South Pacific Regional Fisheries Management Organisation

12th MEETING OF THE SCIENTIFIC COMMITTEE

30 September to 05 October 2024, Lima, Peru

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Encounter Review Standard for the SPRFMO

New Zealand

South Pacific Regional Fisheries Management Organisation

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Contents

SPRFMO Encounter Review Standard

1. Encounter Review Standard sections

Supporting background information is given in Appendix A. Appendix B provides step-by-step checklists to support the reviews of the Member or Cooperating non-Contracting Party (CNCP) and the Scientific Committee. Appendix C provides information relevant to the definition and distribution of vulnerable marine ecosystems (VMEs) and significant adverse impacts (SAIs). Appendix D provides example of different methodologies to help assess bottom fishing impacts on VMEs. Appendix E provides a compilation of relevant and up-to-date datasets and reports that can be used to inform the review processes described in this standard.

2. Requirements to review encounters with potential VMEs

The Conservation and Management Measure for the Management of Bottom Fishing in the SPRFMO Convention Area (CMM 03[1]) requires that where VME indicator taxa are encountered in any one tow at or above the weight threshold in Annex 6A, or three or more different VME indicator taxa at or above the weight thresholds in Annex 6B, Members and CNCPs shall require any vessel flying their flag to cease bottom fishing immediately within an encounter area of one (1) nautical mile either side of the trawl track extended by one (1) nautical mile at each end (hereafter referred to as the encounter area). Vessels are then required to report the encounter immediately to the Member or CNCP whose flag the vessel is flying and to the Secretariat, in accordance with the Guidelines for the preparation and submission of notifications of encounters with potential VMEs, contained in Annex 7 of CMM 03.

In the event of an encounter, Members and CNCPs are required to cooperate to the extent possible with the Secretariat and other Members or CNCPs engaged in bottom fishing to exchange such data and information as may be relevant to the Scientific Committee's consideration of the encounter area. To this effect, The Secretariat may request all Members and CNCPs to provide relevant data (either directly to the Member or through the Secretariat) once an encounter occurs. If data cannot be provided by other bottom fishing Members or CNCPs within 90 days since the Secretariat's request, for example because of confidentiality concerns and time or legal challenges, the Member or CNCP should have the discretion to conduct a review with the information available.

Members and CNCPs are required to submit to the Scientific Committee a detailed description of each encounter by vessels flying their flag that resulted in a temporary suspension pursuant to paragraph 28 of CMM 03, a review of the encounter and suggested management actions to prevent SAIs on VMEs. As part of the review process, members and CNCPs are required to provide as much detail as possible to verify whether a VME is likely to be present at the encounter area and/or the surrounding area, whether a significant adverse impact has occurred, and the risk of a significant adverse impact occurring in the future if bottom fishing within the encounter area is to resume.

The Scientific Committee, at its next annual meeting, is required to review all encounters reported, once the relevant Member or CNCP has provided its reviews, and provide advice on management actions proposed by the relevant Member or CNCP and any alternate or additional management actions the Scientific Committee considers appropriate to prevent SAIs on VMEs.

The Commission then determines, based on advice from the Scientific Committee, management actions for each encounter to prevent SAIs on VMEs, which may include: the closing of areas to some or all bottom fishing gear, temporal restrictions, spatial restrictions and reopening areas.

This standard presents the required components of the Member or CNCP (Section 3) and the Scientific Committee (Section 4) reviews of encounters with potential VMEs.

3. Member or CNCP review

The Member or CNCP must complete the three-step review process described here for all bottom fishing encounters that occurred more than 90 days before the start of the Scientific Committee's annual meeting by vessels flying their flag, and that resulted in a temporary suspension pursuant to paragraph 28 of CMM-03. Where an encounter event occurred less than 90 days before the start of Scientific Committee's annual meeting, a Member of CNCP may, at their discretion, complete the review process for consideration by the Scientific Committee in the same year or in the following year.

Step 1: Member or CNCP provides a detailed description of each encounter

A Member or CNCP provides a detailed description of each encounter for the consideration of the Scientific Committee, that includes at a minimum:

- The date and time that the encounter occurred;
- The date of encounter notification (by the vessel to the Member or CNCP whose flag the vessel is flying and the Secretariat);
- The start and finish positions of the encounter trawl tow (to the nearest 0.01 decimal degree);
- The start and finish depths of the encounter trawl tow;
- Details of the relevant fishing activity, including:
    - The Management Area (Bottom Trawl or Midwater Trawl) and Fishery Management Area (FMA) in which the encounter occurred;
    - Detailed description of fishing methods used, providing the information needed to evaluate potential impacts, such as net type, net dimensions, trawl-door type, size and weight, footrope dimensions and type, ground gear (bobbins, rock-hopper gear, etc.), range in fishing height off bottom, net opening and any factors affecting gear selectivity;
    - Target species.
- The composition and weight of all benthic invertebrate bycatch within the tow that triggered the encounter, including but not limited to:
    - The number of VME indicator taxa encountered;
    - A description of the biological and ecological characteristics of each VME indicator taxa encountered
    - The total weight of each VME indicator taxon encountered (including any under encounter thresholds);

- The number of other benthic invertebrate taxa (non-VME indicator taxa) encountered;
- The total weight of each other benthic invertebrate taxon encountered.

A Member or CNCP provides a detailed description, including maps, of historic fishing activity and the known or likely distributions of VMEs within the area in which the encounter occurred for the consideration of the Scientific Committee, that includes at a minimum:

- The location of all historical bottom trawl tows within at least 5 nm of the encounter tow track, or preferably, for the entire open Bottom Fishing Management Areas (i.e., BTMA/MWTMA and FMA) in which the encounter occurred.
- The composition and weight of all benthic invertebrate bycatch, including but not limited to, VME indicator taxa, in historical trawl tows within at least 5 nm of the encounter tow track, or preferably in the Bottom Fishing Management Areas (i.e., BTMA/MWTMA and FMA) in which the encounter occurred (to the extent that these data are available to the Member or CNCP);
- The existing model predictions (and associated estimates of uncertainty), with and without discounting for historical fishing impacts, of suitable habitat and/or abundance for VME indicator taxa (Appendix E - Table E1) within five (5) nautical miles either side of the encounter track extended by five (5) nautical miles at each end, or preferably for the Bottom Fishing Management Areas (i.e., BTMA and FMA) in which the encounter occurred. A list of existing VME model predictions is provided in Appendix E.

Where applicable, maps should have the following characteristics:

- Include oceanographic, topographical, hydro-physical, or geomorphological features (e.g., bathymetry, seamount polygons, hydrothermal vents) as available;
- Overlays of the encounter trawl tow track, corrected, to the extent practicable, for differences between the location of the vessel and the gear;
- Overlays of historical trawl tows, corrected, to the extent practicable, for differences between the location of the vessel and the gear;
- A minimum resolution (grid cell size) of 1 km x 1 km, or higher. The resolution should be at a level clear enough for the Scientific Committee to make an assessment of whether VMEs may be present;

Appendix E – Relevant data to inform review processes provides a compilation of publicly available data and resources to be considered at the discretion of each Member and CNCP undertaking a review process.

Data confidentiality considerations

If any of the data to be provided by the Member or CNCP is subject to internal regulations regarding the protection of private and commercially sensitive information, the member or CNCP should either:

- Establish a data confidentiality agreement between the Member or CNCP and the Scientific Committee with the aim of ensuring that all the provided information by the Member or CNCP cannot be shared externally and can only be used for the purpose of informing the encounter review.

- Withhold sensitive information while ensuring, to the best of the Member or CNCP capacity, that all relevant information is provided to the Scientific Committee and that the nature of the data being withheld is clearly described, along with its limitations, allowing the Scientific Committee to evaluate if the withheld information could materially change the conclusions and recommendations of the review process.

