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Review of the biodiversity component of the New Zealand Vulnerable Marine Ecosystem Evidence Process

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EXECUTIVE SUMMARY

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The process and scientific analyses used to develop the New Zealand VME Evidence Process are summarised and reviewed. Scientific observer data for bottom trawling in the SPRFMO Convention Area over the period 2002–2014 are used to generate updated analyses of numbers and weight distributions of VME taxa caught in the SPRFMO Convention Area. These analyses are compared with the original analyses by Parker (2008) and Parker et al. (2009). Particular attention is given to analysis of the frequency of catches of different numbers of VME taxa in individual tows, and of the cumulative weight-frequency distributions of VME evidence taxa in the SPRFMO bottom trawl data.

In relation to the biodiversity component of the current New Zealand VME Evidence Process, analyses presented show the ranges in retained VME taxa weights, and in number of retained VME taxa, per bottom trawl tow in the SPRFMO Convention Area since 2002. The results of these analyses can be used to explore the implications of implementing encounter weight thresholds for VME indicator taxa at various levels along their respective cumulative weight frequency plots, and of varying the number of indicator taxa required to constitute evidence of a VME. The review and analyses are used to develop the following recommendations:

1. SPRFMO VME encounter protocols should be based on analyses of data for bottom fishing activities in the SPRFMO Convention Area, using the gear type, targeting the species and operating in the areas in which the encounter protocol is intended to be applied.
2. Further consideration should be given to the list of benthic indicator taxa, for the SPRFMO Convention Area, particularly secondary taxa indicating the presence of primary taxa, based on analyses of recent observer data and benthic community association imagery. Such benthic community association analyses could be particularly useful for determining which species, and perhaps how many of those species, could be considered to be reliable indicators of the presence of more important habitat forming taxa.
3. The number of taxa to use to constitute evidence of a VME is a choice that depends on the desired sensitivity of the encounter protocol. There is a trade-off between a risk (of impacts on VMEs)-averse rule potentially giving false-positives, and a risk-prone rule potentially giving false negatives. The current value of three taxa would be expected to result in 8% of tows constituting evidence of a VME. Decreasing this to two taxa would have increased the tows providing evidence of VMEs to 23%. Increasing this to four taxa would have reduced the tows providing evidence of a VME to 3%. More than four VME taxa were only reported in 1% of tows.
4. Having developed a list of indicator taxa for a region, there would seem to be two choices for accounting for biodiversity in a VME encounter threshold using these taxa. If these are to be individually accounted for to provide a direct measure of biodiversity, then the current VME Evidence Process is designed to do this. Alternately, indicator taxa lists can be used to determine which species should be aggregated to determine whether some predetermined threshold of the combined weight or volume thresholds for the indicator species or species groups has been exceeded, as is done under the CCAMLR VME encounter protocol.
5. Move-on rules should be considered to be temporary measures, providing precautionary protection for areas showing evidence of VMEs until objectively planned spatial closures can be implemented to protect known and highly bio-diverse VME areas (SPRFMO 2013).

1. INTRODUCTION

The overall objective of this report is:

- To prepare a review of the scientific basis for the 'biodiversity component' of the move-on-rule thresholds comprising the current New Zealand Vulnerable Marine Ecosystem Evidence Process.

This objective is addressed under each of the following specific objectives:

a) Review of the scientific and management basis of using three (as opposed to another number of) VME indicator taxa to trigger the biodiversity component of the move-on-rule;

b) Review of the scientific and management basis for using just occurrence (presence) rather than a specified amount (weight or volume threshold) as the indicator to trigger the biodiversity component of the move-on-rule;

c) Provision of scientifically justified recommendations relating to either retaining the current approach, or changing the approach in terms of the number of taxa and/or the quantity of retained benthic bycatch used to trigger the biodiversity component of the move-on-rule.

This report provides an overview, but does not critically review, the scientific basis for other components of the VME Evidence Process, such as the list of taxonomic groups used as the basis for the evidence process, the taxonomic levels chosen to designate the currently specified taxonomic groups included in the process, the trigger weight thresholds used for Porifera, Scleractinia, Antipatharia, Alcyonacea, Gorgonacea or Hydrozoa, or aspects of the overall VME evidence scoring process other than the use of presence of three species to trigger the move-on-rule (the 'biodiversity component').

The New Zealand VME Evidence Process is currently only applicable to bottom trawling operations in the SPRFMO Convention Area and this review only addresses the detection of evidence of VMEs encountered during bottom trawling operations, and not evidence of VMEs encountered during other bottom fishing operations such as bottom lining.

This section provides an overview of the timeline and key steps in the development of international resolutions, recommendations and guidelines relating to protection of VMEs from impacts of bottom fishing in the high seas, as background to understanding New Zealand's approach to developing VME encounter protocols and move-on provisions.

1.1 International context for measures to protect VMEs in the high seas

Obligations to detect fishing encounters with vulnerable marine ecosystems in the high seas originated with the inclusion by the United Nations General Assembly in 2006, into their annual resolution on sustainable fisheries, of provisions for the protection of vulnerable marine ecosystems in the high seas. Their 2006 annual resolution on sustainable fisheries called upon regional fisheries management organizations (RFMOs) to adopt conservation measures to protect vulnerable marine ecosystems (VMEs) from significant adverse impacts of bottom fishing activities, or to cease bottom fishing activities in areas where VMEs are likely to occur. This resolution is also the origin of requirements for bottom fishing vessels to cease fishing and move away from areas where VMEs are encountered. This has since become better known as the 'move-on rule'.

UN General Assembly Resolution 61/105

83. Calls upon regional fisheries management organizations or arrangements with the competence to regulate bottom fisheries to adopt and implement measures, in accordance with the precautionary approach, ecosystem approaches and international law, for their respective regulatory areas as a matter of priority, but not later than 31 December 2008:

(a) *To assess, on the basis of the best available scientific information, whether individual bottom fishing activities would have significant adverse impacts on vulnerable marine ecosystems, and to ensure that if it is assessed that these activities would have significant adverse impacts, they are managed to prevent such impacts, or not authorized to proceed;*

(d) *To require members of the regional fisheries management organizations or arrangements to require vessels flying their flag to cease bottom fishing activities in areas where, in the course of fishing operations, vulnerable marine ecosystems are encountered, and to report the encounter so that appropriate measures can be adopted in respect of the relevant site;* (UNGA 2007)

The provisions of UNGA Resolution 61/105 are non-binding and it was intended that implementation would primarily rely on RFMOs adopting conservation measures, binding upon their members, to prevent significant adverse impacts on VMEs, including through implementation of move-on rules. At that stage, although negotiations to establish the South Pacific Regional Fisheries Management Organisation (SPRFMO) had been underway since February 2006, no RFMO existed for the southern Pacific Ocean. (The SPRFMO Convention entered into force in August 2012). However, UNGA Resolution 61/105 extended the above provisions to "States participating in negotiations to establish a regional fisheries management organization or arrangement", calling upon them to adopt and implement measures consistent with paragraph 83 by no later than 31 December 2007, one year earlier than for established RFMOs.

As a leading participant in the negotiations to establish the SPRFMO, New Zealand took a proactive approach to implementing measures at flag state level to comply with the requirements of UNGA Resolution 61/105. However, this was complicated by the fact that the UNGA Resolution offered no definition of VMEs other than reference to "seamounts, hydrothermal vents and cold water corals". More importantly for this review, the UNGA Resolution offered no advice on how encounters with VMEs during high seas fishing operations should be detected. While the resolution did task the Food and Agriculture Organisation of the United Nations (FAO) with developing "standards and criteria for use by States and regional fisheries management organizations or arrangements in identifying vulnerable marine ecosystems and the impacts of fishing on such ecosystems", such work would not be completed before the implementation date of 31 December 2007 for participants in the negotiations to establish SPRFMO, leaving flag states, including New Zealand, to develop their own interim definitions of VMEs, and their own criteria for detecting encounters with VMEs.

In response to UNGA Resolution 61/105, participants in the third meeting of the negotiations to establish the SPRFMO, held in Reñaca, Chile in May 2007, adopted a set of interim measures for pelagic and bottom fisheries. The interim measures for bottom fisheries directly implemented the calls in UNGA 61/105 to either close areas where VMEs are known or likely to occur, or to establish other measures to prevent significant adverse impacts on VMEs. The interim measures also directly specified move-on provisions for bottom fisheries in the SPRFMO Convention Area.

Interim Measures adopted by participants in Negotiations to establish the South Pacific Regional Fisheries Management Organisation

<u>*Bottom Fisheries*</u>

6. *In respect of areas where vulnerable marine ecosystems are known to occur or are likely to occur based on the best available scientific information, close such areas to bottom fishing unless, based on an assessment undertaken in accordance with paragraphs 11 and 12 below, conservation and management measures have been established to prevent significant adverse impacts on vulnerable marine ecosystems and the long-term sustainability of deep sea fish stocks or it has been determined that such bottom fishing will not have significant adverse impacts on vulnerable marine ecosystems or the long term sustainability of deep sea fish stocks.*
7. *Require that vessels flying their flag cease bottom fishing activities within five (5) nautical miles of any site in the Area where, in the course of fishing operations, evidence of vulnerable marine ecosystems is encountered, and report the encounter, including the location, and the type of ecosystem in question, to the interim Secretariat so that appropriate measures can be adopted in respect of the relevant site. Such sites will then be treated in accordance with paragraph 6 above.* (SPRFMO 2007)

Although these interim measure were also not legally binding (there being no enabling SPRFMO Convention in place yet), there was a stated intention by the bottom fishing nations, including New Zealand, that such measures would be implemented. These measures again created difficulties and posed further questions for flag states to address. Most relevant to this review, these measures defined a move-on rule for participants in SPRFMO bottom fisheries requiring vessels to move five nautical miles away from sites where "evidence of vulnerable marine ecosystems is encountered". However, these interim measures offered no definition or guidance on what such evidence might be. The SPRFMO interim measures also incorporated the UNGA Resolution 61/105 requirement for participants in bottom fisheries to prepare and submit assessments of whether their bottom fishing activities would have significant adverse impacts on vulnerable marine ecosystems, with description of the proposed management measures to prevent such impacts. Participants tasked the interim Scientific Working Group with preparing an interim standard to guide participants in preparing these assessments, and against which to review assessments submitted by participants.

The UNGA has continued to re-emphasise and strengthen calls for implementation of measures to prevent significant adverse impacts of high seas bottom fisheries on VMEs, with resolutions becoming increasingly explicit regarding the need to develop science-based protocols to define evidence of VMEs encountered during high seas bottom fishing operations. In 2009, UNGA Resolution 64/72 (UNGA 2010) concluded that further actions were needed to strengthen the implementation of UNGA Resolution 61/105 and called upon RFMOs to establish and implement science-based protocols, including "threshold levels and indicator species", that would define evidence of an encounter with a VME.

UN General Assembly Resolution 64/72

119. Considers that, on the basis of the review carried out in accordance with paragraph 91 of resolution 61/105, further actions in accordance with the precautionary approach, ecosystem approaches and international law are needed to strengthen the implementation of paragraphs 80 and 83 to 87 of resolution 61/105 ...

(c) Establish and implement appropriate protocols for the implementation of paragraph 83 (d) of resolution 61/105, including definitions of what constitutes evidence of an encounter with a vulnerable marine ecosystem, in particular threshold levels and indicator species, based on the best available scientific information and consistent with the Guidelines, and taking into account any other conservation and management measures to prevent significant adverse impacts on vulnerable marine ecosystems, including those based on the results of assessments carried out pursuant to paragraph 83 (a) of resolution 61/105 and paragraph 119 (a) of the present resolution; (UNGA 2010)

The implementation of these measures by RFMOs was reviewed by the General Assembly in 2011 and, in response to the findings of that review, UNGA Resolution 66/68 (2012) noted that the actions called for by the previous resolutions have not been fully implemented and called for further actions to strengthen procedures for carrying out and updating assessments, including addressing cumulative impacts. More relevant to this review, UNGA Resolution 66/68 tasked the FAO with providing technical guidance on encounter protocols, including "encounter thresholds and move-on distances", as well as providing further guidance on applying criteria for identifying VMEs

UN General Assembly Resolution 66/68

135. Invites the Food and Agriculture Organization of the United Nations, in facilitating implementation by States and regional fisheries management organizations and arrangements of the Guidelines, to consider undertaking the following work as part of its ongoing programme for deep-sea fisheries:

(a) To compile, clarify the use of and make available technical guidance on encounter protocols and related mitigation measures, including encounter thresholds and move-on distances;

(b) To develop guidance on the application of criteria for identifying vulnerable marine ecosystems contained in the Guidelines; (UNGA 2012)

1.2 FAO International Guidelines for Management of Deep-Sea Fisheries in the High Seas

The guidelines for management of deep-sea fisheries in the high seas mandated by UNGA Resolution 61/105 were developed by the FAO in collaboration with members of the Committee on Fisheries (COFI) during two technical consultations in 2008. The resulting guidelines were adopted by COFI and published in 2009 (FAO 2009). These guidelines attempted to define VMEs in terms of the life history and vulnerability (to impacts of fisheries) characteristics of the component species of such ecosystems. The guidelines provide a list of characteristics that have served since then as the principle means of defining and identifying VME indicator species.

> ***International Guidelines for the Management of Deep-Sea Fisheries in the High Seas Identifying vulnerable marine ecosystems and assessing significant adverse impacts***
>
> *42. A marine ecosystem should be classified as vulnerable based on the characteristics that it possesses. The following list of characteristics should be used as criteria in the identification of VMEs.*
>
> *i. Uniqueness or rarity – an area or ecosystem that is unique or that contains rare species whose loss could not be compensated for by similar areas or ecosystems. These include:*
>
> - *habitats that contain endemic species;*
> - *habitats of rare, threatened or endangered species that occur only in discrete areas; or*
> - *nurseries or discrete feeding, breeding, or spawning areas.*
>
> *ii. Functional significance of the habitat – discrete areas or habitats that are necessary for the survival, function, spawning/reproduction or recovery of fish stocks, particular life history stages (e.g. nursery grounds or rearing areas), or of rare, threatened or endangered marine species.*
>
> *iii. Fragility – an ecosystem that is highly susceptible to degradation by anthropogenic activities.*
>
> *iv. Life-history traits of component species that make recovery difficult – ecosystems that are characterized by populations or assemblages of species with one or more of the following characteristics:*
>
> - *slow growth rates;*
> - *late age of maturity;*
> - *low or unpredictable recruitment; or*
> - *long-lived.*
>
> *v. Structural complexity – an ecosystem that is characterized by complex physical structures created by significant concentrations of biotic and abiotic features. In these ecosystems, ecological processes are usually highly dependent on these structured systems. Further, such ecosystems often have high diversity, which is dependent on the structuring organisms. (FAO 2009)*

In response to UNGA Resolution 66/68, the FAO held a technical workshop in Busan, Korea in 2010 to discuss options for improving implementation of the deepwater guidelines, including developing technical guidelines for VME encounter protocols and application of the criteria for identifying VMEs. The workshop discussed move-on rules but made little progress towards providing advice on encounter protocols, recognising that "implementing the move-on rule is proving to be a major challenge because of difficulties in defining an encounter with a VME". The workshop re-iterated calls to develop guidance on appropriate threshold levels or triggers in relation to move-on rules, clarify move-on provisions, undertake studies to determine the effectiveness of the move-on rule and stimulate research to improve the use and understanding of the move-on rule (FAO 2011). The FAO, in response to increasingly specific requests for technical advice in UNGA Resolutions on Sustainable Fisheries, has provided useful definitions of VME species which have been available for use since first drafted at the technical consultations in 2008. However, the FAO has not, as yet, provided any advice or technical guidance on what constitutes evidence on an encounter with a VME during bottom fishing operations. Participants in deep-sea fisheries in the high seas are therefore currently still in a position of having to determine for themselves, based on best available scientific information, what constitutes evidence of an encounter with a VME, and to feed the results of such work into the FAO process.

