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Report of the

FAO/NPFC Workshop on Protection of Vulnerable Marine Ecosystems in the North Pacific Fisheries Commission Area: Applying Global Experiences to Regional Assessments

12–15 March 2018 • Yokohama, Japan

ABNJ Deep Seas Project

Sustainable Fisheries Management and Biodiversity Conservation of Deep-sea Living Marine Resources and Ecosystems in the Areas Beyond National Jurisdiction

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REPORT OF THE FAO/NPFC WORKSHOP ON PROTECTION OF VULNERABLE MARINE ECOSYSTEMS IN THE NORTH PACIFIC FISHERIES COMMISSION AREA: APPLYING GLOBAL EXPERIENCES TO REGIONAL ASSESSMENTS

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PREPARATION OF THIS DOCUMENT

This is the report of the FAO/NPFC workshop on protection of vulnerable marine ecosystems in the North Pacific Fisheries Commission Area: applying global experiences to regional assessment. The event was held in Yokohama, Japan on 12–15 March 2018. The report is written by the North Pacific Fisheries Commission (NPFC). The primary author is Dr Loh-Lee Low, former chair of the Commission's Small Scientific Committee on Vulnerable Marine Ecosystems and the co-chair of the workshop. The report was finalized with support from Dr Masashi Kiyota, the workshop co-chair, and the NPFC Secretariat. Reviews from the workshop participants and the FAO also contributed to the report.

The workshop was organized by the NPFC with financial support from the FAO ABNJ Deep Seas Project. This is the second VME workshop with respect to the NPFC Area. The first workshop was held in Tokyo, Japan from 11–13 March 2014. The goal of this workshop is to update NPFC's understanding of how fishing activities over seamounts impact vulnerable marine ecosystems in the Convention Area. The workshop brought together NPFC and global experts to review their assessment experiences from the World's Oceans and made recommendations to the NPFC Scientific Committee via the Small Scientific Committee on vulnerable marine ecosystems.

ABSTRACT

The subject matter of this workshop was protection of vulnerable marine ecosystems (VME) in the North Pacific Fisheries Commission (NPFC) Area, with the aim of applying global experiences to the regional assessments and to build capacity to protect VMEs and related management issues in the North Pacific Ocean region. The workshop focused on the mitigation of bottom fishing impacts on VMEs within the framework of the Food and Agriculture Organization of the United Nations (FAO) *International Guidelines for the Management of Deep-Sea Fisheries in the High Seas*. Workshop participants identified historical and existing seamount fisheries that impacted benthic VMEs, with a particular focus on corals. Participants reviewed actions that have already been taken to mitigate VME issues associated with the two areas of seamount fisheries: the Emperor Seamount area of the northwestern Pacific Ocean, and a few seamounts off Canada in the high seas of the northeastern Pacific Ocean. The workshop brought together global experts to advise on methodologies and options for protecting VMEs. For the Emperor Seamounts, it was determined that significant adverse impacts (SAIs) on corals had occurred in the past, are likely still occurring, and likely to continue to occur if the fisheries continue with the current regulatory mechanism. Since coming into force in 2015, NPFC has established a limited fishery for bottom fish that likely will have SAIs on corals. However, new research reported at this workshop suggest that some meaningful signs of recovery to damaged areas on the Emperor seamounts were detected in the 30-40 year time scale. While the northeast Pacific seamount fishery is very small, the risk of possible SAIs on corals remains. Considering this, the workshop suggested future requirements and support mechanisms for the Commission, including data collection, scientific observer systems, fishing footprints, taxa of VME indicators, impact assessments, exploratory fishing protocols, mapping coral distributions, spatial area management, research planning, encounter protocols, and performance reviews. A spatial management process was suggested and a set of recommendations was made for the Small Scientific Committee (SSC) on VMEs to review for its Scientific Committee and the Commission.

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ABBREVIATIONS AND ACRONYMS

ABNJ	Areas Beyond National Jurisdiction
CBD	Convention on Biological Diversity
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources
CMM	Conservation and Management Measure
EBSA	Ecologically or Biologically Significant Area
EEZ	Exclusive Economic Zone
DFO	Department of Fisheries and Oceans, Canada
FAO	Food and Agriculture Organization of the United Nations
FAO-DSF Guidelines	International Guidelines for the Management of Deep-Sea Fisheries in the High Seas (FAO-DSF Guidelines, FAO 2009)
ICES	International Council for the Exploration of the Sea
MSC	Marine Stewardship Council
NAFO	Northwest Atlantic Fisheries Organization
NEAFC	Northeast Atlantic Fisheries Commission
NGO	Non-Governmental Organization
NOAA	National Oceanic and Atmospheric Administration, USA
NPFC	North Pacific Fisheries Commission
PICES	North Pacific Marine Science Organization
RFMO/A	Regional Fisheries Management Organization/Arrangement
SAI	Significant Adverse Impact
SC	Scientific Committee (of NPFC)
SDG	Sustainable Development Goal (of UN)
SEAFO	South East Atlantic Fisheries Organization
SPRFMO	South Pacific Regional Fisheries Management Organization
SSC VME	Small Scientific Committee on Vulnerable Marine Ecosystems (of NPFC)
TCC	Technical and Compliance Committee (of NPFC)
UNGA	United Nations General Assembly
UNCLOS	United Nations Convention on the Law of the Sea
USA	United States of America
VME	Vulnerable Marine Ecosystem
VMS	Vessel Monitoring System

1. INTRODUCTION

The *International Guidelines for the Management of Deep-Sea Fisheries in the High Seas* (the FAO-DSF Guidelines; FAO 2009) provide guidance to states and regional fisheries management organizations or arrangements (RFMO/As) on the long-term conservation and sustainable use of living marine resources in the high seas. This guidance greatly assists with the implementation of Paragraph 83 (and more generally, paragraphs 80–86) of United Nations General Assembly (UNGA) Resolution 61/105 (2006) as well as the more recent Resolutions 64/72 (2009), 65/38 (2010) and 66/68 (2011).

The Food and Agriculture Organization of the United Nations (FAO) has developed a programme to support the implementation of the Guidelines consistent with the ecosystem approach to fisheries. FAO is the co-executing agency, along with UN Environment, of the GEF-funded Areas Beyond National Jurisdiction (ABNJ) Deep Seas Project that will further support sustainable deep-sea fisheries and biodiversity conservation throughout the world's oceans.

In May 2010, a workshop was held in Busan, Republic of Korea to develop ways for implementation of the FAO-DSF Guidelines. The workshop identified a specific programme of work and activities to further guide the use of vulnerable marine ecosystem (VME) criteria and associated measures. In December 2011, a workshop was held at FAO Headquarters in Rome, Italy, to discuss stakeholder needs and to develop a strategy for information-sharing mechanisms for a VME DataBase (http://www.fao.org/in-action/vulnerable-marine-ecosystems/vme-database/en/vme.html).
The workshop noted the need for regional approaches, and the need to share resulting developments among the regions and wider interested stakeholders.

The FAO started a third in a series of workshops to facilitate regional information-sharing and discussion on VMEs issues among stakeholders. The workshops were held in July 2012 in Mauritius for the Indian Ocean, April 2013 in Namibia for the southeast Atlantic Ocean, and March 2014 in Tokyo for the North Pacific Ocean. This workshop in 2018 is a follow-up on the Tokyo event.

The subject matter of this workshop is on protection of VMEs in the North Pacific Fisheries Commission (NPFC) Area, with the emphasis of applying global experiences to its assessments. This workshop brought together NPFC and global experts to review the fisheries, impact assessments methodology, and experiences from other areas of the World's Ocean. The workshop addressed the knowledge base of the fisheries, assessment and management of fishery impacts on VMEs, the data needs, and further steps needed to improve NPFC's assessments. A set of recommendations was made to the NPFC Scientific Committee (SC) via the Small Scientific Committee on VMEs (SSC VME).

The FAO/NPFC workshop on Protection of Vulnerable Marine Ecosystems in the North Pacific Fisheries Commission Area: Applying Global Experiences to Regional Assessments (FAO/NPFC VME workshop) took place in Yokohama, Japan, from 12-15 March 2018 at the National Research Institute of Fisheries Science (NRIFS) with the Japan Fisheries Research and Education Agency (FRA). The workshop was jointly sponsored and organized by NPFC and the FAO Areas Beyond National Jurisdiction (ABNJ) Deep Seas Project. The North Pacific Marine Science Organization (PICES) also supported the workshop. The workshop was attended by representatives of NPFC Member Countries from Canada, China, Japan, the Republic of Korea, the Russia Federation, and the United States of America. Other participants were representatives and invited experts from Australia, New Zealand, the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR), the Deep Sea Conservation Coalition (DSCC), and the South Pacific Regional Fisheries Management Organization (SPRFMO).

NPFC is an inter-governmental organization established by the Convention on the Conservation and Management of High Seas Fisheries Resources in the North Pacific Ocean (Moon, 2017; NPFC, 2019). The Convention came into force on 19 July 2015 and current Members include: Canada, China, Japan, the Republic of Korea, the Russian Federation, Taiwan Province of China, the United States of America, and Vanuatu. The Convention Area is the ABNJ high seas area of the North Pacific Ocean (Figure 1).

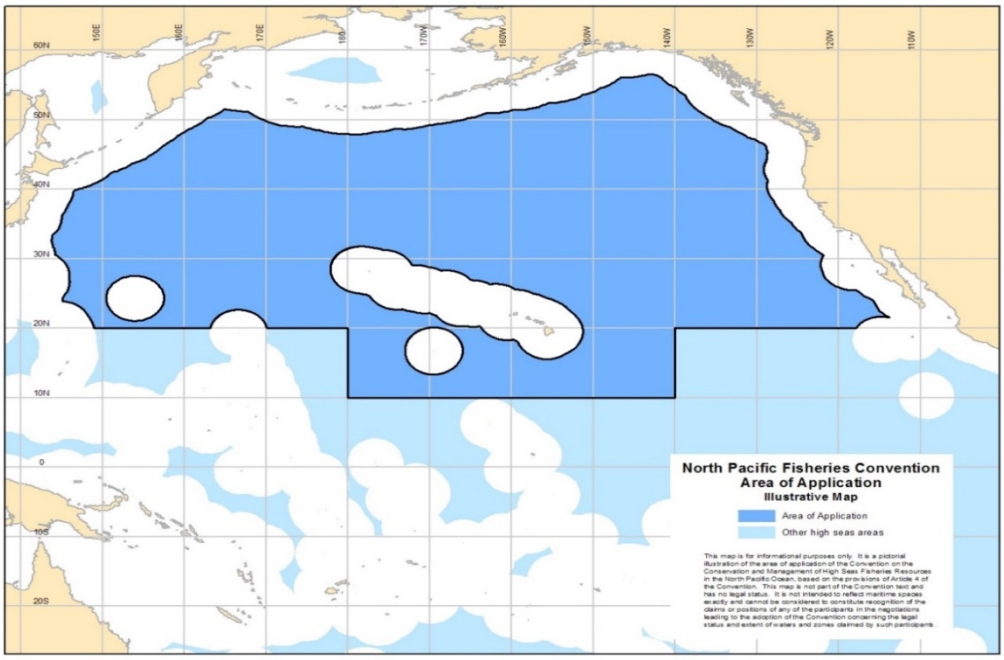

Figure 1. Map of the North Pacific Fisheries Commission Convention area
Note: This map is for informational purpose only. It is a pictorial illustration of the area of application of the Convention on the Conservation and Management of High Seas Fisheries Resources in the North Pacific Ocean, based on the provisions of Article 4 of the Convention. This map is not part of the Convention text and has no legal status. It is not intended to reflect maritime spaces exactly and cannot be considered to constitute recognition of the claims or positions of any of the participants in the negotiations leading to the adoption of the Convention concerning the legal status and extent of waters and zones claimed by such participants.

The sea floor of the northwestern Pacific Ocean is dominated by a prominent submarine ridge known as the Emperor Seamounts chain, which runs south from the Aleutian Islands southwards toward the Hawaiian Islands. The southern half of this chain contains many relatively flat-topped and shallow seamounts which have supported bottom trawl fisheries targeting North Pacific armourhead (slender armourhead, *Pentaceros (=Pseudopentaceros) wheeleri*), and splendid alfonsino (*Beryx splendens*). These fisheries have occurred since the late 1960s and 1970s.

In the northeast Pacific Ocean, seamounts are found extending off the Aleutians, into the Gulf of Alaska, and waters off Canada and extending southwards to California and beyond. Most of the seamounts off the EEZ of the United States of America are not currently fished, though a small sablefish fishery occurs off the EEZ of Canada. There are also hundreds of seamounts found throughout the entire North Pacific Ocean where there has been no fishing and little information is known about them.

The objective of the Convention is to ensure the long-term conservation and sustainable use of the fisheries resources in the Convention Area while protecting the marine ecosystems of the North Pacific Ocean in which these resources occur. The fisheries resources covered by the Convention are all fish, molluscs, crustaceans and other marine species caught by fishing vessels within the Convention Area, excluding: (i) sedentary species insofar as they are subject to the sovereign rights of coastal States; and indicator species of VMEs as listed in, or adopted pursuant to the NPFC Convention; (ii) catadromous species; (iii) marine mammals, marine reptiles and seabirds; and (iv) other marine species already covered by pre-existing international fisheries management instruments within the area of competence of such instruments.

