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SC7-DW14

Availability of Data to Assess Catchability of VME Indicator Taxa

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Evaluating the availability of data to assess catchability of VME indicator taxa

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1. Purpose of paper

The purpose of this paper is to re-evaluate if New Zealand holds enough information from within the SPRFMO Convention Area to assess the catchability of VME indicator taxa by trawl fisheries and, where insufficient data exists, propose approaches to provide meaningful quantitative estimates of catchability. Catchability estimates could help inform future review of the encounter protocol included on CMM 03-2019 by allowing the extent of impact on the seafloor corresponding to a given encounter threshold level to be estimated.

2. Introduction

In February 2019, the Commission of the South Pacific Regional Fisheries Management Organisation (SPRFMO) adopted Conservation Management Measure CMM 03-2019, which marks a significant advancement in the conservation and management of bottom fisheries and vulnerable marine ecosystems (VMEs) in the South Pacific. The CMM includes a combination of spatial management and complementary encounter protocols to prevent significant adverse impacts of bottom fishing on VMEs, as required by the 2006 United Nations General Assembly (UNGA) Resolution 61/105 and the Convention text (Article 20(1)(d)). The spatial management component, which includes areas open and closed to bottom trawling, was informed by an analysis of the predicted distribution of VMEs and fishing value within an evaluated area of the western SPRFMO Convention Area (Cryer et al. 2018; Rowden et al. 2019). Recognizing that there is a level of uncertainty associated with the predicted distributions of VMEs, which may result in spatial management not providing the expected level of conservation value, CMM 03-2019 also implemented a VME encounter protocol within areas open to bottom trawling. This encounter protocol was considered as a “backstop” to spatial management, with vessels required to cease fishing if they catch VME indicator taxa in quantities that exceed either: (1) taxon-specific weight thresholds; or (2) biodiversity (multiple VME indicator taxa) thresholds. The thresholds included within CMM 03-2019 were developed using a data-informed approach that examined taxon-specific cumulative catch curves to distinguish between the initial part of the curve associated with linear increase, and the final part of the curve associated with asymptotic decrease, with the area distinguishing between these two parts potentially indicating an ecologically relevant reference point with taxon-specific weight thresholds falling to the right and biodiversity threshold to the left (Fig. 1) (Cryer et al 2018). Although the 6th meeting of the SPRFMO Scientific Committee (SC-06) noted that the selection of the final thresholds was somewhat arbitrary, they also acknowledged that there was at the time insufficient data on the distribution and density of VMEs, and on trawl catchability, to apply more sophisticated methods in determining encounter protocol thresholds (SC6’s report). When encounter protocols are triggered under CMM 03-2019, all bottom trawling must cease immediately within one nautical mile either side of the trawl track until the encounter has been reviewed by the SC and it is determined if the closure should stay in effect or be lifted. The encounter protocol therefore allows a rapid response to benthic bycatch events that may suggest the models used to predict the distribution of VME taxa are misleading (following guidance in the SC-05 report[1]), offering a quick, short-term intervention to limit impact on areas that may support VMEs while further assessment is undertaken.

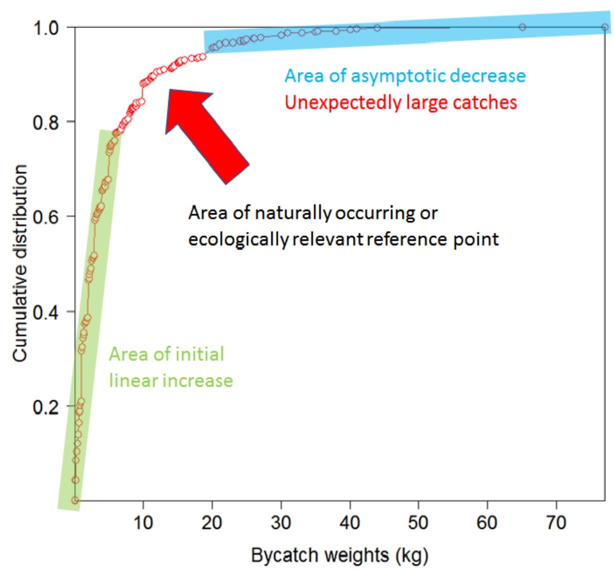

Fig.1 | Cumulative distribution curve for the weight of Actiniaria bycatch from the 2008-19 New Zealand bottom trawl fishery in the SPRFMO Convention Area, where the initial part of the curve associated with linear increase is distinguished from the final part of the curve associated with asymptotic decrease of slope. The area distinguishing between these two parts of the curve potentially indicates a naturally occurring or ecologically relevant reference point. Thresholds indicating unexpectedly large catches that indicate the models used to predict the distribution of VME indicator taxa are misleading should ideally fall to the right of such points, whereas "biodiversity weights" indicating increasing numbers of taxa in a single tow at weights below the threshold triggers indicating unexpectedly large catches should occur to the left.

