Mapping VMEs

FAO DSF Guidelines and actions taken by RFMOs in other regions

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FAO workshop on vulnerable marine ecosystems (VMEs) for the SIOFA region

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National Research Institute of Fisheries Science, Yokohama, Japan

Outline

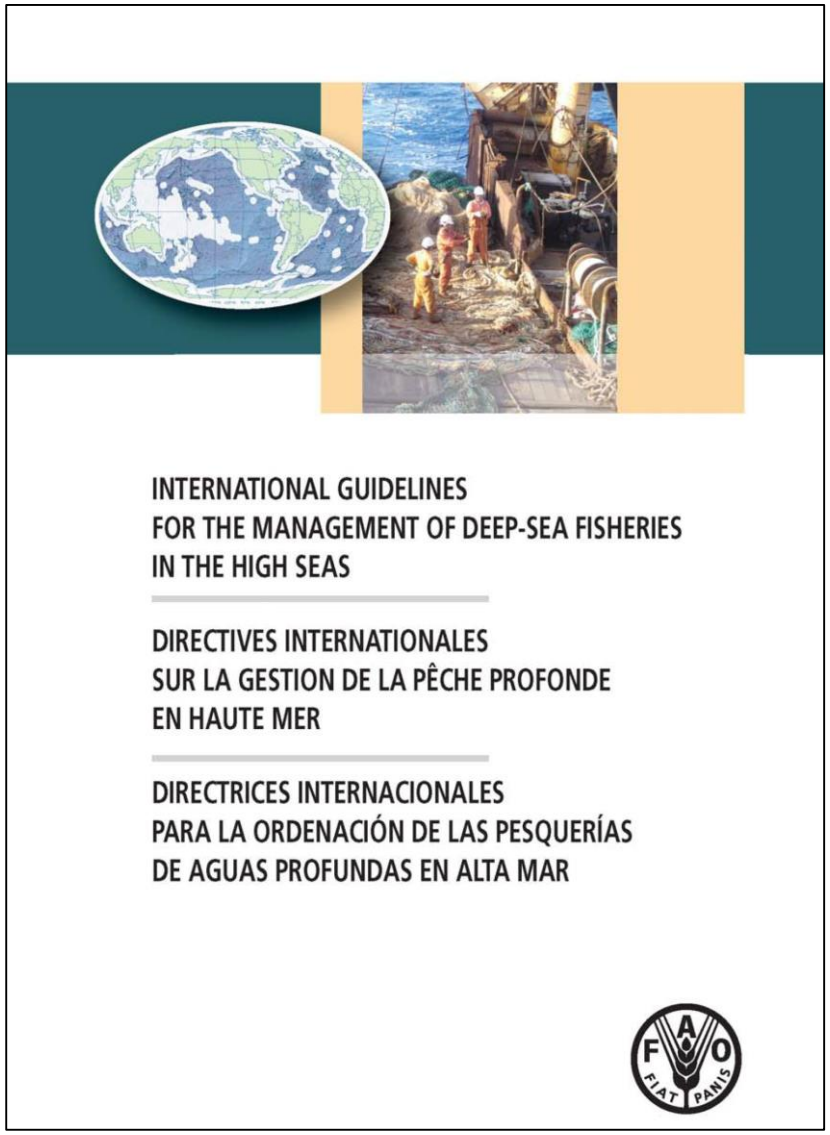
- FAO Guidelines
- NAFO
- SPRFMO
- Mapping VME issues
- Recent developments and future directions

Background

- Bottom trawling impacts seafloor habitats, communities and species
- UNGA passed resolutions to protect VMEs in 2006 and 2009
- RFMOs obliged to prevent SAI to VMEs
- FAO produces guidelines in 2009 to assist RFMOs

FAO Guidelines

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.



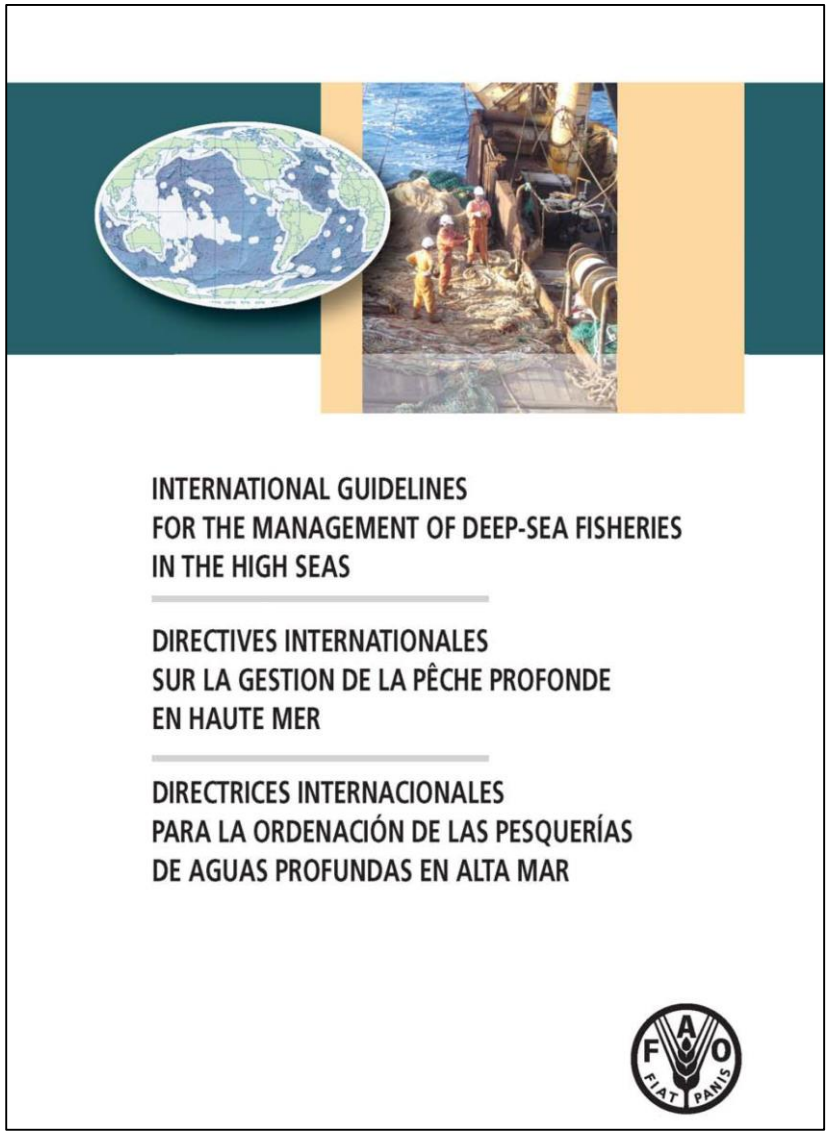
FAO Guidelines

12. **In order to achieve these objectives, States and RFMO/As should:**

…

ii. identify areas where VMEs are known or likely to occur;

…



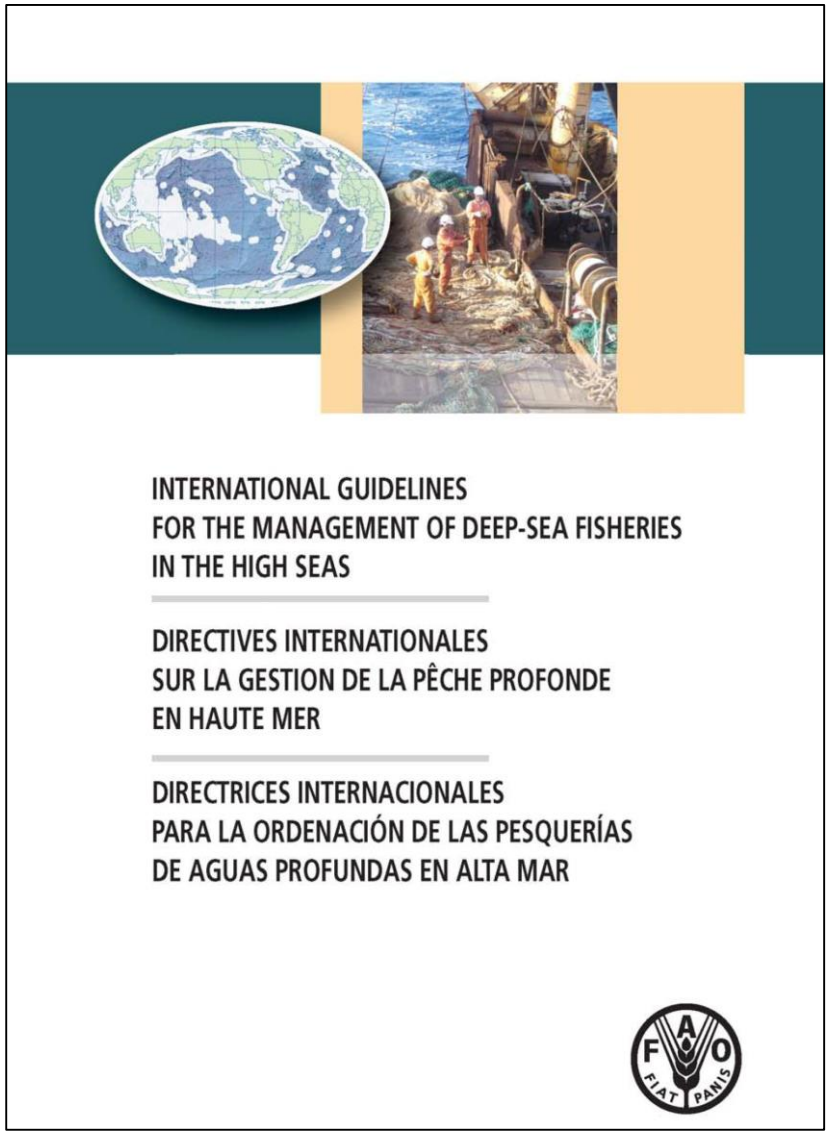
FAO Guidelines

47. Flag States and RFMO/As **should conduct assessments** to establish if deep-sea fishing activities are likely to produce significant adverse impacts in a given area. Such an impact assessment should address, *inter alia*:

…

iii. identification, description and mapping of VMEs known or likely to occur in the fishing
area;

…

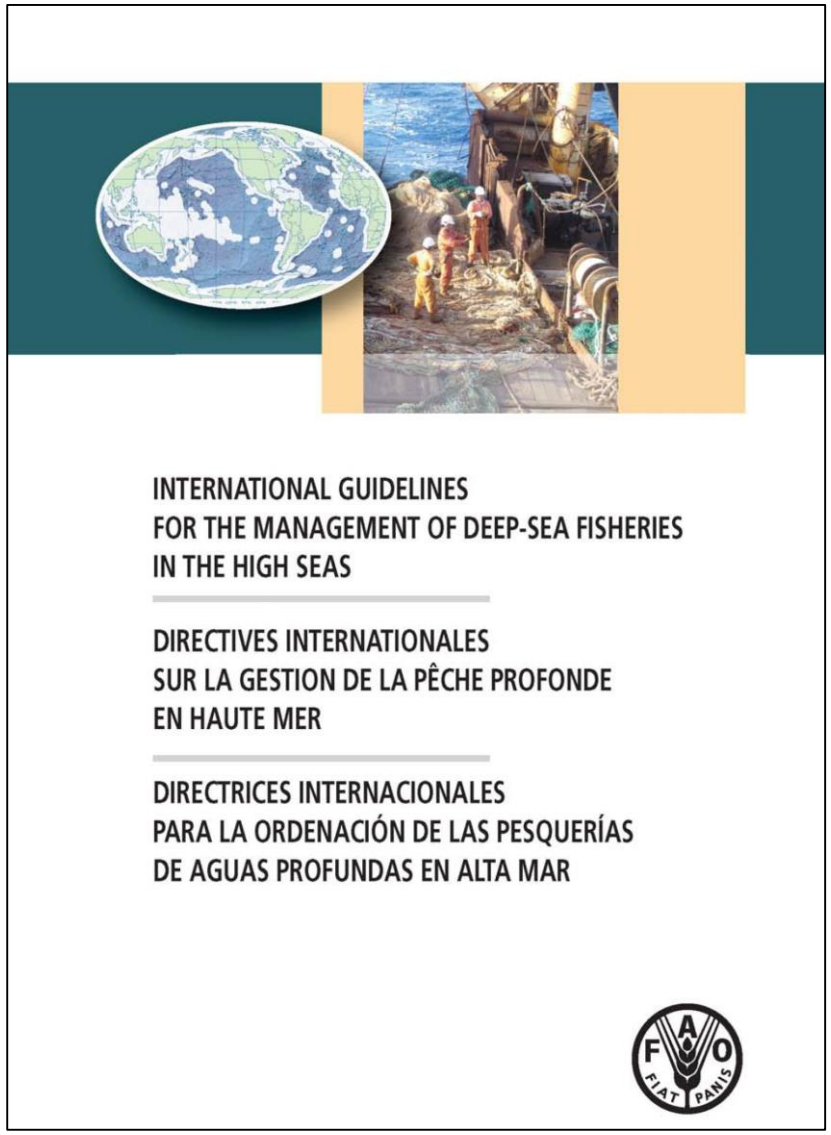


FAO Guidelines

32. Sufficiently fine-scaled data are required as a basis for the assessment of stock status and impacts on VMEs. In addition, fishery-independent research surveys are encouraged, in particular to provide relevant information on VMEs and how they are affected by anthropogenic activities.

