Cobalt-rich crusts: ecosystem characteristics of seamounts relevant to zone design

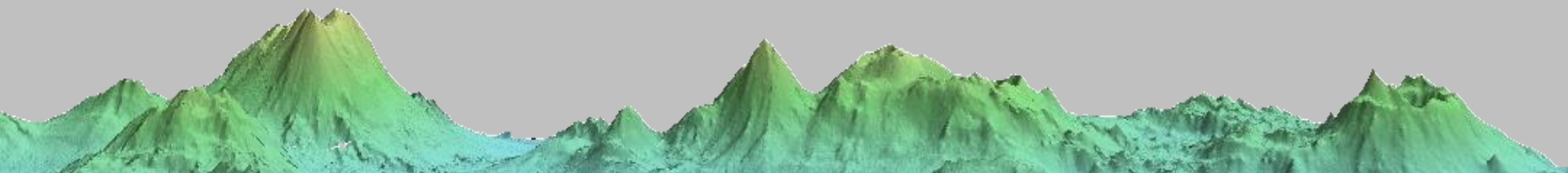
Malcolm Clark

NIWA, New Zealand

ISA IRZ-PRZ Workshop, Berlin, September 2017

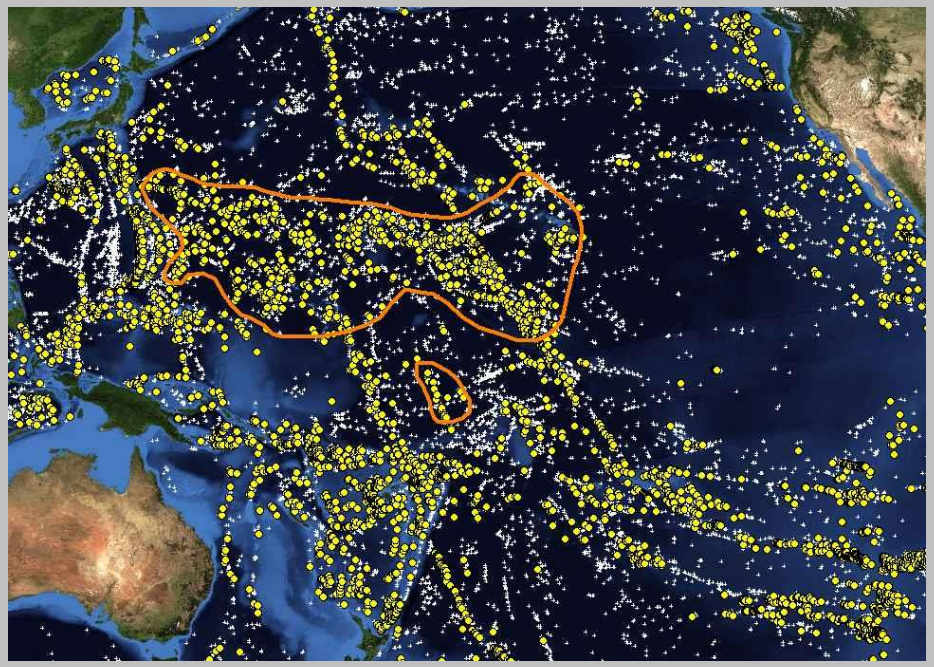
Presentation Outline

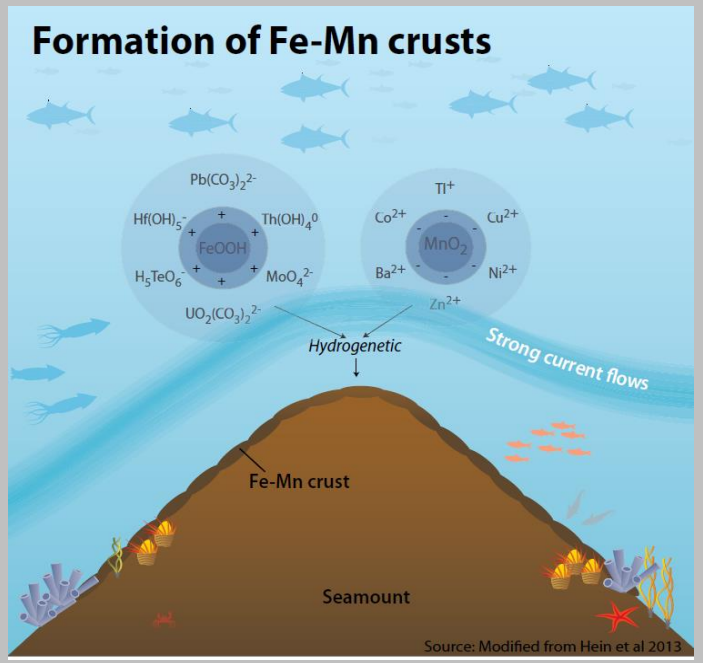
- Background
  - seamount characteristics (resource topography and geology)
  - seamount biodiversity
  - seamount mining
- Environmental issues
  - Focus on spatial and temporal aspects
  - Topography and geology
  - Oceanography
  - Faunal composition and distribution
  - Connectivity
- Concluding thoughts for tomorrow



Background-geology

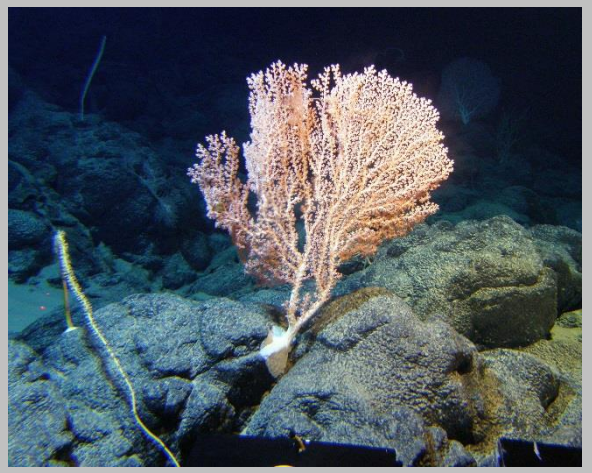
- Seamount/guyot features
- Low sedimentation areas
- Hard substrate
- Cover extensive areas (10s-100s km^2)
- 800-2500m depth

