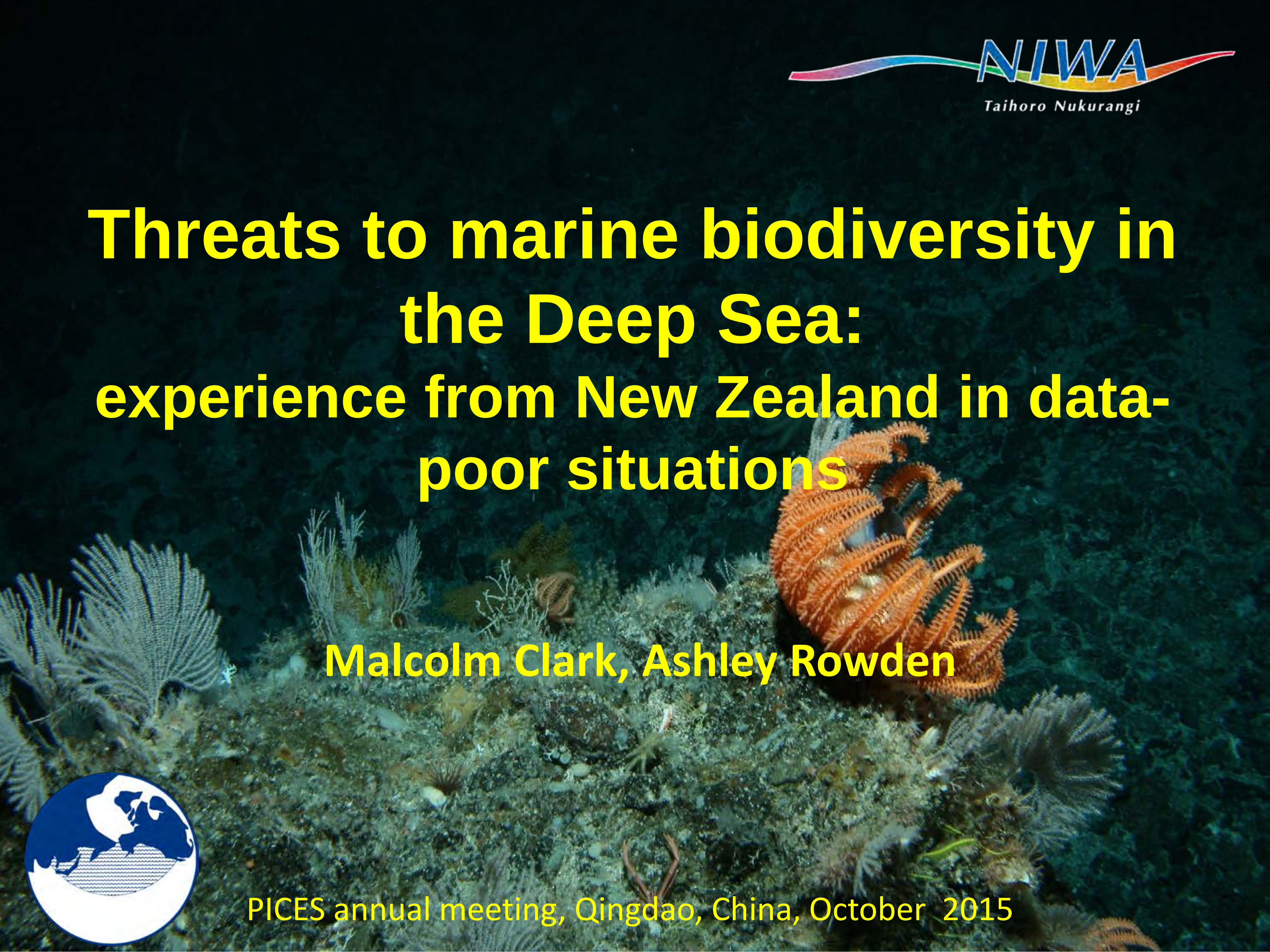

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Threats to marine biodiversity in the Deep Sea:

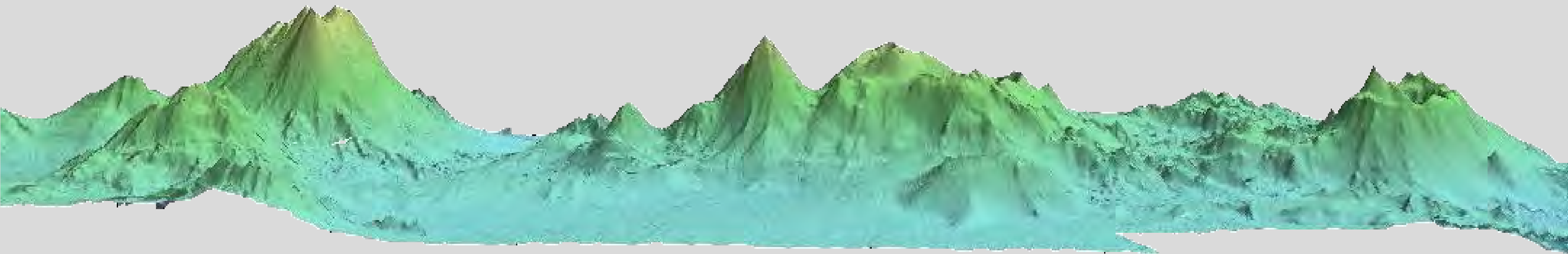
experience from New Zealand in data-poor situations

Malcolm Clark, Ashley Rowden

PICES annual meeting, Qingdao, China, October 2015

Presentation Outline

- Background
  - Threats to the deep-sea
  - Deep-sea biodiversity
- Biodiversity “hotspot” approaches
  - EBSAs
  - VMEs
- Risk assessment
- Spatial management
- Focus on recent New Zealand work, not give an overview



Threats

- Fishing

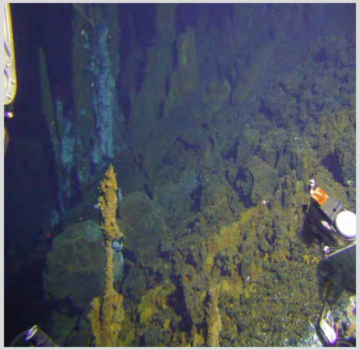


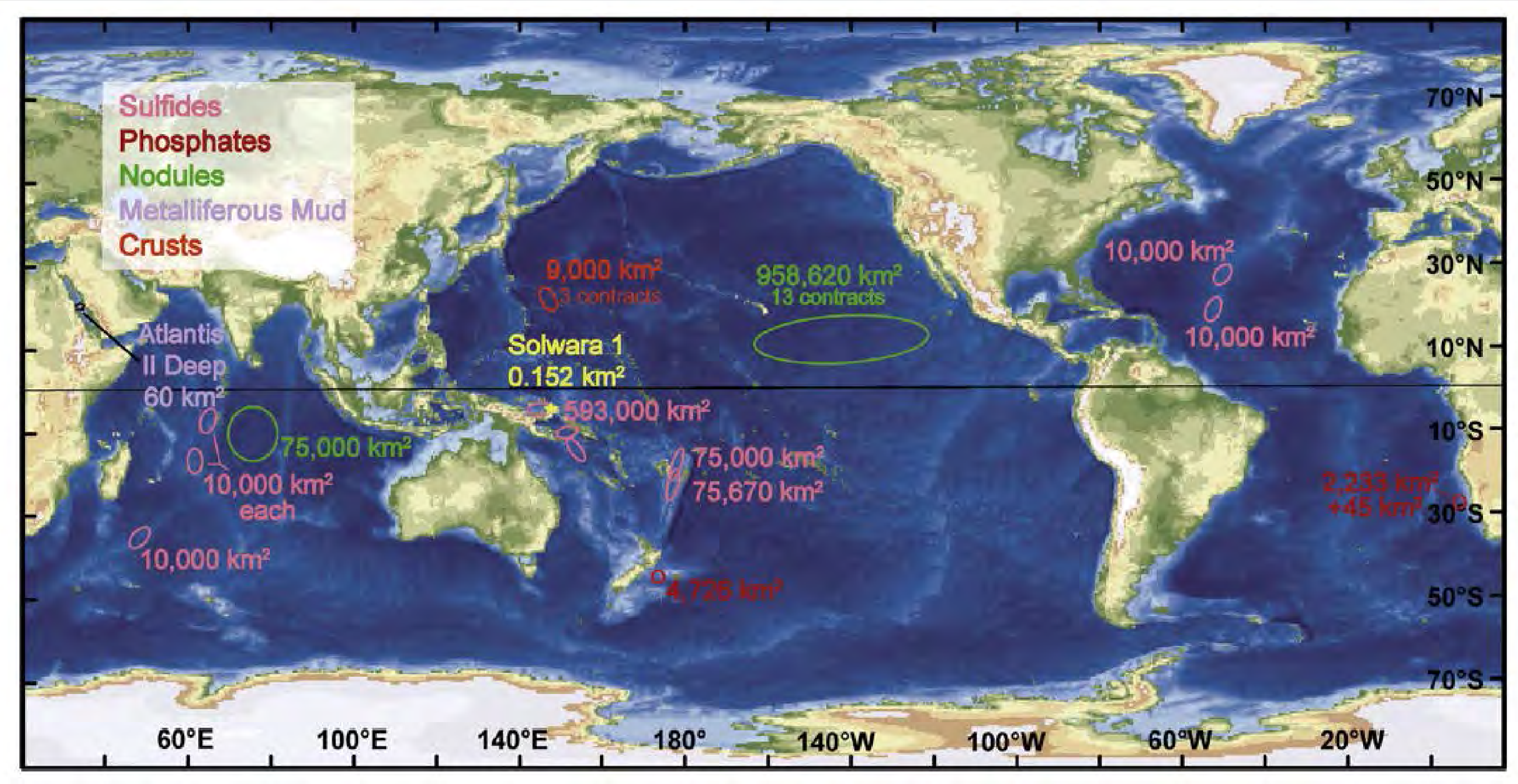
Common name	Scientific name	Total catch 2012 (t)	Depth (m)	Gear type
Patagonian and blue grenadier	Macruronus novaezelandaie, M. magellanicus	307401	300-800	Bottom trawl, midwater trawl
Redfish	Sebastes spp.	56255	400-800	Bottom and midwater trawl, longline
Sablefish	Anaplopoma fimbria	21017	500-1000	(Bottom trawl), line, pot
Scabbard fish(silver & black)	Aphanapus carbo,	18951	600-800	Bottom, and midwater trawl, longline
Moras (ribaldos)	Mora moro	16951	500-1000	Bottom, and midwater trawl
Oreos	Pseudocyttus maculatus, Allocyttus niger	11850	600-1200	Bottom trawl
Blue ling	Molva dypterygia	7994	250-500	Bottom trawl
Orange roughy	Hoplostethus atlanticus	6731	600-1200	Bottom trawl
Alfonsino	Beryx splendens, B. decadactylus	6369	300-600	Bottom, and midwater trawl, some longline, gillnet
Red shrimps	Aristeus spp.	6267	400-800	Bottom trawl
Roundnose grenadier	Coryphaenoides rupestris	4945	800-1000	Bottom, and midwater trawl
Toothfish	Dissostichus eleginoides, D. antarcticus	4217	500-1500	Longline, bottom trawl
Rough-head grenadier	Macrourus berglax	3099	300-500	Bottom and midwater trawl
Bluenose warehous	Hyperoglyphe antarctica	1378	300-700	Bottom, and midwater trawl
Smootheads	Alepocephalus bairdii	930	500-1200	Bottom trawl
Cardinalfish	Epigonus telescopus	658	500-800	Bottom (and midwater trawl)
Armourheads	Pseudopentaceros wheeleri, P. richardsoni	193	250-700	Bottom and midwater trawl
Deepwater crab	Geryon spp.	153	500-800	Trap, pot
Total		**475,359**		[Clark et al.2015]