2. DEVELOPMENT OF THE NEW ZEALAND VME EVIDENCE PROCESS

This section provides an overview of approaches taken by New Zealand and by various RFMOs to develop VME encounter protocols and move-on rules, to provide context for the subsequent review of the biodiversity component of the VME Evidence Process (shown in Appendix A).

UNGA Resolution established an obligation for New Zealand, as a participant in negotiations to establish the SPRFMO, to develop and implement measures to prevent significant adverse impacts on VMEs by 31 December 2007. Requirements in this regard were made more specific in the SPRFMO interim measures adopted by participants in 2007, including requirements to conduct impact assessments and to implement measures to detect encounters with VMEs in order to comply with the SPRFMO interim move-on rule. This left New Zealand, as the main bottom fishing nation in the SPRFMO Convention Area, to take the lead in attempting to define what would constitute evidence of a VME during bottom trawling operations in the SPRFMO Convention Area. New Zealand also took the lead in developing the initial draft of the Bottom Fishery Impact Assessment Standard requested by the interim measures.

To conduct this work, the then Ministry of Fisheries initiated two parallel processes in 2007 to:

- Prepare a draft Benthic Assessment Standard (as it was initially called) for use by New Zealand in preparation of their bottom fishery impact assessment, and for subsequent submission to SPRFMO as a draft assessment standard. This was prepared under Ministry of Fisheries project IFA2007-02 contracted out to the National Institute of Water and Atmospheric Research (NIWA).
- Preparation of the New Zealand SPRFMO Convention Area bottom fishery Impact assessment for submission to SPRFMO, This was prepared by the Ministry of Fisheries in consultation with the fishing industry and other stakeholders, under the guidance of the developing Benthic Assessment Standard from project IFA2007-02.

2.1 Overview of Project IFA2007-02

The purpose of this section is to provide an overview of the fisheries data, scientific analyses and results that underpinned the final VME Evidence Process developed under project IFA2007-02, to aid understanding of the critical review of the biodiversity component of the process in the next section.

The overall objective of project IFA2007-02 was to:

- ➢ Develop a draft Bottom Fishery Impact Assessment Standard (BFIAS) for consideration by the South Pacific Regional Fishery Management Organisation (SPRFMO) based on a draft framework developed during previous SPRFMO meetings. Further, there is a need to develop specific implementation guidelines for New Zealand vessels fishing in the SPRFMO Convention Area in order to protect vulnerable marine ecosystems from fishing impacts.

Objective 1 of project IFA2007-02 provided for generation of data sets and maps of New Zealand historical high-seas bottom trawling catch and effort in SPRFMO Convention Area. Objective 2 provided for the mapping of VMEs in the SPRFMO Convention Area. These then supported the development of the draft Benthic Assessment Standard and the initial development of an observer VME detection protocol under Objective 3, with the following specific objectives.

<u>Objective 3</u>

- To develop a draft framework for a benthic assessment standard for use in identifying, mapping and classifying VMEs, and evaluating potential impacts of bottom trawling activities on these VMEs: by 25 August 2007.

- To develop standards and guidelines for scientific observers to use in detection of fishing on VMEs from benthic material brought up in trawl nets, by 30 September 2007.
- To conduct a review of benthic assessment best practice, regional and international standards, guidelines and specifications for identifying vulnerable marine ecosystems, assessing the impacts of fishing activities on such ecosystems, evaluating vulnerability and recovery rates, and avoiding, mitigating or managing benthic impacts: by 31 March 2008.
- To develop a draft benthic assessment standard for use in identifying, mapping and classifying VMEs, and evaluating potential impacts of bottom trawling activities on these VMEs: by 31 March 2008.
- To prepare a draft research report on all of the above reporting requirements, and to present this report to a meeting of the Deepwater Fisheries Working Group and/or the Aquatic Environment Working Group: in March 2008.
- To submit to the Ministry of Fisheries a Final Research Report as specified in Research Reporting form 5 or a draft Fishery Assessment Report as specified in Research Reporting form 7: by 30 June 2008.

An additional Objective 4 was added following requests by stakeholders for additional analysis of threshold weights indicating evidence of VMEs. This additional objective resulted in much of the analysis that was finally used to develop the VME evidence process, including the threshold weights. The biodiversity component of the VME Evidence Process evolved out of these additional analyses.

Objective 4

- Conduct additional spatial and performance analyses to support the threshold weight criteria developed for the Benthic Assessment Standard.
- Compare threshold weight analyses for all tows that caught any of the VME taxa to be included on the VME Evidence Process form inside and outside the New Zealand EEZ during the proposed reference period for VME analyses of 1998 – 2002.
- Compare cumulative weight curves, threshold weight analyses and proportions of tows exceeding proposed VME evidence criteria inside and outside zones in the 1998 – 2002 reference period, and the full data set from 1990 – 2007.
- Incorporate these additional analyses and results into the rationale and supporting results and discussion for the Evidence of a VME form, which is part of the draft Benthic Assessment Standard.

2.2 Data used in analysis of historical benthic bycatch

Some consideration should be given to the selection of data used by Parker (2008) as the scientific basis for the VME Evidence Process proposed in 2008. There were questions by stakeholders at the time concerning the selection of data for that analysis, and these questions remain relevant.

New Zealand has one of the most comprehensive sets of scientific observer data for bottom fishing operations in the high seas, and has the most comprehensive data set for benthic bycatch in the SPRFMO Convention Area. However, the attention paid to collection of benthic bycatch data by scientific observers has varied historically and the level of resolution has steadily increased as observers have been tasked and trained to collect increasingly detailed benthic bycatch data.

Parker (2008) noted that data used in the analyses were chosen to try to obtain "adequate sample sizes for categories of the most representative tows". In comparison to thousands of observed tows within the EEZ, there were hundreds of observed tows in the high seas, prompting an early decision to use data from both inside and outside the EEZ. This led to choosing a wide range of target species when selecting tows for analysis, as target species inside the EEZ differ. In addition to the deepwater species typically caught on seamounts in the SPRFMO Convention Area (orange roughy *Hoplostethus atlanticus*, alfonsino *Beryx splendens*, oreos Oreosomatidae and cardinalfish *Epigonus telescopus*), target species such as hoki *Macruronus novaezelandiae*, hake *Merluccius australis*, ling *Genypterus blacodes* and southern blue whiting *Micromesistius australis*, usually caught on long tows on flat ground inside the EEZ, were included. Tows targeting species such as squid and prawns were excluded.

Using all observed bottom trawls inside and outside the EEZ from 1990 to 2007 with the chosen target species, Parker (2008) concluded that there was a trade-off in selection of data between the early exploratory phase when benthic by-catches were poorly identified but tended to be higher, and more recent years with lower bycatch but improved identification of benthic taxa. The designated VME indicator taxa (see next sub-section) were typically not recorded by observers until 1998. Species identification beyond 'unidentified coral' or 'sponge' slowly improved up to 2005 and then improved significantly after the *Guide to Deep Sea Invertebrates of New Zealand* was published (Tracey et al. 2005). Recorded encounter rates with VME taxa peaked shortly after 1998 and total benthic bycatch weight was generally declining by 2001 (Figure 1).

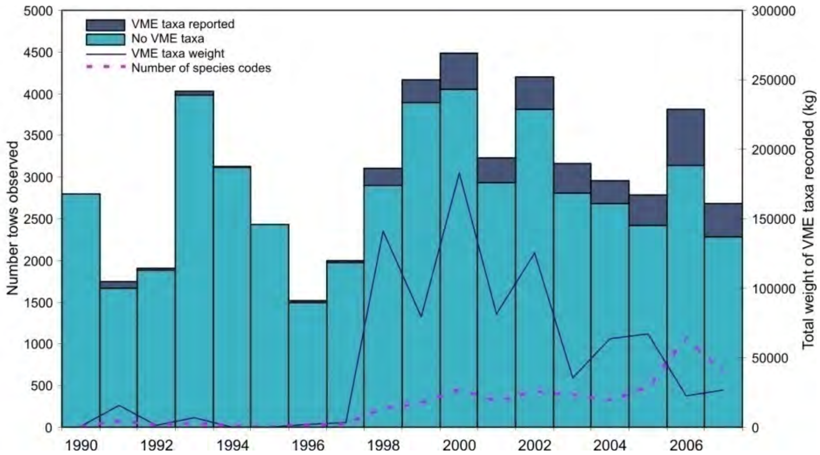

Figure 1: Total number of observed tows each year with and without VME taxa present in the catch (bars). The solid blue line shows the total VME taxa weights recorded by observers each year (bars) and the number of VME taxa species codes recorded each year (from Parker2008).

Based on these results, Parker (2008) decided to use all observed tows over the period 1998 to 2002, providing "1,603 tows in the best available representative dataset, used to predict the catch distributions of VME taxa during fishing in the SPRFMO convention area".

2.3 Selection of VME Indicator Taxa for the SPRFMO Convention Area

By the time project IFA2007-02 was initiated, the draft FAO deepwater management guidelines (FAO 2009) were available, establishing an expectation, if not an obligation, to ensure that any process to designate VME indicator taxa for a particular area or fishery take account of the FAO designated characteristics of VME taxa: vulnerability, uniqueness, rarity, functional significance, slow growth and structural complexity.

Parker (2008) notes that all benthic ecosystems are vulnerable to anthropogenic disturbance to some degree, with many of the component species being sessile, filter-feeding invertebrates which create complex and fragile biogenic substrata that may serve as habitat for other organisms (Auster 2005, Buhl-Mortensen & Mortensen 2005). As already indicated in UNGA Resolution 61/105, these include cold water stony corals (Scleractinia), bubble gum corals (Paragorgiidae), black corals (Antipatharia) and sponges (Porifera). Based on the FAO characteristics, Parker (2008) adopted the following rationale in selecting taxa for inclusion in the VME Evidence protocol:

- Any taxonomic group specifically listed by FAO as examples of VME inhabitants is included if retained in trawl gear and identifiable to group. Some groups mentioned by FAO are not included because they are not encountered in deep sea fisheries, not retained by fishing gear, or are difficult to identify (e.g. shallow water sponges, xenophyophores). It must be noted, however, that poor retention by trawl gear means that low weight thresholds can indicate higher benthic impacts.
- Taxonomic groupings that are known to be associated with hard substrata in deep water are included, but only as indicators of suitable habitat.

Using these criteria, and based on an analysis of the frequency of occurrence and rate of retention of various benthic species in New Zealand bottom trawl tows, Parker et al. (2009) selected 10 taxonomic groups (Table 1) as being vulnerable groups or indicator taxa in the SPRFMO Convention Area.

Table 1: Taxonomic groups assessed as vulnerable to bottom trawl fishing in the South Pacific Ocean. Habitat indicators are taxa often found in association with vulnerable marine ecosystem (VME) taxa and indicate that habitat associated with a VME is present (from Parker et al. 2009).

Taxonomic level	Common name
<u>Vulnerable taxa</u>	
Phylum Porifera	Sponges
Phylum Cnidaria	
Class Anthozoa	Anemones
Order Actiniaria	Soft corals
Order Alcyonacea	Sea fans
Order Gorgonacea	Sea pens
Order Pennatulacea	Stony corals
Order Scleractinia	Black corals
Order Antipatharia	
Class Hydrozoa	
Order Anthoathecatae	
Family Stylasteridae	Hydro corals
<u>Habitat indicators</u>	
Phylum Echinodermata	
Class Crinoidea	Sea lilies
Class Asteroidea	
Order Brisingida	Armless stars

Parker (2008) provides a table with a detailed explanation of why each of these taxa was chosen as either a primary taxon or an indicator taxon for the VME Evidence Process for bottom trawling in the SPRMO Area (shown in Appendix B). Readers should refer to that for the detailed rationale.

There is an important difference in concept between primary, habitat forming VME taxa and indicator species, which is recognised in the UNGA Resolution 64/72 call for "... *definitions of ... threshold levels and indicator species*" (UNGA 2010). This is illustrated by the photograph shown in Plate 1 taken on Forde Guyot in the central Louisville Ridge in May 2014 during NIWA research trip TAN1402 under Project VMES133 (Clark et al. 2014). This shows an example of sparse sea urchins, Crinoidea feather stars and Brisingida brittle stars on large and abundant outcrops of fragile, habitat-forming scleractinian coral *Solenosmilia variabilis.*

Accumulated evidence of such associations led Parker (2008) to propose Crinoidea and Brisingida as species that indicate the likely presence of habitat-forming corals such as *Solenosmilia*, even though they themselves might not contribute substantially to bycatch weights. The rationale resulting in explicit specification of primary VME taxa and additional indicator taxa in the VME Evidence Process is explained in Appendix B.

Plate 1: Mixed benthic community of habitat-forming stony corals with associated indicator brisingid seastars, feather stars and urchins on Forde Guyot. (©NIWA 2014, from Clark et al. 2014)

2.4 Determination of weight thresholds indicating evidence of VMEs

While it is not the purpose of this report to critically review the VME Evidence Process weight thresholds determined by Parker (2008) and Parker et al. (2009) for the main vulnerable taxa in the VME Evidence Process, it is useful to understand how these were derived. This can aid understanding of options and supporting evidence for whether weight thresholds are feasible for the indicator species used in the biodiversity component of the move-on rule.

Parker (2008) found that a low percentage of bottom trawl tows retained VME taxa, with an average 10.6% of tows retaining VME taxa across the entire data set (8.4% over 1998–2002 and 13.4% over 2003–2007). The percentage of tows retaining VME taxa was, however, highly variable between areas and time periods, ranging from 1% of tows in some inside-EEZ areas to 55% of tows on the West Norfolk Ridge (Parker 2008, table 7.) In the tows that did retain benthic taxa, Parker (2008) noted a wide range of retained VME taxa weights per tow, with the highest number of tows retaining less than 10 kg of combined benthic taxa, the majority of tows retaining less than 100 kg and only 187 (out of 1603) tows retaining more than 510 kg (Figure 2).

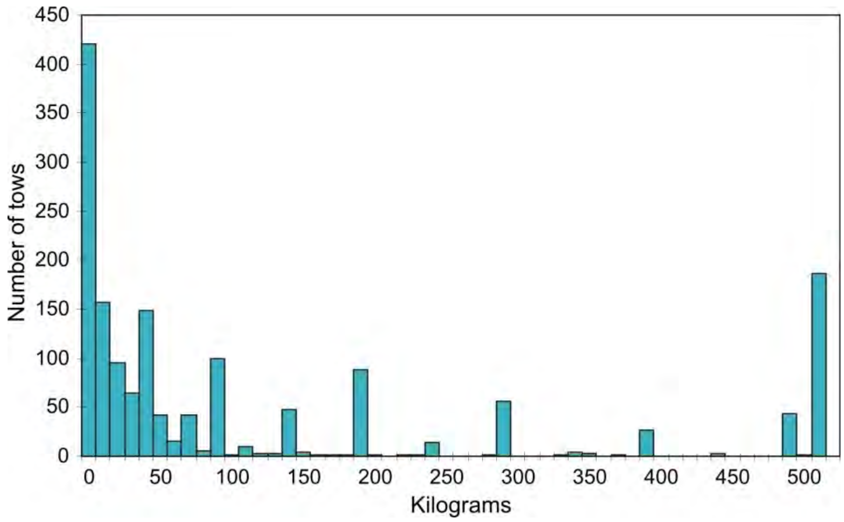

Figure 2: Frequency distribution of VME taxa total weights per tow for tows observed from 1998–2002 (n = 1603). The final bar at 510 kg contains 187 observations above 510 kg in weight. Maximum observed catch was 20 000 kg (from Parker 2008).

