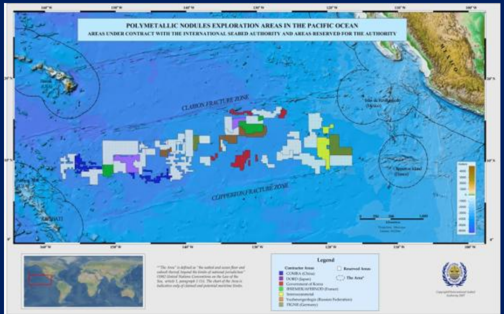
Areas of Particular Environmental Interest (or "Protected Areas") for Ecosystem Based Management of the Clarion-Clipperton Zone: Rationale and Recommendations to the International Seabed Authority



From

Craig R. Smith**, Steven Gaines **, Les Watling**, Alan Friedlander*, Charles Morgan*, Andreas Thurnherr*, Sarah Mincks*, Alex Rogers **, Malcolm Clark**, Amy Baco-Taylor*, Angelo Bernardino*, Fabio De Leo*, Pierre Dutrieux*, Alison Rieser**, Jack Kittinger*, Jacqueline Padilla-Gamino*, Rebecca Prescott* and Pavica Srsen*

20 Expert participants in the workshop to *Design Marine Protected Areas for Seamounts and the Abyssal Nodule Province in Pacific High Seas,* Oct 23-26, 2007, University of Hawaii

* Marine Geologist
*Conservation Ecologists
*Biological Oceanographers
*Physical Oceanographers
*Pew Fellows in Marine Conservation
* Fisheries Biologist
* International Lawyer
11 institutions, 8 nationalities

Sponsors: Pew Foundation for Marine Conservation, Kaplan Fund, Sloan Foundation (CoML), International Seabed Authority, University of Hawaii

Marine protected areas are used widely in ecosystem-based environmental management plans to protect –

- Biodiversity
- Ecosystem functions and services
- Sustainability of resources

In the presence of fishing, oil drilling, mining, and other human impacts.

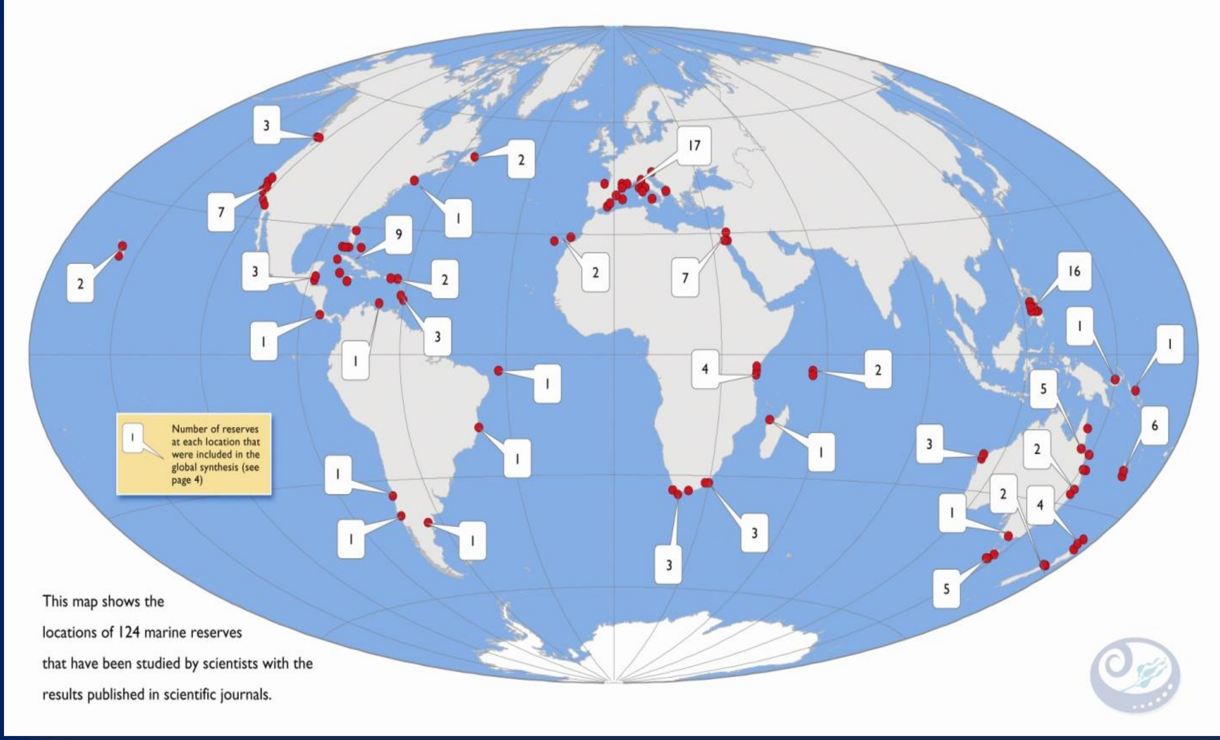
Science of MPA design and application is well developed –

It is critically important to apply this knowledge to extractive activities in the deep sea in *The Area*,

E.g., NODULE MINING

Before –

- Extractive activities begin
- Coverage by claims excludes effective siting of protected areas



Workshop outcome:

- Recommend dividing Clarion-Clippteron Zone into 9 ecological subregions

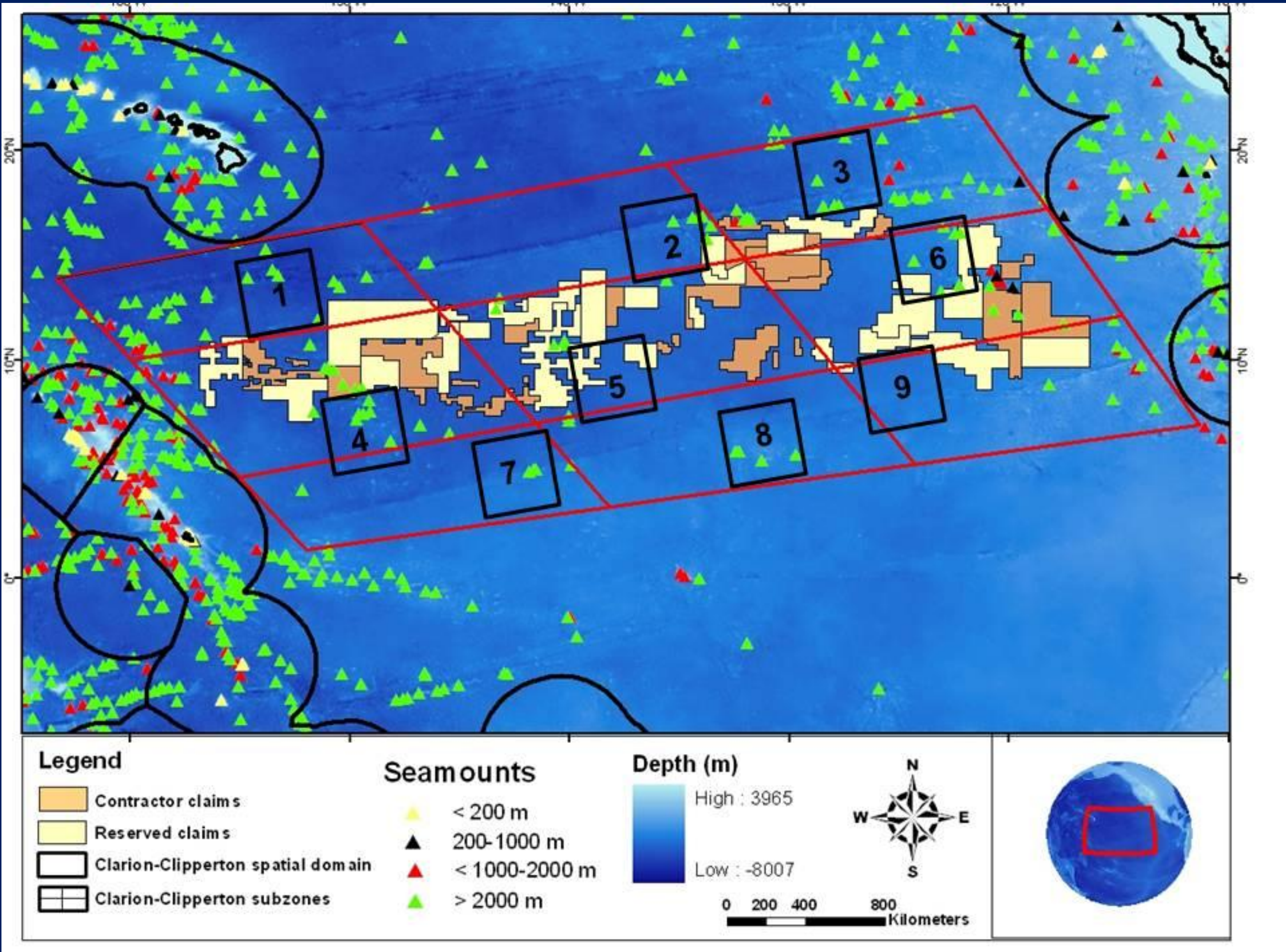
  - Each with one 400 km x 400 km Area of Particular Environmental Interest (APEI), i.e., protected area

  - APEIs integrated into current exploration mining claim framework

  - ~30% of management area protected (~optimizes conservation benefits)

Locations of APEIs within subregions is flexible –

Allowing adaptive management



How did we arrive at these recommendations?

A) Started from set of reasonable assumptions concerning mining impacts and CCZ ecology and biogeography –

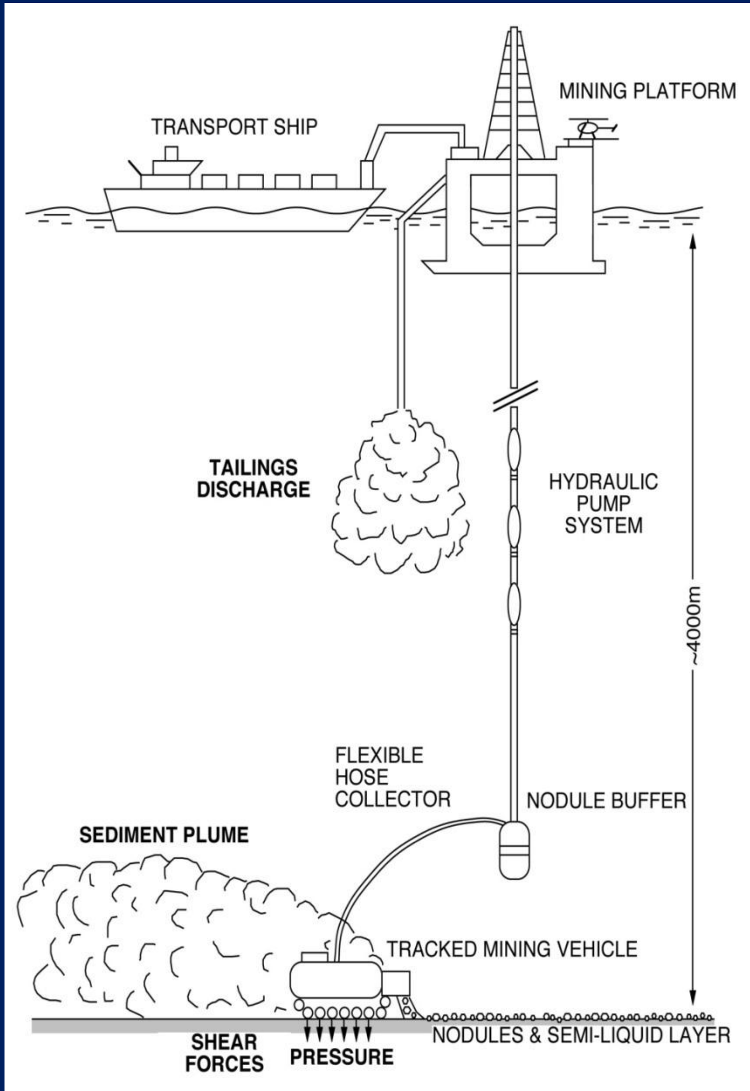
B) Then applied 8 guidelines and rationales from the ISA and conservation biology

A) ASSUMPTIONS:

Mining will affect large areas of seafloor due to –

- direct disturbance (300-600 km^2 y^{-1})

- sediment plumes (10's of km from site)

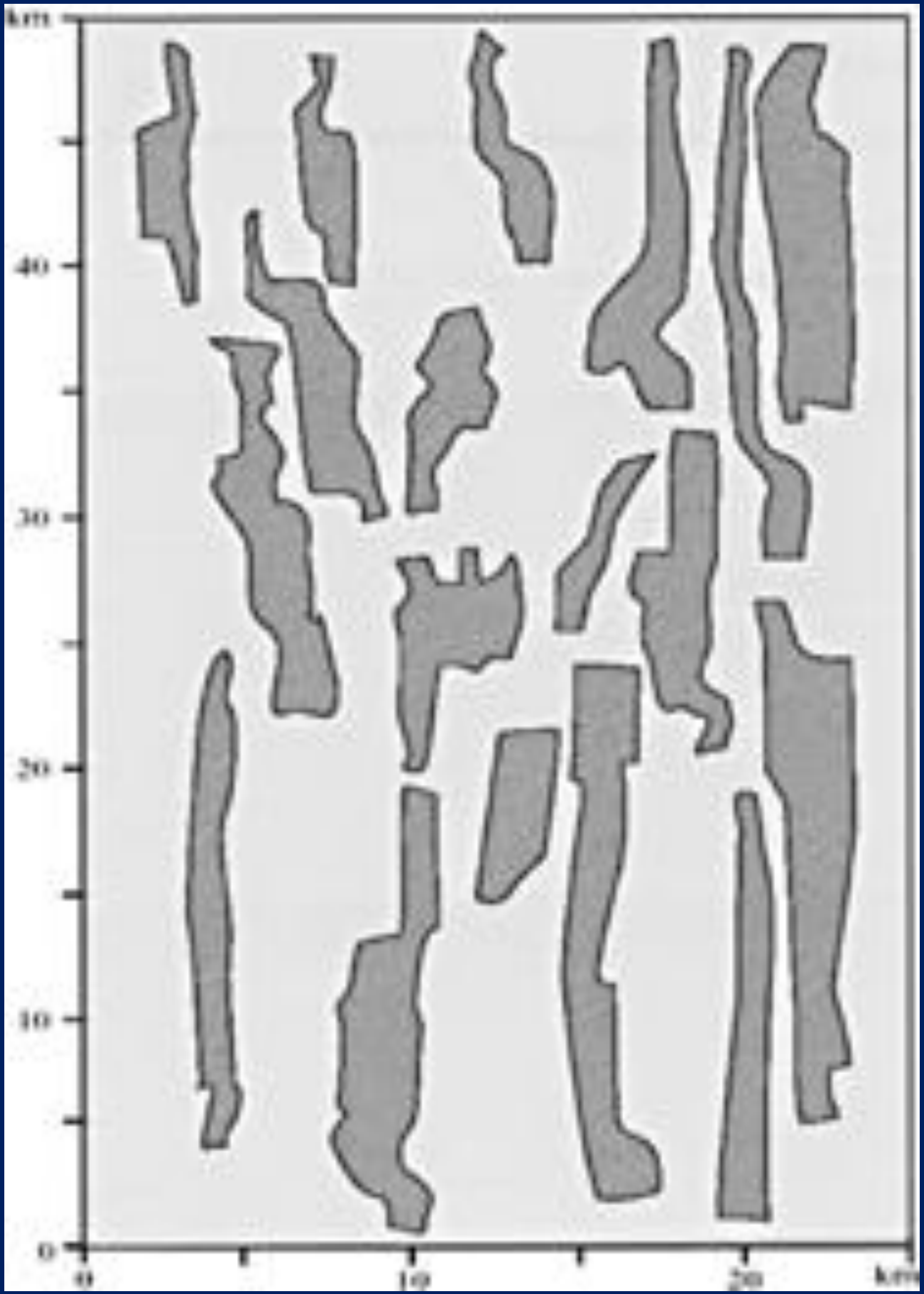


Oebius et al. (2001)

Heterogeneous distribution of nodules will be reflected in mining patterns –

Over 15 yr mining operation, anywhere in a claim area can mined and impacted –

Thus – the entire area of each 75,000 km^2 claim must be considered to be potentially impacted.



Size and relative position of potential mining blocks in the French pioneer area, N. Pacific Ocean (modified from Lenoble 1999).