The assessment of the impact of bottom fishing activities on VMEs is a key assignment of the United Nations General Assembly (UNGA) Resolution 61/105 (UN 2006) and subsequent resolutions (e.g., 64/72 (2010), 66/68 (2011), and 71/123 (2016)). The specific guidelines on how this should be achieved

were developed by FAO, namely through the FAO International Guidelines for the Management of Deep-Sea Fisheries in the High Seas (FAO-DSF Guidelines, FAO, 2009). The NPFC has adopted the criteria from the FAO-DSF Guidelines in order to be consistent with the criteria of other regional fisheries management organizations or arrangements (RFMO/A).

The goal of this workshop is to update and expand NPFC's understanding of how bottom fishing activities over seamounts may result in significant adverse impacts (SAIs) on VMEs, and how these SAIs can be mitigated in the Convention Area. The workshop brought together NPFC and global experts to review the situations of assessments and protection of VMEs in the North Pacific Ocean and other oceans.

1.1. Workshop opening

Dr Dae-Yeon Moon (Executive Secretary of the NPFC), opened the meeting and welcomed the participants. Dr Moon extended his gratitude to the Government of Japan for hosting the workshop, and to FAO for initiating and supporting it. He also expressed his hope that the workshop would contribute to further protection of VMEs.

The workshop was co-chaired by Dr Loh-Lee Low, former chair of NPFC's SSC VME, and Dr Masashi Kiyota of the Fisheries Research and Education Agency, Japan. Dr Aleksandr Zavolokin, Science Manager of NPFC, provided support to organize and run the workshop. Alex Meyer (from Urban Connections) was the rapporteur.

1.2. International frameworks and obligations for SAI assessments

Dr Hassan Moustahfid (FAO) elaborated on the FAO Deep Sea Fisheries programme goals and its aim to support the implementation of the FAO-DSF Guidelines. Dr Moustahfid described the ABNJ Deep Seas Project and its four components: improving application of policy and legal frameworks, reducing adverse impacts on VMEs and components of ecologically or biologically significant areas (EBSAs), improving planning and adaptive management of deep-seas fisheries, and developing methodologies for area-based planning in the ABNJ.

Dr Tony Thompson (FAO) presented on the legal frameworks to sustainable fisheries conservation that began with the United Nations Convention on the Law of the Sea (UNCLOS) (NPFC-2018-WS VME01-WP12). UNCLOS stipulates the right to fish in the ABNJ is subject to States cooperating and adopting measures to ensure fishing on high seas would be sustainable. UNCLOS requires States to consider the effects of fishing activities on species associated with or dependent upon harvested species, including other species interacting with fisheries, thus encompassing the entire ecosystem.

The UN Fish Stock Agreement also emphasizes the need to conserve and manage species belonging to the same ecosystem and maintaining populations above levels at which their reproduction would not be seriously threatened. This agreement emphasizes the protection of biodiversity in the marine environment. The FAO Code of Conduct for Responsible Fisheries (FAO, 1991) is another instrument widely acknowledged by most RFMO/A treaties. This code talks of maintaining biodiversity and populations and it advocates the use of precautionary principles to fisheries management to sustain fisheries resources and their ecosystems.

The UNGA Resolution 61/105 of 2006 set specific deadlines to protect VMEs, and the subsequent FAO-DSF Guidelines set clearer criteria for implementation. The UNGA resolution calls upon RFMO/As to identify known or likely VME areas, assess SAIs, mitigate actions to prevent SAIs, differentiate between fished and unfished areas, and take precautionary measures to fishing activities.

VMEs are thought of as broader habitats rather than limited to specific species and are often linked to underwater topographical features. The Guidelines stressed the need to develop baseline information, map VME distributions in relation to fishing footprints, develop methods to identify impacts, evaluate the scale of impacts, conduct risk assessments, and mitigate and develop harvesting plans.

The following factors are some specific impact assessments criteria set out by the FAO-DSF Guidelines:

(i) Intensity and severity of impact at specific site by fishing gear;
(ii) Spatial extent of impact relative to availability of habitat type;
(iii) Sensitivity/vulnerability of the ecosystem to the impact where features can be quantifiable at the individual species level to the ecosystem level, and
(iv) Ability of ecosystems to recover from harm and rate of such recovery.

While ecosystem functions may be altered by the impact of fishing, any such alteration is largely unknown.

Dr Tony Thompson referred to the Busan workshop in 2010 that identified specific areas of work and activities that would be needed to further the implementation of the FAO-DSF Guidelines, including that impact assessments should be integrated across all fishing entities, nations and gears. Impact assessments should be done in all areas, and especially where information is lacking or where SAIs are likely to occur. Cumulative effects of fishing must also be considered and mapping of the fishing footprint by gear type will be important. Dr Thompson referred to a series of important questions of scale and significance to be addressed: what constitutes a “significant concentration” or a “significant impact” and how to quantify SAIs.

Climate change effects on the marine environment are rapidly occurring. Thus, closer monitoring of fishing impacts in relation to climate change is important, albeit difficult to quantify. Distributional changes are expected, though accurate prediction requires more informed modelling processes.

2. OVERVIEW OF SEAMOUNT BOTTOM FISHERIES THAT IMPACT CORAL VMES

2.1. Global seamount fisheries

Dr Ellen Kenchington (DFO, Canada) presented on global seamount fisheries on behalf of Dr Odd Aksel Bergstad (IMR, Norway), and covered experiences from the Atlantic RFMO/As (NPFC-2018-WS VME01-WP09): the Northwest Atlantic Fisheries Organization (NAFO), the North East Atlantic Fisheries Commission (NEAFC), and the South East Atlantic Fisheries Organisation (SEAFO). The high-seas seamount fisheries have largely taken place in the Atlantic, Pacific, Indian and the Southern Oceans and adjacent seas. RFMO/As that have been formed to deal with deep-sea fisheries management issues in these areas have currently taken up active roles to address the impact on VMEs as required by UNGA Resolution 61/105. Each region addresses their mitigation issues based upon their unique ecological situations, and all incorporate elements of the FAO-DSF Guidelines. Generally, the process is to seek scientific advice either from the scientific bodies of the RFMO/As, or through independent science advisory organizations. For example, in the case of NEAFC, scientific advice is obtained from the International Council for the Exploration of the Sea (ICES).

In the northeastern Atlantic, SAIs on seamounts have been determined to have occurred in the past, and since then awareness on VME protection has increased significantly in the region. At present, the adverse impacts on VMEs in the northeast Atlantic appear to be generally low and areas where the impacts have been significant have been closed to bottom fishing.

In the southeastern Atlantic seamount fisheries, less than 2 percent of the area is shallower than 2 000 m. At present, there are only two fisheries and vessels under the management of the SEAFO, and neither are operational at time of writing this report. Such a small-scale fishery presents a problem of a different nature to management: what to do in such cases when so few vessels fish a small fishing area where fishery resources are small and there is a chronic shortage of data. SEAFO enacted CMMs that limited fishing activities to agreed existing fishing areas, or footprints, and strictly regulate exploratory fishing outside of these footprints. In addition, SEAFO partners with other programmes and initiatives to collect data from research surveys taking place in the convention area, and have developed new protective measures based on the results of the data.

While many seamounts have intact VMEs despite historical and current fisheries and that much protection of VMEs has been achieved, the science underlying the management advice requires further development. Furthermore, uncertainty is a factor that often leads to ineffective management measures. In these cases, independent science and data collection should be promoted and the precautionary principle should be applied.

It was noted that it is relevant for NPFC to address the broader implications of the conservation and management measures that are already protecting a large percentage of the Convention Area, and that this perception seems consistent with the spirit of the UN Resolutions. However, cumulative effects of specific small-scale SAI events will still have to be considered in a more localized scale by the Commission.

It was further noted that some of the experiences from other regions indicated that they (i) apply a generalized method to assess the various parameters, such as percentage of trawls that touch the seabed; (ii) regulate gear configurations in order to take into account the issue of mid-water trawls and whether the gear touched the sea bottom; and (iii) it is very difficult to enforce small area closures and that they may not be very effective.

2.2. The Southern Ocean – CCAMLR

Dr Dirk Welsford (CCAMLR) reported on the seamount fisheries in the Southern Ocean (NPFC-2018-WS VME01-WP14). After the Second World War, offshore trawl-based fisheries were started by Japan

and the then USSR. In the 1970s, the rapid expansion of unregulated trawling led to collapse of major fisheries. Such a collapse led to the foundation of CCAMLR, and the Convention on the Conservation of Antarctic Marine Living Resources was ratified in 1981.

CCAMLR implements an ecosystem-based conservation approach that includes a mandate for fisheries to monitor and regulate fishing activities. Part of this management system requires avoidance of irreversible impacts on VMEs. Most of the existing CCAMLR conservation measures were introduced in the mid-1990s and are refined regularly. These include limited entry, restriction on gear types, catch limits, compliance observer requirements, data reporting, and fishery closure areas (e.g. all areas shallower than 550 m are closed to exploratory toothfish bottom fishing).

The impetus for bycatch mitigation measures in CCAMLR was initially in response to bycatch of seabirds. The principle of mitigation is to minimize bycatch through avoidance using closed seasons, closed areas, gear modifications, and bycatch catch limits. Dr Welsford highlighted the idea of a regional risk-based approach that accounts for different regions having different risks, thus the need for identification of high-risk fished areas and unfished lower risk areas.

As benthic ecosystems would also be impacted from fishing, CCAMLR also has supported UNGA Resolution 61/105. While the theory of mitigation is fairly well founded, the basic data to assess impacts on benthic assemblages are very sparse. Just like other oceans, many deep-sea fauna of the Southern Ocean are vulnerable due to their fragility and biological life history of slow growth and regeneration. Impact assessment processes in CCAMLR require information on what and where the biota is located, what gear is used and their fishing footprints, what happens when fishing gear and VMEs meet, and how to minimize contact with VMEs.

CCAMLR has taken many actions to protect VMEs. CCAMLR scientific working groups are charged to recommend new conservation measures and updating existing conservation measures, including banning of commercial bottom trawl, requiring members to provide information about known or anticipated impacts of bottom fishing activities, locations of VMEs, requires members to report bycatches of VME indicator species for designation and closing of risk areas, bans exploratory toothfish fishing shallower than 550 m, and registers and protect VMEs identified in the CCAMLR area.

Exploratory fishery measures have also been developed, initially in response to a proposal to develop a crab fishery in the southeast Atlantic sector in the mid-1990s. The importance of expanding at a slow pace is emphasized and exploratory fishing should not expand faster than assessments can be made. There are clear requirements before allowing an exploratory fishery to become an established fishery: assessment of impacts on target species and impacts on dependent and related species, setting of appropriate harvest catch levels, and control of effort levels and fishing gears.

CCAMLR has also published a VME Taxa Classification Guide (CCAMLR, 2009) for use in monitoring and management. Camera technology is deployed to study the gear footprint including longlines. The impact studies assess what happens when interactions occur (mortalities, damage, and escape) and cumulative effects are measured. The scale of impacts is important and is best tracked to the finest scale possible for both footprint and habitat modelling. CCAMLR has studied whether Patagonian toothfish (*Dissostichus eleginoides*) prefer habitats with high levels of VME indicators; but there is no evidence to support this association. However, CCAMLR found that toothfish seems to have a weak association with complex habitats. CCAMLR has also developed models for assessing risk of SAI.

CCAMLR's experiences show that good governance is needed before VME regulations came through, and that working with different stakeholders to deal with protection issues, such as seabird bycatch mitigation has been a good practice. CCAMLR has also recognized that a lack of information requires precautionary, risk-based approach to management.

2.3. The North Pacific - NPFC

Dr Robert Stone (USA) presented on VMEs in the North Pacific, highlighting their characteristics and ecological importance, ongoing research, and future research needs (NPFC-2018-WS VME01-WP17).

The VME situations of special interest tend to be focused in the northwest Pacific Ocean in the Northwest Hawaiian Ridge-Emperor Seamount (NWHR-ES) and in the northeast Pacific Ocean off Canada. Historically, the northeast Pacific is lightly fished, while the NWHR-ES area had major fisheries for North Pacific armourhead and splendid alfonsino. The extent of the earlier coral drag fishery is unknown, but it is widely considered to have had severe impacts on benthic habitats.

VME indicator species are rich throughout the Emperor Seamounts ridge, Gulf of Alaska, the Aleutian Islands, and to seamounts off the Pacific Northwest. Four groups of corals (Alcyonacea, Gorgonacea, Antipatharia, Scleractinia) are dominant in the NWHR-ES area, with Gorgonians being the most species-rich taxa, and soft corals do not appear to be important fauna in the Emperor Seamount. Black coral is the most abundant group in the region. Some taxa are widespread and some only exist on single seamount. Some have limited depth range while others occur all over the sampling region. There is a lack of sponges in the NWHR-ES area that is probably due to lack of sampling resulted from low coefficients of catchability and retention by the fishing gear. The NPFC has identified the four groups of corals for special focus. Two other groups, sponges and hydrocorals are more endemic to the northeast Pacific Ocean.

The North Pacific Fishery Management Council of USA has identified some VMEs as Habitat Areas of Particular Concern (HAPC). These HAPC's generally contain VME species and are sometimes closed to certain types of fishing activity. There are many VME indicator species, and the habitats they form can be of ecological importance as fish habitats. They can also form structural refuge from predation and currents, focal sites for foraging, and become spawning habitats. VME habitats can also be hotspots of biodiversity and increased productivity, and can provide other unknown ecosystem services we are unaware of, for example sponge gardens may affect water currents. However, little is known about the functions of VMEs in the area.

