Benthic flora and fauna of the Patea Shoals region, South Taranaki Bight

Prepared for Trans-Tasman Resources Ltd

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Executive summary

Trans-Tasman Resources Ltd (TTR) is applying for consents for iron sand extraction in the South Taranaki Bight (STB). The proposed project area (PPA) is located within the STB in an area of seabed known as "Patea Shoals", approximately 25-40 km offshore in water depths of 25-45 m. As very little was known about the types of habitats and organisms found in this region, NIWA was contracted by TTR to survey and describe the benthic (seafloor) flora and fauna on and in the sediments of the broader Patea Shoals region, and to compare the PPA with adjacent mid-shelf, inner shelf and deeper offshore areas. Excavation of seabed sediments will result in large volumes of sediment being processed with the de-ored sediments deposited back onto the seabed. NIWA was also contracted by TTR to experimentally compare the recolonisation of iron rich and de-ored sediments by benthic organisms. This report presents the findings of these investigations.

Seabed sampling of the broader Patea Shoals region was conducted between September 2011 and May 2012. Sampling sites were allocated within the PPA, and across the broader Patea shoals region cover the inner shelf, mid-shelf and deeper offshore areas. Seabed habitats and macrobenthos were visually characterised at 144 sites using underwater video footage and still photographs. Surficial sediments and associated infauna were collected from 331 samples from 103 sites (~3 replicates cores per site), while benthic macrofauna and macroflora specimens were collected form 116 sites using a benthic dredge. All samples were collected under NIWA's special permit (505) issued by the Ministry of Fisheries (now Ministry for Primary Industries (MPI)).

Video observations of the seabed identified seven major habitat types. The most common habitat was rippled sands, which occurred across most of the inner to mid-shelf areas in depths of 15-50 m, including inside and adjacent to the PPA. In addition to rippled sands, a few inner shelf sites supported more dynamic sand-wave bedforms or had small low-lying rocky outcrops that were either surrounded by and/or partially covered by rippled sands. Large areas of the seabed within and adjacent to the PPA were characterised by worm communities, termed 'wormfield' habitats. These habitats were dominated by the infaunal tubeworm, *Euchone* sp A, which live in the upper sediments where they bind sediments together to form their tubes, and can occur in high but patchy densities (mean 1,137.52 ± 180.95 SE, 2 SE range 775.62-1,499.42 per m^2 in this study) across the central and northern mid-shelf zone. Overall inner and mid-shelf habitats, however, supported very few visible epifauna. The exception to this was a comparatively diverse epibenthic assemblage on small and scattered inner shelf rocky outcrops.

In deeper areas offshore, the seabed was characterised by two types of low-relief biogenic habitat: bivalve rubble and bryozoan rubble. Bivalve rubble were characterised by the large robust dog cockle, *Tucetona laticostata*, both living buried in the sediments and with relict shells that have accumulated on the surface of the seabed. Live *T. laticostata* were recorded in water depths of 26-83.5 m, while the shell debris of this species – that formed the dominant biogenic structure in deeper offshore areas - occurred within a much narrow depth contour (44-69 m depths). In deeper zones (>60 m), bryozoan rubble combined with more generic shell debris became the dominant habitat type. These biogenic habitats both supported diverse benthic assemblages dominated by sessile suspension-feeding taxa (e.g. bryozoa, sponges, colonial ascidians, brachiopods and epiphytic bivalves), and in turn provide structure to a plethora of motile species (e.g. crabs, ophiuroids, holothurians, gastropods, and nudibranchs).

The dredge survey was used to verify habitat types and to enable the detailed identification and quantification of many of the organisms observed in the video footage, as well as small organisms and communities buried within the sand that could not be seen in the video footage. Sediment and infaunal HAPS-core samples provided quantification of smaller macrofauna and meiofauna not well sampled by the dredge.

Taxa distribution plots along with similarities/dissimilarities analyses identified that the PPA and adjacent mid and inner shelf habitats supported low numbers of organisms and species, with no significant differences between the PPA and these adjacent-shelf habitats. This pattern of low abundance and species richness is typical of highly disturbed shelf sediments. Although the deeper areas of PPA supported wormfield habitats dominated by high but patchy numbers of *Euchone* sp A, wormfield habitats were also abundant in sediments outside of the PPA area, particularly in mid-shelf areas to the north. These habitats were correlated with medium to fine sediment grains and flatter sediment bedforms, although it is unclear whether *Euchone* sp A is responding to pre-existing sediment conditions or are potential drivers of these benthic conditions. Either way, there was no evidence to suggest that the PPA was “unique” with respect to benthic epifauna or infauna collected from or observed on the seabed during this survey.

The PPA and adjacent-shelf habitats, however, supported comparatively depauperate epifaunal assemblages compared to the diverse and abundant epifaunal assemblages recorded from the deeper offshore bivalve rubble and bryozoan rubble habitats. These offshore biogenic habitats supported abundant and diverse assemblages dominated by suspension feeding taxa. The shallower bivalve rubble habitat, however, supported early successional species, dominated by encrusting coralline algae and small encrusting invertebrates, while the deeper bryozoan rubble habitat supported later stage successional species, dominated by small branching and foliose bryozoans, sponges, and higher mean densities of small motiles species. Bryozoan rubble habitats also supported significantly higher abundances of infauna, although both habitats were dominated by the foraminiferan *Miniacina miniacina*, with much lower numbers of all other infaunal taxa.

NIWA’s initial brief for the recolonisation study was to conduct an experiment, using treatments of iron-rich and de-ored sand, at two sites within TTR’s permitted prospecting areas in the STB. Due to the exposure of the study site and the likelihood of storm disruption it was considered likely that all or part of the experiment would be lost or compromised. Pilot studies off the south coast of Wellington and in the STB (both exposed coasts), proved that it was not possible to conduct experiments into re-colonisation of sandy substrates on wave-exposed coastlines due to scour/replacement of the experimental sand surface. As a result, a more constrained re-colonisation experiment was carried out at two sites (Mahanga Bay and Evans Bay) within Wellington Harbour. At each site, three replicates of each of three experimental treatments were deployed, using treatments of high-iron, medium-iron and low-iron (de-ored sand) concentrations. The sand used in the experiment was collected from within the PPA, in the STB.

Several sampling events were undertaken to help determine the end point of the experiment. On each event, divers collected two sediment cores (30 mm diameter x 110 mm deep) from each replicate treatment. Three cores were also taken from the surrounding natural sediments. Each sediment core was analysed for benthic community structure, concentration of iron (by weight) and particle size of sediments. Only the results of the latest sampling event, at approximately 7 months since deployment at each site, are reported here.

After 7 months at Evans Bay, the more sheltered of the two sites, the experimental surface appeared to have remained relatively undisturbed. However, at Mahanga Bay the experimental surfaces had been noticeably scoured. Despite these apparent differences, at the end of the experiment both sites had very similar concentrations of iron within the three experimental treatments (approximately 3 % within the low iron treatments, approximately 20 % iron in the medium treatments and approximately 30 % iron in the high iron treatments).

Multivariate analyses of the data identified significant differences in benthic community structure between sites but little effect of iron concentration, which explained less than 4 % of the variation in species composition despite the highly contrasting iron-ore treatments. There was also no significant interaction between site and treatment. Further analysis identified that the relatively small differences in sediment properties among treatments had a larger influence on community structure than the very large differences in the concentration of iron.

Overall there was no evidence within the data to suggest that the proposed extraction or de-ored sand deposit areas are "unique" with respect to macrofauna collected/observed during the survey. Importantly, neither the video observations, dredges, sediment cores (macro or meiofauna), nor the recolonisation experiment showed a significant relationship between iron concentration and community structure. Discussion of the potential effects of TTR's proposed activities on the benthos will be addressed separately.

2015 Amendment:

At the time of writing and submitting the original Beaumont, et al (2013) NIWA Client Report No: WLG2012-55, TTR's Proposed Project Area extended well inshore of the 12 nm limit, and a separate offshore deposition site ('proposed tailings area') to the south was proposed. As a consequence, the original multivariate analyses presented in Beaumont et al., 2013 compared community types both inside vs outside of a much larger Proposed Mining/Project Area, as well as the now obsolete deposition site. Revised multivariate analyses on the video, epifaunal and infaunal datasets were submitted in Feb 2014 as part of Dr Tara J. Anderson's expert evidence[1]. These analyses were undertaken on the same data but compared communities inside versus outside of the revised Proposed Mining/Project Area (now the joint mining and deposition area located offshore of the 12 nm limit). Additional analyses also examined the relationship between community structure of these datasets relative to major habitat types (e.g. rippled sands, wormfields, etc.) and the physical characteristics of these habitats (e.g. grain size). The revised figures and findings of these analyses are now presented in Appendix A.

Information relating to TTR's additional scientific work undertaken since Feb 2014 has been provided and the conclusions in this report, inclusive of the analytical amendments in Appendix A, remain valid.

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[1] Anderson, T.J. 2014. "*Statement of Evidence in Chief of Dr Tara Anderson on behalf of Trans-Tasman Resources Ltd*". Evidence prepared for Environment Court in the application for Ironsands extraction offshore in the South Taranaki Bight, submitted 14 February 2014 (EEZ000004-26-A) and Appendix B (Figures and Tables; EEZ000004-26-B), and presented 2 April 2014.
http://www.epa.govt.nz/eez/EEZ000004/EEZ000004_26_Tara%20Anderson_(Benthic%20Ecology).PDF
http://www.epa.govt.nz/eez/EEZ000004/EEZ000004_26B_Tara%20Anderson_(Benthic%20Ecology).PDF

1 Introduction

1.1 Background

1.1.1 Iron ore and seabed extraction

Shelf sediments within the South Taranaki Bight (STB) on the West Coast of the North Island contain a rich source of magnetic iron ore, and the oxides of titanium and vanadium, collectively known as Vanadium Titano-Magnetite (VTM). These sediments have terrigenous origins resulting from eroded volcanic rock washed down from Mount Taranaki and the Central Plateau. Trans-Tasman Resources Ltd (TTR) is seeking consent to extract seabed material from the STB. The proposed project area (PPA) is located in an area of seabed known as “Patea Shoals”, approximately 15-40 km offshore in water depths of 25-45 m (Figure 1). Once the iron ore has been extracted, large amounts of de-ored sand will be re-deposited on the seafloor of the South Taranaki Bight within the PPA.

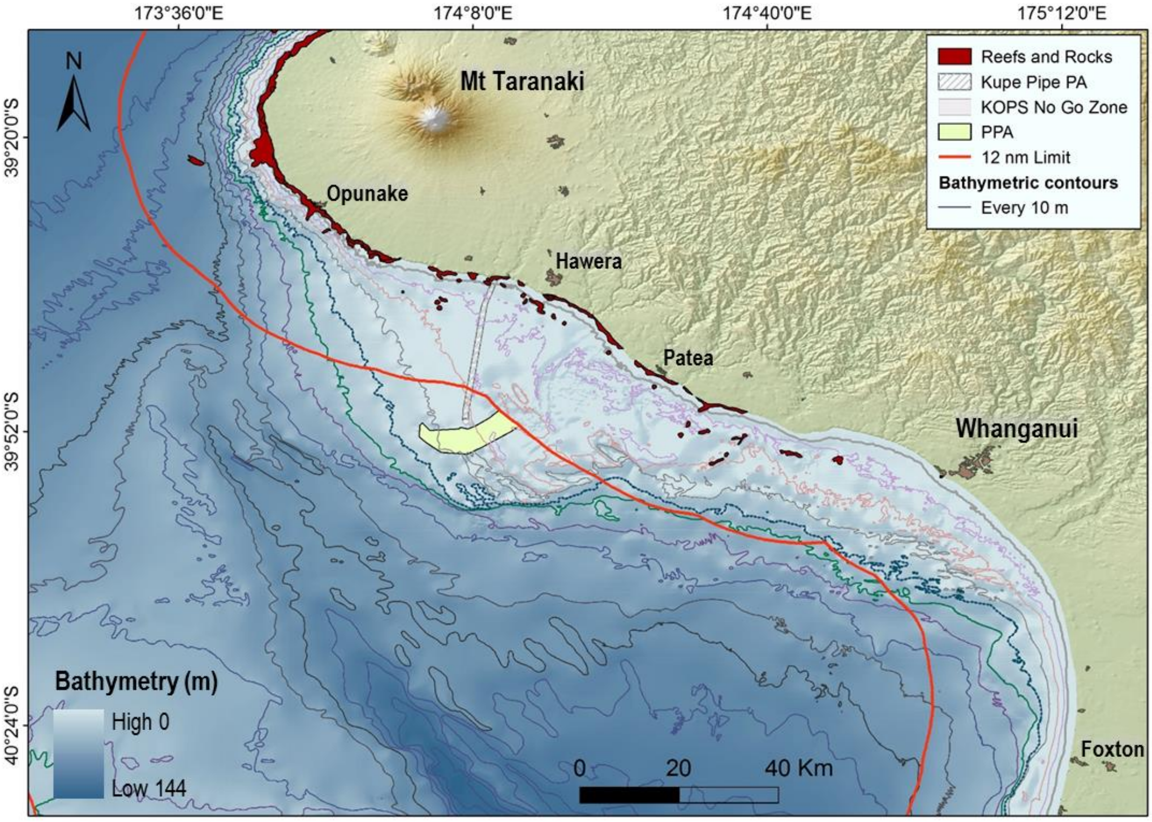

Figure 1: Map of the South Taranaki Bight with the location of TTR's Proposed project Area (PPA) beyond the 12 nm limit.

The PPA is situated over an area of seabed known locally as the “rolling grounds” or “Patea shoals” – a relatively shallow subtidal (approx. 20 to 50 m depth), sandy area offshore from Patea Township. The area is exposed to southerly and westerly storms resulting in regular large swell events. These storm events have been shown to increase the near-bed orbital velocity to several times the mean strength from tidal currents (Hadfield 2011), greatly increasing the resuspension and movement of sediments/sand in to the water column and along the seafloor (MacDonald et al., 2012). This results in a highly dynamic seabed environment, likely to have high rates of natural disturbance. This area, particularly towards the southwest of the study area, is also known to be actively fished using bottom trawl gear (see Figure 5.2 in MacDiarmid et al. 2012).

1.2 Previous research on the benthic fauna of the South Taranaki Bight

Previous work in the STB area has suggested the benthic fauna to be generally species poor with a low abundance of benthic organisms in both the subtidal and intertidal zones when compared to other coastal areas of New Zealand (see reviews by DOC 2006, MacDiarmid et al. 2010). This is thought to be particularly true for the shallow sandy habitats; however, there have been very few detailed benthic surveys in this area. For instance, McKnight (1974), who described the benthic fauna of the shelf on the west coast of the North Island, sampled approximately 10 sites within the region of interest to this study. Beaumont et al. (2008) showed there to be very limited marine taxonomic and ecological information on the benthos, with respect to national datasets, inhabiting the STB area (and many other areas on the west coast of both main islands).

1.3 NIWA's brief

NIWA was contracted by TTR to sample the benthic flora and fauna (macrobenthos through to meiobenthos) in the STB, in relation to TTR's permit areas, in order to characterise faunal communities across naturally occurring gradients in the vicinity of the areas proposed for iron-sand dredging and de-ored sand deposition. The relationship between the concentration of iron in sediments and the benthic community structure was also investigated. This report sets out factual findings of the investigation. Discussion of the potential effects of TTR's proposed activities on the benthos will be discussed separately. This report also describes an experimental study into the influence of iron ore (VTM) concentration, on the re-colonisation of sandy habitats by benthic fauna.

2 Methods

2.1 Study site

TTR's proposed project area (PPA) is located in an area of seabed known as "Patea Shoals" (or "The Rolling Ground" on LINZ chart NZ45), approximately 15-40 km offshore in water depths of 25-45 m (Figure 2). The continental shelf across the STB - informally known as the Whanganui shelf – expands out from a narrow band around Mount Egmont to a broad shelf across the south Taranaki Bight. The shelf has a gradual (<1^{o}) slope extending out 100 km offshore to a depth of around 110 m, (Gillespie et al., 1998). The seabed environment within this region is exposed to high energy conditions resulting in natural and regular seabed disturbances from waves, storm events, and tidal currents (Pickrill and Mitchell, 1979; Gorman et al., 2003; Orpin et al., 2009). Strong prevailing southerly and westerly winds from the Southern Ocean generate a highly energetic wave environment that produces persistent south-westerly swells (period of 9–12 s) with storm-generated waves (1–3 m and 6–8 s, max. of 8 m) driven by southerly, westerly, and north-westerly wind events (Pickrill and Mitchell, 1979; Harris, 1990). Tidal currents are also moderately strong within the STB region with tidal current speeds ranging from 7-25 cms-^{1} (Proctor and Carter, 1989). Patea shoals in particular, is exposed to the strongest tidal currents on the STB shelf with speeds of up to 0.2 ms^{-1} (MacDiarmid et al., 2010). As a consequence of this high energy environment, bed resuspension and movement of sediment across much of the shelf is common (Orpin et al., 2009; MacDiarmid et al., 2010; MacDonald et al. 2012). Sediment samples and seabed photographs collected from various locations across the STB have recorded dynamic high-energy benthic environments dominated by sand rippled and mega-rippled iron-rich bedforms, comprising coarse grained sands that are largely devoid of mud (Gillespie and Nelson, 1996; *review in* MacDiarmid et al., 2010). The sediments, however, generally support low species diversity and abundance compared to other coastal locations around New Zealand (MacDiarmid et al., 2010). Beyond this, relatively little is known about the organisms that live on (epibenthos) or in (infauna) the sediments of the STB (*although see* Gillespie and Nelson, 1996).

2.2 Survey Design

To describe the physical composition of the seabed and its associated epibenthos (*fauna and flora living on the seabed*) and infauna (*organisms living in the sediment, including both macrofauna [>500 µm] and meiofauna [63-500 µm]*), a total of 145 sites were sampled within the broader Patea Shoals region using combinations of video transects (144 sites), epifaunal dredges (116 sites) and sediment cores (103 sites) (Figure 1 and Figure 2). Seabed sampling was conducted over a 9-month period (2nd September 2011 to the 6th May 2012) on board one of three research vessels (Ikatere [IKA1101], Kaharoa [KAH1201 and KAH1206] and Tranquil Image [TQI1201]) (Figure 2, Table 1 and Appendix A). In order to provide a baseline comparison of the seabed environment and benthos across the broader Patea shoals region relative to proposed extraction activities, study sites were chosen to 1) include areas within and 2) adjacent to the PPA; 3) within and adjacent to several potential de-ored deposition sites, and 4) encompass a range of depths and sediment types across the broader Patea Shoals region using available geological data (Orpin et al., 2009, MacDiarmid et al., 2010). During the course of this survey program, TTR’s proposed extraction and deposition sites were altered, with expansions and reductions in boundary extents and new deposition sites examined (Figure 2). Where possible, sampling sites within these new areas were included within the broad-scale sampling program and sampled during subsequent surveys.

Table 1: Temporal summary of the sites surveyed by gear type within the STB between Sept-2011 to May-2012 (IKA1101, KAH1201, TQI1201 and KAH1206 surveys). Numbers within core, camera (Coastcam2 setup) and dredge sites, denote the site numbers sampled and the order they were sampled in (see Appendix A for sampling and replicate-core details).

Time	Date	Survey No.	Core sites	Camera sites	Dredge sites
Spring	22-Sep-2011	IK1101	1, 2, 59, 60		
Spring	23-Sep-2011	IK1101	3, 4, 35, 51, 65-67		
Spring	29-Sep-2011	IK1101	28, 57, 61		
Spring	30-Sep-2011	IK1101	6, 11, 14, 18, 20, 24, 27, 38		
Spring	1-Oct-2011	IK1101	17, 31-34*, 56, 58		
Spring	31-Oct-2011	IK1101	12, 16, 26, 34*, 41, 45, 54, 55		
Spring	1-Nov-2011	IK1101	7, 10, 25, 44, 46, 49, 50, 53, 62		
Spring	2-Dec-2011	IK1101	5, 9, 15, 21-23, 42, 48		
Summer	10-Dec-2011	IK1101		3, 65,	65, 4, 1, 2
Summer	11-Dec-2011	IK1101		4, 35, 62, 67	
Summer	12-Feb-2012	KAH1201	68-70, 79, 96, 100-103, 116, 117, 119, 120, 133-135		116, 117
Summer	13-Feb-2012	KAH1201	72-77, 79, 81, 83, 87, 92-95, 97-99, 105, 131, 132, 137, 138		119x
Summer	14-Feb-2012	IK1101		84, 88	
Summer	26-Feb-2012	IK1101			11, 12, 618, 20, 24, 35, 61, 66, 44, 21, 46
Summer	27-Feb-2012	IK1101		122, 123, 128	
Summer	28-Feb-2012	IK1101		1, 11, 14, 16, 22, 28, 51, 59, 60, 75, 76, 78, 96, 136	
Summer	29-Feb-2012	IK1101		23, 25, 26, 48, 50, 56, 57, 61	
Autumn	5-Mar-2012	IK1101		2, 38, 41, 77, 92, 97, 106, 109, 129, 130, 137, 138	
Autumn	6-Mar-2012	IK1101		12, 18, 20, 71-74, 93, 95, 101-104	
Autumn	*10-Mar-2012	IK1101		79, 82, 83, 90, 91, 99, 110, 115, 117, 118, 124, 125, 126, 127	
Autumn	*11-Mar-2012	IK1101		86, 89	
Autumn	*10-Mar-2012	TQ1201	78, 71, 136, 104, 130		104, 102, 103, 135, 101, 96, 100, 105, 99, 130, 98, 97
Autumn	*11-Mar-2012	TQ1201			95, 138, 131, 93, 94, 92, 41, 38, 27, 137, 59, 60, 51, 3, 28, 26, 14, 136, 57, 55, 54,

Time	Date	Survey No.	Core sites	Camera sites	Dredge sites
					68-78, 56, 31, 49, 58, 67, 10, 25, 22, 23, 48
Autumn	12-Mar-2012	TQ1201			45, 50, 53, 7
Autumn	16-Mar-2012	IK1101		108, 112, 113	
Autumn	17-Mar-2012	IK1101		7, 10, 15, 31, 42, 44, 49, 53, 58, 80, 81, 85, 107, 119, 120, 132, 133, 134	
Autumn	18-Mar-2012	IK1101		68, 69, 70, 94, 98, 100	
Autumn	19-Apr-2012	KAH1206			147, 151, 109, 113, 108, 116, 115, 112, 108a, 107, 140, 139, 145, 142, 157, 144
Autumn	20-Apr-2012	KAH1206	141, 142, 145, 146, 148, 149, 154-159, 161		143, 146, 156, 148, 149, 141, 153, 152, 154, 150, 155, 158, 160, 159, 161
Autumn	21-Apr-2012	KAH1206	7*, 15, 20, 42, 46, 75, 93, 94, 97, 138		42, 15, 5, 9, 17, 33, 32, 34, 43
Autumn	3-May-2012	IK1101		142, 144-146, 148, 149, 151, 153, 154, 156, 157, 160	62
Autumn	4-May-2012	IK1101		111, 114, 116, 131, 139, 140, 143, 147	
Autumn	5-May-2012	IK1101		6, 141, 150, 152, 155, 158	
Autumn	6-May-2012	IK1101		9, 17, 21, 24, 32-34, 45, 46, 54, 55, 66, 105, 135, 159, 161	
Autumn	7-May-2012	IK1101		5	

* IK1101 and TQ1201 surveys overlapped in time from the 10-11th March 2012.

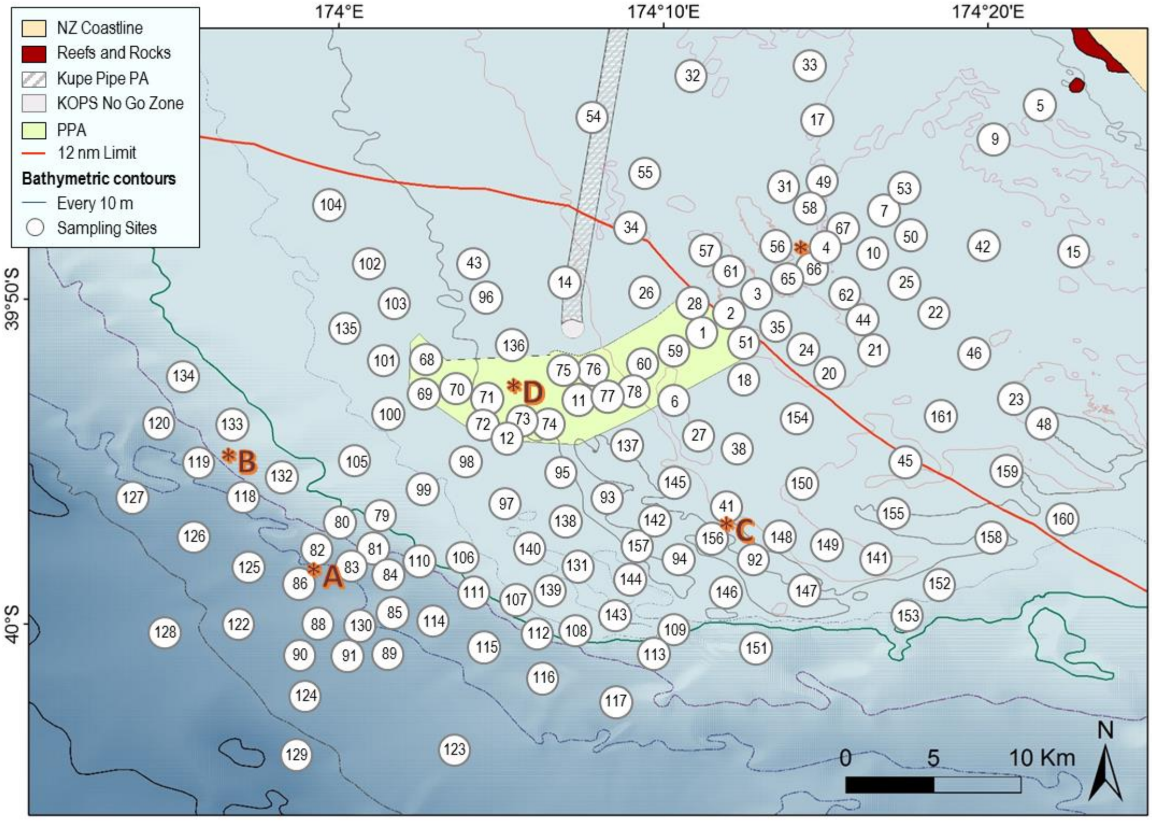

Figure 2: Location of sampling sites across Patea Shoals within the South Taranaki Bight (STB). PPA= Proposed Extraction Area; Kupe Pipe PA = Kupe Pipe protected area; KOPS no go zone = Kupe Oil Platform Safety no go zone. Depth contours are in 10 m intervals. *A-*C indicate TTR's preliminary deposition-assessment areas, *D indicates TTR's proposed extraction/deposition area/PPA. '*' depicts the inner shelf area prior to contraction of the PPA area.

2.3 Sampling Methods

2.3.1 Coastcam observations

Benthic habitats and macro-organisms were visually surveyed at 144 sites using NIWA's Coastcam2 underwater towed imaging system (Figure 3, Table 1 and Appendix A). The standard Coastcam2 imaging system was fitted with a high resolution down-facing video camera (Tritech Ltd Typoon colour video camera: 4 mm wide angle lens, 470 line-resolution), with live feed to the surface, and a down-facing high-resolution stills camera (450D digital Canon SLR camera in an underwater housing) with associated lights, an altimeter and a tail-vane attached to the back of the tow-body system to ensure the camera faced in the direction of travel. At the onset of the camera surveys, the Tritech video camera returned over-exposed (flared) images of the seabed. To resolve this problem, the Tritech video camera was removed from the tow body, and was then re-fitted with a Deep Blue Pro colour video camera (3.6 mm wide angle lens, 520 line-resolution, with 0.1 lux sensitivity). The Deep Blue Pro video camera still provided live feed to the surface but its lower light capabilities provide a much better image of the seabed. All sites were then surveyed (or resurveyed) using the new, modified-camera system (here on referred to as 'Coastcam2) (Figure 3c). Sites where video was collected, but the stills camera failed to capture images of the seabed, were also resurveyed, later in the survey when time allowed.

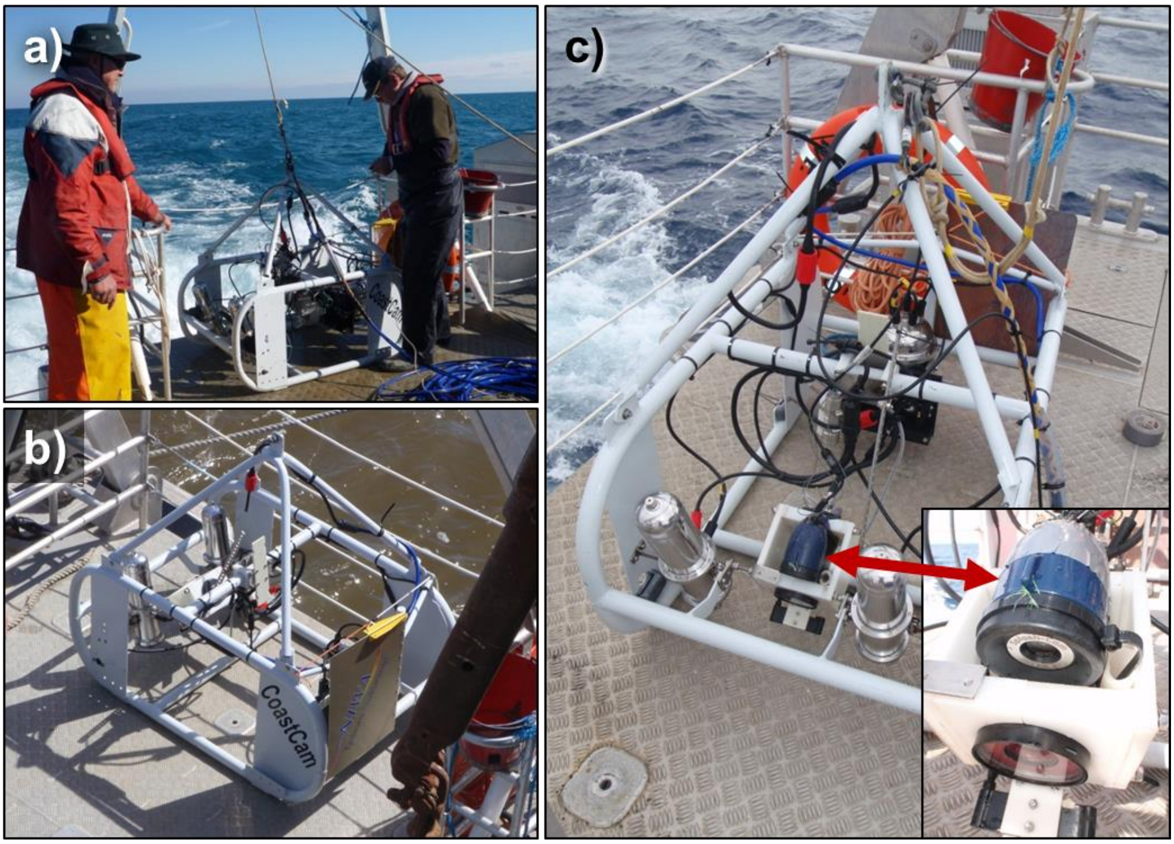

Figure 3: **NIWA's Coastcam2 towed-video system.** a-b) Coastcam2 ready for deployment on the deck of the RV Ikatere, c) Coastcam2 re-fitted with the Deep Blue Pro low-light video camera.

At each site, the Coastcam2 was deployed from the stern of the R.V. Ikatere and towed at ~1.0-1.5 m above the seabed at a speed of 0.5-1.0 knots. A single 10-min video transect (˜300 m long) was surveyed with concurrent high-resolution (12 megapixels) still photographs automatically captured every 15 seconds. Video footage along each transect was transmitted in real-time, via coaxial cable, to a ship-board video-monitor enabling real-time observations of the seabed environment, while an axillary feed to a second video-monitor enabled the hydraulic winch operator to regulate the altitude of Coastcam2 above the seabed. The start and end of each video transect (i.e. time on and off the seabed) and the spatial position along each transect (1-2 second trackline files) were recorded using the ships GPS navigation system. A Furuno RD-30 display was linked to the video-system to enable researchers to co-monitor the ships GPS position, speed over ground and heading. Real-time video footage was then fed through a Horita time stamp (GPT-50) device that stamped GPS and UTC date and time information onto the video image as it was being recorded to digital mini-DV tape using a Sony recording device. Still images were captured to a digital memory card and downloaded to an external hard drive at the completion of each camera tow. Mini-DV tapes and still images were then archived to separate digital hard drives and later stored at NIWA, Greta Point Wellington.

Video surveys were undertaken over a 5-month period during the summer and autumn of 2011-2012 (10 Dec – 5th of May), with the majority of sites (77%) sampled during a 7 week period in autumn (Table 1 and Appendix A). The more extended 5-month period of sampling was due to a sequence of changes in TTR's proposed extraction and deposition areas, challenging weather conditions and vessel restrictions, combined with the large number of sites needed to be sampled. Due to camera difficulties, a total of the 44 sites were revisited during the course of the survey. No noticeable differences in either seabed geomorphology or biological habitat composition was observed at these sites. Consequently this time frame was deemed acceptable for the purposes of describing benthic habitats at each site.

In the laboratory, the ships GPS 1-2 second trackline files were saved as Ascii files with OFOP-readable headers, and then imported into OFOP (Ocean Floor Observation Protocols software v3.3.3, Greinert 2009) where they were interpolated to exact 1-sec records. Video footage for each transect was then sequentially imported into OFOP, linked by time with the navigation file, and processed for seabed habitat (i.e. substratum type and geomorphology) and biological (presence of key organisms) observations. Habitat and biota observations were recorded every few seconds along each transect. For each observation recorded, OFOP automatically captured and entered time and ships-GPS position. Every few seconds along each transect, the most dominant substratum type (i.e. bedrock, boulders, cobbles, pebbles, gravel, shell-hash, coral rubble, sand, mud – as defined in Greene et al., 1999) and for soft-sediments the characteristic geomorphic bedform (sediment waves, sediment ripples or sediment flats) was recorded. Any macro-fauna, macro-flora (organisms visible to the eye [> 4 cm]) or lebensspuren activity (signs of life, such as trails, burrows and mounds) seen along each transect were recorded as presence, with the ship-GPS position captured for that record. Biota were identified to species where possible or group levels (e.g. starfish, bryozoan and macroalgae). Still images, which often provided finer-resolution, were used to assist in the identification of species/taxonomic groups, especially smaller sized organisms.

2.3.2 Sediment and Infaunal Sampling

2.3.4.1 Acquisition field processing of sediment cores

Seabed sediments and the associated infauna were sampled from 103 sites during the spring of 2011 (22nd Sept – 2 Dec) (Table 1 and Appendix A). At each coring site, a target of three replicate sediment cores - separated by at least 20 m - were sampled using NIWA's KC-Denmark HAPS corer (Figure 4a,b). The HAPS corer has a base frame of 80 x 80 cm, is 156 cm high and weighs 170 kg, and was deployed by winch off the stern of the vessel. Upon hitting the seabed, a single 13 cm diam. sediment core penetrates the seabed to a maximum depth of 31 cm, collecting an undisturbed surficial sediment sample. Not all cores were successful, as the depth at which the core penetrated the benthic sediment varied considerably between sites (range 0-23 cm). In total, 373 cores were attempted, of which 331 samples from 103 sites were successful (see Table 2) and reflected a mean penetration depth of 10.79 cm ± 0.24 cm standard error (SE). A core was deemed successful if it collected ≥5 cm of vertical sediment. Where a core failed, another core was undertaken. Six sites (e.g. 116-120) failed to return any sample after multiple attempts due to hard ground habitats (e.g. bryozoan and bivalve habitats). After identifying these habitats from video observations, cores from similar habitats were not attempted. A further 10 sites (total of 14 core samples) returned only a partial sample (< 5 cm of vertical sediment collected), these occurred in sites where the seabed was comprised of hard material such as bedrock, gravel or other structure (e.g. sites 5, 7, 15, 42, 50 and 53). These latter samples were processed for infauna to provide a record of species occurrences.

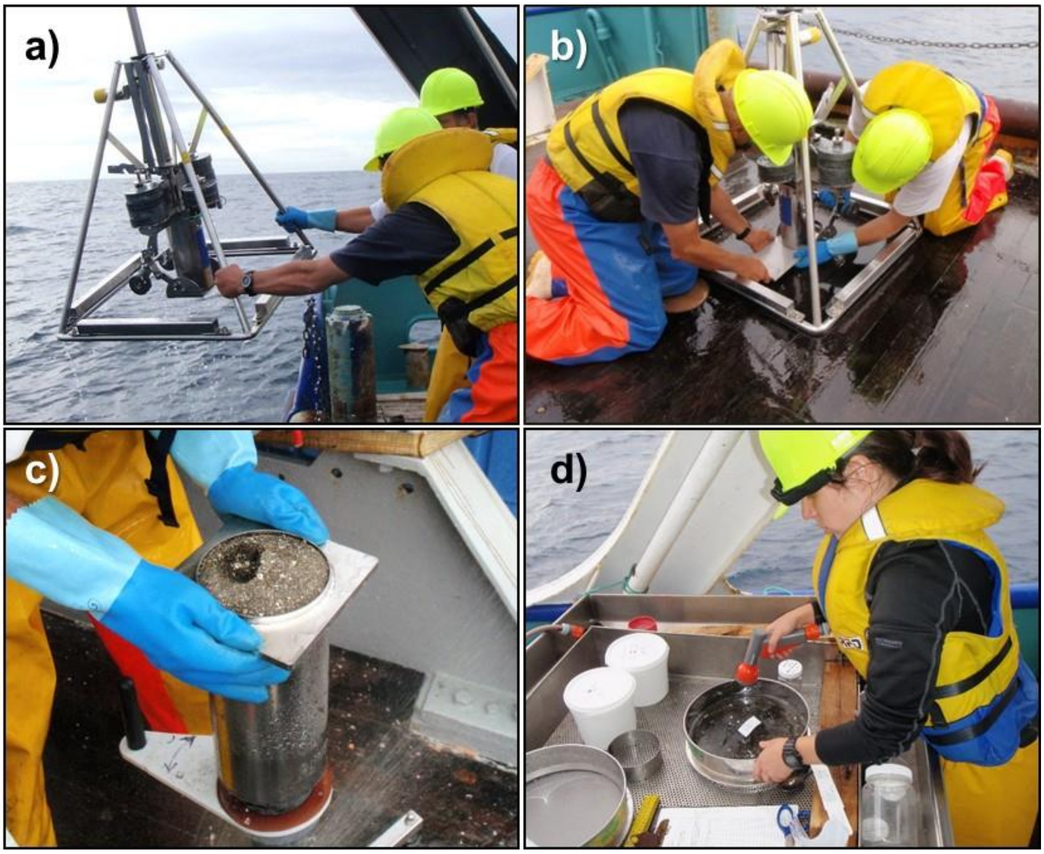

Figure 4: Sediment and infaunal sampling using NIWA's KC-Denmark HAPS corer.

Upon retrieval of the HAPS corer safely back on to the deck of the vessel, a metal plate was positioned beneath the core cylinder (Figure 4b), the core was then carefully removed and transferred to a piston press to extrude the sediment core from its cylinder (Figure 4c). Before extrusion, the surface of the sediment was photographed with a sample label, and a sediment sample (approx. 15 ml), collected from the centre of the cores surface, was bagged with a label and retained in a cool store at 4^{o} C until laboratory analysis. The remaining sediment was then processed for infauna. To do this, the piston press was carefully wound so that the top 5 cm of sediment (0-5 cm vertical section = 664 cm^2) extruded from the cylinder. This vertical section was then cut off and placed in a labeled 2.5 L bucket and preserved in 10% buffered formalin with rose Bengal for detailed laboratory processing. The next two vertical sections (5-10 cm and 10-15 cm) were then similarly and sequentially extracted from the piston press. In turn, each section was carefully washed through a 500 µm sieve, with the remaining sediments placed respectively in labelled jars and preserved in 4% buffered formalin with Rose Bengal solution (to stain specimens to assist in sorting). This approach meant that all 331 samples from 103 sites had a 0-5 cm vertical section, while 281 samples from 101 sites had an additional 5-10 cm vertical section, and 174 samples from 80 sites had a further 10-15 cm vertical section. A further 34 cores from 21 sites collected >15 cm of sediment, of which 11 cores from 10 sites had enough sample to process an additional vertical layer. However initial sorting found little to no infauna in these deep sediment strata, and due to logistical constraints further samples were not kept.

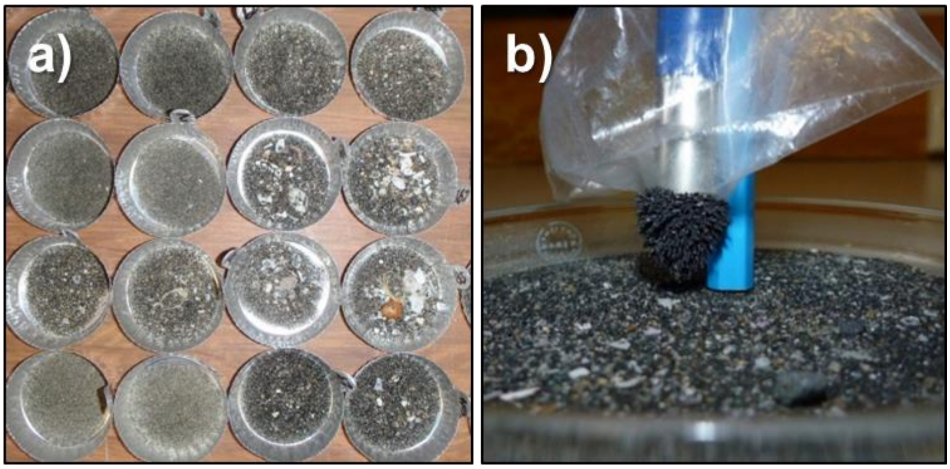

Figure 5: **Sediment processing.** a) Examples of sediment subsamples in drying trays, b) extracting iron by moving a magnet systematically across the subsample at a height of 1.3 cm.

2.3.4.1 Sediment post-processing

To quantify both the amount of iron-ore present in the sediments and the grain size distributions of those sediments, back in the laboratory each sediment sample was split into 3 subsamples to check for measurement heterogeneity, dried in small, pre-labelled, foil trays (Figure 5a), and weighed. To quantify the amount iron-ore present, each subsample was carefully spread out on a glass petri-dish. Iron-ore was then collected by systematically passing a magnet, placed in a small plastic bag, across the sample at a height of 1.3 cm to attract magnetic material assumed to be iron-ore (Figure 5b). The collected iron-ore was then dropped into a clean petri-dish (by removing the magnet from the plastic bag) and weighed.

Grain size distributions for most sediment samples were quantified using a Beckman Coulter LS 13 320 Dual Wavelength Laser Particle Size Analyser, as this method provides higher efficiency, accuracy, resolution and repeatability than the more traditional stacked sieve methods (Orpin, 2012, also see McCave et al. 2006; McCave and Syvitski 1991). To do this the three subsamples from each core along with the extracted magnetic ore were recombined. The sediment sample was then homogenised, whereby 0.5 cm^3 of sediment was re-suspended in distilled water in a 50 ml container, invigorated using ultrasound, and then washed through a 1.6 mm sieve into the laser-sizer where it was analysed for 90 seconds. Standard granulometric statistics (mean grain size, sorting, skewness and kurtosis) were then calculated for each site from the 'percent by volume' laser data using GRADISTAT (Blott and Pye, 2001) and provided standard textural descriptions (e.g. Folk, 1974). As the laser sizer is limited to grains <1.6 mm, the proportion of coarser grained sediments per site was determined using dry sieve stacks. Samples with a large proportion of shell and/or gravel fraction (> 1.6 mm) could not be analysed using the Laser Particle Sizer. Instead, the entire grain size distribution (i.e. proportions of sand, mud and gravel) of these samples was determined using dry sieve stacks (all grain size categories are listed in Appendix A).

2.3.4.2 Infaunal post-processing

All infauna were post-processed from each vertical sediment layer back in the laboratory. As most organisms live in the upper 5 cm of benthic sediments (Hines & Comtois, 1985; Blake, 1994) and all cores sampled during the survey (n=331 samples, from 103 sites) collected this top vertical layer, both the macrofauna (*>500 µm*) and smaller meiofauna (*63-500 µm*) were systematically processed from this layer. First, macrofauna (>0.5 mm) were extracted from the surface sediments by carefully washing all the sediments through a 500 µm sieve. Sediments that passed through this sieve were then carefully elutriated and sieved through a finer 63 µm sieve to extract the meiofauna. Material finer than this (<63 µm fraction) was discarded. The macrofauna and then meiofauna were then sorted sequentially from the retained sediments under a dissecting microscope.

Macrofauna were then grouped into coarse taxonomic groups (e.g. amphipods, copepods, polychaetes, bryozoans, molluscs, algae, etc.) and preserved in either 4 % buffered formalin (e.g. polychaete worms) or ethanol (e.g. most other taxa). The macrofauna-only from the two deeper strata (i.e. the 5-10 cm and 10-15 cm vertical sections) - already been passed through a >0.5 mm sieve at sea - were then similarly sorted under a dissecting microscope and preserved. Biological specimens from each taxonomic group (e.g. amphipods, copepods, polychaetes, bryozoans, molluscs, algae, etc.) were then transferred to taxonomic specialists for identification to species or operational taxonomic unit (OTU's – i.e. lowest taxonomic level possible), enumeration and the description of any new species. Number of infaunal specimens and species are presented per 1 m^2. Finally, meiofauna were carefully sorted into broad taxonomic groups (e.g. nemotodes, copepods, ostracods, small polychaetes and other annelid worms, cumaceans, etc.) and enumerated. Numbers of meiofauna per taxonomic group are presented per 1 m^2.

2.3.3 Epibenthic sampling

Benthic macrobenthos (*macrofauna and macroflora on or at the surface of the seabed*) was sampled from 116 sites (1 dredge per site) using NIWA's small (80 cm wide by 25 cm high) Agassiz dredge (Table 1, Appendix A and Figure 6). The dredge was fitted with a standard 2 m long and 28 mm diagonal mesh net, encased within a 100 mm chaffing mesh to protect the internal cod end from damage (Figure 6a). Dredge sampling was undertaken between the summer-autumn of 20011-2012 (Table 1 and Appendix A), with the majority of sites (85%) sampled during a 6 week period in autumn 2012 (10th March to the 21 April). These samples were undertaken during one of two surveys on the M/V Tranquil Image [TQ1201] or NIWA's R.V. Kaharoa [KAH1206]), while the remaining sites (15%) were sampled during summer on the RV Ikatere (Table 1 and Appendix A). As with the towed-video sampling this extended sampling window was due to changes to TTR's proposed extraction and deposition areas combined with sampling all 116 dredge sites within short and unpredictable weather window, where research vessels with the necessary dredging capabilities were also available. To reduce any systematic sampling bias associated with time, the temporal order in which sites were sampled was assigned based on random allocation between broad scale areas (PPA, adjacent mid-shelf, inner shelf and offshore zones), constrained by maximum feasible distances travelled between sites (max. 15 km). As the aims of the dredge sampling were to describe the types of biological specimens present within the PPA compared to adjacent zones (i.e. inner shelf, mid-shelf and offshore seabed areas) across the broader Patea Shoals region, this approach was more than adequate, as any temporal variability was included in the variation of the mean for each zone.

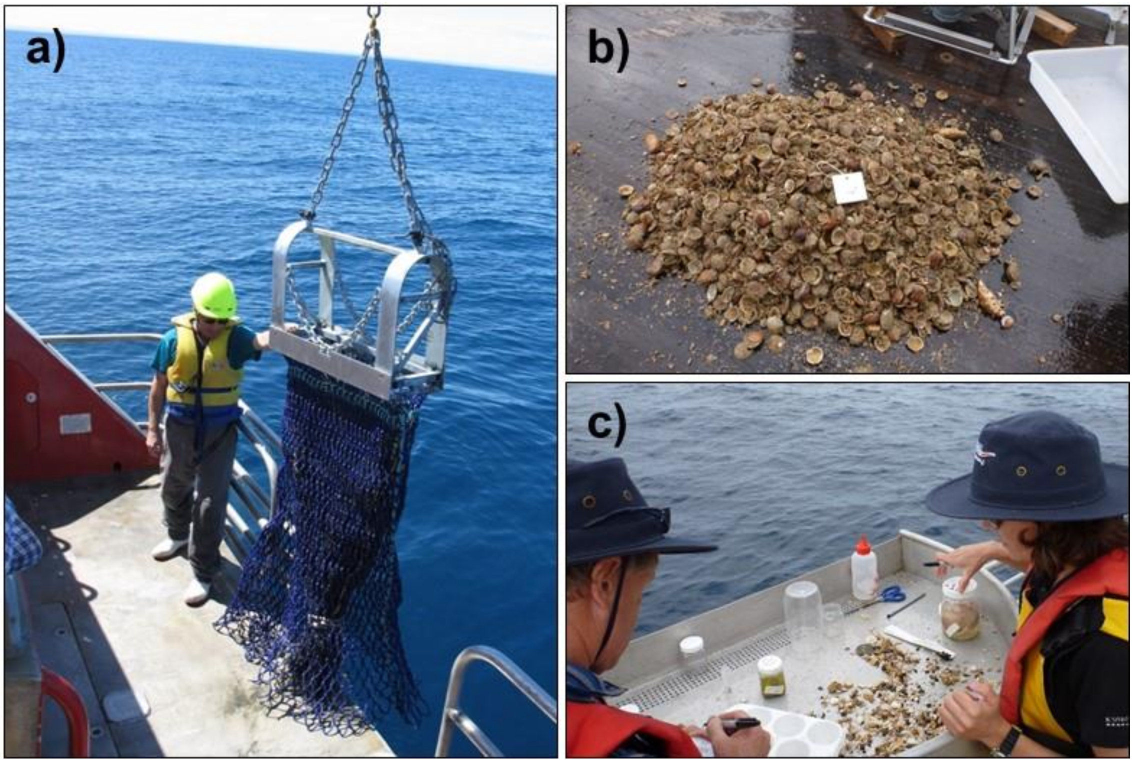

Figure 6: Epibenthic sampling using NIWA's small Agassiz dredge and associated catch. a) Agassiz epibenthic dredge; b) A typical catch from an offshore benthic sites (here site 113) showing bivalve shell-debris (mostly the dog cockle, *Tucetona laticostata*), which forms a distinct biogenic habitat; c) researchers sorting the epifaunal catch (site 151) into taxonomic groups for preserving.

At each site, the benthic dredge was deployed from the stern of the vessel and towed along the seabed at approximately 2 knots for 5 minutes, covering a linear distance of ~300 m. The start and end of each benthic dredge (i.e. time on and off the seabed) was recorded using the ships GPS navigation system, and was used to calculate tow distance. Upon retrieval of the dredge back onto the deck of the ship, the net was emptied either directly onto the deck (large catches) or into plastic fish-bins (smaller catches). The entire catch was photographed (e.g. Figure 6b) and then moved to the sorting table where researchers carefully separated specimens into broad taxonomic groups (e.g. bryozoans, sponges, ophiuroids, algae, worms, and crustaceans) (Figure 6c). Where dredges captured large amounts of benthic material (up to 130 kg), a subsample of the catch was retained for sorting. For these catches the amount of subsample taken was a proportion of the total catch was recorded, and the remainder of the catch was then returned to the seafloor. After sorting into taxonomic groups, all retained specimens were preserved in either 99% ethanol (e.g. most taxa), 4% buffered formalin (e.g. algae and worms), dried (bryozoan) or refrigerated and then frozen at -20^{o}C (e.g. sponges, bivalves and gastropods). Upon completion of the survey, biological specimens were transported to NIWA Greta Point where specimens were catalogued and then transferred to taxonomic specialists for identification to species or operational taxonomic unit (OTU's – i.e. lowest taxonomic level possible). Once identified, specimens were returned and archived in NIWA's Museum collection at Greta Point. The exception was sponges, which are housed in the Sponge collection at NIWA Auckland. New or rare species, along with new or rare records of species within the south Taranaki Bight, were then entered into NIWA's Taxonomic database 'SPECIFY'. All benthic samples were collected under NIWA's special permit (505) with the Ministry for Primary Industries (MPI). Number of epibenthic specimens and species are presented per 250 m^2.

2.4 Data analysis

Sediment core sections (0-5, 5-10 and 10-15 cm depths) were analysed separately in order to provide comparable samples between sites. Cores of at least 5 cm deep were achieved from all sites, with the exception of sites where coring was not possible due to too much shell-hash/gravel. Fewer core sections were obtained from the 5 – 10 cm and particularly the 10 – 15 cm depths. The vast majority of fauna (88 % of organisms) were recorded within the top 5 cm of sediment and so this core fraction was analysed to a greater extent than deeper core sections.

2.4.1 Distribution plots

The Geographic Information System (GIS) ArcMap v 10 was used to create distribution plots of substrate and biological data. Substrate observations for each transect were summed by substrate type (sand, shell-hash, bedrock etc.) and plotted as a percentage for each site in order to identify key habitats within the study area. Observations of flora and fauna were plotted to show the distribution of the total number of records and species/taxonomic groups in relation to the proposed extraction and de-ored sand deposit areas. The number of individuals and species per phyla at each site was also plotted.

2.4.2 Multivariate analyses[2]

Non-Multidimensional Scaling (nMDS) plots and analysis of similarity tests (ANOSIM in PRIMER-E, Clarke & Warwick 2001) were used to identify differences/similarities in the assemblage of benthic organisms between *a-priori* specified groups of sampling sites (Extraction, Deposition and Non-extraction). Distance based linear models (DISTLM in PERMANOVA+ for PRIMER, Anderson et al. 2008) test how much variation in community structure is explained by each predictor (environmental) variable. DISTLM analyses were used to identify key drivers in community structure for each dataset (coastcam, dredge and sediment core), particularly with respect to the influence of iron on community structure. The DISTLM model runs sequentially (i.e. how much variation does variable 1 explain, then how much more variation does variable 2 explain and so on) and so the order in which the variables are tested is important. Marginal tests (all specified, R^2) were used to identify the order of variables before the sequential tests were carried out. Although the sequential DISTLM model is a robust statistical technique, as well as being useful in that it partitions variability, it does not allow indirect or correlated effects to be assessed. In order to check that variables important to this study (i.e. iron) had not been omitted from the analyses due to association the model was re-run with a backwards selection using AIC[3]. In this way, the backwards elimination model highlights (eliminates) those variables that are definitely not important in structuring the biological community and selects all those that are. Note that only sandy sites, within similar depth ranges to the proposed extraction and de-ored sand deposition areas, for which environmental data were available (from sediment core data) were included within the multivariate analyses.

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[2] Multivariate analyses for the coastcam, dredge and sediment core datasets (with the exception of the meiofauna data, which required no revision as the original comparisons were all located offshore of 12 nm limit) were been re-analysed by Dr Tara J. Anderson as of Feb 2014 to reflect the revised mining and non-mining area boundaries following the methods described in this section. The finding of these revised analyses and the methods used for additional analyses -that examine community structure relative to major habitat types and physical characteristics of these habitats - are now presented in Appendix A.

[3] "Backwards elimination begins with a full model containing all predictor variables. The variable which, when removed, results in the greatest improvement in the selection criterion is eliminated first. Variables are eliminated from the model sequentially until no further improvement in the criterion can be achieved" Anderson, M.J.; Gorley, R.N.; Clarke, K.R. (2008). PERMANOVA+ for PRIMER: Guide to Software and Statistical methods. PRIMER-E: Plymouth, UK.

3 Results

3.1 Coastcam observations

3.1.1 Benthic habitat and assemblages

Seabed habitats and macrobenthos were visually characterised at 144 sites. Seven major habitat types were identified (Figure 7, Figure 8, Figure 9 and Appendix A). Rippled sands were the most common bedform occurring at 53% of all sites, and 72% of all inner to mid-shelf areas across a depth range of 15-50 m (e.g. Figure 8e,f,i). In addition to rippled sands, a few inner shelf sites supported more dynamic sand-wave bedforms (4% of sites, Figure 8a) or had some amount of rock outcrop (5% of all sites, Figure 8b-c). However, sites with rock outcrops were not homogenous bedrock, but rather were mostly rippled sands (94% of video transects) with only small amounts of bedrock (0.62%), boulders (1.53%), cobbles (0.67%) and rubble/gravel (1.08%) (i.e. only 3.8% of hard substrata in total). These small and broken rock outcrops were generally low relief (< 30 cm in height) and were surrounded or partially covered by rippled sands. On the mid-shelf, only two habitat types (rippled sands and wormfield habitats) were present. Rippled sediments occurred in both the inner region of the PPA (< 30 m) and across most of the southern mid-shelf zone (e.g. Figure 8e,f,i). Conversely, wormfields occurred in both the deeper region of the PPA (>30 m) and across most of the northern mid-shelf zone (20% of all sites: Figure 7, Figure 8d,g,h and Figure 11a). Wormfields were characterised by often high but locally patchy densities of infaunal tubeworms (a sabellid tubeworm, here called *Euchone* sp A) that were visible at the surface by their exposed sediment tubes and/or their small suspension-feeding appendages (Figure 8d,g,h and insert; see Chapter 3.3.2.1 for more details of this infaunal species). Highest occurrence were recorded in water depths of 30-50 m, however some sparse sites were also recorded within depths of 20 - 70 m. Sediment bedforms were more subdued (flatter or with less pronounced ripples) where Sabellid tubeworms were visibly common (e.g. Figure 8d). Other than Sabellid tubeworms, very few other epifauna were observed in these areas, with the exception of lebensspuren activity in the form of small and large trails across and beneath the sediment surface (Figure 11b) and horse-shoe shaped divots in the sediment (possibly sediment depressions created by burying scallops) (Figure 11d). Taxa commonly observed in the wormfields, albeit in low numbers, were hermit crabs, small gastropods and the sparsely but characteristically present orange bryozoan (Family: Catenicellidae; with 1-15 indiv. recorded per 300 m transect) (e.g. Figure 8g, Figure 11c; also see Figure 19i-l). More mobile sediments (ripples and sand waves) across the inner and mid-shelf zones, supported even fewer visible macrofauna. These habitats supported sparse occurrences of more broadly distributed species, such as hermit crabs, the small benthic opalfish (*Hemerocoetes monopterygius*; e.g. Figure 8h and Figure 11e), and sometimes a single scallop (e.g. Figure 8I and Figure 11f). Otherwise, these mobile habitats were visually barren. Total abundance and species richness were generally low for all soft-sediment habitats on both the mid-shelf and inner shelf zones, with no significant difference between the PPA and non-PPA sites in this region (Figure 10a,b). In contrast, rocky outcrops present in the inner shelf zone supported diverse macrobenthic assemblages (e.g. Figure 7, Figure 8b,c and Figure 10b). However, rocky outcrops were so small and rare within the 7 sites where they occurred, that the overall abundance of macrofauna at these sites was still very low (Figure 10a).

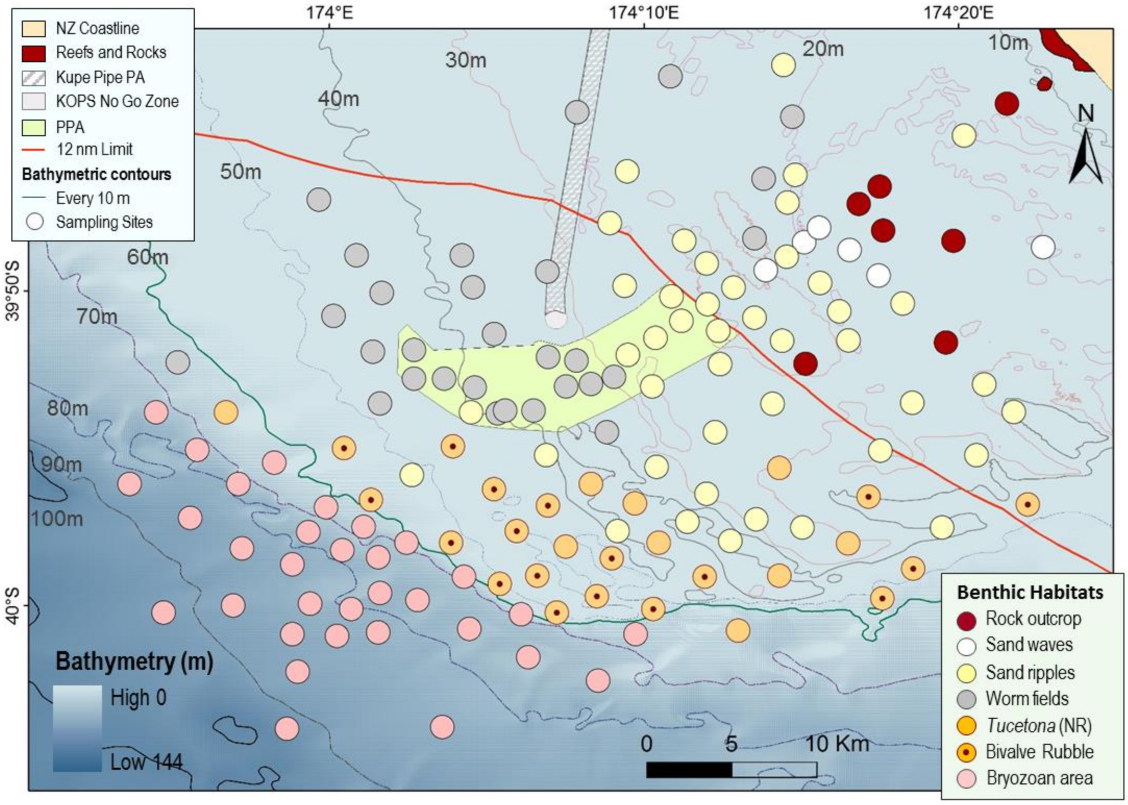

Figure 7: Seabed habitat types observed at each site within the Patea Shoals region, STB. PPA = Proposed Project Area (captions are provided in Figure 2); Coloured circles represent survey sites; *Tucetona* (NR) = sites with live *T. laticostata* but little to no shell debris (i.e. No Rubble).

In deeper areas offshore, the seabed was characterised by two forms of low-lying biogenic habitat: bivalve rubble (live *Tucetona laticostata* bivalves and bivalve shell-debris) and a deeper bryozoan rubble habitat (Figure 7, Figure 9 and Figure 12). Beyond a depth of approximately 45 m, the slope of the shelf steepens to around 65-70 m where it then becomes more gradual again (Figure 1 and Figure 7). This increase in slope is most pronounced in the southern part of the Patea Shoals region (Figure 1), and appears to be an important factor driving the depth distributions of the two biogenic habitats (Figure 7). The upper section of this slope was characterised by rippled sediments and the large and physically robust dog cockle, *T. laticostata* (Figure 7, Figure 9a-c, Appendix A), which lives buried in the sediments and filter-feeds from the water currents passing above. Live *T. laticostata* were recorded across a broad depth range of 26-83.5 m, but the highest densities were observed in the southern section of the survey area in depths of 45-60 m (Figure 12b, also see Appendix A for site-specific descriptions). This depth zone is likely to have the highest exposure to oceanic currents, indicating that this zone may support either better access to or higher amounts of current-borne nutrients. *Panopea* shell debris (shells of ~6-8 cm in length) was also observed at several southern sites in this depth zone (i.e. Sites 48, 150, 155 and 160; Figure 11h), but no live animals were seen or collected during this survey. Live *Panopea smithae*, however, are known from this location (Te Papa Museum record m.050073: 3 specimens - 39^{o} 56.0 S, 174^{o} 26.0 E, *RV Acheron* March 1976; Figure 13).

The spatial location of the *Tucetona* bivalve beds appear to be temporally stable as large amounts of shell debris has accumulated across the lower section of the slope (highest densities in 60-75 m depth), forming a dominant biogenic habitat. Above 60 m, this biogenic debris (termed 'bivalve rubble') supports a range of early stage colonisers, dominated by encrusting coralline paint, other small encrusting invertebrates and ophiuroids (mostly *Ophiopsammus maculata*) (Figure 9a-c; also see Figure 20d-i). In contrast, the accumulation of shell debris below 60 m (termed 'bryozoan rubble') is heavily encrusted with late stage colonisers, dominated by branching bryozoans along with array of other sessile suspension-feeding invertebrates (e.g. encrusting and erect sponges, foliose bryozoans, colonial and solitary ascidians, brachiopods and epiphytic bivalves [e.g. *Talochlamys*]), which collectively bind and stabilise the shell debris, and provide further structural refuge for a diverse array of motile species (e.g. crabs, ophiuroids, holothurians, gastropods, nudibranchs and the deepwater triplefin, *Matanui profundum*) (e.g. Figure 9d-f, Figure 10, Figure 12, Appendix A; also see Figure 20j-l). Faecal casts, mostly from holothurians (i.e. many seen to be deposited by holothurians) were common in the bryozoan rubble habitat, indicating reduced water current movement across the benthos in these areas. Epifaunal total abundance and species richness were both significantly higher in these deeper biogenic habitats, than in the mid-shelf (PPA and adjacent areas) and inner shelf habitats - with the exception of rocky outcrops (Figure 10a, b). Epibenthos total abundance and species richness was also higher in the later-stage bryozoan/rubble habitat compared to the more poorly colonised shell debris of the bivalve beds (Figure 10a,b), although both assemblages supported similar functional epibenthic assemblages (Figure 10c,d). Further offshore (>80 m), the biogenic zone became less abundant. These areas were still characterised by bryozoan/rubble with mixed bryozoan and invertebrate assemblages, but the occurrence of structurally complex habitats was lower and patchier, yet diversity and abundance of the associated assemblages was still high. These deeper sites (e.g. sites 126 and 127) also supported a range of deeper species, such as solitary cup corals (Family Flabellidae; Figure 11g), juvenile sea perch (*Helicolenus percoides*, Figure 12g), along with the occurrence of large suspension-feeding polychaete worms (identity unknown) that were seen with their feeding appendages (distinct orange and white banding) protruding up into the water column from numerous large, single burrows.

Bioturbation, or lebensspuren activity (i.e. any signs of life), was most commonly observed in the more stabilised sediments (e.g. wormfields and deeper sites offshore), while signs of lebensspuren activity was extremely rare in the highly mobile sediments across most of the inner and mid-shelf. Mobile sediments, however, are likely to cover animals' activities, such as trails or burrows, very quickly, while stable sediments will retain the imprint of an animal's activities for much longer. For example, scallops were found in low numbers throughout the wormfields and across the mobile rippled sands to the south (Figure 11f), however the lebensspuren divots - likely caused by these scallops burying into the sediment and then moving up and away – were only observed in the stable sediments within the wormfields (Figure 11d). Consequently, it is unclear whether differences in lebensspuren activity between habitat types is simply a function of sediment stability, is a true difference in Lebensspuren activity, or reflects some combination of the two.

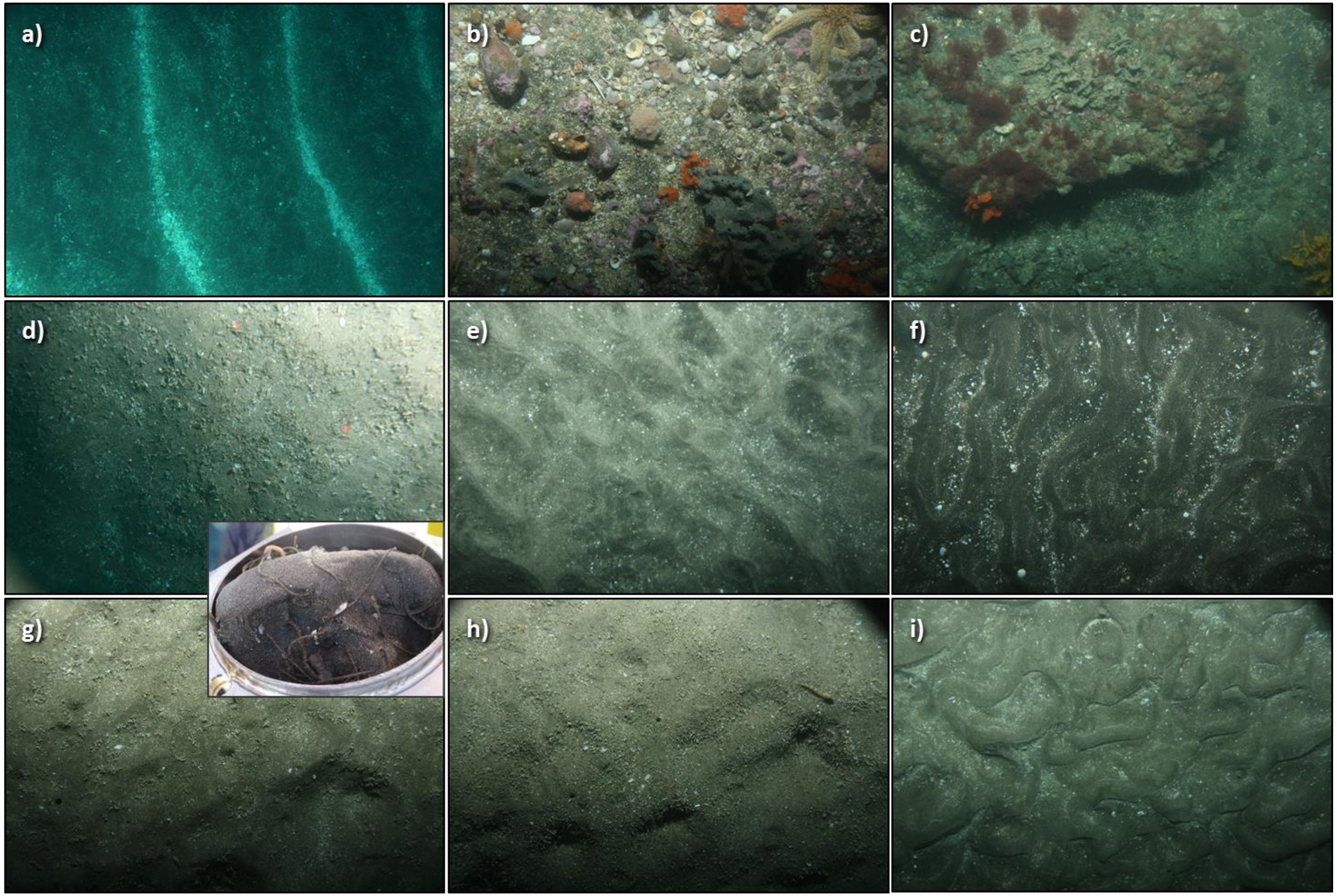

Figure 8: **Still photographs of characteristic inner shelf and mid-shelf habitats in the Patea Shoals region, STB.** **a)** Sand waves at site 1 (29 m depth), with coarse shell-hash and gravel in the troughs; **b)** Low-lying rock outcrop at site 42 (26 m) - mostly rippled sands with <1% rock outcrop; **c)** Low-lying rock outcrop at site 7 (26 m) –rippled sands with 7.36% rock outcrop; **d)** Wormfields at site 68 (PPA, 45 m); **e)** Rippled sands at site 60 (PPA, 26 m); **f)** Rippled sands at site 145 (south of PPA, 36 m); **g)** Wormfields at site 104 (north of PPA, 48 m), with characteristic orange bryozoan (solitary-bushy, Catenicellidae); **h)** Wormfields at site 69 (PPA, 46 m) & opalfish;
i) Rippled sands at site 99 (offshore of PPA, 70 m).Insert showing a sediment core with *Euchone* sp A worms.

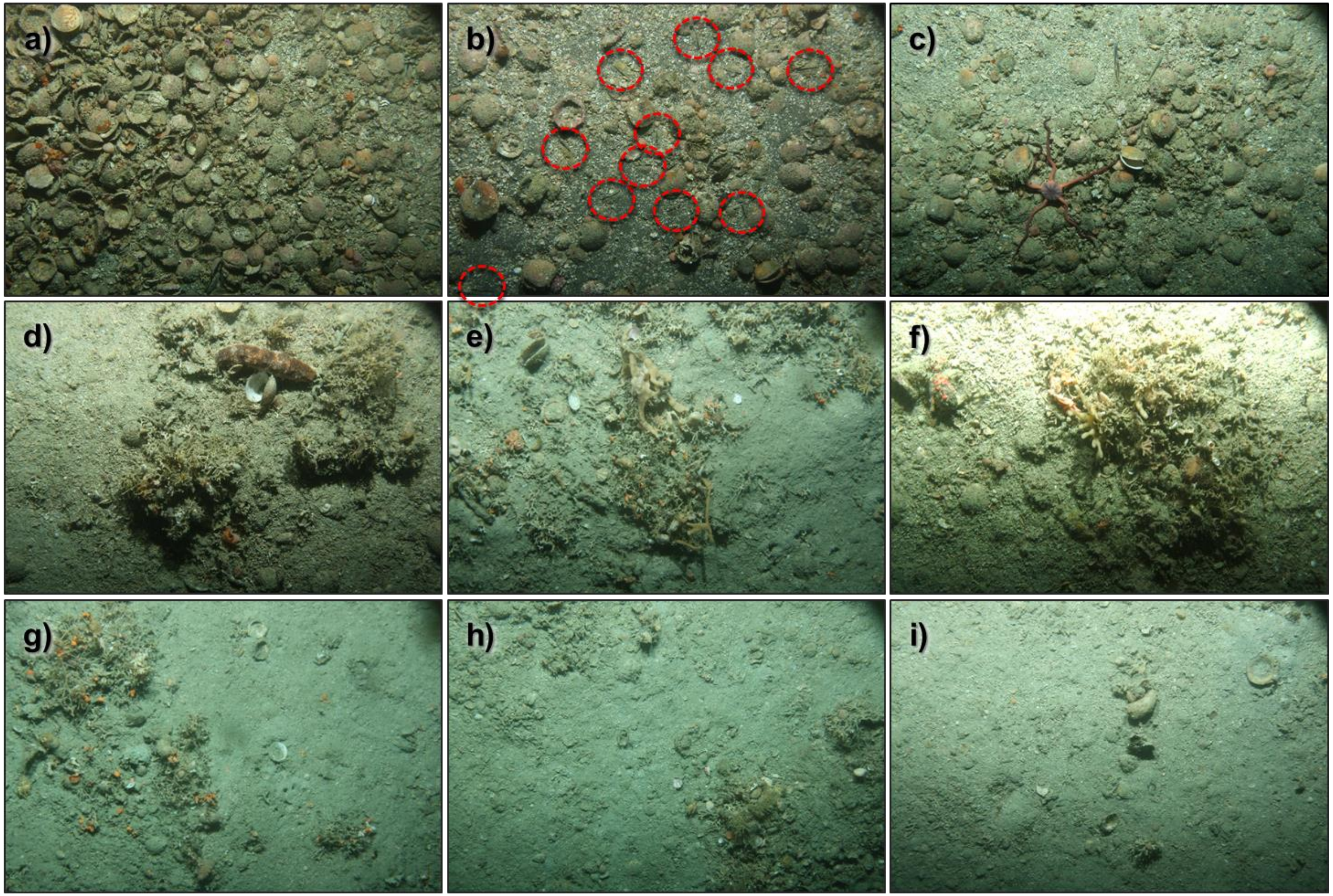

Figure 9: Still photographs of offshore biogenic habitats in the Patea Shoals region, STB. a) Bivalve/rubble at site 106 (60 m depth): dense *Tucetona* shell debris encrusted with invertebrates; b) Live *Tucetona laticostata* at site 146 (49 m) & sparse shell debris; c) Bivalve/rubble at site 109 (57 m): bryozoan & the ophiuroid (*Ophiopsammus maculata*); d) Bryozoan/rubble at site 116 (76 m): branching bryozoa, small foliose bryozoa & holothurian (*Australostichopus mollis*) ; e) Bryozoan/rubble at site 123 (85 m): branching bryozoan, sponges & epiphytic bivalves; f) Bryozoan/rubble at site 115 (80 m); g-i) Bryozoa/rubble in muddier offshore sediments: sites 122 (84 m), site 130 (82 m) and site129 (94 m), respectively. Red dashed circles indicate the location of live *T. laticostata*.

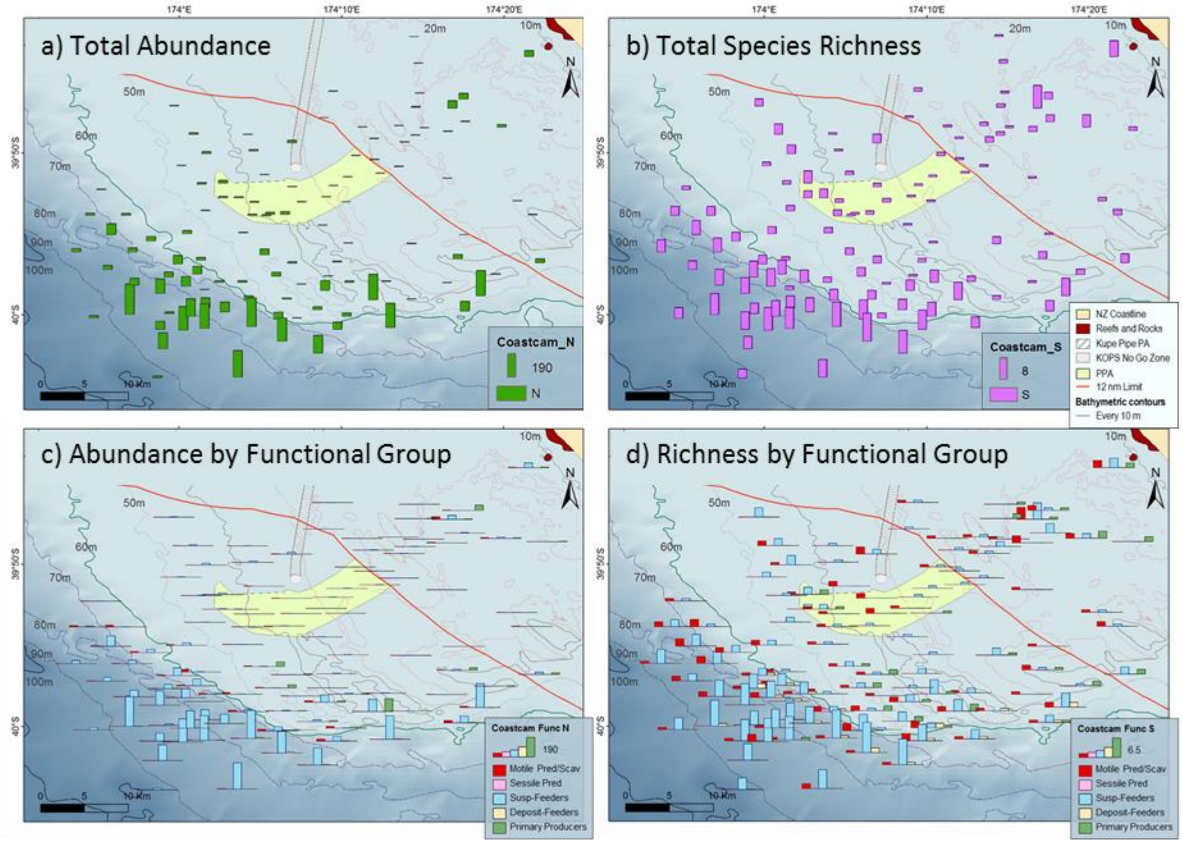

Figure 10: Spatial distribution of epibenthic assemblage indices per 10 minute Coastcam2 tow (~300 m). a) The green bars represent the total number of individuals (N) observed; b) The pink bars represent the total number of taxa (S) observed; c) The total number of individuals (N) within each functional group; d) The total number of taxa (S) within each functional group. Relative scale bar are provided in the legend of each graph.

