Pilot ecological risk assessment for protected corals

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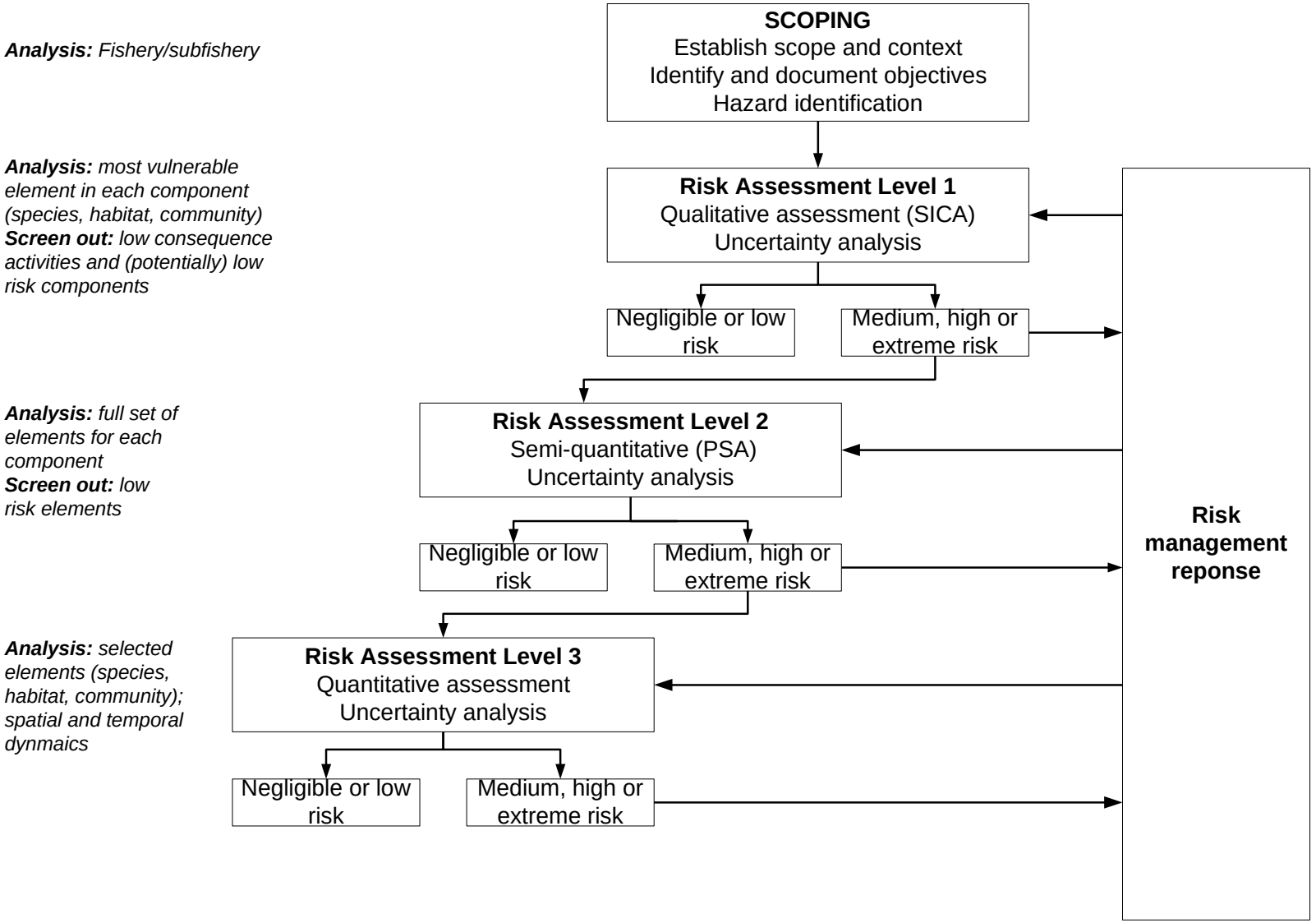
Objectives

- The project has two objectives:
  1) Produce models of protected coral distribution refined using the most recent data.
  2) Use refined predictive models to inform an assessment of their risk to commercial fishing gear.
- This study is an extension of the second objective, and carries out a preliminary ecological risk assessment (ERA) in order to:
  - Inform managers of the type of outputs a risk assessment may produce,
  - Identify where there might be major knowledge gaps that limit the ERA, and
  - Provide an indication of the relative vulnerability of different corals relevant for developing management options to reduce impacts from trawling.