VMEs are sensitive to disruptive activities, often being fragile and typically have little resistance to survive damage caused by passing fishing gear. Some species are more vulnerable due to their distribution and depth. VMEs that attract commercially important species are more vulnerable as fishing takes place in them. Coral-based VMEs generally have low resilience, are long-lived, have slow maturity rates, and low recruitment rates. Speedy recovery from disturbance for these VMEs is highly unlikely.

More research needs to be done to enhance current NPFC measures to avoid SAIs on VMEs. Some example research needs are site reconnaissance, habitat parameters, and habitat suitability modelling to determine the extent of VME habitats that cannot yet be surveyed. One fundamental aspect of VME research is the development of a standard field guide for coral identification for all Members to use. There has been active collaboration among Japan, the Republic of Korea and the United States of America on this task. A standard field guide has also been drafted in all three languages for use by observers and scientists at sea.

Climate change is a wide scale event that has broad implications on the distribution of fish and their fisheries, and thus would have implications to fishing impacts on VMEs. Similarly, climate change will have effects on the biology of the VMEs themselves, which in turn could increase their vulnerability to fishing impacts. Dr Stone indicated that much of the work on deep-sea corals globally show that they are thriving below the carbon saturation horizons. Many scientists expected that deep-sea corals would dissolve, but it has not been the case. Most corals are protected by an organic matrix and the calcifying is taking part inside the animal. The apparent change is an energy cost to the up-regulating pores, thus not reproducing as effectively.

2.4. The Emperor Seamounts – North Pacific

The northwest Pacific VME-knowledge base was presented via remote connection by Dr Amy Baco-Taylor of Florida State University (Baco et al. 2017; NPFC-2018-WS VME01-IP02). The presentation described research surveys that took place during 2015-2016 in the northwest Hawaiian Islands (NWHI, Figure 2).

In 1977, when the United States of America (USA) established its EEZ, seamounts in question in the NWHI became protected. The USA also banned fishing on North Pacific armourhead in its EEZ from the early 1980s to promote rebuilding of the stock, thus relieving any impact of VMEs in the NWHR-ES area.

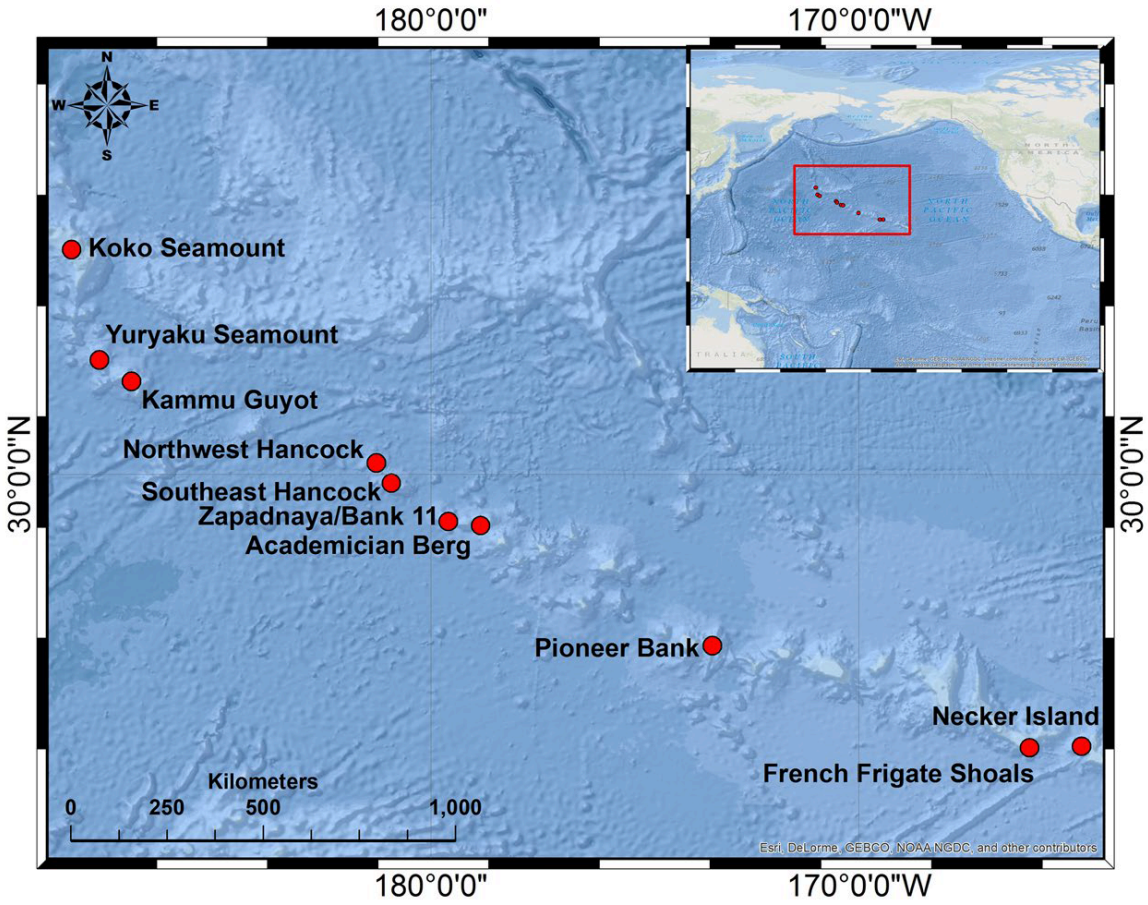

Figure 2. Map showing the geographic locations of surveyed seamount sites by Florida State University reported in Baco et al. (2017)

The main survey gear used was an Autonomous Underwater Vehicle (AUV) and a remotely operated vehicle (ROV) was later deployed in special areas of interest in the study. The dominant taxa found were corals, sponges, brittle stars, crinoids and urchins. These taxa were easily distinguishable groups, but it was difficult to identify them to the species level from an AUV. In addition, the surveys found scleractinian (stony coral) reefs on 6 of 10 seamounts. The reefs were distributed at 530–730 m depth. The surveys found two peaks of corals and suspect that two species exist with some overlap.

A key result of the research surveys indicated that because the USA-EEZ NWHI had been closed to fishing for a long time, the some meaningful signs of recovery to damaged areas in the 30-40 year time scale were detected. The surveys also studied some seamounts where fishing still continues in the Emperor Seamounts outside the USA EEZ, which provided some comparisons of a protected recovering area versus an actively fished area.

The following summarizes key results from the research surveys:

(i) *Koko Seamount*: mapping found a few small patches of corals that appeared to be colonies growing back from fragments after previous fishing gear impacted the area. On the south side of Koko Seamount, the survey found scleractinian coral and octocorals and the survey was also able to determine that trawling had taken place according to observations of trawl gear and gear marks on the substrate.
(ii) *Yuryaku Seamount*: surveys showed that there is a higher proportion of area with evidence of trawling and most of the observed coral reefs were in a disturbed state. Most of the reefs had also been reduced to rubble with only a few live colonies visible. However, the surveys found various live patches of corals, with few patches at higher densities in the southeast corner and quite a few sponges were found.
(iii) *Kammu Seamount*: surveys showed that the area was mostly coral rubble with few patches of live coral. Many base stumps of octocorals and gold coral were observed, along with dead and unattached individuals. Some sponges and many brittle stars were also detected.
(iv) *Colahan Seamount*: submarine dives were used to survey this seamount, which revealed many scleractinian reefs in an extensive area, including different species of sea urchins and primnoids. However, there was also evidence of extensive impacts from fishing; reef rubble was found as well as lost trawl gear.

The study concluded with a comparison of currently fished seamounts with recovering, protected seamounts. While gear marks could still be found on recovering seamounts, particularly on summits, and there were still many signs of damage, including lost gear (particularly on the Hancock Seamount), there were signs of recovery. It was clarified that while corals were generally more diverse in shallower zones, the spatial extent of the scleractinian reef was limited to a small area.

It was noted that a meaningful degree of recovery is possible on a 30-40-year time scale. There is a statistically significant difference in the abundance of megafauna on recovering seamounts compared to still trawled seamounts. Corals are known to have low recruitment with slow growth rates and recovery had been estimated previously to be decades to hundreds of years (although Primnoids, wire corals, and soft corals seem to recover faster than stony corals). The Florida State University's studies suggested that meaningful degrees of recovery seem possible on a 30-40-year time scale to the coral groups on the Emperor seamounts. Koko and Colahan Seamounts have the most developed colonies of corals, and the Kammu and Yuryaku Seamounts were more heavily impacted by fishing but have patches that shown signs of recovery.

During the discussion, the following points were noted:

Coral recovery. Stony coral recovery from fragmentation and fresh recruitment seems to occur depending on area and recovery can begin after 30-40 year time scale. While UNCLOS includes the responsibility of State to maintain or restore populations to levels where their reproduction is not impaired, it is unclear that any population has recovered to such a level.

Areas of priority protection. In terms of where priority protection could be, it was suggested that the northwest ridge of Colahan Seamount had well-developed coral reefs and would be a priority place to protect. Certain areas of Yuryaku Seamount with patches of corals could also be protected, and certain areas on Koko Seamount have shown reasonable abundances for recovery. Whether or not protection should be placed on sparsely populated areas versus densely populated areas, it would depend in part on species composition.

Ecological significance of corals compared to other fauna. There is quite a diversity of invertebrates associated with octocorals, which perform a similar function to scleractinian coral reefs for all kinds of invertebrates, including commercial species harvested (e.g. splendid alfonsino and North Pacific armourhead).

Other impacts in recovering areas. It was explained that because deep-water corals do not rely on a symbiotic association with zooxanthella, as many shallow-water corals do, they are therefore are not susceptible to bleaching. However, a number of these reefs are below the aragonite saturation horizon (ASH), which is getting shallower due to ocean acidification. Those coral species above the ASH have the most urgent need of protection associated with ocean acidification.

Information available on lost gears. The study did not yet quantify the gear, but there were lots of observed lost gear on Hancock Seamount (most of them were anchored), and some nets are still ghost fishing. The surveys also saw trawling and tangle net gear.

3. HISTORICAL SAI ASSESSMENTS BY NPFC MEMBERS

Dr Loh-Lee Low made a presentation of past SAI assessments made by NPFC Members. During the preparatory conferences of the NPFC, the negotiating Parties self-assessed the impact of their fisheries over seamounts in the high seas of the North Pacific. The reports by Japan, the Republic of Korea, the Russian Federation and the United States of America were submitted in 2008-2009, and Canada submitted its report in 2013.

Historically, there was suspected coral dragging by hundreds of vessels over seamounts in the northwest Pacific, largely in the NWHR-ES area and within the 200 nm zone of the Hawaiian Islands. However, there is no credible information about these fisheries. The only citation of amount taken in this historical fishery was 2 000 tonnes, although no credible source could be found for this citation. These drag fisheries that targeted precious corals were the most damaging on VMEs. Coral dragging is suspected to have ceased by 1992, although reports of suspected activity still occurred in the early 2000s.

The other fisheries in the NWHR-ES are for fish that started in the 1960s. These fisheries targeted fish and crabs on the Emperor Seamounts and adjacent areas. The number of vessels that fished in 1960-1980s was largely unknown and the main gear used were bottom trawls. Other gear types were bottom gillnets, longlines, and pots. In the northeast Pacific, longlines and traps were used by Canada that targeted sablefish with only a few vessels. Bottom trawling targeted mostly North Pacific armourhead and splendid alfonsino, bottom gillnets and longlines targeted rockfishes, and bottom pots fished for crabs.

The NPFC has focused its VME interest on corals. Four groups of corals, Alcyonacea, Gorgonacea, Antipatharia, Scleractinia, were selected as VME indicators of primary interest by NPFC, and two other groups, sponges and hydrocorals, are under consideration.

Impact assessments in the northwest Pacific. The NPFC provided an outline to guide the format of impact assessments for the Parties that were negotiating the Convention. An example of this is the 2008-2009 impact assessment report conducted by Japan for its trawl fisheries over the Emperor seamounts. This report indicated that the area of fishing was a very small fraction in relation to the entire North Pacific ABNJ area and no SAI was determined by Japan. The report, however, acknowledged that SAIs were highly likely, which is consistent with the results of other SAI reports submitted by NPFC members in 2008-2009. Japan also implemented 100 percent observer coverage and closed an area where precious corals were observed. Japan also reported that they would voluntarily cease trawling deeper than 1 500 m, conduct no fishing in November-December and north of 45ºN of the Emperor Seamount chain, voluntarily reduce their fishing by 20 percent, and conduct low fishing on strong-year classes of North Pacific armourhead.

After the review of the impact reports made by the negotiating Parties, the Parties identified the four groups of corals (Alcyonacea, Gorgonacea, Antipatharia, Scleractinia) as VME indicator taxa for NPFC. The Commission adopted the following interim measures: a threshold level of 50 kg per haul of live corals, a move-on distance of 5 nm, requirements for data collection, 100 percent observer coverage, and no fishing north of 45^{o} N latitude or deeper than 1 500 m. The Parties also agreed to a process of having a scientific working group continue to assess the VME situation. These voluntary actions demonstrated the good faith of the negotiating Parties to implement the UNGA Resolution 61/105 and the FAO-DSF Guidelines in a precautionary manner and at an early stage. These interim measures have eventually been carried through to the present time as formal CMMs of NPFC (CMM 2018-05 and 2017-06).

