Protected coral distribution

Observed and predicted distribution and overlap with bottom trawling in NZ waters

Baird, Tracey, Mormede, & Clark

Prepared under DOC12303 & presented at DOC TWG 27 November 2012

Project aims

Specific objective 1:
To expand recent work on identifying areas where deep sea corals are at highest risk of interactions with commercial fishing gear by using additional sources of information relevant to the distribution of corals.

Specific objective 2:
To provide recommendations on any future research required to further improve the estimation of risk to protected corals from commercial fishing

Background

1. Protected corals caught during fishing

2. Limited distribution information from fishing data – quality & quantity
    - Fishing gear not good sampling methods
    - Uneven sampling distribution
    - Detection level and identification by observers
    - Location of 'capture'

3. Broader data available re coral sampling

4. Methods developed to model species distributions — e.g., Tracey et al. (2011)

Objective 1 — The Plan

A. Consult with DOC

1. Use coral records from a range of sources over many years.

2. Explore the use of predictive modelling methods

B. Assemble dataset and describe broad distribution of corals
        plot by species and families/groups and 'functional groups'

Methodology was presented to the DOC TWG December 2011

C. Model species/groups distributions to predict probability of occurrence – large areas where no samples so use relevant environ data to identify characteristics that best represent distribution

D. Compare with fishing effort

Objective 1 — The Data

Four datasets were assembled

1. 'presence' data — locations of coral samples

2. 'absence' data — locations of sampling stations where no records exist for a specific coral order

3. GIS layers of environmental data

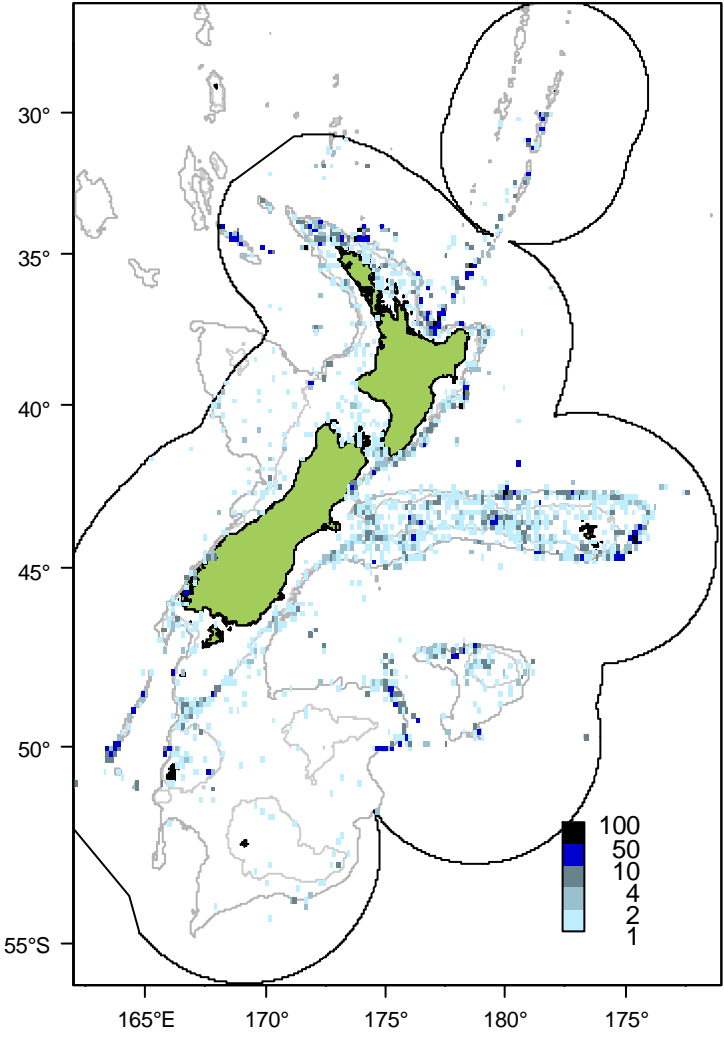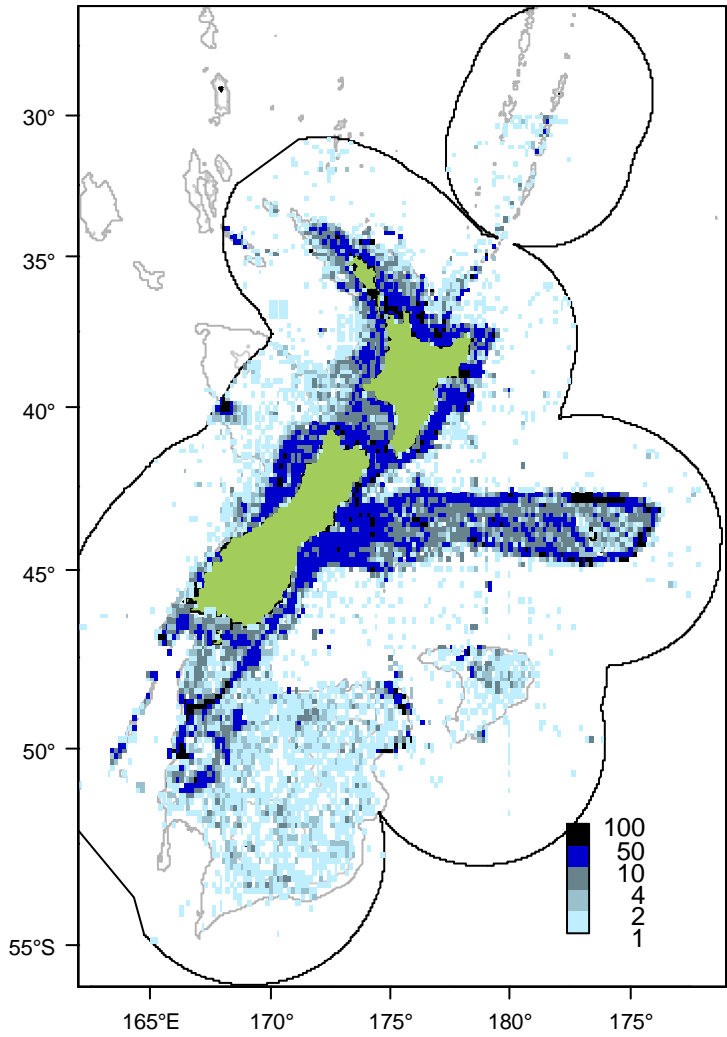4. GIS trawl footprint layers

