Before the Environmental Protection Authority

Application for Marine Consent by Trans-Tasman Resources Ltd

IN THE MATTER OF the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012

AND

IN THE MATTER OF An application by Trans-Tasman Resources Ltd for a marine consent application made to excavate iron sand from the seabed of the exclusive economic zone in the South Taranaki Bight, process that sand to remove iron particles and return the remaining sand to the seabed.

Evidence of Brian Lee Paavo
on behalf of
Kiwis Against Seabed Mining Incorporated
STATEMENT OF EVIDENCE OF BRIAN PAAVO
ON BEHALF OF KIWIS AGAINST SEABED MINING (KASM)

Date: 24 February 2014
INTRODUCTION, QUALIFICATIONS AND EXPERIENCE

1. My full name is Brian Lee Paavo and I am a New Zealand citizen. I am currently the Director and Principal Consultant of Benthic Science Limited, a position I have held since July 2004. Benthic Science Limited helps companies, government, iwi, ports, and independent researchers discover, protect, and responsibly develop the marine environment through physical and zoological marine research programmes and benthic engineering services.

2. I am a marine benthic ecologist, and hold a doctorate in Marine Science from the University of Otago, and a Bachelor of Science from University of Hawai‘i Manoa. My doctoral thesis examined the soft-sediment ecology of Aramoana and Blueskin Bay, Dunedin, and the impacts of dredge spoil disposal. My undergraduate study focused on the ecology, biology, and evolution of marine invertebrates.

3. I have worked as a macrofaunal and/or meiofaunal researcher in New Zealand for 12 years, and overseas for six years (including US EPA, State, US Army Corps of Engineers, and SeaGrant programmes). Additionally, I have worked as a marine educator in public, primary, secondary (4 years), and tertiary (3 years) institutions.

4. I am a regular, multi-year member of the New Zealand Marine Sciences Society (past board member), the International Polychaetology Conference, and the New Zealand Skeptical Society.
Prior to my current role, I have been a teaching fellow at the University of Otago, Dunedin in the Marine Science department from July 2008 to February 2010, where I helped develop two papers on Local Marine Invertebrates (202) and Marine Vertebrates (302) in addition to teaching on special topics in soft-shore ecology, impacts of dredging, general oceanography, and population modeling as well as fulfilling a number of research assistant roles.

My specialisation and expertise includes marine development resource consent and project consultation, macrofaunal identification and benthic community analyses, field sampling, sediment profile imagery, experimental equipment design and construction, and benthic image analysis.

I have worked on a number of projects relating to sediment analyses, scanning electron microscopy, science protocol quality control and assurance advice; and independent peer reviews in addition to primary research on ecological processes and anthropogenic impacts in coastal environments, mariculture, and ocean discharges.

I have authored or co-authored 12 peer-reviewed publications in addition to dozens of technical reports, conference and public presentations, book chapters, encyclopedia articles, and online content dealing with coastal soft-sediment invertebrate communities as indicators of environmental health, animal-sediment interaction, and study methodologies.

SCOPE AND STATUTORY DECLARATIONS REGARDING THIS EVIDENCE

My evidence represents an examination of the application and accompanying documents with respect to benthic impacts associated with proposed subtidal iron sand extraction. My assessment is limited to the appropriateness of the methods and
robustness of the analyses with respect to the conclusions made in keeping with accepted industrial and scientific practices. The current application process does not permit adequate time, nor were resources available to independently audit the data, nor replicate analyses. Although I may reference relevant literature this evidence does not include a comprehensive review of relevant measurements nor processes external to submitted reports, potential project impacts, or recommendations for the project as a whole. NZEPA documentation states a preference for expert conferences prior to the submission of evidence in order to streamline proceedings, however the timecourse of these proceedings precluded that constructive process.

10 The relevance of my work experience and existing role I have in relation to this application are:

10.1 Macrofaunal identification, benthic community analyses, and biotic/abiotic factors in benthic ecology;

10.2 Designing, undertaking, facilitating, and evaluating surveys from intertidal estuaries to deep oceanic seeps; and

10.3 Field sampling, dredging process, and ecological risk assessment and mitigation

11 My evidence is given in relation to the application for a consent to undertake offshore iron ore extraction and processing by Trans-Tasman Resources Ltd (TTR) in the South Taranaki Bight presented before the Decision Making Committee (DMC) of the New Zealand Environmental Protection Authority (NZEPA). I am familiar with ordinary procedures under the Resource Management Act, but I respectfully ask the forbearance of the DMC with regard to presenting evidence under the new and evolving procedures of the NZEPA with respect to the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 (EEZ Act).
I am familiar with the description of the proposed activities and many of the technical reports provided by the applicant as served by the NZEPA on 21 February 2014.