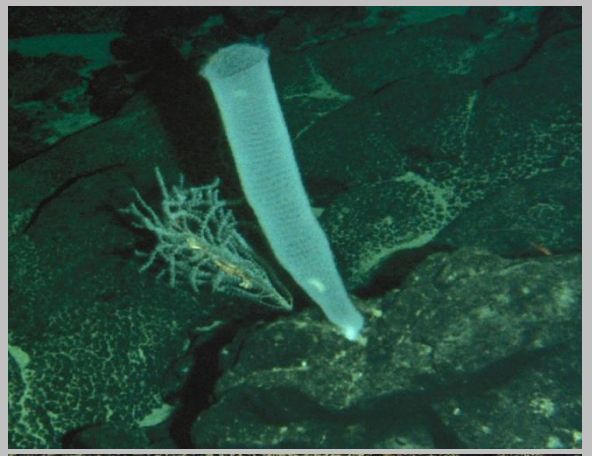




Background-biology

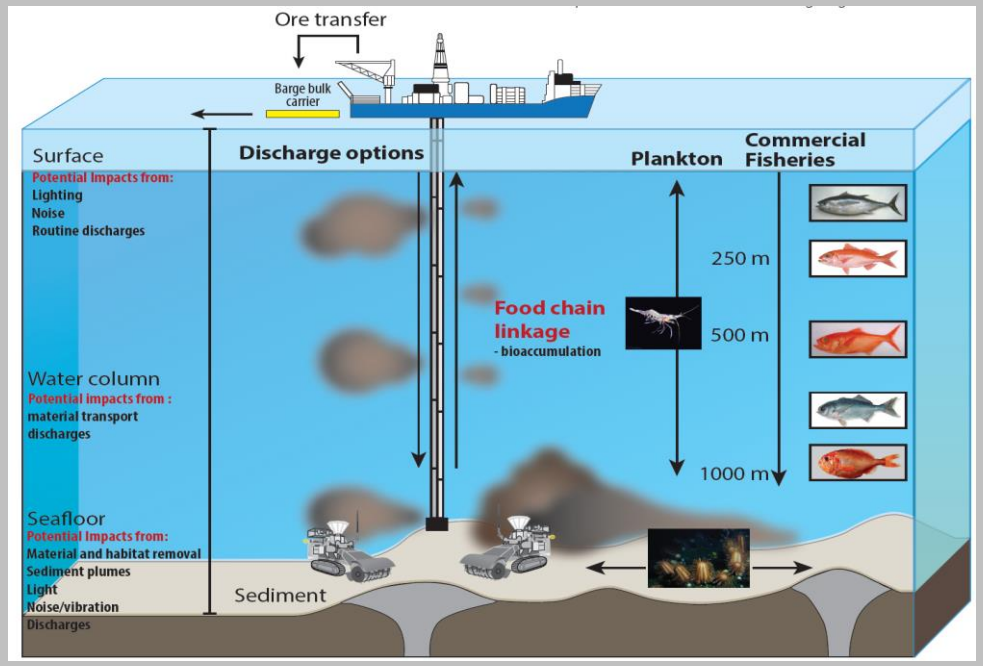
- Seamounts are well known for their diverse and abundant communities
  - Commercial fisheries (e.g., alfonsinos, armourheads, deepwater snappers)
  - Benthic invertebrates
- Focus on benthic fauna
  - Corals, sponges, featherstars
  - Sessile communities especially vulnerable to impacts





Background-mining

- 20 km^2 block structure
- Several 100s -1000 km^2 mine site area for 20 yrs
  - Multiple seamounts
- Scraping and digging over large areas
- Major physical impact
- Extensive plume of fine particles and sediment

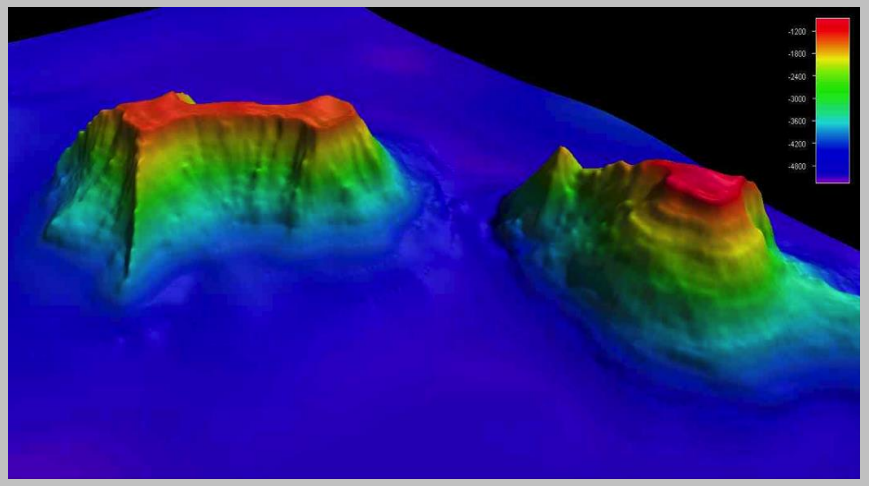


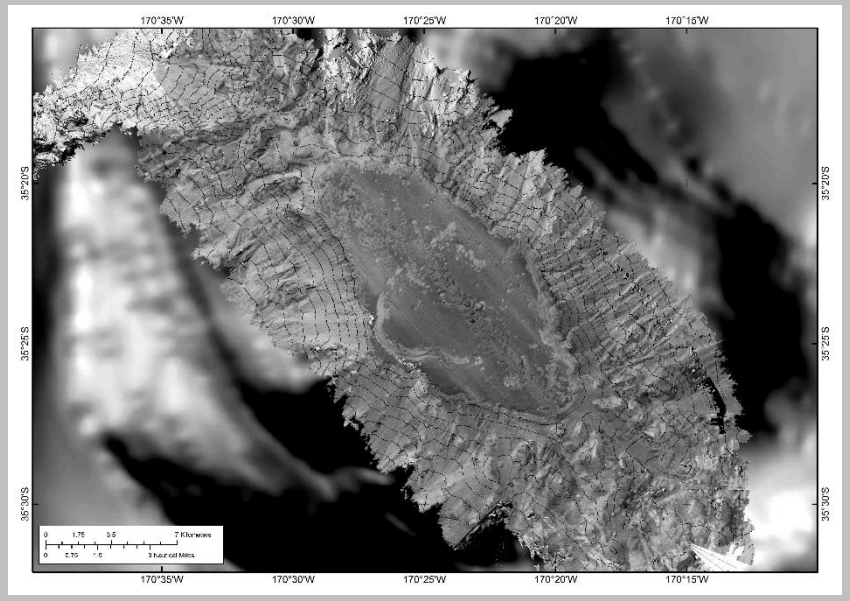
Key environmental issues for IRZ-PRZ design

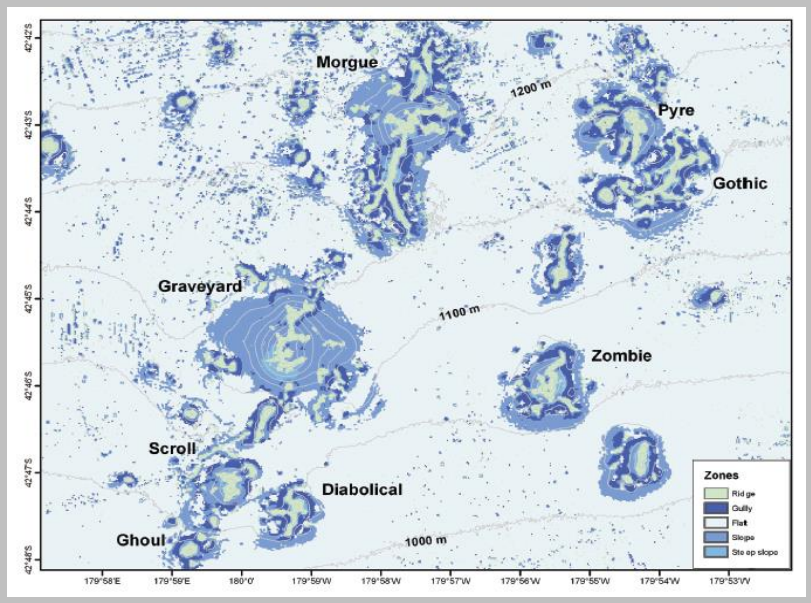
- Location (where should the PRZ/s be placed)
- Number (how many might be needed)
- Size (how large do they need to be)
- Distance separation (between IRZ and PRZ)
- Longevity (how long does a PRZ need to be in place and monitored)
- On seamounts, this comes down to the SPATIAL (and temporal) scale of variability
- Next slides cover aspects of these elements to inform discussions tomorrow and Friday

Geology and topography

- Depth changes
  - 500-4000 m
- Substrate patchiness
  - scales of 10-100s m
- Terrain variability
  - scales of 100s m