Summary

Four protected coral orders:
1. were distributed throughout the 10 FMAs – variation in distribution within orders at lower taxonomic levels
2. had wide range of values similar to that seen in the EEZ-wide data
3. had own preferences re environment/habitat suitability
4. were predicted to have suitable habitat in generally deeper waters and areas of high relief – mostly outside areas where fishing other than for deepwater species and scampi occurs
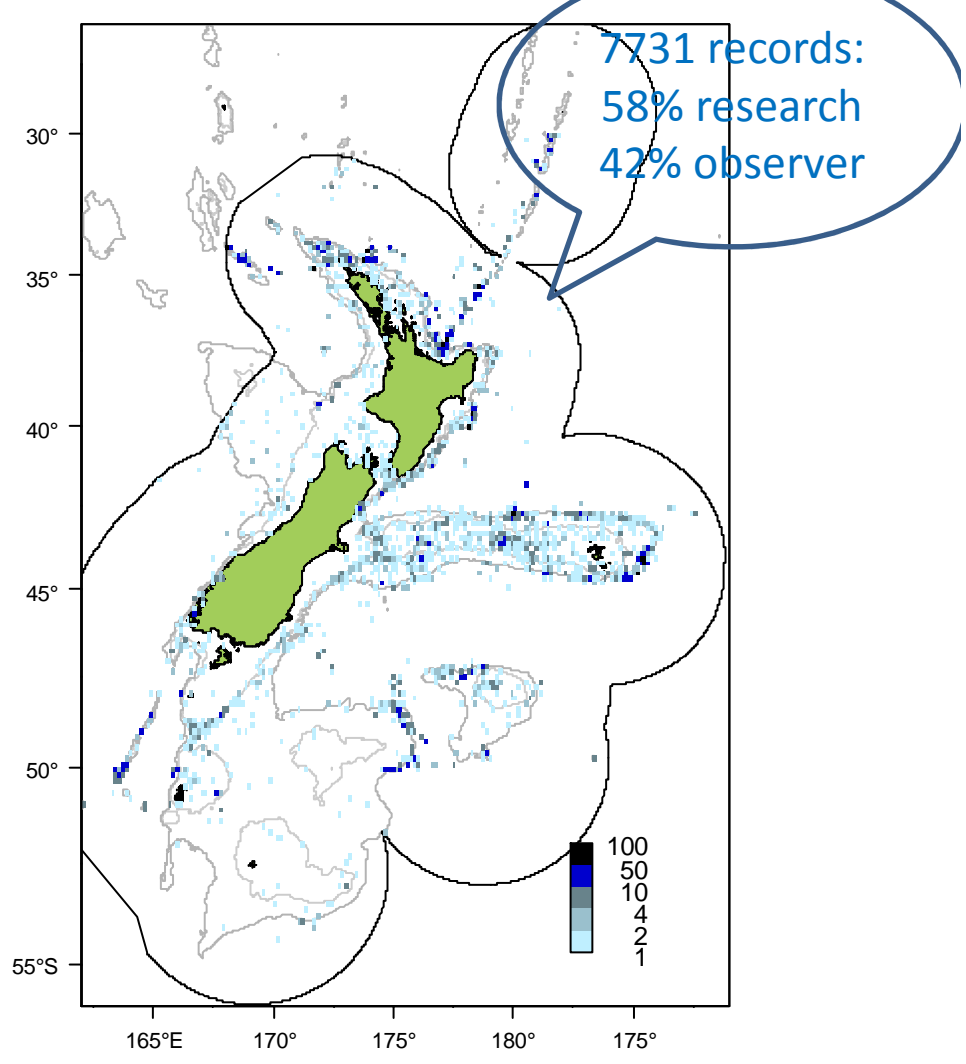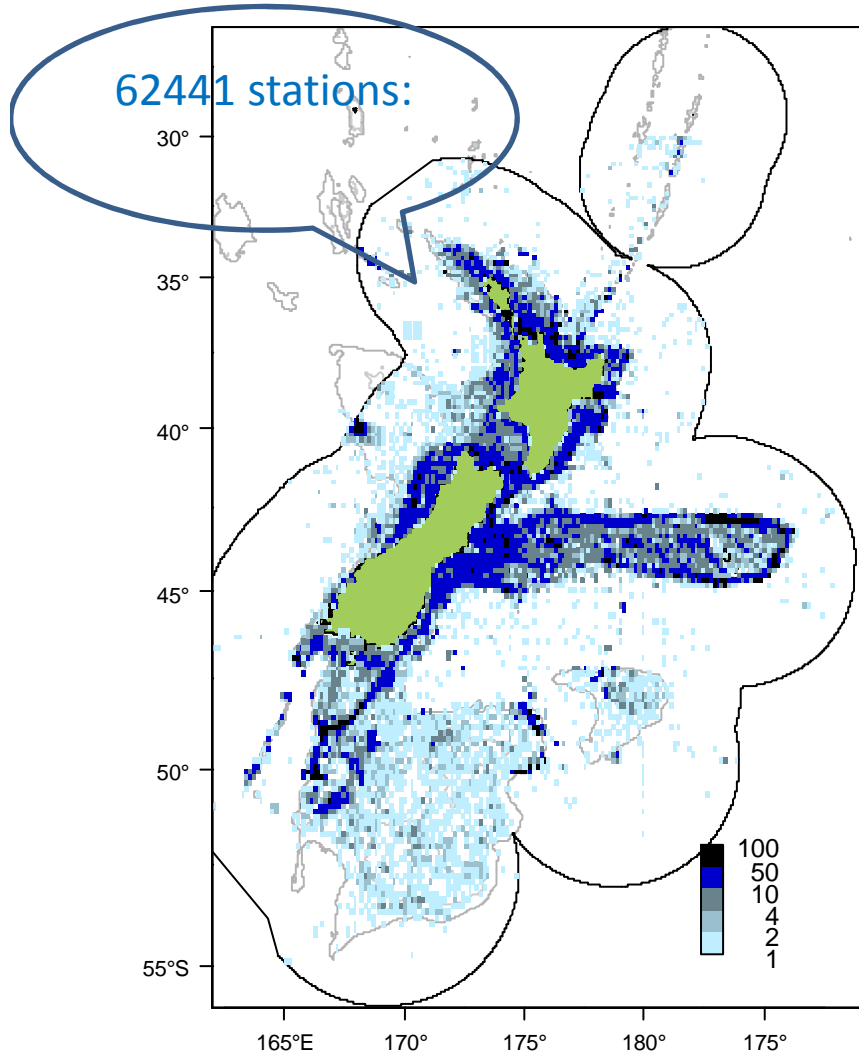
Research to inform risk assessments
1. data collection on distribution
2. coral biology and
3. inclusion of other environmental layers

Sampling station and coral location density

Sampling station and coral location density

62441 stations:

7731 records:
58% research
42% observer

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NZ protected coral records 200–2000 m

Order Anthoathecata (hydrocorals) **11%**

     1 family (Stylasteridae); 16 genera

Order Antipatharia (black corals) **10%**

     7 families; 26 genera

Order Gorgonacea (now part of Alcyonacea) **33%**

     8 families ; 57genera

Order Scleractinia (stony corals) **46%**

     15 families; 56 genera

Functional groups

In 200–2000 m n = 6965 coral records

Reef-like

Whip-like

20 cm

**3 families (10 genera)
branching stony
21%**

**1 black coral genus
2 gorgonian genera
1%**

[Table C3]