Threats

- Mining (minerals)



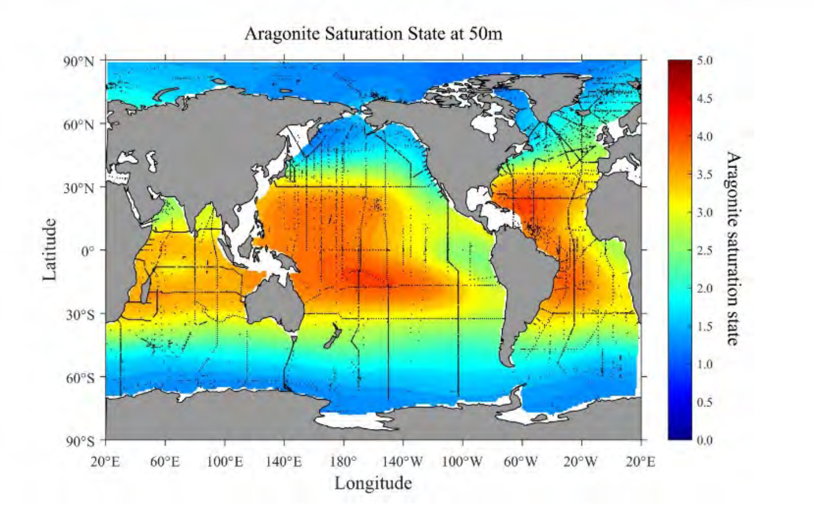


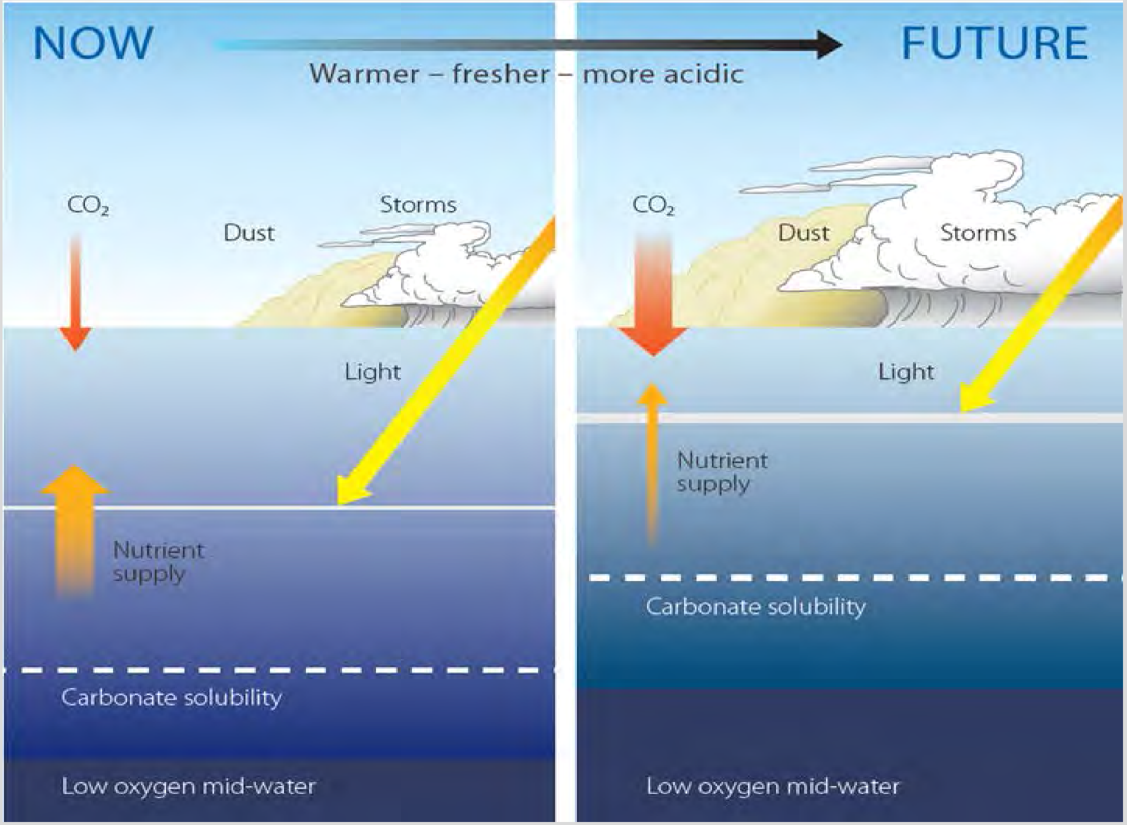


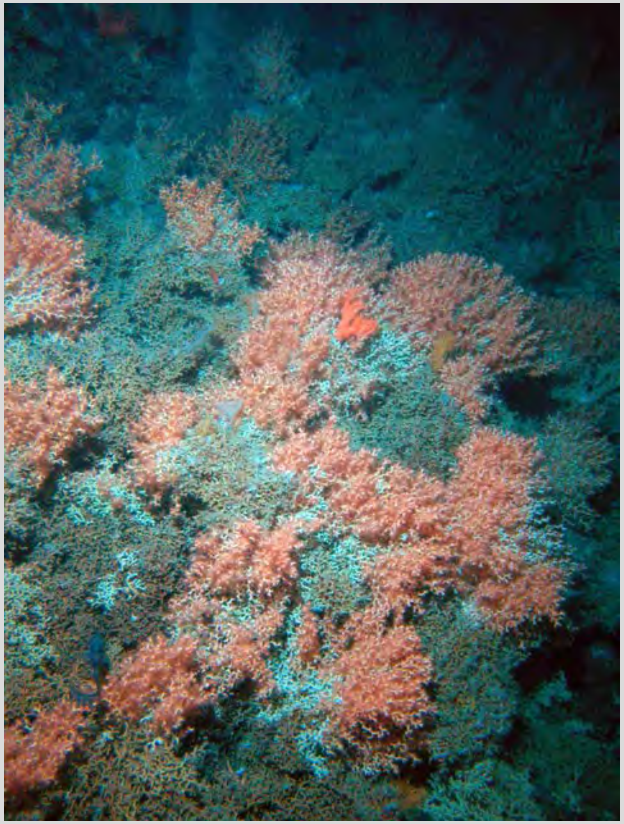
Hein et al. 2013

Threats

- Climate change:
    - ocean acidification

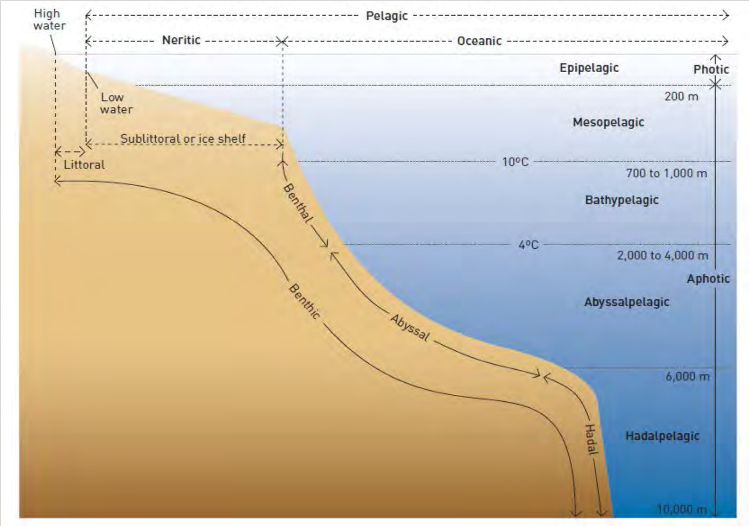


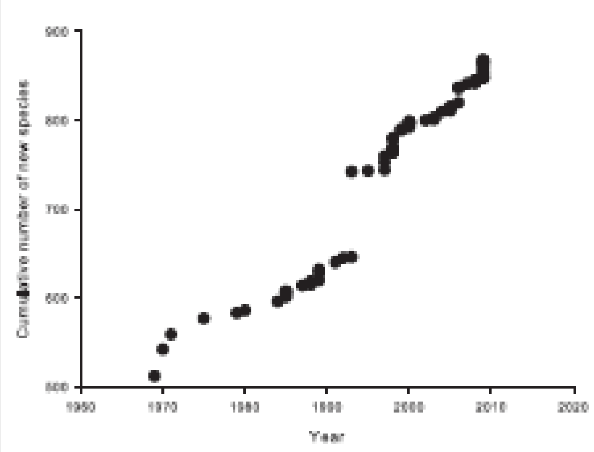




Deep-sea biodiversity

- 200 m and deeper
- Global data
  - OBIS db
  - 30million records
  - 130,000 species
  - WoRMS 250,000 marine species
- Benthic focus
  - ?Deep pelagic
- Very high discovery rate
  - Nematode example
  - Seamounts, between 5 and 10% of epifauna on any survey will be new species or new records
- The 4th threat-our ignorance





