Bottom Fishery Impact Assessment Standard

Contents

1. Introduction

Fishing with gears that make contact with the seabed (bottom fishing) has the potential to significantly impact the abundance and diversity of benthic species (Kaiser 1998, Koslow et al. 2001, Clark and Koslow 2007). The most fragile and vulnerable species are those that form complex biogenic structures which other species use as habitat, food or shelter from predation (Auster 2005). Deepwater habitat-forming species are often rare or endemic to isolated seamounts, creating areas of high biodiversity which are vulnerable to disturbance (Koslow et al. 2001, Richer de Forges et al. 2000, FAO 2008). These structure-forming organisms are typically slow growing and long lived, making them slow to recover and vulnerable to cumulative impacts from fishing (Clark et al. 2006). Benthic ecosystems that include organisms with these characteristics are referred to as 'vulnerable marine ecosystems' (VMEs) (UNGA 2007, FAO 2008, Rogers et al. 2008).

Many deep sea fish stocks have biological characteristics that result in low productivity, including: maturing at relatively old age, have slow growth, long life expectancies, low natural mortality rates, intermittent recruitment success and may not spawn every year. Their low productivity means that they are not able to sustain high exploitation rates and if depleted their populations are likely to recover very slowly. There are also limited data and information available to support management and so they pose a challenge for ensuring their sustainable utilization and exploitation (FAO 2008).

In response to the 2006 United Nationals General Assembly (UNGA) Resolution 61/105, the participants in the negotiations to establish a South Pacific Regional Fisheries Management Organization (SPRFMO) adopted interim management measures for bottom fisheries, these require participants to:

> *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* (SPRFMO 2007a)

In line with this participants are required to prepare impact assessments for bottom fishing activities to:

> *11. 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.* (SPRFMO 2007a)

The interim measures also require the Science Working Group (SWG) to:

> *12. b) "design a preliminary interim standard for reviewing the benthic impact assessments and develop a process to ensure comments are provided to the submitting Participant and all other Participants"* (SPRFMO 2007a).

Pending development of a more detailed standard, an interim Benthic Assessment Framework was developed by the SWG and adopted by the 6th Meeting of SPRFMO Negotiations (September 2007).

This document provides the interim SPRFMO Bottom Fishery Impact Assessment Standard as adopted by the 10th meeting of the Science Working Group (Vanuatu, 2011). It has been developed using a broad range of currently available information, in particular the general principles developed internationally in response to the UNGA Resolution 61/105 (2006) and Resolution 64/72 (2009), particularly the FAO International Guidelines for the Management of Deep-Sea Fisheries in the High Seas (FAO 2008)–referred to as the FAO Guidelines.

2. Purpose of the Standard

The purpose of the BFIAS is to provide a minimum standard for assessing the potential impacts of proposed bottom fishing activities on VMEs and deep sea fish stocks. This standard is intended to guide SPRFMO participants in preparing the required bottom fishery impact assessments, and to guide the SWG when reviewing these assessments. It is intended to constitute the standardised approach to be taken by all participants when preparing risk and impact assessments for high seas bottom fishing activities in the SPRFMO area.

The definitions and process in the BFIAS aim to be consistent with international principals and contribute to achieving the main objectives articulated in the FAO Guidelines:

> *11. The main objectives of the management of DSFs are to promote responsible fisheries that provide economic opportunities while ensuring the conservation of marine living resources and the protection of marine biodiversity, by:*
>
> *i. ensuring the long-term conservation and sustainable use of marine living resources in the deep seas; and*
>
> *ii. preventing significant adverse impacts on VMEs* (FAO 2008)

The BFIAS aims to ensure that areas containing VMEs and low productivity deep sea resources are protected from significant adverse impacts due to bottom fishing, by ensuring that management decisions are informed by reliable and robust impact assessments based on the best data available.

As SPRFMO management measures for bottom fisheries are revised, and as information on distribution of VMEs, abundance of low productivity deep-sea resources and the impacts of bottom fishing activities in the SPRFMO Area improves, this standard should be updated and amended accordingly.

3. Area of Application

The BFIAS applies to all bottom fishing operations within the SPRFMO Area as defined in the *Convention on the Conservation and Management of High Seas Fishery Resources in the South Pacific Ocean*.

The BFIAS is intended to apply to all fishable depths within the SPRFMO area.

4. Bottom Fishery Impact Assessment Process

The process for preparing, submitting, evaluating and commenting on impact assessments prepared in accordance with this BFIAS was adopted at the 4th meeting of SPRFMO Negotiations in September 2007 (SPRFMO 2007c). The process consists of the following steps:

- Participants are required to prepare bottom fishery impact assessments for all proposed bottom fishing activities in the SPRFMO Area, irrespective of the proposed scale, area or previous history of such fishing activities.
- Such impact assessments are to be prepared and submitted to the SPRFMO Secretariat prior to commencement of any bottom fishing evaluated under the assessment. Fishing may then proceed in accordance with the management and mitigation measures proposed in the assessment while the assessment is being evaluated.
- All bottom fishery impact assessments are to be posted on the SPRFMO website for public comment for a period of 30 days, and forwarded to the SWG for comment.
- The SWG is required to evaluate all assessment and provide written comments back to flag states through the SPRFMO Secretariat within 60 days of assessments being received. SWG comments on assessments are to be posted on the SPRFMO website.
- Flag states are required to respond to the written comments provided by the SWG.

Participants are required to prepare a new bottom fishery impact assessment if a substantial change in the fishery has occurred, such that it is likely that the risk or impacts of the fishery may have changed. Changes that might trigger a re-assessment would include changes in intended fishing areas, management measures or the use of new gear.

In line with the SPRFMO interim management measures, participants are required to prepare assessments, and submit these for review, before opening any new regions of the Area to fishing, or expanding fishing effort or catch beyond existing levels:

> *3. Starting in 2010, before opening new regions of the Area or expanding fishing effort or catch beyond existing levels, establish conservation and management measures to prevent significant adverse impacts on vulnerable marine ecosystems1 and the long-term sustainability of deep sea fish stocks from individual bottom fishing activities or determine that such activities will not have adverse impacts, based on an assessment undertaken in accordance with paragraphs 11 and 12.* (SPRFMO 2007a)

5. Bottom Fishing Impact Assessment Standard

5.1. Definitions

The BFIAS requires clear and specific operational definitions of risk, VMEs and significant adverse impacts.

The FAO Guidelines currently provide the most comprehensive international definitions of these terms. Aspects of these guidelines that are relevant to SPRFMO Area fisheries have therefore been directly incorporated into this standard, in the definitions below.

5.1.1. Bottom Fishing

Bottom fishing is defined as fishing with any gear type likely to come in contact with the seafloor or benthic organisms (FAO 2008).

5.1.2. Risk

The definition of risk for an assessment needs to be based on clearly stated objectives. The risk that is being assessed is then the risk of not achieving those stated objectives.

The high level objectives implied by the SPRFMO interim measures are:

1. That there are no significant adverse impacts from bottom fishing on VMEs
2. That deep sea fish stocks are managed for long-term sustainability.

These objectives need to be operationalized so that they become measurable and the risk can be assessed. This should be clarified in the impact assessment and guidance on this is provided in Section 7. The impact assessment must assess the risk of significant adverse impacts on VMEs and the risk of over-exploitation of deep sea fish stocks. The risk-based approaches used must account for risks arising from limited data availability to directly quantify all potential impacts.

