Methods and challenges for identifying vulnerable marine ecosystems as part of an ecosystem approach to fisheries management: perspectives from SPRFMO

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NIWA
Taihoro Nukurangi

Symposium on:
Applying the Ecosystem Approach to Fisheries Management in ABNJ
Rome,11–13 March, 2025
Session 2: Discarded and vulnerable species

Food and Agriculture Organization of the United Nations

Northwest Atlantic Fisheries Organization

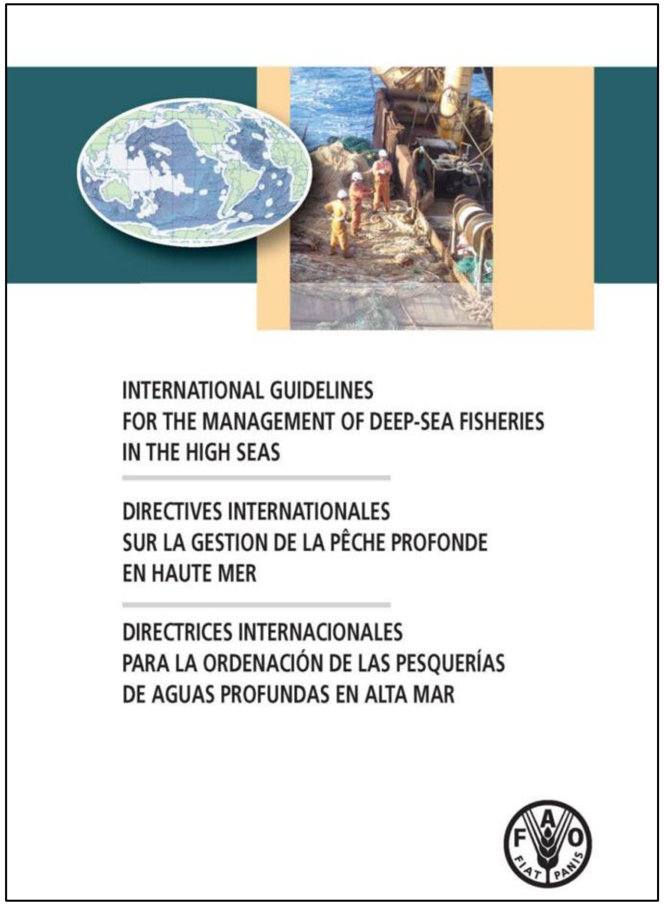
ICES CIEM

VMEs – DSF guidelines

- International Guidelines for the Management of Deep-sea Fisheries in the High Seas (FAO, 2009)

6. The role of the Guidelines is to provide tools, including guidance on their application, to facilitate and encourage the efforts of States and RFMO/As towards sustainable use of marine living resources exploited by deep-sea fisheries, the prevention of significant adverse impacts on deep-sea VMEs and the protection of marine biodiversity that these ecosystems contain.

- Guidelines include a description of the concept of a **vulnerable marine ecosystem (VME)**, how to identify them (criteria), and provide examples



FAO (2009)

http://www.fao.org/documents/card/en/c/b02fc35e-a0c4-545a-86fb-4fc340e13b52

Identifying VMEs - criteria

5.2 Identifying vulnerable marine ecosystems and assessing significant adverse impacts

42. A marine ecosystem should be classified as vulnerable based on the characteristics that it possesses. The following list of characteristics should be used as criteria in the identification of VMEs.

i. Uniqueness or rarity – an area or ecosystem that is unique or that contains rare species whose loss could not be compensated for by similar areas or ecosystems. These include:
   - habitats that contain endemic species;
   - habitats of rare, threatened or endangered species that occur only in discrete areas; or
   - nurseries or discrete feeding, breeding, or spawning areas.

ii. Functional significance of the habitat – discrete areas or habitats that are necessary for the survival, function, spawning/reproduction or recovery of fish stocks, particular life-history stages (e.g. nursery grounds or rearing areas), or of rare, threatened or endangered marine species.

iii. Fragility – an ecosystem that is highly susceptible to degradation by anthropogenic activities.

iv. Life-history traits of component species that make recovery difficult – ecosystems that are characterized by populations or assemblages of species with one or more of the following characteristics:
   - slow growth rates;
   - late age of maturity;
   - low or unpredictable recruitment; or
   - long-lived.

v. Structural complexity – an ecosystem that is characterized by complex physical structures created by significant concentrations of biotic and abiotic features. In these ecosystems, ecological processes are usually highly dependent on these structured systems. Further, such ecosystems often have high diversity, which is dependent on the structuring organisms.

FAO (2009)

Identifying VMEs - application

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

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

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

FAO (2009)

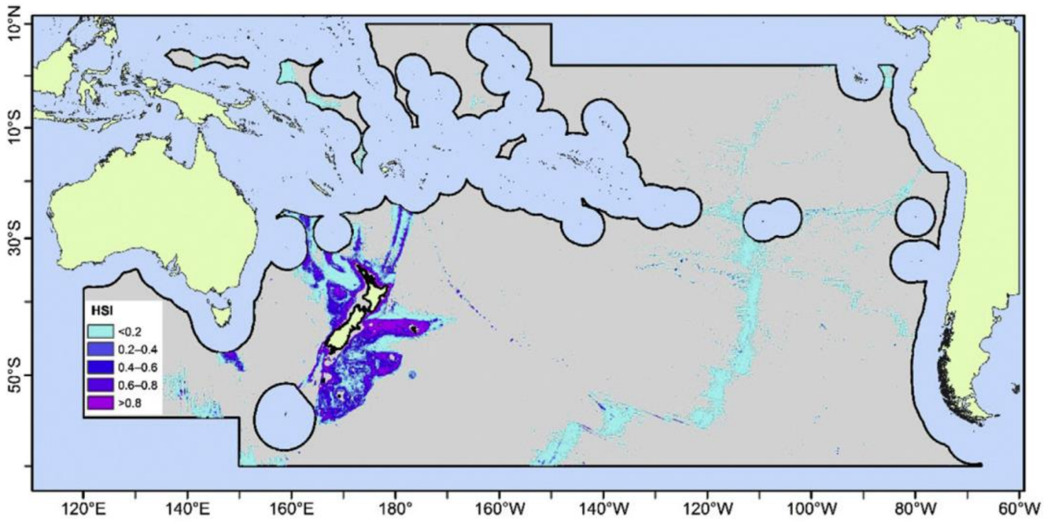
Identifying VMEs - models

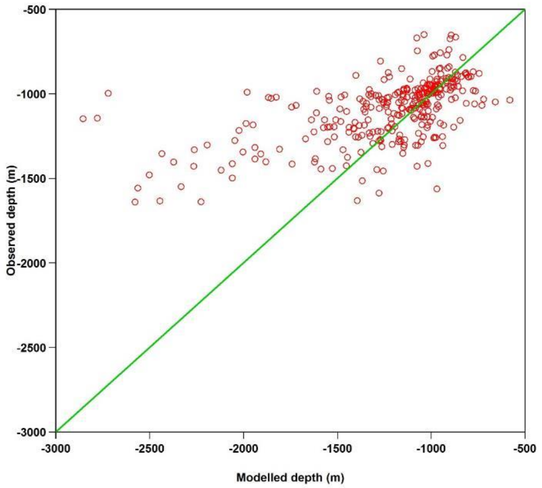
"Essentially, all models are wrong, but some are useful."

