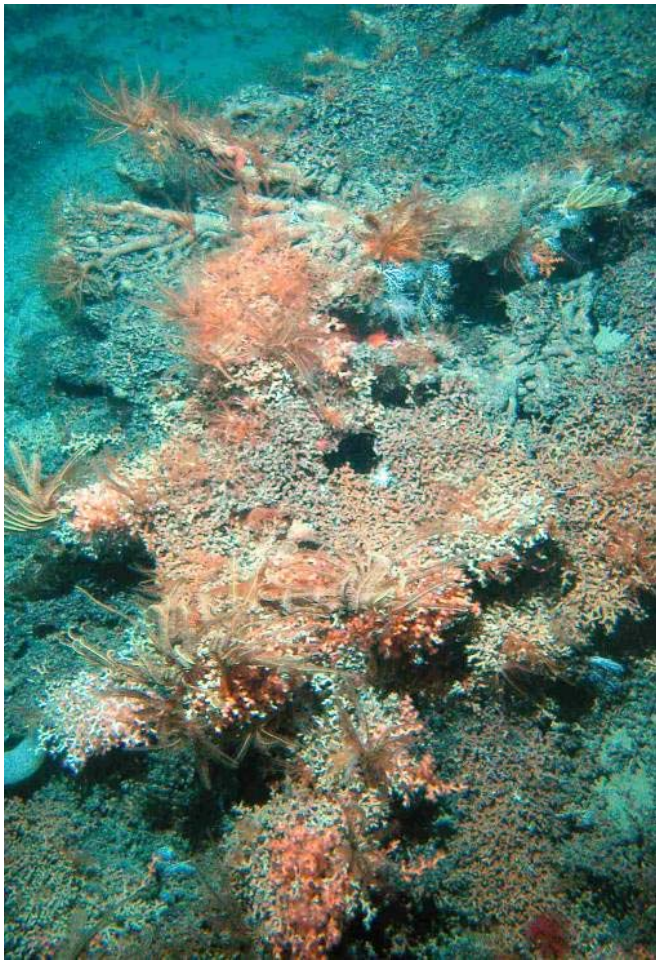
Report on the Joint Science and Technology Commission Meeting (JCM) Ocean and Marine Sciences Workshop

25 – 26 January, 2010
National Institute of Water & Atmospheric Research (NIWA)
Wellington, New Zealand.



Prepared by:
Dianne Tracey
Malcolm Clark
Mireille Consalvey
(NIWA)
& Thomas Hourigan
(NOAA)

National Marine Fisheries Service (NOAA)
National Institute of Water & Atmospheric Research (NIWA)

Contents

Ocean and Marine Sciences: Key summary and collaborative possibilities

A summary of the major outcomes of the Ocean and Marine Sciences Workshop was presented on January 26th 2010 (at Te Papa Tongarewa) by Malcolm Clark and Thomas Hourigan to the US-New Zealand Joint Commission Meeting on Science & Technology Cooperation. The practical steps that the United States (US) and New Zealand (NZ) Governments can take over the next two to three years to foster bilateral cooperation in ocean and marine sciences were outlined under three cores themes:

I. Deep-sea coral taxonomy and data

Areas for increased cooperation and activity:

(1) Improve consistency of coral taxonomy – utilizing NZ collections;
(2) Increase taxonomic capability;
(3) Improve deep-sea coral data accessibility and fill data gaps in the Pacific.

Potential collaborative activities:

(1) Workshops to improve taxonomy of key taxa;
(2) Post-graduate and post-doctoral research placements to improve training and recruitment of young taxonomists. Support (e.g. Exchange programmes, Internships with end-users).

II. Vulnerable marine ecosystems (VMEs)

Areas for increased cooperation and activity:

(1) What constitutes a VME? – Characteristics, importance and vulnerability;
(2) Where do VMEs occur? – Distribution of VMEs in the Pacific;
(3) Understand fishing impacts and develop science-based options for management.

Potential collaborative activities:

(1) Workshops and conference sessions:

- Vulnerability of Pacific Basin deep-sea communities;
- Ecosystem services provided by VME communities - PICES 2011;
- Operational Management Procedures to evaluate management alternatives and test the effectiveness of management measures (simulation modelling).

(2) Collate existing bathymetric /multibeam maps to help define VME likelihood;
(3) Support continued collaborations, data collection and analysis efforts of existing international cooperative programmes (e.g. Census of Marine Life);
(4) Complementary *in situ* studies of VME communities and gear-specific habitat impacts in the NE, Central and SW Pacific.

I&II. Deep-Sea Coral and VME Data

Potential collaborative activities:
(1) Assemble and share existing research and fishery datasets;
(2) Mobilize existing unprocessed data sets and samples;
(3) Update information on VME species distribution and association with environmental variables.

III. Habitat suitability and predictive modelling of deep-sea corals

Areas for increased cooperation and activity:
(1) Incorporate better environmental data layers (more variables and better spatial resolution) and improve access to data;
(2) Include 'connectivity' into predictive species distribution modeling efforts;
(3) Integrate modeling efforts predicting species distributions into fisheries; management (including VME process in RFMOs) and conservation;
(4) Validate predictive models (field ground-truthing).

Potential collaborative activities:
(1) Produce predictive models for VME taxa and use to assess effectiveness of VME management in the Pacific;
(2) Share access to current 'best' environmental data layers (global); Encourage/contribute to development of new environmental data layers (e,g., bathymetry) and data sources (e.g. fishing industry);
(3) Validate existing models for deep-sea corals using other data sets and field work – e.g. VME interest area – Louisville Seamounts;
(4) Joint research work to include 'connectivity' into distribution models – build on oceanography and genetics.

Obstacles and Issues

(1) No current funding specifically for collaborative research;
(2) Field research and ground-truthing of predictive modelling involves vessel time to survey an area/s – e.g. currently collaborating on a joint NZ/US proposal for submersible work;
(3) New Zealand region lacks higher technology equipment (e.g., subs, ROVs, AUVs) - importance of partnerships with US – e.g., Woods Hole/NIWA/GNS Memorandum of Understanding (MOU).

Roadmap for next 2-3 years

Aim: Better coordinate and utilize existing data, information and expertise to inform deep-sea management and conservation efforts

Activities:
(1) Establish steering committee to coordinate US/NZ cooperative activities;
(2) Implement NIWA/GNS/Woods Hole MOU and explore a broader NOAA/NIWA MOU;

(3) Targeted workshops and PICES Symposium on VMEs;
(4) Test and validate habitat suitability models for corals;
(5) Participation of scientists on research cruises;
(6) Identify specific research projects for enhanced collaboration.

Desired outcomes: Improved science and its application to enhance conservation and management of Pacific deep-sea ecosystems.

Background: Ocean and Marine Sciences Workshop

The overall theme for the Joint Science and Technology Commission Meeting (JCM) was Global Challenges – United States (US)-New Zealand (NZ) relationships. Six one –day scientific workshops were held across New Zealand: (1) Bioenergy; (2) Electrical grids and renewable energy; (3) Agriculture and food innovation; (4) Ocean and marine sciences; (5) Climate change in the Pacific; and (6) Antarctic research (25^{th} January, 2010).

The aim of each workshop was to identify potential US-NZ cooperative activities and research programs. The Ocean and marine sciences workshop was hosted by the National Institute of Water and Atmospheric Research and the themes of this workshop were:

I. Identification, Taxonomy and Core Data Sets for Deep-Sea Corals
II. Vulnerable Marine Ecosystems (Identification, ecology and conservation science)
III. Habitat suitability and Predictive Modeling of Deep-Sea Corals

Research over the last decade has revealed complex and potentially vulnerable habitats in the deep sea structured by corals and other biogenic organisms. Much of the work on deep-sea coral ecosystems has occurred in the North Atlantic, and basin wide trans-Atlantic scientific collaboration is becoming well established. In contrast, much of the Pacific remains to be explored. New Zealand the US have been leaders in much of the Pacific research completed to date, generally within our Extended Economic Zones (EEZs), providing a strong basis for future collaboration.

Discoveries of the numbers and diversity of deep sea coral fauna have led to calls for enhanced protection of these and other vulnerable marine ecosystem (VME) species in the deep sea from the impacts of bottom fishing and other human activities. For example, New Zealand and the US are participating actively in the development of new Regional Fishery Management Organizations in the Pacific to address fishing impacts, and many of the approaches to develop impact assessment standards for high seas bottom fisheries have been based on work by New Zealand scientists.

Invited participants presented under each of the themes (Appendix 1-3) and subsequently three break out groups considered each theme with a view to future exploration and collaboration. Overall the workshop provided an important venue to reinforce science collaborations started under the Census of Marine Life initiative (which ends in 2010), and pointed to new opportunities for bilateral and regional cooperation. Participants mapped out future collaborative science efforts needed to understand and conserve Pacific deep-sea coral ecosystems. The key summary and collaborative possibilities are discussed under each theme below.

Discussion of key summary and collaborative possibilities

I. Identification, Taxonomy and Core Data Sets for Deep-Sea Corals

Participants: Dianne Tracey (NZ; facilitator); Steven Cairns (US; facilitator); Isabella Cawthorn (NZ); Mark Costello (NZ) with input from Malcolm Clark (NZ) and Thomas Hourigan (US).

The Pacific region is host to a diverse deep-sea coral fauna. Reliable taxonomic identifications which are represented in centralized databases are essential to serve scientific (e.g. predictive modeling of deep-sea coral distribution, assessments of habitat suitability) and management needs (e.g. identification of vulnerable marine ecosystems). With future exploration and collaboration in mind the following aims were identified to support and progress science and management:

(1) *Improve consistency of coral taxonomy – utilizing NZ collections*: Obtaining accurate deep-sea coral identification is an international problem (e.g. inconsistencies in coral taxonomy, variation in the reliability of identifications) but not limited to this taxonomic group e.g. other key Vulnerable Marine Ecosystem (VME) invertebrate groups such as the sponges are also poorly reconciled. To improve taxonomy and further verify preliminary "at-sea" identifications of deep-sea corals, participants recommended a taxonomic workshop. In the first instance the workshop would focus on octocorals (identified as a priority for work in the Pacific region) and it was proposed that the New Zealand NIWA Invertebrate Collection (NIC) would be a suitable venue – holding a critical mass of unidentified taxa. To maximise the efficiency of such a workshop a series of "pre-workshop" tasks were identified:

- Declare standards for good practice taxonomic identification;
- Distribute tasks for two collaborative publications - due two-three years hence; (e.g. an online monograph of New Zealand corals and production of a revised identification guide for ease of use by skippers and observers at sea);
- Develop protocols for standardised, best-practice sampling methodologies;
- Compilation of data and metadata to international standards (i.e. GBIF & OBIS);
- Development of protocol for standardised habitat classification

(2) *Increase taxonomic capability:* At the regional and global scale there is both a shortage of fully trained taxonomists and an ageing population of taxonomists. To date, there has been little succession planning. Workshop participants endorsed improved training and recruitment of young taxonomists. It was proposed that we:

- Promote the relevance / applicability of taxonomy as a career
- Support post-graduate and post-doctoral research placements
- Facilitate exchange programmes between universities and science institutions (e.g. Smithsonian)
- Establish Internships with end-users of taxonomic data (e.g. MAF Biosecurity, NOAA)

(3) *Improve deep-sea coral data accessibility and fill data gaps in the Pacific*: Workshop participants identified coral data gaps in the Pacific and the need to strategically gather new data as well as tap into existing data resources. It was proposed to extend trans-Pacific collaborations with other Pacific nations in order to:

- Collect data according to *priority* data gaps;
- Identify unidentified existing data-bodies – focus on high seas relevant to Pacific and South American countries (e.g. Chile, Peru);
- Publish data to international standards (publish = open access, online – via the Global Biodiversity Information Facility GBIF).

To further develop this third aim, it was suggested a particular study area in the Pacific could be focused on (e.g. Louisville Ridge), and along with the improved identification of taxa (e.g. octocorals), results would contribute to predictive modeling efforts and studies investigating effects of ocean acidification.

II. Vulnerable Marine Ecosystems (Identification, ecology and conservation science)

Participants: Alistair Dunn (NZ); Suzie Iball (NZ); David Middleton (NZ); Steve Parker (NZ; facilitator); Andrew Penney (NZ); Allison Reed (US); Robert Stone (US; facilitator), Richard Templar (NZ) with input from Malcolm Clark (NZ) and Thomas Hourigan US).

Considerable research is needed to inform and support management measures to protect fragile benthic organisms such as corals and sponges from significant impacts due to bottom fishing activities. This issue is of great importance to marine science in both New Zealand and the United States, and has significant implications for management of high seas resources. The workshop participants identified high priority research areas and developed collaborative opportunities to address these information needs utilizing the scientific capabilities and infrastructure currently available in the United States and New Zealand. Research topics identified for future collaboration follow four main themes.

(1) *What constitutes a VME? VMEs* are typically dominated by organisms with life history characteristics such as longevity, slow growth rates, low reproductive output and recruitment rates. Research is needed to understand how these characteristics drive vulnerability in benthic ecosystems at both small and large spatial scales. Understanding how these organisms respond to disturbance and which factors influence recovery dynamics will be important to include in developing management options.

(2) *Where do VMEs occur?* Few areas of the Pacific Ocean have been investigated to document the presence or absence of vulnerable communities, especially in high seas areas. Observations of fishery bycatch often provide the only data on the potential distribution of various species, yet these data are not generally available. These data need to be brought together and carefully analysed so that areas that likely support VMEs can be identified. These analyses can also be used to develop future sampling

methodologies to enhance our knowledge of VME distribution. Developing the highest resolution bathymetric maps, and identifying high priority sites for reconnaissance will be key outputs from such a collaborative research programme and will link directly with the other themes of the workshop- coral taxonomy and developing predictive models of coral distributions. This goal will build on current efforts underway through the Census of Marine Life Programme.

(3) *What are the best approaches to manage impacts to VMEs?* Two main approaches to manage impacts to VMEs have been utilized to date: the use of representative spatial closures to avoid impacts, or modeling the impacts of fishing disturbance on VMEs and then subsequently modeling the effectiveness of imposing various management rules such as reduced fishing effort, changes in spatial distribution of effort, or periodic closures on the overall impact on VME distribution and abundance. These two approaches are obviously inter-related and both require a great deal of scientific input to ensure actual VME impacts are not significant. A productive way forward would be to begin to specify, through scientific collaboration, the main drivers of VME dynamics, response to disturbance, and potential for recovery. This exercise would be done for representative faunal groups, with the most vulnerable likely to drive the subsequent management response. There are significant challenges in this endeavor, as it requires adequate knowledge of many factors including life history and distribution of vulnerable species, recovery dynamics, behaviour of the fisheries, and the development of operation management procedures in order to simulate how the ecosystem may respond to fishing under certain rules.

(4) *How can we develop bycatch thresholds and move-on rules that are ecologically based?* In addition to developing a management approach, scientific input is needed to develop ecologically meaningful move-on rules for fishing that occurs in areas where VME distributions are unknown. The development of appropriate bycatch threshold levels for particular gear types is critical to this goal and requires a comprehensive understanding of fishing gear performance (footprint and mechanisms of interaction with various taxa), species or taxon-level selectivity (what is impacted on the bottom) and catchability (bycatch), and the potential mortality resulting from an impact. This effort will require gear-specific habitat impact studies that will often be region and fishery specific. Knowledge of the scale of impacts, species composition, VME patch size and overall patch density (number of patches per unit area) is needed to inform the development of appropriate move-on rule distances and conditions. Attaining this goal will require major field studies, but the findings will have broad application since real-time monitoring of impacts to VMEs from fisheries in the high seas is a pressing management need globally.

III. Habitat suitability and Predictive Modeling of Deep-Sea Corals

Participants: Tanya Compton (NZ), John Guinotte (US; facilitator), Mary Livingston (NZ), Pamela Mace (NZ), Ashley Rowden (NZ; facilitator) Timothy Shank (US) with input from Malcolm Clark and Thomas Hourigan.

Recognising that managers will never have sufficient ground-truthed information on the locations of VMEs in the Pacific, modeling approaches (such as those being led by researchers in both New Zealand and the US) provide an opportunity for targeting both future research and management actions. However, there are specific practical challenges in predicting VMEs based on research, observer data, and known environmental, bathymetric variables. Workshop participants identified the following core issues and tasks (those denoted with a ***** were deemed high priority):

(1) *No field validation of predictive models.* Participants recommended the need to both (i) validate existing global model for stony/octocoral corals (in NZ region where records were not used for global model) (ii) validate existing NZ regional predictive models for stony corals e.g. engage in opportunistic and directed sampling from a VME interest area such as the Louisville Seamounts.

(2) *The need for better environmental data layers*.* Scientific effort is required to improve the spatial resolution of the environmental data layers, as well as increase the variables and ensure that the information is more widely available. To this end participants recommended researchers:

- Share access to current 'best' environmental data layers (global)
- Encourage/contribute to the development of new environmental data layers (e,g. bathymetry)

(3) *Coral datasets.* Currently models are restricted (both spatially and taxonomically) by access to coral data and therefore the participants identified the need to improve coral data sharing e.g. open access to databases).

(4) *The need to better integrate predictive modeling results into fisheries management (including VME process in RFMOs) and conservation* ***.** e.g. assess effectiveness of VME closures and move on rules (e.g. distance to move) with scope to use NZ region as example.

(5) *The need for a wider Pacific Ocean deep-sea coral biogeography.* Participants recommended the undertaking of 'community' coral modeling to generate a deep-sea coral biogeography for Pacific Ocean which could be used in management initiatives such as VMEs.

(6) *The need to improve our understanding of what environmental variables drive distribution of corals.* Such an understanding would be increased by conducting smaller spatial studies where environmental variables are better resolved (e.g. on individual seamounts) to better answer the question of why over where.

(7) *Limited understanding of the connectivity of deep-sea corals*.* Participants recommended:

- Access to coral material for genetic connectivity studies e.g. make NZ region material more widely available for genetic studies (link with taxonomy topic);
- Include 'connectivity' in predictive species distribution modeling efforts, and integrate with conservation/management;
- Explore how to include 'connectivity' in distribution models (which also include current direction).

(8) *The need to build temporal models in order to assess anthropogenic effects*. e.g. ocean acidification, fishing effort. To this end researchers need to compile data (biological and environmental) to construct temporal models.

(9) *Methodological issues that influence usefulness and adoption of habitat suitability/species distribution models.* Participants recommended having a workshop to progress method development (compare approaches and results, examine autocorrelation issues, adopt 'best' approach?).

(10) *Limited access to HOVs, ROVs, AUVs in NZ region to take samples/survey habitat.* Future research initiatives could:

- Exploit/develop projects that will bring HOVs/ROVs/AUVs to NZ region;
- Co-share cruises (participation to improve links but also access to material).