Functional groups

7 black coral families
9 gorgonian families
43%

1 hydrocoral family
13 stony cup families
29%

Tree-like

Solitary, small

[Table C3]

Environmental variables

Variable	Relevance
Depth	measure for changes in variables such as salinity, temperature, pressure, and nutrients, all of which influence the distribution of benthic organisms in the deep sea
Slope	more localised processes, especially water flow, food supply, and sedimentation plus rough proxy for substrate
Bottom temperature	influence on physiological processes such as reproduction and dispersal potential
SST gradient	location of frontal zones. Fronts are features where primary productivity can be concentrated/particulate matter flux enhanced, and which may provide barriers to larval dispersal and thereby influence species distribution patterns
Dynamic topography	relative sea surface height = proxy for surface current velocity

[see Figs B1-B3]

Environmental variables

Variable	Relevance
Tidal current speed	delineates areas where structurally strong organisms may live and where sessile organism require regular food supply
Surface primary productivity	measure of potential food source
Dissolved organic matter	measure of food availability for suspension feeding animals
Particulate organic carbon flux	measure of food availability for suspension feeding animals
Proximity to seamount	Indicator of hard substrate and good conditions

[see Figs B1-B3]

Boosted Regression Tree modelling

Modelled RS environmental data from Tracey et al. (2011)

BRT models the best relationship between coral and variables and predicts for a given set of variables

Within environmental space relevant to sampled corals and fishable depths

Model predicts only within the range of values within the response dataset

PREDICTS where a suitable habitat may exist for a given coral order — based on the available environmental variables
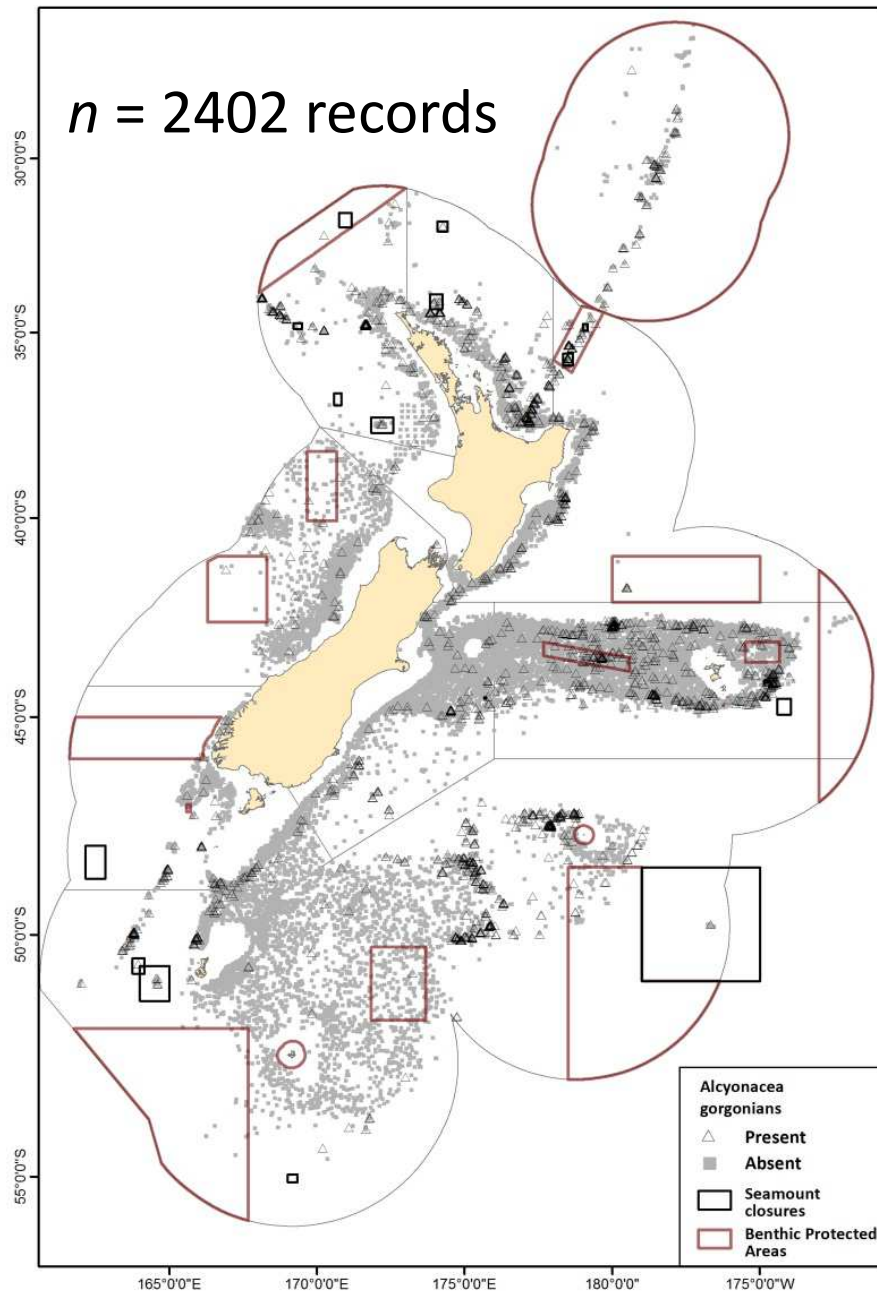
Boosted Regression Tree modelling

Uses recursive binary splits within a tree structure to explain relationship between the response and predictor variables.

Output gives relative contribution of each of the predicted variables and model estimates several cross-validation measures.

AUC = how well fitted values discriminate presences and absences

"model"	Deviance explained	AUC
Alcyonacea	0.20	0.81
Anthoathecata	0.15	0.70
Antipatharia	0.21	0.84
Scleractinia	0.16	0.76

n = 2402 records

Alcyonacea gorgonians
△ Present
▪ Absent
☐ Seamount closures
▭ Benthic Protected Areas