Ramirez-Llodra et al. 2010

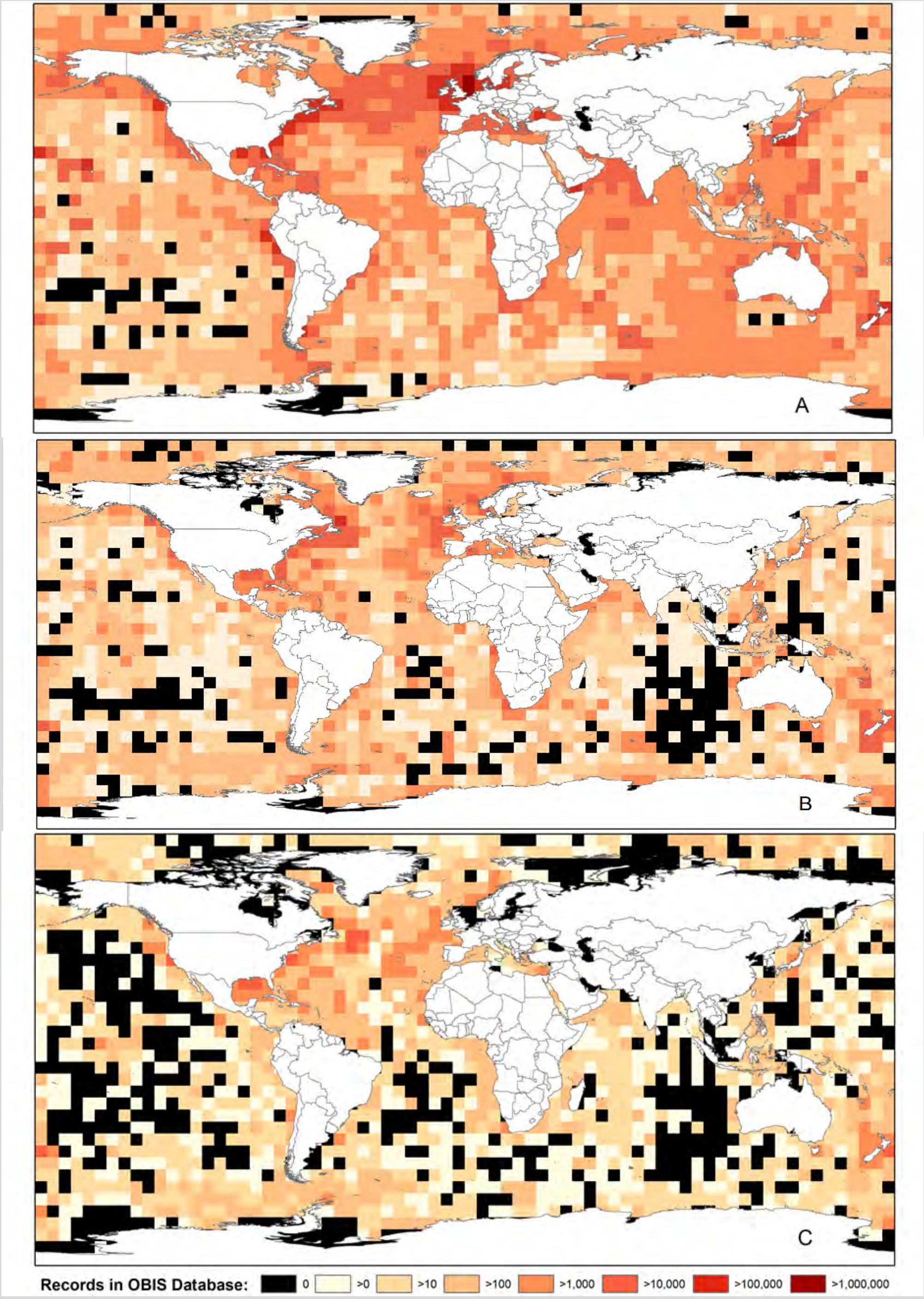
Deep-sea habitats

Benthic habitat	Area (km2)	% of area	% investigated
Deep-sea floor	326,000,000		
Abyssal plains	294,360,000	75	<1.0
Continental slope	40,000,000	11	minimal
Ridges	30,000,000	9	10
Seamounts	8,500,000	2.6	0.25
Hadal zone	? (n=37)	1.0	minimal
Canyons	? (n=448)	?	minimal
Benthic OMZ	1,148,000	0.3	<1.0
Coldwater coral reefs	280,000	0.1	minimal
Hydrothermal vents	? (n=2000)	?	10
Cold seeps	10,000	0.003	2.0
Whale falls	35	-	0.005

Ramirez-Llodra at al 2010

OBIS records

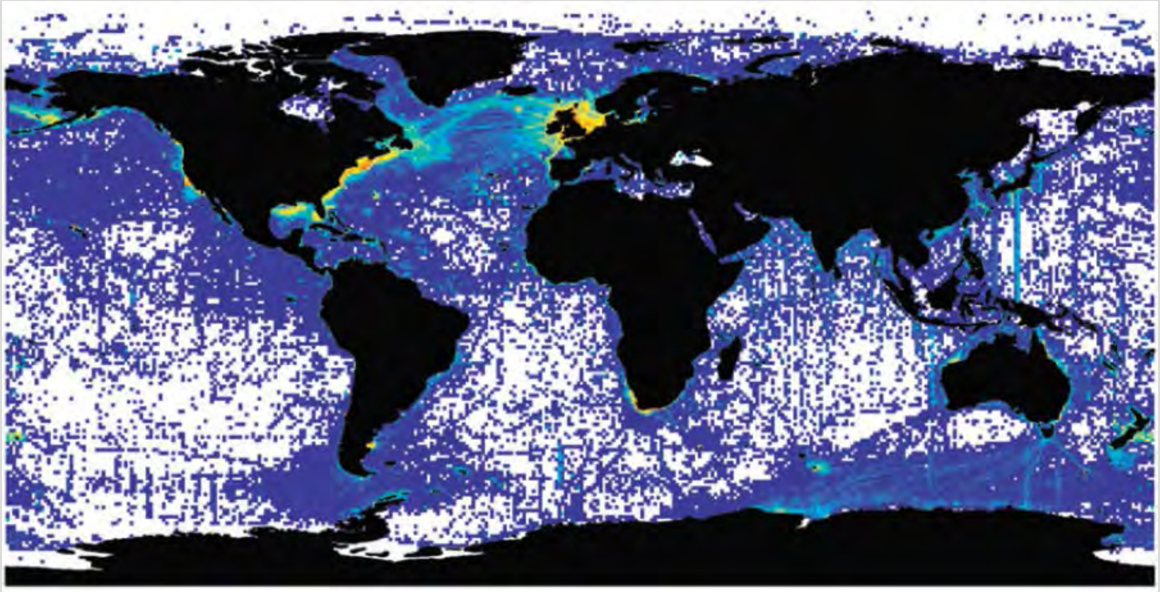
- 0-200 m
  - Not too bad
  - Still lots light pink
- 200-1000 m
  - A lot more black
  - Gaps in Indian and Pacific Oceans appearing
- >1000 m
  - Pretty horrible offshore
  - All ocean basins with exception of North Atlantic



Sutton et al. submitted

Data-poor situations

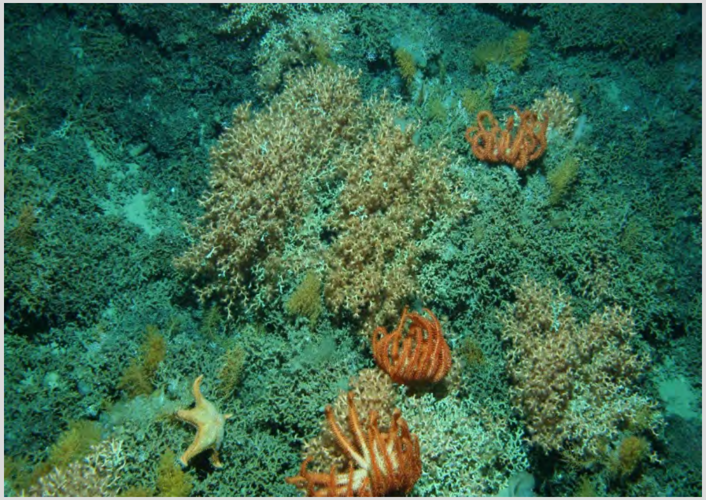
- Biodiversity poorly known at the scale of large ocean basins
- Offshore, deep sea in particular
- Both the North and South Pacific Oceans



- So, given data limitations, what can we do to identify habitats, communities, and ecosystems under threat

Vulnerable Marine Ecosystems

- A concept directed at fisheries management and conservation of biodiversity (under auspices of FAO)
- VMEs are ecosystems that are vulnerable to effects of fishing
- Occurrence of certain indicator taxa
  - Thresholds, move-on rules
- VMEs clear in surveyed areas

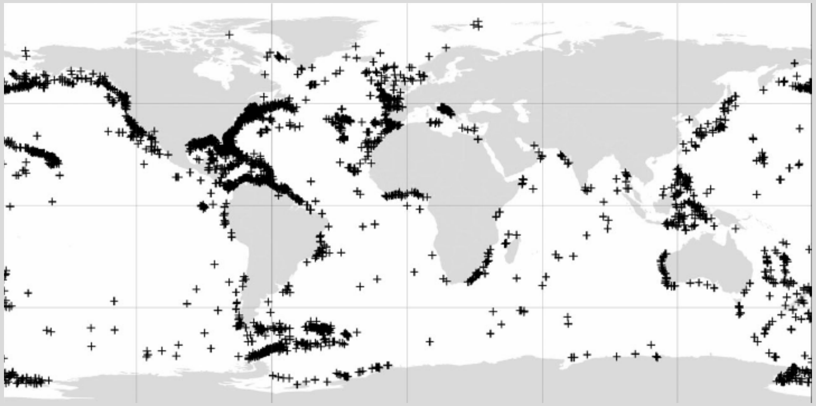


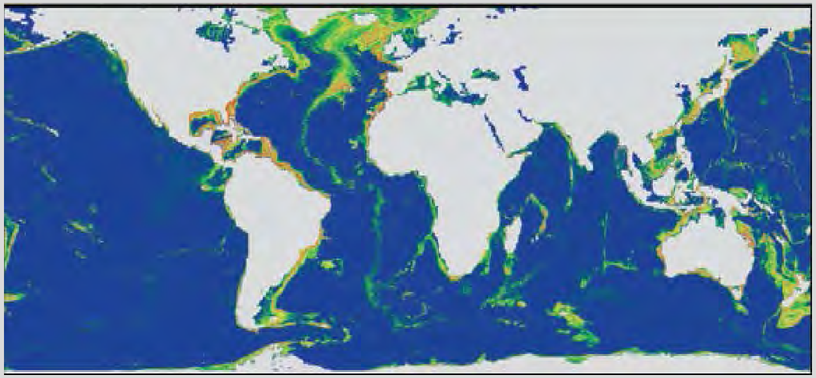
- But not offshore and deep sea…

Vulnerable taxa
Phylum Porifera - Sponges
Phylum Cnidaria
Class Anthozoa
Order Actiniaria – Anemones
Order Alcyonacea - Soft corals
Order Gorgonacea - Sea fans
Order Pennatulacea - Sea pens
Order Scleractinia - Stony corals
Order Antipatharia - Black corals
Class Hydrozoa
Order Anthoathecatae
Family Stylasteridae - Hydro corals
Habitat indicators
Phylum Echinodermata
Class Crinoidea - Sea lilies
Class Asteroidea
Order Brisingida - Armless stars

The application of species modelling

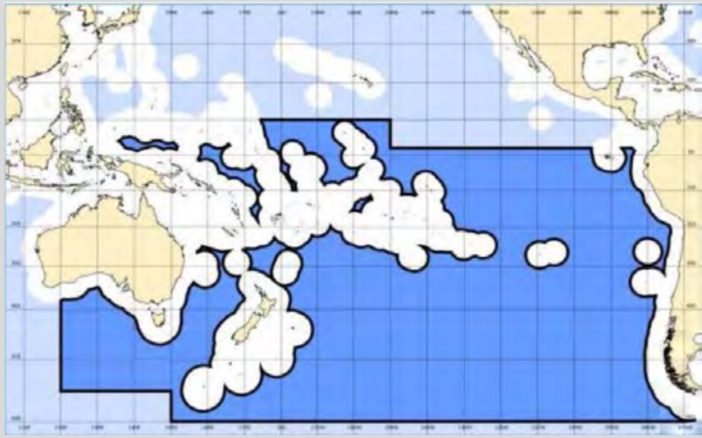
- RFMOs are faced with wanting to know where these are
- But most offshore areas, no data
- Habitat suitability (or species distribution)modelling
    - Taxon presence data
    - Environmental data
    - Determines relationships
    - Environmental proxies
    - To extrapolate beyond data
- Very "popular" method
    - Octocorals
    - Stony corals
    - Sponges
    - Most VME taxa





