NIWA

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Climate, Freshwater & Ocean Science

Identification of protected coral hotspots using species distribution modelling

Prepared for Conservation Services Programme, Department of Conservation (project POP2021-02 – DOC21304)

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Project Objectives

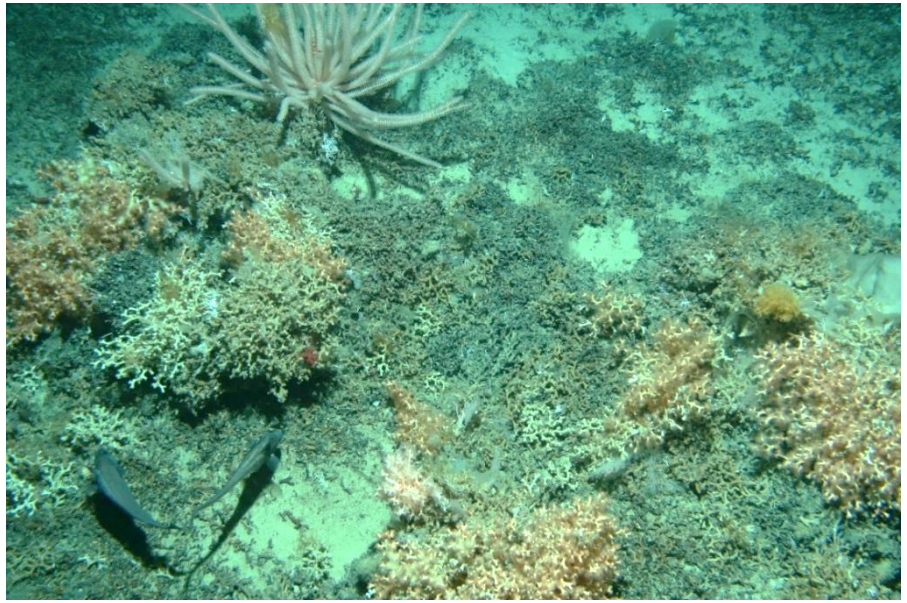
1. To collate and analyse cold water coral records from existing seabed towed camera transects in the New Zealand region, with a particular focus on areas known to overlap with fishing effort.

2. To identify hotspots for selected protected coral species in the New Zealand region using predictions from abundance-based species distribution models.

3. To better understand the historical effects of fishing on observed patterns of coral distribution and relative abundances.

Introduction

- A long history of bycatch of deep-sea corals in our fisheries indicates a strong overlap between coral distributions and commercial fishing grounds
- Evaluation of the adverse effects of fishing on protected species and knowledge of their distribution are crucial for ensuring adequate mitigation measures are in place
- Before now, predictions of protected coral distributions were based on presence-absence data or, if abundance data were used, were limited to only parts of the New Zealand maritime realm
- In this project a database of abundance data for corals was assembled from video-transect surveys and complex models built to predict their abundance at a regional scale…
- ….and to determine hot-spots of high overall coral abundance



Methods

Coral taxa of interest

Scleractinia
(stony corals)

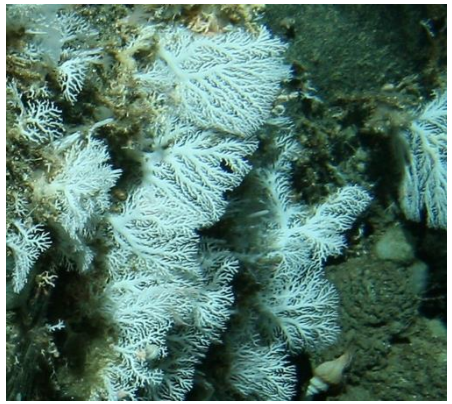
PROTECTED

Alcyonacea
(soft corals,
gorgonian corals)

PROTECTED

Antipatharia
(black corals)

PROTECTED



Stylasteridae
(hydrocorals)

PROTECTED

Pennatulacea
(sea pens)

NOT PROTECTED

Methods

Selection of coral taxa for modelling and aggregation of DTIS data

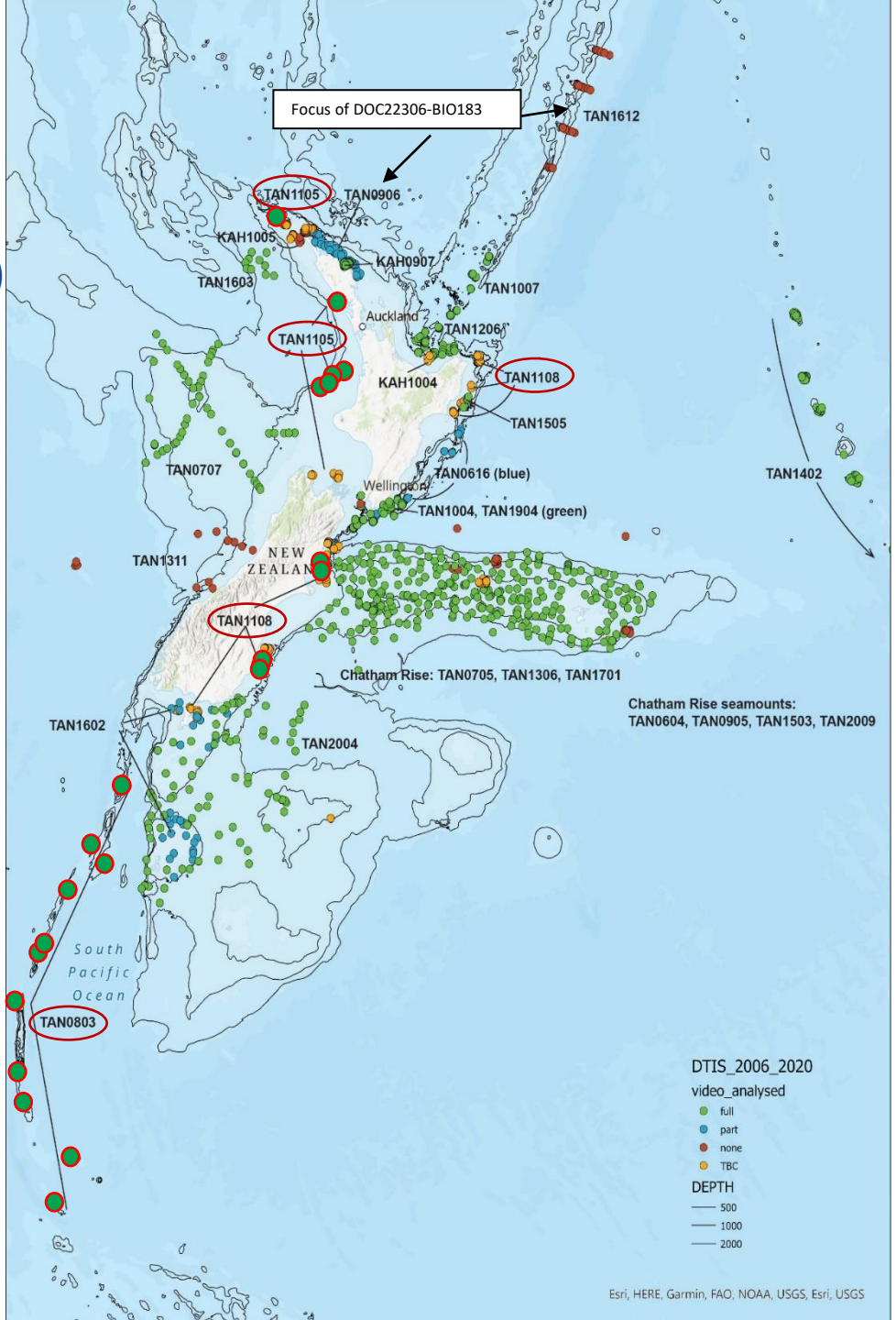
- Deep Towed Imaging System (DTIS), high-resolution video and stills
- Spatially referenced observations using the software Ocean Floor Observation Protocol (OFOP)
- Post-voyage analysis, count and identification of substrate and benthic fauna

Methods

Regional coverage – Survey selection (Milestone 4)

1. **TAN0803** (Macquarie Ridge 2008): diverse coral assemblages west and south of SDM focus area.
   (all 21 stations processed)
2. **TAN1105** (Biogenic Habitats I 2011): shallow (19–480 m), NZ North Island, localised high abundances of corals.
   (14 stations processed)
3. **TAN1108** (Biogenic Habitats II 2011): shallow (20–327 m), NZ East coast North Island and South Island, localised high abundances of corals.
   (9 stations processed)

Total = 44 DTIS transects added to model under this project



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Methods

Selection of coral taxa for modelling and aggregation of DTIS data

Order	Taxon	Description	Number of DTIS records
Scleractinia	*Solenosmilia variabilis*	Reef-forming coral	108
	Goniocorella dumosa	Reef-forming coral	73
	Enallopsammia rostrata	Reef-forming coral	21
	Madrepora oculata	Reef-forming coral	18
	Caryophylliidae	Solitary coral	228
	Stephanocyathus spp.	Solitary coral	41
	Flabellum spp.	Solitary coral	301
Alcyonacea	Gorgonians (all)	Sea-fans/sea-whips	405
	Keratoisididae/Mopseidae	Bamboo corals	144
	Primnoidae	Sea-fans and bottle brush corals	196
	Paragorgiidae	Bubblegum corals	25
	Radicipes spp.	Sea whips	113
Antipatharia	Antipatharia (all)	Black corals	221
Anthoathecata	Stylasteridae	Hydrocorals	232
Pennatulacea	Pennatulacea	Sea-pens	415