Benthic ecosystem recovery will be slow – requiring

- Decades for soft sediment community structure and function

Example of slow recovery of habitat structure in CCZ -

OMCO Testing mining Track in CCZ

~1.5 m wide

~10 cm deep

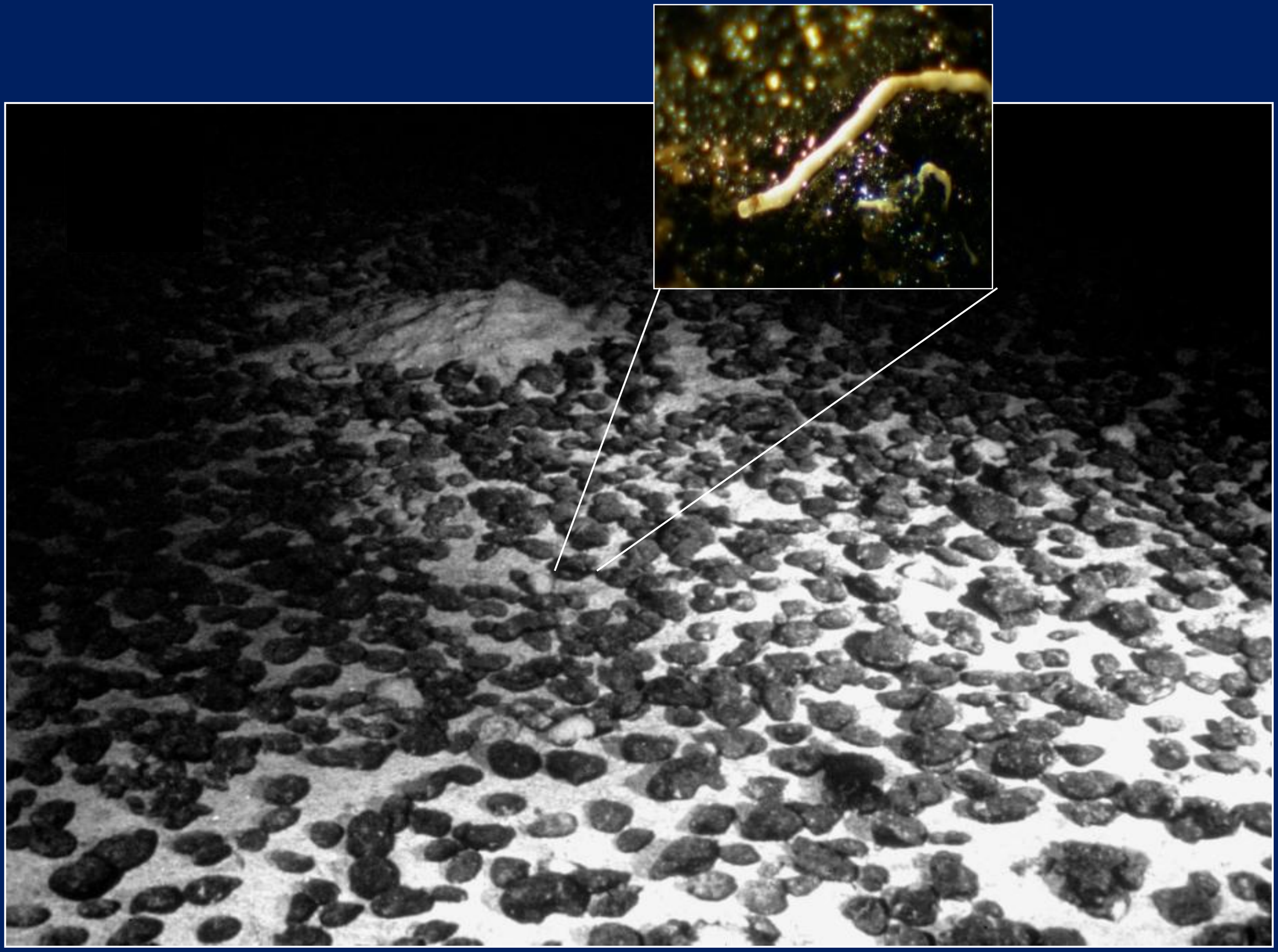
Appears very fresh.

How old is it?

26 years!

Recovery for nodule specializing fauna?

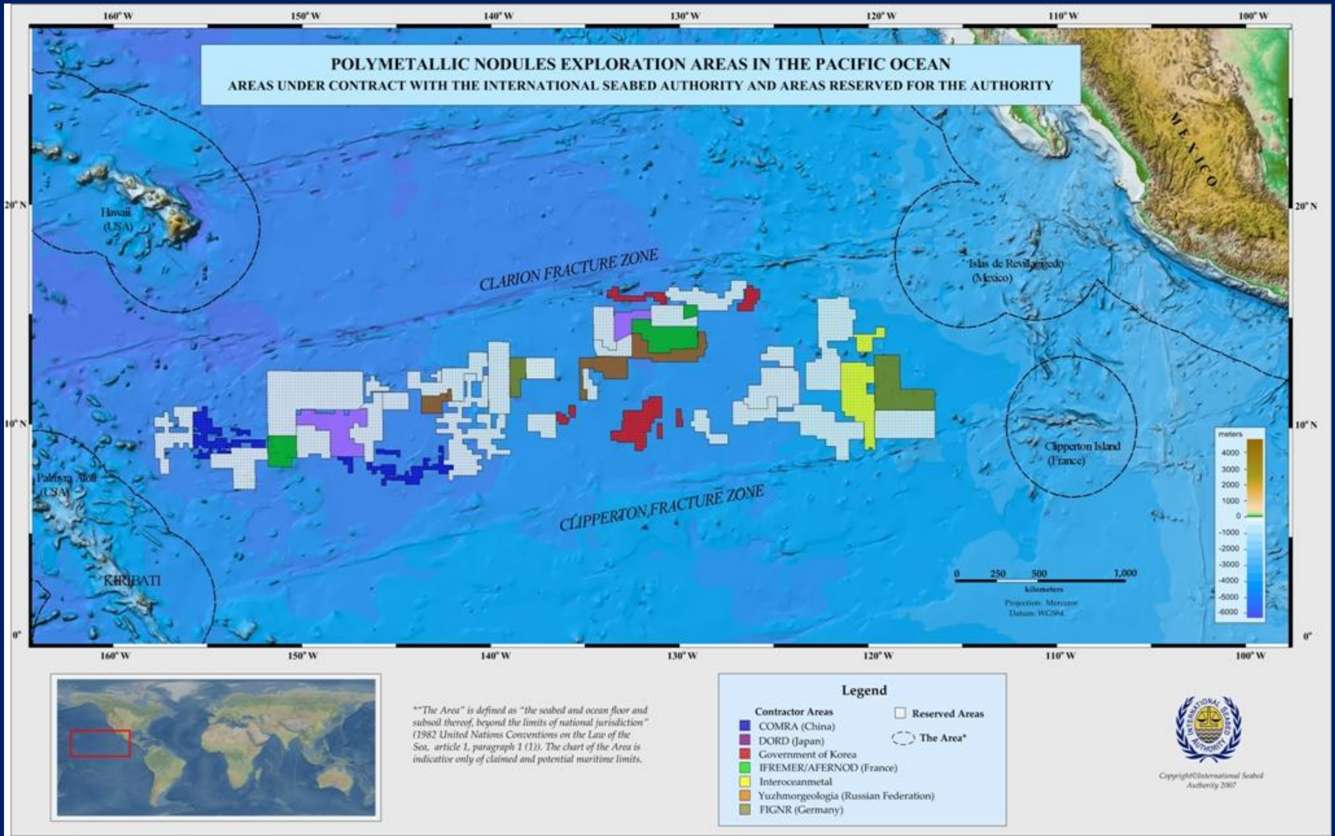
Millennia - Because nodules grow back at a few mm per million years



Conclusion:

Over time scales of benthic ecosystem recovery (decades - millennia) all current mining claims will potentially be impacted by mining, i.e. –

Environmental impacts of mining will be simultaneous and widespread across the CCZ, requiring that conservation be managed across the region as a whole.



B) Guidelines and rationales for designing protected areas (APEIs) in the CCZ

Guideline/Rationale 1:

1)APEI design and implementation should fit into the existing legal mandate of the ISA for managing seabed mining and protecting the marine environment.

<u>ISA Guidelines: ISBA / 4 / C / 4 / Rev. 1, annex 4, section 5.6</u>

-Protected areas will be delineated “in which no mining will occur to ensure representative and stable biota of the seabed”

-“The preservation reference zone[s] … should be large enough so as not to be affected by the natural variations of local environmental conditions.”

-“The zone[s] should have species composition comparable to that of the test mining area[s].”

-“The preservation zone[s] should be outside of test mining area[s] and areas influenced by the plume”

In brief, ISA guidelines stipulate that:

- Prior to test mining and mining, protected areas must be erected beyond the potential influences of mining.

- Protected areas should be designed (as a whole) to sustainably preserve representative biota for all mining claim areas in terms of species composition and biodiversity.

- The full range of habitat and community types potentially found in mining claim areas must be represented in protected areas.

- The scale of protected areas must be large enough that these community types are “stable”, i.e., sustainable.

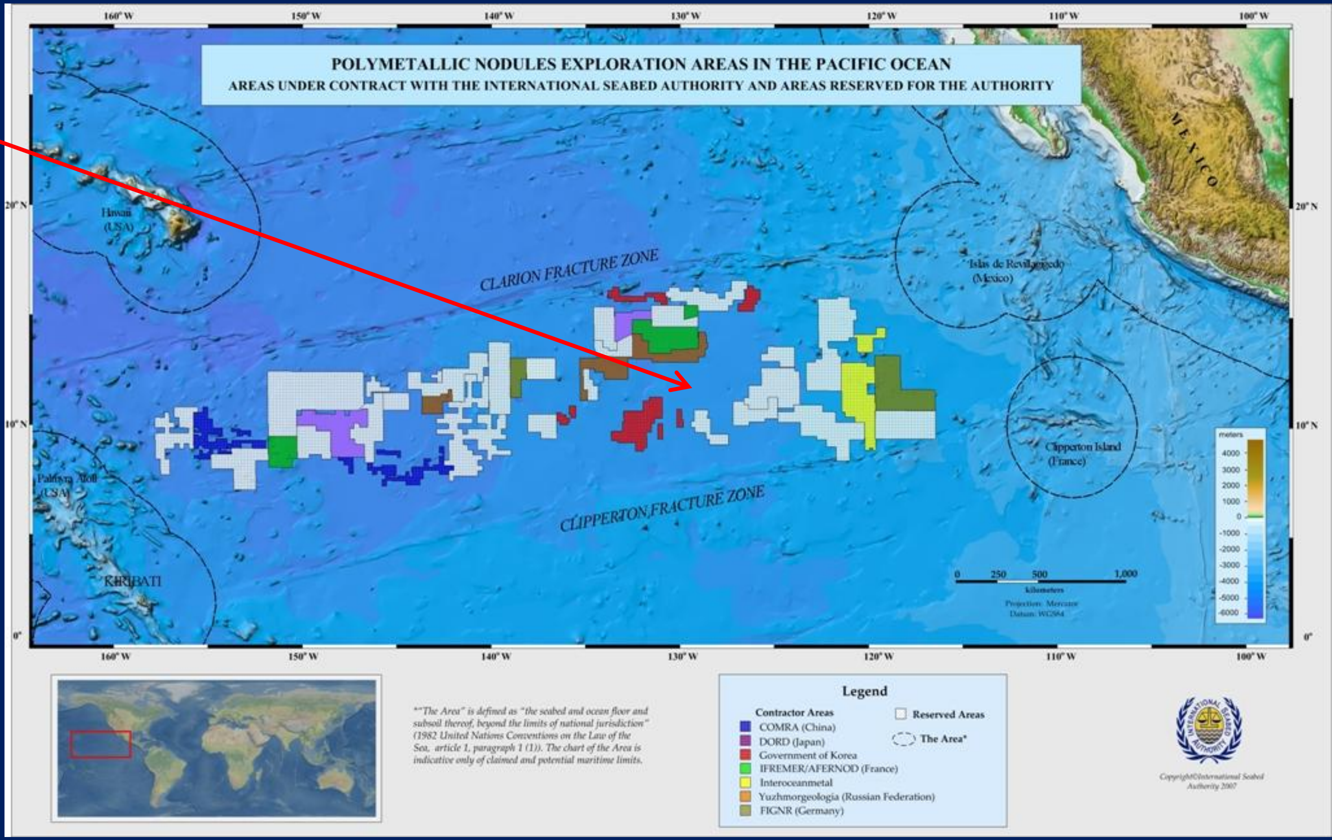
Guideline/Rationale 2:

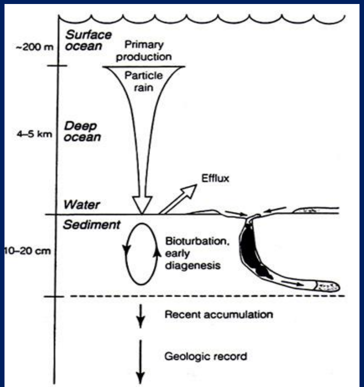
2) The interests of all stakeholders (ISA, UNCLOS signatories, nodule-mining claim holders, NGOs, the science community) should be incorporated into the design. Protected areas should be established as soon as possible so ecosystem-based management can be incorporated into mining strategies and positioning of new claim areas.

E.g., position protected areas in unclaimed portions of CCZ

&

Consider links among all living and nonliving components of the ocean ecosystems





Guideline/Rationale 3:

3) The protected area system is designed with the following conservation goals for CCZ -

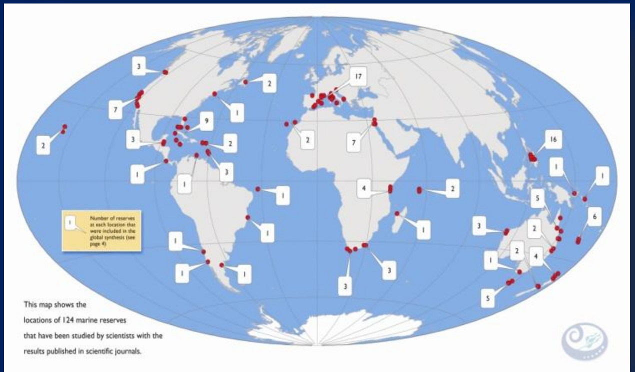
- Preserve Representative and Unique Marine Habitats

- Preserve Marine Biodiversity, and Ecosystem Structure & Function

- Facilitate the Management of Mining to Maintain Sustainable, Intact, and Healthy Marine Ecosystems

These goals are in agreement with the ISA's mandate to protect the marine environment and to manage seabed mining to sustain the ocean environment and its resources as the common heritage of mankind.

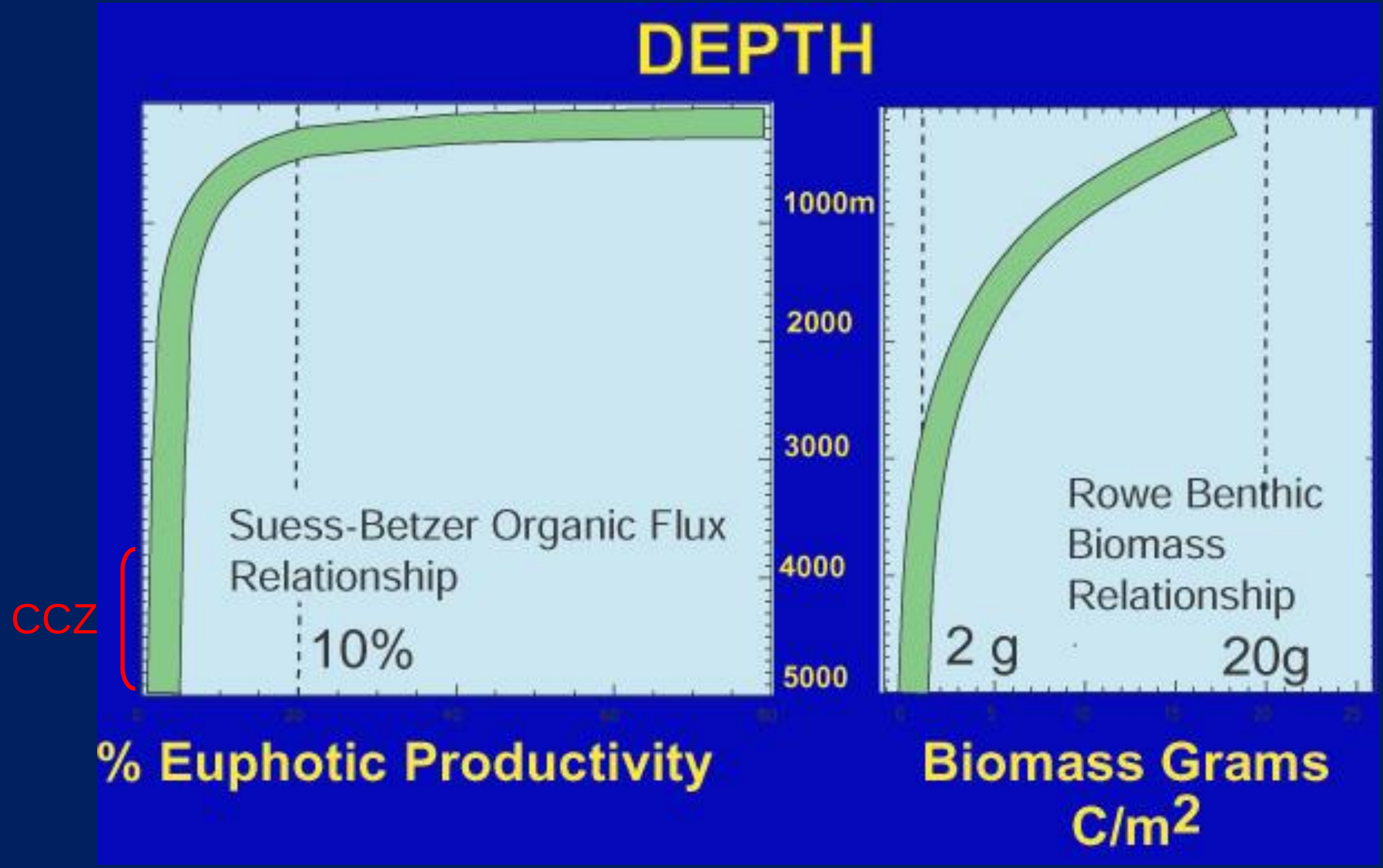
Also consistent with general design goals for marine reserves (and Ecosystem Based Management) as widely applied (e.g., NRC 2001, CBD IX/20 Annex 1)



Guideline/Rationale 4:

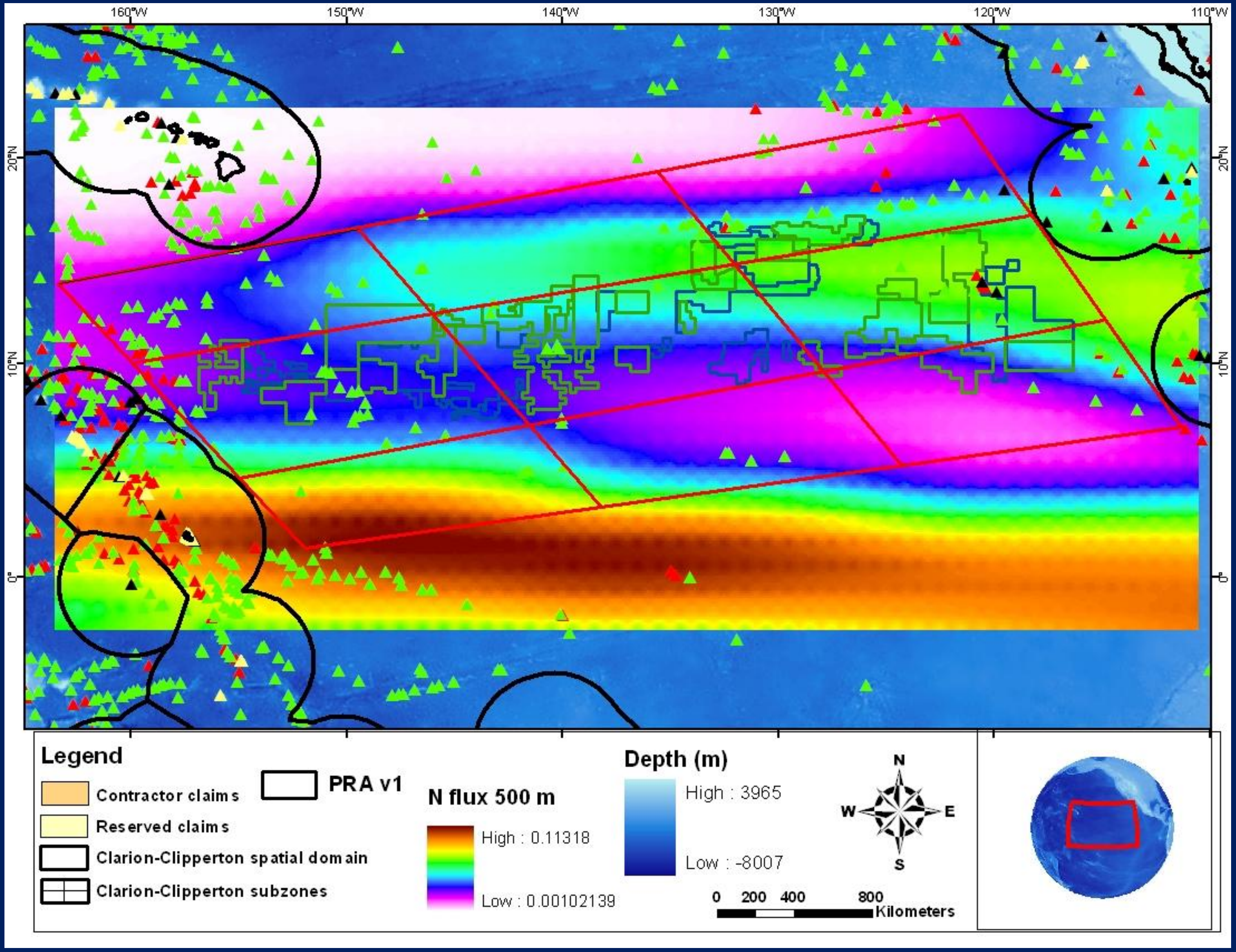
4) The CCZ region can be divided into three east-west and three north-south strata for conservation management because of strong productivity driven gradients in ecosystem structure and function from east to west and south to north. This yields nine distinct subregions within the CCZ, each requiring a protected area (or APEI).