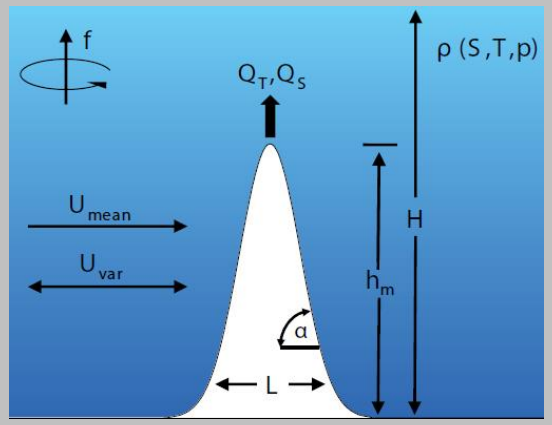


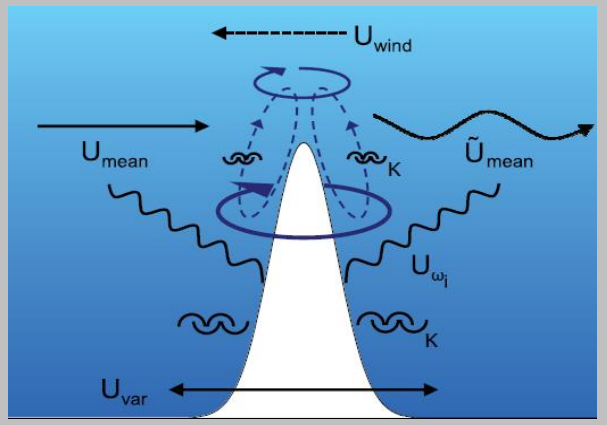


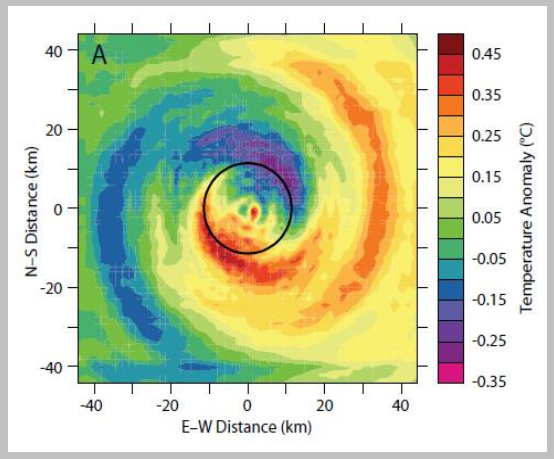


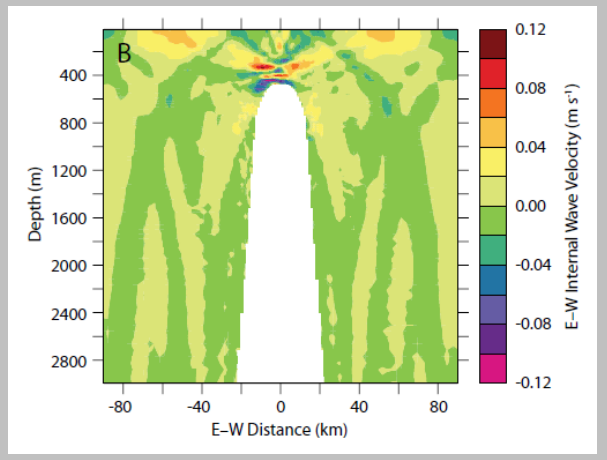
Oceanography

- Size and shape drive current flows
  - Turbulence
  - Upwelling
  - Downwelling
  - tidal flows
  - Taylor columns
  - Temperature variability
  - Internal waves of variable speed
- Affect both sediment composition and faunal distribution







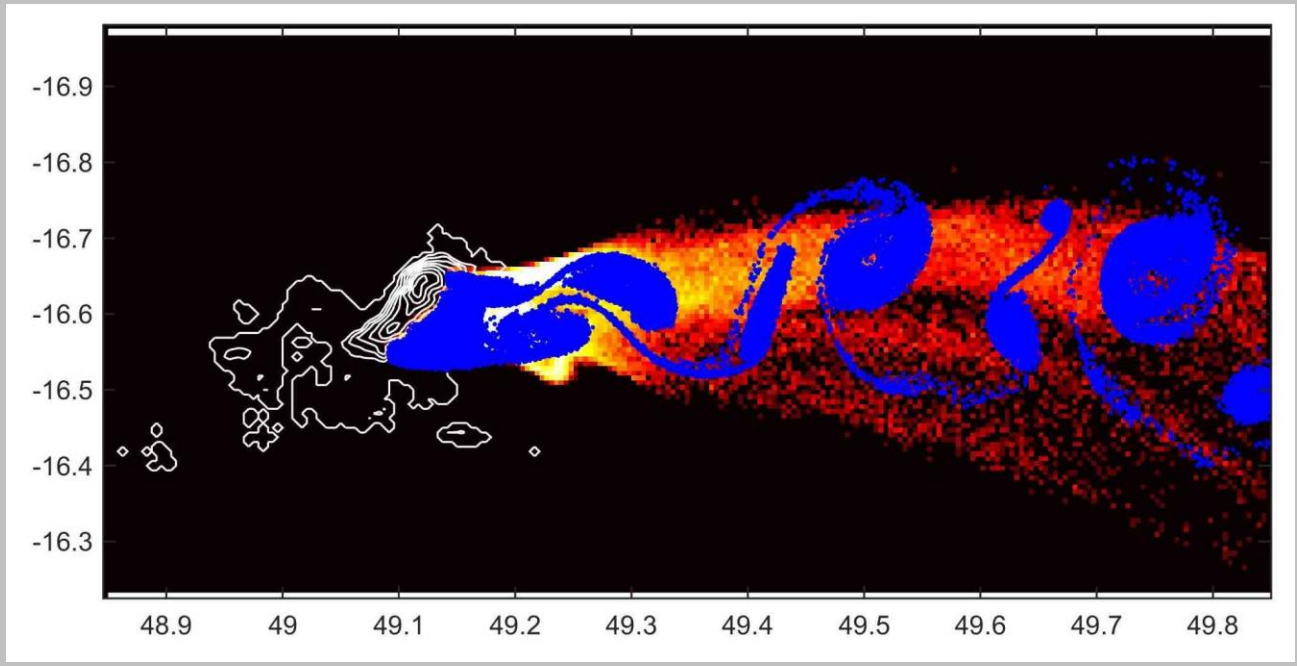


[Lavelle & Mohn 2010]

Plume dispersal

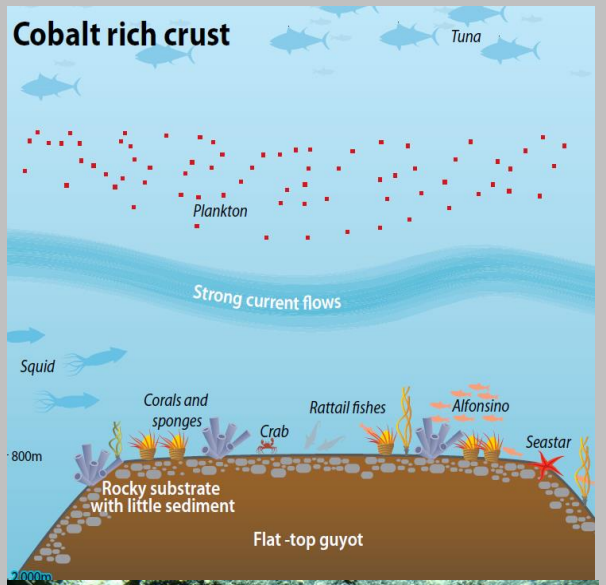
- A key result of oceanographic conditions
- Issues of both suspended and settled sediment
- Example from MIDAS of deep hill (after 30 days)
  - White = 1 cm (20 km)
  - Yellow=1mm (40 km)
  - Red=0.1mm (80 km)

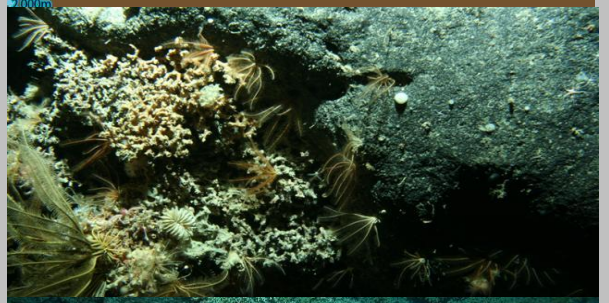
Biological effects of this settlement is uncertain…



