Deep-sea nodule and crust ecosystems: benthic assemblages of manganese nodules and cobalt-rich crusts

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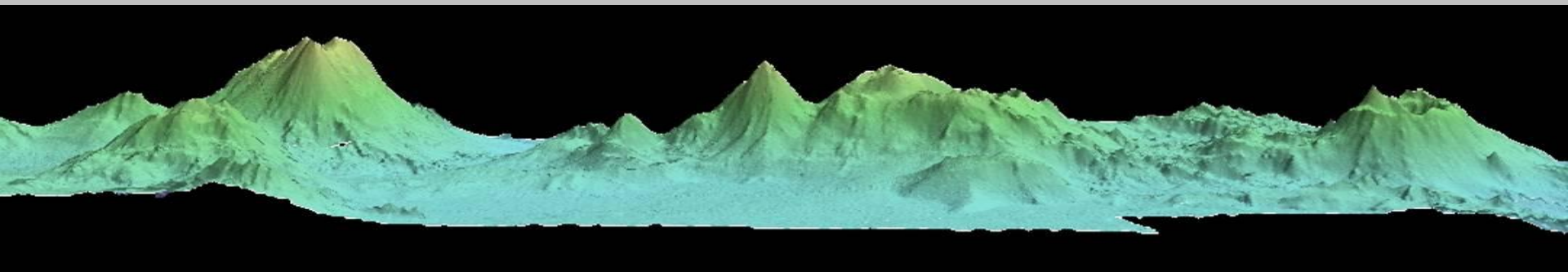
Outline

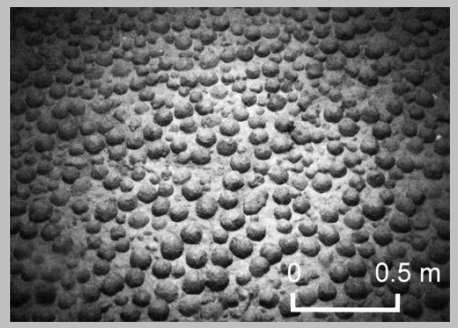
- Background: geological context
- Deep-sea benthic biodiversity
  - Manganese nodules
  - Cobalt-rich crusts
    - Seamounts
    - ISA and CenSeam Workshops
- Environmental considerations
- Conservation issues



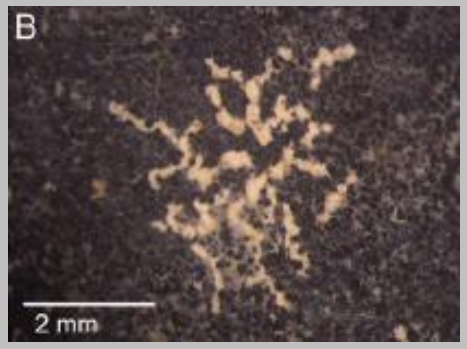
- Focus on cobalt-rich ferromanganese crust
  - partly because nodules have received a lot of attention from the ISA (several very good reports)
  - partly because crust are common in the SW Pacific region
  - partly because of new work that hasn't yet been widely disseminated

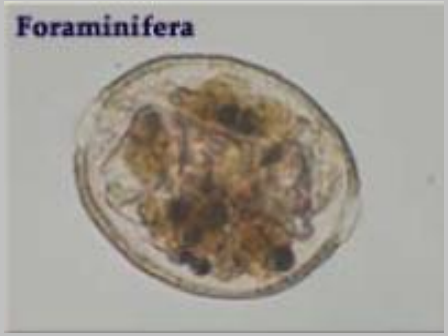
Country	MN	CRC	SMS
Kiribati	√	√	
Cook Islands	√		
Tuvalu	√	√	
Samoa		√	
Tonga			√
PNG			√
Solomon Islands			√
Vanuatu			√
Fiji			√
Marshall Islands		√	
Federated States of Micronesia		√	
Niue	√	√	

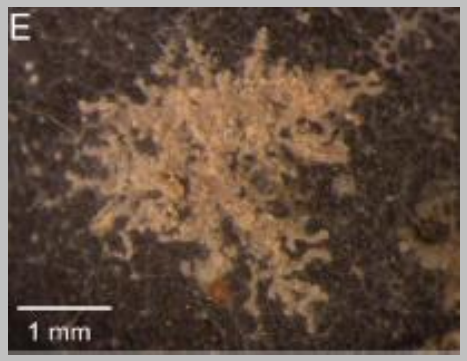
Manganese nodule fauna



- 4000-5000 m depth-abyssal plain
- Seafloor primarily soft-sediment
- Hard substrate seamounts & nodules
- Attached fauna
  - mainly protozoans (CCZ, 73 spp)
  - 90% Foraminifera
  - few metazoa taxa (CCZ, 17 spp)
  - limited macrofauna (polychaetes, bryozoans, sponges, holothurians)



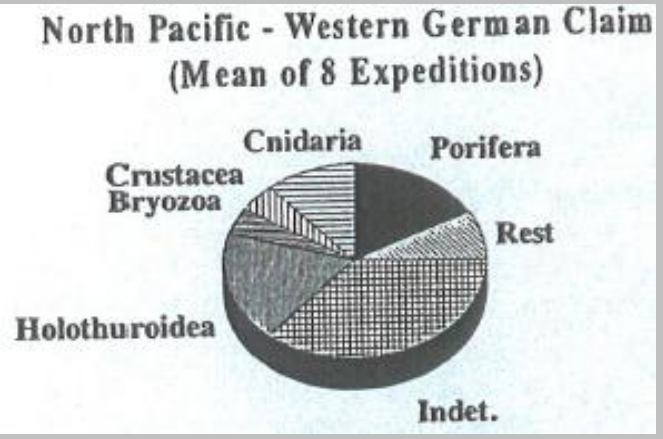


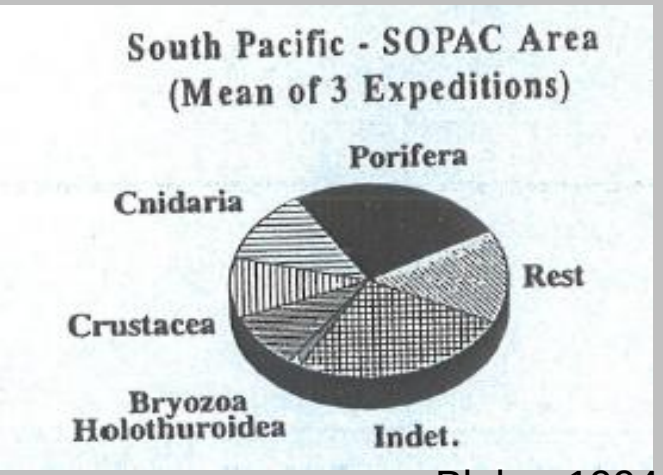


Manganese nodule fauna (2)

- General regional fauna
  - highly diverse soft sediment communities
  - Nematodes, polychaetes, amphipods, isopods

  - Less diverse and abundant surface macrofauna
  - sponges, octocorals, holothurians


North Pacific - Western German Claim
(Mean of 8 Expeditions)
Cnidaria
Porifera
Crustacea
Bryozoa
Rest
Holothuroidea
Indet.


South Pacific - SOPAC Area
(Mean of 3 Expeditions)
Porifera
Cnidaria
Rest
Crustacea
Bryozoa
Holothuroidea
Indet.

Bluhm 1994

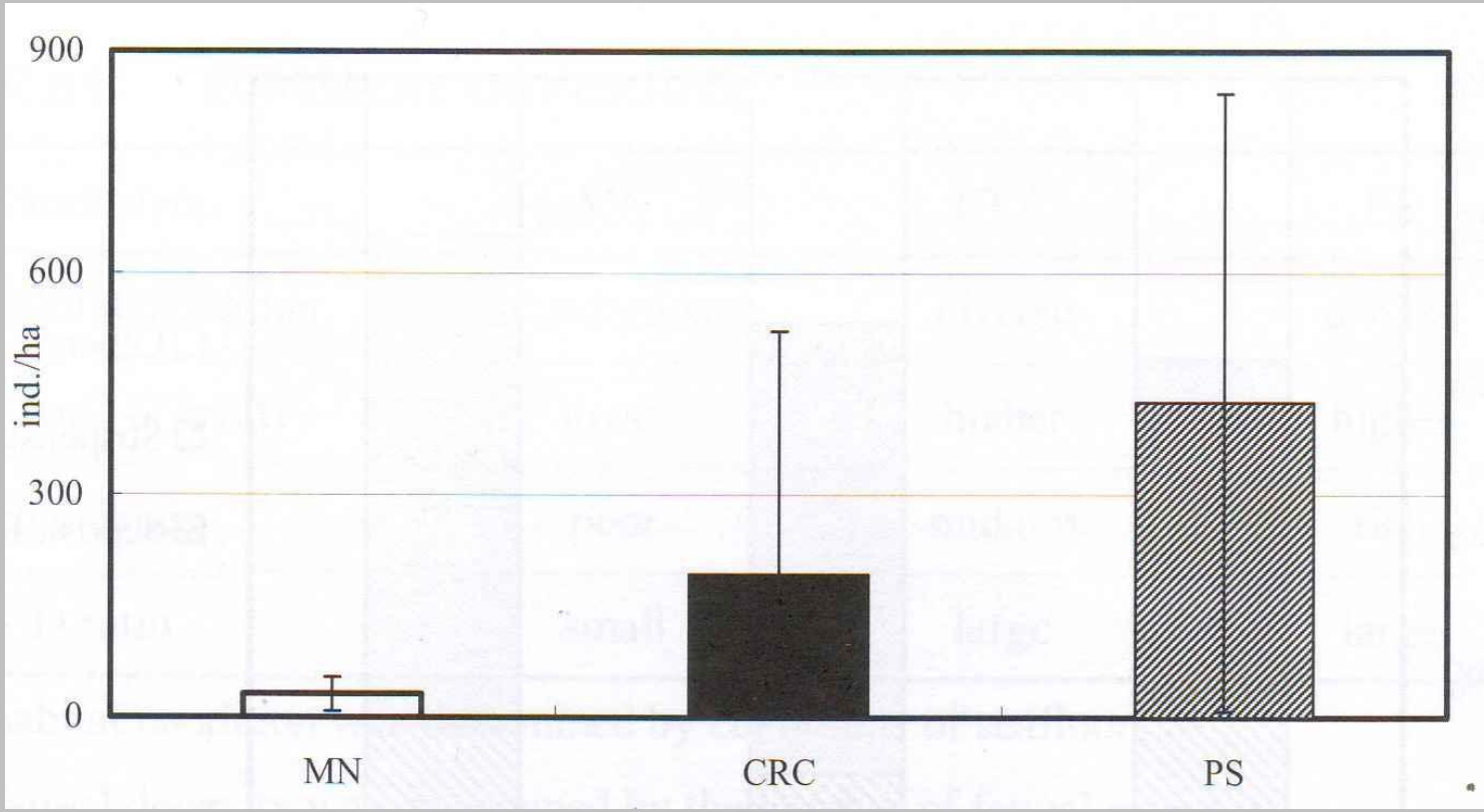

Hyphalaster


Anemone


Glass sponge & brisingids


Psychropotes longicauda
NOOINAUT

Low abundance



Comparison of epibenthic macrofauna in the SW Pacific

SOPAC-Japan surveys 1990s (Fukushima 2007)

