Linkages and connectivity of cold-water coral communities along the slope, canyons, and seamounts in the North Atlantic Ocean (an overview)

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EXPLORE

NSF

TRACES: *Trans-Atlantic Coral Ecosystem Study*

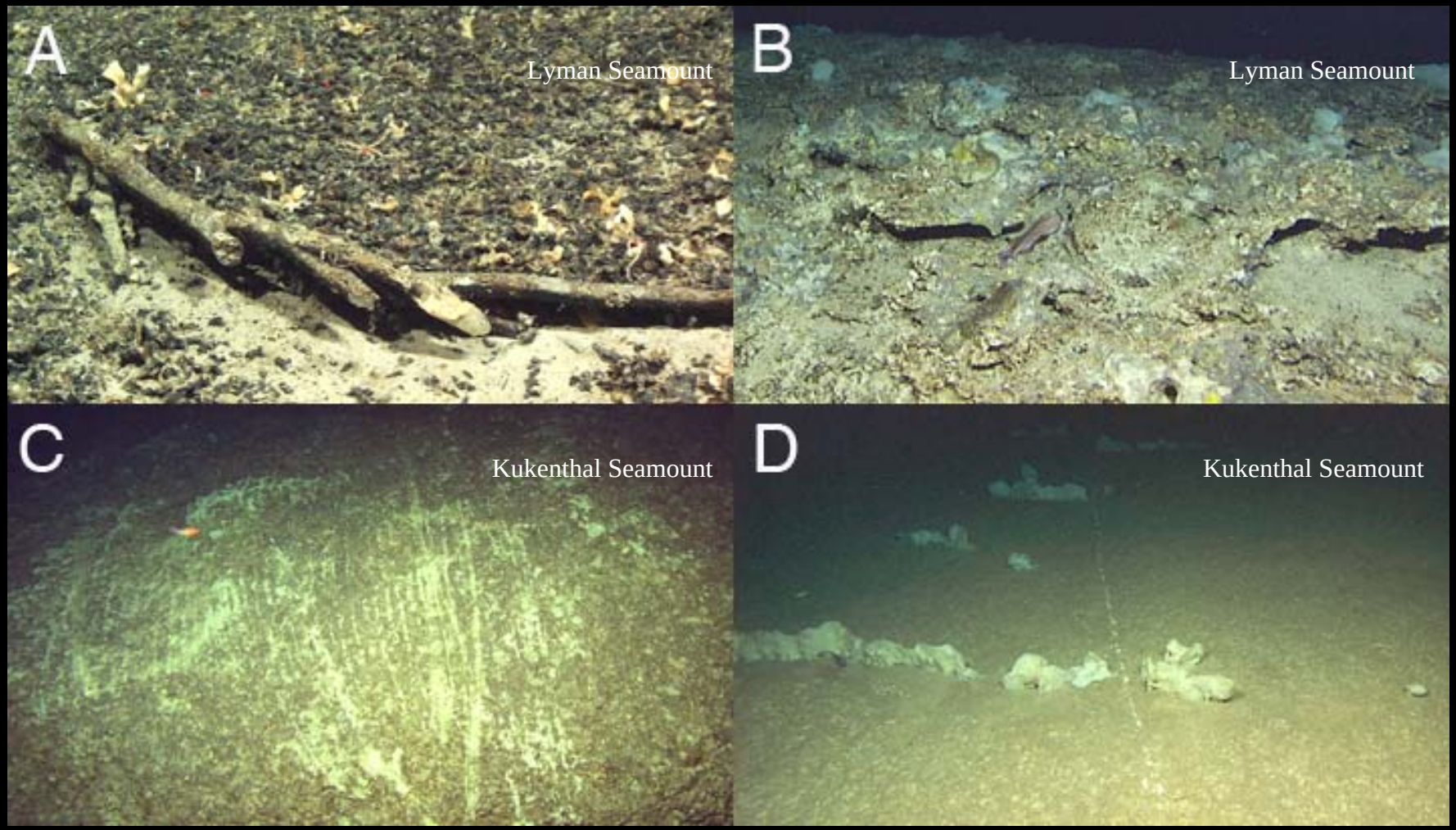
University of North Carolina WILMINGTON

Coral ecosystems are under increasing and unprecedented stress from human activities- leading to calls for new management approaches to counter anthropogenic impacts

Auster

Coral Communities and Habitat= resources and consequences

- Low productivity and and slow recovery rates make coral ecosystems vulnerable to disturbance (e.g., fisheries activities and mining)