George Box

Identifying VMEs – habitat suitability models

- VME indicator taxa
- Iterative development of modelling approaches (since 2013) and appropriate spatial scale
- First model for whole SPRFMO area unreliable (not useful) – global bathymetry issue
- Revealed by ground truthing





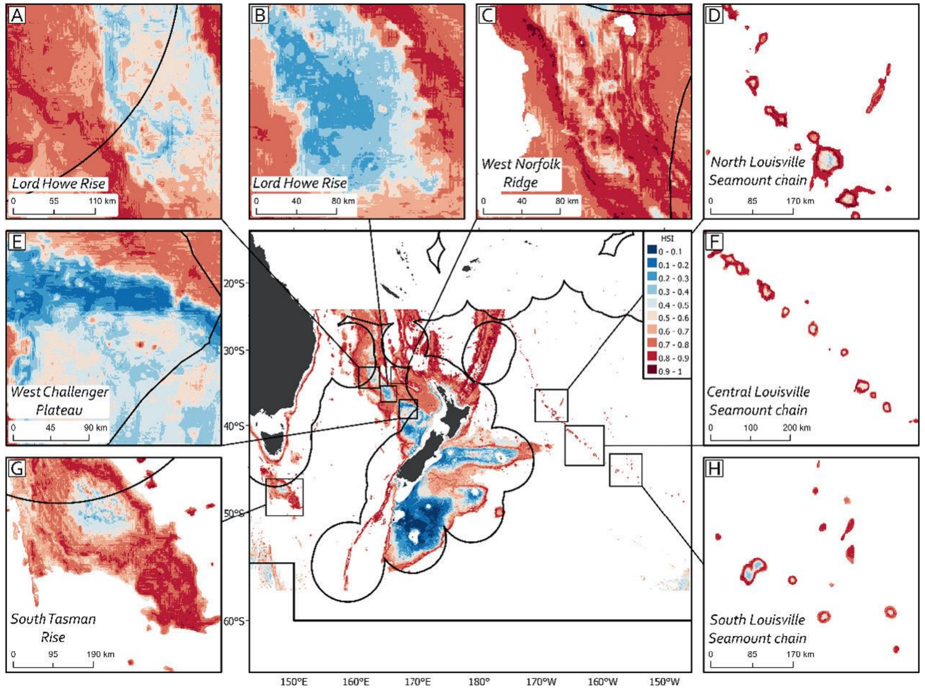
https://www.sciencedirect.com/science/article/pii/S0964569115300740 Anderson et al. (2016)

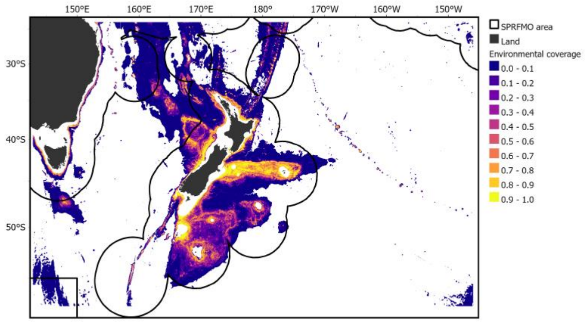
Identifying VMEs – habitat suitability models

- Latest models for 18 VME indicator taxa for subset of SPRFMO area where environmental data more reliable and orange roughy fishery located

- Ensemble modelling approach (averaged output weighted by individual model performance)

- Mapped model uncertainty and environmental coverage



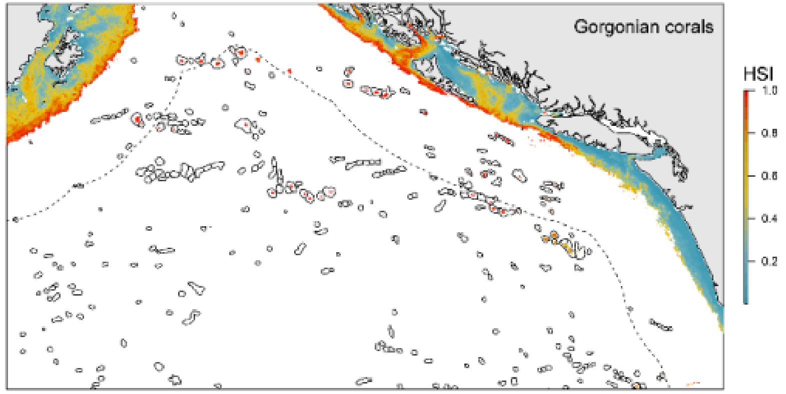


https://onlinelibrary.wiley.com/doi/epdf/10.1111/fme.12700

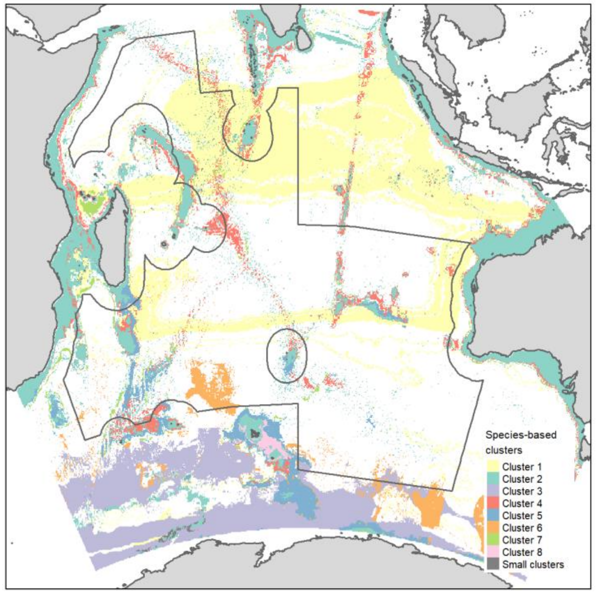
Bennion et al. (2024a)

Identifying VMEs – habitat suitability models

- Various forms of HS models used by RFMOs to infer presence of VMEs
- Sometimes in support/basis of other methods (e.g., **NPFC**)
- But particularly useful for data-poor areas (e.g., **SIOFA**, recently made HS models for VME indicator taxa, although these used ultimately to identify VME bioregions)



https://www.npfc.int/system/files/2021-11/NPFC-2021-SSC%20BFME02-WP05%20Predictive%20Habitat%20Models%20and%20Visual%20Surveys%20to%20Identify%20VMEs.pdf Warawa et al. (2021)



https://siofa.org/sites/default/files/files/VMEMapping_FullReport.pdf Ramiro-Sanchez &Leroy (2023)

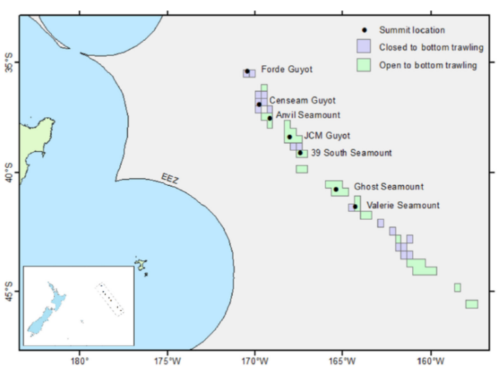
Identifying VMEs – abundance-based species distribution models

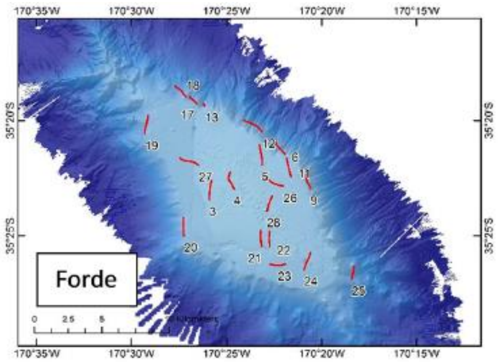
- Seafloor imagery allows for making of SDMs for VME indicator taxa using abundance data