Calcaxonia octocorals: Yesson et al.2012

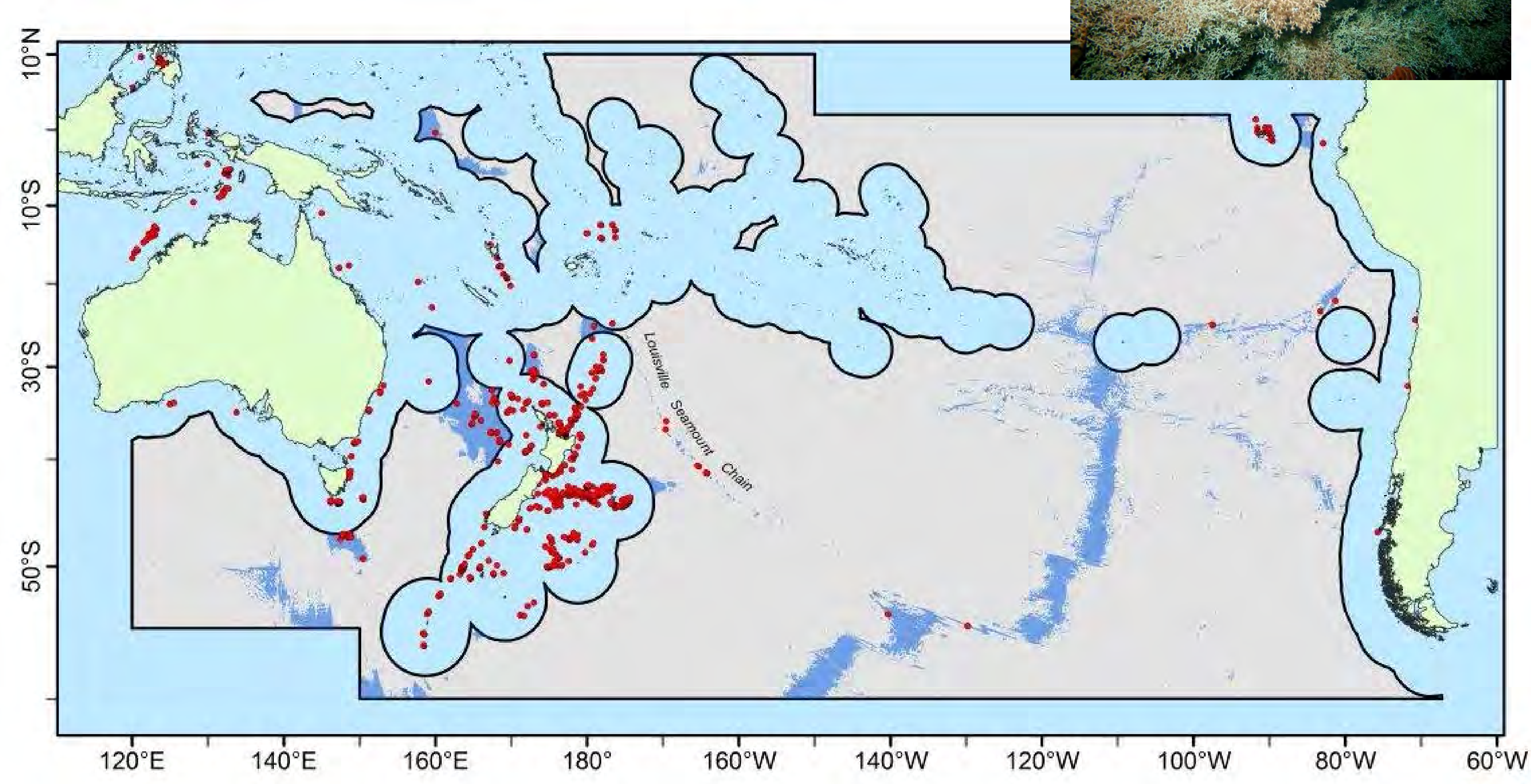
South Pacific VME example



- SPRFMO objective through NZ Fisheries
- Database development
  - Biological records for all 10 SPRFMO VME taxa
  - Environmental data (9 variables)

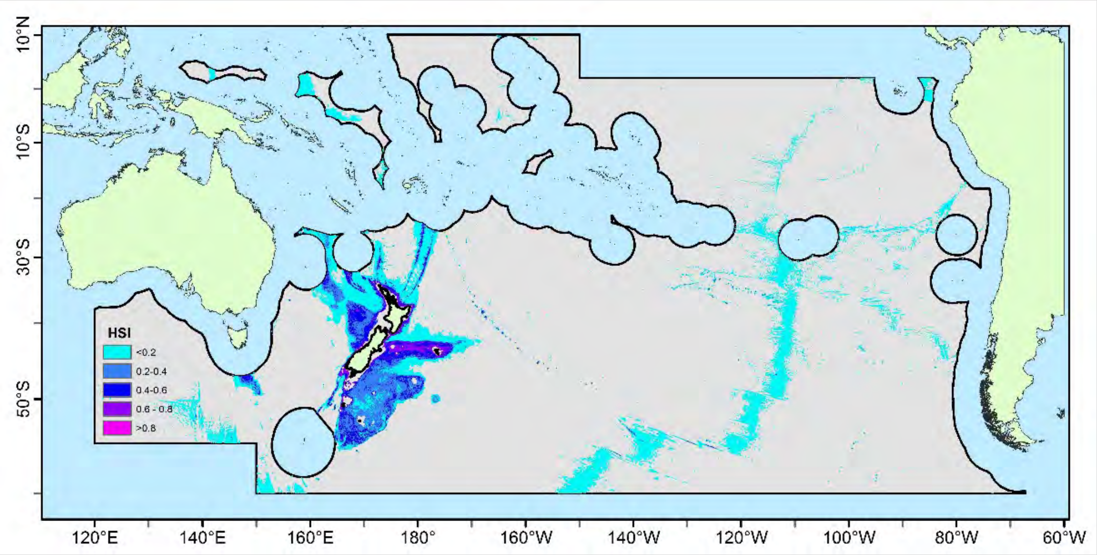
Taxon / group	N records
Phylum Porifera – Sponges	31 405
Phylum Cnidaria, Class Anthozoa,	
Order Actiniaria – Anemones Order Alcyonacea – Soft corals and the gorgonian sea	14 315
fans (previously Gorgonacea)	25 005
Order Pennatulacea – Sea pens	1 432
Order Scleractinia – Stony corals	120 792
Order Antipatharia – Black corals	2 837
Class Hydrozoa, Order Anthoathecatae, Family Stylasteridae – Hydro corals	4 034
Phylum Echinodermata, Class Crinoidea – Sea lilies	2 006
Class Asteroidea, Order Brisingida – Armless stars	754

Scleractinian (stony) coral

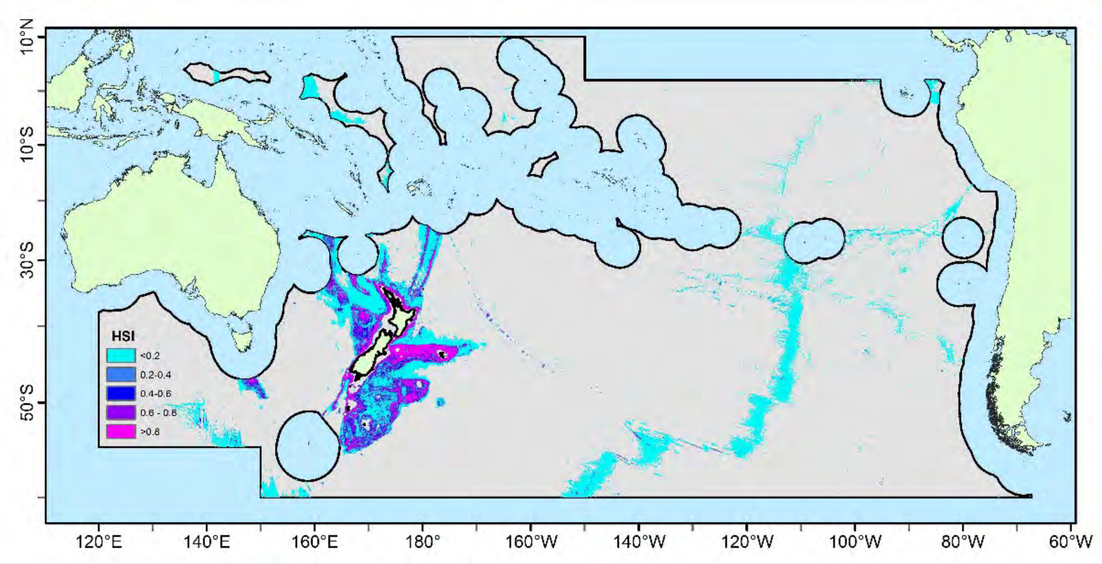


120,000 records: but very uneven distribution

Modelling results



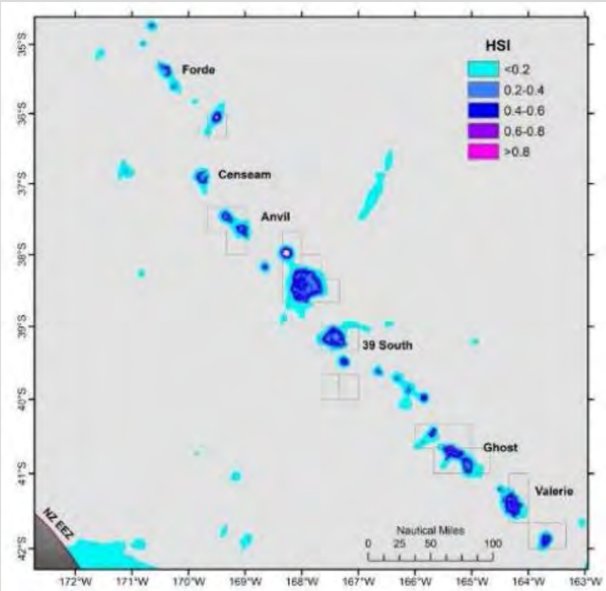
Maxent: maximum entropy

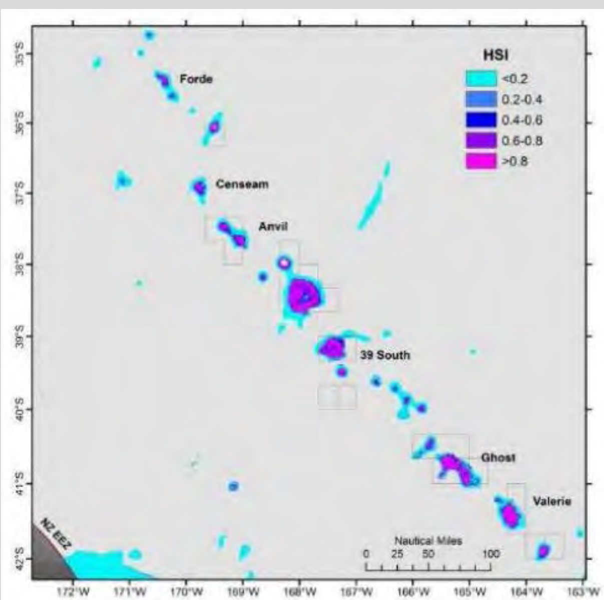


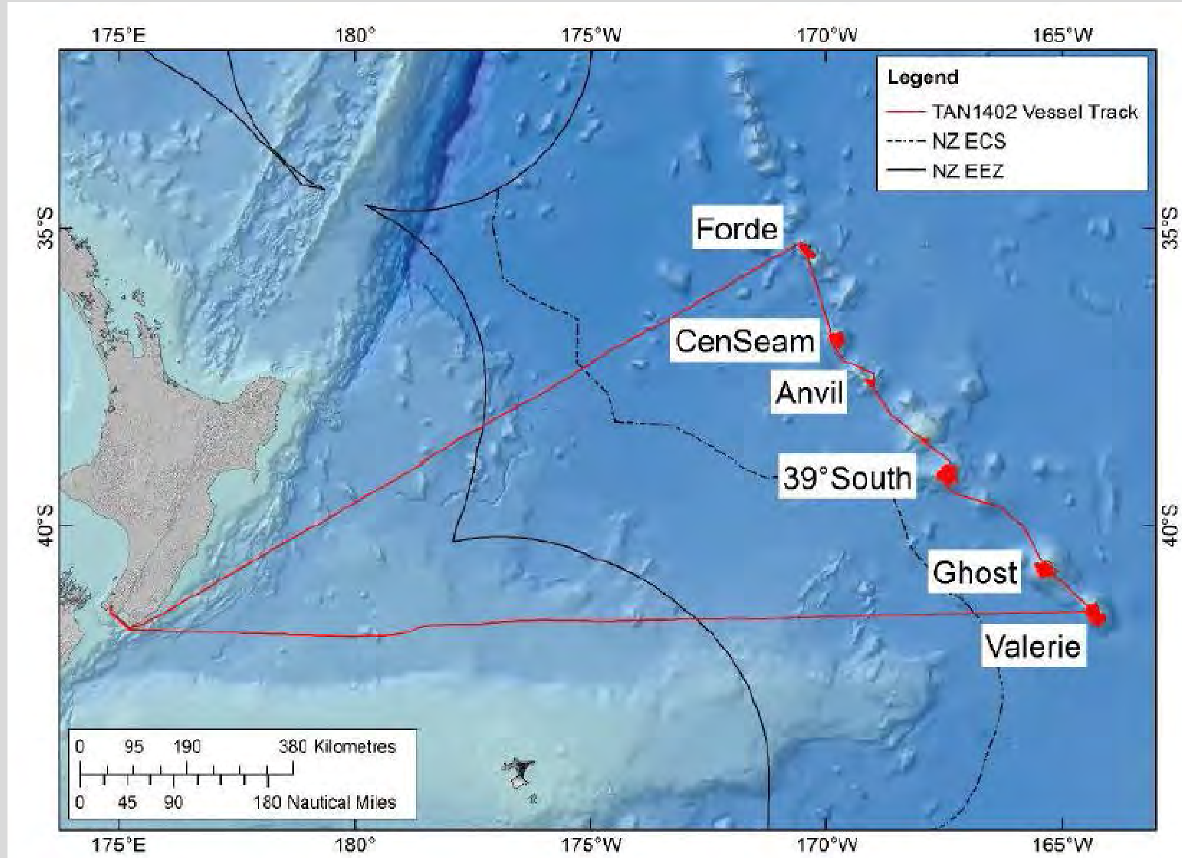
BRT: boosted regression tree

Anderson et al.submitted)

