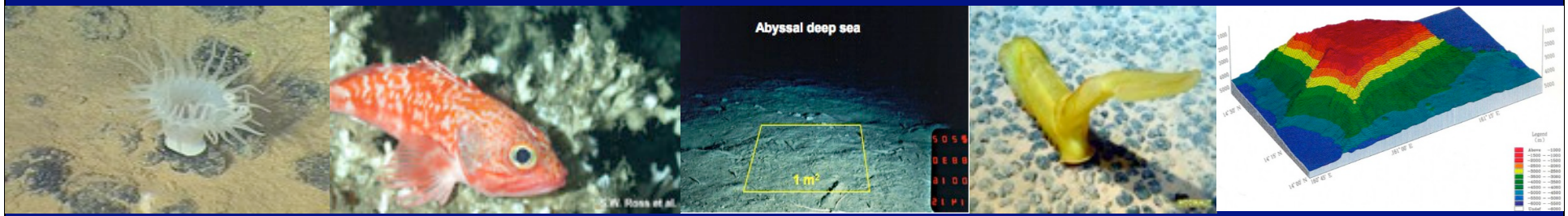
Integrating geomorphological, biological, & human dimension information in GIS to aid in the design of deep sea MPAs



AAG Marine Geomophology Session
April 2009

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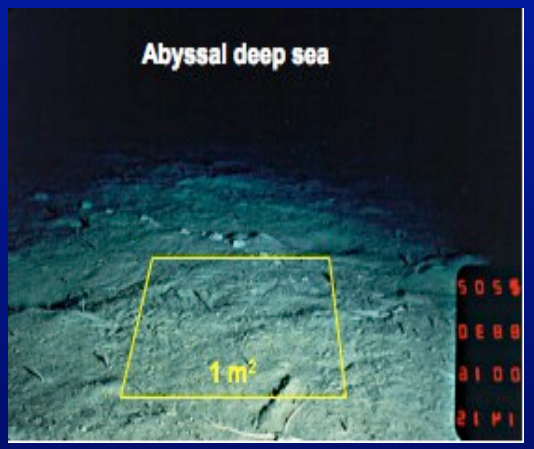
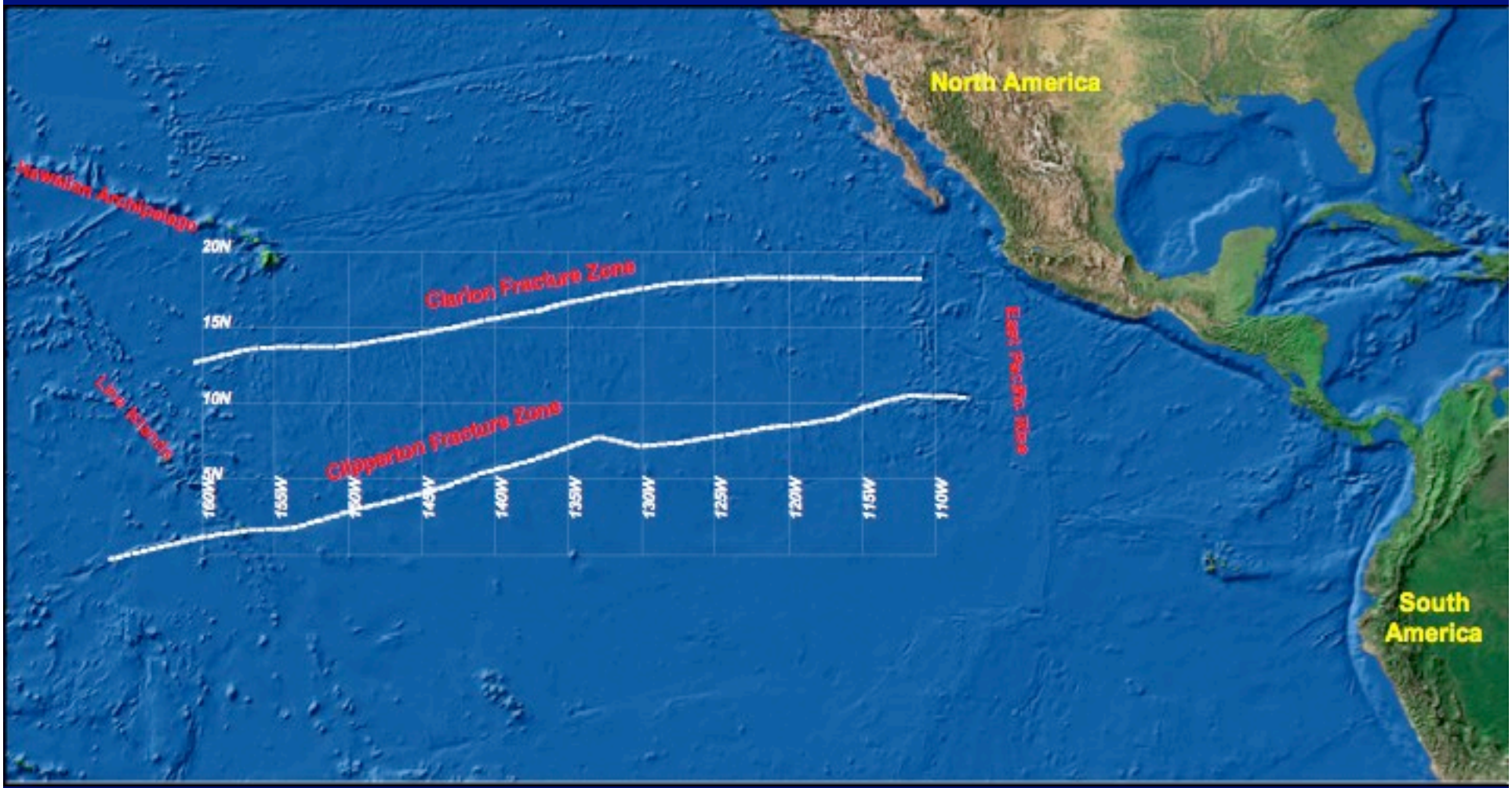
Presentation Outline

- Intro: Clarion-Clipperton Fracture Zone study area
- Research Objectives
- Background: Deep sea ecosystems
  - Value, threats & marine policy in the abyssal Pacific
- Using GIS to cite deep sea MPAs
  - Methods and spatial approach
- Evaluation and discussion
  - Key findings and policy recommendations



Clarion - Clipperton Fracture Zone (CCZ)



Goal and Objectives:

Overall Goal:

Design a set of MPAs to safeguard biodiversity & ecosystem function in abyssal Pacific region (CCZ)

Objective 1:

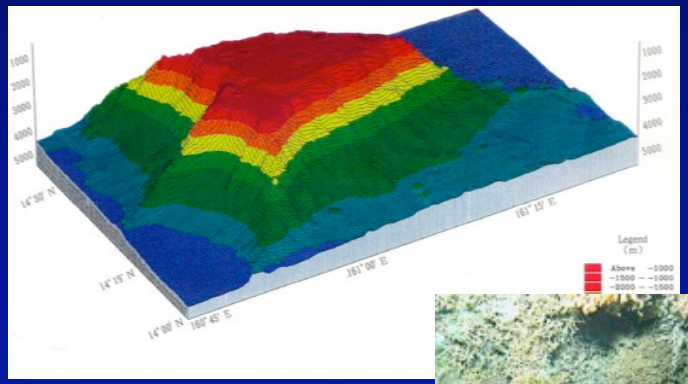
Integrate oceanographic, geological, biological, and human dimension into a GIS database to provide spatially explicit decision support

Objective 2:

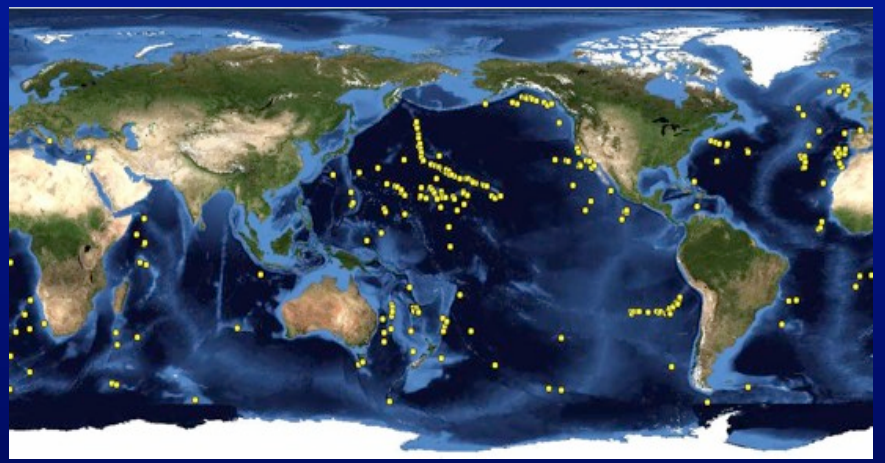
Provide a set of MPA design scenarios and recommendations to the International Seabed Authority

Deep Sea Ecosystems: Seamounts

- Seamounts provide a range of depths and habitats for different biological communities

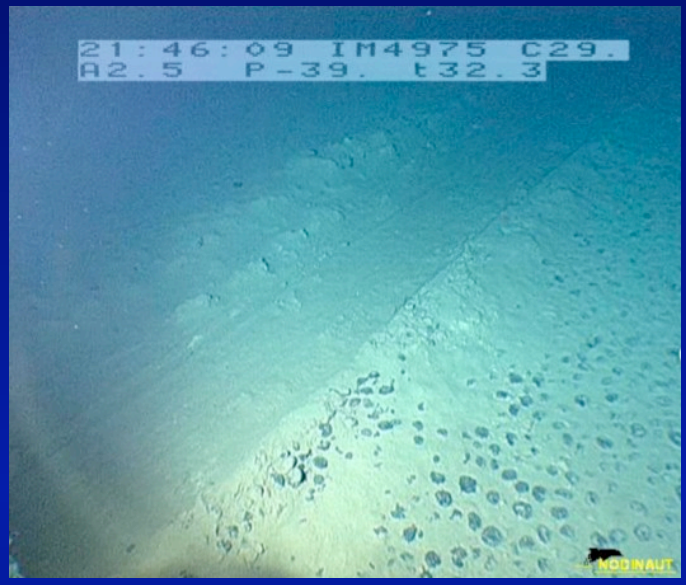


- Seamounts are important & unique marine ecosystems
  - High level of biodiversity
  - High endemism due to geographic isolation
  - Form critical habitat for fish spawning aggregations
  - Sensitive to fishing extraction and impacts from mining



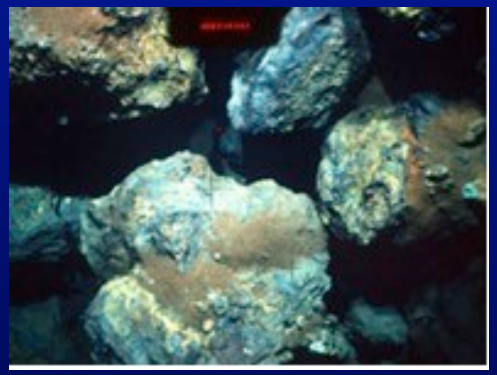
Deep Sea Ecosystems: Abyssal Plains

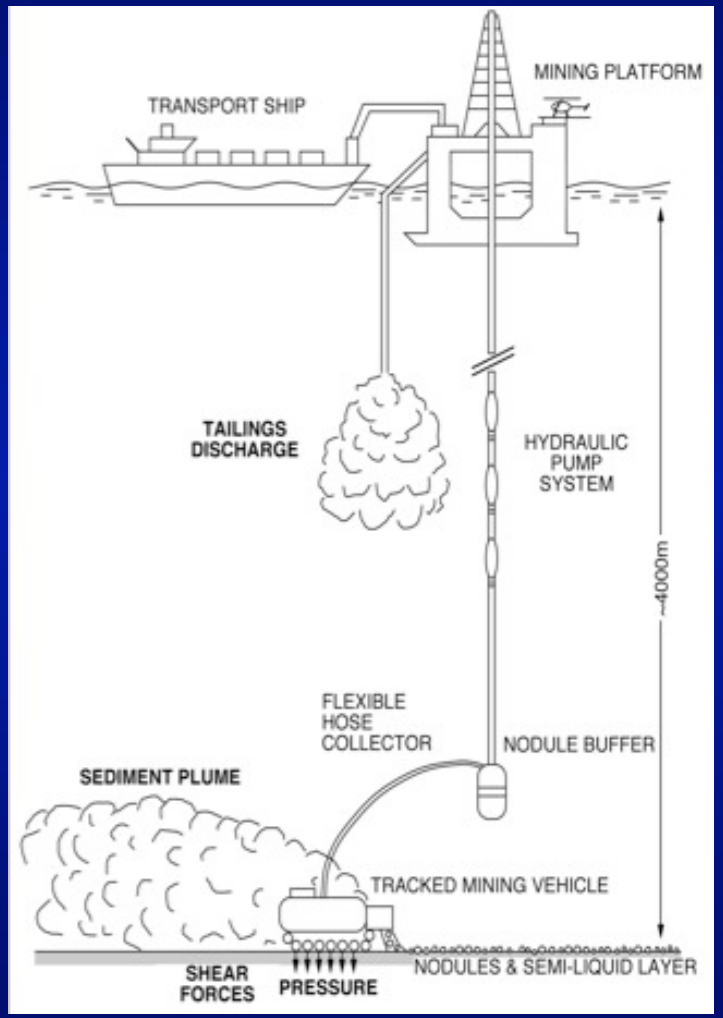
- Abyssal zone (3000-6000 m)
  - covering 54% of Earth's surface
- Abyssal plains of soft bottom sediment
  - Local biodiversity in abyssal plains can be high
- Hard substrates (manganese nodules) support distinct biological assemblages from sediment community