Polychaete biodiversity

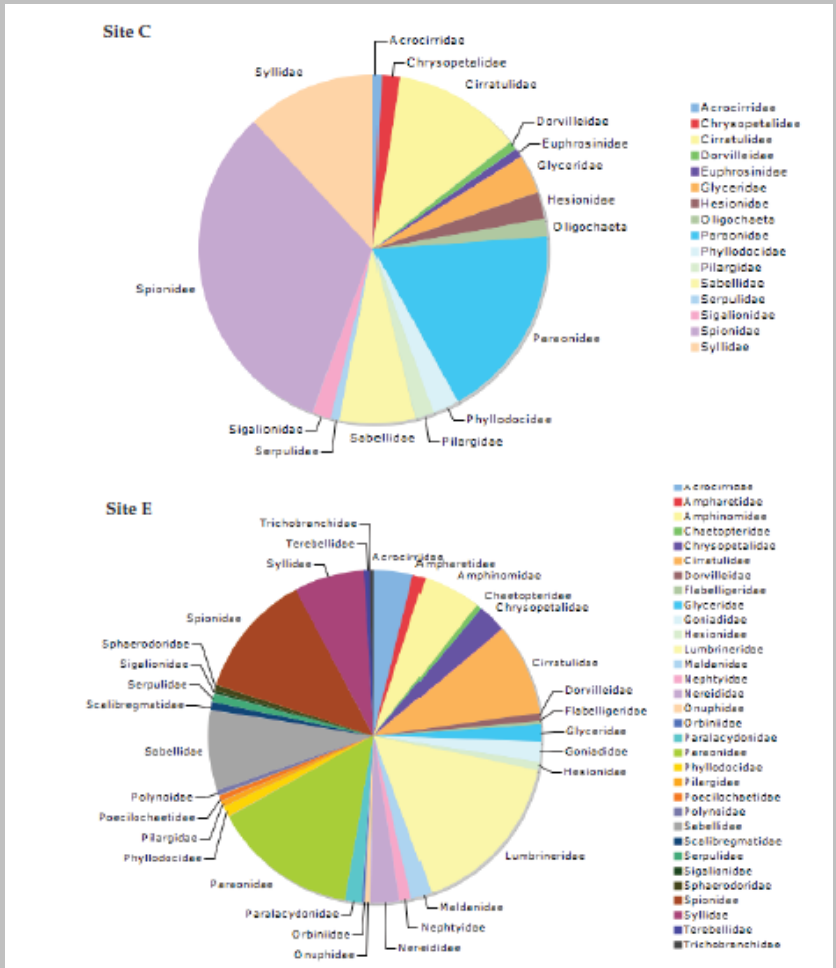
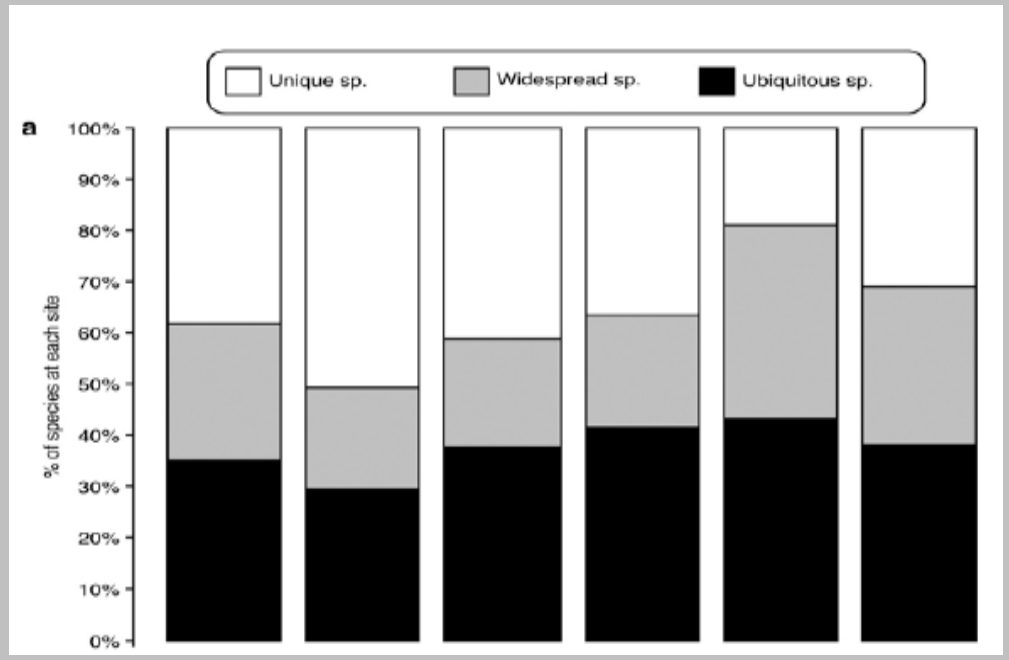


Figure 7. Percentage dominance of polychaete families at Sites C and E.

Smith-ISA 2008



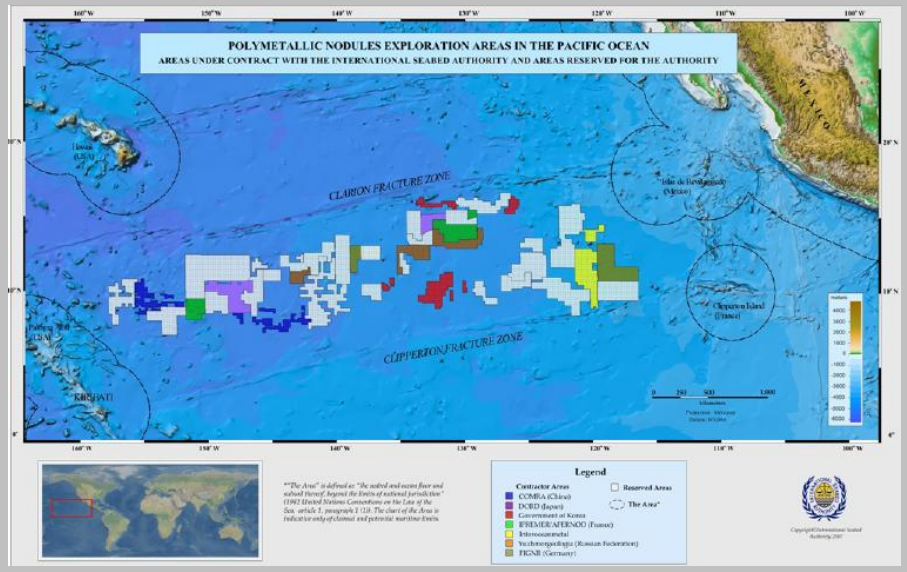
Smith et al. 2006

Possibly high levels of endemism (in terms of 100-1000 km spatial scale)

Many families (>30): a worm is not just a worm

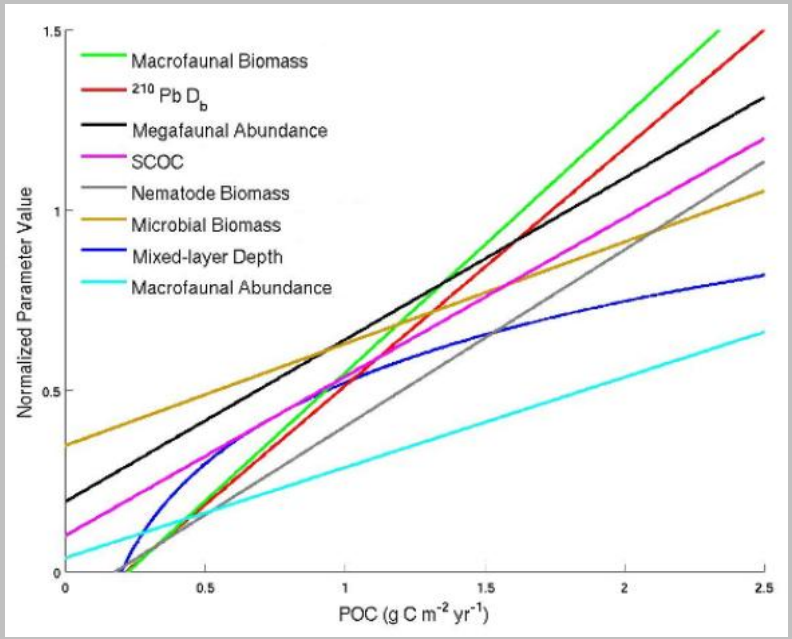
Understanding drivers key to successful conservation

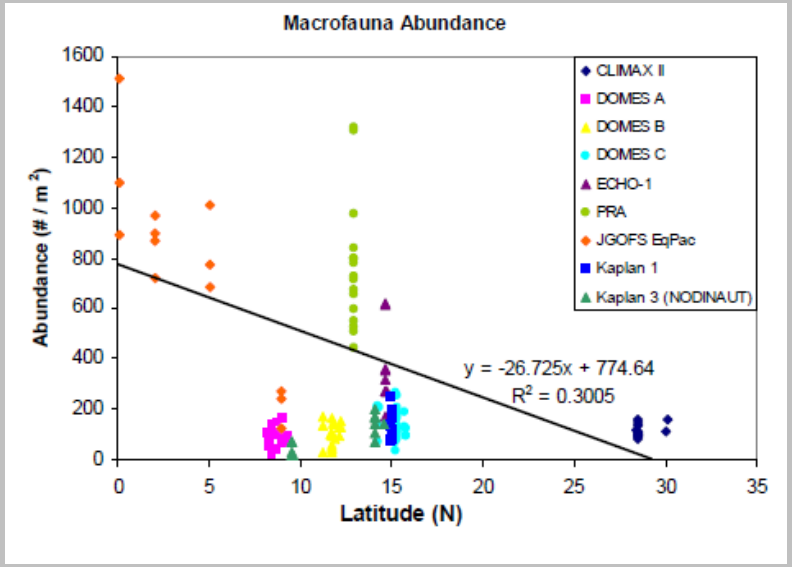
- Manganese nodules
  - specialised attached fauna (substrate)
  - depth-based faunal pool
  - food availability (flux gradients)
  - nodule size and shape
  - location (substrate mix)