Impact assessments in the northeast Pacific. Only Canada currently fishes in the high seas of the northeast Pacific. Canada noted that all corals are likely VME indicators, and they conducted impact assessments around the Cobb Seamount, a small spatial extent where VMEs are sensitive and vulnerable to damage. It was also noted that analysis of SAIs is challenging, particularly with data uncertainty. The impact report from Canada indicated that there was no conservation concern for the target sablefish

(*Anoplopoma fimbria*) species. While no analysis of SAIs on corals and sponges was made, caution was expressed that SAIs on the VMEs may still occur. The Canada report suggested that there should be measurable objectives of SAIs for VME protection.

In the following discussions, it was indicated that SPRFMO now has a good process for advancing decision making relating to the mapping of SAIs, although it took many years and a large amount of funding to develop this process. Despite this, however, the SPRFMO process was thought to be a good model suitable for other RFMOs.

In conclusion, the SAI reports from Japan revealed that their trawl and gillnet fisheries did not have any SAIs on corals in the northwest Pacific during their years of assessments, and other Parties noted that while their fishing impact assessments generally lacked data, it still did not reveal to have SAIs on corals.

The NPFC Convention prohibits directed coral fisheries on the following groups: Alcyonacea, Antipatharia, Gorgonacea, and Scleractinia, as well as any other indicator species for VMEs as may be identified by the Scientific Committee and adopted by the Commission. The SAI reports from Canada and the United States of America cautioned that SAIs could occur that would lead to altered functions for biodiversity and ecosystems. The SAI reports also generally noted that only a small fraction of all seamounts were fished in the Commission area, thus potentially limiting any severe impacts. While VMEs had not yet been clearly identified, the Parties recognized that corals would fit the designation.

4. UPDATES OF IMPACT ASSESSMENTS BY NPFC MEMBERS

4.1. Canada – seamounts off the west coast of Canada

Dr Cherisse Du Preez reported on the identification of VMEs and the assessment of SAIs on seamounts currently fished off the west coast of Canada (NPFC-2018-WS VME01-WP15). The seamount fishery occurs at four seamount aggregations, comprised of eight seamounts off the EEZ of Canada (Figure 3), and targets sablefish with bycatch of mostly nine species. Landing limits are also in place for rough eye rockfish (*Sebastes aleutianus*) and other rockfish, sole, and flounder. Quantitative information on other bycatch species, such as crustaceans and sessile organisms, is not currently available for the offshore southern seamount fishery.

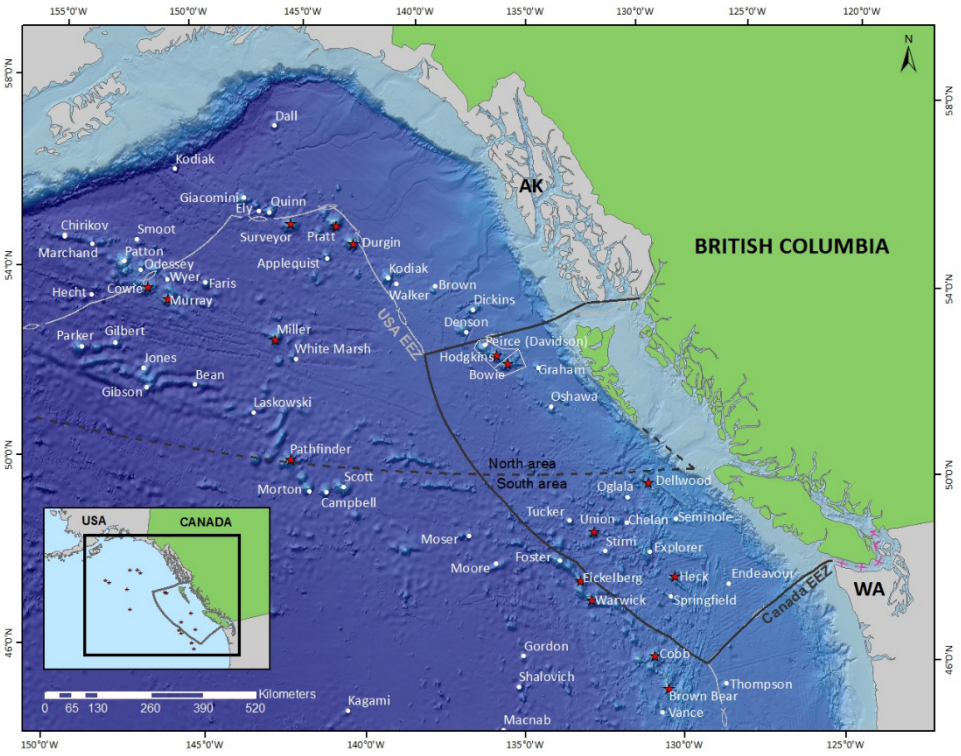

Figure 3. Eight seamounts outside the exclusive economic zone off the west coast of Canada that have been fished

Fishing effort during 2012-2017 was relatively low with about six vessels per year. Only one vessel is permitted to fish per month and a lottery draw of applicants for eligible licenses determines those vessels permitted to participate in the seamount fishery. The vessels are 25 m in length on average. Between 2012 and 2017, there were a total of 17 trips, 191 days, and 635 fishing events. The gears used are 98 percent longline-traps (traps set along the seafloor in long strings) and only 2 percent by longline-hooks. Fishing can occur from summit to 1 600 m depth.

Fishery impacts. Canada believes its fishery does not pose any known conservation concern to sablefish populations and evidence suggests that the seamount stock is a part of a meta-population. The abundance on offshore seamounts is largely driven by a net exchange with coastal sablefish where the stock is highly regulated. Thus, irreversible harm by seamount fisheries is highly unlikely. Canada imposes input controls to manage the Canadian fleet, and output controls are fishing limitations on size and monthly vessel limits. Mandatory reporting and monitoring are required through observers or electronic monitoring.

Management Strategy Evaluation. There is a new requirement to re-evaluate stock assessments on a three-year timeline. A recent improvement is the development of a spatially explicit sablefish population model based on the entire range of sablefish that extends into waters of the United States of America.

Research. The Department of Fisheries and Oceans (DFO) and National Oceanic and Atmospheric Administration of the United States of America (NOAA) have both separate and joint expeditions to study VMEs. The deepest research shows a high diversity of predominantly non-endemic species, where the majority of benthic communities are typified by large structure-forming cold-water corals and glass sponges, and communities are defined by other species known to be vulnerable (e.g. hydrocorals and sponges), in addition to the presence of the current four NPFC VME indicator taxa.

Impact on VMEs. Over the 22-year period analyzed for the Cobb Seamount (1996-2017), the most impacted habitats are between 600-650 m and 650-700 m depth, with ~4.7 percent for minimal degree of gear drag assumed and ~7 percent for moderate degree of gear drag assumed. Fishing events overlap the known distribution of VME indicator taxa. A recent shallowing of fishing events means that shallower VMEs are at risk. Cobb seamount was previously heavily fished by several nations and has accumulated an abundance and variety of lost fishing gear, with ongoing observable impacts including ghost fishing and habitat alteration (e.g. coral entanglement).

Canadian seamounts. Canada is very committed to the UN Sustainable Development Goal (SDG) 14 target of 10 percent coastal and marine areas to be assigned as MPAs by 2020. Canadian seamounts are identified as Ecologically and Biologically Significant Areas (EBSAs). The large Offshore Pacific Area of Interest, an area of interest west of Vancouver Island, contains at least 40 seamounts. In 2017, 60 percent of the Area of Interest has been closed to bottom-contact activities. In January 2018, SGaan Kinghlas-Bowie Seamount was closed to any bottom-contact fishing activity. At present, there are no seamounts in Canadian waters at fishable depths that are open to bottom-contact fishing. By 2020, Fisheries and Oceans Canada aims to establish this Area of Interest as an MPA, protecting, representing ~93 percent of known Canadian seamounts and 100 percent of known Canadian hydrothermal vents (DFO, 2019).

Other Canadian ongoing research includes long-term variability studies in the oxygen minimum zones in the northeast Pacific, lost fishing gear, and cumulative impacts on seamount communities, submarine islands of benthic biodiversity within and adjacent to an offshore transitional area, biogeography, and beta-diversity studies for northeast Pacific seamounts within and outside the Canadian EEZ.

In the discussion that ensued, it was noted that Canada is also collecting underwater cable observations. Additionally, while Canada is not investigating specifically whether ghost gears may be creating new substrates as habitats, rather than causing destruction, their research did observe gillnets with corals growing through them (not on them). However, it is clear that lost gillnets from 20 years are still catching fish in the area and corals entangled in lost gear were damaged, toppled, or dead. Some NOAA research also now documents where and how far such gear travels.

4.2. Japan – The Emperor Seamounts

Dr Masashi Kiyota reported on the identification of VMEs and assessment of impacts caused by Japanese bottom fishing activities on VMEs and other marine species in western part of the NPFC Convention Area (NPFC-2018-WS VME01-WP01). There were two reports from its fisheries (by trawls and gillnets) and five reports on Japanese research results.

Japanese fisheries occur on the southern Emperor Seamounts, which have been continuing since 1969, and are normally conducted by bottom trawl and bottom gillnet gears. In 2017, two trawlers and one gillnet vessel operated in the area for North Pacific armourhead, primarily, followed by splendid alfonsino. The stock level of North Pacific armourhead has large annual fluctuations that depend on the size of recruitment. The NPFC is evaluating an adaptive management process to manage the multi-target fisheries and the bottom fish stocks.

For assessments of fishery impacts on VMEs, Japan has followed a series of steps for its studies. Step 1 involves identification of fished and unfished areas. This step is based on several pieces of information: historical records from the 1970s and 1980s, logbook data from late 1980s to present, and scientific observer data that began in 2009. The spatial resolution is better in scientific observer data, and very coarse for the old data. There are also intentions to search through historical literature from the Russian Federation and the United States of America to identify fished seamounts, and Japanese fishing logbooks would be examined to identify fished seamounts from the 1980s. While the logbook records do not show exact location of fishing operations, they can be used to estimate the location of fished seamounts. The Japanese scientific observer program has records of starting points and ending points of trawl hauls or gillnet sets. These records can be plotted on 30x30 second grid using GIS and the grids the trawl lines pass are considered fished grids.

The Step 1 phase of the research has led to the following observations (NPFC-2018-WS VME01-WP03): the Jingu Seamount has been lightly fished in recent years, as well as Suiko Seamount; the Northern Koko Seamount had trawl and gillnet fisheries; the Koko Seamount is the largest of the fished seamounts where trawls operated on the flat area and gillnets on cliffs and marginal areas. Combining this information with data presented by Dr. Baco-Taylor would be interesting and useful. However, there is an issue of confidentiality and restrictions on sharing data. On Yuryaku Seamount there was no Japanese trawl and gillnet fishing occurring in the areas where Dr. Baco-Taylor identified VMEs.

Seamounts between 31ºN and 45ºN have traditionally been used by Japanese fishing vessels and flat tops and upper slopes less than 1 500 m deep are considered existing fishing grounds for Japanese bottom fishing fleets. Other NPFC Members were encouraged to conduct similar analyses. Once the existing fishing areas are comprehensively and explicitly defined, NPFC members should share the maps of fished seamounts and distinguish them from rest of the unfished areas.

Step 2 analyzed characteristics of benthic fauna based on biological samples and seafloor observations. Example analyses included co-occurrence of taxa in scientific survey hauls and those identified by community cluster analyses. The results show that Gorgonacea and Scleractinia are dominant components of sessile benthos in the southern Emperor Seamounts (Miyamoto et al. 2017). Association analyses of co-occurrence show that these taxa are effective indicators of benthic community diversity in the area (Miyamoto and Kiyota 2017).

Step 3 analyzed the interaction between fishing operations and existing VMEs (NPFC-2018-WS VME01-WP04). Scientific observer and survey data were used to reveal the occurrence frequency of live indicator taxa and sponges in trawl and gillnet bycatch. By weight composition, Gorgonacea is dominant in both commercial fisheries and scientific surveys data. Sponges occupy a larger percent composition of VME indicator taxa due to their large water content. Scleractinia was not high as bycatch, likely due to low catchability and retention by the gear. It was noted that this research needs to be developed further.

Step 4 was a fine-scale analysis to assess the spatial overlap between fishing activities and benthic taxa, which included: (i) characterization of benthic communities, (ii) fine scale overlap with fishing efforts, (iii) risk scoring of underwater locations, and (iv) identification of VME sites. The analyses used seafloor images and fishing operation data (NPFC-2018-WS VME01-WP05) to map fishing activity on fishing seamounts that was overlaid with visual survey locations to determine the extent of the overlap.

The results showed that the northern Koko Seamount has a high density of Gorgonacea locations just outside of the main trawling and gillnet area. Several locations of high locations of Gorgonacea were also found in the northwest part. Three high density spots were located at the outer margin of trawl and gill net activities. The studies also looked for the other four VME indicator taxa of NPFC, as well as for sponges and hydrocorals.

Detecting VME indicator taxa through visual seafloor images appears to be a robust approach to determine the presence of VMEs. It is possible to determine the highest potential risk sites by examining the density of taxa versus intensity of fishing activity. Detailed examination of visual seafloor images in the survey indicated that only sparse patches of small colonies of cold water corals were found in the main fishing grounds. It was noted that these are not considered VMEs based on VME criteria specified in the NPFC CMM. In two cases, dense patches of large colonies of Gorgonacea and Scleractinia were found at the outer margin of the main fishing grounds, which were qualified as VMEs. According to the precautionary approach, these two sites should be considered for closure.