While providing this evidence I am mindful that the purpose the EEZ Act and the DMC is (Part 1 s10(2)) to manage the use, development, and protection of natural resources in a way or at a rate, that enables people to provide for their economic well-being while–

(1.a) sustaining the potential of natural resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and

(1.b) safeguarding the life-supporting capacity of the environment; and

(1.c) avoiding, remediying, or mitigating any adverse effects of activities on the environment.

I note that the applicant has stated that the extraction project will not be attempted if the expert commissioners appointed to consider and impose consent conditions at their discretion, apply spatial restrictions on the consent. This precludes principal adaptive management and mitigation strategies through impact extent (area boundaries) and density (swath patterns). The applicant is only prepared to accept impact mitigation, remedy, or avoidance conditions which employ timing and/or methodological alterations to the activities described in the proposal. Consequently my evidence does not comprehensively address some of the most demonstrably effective mitigation measures globally employed in reducing impacts of seabed extraction programmes.

I have read the Directions and Hearing Procedures of the Decision-making Committee (Feb 2014). I have read the Code of Conduct for Expert Witnesses as contained in the Environment Court Consolidated Practice Note (2011), and I agree to comply with it.
My qualifications as an expert are set out above. I confirm that the issues addressed in this brief of evidence are within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

I do not act as an advocate for any party in these proceedings. I have been contracted by KASM to provide material facts and expert opinion on scientific matters relating to the application. No regular employment relationship exists between the applicant and myself nor KASM and myself though I have provided technical advice to both on an independent contractual basis. I also have a contractual relationship with the NZEPA to serve as one of the DMC commissioners, however, as I was not appointed to the committee for this application I have not had access to any information outside the public domain with regard to pre-hearing discussions with Trans-Tasman Resources. All parties have been informed of my activities with other parties. I consulted with NZEPA in November 2013 to clarify and resolve any potential conflicts of interest. I will, upon request, release financial data to the DMC in support of my limited involvement with all parties. TTR has acknowledged my peer review work in their submitted evidence and I recommend that they consider releasing that work to all parties in keeping with their stated goals of informing the Commissioners and consultation process with the best possible information available. I believe my evidence to be free from conflict of interest insofar as it is practical within the limits of my area of specialty.

BENTHIC ECOLOGICAL IMPACTS

Adequate evaluation of the technical reports submitted with this application requires a considerable technical vocabulary and robust understanding of physical and biological processes on the seafloor unfamiliar to many laypersons. Certain terms, when used
across disciplines, can even carry different denotative and connotative meaning among experts. Technical reports do not always provide clear operating definitions nor highlight such differences across fields. I therefore hope it is acceptable to the commissioners and helpful for avoiding misunderstanding that I include a glossary for those terms which I consider of key importance to holding a discussion of the issues with a layperson (Appendix A).

White and Picket (1985) define eight disturbance parameters necessary for describing disturbances to patchy environments such as the marine benthos (Table 1). Assessing the short and long-term damage to the life-supporting capacity of the environment, the sustainability of disturbance-associated activities, and creating effective methods of avoiding, mitigating, or remedying impacts therefore requires quantification or substantiated estimation of the type and rate of natural responses of living communities and abiotic parameters (e.g. sediment structure) to each of these disturbance characteristics. Given the systematic mining process described by TTR's documentation, each of these parameters has been defined, however the environmental impact reports addressing benthic ecology rarely offered a formal, quantified hypothesis predicting the response of communities to any of these stress characteristics. By analogy, economic impact predictions offer testable projections of jobs and profit whereas ecological predictions are often couched in ambiguous terms such as 'minimal impacts' or 'rapid recovery.' I will detail substantive issues with the benthic impact reports, but, in overview, they represent limited observations of the recent state of the environment and collectively do not offer sufficient objective evidence for predictive power which is the essence of an impact assessment. My evidence will demonstrate that the responses to these disturbance stressors are knowable with adequate research effort and due scientific diligence. I broadly agree with the findings of the brief review provided by Sinclair Knight Merz Ltd (2013) to the
NZEPA. In the interests of brevity I will therefore avoid repeating the inadequacies they present.