Methods

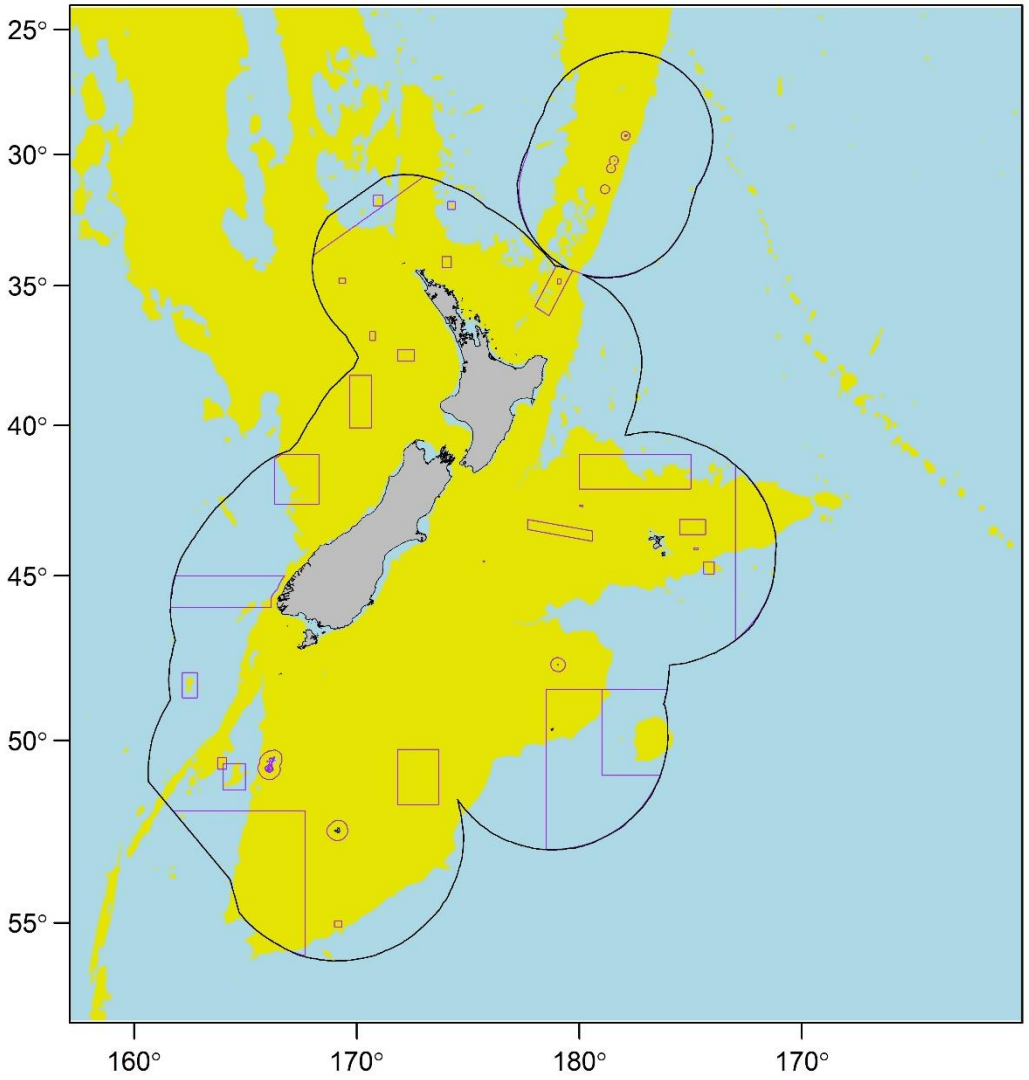
Environmental variables

Variable	Units	Source
Seafloor Characteristics		
Percent gravel	%	Bostock et al. (2018a, 2018b)
Percent mud	%	Bostock et al. (2018a, 2018b)
Ruggedness[1] (VRM)	–	Derived from bathymetry (Mackay et al., 2015)
Slope SD[1]	–	Derived from bathymetry
Bathymetric Position Index – broad	–	Derived from bathymetry
Seamounts	–	Clark et al. 2022
Water Chemistry		
Aragonite saturation state at depth	–	Bostock et al. (2013)
Calcite saturation state at depth	–	Bostock et al. (2013)
Dissolved oxygen at depth	ml l^{-1}	Garcia et al. (2013)
Temperature at depth	°C	Locarnini et al. (2013)
Productivity		
Particulate organic carbon export	mg C m^{-2} d^{-1}	Pinkerton et al. (2016) and Cael et al. (2018)
Human impacts		
Fishing effort	Fraction (0–1)	Rowden et al (in press)

Methods

Model extent

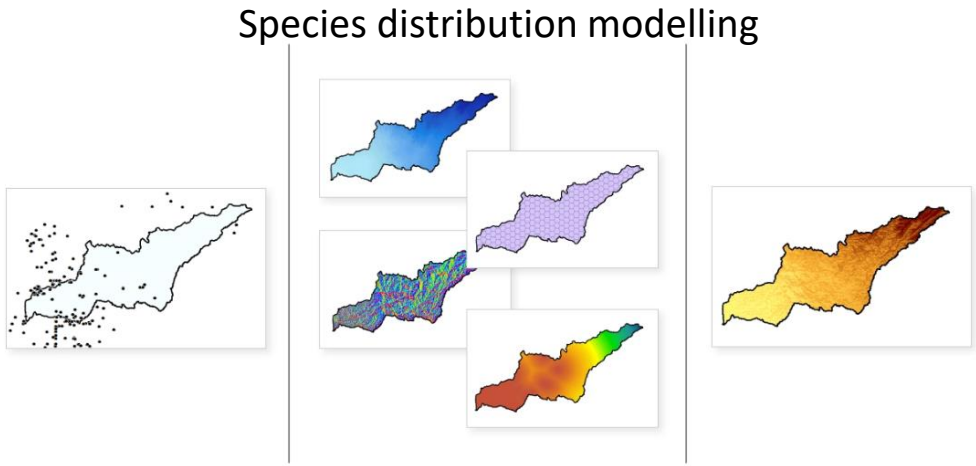
- The New Zealand region
- 50–3000 m depth range
- Includes current network of protected areas



Methods

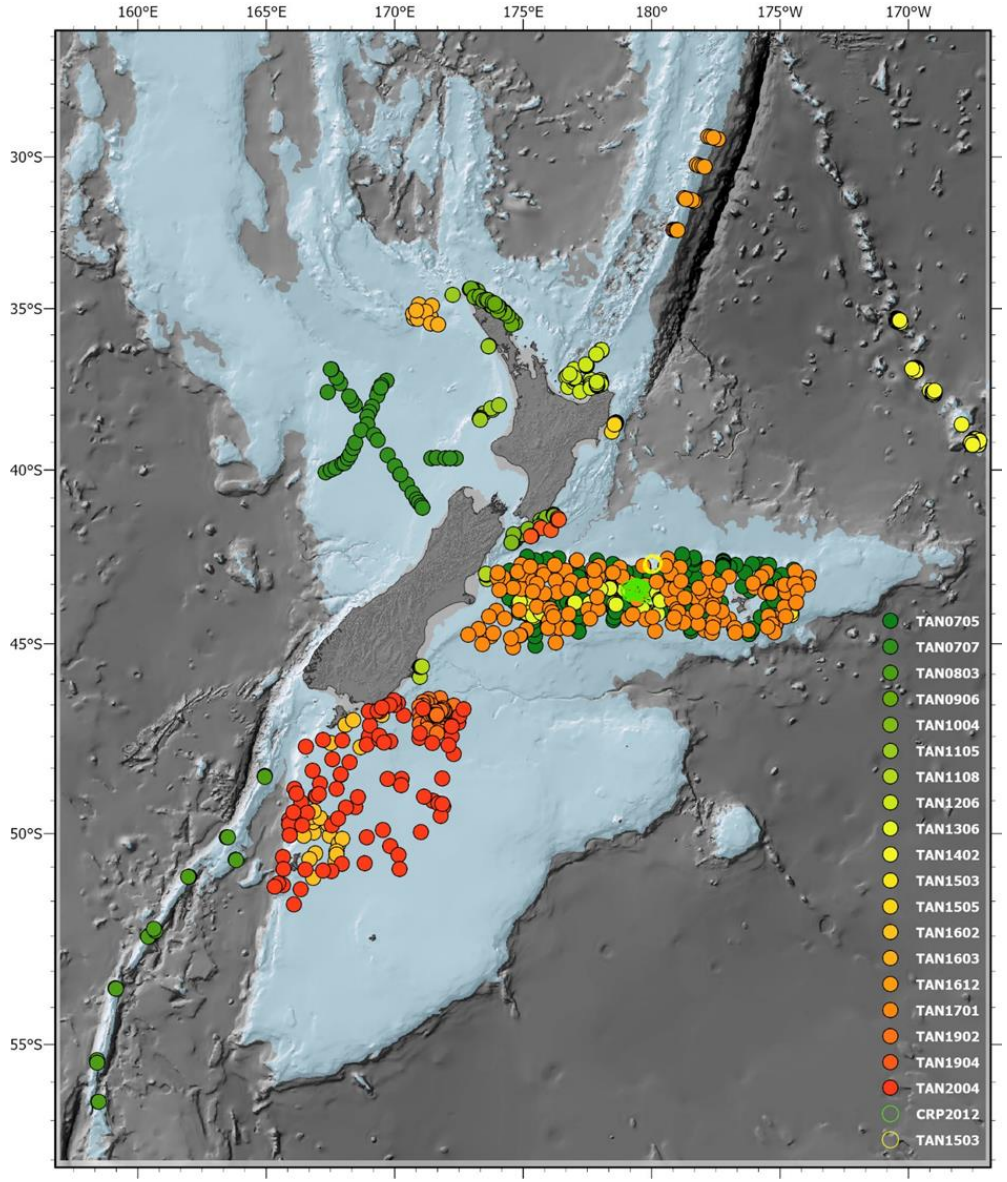
Abundance models

- **Model type**: Ensemble of two independent methods. Boosted Regression Trees (BRT) and Random Forests (RF)
- **Model structure**: Hurdle model; each BRT/RF model comprised two components; 1, Presence-absence binary model; 2, abundance regression model (presence records only)
- **Transformations**: Regression model abundances log(x+1) transformed; predictions back-transformed, exp(x)-1
- **Hurdle models**: Probabilities from first component multiplied by abundance predictions from second component to produce independent BRT & RF hurdle models
- **Uncertainty**: Estimated using a bootstrap resampling technique
- **Ensemble model**: Formed as weighted averages of predictions from BRT & RF hurdle models; two-part weighting method with equal contributions from model performance metrics and