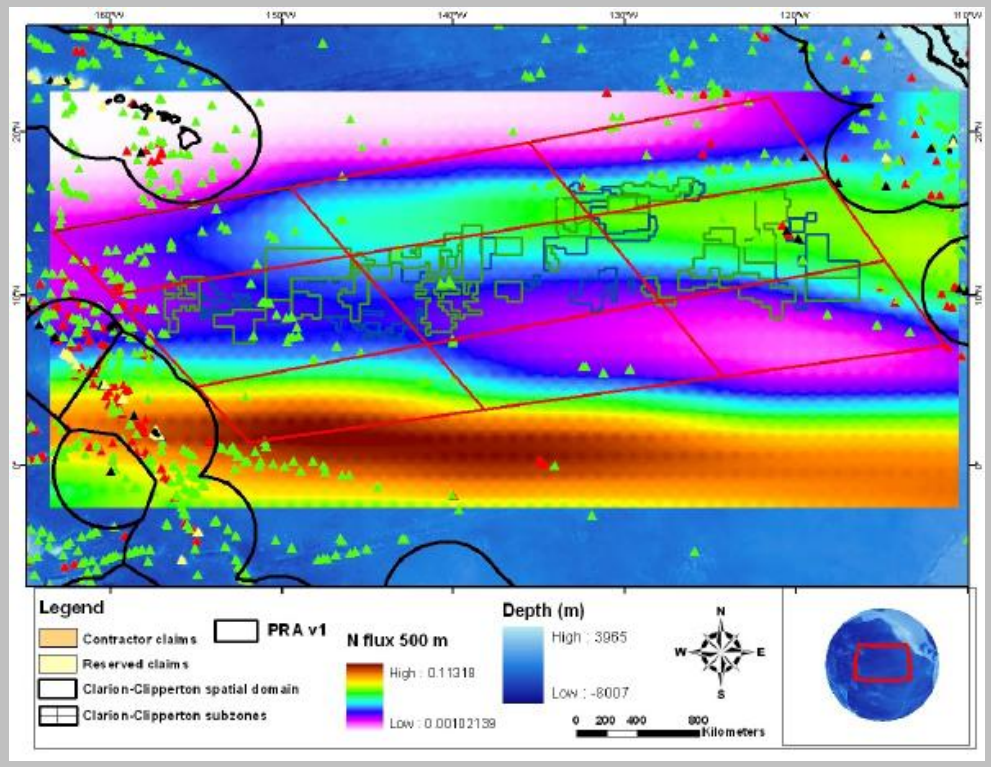


Decades of research in the CCZ, East Pacific

Effects of Productivity







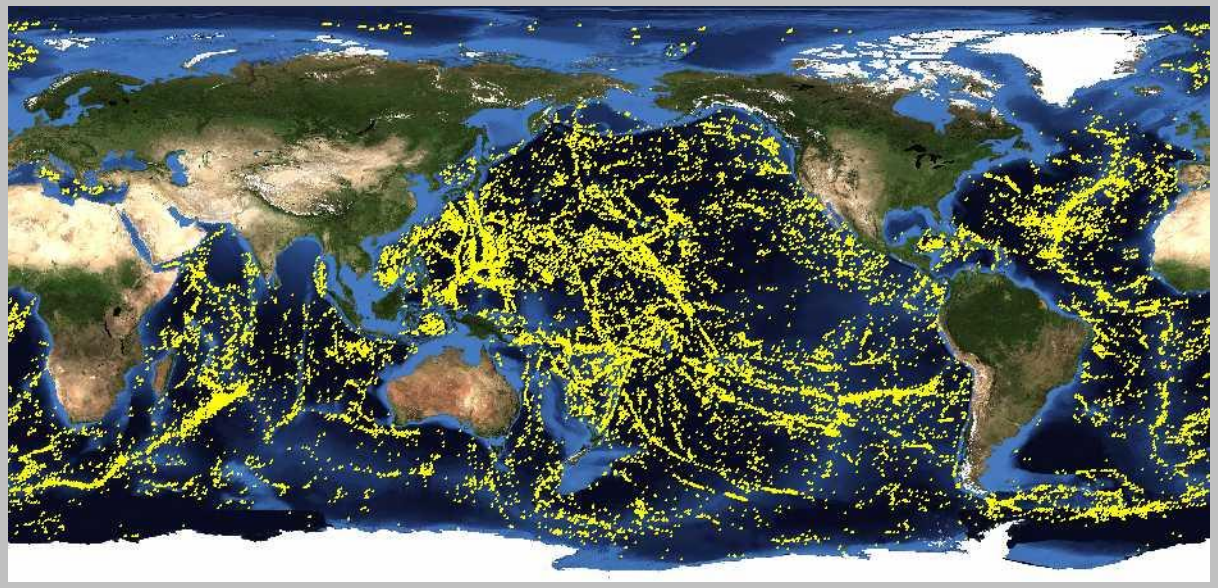
Even at great depth, gradients in the amount of “food” sinking to the seafloor has a major effect

Mincks & Smith 2006

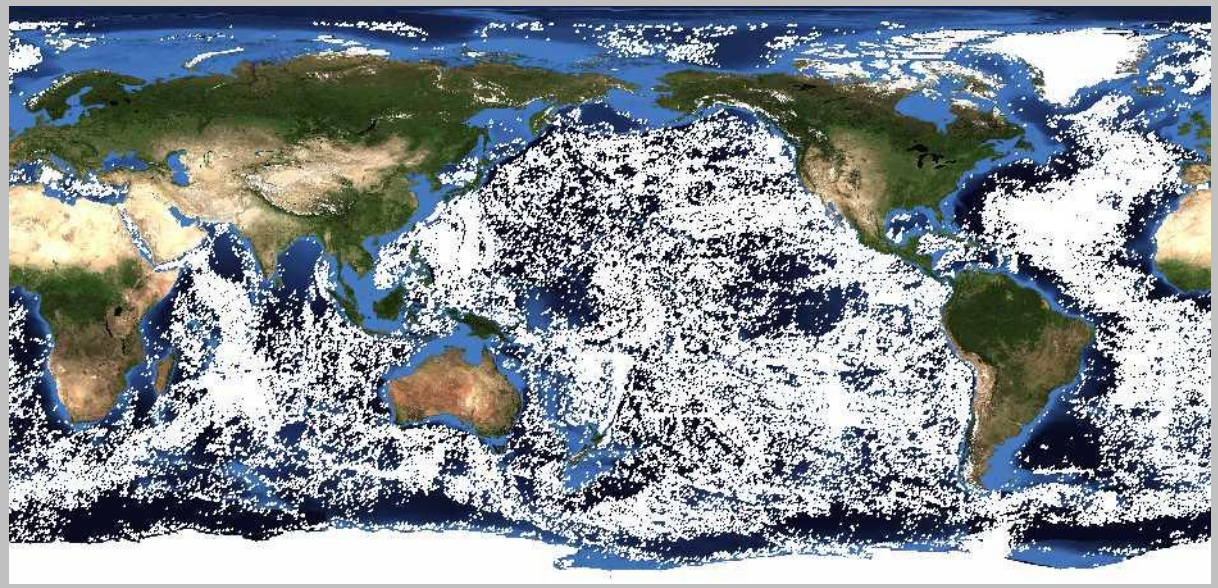
Ferromanganese Crust fauna

- 800-2500 m depth-seamounts/guyots
- Seafloor hard substrate (no sediment)
- Extensive areas (continuous, not small scale like nodules)
- Ability for high densities of sessile fauna characteristic of many deep-sea seamounts
- Seamounts are a very prominent topographic feature in the Pacific Ocean

Global estimates of seamounts



Seamounts
(>1000m high)
33,400



Knolls
(250-1000m)
138,400

Yesson et al.
2011

Central Pacific region

Large number of seamounts (excluding knolls) (14,300)
Large number of seamounts at Co-crust depths (4,100)
Cobalt-Rich Zone defined by orange polygon

Biological data sources

- Few published studies specifically on ferromanganese crust fauna
  - indicated low diversity, low abundance
  - Mostly from North Pacific seamounts, Cross Seamount in particular
- Global seamount database
  - SeamountsOnline
  - OBIS
  - About 20,000 records
  - However, very few from CRZ