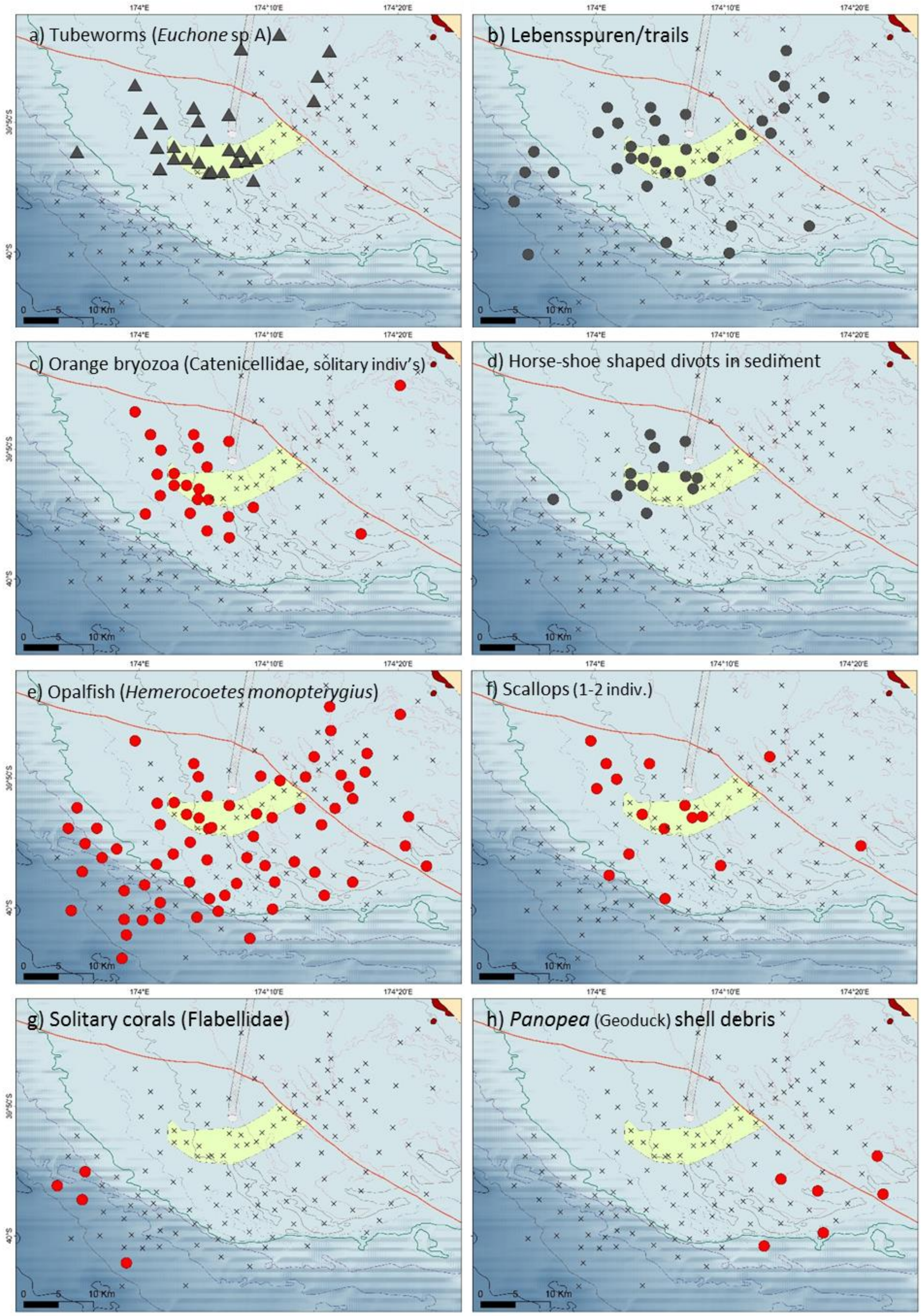

Figure 11: Distribution (presence/absence) of biological activity and key taxa across the shelf.

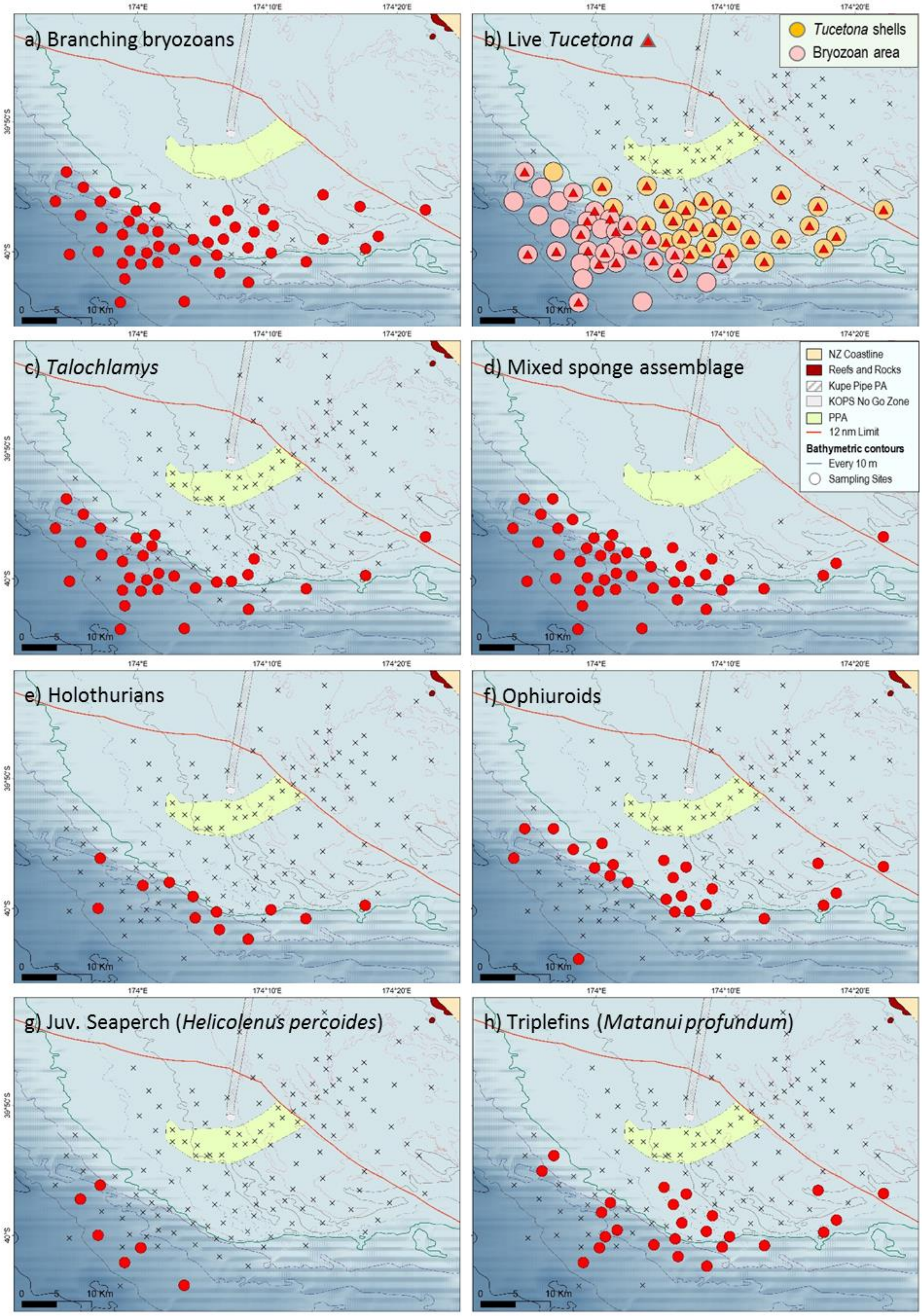

Figure 12: **Distribution (presence/absence) of key taxa associated with the offshore biogenic habitats.**

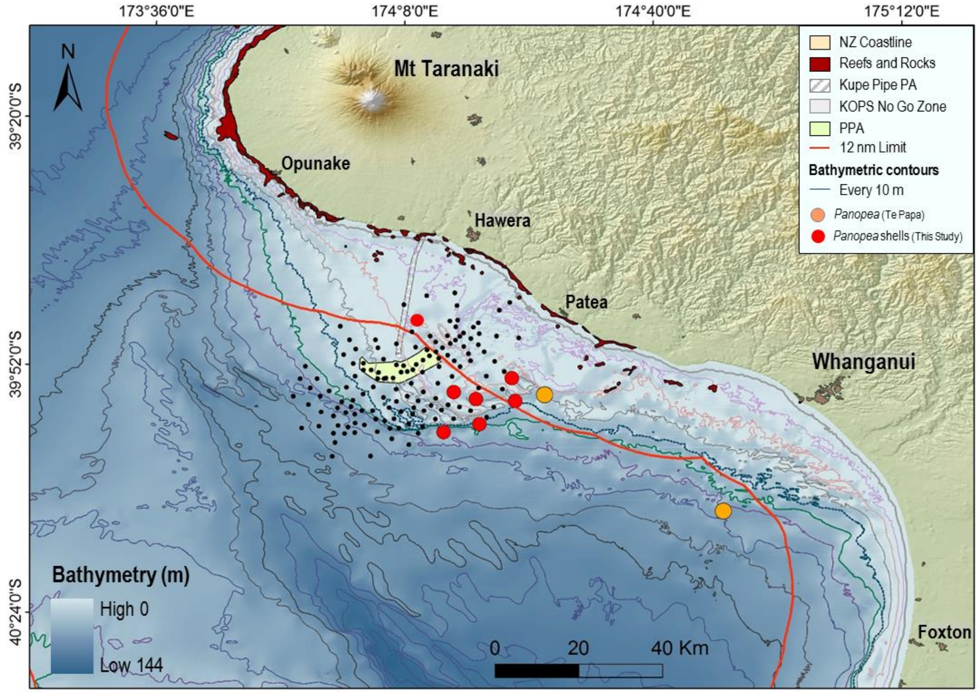

Figure 13: Distribution of *Panopea* shells (this study) and known occurrence of live specimens (Te Papa records). Small black circles indicate sites (this survey) where no *Panopea* shell were seen or collected.

3.1.2 Multivariate analysis: Coastcam2 data[4]

Multivariate analyses (PRIMER-E, Clarke & Warwick 2001) of a subset of the data were carried out in order to identify whether the PPA supported a “unique” benthic community.

A non-multidimensional scaling (nMDS) plot of Bray Curtis similarities of log transformed data (Figure 14) gives a two-dimensional representation of the relative similarities or dissimilarities of each sample site. The closer two sites are to each other in the plot the more similar they are with respect to community structure. Each sample site has been colour coded to represent whether the site sits within the mining site, compared to initial deposition sites and adjacent non-mining sites. An ANOSIM routine confirmed that there were no significant differences between areas ($p > 0.05$, Global $R = -0.039$) and that the overall community structure within the original mining site, as seen from the Coastcam2 video footage, were not uniquely different from adjacent communities across the broader Patea Shoals region.

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[4] Please see Appendix A for the findings of the revised 2014 multivariate analyses.

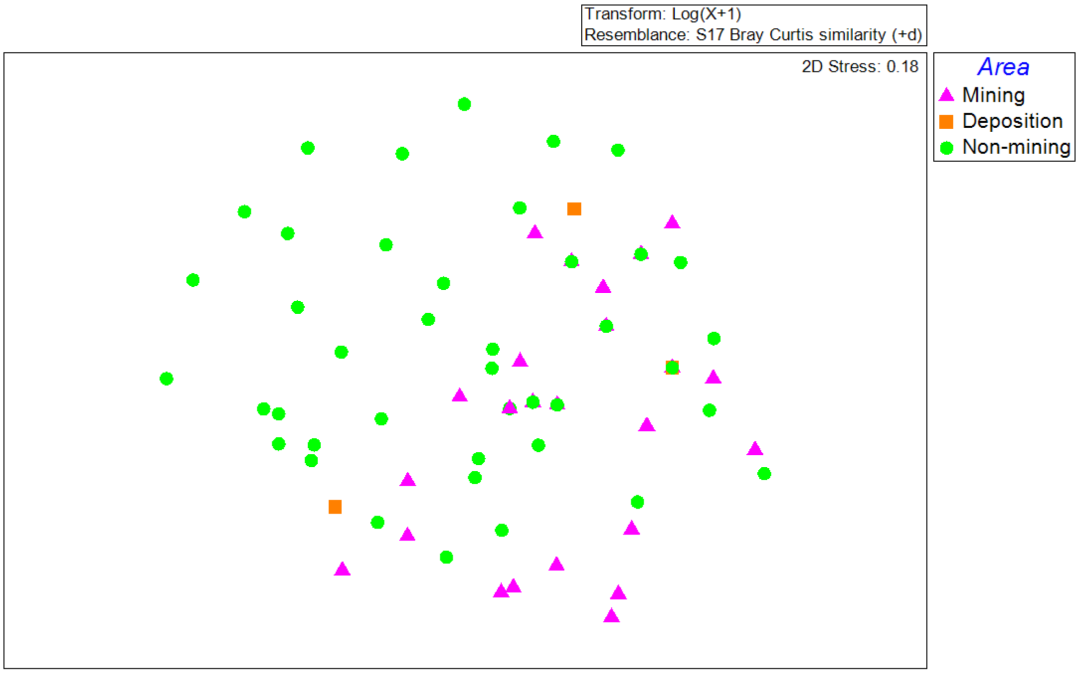

Figure 14: **nMDS plot showing the Coastcam2 data according to area (extraction, deposition, non-extraction).** No significant differences were found between "area" (ANOSIM, p>0.05).

Due to the relatively lengthy timeframe of sampling, both month of the year and time of day of sampling were investigated for interactions with the response variables. Month of the year was not significant (ANOSIM, $p > 0.05$) but time of day was significant and so time was included in more detailed analyses below (ANOSIM, $p < 0.05$, Global R = 0.07).

Although the different “areas” have been shown not to be unique with respect to community structure, further analyses were carried out to determine which environmental variables, if any, were significantly driving the benthic community structure across sites. Note that only the sites with sandy substrate where sediment coring was possible were included in this analysis. Only these sites had a complete suite of environmental variables as data on substrate type/particle size analysis was taken from the sediment core data (3 sediment cores from each study site where the camera transect was carried out).

A distance-based linear model (DISTLM) within PERMANOVA+ for PRIMER-E (Anderson et al. 2008) tests how much of the total variation each predictor (environmental) variable explains. The model works sequentially (i.e. how much variation does variable 1 explain, then how much more variation does variable 2 explain and so on) and so the order the variables should be tested in is important. Marginal tests within the DISTLM routine showed that the variables should be tested in the sequential tests in the following order: Depth, silt, clay, distance from shore, fine gravel, medium sand, iron, coarse sand, medium gravel/shell, time, fine sand, and very find sand.

Sequential tests within DISTLM (Table 2) explained 35 % of the total variation and showed that depth was the main driver of the variation in macrofauna assemblages observed using the Coastcam2 (explaining 16.1 % of the total variation). Silt was also a significant variable ($p < 0.05$), but only explained 2.6 % of the variation. The percentage of iron in the sediments was not significant ($p = 0.418$) and only explained 0.08 % of variation.

A dbRDA plot (Figure 15) gives a graphical representation of the DISTLM results. The two axes explain 27.7 % of total variation (compared with 35 % variation explained by the DISTLM). As with the nMDS plot, those samples plotted close together are more similar than those plotted further apart. The vector plot can be interpreted as the influence of a given predictor variable (the longer the vector the bigger the effect).

Table 2: **DISTLM results: sequential tests.** Those predictor variables significantly contributing to the explained variation are highlighted in yellow ($p < 0.05$). The column "Prop." gives the proportion of variation explained for each variable.

SEQUENTIAL TESTS

Variable	R^2	SS(trace)	Pseudo-F	P	Prop.	Cumul.	res.df
DEPTH	0.1611	25920.00	19.0130	0.001	0.1611	0.16111	99
SILT	0.1874	4234.70	3.1745	0.016	0.0263	0.18743	98
CLAY	0.1945	1131.40	0.8468	0.516	0.0070	0.19446	97
DISTANCE FM SHORE	0.2319	6029.00	4.6839	0.002	0.0375	0.23194	96
FINE GRAVEL	0.2529	3368.20	2.6620	0.018	0.0209	0.25287	95
MEDIUM SAND	0.2675	2352.40	1.8763	0.100	0.0146	0.26749	94
IRON	0.2753	1260.30	1.0053	0.418	0.0078	0.27533	93
COARSE SAND	0.3062	4971.40	4.0976	0.003	0.0309	0.30623	92
MEDIUM GRAVEL	0.3202	2246.70	1.8693	0.104	0.0140	0.32019	91
TIME (UTC)	0.3391	3047.60	2.5797	0.036	0.0189	0.33913	90
FINE SAND	0.3461	1115.90	0.9440	0.445	0.0069	0.34607	89
VERY FINE SAND	0.3499	622.86	0.5241	0.699	0.0039	0.34994	88

From these analyses it is possible to identify relationships between taxonomic groups and predictor variables. Table 3 gives the relationship between the dbRDA coordinate axes and the orthonormal X variables (predictor/environmental variables). For example, the variable with the strongest positive relationship with axis 1 was depth. Although relatively weak, iron had the strongest negative relationship with axis 1, which is surprising considering iron was not a significant driver in the DISTLM results (Table 2). Interpretation of these data, together with the relationship between taxonomic groups and the dbRDA axes, allows the identification between predictor variables and taxonomic groups (Table 4).

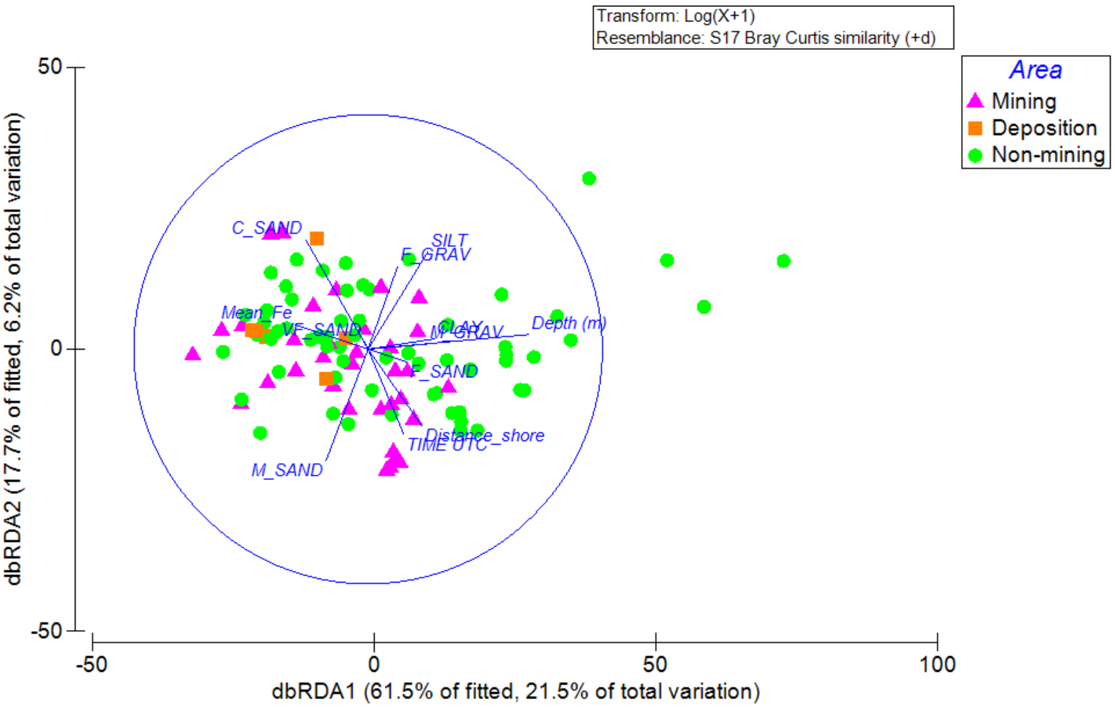

Figure 15: **dbRDA plot of the Coastcam2 data.** This is a visual representation of the DISTLM analysis. The two axes explain 27.7 % of total variation (compared with 35 % variation explained by the DISTLM). The vector plot can be interpreted as the effect of a given predictor variable (the longer the vector the bigger the effect).

Table 3: **Relationships between dbRDA coordinate axes and orthonormal X variables (multiple partial correlations).** The strongest positive and negative relationships for both axes 1 and 2 are highlighted in yellow.

	Axis number (and % variation explained)				
	1 (61.48)	2 (17.74)	3 (7.2)	4 (5.85)	5 (4.57)
DEPTH	0.686	0.063	0.013	-0.478	-0.272
CLAY	0.282	0.044	0.012	-0.032	-0.019
SILT	0.255	0.414	0.436	0.299	0.335
MEDIUM GRAVEL/SHELL	0.253	0.022	-0.429	0.249	0.112
DISTANCE FM SHORE	0.23	-0.327	0.452	0.078	0.45
FINE SAND	0.166	-0.055	-0.155	0.054	0.178
TIME UTC	0.153	-0.364	-0.279	0.63	-0.077
FINE GRAVEL/SHELL	0.127	0.353	0.312	0.455	-0.527
VERY FINE SAND	-0.014	0.032	0.046	0.05	-0.036
MEDIUM SAND	-0.18	-0.476	0.415	-0.004	-0.446
COARSE SAND	-0.266	0.466	-0.142	0.003	-0.102
IRON	-0.312	0.104	0.167	-0.057	0.269

Table 4: **Relationship between taxonomic groups and the dbRDA axes.** Using data from Table 3, these data have been interpreted to give the correlation between taxonomic groups and the predictor variables.

	Axis 1, dbRDA1 (61.5% of fitted, 21.5% of total variation)	Correlation with predictor variables

Bryozoan	0.636022085	Strong positive correlation with Depth Weaker negative correlation with iron
Sponge	0.518916379	
Ascidian	0.457055078	
Holothurian	0.408894757	
Ophiuroid	0.399408994	
Fish	0.386972245	
Crustacean	0.369905618	
Annelida	0.284271165	
Hydroids	0.254920002	
Bivalve	0.251644746	
Algae	0.182019275	
Cartilaginous fish	0.122626976	
Asteroid	0.10175565	
Echinoid	0.08420282	
Brachiopod	0.057542455	
Anemone	0	
Gastropod	-0.005793267	Weak positive correlation with iron Strong negative correlation with depth

	Axis 2, (17.7% of fitted, 6.2% of total variation)	Correlation with predictor variables
Fish	0.317643543	Positive correlation with coarse sand and silt Negative correlation with medium sand
Bryozoan	0.27149504	
Bivalve	0.251964596	
Ophiuroid	0.213069989	
Ascidian	0.195571358	
Holothurian	0.175171295	
Cartilaginous fish	0.097430996	
Hydroids	0.074777231	
Gastropod	0.049210528	
Annelida	0.032135779	
Anemone	0	
Sponge	-0.003521358	Positive correlation with medium sand Negative correlation with silt and coarse sand
Algae	-0.01754877	
Crustacean	-0.040902341	
Brachiopod	-0.080507325	
Asteroid	-0.113152778	
Echinoid	-0.169984156	

A second DISTLM (backwards AIC) confirmed that iron was not an important factor in driving community structure of the organisms observed on the Coastcam2video, despite there being a weak negative relationship with axis 1 in the dbRDA above. Clay, iron and time were all eliminated by the backwards AIC (p = 0.735, 0.803 and 0.431 respectively) (Table 5). This model selected the following nine variables as being important factors (in no particular order: distance from shore, depth, mean gravel, fine gravel, coarse sand, medium sand, fine sand, very fine sand and silt.

Table 5: DISTLM results (backwards AIC). Sequential tests show which variables were eliminated from the analysis and in which order.

SEQUENTIAL TESTS

Variable	AIC	SS(trace)	Pseudo-F	P	Prop.	Cumul.	res.df
CLAY	408.74	6.7214	0.12998	0.735	0.0010	0.30771	89
IRON	407.09	15.837	0.30929	0.803	0.0024	0.3053	90
TIME UTC	406.22	51.444	1.0125	0.431	0.0078	0.29749	91

3.2 Dredge assemblages

3.2.1 Dredge assemblage structure

A total of 117 dredge samples were collected from 116 sites within the study area. Sites were sampled from all habitat types, and across the spatial and depth extent of the survey area. Due to the breakable nature of the deeper bryozoan/rubble habitat, comparatively fewer sites were sampled to avoid undue removal of biogenic material from this ecosystem. In total, 27,714 specimens (allowing for scaling up of sub-sampled dredge hauls) from 457 species/groups were recorded from the dredge tows. Macrobenthic assemblages differed significantly between habitat types (Figure 17). Sand wave and rippled sand habitats supported the lowest macrofaunal abundances (<46 specimens) and the lowest number of species (< 10 species) p/250m^2 (Figure 17, e.g. Figure 19a,e-h, and Figure 16). As with the camera observations, the PPA was representative of adjacent mid-shelf and inner shelf soft sediments, all of which were characterised by low numbers of individuals and species at most sites (Figure 16 and Figure 18). Wormfields within and north of the PPA supported low overall abundances, with only slightly more species than rippled sands and sand wave habitats (Figure 17). Wormfields habitats were characterised by hermit crabs, gastropods and the characteristic occurrence of an orange bryozoa (Catenicellidae) – all in low numbers (e.g. Figure 19i-l, and Figure 16).

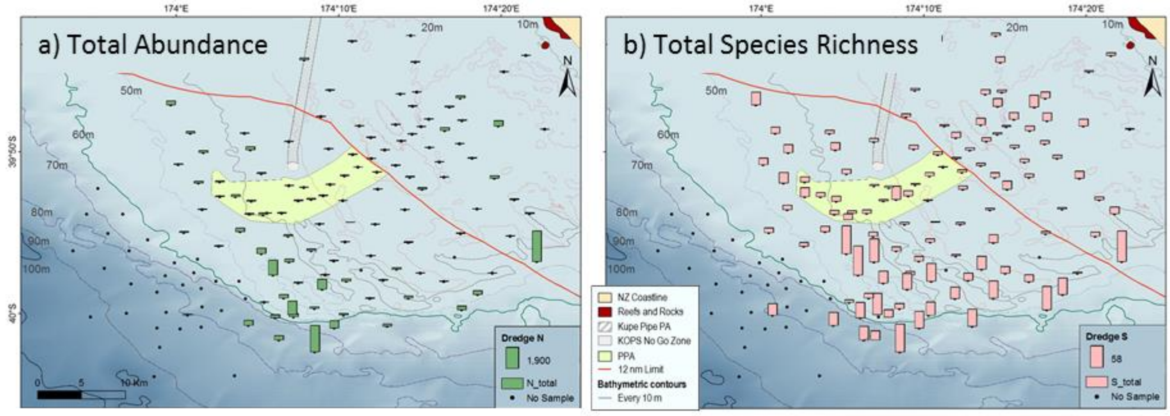

Figure 16: Spatial distribution for each macrobenthic indices per dredge/site (250m^2). a) The green bars represent the total number of individuals (N) collected; b) The light brown bars represent the total number of species/OTU's (S) collected. Relative scale bars are presented for each graph.

Further offshore, biogenic offshore habitats (i.e. bivalve rubble and bryozoan rubble) supported higher numbers of organisms and species (Figure 16, Figure 17a,b and Figure 18). Dredges in these offshore biogenic habitats, collected high volumes of dead *T. laticostata* shells that were often heavily encrusted with a diverse array of sessile epifauna and flora (e.g. Figure 20e-i). The shallower bivalve rubble habitat supported early colonising species, with shell debris encrusted mostly with coralline algae and encrusting invertebrates, while the deeper bryozoan rubble supported later stage successional species, dominated by small branching and foliose bryozoan and sponge growth forms (e.g. Figure 20e-l) - with some hauls collecting up to 3896 live specimens across combined taxa. The intermediate habitat between the offshore and mid-shelf zones characterised by live *Tucetona* but very little to no bivalve-debris (e.g. Figure 20a-d), supported similar species richness to the deeper biogenic habitats but significantly lower overall abundances that were more similar to soft-sediment habitat on the mid and inner shelf zones (Figure 16 and Figure 17).

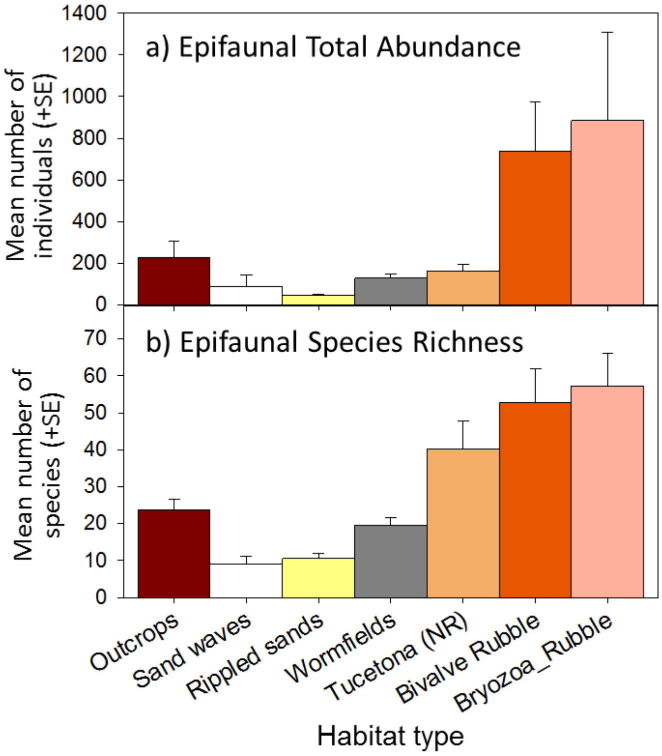

Figure 17: Epifaunal abundance and species richness, per 250 m^2 dredge tow, plotted by habitat type. Refer to Figure 7 (above) for the spatial distribution of habitat types; *Tucetona* (NR) = sites with live *T. laticostata* but little to no shell debris (i.e. No Rubble).

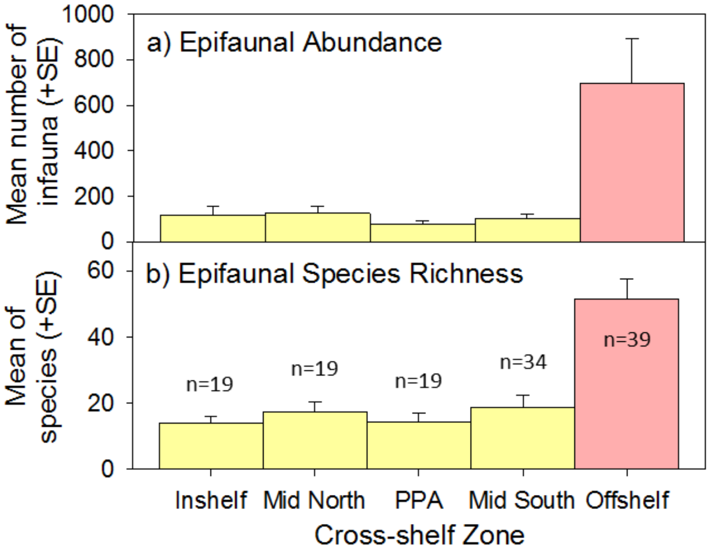

Figure 18: Epifaunal abundance and species richness, per 250 m^2 dredge tow, plotted relative to cross-shelf zones. Mid-shelf zones have been divided into PPA, mid-north (sites north of the PPA) and mid-south (sites south of the PPA) to provide spatial comparisons. n= the number of sites/dredges sampled per zone.

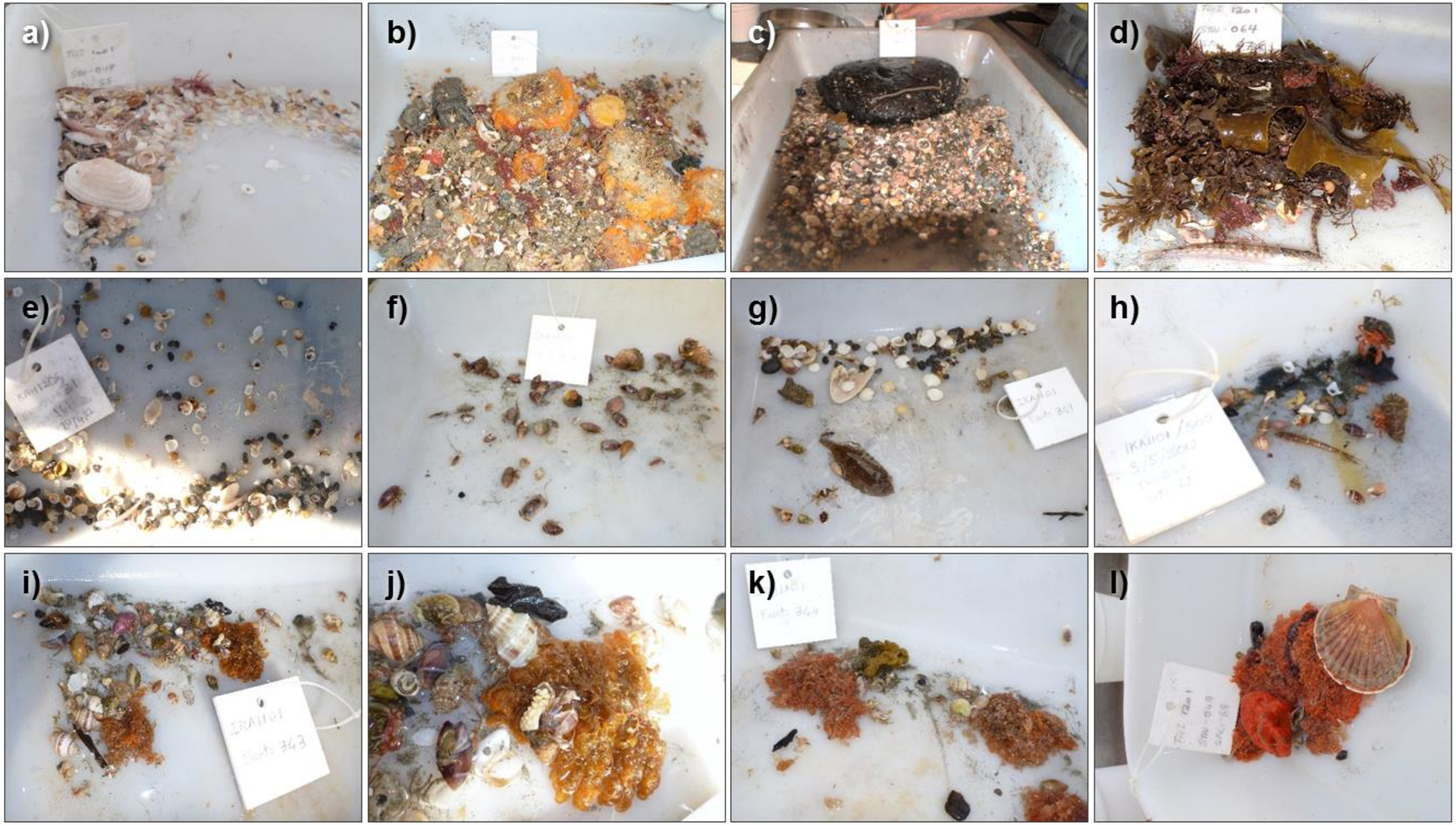

Figure 19: Types of macrofauna collected (per 300 m dredge) from inner and mid shelf sites in the Patea Shoal Region, STB. a) Site 55 (28 m) - Rippled sands with small *Panopea* shell; **b)** Site 7 (29 m) - Rock outcrop/ sand, with reef-sponges and red algae; **c)** Site 10 (28 m) - Sand waves with boulder; **d)** Site 67 (24 m) - Sand waves, with brown drift algae and two opalfish (*H. monopterygius*); **e)** Site 161 (25 m) - Rippled sands, gravel/shell-hash and opalfish; **f)** Site 66 (28 m) – Rippled sands with shell-hash, gastropods (Olividae), hermit crabs and opalfish; **g)** Site 35 (34 m) – Rippled sands with shell-hash, small flatfish, hermit crabs and small crab; **h)** Site 62 (21 m) – Rippled sands, with hermit crabs, gastropods (Olividae),seastar and an opalfish; **i-j)** Site 11 (PPA, 36 m) – Rippled sands/wormfields, with hermit crabs and characteristic orange bryozoa (Catenicellidae); **k)**

Site 12 (PPA, 36 m) – Rippled sands/wormfields – hermit crabs, orange bryozoa (Catenicellidae) & a sponge; **l)** Site 68 (PPA, 45 m) – Wormfields (dense), with orange bryozoa (Catenicellidae), a sponge and a live scallop.

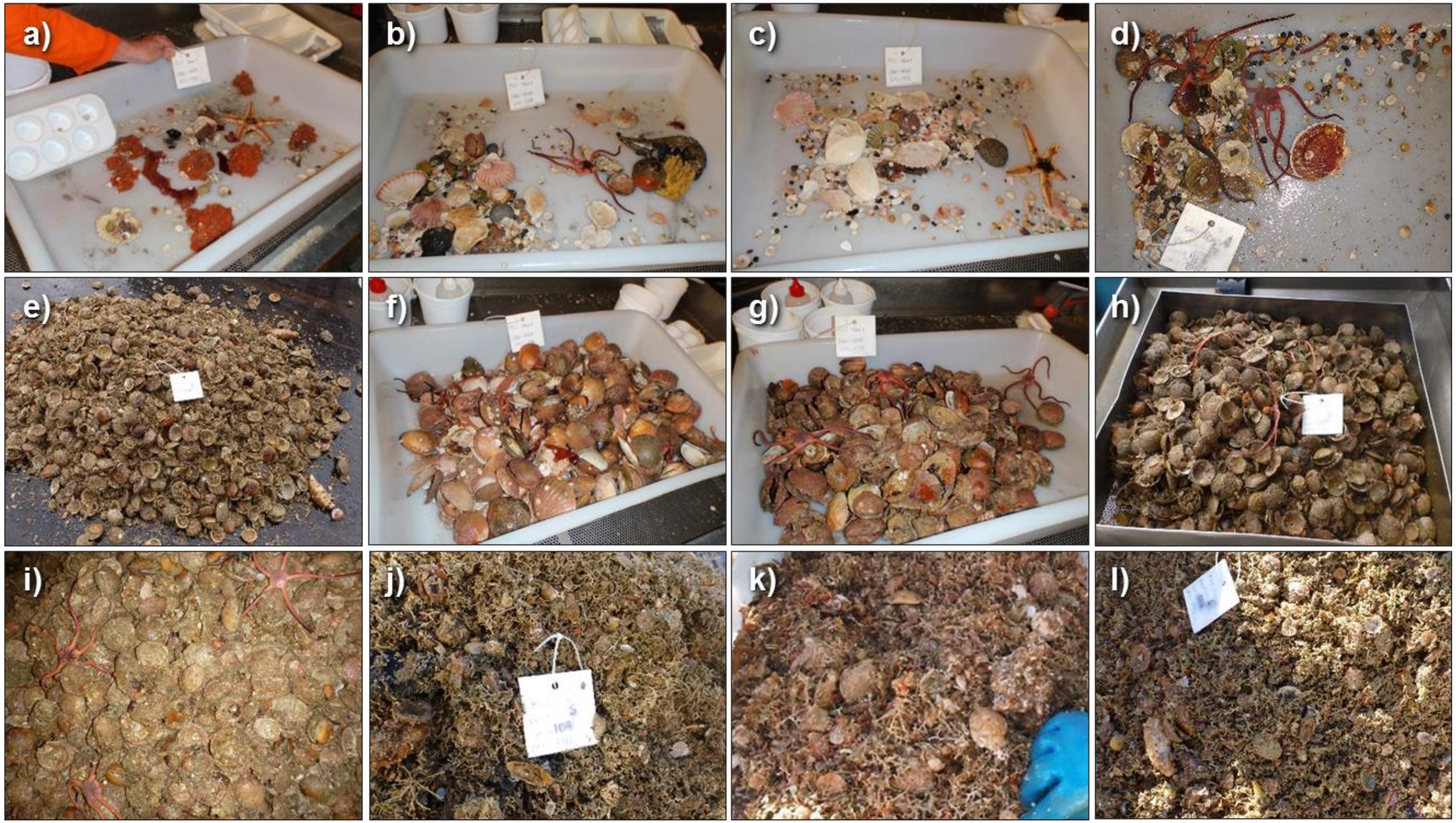

Figure 20: Types of macrofauna collected (per 300 m dredge) from the deeper offshore area of the Patea Shoal Region, STB. a) Site 95 (40 m) - Rippled sand, orange bryozoa (Catenicellidae), starfish, algae & hermit crabs (NB: *Euchone* sp A in cores); **b)** Site 131 (47 m) - Rippled sands/live *Tucetona*, light shell debris, horse-mussel, sponge & ophiuroid (*O. maculata*); **c)** Site 92 (40 m) - rippled sands, light shell debris & seastar; **d)** Site 146 (48 m) - bivalve rubble/live *Tucetona*, ophiuroids (*O. maculata*), sml conger eel (*Gnathophis habenatus*), & a scallop; **e)** Site 113 (67 m) - Bryozoan Rubble/hard ground, dense bivalve debris, bryozoans & holothurians (*Australostichopus mollis*); **f)** Site 94 (42 m) - Rippled sands/live *Tucetona*, ophiuroids & octopus (*O. huttoni*); **g-i)** Sites 13 (50 m), 109 (57 m) and 144 (54 m), respectively - bivalve rubble/live *Tucetona*, encrusting invertebrates & ophiuroids (*O. maculata*); **j)** 108 (46 m) - transitional zone between bivalve rubble/live *T. laticostata*, and bryozoan rubble; **k-l)** Sites 117 (73 m) and 116 (76 m) - Bryozoan rubble (bryozoan & shell debris matrix) with diverse macrofauna.

3.2.2 Distribution of taxonomic groups: Dredge data

3.2.2.1 Bryozoa

Bryozoa are sessile (immobile) suspension-feeding colonial organisms generally associated with hard substrates such as rocky or biogenic reefs (e.g. shells). As suspension feeders, bryozoa rely on a constant supply of water passing across their feeding appendages in order to feed, and thus grow and reproduce. Many bryozoan species form relatively small colonies (just a few millimetres across) but some form larger, habitat forming colonies (up to approximately 30 cm high) and support a number of associated species.

A total of 14,680 live bryozoan colonies from 161 species were recorded from the dredge data (Appendix D1). Of these, several species collected were species that form significant habitats in other parts of the country, e.g. *Cinctipora elegans* on Otago Shelf and in Foveaux Strait, *Celleporaria agglutinans* ('Tasman Bay coral') in Tasman Bay and elsewhere, *Celleporina grandis* on Otago Shelf, *Adeonellopsis* sp. on the sills at the entrances to the fiords (Dennis Gordon, NIWA, *pers. comm.*). These species can normally achieve 10 cm (*C. grandis*) or up to 30 cm height or diameter in undisturbed localities. However, owing to the fragmented state of the sample it was impossible to say how big these Taranaki samples were. Additional species (*Diaperoecia purpurascens*, *Hippellozoon novaezelandiae*) can form visually significant clumps (fist-sized) in other parts of the country and the size and healthy-looking state of *H. novaezelandiae* in the samples indicates that they had not been disturbed for several years (maybe in the region of 5 years – but little is known about the growth rates of these species).

Numerous encrusting species were found mostly on the dead and some live mollusc shell in the samples. *Celleporaria agglutinans* and large old *C. elegans* can support other bryozoans and locally increase species richness in undisturbed habitats, and this may be the case in this setting. In any case, the mollusc fraction is important in providing islands of hard substrata upon which the larvae of the large habitat-forming bryozoan and many encrusting species can settle. On-going bottom trawling in the area may account for the lack of any large, robust colonies. However, the frequency of disturbance in individual areas seems sufficiently low to maintain reasonable biodiversity and moderate colony sizes.

Several species were collected that were new records for the STB region. The Wanganui shelf marks the northernmost range of the important habitat forming bryozoan, *Cinctipora elegans* (apart from one nominal record near East Cape), the first record of *Schizomavella aotearoa* outside its Milford Sound type locality, and the first record of *Parasmittina livingstonei* outside of its Three Kings type locality (Dennis Gordon, NIWA, *pers. comms*.) *Smittoidea* n. sp., an epizoic encruster, is a new species; several other undescribed taxa recorded within this study are known from elsewhere in New Zealand (see Appendix D1 for a full species list).

A distribution plot of the number of bryozoan individuals at each site show large numbers of bryozoa at some of the deeper sites and at one site out to the far east of the study site (Figure 21a). All other sites had relatively low or very low abundances of bryozoa. Interestingly, many sites had a relatively high species richness, particularly those in the biogenic habitat zone in depth of ~ 60 to 80 m (Figure 21b).

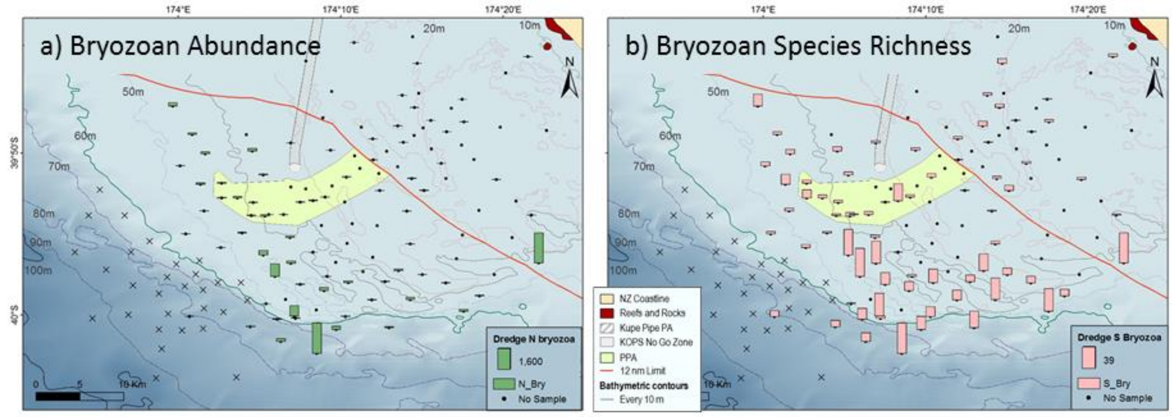

Figure 21: Spatial distribution of bryozoa per dredge/site (250m^2). a) The green bars represent the total number of individuals (N) collected. However, due to the very fragile nature of many bryozoan colonies and the potential breakage during collection, abundance estimates should be viewed as relative measures rather than absolute numbers of colonies. b) The light brown bars represent the total number of species/OTU's (S) collected. Relative scale bars are provided in the legend of each graph.

3.2.2.2 Molluscs

Molluscs were the second most dominant phyla recorded in the dredge survey with 4,512 molluscan specimens from 74 species collected (Appendix E1; Figure 22a,b). Molluscs were numerically dominated by bivalves and gastropods, with only a few occurrences of cephalopods (mostly the small cryptic octopus, *O. huttoni*). No new species of molluscs or new records for the STB region were recorded. Molluscs were collected at most sites across the Patea shoal region, although abundance was much higher across the inner shelf and offshore zones, with only low numbers of a few species collected on the mid-shelf zone (Figure 22a,b). Inner shelf abundances were driven by high numbers of the small dog cockle, *Glycymeris modesta* (1625 specimens from 43 sites) collected in depths of ~20-35 m (Figure 22c), along with much lower numbers of *Corbula zelandica* (150 specimens from 21 sites – mostly inner shelf); while offshore abundances were driven by the presence of the larger more robust dog cockle, *T. laticostata* (179 specimens across 27 sites) collected from depths >35 m. The presence of dead *T. laticostata* shells in the offshore zone, also provided an important biogenic habitat for a range of other species, including the small grooved fanshell, *Mesopeplum convexum* (521 specimens from 12 sites) and many small epiphytic bivalve species, such as the hairy mussel, *Modiolus areolatus,* and the small epiphytic scallop, *T. zelandiae,* which were found growing on the shell debris in the offshore biogenic zones (Appendix E). The offshore biogenic zones were also important habitats for many gastropods, including the two most numerically abundant species: the graze, *Astraea heliotropium* (579 specimens from 27 sites) and the predator, *Murex octogonus* (185 specimens from 19 sites) (Figure 22e and f, respectively) and the small cryptic octopus, *O. huttoni* (77 specimens from 23 sites). In contrast, the gastropod, *Amalda australis* (Family: Olividae), occurred across inner and mid-shelf (96 specimens from 25 inner shelf and mid-shelf sites), and was also observed in still images of the seabed in the offshore biogenic zone.

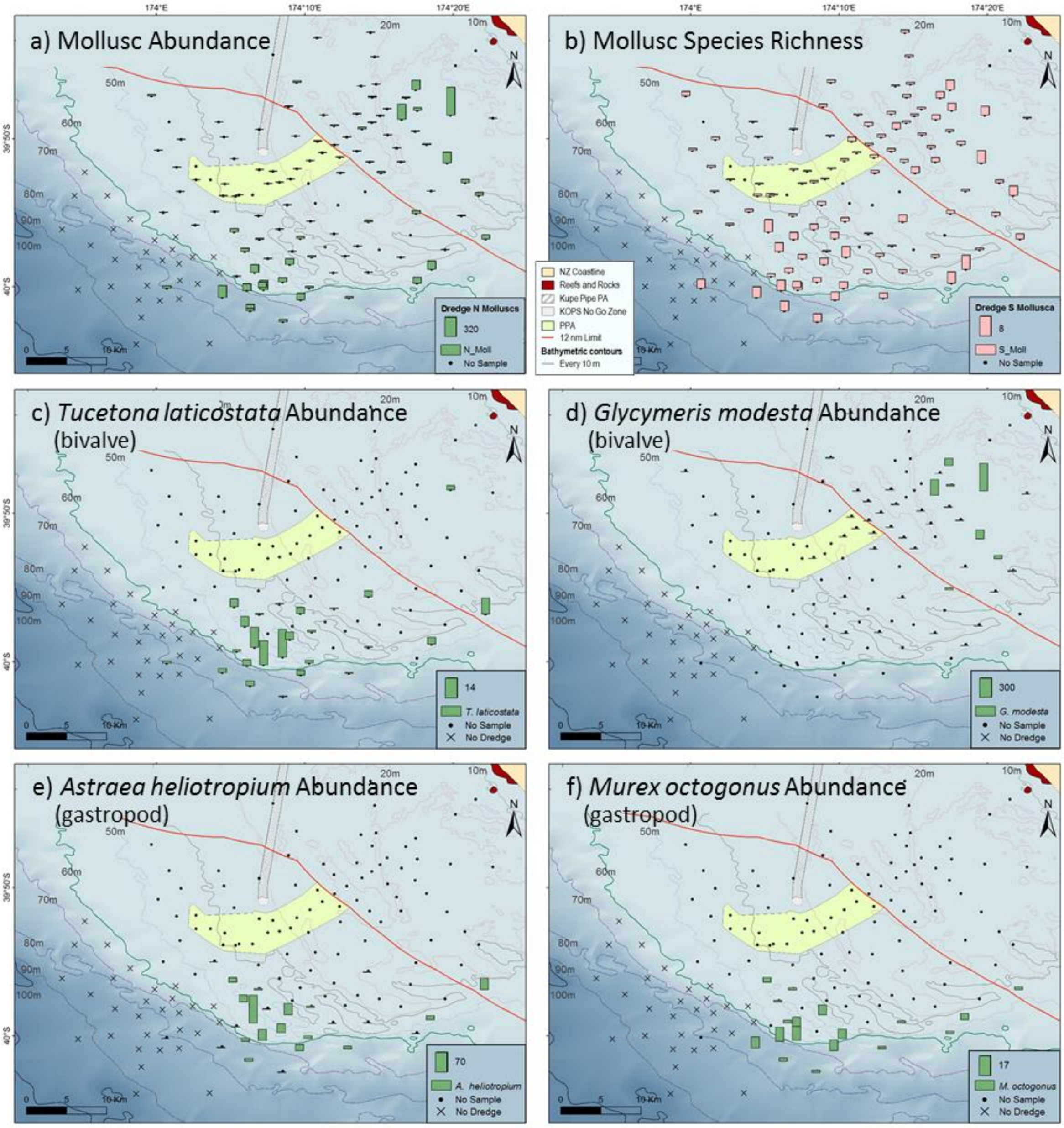

Figure 22: **Spatial distribution of molluscs per dredge/site (250m^2).** a) The green bars represent the total number of individuals (N) collected. b) The light brown bars represent the total number of species/OTU's (S) collected. c-f) Total numbers p/site of bivalves c) *T. laticostata*, d) *G. modesta*, and gastropods e) *A. heliotropium*, and f) *M. octogonus*. Relative scale bars are provided in the legend of each graph.

3.2.2.3 Decapod crustaceans

A total of 3,194 specimens from 22 species of decapods were collected in the dredge samples (Appendix G1). Decapods were a common component of dredge collections, and while the number of specimens captured was highly variable (Figure 23a), the number of species collected was relatively even across the entire Patea Shoals region (Figure 23b). The most common decapods collected were two genera of hermit crabs: *Lophopagurus* spp. and *Areopaguristes setosus* (81% of all decapods collected) (Figure 25c and d, respectively; Appendix G1).

Lophopagurus spp. was the most abundant taxon, with a total of 1497 specimens collected from 84 sites within water depths of 20-84 m (mean 13.4 ± 3.3 specimens, range: 0-309 specimens per site/250m^2) (Figure 25c). *Lophopagurus* spp. included 2 species that were not able to be distinguished without dissection. This species/group was common across the inner and mid-shelf zones, although markedly higher abundances occurred at two mid-shelf sites (200 specimens from Site 98 and 200 specimens from Site 93). *A. setosus* was also common across the inner and mid-shelf zones (995 specimens from 79 sites: mean 8.6 ± 1.7 specimens, range 0-179), although abundance was higher across the northern inner shelf zone (Figure 25d) - driven in part by the collection of 179 specimens from site 54.

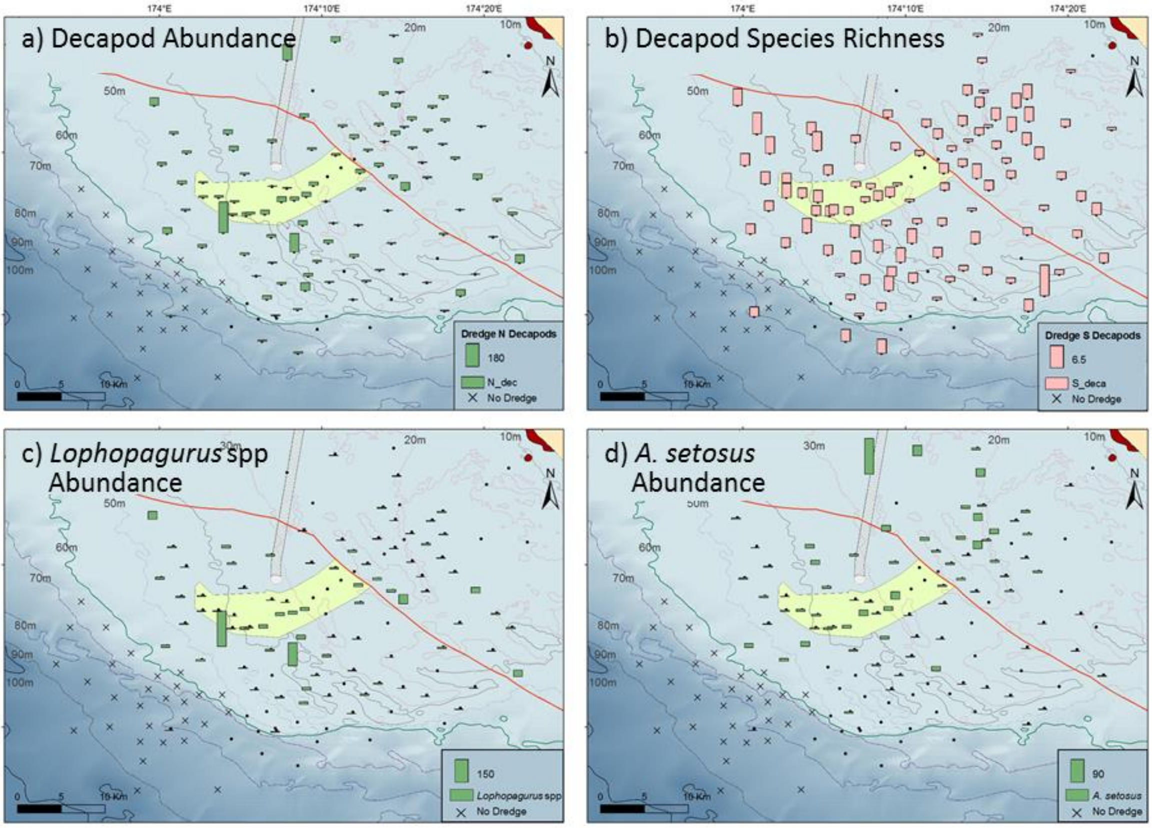

Figure 23: Spatial distribution of decapods per dredge/site (250m^2). a) The green bars represent the total number of individuals (N) collected. b) The light brown bars represent the total number of species/OTU's (S) collected. Relative scale bars are provided in the legend of each graph. c) Densities of the hermit crab *Lophopagurus* spp. per site/250 m^2; d) Densities of the hermit crab *Areopaguristes setosus* per site/250 m^2.

3.2.2.4 Annelida and worm-like phyla

A total of 1,295 worms from 49 species were collected in the dredge data (full species list provided in Appendix F1). Of these 98% were polychaete worms (i.e. segmented worms) belonging to 48 species/genera from 22 families. The remaining 2% were all nemertean worms (31 specimens from 17 sites), but these were only identified to phyla (Nemertea). Worms collected in the dredges were mostly large specimens living on or very near the sediment surface (e.g. *Eunice* spp.), or living in amongst shell debris (e.g. *Odontosyllis polycera*), while small worms living in the sediments are better sampled in the sediment cores (see Chapter 3.3.3.1 and Appendix F2). Species richness and abundance of the worms collected in the dredges were highest offshore in the biogenic habitat zones

(Figure 24a-b). The most abundant polychaete worms collected in the dredges were species known to hide under stones and shell debris. These included two species of eunicid worms (large, muscular worms): *Eunice laticeps* (210 specimens from 11 mid-offshore sites) and *Eunice australis* (200 specimens from 15 mid-offshore sites) (Figure 24c), along with a range of Syllidae worms dominated by *Odontosyllis polycera* (126 specimens from 6 sites) (Figure 24d). These species were all collected from the offshore biogenic zone where shell debris was prevalent.

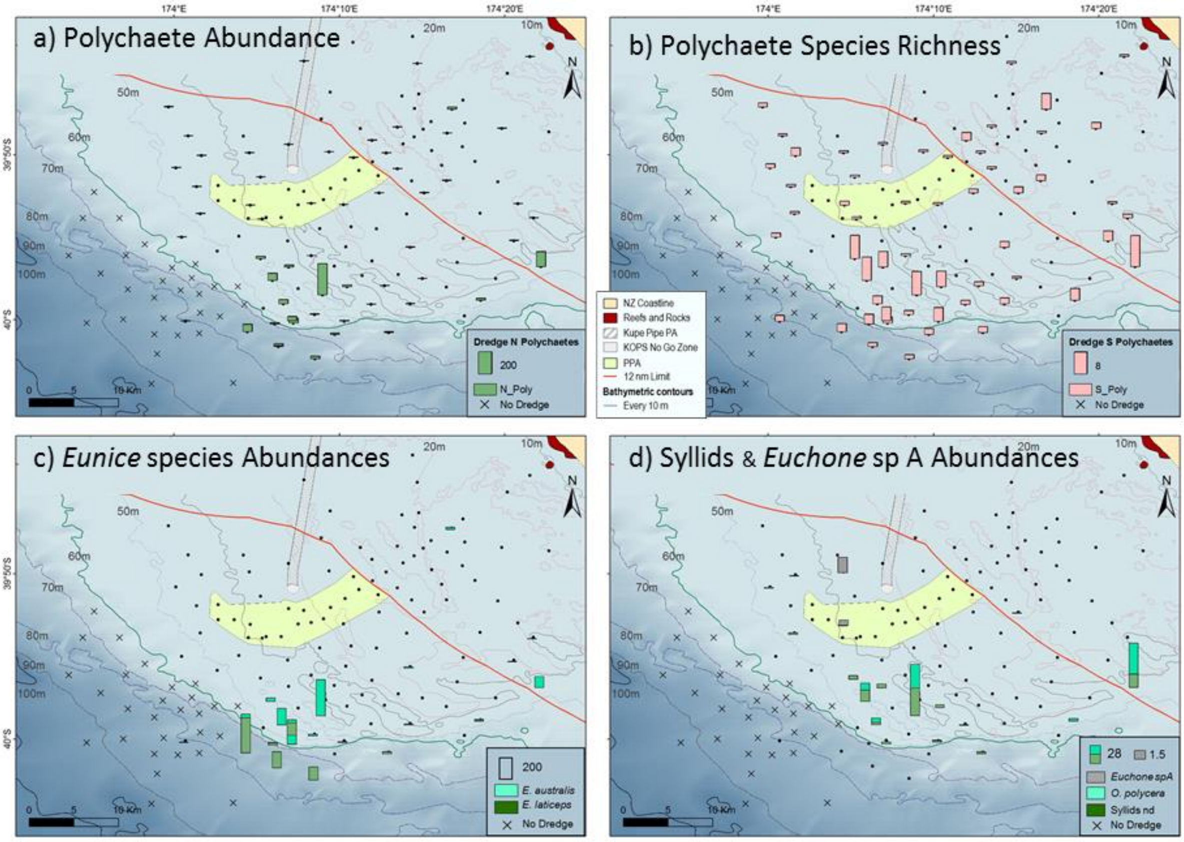

Figure 24: Spatial distribution of polychaete worms per dredge/site (250m^2). a) The green bars represent the total number of individuals (N) collected. b) The light brown bars represent the total number of species/OTU's (S) collected. c) Densities of the *Eunice* species: *E. australis* and *E. laticeps* per site/250 m^2; d) Densities of syllid worms (*O. polycera* and other undetermined Syllids) and *Euchone* sp A per site/250 m^2. Relative scale bars are provided in the legend of each graph.

Taxonomically note-worthy species/genera collected in the dredges were *Lacydonia* sp *A* (Family: Lacydoniidae) and *Euchone* sp A (Family: Sabellidae) (Appendix F1). *Lacydonia* sp A (10 specimens from 4 sites) represent a new family record for New Zealand, while *Euchone* sp A (4 specimens from 2 sites: Sites 96 and 71) is a small undescribed *Euchone*-like tubeworm (Geoff Read, NIWA, *pers comm*) (NB: a more detailed description of *Euchone* sp A is provided in Chapter 3.3.2). Due to the fact that the shallow benthic environments on the west coast of New Zealand have been very poorly studied, it is unknown if newly recorded taxa from this study are unique to the Patea Shoals or STB region, or occur over much larger areas along the west coast of New Zealand.

3.2.2.5 Foraminifera

Only one species of foraminiferan, *Miniacina miniacea* (Family: Homotrematidae), was collected in the dredge samples (Appendix O1). This is a small, red, encrusting species that was found in relatively high abundance (911 specimens) growing on dead *T. laticostata* shells in the offshore biogenic zone (17 sites; 5-218 specimens per site; Figure 25a,b).

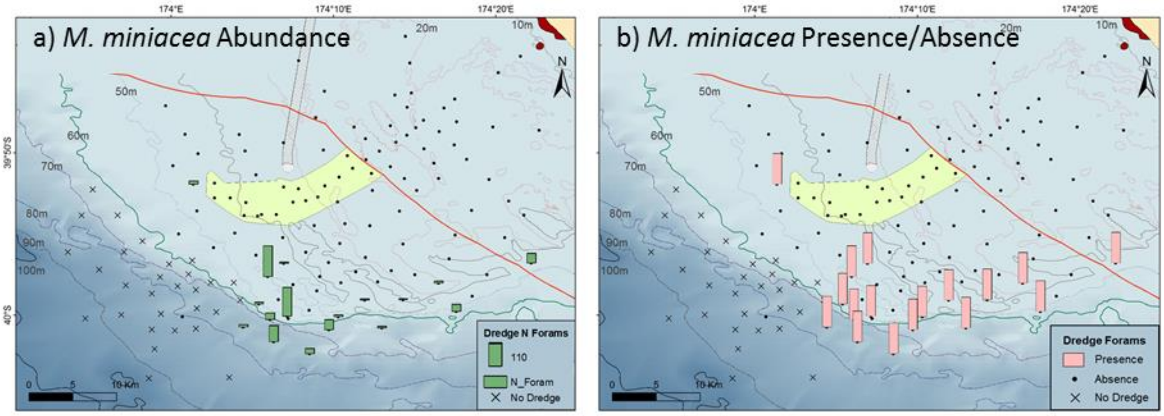

Figure 25: Spatial distribution of the foraminifera, *Miniacina miniacea,* per dredge/site (250m^2). a) The green bars represent the total number of individuals (N) collected. b) The light brown bars represent presence/absence of *M. miniacea* per site. Relative scale bars are provided in the legend of each graph.

3.2.2.6 Echinodermata

A total of 674 echinoderm specimens from 22 species were collected from 45 sites (range: 1-100 specimens per site/250m^2) (Appendix J1; Figure 26a,b). Echinoderms were numerically dominated by ophiuoids (594 individuals, 12 species) and holothurians (65 individuals, 6 species), with much lower numbers of asteroids (11 individuals, 3 species) and echinoids (9 individuals, 2 heart urchin species). These are all mobile organisms with a range of feeding strategies including predators/scavengers (e.g. ophiuroids and asteroids) and deposit feeders (e.g. echinoids and holothurians) (Appendix C).

Echinoderms were most abundant and diverse in the offshore biogenic zone in depths of 45-75 m (Figure 26a,b). However this association with offshore habitats was driven by the distribution of the four most abundant species, which included three ophiuorids (O. *maculate* [260 individuals, 18 offshore sites, 42-74 m]*, Ophiomyxa brevirima* [134 individuals, 15 sites, 46-84 m] and *Ophiopeza cylindrical* [101 individuals, 15 sites, 44-84 m]) and the holothurian, *A. mollis* (49 individuals, 12 sites, 28-80 m) (Figure 26c,d). Ophiuroids, particularly *O. maculata*, were commonly observed under clusters of bivalve shells with their arms poking out (*video obs*.). In contrast to offshore habitats, only a few individuals were collected on either rocky outcrops (e.g. *Patiriella morttenseni*) or sandy sediments (e.g. *Apatopygus recens*: 4 specimens from 3 inner shelf sites) on the inner shelf, or from the mid-shelf zone (e.g. *Astropecten polyacanthus:* 6 specimens from 6 mid-shelf sites, and *Coscinasterias muricata:* 2 PPA sites).

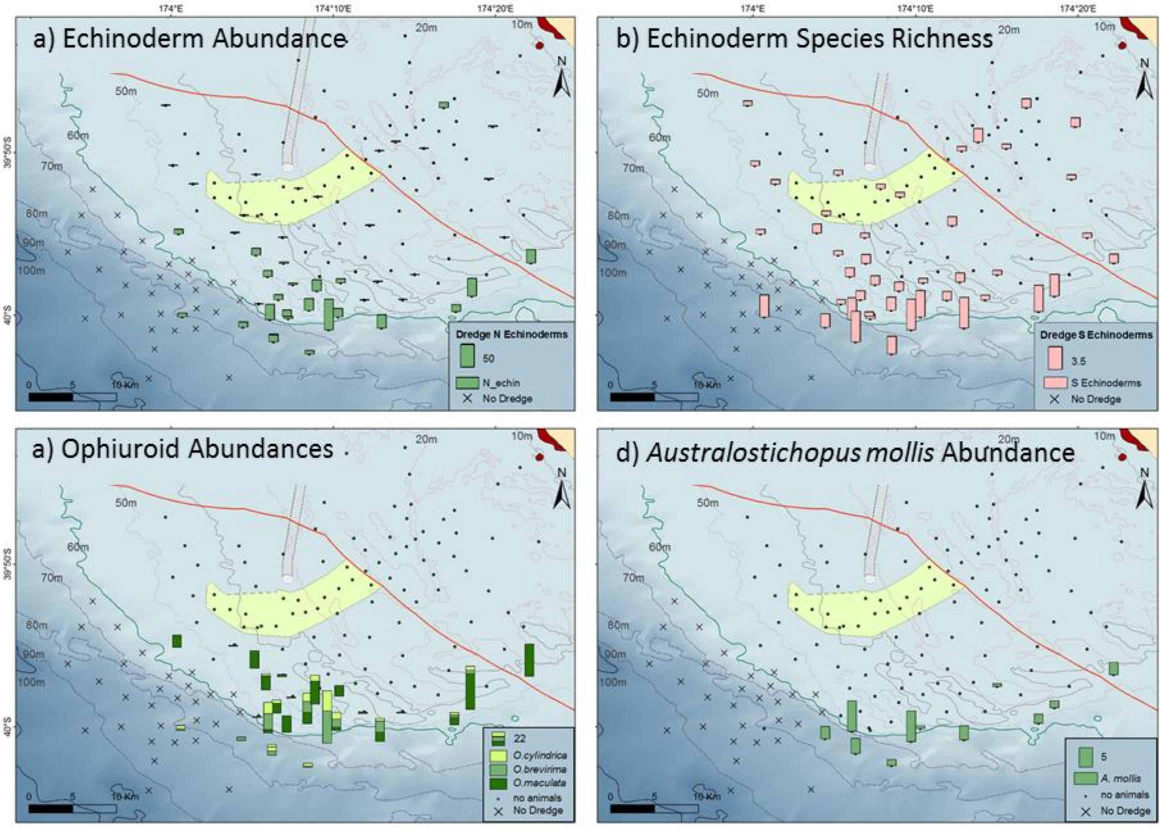

Figure 26: Spatial distribution of echinoderms per dredge/site (250m^2). a) The green bars represent the total number of individuals (N) collected; b) The light brown bars represent the total number of species/OTU's (S) collected. c) Comparative densities of the three most abundant ophiuroids (*O. maculate, O. maculate, O. cylindrical*) per site/250 m^2; d) densities of the dominant holothurian, *A. mollis*, per site/250 m^2. Relative scale bars are provided in the legend of each graph.

3.2.2.7 Porifera

The porifera, or sponges, are sessile colonial organisms normally found attached to hard substrata such as rock and cobble or growing on biogenic substratum such as shells. Most sponges are suspension feeders, reliant on access to a supply of water to pump through the colony to provide nourishment. A total of 596 sponges from 47 species (22 families; 9 orders) were collected from the dredge samples (Appendix H1). Of these, 46 species belonged to the class Demospongiae, with only one species from the Class Calcarea. Five new species (*Dictyodendrilla* sp 3, *Psammopemma* sp 7, *Cymbastella* sp 1, *Ircinia* sp 6 and *Neopetrosia* sp 11) were identified from this survey, along with new records for the region of two species (*Polymastia lorum* and *Tethya amplexa*) and one genera (*Higginsia*) (Appendix H1). In addition, the presence of *Stellata conulosa* (Bergquist 1968, 5 specimens from offshore site 116) are the only records of this species since 1968. *Pseudoceratina* sp 1 (Family: Pseudoceratinidae, Order: Verongida) is only the third record of the order Verongida within New Zealand waters – previously recorded from 17 nm west of Pandora Bank (off Cape Reinga) and the Three King Islands. *Pseudoceratina* sp 1, is a purple agglutinating vermetid sponge (i.e. sponges associated with vermetid gastropods), collected in relatively high numbers at several offshore sites (53 specimens from sites 108, 113, 115 and 117), with worm snail gastropods (Family Vermetidae) found in all 53 specimens. As very few sponges have been collected from the continental shelf along the west coast of the North Island these sponges provides an important reference collection for taxonomists and ecologists (Michelle Kelly, NIWA, *pers. comm*.).

The highest abundances (N) and species richness of sponge colonies were recorded in the offshore biogenic zone (Figure 27a-b), where diverse array of sponge were collected growing on old bivalve shells. Rocky outcrops on the inner shelf (e.g. site 7) also supported a range of sponge species although the total number of sponges was low (Figure 27a-b). Conversely, adjacent sand wave and rippled sands, especially inside the PPA, had few sponges (Figure 27a-b).

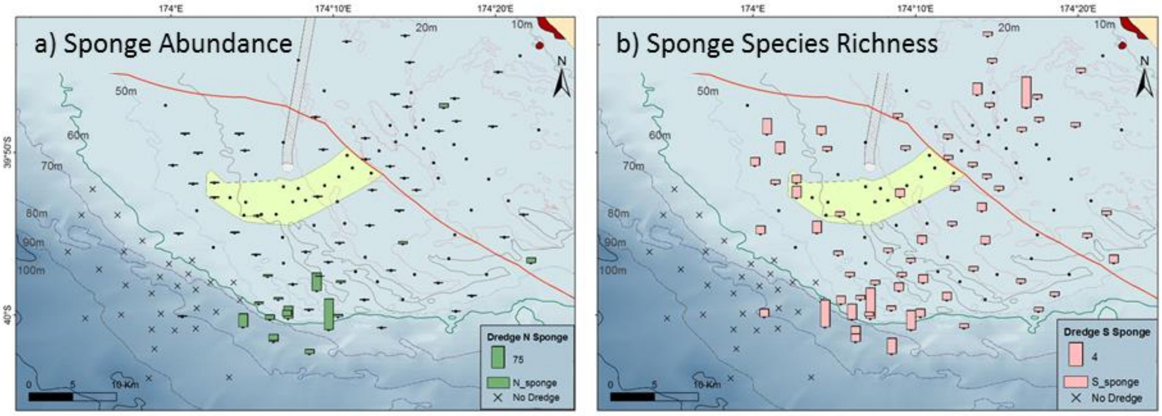

Figure 27: Spatial distribution of the sponges per dredge/site (250m^2). a) The green bars represent the total number of individuals (N) collected. b) The light brown bars represent the total number of species/OTU's (S) collected. Relative scale bars are provided in the legend of each graph.

3.2.2.8 Chordata (Fish)

A total of 558 fish from 13 species (2 classes, 12 families and 13 genera) were recorded in the dredge data (*see* Appendix K1; Figure 28a,b). Fish captured in the dredges were mostly small cryptic fishes (e.g. 3 triplefin species and the opalfish), while large, more motile species (e.g. bluecod and leatherjackets) were only rarely captured. Fish abundances were highest offshore in the biogenic zone (Figure 28a), while species richness was more evenly distributed across the region (Figure 28b). These patterns reflected the combination of high abundances of the small deepwater triplefin, *Matanui profundum* (Family: Tripterygiidae) in the offshore biogenic habitats, and the more generic distribution of opalfish (*H. monopterygius,* Family: Percophidae) and flatfish (*Arnoglossus scapha*) across the inner and mid-shelf.

The deepwater triplefin, *M. profundum*, was the most abundant species collected, accounting for 80% of all fish collected in the dredges (445 specimens from 22 offshore sites) (Figure 28c), and reflect some of the highest densities of *M. profundum* ever recorded (Peter MacMillan, NIWA, *pers. comm*.). This species was also observed in still images in relatively high numbers across most bryozoan rubble sites, However, the apparently high numbers of this species may simply reflect the lack of deepwater surveys along the continental shelf of the west coast (Peter MacMillan, NIWA, *pers. comm*.), particularly within offshore biogenic habitats, which are likely to provide small motile species, such as the deepwater triplefin, substantial refuge and a variety of small prey items to feed on. Opalfish, on the other hand, were common across the inner and mid-shelf zones – albeit in low numbers (48 individuals across 28 sites; Figure 28d). Dredges also captured the small lumpfish (or clingfish), *Trachelochismum pinnulatus* (Family: Gobiesocidae). This species had previously been thought to occur only in intertidal rock pools and the shallow subtidal to 12 m water depth (Paulin and Roberts, 1992; Peter MacMillan, NIWA, *pers. comm*.). However, dredge samples from this survey, collected *T. pinnulatus* from depths of 27-54 m, from the inner shelf (11 specimens Sites 20, 25, 46 and 53) and offshore in the biogenic zone (15 specimens from Sites 140 and 144).

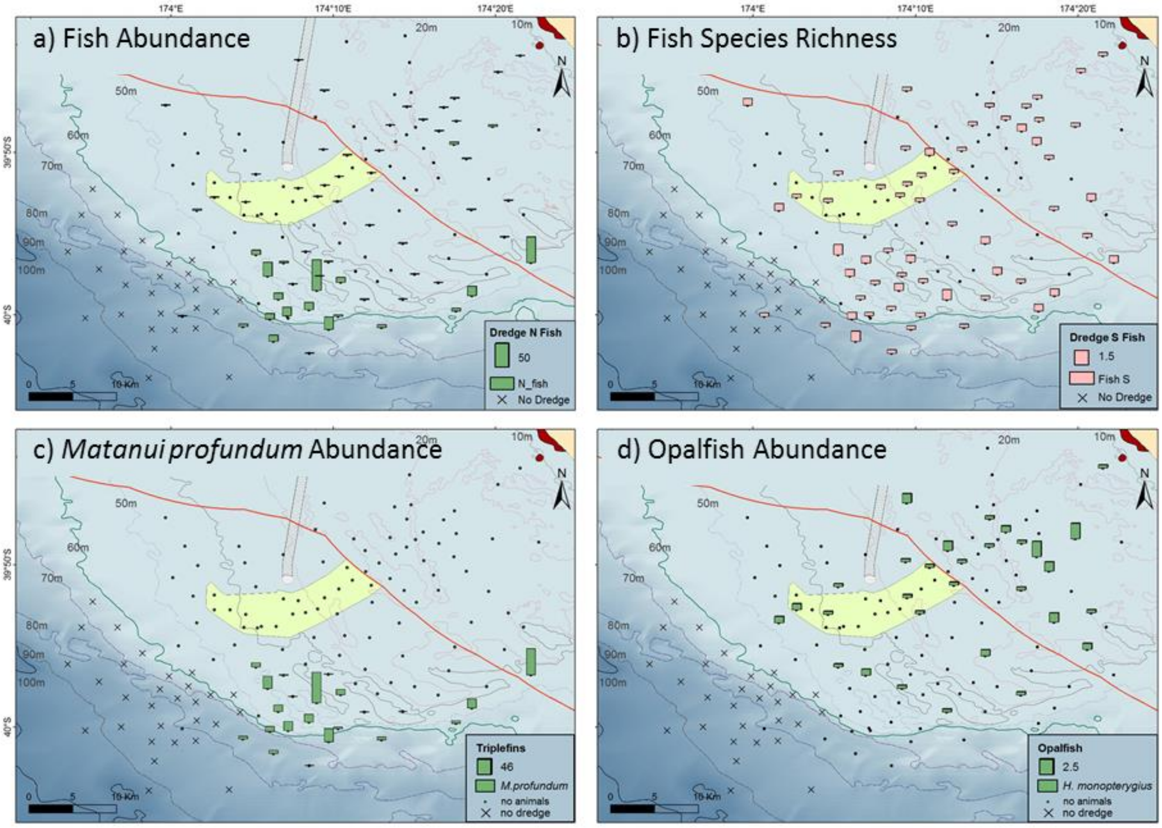

Figure 28: Spatial distribution of fish per dredge/site (250m^2). a) The green bars represent the total number of individuals (N) collected; b) The light brown bars represent the total number of species/OTU's (S) collected. c) Densities of the deepwater triplefin, *M. profundum*, per site/250 m^2; d) densities of the opalfish, *H. monopterygius*, per site/250 m^2. Relative scale bars are provided in the legend of each graph.

