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Validation and Improvement of VME Indicator Taxa Abundance Models: Progress Report

New Zealand

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Validation and improvement of VME indicator taxa abundance models: Progress report

New Zealand

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1. Contents

1. Purpose

The purpose of this paper is to provide an account of the progress made towards validation of existing spatial models of VME indicator taxa abundance, and the development of updated models through the addition of abundance data from unprocessed historical video imagery and a review of available environmental predictor variables for modelling. This work is reflected in item 2.5.2 of the Scientific Committee Multi-Annual Plan 2026-2028 "*For VME taxa potentially at risk of SAI, improve and validate abundance models, using independent data*" (COMM14-Doc06). While it was not possible to complete these tasks prior to SC-14, agreements were reached in meetings of the Fisheries New Zealand South Pacific Working Group on the prioritisation of available seafloor imagery sample data required for analysis and models, the updating of critical predictor variables, and details of methods to be applied for validation.

2. Background

The current Cumulative Bottom Fishery Impact Assessment (BFIA) for Australian and New Zealand bottom fisheries (SC11 – DW01_rev1) provides an assessment of benthic status for a range of VME indicator taxa, based on the dynamic version of the relative benthic status (hereafter dRBS) approach of Pitcher et al. (2015) and Pitcher et al. (2017). Inputs for this approach comprise taxon-specific estimates of productivity/recovery and depletion rates from bottom-contact fishing methods (trawl and longline), along with spatial representations of fishing effort and species abundance. Species abundances in the current BFIA status assessments are represented by models of habitat suitability (relative probability of presence) based on presence and 'target-group background' absence data from catch records, transformed to approximations of abundance using methods which compare taxon density data from camera surveys with co-located habitat suitability estimates. It has been recognised by SPRFMO that this representation of abundance is a weakness in the dRBS assessment of status as there is considerable uncertainty in the relationship between habitat suitability and abundance (Bowden et al., 2021; Bennion et al., 2024), and accurate measurement of VME indicator taxa abundance is crucial to assessment of protections afforded to VMEs through spatial management measures. Consequently, there is a desire to replace habitat suitability models with abundance models, once these have been suitably validated and accepted. Noting that this substantial change in the sample data underlying distribution models for VME indicator taxa may be expected to alter the assessments of the existing BFIA, potentially substantially. Additionally, preliminary abundance models for VME indicator taxa have been used to help assess encounters with potential VMEs, including in quantitative benthic impact assessments at multiple spatial scales (New Zealand, 2025). Robust abundance models for VME indicator taxa are intended to be a key component of a multi-spatial scale risk-based approach to assess encounters with potential VMEs, which remains to be formally developed (see item 2.6.1 of COMM14-Doc06).

Abundance models based on towed-video camera data are currently available for 15 VME indicator taxa (Bennion et al. 2025) but these have yet to be accepted by SPRFMO for use for the BFIA, in preference to the habitat suitability models that have been in use for some time, due in part to limitations in the spread of sample data and the need for further independent data to validate abundance model predictions.

Recognising the requirement under SPRFMO guidelines (CMM 03-2025) for the BFIA to be updated in 2027, the Multi-Annual Workplan of the SPRFMO Scientific Committee (COMM14 – Report) includes the following sub-task for the Deepwater Working Group:

> Subtask 2.5.2: *For VME [indicator] taxa potentially at risk of SAI, improve and validate abundance models, using independent data*.

To address this sub-task, Fisheries New Zealand engaged Earth Sciences New Zealand (ESNZ) (formerly the National Institute of Water and Atmospheric Research; NIWA) to develop a workplan and methodology for improving and testing abundance models by adding to the database of sample data and creating a new set of abundance models. The following sections of this report describe this process and the progress made to-date.