Order Alcyonacea (gorgonian corals)
8 families, 57 genera

SUITABLE ENVIRONMENT

Range of surface current velocity

Low particulate organic carbon flux

Relatively deeper waters
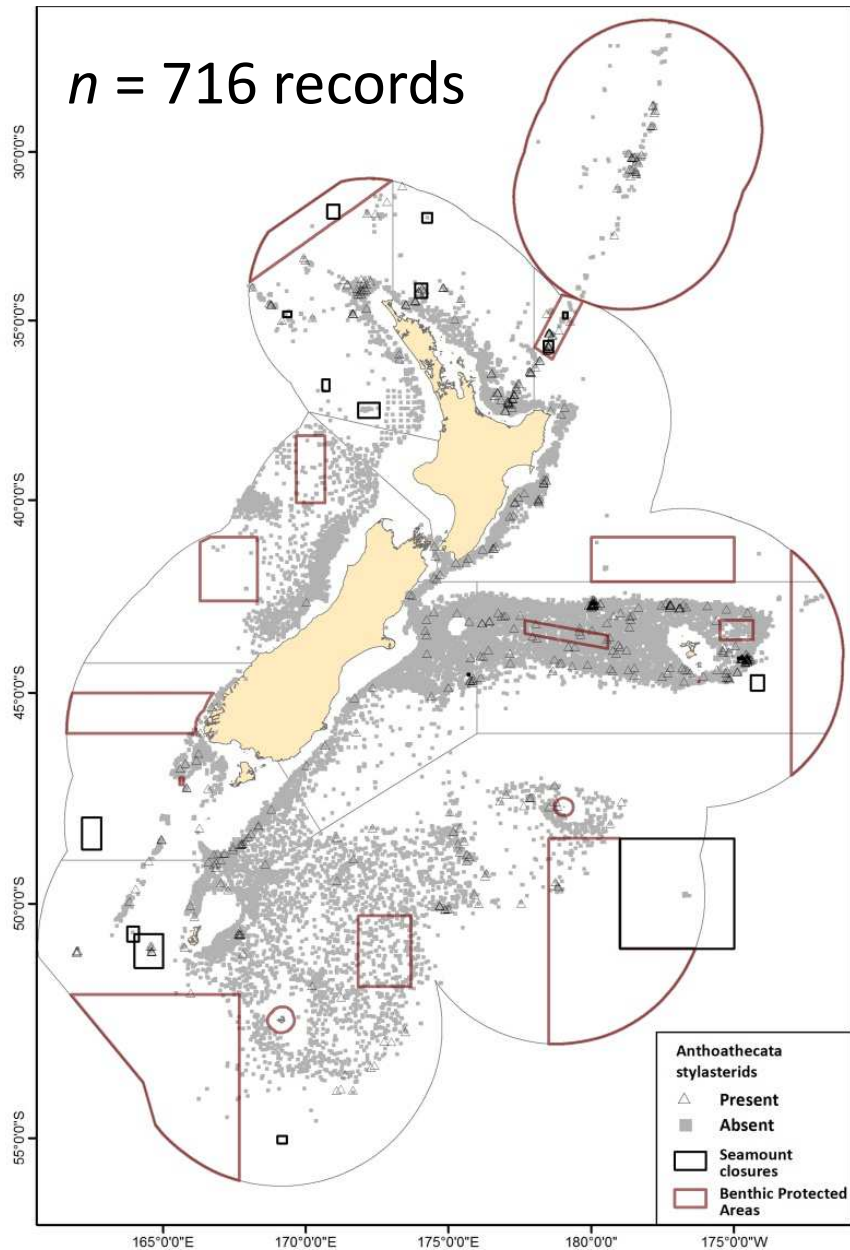
Cool and warm water masses

Relatively low levels of dissolved organic matter, primary prod & current speed

Relatively high SST gradient

Slopes up to about 22°

Strong association with seamounts

[Figs 3-3 & 3-5]

n = 716 records

Anthoathecata stylasterids
△ Present
▪ Absent
☐ Seamount closures
▭ Benthic Protected Areas

Order Anthoathecata
(F. Stylasteridae) 16 genera

SUITABLE ENVIRONMENT

Range of surface current velocity
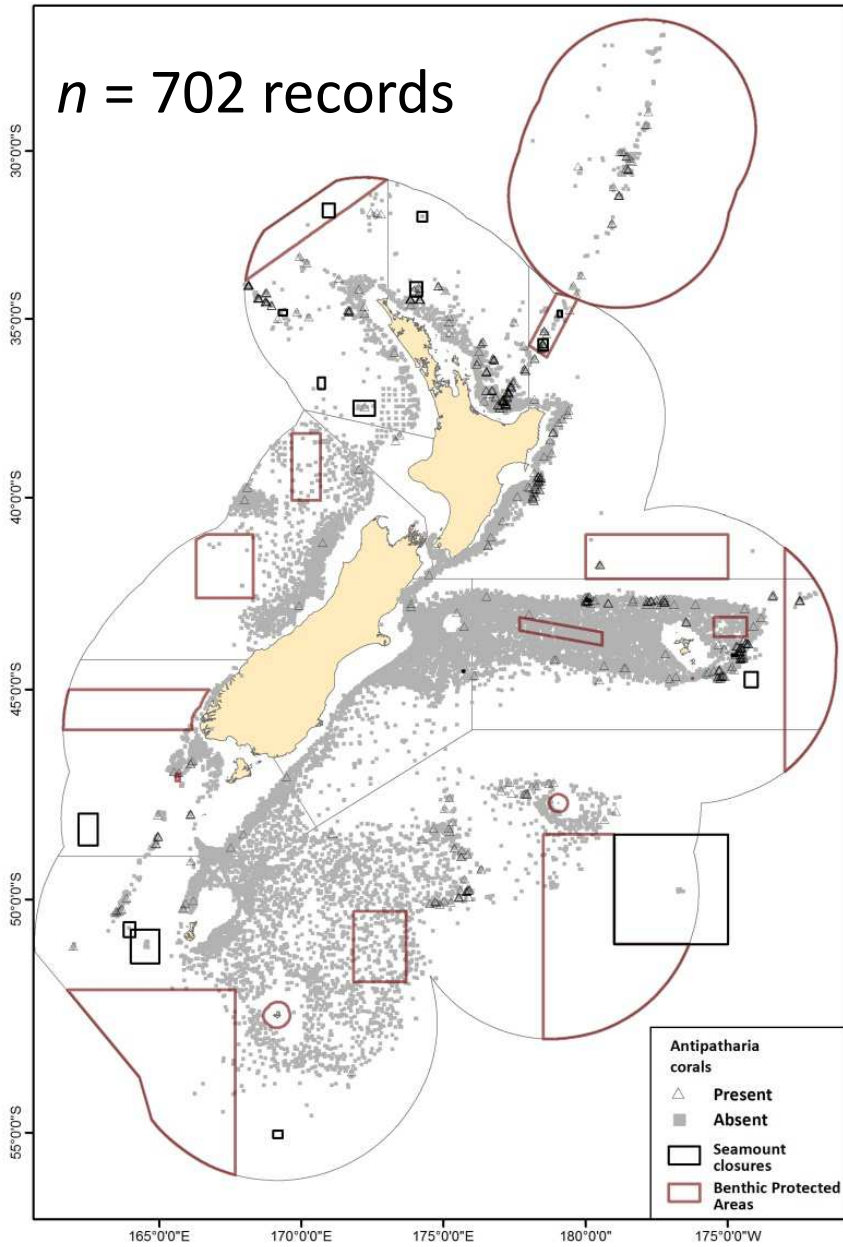
Low tidal current speed