5.1.3. Low Productivity Deep Sea Resources

The FAO Guidelines (FAO 2008, paragraph 13) recognize that marine living resources exploited by deep sea fisheries in the high seas often have low productivity, can only sustain low exploitation rates and are slow to recover once depleted. Key biological characteristics of these low productivity species include maturation at relatively old ages; slow growth; long life expectancies; low natural mortality rates; intermittent recruitment of successful year classes; and spawning that may not occur every year (FAO 2008). Species with these characteristics within the SPRFMO Area will be considered to constitute low productivity resources, and need to be managed in accordance with the relevant guidelines and best practices for sustainable management of such resources.

5.1.4. Vulnerable Marine Ecosystems

The FAO Guidelines define a number of characteristics which should be used as criteria in the definition of vulnerable marine ecosystems:

> *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 2008)

The above characteristics should guide the identification and specific definition of VMEs in the SPRFMO Area. However, to provide operational definitions for use during fishing operations, it is necessary to use the above characteristics to develop lists of specific taxa (orders, families, genera or species) which are considered to contribute to VMEs in the SPRFMO Area. Annex 1 of the FAO Guidelines provides a list of examples of potentially vulnerable species groups, communities and habitats, as well as features that potentially support them and should be used as the basis for determining what constitutes VME taxa in the SPRFMO area:

FAO Guidelines Annex 1. Examples of potentially vulnerable species groups, communities and habitats, as well as features that potentially support them.

The following examples of species groups, communities, habitats and features often display characteristics consistent with possible VMEs. Merely detecting the presence of an element itself is not sufficient to identify a VME. That identification should be made on a case-by-case basis through application of relevant provisions of these Guidelines, particularly Sections 3.2 and 5.2.

Examples of species groups, communities and habitat forming species that are documented or considered sensitive and potentially vulnerable to DSFs in the high-seas, and which many contribute to forming VMEs:
i. certain coldwater corals and hydroids, e.g. reef builders and coral forest including: stony corals (Scleractinia), alcyonaceans and gorgonians (Octocorallia), black corals (Antipatharia) and hydrocorals (Stylasteridae);
ii. some types of sponge dominated communities;
iii. communities composed of dense emergent fauna where large sessile protozoans (xenophyophores) and invertebrates (e.g. hydroids and bryozoans) form an important structural component of habitat; and
iv. seep and vent communities comprised of invertebrate and microbial species found nowhere else (i.e. endemic).

Examples of topographical, hydrophysical or geological features, including fragile geological structures, that potentially support the species groups or communities, referred to above:
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).

(FAO 2008)

For the purposes of this assessment vulnerable marine ecosystems are defined as: any marine ecosystem whose integrity is threatened by significant adverse impacts resulting from physical contact with bottom gears in the normal course of fishing operations, including, inter alia, reefs, seamounts, hydrothermal vents, cold water corals,. cold water sponge beds and low productivity or vulnerable species.
The definition of VMEs for this assessment will need to be reviewed periodically, in the light of improved information on VMEs in the SPRFMO area.

The unit of analysis for the impact assessment for VMEs is currently suggested to be 'VMEs' as a group rather than individual taxa. As more information becomes available (such as the location of different types of VMEs) it may be more appropriate to undertake the impact assessment for different types of VMEs, such as particular benthic communities or assemblages. In terms of deep sea fish stocks the unit of analysis should be the stock, although data availability may similarly constrain the unit of analysis to the species or resource assemblage level. As with VMEs, as more information becomes available it may be more appropriate to update assessments to the stock level.

5.1.5. Predictors to Evaluate Likelihood of Occurrence of VMEs

The FAO Guidelines note (paragraph 45) that, "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". This is reflected in the examples provided in FAO Guidelines Annex 1, shown above.

For much of the SPRFMO Area, data on seabed biodiversity and benthic community composition are not available. Therefore, ancillary information on other factors that influence the location of VMEs will need to be used to predict likelihood and suitability of areas for supporting VMEs.

Predictive Habitat Modelling

Benthic biodiversity data are scarce for the SPRFMO Area and so use should be made of predictive habitat models to identify areas where VMEs are likely to occur. This will contribute to the quantitative evaluation of the risk of significant adverse impacts and the effectiveness of any proposed management and mitigation measures. The recent publication of global habitat prediction models for deep sea scleractinian corals and other species (Tittensor et al 2009, Davies & Guinotte 2011, Anderson et al. 2011) enables the identification of areas where VMEs are predicted to occur.

While existing global habitat models will be useful for risk assessments, the development of regionally-tailored, high resolution, predictive models for the SPRFMO area is seen as a priority. These should be of the highest resolution permitted by available bathymetric data, and should be designed to predict occurrence of all of the VME species of interest in the SPRFMO Area. Development of regionally tailored models will require, where possible, the collection of high resolution data on bathymetry and bycatch of VMEs and participants should include provisions for the collection of such data into conditions for bottom fisheries in the SPRFMO Area. Where possible and appropriate, use should also be made of opportunities presented by presence of fishing vessels in the SPRFMO Area to collect seabed imaging information (using underwater video or cameras) to validate and improve regional habitat prediction models.

Seabed Depth Range and Topography

Seabed depth range and topography are good indicators of seabed geology, and therefore of substratum suitability for supporting VME species. In the absence of benthic biodiversity data and predictive habitat modelling, risk assessments should use depth and analysis of topography, particularly depth range, slope, rugosity and specific topographic features, as indicators of habitat likely to support VMEs. The FAO Guidelines recognizes the following as being features that potentially support species, groups or communities which may contribute to forming VMEs:

- *Submerged edges and slopes; summits and flanks of seamounts, guyots, banks, knolls, and hills; canyons, trenches and hydrothermal vents* (FAO 2008)

5.1.6. Significant Adverse Impacts

The FAO Guidelines provide guidance on what would constitute a significant adverse impact on VMEs:

> *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 an impact, the following six factors should be considered:*
> *i. the intensity or severity of the impact at the specific site being affected;*
> *ii. the spatial extent of the impact relative to the availability of the habitat type affected;*
> *iii. the sensitivity/vulnerability of the ecosystem to the impact;*
> *iv. 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*
> *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.* (FAO 2008)

When evaluating the potential significance of adverse impacts of bottom fishing activities in the SPRFMO Area, the above factors should all be considered. Assessments should evaluate the impact which each type of fishing gear is likely to have on areas likely to contain VMEs, both on a per set basis and cumulatively. Paragraph 20 of the FAO Guidelines states that “In circumstances of limited information, States and RFMO/As should apply the precautionary approach in their determinations regarding the nature and duration of impacts”.

Each bottom fishery impact assessment will need to detail how the above factors were used to develop a definition of 'significance' for the purposes of the assessment. This should include at a minimum the criteria:

- The intensity or severity of the impact at the specific site affected (i.e. are entire colonies/habitats destroyed, or just a few branches broken), this will be gear specific (and may link be guided by the Hierarchy of Bottom Fishing Impacts (Table 1);
- The ecological consequence of a given impact (which depends on the distribution, density, and recovery potential of the organisms in question), including estimation of the likelihood of interaction;
- The spatial extent of the impact relative to the extent of the VME and whether there may be offsite impacts;
- The frequency of the impact and the cumulative fishing effort. The rate of impact (on a temporal and geographical scale) in relation to rates of recovery of taxa needs to be considered.