3. Methods

Selection of sample data

Existing abundance models for VME indicator taxa in the SPRFMO Evaluated Area (Bennion et al. 2025) are based almost entirely on towed-camera video imagery from the ESNZ Deep-Towed Imaging System (DTIS). Benthic imagery has been captured by this system at over 1700 stations throughout the New Zealand Exclusive Economic Zone (EEZ) and Territorial Seas (TS), and Evaluated Area, during many seabed biodiversity-focussed research voyages between 2005 and 2025. However, the video imagery from many of these stations has not been fully analysed to produce taxon density values (i.e., number of individuals per m^2) and therefore is not available to the models. Current abundance models are based on data from 832 DTIS stations, with these models restricted to stations within the 200–3000 m depth range. Fully analysed DTIS stations are available from an additional 117 stations outside of the 200–3000 m depth range and another 69 stations that were analysed or identified since the existing models were built. Support from Fisheries New Zealand has provided for analysis of up to 9 additional DTIS stations, from the remaining 815 stations yet to be processed (Figure 3-1). These stations were to be selected from locations expected to provide the greatest benefit to the predictive power of the models.

In order to prioritise sample stations for processing, data for all available unused DTIS stations were collated and the following range of metrics considered:

- **Environmental coverage**. Environmental coverage (0–1) is the extent to which the multidimensional environmental space (i.e., considering all environmental variables simultaneously) was captured by the locations of the training data used to build a species distribution model. A single environmental coverage spatial layer representing all taxa modelled, produced alongside the abundance models of Bennion et al. (2025), was used to provide an environmental coverage value for each unprocessed station. Higher priority was given to stations at locations with low environmental coverage, so that including data from these stations in revised models would expand the overall environmental space represented by the sample data.

- **Unsampled locations**. To complement the low environmental coverage metric, which doesn't directly take into account geographic location, sample stations from regions with low DTIS sampling effort were identified.
- **Historical fishing effort**. To avoid 'false' absences or low/altered densities due to impacts from bottom contact fishing, stations with lower cumulative historical fishing effort were identified and prioritised. Swept area grids based on total reported fishing between 1989 and 2023, as used in the most recent BFIA for the Evaluated Area (SPRFMO 2023), were used to provide a value for fishing effort at each sample location.
- **Depth**. Sample stations between 200 m and 3,000 m were given priority over shallower or deeper stations. Although this range expands beyond the narrower limits of most bottom contact fishing activities in the Evaluated Area, including stations within it will allow updated models to better describe the relationship between depth and taxon density. Stations shallower than 200 m may also have been considered, but many of these are expected to be processed under a related research programme addressing fishing impacts inside the New Zealand EEZ/TS and these processed samples (an expected total of about 50 stations) are likely to also be available for inclusion in updated models.
- **High biodiversity**. Although locations of true absence for a taxon are valuable in species distribution modelling, stations with a range of densities of multiple taxa will be more useful overall than stations with low or zero densities of VME indicator taxa. To exclude stations with low overall biodiversity, sets of still images collected at the same time as video data were examined for a selected set of stations narrowed down through the metrics outlined above.
- **Coverage of biogeographic regions**. As a final check of representativity across spatial variability in biological realms, the distribution of sample sites among the classes of the New Zealand Seafloor Community Classification (NZSCC; Stephenson et al., 2022) was assessed. This classification was based on compositional turnover of a combination of macro algae, benthic invertebrates, reef and demersal fish, and although confined to the New Zealand EEZ/TS represents the most relevant classification of seafloor assemblages available.