Appendix 1: Ocean and Marine Sciences Workshop Participants

Participant	**Organization**	**Email**
Susie Iball (NZ)	South Pacific Regional Fisheries Management Organisation	s.iball@ southpacificrfmo.org
Steven Cairns (US)	Smithsonian Institute	cairnss@si.edu
Isabella Cawthorn (NZ)	MoRST	Isabella.Cawthorn@morst.govt.nz
Malcolm Clark (NZ)	NIWA	m.clark@niwa.co.nz
Tanya Compton (NZ)	NIWA	t.compton@niwa.co.nz
Mark Costello (NZ)	University of Auckland	m.costello@auckland.ac.nz
Alistair Dunn (NZ)	NIWA	a.dunn@niwa.co.nz
John Guinotte (US)	Marine Conservation Biology Institute	john@mcbi.org
Tom Hourigan (US)	National Oceanic and Atmospheric Administration	Tom.Hourigan@noaa.gov
Mary Livingston (NZ)	Ministry of Fisheries	Mary.Livingston@fish.govt.nz
Pamela Mace (NZ)	Ministry of Fisheries	Pamela.Mace@fish.govt.nz
David Middleton (NZ)	NZ Seafood Industry Council	David.Middleton@seafood.co.nz
Allison Reed (US)	NOAA International Office	Allison.Reed@noaa.gov
Ashley Rowden (NZ)	NIWA	a.rowden@niwa.co.nz
Steven Parker (NZ)	NIWA	s.parker@niwa.co.nz
Andrew Penney (NZ)	Ministry of Fisheries	Andrew.Penney@fish.govt.nz
Timothy Shank (US)	Woods Hole Oceanographic Institution	tshank@whoi.edu
Robert Stone (US)	Alaska Fisheries Science Center, NMFS	bob.stone@noaa.gov
Richard Templer	Group Manager, Industry & Environment (Foundation for Research Science and Technology)	richard.templer@frst.govt.nz
Dianne Tracey (NZ)	NIWA	d.tracey@niwa.co.nz

Unable to attend:

Sean Cooper (NZ)	Department of Conservation	scooper@doc.govt.nz
Paul Mitchell (NZ)	Ministry for Economic Development	paul.mitchell@med.govt.nz

Appendix 2: Ocean and Marine Sciences Workshop Agenda

MORNING SESSION – PRESENTATIONS	
8.45am	Gather, tea, coffee, name badges, folder hand out, housekeeping.
09:00	Welcome, introductions, opening statements. Malcolm Clark (NZ), Tom Hourigan (US)
09:15	International, national context, Workshop agenda and aims, roles (e.g. facilitator / time-keeper) and linkages/aims with Day 2. Introduce 1st speaker. Malcolm Clark (NZ), Tom Hourigan (US)
09:30	TOPIC ONE (US) Coral taxonomy: general outline of the status of coral taxonomy, covering all groups-so how much we know, what we don't know: Steve Cairns.
09:45	Questions/ Handover / Introduce next speaker.
09:50	TOPIC ONE (NZ): Coral data-what data sets are available from the Pacific that can be better combined: Di Tracey
10:05	Questions/ Handover / Introduce next speaker.
10:10	TOPIC ONE (US): Coral data-what data sets are available from the Pacific that can be better combined: Di Tracey for Amy Baco-Taylor
10:25	Questions.
10:30	MORNING TEA
10:45	Introduce next speaker.
10:45	TOPIC TWO (US): Identification, ecology and conservation science: Vulnerable Marine Ecosystems: Robert Stone
11:00	Questions/ Handover / Introduce next speaker.
11:05	TOPIC TWO (NZ): Identification, ecology and conservation science: Vulnerable Marine Ecosystems: Steve Parker
11:20	Questions/ Handover / Introduce next speaker.
11:25	TOPIC TWO (NZ): An alternative approach to VME management: Alistair Dunn
11:30	Questions/ Handover / Introduce next speaker.
11:35	TOPIC TWO (US): US/NWPRFMO management issues: Tom Hourigan
11:50	Questions/ Handover / Introduce speaker.
11:55	TOPIC TWO (NZ): NZ/SPRFMO management issues: Andrew Penney
12:10	Questions/ Handover / Introduce speaker.
12:15	TOPIC THREE (US): Habitat suitability and Predictive Modeling of Deep-Sea Corals: John Guinotte
12:30	Questions/ Handover / Introduce next speaker.
12:35	TOPIC THREE (NZ): Habitat suitability and Predictive Modeling of Deep-Sea

	Corals: Tanya Compton/Ashley Rowden
12:50	Questions/ Handover / Introduce next speaker.
12:55	TOPIC THREE (US): Connectivity issues: Tim Shank
13:05	Facilitator closes morning session, reminds all of afternoon agenda and aims.
	LUNCH
AFTERNOON SESSION – WORKSHOPS	
14:00	Opportunity to review any outstanding issues from morning session.
14:30	Briefing on format, length, and outcomes of break-out sessions.
	3 simultaneous breakout sessions in 3 breakout rooms under sub-topics. US and NZ and interested audience members for each sub-topic gather together to discuss ideas presented at the workshop and possible future US-NZ collaborative activities. [Allen Board Room / Allen Third Floor Meeting Room / Brodie Board Room]
3.45	AFTERNOON TEA – Together (i.e. not in break out rooms)
	Dianne Tracey from sub-topic ONE presents key summary and collaborative possibilities.
	Steven Parker from sub-topic TWO presents key summary and collaborative possibilities.
	Ashley Rowden from sub-topic THREE presents key summary and collaborative possibilities.
	Facilitated agreement on summary points and identified potential future cooperative activities/programmes. Agreement that these 3 summaries will be collated and presented to Day 2 JCM Officials Meeting (Wellington, 26th Jan).
	Formal thanks, acknowledgements – hosts, sponsors etc, hand out any Day 2 required info, instructions etc.
5.15	Drinks and nibbles, mingling.
	Evening meal at venue TBC.

Appendix 3: Ocean and Marine Sciences Workshop Presentations

1. Coral taxonomy: general outline of the status of coral taxonomy, covering all groups-so how much we know, what we don't know: Steve Cairns.
2. Core deep-sea coral datasets in the New Zealand Region: Dianne Tracey.
3. What data sets are available from the Pacific that can be better combined?: Dianne Tracey for Amy Baco-Taylor.
4. Vulnerable Marine Ecosystems – North Pacific Perspective: Robert Stone.
5. VME identification and conservation science: New Zealand's progress: Steve Parker.
6. Fisheries management of VMEs: Alistair Dunn.
7. Protecting Pacific Vulnerable Marine Ecosystems: Science to Inform Management: Tom Hourigan.
8. Conservation and Management of Vulnerable Marine Ecosystems in the South Pacific Regional Fisheries Management Organisation Area: Andrew Penney.
9. Predicting the distribution of bioherm-forming (scleractinian) cold-water corals: John Guinotte.
10. Predicting the spatial distribution of five deep sea coral species around New Zealand: Tanya Compton/Ashley Rowden.
11. Connectivity of Deep-Water Coral Ecosystems: Timothy Shank.
12. Key Summary: Topic I. Identification, Taxonomy and Core Data Sets for Deep-Sea Corals.
13. Key Summary: Topic II. Vulnerable Marine Ecosystems (Identification, ecology and conservation science).
14. Key Summary: Topic III. Habitat suitability/species distribution modeling.
15. US-NZ Joint Commission Meeting on Science and Technology Cooperation: Report from the Ocean and Marine Sciences workshop: Malcolm Clark and Thomas Hourigan.

CORALS	Deep-Water NZ Species	% of all Species Worldwide	% of all Deep-Water Species	CITES	Taxonomic Know-ledge (x/10)
Scleractinia	114	7.7%	18.5%	Yes	9
Stylasteridae	59	24%	27%	Yes	9
Antipatharia	*47	19.8% (*28%)	26.4% (*37%)	Yes	3
Octocorallia	**58	1.9% (**7.8%)	2.5% (**10.5%)	No	3
TOTAL	***278	278/5064 = 5.5% (***9.5%)	278/3333 = 8.3%		

* Plus 19 undescribed species = 66
** Plus 185 undescribed species = 243
*** Plus 204 undescribed species = 482

New Zealand Marine Species 12,971 (5.8% of...
Worldwide Marine Species 224,787

CORALS	Deep-Water NZ Species	% of all Species Worldwide	% of all Deep-Water Species	CITES	Taxonomic Know-ledge (x/10)
Scleractinia	114	7.7%	18.5%	Yes	9
Stylasteridae	59	24%	27%	Yes	9
Antipatharia	*47	19.8% (*28%)	26.4% (*37%)	Yes	3
Octocorallia	**58	1.9% (**7.8%)	2.5% (**10.5%)	No	3
TOTAL	***278	278/5064 = 5.5% (***9.5%)	278/3333 = 8.3%		

* Plus 19 undescribed species = 66
** Plus 185 undescribed species = 243
*** Plus 204 undescribed species = **482**

Cairns, 1995

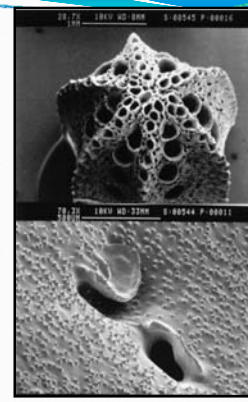
Solenosmilia variabilis

CORALS	Deep-Water NZ Species	% of all Species Worldwide	% of all Deep-Water Species	CITES	Taxonomic Know-ledge (x/10)
Scleractinia	114	7.7%	18.5%	Yes	9
Stylasteridae	59	24%	27%	Yes	9
Antipatharia	*47	19.8% (*28%)	26.4% (*37%)	Yes	3
Octocorallia	**58	1.9% (**7.8%)	2.5% (**10.5%)	No	3
TOTAL	***278	278/5064 = 5.5% (***9.5%)	278/3333 = 8.3%		

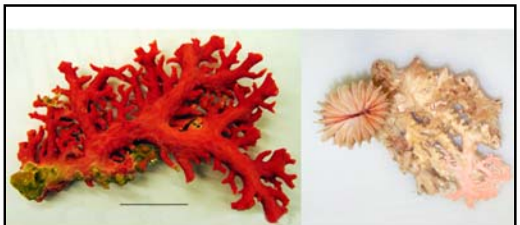
* Plus 19 undescribed species = 66
** Plus 185 undescribed species = 243
*** Plus 204 undescribed species = **482**

Cairns, 1991

The stylasterid, *Lepidopora polystichopora* Cairns, 1985



Stylasterid (left) and a solitary scleractinian attached to a stylasterid (right)

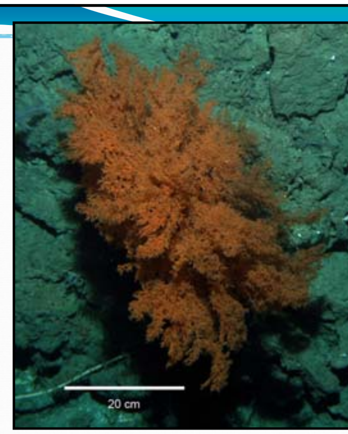


Errina chathamensis

CORALS	Deep-Water NZ Species	% of all Species Worldwide	% of all Deep-Water Species	CITES	Taxonomic Know-ledge (x/10)
Scleractinia	114	7.7%	18.5%	Yes	9
Stylasteridae	59	24%	27%	Yes	9
Antipatharia	*47	19.8% (*28%)	26.4% (*37%)	Yes	3
Octocorallia	**58	1.9% (**7.8%)	2.5% (**10.5%)	No	3
TOTAL	*****278**	278/5064 = 5.5% (***9.5%)	278/3333 = 8.3%		

* Plus 19 undescribed species = 66
** Plus 185 undescribed species = 243
*** Plus 204 undescribed species = **482**

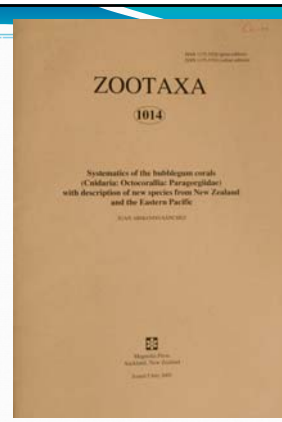
Deep-water antipatharian



CORALS	Deep-Water NZ Species	% of all Species Worldwide	% of all Deep-Water Species	CITES	Taxonomic Know-ledge (x/10)
Scleractinia	114	7.7%	18.5%	Yes	9
Stylasteridae	59	24%	27%	Yes	9
Antipatharia	*47	19.8% (*28%)	26.4% (*37%)	Yes	3
Octocorallia	**58	1.9% (**7.8%)	2.5% (**10.5%)	No	3
TOTAL	***278	278/5064 = 5.5% (***9.5%)	278/3333 = 8.3%		

* Plus 19 undescribed species = 66
** Plus 185 undescribed species = 243
*** Plus 204 undescribed species = **482**

Sanchez, 2005

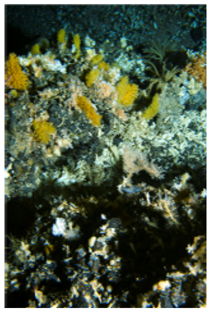


CORALS	Deep-Water NZ Species	% of all Species Worldwide	% of all Deep-Water Species	CITES	Taxonomic Know-ledge (x/10)
Scleractinia	114	7.7%	18.5%	Yes	9
Stylasteridae	59	24%	27%	Yes	9
Antipatharia	*47	19.8% (*28%)	26.4% (*37%)	Yes	3
Octocorallia	**58	1.9% (**7.8%)	2.5% (**10.5%)	No	3
TOTAL	***278	278/5064 = 5.5% (***9.5%)	278/3333 = 8.3%		wt ave = 5.1

* Plus 19 undescribed species = 66
** Plus 185 undescribed species = 243
*** Plus 204 undescribed species = **482**

- 278

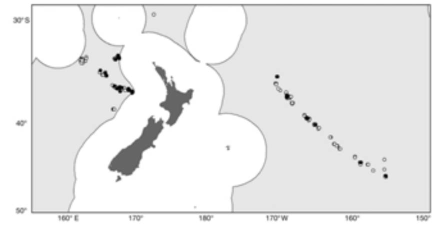
Core deep-sea coral datasets in the New Zealand Region



Di Tracey
(National Institute of water and Atmospheric Research - NIWA)

Presentation to the 2nd United States - New Zealand Joint Commission Meeting on Science & Technology Cooperation workshop on Pacific deep-sea corals & vulnerable marine ecosystems (VME's)

NZ region (high seas & Ross Sea Antarctic region)

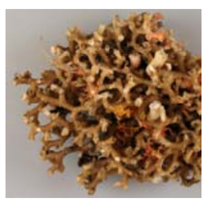


From Parker et al, 2008

Accurate identification of deep-sea coral taxa, and access to existing coral data provide key information for:

• identification of vulnerable marine ecosystems (VMEs)

• assessing habitat suitability and predictive modelling of deep-sea corals



What data sets have been compiled and are available to evaluate species distribution and community composition from the NZ region (NZ EEZ, High Seas & Ross Sea)?

- What has been collated - databases, individual datasets, literature?
- What is out there in the public domain versus held in institutes?
- What key coral groups have been mapped – to provide us with distribution and depth data.
- What are the future priorities for improving datasets, where do we need to focus?

(1) Data – databases (db's)

- *Specify* NIWA Invertebrate Collection db
- *trawl* MFish trawl survey db
- *COD* MFish Centralised Observer db
- *BIO_ds* Biodiversity db
- NABIS MFish National Aquatic Biodiversity Information System
- Te Papa db

Output
(e.g for a specimen from a seamounts survey) extracts can be produced from ***Specify*** with the following database headers:

- Catalog number (NIC *Specify* database Catalogue number)
- Trip
- Vessel
- Station_no
  - Latitude_start
  - Longitude_start
  - Start / Finish depth
- PhylumTaxonName
- ClassTaxonName
- SubclassTaxonName
- OrderTaxonName
- FamilyTaxonName
- GenusTaxonName
- SpeciesTaxonName
- Determination (species name e.g.*Bathypathes* sp. B)
- Lot number
- No of specimens
- Identified by (e.g. Opresko, Dennis)
- Date last modified (e.g. 9122008 10:10:33 a.m.)
- Remarks (e.g. Opresko, Dennis Sub-sampled from oversized *Bathypathes* B (orange) from freezer for genetics;
- Dead or Live status

(1) Data - Literature

- NZOI/NIWA Biodiversity Memoirs

e.g. Cairns 1995

- Research publications

e.g. Sanchez 2005

- Voyage, data, Client reports / grey literature

e.g. US, German, Soviet surveys (*Eltanin* report; Noé unpub. *Sonne* data; Keller et al. 2005)

(1) Data – from db's & literature compiled from multiple sources for a specific purpose

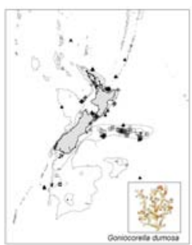
e.g. collated data for Scleractinian (stony coral group), important deepsea VME group

- 3-D structure
- habitat forming

Enallopsammia rostrata

(1) Data – Datasets stony coral

- data for distribution, depth range, habitat type (e.g. seamounts, slope), & application predictive mapping
- 5 of the most common habitat forming branching stony corals (Scleractinia)
  Madrepora oculata
  Solenosmilia variabilis
  Goniocorella dumosa
  Enallopsammia rostrata
  Oculina virgosa



(Tracey et al, in prep)

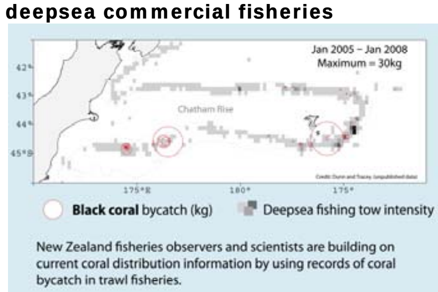
(2) Data availability

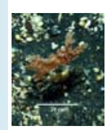
- db's – various levels of access
  Specify extracts available on request
  trawl & *COD* require MFish permissions
- global databases / datasets
  - Census of Marine Life on Seamounts (CenSeam)
  - Seamounts Online
  - Ocean Biogeographic Information System (OBIS)
  - Hexacorallia db (Fautin)
- literature – less available are the historical reports, client reports, & voyage reports, e.g. *Sonne* voyage reports

(3) VME coral taxa distribution

While focus has been stony corals - distribution & depth data have been compiled for other VME coral groups

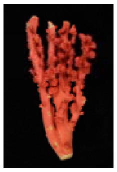
(3) VME coral taxa - interactions with the deepsea commercial fisheries

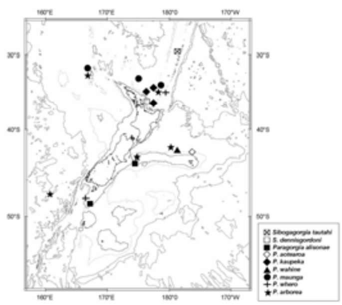




Plot of orange roughy catch data (1/2 degree square) overlaid with Observer collected coral data, Chatham Rise (Tracey 2009).

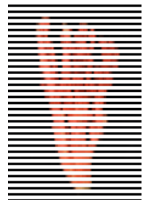
(3) VME coral taxa distribution bubblegum corals (PAB) Paragorgiidae species

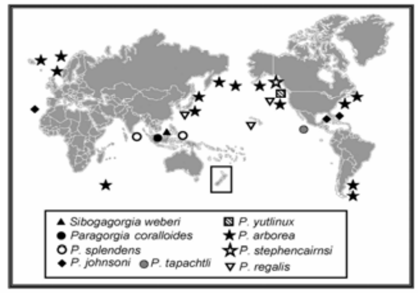




Sanchez 2005

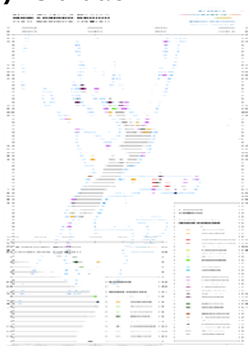
(3) VME coral taxa distribution bubblegum corals (PAB) Paragorgiidae species





Sanchez 2005

(3) VME coral taxa distribution bamboo corals (ISI) Isididae



Sánchez et al 2008

(3) There are still several gaps e.g. for Gorgonian corals – 'rasta' coral, sea fans, sea fans, & other VME groups - sponges

Narella spp

Demospongiae

Primnoidae

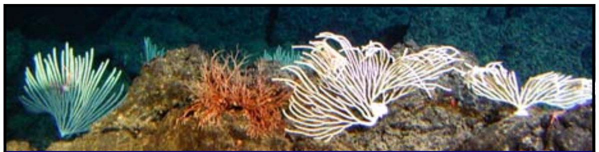
Current coral research in NZ

- taxonomy – for Cnidaria fauna (corals) 278 species & ~ 500 unidentified region (Gordon 2009; Cairns pers comm); reliant on OE experts to ground truth our identifications
- genetics
- ID Guides Invertebrates (Ministry of Fisheries, Department of Conservation, SPRFMO, CCAMLR)
- distribution & habitat, interactions with the deepsea commercial fisheries
- age/growth
- paleoclimate
- acidification

(4) Future data-related priorities

NZ / NZ-US / General

- Update data compilation from recent NZ region surveys – focus on particular areas (e.g. High Seas & Ross Sea to support VME work) and identification of taxa (e.g. octocorals to support modelling & studies looking at effects of ocean acidification)
- Extract & compile data from surveys undertaken by other nations in NZ waters – focus on US sources (e.g. NOAA surveys)
- Extend collaborations with other Pacific nations in order to improve data in the wider region – focus on S. American countries (e.g. Chile, Peru)
- Assess what data (and where) are needed to support ground truthing of predictive models – focus on groups for which models are already being produced (e.g. habitat-forming scleractinians)



TOPIC ONE (US)

What data sets are available from the Pacific that can be better combined?

Amy Baco-Taylor

What US data sets have been compiled and are available to evaluate species distribution and community composition in the North Pacific?

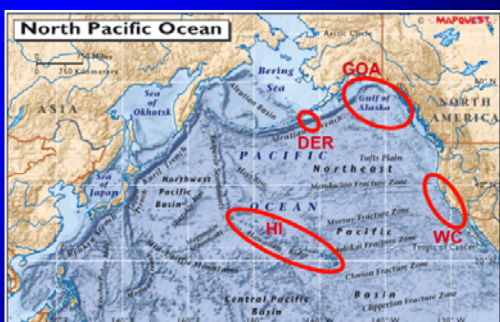
(1) What has been collated - databases, individual datasets, literature?