Many of these criteria are difficult to measure directly for deepwater fisheries and so assumptions must be made based on studies conducted elsewhere or expert input. All assumptions must be clearly documented in the impact assessments to ensure transparency.

5.1.7. Hierarchy of Bottom Fishing Impacts

The intent of UNGA Resolutions (61/105 and 64/72) and the SPRFMO interim measures is to prevent significant adverse impacts on fragile benthic species in deep water. While some benthic ecosystems are more vulnerable to disturbance than others, they are also differentially vulnerable to the impacts of different bottom fishing gears.

Gear type and how the gear is to be fished is an important component of the evaluation of any fishing plan. Gear impact should be evaluated as a product of the typical seabed impact footprint per set or tow of the gear type to be used, the planned number of fishing events (to provide an estimate of the overall extent of physical impact), the likelihood of encountering vulnerable species in proposed fishing areas (including the proportion of planned deployments occurring in new areas) and the expected degree of impact by the gear type concerned, to generate an index of potential disturbance. Default rankings of expected level of impact by gear type are provided in Table 1. This ranking of gear impacts may be revised as necessary, following scientific analyses undertaken in the SPRFMO area.

Table 1. Ratings of habitat impact for each gear class on a scale of 1 (very low) to 5 (very high). Source: Chuenpagdee et al. (2003)

Gear Class	Benthic Habitat	
	Physical	Biological
Gillnet –midwater	1	1
Hook and line	1	1
Longline – pelagic	1	1
Purse seine	1	1
Trawl – midwater	1	1
Longline – bottom	2	2
Gillnet – bottom	3	2
Pots and traps	3	2
Trawl – bottom[2]	5	5
Dredge	5	5

5.1.8. New and Exploratory Fisheries

The Convention of the South Pacific Regional Fisheries Management Organisation (SPRFMO) in Article 22 defines the following concepts and issues related to new or exploratory fisheries:

> "A fishery that has not been subject to fishing or has not been subject to fishing with a particular gear type or technique for ten years or more shall be opened as a fishery or opened to fishing with such gear type or technique only when the Commission has adopted cautious preliminary conservation and management measures in respect of that fishery, and, as appropriate, non-target and associated or dependent species, and appropriate measures to protect the marine ecosystem in which that fishery occurs from adverse impacts of fishing activities. Such preliminary conservation and management measures, which may include requirements regarding notification of intention to fish, the establishment of a development plan, mitigation measures to prevent adverse impacts on marine ecosystems, use of particular fishing gear, the presence of observers, the collection of data, and the conduct of research or exploratory fishing, shall be consistent with the objective and the conservation and management principles and approaches of this Convention. The measures shall ensure that the new fishery resource is developed on a precautionary and gradual basis until sufficient information is acquired to enable the Commission to adopt appropriately detailed conservation and management measures.
>
> The Commission may, from time to time, adopt standard minimum conservation and management measures that are to apply in respect of some or all new fisheries prior to the commencement of fishing for such new fisheries."

Section 8 discusses bottom fishing impact assessments in relation to new or exploratory fisheries.

[2] 'Bottom trawl' is defined for the purposes of this standard as any trawl net fished in such a way that it has a likelihood of coming into contact with the seabed at some time during the trawling operation.

6. Distribution of Vulnerable Marine Ecosystems

To implement the SPRFMO interim management measures (2007) details of species or higher level taxa known or likely to contribute to VMEs in the South Pacific, and the catching of which could indicate evidence of such VMEs, need to be established. The relevant SPRFMO interim measures state:

> *Bottom fisheries: In respect of bottom fisheries, Participants resolve to:*
>
> 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 2007a)

Implementation of these measures requires definitions of:

- Evidence of a VME to trigger the move-on provisions of interim measure 7; and
- Existence of areas known or likely to contain VMEs, to trigger the management requirements of interim measure 6.

A protocol to determine 'evidence of a VME' is required to enable a rapid assessment and immediate management response during actual fishing operations at sea, to limit immediate impact on areas which appear to support significant quantities of VME species. In contrast, 'designating a VME' requires a scientific and deliberative longer-term analysis to integrate data from individual encounters and assess information on occurrence of VMEs across larger spatial scales, in order to identify, map and designate areas which are considered to constitute actual VMEs. Paragraph 119(b) of UNGA Resolution 64/72 states that States and RFMOs are to "conduct further marine scientific research and use the best scientific and technical information available to identify where vulnerable marine ecosystems are known to occur or are likely to occur."

6.1. Detection of 'evidence of VMEs'

UNGA resolution 64/72 in paragraph 119 (c) calls on RFMOs and States to

> *establish and implement appropriate protocols for the implementation of paragraph 83 (d) of its 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 its resolution 61/105 and paragraph 119 (a) of the present resolution.*

SPRFMO interim management measure 7 is intended to apply in cases of unexpected interactions with VMEs during individual fishing operations, in areas where no other pre-determined management action has been implemented to prevent significant adverse impacts. In developing a protocol to detect evidence of a VME, the appropriate scientific analyses should be conducted and the following principles should be considered:

Principles for a Protocol to Identify 'Evidence of a VME'

- Evidence of a VME needs to be defined in a way which makes this measure implementable at sea. The protocol should be rapid to implement at the end of each tow or set, and should not require a high level of taxonomic identification expertise. Relatively few, higher order taxonomic groups should be used, rather than individual species or genera.
- The evidence must be defined in terms of benthic bycatch made during individual bottom fishing operations (e.g. trawl tows or line sets).
- Evidence should be derived from species which possess the characteristics considered to make them vulnerable to deep sea bottom fisheries, as defined in the FAO Guidelines. Emphasis should be placed on taxonomic groups which may contribute to forming VMEs (FAO 2008, Annex 1) in the SPRFMO Area.
- A measure of quantity needs to be incorporated to allow the protocol to distinguish between a sporadic capture of a single organism which may not indicate evidence of a VME and a quantity of by-catch which is considered to constitute evidence of a VME.
- The thresholds chosen to indicate evidence of encounter with a VME should be based on analysis of bycatch data for the fishery and gear type concerned, or a comparable fishery using the same gear type. The thresholds should be also be precautionary.
- Higher ranks / scores should be accorded to species considered more vulnerable to fishing impacts, or which are considered to be strong indicators of VMEs. The protocol should also incorporate some measure of biodiversity, to accord higher scores to bycatches of many species, as opposed to a single species.