3.2.2.9 Ascidia

Ascidians (sea squirts) are sessile suspension feeding organisms that, like sponges, filter organisms from the water column. A total of 535 specimens from 12 species were collected from 20 sites (range: 1-105 specimens per site/250m^2) (Appendix I1; Figure 29a,b). Although some colonial ascidians were observed in still photographs of the seabed - mostly in the deeper biogenic bryozoan habitats (see Appendix A) - specimens captured in the dredge samples were all solitary ascidians from the family Styelidae, indicating that more ascidians species are present in these offshore biogenic habitats than were collected during the dredge survey. Solitary ascidians were collected from sites with either hard substratum (e.g. inner shelf sites 5 and 7) or from offshore sites where dead *T. laticostata* shells were prevalent (Figure 29a,b). *Corella eumyota*, the orange tipped sea squirt, was the most abundant ascidian species collected in the dredge (61% of all ascidians collected), with 326 individuals collected from 9 offshore sites (range: 1-84 specimens per site/250m^2, Figure 29c). This species grows up to 8 cm high on any hard substrata where it can quickly form large clumps due to short dispersal mechanisms. *Pyura molguloides* - a sea squirt endemic to South Australia (Herdman, 1899) - was recorded from two offshore sites (Sites 144 and 160) and is the first record of this species in New Zealand (Mike Page, NIWA, *pers comms*.) (Figure 29c).

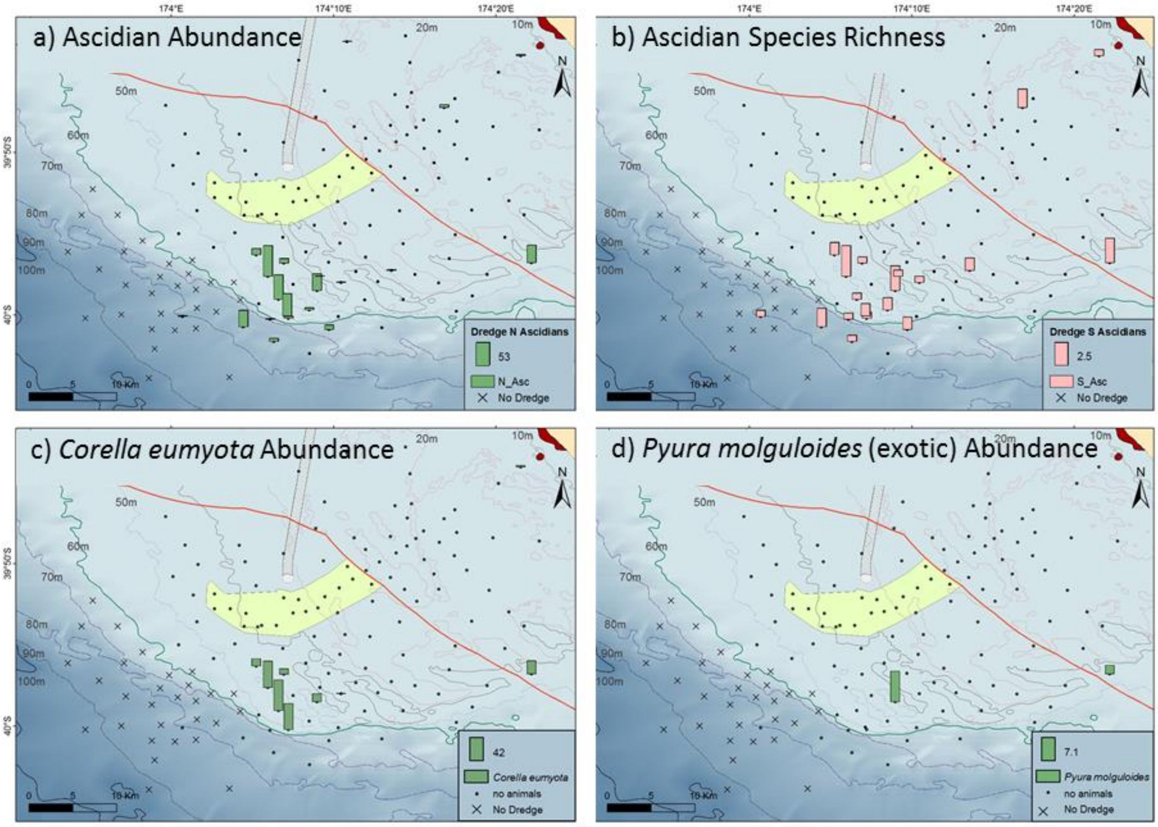

Figure 29: Spatial distribution of ascidians per dredge/site (250m^2). a) The green bars represent the total number of individuals (N) collected; b) The light brown bars represent the total number of species/OTU's (S) collected. c) *Corella eumyota* densities per site/250 m^2; d) *Pyura molguloides* (exotic species) densities per site/250 m^2. Relative scale bars are provided in the legend of each graph.

3.2.2.10 Brachiopoda

Brachiopods (or lampshells) are sessile, shelled, suspension feeding organisms. They attach to hard substrata, including rocks and shells using a strong ligament that protrudes through a hole in the lower shell. A total of 395 brachiopod specimens from 3 species (Family: Terebratellidae - *Calloria inconspicua*, *Neothyris lenticularis* and *Terebratella* sp.), were collected in the dredge samples (Appendix O1). The most abundant of these species was *C. inconspicua* with 350 individuals (89% of all brachiopods collected) recorded from 19 sites. Most brachiopods (97.8%) were collected from the offshore biogenic habitats (Figure 30a). Brachiopods were also prevalent in the still photographs taken at most sites in the bryozoan rubble habitats (*video obs*.). In contrast, few brachiopods were collected (or seen) up on the mid-shelf, these were mostly *C. inconspicua* (9 specimens) collected from the wormfields on the northern mid-shelf (Appendix O1; Figure 30a,b).

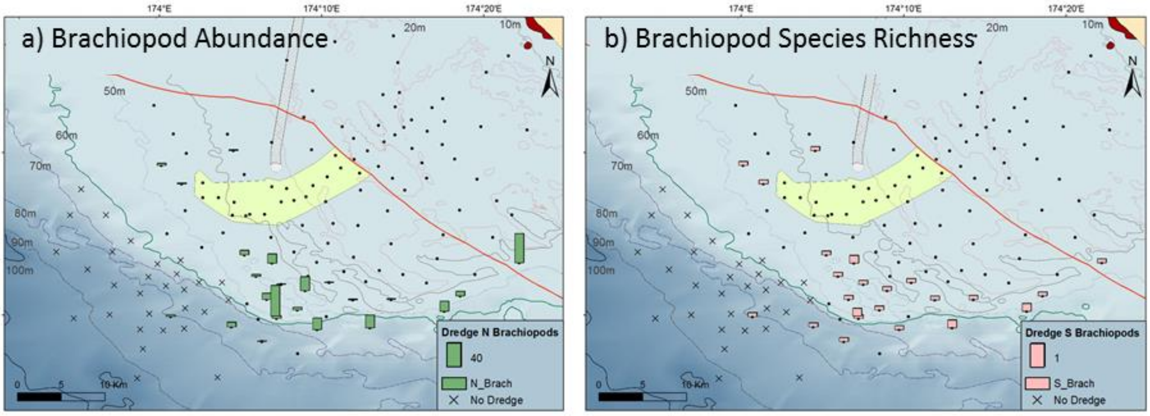

Figure 30: Spatial distribution of brachiopods per dredge/site ($250m^2$). a) The green bars represent the total number of individuals (N) collected; b) The light brown bars represent the total number of species/OTU's (S) collected. Relative scale bars are provided in the legend of each graph.

3.2.2.11 Non-decapod crustaceans and pycnogonids.

In total, 266 non-decapod crustacean and pycnogonid specimens were recorded from the dredge samples. These consisted mostly of amphipods (sand hoppers), isopods (slaters) and a few pycnogonids (sea spiders) (Appendix L1), while most other non-decapod crustacea were better sampled in the sediment cores (see Chapter 3.3.3.2 and Appendix L2). Amphipods and isopods were mostly identified to family-level only due to the small nature of the individuals and the need to dissect each individual's mouth parts to be able to identify them further. The abundance and species richness of non-decapod crustacea were highest within the south western end of the PPA (Figure 31a) and immediately to the north (Figure 31a-b). Nine different amphipod families were identified within the samples, the most abundant of which was Pardaliscidae (a gammarid amphipod) with 110 specimens from 12 sites within the PPA and northern mid-shelf zones (Appendix L1). Caprellidae cf. *Caprella* (a caprellid amphipod) was the second most abundant species/group, with 51 specimens collected from 7 sites across the inner to mid-shelf zones (Appendix L1). Three isopod families were identified, the most abundant of which was Holognathidae (*Holognathis* sp.) with 16 specimens from 7 sites across both the inner and mid-shelf zones. Only two pycnogonids (*Pallenopsis oblique*) were recorded, one at each of two sites (Sites 97 and 98).

There were some taxonomically interesting records within the amphipoda. *Liljeborgia hansoni* (Liljeborgiidae) was found in greater numbers than expected considering the shallow depth range of the study area. In addition, members of the family Platyischnopidae were taxonomically investigated further and 27 specimens were found to belong to a new family, *Otagia neozelanica* (Hughes and Lörz, 2013).

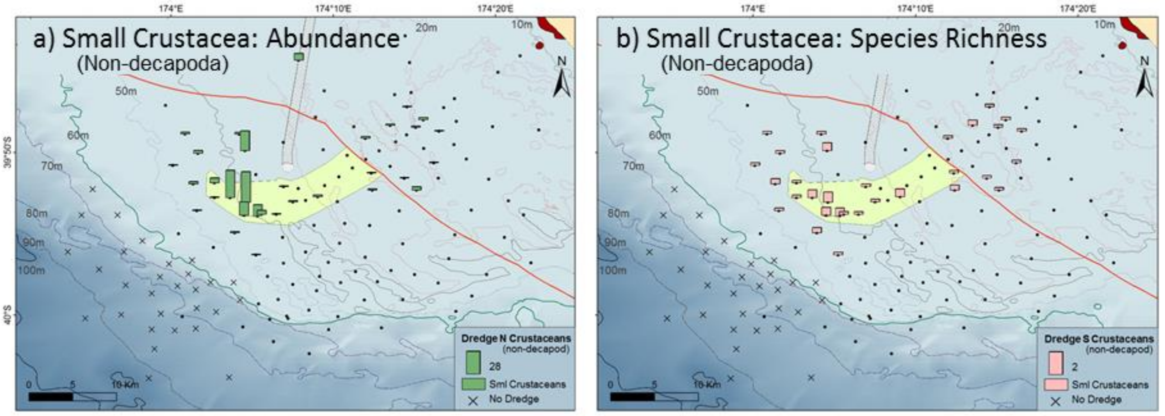

Figure 31: Spatial distribution of small non-decapod crustacea per dredge/site (250m^2). a) The green bars represent the total number of individuals (N) collected; b) The light brown bars represent the total number of species/OTU's (S) collected. Relative scale bars are provided in the legend of each graph.

3.2.2.12 Algae

Although a wide range of algal specimens were collected in the dredges, it was often unclear whether pieces of algae collected in a single dredge represented different specimens or multiple fragments from the same specimen. Consequently, algae collected in the dredges were identified to species but were recorded as presence/absence only. Therefore, no abundance information is provided. A total of 27 algal species belonging to 20 families were collected within the dredges (Appendix M1). Algal species collected were dominated by reds (15 species from 11 families), along with browns (9 species from 5 families) and green algal species (2 species from 2 families). A new genus of red alga was collected from 5 sites on the southern mid-shelf in water depths of 35-39 m (Appendix M1). This foliose red alga was initially referred to the genus *Cryptonemia* on the basis of its vegetative anatomy, however, RbcL genetic sequencing has identified that this is a new species belonging to a new genus (Galene profundae) that requires further studies (Roberta D'Archino, NIWA, *pers comms*.).

Most algae was collected from the inner shelf, in areas where rocky outcrops were present, while, few algal species were collected on the mid-shelf, while little to no algae was collected from deeper habitats offshore (Figure 32). However, small foliose red algae was observed in still photographs of the offshore biogenic zone, where it was seen growing on bivalve shell debris (see Appendix A). Low numbers of dredges in these habitats may in part explain the low occurrences of algal in these deeper habitats (Figure 32).

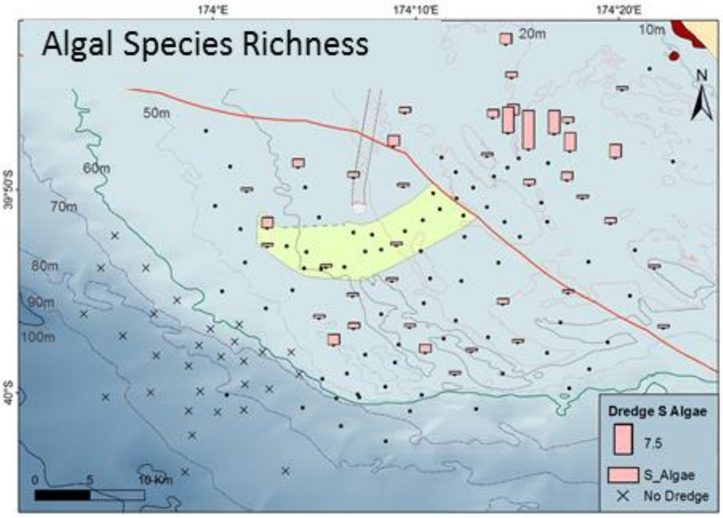

Figure 32: **Spatial distribution of algal species per dredge/site (250m^2).** The light brown bars represent the total number of species/OTU's (S) collected at each site. Algae was only recorded as presence/absence, so no abundance is available. Scale bar is provided in the legend of the graph.

3.2.2.13 Cnidaria

Cnidarians recorded within the study site included eight types of hydroid (from 6 families), Actinaria (anemones) and some gelatinous "blobs" which were thought to be juvenile anemones. Hydroids are sessile organisms that live attached to hard substrates and feed by capturing prey items within their feeding appendages as the prey passes them in the water column. The hydroids collected in the dredge were small, fragile-looking, feather-like colonies. The most abundant hydroids were *Dictyocladium monolifer* (Family Sertulariidae, 18 specimens from 6 sites) and *Aglaophenia laxa* (Family Aglaopheniidae, 14 specimens from 2 sites) (Appendix N1). Anemones are mostly sessile organisms (able to move slowly) that capture prey with their tentacles when the prey comes within reach. Many anemones live attached to hard substrata, though there are also burrowing anemones which live in soft sediments. Only two individual anemones were recorded within the dredge samples. One was a small burrowing anemone and one a small sessile anemone (both within the order Actinaria).

Few cnidarian specimens (45 specimens from 10 species/taxa groups) were collected during the survey (Appendix N1). The highest abundances of cnidarians were located in the offshore biogenic zone, in water depth > 55 m (Figure 33a), where they were found growing on, or were in amongst, shell debris. In contrast, only a few isolated specimens were collected across the inner and mid-shelf zones (Figure 33b), reflecting a few solitary specimens found growing on gastropod-shells occupied by large hermit crabs or isolated debris.

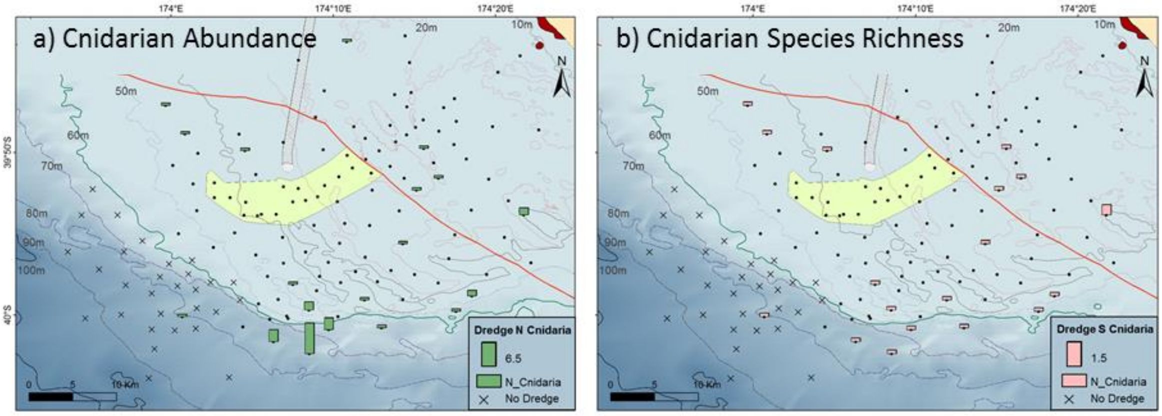

Figure 33: **Spatial distribution of cnidaria per dredge/site (250m^2).** a) The green bars represent the total number of individuals (N) collected; b) The light brown bars represent the total number of species/OTU's (S) collected. Relative scale bars are provided in the legend of each graph.

3.2.3 Multivariate analysis: Dredge data[5]

The nMDS plot of Bray Curtis similarities of log transformed data (Figure 34) gives a two-dimensional representation of the relative similarities or dissimilarities of the community structure from dredge data at selected sites. Data points were colour coded for area. There were no significant differences between the PPA, compared to adjacent mid and inner shelf areas, but there were significant differences in community structure between the PPA and the deeper offshore areas (triangles and squares in Figure 34, Table 6). ANOSIM tests also showed both month and time of sampling were significant ($p < 0.5$) so these were included as variables in more detailed DISTLM analyses below.

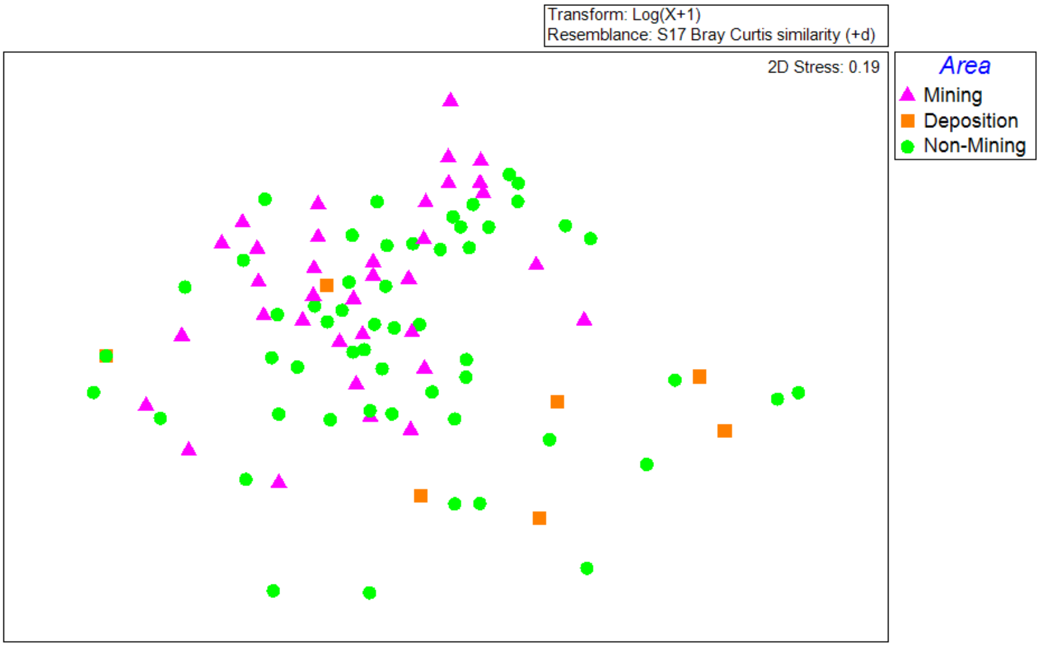

Figure 34: **nMDS plot showing the similarities of the community structure at each of the sandy sites, colour coded for area (Mining, deposition and non-mining sites).** No overall significant differences between areas were found (ANOSIM $p > 0.05$, Global R= 0.065)

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[5] Please see Appendix A for the findings of the revised 2014 multivariate analyses

Table 6: ANOSIM pairwise results for dredge data (sandy sites only): percentage dissimilarity between sites. * significant ($p < 0.05$), ** significant ($p < 0.01$).

Deposition	53.0**	
Non-Extraction	-2.7	27.2*

To determine if the dominant benthic community structure differed between the original mining site, deposition site, and non-mining site areas, key taxa were examined using the SIMPER routine (PRIMER-E). The mean abundance of species which represented greater than 5 % contribution to the community structure for each area, or 5 % contribution to differences in community structure between areas are shown in Figure 35. These were *G. modesta*, the small dog cockle; *Lophopagurus* spp. and *A. setosus*, hermit crabs; *Tubilipora* sp. and *Perkemavella punctigera*, both bryozoans.

G. modestus and *Lophophagus* spp. were the most abundant of these taxa, with mean values within the non-extraction area of approximately 20 individuals per dredge/site. Both of these taxa had lower abundances within the mining site (approximately 10 individuals per dredge/site) and low abundances within the proposed de-ored sand deposition area (approximately 1 and 5 individuals per dredge/site respectively).

Tubilipora sp followed a similar trend, with highest mean abundances within the non-extraction area (approximately 17 individuals per dredge/site) and lower abundances within the PPA. *Tubilipora* sp. was not recorded from the proposed de-ored sand deposition area. *A. setosus* had mean abundances of approximately 10 individuals per site at both the PPA and within the non-extraction area and a lower mean abundance within the proposed de-ored sand deposition area. *P. punctigera* was absent from the mining site and had a very low mean abundance in the non-mining area but higher mean abundance (of approx. 2 colonies per site, with large variation) within the proposed de-ored sand deposition area.

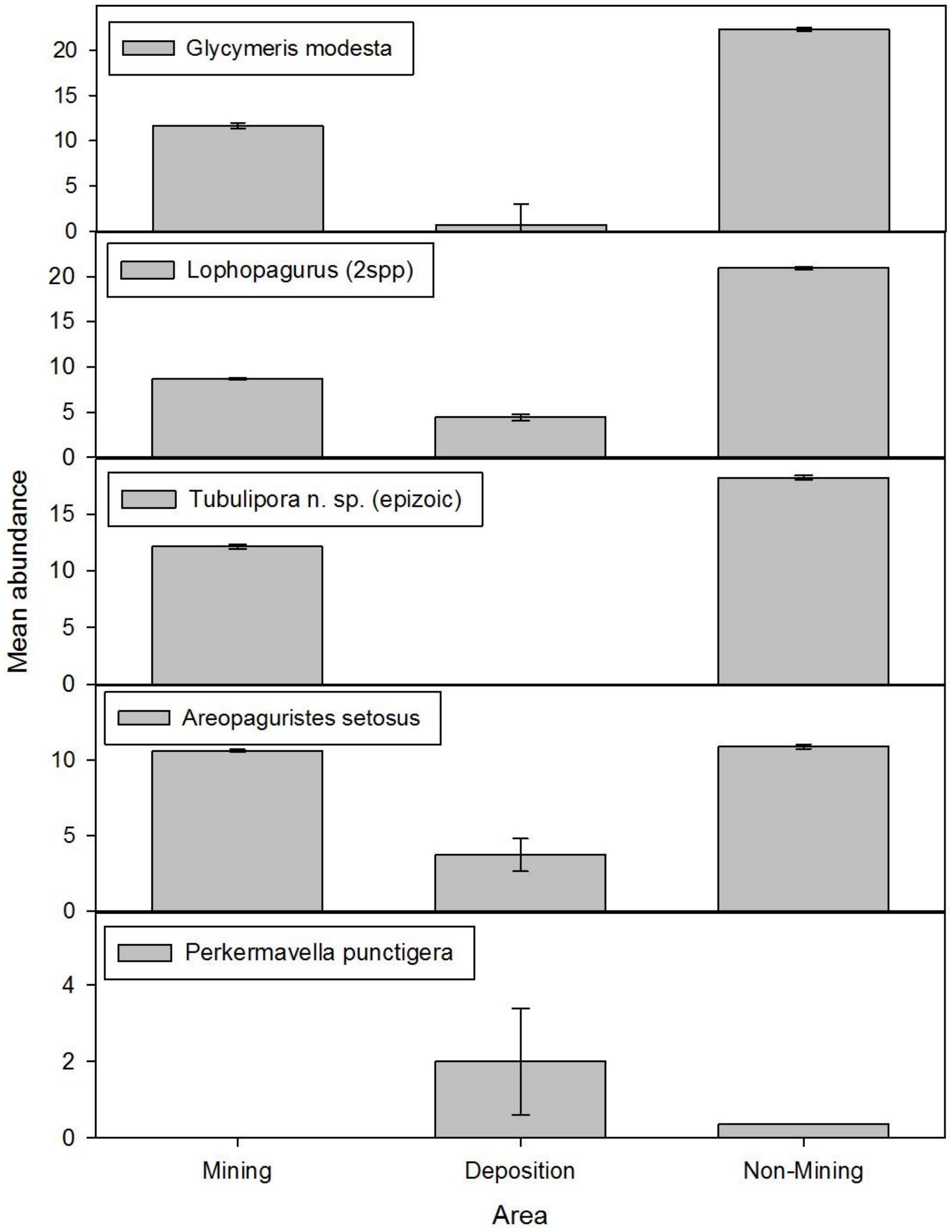

Figure 35: Dredge data: Key taxa. Those species/taxa which had greater than 5% contribution to community structure and/or dissimilarities between areas. Mean values with standard deviations.

A DISTLM routine (all selected, R^2) was run on data from sandy sites only, to determine the key drivers in structuring the benthic community (with respect to dredge data). Marginal tests showed the variables should be sequentially tested in the following order: depth, distance from shore, coarse sand, fine sand, fine gravel, month, medium gravel, very fine sand, clay, hour, iron, silt, and medium sand.

Sequential tests (Table 7) explained 31.9 % of total variation. Depth was the variable that explained the most variation (7.8 %). Depth, distance from shore, coarse sand, and fine sand all significantly increased the explained variation ($p < 0.05$). Month, medium gravel and clay also had significant p-values but as these follow a variable with a larger p-value in the testing sequence, these should not be trusted (Anderson et al. 2008). Note that the concentration of iron in the sediments was not a key driver of epibenthic community structure, and only explained 1% of the total variation (p = 0.185). A graphical representation of these results is given in Figure 36.

From these analyses it was possible to identify relationships between taxonomic groups and predictor variables. Table 8 gives the relationship between the dbRDA coordinate axes and the orthonormal X variables (predictor/environmental variables). For example, the variables with the strongest positive relationship with axis 1 were depth and distance from shore. Interpretation of these data, together with the relationship between taxonomic groups and the dbRDA axes, allows the identification between predictor variables and taxonomic groups (Table 9).

A second DISTLM (backwards AIC) confirmed that iron was not an important variable in driving epibenthic community structure (Table 10). The backwards model eliminated 7 variables from the model in the following order: clay, iron, time of day, medium gravel, very fine sand, fine gravel and fine sand. The model selected just 6 important variables in determining epibenthic community structure (in no particular order): depth, distance, coarse sand, medium sand, silt and month of sampling. It is interesting to note that fine sand was eliminated despite being found to be significant in the all-selected DISTLM (Table 7), but this was likely due to the correlation between fine and medium sands.

Table 7: DISTLM results: sequential tests. Those predictor variables significantly contributing to the explained variation are highlighted in yellow ($p < 0.05$). The column "prop." gives the proportion of variation explained for each variable.

SEQUENTIAL TESTS

Variable	R^2	SS (trace)	Pseudo-F	P	Prop.	Cumul.	res.df
DEPTH	0.0775	21759.0	7.901	0.001	0.0775	0.0775	94
DISTANCE FM SHORE	0.1082	8616.2	3.202	0.001	0.0307	0.1082	93
COARSE SAND	0.1745	18588.0	7.381	0.001	0.0662	0.1745	92
FINE SAND	0.1920	4915.9	1.973	0.013	0.0175	0.1920	91
FINE GRAVEL	0.2012	2596.6	1.043	0.355	0.0093	0.2012	90
MONTH	0.2254	6768.0	2.771	0.004	0.0241	0.2254	89
MEDIUM GRAVEL	0.2412	4433.6	1.832	0.026	0.0158	0.2412	88
VERY FINE SAND	0.2495	2331.1	0.963	0.486	0.0083	0.2495	87
CLAY	0.2765	7593.6	3.216	0.001	0.0271	0.2765	86
HOUR (UTC)	0.2894	3608.7	1.538	0.066	0.0129	0.2894	85
IRON	0.3002	3027.8	1.295	0.185	0.0108	0.3002	84
SILT	0.3130	3600.3	1.550	0.052	0.0128	0.3130	83
MEDIUM SAND	0.3190	1672.4	0.718	0.696	0.0060	0.3190	82

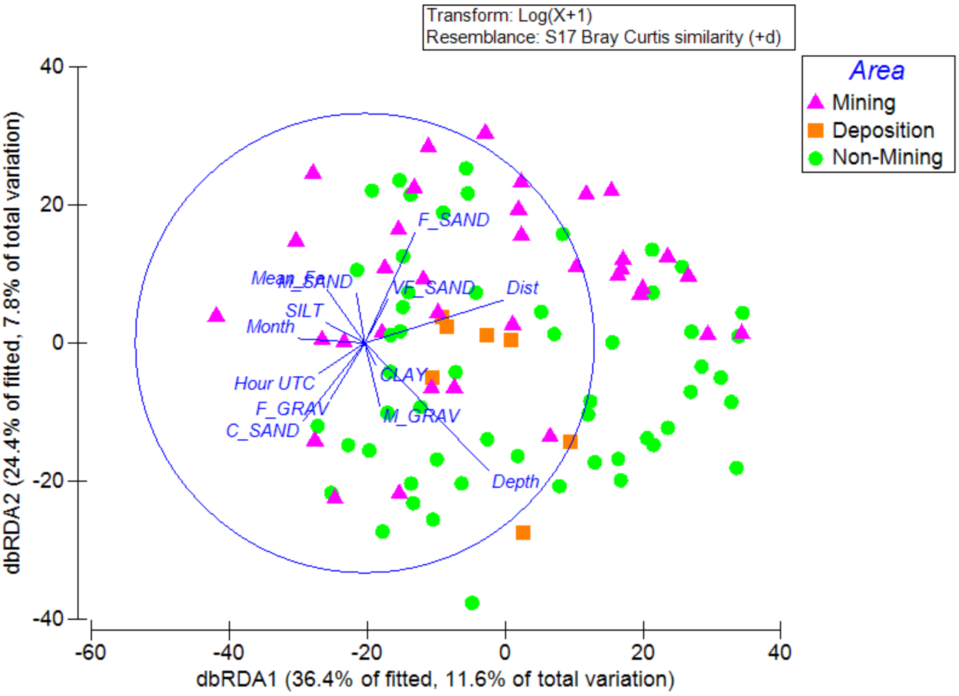

Figure 36: dbRDA plot of the dredge data. This is a visual representation of the DISLTM analysis. The two axes explain 19.4 % of total variation compared with 31.9% variation explained by the DISTLM). The vector plot can be interpreted as the effect of a given predictor variable (the longer the vector the bigger the effect).

Table 8: Relationships between dbRDA coordinate axes and orthonormal X variables (multiple partial correlations). The strongest positive and negative relationships for both axes 1 and 2 are highlighted in yellow.

	Axis number (and % variation explained)							
	1 (36.38)	2 (24.44)	3 (11.16)	4 (6.88)	5 (5.65)	6 (3.46)	7 (3.24)	8 (2.69)
DEPTH	0.543	-0.558	-0.145	0.035	-0.064	0.039	0.329	0.278
DISTANCE FM SHORE	0.604	0.187	0.574	0.244	-0.125	-0.06	0.035	-0.102
COARSE SAND	-0.268	-0.338	0.373	0.33	0.03	-0.23	0.131	-0.285
FINE SAND	0.221	0.483	-0.121	-0.304	0.014	0.066	0.065	-0.198
FINE GRAV	-0.148	-0.241	-0.11	-0.035	0.126	0.105	0.115	-0.24
MONTH	-0.291	0.019	0.424	-0.442	-0.438	-0.205	0.396	0.121
MEDIUM GRAVEL	0.066	-0.276	-0.104	-0.51	-0.236	0.118	0.041	-0.001
VERY FINE SAND	0.102	0.191	0.026	-0.163	0.095	-0.548	-0.151	0.337
CLAY	0.049	-0.097	0.492	-0.349	0.366	0.548	-0.216	0.007
TIME	-0.2	-0.132	0.17	0.14	-0.302	0.107	-0.554	0.353
IRON	-0.163	0.23	0.023	0.193	-0.077	0.278	0.418	-0.147
SILT	-0.171	0.089	0.115	0.052	0.553	0.011	0.361	0.567
MEDIUM SAND	-0.036	0.216	-0.085	0.27	-0.413	0.425	0.126	0.371

Table 9: Relationship between taxonomic groups and the dbRDA axes. Using data from Table 8, these data have been interpreted to give the correlation between taxonomic groups and the predictor variables.

Axis 1, dbRDA1 (36.4% of fitted, 11.6% of total variation)	Correlation with predictor variables

Tubulipora n. sp. (epizoic)	0.687111	Positive correlation with depth and distance
Costaticella bicuspis	0.65585	
Emma crystallina	0.597654	
Bicrisia edwardsiana	0.575899	
Disporella novaehollandiae	0.512778	
Scalicella crystallina	0.483105	
Bellidilia cheesmani	0.403016	
Phylladiorphynchus pusillus	0.400819	
Lophopagurus (2spp)	0.395519	
Mycale (Carmia) cf tasmani	0.394497	
Pratulum pulchellum	0.385487	
Notromithrax peroni	0.371392	
Pardaliscidae	0.36572	
Caberea zelandica	0.313627	
Glycymeris modesta	-0.38877	Negative correlation with depth and distance

	Axis 2, dbRDA2 (24.4% of fitted, 7.8% of total variation)	Correlation with predictor variables
Areopaguristes setosus	0.578837	Positive correlation with fine sand
Amalda (Baryspira) australis	0.327868	Negative correlation with depth
Purpurocardia purpurata	-0.31393	Positive correlation with depth
Eunice australis	-0.31393	Negative relationship with fine sand
Pecten novaezelandiae	-0.32352	
Corbula zelandica	-0.34618	
Zeatrophon ambiguus	-0.3481	
Nectocarcinus antarcticus	-0.47039	
Glycymeris modesta	-0.50655	

Table 10: DISTLM results (backwards AIC). Sequential tests show which variables were eliminated from the analysis and in which order.

SEQUENTIAL TESTS

Variable	AIC	SS (trace)	Pseudo-F	P	Prop.	Cumul.	res.df
CLAY	756.09	1672.4	0.7175	0.705	0.0060	0.3130	83
IRON	755.63	3128.7	1.3469	0.157	0.0111	0.3018	84
TIME UTC	755.3	3433.8	1.4722	0.069	0.0122	0.2896	85
MEDIUM GRAVEL	755.03	3629.5	1.5475	0.061	0.0129	0.2767	86
VERY FINE SAND	754.32	2745.3	1.1631	0.258	0.0098	0.2669	87
FINE GRAVEL	753.47	2480.3	1.0488	0.383	0.0088	0.2581	88
FINE SAND	752.79	2875.4	1.2152	0.228	0.0102	0.2478	89

3.3 Sediment core data

Three sediment cores were collected from as many of the proposed sample sites as possible, however some sites could not be cored due to the presence of gravel or large bivalve shells. Figure

43 shows the location of the sites where coring was carried out successfully. In total, 331 sediment cores were collected from 103 sites. All cores were processed though some were later discarded from the analysis of mean values per site in preference of cores that penetrated further into the substrate.

3.3.1 Sediment characteristics

The mean percentage of each particle size (medium gravel/sand (> 8 mm), fine gravel/sand (1.6 – 8 mm), coarse sand (500 µm – 1.6 mm), medium sand (250 – 500 µm), fine sand (125 – 250 µm), very fine sand (63 – 125 µm), silt (2 – 63 µm) and clay (< 2 µm)) from each site (n = 3 sediment cores) is shown in Figure 37. There were large differences across the sites, with a general trend of finer sands in the north of the study area and a greater proportion of coarse sand and gravels (including shell debris) to the south (Figure 37). Offshore sediments were a mixture of finer silts combined with coarser sands and fine gravels (Figure 37).

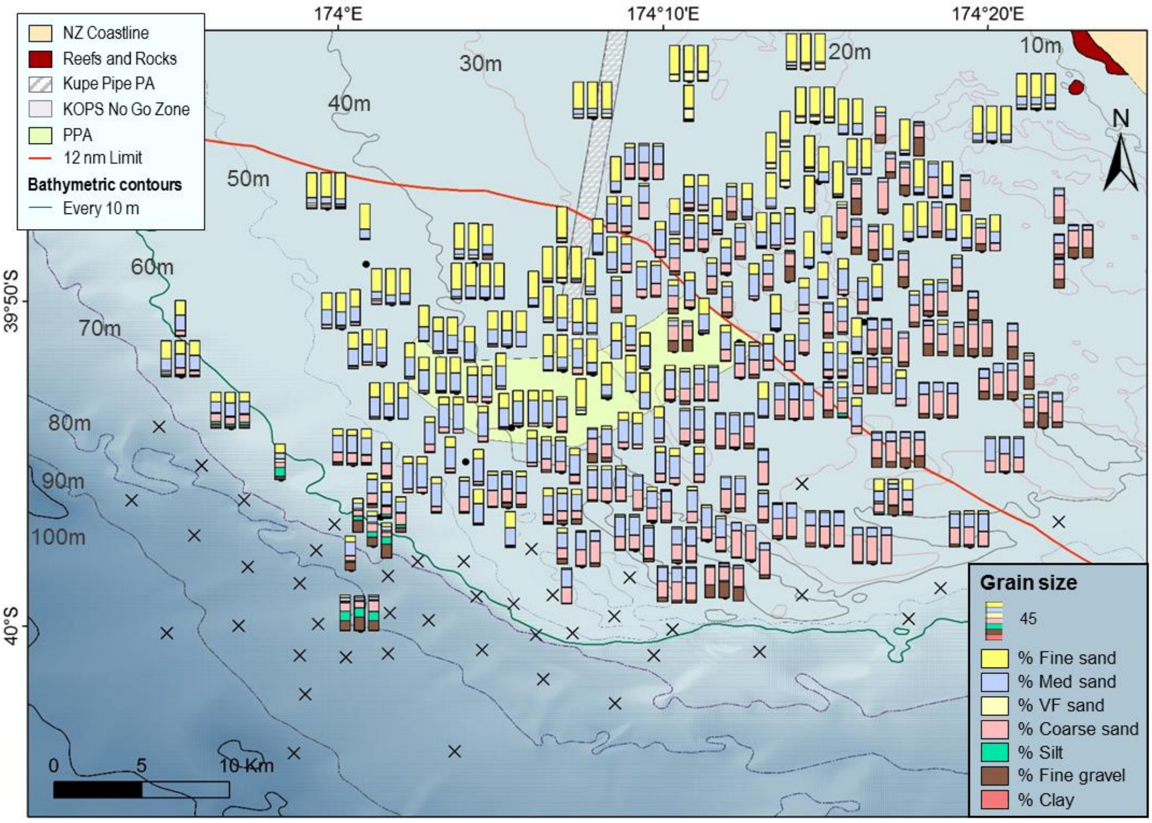

Figure 37: Sediment grain size distribution (%sand, gravel, etc.) per core (0-5 cm surface sediments). Med=medium; FV=very fine. X indicates sites where no core sediment sample was collected.

The percentage of iron within the surface sediments of each core was also determined. This was done using three small subsamples from a sample taken from the surface of each core in order to estimate the variance in the measurement of iron concentration for each sediment core. Figure 39 gives an example of the estimated iron concentration with the variance, which was generally small except when iron concentration estimates were very high. The mean concentration of iron per site (n = 3 cores) is plotted in Figure 40. Note the large range of concentrations observed but the dominance of low concentrations in surface sediments, which is where the majority of benthic fauna occur. An example of the variation of the mean for these iron concentration (% by weight) estimates per site is given in Figure 40. Note that each core was treated as an individual sample when correlating biota with iron content and sediment grain size.

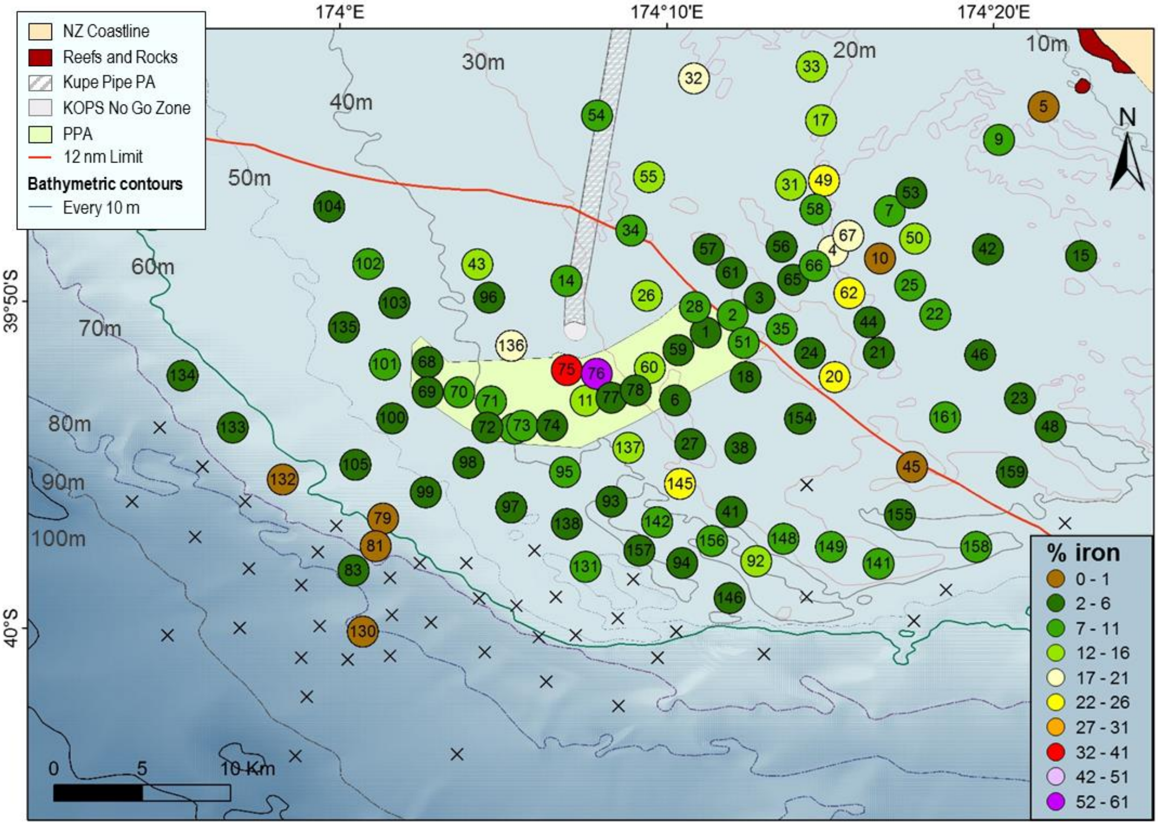

Figure 38: Mean percentage of iron (by weight) per site for surface core sediments (3 cores per site). Note the large range but the dominance of low concentrations of iron in surface sediments. Numbers in the centre of the circles= site numbers. X indicates sites where no core sediment sample was collected.

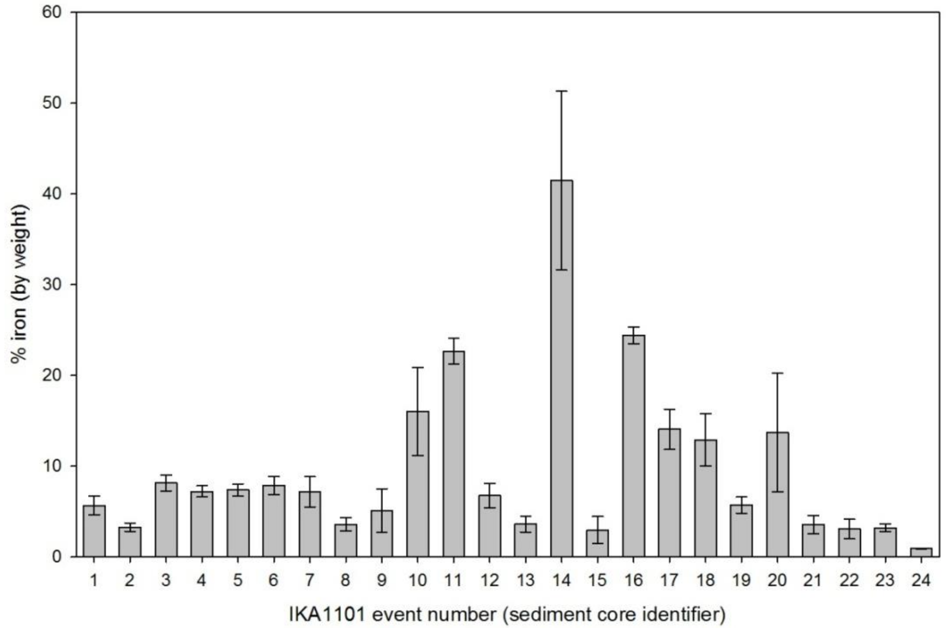

Figure 39: Examples of the variance in % iron ore measurement per core sample from cores taken from the Ikatere. With the exception of the cores with very high iron content, the measurement variation was generally very small.

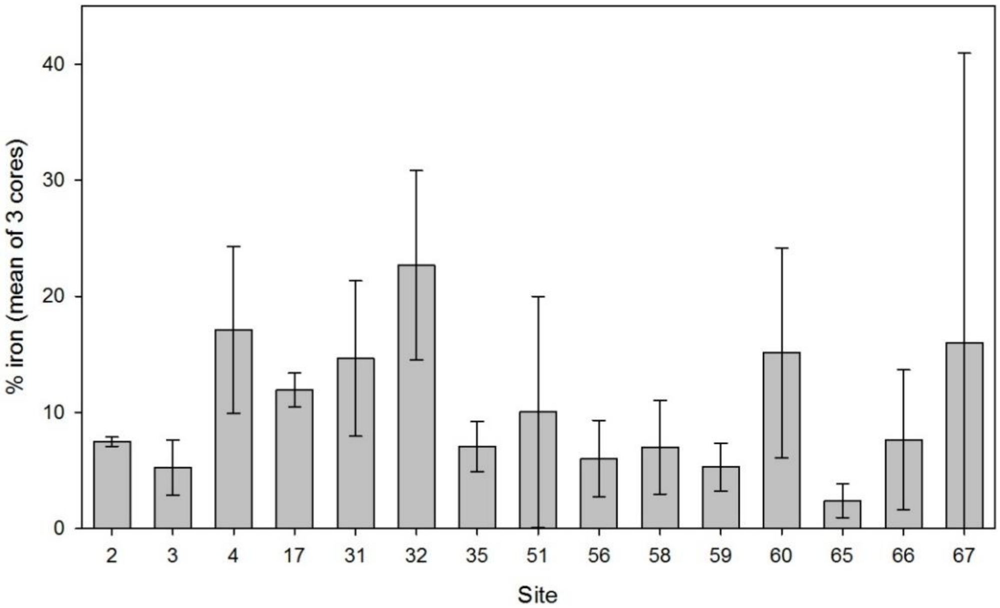

Figure 40: Mean % iron (by weight) per sample site of sediment collected in sand cores at a selection of sites. The sediment was highly variable at some sites (e.g. site 67). Observations on video footage suggest that this was due to sand waves unevenly distributing fine sand, iron and coarser sand and shell fragments.

3.3.2 Infaunal assemblage structure

The 331 core samples collected from 103 sites within the study area were sampled from a broad range of habitat types across the shelf. Only a limited number of cores were successfully collected from either rocky outcrop sites on the inner shelf or the hard ground/biogenic habitats offshore - due to the inability of the cores to penetrate the seabed. However some cores were successfully collected from both these habitat types and provide valuable, albeit limited, information on the infaunal assemblages in these habitats/zones. Overall, a total of 9,707 specimens from 430 species/groups were collected in the top or 'surface' sediments (0-5 cm fraction) of the cores (mean 29.3 ± 1.9 specimens per core), while significantly fewer specimens were collected from either the 5-10 cm vertical fraction (1,032 specimens from 89 species/groups) or the deepest 10-15 cm vertical fraction (169 specimens from 51) (see Figure 41 and Figure 42). The surface sediments (0-5 cm) accounted for 89% of all infauna collected. Within these surface sediments, polychaete worms were the most numerous and speciose taxon (4,644 specimens, 88 species/OTU's), numerically dominated by the small tubeworm *Euchone* sp A (31% of infaunal worms and 15% of the entire infaunal collection) (Figure 41c). Non-decapod crustacean were the next most numerous with 2,266 specimens, then molluscs (923), bryozoa (872 colonies), foraminifera (817), decapods (51), echinoderms (32), fish (15), cnidaria (14), brachiopods (5) and sponges (4).

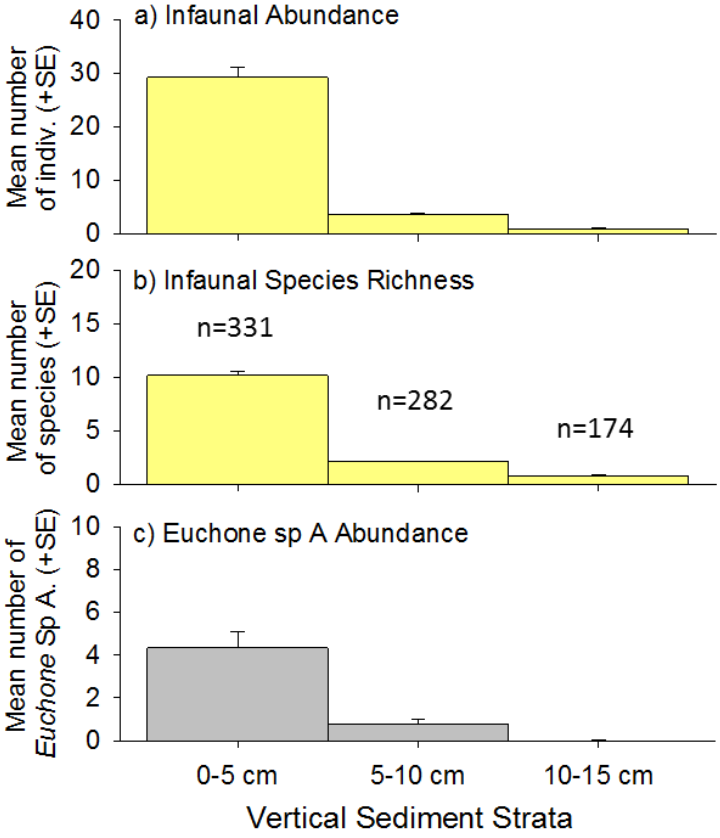

Figure 41: Number of infaunal specimens and species collected in sediment cores delineated by vertical depth (0-5 cm, 5-10 cm and 10-15 cm sediment strata). a) Infaunal abundance, b) Species richness, and c) Abundance of *Euchone* sp A - the Sabellid tubeworm. N = the number of cores collected per vertical sediment strata.

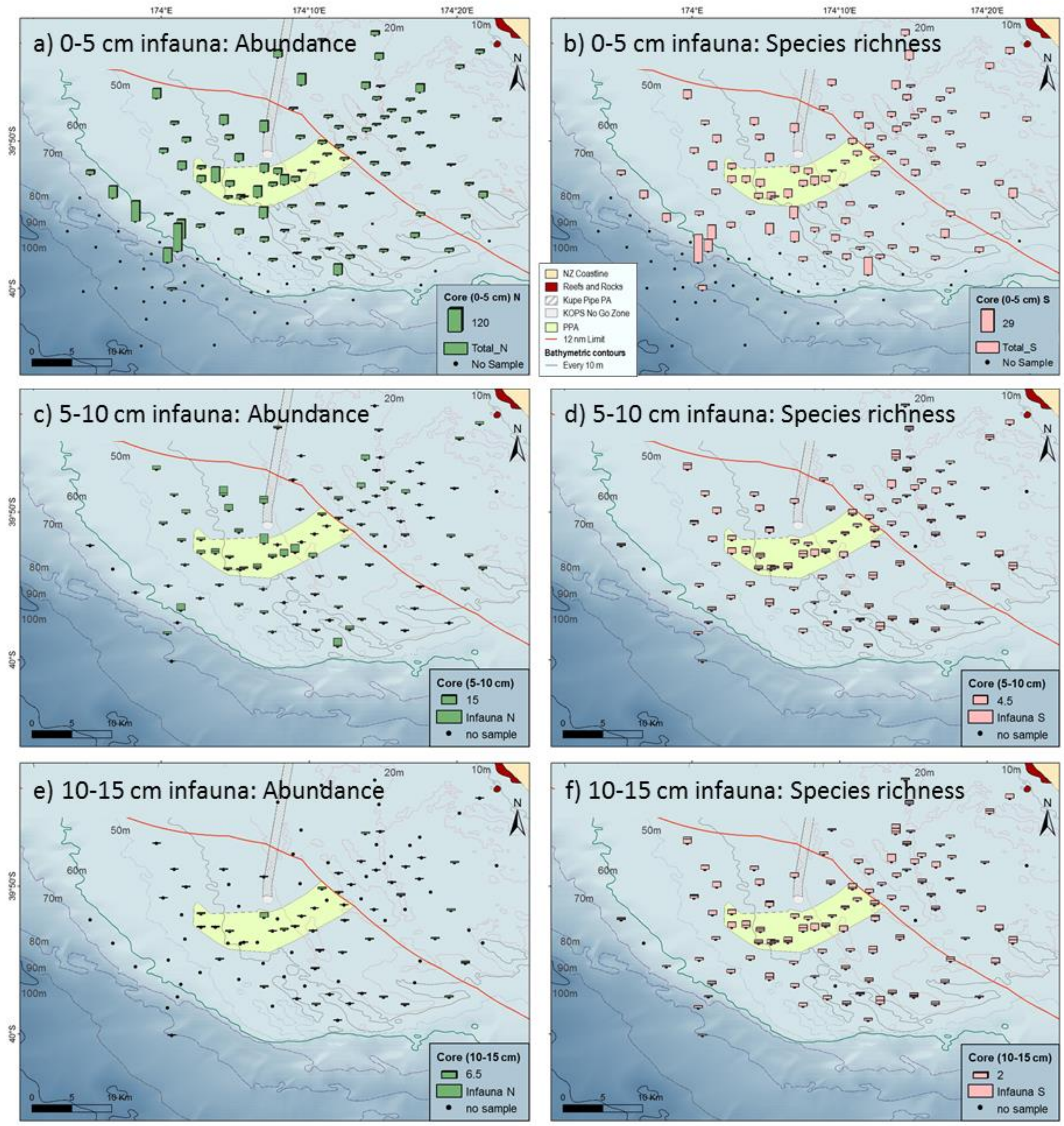

Figure 42: Spatial distribution of mean macro-infaunal abundance and species richness per site for the three vertical section of sediment (p/664 cm^2). a-b) 0-5 cm vertical section; c-d) 5-10 cm vertical section; and e-f) 10-15 cm vertical section. The green bars represent the total number of individuals (N) collected while the light brown bars represent the total number of species/OTU's (S). Relative scale bars are provided in the legend of each graph.

Infaunal assemblages differed between habitat types (Figure 42a-b, Figure 43 and Figure 44). Although few cores successfully penetrated the hard ground within the biogenic habitats, offshore sites that could be sampled had the highest infaunal abundance and species richness of all habitat types and zones (Figure 42a-b, Figure 43 and Figure 44). Wormfields were associated with the fine and medium grained sediments within the central (PPA) and northern mid-shelf zones (Figure 45) and supported abundant infauna, but this was driven by high, albeit locally patchy, densities of the Sabellid tubeworm, *Euchone* sp A (mean 1,137.52 ± 180.95 SE, 2 SE range 775.62-1,499.42 per m^2) (Figure 43, Figure 44 and Figure 42a; also see Chapter 3.3.3.1). Although densities of *Euchone* sp A were variable between replicates and sites within the wormfields, there was no significant difference in total infaunal abundance or species richness between the central (PPA) and northern mid-shelf zones (Figure 44). Southern mid-shelf sites were characterised by coarse grained sands and gravels (Figure 45) and although supported similar species richness, this zone supported significantly lower infaunal abundances (Figure 44). Shallow PPA sites (water depths < 30 m) were characterised by coarse sands and had an infaunal assemblage more similar to the southern mid-shelf with few or no *Euchone* sp A (e.g. Figure 42a,b and Figure 46). Other inner and mid-shelf habitats supported low abundance and diversity of macro-infauna (Figure 42a,b and Figure 43).

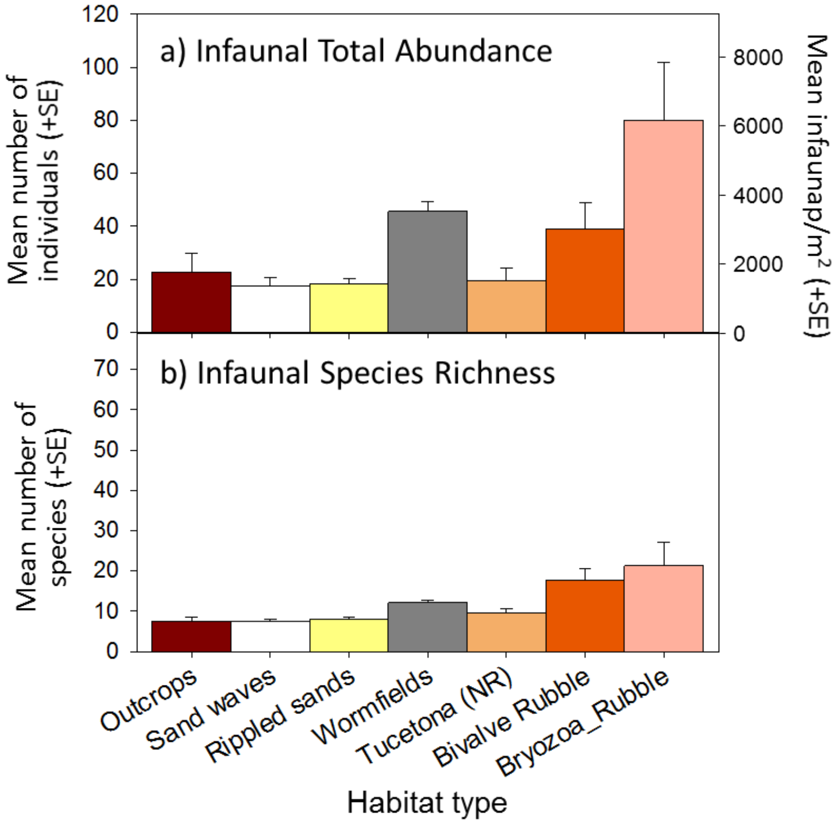

Figure 43: Infaunal abundance and species richness, for the 0-5 cm vertical section (p/664 cm^2), plotted by habitat type. Refer to Figure 7 (above) for the spatial distribution of habitat types.

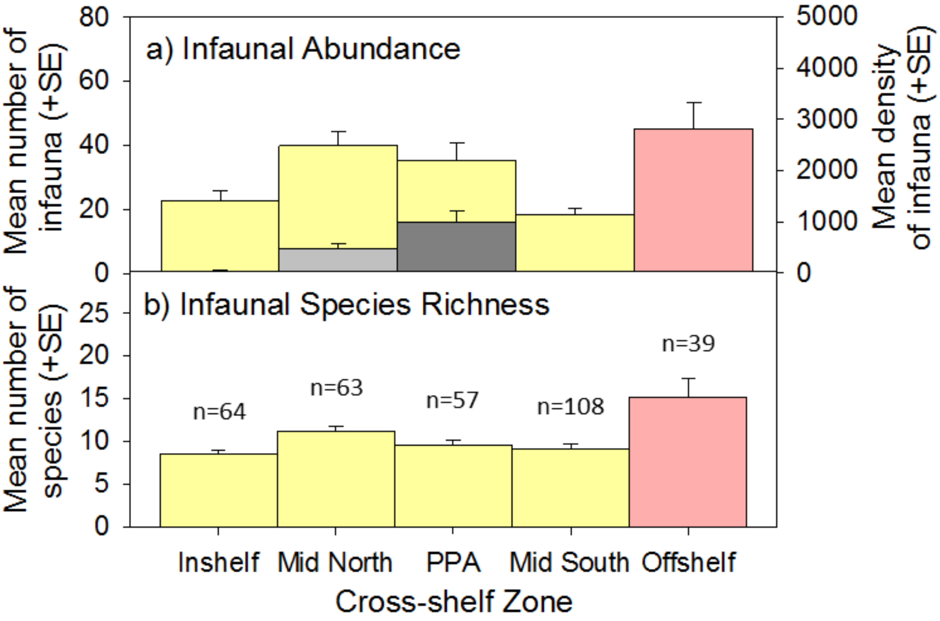

Figure 44: Infaunal abundance and species richness for the 0-5 cm vertical section (p/664 cm^2) relative to cross-shelf zones. Mid-shelf zones have been divided into PPA, mid-north (sites north of the PPA) and mid-south (sites south of the PPA) to provide spatial comparisons. n= the number of cores sampled per zone. Light and dark grey bars on figure (a) depict the relative abundance, and overall contribution, of the tubeworm *Euchone* sp A.

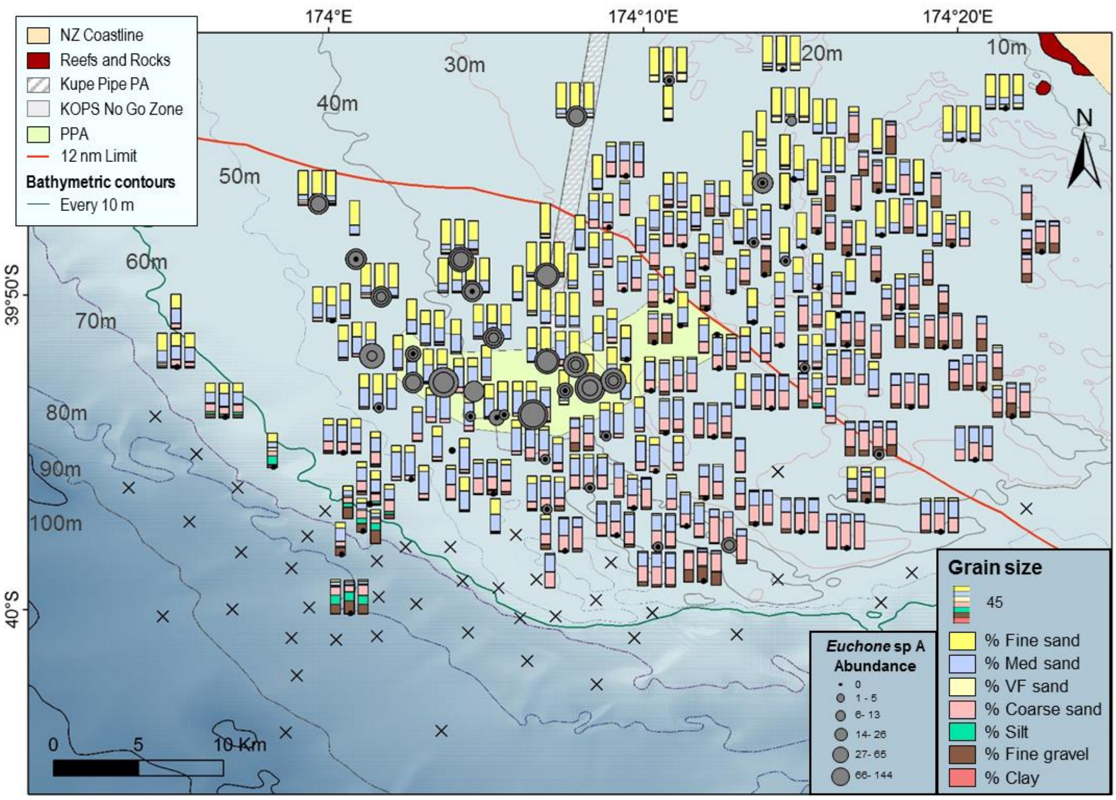

Figure 45: Sediment grain size distribution (%sand, gravel, etc.) and *Euchone* sp A abundance per core (0-5 cm surface sediments). Med=medium; FV=very fine. X indicates sites where no core sediment sample was collected.

3.3.3 Infaunal distributions - Macrofaunal in the 0-5 cm core fraction

All distribution plots here describe the mean value of three cores (0 – 5 cm depth fraction) at each site. The most numerous taxonomic group within the core data were the worms (dominated by annelids) with 4644 specimens. Non-decapod crustacean were also abundant with 2266 specimens, then molluscs (923), bryozoa (872 colonies), foraminiferans (817), decapods (51), echinoderms (32), fish (15), cnidarians (14), brachiopods (5), sponges (4) and an ascidian (1).

3.3.3.1 Annelida and worm-like phyla

A total of 6 worm phyla were collected in the surface sediments of the cores (0-5 cm fraction) (Appendix F2). The most abundant phyla were the annelid worms (93% of all worms), with a total of 4,644 worms from 88 species/groups collected (Appendix F2). Worms from other phyla included ribbon worms (Phylum: Nemertea, 188 specimens), roundworms (Phylum: Nematoda, 133 specimens), peanut worms (Phylum: Sipuncula, 10 specimens), horse-shoe worms (Phylum: Phoronida, 5 specimens of a single species: *Phoronis psammophila*) and a flatworm (Phylum: Platyhelminthes, 1 specimen) (Appendix F2). Most of these worms are poorly known in New Zealand and therefore were not identified to species, with the exception of the phoronid *P. psammophila*. Of the annelid worms, polychaetes were the most abundant (97% of annelid worms, 90% of all worms), with a total of 4,190 polychaete worms from 87 species/groups were collected from the surface sediments. Other annelid worms included oligochaete worms (125 undetermined specimens from 57 cores) and a single sea leech (Class: Huridinea, Site 130 in the offshore bryozoan rubble, 83 m water depth) collected.

A total of 4,190 polychaete worms from 87 species/groups were collected from the surface sediments. Polychaete abundance was highest inside and to the north of the PPA, including sites along the Kupe pipeline (Figure 46a). In contrast, the rippled sediments in the southern mid-shelf zone supported much lower abundances of worms (Figure 46a). Species richness, however, was more evenly distributed across the region (Figure 46b). The most abundant infaunal species collected (34% of all polychaetes and 15% of all infauna) was an undescribed *Euchone*-like sabellid tubeworm, here called *Euchone* sp A (Figure 47). *Euchone* sp A is a small suspension-feeding worm that lives in the surface sediments within vertical tubes (often 4 x longer than the worm itself) that it constructs by cementing sand grain together (Figure 47; G. Read, *pers. comm.*). This species occurred across much of the central and northern mid-shelf zone (1,438 worms from 80 cores/36 sites) within sediments composed of fine to medium grained sands (Figure 45), although, it is unclear whether this relationship is a response to environmental drivers (e.g. worms select or are restricted to finer-sediments) or a consequence of the worms presence (i.e. the accumulation of tubeworms trap finer grained sediments). Although this is a previously undescribed species, specimens of *Euchone* sp A have previously been recorded (then termed *Euchone* sp.) from the Patea Shoal region, where they were collected from the end of the then 'proposed' Kupe pipeline (Page et al., 1993; G. Read, *pers. comm.*). In Page et al. (1993) study, *Euchone* sp. was the most abundant infaunal species sampled using an anchor dredge (range: 233.4 - 908.5 per 0.01 m^3), although densities varied significantly among sites within the three locations. These locations occur within the Patea Shoals study region immediately north of the PPA, and are comparable with densities found within the surface sediments of the PPA wormfields (mean 374.19 ± 80.36 SE per 0.01 m^3) and across the broader wormfield zones (mean 227.96 ± 36.26 SE per 0.01 m^3).

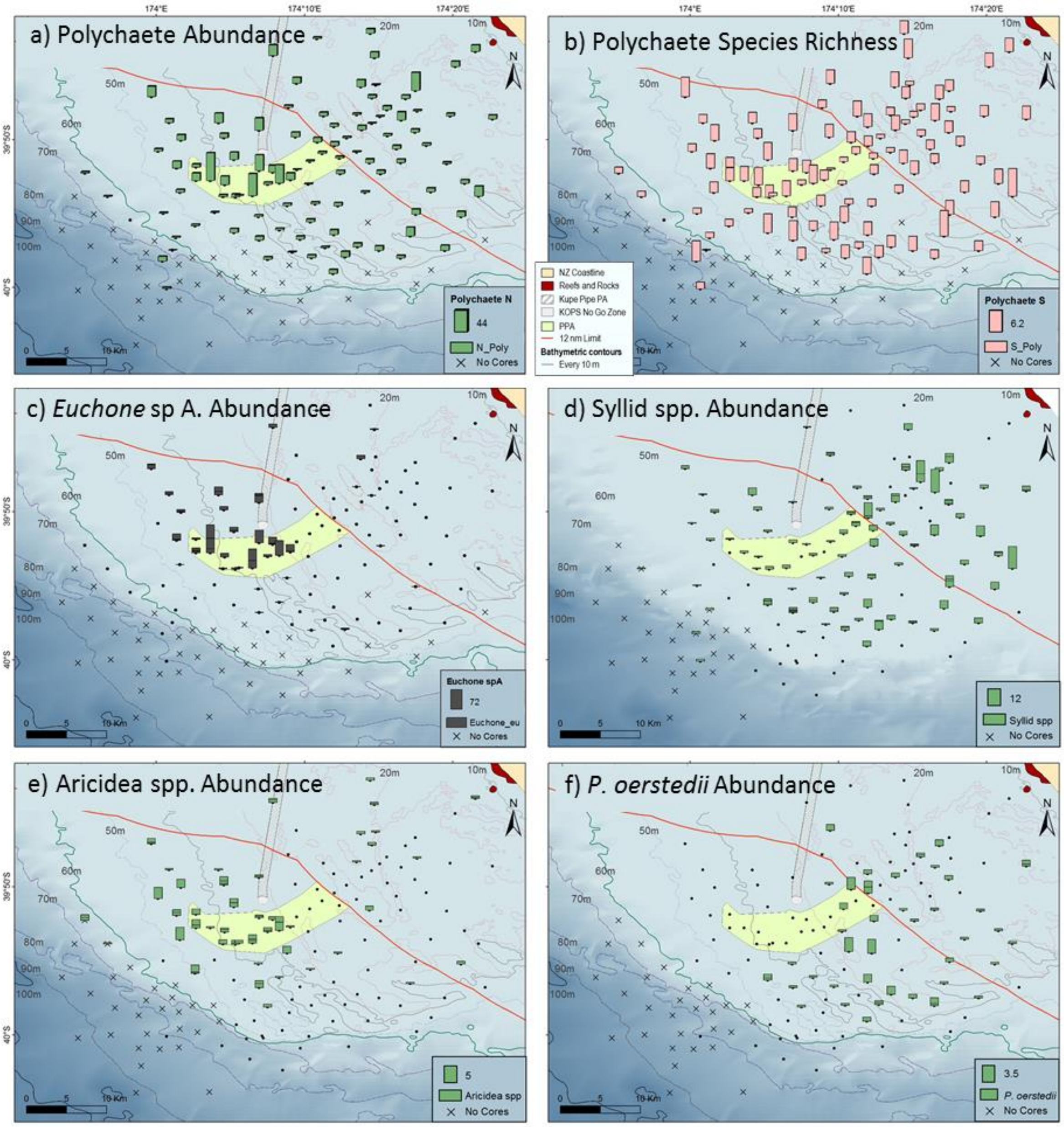

Figure 46: Spatial distribution of polychaete worms per site for the top vertical section of sediment (0-5 cm, p/664 cm^2). a) The green bars represent the mean number of individuals (N) collected; b) The light brown bars represent the mean number of species/OTU's (S) collected. c-f) Mean numbers p/site of: c) *Euchone* sp A; d) Syllid spp; e) Aricidae spp; and f) *Pisione oerstedii*, per site. Relative scale bars are provided in the legend of each graph.

Other notable worm species collected included *Ophelia* sp *A* (Opheliidae) and *Hesiospina aurantiaca* (Hesonidae), which were both new genera records for New Zealand, while *Lacydonia* sp A (Lacydoniidae) was a new family record for New Zealand. Also a newly discovered syllid-like taxon, abundant in the samples, is here labelled a "para-syllid" as its exact placement is currently unknown. *Pisione oerstedii* was also relatively abundant/common within the samples but has only been previously known from a couple of records. This is the only *Pisione* recorded in New Zealand waters. *Polygordius* sp A recorded here, belongs to Polygordiidae, a family common in the Antarctic with only a handful of previous New Zealand records. There were several species believed undescribed, including *Euchone* sp A (Figure 47 and Figure 46c) and a second less common *Euchone*-like sabellid species: *Euchone* sp. B.

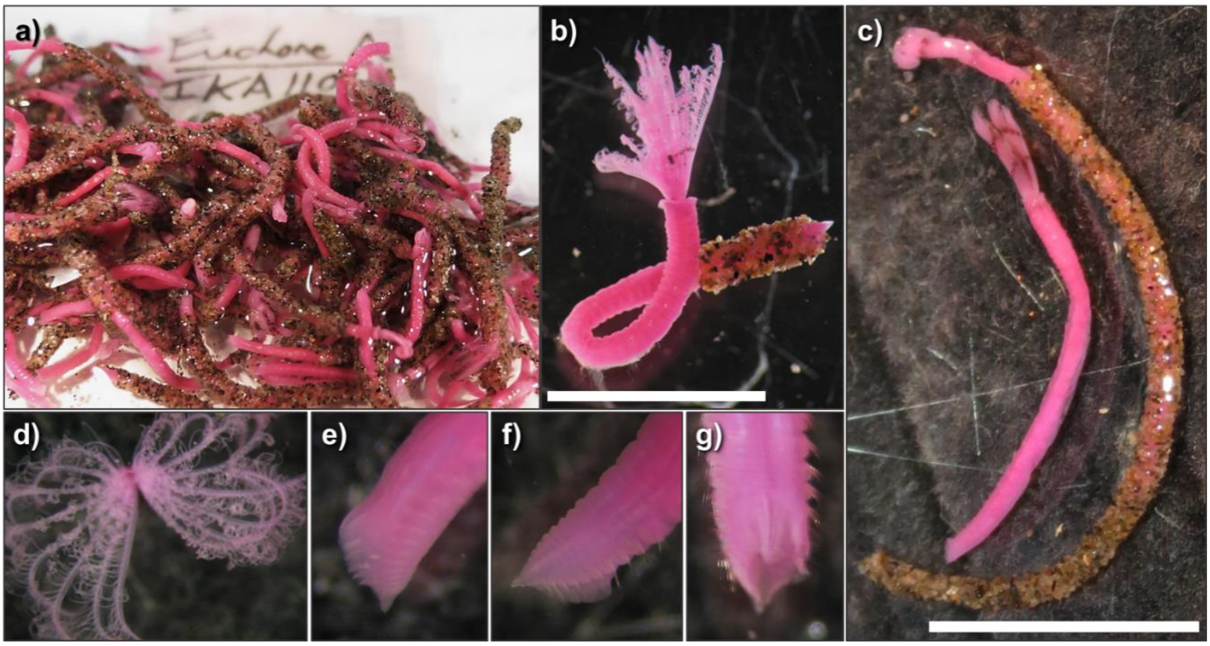

Figure 47: *Euchone* sp A specimens collected in a sediment core (Station 20) within the wormfields in the STB. a) Collection of *Euchone* sp A within cemented sand grain tubes (many only partially intact due to collection); b) whole specimen (with only some sand grains still attached around posterior region), scale bar is 5 mm; c) two whole specimens: One fully encased in its sand-grained tube with only its fan-like feeding appendages (termed 'crown') exposed (specimen dimensions: body length 30.26 mm, crown length 6.48 mm & body width 1.05 mm), the other removed from its sand grain tube, clearly showing 2 sets of distinctive pigment bands on the radioles, scale bar is 10 mm; d) crown showing 8 pairs of radioles and the finer paired pinnules branching off each radiole – which filter out food from the passing water; e-g) posterior end showing the wings around the anal depression: e-lateral, f-dorsal and g-ventral view. Specimens were stained with Rose Bengal solution. Photos by Tara Anderson and Kareen Schnabel, NIWA.

3.3.3.2 Non-decapod crustacea

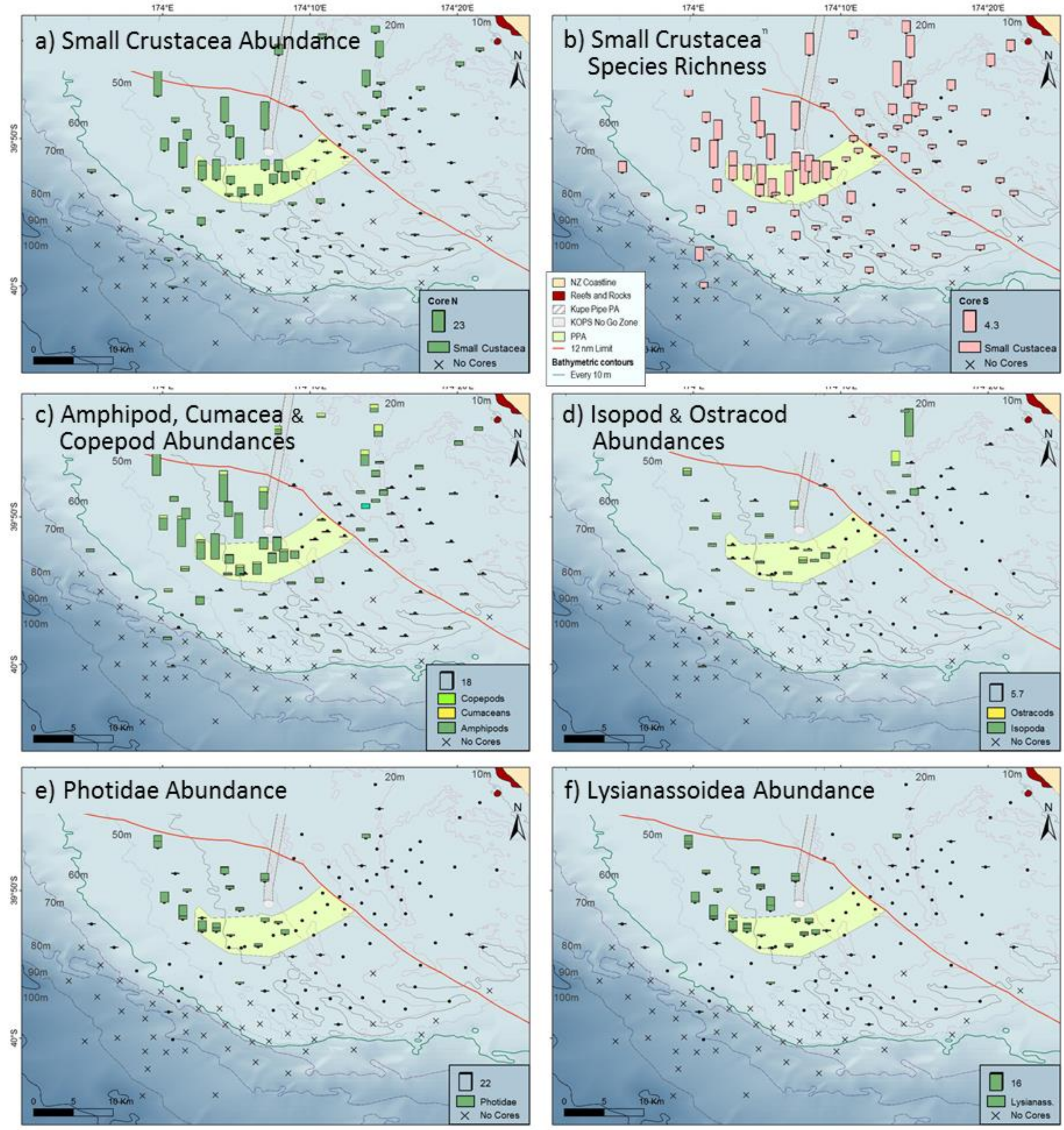

Figure 48: Spatial distribution of non-decapod crustacea per site for the top vertical section of sediment (0-5 cm, p/664 cm^2). a) The green bars represent the mean number of individuals (N) collected; b) The light brown bars represent the mean number of species/OTU's (S) collected. c-f) Mean numbers per site of: c) amphipods, cumaceans, and copepods; d) isopods and ostracods; e) the amphipod group, Photidae, and f) the amphipod group, Lysianassoidea, per site. Relative scale bars are provided in the legend of each graph.