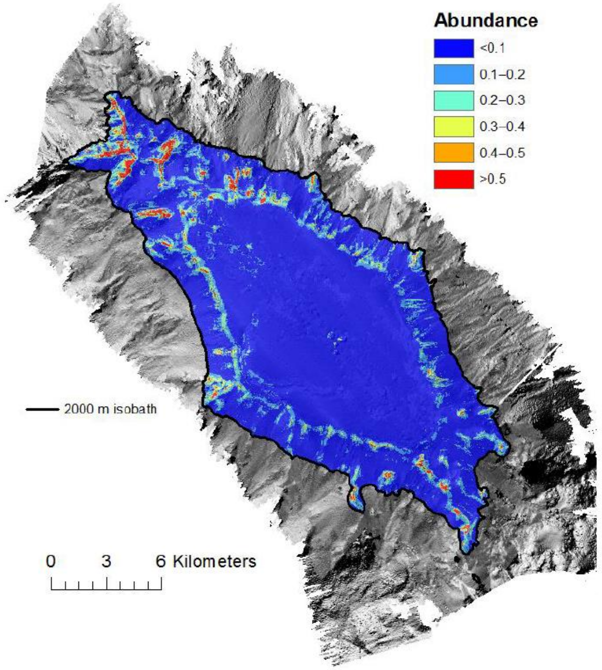
- More useful for identifying VMEs

- Louisville Seamounts and 3 VME indicator taxa

- MBES derivatives as predictors to make fine-scale resolution (25 x 25 m) maps







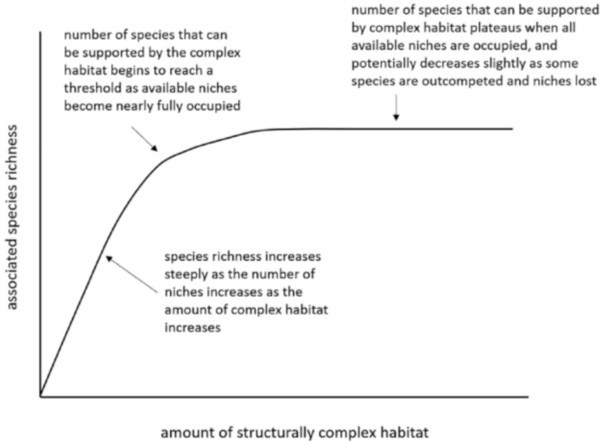
https://www.sciencedirect.com/science/article/pii/S0964569115300740 Rowden et al. (2017)

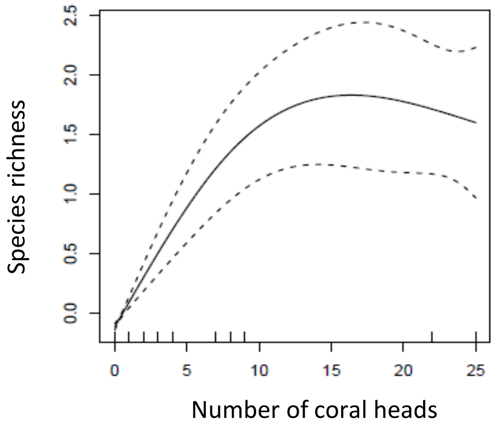
Identifying VMEs – operationalising VME criteria

- Abundance data/models allows for application of VME FAO criteria to identify VMEs

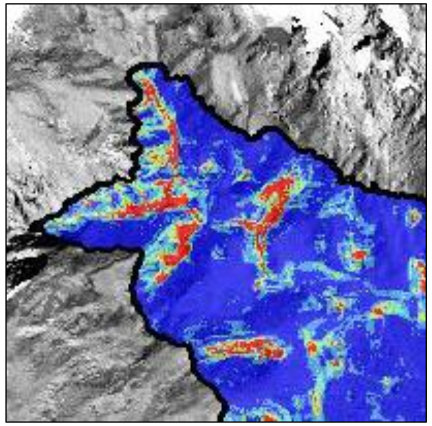
v. Structural complexity – an ecosystem that is characterized by complex physical structures created by significant concentrations of biotic and abiotic features. In these ecosystems, ecological processes are usually highly dependent on these structured systems. Further, such ecosystems often have high diversity, which is dependent on the structuring organisms.

- Identification of abundance thresholds for structural complex VME applied to abundance models

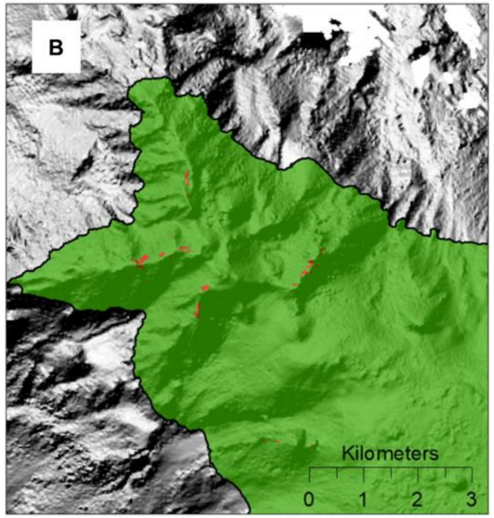




Coral abundance



Coral reef VME

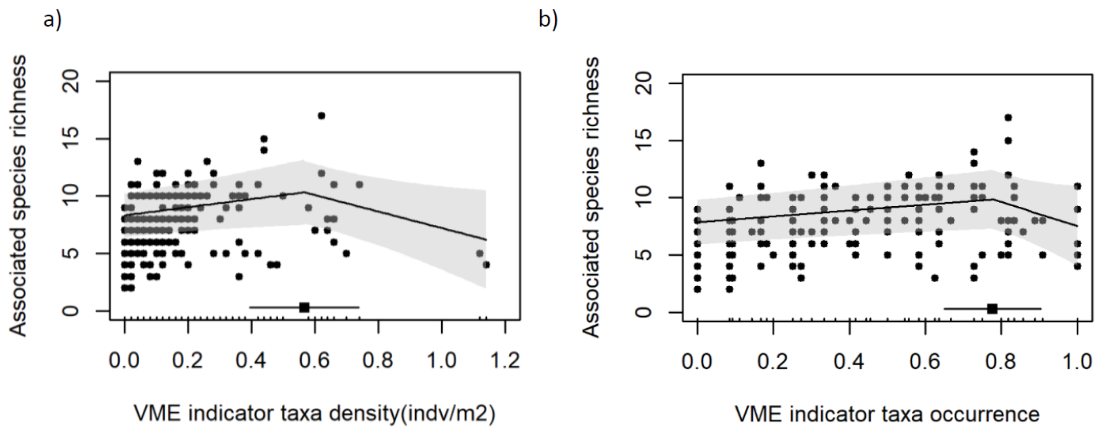


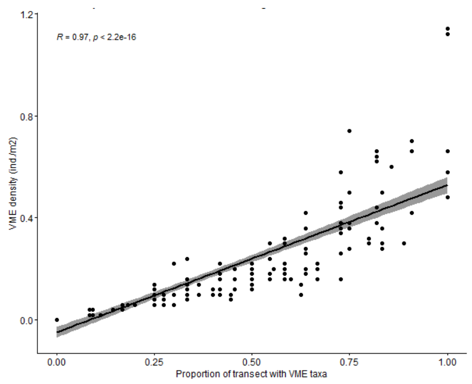
https://www.frontiersin.org/journals/marine-science/articles/10.3389/fmars.2020.00095/full Rowden et al. (2020)

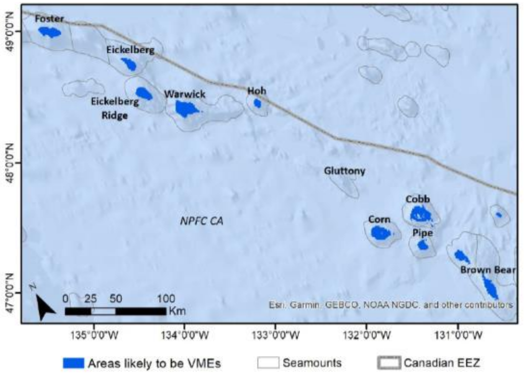
Identifying VMEs - operationalising VME criteria