An ongoing challenge is that, although threshold weights implemented in CMM 03-2019 are considered to constitute a "backstop" to unexpected evidence of a potential VME, there is an implicit assumption that the thresholds used to trigger encounter protocols have an ecologically relevant value (being higher than the ecologically relevant reference point). However, the threshold values are not supported by any explicit demonstration of relationships between biomass or density of VME indicator taxa on the seafloor, the catch efficiency of bottom trawl gear, and the biomass of VME indicator taxa retained as bycatch on the deck of fishing vessels. The reasoning that the encounter protocol acts as a "backstop" to spatial management therefore requires untested assumptions regarding the level of permissible bycatch before further management action is required. SC6, therefore, considered it important to explore the possible relationship between catch, catch efficiency, and the biomass of VMEs impacted by bottom trawling.

Although studies linking the density or biomass of VME indicator taxa on the seafloor to bycatch are limited, those that have been attempted indicate that bycatch of individual trawl events may be a poor indicator of the composition and density of VME indicator taxa on the seabed. This issue is largely because bottom trawl gear, which is designed to catch fish, is poor at sampling sessile benthic organisms. Light, flexible and fragile specimens tend to be fragmented during contact with trawl gear and lost through the mesh, whereas those that are heavy and fragment, are typically lost through mesh in the bottom of the net (Auster et al. 2011). Comparing density estimates based on area swept

[1] SC-05 **agreed** that, should a move-on rule be implemented as part of the revised CMM for bottom fisheries, the threshold for triggering such a rule should be high… involving weights of bycatch of benthic fauna that would indicate the models used to predict the distribution of VME taxa are misleading.

by trawl with density estimates from seabed imagery at eight sites 206–274 m deep off southwest Alaska, Freese et al. (1999) estimated a catch efficiency of < 1% for asteroids, echinoids and molluscs, and approximately 5% for holothurians.

Using threshold values of 250 kg for stony corals and 50 kg for sponges that trigger an encounter protocol under CMM 03-2019, the biomass of impacted taxa can be predicted across a gradient of catch efficiencies (Fig.2). For example, at a catch efficiency of 5%, 5000 kg of coral and 1000 kg of sponges would be impacted. Further, strong positive relationships between the biomass of coral and the diversity of associated fauna (Jensen and Frederiksen 1992) suggest the impact of removing 5000 kg of coral could result in the mortality of many thousands of individuals associating with the coral habitat. These numbers, of course, need to be evaluated in the context of the full extent and numerical abundance of the impacted taxon or habitat.

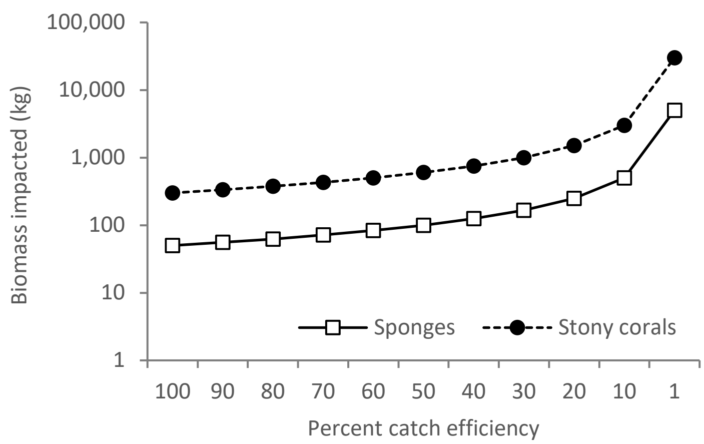

Fig.2 | A comparison of the weight of coral and sponge taxa impacted by mobile gear based on a gradient of catch efficiencies. The origin of each line is the encounter threshold weight of 250 kg of corals and 50 kg of sponges that triggers a move-on rule as described in CMM 03-2019. Note y-axis is on a log scale. Figure adapted from Auster et al 2011.