Results

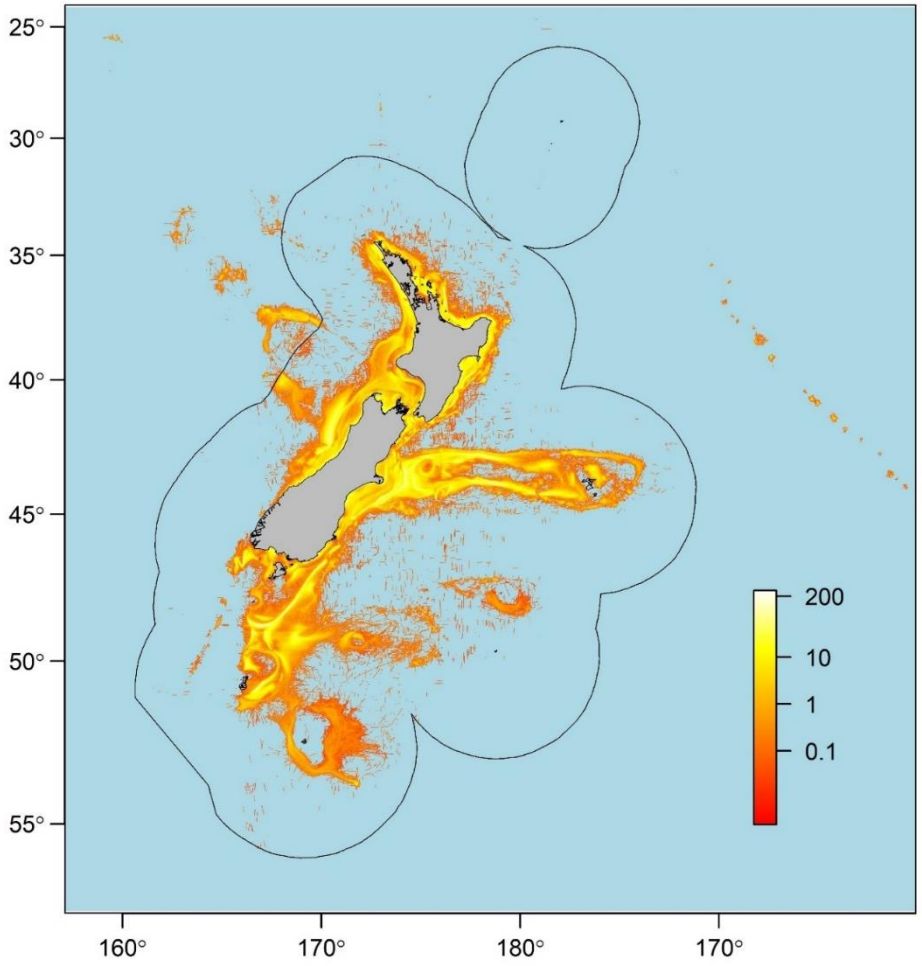
Voyage code	Voyage location and year	Fully processed-previously	Formatted for this study	Fully processed-this study	Total
TAN0705	Chatham Rise 2007	108			108
TAN0707	Challenger Plateau 2007		46		46
TAN0803	Macquarie Ridge 2008			21	21
TAN0906	Northland Plateau 2009		38		38
TAN1004	Cook Strait and Hikurangi 2010		39		39
TAN1105	Cape Reinga, E coast N Island, N coast S Island 2011			14	14
TAN1108	E coast from Stewart Is. to East Cape 2011			9	9
TAN1206	Bay of Plenty 2012		61		61
CRP2012*	Chatham Rise 2012	39			39
TAN1306	Chatham Rise 2013	53			53
TAN1402	Louisville seamounts 2014		118		118
TAN1503*	Chatham Rise: Graveyard and Andes seamounts 2015	11			11
TAN1505	East Cape 2015		12		12
TAN1602	Stewart Island and Auckland Island shelves 2016	23			23
TAN1603	Project West, Northland 2016		11		11
TAN1612	Kermadec Islands 2016		21		21
TAN1701	Chatham Rise 2017	147			147
TAN1902	Great South Basin 2019		63		63
TAN1904	Cook Strait and Hikurangi 2019		29		29
TAN2004	Challenger Plateau 2020	86			86
All (20 voyages)	**All New Zealand Region**	**467**	**438**	**44**	**949**



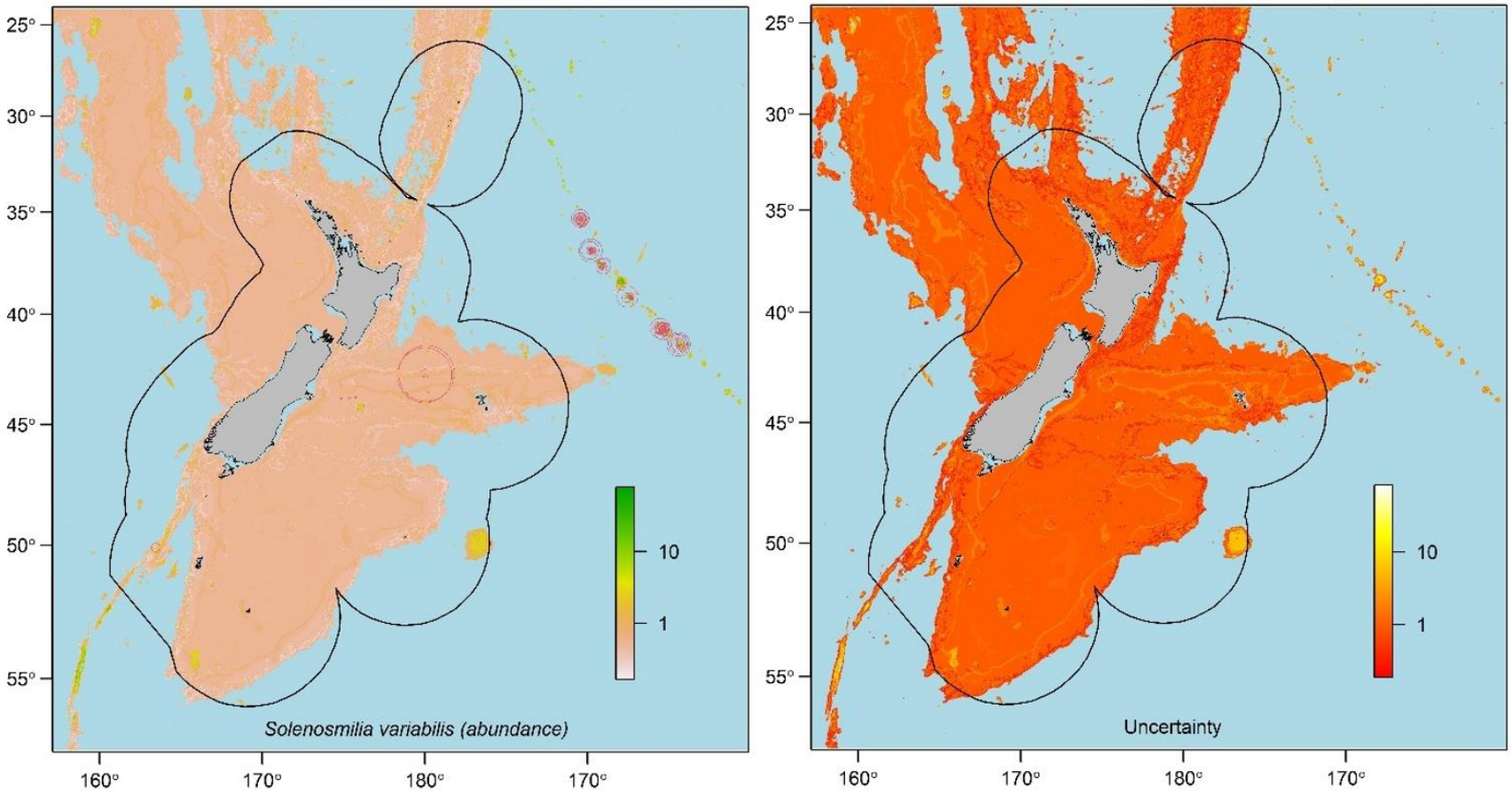
Results

Development of fishing effort layer

- An environmental predictor was built from recorded bottom trawling effort between 1990 & 2020
- Swept-area per cell ranges from 0 to 250 square km
- Prior effort was calculated at each sample site according to year of survey
- Potential for predicting pre-fishing species distributions