- Warawa et al. (2022), for **NPFC**, used similar approach to Rowden et al. (2020) for identifying VME thresholds

- Both for density *and* relative occurrence – and showed relative occurrence good proxy for density – so possible to use occurrence models for VME identification



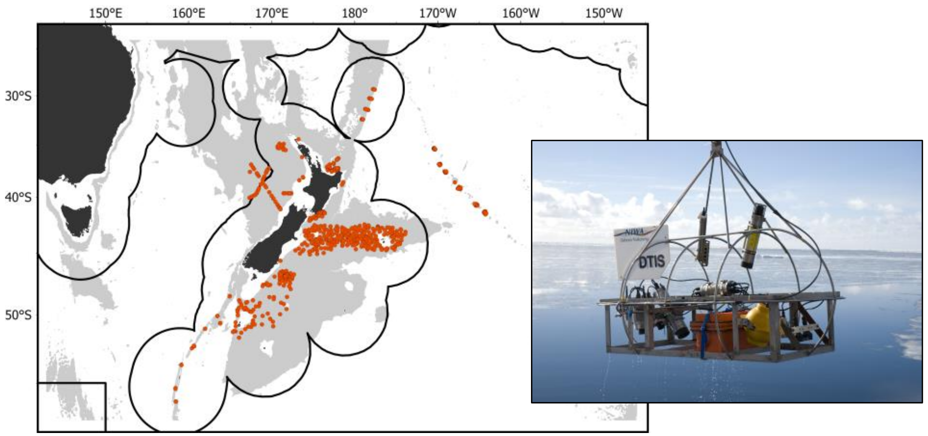


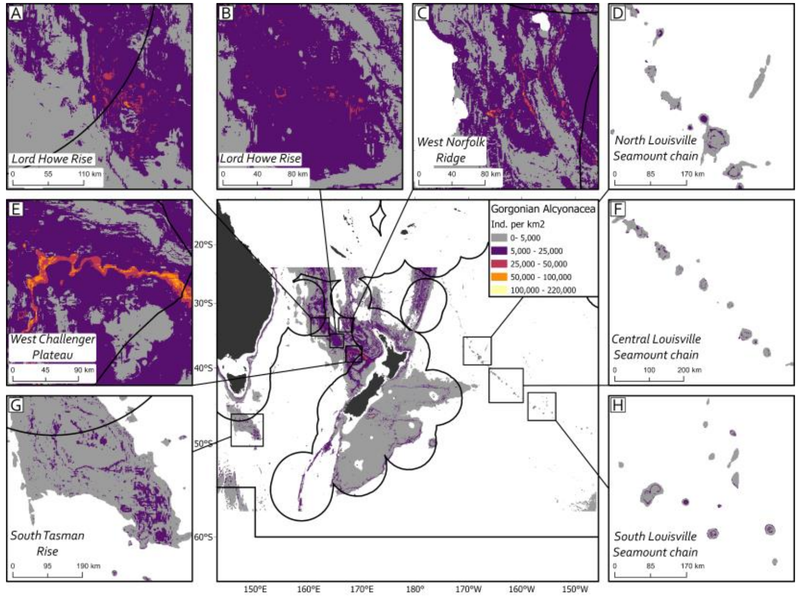


https://www.npfc.int/system/files/2022-11/NPFC-2022-SSC%20BFME03-WP03%20Identifying%20VMEs.pdf Warawa et al. (2022)

Identifying VMEs – abundance-based species distribution models

- New models for subset of SPRFMO area – based on towed-camera abundance data
- 17 VME indicator taxa
- Ensemble approach, uncertainty, and environmental coverage
- Performance promising
- Independent data for testing (pending)



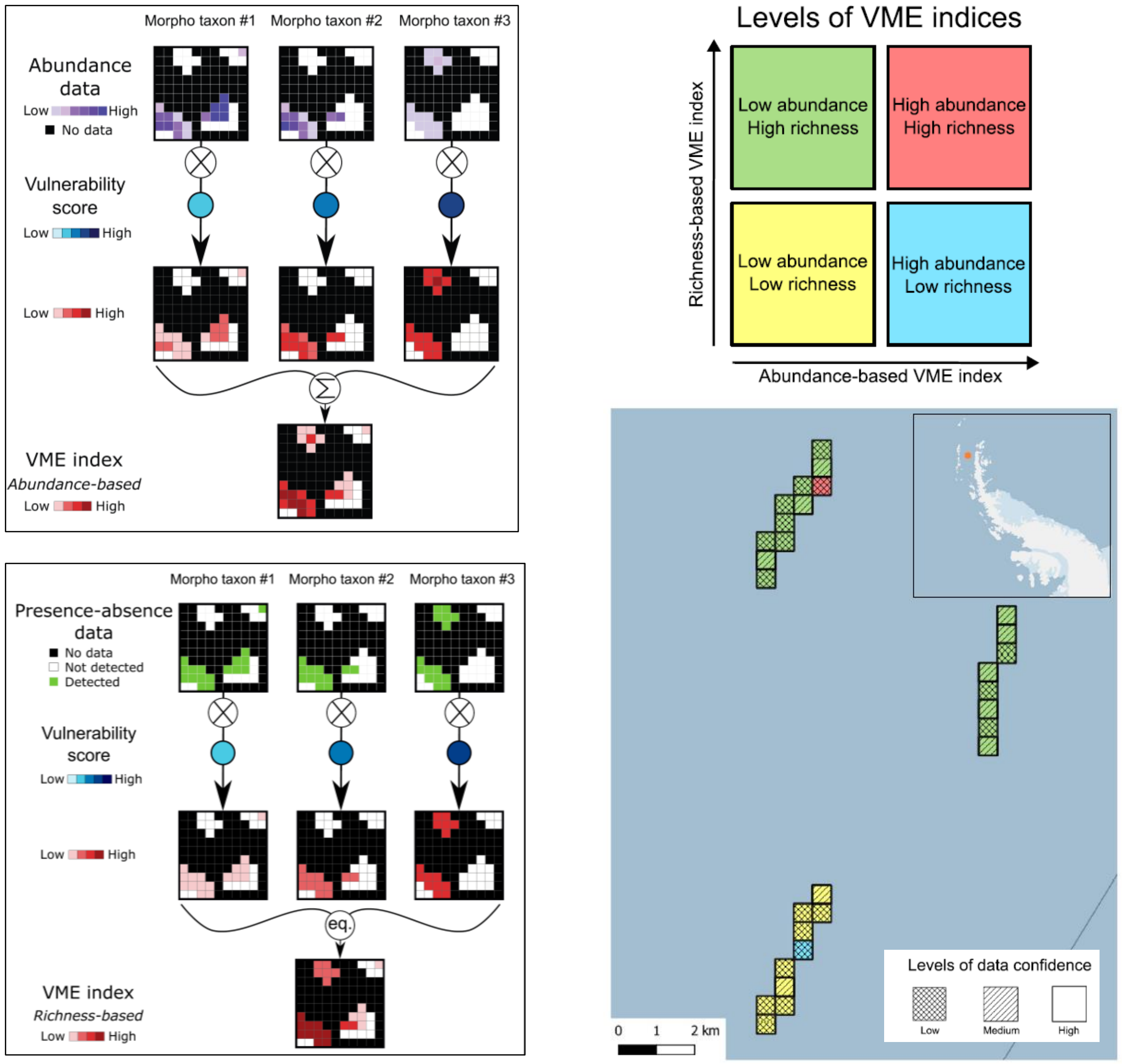


https://onlinelibrary.wiley.com/doi/epdf/10.1111/fme.12751) Bennion et al. (2024b)