In CCZ , food from sinking POC flux ⟶ *"Food Limited"*



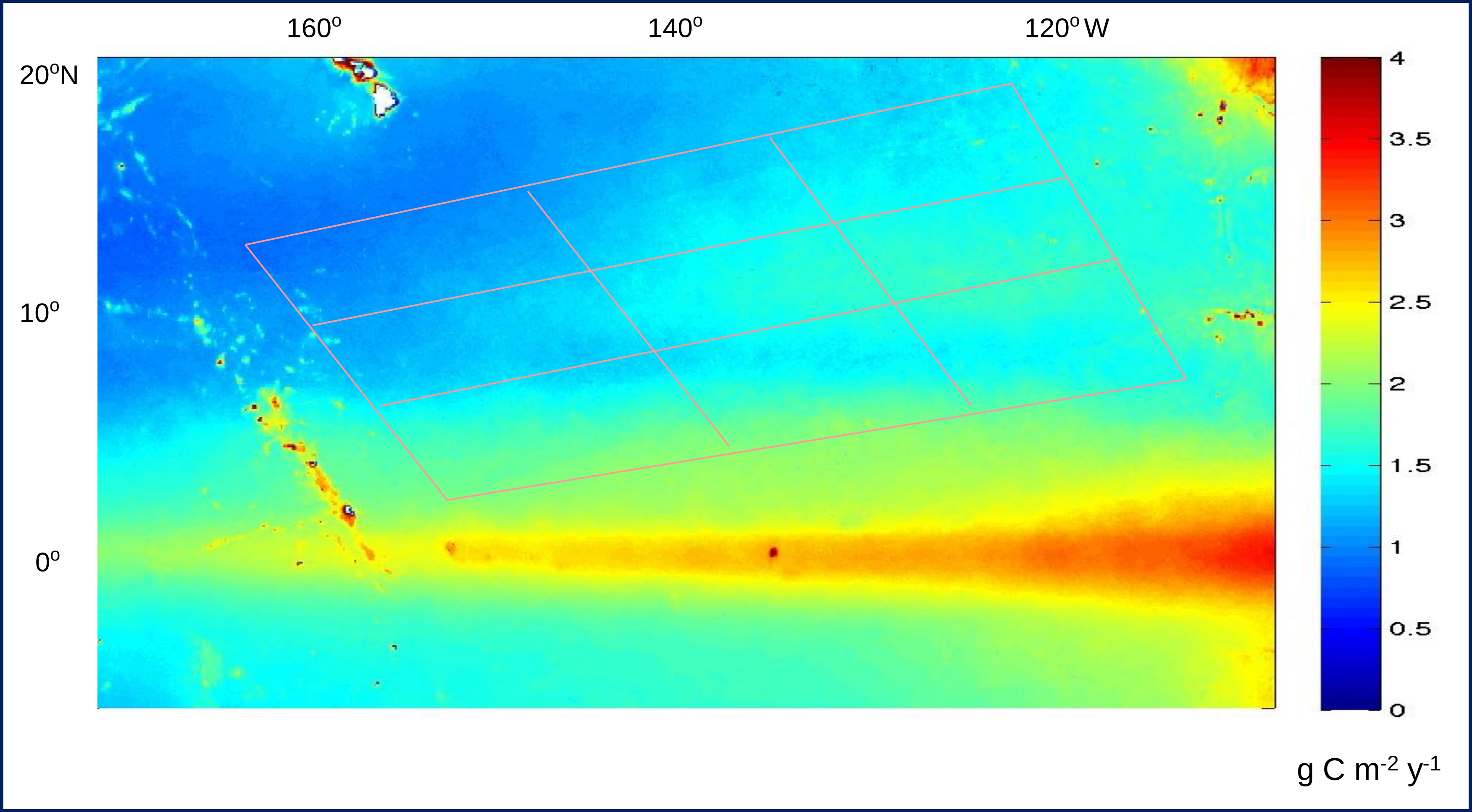
- Biomass, community structure, production, growth rates, recolonization rates all controlled by the flux of sinking POC

From R. Carney



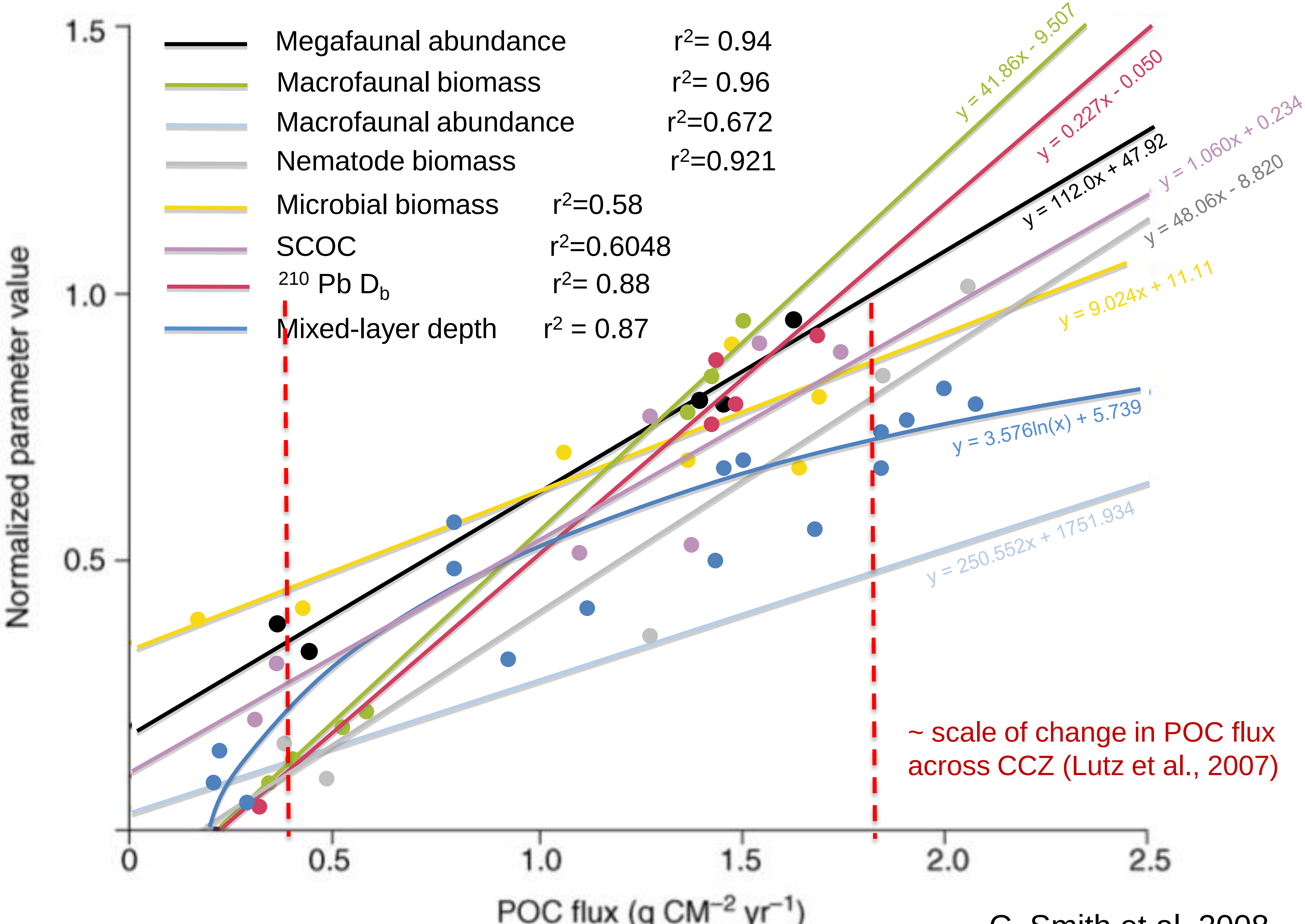
Export flux (mmol N m^2 d^{-1}) for CCZ estimated from Yool et al. (2007) model. Note N-S and E-W gradients and that each of 9 subregions has different export flux regime.

Estimates POC flux to the seafloor yields similar N-S and E-W gradients, and similar “food availability” regimes in CCZ (Lutz et al., 2010).



Why is this important to abyssal CCZ?

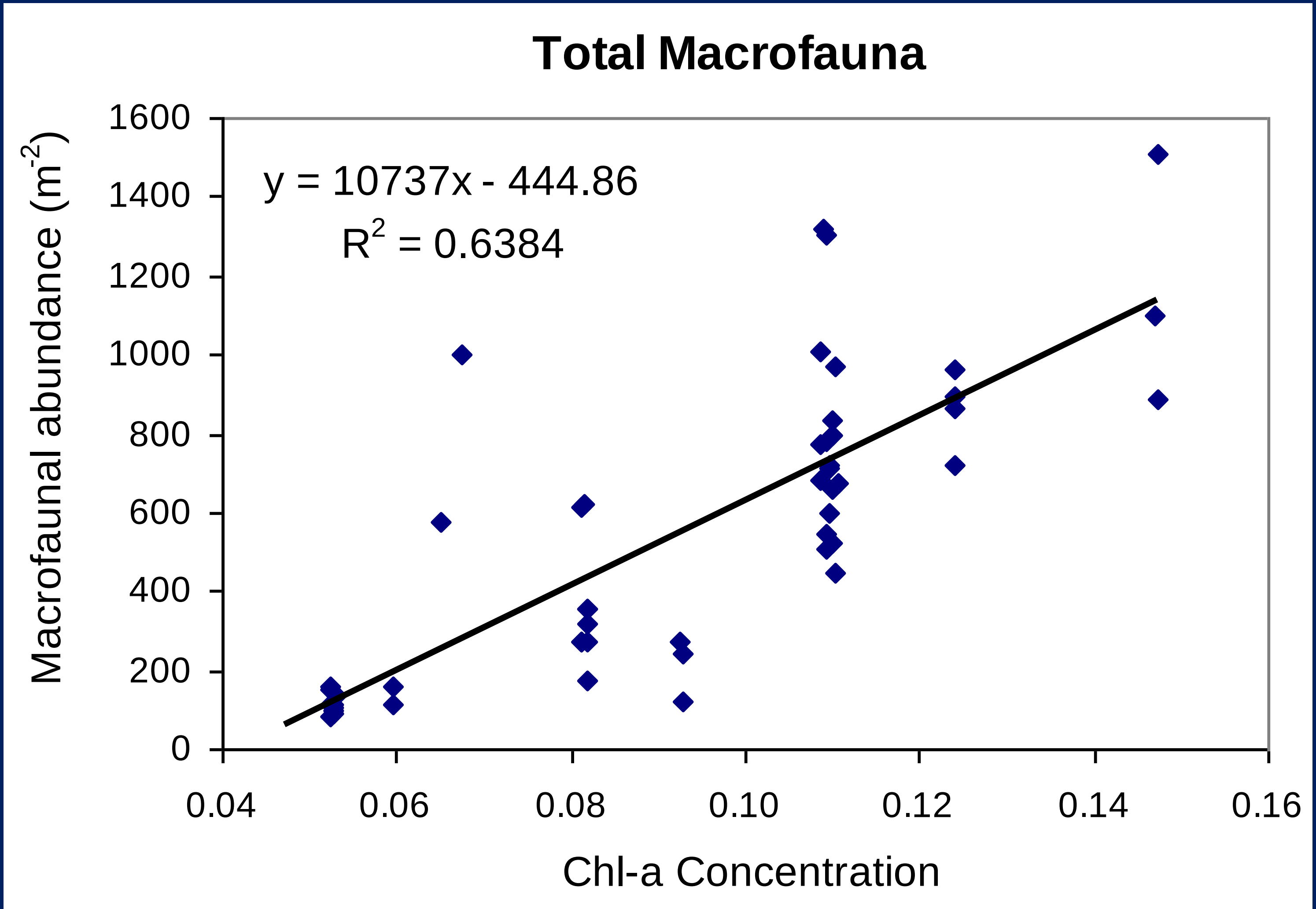
On regional scales, abyssal ecosystem structure & function is strongly correlated with annual POC flux -



C. Smith et al. 2008

CCZ example - Macrofaunal abundance and (abundance of polychaetes, tanaids and isopods), strongly correlated with overlying production and food availability at the CCZ seafloor (Mincks et al., in prep.).

Data from CCZ Region



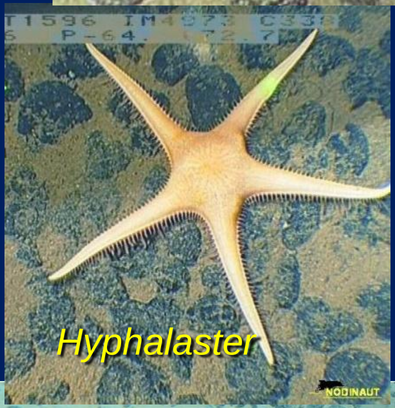
Also important to note: CCZ fauna surprisingly diverse, e.g., “charismatic” megafauna:

Nautile dives June 04, > 20 spp. in few km^2

Glass sponge & brisingids

Cirrate Octopod

Eyeless Fish (Ophidiid?)