Ecological risk assessment

- An assessment of the risk to something, from something
  - In this case, risk to protected coral species, from fishing
- Typically three levels of ERA
- Level 1: Qualitative
  - Expert panel
  - Screening procedure to identify high risk units
- Level 2: Semi-quantitative
  - Less reliance on subjective panel approaches
  - Relative risk rather than absolute
- Level 3: Quantitative
  - Operational modelling level (e.g., stock assessment model)
  - Absolute estimation of risk


Analysis: *Fishery/subfishery*
SCOPING
Establish scope and context
Identify and document objectives
Hazard identification
Analysis: *most vulnerable element in each component (species, habitat, community)*
Screen out: *low consequence activities and (potentially) low risk components*
Risk Assessment Level 1
Qualitative assessment (SICA)
Uncertainty analysis
Negligible or low risk
Medium, high or extreme risk
Analysis: *full set of elements for each component*
Screen out: *low risk elements*
Risk Assessment Level 2
Semi-quantitative (PSA)
Uncertainty analysis
Negligible or low risk
Medium, high or extreme risk
Analysis: *selected elements (species, habitat, community); spatial and temporal dynmaics*
Risk Assessment Level 3
Quantitative assessment
Uncertainty analysis
Negligible or low risk
Medium, high or extreme risk
Risk management reponse

Various approaches and methodologies

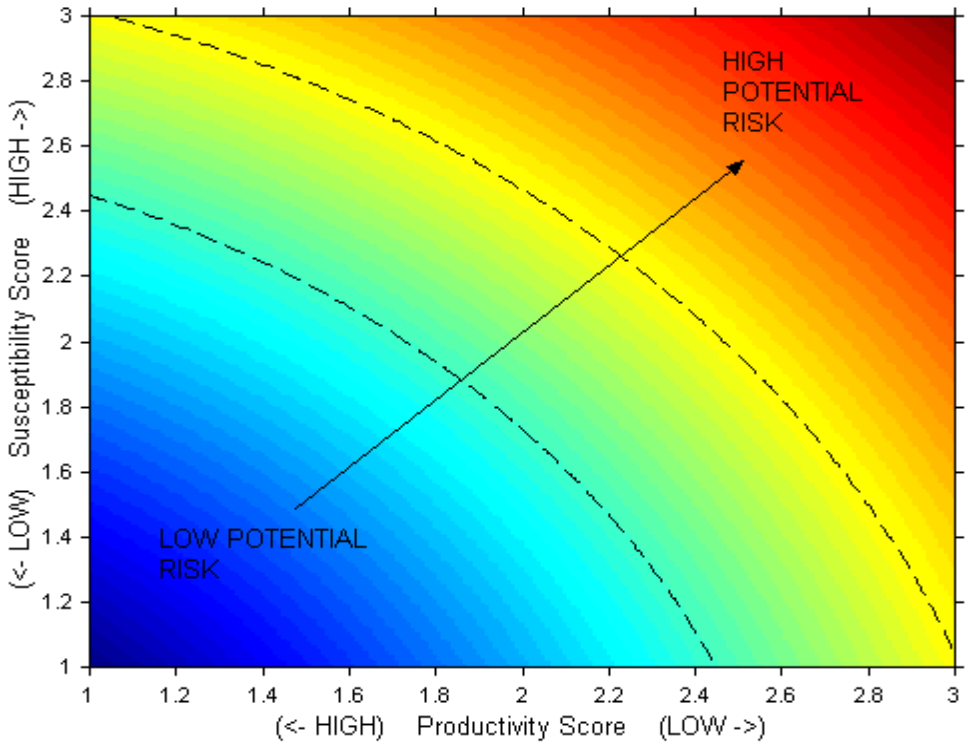
- Likelihood-Consequence methods (level 1)
  - Hoki level 1 assessment (2003, 2010)
  - Deepwater fisheries (2007)
  - Seabed minerals mining operations (2011)
- Scale-Intensity-Consequence-Analyses
  - Level 1 shark assessment (2014)
- Productivity-Susceptibility-Analyses (Level 2)
  - Seamount habitat (2010)
  - Deep-sea corals (2014)
- ERAEF variable level (NZ FERA 2012)
- Production-Biomass-Ratio methods (Level 2)
  - Seabirds (2009)
  - Marine mammals (2011)
- Spatially explicit approach (Level 2)
  - Fisheries bycatch species (2014-15)
  - Benthic species and habitats (2015)