Identifying VMEs – VME indices

- Gros et al. (2023) developed VME index based on abundance *and* diversity of VME indicator taxa

- Builds on work of others who have promoted and applied multi-criteria VME indices (e.g., Morato et al. 2018; Burgos et al. 2020)



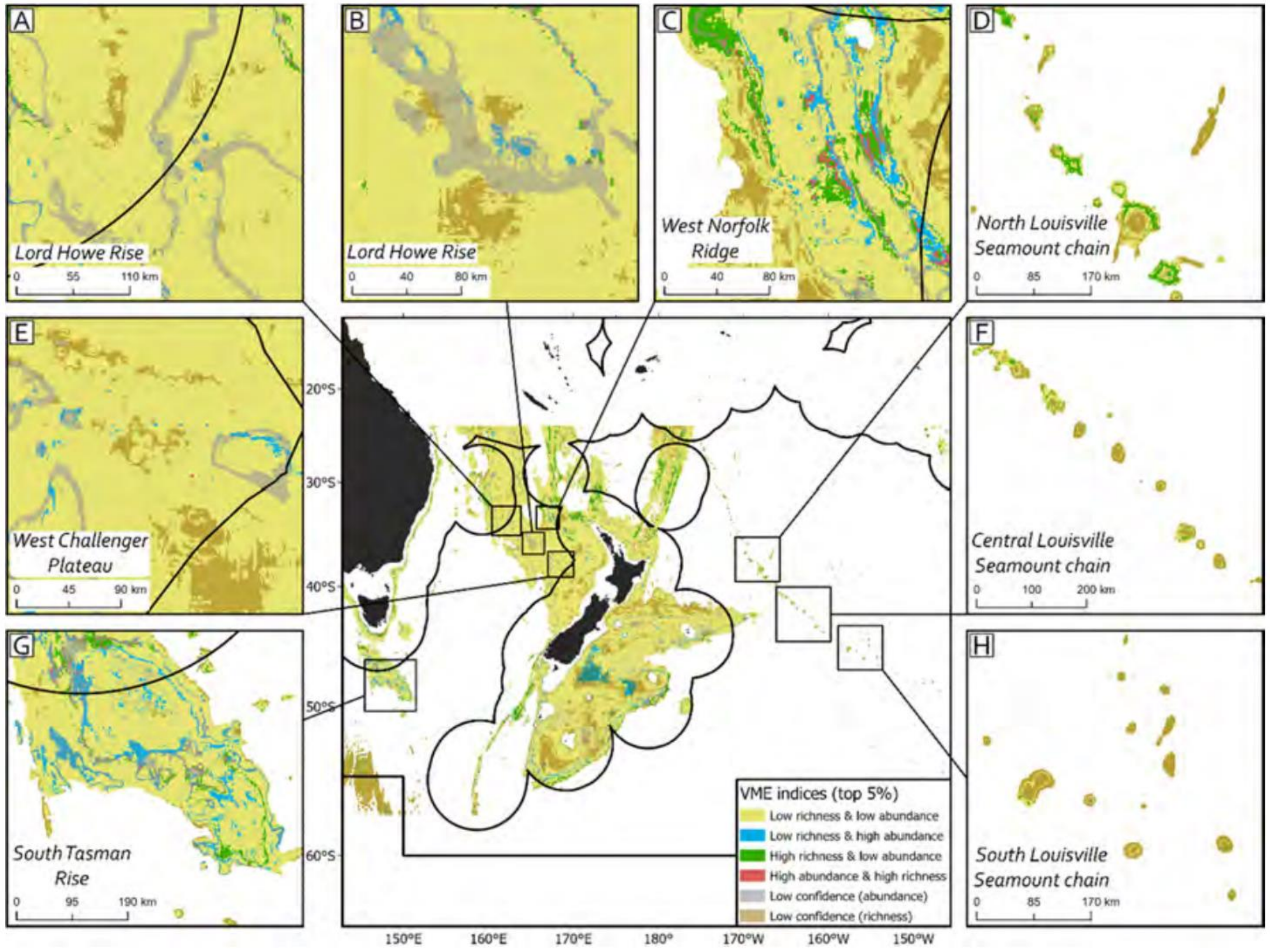
https://academic.oup.com/icesjms/article/80/4/972/7058020

Gros et al. (2023)

Identifying VMEs – VME indices

- Applied Gros et al. (2023) approach to JSDM model outputs for VME indicator taxa in NZ EEZ (Stephenson et al. 2024)

- Trialled same method using recent VME indicator taxa abundance models SPRFMO sub-area



https://onlinelibrary.wiley.com/doi/epdf/10.1111/fme.12751) Bennion et al. (2024b)

Identifying VMEs - challenges

- Habitat suitability models for VMEs (presence only) reached limit of performance and usefulness
- Fine-scale models for VMEs using MBES derivatives unattainable for large areas
- Abundance-based VME models using imagery data are the ideal – but available imagery limited – need more fisheries-independent surveys
- Model outputs for VME indicator taxa not closely enough aligned with VME concept – need model outputs that incorporate VME criteria, e.g., thresholding abundance-based models, VME indices etc
- Acceptance of methodologies within an RFMO takes time – research, debate, refinement, resistance
- Opportunities for across-RFMO fertilization and alignment – need more across-RFMO work – how can this be facilitated? By FAO? Other means? – can be difficult when scientific input sits in different places in different RFMO processes

Identifying VMEs – modelling challenges

Read this….

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REVIEW
published: 27 June 2022
doi: 10.3389/fmars.2022.870145

Vulnerable, but Still Poorly Known, Marine Ecosystems: How to Make Distribution Models More Relevant and Impactful for Conservation and Management of VMEs?

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Specialty section:
This article was submitted to Deep-Sea Environments and Ecology, a section of the journal Frontiers in Marine Science

Received: *06 February 2022*
Accepted: *12 May 2022*
Published: *27 June 2022*

Citation:
Gros C, Jansen J, Dunstan PK, Welsford DC and Hill NA (2022) Vulnerable, but Still Poorly Known, Marine Ecosystems: How to Make Distribution Models More Relevant and Impactful for Conservation and Management of VMEs? Front. Mar. Sci. 9:870145. doi: 10.3389/fmars.2022.870145

Human activity puts our oceans under multiple stresses, whose impacts are already significantly affecting biodiversity and physicochemical properties. Consequently, there is an increased international focus on the conservation and sustainable use of oceans, including the protection of fragile benthic biodiversity hotspots in the deep sea, identified as vulnerable marine ecosystems (VMEs). International VME risk assessment and conservation efforts are hampered because we largely do not know where VMEs are located. VME distribution modelling has increasingly been recommended to extend our knowledge beyond sparse observations. Nevertheless, the adoption of VME distribution models in spatial management planning and conservation remains limited. This work critically reviews VME distribution modelling studies, and recommends promising avenues to make VME models more relevant and impactful for policy and management decision making. First, there is an important interplay between the type of VME data used to build models and how the generated maps can be used in making management decisions, which is often ignored by model-builders. Overall, there is a need for more precise VME data for production of reliable models. We provide specific guidelines for seven common applications of VME distribution modelling to improve the matching between the modelling and the user need. Second, the current criteria to identify VME often rely on subjective thresholds, which limits the transparency, transferability and effective applicability of distribution models in protection measures. We encourage scientists towards founding their models on: (i) specific and quantitative definitions of what constitute a VME, (ii) site conservation value assessment in relation to VME multi-taxon spatial predictions, and (iii) explicitly mapping vulnerability. Along with the recent increase in both deep-sea biological and environmental data quality and quantity, these modelling recommendations can lead towards more cohesive summaries of VME's spatial distributions and their relative vulnerability, which should facilitate a more effective protection of these ecosystems, as has been mandated by numerous international agreements.