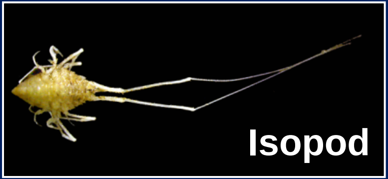
Hyphalaster

Anemone

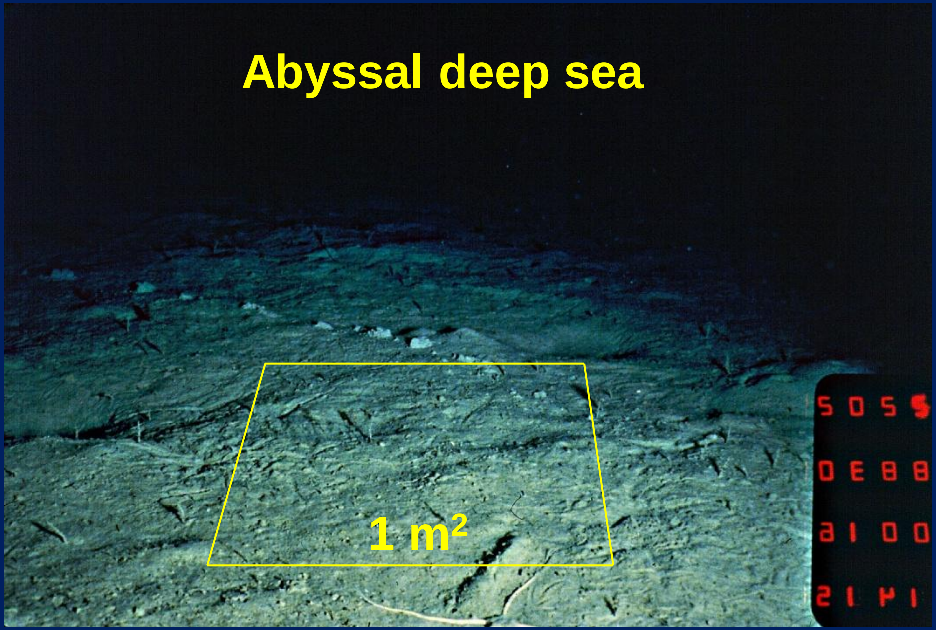
Psychropotes longicauda

Psychropotes semperiana

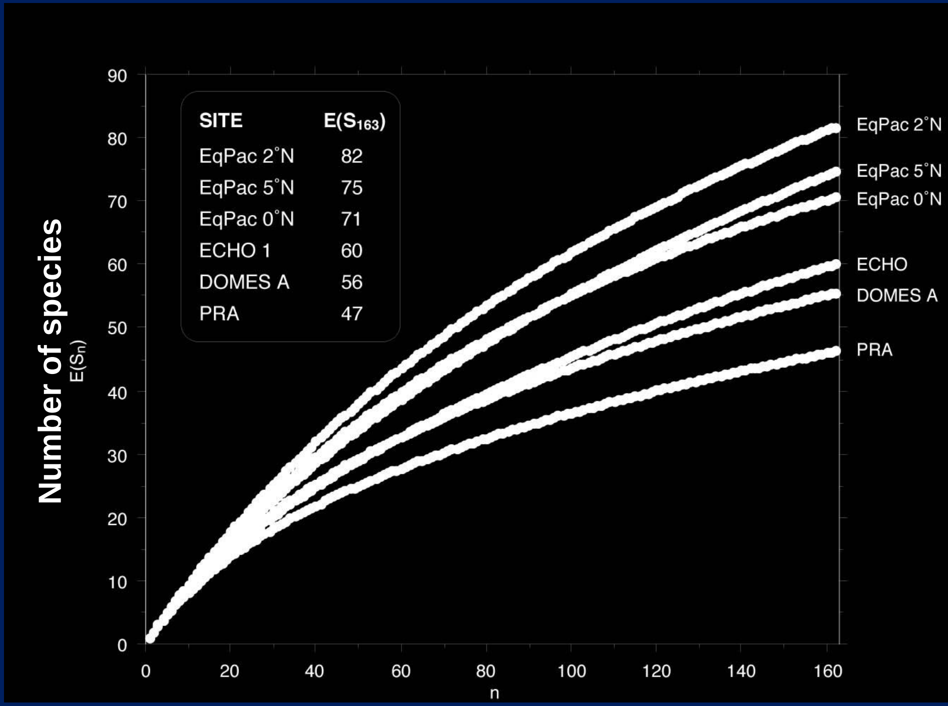
- Macrofauna also has very high <u>local</u> species diversity



80 - 100 macrofaunal species per m^2



~ 50 spp per 100 individuals



Number of individuals

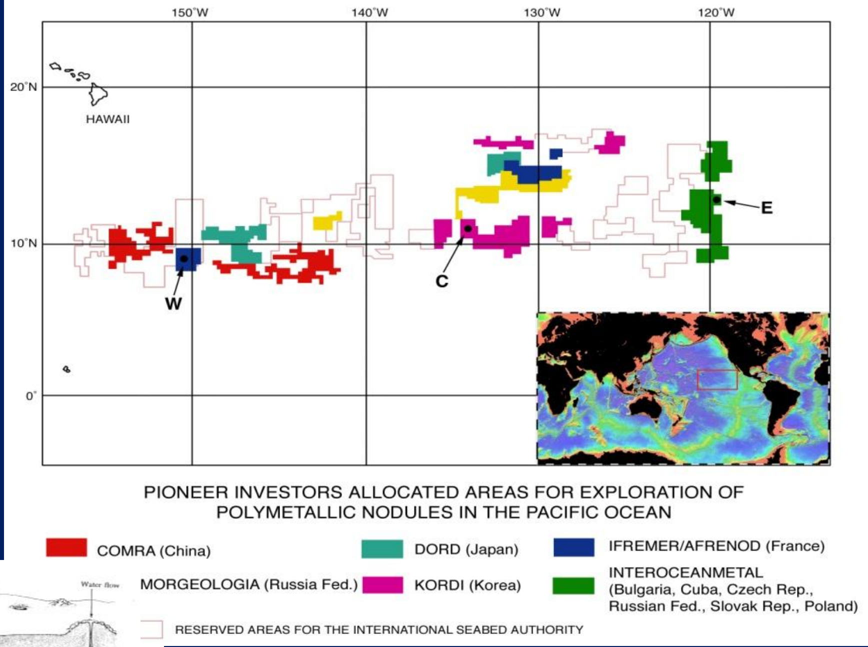
Despite low habitat complexity – Rivals most diverse ecosystems on earth

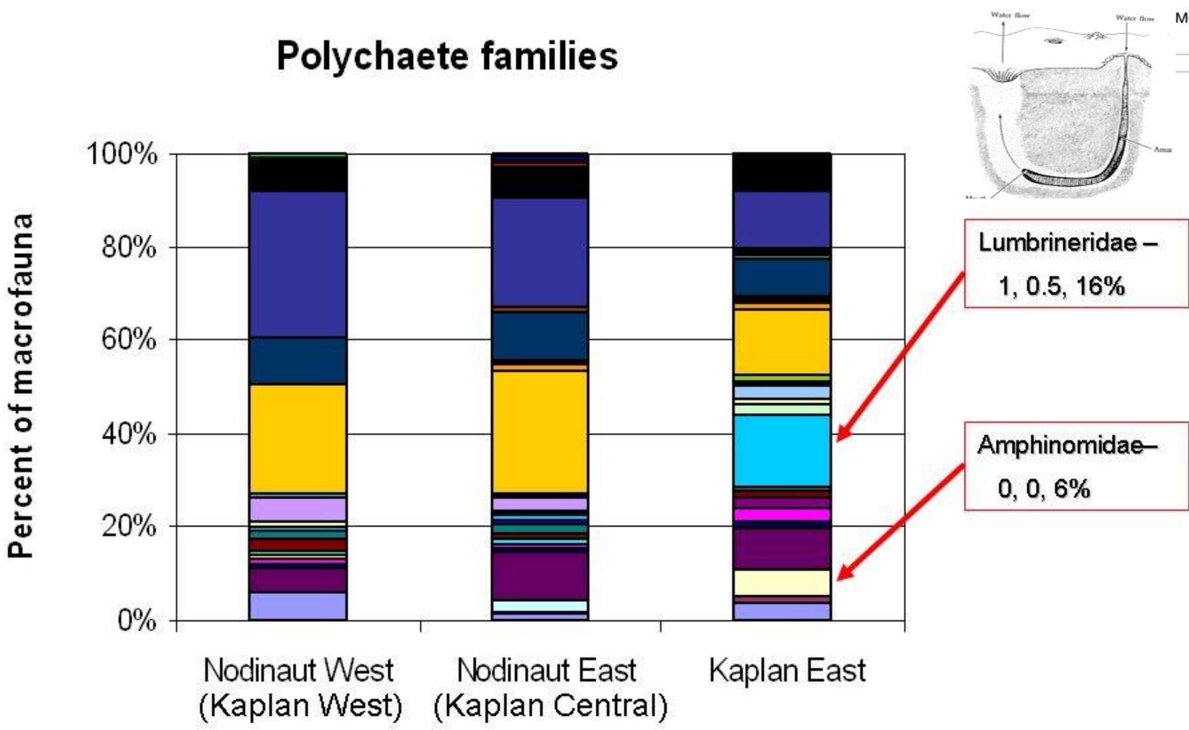
Species structure of this diverse fauna varies across CCZ with productivity -

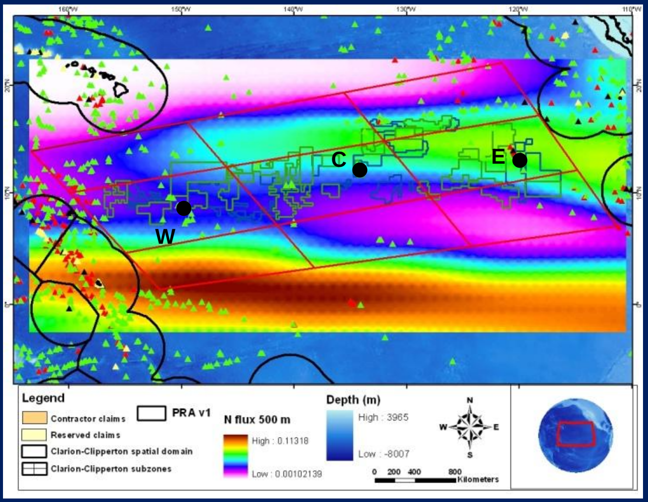
E.g., three sites in CCZ (~1500 km apart)

- Major differences in polychaete fauna at family level (Kaplan Project, Smith et al. 2007)

- Driven by productivity gradient?







Similar turnover seen in polychaete and foraminiferan spp. (Smith et al. 2008, ISA Technical Study ; no.3).

Proportion of lumberinerids significantly lower at C and W ($p \leq 0.05$, Chi square test)

Proportion of Amphinomids significantly lower at Kaplan C than E ($p < 0.025$)

Guideline/Rationale 5:

5) The boundaries of protected areas (APEIs) should be straight lines to facilitate rapid recognition by all parties.

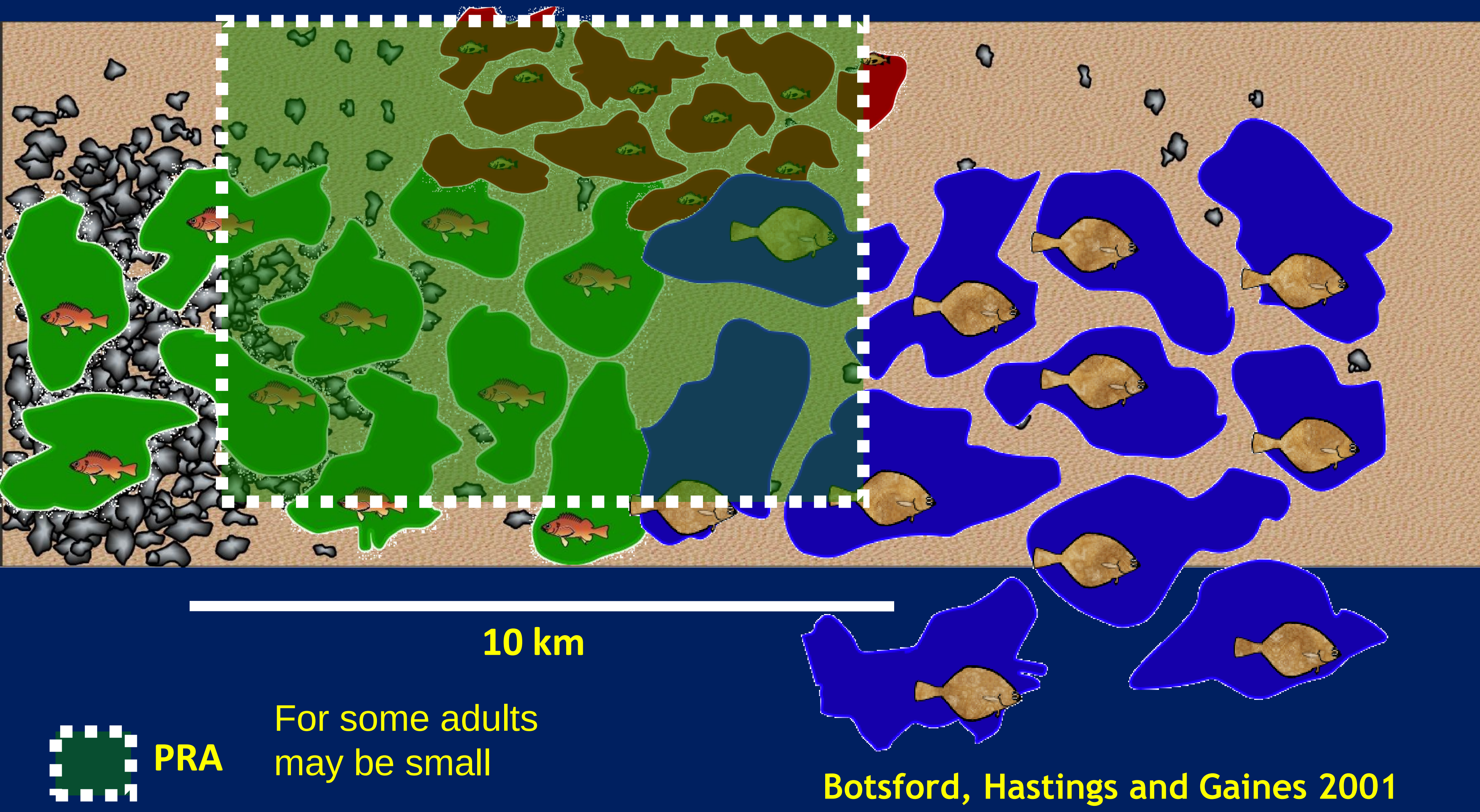
Straight-line boundaries = basic principle of the design of marine protected areas that facilitates recognition, monitoring and enforcement of APEIs as no-mining zones.

Guideline/Rationale 6:

6) Core area of each protected area (APEI) should be at least 200 km in length and width, i.e., large enough to maintain minimum sustainable population sizes for species potentially restricted to a subregion of the CCZ.

Because animals leaving protected areas (APEIs) may not survive –

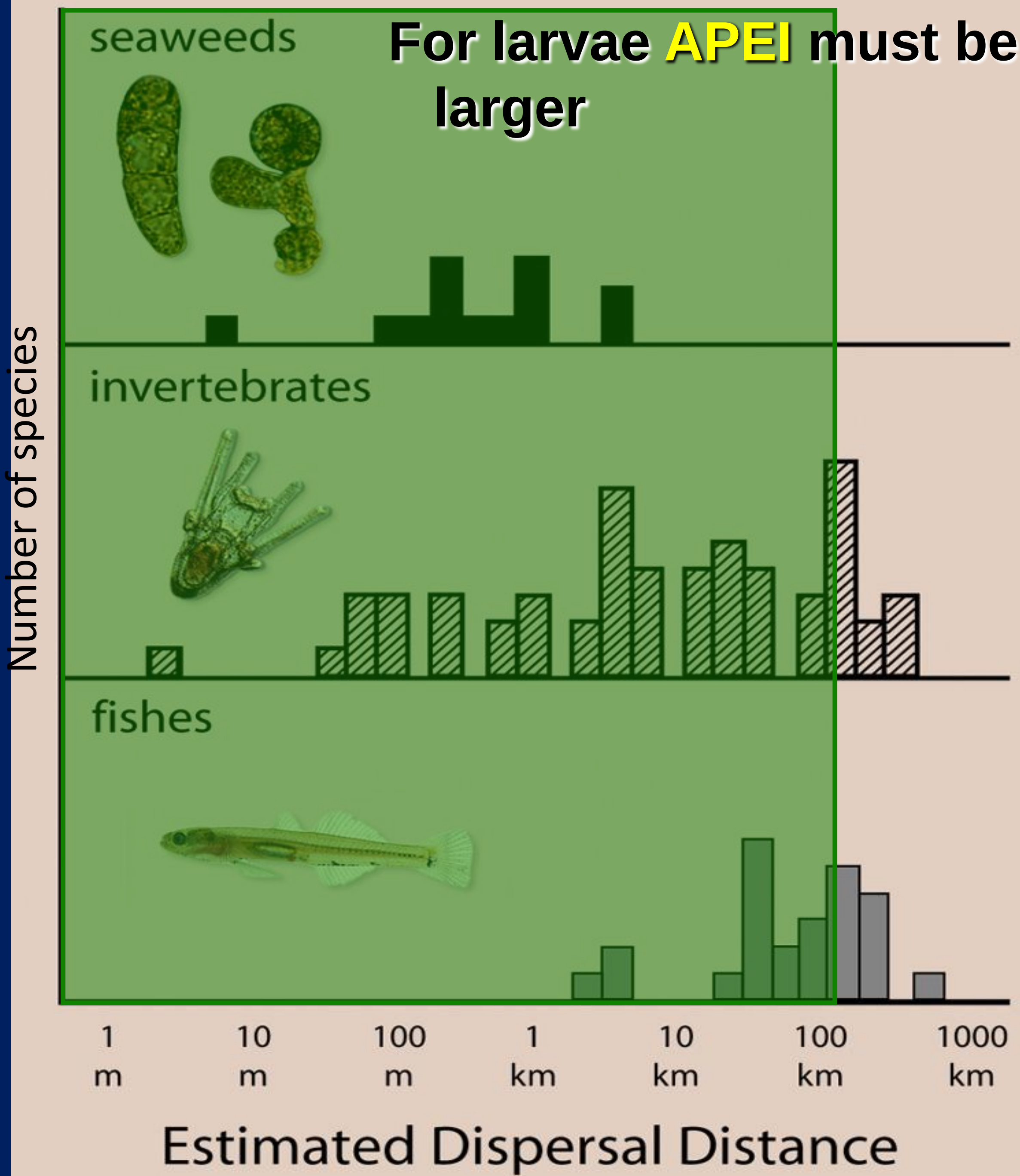
To promote sustainable populations: APEI size > distance of movement of animals



For some adults may be small

Botsford, Hastings and Gaines 2001

For larvae **APEI** must be larger



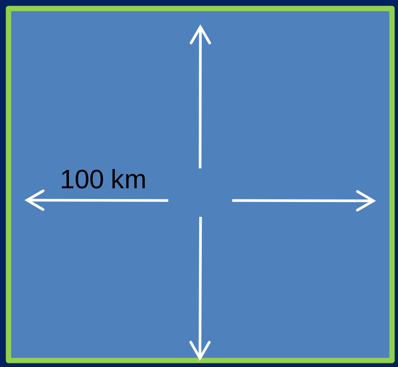
Kinlan and Gaines, 2001

For sustainable populations, APEI size must be 2X average dispersal distance of larvae (Lockwood et al. 2002; Almany et al. 2009)

