NIWA

Taihoro Nukurangi

Habitat Suitability Modelling for Protected Corals in New Zealand Waters (POP2018-01)

Draft methodology report

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Objectives

- To carry out improved habitat suitability modelling for protected corals in the New Zealand region
- To help identify areas of risk from interactions with commercial fishing gear

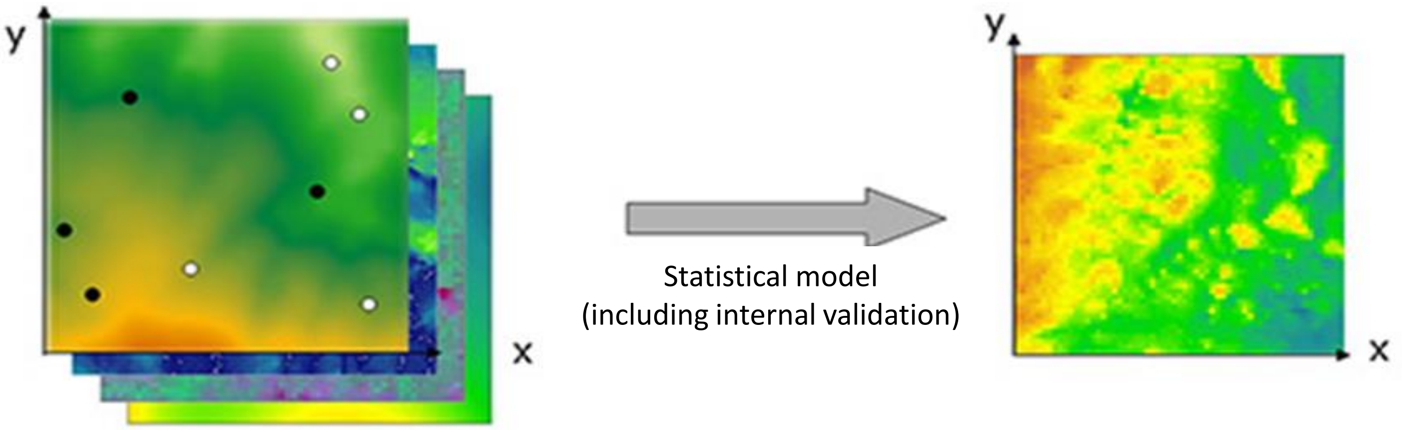
Solenosmilia variabilis reef-like habitat forming scleractinian coral

Rationale

- Protected corals frequently occur as bycatch in NZ commercial fisheries (mainly bottom trawl)
- To determine the extent of the overlap between fishing and protected coral habitat, first we must determine the spatial extent of each
- Habitat Suitability Models – used to explore the relationship between point-sampled species occurrence records and sets of spatially continuous environmental variables
- We build on previous studies, incorporating new records, new regional environmental predictor layers from the NZ Earth System Model, and updated modelling approaches
- Resulting grids of predicted coral distributions (present and future) can then be used to more precisely define the risk to corals from fishing (and climate change); and inform resource management planning

Keratoisis bamboo coral

Habitat suitability modelling



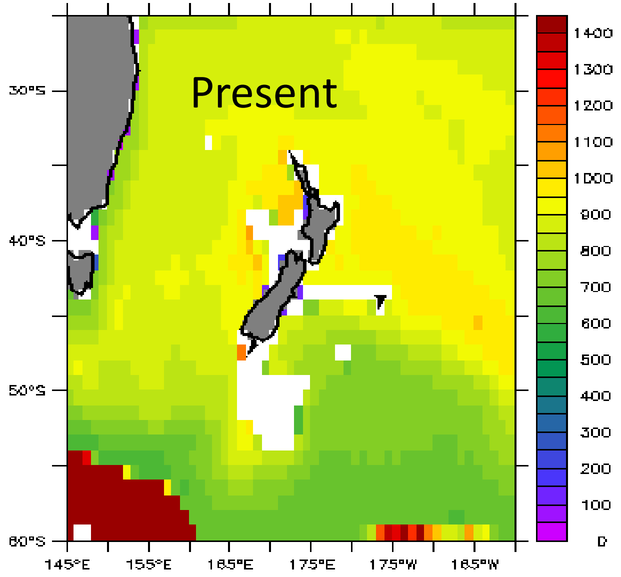
Species occurrence records and maps of environmental variables