Should an encounter have legal implications, e.g., subject of an ongoing investigation that may lead to prosecution, or time prove insufficient to develop a detailed analysis, the Member or CNCP whose vessel triggered the encounter might seek approval from the Scientific Committee to either:

- Defer its consideration to the following year.
- Delay its consideration to an intersessional activity after the meeting of Scientific Committee.
- Ensure that information provided to the Scientific Committee does not conflict with ongoing investigations (withholding sensitive information that is not crucial to the review). In this case, the nature of the data being withheld must be clearly described, along with its limitations, allowing the Scientific Committee to evaluate if the withheld information could materially change the conclusions and recommendations of the review process.

Step 2: Member or CNCP provides an assessment of whether a VME is known or likely to occur within the encounter area

Triggering of the encounter protocol indicates the potential presence of a VME. However, merely detecting the presence of a VME indicator taxon itself is not sufficient to identify a VME. That identification should be made on a case-by-case basis through application of relevant provisions in the Food and Agriculture Organisation (FAO) International Guidelines for the Management of Deep-Sea Fisheries in the High Seas (hereafter referred to as the FAO Deep-Sea Fisheries Guidelines), particularly Sections 3.2 and 5.2.

> ***3.2 Vulnerable marine ecosystems***
>
> *14. Vulnerability is related to the likelihood that a population, community, or habitat will experience substantial alteration from short-term or chronic disturbance, and the likelihood that it would recover and in what time frame. These are, in turn, related to the characteristics of the ecosystems themselves, especially biological and structural aspects. VME features may be physically or functionally fragile. 5 The most vulnerable ecosystems are those that are both easily disturbed and very slow to recover, or may never recover.*
>
> *15. The vulnerability of populations, communities and habitats must be assessed relative to specific threats. Some features, particularly those that are physically fragile or inherently rare, may be vulnerable to most forms of disturbance, but the vulnerability of some populations, communities and habitats may vary greatly depending on the type of fishing gear used or the kind of disturbance experienced.*
>
> *16. The risks to a marine ecosystem are determined by its vulnerability, the probability of a threat occurring and the mitigation means applied to the threat.*

5.2 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. Examples of potentially vulnerable species groups, communities and habitats, as well as features that potentially support them are contained in Annex 1. 9*

43. *These criteria should be adapted and additional criteria should be developed as experience and knowledge accumulate, or to address particular local or regional needs.*

44. *As a necessary step toward the identification of VMEs, States and RFMO/As, and as appropriate FAO, should assemble and analyse relevant information on areas under the competence of such RFMO/As or where vessels under the jurisdiction of such States are engaged in DSFs or where new or expanded DSFs are contemplated.*

45. *Where site-specific information is lacking, other information that is relevant to inferring the likely presence of vulnerable populations, communities and habitats should be used.*

46. *When designating an ecosystem as vulnerable, habitats and ecosystems should be evaluated against the criteria presented in paragraph 42, individually or in combination,*

using the best available scientific and technical information. Characteristics should be weighted according to their relative contribution to an ecosystem's vulnerability.

Multi Criteria Analysis Methods (MCAM) or Multi Criteria Decision Making (MCDM) assessment methods should be used as a robust approach for evaluating different "lines of evidence" and the "weight" of these lines of evidence against sections 3.2 and 5.3 of the FAO Deep-Sea Fisheries Guidelines and determining whether an encounter constitutes evidence of a VME. MCDM and MCAM are analysis techniques that explicitly evaluate multiple criteria in decision making (see e.g., Franco and Montibeller 2010). Notably, these have not been widely applied to fisheries management (but see Morato et al. 2018 and Gros et al. 2023 for detecting VMEs). Different lines of evidence should be weighted, wherever possible, based on their robustness as assessed through either quantitative or qualitative methods. Assessments should integrate as much relevant information as possible into the process of identifying the known or likely occurrence of a VME. This includes a variety of data sources, from 'direct assessment' methods such as video, echo-sounder and multi-beam surveys, to 'indirect assessment' methods such as evaluation of historic VME indicator taxa bycatch, thresholding of predictive habitat suitability and abundance modelling for VME indicator taxa, and assessment of the presence of topographical, hydro-physical or geomorphological features which are associated with VME indicator taxa and have the potential to support VMEs. Such a multi-criteria approach for assessments is widely used in environmental decision-making processes (e.g., Carvalho et al., 2020, Turschwell et al., 2023, Vanegas-Cantarero et al, 2022), and is included in the NAFO and ICES 'benchmark' processes for identifying VMEs and assessing SAIs (NAFO 2020, ICES 2022).

In situations where the Member or CNCP deems that the density and accuracy of relevant VME indicator taxa biomass data (e.g., research trawl bycatch data) across an area of interest may be enough to inform quantitative approaches to help identify the potential presence of a VME, such approaches are encouraged to be undertaken, subject to each Member or CNCP capabilities and capacity. NAFO has used research vessel trawl survey data to help delineate areas that host densities of certain VME indicator taxa above pre-defined levels (see Appendix D – Examples of quantitative methods to identify VMEs and evaluate risks) (Kenchington et al. 2019).

Direct assessment methods are likely to provide the most robust information for identifying VMEs and should be the preferred assessment approach. Evidence from direct assessments can be further strengthened by integrating information from indirect assessments, as suggested by Baco et al. 2023. However, there are often challenges related to the spatial scale of surveys and the resourcing required to undertake surveys that could limit the ability of Members or CNCPs to undertake direct assessments of potential VMEs. In these situations, it is increasingly important that indirect assessments integrate as much relevant information as possible into the process of identifying the known or likely occurrence of a VME.

Direct assessment of potential VME presence

Direct assessments involve surveying and mapping the encounter area to directly confirm the presence and extent of a VME. In SPRFMO, direct assessments could be undertaken using on-site camera observations from vessels or remote vehicles and seabed mapping through echosounders or multi-beam sounders (see UNGA 74/18 para 201 and UNGA72/72 para 185), as is done in the Southeast Atlantic Fisheries Organisation (SEAFO) and the North-East Atlantic Fisheries Commission (NEAFC).

As an example, within the SPRFMO Evaluated Area, previous surveys have been carried out by New Zealand in the Louisville Seamount Chain using a towed underwater camera system to collect biological data from the benthos as well as detailed bathymetric and topographic data using multibeam echosounders of underwater topographical features (Clark et al. 2015). Collected imagery has been used to detect the presence of "stony coral reef or thicket" (as defined in the New Zealand's Exclusive Economic Zone and Continental Shelf (Environmental Effects – Permitted Activities) Act Regulations 2013)) structures on the surveyed seamounts, which cover 15% or more of the seabed within a surveyed seabed area of 100 m^2 or more. Similarly, seafloor imagery has been collected from individual seamount features in the North Pacific Fisheries Commission (NPFC) Convention Area by fishery-independent surveys to assess the presence of VME indicator species (e.g., Curtis et al. 2015, Miyamoto and Kiyota 2017). Baco et al. (2023) provide example images of sponges, coral gardens, Scleractinia reefs, chemosynthetic ecosystems and soft-sediment communities that can be identified as a VME from a single image. They also provide examples of images of VMEs that are harder to distinguish from a single image.

A compilation of relevant publications and materials related to the design and undertaking of surveys to identify VMEs is provided in Table E3 of Appendix E.

Indirect assessment of potential VME presence

Indirect assessments rely on information that can be used to infer the likely presence of a VME within the encounter area. Relevant information includes, inter alia, predictive habitat suitability and abundance models for VME indicator taxa, historic bycatch of VME indicator taxa, and topographical, hydro-physical or geomorphological features which can be associated with VME indicator species and have the potential to support VMEs.

Distribution models

Many quantitative approaches to the identification of VMEs focus on predicting the distribution of VME indicator taxa. Rowden et al. (2020) analysed video and still images to identify areas where corals support a high diversity of associated taxa. They found significant relationships between coral density and the richness of associated benthic organisms and suggested that a density threshold could be used in combination with predictive models to map areas where the density of VME indicator taxa was equal to or greater than that threshold and were therefore VMEs at risk of SAIs.