Table 1. Definition of key terms for describing disturbances in patchy environments.

<table>
<thead>
<tr>
<th>Descriptor</th>
<th>Definition</th>
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<tbody>
<tr>
<td>Distribution</td>
<td>Spatial distribution, including relationship to geographic, bathymetric, environmental, and community gradients</td>
</tr>
<tr>
<td>Frequency</td>
<td>Mean number of events per time period</td>
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<tr>
<td>Return interval</td>
<td>Inverse of frequency</td>
</tr>
<tr>
<td>Rotation period</td>
<td>Mean time required to disturb and area (impact area must be explicitly defined)</td>
</tr>
<tr>
<td>Predictability</td>
<td>A scaled inverse function of variance in the return interval</td>
</tr>
<tr>
<td>Area</td>
<td>Area disturbed (frequently a percentage of total available, equivalent area)</td>
</tr>
<tr>
<td>Magnitude (intensity)</td>
<td>Physical force of event per area per time unit</td>
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<tr>
<td></td>
<td>(severity) Impact on the organism, community, ecosystem (e.g. basal area removed)</td>
</tr>
<tr>
<td>Synergism</td>
<td>Effects on other disturbances (e.g., drought increases fire intensity, reduced sediment cohesion decreases shear force required for resuspension, etc.)</td>
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The site and project-specific analyses informing the benthic ecology evidence of Drs. Alison MacDiarmid and Tara Anderson relied principally upon two technical reports (Beaumont et al. 2013; Anderson et al. 2013) which contributed to the supporting information (predominantly in Chapters 6 and 12) of TTR’s Final Impact Assessment document. The chain of evidence, therefore, must offer supporting data in these reports that 1) the benthic investigations addressed appropriate questions incorporating the best available information, 2) the methods used were designed to demonstrably detect relevant phenomena, 3) analyses were of appropriate rigour, 4) analytical or experimental methods were used to attempt to falsify assumptions and/or predictions, and 5) conclusions of a quality sufficient to warrant nationally significant
policy decisions are supported by the weight of evidence from novel data and the broader scientific literature.

**BEAUMONT ET AL. 2013**

20 The aims of this report were stated to be a survey of existing meio- and macrofauna across presumed natural gradients in the study area and investigate the relationship between iron content of sediments and animal communities. The report also aimed to experimentally determine the effect of ore concentration on the recolonisation of sandy sediments. The report does not attempt to discuss the potential effects of the proposed activities on the benthos.

21 The methods used in this technical report were not suitable for the purpose to which the data were put

21.1 Study design

(1.a) Investigators appropriately chose core and dredge sites across previously known bathymetric and sedimentary gradients, but sampled those sites in a systematic pattern with respect to bathymetry and a southeastern spatial progression (Table 1, pg 15 and Figure 2, pg 17). At these latitudes it is reasonable to expect at least a two to three-fold change in macrofaunal abundances (especially polychaetes) across seasons. Such seasonal signals have been documented in similar fine, hydrodynamically energetic sediments in waters 18–32 m deep on the inner continental shelf off Otago (Paavo 2007, Paavo 2011a, Paavo et al. 2011b, and several additional publicly available reports and evidence relating to sediment discharges to the seabed lodged with the Otago Regional Council). When it became apparent during the investigation
that core and dredge samples could not be appropriately sampled in time, one corrective course of action would have been to resample a suite of stations repeatedly so that the seasonal signal could be subtracted from abundances at other stations. This is a gross design error which reasonably makes spatial patterns of macrofaunal and meiofaunal abundance suspect as it is likely to swamp the environmental signal and specifically confounds the sedimentary texture gradient response (see report Fig. 37, pg 62). Section 2.3.3 shows that the investigators were cognisant of this serious problem and, though inadequate, took some measures to mitigate the bias in dredge (but not core) samples.