Biological distribution

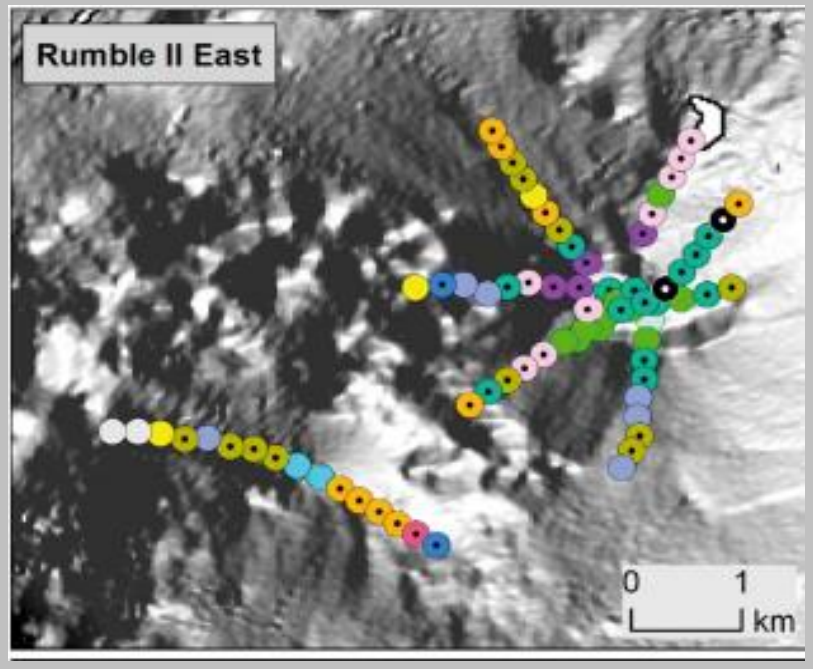
- Faunal communities can differ substantially between seamounts, and within seamounts
- Few studies specifically on CRC features
- Uncertain how much actual CRC substrate affects composition and abundance
  - Grigg et al (1997) less diverse
  - Verlaan (1992) forams more abundant
  - Veilette et al (2007) no clear pattern
  - Schlacher et al. (2013) more abundant
- Next few slides present information relevant to CRC seamount environments on within and between faunal variability, and some of the key environmental factors to consider

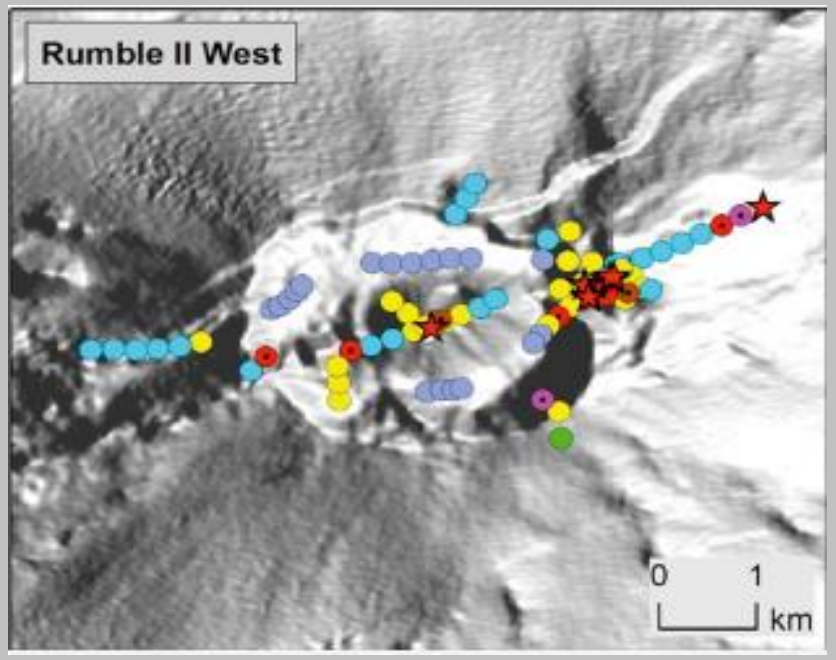




Spatial scale of differences between seamounts

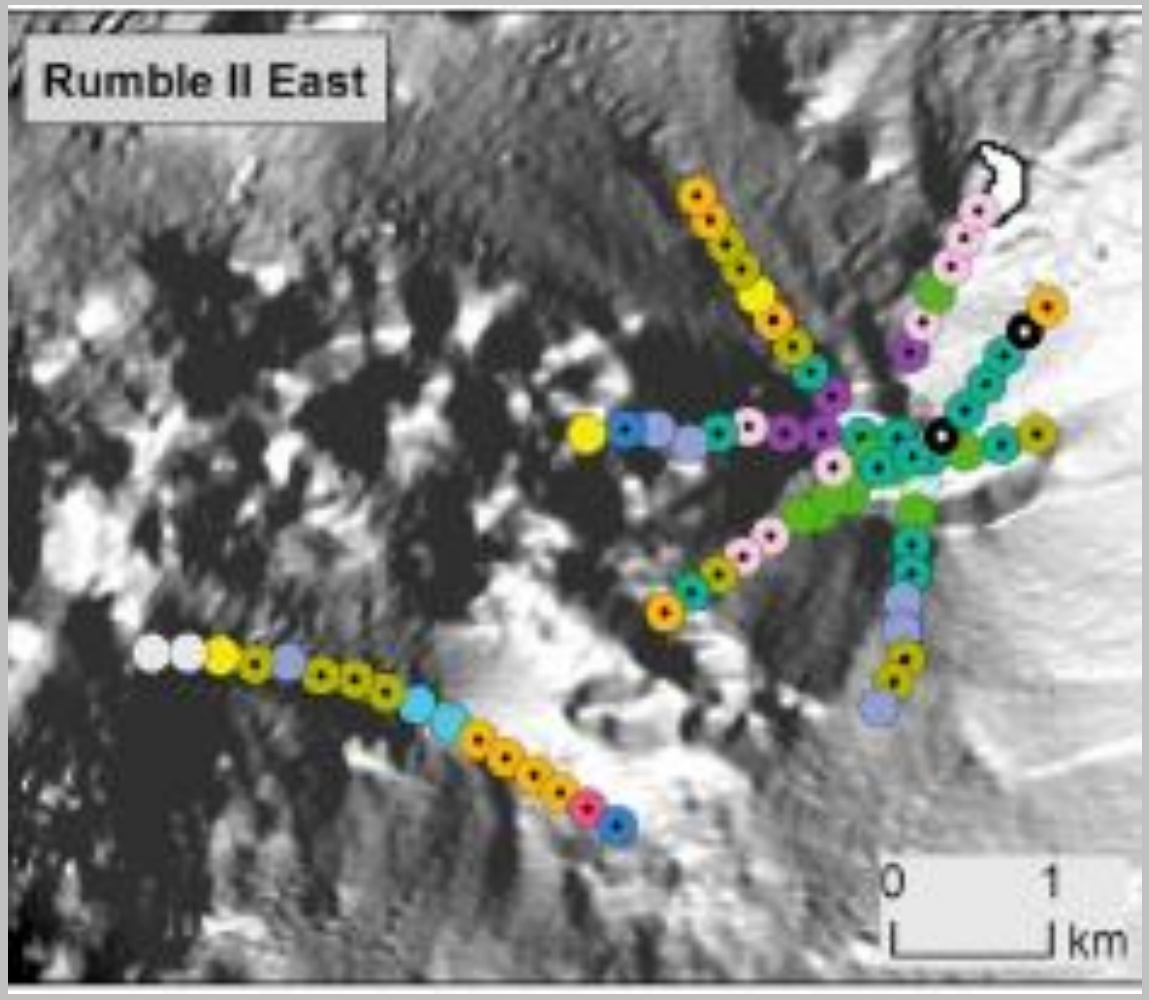
- Two seamounts 20 km apart
- Rumble II East (1035m, 40 km^2)
  - 14 total, 8 unique
- Rumble II West (1140m, 100 km^2)
  - 8 total, 3 unique