Threats to Deep Sea Environments

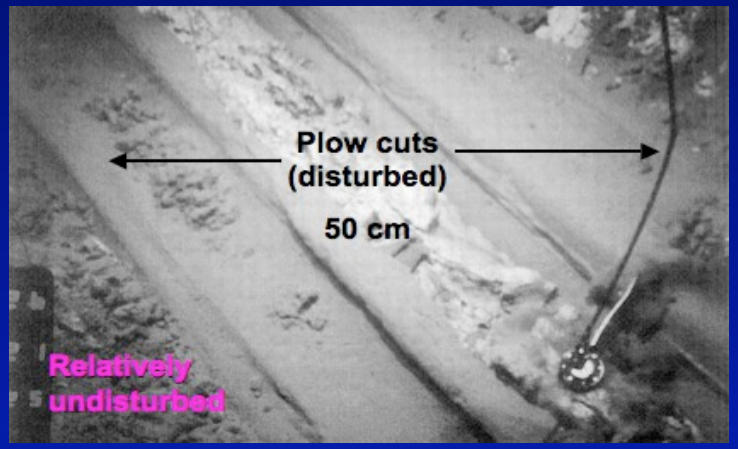
- Targeted for fishing activities (e.g. bottom trawling)
- Seafloor mining of crusts and nodules are increasing as the demand for industrial metals & metals prices rise worldwide
- Seamounts also occur in the regions targeted for nodule mining will be impacted by mining plumes
  - redeposition from sediment plumes 10-100 km from mining site



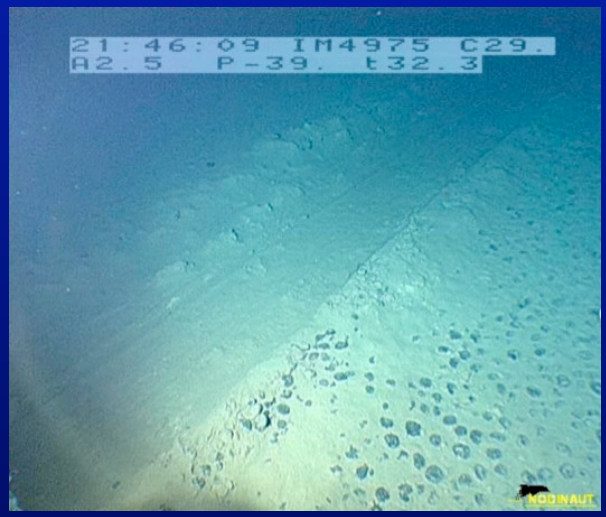


Threats: Abyssal nodule mining

- Abyssal nodule mining affects seafloor due to direct mining disturbance



- Benthic ecosystem recovery from mining impacts will be very slow
  - decades for the soft-sediment fauna
  - thousands to millions of years for the biota specializing on manganese nodules