(2) What is out there in the public domain versus held in institutes?

(3) What sort of work are we doing on the biology of the main groups?

(4) What are the future priorities for improving datasets, where do we need to focus?

North Pacific Seamount Sampling



Base map from: http://go.hrw.com/atlas/norm_htm/npacific.htm

(1) Data - Databases

- Hawaii Undersea Research Laboratory (HURL) – submersible and video log database (30,000 records)
- Smithsonian databases (museum collection dbs)
- Aleutian corals database (NOAA)
- Alaska & West Coast US research trawl db (RACE)
- Fisheries Observer db (NOAA)
- Pacific Coast Ocean Observatory System
- USGS/NOAA cold-water corals db
  - east coast stony corals, NE coast gorgonians, Gulf of Mexico
  - **developing into US-wide comprehensive & centralised db**

Data – Datasets (compiled from multiple sources for specific purpose)

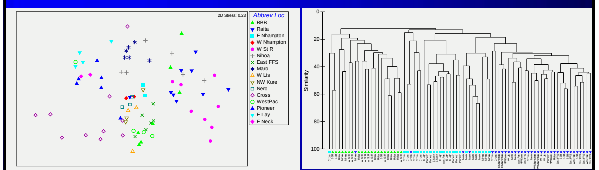
- 'CenSeam all seamount coral data' for global distribution analysis (Rogers et al 2007)
- 'CenSeam Scleractinia (seamounts) dataset' for predictive modeling (Clark et al 2006, Tittensor et al 2009)
- 'CenSeam Octocoralia (all habitats; 13, 000 records) dataset' for predictive modeling (various in prep)
- 'CenSeam/ISA' subset of HURL (Hawaiian Underwater Research Lab) database (13,175 records) used for analyses to compare benthic invertebrate fauna of cobalt-rich and non-cobalt rich crusts (on seamounts)

(2) Data availability

- similar to New Zealand situation
- extracts made available to scientists or agencies with permission of the funding agency

(3) Coral taxa distribution

- Seamount benthic invertebrate data from HURL

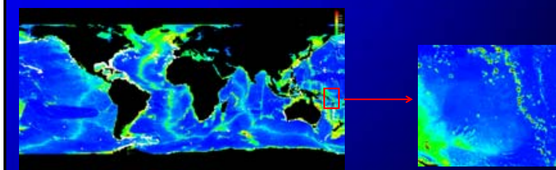


Updated from Clark et al, ISA report, 2009

- variation by location
- variation by depth
- understanding drivers of community structure

Octocoral distribution

- Compilation of (>50m depth) octocoral records from all habitat types, not just seamounts
- Database of >13,000 octocoral records compiled
- 25 physical, biological and chemical correlates
- Habitat suitability for S-O. Calcaxonia



Extremely high-resolution upscaled physical data, so individual features can be picked out on habitat suitability plots

Types of Deepsea Coral (DSC) Studies on North Pacific Seamounts

- DSC taxonomy
- DSC distribution
- DSC aging and paleoclimate
- DSC as habitat for invertebrates
- Phylogeographic patterns of North Pacific DSC
- Precious coral population genetics
- Precious coral reproductive biology
- Precious coral ecology
- Monk Seal foraging in precious coral beds

(4) Future data-related priorities

- Make use of existing data: e.g. additional 60,000 records in HURL database
- Obtain historical datasets where voyage samples need to be worked up and entered into db
- Promote standardized sampling regime
  - issues of multiple platforms (most work in N Pacific is subs/rovs; in SW Pacific trawls, sleds, towed cameras

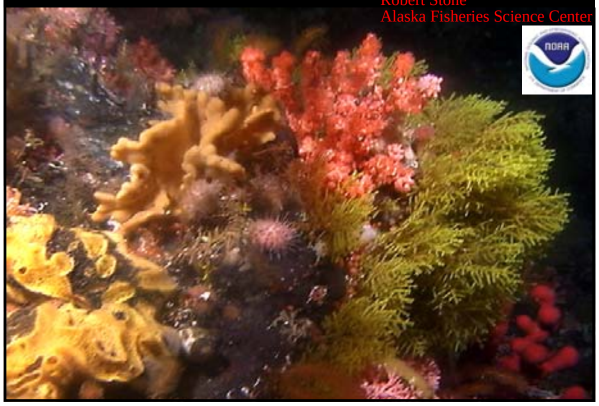
Future data-related priorities (cont.)

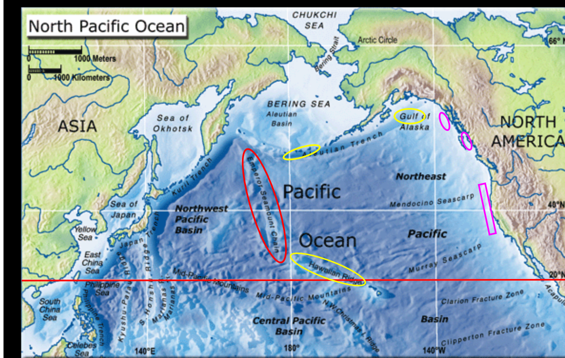
  - across habitats (seamounts, slopes etc)
  - sample consistent depths to compare between features

- Improve taxonomic consistency of databases/datasets

Vulnerable Marine Ecosystems – North Pacific Perspective

Robert Stone
Alaska Fisheries Science Center

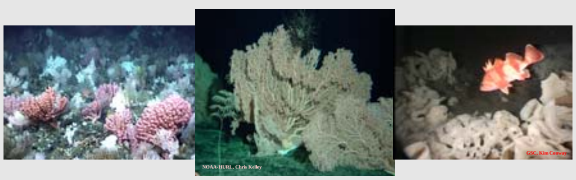




North Pacific Ecosystem Metadatabase

Vulnerable Marine Ecosystems Identification & Ecology

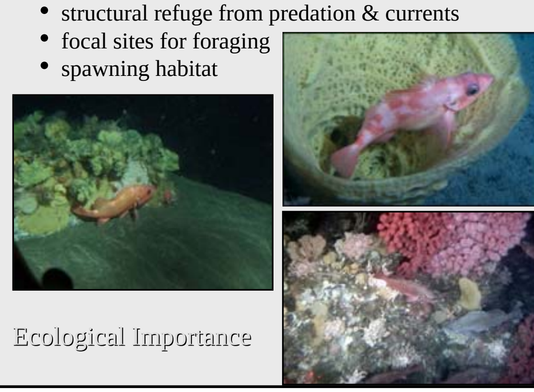
VMEs ("NPRFMO") – ecosystems that are **easily disturbed** and very **slow to recover**, or may never recover. Candidate habitats presently include seamounts, hydrothermal vents and cold-water corals (*Corallium* sp.).



HAPCs – EFH that is of particular **ecological importance** to the long-term sustainability of managed species, is of a **rare** type, or is especially **sensitive** to degradation. Presently include seamounts, coral gardens, cold water coral thickets (*Primnoa* sp.) and hexactinellid sponge reefs.

Importance as Fish Habitat

- structural refuge from predation & currents
- focal sites for foraging
- spawning habitat

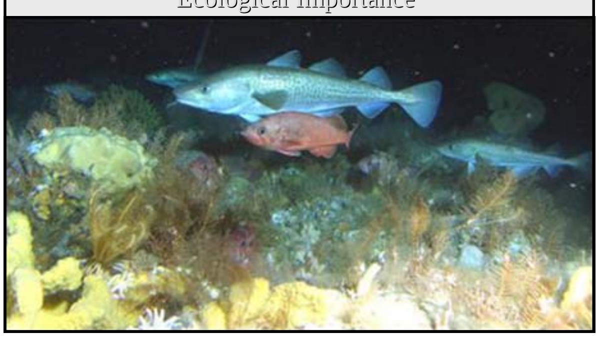


Ecological Importance

Importance as Fish Habitat

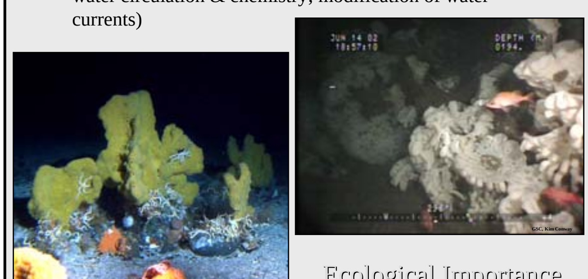
- Increased Productivity & Species Biodiversity

Ecological Importance

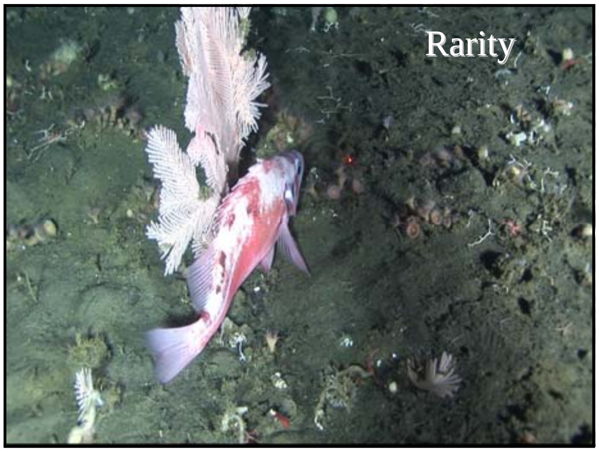


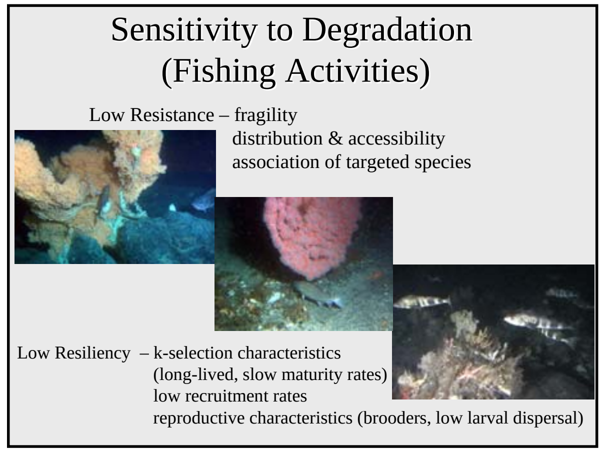
Importance as Fish Habitat

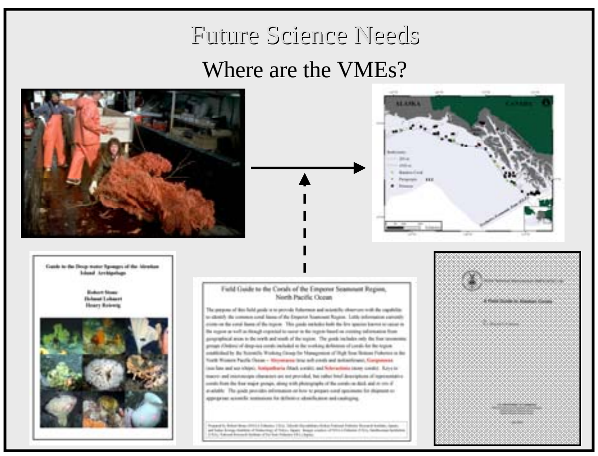
- Ecosystem Services (sponge gardens – proximal changes in water circulation & chemistry; modification of water currents)

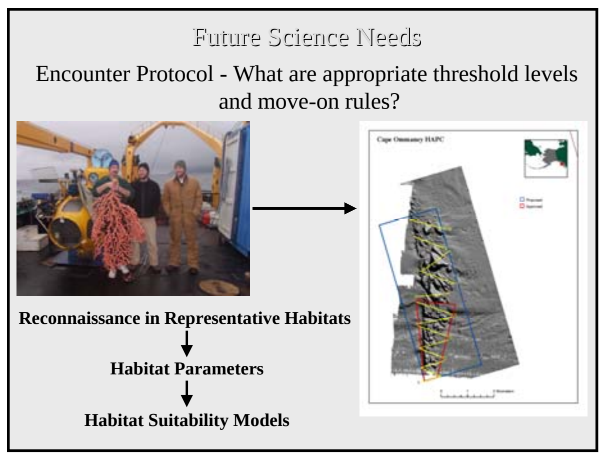


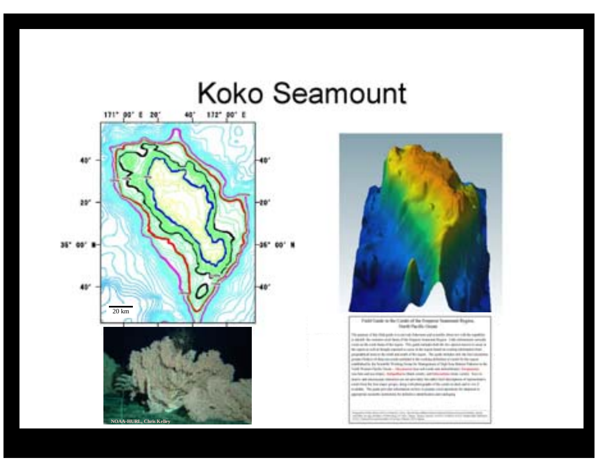
Ecological Importance


Rarity


Sensitivity to Degradation
(Fishing Activities)
Low Resistance – fragility
distribution & accessibility
association of targeted species
Low Resiliency – k-selection characteristics
(long-lived, slow maturity rates)
low recruitment rates
reproductive characteristics (brooders, low larval dispersal)


Future Science Needs
Where are the VMEs?
Field Guide to the Corals of the Emperor Seamount Region, North Pacific Ocean


Future Science Needs
Encounter Protocol - What are appropriate threshold levels and move-on rules?
Reconnaissance in Representative Habitats
Habitat Parameters
Habitat Suitability Models


Koko Seamount

VME identification and conservation science: New Zealand's progress

Steve Parker
National Institute of Water and Atmospheric Research, ltd.
Nelson, New Zealand

Scoping the issues

Scientists and managers are struggling with intent and terminology:
- What is a VME?
  - Which species are we concerned with?
  - How can a VME be identified?
  - Should there even be criteria?
- How much impact is ecologically too much?
- What does recovery mean?

High-seas fisheries with NZ involvement

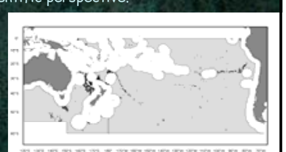
NZ has been proactive in implementing the UNGA resolution 61/105 and the associated FAO guidelines from a scientific perspective.

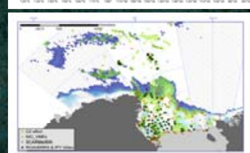
VME monitoring and move-on rule development in SW Pacific
- Bottom trawl fishery
- Bottom line fishery - ongoing

VME monitoring and impact assessment in Ross Sea
- Bottom longline fishery

Both areas have little scientific survey information available where the fishery occurs.

Fishery bycatch collections provide:
- access to samples
- large sample sizes
- presence-only distribution





Taxa selection criteria

- Interpret FAO guidelines
  - Fragile relative to the disturbance type.
  - Functionally significant to the community or ecosystem.
    - Create structural complexity by forming biogenic structures that can create habitat for other organisms
    - Provide unique and important functions that control other system functions.
  - Unique, rare or endemic to a small area.
  - Low productivity due to life history traits such as slow growth, longevity, late age at maturity, low fecundity, or unpredictable recruitment.
- CCAMLR VME workshop:
  - 7 vulnerable traits: Habitat-forming; High Longevity; Slow growth; Fragility relative to disturbance; Larval dispersal potential; Lack of adult motility; Rare or Unique populations

NZ – Southwest Pacific VME taxa

- Phylum Porifera (sponges)
- Phylum Cnidaria
  - Anthozoa
    - Actiniaria (Anemones)
    - Scleractinia (Stony corals)
    - Antipatharia (Black corals)
    - Alcyonacea (Soft corals)
    - Gorgonacea (Sea fans)
    - Pennatulacea (Sea pens)
  - Hydrozoa: Anthoathecatae:
    - Stylasteridae (Hydrocorals)
    - Hydroida (Hydroids)

- Habitat indicators
  Phylum Echinodermata
  Crinoidea, Brisingida
- Taxonomic diversity as a weighting factor

CCAMLR's list

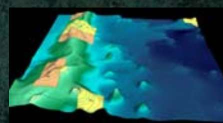
Table 3.1 Intrinsic factors contributing to the vulnerability from physical disturbance of invertebrates in the Southern Ocean.

Taxon	Habitat forming	Rare or unique populations	Longevity	Slow growth	Fragility	Larval dispersion potential	Lack of adult motility
Phylum Porifera							
Hexactinellida	H	L	H	H	H	M	H
Demospongiae	H	M	H	H	H	M	H
Phylum Cnidaria							
Actiniaria	L	L	H	L	L	M	M
Scleractinia[1]	H	M	H	H	H	M	H
Antipatharia	M	L	H	H	H	L	H
Alcyonacea	M	L	M	L	M	M	H
Gorgonacea	M	L	H	H	H	M	H
Pennatulacea	L	H	H	M	H	L	M
Zoanthida	L	L			M	L	H
Hydrozoa							
Family Stylasteridae	H	L	H	M	H	H	H
Hydroidolina	L	L			L		H
Phylum Bryozoa	H	L	H	M	H	H	H
Phylum Echinodermata							
Crinoidea: Stalked crinoid orders	L	H	H		H		H
Echinoidea: Order Cidaroida	M	L	H	H	M	H	L
Ophiuroidea: Family Gorgonocephalidae	L	L			H	L	M
Phylum Chordata: Class Ascidiacea	M	L		L	L	L	H
Phylum Brachiopoda	L	H	H	L	M	M	H
Phylum Annelida: Family Serpulidae	M	L			H	L	H
Phylum Arthropoda: Infraclass Cirripedia: Bathylasmatidae sp.	L	H	H		M	L	H
Phylum Mollusca: Pectinidae: *Adamussium colbecki*	L	H	H	M	M	L	M
Phylum Hemichordata: Pterobranchia	M	M			M	H	H
Phylum Xenophyophora	L	H			H		H
Chemosynthetic communities	H	H	H	H	H	L	H

[1] As of 2009, almost all records of Scleractinia in the CCAMLR convention area are of cup corals (*Desmophyllum* and *Flabellum* sp.). However records of matrix forming scleractinians (*Madrepora oculata* and *Solenosmilia variablis*) do exist in the northernmost areas, as far south as 60° S. Cup corals are typically not habitat-forming, but Scleractinia were classified as "high" for the habitat-forming criterion to be consistent with the approach of using the most conservative attributes of the members of each taxon.