Historic bycatch

Historical bycatch data should be used to assess whether the encounter is likely to indicate the presence of a VME. Ideally, this should be done at spatial scales that are deemed appropriate for identifying VMEs. However, despite attempts to further refine what constitutes a VME (e.g., Watling

& Auster 2017, Baco et al. 2023), the range of relevant ecological spatial scales at which VMEs can be identified remains an open question (and as such, a sub-task “Developing a multi-spatial scale risk-based approach to assess encounters with VME indicator taxa” remains in the 2024 Scientific Committee Multiannual workplan). VMEs as vulnerable “populations, communities and habitats” (FAO 2009) can occur within spatial units that range from meters to thousands of kilometres. Therefore, and as an interim approach, assessments of historical bycatch data should evaluate the taxa, weight and catch density and frequency of all species within the individual encounter tow track, within the encounter area and within a 5 nm buffer area around the encounter tow track and at the scale of the Management Area (Bottom Trawl or Midwater Trawl) to identify consistent spatial and taxonomic patterns that would suggest VME presence. Examples of possible approaches include the identification of specific locations where ‘clusters’ of VME indicator taxa bycatch include: (1) multiple bycatch events of a VME indicator taxon at or near it’s taxon-specific encounter threshold representative of high densities of the VME indicator taxa, potentially indicating an area with functional significance and/or structural complexity that may imply the presence of a VME; and (2) multiple VME indicator taxa representative of a diverse seabed fauna potentially indicating the presence of a VME. These ‘clusters’ should be used to infer the presence of a VME, as is done in NAFO to close “Areas of higher sponge and coral concentrations” to bottom fishing activities (Kenchington et al. 2014). Morato et al. (2018) provides a sophisticated (and data-demanding) multi-criteria approach that accounts for both the quantity and quality of the data available, resulting in a taxon-specific measure used to infer VME presence, further tailored to CCAMLR by Gros et al. (2023). We note that taxonomic resolution may be variable throughout historic datasets (and generally poorer in older data), which could pose a challenge when analysing patterns through time. Adjusting taxonomic resolution should be done on an as need-basis, with the aim of ensuring that an appropriate level of resolution to inform management decisions is maintained while ensuring data that could be used in the review is not discarded. Exploring the relationships between the occurrence of VME indicator taxa and other macrofaunal assemblages that may be associated with VMEs can be used to infer presence of VMEs subject to the availability of suitable data (see Ashford et al. 2019 where the authors assessed the influence of VME indicator taxa on crustacean assemblages within the NAFO Regulatory Area).

Topographical, hydro-physical or geomorphological features

Topographical, hydro-physical or geomorphological features which are associated with VME indicator species in a global context and have the potential to support VMEs and should be used to compliment other lines of evidence (e.g., higher concentrations of VME indicator taxa) to identify the likely presence of a VME. Annex 1 of the FAO Deep-Sea Fisheries Guidelines provides examples of topographical, hydro-physical or geomorphological features, including fragile geological structures, that potentially support VMEs:

i. submerged edges and slopes (e.g. corals and sponges);
ii. summits and flanks of seamounts, guyots, banks, knolls, and hills (e.g. corals, sponges, xenophyphores);
iii. canyons and trenches (e.g. burrowed clay outcrops, corals);
iv. hydrothermal vents (e.g. microbial communities and endemic invertebrates); and
v. cold seeps (e.g. mud volcanoes for microbes, hard substrates for sessile invertebrates).

Step 3: Member or CNCP determines if reopening the encounter area will expose any VMEs to SAIs

If the encounter is deemed to constitute evidence of the presence of a VME, the Member or CNCP is required to evaluate whether reopening the area will expose any VMEs to SAIs. That determination should be made on a case-by-case basis through the application of relevant provisions in the FAO Deep-Sea Fisheries Guidelines, particularly Section 3.3 and Article 47.

> ***3.3 Significant adverse impacts***
>
> *17. Significant adverse impacts are those that compromise ecosystem integrity (i.e. ecosystem structure or function) in a manner that: (i) impairs the ability of affected populations to replace themselves; (ii) degrades the long-term natural productivity of habitats; or (iii) causes, on more than a temporary basis, significant loss of species richness, habitat or community types. Impacts should be evaluated individually, in combination and cumulatively.*
>
> *18. When determining the scale and significance of the intensity or severity of the impact at the specific site being affected;*
>
> *i. the spatial extent of the impact relative to the availability of the habitat type affected;*
> *ii. the sensitivity/vulnerability of the ecosystem to the impact;*
> *iii. the ability of an ecosystem to recover from harm, and the rate of such recovery; v. the extent to which ecosystem functions may be altered by the impact; and*
> *iv. the timing and duration of the impact relative to the period in which a species needs the habitat during one or more of its life-history stages.*
> *v. the extent to which ecosystem functions may be altered by the impact; and*
> *vi. the timing and duration of the impact relative to the period in which a species needs the habitat during one or more of its life-history stages.*
>
> *19. Temporary impacts are those that are limited in duration and that allow the particular ecosystem to recover over an acceptable time frame. Such time frames should be decided on a case-by-case basis and should be in the order of 5-20 years, taking into account the specific features of the populations and ecosystems.*
>
> *20. In determining whether an impact is temporary, both the duration and the frequency at which an impact is repeated should be considered. If the interval between the expected disturbance of a habitat is shorter than the recovery time, the impact should be considered more than temporary. In circumstances of limited information, States and RFMO/As should apply the precautionary approach in their determinations regarding the nature and duration of impacts.*
>
> *47. Flag States and RFMO/As should conduct assessments to establish if deep-sea fishing activities are likely to produce significant adverse impacts in a given area. Such an impact assessment should address, inter alia:*

i. type(s) of fishing conducted or contemplated, including vessels and gear types, fishing areas, target and potential bycatch species, fishing effort levels and duration of fishing (harvesting plan);
ii. best available scientific and technical information on the current state of fishery resources and baseline information on the ecosystems, habitats and communities in the fishing area, against which future changes are to be compared;
iii. identification, description and mapping of VMEs known or likely to occur in the fishing area;
iv. data and methods used to identify, describe and assess the impacts of the activity, the identification of gaps in knowledge, and an evaluation of uncertainties in the information presented in the assessment;
v. identification, description and evaluation of the occurrence, scale and duration of likely impacts, including cumulative impacts of activities covered by the assessment on VMEs and low productivity fishery resources in the fishing area;
vi. risk assessment of likely impacts by the fishing operations to determine which impacts are likely to be SAIs, particularly impacts on VMEs and low-productivity fishery resources; and
vii. the proposed mitigation and management measures to be used to prevent significant adverse impacts on VMEs and ensure long term conservation and sustainable utilization of low-productivity fishery resources, and the measures to be used to monitor effects of the fishing operations.

As for Step 2, it is envisioned that assessments against the Section 3.3 and Article 47 of the FAO Deep-Sea Fisheries Guidelines would aim to compare and evaluate different "lines of evidence" and the "weight" of these lines of evidence using Multi Criteria Analysis Methods (MCAM) or Multi Criteria Decision Making (MCDM).

Where available, members should incorporate taxon-specific catchability in their evaluation of impacts. For example, estimates of catchability may be useful in converting reported bycatch of VME indicator taxa into estimates of the extent of impact on VMEs on the seafloor. Catchability relates the amount of bycatch landed on deck to the amount of taxa impacted on the seafloor, with catchability likely to differ between taxa, depending on their morphology and susceptibility to the impacts of bottom fishing gear. Ideally, estimates of catch efficiency (catchability) should be specific to area, fishery and VME indicator taxon. Previous analyses (e.g., SC10-DW04) indicate that in general the catchability of VME indicator taxa by bottom trawl is low (< 5%) although for some taxa can be higher (> 20%), and rates can vary by geographical area and depth. Any uncertainty in catchability estimates should be appropriately evaluated and communicated when considering its effect on VME presence, estimated impacts or SAIs risk.