6.1.1. Designation of Taxa Constituting Evidence of a VME

The FAO Guidelines (paragraph 42) identify characteristics of species or communities that should be considered to be vulnerable to impacts of bottom fishing. Annex 1 of the FAO Guidelines provides examples of taxonomic groups of organisms which have those characteristics, and which could contribute to forming VMEs (FAO 2008). A CCAMLR VME Workshop (CCAMLR 2009) expanded on the FAO guidelines to develop a set of criteria that characterise species constituting VMEs:

- ***Habitat-forming*** *– One of the main characteristics of the structural species within VMEs is the degree to which they create habitat that could be used by other organisms. Organisms that are large, with a strong three-dimensional shape, or which create a complex surface by clustering in high densities, or changing the character of the substratum (e.g. sponge spicule mats), create habitats for other organisms.*

- ***Longevity*** *– Mortality of long-lived organisms can result in long recovery periods to regenerate unfished age structure, from decades to centuries. Vulnerability of these species is proportional to longevity.*

- ***Slow growth*** *– Organisms which grow slowly will take a longer time to attain a large size or reproductive maturity. Slow growth rates of organisms are correlated with high longevity, but independent of age, slow growth requires longer times to generate maximum size.*

- ***Fragility*** *– The potential for damage or mortality resulting from physical disturbance from bottom fishing gear.*

- ***Larval dispersal potential*** *– The range of dispersal by larvae and propagules influences the ability of a species to recolonise impacted areas. Species which brood larvae, or otherwise have limited dispersal abilities, are less resilient to fishing disturbance because new recruits may not be available from a nearby source, and recruitment, recolonisation and recovery could be delayed. Organisms with high dispersal potential have a higher probability of supplying larvae to a disturbed area and are therefore more resilient.*

- ***Lack of adult motility*** *– Motility in itself should not exclude taxa from being vulnerable or less resilient to bottom fishing gear, as organisms which can move to some degree may still meet all the other criteria of vulnerability. However, the lack of motility does add some degree of vulnerability and decreases resilience because as adults those organisms cannot redistribute themselves in response to a direct disturbance, adjust their position if altered in some way, or move into a disturbed area to recolonise.*

- ***Rare or unique populations*** *– Vulnerable taxa containing species that create dense, isolated populations are intrinsically vulnerable because they have a more limited potential for recovery. This criterion also indicates vulnerability to physical disturbance and is independent of the habitat-forming characteristics of the taxon.* (CCAMLR 2009)

Taxonomic groups which meet the above criteria, and which have been encountered in bottom trawl fisheries in the SPRFMO Area, (Parker et al. 2009) are listed in Table 2. Taxa such as bryozoans and feathery hydroids have been excluded from this list because they are generally not retained by bottom fishing gears. The work provides an example of taxonomic groups that could be used to identify evidence of a VME.

Table 2. Example of a list of taxonomic groups which could be used to identify evidence of a VME in the South Pacific Ocean, based on the work of Parker et al. (2009)

Taxonomic Group	Common Name
Phylum: Porifera	sponges
Phylum: Cnidaria	
Class Anthozoa:	
Order: Actiniaria	anemones
Scleractinia	stony corals
Antipatharia	black corals
Alcyonacea	soft corals
Gorgonacea	sea fans
Pennatulacea	sea pens
Class: Hydrozoa:	
Order: Anthoathecatae	
Family Stylasteridae	hydrocorals
Unidentified corals	corals
Phylum: Echinodermata	
Class: Crinoidea	sea lilies
Order: Brisingida	armless stars

Parker et al. (2009) describe a 'VME Evidence Protocol' for bottom trawl fisheries in the SPRFMO Area, combining the taxa (Table 2) with VME vulnerability scores and weight thresholds determined from analysis of historical New Zealand bottom trawl benthic by-catch data. VME taxonomic lists may need to be developed separately for separate regions of the SPRFMO area, and for different gear types.

6.2. Mapping of Known or Likely VMEs

Procedures for mapping known or likely VMEs are described in Appendix A. This mapping is likely to rely on the use of predictors to evaluate the likelihood of occurrence of VMEs.

7. Bottom Fishery Impact Assessment Sections

The FAO Guidelines (FAO 2008) provide guidelines on the content of impact assessments for deep sea fisheries:

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 significant adverse impacts, 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.

48. Risk assessments referred to in paragraph 47 (vi) above should take into account, as appropriate, differing conditions prevailing in areas where DSFs are well established and in areas where DSFs have not taken place or only occur occasionally. (FAO 2008)

Following these guidelines, impact assessments for proposed bottom fishing activities in the SPRFMO Area should provide information under the following sections:

7.1.1. Description of the Proposed Fishing Activities

Assessments shall contain a detailed fishing plan, providing a quantified description of the planned fishing activities, including:

- Details of the vessels to be used, providing all vessel data required in terms of the SPRFMO Data Standards for vessel data, and confirmation that they appear on the list of approved SPRFMO vessels submitted by flag states to the SPRFMO Secretariat.
- Detailed description of fishing methods (trawls, hook and lines, traps, gillnets, tangle nets) to be used, including a description and gear plan, providing the information needed to evaluate potential impacts, such as net or bottom line types, net dimensions or bottom line lengths / number of hooks, 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.
- Seabed depth range to be fished.
- Target species, and likely or potential by-catch species.
- Intended period and duration of fishing.
- Effort indices: How many vessels, how many tows (cumulative effects), estimated tow durations or distance (ranges).
- Estimated total catch and discard quantities by target and bycatch species.

In instances where new or exploratory fisheries are being undertaken, assessments shall provide a quantified description of the planned fishing activities, including:

- Details of the vessels to be used, providing all vessel data required in terms of the SPRFMO Data Standards for vessel data, and confirmation that they appear on the list of approved SPRFMO vessels submitted by flag states to the SPRFMO Secretariat.
- Detailed description of fishing methods (trawls, hook and lines, traps, gillnets, tangle nets) to be used, including a description and gear plan, providing the information needed to evaluate potential impacts, such as net or bottom line types, net dimensions or bottom line lengths / number of hooks, 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.
- Seabed depth range to be fished.
- Target species, and likely or potential by-catch species.
- Intended period and duration of fishing.
- Effort indices: How many vessels, how many tows (cumulative effects), estimated tow durations or distance (ranges).

Given the nature of new or exploratory fisheries, the expected or planned characteristics of the fishery in terms of the above information should be provided. Once the new or exploratory fishery has concluded, detailed quantification of the above information should be submitted to the Secretariat.

7.1.2. Mapping and Description of Proposed Fishing Areas

Maps of the proposed fishing areas in relation to available information on VMEs and seabed bathymetry should be presented including:

- Maps of the intended fishing areas, at the appropriate resolution (see Appendix B) in relation to the most recent SPRFMO maps of historically fished areas.
- Mapping of results of predictive habitat models for VME species occurring in the SPRFMO Area, or topographic features likely to support such VMEs, including geospatial data available from the Secretariat on predicted distribution of VMEs and topographic features.
- Mapping of all known VMEs, or evidence of VMEs, in the proposed fishing areas, in particular, all geospatial data available from the Secretariat on distributions of known VMEs or evidence of VMEs.
- Baseline data and description of the proposed fishing areas, presenting any available information that might be useful to assessing the potential impacts of fishing – such as past history of fishing, seabed type, depth ranges, location / presence of any known seabed topographic features and VMEs.

The SPRFMO Secretariat will make the SPRFMO geospatial maps of VMEs, predicted VME habitat, bathymetry and historically fished areas available to facilitate mapping of proposed fishing activities in context with this baseline geo-spatial information.

To facilitate evaluation of the relationship between proposed fishing areas, the joint trawl footprint and existing VME maps, Flag States should provide all maps related to proposed fishing activities to the Secretariat in a compatible GIS format, for inclusion in the SPRFMO geo-spatial database.

7.1.3. Impact Assessment

Scoping of Issues of Concern

The initial step in a risk assessment process should be a scoping. This includes explicitly stating the management objectives against which the risk will be assessed and the identification of all of the potential issues of concern (hazards) related to the proposed fishing activities. These will be guided by the UNGA Resolutions 61/105 and 64/72, the SPRFMO interim management measures (2007) and the FAO Guidelines.

The risk assessments should evaluate the potential impact of the 'hazards':

- Fishing activity, this will need to be evaluated for each gear type used by a participant's vessels (e.g. trawling, longlining, etc.)
- Loss of bottom fishing gear, including the risk of ghost fishing and ongoing physical impact of lost gear.