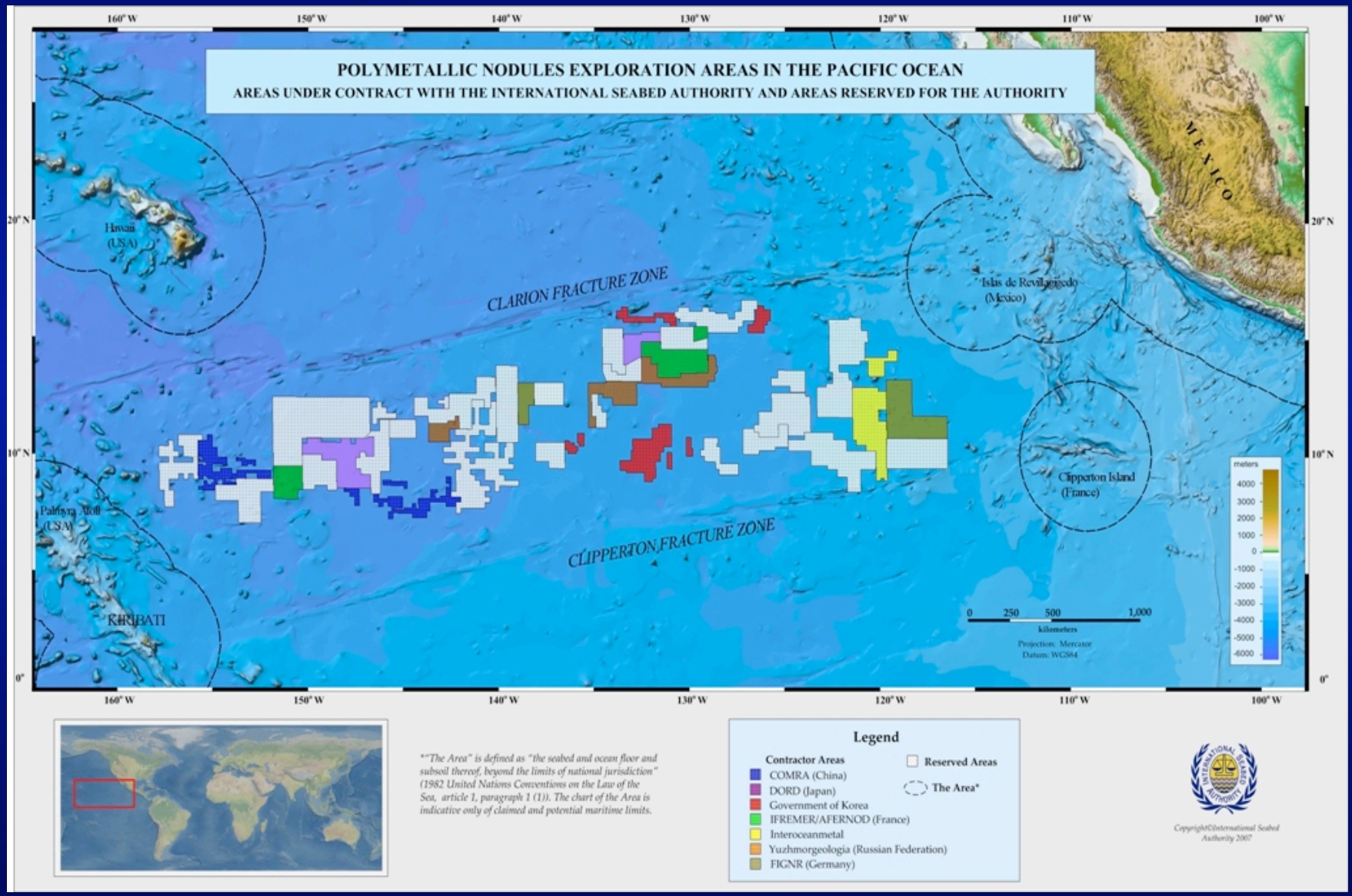


- Slow ecosystem recovery rates will cause significant mining impacts in CCZ

Spatial Management of CCZ International Seabed Authority (ISA)

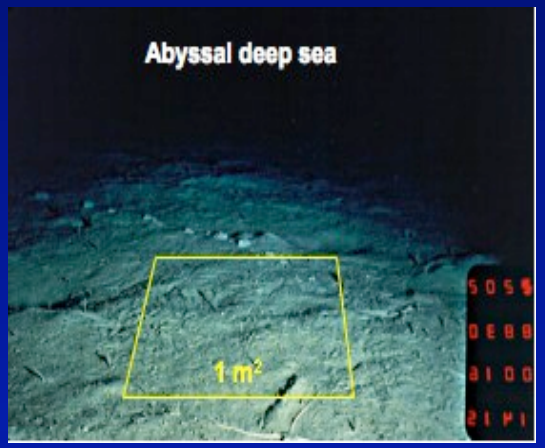
- ISA was established by UN Convention on the Law of the Sea
    - agreement relating to deep-sea bed mining (1994)
- ISA manages and administers the mineral resources in the international marine areas

Seafloor mining claims in Clarion Clipperton Fracture Zone



MPA Designation Process under ISA

- A general framework was established under the ISA relating to protection of marine environment



Article 145 requires the ISA to take all necessary measures to <u>protect the environment</u> from

1) prospecting
2) exploration
3) mining

Article 162 in relation to mining, allows the ISA to <u>designate specific areas as off-limits</u>

- ***In ISA rules MPAs must be established***

Guidelines for ISA protected area design in CCZ

(Smith et al. 2008, based on UH workshop)

1) MPA design should fit into the existing legal framework of the ISA

2) The interests of all stakeholders will be incorporated into process

3) The MPA system is designed to preserve biodiversity, representative habitats and facilitate management of mining activities

4) The CCZ region should be divided into strata (9 subregions)

5) The boundaries of MPAs should be straight lines

6) The core area of MPAs should be at least 200 km^2
   - large enough to maintain min. viable pop. sizes for species

7) Each MPA should protect a full range of habitat types

8) Each MPA core area surrounded by buffer zone (100-km wide)
   - to insure that the PRA core is not affected by mining plumes

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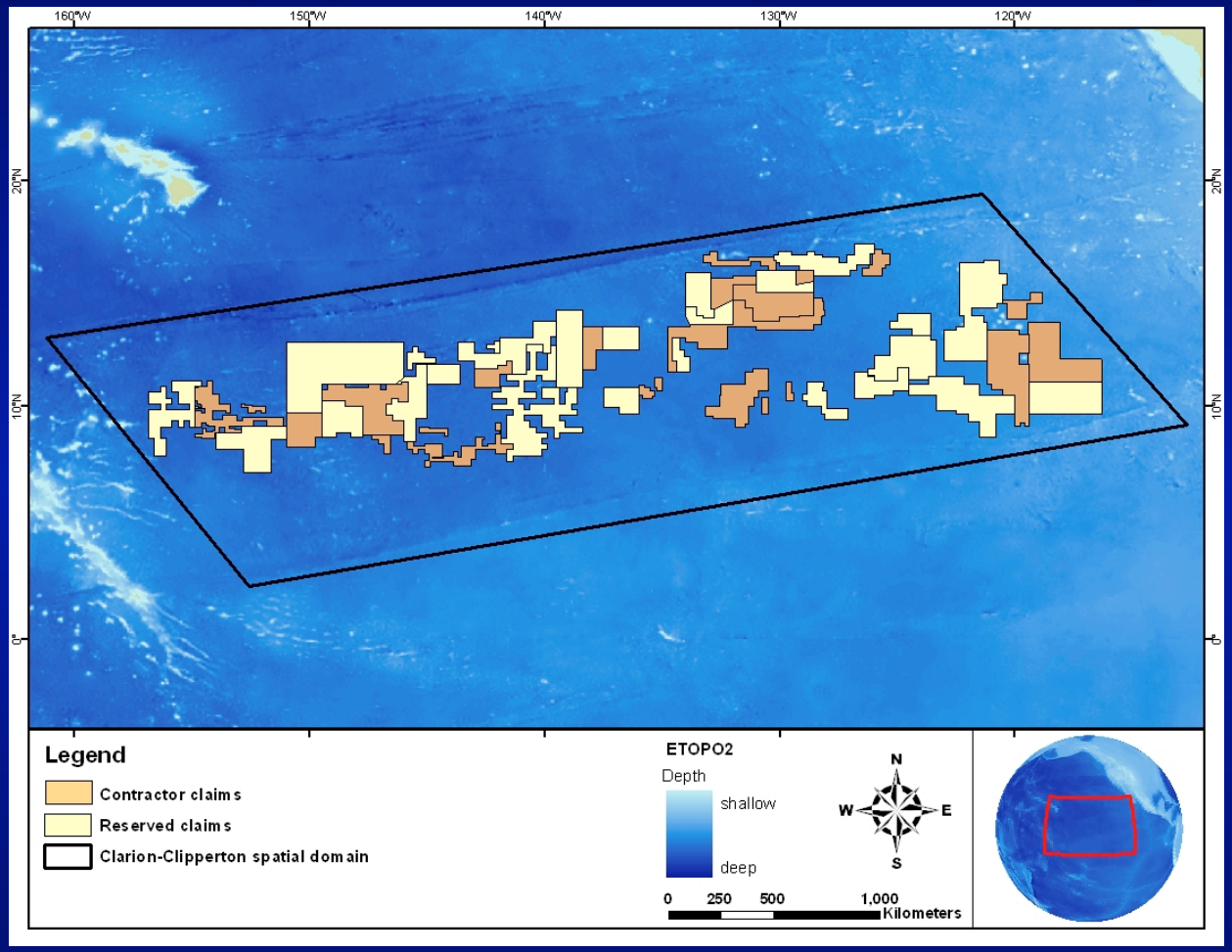
Spatial Data for GIS based MPA Design