It was noted that possible actions to avoid SAIs on fished seamounts could include spatial restrictions of fishing from small areas identified with VMEs. This approach would be supplemented by improvement of encounter protocols for preventing unanticipated interactions, and the refinement of exploratory fishing protocols for unfished areas. Specific partial closures could also be possible, however the question of how to enforce these closures is a concern. It was recalled that seamounts may not be big enough to provide the buffer zones needed for fishermen, and in particular trawl fishermen require space to deploy and recover their gears from great depths. Thus, closing a small VME site may be operationally problematic.

Recent stock assessments for the North Pacific armourhead indicate poor status for the stocks, and preliminary analysis of splendid alfonsino shows that the size of fish is getting smaller. Therefore, there is a need for a recovery plan for these fish stocks to be developed by NPFC.

4.3. The Republic of Korea – Emperor Seamounts

Dr Eunjung Kim of the Republic of Korea reported on assessment of impacts by Korean bottom trawl fishing activities on VMEs in the northwest Pacific Ocean, particularly the Emperor Seamounts (NPFC-2018-WS VME01-WP11). The Korean fishery started with two trawlers and one longliner in trial surveys in 2005. Since then, one or two trawlers have been operating in the Emperor Seamounts. The fisheries targeted are for the North Pacific armourhead and splendid alfonsino. Average fishing days in 2004-2014 ranged from 51-256 days, and average fishing days in 2015-2017 dropped to 65 days, with the main fishing months being March to May and a seasonal closure in November-December, according to NPFC's CMM 2018-05.

VME data availability. All Korean vessels operating in the Emperor Seamounts are required to have observers onboard to collect data and samples of target species and bycatch of VME indicator taxa. From 2013-2017, VME indicator taxa were observed for 17-57 percent of total number of hauls. The Republic of Korea is cooperating with NOAA through a formal Korea- USA Joint Project Agreement on VME research. Coral specimens collected by the Republic of Korea are identified by NOAA and experts from the Smithsonian Institute in Washington D.C. As of now, this joint research has discovered two new species of corals, yet unnamed. At this stage, it is not possible to determine if these new coral species are considered rare on the seamount since there has been very little taxonomic work done on this.

Spatial distribution of VME bycatch. Most bycatch was observed at Koko Seamount with the largest haul being no larger than 5 kg. Gorgonacea and Antipatharia were widely distributed, while Alcyonacea was found in narrow depth range of 340-350 m, and bycatch of Scleractinia occurred at 290-300 m. There was no observation of greater depths because the Korean vessels do not fish deeper than 500 m.

In conclusion, the Korean bottom trawl fishery continues to be relatively small and the VME data and samples collected by observers are valuable information. However, it is important to note that observer ability may result in data bias. The Republic of Korea has proposed the creation of a NPFC field VME identification guide for observers and fishers at previous NPFC meetings, and there are already field guides developed by Japan and the Republic of Korea that should be consolidated into a common guide. While this collaboration is occurring in the margins of NPFC meetings, data sharing among NPFC members is very important for mapping VME indicator taxa for further work.

5. GLOBAL OVERVIEW OF ACTIONS TAKEN TO PREVENT SAIS

5.1. Scientific support – NAFO experience

Dr Ellen Kenchington of Canada presented on the NAFO experience of using scientific support for management decisions, including the identification of VME indicators and the production of identification guides, among others (NPFC-2018-WS VME01-WP10).

Scientific impact assessments on VMEs have started in earnest for all deep-sea RFMO/As. Within NAFO, Canada has provided information on the identification of bioregions and helped define many areas with different oceanographic qualities, fish fauna, and invertebrate fauna, etc. To do this, the steps taken to define and delineate VME areas in the northwest Atlantic are: (i) identify VME indicator taxa, (ii) map known distribution, (iii) identify significant concentrations using Kernel density analysis because the species tend to be highly aggregated, (iv) model species distribution, and (v) conduct independent surveys to ground-truth modelled outputs.

Directed research studies are important to ground-truth information. Canada has identified increased biodiversity at sponge habitats, including greater diversity and abundance of taxa. A study on the influence of fishing on distribution of sponge habitats did not find any evidence to suggest that sponge distribution was influenced by fishing activity.

Canada has compiled fishing effort data for 2005-2015 from logbooks and VMS data. Overlap between sensitive benthic areas and the fishing footprint have been identified. However, some areas have still not being protected by NAFO, either because measures were implemented before advice was completed or there is a more cautious approach to implementing more measures. More analyses will be made on simulating the cumulative unit area of fishing impact to a broader area.

In discussions that followed the presentation, the following points were answered by Dr. Kenchington:

(i) What are key criteria to be used for VME closures? It would depend on where the fishing was. In NAFO, less than 1 percent of VME closed areas affect fishing areas. Nevertheless, VME closures are reviewed every 5 years to consider new data.

(ii) Any debate on how VMS data are used? Currently in NPFC, VMS data have not been used for scientific analysis. For scientific purposes, VMS data have been used to identify the overlap of VME distribution and the fisheries.

(iii) Data confidentiality. In the NAFO area, the compilation of data from the past was not constrained by confidentiality issues. In Canada, there are restrictions on the use of VMS data and members of government can check into the data records but not share them with others.

(iv) Climate-change-related studies. Canada has conducted a study in the North Atlantic that looked at IPCC models. According to current predictions, deep-sea areas will be affected, except for hydrothermal vents, which have their own environment. The next step will be to look at regional models which have shorter time-frames than IPCC models. A challenge for this will be when fish start moving and increased management pressure to fish on VME areas could occur. It is less of a challenge to the management of benthic species as they are mostly sessile.

(v) How useful are species-level VME indicators? Most VME protection issues are common to a family so it may not be necessary to look at species level resolution. NAFO is looking into functional groups, and this approach has worked quite well, although if it is difficult to get accurate identification, it does not make sense to have VME indicators at the species level and it is not realistic to expect detailed population dynamic information for the different species. Off the east coast of Canada, four functional groups have been identified: sponges, sea pens, large gorgonian corals, and small gorgonian corals and there are closures to protect all four groups.

(vi) What percentage of the areas where the sponges have been around for thousands of years are now closed? What might be the risk of losing VMEs if the rest of VME distribution outside hotspots is not protected? Observations on one Canadian cruise identified 500 species that were all screened. Sponges that have been around for thousands of years are partially covered by closures and efforts are being made to expand closures. Canada also plans to conduct studies about the biology of the sponges, such as reproductive habits, larval durations, etc.

(vii) What are the key indicator groups in VMEs? Cold-water Octocorallia are some of the largest and oldest marine species on Earth. Soft corals and gorgonians are also key group because they occupy in large areas in coral reefs in the tropics. The vast majority of pharmaceutical drugs from marine invertebrates come from sponges and this would be an important area for future research. Deep-water Octocorallia have high diversity but their study is poor at the species level. Well-known examples are from the families Primnoidae and Paragorgiidae, although not enough is known about deep-water Octocorallia in the northwest Pacific. The gorgonian genus *Calcigorgia* is a VME indicator in the North Pacific; there are seven species in the Kurile Islands and two species in the Aleutian Islands. Not all VME areas can be closed to fisheries, thus it is important to collect data using non-contact techniques, describe functional structure and assess initial risk.

(viii) In terms of future research, potential studies could include genome and detailed morphology for taxonomy, natural hybridization relations between local faunas of Octocorallia, reproduction and growth studies to know real pathways for dispersal of both shallow water and cold-water corals and their conservation, and physiological responses of corals and larvae to short- and long-term fluctuations in the environment and climate.

(ix) Connectivity studies are also very important when understanding coral distributions. In the Canadian east coast region, incomplete information on the spawning seasons, larval durations, and positions in the water column exists for coral species. SPRFMO used genetic techniques for a range of VME indicator taxa to test the level of connectivity among bioregions and large geographically distributed geomorphic features. Another approach was to look at concordance between genetic connectivity patterns and modelled dispersal patterns.

The co-chairs concluded that countries should unite experience and knowledge of stakeholders to synthesize fragmentary data. There is general agreement that collaboration is important because no country can study all aspects, and such collaboration is important for developing a regional conservation and management plan for deep-sea areas in the Convention Area. For VME groups, the important factors to include are connectivity, functionality, and species identification.

5.2. Encounter protocols – broad view

Dr Masashi Kiyota of Japan made a presentation that reviewed encounter protocols (NPFC-2018-WS VME01-WP02). VME encounter protocols were first referred to in UNGA Resolution 61/105 and further elaborated in the FAO-DSF Guidelines. As such, States and RFMO/As should consider appropriate protocols to respond to VME encounters in their region. The key elements of encounter protocols in the various management bodies are VME indicator taxa, encounter thresholds, move-on rules, and post-encounter processes.

VME indicator taxa – All management bodies listed a number of VME indicator taxa. However, not all taxa are linked to encounter thresholds because detailed taxonomic identification is not possible. In NPFC, four groups of corals have been designated as VME indicators. NAFO, Northeast Atlantic Fisheries Commission (NEAFC) and CCAMLR have a more detailed VME indicator list, and SPRFMO has VME indicators determined pursuant to FAO Guidelines.

Thresholds – In NPFC, the encounter threshold is 50 kg of live coral per haul. No encounter that exceeded the thresholds has been reported in the existing NPFC fisheries, and it was noted there is a definite need to fine-tune the thresholds levels. In SPRFMO, Members agreed to establish encounter

thresholds for trawl vessels flying their flags and government observers assess the catch of VME taxa determined by scientific analysis to be appropriate for SPRFMO waters. CCAMLR has a unique system for encounter thresholds consisting of two stages.

Move-on rules – While encounter protocols in most RFMOs have set a move-on distance of 1 to 5 nm after a threshold encounter, it is important to think about how fishers would behave and whether the move-on rule is enforceable. The present NPFC move-on distance is 2 nm, modified from 5 nm set previously in 2017.

Post-encounters – Many management bodies have distinguished existing fishing grounds and unfished areas. Some management bodies close the area around the VME encounter point in new fishing areas. Currently, NPFC has no designated post-encounter treatment except reporting. The NPFC needs a clear post-encounter measure.

The discussions followed on:

(i) *Threshold levels* – these should be precautionary and, where possible, be based on good data and science. Catch efficiency of gear is an important factor to consider as most corals, when impacted, would not be retained by the fishing gear. In SEAFO, all encounters are presented in their scientific reports, even sub-threshold encounters. In NAFO and NPFC, only above threshold encounters are reported, and none has been presented so far. There were concerns about the effectiveness of encounter protocols, and it was generally agreed that spatial restrictions and closures were more effective at protecting VMEs. However, encounter protocols still play an important role in areas that have not been fully mapped for the presence of VMEs.

(ii) *Spatial management* – the group felt that there should be a distinction between fished areas, lightly-fished and unfished areas, and that closures were preferable to encounter protocols for the protection of VMEs. Encounter protocols (if any) should focus on catches of VME taxa that would raise a flag about the VME habitat suitability models on which the current spatial management is based. The realistic conservation measure is closure and if properly designated, encounters in fished areas would not be expected or be rare.

(iii) *Encounter Protocols* – It is generally understood that move-on rules were originally developed for fish stock protection and additional mitigation measures may be required for optimal protection of VMEs. Once an encounter occurs, a report should be made to the designated authority, and some RFMOs have adopted immediate temporary closures following an encounter above threshold. In the case of the NPFC, the Emperor Seamounts fishing area is very far from the fishing countries. Observations from the fisheries are very difficult to obtain in practice and it can be argued that the encounter protocols should be a secondary part of management procedures because their effectiveness is very uncertain. CCAMLR has a registry system for encounters where notifications are sent out to members whenever encounter occurs.

(iv) *Observer coverage* – Most RFMO/As require scientific observer coverage. In SPRFMO, New Zealand and Australia have total observer coverage in their trawl fisheries (and at least 10 percent for longline fisheries). These countries also collect very detailed information at a tow-by-tow level, which they report to their scientific committee and use to improve habitat suitability models for VME indicator taxa. The NPFC also has a 100 percent observer coverage requirement, but implementation details are left to each fishing member.

(v) *Compliance* – It is difficult to enforce compliance following encounters with VME indicator taxa, thresholds, and move-on rules. This deficiency again points to spatial management may be the practical path.

5.3. Spatial management – New Zealand

Dr Ashley Rowden reported on New Zealand's experience on spatial management within SPRFMO (NPFC-2018-WS VME01-WP16). Interim mitigation measures began in 2007 for bottom fishing in SPRFMO. The fishing footprint was compared with the predicted presence of several VME indicator taxa and threshold weights for encounter protocols were set based on the median weights of each taxon in historical encounters in fisheries inside EEZs, as well as on the high seas. New Zealand developed a three-tiered spatial management approach for its trawl fisheries where the most lightly-fished areas were closed to fishing, fishing in moderately fished areas were subject to a move-on rule, and only some fishing in heavily fished areas were allowed without a move-on rule. Australia implemented a different single-tier approach under the SPRFMO measures, using different spatial management areas and different encounter protocols.

A performance and cost-benefit analysis for New Zealand's spatial measures was conducted in 2013 using the distribution of catch and early habitat suitability models. Based on that analysis, the optimal distribution of spatial closures would increase protection of VME indicator habitat from 63 percent to 72 percent at a similar cost to the industry.