For each activity (hazard) to be evaluated a brief description of the expected impacts should be provided, in terms of what may be affected and how.

Risk Assessment

The level of risk posed by each activity (hazard) should be assessed in a transparent, scientific manner. Determining the level of risk for each activity should be based on quantifiable criteria where possible. Where qualitative criteria are used due to data gaps, qualitative judgements should be underpinned as far as possible by quantitative analyses, and sufficient documentation should be provided to enable the SWG to determine if the assigned risk levels are appropriate.

In determining the level of risk (low, medium, high) posed by an activity, the elements that should be specifically evaluated are:

1. **Intensity -** The intensity or severity of the impact at the specific site affected. This may be quantified by previous studies or an expert evaluation of the magnitude of the impact. e.g. *None*

(no detectable impact); *Low* (some physical damage to some taxa/colonies); *Medium* (substantial damage to a small proportion of colonies/taxa, or small damage to a large number of taxa at the site, likely to modify biological and ecological processes e.g. reproduction) or *High* (significant damage to a significant proportion, where environmental functions and processes are significantly altered such that they temporarily or permanently cease).

2. **Duration –** how long the effects of the impact are likely to last.
3. **Spatial extent** – The spatial impact relative to the extent of the VMEs (e.g. will fishing impact 5%, 30% or 80% of the VME distribution) and whether there may be offsite impacts (e.g. will reproduction be impacted at a broader spatial scale).
4. **Cumulative impact** - The frequency of the impact will influence the risk, with activities occurring repeatedly at a site likely to have a greater risk. This will depend on the amount of fishing effort and should be considered in relation to the recovery of the VMEs/taxa.

Overall Risk. The overall risk ranking of an activity is then evaluated from the combination of the criteria used. The method for combining these criteria to assign low, medium or high risk to an activity should be detailed in the assessment report.

- Low: Where the impact will have a negligible influence on the environment and no active management or mitigation is required. This would be allocated to impacts of low intensity and duration, but could be allocated to impacts of any intensity, if they occur at a local scale and are of temporary duration.
- Medium: Where the impact could have an influence on the environment, which will require active modification of the management approach and / or mitigation. This would be allocated to short to medium-term impacts of moderate intensity, locally to regionally, with possibility of cumulative impact.
- High: Where the impact could have a significant negative impact on the environment, such that the activity(ies) causing the impact should not be permitted to proceed without active management and mitigation to reduce risks and impacts to acceptable levels. This would be allocated to impacts of high intensity that are local, but last for longer than 5-20 years, and/or impacts which extend regionally and beyond, with high likelihood of cumulative impact.

The risk assessment should be based on criteria that are independent, such that they provide separate measures of risk. Criteria should also be quantifiable, preferably with the method of quantification and ranking categories determined beforehand.

In terms of deep sea fish stocks if a robust stock assessment is available, with relevant reference points. This would constitute a high standard of risk assessment, where the outputs of the stock assessment, relative to the reference points indicates the risk to the stocks. This should be worked towards for key stocks.

Where there are data limitations a robust expert based risk assessment should be used which considers the criteria above.

Examples of different risk assessment approaches include:

- CSIRO Ecological Risk Assessment for Effects of Fishing: ERAEF is a hierarchical framework that moves from a Level 1 qualitative analysis through to a more focussed semi-quantitative Level 2 to Level 3 which is model based and fully quantitative. This approach leads to a rapid identification of high risk activities, and evaluation of how fishing impacts on ecological systems (Hobday *et al*. 2007).
- ICES: There have been two main approaches to assessing the sensitivity of habitat to fishing: i) ranking sensitivity of habitat units (physical and biological) to disturbance; and ii) ranking the impacts of the gear. ICES conclude that these approaches should be combined.

- NOAA EIS: Spatial and temporal analysis of the distribution of habitat type, distribution of biota, habitat use, habitat sensitivity, dynamics of fishing effort.
- MarLin: Approach consists of i) Identify "key / important" species in habitat/biotype; ii) Assess biotype sensitivity based on key species; iii) Assess recoverability of key/important species (Tyler-Walters *et al*. 2001).
- UK Department for Environment, Food & Rural Affairs: (DEFRA) Guidelines for Environmental Risk Assessment and Management.
- CCAMLR An impact assessment framework for bottom fishing methods in the CCAMLR convention area (Sharp et al. 2009. *CCAMLR Science*, 2009)

Interactions with VMEs

This section should specifically address the expected and potential interaction and impacts of the proposed fishing gear on VMEs:

- What impacts are likely to result from the fishing gears to be used? All impacts should be identified, characterised and quantified or ranked. All interactions of fishing gear with the seabed will have some impact, but the nature and severity will be species / habitat dependant. Information on known or likely species and habitats in the proposed fishing area should be used to evaluate potential impacts of the fishing gears to be used.
- What will the probability, likely extent (% of habitat targeted) and intensity of the interaction between the proposed fishing gear / targeting practices on the VMEs in the proposed fishing areas be?
- What are the characteristics of the habitats and benthic communities which may be impacted? Are the fished seabed features likely to support VMEs? Do these VMEs include fragile or biogenic habitat-forming species? What proportion of the estimated distribution range of these VMEs areas will the proposed fishing activities impact? How widespread or rare are the VMEs / species? How vulnerable are the VMEs to impact by the fishing gears to be used?
- How diverse is the ecosystem in the proposed fishing areas, and will the fishing activity reduce this biodiversity? Do the proposed fishing areas contain rare species which do not occur elsewhere? What are the levels of endemism - could fishing lead to localised / global extinctions?
- What is the likely spatial scale and duration of the impacts? Will impacts be cumulative with previous impacts in the area? The overall scale of impact will be the product of spatial scale, duration and cumulative impact on VMEs and low productivity resources. Loss of substantial areas of habitat forming coral could have a prolonged impact on the environment, whereas other faunal groups may be able to recover quickly. To the extent possible, rates of recovery, regeneration and re-colonisation should be quantified or estimated.
- Are there any other threats or issues of concern expected from the proposed fishing activities, such as gear loss and ghost fishing, incidental bycatch discards, protected or endangered species mortalities, effects on ecosystem functioning?

In instances where new or exploratory fisheries are intended to be undertaken the assessment should include:

- What impacts are likely to result from the fishing gears to be used? All impacts should be identified, characterised and ranked. Information on known or likely species and habitats in the proposed fishing area should be used to evaluate potential impacts of the fishing gears to be used.

- What will the probability, likely extent (% of habitat targeted) and magnitude of the interaction between the proposed fishing gear / targeting practices on the VMEs in the proposed fishing areas be?
- What are the characteristics of the habitats and benthic communities which may be impacted? Are the fished seabed features likely to support VMEs?
- How diverse is the ecosystem in the proposed fishing areas, and will the fishing activity reduce this biodiversity? Do the proposed fishing areas contain rare species which do not occur elsewhere?
- What is the likely spatial scale and duration of the impacts? The overall scale of impact will be the product of spatial scale, duration and cumulative impact on VMEs and low productivity resources. To the extent possible, rates of recovery, regeneration and re-colonisation should be quantified or estimated.
- Are there any other threats or issues of concern expected from the proposed fishing activities, such as gear loss and ghost fishing, incidental bycatch discards, protected or endangered species mortalities, effects on ecosystem functioning?