Range water temperatures but tendency for cooler waters

Relatively low levels of dissolved organic matter & primary production

Slopes between 2° & 20°

Relatively strong association with seamounts

[Figs 3-3 & 3-5]

n = 702 records

Antipatharia corals
△ Present
■ Absent
▢ Seamount closures
▭ Benthic Protected Areas

Order Antipatharia
7 families, 26 genera

SUITABLE ENVIRONMENT

Range of surface current velocity

Low particulate organic carbon flux

Relatively deeper waters
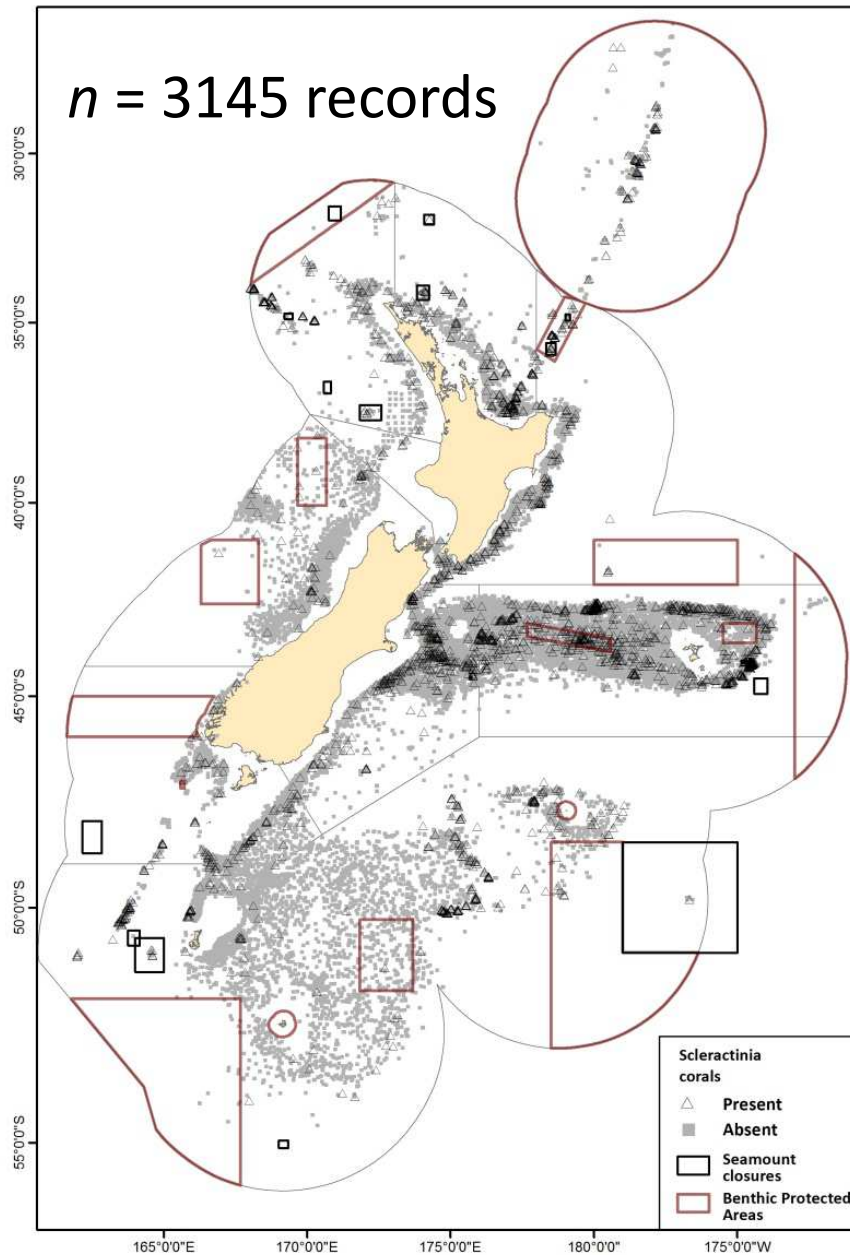
Cool and warm water masses

Relatively low levels of dissolved organic matter, primary prod & current speed

Relatively low SST gradient

Slopes between 2° & 15°

Weak association with seamounts

[Figs 3-4 & 3-6]

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n = 3145 records

Scleractinia corals
△ Present
■ Absent
▢ Seamount closures
▢ Benthic Protected Areas

