BEFORE THE FAST TRACK PANEL
AT WELLINGTON

I MUA I TE KŌTI TAIAO O AOTEAROA
TE WHANGANUI-A-TARA ROHE

UNDER	the Fast Track Approvals Act 2024 (the “**Act**”)
IN THE MATTER	of an application by Trans-Tasman Resources (TTR) for marine and discharge consents to undertake iron sand extraction in the South Taranaki Bight
BETWEEN	**TRANS-TASMAN RESOURCES LIMITED (TTRL)**
	Applicant
AND	**THE ENVIRONMENTAL PROTECTION AUTHORITY**
	The EPA

STATEMENT OF EVIDENCE OF DR TARA JULIE ANDERSON FILED ON BEHALF OF KIWIS AGAINST SEABED MINING AND GREENPEACE AOTEAROA LIMITED

Dated 6 October 2025

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INTRODUCTION

1) My full name is Dr Tara Julie Anderson.

2) I have been asked by Kiwis Against Seabed Mining and Greenpeace Aotearoa New Zealand to prepare a statement of evidence on the potential effects to benthic ecology from the proposed Taranaki VTM Project [FTAA -2504-1048] being considered under the Fast Track Act 2024.

Qualifications and Experience

3) I am a self-employed Marine Ecology Scientist, in Auckland. I have over 29 years of professional experience in marine benthic ecology, understanding and predicting the relationships between benthic organisms and the benthic habitats and seafloor environments they occur in.

4) I have a PhD in Zoology from the University of Melbourne, Australia 2004; a Master of Science (with 1st Class honours) from the University of Auckland 1994; and a Bachelor of Science in Zoology from the University of Auckland 1991.

5) Prior to being self-employed, I was employed as a Marine Ecology Scientist at the National Institute of Water Atmospheric Research ("NIWA") for 8 years - in Nelson (2013-18) and Wellington (2018-21) where I was the lead scientist on a variety of Coastal Marine Habitat and Ecology projects. Prior to this, I was employed as a Senior Scientist and Team Leader of the Benthic Ecology Programme at Geoscience Australia in Australia, during that time I was also in-charge of Australia's National Marine Biodiversity Surrogacy [biological and habitat mapping] programme. I previously undertook 6-yrs of postdoctoral research under three consecutive postdoctoral positions: as a senior research fellow at the Australian Institute of Marine Science in Townsville, Australia (2005-07), and as a postdoctoral fellow at the University of California, Santa Cruz, USA (2001- 03 and 2003-05) - jointly funded by the US federal government (NOAA Fisheries and US Geological Survey) and the US Marine Protected Areas Science Centre.

6) I have expert knowledge in benthic marine ecology, biogenic habitats, marine habitat mapping (including Multibeam mapping), organism-habitat relationships, seascape/landscape ecology, and have broad experience in marine biodiversity, spatial ecology, community and ecosystem structure and function, and natural and anthropogenic impacts on marine ecosystems.

Over the last 20 years I have led benthic ecology and seabed mapping surveys and projects at both regional and National scales in New Zealand, Australia and the United States. I have undertaken large-scale field-intensive benthic ecological surveys (incl. in the Marlborough Sounds and the Hauraki Gulf); including examining biogenic habitats as nursery habitats for snapper and juvenile blue cod (<38 m), mapping marine biodiversity and ground-truthing seafloor habitats from large-scale multibeam surveys in depths of 1-132 m. I have also undertaken a range of benthic fields surveys, including SCUBA diving, towed-video surveys, multi-disciplinary and multibeam mapping surveys. I have authored and co-authored over 70 publications, including science journal papers, book chapters and published reports focused on this research; including lead author on 'A review of New Zealand's Key Biogenic habitats' (Anderson et al. 2019) as part of MFE's state of the environment reporting, and was a co-author on the National mapping of key ecological areas in the New Zealand marine environment (Stephenson et al. 2018; Lundquist et al. 2020).

7) I have appeared as an expert witness on the topic of benthic marine ecology before an EPA decision making committee, in RMA hearings in the Environment Court and judicial review proceedings in the High Court.

Work on prior TTR application

8) I previously presented evidence on the offshore benthic marine ecology of Pātea Shoals, and nearshore soft-sediment and rocky reefs habitats and communities of the STB at the EPA (Board of Inquiry) Hearing for Trans-Tasman Resources Ltd seabed mining (2014–2015).

9) While working for NIWA (2013–21), I led the benthic ecology component of the NIWA–TTR programme (April 2013–2014), under the guidance of programme leader Dr MacDiarmid. In this role, I co-authored the two primary benthic ecology reports for the South Taranaki Bight (STB): Beaumont et al. (2013/2015) and Anderson et al. (2013/2015).

10) The offshore Pātea Shoals surveys (2011–2012) were designed and conducted by Drs Beaumont and MacDiarmid, with Dr Beaumont undertaking initial analyses and drafting sections of the report. When Dr Beaumont was on leave (2013–2014), I completed and

revised the analyses and led the final write-up of the offshore benthic ecology report (Beaumont et al. 2013).

11) I also designed, led, analysed, and was lead author on the nearshore benthic ecology report (Anderson et al. 2013).

12) In 2015, I revised both reports to include minor additions (Beaumont et al. 2013/2015; Anderson et al. 2013/2015) and assisted Dr MacDiarmid in preparing for the 2016 Hearing, where she presented evidence on the overall programme and findings, incl. benthic ecology. I did not attend the 2016 hearing, and have had no further involvement with the TTR programme since that time (TTR Hearing, December 2016).

Code of Conduct

13) I confirm I have read the Expert Witness Code of Conduct, contained in the Environment Court's Practice Note 2014. I also agree to comply with the code when presenting evidence to the Environment Court. I confirm that unless stated otherwise, this evidence is within my area of expertise, and I have not omitted considering material facts known to me that might alter or detract from the opinions I express.