In the absence of a 'formal ecological risk assessment' specified within this review standard, a minimum of an "expert judgement" approach should be undertaken. Alternatively, formal ecological risk assessments could be undertaken using tried and tested approaches. For example, the "Ecological Risk Assessment for the Effects of Fishing" (ERAEF) framework developed in Australia (Hobday et al. 2011). The ERAEF framework has already been used to assess risk to seamounts (i.e., VME features or elements) on the Chatham Rise within the New Zealand EEZ (Clark et al. 2011), and the PSA component of the ERAEF has been trailed as an ERA methodology for assessing the risk of impacts from fishing to deepwater corals (i.e., VME indicator taxa) in the New Zealand EEZ (Clark et al. 2014).

Using quantitative benthic risk assessments such as those used to evaluate risks on VMEs in the Cumulative Bottom Fishery Impact Assessment for Australia and New Zealand (SC8-DW07_rev1, SC11-DW01_rev1) are also one of the options Members and CNCPs may consider when assessing the current and future likelihood of SAIs on VMEs using a MCAM or MCDM approach (see Appendix D – Examples of quantitative methods to identify VMEs and evaluate risks

).

Step 4: Member or CNCP identifies management actions they consider necessary to prevent SAIs on VMEs

Based on their assessment of the scale and significance of historical and likely future fishing impacts, the Member or CNCP should provide a description and justification for recommended management actions, if any, that they consider necessary to prevent SAIs on VMEs.

Those actions may include:

- Maintaining closure of the encounter area/s when there is:
    - insufficient evidence to review the temporary closure has been provided, OR
    - reopening the area could reasonably result in SAIs on VMEs;
- Proposing to register a VME in Annex 9 of CMM 03 and updating Management Area Boundaries established in paragraph 14 and Annex 4 of CMM 03 to exclude the VME from areas open to fishing where the review identifies areas as VMEs.
- Re-opening the encounter area/s to fishing, when the review identifies that no VMEs are known or likely to occur in the encounter area;
- Changing the boundaries of the open area/s where closures occur close to the boundary, and modified boundaries can be kept simple to avoid unreasonable complexity, where modifying boundaries is reasonably required to prevent SAIs on VMEs if fishing is resumed;
- Any other changes considered appropriate, including e.g. recommending further research on the closed area (e.g. video or acoustics), reopening only part of the closed area, temporal restrictions, other spatial restrictions.

The Member or CNCP should provide a summary of key points for the Scientific Committee to consider, including assumptions, limitations and uncertainties of their analysis, identifying how those assumptions, limitations and uncertainties are reflected in the formulation of the Member of CNCP management recommendations.

4. Scientific Committee review

A checklist of the steps and elements for the Scientific Committee review process is provided in Appendix B.

Step 1: Scientific Committee reviews encounters

The Scientific Committee is required to review all encounters once the relevant Member or CNCP has provided its review pursuant and provide advice on management actions proposed by the Member or CNCP and any alternate or additional management actions the Scientific Committee considers appropriate.

In reviewing the encounter, the SC is required to:

a) Consider the detailed analyses provided by a Member or CNCP, including:
   i. historical fishing events within 5nm of the encounter tow, in particular, any previous encounters, and all information on benthic bycatch;
   ii. model predictions for all VME indicator taxa and associated uncertainty layers, including predictions discounted for historical fishing impacts;
   iii. details of the relevant fishing activity, including the bioregion in which the encounter occurred (noting that different regions have different compositions of benthic bycatch, for example stony coral are more commonly caught on the Louisville than elsewhere); and
   iv. any other information the Scientific Committee considers relevant. This could include spatial scales of endemicity for the taxa impacted, spatial scales of connectivity and meta-population dynamics, catchability of VME indicator taxa, and taxonomic resolution of the bycatch records in relation to species complexes.
b) Apply the FAO Deep-Sea Fisheries Guidelines, including to use the full set of criteria contained therein to identify where VMEs occur or are likely to occur, as well as for assessing SAIs on such ecosystems, including their associated and dependent species;

In its review, the Scientific Committee must provide a clear determination regarding the inadequacy of information included in the members review, including the robustness of the analyses, to:

a) determine if a VME is known or likely to occur within the encounter area.
b) determine if reopening the encounter area will expose any VMEs to SAIs
c) provide meaningful advice and recommendations.

Because the onus is on the Member or CNCP whose vessel triggered an encounter to provide sufficient information for Scientific Committee to review that encounter and temporary closures remain in place until adequately reviewed, there should be no need for any additional work or development of papers between the Scientific Committee meeting and the following Commission meeting. However, the Member or CNCP might seek intersessional work arising from cases when the encounter may have legal implications (see 'Data confidentiality considerations' outlined in Step 1 of the 'Member or CNCP review'), where timing is particularly challenging.

Where legal proceedings delay the completion of a Member or CNCP review, the Compliance and Technical Committee (CTC) may need to review compliance with the conservation and management measures adopted under the SPRFMO Convention and provide advice and recommendations to the Commission.

Step 2: Scientific Committee develops advice on management actions it considers appropriate, and provides advice to the Commission

Using the management actions proposed by the Member or CNCP as a starting point, the Scientific Committee is required to develop a proposed package of advice and recommendations it considers appropriate for the Commission to consider.

The Scientific Committee must ensure that its advice and recommendations are evidence-based, clear on uncertainties and trade-offs, and properly framed in the context of advice to the Commission. The Scientific Committee must ensure its advice and the recommendations arising are provided with the objective of avoiding SAIs on VMEs. In doing this, the Scientific Committee is required to apply the Convention, including the precautionary approach, to preserve the marine ecosystems in which fisheries resources occur. Scientific Committee advice to Commission should:

i. be more cautious when information is uncertain, unreliable, or inadequate;
ii. not use the absence of adequate scientific information as a reason for postponing or failing to provide advice and recommendations; and
iii. take account of best international practices regarding the application of the precautionary approach, including Annex II of the 1995 Agreement and the Code of Conduct.

The Scientific Committee's report will include specific recommendations to the Commission on a management response for each encounter area and, as appropriate, all encounter areas combined.

Scientific Committee recommendations to Commission could include some or all of:

- Maintaining closure of the encounter area/s when the Scientific Committee's assessment is that:
    - insufficient evidence to review the temporary closure has been provided, OR
    - the benthic bycatch recorded during individual trawl tows (or a series of trawl tows) was inconsistent with model predictions, OR
    - reopening the area could reasonably result in SAIs on VMEs;
- Proposing to register a VME in Annex 9 of CMM 03 and updating Management Area Boundaries established in paragraph 14 and Annex 4 of CMM 03 to exclude the VME from areas open to fishing where the Scientific Committee's review identifies areas as VMEs;
- Re-opening the encounter area/s to fishing, when the Scientific Committee review identifies that no VMEs are known or likely to occur in the encounter area;
- Changing the boundaries of the open area/s where closures occur close to the boundary, and modified boundaries can be kept simple to avoid unreasonable complexity, where modifying boundaries is reasonably required to prevent SAIs on VMEs if fishing is resumed;
- Any other changes the Scientific Committee considers appropriate, including e.g. recommending further research on the closed area (e.g. video or acoustics), reopening only part of the closed area, temporal restrictions, other spatial restrictions.

The recommendation to the Commission should clearly indicate what management actions would be most appropriate to prevent SAIs on potential VME.

Appendix A – Background and supporting information

1.1.1 SPRFMO International Obligations

The United Nations General Assembly (UNGA) Resolution 61/105 set specific targets and deadlines for action by 31 December 2008, calling on States, either individually or through RFMO/As, to manage bottom fisheries on the high seas in order to sustainably manage fish stocks (Article 80) and prevent significant adverse impacts on VMEs (Article 83), among other requirements. Later Resolutions, such as 64/72 and 66/88, have called for further actions to define what constitutes evidence of an encounter with VME (particularly weight thresholds levels and species), and to protect VMEs from significant adverse impacts while ensuring sustainable management of bottom fisheries.