Monitoring and recording

- Overall management approach
  - Spatial measures
  - Effort controls
    - Gear restrictions
    - Research requirements
    - Limit effort based on recovery dynamics
  - Monitor impacts and recovery
    - Bottom Fishing Impact Assessments
    - Impact assessment methodology
- Encounters while fishing
  - Premise that initial observed impacts are likely not significant, so "pre-emptive" action can still occur
  - Real-time monitoring requires trigger event.
  - Scientific justification for trigger level is needed



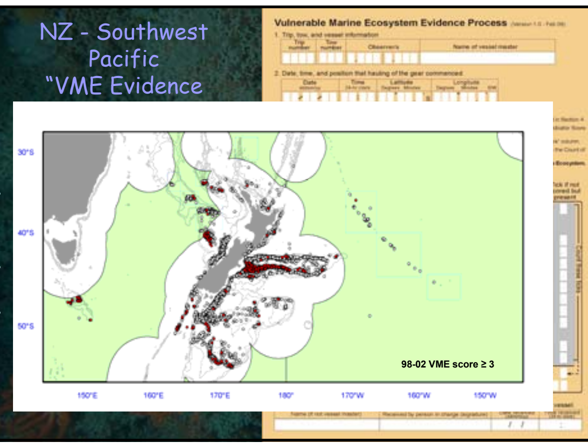
Real-time identification

- Specimens need to be identified: groups at sea; species level later.
- At-sea classification to be conducted by scientific observers or crew.
- NZ has developed classification guides specific to VME taxa for SW Pacific and CCAMLR
  - Different purpose than a identification guide
    - Taxonomic level depending on available macroscopic characteristics
    - Aid in specimen collection
    - Implement move-on rules
- Fishing occurs in many places
  - Enhance specimen collection
- Ancillary data collection
  - Bathymetry
  - Oceanography
  - Detailed catch
  - Benthos video
  - Extra fishing "sampling" effort

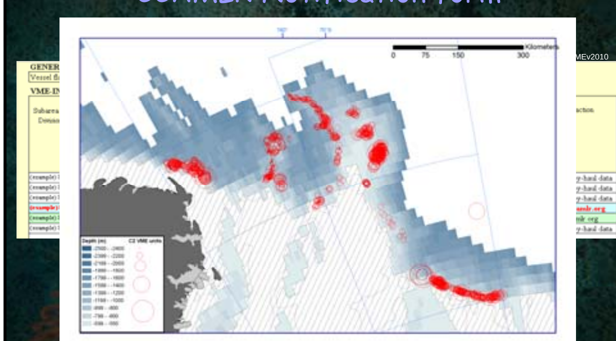
Trigger levels

- Presence/absence
  - Ignores species density
  - Ignores catchability issues
- Single trigger level: all vulnerable taxa are equal
  - CCAMLR uses 10kg or 10L VME taxa per 1200m main line or 1000hooks
  - Allows negotiation on level, but not based on knowledge of ecological impact
- Variable trigger:
  - Makes biological sense, but requires extensive data
  - NZ uses taxon-specific weight thresholds in SW Pacific based on distribution of observed bycatch weights and longevity for each taxon
  - Also includes taxonomic diversity in the trigger
  - CCAMLR is now discussing (heavy vs light taxa)

NZ - Southwest Pacific "VME Evidence

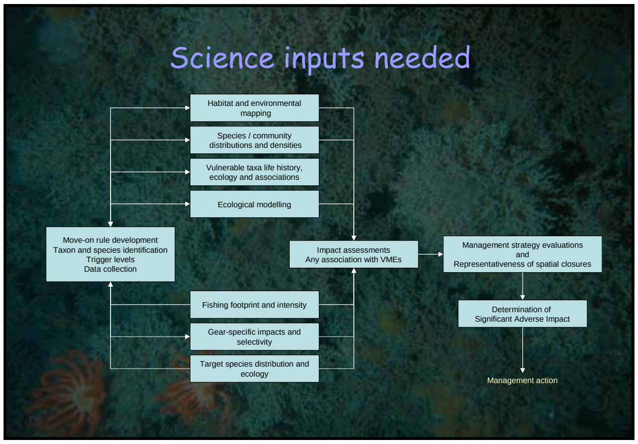


CCAMLR Notification form



Key scientific questions

- **Management approach science needs**
  - Is there any association between targeted species and VME taxa distributions (Is fishing targeting VME habitats?)
  - Taxon-level spatial distributions and the relations to species-level spatial distributions
  - Community size and relation to ecological function
  - Factors affecting representativeness of spatial closures
  - Actual impact levels resulting from fishing activities
  - Recovery dynamics for vulnerable taxa
- **Real time monitoring science needs**
  - Catchability by gear type and configuration (including selectivity)
  - Collection of quality data: Classification skills of users, impact positioning, ancillary environmental data for model development
  - Patch size and concentration of patches - how far to move
  - Game theory of move-on rules and impacts
  - Incorporation of new data into management approach


Science inputs needed
Habitat and environmental mapping
Species / community distributions and densities
Vulnerable taxa life history, ecology and associations
Ecological modelling
Move-on rule development
Taxon and species identification
Trigger levels
Data collection
Impact assessments
Any association with VMEs
Management strategy evaluations
and
Representativeness of spatial closures
Determination of
Significant Adverse Impact
Fishing footprint and intensity
Gear-specific impacts and selectivity
Target species distribution and ecology
Management action

Fisheries management of VMEs

Alistair Dunn
National Institute of Water and Atmospheric Research, Ltd.
Wellington, New Zealand

Managing fishery impacts

- Requirement for scientific advice on how to manage the impacts of fisheries on vulnerable marine ecosystems…
- But
  - Few data on which to determine the distribution and abundance of different benthic habitats
  - Fishing gear effects on marine organisms are not well known
  - Ecosystem effects of such impacts are not well known
  - Little knowledge on what is required to maintain the ecology and function of these habitats

Development of management approaches in the CCAMLR region

- CCAMLR has
  - Noted that there are information gaps in understanding ecosystem impacts, and that these are unlikely to be resolved in any foreseeable timeframe
  - Recognised that there are competing objectives (e.g., exploitation of fishing resources versus protection of vulnerable marine ecosystems)
- Hence methods are being developed that use an approach known as Operational Management Procedures (OMPs)
  - Also known as Management Procedures (MPs) and Management Strategy Evaluations (MSEs)

Operational Management Procedures

- Currently used to manage fish stocks in many different regions
- Used to formally assess the consequences of a range of management options and evaluate the trade-offs across a range of objectives
- Aim to provide decision makers with the information on which to base a decision, given the objectives, preferences, and acceptable risks

OMP Method

- Define the (often conflicting) management objectives
- Simulate the system dynamics
- Simulate from a series of plausible operating models and apply a series of candidate decision rules
- Evaluate the performance of the decision rules in each simulation
- Aggregate the results across simulations to choose the 'best'
- Implement the chosen decision rule

Advantages

- Requires explicit definition of management objectives
- Makes transparent the management trade-offs in decision making
- Lack of specific knowledge can be addressed by simulating from alternative operating models
- Effect on management outcomes of competing theories of ecosystem impact or function can be evaluated

Disadvantages

- Requires explicit definition of management objectives
- Assumes that we can simulate adequate approximations to the real world
- Can be a time-consuming and complex computer based procedure
- Requires ongoing information collection on the impacts of fishing to inform the decision rule

Acknowledgements

- Thanks to Steve Parker (NIWA), Stuart Hanchet (NIWA), and Neville Smith (MFish) for discussions on the management of VMEs in the CCAMLR context
- The development of simulation based Operational Management Procedures for managing benthic impact in the CCAMLR region is discussed by Andrew Constable (Australian Antarctic Division) in CCAMLR papers WG-SAM-09/21 and WG-FSA-09/42.

Protecting Pacific Vulnerable Marine Ecosystems Science to Inform Management

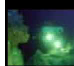
Thomas F. Hourigan, Ph.D.
National Oceanic and Atmospheric Administration

United States – New Zealand
Joint Cooperative Meeting on Science and Technology
January 25, 2010

Overview


Pacific Deep-Sea Management

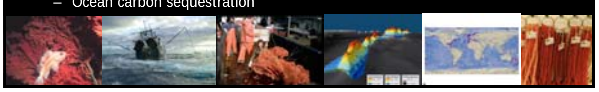

Addressing Fishing Impacts to Vulnerable Marine Ecosystems (VMEs) in the North Pacific


Protecting VMEs – Key Science Questions

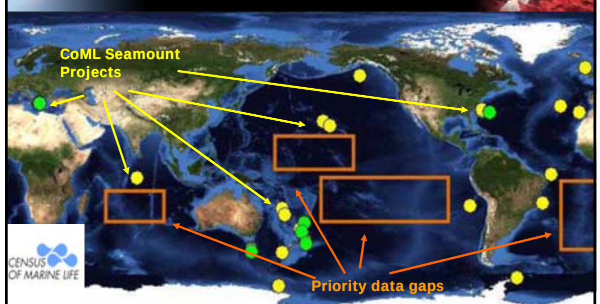

Priorities for Pacific Science Cooperation

Science Cooperation to Support Conservation

- U.N. General Assembly (UNGA) Resolution 61/105: Managing impacts to vulnerable marine ecosystems by of deep sea fisheries on the High Seas
- Other issues:
  - Convention on Biological Diversity (CBD) – Scientific criteria for ecologically and biologically sensitive areas in the deep sea
  - Listing proposal for *Corallium* under the Convention on International Trade in Endangered Species (CITES)
- Emerging issues:
  - Deep-sea mining
  - High seas MPAs
  - Ocean acidification
  - Ocean carbon sequestration



Pacific Deep-Sea Conservation Science Context



UNGA Resolution 61/105

Assess whether individual bottom fishing activities would have significant adverse impact on VMEs and, if so,

- Implement conservation measures to prevent impacts; or
- Do not authorize fishing to proceed;

Close areas to bottom fishing where VMEs are known or likely to occur, until conservation measures are in place to prevent significant adverse impact.

Ensure long term sustainability of deep sea fish stocks;

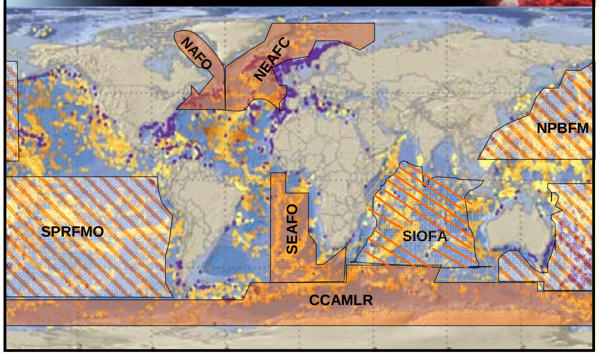
Cease bottom fishing and move on if a VME is encountered and report the location

Vulnerable Deep-Sea Marine Ecosystems

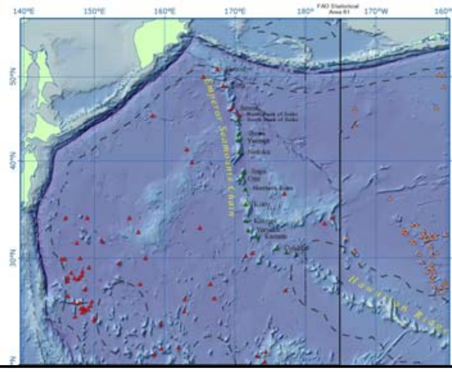
Potentially contribute to VMEs (FAO Guidelines):

- Species, groups, communities
  - Cold-water corals
  - Sponge-dominated communities
  - Dense emergent fauna
  - Seep and vent communities
- Features that support these
  - Edges & slopes
  - Seamounts, etc.
  - Canyons & trenches

Regional Fishery Management Organizations



North Pacific Fisheries Organization

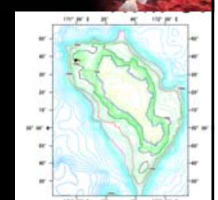


North Pacific Fisheries Organization

- Fisheries:
  - 18 to 50 vessels; 8,000 – 20,000 tons/year
  - Flag states: Japan, S. Korea, Russia & Belize
  - Taiwan – Precious coral drag fisheries
- Negotiations began 2006
- Interim measures for NW Pacific (2007)
  - Footprint frozen → Exploratory fisheries protocol (2009)
- Decision to expand area to NE Pacific (2008)

Japan Assessment

- Indicator taxa:
  - Gorgonacea (especially *Corallium*)
  - Antipatharia
  - Scleractinia
- Methods – ROV & drop camera
- Few "aggregations" reported
- Tentative agreement to close one seamount
- Japan – no fishing below 1500 m



Interim Encounter Criteria

- 5 nm move-on rule
- No agreement on how applied
- Bycatch threshold:
  - 50 kg coral per tow or set (Japan)
  - No criteria identified

Protecting VMEs Key Science Questions

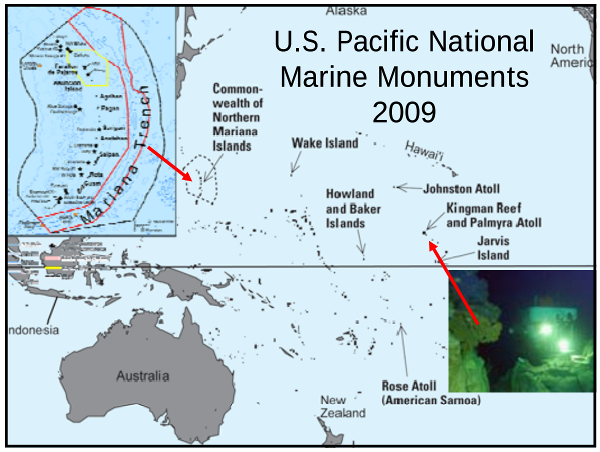
- Fishing Assessments:
  - What are impacts of gear on VME indicator taxa?
  - What factors determine vulnerability or recovery
- Bottom Closures:
  - Where are VMEs?
    - Species distributions
    - Density and patchiness
  - Where are VMEs Likely?
    - Habitat suitability modeling
    - Other proxies – U.S. approach – Habitat features

Protecting VMEs Key Science Questions

- Encounter Provisions:
  - What is on bottom v. what is in net
  - How to address rare species

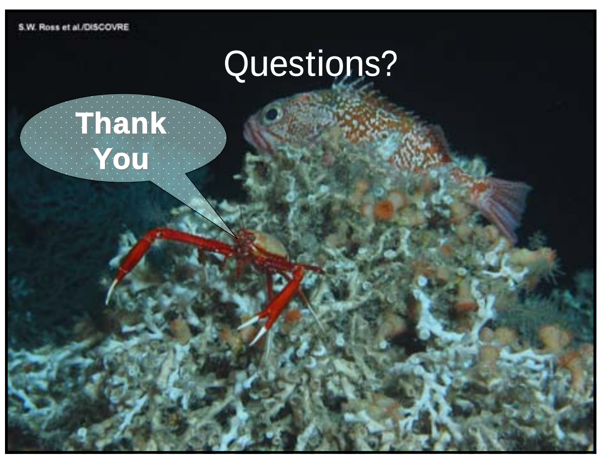
U.S. Pacific Interests

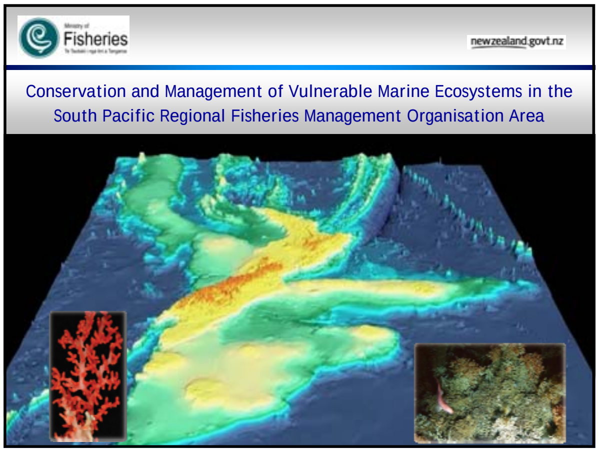
- U.S. – world's largest EEZ, with diverse Pacific deep-sea habitats
- Domestic trawl and other bottom fisheries in NE Pacific
- Currently no high seas bottom-fisheries
- New Pacific conservation authorities



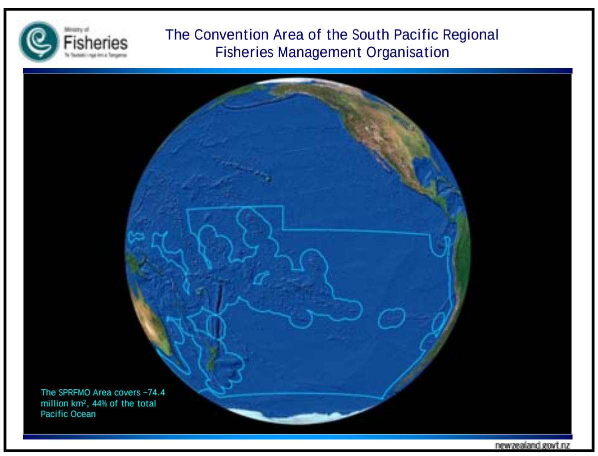
Priorities for Science Cooperation

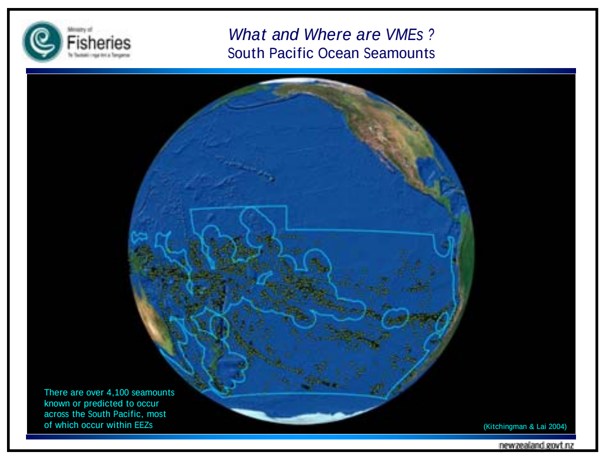
1) Identify VMEs
   - Develop and share datasets on distribution of VME taxa
   - Develop and refine
     - Habitat suitability models
     - Biogeographic classifications
2) Understand fishing impacts
   - Gear interactions with benthos
   - Bycatch identification and quantification
3) Science exchange in research within our EEZs

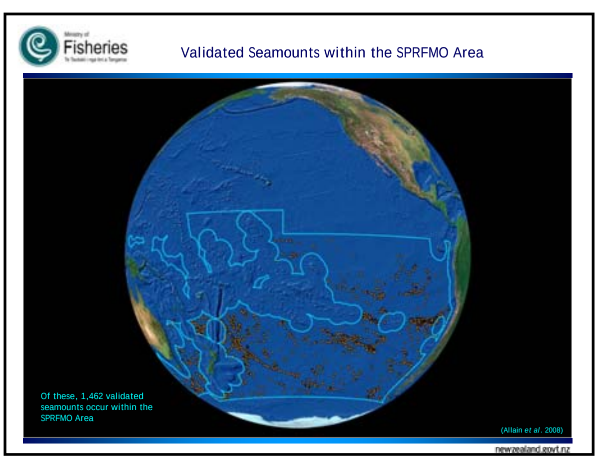


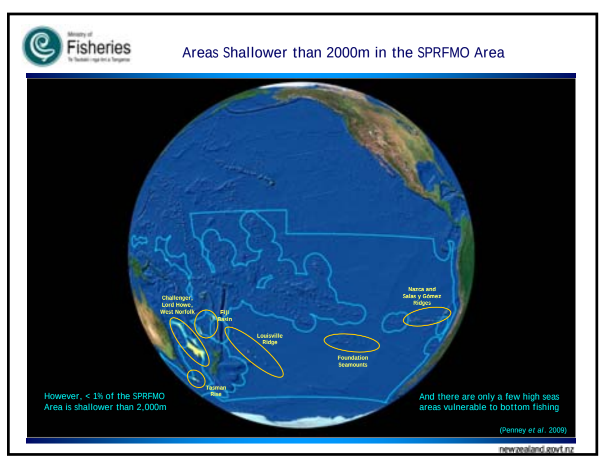

Ministry of Fisheries
newzealand.govt.nz
Conservation and Management of Vulnerable Marine Ecosystems in the South Pacific Regional Fisheries Management Organisation Area


Ministry of Fisheries
What are We Trying to Protect ?
The Pacific Ocean in Global Context
The Pacific Ocean covers ~169.2 million km², 46% of the Earth's sea surface area
newzealand.govt.nz

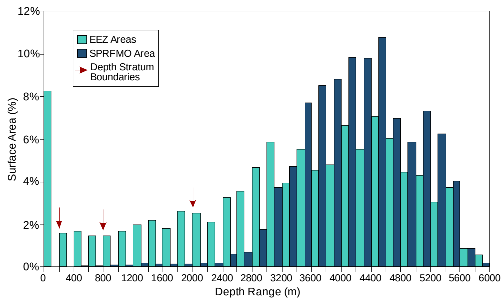

Ministry of Fisheries
The Convention Area of the South Pacific Regional Fisheries Management Organisation
The SPRFMO Area covers ~74.4 million km², 44% of the total Pacific Ocean
newzealand.govt.nz


Ministry of Fisheries
What and Where are VMEs ?
South Pacific Ocean Seamounts
There are over 4,100 seamounts known or predicted to occur across the South Pacific, most of which occur within EEZs
(Kitchingman & Lai 2004)
newzealand.govt.nz


Ministry of Fisheries
Validated Seamounts within the SPRFMO Area
Of these, 1,462 validated seamounts occur within the SPRFMO Area
(Allain et al. 2008)
newzealand.govt.nz


Ministry of Fisheries
Areas Shallower than 2000m in the SPRFMO Area
Challenger, Lord Howe, West Norfolk
Fiji Basin
Louisville Ridge
Tasman Rise
Foundation Seamounts
Nazca and Salas y Gómez Ridges
However, < 1% of the SPRFMO Area is shallower than 2,000m
And there are only a few high seas areas vulnerable to bottom fishing
(Penney et al. 2009)
newzealand.govt.nz

EEZs & SPRFMO Area Depth Distributions



Most fishable depths occur within EEZs, including the first three depth strata recommended for stratification of representative spatial closures. Most of the SPRFMO Area lies between 2,800m and 5,600m depth.