Previous studies quantifying the relationship between catch, catch efficiency, and the biomass of VME indicator taxa impacted by bottom trawling may not be particularly reliable due to small sample sizes, and not generalizable to the SPRFMO Convention Area due to inconsistencies in the taxonomic resolution of VME indicator taxa evaluated and the configurations of bottom trawl gear. Ideally, such estimates of catch efficiency should be specific to area, fishery and VME indicator taxon. Acknowledging that SPRFMO SC6 agreed further work should be done to assess catchability in both trawl and bottom-line fisheries (which could help with estimating the extent of impact on the seafloor corresponding to a given encounter threshold level and inform future review of the encounter protocol included on CMM 03-2019), we undertook a data exploration exercise to re-evaluate if sufficient information exists from within the SPRFMO Convention Area to conduct such analyses for bottom trawls.

3. Methods/Results

To evaluate if sufficient information exists from within the SPRFMO Convention Area to assess catchability of VME indicator taxa, we undertook exploratory data analysis quantifying catch efficiency of trawl- and sled-caught VME indicator taxa by comparing biomass estimates from the swept area of trawls and sleds with biomass estimates from seabed imagery. Results for the exploratory analysis for trawl and sled data suffered from similar limitations, and led to similar conclusions regarding the sufficiency of information to evaluate catchability; therefore, for brevity we focus here on data exploration for the trawl data, which is most relevant to the encounter protocol for bottom trawl included in SPRFMO CMM 03-2019.

Data used in the exploratory analysis relating to the identity and biomass VME indicator taxa retained by bottom trawl tows were extracted from the New Zealand Centralized Observer Database (*cod*; accessed 14 May 2019). Data were collected by scientific observers (the New Zealand bottom trawl fleet has 100% observer coverage in the SPRFMO Convention Area) and included 9,802 New Zealand bottom trawl tows (including mid-water trawls targeting bentho-pelagic fish species) conducted in the Convention Area over the period 2008–2019 (although 2019 data was for a partial fishing year and was restricted to 1–12 January). These data consisted of tow-by-tow observer data with one record for each benthic taxon encountered on each tow, and included trip number, station number, event number, target species, benthic bycatch code, common name, bycatch weight, method of weight analysis, and observer comments. For each tow, we used taxonomic designations from the World Register of Marine Species (WoRMS, RRID:SCR_013312) to assign relevant benthic bycatch to the groupings of VME indicator taxa presented in Table 2 of SPRFMO SC7 DW-13.

Data for the biomass of VME indicator taxa was derived from seabed imagery provided by New Zealand's National Institute for Water and Atmospheric Research (NIWA) from *RV* Tangaroa voyage TAN1402. Count data for benthic taxa were from seafloor video taken from 105 Deep Towed Imaging System (DTIS) transects (towed camera transects designed to sample epifauna, demersal fish and substrate type) from six features on the Louisville Ridge (39-South Seamount, Censeam Guyot, Forde Guyot, Ghost Seamount, JCM Guyot, and Valerie Guyot) that reflected a general gradient in fishing from North to South (Clark et al 2014). A full description of DTIS sampling protocol can be found in the voyage project report VMES133.

Using these datasets, exploratory data analysis followed the 8-step process outlined below:

Step 1. To ensure that any comparisons between VME indicator bycatch from bottom trawl fisheries and the TAN1402 survey are not temporally confounded, we subsetted the trawl bycatch data to only include observations made between 1 January 2012 and 31 December 2016. Although the selection of the interval over which to include trawl data in the analysis is somewhat arbitrary, it must balance including enough data to allow an analysis to be conducted, and ensuring that any potential reductions in the biomass of VME indicator taxa on the seafloor resulting from interactions with bottom trawling do not confound the results.

Step 2. We then queried the DTIS and trawl datasets to determine data availability for each of the six topographic features proposed to be included in the analysis. As no trawls were conducted on Censeam and Forde guyots, and only a single DTIS tow was conducted on JCM Guyot at the opposite end of the feature to which two bottom trawls were conducted (Table 1), we excluded these three features from further analysis.

Table 1: The number of DTIS tows and bottom trawls conducted on each feature between 2012 and 2016.