(1.b) Meio- and macrofauna recovered from the core samples are typically called infauna throughout the report and subsequent documents. The mean core penetration was 108 mm, though the most detailed analyses were conducted only on those animals recovered from the top 50 mm of sediments, typically a stratum with the greatest number of animals. Such animals exist at the arbitrary boundary of infauna and epifaunal classification. The seabed disturbance by the mining crawler is designed to trench 2,000–11,000 mm into the seabed. Mature continental shelf sediments are expected to develop a deeply buried infaunal community unless sediment resuspension is severe and frequent enough to prevent it. These deep-dwelling infauna provide many of the goods and services provided by benthic ecosystems including providing feed for demersal fish stocks. Whereas, on land, biodiversity is often directly related to the structure, goods, and services provided by flora (trees, shrubs, etc.), infauna provide analogous structure in marine soft sediments (Figures 1 & 2). The investigators identified the presence of such an infaunal community by bioturbation such as burrows, pits, and trails in Coastcam
images and also by direct capture of one of its shallower burrowing species, *Tucetona laticostata*. Significant *T. laticostata* and *Panopea* shell debris were also found, yet the investigators used methods with very low likelihood of recording this important community. The choice of sampling methods was predictably not consistent with an ability to detect and quantify communities most likely to be negatively and directly impacted by the proposed activities.

**Figure 1.** Figure 1 from Rhoads and Germano (1982) showing the succession of epifaunal to infaunal colonisation relative to physical disturbance and its similarity to pollution (organic enrichment in this case) gradients described by Pearson and Rosenberg, 1978.
Figure 2. Examples of infaunal community characterisations on continental shelf. Typical descriptive parameters to assess infaunal community impacts include composition, abundance, diversity, biomass, depth of sediment reworking, and rate of sediment reworking which provides the goods and services available to the rest of the local ecosystem (including human use).
(1.c) A single core sample was used for both faunal analysis and sediment analysis. This represents an outmoded and unacceptable practice because of its inherent flaws despite the benefits of expediency. Accepted practice is to collect samples or area-controlled subsamples specifically for faunal analysis. The report states that approximately 15 ml (15,000 mm$^3$) of sediment were extracted from an unknown area in the top (most densely populated) layer of sediment the analysis of which depends (very sensitively due to multiplication effects) upon rigorous areal equivalency. In addition, the area of the core required to obtain this volume (even if it were standardised) varies systematically with sediment texture thereby introducing more error.

(1.d) The collection of raw benthic imagery is well-described in the report, but the methods used to extract data from that imagery was well-below internationally accepted standard and industrial practices. Observers were not blinded to location, depth, nor time. Repeat measures testing was not conducted for quantitative nor qualitative data.

(1.e) Though the report aimed to describe the meiofauna of the area, these taxa were extracted from only a small subset of cores within a restricted bathymetric range. Interstitial meiofaunal communities (frequently linking microphytobenthos, microbial, and fungal communities with macrofauna and predatory trophic levels) often provide the most readily detectable animal community response to trace metal contamination and nutrients through pore water.

(1.f) A large portion of this report addresses a colonisation experiment intended to address the issue of recolonisation of de-ored sediments. These data and the conclusions drawn from them must be entirely
withdrawn from DMC consideration of the application as *non-sequitur*.

Data from the experiment, while academically interesting to me, provide no predictive value relevant to the application. The authors recognise this (see pg. 117) yet still draw conclusions from admittedly inappropriate data, "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 scientifically and ethically egregious. Furthermore, the authors state " no re-colonisation studies of subtidal sandy substrates on highly exposed coastlines were found in the primary literature. " Data pertaining to such questions is contained in some primary sources, and at least some of the investigators are aware of such information in New Zealand shelf systems, however the bulk of the material is in the 'grey' literature; often in reviewed theses and non-peer-reviewed reports prepared for industrial, management, or pilot studies. It does not appear that the investigators performed due diligence with respect to this, albeit much more difficult to examine, literature. I further disagree with the investigators that recolonisation of deored sediments will primarily be through juvenile planktonic recruitment, but such a disagreement is, perhaps, best resolved through consideration of technical data in conference. I here list some of the significant discontinuities between the recolonisation data provided and their inferential value to the DMC with respect to the application.

(1.f.i) The fauna of Evans Bay and Mahanga Bay bear little resemblance to those at the proposed activity site.

(1.f.ii) Sediments were intentionally immobilised.
1. Sediments were intentionally put in a different hydrodynamic regime when hydrodynamics were, *a priori*, one of the major community shaping gradients.

2. Benthic recolonisation was intentionally impeded when the majority of the fauna examined in the study area are brooders.

3. Benthic structure from the study site (fabric) is not included in the design.

4. Drastic differences exist between experimental and field scales on a process with an accepted area and edge-dependent effect.