ERAEF as an example method

- Ecological Risk Assessment for the Effects of Fishing
- A three-stage analysis that rates fishing activities for their effects on five ecological components of the ecosystem:
  - Target species
  - By-product and bycatch (non target) species
  - Threatened, endangered, and protected species
  - Habitats
  - Ecological communities
- Examines extent of impact due to fishing, determined by:
  - Susceptibility of the species to the activity
  - Productivity of the species which affects their potential recovery

PSA plot

- High susceptibility and low productivity = high risk
- Low susceptibility and high productivity = low risk



The Pilot ERA for Protected Corals

- Region of focus
  - Chatham Rise (effectively ORH 3B out to edge of EEZ)
  - Down to 1500 m depth
- Fishery
  - Orange roughy trawl fishery (bottom trawl)
- Coral species
  - 15 coral species or groupings
  - Representative of the range of coral types in the EEZ
  - Span a range of different characteristics
    - Reef-like (stony corals e.g., *Solenosmilia variabilis*),
    - tree-like (e.g., black corals, bubblegum corals),
    - whip-like (e.g., golden coral),
    - solitary small (e.g., stylasterids)
- Method
  - PSA level 2
  - Use of “Habitat” attributes rather than ETP or Bycatch

Availability

- Overlap of region with a species distribution
- Compare distribution and depth of coral species throughout New Zealand with that on the Chatham Rise

	Aspect	Concept and Rationale		Ranks	
	Attribute (s)		1 (low risk)	2 (medium)	3 (high risk)
	Availability				
A1	Spatial overlap (geographical and depth range)	Spatial overlap of the general geographic area with the geographical and depth range of the coral taxon.	Very little overlap (<10% of its distribution in NZ is located in the region of focus)	Partial overlap (10-50%)with its distribution range around NZ	Considerable overlap (>50%) with species distribution (e.g., Chatham Rise endemic)

Encounterability

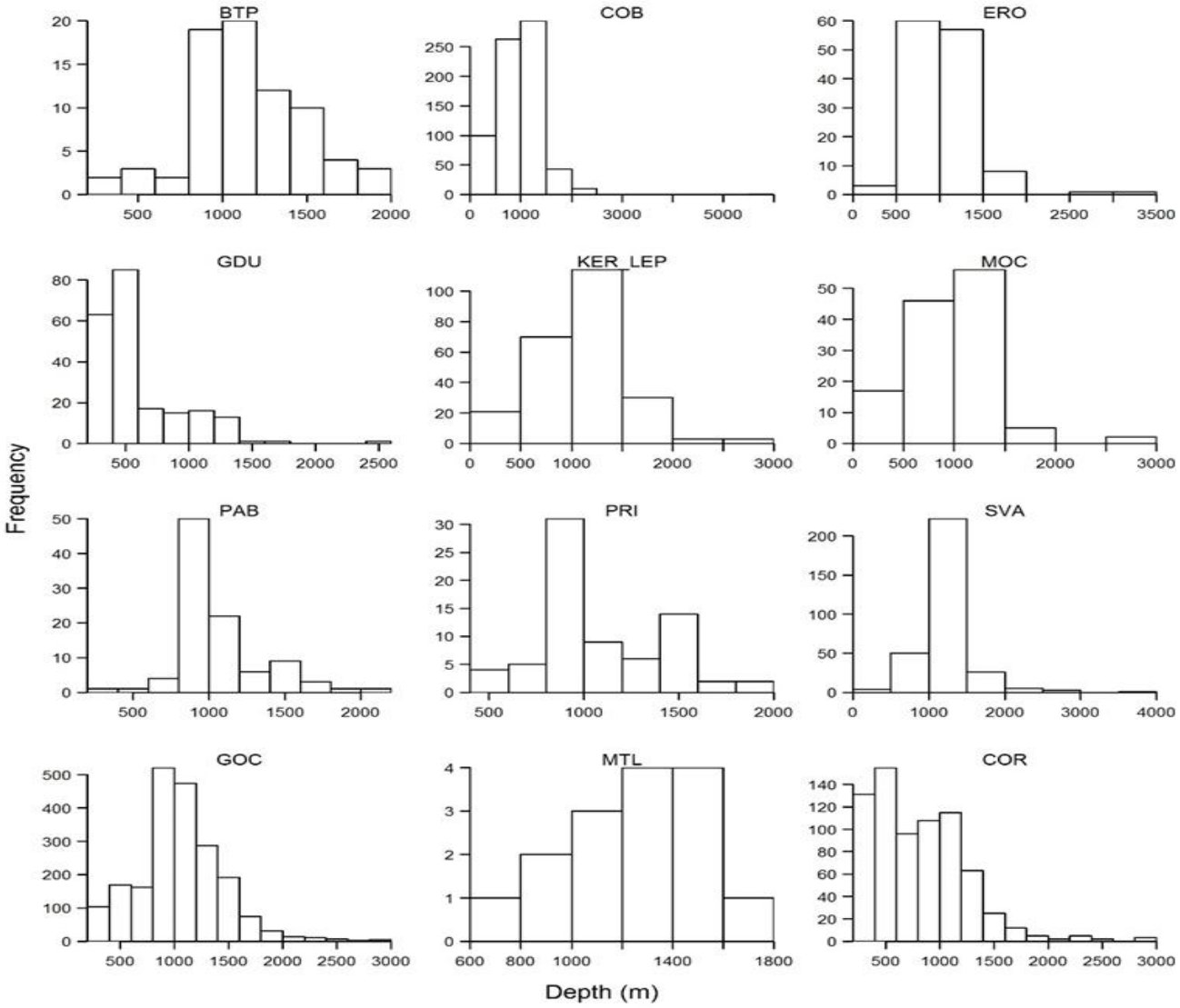
- likelihood that fishing gear deployed within the region of focus will encounter a given taxon (based on adult habitat and depth range)