Non-decapod crustacea were a dominant and relatively diverse component of the organisms collected in the cores. A total of 2266 small (non-decapod) crustacea from 60 taxonomic groupings were collected in the surface sediments of the cores (0-5 cm fraction) (Appendix L2). These specimens were small and difficult to identify without dissection of the specimens (e.g. mouthparts of each individual) and so were often identified only to family. Non-decapod crustacean were numerically dominated by amphipods (1,688 specimens from 31 species/groups [75% of all small crustacea]), with much fewer cumaceans (322 specimens from 5 species/groups), isopods (157 specimens from 14 species/groups), copepods (30 specimens from 4 species/groups), ostracods (49 specimens from 2 species/groups) and only rare occurrences of tanaids (12 specimens), leptostracans (5 specimens), pycnogonids (2 specimens) and euphausids (26 larvae).

Abundance and species richness of non-decapod crustacea were highest in northern sites on the inner shelf and across the mid-shelf within the wormfields (Figure 48a,b). These patterns were driven by high numbers of amphipods, particularly Photidae (24% of all non-decapod crustacean) and Lysianassoidea (12% of all non-decapod crustacean) species within the worms fields, particularly the wormfields north of the PPA (Figure 48c,e,f), and isopod (particularly Arcturidae sp2 and *Pseudaega quarta*) and ostracod occurrences at northern inner shelf sites (Figure 48d).

3.3.3.3 Molluscs

A total of 923 mollusc specimens were collected from the surface sediments of the cores (0-5 cm fraction) (Appendix E2). Molluscs collected in the cores were numerically dominated by bivalves (864 specimens from 36 species), with low numbers of gastropods (51 specimens from 18 species) and only a few chitons (8 specimens from 4 species) (Appendix E2). The mean abundance of molluscs in sediment cores was generally low, with the exception of large numbers of small, juvenile, *Scalpomactra scalpellum* collected from site 55 just slightly to the east of the Kupe oil pipeline (Figure 49a). In contrast, mean species richness was more evenly distribution across the region (Figure 49b). The most abundant bivalves were *S. scalpellum* (355 specimens from 54 cores/34 sites – although 57% of all specimens were collected from replicate cores at Site 55), *G. modesta* (143 specimens from 58 cores) and *Myadora* spp. (115 specimens from 61 cores), while *T. laticostata* although abundant in the video and still imagery were rarely captured in these small cores (34 specimens from 15 cores) (Figure 49c-e). The most numerous gastropod collected was *Tanea zelandica* (11 specimens from 11 cores), while most other gastropods were collected in low numbers across the inner to mid-shelf zones (Figure 49f).

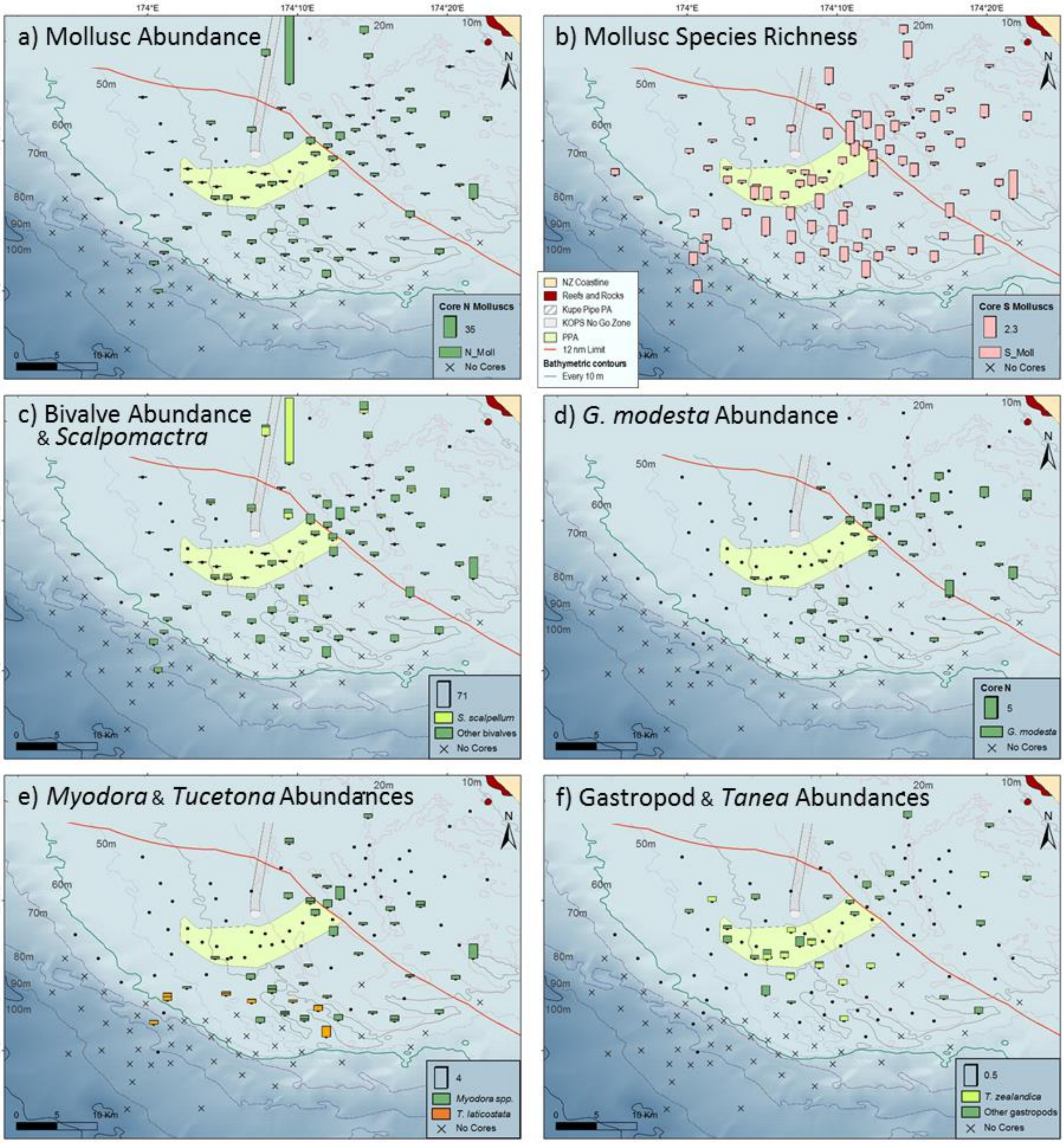

Figure 49: Spatial distribution of molluscs per site for the top vertical section of sediment (0-5 cm, p/664 cm^2). a) The green bars represent the mean number of individuals (N) collected; b) The light brown bars represent the mean number of species/OTU's (S) collected; c-f) Mean numbers p/site of c) bivalve *S. scalpellum*, d) bivalve *G. modesta*, e) bivalves, *Myodora* spp. and *T. laticostata*, and f) the gastropod, *Tanea zealandica,* relative to other gastropods. Relative scale bars are provided in the legend of each graph.

3.3.3.4 Bryozoa

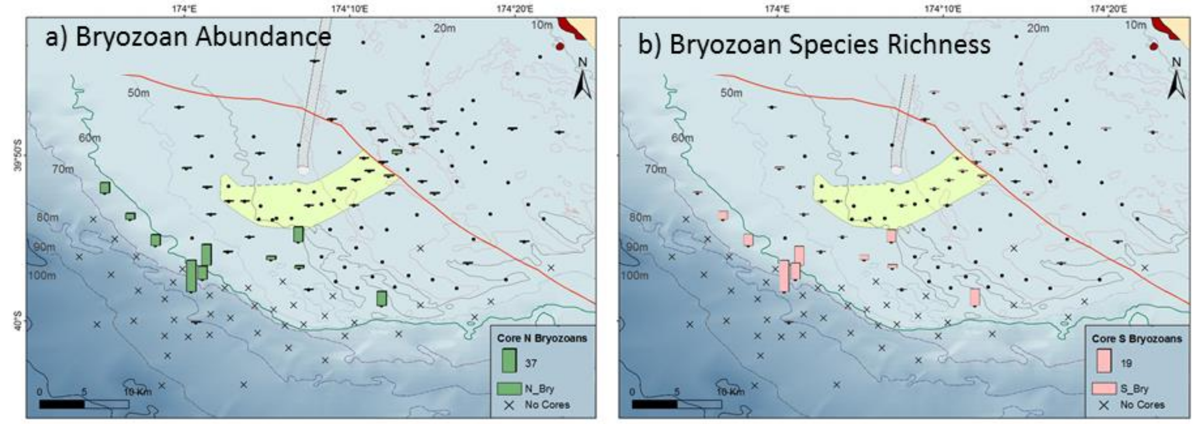

Figure 50: Spatial distribution of bryozoans per site for the top vertical section of sediment (0-5 cm, p/664 cm^2). a) The green bars represent the mean number of individuals (N) collected; b) The light brown bars represent the mean number of species/OTU's (S) collected. Relative scale bars are provided in the legend of each graph.

Most sessile epibenthos are only rarely collected in sediment cores - as would be expected given each core only sampled 0.047 m^2 of the surface sediment. However, a total of 872 live bryozoan colonies from 111 species were collected from the surface sediments of the cores (0-5 cm sediment core fraction) (Figure 50; Appendix D2). The highest abundance of bryozoa was collected offshore (14.6 ± 3.6 specimens p/core), again highlighting the dominance of bryozoa in the offshore zone where it forms the primary biogenic structure. Bryozoan species richness was also highest offshore (Figure 50b), reflecting the collection of many small colonies growing on small pieces of shell debris. In contrast, few specimens and species were collected from across the mid to inner shelf (<1.6 ± 0.97 specimens p/core) (Figure 50a). The most common bryozoan species collected in the cores, were three *Otionellina* species (Family: Otionellidae): *Otionellina affinis* (104 specimens from 25 cores – found mostly offshore), *Otionellina proberti* (59 specimens from 31 cores on the inner-mid-shelf) and *Otionellina symmetrica* (44 specimens from 24 cores on the inner and mid-shelf). These are relatively small free-living bryozoa that form domed/disc shaped colonies (diam. sizes of ≤ 6.8 mm, ≤ 5.9 mm and ≤ 3.3 mm, respectively) (Appendix D2).

Two new taxonomic records were recorded for the STB. A single colony of *Buffonellaria christinelloides* (Gordon, 1984, Family: Celleporidae) was collected from site 79 in the bivalve rubble habitats in 59 m water depth. Previously, this species had only been recorded from Macauley Island on the Kermadec Ridge, collected back in 1984 (Dennis Gordon, NIWA, *pers comms*.). In addition, a single dead colony of *Buffonellodes globosa* was also collected in the core samples. This species has previously only been described from the Three Kings area. These are the first records of *B. christinelloides* or *B. globosa* both for the STB and for the New Zealand mainland coast.

3.3.3.5 Foraminifera

A total of 817 foraminiferans (*Miniacina miniacea*) were collected from 24 cores (13 sites) (Appendix O2). This conspicuous bright pink foraminiferan was found in highest numbers offshore in the biogenic habitats, and in lower numbers on the southern mid-shelf (depth range 38-67 m) (Figure 51a,b). As only a few cores were taken in the biogenic habitats it is unclear if this species extends across the entire bivalve and bryozoan rubble habitats. *M. miniacea* were counted as accurately as possible, though it was difficult to differentiate between live and dead individuals (Dennis Gordon, NIWA, *pers. comm.)* therefore the abundance given should be taken as a guide only.

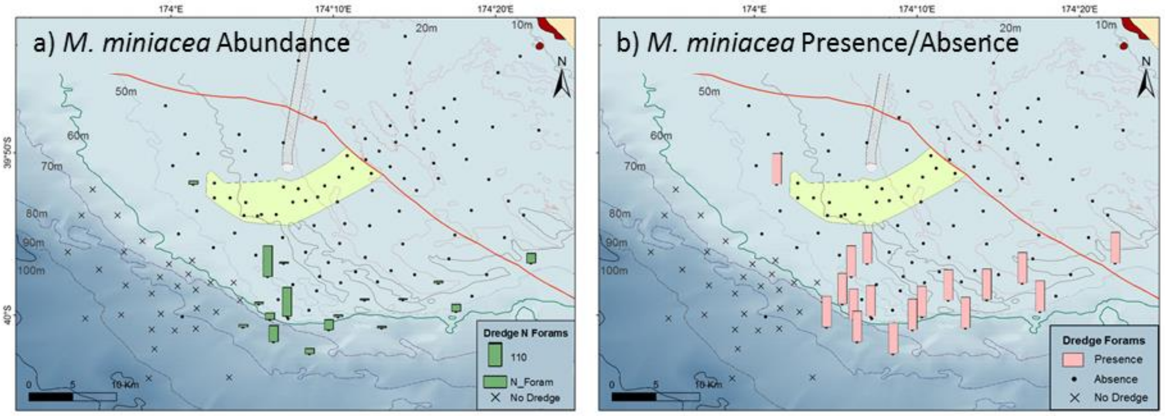

Figure 51: Spatial distribution of the foraminifera, *M. miniacea,* per site for the top vertical section of sediment (0-5 cm, p/664 cm^2). The green bars represent the mean number of individuals (N) collected. Scale bar is provided in the legend.

3.3.3.6 Decapod crustacea

A total of 51 decapod crabs from 8 species were collected in the core surface sediments (Appendix G2). Of these 63% were hermit crabs from 2 species/group (*Areopaguristes setosus* and *Lophopagurus* spp), and 4 true crabs (*Bellidilia cheesmani*), a ghost/mud shrimp (Axiidae sp), a juvenile mantis shrimps (*Heterosquilla laevis*) and an unknown juvenile shrimp. The highest mean abundance of decapods, driven by the two hermit crab species (*Lophopagurus* spp. and to a lesser extent *A. setosus*), was recorded across northern and central/PPA mid-shelf areas (Figure 52 and Appendix G2).

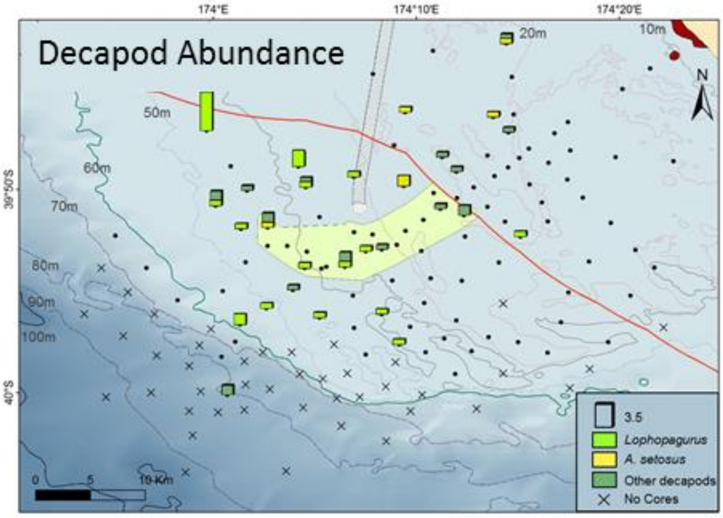

Figure 52: Spatial distribution of decapods per site for the top vertical section of sediment (0-5 cm, p/664 cm^2). Bars represent the mean number of individual hermit crabs (*Lophopagurus* spp and *A. setosus*) and other decapods (mixed species) collected. Scale bar and references colours are provided in the legend of the graph.

3.3.3.7 Echinodermata

Very few echinoderms were collected in the core surface sediments (32 specimens from 15 species) (Appendix J2), likely due to the low number of cores collected from the offshore biogenic zone, and the relatively small size of these cores (13 cm diam.). Of the echinoderms collected in the cores, most were ophiuroids (23 specimens, 13 species/groups), with a few heart urchins (8 specimens of *Echinocardium cordatum*, 7 inner shelf sites) and a single holothurian (*Chiridota nigra* specimen at Site 105). Echinoderm abundance was higher on the northern section of the inner shelf zone, driven by heart urchins (echinoids), and offshore in depths > 45 m driven by ophiuroids (Figure 53a,b).

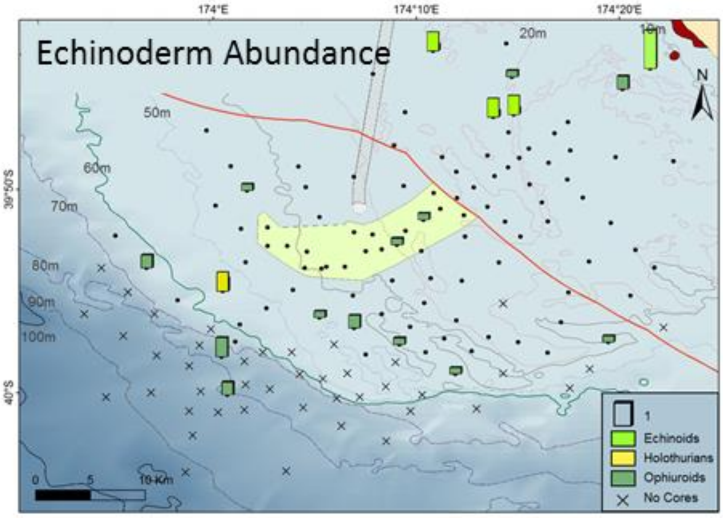

Figure 53: Spatial distribution of echinoderms per site for the top vertical section of sediment (0-5 cm, p/664 cm^2). Bars represent the mean number of individual echinoids (*Echinocardium cordatum*), holothurians (*Chiridota nigra*, n=1) and ophiuroids (mixed species) collected. Scale bar and references colours are provided in the legend of the graph.

3.3.3.8 Fish and Lancelet species

Fish were not well sampled in core samples, as would be expected, with only three fish captured: 2 tommy fish (*Limnichthys rendahli*) and one opalfish (*H. monopterygius*) (Appendix K2). However, 12 lancelets or puhi, *Epigonichthys hectori* (only species found in New Zealand), were collected from 9 inner shelf sites (Figure 54 and Appendix K2). Lancelets are small (≤ 2 cm TL) transparent fish-like marine chordates that live partially buried in sandy burrows in well irrigated sediments in ~ 30-50 m water depths. They are filter-feeders that use whiskery growths around their mouths to trap food.

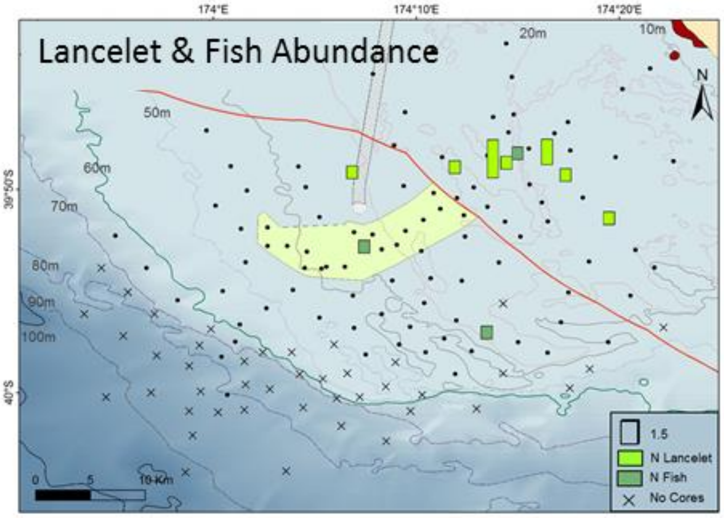

Figure 54: Spatial distribution of lancelet/fish per site for the top vertical section of sediment (0-5 cm, p/664 cm^2). Bright green bars represent the mean number of individual lancelet collected, while dark green bars represent the mean number of individual fish collected. Scale bar is provided in the legend of the graph.

3.3.3.9 Other epifauna (not well sampled by cores).

Although sessile epifauna were common at many sites, particularly offshore, most sessile epifauna were only rarely collected in the cores - as would be expected given each core only sampled 0.047 m^2 of the surface sediment. Of the few sessile epifauna collected in the cores, these included cnidaria (14 specimens, 4 species/taxa), brachiopods (5 specimens, 2 species), sponges (4 specimens, 4 families) and algae (29 occurrences of coralline algae) (Figure 55a-d, respectively). Cnidarian specimens were collected from the inner and mid-shelf regions (Figure 55a) and included 13 anemones (2 burrowing anemone, *Edwardsia* sp. [Sites 17 and 154] and 11 small unknown gelatinous anemones) and a single hydroid (*Zygophylax sibogae* [Site 159]) (Appendix N2). Brachiopods were only collected from 3 sites: Four specimens of *Calloria inconspicua* were collected from 2 sites (Sites 46 and 146), while 1 specimen of *Neothyris lenticularis* was collected from a single mid-shelf/PPA site (Site 70) (Figure 55b and Appendix O2). Similarly, while sponges and ascidians were characteristic features of offshore habitats in both the video footage and the dredge samples (Figure 12d and Figure 27a,b), only four small sponge fragments and a single solitary ascidian were collected in cores (Figure 55c and Appendix H2). Twenty nine occurrences of red algae were collected from a range of inner and mid-shelf sites (Figure 55d and Appendix M2), but these were all non-geniculate coralline algae found encrusting small shells and stones.

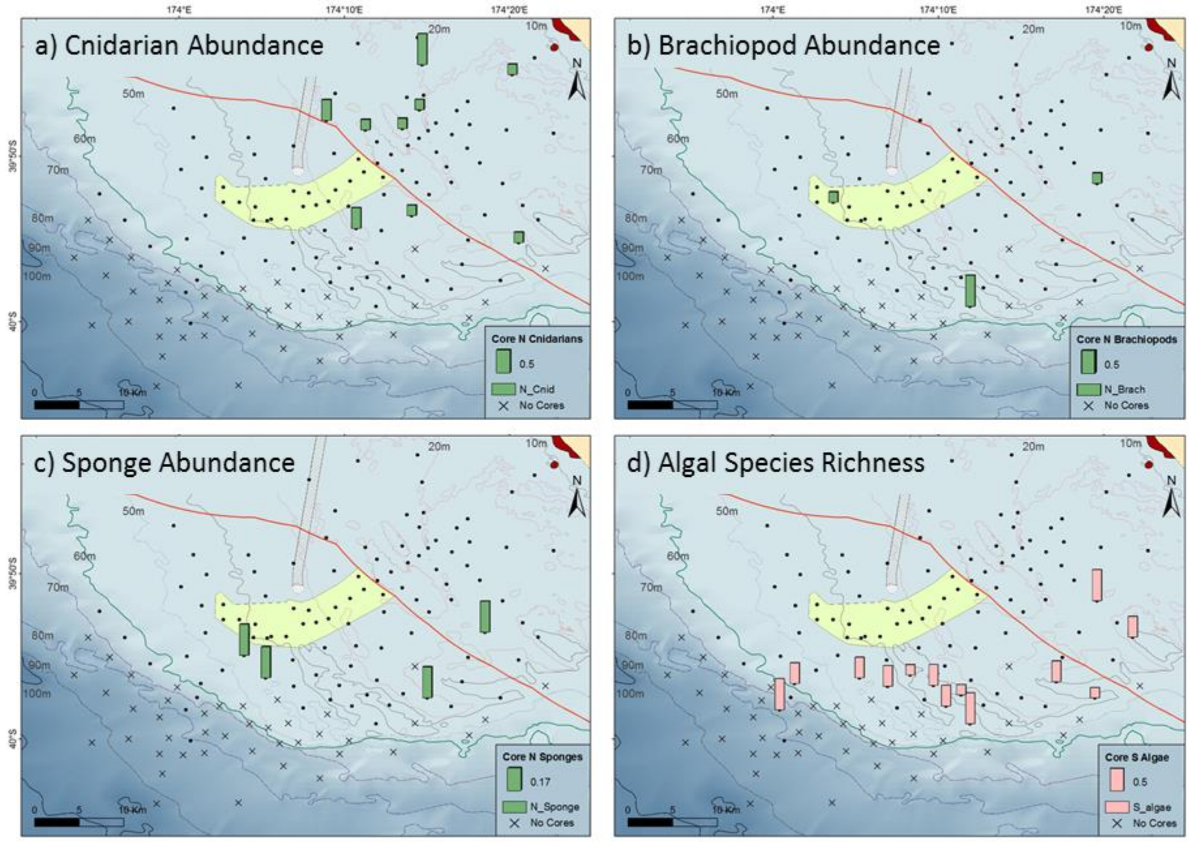

Figure 55: Spatial distribution of epifaunal taxa (not well sampled by cores) per site for the top vertical section of sediment (0-5 cm, p/664 cm^2). The green bars represent the mean number of individuals (N) collected. The light brown bars represent the mean number of species/OTU's (S) collected. Taxa labels and scale bar are provided in the legend of each graph.

3.3.4 Multivariate analysis of macro faunal data: 0-5 cm core fraction[6]

As with the Coastcam2and dredge data, multivariate analyses were used to determine whether the community structure in sediment cores (0 – 5 cm) were unique within the PPA, compared to adjacent mid and inner shelf, or deeper offshore areas. An nMDS plot (Figure 56) of Bray Curtis similarities of log transformed data shows that there was no apparent spatial separation between the PPA and adjacent shelf areas, and the deeper offshore areas (ANOSIM, p > 0.05, Global R = -0.027).

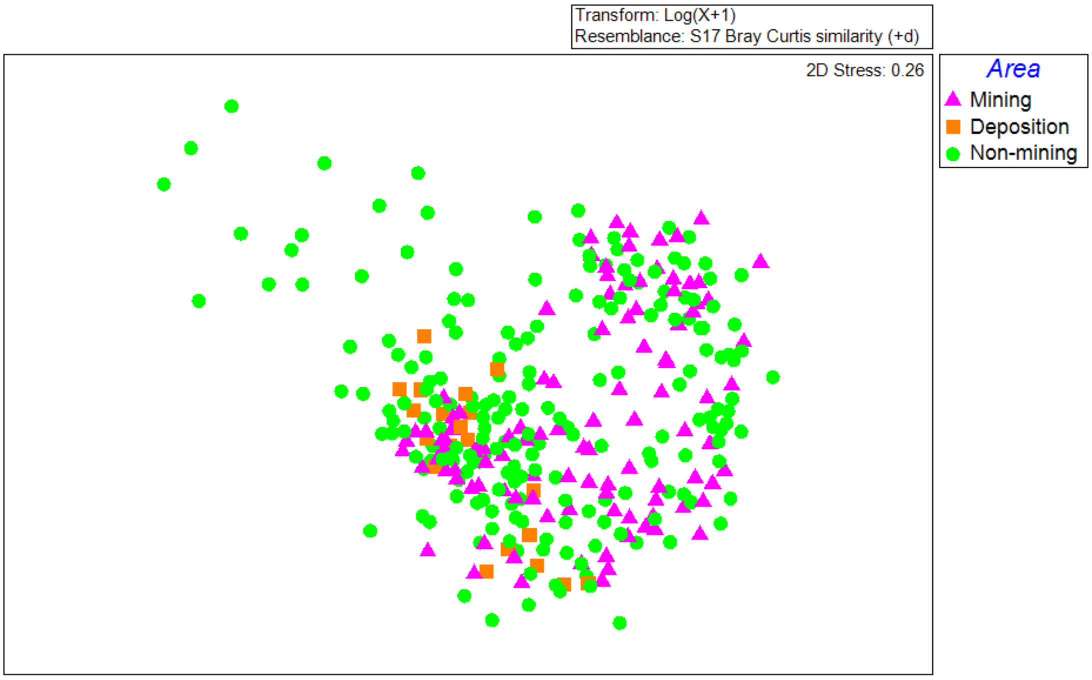

Figure 56: nMDS plot of core data (0-5 cm fraction). Sites are colour coded by area

A SIMPER analysis identified the characteristic taxa within each area (> 5 % contribution) and as well as those taxa contributing greater than 5 % to the differences between areas. These were the polychaetes *Euchone* sp A, ("para-syllid") nd, (syllids) nd, (dorvilleids) *dorvilleid* sp A, Aricidea nd and *P. oerstedii*; the nemertea (micro-nemertean) nd; and the bivalve *Myadora* spp. The mean abundances of these taxa within each area (PPA, adjacent-shelf, and offshore areas) are shown below. There was no consistent trend in abundance between PPA, adjacent-shelf, and offshore areas. *Euchone* sp A was the only species within the key taxa to have a much higher mean abundance in the PPA than in the adjacent-shelf, and offshore areas (Figure 57).

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[6] Please see Appendix A for the findings of the revised 2014 multivariate analyses.

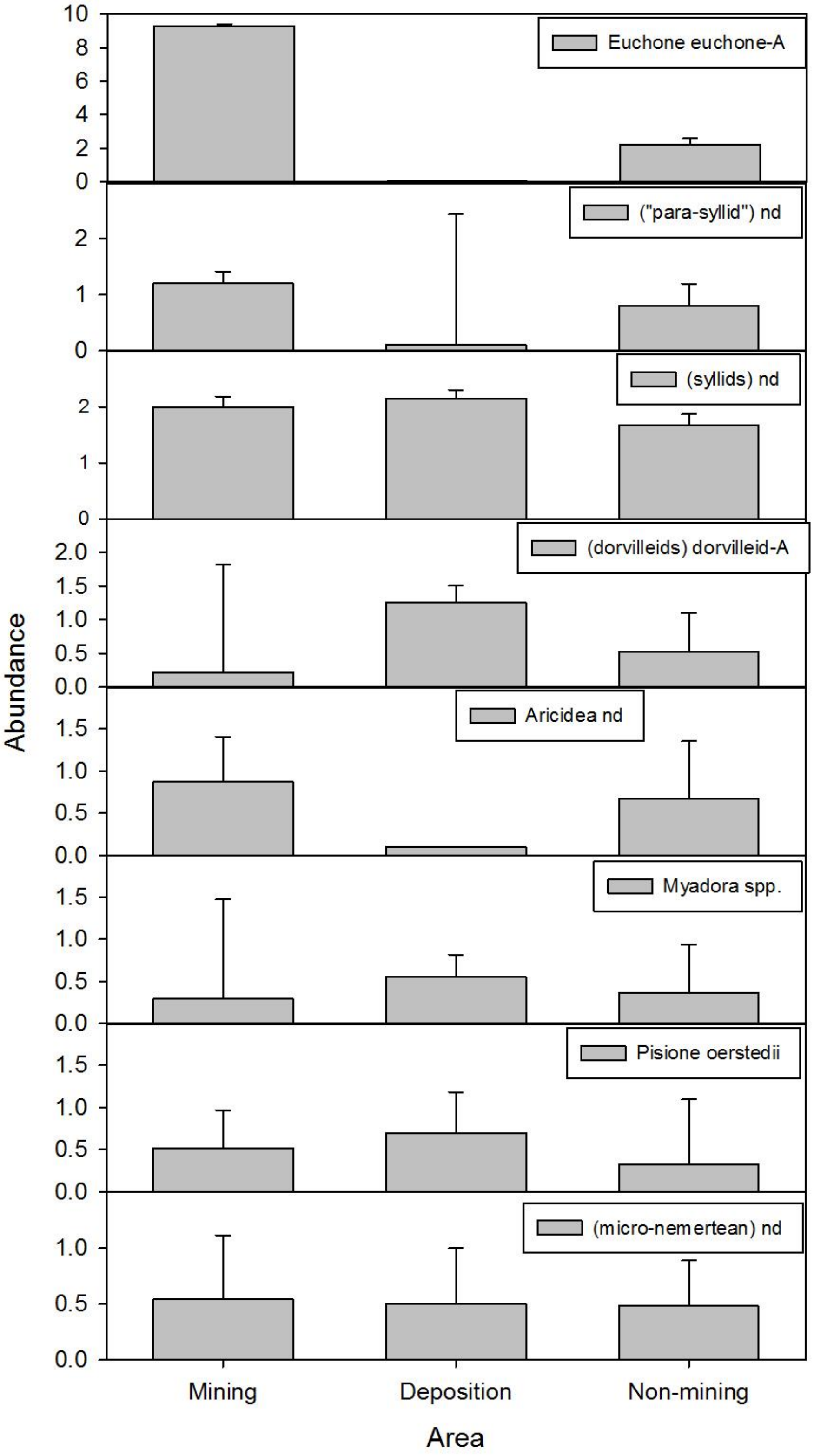

Figure 57: Key taxa: core data. Mean plus standard deviation. All taxa within the sediment core data with a greater than 5% contribution to community structure within each area and with differences between areas.

A DISTLM routine (all-selected, R^2) was carried out to determine the key drivers in the community structure of the sediment core data. Marginal tests showed that the predictor variables should be sequentially tested in the following order: Coarse sand, fine sand, fine gravel, very find sand, depth, distance from shore, month, silt, clay, medium sand, iron, medium-coarse gravel, and time.

Sequential tests (Table 11) explained 25.6 % of total variation. The percentage of coarse sand in the sediment cores was the variable that explained the most variation (10.1 %). Coarse sand, fine sand, fine gravel, very fine sand, depth, distance from shore, month, silt, clay and medium sand all significantly increased the explained variation ($p < 0.05$). Time appeared to be significant but as it followed large, non-significant p-values, this significance should not be trusted (Anderson et al. 2008). Note that neither the concentration of iron (% by weight) nor the percentage of medium-coarse gravel in the sediments were key drivers of community structure, explaining just 0.3 and 0.2 % of variation respectively ($p = 0.2$ and 0.552 respectively). A graphical representation of these results is given in Figure 58.

From these analyses it was possible to identify relationships between taxonomic groups and predictor variables. Table 12 gives the relationship between the dbRDA coordinate axes and the orthonormal X variables (predictor/environmental variables). For example, the variable with the strongest positive relationship with axis 1 was fine sand. Coarse sand had a strong negative relationship with axis 1. Interpretation of these data, together with the relationship between taxonomic groups and the dbRDA axes, allows the identification between predictor variables and taxonomic groups (Table 13).

Table 11: DISTLM results: sequential tests. Those predictor variables significantly contributing to the explained variation are highlighted in yellow ($p < 0.05$). The column "prop." gives the proportion of variation explained for each variable.

SEQUENTIAL TESTS

Variable	R^2	SS (trace)	Pseudo-F	P	Prop.	Cumul.	res.df
COARSE SAND	0.1013	104950.0	36.508	0.001	0.1013	0.1013	324
FINE SAND	0.1202	19625.0	6.952	0.001	0.0189	0.1202	323
FINE GRAVEL	0.1332	13425.0	4.812	0.001	0.0130	0.1332	322
VERY FINE SAND	0.1435	10712.0	3.874	0.001	0.0103	0.1435	321
DEPTH	0.1819	39802.0	15.022	0.001	0.0384	0.1819	320
DISTANCE FM SHORE	0.2007	19517.0	7.516	0.001	0.0188	0.2007	319
MONTH	0.2151	14878.0	5.816	0.001	0.0144	0.2151	318
SILT	0.2325	17998.0	7.172	0.001	0.0174	0.2325	317
CLAY	0.2419	9828.4	3.953	0.001	0.0095	0.2419	316
MEDIUM SAND	0.2459	4140.2	1.669	0.022	0.0040	0.2459	315
IRON	0.2489	3078.8	1.242	0.200	0.0030	0.2489	314
MEDIUM-COARSE GRAVEL	0.2511	2320.3	0.936	0.552	0.0022	0.2511	313
TIME	0.2565	5498.8	2.226	0.001	0.0053	0.2565	312

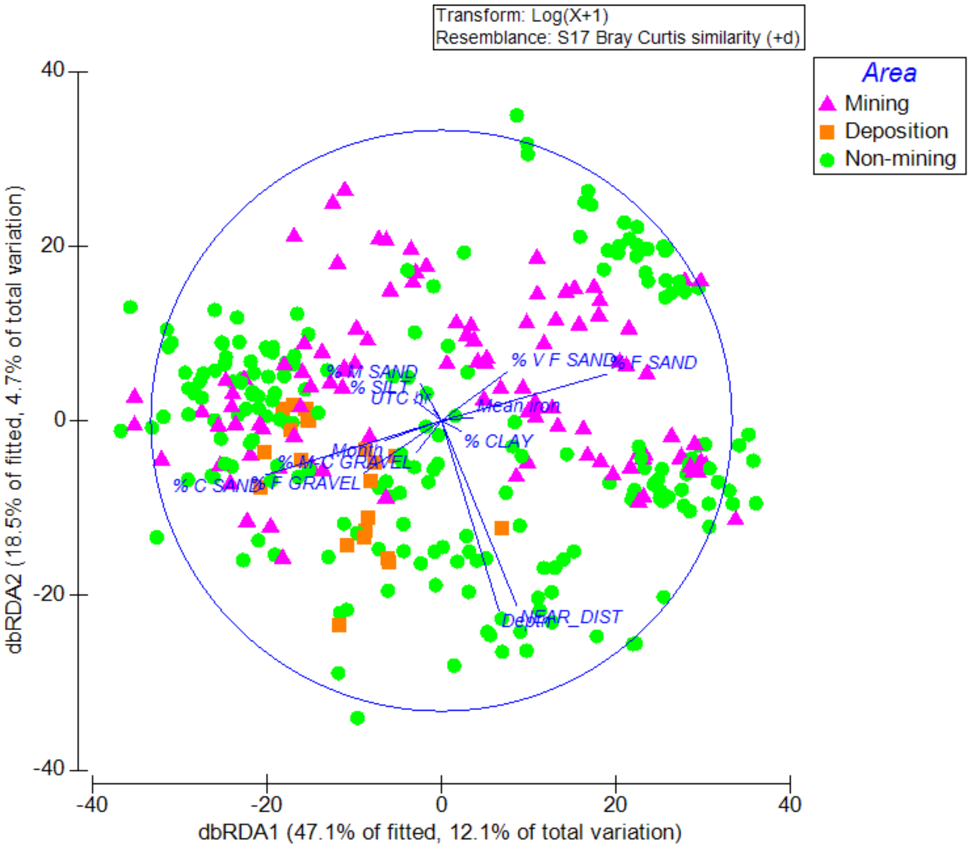

Figure 58: **dbRDA plot of the sediment core data.** This is a two-dimensional visual representation of the DISTLM results. The two axes explain 16.8 % of total variation (compared with 25.6 % explained by the DISTLM). The vector plot can be interpreted as the effect of a given predictor variable (the longer the vector the bigger the effect).

Table 12: **Relationships between dbRDA coordinate axes and orthonormal X variables (multiple partial correlations).** The strongest positive and negative relationships for both axes 1 and 2 are highlighted in yellow.

	Axis number (and percentage variation explained)							
	1 (47.13)	2 (18.49)	3 (8.57)	4 (7.56)	5 (5.24)	6 (3.86)	7 (2.75)	8 (1.85)
COARSE SAND	-0.608	-0.188	-0.133	0.089	0.107	0.222	0.115	-0.39
FINE SAND	0.569	0.16	-0.064	0.068	0.386	-0.197	-0.055	-0.061
FINE GRAVEL	-0.267	-0.18	0.157	0.427	0.103	-0.149	0.004	0.32
VERY FINE SAND	0.227	0.169	0.243	0.288	-0.081	0.176	0.672	-0.357
DEPTH	0.198	-0.655	0.078	0.232	-0.248	-0.502	0.002	-0.155
DISTANCE	0.26	-0.639	0.083	-0.362	0.122	0.513	0.178	0.144
MONTH	-0.195	-0.069	-0.094	-0.437	0.53	-0.454	0.289	-0.193
SILT	-0.097	0.074	0.885	-0.165	0.154	-0.077	-0.119	-0.108
CLAY	0.068	-0.037	0.091	-0.114	-0.208	0.099	-0.519	-0.576
MEDIUM SAND	-0.072	0.127	0.065	-0.528	-0.551	-0.212	0.209	0.217
IRON	0.111	0.011	-0.164	-0.149	0.186	0.121	-0.196	-0.11
MEDIUM-COARSE GRAVEL	-0.085	-0.108	0.057	0.01	0.152	-0.096	-0.204	0.182
TIME	-0.028	0.038	0.218	0.071	0.191	0.23	-0.1	0.311

Table 13: Relationship between taxa and the dbRDA axes. Using data from Table 12, these data have been interpreted to give the correlation between taxa and the predictor variables. Only those data with strong correlations (> 0.3) to either axis 1 or 2 have been included in the table.

	Axis 1, dbRDA1 (47.1% of fitted, 12.1% of total variation)	Correlation with predictor variables
Euchone sp A	0.533319	Positive correlation with fine sand Negative correlation with coarse sand
Aricidea nd	0.525545	
Photidae	0.511929	
Lysianassoidea	0.509013	
Cyclaspis sp.	0.476376	
Phoxocephalidae sp 1	0.470709	
Oedicerotidae	0.427402	
Spiophanes modestus	0.371214	
Prionospio tridentata	0.334062	
Pseudaega quarta	0.33046	
Dorvilleid sp A	-0.40194	Positive correlation with coarse sand Negative correlation with fine sand
(micro-nemertean) nd	-0.40842	
(syllids) nd	-0.41369	
Pisione oerstedii	-0.45247	
(oligochaetes) nd	-0.32991	

	Axis 2, dbRDA2 (18.5% of fitted, 4.7% of total variation)	Correlation with predictor variables
("para-syllid") nd	0.570552	Negative correlation with depth and distance from shore
Crepidacantha crinispina	-0.30636	Positive correlation with depth and distance from shore
non geniculate coralline	-0.32249	
Tucetona laticostata	-0.3301	
Miniacina miniacea	-0.33117	

A second DISTLM (backwards AIC) model eliminated both clay and iron from the model (Table 14). The model selected 11 important variables in determining community structure (in no particular order): medium-coarse gravel, fine gravel, coarse sand, medium and, fine sand, very fine sand, silt, month, time, depth, distance from shore. It is interesting to note that clay was deemed to be a significant factor in the sequential tests above (Table 11) but was eliminated in the backwards model. However, iron was not selected as being important in either model, which confirms that it is not an important variable in driving community structure of the sediment core data.

Table 14: DISTLM results (backwards AIC). Sequential tests show which variables were eliminated from the analysis and in which order.

SEQUENTIAL TESTS

Variable	AIC	SS(trace)	Pseudo-F	P	Prop.	Cumul.	res.df
CLAY	2559.3	2268.9	0.91863	0.572	0.0022	0.2543	313
IRON	2558.6	3018.9	1.2226	0.21	0.0029	0.2514	314

3.3.5 Distribution plots of macro faunal data: 5–10 cm core fraction

In total, 280 core samples from the 5 – 10 cm fraction, collected across 101 sites were examined in detail (Figure 59).

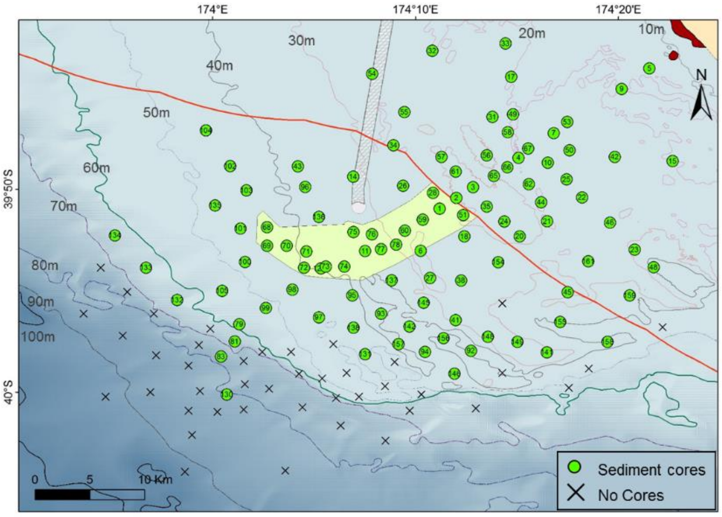

Figure 59: Location of study sites where at least one 5 - 10 cm core fraction was collected.

In total, 754 worms (of which 671 were polychaetes), 151 non-decapod crustacea, 92 bryozoa colonies, 53 foraminifera, 28 molluscs (of which 27 were bivalves), 10 cnidaria, 3 echinoderms, 1 sponge, 1 fish, 1 holothurian and 4 records of algae (one species, a coralline algae, at each of 4 sites) were recorded from the 5 – 10 cm core fractions. This is far fewer specimens than was collected in the top 5 cm fraction of cores.

Some of these phyla could be expected to burrow to greater than 5 cm depth, however, others, such as the sessile and suspension feeding sponges, bryozoans and forams and phototrophic algae would only be expected to be found of the surface of sediments. The distributions of annelids and non-decapod crustacean are shown below (Figure 60, Figure 61, Figure 62, and Figure 63). Distributions of all taxa found within the 5 – 10 cm fraction of cores are given in Appendix N.

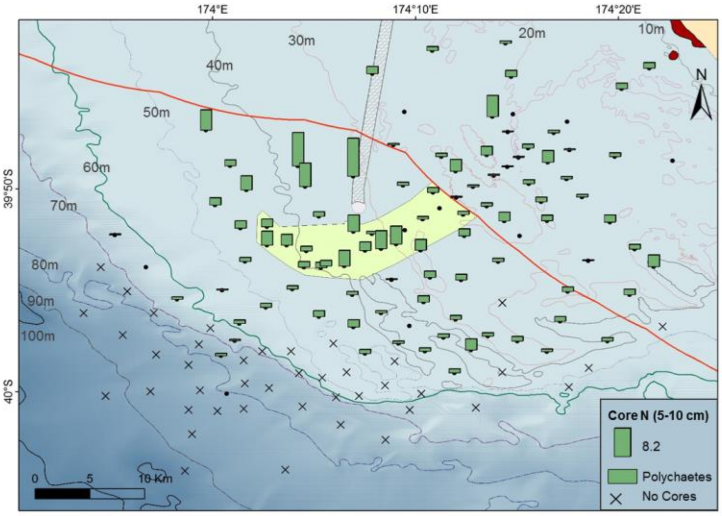

Figure 60: Distribution of the mean abundance (N) of annelids within the 5 - 10 cm core fraction (n varies between 1 and 3 cores per site). A scale bar is provided in the legend.

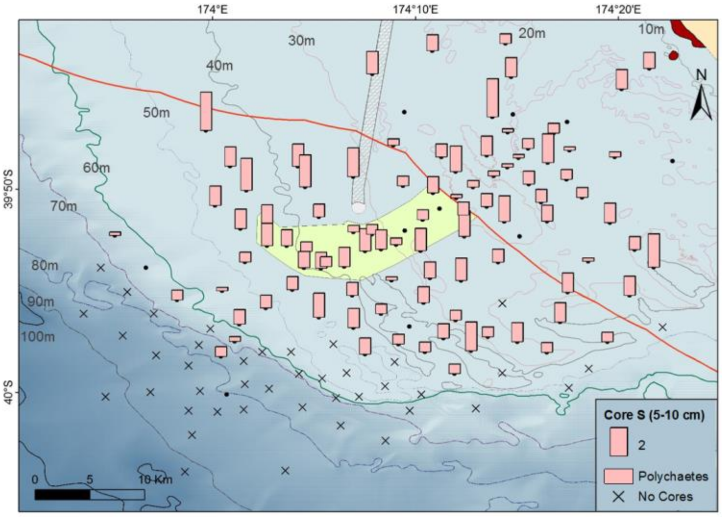

Figure 61: Distribution of mean species richness (S) of annelids within the 5 - 10 cm core fraction (n varies between 1 and 3 cores per site). A scale bar is provided in the legend.

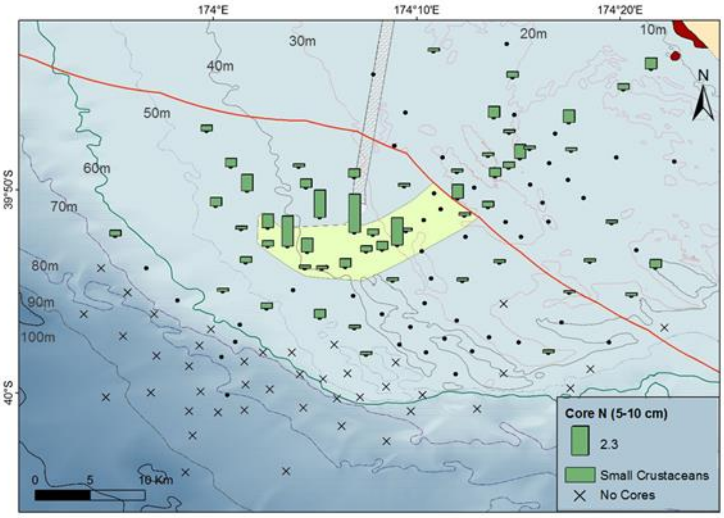

Figure 62: **Distribution of the mean abundance (N) of non-decapod crustacea within the 5 - 10 cm core fraction (n varies between 1 and 3 cores per site).** A scale bar is provided in the legend.

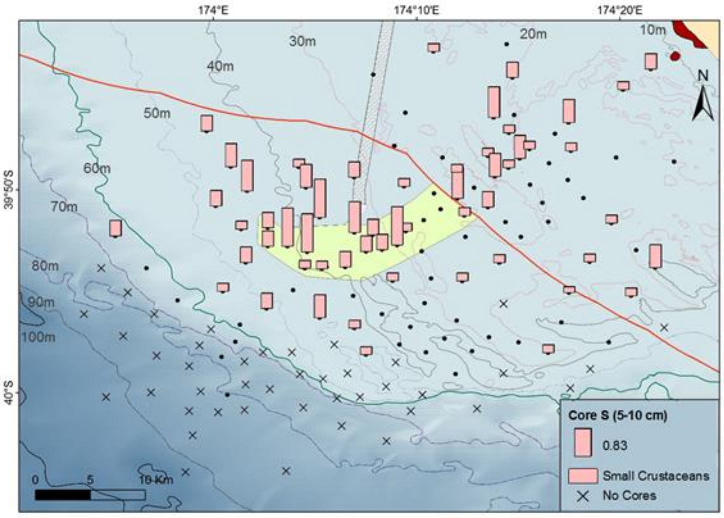

Figure 63: **Distribution of mean species/family richness (S) of non-decapod crustacea within the 5 - 10 cm core fraction (n varies between 1 and 3 cores per site).** A scale bar is provided in the legend.

3.3.6 Multivariate analysis of macro faunal data: 5 – 10 cm core fraction

The nMDS plot of Bray Curtis similarities of log transformed data (Figure 64) gives a two-dimensional representation of the relative similarities or dissimilarities of the community structure within the 5-10 cm core fractions. Data points were colour coded for area.

As with the 0-5 cm core fractions, ANOSIM tests showed no significant differences between areas ($p > 0.05$, Global R = -0.033).

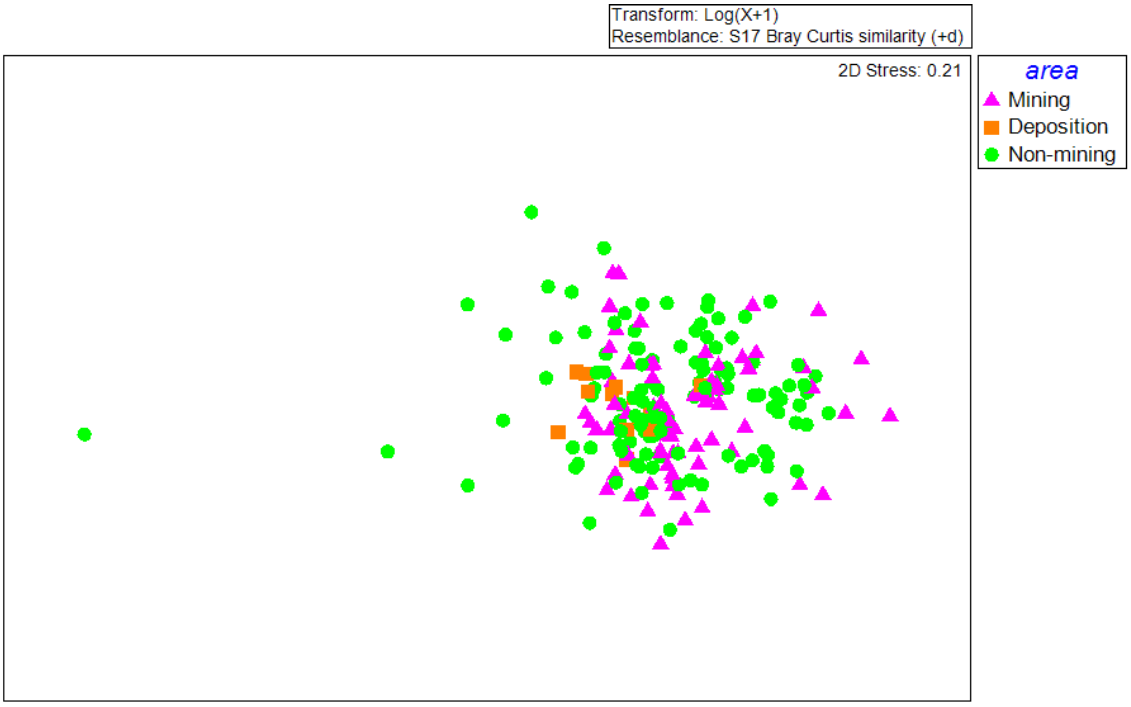

Figure 64: nMDS plot of core data (0-5 cm fraction). Sites are colour coded by area.

3.3.7 Macrofaunal data: 10–15 cm core fraction

Of the 331 cores sampled, 175 cores penetrated the sediments deep enough to attain the 10-15 cm fraction. Sediments at these depth contained very few specimens compared to sediment layers closer to the surface (Figure 41). Of the 169 specimens collected from these deep sediments (10-15 cm fraction), 98 were worms (incl. 84 polychaetes), 72 bryozoa colonies, 34 non-decapod crustacea, 26 molluscs (25 bivalves, 1 gastropod), 6 forams, 2 cnidaria (anemones) and 1 sponge colony were recorded. No further analyses have been carried out on these data.

3.3.8 Meiofauna

A sub-set of the sediment cores was analysed for meiofaunal abundance to determine if iron concentration affected the makeup of this specialised interstitial community. This subset of cores was chosen to give a wide range of iron concentrations in the sediments (by % weight), to have a small depth range (30 to 40 m), and to have similar sediments with respect to particle size analysis (Figure 65). Only the top 0-5 cm depth fraction of each sediment core was used to collect and enumerate meiofauna. The concentration of iron (% weight) in each of the 21 cores analysed for meiofauna is given in Figure 66.

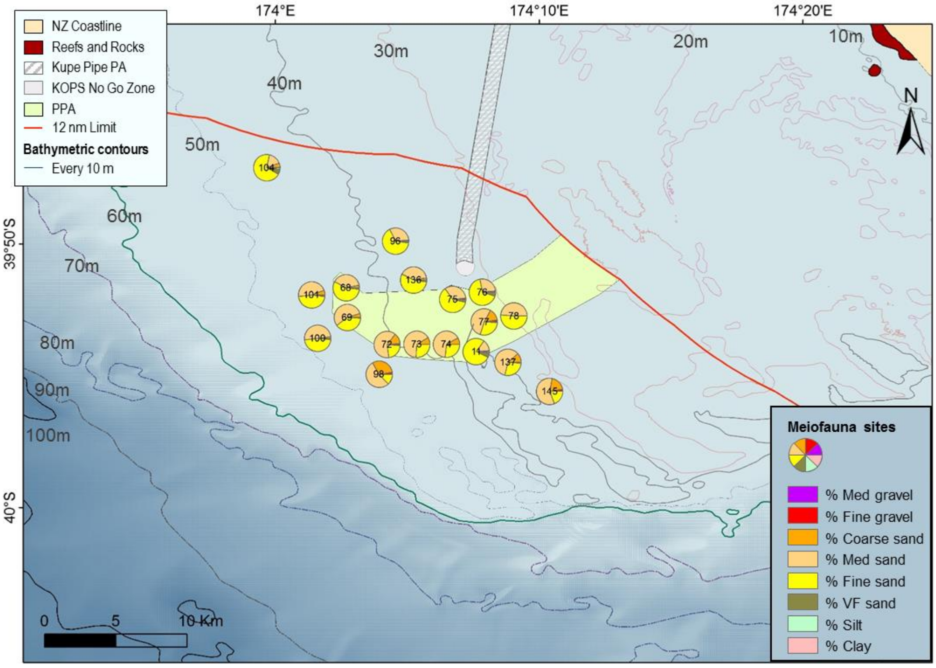

Figure 65: Location of sites used for meiofaunal analysis. The pie charts show the proportion of each size class of sediments present within cores at each site (mean of 3 cores).

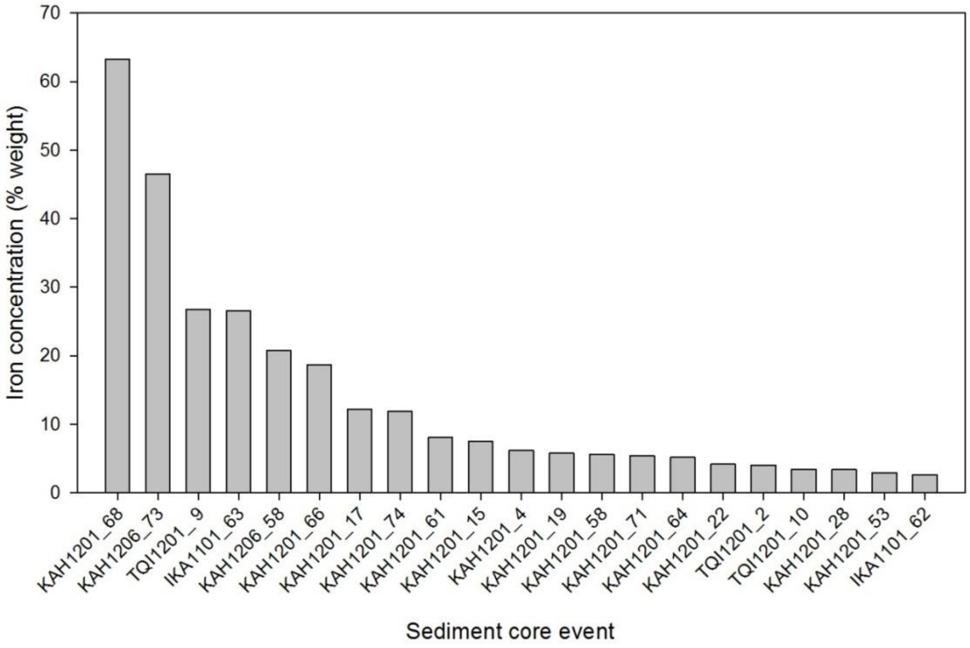

Figure 66: Percentage iron (by weight) of iron within surface sediments of each core analysed for meiofauna. The sediment core event number is the vessel code plus the unique identifier for each sampling event that took place on each voyage.

The abundance of each phylum recorded within the meiofauna data are given in Figure 67, Figure 68 and Figure 69 below. The most abundant phylum were nematoda with abundances between 151 and 2970 individuals per core section. Copepoda were the next most abundant, ranging from 43 to 883 per core. When the trends were compared with the concentration of iron (Figure 66) there was no statistically significant relationship between abundances and concentration of iron. Nematodes had the strongest relationship with iron concentration, with an r^2 of 0.0496. Copepods had an r^2 of 0.0148 and all other phyla had r^2 values of less than 0.01.

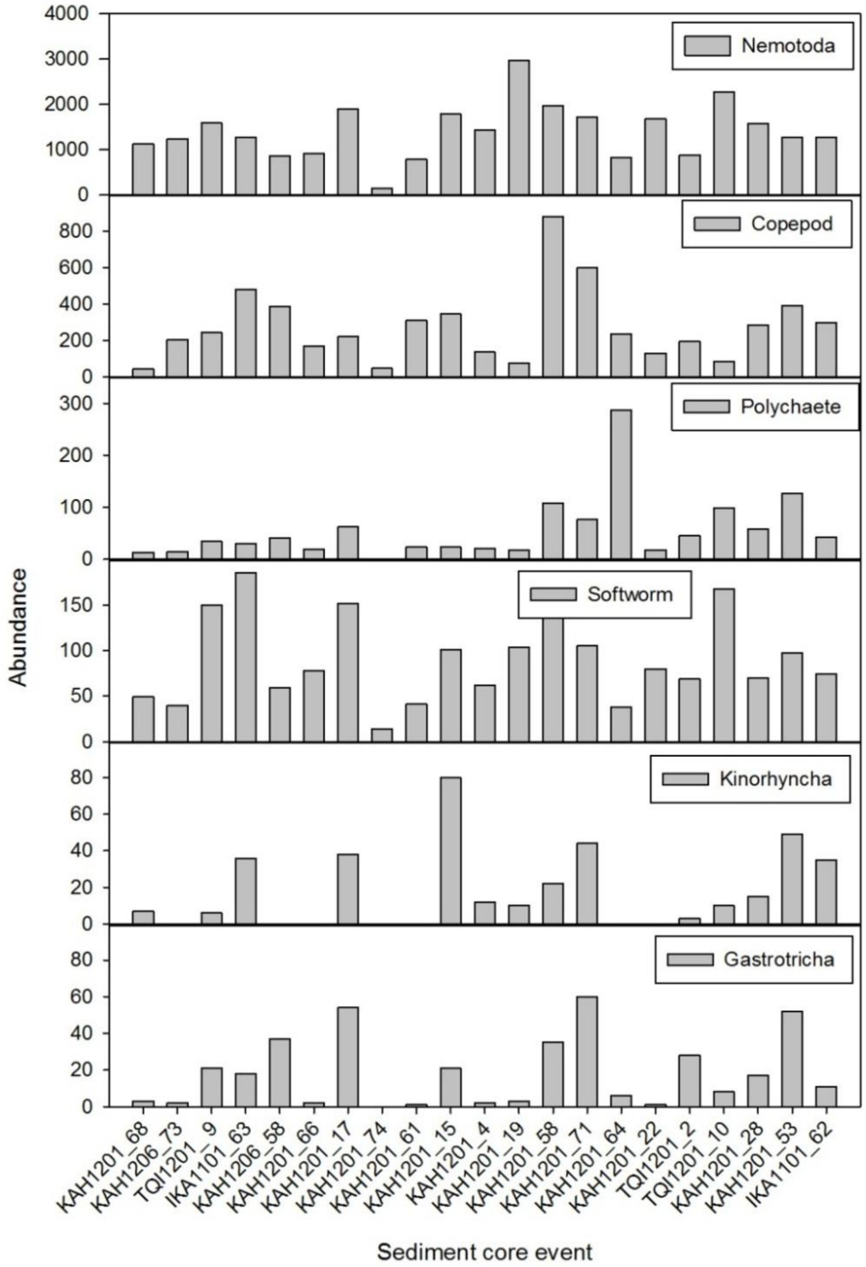

Figure 67: Abundance of meiofaunal groups (phyla) within each sediment core. Note that the scale changes for each graph. The order of the samples along the x axis is the same as in Figure 66.

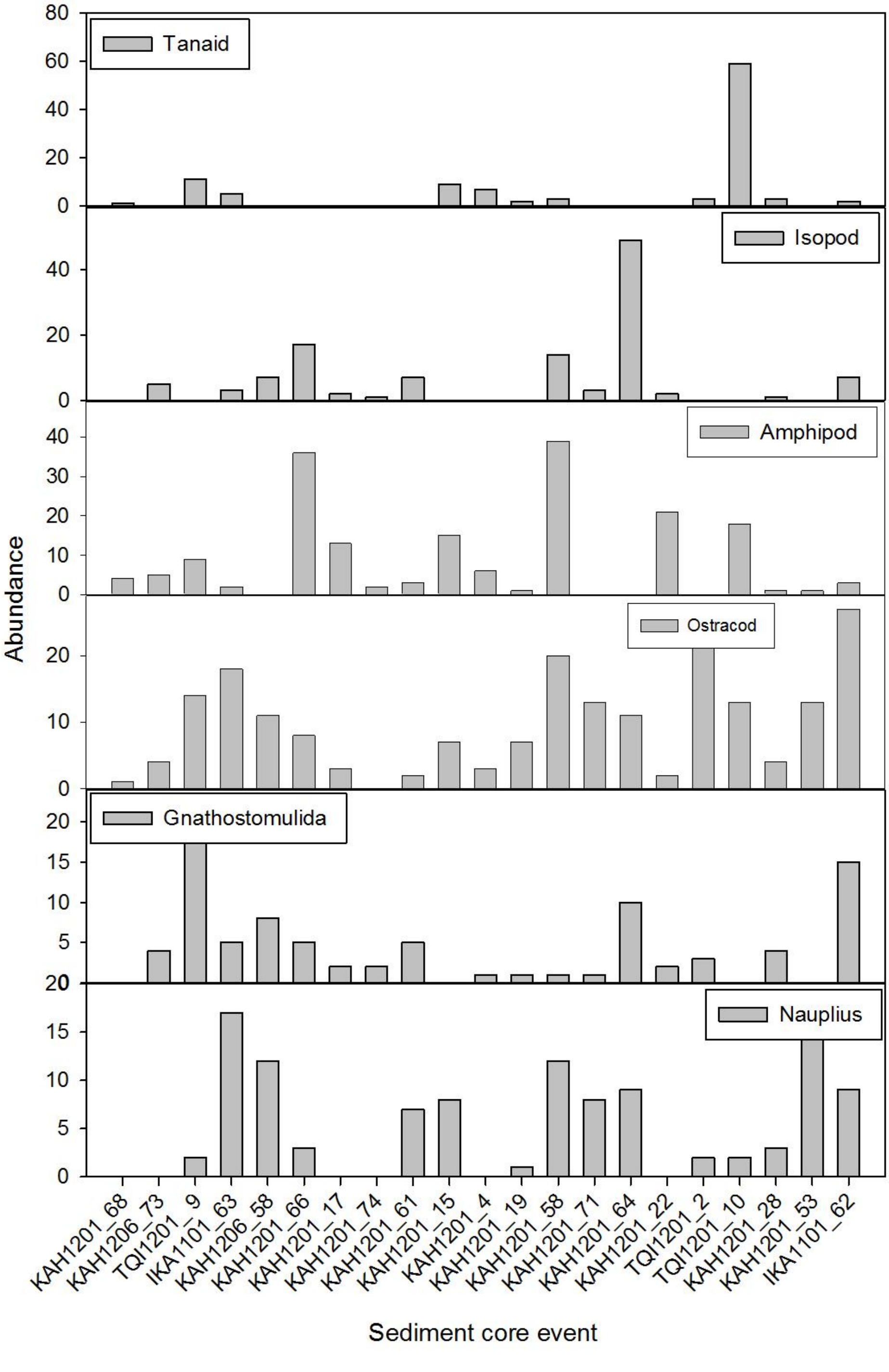

Figure 68: Abundance of meiofaunal groups (phyla) within each sediment core. Note that the scale changes for each graph. The order of the samples along the x axis is the same as in Figure 66.

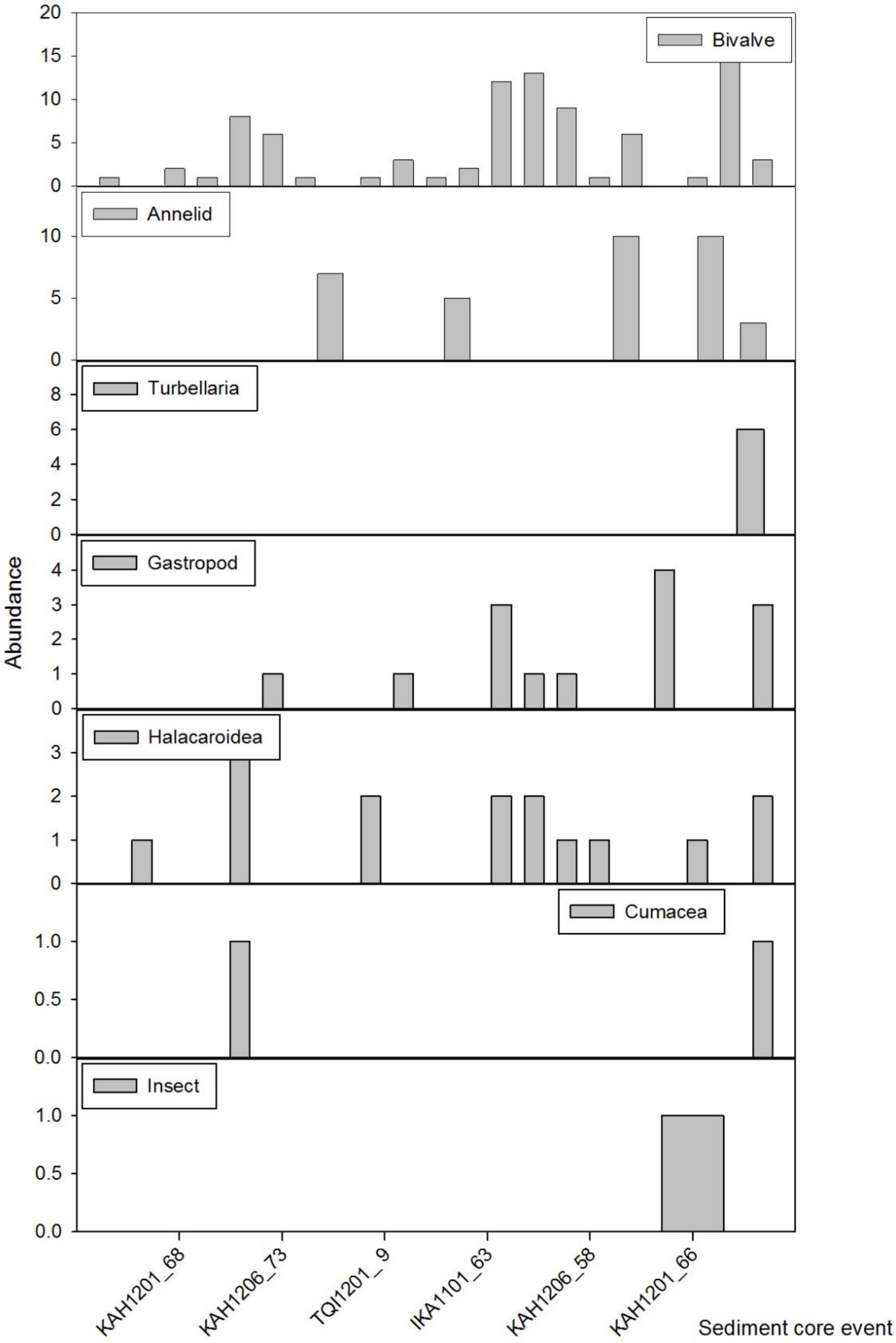

Figure 69: Abundance of meiofaunal groups (phyla) within each sediment core. Note that the scale changes for each graph.

3.3.9 Multivariate analysis: Meiofauna

An nMDS plot (Figure 70) of S15 Gower similarities of log transformed data shows the similarity or otherwise of the community structure of the meiofauna (identified to phyla) within each core. Note that no *a-priori* areas were established prior to analysis so the sites have been coded by site. Just one core was selected from most sites. However, two cores were used from each of sites 11, 75, and 101. On the nMDS these did not appear to cluster more closely together than any other core sample (from different sites) suggesting intra-site variability was relatively high.

A key question pertaining to TTR's proposed extraction activities is whether there is a relationship between the concentration of iron in the sediments and the meiofaunal community structure. An nMDS plot with the concentration of iron in each sediment core (by % weight) overlaid as a bubble plot shows that there is no strong relationship between community structure of meiofauna and the concentration of iron (Figure 71).

A DISTLM analysis (all-selected, R^2) showed there was no significant relationship between the concentration of iron and meiofaunal community structure. Marginal tests showed the predictor variables should be sequentially tested in the following order: medium sand, fine sand, depth, very fine sand, silt, medium gravel, coarse sand, distance from shore, iron, clay and fine gravel.

Sequential tests explained 53.3 % of total variation (Table 15). The proportion of medium sand within each core was the main driver of meiofaunal community structure, explaining 12.4 % of total variation (p = 0.047). No other predictor variable significantly contributed to the explained variation. The concentration of iron in surface sediments explained only 4 % of variation and was not statistically significant (p = 0.451). A visual representation of these results is given in Figure 72. Note that the Bray-Curtis similarity measure gave similar results but explained less variation than Gower measure (47.5%) so results using the S15 Gower similarity measure are shown here.

A second DISTLM (backwards AIC) confirmed that iron was not an important variable in driving community structure (Table 16). The backwards model eliminated 5 variables from the model in the following order: iron, distance from shore, depth, silt, medium gravel. The model selected just 6 important variables in determining community structure (in no particular order): fine gravel, coarse sand, medium sand, fine sand, very fine sand, clay.

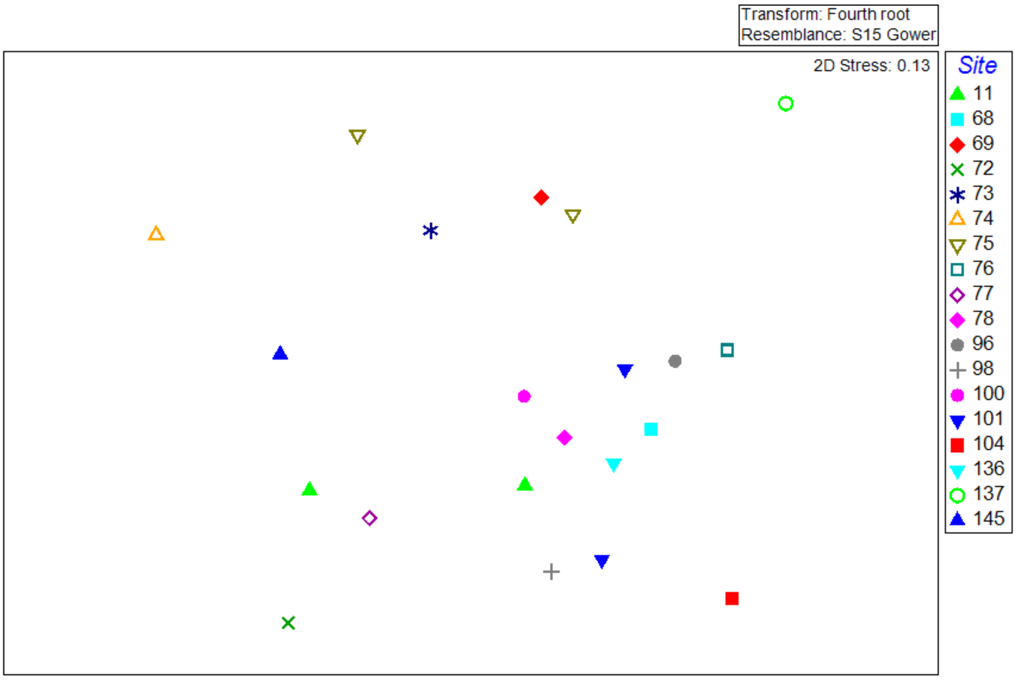

Figure 70: **nMDS plot showing the spread of sites with respect to similarity of meiofaunal community structure.** Those sites closest together on the plot had a more similar community structure.

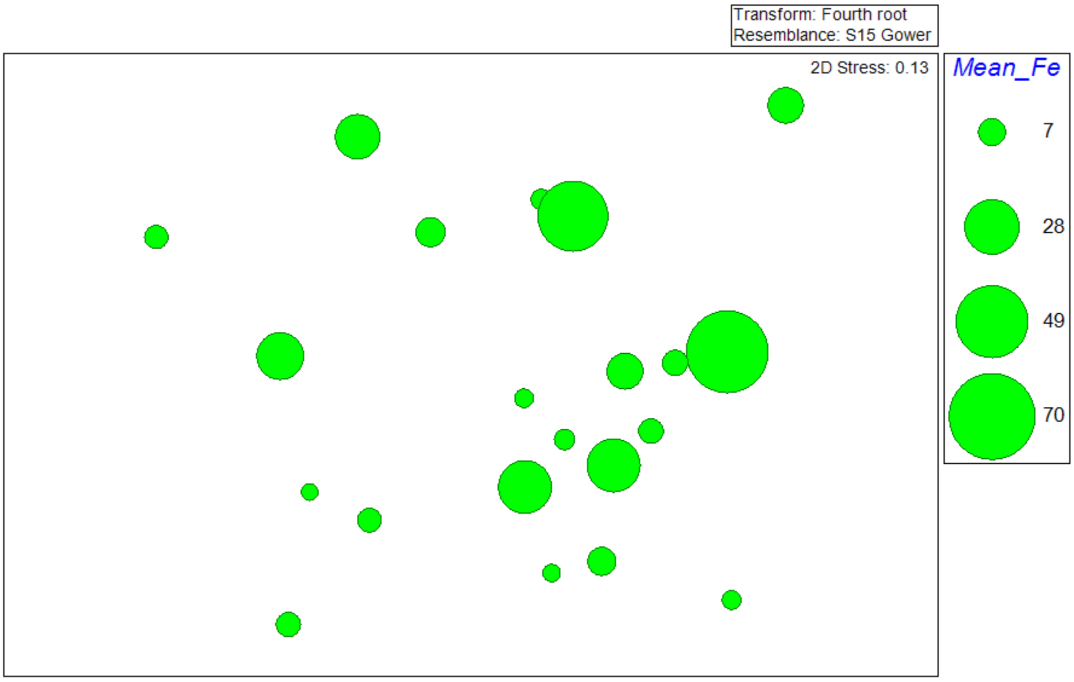

Figure 71: **nMDS plot of the meiofauna data for each site with the iron concentration of each core included as a bubble plot.** The greater the size of the bubble, the greater the concentration of iron (% weight).

Table 15: DISTLM results: sequential tests. Those predictor variables significantly contributing to the explained variation are highlighted in yellow ($p < 0.05$). The column "prop." gives the proportion of variation explained for each variable.