The 1998–2002 data set was used by Parker (2008) to generate cumulative weight frequency distributions for most of the designated VME indicator species used in the VME Evidence Process. However, Gorgonacea and Hydrozoa were not identified to that taxonomic level in the 1998–2002 data and so Parker (2008) used data for the 2003–2007 period for these taxa. For the purpose of his analysis, and to allow earlier and more recent data to be compared, Parker (2008) interpreted the COU (unidentified coral) code to indicate stony corals (Scleractinia, SIA), based on advice from the Observer Programme. The resulting cumulative weight curves were used to propose encounter threshold weights for these taxa using the 50th percentile (median) of these curves.

Figure 3 shows a repeat analysis of the Parker (2008) data set, showing magnified initial sections of the cumulative weight frequency curves to make it easier to distinguish the VME taxon weights associated with the median cumulative weight frequencies. Cumulative weight curves for Gorgonacea and Hydrozoa were generated by Parker (2008) using data for the period 2003–2007, despite this being a period of decreasing overall benthic bycatch weights, because these taxa were not identified as such by observers prior to 2003.

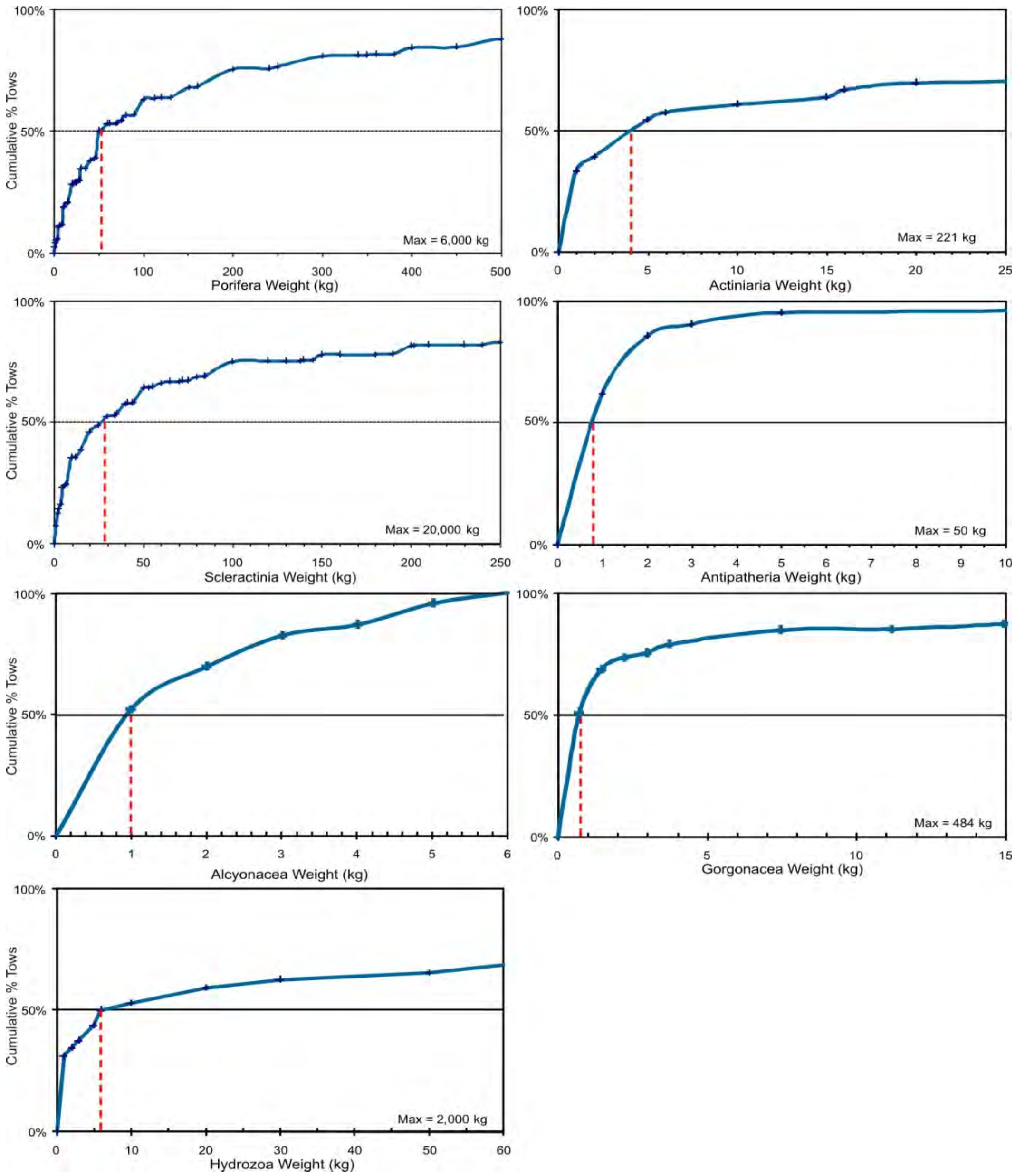

Figure 3: Magnified sections of cumulative weight-frequency distributions for tow catch weights of VME indicator taxa used to determine threshold weights. Red dashed lines indicate the 50% median weight values. Prepared using the 1998–2002 data set used by Parker (2008) for Porifera, Actiniaria, Scleractinia, Antipatharia and Alcyonacea. Data for the period 2003–2007 were used for Gorgonacea and Hydrozoa, which do not appear in the 1998–2002 data.

Parker (2008) used the cumulative weight frequency distributions from the analyses shown in Figure 3 to determine a range of threshold weights for each VME taxon, at 50%, 75%, 80% and 90% (see Table 2, e.g. 75% of the tows retained less than 100 kg of Actiniaria). He notes that the choice of which cumulative weight percentile to use to as a threshold weight indicating evidence of a VME encounter is a management choice somewhere between presence/absence (no weight threshold), and an excessively high weight threshold that would be triggered only by rare large bycatches of corals and sponges. He provides a rationale for the choice of the median (50%) cumulative weight level, largely based on the fact that fragile and habitat forming VM species such as corals and hydrozoans are poorly retained by bottom trawl nets, so that "a low weight in the catch indicates much higher densities on the seafloor".

Table 2: Threshold percentile weights (kg) for each VME taxon derived from the analyses shown in Figure 4 (from Parker et al. (2009), codes as specified on the VME Evidence Process form).

Taxon	50th %	75th %	80th %	90th %
Porifera - ONG	50	200	300	750
Actiniaria - ATR	5	100	120	171
Scleractinia - SIA	30	100	200	1000
Antipatharia - COB	1	2	2	3
Alcyonacea - SOC	1	2	2	5
Gorgonacea - GOC	1	2	4	20
Hydrozoa - HDR	6	80	118	193

2.5 The biodiversity component of the VME Evidence Process

The 'biodiversity component' of the VME Evidence Process evolved towards the end of project IFA2007-02 following the additional analyses requested under added Objective 4. In proposing threshold weights for the primary indicator taxa, Parker (2008) chose the 50% (median) cumulative weight levels from the analysis shown in Figure 3. In doing so he provided no scientific rationale for that choice, noting that it was a management choice that was made at the time in consultation with the Ministry of Fisheries. Low 50% cumulative weight frequency values for the secondary VME indicator taxa for the SPRFMO Convention Area raised questions about how these should be catered for in the VME Evidence Process, given that 1 kg was probably the minimum weight that could feasibly be determined by observers at sea.

Parker (2008) gave the rationale for the incorporation of some measure of biodiversity, in addition to the weight thresholds of primary taxa, as being: " ... the assessment of “Evidence of a VME” should ideally also incorporate other information available from the catch, such as the diversity of taxa encountered ... . The “Evidence of a VME” form developed uses an additional presence / absence score to capture diversity among broad taxonomic groups by assigning a single point to any listed taxon present in the catch, but below the threshold level. Summing those points provides a weighting factor that slowly increases the total VME score, even where threshold weights are not exceeded."

The justification for incorporation of additional scores for presence of the secondary indicator species was that (having chosen those taxa as indicators of the possible occurrence of VMEs as defined by FAO 2009) low weights of these taxa are typically retained by bottom trawls. While the presence of a single one of those taxa is probably not adequate to indicate an encounter with a VME (as would a large catch of one of the primary indicator species), an increasing number of these species in a tow indicated an increasing likelihood that the trawl had encountered a biodiverse area, constituting evidence of an encounter with a VME.

Parker et al. (2009) explain that "In developing the scoring process, we considered that the move-on rule should be triggered either by a single very large catch of a vulnerable taxon or if several vulnerable groups were observed, even if the catch is below the group threshold weights." Parker (2008) and Parker et al. (2009) do not provide a clear explanation for the choice of three species to trigger a move-on as a result of an indication of biodiversity. However, this can be inferred from the explanation by Parker (2008, Section 4.5) of how the 'rapid assessment process' (as the VME Evidence Process was referred to when implemented by scientific observers) was proposed to work.

It appears evident from his explanation that Parker (2008) initially considered that threshold weights be used for all of the indicator taxa ("If the weight of a group exceeds the threshold catch weight in a tow"), and that a score be applied to each group exceeding its threshold weight depending on the importance of that group in the list of indicator species: Low=1, Medium=2, High=3. The VME score value of three constituting evidence of a VME and triggering a move-on resulted directly from this proposal, with a move-on being triggered by the weight threshold being exceeded for any one of the primary (importance score of 3) taxa.

What is now referred to as the 'biodiversity component' then evolved from two considerations:

- It was considered that no taxon could be confidently accorded an importance ranking of 2, this being a level of resolution that could not be justified using the FAO (2009) criteria for VME taxa. This reduced the taxonomic importance options to High=3 (retained for the already designated primary vulnerable and habitat-forming taxa: Porifera, Scleractinia, Antipatharia, Alcyonacea, Gorgonacea and Hydrozoa) and Low=1 (for all other taxa chosen as indicator taxa).
- The 50% cumulative weight frequency values for the secondary taxa were typically less than 1 kg and weight thresholds set at such low values could not be rapidly and reliably determined by scientific observers at sea, resulting in the proposal that the presence of these lower importance species be used rather than attempting to determine weights of less than 1 kg on board ship.

The total score constituting evidence of a VME and triggering a move on was retained at three (based on the initial decision to trigger a move on if the weight of the primary species is exceeded resulting in a score of three), meaning that the presence of three taxa not exceeding their threshold weights, and each therefore being accorded a score of one, would trigger a move-on. This resulted in the VME Evidence Process Form shown in Appendix A.

2.6 Incorporation of the VME Evidence Process into the New Zealand SPRFMO bottom fishing impact assessment

The New Zealand report on *Bottom Fishing Activities by New Zealand Vessels Fishing in the High Seas in the SPRFMO Area during 2008 and 2009* (MFish 2008) was submitted to the 7th meeting of the SPRFMO Interim Scientific Working Group in Lima, Peru, in May 2009. The move-on provisions in that assessment were based on the outcomes of project IFA2007-02, as reported by Parker (2008). Key findings of that report were subsequently published in Parker et al. (2009) following presentation of this work at the Fourth International Deep Sea Coral Symposium held in Wellington in 2008. Parker (2008) and Parker et al. (2009) provide further explanation of the management requirements (primarily in response to the SPRFMO interim measures), the logic underlying the VME Evidence Process and move-on rule, and how the process and rule were intended to be applied by observers on bottom trawling vessels fishing in the SPRFMO Convention Area.

3. REGIONAL FISHERIES MANAGEMENT ORGANISATION MOVE-ON RULES

RFMOs with jurisdiction over bottom fisheries in the Atlantic and Pacific Oceans have responded to UNGA Resolutions 61/105 and 64/72 by developing VME encounter protocols and move-on rules tailored to their respective regions and fisheries. Following the adoption of UNGA resolution 61/105 in 2006, and in preparation for the UNGA review of implementation of Resolutions 61/105 and 64/72 in 2011, there have been a number of reviews of move-on rules, particularly those implemented by RFMOs or their participants. These were initially prompted by efforts to clarify or provide advice on the requirements for effective VME encounter protocols and move-on rules. They subsequently focussed on criticism of move-on rules implemented by RFMOs, evolving into critical reviews in direct preparation for the 2011 UNGA review itself. It is useful to consider some of the key findings of these reviews, particularly as they relate to comparison of the New Zealand VME Evidence Process and those developed by other RFMOs.

3.1 International Reviews of Move-On Rules

One of the first influential responses to UNGA Resolution 61/105 was the International Union for the Conservation of Nature (IUCN) paper by Rogers et al. (2008), predating the FAO deepwater guidelines (FAO 2009), providing scientific advice on what might constitute evidence of a VME in commercial fisheries benthic bycatch. While not being designed for any specific region, the authors note that their "practical guidelines have been drawn from observations of the quantities of by-catch that may be associated with the existence of VMEs on the seabed from different types of fishing gear". These observations included work by NIWA on the New Zealand bottom trawl fishery and it is useful to compare these early recommendations with the New Zealand VME evidence weight thresholds, and with those subsequently implemented by RFMOs. Rogers et al. (2008) recommended that the following thresholds should be considered to define significant encounters with a VME:

- A single haul constituting more than 5 kg of stony coral, coral rubble, sponge or other habitat-forming epifauna, or a single haul containing more than 2 kg of black corals or octocorals or more than 2 coral colonies.
- Two or more consecutive hauls containing more than 2 kg each of live corals or more than 5 kg of sponges on the same trawl track or setting area for fishing gear or where consecutive trawling tracks or sets intersect.
- More than four encounters of corals over 2 kg within an area (1 km^2) within one year, or 10 encounters of more than 2 kg sponges or other habitat-forming epifauna in an area (1 km^2) within one year, or more than 4 corals per 1000 hooks in a long line fishery within one year within an area (10 km^2).
- More than 15% of hauls of any gear within an area (10–100 km^2) containing corals, sponges or other habitat-forming epifaunal taxa.

Encounter protocols and move-on rules of were developed and implemented by RFMOs by the UNGA deadline at the end of 2008 and Kenchington (2011) provides a detailed description and critical commentary of all of these. He notes that encounter protocols and move-on rules had existed in some form from about 1990 onwards in various jurisdictions, to manage problems associated with undesired fish bycatches in various fisheries. These include: 1990 soft shell crab closures in Canada from 1990 onwards; 1990s small-fish protocols in the Gulf of St Lawrence groundfish fishery; 1995 CCAMLR move-on rule for fish bycatch in the myctophid *Electrona carlsbergi*, toothfish and icefish fisheries; 1997 salmon and rockfish bycatch move-on in the US Pacific hake fishery; New Zealand 2001 small fish move-on in the hoki fishery; US 2002 Bering Sea salmon bycatch move-on in the pollock fishery; US 2003 move-on provision for bycatches of turtles, marine mammals or sawfish in the Atlantic tuna longline fishery; and the 2006 NAFO move-on for vessels that exceed fish bycatch allowances.