In 2012, New Zealand initiated the South Pacific VME Project, the objective of which was to develop more sophisticated VME habitat suitability models and to evaluate the utility of decision-support software tools to inform New Zealand initiatives on spatial management planning in the SPRFMO area. The VME project generated models at three scales: ocean scale covering the entire SPRFMO area; regional scale covering the areas where bottom fishing generally occurred; and the seamount scale, covering just five features with the necessary detailed information. Habitat suitability models at the ocean scale were found not to be useful, largely because of the lack of reliable bathymetry data over most of the ocean, but regional and finer-scaled models were found to be more useful and broadly consistent with fishers' experience.

Between 2014 and 2017, the utility of the spatial decision-support tool *Zonation* was tested within the VME project in consultation with all stakeholders and officials. Such tools provide automated routines to optimise biodiversity (VME) protection while avoiding outcomes that entail a high cost to users or other values. The software generates gridded maps of areas prioritised for protection from disturbance by fishing, given the details of the particular scenario, and diagnostic plots to show how the solution meets the objectives of the analysis. SPRFMO's Scientific Committee agreed in 2017 that the approach was scientifically sound and appropriate.

Dr Martin Cryer presented on stakeholder workshops and consultation processes that New Zealand had convened in 2017, including stakeholders, scientists, and officials from both New Zealand and Australia. The series of workshops showed stakeholders and officials how the *Zonation* tool could be used to identify candidate spatial management areas that best met the objectives of all participants. Using a decision-support tool like Zonation is an open and transparent way of showing the consequences of each choice to all stakeholders for their particular objectives and those of other stakeholders.

Officials from key government departments in New Zealand and Australia took stakeholder feedback and ideas very seriously as they developed initial candidate spatial management areas for consultation with stakeholders. Additional workshops and consultations were then held to discuss the details of candidate spatial management areas and the draft of a new bottom fishing measure for SPRFMO. At the time of the Yokohama workshop, New Zealand and Australia were still negotiating on some of the fine details of that measure and no spatial management areas had been finalized by SPRFMO.

The key lessons learned in the SPRFMO context are that:

- the underpinning science is not easy because data are sparse and modelling approaches are still developing;

- spatial decision-support tools are useful for viewing information and identifying trade-offs in potential candidate management areas among stakeholders' and officials' objectives for management;
- substantial gains in the protection of VME habitats were possible using this approach. The spatial management areas developed in late 2017 increased protection of VME habitat from an estimated 65 percent in the current management regime to 84 percent on average, while providing slightly better access to high-value fishing grounds;
- it takes a long time to gain confidence and buy-in from stakeholders, officials, and RFMO scientific committees; and
- the process is resource-intensive, given the need for substantial science and research plus multiple technical working groups, workshops, and consultations.

The question was raised that one might also evaluate cost by different metrics, like employment instead of catch value. Dr Rowden responded that they did discuss metrics of value and distance, but ultimately decided on catch, although similar analyses could be done whatever metric stakeholders may choose to reflect their values. The industry wanted to continue fishing in the areas previously fished, whereas the environmental Non-Governmental Organizations (NGO) wanted the wider stakeholder participation that such analytical methods provided. It was suggested that the NPFC area has similar issues and habitats. Thus, using an equivalent approach to fishing ground closure designation as presented in the New Zealand case should be discussed at NPFC.

5.4. Fished and unfished areas – Alaska experience

Dr Chris Rooper on behalf of PICES reported on protection of corals and VMEs in fished and unfished areas in EEZ waters of the United States of America (NPFC-2018-WS VME01-WP08). This work is part of NOAA's strategic plan to protect Essential Fish Habitats (EFH). The tools used to meet these goals are area closures, marine sanctuaries, freezing fishery footprints, and systematic evaluation of area closures. Other tools include bycatch reduction through gear modification or restrictions, and self-monitoring of bycatch among fisheries.

Historically, most closures to protect VMEs started around 2006 and related to the USA Magnuson-Stevens Fishery Conservation and Management Act (MSA) reauthorization. Each of the national fishery management councils implemented at least some closures for VMEs. For example, the North Pacific Fishery Management Council (NPFMC) has employed large closures off Alaska mostly for coral habitat that was based mainly on research data and freezing of fishing footprints.

The USA has also conducted groundfish and crab bottom trawl surveys in Alaska nearly every year since the implementation of the MSA in 1977. Thus, there is a rich database from which to draw. The USA conducted extensive modelling of fisheries and bycatch resource distributions off Alaska beginning in 2012, and independent survey data were used to validate the model results in two regions. The USA is also looking at ecosystem-based management systems. Models would monitor trends in habitat disturbance, bycatch and abundance of VME indicator taxa. A PICES Working Group 32 is organizing a topic session to evaluate anthropogenic effects on benthic invertebrates, and assessing biodiversity indicators for biogenic habitats.

In the Aleutian Islands, the model evaluated family-level diversity of corals and the fishing footprints of areas fished. The predictive models indicated 31 percent of the total area being closed and protected 41 percent of the high density VME areas. The study also looked at the proportion of closed areas devoid of VMEs and found that only about 5 percent of the areas are devoid of all three VME indicator groups (corals, sponges, and pennatulaceans). In the Gulf of Alaska, around 50 percent of the areas are devoid of the three VME indicator groups. The overall protection was 33 percent for coral, 24 percent for sponges, and 6 percent for pennatulaceans for all of Alaska.

For sponge and coral distribution modelling, presence-absence prediction models were developed using bottom trawl survey data. Drop camera surveys were used to validate model results and potential areas

for closures were evaluated. The models showed distributions, calculated the percentage of each taxa (corals, sponges, others) to be protected in selected areas in the Aleutians, Gulf of Alaska and the Eastern Bering Sea. Coral and sponge density figures for Alaska are among the highest in the USA EEZ. In the Aleutian Islands (where the fishery footprint was effectively frozen in 2006), densities of VME taxa are actually higher in fished areas than in the closed areas, due to the presence of more hard substrate in fished areas than closed areas. More research is needed on coral and sponge population modelling, including for parameters on starting biomass, derived from mean height and height-weight relationship; time series of fishery removals; estimates of intrinsic population growth rates; estimates of carrying capacity; and catch efficiency for commercial catch.

Studies also looked at vulnerability as a function of initial size and abundance, recruit, growth, and impact rate and combined vulnerability maps across all taxa were developed. Fishing effort maps were then overlaid with the vulnerability map, and revealed that there was not much interaction between the existing fisheries and where corals are occurring. However, one area in and around Pribilof Canyon, was identified as requiring close monitoring. Follow-up drop-camera transects found a lot of lost fishing gear, and there were a handful of cases of damage to coral and sponges.

In one study, bycatch reduction research indicated that 13-63 percent reduction in damaged sea whips could be achieved when using fishing gear sweeps were modified to 6 inches (15 cm) above the seafloor. No significant reduction to flatfish catch was observed, but there was also a reduction to king crab bycatch.

In conclusion, distribution models help make better decisions, but model validation is still needed to demonstrate model accuracy. Transparency on decision-making is also important, such as public presentations and making data available immediately.

In the discussions that followed, questions about parameterizing stock assessment models were posed. In New Zealand, modellers compared models of probability of coral presence with models of coral abundance, and observations of coral reef habitat. At probabilities of presence of 30-40 percent, high abundances of coral plateaued and corresponded to observations of coral reef habitat. The Alaska models used a threshold that balanced positive and negative rates of error and the probability rates were set quite low. Dr Kenchington stated that Canada has experience using the probability of prevalence in occurrences. Dr Welsford indicated that sustainable levels of benthos are not optimistic as VME patch dynamics is very complex.

6. DATA REQUIREMENTS AND DATA COLLECTION BY THE MEMBERS

Dr Tony Thompson of FAO reported on the global overview on data requirements to implement deep-sea fisheries measures to protect VMEs (NPFC-2018-WS VME01-WP20). Data requirements include: vessel registry, catch statistics, fishing effort, vessel position, VMS, biological information on stocks, independent surveys, log-books, electronic logbooks (real time reporting), port sampling, socio-economic surveys/value chain, stock assessment and catch control.

Data Systems. The Republic of Korea had been delegated as the lead within NPFC to develop the system of formatting and collecting data. The Republic of Korea used the system of CCAMLR as a model, which is very detailed and poses problems for NPFC members.

VMS Data. The data is critical to understanding behaviour of fisheries. In many regions, designated centres monitor fishing vessels, often collecting information from all nations fishing in the area, as part of their compliance programmes. It is vital to know where vessels are, how much effort is in each area, and to be able report on this information.

Electronic logbook reporting. NPFC does not yet have electronic logbook reporting, and port sampling and port state measures should be considered.

Observers. Each country has observer requirements, but there is no NPFC centralized or coordinated observer programme. Training programmes for observers on VME and other bycatch identification field guides will be useful for the Emperor Seamount fisheries. Canada does not have observers on boats most of the time, and the vessels can choose electronic monitoring and third-party confirmation of log books. On training programmes for observers, there should be opportunities to share experiences and it might be worthwhile to look at the flow of observer reports. There are directions within the NPFC's CMM, but perhaps more work is needed on training programmes and observer data.

Coral identification guides. The Republic of Korea and the United States of America are collaborating on developing coral identification guides that are already in NPFC plans. Each Member already has its own guide and experts are working on a joint guide.

Compliance. Both enforcement at sea and enforcement at port are important, the latter more for fish than VME monitoring. NPFC does not have designated landing sites. Mr Flewwelling stated that there is a vessel list being maintained by NPFC. Thus, NPFC has a good idea of Member vessels authorized to fish. However, NPFC does not currently monitor the vessels actually fishing in its area.

Benthic habitats, bathymetry, mapping, and predicative models. Predictive models have been experimented with by Japan, Canada and the United States of America to support scientific decision.

Sponge information. While fisheries on the Emperor Seamounts have not reported sponge encounters and research hardly encounters them as well, new information suggests that they are present. Sponges and other orders of taxa can be added for monitoring as more information are collected.

Encounter threshold. Scleractinian bycatch is an issue. Their catchability or retention is very low. Thus, there is a need to modify their thresholds in exploratory and encounter protocols. The NPFC encounter threshold of 50kg/haul of live coral to trigger the move-on rule has never been reported to have been triggered by the fishers. This fact raises the issue that thresholds need to be further reviewed. The remark was made that all encounters should be reported, not only those above threshold.

Joint research. It was noted that there should be a workshop with NPFC Member scientists to plan joint research in areas of interest. Russia is in favour of participating. Russia has submersibles that could be used. NPFC could take the initiative with PICES joint modelling. Dr Zavolokin indicated that NPFC and PICES already has established a cooperative mechanism for identifying points of cooperation.

Fishing footprints. Dr Thompson commented that NPFC has footprint information, but not developed in the same way as other regions with haul by haul information. It was noted that it would be worthwhile to identify the distribution of fishing effort by gear type, both on individual seamounts and over all the seamounts, to see which seamounts are fished more than others. Better maps with more information would help managers make better decisions.

VME Recovery. UNCLOS has language to restore recovering populations above levels where their reproduction may become seriously threatened. This language is not reflected in FAO Guidelines. Dr Stone commented that remnant, fragment, and disturbed coral colonies have been identified in Dr Baco-Taylor's presentation that meaningful signs of recovery were occurring in some areas. In Alaska, recovery of disturbed habitats has very specific requirements. If given an opportunity, a heavily damaged coral ecosystem can recover. The Scleractinian reefs observed by Dr Baco-Taylor in the Emperor Seamounts are very rare and worthy of special consideration for protection. The study of coral recovery is opportune for the NPFC to take the lead.

Dr Dautova remarked that in deep-sea coral systems, the instruments necessary to track recovery changes in time and space are not well developed. We need to find instruments that allow us to monitor changes in population and whether degradation is occurring. A working group can study this issue.

Canada

Dr Du Preez reported that Canada has all the essential components of a good data system in place (NPFC-2018-WS VME01-WP18). All Canadian vessels are required to have 100 percent at-sea monitoring by either independent observers or electronic monitoring systems. Information collected are retained catch and effort from specific fishing events. Location, time, date, depth, gear, retained and released catch. Catch is identified by species and weighed. Canada has a privacy rule of three vessels. Since the northeast Pacific Seamount fishery has no other vessel to pool data with, there is difficulty for data sharing. Historic fishing effort from different nations is not available, although fishing by other nations is known to have occurred over the past 50 years.

Lost gear is recorded. Gear recovery events and unintentional retrievals are not recorded (there is no obligation to retain catch or information from these gears).

Scientific data. Submersibles and SCUBA visual surveys were conducted by Canada over Cobb Seamount. This data-rich seamount research was conducted from the 1970s. Limited data was collected over Warwick, Brown Bear, and Eickelberg seamounts.

Canada has limited bathymetry data for Species Distribution Models/HSMs inside its EEZs. To supplement this data, fisheries data such as start/end location, depth, etc. were interpolated to get better bathymetry maps. These maps have vastly improved bathymetry comparisons to other global situations.

Japan

Dr Kiyota reported on Japan's data availability and deficiencies (NPFC-2018-WS VME01-WP19), the historical part of the commercial fishery logbook data is incomplete: there were substantial missing data in the 1970s and 1980s. Complete data sets are available from the 1990s and the logbook data include daily catch and effort and noon positions. The VMS data are currently unavailable for scientific analysis as data security and handling procedure is under development in the NPFC Scientific Committee and the Commission. Scientific observer data and samples have been collected from 2009 and the data format is specified in CMM 2018-05 based on the FAO Guidelines. The observer data include fishing operations and catch, but there are confidentiality issues, especially for gillnets that only had one vessel fishing. The data collected also include bycatch, photos, and coral samples. Field guides in Japanese are available for observers and NPFC is discussing a consolidated VME identification field guide. Scientific seamount surveys have been conducted annually since 2006 by the Japanese research vessel *Kaiyo-maru*, mainly over the fishing grounds but also in some unfished areas. ROVs and drop cameras were used for recording visual images. Dredge and beam trawl samples were also collected. Recently,

Japan has completed some fine-scale bathymetry surveys over CH, Colahan and Kammu seamounts, and the Koko Seamount survey is ongoing.