Where quantitative risk assessment approaches are used, evaluations of interactions will be directly provided by those assessments

7.1.4. Information on Status of the Deepwater Stocks to be Fished

This section should provide information on the estimated state of the deepwater stocks of the intended target and by-catch species. Such information should include:

- A list of the intended target and likely by-catch species.
- Tables of historic catches and catch trends of these species in the intended fishing area.
- Tables, figures of analyses of historic nominal and/or standardised CPUE trends in these species.
- Results of any surveys conducted on the stocks to be fished.
- Results of the most recent stock assessments that have been conducted for the stocks to be fished, if any such stock assessments have been conducted.
- Any other information relevant to understanding the status and sustainability of target and by-catch species.

In instances where new or exploratory fisheries are being undertaken the assessment should include:

- A list of the intended target and likely by-catch species.
- Tables of historic catches and catch trends of these species in the intended fishing area, if available.
- Results of any surveys conducted on the stocks to be fished.
- Results of the most recent stock assessments that have been conducted for the stocks to be fished.
- Any other information relevant to understanding the status and sustainability of target and by-catch species.

Predictive Stock Assessments

Representative abundance indices for deepwater fish stocks are generally not available for use in quantitative stock assessments. Under such circumstances, predictive modelling approaches, could

be attempted. Such predictive approaches can use indices of abundance of deepwater species from historical fisheries, related to topographic and oceanographic predictor variables, particular seamount size, height, profile, latitude and longitude, to predict abundance of those species in other areas. Clark et al. (2010) provide an example of such an approach for orange roughy fisheries on seamounts in the western SPRFMO Area.

7.1.5. Monitoring, Management and Mitigation Measures

Monitoring, management and mitigation measures would be expected to address the risks identified in the impact assessment.

This section should detail proposals for how the fishing activities will be planned and managed to avoid or minimise significant adverse impacts on VMEs and ensure long term sustainability of deep sea fish stocks. There should be a detailed description of specific monitoring, management and mitigation measures that are currently in place or planned to be implemented to reduce impacts to acceptable levels. Proposed management measures must be specifically designed to achieve the following results for each level of significance.

Effective monitoring measures should be implemented to ensure the effectiveness of the measures and to detect any change in the degree of impact which would prompt the need for a re-assessment. In addition to proposed management or mitigation measures, the following monitoring measures should be implemented including the use of observers, should follow the SPRFMO Data Standards and include:

1. VMS positional information should be collected in accordance with the SPRFMO Data Standards. Provide details of VMS systems to be operated on vessels, including who these will report to, reporting frequency and reporting accuracy.

2. Details of catch and effort data collection systems to be used, including catch and effort reporting systems to the flag states concerned, and additional systems to be implemented specifically for the proposed activity. Report how these data collection systems comply with the SPRFMO data standards. These monitoring systems should specifically address how retained and discarded by-catches are to be monitored and reported. There should also be reporting systems in place to record whether a VME has been encountered during fishing.

3. Details of any scientific observer coverage planned for the proposed fishing activity, including levels of coverage, how deployments will be designed to achieve statistically representative coverage of the proposed fishing activities, and what information observers will be collecting. Observer data should be collected in accordance with the SPRFMO Observer Data Standard.

4. Description of the data that will be provided to the SPRFMO Secretariat for the fishing activity including, as a minimum, data required in terms of the adopted SPRFMO data standards, but also describing other information (e.g. seabed bathymetry or mapping, VME identification and characterization) that will be provided. Details regarding the reporting of evidence of a VME to the SPRFMO Secretariat should be included.

Where quantitative risk assessment approaches are used, these approaches should also be used to evaluate the effectiveness of proposed mitigation measures, by quantitatively evaluating the reduction in risk resulting from those mitigation measures (see e.g. Penney & Guinotte in prep).

8. New and Exploratory Fisheries

The bottom fishing impact assessment for new and exploratory fisheries would be expected to consider all the elements of Section 7, except where differences have been identified. The following section describes these differences.

8.1. Description of the Proposed Fishing Activities

The estimates of total catch and discard quantities would not be available given the nature of the fisheries and so estimates of the other factors, such as fishing duration, number of tows and potential catch rates should be provided. Once information is available from the new or exploratory fishery the impact assessment would be updated using this data.

8.2. Impact Assessment

Where little information is available, predictive approaches should be used to evaluate the likelihood of interaction with, and potential impact on, VMEs. All assumptions used in the impact assessment should be clearly stated. This section should include a trigger for when a new assessment should be completed.

8.3. Information on Status of the Deepwater Stocks to be Fished

Predictive approaches and information from other fisheries should be used to inform the assessment of impact on deepwater stocks to be fished.

8.4. Monitoring, Management and Mitigation Measures

In situations where new or exploratory fisheries are being undertaken monitoring and precautionary measures are critical. As outlined in the FAO Guidelines:

> 65. *Precautionary conservation and management measures, including catch and effort controls, are essential during the exploratory phase of a DSF, and should be a major component of the management of an established DSF. They should include measures to manage the impact of the fishery on low-productivity species, non-target species and sensitive habitat features. Implementation of a precautionary approach to sustainable exploitation of DSFs should include the following measures:*
>
> > *i. precautionary effort limits, particularly where reliable assessments of sustainable exploitation rates of target and main by-catch species are not available;*
> >
> > *ii. precautionary measures, including precautionary spatial catch limits where appropriate, to prevent serial depletion of low-productivity stocks;*
> >
> > *iii. regular review of appropriate indices of stock status and revision downwards of the limits listed above when significant declines are detected;*
> >
> > *iv. measures to prevent significant adverse impacts on vulnerable marine ecosystems; and*
> >
> > *v. comprehensive monitoring of all fishing effort, capture of all species and interactions with VMEs* (FAO 2008)

Therefore, assessments for new or exploratory fisheries must include a description of the monitoring, mitigation and precautionary management measures that will be in place, as outlined above. Details regarding the reporting of evidence of a VME to the SPRFMO Secretariat should be included.

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10. Appendix A

10.1. Mapping of Bottom Fishing Effort and VMEs

Mapping of known or likely vulnerable marine ecosystems is an important pre-requisite for risk assessment and development of management and mitigation measures to prevent significant adverse impacts in such areas. Scientific analyses are required to designate areas known or likely to support VMEs, to allow these areas to be characterised and mapped. Such analyses should use all potential sources of information, including:

- Data on repetitive encounters of fishing vessels with vulnerable species in a particular area (e.g. Rogers et al. 2008, Parker et al. 2010).
- Distribution of predicted habitat suitability derived from predictive habitat models for vulnerable marine taxa (Tittensor et al. 2009, Davies & Guinotte 2011, Anderson et al. 2011), or from other physical data/surrogates, used to inform habitat-suitability analyses (Hirzel et al. 2002, Clark et al. 2006, Davies et al. 2008).
- Data from scientific seabed biodiversity surveys which may be integrated into, or used to inform, habitat suitability analyses (Williams et al. 2009, Anderson et al. 2011).

The SWG will coordinate analyses of data from these sources to develop habitat suitability indices, and to predict and map locations of seabed areas with a high likelihood of supporting VMEs in the SPRFMO Area. The results of these analyses should be considered by participants in their impact assessments.