Kenchington (2011) makes the important observation that all of these move-on rules were focused on the avoidance of ephemeral problems involving the presence, on commercial fishing grounds, of concentrations of fish or other mobile species that are not desirable to catch. Encounter protocols evolved to deal with such situations were seen to offer a swifter and more efficient response than long term spatial closures, where such concentrations are localized, variable in time and space and mobile. He then notes that "such protocols will inevitably be inefficient, if not actually ineffective or even counter-productive, for protecting VMEs since those are not ephemeral", given that what makes a typical VME vulnerable is that the habitat-forming species are sedentary and very long-lived.

Kenchington (2011) describe encounter protocols, particularly VME species lists and weight thresholds, for the Northwest Atlantic Fisheries Organisation (NAFO), North-East Atlantic Fisheries Commission (NEAFC), South-East Atlantic Fisheries Organisation (SEAFO), Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), the South Indian Ocean Fisheries Agreement (SIOFA) and flag state responses in the Southern and Northern Pacific Ocean. Readers should refer to that paper for more details on these processes, and of the encounter weight thresholds established for categories of VME taxa at that time.

Kenchington (2011) provides substantial commentary and criticism of the New Zealand VME Evidence Process. He notes that it is "without doubt the most highly developed yet implemented", but that it has weaknesses which should be considered before the approach is used elsewhere. Regarding weight thresholds and the biodiversity component of the New Zealand approach, Kenchington (2011) observes that:

- "The New Zealand encounter protocol is ... the sole example globally of an attempt to apply different thresholds to different species, beyond the crude separation of corals and sponges used by the Atlantic RFMO/As. It is also one of only two attempts that explicitly has considered a wider range of taxa – two complexities that have been urged ... by Rogers & Gianni (2010)."
- "The New Zealand attempt to incorporate a measure of diversity into its encounter protocol, while of questionable merit as it was implemented, deserves further consideration. ... There was a desire to provide protection to areas of high biodiversity, in addition to those where a single VME species was notably abundant, and hence the hybrid approach was adopted, with a move triggered either by the presence of multiple taxa or by a high catch of any one."

His criticism of the biodiversity component focussed on the use of presence-only, without weight thresholds, and the choice of three taxa to trigger a move-on. He considered this to be too sensitive, likely to be triggered often, resulting in frequent move-on and spread of fishing effort away from preferred fishing areas. In contrast, in the following year, Auster et al. (2010) criticised the weight thresholds adopted by RFMOs, as "not supported by any explicit demonstration of biomass–density relationships that produce some critical threshold for a VME". Freese et al. (1999) found catch efficiencies for bottom trawl nets to be less than 1 percent for asteroids, echinoids and molluscs, and 4.6 percent for holothurians. At a 1% benthic retention efficiency for bottom trawl nets, the 60 kg live coral and 800 kg sponge NAFO and NEAFC weight thresholds would result in 6000 kg of coral or 80 000 kg of sponge being impacted. Auster et al. (2010) conclude that "greatly reducing the threshold to trigger a move-on rule to any detectable catch of VME indicator species (i.e. a simple presence–absence rule, rather than actual weight thresholds) would better match ecological realities with obligations under UNGA 61/105 and the FAO deep-water guidelines".

Weaver et al. (2011) report on an international scientific workshop held to provide a scientific review of implementation of UNGA Resolutions 61/105 and 64/72 to the UNGA implementation review conducted in 2011. They observe that encounter protocols and move-on rules have "generally set the bycatch limits at such high levels that the rule becomes meaningless". They note that, in 2008, the NAFO Working Group on Ecosystem Approach to Fisheries Management (WGEAFM) determined that large catches of corals and sea pens indicating the presence of potential VMEs were rare events and that bycatch threshold levels for corals and sponges exceeded scientific estimations of 1.6 kg per trawl for sea pens, 0.2 kg per trawl for small gorgonian octocorals, 2 kg per trawl for larger gorgonians, and 75 kg for sponges by one to two orders of magnitude (WGEAFM 2008). They emphasise the high biodiversity of deep sea coral ecosystem VMEs, noting that more than 1300 species of animals were found in association with *Lophelia pertusa* reefs in the northeast Atlantic (Roberts et al. 2006), and that small (18.5 kg) coral blocks dredged off the Faroe Islands were found to contain 256 species (Jensen & Frederiksen 1992). They conclude by recommending more explicit approaches to detecting and protecting coral ecosystems, rather than focussing on individual species, and reduction of bycatch threshold levels.

The review and comparison of move-on rules by Hansen et al. (2013) describes updates in the weight thresholds applied by RFMOs. Some of these have changed substantially over time, particularly those applied by NAFO, NEAFC and SEAFO. These organisations, following the lead of NAFO (Kenchington 2011), initially adopted weight thresholds in 2008 of 100 kg per set of live corals and 1000 kg of live sponges. In 2009, these were reduced to 60 kg of live corals and 800 kg of live sponges. In 2012 NEAFC and NAFO halved their thresholds to 30 kg of live corals and 400 kg of sponges. The 2012 NAFO revision also introduced a protocol to account for cumulative impacts of encounters below threshold levels, with two encounters of 15 kg of corals in the same area treated as equivalent to a 30 kg catch, triggering a move-on. In 2013 SEAFO reduced the threshold for sponges to 600 but retained the 60 kg limit for corals. NAFO updated its thresholds again in 2013 by adding a threshold for sea pens (7 kg), further reducing the threshold of sponges to 300 kg, and increasing the threshold for other live corals back to 60 kg.

Regarding the New Zealand encounter protocol, Hansen et al. (2013) note that it provides the most complex example of adopting different trigger weights for different taxa and that, by indentifying a wider variety of VME indicator taxa, both the New Zealand and CCAMLR protocols allow for different weight thresholds for different taxa and provide some measure of biodiversity. The CCAMLR VME indicator species were initially based on the New Zealand list of SPRFMO VME taxa, but was subsequently revised and expanded to include 21 taxonomic groups, including or subdividing those proposed by Parker et al. 2009. While supporting the use of cumulative weight-frequency analyses as a basis for recommending threshold weights, Hansen et al. (2013) recognise that the low resulting thresholds for some taxa, coupled with the difficulty of determining small weights at sea, could require presence-absence to be used for some taxa. They recognise two possible approaches for such rules: presence of multiple species could be used to generate a biodiversity score (as done in the New Zealand rule); or multiple encounters within a small area could be considered to indicate a VME area (as is done by CCAMLR).

Most recently, Ardron et al. (2014) report on a scientific workshop held in 2011 to discuss “Science requirements for effective governance of bottom fisheries in areas beyond national jurisdiction” which recommended a 10-step process for the identification and protection of VMEs. They recommend the systematic development, testing, and revision of threshold values, with threshold weights or volumes being set by taxonomic group and not just for the entire bycatch. They support the approach taken by New Zealand and in initial Northwest Atlantic analyses (Kenchington et al. 2009) of determining threshold values of VMEs based on patterns in the cumulative catch curves, "such that a point of maximum curvature or rapid change toward the asymptote may indicate a naturally occurring or ecologically relevant reference point". They also note that the New Zealand encounter protocol has separate weight thresholds for different taxa and recognise that the biodiversity scoring component "allows management action to be informed by overall VME indicator bycatch, in addition to landings of individual indicator taxa".

3.2 Comparison of the New Zealand with other RFMO protocols

There are a number of notable differences between the New Zealand VME Evidence Process and other encounter protocols implemented by RFMOs.

- Whereas the threshold weight values implemented by RFMOs have been set at high levels, well above those scientifically recommended, the New Zealand weight thresholds are based on analysis of bycatch weight frequencies in the fishery, and have been low from the outset.
- The list of species adopted by New Zealand, and even more so that adopted by CCAMLR, as VME habitat-forming taxa or indicator species, is more comprehensive than others. Specification of this range of taxa, and the requirement that they all be considered when evaluating evidence of an encounter with a VME, provides the foundation for explicit consideration of the biodiversity of that evidence.
- The New Zealand protocol is the only protocol that includes a direct measure of the biodiversity of benthic bycatch, based on a count of the designated VME taxa present.

These differences set the New Zealand protocol apart from all others and it is not surprising that they have attracted such interest, commendation and criticism.

4. REVIEW OF THE BIODIVERSITY COMPONENT OF THE VME EVIDENCE PROCESS

At the time that the analyses conducted by Parker (2008) were discussed at the Deepwater Working Group and stakeholder consultations, questions were raised about the validity of using within-EEZ trawl data, and data for trawls targeting species such as hoki, to develop VME encounter protocols for deepwater trawls targeting species such as orange roughy on hills (D. Middleton, written comment). These were valid questions and should be addressed by means of comparative analyses using data for deepwater-species targeted trawls conducted in the SPRFMO Convention Area. A discussion of the number of taxa, and the retained weights of these taxa, that could be considered to constitute evidence of interaction with a VME on the high seas, should also be informed by such analyses. This section therefore provides an analysis comparative to that conducted by Parker (2008), using data for deepwater-species targeted bottom trawls conducted in the SPRFMO Convention Area.

4.1 Data used for updated analyses

Data used to update the analyses by Parker (2008) relating to taxa retained, benthic bycatch weight distributions, numbers of taxa caught per tow and cumulative weight frequency distributions were extracted from the MPI COD observer database and provided by the Fisheries Data Management team. Data used were tow-by-tow observer data for observed trawl tows that reported some benthic bycatch (i.e. not all observed tows) in the high seas SPRFMO Convention Area over the period 1987–2014 (although with very few records for 2014). The data consisted of multiple records per tow, one record per benthic taxon encountered on each tow, with trip number, tow number, fishing method, trawl type, benthic species code, common name and bycatch weight.

Of the total 5687 individual benthic bycatch records, 682 were deleted for rocks, mud, rubbish, fish eggs and oil, egg cases, wood, rubber, pipis, kina and unidentified invertebrates (codes EGC, EGG, INV, MUD, OIL, PPI, ROK, RUB, SEO, SUR, UNX, WOD, WRM, ZFM, ZFO, ZFP, ZFT, ZHG, ZHM, ZHP, ZHT, ZOO). A further 115 records with missing or zero weight (as a result of observers recording numbers or presence only, but not weight) were deleted. All analyses were restricted to bottom trawl tows only (excluding midwater, mixed or unknown trawls), resulting in deletion of a further 123 records. Individual benthic species were then aggregated up into higher taxonomic groups (shown in Appendix D), resulting in a final 4125 individual aggregated taxa records, representing 2532 bottom trawl tows that recorded weight of any benthic taxa. No other data checking or error correction, such as checking tow positions, was conducted.

The targets reported on these bottom trawl records were orange roughy, oreos, alfonsino, cardinalfish, tarakihi and boarfish as targets (codes BOE, BYS, BYX, CDL, OEO, ORH, SSO, TAR, YBO), confirming that these tows were indeed targeting the main deepwater species fished in the SPRFMO Convention Area. Of the 2532 tows recording any benthic taxa, 2237 were conducted over the period 2002–2014 since SPRFMO negotiations commenced, of which 1771 reported bycatches of at least one of the 11 VME Evidence Process taxa (see Appendix A). The totals of various tow records used in analyses is summarised in Table 3.

Table 3: Summary of number of observed tows with benthic bycatch in the observer data extract for the SPRFMO Convention Area, and the number of bottom trawl tows used for analyses over the period 2002–2014.

Total number of tows with benthic bycatch	2 884
Number of tows with weighed valid species	2 580
Bottom trawl tows only	2 532
Bottom trawl over 2002–2014 with benthic bycatch	2 237
Bottom trawl over 2002–2014 with VME evidence taxa	1 771

The VME Evidence Process groups benthic taxa into higher level taxonomic categories than some of the finer levels used by observers to report bycatch. Higher level taxonomic codes used in the VME Evidence Process, or at similar taxonomic levels (typically Class or Order), were allocated to each taxon using the allocated VME taxa codes listed in Appendix D (verified using the World Online Register of Marine Species). All analyses were then conducted using these allocated VME taxa codes. Most analyses were restricted to the period 2002–2014. All analyses were conducted in both R (version 3.0.3) and Microsoft Excel, checking to ensure that the same results were obtained using both sets of software. Final plots were produced in Excel.

4.2 Benthic bycatch weights-per-tow

The distribution of combined (all taxa) benthic bycatch weights per bottom trawl tow conducted in the SPRFMO Convention Area over the years 2002–2014 that did retain some benthic bycatch (n = 1480) is shown in Figure 4. In contrast with the results of Parker (2008) shown in Figure 2, which were based on data primarily from within the EEZ, a higher proportion of tows in the SPRFMO Convention Area have retained lower bycatch weights. Of the 1480 tows included, 87% reported less than 10 kg total (all species) benthic bycatch, and 97% reported less than 50 kg benthic bycatch.

This is a result of the shorter, typically hill-targeting, bottom trawls in the SPRFMO Convention Area generally making smaller benthic bycatches than longer flat-ground tows within the EEZ. However, occasional large benthic bycatch weights have been recorded, the maximum of 15 000 kg of unidentified coral on one tow in the SPRFMO Convention Area, compared to 20 000 kg reported by Parker (2008). The distribution of bycatch weights per tow is therefore highly skewed, with the few occasional larger catches increasing the average bycatch weight well above typical bycatch weights. This has important consequences when considering what threshold weights should be used to indicate evidence of an encounter with a VME in the SPRFMO Convention Area, particularly for the smaller and less frequently retained indicator species.

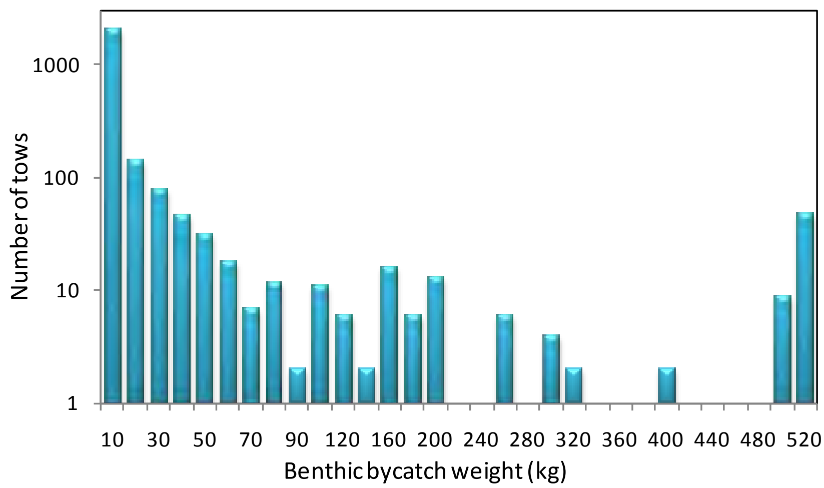

Figure 4: Frequency distribution of total benthic bycatch weights (all taxa summed) per tow for observed tows, bottom trawl only, conducted in the SPRFMO Convention Area over the years 2002–2014, which retained some benthic bycatch. The final weight category (520 kg) contains 49 tows that reported benthic bycatch weights over 500 kg. The maximum observed bycatch was 15 000 kg of unidentified coral.

The average benthic bycatch weights of the primary VME evidence process taxonomic groups have changed over time, related partially to the fact that species identification has improved. Figure 5 and Appendix C show the average weight per tow per year of each of the six primary VME evidence process taxonomic groups (for which threshold weights are used) over the years 2000–2013 (there were no records of these groups for 2014). Also shown is the average combined weight of all taxa, including the secondary VME evidence taxa and all taxa not used in the evidence process.