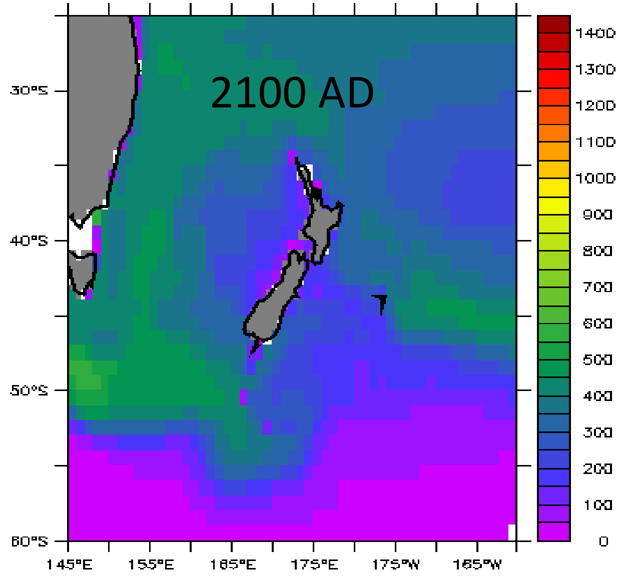
Map of probability of suitable habitat

Environmental predictors

New Zealand Earth System Model (NZESM)

- Currently under development by NIWA
- Incorporates component models of ocean biogeochemistry and other aspects of biology and chemistry to provide a highly complex model of the climate system
- This ESM is specifically tuned to the New Zealand region of the Pacific and Southern Oceans
- Capable of producing projections for up to 200 years into the future (Williams et al. 2016).





Environmental predictors

Variable	Description	Units	Reference
Seamount	Seamount positions in the New Zealand region	–	Rowden et al. (2008), Mackay (2007)
Slope	Seafloor slope derived from bathymetry	°	CANZ (2008), Hadfield et al. (2002)
Dissolved Inorganic Carbon	Seafloor DIC concentration	mol/m3	NZESM
Sea surface height	Sea surface height above geoid	m	NZESM
Bottom temperature	In-situ bottom temperature	Degrees C	NZESM
Aragonite concentration	Seafloor aragonite concentration	mol/m3	NZESM
Calcite concentration	Seafloor calcite concentration	mol/m3	NZESM
Nitrate concentration	Seafloor dissolved nitrate concentration	mol/m3	NZESM
Phosphate concentration	Seafloor dissolved phosphate concentration	mol/m3	NZESM
Oxygen concentration	Seafloor dissolved oxygen concentration	mol/m3	NZESM
Chlorophyll concentration	Seafloor total chlorophyll mass concentration	kg/m3	NZESM
Salinity	Seafloor salinity	g/kg	NZESM
Sediment	Percent mud or gravel	%	Bostock et al. 2018ab