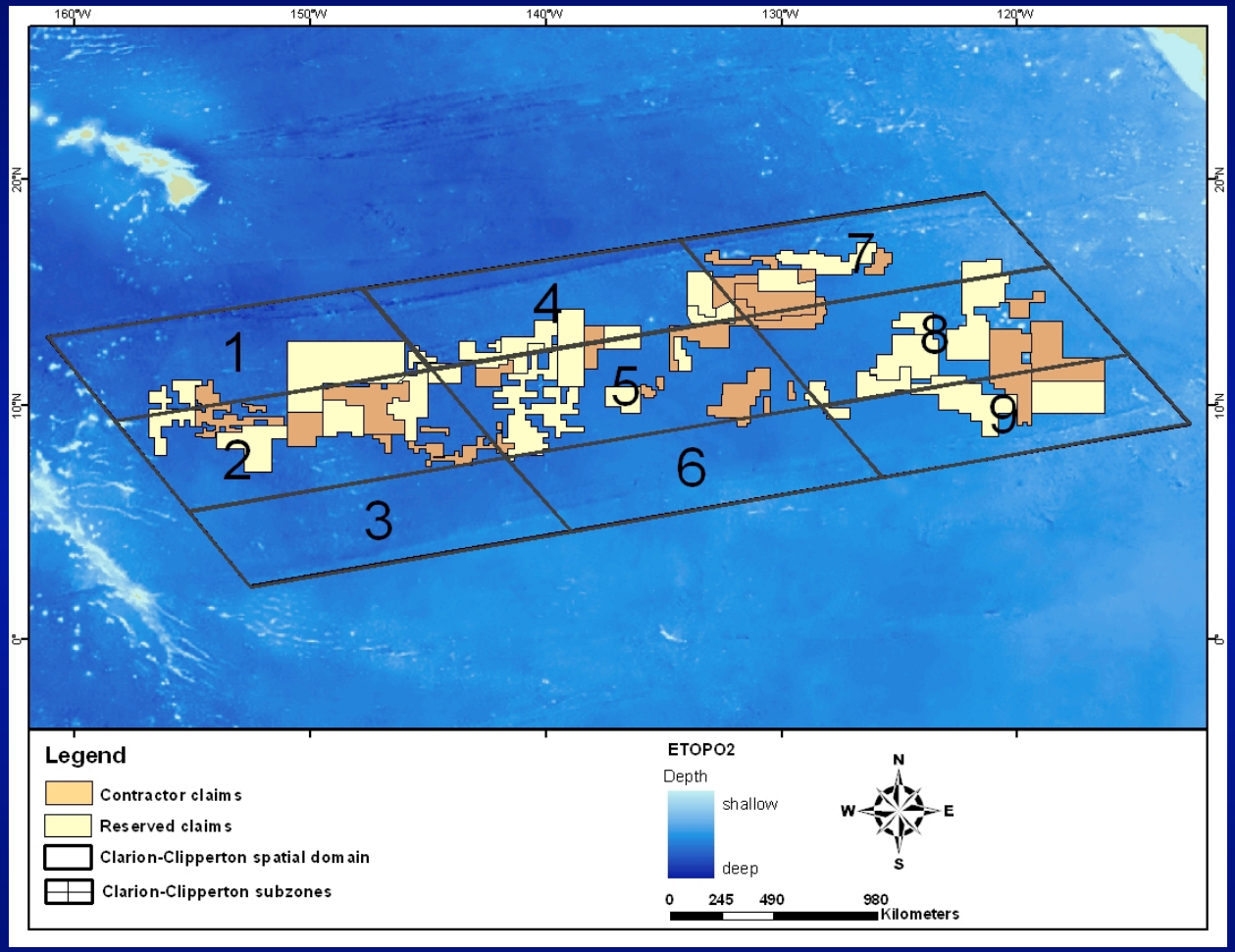
GIS Data Sets	Units	Strata
Mining claims	km^2	Contractor Reserved
Seamounts	m	<200 m 200-1000 m 1000-2000 m > 2000 m
Nitrogen flux	mmol N cm^{-2} d^{-1}	100 m 200 m 500 m
Bathymetry	m	
Polymetallic nodule abundance	kg m^{-2}	
EEZ	km^2	
Macro invertebrate abundance		