As noted and predicted by Parker (2008), there has been a steady improvement in species identification and a steady increase in the number of taxa reported by observers, particularly after about 2005. Early benthic bycatches tended to be reported primarily as unidentified corals or 'hydrozoa' (probably stony corals), with high average weights of these being reported in early years. Reporting of 'hydrozoa' has been replaced by increasing reporting of Scleractinia, presumably the correct identification, plus low weights of an increasing range of species.

There has been a tendency for bycatch weights to reduce over time, notably of the sponges. The combined average weight per tow of all species (including those not used in the VME process) has decreased markedly from peaks of 1489 kg and 727 kg in 2001 and 2004 to 5 kg or less in recent years (Figure 5). Parker (2008) ascribed a similar decline in bycatch weights within the EEZ to reduced abundance of benthic species in heavily trawled areas. This may also be an explanation in some of the more heavily trawled high seas areas such as the Challenger Plateau or central Louisville Ridge. However, it is also likely that improved operational fishing methods have reduced the degree of trawl impact on the seabed, as was reported in MFish (2008).

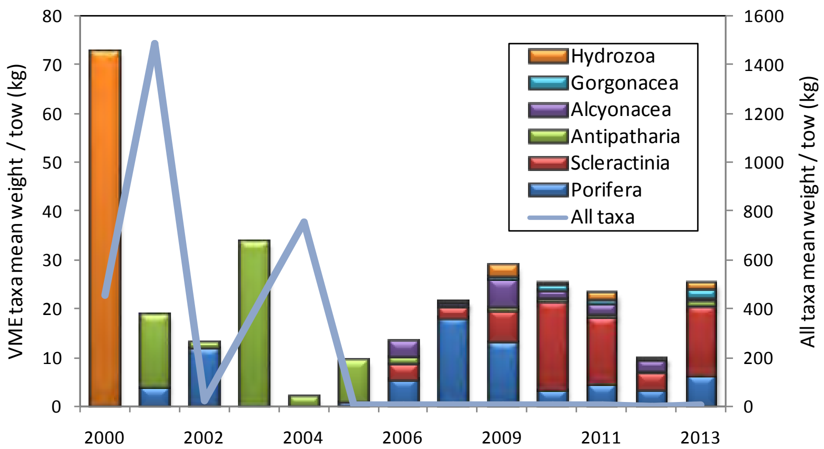

Figure 5: Average weights per tow (kg) of the six primary VME evidence process taxonomic groups caught by bottom trawl in the SPRFMO Convention Area over 2000–2013, and the average combined weight per tow of all benthic taxa, including species not used in the VME evidence process (data shown in Appendix C).

4.3 Number of VME taxa reported per tow

The main question being asked in the objectives is: the presence of how many taxa could be considered to provide evidence of a VME from a biodiversity perspective? Before considering how many VME taxa should be required to constitute evidence of a VME under the biodiversity component of the VME Evidence Process, it is informative to investigate how many taxa have typically been caught in bottom trawl tows in the SPRFMO Convention Area.

Table 4 shows a summary of the number of tows reporting different numbers of the 11 VME taxonomic groups used in the VME Evidence Process over different historical time periods from 1995 onwards, as well as the SPRFMO period of 2002–2014.

Table 4: Summary of the number of tows reporting different numbers of the 11 VME taxonomic groups used in the VME Evidence Process over various time periods.

Number of	Time period				SPRFMO
VME Taxa	1995–1999	2000–2004	2005–2009	2010–2014	2002–2014
1	122	264	266	752	1 149
2	7	6	127	275	407
3	1		58	82	140
4			29	27	56
5			6	6	12
6			2	2	4
7			1		1
Total	130	270	489	1 144	1 769

The numbers of tows reporting different numbers of the 11 VME Evidence Process taxa over the time periods in Table 4 are shown as percentages in Figure 6. Over all periods, most tows have reported a single VME 'taxon'. In early years, bycatch in virtually 100% of tows was reported as a single taxon as a result of benthos usually being classified as 'unidentified coral' of 'hydrozoa'. However, even in recent years, with about 150 different species codes being reported by observers, by the time these are grouped into the VME taxa used in the VME Evidence process, over half the tows still report only a single VME taxon. With improved identification, the total number of VME taxa reported has tended to increase over time with one tow over 2005–2009 reporting seven of the 11 VME taxa. The number of tows reporting three of the VME taxa (the presence of which would constitute evidence of a VME using the biodiversity score in the current VME Evidence Process) peaked at 11.9% over 2005–2009, decreasing again to 7.2% over 2010–2014.

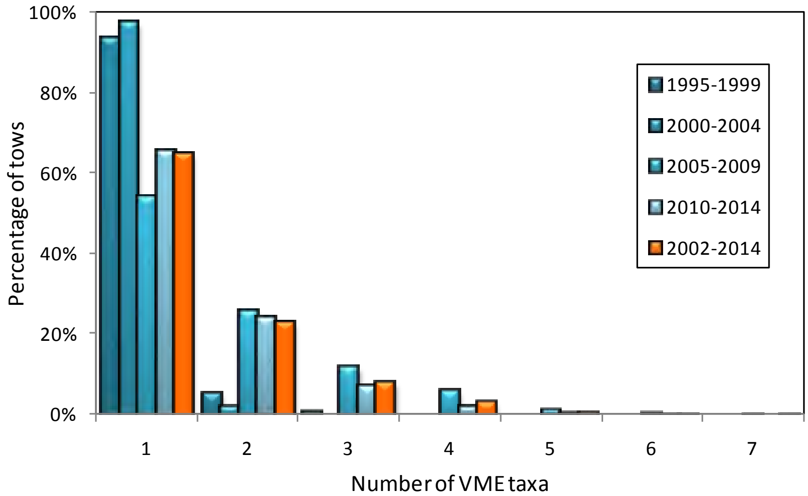

Figure 6: Percentage of tows reporting different numbers of the primary VME Evidence Process taxa over various time periods from 1995 onwards, and over the entire 2002–2014 period since SPRFMO started. The SPRFMO period is highlighted in orange.

The percentages of tows reporting various numbers of the VME evidence taxa over the entire 2002–2014 SPRFMO period is shown in Figure 7. Over that period, 65% of tows reported only one of the 11 VME evidence taxa, 23% reported two of the 11 VME taxa and 8% reported three of the VME taxa. Only 3% of tows recorded four VME evidence taxa and only 1% of tows recorded more than four VME evidence taxa. 8% of these tows would therefore have been considered to have encountered 'evidence of a VME', achieving a biodiversity score of three, even if none of the primary taxa threshold weights had been exceeded.

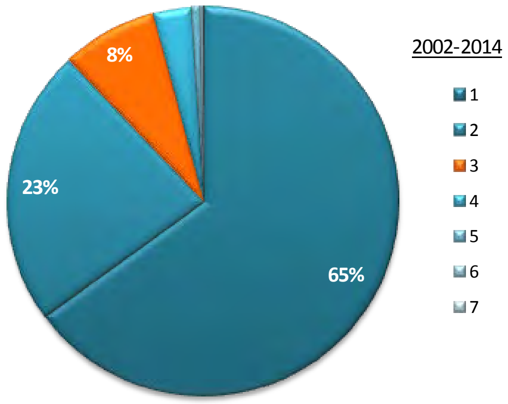

Figure 7: Percentage of tows reporting various numbers of the 11 VME evidence taxa over the period 2002–2014. The percentage of tows reporting three taxa (the number constituting evidence of a VME under the current VME Evidence Process) is highlighted in orange.

4.4 VME taxa cumulative weight frequencies

The second question being asked in the objectives is whether presence of a VME taxa is adequate to constitute evidence of a VME if a number of the VME species is encountered, or whether these species, when used as indicators, should all be required to exceed some weight threshold before being counted towards a VME evidence score. Discussion of this question is aided by some analysis of typical weights of the 11 VME evidence taxa that have historically been caught in bottom trawls in the SPRFMO Convention Area.

Parker (2008) conducted a cumulative weight frequency analysis for the primary VME taxa, in order to propose threshold weights for Porifera, Scleractinia, Antipatharia, Alcyonacea, Gorgonacea and Hydrozoa. Results of those analyses are repeated in Figure 3. However, he did not provide cumulative weight frequency analyses for the secondary indicator species used to contribute to the biodiversity score in the VME Evidence Process. He also primarily used data for within the EEZ, including tows targeting hoki on flat ground, prompting questions and concerns that within EEZ data would have produced different results from an analysis using high-seas deepwater-species targeted tows.

A cumulative weight-frequency analysis was therefore conducted using the same methods used by Parker (2008), but for all 11 of the VME evidence taxa using the SPRFMO Convention Area bottom trawl data for the period 2002–2014 described in Section 2.2. The resulting cumulative weight frequency curves for the 11 VME evidence taxonomic groups are shown in Figure 8 for the primary VME taxa and in Figure 9 for the secondary indicator taxa.

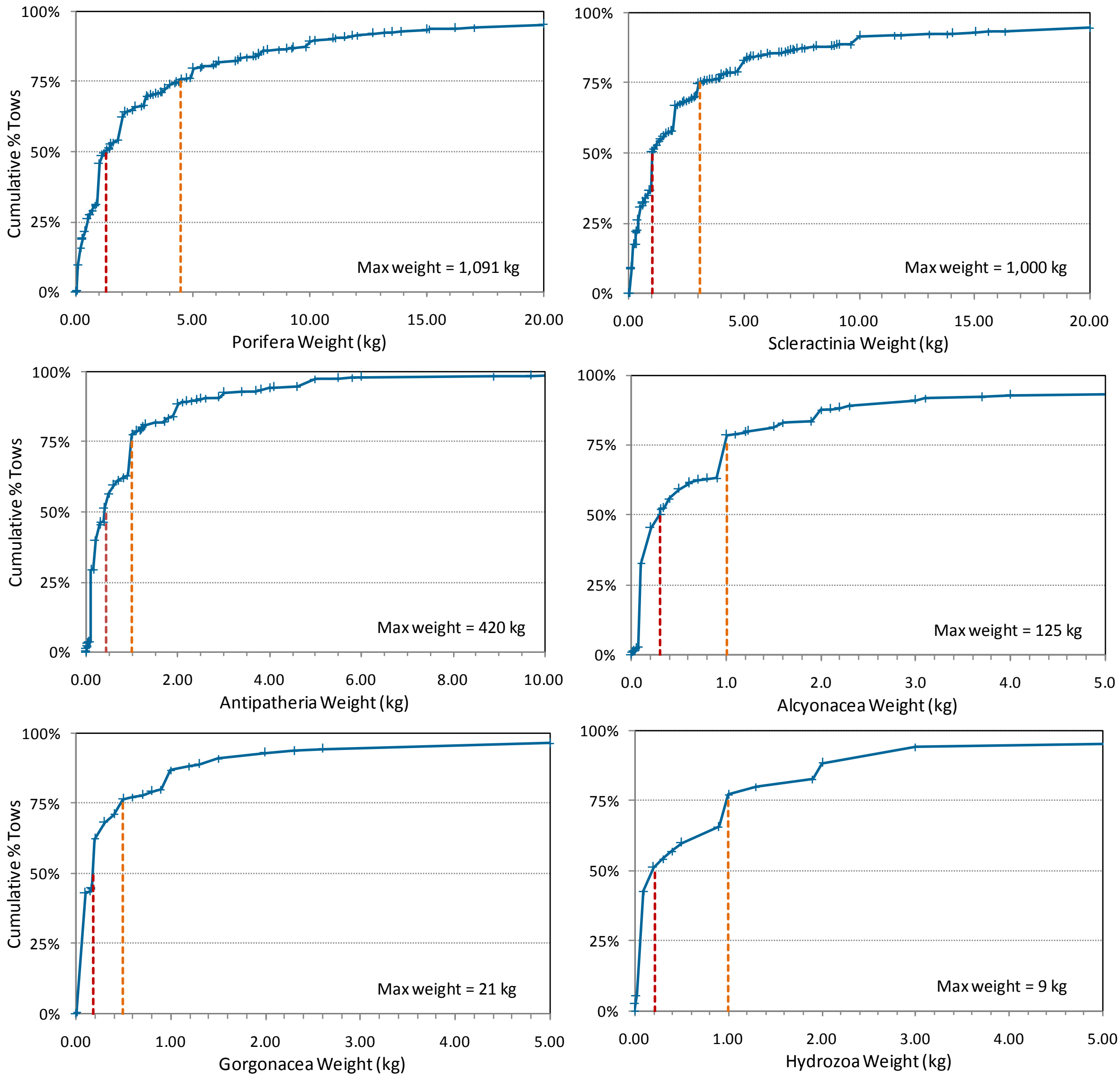

Figure 8: Cumulative weight frequency curves for primary VME taxa (for which weight thresholds are used) in the VME Evidence Process using observer data for bottom trawls only conducted in the SPRFMO Convention Area over the years 2002 to 2014. Red dashed lines indicate median (50%) threshold weight values and orange dashed lines indicate the 75% values, which are summarised in Table 5.

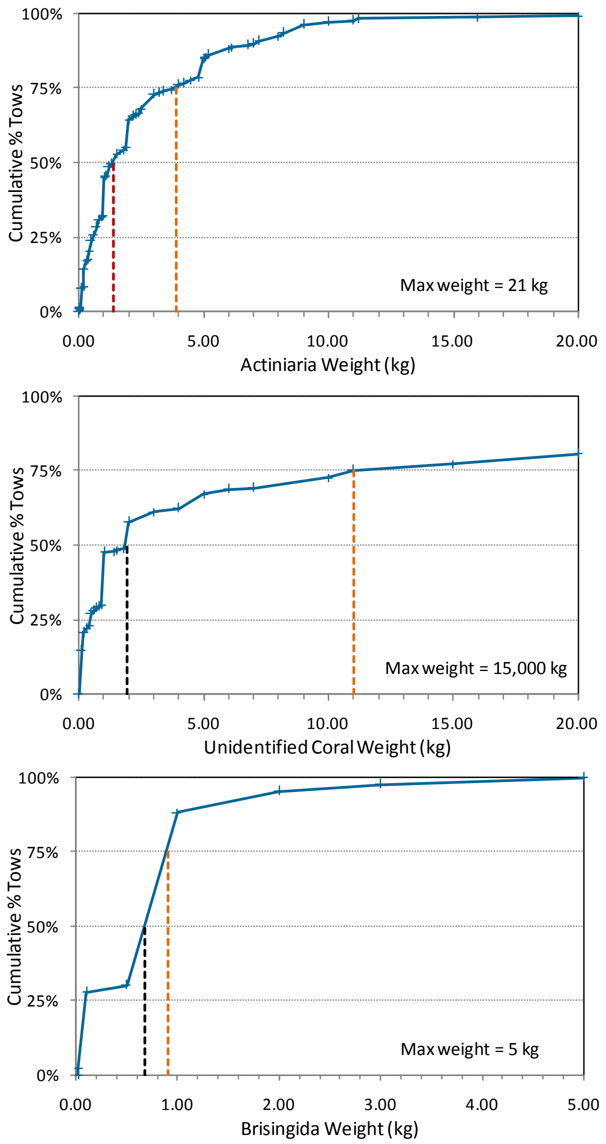

Figure 9: Cumulative weight frequency curves for secondary indicator VME taxa (for which weight thresholds are not used) in the VME Evidence Process using observer data for bottom trawl only conducted in the SPRFMO Convention Area over the years 2002 to 2014. Red dashed lines indicate median (50%) threshold weight values and orange dashed lines indicate the 75% values, which are summarised in Table 5.