(Clark 2008, Penney *et al*. 2009)

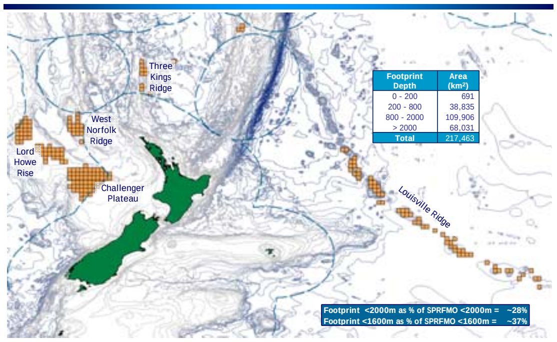
What Protection Frameworks are in Place ?
SPRFMO Interim Measures on Bottom Fisheries

SPRFMO bottom fishery participants are required to:

2. Not expand bottom fishing activities into new regions of the Area where such fishing is not currently occurring. *('Fishing Footprint')*
6. Close areas where vulnerable marine ecosystems are known or likely to occur, unless conservation and management measures have been established to prevent significant adverse impacts on vulnerable marine ecosystems. *(Spatial Closures)*
7. Require that vessels flying their flag cease bottom fishing activities within 5 nautical miles of any site where, in the course of fishing operations, evidence of vulnerable marine ecosystems is encountered. *('Move-On Rule')*

FAO Deepwater Guidelines: Vulnerable Species
• Coldwater corals and hydroids • Sponge communities • Dense habitat-forming fauna • Vent and seep communities
FAO: Seabed Features that support VMEs
• Seamounts, guyots, banks, knolls and hills • Edges, slopes, canyons and trenches • Hydrothermal vents and cold seeps

Restriction of Fishing to Recently Fished Areas



Footprint Depth	Area (km²)
0 - 200	691
200 - 800	38,835
800 - 2000	109,906
> 2000	68,031
Total	217,463

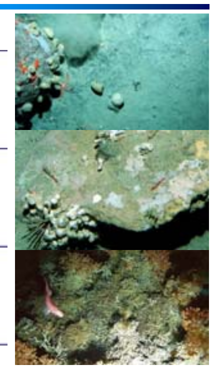
Footprint <2000m as % of SPRFMO <2000m = ~28%
Footprint <1600m as % of SPRFMO <1600m = ~37%

The New Zealand high seas bottom trawl footprint consists of 200 x 20' blocks fished over 2002 – 2006 in the Lord Howe Rise, Challenger Plateau, West Norfolk, Three Kings and Louisville Ridge areas

Precautionary Spatial Closures

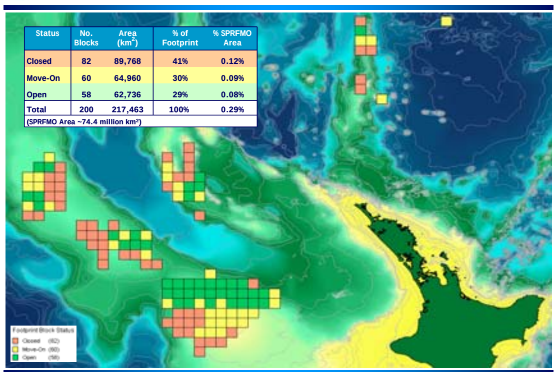
Three-Tiered Approach Tailored Levels of Past Effort

Open (Trawls / yr = > 9) (No. blocks = 69) (34.5%)	**Heavily Trawled Blocks** Past fishing effort - High Seamounts / VMEs - Yes Past seabed impact - Heavy Additional blocks closed as precautionary interim measure to protect representative areas within this tier.
Move-On (Trawls / yr = 1 - 9) (No. blocks = 69) (34.5%)	**Moderately Trawled Blocks** Past fishing effort - Moderate Seamounts / VMEs - ? Past seabed impact - Moderate Review of VME encounters conducted periodically and blocks with high VME encounter rates also closed.
Closed (Trawls / yr = 0) (No. blocks = 62) (31%)	**Lightly Trawled Blocks** Past fishing effort - Negligible Seamounts / VMEs - ?? Past seabed impact - Negligible Remain closed during the period of the interim measures.



Spatial Closures in the Lord Howe, Challenger, West Norfolk and Three Kings Areas

Status	No. Blocks	Area (km²)	% of Footprint	% SPRFMO Area
Closed	82	89,768	41%	0.12%
Move-On	60	64,960	30%	0.09%
Open	58	62,736	29%	0.08%
Total	200	217,463	100%	0.29%
(SPRFMO Area ~74.4 million km²)				



How Representative are Spatial Closures ?

In the absence of data on seabed biodiversity, how can we evaluate whether closures are representative of habitats likely to support VMEs ?

Biogeographic Zone

•This reflects oceanographic conditions (water masses) in large ocean areas:

–Tasman Sea; Western South Pacific.

Seamounts & Seabed Topography

•Features which potentially support VMEs include (FAO Deepwater Guidelines 2008):

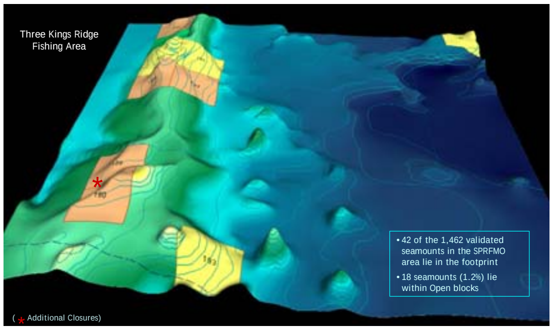
–Submerged edges and slopes; summits and flanks of seamounts, guyots, banks, knolls, and hills; canyons, trenches and hydrothermal vents.

Seabed Depth Range / Summit Depth

•Depth is a major determinant of species composition. Elevation above the abyssal plain is also a relative measure of seamount size (Clark 2008):

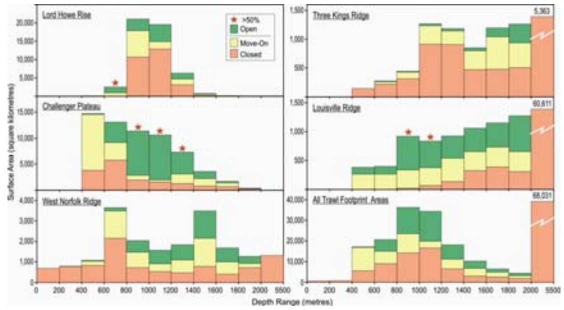
–0–200m (photic); 201–800m (upper bathyal); 801–2000m (lower bathyal); >2000 m (below trawlable depth).

Representivity of Closures by Seamounts & Seabed Topography



97% of the known seamounts lie outside the trawl footprint area. In this Three Kings Ridge area, much of the ridge also lies outside the footprint, with further areas protected by the closures and move-on blocks.

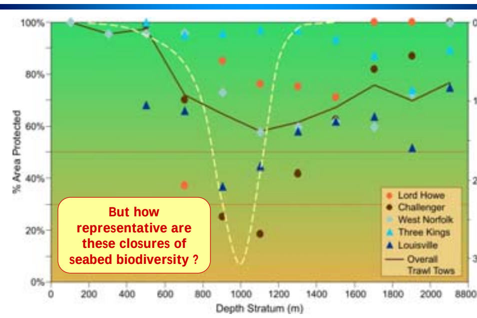
Representivity of Closures by Depth Range



In all but a few fishing area / depth strata, the combination of Closed and Move-On area exceeds 50% of each stratum. Overall, 71% of the footprint area has been closed or made subject to a move-on rule. The strata in which Open areas exceed 50% of the stratum reflect predominance of historical fishing effort in those strata.

(Penney *et al*. 2009)

Adequacy of Protection Measures by Depth Range



49 of the 55 area/depth strata comprising the trawl footprint have been protected (closure or move-on) above recommended 30% - 50% levels. Two strata have had <30% protected. This reflects heavy historical fishing effort on these strata and the management decision to focus future effort on previously impacted areas.

(Lauck *et al*. 1998, Rogers *et al*. 2008, Penney *et al*. 2009)

Move-On Rules vs. Spatial Closures ?

- Move-on rules are increasingly being criticised as being inadequate to properly protect VMEs.
- These should only be considered as an initial measure, to be used under conditions of low knowledge, preparatory towards implementing measures such as spatial closures or gear restrictions.
- The FAO Deepwater Management Guidelines emphasize the importance of spatial closures, and area closures have already been established by CCAMLR, NEAFC and NAFO.
- The SPRFMO Scientific Working Group has noted that:
  - *"... an effective approach ... would probably require the establishment of specific spatial closures designed to protect adequate and representative proportions of various VMEs."*
- **But how do we measure 'representivity', and how much is 'adequate' ?**

What Information is Needed ?

➢ *South Pacific-Wide Benthic Habitat & Community Classification Models*

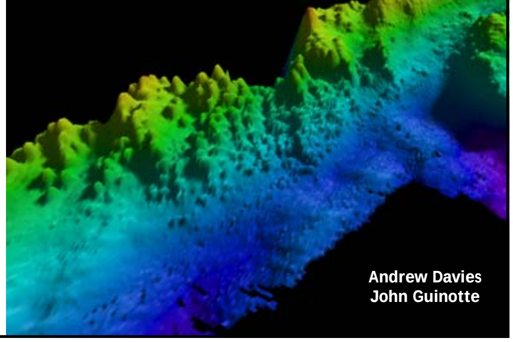
e.g. Marine Environmental Classification (Snelder *et al*. 2004), Niche Factor Analysis (Clark *et al*. 2006), Species Spatial Prioritization (Leathwick *et al*. 2008), Geomorphic Biodiversity Surrogates (Williams *et al*. 2009)

- Detailed seabed bathymetry, and topographical analysis to describe seabed profile and map geo-morphological feature types in relation to depth.
- Database of other factors influencing benthic community composition and structure on identified geo-morphological seabed types.
- Physical oceanographic data useful to developing habitat classification models - SST, radiation, chlorophyll, currents.
- Data on distribution of demersal fishery target and by-catch species, particularly for low productivity stocks.
- **Data on actual seabed substratum type and benthic community biodiversity from selected areas, to ground-truth predictive models.**

Questions that Need to be Addressed

- Who should be involved in a project of this magnitude and geographic scope ?
- What habitat and community classification and predictive modelling approaches should we be working towards ?
- What should the geographic scope of these models be ?
- What data do these modelling approaches require, which of these data exist and where are they to be found ?
- Who should be developing and maintaining the databases required for South pacific habitat classification modelling ?
- How are we going to fund and conduct seabed type and benthic community composition surveys to calibrate and ground-truth the habitat and community classification models ?

Predicting the distribution of bioherm-forming (scleractinian) cold-water corals



Andrew Davies
John Guinotte

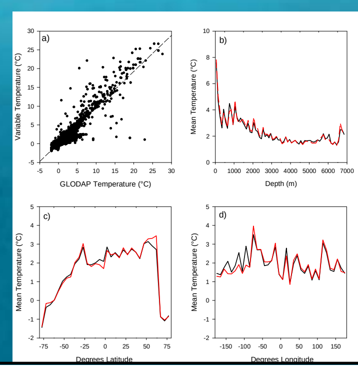
Why?

- Cost effective method for identifying potential VMEs on the high seas and within EEZs
  - *Future MPAs*
- Useful for targeting areas for future research/cruise planning.
  - Multibeam targets
- Helps provide insight into the drivers that govern coral distribution
  - Climate / ocean acidification implications

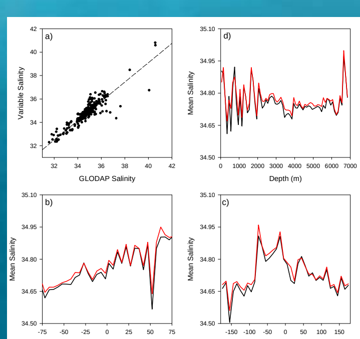
Methodology

- Uses Maxent model (Phillips et al. 2006).
- 29 global variables at 1km resolution for the ocean floor.
  - **Geophysical**: slope, depth, rugosity, etc.
  - **Chemical**: carbonate chemistry, nutrients, salinity, etc.
  - **Biotic**: food supply, POC.
  - **Physical**: currents, temperature etc.

Validation of 1km environmental layers with GLODAP water samples (Temp)



Validation of 1km environmental layers with GLODAP water samples (Salinity)



Validation statistics comparing the performance of five 1km environmental variables with GLODAP water samples (all statistics significant at $p = 0.001$).

Dataset	*n*	Mean diff (SE)	Regression	Correlation
Temperature	6972	0.002 (0.01)	0.854	0.92
Salinity	6891	0.02 (0.001)	0.835	0.91
Phosphate	6386	0.036 (0.003)	0.851	0.92
Nitrate	6598	0.52 (0.04)	0.833	0.91
Silicate	6994	7.434 (0.35)	0.677	0.82

Results

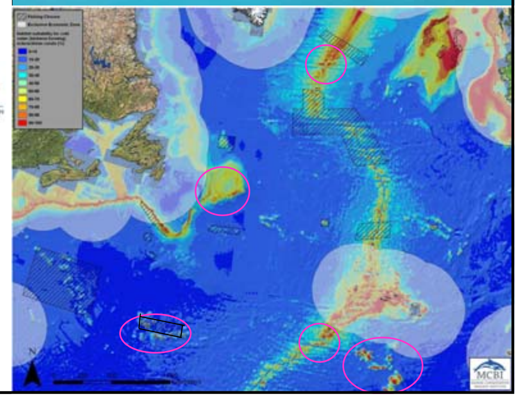
- Results presented here are for 6 species of bioherm forming scleractinians

  (*Lophelia pertusa, Madrepora oculata, Desmophyllum dianthus, Solensomilia variablis, Goniocorella dumosa, Enallopsammia rostrata*)

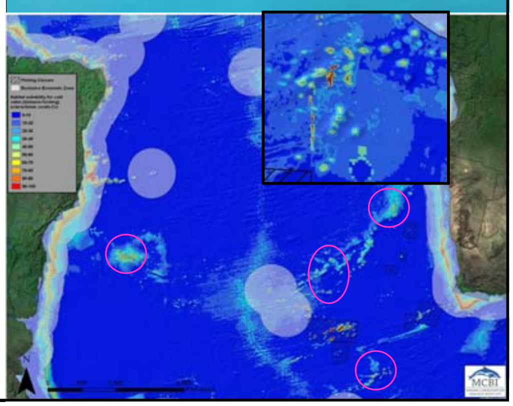
- In total, we modelled the niche using 4140 records

- Octocorals and Antipatharians are also being modeled using 1km data
  - Derek Tittensor and Alex Rogers leading this effort

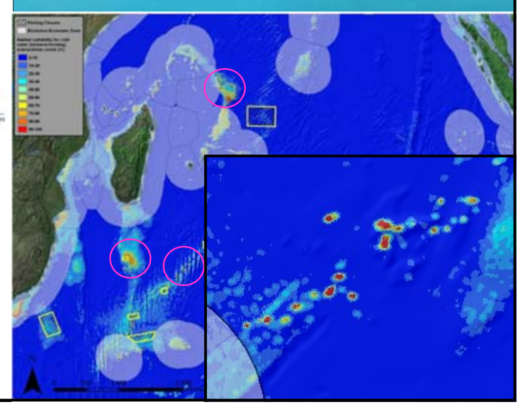
N Atlantic Closures-VMEs



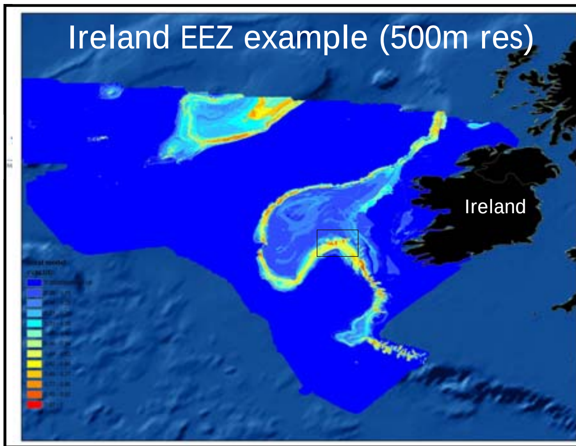
S Atlantic Closures-VMEs

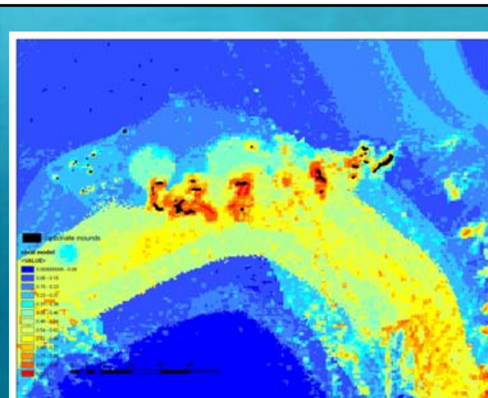


S Indian Ocean Vol Closures-VMEs

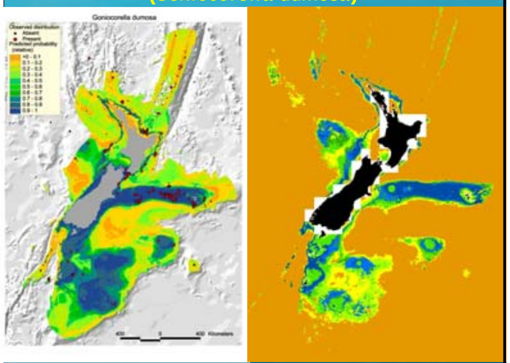


Ireland EEZ example (500m res)





NIWA coral model and global prediction comparison (*Goniocorella dumosa*)



NIWA (preliminary) Global (1km)

What are the major environmental drivers globally?

- Combination:
  - Carbonate chemistry.
  - Temperature.
  - Salinity.
  - Nutrients.
  - Dissolved O_2.
  - Topography.
  - Food supply.
- Caveat: Model can only provide an indication of "niche."

  Does not resolve temporal variability, competition, etc.

Still need experiments, observations, field validation.

Models planned or under development

- Southeast United States (funded-private)
- Alaska (funded-private)
- West coast United States (NOAA-pending)
- Tasmania (CSIRO)
- High seas (GOBI-Global Ocean Biodiversity Initiative)
  - Scleractinians, Octocorals, Hexactinellids (glass sponges)
- Future changes in carbonate chemistry
  - Preindustrial-2100 time series being calculated now at 1km resolution for the ocean floor

Relevance to this group (NZ-US)

- Pacific CWC habitat has been modeled for 6 sp. Scleractinians
  - Has not been examined in any detail.
- Pacific Octocoral models will be finished soon (1-3 mos)
- Model application not limited to corals
  - Env database can be used for other taxa
- Methods and database can be used to identify other potential VMEs.