Feature	No. DTIS tows in 2014	No. trawl tows from 2012-16
39-South	17	5
Ghost	30	375
Valerie	16	115
Censeam	19	0
Forde	17	0
JCM	1	2

Step 3. To ensure that any comparisons between DTIS and trawl bycatch was not confounded by depth (as a proxy for suitable habitat for the VME indicator taxa), we then queried the DTIS and trawl datasets to determine the depth distribution of tows. For trawls, we used depth of the net rather than depth below the position of the vessel. Trawls that didn't have the depth of the net at the start and end of the trawl were removed from the dataset (*n* = 43 tows). As the depth profiles for each feature differed (for example, the depth profiles of tows on the Ghost Seamount were steeper than those on Valerie Guyot and 39-South Seamount), we constructed feature-specific depth classes and assigned DTIS and trawl tows to depth classes based on the depth averaged across the start and end position of a tow. For the Ghost Seamount, only DTIS and trawl tows that occurred within the 700-1000 depth category were included in subsequent analyses (Table 2). For the Valerie Guyot and 39-South Seamount, only trawls that occurred within the 800-1000 m depth category were included in subsequent analyses (Table 2).

Table 2: The number of DTIS and bottom trawl tows for each feature and depth class.

Feature	Depth class (m)	No. DTIS tows	No. trawls tows
Ghost	< 700	0	1
	700-1000	10	312
	1000-1200	14	62
	> 1200	6	0
Valerie	600-800	1	0
	800-1000	4	52
	1000-1200	0	63
	> 1200	11	0
39-South	600-800	0	0
	800-1000	5	4
	1000-1200	7	1
	> 1200	5	0

Step 4. To ensure that analyses were not spatially confounded within features, we only included trawl and DTIS tows that were of similar lengths and occurred within 3 nm of each other (most occurred within 1 nm) in subsequent analyses. Because for bottom trawls the start and end position are recorded at the position of the vessel and not the fishing gear, the position of each trawl was corrected by first determining the direction of travel of the vessel (the end position minus the start position) and then offsetting the start and end positions backward by a distance 1.7 times the recorded start depth of the trawl net. Geometrically this corresponds to the length of the warp being 2 times the fishing depth, which was the approximation recommended by fishers familiar with the operation of the SPRMO bottom trawl fishery. An additional spatial limitation of the trawl data was that reported fishing locations within the *cod* database are generally rounded to the nearest minute, corresponding to approximately 1 nm. Although we were unable to correct for this rounding, we don't expect this issue to have qualitatively influenced the conclusions of the exploratory analysis. The number of DTIS and bottom trawl tows retained in the analysis for each feature is presented in Table 3.

Table 3: The number of DTIS and bottom trawl tows for each feature retained within the analysis.

Feature	No. DTIS tows retained at Step 4	No. trawl tows retained at Step 4
Ghost	9	186
Valerie	3	33
39-South	4	4

Step 5. Having subsetted the DTIS and trawl datasets to only include relevant tows, we assigned benthic taxa within each dataset to VME indicator taxa groups as specified in SPRFMO CMM 03-2019. For trawl data, we aggregated taxa into higher-level VME indicator taxa using taxonomic designations from the World Register of Marine Species (WoRMS, RRID:SCR_013312). For DTIS data, aggregated taxa into VME indicator taxa groups as per Table 4.

Table 4: Assignment of taxa identified from DTIS imagery to higher order VME indicator groups.

VME indicator taxa	DTIS taxa included in grouping
Porifera	[204] Sponge (demospongiae); [205] Sponge (hexactinellidae); [660] Encrusting sponges; [2100] Euplectellidae; [2071] Farreidae/Euretidae; [2037] Hyalascus sp.; [2072] Poecillastra laminaris; [2086] Symplectella sp
Gorgonacea	[503] Gorgonacea; [699] Radicipes spp; [695] Paragorgiidae; [698] Chrysogorgiidae; [694] Thouarella; [667] Isididae; [2272] Primnoid_whip-like
Stylasteridae	[506] Stylasteridae
Scleractinia	[675] Solenosmillia variabilis; [676] Madrepora spp; [504] Scleractinia; [678] cup corals (stalked); [679] cup corals (cup); [689] Goniocorella dumosa; [682] Flabellum; [677] Enallopsammia spp ; [680] Desmophyllum/ Caryophyllia
Anthipatharia	[505] Antipatharia; [703] Bathypathes
Actiniaria	[203] Anemones
Alyconacea	[501] Alcyonacea; [688] Anthomastus sp.
Pennatulacea	[502] Pennatulacea; [688] Anthomastus sp.; [1944] Kophobelemnon
Crinoidea	[507] Crinoidea (motile), [711] Crinoidea (stalked)
Brinsingida	[120] Brisingida; [706] Brisingidae

Step 6. For the DTIS data, we converted count data to biomass using conversion factors presented in Table 2 of Rowden et al. (2010) and summarized in Table 5. We also explored calculating a separate suite of conversion factors using count and biomass data from the sled tows conducted during the TAN1402 voyage; however, the sled data didn't include the full range of VME indicator taxa, and there were difficulties in distinguishing between biomass estimates of whole and fragmented samples of VME indicator taxa.