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.



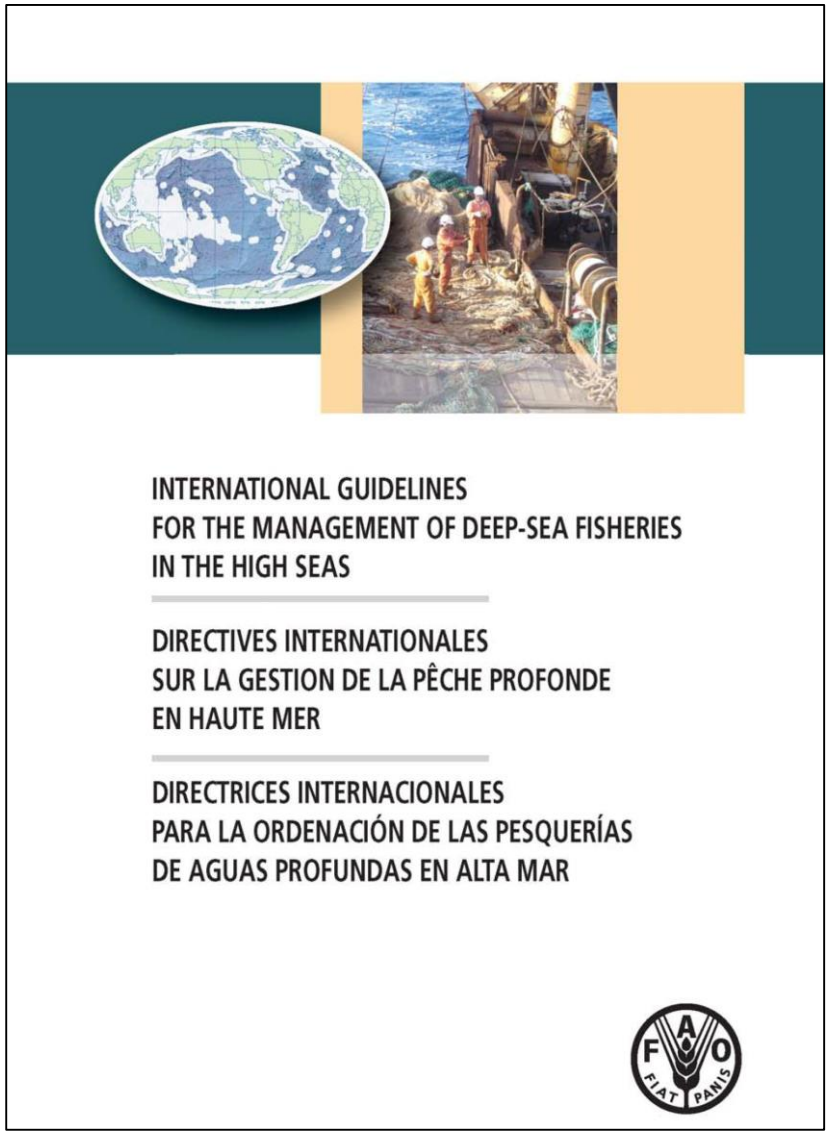
FAO Guidelines

To avoid SAI on VMEs, RFMOS should:

- Identify areas where VMEs are known or likely to occur

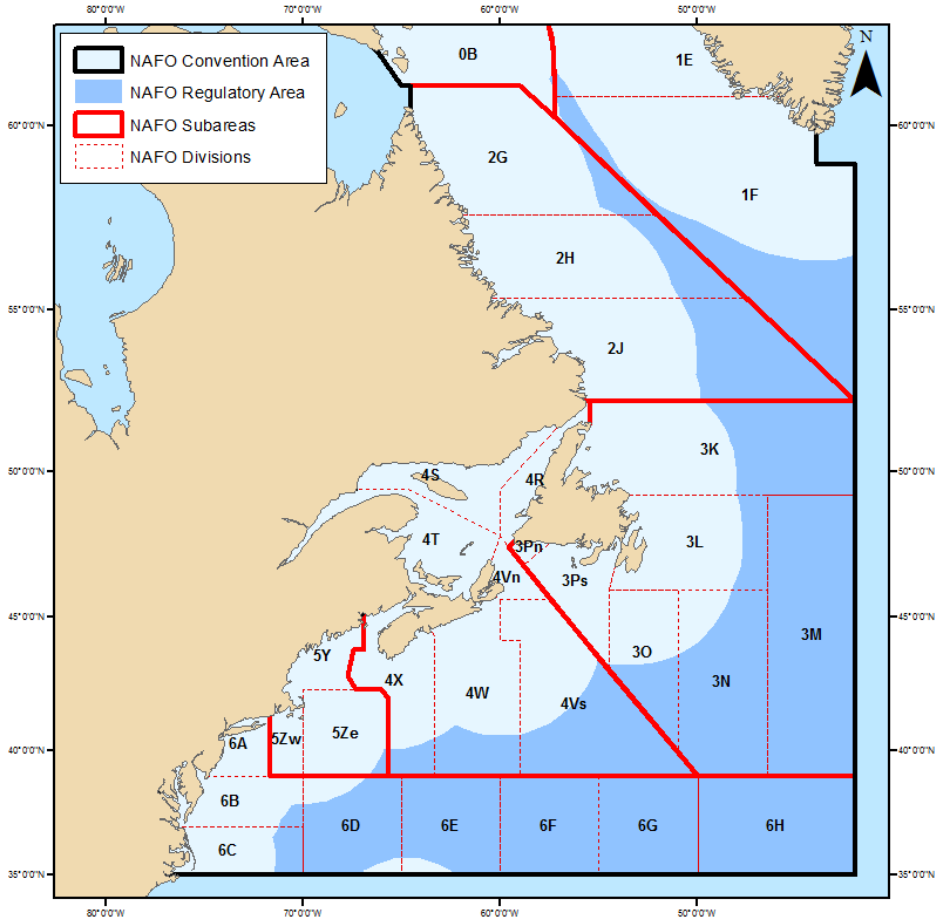
➢ Use data from stock assessment surveys, independent surveys, fisheries bycatch

➢ Infer distribution of VMEs where data lacking

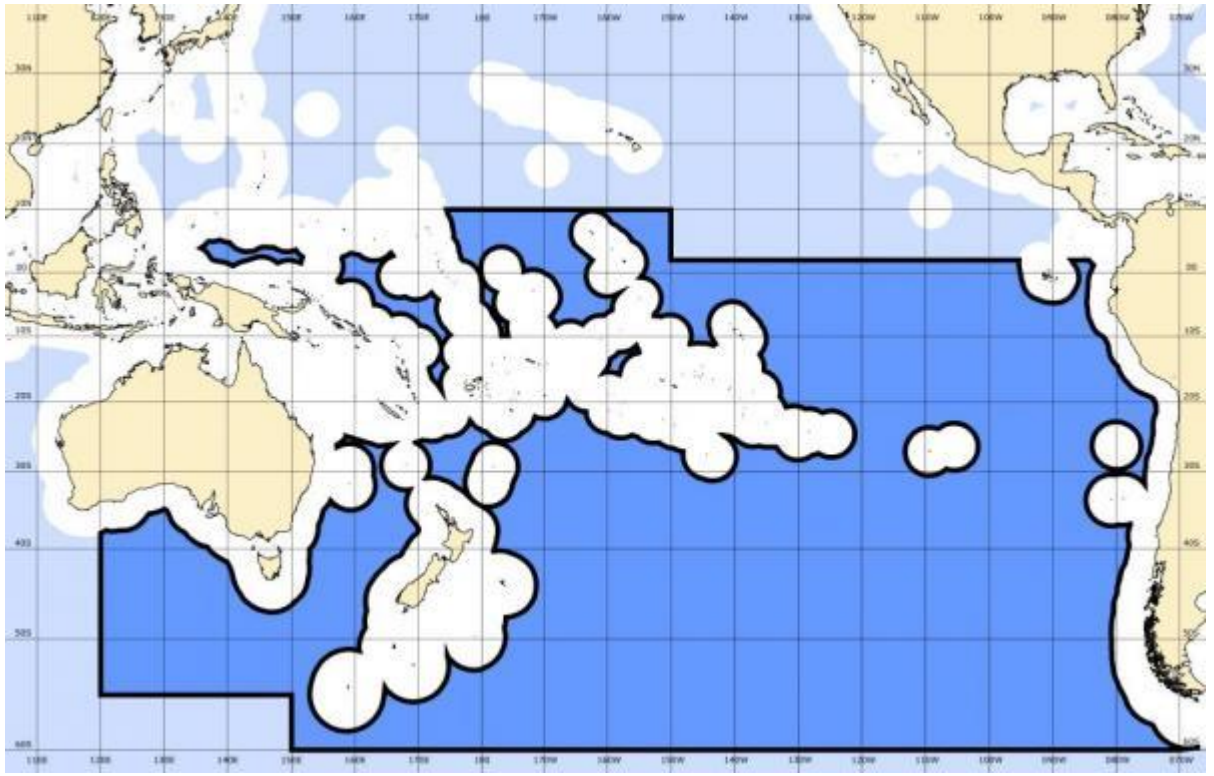


How do you identify areas where VMEs are known or likely to occur?