5. A systematic increase of sediment structure (PVC piping) throughout trials existed without adequate control.

6. Silt content of sediments (with fundamental surface area implications for fauna) differed dramatically between experimental and field samples.

7. Experimental structure created substantially different ecological effects (predation, competition, etc.) without control.

### 21.2 Analytical Methods

2. Assessment of biodiversity is an important part of the TTR documentation and the DMC must have particular regard to biodiversity issues due to national policy statements and several international agreements (see [http://www.biodiversity.govt.nz/resources/international/](http://www.biodiversity.govt.nz/resources/international/)). The analytical methods employed in this report fundamentally rely upon the identification of the primary ecological unit, a specimen of a distinct species. When species are identified as undescribed it is industrially accepted practice to use morphospecies as a proxy for species. Given the variation in life histories among species, even within the same genus, one can only reliably predict a few of the ecological functions a morphospecies performs without adequate observation. This report uses
the concept of operational taxonomic units (OTUs) and disingenuously
states that this is the lowest taxonomic resolution possible when it is
merely time consuming\footnote{Species descriptions and life history observations are routinely done all the time. In fact, surveys related to impact studies are a substantial route through which new species are discovered, described, and their ecological importance investigated.}. Analyses using OTUs must take special
statistical care when they are known to be at taxonomic levels other than
species or morphospecies. For instance several known morphospecies
were lumped into families (e.g. Syllidae spp.) or genera. An appropriate
terrestrial analogy would be to evaluate the biodiversity of two
neighbourhoods, by counting all the people as one species, the dogs as
one species, the cats as one species, and all birds as only one species.
The biodiversity of these neighbourhoods would be equivalent in these
analyses even if one had only sparrows and the other had kiwis, fantails,
kereru, morepork, and takahe. This fundamental ignorance fatally
weakens the biodiversity data presented, the conclusions that rely upon
them, and all statements indicating that no unique, rare, or significant
species or communities are present in the proposed project area. Indeed
the authors logically contradict themselves;

“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. “

and

“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’:

followed by

“...there was no evidence to suggest that the PPA was “unique” [sic] with
respect to benthic epifauna or infauna collected from or observed on the seabed
during this survey. "

I used polychaetes here as an illustrative example for which I am most
specifically qualified, but other cognitively dissonant examples could be
used.

ANDERSON ET AL. 2013

22  This report had several of the same methodological flaws such as not examining
infaunal community analysis, not compensating for OTUs, poor image analysis
controls, etc. To save time I will include below only additional errors present in this
report.

23  This report aimed to survey and characterise inshore benthic habitats, macrofauna,
macroalgae, and surface sediments. The report was not designed nor does it present
objective predictive impact information for the DMC.
Design

24.1 The restriction of sampling to computer model boundaries substantially decreases its utility for posthoc model validation, impact monitoring, or comparison to appropriate control sites in the STB (since the model boundaries were selected a priori to delineate a suspected gradient).

Methods

25.1 The investigators state that benthic imagery was ‘...rectified in space using the known distance between the lasers...” This is not geometrically possible using two known points with an angular offset on an irregular bottom. Given the other irregularities in data collection I do not think that this practice substantively reduced an already low data quality in areal measurements but it is illustrative of the technical naiveté of the investigators and obfuscating language prevalent in the report.

25.2 In section 2.5 the authors recognise the the systematic problems of dredge efficiencies (especially important in cases where efficiency drops to zero).

“This means that different sites may not be directly comparable in terms of quantities, but will be indicative of species occurrences, assemblage structure and trophic function. ”

But do not subsequently transform their data. This language has the effect of implying due diligence to the non-technical reader without actually undertaking the consequent analytical effort nor adequately qualifying conclusions based upon them.

25.3 Section 3 contains statements which appear to represent inadequate reporting or a misunderstanding of the processes leading to different sediment ripple structures observed within the frame limits of the benthic cameras. As an example there is confusion about oscillatory and bulk flow processes. A unidirectional flow (possible in tidal systems where currents exist) would be
reasonably hypothesised by asymmetric ripple cross-section, but a linear bedform is insufficient for such a conclusion and linguoid or catenary shapes are insufficient to discount flow in the absence of bed rugosity and fabric information. The methods used were unable, without accompanying sidescan or similar visualisations, to distinguish ecologically-relevant bedforms of wavelength greater than about 300 mm.