Table 5: Conversion factors from Rowden et al (2010) used to calculate biomass from counts of VME indicator taxa.

VME indicator taxa	Conversion factor (g)
Porifera	42.49
Gorgonacea	93.63
Stylasteridae	5.44
Scleractinia	769.74 for Solenosmillia variabilis
	111.85 for Madrepora spp.
	21.22 for all other Scleractinia taxa
Anthipatharia	38.00
Actiniaria	24.17
Alyconacea	34.73
Pennatulacea	39.50
Crinoidea	10.48 for motile Crinoids
	43.17 for stalked Crinoids
Brinsingida	218.50

Step 7. We then calculated biomass per VME indicator taxa per 1000 m^2. For DTIS data, we used per tow biomass estimates from Step 6 and calculated tow area as tow length multiplied by 2 m (the typical width of the video imagery). For trawl data, we used biomass estimates from reported observer data and calculated trawl area as tow length multiplied by 22 m. Twenty-two meters is the agreed width of the trawl ground gear as characterized during workshops in which fishing industry experts and fishers with practical knowledge of fishing operations described in detail fishing gear (including the footprint widths for different components) and its operation in a standard fishing event, with an emphasis on the distinct levels and types of impact different components of fishing gear have on vulnerable marine organisms. The workshop agreed that fishing on features (such as those included in this analysis) is characterized by shorter tows (relative to fishing on slopes) targeting identified fish aggregations, where the objective is to minimize bottom contact except in the location of the aggregation. Consequently, for much of the tow, the doors are often flown off the bottom. We note that were assessments to be conducted for fishing events on slopes, the total width of door spread should be included in the calculation of trawl tow area.

Step 8. Having calculated the biomass per 1000 m^2 for each DTIS and bottom trawl tow on each feature, we constructed boxplots to visualize the data (Figs 2 and 3).

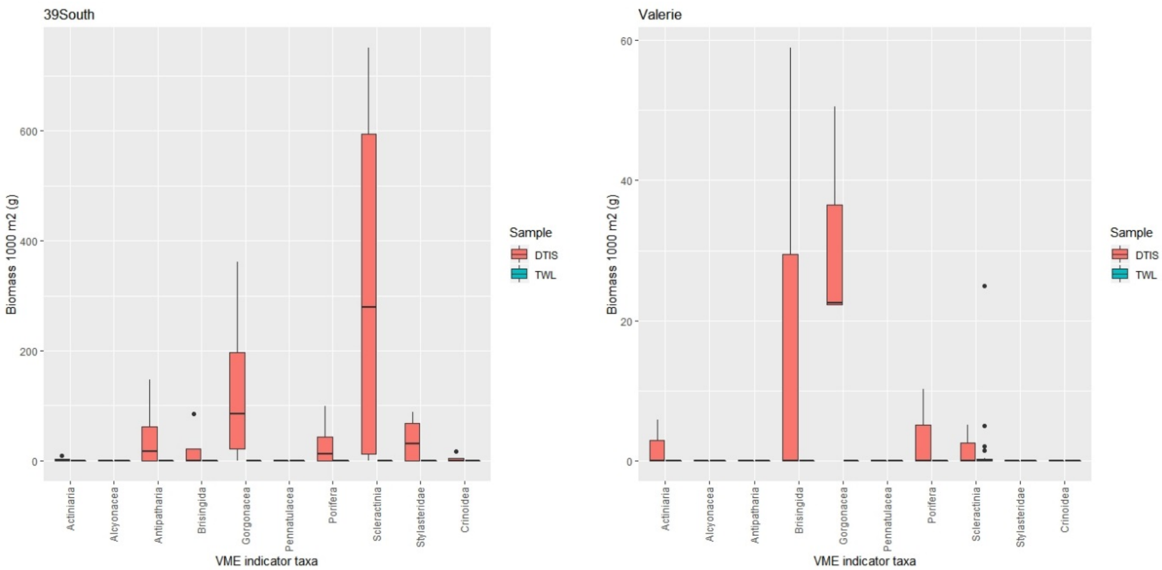

Fig.3 Boxplot of the relationship between the biomass of VME indicator taxa sampled by DTIS (red boxes) and trawl tows (blue boxes) for 39-South Seamount (left) and Valerie Guyot (right). The median in each box is represented by a horizonal black line. The lower and upper hinges correspond to the first and third quartiles (the 25th and 75th percentiles). The upper whisker extends from the hinge to the largest value no further than 1.5 * IQR from the hinge (where IQR is the inter-quartile range, or distance between the first and third quartiles). The lower whisker extends from the hinge to the smallest value at most 1.5 * IQR of the hinge. Data beyond the end of the whiskers are plotted individually.