Examples from…



Northwest Atlantic Fisheries Organisation

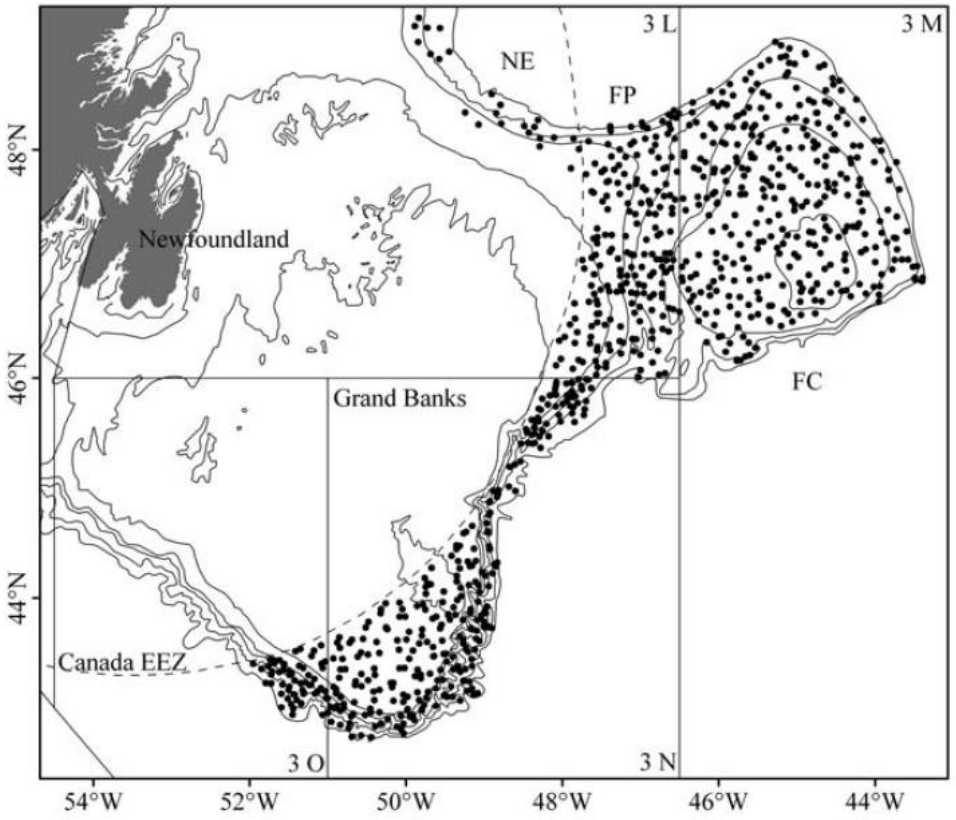


South Pacific Regional Fisheries Management Organisation

NAFO

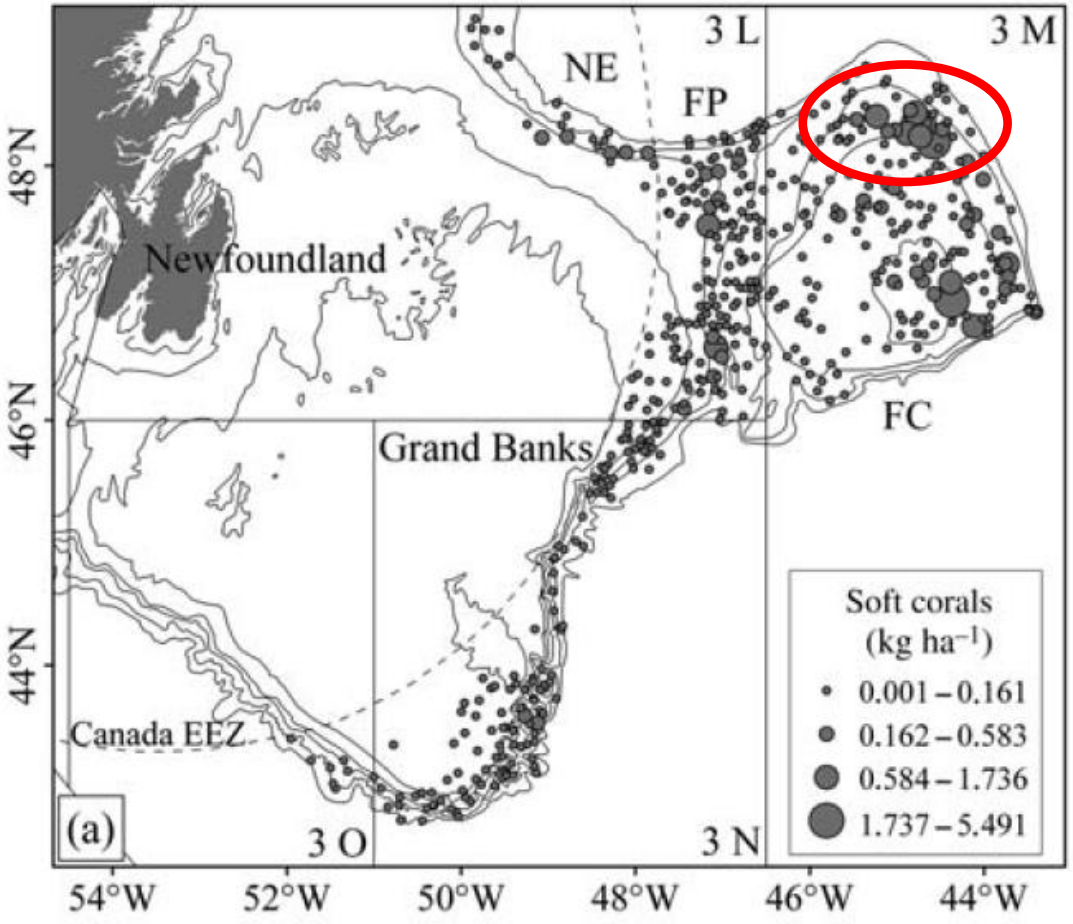
- **Biomass and species richness distribution** of VME indicator taxa
- **Kernel density** approach to identify concentrations of VME indicator taxa
- Canadian and Spanish/EU bycatch data for – sponges, corals, seapens

Sample locations

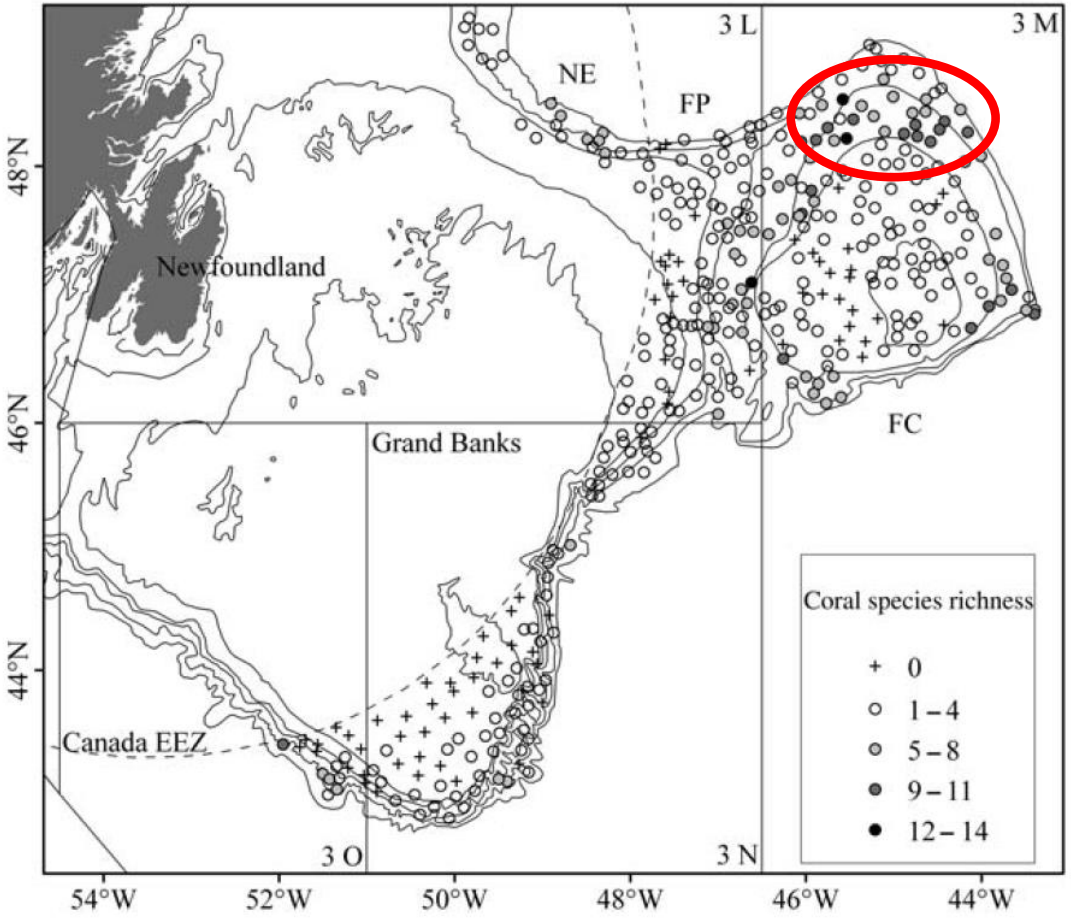


Murillo et al. (2011)

Biomass and species richness distribution



Biomass



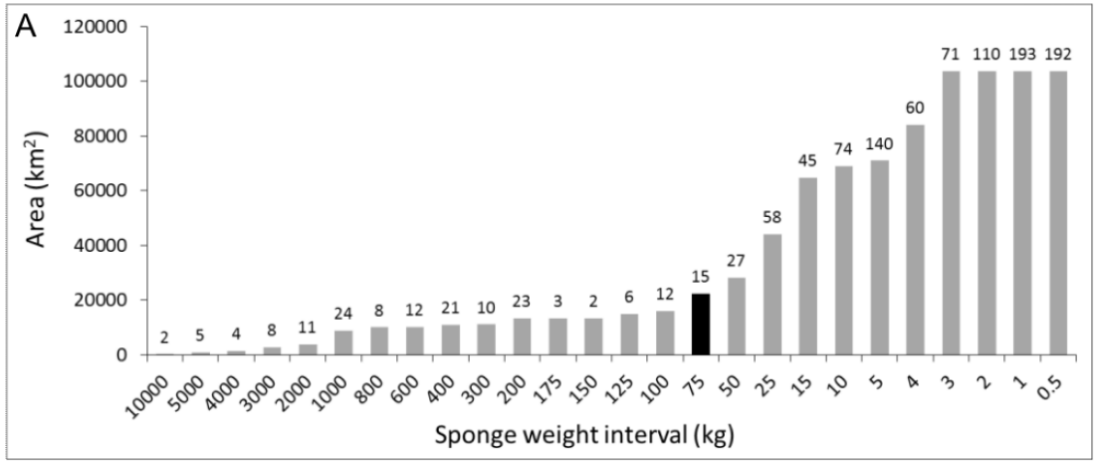
Species richness

Murillo et al. (2011)

Kernel density

- Identifies ‘hotspots’ based on a neighbourhood approach using a spatially-defined threshold

- Software used in GIS to automate production of the polygon surfaces for range of thresholds to identify most appropriate threshold of ‘natural’ concentrations