Review of habitat suitability modelling

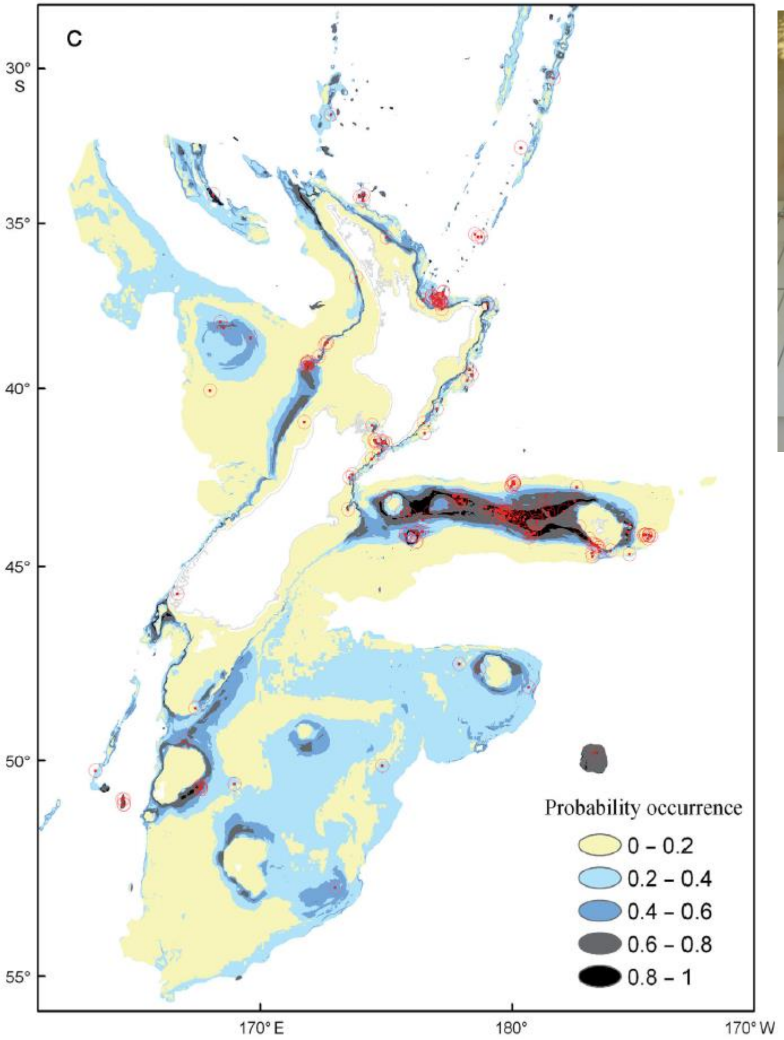
Commonly used methods

- Generalised Linear Models (GLMs and GAMs) (McCullagh & Nelder 1989, Hastie & Tibshirani 1990)
- Maximum Entropy (Maxent) (Phillips et al. 2006)
- Random Forests (RF) (Brieman 2001)
- Boosted Regression Trees (BRT) (Elith et al. 2008)
- Genetic Algorithm for Rule-Set Production (GARP) (Stockwell 1999)
- Multivariate Adaptive Regression Splines (MARS) (Friedman 1991)
- Ecological Niche Factor Analysis (ENFA) (Hirzel et al. 2002)
- Artificial Neural Networks (ANNs)
- BIOCLIM (Nix 1986)

New Zealand examples – deep-sea corals

Goniocorella dumosa
Tracey et al. (2011)