	Aspect	Concept and Rationale		Ranks	
	Attribute (s)		1 (low risk)	2 (medium)	3 (high risk)
	Encounterability				
E1	Depth zone	The depth distribution of the coral species relative to the depth at which fishing activity occurs	Depth overlap <10% (generally <500 m or > 1200 m)	Depth overlap 10-50% (generally 500-800 m)	Depth overlap > 50% (800-1200 m)
E2	Geographical area	Encounters driven by expectation of finding target fish species. Overlap of the trawl footprint and modelled distribution	<10% overlap between trawl footprint and species distribution	10-50% overlap between trawl footprint and species distribution	>50% overlap between trawl footprint and species distribution
E3	Ruggedness	Relief, rugosity, hardness and seabed slope influence accessibility to bottom trawling and coral occurrence	Predominantly high relief (>1.0 m), rugged, difficult to trawl (crevices, overhangs, boulders); > 30° slope.	Predominantly low relief (<1.0 m), rough surface but trawlable (rubble, small boulders); <30° slope.	No relief to impede trawling, smooth simple surface; < 30° slope.
E4	Level of disturbance	The degree of impact that an encounter will have on individual colonies of a taxon	Many encounters needed for a significant impact on individual colonies	Several encounters needed to damage individual colonies	Single trawl will cause significant damage to individual colonies