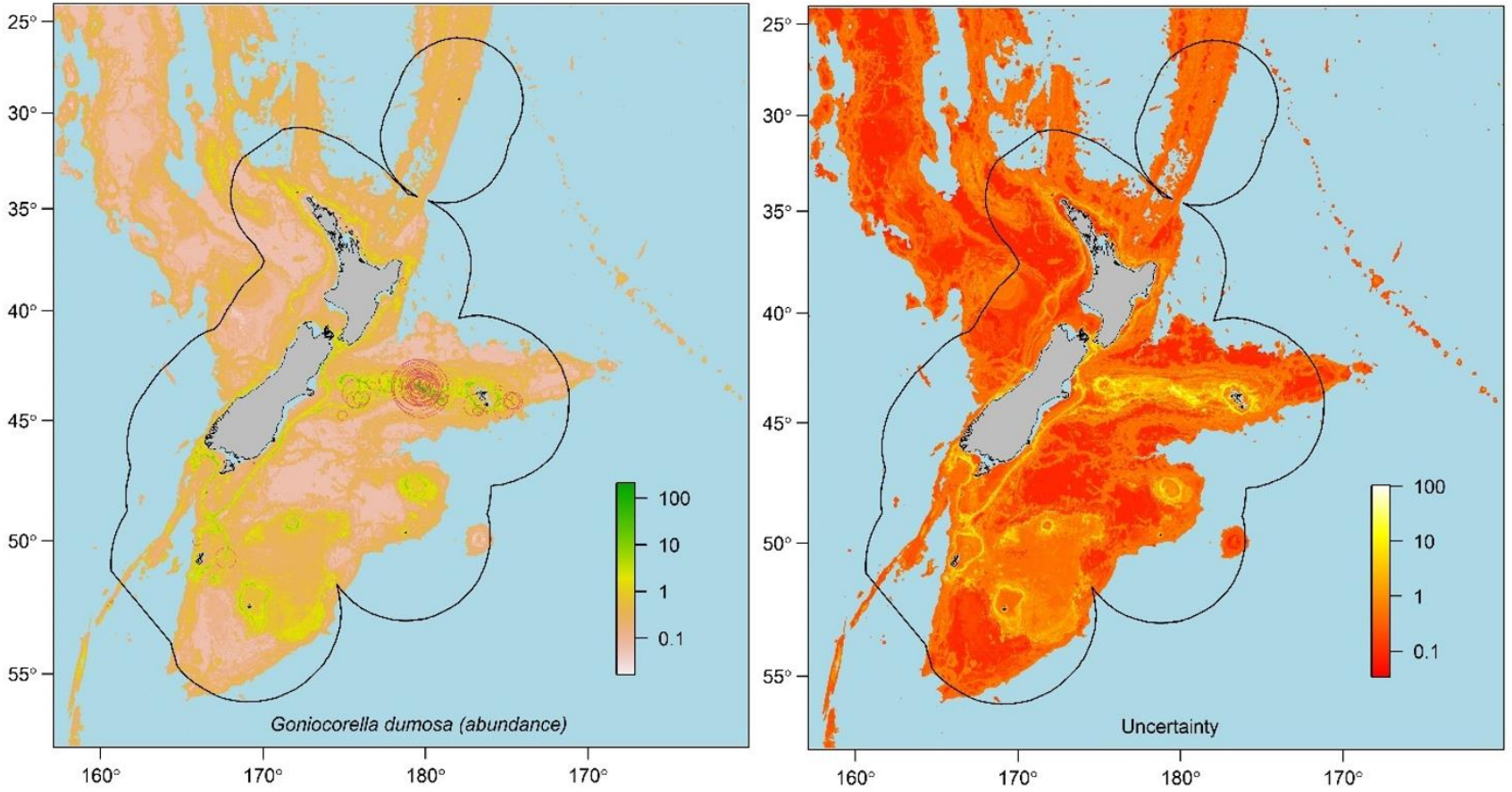


Model predictions



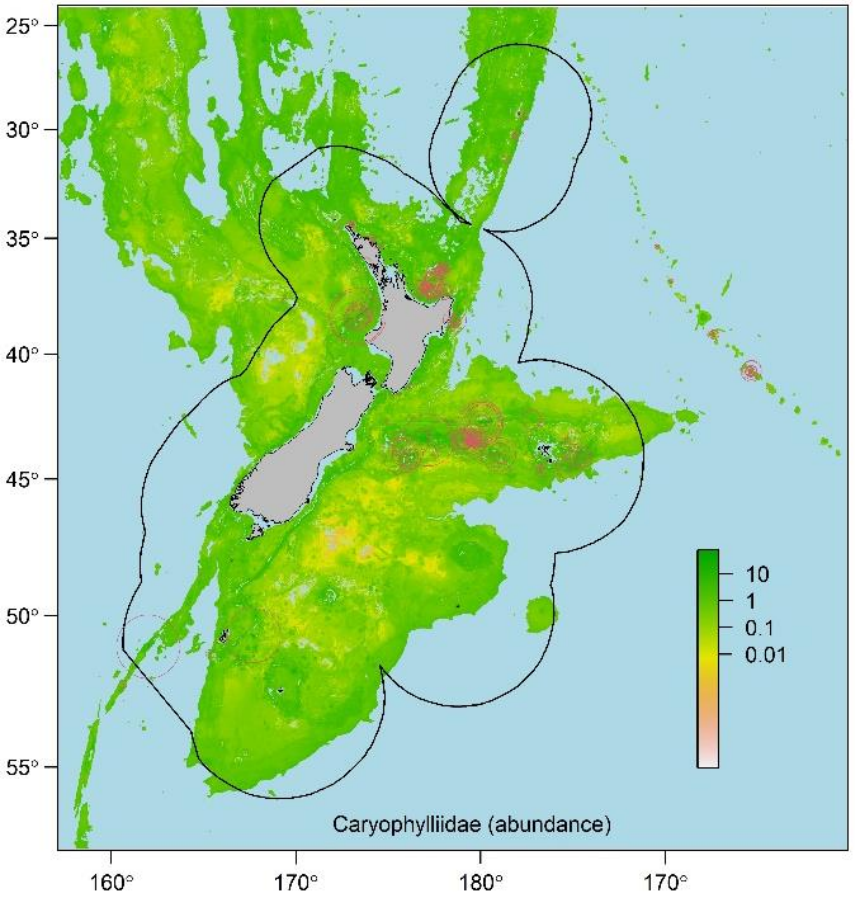
Solenosmilia variabilis. Left, predicted abundance (number of individuals per 1000 m^2); right, model uncertainty (Standard Deviation).

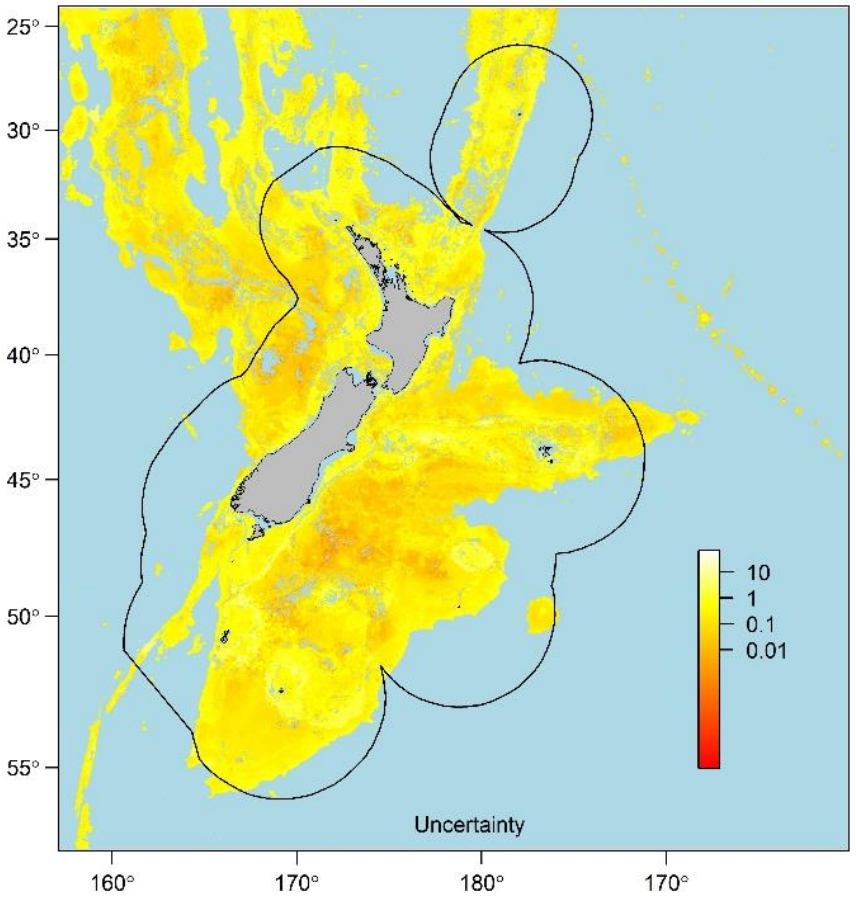
Model predictions



Goniocorella dumosa. Left, predicted abundance (number of individuals per 1000 m2); right, model uncertainty (Standard Deviation).

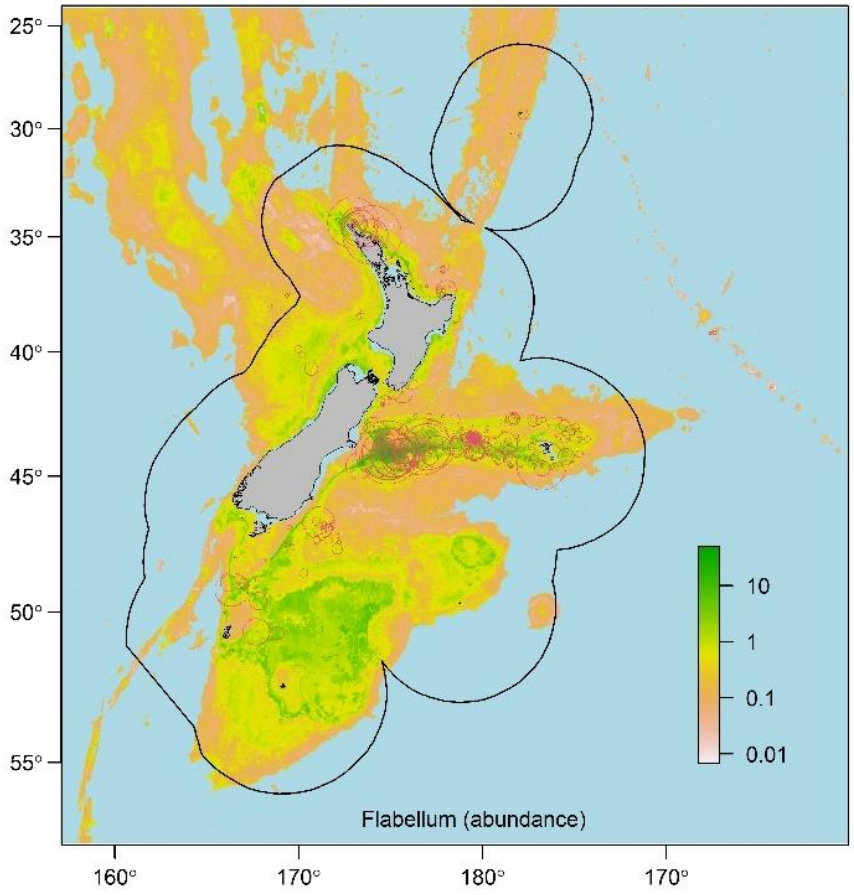
Model predictions

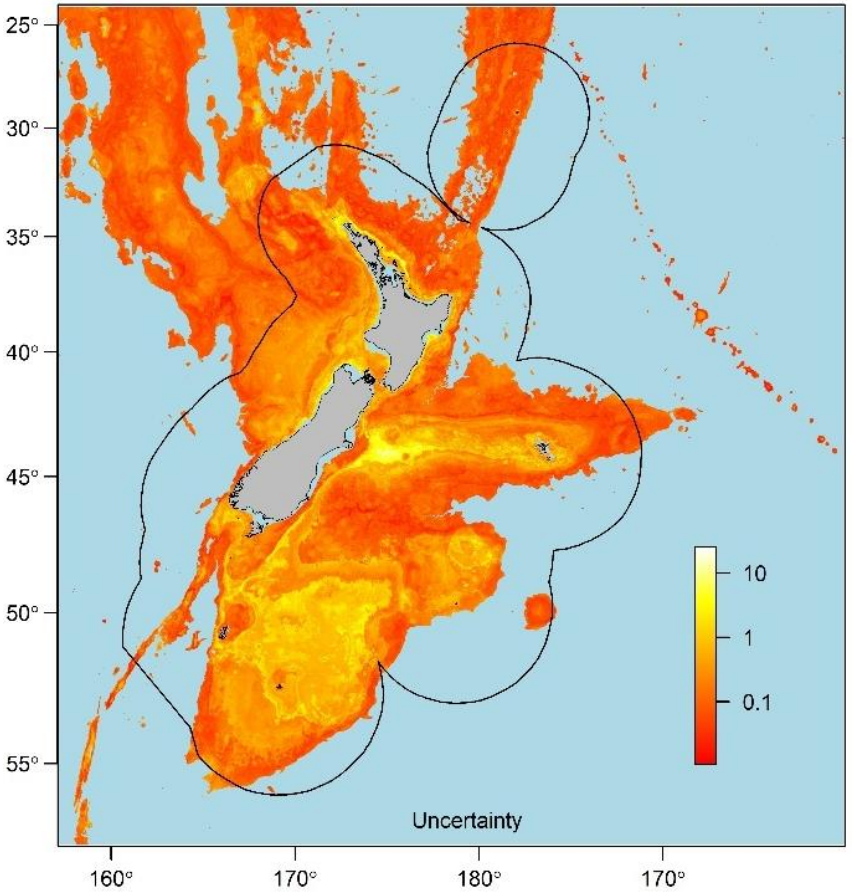




Caryophylliidae. Left, predicted abundance (number of individuals per 1000 m2); right, model uncertainty (Standard Deviation).