- BRT
- MBIE, MPI, NIWA

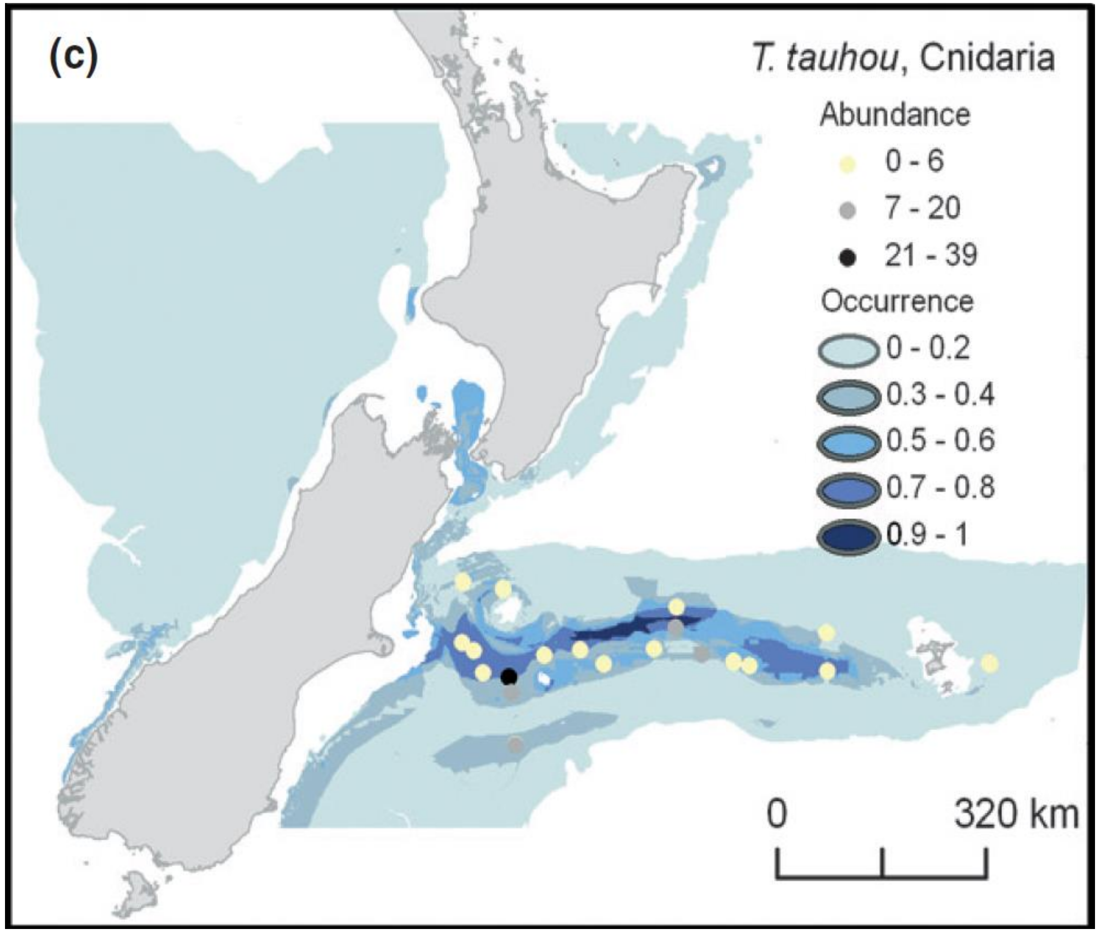


G. dumosa

New Zealand examples – deep-sea corals

Taiaroa tauhou
Compton et al. (2013)

- BRT
- MPI, DOC, LINZ, NIWA

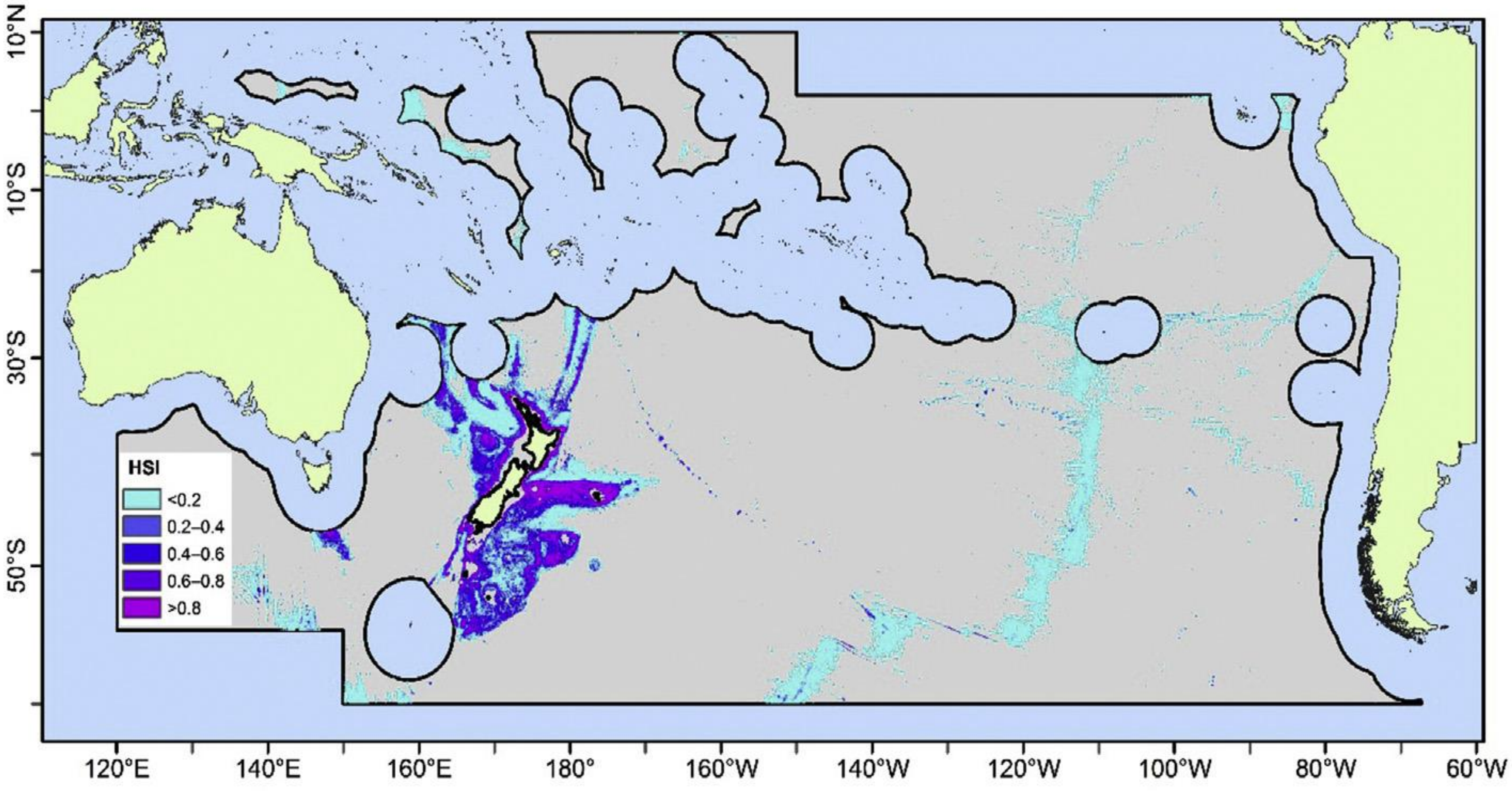


T. tauhou
Endemic solitary soft coral

New Zealand examples – deep-sea corals

Reef-forming scleractinians
Anderson et al. (2016a)