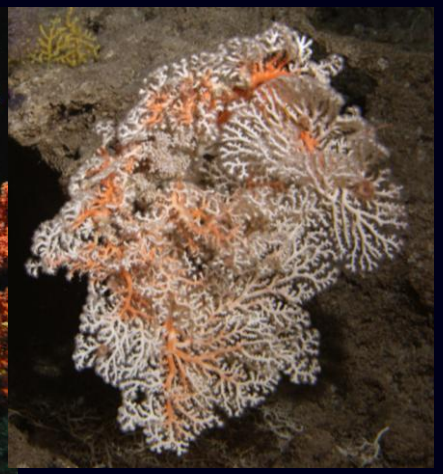
2006 ISA Workshop

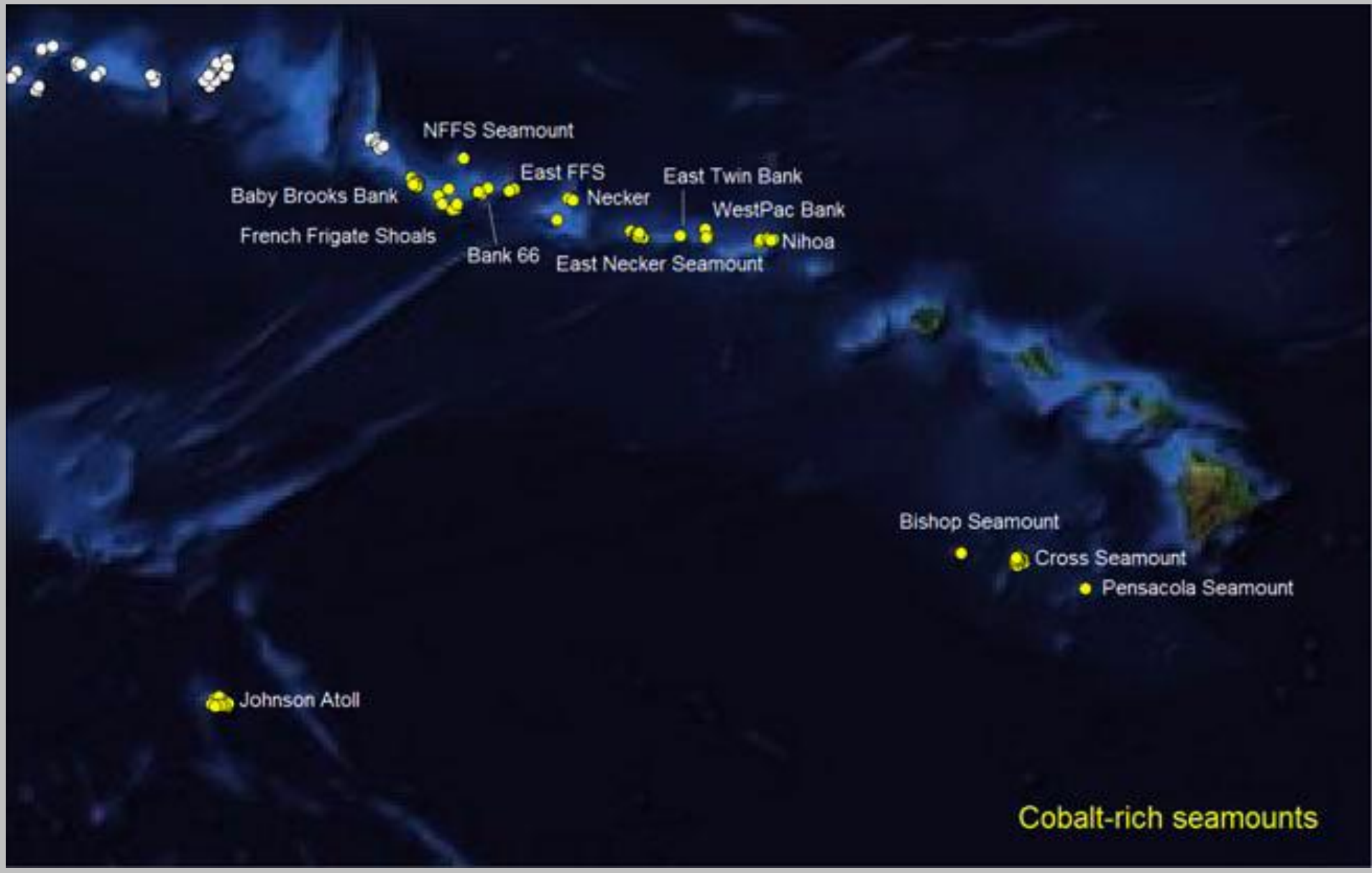
- ISA Workshop in association with CenSeam (DAWG) on Deep sea cobalt-rich ferromanganese crust deposits and distribution patterns of seamount fauna.
- Assessed data sets in Atlantic and Pacific
- Some preliminary analyses done (mainly SW Pacific, Nazca & Sala y Gomez chain)
- Not much data were available from the core areas of interest (few seamounts sampled well)

- But it was clear that more could potentially be done using data sets from Hawaii
- CenSeam proposal 2007 funded by ISA
- Subsequent analyses and report 2009

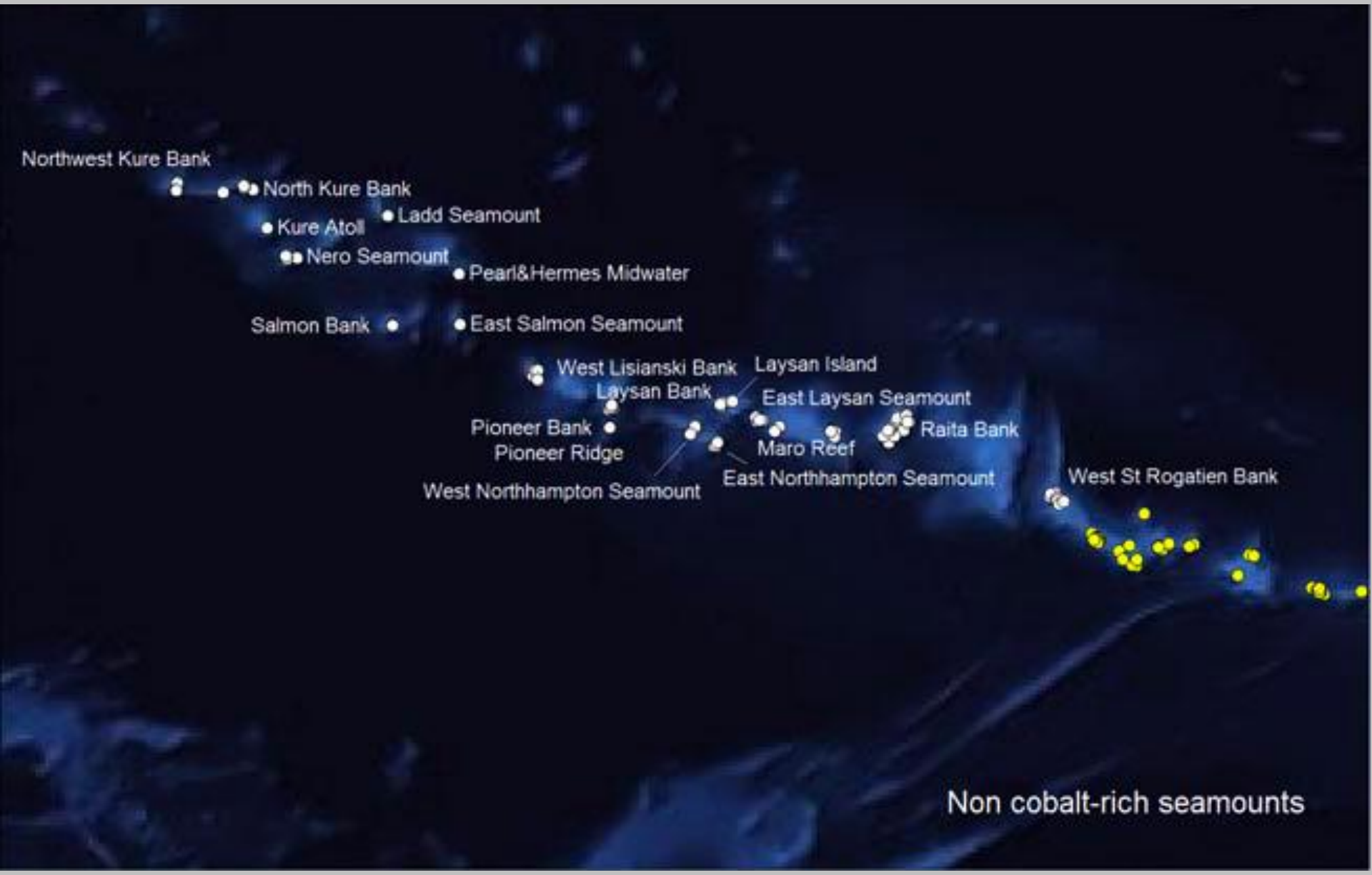
HURL Video Log Database

- Records of all fauna seen in submersible dives
- Pisces IV and V
- Subset of 13,175 records
- 200 -2000 m
- 16 sites, 83 dives
- Benthic invertebrates only
- 448 species





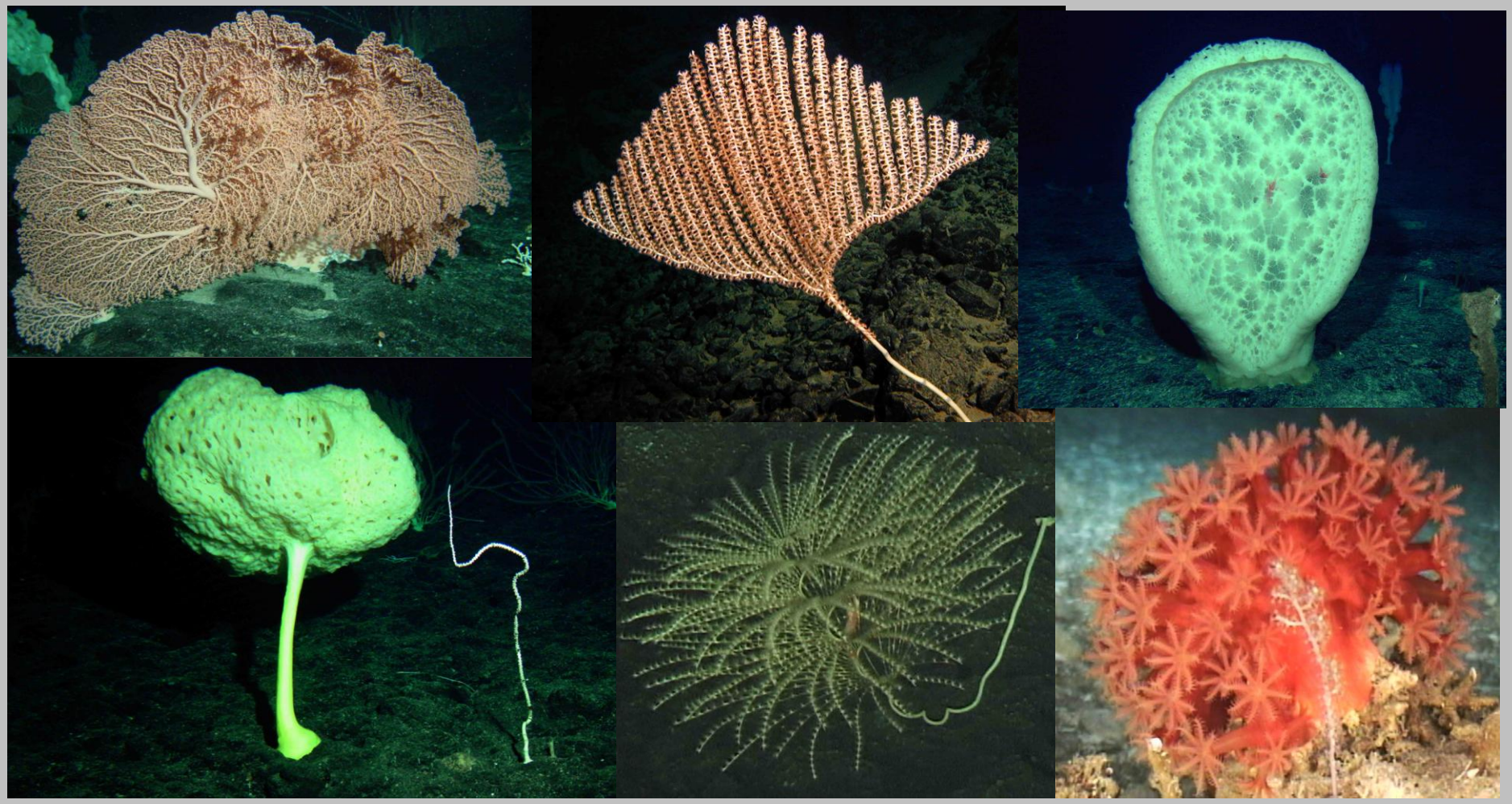
Cobalt-rich seamounts on Hawaiian seamount chain based on CRZ defined by Jim Hein