14) The data, information, facts and assumptions I have considered in forming my opinions are set out in my evidence to follow. The reasons for the opinions expressed are also set out in the evidence to follow.

Purpose and Scope of Evidence

15) In preparing this evidence, I have reviewed the fast-track application and supporting evidence.

16) This evidence covers the following matters:

a) Effects of the proposed capital seabed mining proposal on benthic marine habitats and communities.

Documents Reviewed in Preparing this Application

17) I have specifically considered the following documents included in the substantive application document for the Taranaki VTM project (available online) including:

a) The Taranaki VTM application

b) FTAA-2504-1048[1]: Response to request for section 51 report for Taranaki VTM Project. Fast-track substantive application requested advice. Comments by Dr Ursula Rojas Nazar,

c) Dr MacDiarmid – Report-20b-Rebuttal-evidence-MACDIARMID-Jan-2024

d) Dr MacDiarmid – Report-20c-Evidence-statement-Macdiarmid-May-2023

e) Dr MacDiarmid – EPA Hearing presentation_2024_Day3 (ppt)

f) Dr MacDonald – Report-20d-Rebuttal-evidence-MACDONALD-Jan-2024

g) Dr MacDonald – Report-20e-Evidence-statement-Macdonald-May-2023

h) Dr MacDonald – EPA Hearing presentation_2024_Day2 (ppt)

i) Dr Greer – EPA Hearing presentation_2024_Day2 (ppt)

j) Joint statement of experts in the fields of: Sediment plume modelling; and effects on benthic ecology Dated 23 February 2024

k) Rebuttal evidence Dr Michael Dearnaley 23 January 2024 (PDF, 221KB)

18) And the following documents listed under Technical Reports:

a) Anderson et al (2015/2013): Report-2-NIWA-Benthic-Habitats-Report-FINAL

b) Anderson, T.J., Morrison, M., MacDiarmid, A., et al. (2019) Review of New Zealand's Key Biogenic Habitats. *NIWA Client Report* No. 2018139WN, prepared for the Ministry for the Environment: 184. https://www.mfe.govt.nz/sites/default/files/media/Marine/NZ-biogenic-habitat-review.pdf

c) Beaumont (Anderson) et al. (2013/2015): Report-3-NIWA-Patea-Shoals-Benthic-Ecology-FINAL

d) Cummings et al. (2020): Responses of a common New Zealand coastal sponge to elevated suspended sediments: indications of resilience. *Marine Environmental Research 155.*

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[1]https://www.fasttrack.govt.nz/__data/assets/pdf_file/0007/12310/FTAA-2504-1048-EEZ-Apps-response-to-s51-request-for-advice.pdf

e) Lundquist et al. (Anderson) (2020). Evaluating Key Ecological Areas datasets for the New Zealand Marine Environment. NIWA Report 2020109HN. Prepared for Department of Conservation April 2020.

f) Morrison et al. (2022). Offshore-subtidal-rocky-reef-habitats-on-Patea-Bank-South-Taranaki-2 (2238-TRC002-FINAL)

19) I have also reviewed the following documents:

a) Executive Summary of Evidence of Dr Tara Anderson on behalf of Trans-Tasman Resources Ltd, 29 March 2014.

b) Stephenson et al.[2] (2019) Mapping Key Ecological Areas in the New Zealand Marine Environment: Data collation. *NIWA Client Report* 2018332HN, prepared for the Department of Conservation.

Supplementary Appendix (Figures 1-7).

20) My evidence is presented below, with figures - based on data and information presented in Morrison et al. 2022 - provided in the attached pdf *(Statement of Evidence of Tara Anderson on behalf of Kiwis Against Seabed Mining and Greenpeace Aotearoa Limited 06-10-2025: Figures*).

Summary of Evidence

21) **Benthic invertebrate distribution modelling**

(a) Dr. MacDiarmid stated that new information on benthic invertebrate distribution modelling had become available since 2017, noting that Lundquist et al. (2020) predicted occurrence probabilities for 17 genera (including corals, sponges, bryozoans, lamp shells, and a bivalve), partly using NIWA data from TTRL surveys. While Dr. MacDiarmid considered the models useful, she felt they did not alter her conclusions.

(b) I am a co-author on the Lundquist et al. (2020) report, and agree with Dr. MacDiarmid that the models used in that report used some TTRL data, but that this

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[2] This technical report documents dataset used in the models presented in Lundquist et al. (2020). The authors of this technical report incl. Lundquist, C and Anderson, T. (myself).

dataset was very limited, relying only on presence records of Museum specimens and certain habitat-forming taxa. As such, the benthic invertebrate distribution models reflect only a small subset of the available TTRL data. If modelling is to be required by the EPA panel, updated models should be developed using the full TTRL dataset, including the new reefal data from Morrison et al. (2022).

22) **Updated information on rocky reef occurrence in the STB**

(a) New surveys since 2017 have expanded knowledge of rocky reefs in the South Taranaki Bight (STB). While early NIWA studies identified 12 sites, Morrison et al. (2022) confirmed 14 reefs and identified several more likely features, showing reef habitats are more common across Pātea Shoals than previously reported. Dr. MacDiarmid stated that these reefs act as biodiversity “islands,” supporting more abundant and diverse communities than surrounding sands.

(b) Reefs varied in size, relief, and substrata. High-relief reefs supported kelp (*Ecklonia radiata*) and *Caulerpa flexilis*, while flatter reefs (e.g., Sites Papa and D) were dominated by sponges, reflecting greater tolerance of sediment disturbance.