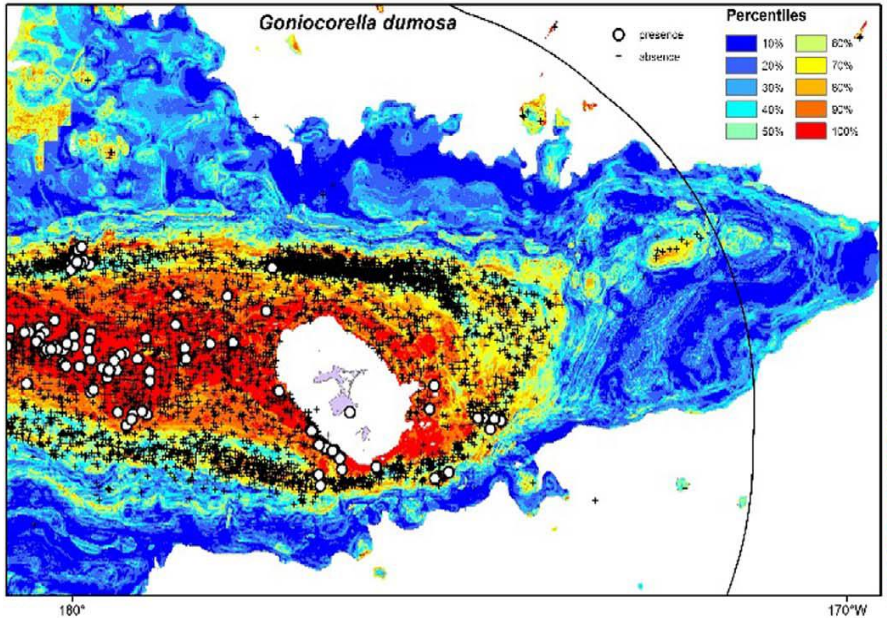
- BRT & MaxEnt
- SPRFMO region
- MBIE, MCI, NIWA

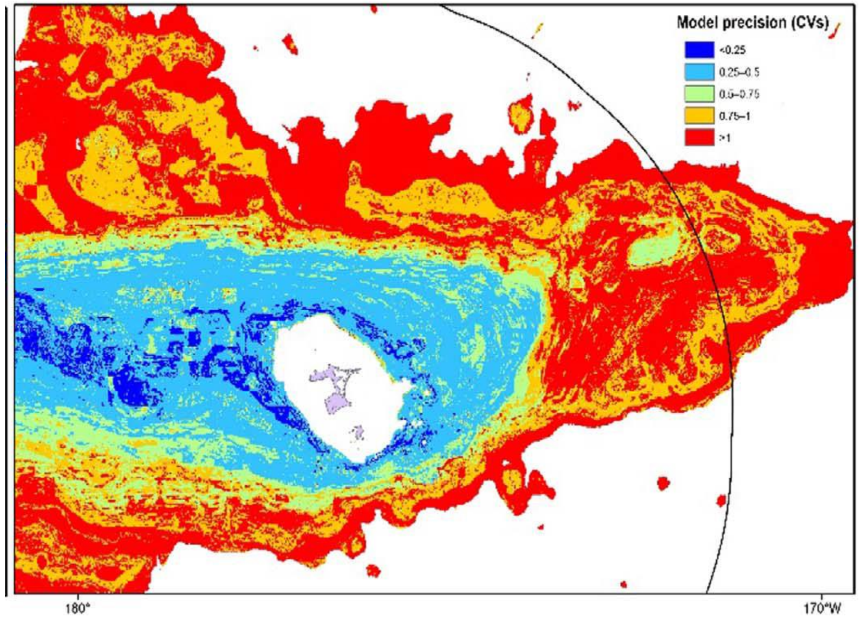


New Zealand examples – deep-sea corals

Goniocorella dumosa
Anderson et al. (2016b)