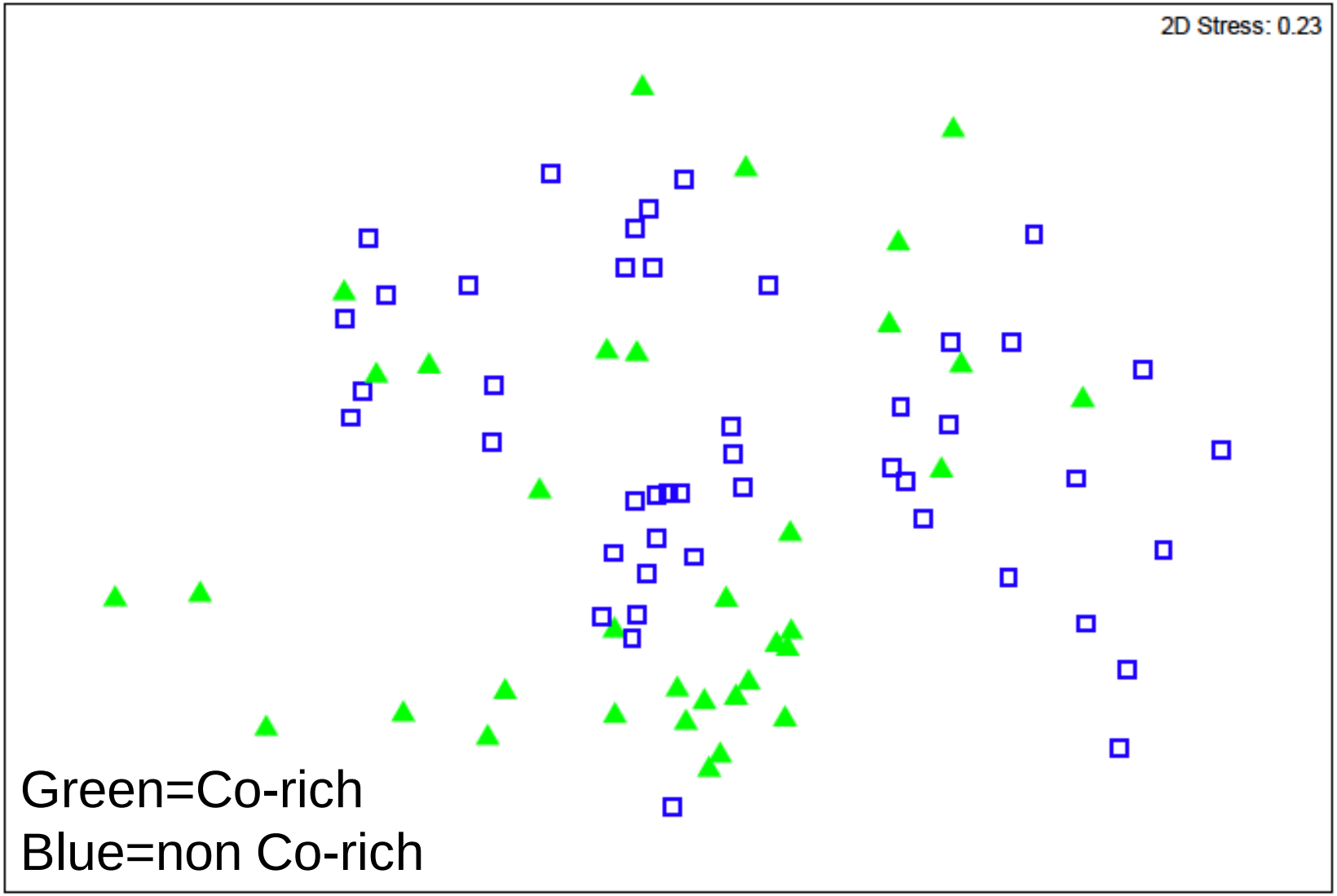
Further NW along Hawaiian seamount chain less cobalt-rich