25.4 The executive summary states that “No records of new species were found.” This is technically true, but scientifically disingenuous as many of identifications did not resolve organisms to species level and the methods employed would only be able to detect such species if they were large and abundant – characteristics of common, well known species.

25.5 I regret that time does not permit further analytical treatment of this report and the expert evidence based on the data it presents. I would welcome the opportunity to update my evidence with a more comprehensive evidence-based analysis if the DMC allows.

IN CONCLUSION

26 Without robust data and analyses with predictive value from the actual study site, the DMC’s decision pertaining to deleterious benthic ecological effects, an admittedly major issue recognised by the applicant and many submitters, relies solely upon the opinions of expert witnesses based on their varied understanding and experience with similar systems elsewhere and their understanding of the mining process. When scientific work is not done rigorously, it is my opinion that we cannot trust the inherent consistency of their conceptual model of benthic impacts.

27 I regret that the time available to me was not sufficient to review all of the physico-chemical material provided by TTR comprehensively with respect to the wider
literature and documented outcomes of other extraction processes. Such impacts are
synergistic with the physical disturbance processes I've examined here and warrant
further critical review. I welcome an opportunity to address any questions from the
DMC.
BIBLIOGRAPHY


Paavo, B.L. (2011a) AO Mapping: Benthic observations near the dredge spoil disposal site 'A0' proposed by Port Otago Limited. A report by Benthic Science Limited, Dunedin, New Zealand, 53 p.


Ecology of Natural Disturbance and Patch Dynamics. S.T.A. Pickett and P.S. White. Orglando, FL,
APPENDIX A – GLOSSARY OF KEY TERMS (BOLD IN TEXT)

**Benthic** – Pertaining to the seafloor

**Bioturbation** – reworking of soft sediments by animal activities including burrowing, feeding, tube building, migration, etc. Careful and systematic observation and categorisation of distinctive bioturbation patterns (see lebensspuren) can often identify taxa and some of their activities in an area.

**Epifauna** – animals living on or very near the surface of the seabed

**Fabric** – In a soft-sediment context ‘fabric’ refers to the cohesive quality of sediments resulting from the distribution of grain sizes, the binding of sediments by flora and fauna (mucous tubes, bacteria, microphytobenthos, etc.) and several other factors like the shape of the grains and water content. Many of the processes leading to a sediment’s fabric take time and certain environmental conditions (e.g. oxidation-reduction potential) to develop. Like terrestrial soil, the fabric of undersea sediments determine, in a large way, how organisms interact with them, including colonisation, and how they respond to shear stresses (e.g. waves, currents, etc.).

**Goods and Services** – a concept, when used in resource management contexts, referring to the estimated real monetary value natural processes provide. Typical benthic examples include providing food to other species by providing critical links in local foodwebs, reducing coastal damage through sediment stabilisation by tubes and mucous binding, improving sediment productivity through bioturbation (like tilling a paddock), and even passive value such as real estate with variable value (usually relative to port proximity) to receive ocean discharges.

**Infauna** – animals living buried in the seafloor

**Interstitial organisms** – live in the water-filled spaces between individual sand grains

**Lebensspuren** – Traces or sign of animal activity left in sediments

**Macrofauna** – as used in the NIWA reports this means animals retained on a 0.50 mm aperture mesh when sediment samples are sieved. When macrofauna are reported from camera surveys, only animals tens of millimetres in least dimension are typically recorded.

**Meiofauna** – as used in the NIWA reports this means animals passing through a 0.50 mm aperture mesh, but collected on a 0.063 mm aperture mesh. Due to differing animal shapes, rigidity, and
undocumented differences in extraction procedures it is not uncommon for animals several mm in length to be among meiofaunal samples. Some investigators use a smaller mesh to capture animals clearly occupying the interstitial niche associated with meiofauna blurring the line between meiofauna and microfauna. Though small, meiofauna can represent significant biomass because of their great numbers in some sediments. Meiofauna play a significant role in ecosystems by connecting microbial communities with larger animal communities.

**Morphospecies** – Where an organism is recognised as different from known organisms, but a formal description has not yet been made, it is common practice to identify taxa according to biological traits (e.g. shape of body, number and type of sense organs, ornamentation, etc.) which are widely accepted to be indicative of different species within that group. Essentially this groups organisms which look alike as the same thing and excludes them from things that look importantly different. This is always a tentative indication as many organisms differ among sexes or at different life stages.