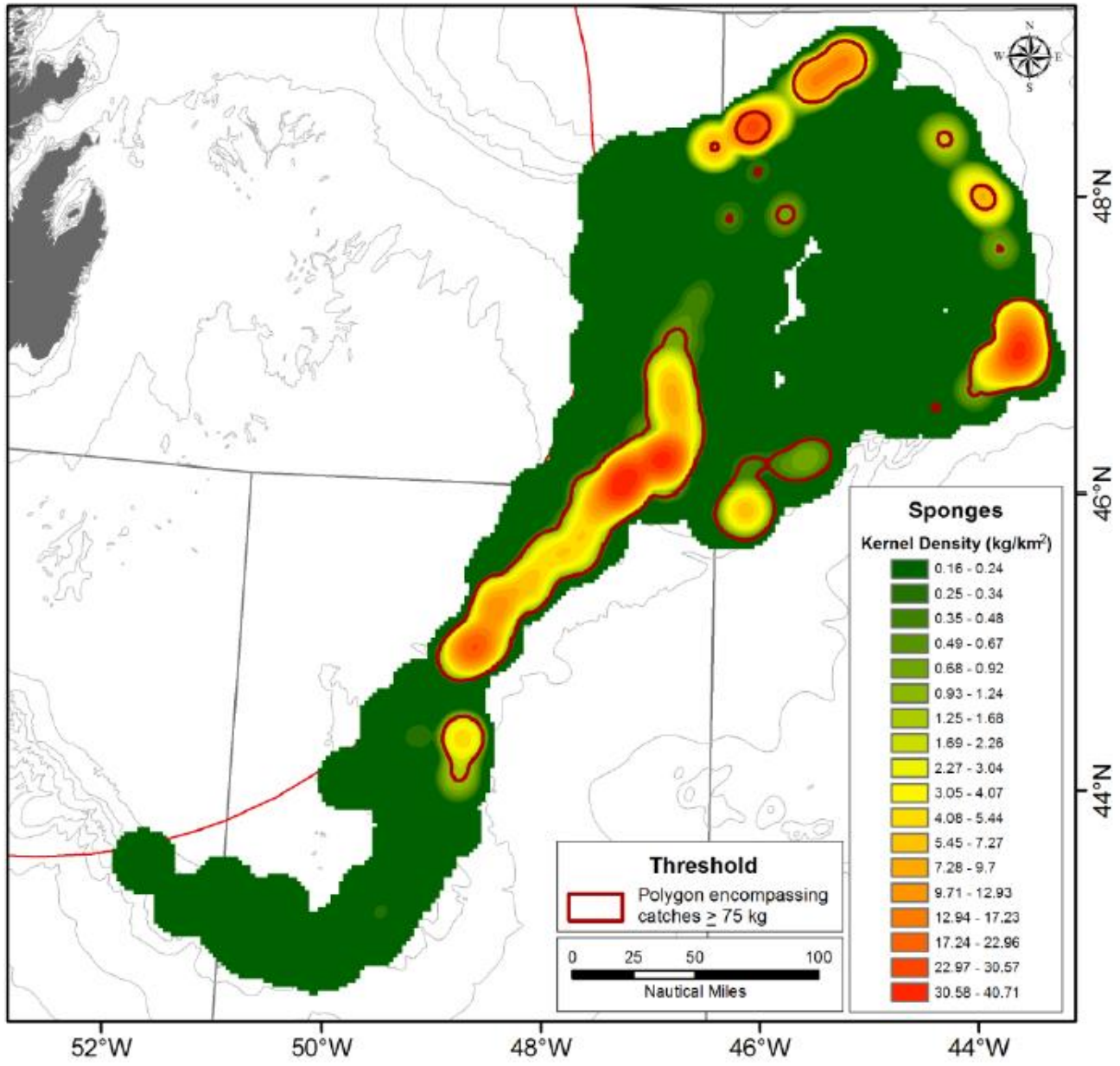


Kenchington et al. (2014)

Kernel density

- Kernel density map showing 75 kg threshold used to define VMEs and range of other biomass thresholds

- Cross-checked against other criteria and data

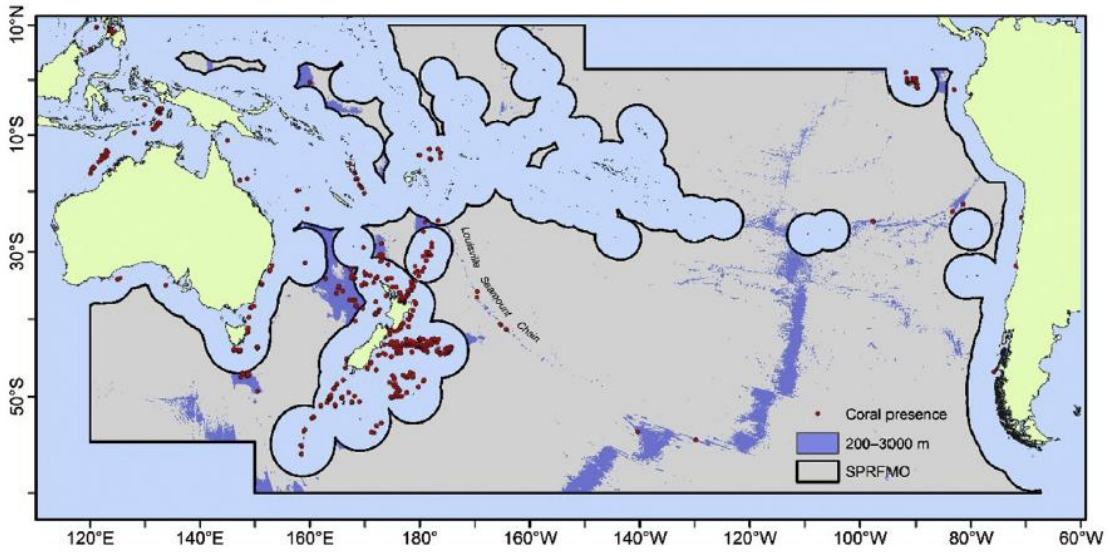


Kenchington et al. (2014)

SPRFMO

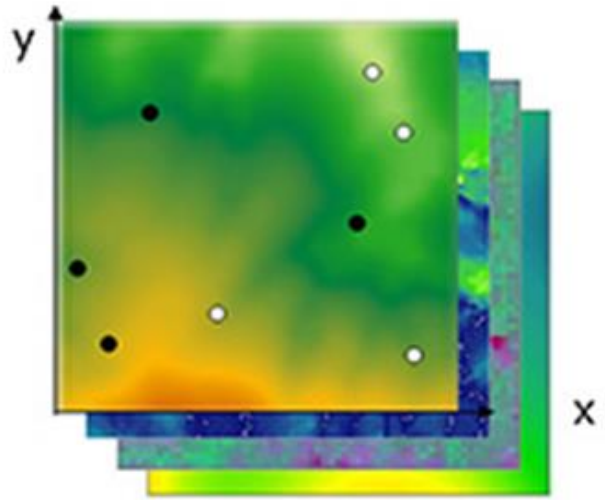
- **Habitat suitability modelling** of VME indicator taxa
- Trialled different scales of HSM
- Mostly NZ and Australian data for 10 VME indicator taxa, including corals, sponges etc

Corals



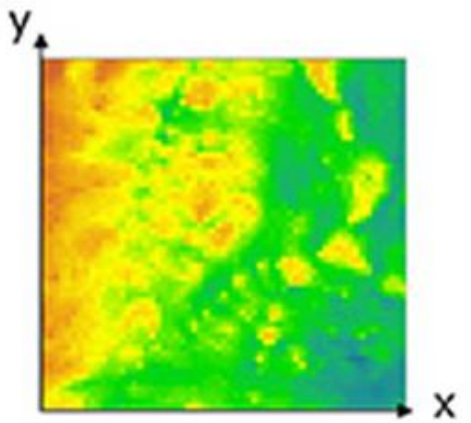
Anderson et al (2016a)

Habitat suitability modelling
(also known as Species Distribution Modelling)



Field records for species or community and maps of environment

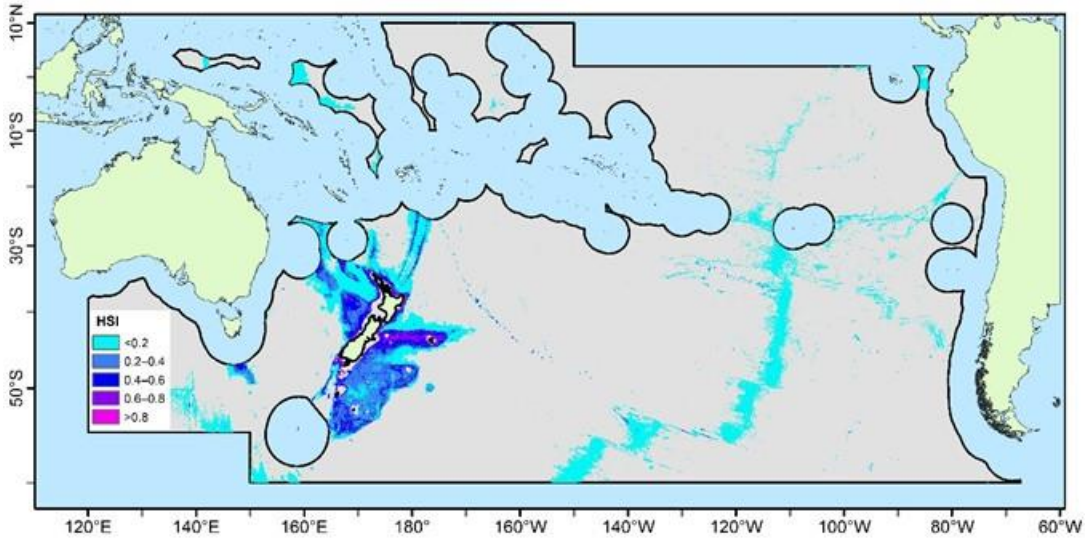
Statistical model
(including internal validation)

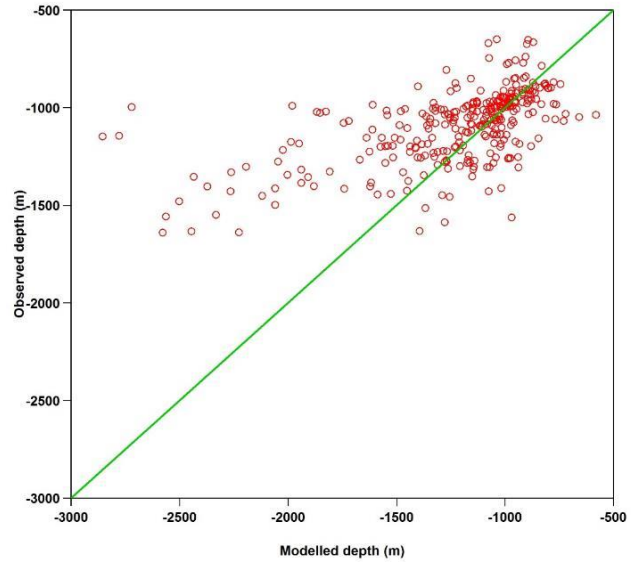


Map of probability that species or community is present

Habitat suitability modelling

- SPRFMO-scale models
- Ground truth validation revealed poor performance
- Mostly related to inaccurate global bathymetry

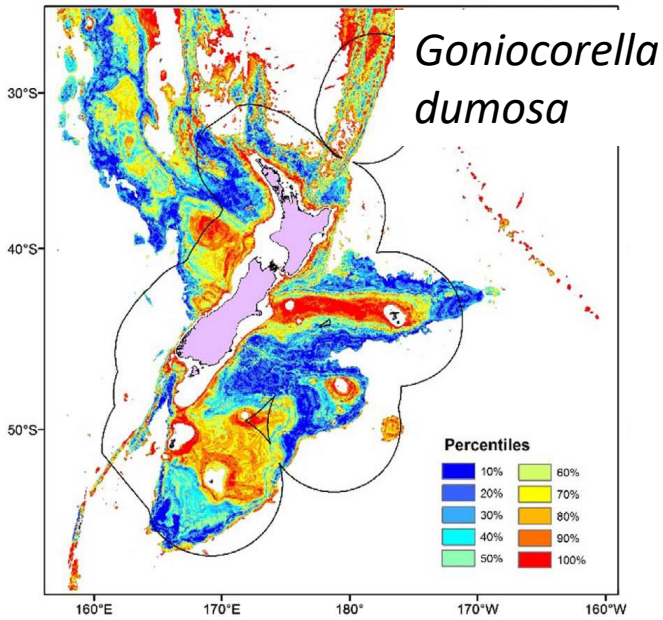


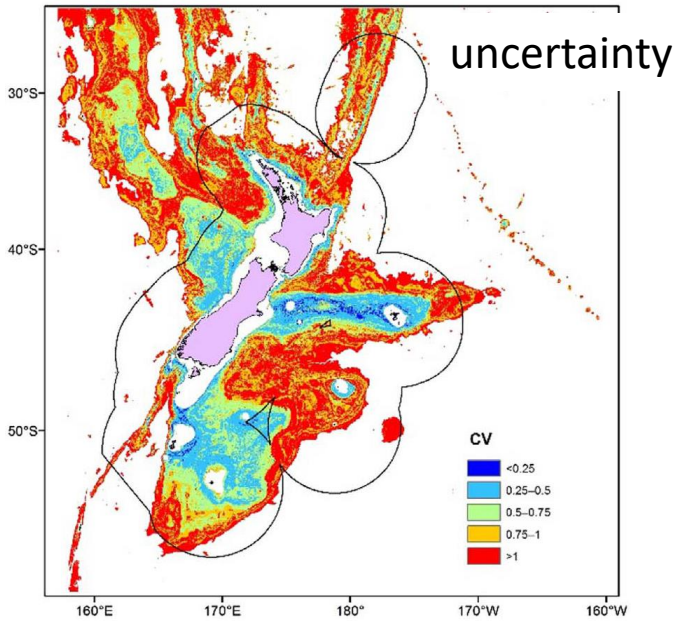


Anderson et al (2016a)