Spatial scale within a seamount

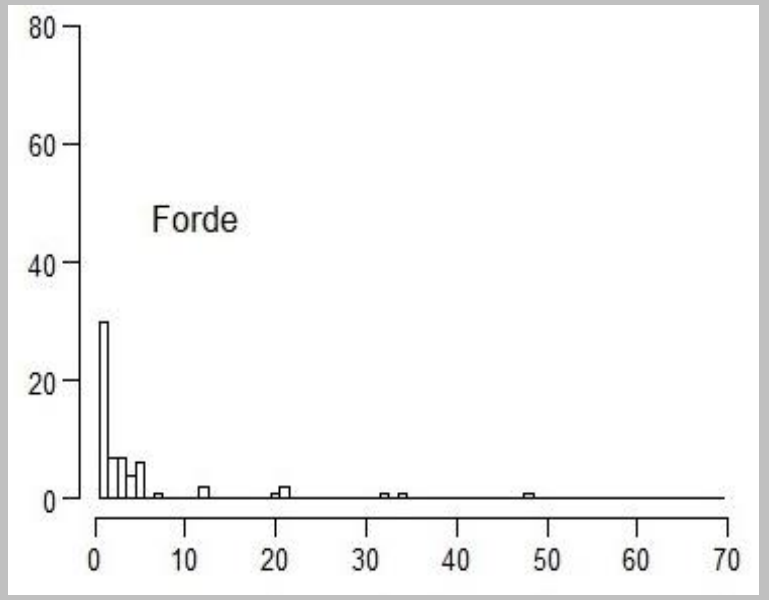
- Highly variable community structure, driven by:
  - Depth
  - Topography
  - Substrate
- Community composition changes over distances of 10s m

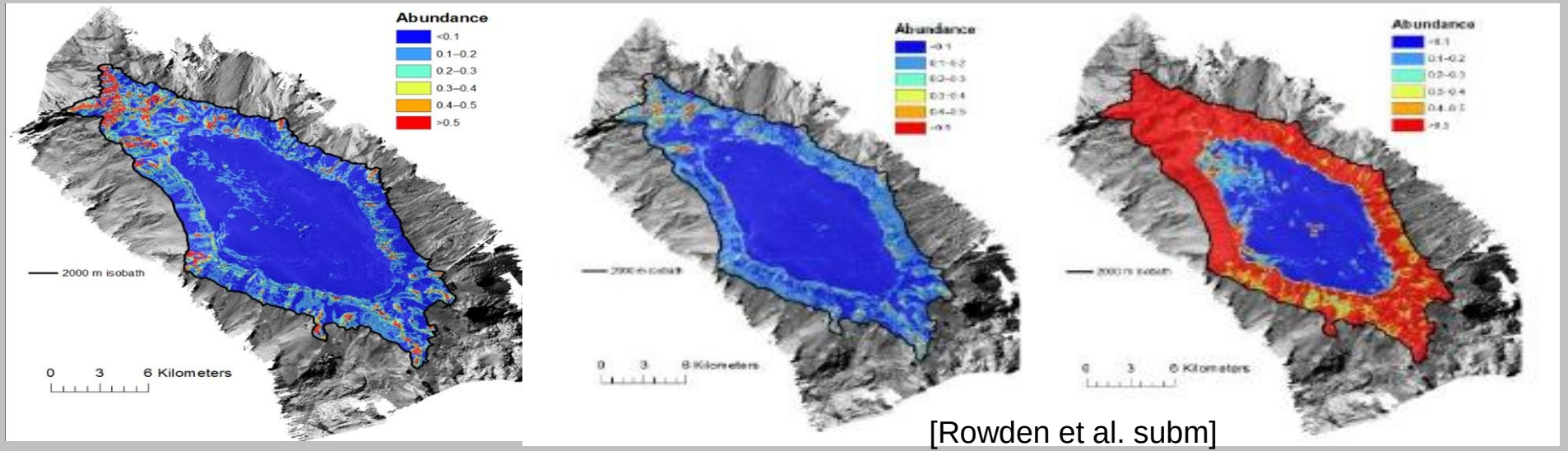


[Boschen et al. 2015]

Within seamount scales

- A larger guyot example
  - Camera survey followed by habitat suitability modelling for full inferred distn
- Forde Guyot
  - Distribution of taxa (SVA,BRG,CRI)
  - Patch size (Frequency of 25x25cell)

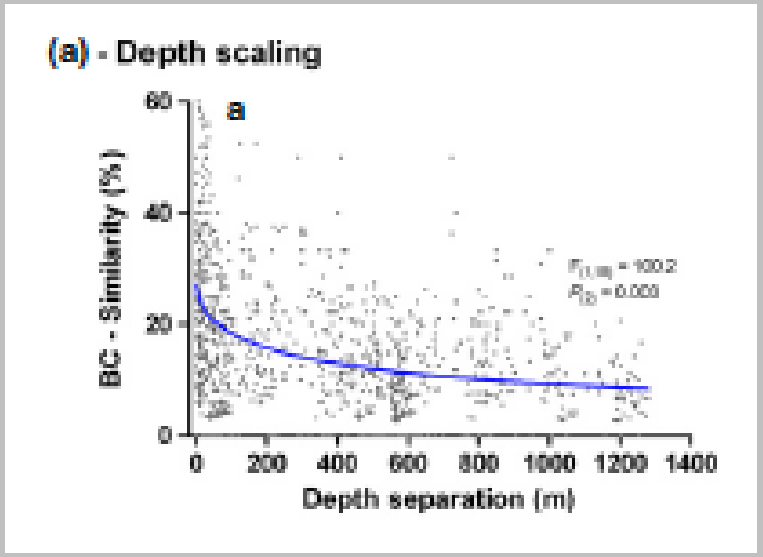


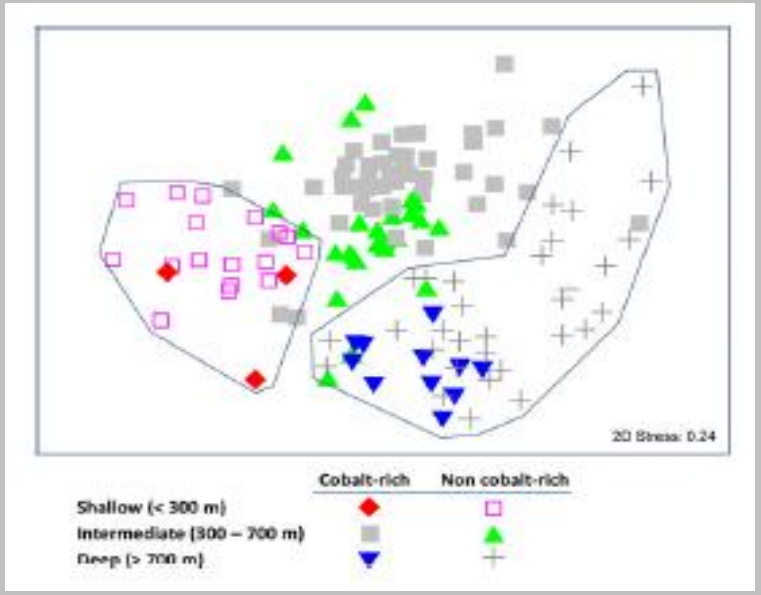


[Rowden et al. subm]

Environmental drivers (1)