Order Scleractinia
15 families, 56 genera

SUITABLE ENVIRONMENT

Low-moderate particulate organic carbon flux

Relatively low levels of dissolved organic matter, primary prod & current speed

Across all depths and water masses

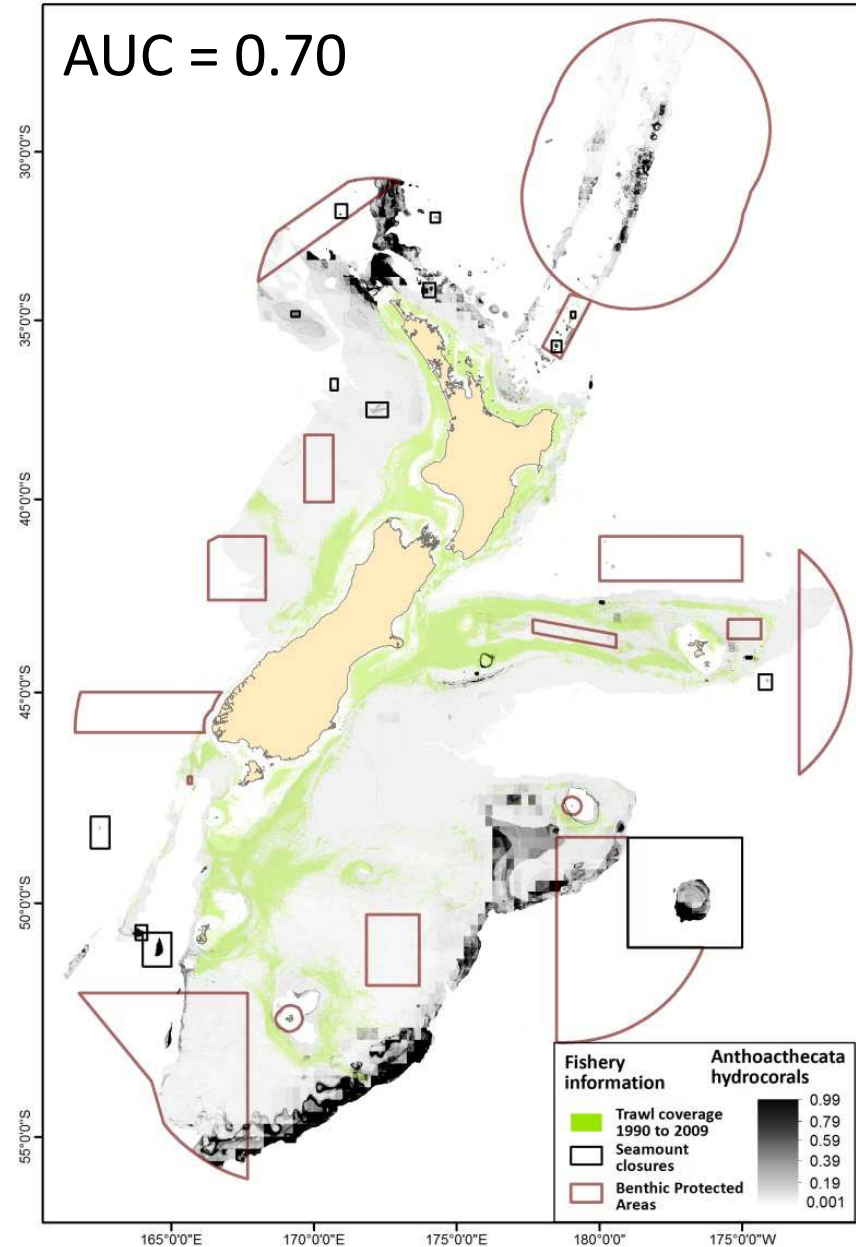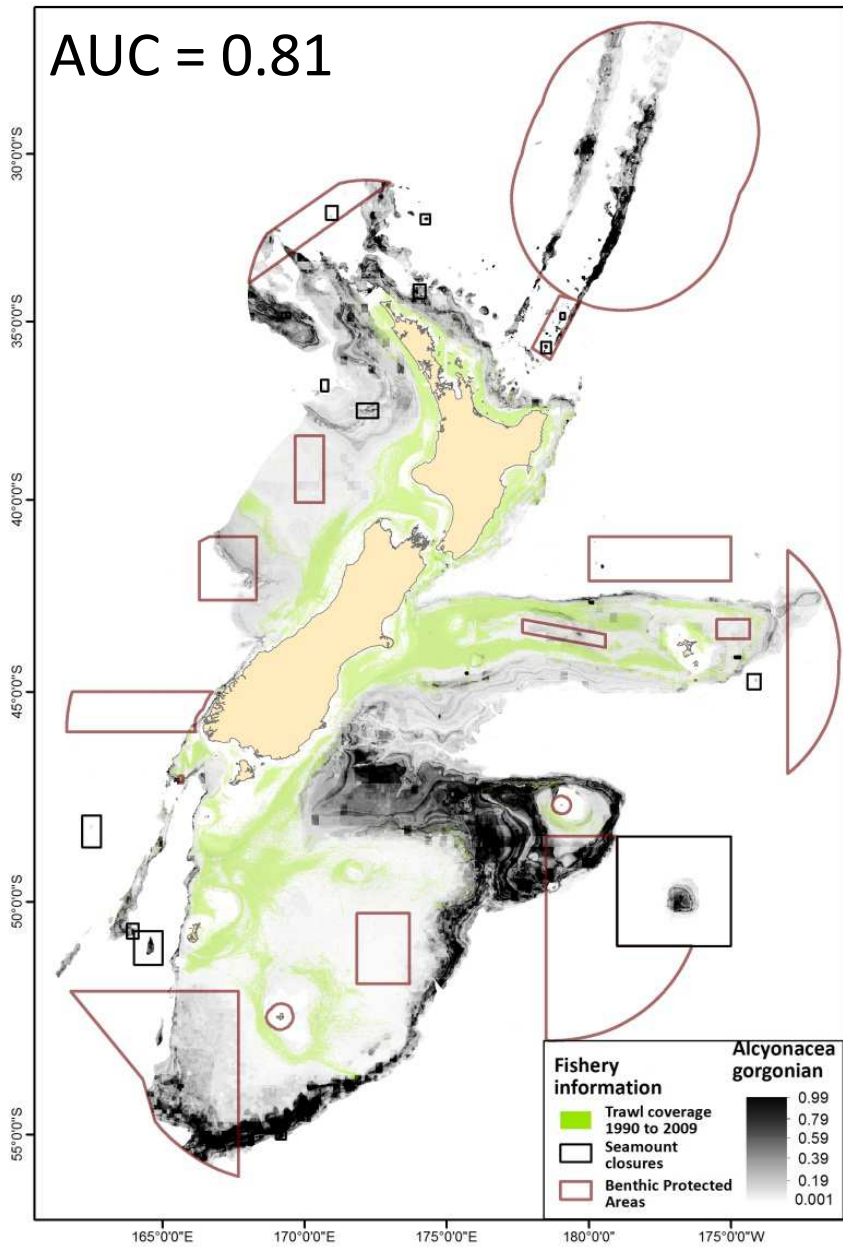Relatively low bottom temperatures

Relatively high SST gradient

Slopes between 2° & 20°

Moderate association with seamounts

[Figs 3-4 & 3-6]

Environmental variable contribution summary

Variable	Alcyonacea	Anthoathecata	Antipatharia	Scleractinia
bottom temperature	12.2	14.2	12.4	10.2
bottom tidal current	6.3	15.9	11.4	14
depth	13.9	na	10.3	11.4
dissolved organic matter	8.6	12.6	10.3	9.8
dynamic topography	20.6	23.2	17.9	10.3
particulate organic carbon flux	14.9	na	14.3	17.9
primary production	6.5	10.5	7.3	9.7
seamount	3.4	9.5	1	2.1
slope	7.6	14.1	9.2	8.3
SSTgradient	6	na	5.8	6.3

AUC = 0.81

Fishery information
- Trawl coverage 1990 to 2009
- Seamount closures
- Benthic Protected Areas

Alcyonacea gorgonian
- 0.99
- 0.79
- 0.59
- 0.39
- 0.19
- 0.001

AUC = 0.70

Fishery information
- Trawl coverage 1990 to 2009
- Seamount closures
- Benthic Protected Areas

Anthoacthecata hydrocorals
- 0.99
- 0.79
- 0.59
- 0.39
- 0.19
- 0.001

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AUC = 0.84

AUC = 0.76

Fishery information
Antipatharia

Trawl coverage 1990 to 2009
Seamount closures
Benthic Protected Areas

0.99
0.79
0.59
0.39
0.19
0.001

Fishery information
Scleractinia

Trawl coverage 1990 to 2009
Seamount closures
Benthic Protected Areas

0.99
0.79
0.59
0.39
0.19
0.001

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Fishery overlap

Observed data:

- 22% of hydrocorals, 40% of stony corals, 47% of alcyonacea gorgonians & 55% black corals
- All areas except FMA 8 & most from FMAs 4 & 6, then 1 & 9
- Mostly trawl, but also bottom longline and setnet
- Variety of target, but primarily deepwater species and scampi
- All coral orders represented in deepwater fisheries
- Mainly stony corals in middle depth fisheries – especially cup
- All orders in shallower water fisheries
- Closed areas included 27 families from 4 orders (107 genera of which 23 recorded only from those areas)

Summary

Four protected coral orders:
1. were distributed throughout the 10 FMAs – variation in distribution within orders at lower taxonomic levels
2. had wide range of environmental values similar to that seen in the EEZ-wide data & created problems in distinguishing some habitat
3. had own preferences re environment/habitat suitability
4. were predicted to have suitable habitat in generally deeper waters and areas of high relief – mostly outside areas where fishing other than for deepwater species and scampi occurs

Highlighted areas where 'new' fisheries were exploited – observer coverage of SCI on Chatham Rise and various oreo fisheries west of Bounty Platform

Summary

Model evaluation. Overall, models were moderately well estimated for each coral order.