GIS Data Sets: Bathymetry (ETOPO 2) & Mining Claims



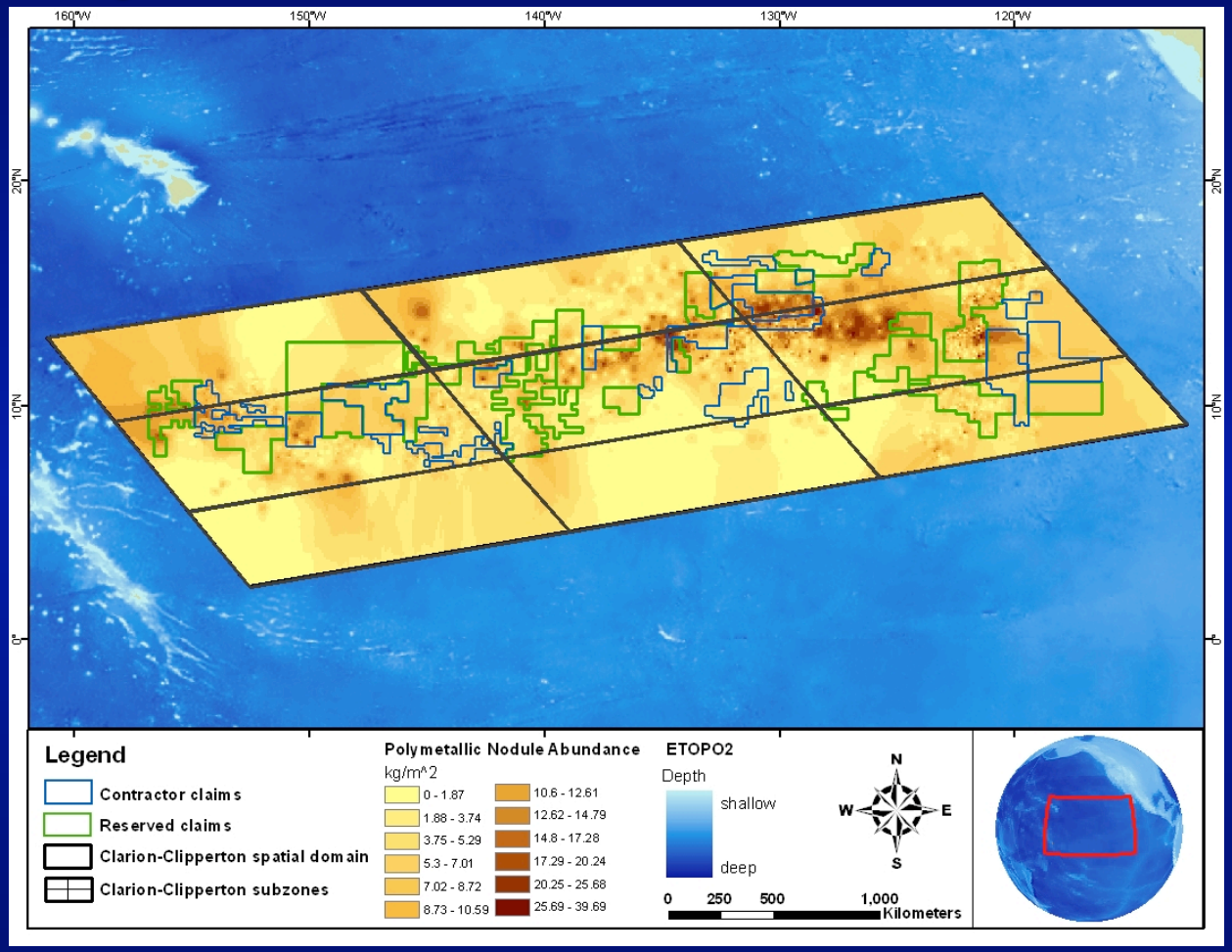
- International Sea Bed Authority administers mineral resources
- Claims: China, Japan, Korea, France, Germany, Russian Federation, Interoceanmetal Joint Organization, ISA Reserved Areas

GIS Data Set: CCZ and Subzones



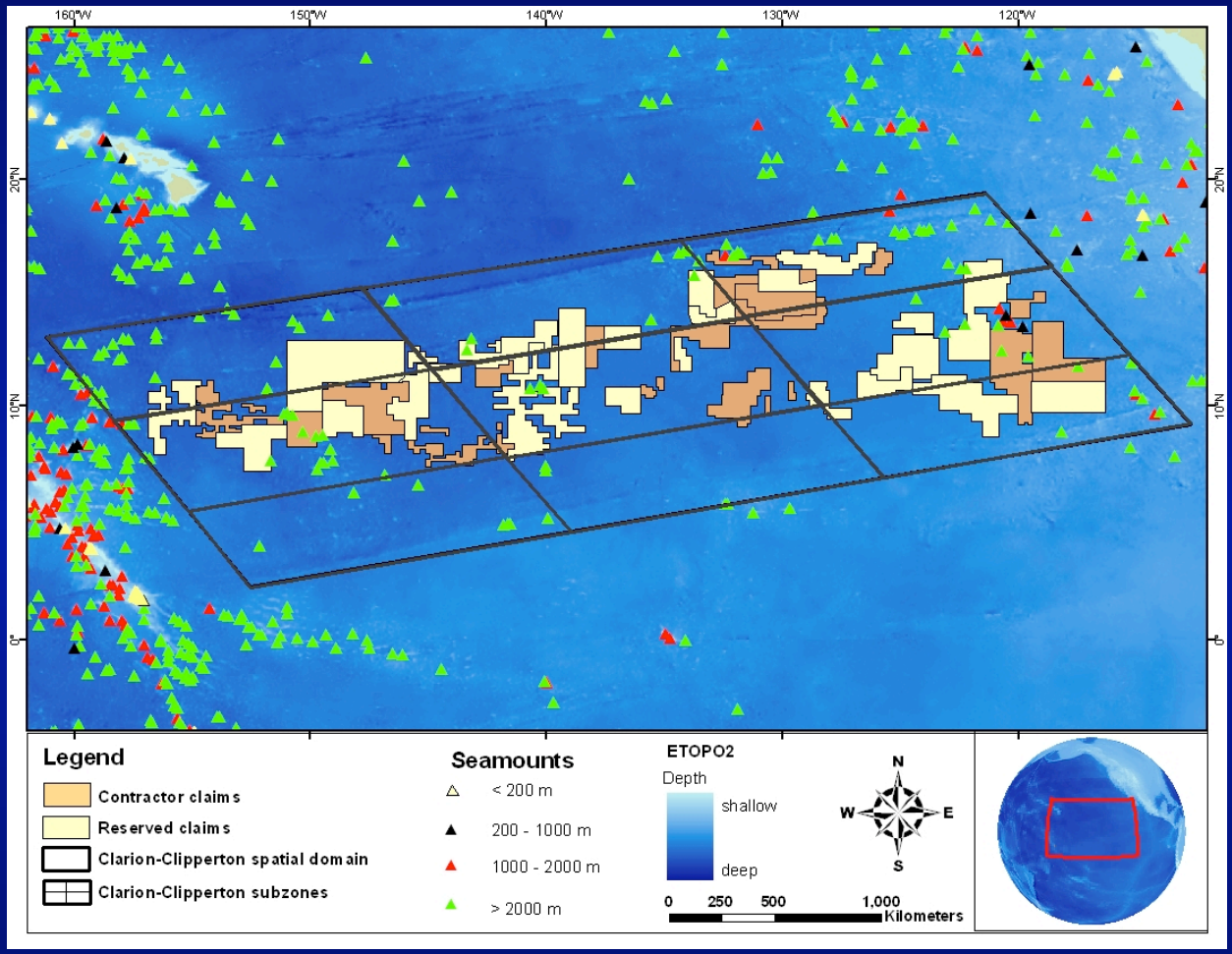
- The CCZ region should be divided into strata (9 subregions)
- Protect representative biogeographic zones across an oceanographic gradient of productivity