Further, UNGA Resolutions 71/123 and 72/72 call upon RFMOs to use the full set of criteria in the FAO International Guidelines for the Management of Deep-Sea Fisheries in the High Seas (FAO Deep-Sea Fisheries Guidelines; FAO 2009) to identify where VMEs occur or are likely to occur as well as for assessing significant adverse impacts, including for cumulative impacts of activities such as fishing.

In response to the UNGA Resolutions and the implementation of the FAO Deep-Sea Fisheries Guidelines, SPRFMO has adopted a spatial management approach through CMM 03 (Bottom Fishing) that seeks to protect potential VME habitat across large areas of the South Pacific Ocean while still allowing for sustainable and profitable fisheries to occur. This approach is complemented by precautionary measures to protect potential VME habitats within areas that are open to fishing:

- The Encounter Protocol: where a catch of a single or three or more VME indicator taxa at or above threshold levels set out in Annex 6A and Annex 6b of CMM 03, respectively, results in the immediate halt of bottom fishing within a buffer of 1 nm around the trawl track;
- Continuous review of benthic bycatch (including bycatch of VME indicator taxa) to help evaluate the effectiveness of spatial management measures;
- Assessments of cumulative impacts of past and proposed bottom fishing. This is guided by the Bottom Fishing Impact Assessment Standard (BFIAS), which is updated at least every 5 years, and results in a Bottom Fishing Impact Assessment (BFIA) which must be at least updated every 3 years.

2.1.1 Objectives of CMM 03 Bottom Fishing

As set out in paragraph 1 of CMM 03:

The objective of the CMM together with CMM 03a-2023 (Deepwater Species) is, through the application of the precautionary approach and an ecosystem approach to fisheries management, to ensure the long-term conservation and sustainable use of deep sea fishery resources, including target fish stocks as well as non-target or associated and dependent species, and, in doing so, to safeguard the marine ecosystems in which these resources occur, including inter alia the prevention of significant adverse impacts on vulnerable marine ecosystems.

The objective reflects the Objective statement as set out in the SPRFMO Convention, but it is tailored to bottom fisheries, with specific emphasis on the requirement to prevent significant adverse impacts (SAIs) on vulnerable marine ecosystems (VMEs).

3.1.1 Reviewing Encounters

CMM 03 provides a detailed description of procedures following encounters (as defined in paragraph 27 of CMM 03) that are to be undertaken by Members and CNCPs (Cooperating non-Contracting Parties), the Scientific Committee, and the Commission.

32. *Members and CNCPs shall submit to the Scientific Committee a detailed description of each encounter by vessels flying their flag that resulted in a temporary suspension pursuant to paragraph 28, a comparison of the encounter with the existing model prediction, and suggested management actions to prevent significant adverse impacts on VMEs. Members should provide as much detail as possible to verify whether a VME is likely to be present at the encounter area and/or the surrounding area, whether a significant adverse impact has occurred, and the risk of a significant adverse impact occurring in the future.*

33. *The Scientific Committee, at its next annual meeting, shall review all encounters reported pursuant to paragraph 28(b) once the relevant Member or CNCP has provided its review pursuant to paragraph 32, and provide advice on management actions proposed by the relevant Member or CNCP under paragraph 32 and any alternate or additional management actions the Scientific Committee considers appropriate. The Scientific Committee shall:*

    a) Apply the Convention, including Article 3(2)(a);

    b) Consider the detailed analyses provided by a Member or CNCP pursuant to paragraph 32 including:

        i. historical fishing events within 5nm of the encounter tow, in particular, any previous encounters, and all information on benthic bycatch;
        ii. model predictions for all VME indicator taxa;
        iii. details of the relevant fishing activity, including the bioregion; and
        iv. any other information the Scientific Committee considers relevant;

    c) review the adequacy of the information submitted pursuant to paragraph 31, including the robustness of the analysis;
    d) apply the FAO Deep-Sea Fisheries Guidelines, including to use the full set of criteria contained therein to identify where VMEs occur or are likely to occur, as well as for assessing significant adverse impacts on such ecosystems, including their associated and dependent species;
    e) consider whether an area or areas should be closed to prevent significant adverse impacts on VMEs; and
    f) ensure its advice and recommendations arising from the review are provided with the objective of avoiding significant adverse impacts on VMEs.

34. *Notwithstanding paragraph 33, the Scientific Committee may defer consideration of an encounter if:*
    a) there is inadequate information to provide meaningful advice and recommendations; or
    b) The relevant Member of CNCP has notified the Scientific Committee of a delay pursuant to paragraph 32; or

c) There has been insufficient time for the flag State to present the relevant information within the normal timeframes for the submission of working papers to the Scientific Committee.

35. *At its next annual meeting, the Commission shall determine, for each encounter, management actions to prevent significant adverse impacts on VMEs, which may include: the closing of some areas to some or all bottom fishing gear, temporal restrictions, spatial restriction, reopening areas. Management actions determined by the Commission will apply as appropriate, unless otherwise determined, from the conclusion of the relevant Commission meeting. The Commission shall base its decision on the Scientific Committee's advice; and be satisfied that its decision is consistent with the requirements of the Convention, including Article 3(2)(a).*

36. *For the avoidance of doubt, each VME encounter shall be assessed against the requirements of the relevant CMM in effect at the time of the encounter. However, this shall not preclude the Scientific Committee and/or the Commission from taking into account the best available science in relation to the encounter in discharging their respective functions within the encounter review process*

Paragraphs 32 to 34 are fully addressed in the steps described in the Member or CNPC and the Scientific Committee review sections within the body of the Encounter Review Standard.

Appendix B – Checklists

Member or CNCP review process

Step 1: Member or CNCP provides a detailed description of each encounter

Has the Member or CNCP provided the following information for the consideration of the Scientific Committee?

Event details	
The date and time that the encounter occurred	
The date of encounter notification (by the vessel to the Member or CNCP whose flag the vessel is flying and the Secretariat)	
The start and finish positions of the encounter tow ((to the nearest 0.01 decimal degree)	
The start and finish depths of the encounter tow	
Details of the relevant fishing activity, including BTMA/MWTMA and FMA, description of methods and gear and target species	
Bycatch details	
The composition and weight of all benthic invertebrate bycatch within the encounter tow, including number and total weight of each VME indicator taxa and number and total weight of each other benthic bycatch invertebrate taxa	
A description of the biological and ecological characteristics of each VME indicator taxa encountered	
The location of all historical trawl tows within at least 5 nm of the encounter tow, or preferably, for the entire open area in which the encounter occurred	
The catch weight of all benthic invertebrate species, including but not limited to, VME indicator taxa, in the encounter tow and all other trawl tows within at least 5 nm of the encounter tow or preferably in the entire open area in which the encounter occurred (to the extent that these data are available to the Member)	
Maps	
The location of all historical bottom trawl tows within at least:	
5 nm buffer area around the encounter tow	
entire Bottom Fishing Management Area (i.e., Bottom Trawl Management Area) in which the encounter occurred	
entire Fishery Management Area in which the encounter occurred	
The composition and weight of all benthic invertebrate bycatch, including but not limited to, VME indicator taxa, in historical trawl tows within at least 5 nm of the encounter tow, or preferably in the Bottom Fishing Management Area (i.e., BTMA/MWTMA and FMA) in which the encounter occurred	
The existing model predictions (and associated estimates of uncertainty), with and without discounting for historical fishing impacts, of suitable habitat and/or abundance for VME indicator taxa within five (5) nautical miles either side of the encounter track extended by five (5) nautical miles at each end, or preferably for the Bottom Fishing Management Areas (i.e., BTMA and FMA) in which the encounter occurred	

For each encounter event, have maps been provided having the following characteristics?