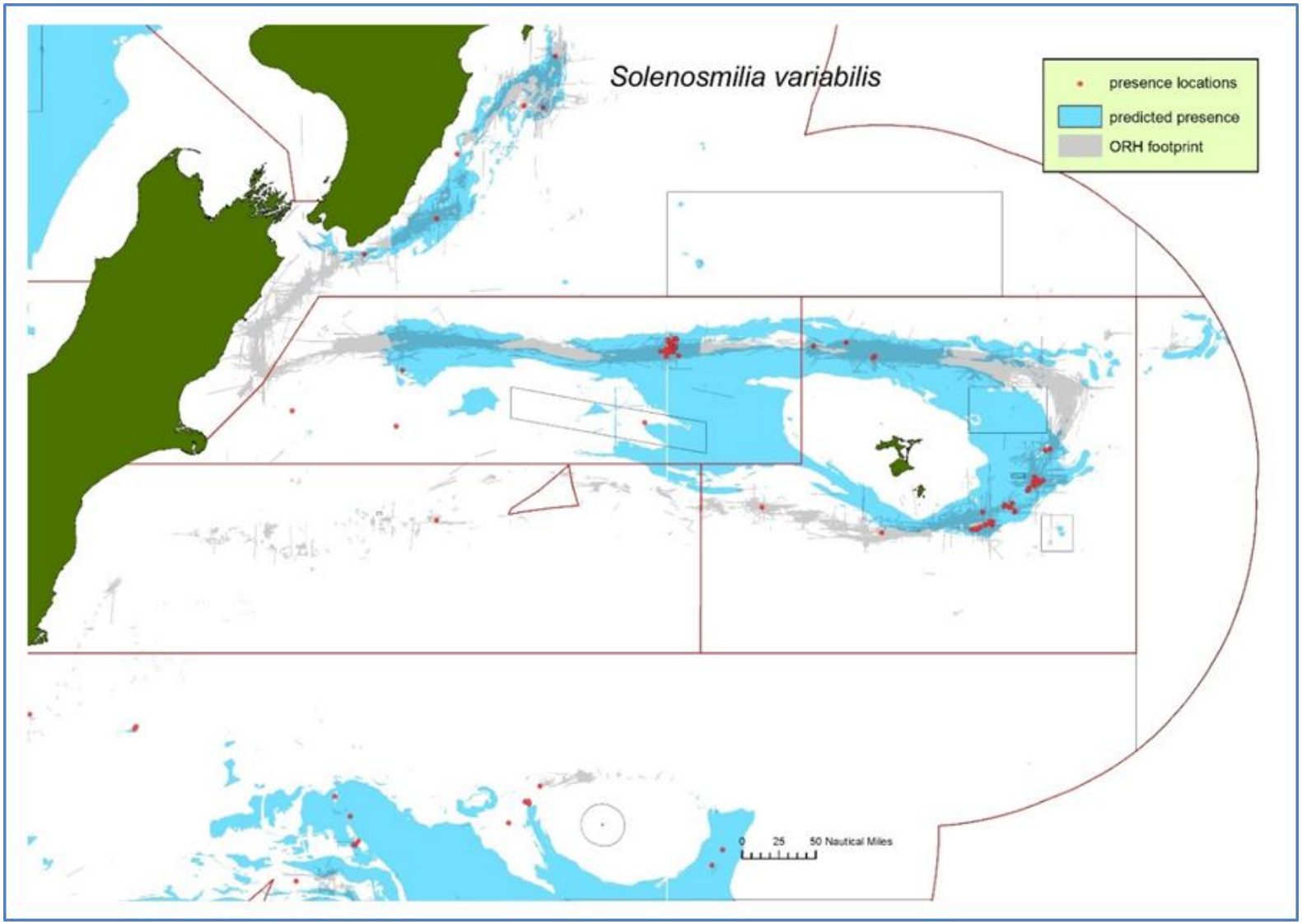
Encounterability criteria

- E1 was assessed from comparing the known depth distribution of orange roughy fisheries (primarily 800–1200 m) with frequency distribution plots of coral depth records compiled for habitat suitability modelling (Tracey et al. 2013) (see Section 2.6.1).
- For E2, the area overlap attributes, the orange roughy trawl footprint layer generated for the Chatham Rise for the fishing years 1990–91 to 2012–13 was used (based on Black et al. 2013).
    - Geographical overlap compared the trawl footprint with the average values of the likelihood of coral presence from the predictive model distributions (Anderson et al. 2014).
- Ruggedness (E3) was evaluated by the authors based on their own experience with trawling grounds in the region, and knowledge of coral habitat from seafloor photographs.
- The level of disturbance component (E4) was evaluated using literature on trawling impacts where the frequency or number of trawls had been studied (section 2.6.2).

Depth data


BTP
COB
ERO
GDU
KER_LEP
MOC
PAB
PRI
SVA
GOC
MTL
COR
Frequency
Depth (m)

Spatial overlap data



Selectivity

- Selectivity considers the potential of the fishing gear to capture or retain species
- S1 and S2 were assessed by the author's knowledge of the morphology of the coral species and associated communities, S3 used the predicted coral distribution from habitat suitability modelling work