SEQUENTIAL TESTS

Variable	R^2	SS (trace)	Pseudo-F	P	Prop.	Cumul.	res.df
MEDIUM SAND	0.1242	1227.6	2.6945	0.047	0.1242	0.1242	19
FINE SAND	0.1826	577.4	1.2864	0.262	0.0584	0.1826	18
DEPTH	0.2552	717.4	1.6566	0.170	0.0726	0.2552	17
VERY FINE SAND	0.2674	120.9	0.2672	0.910	0.0122	0.2674	16
SILT	0.3193	512.7	1.1430	0.341	0.0519	0.3193	15
MEDIUM GRAVEL	0.3457	260.4	0.5637	0.643	0.0263	0.3457	14
COARSE SAND	0.3745	284.9	0.5990	0.626	0.0288	0.3745	13
DISTANCE FM SHORE	0.4513	759.4	1.6804	0.194	0.0768	0.4513	12
IRON	0.4908	390.4	0.8534	0.451	0.0395	0.4908	11
CLAY	0.5331	417.8	0.9053	0.445	0.0423	0.5331	10
FINE GRAVEL	0.5331	0.0	0.0000	1.000	0.0000	0.5331	10

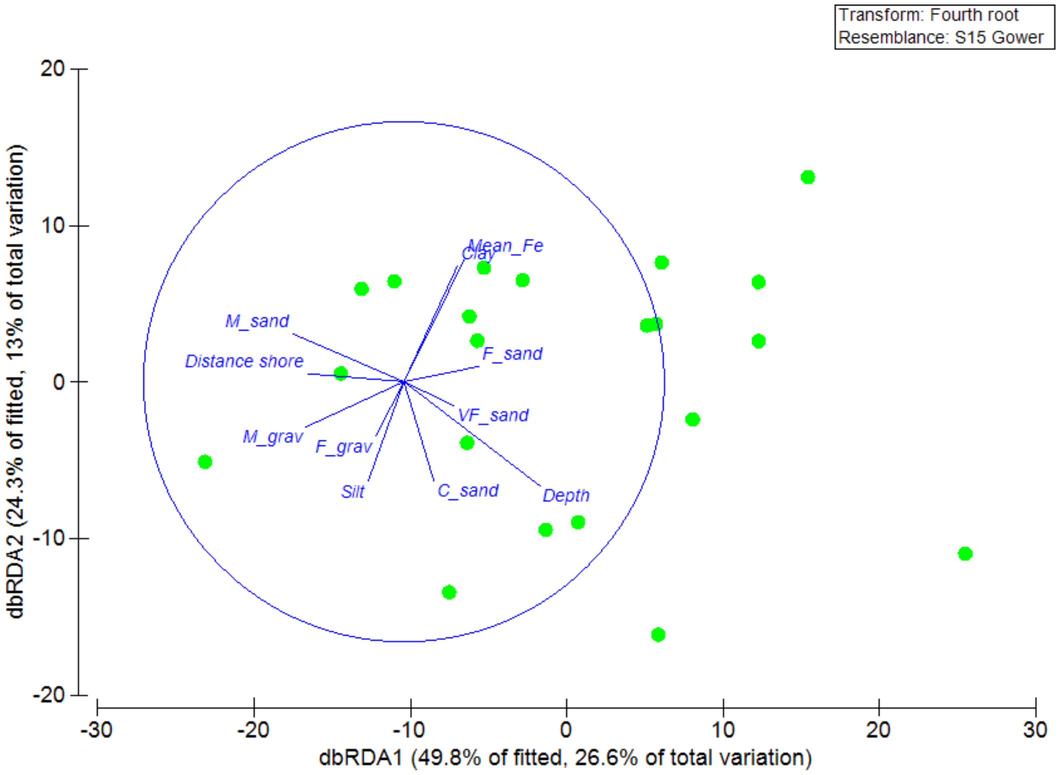

Figure 72: dbRDA plot of the meiofaunal data. This is a visual representation of the DISTLM analysis. The two axes explain 39.6 % of total variation (compared with 53.3 % of variation explained by the DISTLM). The vector plot can be interpreted as the effect of a given predictor variable (the longer the vector the bigger the effect).

Table 16: DISTLM results (backwards AIC). Sequential tests show which variables were eliminated from the analysis and in which order.

SEQUENTIAL TESTS

Variable	AIC	SS (trace)	Pseudo-F	P	Prop.	Cumul.	res.df
IRON	134.3	237.63	0.5149	0.691	0.0240	0.5090	11
DISTANCE FM SHORE	134.04	418.52	0.94871	0.445	0.0423	0.4667	12
DEPTH	133.69	433.24	0.9863	0.385	0.0438	0.4229	13
SILT	133.69	0.00	0	1	0.0000	0.4229	13
MEDIUM GRAVEL	132.41	197.51	0.45011	0.691	0.0200	0.4029	14

4 Recolonisation experiment

4.1 Introduction

Commercial-scale extraction of iron sand from the seabed 22-40 km offshore in the STB will necessarily result in a large volume of defaunated (lifeless), de-ored sand to be re-deposited on or near the extraction site. The processed sand is highly likely to have little or no living material remaining after suction from the seabed, pumping to and processing by the overhead processing vessel. It is therefore important to address the question of whether de-ored sand will be recolonized by benthic fauna and flora to the same extent as fully mineralised sand. In other words, will a reduction in the concentration of iron sands to just a few percent affect the structure of the benthic community that colonises the seabed?

In oceanic systems, iron enrichment experiments (as a macronutrient) have clearly shown that the presence of iron stimulates the production of chlorophyll *a* and oceanic primary production (see review by Boyd et al 2007). However, there appears to have been no previous work available in the published primary literature on the effects of the presence of iron ore on benthic communities, either *in-situ* or experimentally.

There have, however, been experimental studies on the re-colonisation of defaunated sandy sediments (e.g., Ellis and Taylor 1988, Lu and Wu 2000), as well as studies investigating the effects of the following on re-colonisation: disturbance (e.g. Colangelo et al 1996); copper, cadmium and contaminated harbour sediments (e.g. Trannum et al 2004); high concentrations of organic matter (e.g. Guerra-Garcia and Carcia-Gomez 2009); and crude oil (e.g. Berge 1990). All of these studies were conducted in sheltered waters (marinas, sheltered harbours or fjords) using shallow trays. While recolonisation studies of sandy beaches and intertidal sand flats have been undertaken (e.g., Grant 1981, Brazeiro 2001), no re-colonisation studies of subtidal sandy substrates on highly exposed coastlines were found in the primary literature. Pachero et al. (2010) noted that although it is possible in less exposed muddy areas to predict the succession of benthic communities from a starting point to a deterministic end point, succession is more variable in sandy subtidal habitats. In these more dynamic environments succession is complex and requires system specific evaluations (Pachero et al. 2010).

The re-colonisation of disturbed marine communities is dependent on a number of physical and biological factors. Some invertebrates are mobile (e.g. many polychaetes, echinoderms and crustaceans) and can colonise new areas through juvenile or adult migration. Many other marine invertebrates are sessile (fixed to a substrate) or sedentary and do not move large distances within the sediments (e.g. some bivalves). However, many marine invertebrates are able to rapidly colonise new areas through the dispersal of planktonic propagules, or larvae, into the water column (Zimmer et al. 2012) (Figure 73). It is this latter dispersal method that is expected to be most relevant in the recolonisation of large areas of deposited de-ored sand, while migration will increasingly affect recolonisation towards the margins of a deposition area.

The settlement of planktonic larvae is a complex process involving physical, chemical and biological cues, and propagules have been shown to demonstrate the ability to select surface characteristics that will enhance their chances of survival (Brown et al. 2003, Crisp 1974, Morgan 2001, Richmond & Seed 1991, Zimmer et al. 2012). These include biological cues in the form of biofilms (Hurlbut 1991, Keough & Raimondi 1995, Todd & Keough 1994, Wieczorek et al. 1995) as well as surface roughness/texture (Brown 2005, Brown et al. 2003, Walters & Wethey 1996), colour (James &

Underwood 1994) and particle size (Pearson 1970). The composition of sediments with respect to particle size, particularly of the coarse- and medium-sand fractions, has also been shown to be important in the community structure of benthic communities in the STB (Chapter 3).

While these processes greatly influence the settlement of planktonic propagules to any substrata they can only affect settlement once the propagule has arrived at the settlement site. It has, therefore, been suggested that the supply of larvae to an area is the critical first step in determining the structure of epibiotic assemblages, a concept termed supply-side ecology (Lewin 1986, Underwood & Keough 2001).

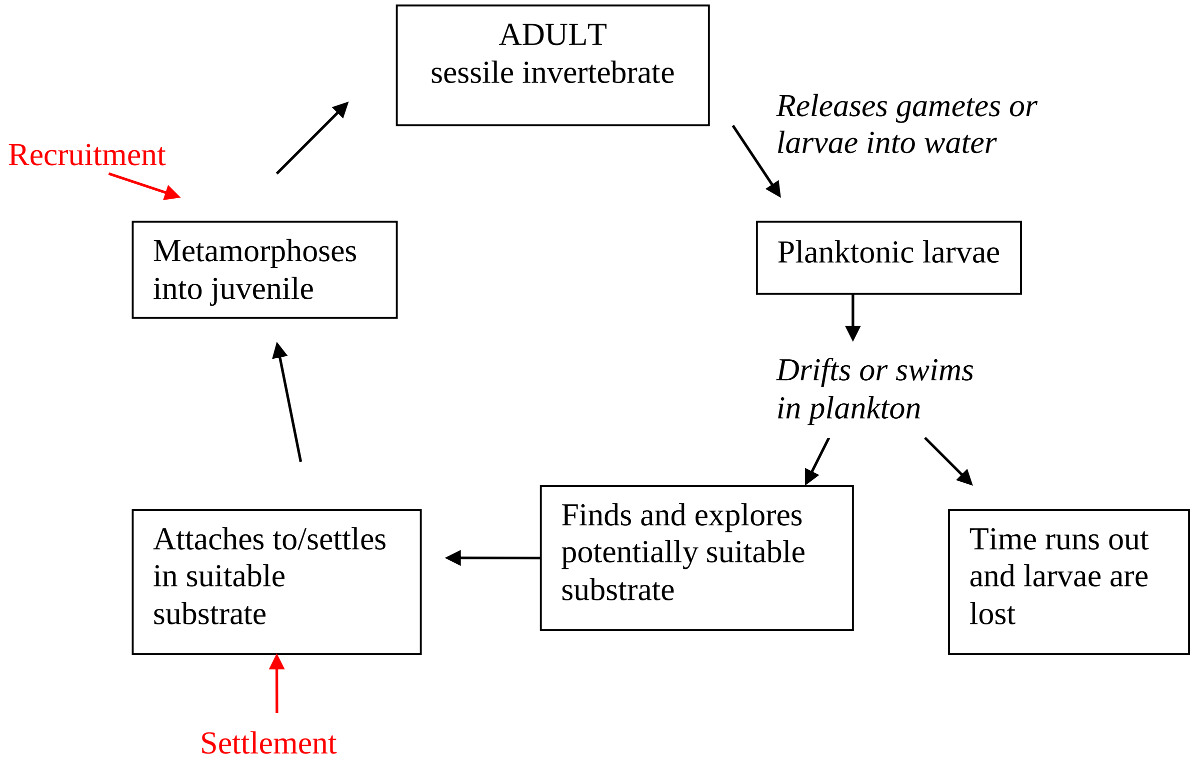

Figure 73: **Life-cycle of a typical sessile marine invertebrate.**

4.1.1 Pilot studies

NIWA's initial brief was to conduct a sand re-colonisation experiment, using treatments of iron-rich and de-ored sand, at two sites within TTR's permitted prospecting areas in the STB. Due to the exposure of the study site and the likelihood of storm disruption it was considered likely that all or part of the experiment would be lost of compromised. In order to minimise this risk, some pilot studies/trials were carried out to test the experimental design prior to the start of the main experiment.

4.1.1.1 Lyall Bay trials

Following some initial testing within NIWA's aquarium facility to determine the suitability of various containers, three different types of re-colonisation container were trialled in Lyall Bay on the exposed south coast of Wellington: cubes or "red crates" (357 x 357 wide x 290 mm high), 20 litre buckets and large white crates (432 x 324 mm x 305 mm high). Note that extra tall buckets (760 mm high by 310 mm diameter) were rejected from the experiment following the aquarium trials. While these would be expected to retain the experimental sand there would be insufficient water flow across the sediment surface to allow larval settlement and/or to oxygenate the sediments.

Each container was filled (up to approx. 5 cm below the rim) with clean, dried sand from Lyall Bay and filled with water to keep as much sand in the containers as possible during deployment into 15 m water depth. This depth was chosen to ensure exposure to a reasonable swell to test the design against conditions that could be experienced in 30 m water depth in the STB. Each bucket was weighed down with approximately 5 kg of lead and was attached to a surface float. To prevent the buckets from being pulled about in the swell, and following consultation with NIWA's moorings group, a Z-system was used (a sub-surface float and a mid-water weight).

The experimental containers were recovered after 2 weeks. All containers placed in Lyall Bay remained upright and in position despite being exposed to a large southerly swell during the trial. This suggested that both the moorings and containers were a good design for an exposed coastline. However, while most of the containers were still full of sand, it appeared that many had been disturbed by the ground swell as shells and algae were found throughout some of the containers. Some photos of the experimental containers taken at the end of the trial are given in Appendix O.

4.1.1.2 Taranaki trials

As the Lyall Bay trial was a success with respect to the mooring design, a second field trial was conducted in the STB. Eight containers filled (to 5 cm below the top of the container) of Lyall Bay sand (with low iron content) were deployed in 30 m depth within TTR's proposed iron sand extraction area (within the area bordered by 39° 21.021S, 39° 50.678S, 174° 11.759E and 174° 11.807E) and left *in-situ* for 2 weeks.

Again, the mooring design proved to be suitable for the conditions as all 8 containers were recovered from the study site full of sand, despite some significant wave action during the timeframe of the experiment. However, as with the Lyall Bay trials, it was apparent that the sand within the containers had been disturbed. An increase in the concentration of iron within the experimental sediments at the end of the trial compared with sand from Lyall Bay (which was in the experimental containers at the start of the trial) confirmed that the low-iron sand from Lyall Bay had been replaced/mixed with sand containing ironsand from the STB (Figure 74 and see Appendix P for photographs of recovered sand).

The results from these trials suggested that an *in-situ* re-colonisation study was not feasible as it was not possible to retain the original, treatment, sand within the experimental containers.

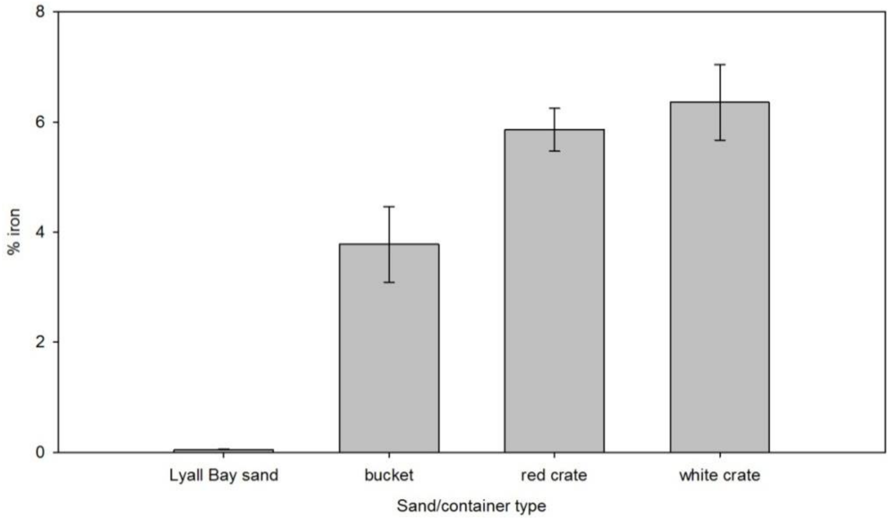

Figure 74: The percentage of iron (by weight) within the sand recovered from each type of container at the end of the Taranaki trial.

4.1.2 This study

As a result of the pilot studies described above, it was decided to use the relatively sheltered waters of Wellington harbour to investigate the effects of iron-ore concentration on the re-colonisation of sand. The iron ore resource that TTR proposes to remove from parts of the STB is VTM, here-after referred to as "iron".

The hypothesis to be tested was thus altered to reflect the difference in exposure, current regime and pool of potential colonisers between the STB and Wellington Harbour. The null hypotheses tested was: There is no difference in the marine faunal communities colonising iron-rich and de-ored sand originating from the proposed iron sand extraction sites in the STB. This was a conservative test as the available faunal pool in Wellington Harbour was unlikely to have species present that were adapted to high iron concentrations.

4.2 Methods

4.2.1 Study sites

Two sites within Wellington harbour were selected for the experiment (Figure 75). Both had a flat sandy or muddy-sandy seabed and were approximately 6 m deep. The first, Mahanga Bay, is on the eastern side of the Miramar Peninsular, at the northern end of the harbour entrance. This site is sheltered from a southerly swell but is subject to a small chop during northerly storms. The second site, Evans Bay, while slightly less sandy, was very sheltered from all wind directions. A coastal permit was granted by Wellington Regional Council as the deployment of the experiment was to be greater than 30 days.

TTR provided dried, defaunated, sand collected from the STB with a range of iron concentrations (raw ironsand and de-ored sand). Sand was selected for use in the experiment according to the iron concentration as well as standardising, as much as possible, for particle size of the sediment.

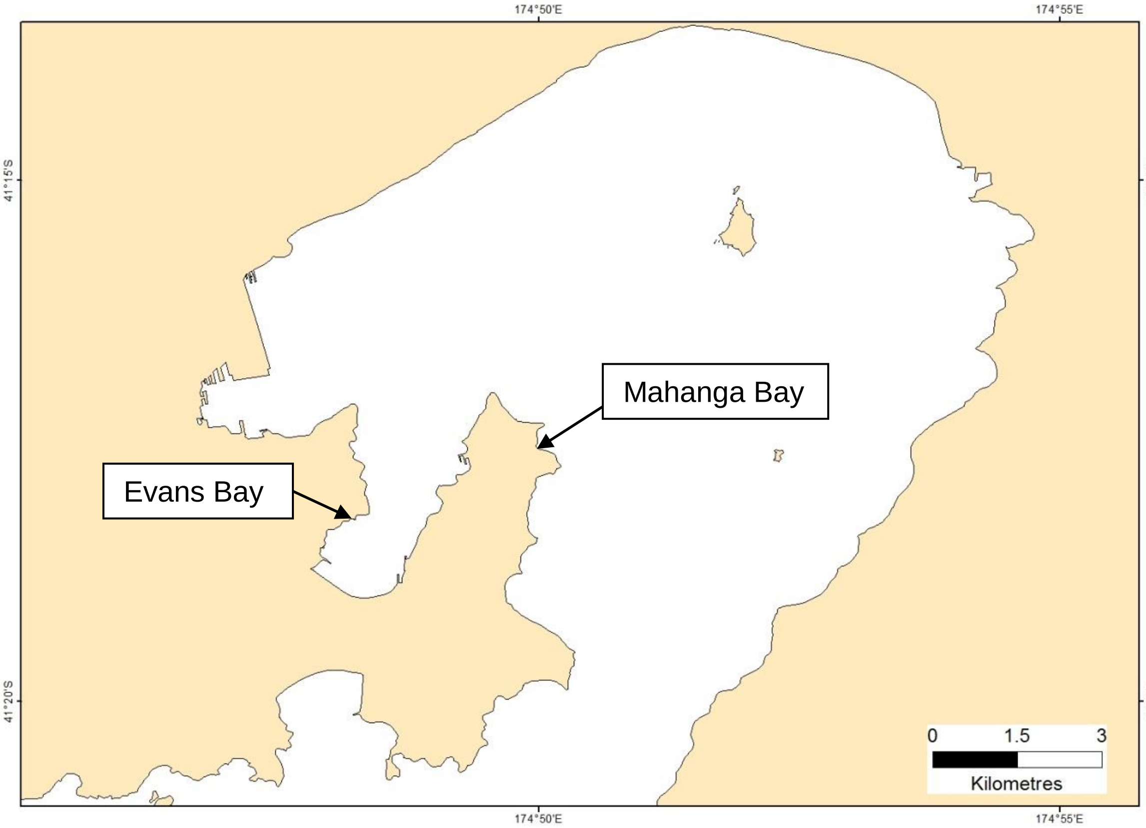

Figure 75: Location of study sites within Wellington harbour.

At each site, three fish-bins (645 x 413 mm by 200 mm high) of each of three experimental treatments were deployed. Note that fish-bins were used here, in preference to the container types used in the trials, to increase the experimental surface area for settlement. Fish-bins were not considered during the initial trials due to the exposed nature of the initial study sites. The treatments were high-iron "red" treatment with approximately 30 % iron by weight, medium-iron "yellow" treatment with approximately 20 % iron by weight and low-iron "green" treatment with approximately 3 % iron by weight (de-ored sand). Each fish-bin was filled to within 5 cm of the top of the fish-bin, and labelled with appropriately coloured cable ties prior to deployment.

The fish-bins were lowered gently from a small boat onto the seabed, in a depth of 6 m. A cement-fibreboard lid covered the surface of the sand to keep it in place during the deployment. Once all fish-bins were on the seabed, divers tied the fish-bins together with a ground line and removed the lids to start the experiment.

At Mahanga Bay, the experiment was connected to the end of an outfall pipe (from the aquaculture facility) by a ground-line in order for divers to be able to find the experiment easily without the need for a surface buoy (Figure 76). At Evans Bay, the experiment was set-up in line with the jetty and a building on the adjacent shore (ISO bar) enabling divers to find the experiments without the need for a surface buoy (Figure 77). The fish-bins were laid out, at both sites, in a randomised design (Figure 78, Figure 79).

No attempt was made to bury the fish-bins into the sediment. The experimental sediments were kept separate from the surrounding sediments in order to assess the arrival of organisms through planktonic dispersal rather than through post-settlement dispersal within sediments.

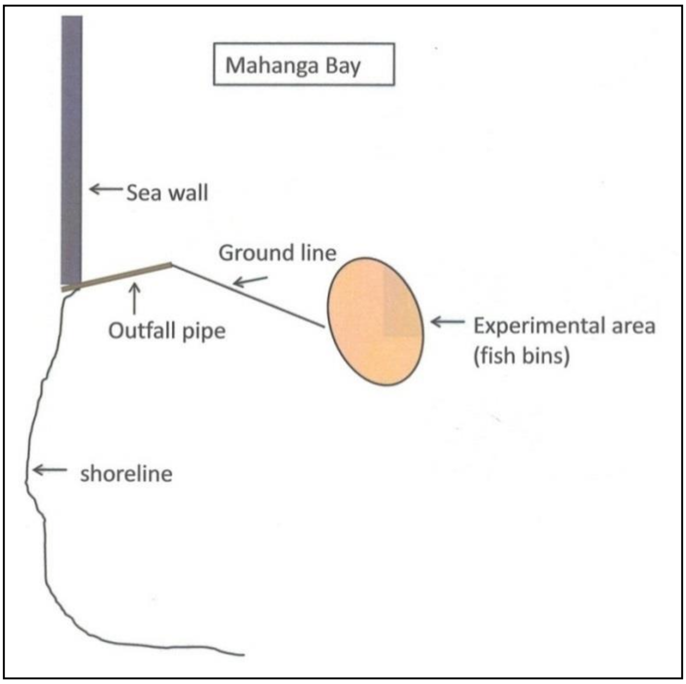

Figure 76: Site layout, Mahanga Bay (not to scale).

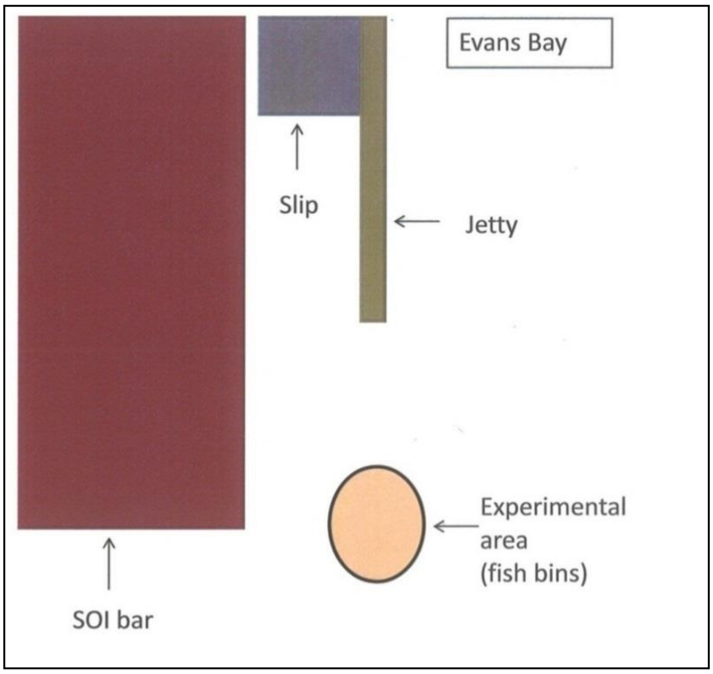

Figure 77: Site layout, Evans Bay (not to scale).

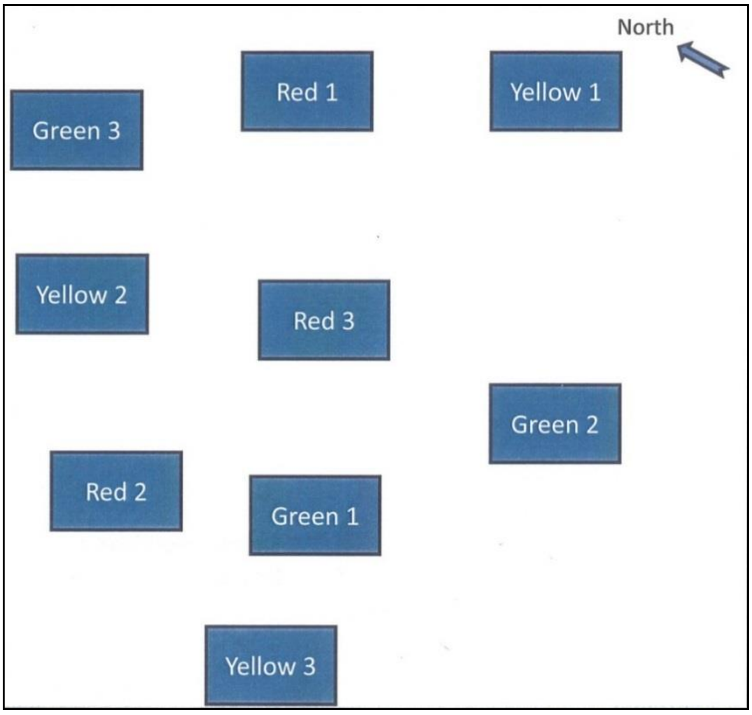

Figure 78: Layout of fish-bins and treatments at Mahanga Bay (not to scale).

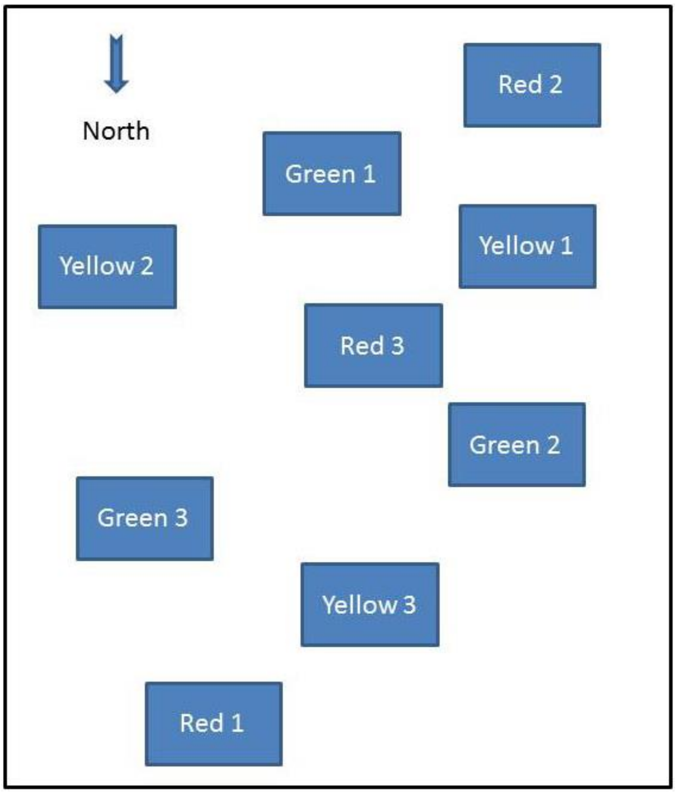

Figure 79: Layout of fish-bins and treatments at Evans Bay (not to scale).

4.2.2 Sampling

At each sampling event, divers collected two sediment cores from each replicate using cut-off 50 ml plastic syringes (110 mm deep by 30 mm diameter). Three cores were also taken from surrounding, natural, sediments to identify the dominant, small, infauna inhabiting these substrates. The experiment was sampled 5 times at Mahanga Bay and 4 times at Evans Bay (Table 17). As each sediment core was taken, a piece of plastic orange PVC piping was pushed into the hole to prevent that area of sediment from being re-sampled in future sampling events. The sample collected by each sediment corer was preserved as soon as practical (always within 2 hours) in 4% buffered formalin with Rose Bengal stain.

Table 17: Sampling schedule.

Mahanga Bay	Evans Bay
21/12/2012 (deployed)	22/12/2012 (deployed)
12/01/2012	13/01/2012
08/02/2012 (sand starting to be washed out)	
27/02/2012	24/02/2012
29/03/2012	29/03/2012
19/07/2012	01/08/2012

4.2.3 Sample processing

Each core was initially elutriated to remove small organisms from the sediments. First the formalin from each sample was poured into a chemical waste container over a 63 µm sieve. The remaining sediment and sample were washed into a 2 L bucket using clean, fresh water. The 2 L bucket was then filled to one third full with fresh water. The contents of the bucket were mixed with a stirrer: 6 times in a clockwise direction, 6 times in an anticlockwise direction and 6 times across the bucket. This was left to settle for 12 seconds before the water and suspended matter was poured into a waste bucket over the same 63 µm sieve. This washing and decanting was repeated 3 times in total. The contents of the 63 µm sieve were re-preserved in 4 % buffered formalin.

The sand left behind in the bucket was then washed onto a sorting tray and picked through for any remaining macrofauna. This was added to the sample jar, the contents of which were sorted and identified by taxonomic experts.

The defaunated sand was then dried in a labelled foil tray at 60 °C. From each dried sample a teaspoon-sized sample of sand was weighed in a glass dish on fine scales (accurate to 0.01 g). A magnet (in a plastic bag to aid separation of iron from the magnet) was then passed over each sample at a height of 1.3 cm to remove the iron-ore, which was collected and weighed. This was carried out 3 times for each sample to estimate the variation in measurement of iron concentration for each sample.

Sand samples, with the iron replaced, were then analysed for particle size using a Beckman Coulter LS 13 320 Dual Wavelength Laser Particle Sizer. The basis of the method is well established and the instrument has been a popular choice in commercial and research applications, particularly for sandy sediments (e.g. McCave et al. 2006, McCave & Syvitski 1991). A laser light source is used to illuminate the suspended particles passing through a glass chamber. The light scattered by the particles is detected by silicon photo-detectors. The intensity of light on each detector, measured as a function of angle, is then subjected to mathematical analysis using a complex inversion matrix algorithm. The result is a particle size distribution covering a size range from 0.4–2,000 µm, displayed as volume percent across 92 discrete size classes. This method offers several advantages over traditional sieve stacks, including much improved efficiency and accuracy; resolution and repeatability (see Orpin (2012) for the Standard Operating Method).

Operational protocols followed well-established laboratory procedures for heterogeneous marine sediments. To achieve appropriate obscuration (a function of turbidity) approximately 0.5 cm3 of sediment was initially dispersed in a standard dispersant (Calgon) in a 50 ml container, briefly invigorated using ultrasound and then washed, through a 1,600 µm sieve, into the laser-sizer's sample bath containing approximately 1 L of tap water.

Results were checked after each analysis to ensure correct instrument operation, and exported into an Excel spreadsheet and analysis in GRADISTAT version 8.0 (Blott 2010), which calculates the standard granulometric statistics and textural descriptions. The size classes used by GRADISTAT are shown in Appendix A.

4.2.4 Data analyses

Multivariate analyses were used to explore the difference between sites and between the ambient and treatment communities, key taxa contributing to differences in communities and the key drivers of community structure (PERMANOVA + for PRIMER and PRIMER-E, Anderson et al. 2008, Clarke & Warwick 2001 respectively).

4.3 Results

Only the latest sampling event from each site is reported here (Evans Bay on 19/07/2012 and Mahanga Bay on 01/08/2012). The experiment had been running for approximately 7 months at each site. At the end of the experiment, replicates at Evans Bay, with the exception of some epifouling on the plastic and some fine sediment visible on the surface, appeared to have been undisturbed since they were first deployed (Figure 80). However, replicates at Mahanga Bay, subject to occasional northerly/north-easterly storms, had been noticeably scoured (Figure 81).

Figure 80: Experimental treatment at Evans Bay, taken 19/7/2012.

Figure 81: Experimental treatment at Mahanga Bay, taken 1/8/2012. Note that some of the experimental sand has been scoured out of the fish-bin.

4.3.1 Environmental data/predictor variables

Sediment from each sediment core was analysed for both particle size analysis and iron concentration (% by weight). Despite the apparently large amount of sediment scouring at the Mahanga Bay experiment, at the end of the experiment both sites had very similar percentages of iron within sediment cores from different treatments, with almost no iron in the ambient cores, approximately 3 % in the "green" treatments, approximately 20 % iron in the "yellow" treatments and approximately 30 % iron in the "red" treatments (Figure 82).

Particle size analysis of the sediments in each core showed that the ambient samples were very distinct from the treatment samples, with fine sand (F SAND) dominating the sand fraction (Figure 83) in comparison to the experimental treatments which were dominated by medium sand (M SAND). The ambient samples also had much higher percentage of very coarse silt (VC SILT) than the experimental treatments (Figure 84). Ambient samples from Evans Bay, in particular, had higher percentage of silt than any other site/treatment. While there were some differences in the sediment properties of the three experimental treatments, these were relatively small, particularly when compared with the scale of the differences in the concentration of iron between treatments (Figure 82, Figure 83 and Figure 84).

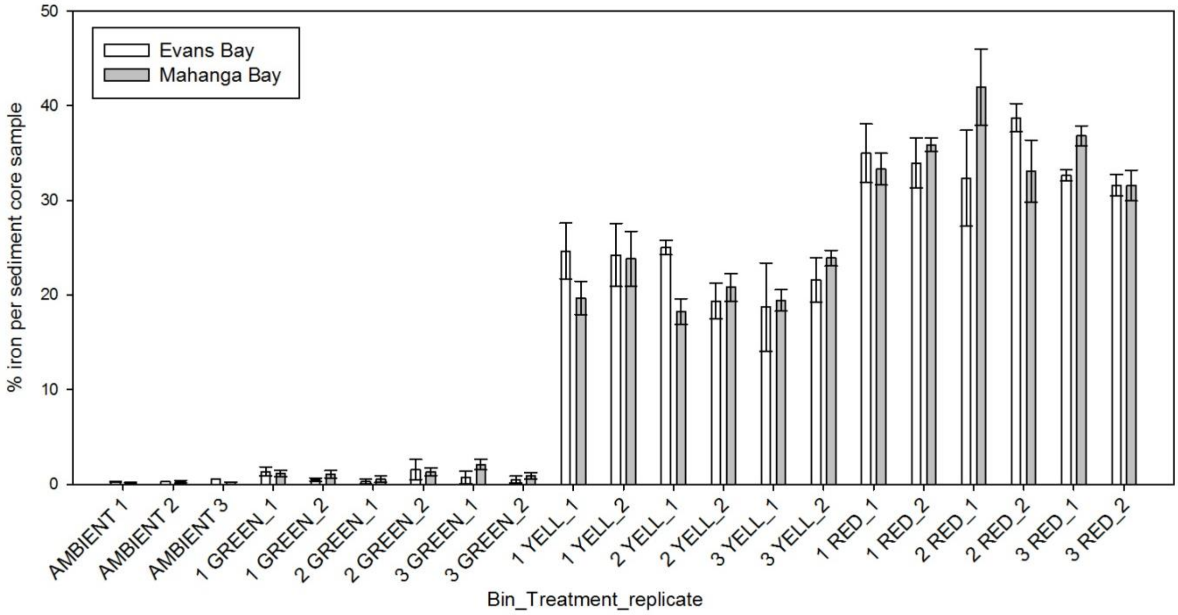

Figure 82: Mean percentage of iron, by weight, in each core sample + SE. EB = Evans Bay, MB = Mahanga Bay. Red = high iron concentration; Yellow = medium iron concentration; Green = low iron concentration

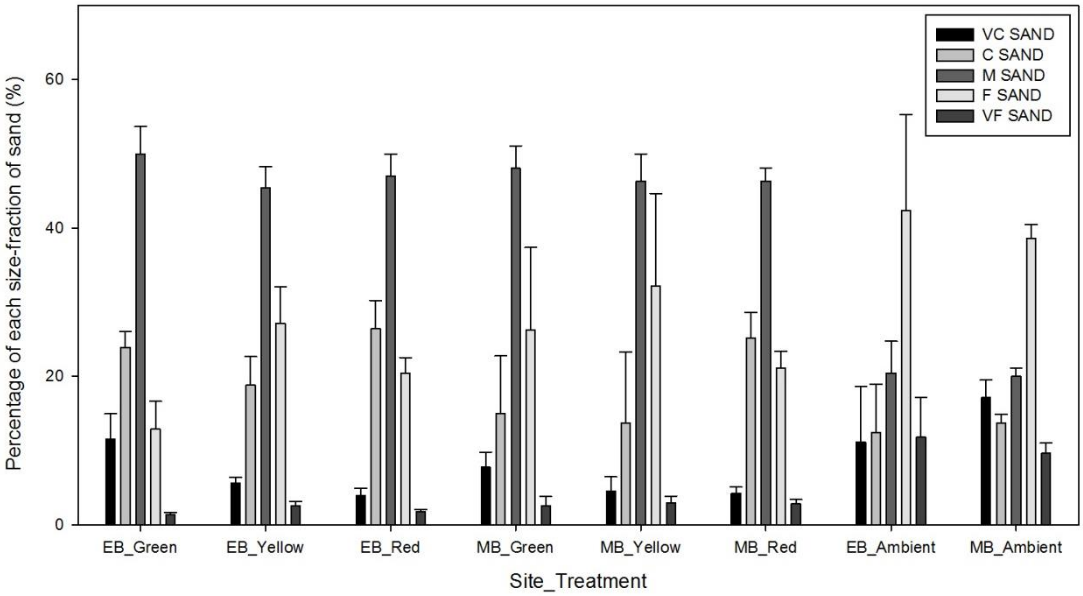

Figure 83: Percentage of each sand size-fraction in cores from each site/treatment. EB = Evans Bay, MB = Mahanga Bay. Red = high iron concentration; Yellow = medium iron concentration; Green = low iron concentration

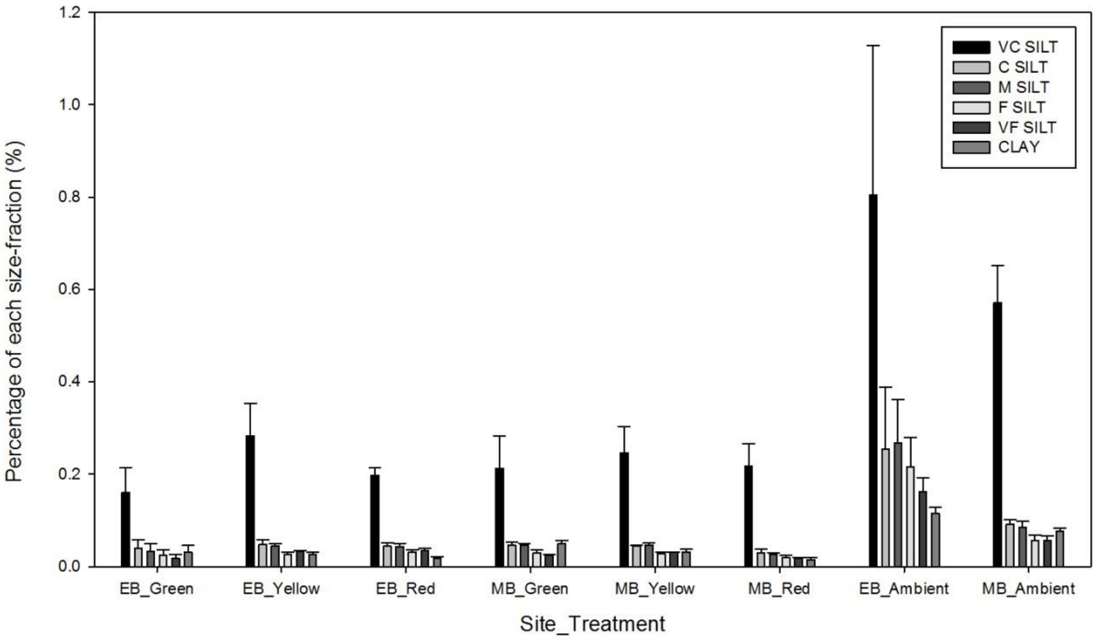

Figure 84: Percentage of each silt/clay size-fraction in cores from each site/treatment. EB = Evans Bay, MB = Mahanga Bay. Red = high iron concentration; Yellow = medium iron concentration; Green = low iron concentration

4.3.2 Multivariate analysis

Multivariate analysis (PRIMER-E, Clarke & Warwick 2001) was used to investigate differences in community structure between treatments. The data from each of the two sediment cores from each replication were pooled to avoid issues with pseudoreplication (Hurlbert 1984). A non-multidimensional scaling plot (nMDS) of Bray Curtis similarities of log transformed data showed that there were quite distinct differences between the community structure between Evans Bay and Mahanga Bay sites (Figure 85). Note that samples plotted close together are more similar to each other than those plotted further away. It is also apparent that the community structure within the sediment cores from the surrounding sediments (ambient) at each site were quite distinct from the experimental treatments (cores taken from within replicate). There also appears to be some separation between treatments at each site and less variation in the community structure within a site in high iron treatments (red) than in medium or low iron treatments (yellow and green respectively). A 2-way crossed ANOSIM (analysis of similarity) was used to explore differences between sites and between the ambient and treatment communities. This analysis showed significant differences between sites ($p < 0.01$, Global R = 0.741) and treatments ($p < 0.05$, Global R = 0.289), driven by differences between the ambient and the iron-ore treatments (Table 18).

A SIMPER routine within PRIMER-E (Appendix Q) identified key taxa (having greater than 5 % contribution to similarities/dissimilarities) between treatments at each site (Figure 86, Figure 87). Nematodes and copepods were the most abundant taxonomic groups after 7 months of re-colonisation. Nematodes were particularly abundant in the ambient sample from Evans Bay, but no consistency was observed across the experimental treatments at either site. For example, the copepods were more abundant in the experimental treatments than the ambient samples, with no obvious differences between the treatments at Evans Bay. However, at Mahanga Bay the abundance of copepods appeared to increase from ambient to low, medium, and high iron treatments.

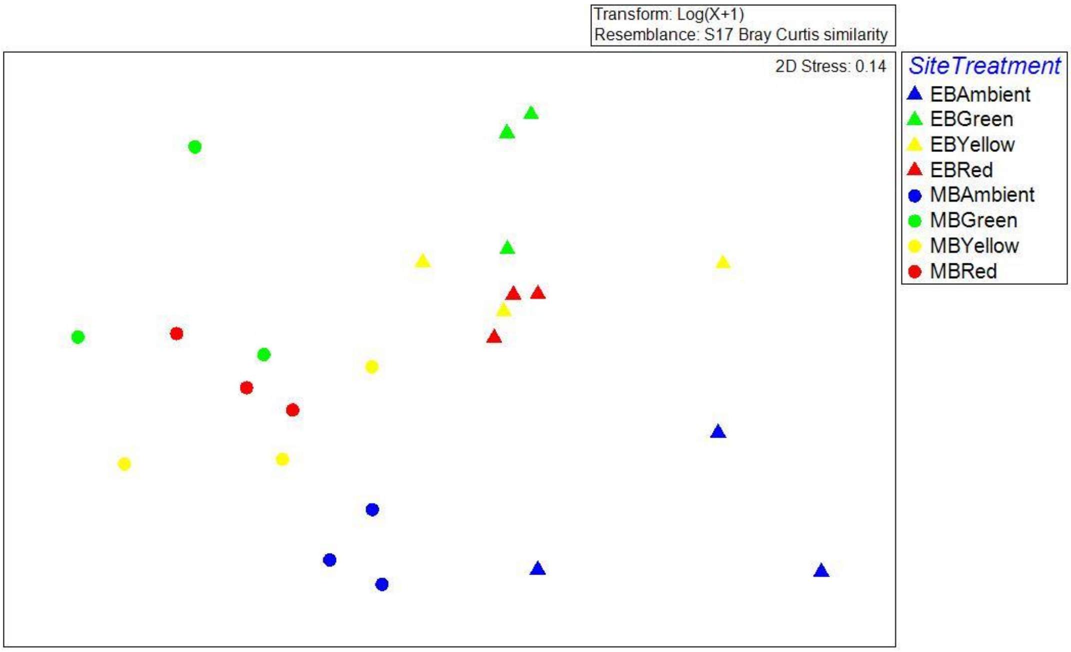

Figure 85: nMDS plot of pooled data. Sites appear to be separated, as do the ambient samples from the treatments. EB = Evans Bay, MB = Mahanga Bay. Red = high iron concentration; Yellow = medium iron concentration; Green = low iron concentration; Blue = Ambient

Table 18: Percentage dissimilarity of community structure of each treatment .

Treatment	Low Green	Medium Yellow	High Red
Medium Yellow	5.6		
High Red	16.7	13	
Ambient	7.04	29.6	57.4

The polychaete, *Capitella capitata*, was the next most numerous taxon identified within the experiment. This had relatively low abundances at the Evans Bay site, particularly in the ambient, low and medium iron treatments but with higher abundance in the high iron treatment. However, at the Mahanga Bay site it was the medium iron treatment that had the highest abundance. Figure 86 and Figure 87 show that while abundances of most taxa varied across treatments and sites, there was no apparent consistent pattern across taxa and/or sites with respect to a response to iron concentration.

The ambient samples were collected from each site in order to identify the dominant, small, infauna inhabiting the surrounding sediments that may colonise the treatments directly or via larval movement. However, there was no *a priori* reason to expect the treatment and ambient communities to be similar and as the ambient communities were not part of the test of the experimental hypothesis they were excluded from further analyses.

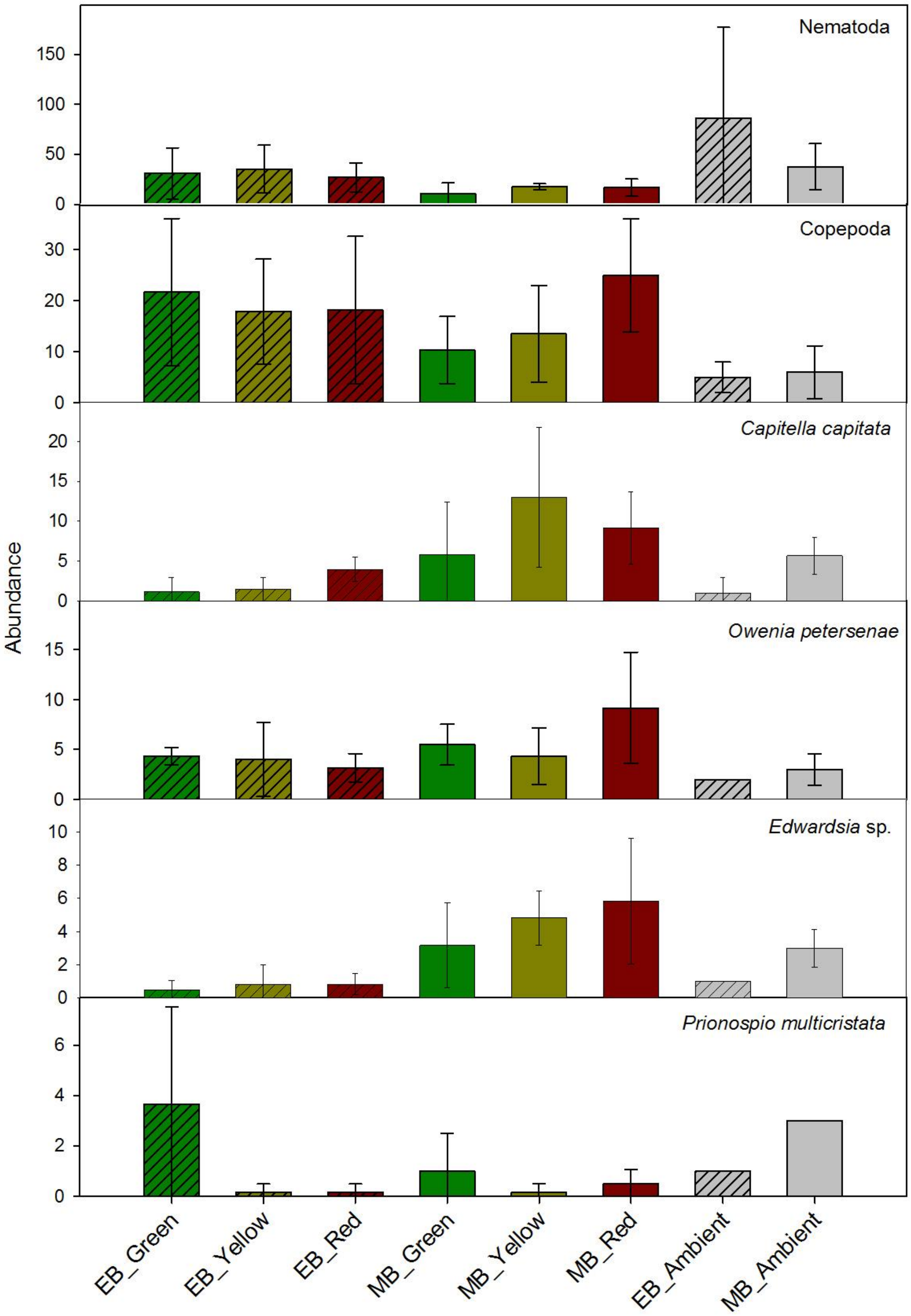

Figure 86: Mean abundance (+ SE) of Key taxa graph 1 (> 5% contribution to communities in treatments and/or differences between treatments). EB = Evans Bay (striped bars), MB = Mahanga Bay (plain bars). Red = high iron concentration; Yellow = medium iron concentration; Green = low iron concentration; Blue = Ambient

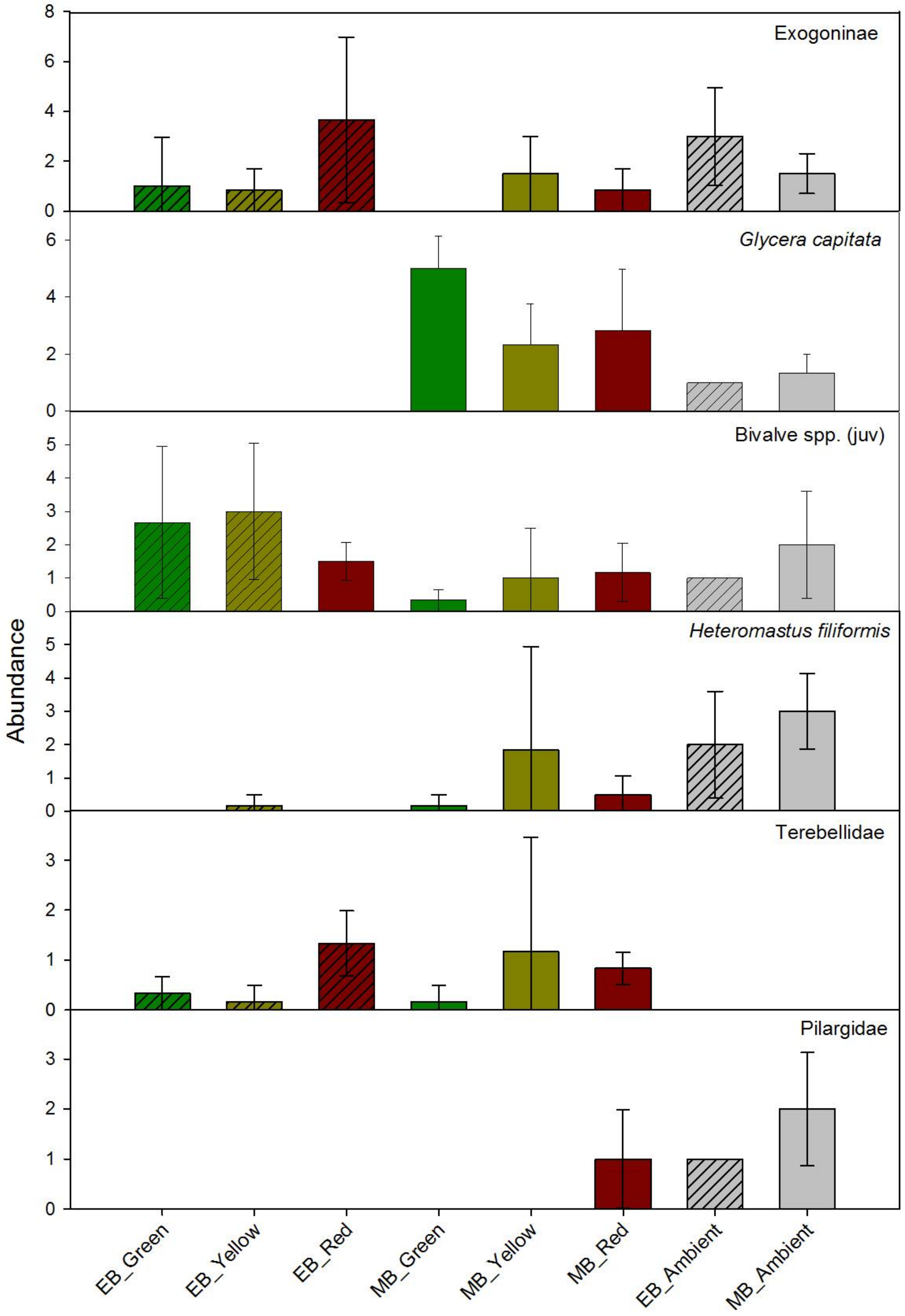

Figure 87: Mean abundance (+ SE) of Key taxa graph 2 (> 5% contribution to communities in treatments and/or differences between treatments). EB = Evans Bay (striped bars), MB = Mahanga Bay (plain bars). Red = high iron concentration; Yellow = medium iron concentration; Green = low iron concentration; Blue = Ambient.

A permutational MANOVA (PERMANOVA) analysis (PERMANOVA+ for PRIMER, Anderson et al. 2008) was carried out on the pooled abundance data from both sites across all treatments (Table 19). Site was treated as a random factor and treatment as a fixed factor. This showed a significant difference in community structure between sites ($p < 0.01$) but not between treatments ($p > 0.05$). No significant interaction was identified between site and treatment ($p > 0.05$).

Table 19: PERMANOVA table of results. Significant differences were found between sites but not between treatments.

Source	df	SS	MS	Pseudo-F	P$_{(perm)}$	perms Unique
Site	1	5134.1	5134.1	9.0859	0.001	999
Treatment	2	1834.7	917.33	1.7082	0.217	60
Interaction	2	1074.1	537.03	0.95039	0.57	997
Residual	12	6780.7	565.06			
Total	17	14823				

A Distance Based Linear Model (DISTLM) routine (PERMANOVA+ for PRIMER) was used to identify the key environmental drivers in community structure (Table 20). Raw (not pooled) data was used as environmental data for each sediment core were available. Therefore each core was treated as a separate sample for the DISTLM analysis. Overall, 40.5 % of the total variation in community structure was explained by the variables listed in Table 20. Very fine sand explained the greatest proportion of variation at 5.4% ($p < 0.05$). Clay explained 4.5% of variation though had a relatively low pseudo-F value ($p = 0.81$). Very coarse silt and very fine silt also had low p-values but these results should not be trusted as they followed some larger p-values in the sequence of variables selected by the routine (Anderson et al. 2008). Note the concentration of iron, though varying from near 40% to <1%, explained 3.4 % of variation but did not significantly increase the explained variation ($p = 0.246$).

Table 20: DISTLM results showing the amount of variation explained by each variable and the significance to the community structure (P).

Sequential tests

Variable	R^2	SS (trace)	Pseudo-F	P	Proportion of variance explained	Cumulative proportion of variance explained	Residual degrees of freedom
Very fine sand	0.0539	2347.8	1.9383	0.043	0.0539	0.0539	34
Clay	0.0990	1960.1	1.6491	0.081	0.0450	0.0990	33
Iron	0.1331	1483.8	1.2581	0.246	0.0341	0.1331	32
Very fine silt	0.1855	2282.0	1.9951	0.063	0.0524	0.1855	31
Coarse silt	0.2155	1306.7	1.1479	0.319	0.0300	0.2155	30
Medium silt	0.2489	1455.3	1.2908	0.244	0.0334	0.2489	29
Fine silt	0.2713	972.8	0.8587	0.555	0.0223	0.2713	28
Very coarse silt	0.3346	2758.1	2.5710	0.023	0.0634	0.3346	27
Medium sand	0.3681	1455.5	1.3757	0.204	0.0334	0.3681	26
Coarse sand	0.3756	326.6	0.3004	0.985	0.0075	0.3756	25
Fine sand	0.4046	1265.4	1.1718	0.340	0.0291	0.4046	24

Very coarse sand	0.4046	0.0	0.0000	1.000	0.0000	0.4046	24

The dbRDA plot (Figure 88) gives a 2-dimensional visual representation of the DISTLM results. Note that the dbRDA1 axis (x-axis) explains 42.4 % of the fitted variation and dbRDA2 (y-axis) explains only 16.8% of the fitted variation. Axis 3, not plotted here, explained 12% of fitted variation and 4.9 % of total variation.

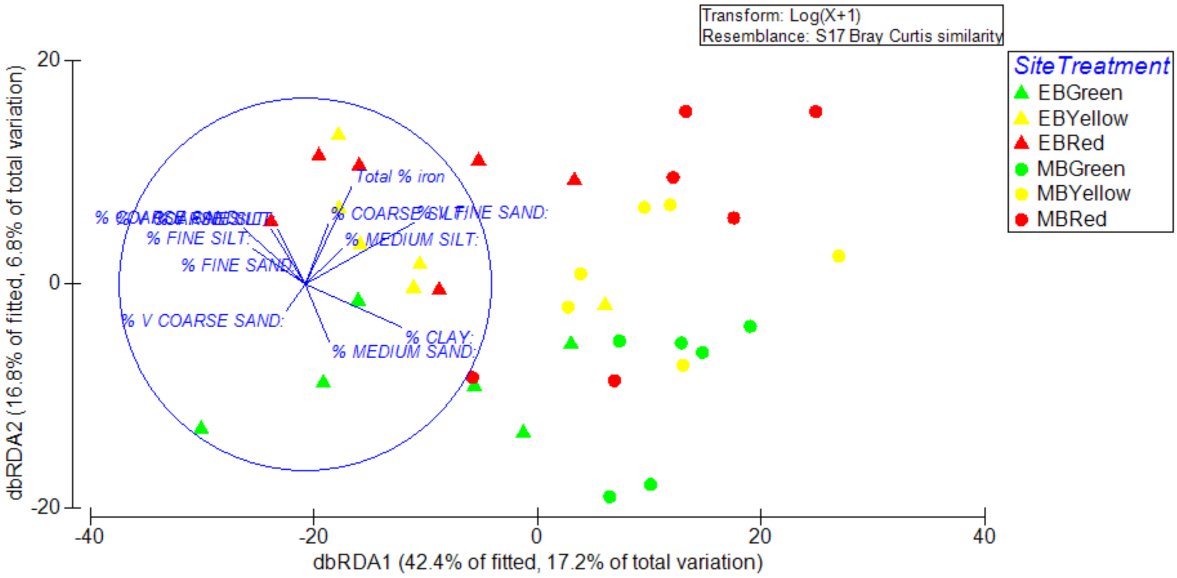

Figure 88: A dbRDA plot of all experimental data. This is a visual representation of the DISTLM analysis. The two axes shown explain 28.5 % of total variation (compared with 40.5 % of variation explainable by all axes). The vector plot can be interpreted as the effect of a given predictor variable (the longer the vector the bigger the effect). Red = high iron concentration; Yellow = medium iron concentration; Green = low iron concentration; Blue = Ambient

Although the sequential DISTLM model is a robust statistical technique, as well as being useful in that it partitions variability, it does not allow indirect or correlated effects to be assessed. In order to check that variables important to this study (i.e. iron) had not been omitted from the analyses due to association, the model was re-run with a backwards selection using AIC[7]. In this way, the backwards elimination model highlights (eliminates) those variables that are definitely not important in structuring the biological community and selects all those that are.

This second DISTLM (backwards AIC) confirmed that iron was not an important variable in driving community structure (Table 21). The backwards model eliminated 3 variables from the model in the following order: fine silt, medium silt and iron. The model selected 9 important variables in determining community structure (in no particular order): very coarse sand, coarse sand, medium sand, fine sand, very fine sand, very coarse silt, coarse silt, very fine silt, and clay.

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[7] "Backwards elimination begins with a full model containing all predictor variables. The variable which, when removed, results in the greatest improvement in the selection criterion is eliminated first. Variables are eliminated from the model sequentially until no further improvement in the criterion can be achieved" ibid.

Table 21: DISTLM results (backwards AIC). Sequential tests show which variables were eliminated from the analysis and in which order.

Sequential tests

Variable	AIC	SS (trace)	Pseudo-F	P	Proportion of variance explained	Cumulative proportion of variance explained	Residual degrees of freedom
Fine silt	260.85	0.0	0	1	0.0000	0.40463	24
Medium silt	260.06	887.7	0.82203	0.588	0.0204	0.38424	25
Iron	259.74	1281.1	1.1948	0.284	0.0294	0.35481	26

4.4 Discussion

The original aim of the recolonisation study was to address whether the concentration of iron in sediments was a key driver in the re-colonisation of infaunal community structure *in-situ* in the STB. However, even in 30 m water depth, the seafloor environment in the STB proved too dynamic to allow the placement of experimental sand treatments which could be recovered, at a later date, with the same sand still in place (without compromising the water flow/aeration of the experimental surface). As a result a comparison was made of the re-colonisation of high, medium and low iron treatments in the relatively sheltered waters of Wellington Harbour. The environment in Wellington Harbour is, of course, completely different from that in the STB. The experimental sites were shallower, and much less exposed to wave action and to currents than the proposed seafloor extraction sites in the STB. Moreover, the available pools of settling larvae were expected to be different in the two environments. Nonetheless, the experiment addressed a simple but pertinent question – does a reduction of iron concentration from background levels of >30% to approximately 3% lead to a biologically significant difference in the make-up of communities that colonise sandy substrates? We suggest this was a conservative test as the available faunal pool in Wellington Harbour was unlikely to have species present that were adapted to sediments with high iron concentrations.

All analyses carried out showed that iron concentration in sediments was not an important factor in determining community structure. Small differences in the sediment grain size distribution (see Figures 116 and 117) were more important in driving community structure than the large differences in the concentration of iron (see Figure 115).

The cause of between-site differences was not within the scope of this study and has not been investigated within this experiment. However, it is likely that differences in location (Evans Bay was more sheltered than Mahanga Bay) with respect to both exposure to disturbance (sediment scouring) as well as possible differences in hydrodynamics, water temperature, salinity and larval supply (supply side ecology) could also be potential driving factors in differences in community structure.

No weight should be placed on the finding that the samples taken from surrounding, natural, sediments were significantly different to samples taken from the experimental treatments. Cores from the surrounding, natural, sediments were taken to merely identify the naturally occurring dominant, small, infauna inhabiting the surrounding substrates which may contribute larvae to the experimental treatments and were not part of the hypothesis testing. In addition, although sites were selected to have a sandy seabed, particle size analysis of sediments from these samples showed that the surrounding sediments had higher percentages of silt than the experimental treatments. The experimental treatments were also likely exposed to altered hydrodynamics within the fish-bins compared with ambient samples. In addition, communities within ambient sediments would have been expected to be more mature and, therefore, subject to ecological processes such as succession, predation and competition to a different extent than the communities within the experimental treatments.

The experiment was run for 7 months. After this time, several of the dominant taxa found within treatments were "opportunistic species" (Gremare et al. 1989, Lu & Wu 2000, Lundquist 2012) such as copepods and small polychaetes (e.g. *Capitella capitata).* This suggests that the community structure could still be immature with respect to succession (Gremare et al. 1989) as species such as *C. capitata* could be expected to be less dominant in a more mature benthic community. The proposed iron sand extraction operations will be conducted in a highly dynamic sandy environment in the STB where much of the benthic community is regularly disturbed by storm waves (Hadfield 2011, MacDonald et al. 2012). Therefore, it is likely that the natural benthic community of the sandy habitat within TTR's target area is often in a phase of recovery following natural disturbance (e.g., Kroger et al 2006). As such, the timescale for this experimental study is considered appropriate despite the apparent relatively immature community studied.

Although significant differences in benthic faunal composition were found between sites but not between treatments (high, medium and low iron concentrations) it should be noted that the power of the statistical tests to detect significant treatment effects within this study proved to be relatively low. This was a direct consequence of the small effect of the large range of iron concentrations on the benthic fauna (the effect size). To reduce the possibility of a Type II statistical error (concluding there is no difference when there really is one), large numbers of replicates (approximately[8] 190) would have been required; this was impractical. However, the small effect size found within this experiment suggests that the amount of change expected with changing iron concentrations within sediments is small when compared with natural variability in abundance of the key species. In addition, neither the abundance plots, PERMANOVA or DISTLM routines suggest iron was a driving factor in community structure within the experimental units despite such large a gradient in iron concentration compared with other predictor variables

Direct extrapolation of results from the sheltered Wellington Harbour to the exposed STB is not possible as environmental conditions, and the potential supply of settling organisms are very different between regions. However, the lack of strong relationship between treatments (iron concentration) and community structure after 7 months of re-colonisation at both experimental sites (Mahanga Bay and Evans Bay) suggests that it is unlikely that iron concentration will be a key driver in the re-colonisation of disturbed sediments in the STB. This is consistent with the absence of any effect of iron concentration on the benthic faunas described in Section 3.

5 Overall Discussion

Video footage and still photography identified seven main habitat types within the broader Patea Shoals region of the STB. These include sand waves, rippled sands and small patches of rock outcrop on the inner shelf, rippled sands and wormfields on the mid-shelf, and low-lying biogenic habitats

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[8] Calculated *post-hoc* using data from the 12 key taxa (presented within figures 120 and 121) to estimate power, variance and effect size rather than on the whole community data used for multivariate analyses.

dominated by bivalve beds (live and shell-debris zones) and bryozoan/rubble habitats further offshore.

Epibenthic assemblages differed significantly between habitat types (Figure 17 to Figure 16), with motile bedforms supporting the most depauperate assemblages, while the deeper biogenic habitat supported highly diverse epibenthic assemblages dominated by suspension-feeding taxa. Video observations of these structurally complex and biologically diverse habitats, provided early feedback to TTR regarding the locations of potential deposition sites, and enabled early re-location of the initial proposed de-ored sand deposition area from deepwater to within the excavated areas of the PPA.

Data from the dredge survey enabled the species identification and enumeration of relatively sparse and species poor biological communities within the sandy substrata, and more structurally complex, species rich and higher biomass areas of both biogenic, relict shell, reef and rippled sand habitat towards the southwest of the study area. Biogenic habitats, however, were not intensively sampled with the dredge due to the fragile nature of the taxa occupying this habitat and as a result of the re-location of the de-ored sand deposition area which removed the necessity for detailed sampling of this area. The dredge data also allowed the detailed identification and quantification of many of the organisms observed in the video footage as well as small organisms and communities buried within the sand that could not be identified by video analysis.

The sediment core data enabled the quantification of smaller macro-infauna not well sampled by a dredge net, as well as sediment meiofauna. Remote sediment coring in sandy habitats is notoriously difficult and although the corer performed well in a variety of sandy substrata, cores were not able to be successfully collected in areas with high numbers of large shells and/or pebbles within the sand.

There were no significant differences in benthic community structure between the PPA and adjacent shelf areas for any of these datasets. The PPA comprised two seabed habitats and benthic community types: rippled sands supporting a relatively depauperate macrobenthic assemblage, and wormfield communities, dominated *Euchone* sp A. The seabed south of the PPA also supported extensive areas of rippled sands with few macrofauna, while the seabed to the north of the PPA was characterised by worm communities, also dominated *Euchone* sp A. Consequently, there was no evidence to suggest that the PPA was “unique” with respect to macrofauna collected or observed on the seabed during this survey. The distribution of these two benthic habitats/communities, suggests that the PPA may lie along a latitudinal transition between a northern *Euchone*-dominated region and the coarser more mobile sediment assemblage to the south. However, as very few studies have been undertaken across the mid-shelf region of the west coast, it is unclear what the larger west-coast scale distributions of these habitats are.

The PPA and adjacent-shelf areas supported significantly lower abundance and diversity of both infauna and epifauna than deeper offshore areas. Offshore habitats were characterised by bivalves, bivalve debris and bryozoan rubble that formed distinct biogenic habitats dominated by suspension feeding taxa. A build-up of biogenic material in these habitats meant that cores were physically unable to penetrate the seabed and therefore were unable to collect sediment samples from many of the offshore sites. However, sites that could be sampled, identified that offshore habitats supported significantly higher infaunal abundance and diversity than mid-shelf and inner-shelf habitats. Camera observations along with dredges and sediment cores identified that these offshore habitats were characterised by the large robust bivalve, *Tucetona laticostata*, living buried in the sediments and/or the shell debris from this species. The accumulation of shell-debris in a relatively narrow depth contour (~50-70 m water depth) in these offshore areas provides a low-relief biogenic habitat that in turn supports a diverse benthic assemblage. The remnant shells of this species enable a broad range of sessile species (e.g. bryozoan, sponges, colonial ascidians, brachiopods and epiphytic bivalves) to attach and grow. Encrusting invertebrates help bind and stabilise the shell debris, and provide further refuge for a wide variety of motile species (e.g. crabs, ophiuroids, holothurians, gastropods, and nudibranchs). Although these biogenic habitats occur within a narrow depth contour, these habitats appear to occur at similar depth ranges in other areas. Previous studies have found wide occurrence of bivalve dominated habitats within the Patea Banks area (McKnight 1974), with bryozoan habitat occurring in deeper water off the Patea Bank and continuing east towards Wanganui (Gillespie & Nelson 1998). National scale studies (NIWA 20/20 surveys, *unpublished data*) have also found bivalve shell-debris and bryozoan habitats at similar depths around the north and south islands of New Zealand.

Importantly, neither the video data, dredge data nor sediment core data (macro nor meiofauna) showed a significant relationship between iron concentration (% weight) and community structure. This finding is in agreement with the recolonisation experiment carried out in Wellington Harbour (Chapter 4). Direct extrapolation of results from the relatively sheltered experimental site to the exposed STB is not possible as environmental conditions, and the potential supply of settling organisms are very different between regions. However, the lack of strong relationship between treatments (iron concentration) and community structure after 7 months of re-colonisation at both experimental sites (Mahanga Bay and Evans Bay) suggests that it is unlikely that iron concentration will be a key driver in the re-colonisation of disturbed sediments in the STB.

Predictor variables used in the DISTLM analyses (examining relationships between community structure and environmental variables) included depth, distance from shore, concentration of iron, proportion of different particle size fractions of sediment (e.g. medium and fine sand), time-sampled. Physical variables explained between 25.6 % and 53.3 % of total variation, in the sediment core and meiofauna data respectively. The inclusion of a variable to reflect the “time since the last storm event” might further add to the explained variation as storms are known to move large volumes of sand around the study area (MacDonald et al. 2012). The majority of fauna were found to inhabit the top few centimetres of sediment (see sections 3.3 to 3.5) and it is likely that it takes some time for communities to re-establish in the top few centimetres after being buried by moving sand during a storm.

Biological organisms were important predictors of the seabed environment. Mid-shelf sediments were dominated by tubeworms, particularly the sabellid tubeworm, *Euchone* sp A Flat sediment bedforms were recorded in areas with high localised densities of this species. The dog cockle, *T. laticostata,* occurred in sediments across the outer shelf. Accumulation of shell material from this species provided the underlying biogenic structure for the later-colonising bryozoan and suspension-feeding assemblages that were characteristic of this deeper offshore environment.

The exposure of the STB and the study area to storms results in the shallow sandy habitat in the vicinity of the PPA, being a highly disturbed community. It was, therefore, unsurprising that the mid-shelf and inner shelf area supported low overall faunal abundance and species richness. The species that do occur here were either ubiquitous across the region and/or were typically mobile deposit feeders and small scavengers, phoxocephalid amphipods and other small crustaceans that are capable of recovery from regular natural disturbance such as burial and/or relocation (i.e. opportunistic early colonists (Lundquist, 2012)).

Ecological communities are complex interactive systems and it would be unrealistic to expect the majority of variation in benthic community composition to be explained by physical and temporal variables alone. Interactions among species (predation, competition, facilitation) are highly likely to play an important role, but describing and quantifying these was outside the scope of this study.

New species of bryozoan, sponge, annelids and algae, as well as new records for many groups for the region, were identified during the survey. This was not surprising due to the lack of detailed sampling within this part of the New Zealand shelf prior to this study. As a result these datasets have significantly contributed to the taxonomists (and ecologists) knowledge of the shallow west coast communities.

None of the species sampled are listed as threatened in the New Zealand Threat Classification System lists (Freeman et al. 2010). However, 6 mollusc genera are listed as naturally uncommon within the Department of Conservation's list of Threatened and At Risk New Zealand species, though it is unclear which species within these genera the DOC list applies to. This uncertainty may reflect the poor level of sampling within the New Zealand EEZ.

The thoroughness of this survey with respect to both spatial distribution of sampling sites and the sampling that was undertaken means that these data could be used as a baseline for future monitoring, if required.

6 Conclusions

1. Seven major habitat types were identified within the STB. These were sand waves, rippled sands and small patches of rock outcrop on the inner shelf, rippled sands and wormfields on the mid-shelf, while offshore zones contained low lying biogenic habitats dominated by bivalve beds (live and shell-debris zones) and bryozoan/rubble habitats.

1. Sand wave and rippled sands supported low abundances and species richness of both infauna and epifauna organisms.

2. Wormfields supported significantly higher abundances of infauna, but this pattern was driven by high but patchy densities of the Sabellid tubeworm, *Euchone* sp A, along with a few characteristic but low densities species. *Euchone* sp A, although common throughout the mid-shelf zone, appears to be an undescribed species.

3. The PPA supported similar infauna and epifauna to adjacent mid-shelf, with rippled sediments with few macrofauna found across the southern mid-shelf, while wormfields, dominated by *Euchone* sp A were found across the northern mid-shelf. Overall the inner and mid-shelf zones, supported low abundance and diversity of macrofauna, meiofauna and marine algae, characteristic of highly disturbed shelf environments.

4. Biogenic habitats present in deeper areas offshore of the PPA supported significantly higher diversity and abundance than mid-shelf and inner-shelf zones. These offshore habitats were characterised by both early-colonising bivalve/rubble epifauna in the shallower (45-60 m) offshore depth zones, and late colonising bryozoan/rubble assemblages in the deeper (>60 m) offshore zone. Previous research has identified similar biogenic habitats and associated

assemblages in similar depth zones along the west coast of the north and south islands of New Zealand.

5. New species of bryozoan, sponge, annelids and algae, as well as new records for many groups for the region, were identified during the survey. This was not surprising given the previous lack of detailed sampling within this exposed region of New Zealand.

6. None of the species collected during the survey are listed as threatened in the New Zealand Threat Classification System lists. However, 6 mollusc genera are listed as naturally uncommon within the Department of Conservation's list of Threatened and At Risk New Zealand species, although it is unclear which species within these genera this list applies to. This uncertainty may reflect the poor level of sampling within the New Zealand EEZ.

7. Biological organisms may be important predictors of the seabed environment. The presence of *Euchone* sp A, for example, was correlated with flatter bedforms and fine to medium coarse sediments, while, habitat-forming bivalves and bryozoan provide substantial, albeit low-relief, biogenic structure in the deeper offshore environment.

8. The concentration of Vanadium Titano-Magnetite in the surface sediments appears to play an insignificant role in structuring marine benthic communities in the study area. This is further supported by results of the recolonisation experiment which showed that the concentration of iron in sediments was not a key driving factor in the re-colonisation of soft-sediment (sandy) communities at either of the Wellington Harbour study sites.

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Appendix A Revised multivariate analyses (Feb 2014).

Dr Tara J. Anderson.

Information presented in this appendix is based on "Anderson, T.J. 2014. *Statement of Evidence in Chief of Dr Tara Anderson on behalf of Trans-Tasman Resources Ltd*. Evidence prepared for Environment Court in the application for Ironsands extraction offshore in the South Taranaki Bight, submitted 14 February 2014 (EEZ000004-26-A[9] Statement; EEZ000004-26-B[10] Appendix B - Figures and Tables), and presented 2 April 2014."

Summary:

Although Patea Shoal habitat types supported significantly different benthic assemblages, mining sites (reduced extent) did not differ significantly from non-mining sites in either the video, epifaunal dredge or infaunal core datasets. This was because the two habitat types present within the PPA (i.e. wormfields and rippled sands) were also common in non-mining areas, albeit distributed inversely alongshore with wormfields in the mid-to-north while expansive rippled sands occurred in the lower section of the mining area and south. The majority of key epifaunal and infaunal species/taxa were more abundant in non-mining sites, or were absent from mining sites. In contrast, the Sabellid worm, *Euchone* sp A - that characterised the wormfields - was significantly more abundant in mining sites, but other than higher abundances of this worm there was no evidence within any of the datasets to suggest that the PPA is "unique" with respect to sediment characteristics or benthic organisms. Iron concentrations were positively correlated with very fine sands, but did not appear to play a significant role in structuring marine benthic communities within the Patea Shoals region.

Background and Methodology

At the time of writing and submitting the original Beaumont, et al (2013) NIWA Client Report No: WLG2012-55, TTR's Proposed Project Area (PPA) extended inshore of the 12 nm limit, and included a deposition site south of the PPA (referred to as the 'proposed tailings area') (Figure 1). The revised PPA and project design, meant that while Beaumont et al (2013) contained the relevant biological and physical data and benthic descriptions for STB region, the allocation of these data to mining, deposition and non-mining sites and the multivariate analyses – specifically, analytical comparisons presented in Sections 3.1.2 (Multivariate analysis: Coastcam2 data, p33), Section 3.2.3 (Multivariate analysis: Dredge data, p57), and Section 3.3.4 (Multivariate analysis of macro faunal data: 0-5 cm core fraction, p81) - were no longer relevant to the final PPA boundaries and project design. To rectify this,in Feb 2014 sampling sites for the video, epifaunal dredge, and infaunal core datasets were reclassified relative to the revised PPA boundaries (here referred to as Area2), and then re-analysed following the methods presented in Beaumont et al. (2013 – section 2.4.2). These revised analyses now compare species densities and community structure between the revised-mining and non-mining areas.