Keywords: vulnerable marine ecosystems, species distribution model, habitat suitability model, marine conservation, environmental impact assessment

https://www.frontiersin.org/journals/marine-science/articles/10.3389/fmars.2022.870145/full

Gros et al. (2022)

Interaction with threats, assessment of impact and mitigation performance

- SPRFMO adopted FAO definition of **Significant Adverse Impacts (SAIs)**
- Assessment of SAIs delivered through BFIA – i.e., risk assessment approach
- Likelihood of SAIs evaluated using a 3-part workflow: Spatial distribution of VME indicator taxa and fishing distribution; status of VME indicator taxa; management measure performance (primarily spatial)

This workflow includes determining: (1) the spatial distribution of VME taxa and bottom fishing effort; (2) changes in the status of VME taxa due to the impacts of historical fishing; and (3) evaluating the performance of management measures, including spatial management and move-on rules, taking into consideration the spatial scale at which managers may deem it necessary to prevent SAIs on VMEs, and the uncertainty associated with the data informing the assessment (Figure 36). This process was guided through one of New Zealand's standing science working groups, the South Pacific Fishery Assessment Working Group (SPACWG), which provided a forum to discuss the assessment approach collegially among scientific, policy and management representatives of Australia and New Zealand, environmental non-government organisations and fishing industry representatives.

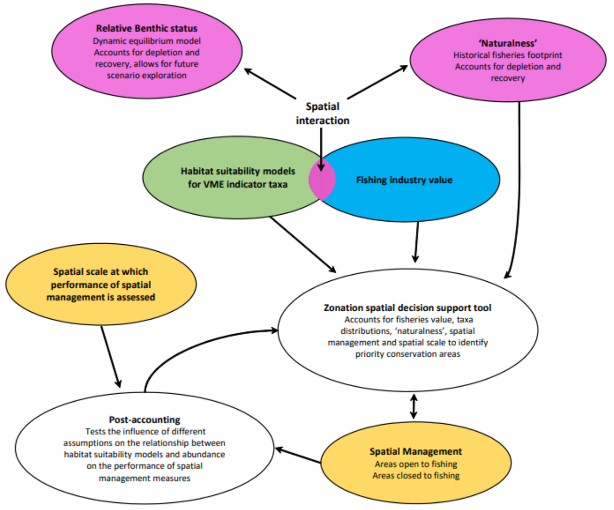
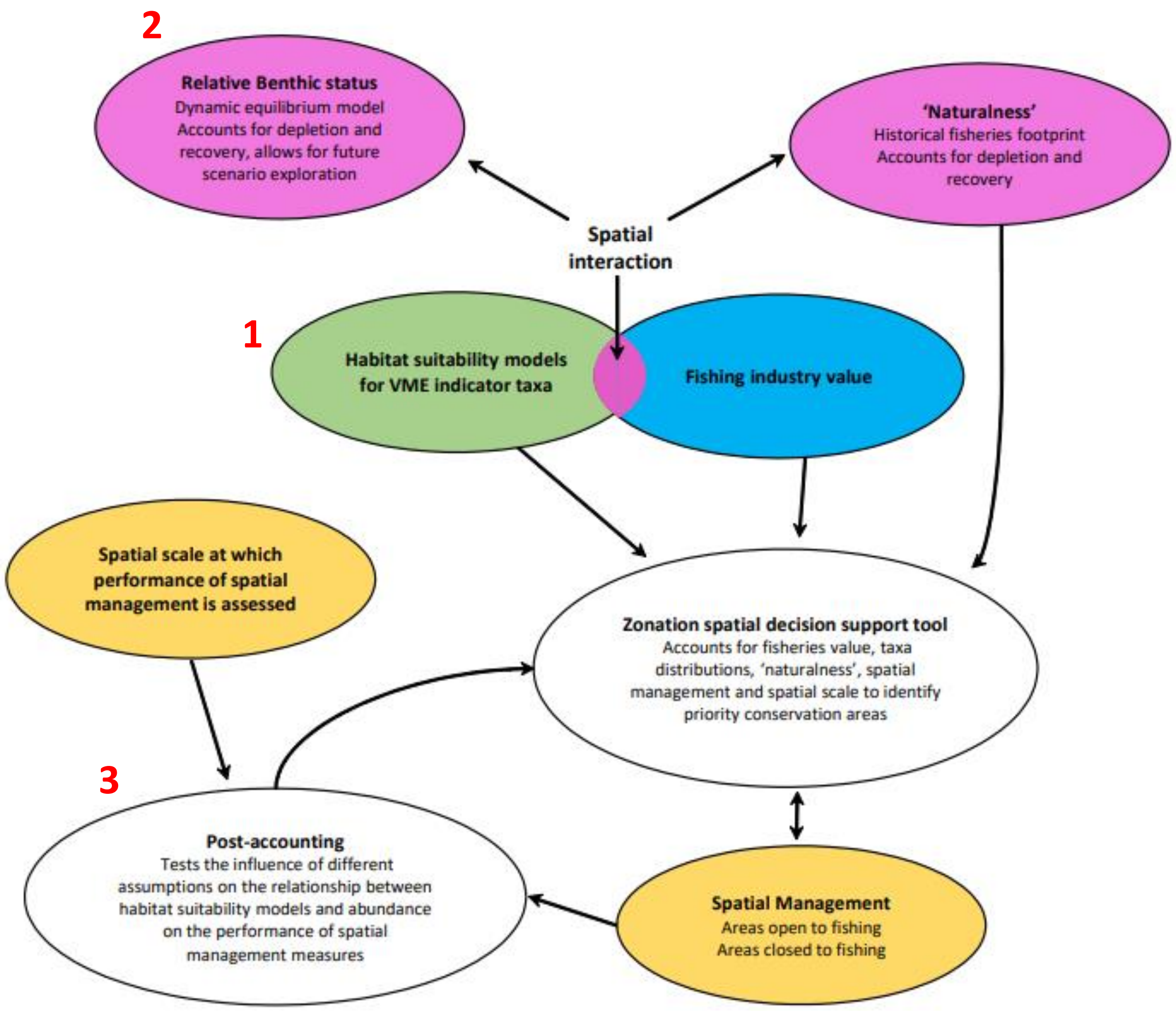


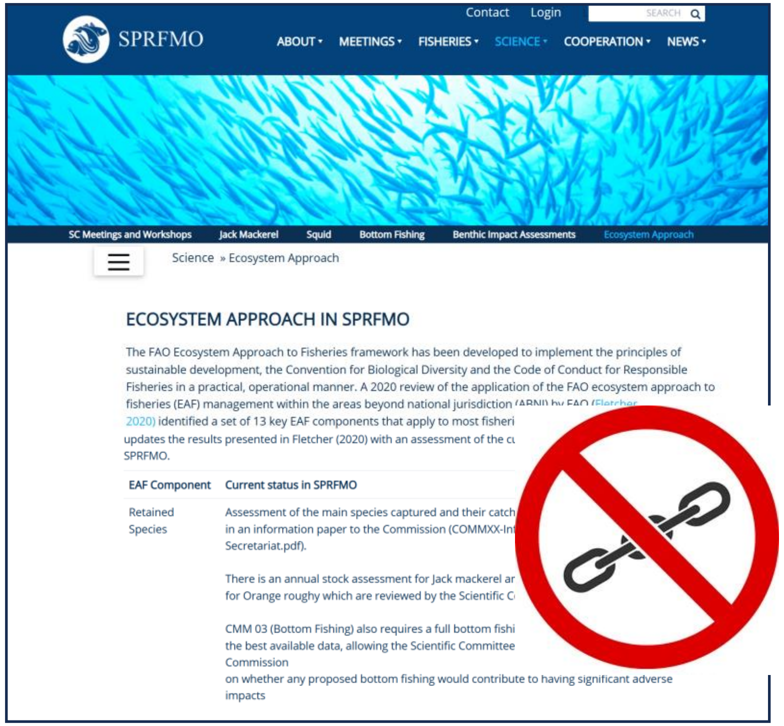
Figure 36: Schematic representation of the workflow used to assess the likely current and future state of VME indicator taxa and assess the likely performance of current spatial management arrangements.