	Variable	Unit	Name	Cell size (x,y)	Depth Range (levels)	Reference
Geophysical variables		-				
1	Depth	m	DEPTH	0.0083°	Ocean depth (1 level)	Becker et al. (in press)
2	Slope	m m^{-1}	SLOPE	0.25°, 0.2°	Ocean depth (1 level)	Becker & Sandwell (2008)
3	Rugosity	-	RUGOS	0.0083°	Ocean depth (1 level)	Derived from Becker et al. (in press)[1]
4	Aspect eastings	-	ASPE	0.0083°	Ocean depth (1 level)	Derived from Becker et al. (in press)[2]
5	Aspect northings	-	ASPN	0.0083°	Ocean depth (1 level)	Derived from Becker et al. (in press)[2]
6	Bathymetric position index	-	BTM1	0.0083°	Ocean depth (1 level)	Derived from Becker et al. (in press)[1] 1 – 5[1]
7	Bathymetric position index	-	BTM2	0.0083°	Ocean depth (1 level)	Derived from Becker et al. (in press)[1] 2 - 10[1]
8	Slope 2	°	SLOPE2	0.0083°	Ocean depth (1 level)	Derived from Becker et al. (in press)[1]
Hydrographic variables						
9	Regional current flow	cm s^{-1}	REGFL	0.5°	5-5374m (40 levels)	Carton et al. (2005)[3]
10	Vertical flow	m/s	VERTFL	0.5°	5-5374m (40 levels)	Carton et al. (2005)[3]
Chemical variables						
11	Alkalinity	μmol cm^{-3}	ALK	3.6°, 0.8-1.8°	6-4775 m (25 levels)	Steinacher et al. (2008)[4]
12	Apparent oxygen utilisation	ml l^{-1}	AOXU	1°	0-5500 m (33 levels)	Garcia et al. (2006a)
13	Aragonite	Ω_{arag}	ARAG	3.6°, 0.8-1.8°	6-4775 m (25 levels)	Steinacher et al. (2008) [4]
14	Calcite	Ω_{calc}	CALC	3.6°, 0.8-1.8°	6-4775 m (25 levels)	Steinacher et al. (2008) [4]

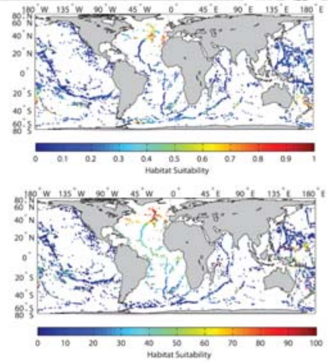
	Variable	Unit	Name	Cell size (x,y)	Depth Range (levels)	Reference
15	Carbonate ion concentration	μmol cm^{-3}	CION	3.6°, 0.8-1.8°	6-4775 m (25 levels)	Steinacher et al. (2008) [4]
16	Dissolved inorganic carbon	μmol cm^{-3}	DIC	3.6°, 0.8-1.8°	6-4775 m (25 levels)	Steinacher et al. (2008) [4]
17	Dissolved oxygen	ml l^{-1}	DISO2	1°	0-5500 m (33 levels)	Garcia et al. (2006a)
18	Nitrate	μmol l^{-1}	NITR	1°	0-5500 m (33 levels)	Garcia et al. (2006b)
19	pH	-	PH	3.6°, 0.8-1.8°	6-4775 m (25 levels)	Steinacher et al. (2008) [4]
20	Phosphate	μmol l^{-1}	PHOS	1°	0-5500 m (33 levels)	Garcia et al. (2006b)
21	Percent oxygen saturation	%	POXS	1°	0-5500 m (33 levels)	Garcia et al. (2006a)
22	Salinity	-	SAL	0.25°	0-5500 m (33 levels)	Boyer et al. (2005)
23	Silicate	μmol l^{-1}	SIL	1°	0-5500 m (33 levels)	Garcia et al. (2006b)
24	Temperature	°C	TEMP	0.25°	0-5500 m (33 levels)	Boyer et al. (2005)
Biological variables						
25	Primary productivity	mg m^{-3}	MODIS	0.04°	Surface (1 level)	MODIS L3 Annual SMI[5]
26	Primary productivity export	mg C m^{-2} yr^{-1}	VGPM	0.05°	Surface (1 level)	Behrenfield & Falkowski (1997)[6]

Contribution of environmental variables to Ireland coral prediction
(note: aragonite saturation state was not included as the entire water column is supersaturated)

- The following table gives a heuristic estimate of relative contributions of the environmental variables to the Maxent model. To determine the estimate, in each iteration of the training algorithm, the increase in regularize gain is added to the contribution of the corresponding variable, or subtracted from it if the change to the absolu value of lambda is negative. As with the jackknife, variable contributions should be interpreted with caution when the predictor variables are correlated.
-
- Variable Percent contribution
- depth 25
- rug 19
- o2 19
- temp 16
- salinity 13
- phos 5
- slope 2

Comparing two different algorithms: MaxENT and ENFA – predicted habitat suitability for Scleractinia

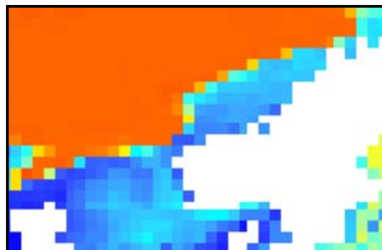
Model results similar but MaxEnt performed significantly better than ENFA



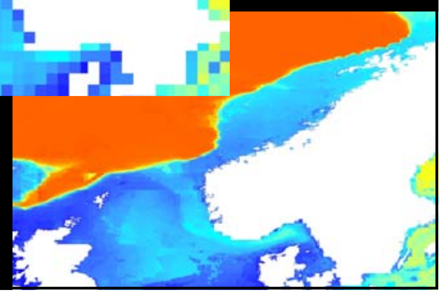
2008, on our first attempt, We encountered limitations…

- Low resolution of environmental data.
- Incomplete geographical distribution of environmental data.
- Paucity of presences.
- Lack of absences reduces the available modelling techniques.

- How can we address these?

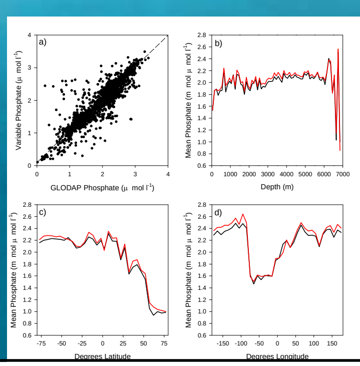


Bottom temperature generalised 1 km^2 grid. Constructed using 33 depth layers from World Ocean Atlas.

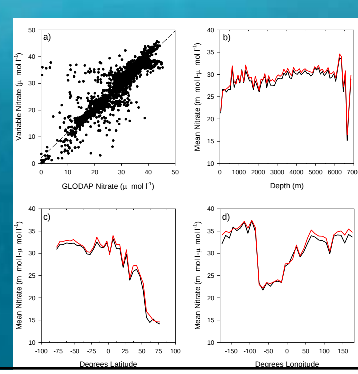


* Not yet verified by independent measures *

Validation of environmental layers with GLODAP bottle data (Phosphate)



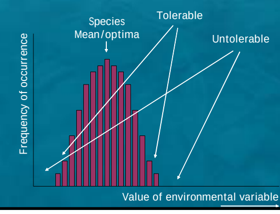
Validation of environmental layers with GLODAP bottle data (Nitrate)



Data	Presences / Environmental data	95%
Processing	Model	2%
Output	Idealised niche = Possible distribution	3%

How can we find where a species is?

- Niche
  - The range of environmental conditions (biological and physical) under which an organism can exist.
- Tolerance
  - The ability of organisms to exist at the fringes of its niche.



Predicting the spatial distribution of five deep sea coral species around New Zealand

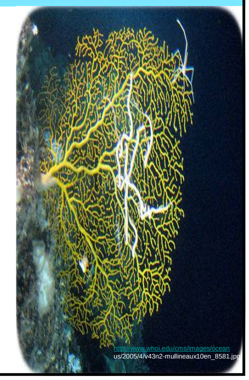
Tanya J. Compton
John R. Leathwick
Ashley A. Rowden
Dianne Tracey

INTRODUCTION

Slow growing cold water corals structurally complex habitats that support a diversity of fauna (Freiwald et al. 2002)

May even support greater diversity than shallow reefs (Rogers 1999)

BUT vulnerable to anthropogenic pressures, e.g. fishing, hydrocarbon drilling, seabed mining and ocean acidification



A NEED FOR DISTRIBUTION MODELS

Despite their ecological importance, records of deep sea corals are patchy and unavailable (Tittensor et al. 2009)

A lack of knowledge about coral distributions in combination with anthropogenic pressures, there are immense challenges to their protection

Tools like distribution modelling can be used to increase knowledge on the locations of corals and thus aid marine protection

DISTRIBUTION MODELLING

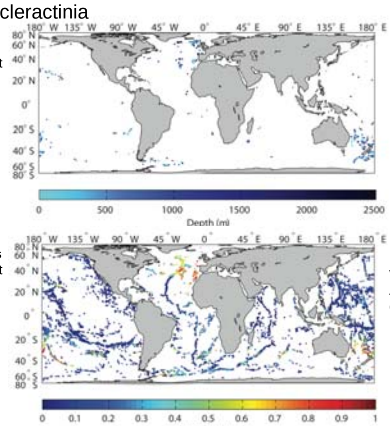
Distribution modelling approaches can be used to:

1) Identify the physical, chemical and/or biological factors associated with coral distributions
2) Predict occurrences of corals based on these variables

Order Scleractinia

Raw data of seamount corals

Predictions of seamount corals



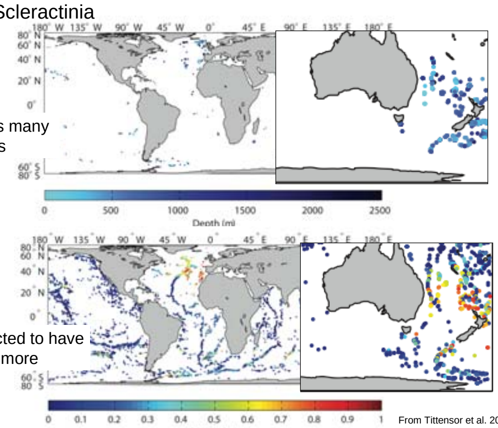
Models based on World Ocean Atlas and other global datasets

From Tittensor et al. 2009

Order Scleractinia

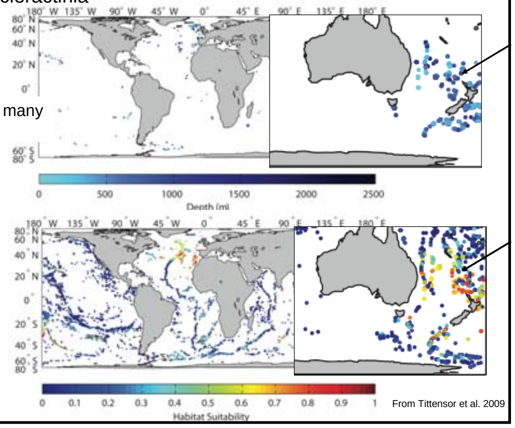
NZ has many records

Predicted to have many more



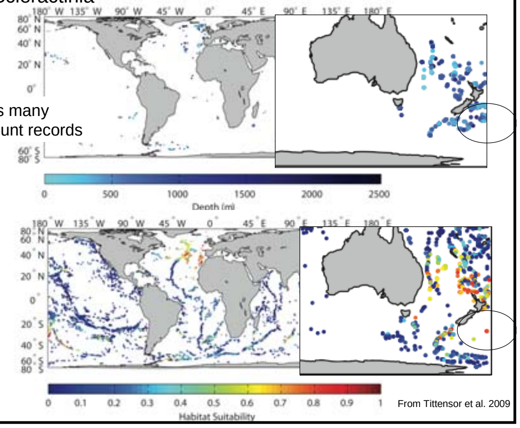
From Tittensor et al. 2009

Order Scleractinia



From Tittensor et al. 2009

Order Scleractinia



From Tittensor et al. 2009

Deep sea corals around New Zealand

To evaluate the validity of
1) a global approach to predictive modeling
2) use of coarse taxonomic resolutions
we need to focus on smaller areas with **high resolution** coral and environmental data

Predicting the spatial distribution of five deep sea coral species around NZ

Identify the environmental variables associated with the distribution of five coral species

Make spatial predictions

Deep sea corals: DATA

Goniocorella dumosa (n = 162)

Enallopsammia rostrata (n = 65)

Madrepora vitiae (n = 66)

Solenosmilia variabilis (n = 55)

Oculina virgosa (n = 15) found in northern NZ

Absences - locations corals not found during various cruises

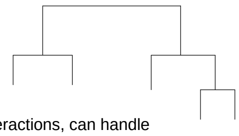
ENVIRONMENTAL DATA

Environmental variable	Abbreviation
Bathymetry around NZ	bathy
Dissolved organic matter	disorg
Roughness. An estimate of seabed relief	roughness
Salinity at the seafloor.	sal
Sea surface temperature spatial gradient. A measure of oceanic fronts and water masses around NZ.	sstgrad
Temperature residuals. Residuals from a GLM relating temperature to depth using natural splines. High values indicate warm water masses, whereas low values indicate cold water.	tempres
Tidal current. Depth averaged maximum tidal current	tid
Surface water primary productivity. As estimated from the Vertically generalized production Model (VGPM)	vgpm
Sediment as determined from sediment charts around NZ	sed
Sediment resuspension estimated from a wave model and sediment data	sedfrn
Estimates of average orbital velocities at the seafloor	orbv

Modelled layers for NZ region, 1 km x 1 km grid

Boosted regression trees

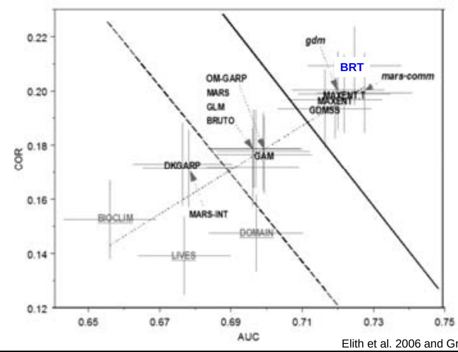
Robust approach for modelling and predictions
(reviews Elith et al. 2008, De'Ath 2007)



Regression trees automatically fit interactions, can handle missing values, insensitive to outliers and can handle any type of predictor

Boosting improves the accuracy of regression trees by fitting regression trees to the data in a stochastic manner continuously emphasizes poorly explained data

Boosted regression trees

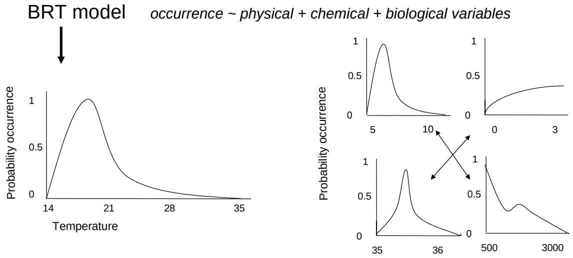


Elith et al. 2006 and Graham et al. 2008

Boosted regression trees

STEP1. Identify the variables best associated with coral occurrence

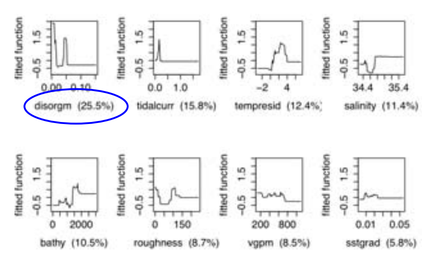
Need coral occurrences
Need environmental data
BRT model *occurrence ~ physical + chemical + biological variables*



Boosted regression trees

STEP1. Identify the variables best associated with coral occurrence

Need coral occurrences
Need environmental data
BRT model

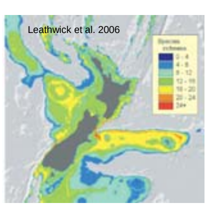


Boosted regression trees

STEP2. Make spatial predictions using the BRT model

Need environmental data layers
And the selected BRT model

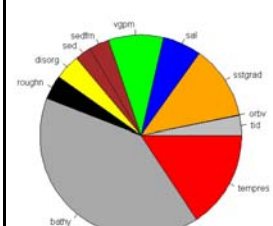
*Model should predict observed and "new" occurrences



*confidence intervals

CONTRIBUTIONS TO MODEL

Goniocorella dumosa

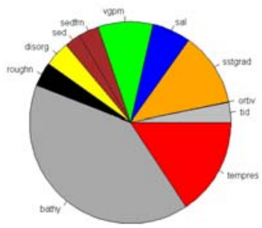


Bathymetry
Temperature residuals
SST gradient
Primary productivity

CONTRIBUTIONS TO MODEL

Goniocorella dumosa

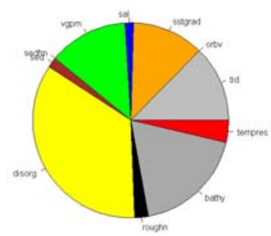
NOTE: depth in unlike other variables
It is an indirect surrogate for other
proximate drivers of distribution,
e.g. light, pressure, oxygen
and aragonite



Bathymetry
Temperature residuals
SST gradient
Primary productivity

CONTRIBUTIONS TO MODEL

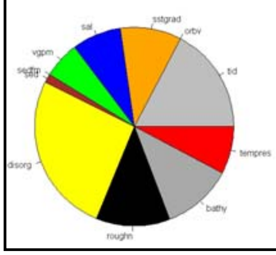
Enallopsammia rostrata



Dissolved organic matter
Bathymetry
Tidal current
Primary productivity

CONTRIBUTIONS TO MODEL

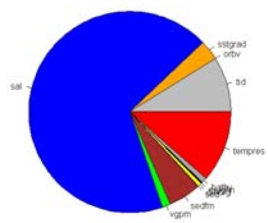
Madrepora vitiae



Dissolved organic matter
Tidal current
Roughness
Bathymetry

CONTRIBUTIONS TO MODEL

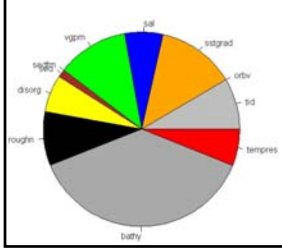
Oculina virgosa



Salinity
Temperature residuals
Tidal current
Suspended sediment

CONTRIBUTIONS TO MODEL

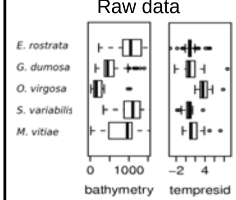
Solenosmilia variabilis



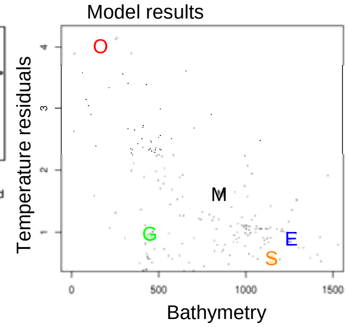
Bathymetry
SST gradient
Primary productivity
Roughness

Model validation

Raw data

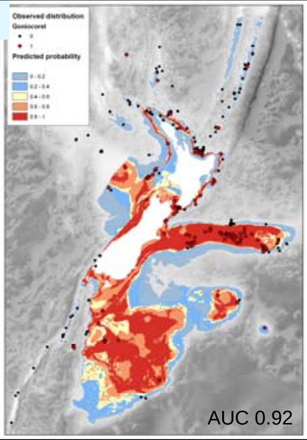


Model results



PREDICTIONS

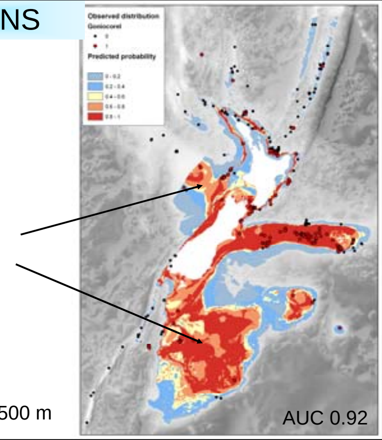
Goniocorella dumosa



Depth restricted to 1500 m

PREDICTIONS

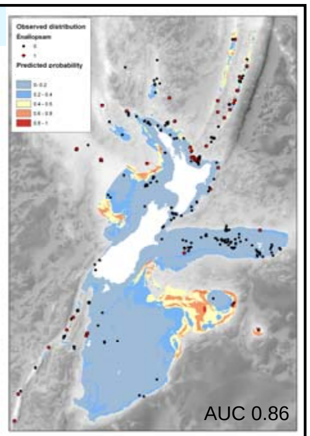
Goniocorella dumosa



Depth restricted to 1500 m

PREDICTIONS

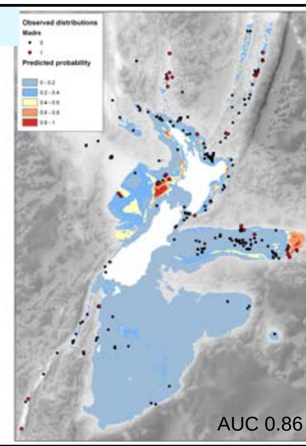
Enallopsammia rostrata



Depth restricted to 1500 m

PREDICTIONS

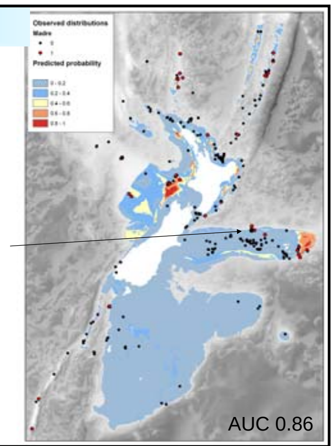
Madrepora vitiae



Depth restricted to 1500 m

PREDICTIONS

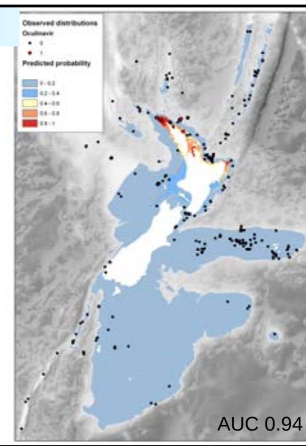
Madrepora vitiae



Depth restricted to 1500 m

PREDICTIONS

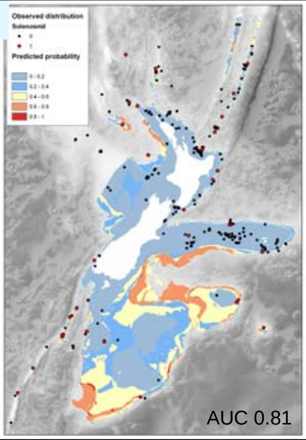
Oculina virgosa



Depth restricted to 1500 m

PREDICTIONS

Solenosmilia variabilis

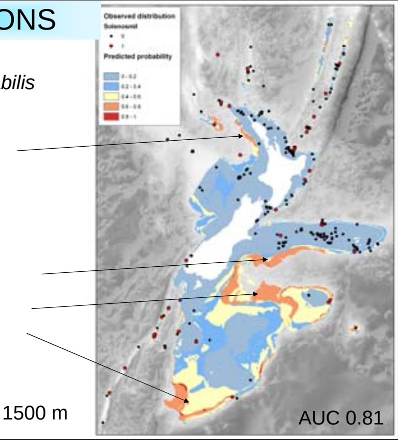


Depth restricted to 1500 m

AUC 0.81

PREDICTIONS

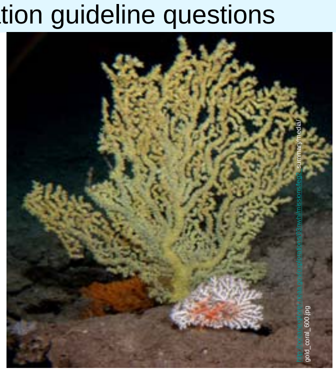
Solenosmilia variabilis



Depth restricted to 1500 m

AUC 0.81

Answers to questions from the JCM presentation guideline questions



Ground-truthing to test predictions?