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[9] http://www.epa.govt.nz/eez/EEZ000004/EEZ000004_26_Tara%20Anderson_(Benthic%20Ecology).PDF

[10] http://www.epa.govt.nz/eez/EEZ000004/EEZ000004_26B_Tara%20Anderson_(Benthic%20Ecology).PDF

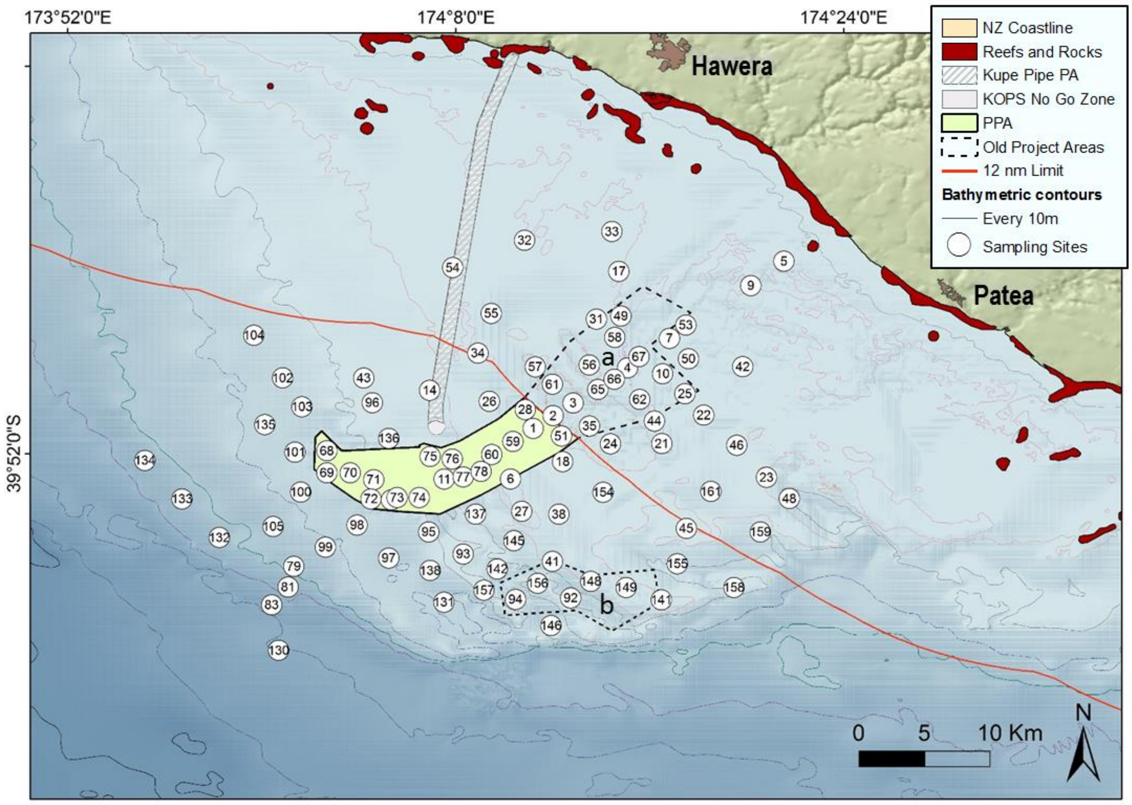

Figure 1: Benthic ecology sampling stations relative to TTR's mining and extraction changes. 2014-15 Proposed Project Area (PPA) now reduced to the area offshore of the 12 nm limit for both extraction & deposition; locations of a and b indicate the old proposed mining and deposition (proposed tailing area (PTA)) boundaries, respectively.

Additional analyses were also undertaken in Feb 2014 to determine the relationship between community structure and habitat types (rippled sediments, wormfields, etc.) and sediment grain size (measured using the laser grain sizer and calculated in Gradistat software package that examines sediment grain size distributions) to gauge how community structure might predictably change if habitat changed, or deposited mined-sediments in the PPA were finer or coarser than those removed. To examine epifaunal and infaunal community structure relative to both habitat type and cross-shelf zones, the revised dbRDA plots were colour-coded by habitat type and distinguished by cross-shelf zones. To examine the relationship between infaunal community structure and sediment grain size, I ran a Canonical Correlation Analysis on the infaunal replicate core-level data matrix using the CanCorr procedure in SAS[11], and then plotted the total structure coefficients of the common infauna (>15% occurrence) in habitat space. As only a subset of sites were processed using the Gradistat analyses (n=224 of the 331 replicate cores), only those sites with Gradistat grain size data were included in the CanCorr. Results of these revised and additional analyses are presented below.

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[11] SAS Copyright (c) 2002-2008 by SAS Institute Inc., Cary, NC, USA version 9.2. SAS Systems is a Statistical Analysis Software package that integrates data access, data management, analysis and presentation.

Results

The revised Proposed Project Area (PPA) occurs on the midshelf in water depth of 20-55 m and covers two of the seven habitat types: ‘rippled sands’ in depths of 20-30 m and ‘wormfields’ in the depths of 30-55 m (described in Section 3.1.1 Benthic habitat and assemblage, p25 and Figure 7 of the main report). Although these two habitats supported significantly different benthic assemblages (Table 1 and Table 3), the revised mining and non-mining sites did not differ significantly (ANOSIM, $p<0.05$) in either their overall habitat structure (Figure 2 and Figure 3), or in their total epifaunal (Figure 4 and Figure 5) or infaunal (Figure 9 and Figure 10) assemblages. This was because both habitats were widespread across the midshelf, albeit distributed inversely alongshore with wormfields in the mid-to-north, bordering expansive rippled sands from the mid-to-south. Both habitats also occurred less commonly inshore.

Rippled sands – in both mining and non-mining sites - supported low abundance and diversity of both epifauna ($\bar{x}$ 44.8 ± 6.0 indiv. and 10.5 ± 1.3 species p/250m^2) and infauna ($\bar{x}$ 18.3 ± 0.5 indiv. and 8.0 ± 0.5 species p/664 cm^2) , and did not differ significantly from assemblages in sand wave habitats inshore or *Tucetona* habitats further offshore (Table 1 and Table 3). Similarly, the slightly deeper *Tucetona* beds supported an assemblage of epifauna and infauna taxa that overlapped with assemblages from shallower rippled sands and deeper bivalve rubble habitats (Figure 6), indicating a progressive shift in assemblage structure offshore, rather than clear demarcations.

In contrast, wormfields were significantly different to all other habitat types (ANOSIM, $p<0.01$) in both their epifaunal (Table 1, Figure 6) and infaunal assemblages (Table 3, Figure 11). Wormfield habitats (PPA-north) supported intermediate epifaunal abundances and richness ($\bar{x}$ 128.2 indiv. ± 21.6 and 19.5 ± 2.2 species p/250m^2), with higher abundances of infauna ($\bar{x}$ 45.5 ± 3.8 indiv. and 12.2 ± 0.5 species p/664 cm^2) - driven by significantly higher, albeit patchy, densities of the Sabellid tubeworm, *Euchone* sp A ($\bar{x}$ 1,137.5 ± 182.0 indiv. p/m^2) along with a few characteristic but much lower density species (Aricidea nd[12], *Cyclaspis* sp, Lysianassoidea, Photidae, Phoxocephalidae sp1) (Figure 16). Mean abundance of *Euchone* sp A was significantly higher within the PPA than non-mining sites (Figure 15), including north of the PPA where wormfields were common (Figure 16b). Conversely, other wormfield species were either more abundant in the mid-north (e.g. Photidae) or did not differ between the PPA and mid-north (e.g. Aricidea nd) (Figure 16b).

Taxa distribution plots along with similarity/dissimilarity analyses identified that the PPA and adjacent midshelf and inshelf habitats supported low numbers of organisms and species, typical of highly disturbed shelf sediments (MacDiarmid et al., 2010). Most key epifaunal and infaunal species/taxa were either more abundant in non-mining sites (e.g. *Glycymeris modesta*, syllids nd, micro nemertean nd, and nematodes nd, *Pisione oerstedii*), ecologically absent from mining sites (e.g. Dorvilleid sp A, *Perkemavella punctigera*), or exhibited no significant difference between mining and non-mining sites (e.g. the hermit crabs, *Lophopagurus* spp. and *A. setosus*, para syllids) (Figure 7 and Figure 15). These species were also relatively ubiquitous across all habitat types (Figure 8 and Figure 17), with the exception of *G. modesta* and para syllids which were positively correlated with inshore habitats, and *Myadora* spp, which was only common in bivalve rubble and rippled sand habitats (Table 2, Table 4, Figure 8 and Figure 17). In contrast, the Sabellid worm, *Euchone* sp A, which characterised the wormfields, was the only key benthic species that was significantly more abundant within the PPA than adjacent non-mining areas (Figure 15, but also see *Tubilipora* sp., below).

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[12] nd = species-level not determined

Euchone sp A were strongly associated with fine sands (x̄ grain size: 248.5 ± 4.9, range approx. 182-331 um) in northern and middle latitude sites (Table 4 and Figure 14), although it is unclear whether this is a pre-requisite for the worms or the consequence of worm densities trapping fine sediments. Other wormfield-associates were either more abundant in non-mining sites north of the PPA (e.g. the amphipods: Lysianassoidea and Photidae) or did not vary significantly between mining and the non-mining sites north (e.g. (e.g. Aricidea nd, *Cyclaspis* sp, Phoxocephalidae sp1) (Figure 14 and Figure 16). Although the bryozoan, *Tubilipora* sp., was significantly more abundant in mining than non-mining sites when examining grand means (Figure 7; ANOSIM p<0.05), closer examination by habitat type and zone found that while almost all specimens were collected from wormfield habitats (both inside and outside of the PPA, Figure 8a), densities were significantly higher in the non-mining worm-field sites to the north of the PPA than inside the PPA (Figure 8b).

Sediment characteristics varied both alongshore and offshore (described in Section 3.3.1 Sediment characteristics, p63 and Figure 37 of the main report). Alongshore, sediment composition varied along a north to south gradient across the midshelf and inshelf. Northern and deeper mid-latitude sites (i.e. wormfields) were characterised by higher percentages of fine and very fine sands and the absence of gravels (Figure 12; and Figure 45 of the main report). Conversely, southern sites and shallower-mid latitude sites (i.e. rippled sands) were characterised by higher percentages of coarse sands and gravels (Figure 12; and and Figure 45 of the main report). Offshore (>~50 m), sediments were characterised by a more poorly sorted, diverse mixture of coarse sands, gravels and silts (Figure 12). Inside the PPA, mining sites were characterized either by fine and very fine sands in water depths > 30 m, or by coarse sands with gravels in depths < 30 m (Figure 11 and Figure 12a); however, these sediment characteristics were also shared with non-mining sites in the mid-north and mid-south, respectively (Figure 11 and Figure 12b).

Habitat types and their sediment characteristics were important in describing infaunal assemblage structure (Table 1, Table 3, and Figure 14). Wormfields within the PPA (mining sites) and in the northern midshelf zones (non-mining sites) shared similar sediment characteristics (Figure 12) and benthic assemblages (Figure 14). Sediments in these two zones were characterized by well sorted (x̄ 1.41 ± 1.28 um S.E.) fine grained sands (x̄ grain size: 248.5 ± 4.9, range approx. 182-331 um) and distinct communities characterised by *Euchone* sp A, Aricidea nd, *Cyclaspis* sp, Lysianassoidea, Photidae, Phoxocephalidae sp1.

Conversely, the rippled sands within the PPA (mining sites) and to the south (non-mining sites) were characterized by a broader range of significantly coarser grained sands and gravels (x̄ grain size: 500.8 ± 13.9, range 300-781 um; ANOVA p<0.0001), although sediments were still well sorted (Figure 12). Rippled sand communities were characterized by a much wider variety of species, including but not limited to syllids nd, Dorvilleid sp A, *Pisione oerstedii*, micro nemertean nd, and nematodes nd (Figure 14).

Biogenic habitats (i.e. bivalve rubble and bryozoan rubble) were deeper, further offshore, and were characterized by more poorly sorted sediments (x̄ 6.4 ± 0.81 um) reflecting the combination of very fine grained silts along with much coarser sands and gravels (x̄ 157.8 ± 26.7, range 96-327 um). These deeper habitats were characterised by the absence of common infauna and lower numbers of key infaunal species (Figure 14, Figure 16 and Figure 17), although care in interpretation should be taken here as only a few sediment cores were successfully collected in these rubble habitats.

Inshelf habitats were more diverse in their sediment composition (Figure 14). Inshelf sediments were well sorted but ranged from very coarse-grained rippled sands to very fine-grained wormfields (Figure 13 and Figure 15). Inshelf sediments, like those in the offshore zone, were very negatively ‘or finely' skewed in their distribution (indicating a tail of finer particles), this was in contrast to the slightly positive 'more symmetrical' distributions of the wormfields and the slightly more positive 'coarsely skewed' distributions of the rippled sands (indicating a tail of coarser particles) (Figure 12).

The percentage of iron in core sediments (by weight) was strongly and positively correlated with very fine sands, and strongly negatively correlated with increasing depth (Multiple Regression $p<0.0001$; Figure 13). Percentage iron, however, does not appear to play a significant role in structuring marine benthic communities within the Patea Shoals region. Percent iron did vary significantly between wormfield and non-wormfield habitats (all other habitats combined) (One Way ANOVA $p< 0.05$). However, this appeared to reflect a spatial overlap in distributions (i.e. they occur in the same area) reflecting different sediment correlations (i.e. iron with very fine sands and wormfields with fine sands), as no significant linear relationships were found between % iron and either *Euchone* sp A or other key taxa (Table 2 and Table 4). Numerous species were weakly negatively correlated with iron (Table 2 and Table 4), but this appeared to reflect their association with rippled sands in the south where iron concentrations were low.

Coastcam Video Analyses (for revised Mining Area)

Reanalysis of the coastcam data given the new Area2 designation, found that the revised Mining and Non-Mining sites did not significantly differ in their visible physical and epifaunal composition (ANOSIM, p>0.05) (Figure 2 and Figure 3). Mining sites were characterized physically, by medium, fine and very fine sands, but these characteristics were also common in other non-mining sites (Figure 3).

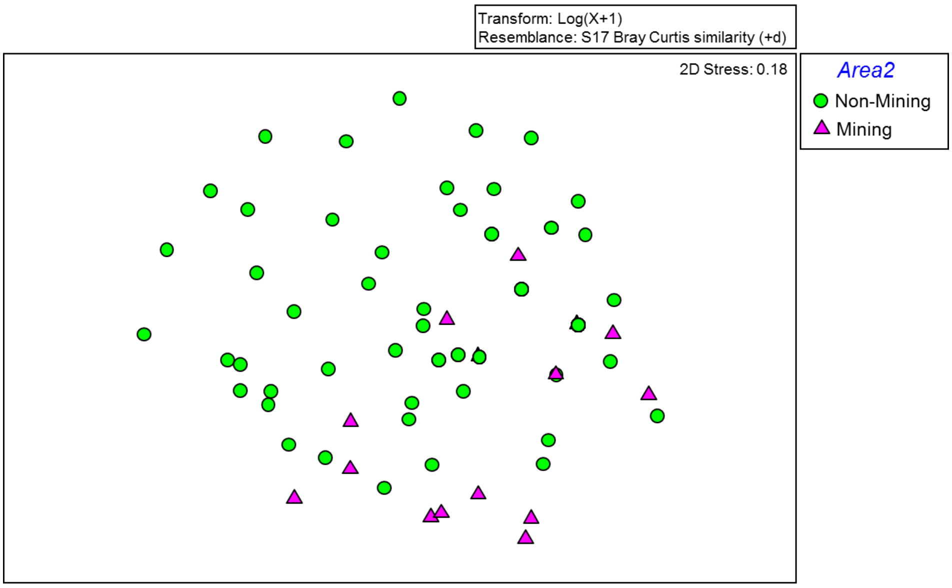


Figure 2: Revised nMDS plot showing the Coastcam2 data according to the revised Mining and Non-Mining areas (here termed 'Area2'). Revised ANOSIM analyses for Area2 found that Mining and Non-Mining sites for the Coastcam data were not significantly different (ANOSIM, p>0.05).

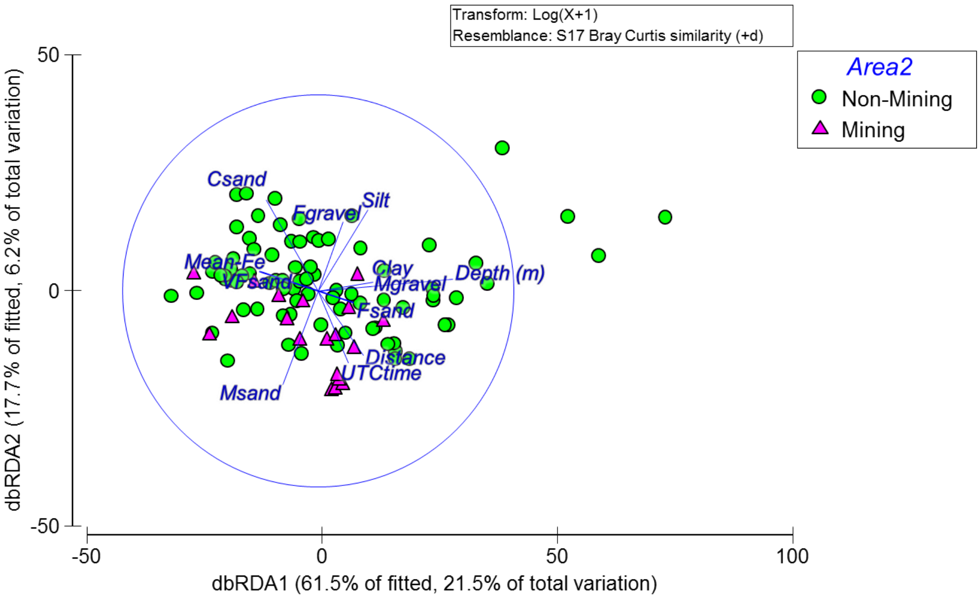


Figure 3: Revised dbRDA plot of the Coastcam2 data, for the revised Mining and non-mining areas (here termed 'Area2'). Sediment variables are percentages (VFsand=Very Fine sand; Fsand=Fine sand; Msand=medium sand; Csand=Coarse sand; VFgravel=Very Fine gravel; MCgravel=Medium Coarse gravel); distance=Distance from shore; Mean-Fe= Mean Iron content.

Epifaunal Dredge Analyses (for revised Mining Area)

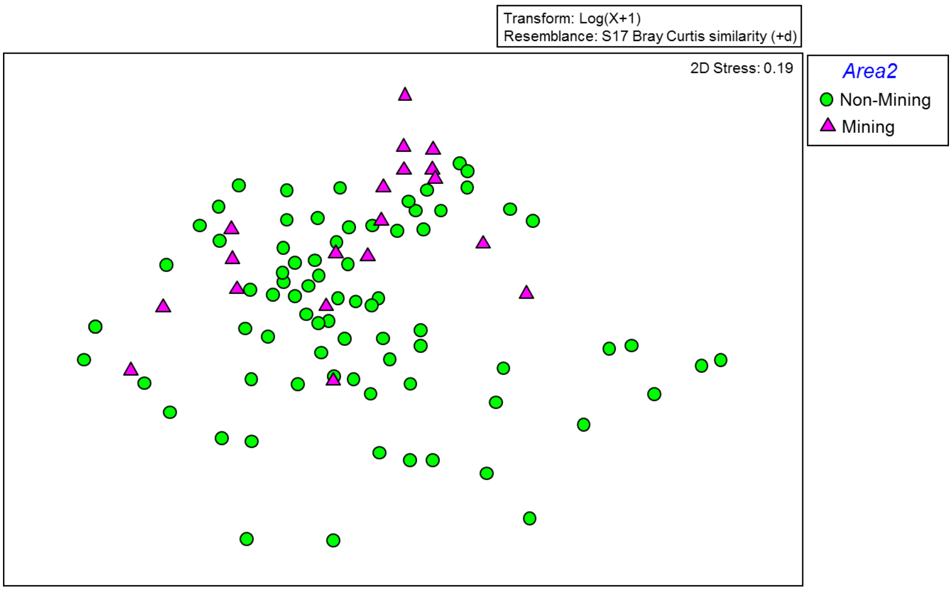


Figure 4: Revised nMDS plot showing the similarities of the community structure at each of the sandy sites, colour coded for area2 (revised Mining vs Non-Mining sites). In these analyses, only sites with corresponding sediment data were included (n=96 of the 117 dredge sites) replicating the earlier analyses of Beaumont et al. (2013). Analyses reflect mostly mid-shelf and inshore comparisons, as only 10 offshore sites (4 Tucetona, 5 bivalve rubble and 1 bryozoan rubble) had sufficient sediment data for inclusion in these analyses (NB: 19 offshore sites, 1 mid-shelf site [site 150], and 1 onshelf site [site 7] were dropped). Revised ANOSIM analyses for Area2 found epifaunal assemblages on the midshelf and inshelf did not differ significantly between Mining and Non-Mining sites (ANOSIM, p>0.05).

Table 1: ANOSIM pairwise results for epifauna (midself and inshelf sites only): percentage dissimilarity between sites by habitat type. ** + bold values indicate highly significant differences (p < 0.01), * + italised values indicate significant (p < 0.05), ns= not significant. NB: only 6 of the 25 Bivalve rubble sites are included in this analysis, due to the absence of associated sediment data, so habitat comparisons with bivalve rubble habitats should be interpreted with care.

Factors	Rippled	Tucetona	Bivalve Rubble	Outcrop	Sand Wave	Wormfields
Rippled	-	-	-	-	-	-
Tucetona	ns	-	-	-	-	-
Bivalve Rubble	**0.5692****	ns	-	-	-	-
Outcrop	*0.4009**	ns	ns	-	-	-
Sand Wave	ns	*0.4507**	ns	ns	-	-
Wormfields	**0.2201****	**0.6504****	*0.5309**	**0.7497****	**0.5388****	-

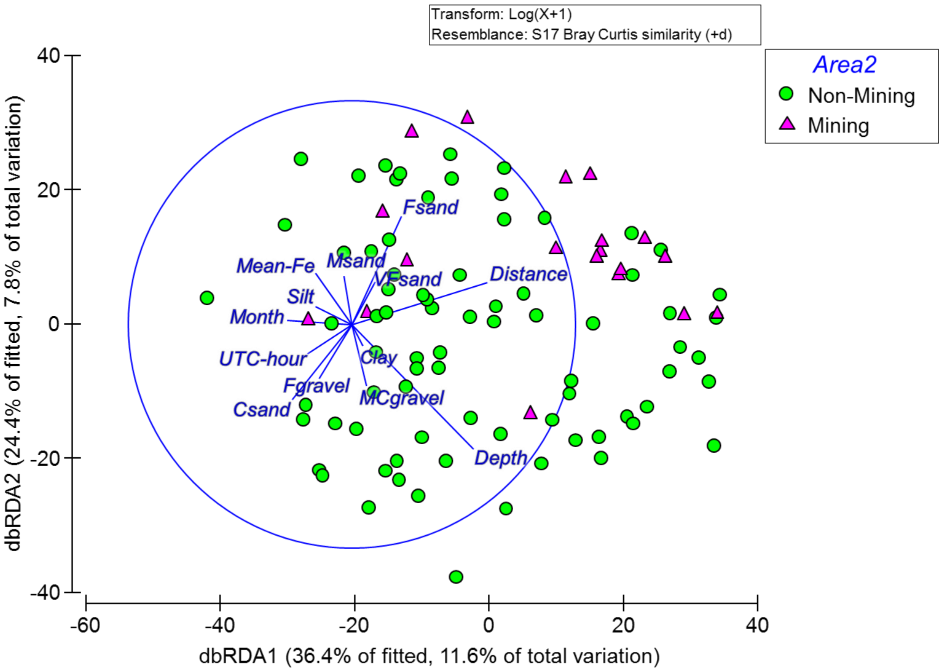


Figure 5: **Revised dbRDA plot of the dredge data for area2 (revised Mining vs Non-Mining sites).** The two axes explain 19.4 % of total variation compared with 31.9% variation explained by the DISTLM). Only sites with corresponding sediment data were included in these analyses (n=96 of the 117 dredge sites) as defined in Figure 4.

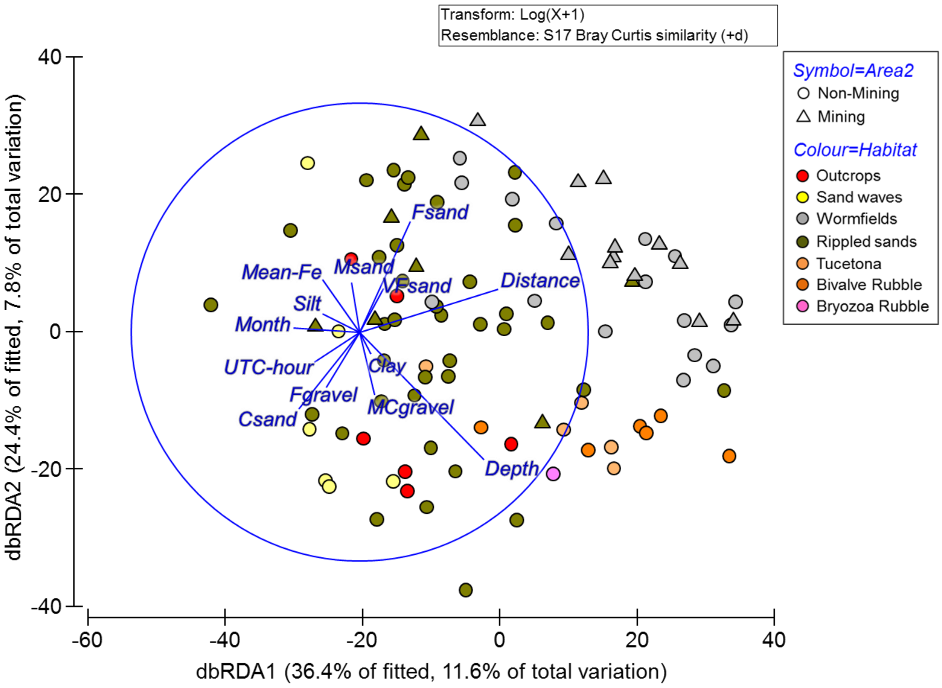


Figure 6: **dbRDA plot of the dredge data for a) Habitat types and b) Cross-shelf zones).** Sediment variables are percentages with VFsand=Very Fine sand; Fsand=Fine sand; Msand=medium sand; Csand=Coarse sand; VFgravel=Very Fine gravel; MCgravel=Medium Coarse gravel; Mean-Fe = mean iron content of the sediments; Distance=distance to shore.

Table 2: Multiple regression table of common epifaunal taxa (>15% occurrence) with spatial position and benthic habitat variables. The strength of correlations is indicated by font. >3.5 bold = strong correlation, 3.5-1.5 normal = moderate correlation, <1.5 italic = weak correlation, underline = negative correlation. Latitude Position (North, Middle, South); location offshore (Inshelf, Midshelf, Offshelf); sediment type (VFsand=Very Fine sand; Fsand=Fine sand; Msand=medium sand; Csand=Coarse sand; VFgravel=Very Fine gravel; MCgravel=Medium Coarse gravel; Iron =iron content of core sediments).

Epifaunal Taxa	Latitude	Cross-Shelf Position	Sediment Type	RSQ	AdjRSQ
Amalda (Baryspira) australis	-	-	-	*ns*	*ns*
Areopaguristes setosus	North			0.4004	0.3148
Austrofusus glans	-	-	-	*ns*	*ns*
Bellidilia cheesmani	-	-	-	*ns*	*ns*
Bicrisia edwardsiana	Middle	Offshelf		0.2278	0.1174
Costaticella bicuspis	North	Offshelf	Iron	0.2971	0.1967
Diacanthurus spinulimanus	-	-	-	*ns*	*ns*
Disporella novaehollandiae		Midshelf-Offshelf		0.2622	0.1568
Emma crystallina	North	Midshelf-**Offshelf**		0.3862	0.2985
Glycymeris modesta		**Inshelf**	Coarse Sand, Iron	0.4072	0.3225
Hemerocoetes monopterygius	-	-	-	*ns*	*ns*
Liocarcinus corrugatus	South	Midshelf	VFsand, Msand, **MCgravel**, Silt	0.2217	0.1105
Lophopagurus 2spp	-	-	-	*ns*	*ns*
Nectocarcinus antarcticus		Inshelf	VFsand, Msand, MCgravel	0.2409	0.1325
Notromithrax peroni		Offshelf	Fine Sand, Msand, Silt, Iron	0.4386	0.3583
Pecten novaezelandiae		Offshelf	MCgravel,Silt	0.2341	0.1247
Scalicella crystallina	-	-	-	*ns*	*ns*
Tanea zelandica	-	-	-	*ns*	*ns*
Tubulipora sp epizoic	North	**Offshelf**	Silt, Iron	0.4594	0.3821
nemerteans nd	-	-	-	*ns*	*ns*
Species Richness		**Offshelf**	Msand, Fgravel	0.2953	0.1946
Total Abundance	-	-	-	*ns*	*ns*

NB: silt only occurred in the biogenic habitats offshore, so positive or negative correlations with silt are likely to reflect positive or negative correlations with biogenic habitats offshore, driven by only a very few biogenic sites retained in these analyses, although often highly abundant catches were collected from these sites. Negative correlations with Iron are likely to reflect an indirect association with other confounding/suppressor variables as these relationships were often absent in stepwise/forward/backward regression models and simple correlations.

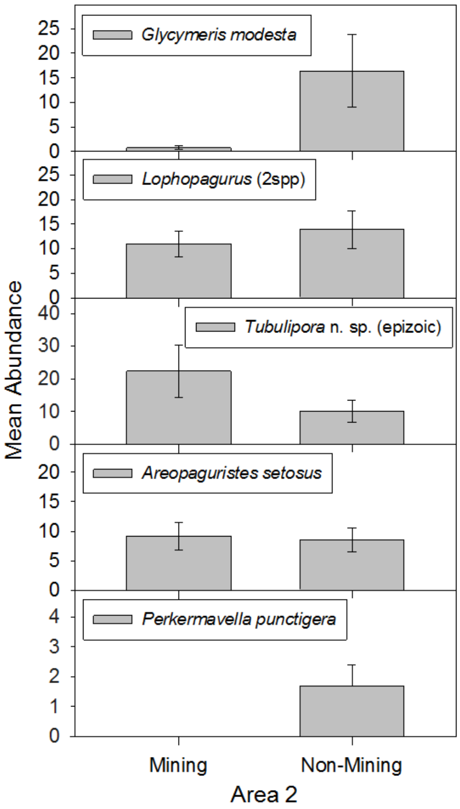


Figure 7: **Revised distributions of key epifaunal species collected from the Dredges within the revised Mining and Non-Mining areas (Area2).** Those species/taxa which had greater than 5% contribution to community structure and/or dissimilarities between areas. Mean values with standard deviations.

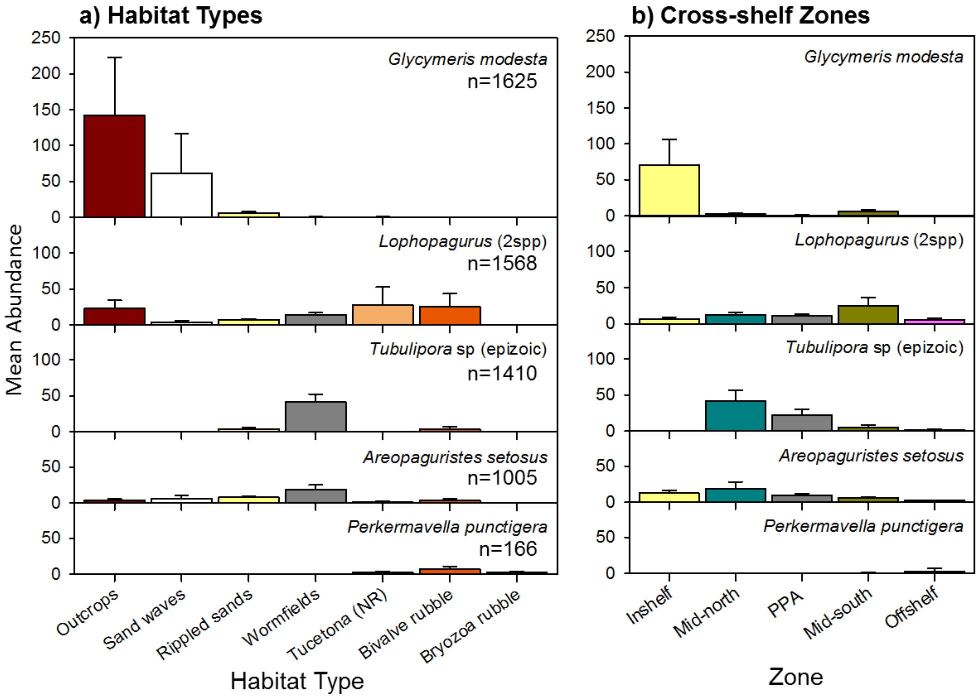


Figure 8: **Mean abundance of key epifaunal species collected from the dredges relative to a) Habitat types, and b) Cross-shelf zones.** Those species/taxa which had greater than 5% contribution to community structure and/or dissimilarities between areas. Mean values with standard deviations.

Infaunal Sediment Core Analyses (for revised Mining Area)

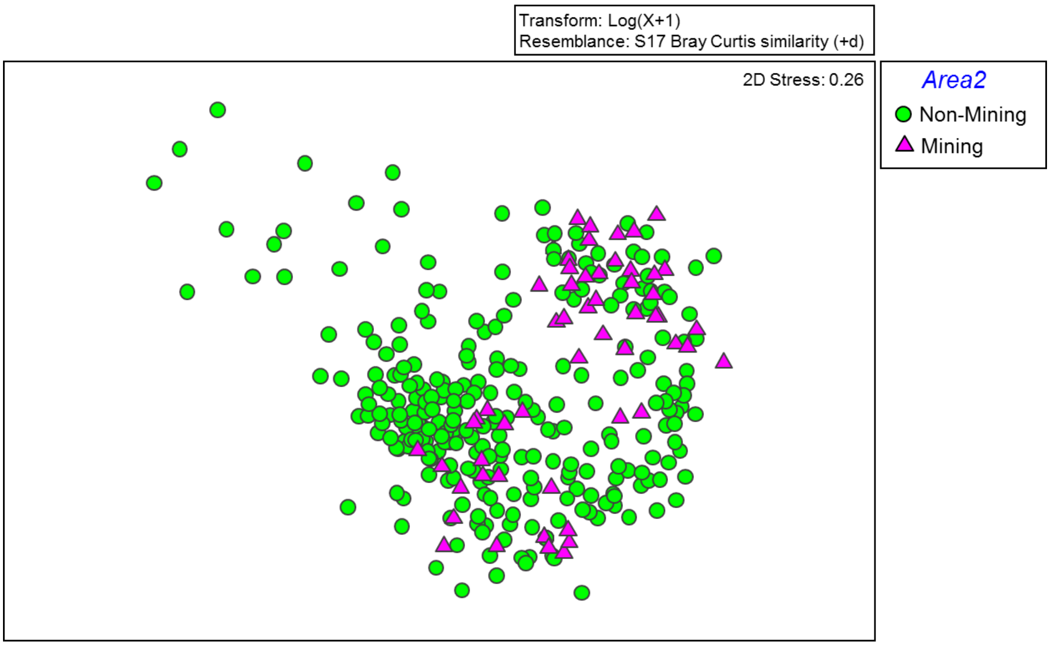


Figure 9: Revised nMDS plot of infaunal core data (0-5 cm fraction) for area2 (revised Mining vs Non-Mining sites). Revised ANOSIM analyses for Area2 found that the infaunal assemblage did not significantly differ between Mining and Non-Mining sites (ANOSIM, p>0.05).

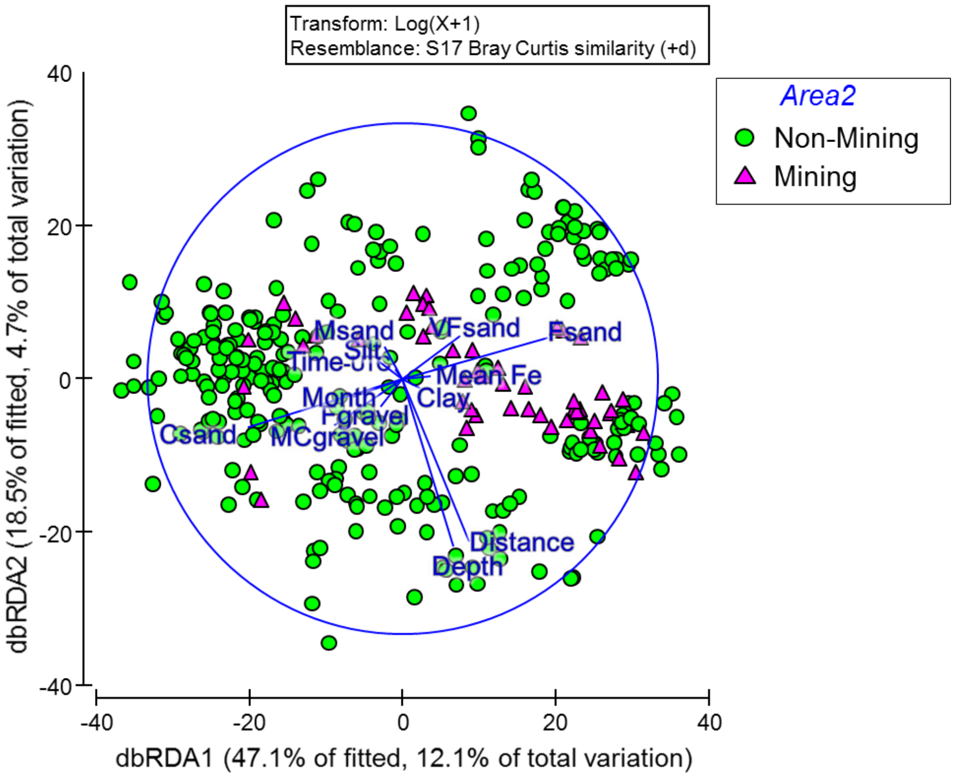


Figure 10: Revised dbRDA plot of the infaunal core data for area2 (revised Mining vs Non-Mining sites). Sediment variables are percentages with VFsand=Very Fine sand; Fsand=Fine sand; Msand=medium sand; Csand=Coarse sand; VFgravel=Very Fine gravel; MCgravel=Medium Coarse gravel.

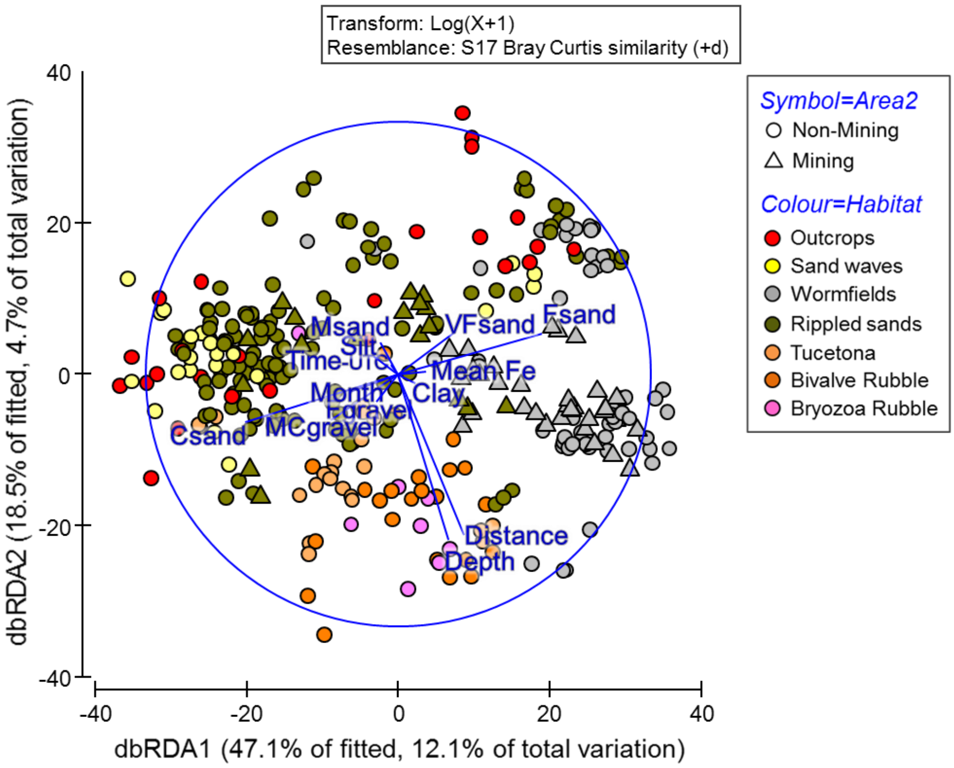


Figure 11: **Revised dbRDA plot of the infaunal cores by a) habitat types and b) cross-shelf zones.** Sediment variables are percentages (VFsand=Very Fine sand; Fsand=Fine sand; Msand=medium sand; Csand=Coarse sand; VFgravel=Very Fine gravel; MCgravel=Medium Coarse gravel); distance=Distance from shore; Mean-Fe= Mean Iron content.

Table 3: **ANOSIM pairwise results for infauna: percentage dissimilarity between sites by habitat type.** bold values indicate highly significant differences (p < 0.01), italised values indicate significant (p < 0.05), ns= not significant.

	Rippled	Bivalve rubble	Tucetona	Wormfields	Outcrop	Sand waves	Bryozoan rubble
Rippled	-	-	-	-	-	-	-
Bivalve	**0.4963**	-	-	-	-	-	-
Tucetona	ns	**0.1383**	-	-	-	-	-
Wormfields	**0.5636**	**0.7497**	**0.6846**	-	-	-	-
Outcrop	ns	**0.3081**	**0.1663**	**0.5694**	-	-	-
Sand waves	ns	**0.3676**	**0.2248**	**0.6993**	ns	-	-
Bryozoan rubble	**0.7917**	*0.2685*	**0.6139**	**0.9102**	**0.7092**	**0.8606**	-

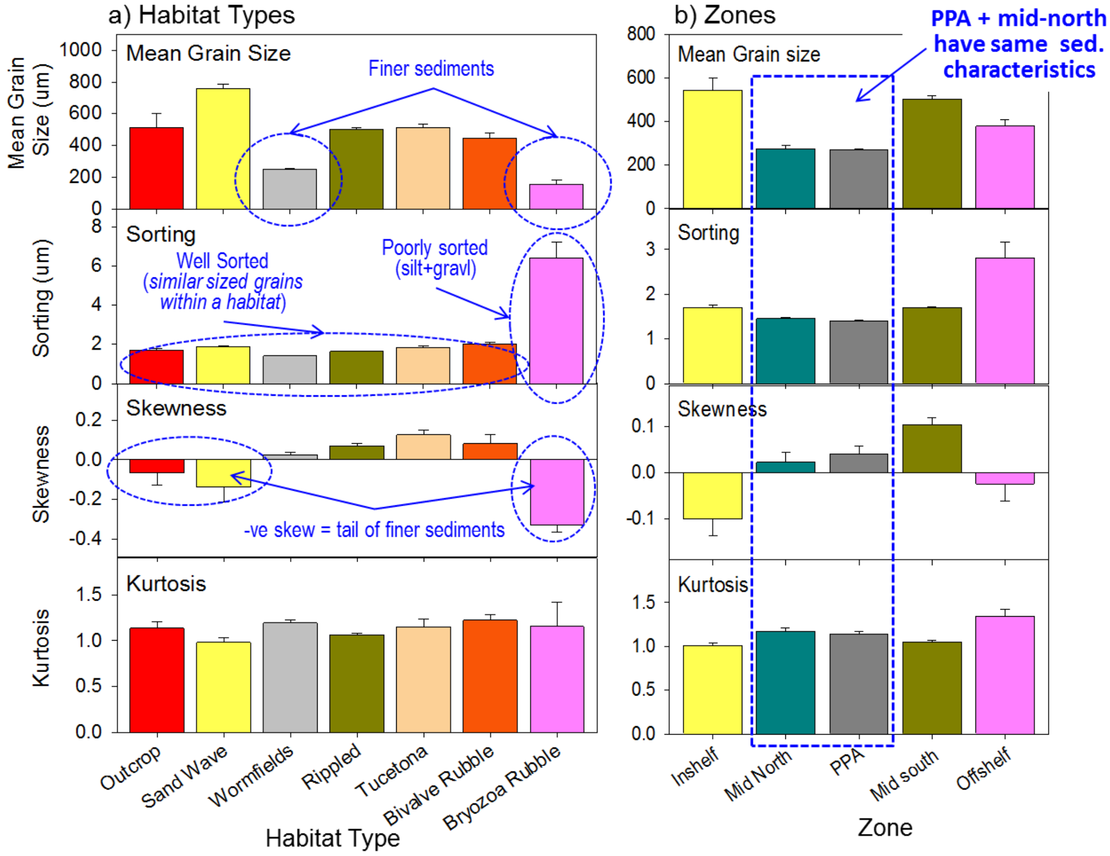


Figure 12: **Laser-sized sediment characteristics by a) habitat types, and b) zones.** Plots represent Gradistat sediment variables (Mean grain size, sorting, skewness and Kurtosis) for 224 sites.

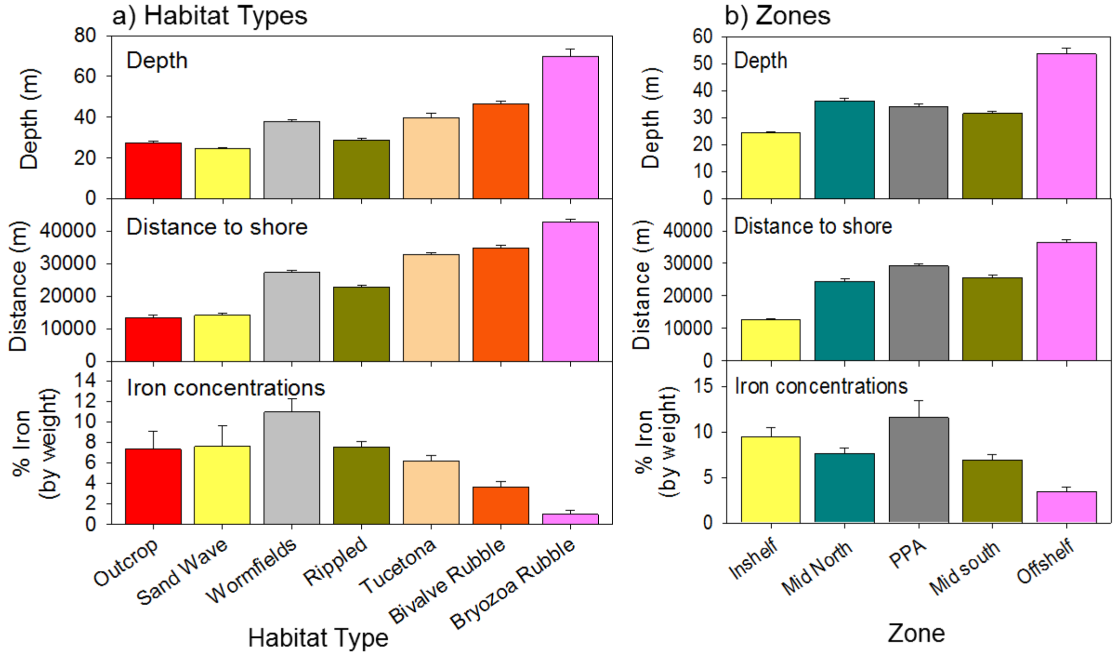


Figure 13: **Physcial characteristics by a) habitat types, and b) zones.** To provide direct comparison with Gradistat cores, plots here represent the same 224 Gradistat core sites.

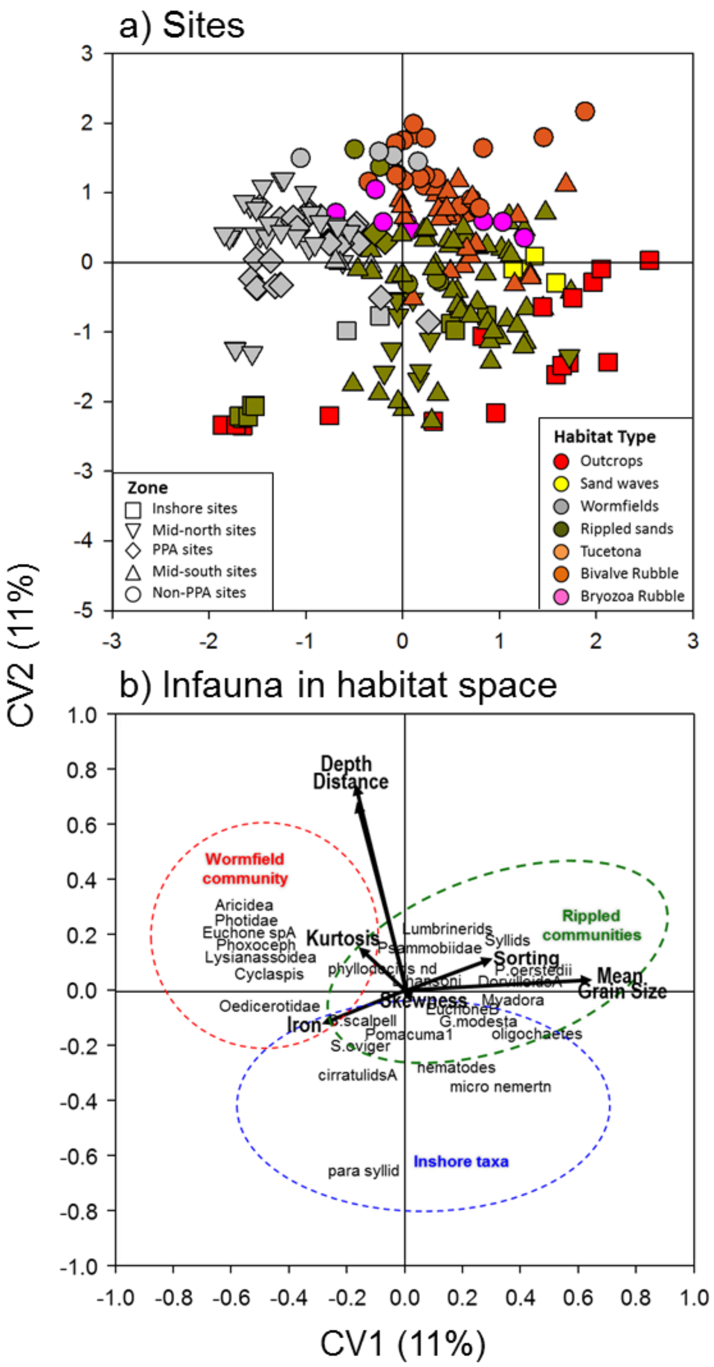


Figure 14: **Canonical Correlation of infauna in habitat space.** a) Sites coded by habitat type (colours) and zonal position (symbols) [n=224 sites], and b) Infaunal species/taxa plotted in habitat space (physical and laser-sized Gradistat sediment variables).

Table 4: Multiple regression table of common infaunal taxa (>15% occurrence) with spatial position and benthic habitat variables . The strength of correlations is indicated by font. >3.5 bold = strong correlation, 3.5-1.5 normal = moderate correlation, <1.5 italic = weak correlation, underline = negative correlation. Latitude Position (north, middle, south); location offshore (inshelf, midshelf, offshelf); sediment type (VFsand=Very Fine sand; Fsand=Fine sand; Msand=medium sand; Csand=Coarse sand; VFgravel=Very Fine gravel; MCgravel=Medium Coarse gravel; Iron =iron content of core sediments).

Infaunal Taxa	Latitude	Cross-Shelf Position	Sediment Type	AdjRSQ	RSQ
Aricidea nd	Midshore	**Offshelf**	**Fine Sand**, **Silt**, Iron	0.3559	0.3798
Cirratulids nd A	North	**Inshelf**	**VFsand**, Msand, **Fgravel**, MCgravel, **Iron**	0.3002	0.3261
Cyclaspis sp	North	Inshelf	Fine Sand, VFsand, Msand, Silt	0.3072	0.3328
Dorvilleids spA	South		Coarse Sand, Fgravel, *MCgravel*	0.2330	0.2614
Euchone spA	North, Middle	Midshelf-**Offshelf**	Fine Sand, Msand, Silt	0.1708	0.2015
Euchone spB	South		VFsand	0.0615	0.0962
Glycymeris modesta		Inshelf	Msand, Fgravel	0.0947	0.1282
Liljeborgia hansoni	-	-	-	*ns*	*ns*
lumbrinerids nd		Middle		0.0626	0.0973
Lysianassoidea	**North**-Middle	Midshelf-**Offshelf**	**Fine Sand**, VFsand, **Msand**, Silt	0.4047	0.4267
Micro nemertean nd	North	**Inshelf**	Coarse Sand, Fgravel	0.2844	0.3109
Myadora spp	Middle		Coarse Sand, Msand, MCgravel	0.1692	0.2000
Nematodes nd	North, Middle	**Inshelf**	Msand, MCgravel	0.0681	0.1026
Oedicerotidae	South, Middle		**Fine Sands**, **Msand**, Fgravel, Silt, Iron	0.3063	0.3320
Oligochaetes nd	Middle	Inshelf	Coarse Sands, MCgravel	0.1376	0.1695
Para syllid nd		**Inshelf**	VFsand, **Msand**	0.2912	0.3174
Photidae	**North**, **Middle**	Midshelf-**Offshelf**	**Fine Sand**, VFsand, Msand, Silt	0.4149	0.4365
Phoxocephalidae sp1	North	Midshelf-Offshelf	Fine Sand, Silt	0.2374	0.2657
Phyllodocids nd	North		MCgravel, Silt	0.0305	0.0664
Pisione oerstedii		Midshelf-Offshelf	**Coarse Sand**, Msand, MCgravel, Silt	0.2842	0.3107
Platyischnopidae	South-Middle	Inshelf	Fine Sand, Iron	0.1664	0.1973
Pomacuma sp1		Offshelf		0.0389	0.0745
Psammobiidae spp	North-Middle		Msand, Fgravel, Silt, Iron	0.1170	0.1497
Scalpomactra scalpellum	North		Fgravel	0.1083	0.1413
Sigalion oviger	South	Offshelf	Fine Sand, Msand	0.0358	0.0715
Spiophanes modestus	North		Fine Sand, Msand, Silt	0.1868	0.2169
Syllids nd		Midshelf	Fgravel	0.2272	0.2559
Species Richness		Offshelf	Fine Sand, Fgravel, Silt, Iron	0.1032	0.1364
Total Abundance	North	Offshore	Fine Sand, Msand, Silt, Iron	0.1529	0.1843

NB: silt only occurred in the biogenic habitats offshore, so positive or negative correlations with silt are likely to reflect positive or negative correlations with biogenic habitats offshore, driven by only a very few biogenic sites retained in these analyses, albeit often highly abundant catches were collected from these sites.

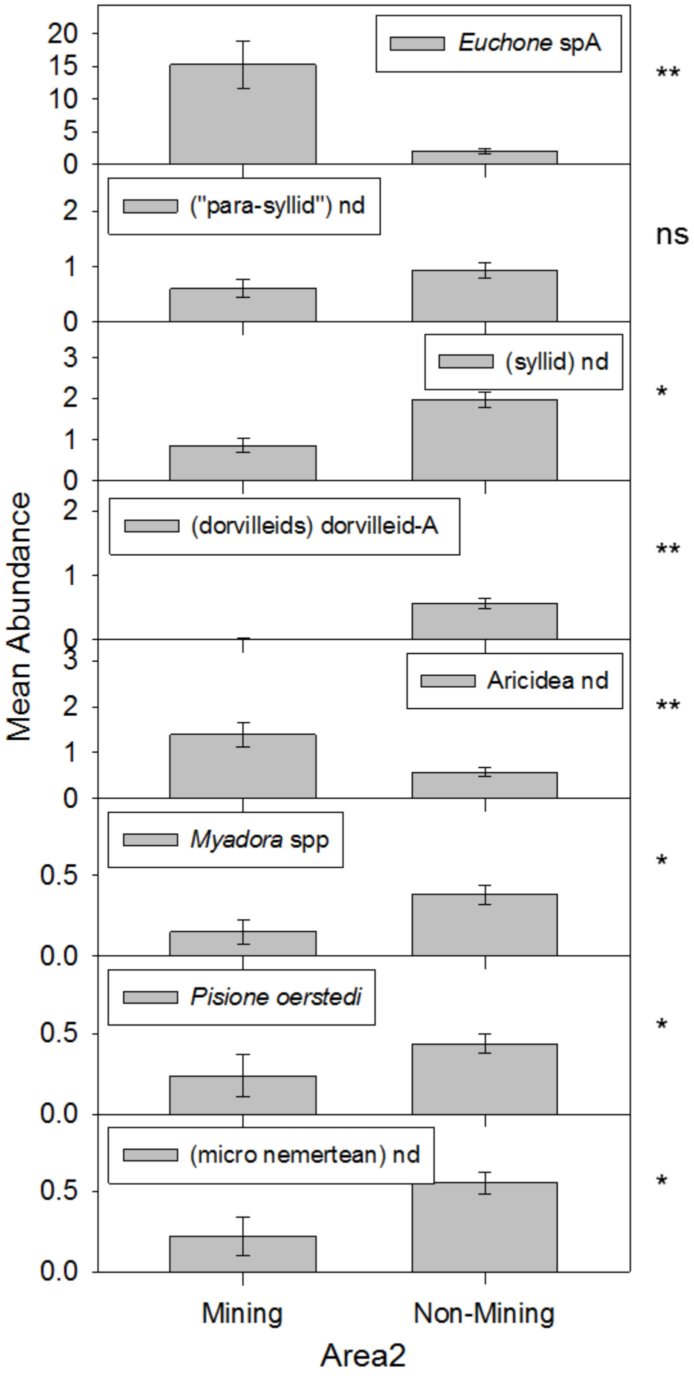


Figure 15: Revised distributions of key infauna collected from the sediment cores (0-5 cm fraction) within the revised Mining and Non-Mining areas (Area2). All taxa within the sediment core data with a greater than 5% contribution to community structure within each area and with differences between areas. ** significant (<0.001), * significant (<0.05), ns= not significantly different.

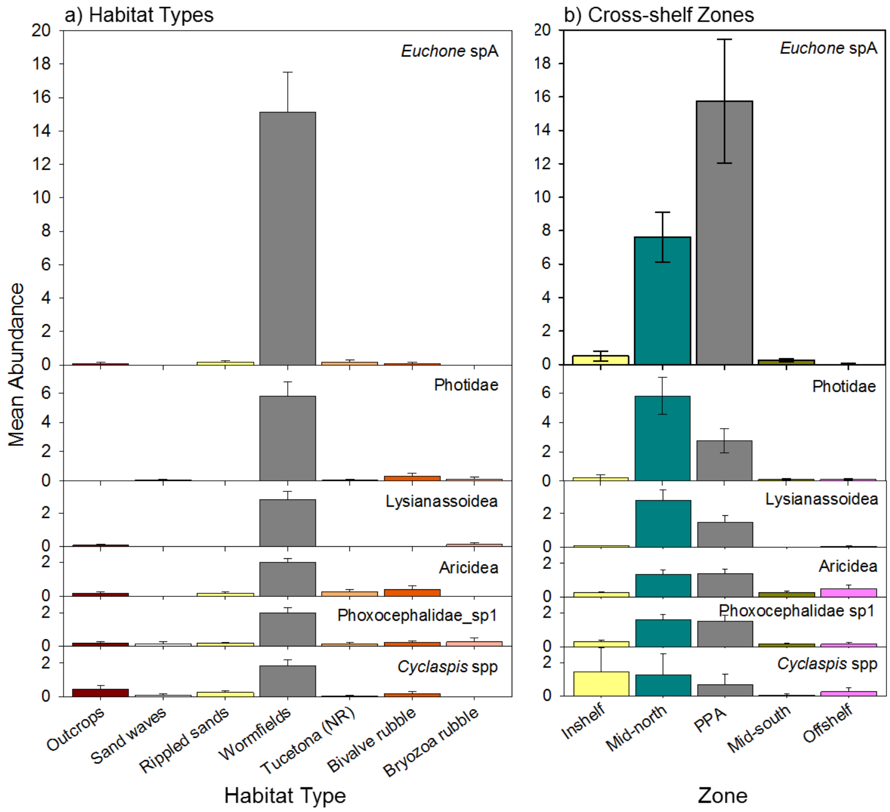


Figure 16: Mean abundance of infaunal species (top 5cm fraction) associated with 'wormfield' habitats by a) Habitat types, and b) Cross-shelf zones. Mean values + S.E.for the 0-5cm fraction of replicate cores.

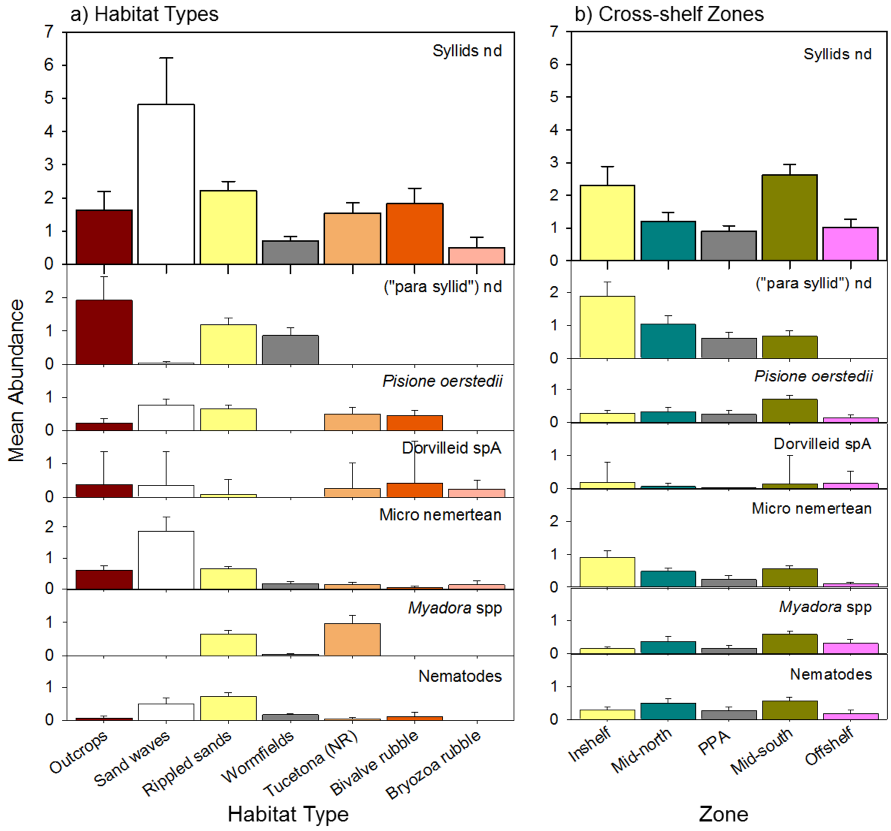


Figure 17: Mean abundance of other key infaunal species (top 5cm fraction) by a) Habitat types, and b) Cross-shelf zones. Mean values + S.E. for the 0-5cm fraction of replicate cores.

Appendix B Summary of physical and biological sampling

Seabed samples collected during the benthic shelf survey on and adjacent to Patea Shoals, in the STB. Survey_station numbers (e.g. IKA1101_189) reflect the survey (IKA1101) and station (189) order in which samples were collected. Core Reps = Number of replicate cores collected per site. PPA= Proposed project area; Inner shelf=inner shelf zone.

Area	Site	Coastcam	Agassiz Dredge	KC-Denmark HAPS corer	Core Reps	Seabed Description
PPA	1	IKA1101_361	IKA1101_189	IKA1101_1-3	3	**Rippled sands:** iron-rich sands with coquina and shell-hash; trails, sml burrow, no visible biota
PPA	2	IKA1101_384	IKA1101_190	IKA1101_4-6	3	**Rippled sands:** iron-rich sands with coquina and shell-hash in troughs, no visible biota
Inner shelf	3	IKA1101_186	TQI1201_41	IKA1101_25-27	3	**Rippled sands:** iron-rich sands with heavy coquina and shell-hash in troughs, large trails, opalfish x1
Inner shelf	4	IKA1101_194	IKA1101_183	IKA1101_16-18	3	**Sand waves**: coarse iron-rich sands
Inner shelf	5	IKA1101_543	KAH1206_90	IKA1101_159-161	3	**Rocky outcrop/rippled sands:** low-relief outcrop with bryozoans and macroalgae, adjacent to rippled iron-rich sands (catenary-shaped), sml burrows
PPA	6	IKA1101_526	IKA1101_345	IKA1101_52-54	3	**Rippled sands:** iron-rich sands, catenary-shaped ripples with shell-hash/gravel/pebbles (mod) in troughs, hermit crab, opalfish x1
Inner shelf	7	IKA1101_440	TQI1201_73	IKA1101_137-138, KAH1206_87, XX	3	**Rocky outcrop/rippled sands:** low-relief bedrock, boulders, cobbles and pebbles partial covered in iron-rich sands with shell-hash; filamentous and turfing red algae, sponges (encrusting, massive, ball), sponges, blue cod x10, spotties x1, cardinalfish x1, fanworms sp1, seastar x1
Inner shelf	9	IKA1101_542	KAH1206_91	IKA1101_156-158	3	**Rippled sands:** iro-rich sands with silt in troughs, orange bryozoan (Catenicellidae) x1, opalfish x1
Inner shelf	10	IKA1101_444	TQI1201_65	IKA1101_119-121	3	**Sand waves**: coarse sand, with shell-hash and gravel in troughs, 1x cobble, no visible biota (except loose massive sponge, piece of drift kelp), school of baitfish
PPA	11	IKA1101_369	IKA1101_343	IKA1101_61-63	3	**Rippled sands/wormfields**: iron-rich sands (horse-shoe divets); *Euchone* tubeworms (mod/dense), some coquina, sml burrows, gastropods, live scallop x2, seastar (*Coscinasterias*), flatfish, baitfish
PPA	12	IKA1101_401	IKA1101_344	IKA1101_106-108	3	**Rippled sands/wormfields:** iron-rich sands; *Euchone* tubeworms (dense/patchy), burrows, gastropod shells, trails, salp, opalfish x3, live scallop, orange bryozoan (Catenicellidae) x1.
Mid-shelf	14	IKA1101_371	TQI1201_44	IKA1101_64-68	5	**Rippled sands/wormfields**: iron-rich sands (horse-shoe divets); *Euchone* tubeworms (dense), some coquina, gastropods, orange bryozoan (Catenicellidae) x3, trails.
Inner shelf	15	IKA1101_437	KAH1206_89	IKA1101_153-155, KAH1206_83-84	5	**Sand waves:** iron-rich sands with shell debris in troughs; crabs
Inner shelf	17	IKA1101_541	KAH1206_92	IKA1101_77-79	3	**Rippled sands/wormfields**: iron-rich sands with heavy coquina and shell-hash in troughs, *Euchone* tubeworms (sparse-mod), trails, opalfish x1, faecal casts.
Mid-shelf	18	IKA1101_395	IKA1101_346	IKA1101_49-51	3	**Rippled sands:** iron-rich sands, shell-hash and gravel in troughs; sml crustacean, opalfish x1
Inner shelf	20	IKA1101_396	IKA1101_347	IKA1101_46-48, KAH1206_78-79	5	**Rocky outcrop/rippled sands:** low-relief outcrop partially buried by rippled sands, shell debris and gravel/pebbles in troughs, mudstone cobble; opalfish x5, sml fish x1.
Inner shelf	21	IKA1101_537	IKA1101_353	IKA1101_147-149	3	**Rippled sands:** iron-rich sands, coquina, some pebble/gravel in troughs, opalfish x1
Inner shelf	22	IKA1101_365	TQI1201_67	IKA1101_162-164	3	**Rippled sands:** iron-rich sands with coarse shell-hash and pebble/gravel; no visible biota
Inner shelf	23	IKA1101_379	TQI1201_68	IKA1101_143-146	4	**Rippled sands** iron-rich sands with coarse shell-hash and pebble/gravel, opalfish x1
Inner shelf	24	IKA1101_532	IKA1101_348	IKA1101_43-45	3	**Rippled sands** with shell hash;
Inner shelf	25	IKA1101_378	TQI1201_66	IKA1101_129-133	5	**Sand waves:** iron-rich coarse sands heavily laiden with coquina/shell-hash and gravel/pebbles, opalfish x1

Area	Site	Coastcam	Agassiz Dredge	KC-Denmark HAPS corer	Core Reps	Seabed Description
Mid-shelf	26	IKA1101_373	TQI1201_43	IKA1101_90-92	3	**Rippled sands:** iron-rich sands with shell-hash/gravel (heavy) in troughs, opalfish x1
Mid-shelf	27		TQI1201_36	IKA1101_55-57	3	*No video or stills collected at this site*
PPA	28	IKA1101_362	TQI1201_42	IKA1101_34-36	3	**Rippled sands**: coarse iron-rich sands with coquina and shell-hash, opalfish
Inner shelf	31	IKA1101_442	TQI1201_61	IKA1101_80-82	3	**Rippled sands/wormfields**: iron-rich sands; *Euchone* tubeworms (sparse-mod), some coquina, trails, a cobble with a sea squirt and filamentous red algae growing on it.
Inner shelf	32	IKA1101_539	KAH1206_94	IKA1101_73-76	4	**Rippled sands/wormfields**: iron-rich fine sands; *Euchone* tubeworms (sparse-mod).
Inner shelf	33	IKA1101_540	KAH1206_93	IKA1101_70-72	3	**Rippled sands**: iron-rich sands with discrete patches of cobbles and shell hash
Inner shelf	34	IKA1101_531	KAH1206_95	IKA1101_69,93-95	4	**Rippled sands:** iron-rich sands with sparse coquina
Inner shelf	35	IKA1101_193	IKA1101_349	IKA1101_28-30	3	**Rippled sands:** iron-rich sands lightly rippled with coquina (heavy) in shallow troughs, hermit crab, large trails
Mid-shelf	38	IKA1101_383	TQI1201_35	IKA1101_58-60	3	**Rippled sands:** iron-rich sands with coquina, shell-hash and gravel/pebbles in troughs
Mid-shelf	41	IKA1101_382	TQI1201_34	IKA1101_109-111	3	**Rippled sands:** iron-rich sands with sparse coquina; opalfish
Inner shelf	42	IKA1101_438	KAH1206_88	IKA1101_150-152 XXX	3	**Rocky outcrop/rippled sands:** Low-lying bedrock and cobbles, partially covered in coarse sand with shell-hash, adjacent to linear-rippled sand with shell-hash and gravel/pebbles in troughs. Bedrock with sponges (encrusting, massive, ball), coralline algae, sea squirt, seastar (*Coscinasterias*), filamentous red algae
Mid-shelf	43	IKA1101_370	KAH1206_96	IKA1101_103-105	3	**Rippled sands/wormfields:** iron-rich sands (horse-shoe divets); *Euchone* tubeworms (mod/dense), sml burrows, orange bryozoan (Catenicellidae) x6, trails, hermit crabs, live scallop x2, opalfish x3, faecal casts.
Inner shelf	44	IKA1101_445	IKA1101_352	IKA1101_125-127	3	**Rippled sands**: iron-rich sands, coquina; opalfish x2
Mid-shelf	45	IKA1101_533	TQI1201_70	IKA1101_112-115	4	**Rippled sands*:** iron-rich sands with coquina, shell-hash and gravel/pebbles in troughs, burrows.
Inner shelf	46	IKA1101_536	IKA1101_354	IKA1101_128, KAH1206_80-82	4	**Scree field/rippled sand:** coarse sands with gravels, pebbles, cobbles and shell hash. and shell hash; (NB: possibly *shallow buried reef as 3x sponges collected in dredge)*
Inner shelf	48	IKA1101_380	TQI1201_69	IKA1101_165-168	4	**Rippled sands:** iron-rich coarse sands heavily laiden with shell-hash, shell-debris and pebble/gravel, fanworm sp1, blue cod x2, geoduck shell-debris
Inner shelf	49	IKA1101_441	TQI1201_62	IKA1101_116-118	3	**Rippled sands**: iron-rich sands, surface silt in troughs, opalfish x1, drift kelp
Inner shelf	50	IKA1101_377	TQI1201_71	IKA1101_134-136	3	**Rocky outcrop/rippled sands:** buried bedrock, boulders, cobbles and pebbles partial covered in iron-rich sands with shell-hash; filamentous algae, trails opalfish x2
PPA	51	IKA1101_364	TQI1201_40	IKA1101_31-33	3	**Rippled sands**: iron-rich sands with coquina, and light shell-hash in troughs, no visible biota
Inner shelf	53	IKA1101_439	TQI1201_72	IKA1101_139-142	4	**Buried rock/Rippled sands:** shell-debris flats with sml tufts of filamentous red growing underlying bedrock, adjacent to iron-rich rippled sands with heavy shell-debris and gravel/pebbles in troughs. Large shell debris encrusted with coralline paint
Inner shelf	54	IKA1101_529	TQI1201_48	IKA1101_100-102	3	**Rippled sands/wormfields:** iron-rich sands, linear-ripples with coquina/shell-hash in troughs (light), *Euchone* tubeworms (mod/patchy), burrow, hermit crab, worm-tube burrows (sparse), sml pelagic fish
Inner shelf	55	IKA1101_530	TQI1201_47	IKA1101_96-99, X	4	**Rippled sands:** iron-rich sands with shell hash; loose red-sponge
Inner shelf	56	IKA1101_376	TQI1201_60	IKA1101_86-89	4	**Rippled sands/wormfields**: iron-rich sands with shell hash, worm-tubes on surface, scallop, opalfish.
Inner shelf	57	IKA1101_374	TQI1201_46	IKA1101_40-42	3	**Rippled sands:** iron-rich sands with coquina/shell-hash/gravel (heavy) in troughs;
Inner shelf	58	IKA1101_443	TQI1201_63	IKA1101_83-85	3	**Rippled sands**: iron-rich sands, surface silt in troughs, sml burrows, trails, no visible biota
PPA	59	IKA1101_360	TQI1201_38	IKA1101_7-9	3	**Rippled sands**: iron-rich sands, shell-hash gravel/pebbles in troughs
PPA	60	IKA1101_359	TQI1201_39	IKA1101_10-12	3	**Rippled sands**: iron-rich sands, with coquina (sparse); sml gastropod

Area	Site	Coastcam	Agassiz Dredge	KC-Denmark HAPS corer	Core Reps	Seabed Description
Inner shelf	61	IKA1101_375	IKA1101_350	IKA1101_37-39	3	**Rippled sands**: iron-rich sands, with shell hash in troughs; no visible biota (except loose red-sponge)
Inner shelf	62	IKA1101_196	IKA1101_500	IKA1101_122-124	3	**Rippled sands:** iron-rich sands with coquina/shell-hash (mod/heavy) in troughs, opalfish x1, salps
Inner shelf	65	IKA1101_185	IKA1101_182	IKA1101_22-24	3	**Sand waves:** coarse iron-rich sands with coquina/shell-hash (high amounts) in troughs,
Inner shelf	66	IKA1101_538	IKA1101_351	IKA1101_19-21	3	**Rippled sands:** iron-rich sands with coquina in troughs, trails.
Inner shelf	67	IKA1101_195	TQI1201_64	IKA1101_13-15	3	**Sand waves:** coarse sands with coquina/shell-hash in troughs
PPA	68	IKA1101_447	TQI1201_49	KAH1201_18-20	3	**Wormfields:** iron-rich sands (horse-shoe divets), large and small trails, subsurface trails, gastropod, hermit crabs, orange bryozoan (Catenicellidae) x5, salps, opalfish x1, sml flatfish x1
PPA	69	IKA1101_448	TQI1201_50	KAH1201_21-23	3	**Wormfields:** iron-rich sands (horse-shoe divets), *Euchone* tubeworms (mod/dense), large and small trails, sml burrows, orange bryozoan (Catenicellidae) x9
PPA	70	IKA1101_446	TQI1201_51	KAH1201_24-26	3	**Wormfields:** iron-rich sands (horse-shoe divets), *Euchone* tubeworms (mod/dense), large and small trails, orange bryozoan (Catenicellidae) x3, live scallop, opalfish x3
PPA	71	IKA1101_402	TQI1201_52	TQ1201_4-6	3	**Rippled sands/wormfields:** iron-rich sands with coquina; *Euchone* tubeworms (mod-dense/patchy), sub-surface trails, trails, opalfish x2, salps, orange bryozoan (Catenicellidae) x2, gastropod shells
PPA	72	IKA1101_400	TQI1201_53	KAH1201_56-58	3	**Rippled sands:** iron-rich sands with shell-hash in troughs; orange bryozoan (Catenicellidae) x2
PPA	73	IKA1101_399	TQI1201_54	KAH1201_59-61	3	**Rippled sands/wormfields:** iron-rich sands with shell-hash and shell debris in troughs; *Euchone* tubeworms (sparse/patchy), opalfish x3, salps
PPA	74	IKA1101_398	TQI1201_55	KAH1201_62-64	3	**Rippled sands/wormfields:** iron-rich sands; *Euchone* tubeworms (moderately dense/patchy), sub-surface trails, ascidian x3?, sub-surface trails, *Euchone* tubeworms (rare), salps
PPA	75	IKA1101_367	TQI1201_56	KAH1201_65-66, KAH1206_73, XXXX	3	**Rippled sands/wormfields:** iron-rich sands (horse-shoe divets), *Euchone* tubeworms (mod/dense), live scallop, opalfish x6, trails
PPA	76	IKA1101_368	TQI1201_57	KAH1201_68-70, XXX	3	**Wormfields:** iron-rich sands (horse-shoe divets), *Euchone* tubeworms (mod/dense), worm-tube burrow
PPA	77	IKA1101_386	TQI1201_58	KAH1201_71-73	3	**Rippled sands/wormfields:** iron-rich sand with shell-hash and gravel/pebble in troughs; *Euchone* tubeworms (sparse); live scallop
PPA	78	IKA1101_358	TQI1201_59	TQ1201_1-3	3	**Rippled sands/wormfields:** *Euchone* tubeworms (dense), shell-hash (patchy), gastropod shells, sml burrows, trails, opalfish
Offshore	79	IKA1101_410		KAH1201_42-45, XXXXX	4	**Bivalve debris/live *Tucetona:*** Live *Tucetona laticostata* (dense) and *Tucetona*-shell debris encrusted with invertebrates, rippled sands (patchy), shell-hash, bryozoans (e.g. branching, foliose), encrusting invertebrates, sponges (encrusting, yellow-sponge finger), ophiuroids, gastropods, fanworm sp1 (common), brachiopods, *Talochlamys*, opalfish x4
Offshore	80	IKA1101_435				**Hard ground/rubble/live *Tucetona*:** Live *Tucetona laticostata* (x2), bivalve-shell debris (mod/dense), shell-hash (mod/dense), bryozoan rubble (mod); encrusting invertebrates, bryozoans (mod/mixed: branching, foliose), ascidians, sponges, hydroids, *Talochlamys*, brachiopods (frequent), gastropod-A, ophiuroid, tubeworms
Offshore	81	IKA1101_436		KAH1201_46-48, XX	3	**Hard ground/rubble/live *Tucetona*:** Live *Tucetona laticostata* (x2), bivalve-shell debris (mod), shell-hash (heavy), bryozoan rubble (mod/dense); encrusting invertebrates, bryozoan (patchy/sparse: branching, foliose), ascidians, *Talochlamys*, ophiuroid, burrows, live scallop, hermit crab, brachiopod, tubeworms, triplefins x2, faceal casts
Offshore	82	IKA1101_411				**Hard ground/rubble/live *Tucetona*:** Live *Tucetona laticostata* (few), bivalve-shell debris (sparse/mod), shell-hash (mod/heavy), bryozoan rubble (mod/dense), bryozoans (patchy/mod/mixed: branching, foliose, lattice) and bivalve-shell debris (*Tucetona, Dosinia*); encrusting invertebrates, sponges, ascidians, unkown sml fish (pinky/orange), brachiopods, sea squirt
Offshore	83	IKA1101_412		KAH1201_49, XXX	1	**Hard ground/rubble**: bivalve-shell debris (sparse/mod), shell-hash (mod/heavy), bryozoan rubble (mod), bryozoans (mixed: branching, foliose, lattice), and bivalve-shell debris (Tucetona), encrusting