(c) I present several Supplementary figures to help examine the spatial distribution of these rocky reefs relative to potential effects. When compared with modelled mining plumes, over 60% of mid-shelf reefs lie downstream of the PPA. Even under mean conditions, some reefs (e.g., Site D) showed small SSC increases, while worst-case scenarios predicted and increase from >20 mg/L^{-1} to >100 mg/L^{-1} at multiple sites, including Project Reef and North and South Traps. With mining expected to last 20 years, long-term exposure to elevated SSC poses significant risks, especially to sensitive taxa as it may lead to chronic sediment accumulation, reduced light penetration, smothering of filter feeders, and progressive loss of ecological function across these habitats.

(d) Consequently, there is considerable uncertainty over whether prolonged mining impacts would cause material harm to these sensitive rocky reef habitats.

23) **Sediment tolerance of benthic habitats**

(a) Since 2017, new experimental studies have provided additional insight into benthic sediment tolerance in the South Taranaki Bight. Experimental work under the Sustainable Seas programme shows that the sponge *Crella incrustans* (Cummings et al., 2020) and the bivalve *Tucetona laticostata* (Sustainable Seas webinar pdf[3]) can tolerate short-term (≤4 weeks) elevated SSC, exhibiting mechanisms to clear sediment and maintain function. However, stress responses were observed even in these relatively resilient species, while their response to decades of chronic exposure remains unknown.

(b) No comparable experimental data exist for other downstream taxa, including raised reef species (*Ecklonia*, *Caulerpa flexilis*) and fragile frame-building invertebrates, which may vary in their vulnerability to elevated SSC. Similarly, blue cod nursery habitats occur within the predicted downstream plume, and juvenile fish are known to be sensitive to increased turbidity, potentially affecting growth and feeding.

(c) Overall, while short-term tolerance is evident for some STB species, the long-term effects of mining-related sediment on key benthic communities and nursery habitats remain uncertain, highlighting the need for further assessment of chronic and cumulative impacts.

24) **Brine-Plume Interaction with marine habitats**

(a) Brine plumes can create hypersaline layers near the seabed, potentially affecting sensitive habitats such as rocky reefs. While some benthic species (e.g., *Crella* sponges and *Tucetona* bivalves) can tolerate additional SSC, raised-reef communities, including *Ecklonia* and *Caulerpa flexilis*, may have enhanced survival and growth on elevated reef structures with lower sediment loads. The thresholds for these communities remain largely unknown, highlighting the need to assess brine dispersion and potential deposition before evaluating ecological impacts on downstream reef systems.

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[3] Pdf link:
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjSrqH-rouQAxWm8DQHHTHKHbcQFnoECBYQAQ&url=https%3A%2F%2Fwww.sustainableseaschallenge.co.nz%2Fassets%2Fdms%2FNews-and-Events%2F2017-Conference%2FMalcolm-Clark-Those-offshore-sediments-IF4-3-2%2FMalcolm-Clark-IF4.3.2-Offshore-sediments.pdf&usg=AOvVaw2wjv0arISKIsLboysUsLdN&opi=89978449

25) **Recovery of functional benthic habitats**

a) Recovery of habitat-forming benthic communities, such as *Euchone* spA wormfields, may be highly uncertain following mining. While communities in sandy, high-energy environments are often frequently disturbed and remain in early transitional stages, the recovery of *Euchone* wormfields may be far more complicated. Although individual worms of this species would be expected to recolonise once operations cease, the development of extensive sediment-stabilising bedforms will likely depend on specific precursor conditions that may not naturally return. Excavation and redeposition of sediments are expected to alter sediment characteristics and create a highly uneven seafloor topography (5–11 m trenches and mounds, in places potentially totalling up to 5-22 m). Such changes would replace the flat, stabilised sediments these wormfields naturally occupy, further reducing the likelihood of recovery. Given the apparent uniqueness of these wormfields to the Pātea Shoals region, and the absence of comparable habitats elsewhere in New Zealand, their loss could carry significant long-term ecological consequences. This uncertainty, together with the worms' reliance on narrow sediment conditions and association with flat seafloor bedforms, underscores the need for a high level of caution, and given the unknown timeframe for recovery and the likelihood that recolonisation may be precluded, it cannot be concluded that their removal would result in no material harm.

26) **Cumulative Effects**

(a) Cumulative effects from mining, combined with natural disturbances and other stressors such as land-derived runoff, may act additively or synergistically, potentially impeding recovery of slow-growing, longer-lived benthic species. Biogenic habitats, including those found on raised reefs in the STB and the sediment-stabilising *Euchone* spA wormfields, may be vulnerable to cumulative and/or chronic increases in suspended sediments, sediment deposition due to burial and smothering, and altered seafloor bedforms. The long-term ecological consequences of these combined stressors are highly uncertain or are simply not known.

Main Evidence

Benthic invertebrate distribution modelling

27) I have reviewed Dr MacDiarmid's evidence (*Report-20c-Evidence-statement-Macdiarmid-May-2023* on behalf of TTR) and her EPA Hearing presentation (2024, Day3).

(a) In her March 2024 presentation on "Benthic invertebrate distribution modelling," Dr MacDiarmid:

(i) stated that "*Lundquist et al. (2020) provide modelled predicted probability of occurrence for 17 benthic invertebrate genera including 9 corals, 2 sponges, 3 bryozoans, 2 lamp shells, and 1 bivalve, which include one or more species of habitat forming/sensitive environment species*"

(ii) and that "*In part these models use the information previously collected by NIWA during benthic surveys undertaken for TTRL"* and *"While useful for predicting the occurrence of these genera outside the areas sampled do not change my conclusions."*

(iii) I agree that Lundquist et al. (2020) – on which I am a co-author – incorporated some NIWA data from the TTRL surveys. However, the dataset used was very limited - only presence records entered into NIWA's SPECIFY database (a small subset of TTRL specimens); these data were defined as habitat-forming taxa - when found with at least two other habitat-forming or habitat-contributing species or individuals (Anderson et al. 2019; Stephensen et al. 2019). While useful, the models therefore represent only a very restricted subset of the TTRL benthic invertebrate data.