10.2. Designation of Areas as VMEs

The FAO deep-sea guidelines recognise that 'Merely detecting the presence of an element itself is not sufficient to identify a VME'. (FAO 2008, Annex 1). Single encounters with evidence of a VME indicate the presence of a vulnerable species at some point in the area fished during the tow or set, but may not indicate the presence of a vulnerable ecosystem. Further analyses are required to designate areas known to support VMEs based on repetitive encounters with vulnerable species in a particular area, prediction of areas likely to support VMEs based on information on habitat suitability for vulnerable deepwater benthic species, or seabed biodiversity surveys.

Repetitive Encounters with Vulnerable Taxa

While an encounter with evidence of a VME at a single site 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, and reported to the SPRFMO Secretariat, should be regularly analysed to identify, map and characterise areas in which multiple or repetitive encounters with VME species are found. Guidelines on what constitutes repetitive encounters with vulnerable taxa indicating presence of a VME are provided by Rogers et al. (2008):

- Two or more consecutive hauls containing > 2kgs each of live corals, or > 5kg sponges or other habitat-forming epifauna, on the same trawl track or setting area, or where consecutive trawling tracks or sets intersect.
- > 4 encounters of > 2kg of corals, or > 10 encounters of > 2kg of sponges or other habitat-forming epifauna, within an area (1km^2) within one year.
- > 4 corals per 1000 hooks in a long line fishery within one year within an area (10km^2).

- > 15% of hauls of any gear within an area (10 - 100km^2) containing corals, sponges or other habitat forming epifaunal taxa.

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, 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, Williams et al. 2009) 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 geo-morphological classification derived from seismic surveys can be used to identify areas of particular substratum types that can be correlated with particular benthic communities (Anderson et al. 2011).

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

In addition to data on interactions with evidence of a VME, SPRFMO participants should collect and contribute data that are potentially useful to habitat suitability analyses. These data could include high-resolution or multi-beam bathymetry, VME by-catch data or seabed imagery, and should be used in periodic analyses coordinated by the SWG to develop habitat suitability indices, predict and map locations of seabed areas with a high likelihood of supporting VMEs in the SPRFMO Area.

Seabed Biodiversity Surveys

The most reliable data on seabed 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 (Constable and Holt 2007, CCAMLR 2007) along planned survey transects. Where feasible, efforts should be made to conduct such sampling in areas of particular interest or concern, such as those predicted from habitat suitability analyses to be highly likely to support VMEs.

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 VME 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 participants.

Where scientific surveys are not considered to be cost effective, industry fishing vessels may be suitable platforms for conducting opportunistic 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.

Designation of VME Areas

Information and data on interactions with VME species, predictive analyses of habitat suitability and results of seabed biodiversity surveys should form the basis for mapping and designation of areas known or likely to support VMEs within the SPRFMO Area. The SWG should develop recommendations for measures to protect such areas from significant adverse impacts of bottom fishing.

10.3. Mapping of Bottom Fishing Effort

Participants are to provide bottom fishing effort distribution maps, of areas that will be fished, and areas that have been fished throughout the history of the fishery. These maps will be prepared at 0.1 degree (6 minute) grid resolution, noting SPRFMO confidentiality provisions. Bottom fishing effort distribution maps are to be prepared using all available individual tow-by-tow data. These data should also be submitted to the Secretariat in accordance with the SPRFMO Data Standards (SPRFMO 2007b).

Areas below fishable depth (currently about 1500m depth for bottom trawl fishing in the SPRFMO Area) 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 are required for quantitative risk assessment of seabed impact areas, risk of interaction with VMEs and discounting of biodiversity in previously fished areas (Penney & Guinotte in prep). The SPRFMO Secretariat, in cooperation with the SWG, will develop and maintain electronic geospatial maps of joint bottom fishing effort for all Participants in bottom fisheries in the SPRFMO area at the agreed resolution, and will make these maps available to participants through the SPRFMO geospatial database

Different bottom fishing methods have different levels of expected impact (Chuenpagdee et al. 2003), with mobile gears such as bottom trawling (benthic or bentho-pelagic trawling) or dredging ranked as having the highest impact, and stationary gears (such as bottom lining) having lower impact. Bottom fishing effort distribution maps should therefore be prepared separately for each of the main bottom fishing methods: trawling, dredging, lining, stationery netting, potting and trap fishing. Maps of the fishing effort distribution should also be prepared for different periods of years, so that the SWG can evaluate both the cumulative duration of fishing impacts in various areas, and also the recovery time for areas fished in the past.

10.4. Mapping of Vulnerable Marine Ecosystems

Mapping of available data on the known or likely distribution of VMEs in the SPRFMO area is critical to informing the bottom fishery impact assessments participants will conduct. There a number of steps towards mapping VMEs in the SPRFMO area:

- Mapping of predicted distribution of VMEs based on the results of predictive habitat suitability models for VME taxa.
- Mapping of known or predicted underwater topographic features, particularly seamounts, which may support vulnerable benthic species and ecosystems.
- Mapping of fishing positions observed to contain ‘evidence of VMEs’, as defined in the rapid VME evidence assessment protocol in the BFIAS, and of scientific observer data on benthic bycatches.
- Mapping of seabed biodiversity data from research surveys, underwater visual images or scientific sampling programmes.

- Analysis of the above information to identify, designate and map areas which are known or likely to contain VMEs, and which require protection from fishing impacts.

10.5. Mapping of Underwater Topographic Features

UNGA Resolutions 61/105, 64/72 and the SPRFMO interim measure both identify seamounts as areas of particular concern regarding potential impact of fishing on VMEs which may occur on such features. The FAO deep-sea guidelines extend this to list a number of underwater topographic features or habitats which 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 2008, Annex 1).

The SPRFMO SWG has requested the Secretariat to include data on such features in the SPRFMO Geospatial Database. Primary sources of such data include:

- The global database of predicted seamount features produced by Kitchingman & Lai (2004).
- The database of validated and cross-checked seamount features occurring in the SPRFMO Area produced by Allain *et al*. (2008).
- The updated global database of seamount based on GEBCO 30 arc-second bathymetry produced by Yesson et al (2011).
- Global predicted coral habitat suitability maps from habitat suitability analyses by Tittensor et al. (2009) and Davies & Guinotte (2011), and classifications of the above seamounts database using these model results.
- Available bathymetric grid data for the South Pacific region from the General Bathymetric Chart of the Oceans (GEBCO), and for the Tasman Sea area from GeoScience Australia.
- Additional high resolution bathymetric data which may be collected during surveys, or by the fishing industry during fishing operations in the SPRFMO Area.

The bathymetric data sets should be used in geostatistical analyses coordinated by the SWG to detect and delineate seabed features with particular profile, slope, depth and elevation which characterise features which are likely to support VMEs. Such features should then be added into the SPRFMO geospatial database of underwater topographic features which may support VMEs.

10.6. Mapping of Sites with Evidence of VMEs

The SPRFMO bottom fishing interim measures require participants to monitor bottom fishing operations for ‘evidence of VMEs’ and report all such encounters, including details of the evidence obtained, to the SPRFMO Secretariat (bottom fishing IM 7, SPRFMO 2007a) so that such sites can be managed to prevent significant impacts of bottom fishing.

Mapping of all sites found to contain evidence of VMEs is an essential first 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 (see Section 1.0 - Designation of Areas as VMEs). Data on encounters with evidence of VMEs should be reported to the SPRFMO Secretariat immediately after the completion of each trip on which evidence of VMEs was encountered. Data should be reported separately for each fishing event and should include:

- Date of the fishing event.
- Fishing gear type.
- Exact location of the encounter (position of start of haul of the fishing gear in Lat / Lon to the nearest 1/10th degree).
- Depth of fishing event (start of haul).