GIS Data Set: Polymetallic Nodule Abundance



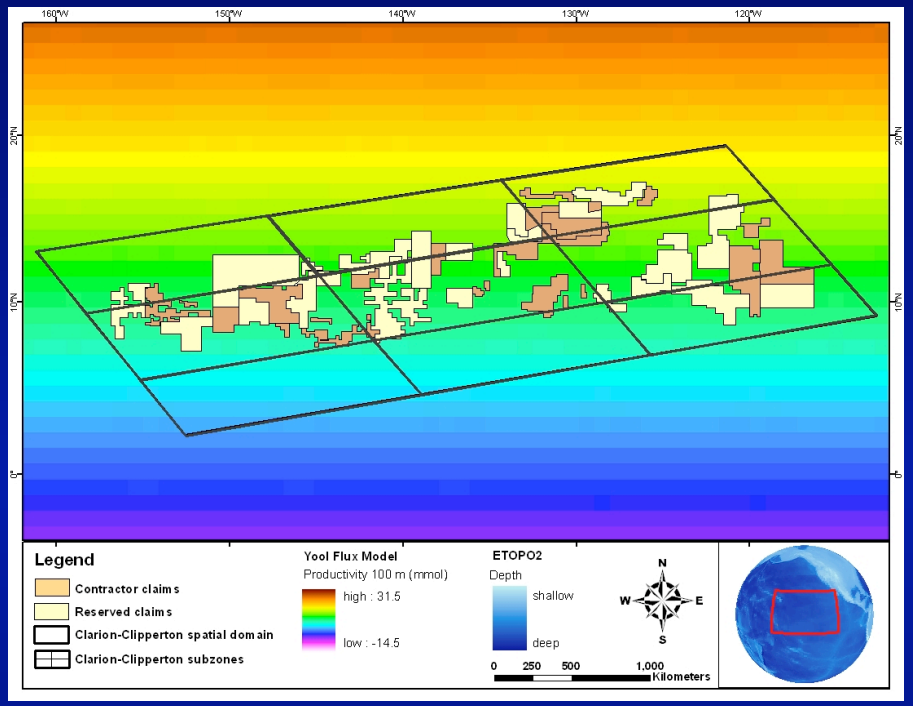
- Data set represents nodule abundance based on oceanographic surveys in CCZ

GIS Data Set: Seamounts

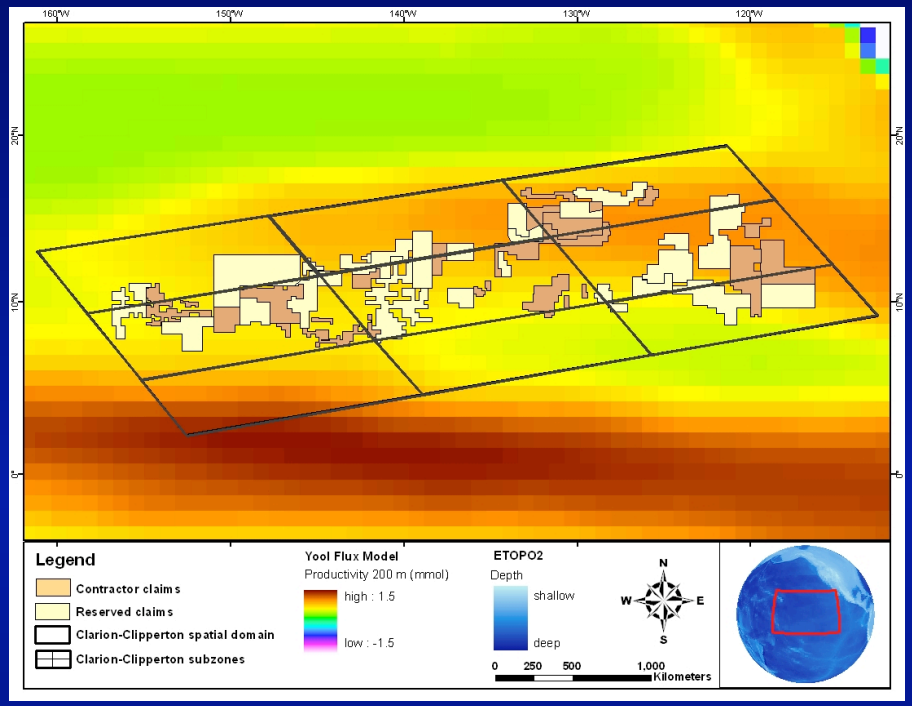


- Goal to protect a high number of seamounts in each MPA to protect against impacts from mining plumes
- Seamount data layer: <200 m 200-1,000 1,000-2,000 >2,0000

GIS Data Set: Seamounts



Productivity (100m)



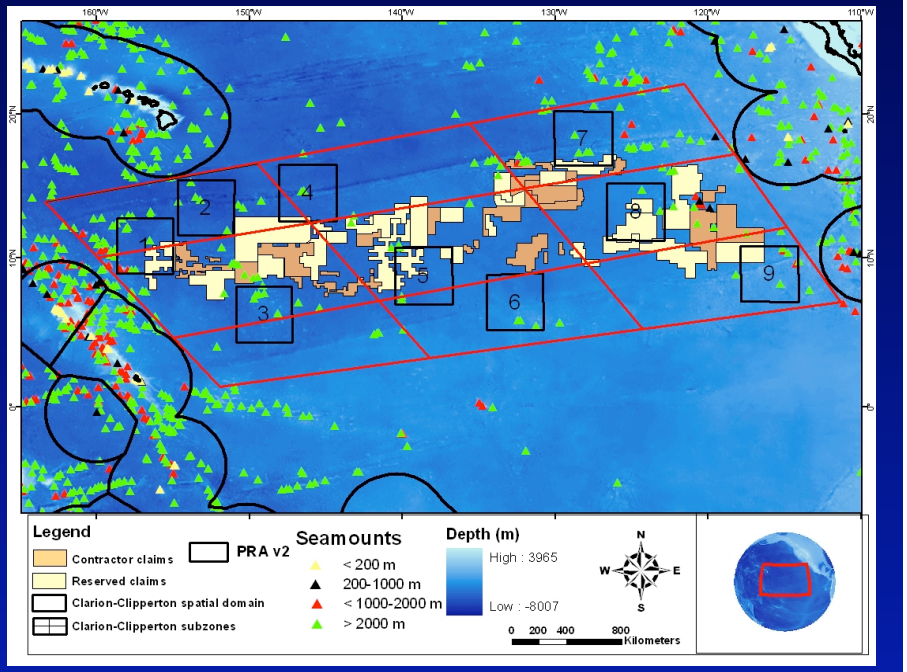
Productivity (200 m)