	Aspect	Concept and Rationale		Rank	
	Attribute (s)		1 (low risk)	2 (medium)	3 (high risk)
	Selectivity				
S1	Removability/ mortality of morphotypes	Erect, large, rugose, inflexible, delicate forms incur higher impacts	Low, robust or small (<5 cm), smooth or flexible types.	Erect or medium sized (5-30 cm), moderately robust/inflexible.	Tall, delicate or large (> 30 cm high), rugose or inflexible.
S2	Associated faunal diversity	Diversity/species richness associated with the coral species or biogenic habitat, including relative ecological importance for other species.	Diversity low. Few, if any, species grow on or with the coral	Diversity medium. Some species grow or live on or in the coral	Diversity high. Many species utilize the matrix of a biogenic form
S3	Areal extent	Proportion of predicted coral distribution relative to total area considered. Larger areal extent means less risk for maintaining biodiversity and community function.	Common (> 10%) within the area)	Moderately common (1-10%) within the area	Rare (<1%) within the area. Small impacts may affect a large proportion of the taxon

Productivity

- the potential of a unit to recover from impacts

	Aspect Attribute (s)	Concept and Rationale	Ranks 1 (low risk)	2 (medium)	3 (high risk)
	Productivity				
P1	Regeneration of fauna	Accumulation/ recovery of coral habitat to a mature successional state. Based on intrinsic growth and reproductive rates that vary with temperature, nutrient, productivity.	< Decadal	> Decadal	>100 years
P2	Natural disturbance	Level of natural disturbance affects how organisms or communities are adapted to being disturbed, and their intrinsic ability to recover.	High disturbance (e.g.,volcanism, earthquakes, landslides)	Intermediate	Little natural disturbance
P3	Naturalness	The historical level of trawl impact determines present status of benthic habitat	High trawling effort	Medium effort	Low effort
P4	Connectivity	The dispersal distance or connectedness of coral habitats is important for recruitment to trawled areas or patches of coral habitat.	High connectivity (able to disperse large distance, or distance between coral patches <25 km)	Moderate (25-100 km)	Low connectivity (limited dispersal ability, or isolated patches (>100 km)

Productivity scoring data

- P1 (regeneration) was assessed using data on age and growth of coral species from the literature (see section 2.6.4).
- P2 was evaluated using knowledge of the topography on the Chatham Rise (no active volcanism, apart from the northwest corner with the Hikurangi Trough no landslide potential) and the depth distribution of coral species (depths >100 m will not be affected by surface weather events).
- P3 was scored by the author's judgement of whether the coral habitat overall had been heavily trawled (>100 tows), been impacted by medium levels of effort (50-100 trawls), or been lightly trawled<50 tows) over the duration of the fishery.
- Connectivity (P4) was a combination of data and knowledge of the patchiness of coral distribution (high density) and their reproductive capacity from the literature.

RESULTS

- Summary of raw risk values

	A1	av	E1	E2	E3	E4	av	S1	S2	S3	av	P1	P2	P3	P4	av
Solenosmilia	2.00	2.00	3.00	2.00	2.00	3.00	2.50	3.00	3.00	1.00	2.33	3.00	3.00	1.00	2.00	2.25
Goniocorella	2.00	2.00	1.00	1.00	3.00	2.00	1.75	2.00	3.00	1.00	2.00	2.00	3.00	3.00	2.00	2.50
Madrepora	2.00	2.00	3.00	2.00	2.00	3.00	2.50	3.00	3.00	1.00	2.33	3.00	3.00	1.00	2.00	2.25
Oculina	3.00	3.00	1.00	1.00	2.00	2.00	1.50	2.00	2.00	3.00	2.33	2.00	2.00	3.00	2.00	2.25
Enallopsammia	2.00	2.00	3.00	2.00	2.00	3.00	2.50	3.00	3.00	1.00	2.33	3.00	3.00	1.00	2.00	2.25
Black corals	2.00	2.00	3.00	2.00	2.00	3.00	2.50	3.00	2.00	1.00	2.00	3.00	3.00	2.00	3.00	2.75
Bathypathes	2.00	2.00	2.00	2.00	2.00	3.00	2.25	3.00	2.00	2.00	2.33	3.00	3.00	2.00	3.00	2.75
Gorgonians	2.00	2.00	2.00	2.00	2.00	3.00	2.25	3.00	2.00	1.00	2.00	2.00	3.00	2.00	3.00	2.50
Paragorgia	3.00	3.00	3.00	1.00	2.00	3.00	2.25	3.00	2.00	2.00	2.33	2.00	3.00	2.00	3.00	2.50
Primnoa	2.00	2.00	2.00	1.00	2.00	2.00	1.75	2.00	2.00	2.00	2.00	2.00	3.00	2.00	2.00	2.25
Bamboo corals	2.00	2.00	2.00	2.00	2.00	3.00	2.25	3.00	2.00	1.00	2.00	2.00	3.00	2.00	2.00	2.25
Metallogorgia	2.00	2.00	2.00	2.00	2.00	2.00	2.00	1.00	1.00	2.00	1.33	2.00	3.00	2.00	3.00	2.50
Cup corals COF	2.00	2.00	2.00	1.00	3.00	2.00	2.00	1.00	1.00	1.00	1.00	2.00	3.00	2.00	2.00	2.25
Cup corals CAY	2.00	2.00	3.00	2.00	2.00	2.00	2.25	1.00	1.00	1.00	1.00	2.00	3.00	1.00	2.00	2.00
Hydrocorals	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	1.00	1.00	1.33	1.00	3.00	2.00	2.00	2.00