- Details of the VME evidence encountered, listing each taxonomic group recorded under the VME evidence protocol, with quantitative estimates (weight or volume) of bycatch of each taxon.

All detailed scientific observer data on benthic by-catch observed while monitoring bottom fishing operations should also be reported to the Secretariat in a similar format to the above evidence data, but with benthic species identified to the lowest taxon possible, and by-catches of each taxon quantified by weight or volume.

10.7. Identification of Areas Known or Likely to Contain VMEs

Section 9.6 details a process for analysing data on sites with repetitive encounters with evidence of VMEs, or analyses of the distribution of habitats predicted to be likely to support VMEs. Results of such analyses should be included in the SPRFMO geospatial database to contribute to the scientific basis for recommended management measures to protect adequate and representative areas known or likely to support VMEs in the SPRFMO Area.

In the absence of benthic biodiversity survey data, scientific classification of the likelihood that particular areas or features will contain VMEs will have to rely on predictive habitat suitability modelling. The latest developments in this field relate to development and improvement of global coral habitat suitability models, particularly recent global maximum entropy (Maxent) models published by Tittensor et al, (2009) and Davies & Guinotte (2011). Of these, the Davies & Guinotte predictive model has been developed at higher resolution (30 arc-second, about 1 km^2). Figure 3 shows a map of the predicted habitat suitability for *Solenosmilia variabilis*, the most dominant habitat forming coral in the region around New Zealand and Australia.

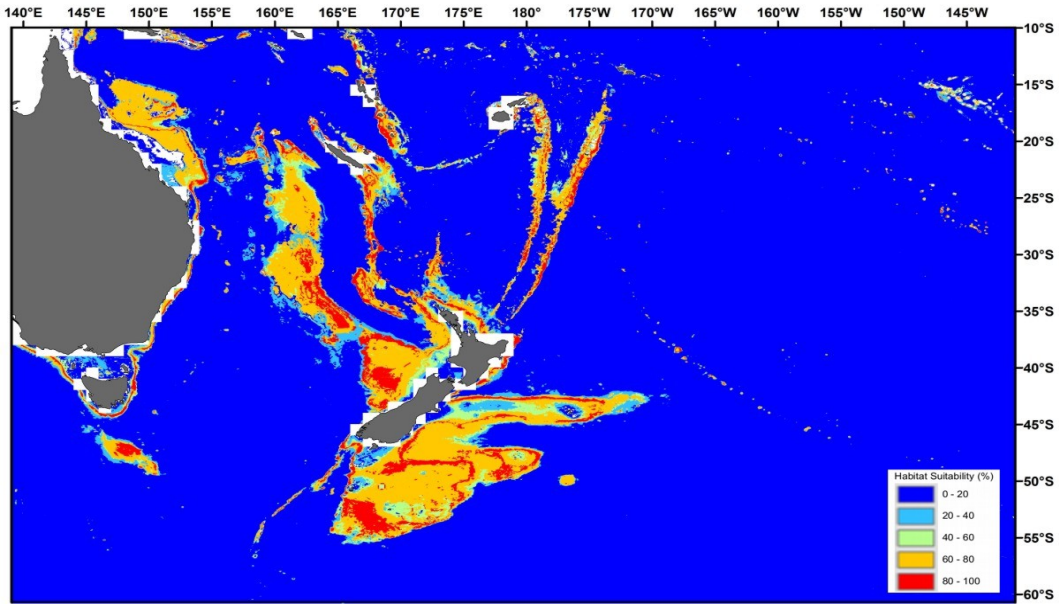

Figure 3. Map of the western part of the SPRFMO Area around New Zealand and Australia showing the predicted habitat suitability for the framework-forming scleractinian coral Solenosmilia variabilis, from the global scleractinian habitat suitability model of Davies & Guinotte (2011)

The predicted coral habitat suitability model results of Davies & Guinotte have been used to classify the summits of the updated global seamounts data developed by Yesson et al. (2011), and figure 4 shows a map of the distribution of these seamounts in the SPRFMO Area, classified by predicted coral habitat suitability.

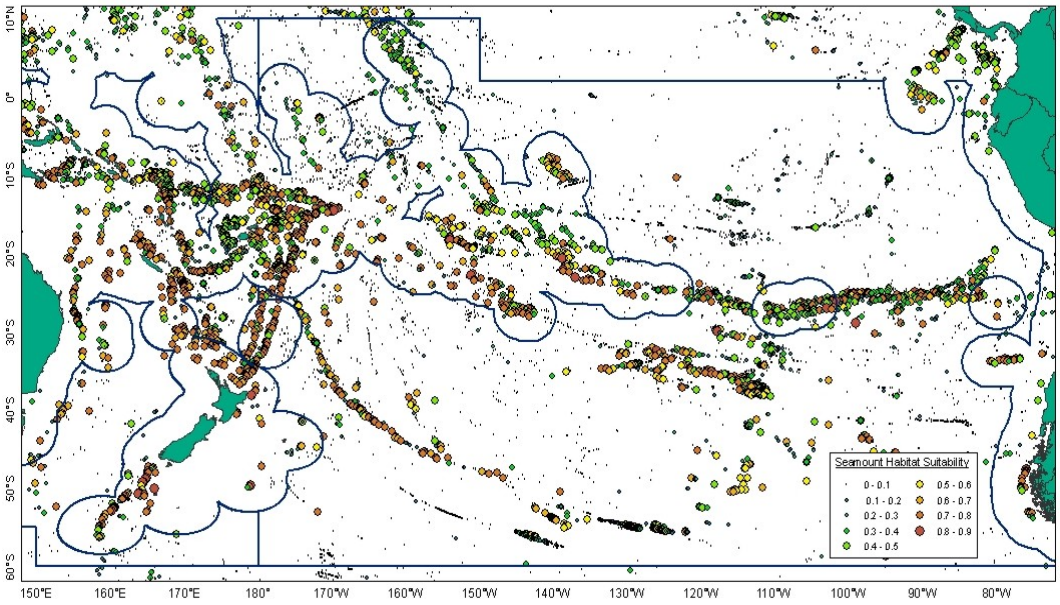

Figure 4. Map of the updated global seamounts database of Yesson et al. (2011) in the SPRFMO Area, showing seamount summits classified by coral habitat suitability indices from Davies & Guinotte (2011)

The above geospatial information and maps will be made available to Participants for preparation of Bottom Fishery Impact Assessments. In preparing assessments, Participants should ensure that:

- Bottom fishery impact assessments specifically take account of all the above information on distribution of VMEs, evidence of VMEs and features likely to support VMEs in the intended fishing areas.
- Risk assessments evaluate the risk of interactions and significant adverse impacts on these known or likely VMEs and proposed management and mitigation measures should be designed to prevent significant adverse impacts on such areas.
- Monitoring arrangements are designed to collect relevant information which may be useful to improving the above geospatial databases and maps, including data on sites with evidence of VMEs, scientific observer data on benthic by-catch composition, visual images or sampling data which might be collected in fishing areas and high resolution bathymetric data.

10.8. Provision of Geospatial Data

Any significant geospatial datasets used to map VMEs should be submitted to the Secretariat for future use.