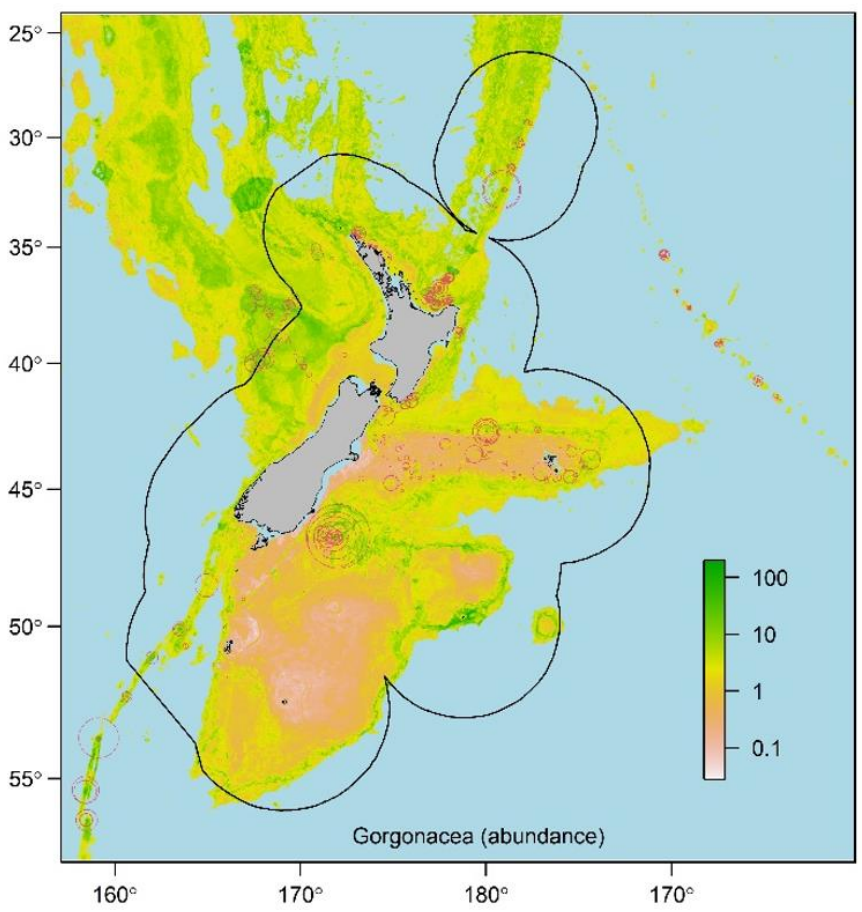
Model predictions

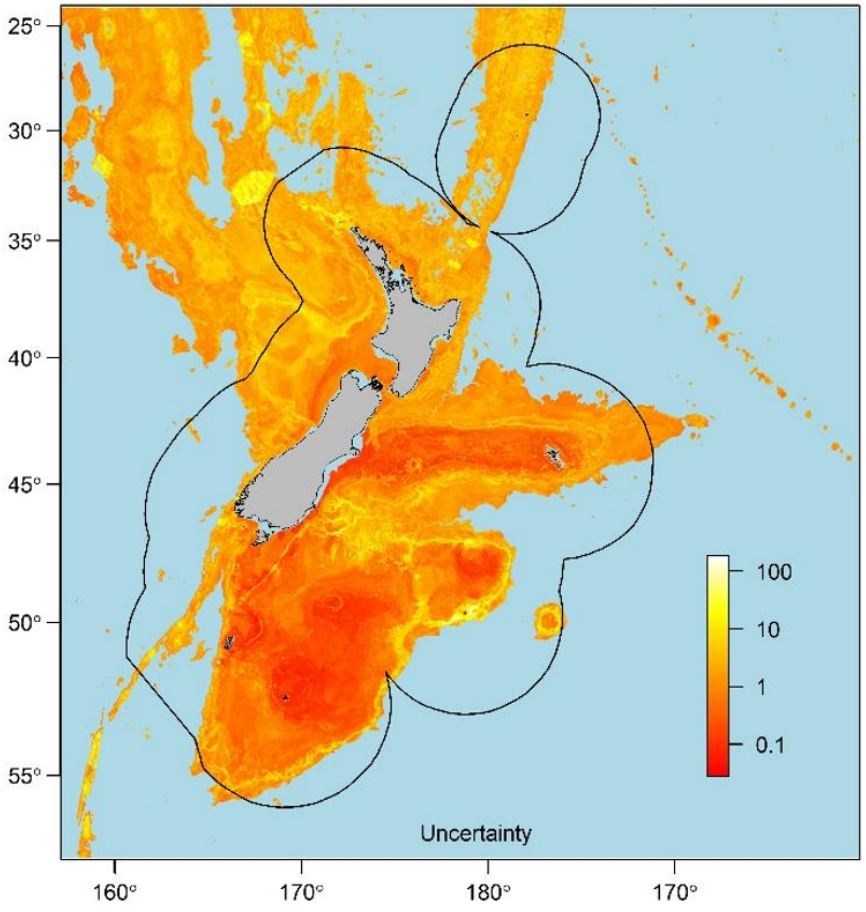




***Flabellum* spp**. Left, predicted abundance (number of individuals per 1000 m2); right, model uncertainty (Standard Deviation).

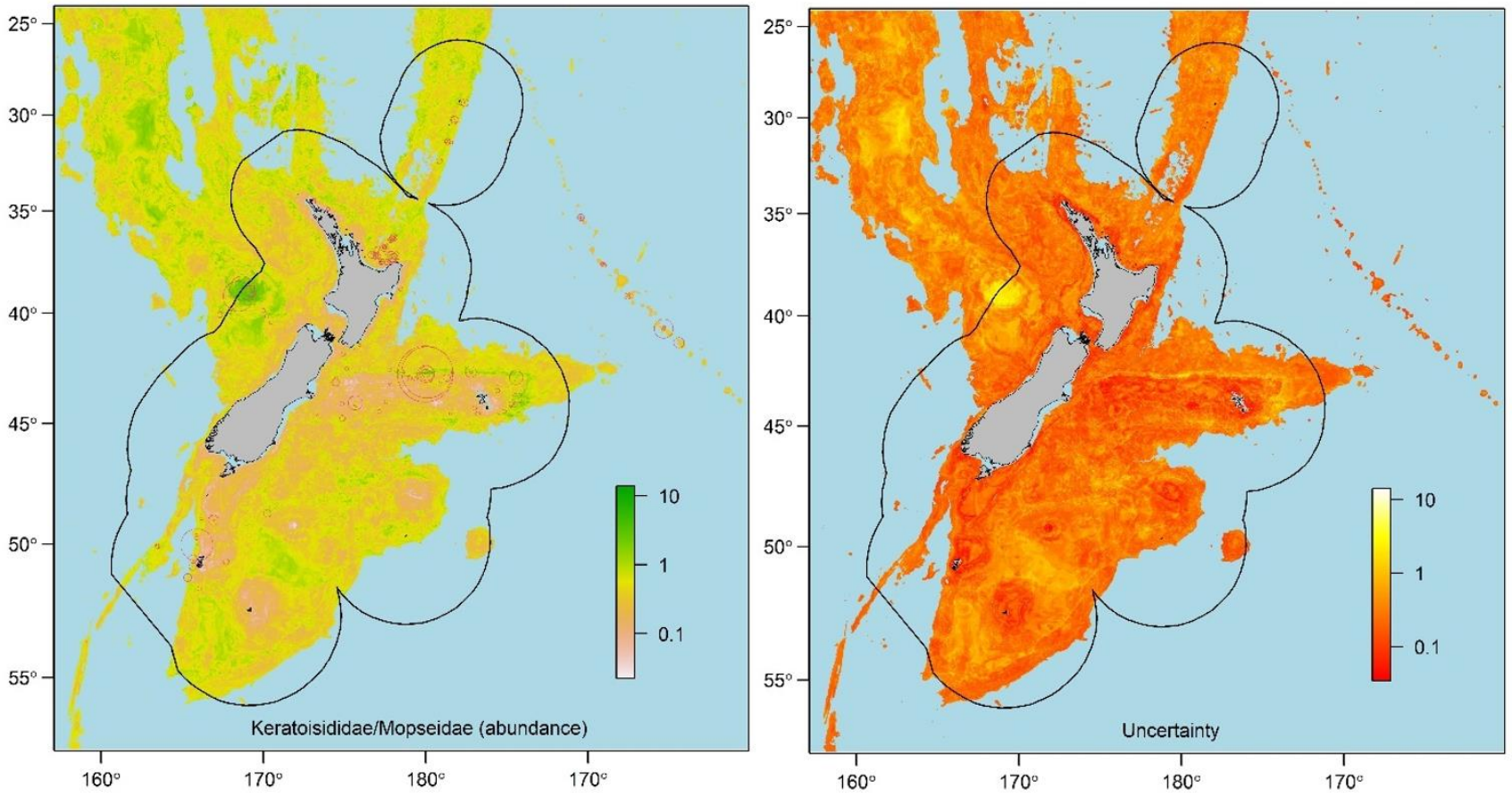
Model predictions





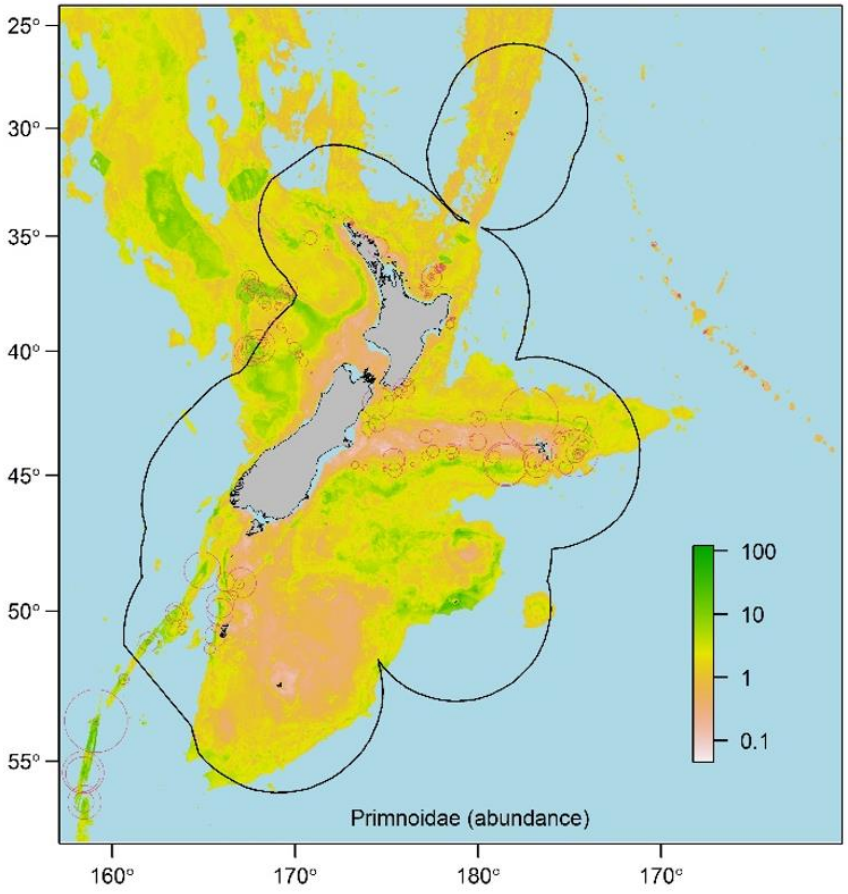
Gorgonians. Left, predicted abundance (number of individuals per 1000 m2); right, model uncertainty (Standard Deviation).