Our preliminary results identify new areas of coral occurrence

Ground-truthing: None so far…

Need to coordinate with new surveys to take samples and thus test the models

Modelling related issues

Our models also do not predict some observed occurrences

Environmental data needs improvements
- –Sea-floor relief – difficult with low-res bathymetry
- –Dissolved organic/suspended particulate matter?
- –Many predictors are inter-correlated

Need to explore other predictor variables?
- –Oxygen, calcium, aragonite?
- –But strongly depth correlated – normalise?

Knowledge on coral dispersal abilities? Effect on distribution modelling?

Dispersal abilities - little information on dispersal abilities of coral (more studies on coral life histories needed)

We have current speed but not current direction

There is currently work to improve oceanographic models, e.g. Bluelink, that shows promise for inclusion in future distribution models

Linking distribution models with genetic data to identify levels of connectivity

Taxonomic aggregation?

Reliable species level data is most ideal but often unavailable (lack of consistency issues)

Higher level aggregation can produce useful results (e.g. Tittensor et al. 2009)

Would be useful to evaluate the loss of information between different levels taxon aggregation

How can this work be tailored to the needs of the RFMOs to identify Vulnerable Marine Ecosystems?

Compile data at the same taxonomic levels as used by the VME identification guide

Compile data for particular regions of their interest, e.g. Ross Sea, then produce distribution maps to guide avoidance of VMEs

Methods future research directions/collaborations

Improving environmental data layers (more variables and higher resolution)

Examine means to deal with autocorrelation, e.g. normalise oxygen saturation

Compare individual versus community based models (e.g. generalized dissimilarity models)

Applied future research directions/collaborations

Use distribution maps to identify VMEs

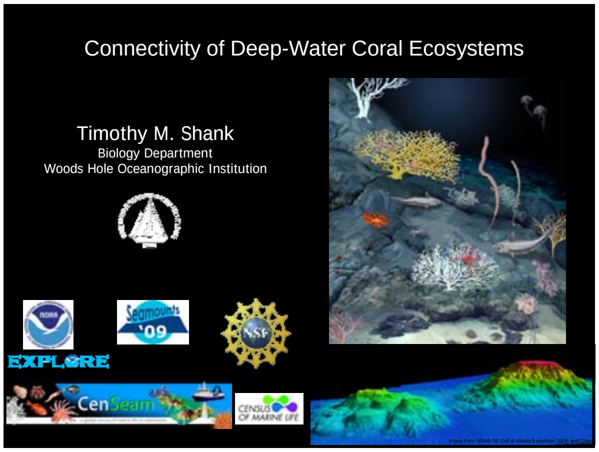
Use distribution modelling with conservation modelling, e.g. zonation and marxan, to identify MPAs

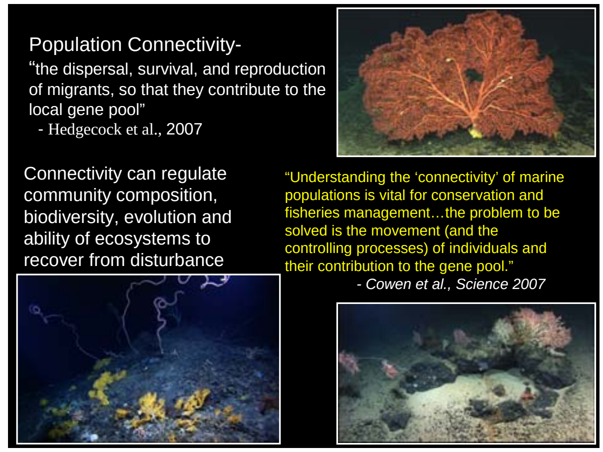
Use distribution modelling to assess the effects of climate change, ocean acidification and fishing

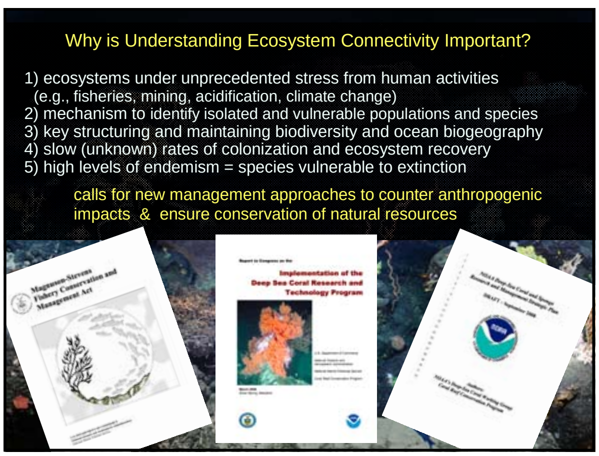
Fundamental future research directions/collaborations

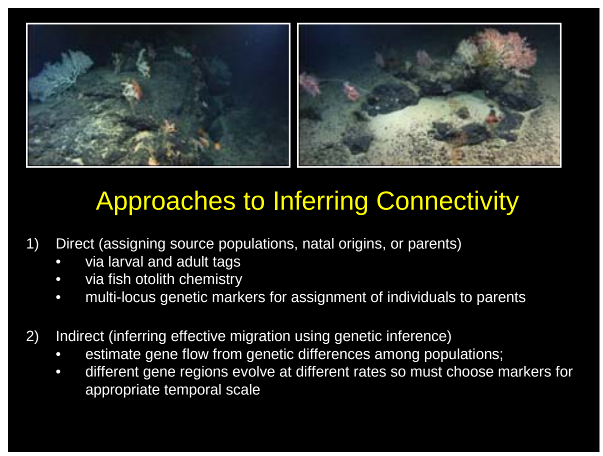
Wider biogeography in the Pacific Ocean

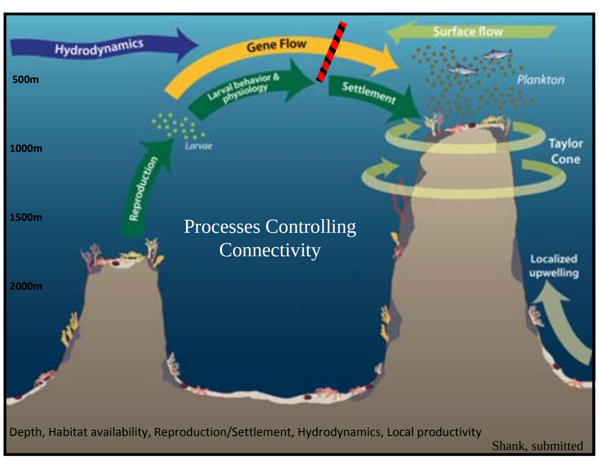
Use distributional models to compare the variables that are associated with corals on individual seamounts to look at the *Why* component

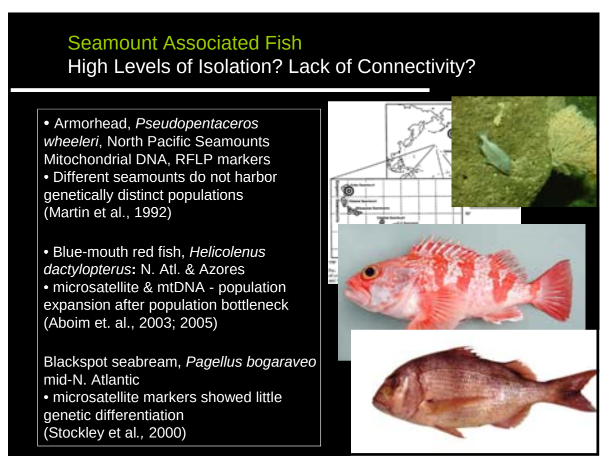

Connectivity of Deep-Water Coral Ecosystems
Timothy M. Shank
Biology Department
Woods Hole Oceanographic Institution
Seamounts '09
NSF
EXPLORE
CenSeam
CENSUS OF MARINE LIFE


Population Connectivity-
"the dispersal, survival, and reproduction of migrants, so that they contribute to the local gene pool"
- Hedgecock et al., 2007
Connectivity can regulate community composition, biodiversity, evolution and ability of ecosystems to recover from disturbance
"Understanding the 'connectivity' of marine populations is vital for conservation and fisheries management…the problem to be solved is the movement (and the controlling processes) of individuals and their contribution to the gene pool."
- Cowen et al., Science 2007


Why is Understanding Ecosystem Connectivity Important?
1) ecosystems under unprecedented stress from human activities (e.g., fisheries, mining, acidification, climate change)
2) mechanism to identify isolated and vulnerable populations and species
3) key structuring and maintaining biodiversity and ocean biogeography
4) slow (unknown) rates of colonization and ecosystem recovery
5) high levels of endemism = species vulnerable to extinction
calls for new management approaches to counter anthropogenic impacts & ensure conservation of natural resources
Magnuson-Stevens Fishery Conservation and Management Act
Implementation of the Deep Sea Coral Research and Technology Program


Approaches to Inferring Connectivity
1) Direct (assigning source populations, natal origins, or parents)
• via larval and adult tags
• via fish otolith chemistry
• multi-locus genetic markers for assignment of individuals to parents
2) Indirect (inferring effective migration using genetic inference)
• estimate gene flow from genetic differences among populations;
• different gene regions evolve at different rates so must choose markers for appropriate temporal scale


Hydrodynamics
Gene Flow
Surface flow
500m
Larval behavior & physiology
Settlement
Plankton
1000m
Larvae
Taylor Cone
Reproduction
1500m
Processes Controlling Connectivity
Localized upwelling
2000m
Depth, Habitat availability, Reproduction/Settlement, Hydrodynamics, Local productivity
Shank, submitted

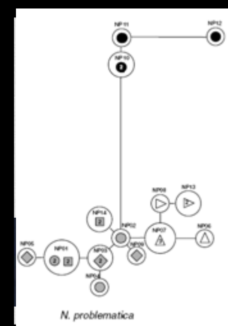

Seamount Associated Fish
High Levels of Isolation? Lack of Connectivity?
• Armorhead, Pseudopentaceros wheeleri, North Pacific Seamounts
Mitochondrial DNA, RFLP markers
• Different seamounts do not harbor genetically distinct populations
(Martin et al., 1992)
• Blue-mouth red fish, Helicolenus dactylopterus: N. Atl. & Azores
• microsatellite & mtDNA - population expansion after population bottleneck
(Aboim et. al., 2003; 2005)
Blackspot seabream, Pagellus bogaraveo mid-N. Atlantic
• microsatellite markers showed little genetic differentiation
(Stockley et al., 2000)

Seamount Corals
High Levels of Isolation? Lack of Connectivity?

- **Precious Pink Coral:**
  - 6 microsatellite loci revealed:
  - No significant structuring between populations on Oahu
  - Some genetic structure between pops on Brooks Banks
- **Precious Red Coral:**
  - Kauai population and Bank 8 populatio[n] isolated from other populations (Baco and Shank 2005)
  - 2 sympatric species with different dispersal patterns; 100km scale dispersal

Seamount Invertebrates
High Levels of Isolation? Lack of Connectivity?

- Examined population genetics of 2 galatheid, 2 chirostylid and 2 gastropod species from Norfolk Ridge seamounts and nearby slope
- NO genetic structure between populations in different habitats for the 4 crab species and 1 species of snail (*Sassia remensa*) with planktotrophic larvae
- Genetic structure for 1 non-planktotrophic snail with limited dispersal ability
- Limited potential for endemism



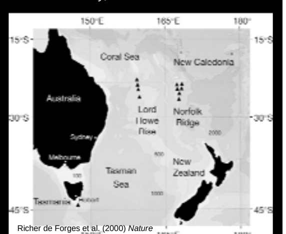
Samadi et al. (2006) *Marine Biology*

Seamount Invertebrates
High Levels of Isolation? Lack of Connectivity**?**

- Compared the genetic structure (*mtCOI*) of gastropod species with different larval modes, living on seamounts near New Caledonia.
- NO genetic structure between populations on different seamounts for the 2 species with planktotrophic larvae
- Genetic structure for 1 non-planktotrophic gastropod with limited dispersal ability
- Confirmed the correlation between genetic connectivity and mode of larval development

Connectivity in Oceanic Seamounts Systems: Comparative Phylogeography of Gastropods with Contrasted Reproductive Strategies

- Magalie Castelin et al., *World Conference on Marine Biodiversity, 2008.*



Richer de Forges et al. (2000) *Nature*

Northwestern Atlantic Seamounts

16 Dives
10 Seamounts
2.83km length (avg)
13 hours per dive; 209 hours of HD video

In association with *Candidella imbricata*

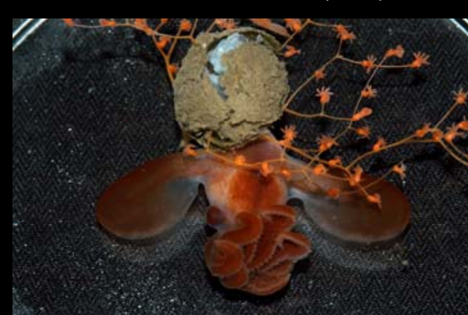
Ophioplinthaca abyssalis
92% of the observations

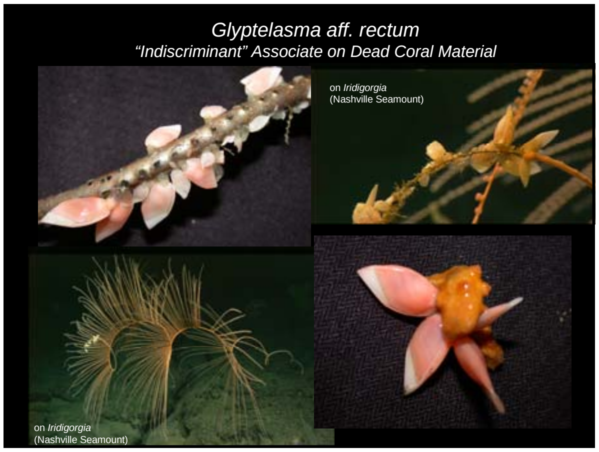
Gorgoniapolynoe caeciliae
100% of the observations

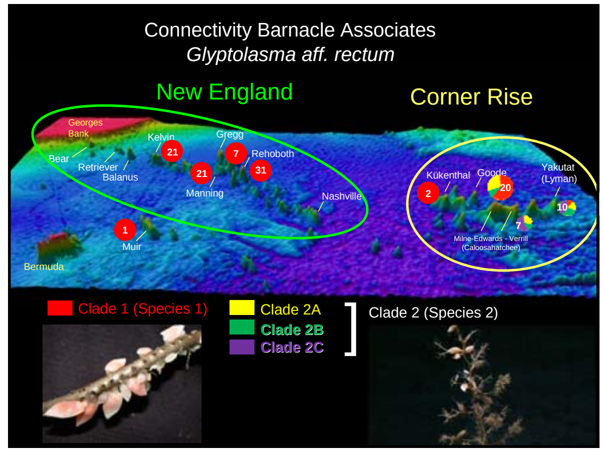

Eckelbarger et al. 2005

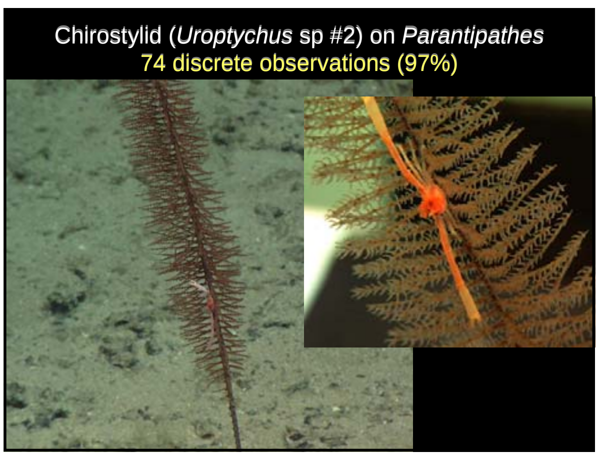
Cirrate octopod hatchling from egg attached to 3 octocorals (*Chrysogorgia sp., Acanella sp., Metalagorgia*)

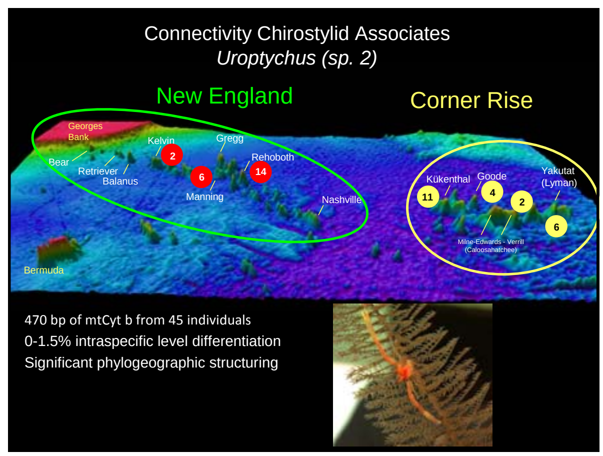
25 discrete observations (100%)

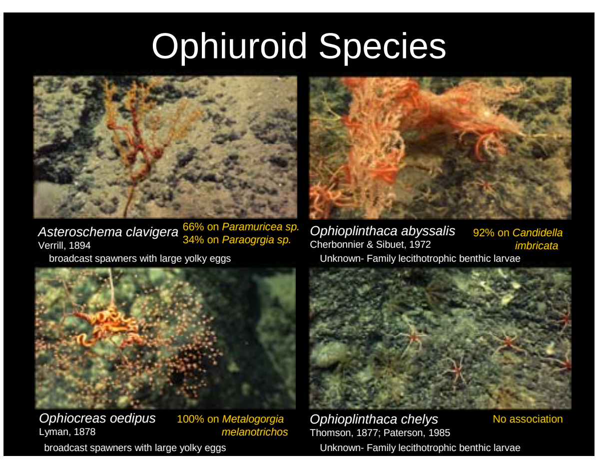


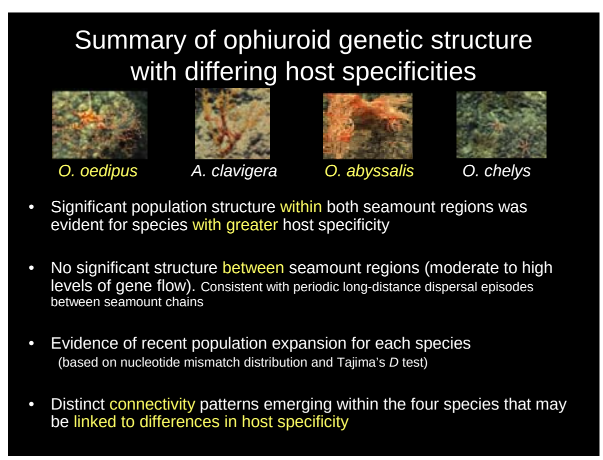

Glyptelasma aff. rectum
"Indiscriminant" Associate on Dead Coral Material
on Iridigorgia
(Nashville Seamount)
on Iridigorgia
(Nashville Seamount)


Connectivity Barnacle Associates
Glyptolasma aff. rectum
New England
Corner Rise
Georges
Bank
Bear
Retriever
Balanus
Kelvin
21
Gregg
7
Rehoboth
31
21
Manning
Nashville
1
Muir
Bermuda
Kükenthal
2
Goode
20
Yakutat
(Lyman)
10
7
Milne-Edwards - Verrill
(Caloosahatchee)
Clade 1 (Species 1)
Clade 2A
Clade 2B
Clade 2C
Clade 2 (Species 2)


Chirostylid (Uroptychus sp #2) on Parantipathes
74 discrete observations (97%)


Connectivity Chirostylid Associates
Uroptychus (sp. 2)
New England
Corner Rise
Georges
Bank
Bear
Retriever
Balanus
Kelvin
2
Gregg
Rehoboth
14
6
Manning
Nashville
Bermuda
Kükenthal
11
Goode
4
2
Yakutat
(Lyman)
6
Milne-Edwards - Verrill
(Caloosahatchee)
470 bp of mtCyt b from 45 individuals
0-1.5% intraspecific level differentiation
Significant phylogeographic structuring


Ophiuroid Species
Asteroschema clavigera
Verrill, 1894
66% on Paramuricea sp.
34% on Paraogrgia sp.
broadcast spawners with large yolky eggs
Ophioplinthaca abyssalis
Cherbonnier & Sibuet, 1972
92% on Candidella imbricata
Unknown- Family lecithotrophic benthic larvae
Ophiocreas oedipus
Lyman, 1878
100% on Metalogorgia melanotrichos
broadcast spawners with large yolky eggs
Ophioplinthaca chelys
Thomson, 1877; Paterson, 1985
No association
Unknown- Family lecithotrophic benthic larvae


Summary of ophiuroid genetic structure
with differing host specificities
O. oedipus
A. clavigera
O. abyssalis
O. chelys
• Significant population structure within both seamount regions was evident for species with greater host specificity
• No significant structure between seamount regions (moderate to high levels of gene flow). Consistent with periodic long-distance dispersal episodes between seamount chains
• Evidence of recent population expansion for each species
(based on nucleotide mismatch distribution and Tajima's D test)
• Distinct connectivity patterns emerging within the four species that may be linked to differences in host specificity

Needs to understand connectivity of VME populations (ideally)

• Measure physical oceanographic flows, habitat availability, rates of colonization, growth, and dispersal in concert with genetic data to understand mechanisms of connectivity.