Louisville validation





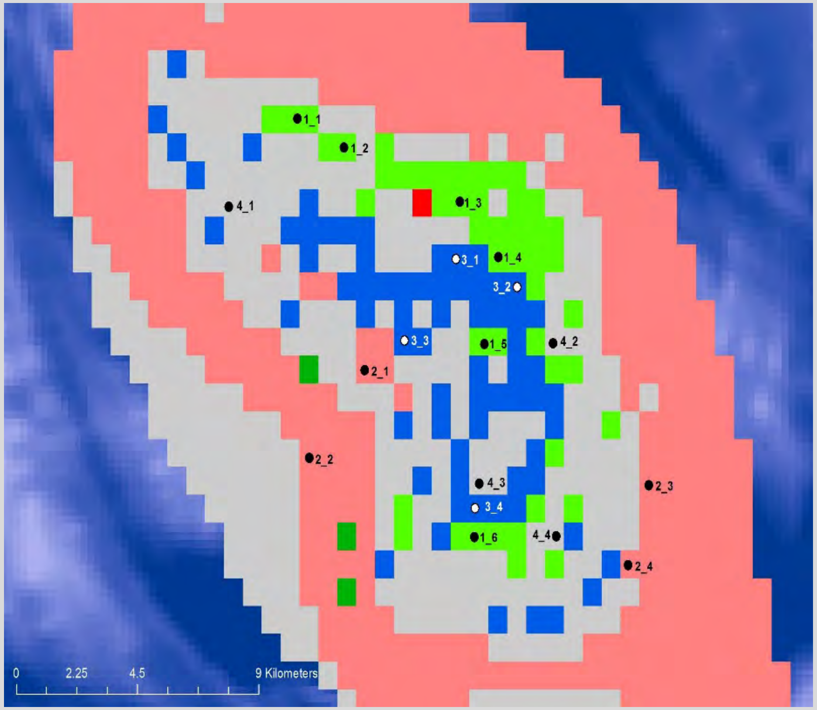


- Specific validation survey, February 2014
- 6 seamounts
- Seafloor video and still camera, sled sampling
- Targeting cells ($1km^2$) with varying model predictions

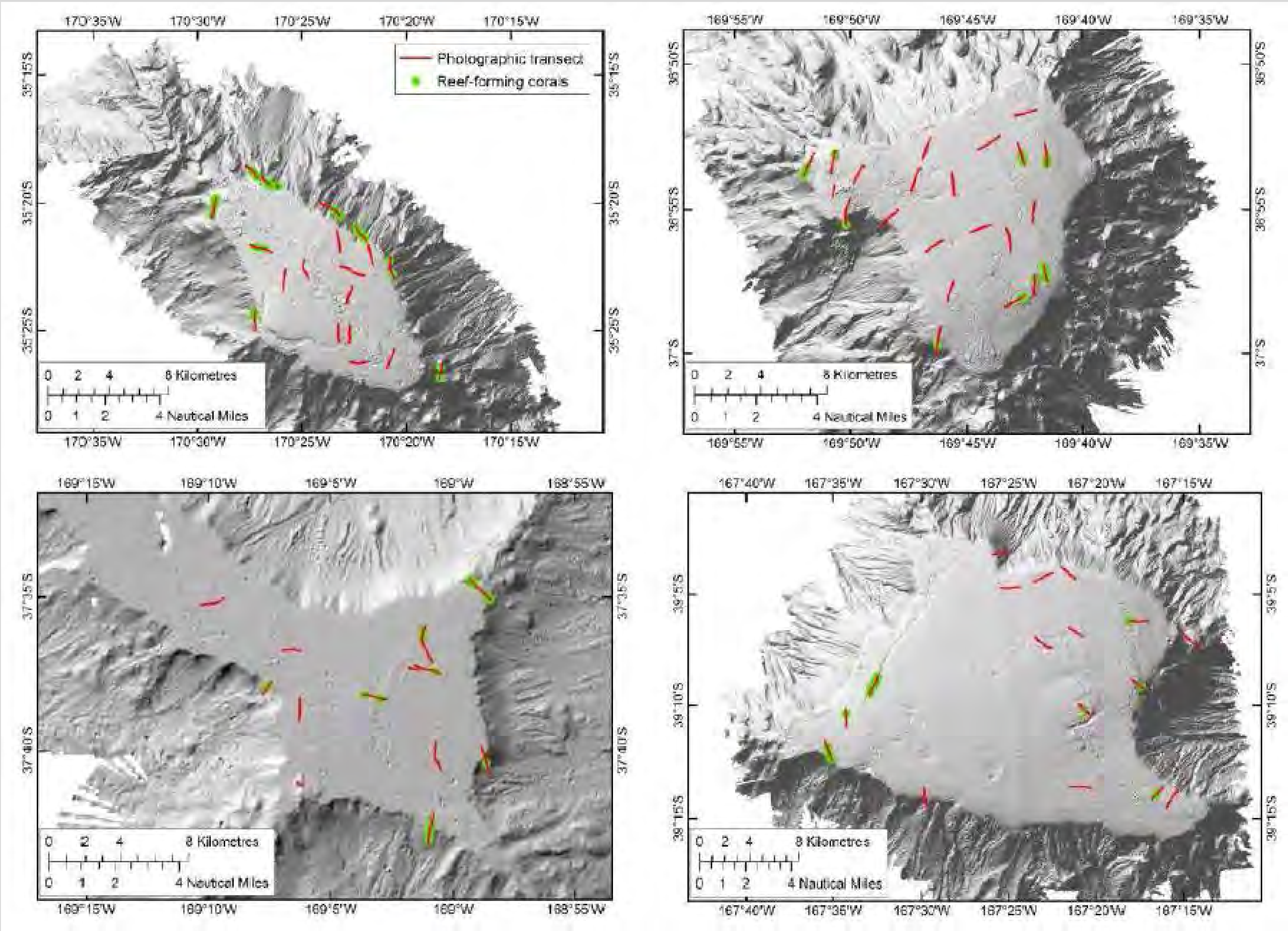
Sampling design

- Stratification designed to test 5 different types of distribution results
- Plus evaluate different models
- Plus fishing impacts
- Random design, plus later targeting to provide data for model development

Stratum	Colour	Conditions
0001	Green	High probability of coral occurrence, both BRT and Maxent , unfished
0002	Pink	Low probability of coral occurrence, both BRT and Maxent, unfished
0003	Blue	Different probability between models (one high, one low), unfished
0004	Grey	Intermediate probability of coral occurrence (neither high nor low), BRT model, unfished
0005	Red	High probability of coral occurrence, both BRT and Maxent, fished.



Species distributions



All VME taxa evaluated (10 SPRFMO indicator taxa)




Clark et al. 2015

How did it do?

Table as shown is not presented, as analyses are in review and not yet published (Anderson et al. submitted)

Seamount	No. transects	No. transects on which stony corals observed	No. of transects on which coral reef/thicket VMEs observed
Forde	19	11	2
CenSeam	22	6	0
Anvil	12	7	0
39 South	18	6	1
Ghost	28	7	2
Valerie	16	12	2

Clark et al. 2015

Summary of validation findings

- The models performed poorly
- Several reasons
  - Low accuracy of some variables (e.g., bathymetry)
  - Scale of $1km^2$ relative to precision of environmental data
  - Lack of some key variables (e.g., substrate, topography)
  - Species-environment relationship derived from continental setting, not oceanic
- Adequate for seamount level assignation
- Inadequate for within feature distribution
- Second set of modelling being done using survey data
- Move from presence to abundance is needed.

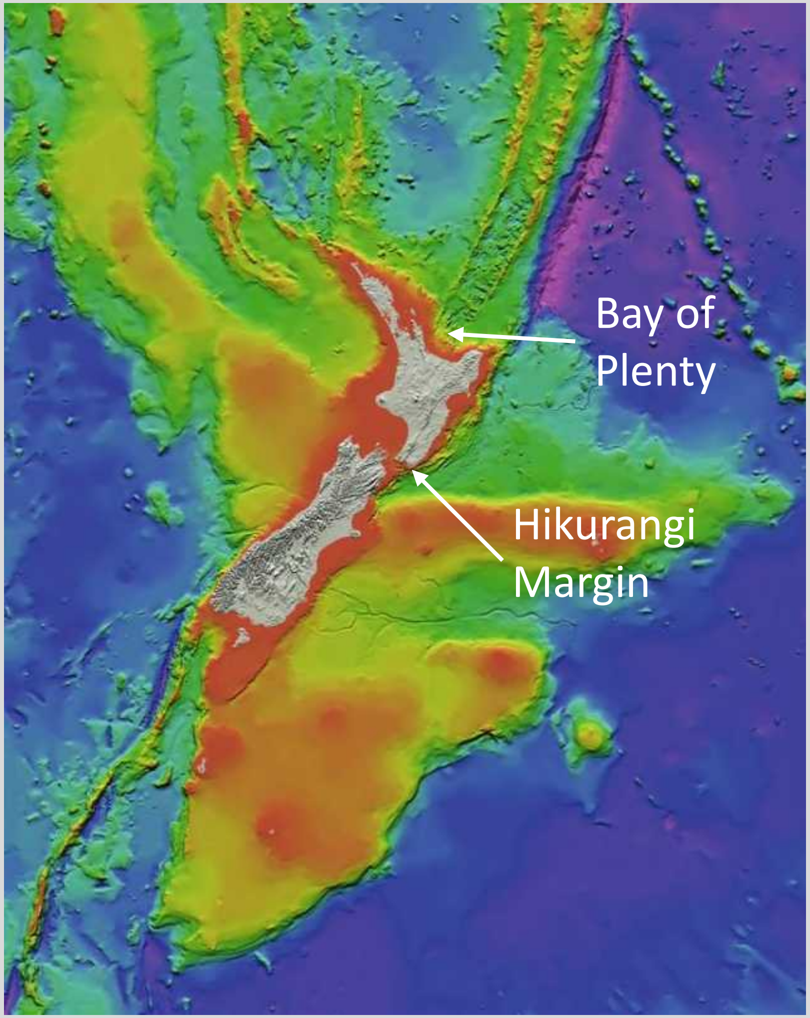
Does it matter?