Habitat suitability modelling

- NZ-regional models
- Performed better (internal validation only) using regional bathymetry
- Mapped model uncertainty
- But map did not include all areas of interest

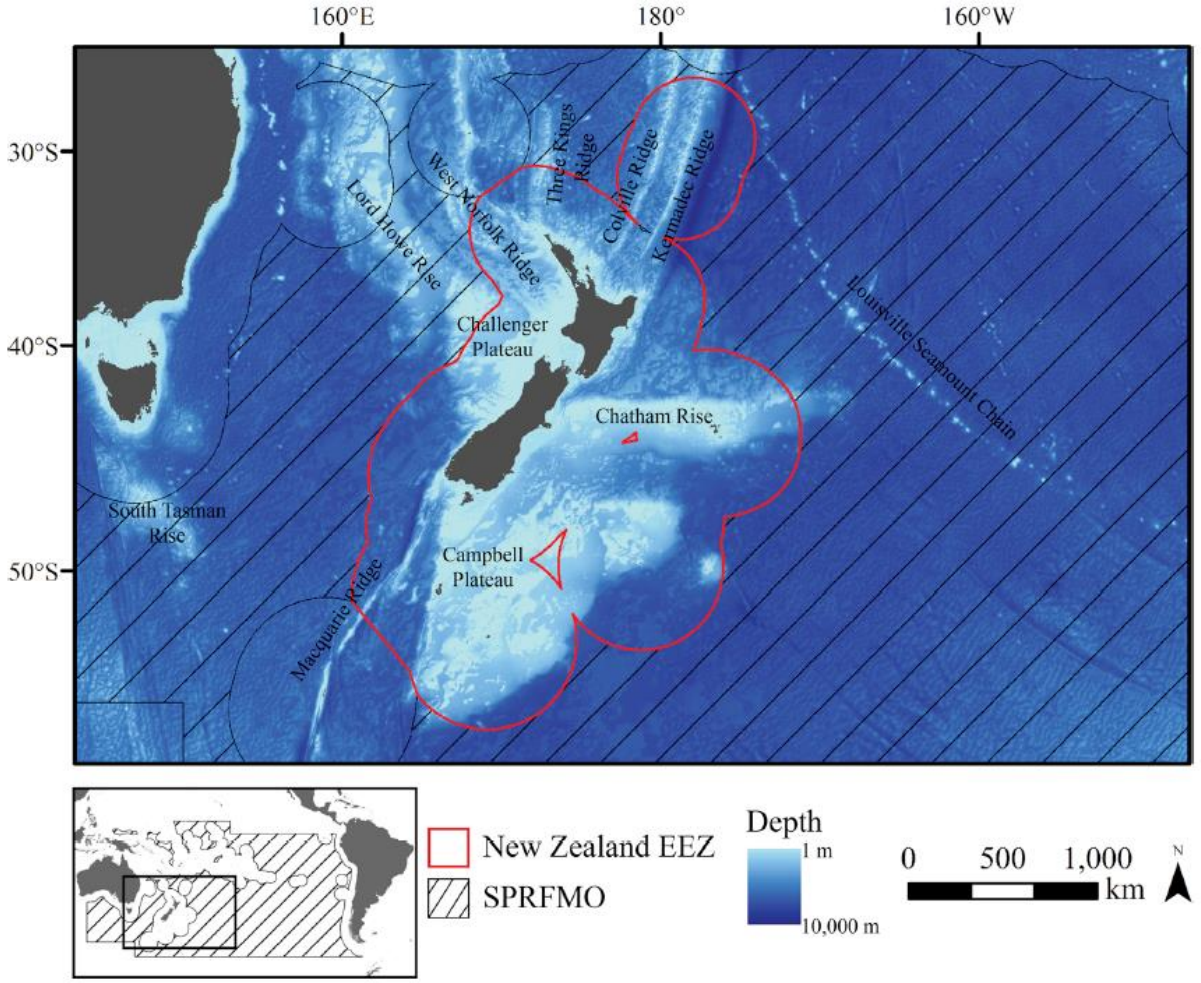




Anderson et al (2016b)

Habitat suitability modelling

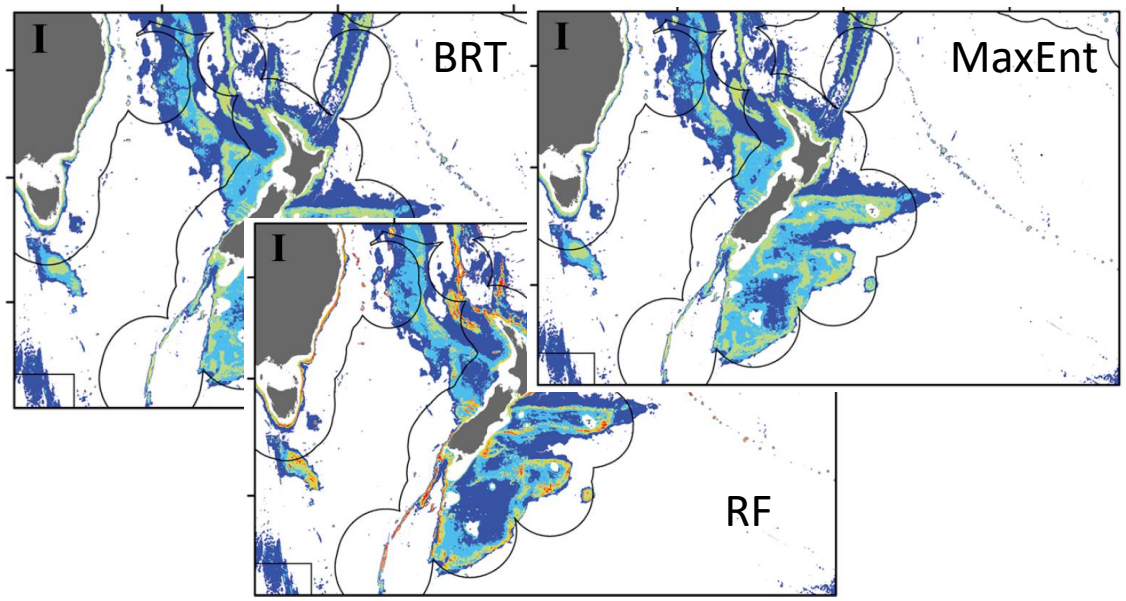
- SW Pacific-scale models
- Three types of models - RF, BRT, MaxEnt – for each VME indicator taxon
- Also mapped model uncertainty

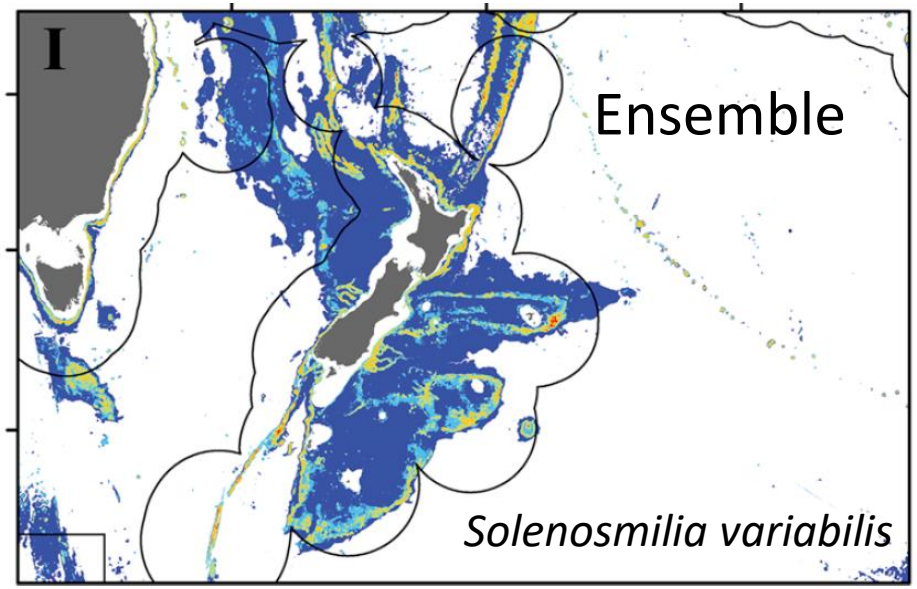


Georgian et al (2019)

Habitat suitability modelling

- Many different types of HSM models – which should you use?
- Ensemble approach combines models by averaging output weighted by individual model performance

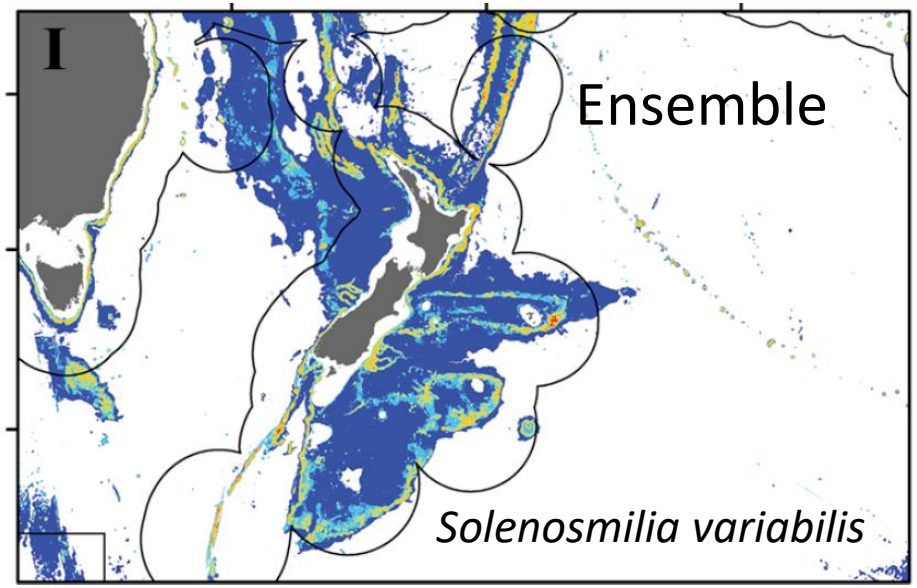


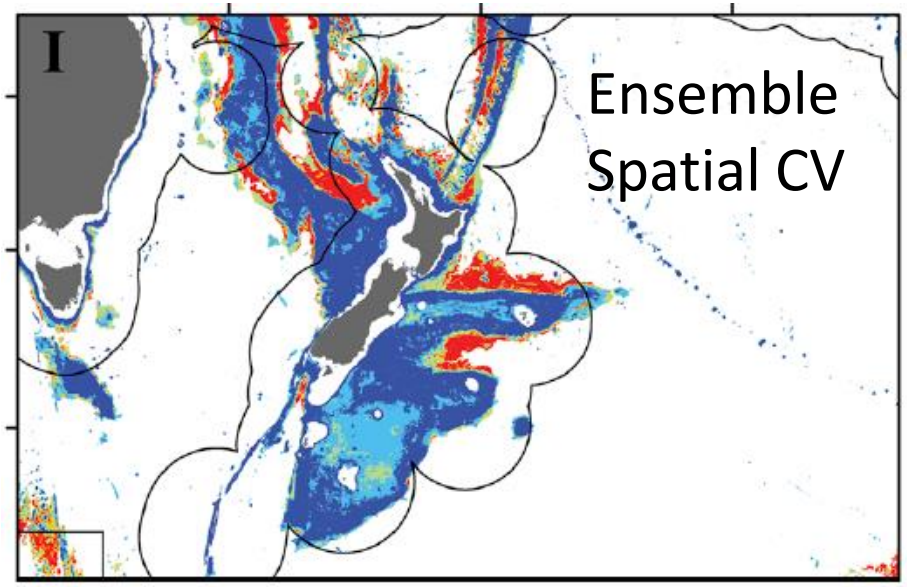


Georgian et al (2019)