•Multi-disciplinary approach: inherent bio-physical problem
- –Hydrodynamics- local and large-scale patterns
- –Mapping- where are natural breaks in *ecosystem* distribution?
- –Processes behind patterns- compare species- test for congruence
- –Larval biology and behavior
- –Realize that each seamount system may be inherently different
- –Use genetic data to evaluate conservation management performance

Strategic management will require an increased understanding of the the impact of these roles of connectivity of VME populations

Areas and Actions for US – NZ Cooperative Research in Coral Ecosystem Connectivity and Conservation

Next 2-3 years

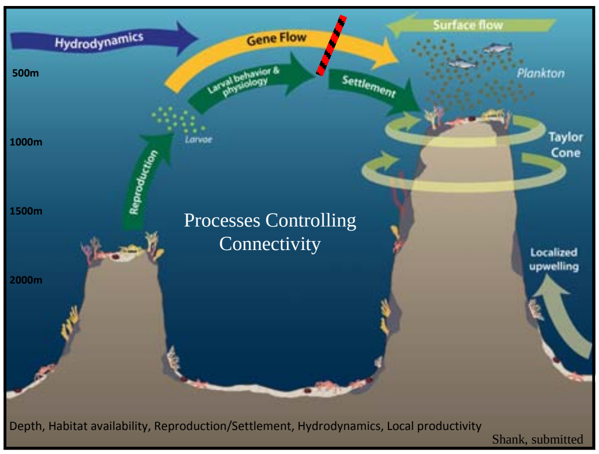
• Further collaborations through ongoing genetic connectivity studies through sample and genetic data and marker development sharing, access to cruises and samples:

NE Pacific (corals, *Baco*)
SW Pacific (crabs, *Miller*; snails, *Castelin*; ophiuroids, *O'Hara*; coral associates, *Shank*)
Atlantic (corals, *France*; ophiuroids, crabs, barnacles, and polychaetes, *Shank*)

• Examine connectivity in areas non-impacted as well as recovering from disturbance –
Connectivity of colonizing species to determine larval sources & impact on genetic diversity
Utilize wealth of coral and invertebrate samples (predictive model of source and sink locations)
Could examine unaffected areas where fisheries activities *will* occur

• Molecular taxonomy /barcoding of diverse NZ seamount collections in conjunction with US/NZ
Provide first order systematics with which to launch connectivity studies
Seamount Barcoding Association (set for March 2010 release)

• Bring US deep-submergence assets to bear on NZ knowledge of coral habitats
Examples:
1) High-res autonomous underwater vehicle mapping, including backscatter and imaging to identify potential hard bottom areas for corals and their extent
2) High-res submersible sampling of coral habitats and associated fauna



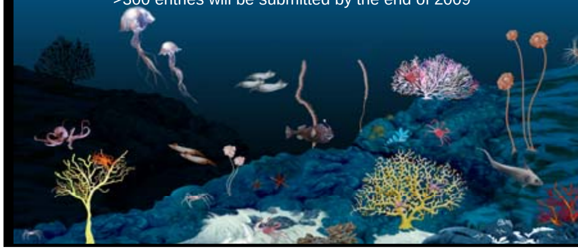
Seamount Barcoding Association

Database for the DNA Barcoding of Life on Seamounts

Seamount Barcoding Association- to accelerate acquisition of and access to knowledge of biodiversity using DNA sequences (taxa-dependent gene regions).

http://sba.whoi.edu/

>300 entries will be submitted by the end of 2009



Genetic Approaches to Assess Diversity and Connectivity of Seamount Fauna

Molecular systematics
• address questions of taxonomic boundaries, identification and determination via comparison of morphological characters with genetic markers (DNA barcoding & identifying species-specific larvae)

Phylogenetics
• address questions of inter-specific/generic/familial relatedness; formation and radiation of diversity; speciation events; evolution of ecological adaptations of species and groups (interspecific approach)

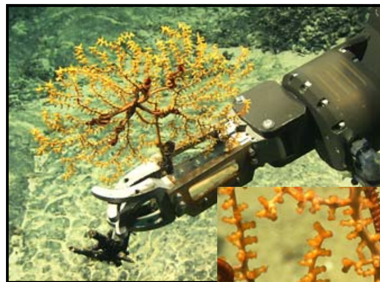
Population genetics (includes phylogeography or historical population migrations)
• seeks to understand the history, formation, and persistence of the factors that inhibit, promote, and control dispersal; mechanisms of larval dispersal; identification of dispersal barriers, biogeographic boundaries, and stock structure for conservation and management (intraspecific approach)

"Community- co-evolutionary genetics"
• assessing host coral and faunal associate relationships; co-evolution among species and populations; including congruence of dispersal patterns and mechanisms

Key challenges for understanding "connectivity"

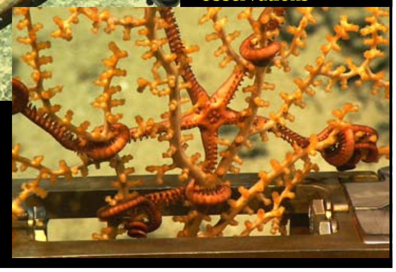
1. Identifying the dynamic temporal and spatial scales over which the "connective" processes interact
2. Designing the appropriate sampling design to address questions of connectivity on these scales
3. Identifying species through morph. & molecular taxonomy
4. Identifying population/phylogeographic boundaries
5. Obtaining enough samples/individuals for population genetics
6. Finding the appropriate genetic marker for the question
7. Obtaining co-located/co-incident physical and environmental data

- 1. How do the dominant processes structure differences in connectivity in coral ecosystems?
- 2. What are the key temporal and spatial scales over which these processes operate…to cause differences in connectivity?- what do managers really want?
- 3. Is it effective to identify a VME without knowing about connectivity? –all seamount ecosystems above 1500m are "vulnerable" –useful is the use of "source" and "sink" inferences of connectivity to determine how vulnerability
- 4. Can use coral ecosystem connectivity (ecological and evolutionary) to minimize the impacts of fisheries, energy exploration, and climate change on coral ecosystem effectively?



Asteroschema clavigera

on *Paramuricea sp.* 66% of the observations



on *Paragorgia sp.* 34% of the observations

Variety of Genetic Tools for Inferring Connectivity

- Allozymes
  - multiple, independent, codominant loci; relatively easy; low cost
- Mitochondrial DNA
  - modest cost; amenable to genealogical analysis maternally inherited
  - *Low variability in deep-water corals provides little utility*
- Nuclear DNA sequences
  - amenable to genealogical analysis;
  - diploid; recombination; start-up time may be considerable
- DNA microsatellites (and Expressed Sequence Tags)
  - nuclear; can get dozens of loci relatively easily
  - recombination; state characters; start-up time and cost$ is great

and Assessing Taxonomy in Corals and Invert Associates

"Global deficiency of scientific expertise in [morphological] taxonomy" is a significant impediment to our understanding of deep-sea coral diversity, coral biogeography, and seamount ecology – *Rogers et al., 2007*)

• MSH1, NADH, and ITS are typical genes used with morphology for coral taxonomy

Key Summary: Topic I

Identification, Taxonomy and Core Data Sets for Deep-Sea Corals

- Problem: Inconsistency of coral taxonomy (variation in quality). *This problem is common to other VME groups, eg sponges.*
- Solution: bring people together – workshops
- Action (eg): host DSC workshops to improve taxonomy.
  - Verify preliminary at-sea identifications
  - focus on octocorals
  - Use NZ collection resources (critical mass of unidentified taxa here)
  - Include funding for pre-workshop data and sample compilation

<u>Pre-workshop task</u>:

Compile data and create metadata to international standards (i.e. GBIF & OBIS)

<u>Workshop tasks</u>:

- Declare standards for good practice taxonomic identification
- Distribute tasks for two collaborative publications - due two-three years hence; web-available
  - NZ ID of corals (monograph)
  - Refine ID guide for skippers & observers

- Plan development of protocol for standardised, best-practice sampling methodologies
- Plan development of protocol for standardised habitat classification

- Problem: taxonomic sustainability
- Solution: Improve training and recruitment of young taxonomists. Promote the relevance / applicability of taxonomy as a career
- Action: Support post-graduate and post-doctoral research placements
  - Exchange programmes between universities and science institutions (eg Smithsonian)
  - Internships with end-users of taxonomic data (eg MAF Biosecurity, NOAA)

- Problem: Deep-sea coral data gaps in the Pacific
- Solution: [Strategically] gather new data and tap into existing data resources
- Action: Extend trans-Pacific collaborations with other Pacific nations in order to
  - Collect data according to *<u>priority</u>* data gaps
  - Identify unidentified existing data-bodies – focus on high seas relevant to Pacific and S. American countries (e.g. Chile, Peru)
  - Publish data to international standards (publish = open access, online – via GBIF)

(4) Future data-related priorities

NZ / NZ-US / General

- Update data compilation from recent NZ region surveys – focus on particular areas (e.g. High Seas & Ross Sea to support VME work) and identification of taxa (e.g. octocorals to support modelling & studies looking at effects of ocean acidification)
- Extract & compile data from surveys undertaken by other nations in NZ waters – focus on US sources (e.g. NOAA surveys)
- Extend collaborations with other Pacific nations in order to improve data in the wider region – focus on S. American countries (e.g. Chile, Peru)
- Assess what data (and where) are needed to support ground truthing of predictive models – focus on groups for which models are already being produced (e.g. habitat-forming scleractinians)

(4) Future data-related priorities

- Make use of existing data: e.g. additional 60,000 records in HURL database
- Obtain historical datasets where voyage samples need to be worked up and entered into db
- Promote standardized sampling regime
  - issues of multiple platforms (most work in N Pacific is subs/rovs; in SW Pacific trawls, sleds, towed cameras

Future data-related priorities (cont.)

  - across habitats (seamounts, slopes etc)
  - sample consistent depths to compare between features

- Improve taxonomic consistency of databases/datasets

Key Summary: Topic II

Vulnerable Marine Ecosystems (Identification, ecology and conservation science)

Information Needs Problems

For science to support management needs, information is needed to address the following questions:

1. What are VMEs?

Solution: Understand ecosystem structure and function

Activities: Further studies on ecosystem services, life history traits and recovery dynamics, habitat associations, spatial connectivity, develop methods for taxonomic identification

Collaborations:

- Workshop to categorize the vulnerability of emergent epifauna in the Pacific Basin
- Literature review of responses to disturbance
- Symposium session current knowledge of ecosystem services provided by VME communities - PICES 2011.
- Collaborative parallel in situ studies of functions etc. of known VME ecosystem (N and S Pacific).

Information Needs Problems

2. Where are the VMEs?

Solution: Map known VMEs, Identify areas likely to contain VMEs

Activities: Assemble bathymetric /multibeam maps, Develop predictive models, develop new indicators of VMEs, Assemble existing research and fishery datasets, Site reconnaissance

Collaborations:

- Support continued collaborations, data collection and analysis efforts – CoML
- Develop datasets that include currently unavailable information on VME species distribution and association with environmental variables.

Information Needs Problems

3. How can science advise managers on the best approaches to manage impacts to VMEs?

Solution: Develop modeling approaches to simulating fishery impacts on VMEs and their response.

Activities: Evaluate management alternatives, develop plausible ecosystem models

Collaborations:

- Workshop to develop plausible scenarios of ecosystem dynamics and the responses to disturbance
- Develop Operational Management Procedures to test management measures

- **4. How can threshold levels and move-on rules be ecologically meaningful?**

Solution: Utilize fishery bycatch and directed in situ studies to characterise habitats and impacts of various gear types

Activities: document mortality rates, gear footprints, taxon selectivity and catchability, develop move-on rule threshold levels, develop catchability model for VME taxa

Collaborations

- Conduct gear-specific habitat impact studies
- Conduct gear performance studies (selectivity and catchability)
- Conduct simulation studies to develop appropriate move-on distances

TOPIC 3

Habitat suitability/species distribution modeling

stars indicate top three priorities *** = top priority

ISSUES AND ACTIVITIES

No field validation of predictive models

- Validate existing global model for stony/octocoral? corals (in NZ region where records not used for global model)
- Validate existing NZ regional model for stony corals (opportunistic and some directed sampling – focused? VME interest area – Louiville Seamounts)

* Need better environmental data layers (more variables and better spatial resolution) and improve access to these layers

- Share access to current 'best' environmental data layers (global)
- Encourage/contribute to development of new environmental data layers (e,g. bathymetry)

ISSUES AND ACTIVITIES

Currently models restricted (spatially and taxonomically) by access to coral data

- Improve coral data sharing (open access to databases)

** Need to better integrate predictive modeling results into fisheries management (including VME process in RFMOs) and conservation

- Produce predictive models for VME taxa and use to assess effectiveness of VME closures and move on rules (e.g. distance to move) {use NZ region as example?]

ISSUES AND ACTIVITIES

Need for a wider Pacific Ocean deep-sea coral biogeography (use in management initiatives such as VMEs)

- Undertake 'community' coral modeling to generate a deep-sea coral biogeography for Pacific Ocean

Need to improve understanding of what env variables drive distribution of corals (as opposed to using proxies which can be used to indicate Where a coral is rather than Why)

- Conduct smaller spatial studies where env variables better resolved (e.g. on individual seamounts)

ISSUES AND ACTIVITIES

Limited access to coral material for genetic connectivity studies

- Make NZ region material more widely available for genetic studies (link with taxonomy topic)

*** Include 'connectivity' into predictive species distribution modeling efforts, and integrate with conservation/management

- Explore how to include 'connectivity' into distribution models (which also include current direction)

Need to build temporal models in order to assess anthropogenic effects – e.g. ocean acidification, fishing effort

- Compile data (bio and env) so as to construct temporal models

ISSUES AND ACTIVITIES

Methodological issues that influence usefulness and adoption of habitat suitability/species distribution models

- Have a workshop to progress method development (compare approaches and results, examine autocorrelation issues, adopt 'best' approach?)

Limited access to HOVs, ROVs, AUVs in NZ region to take samples/survey habitat

- Exploit/develop projects that will bring HOVs/ROVs/AUVs to NZ region
- Co-share cruises (participation to improve links but also access to material)

US-NZ Joint Commission Meeting on Science and Technology Cooperation: *Report from the Ocean and Marine Sciences workshop*

26 January 2010
Wellington, New Zealand

Tom Hourigan (NOAA) and Malcolm Clark (NIWA)

Summary of Workshop Content

Rationale:

- **Deep-Sea Ecosystems of the Pacific**
  - Vast and biologically diverse, but largely unexplored
  - Focus of increased conservation concern – Impacts of fishing on vulnerable marine ecosystems (VMEs)
  - Area of NZ and US expertise and management responsibilities

Key Issues:

- **Vulnerable marine ecosystems (VMEs)**
  - Identification, ecology and conservation science (Corals as sentinel species)
  - Science needed for management – developing Regional Fishery Management Organizations (RFMOs) in the Pacific
- **Deep-sea coral taxonomy and data**
  - Coral taxonomy: Current status and constraints
  - Databases and datasets to inform science and management
- **Habitat suitability and predictive modelling of deep-sea corals**
  - NZ and US advances in methods and analysis of environmental datasets
  - Incorporating connections between animal distributions and dispersal capabilities

Areas identified for increased cooperation/activity

- **Vulnerable marine ecosystems (VMEs)**
  - (1) What constitutes a VME? – Characteristics, importance and vulnerability
  - (2) Where do VMEs occur? – Distribution of VMEs in the Pacific
  - (3) Understand fishing impacts and develop science-based options for management
- **Deep-sea coral taxonomy and data**
  - (1) Improve consistency of coral taxonomy – utilizing NZ collections
  - (2) Increase taxonomic capability
  - (3) Improve deep-sea coral data accessibility and fill data gaps in the Pacific
- **Habitat suitability and predictive modelling of deep-sea corals**
  - (1) Incorporate better environmental data layers (more variables and better spatial resolution) and improve access to data
  - (2) Include 'connectivity' into predictive species distribution modeling efforts
  - (3) Integrate modeling efforts predicting species distributions into fisheries management (including VME process in RFMOs) and conservation
  - (4) Validate predictive models (field ground-truthing)

Potential Collaborative Activities

Vulnerable Marine Ecosystems

- Workshops and conference sessions:
  - Vulnerability of Pacific Basin deep-sea communities
  - Ecosystem services provided by VME communities - PICES 2011.
  - Operational Management Procedures to evaluate management alternatives and test the effectiveness of management measures (simulation modelling)
- Collate existing bathymetric /multibeam maps to help define VME likelihood.
- Support continued collaborations, data collection and analysis efforts of existing international cooperative programmes (e.g., Census of Marine Life).
- Complementary *in situ* studies of VME communities and gear-specific habitat impacts in the NE, Central and SW Pacific

Potential Collaborative Activities

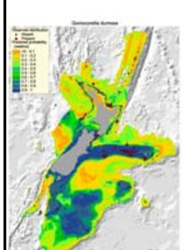
Deep-Sea Coral Taxonomy

- Workshops to improve taxonomy of key taxa
- Post-graduate and post-doctoral research placements to improve training and recruitment of young taxonomists. Support (e.g., Exchange programmes, Internships with end-users)

Deep-Sea Coral and VME Data

- Assemble and share existing research and fishery datasets and
- Mobilize existing unprocessed data sets and samples
- Update information on VME species distribution and association with environmental variables

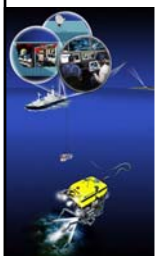
Potential Collaborative Activities



Habitat Suitability and Predictive Modelling

- Produce predictive models for VME taxa and use to assess effectiveness of VME management in the Pacific
- Share access to current 'best' environmental data layers (global). Encourage/contribute to development of new environmental data layers (e.g., bathymetry) and data sources (e.g., fishing industry)
- Validate existing models for deep-sea corals using other data sets and field work – e.g., VME interest area – Louisville Seamounts
- Joint research work to include 'connectivity' into distribution models – build on oceanography and genetics

Obstacles or issues



- Cross-linkages and synergies exist with established research programmes; many established networks and contact between US and NZ scientists
- No current funding specifically for collaborative research
- Field research and ground-truthing of predictive modelling involves vessel time to survey an area/s – e.g., Currently collaborating on a joint NZ/US proposal for submersible work
- New Zealand region lacks higher technology equipment (e.g., subs, ROVs, AUVs) - importance of partnerships with US – e.g., Woods Hole/NIWA/GNS Memorandum of Understanding (MOU)

morst

Roadmap for next 2-3 years

- Priority – Better coordinate and utilize existing data, information and expertise to inform management and conservation efforts
- Activities
  - Establish steering committee to coordinate US/NZ cooperative activities
  - Implement NIWA/GNS/Woods Hole MOU and explore a broader NOAA/NIWA MOU
  - Targeted workshops and PICES Symposium on VMEs
  - Test and validate habitat suitability models for corals
  - Participation of scientists on research cruises
  - Identify specific research projects for enhanced collaboration
- Desired outcomes – Improved science and its application to enhance conservation and management of Pacific deep-sea ecosystems

morst