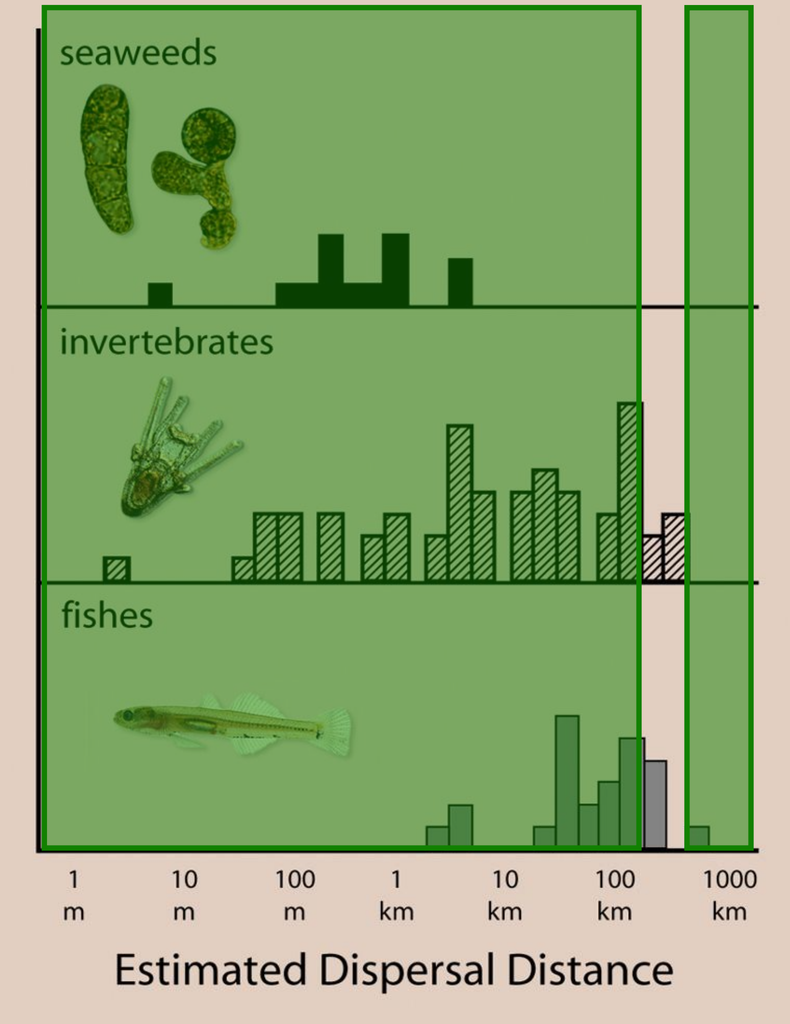
Most marine benthos have mean larval dispersal distances <100 km

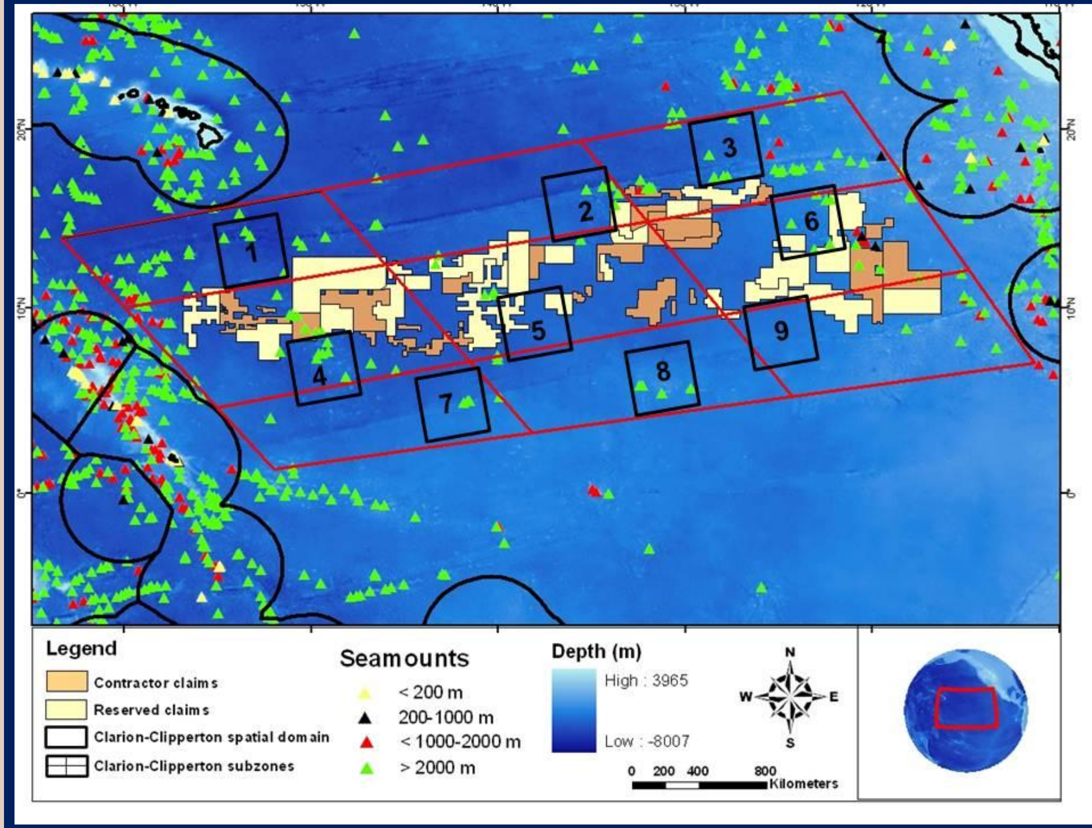
Recommended PRA core size -

200 x 200 km



Note also that the spacing between core areas of adjacent APEIs is of variable and of order 300 – 500 km, leaving little gap in the within and the between APEI scales. Thus, larvae dispersing out of APEIs are unlikely to land only in the gaps (Almany et al. 2009).

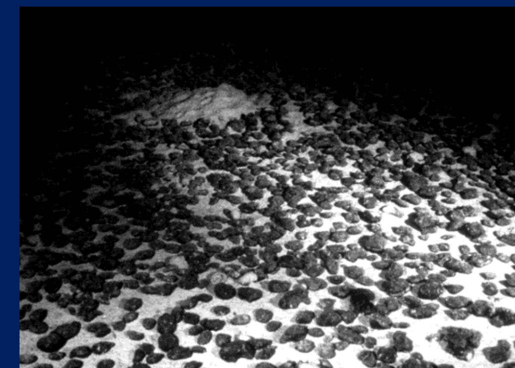




APEIs can function as network

Guideline/Rationale 7:

7) Each protected area (APEI) should contain the full range of habitat types found within its subregion:



Abyssal plains/abyssal hills

with and without nodules

(200 x 200 km adequate)

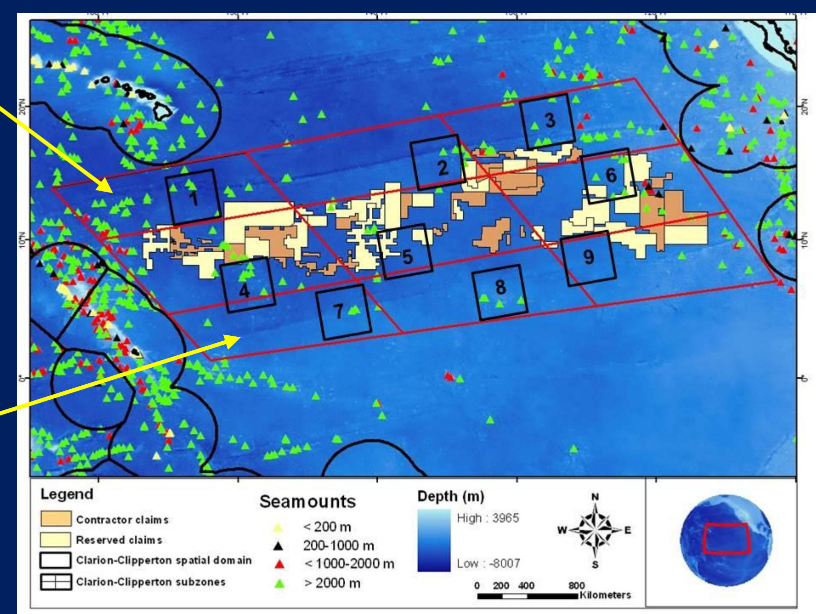
Seamounts

(often harbor unique,

vulnerable, diverse

communities – protect

30-40% in each subregion)



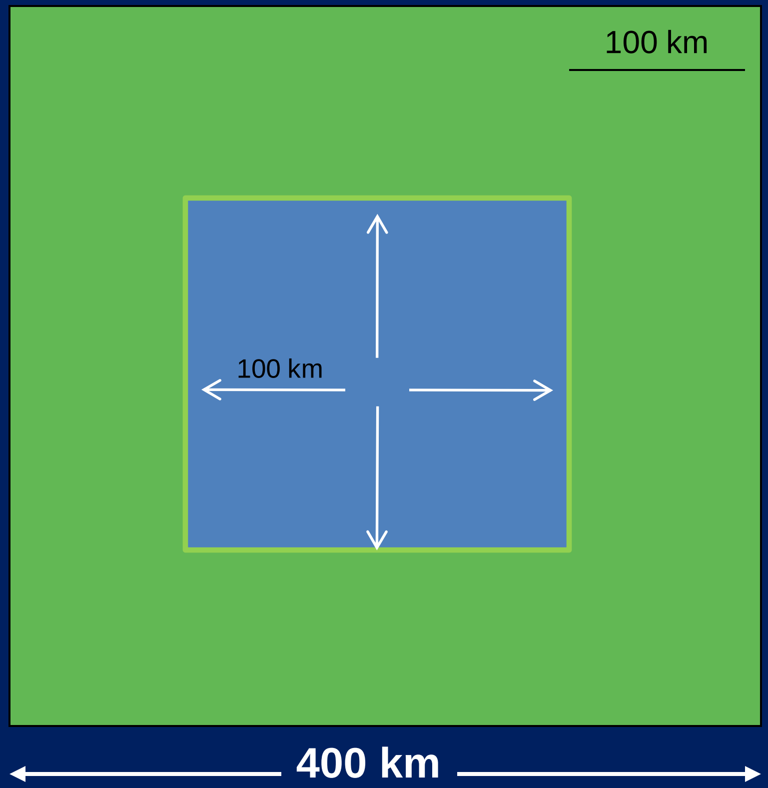
Fracture zones

If prudently placed, scales of 200 km likely to capture full range of habitat types

Guideline/Rationale 8:

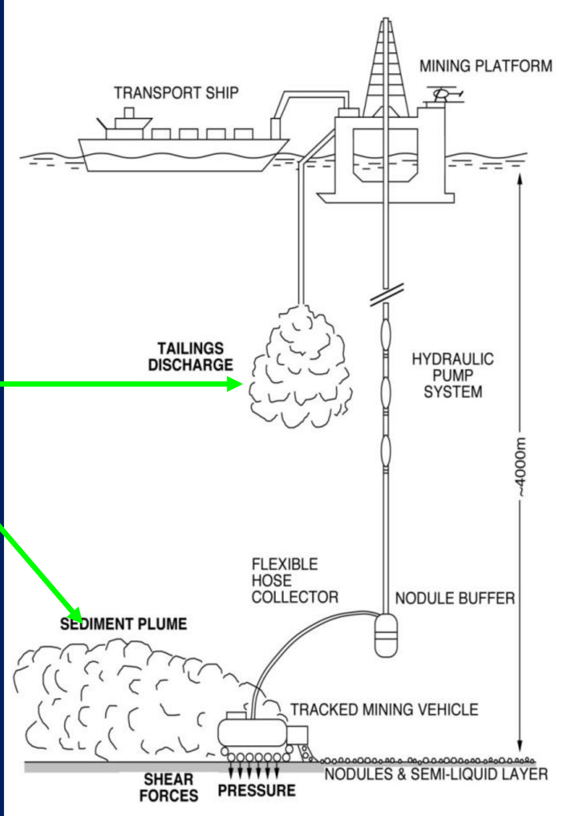
8) Each PRA core area should surrounded by a buffer zone 100-km wide to insure that benthic communities in the APEI core is not affected by mining plumes.

PRA core + buffer



Physical oceanographic models and tracer experiments suggest plume disturbance of ***benthos*** over scales of ≤100 km

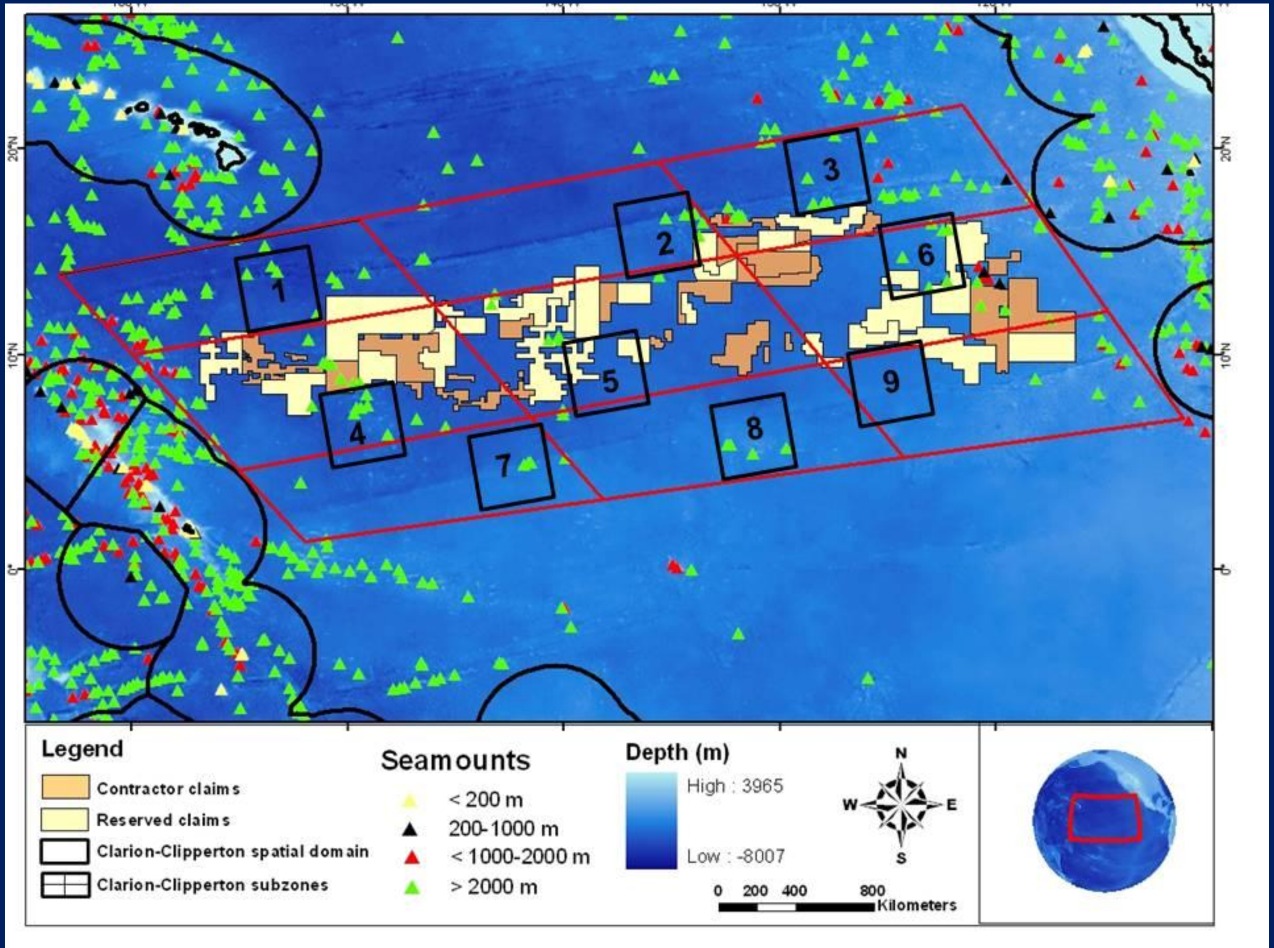
(Oebius, 2001; Rolinski et al. 2001; Ledwell 2000; Thurnherr 2004)



Summary of Recommendations –

- Nine 400 x 400 km protected areas (APEIs) within the CCZ. One APEI in each of the 9 subregions defined by productivity gradients and faunal turnover. APEIs situated to avoid or minimize overlap with existing mining exploration and reserved claim areas and to protect as many seamounts as possible within a subregion.