Habitat suitability modelling

- Calculated CV (from bootstrapping) as metric of model uncertainty – projected spatially
- There are other ways to measure uncertainty
- Important to do





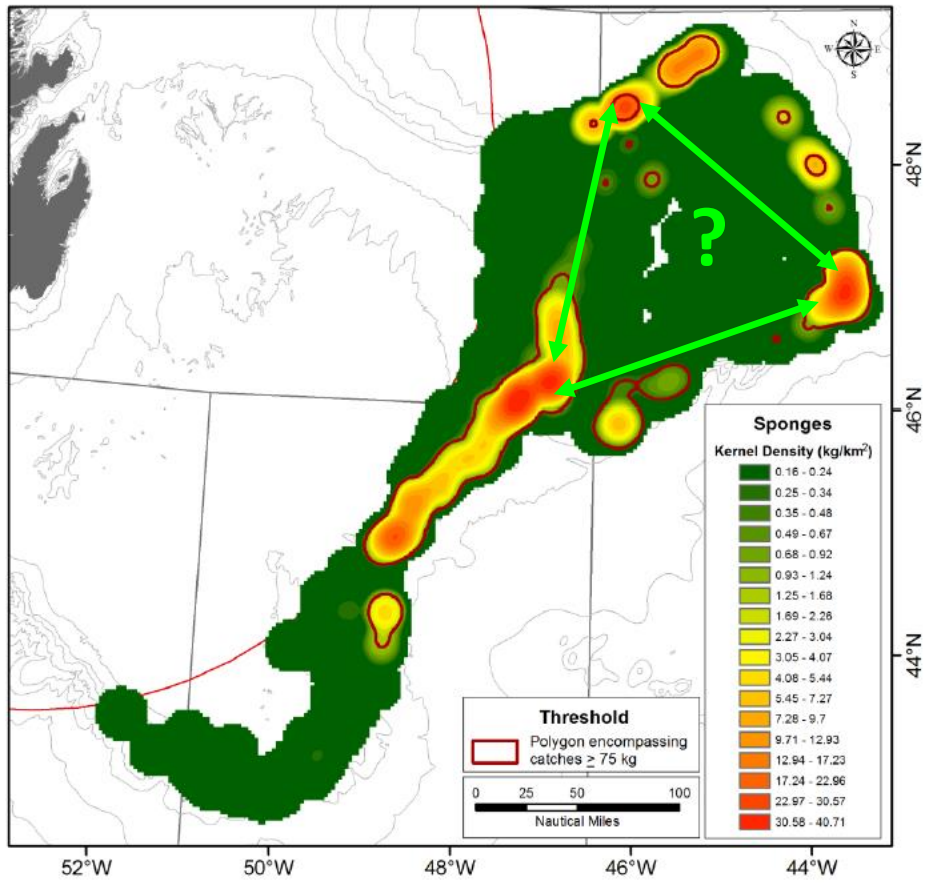
Georgian et al (2019)

“Essentially, all models are wrong, but some are useful.”

George Box

Mapping VME issues

- Are the mapped VMEs connected or isolated? – need to know the likely extent of connectivity among VMEs in different areas

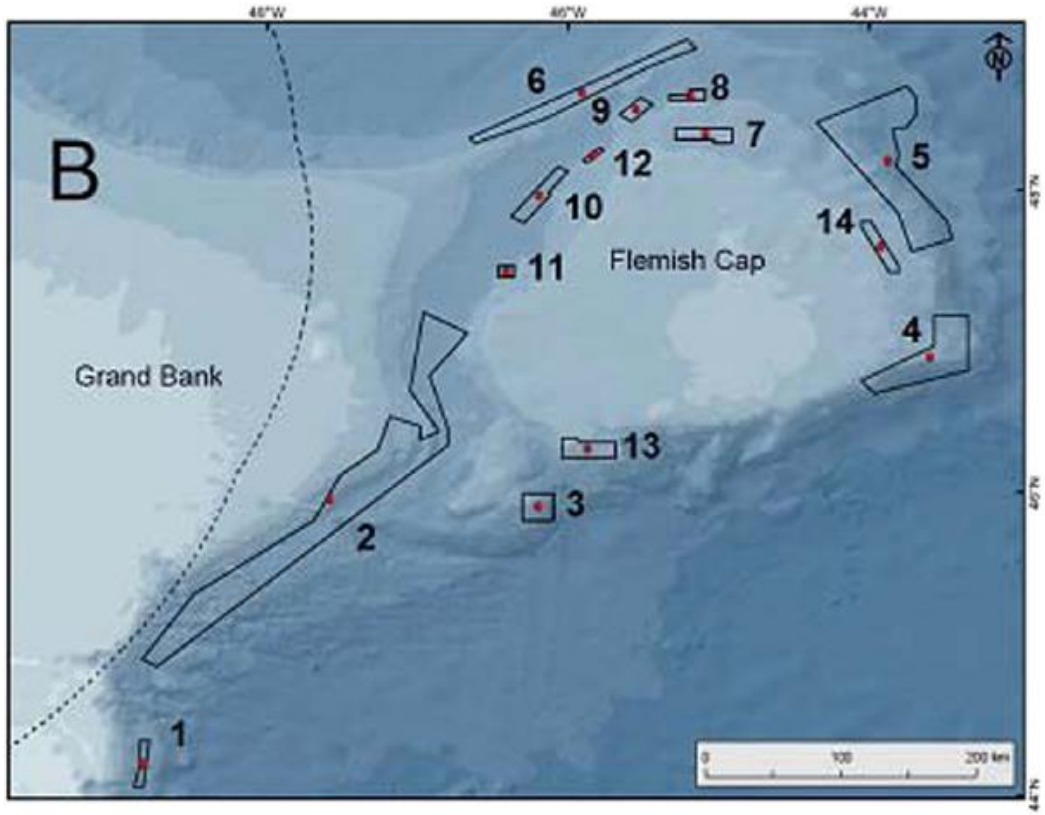


e.g., VMEs in some areas will be more or less important for providing recruits to sustain overall population in region, and recovery in disturbed areas – and thus more important to protect from trawling impacts

Recent developments and future directions

Determining VME connectivity

- NAFO area study
- Determine connectivity of VME indicator taxa among closed areas to assess their effectiveness

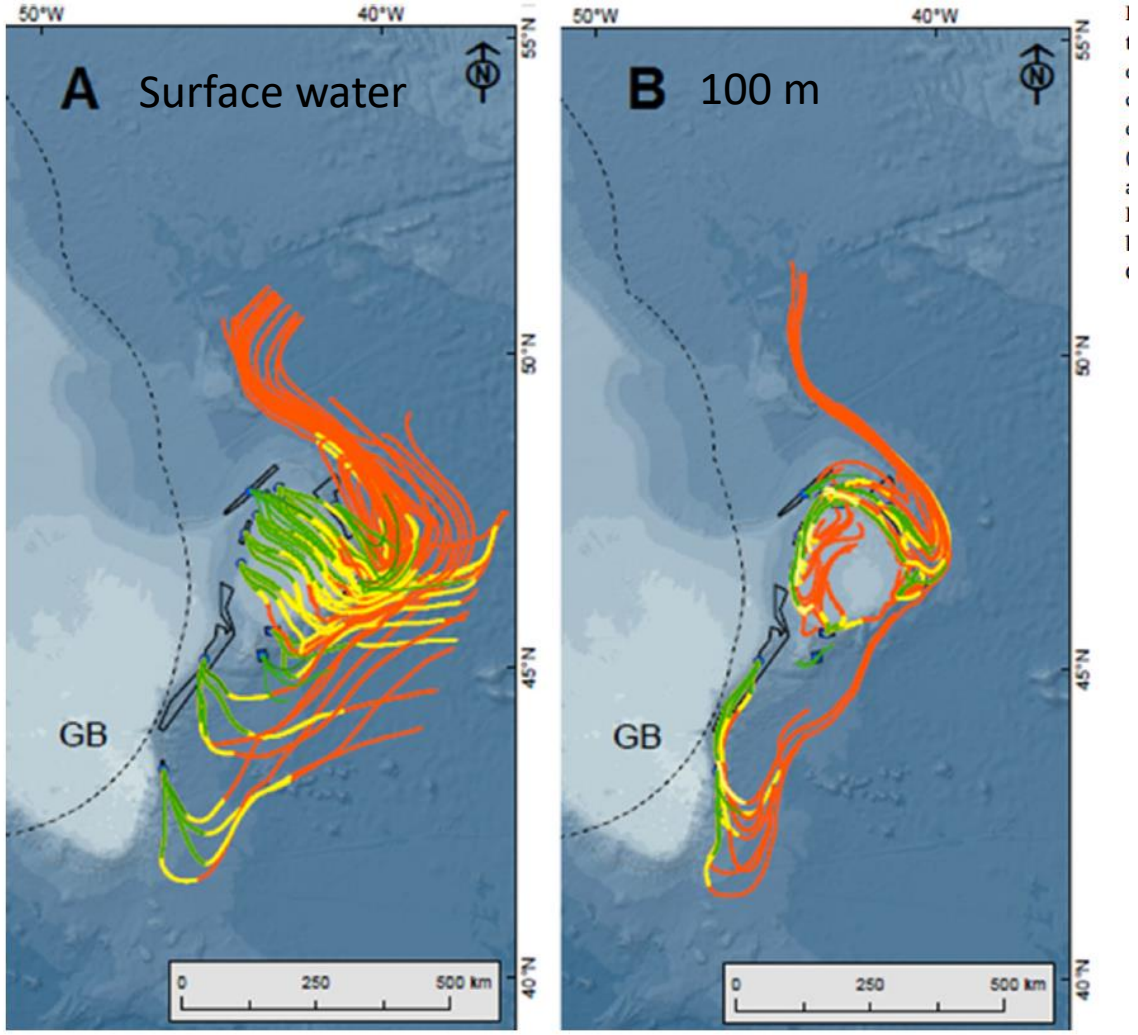


Kenchington et al. (2019)

Recent developments and future directions

Determining VME connectivity

- Biologically parametrised particle tracking models
- Determine spatial and temporal dispersal paths of theoretical larvae from closed areas