Although the DTIS tows sampled eight of the ten VME indicator taxa on the 39-South Seamount, no VME indicator taxa were recorded by observers from the three trawls conducted between 1 January 2012 and 31 December 2016 in the 800–1000 m depth category on 39-South Seamount (Fig. 3).

Five VME indicator taxa were recorded in the three DTIS tows from the Valerie Guyot (Fig.3). Only Scleractinia was recorded as VME indicator taxa bycatch from the 33 trawl tows on Valerie Seamount that were included in the analysis (Fig.3).

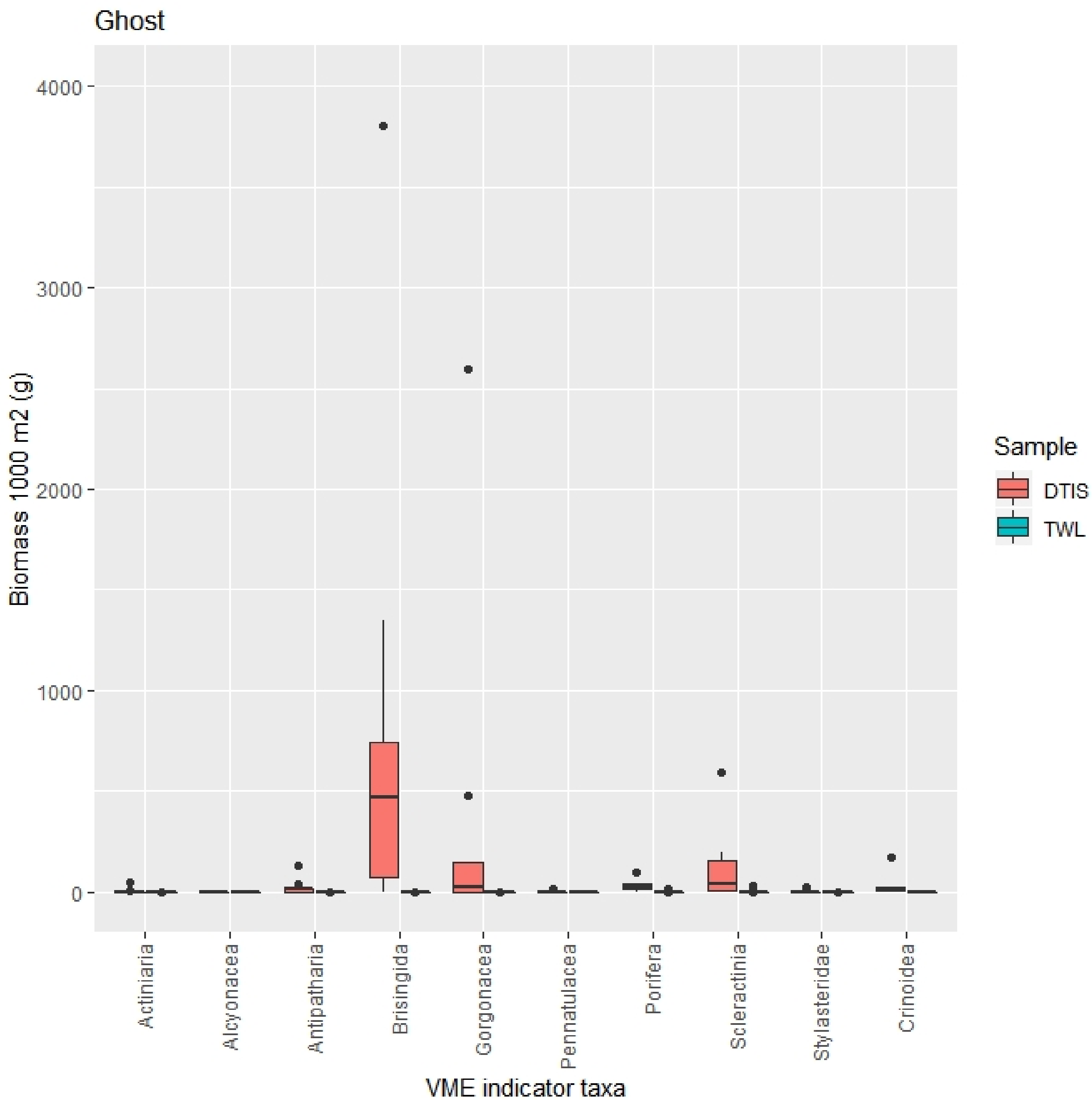

Fig.4 Boxplot of the relationship between the biomass of VME indicator taxa sampled by DTIS (red boxes) and trawl tows (blue boxes) for Ghost Seamount. The median in each box is represented by a horizonal black line. The lower and upper hinges correspond to the first and third quartiles (the 25th and 75th percentiles). The upper whisker extends from the hinge to the largest value no further than 1.5 * IQR from the hinge (where IQR is the inter-quartile range, or distance between the first and third quartiles). The lower whisker extends from the hinge to the smallest value at most 1.5 * IQR of the hinge. Data beyond the end of the whiskers are plotted individually.

Of the three features included in the analysis, Ghost Seamount had the largest sample size (*n* = 9 for DTIS and 186 for trawl). Of the 10 VME indicator taxa included in the analysis, nine were sampled by the DTIS and seven were sampled by trawls (Fig.4). Neither DTIS nor trawls sampled Alcyonacea. For all VME indicator taxa sampled by trawls, median biomass estimates were higher in DTIS samples (Fig.4).

We used the mean value from the distribution of DTIS and trawl biomass estimates on each seamount to determine the mean and range of percent efficiency of trawls in sampling VME indicator taxa relative to DTIS samples[2]. Percent efficiency was less than 1% for all taxa for which it could be calculated, with the exception of Scleractinia which ranged from 0-64% catch efficiency (Table 6).

Table 6: Estimates of catch efficiency for each VME indicator taxon, derived from the relations between mean biomass estimates from DTIS imagery (D_m) and bottom trawl tows (T_m).