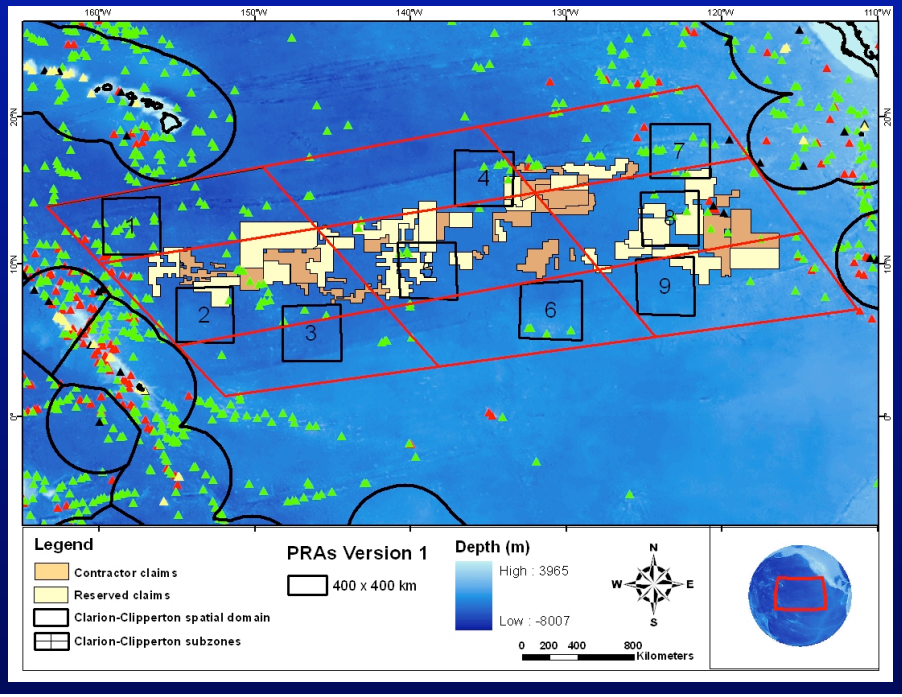
- Productivity data sets represented by nitrogen flux (mmol N cm^{-2} d^{-1})
- 100, 200 and 500 m data sets, productivity varied greatly with depth
- Strong productivity driven gradients in ecosystem structure

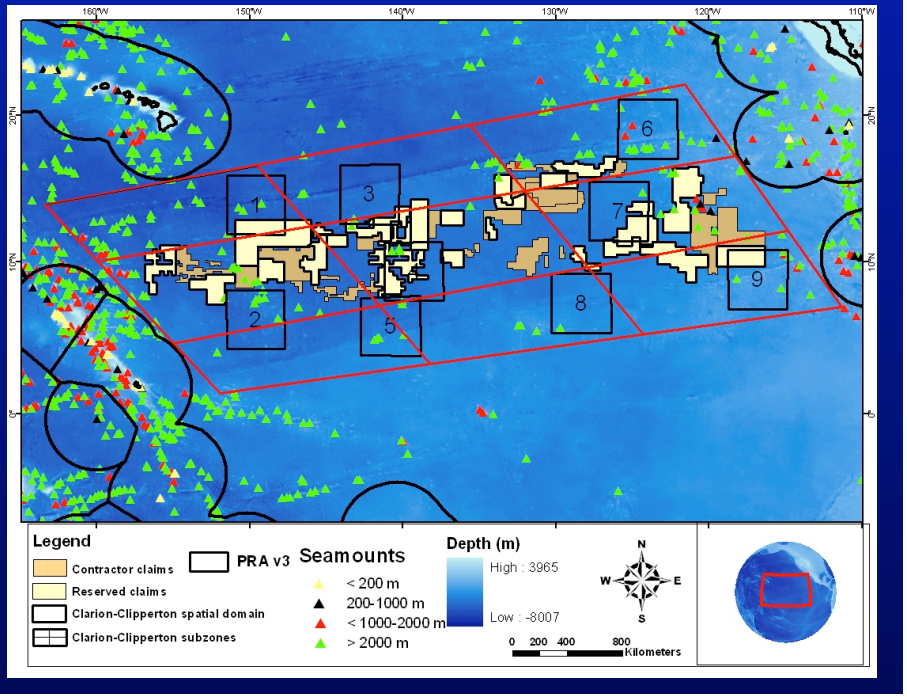
MPA design scenarios:

- workshop created 3 MPA design scenarios & submitted recommendations to ISA for review in Fall 2008

- GIS analysis used to summarize the # of seamounts, depth ranges, habitats, nodule abundance and productivity in each MPA







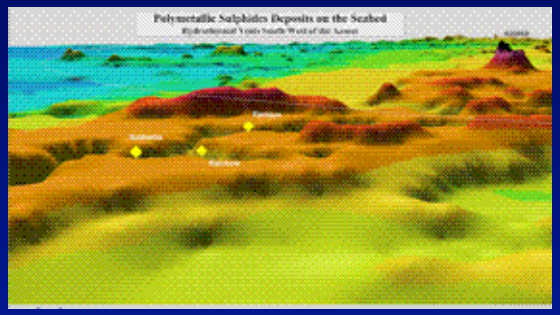
Results of GIS analysis

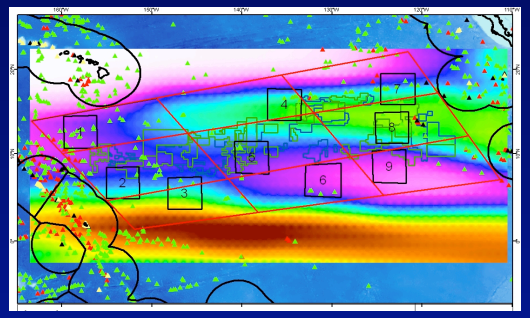
- The CCZ region was divided into 9 subregions in GIS
  - No overlap with EEZ or mining claims (*EEZ, ISA claim*)
- Simple boundaries were created
  - GPS points for implementation and enforcement
- MPA core area were created at 200 km^2
  - With 100 km^2 buffer zone to address affects of mining plumes
- Each MPA protected a full range of habitat types (e.g. abyssal plains, abyssal hills, seamounts and fracture zones)
  - Greatest number of seamounts in MPA (*seamount*), and full range of depths (*ETOPO 2*)
  - Network of protected areas across a gradient of productivity (*Nitrogen flux*)

Presentation Summary

- First International deep-sea MPA proposed
- Proposed 9 interconnected MPAs covering 1.44 million km^2
- MPAs represent forms of spatial management & a GIS approach provides powerful support to the MPA design process

Conclusion: Utility of a Spatial Approach to Management





- The way people view the ocean determines how we manage it
- Problem: if we see the ocean as homogenous w/o vulnerable areas or any spatial patterns of biota or human use
  - then ocean zoning does not seem important
- Mapping the complex mosaic of habitat types, environmental gradient & patterns of diversity helps us see that place matters in the sea
  - By identifying & placing value to heterogeneity at sea we begin to see the great value of specific areas for conservation
  - this understanding will allow us to create better MPAs & provide rationale for future conservation efforts

Norse (2008)