Hard substrate fauna

- Corals and sponges dominant

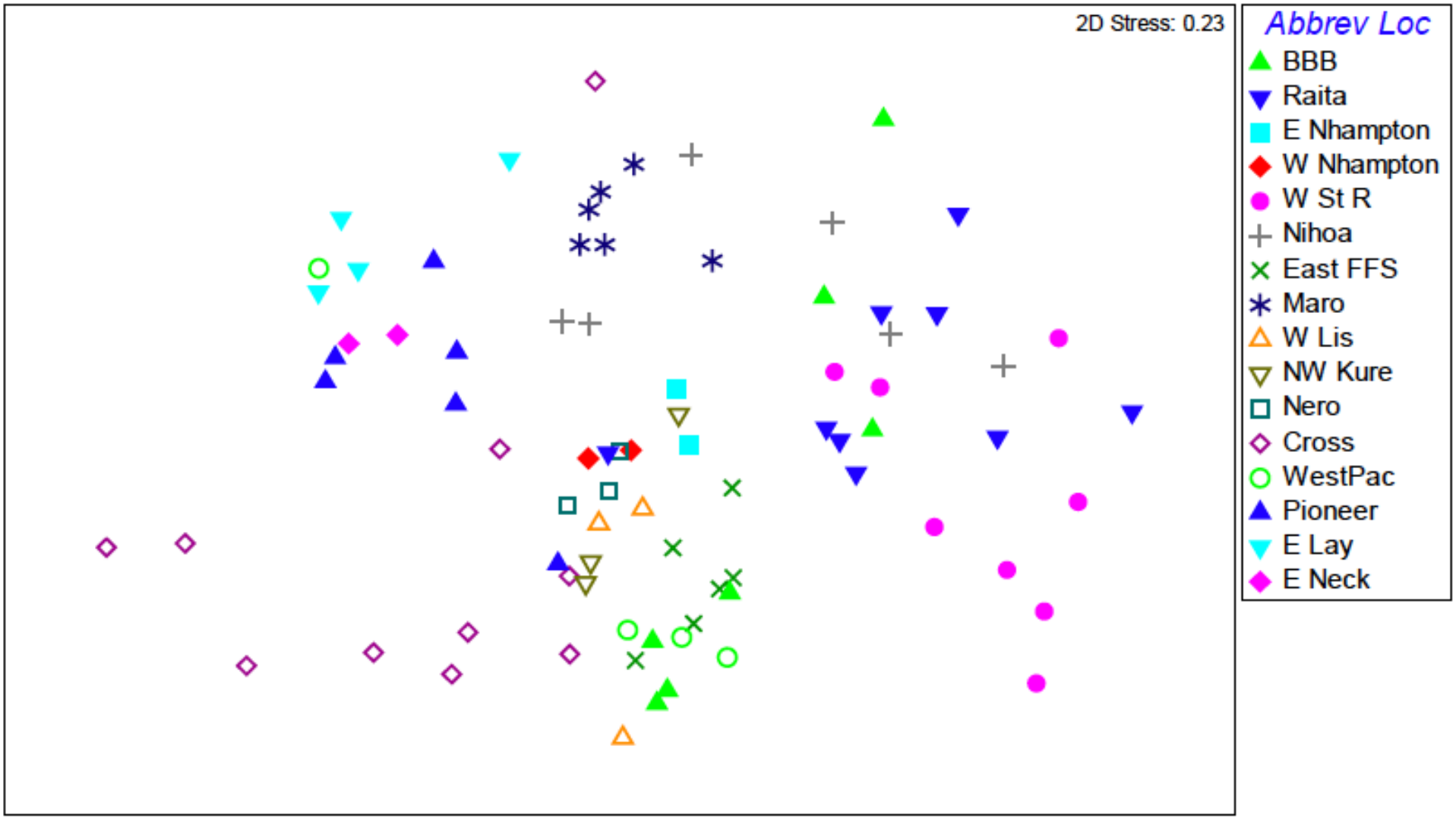


MDS of Cobalt zone

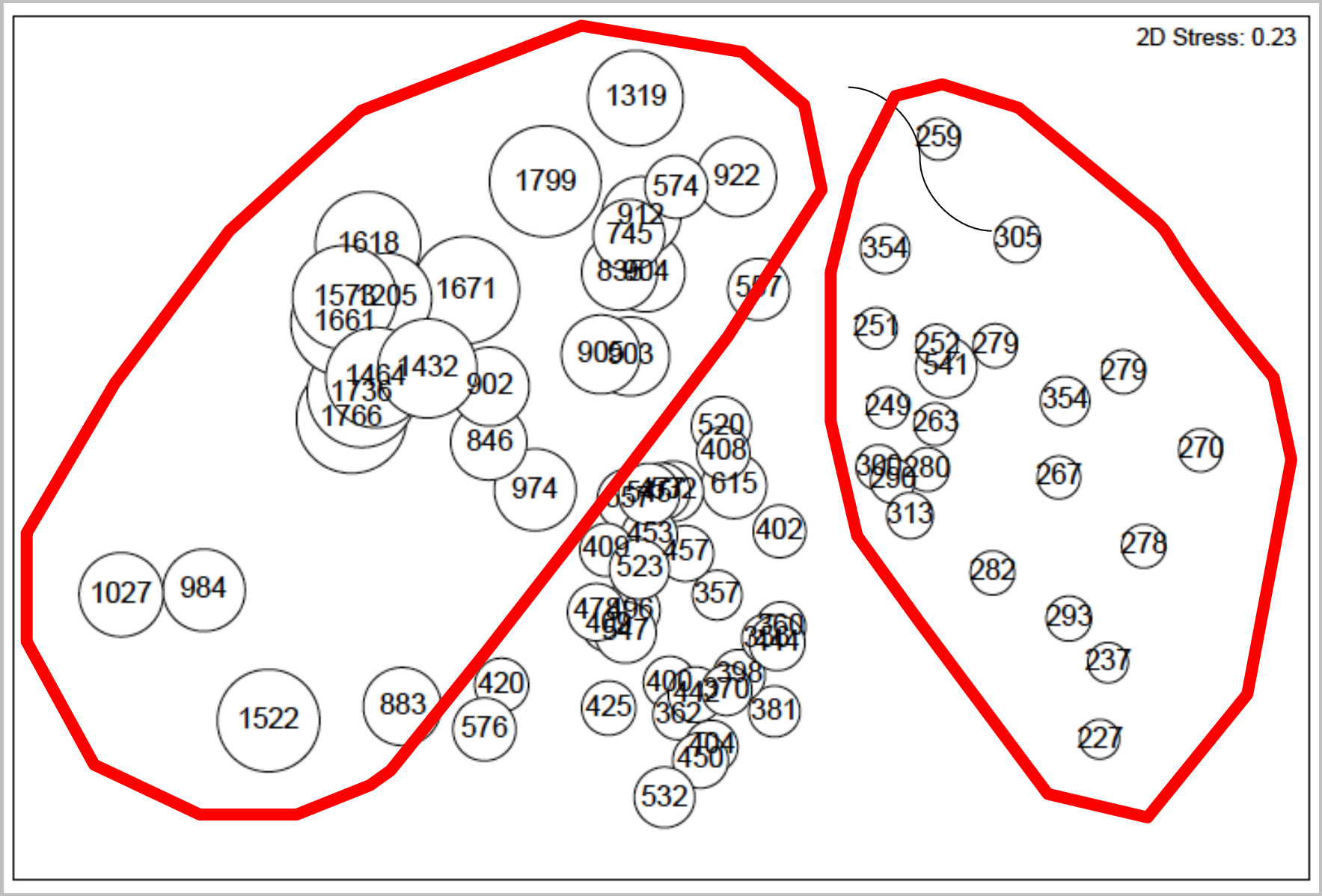


R =0.042, p=0.315

By Location

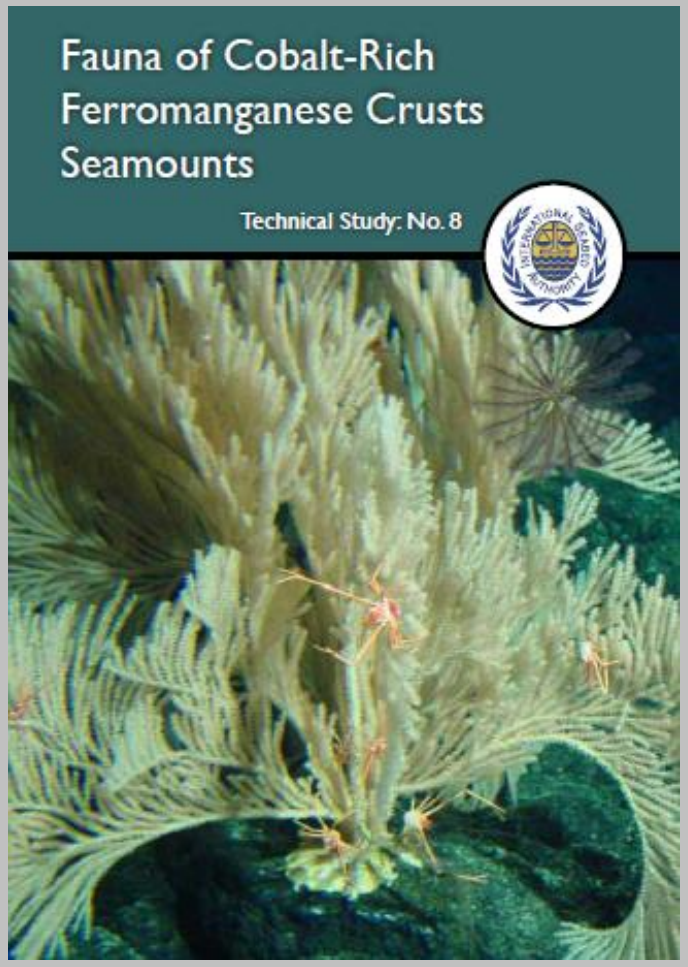

2D Stress: 0.23
Abbrev Loc
BBB
Raita
E Nhampton
W Nhampton
W St R
Nihoa
East FFS
Maro
W Lis
NW Kure
Nero
Cross
WestPac
Pioneer
E Lay
E Neck

Mean Depth of Dive



2009 Conclusions

- Distribution of benthic communities is not related to cobalt-rich crust
- Strong correlation to depth
- Location also important



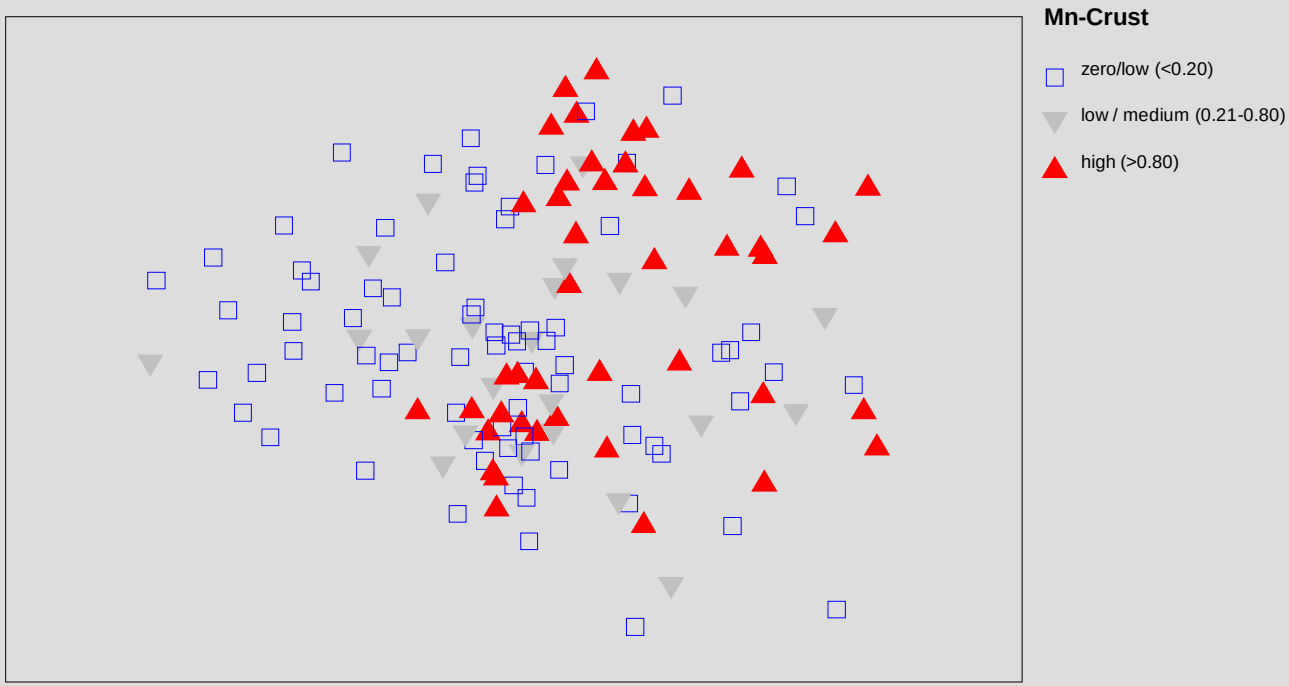
Clark, M., C. Kelley, A. Baco, A. Rowden. (2011) Fauna of Cobalt-rich ferromanganese crust seamounts. **ISA Technical Study No. 8**

2011 Workshop

- More image data available from HURL
- Substrate information included
- Faunal density-abundance measures
- Analyses ongoing
- Preliminary results:
  - Some similar
  - Some differ

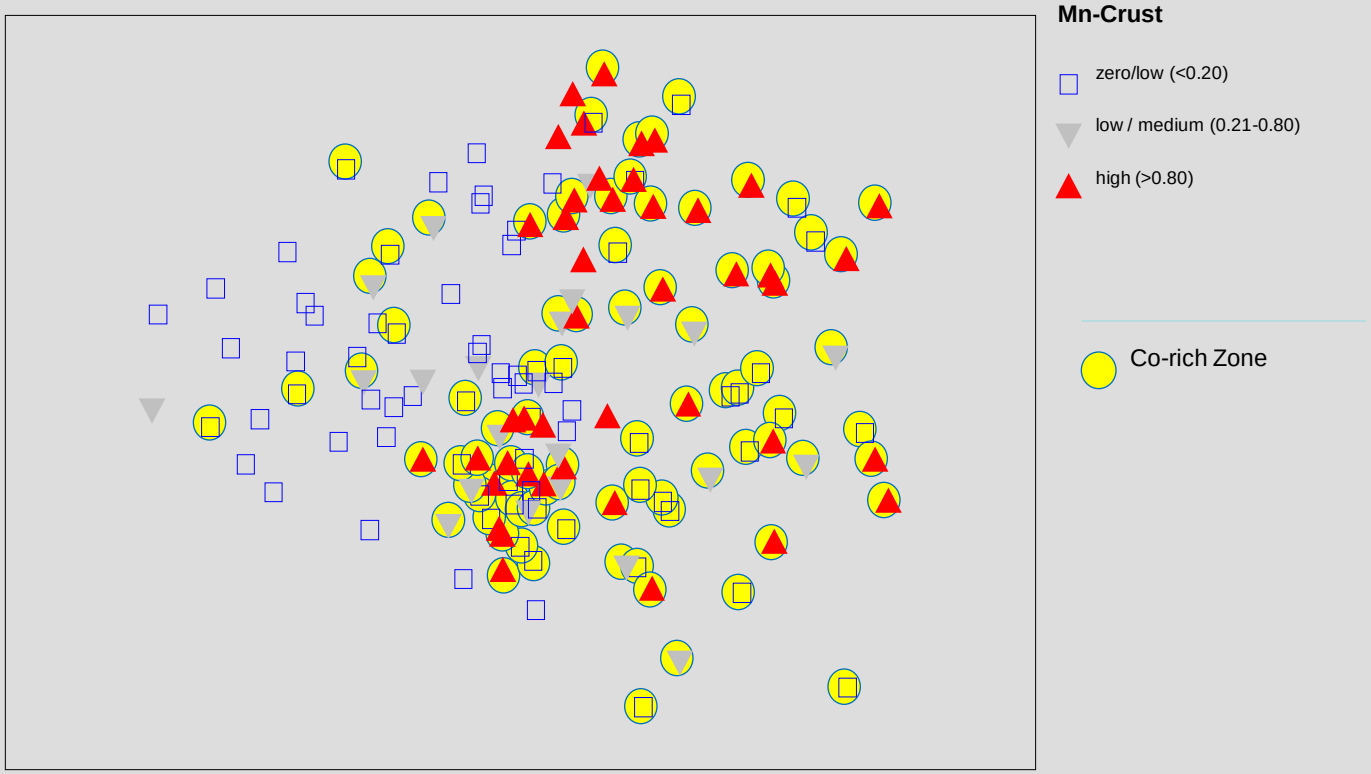
Preliminary results

- Depth is a key driver of community composition
- Substrate is important driver of community composition
- **Mn-crust does influence community composition**



Preliminary results (2)

- The effect of the Hein CRZ was also significant. (PERMANOVA, CRZ nested within depth)