One option for location of APEIs within subregions (locations are flexible, i.e., negotiable subject to stakeholder interests, capture of full range of habitats, and improving knowledge of CCZ)



Strengths of approach:

1) It is based on sound conservation management principles

2) Protects ~30% of CCZ, i.e., optimizes conservation and sustainability benefits (many references)

3) Manages CCZ conservation as a whole, facilitating cooperation in –

- selection (and monitoring) of protected areas (APEIs)
- maintenance of biodiversity and ecosystem function across the region


Questions ?
NODINAUT

Very similar to recommendations in UNESCO report of Tilot, 2010 (*Options for the management and conservation of the biodiversity Vol.3 The nodule ecosystem in the Clarion Clipperton Fracture Zone: scientific, legal and institutional aspects)*

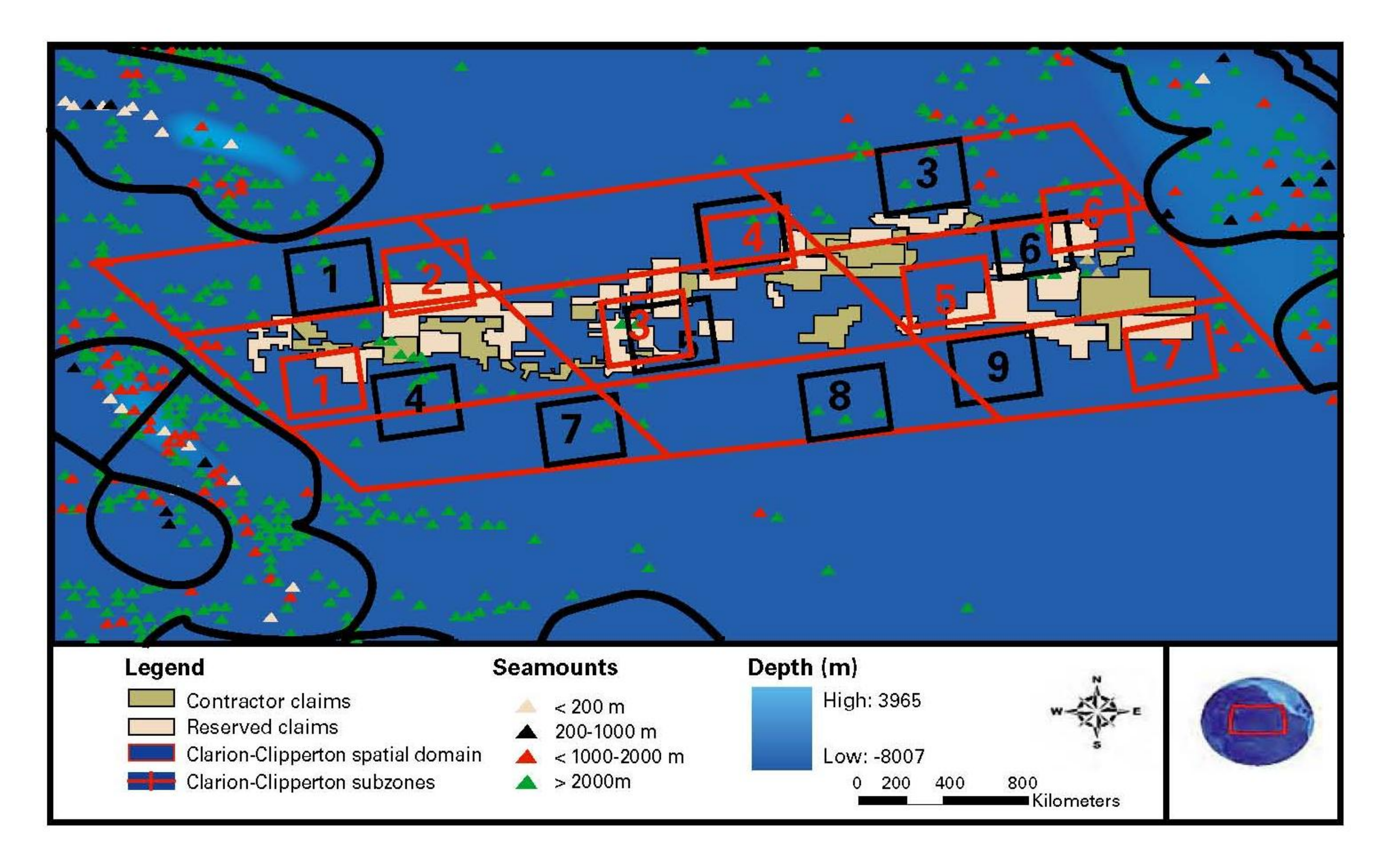
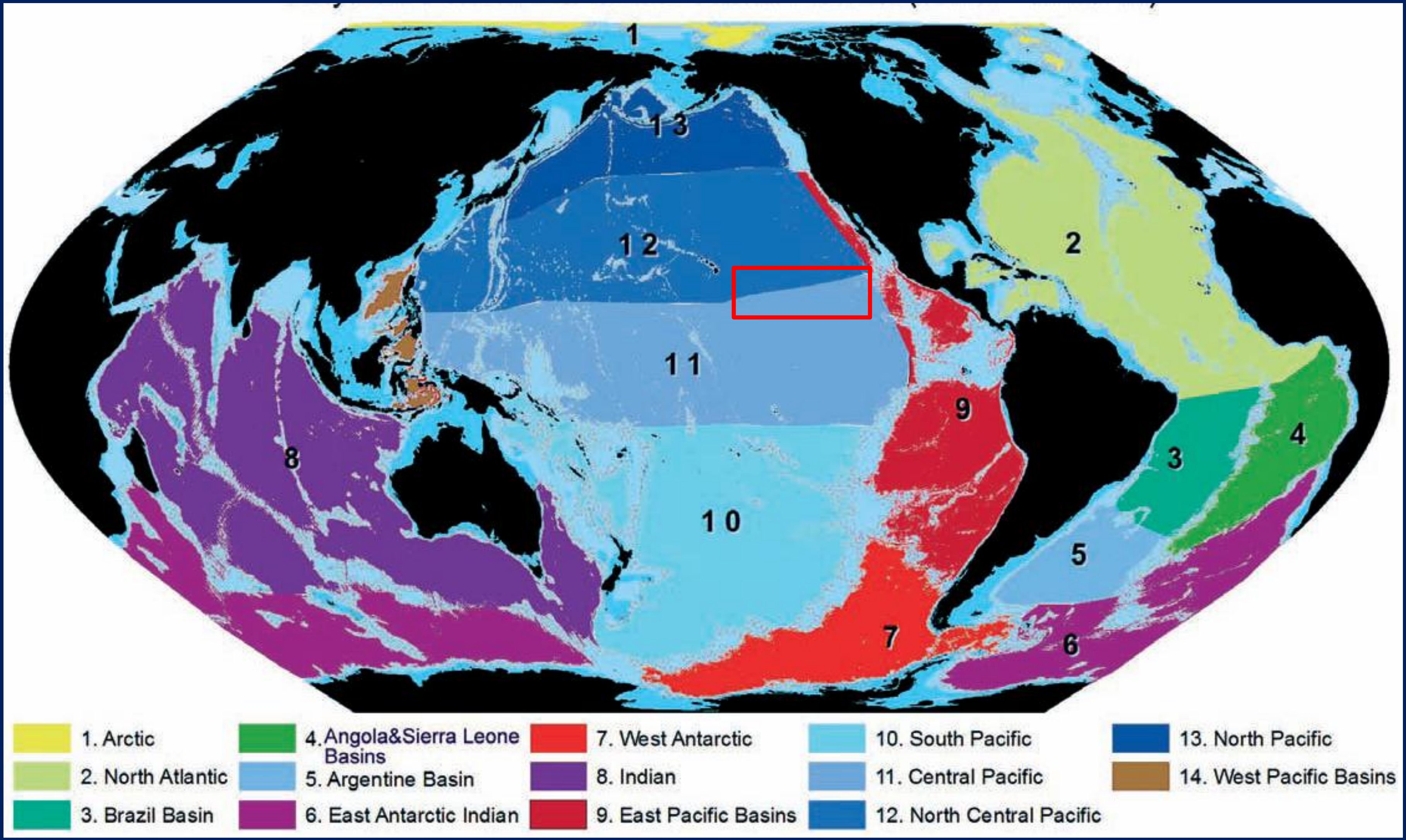


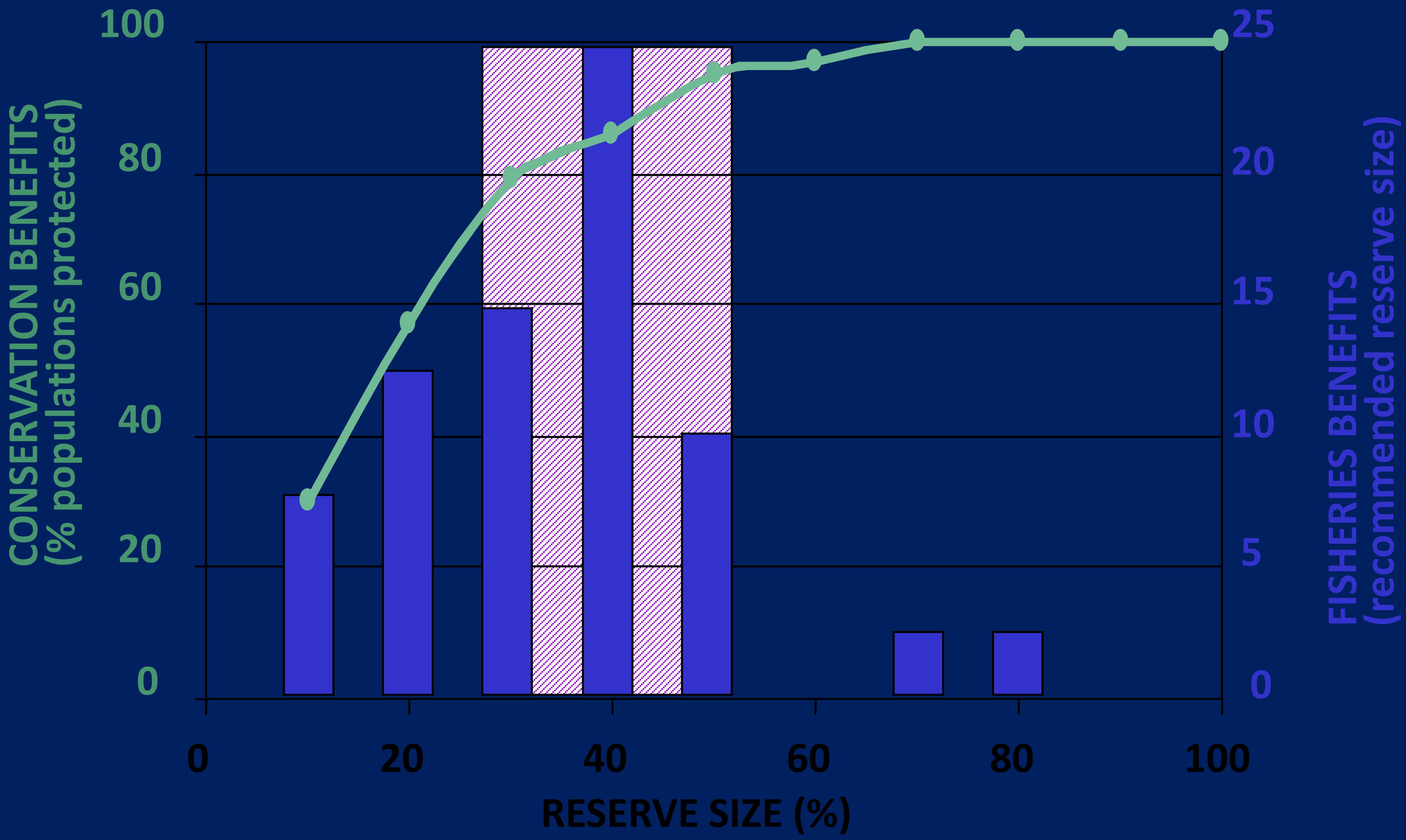
Fig.15. Tilot proposal of a network of seven Seabed Preservation Reference Areas (**red squares**), each 400 x 400 km compared to one option of the Pew Workshop Recommendations (**black squares**).

CCZ cuts across hypothesized Biogeographic Provinces of the Abyssal Ocean (3500-6500 m)

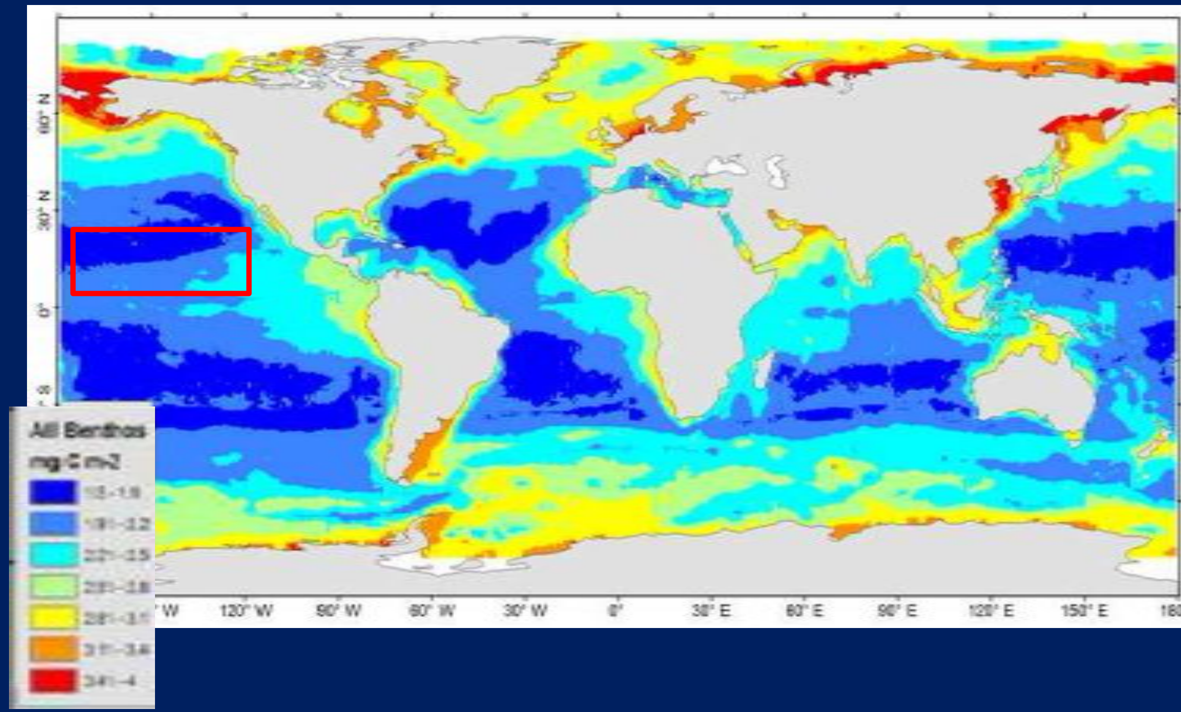


UNESCO. 2009. *Global Open Oceans and Deep Seabed (GOODS) – Biogeographic Classification. Paris, UNESCO-IOC. (IOC Technical Series, 84.)*

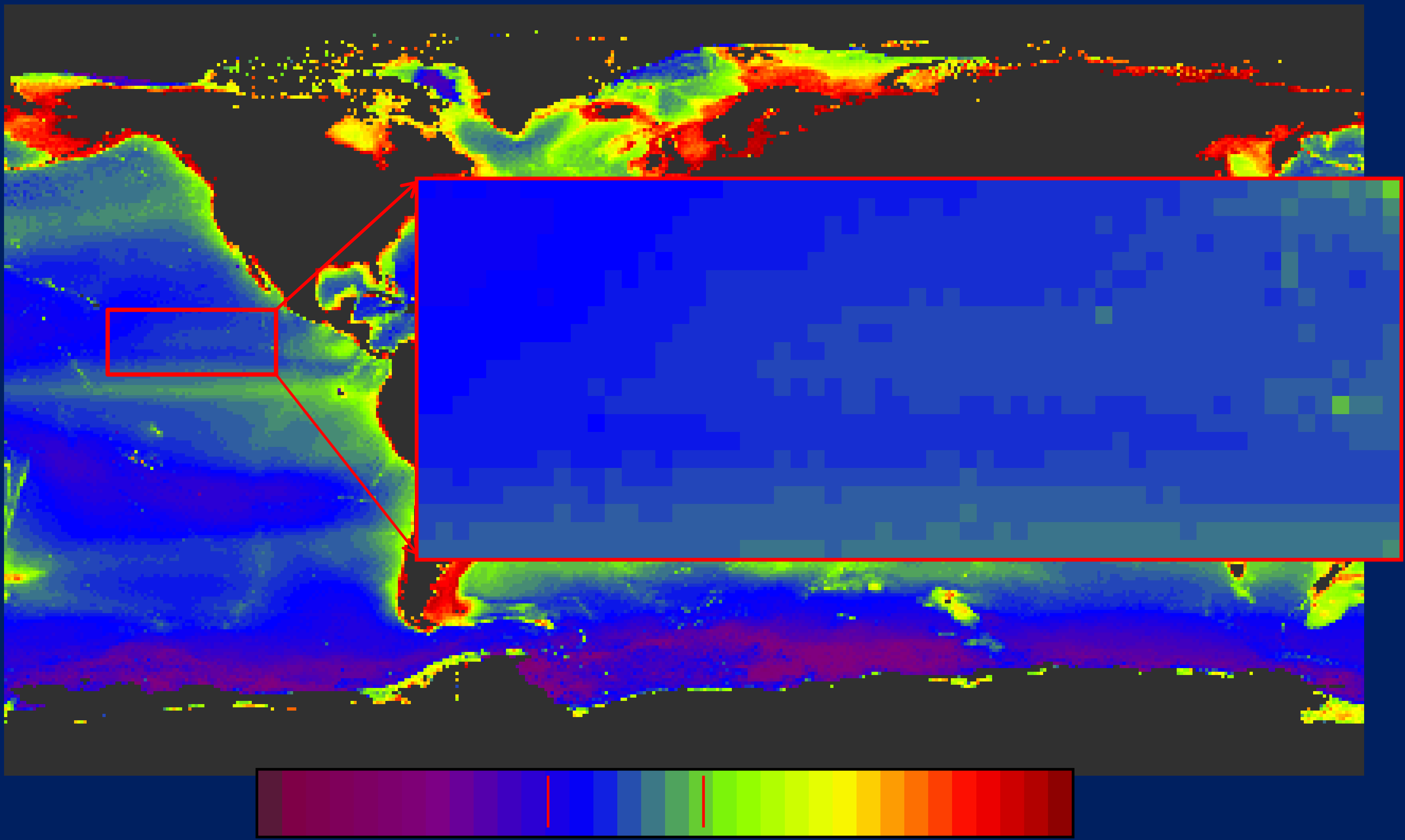
Common Solutions



From Airame *et al.* 2002, NCEAS Marine Reserve Working Group

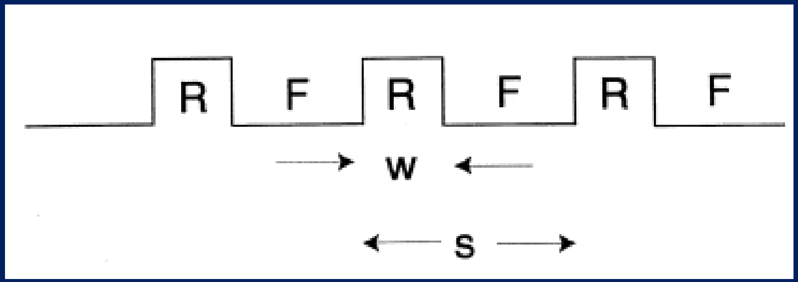


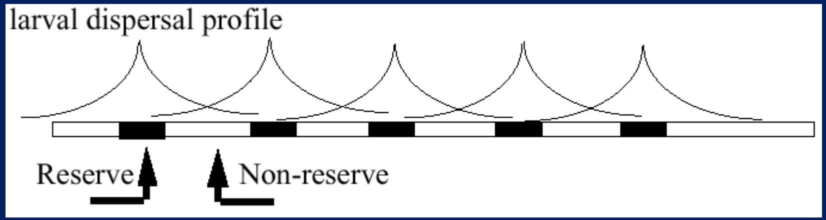
Wei, C.-L., In review. Global Patterns and Predictions of Seafloor Biomass Using Random Forests. *PLOS One*