Example of scoring: SVA

Attribute		Score	Rationale
A1	Spatial overlap (regional)	2	Distributed throughout much of NZ
E1	Depth zone	3	Depth range in middle of ORH zone, overlap >50%
E2	Geographical area	2	Geographical overlap with footprint about 35%
E3	Ruggedness	2	Occurs mainly in trawlable areas, some seamounts too rough
E4	Disturbance	3	Colonies easily damaged by single bottom trawl
S1	Removability	3	Tall (m), rigid, fragile
S2	Faunal diversity	3	Matrix forming, many species inside and on surface
S3	Areal extent	1	Common on Chatham Rise (40%)
P1	Regeneration	3	High longevity (reefs >100s yr), slow growth (mm/yr)
P2	Natural disturbance	3	No non-human disturbance
P3	Naturalness	1	High trawling effort in many SVA habitats (e.g., seamounts)
P4	Connectivity	2	Moderate dispersal capability (25-100km), widespread patchy distribution

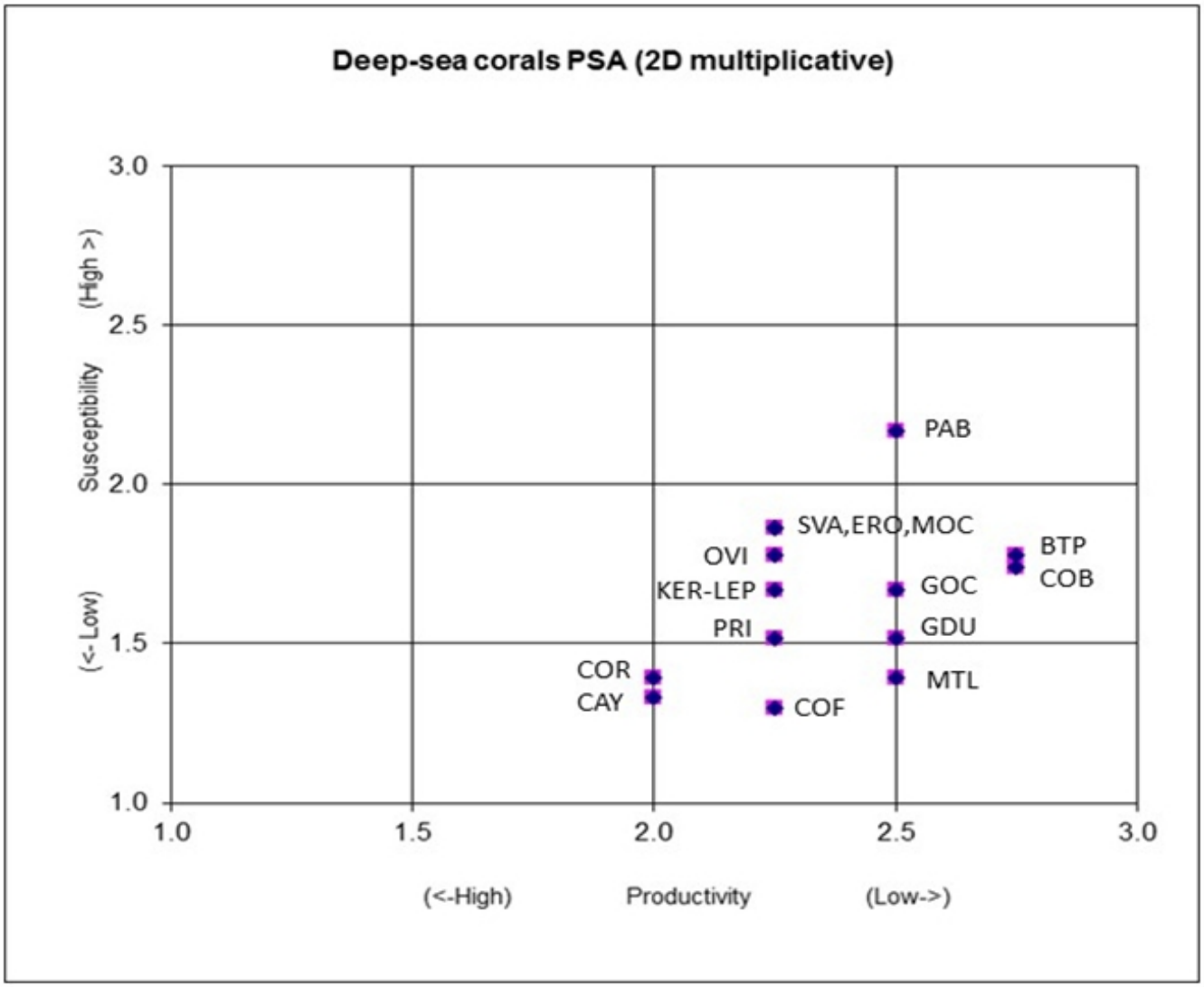
Risk ranking

- Summary of Productivity and Susceptibility scores and overall ranking

Coral species	Code	Productivity score (Average)	Susceptibility score (Multiplicative)	Overall Risk Value	Overall Risk Ranking
Solenosmilia	SVA	2.25	1.86	2.92	Med
Goniocorella	GDU	2.50	1.52	2.93	Med
Madrepora	MOC	2.25	1.86	2.92	Med
Oculina	OVI	2.25	1.78	2.87	Med
Enallopsammia	ERO	2.25	1.86	2.92	Med
Black corals	COB	2.75	1.74	3.25	High
Bathypathes	BTP	2.75	1.78	3.27	High
Gorgonians	GOC	2.50	1.67	3.00	Med
Paragorgia	PAB	2.50	2.17	3.31	High
Primnoa	PRI	2.25	1.52	2.71	Med
Bamboo corals	KER-LEP	2.25	1.67	2.80	Med
Metallogorgia	MTL	2.50	1.40	2.86	Med
Cup corals	COF	2.25	1.30	2.60	Low
Cup corals	CAY	2.00	1.33	2.40	Low
Hydrocorals	COR	2.00	1.40	2.44	Low

Graphical display

- PSA plot for 15 species



Conclusions

- This Level 2 assessment study is the first ERA carried out for New Zealand deep-sea coral species.