As expected, the 50% threshold weights for all of the primary VME evidence taxa are substantially lower, when derived from the SPRFMO Convention Area bottom trawl data, than those derived by Parker (2008) using within-EEZ data. The fact that benthic bycatch weights are lower in deepwater-species targeted tows in the SPRFMO Convention Area is already evident from the comparison of Figure 2 and Figure 4. The approximate 50% cumulative weight values derived from these graphs for each of the 11 VME evidence taxa are summarised in Table 5, together with the number of tows reporting each taxonomic group over 2002–2014, the mean weights and the maximum reported weights of bycatch of these 11 taxa.

Table 5: Updated analysis of 50th and 75th percentile threshold weights (kg) for VME taxa used in the VME Evidence Process, using observer data for bottom trawl only conducted in the SPRFMO Convention Area over the years 2002–2014. Cumulative weight curves from which the median values are derived are shown in Figure 8 for primary taxa and in Figure 9 for indicator taxa.

	Primary taxa with threshold weights				
Taxon	No. of tows	50% weight kg	75% weight kg	Mean weight kg	Max weight kg
Porifera	412	1.30	4.5	7.9	1 091
Scleractinia	879	1.00	3.1	10.9	1 000
Antipatharia	460	0.43	1.0	2.2	420
Alcyonacea	288	0.30	1.0	2.6	125
Gorgonacea	146	0.18	0.5	0.9	21
Hydrozoa	50	0.22	1.0	24.5	9
	Indicator taxa without threshold weights				
Actiniaria	192	1.40	3.9	2.7	22
Pennatulacea	19	0.40	0.7	0.6	1
Unidentified coral	473	1.90	11.0	486.6	15 000
Crinoidea	12	0.07	0.1	0.4	2
Brisingida	43	0.68	0.9	0.9	5

This analysis shows that, using data for bottom trawl in the SPRFMO Convention Area only over the years 2002–2014, the 50% cumulative weight values for the primary taxa only reach or exceed 1 kg for Porifera (weight threshold in the VME evidence process 50 kg) and Scleractinia (weight threshold in the VME evidence process 30 kg), but only slightly, at 1.3 kg and 1.0 kg respectively. The 50% cumulative weight values for the indicator species exceed 1 kg for Actiniaria (1.4 kg) and Unidentified coral (1.9 kg). For all the other taxa, including the primary taxa of Antipatharia, Alcyonacea, Gorgonacea and Hydrozoa, 50% cumulative weight values are less than 0.5 kg. Despite occasional large catches of these taxa being made (up to 15 000 kg of unidentified coral), 50% of the catches of these species barely exceed 1 kg.

The 75% cumulative weight values for bycatches of these VME evidence taxa in the SPRFMO Convention Area over 2002–2014 are also below 1 kg for Gorgonacea, Pennatulacea, Crinoidea and Brisingida. 75% weight values are in the range 2–3 kg for Antipatheria, Alcyonacea, and Actiniaria and are only well above 1 kg for the broad taxonomic groups of Scleractinia (stony corals), Hydrozoa (previously used by observers as a general category for corals, probably including stony corals) and unidentified corals (primarily stony corals).

5. DISCUSSION AND RECOMMENDATIONS

Recommendations are provided in numbered boxes following the discussion within each section.
The process to develop an objective, evidence-based VME encounter protocol and move-on rule necessarily consists of a series of sequential and inter-dependent steps. The results at each step, and the extent to which they determine options in subsequent steps, are dependent on the geographic region under consideration, the operational characteristics of the fishery in that region (which will certainly change over time) and the data available to inform decisions at each step.

More importantly, it should be recognised from the outset that decisions made at each step depend on the priorities and values of the societal stakeholder groups contributing to those decisions. There is therefore no single correct, scientific, evidence-based answer to the questions that arise during development of an encounter protocol. The analyses presented here, and those previously presented by Parker (2008), and Parker et al. (2009) provide information on the sensible range within which those choices can be made, with some measure of the results of making choices at some point along that range.

The choices made at each stage, although they may be informed by the scientific analyses and evidence available, depend on the degree of risk-acceptance or risk aversion of the participants in the process. As noted by Ardron et al. (2014), there will be a higher likelihood of false positives if an encounter protocol is designed to be particularly sensitive, with areas containing small or isolated quantities of benthic organisms being considered to provide evidence of VMEs. Conversely, encounter protocols designed to be particularly insensitive will have a higher likelihood of false negatives, resulting in areas containing substantial and biodiverse benthic communities not being detected.

International experience has shown that the fishing industry tends to resist approaches with a higher likelihood of false positives. For example, the development of move-on rules at most RFMOs has been characterised by the initial development of rules with high threshold weights for only a couple of broad taxonomic categories, typically 'corals' and 'sponges'. These rules seem designed to trigger a move-on as seldom as possible (see reviews by Kenchington 2011, Hansen et al. 2013). Conversely, conservation organisations are opposed to approaches with a high risk of false negatives, arguing for encounter protocols to be made increasingly sensitive. The results is a trade-off between these views, often resulting in encounter protocols being initially designed to be insensitive and seldom triggered, until 'more work is done' to evaluate options. Over time, encounter protocols have then been made increasingly sensitive by specifying increasing number of indicator taxa for the region concerned and by decreasing threshold weights constituting evidence of an encounter with a VME (Hansen et al. 2013).

The following discussion and recommendations are intended to provide for an informed discussion of the 'biodiversity component' of the VME Evidence Process, so that participants can make informed choices within the ranges relating to each choice.

5.1 Data used to develop SPRFMO encounter protocols

Data for the SPRFMO Convention Area, and for fisheries operating in the way they do in the SPRFMO Convention Area, should preferably be used to support the development of encounter protocols for bottom fisheries in the SPRFMO Convention Area. Previous analyses by Parker et al. (2008) were questioned due to their primary reliance on data from within the New Zealand EEZ. At the time, this was necessitated by the small amount of observer data available for bottom fishing in the SPRFMO Convention Area. Participants have implemented 100% observer coverage on bottom trawling in the SPRFMO Convention Area since the adoption of the SPRFMO interim measures in 2007 and there is now a substantial amount of benthic bycatch data available for bottom trawling in the SPRFMO Convention Area.

1. SPRFMO VME encounter protocols should be based on analyses of data for bottom fishing activities in the SPRFMO Convention Area, using the gear type, targeting the species, and operating in the areas, in which the encounter protocol is intended to be applied.

5.2 Indicator taxa for the SPRFMO Region

This report has not reviewed the list of indicator taxa currently used in the VME Evidence Process and no recommendations are made to change these taxa. All analyses and all recommendations in this report therefore assume the current list of VME evidence taxa, both the primary taxa (with weight thresholds) and the indicator taxa (without weight thresholds). However, as Hansen et al. (2013) note, the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) has specified increasing numbers of taxa considered to be indicators of VMEs in the CCAMLR Area. They have divided sponges into the classes Hexactinellida and Demospongia and have included Cidaroida sea urchins as VME indicator species (Hansen et al. 2013). These taxa are also represented in SPRFMO bottom trawl catches.

Analyses presented in this report show that scientific observers are now recording over 150 benthic taxa in bottom trawl benthic bycatches in the SPRFMO Convention Area. The recent NIWA research voyage to the central Louisville Ridge (Project VMES133, Clark et al. 2014) collected underwater photographic images supported by dredge sampling of benthic communities that could be used to conduct an analysis of benthic community composition and associations, to provide recommendations on which species indicate the presence in the area of substantial habitat-forming taxa.

2. The list of benthic indicator taxa for the SPRFMO Convention Area, particularly secondary taxa indicating the presence of primary taxa, should be reviewed based on analyses of recent observer data and benthic community association imagery. Such benthic community association analyses could be particularly useful for determining which species, and perhaps how many of those species, could be considered to be reliable indicators of the presence of more important habitat forming taxa.

5.3 Number of taxa providing evidence of a VME

The current number of VME taxa constituting 'evidence of a VME' under the biodiversity component is a consequence of the original choice of Low=1 as a score for indicator species, with High=3 for a primary species exceeding its weight threshold, resulting in the overall score of 3 to trigger a move-on. As already emphasised, there is no 'correct' scientific answer to the number of species that would constitute evidence of a VME.

Central to discussion of this question is the call in UNGA Resolution 64/72 to "*implement appropriate protocols ... including definitions of what constitutes evidence of an encounter with a vulnerable marine ecosystem, in particular threshold levels and indicator species*" (UNGA 2010). Threshold levels and indicator species are potentially two separate concepts and this is how they have been interpreted in the VME Evidence Process. Threshold levels are used for primary habitat-forming VME taxa, considered individually to be potentially capable of forming VMEs, provided there is a large enough abundance of them to do so. The threshold levels should be set, taking into account the sampling efficiency of the fishing gear concerned, to indicate the presence of a high abundance of those habitat-forming taxa.

Indicator taxa, on the other hand, are just that - their presence indicates the presence of something else, in this case the presence of the habitat-forming taxa with which they are usually associated or on which they are dependent, such as crinoids and brisingids. Provided that the indicator species have been chosen to be appropriate (and for the purposes of this report it is assumed that they have been), then the number of species constituting evidence of a VME is a choice, depending on how risk-averse you wish to be, and how sensitive you want the encounter protocol to be. One view would be that any of those species, given that they are accepted as VME indicator species, provides evidence of the likely occurrence of the habitat-forming species with which they are usually associated. On the other hand, a small coral outcrop may support a few crinoids, neither of them constituting a VME.

The analyses provided in this report show that 65% bottom trawls in the SPRFMO Convention Area have retained only one of the 11 VME evidence taxa, as reported by observers. 23% of tows reported two VME taxa, 8% of the tows retained three VME evidence taxa over 2002–2014, 3% reported four taxa and only 1% reported more than four taxa (Figure 7). The maximum number of VME evidence taxa reported was seven, this only being reported once. The current stipulation of three taxa would have, based on the data set analysed, resulted in 8% of the bottom trawl tows that did retain any benthic taxa triggering a move-on rule, even if none of the weight thresholds for the primary taxa were exceeded.

3. The number of taxa to use to constitute evidence of a VME is a choice that depends on the desired sensitivity of the encounter protocol. There is a trade-off between a risk (of impacts on VMEs)-averse rule potentially giving false-positives, and a risk-prone rule potentially giving false negatives. The current value of three species would have resulted in 8% of tows constituting evidence of a VME. Decreasing this to two taxa would have increased the tows providing evidence of VMEs to 23%. Increasing this to four taxa would have reduced the tows providing evidence of a VME to 3%. More than four VME taxa were only reported in 1% of tows.

5.4 Weight thresholds for VME indicator taxa

Weight thresholds for VME taxa should be based on scientific analysis of the weight-frequency distributions of benthic bycatch in the fishery and region concerned (Hansen et al. 2013). The New Zealand VME Evidence Process was the first encounter protocol to be based on such an analysis and probably still constitutes best practice in this regard. However, the choice of the 50% cumulative weight level as the threshold level was not a scientific choice. It was a management choice such that half of the tows that did report that specific taxon would have triggered the move-on rule. This choice is again a trade-off between an insensitive protocol using higher thresholds (as has typically been initially adopted by RFMOs), and a sensitive protocol using low thresholds.

The analyses presented in this report, using data for bottom trawling in the SPRFMO Convention Area rather than the EEZ, show that the current weight thresholds for Porifera and Scleractinia determined using EEZ data are likely to be triggered very seldom, as a result of the lower weights of these taxa caught in the high-seas fishery. In the SPRFMO Convention Area, these are therefore likely to function more as indicator taxa. These analyses show further that the median thresholds for Actiniaria and Unidentified coral are less than 2 kg, with the 50% thresholds for the other taxa being less than 1 kg. If the 50% cumulative weight value is used as the threshold for these taxa, then application of weight thresholds to the other indicator taxa would result in them being set between 0.07 kg (Crinoidea) and 1.9 kg (unidentified coral) (Table 5). It is unclear how appropriate such a value would be for unidentified coral, given that the maximum reported catch of this category in the SPRFMO Convention Area was 15 000 kg.

Having such low individual weight thresholds for all of the indicator species would probably be impractical for observers to weigh on board ship, and would result in a protocol that was slower and more difficult to implement. In recognition of this, Parker (2008) presented the argument for using presence-only as an indicator of VME species given the poor efficiency of trawl nets at sampling most of these species quantitatively, and the difficulty of reliably determining weights under 1 kg on board ship. The current New Zealand approach of evaluating likelihood of VMEs based on a count of the species present in the bycatch has been recognised as an explicit approach to measuring biodiversity (Weaver et al. 2011, Hansen et al. 2013), similar to the species richness measures used to scientifically measure biodiversity.

Various RFMOs have also developed lists of indicator taxa for their respective regions, based on scientific analyses of bycatch composition. However, they have taken a different approach to the use of these lists of indicator taxa, establishing combined weight (or volume) thresholds for all these taxa combined (e.g. CCAMLR or the Australian SPRFMO encounter protocol, see Hansen et al. 2013), or dividing the indicator taxa into a few groups and establishing combined weight (or volume) thresholds for each group. This approach combines the two ideas of taking account of a pre-determined list of indicator species, but requiring these, in aggregate, to exceed some threshold before considering them to be evidence of a VME, although it loses the explicit measure of biodiversity.

4. Having developed a list of indicator taxa for a region, there would appear to be two choices for accounting for biodiversity in a VME encounter threshold using these taxa. If these are to be individually accounted for to provide a direct measure of biodiversity, then the current VME Evidence Process is an efficient and defensible way of doing so. Alternately, indicator taxa lists can be used to determine which species should be aggregated to determine whether the combined weight or volume thresholds for the indicator species or species groups has been exceeded. Threshold weight values for these taxa can be used to arrive at a threshold for the group.

5.5 Broader considerations regarding SPRFMO move-on rules

The New Zealand VME Evidence Process is unique in having a specific and separately stated biodiversity component (Hansen et al. 2013). RFMOs have tended to rather use indicator taxa lists to determine which species to use when evaluating bycatch against a group threshold value. The encounter protocol and move-on rule adopted by SPRFMO will have to be negotiated and accepted by all participants. It is therefore questionable whether it is worth putting substantial effort into independently revising the New Zealand approach, rather than initiating a process to develop proposals for a SPRFMO encounter protocol applicable to all participants. Having the most comprehensive data set, New Zealand would be in a position to take the lead in this process.

However, the use of move-on rules as a management measure for preventing significant adverse impacts on VMEs has been increasingly criticised as being ineffective at preventing impacts on VMEs if weight thresholds are set too high, and potentially resulting in spread of effort onto previously unfished areas if encounter thresholds are too sensitive. Kenchington (2011) noted that such protocols will be inefficient, if not ineffective or even counter-productive, for protecting VMEs, given that these are long-lived and sedentary. He considers that it will always be better to avoid encounters in the first place by closing areas before they are fished, rather than moving fishing vessels away after the damage is done.

Auster et al. (2010) remind us that the alternative approach envisaged in the FAO deep sea guidelines, but rarely implemented, is prior environmental impact assessments, followed by prior implementation of measures to “prevent significant impacts to VMEs”, before fishing is conducted. They conclude that, given the overlap between fishing grounds and location of VMEs, an ecosystem approach to management of deep-sea fisheries should include impact assessments, closed areas, gear restrictions, and fishing effort controls to prevent significant adverse impacts to VMEs.