Australia and New Zealand 2023 Bottom Fishery Impact Assessment (BFIA)
https://www.sprfmo.int/assets/Meetings/02-SC/11th-SC-2023/Deepwater/SC11-DW01_rev1-Cumulative-Bottom-Fishery-Impact-Assessment-for-AUS-and-NZL-bottom-fisheries-2023.pdf


2
Relative Benthic status
Dynamic equilibrium model
Accounts for depletion and recovery, allows for future scenario exploration
'Naturalness'
Historical fisheries footprint
Accounts for depletion and recovery
Spatial interaction
1
Habitat suitability models for VME indicator taxa
Fishing industry value
Spatial scale at which performance of spatial management is assessed
Zonation spatial decision support tool
Accounts for fisheries value, taxa distributions, 'naturalness', spatial management and spatial scale to identify priority conservation areas
3
Post-accounting
Tests the influence of different assumptions on the relationship between habitat suitability models and abundance on the performance of spatial management measures
Spatial Management
Areas open to fishing
Areas closed to fishing

EAFM in SPRFMO

- The BFIA is a tool for EAFM in SPRFMO
- Impact risk assessment part for VMEs is not directly linked within BFIA to other risk assessments (using different approaches) for target species, retained and non-retained bycatch - including other vulnerable species (birds, mammals, reptiles)
- EAFM is largely implemented through Conservation and Management Measures (CMMs); e.g., for ‘Bottom Fishing’ and ‘Deepwater Species’
- Little evidence of integrated approach to EAFM (post-hoc mapping of CMMs to EAFM components)



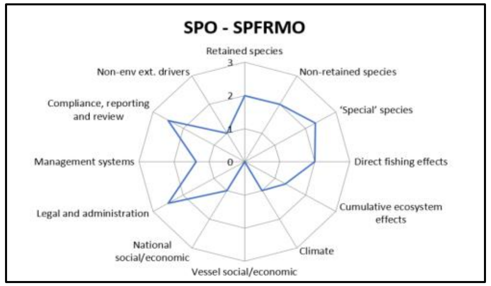
little evidence of integrated EAFM

General aspects

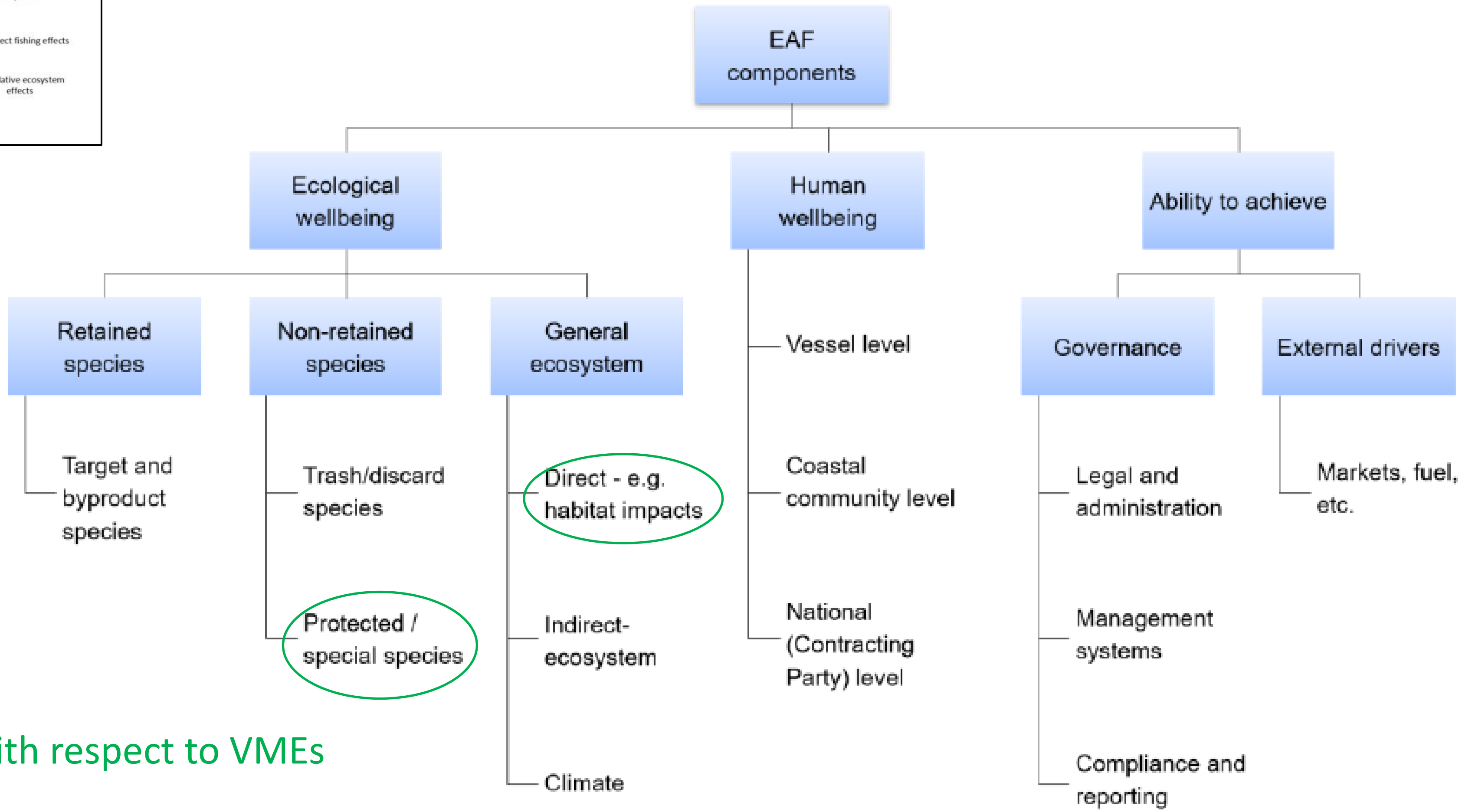
- Drafting an EAFM assessment or framework document
- Outline all EAF-related issues and associated risk assessments
- Long-term management plans and objectives
- Greater involvement of fisheries managers to guide EAFM process
- Consideration on working with dsRFMOs contracting parties on socio-economic components of EAFM

Thompson; Background paper for EAFM symposium

EAFM in SPRFMO

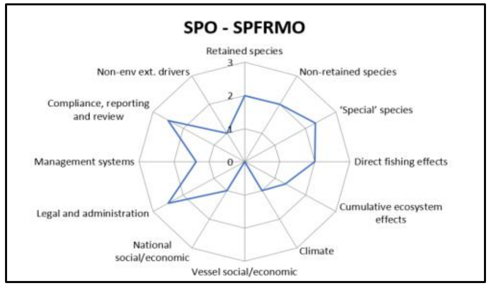


Fletcher (2020)