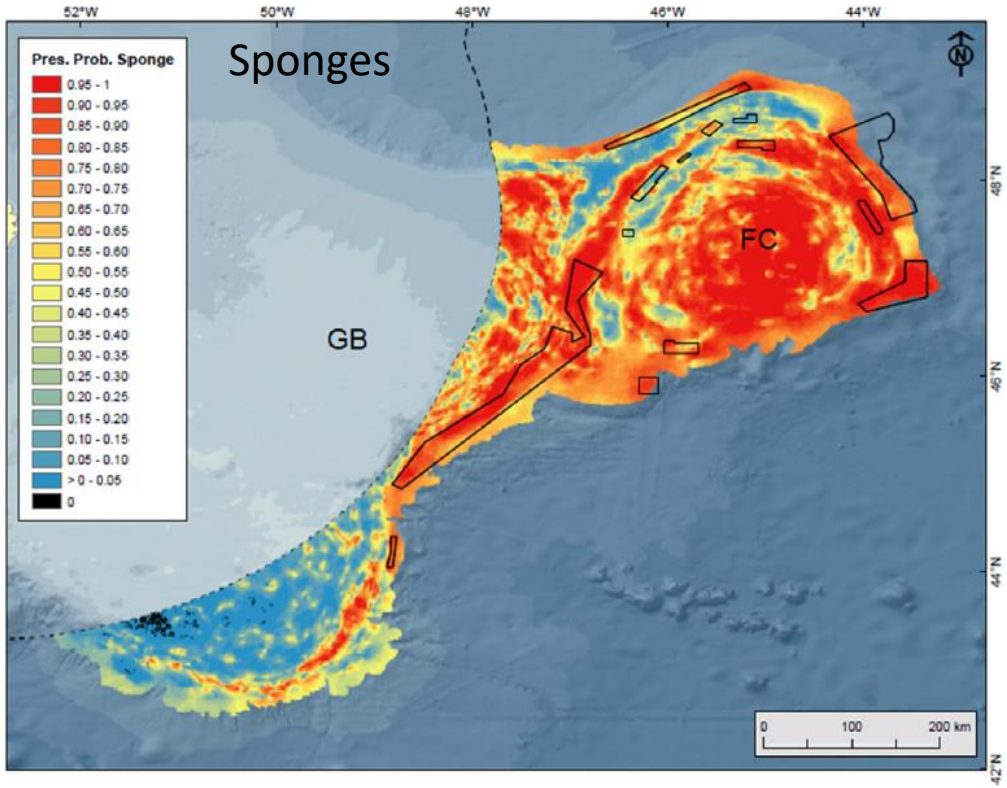
Kenchington et al. (2019)

Recent developments and future directions

Determining VME connectivity

- Hindcast dispersal models to assess the source of larvae for the the closed areas

- Potential source populations inferred from habitat suitability models



Kenchington et al. (2019)

Recent developments and future directions

Determining VME connectivity

- Dispersal models indicate a degree of connectivity among closed areas, with some areas being key suppliers of recruits
- Hindcasting indicates that some recruitment likely from VMEs outside of closed areas

Table 4
Drift trajectories from closed area centroids that end within or near initial closed area.

Drift depth	Drift duration	Season Spring	Summer	Autumn	Winter
Endpoint within closed area					
100 m	2 weeks	Areas 2, 3, 4, 13		Area 5	Area 4
100 m	1 month	Area 4			
100 m	3 months				Area 4
Endpoint within 2 km of closed area					
100 m	1 month	Area 13		Area 5	
100 m	3 months	Area 4			
Endpoint within 10 km of closed area					
100 m	2 weeks	Areas 5, 9	Areas 13, 11		Area 14
100 m	1 month		Area 2		Area 4

Kenchington et al. (2019)

Mapping VME issues

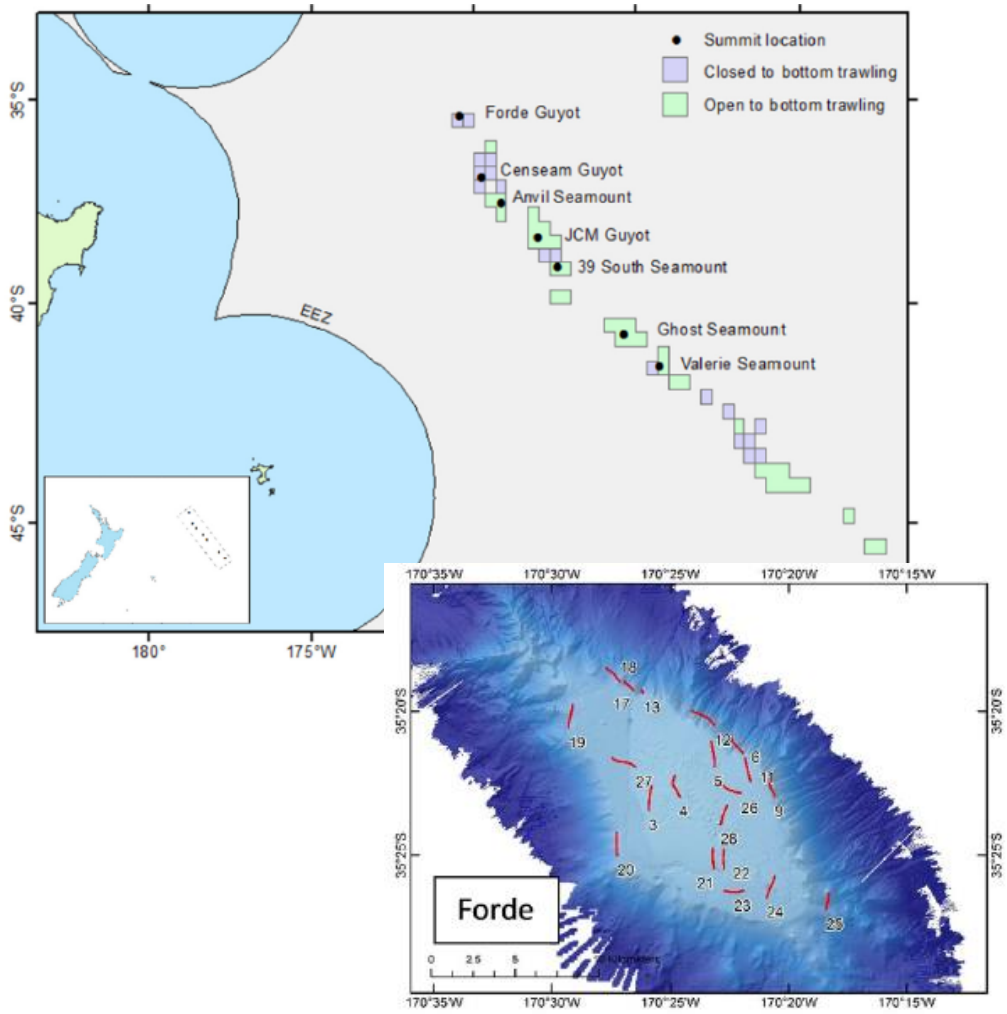
- Are we actually mapping VMEs? – need to identify abundance or biomass thresholds that relate to the FAO's VME functional criteria

e.g., structurally complex VMEs should be "created by significant concentrations of biotic and abiotic features", ***and*** that "such ecosystems often have high diversity, which is dependent on the structuring organisms"

Recent developments and future directions

Identifying thresholds

- Seamount-scale models
- 25 m resolution
- Based on image records and bathymetric variables derived from MBES data



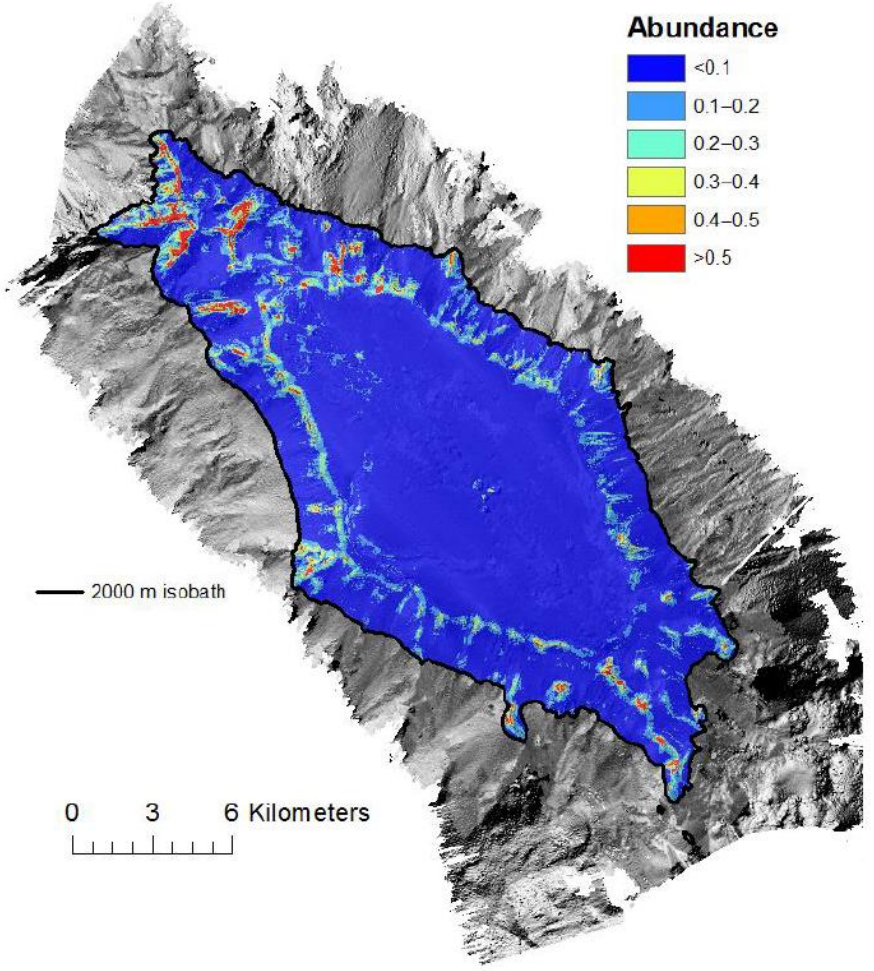
Rowden et al. (2017)

Recent developments and future directions

Identifying thresholds

- Ensemble P/A and abundance models
- Applied a subjective/expert density threshold to abundance models to identify coral reef VMEs

Solenosmilia variabilis

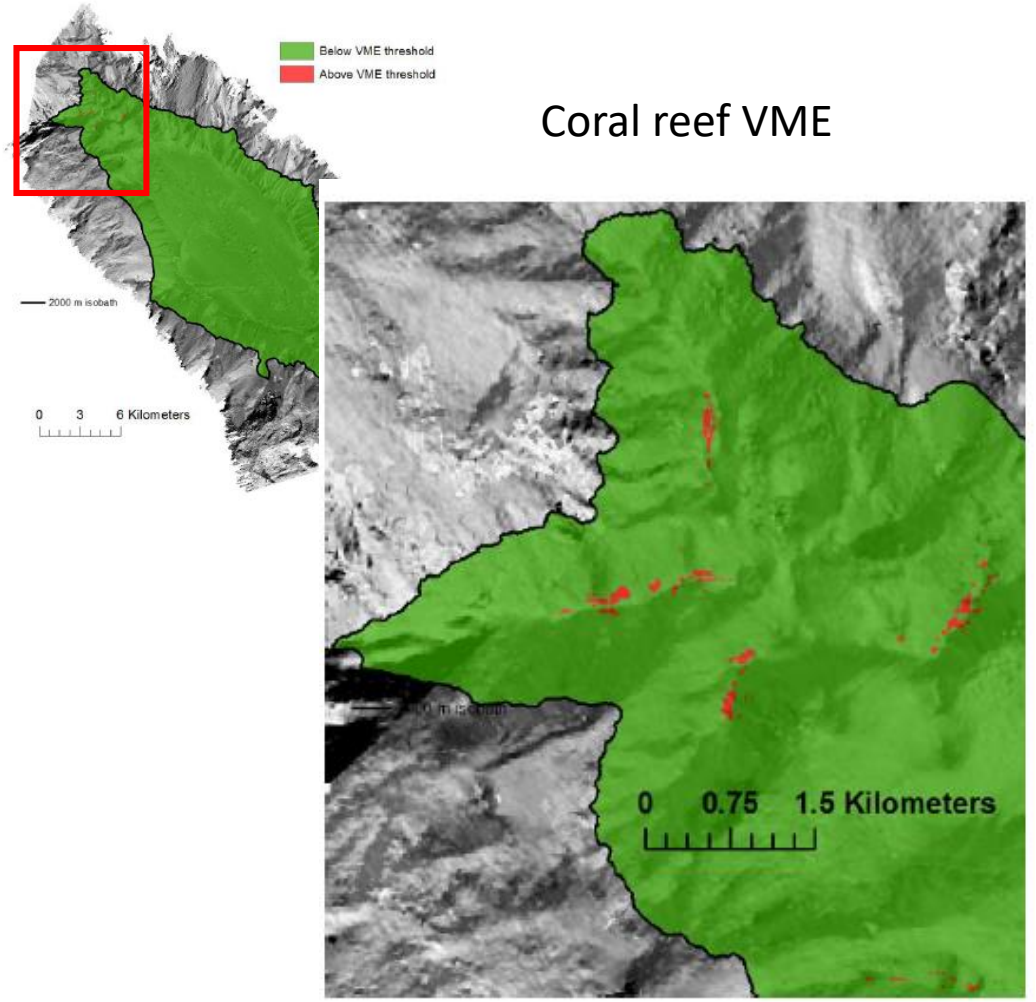


Rowden et al. (2017)