- Depth
  - Taxa turnover substantial across depth gradients
  - Similarity of assemblage structure decreases with bathymetric separation of dives
  - Strong clustering of assemblages <300m, 300-700m, deeper than 700m
  - Need similarity of depth zones

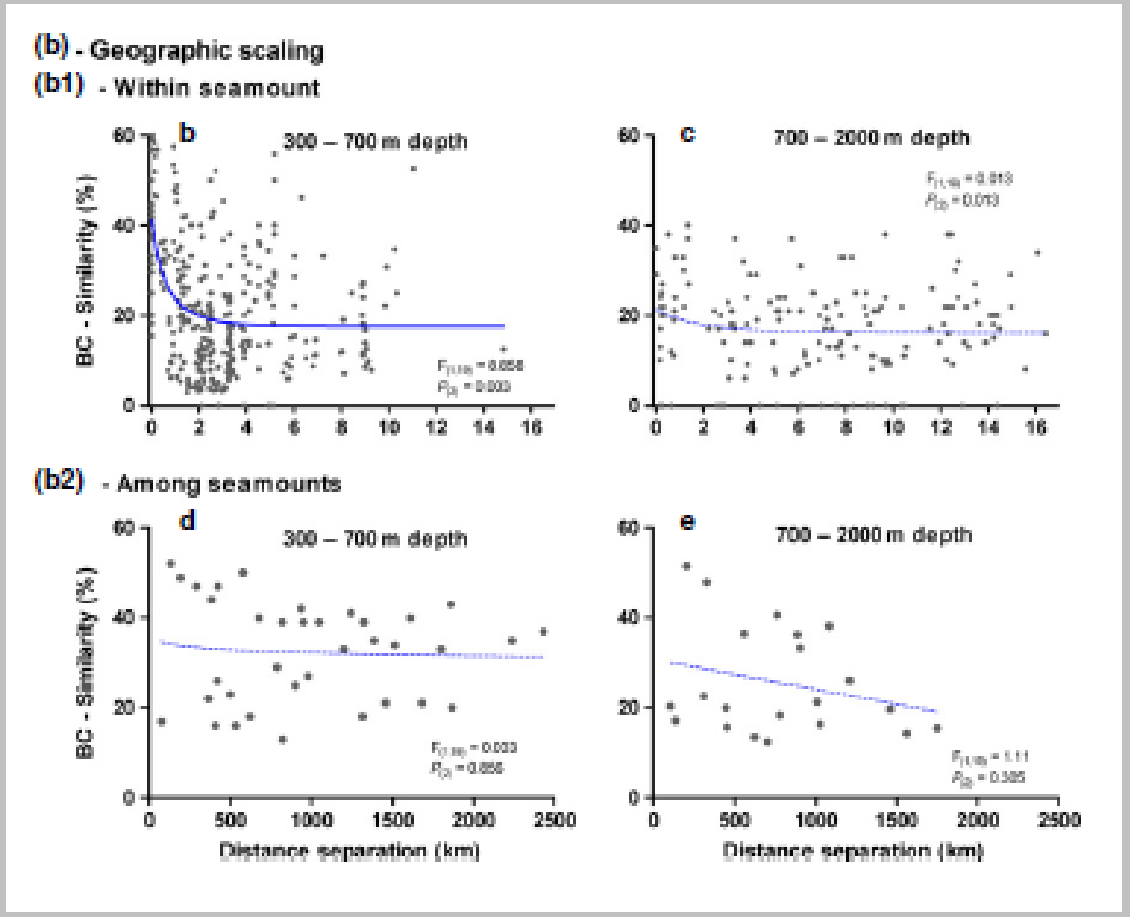




[Schlacher et al. 2013]

Key environmental drivers (2)

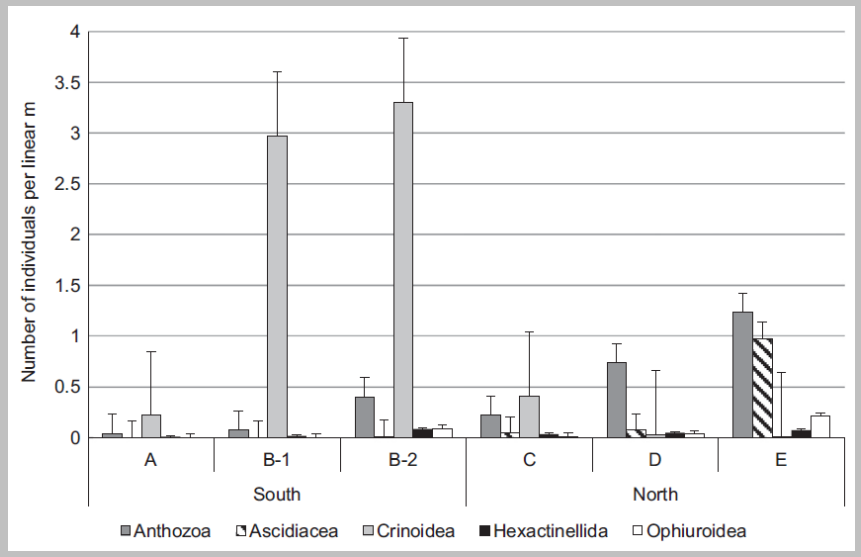
- Distance
  - Within same seamount, similarity decreases rapidly to about 2km, then levels off at high dissimilarity
  - Less pronounced effect among seamounts

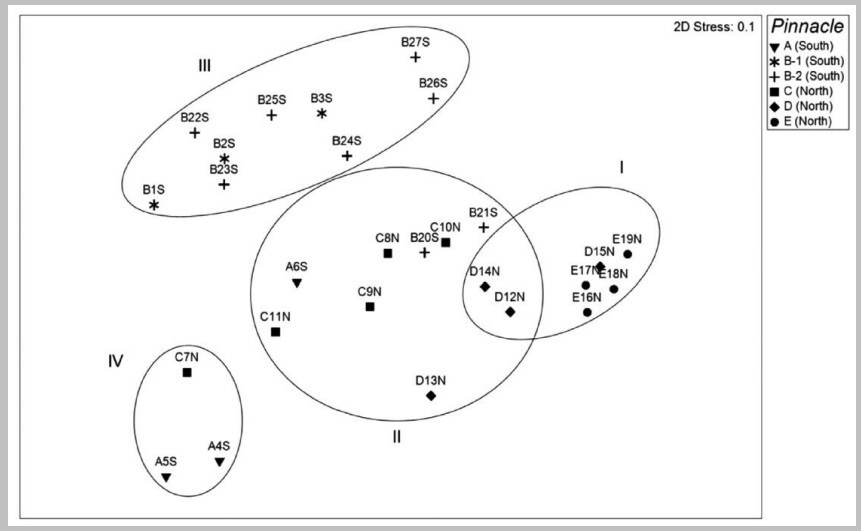


[Schlacher et al. 2013]

Environmental drivers (3)

- Distribution patterns
  - Variability between seamounts can be pronounced
  - Often abundance more than composition (Schlacher et al (2013) and Morgan et al (2015))
  - A range of different environmental variables important in studies:
    - Depth, salinity, oxygen, substratum composition, latitude/longitude
  - Need multiple seamount studies to determine regional patterns
    - Assess whether IRZs/PRZs can be on different seamounts