(iv) Accordingly, if benthic invertebrate distribution modelling is required by the EPA panel, updated models should be developed using the full TTRL dataset, including more recent reefal data collected by Morrison et al. (2022).

Updated information on rocky reef occurrence in the STB

28) I have reviewed Dr MacDiarmid's evidence (*Report-20c-Evidence-statement-Macdiarmid-May-2023* on behalf of TTR); Morrison et al. (2022) (NIWA technical report on '*Offshore subtidal rocky reef habitats on Pātea Bank, South Taranaki*); Dr

MacDiarmid's EPA Hearing presentation (2024, Day3) and Dr MacDonald's EPA Hearing presentation (2024, Day2)

29) In her 2023 Evidence, Dr MacDiarmid stated that:

(a) Since her 2017 evidence, new information is available on rocky reef distribution in the STB (citing Morrison et al. 2022).

(b) Initial NIWA surveys (Beaumont et al. 2015; Anderson et al. 2015) reported 12 rocky reef sites inshore of the PPA.

(c) "*More recently, Morrison et al. (2022) identified further areas of rocky reef in this same general area, and it is highly likely that other areas of rocky reef occur in this area inshore of the PPA and may be known to the local fishing and diving community but remain to be formally mapped*"

(d) "*These rocky habitats are islands of biological diversity among the otherwise low diversity communities occurring on the surrounding sandy flats".*

(e) *"Although much rarer in spatial extent than surrounding sands, rocky reefs support a much more abundant and diverse benthic biota dominated by suspension-feeders and primary producers".*

(f) *Outcrop assemblages were characterised in NIWA surveys by bryozoans, macroalgae and sponges, as well as more motile species, (e.g., crabs, amphipods, starfish, brittle stars, gastropods and polychaete worms)."*

(g) Based on my review of the Morrison et al. (2022) report – as described below – I agree with Dr MacDairmid's above statements (i-iv).

30) Morrison et al. (2022) conducted a multibeam sonar survey, followed six months later by towed-video surveys and baited fish-trap deployments:

(a) The Multibeam Sonar survey was not able to map the entire areas in and around reefs, but rather was limited to cost-efficient transects run across targeted mid-shelf areas.

(b) The multibeam survey routes and targeted sites were informed by knowledge from local divers and fishers, DOCs National predicted rocky reefs layer, and rocky reef sites from Beaumont et al. (2015).

(c) The multibeam transects identified numerous additional reef features, many of which extended beyond initial transects.

(d) Twenty multibeam sites were selected for towed-video verification, although only 14 are reported. These 14 sites (including two previously known reefs) were confirmed as rocky reefs with diverse benthic assemblages: Sites A, B, Papa, D, J, L, K [Project Reef], O, Q [South Traps], R, S, T, U, and V.

(e) Seven further sites (Z1–Z6, Z8) were identified as likely reefs based on bathymetry and backscatter but were not visually verified.

(f) Two additional raised features (Z7, Z9) were mapped but not confirmed. Site Z9, in my expert opinion, likely represents rocky habitat buried under a thin sediment veneer, consistent with sediment mobility in this dynamic environment.

(g) These surveys confirm that rocky reef habitats are more common and widespread on Pātea Shoals than previously documented in the scientific literature. Although no exact estimates (based on survey effort) were reported.

(h) These surveys confirm that rocky reef habitats are more common and widespread on Pātea Shoals than previously documented in the scientific literature.

(i) In total, the multibeam sonar mapped 61.5 km^2 of seafloor inshore of Pātea Shoals; with 13.5% of the multibeam transects verified as 'reef' and/or 'likely reef' (including block 5 features) and 9.3% (excluding block 5 features – which were unverified and based on the MBES maps were considered "*highly likely to be soft sediment bedform features*").

(j) Although the aim of this survey was to target known and likely reef areas (so biased towards finding reefs), the long near continuous multibeam transects that criss-crossed the mid-shelf of Pātea Shoals should provide a good initial estimate/guide as to how much rocky reef habitat might be present across the remaining unmapped regions of this mid-shelf. Although some over estimation may occur, where features seen in the multibeam are not reefs, but conversely many of the verified reef features, extended beyond the multibeam transects – and therefore would underestimate the areal extent of these reefs.

(k) A regional overview of previous studies was also provided. Previous reports and Evidence have also highlighted these habitats:

(i) The North and South Traps were surveyed by ASR Ltd in 2005 (reported in Anderson 2014 Evidence), with original images (provided by ASR) presented at the 2014 Hearing.

(ii) Project Reef (Site K) was surveyed by Harris et al. (2021) using ROV, with Morrison et al. (2022) noting that Pātea exhibited the highest sponge 3D-complexity score across national survey sites, highlighting its ecological significance.

(l) Demersal fish were also identified and counted from the tow-video footage across the fourteen verified reef sites.

(i) More than four thousand demersal fishes from twenty-six species were recorded from the towed video survey. Based on Table 8 (page 51), five common species comprised 96% of all fish recorded. These species were: Blue cod (*Parapercis colias*); Butterfly perch (*Caesioperca lepidoptera*); Scarlet wrasse (*Pseudolabrus miles*); Leatherjacket (*Meuschenia scaber*) and Tarakihi (*Nemadactylus macropterus*) (Supplementary Appendix Figure 6).

(ii) Newly settled and juvenile blue cod (440 small juveniles <12 cm) were also reported, in numbers that defined four sites (Sites D, L*[4], U, and V) as blue cod nursery habitats (Supplementary Appendix Figure 6).