BUT, there was a mismatch between the resolution of:
- the 'presence' data within coral orders (different sampling methods)
- the 'presence' and 'absence' data and the environmental data

AND the aggregation of all genera of a coral order meant that it was not possible to identify any distinction between individual species or genera

AND some important environmental data were not able to be incorporated into the analysis (e.g., sediment/substrate)

Recommendations for future research

Objective 2: Provide recommendations on any future research required to further improve the estimation of risk to protected corals from commercial fishing

- **General background to risk estimation within NZ with examples of possible assessment methods**

- **Recommendations on research required to fill gaps in data and/or knowledge, and to inform an Ecological Risk Assessment (ERA)**

Risk assessment

A focus on Ecological Risk Assessment (ERA) is recognised as part of routine fisheries assessments globally

Evaluation of ecological risk requires consideration of several aspects:

- Definition of risk in the relevant management context - risk to what from what

- Clear management objectives, which enable appropriate parameters to be identified, and criteria assigned to determine risk threshold levels at the resolution required to inform management

- An Ecological Risk Assessment (ERA) framework under which various methods can be applied that are tailored to the particular situation

- Adequate data to enable a sufficiently comprehensive and robust ERA

Two semi-quantitative approaches discussed:

1. The Ecological Risk Assessment for the Effects of Fishing (ERAEF)

2. New Zealand Fisheries Ecological Risk Assessment (NZ FERA)

Ecological Risk Assessment for the Effects of Fishing (ERAEF)

Australian ERAEF approach (Hobday et al. 2007, 2011)

- Incorporates Productivity-Susceptibility-Analysis (PSA)

- Clark et al. (2011) trialled method, successfully determined the relative risk to the benthic habitat (stony branching corals *S. variabilis* and *M. oculata*) on Graveyard seamounts, Chatham Rise, from bottom trawling for orange roughy

4 main factors evaluated in ERAEF approach

- Availability, Encounterability, Selectivity, and Productivity

  these describe the susceptibility of the coral habitat to trawling, and productivity of the corals

Attributes required to apply the ERAEF method

Factor & attributes	Relevant coral data
Availability	
Spatial overlap	Overlap of fishery with habitat (geography and depth)
Level of current protection	Some areas are closed
Distance to port	Areas close to port will be more accessible for fishing
Encounterability	
Depth zone	Detailed depth zonation of corals
Geographical area	Detailed geographical distribution of corals
Ruggedness	Rough terrain may mean trawling is difficult and will not occur
Selectivity	
Removability/mortality of morphotypes	Growth form of corals (erect, inflexible, delicate, rugose etc)
Reduction of faunal diversity	Species association with corals (high diversity with reef-forming, lower for solitary forms)
Special ecological value	Endemic or rare species
Biogenic habitat area	Areal extent of various biogenic taxa
Removability of substratum	
Substratum hardness	Soft substrate will not have high densities of certain coral taxa
Seabed slope	Higher levels of structural fauna and densities of filter-feeders in steep flank and summit areas
Productivity	
Regeneration of fauna	Recovery of fauna. Based on intrinsic growth and reproductive rates
Natural disturbance	Shallow corals will be subject to storm events above 100 m. Deep corals near active seamounts may be subject to catastrophic events (though rarely)
Naturalness	Historic level of trawl impact
Proximity	Surrogate for connectivity if no genetic/larval dispersal information available
Export production to seafloor	Flux of organic matter to seafloor, reflecting production potential.

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New Zealand Fisheries Ecological Risk Assessment (NZ FERA) [Clark et al. Draft to MPI under DEE201004]

- **Assesses a separate 'Habitats' component**
- **Evaluates threats of fishing activities on habitat type and habitat structure and function categories**
- **Uses data on coral distribution and productivity to determine risk on a 4-level scale**

Not as detailed as a PSA, yet focuses on the same key elements of risk from fishing

Thresholds of change determined in consultation with management agencies to ensure they are appropriate to meet the management objectives

Attributes required to apply the NZ FERA method - decision criteria

X, XX% = to be determined by MPI

Subcomponent	Consequence Category Score			
	1	2	3	4
Habitat types	No detectable impact on spatial extent of habitat type since start of fishery activity under consideration (based on catch data and MEC/BOMEC where appropriate and/or defined spatial extent)	Spatial extent of impact on habitat type no more than X% since start of fishery activity under consideration (based on catch data and MEC/BOMEC where appropriate and/or defined spatial extent)	Spatial extent of impact on habitat type no more than XX% since start of fishery activity under consideration (based on catch data and MEC/BOMEC where appropriate and/or defined spatial extent)	Spatial extent of impact on habitat type more than XX% since start of fishery activity under consideration (based on catch data and MEC/BOMEC where appropriate and/or defined spatial extent)
Habitat structure & function	No detectable change to the internal dynamics of the habitat type.	Where the spatial scale of impact on Habitat Type scores 3, or 4, there will likely be a detectable impact on habitat structure and function. Time to recover to pre-disturbed state on the scale of days to months, regardless of spatial scale.	Where the spatial scale of impact on Habitat Type scores 3, or 4, there will likely be a detectable impact on habitat structure and function. Time to recover to pre-disturbed state on the scale of years to a decade, regardless of spatial scale.	Where the spatial scale of impact on Habitat Type scores 3, or 4, there will likely be a detectable impact on habitat structure and function. Time to recover to pre-disturbed state on the scale of decades, regardless of spatial scale.