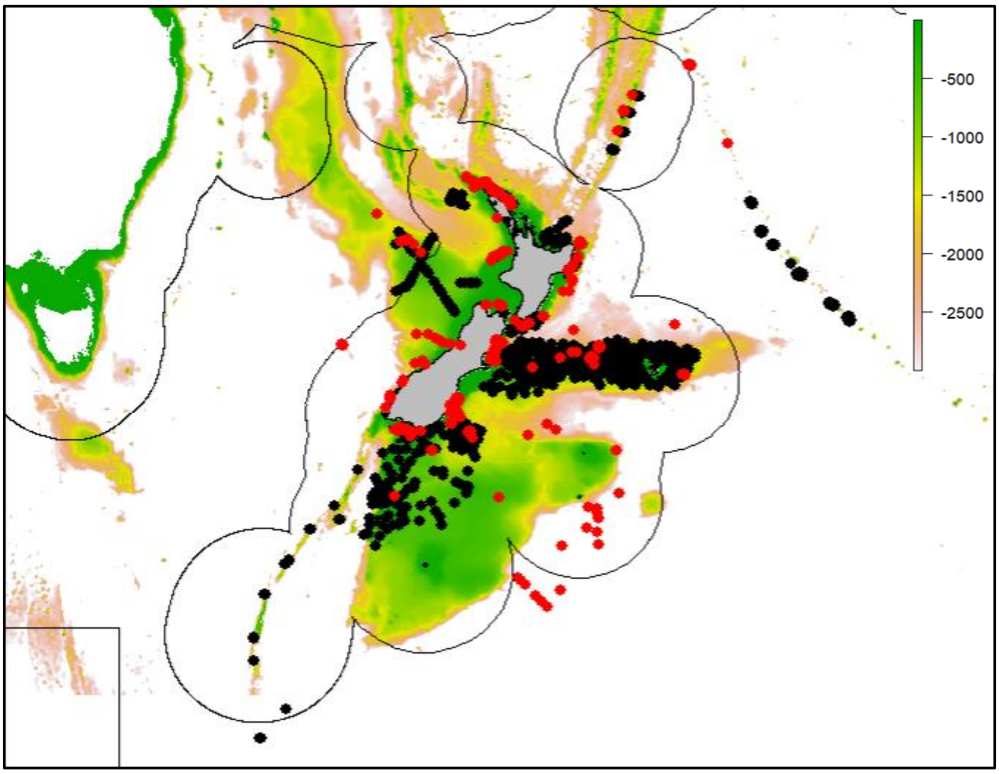

Figure 3-1 | Location of all 949 fully-processed seafloor imagery stations (black dots) and 815 unprocessed stations (red dots) within the New Zealand EEZ/TS and SPRFMO Evaluated Area (black line), shown over an underlying bathymetry raster (0–3000 m).

Validation and evaluation of existing models

Model validation and evaluation will be undertaken using the following two methods.

1. The statistical correlation between predicted abundance from the model and observed abundance from the new image data will be measured using R^2 (coefficient of determination) and Pearson's correlation for each taxon with sufficient new data. These correlations can be visualised using scatterplots to assess relationships at differing levels of abundance.
2. New environmental coverage estimates will be generated from the full set of updated sample stations. An increase in the number of samples used in the models, selected in part to represent areas of low environmental coverage in existing models, is expected to raise environmental coverage in those areas. The gain in environmental coverage across the spatial extent of the model can be measured by overlapping the new and old estimates and producing a plot to illustrate the improvement. It is hoped that the additional samples available from the New Zealand EEZ/TS research programme will be available for the updated models and therefore also for inclusion in estimation of revised environmental coverage, with the expectation of a substantial improvement. Comparison of environmental coverage between existing and new models will require the use of the same set of environmental predictors in the calculations; a further environmental coverage layer will be created for the new models using the revised set of environmental predictor variables (see below).

Updating and improving abundance models

The current set of abundance models covers 15 VME indicator taxa (Table 3-1); most data derive from sample locations outside of the SPRFMO Evaluated Area (i.e., within the New Zealand EEZ). Currently there are insufficient records to build reliable models for two VME indicator taxa; the reef-building scleractinian coral species *Enallopsammia rostrata* and *Madrepora oculata*. The first abundance models for these species will be built alongside updated models for the other taxa if sufficient new records for these species are available from the new samples.

Table 3-1 | Number of presence and absence sample stations in existing abundance model training data for VME indicator taxa (from Bennion et al. 2025).