The Republic of Korea

Dr Eunjung Kim indicated that Korea's data system to Japan. Commercial fisheries data are collected from traditional logbooks. An electronic logbook system began in 2015 and is currently being updated to include VME bycatch data. Korea's data on VMEs relies heavily on observer data from their 100 percent scientific observer coverage, who collect bycatch and biological samples.

In conclusion, all Members have their own data reporting system, even though not all were presented at this workshop. Research is being conducted by Japan, the Republic of Korea, and Canada in the NPFC area, and the USA mainly conducts research mainly within its EEZ, with the exception of the Emperor Seamount surveys. In the USA, Government agencies have an obligation to get its research data to the public and to post the results online within months of survey completion. Dr Chris Rooper indicated that for VMEs, there is a publically-accessible data portal that lists all observations from historical and bycatch data.

7. GROUP DISCUSSIONS ON COMPARING THE NPFC APPROACH WITH OTHER REGIONS

7.1. Surveys and VME identification

Surveys are largely limited to fisheries by participating nations and, in general, there have been few historical research cruises in the North Pacific. Recently there has been a few dedicated expeditions.

The challenges including: 1) these types of surveys are costly and funding is limited. Logistically, the surveys are difficult to conduct as well because of the remote location of the seamounts; 2) as such, there are few opportunities to conduct new surveys despite there being a great added-value for this knowledge; 3) there is limited and declining global taxonomic expertise. The four groups of corals used by the NPFC are generally adequate as VME indicators, and sponges and hydrocorals are also being considered to add to the four taxa groups for monitoring, however other associated VME indicator taxa should also be identified; and 4) there has been no ability to determine coral abundance from the fishing surveys, likely due to the scientific knowledge of observers who are generally not trained scientists.

The use of cameras on fishing gear appears to be a good application and this would be easier and cheaper than using research surveys. The use of AUV missions on seamounts is very useful, but costly and AUV operations need almost constant monitoring, particularly when operating near the sea bottom.

7.2. Bottom fishing footprints

Dr Ellen Kenchington led this discussion session, including monitoring gear and effort changes. Some points to consider are: 1) Technology and data collections issues. Do we have adequate capabilities? We may need more detailed footprints information; 2) Corals are immobile organisms, so should be able to map encounters quite directly. How can we get better information on encounters (location, composition, amount)?; 3) Vessels should have instruments to identify geographical locations and depth and technology needs to be deployed; and 4) What level of detailed data is feasible and how can we use the data?

Discussions continued on the collection of more detailed footprints. The example of Japan was given, who are using 30 by 30 second geographical grids to better visualize the footprint using only Japanese data. Their analyses are aimed to identify fished areas and unfished areas and to conduct SAI analyses. NPFC is considering the development and evaluation of the combined footprints of all Members, but there are issues of data-sharing and confidentiality. NPFC is in the process of consulting the Scientific Committee and Commission for the data sharing.

Other possibilities include the use of electronic reporting for VME encounters. The example of the iNaturalist application was given that relies on crowd sourcing a network of experts to help identify taxonomic specimens through the internet (https://www.inaturalist.org/ download for IOS or Android). Photos can be uploaded with phone's metadata (location, time, etc.) for outside experts to view. Electronic reporting of VME encounters will be useful for fishermen and survey scientists to upload such data electronically from their field sampling to an internet group for assistance in real time.

VMS data. VMS is usually developed for compliance and is the same case in NPFC. This case was confirmed by Mr Flewwelling that it is a compliance tool for NPFC. Presently there is no regional VMS collection, only nationally owned ones. Confidentiality issue has not yet been resolved within NPFC. It is both a compliance and science issue.

Dr Kenchington asked if anyone has seen use of "lights from satellites" for monitoring. Dr Kiyota indicated that satellite images of fishing lights can be used to detect light-based pelagic fisheries, like those on Pacific saury and squid. However, it is probably not useful to track trawl vessels over the Emperor Seamounts which do not use much light.

7.3. VME encounter protocols

There are already exist NPFC CMMs for both the northeast and northwest Pacific Ocean on encounter protocols (CMMs 2018-05 and 2017-06). Key elements included are four designated cold-water corals indicator taxa, thresholds of 50 kg to trigger the 2 nm move-on rule, and encounters are to be reported to the NPFC Secretariat.

Encounter protocols in the NPFC area were originally introduced as a precautionary measure to avoid SAIs on VMEs. NPFC now recognizes they need to be refined for use in fished and unfished areas for the eastern and western part of Convention Area, based on regional differences in benthic fauna. Sponges and hydrocoral taxa are under consideration by the Scientific Committee of NPFC for inclusion, and determination of the taxonomic resolution of VME indicator taxa requires a consideration on the balance between practicality and biological significance. Currently, NPFC does not have post-encounter protocols in place, except for the move-on rule and obligation to report the encounter to the NPFC Secretariat.

The threshold of 50 kg of live weight per haul has not been triggered so far in the NPFC area, which suggests the need for a review. The original basis of the threshold was to follow the example of NAFO, although it was noted this threshold also lacks a scientific basis. Thus, NPFC should consider taxa-specific thresholds, at least for differences in catchability and retention coefficients by the fishing gear: thresholds may be kept lower in unfished areas, and more gear-specific thresholds would be useful to consider. For example, in New Zealand, SPRFMO measures have taxa-specific thresholds that were determined from catch data, and NAFO now incorporates mean trawl length to determine thresholds.

In NAFO, scientists have proposed that all encounters outside the fishing footprint be reported. Management did not accept this proposition. There is a different purpose to reports inside and outside encounters. Outside reporting is a chance to learn something new about VMEs. Currently, NPFC CMMs require all encounters from exploratory fishing to be reported to its SC. There is no exploratory fishing yet. The question was asked if there is a requirement to close the exploratory fishery if a VME encounter happens, to which the response indicated that this was not the case and that it is a matter to consider before an exploratory fishing permit is issued by NPFC.

The move-on distance for NPFC was changed in 2017 from 5 nm to 2 nm and should be re-examined as this distance could still be too large. Dr Kiyota clarified that this was a compromise between burden on fishermen and conservation. Generally, 2 nm makes sense based on mapping information, but it was noted that the current move-on rule has no reference point and direction of move. New Zealand move-on rules require a certain distance from the hull point of the vessel, and Australia's move-on rule, if triggered, would close the area to all vessels for the rest of the year. There is a new proposal to SPRFMO for polygon definition and a temporary closure. Currently, NPFC does not have a post-encounter treatment except for the vessel to move-on when the threshold is triggered and to report to the NPFC secretariat.

In summary, it was determined that NPFC needs to establish taxon-specific thresholds to account for very low catchability and retention coefficients. It was generally considered that thresholds are used to indicate that a vessel may be fishing in a VME, and a VME is a significant concentration of attached benthic organisms. Therefore, the threshold should be high enough to exclude encounters with isolated VME indicator species that do not form ecosystems or habitats. Thus, NPFC needs to refine the thresholds and find a right balance to indicate the area being fished has the potential for being a VME.

7.4. Significant impact assessments

Regarding significant impact assessments, all NPFC Members follow a report template for reporting of their research, analyses, and actions taken to mitigate SAIs on VMEs in their fisheries. Canada, Japan, and the Republic of Korea had presented their updates to this workshop and all members are conducting research to improve their understandings. The United States and Canada conducted research mainly

within their own EEZs in the northeast Pacific Ocean, and this EEZ research is directly pertinent to seamount areas outside of the EEZs. In the northwest Pacific, research cruises have been conducted annually by Japan and the Republic of Korea does its research on VME identification, using observers to collect specimens and data.

In the northeast Pacific, Canada did not identify any SAIs on their target species (sablefish) or on corals. In the United States does not fish on seamounts in the NPFC area, and thus have no SAIs on these VMEs. In the northwest Pacific, specifically on the Emperor Seamounts, Japan did not identify any specific SAI but identified two sensitive areas over Colahan and Koko Seamounts where closures should be considered. The Republic of Korea also noted that its fisheries had no SAIs on VMEs.

It was roundly agreed that all NPFC Members seriously consider SAI issues, and there was a general agreement that more research and observations are needed to better understand the NPFC area. It was also noted that all the assessments are self-assessments by the Members and not cumulative through time nor collectively by all members, and thus it is important to avoid drawing incorrect conclusions from individual Member reports.

Dr Ashley Rowden was of the view that SAIs had occurred in the past. The evidence of criss-cross scars and removal from Dr Baco-Taylors presentation clearly indicates that SAIs have occurred. The presentation of Dr Baco-Taylor of Florida State University's research in the NWHR-ES area has definitely changed the workshop participants' perception of SAIs in the Emperor seamount area. The new information presented by Dr Baco-Taylor has changed the baseline information. NPFC appears to have an impacted ecosystem with VMEs removed from some parts of the seamounts. The co-chairs noted that coral dragging of the past probably caused the SAIs. These dragging have stopped under 200-mile extended jurisdiction and is also currently prohibited under NPFC rules. Whether or not the existing seamount fisheries are continuing to cause SAIs is still subject to further assessments.

There was evidence of recovery shown in Dr Baco-Taylor's presentation, probably because of no drag fisheries since the late 1970s and also decreasing bottom fishing activities around those locations. Dr Baco-Taylor suggested that meaningful signs of recovery can occur within 30-40 year time scale. Other RFMOs are not considering recovery yet, but this could be an area of research work in the northwest Pacific.

Dr Low raised the issue of scale. Small areas are at risk from bottom fishing, but not the larger area outside of the footprint. How broad should we look? Can measurable objectives be set to protect a certain percentage of the entire NPFC area? Dr. Kenchington remarked that these questions are difficult to answer. It depends upon how you define ecosystem. These regulations are not about protecting coral and sponges around the world. It is about areas where interactions between bottom fishing and VMEs take place. Our scope should be small in areas that are fished. However, Dr. Rowden noted that it is important not to lose sight of the bigger picture, while still focusing on smaller scale where fishing occurs.

7.5. Exploratory fishing protocols

Exploratory fishing is allowed only by permit from NPFC and the requirements are stated in NPFC's CMMs (CMMs 2018-05 and 2017-06). A proposal must be submitted to the Commission for evaluation by its various committees. So far, no proposal has been submitted.

In CCAMLR, any exploratory fishery remains exploratory until three criteria are fulfilled including evaluation of distribution, abundance, and demography of the target species, review of the fishery's potential impacts on dependent and related species, and advice from the Scientific Committee. A CMM also exists for exploratory fisheries in SPRFMO, which was based on that used in CCAMLR. In NPFC, there are several layers of review and criteria to be cleared before exploratory fisheries permits can be issued.

The discussions focused on the information provided by exploratory fisheries. The exploration would have to be in a new area or depth, and thus would require full data reporting. Questions were also raised about research fishing which is separate to the "commercial" exploratory fishing activities. Most RFMOs have their own regulation regarding research activities and research surveys, and these are generally becoming more regulated. Data from research is also not normally required to be reported and shared freely, and guidelines on sharing research data can be complicated.

7.6. Spatial management

Currently, NPFC limits fishing efforts to existing levels, freezing vessel numbers, limited fishing on seven seamounts, and no seamount fishing north of 45ºN latitude. There has been substantial discussions on encounter protocols that point to area closures as being the most effective tool to prevent SAIs on VMEs. It is however important to assess management needs and decide on objectives. The fisheries need evaluating, as well as the VME situation before you can decide how best to comply with VME protection to support UNGA Resolution 61/105 and the FAO-DSF Guidelines. Cumulative impact of fishing on VMEs by all gear and country must be considered.

The example of spatial planning by New Zealand for SPRFMO has been thoroughly described in the earlier sections of this report, and comparable work has also been done in CCAMLR to support the Ross Sea marine protected area.

The geographical scale of closures is very important to be evaluated in the Emperor Seamounts area, which is already a very small area in relation to all the other seamount areas that are not being fished. It was noted that the VME measures are in place to avoid SAIs from bottom fisheries: they do not attempt to list and manage all areas having the characteristics of VMEs nor do they mitigate against other forms of (non-fisheries) impacts.

A spatial management planning plan similar to the New Zealand-Australia case could be used by NPFC, however it is an expensive and lengthy process that must bring together different stakeholders from science, fishers, consumers, managers, government officials and non-government entities. The New Zealand-Australia experience also suggests the use of spatial management planning decision-making tools to assess costs, rewards and risks. This process would be complex and can involve scales of individual seamounts to regional groups of seamounts, and to a broader area as large as the entire western and eastern half of the Convention area.

The discussions that took place in this session also brought up other issues that spatial planning would need:

(i) Spatial management planning is a lengthy and costly process and it is critical to have a formal stakeholder process involving all members for transparency, objectivity, and acceptance;
(ii) A good lead is important and a collective analysis of members by an independent organizer may the way to proceed;
(iii) There is opportunity to consider including recovering areas in spatial management plans;
(iv) Finer scale closures of seamounts would be difficult to evaluate, difficult to enforce, difficult to model, and may not be operationally feasible for the gear;
(v) Metrics for measurement, data availability and reliability, footprint information and other parameters of VME predictive modelling will have to be determined;
(vi) The point about collating all data cannot be overemphasized;
(vii) Independent data is desirable but can come with difficulties, for example the need to collect data outside the NPFC region and in national waters, which can be an impediment;
(viii) Other sources of data should be considered, such as in historical literature or user-knowledge from the fishing industry; and
(ix) Periodic reviews will be needed to continually improve measures to account for changes in the environment or to reflect new information.