(iii) Fish were also caught and videoed from 13 baited fish traps (BFT) collected at 6 sites (far fewer than planned), and provided some additional reef-fish and habitat observations.

31) Morrison et al. (2022) provide an excellent characterisation of the 14 verified reef sites, including towed-video imagery that gives a representative overview of habitats present at each site. The report also includes data tables documenting substrata proportions[5], benthic taxa (species and growth forms), and fish counts by species and size class

32) However, no information was presented on the location of these newly mapped/verified reefs and their physical and biological attributes, in relation to the PPA or to modelled plumes of suspended sediment concentrations (SSC) from background, mining, and

[4] This site was reported to provide only a limited nursery area.

[5] Although I note here that substratum types recorded at Site U totalled 69.3% - leaving 30.7% of the benthos unaccounted for.

combined sources. To enable spatial comparison of these rocky reefs with their physical and biological attributes, I converted Morrison et al.'s (2022) data tables into ArcGIS shapefiles and plotted them for spatial examination (see Supplementary Appendices to my Evidence: Figures 1-6). I also geo-rectified figures from Dr MacDonald's EPA Hearing presentation showing the modelled plumes (median and 99th percentile) for background, mining, and combined scenarios (see Supplementary Appendices to my Evidence: Figures 7). This allowed a clearer examination of reef features relative to potential impacts.

(a) Examination of the new rocky reef information, plotted spatially and compared with DOC's modelled rocky reef layer, shows good alignment with the bathymetric contour lines and the verified presence of rock outcrops of varying sizes. However, Morrison et al. (2022) stated that some DOC rocky reef polygons were found to be soft sediment. Conversely, several reefs (e.g., sites 5 and 6 in Anderson et al. 2015) occurred in areas with no apparent bathymetric complexity, indicating that additional reefs likely exist beyond those predicted by contour data, particularly further inshore

(b) The 14 rocky reefs varied in their substratum composition, reef area and reef height (Appendix Figures 1-3)

    (i) Reefs in the north (Sites A, B and +7) were relatively large in size characterised by the presence of most substratum types, with reefs dominated by low to high relief (Site A) or low relief (Site B) structure.

    (ii) Reefs in the centre (e.g., Project Reef/Site K, L, O and J) were generally small in area, dominated by cobble/boulder substrata and low-relief reefs, with no high relief reef features (Appendix Figures 1-3).

    (iii) Reefs in the south (South Traps/Site Q, R, S, T, and U; and North Traps/Site P – only area available) ranged in areal size, but supported reef features dominated by high depth ranges and/or vertical height above the seafloor (Appendix Figures 1-3). Of the reefs surveyed with towed-video, South Traps/Site Q was unique compared to other surveyed reefs in that comprised notably large amounts of high-relief reef (Appendix Figures 3c), while North Traps/Site P supported the largest reef size (Appendix Figures 3c).

(iv) Site V were also dominated by low-lying rock with only limited raised sections (Appendix Figures 2-3).

Raised Reef Features

(c) High relief reef and depth range/height above the seafloor appeared to be a determinant of biogenic habitat types and a useful proxy for late-successional communities, which are often more vulnerable to elevated SSC and sediment deposition. Low-relief reefs in the highly dynamic sedimentary environment of the STB, are particularly susceptible to burial, scouring, and re-exposure during storms. Sites Papa and D supported the flattest reef structure, with minimal vertical relief and the lowest biogenic cover (Appendix Figures 4-5), and tended to support communities dominated by sponges (including *Crella*) (Appendix Figures 4-5) - that are comparatively tolerant to turbid environments with periodic sediment perturbations.

(d) Across sites, raised reef areas with greater relief frequently supported *Ecklonia radiata* (ranging from dense and patchy forests to scattered individuals) and *Caulerpa flexilis* (dense to sparse patches) - particularly on steep slopes: consistent with observations from other regions (Anderson et al. 2020[6], 2025[7]). Based on species distribution and abundance, Sites A, Q, R, S, and U are likely to contain such steeply sloping reef, although slope and rugosity data were not reported by Morrison et al. (2022). These features could, however, be readily derived from the available multibeam dataset.

Rocky reefs in relation to plume models

(e) Supplementary Appendix Figure 7 shows the distribution of known reefs relative to modelled plumes (median and 99th percentile) for background, mining, and combined scenarios. Several key patterns emerge:

[6] Anderson, T.J; et al. (2020) Life on the seafloor in Queen Charlotte Sound, Tory Channel and adjacent Cook Strait. NIWA Client Report 2019081WN. Prepared for Marlborough District Council: 336p. PDF weblink

[7] Anderson, T.J., Pardo, E., Broadribb, M. and Robertson, J. (2025). Benthic habitats and community structure within the Te Tapuwae o Rongokako Marine Reserve. Prepared for the Department of Conservation, February 2025. Marine Bioservices Client Report No. MBS2502, 78pp.

(i) >60% of known mid-shelf reefs on the Pātea Shoals/STB lie downstream of the mining sites. These include Sites D, K, L, O, P, Q, R, S, T, U, V, and +5, with additional exposure at Sites Papa and +6.

(ii) Although many reefs are located 2–8 km from the PPA, some sites (e.g. Site D) still showed small but measurable increases in suspended sediment concentrations (SSC) under the combined background and mining mean conditions (Appendix Figure 7 C1).

(iii) Conditions were notably worse under the 99th percentile (worst-case) scenarios (parameters determined during expert conferencing) (Figure 7 B2 and C2). Here, significant increases in SSC downstream occur over most of the mid-shelf reefs, with SSC increasing at Project Reef/Site K, the North and South Traps (Sites P and Q), and Sites L and O from 10–20 mg/L to >100 mg/L. Many of these reefs host diverse biogenic habitats and sessile species that are unable to avoid such stressors.