Implications for Co-crust Management

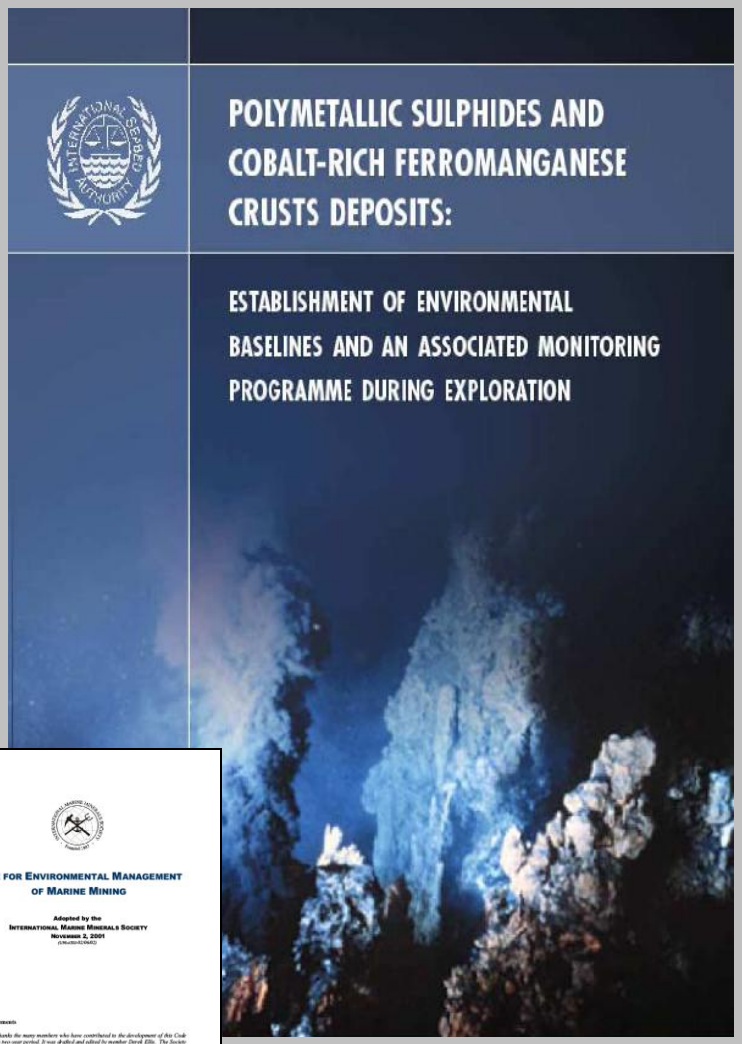
- Co-rich crust seamounts may have different fauna from non cobalt-rich crust
- Implies control-exploitation sites need to be chosen carefully
- Depth is a critical consideration in any design of conservation areas
- Results are preliminary, hope ISA will support further work
- Knowledge of biodiversity in CRZ poor, and much basic data needed with exploration

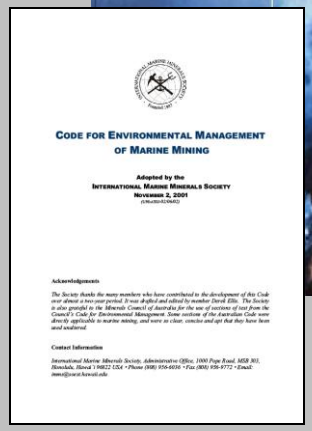
Environmental considerations

- Faunas of manganese nodule and cobalt-rich ferromanganese crusts are very different
- Hence need to consider impacts separately, especially given the shallower crust operation
- Mining of either resource is not “sustainable” in terms of localised impact
- So the management objective is not to “preserve” but to balance exploitation and conservation
- Spatial management is the likely solution, based on good science to inform about impacts and assessment of risk.

Existing guidance

- Many countries have developing environmental policies and guidelines
- But need more than just “do an EIA”
- Standards and guidelines
- ISA reports
  - environmental guidelines for polymetallic nodules
  - guidelines for polymetallic sulphides and cobalt-rich crusts
- International Marine Minerals Society code
- InterRidge “code of conduct” for scientific operations also





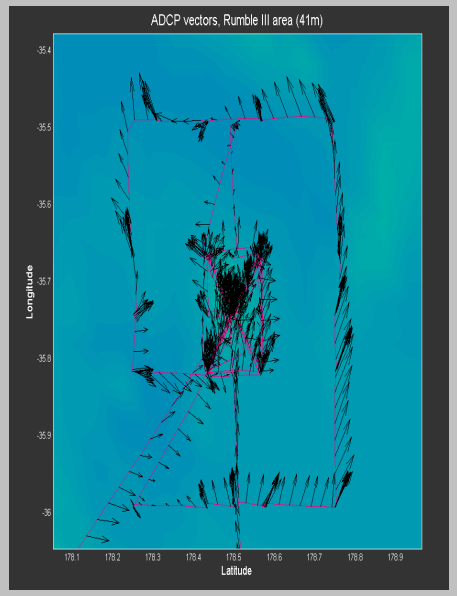
Key impacts to consider

- **Potential benthic impacts**
  - direct physical impact of mining/sampling gear
  - smothering/burying of animals by sediment
  - clogging of suspension feeders
  - toxic effects with metal release
  - loss of essential habitat (spawning/nursery grounds etc)
- **Potential water column impacts**
  - plankton/mesopelagic fish mortality
  - bioaccumulation of toxic metals though food chain
  - sediment plume through water column
  - potential oxygen depletion
  - effects on deep-diving marine mammals
- **Potential surface impacts**
  - reduction in primary production through sediment plume shading
  - effects on behaviour of surface/deep-diving mammals and birds through changes in water clarity

Key biological research elements (1)

- **Physical topography**
  - Co-crust associated with large seamounts
  - Variable habitat on different scales
  - mining sites likely to be extensive
  - substrate type (sediment disturbance)

- **Oceanography**
  - current flows, stratified through water column
  - seamount effects important
  - important for spatial scale of animal distribution and dispersal, as well as any mining impacts
  - strong linkage with chemical composition/toxic release, and turbidity



Key biological research elements (2)

- **Benthic biodiversity**
  - mega-epifauna down to meiofauna, infauna
  - determine species distribution & abundance
  - stratification by topography/habitat can be small scale, but regional biodiversity setting can be large scale
  - of special note are sessile animals, low dispersal capability, slow growth rates, restricted distribution. i.e. high vulnerability to impact

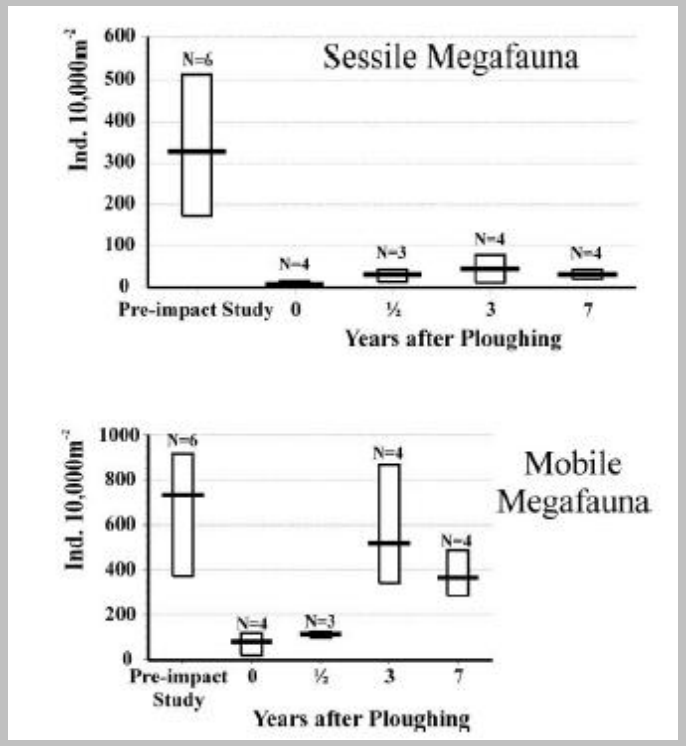
- **Pelagic biodiversity**
  - less developed science than benthic
  - maybe of less immediate concern

Spatial management issues

- Forget about community “recovery” or resilience
- Need to protect areas from any disturbance
- Areas may need to be large (40% of habitat area is possibly required)
- Entire seamount management may be necessary (rather than sectors)
- Physical disturbance is “easy” to understand, but indirect effects more difficult to measure
- Connectivity of habitat critical

Recovery is slow...very slow

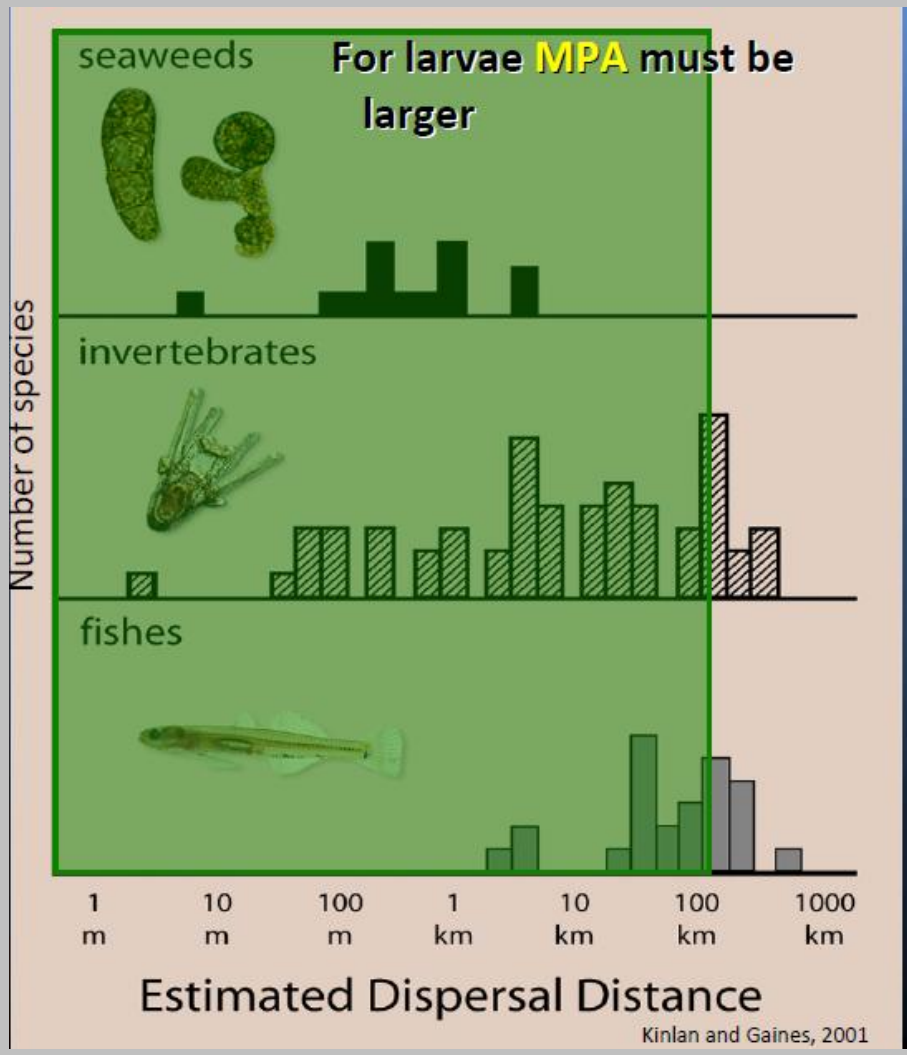
Dredge track after 26 years...(CCZ)