Recent developments and future directions

Identifying thresholds

- Application of threshold identifies only small areas of patch reefs
- But these VME maps depend on the veracity of threshold definition



Coral reef VME

Rowden et al. (2017)

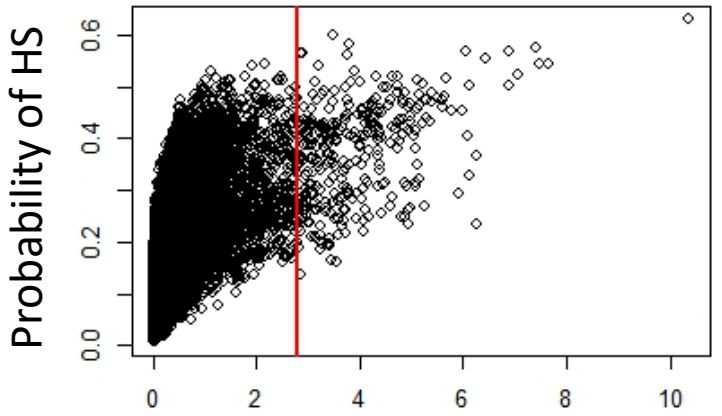
Recent developments and future directions

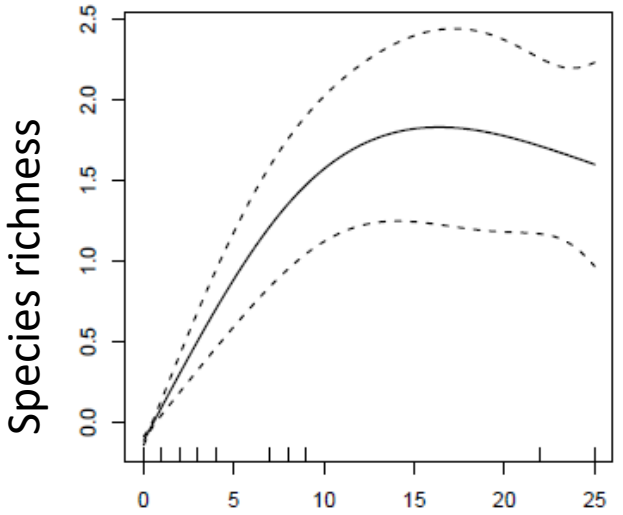
Identifying thresholds

- A later comparison of P/A and abundance models indicates that perhaps threshold is ok

- New work trying to establish link between abundance and function of VME (i.e. elevated biodiversity)

Modelled data for Forde



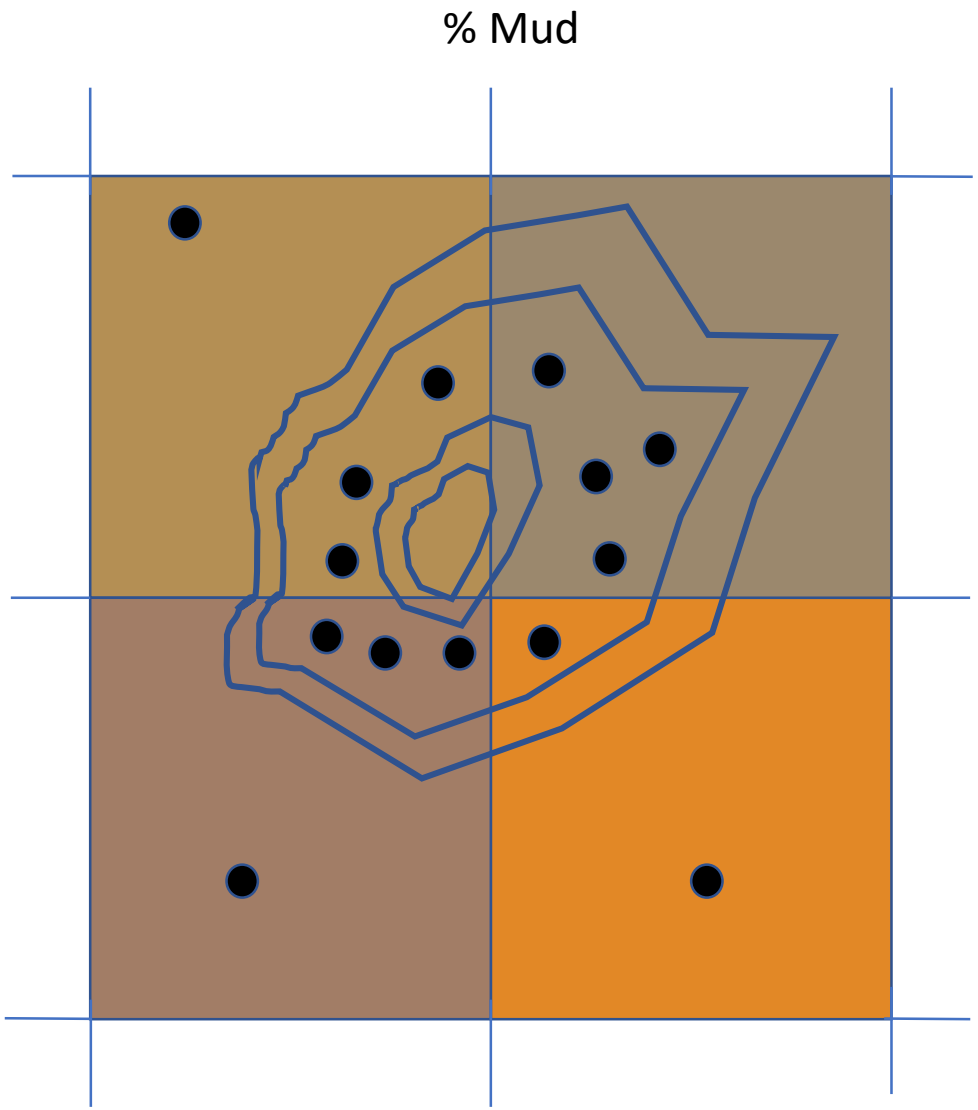


Rowden et al. (in prep.)

Recent developments and future directions

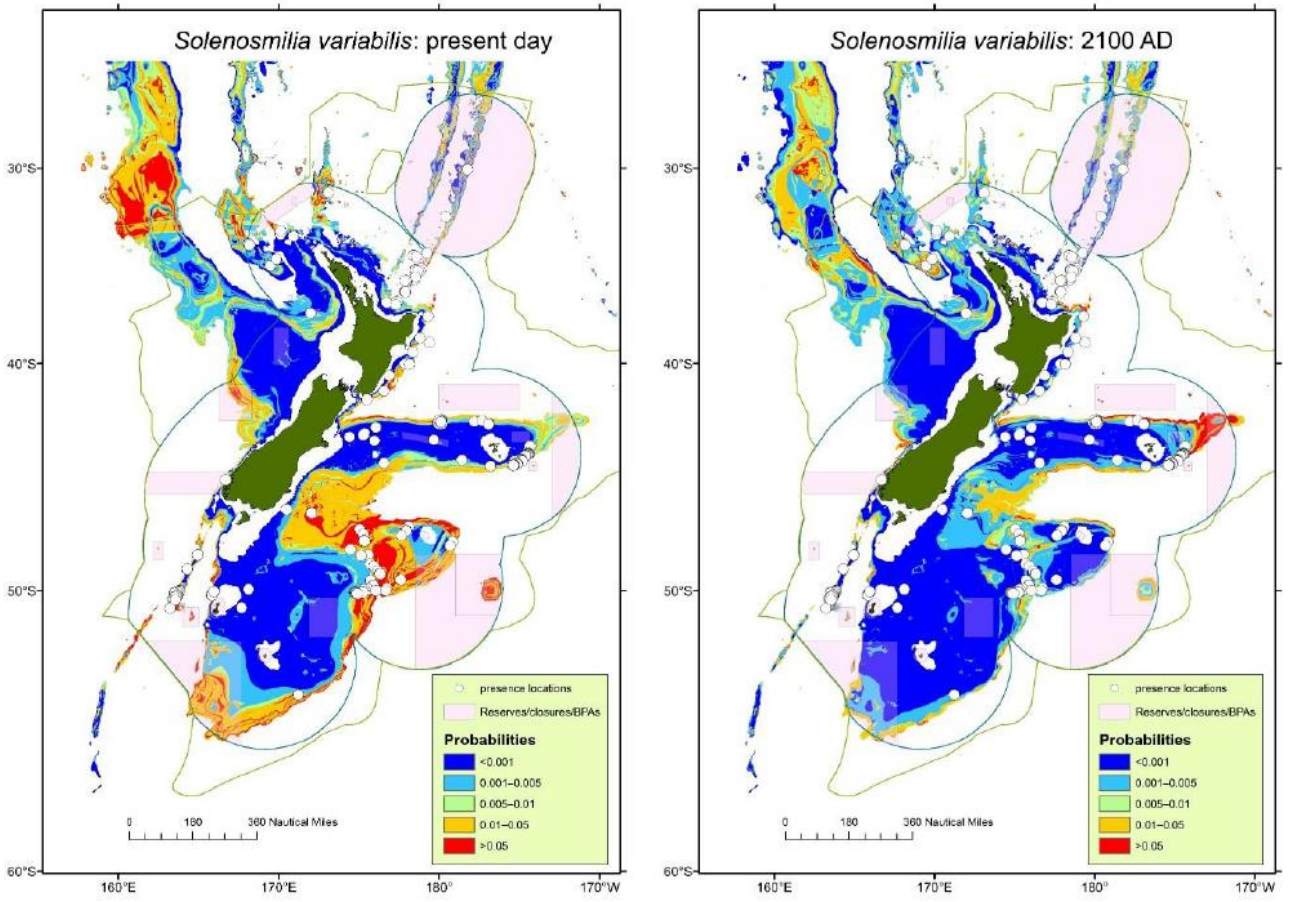
- Improve mismatch between scale of environmental predictors and biological records/response

- Incorporate uncertainty in environmental predictor variables in models



Recent developments and future directions

- Model and map recovery potential of VMEs
- Predict and map effect of future climate change on HS for VMEs



Anderson et al. (2015)

Thank you