- BRT & MaxEnt (ensemble)
- Precision estimated
- NZ region
- MBIE, MCI, NIWA

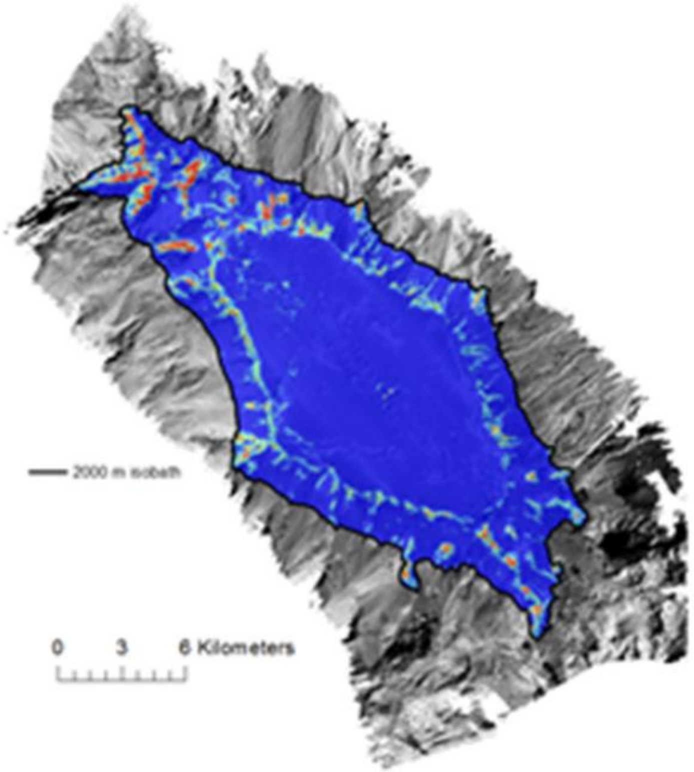


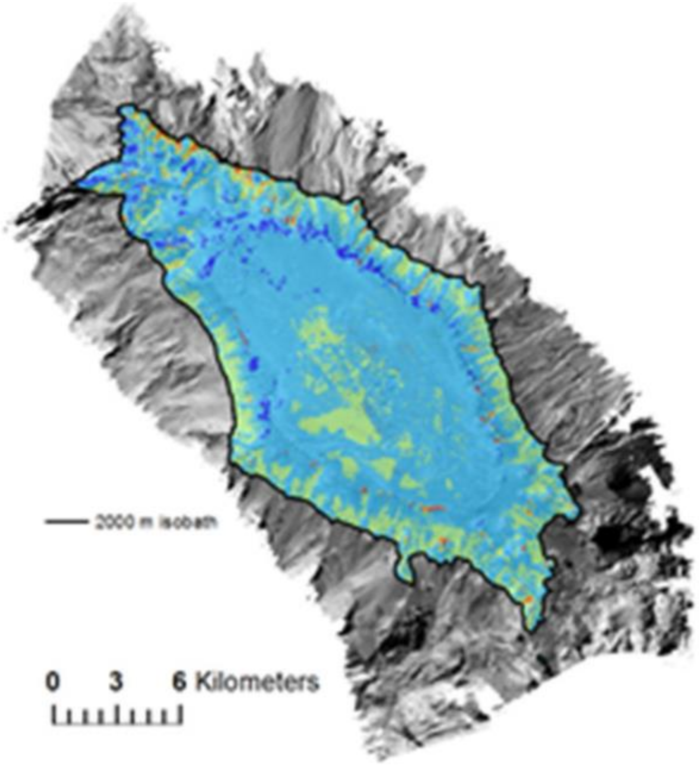


New Zealand examples – deep-sea corals

Solenosmilia variabilis
Rowden et al. (2017)

- BRT & GAM &RF (ensemble)
- High resolution (25m^2)
- Precision estimated
- Louisville Seamount Chain
- MBIE, MCI, NIWA