- Black corals (at the order level, and the genus *Bathypathes*) and the gorgonian coral genus *Paragorgia*, were classified as high risk, due to their very low productivity, and moderate-high susceptibility. Most reef-building scleractinian corals, as well as other gorgonian coral taxa, were medium risk, and cup corals and hydrocorals (small bodied, low susceptibility to bottom trawling, fast growing) were relatively low risk
- These results were consistent with expectations based on the form and biology of the corals, and knowledge of trawling impacts.
- Gives some confidence that the ERA methodology was sensible, and available data were adequate
    - Productivity data were the main limiting factor, especially gaps in age-growth for some species, more generally little known about dispersal capability, and knowledge of colonisation/settlement

Conclusions (2)

- This work was not intended to be a definitive ERA, but rather to investigate whether such a semi-quantitative level 2 approach could be carried out given the data available, and whether it produced sensible results in terms of relative risk.
- The PSA method allows sufficient transparency to track and understand where and how certain attribute scores affect results, and wherever possible is based on data, and not subjective scoring.
- Although only a pilot assessment, it is hoped the study can give scientists and managers a better understanding of this type of ERA methodology, as well as the various aspects and characteristics of coral species and the fishery that contribute to risk determination. This can lead to further evaluation of risk, target areas where more data are necessary, and also stimulate discussion about potential management approaches or methods that could reduce risk where it is high.

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