Ardron et al. (2014) noted that, in the Northwest Atlantic, the encounter threshold for sponge bycatch (300 kg) is rarely met. In the Northeast Atlantic, where there is not an observer programme, no encounters above the coral-sponge thresholds have ever been reported. However, the NAFO and NEAFC encounter protocols cannot be considered in isolation but only as secondary measures for preventing significant adverse impacts on VMEs. From the outset, the NAFO Fisheries Council has placed primary reliance for protecting VMEs on coral and sponge protection zones closed to bottom-fishing activities for a period of two years in January 2010, as interim measures pending further review. Those closures protect much of the depth on the Flemish Cap where dense sponges occur and extend along the continental slope around the Nose of the Grand Bank. Similarly, the primary response by NEAFC has been to implement extensive closures of VME areas to bottom fisheries, with areas on Rockall and Hatton banks closed in 2007 to protect corals and extensive portions of the Mid-Atlantic Ridge closed in 2009 (Kenchington 2011).

In recognition of the shortcomings of move-on rules, the SPRFMO interim Scientific Working Group and Scientific Committee have recommended that move-on rules should not be relied on to prevent significant adverse impacts on VMEs and should be considered to be temporary measures until spatial protection measures can be implemented. The latest repetition of that recommendation, made at the first meeting of the SPRFMO Scientific Committee in La Jolla, USA in October 2013, is repeated here (from SPRFMO 2013).

5. Move-on rules should be considered to be temporary measures, providing precautionary protection for areas showing evidence of VMEs until objectively planned spatial closures can be implemented to protect known and highly bio-diverse VME areas (SPRFMO 2013).

6. MANAGEMENT IMPLICATIONS

The analyses presented in this report provide fisheries managers with scientific information to inform management choices and decisions relating to the design of a VME encounter protocol for high-seas bottom trawling activities in the SPRFMO Convention Area. In particular, in relation to the biodiversity component of the current New Zealand VME Evidence Process (see Appendix A), these analyses show the ranges in retained VME taxa weights, and in number of retained VME taxa, per bottom trawl tow in the SPRFMO Convention Area since 2002. The results of these analyses can be used to explore the implications of implementing encounter weight thresholds for VME indicator taxa at various levels along their respective cumulative weight frequency plots, and of varying the number of indicator taxa required to constitute evidence of a VME.

7. ACKNOWLEDGMENTS

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9. APPENDIX A: VME EVIDENCE PROCESS FORM

Vulnerable Marine Ecosystem Evidence Process (Version 1.0 - Apr 08)

1. Trip, tow, and vessel information

Trip number	Tow number	Observer/s	Name of vessel master
		. .	

2. Date, time, and position that hauling of the gear commenced

Date dd/mm/yy	Time 24-hr clock	Latitude Degrees Minutes	Longitude Degrees Minutes E/W
/ /	:	° . ' S	° . '

3. Instructions

Assess the total weights of all organisms whether dead or alive in each of the relevant taxonomic groups and record in Section 4.

If the Observed Weight of a taxonomic group is **greater than** (not equal to) the Threshold Weight, write the VME Indicator Score for that group in the "Score" Column.

If a taxonomic group is present, but the Observed Weight is **not** greater than the Threshold Weight, tick in the "Tick" column.

Sum the scores and count the ticks. Record these totals at the bottom of the columns. Add the Sum of scores to the Count of ticks and record it as the Total VME Indicator Score.

If the Total VME Indicator Score is 3 or greater, the area is considered to have Evidence of a Vulnerable Marine Ecosystem.

The taxonomic groups recorded on this form may not be a complete record of all benthic material present in the tow.

4. Relevant taxonomic groups, weights, and scores

Taxonomic Group	Code	Method of Weighting	Observed Weight (kg)	Threshold Weight (kg)	VME Indicator Score	Score if Threshold Weight exceeded	Tick if not scored but present
PORIFERA	ONG		.	50	3		
CNIDARIA							
Anthozoa (class)							
Actiniaria (order)	ATR		.	0	1		
Scleractinia (order)	SIA		.	30	3		
Antipatharia (order)	COB		.	1	3		
Alcyonacea (order)	SOC		.	1	3		
Gorgonacea (order)	GOC		.	1	3		
Pennatulacea (order)	PTU		.	0	1		
Hydrozoa (class)	HDR		.	6	3		
Unidentified Coral	COU		.	0	1		
ECHINODERMATA							
Crinoidea (class)	CRI		.	0	1		
Brisingida (order)	BRG		.	0	1		

Sum these scores + Count these ticks

Total VME Indicator Score → Sum of scores + count of ticks =

5. Vessel notification

As soon as the form is completed for any tow provide a copy to the person in charge of the vessel.

Name (if not vessel master)	Received by person in charge (signature)	Date received (dd/mm/yy)	Time received (24-hr clock)
		/ /	:

10. APPENDIX B: RATIONALE FOR INCLUDING TAXONOMIC GROUPS AS INDICATORS OF VMEs

The table below summarises the original rationale provided by Parker (2008) for including each taxonomic group in the New Zealand VME Evidence Process, including how a threshold weight was chosen and why it was considered to be important as a VME indicator.

Taxon	Rationale		
	Include/exclude	Threshold Weight	VME score
Porifera (Sponges)	Include both classes (Demospongiae and Hexactinellida). These are found in the deep sea, can form complex structures and are vulnerable to disturbance by fishing gears.	No data on individual classes are available to predict catches for each class, but the vulnerability of Hexactinellid sponges is likely to be higher. Data from new collections will aid in splitting Porifera into appropriate groups.	Sponge fields and large colonies form complex structures and may provide habitat for many species, justifying a Level 3. Longevity and resilience of cold-water sponges is unknown.
Cnidaria	Excluded as a grouping taxon because non-structure forming classes such as Scyphozoa (jellyfish) should not be included. However, it is listed on the “Evidence of a VME” form to show the structure of taxa included in the evaluation.		
Anthozoa	Excluded as a grouping taxon because several Anthozoan Orders are small, tropical in distribution, or not encountered in bottom fishing gear in the SPRFMO Convention Area. All Anthozoa should be classified to the appropriate order as shown on the form.		
Alcyonacea (Soft corals)	Include soft corals because they may provide structural habitat in the deep sea. Some species can become large.	These are usually small organisms, but some deep sea species may be large. Only 11 observations of Alcyonacea exist in the observer data since 1998, so this code should not be a dominant indicator, but when present it is useful.	Level 3- Specifically listed by FAO, so given high importance based on life history, but not likely to be a functional taxon for identification of VMEs. If found in high densities, they would be vulnerable to fishing gear.
Gorgonacea (Sea fans)	Included because these organisms may be large, fragile, and form complex biogenic structure. Although many families and species are identifiable by observers, actions would be the same, so they are pooled for rapid VME assessment.	This category was not used until recently, so may not represent high catch areas from 98–02. The distribution of catch weights shows 50% of catches having weights of 1 kg or less. As a 1 kg sample could still contain several species from this order, this method does not provide a separate index of diversity within the taxon.	Level 3- Gorgonians are specifically listed in the FAO guidelines as examples of vulnerable ecosystem components to protect. This group includes several large structure-forming species. Gorgonians are prime examples of the large, complex, low-productivity cold water corals the interim measures are designed to protect.
Pennatulacea (Sea pens)	Sea pens are not included in the NZ EEZ listing of benthic materials as corals, but are listed by	Although sea pens can occur in dense patches, previous observer data has only recorded very low	Level 1- Sea pens are specifically listed as VME examples by FAO guidelines, but do

		FAO guidelines for international waters and included here. They are typical of softer substrates but do provide complex structure, have been associated with fish species and are vulnerable to trawl gear because they can be tall and often live in trawlable habitat.	weights for individual tows leading to a low threshold of only 1 kg, but this is likely to be an underestimate due to limited distribution deeper than 200 m or retention in the net after dumping catch. A presence / absence indicator is all that is necessary.	not indicate hard substrate or stony corals. They do, however, suggest a different type of VME. They are scored here as in indicator of habitat containing vertical structure but do not qualify as evidence of a VME alone. Categorizing this group is still under discussion at international levels.
	Actiniaria (Anemones)	Anemones are not listed by FAO (2007), but are indicators of hard substrate and habitats which support corals, so are included as an indicator of vulnerable species. They can also be endemic, and large with unknown longevity and productivity.	Anemones are variable in size, but can be abundant. As an indicator of habitat suitable for corals, a presence / absence indicator is all that is necessary.	Level 1- As an indicator of other VME components, a low importance of 1 effectively utilizes anemones as an indicator group. However, longevity and resilience of deep-sea anemones is an area of uncertainty and active research.
	Scleractinia (Stony corals)	Include the stony corals, especially complex branching taxa which form thickets or large mounds, are specifically listed by FAO guidelines as one of the main target taxonomic groups of the VME definition.	Various size organisms exist in different subtaxa. They are fragile and brittle, and not well retained in trawl gear- so a low threshold is expected. However, these were often coded as COU (Unidentified coral), which for 1998–2002 had a median weight of 30 kg. No data exists to separate catches of smaller cup corals from branching corals, but these will be collected in the future.	Level 3- These are slow growing, structure-forming species vulnerable to disturbance by fishing gear, with unknown recovery rates. Accordingly, a high importance is given.
	Antipatharia (Black corals)	Included because black corals are structure-forming, complex structures, and vulnerable to fishing gear.	The organisms are relatively light and fragile in structure, so a low weight is expected. This is supported by observer data showing that 50% of samples weigh less than 1 kg.	Level 3- These are low productivity, structure-forming species vulnerable to fishing gears and are also specifically protected in NZ waters.
Hydrozoa (Hydroids and Stylasterids)		Include because this taxon includes hydrocorals, which are specifically listed by FAO. It also includes smaller hydroids, but species codes do not separate these two groups. Further, most hydroids are very small, so they may not fit biologically with the characteristics of hydrocorals, such as Stylasterids, which can be very large. Considering only Stylasterids leaves the smaller hydroids ignored and slightly underestimates total Hydrozoa weight.	Some of these individuals can be very large, and they can found at high densities. 50% of tows catching Stylasterids catch less than 6 kg, but as these also occur as smaller individuals that may be colonizing impacted areas, many colonies could be impacted before 6 kg is retained in recovering areas.	Level 3- This class contains several NZ protected species in the *Errina* genus. They may also form very large complex, yet brittle structures.

Unidentified Coral	Specimens that cannot be placed in an Order still provide information that the area either recently or still does support vulnerable taxa. It is included here as a separate indicator of VME habitat.	Skeletal fragments are indicators of habitat suitability for live corals and may even be part of the base of a live coral specimen. However, large quantities are not recorded in the database. They are likely not well retained by trawl gear.	Level 1. Unidentified Coral is only considered as a suitable habitat indicator if dead or degraded specimens occur. However, for truly unknown corals, the new information would be incorporated into future VME scoring methods.
Echinodermata-Crinoids	This group of Echinoderms is associated with hard substrates and often with coral so it is included as an indicator. They are not however, specifically listed by FAO as vulnerable taxa, and do not possess the life history traits that FAO considered vulnerable when defining VMEs.	As crinoids are relatively small and light, and infrequently observed in the catch, 50% of catches are less than 1 kg. Crinoids are only recorded 9 times since 1998, so may not provide a useful indicator.	Level 1-Once detected, crinoids would still only be an indicator of hard substrate, so a Level 1 score is used.
Echinodermata-Brisingid stars	Brisingid stars (armless stars) inhabit hard substrates and are often found with corals.	These stars have not been recorded specifically during the target period, but newer observations using the benthic materials form should provide data on their distribution and relative abundance.	These stars are indicators of suitable habitat only, and used as a Level 1 score.
Diversity Index	The "Evidence of a VME" form incorporates taxonomic diversity in a crude manner, especially if several taxa are observed below the threshold weight. Full discussion of a diversity index is more appropriate during an annual review of areas to be designated as a VME and is discussed under those criteria.	A coarse diversity index is accomplished simply by identifying groups that were observed but below their weight threshold, establishing a presence- absence scale at the Order level.	Biodiversity is scaled by adding 1 point per listed taxa at the Order level.

11. APPENDIX C: AVERAGE WEIGHTS OF BENTHIC TAXA PER TOW

Average weight of all benthic taxa retained per tow per year on observed tows, bottom trawl only, in the SPRFMO Convention Area over the period 1995–2013. The table is divided into the primary VME taxa used with weight thresholds in the VME Evidence Process, VME indicator taxa used without weight thresholds in the VME Evidence Process and other taxa not currently included in the VMW Evidence Process.

Taxon	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006	2008	2009	2010	2011	2012	2013	1995-2013
Porifera		2.0	9.5		4.0	12.0			1.0	5.6	18.1	13.3	3.3	4.6	3.5	6.2	7.9
Scleractinia										3.2	2.2	6.4	18.2	13.8	3.3	14.3	10.9
Antipatharia		1.5	1.0		14.8	1.3	33.9	2.0	8.4	1.4	0.4	0.8	0.6	0.6	0.5	1.2	2.2
Alcyonacea										3.2	0.7	5.6	1.7	2.1	2.4	0.6	2.6
Gorgonacea											0.2	0.7	1.2	0.9	0.1	1.7	0.9
Hydrozoa		165.0		72.9							0.0	2.4	0.3	1.4	0.1	1.2	24.5
Actiniaria		1.0	1.0					5.3		6.4	0.2	1.2	2.2	1.7	3.2	0.5	2.7
Pennatulacea												0.8	0.5	0.2			0.6
Anthozoa	200.0	1107.3	400.8	544.0	2411.5	24.7	597.1	1020.8	5.0	7.4	0.2	0.7	0.4	0.7	0.4	0.1	486.6
Crinoidea										1.0		0.1	1.1	0.1	0.1	0.3	0.4
Brisingida										2.1	0.0		0.6	0.4	0.9		0.9
Ascideacea				2.0						1.0		0.3					0.9
Asteroidea			1.0							4.7	0.2	3.0	1.3	1.3	1.1	1.3	2.1
Bryozoa																4.0	4.0
Crustacea			1.0	1.0					1.0		0.9	2.1		0.2		0.3	1.2
Echinodermata			1.0	10.0				2.0		1.1			1.0	0.3			1.5
Echinoidea		3.7	5.8	3.0		25.0	13.0			3.7	1.0	1.0	3.1	1.7	1.2	2.6	2.6
Holothuroidea								1.0		1.0		1.6	6.9	2.0	1.3	1.7	2.8
Mollusca		5.0	2.5							1.3		0.7	2.0	0.8	0.7		1.4
Ophiuroidea										2.5	0.2	0.7	2.9	0.7	1.1	1.0	1.6
Polychaeta										1.0							1.0
Pycnogonida										1.0		1.0		1.0			1.0
Thaliacea										23.7		1.1	5.7			2.5	6.2
All taxa	200.0	903.3	287.2	453.1	1488.8	21.7	387.8	756.3	6.9	4.0	3.4	5.0	6.6	3.9	2.0	5.4	59.9

12. APPENDIX D: BENTHIC TAXONOMIC CLASSIFICATION

Benthic taxonomic codes used by scientific observers in reporting benthic bycatch in the SPRFMO Convention Area