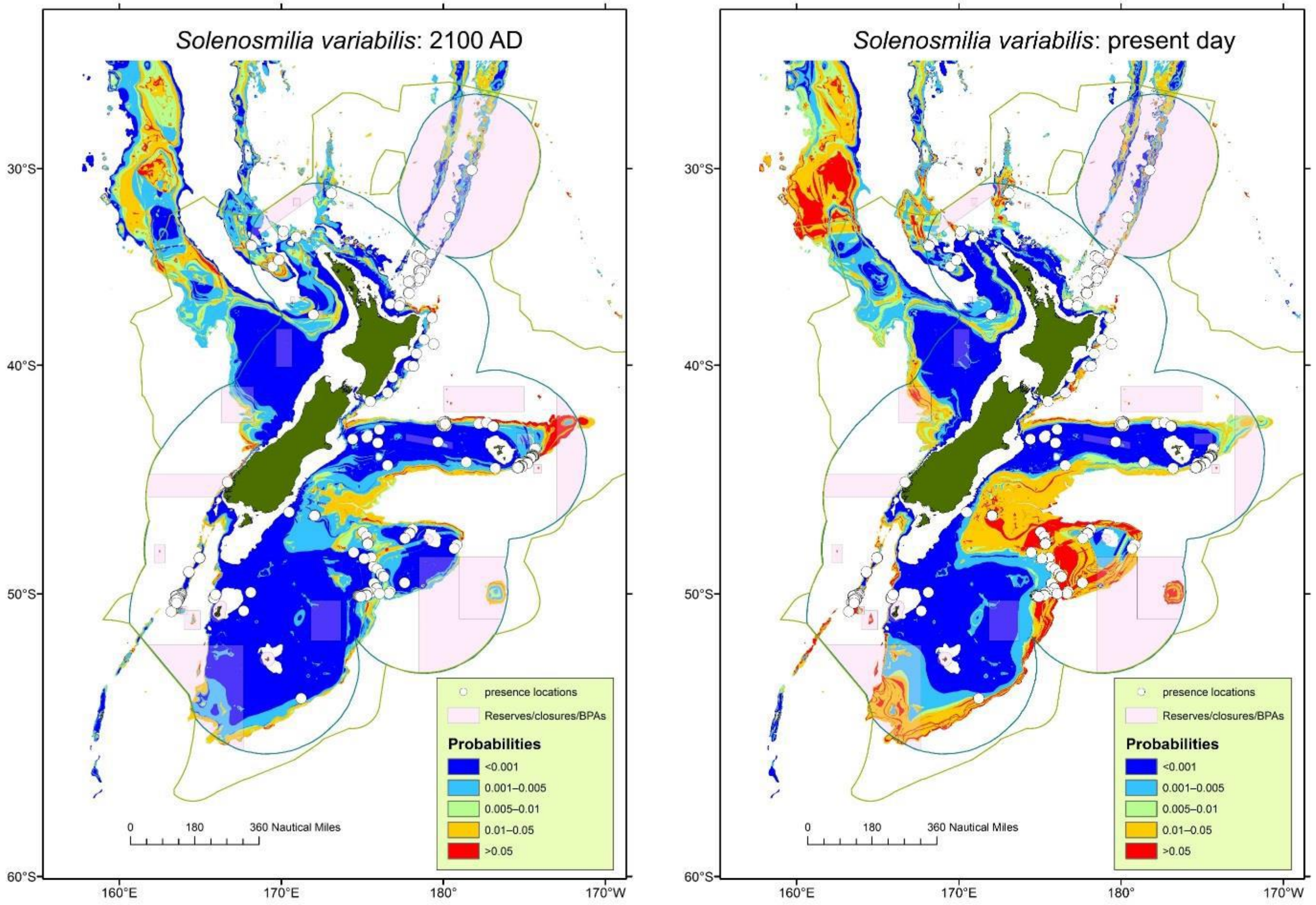


New Zealand examples – deep-sea corals

Solenosmilia variabilis
Anderson et al. (2015)

- BRT
- Predicting present AND future distributions

- DOC, NIWA



Proposed methodology

Lessons learned from previous work

Recent model validation analyses indicated a general improvement in model reliability over time. The best-performing models were those:

- Developed for individual species rather than groups of species
- For frequently-recorded species rather than rare species
- With a more restricted spatial extent tuned specifically to local environmental conditions
- Based on real absence records rather than random background points (pseudo-absence data).

Proposed methodology

Coral presence/absence records

- Several years of additional records now available, from Observers, research surveys, and overseas institutes
- Records from shallower than 200 m will now be included
- The focus will be on producing models at the genus or species level
- Absence data will be based on research survey stations where the particular taxon was not caught

Proposed methodology

Selection of taxa to model

- Although models for grouped taxa may be less reliable, this needs to be balanced against limited resources to produce models for many individual species, and also the limited number of individual species with sufficient presence data

- Therefore if agreed, some models will be at the genus level and others the species level

- Models will be more complex than previous, limiting the total number possible

Proposed methodology

Prioritisation of taxa to model

Selection of taxa to model (prioritisation)