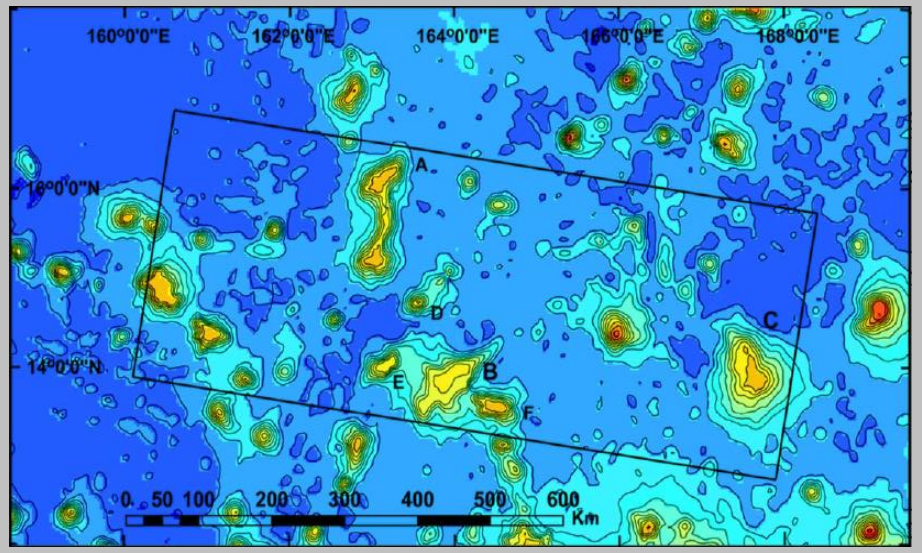


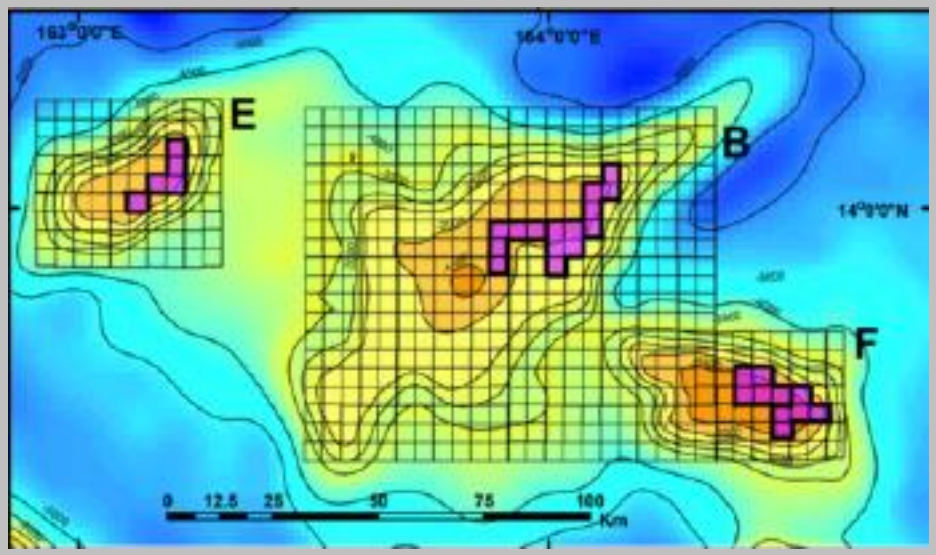


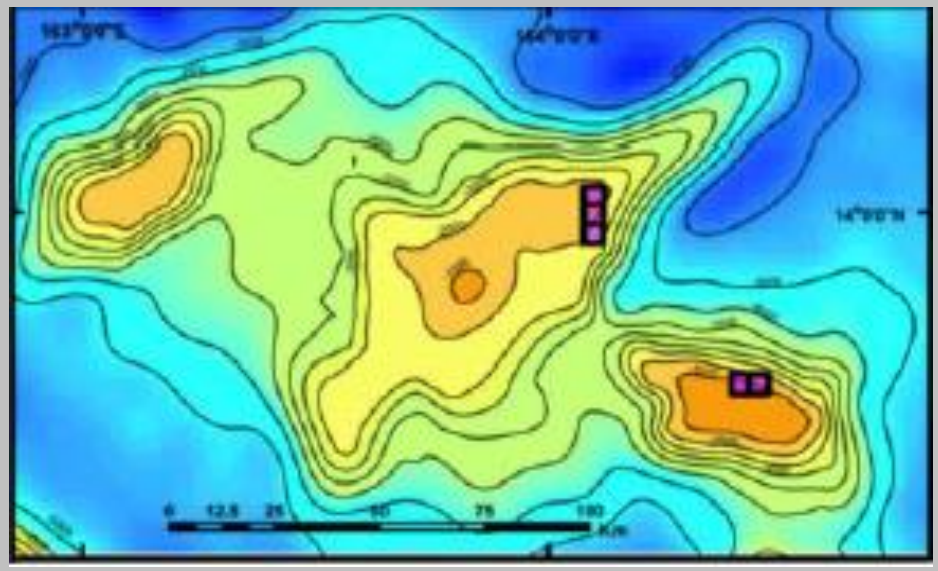
[Morgan et al 2015]

Connectivity

- Issues of how patches/populations are connected depend on what mining might look like
- The Mine-Site model (Hein et al. 2009
- Exploration blocks reduce for exploitation, but could be single or multiple seamounts

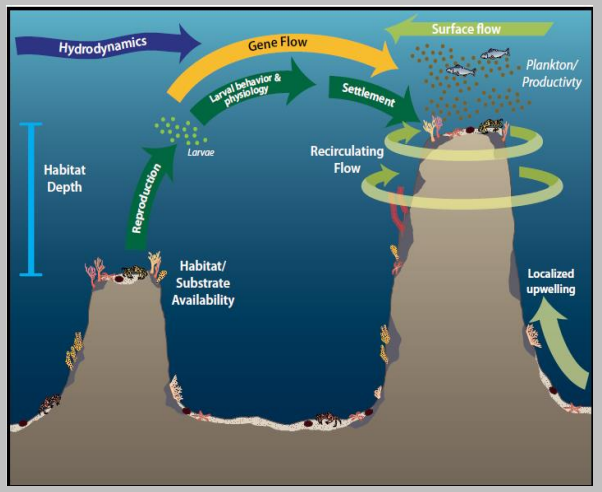


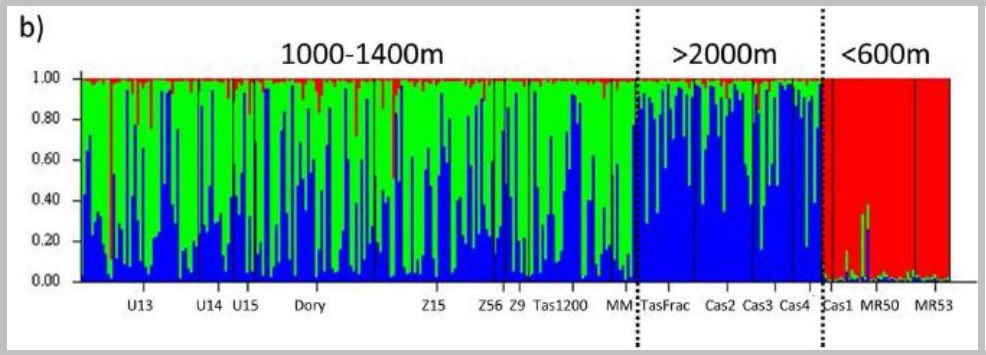


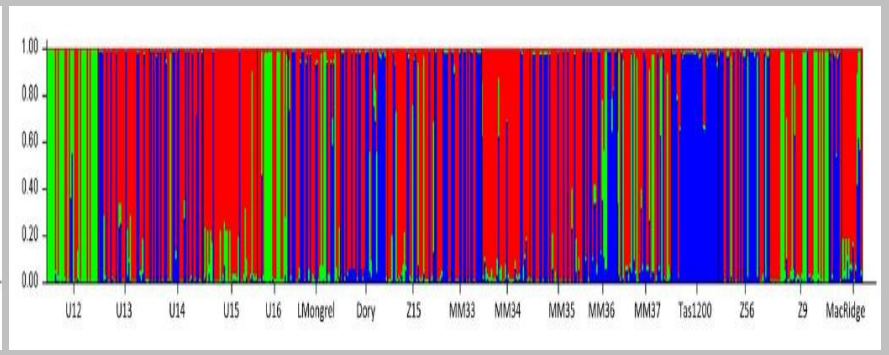


Connectivity (2)