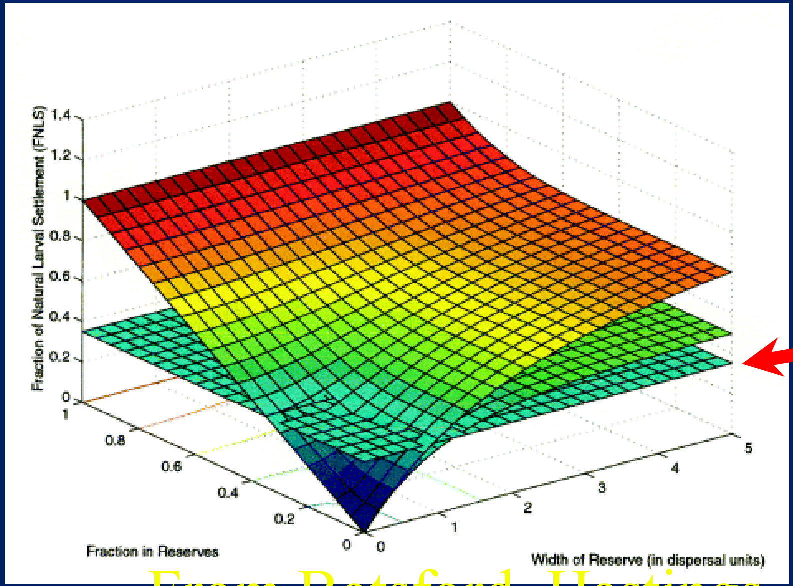


Seafloor annual POC flux (Lutz et al., 2007)

Reserves and Species Persistence







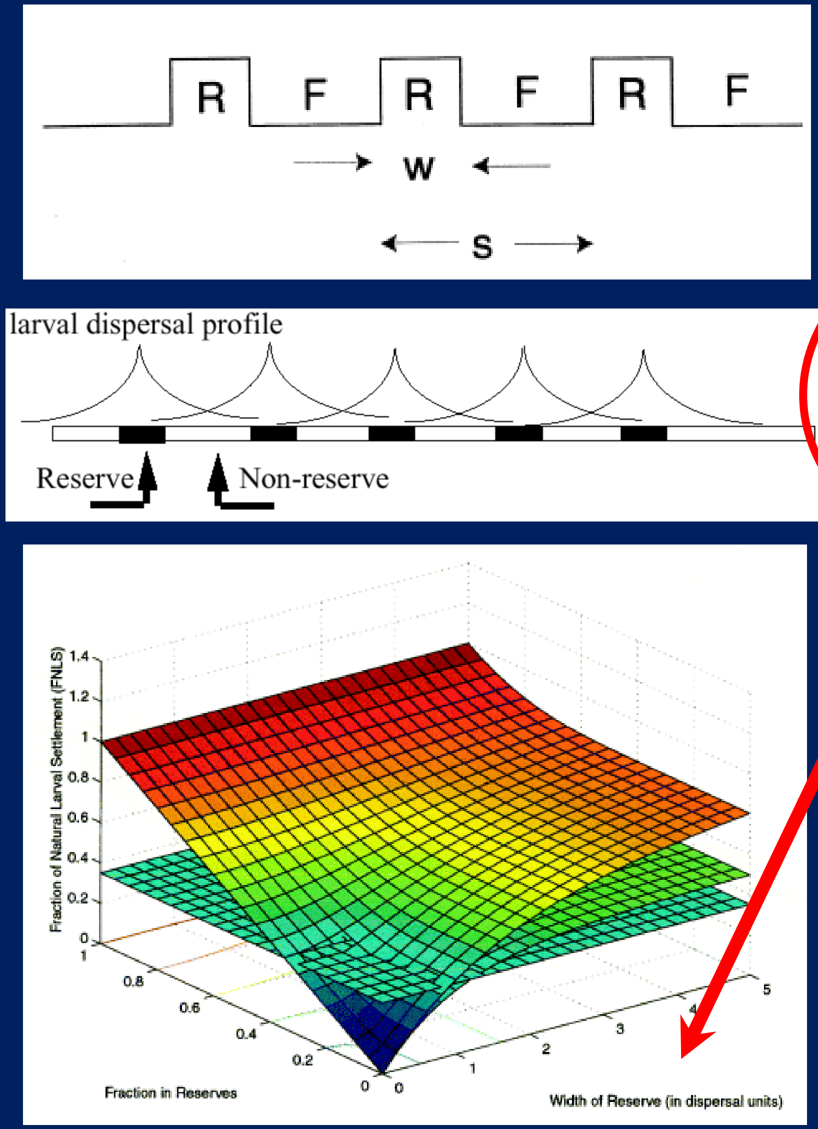
Worst Case Scenario:

Species Extinct Outside Reserves

Persistence Threshold

From Botsford, Hastings, & Gaines. 2001. *Ecology Letters*

Reserves and Species Persistence



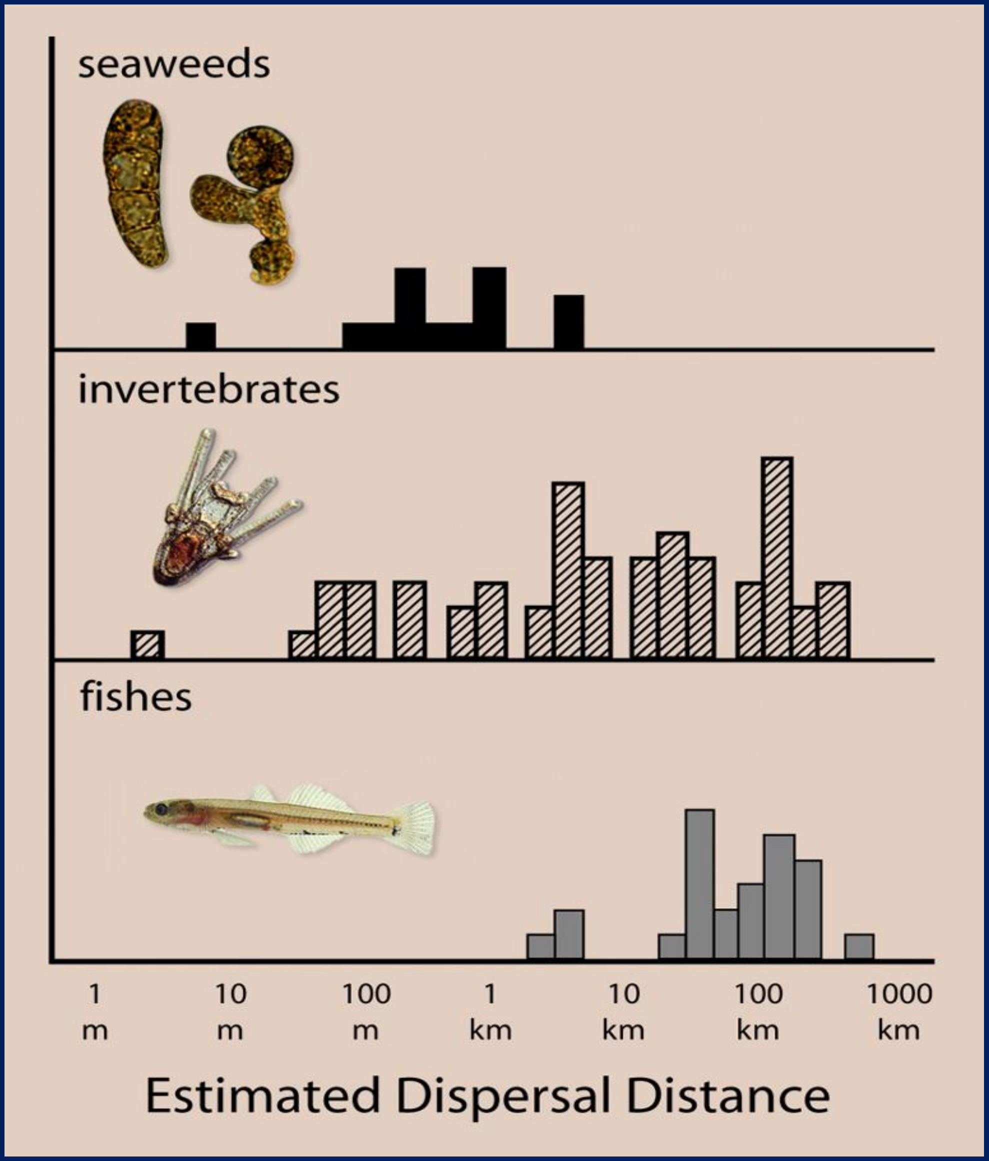
2 Conservation Solutions:

Large Individual Size

- > mean dispersal distance
- 2 - 3x mean dispersal distance with advection

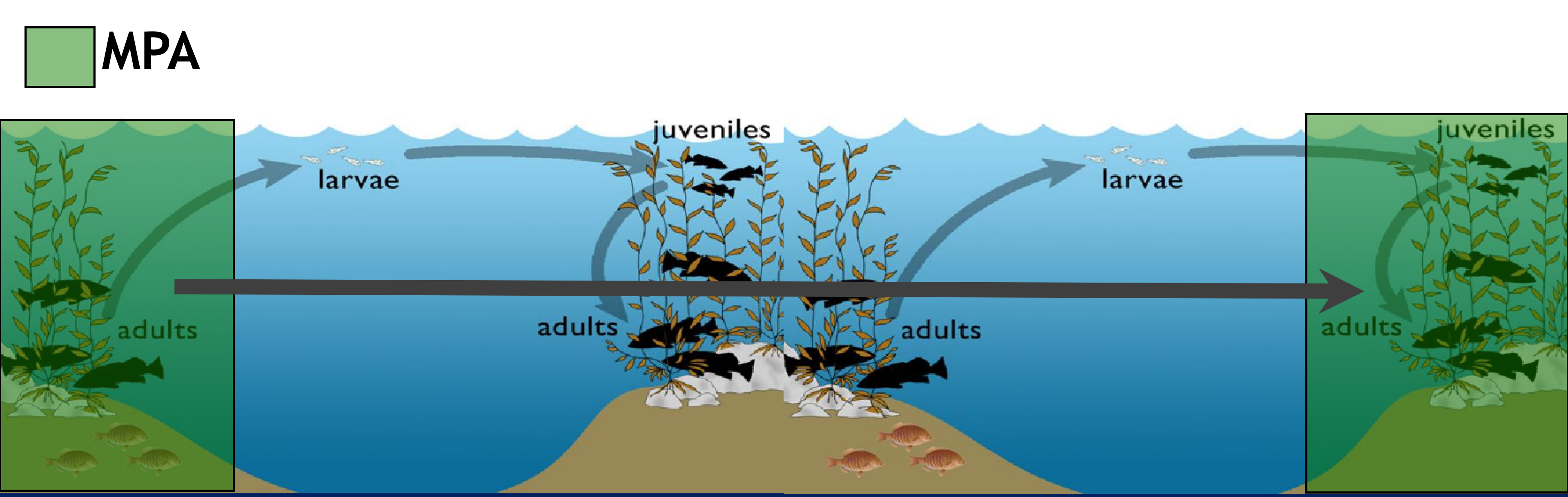
From Botsford, Hastings, & Gaines. 2001. *Ecology Letters*

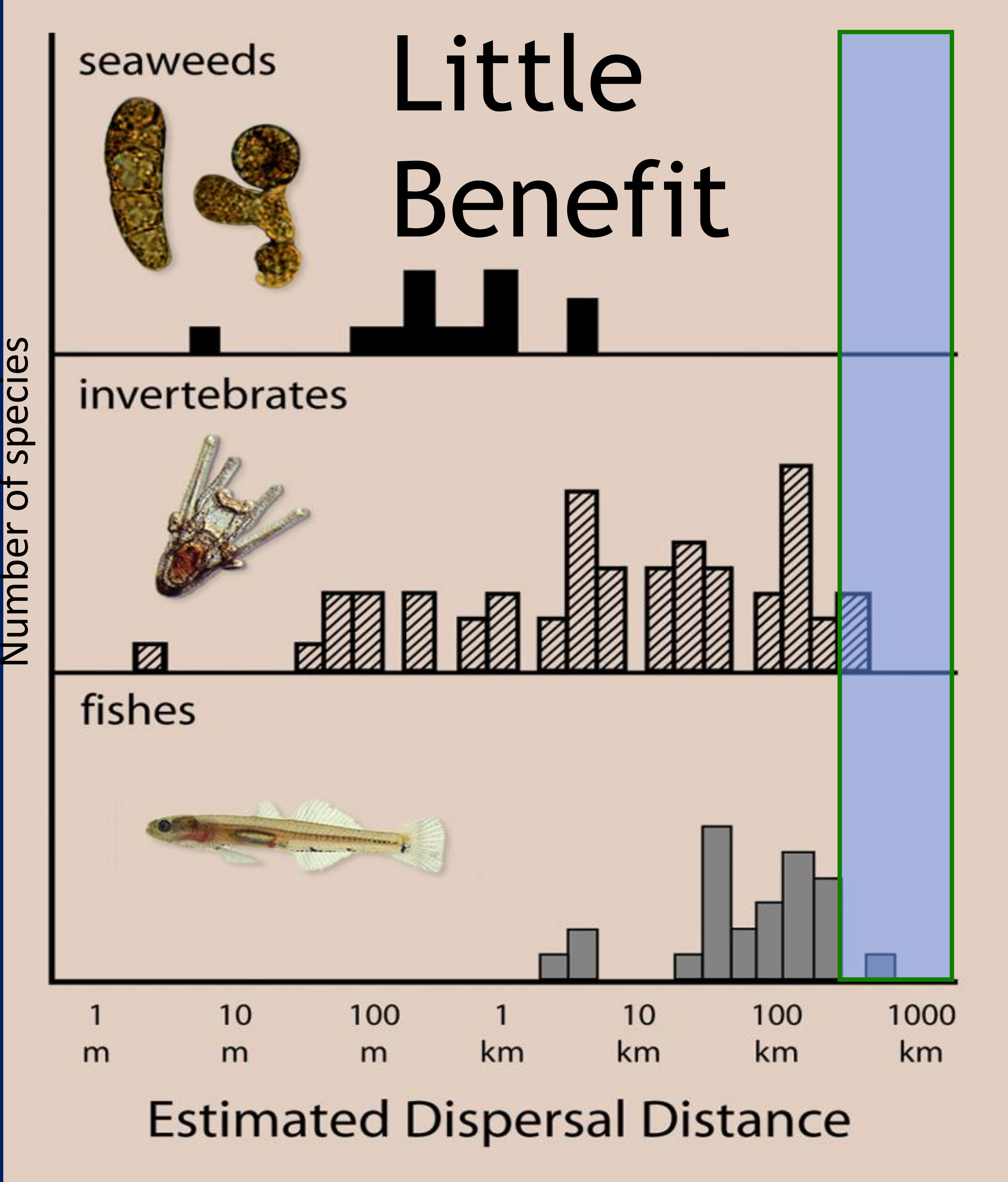
Same Rules for Dispersal of Young
MPA size > movement



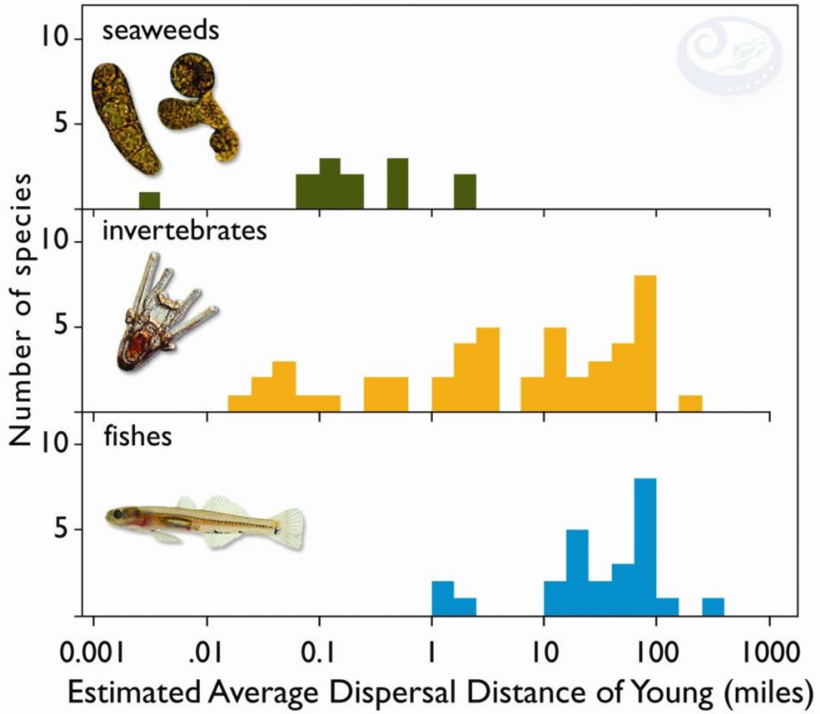
Key Criterion:

Spacing of MPAs < Larval Dispersal





500 km Spacing



The estimated average distances traveled by young invertebrates (51 species), fishes (26 species), and seaweeds (13 species) prior to settling at their adult homes. Distances are based on genetic analysis of species around the world.
Data: Kinlan & Gaines (2003) Ecology

Results of plowing in DISCOL & others: few mm of deposition

→ Dramatic declines in abundance & diversity of macrofauna and megafauna within 11 km^2 after 7 years