	Out of zone: Including EEZs		Evaluated area: Excl. EEZs	
VME indicator taxa	**presence**	**absence**	**presence**	**absence**
Actiniaria	644	188	29	81
Alcyonacea	256	576	39	71
Antipatharia	192	640	40	70
Brisingida	253	579	67	43
Bryozoa	384	448	5	105
Crinoidea	304	528	69	41
Demospongiae	527	305	62	48
Enallopsammia rostrata[1]	21	811	0	110
Goniocorella dumosa	69	763	0	110
Gorgonian Alcyonacea	365	467	69	41
Hexactinellida	378	454	60	50
Hydrozoa	413	419	28	82
Madrepora oculata[1]	18	814	0	110
Pennatuloidea	383	449	32	78
Solenosmilia variabilis	108	724	77	33
Stylasteridae	214	618	46	64
Zoantharia	133	699	11	99

[1] No existing abundance models for these species (see text).

Model performance of updated models will be assessed by calculating the correlation between predicted and observed abundance and also R^2 (the coefficient of determination). Figure 3-2 provides an example scatterplot of this correlation, for black coral (Antipatharia), from Tablada et al. (2023). Mean correlation and R^2 values will be derived from the training and evaluation datasets used in bootstrap sampling for each model method used (e.g., Random Forests and Boosted Regression Trees).

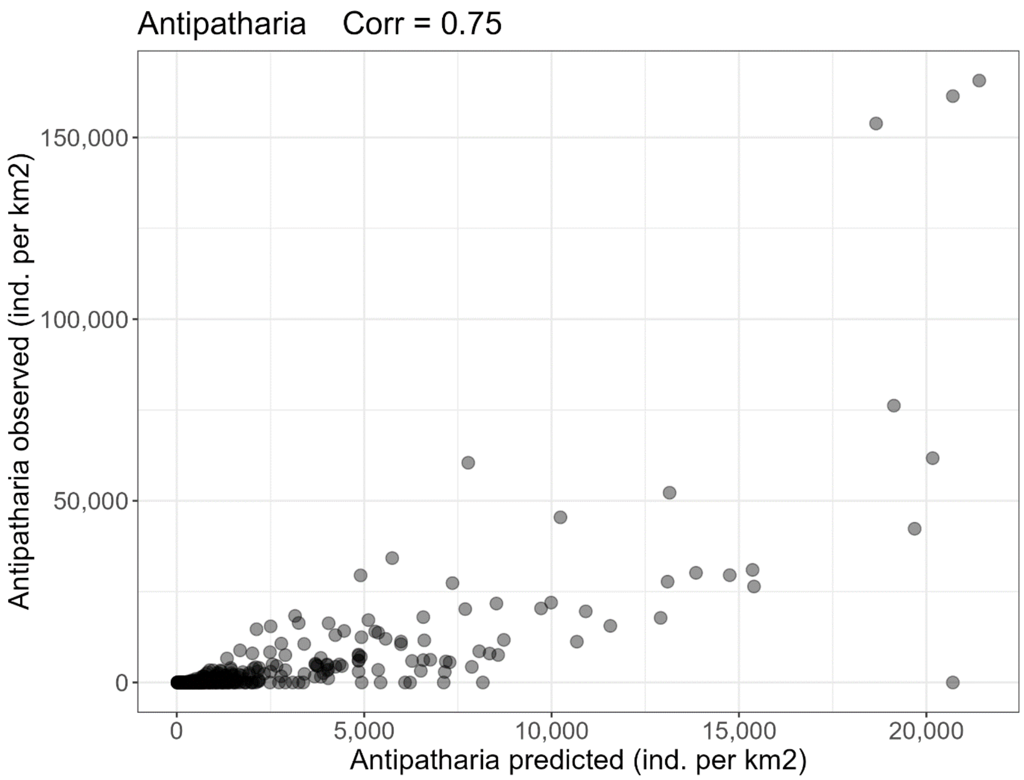

Figure 3-2 | Example scatterplot plot showing correlation between model prediction (x-axis) and all DTIS observations of black corals (Antipatharia) used to train the model (y-axis); Pearsons' r (Corr) shown at top.