- So for the Louisville, the HS modelling is of limited use
- Problems with amount and distribution of deep-sea data
- Problems with our ability to model species distributions
- But: Is the deep sea sufficiently homogenous to assume different areas and habitats are similar enough to manage as large units?
- Assessment of risk to deep-sea ecosystems

New Yorker 1983

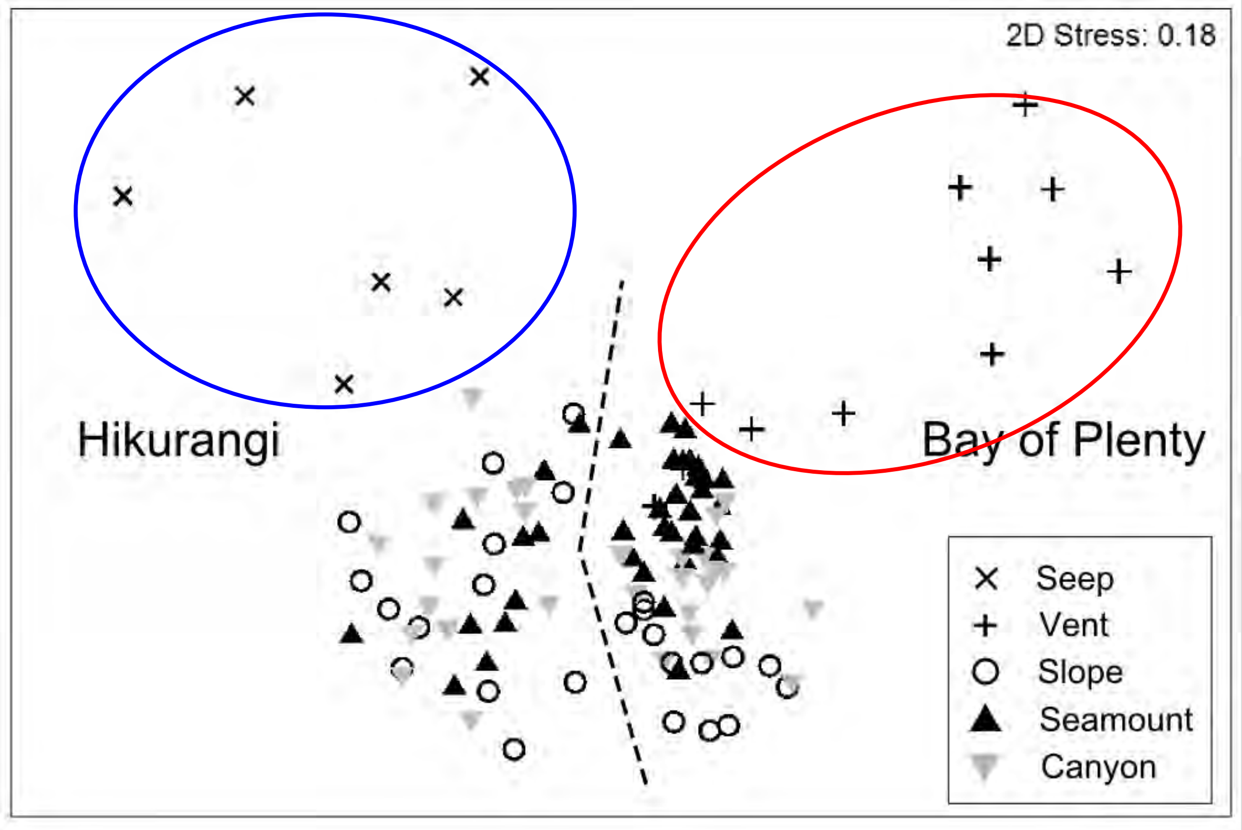
Deep-sea habitats survey

- 6 year NIWA project
- Aim to evaluate benthic communities in different habitats, and their vulnerability to disturbance.
- Two surveys, in different locations
- Multiple habitats in each location
  - Continental slope
  - Seamounts
  - Hydrothermal vents
  - Cold seeps
  - Canyons
- 4 depths (700-1500m)
- Meibenthic infauna to megabenthic epifauna



Results -megafauna

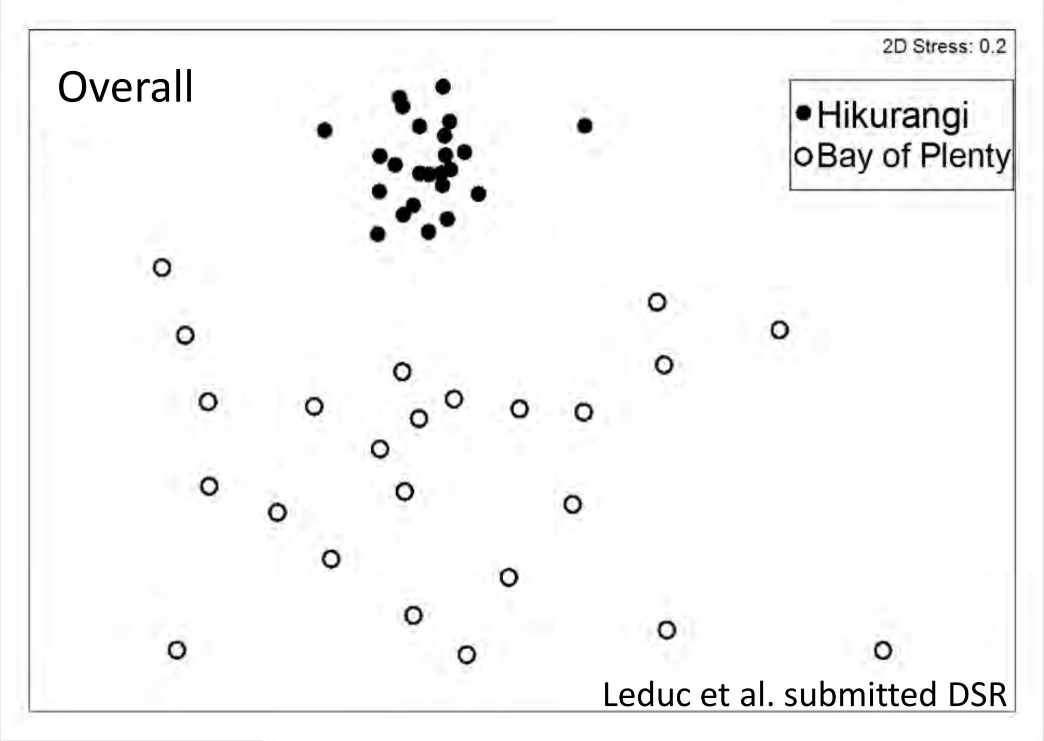
- Significant region effect
- Seep and vent communities clearly different
- Canyon, slope and seamount similar in HIK
- Communities significantly different among habitats in BOP



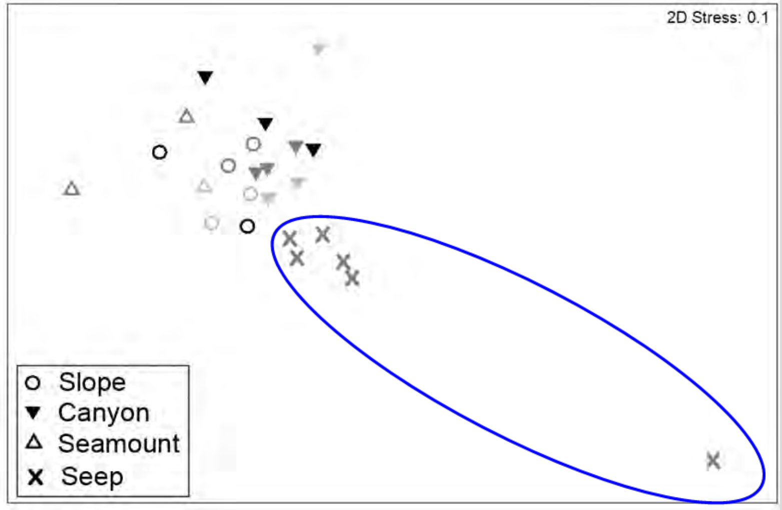
Bowden et al. submitted DSR

Results -macroinfauna

- Two regions were clearly distinct, between canyon and slope habitats
- No difference between habitats in BOP
- Differences in HIK
  - Seeps separate out
  - Canyons not as distinct, but differ from seamount and slope

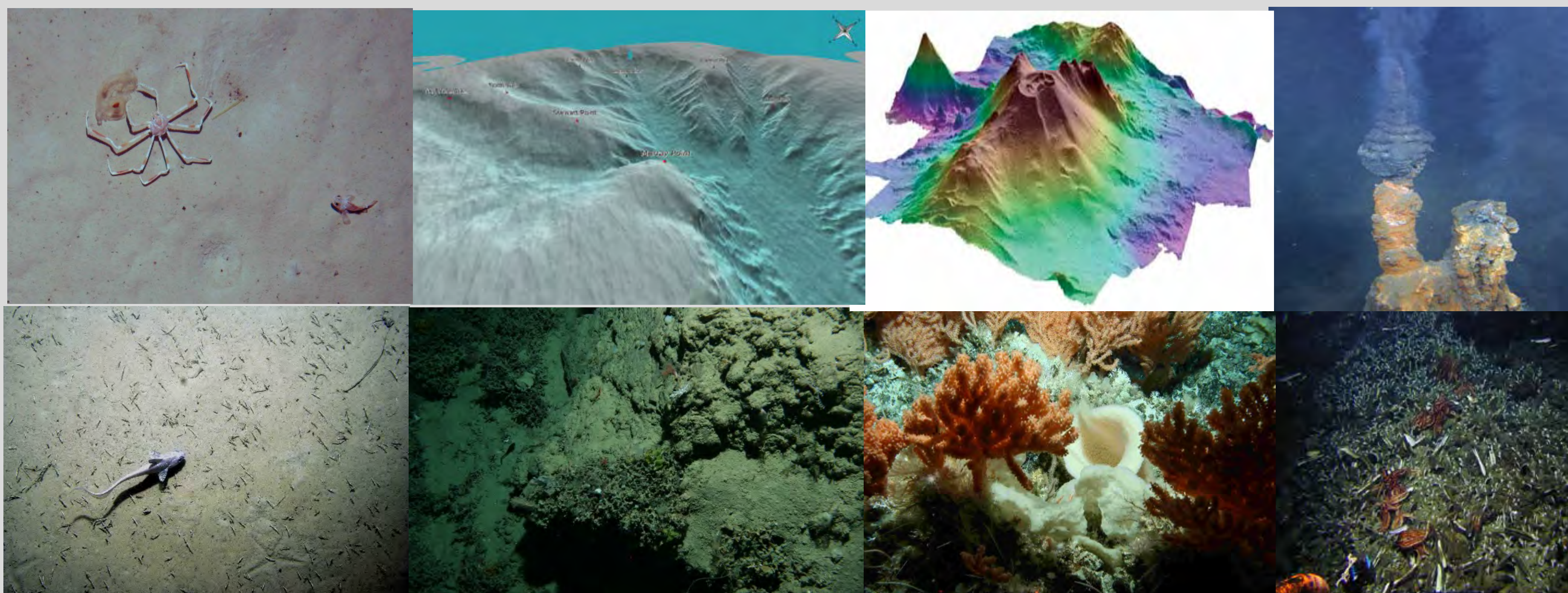


Leduc et al, submitted



Survey conclusions….

- All deep-sea habitats are not the same
- Biodiversity patterns not necessarily consistent
- Implications for management
  - What does it mean if communities differ?
  - Do habitats need to be managed separately?