Both approaches highlighted the need for future research e.g., to obtain productivity parameters (age and growth), size and flexibility data

Research recommendations for future research to support a risk assessment

Three main areas:

A. Coral distribution

- Update and maintain protected coral dataset
- Increase observer coverage
- Improve quality of observed data
- Improve identification of protected corals

A. Update and maintain protected coral dataset

Coral data collection from commercial fisheries:

- valuable (bottom longline, setnet, and various trawl fisheries)
- extends knowledge of the spatial distribution acquired from research surveys
- provides information on depths, areas, and sampling methods in relation to coral bycatch

Recommendation:

To update database annually from data collected by research surveys and observed commercial fisheries, and summarise updates to highlight new information

A. Increase observer coverage and improve quality of observed data

Tracey et al. (2011) and Baird et al. (2012) have included the need to carry our regular training and briefings of Government Observers

This will improve the reliability of observer bycatch data used to monitor interactions with commercial fisheries

Recommendation:

To have an annual workshop on coral identification, regular briefings, and provide feedback

(e.g., quarterly summary document)

A. Improve identification of protected corals

Dataset in this study

- 51 species identified in Order Anthoathecata (stylasterid hydrocorals)

- 33 species in Order Antipatharia (black corals)

- 43 species in Order Alcyonacea (gorgonian corals)

- 101 species identified in Order Scleractinia (stony corals)

Just over 85% of all coral records were identified to family, 56% to genus, and 33% to species

Level of identification to species level would increase if samples could be returned from observed fishing in the future, and outstanding historical samples identified

Recommendation:

To carry out regular taxonomic identification of samples to update the dataset

A. Improve identification cont'd

- Identification is on-going by experts, and the output from this will contribute to database updates and to 'Special ecological value - Endemic or rare species'

    a special ecological value factor in ERA

Recently >200 black corals identified or had identifications confirmed

  ➢ Includes rare record of genus previously known only from Mauritius region
  ➢ Rare *Heteropathes* record seen for 1st time in NZ Collection

    (D. Opresko pers comm. Nov 2012)

  Accurate taxonomic identification defines better population size, where rare species are in relation to common occurrences

Research recommendations

B. Coral biology

- Collect information on coral age, growth, and structure
- Review international literature on biological parameters
- Species associations

B. Coral biology - coral age, growth

- Validated age and growth data for the region can be used to assess recovery. Some data are available:

Bamboo corals *Keratosis* and *Lepidisis*

> 7.4 mm average radius was 43 yrs old with an average radial growth rate of 0.18 mm / yr (Tracey et al. 2007)

Stony branching coral *Solenosmilia variabilis*

> Age corrected radiocarbon years, ranges from ~100 to 300 years. Linear growth rates calculated range from 0.3 to 1.3 mm/yr, it will take ~150-660 years for a colony to reach ~20 cm (conservative estimate of matrix height), and will take ~750-3000 years to build a diameter of 1 m (Neil et al. in prep)

Recommendation:

To acquire information on coral age and growth

B. Coral biology cont'd

- Size, form, and flexibility data can be used to assess the selectivity attribute of 'removeability/mortality'

Recommendation:

To collate information on coral size and form

- Genetic/larval dispersal information. As well as use of molecular data for coral identification and to complement taxonomy, genetic data also provide information to help understand connectivity and thus to determine links between corals in a particular area and "source" populations

Recommendation:

To collect samples for molecular analyses

B. Coral biology cont'd

- Species association data can be recorded on catch forms e.g., on benthic form and research forms, and in databases (*OSD*, *trawl*, biodiversity *Specify*)

Recommendation:

To revise sampling collection regime to collect data on species association

A Euryalid snake star from the Bay of Islands intertwined on a primnoid gorgonian coral. Always found commensally on gorgonian sea fan corals.

B. Coral biology cont'd

Previous recommendations will inform ERA (see Table 2, from Clark et al. 2010), and also complement the Think Tank and 3rd JCM recommendations - Ocean and Marine Workshops

JCM Action Topic 2: Deep-sea Coral Taxonomy and Data - secure funding to increase post-doctoral participation in initiatives that improve taxonomy of deep-sea corals, develop specimen-based databases and make them available publically with a view to improved understanding of deep-sea biogeography of the Pacific Basin, workshops on merging genetic and morphological taxonomy for key deep-sea coral taxa

Research recommendations
C. Additional environmental data layers

Carbonate saturation states around NZ
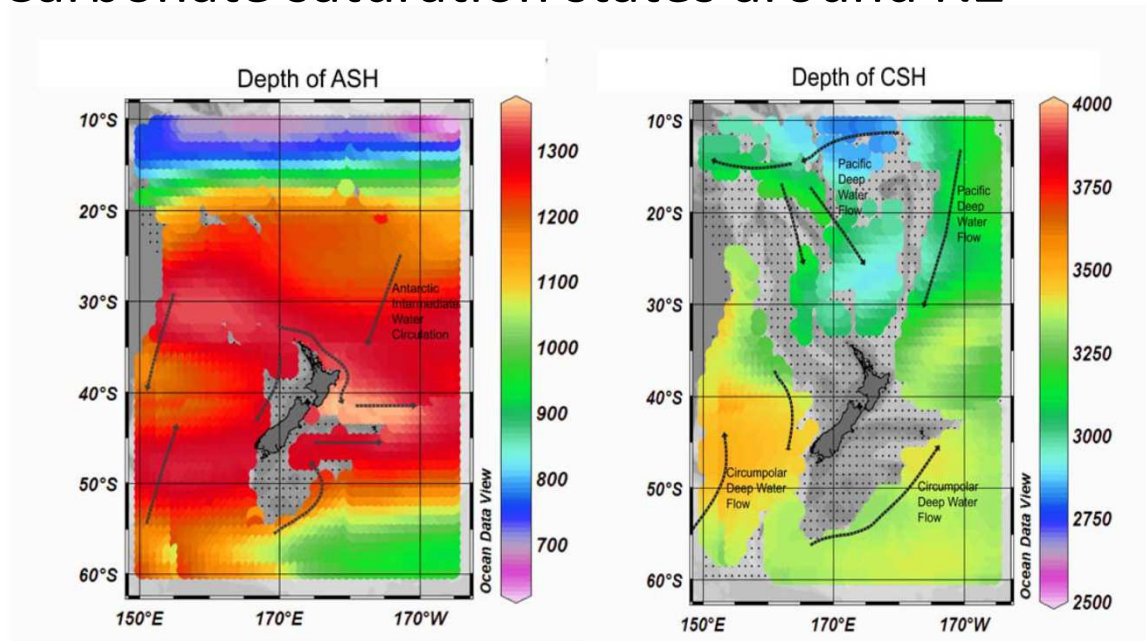
Water sampling for carbonate parameters (alkalinity and DIC (dissolved organic carbon) used to estimate ASH, CSH). On-going modelling will provide more detailed maps of saturation states
(Bostock et al. June 2013; MPI ZBD201041)

Research recommendations
C. Additional environmental data layers cont'd

- **Mineralogy data:** Knowledge of the corals mineralogy will allow us to determine if corals such as the stony branching group are restricted by the carbonate ion concentration in the intermediate and deep sea, and if they will be affected by future ocean acidification, which further reduces the aragonite saturation state.

Scleractinia branching stony corals are aragonite,
Alcyonacea gorgonian corals Mg calcite

Oculina virgosa

Research recommendations
C. Additional environmental data layers cont'd

Recommendation:

That the regional data for ASH and

**CSH made available as an additional
environmental variable to update
the coral prediction models for the
region**

Acknowledgments