Inclusion of oceanographic, topographical, hydro-physical, or geomorphological features (e.g., bathymetry, seamount polygons, hydrothermal vents) as available	
A colour scale indicating the predicted suitable habitat and/or abundance for VME indicator taxa for each VME indicator taxon within the encounter area, at a scale (granularity) of 1 km, and within at least 5 nm of the encounter trawl	
The estimated uncertainty associated with the predicted suitable habitat and/or abundance for VME indicator taxa	
Overlays of the encounter trawl tow, corrected, to the extent practicable, for differences between the location of the vessel and the gear	
Overlays of historical trawl tows, corrected, to the extent practicable, for differences between the location of the vessel and the gear	
A minimum resolution (grid cell size) of 1 km x 1 km	

Step 2: Member or CNCP provides an assessment of whether a VME is known or likely to occur within the encounter area

Has the Member or CNCP provided a direct and/or indirect assessment of potential VME presence?

A direct assessment involving surveying and mapping the encounter area to directly determine the presence and extent of a potential VME has been undertaken	
An indirect assessment evaluating the taxa, weight and catch frequency of all species within at least 5 nm of the trawl track to identify consistent spatial and taxonomic patterns that would suggest VME presence has been undertaken	
A combination of direct and indirect assessments	

Step 3: Member or CNCP determines if reopening the encounter area will expose any VMEs to SAIs

Has the Member or CNCP evaluated whether reopening the area will expose any VMEs to SAIs?

An assessment of the scale and significance of historical and likely future fishing impacts has been provided	

Step 4: Member or CNCP identifies management actions they consider necessary to prevent SAIs on VMEs

Has the Member or CNCP proposed management actions to prevent significant adverse impacts on VMEs?

Registering a VME in Annex 9 of CMM 03 and updating Management Area Boundaries established in paragraph 14 and Annex 4 of CMM 03 to exclude the VME from areas open to fishing where the review identifies areas as VMEs	
Maintaining closure of the encounter area/s	
Re-opening the area/s to fishing	
Changing the boundaries of the open area/s	
Other changes (specify below)	

Has the Member or CNCP provided a summary of key points for the SC to consider, including assumptions, limitations and uncertainties of their analysis, identifying how those assumptions, limitations and uncertainties are reflected in the formulation of the Member of CNCPs management recommendations?

One- to two-page summary of the Member or CNCP's view of the key points for SC to consider, including assumptions, limitations and uncertainties in their review of the encounter	

Scientific Committee review process

Step 1: Scientific Committee reviews encounters

Has the Scientific Committee considered the following information to formulate a recommendation to the Commission?

The detailed analyses provided by the Member or CNCP	
Historical trawl tows within at least 5 nm of the encounter tow but preferably for the open Bottom Fishing Management Area (i.e., BTMA/MWTMA and FMA) in which the encounter occurred, any previous encounters, and all information on benthic bycatch	
Model predictions for all VME indicator taxa and associated uncertainty layers, including predictions discounted for historical fishing impacts	
Details of the relevant fishing activity, including the bioregion (noting that different regions have different compositions of benthic bycatch, for example stony coral are more commonly caught on the Louisville than elsewhere)	
Any other information the Scientific Committee considers relevant (specify below)	

Has the SC provided a clear determination regarding the adequacy of the information included in the members review, including the robustness of the analysis to:

determine if a VME is known or likely to occur within the encounter area?	
determine if reopening the encounter area will expose any VMEs to SAIs?	
provide meaningful advice and recommendations?	

Step 2: Scientific Committee develops advice on management actions it considers appropriate, and provides advice to the Commission

Has the SC ensured its advice and the recommendations are provided with the objective of avoiding SAIs on VMEs, giving effect to the Convention and the precautionary approach?

Is the SCs advice consistent with the Convention and the precautionary approach?	
Is SC advice consistent with the objective of avoiding SAIs on VMEs?	

Has the Scientific Committee clearly indicated what management actions would be most appropriate to prevent SAIs on potential VME?

Using the management actions proposed by the Member as a starting point, which of the following management actions has the Scientific Committee identified for the Commission to consider:	
Maintaining closure of the encounter area/s	
Re-opening the area/s to fishing	
Changing the boundaries of the open area/s	
Other changes (specify below)	

Appendix C – Vulnerable Marine Ecosystems and Significant Adverse Impacts

Distribution of Vulnerable Marine Ecosystems

In accordance with Annex 5 of CMM 03, a list of species or higher-level taxa known or likely to indicate the presence of potential VMEs in the South Pacific, and the catching of which could indicate evidence of such VMEs, has been developed. Habitat suitability modelling (Georgian et al. 2019, Stephenson et al. 2021) has been used in the western SPRFMO Area to indicate the existence of areas likely to contain VMEs, with this modelling underpinning the spatial management approach embedded within CMM 03 (Bottom Fishing).

Implementation of CMM 03 (Bottom Fishing) requires a definition of potential 'evidence of a VME' to trigger the move-on provisions. Accordingly, a protocol to determine potential 'evidence of a VME' has been developed to enable an immediate management response (i.e. a move-on rule) during fishing operations at sea, to limit immediate impact on areas which appear to demonstrate unexpectedly high quantities of VME taxa based on the habitat suitability modelling that underpins CMM 03 (Bottom Fishing).

The move-on rule under SPRFMO CMM 03 (Bottom Fishing) applies in cases of any interactions that trigger the specified threshold weights of VME indicator taxa during fishing operations. For new and exploratory fisheries, encounter protocols should be sufficiently precautionary to account for a likely paucity of information on the distribution and characteristics of potential VMEs.

In contrast, 'designating a VME' requires a scientific and deliberative analysis to integrate data from individual or cumulative encounters and assess information on occurrence of VMEs across multiple spatial scales, in order to identify, map and designate areas which are considered to constitute actual VMEs.

This is to be undertaken in accordance with CMM 03 (Bottom Fishing) paragraphs 32-36. Procedures for mapping known or likely VMEs and bottom fishing effort are described below.

Mapping and designation of VMEs

Mapping of known or likely vulnerable marine ecosystems is an important prerequisite for impact assessment and development of management and mitigation measures to prevent significant adverse impacts in such areas. Information and data on gear interactions with VME indicator taxa, predictive analyses of habitat suitability and taxa abundance, and results of seabed biodiversity surveys have formed and should continue to form the basis for mapping and designation of areas known or likely to support VMEs within the SPRFMO Convention Area.

Annex 1 of the FAO Deep-Sea Fisheries Guidelines recognise that "Merely detecting the presence of an element itself is not sufficient to identify a VME" (FAO 2009). Single encounters with VME indicator taxa indicate the presence of a vulnerable species or taxa at some point in the area fished during the tow or set, but may not indicate the presence of a vulnerable ecosystem. Further data and analyses may be required to designate areas known to support VME indicator taxa based on repetitive encounters in a particular area, prediction of areas that may support VMEs based on information on habitat suitability models for vulnerable deepwater benthic species, or seabed biodiversity surveys.

Areas known or likely to support VMEs should be defined and mapped using all potential sources of information, including:

- Mapping of fishing positions observed to contain 'evidence of VMEs', as defined in the encounter protocol in CMM 03 (Bottom Fishing), and of scientific observer data on bycatches of VME indicator taxa and other associated benthic taxa.
- Distribution of predicted habitat suitability derived from predictive habitat models for vulnerable marine taxa (Rowden et al. 2013, Pitcher et al. 2015, Anderson et al. 2016a, Anderson et al. 2016b, Rowden et al. 2017, Georgian et al. 2019, Stephenson et al. 2021), or from other physical data/surrogates, used to inform habitat-suitability analyses (Hirzel et al. 2002, Clark et al. 2006, Davies et al. 2008).
- Mapping of known or predicted underwater topographic features, particularly seamounts, which may support VME indicator taxa (Harris et al. 2014).
- Data from scientific seabed biodiversity surveys which should be integrated into, or used to inform, habitat suitability analyses (Pitcher et al. 2007a,b, Williams et al. 2009, Anderson et al. 2011; Pitcher et al. 2016b, Anderson et al. 2016a,b).