Assessment of ecological risk

- Ecological risk assessment to address this issue
- Many methods for conducting ERA, ranging from qualitative to fully quantitative
- Most habitat assessments are intermediate (semi-quantitative)
- Two examples, different approaches
- Ecological traits
  - Addresses functional structure of a community
  - Two elements:
    - sensitivity to disturbance
    - ability to recover from impact

Assessment of ecological risk

- **Sensitivity**-recoverability approach

Attribute	Traits	Response to disturbance
Feeding	Scavengers & predators	Positive; Provision of additional food source
	Suspension, deposit, grazers	Neutral; dependent on location, disturbance regime and individual traits
Habit	Erect	Negative; Liable to breakage
	All others	Neutral; other habits are related to living position
Mobility	Sedentary	Strongly negative; Unable to move away from approaching disturbance
	Limited	Negative; May be able to move away
	High	Neutral; Able to move away from (or bury below) approaching disturbance
Living position	Sediment surface	Strongly negative; Will be disturbed
	In top 2cm of sediment	Negative dependent on disturbance;
	Deeper than 2 cm in sediment	Neutral dependent on depth of disturbance;
Fragility	Very fragile	Strongly negative; Will be damaged/killed if disturbed
	Fragile	Negative; Will be damaged if disturbed
	Robust or not known	Neutral

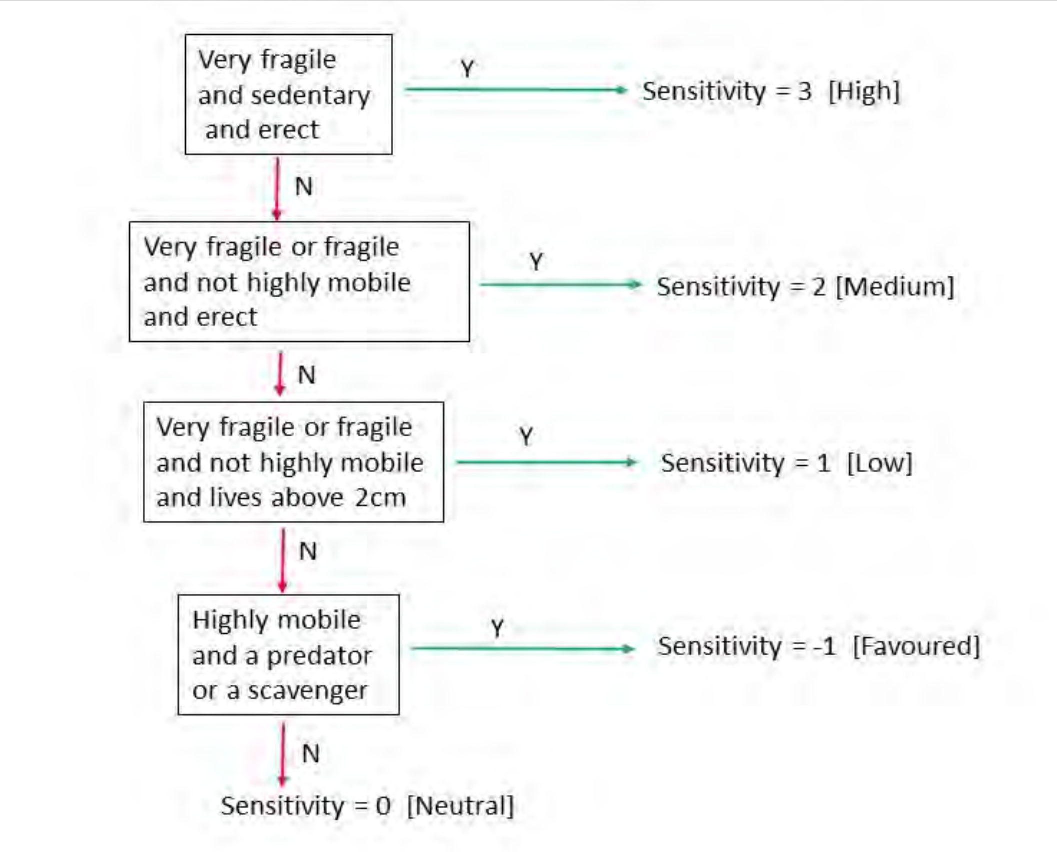
Assessment of ecological risk

- Sensitivity-**recoverability** approach

Biological attribute	Traits	Rationale
Generation time	Short (years) Intermediate (decades) Long (century scale)	Positive: Higher turnover enhances contribution to increased abundance Negative: Low productivity with high longevity
Larval output/reproductive frequency	Semi-continuous Iteroparous (each year) Semelparous (1x life)	Positive: Higher reproductive frequency and output increases the number of potential recruits available to the impacted area
Dispersal capability/larval development mode	Fragmentation Planktotrophic larvae Lecithotrophic larvae Brooders	Positive: Greater dispersal increases the likelihood of recruitment success. Feeding larvae Negative: Non-feeding larvae, localised dispersal
Mobility	Highly mobile Crawlers Sessile	Positive: Higher mobility increases the ability to emigrate into impacted area Negative: sessile, no capability to migrate.

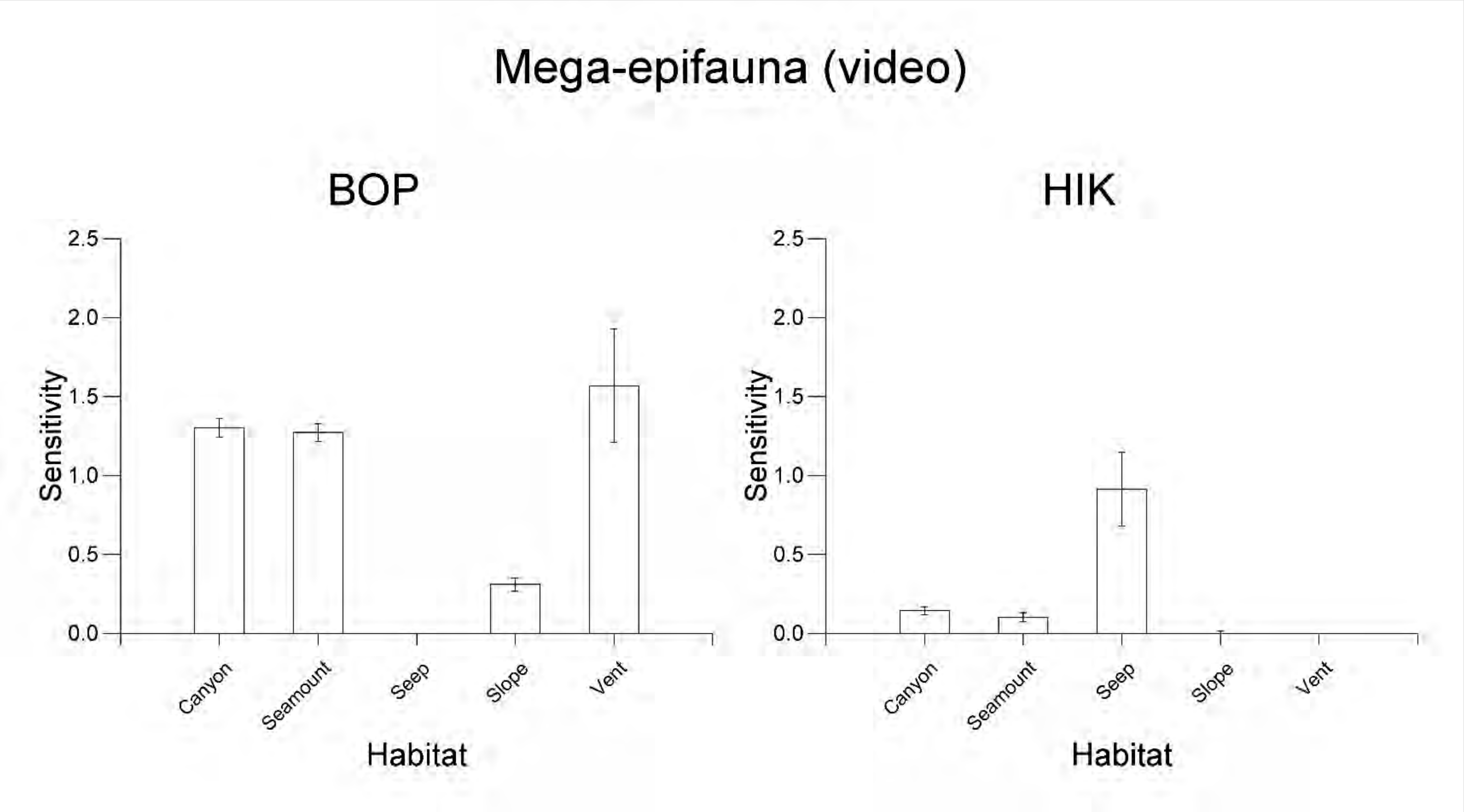
Sensitivity ranking

- Utilises a decision tree approach



- Analysis is of the top “characterising” species (SIMPER 75%)
- Combined into a “community profile”

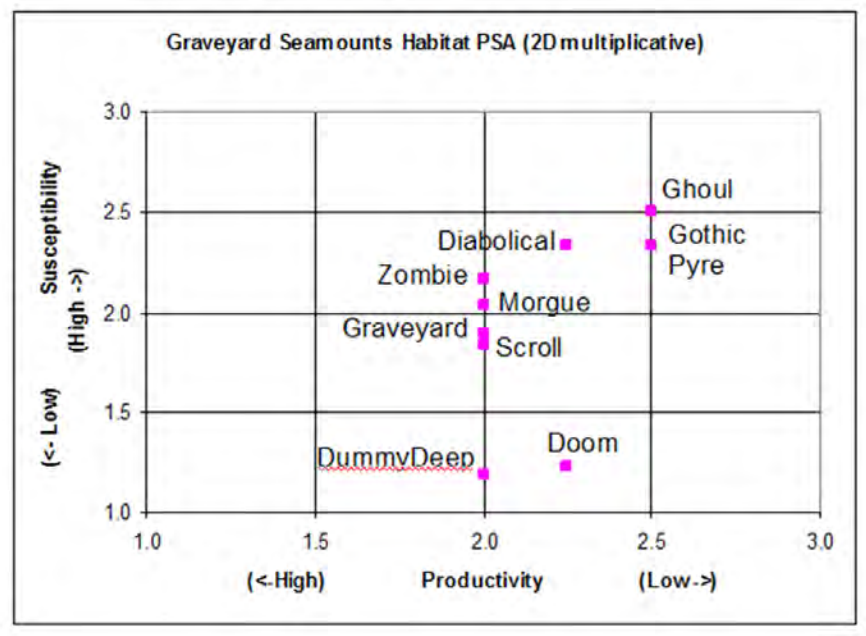
Sensitivity comparison

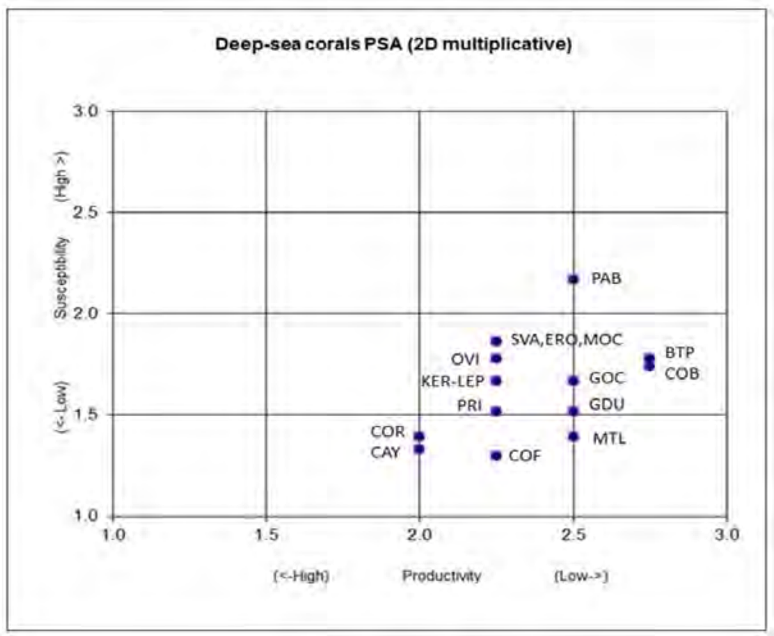


- Slope very clearly lower sensitivity
- Differences by region, with sensitivity HIK<BOP
- Different patterns between habitats by region
- Habitat does matter