Area	Site	Coastcam	Agassiz Dredge	KC-Denmark HAPS corer	Core Reps	Seabed Description
						invertebrates, sponges (encrusting), sea squirt, ascidians, *Talochlamys*, brachiopods, burrows, opalfish x1, triplefin, hermit crab, holothurian
Offshore	84	IKA1101_316				**Hard ground/rubble/live *Tucetona*:** Live *Tucetona laticostata* (few), bivalve-shell debris (sparse/mod), shell-hash (mod), bryozoan rubble (mod), encrusting invertebrates, bryozoans (sparse/patchy: branching); sponge (encrusting, erect), *Amalda* gastropod, burrow, bachopod (frequent), faecal casts
Offshore	85	IKA1101_429				**Hard ground/rubble:** shell and bryozoan debris (sparse/mod), Bryozoans (sparse/patchy: mixed branching, foliose), bivalve-shell debris (sparse/mod) encrusted with invertebrates, sponges, *Talochlamys*, hydroids, brachiopods, triplefin x1, burrows, nudibranch (*Ceratosoma amoenum*), faecal casts, gastropods, opalfish x1
Offshore	86	IKA1101_423				**Hard ground/live *Tucetona*:** Live *Tucetona laticostata* (few/patchy), Bryozoans (sparse/patchy: branching, otherwise mostly rubble) and bivalve shell debris (sparse/mod), encrusting invertebrates, sponges, hydroids, *Talochlamys*, sea squirt, brachiopods (common), gastropods, feather-duster tubeworm, opalfish x2
Offshore	88	IKA1101_317		XXX	0	**Hard ground/rubble/ live *Tucetona*:** Live *Tucetona laticostata* (few), bryozoans (mod/mixed: branching, foliose), shell-hash (mod/dense), hairy mussel, burrows, bivalve-shell debris (sparse/mod); encrusting invertebrates, sponges, hydroids, sea squirt, *Talochlamys*, gastropod, Amalda, ascidians, fanworm sp1
Offshore	89	IKA1101_422				**Hard ground/live *Tucetona*:** Live *Tucetona laticostata* (few), Bryozoans (patchy: branching, rubble), shell-hash (mod/dense), bivalve shell debris (sparse/mod), encrusting invertebrates, sponges (encrust., erect), *Talochlamys*, ascidians, gastropods, brachiopods (common) tubeworms, opalfish x1
Offshore	90	IKA1101_419				**Hard ground:** bivalve-shell debris (sparse), shell-hash (mod), bryozoan rubble (mod), encrusting invertebrates, bryozoans (sparse/patchy: branching, foliose), encrusting invertebrates, sponges (encrusting, erect), ascidians, hydroids, burrows, gastropod-A (frequent), *Talochlamys*, nudibranch (white), tubeworm, opalfish x1
Offshore	91	IKA1101_421				**Hard ground live *Tucetona*:** Live *Tucetona laticostata* (few), Bryozoans (mod/mixed: branching, foliose), shell-hash and bryozoan rubble (mod), bivalve shell debris (sparse/mod), encrusting invertebrates, sponges (encrusting, erect, digitate), *Talochlamys*, brachiopod, ascidians, gastropods, burrows, hydroids, sea squirts, tubeworms, opalfish x2, juv. Sea perch x2, triplefin x3, gastropod-A, , fanworm sp1
Mid-shelf	92	IKA1101_381	TQI1201_33	KAH1201_84-86	3	**Rippled sands:** iron-rich sands with shell hash; no visible biota
Mid-shelf	93	IKA1101_393	TQI1201_31	KAH1201_80-83, KAH1206_71	5	**Rippled sands/live *Tucetona:*** shell hash and gravel (heavy) in troughs, shell debris (sparse); live *Tucetona laticostata* (few), opalfish x2
Mid-shelf	94	IKA1101_451	TQI1201_32	KAH1201_87-89, KAH1206_76-77	5	**Rippled sands/live *Tucetona:*** iron-rich sands with coquina and shell hash, trails, live *Tucetona laticostata* (common), bivalve-shell debris (sparse) with encrusting and digitate sponges and red algae, wormtube-burrows, yellow finger sponge, fanworm sp1 (common), hermit crab, , opalfish x2
Mid-shelf	95	IKA1101_394	TQI1201_28	KAH1201_77-79	3	**Rippled sands:** iron-rich sands with coquina and some shell hash and gravel in troughs, orange bryozoan (Catenicellidae) x1, tracks, baitfish
Mid-shelf	96	IKA1101_372	TQI1201_18	KAH1201_3-6	4	**Rippled sands/wormfields**: iron-rich sands (horse-shoe divets); *Euchone* tubeworms (mod/dense), some coquina, sml burrows, opalfish x5, trails, yellow sponge finger, orange bryozoan (Catenicellidae) x5, trails
Mid-shelf	97	IKA1101_391	TQI1201_27	KAH1201_96-97, KAH1206_72, XXX	3	**Bivalve-debris/live *Tucetona*:** Live *Tucetona laticostata* (common) and *Tucetona*-shell debris (sparse/mod) encrusted invertebrates, coarse grained sands with shell-hash, bryozoan (mixed), red algae, ophiuroids, fanworm sp1, triplefin, opalfish, orange bryozoan (Catenicellidae)
Mid-shelf	98	IKA1101_450	TQI1201_26	KAH1201_53-55	3	**Rippled sands/live *Tucetona:*** iron-rich sands (occasional horse-shoe divets), heavy shell-hash, large and small trails, orange bryozoan (Catenicellidae) x2, live *Tucetona laticostata* (few), opalfish x1, salps

Area	Site	Coastcam	Agassiz Dredge	KC-Denmark HAPS corer	Core Reps	Seabed Description
Offshore	99	IKA1101_409	TQI1201_21	KAH1201_50-52	3	**Rippled sands:** iron-rich sand (languiod shaped ripples), silt and shell-hash in troughs, tubeworms, opalfish x1, hermit crab, live scallop, gastropod (*Amalda*), sml burrows
Mid-shelf	100	IKA1101_449	TQI1201_19	KAH1201_27-29	3	**Rippled sands/wormfields:** iron-rich sands (occasional horse-shoe divets), *Euchone* tubeworms (low patchy density), large and small trails, orange bryozoan (Catenicellidae), gastropods (e.g. *Amalda*), yellow finger sponge, opalfish x4
Mid-shelf	101	IKA1101_406	TQI1201_17	KAH1201_15-17	3	**Rippled sands/wormfields:** iron-rich sand; *Euchone* tubeworms (dense), orange bryozoan (Catenicellidae) x23, opalfish x5, burrows, salp
Mid-shelf	102	IKA1101_404	TQI1201_14	KAH1201_10,10a,11	3	**Rippled sands/wormfields:** iron-rich sand; *Euchone* tubeworms (mod/patchy), orange bryozoan (Catenicellidae) x20, trails, hermit crab, yellow-sponge-finger, live scallop, baitfish
Mid-shelf	103	IKA1101_405	TQI1201_15	KAH1201_7-9	3	**Rippled sands/wormfields:** iron-rich sand; *Euchone* tubeworms (mod/patchy), orange bryozoan (Catenicellidae) x17, hydroid (large), trails, yellow-sponge-fingers, burrows, live scallop x3
Mid-shelf	104	IKA1101_403	TQI1201_13	TQ1201_10-12	3	**Rippled sands/wormfields:** iron-rich sand; *Euchone* tubeworms (mod/patchy), orange bryozoan (Catenicellidae) x12, fanworm sp1, opalfish x2, burrows, live scallop, gastropod shells
Offshore	105	IKA1101_527	TQI1201_20	KAH1201_39-41, X	3	**Bivalve-debris/live *Tucetona*:** Live *Tucetona laticostata* (common), *Tucetona*-shell debris (frequent) encrusted invertebrates, bryozoan fragments/shell-hash (mod/dense), bryozoans (mixed, branching), orange bryozoan (Catenicellidae) x17, sml burrows, shell-encrusting red tubeworms, red algae, brachiopod, ophiuroids (frequent), sml hydroids
Offshore	106	IKA1101_390				**Bivalve-debris/live *Tucetona*:** Live *Tucetona laticostata* (few), *Tucetona*-shell debris (dense) with encrusted invertebrates, fanworm sp1, bryozoan, opalfishes, faecal casts, brittlestar, sml fish
Offshore	107	IKA1101_428	KAH1206_10			**Bivalve-debris/live *Tucetona*:** Iron-rich sand, shell-hash in troughs (mod), bivalve-shell debris, Live *Tucetona laticostata* (few) ,tubeworm, sponges, ophiuroid, worm-burrows, live scallop, trails, live scallop, opalfish x2
Offshore	108	IKA1101_426	KAH1206_5 KAH1206_9			**Bivalve-debris/live *Tucetona*:** Live *Tucetona laticostata* (dense) and *Tucetona*-shell debris encrusted with invertebrates (incl. coralline paint), bryozoans (mixed, branching, foliose), shell-hash, *Talochlamys,* gastropods, ophiuroids, red algae
Offshore	109	IKA1101_387	KAH1206_3			**Bivalve-debris/live *Tucetona*:** Live *Tucetona laticostata* (few), *Tucetona*-shell debris (dense) with encrusted invertebrates, brachiopods, bryozoans (mixed), brittlestars, holothurian, sea squirt, sponges, trails, faecal casts, fanworm sp1, nudibranch (*Ceratosoma amoenum*), batifish, opalfish, triplefin, other sml fish
Offshore	110	IKA1101_408				**Hard ground/live *Tucetona*:** Live *Tucetona laticostata* (few), bivalve-shells debris (mod/dense), shell-hash (heavy), encrusting invertebrates, bryozoans (sparse/mod: branching, foliose, lattice), ascidians, ophiuroids, holothurian, decorator crab, sml fish, tubeworm
Offshore	111	IKA1101_516				**Hard ground/live *Tucetona*:** Live *Tucetona laticostata* (common), bryozoans (e.g. branching) and bivalve-shells debris; sponges, holothurians, brittlestars, brachiopod
Offshore	112	IKA1101_427	KAH1206_8			**Hard ground/live *Tucetona*:** bryozoans (mod-cover, branching, foliose) and bivalve-shells debris (e.g. *Tucetona*), encrusting invertebrates, Live *Tucetona laticostata* (common), sponges (encrusting, digitate, erect), ascidians, brachiopod, *Talochlamys*, holothurians (common), ophiuroids, hermit crab, sea squirt, triplefin x3, faecal casts, baitfish, opalfish x1, triplefin x2
Offshore	113	IKA1101_425	KAH1206_4			**Hard ground/live *Tucetona*:** Live *Tucetona laticostata* (common), bivalve-shells debris (e.g. common), shell-hash/bryozoan rubble; bryozoans (mod: branching, foliose, lattice), encrusting invertebrates, ascidians, brachiopod, hermit crab, feather-duster tubeworm, triplefin x1
Offshore	114	IKA1101_517				**Hard ground/live *Tucetona*:** Live *Tucetona laticostata* (few), bryozoans (mod/mixed: branching, foliose, lattice) and bivalve-shells debris (mod/dense); sponge (common: encrusting, erect), ascidians, fanworm sp1, hydroids, brachiopods, *Talochlamys*, tubeworm,
Offshore	115	IKA1101_407	KAH1206_7			**Hard ground/live *Tucetona*:** Live *Tucetona laticostata* (x2), bryozoans (e.g. mod-cover, mixed, foliose, lattice) and bivalve-shells debris (e.g. *Tucetona*); burrows, holothurian, sponges (encrusting, erect),

Area	Site	Coastcam	Agassiz Dredge	KC-Denmark HAPS corer	Core Reps	Seabed Description
						encrusting invertebrates, *Talochlamys,* giant hydroids, spiny seadragon *(Solegnathus spinosissimus)*, opalfish x1, ascidians, triplefin x1, tubeworm sp2
Offshore	116	IKA1101_518	KAH1206_6,_01	XXX	0	**Hard ground/live *Tucetona*:** Live *Tucetona laticostata* (frequent), bryozoans (mod/mixed: branching), bivalve-shells debris (mod); shell-debris encrusted with invertebrates, sponges (encrusting, erect, massive), holothurians, fanworm sp1, ascidians, brachiopods, holothurian x4, sea squirts, tubeworms, triplefin x1, triplefin-B x1, nudibranch (aplysia-like), hydroid, nudibranch (white),
Offshore	117	IKA1101_415	KAH1201_02	XXX	0	**Hard ground:** Bryozoans (moderate cover, mixed: branching, foliose), bivalve-shell debris (sparse e.g. *Tucetona)*, encrusting invertebrates, sponges, *Talochlamys*, hydroids, holothurians, ascidians, brachiopods, triplefin x2, opalfish x2, fanworm sp1, gastropods, faecal casts
Offshore	118	IKA1101_414		XXX	0	**Hard ground:** Bryozoans (mixed, branching, foliose), bivalve-shell debris (sparse e.g. *Tucetona)*, encrusting invertebrates, sponges, holothurians, ascidians, *Talochlamys*, brachiopods, sea squirt, feather duster tubeworm, burrows, fanworm sp1, juv. Seaperch, opalfish x1
Offshore	119	IKA1101_433	KAH1201_37‡	XXX	0	**Hard ground/rubble:** shells debris (e.g. *Tucetona*) encrusted with invertebrates, shell-hash/bryozoan rubble; bryozoans (sparse/patchy/mixed: branching, foliose), sponges, *Talochlamys*, sea squirts, ascidians, hermit crabs, gastropod-A, fanworm sp1, triplefin x1, opalfish x2, nudibranch (*Ceratosoma amoenum*), nudibranch (white), hairy mussel, burrows, solitary corals (Flabellidae) x2
Offshore	120	IKA1101_432		XXX	0	**Hard ground/live *Tucetona*:** Live *Tucetona laticostata* (few), shell-hash and bryozoan rubble (mod/dense), bryozoans (sparse/patchy, mixed: branching, foliose), sponges, *Talochlamys*, brachiopods, fanworm sp1, hydroids, ophiuroid, tubeworms, gastropods, trails, burrows, opalfish x2
Offshore	122	IKA1101_356				**Hard ground/live *Tucetona*:** Live *Tucetona laticostata* (few), Bryozoans (mod/patchy: mixed) and bivalve shell debris, sponges (encrusting, erect), ascidians, hydroids, holothurians, fish, fanworm sp1, brachiopods, hairy mussel, gastropod-A, gastropods, burrows, juv. Seaperch
Offshore	123	IKA1101_355				**Hard ground:** Bryozoans (mixed) and bivalve shell debris, sponges, ascidians, fanworm sp1, hermit crabs, *Talochlamys*, seasquirt, sml burrows, juv. Seaperch, sml fish
Offshore	124	IKA1101_420				**Hard ground:** Bryozoans (patchy/sparse-mod: branching, bushy, lattice), shell-hash and bryozoan rubble (mod), bivalve shell debris (sparse/mod) encrusted with invertebrates, sponges (encrusting, erect, digitate), *Talochlamys*, hydroids, burrows, juv. sea perch x2, opalfish x2, triplfin, fanworm, gastropod-A, gastropods, solitary corals (Flabellidae) x1
Offshore	125	IKA1101_418				**Hard ground:** Bryozoans (mixed: rubble, branching) and bivalve shell debris, encrusting invertebrates, sponges, ascidians, sml fish, burrows, *Talochlamys*, juv. horse-mussel shell, gastropods
Offshore	126	IKA1101_417				**Hard ground:** bivalve-shell debris, muddy sediments, hydroids, *Talochlamys*, sponges (encrusting, 1x massive), bryozoans (sparse/patchy: branching), brachiopods, large burrows (like sites 127-129), solitary corals (Flabellidae) x6, gastropods, juv. Gurnard, nudibranch, opalfish x1, juv. seaperch x1
Offshore	127	IKA1101_416				**Hard ground:** shell debris, muddy sediments, hydroids (common), *Talochlamys*, burrows (common), sponges, bryozoans (sparse/patchy: branching, otherwise mostly rubble/fragments), sml ophiuroid, trails, large single burrows with feeding arm sprotruding (orange/white banding), solitary corals (Flabellidae) x2. Lots of large single burrows with feeding arm protruding (orange/white banding).
Offshore	128	IKA1101_357				**Hard ground/rubble/live *Tucetona*:** Live *Tucetona laticostata* (few), Bryozoans (mixed/sparse/patchy, branching) and bivalve shell debris, sponges, sml burrows, *Talochlamys,* opalfish, brachiopods, trails, large single burrows with feeding arm sprotruding (orange/white banding).
Offshore	129	IKA1101_388				**Hard ground/live *Tucetona*:** Live *Tucetona laticostata* (few/patchy), bryozoan rubble (mod), bivalve-shell debris (sparse/mod), sponges (encrusting, erect), *Talochlamys,* burrows, giant hydroids, sml ophiuroid, brachiopods, gastropod, opalfish, sea squirt
Offshore	130	IKA1101_389	TQI1201_25	TQ1201_22-24	3	**Hard ground/rubble/live *Tucetona*:** Live *Tucetona laticostata* (few), bryozoan (mixed/sparse/patchy, branching, foliose), bivalve-shell debris (sparse/moderate) encrusted with invertebrates, shell-deris (mod) *Talochlamys,* fanworm sp1, burrows, ascidian, brachiopods, hydroids, sea squirts, sponges (encrusting), tubeworms, triplefin,

Area	Site	Coastcam	Agassiz Dredge	KC-Denmark HAPS corer	Core Reps	Seabed Description
Mid-shelf	131	IKA1101_513	TQI1201_30	KAH1201_90-92	3	**Rippled sands/ live *Tucetona*:** Live *Tucetona laticostata* (few) shell debris (mod/heavy) and gravel/pebble/cobble in troughs, burrow-tubes, small sponge on shell, crab, opalfish, burrow
Offshore	132	IKA1101_434		KAH1201_38, XXXX	1	**Hard ground/rubble/live *Tucetona*:** Live *Tucetona laticostata* (few) shell debris (mod/heavy), shell-hash (mod/dense) and bryozoan rubble (mod); encrusting invertebrates, bryozoans (sparse: branching, foliose), sponges (encrusting, erect), sea squirts, gastropod-Aophiuroid, brachiopod, opalfish x2, sml fish, faecal casts
Offshore	133	IKA1101_430		KAH1201_34-36	3	**Rippled sands:** coarse sands, shell-hash (mod/dense), horse-shoe divets, shell debris (sparse/mod), bryozoan rubble (sparse), trails, tubeworm, ophiuroids (common), opalfish x10, triplefin x1, salp
Offshore	134	IKA1101_431		KAH1201_30-33	4	**Rippled sands/Wormfields:** iron-rich sands with *Euchone* tubeworms (sparse/patchy), fanworm sp1, worm-tube burrows, crustacean, sponge-yellow finger, trails, opalfish x4, horse-shoe divots
Mid-shelf	135	IKA1101_528	TQI1201_16	KAH1201_12-14	3	**Rippled sands/wormfields:** iron-rich sands with coquina/shell-hash in troughs (sparse/ patchy); *Euchone* tubeworms (sparse-mod, patchy), trails, live scallop x1, sml fish x1
Mid-shelf	136	IKA1101_366	TQI1201_45	TQ1201_7-9	3	**Wormfields**: iron-rich sands (horse-shoe divets), *Euchone* tubeworms (patchy, sparse/mod), trails, orange bryozoan (Catenicellidae), opalfish x3
Mid-shelf	137	IKA1101_385	TQI1201_37	KAH1201_74-76	3	**Rippled sands/wormfields:** iron-rich sands with shell-hash gravel/pebbles in troughs, opalfish x4, *Euchone* tubeworms (few/patchy), trails, orange bryozoan (Catenicellidae)
Mid-shelf	138	IKA1101_392	TQI1201_29	KAH1201_93-95, KAH1206_74-75, XX	5	**Bivalve-debris/live *Tucetona*:** Live *Tucetona laticostata* (few) and shell debris (sparse/mod) encrusted invertebrates, coarse grained sands, shell-hash, bryozoan (mixed), red algae, ophiuroids, gastropod, triplefins (common) sponges, sml fish, fanworm sp1, orange bryozoan (Catenicellidae), baitfish
Mid-shelf	139	IKA1101_515	KAH1206_12			**Bivalve-debris/live *Tucetona*:** Live *Tucetona laticostata* (dense) and *Tucetona*-shell debris (sparse/mod) encrusted with invertebrates, sponges, bryozoan (mixed, foliose, lattice), hydroids, ophiuroids, red algae, Triplefin x4, opalfish x1, sml fish
Mid-shelf	140	IKA1101_514	KAH1206_11			**Bivalve-debris/live *Tucetona*:** Live *Tucetona laticostata* (common/abundant), iron-rich sands and *Tucetona*-shell debris (sparse) encrusted with invertebrates, shell hash (mod/dense), sponges (encrusting), bryozoan (branching), hydroids, ophiuroids (common), hermit crab, decorator crab, red algae, gastropod, triplefin x1, juv. Horse mussel shells x2
Mid-shelf	141	IKA1101_523	KAH1206_22	KAH1206_44-46	3	**Rippled sands/live *Tucetona*:** iron-rich sands with coquina and gravel/pebbles in troughs; Live *Tucetona laticostata* (sparse/patchy), trails, worm-tube burrows (frequent), opalfish x2
Mid-shelf	142	IKA1101_503	KAH1206_14	KAH1206_59-61	3	**Rippled sands/live *Tucetona*:** iron-rich sands with shell-hash, shell debris (sparse/mod) and gravel in troughs; Live *Tucetona laticostata* (sparse/patchy); worm-tube burrows (frequent), sponge finger, live scallop, encrusting sponges on *Tucetona*-shell debris, opalfish x1, sml fish x1
Mid-shelf	143	IKA1101_519	KAH1206_17			**Bivalve-debris/live *Tucetona*:** Live *Tucetona laticostata* (mod/dense) and *Tucetona*-shell debris (mod/dense) encrusted with invertebrates, bryozoans (mixed: branching, foliose), brachiopods (common), sea squirts, sponges (encrusting, erect, digitate), ophiuroids (frequent), *Talochlamys*, gastropods, encrusting sponges, triplefin x1
Mid-shelf	144	IKA1101_511	KAH1206_16			**Bivalve-debris/live *Tucetona*:** Live *Tucetona laticostata* (mod/dense) and *Tucetona*-shell debris (mod/dense) encrusted with invertebrates, bryozoans (mixed: branching, foliose, lattice), brachiopods (common), sea squirts, sponges (encrusting, erect, digitate), ascidians, ophiuroids (frequent), *Talochlamys*, gastropods, red algae, wormtube, red shell-encrusting tubeworms, triplefin x2
Mid-shelf	145	IKA1101_502	KAH1206_13	KAH1206_56-58	3	**Rippled sands:** iron-rich sands with shell-hash and shell debris (sparse) in troughs; no visible biota
Mid-shelf	146	IKA1101_510	KAH1206_18	KAH1206_68-70	3	**Bivalve-debris/live *Tucetona*:** Live *Tucetona laticostata* and shell debris encrusted with invertebrates
Mid-shelf	147	IKA1101_520	KAH1206_1			**Rippled sands/live *Tucetona*:** iron-rich sands, shell-hash and gravel/pebbles (sparse) in troughs; worm-tubes (sparse), live *Tucetona* (rare), sml burrow, yellow finger sponge, hermit crab, opalfish x1
Mid-shelf	148	IKA1101_505	KAH1206_20	KAH1206_50-52	3	**Rippled sands:** iron-rich sand with gravel/pebbles (mod) in troughs, some shell-hash, opalfish x3

Area	Site	Coastcam	Agassiz Dredge	KC-Denmark HAPS corer	Core Reps	Seabed Description
Mid-shelf	149	IKA1101_506	KAH1206_21	KAH1206_47-49	3	**Rippled sands:** iron-rich sand with gravel/pebbles (mod) in troughs, some shell-hash, sml fish x1
Mid-shelf	150	IKA1101_525	KAH1206_26			**Rippled sands/live *Tucetona*:** iron-rich sand with shell-hash (mod/dense) and gravel/pebbles (frequent) in troughs, live Tucetona (sparse/patchy), smaller geoduck shell-debris (frequent, ~5-7 cm shell length), worm tubes (frequent), horse mussel shell-debris x1, *Tucetona*-debris (sparse) encrusted with invertebrates, ascidians, sponge, hydroid, red algae
Offshore	151	IKA1101_509	KAH1206_2			**Bivalve-debris/live *Tucetona*:** live *Tucetona* (abundant), *Tucetona* shell debris (moderate) encrusted with invertebrates, shell-hash and bryozoan rubble (mod/dense), bryozoan (mixed, branching), sponges (mixed, encrusting, erect, massive), ascidians, brachiopods, *Talochlamys*, hydroids, holothurians, ophiuroids, gastropod shells, brachiopods, fanworm sp1, tubeworm, triplefin x2, faecal casts, *Panopea* shell x1 (~7 cm shell length)
Offshore	152	IKA1101_522	KAH1206_24			**Bivalve-debris/live *Tucetona*:** live *Tucetona* (common), *Tucetona*-shell debris (sparse), shell-hash and bryozoan rubble (mod/dense), shells encrusted with invertebrates, coralline paint, sponges, bryozoan (moderate/mixed, branching), ascidians, hydroids, brachiopods, hairy-mussels (*Modiolus*, frequent), ophiuroids, worm tubes (common), feather-duster tubeworm, burrows (frequent), gastropods, hermit crab, fanworm sp1, triplefin x2, faecal casts, horse-mussel shells x6
Offshore	153	IKA1101_508	KAH1206_23			**Bivalve-debris/live *Tucetona*:** live *Tucetona* (abundant), *Tucetona* shell debris (sparse) encrusted with invertebrates, shell-hash and bryozoan rubble (mod/dense), bryozoan (moderate/mixed, branching, foliose, lattice), sponges (mixed, encrusting, erect, massive), ascidians, hydroids, *Talochlamys*, brachiopods (common), sea squirts, gastropods, ophiuroids (frequent), holothurian x2, nudibranch (*Ceratosoma amoenum*), nudibranch (aplysia-like), sml burrows, fanworm sp1, horse mussel shell debris x3, triplefin x4, *Panopea* shell x1 (~ 8 cm shell length)
Mid-shelf	154	IKA1101_501	KAH1206_25	KAH1206_53-55	3	**Rippled sands:** iron-rich sand with gravel/pebbles in troughs, some shell-debris (sparse), opalfish x1
Mid-shelf	155	IKA1101_524	KAH1206_27	KAH1206_41-43	3	**Bivalve-debris/live *Tucetona*:** *Tucetona* shell debris (sparse), shell-hash (mod), live Tucetona (sparse/patchy), shell-debris encrusted with invertebrates, coralline paint, sponges (encrusting, erect), red algae, hydroids, worm tubes (common), ophiuroids, gastropods, hermit crabs, fanworm sp1, yubeworms, sml burrow, orange bryozoan (Catenicellidae) x1, triplefin x2, horse mussel shell x1, *Panopea* shell x1 (~6.3-9 cm shell lengths)
Mid-shelf	156	IKA1101_504	KAH1206_19	KAH1206_65-67	3	**Rippled sands:** iron-rich sands with coquina and shell-hash in troughs; sml burrow, no visible biota
Mid-shelf	157	IKA1101_512	KAH1206_15	KAH1206_62-64	3	**Rippled sands:** iron-rich sands, catenary-shaped ripples with coquina/shell-hash (light) in troughs; sml burrow (few)
Mid-shelf	158	IKA1101_521	KAH1206_28	KAH1206_38-40	3	**Rippled sands:** iron-rich sand with moderate shell-hash, Grabs collected bivalves, gastropods and polychaete worms. No still photos for this site.
Inner shelf	159	IKA1101_534	KAH1206_30	KAH1206_35-37	3	**Rippled sands:** iron-rich sands with coquina, shell-hash and gravel/pebbles in troughs (light), burrows, worm-tube burrows (frequent), live scallop x5, hermit crab, opalfish x1
Inner shelf	160	IKA1101_507	KAH1206_29			**Bivalve-debris/live *Tucetona*:** *Tucetona* and *Panopea* shell debris (mod/dense), shell-hash, shells encrusted with invertebrates, coralline paint, sponges, bryozoan (moderate/mixed, branching, foliose), live Tucetona (frequent), sea squirts, *Talochlamys, brachiopods,* ophiuroids (common), gastropods, red algae, triplefin x5, small unkn fish x2 (very skinny opalfish-like), geoduck shell-debris (common), horse-mussel shell x3
Inner shelf	161	IKA1101_535	KAH1206_31	KAH1206_32-34	3	**Rippled sands:** iron-rich sands with coquina, shell-hash and gravel/pebbles in troughs (light), burrows, worm-tube burrows (frequent)

X = gear deployed but no sample recovered. The number of X's depicts the number of failed deployments, and for core deployments depicts impenetrable ground at these sites.

‡ = Exploratory dredge only (a subsample kept but not processed).

Appendix C GRADISTAT size scale

Size scale adopted in the GRADISTAT program (taken from GRADISTAT, Blott (2010))

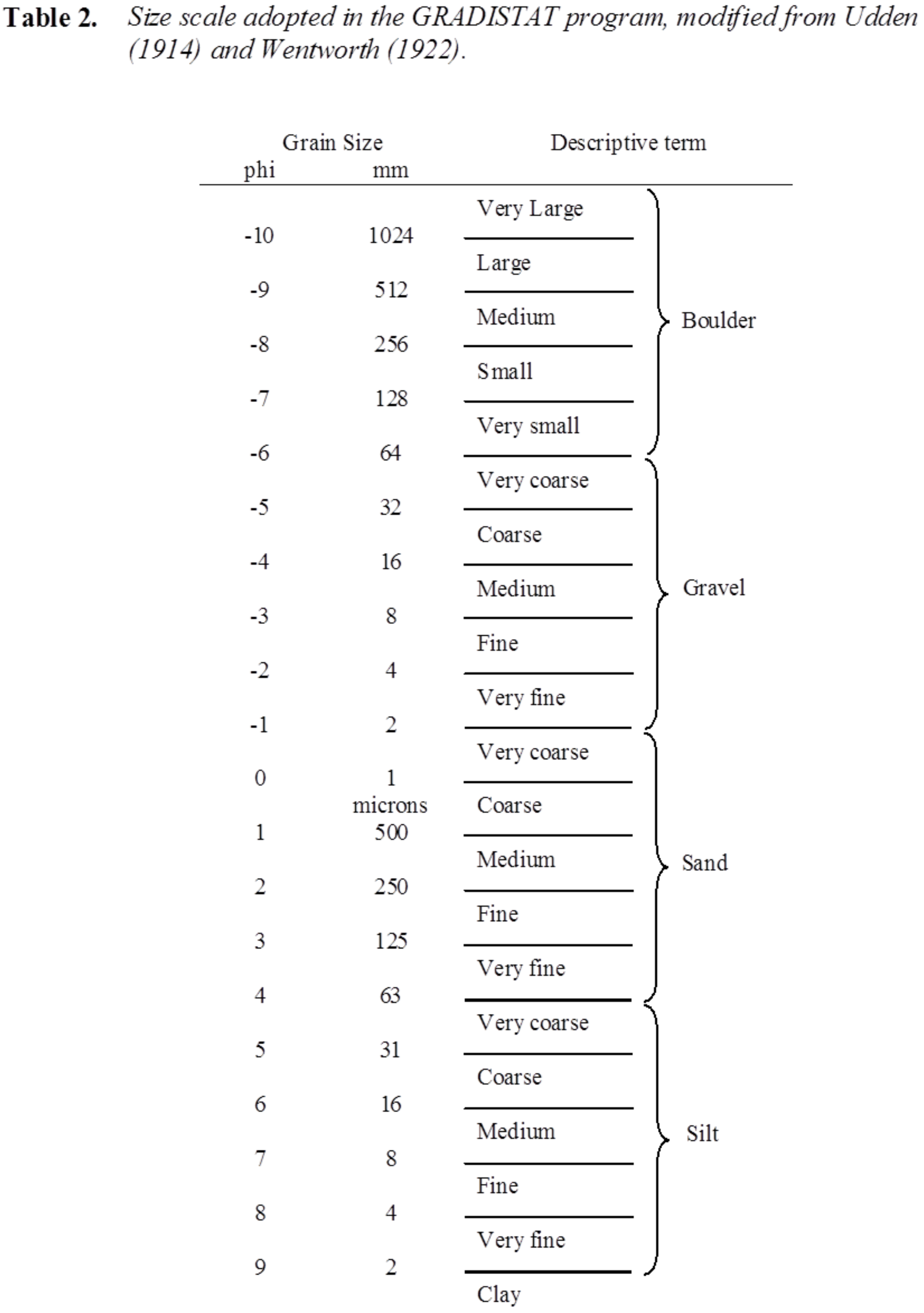


Table 2. *Size scale adopted in the GRADISTAT program, modified from Udden (1914) and Wentworth (1922).*

Grain Size phi	 mm	Descriptive term	
		Very Large	Boulder
-10	1024	Large	
-9	512	Medium	
-8	256	Small	
-7	128	Very small	
-6	64	Very coarse	Gravel
-5	32	Coarse	
-4	16	Medium	
-3	8	Fine	
-2	4	Very fine	
-1	2	Very coarse	Sand
0	1 microns	Coarse	
1	500	Medium	
2	250	Fine	
3	125	Very fine	
4	63	Very coarse	Silt
5	31	Coarse	
6	16	Medium	
7	8	Fine	
8	4	Very fine	
9	2	Clay	

Appendix D Functional groups for Coastcam2 analysis

Classification of functional groups for Coastcam2 data analysis

Funcional group	**Phyla/group**
Primary producer	Algae
Sessile predator	Anemone
Suspension feeder	Annelida
Suspension feeder	Ascidian
Suspension feeder	Bivalve
Suspension feeder	Brachiopod
Suspension feeder	Bryozoan
Suspension feeder	Hydroids
Suspension feeder	Sponge (demo)
Suspension feeder	Sponge (hex)
Mobile deposit feeders/opportunists	Annelida
Mobile deposit feeders/opportunists	Holothurian
Mobile predator/scavenger	Asteroid
Mobile predator/scavenger	Cartilagenous fish
Mobile predator/scavenger	Crustacean
Mobile predator/scavenger	Echinoid
Mobile predator/scavenger	Fish
Mobile predator/scavenger	Gastropod
Mobile predator/scavenger	Ophiuroid
Planktonic	Planktonic cnidarian

Appendix E Bryozoa species list

Table D1: List of the bryozoan species collected in the dredges. Abd= Total number of specimens collected; Occur.= number of dredges/sites specimens occurred in. Inner shelf-Offshore values depict mean densities per 250 m^2. Underlined species = can form significant habitats, ^ = may form visually significant clumps; *STB =new record for the south Taranaki Bight; *NS=new species.

Taxa/group	Species	Abd	Occur.	Inner shelf	Mid north	PPA	Mid south	Offshore
Stenolaemata	*Tubulipora* sp epizoic	1410	25	0.158	41.632	22.368	4.706	1.192
Gymnolaemata	*Caberea zelandica*	987	24	0	0.895	0.158	1.588	35.113
Stenolaemata	*Telopora lobata*	796	14	0	0	0	0.088	30.509
Gymnolaemata	*Rhynchozoon zealandicum*	505	18	0	0.105	0.053	1.000	17.986
Gymnolaemata	*Bugula prismatica*	419	10	0	0	0	2.706	12.577
Stenolaemata	*Disporella pristis*	400	13	0	0	0.053	2.735	11.769
Gymnolaemata	*Crepidacantha crinispina*	361	21	0	0.053	0.053	0.971	12.541
Stenolaemata	*Crisia* sp	336	17	0	0.105	0.263	0.176	12.429
Gymnolaemata	*Calloporina angustipora*	316	21	0	0	0.053	1.588	10.019
Gymnolaemata	*Celleporina sinuata*	313	20	0.316	0.105	0.316	1.176	9.942
Stenolaemata	*Tubulipora* sp	276	22	0.053	0.158	0.316	0.676	9.357
Stenolaemata	*Diaperoecia purpurascens* ^	271	15	0.053	0	0.053	0.147	10.140
Stenolaemata	*Crisia tenuis*	256	15	0	0.053	0	0.912	8.599
Gymnolaemata	*Micropora* sp	243	17	0.053	0.053	0	0.647	8.404
Gymnolaemata	*Emma crystallina*	230	22	0.105	6.737	4.842	0.235	0
Gymnolaemata	*Figularia huttoni*	223	15	0	0	0	0.265	8.212
Gymnolaemata	*Cellaria tenuirostris*	223	12	0.105	0.053	0.316	0	8.238
Gymnolaemata	*Microporella speculum*	216	19	0	0.158	0.053	0.676	7.275
Stenolaemata	*Bicrisia edwardsiana*	210	26	0	3.895	1.632	1.353	2.269
Gymnolaemata	*Hippellozoon novaezelandiae* ^	208	17	0	0.263	0	0.147	7.600
Stenolaemata	*Disporella novaehollandiae*	198	25	0.158	4.947	3.368	0.676	0.519
Gymnolaemata	*Bitectipora rostrata*	185	19	0.053	0	0.105	1.118	5.549
Gymnolaemata	*Macropora levinseni*	172	17	0	0.053	0	0.206	6.306
Gymnolaemata	*Parasmittina delicatula*	172	15	0	0	0.105	0.088	6.433
Gymnolaemata	*Arachnopusia unicornis*	166	18	0.053	0.053	0.105	0.118	6.073
Gymnolaemata	*Perkermavella punctigera*	166	14	0	0	0	0.824	5.288
Gymnolaemata	*Escharella spinosissima*	166	11	0	0	0	0.206	6.121

Taxa/group	Species	Abd	Occur.	Inner shelf	Mid north	PPA	Mid south	Offshore
Gymnolaemata	*Escharoides angela*	160	11	0	0	0.105	0.206	5.808
Gymnolaemata	*Microporella agonistes*	156	16	0	0	0.421	0.500	5.044
Gymnolaemata	*Stephanollona scintillans*	155	15	0	0	0	0.206	5.697
Gymnolaemata	*Cellaria immersa*	153	16	0	0.053	0	0.294	5.461
Stenolaemata	*Caprinsula* sp	143	12	0	0.158	0	0.088	5.255
Gymnolaemata	*Adeonellopsis pentapora*	141	9	0	0	0	0	5.429
Gymnolaemata	*Micropora mortenseni*	124	16	0.158	0.368	0.105	0.559	3.588
Gymnolaemata	*Rhynchozoon paa*	124	13	0	0.105	0.105	0.676	3.714
Gymnolaemata	*Hippothoa flagellum*	122	15	0	0	0.105	0.118	4.480
Gymnolaemata	*Celleporina costazii*	117	10	0	0	0	0	4.486
Gymnolaemata	*Galeopsis porcellanicus*	116	11	0.053	0.158	0.263	0	4.102
Gymnolaemata	*Microporella intermedia*	110	13	0	0	0	0.647	3.375
Gymnolaemata	*Escharoides excavata*	108	9	0	0.053	0	0	4.133
Stenolaemata	*Microeciella* sp white	107	8	0	0	0	0.029	4.077
Gymnolaemata	*Parasmittina aotea*	104	15	0	0	0.053	0.471	3.332
Stenolaemata	*Plagioecia sarniensis*	103	10	0	0.474	0.053	0.088	5.397
Gymnolaemata	*Calyptotheca immersa*	98	9	0	0	0	0.294	3.365
Gymnolaemata	*Aimulosia marsupium*	97	13	0	0.526	0	1.500	1.365
Gymnolaemata	*Figularia mernae*	97	3	0	0	0	0	3.742
Gymnolaemata	*Smittina rosacea*	91	8	0	0	0	0.088	3.381
Gymnolaemata	*Costaticella bicuspis*	90	27	0.053	2.105	1.316	0.294	0.525
Gymnolaemata	*Crassimarginatella cucullata*	85	8	0	0.053	0	0.029	3.198
Gymnolaemata	*Corbulella corbula*	78	16	0	0.053	0.053	0.353	2.467
Gymnolaemata	*Smittoidea maunganuiensis*	69	6	0	0	0.105	0.088	2.462
Stenolaemata	*Idmidronea* sp	67	4	0	0	0	0	2.577
Gymnolaemata	*Fenestrulina reticulata*	65	11	0	0	0	0.118	2.332
Gymnolaemata	*Leptinatella gordoni*	65	5	0	0	0	1.029	1.154
Gymnolaemata	*Caberea rostrata*	64	8	0	0	0.053	0.412	1.885
Gymnolaemata	*Escharoides* sp	63	8	0	0	0	0.294	2.044
Gymnolaemata	*Odontionella cyclops*	62	10	0	0.105	0.105	0.118	2.080
Gymnolaemata	*Macropora grandis*	62	9	0	0	0	0.206	2.120
Gymnolaemata	*Smittina palisada*	62	5	0	2.579	0.316	0.206	0
Gymnolaemata	*Opaeophora monopia*	58	4	0	0	0	0	2.217

Taxa/group	Species	Abd	Occur.	Inner shelf	Mid north	PPA	Mid south	Offshore
Gymnolaemata	*Eurystomella biperforata*	57	11	0	0	0.158	0.059	2.004
Stenolaemata	*Favosipora tincta*	53	7	0	0.053	0	0.294	1.615
Gymnolaemata	*Mollia amoena*	52	11	0	0	0	0.088	1.870
Stenolaemata	*Tubulipora* sp purple	51	2	0	0	0	0	1.942
Gymnolaemata	*Microporella discors*	50	6	0	0.316	0.105	0.059	1.538
Plagioeciidae	*Plagioecia sarniensis*	50	1	0	0.474	0.053	0.088	5.397
Gymnolaemata	*Smittina torques*	49	12	0	0.579	0.053	0.265	1.058
Gymnolaemata	*Figularia carinata*	49	11	0	0	0	0.265	1.547
Gymnolaemata	*Buffonellaria turbula*	48	13	0	0.053	0.053	0.382	1.261
Gymnolaemata	*Buffonellaria biavicularis*	47	2	0	0	0	0	1.795
Gymnolaemata	*Fenestrulina disjuncta*	46	8	0	0	0.211	0.059	1.538
Gymnolaemata	*Chaperiopsis lanceola*	45	2	0	0	0	0	1.731
Gymnolaemata	*Schizosmittina cinctipora*	44	13	0.053	0.368	0.368	0.324	0.692
Gymnolaemata	*Buffonellodes rhomboidalis*	44	8	0	0.158	0	0.088	1.442
Stenolaemata	*Cinctipora elegans* (*STB)	44	6	0	0	0	0	1.698
Gymnolaemata	*Galeopsis polyporus*	42	6	0	0	0.158	0.029	1.442
Gymnolaemata	*Exochella conjuncta*	41	8	0	0	0	0.118	1.423
Gymnolaemata	*Buffonellaria regenerata*	40	13	0.053	0.053	0	0.088	1.338
Stenolaemata	*Hornera* sp	40	5	0	0	0	0.059	1.467
Stenolaemata	*Microeciella* sp pink	40	5	0	0	0	0	1.538
Gymnolaemata	*Adeonellopsis* sp	38	5	0	0	0	0	1.449
Gymnolaemata	*Aetea truncata*	36	11	0	0.053	0.105	0.265	0.904
Gymnolaemata	*Fenestrulina gelasinoides*	34	6	0	0	0	0.324	0.897
Gymnolaemata	*Hippomenella vellicata*	33	8	0	0	0	0.029	1.217
Gymnolaemata	*Beania intermedia*	33	7	0	0	0	0.029	1.217
Gymnolaemata	*Antarctothoa tongima*	30	14	0.105	0.263	0.368	0.471	0
Gymnolaemata	*Exochella jullieni*	30	10	0.053	0.053	0	0.059	1.005
Gymnolaemata	*Chaperiopsis spiculata*	30	1	0	0	0	0	1.154
Gymnolaemata	*Beania magellanica*	28	8	0.053	0.105	0.105	0.235	0.558
Gymnolaemata	*Schizomavella aotearoa* (*STB)	28	4	0	0	0	0	1.058
Gymnolaemata	*Orthoscuticella fissurata*	27	17	0.105	0.263	0.368	0.206	0.231
Gymnolaemata	*Scalicella crystallina*	27	16	0.053	0.737	0.368	0.088	0.077
Gymnolaemata	*Canda filifera*	27	7	0	0	0.053	0.147	0.808

Taxa/group	Species	Abd	Occur.	Inner shelf	Mid north	PPA	Mid south	Offshore
Gymnolaemata	*Beania discodermiae*	26	11	0.053	0.105	0.105	0.147	0.615
Gymnolaemata	*Chorizopora brongniartii*	25	5	0	0	0	0.029	0.929
Gymnolaemata	*Hemismittoidea hexaspinosa*	25	4	0	0	0	0.029	0.923
Stenolaemata	*Favosipora otagoensis*	24	8	0.211	0.421	0.368	0.147	0
Gymnolaemata	*Osthimosia cyclops*	23	2	0	0.158	0	0	0.769
Gymnolaemata	*Smittoidea discoveriae*	22	8	0	0.053	0.053	0.118	0.596
Gymnolaemata	*Cornuticella trapezoidea*	21	2	0	0	0	0	0.808
Gymnolaemata	*Penetrantia parva*	20	9	0.053	0.105	0.421	0.029	0.308
Gymnolaemata	*Cribellopora napi*	20	1	0	0	0	0	0.769
Gymnolaemata	*Amastigia harmeri*	20	1	0	0	0	0	0.769
Gymnolaemata	*Pterocella scutella*	17	12	0.211	0.526	0.158	0	0
Gymnolaemata	*Crepidacantha kirkpatricki*	17	7	0	0	0.105	0	0.593
Gymnolaemata	*Celleporaria agglutinans*	17	3	0	0	0	0	0.654
Gymnolaemata	*Gregarinidra* sp	17	3	0	0.053	0.053	0.441	0
Gymnolaemata	*Odontoporella bishopi*	16	8	0	0.105	0	0.206	0.250
Stenolaemata	Platonea sp	15	6	0.053	0	0	0.118	0.385
Gymnolaemata	*Alderina gorensis*	15	4	0	0	0	0.029	0.519
Gymnolaemata	*Steginoporella magnifica*	14	6	0	0	0.053	0.029	0.453
Gymnolaemata	*Celleporina grandis*	13	3	0	0	0	0	0.505
Gymnolaemata	*Inversiula fertilis*	13	3	0.053	0	0	0	0.462
Gymnolaemata	*Penetrantia* sp	12	2	0	0	0	0	0.462
Gymnolaemata	*Orthoscuticella innominata*	11	8	0.053	0.158	0.158	0	0.154
Gymnolaemata	*Otionellina squamosa*	11	6	0	0.053	0.105	0.088	0.192
Gymnolaemata	*Rogicka biserialis*	11	2	0	0	0.053	0	0.385
Gymnolaemata	*Smittina purpurea*	10	4	0	0	0.263	0.029	0.135
Gymnolaemata	*Fenestrulina thyreophora*	10	2	0	0	0.105	0	0.308
Gymnolaemata	*Cellaria* sp	10	1	0	0	0	0	0.385
Gymnolaemata	*Menipea vectifera*	10	1	0	0	0	0	0.385
Gymnolaemata	*Bugula cuspidata*	10	1	0	0	0	0.294	0
Stenolaemata	*Tubulipora* sp blue	10	1	0	0	0	0	0.385
Gymnolaemata	*Catenicella* sp	9	9	0.211	0.158	0.105	0	0
Gymnolaemata	*Beania* sp	9	4	0.105	0	0.158	0	0.154
Gymnolaemata	*Opaeophora lepida*	9	4	0	0	0	0.118	0.173

Taxa/group	Species	Abd	Occur.	Inner shelf	Mid north	PPA	Mid south	Offshore
Stenolaemata	*Hastingsia* sp	8	5	0	0.053	0.053	0	0.231
Gymnolaemata	*Otionellina symmetrica*	8	3	0	0	0	0	0.324
Stenolaemata	*Telopora watersi*	8	1	0	0	0	0	0.308
Gymnolaemata	*Bicellariella ciliata*	7	4	0	0.053	0.053	0.118	0.038
Gymnolaemata	*Cosciniopsis vallata*	7	4	0	0	0	0.118	0.115
Gymnolaemata	*Akatopora circumsaepta*	7	2	0	0	0	0	0.250
Gymnolaemata	*Immergentia zelandica*	6	5	0	0.105	0	0.088	0.038
Gymnolaemata	*Schizosmittina conjuncta*	6	4	0	0.053	0.158	0.029	0.038
Gymnolaemata	*Chorizopora* sp	6	3	0.053	0	0	0	0.192
Gymnolaemata	*Valdemunitella valdemunita*	6	2	0.053	0	0	0	0.192
Gymnolaemata	*Bugulopsis monotrypa*	5	5	0.105	0.053	0.053	0.029	0
Gymnolaemata	*Prenantia firmata*	5	3	0	0	0	0.118	0.038
Gymnolaemata	*Celleporina hemiperistomata*	5	2	0	0	0	0	0.192
Stenolaemata	*Hornera foliacea*	5	2	0	0	0	0	0.192
Gymnolaemata	*Mobunula bicuspis*	5	1	0	0	0	0	0.192
Gymnolaemata	*Cornuticella taurina*	4	4	0	0.053	0	0.029	0.082
Gymnolaemata	*Pterocella vesiculosa*	4	4	0.105	0.053	0.053	0	0
Gymnolaemata	*Aetea australis*	4	3	0	0	0.105	0	0.077
Gymnolaemata	*Otionellina proberti*	4	2	0	0	0	0.029	0.096
Gymnolaemata	*Lacerna styphelia*	4	1	0	0	0	0	0.154
Stenolaemata	*Mesenteripora triregnator*	4	1	0	0	0	0	0.154
Gymnolaemata	*Orthoscuticella margaritacea*	3	3	0.105	0.053	0	0	0
Gymnolaemata	*Beania plurispinosa*	3	2	0.053	0	0.105	0	0
Gymnolaemata	*Chaperiopsis cervicornis*	3	2	0.105	0	0	0	0.038
Gymnolaemata	*Fenestrulina incompta*	2	2	0	0	0.105	0	0
Gymnolaemata	*Membranipora pura*	2	2	0.105	0	0	0	0
Stenolaemata	*Entalophoroecia* sp	2	2	0	0.053	0	0	0.038
Gymnolaemata	*Antarctothoa delta*	1	1	0	0.053	0	0	0
Gymnolaemata	*Arachnopusia quadralabia*	1	1	0	0	0	0	0.044
Gymnolaemata	*Dimetopia cornuta*	1	1	0.053	0	0	0	0
Gymnolaemata	*Exochella armata*	1	1	0	0.053	0	0	0
Gymnolaemata	*Fenestrulina littoralis*	1	1	0	0	0	0.029	0
Gymnolaemata	*Microporella appendiculata*	1	1	0	0	0	0.029	0

Taxa/group	Species	Abd	Occur.	Inner shelf	Mid north	PPA	Mid south	Offshore
Gymnolaemata	*Osthimosia amplexa*	1	1	0	0.053	0	0	0
Gymnolaemata	*Phonicosia circinata*	1	1	0	0	0.053	0	0
Gymnolaemata	*Retevirgula sejuncta*	1	1	0	0	0.053	0	0
Gymnolaemata	*Scruparia ambigua*	1	1	0	0	0.053	0	0
Gymnolaemata	*Scrupocellaria ornithorhyncus*	1	1	0	0	0.053	0	0
Gymnolaemata	*Valdemunitella fraudatrix*	1	1	0	0	0	0.029	0
Stenolaemata	*Crisia setosa*	1	1	0	0	0	0.029	0
Gymnolaemata	*Smittoidea sp E (*NS)*		1	0	0	0	0	0.053
Gymnolaemata	*Parasmittina livingstonei* (*STB)	1d	1d	0.029	0	0	0	0
Gymnolaemata	*Buffonellodes globosa* (*STB)	1d	1d	0	0	0	0.029	0

Table D2: List of bryozoan species collected in the cores. Abd= Total number of specimens collected; Occur.= number of cores that specimens occurred in; ds=specimens only found in deeper sediments. Inner shelf-Offshore values depict mean densities per 1 m^2 for each cross-shelf zone.

Type	Species	Surface sediments (0-5 cm)						
		Abd	Occur.	Inner shelf	mid north	PPA	mid south	Offshore
Gymnolaemata	*Otionellina affinis*	104	25	0	13.13	5.28	2.78	163.87
Gymnolaemata	*Otionellina proberti*	59	31	2.35	47.74	9.23	6.96	0
Gymnolaemata	*Crepidacantha kirkpatricki*	44	13	0	0	0	5.57	69.40
Gymnolaemata	*Otionellina symmetrica*	44	24	9.40	20.29	18.47	3.48	0
Gymnolaemata	*Buffonellaria turbula*	34	14	0	0	0	9.75	38.56
Gymnolaemata	*Crepidacantha crinispina*	34	14	0	0	0	8.35	42.41
Gymnolaemata	*Figularia carinata*	23	10	0	0	0	4.87	30.85
Gymnolaemata	*Macropora levinseni*	21	12	0	0	0	4.18	28.92
Gymnolaemata	*Caberea zelandica*	19	8	0	1.19	0	2.09	28.92
Gymnolaemata	*Eurystomellidae biperforata*	17	9	0	0	0	1.39	28.92
Gymnolaemata	*Otionellina squamosa*	16	12	1.17	13.13	1.32	2.09	0
Gymnolaemata	*Stephanollona scintillans*	16	7	0	0	0	1.39	26.99
Gymnolaemata	*Corbulella corbula*	15	8	0	0	0	2.78	21.21
Gymnolaemata	*Microporella speculum*	15	5	0	0	0	4.87	15.42
Gymnolaemata	*Rhynchozoon paa*	15	8	0	0	0	4.18	17.35
Gymnolaemata	*Rhynchozoon zealandicum*	15	5	0	0	0	3.48	19.28

Type	Species	Surface sediments (0-5 cm)						
		Abd	Occur.	Inner shelf	mid north	PPA	mid south	Offshore
Gymnolaemata	*Fenestrulina gelasinoides*	14	6	0	0	0	0.70	25.06
Gymnolaemata	*Micropora gracilis*	14	6	0	0	0	2.09	21.21
Gymnolaemata	*Retevirgula sejuncta*	14	8	0	0	0	2.78	19.28
Gymnolaemata	*Diaperoecia purpurascens*	13	7	0	0	0	2.09	19.28
Gymnolaemata	*Fenestrulina reticulata*	13	7	0	0	0	0	25.06
Gymnolaemata	*Micropora* sp	13	6	0	0	0	4.87	11.57
Gymnolaemata	*Microporella agonistes*	12	9	0	0	0	1.39	19.28
Gymnolaemata	*Phonicosia circinata*	11	6	0	0	0	2.78	13.50
Gymnolaemata	*Calloporina angustipora*	10	8	0	0	0	1.39	15.42
Gymnolaemata	*Crisia tenuis*	10	4	0	0	0	0	19.28
Gymnolaemata	*Microporella appendiculata*	10	6	0	0	0	1.39	15.42
Gymnolaemata	*Osthimosia cyclops*	10	6	0	0	0	0	19.28
Gymnolaemata	*Hippothoa flagellum*	9	6	0	0	0	1.39	13.50
Gymnolaemata	*Buffonellaria regenerata*	7	5	0	0	0	2.09	7.71
Gymnolaemata	*Hippomenella vellicata*	7	4	0	0	0	0	13.50
Gymnolaemata	*Inversiula fertilis*	7	4	2.35	0	0	0	9.64
Gymnolaemata	*Macropora grandis*	7	6	0	0	0	0	13.50
Gymnolaemata	*Micropora mortenseni*	7	4	1.17	0	0	0	11.57
Gymnolaemata	*Alderina gorensis*	6	3	0	0	0	1.39	7.71
Gymnolaemata	*Beania intermedia*	6	4	0	1.19	0	0	9.64
Gymnolaemata	*Celleporina hemiperistomata*	6	4	0	0	0	2.78	3.86
Gymnolaemata	*Escharoides excavata*	6	3	0	0	0	0	11.57
Gymnolaemata	*Fenestrulina littoralis*	6	2	0	0	0	2.78	3.86
Gymnolaemata	*Prenantia firmata*	6	5	0	0	0	0.70	9.64
Stenolaemata	*Hornera* sp	6	5	0	0	0	0.70	9.64
Gymnolaemata	*Celleporina sinuata*	5	3	0	0	0	0.70	7.71
Gymnolaemata	*Escharoides* sp	5	3	0	0	0	0	9.64
Gymnolaemata	*Favosipora tincta*	5	4	0	0	0	0	9.64
Gymnolaemata	*Gigantopora oropiscis*	5	4	0	0	0	1.39	5.78
Gymnolaemata	*Hippellozoon novaezelandiae* ^	5	4	0	0	0	0.70	7.71
Gymnolaemata	*Parkermavella punctigera*	5	4	0	0	0	1.39	5.78
Gymnolaemata	*Valdemunitella fraudatrix*	5	2	0	0	0	1.39	5.78

Type	Species	Surface sediments (0-5 cm)						
		Abd	Occur.	Inner shelf	mid north	PPA	mid south	Offshore
Gymnolaemata	*Calyptotheca immersa*	4	4	0	0	0	0.70	5.78
Gymnolaemata	*Crisia* sp	4	4	0	0	0	0	7.71
Gymnolaemata	*Fenestrula incompta*	4	3	0	0	0	0	7.71
Gymnolaemata	*Hastingsia* sp	4	2	0	0	0	2.09	1.93
Gymnolaemata	*Mollia amoena*	4	3	0	0	0	0	7.71
Gymnolaemata	*Parasmittina aotea*	4	3	0	0	0	0	7.71
Gymnolaemata	*Penetrantia parva*	4	4	0	0	0	1.39	3.86
Gymnolaemata	*Penetrantia* sp	4	2	0	0	0	1.39	3.86
Stenolaemata	*Bicrisia edwardsiana*	4	3	0	0	0	1.39	3.86
Gymnolaemata	*Arachnopusia unicornis*	3	2	0	0	0	0.70	3.86
Gymnolaemata	*Escharella spinosissima*	3	3	0	0	0	0.70	3.86
Gymnolaemata	*Exochella conjuncta*	3	2	0	0	0	0.70	3.86
Gymnolaemata	*Figularia huttoni*	3	3	0	0	0	0.70	3.86
Gymnolaemata	*Odontoporella bishopi*	3	3	0	0	0	0	5.78
Gymnolaemata	*Smittoidea discoveriae*	3	2	0	0	0	1.39	1.93
Stenolaemata	*Telopora lobata*	3	2	0	0	0	0.70	3.86
Gymnolaemata	*Aetea truncata*	2	2	0	0	0	0	3.86
Gymnolaemata	*Beania* sp	2	2	0	0	0	0	3.86
Gymnolaemata	*Bitectipora rostrata*	2	1	0	0	0	0	3.86
Gymnolaemata	*Buffonellodes rhomboidalis*	2	2	0	0	0	0	3.86
Gymnolaemata	*Chaperia granulosa*	2	2	0	0	0	0	3.86
Gymnolaemata	*Chaperiopsis cervicornis*	2	2	0	0	0	0	3.86
Gymnolaemata	*Cosciniopsis vallata*	2	2	1.17	0	0	0	1.93
Gymnolaemata	*Crassimarginatella cucullata*	2	2	0	0	0	0.70	1.93
Gymnolaemata	*Figularia mernae*	2	2	0	0	0	0	3.86
Gymnolaemata	*Filifascigera* sp	2	2	0	0	0	0	3.86
Gymnolaemata	*Hemismittoidea hexaspinosa*	2	2	0	0	0	0	3.86
Gymnolaemata	*Microeciella sppink*	2	1	0	0	0	0	3.86
Gymnolaemata	*Microporella discors*	2	2	0	0	0	0	3.86
Gymnolaemata	*Odontionella cyclops*	2	2	0	0	0	0	3.86
Gymnolaemata	*Steginoporella magnifica*	2	2	0	0	0	0	3.86
Stenolaemata	*Disporella pristis*	2	1	0	0	0	0	3.86

Type	Species	Surface sediments (0-5 cm)						
		Abd	Occur.	Inner shelf	mid north	PPA	mid south	Offshore
Stenolaemata	*Tubulipora* sp	2	2	0	0	0	0	3.86
Gymnolaemata	*Antarctothoa tongima*	1	1	1.17	0	0	0	0
Gymnolaemata	*Beania magellanica*	1	1	0	0	0	0	1.93
Gymnolaemata	*Buffonellaria christinelloides* (*STB)	1	1	0	0	0	0	1.93
Gymnolaemata	*Chaperiopsis rubida*	1	1	0	0	0	0	1.93
Gymnolaemata	*Chorizopora foramen*	1	1	0	0	0	0	1.93
Gymnolaemata	*Cornuticella taurina*	1	1	0	0	0	0.70	0
Gymnolaemata	*Costaticella bicuspis*	1	1	0	0	0	0.70	0
Gymnolaemata	*Crepidacantha parvipora*	1	1	1.17	0	0	0	0
Gymnolaemata	*Entalophoroecia* sp	1	1	0	0	0	0	1.93
Gymnolaemata	*Fenestrulina disjuncta*	1	1	0	0	0	0	1.93
Gymnolaemata	*Fenestrulina thyreophora*	1	1	0	0	0	0.70	0
Gymnolaemata	*Galeopsis polyporus*	1	1	0	0	0	0	1.93
Gymnolaemata	*Galeopsis porcellanicus*	1	1	0	0	0	0.70	0
Gymnolaemata	*Microporella* sp 6 [7 spines]	1	1	0	0	0	0	1.93
Gymnolaemata	*Opaeophora lepida*	1	1	0	0	0	0.70	0
Gymnolaemata	*Parasmittina delicatula*	1	1	0	0	0	0	1.93
Gymnolaemata	*Plagioecia sarniensis*	1	1	0	0	0	0.70	0
Gymnolaemata	*Schizomavella aotearoa*	1	1	0	0	0	0	1.93
Gymnolaemata	*Schizosmittina cinctipora*	1	1	0	1.19	0	0	0
Gymnolaemata	*Smittina rosacea*	1	1	0	0	0	0.70	0
Gymnolaemata	*Smittina torques*	1	1	0	0	0	0	1.93
Gymnolaemata	*Valdemunitella hara*	1	1	0	0	0	0	1.93
Stenolaemata	*Caprinsula* sp	1	1	0	0	0	0	1.93
Stenolaemata	*Disporella novaehollandiae*	1	1	0	0	0	0.70	0
Stenolaemata	*Idmidronea* sp	1	1	0	0	0	0	1.93

Appendix F Mollusca species list

Table E1: List of molluscan species collected in the dredges. Abd= Total number of specimens collected; Occur.= number of dredges/sites specimens occurred in. Inner shelf-Offshore values depict mean densities per 250 m^2. No new species of molluscs or new records for the STB region were recorded.

Type	Species	Abd	Occur.	Inner shelf	Mid north	PPA	Mid south	Offshore
Bivalvia	*Glycymeris modesta*	1625	43	70.699	2.789	0.737	6.059	0.320
Gastropoda	*Astraea heliotropium*	579	27	0	0	0	1.000	20.947
Bivalvia	*Mesopeplum convexum*	521	12	0	0	0	0	20.037
Bivalvia	*Modiolus areolatus*	200	5	0.226	0	0	0.029	7.489
Gastropoda	*Murex octogonus*	185	19	0	0	0	0.294	6.725
Bivalvia	*Tucetona laticostata*	179	27	0.226	0	0	0.676	5.828
Bivalvia	*Corbula zelandica*	150	21	2.105	1.632	0	1.471	1.123
Bivalvia	*Talochlamys zelandiae*	125	7	0	0.053	0	0	4.769
Gastropoda	*Amalda Baryspira australis*	96	25	2.105	0.947	0.526	0.794	0.038
Gastropoda	*Tanea zelandica*	61	26	0.842	0.789	0.316	0.676	0.038
Bivalvia	*Pecten novaezelandiae*	58	20	0.053	0.263	0.211	0.735	0.885
Cephalopoda	*Octopus huttoni*	57	20	0	0.053	0.053	0.294	1.744
Gastropoda	*Austrofusus glans*	48	25	0.526	0.211	0.316	0.824	0
Bivalvia	*Limaria orientalis*	46	8	0	0	0	0	1.780
Bivalvia	*Limatula maoria*	43	7	0	0	0	0	1.667
Gastropoda	*Ranella australasia*	41	7	0	0	0	0.206	1.298
Bivalvia	*Cardita distorta*	38	10	0	0	0	0.029	1.422
Bivalvia	*Pratulum pulchellum*	38	14	0	0.263	0.053	0	1.217
Bivalvia	*Barbatia novaezealandiae*	34	5	0	0	0	0.029	1.272
Gastropoda	*Cominella adspersa*	33	6	1.474	0	0	0.147	0
Gastropoda	*Coelotrochus tiaratus*	30	5	1.158	0	0	0	0.308
Bivalvia	*Ostrea chilensis*	20	4	0.075	0	0	0.529	0.038
Cephalopoda	*Octopus* sp	20	3	0	0	0	0	0.769
Gastropoda	*Zeatrophon ambiguus*	19	9	0.316	0	0	0.382	0
Polyplacophora	*Rhyssoplax canaliculata*	19	7	0.158	0	0	0.353	0.154
Gastropoda	*Calliostoma Maurea waikanae*	18	7	0	0	0	0.118	0.538
Polyplacophora	*Rhyssoplax stangeri*	18	4	0.526	0	0	0.235	0
Polyplacophora	*Notoplax rubiginosus*	15	4	0	0	0	0.324	0.171
Bivalvia	*Dosinia subrosea*	13	4	0.053	0.053	0	0.324	0

Type	Species	Abd	Occur.	Inner shelf	Mid north	PPA	Mid south	Offshore
Bivalvia	*Lima zealandica*	12	4	0	0	0	0	0.449
Gastropoda	*Coelotrochus viridis*	12	1	0.632	0	0	0	0
Gastropoda	*Charonia lampas*	10	3	0	0	0	0	0.385
Gastropoda	*Maoricolpus roseus*	10	1	0	0	0	0	0.385
Bivalvia	*Tawera* spissa	9	5	0.421	0	0	0.029	0
Gastropoda	*Amalda Baryspira mucronata*	9	4	0.158	0	0	0.029	0.192
Gastropoda	Gen sp	9	5	0.053	0	0	0.059	0.231
Gastropoda	Gen1 sp Little stripped	9	2	0.368	0	0	0.059	0
Bivalvia	*Myadora striata*	8	4	0.263	0	0	0.088	0
Bivalvia	*Hiatella artica*	7	2	0.158	0	0.211	0	0
Gastropoda	*Calliostoma Maurea punctulata*	7	1	0.368	0	0	0	0
Gastropoda	*Calliostoma Maurea selectum*	6	3	0	0	0	0.029	0.173
Polyplacophora	Parachiton sp	6	3	0	0	0	0.118	0.077
Bivalvia	*Purpurocardia purpurata*	5	3	0	0	0	0.118	0.038
Gastropoda	*Alcithoe arabica*	5	4	0	0	0	0.059	0.128
Gastropoda	*Maoricrypta Crepidula costata costata*	5	1	0	0	0	0	0.192
Polyplacophora	*Callochiton* sp	5	2	0	0	0	0.088	0.077
Gastropoda	*Cymatium Monoplex parthenopeum*	4	1	0	0	0	0	0.154
Gastropoda	*Penion sulcatus*	4	3	0.053	0	0	0.029	0.089
Gastropoda	*Tugali elegans*	4	1	0	0	0	0	0.154
Bivalvia	*Scalpomactra scalpellum*	3	3	0.053	0.105	0	0	0
Gastropoda	*Aeneator otagoensis*	3	1	0	0	0	0	0.096
Gastropoda	*Calliostoma Maurea granti*	3	1	0	0	0	0	0.096
Bivalvia	*Barnea Anchomasa similis*	2	1	0	0	0	0.059	0
Bivalvia	*Irus* sp	2	1	0	0	0	0	0.077
Cephalopoda	*Sepioloidea* sp	2	2	0.053	0	0	0	0.038
Gastropoda	*Antisolarium egenum*	2	2	0.053	0	0	0.029	0
Gastropoda	*Cabestana spengleri*	2	1	0	0	0	0	0.089
Gastropoda	*Semicassis pyrum*	2	2	0.053	0	0.053	0	0
Gastropoda	*Sigapatella novaezelandiae*	2	2	0.053	0	0	0.029	0
Polyplacophora	*Pseudotonicia cuneata*	2	2	0.053	0	0	0.029	0
Polyplacophora	*Rhyssoplax* sp	2	1	0.105	0	0	0	0

Type	Species	Abd	Occur.	Inner shelf	Mid north	PPA	Mid south	Offshore
Bivalvia	*Elliptotellina urinatoria*	1	1	0.053	0	0	0	0
Bivalvia	*Gari Gobraeus stangeri*	1	1	0.053	0	0	0	0
Bivalvia	*Nucula nitidula*	1	1	0.053	0	0	0	0
Bivalvia	*Pododesmus zelandicus*	1	1	0	0	0	0	0.038
Gastropoda	*Alloiodoris lanuginata*	1	1	0	0	0	0	0.038
Gastropoda	*Cabestana* sp	1	1	0	0	0	0	0.038
Gastropoda	*Ceratostoma amoena*	1	1	0	0	0	0	0.038
Gastropoda	*Dendrodoris citrina*	1	1	0	0	0	0	0.038
Gastropoda	*Lamellaria* sp	1	1	0	0	0	0	0.038
Gastropoda	*Sigapatella spadicea*	1	1	0	0	0	0.029	0
Gastropoda	*Xymene* sp	1	1	0	0	0	0	0.038

Table E2: List of molluscan species collected in the cores. Abd= Total number of specimens collected; Occur.= number of cores that specimens occurred in; ds=specimens only found in deeper sediments. Inner shelf-Offshore values depict mean densities per 1 m^2. Mean densities for surface sediments are presented per cross-shelf zones, while values in for deep sediment sections are presented simply as a total mean for all locations.

Type	Species	Surface sediments (0-5 cm)							5-10cm (mean)	10-15cm (mean)
		Abd	Occur.	Inner shelf	mid north	PPA	mid south	Offshore		
Bivalvia	*Scalpomactra scalpellum*	355	54	45.82	319.85	26.38	16.71	7.71	1.07	0.43
Bivalvia	*Glycymeris modesta*	143	58	39.94	23.87	18.47	46.64	15.42	4.00	5.62
Bivalvia	*Myadora* spp	115	61	10.57	27.45	11.87	43.16	23.13	0	0
Bivalvia	Psammobiidae spp	57	42	7.05	10.74	17.15	15.32	13.50	0	0
Bivalvia	*Dosinia subrosea*	38	26	4.70	1.19	1.32	21.58	1.93	0.53	0.43
Bivalvia	*Tucetona laticostata*	34	15	0	0	0	9.05	40.49	0	0
Bivalvia	*Elliptotellina urinatoria*	24	12	0	0	1.32	8.35	21.21	0	0
Bivalvia	*Paphies australis*	18	11	3.52	1.19	10.55	2.78	3.86	0	0
Bivalvia	*Corbula zelandica*	11	10	3.52	0	0	4.18	3.86	0.27	1.73
Gastropoda	*Tanea zelandica*	11	11	1.17	1.19	5.28	2.78	1.93	0	0
Bivalvia	*Macta* sp	9	1	10.57	0	0	0	0	0	0
Bivalvia	*Talochlamys zelandiae*	7	4	0	0	0	0	13.50	0	0
Gastropoda	*Amalda australis*	7	7	1.17	0	5.28	1.39	0	0	0

Type	**Species**			**Surface sediments (0-5 cm)**					**5-10cm (mean)**	**10-15cm (mean)**
		Abd	**Occur.**	**Inner shelf**	**mid north**	**PPA**	**mid south**	**Offshore**		
Bivalvia	*Dosinia Petunculus moariana*	6	1	0	0	0	4.18	0	0	0
Bivalvia	*Pleuromeris* sp	6	5	0	0	0	3.48	1.93	0.27	0.43
Gastropoda	*Amalda* sp	6	5	1.17	4.77	1.32	0	0	0	0
Polyplacophora	*Leptochiton inquinatus*	6	6	0	0	1.32	2.09	3.86	0	0
Bivalvia	Juvenille bivalve sp1	5	3	1.17	0	2.64	1.39	0	0	0
Bivalvia	*Pleuromeris zealandica*	4	2	0	0	0	2.78	0	0	0
Gastropoda	*Antisolarium egenum*	4	3	0	1.19	2.64	0.70	0	0	0
Bivalvia	*Austrovenus stutchburyi*	3	2	0	0	0	0	5.78	0	0
Bivalvia	*Diplodonta globus*	3	3	1.17	0	1.32	0.70	0	0	0.43
Bivalvia	*Trichomusculus barbatus*	3	1	0	0	0	0	5.78	0	0
Gastropoda	*Marginellae* sp1	3	3	0	1.19	1.32	0	1.93	0	0
Gastropoda	*Trochidae Gensp*	3	3	2.35	0	0	0.70	0	0	0
Bivalvia	*Dosinia* sp	2	2	0	1.19	0	0.70	0	0	0
Bivalvia	*Hiatella artica*	2	1	0	0	0	1.39	0	0	0
Bivalvia	*Irus* sp	2	2	0	0	2.64	0	0	0.27	0
Bivalvia	Limidae sp2	2	2	0	1.19	1.32	0	0	0	0
Bivalvia	*Pratulum pulchellum*	2	2	0	0	0	0.70	1.93	0	0
Gastropoda	*Austrofusus glans*	2	2	0	0	1.32	0.70	0	0	0
Gastropoda	*Coelotrochus tiaratus*	2	2	1.17	0	1.32	0	0	0	0
Gastropoda	Gen1 sp (Little stripped)	2	2	0	0	2.64	0	0	0	0
Gastropoda	*Heterobranchia* Gensp	2	2	0	1.19	0	0.70	0	0	0
Gastropoda	Whelk sp1	2	2	0	1.19	1.32	0	0	0	0
Bivalvia	*Divaricella cumingi*	1	1	0	0	0	0	1.93	0	0
Bivalvia	*Divaricella huttoniana*	1	1	0	1.19	0	0	0	0	0
Bivalvia	*Limidae* sp1	1	1	0	0	0	0.70	0	0	0
Bivalvia	*Mesopeplum convexum*	1	1	0	0	0	0	1.93	0	0
Bivalvia	*Nucula nitidula*	1	1	0	0	0	0.70	0	0	0
Bivalvia	*Oxyperas elongata*	1	1	0	0	0	0.70	0	0	0
Bivalvia	*Perrierina perstriata*	1	1	0	0	0	0	1.93	0	0
Bivalvia	*Petunculus maoriana*	1	1	0	0	0	0.70	0	0	0
Bivalvia	*Powellina brookesi*	1	1	0	0	0	0	1.93	0	0
Bivalvia	Psammobiidae 1	1	1	0	1.19	0	0	0	0	0

Type	Species	Surface sediments (0-5 cm)							5-10cm (mean)	10-15cm (mean)
		Abd	Occur.	Inner shelf	mid north	PPA	mid south	Offshore		
Bivalvia	*Semele brambleyae*	1	1	0	0	0	0	1.93	0	0
Bivalvia	*Talochlamys gemmulata*	1	1	0	0	0	0	1.93	0	0
Bivalvia	*Veneridae Gensp*	1	1	1.17	0	0	0	0	0	0
Gastropoda	*Astraea heliotropium*	1	1	0	0	0	0.70	0	0	0
Gastropoda	*Cominella adspersa*	1	1	1.17	0	0	0	0	0	0
Gastropoda	*Epitonium* sp	1	1	1.17	0	0	0	0	0	0
Gastropoda	*Murex octogonus*	1	1	0	0	0	0.70	0	0	0
Gastropoda	*Pervicacia tristis*	1	1	0	1.19	0	0	0	0	0
Gastropoda	*Serrata parvistriata*	1	1	0	1.19	0	0	0	0	0
Gastropoda	*Sigapatella tenuis*	1	1	0	0	0	0	1.93	0	0
Polyplacophora	*Acanthochitona zelandica*	1	1	0	0	0	0	1.93	0	0
Polyplacophora	*Rhyssoplax c.f. canaliculata*	1	1	0	0	0	0.70	0	0	0
Bivalvia	*Gari* sp1	ds	ds	0	0	0	0	0	0.27	0
Bivalvia	*limatula maoria*	ds	ds	0	0	0	0	0	0	0.43
Bivalvia	*Myadora striata*	ds	ds	0	0	0	0	0	0.53	0.86
Bivalvia	*Purpurocardia reinga*	ds	ds	0	0	0	0	0	0	0.43
Gastropoda	*Maoricrypta* sp1	ds	ds	0	0	0	0	0	0.27	0

Appendix G Annelida and other worm-like phyla species list

Table F1: Species list of annelids and other worm-like phyla collected in the dredges. Abd= Total number of specimens collected; Occur.= number of dredges/sites specimens occurred in. Inner shelf-Offshore values depict mean densities per 250 m^2.

Type	Species	Abd	Occur.	Inner shelf	Mid north	PPA	Mid south	Offshore
Polychaeta	*Eunice laticeps*	210	11	0	0	0	0	8.060
Polychaeta	*Eunice australis*	200	15	0.263	0	0	0.147	7.289
Polychaeta	*Spirobranchus latiscapus*	176	6	0	0	0	0	6.762
Polychaeta	syllids nd	135	15	0	0.316	0.053	0.441	4.363
Polychaeta	*Odontosyllis polycera*	126	7	0	0	0	0	4.846
Polychaeta	*Serpula* nd	56	7	0	0	0	0.059	2.060
Polychaeta	*Nereis falcaria*	45	8	0	0	0	0.235	1.429
Polychaeta	phyllodocids nd	35	12	0	0.105	0	0.294	0.890
Nemertea	nemerteans nd	31	17	0.105	0.684	0.316	0.088	0.269
Polychaeta	terebellids nd	27	7	0	0	0	0.265	0.698
Polychaeta	*Spiochaetopterus* nd	22	6	0.684	0	0	0.118	0.192
Polychaeta	*Metavermilia acanthophora*	21	4	0	0	0	0.029	0.775
Polychaeta	*Protula bispiralis*	21	4	0	0	0	0	0.819
Polychaeta	*Sigalion oviger*	19	12	0.211	0.158	0.053	0.206	0.166
Polychaeta	*Ophiodromus angustifrons*	17	5	0	0	0	0.118	0.500
Polychaeta	*Parasabella aberrans*	17	4	0.053	0	0	0	0.603
Polychaeta	*Trypanosyllis zebra*	14	4	0	0	0	0.059	0.467
Polychaeta	dorvilleids nd	10	3	0	0	0	0.059	0.308
Polychaeta	*Lacydonia* sp A (*NS)	10	4	0	0	0	0.029	0.346
Polychaeta	*Lepidonotus jacksoni*	9	2	0	0	0	0.059	0.275
Polychaeta	*Neanthes cricognatha*	9	2	0	0	0	0.088	0.231
Polychaeta	*Pseudopotamilla laciniosa*	9	3	0.105	0	0	0.059	0.192
Polychaeta	*Euphione squamosa*	8	3	0	0	0	0	0.325
Polychaeta	polynoids nd	8	1	0	0	0	0	0.308
Polychaeta	*Pherusa parmata*	7	2	0	0	0	0	0.250
Polychaeta	*Hyalinoecia incubans*	6	3	0	0.316	0	0	0
Polychaeta	chrysopetalids nd	4	1	0	0	0	0	0.154
Polychaeta	*Euchone* sp A (*NS)	4	2	0	0.158	0.053	0	0

Type	Species	Abd	Occur.	Inner shelf	Mid north	PPA	Mid south	Offshore
Polychaeta	*Glycera benhami*	4	1	0	0	0	0	0.154
Polychaeta	serpulids nd	4	1	0	0	0	0	0.154
Polychaeta	cirratulids nd	3	1	0	0	0	0	0.115
Polychaeta	*Galeolaria hystrix*	3	2	0.053	0	0	0	0.089
Polychaeta	lumbrinerids nd	3	3	0	0.053	0	0.059	0
Polychaeta	*Marphysa* nd	3	1	0	0	0	0	0.096
Polychaeta	*Platynereis australis*	3	1	0	0.158	0	0	0
Polychaeta	*Spiophanes modestus*	3	1	0	0	0	0	0.115
Polychaeta	*Neanthes* sp *A*	2	1	0.105	0	0	0	0
Polychaeta	*Cheilonereis peristomialis*	1	1	0	0.053	0	0	0
Polychaeta	*Clavisyllis alternata*	1	1	0	0	0	0	0.038
Polychaeta	*Euphrosine maorica*	1	1	0	0	0	0.029	0
Polychaeta	*Lumbrineris* *sphaerocephala*	1	1	0.053	0	0	0	0
Polychaeta	*Nothria nothria A*	1	1	0	0	0	0	0.038
Polychaeta	*Owenia petersenae*	1	1	0	0.053	0	0	0
Polychaeta	*Pelogenia antipoda*	1	1	0	0.053	0	0	0
Polychaeta	*Pelogenia semiglabra*	1	1	0.053	0	0	0	0
Polychaeta	*Protocirrineris nuchalis*	1	1	0	0.053	0	0	0
Polychaeta	*Pseudopista rostrata*	1	1	0.053	0	0	0	0
Polychaeta	*Terebella terebella B*	1	1	0	0	0	0.029	0

Table F2: List of annelids and other worm-like phyla collected in the cores. Abd= Total number of specimens collected; Occur.= number of cores that specimens occurred in; ds=specimens only found in deeper sediments. Inner shelf-Offshore values depict mean densities per 1 m^2. Mean densities for surface sediments are presented per cross-shelf zones, while values in for deep sediment sections are presented simply as a total mean for all locations. *= notable species; *STB =new record for the south Taranaki Bight; *NS=new species.