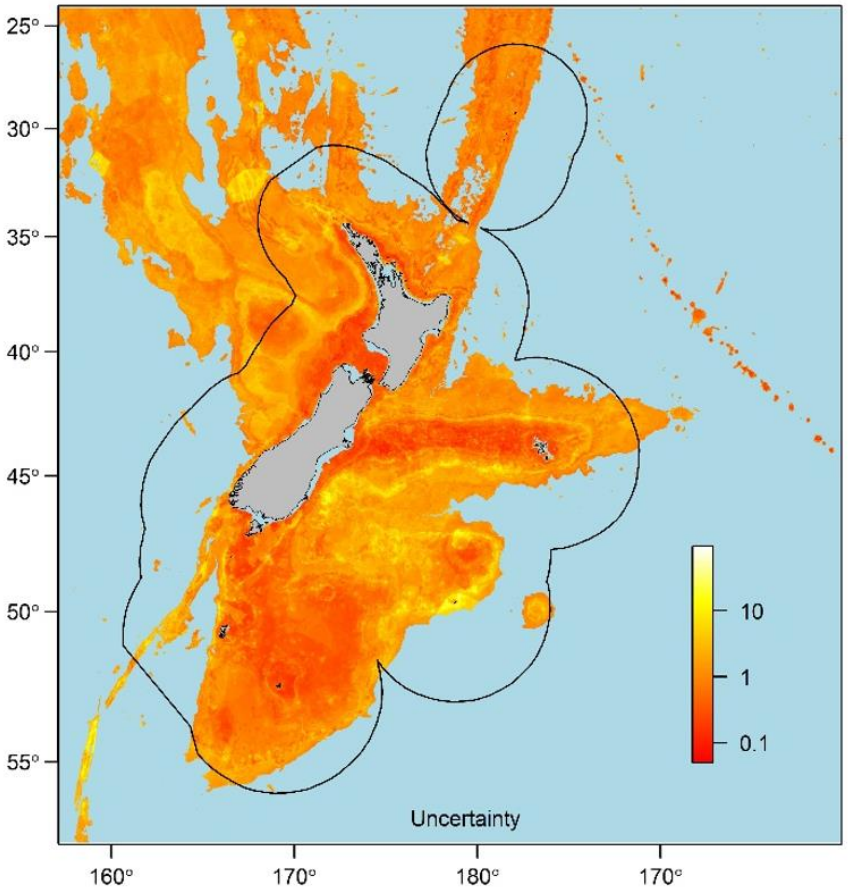
Model predictions



Keratoisididae/Mopseidae. Left, predicted abundance (number of individuals per 1000 m2); right, model uncertainty (Standard Deviation).

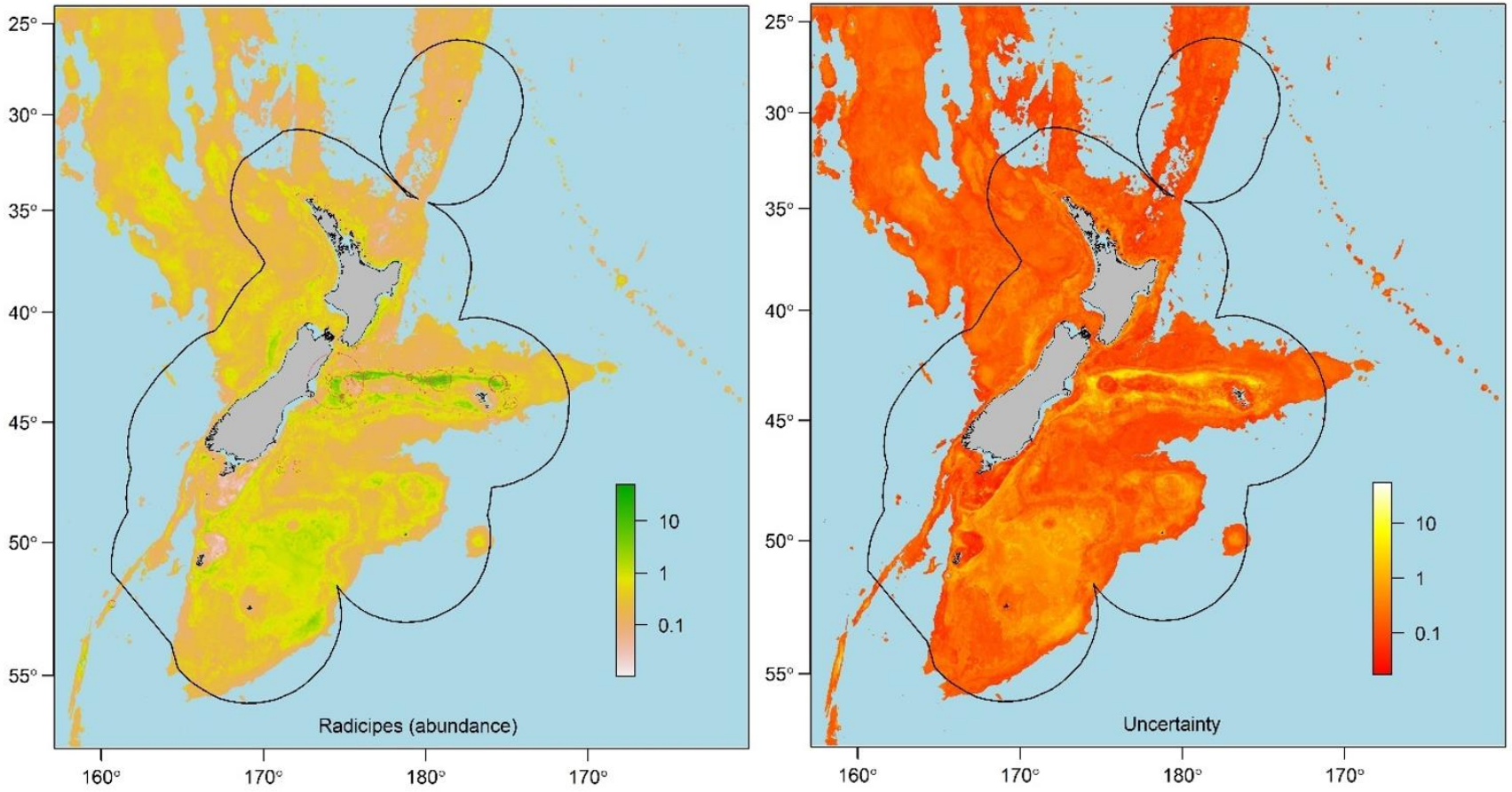
Model predictions





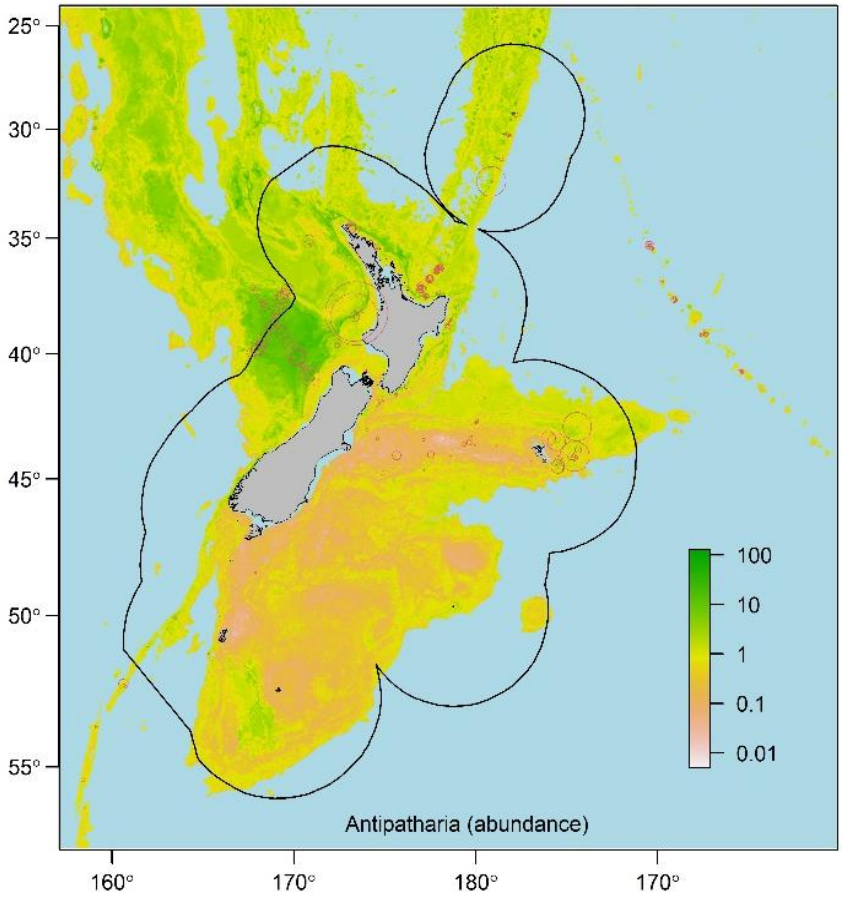
Primnoidae. Left, predicted abundance (number of individuals per 1000 m^2); right, model uncertainty (Standard Deviation).

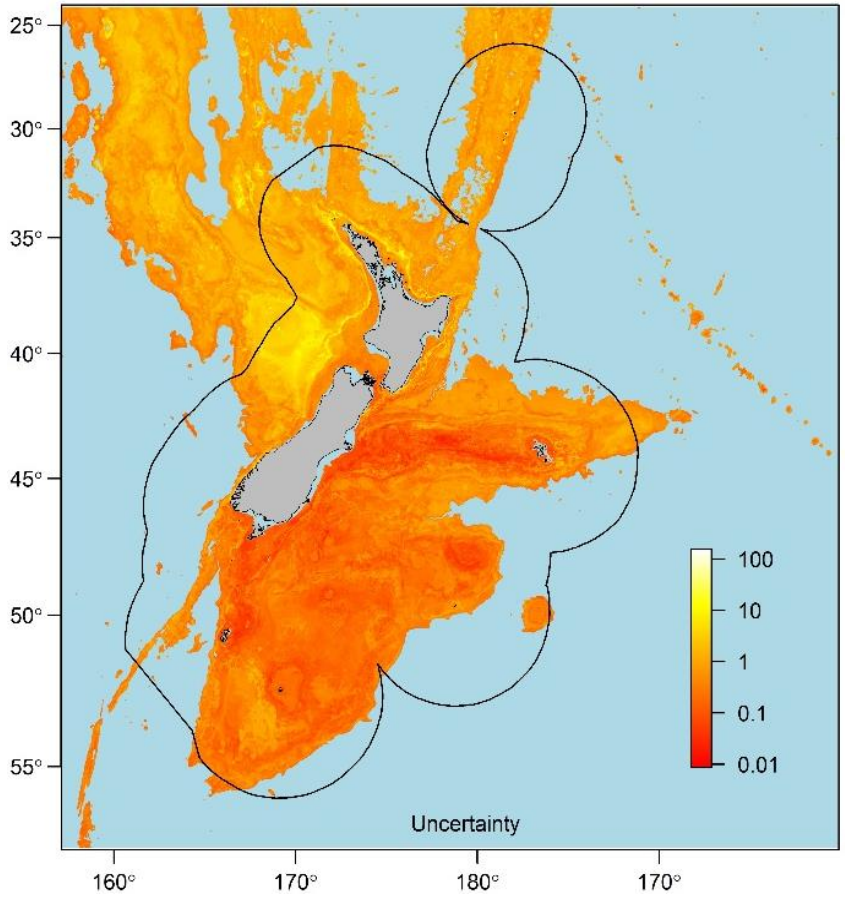
Model predictions



***Radicipes* spp**. Left, predicted abundance (number of individuals per 1000 m^2); right, model uncertainty (Standard Deviation).