With respect to VMEs

EAFM in SPRFMO



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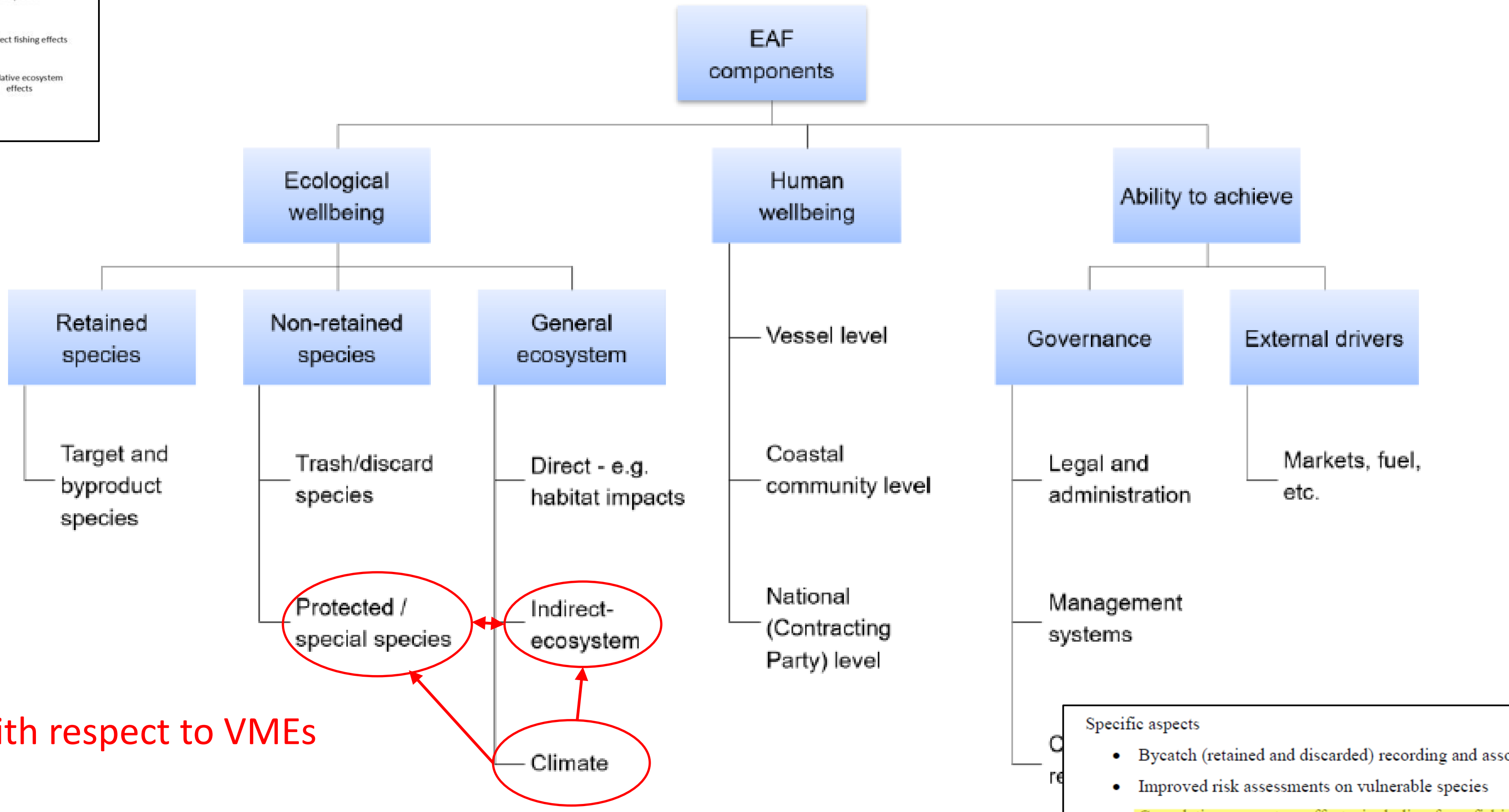


With respect to VMEs

Specific aspects

- Bycatch (retained and discarded) recording and associated catch limits
- Improved risk assessments on vulnerable species
- Cumulative ecosystem effects, including from fishing and climate change
- Greater development of species specific and ecosystem indicators and reference points

Thompson; Background paper for EAFM symposium

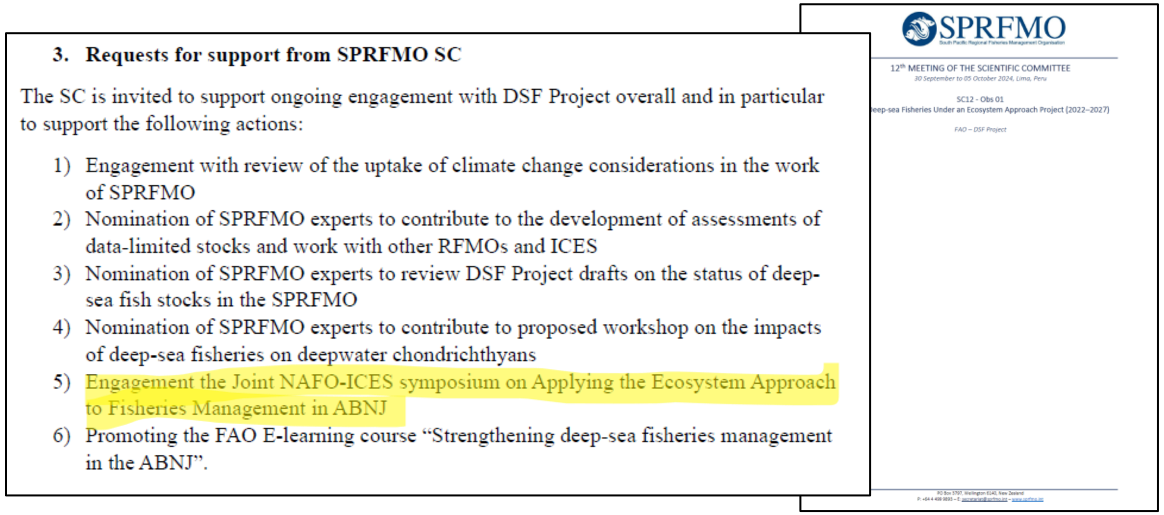
Future?

- RFMOs need to acknowledge the issues and proposed actions in FAO reviews of EAFM implementation

- Use already available FAO resources on EAFM

- Respond to calls for direct engagement with FAO on EAFM issues through DSF project

- Contribute to new resources on EAFM



3. **Requests for support from SPRFMO SC**

The SC is invited to support ongoing engagement with DSF Project overall and in particular to support the following actions:

1) Engagement with review of the uptake of climate change considerations in the work of SPRFMO
2) Nomination of SPRFMO experts to contribute to the development of assessments of data-limited stocks and work with other RFMOs and ICES
3) Nomination of SPRFMO experts to review DSF Project drafts on the status of deep-sea fish stocks in the SPRFMO
4) Nomination of SPRFMO experts to contribute to proposed workshop on the impacts of deep-sea fisheries on deepwater chondrichthyans
5) Engagement the Joint NAFO-ICES symposium on Applying the Ecosystem Approach to Fisheries Management in ABNJ
6) Promoting the FAO E-learning course "Strengthening deep-sea fisheries management in the ABNJ".

Acknowledgements and Thank You

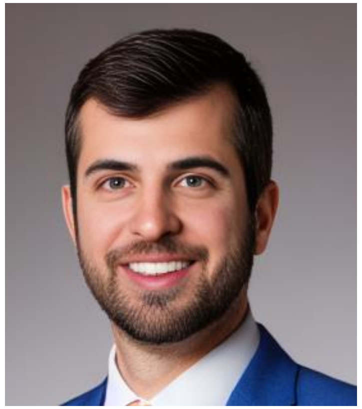

Malcolm Clark


Owen Anderson


David Bowden


Fabrice Stephenson


John Guinotte


Sam Georgian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