Repetitive encounters with taxa listed as vulnerable

Mapping of all sites found to contain evidence of VMEs is an essential step towards subsequent analysis of repetitive encounters with vulnerable species in a particular area, which may lead to that area then being designated as a VME. Management measures for designated VMEs have not yet been established but could include, for example, effort or gear limits, more precautionary thresholds and move-on rules, or full closures. Data on encounters with evidence of VMEs must be reported to the SPRFMO Secretariat immediately in accordance with CMM 03 (Bottom Fishing).

While any encounter with VME indicator taxa at a single site (either above or below the thresholds specified in CMM 03 (Bottom Fishing)) may not indicate presence of an actual VME, multiple or repetitive encounters with such evidence in an area indicate an increasing likelihood that the area does support a benthic VME. Data on evidence of VMEs gathered during fishing operations shall be regularly analysed in accordance with CMM 03 (Bottom Fishing) to identify areas in which multiple or repetitive encounters with VME species are found.

Seabed biodiversity surveys

The most reliable data on benthic biodiversity and presence of VMEs will be provided by scientific seabed biodiversity surveys, either using seabed sampling equipment designed to quantitatively sample the fauna concerned (such as benthic sampling sleds), or using photographic or video imagery along planned survey transects. Where feasible, efforts should be made to conduct such sampling in areas of particular interest or concern, such as those within Bottom Fishing Management Areas with high probability of VME indicator taxa habitat suitability or with a historic record of VME indicator taxa (SC10-DW03, SC11-DW10).

Particular efforts should be made to survey areas proposed for long-term and large-scale spatial closures, to ensure that such areas do contain substantial and biodiverse communities, and that they are representative (in terms of actual or predicted biodiversity and VME abundance) of areas to be left open to possible fishing. Such surveys could be conducted as internationally collaborative surveys between SPRFMO Members, CNCPs and other interested parties (e.g., fishing companies).

Where scientific surveys are not considered to be cost effective, fishing vessels may be suitable platforms for conducting seabed imaging using drop cameras or net-mounted video systems. Simultaneous collection of seabed images and benthic bycatch recording by scientific observers would provide a particularly useful data set for improving understanding of the relationship between seabed biodiversity and benthic bycatches by various fishing gears.

Prediction of habitat suitability and likelihood of VMEs

Data on seabed biodiversity are lacking for most deep-sea benthic areas, except for a few specifically surveyed seamount systems (i.e., Clark et al. 2015), and seabed biodiversity surveys are likely to remain unaffordable for all but a few areas of particular interest. In the absence of such data, biologically important physical factors (Clark 2008) can be used to indicate suitability of specific areas for vulnerable benthic species, and to stratify measures such as spatial closures to protect such areas.

Seabed topography can be combined with physical/chemical factors such as temperature, salinity, depth, chlorophyll, oxygen, currents, productivity and water chemistry using habitat suitability models (Tittensor et al. 2009, Davies & Guinotte 2011, Rowden et al. 2017, Georgian et al. 2019, Stephenson et al. 2021) to predict suitability of particular areas or features as habitats for VME species. Various analyses of this type have been conducted for the South Pacific region. Clark et al. (2006) classified the original Kitchingman and Lai (2004) seamounts in terms of suitability as habitats for cold-water corals, and Allain et al. (2008) classified South Pacific seamounts in terms of depth suitability for various deepwater fish species.

Tittensor et al. (2009) and Davies & Guinotte (2011) developed global predictive habitat suitability models for cold water scleractinian corals. Anderson et al. (2016a) described results of habitat suitability models using presence data and a suite of environmental predictor variables for deep-sea reef-forming coral species across a large region of the South Pacific Ocean and attempted to validate model predictions using photographic surveys. Rowden et al. (2017) built on the sampling and design methodology and results of Anderson et al. (2016a) to produce very high resolution (25x25m) habitat suitability maps for VME indicator taxa and VME habitat on the Louisville Seamount Chain. Georgian et al. (2019) generated broad-scale, high resolution (1x1km) models for ten VME indicator taxa within the New Zealand Exclusive Economic Zone and a portion of the SPRFMO Convention area, which were expanded and further refined by Stephenson et al. (2021), with these results underpinning the spatial management approach embedded within SPRFMO CMM 03 (Bottom Fishing).

Global seamount databases have been updated using the high-resolution (30 arc-second) GEBCO bathymetric data (Yesson et al. 2011, Yesson et al. 2021) and habitat suitability of these seamounts has been classified using the habitat suitability results of Davies & Guinotte (2011). Taxonomic distinctness indices (Warwick and Clarke 1998, Clarke and Warwick 1998, 2001) can be used to evaluate comparative uniqueness, and therefore potential vulnerability, of communities on different features.

In addition to data on interactions with evidence of a VME, SPRFMO participants should collect and contribute sample and/or observations data on VME indicator taxa that are potentially useful to habitat suitability analyses. These data could include high-resolution or multi-beam bathymetry, VME indicator taxa bycatch data or seabed imagery, and should be used in periodic analyses overseen by the Scientific Committee to develop and refine VME indicator taxa habitat suitability and/or abundance models or contribute to other relevant work.

Mapping of Underwater Topographic Features

UNGA Resolutions 61/105 and 64/72 both identify seamounts as areas of particular concern regarding potential impact of fishing on VMEs which may occur on such features. Annex 1 of the FAO Deep-Sea Fisheries Guidelines extend this to list a number of underwater topographic features or habitats that may contain VMEs, including summits and flanks of seamounts, submerged edges and slopes, guyots, banks, knolls, hills, canyons, trenches, hydrothermal vents and cold seeps (FAO 2009).

Mapping of bottom fishing effort

Bottom fishing effort distribution maps are to be prepared using available tow-by-tow or set-by-set data or, if available, Vessel Monitoring System (VMS) data (noting that confidentiality restrictions need to be considered in accordance with CMM 02 (Data Standards)). Confidentiality requirements may influence the level of resolution at which the maps can be displayed (SC10-DW03, SC11-DW10), subject to each Member or CNCP internal regulations. The historic effort data underlying those maps is to be submitted to the Secretariat in accordance with the SPRFMO CMM 02 (Data Standards).

Areas below fishable depth (currently about 1,400m depth for bottom trawl fishing in the SPRFMO Convention Area, see SC11-DW01_rev1) should be excluded in maps of fishing effort distribution. Estimates of actual seabed swept area for bottom trawl fisheries should be based on actual trawl tracks, geospatially buffered with appropriate estimates of trawl swept width. Accurate estimates of seabed swept area at 1 km x 1 km resolution or finer are required for quantitative risk assessment of seabed impact areas, probability of interaction with VME indicator taxa and discounting of biodiversity in previously fished areas (Penney & Guinotte 2013, Pitcher et al. 2016a).

Given the differences in impacts of bottom fishing by different bottom fishing gears (see, for example, Chuenpagdee et al. 2003, Hiddink et al. 2017), effort distribution should therefore be considered and mapped separately for each of the main bottom fishing methods: trawling, lining, potting and trap fishing (SC11-DW01_rev1). Consideration should also be given to fishing effort distribution for different periods of years, so that the Scientific Committee can evaluate both the cumulative duration of fishing impacts in various areas, and also the recovery time for areas fished in the past.

Appendix D – Examples of quantitative methods to identify VMEs and evaluate risks

Examples of different approaches relevant to the identification of VMEs include:

- Kernel Density Analysis (KDE): this method has been used to inform the closure of areas to protect VMEs in the NAFO Regulatory Area. KDEs for several VME indicator taxa (e.g., black corals) have been undertaken over the years using research vessel trawl survey data (Kenchington et al. 2019). KDEs make use of spatially explicit data to model the distribution of a variable (e.g., VME indicator taxa biomass) within an area of interest.
- Computer Vision Models: this data-demanding method can be used to train, count and measure the density of occurrence of a given taxon using annotated imagery. This approach has been used in the North-East Atlantic to explore the population structure of the xenophyophore *Syringammina fragilissima* using seafloor imagery collected by an AUV, producing spatial estimates of both seabed cover and taxa density (Piechaud and Howell 2022).