(iv) The exposure of such a large proportion of rocky reef habitat to elevated SSC downstream of the PPA is of particular concern, given the projected mining timeframe of 20 years. While short-term tolerance has been demonstrated in some species (e.g., the sponge *Crella* by Cummings et al. 2020 – see section below), the consequences of prolonged exposure over decades remain unknown and are likely to be especially severe for more sensitive taxa.

(v) Therefore, while some species may tolerate short-term increases in suspended sediment, the long-term effects of chronic exposure over decades - particularly on sensitive, high-relief reefs supporting complex biogenic communities—remain unknown, and it cannot be assumed that these habitats would avoid material harm under prolonged mining impacts.

Sediment tolerance of benthic habitats

33) I have reviewed the *Summary of expert evidence of Dr Alison MacDiarmid on behalf of TTR* (Presentation, Draft 12 March 2024), as well as Morrison et al. (2022), Cummings et al. (2020), and I also attended the Sustainable Seas webinar presented by Drs M. Clark and V. Cummings (27 August 2021, available online[8]).

(a) In her March 2024 presentation on the "Impact of sediments on benthic fauna," Dr MacDiarmid:

(i) stated that filter feeding bivalves can compensate for short periods of time citing Navarro and Widdows (1997);

(ii) cited two studies on SSC effects in bivalves: horse mussels (Ellis et al. 2002) and green-lipped mussels (Hawkins et al. 1999);

(iii) and referred to work on a common cushion sponge and large dog cockle (Cummings et al. 2020)

(iv) concluded that "*modelled spikes in background plus mining derived SSC on inshore reefs are much lower (by up to 1 or 2 orders of magnitude) than the concentrations reported in the above studies and conclude that effects on reef fauna >2-3 km from mining will be negligible and thus of no 'material harm'."*

(b) Dr MacDiarmid also stated in her presentation that "*A common cushion sponge and large dog cockle, had high survival rates and no effect was observed on oxygen consumption following 4 weeks of experimental exposure to SSCs of up to approximately 700 mg/L (Cummings et al. 2020)."* It should be noted, however, that this study reports on *Crella* only, not *Tucetona*.

(c) I agree that with the findings of the cited studies regarding SSC effects on species studied.

(d) However, broader ecological context is required before drawing conclusions about mining effects across benthic communities

[8] https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiX3-2PhYmQAxXCTmwGHRcsPW0QFnoECBgQAQ&url=https%3A%2F%2Fniwa.co.nz%2Fsites%2Fdefault%2Ffiles%2FClark-Cummings-Webinar_27August_ROBES-and-Sustainable-Seas.pdf&usg=AOvVaw27tU5LOI_g1_wfwNoOHrS6&opi=89978449

(i) Under the *Sustainable Seas* programme *Sediment tolerance and mortality thresholds of benthic habitats*, NIWA (led by Drs M. Clark and V. Cummings) experimentally examined the effects of SSC on the dog cockle (*Tucetona laticostata*) and sponge (*Crella incrustans*) from the South Taranaki Bight. Results for *Crella* are published in Cummings et al. (2020). Specimens were exposed to 16 sediment concentrations (0-820 mg L^{-1}) for 1, 3, or 4 weeks, with two weeks recovery. No strong negative effects were recorded under these conditions, and both species exhibited mechanisms to clear sediment, indicating a short-term tolerance to elevated SSC (at least over the ≤1-month durations tested). Nevertheless, the authors recommended further work on more sensitive measures, sediment-processing mechanisms, and different life stages.

(ii) This tolerance is consistent with their natural habitats: *Tucetona* is an infaunal bivalve living in rippled and sloping sediments adjacent to the mining site, while *Crella* inhabits rocky and soft-sediment habitats, including turbid environments (Anderson, pers. obs.). Still, after four weeks at higher SSC, both species showed stress responses (gill effects in *Tucetona*, tissue effects and morphological changes in *Crella*). While four weeks approximates natural storm events, it remains unknown how these species would respond to 20 years of chronic exposure, even at lower SSC, or how cumulative effects might magnify impacts.

(iii) Crucially, no comparable experimental data are available for more sensitive downstream taxa, particularly raised reef species (*Ecklonia*, *C. flexilis*, and other reef taxa), or fragile frame-building species such as *Galeopsis* (bryozoan), which also occur downstream of the proposed project area (PPA) (Morrison et al. 2022). These taxa occur in a range of reef environments, but their association with raised reef features (Morrison et al. 2020) suggests a preference for reduced sediment loads.

(iv) Understanding the tolerance and endurance of these key downstream species to elevated SSC is therefore essential, given their ecological significance and the proposed 20-year mining duration.

Blue cod nursery habitats

(v) Morrison et al. (2020) also identified four blue cod nursery habitats (Sites D, L*[9], U, and V), recording 440 small juveniles (<12 cm) during reef surveys. Juvenile blue cod are associated with low-relief biogenic habitats, exposed to naturally variable SSC (NIWA unpublished data; Anderson et al. in review; Anderson pers. obs.). All four nurseries identified occur within the predicted downstream mining plume (Appendix Figures 6 and 7). The potential effects of elevated SSC on the nursery function of these habitats remain unclear.

(vi) Blue cod are a major commercial, recreational, and cultural (taonga) fishery resource for New Zealand and local iwi, but are subject to stock declines around New Zealand (Beentjes and Carbine, 2012[10]). Blue cod nursery habitats are critical to population replenishment and long-term health of blue cod stocks.

(vii) Juvenile fish are known to be sensitive to elevated SSC, showing morphological effects and reduced prey capture in turbid waters. For example, juvenile snapper exhibited impacts at TSS >20 mg L^{-3} (Lowe 2013[11]; Lowe et al. 2015[12]).