Revision of predictor variables

Predictor variables used in existing abundance models comprised a combination of bathymetry-derived (ruggedness, standard deviation of slope, bathymetric position index, seamounts (*sensu* Pitcher et al. (2007)), water chemistry (aragonite saturation, calcite saturation, dissolved oxygen, silicate, temperature), substrate (percent gravel, percent mud), and productivity model-derived (particulate organic carbon export to the seafloor) products.

Some of these spatially-explicit data sets have not been updated for several years, e.g., bathymetry (and derivatives), water chemistry, substrate – and could potentially be replaced with more recent versions if available, while others (e.g., seamounts (*sensu* Pitcher et al. 2007) and particulate organic carbon export to the seafloor) are relatively modern. Environmental datasets used in predictive modelling of deep-sea taxa, particularly those characterising substrate type, introduce considerable unquantified uncertainty, as some of these datasets are often the result of interpolations from sparse or very sparse source data (or are predictions themselves) (Stephenson et al., 2021). In this context, any improvements to the environmental predictors used to date is likely to decrease this unquantified uncertainty. Work is underway to source the most recent, verified spatial layers of relevant environmental predictor variables, focussing on those found to be most informative in existing models as well as any that have been tuned for the region of interest for the models (i.e., the SPRFMO Evaluated Area).

4. Progress

The prioritisation process for selection of towed-camera stations for inclusion in updated abundance models produced the set of 15 sample stations shown in Table 4-1, with a minimum of 9 stations to be analysed with available resources. The prioritised stations come primarily from two research voyages, one investigating recovery of biodiversity on features of the Graveyard Seamounts in 2006 (TAN0604), in which Pyre seamount in the "Graveyard Seamount complex" was ranked highly, and the other a more recent biodiversity survey of the Bounty Trough in 2024 (TAN2402) supported by the Ocean Census initiative (https://oceancensus.org/). Depths of the prioritised stations range from 620 m to 1486 m but extend to 314–2740 m and include stations in the Kermadec Ridge and the Tasman Sea off the west coast of the South Island of New Zealand if the additional stations were to be included (Figure 4-1). It is notable that none of the potential sample locations lie within the SPRFMO Evaluated Area. There has, however, been some towed-video data collected recently by Greenpeace in the Tasman Sea following a VME encounter by a New Zealand vessel in October 2024 (see SC13 - Obs 02). Video files from these 12 sample stations have yet to be made available to ESNZ for inclusion in updated models, with release pending from Greenpeace and Fisheries New Zealand.

At the time of preparation of this report (August 2026), processing of the selected video data by seafloor video analysts was complete but imagery-derived density data had yet to be compiled for validation. Once this has been done, VME indicator taxa density data will be integrated into the larger modelling dataset (currently comprised of 832 locations) and where appropriate, abundance models for VME indicator taxa will be improved/updated. It is anticipated that this process will be completed by December 2026.

Table 4-1 | DTIS towed-camera stations prioritised for estimation of VME indicator taxa densities by video analysts. The seamount column signifies whether or not the site is located on a seamount or other type of underwater topographical feature; Historical fishing is categorised into Zero, Low, Medium, and High; Biodiversity is categorised subjectively from low to high. Greyed-out rows indicate additional stations to be analysed if for any reason (e.g., poor video data quality) the 9 with highest priority cannot be used, or if time is available.