Spatial scale of assessment is important

- Need to separate assessment of risk by habitat
- BUT, also by features/areas within habitat
- AND Family/Order level of taxonomic groups



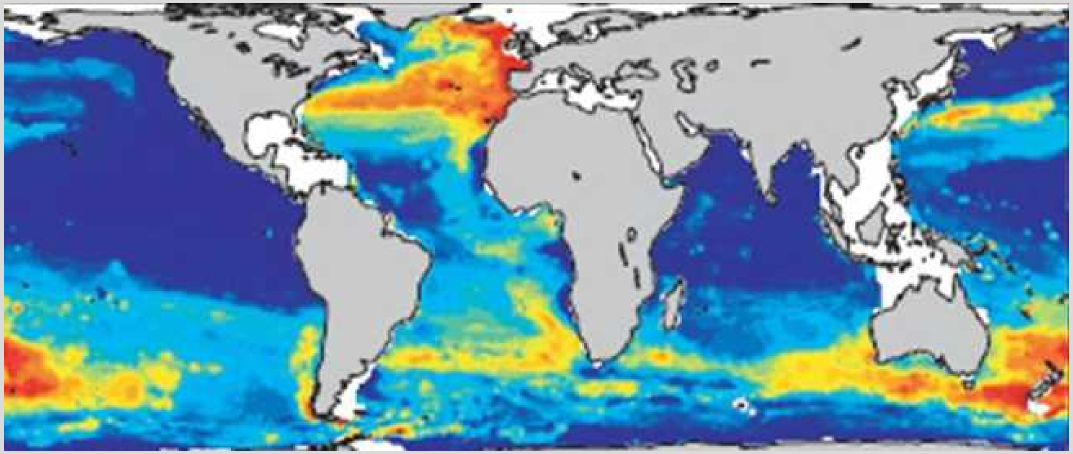


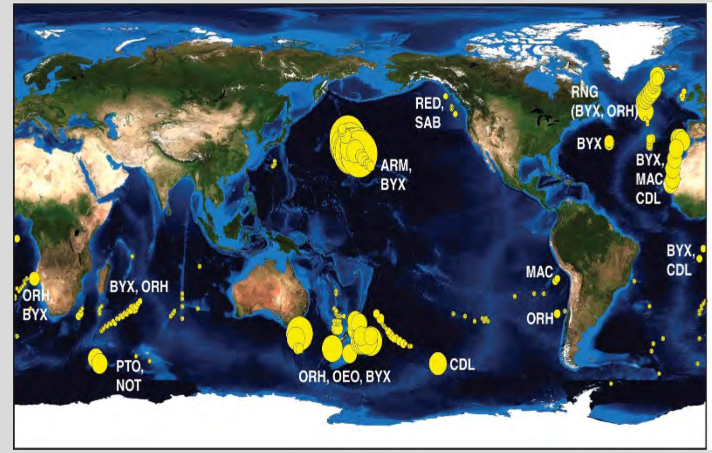
- There is no simple one-size-fits-all…

A different more global approach

- A specific assessment to evaluate the threat of fishing on seamount biodiversity
- Development of an index that measures the relative risk to stony corals on seamounts from bottom trawling
- Uses data on
  - distribution of seamounts and their depth (14,000 records)
  - predicted distribution of stony corals (habitat suitability)
  - geographical and depth distribution of target commercial fish species
  - estimated fish catch on seamounts
  - extent of damage to corals by bottom trawling effort

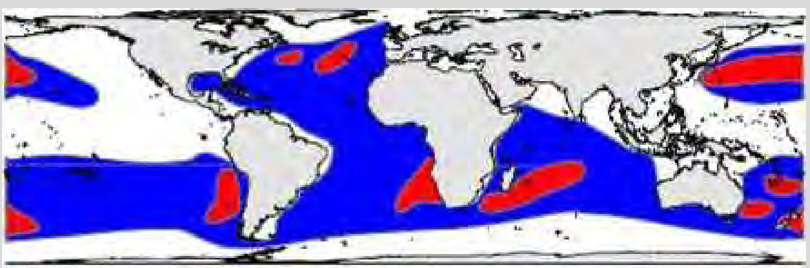
- Habitat suitability for stony corals





- Distribution and catch of commercial target fish species

BYX



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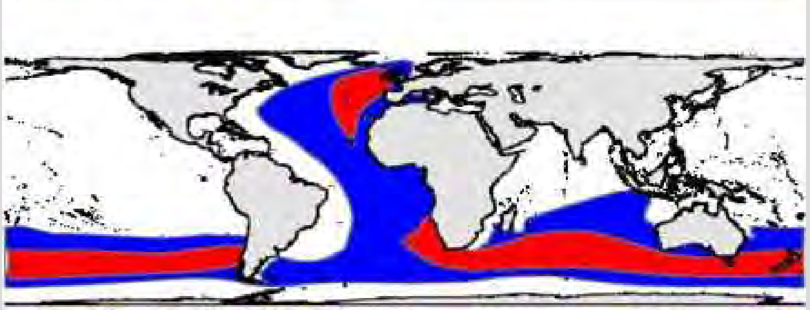
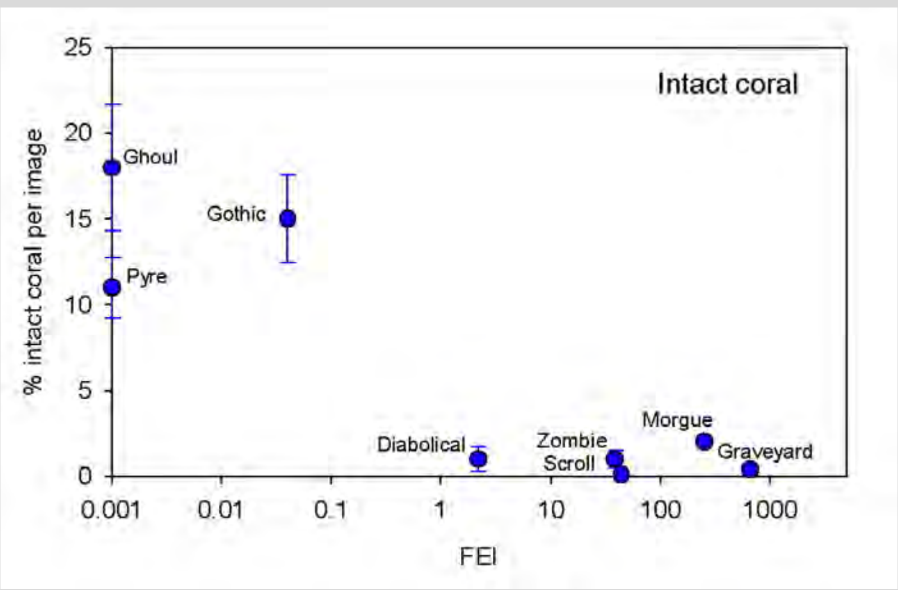
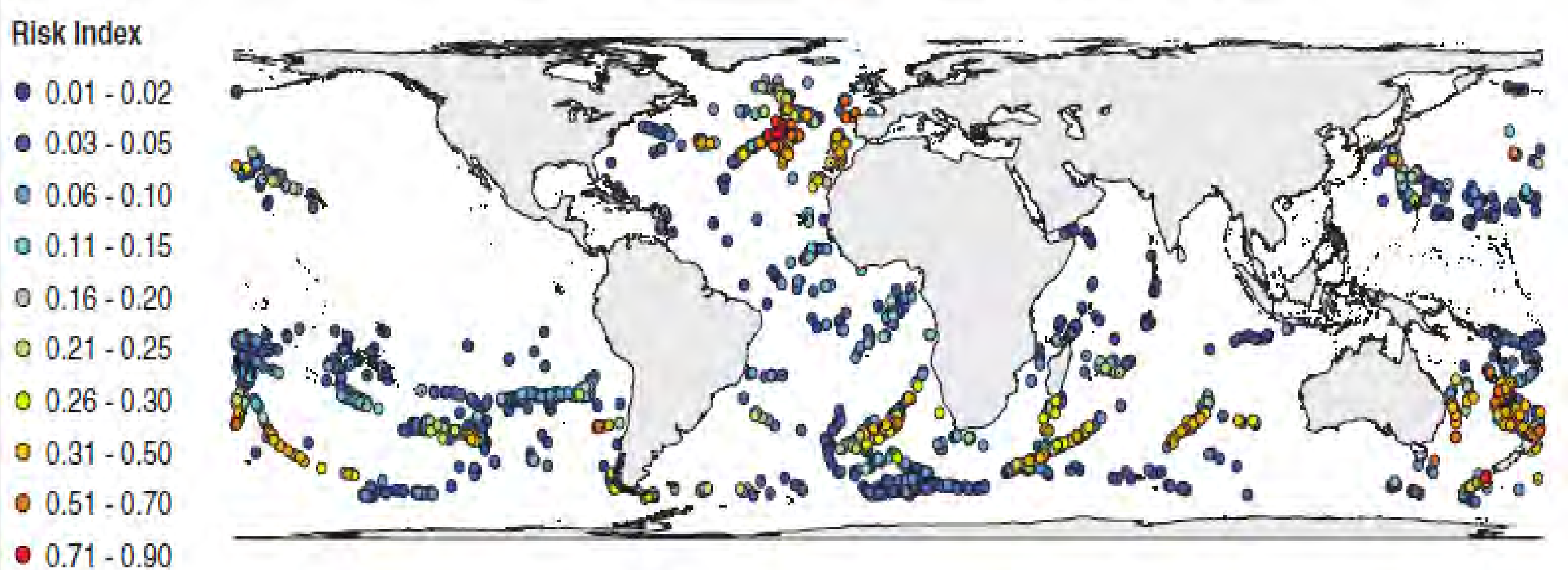




- Factor in level of existing trawling effect on corals

Overall seamount risk map

- High vulnerability + Low fishing effort = High Risk.
  - Overlap of high HS, and high predicted fish distribution
  - Remove areas of high fishing effort (where >50 tows)



Clark & Tittensor 2010

- Enables environmental managers to prioritise action

Conclusions

- We know about the nature of threats, although the extent (distribution, frequency) less so
- We don't know much about deep-sea biodiversity offshore
- We can estimate a number of community/ecosystem metrics with limited data-based on environmental "proxies", and objective and transparent methodologies
- Habitat suitability modelling is a powerful tool for data-limited situations, BUT a lot of care is needed in evaluating and interpreting its usefulness
- Risk is uneven across habitats and faunal groups, and should be used to help identify priority areas for management
- Spatial management is an important option for balancing exploitation and conservation in the deep sea…later talk

谢谢你 Xie Xie Nie

NIWA
Taihoro Nukurangi

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Ministry for Primary Industries
Manatū Ahu Matua

CenSeam
a global census of marine life on seamounts

TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI
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