VME indicator taxa	Mean DTIS biomass estimate (D_m)			Mean Trawl biomass estimate (T_m)			Range in % efficiency (T_m / D_m)*100	
	39 South	Valerie	Ghost	39 South	Valerie	Ghost	Range	Mean (SD)
Porifera	31.04	3.40	29.06	0.00	0.00	0.18	0.00 – 0.62	0.21 (0.36)
Gorgonacea	132.85	31.70	363.31	0.00	0.00	<0.01	0.00 – <0.01	<0.01 (<0.01)
Stylasteridae	37.40	0.00	4.46	0.00	0.00	<0.01	0.00 – 0.13	0.07 (0.09)
Scleractinia	327.03	1.70	130.04	0.00	1.09	1.16	0.00 – 64.11	21.67 (36.76)
Anthipatharia	45.31	0.00	22.91	0.00	0.00	<0.01	0.00 – 0.02	0.01 (0.01)
Actiniaria	2.29	1.93	6.10	0.00	0.00	<0.01	0.00 – 0.02	0.01 (0.01)
Alyconacea	0.00	0.00	0.00	0.00	0.00	0.00	NA	NA
Pennatulacea	0.00	0.00	1.43	0.00	0.00	0.00	NA	0.00 (-)
Crinoidea	4.05	0.00	27.91	0.00	0.00	0.00	0.00	0.00 (-)
Brinsingida	21.11	19.64	806.66	0.00	0.00	<0.01	0.00 – <0.01	<0.01 (<0.01)

[2] We also tried: (1) using the median of catch efficiency; and (2) bootstrap estimates from 1000 random samples from each of the features and calculating median, means and 95% confidence intervals from the bootstrap distributions combined across all features. However, due to the trawl dataset being zero-inflated (VME bycatch was not reported for most trawls), both approaches produced estimates of catch efficiency were almost always 0.

4. Discussion

Comparisons of density estimates of VME indicator taxa from the swept area of trawls and seabed imagery suggest that the catchability of VME indicator taxa is taxa-dependent (likely reflecting morphological differences determining taxa-specific susceptibility to impacts from bottom trawl gear), and generally low (reflecting that bottom trawl gear is designed to sample fish and not benthic invertebrates). The estimates of catch efficiency presented here (typically < 1%) are comparable to those reported by Freese et al. (1999) (although for a different suite of taxa occurring at depths of approximately 200 m) and for similar analyses undertaken in Australia comparing biomass estimates derived from trawl fishery data with seabed imagery (C.R. Pitcher, CSIRO, Australia, pers. comm).