Bluhm 2001

Experimental response-the DISCOL project (Peru Basin)

Connectivity-larval dispersal

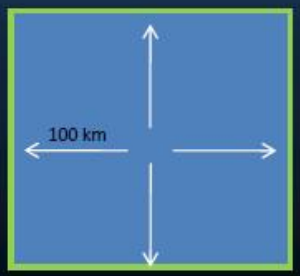


For sustainable populations MPA size must be 2X average dispersal distance of larvae

Most marine benthos have mean larval dispersal distances <100 km

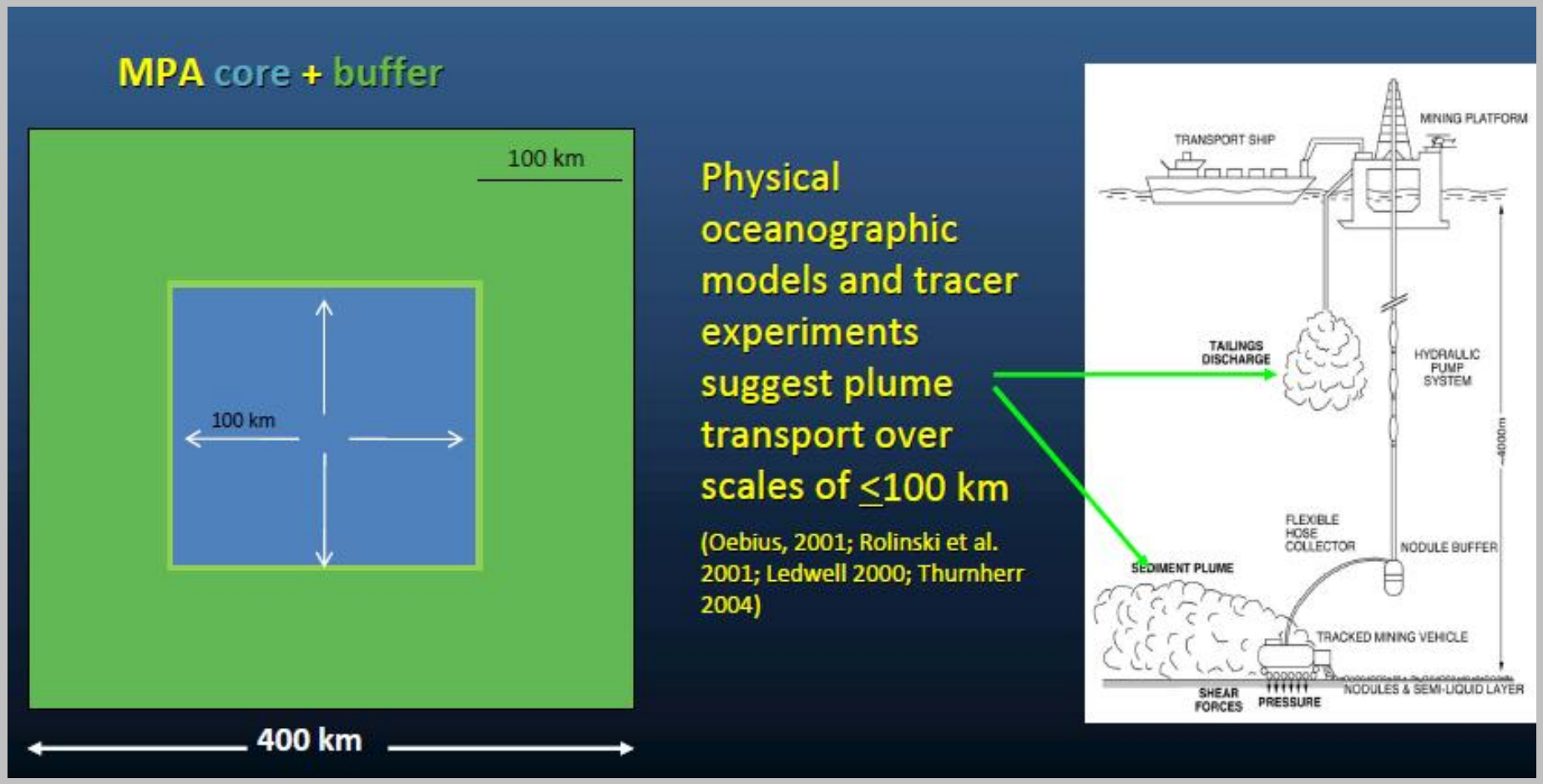
Recommended MPA core size -

200 x 200 km



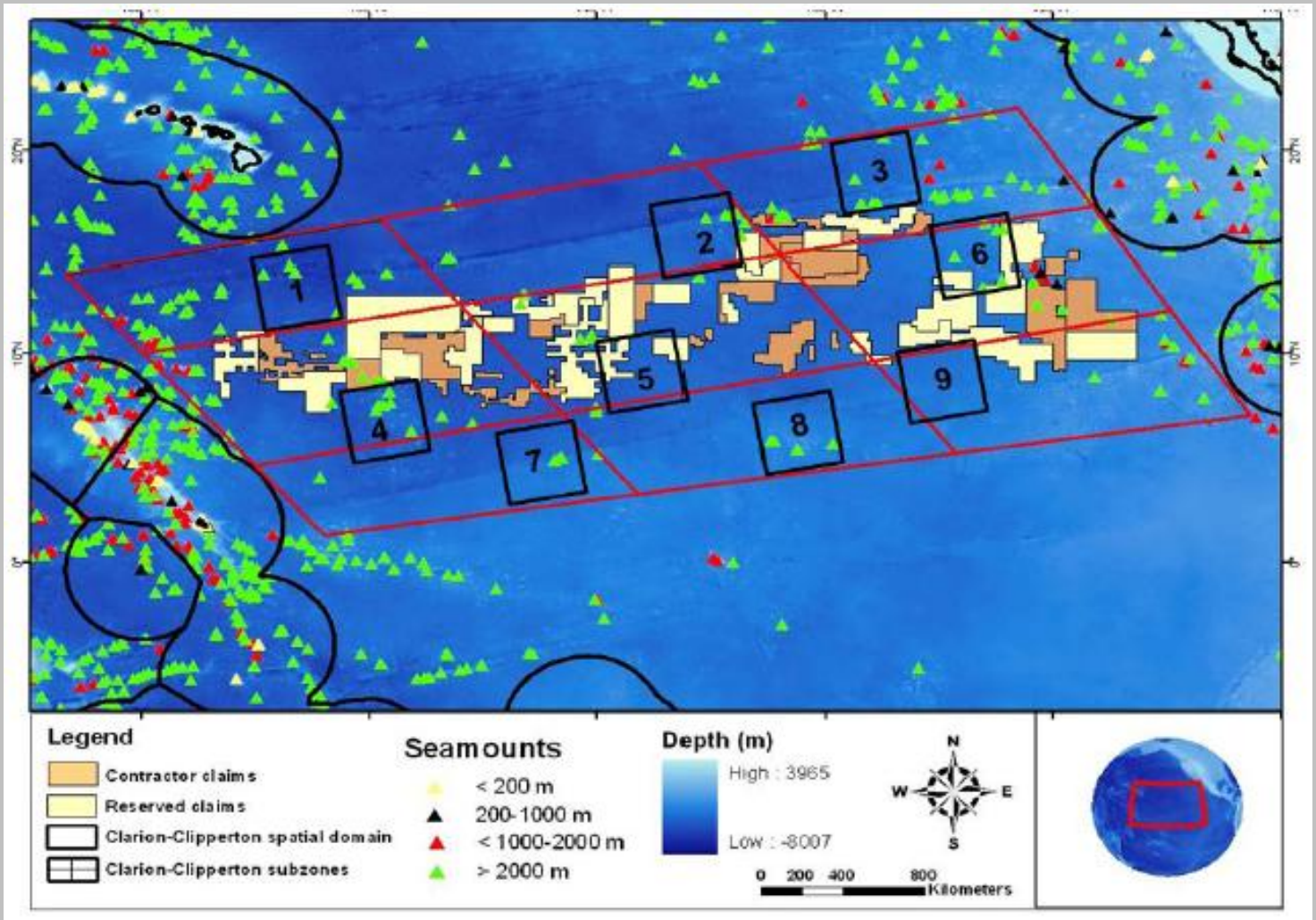
Need to allow for dispersal WITHIN a large MPA, or BETWEEN several smaller units

Sediment plume



Scale of up to 100 km for plume dispersal/settlement
Omni-directional-no clear “downstream” direction
Need for buffer to protect from mining on boundary

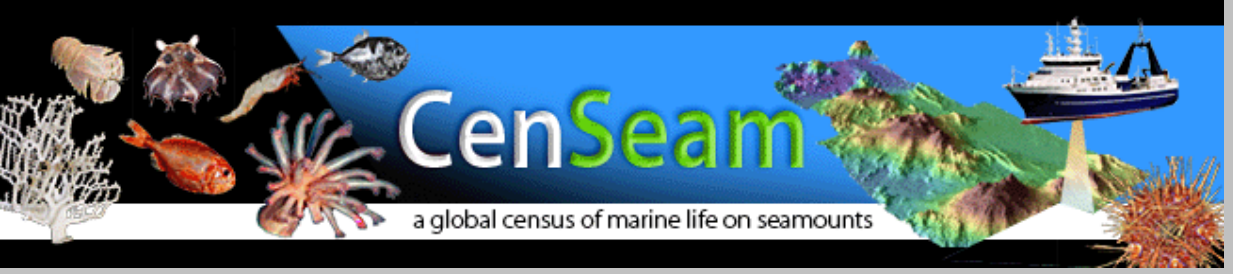
CCZ network of “protected areas”



ISBA/14/LTC/2

Final slide

- Scientific knowledge is limited in deep-sea ferromanganese nodule and crust environments, but sufficient to inform the first steps in developing exploration activities, and avoid undue risk to ecosystems based on inadequate information
- Successful management of deep-sea mining is reliant on a cooperative and integrated approach between all “stakeholders”
  - multidisciplinary science is needed, and involve collaboration between mining and govt agencies
  - the wide ranging attendance here with mining companies, policy makers, lawyers, managers, economists, scientists, conservation agencies, NGOs, societal representatives...is a great start



NIWA
Taihoro Nukurangi

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- ISA for funding workshops and publications
- SOPAC for funding participation

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