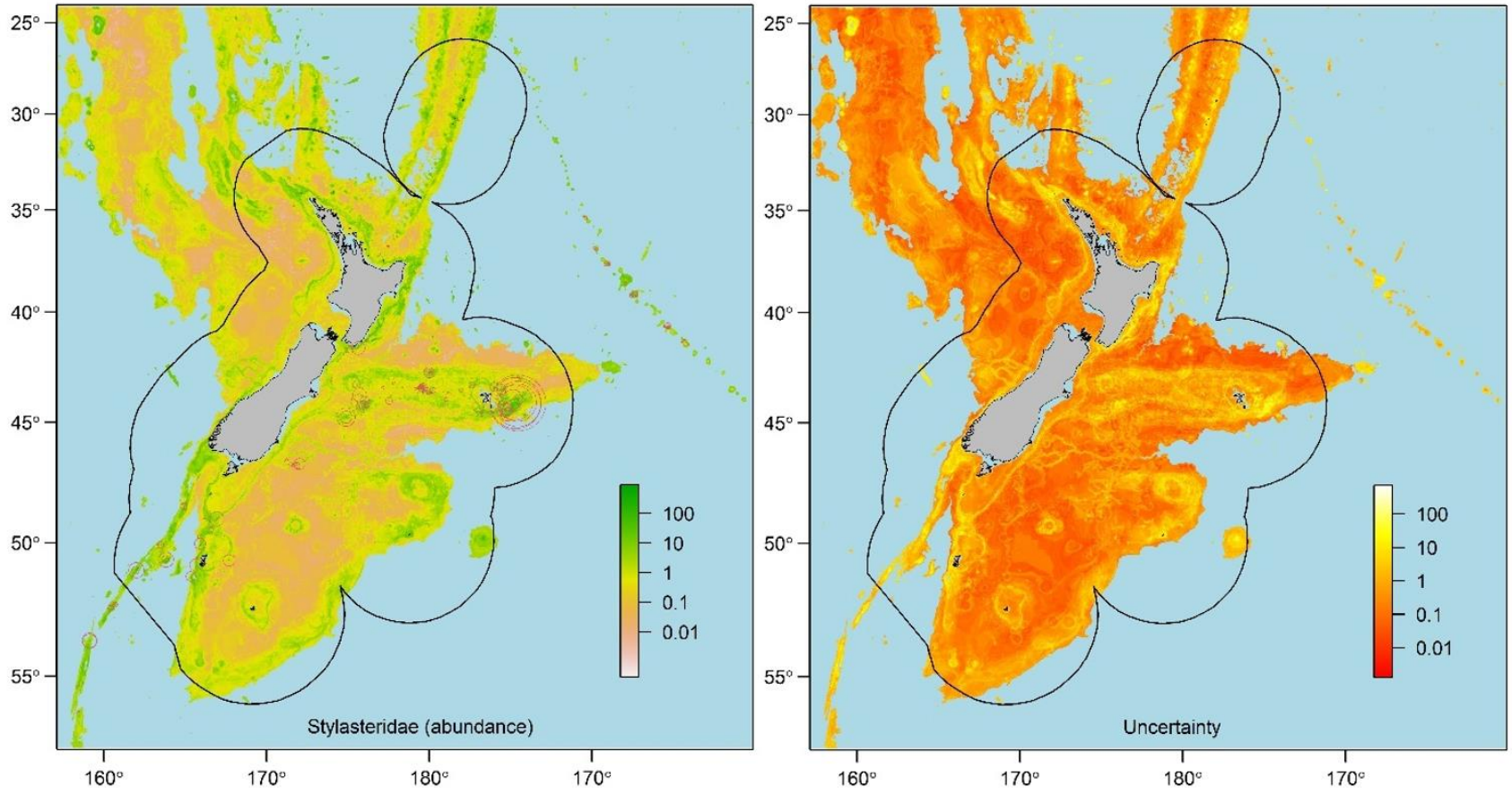
Model predictions

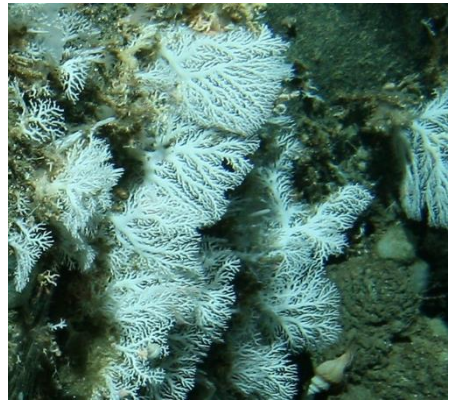




Antipatharia. Left, predicted abundance (number of individuals per 1000 m^2); right, model uncertainty (Standard Deviation).

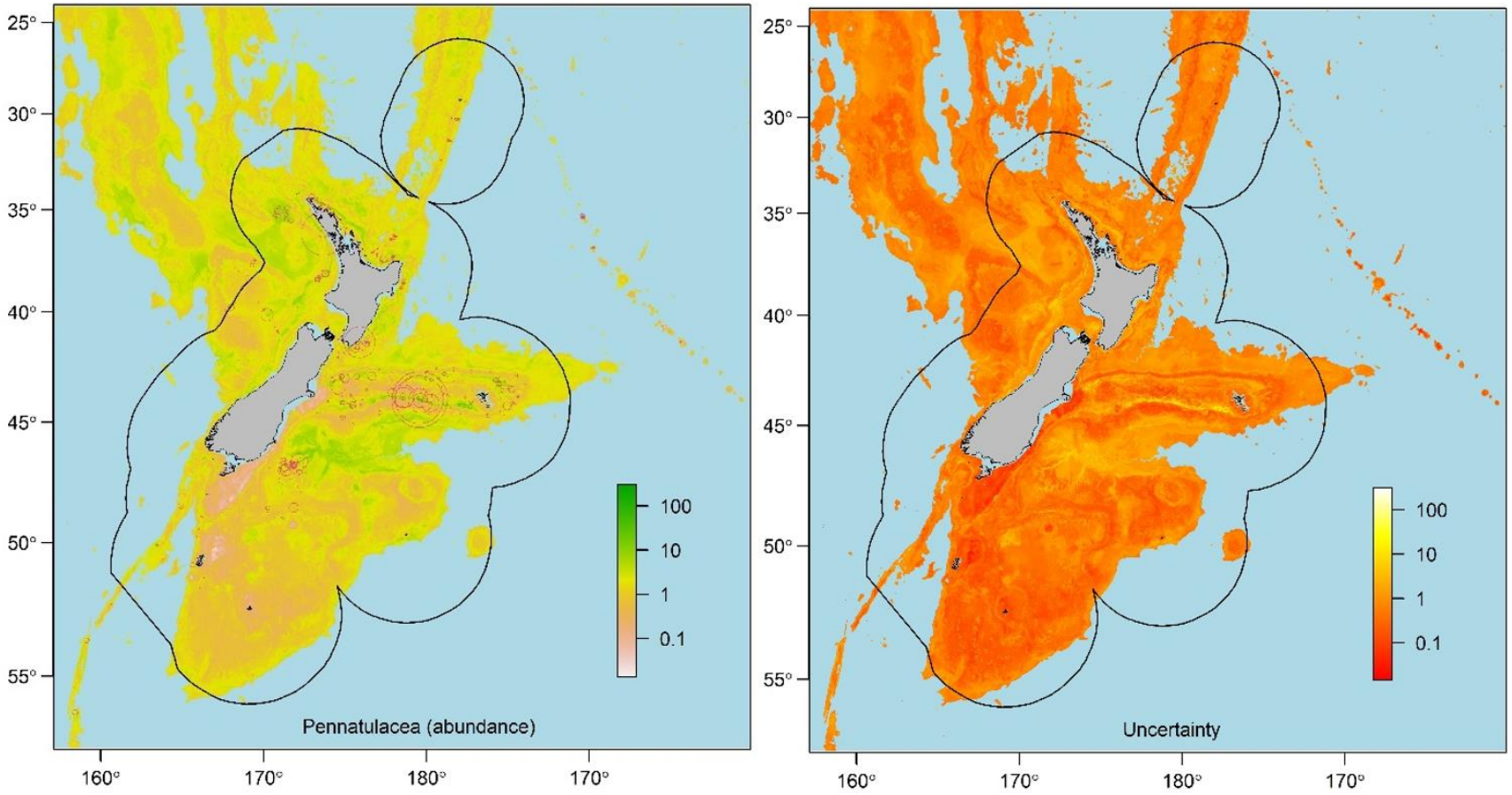
Model predictions





Stylasteridae. Left, predicted abundance (number of individuals per 1000 m^2); right, model uncertainty (Standard Deviation).