Models will be produced for all taxa with priority 1

Preliminary priorities of 2 or 3 set for remaining taxa

Order	Taxon	Description	Number of records	Priority
Scleractinia	*Enallopsammia rostrata*	Reef-forming coral	130	1
	Solenosmilia variabilis	Reef-forming coral	311	1
	Goniocorella dumosa	Reef-forming coral	212	1
	Madrepora oculata	Reef-forming coral	126	1
Alcyonacea	*Paragorgia arborea* (or spp.)	Bubblegum coral (tree-like)	98	2
	Primnoa spp.	Primnoid sea-fans (tree-like)	73	2
	Corallium spp	Precious coral	–	2
	Genera combined (*Keratoisis* spp. *Lepidisis* spp.)	Bamboo corals (tree-like)	241	1
Antipatharia	*Bathypathes* spp.	Black coral (tree-like)	75	1
	Leiopathes spp.	Black coral (tree-like)	67	3
Anthoathecata	*Errina* spp.	Hydrocorals (small, delicate)	–	2
	Lepidopora or *Lepidotheca* or *Stylaster* (spp.)		–	3

Modelling approach

Data

- Finalise selection of presence and absence data
- Finalise selection of environmental variables. A base set of predictors will be chosen for use in all models, modified by specific biological requirements of some taxa.

Models (for each method; BRT, RF)

- Run separate models by taxon, iteratively as necessary, to derive a residual autocorrelation variable (RAC) to account for spatial autocorrelation
- Estimate precision (bootstrapping)
- Assess model performance, as a cross-validated AUC value based on subsets of training/test data
- Produce final model using the full set of input data.
- Use model coefficients to produce two sets of prediction grids; present-day and 2120 AD
- Produce ensemble models by averaging predictions from contributing models, weighted by AUC and uncertainty
- Produce colour-coded maps of habitat suitability and model uncertainty for each modelled taxon and time period

Overlap between protected corals and bottom trawling

Current trawl footprint data obtained from published analysis (Baird & Mules in press)

- 5 km x 5km gridded data
- Provides both footprint (2D) and aggregated fishing effort (3D)
- Covers entire New Zealand EEZ
- Recent fishing activity (2008–2017)
- Depth limited to 200–1600 m

- Visual matching of coral distributions with footprint/aggregated effort
- Overlap statistics calculated
  - E.g. fraction of cells with high habitat suitability (90% quantile) with high footprint area (>20 km^2)

Acknowledgements

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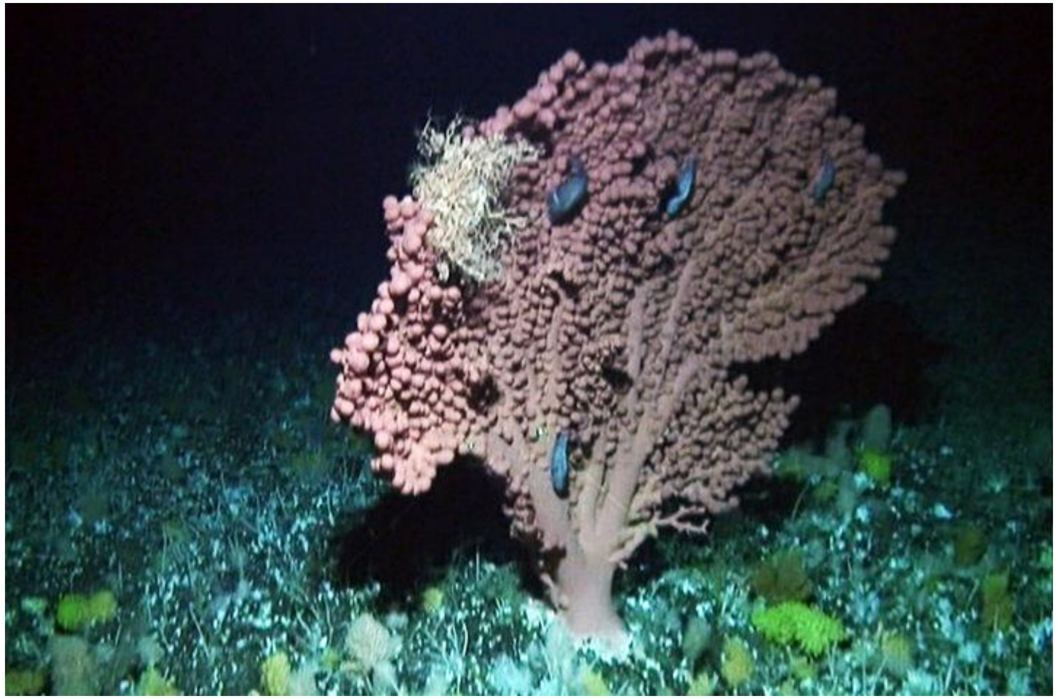

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