Voyage	Station	Depth	Region	Historical fishing	Seamount	Biodiversity	Environmental coverage (0–1)
TAN2402	89	1486	Bounty Trough	Zero	FALSE	Medium	0.057
TAN0604	70	1020	Graveyard smts	Med	TRUE	Medium-High	0.488
TAN2402	87	1446	Bounty Trough	Zero	FALSE	Medium	0.058
TAN0604	71	1004	Graveyard smts	Med	TRUE	Medium-High	0.488
TAN2402	59	1494	Bounty Trough	Zero	FALSE	Low-Medium	0.131
TAN0604	72	1042	Graveyard smts	Med	TRUE	Medium-High	0.488
TAN2402	14	620	Bounty Trough	Med	TRUE	Medium	0.812

TAN0604	73	1047	Graveyard smts	Med	TRUE	High	0.488
TAN2402	38	1385	Bounty Trough	Med	FALSE	Mediuim	0.922
TAN0604	74	1070	Graveyard smts	Med	TRUE	High	0.488
TAN2402	18	1062	Bounty Trough	High	TRUE	Medium	0.946
TAN2402	49	1377	Bounty Trough	High	FALSE	Low-Medium	0.821
TAN1311	51	2740	W coast S. Island	Zero	TRUE	Medium	0.040
TAN2009	86	1711	Graveyard/Andes	Zero	TRUE	Medium-High	0.317
TAN1612	67	314	Kermadec ridge	Zero	FALSE	Medium-High	0.472

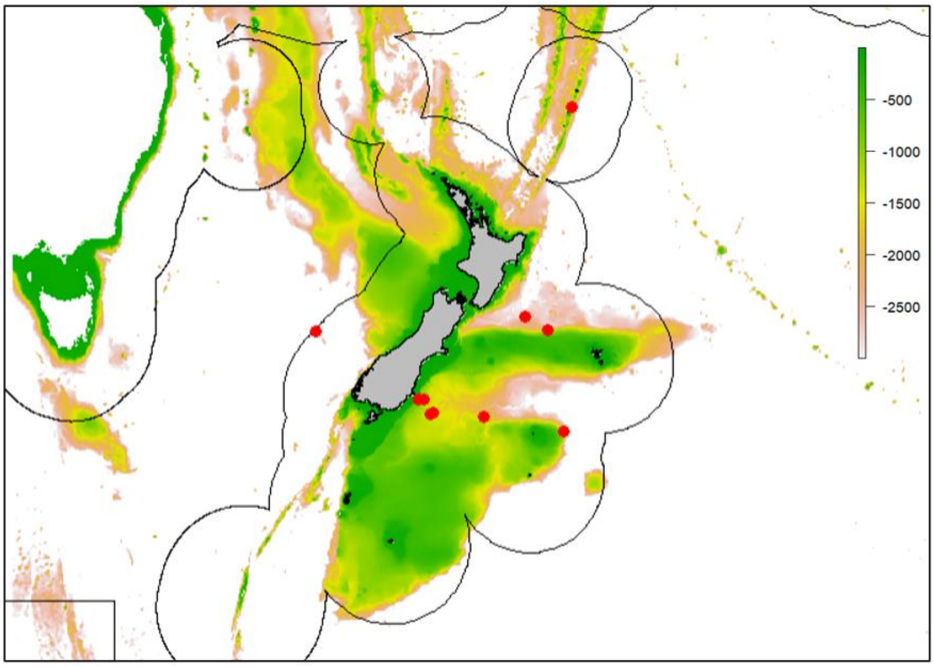

Figure 4-1 | Location of DTIS towed-camera sample stations prioritised for processing by seafloor video analysts to produce density estimates for VME indicator taxa.

5. Recommendations

It is recommended that Scientific Committee:

- **Notes:**
  - that additional imagery data is currently being analysed for further development and validation of abundance models for VME indicator taxa
- **Agrees:**
  - that while it was not possible to complete these tasks prior to SC-14, work should proceed towards validation of existing spatial models of VME indicator taxa abundance, and the development of updated models through the addition of abundance data from unprocessed historical video imagery and a review of available environmental predictor variables for modelling.
  - Following the validation of the new abundance models, they should replace the transformed habitat suitability models for VME indicator taxa in the relevant components in the New Zealand BFIA, including assessments of SAIs and protection levels of VME indicator taxa afforded by current spatial management measures.

6. Acknowledgements

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