Species	Common_Name	Taxonomic_Group	Code	Level	VME_Group	Level	Code
ACN	Bushy bamboo coral	Alcyonacea	SOC	Order	Alcyonacea	Order	SOC
ACS	Deepsea anemone	Actiniaria	ATR	Order	Actiniaria	Order	ATR
AEL	Astroceras elegans	Ophiuroidea	OPH	Class	Ophiuroidea	Class	OPH
ANT	Anemones	Actiniaria	ATR	Order	Actiniaria	Order	ATR
APU	Maroon pimpled ear sponge	Demospongia	DMO	Class	Porifera	Phylum	ONG
ARA	Tam o' shanter urchin	Euechinoidea	URC	Subclass	Echinoidea	Class	URC
ARO	Anthomastus robustus	Alcyonacea	SOC	Order	Alcyonacea	Order	SOC
ASC	Sea squirt	Ascideacea	ASC	Class	Ascideacea	Class	ASC
ASR	Asteroid (starfish)	Asteroidea	STG	Class	Asteroidea	Class	STG
ATR	Sea anemones	Actiniaria	ATR	Order	Actiniaria	Order	ATR
AWA	Astrothorax waitei	Ophiuroidea	OPH	Class	Ophiuroidea	Class	OPH
BAM	Bathyplotes spp.	Holothuroidea	HOL	Class	Holothuroidea	Class	HOL
BCH	Brisinga chathamica	Brisingida	BRG	Order	Brisingida	Order	BRG
BES	Benthopecten spp.	Asteroidea	STG	Class	Asteroidea	Class	STG
BHE	Bathypectinura heros	Ophiuroidea	OPH	Class	Ophiuroidea	Class	OPH
BIV	Bivalves unidentified	Bivalvia	BIV	Class	Mollusca	Phylum	MOL
BOC	Deepsea anemone	Actiniaria	ATR	Order	Actiniaria	Order	ATR
BOO	Bamboo coral	Alcyonacea	SOC	Order	Alcyonacea	Order	SOC
BPI	Benthopecten pikei	Asteroidea	STG	Class	Asteroidea	Class	STG
BRG	Brisingida (Order)	Brisingida	BRG	Order	Brisingida	Order	BRG
BRN	Barnacle	Crustacea	CRU	Subphylum	Crustacea	Subphylum	CRU
BTP	Bathypathes spp.	Antipatharia	COB	Order	Antipatharia	Order	COB
CAL	Giant purple pedinid	Non-cidaroid Echinoid	URC	Class	Echinoidea	Class	URC
CAY	Caryophyllia spp	Scleractinia	SIA	Order	Scleractinia	Order	SIA
CBB	Coral rubble	Anthozoa	ANT	Class	Anthozoa	Class	COU
CBR	Stony branching corals	Scleractinia	SIA	Order	Scleractinia	Order	SIA
CDY	Cosmasterias dyscrita	Asteroidea	STG	Class	Asteroidea	Class	STG
CFU	Smooth white cup sponge	Demospongia	DMO	Class	Porifera	Phylum	ONG
CHR	Golden coral	Alcyonacea	SOC	Order	Alcyonacea	Order	SOC
CJA	Sun star	Asteroidea	STG	Class	Asteroidea	Class	STG
CLG	Callogorgia spp.	Alcyonacea	SOC	Order	Alcyonacea	Order	SOC
CLL	Precious coral	Alcyonacea	SOC	Order	Alcyonacea	Order	SOC
CMP	Cheiraster monopedicellaris	Asteroidea	STG	Class	Asteroidea	Class	STG
CMT	Feather star	Crinoidea	CRI	Class	Crinoidea	Class	CRI
COB	Black coral	Antipatharia	COB	Order	Antipatharia	Order	COB
COF	Flabellum coral	Scleractinia	SIA	Order	Scleractinia	Order	SIA
COR	Hydrocorals	Hydrozoa	HDR	Class	Hydrozoa	Class	HDR
COU	Coral (unspecified)	Anthozoa	ANT	Class	Anthozoa	Class	COU
COZ	Bryozoan	Bryozoa	BZN	Phylum	Bryozoa	Phylum	BZN
CPA	Pentagon star	Asteroidea	STG	Class	Asteroidea	Class	STG
CRE	White hydrocoral	Hydrozoa	HDR	Class	Hydrozoa	Class	HDR
CRI	Sea lilies	Crinoidea	CRI	Order	Crinoidea	Class	CRI
CRM	Airy finger sponge	Demospongia	DMO	Class	Porifera	Phylum	ONG
CRN	Sea lily, stalked crinoid	Crinoidea	CRI	Order	Crinoidea	Class	CRI
CRU	Crustacea	Crustacea	CRU	Subphylum	Crustacea	Subphylum	CRU
CTP	Calyptrophora spp.	Alcyonacea	SOC	Order	Alcyonacea	Order	SOC
CUP	Stony cup corals	Scleractinia	SIA	Order	Scleractinia	Order	SIA
DDI	Desmophyllum dianthus	Scleractinia	SIA	Order	Scleractinia	Order	SIA
DEN	Dendrobathypathes spp.	Antipatharia	COB	Order	Antipatharia	Order	COB
DHO	Sea urchin	Euechinoidea	URC	Subclass	Echinoidea	Class	URC
DMG	Dipsacaster magnificus	Asteroidea	STG	Class	Asteroidea	Class	STG
ECB	Erect cyclostome bryozoans	Bryozoa	BZN	Phylum	Bryozoa	Phylum	BZN
ECH	Echinoderms	Echinodermata	ECH	Phylum	Echinodermata	Phylum	ECH
ECN	Echinoid (sea urchin)	Non-cidaroid Echinoid	URC	Class	Echinoidea	Class	URC
ECT	Echinothuriidae (family)	Non-cidaroid Echinoid	URC	Class	Echinoidea	Class	URC
EEX	Enypniastes eximia	Holothuroidea	HOL	Class	Holothuroidea	Class	HOL

EPZ	Epizoanthus spp.	Zoantharia	ZOT	Order	Anthozoa	Class	COU
ERE	Basket-weave horn sponge	Hexactinellida	HXY	Class	Porifera	Phylum	ONG
ERO	Deepwater branching coral	Scleractinia	SIA	Order	Scleractinia	Order	SIA
ERR	Red coral	Hydrozoa	HDR	Class	Hydrozoa	Class	HDR
ESI	Lacey tube sponge	Hexactinellida	HXY	Class	Porifera	Phylum	ONG
FAR	Lacey honeycomb sponge	Hexactinellida	HXY	Class	Porifera	Phylum	ONG
FMA	Fusitriton magellanicus	Gastropoda	GAS	Class	Mollusca	Phylum	MOL
GAS	Gastropods	Gastropoda	GAS	C;ass	Mollusca	Phylum	MOL
GDU	Bushy hard coral	Scleractinia	SIA	Order	Scleractinia	Order	SIA
GLO	Goblin prawn	Crustacea	CRU	Subphylum	Crustacea	Subphylum	CRU
GLS	Glass sponges	Hexactinellida	HXY	Class	Porifera	Phylum	ONG
GOC	Gorgonian coral	Gorgonacea	GOC	Order	Gorgonacea	Order	GOC
GOR	Gorgonocephalus spp	Ophiuroidea	OPH	Class	Ophiuroidea	Class	OPH
GRE	Curling stone sponge	Demospongiae	ONG	Class	Porifera	Phylum	ONG
GRM	Sea urchin	Euechinoidea	URC	Subclass	Echinoidea	Class	URC
GVE	Ostrich egg sponge	Demospongiae	ONG	Class	Porifera	Phylum	ONG
GYS	Siboga sea pen	Pennatulacea	PTU	Order	Pennatulacea	Order	PTU
HDF	Feathery hydroids	Hydrozoa	HDR	Class	Hydrozoa	Class	HDR
HDR	Hydroid	Hydrozoa	HDR	Class	Hydrozoa	Class	HDR
HEC	Henricia compacta	Asteroidea	STG	Class	Asteroidea	Class	STG
HIS	Histocidaris spp.	Cidaroida	CVD	Order	Echinoidea	Class	URC
HMT	Deepsea anemone	Actiniaria	ATR	Order	Actiniaria	Order	ATR
HTH	Sea cucumber	Holothuroidea	HOL	Class	Holothuroidea	Class	HOL
HTR	Trojan starfish	Asteroidea	STG	Class	Asteroidea	Class	STG
HYA	Floppy tubular sponge	Hexactinellida	HXY	Class	Porifera	Phylum	ONG
IRI	Iridescent coral	Alcyonacea	SOC	Order	Alcyonacea	Order	SOC
ISI	Bamboo corals	Alcyonacea	SOC	Order	Alcyonacea	Order	SOC
LAG	Laetmogone spp.	Holothuroidea	HOL	Class	Holothuroidea	Class	HOL
LEI	Leiopathes spp.	Antipatharia	COB	Order	Antipatharia	Order	COB
LIP	Deepsea anemone	Actiniaria	ATR	Order	Actiniaria	Order	ATR
LLE	Bamboo coral	Alcyonacea	SOC	Order	Alcyonacea	Order	SOC
LNV	Rock star	Asteroidea	STG	Class	Asteroidea	Class	STG
LPT	Spiny lace coral	Hydrozoa	HDR	Class	Hydrozoa	Class	HDR
LSE	Leiopathes secunda	Antipatharia	COB	Order	Antipatharia	Order	COB
MNI	Munida unidentified	Crustacea	CRU	Subphylum	Crustacea	Subphylum	CRU
MOC	Madrepora oculata	Scleractinia	SIA	Order	Scleractinia	Order	SIA
MSL	Starfish	Asteroidea	STG	Class	Asteroidea	Class	STG
MTL	Metallic coral	Alcyonacea	SOC	Order	Alcyonacea	Order	SOC
NAR	Rasta coral	Alcyonacea	SOC	Order	Alcyonacea	Order	SOC
NUD	Nudibranchia	Gastropoda	GAS	Class	Mollusca	Phylum	MOL
OAB	Ophiactis abyssicola	Ophiuroidea	OPH	Class	Ophiuroidea	Class	OPH
OBE	Cidarid urchin	Cidaroidea	URC	Subclass	Echinoidea	Class	URC
ODT	Pentagonal tooth-star	Asteroidea	STG	Class	Asteroidea	Class	STG
ONG	Sponges	Porifera	ONG	Phylum	Porifera	Phylum	ONG
OPH	Ophiuroid (brittle star)	Ophiuroidea	OPH	Class	Ophiuroidea	Class	OPH
OSI	Ophiocreas sibogae	Ophiuroidea	OPH	Class	Ophiuroidea	Class	OPH
OVI	Oculina virgosa	Scleractinia	SIA	Order	Scleractinia	Order	SIA
PAB	Bubblegum coral	Alcyonacea	SOC	Order	Alcyonacea	Order	SOC
PAM	Pannychia moseleyi	Holothuroidea	HOL	Class	Holothuroidea	Class	HOL
PAO	Pillsburiaster aoteanus	Asteroidea	STG	Class	Asteroidea	Class	STG
PCD	Cidarid urchin	Cidaroida	CVD	Order	Echinoidea	Class	URC
PDO	Southern tuatua	Bivalvia	BIV	Class	Mollusca	Phylum	MOL
PFL	Sea urchin	Euechinoidea	URC	Subclass	Echinoidea	Class	URC
PHB	Grey fibrous massive sponge	Demospongia	DMO	Class	Porifera	Phylum	ONG
PHI	Peronella hinemoae	Non-cidaroid Echinoid	URC	Class	Echinoidea	Class	URC
PHM	Phormosoma spp.	Non-cidaroid Echinoid	URC	Class	Echinoidea	Class	URC
PHW	Psammocinia cf hawere	Demospongia	DMO	Class	Porifera	Phylum	ONG
PKN	Abyssal star	Asteroidea	STG	Class	Asteroidea	Class	STG
PLE	Sea fans	Gorgonacea	GOC	Order	Gorgonacea	Order	GOC
PLN	Chipped fibreglass matt sponge	Demospongia	DMO	Class	Porifera	Phylum	ONG
PMN	Primnoa spp.	Alcyonacea	SOC	Order	Alcyonacea	Order	SOC
PMO	Pseudostichopus mollis	Holothuroidea	HOL	Class	Holothuroidea	Class	HOL
POL	Polychaete	Polychaeta	POL	Class	Polychaeta	Class	POL
PRI	Primnoidae	Alcyonacea	SOC	Order	Alcyonacea	Order	SOC

PRU	Pseudechinaster rubens	Asteroidea	STG	Class	Asteroidea	Class	STG
PSE	Sea urchin	Non-cidaroid Echinoid	URC	Class	Echinoidea	Class	URC
PSI	Geometric star	Asteroidea	STG	Class	Asteroidea	Class	STG
PTP	Parantipathes spp.	Antipatharia	COB	Order	Antipatharia	Order	COB
PTU	Sea pens	Pennatulacea	PTU	Order	Pennatulacea	Order	PTU
PYC	Sea spiders	Pycnogonida	PYC	Class	Pycnogonida	Class	PYC
PYR	Pyrosoma atlanticum	Thaliacea	THA	Class	Thaliacea	Class	THA
RGR	Radiaster gracilis	Asteroidea	STG	Class	Asteroidea	Class	STG
SBN	Stalked barnacle	Crustacea	CRU	Subphylum	Crustacea	Subphylum	CRU
SIA	Stony corals	Scleractinia	SIA	Order	Scleractinia	Order	SIA
SLG	Sea slug	Gastropoda	GAS	Class	Mollusca	Phylum	MOL
SLT	Orange fat finger sponge	Demospongiae	ONG	Class	Porifera	Phylum	ONG
SMO	Cross-fish	Asteroidea	STG	Class	Asteroidea	Class	STG
SOC	Soft coral	Alcyonacea	SOC	Order	Alcyonacea	Order	SOC
SOT	Solaster torulatus	Asteroidea	STG	Class	Asteroidea	Class	STG
SPN	Sea pen	Pennatulacea	SPN	Order	Pennatulacea	Order	PTU
SPT	Heart urchin	Non-cidaroid Echinoid	URC	Class	Echinoidea	Class	URC
STI	Stichopathes spp.	Antipatharia	COB	Order	Antipatharia	Order	COB
STP	Solitary bowl coral	Scleractinia	SIA	Order	Scleractinia	Order	SIA
SUR	Kina	Non-cidaroid Echinoid	URC	Class	Echinoidea	Class	URC
SVA	Solenosmilia variabilis	Scleractinia	SIA	Order	Scleractinia	Order	SIA
TAM	Tam o shanter urchin	Non-cidaroid Echinoid	URC	Class	Echinoidea	Class	URC
THO	Bottlebrush coral	Alcyonacea	SOC	Order	Alcyonacea	Order	SOC
TLD	Furry oval sponge	Demospongia	DMO	Class	Porifera	Phylum	ONG
TLO	Encrusting long polyps, coral	Alcyonacea	SOC	Order	Alcyonacea	Order	SOC
TPT	Trissopathes spp.	Antipatharia	COB	Order	Antipatharia	Order	COB
TTL	Bristle ball sponge	Demospongia	DMO	Class	Porifera	Phylum	ONG
TUL	Sea tulip	Ascideacea	ASC	Class	Ascideacea	Class	ASC
URO	Sea urchin other	Non-cidaroid Echinoid	URC	Class	Echinoidea	Class	URC
WHE	Whelks	Gastropoda	GAS	Class	Mollusca	Phylum	MOL
ZOR	Rat-tail star	Asteroidea	STG	Class	Asteroidea	Class	STG