Type	Species	Surface sediments (0-5 cm)							5-10cm (mean)	10-15cm (mean)
		Abd	Occur.	Inner shelf	mid north	PPA	mid south	Offshore		
Polychaeta	*Euchone* sp A (*NS)	1438	80	37.59	572.86	1184.5	18.80	1.93	59.72	2.16
Polychaeta	syllids nd	598	172	173.87	90.70	67.27	197.02	77.12	14.66	7.78
Polychaeta	para syllid nd (*NS)	293	91	142.15	77.57	46.17	50.13	0	9.60	2.59
Polychaeta	Aricidea nd	230	91	18.80	101.44	104.21	20.89	38.56	35.46	4.75

Type	**Species**	**Surface sediments (0-5 cm)**							**5-10cm (mean)**	**10-15cm (mean)**
		Abd	**Occur.**	**Inner shelf**	**mid north**	**PPA**	**mid south**	**Offshore**		
Polychaeta	cirratulids nd A	196	73	118.66	58.48	3.96	27.15	7.71	4.53	1.73
Nemertea	micro nemertean nd	165	89	68.14	35.80	17.15	41.77	7.71	7.73	2.16
Polychaeta	Aphelochaeta nd	161	2	189.14	0	0	0	0	0	0
Polychaeta	dorvilleid sp A	157	70	46.99	8.35	1.32	65.44	28.92	8.00	3.46
Polychaeta	*Pisione oerstedii* (*STB)	135	69	21.15	25.06	18.47	52.91	11.57	7.73	0
Nematoda	nematodes nd	133	73	22.32	37.00	19.79	42.47	13.50	4.80	0.43
Oligochaeta	oligochaetes nd	125	57	15.27	21.48	17.15	52.21	11.57	6.40	1.30
Polychaeta	exogoninae nd	91	31	22.32	0	0	32.72	48.20	1.87	3.02
Polychaeta	*Euchone* sp B (*NS)	70	41	14.10	11.93	0	31.33	5.78	0.53	0
Polychaeta	*Spiophanes modestus*	68	33	14.10	45.35	23.74	0	0	0.53	0
Polychaeta	*Sigalion oviger*	65	58	16.45	11.93	23.74	15.32	1.93	3.47	0
Polychaeta	phyllodocids nd	64	35	7.05	38.19	17.15	6.96	5.78	1.60	0.43
Polychaeta	lumbrinerids nd	62	52	3.52	10.74	2.64	25.76	21.21	5.60	1.73
Polychaeta	*Prionospio tridentata*	42	30	18.80	22.68	7.91	0	1.93	0.80	0
Polychaeta	Goniada nd	36	26	3.52	5.97	7.91	11.14	11.57	0.53	0
Polychaeta	Magelona nd	35	27	2.35	8.35	9.23	8.35	13.50	3.47	0.86
Polychaeta	Paraonella nd	33	21	17.62	14.32	6.60	0.70	0	2.13	1.73
Polychaeta	*Hemipodus simplex*	31	24	10.57	2.39	2.64	10.44	5.78	1.33	0.86
Polychaeta	*Notomastus* sp A	28	21	0	5.97	3.96	11.14	7.71	0.27	0.86
Polychaeta	*Mystides* sp A	26	20	2.35	4.77	21.11	2.78	0	0	0
Nemertea	nemerteans nd	23	16	1.17	3.58	10.55	4.87	7.71	2.67	2.16
Polychaeta	nephtyids nd	20	15	14.10	5.97	0	2.09	0	0	0.43
Polychaeta	cirratulids nd	18	10	0	0	6.60	9.05	0	0	0
Polychaeta	Chaetozone nd	17	14	1.17	8.35	6.60	2.78	0	0.27	0
Polychaeta	*Spio readi*	17	14	0	3.58	15.83	0.70	1.93	0	0
Polychaeta	hesionids nd	15	11	7.05	1.19	0	4.18	3.86	0	0
Polychaeta	*Travisia kerguelensis*	15	14	1.17	2.39	5.28	4.87	1.93	0.80	0
Polychaeta	Pista nd	13	9	0	4.77	3.96	1.39	7.71	0	0
Polychaeta	sigalionids nd	13	12	0	5.97	2.64	0.70	9.64	0	0
Polychaeta	*Notomastus* sp C	11	9	1.17	4.77	0	4.18	0	5.60	0.86
Polychaeta	*Onuphis aucklandensis*	11	10	9.40	3.58	0	0	0	0.53	0
Polychaeta	*Protocirrineris nuchalis*	11	7	0	0	1.32	2.78	11.57	0	0

Type	Species	Surface sediments (0-5 cm)							5-10cm (mean)	10-15cm (mean)
		Abd	Occur.	Inner shelf	mid north	PPA	mid south	Offshore		
Polychaeta	scalibregmatids nd	11	8	0	0	0	3.48	11.57	0	0
Polychaeta	terebellids nd	11	9	0	1.19	0	5.57	3.86	1.33	0
Polychaeta	*Prionospio* nd *tridentata*?	10	9	10.57	1.19	0	0	0	0	0
Sipuncula	sipunculans nd	10	9	7.05	1.19	0	2.09	0	0.27	0.86
Polychaeta	maldanids nd	9	7	0	0	7.91	2.09	0	0.27	0.43
Polychaeta	sabellids nd	9	7	0	0	1.32	0	15.42	0	0
Polychaeta	*Prionospio australiensis*	8	3	7.05	1.19	1.32	0	0	0	0
Polychaeta	*Spiophanes wigleyi*	8	4	0	8.35	1.32	0	0	0.27	0
Polychaeta	*Levinsenia* nd	6	4	0	2.39	0	2.09	1.93	3.47	3.89
Polychaeta	*Nereis falcaria*	6	3	0	0	0	1.39	7.71	0	0.43
Polychaeta	*Polygordius* sp A (*STB)	6	6	0	0	0	3.48	1.93	0	0
Phoronida	*Phoronis psammophila*	5	5	3.52	1.19	1.32	0	0	0.27	0
Polychaeta	*Ampharete kerguelensis*	5	4	0	3.58	0	0	3.86	0	0
Polychaeta	*Prionospio multicristata*	5	4	0	0	0	2.78	1.93	0	0
Polychaeta	*Aglaophamus* nd	4	4	1.17	0	2.64	0.70	0	0	0
Polychaeta	chrysopetalids nd	4	3	0	0	0	0.70	5.78	0	0
Polychaeta	*Lacydonia* sp A (*NS)	4	2	0	0	0	0	7.71	0	0
Polychaeta	*Odontosyllis polycera*	4	3	0	0	0	0.70	5.78	0	0
Polychaeta	*Ophelia* sp A (*NS)	4	3	0	0	0	2.78	0	0.80	0
Polychaeta	*Eunice australis*	3	2	0	1.19	0	0	3.86	0	0
Polychaeta	*Kinbergonuphis proalopus*	3	3	0	1.19	1.32	0.70	0	0	0
Polychaeta	orbiniids nd	3	3	0	0	0	1.39	1.93	0	0
Polychaeta	para exogonin nd	3	2	0	0	0	2.09	0	0	0
Polychaeta	*Prionospio wambiri*	3	3	0	0	0	1.39	1.93	0.27	0
Polychaeta	*Aonides* sp A	2	1	0	0	0	1.39	0	0	0
Polychaeta	*Aonides trifida*	2	2	2.35	0	0	0	0	0.27	0
Polychaeta	*Drilonereis* nd	2	2	0	2.39	0	0	0	0.27	0
Polychaeta	*Hesiospina aurantiaca* (*NS)	2	2	0	0	0	0	3.86	0	0
Polychaeta	*Hyalinoecia longibranchiata*	2	1	0	2.39	0	0	0	0	0
Polychaeta	*Orbinia papillosa*	2	2	1.17	0	1.32	0	0	0	0
Polychaeta	*Owenia petersenae*	2	2	0	2.39	0	0	0	0.27	0
Polychaeta	Polydora nd	2	2	0	0	0	1.39	0	0.27	1.30

Type	Species	Surface sediments (0-5 cm)							5-10cm (mean)	10-15cm (mean)
		Abd	Occur.	Inner shelf	mid north	PPA	mid south	Offshore		
Polychaeta	*Spiophanes japonicum*	2	1	0	2.39	0	0	0	0.80	0
Polychaeta	*Synelmis knoxi*	2	2	0	0	0	0	3.86	0	0
Platyhelminthes	tricladida nd	1	1	1.17	0	0	0	0	0	0
Polychaeta	*Aglaophamus verrilli*	1	1	0	0	0	0	1.93	0.27	0
Polychaeta	*Armandia maculata*	1	1	0	0	1.32	0	0	0	0
Polychaeta	*Euphrosine maorica*	1	1	0	0	0	0	1.93	0	0
Polychaeta	*Glycera lamelliformis*	1	1	0	0	0	0	1.93	0	0
Polychaeta	*Glycera lapidum*	1	1	0	0	0	0.70	0	0	0
Polychaeta	*Macroclymenella stewartensis*	1	1	0	1.19	0	0	0	0	0
Polychaeta	*Maldane theodori*	1	1	0	1.19	0	0	0	0	0
Polychaeta	*Marphysa cf.capensis*	1	1	0	0	0	0.70	0	0	0
Polychaeta	*Marphysa depressa*	1	1	0	0	0	0.70	0	0	0
Polychaeta	*Melinna armandi*	1	1	0	0	0	0	1.93	0	0
Polychaeta	nereidids nd	1	1	0	0	0	0.70	0	0	0
Polychaeta	Nothria nd	1	1	0	0	0	0.70	0	0	0
Polychaeta	*Ophiodromus angustifrons*	1	1	0	0	0	0	1.93	0	0
Polychaeta	*Parasabella aberrans*	1	1	0	1.19	0	0	0	0	0
Polychaeta	*Pelagonia semiglabra*	1	1	0	0	1.32	0	0	0.27	0.43
Polychaeta	*Pelogenia antipoda*	1	1	0	0	0	0.70	0	0	0
Polychaeta	*Phyllochaetopterus* nd	1	1	0	0	0	0	1.93	0	0
Polychaeta	Polychaete nd	1	1	1.17	0	0	0	0	0	0
Polychaeta	Prionospio nd	1	1	0	0	0	0.70	0	0.53	0
Polychaeta	sphaerodorids nd	1	1	0	0	0	0	1.93	0	0
Polychaeta	*Spirobranchus latiscapus*	1	1	0	0	0	0.70	0	0	0
Sea Leach	Huridean sp	1	1	0	0	0	0	1.93	0	0
Polychaeta	*Aglaophamus macroura*	ds	ds	0	0	0	0	0	0	0.43
Polychaeta	*Scoloplos Leodamas* nd	ds	ds	0	0	0	0	0	0.27	0
Polychaeta	spionids nd	ds	ds	0	0	0	0	0	0.27	0

Appendix H Decapod species list

Table G1: Species list of decapod crustaceans collected in the dredges. Abd= Total number of specimens collected; Occur.= number of dredges/sites specimens occurred in. Inner shelf-Offshore values depict mean densities per 250 m^2.

Type	Species	Abd	Occur.	Inner shelf	Mid north	PPA	Mid south	Offshore
Decapoda	*Lophopagurus* 2spp	1568	84	6.632	12.053	11.000	25.206	5.638
Decapoda	*Areopaguristes setosus*	1005	79	12.474	19.053	9.158	5.324	1.974
Decapoda	*Liocarcinus corrugatus*	117	27	0.684	0.316	0.105	0.706	2.772
Decapoda	*Bellidilia cheesmani*	108	26	0.368	1.789	0.316	0.588	1.567
Decapoda	*Diacanthurus spinulimanus*	97	44	0.737	1.105	0.737	0.941	0.607
Decapoda	*Nectocarcinus antarcticus*	89	34	0.789	0.368	0.105	0.794	1.475
Decapoda	*Phylladiorphynchus pusillus*	58	14	0	0.842	0.211	0.088	1.331
Decapoda	*Notromithrax peroni*	35	20	0.368	0.368	0.211	0.029	0.614
Decapoda	*Ovalipes cathrarus*	31	15	0.737	0.053	0.053	0.441	0
Decapoda	*Eurynolambrus australis*	29	4	0	0	0	0	1.106
Decapoda	*Dromia wilsoni*	18	5	0	0	0	0.029	0.665
Decapoda	*Notromithrax minor*	11	9	0.053	0.211	0	0.118	0.089
Decapoda	*Halicarcinus cooki*	10	3	0	0.474	0.053	0	0
Decapoda	*Alpheidae* sp1	4	3	0	0	0	0.029	0.128
Decapoda	*Achaeus curvirostris*	3	2	0	0	0	0	0.128
Decapoda	*Elamena longirostris*	2	2	0	0	0	0	0.077
Decapoda	*Palaemonidae* sp1	2	1	0	0	0	0	0.089
Decapoda	*Pinnotheres* sp	2	2	0	0	0	0.059	0
Decapoda	*Leucosiidae* sp	1	1	0	0	0	0	0.038
Decapoda	*Notomithrax megalopa larva*	1	1	0	0	0.053	0	0
Decapoda	*Petrocheles spinosus*	1	1	0.053	0	0	0	0
Decapoda	*Thacanophrys filholi*	1	1	0	0	0	0	0.038

Table G2: List of molluscan species collected in the cores. Abd= Total number of specimens collected; Occur.= number of cores that specimens occurred in. Inner shelf-Offshore values depict mean densities per 1 m^2. Mean densities for surface sediments are presented per cross-shelf zones, while values in for deep sediment sections are presented simply as a total mean for all locations.

Type	**Species**	**Surface sediments (0-5 cm)**							**5-10cm (mean)**	**10-15cm (mean)**
		Abd	**Occur.**	**Inner shelf**	**mid north**	**PPA**	**mid south**	**Offshore**		
Decapoda	*Lophopagurus* 2spp	25	16	0	17.90	3.96	2.78	5.78	0	0
Decapoda	Stomatopoda juvenile	10	9	2.35	4.77	3.96	0.70	0	0	0
Decapoda	*Areopaguristes setosus*	7	6	2.35	4.77	1.32	0	0	0	0
Decapoda	*Bellidilia cheesemani*	4	4	0	2.39	1.32	0	1.93	0	0
Decapoda	shrimp juvenile	2	2	0	0	2.64	0	0	0	0
Decapoda	Axiidae sp	1	1	0	0	0	0	1.93	0	0
Decapoda	*Heterosquilla laevis*	1	1	0	0	1.32	0	0	0	0
Decapoda	Palaemonidae sp1	1	1	0	0	1.32	0	0	0	0

Appendix I Porifera (sponge) species list

Table H1: Species list of sponges collected in the dredges. Abd= Total number of specimens collected; Occur.= number of dredges/sites specimens occurred in. Inner shelf-Offshore values depict mean densities per 250 m^2. *= notable species; *STB =new record for the south Taranaki Bight; *NS=new species.

Type	Species	Abd	Occur.	Inner shelf	Mid north	PPA	Mid south	Offshore
Demospongiae	*Dactylia palmata*	141	20	0.053	0	0	0.176	5.145
Demospongiae	*Stryphnus ariena*	65	4	0	0	0	0	2.513
Demospongiae	*Stelletta purpurea* *	63	7	0.053	0	0	0	2.385
Demospongiae	*Pseudoceratina* sp 1 (*STB)	54	4	0	0	0	0	2.064
Demospongiae	*Tethya amplexa* (*STB)	54	4	0	0	0	0	2.058
Demospongiae	*Pararaphoxya sp 2* *Raspailia topsenti mimic*	39	4	0	0	0	0	1.500
Demospongiae	*Hymeniacidon hauraki*	22	5	0.211	0	0	0.176	0.462
Demospongiae	*Crella incrustans*	17	15	0.316	0.263	0.158	0.088	0
Demospongiae	*Ircinia* sp 6 (*NS)	15	2	0	0	0	0	0.564
Demospongiae	*Callyspongia* sp 10 *Kenepuru palmate*	11	2	0	0	0	0	0.410
Demospongiae	*Psammopemma* sp 7 (*NS)	8	3	0.421	0	0	0	0
Demospongiae	Dysidea cf n sp 5	7	1	0	0	0	0	0.256
Demospongiae	*Geodia regina*	7	1	0	0	0	0	0.256
Demospongiae	*Mycale Carmia tasmani*	7	6	0	0.263	0.053	0.029	0
Demospongiae	*Stryphnus novaezelandiae*	7	1	0	0	0	0	0.256
Demospongiae	*Xestospongia* sp 6 (*NS)	7	1	0	0	0	0	0.256
Demospongiae	*Chalinidae* sp	6	2	0	0.053	0	0	0.192
Demospongiae	*Chondropsis* sp	5	1	0	0	0	0	0.192
Demospongiae	*Cymbastella* sp 1 (*NS)	5	1	0	0	0	0.147	0
Demospongiae	*Iophon minor*	5	4	0.053	0	0.053	0.088	0
Demospongiae	*Neopetrosia* sp 11 (*NS)	5	1	0	0	0	0	0.192
Demospongiae	*Stellata conulosa* (*STB)	5	1	0	0	0	0	0.192
Demospongiae	*Adocia* sp 1	4	1	0	0	0	0	0.154
Demospongiae	Axinella sp	4	2	0	0.105	0	0.059	0
Demospongiae	*Aaptos tentum*	3	2	0.053	0	0	0.059	0
Demospongiae	*Dictyodendrilla* n sp 3 (*NS)	3	1	0.158	0	0	0	0

Type	Species	Abd	Occur.	Inner shelf	Mid north	PPA	Mid south	Offshore
Demospongiae	*Homaxinella* sp	3	2	0	0.158	0	0	0
Demospongiae	*Hymeniacidon* sp undet	3	2	0	0.105	0.053	0	0
Demospongiae	*Iophon proximum*	3	1	0.158	0	0	0	0
Demospongiae	*Callyspongia diffusa*	2	2	0.053	0.053	0	0	0
Demospongiae	Dysidea sp	2	2	0	0	0.053	0	0.038
Demospongiae	*Haliclona* sp	2	2	0.053	0.053	0	0	0
Demospongiae	*Higginsia* sp (*STB)	2	1	0	0	0	0.059	0
Demospongiae	*Psammopemma* sp	2	1	0	0	0	0	0.077
Calcarea	*Leucosolenia cf discoveryi*	1	1	0	0.053	0	0	0
Demospongiae	*Biemna rufescens*	1	1	0.053	0	0	0	0
Demospongiae	*Callyspongia* sp 12	1	1	0	0	0	0.029	0
Demospongiae	*Callyspongiidae* sp	1	1	0	0.053	0	0	0
Demospongiae	*Halichondria* n sp 7 (*NS)	1	1	0	0	0	0	0.038
Demospongiae	*Polymastia echinus*	1	1	0	0	0	0.029	0
Demospongiae	*Polymastia lorum* (*STB)	1	1	0	0	0	0	0.038
Demospongiae	*Polymastia tapetum*	1	1	0	0	0	0.029	0
Demospongiae	*Pseudosuberites* sp	1	1	0	0	0.053	0	0
Demospongiae	*Raspailia Clathriodendron arbuscula*	1	1	0	0	0	0.029	0
Demospongiae	*Tethya berguistae*	1	1	0.053	0	0	0	0

Table D2: List of sponge species collected in the cores. Abd= Total number of specimens collected; Occur.= number of cores that specimens occurred in. Inner shelf-Offshore values depict mean densities per 1 m^2 for each cross-shelf zone. nd= species not determined.

Type	Species			Surface sediments (0-5 cm)				
		Abd	Occur.	Inner shelf	mid north	PPA	mid south	Offshore
Demospongiae	Axinella nd	1	1	0	0	0	0.70	0
Demospongiae	*Ceratopsion cuneiformis*	1	1	0	0	0	0.70	0
Demospongiae	Polymastiidae sp	1	1	0	0	0	0.70	0
Demospongiae	Suberitidae sp	1	1	0	0	0	0.70	0

Appendix J Ascidia species list

Table I: List of ascidians species collected in the dredges. Abd= Total number of specimens collected; Occur.= number of dredges/sites specimens occurred in. Inner shelf-Offshore values depict mean densities per 250 m^2. Purple text = exotic species.

Phyla	Species	Authority	Abd	Occur.	Inner shelf	Mid north	PPA	Mid south	Offshore
Ascidiacea	*Corella eumyota*	Traustedt 1882	326	9	0.211	0	0	1.029	11.036
Ascidiacea	*Cnemidocarpa hemprichi*	Hartmeyer 1916	73	7	0	0	0	0.029	2.780
Ascidiacea	*Cnemidocarpa otagoensis*	Brewin 1952	26	4	0.053	0	0	0	0.949
Ascidiacea	*Molgula mortenseni*	Michaelsen, 1922	23	7	0.053	0	0	0.059	0.754
Ascidiacea	*Polyzoa opuntia*	Lesson 1830	23	1	0	0	0	0	0.865
Ascidiacea	*Pyura pulla*	Sluiter, 1900	19	2	0	0	0	0	0.748
Ascidiacea	*Pyura molguloides (*Exotic)*	Herdman, 1899	18	2	0	0	0	0	0.703
Ascidiacea	*Pyura rugata*	Brewin 1948	14	3	0	0	0	0.029	0.500
Ascidiacea	*Cnemidocarpa nisiotus*	Sluiter, 1900	6	1	0.316	0	0	0	0
Ascidiacea	*Cnemidocarpa bicornuta*	Sluiter 1900	3	1	0	0	0	0	0.096
Ascidiacea	*Eugyra* sp		3	1	0	0	0	0	0.096
Ascidiacea	*Cnemidocarpa novaezealandiae*	Michaelsen, 1912	2	1	0.105	0	0	0	0

NB: Only one undetermined tunicate was collected from the cores.

Appendix K Echinoderm species list

Table K1: List of echinoderm species collected in the dredges. Abd= Total number of specimens collected; Occur.= number of dredges/sites specimens occurred in. Inner shelf-Offshore values depict mean densities per 250 m^2.

Type	**Species**	**Abd**	**Occur.**	**Inner shelf**	**Mid north**	**PPA**	**Mid south**	**Offshore**
Ophiuroid	*Ophiopsammus maculata*	260	18	0	0	0	0.735	9.057
Ophiuroid	*Ophiomyxa brevirima*	134	15	0	0	0	0	5.147
Ophiuroid	*Ophiopeza cylindrica*	101	15	0	0	0	0.029	3.849
Holothurian	*Australostichopus mollis*	49	12	0	0	0	0.029	1.842
Ophiuroid	*Ophiactis resiliens*	37	6	0.842	0	0	0	0.824
Ophiuroid	*Clarkcoma bollonsi*	19	6	0	0	0	0	0.736
Ophiuroid	*Ophionereis fasciata*	12	4	0.053	0	0	0	0.423
Ophiuroid	*Ophiopteris antipodum*	11	5	0	0	0	0	0.425
Ophiuroid	*Cryptopelta tarltoni*	9	2	0	0	0	0	0.346
Holothurian	*Chiridota nigra*	8	2	0	0	0	0	0.308
Asteroid	*Astropecten polyacanthus*	6	6	0	0.105	0.053	0.088	0
Ophiuroid	*Amphipholis squamata*	5	1	0	0	0	0	0.192
Echinoid	*Apatopygus recens*	4	3	0.158	0	0	0.029	0
Holothurian	*Placothuria huttoni*	4	4	0	0.053	0	0.088	0
Asteroid	*Patiriella morttenseni*	3	2	0.105	0	0	0.029	0
Asteroid	*Coscinasterias muricata*	2	2	0	0	0.105	0	0
Holothurian	*Taeniogyrus dunedinensis*	2	2	0	0.053	0	0.029	0
Ophiuroid	*Amphiura dawbini*	2	1	0	0.105	0	0	0
Ophiuroid	*Amphiura magellanica*	2	1	0	0	0	0	0.077
Holothurian	*Neocucumella bicolumnata*	1	1	0	0	0	0.029	0
Holothurian	*Taeniogyrus* sp	1	1	0	0	0	0.029	0
Ophiuroid	*Amphiura psilopora*	1	1	0	0	0	0.029	0

Table K2: List of echinoderm species collected in the cores. Abd= Total number of specimens collected; Occur.= number of cores that specimens occurred in. Inner shelf-Offshore values depict mean densities per 1 m^2. Mean densities for surface sediments are presented per cross-shelf zones, while values in for deep sediment sections are presented simply as a total mean for all locations.

Type	Species	Surface sediments (0-5 cm)						
		Abd	**Occur.**	**Inner shelf**	**mid north**	**PPA**	**mid south**	**Offshore**
echinoidea	*Echinocardium cordatum*	8	7	9.40	0	0	0	0
Ophiuroidea	*Amphiura alba*	4	3	0	0	0	0	7.71
Ophiuroidea	*Amphiura heraldica*	3	3	1.17	0	1.32	0	1.93
Ophiuroidea	*Amphiura rosea*	3	3	3.52	0	0	0	0
Ophiuroidea	*Amphiura dawbini*	2	2	0	0	0	0	3.86
Ophiuroidea	*Amphiura magellanica*	2	2	0	0	0	0.70	1.93
Ophiuroidea	*Amphiura psilopora*	2	2	0	0	1.32	0.70	0
holothuroida	*Chiridota nigra*	1	1	0	0	0	0	1.93
Ophiuroidea	*Amphipholis squamata*	1	1	0	0	0	0	1.93
Ophiuroidea	*Amphiura micra*	1	1	0	0	0	0	1.93
Ophiuroidea	*Amphiura pusilla*	1	1	0	0	0	0	1.93
Ophiuroidea	*Ophiocentrus novaezelandiae*	1	1	0	1.19	0	0	0
Ophiuroidea	*Ophiopsammus maculata*	1	1	0	0	0	0.70	0
Ophiuroidea	Ophiurida	1	1	1.17	0	0	0	0
Ophiuroidea	Ophiuroid juv	1	1	0	0	0	0.70	0

Appendix L Fish species list

Table L1: List of fish species collected in the dredges. Abd= Total number of specimens collected; Occur.= number of dredges/sites specimens occurred in. Inner shelf-Offshore values depict mean densities per 250 m^2.

Group/Class	Common Names	Species	Abd	Occur.	Inner shelf	Mid north	PPA	Mid south	Offshore
Actinopterygygii	Triplefin	*Matanui profundum*	445	22	0	0	0	0.529	16.406
Actinopterygygii	Opalfish	*Hemerocoetes monopterygius*	53	31	0.947	0.632	0.368	0.441	0.038
Actinopterygygii	Clingfish (Lumpfish)	*Trachelochismus pinnulatus*	26	6	0.368	0	0	0.118	0.563
Actinopterygygii	Flatfishes	*Arnoglossus scapha*	11	9	0.053	0.158	0.211	0.088	0
Actinopterygygii	Bluecod	*Parapercis colias*	8	5	0	0	0	0.088	0.192
Actinopterygygii	Tommyfish	*Limnichthys rendahli*	8	7	0.158	0.053	0	0.059	0.077
Actinopterygygii	Pipefish	*Leptonotus norae*	5	1	0	0	0	0	0.192
Actinopterygygii	Triplefin	*Karalepis stewarti*	5	1	0	0	0	0	0.192
Actinopterygygii	Little conger eel	*Gnathophis habenatus*	4	4	0	0	0	0.088	0.038
Actinopterygygii	Leatherjacket	*Meuschenia scaber*	3	2	0	0.053	0	0	0.089
Actinopterygygii	Weedfish	*Acanthoclinus* sp	2	1	0	0	0	0	0.077
Actinopterygygii	Gurnard	*Lepidotrigla brachyoptera*	1	1	0	0	0.053	0	0
Actinopterygygii	Triplefin	*Fosterygion lapillum*	1	1	0.053	0	0	0	0

Table L2: List of fish and fish-like species collected in the cores. Abd= Total number of specimens collected; Occur.= number of cores that specimens occurred in. Inner shelf-Offshore values depict mean densities per 1 m^2 for each cross-shelf zone.

Group/Class	Common Names	Species	Abd	Occur.	Surface sediments (0-5 cm)				
					Inner shelf	mid north	PPA	mid south	Offshore
Cephalochordata (subphylum)	Lancelet	*Epigonichthys hectori*	12	9	5.87	2.39	0	3.48	0
Actinopterygygii	Opalfish	*Hemerocoetes monopterygius*	1	1	0	0	1.32	0	0
Actinopterygygii	Tommyfish	Creediidae sp	1	1	1.17	0	0	0	0
Actinopterygygii	Tommyfish	*Limnichthys rendahli*	1	1	0	0	0	0.70	0

Appendix M Non-decapod crustacean species/family list

Table M1: Species list of non-decapod crustaceans collected in the dredges. Abd= Total number of specimens collected; Occur.= number of dredges/sites specimens occurred in. Inner shelf-Offshore values depict mean densities per 250 m^2. *NS=new species. n. fam. = new family.

Type	Species	Abd	Occur.	Inner shelf	Mid north	PPA	Mid south	Offshore
Amphipoda	Pardaliscidae	110	12	0	2.211	3.526	0.029	0
Amphipoda	*Caprella* sp	51	7	0.211	0.053	2.421	0	0
Amphipoda	*Dexaminidae*	40	2	0	0	2.105	0	0
Amphipoda	*n. fam. Otagia neozelanica (*NS)*	27	16	0.147	0.029	0	0.029	0.053
Isopoda	*Holognathis* sp	16	7	0.105	0.526	0.158	0.029	0
Amphipoda	Caprellidae	14	1	0	0	0.737	0	0
Amphipoda	*Liljeborgia hansoni*	11	4	0	0.158	0	0.235	0
Isopoda	*Classidina typa*	9	6	0.105	0.316	0.053	0	0
Amphipoda	Synopiidae	6	4	0	0.211	0.053	0.029	0
Amphipoda	Photidae	3	2	0	0.105	0.053	0	0
Amphipoda	Lysianassoidea	2	2	0	0.053	0.053	0	0
Pycnogonid	*Pallenopsis obliqua*	2	2	0	0	0	0.059	0
Amphipoda	Corophioiodea	1	1	0	0.053	0	0	0
Isopoda	Serolidae	1	1	0	0	0.053	0	0

Table M2: List of non-decapod crustacean species collected in the cores. Abd= Total number of specimens collected; Occur.= number of cores that specimens occurred in. Inner shelf-Offshore values depict mean densities per 1 m^2. Mean densities for surface sediments are presented per cross-shelf zones, while values in for deep sediment sections are presented simply as a total mean for all locations.

Type	Species			Surface sediments (0-5 cm)					5-10 cm (mean)	10-15 cm (mean)
		Abd	Occur.	Inner shelf	mid north	PPA	mid south	Offshore		
Amphipoda	Photidae	551	67	16.45	436.81	205.78	7.66	7.71	3.47	5.19
Amphipoda	Lysianassoidea	263	49	4.70	207.66	109.48	0	3.86	1.33	0
Amphipoda	Phoxocephalidae sp1	230	78	23.50	119.35	112.12	13.23	11.57	0.53	0.43
Cumacea	*Cyclaspis* sp	227	71	109.26	94.28	50.13	4.87	19.28	0.80	0
Amphipoda	Oedicerotidae	142	50	76.36	22.68	63.32	6.96	0	0.53	0
Amphipoda	Platyischnopidae	66	34	35.24	10.74	11.87	10.44	5.78	2.67	0.43
Amphipoda	Urohaustoriidae	66	32	18.80	22.68	25.06	2.09	17.35	5.07	1.30

Type	Species	Surface sediments (0-5 cm)							5-10 cm (mean)	10-15 cm (mean)
		Abd	Occur.	Inner shelf	mid north	PPA	mid south	Offshore		
Amphipoda	*Liljeborgia hansoni*	63	42	3.52	15.51	15.83	13.92	28.92	0.53	0
Amphipoda	Phoxocephalidae spx	58	31	0	15.51	34.30	9.75	9.64	1.33	0.43
Cumacea	*Pomacuma* sp 1	47	36	4.70	3.58	21.11	16.71	0	0.27	0
Ostracoda	Ostracocda sp	46	22	15.27	21.48	7.91	4.87	3.86	0	0
Isopoda	Arcturidae sp 2	44	7	35.24	16.71	0	0	0	0	0
Isopoda	*Pseudaega quarta*	37	30	19.97	13.13	10.55	0.70	0	7.73	1.30
Amphipoda	Amphipoda X	36	12	5.87	20.29	6.60	6.27	0	0	0
Cumacea	Lampropidae	30	15	0	17.90	11.87	0	11.57	0	0
Copepoda	Copepoda	26	7	1.17	2.39	1.32	15.32	0	0.27	0
Euphausid	Euphausid larvae	26	2	0	0	0	18.10	0	0	0
Isopoda	*Pseudaega secunda*	26	19	1.17	20.29	10.55	0	0	7.73	2.16
Amphipoda	Corophiidea	25	6	0	1.19	0	4.18	34.70	0.27	0
Amphipoda	Amphipoda nd	24	9	0	16.71	11.87	0	1.93	0	0
Amphipoda	Caprellidae	20	11	0	4.77	19.79	0.70	0	0.27	0
Amphipoda	Amphipoda damaged	19	11	11.75	2.39	2.64	3.48	0	0	0
Amphipoda	Oedicerotidae sp 2	19	9	14.10	2.39	1.32	1.39	3.86	0	0
Amphipoda	Pardaliscidae	17	9	0	1.19	7.91	3.48	9.64	0.53	0
Cumacea	Cumacea sp 3	17	12	3.52	14.32	2.64	0	0	0	0
Amphipoda	Lysianassoidea sp 2	16	6	0	2.39	17.15	0	1.93	0	0
Amphipoda	Urothoidae	15	8	9.40	4.77	2.64	0.70	0	0.53	0
Isopoda	*Eurydice* sp	13	10	1.17	1.19	3.96	2.09	9.64	0	0
Tanaidaeca	*Tanaidaeca* spp	12	10	2.35	9.55	1.32	0.70	0	0	0.43
Isopoda	*Macrochirodothea uncinata*	11	10	7.05	2.39	2.64	0.70	0	0	0
Amphipoda	Ampeliscidae	8	8	1.17	1.19	0	0	11.57	1.07	0
Amphipoda	Phoxocephalidae sp 2	8	6	5.87	2.39	1.32	0	0	0.27	0
Amphipoda	Phoxocephalidae sp 3	8	4	1.17	2.39	6.60	0	0	0.53	0
Amphipoda	Phoxocephalidae sp 4	8	8	1.17	2.39	2.64	1.39	1.93	0	0
Amphipoda	Stegocephalidae	7	2	0	8.35	0	0	0	0	0
Isopoda	Arcturidae sp 4	6	3	0	5.97	1.32	0	0	0	0
Isopoda	Paramunnidae *Sporonana* sp 1	6	5	3.52	1.19	2.64	0	0	0	0
Amphipoda	Amphipoda juv	5	1	0	0	6.60	0	0	0	0
Leptotraca	*Nabalia* sp	5	5	0	2.39	3.96	0	0	0	0

Type	Species	Abd	Occur.	Surface sediments (0-5 cm) Inner shelf	mid north	PPA	mid south	Offshore	5-10 cm (mean)	10-15 cm (mean)
Amphipoda	Dikwidae	4	3	2.35	0	1.32	0	1.93	0	0
Amphipoda	Urohaustoriidae sp 2	4	4	0	2.39	1.32	0.70	0	0.53	0
Isopoda	Paramunnidae sp 2	4	3	0	2.39	2.64	0	0	0	0
Harpacticoid female	Harpacticoid	3	3	1.17	1.19	1.32	0	0	0	0
Isopoda	Isopod ud	3	2	0	2.39	0	0	1.93	0	0
Ostracoda	Ostracocda sp 2	3	1	0	3.58	0	0	0	0	0
Amphipoda	Eusiridae	2	2	1.17	0	0	0.70	0	0	0
Amphipoda	Synopiidae	2	2	0	1.19	0	0	1.93	0.27	0
Isopoda	Austrarcturellidae sp 1	2	2	0	2.39	0	0	0	0	0
Isopoda	Isopod ud 1	2	2	1.17	0	0	0	1.93	0	0
Pycnogonida	Pycnogonida sp	2	2	2.35	0	0	0	0	0.53	0
Amphipoda	Aoridae	1	1	0	0	0	0	1.93	0	0
Amphipoda	Melphidippidae	1	1	0	0	0	0	1.93	0	0
Calenoid copepod	Calanus cIII	1	1	0	0	0	0.70	0	0	0
Calenoid copepod	Clausocalanus female	1	1	0	1.19	0	0	0	0	0
Cumacea	Cumacea sp5	1	1	0	0	0	0	1.93	0	0
Isopoda	Austrarcturellidae sp 3	1	1	1.17	0	0	0	0	0	0
Isopoda	Cirolanidae sp	1	1	1.17	0	0	0	0	0	0
Isopoda	*Natatolana* sp	1	1	0	0	0	0	1.93	0.27	0
Amphipoda	Amphipod	ds	ds	0	0	0	0	0	1.07	0
Amphipoda	Amphipod spx	ds	ds	0	0	0	0	0	1.07	0
Amphipoda	Amphipoda 1	ds	ds	0	0	0	0	0	0	0.43
Amphipoda	Amphipoda 2	ds	ds	0	0	0	0	0	0	0.43
Amphipoda	Amphipoda 3	ds	ds	0	0	0	0	0	0	0.43
Amphipoda	Amphipoda unkn	ds	ds	0	0	0	0	0	0.27	0
Amphipoda	Paracalliopiidae	ds	ds	0	0	0	0	0	0.27	0
Amphipoda	Tiron in Synopiidae	ds	ds	0	0	0	0	0	0	0.43
Copepoda	Paracalanidae	ds	ds	0	0	0	0	0	0	0.43
Cumacea	Cumacea	ds	ds	0	0	0	0	0	0.27	0
Isopoda	Chaetiliidae sp	ds	ds	0	0	0	0	0	0	0.43
Ostracoda	Ostracoda	ds	ds	0	0	0	0	0	0	0.43

Appendix N Algae species list

Table M1: Species list of macroalgae collected in the dredges. Occur.= number of dredges/sites species occurred in. Inner shelf-Offshore values depict the number of occurrence per site. *NS=new species; n. gen. = new genera.

Type	Family	Species	Occur.	Inner shelf	Mid north	PPA	Mid south	Offshore
Red algae	Ceramiaceae	*Ceramium* sp	14	6	4	3	1	0
Red algae	Rhodomelaceae	*Aphanocladia delicatula*	9	7	1	1	0	0
Brown algae	Dictyotaceae	*Zonaria turneriana*	8	8	0	0	0	0
Brown algae	Stypocaulaceae	*Halopteris novae-zelandiae*	6	4	1	1	0	0
Red algae	Halymeniaceae	*n. gen. Cryptonemia-like* sp (*NS)	5	0	0	0	4	1
Red algae	Rhodomelaceae	*Polysiphonia* sp	5	4	0	1	0	0
Red algae	Delesseriaceae	*Hymenena* sp	4	0	3	0	0	1
Red algae	Rhodymeniaceae	*Rhodymenia* sp	4	1	2	1	0	0
Red algae	Scinaiaceae	*Scinaia australis*	4	2	2	0	0	0
Red algae	Wrangeliaceae	*Anotrichium crinitum*	3	3	0	0	0	0
Red algae	Corallinaceae	non geniculate coralline	3	3	0	0	0	0
Green algae	Caulerpaceae	*Caulerpa flexilis*	2	2	0	0	0	0
Red algae	Dasyaceae	*Dasya* sp	2	1	1	0	0	0
Red algae	Gracilariaceae	*Gracilaria truncata*	2	2	0	0	0	0
Red algae	Delesseriaceae	*Haraldiophyllum crispatum*	2	0	0	0	1	1
Red algae	Dasyaceae	*Heterosiphonia squarrosa*	2	2	0	0	0	0
Brown algae	Sporochnaceae	*Sporochnus moorei*	2	1	1	0	0	0
Red algae	Phyllophoraceae	*Stenogramma interruptum*	2	1	0	0	1	0
Brown algae	Sporochnaceae	*Carpomitra costata*	1	1	0	0	0	0
Green algae	Cladophoraceae	*Cladophora* sp	1	0	1	0	0	0
Brown algae	Cladostephaceae	*Cladostephus spongiosus*	1	1	0	0	0	0
Brown algae	Dictyotaceae	*Dictyota papenfussii*	1	1	0	0	0	0
Brown algae	Lessoniaceae	*Ecklonia radiata*	1	1	0	0	0	0
Brown algae	Stypocaulaceae	*Halopteris virgata*	1	1	0	0	0	0
Red algae	Plocamiaceae	*Plocamium cirrhosum*	1	1	0	0	0	0
Brown algae	Dictyotaceae	fragments	1	1	0	0	0	0

Table M2: List of algal species collected in the cores. Occur.= number of cores that specimens occurred in. Inner shelf-Offshore values depict depict the mean number of occurrence per 1 m^2. Mean densities for surface sediments are presented per cross-shelf zones, while values in for deep sediment sections are presented simply as a total mean for all locations.

Type	Family	Species	Surface sediments (0-5 cm)					
			Occur.	Inner shelf	mid north	PPA	mid south	Offshore
Red algae	Corallinaceae	non geniculate coralline	29	3.52	0	0	10.44	21.21

Appendix O Cnidaria species list

Table O1: Species list of cnidaria collected in the dredges. Abd= Total number of specimens collected; Occur.= number of dredges/sites specimens occurred in. Inner shelf-Offshore values depict mean densities per 250 m^2.

Type	Species	Abd	Occur.	Inner shelf	Mid north	PPA	Mid south	Offshore
Hydrozoa	*Dictyocladium monolifer*	18	6	0	0	0	0	0.689
Hydrozoa	*Aglaophenia laxa*	14	2	0	0	0	0	0.538
Anemone	Actiniaria ud	2	2	0	0.053	0	0.029	0
Hydrozoa	*Amphisbetia minima*	2	2	0.053	0.053	0	0	0
Hydrozoa	*Halecium delicatulum*	2	2	0	0	0	0.029	0.038
Hydrozoa	*Plumularia setacea*	2	2	0	0.053	0	0.029	0
Hydrozoa	*Synthecium* sp	2	2	0	0	0	0.029	0.038
Anemone	unkn juv anem (gelatinous blob)	1	1	0	0	0	0.029	0
Hydrozoa	*Halecium* sp	1	1	0	0	0	0.029	0
Hydrozoa	*Halopteris campanula*	1	1	0	0	0	0.029	0

Table O2: List of cnidaria species collected in the cores. Abd= Total number of specimens collected; Occur.= number of cores that specimens occurred in. Inner shelf-Offshore values depict mean densities per 1 m^2 for each cross-shelf zone.

Type	Species	Surface sediments (0-5 cm)						
		Abd	Occur.	Inner shelf	mid north	PPA	mid south	Offshore
unkn	UID juv anemone	11	11	4.70	5.97	0	1.39	0
Anemones	Edwardsiidea sp	2	2	1.17	0	0	0.70	0
Hydrozoa	*Zyglophylax sibogae*	1	1	0	0	0	0.70	0

Appendix P Additional taxa: species list

Table O1: Species list of additional taxa collected in the dredges. Abd= Total number of specimens collected; Occur.= number of dredges/sites specimens occurred in. Inner shelf-Offshore values depict mean densities per 250 m^2.

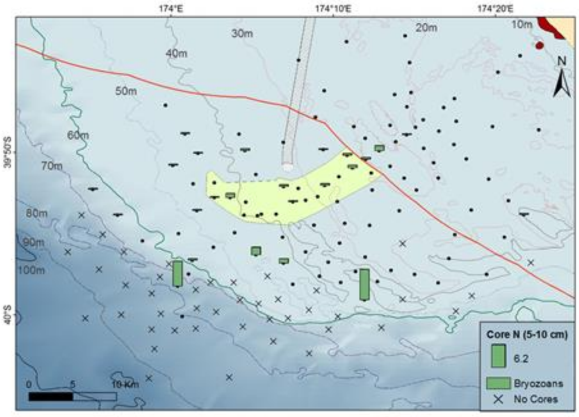
Phyla	Type	Species	Abd	Occur.	Inner shelf	Mid north	PPA	Mid south	Offshore
Foraminifera	Foraminifera	*Miniacina miniacea*	911	17	0	1.105	0	0.618	33.415
Brachiopoda	Rhynchonelliformea	*Calloria inconspicua*	350	19	0	0.474	0	0.559	12.386
Brachiopoda	Rhynchonelliformea	*Neothyris lenticularis*	22	3	0	0	0	0	0.846
Brachiopoda	Rhynchonelliformea	*Terebratella* sp	23	5	0	0	0	0.500	0.231

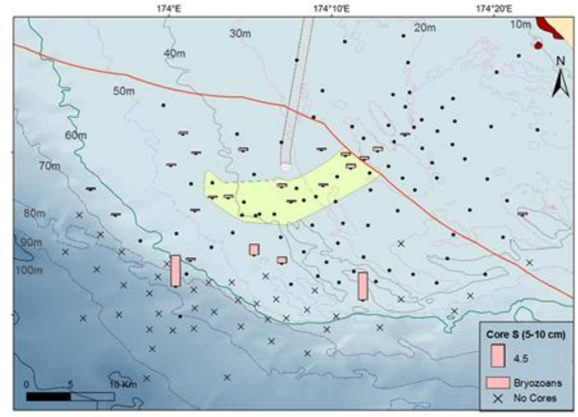
Table O2: Species list of additional taxa collected in the cores. Abd= Total number of specimens collected; Occur.= number of cores that specimens occurred in. Inner shelf-Offshore values depict mean densities per 1 m^2. Mean densities for surface sediments are presented per cross-shelf zones, while values in for deep sediment sections are presented simply as a total mean for all locations.

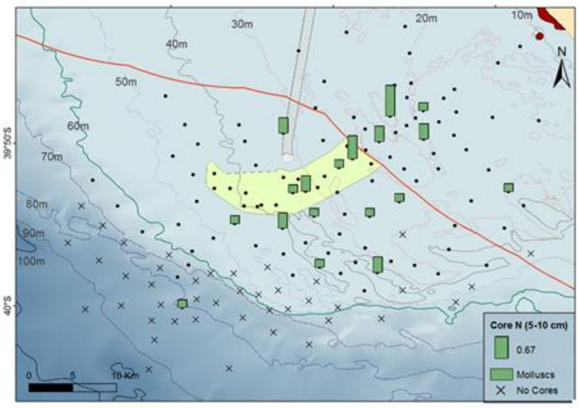
	Type	Species	Surface sediments (0-5 cm)							5-10cm (mean)
			Abd	Occur.	Inner shelf	mid north	PPA	mid south	Offshore	
Foraminifera	Polythalamea	*Miniacina miniacea*	817	24	0	0	1.32	68.92	1382.30	14.13
Brachiopoda	Rhynchonelliformea	*Calloria inconspicua*	4	2	1.17	0	0	0	5.78	
Brachiopoda	Rhynchonelliformea	*Neothyris lenticularis*	1	1	0	0	1.32	0	0	

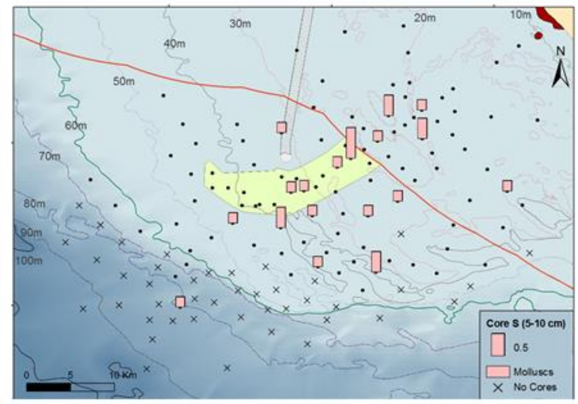
Appendix Q Distribution plots of phyla in 5-10 cm core fraction

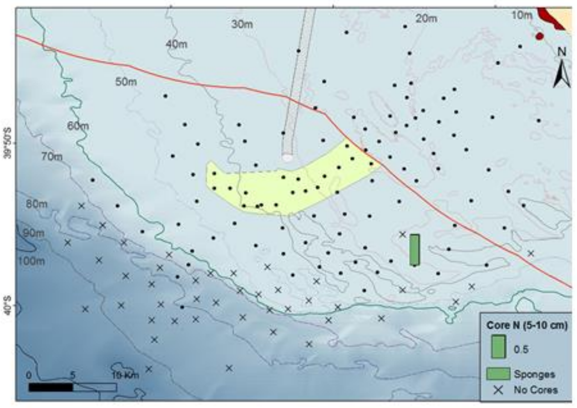
Distributions plots of all taxa found within the 5 – 10 cm fraction of cores

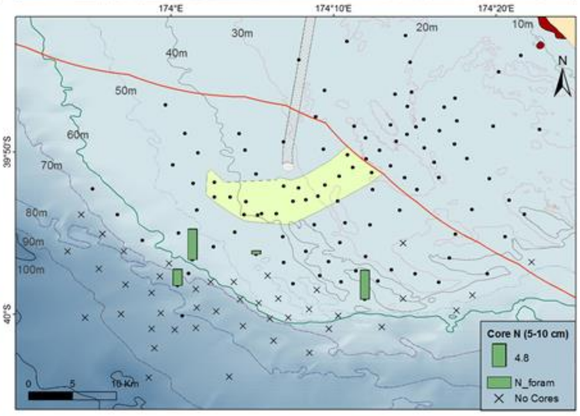


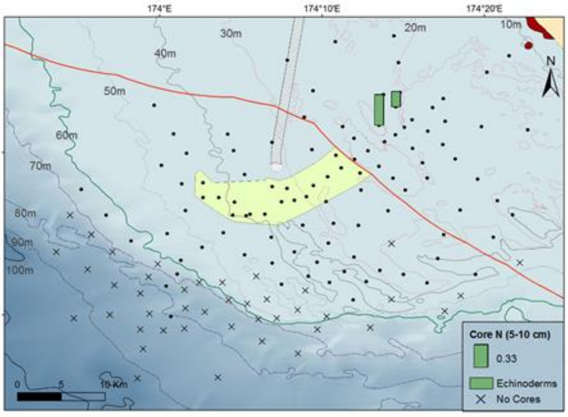








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174°10'E
174°20'E
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10m
40m
50m
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70m
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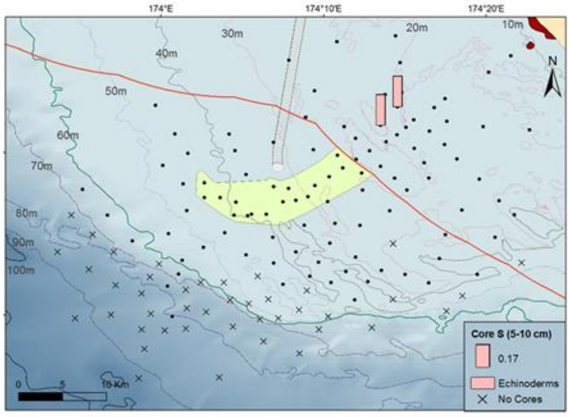
90m
100m
39°50'S
40°S
N
0
5
10 Km
Core N (5-10 cm)
0.33
Echinoderms
No Cores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10 Km
Core S (5-10 cm)
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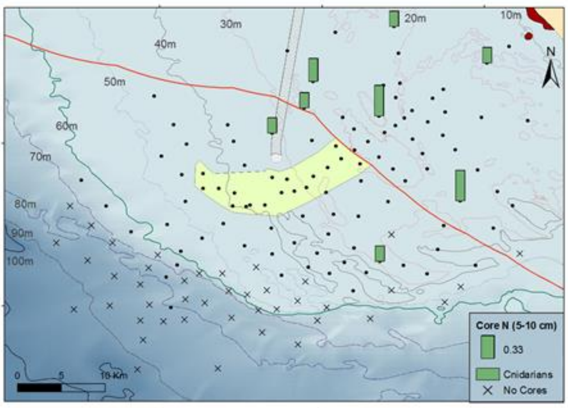
Echinoderms
No Cores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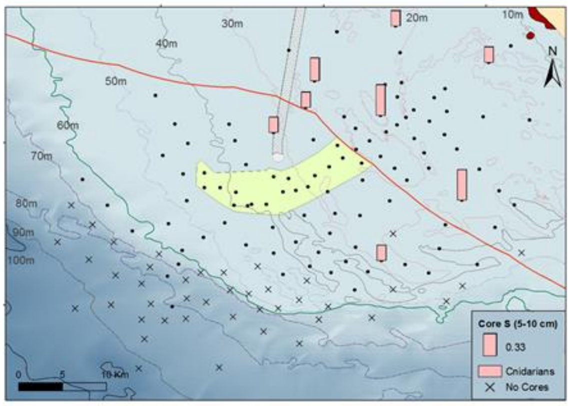
Core N (5-10 cm)
0.33
Cnidarians
No Cores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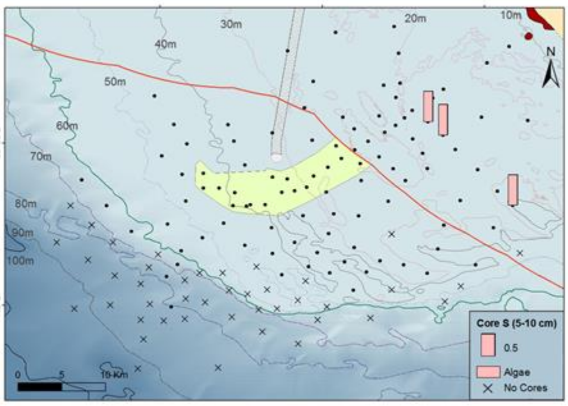
Core S (5-10 cm)
0.33
Cnidarians
No Cores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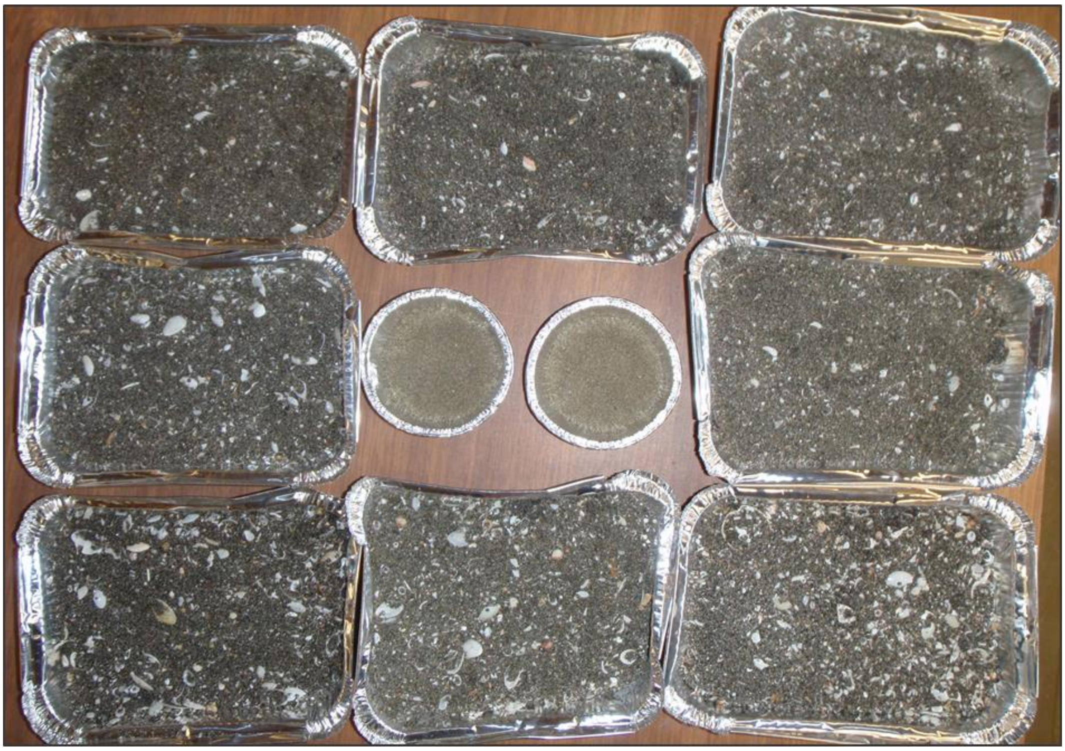
70m
80m
90m
100m
39°50'S
40°S
N
0
5
10 Km
Core S (5-10 cm)
0.5
Algae
No Cores

Appendix R Lyall Bay trials

Lyall Bay trials – photos of the experimental containers at the end of the two week trial. Note that some were still full of sand, some had been scoured out and the sand replaced by algae, and some had a mixture of sand and algae (and the occasional octopus and/or large stone).

Appendix S Taranaki Trials

Taranaki trials: photographs



Sand recovered from the taranaki trials. The large rectangular foil trays contain sand recovered at the end of the experiment. The small circular foil trays in the centre are filled with sand from Lyall Bay. Note the difference in both colour and the percentage of shell hash.

Appendix T SIMPER results

SIMPER: pooled data (mean) including ambient samples

```
Examines Site groups
(across all Treatment groups)

Group EB
Average similarity: 66.94
  Species                 Av.Abund   Av.Sim    Sim/SD    Contrib%   Cum.%

  Nematoda

  Copepoda

  Owenia petersenae

  Bivalve spp. (juv.)

  Exogoninae

  Capitella capitata           0.86

  Prionospio multicristata     0.47

  Terebellidae                                                             90.84


Group MB
Average similarity: 65.36

  Species                        Av.Abund  Av.Sim  Sim/SD  Contrib%  Cum.%
  Nematoda                           2.86   12.37    3.45     18.93  18.93
  Copepoda                           2.46    9.77    3.08     14.95  33.88
```

Capitella capitata	2.06	7.86	2.88	12.02	45.91
Edwardsia sp.	1.57	6.23	5.06	9.53	55.44
Owenia petersenae	1.64	6.13	1.78	9.38	64.82
Glycera ?capitata	1.26	5.24	2.04	8.02	72.84
Polychaete spp. (juv.)	1.12	3.85	3.99	5.88	78.73
Polychaete planktonic larva	0.81	2.44	1.17	3.74	82.46
Heteromastus filiformis	0.65	1.87	0.67	2.87	85.33
Syllidae	0.76	1.67	0.93	2.55	87.88
Pilargidae	0.42	1.43	0.64	2.19	90.07

Groups EB & MB
Average dissimilarity = 45.47

Species	Group EB Av. Abund	Group MB Av. Abund	Av.Diss	Diss/SD	Contrib %	Cum.%
Capitella capitata	0.86	2.06	3.85	1.48	8.47	8.47
Glycera ?capitata	0.06	1.26	3.55	2.12	7.82	16.28
Edwardsia sp.	0.42	1.57	3.35	2.23	7.36	23.64
Polychaete spp. (juv.)	0.27	1.12	2.5	1.6	5.49	29.14
Nematoda	3.54	2.86	2.43	1.39	5.34	34.47
Syllidae	0	0.76	2.25	1.11	4.95	39.42
Polychaete planktonic larva	0.1	0.81	2.03	1.64	4.47	43.89
Copepoda	2.58	2.46	2.02	1.31	4.45	48.34
Bivalve spp. (juv.)	0.91	0.56	1.98	1.38	4.35	52.68
Exogoninae	0.93	0.48	1.94	1.17	4.27	56.96
Owenia petersenae	1.3	1.64	1.78	1.14	3.92	60.88
Prionospio multicristata	0.47	0.38	1.46	0.85	3.21	64.09
Heteromastus filiformis	0.21	0.65	1.44	0.85	3.16	67.25
Boccardia sp.	0.03	0.52	1.3	0.87	2.87	70.12
Phoronidae	0.24	0.11	1.01	0.89	2.22	72.34
Terebellidae	0.31	0.31	0.74	0.6	1.64	73.97
Ostracoda sp. 4	0	0.24	0.73	0.76	1.6	75.57
Euchone	0	0.25	0.7	0.47	1.55	77.11
Pilargidae	0.17	0.42	0.7	0.67	1.54	78.65
?Dosinia juv bivlave	0	0.25	0.68	0.72	1.5	80.15
Torridoharpinia hurleyi	0.16	0.19	0.6	0.73	1.32	81.47
Ostracoda sp. 1	0.08	0.13	0.59	0.61	1.31	82.77
Ostracoda sp. 3	0.09	0.14	0.58	0.68	1.28	84.05
Oedicerotidae	0.07	0.18	0.56	0.62	1.22	85.27
Pectinaridae	0.12	0.07	0.55	0.63	1.21	86.48
Paracalliope sp.	0.13	0.12	0.55	0.55	1.2	87.69
Nemertean	0	0.18	0.53	0.64	1.18	88.86
Armandia maculata	0.06	0.16	0.52	0.7	1.14	90

Examines Treatment groups
(across all Site groups)
Group Green
Average similarity: 64.63

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Nematoda	2.75	14.87	2.31	23	23
Copepoda	2.68	14.81	3.34	22.92	45.93
Owenia petersenae	1.76	10.19	7.44	15.77	61.7
Glycera ?capitata	0.89	4.67	0.9	7.23	68.93
Bivalve spp. (juv.)	0.74	3.62	1.11	5.61	74.53
Prionospio multicristata	0.96	3.59	0.95	5.55	80.09
Edwardsia sp.	0.84	2.97	1.09	4.59	84.68
Polychaete spp. (juv.)	0.8	2.96	1.17	4.58	89.26
Capitella capitata	1.09	2.75	0.82	4.26	93.52

Group Yellow
Average similarity: 63.81

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Nematoda	3.17	17.55	3.15	27.5	27.5
Copepoda	2.7	14.2	2.76	22.25	49.75
Capitella capitata	1.66	6.05	1.26	9.48	59.24
Owenia petersenae	1.5	5.81	1.98	9.1	68.34
Edwardsia sp.	1.12	4.06	1.12	6.36	74.69
Bivalve spp. (juv.)	0.93	3.9	1	6.11	80.81
Polychaete spp. (juv.)	0.9	3.72	5.48	5.83	86.63
Glycera ?capitata	0.57	1.94	0.86	3.05	89.68
Exogoninae	0.66	1.9	0.64	2.98	92.66

Group Red
Average similarity: 73.78

Species	Av. Abund	Av. Sim	Sim/SD	Contrib %	Cum.%
Nematoda	3.02	15.28	2.63	20.71	20.71
Copepoda	2.99	13.9	4.92	18.84	39.55
Capitella capitata	1.92	9.05	6.94	12.27	51.82
Owenia petersenae	1.8	8.01	4.26	10.86	62.68
Edwardsia sp.	1.21	4.54	2.35	6.16	68.84
Exogoninae	0.98	4.04	1.12	5.47	74.31
Bivalve spp. (juv.)	0.82	3.73	1.87	5.05	79.36
Terebellidae	0.71	3.45	2.18	4.68	84.04
Polychaete planktonic larva	0.76	2.62	1.2	3.55	87.58

Glycera ?capitata	0.63	2.01	0.91	2.73	90.31

Group Ambient
Average similarity: 62.39

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Nematoda	3.87	22.55	3.29	36.14	36.14
Copepoda	1.72	8.46	2.03	13.56	49.71
Pilargidae	0.88	5.01	3.19	8.03	57.74
Capitella capitata	1.16	4.48	0.91	7.18	64.92
Exogoninae	0.95	4.3	1.07	6.9	71.82
Heteromastus filiformis	1.03	3.92	1.23	6.29	78.1
Edwardsia sp.	0.8	3.2	0.91	5.12	83.23
Owenia petersenae	0.82	2.09	0.64	3.35	86.58
Glycera ?capitata	0.53	1.86	0.91	2.98	89.56
Polychaete spp. (juv.)	0.58	1.86	0.91	2.98	92.55

Groups Green & Yellow
Average dissimilarity = 36.10

Species	Group Green Av. Abund	Group Yellow Av. Abund	Av.Diss	Diss/SD	Contrib %	Cum.%
Prionospio multicristata	0.96	0.14	3.06	1.06	8.49	8.49
Capitella capitata	1.09	1.66	2.63	1.28	7.28	15.77
Nematoda	2.75	3.17	2.36	1.6	6.54	22.31
Exogoninae	0.23	0.66	2.24	1.42	6.2	28.51
Copepoda	2.68	2.7	1.78	1.41	4.94	33.44
Owenia petersenae	1.76	1.5	1.74	0.92	4.83	38.28
Bivalve spp. (juv.)	0.74	0.93	1.55	1.28	4.3	42.58
Edwardsia sp.	0.84	1.12	1.51	1.26	4.18	46.76
Polychaete spp. (juv.)	0.8	0.9	1.27	1.3	3.52	50.28
Terebellidae	0.2	0.32	1.14	0.83	3.16	53.44
Syllidae	0.45	0.28	1.09	0.81	3.03	56.47
Heteromastus filiformis	0.07	0.43	1.09	0.78	3.01	59.48
Phoronidae	0.15	0.18	1.06	0.95	2.95	62.42
Ostracoda sp. 1	0.15	0.14	0.93	0.69	2.58	65.01
Oedicerotidae	0.29	0.14	0.86	0.96	2.37	67.38
Polychaete planktonic larva	0.31	0.52	0.86	0.94	2.37	69.75
Boccardia sp.	0.12	0.37	0.84	0.61	2.32	72.07
Paracalliope sp.	0	0.3	0.84	0.95	2.32	74.39
Glycera ?capitata	0.89	0.57	0.83	0.72	2.3	76.68
Gastropod sp. 1 (juv.)	0.07	0.14	0.68	0.91	1.89	78.58
Euchone	0.28	0	0.68	0.43	1.89	80.46

Paraonidae	0.12	0.12	0.67	0.68	1.86	82.33
Ostracoda sp. 2	0.07	0.14	0.6	0.91	1.67	83.99
[unsegmented larval organism]	0.15	0	0.49	0.43	1.37	85.36
Torridoharpinia hurleyi	0.14	0.07	0.49	0.73	1.34	86.7
Ostracoda sp. 3	0.07	0.14	0.45	0.76	1.25	87.95
Ostracoda sp. 4	0	0.18	0.44	0.67	1.21	89.17
Nemertean	0.18	0.07	0.42	0.61	1.17	90.34

Groups Green & Red
Average dissimilarity = 33.39

Species	Group Green Av. Abund	Group Red Av. Abund	Av.Diss	Diss/SD	Contrib %	Cum.%
Capitella capitata	1.09	1.92	2.93	1.25	8.77	8.77
Prionospio multicristata	0.96	0.25	2.86	1.1	8.55	17.32
Exogoninae	0.23	0.98	2.61	1.13	7.81	25.13
Copepoda	2.68	2.99	2.24	1.5	6.7	31.83
Nematoda	2.75	3.02	1.96	1.57	5.86	37.69
Terebellidae	0.2	0.71	1.55	1.6	4.63	42.32
Edwardsia sp.	0.84	1.21	1.38	1.2	4.14	46.46
Owenia petersenae	1.76	1.8	1.25	1.66	3.74	50.21
Polychaete planktonic larva	0.31	0.76	1.25	1.2	3.73	53.94
Bivalve spp. (juv.)	0.74	0.82	1.17	1.16	3.51	57.45
Polychaete spp. (juv.)	0.8	0.52	1.17	1.33	3.5	60.96
Boccardia sp.	0.12	0.43	0.94	0.99	2.81	63.76
Ostracoda sp. 1	0.15	0.12	0.86	0.63	2.57	66.33
Euchone	0.28	0.22	0.83	0.67	2.5	68.83
Macomona liliana	0.14	0.18	0.71	0.94	2.14	70.97
Pilargidae	0	0.31	0.71	0.69	2.13	73.1
?Dosinia juv bivlave	0.07	0.37	0.7	0.75	2.1	75.2
Oedicerotidae	0.29	0.07	0.69	0.86	2.08	77.28
Glycera ?capitata	0.89	0.63	0.67	0.72	2.02	79.29
Torridoharpinia hurleyi	0.14	0.27	0.67	1.04	1.99	81.29
Syllidae	0.45	0.34	0.48	0.68	1.43	82.71
[unsegmented larval organism]	0.15	0	0.47	0.43	1.41	84.12
Nemertean	0.18	0.12	0.42	0.63	1.27	85.39
Ostracoda sp. 3	0.07	0.15	0.42	0.54	1.27	86.67
Phoronidae	0.15	0.07	0.41	0.56	1.22	87.88
Asellota sp.	0.07	0.07	0.4	0.66	1.21	89.09
Heteromastus filiformis	0.07	0.18	0.38	0.63	1.14	90.24

Groups Yellow & Red
Average dissimilarity = 32.78

Species	Group Yellow Av. Abund	Group Red Av. Abund	Av.Diss	Diss/SD	Contrib %	Cum.%
Exogoninae	0.66	0.98	2.2	1.16	6.71	6.71
Capitella capitata	1.66	1.92	2.15	0.94	6.55	13.26
Owenia petersenae	1.5	1.8	2.11	1.4	6.44	19.7
Terebellidae	0.32	0.71	2.06	1.97	6.27	25.97
Copepoda	2.7	2.99	2.02	1.31	6.16	32.14
Polychaete spp. (juv.)	0.9	0.52	1.59	1.9	4.86	36.99
Nematoda	3.17	3.02	1.56	1.06	4.76	41.75
Bivalve spp. (juv.)	0.93	0.82	1.5	1.62	4.57	46.32
Edwardsia sp.	1.12	1.21	1.21	1.21	3.69	50.02
Boccardia sp.	0.37	0.43	1.01	1.06	3.09	53.1
Heteromastus filiformis	0.43	0.18	0.98	0.89	2.99	56.1
Polychaete planktonic larva	0.52	0.76	0.97	1.17	2.95	59.04
Syllidae	0.28	0.34	0.84	0.89	2.57	61.61
Phoronidae	0.18	0.07	0.84	0.86	2.56	64.17
Torridoharpinia hurleyi	0.07	0.27	0.75	1.11	2.3	66.47
Paracalliope sp.	0.3	0	0.75	0.97	2.28	68.74
Prionospio multicristata	0.14	0.25	0.66	1	2.02	70.77
?Dosinia juv bivlave	0.07	0.37	0.66	0.74	2.02	72.79
Pilargidae	0	0.31	0.65	0.68	1.97	74.76
Macomona liliana	0.07	0.18	0.64	0.71	1.95	76.71
Ostracoda sp. 3	0.14	0.15	0.61	0.81	1.86	78.57
Ostracoda sp. 2	0.14	0.07	0.53	0.9	1.61	80.18
Gastropod sp. 1 (juv.)	0.14	0	0.52	0.68	1.58	81.75
Oedicerotidae	0.14	0.07	0.49	0.71	1.5	83.25
Glycera ?capitata	0.57	0.63	0.48	0.74	1.47	84.72
Euchone	0	0.22	0.47	0.63	1.43	86.15
Ostracoda sp. 1	0.14	0.12	0.35	0.7	1.05	87.2
Ostracoda sp. 4	0.18	0.07	0.34	0.65	1.02	88.22
Nemertean	0.07	0.12	0.29	0.54	0.89	89.12
Gastropod sp. 2	0	0.14	0.29	0.68	0.87	89.99
Pectinaridae	0.14	0	0.28	0.68	0.86	90.85

Groups Green & Ambient
Average dissimilarity = 47.02

	Group Green	Group Ambient

Species	Av. Abund	Av. Abund	Av.Diss	Diss/SD	Contrib %	Cum.%
Nematoda	2.75	3.87	3.68	1.67	7.83	7.83
Copepoda	2.68	1.72	3.6	1.3	7.65	15.48
Prionospio multicristata	0.96	0.35	3.25	1.07	6.92	22.39
Owenia petersenae	1.76	0.82	3.25	1.26	6.9	29.3
Heteromastus filiformis	0.07	1.03	2.82	1.87	5.99	35.29
Pilargidae	0	0.88	2.8	3.42	5.95	41.24
Exogoninae	0.23	0.95	2.72	1.26	5.78	47.02
Bivalve spp. (juv.)	0.74	0.46	2.69	1.35	5.73	52.75
Capitella capitata	1.09	1.16	2.28	1.2	4.85	57.6
Glycera ?capitata	0.89	0.53	1.64	1.23	3.49	61.09
Phoronidae	0.15	0.3	1.38	0.95	2.94	64.04
Polychaete spp. (juv.)	0.8	0.58	1.38	1.3	2.94	66.98
Edwardsia sp.	0.84	0.8	1.29	1.29	2.75	69.73
Syllidae	0.45	0.44	1.07	0.76	2.27	72
Torridoharpinia hurleyi	0.14	0.23	0.94	0.9	2	74
Pectinaridae	0	0.23	0.86	0.66	1.82	75.82
Oedicerotidae	0.29	0	0.86	0.82	1.82	77.65
Euchone	0.28	0	0.75	0.43	1.59	79.23
Armandia maculata	0.07	0.23	0.69	0.8	1.46	80.7
Terebellidae	0.2	0	0.67	0.92	1.44	82.13
Ostracoda sp. 4	0	0.23	0.66	0.68	1.4	83.54
Polychaete planktonic larva	0.31	0.23	0.63	0.67	1.35	84.89
Ostracoda sp. 1	0.15	0	0.62	0.42	1.32	86.21
Trochodota	0	0.23	0.62	0.68	1.32	87.53
Boccardia sp.	0.12	0.18	0.58	0.56	1.23	88.76
Nemertean	0.18	0	0.52	0.64	1.11	89.87
Paracalliope sp.	0	0.18	0.52	0.43	1.11	90.98

Groups Yellow & Ambient
Average dissimilarity = 41.09

Species	Group Yellow Av. Abund	Group Ambient Av. Abund	Av.Diss	Diss/SD	Contrib %	Cum.%
Copepoda	2.7	1.72	3.38	1.26	8.22	8.22
Owenia petersenae	1.5	0.82	2.93	1.27	7.13	15.35
Bivalve spp. (juv.)	0.93	0.46	2.93	1.26	7.12	22.47
Pilargidae	0	0.88	2.71	3.41	6.6	29.07
Nematoda	3.17	3.87	2.67	1.17	6.51	35.58
Heteromastus filiformis	0.43	1.03	2.28	1.7	5.55	41.13
Capitella capitata	1.66	1.16	2.23	1.19	5.43	46.57

Exogoninae	0.66	0.95	2.2	1.32	5.35	51.92
Polychaete spp. (juv.)	0.9	0.58	1.53	1.33	3.73	55.65
Edwardsia sp.	1.12	0.8	1.43	1.11	3.47	59.12
Paracalliope sp.	0.3	0.18	1.26	1.09	3.06	62.18
Pectinaridae	0.14	0.23	1.23	0.98	2.98	65.17
Syllidae	0.28	0.44	1.14	0.63	2.78	67.94
Prionospio multicristata	0.14	0.35	1.05	0.92	2.56	70.5
Polychaete planktonic larva	0.52	0.23	0.93	1	2.27	72.78
Terebellidae	0.32	0	0.91	0.6	2.22	75
Phoronidae	0.18	0.3	0.89	0.72	2.16	77.16
Boccardia sp.	0.37	0.18	0.89	0.64	2.16	79.32
Torridoharpinia hurleyi	0.07	0.23	0.88	0.68	2.15	81.47
Glycera ?capitata	0.57	0.53	0.83	0.96	2.01	83.48
Armandia maculata	0.07	0.23	0.67	0.79	1.63	85.11
Ostracoda sp. 3	0.14	0.12	0.63	0.78	1.54	86.65
Gastropod sp. 1 (juv.)	0.14	0	0.56	0.65	1.37	88.02
Trochodota	0	0.23	0.56	0.68	1.35	89.37
Oedicerotidae	0.14	0	0.5	0.63	1.22	90.6

Groups Red & Ambient
Average dissimilarity = 41.06

Species	Group Red Av. Abund	Group Ambient Av. Abund	Av.Diss	Diss/SD	Contrib %	Cum.%
Copepoda	2.99	1.72	3.8	1.46	9.26	9.26
Owenia petersenae	1.8	0.82	2.99	1.21	7.28	16.55
Capitella capitata	1.92	1.16	2.91	1.01	7.08	23.62
Nematoda	3.02	3.87	2.61	1.31	6.36	29.98
Heteromastus filiformis	0.18	1.03	2.28	1.68	5.56	35.54
Terebellidae	0.71	0	2.25	1.99	5.49	41.03
Bivalve spp. (juv.)	0.82	0.46	2.02	1.27	4.91	45.94
Pilargidae	0.31	0.88	1.97	1.82	4.79	50.73
Exogoninae	0.98	0.95	1.67	1.18	4.07	54.8
Polychaete planktonic larva	0.76	0.23	1.47	1.38	3.57	58.37
Edwardsia sp.	1.21	0.8	1.46	1.64	3.55	61.92
Phoronidae	0.07	0.3	1.13	0.84	2.76	64.68
Prionospio multicristata	0.25	0.35	1.11	1.16	2.7	67.39
Torridoharpinia hurleyi	0.27	0.23	1	1.31	2.43	69.82
Boccardia sp.	0.43	0.18	1	1.03	2.43	72.25
Glycera ?capitata	0.63	0.53	0.87	0.94	2.13	74.38
?Dosinia juv bivlave	0.37	0	0.86	0.84	2.1	76.47

Pectinaridae	0	0.23	0.85	0.66	2.07	78.54
Syllidae	0.34	0.44	0.83	0.69	2.02	80.56
Polychaete spp. (juv.)	0.52	0.58	0.76	0.89	1.85	82.41
Ostracoda sp. 3	0.15	0.12	0.7	0.68	1.7	84.11
Armandia maculata	0.07	0.23	0.64	0.79	1.56	85.67
Macomona liliana	0.18	0	0.58	0.58	1.41	87.08
Trochodota	0	0.23	0.53	0.69	1.29	88.37
Paracalliope sp.	0	0.18	0.52	0.43	1.26	89.63
Euchone	0.22	0	0.51	0.63	1.23	90.86