H. Bluhm / Deep-Sea Research II 48 (2001) 3841–3868 3851

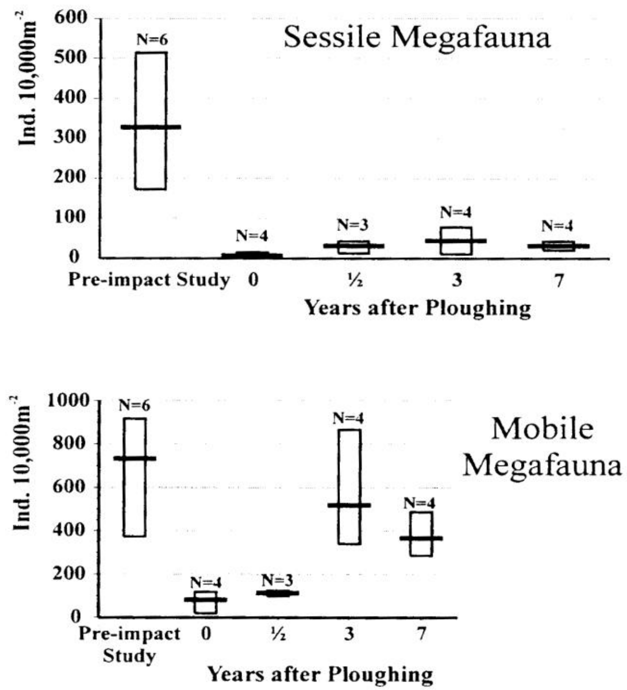
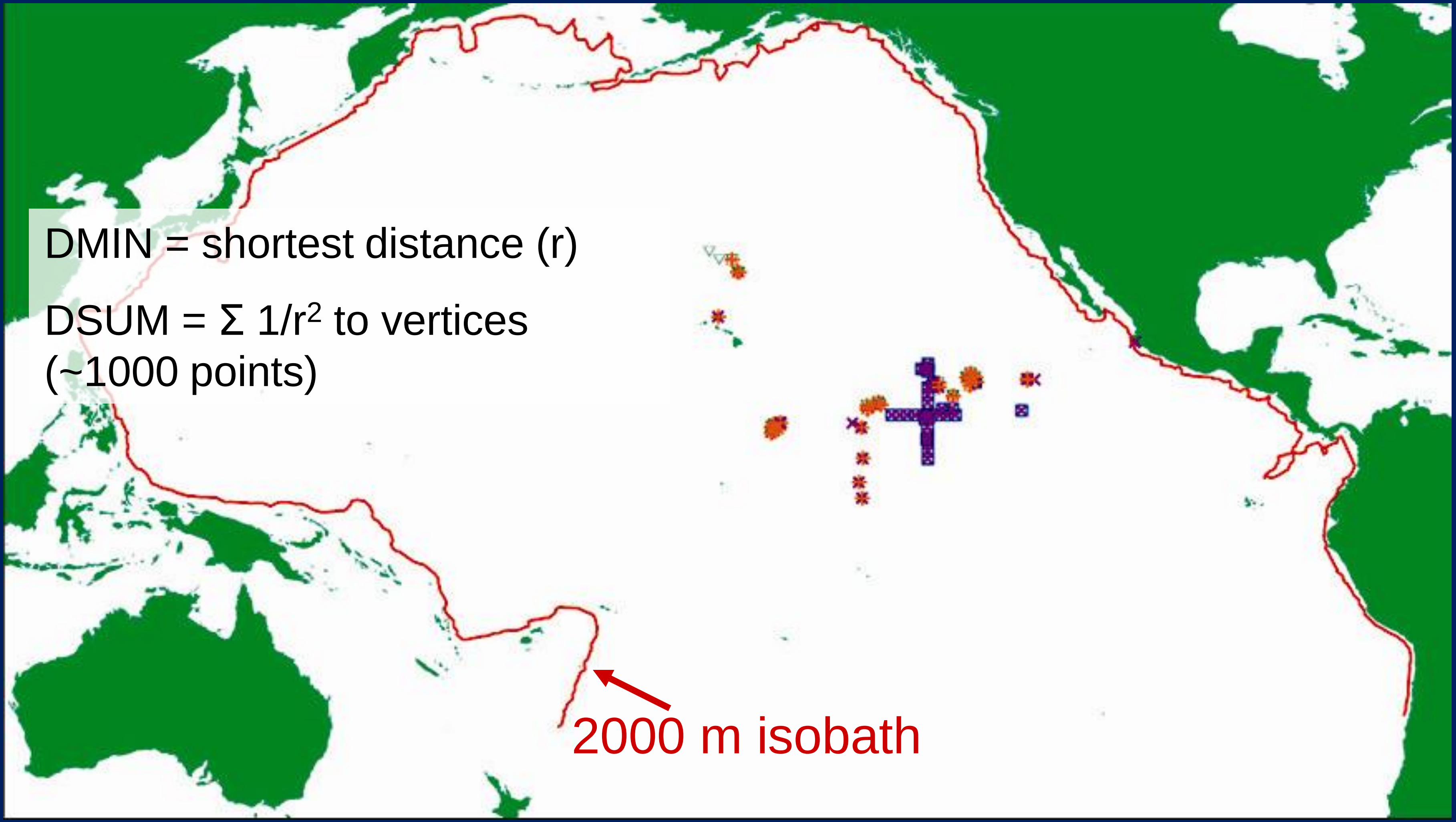


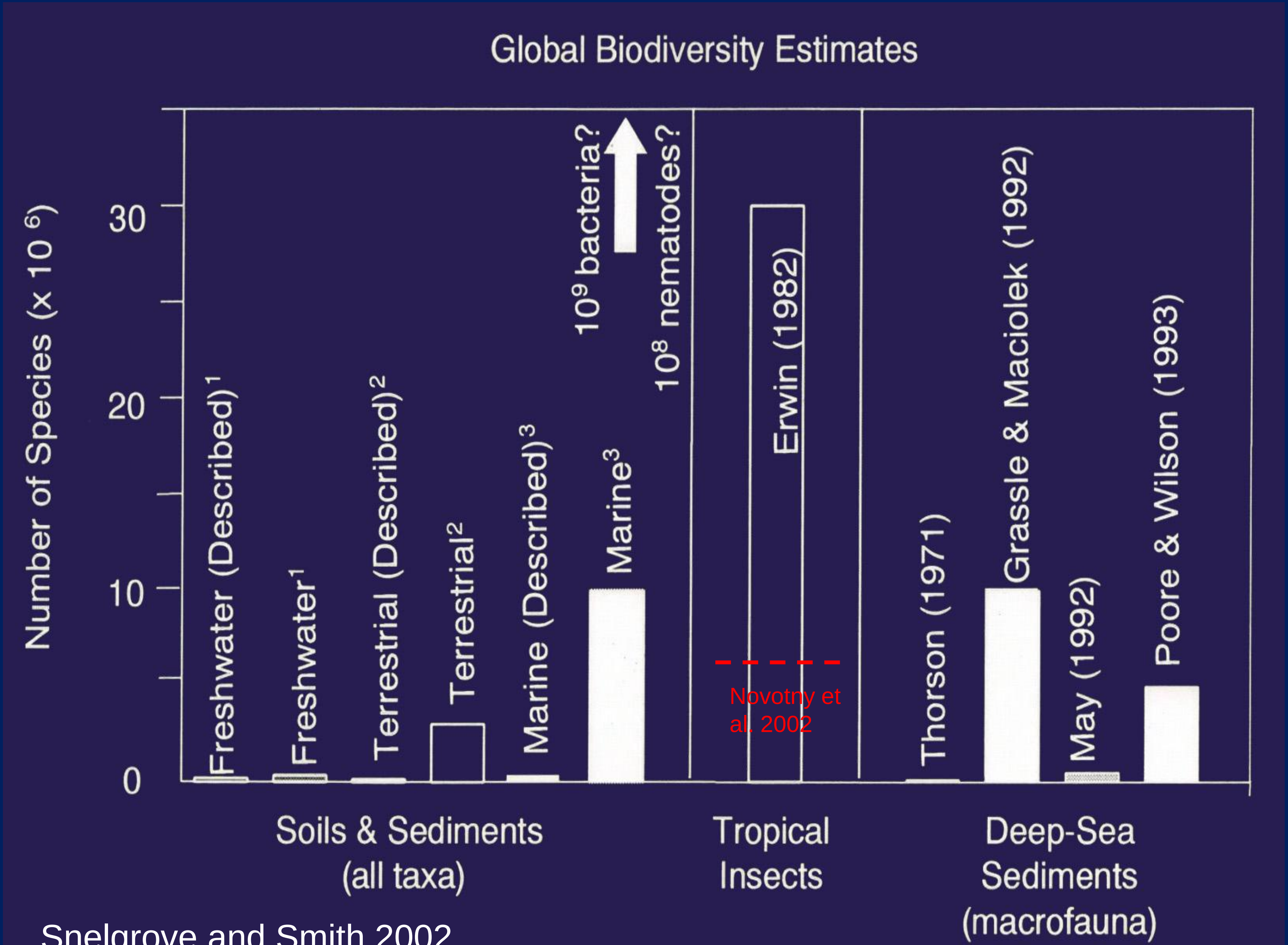
Fig. 2. Disturbed area. Densities (Ind. 10,000 m^{-2}): arithmetic mean, minimum–maximum range and N, the number of records used.

- Redeposited layer low in food quality (Fukushima & Kuboki, 2000)

Are faunal densities in the abyss a function of distance to the slope?



HIGH GLOBAL DEEP-SEA DIVERSITY?



Snelgrove and Smith 2002

Polychaete worms – broad range of repro. strategies

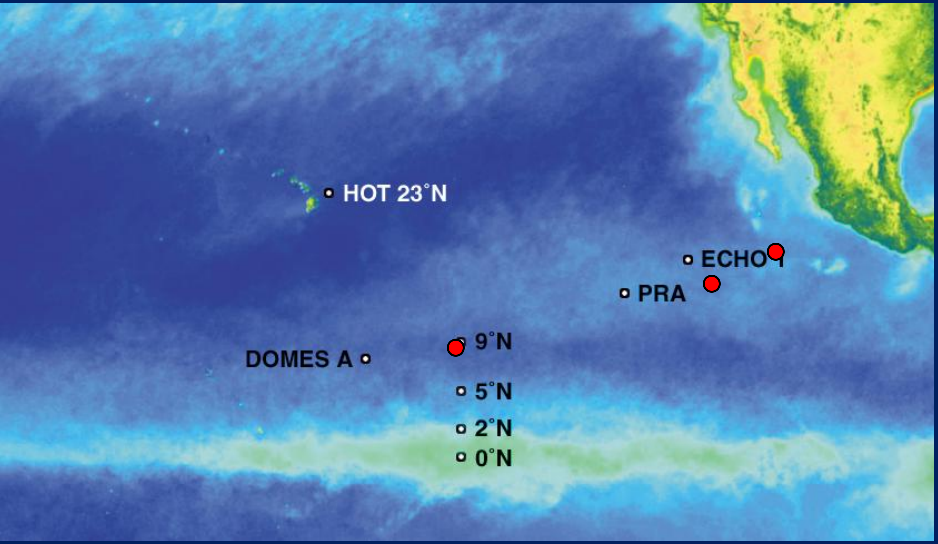
1) >200 species from single deep-sea regions – global richness??
(e.g., Glover et al., 2001, 2002)

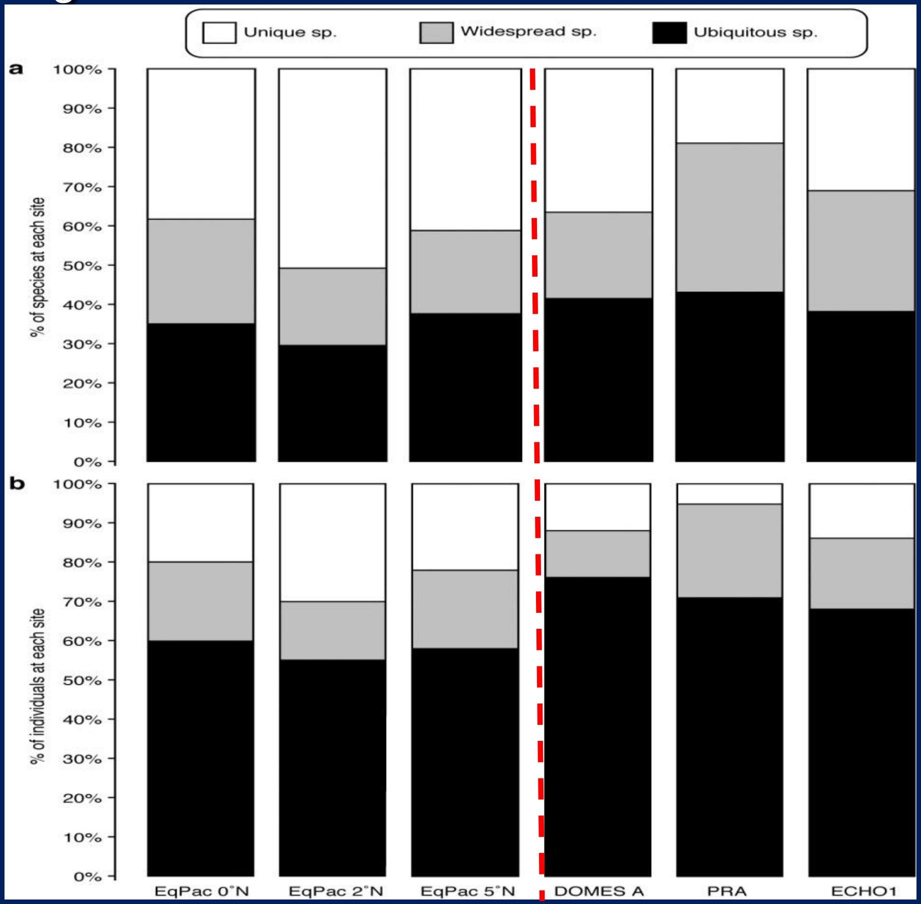
2) Abyssal endemics? - likely, but taxonomy poorly known (>90% undescribed)

3) Some abyssal species could be cosmopolitan – __Aurospio dibranchiata__

(Glover, Mincks, Paterson, Smith – unpublished data)

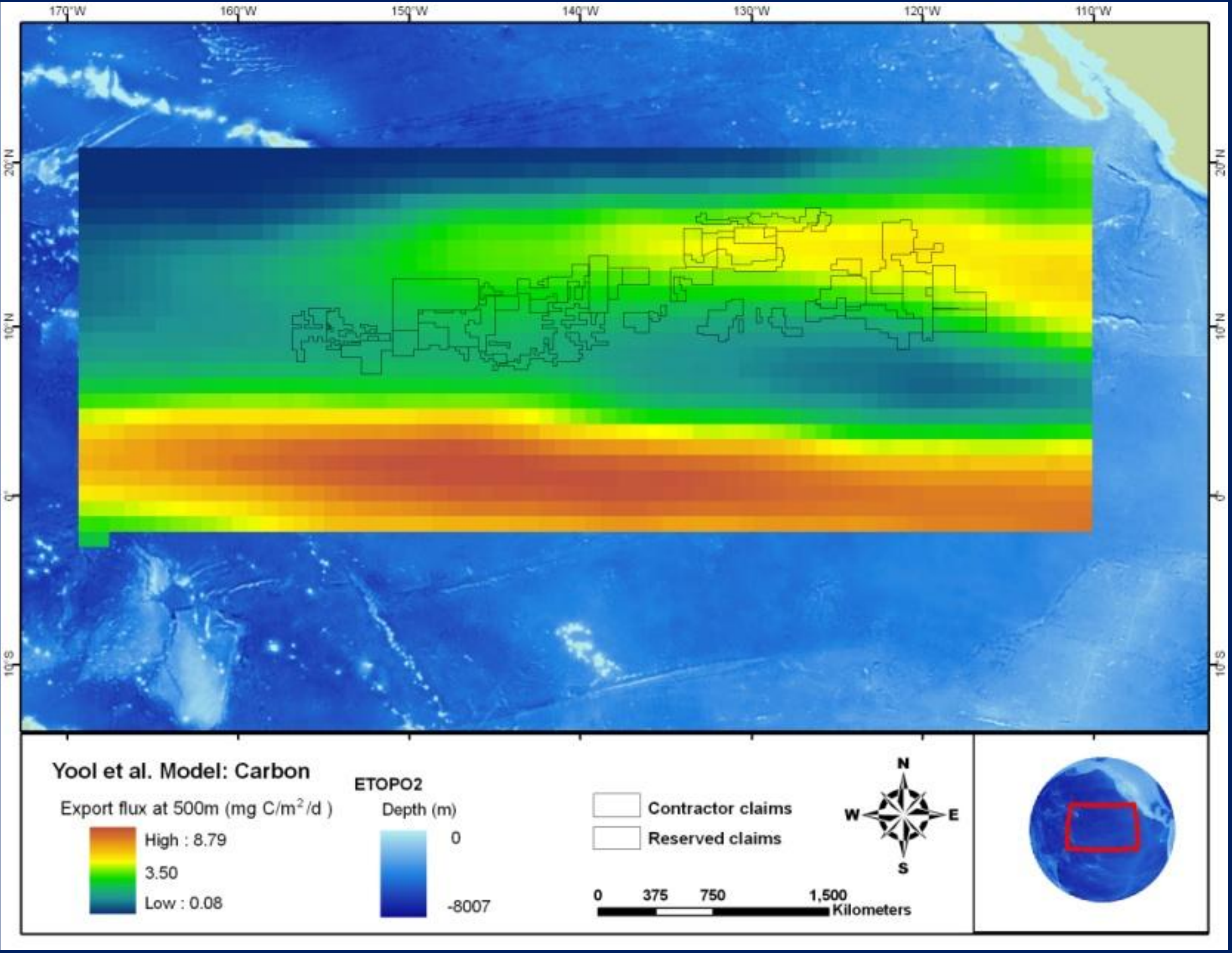
4) Species turnover over 500-1000 k seems high – 20-50% endemism?





May be due to very poor sampling - most species are rare and at no site is species accumulation asymptote approached

Glover et al., 2002


170°W
160°W
150°W
140°W
130°W
120°W
110°W
20°N
10°N
0°
10°S
Yool et al. Model: Carbon
Export flux at 500m (mg C/m²/d)
High : 8.79
3.50
Low : 0.08
ETOPO2
Depth (m)
0
-8007
Contractor claims
Reserved claims
N
W
E
S
0
375
750
1,500
Kilometers

General goals for Marine Protected Areas (also called Preservation Reference Areas = PRA) in region targeted for nodule mining (Clarian-Clipperton Fracture Zone):

1. Protect 30-50% of management area (CCFZ).

2. Each MPA should capture full range of habitat variability (all types of nodule fields, sediment plains, seamounts, scarps, etc.).

3. Each MPA should capture minimum viable population sizes for most components of the fauna to "ensure persistence of representative fauna" (core area 200 km x 200 km).

4. Replicate MPAs across the region to capture N-S and E-W turnover of biota (forced by gradients in primary productivity).

5. Make each MPA large enough that core region is buffered from impacts of mining, e.g., mining sediment plumes (buffer zone of 100 km).

6. Integrate MPAs into existing ISA framework of mining claims, without compromising scientific principles.

7. Straight line boundaries.