The quantitative estimates in this study should, however, be interpreted with caution due to several sources of uncertainty that we have not been able to formally propagate in the analysis, including (but not limited to): (1) unbalanced and small sample sizes for DTIS and trawl biomass estimates; (2) observer bias in the identification of VME indicator taxa (taxonomic designation in the trawl dataset was undertaken by fisheries observers with some error checking by taxonomic experts, versus by taxonomic experts for the DTIS dataset); (3) the estimation of biomass from DTIS count data using mean conversion factors, which may significantly under or overestimate biomass for DTIS data due to high variability associated with the mean conversion factors; (4) the application of generalized biomass conversion factors to groups of VME indicator taxa that incorporate species with a range of morphologies and growth forms; (5) uncertainty in the spatial accuracy of trawl data, with vessel positions rounded to the nearest minute (corresponding to approximately 1 nm) and net position inferred from the direction of vessel movement and warp length; and (6) spatial differences in the distribution of VME indicator taxa, DTIS samples and trawl samples, with DTIS tows generally distributed around well-defined trawl tracks with little spatial overlap.

If there is a non-linear (positive) relationship between the density of VME indicator taxa and catch rate, and a linear relationship between density and detectability by video imagery, the type of approach used in this analysis may not provide estimates relevant to the full range of densities at which VMEs occur. For example, if there is a positive correlation between the density of VME indicator taxa and catch rate, the methods used here, which focussed on areas with high historical trawl effort and low VME density, may underestimate the catchability of VME indicator taxa by trawl gear in areas where VME density is high. Ideally, the catchability of VME indicator taxa should be estimated across a range of VME densities.

Although, the data available for this analysis proved inadequate to yield meaningful quantitative estimates of catchability for VME indicator taxa, qualitatively, our results largely corroborate previous studies. That is, the probability of VME indicator taxa impacted by a bottom trawl on the seabed being retained as bycatch is very low. However, although the amount of bycatch on the deck after one or a few tows is a poor indicator of the composition and density of VME indicator taxa at a site, accumulating bycatch information over a large number of tows can provide useful information at broader scales (e.g., McConnaughey et al. 2000, Cryer et al. 2002, Tuck et al. 2017), especially in more structured trials and when invertebrates are identified by experts.

Several approaches exist to provide more meaningful quantitative estimates of catchability for VME indicator taxa. The first is to augment the data used in the current analysis with additional data from within and/or outside the Convention Area. This could include DTIS and trawl data from the Graveyard seamounts and the Challenger Plateau within New Zealand's EEZ, or NORFANZ data from the Tasman Sea. Although this approach would help bolster the amount of data available to undertake the types of analysis described above and potentially address issues related to unbalanced and small samples sizes, it is still likely to suffer from some of the same limitations, including spatial and temporal differences in the distribution of DTIS and trawl samples. We suggest that desktop studies evaluating the distribution of corals relative to randomized trawl and DTIS tows may be useful in determining if the inclusion of additional data will yield more meaningful results. Preferably, data should be collected from headline and net cameras deployed on commercial trawls, with per-trawl catchability derived from comparisons of the biomass of VME indicator taxa landed on deck with estimates of seabed biomass from the headline and net cameras.

5. Recommendations

It is recommended that the Scientific Committee:

- **Notes** that a pragmatic, data-informed approach has been used to evaluate the availability of New Zealand data to assess the catchability of VME indicator taxa;
- **Agrees** that the data evaluated in this analysis is insufficient to yield meaningful quantitative estimates of catchability for VME indicator taxa;
- **Notes** that New Zealand and Australia hold additional data that could be used to augment the analysis presented here, but that inferences from additional analyses using non-paired data may suffer from similar limitations;
- **Agrees** that the most robust approach to quantifying catchability of VME indicator taxa would be to compare the biomass of VME indicator taxa landed on deck with estimates of seabed biomass from headline and net cameras;
- **Notes** that estimates of catchability may be useful in converting reported bycatch of VME indicator taxa into estimates of extent of impact on VMEs on the seafloor, which could help inform the review of VME indicator thresholds in SPRFMO CMM 03-2019.

6. Acknowledgments

We are grateful for comments, suggestions and inputs from the Fisheries New Zealand's South Pacific Fishery Assessment Working.

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