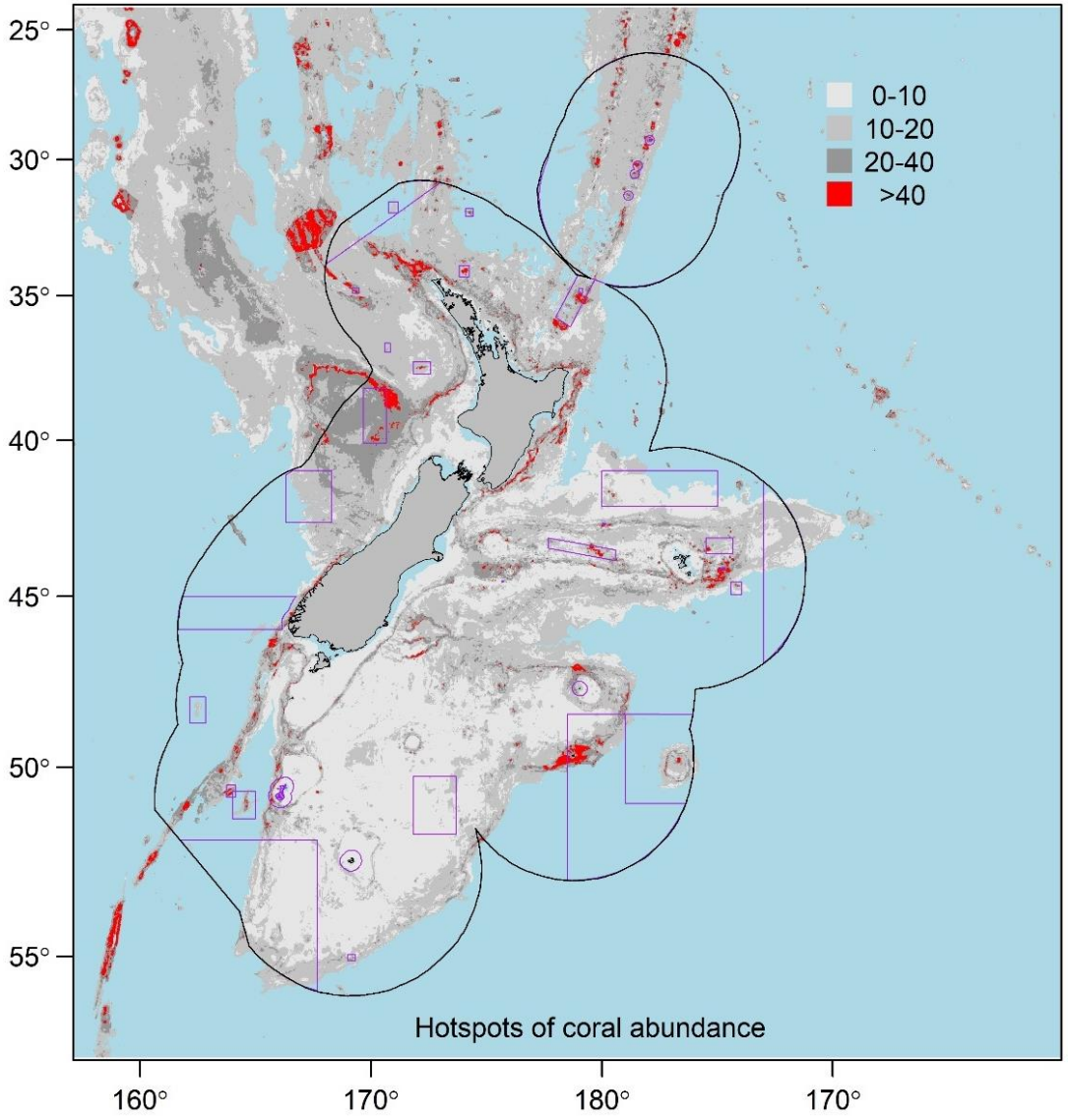
Model predictions



Pennatulacea. Left, predicted abundance (number of individuals per 1000 m2); right, model uncertainty (Standard Deviation).

Hotspots of coral distribution

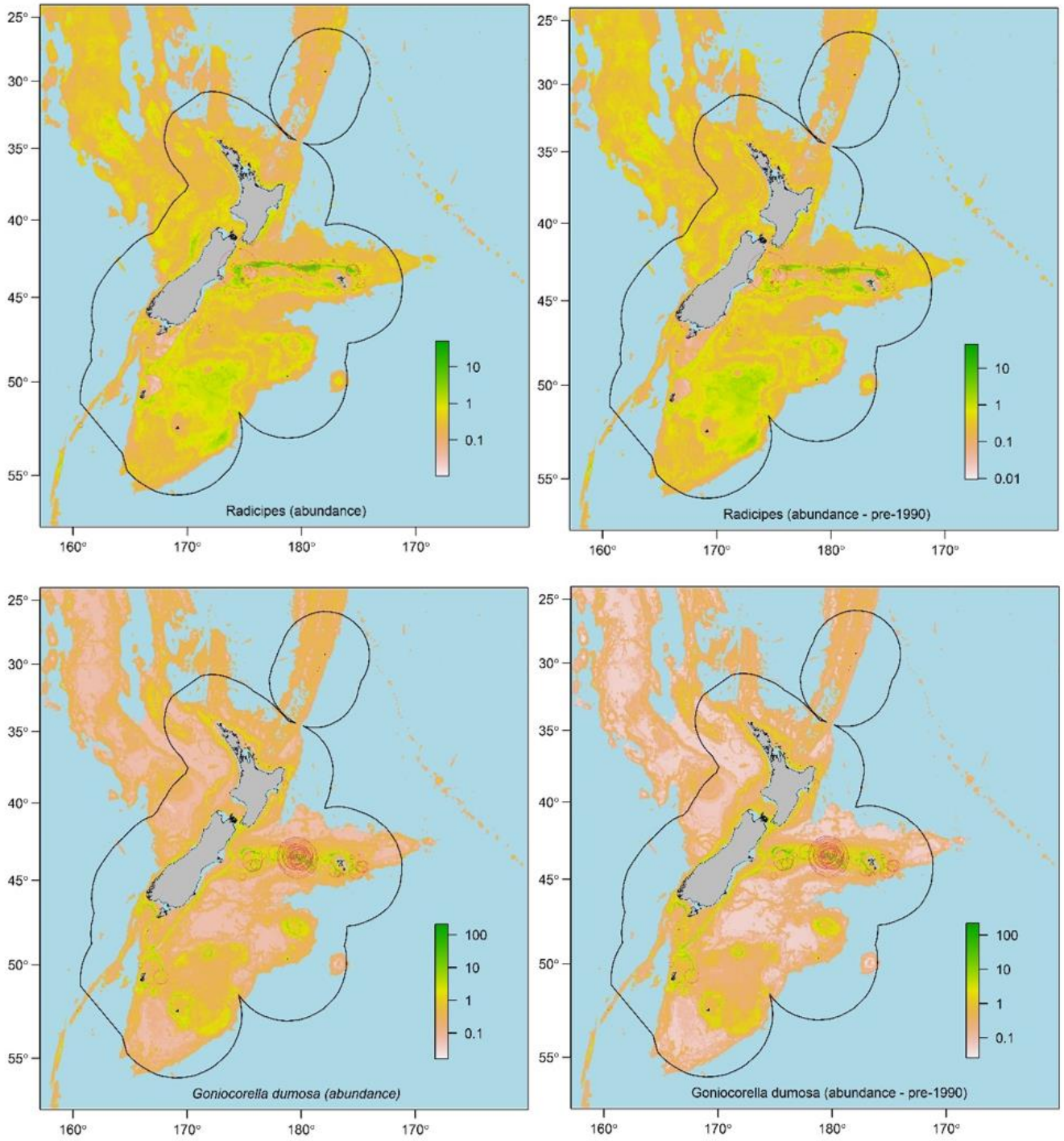
- Abundance estimates added across all eleven taxa modelled
- Map represents number of individuals per 1000 m^2
- 32% of the modelled area has abundance of less than 10 individuals per 1000 m^2
- 2% of the modelled area has abundance of over 40 individuals per 1000 m^2



Influence of fishing effort

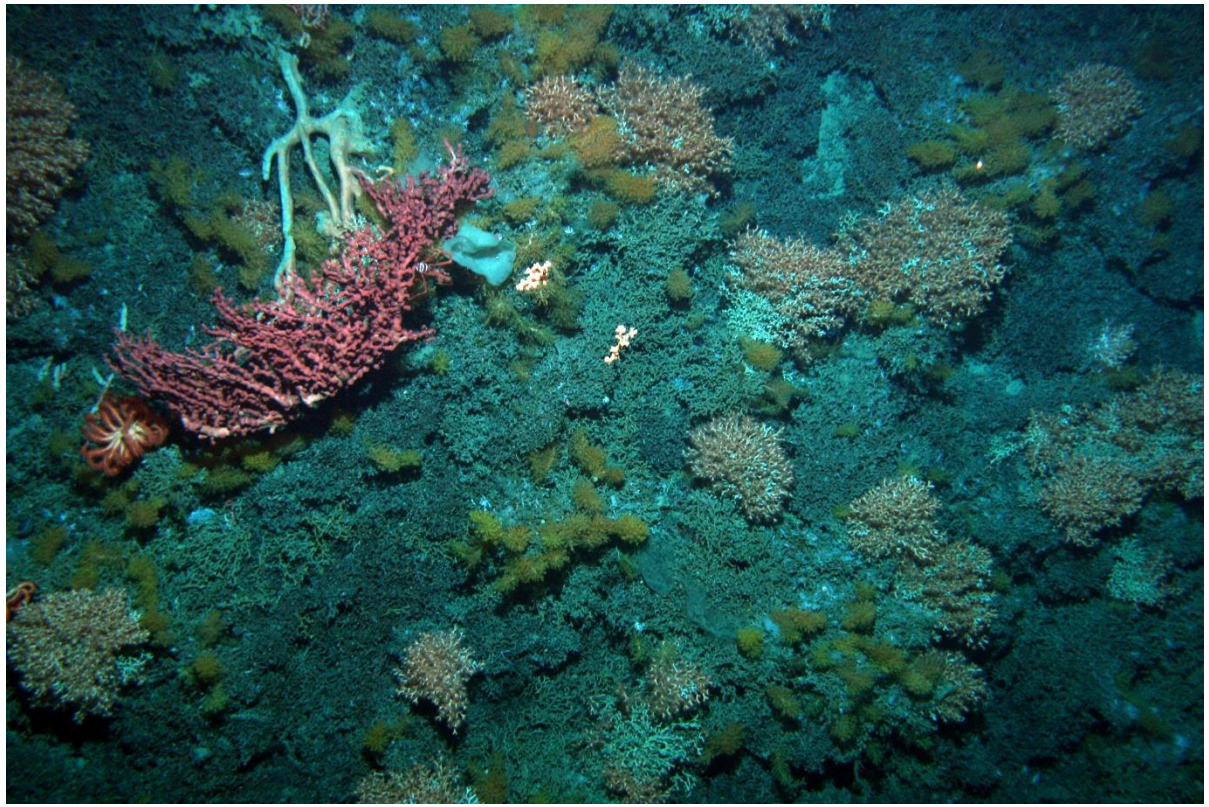
Predicting pre-1990-fishing distributions

- Fishing effort (SAR) was either excluded as a predictor or was of minor influence in models for all but two taxa
- But for *Radicipes* spp. and *Goniocorella dumosa*, SAR was the first or second ranked predictor
- For these two taxa, models were additionally fitted with SAR predictor layer set to zero
- Predicted pre-fishing distributions were very similar to post-fishing predictions
- SAR may be effectively a proxy for unknown factors that drive suitability for both commercial fisheries and corals
- The temporal spread of DTIS surveys (2007 to 2020) may insufficiently overlap that of the fishing history (1990 to 2020)



Next steps

- Build image-based abundance database by processing remaining DTIS video transects
- Gather additional sample data, especially from less sampled areas
- Further model development: other techniques, account for spatial autocorrelation
- Extend models to include other (non-coral) taxa and models for individual species as the database grows




Annual Meeting of the New Zealand
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26-28 June 2023, Wellington

Acknowledgments

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Te Papa Atawhai

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