(e) In summary, while the studies cited by Dr MacDiarmid provide valid examples of species responses, they do not encompass the broader range of sensitive species within the downstream mining-plume zone. Further work is required to understand the tolerance and long-term resilience of these key taxa.

Brine-Plume Interaction with marine habitat

34) I have reviewed the EPA report dated 22 September 2025. In this report Dr Ursula Rojas Nazar states: "*VI: Brine-Plume Interaction with marine habitat: The application*

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[9] Described as a limited nursery area at this site

[10] Beentjes, M.P.; Carbines, G.D. (2012) Relative abundance, size and age structure, and stock status of blue cod from the 2010 survey in the Marlborough Sounds, and review of historical surveys. New Zealand Fisheries Assessment Report 2012/43. 137p.

[11] Lowe, M. (2013). Factors affecting the habitat usage of estuarine juvenile fish in northern New Zealand. Unpubl. PhD thesis, University of Auckland, Auckland.

[12] Lowe, M.L., Morrison, M. and Taylor, R. (2015) Harmful effects of sediment-induced turbidity on juvenile fish in estuaries. Marine Ecology Progress Series. 539: 241-254

does not consider brine modelling. Please note that brine plumes can lead to hypersaline layers affecting benthic and pelagic communities."(page 8) ..*"requiring assessment of whether the brine could settle on the seabed and affect sensitive habitats such as sand or rocky reefs"* (page 9); And that "*A mixing zone assessment to understand how far the brine will disperse and at what dilution levels, could assist to assess potential ecological impacts."* (page 7).

a. I agree with all three points.

b. Brine plumes can generate hypersaline layers near the seabed. Any processes (presently not included in the plume model) that increase plume concentrations or deposition at the seabed would be critical to know before assessing impacts on downstream reef systems. While these reefal habitats exist in the dynamic, turbid environments of the south Taranaki Bight (STB), many benthic organisms mitigate exposure by growing on elevated reef structures away from the dynamic sediment-seafloor interface (Appendix figures – data provided in Morrison et al., 2022). If plumes sink and envelop raised reefs, local conditions may be altered significantly. Although *Ecklonia* and *C. flexilis* tolerate variable sediment deposition and suspended sediment concentrations (SSC) - and the latter some level of temporary burial - their higher abundance on elevated reefs suggests they thrive under reduced sediment loads.

c. Thresholds for these communities remain largely unknown; thus, while some species near the sediment–seafloor interface may withstand additional loading (e.g., the sponge *Crella* and the infaunal bivalve *Tucetona*), raised-reef communities may be more vulnerable to tipping points that lead to degradation and loss of community structure.

<u>Recovery of functional benthic habitats</u>

35) I have reviewed Dr MacDiarmid's evidence (*Report-20c-Evidence-statement-Macdiarmid-May-2023* on behalf of TTR).

(a) In her 2023 Evidence" Dr MacDiarmid stated:

(i) "33. *Generally, communities associated with sand in high energy environments are very frequently disturbed and are likely to be continually in an early transitional stage.*

(ii) While I agree that would be the case in the rippled sand environments over much of the PPA and nearfield sediment habitats, the recovery of habitat-forming communities, like *Euchone* wormfields may be more complicated. While the occurrence of *Euchone* individuals would likely be expected to recruit back into sediments once mining ceases, it is unclear what precursor conditions (beyond grain-size) are likely required for these worms to create extensive sediment-stabilising bedforms.

(iii) Similar to seagrass meadows, extensive disturbance may alter sediment conditions such that recovery fails even over many decades[13]. If these precursor conditions do not return, these habitats may not regenerate.

(iv) Beaumont et al. (2015) found that *Euchone* spA wormfields comprise a considerable portion of the PPA; and are expected to be damaged or destroyed by the proposed mining activity within the PPA. Adjacent areas to the north may also be impacted through 'burial, smothering or gill clogging as a result of sediment plumes and migrating sediments ('sediment spread'). No other *Euchone* spA wormfields are currently documented beyond this localised region. While the species may exist elsewhere, the creation of extensive sediment-stabilising wormfields has not been observed in other areas of New Zealand. Therefore, caution is warranted. To date no additional *Euchone* spA wormfield locations have been documented beyond those reported in Beaumont et al. (2015).

(v) Other habitat-forming worms, such as *Galeolaria hystrix*, are widely distributed but only form significant biogenic mounds under restricted conditions.

(vi) There is no information on the time required for *Euchone* spA to establish dense, sediment-stabilising habitats.

(vii) The consequences of removing these wormfield habitats are potentially important. Loss of sediment-stabilising structures is likely to increase sediment mobility, similar to the effects observed in degraded seagrass beds.

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[13] Fonseca, M.S. and Bell, S.S. (1998). 'Influence of physical setting on seagrass landscapes near Beaufort, North Carolina, USA', *Marine Ecology Progress Series*. 171, pp. 109–121.

(viii) *Euchone* wormfields were found associated with a narrow sediment grain size range (mean 248.5 $^{+}$ 4.9, range 182-331[14]) and were absent from coarser, more mobile rippled sands (Beaumont et al., 2015). Changes in sediment characteristics beyond this range may prevent recolonisation.

(ix) Increased SSC during mining, combined with loss of sediment-stabilising wormfields, could add cumulative sediment resuspension into the system - not currently accounted for in plume modelling.

(x) Mining operations will involve excavation and redeposition of sediments. Trenches up to 11 m deep may be refilled with de-ironed sediment, but initial dredge lines could leave mounds up to 11 m high. This would create highly uneven seafloor topography, potentially inhibiting the regeneration of *Euchone* wormfields and altering local sediment dynamics.