8. RECOMMENDATIONS TO THE SSC VME

The participants recommended the following set of issues to the SSC VME of NPFC, which then went through its review and prioritization process, revised its work plan and made recommendations to the Scientific Committee that, in turn, made recommendations to the Commission for adoption:

8.1. Data

a. Review data availability against data requirements from the FAO-DSF Guidelines, clarify data deficiencies and prioritize actions to fill data gaps;
b. Cooperate with the Technical and Compliance Committee (TCC) in getting information on vessel positions to develop scientific advice on fine scale spatial management in the Emperor Seamounts area;
c. Continue development of the regional observer program and address the issue of observer data sharing;
d. Consider conducting standardized training programs for observers with support from FAO;
e. Continue work on the identification guides for VME indicators;
f. Consolidate all available data including bycatch, scientific surveys, fisheries independent surveys, historical literature, the fishing industry, and potentially relevant information from within EEZs, to get more detailed information about interactions between VMEs and bottom fisheries, including coral drag fishing;
g. Collect and make use of additional data relevant to protection of VMEs including data on potential impacts of climate change and lost fishing gear;
h. Establish data sharing protocols which consider privacy issues to collate all data across Members; and
i. Create a central data repository for the NPFC and ensure data security.

8.2. Encounter protocols

j. *VME indicator taxa* – Develop area-specific indicators that take into account the regional characteristics of benthic fauna, and choose a proper taxonomic resolution that will represent the ecological function of the indicator groups taking the balance of practicality and scientific validity;
k. *Encounter thresholds* – Refine the current thresholds on the basis of scientific information, including bycatch levels and catchability estimates, and use taxon-specific and gear-specific thresholds;
l. *Move-on rules* – consider further refining the move-on distance in relation to the size and distribution of observed VME patches, as well as the size of fishable seamounts (note: NPFC changed from 5 nm to 2 nm in 2016 (CMMs 2016-05, 2016-06); and
m. *Post-encounter protocols* – Prepare a quick reporting protocol to avoid multiple impacts on the same VME site, and consider a process to introduce provisional area-protection around the encounter location, for example, a box with a set distance around the tow path.

8.3. SAI assessements

n. Assess SAIs by bottom fisheries on any other relevant VME indicator taxa, in addition to the four existing taxa, for example sponges and hydrocorals where they are found in the Convention Area;
o. Develop a standardized approach and metrics to assess the cumulative impact of all Members' bottom fisheries on VMEs through time;
p. Develop measurable objectives for determining the occurrence of SAIs; and
q. Assess and monitor the recovery of VME sites and protect recovering sites in addition to pristine VME sites.

8.4. Fishing footprint

r. Map combined fishing footprints and effort to better identify fishing grounds, using data from all NPFC Members by gear type and time;
s. Determine the appropriate scale for collecting and identifying fishing locations to define the fishing footprint in relation to assessing SAIs;
t. Consider methods for accessing electronic data from the fishing vessels operating in the NPFC and from any research vessels, and encourage Members to deploy electronic reporting systems whenever possible, including data on position and catch; and
u. Provide descriptions of the current and historical fishing gears operating in the NPFC area.

8.5. Exploratory fishing protocols

v. Consider the following points with respect to avoiding SAIs on VMEs in the course of exploratory fishing:
    i. Conduct reconnaissance for VMEs in the area to be explored, through fishery-independent surveys, drop-camera deployments from fishing vessels or other low impact sampling prior to fishing, beyond the requirements currently contained in the NPFC regulations; and
    ii. Initial exploratory fishing trips should be short to allow for timely assessment of both VME and fishery but at the same time minimizing any SAIs.
w. Consider banning exploratory fishing in VME closed areas;
x. Clarify the role of observers in collecting and reporting data during exploratory fishing; and
y. Review the application of the exploratory fishery measure to learn from other experiences in implementing exploratory fisheries measures.

8.6. Spatial management measures

z. Assess management needs and decide on objectives that are aligned with the UNGA resolutions and NPFC Convention;
aa. Use spatial mitigation measures that could include gear-specific closures, full-seamount closures, and within-seamount closures (on large seamounts with fine-scale spatial information, if possible);
bb. Develop habitat suitability models and use them with decision-support tools to aid a formal spatial management planning process, for example as used by SPRFMO; and
cc. Introduce a periodic review process that will enable flexibility to change needs and objectives of spatial management, as well as availability of new data to re-test results of analysis and decisions on which they are based.

8.7. General recommendations

dd. Introduce a periodic internal review processes for VME management;
ee. Consider external reviews to audit RFMO performance on VME protection;

ff. Conduct annual pre-reporting of research plans between Members to facilitate collaboration; and
gg. Seek cooperation with other organizations which have related mandates.

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APPENDIX 1 LIST OF DOCUMENTS

Agenda

NPFC-2018-WS VME01-MIP02

North Pacific Fisheries Commission
NPFC/FAO Workshop
Protection of Vulnerable Marine Ecosystems in the North Pacific Fisheries Commission Area: applying global experiences to regional assessments
12-15 March 2018
Yokohama, Japan

Draft Provisional Agenda

Agenda Item 1. Opening of the Workshop
1.1 Welcome Address
1.2 Purpose of Workshop and Expectations
Agenda Item 2. International Obligations for Assessment of Significant Adverse Impacts (SAIs) on Vulnerable Marine Ecosystems (VMEs)
Agenda Item 3. Overview of Seamount Bottom Fisheries Situations and Potential Impacts on Corals
Agenda Item 4. Global Overview of Actions Taken to Prevent SAI on VMEs
4.1 Surveys and VME Identification
4.2 Identifying Existing Fishing Areas
4.3 VME Encounter Protocols
4.4 Exploratory Fishing Protocols
Agenda Item 5. Historical SAI Assessments of NPFC Members (primarily from 2008-2009)
Agenda Item 6. Protection of Corals and VMEs in Fished and Unfished Areas
Agenda Item 7. Reports on Current SAI Assessments
7.1 Northeastern Pacific Ocean
7.2 Northwestern Pacific Ocean
Agenda Item 8. Global Overview Paper on Data Requirements to Implement Deep Sea Fisheries Measures to Protect VMEs
Agenda Item 9. Reports of the Members on Data Availability and Deficiencies
Agenda Item 10. The Global Picture - Discussions on Comparisons of the NPFC Approach with That of Other Regions (including data needs)
10.1 Surveys and VME Identification
10.2 Bottom Fishing Footprints (including monitoring gear and effort changes)
10.3 VME Encounter Protocols
10.4 Exploratory Fishing Protocols
Agenda Item 11. Discussions on Future Options for NPFC to Prevent SAI on VMEs:
11.1 Data and Data Gaps
11.2 Encounter Protocols
11.3 SAI Assessments
11.4 Fishing Footprints and Exploratory Fishing Protocols
Agenda Item 12. Concluding Remarks on Major Findings of the Workshop
Agenda Item 13. Recommendations to the SSC VME
Agenda Item 14. Adoption of the Report
Agenda Item 15. Close of the Workshop

Meeting information papers

Number	Title
NPFC-2018-WS VME01-MIP01 (Rev. 1)	Meeting Information
NPFC-2018-WS VME01-MIP02	Provisional Agenda
NPFC-2018-WS VME01-MIP03 (Rev. 2)	Provisional Annotated Agenda
NPFC-2018-WS VME01-MIP04 (Rev. 2)	Indicative Schedule
NPFC-2018-WS VME01-MIP05 (Rev. 2)	Provisional List of Documents
NPFC-2018-WS VME01-MIP06 (Rev. 1)	Workshop Program

References documents

Reference*	Title
https://www.npfc.int/key-documents/reports-vmes-and-assessment-impacts-caused-bottom-fishing-activities	Historical SAI Assessment Reports
https://www.npfc.int/cmm-2017-05-bottom-fisheries-and-protection-vmes-nw-pacific-ocean	CMM 2017-05 For Bottom Fisheries and Protection of VMEs in the NW Pacific Ocean
https://www.npfc.int/cmm-2017-06-bottom-fisheries-and-protection-vmes-ne-pacific-ocean-0	CMM 2017-06 For Bottom Fisheries and Protection of VMEs in the NE Pacific Ocean
https://www.npfc.int/summary-footprint-bottom-fisheries	Summary Footprint of Bottom Fisheries
https://www.npfc.int/international-guidelines-management-deep-sea-fisheries-high-seas	International Guidelines for the Management of Deep-sea Fisheries in the High Seas

* See NPFC website for the updated reference papers

Working papers

Symbol	Title
NPFC-2018-WS VME01-WP01	Report on identification of VMEs and assessment of impacts caused by Japanese bottom fishing activities on VMEs and other marine species in the western part of the NPFC Convention Area
NPFC-2018-WS VME01-WP02	Updated summary comparison of VME encounter protocols in bottom fish RFMO/As
NPFC-2018-WS VME01-WP03	Identification of existing fishing grounds and unfished areas in the Emperor Seamounts region
NPFC-2018-WS VME01-WP04	Analysis of fishery bycatch and scientific survey data for cold-water corals and sponges in the existing fishing grounds of the Emperor Seamounts region
NPFC-2018-WS VME01-WP05	An assessment of the potential impacts of Japanese bottom fisheries on vulnerable marine ecosystems (VMEs) within fished seamounts of the Emperor Seamounts region
NPFC-2018-WS VME01-WP06	Historical Significant Adverse Impact Assessments of the North Pacific Fisheries Commission Members (abstract)
NPFC-2018-WS VME01-WP07	VMEs in North Western Pacific as life-supporting resources – challenges and possible science-based approaches to solutions (abstract and presentation)
NPFC-2018-WS VME01-WP08	An overview on protection of corals and VMEs in fished and unfished areas (abstract and presentation)
NPFC-2018-WS VME01-WP09	Overview of Seamount Bottom Fisheries Situations and Potential Impacts on Corals (abstract and presentation)
NPFC-2018-WS VME01-WP10	Global Overview of Actions Taken to Prevent SAI on VMEs: Surveys and VME Identification (abstract and presentation)
NPFC-2018-WS VME01-WP11	Report on identification of VMEs and assessment of impacts caused

	by Korean Bottom Trawl Fishing Activities on VMEs or other marine species in the Western part of the NPFC Convention Area
NPFC-2018-WS VME01-WP12	International Obligations for Assessment of Significant Adverse Impacts (SAIs) on Vulnerable Marine Ecosystems (VMEs) (abstract and presentation)
NPFC-2018-WS VME01-WP13	Global Overview Paper on Data Requirements to Implement Deep Sea Fisheries Measures to Protect VMEs (abstract and presentation)
NPFC-2018-WS VME01-WP14	Managing Fishery Interactions with Vulnerable Marine Ecosystems in the Southern Ocean (presentation)
NPFC-2018-WS VME01-WP15	Report on the identification of vulnerable marine ecosystems (VMEs) & assessment of significant adverse impact (SAI) on seamounts currently fished by Canada (presentation)
NPFC-2018-WS VME01-WP16	Spatial Management Strategies: The SPRFMO (New Zealand) Experience (presentation)
NPFC-2018-WS VME01-WP17	VME - North Pacific Perspective (presentation)
NPFC-2018-WS VME01-WP18	Report on the Members on Data Availability and Deficiencies by Canada (presentation)
NPFC-2018-WS VME01-WP19	Data Availability and Deficiencies by Japan (presentation)
NPFC-2018-WS VME01-WP20	Data availability and progress in VME protection in the NPFC against data requirements from the FAO-DSF Guidelines

Information papers

Symbol	Title
NPFC-2018-WS VME01-IP01	Application of association analysis for identifying indicator taxa of vulnerable marine ecosystems in the Emperor Seamounts area, North Pacific Ocean
NPFC-2018-WS VME01-IP02	Defying Dissolution: Discovery of Deep-Sea Scleractinian Coral Reefs in the North Pacific

Note: Some of these documents are located on the NPFC Members' pages.

APPENDIX II LIST OF PARTICIPANTS

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The *Sustainable Fisheries Management and Biodiversity Conservation of Deep Sea Living Resources in Areas Beyond National Jurisdiction* Project (ABNJ Deep Seas Project for short) is a five year project supported by the Global Environment Facility, and implemented jointly by the Food and Agriculture Organization of the United Nations, and the United Nations Environment Programme. The UNEP project component is executed though the UNEP World Conservation and Monitoring Centre.

The Project is designed to enhance sustainability in the use of deep-sea living resources and biodiversity conservation in the ABNJ through the systematic application of an ecosystem approach. It brings together over 20 partners who work on deep-sea fisheries and conservation issues in the ABNJ globally. The partnership includes regional organizations responsible for the management of deep-sea fisheries, Regional Seas Programmes, the fishing industry and international organizations. The Project aims to:

- strengthen policy and legal frameworks for sustainable fisheries and biodiversity conservation in the ABNJ deep seas;
- reduce adverse impacts on VMEs and enhanced conservation and management of components of EBSAs;
- improve planning and adaptive management for deep sea fisheries in ABNJ; and
- develop and test methods for area-based planning.

The ABNJ Deep Seas Project started in September 2015 and is one of four projects under the GEF Common Oceans Programme. More information is available from www.commonoceans.org

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