Examples of different approaches relevant to the assessment of risks to VMEs include:

- Impact assessment framework for bottom fishing methods: This a method for estimating the cumulative bottom footprint and gear impact of past bottom fishing based on an approach presented in CCAMLR (Sharp et al. 2008). The method assumes there is no benthic recovery following fishing impact. It has been applied in SPRFMO (SC5-DW06).
- Relative Benthic Status (RBS) assessment: RBS is quantitative method based on the Schaefer (1954)-type logistic population-growth equation, as commonly used for stock assessments, with an additional term to describe the direct impacts of trawling on seabed benthos, consistent with previous dynamic-modelling approaches seabed assessment (Ellis et al. 2014, Pitcher et al. 2015, Pitcher et al. 2016a, Pitcher et al. 2022). Previous BFIA assessments have used this method (SC8-DW07_rev1, SC11-DW01_rev1) and it has also been used in New Zealand, although its application at a regional level requires further development (Rowden et al., 2024).
- Dynamic RBS assessment: this version of the RBS approach uses an annual time series of trawling intensity, and instead of producing estimates of long-term relative status at equilibrium can provide estimates of status for each year of the time series, including future years if the time series supplied estimates future fishing intensity (Pitcher et al. 2017).

Appendix E – Relevant data to inform review processes

Habitat Suitability models for VME indicator taxa

Table E1 Existing Habitat Suitability Models for each VME indicator taxon in the SPRFMO Evaluated Area and held by the SRPFMO Secretariat as of August 2024. Note abundance models are not currently included in this table as SC11 recommended that existing abundance models require further evaluation before they are used to inform management decisions.

FAO code	VME indicator taxon		Habitat Suitability Model
PFR	Porifera	Demospongiae	Stephenson et al. 2021
		Hexactinallida	Stephenson et al. 2021
CSS	Scleractinia	*Enallopsammia rostrata*	Stephenson et al. 2021
		Goniocorella Dumosa	Stephenson et al. 2021
		Madrepora oculata	Stephenson et al. 2021
		Solenosmilia variabilis	Stephenson et al. 2021
AQZ	Antipatharia		Stephenson et al. 2021
AJZ	Alcyonacea		Stephenson et al. 2021
GGW	Gorgonian Alcyonacea		Stephenson et al. 2021
NTW	Pennatulacea		Stephenson et al. 2021
ATX	Actinaria		SC10-DW05
ZOT	Zoantharia		SC10-DW05
HQZ	Hydrozoa		SC10-DW05
AXT	Stylasteridae		Stephenson et al. 2021
BZN	Bryozoa		SC10-DW05
BHZ	Brisingida		SC10-DW05
CWD	Crinoidea		SC10-DW05

Compilation of documents and datasets to inform review processes

Table E2 Compilation of relevant sources of information (e.g., datasets, scientific papers) sorted by year of publication deemed useful to inform encounter review processes.

Topic	Type	Year	Title, author(s)	Link
Bathymetry	Dataset	2024	GEBCO 2024 Gridded Bathymetry Data	LINK
VME modelling	Paper	2024	Evaluation of the full set of habitat suitability models for vulnerable marine ecosystem indicator taxa in the South Pacific high seas Matthew Bennion, Owen F. Anderson, Ashley A. Rowden, David A. Bowden, Shane W. Geange, Fabrice Stephenson	LINK
VME bycatch	Report	2023	Development of a process to review all recent and historical benthic VME bycatch	LINK
Seamounts	Dataset	2022	New Zealand Seamounts Polygons Ministry for Primary Industries (MPI) - Manatū Ahu Matua and NIWA.	LINK
Seamounts	Dataset	2022	New Zealand Seamounts Points Ministry for Primary Industries (MPI) - Manatū Ahu Matua and NIWA.	LINK
VME modelling	Report	2022	SC10-DW05 Further development of VME indicator taxa distribution models	LINK

Topic	Type	Year	Title, author(s)	Link
VME bycatch	Report	2022	Development of a process to review all recent and historical benthic VME bycatch	LINK
VME modelling	Paper	2021	Presence-only habitat suitability models for vulnerable marine ecosystem indicator taxa in the South Pacific have reached their predictive limit Fabrice Stephenson, Ashley A Rowden, Owen F Anderson, C Roland Pitcher, Matt H Pinkerton, Grady Petersen, David A Bowden ICES Journal of Marine Science, Volume 78, Issue 8, November 2021, Pages 2830–2843.,	LINK
VME modelling	Report	2021	Cumulative Bottom Fishery Impact Assessment for Australian and New Zealand bottom fisheries in the SPRFMO Convention Area, 2020	LINK
Bathymetry	Dataset	2017	New Zealand Bathymetry 250m Imagery/Raster layer NIWA	LINK
Survey	Report	2015	Vulnerable Marine Ecosystems of the Louisville Seamount Chain: voyage report of a survey to evaluate the efficacy of preliminary habitat suitability models New Zealand Aquatic Environment and Biodiversity Report No. 149	LINK
Geomorphology	Paper	2014	Geomorphology of the oceans Harris, P.T., Macmillan-Lawler, M., Rupp, J. and Baker, E.K.	LINK
Geomorphology	Dataset	2014	Global Seafloor Geomorphic Features Harris, P.T., Macmillan-Lawler, M., Rupp, J. and Baker, E.K.	LINK
Survey	Report	2011	Benthic invertebrate samples and data from the Ocean Survey 20/20 voyages to the Chatham Rise and Challenger Plateau, 2007 New Zealand Aquatic Environment and Biodiversity Report No. 65	LINK
Survey	Paper	2011	Composition and distribution of deep-sea benthic invertebrate megafauna on the Lord Howe Rise and Norfolk Ridge, southwest Pacific Ocean A. Williams, F. Althaus, M.R. Clark, K Gowlett-Holmes	LINK
Survey	Report	2006	Biodiversity survey of the seamounts and slopes of the Norfolk Ridge and Lord Howe Rise (NORFANZ). Final Report to the National Oceans Office, April 2005. A. Williams, F. Althaus, K Gowlett-Holmes	LINK

Compilation of documents and datasets to inform the undertaking of surveys to identify VMEs

Table E3 Compilation of relevant sources of information (e.g., datasets, scientific papers) sorted by year of publication deemed useful to design and undertake surveys to help identify VMEs.

Topic	Type	Year	Title	Link
ROV/Acoustic/Arrays	Website	2024	Nautilus Ocean Exploration Trust	LINK
DTIS	Website	2024	Deep Towed Imaging System (DTIS) National Water and Atmospheric Research Taihoro Nukurangi	LINK
Collection of VMEs	Website	Multiple	NAFO surveys and research projects	LINK
ROV	Report	2020	A Pictorial Guide to the Epibenthic Megafauna of Orphan Knoll (northwest Atlantic) Identified from In Situ Benthic Video Footage	LINK

			Alannah Wudrick, Lindsay Beazley, Timothy Culwick, Claire Goodwin, Paco Cárdenas, Joana Xavier, and Ellen Kenchington	
Multibeam/AUV	Paper	2020	Observations of vulnerable marine ecosystems and significant adverse impacts on high seas seamounts of the northwestern Hawaiian Ridge and Emperor Seamount Chain Amy R. Baco, Nicole B. Morgan, E. Brendan Roark	LINK
Multibeam/AUV	Data	2020	Observations of vulnerable marine ecosystems and significant adverse impacts on high seas seamounts of the northwestern Hawaiian Ridge and Emperor Seamount Chain Amy R. Baco, Nicole B. Morgan, E. Brendan Roark	LINK
ROV	Paper	2019	Characterization and Mapping of a Deep-Sea Sponge Ground on the Tropic Seamount (Northeast Tropical Atlantic): Implications for Spatial Management in the High Seas Ramiro-Sánchez B, González-Irusta JM, Henry LA, Cleland J, Yeo I, Xavier JR, Carreiro-Silva M, Sampaio Í, Spearman J, Victorero L, Messing CG.	LINK

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