(xi) Given the uncertainty over the conditions required for *Euchone* wormfields to re-establish, the unknown timeframe for recovery, and the likelihood that altered sediment characteristics may preclude recolonisation, it cannot be concluded that their removal would result in no material harm.

<u>Cumulative Effects</u>

36) Understanding the cumulative and interactive effects of multiple stressors that characterise coastal environments is inherently challenging - as they are difficult to quantify or predict and carry compounding uncertainties. Cumulative effects of mining, combined with natural perturbations and other stressors such as land-derived run-off, however, are an important concern. Multiple stressors may act additively or synergistically, potentially impeding recovery of slow-growing, long-lived benthic species and causing chronic, long-term effects, including threshold or tipping point impacts leading to lasting loss of biodiversity and ecosystem function.

37) . Several key issues are identified here:

a) **Increased suspended sediment concentrations (SSC) from multiple sources:**

i) While the applicant has modelled background and mining-derived suspended sediment separately, uncertainty remains regarding how these projections

[14] Andersons 2014 Evidence p11, pt30.

translate to real-world conditions for benthic habitats. . Natural SSC along the South Taranaki coastline is already highly variable, driven by land runoff, currents, and storms, and the ecological responses of benthic communities to chronic or episodic increases in sediment remain difficult to predict. As a result, even with the modelling, it is unclear how sensitive inshore habitats downstream of the PPA might be affected under prolonged mining operations.

ii) Mining impacts may compound natural events such as storms and sediment resuspension, increasing the frequency and intensity of disturbance to biogenic habitats and their associated communities.

iii) Chronic turbidity can stress sensitive species and alter community composition over time. Benthic species in this area may be acclimatised to high SSC conditions, or alternatively may already be close to tipping points due to high background SSC levels - where even modest increases in SSC could alter community structure, especially under prolonged cumulative conditions.

b) **Sediment deposition and smothering**:

i) Fine sediments settling on the seabed can bury benthic organisms, disrupt habitat structure, and alter substrate for settlement of sessile species.

ii) Low-relief or soft-sediment habitats may be particularly vulnerable to increased sediment deposition and sediment mobility. Sediment redistribution can bury or scour reef features near the sediment-seafloor interface, leading to reduced habitat complexity.

iii) Conversely, raised reef features may be more susceptible to smothering from SSC, particularly where brine solutions alter the dispersal of these suspended sediment particles.

c) **Changes in benthic community composition**:

i) Opportunistic or tolerant species (e.g., sediment-tolerant sponges or infaunal bivalves) may dominate, while sensitive species decline.

ii) The wormfields in the northern Pātea Shoals likely contribute to sediment stability and help limit resuspension. Their loss through mining could therefore increase sediment mobility and contribute to higher suspended sediment concentrations across the region, adding to the cumulative stress already experienced by benthic habitats from natural disturbances and other sediment sources. The proposal does not appear to consider these consequences, nor the potential time required for recovery of these sediment-stabilising habitats and the ecological functions they provide, further compounding uncertainty around cumulative impacts.

d) **Impacts on nursery habitats**:

   i) Juvenile fish, such as blue cod, rely on low-relief biogenic habitats that can be affected by sedimentation and turbidity, potentially reducing recruitment success.

   ii) Reduced recruitment success for large predatory fishes can have significant top-down effects on community structure, with the loss of large urchin-eating fishes, such as large adult blue cod, associated with increased sea urchin densities, where their intensive grazing pressure on large seaweeds like *Ecklonia* can denude kelp zones, leading to 'urchin barrens'.

e) **Potential long-term degradation**:

   i) Repeated sediment disturbance over months, years and decades may prevent recovery of sensitive habitats and lead to persistent shifts in community structure and function.

<u>Conclusions</u>

38) Updated surveys and distribution modelling since 2017 confirm that rocky reef habitats in the South Taranaki Bight are more widespread and ecologically significant than previously understood. A large proportion of mid-shelf reef habitats (>60%) lies within the predicted downstream mining plume zone, exposing their associated biogenic habitats and benthic communities to long-term increases in suspended sediment concentrations (SSC) and along with potential brine plumes over the proposed 20-year mining duration. While some species, such as *Crella* sponges and *Tucetona* bivalves, exhibit short-term tolerance to elevated SSC, the responses of more sensitive reef-building species, juvenile fish in nursery habitats, and raised-reef communities remain largely unknown.

39) Brine plumes may create hypersaline layers near the seabed, potentially affecting sensitive habitats such as raised reefs and habitat. While some benthic species tolerate sediment deposition, communities like *Ecklonia* and *Caulerpa flexilis* were more common on elevated reef structures. The thresholds for these communities are poorly understood, adding further uncertainty to predictions of ecological impact.

40) Recovery of habitat-forming communities is highly uncertain. *Euchone* spA. wormfields, which appear to stabilise sediments maintaining comparatively flat finer sediment bedforms, may not regenerate if precursor sediment conditions are altered by excavation, redeposition, or sediment redistribution. Rocky reef communities may also be affected by chronic SSC, sediment deposition, and brine-plume effects, with unknown thresholds for cumulative impacts. The altered seabed topography and loss of sediment-stabilising biogenic habitats may also further reduce the likelihood of natural recovery.

41) Cumulative effects compound these risks. Mining-derived sediment, combined with natural perturbations and land-derived runoff, may act additively or synergistically, impeding recovery of slow-growing, longer-lived species, altering community composition, and potentially causing threshold or tipping point effects. Given the uncertainties regarding species tolerance, habitat recovery, and the long-term ecological consequences of multiple stressors, it cannot be concluded that mining would avoid material harm to benthic communities and the rocky reefal habitats downstream of the Pātea Shoals proposed project area.

Dated 06 October 2025