- Depends on reproductive and dispersal capabilities
- Example of two deep-sea corals on 17 seamounts off Australia spanning 2000km
- *Desmophyllum dianthus*
  - Widespread dispersal
- *Solenosmilia variabilis*
  - Very localised population structure, asexual budding rather than broadcast spawning
- Implications of seamounts being either isolated islands, or stepping stones for dispersal



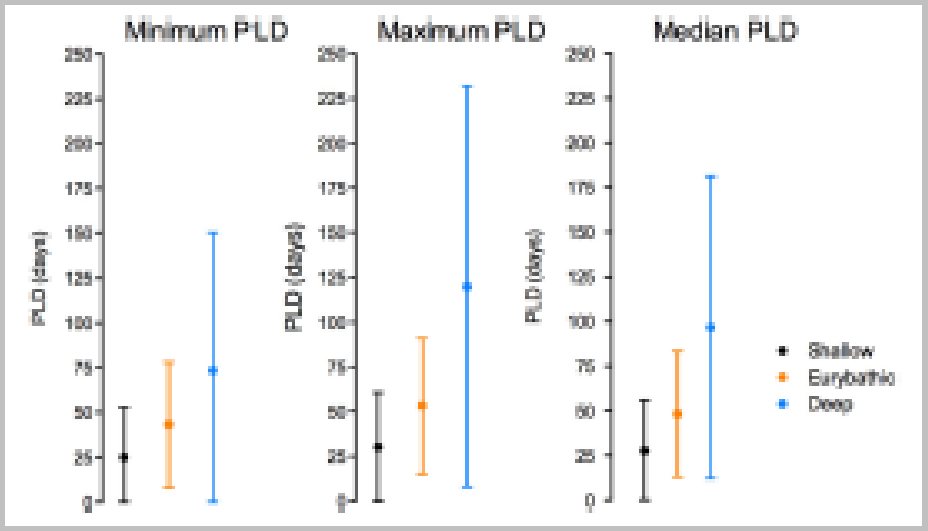




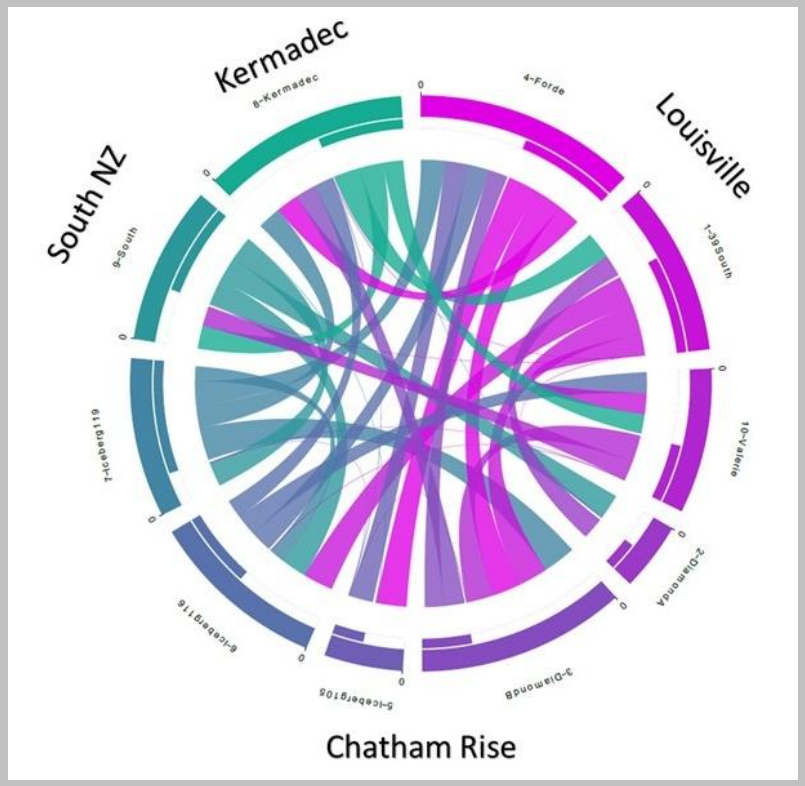
[microsatellite data: Miller & Gunasekera

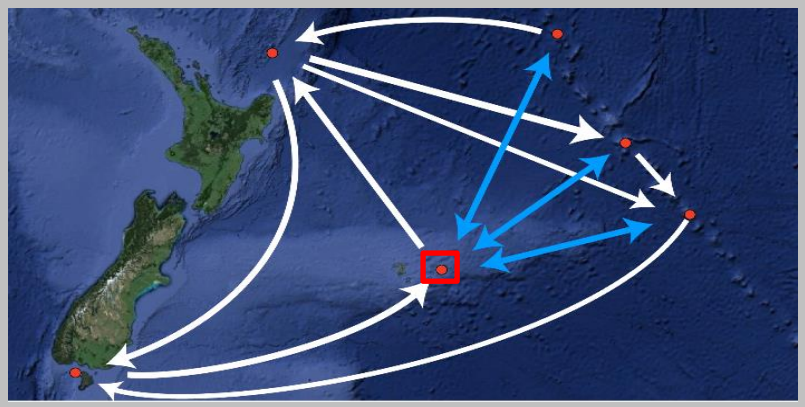
Connectivity (3)

- Deep-sea species can have large dispersal distances
- PLD is relatively high
- Source-sink is an important issue
- Mainly between seamount issues here



[Hilario et al. 2015]





Recovery

- If IRZ-PRZ are also designed for monitoring recovery...
- Recovery comes from:
  - Settlement
  - Growth
  - succession
- Some rapid colonisers
  - Anemones (Australia)
  - Hydrocorals (NZ)

[Clark et al. 2010]

- Dominant fauna on CRC are often slow growing, long-lived (decades-centuries)
- To date, studies on seamounts indicate some change, but few signs of recovery over 5-10 year periods

Marine Ecology. ISSN 0173-9565

ORIGINAL ARTICLE

Seamount megabenthic assemblages fail to recover from trawling impacts

Alan Williams[1], Thomas A. Schlacher[2], Ashley A. Rowden[3], Franziska Althaus[1], Malcolm R. Clark[3], David A. Bowden[3], Robert Stewart[3], Nicholas J. Bax[1], Mireille Consalvey[3] & Rudy J. Kloser[1]

CRC thoughts for tomorrow

- Location
  - Same depth and substrate critical
  - Same seamount rather than different features
  - PRZ upstream of IRZ to be close (but variable current flows problematic-good oceanography important)
- Size
  - Site specific
  - Practical to survey “easily”, detailed coverage necessary
  - Schlacher et al (<2km) and coral patches (<25m) suggest small and close zones to be comparable
- Number
  - Trade-off between few large areas (to encompass representative heterogeneity and multiple patches) and several smaller sites.
  - May need multiple PRZs per IRZ (and potentially multiple IRZs). 2-3 smaller PRZs might be more practical than a single large one (GY)

CRC thoughts (2)

- Separation
  - Communities can change over short distances-distance is not a good proxy for biological distinctness
  - Impact radius uncertain, likely up to 20km-buffer needed around IRZ because of sediment plume effects
  - Emphasise oceanography in minimising distance between IRZ and PRZ to balance these conflicting issues
  - If on different seamounts, long-term connectivity is issue
- Longevity
  - Seasonal and annual environmental variability on oceanic seamounts can be high. Should not influence deep benthos much, but uncertain. 5 year period of monitoring minimum.
  - **If** recovery/rehabilitation is an objective, several decades of monitoring may be required.

Thank you

Thanks to the ISA for funding participation in this workshop, and for the efforts of Stefan Brager, Amber Cobley and Sandor Mulsow in picking up the recommendation of the LTC to host this workshop.