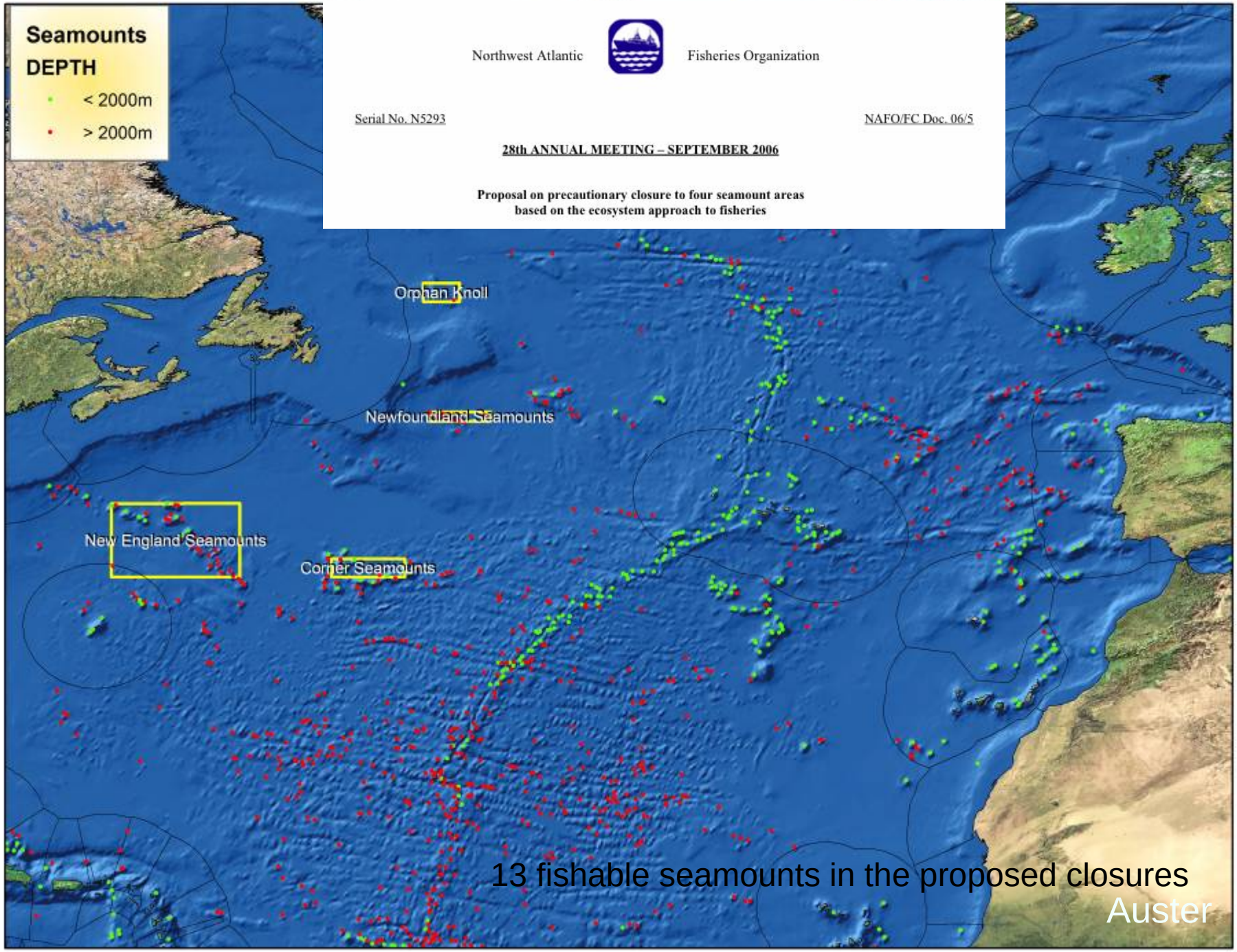


“Fisheries-related habitat damage” on the Corner Rise Seamounts (North Atlantic)

Exploitation (commercial recovery of minerals and fisheries):

- loss of habitat, prohibiting connectivity and reducing genetic diversity
- local, regional, or global extinction of endemic or rare taxa
- decreased diversity (all levels: genetic, species, phylogenetic, habitat)

All pictures taken with ROV Hercules (DASS05_NOAA_IFE). (Waller et al., 2007)


Seamounts
DEPTH
< 2000m
> 2000m
Northwest Atlantic
Fisheries Organization
Serial No. N5293
NAFO/FC Doc. 06/5
28th ANNUAL MEETING – SEPTEMBER 2006
Proposal on precautionary closure to four seamount areas based on the ecosystem approach to fisheries
Orphan Knoll
Newfoundland Seamounts
New England Seamounts
Corner Seamounts
13 fishable seamounts in the proposed closures
Auster

Policy Relevance and Drivers for Connectivity

"Connectivity plays the fundamental role in local and metapopulation dynamics, community dynamics and structure, genetic diversity and evolution, and resiliency of populations to human exploitation.

-Hastings and Harrison, 1994

"Understanding the 'connectivity' of marine populations is vital for conservation and fisheries management…the problem to be solved is the movement (and the controlling processes) of individuals and their contribution to the gene pool.

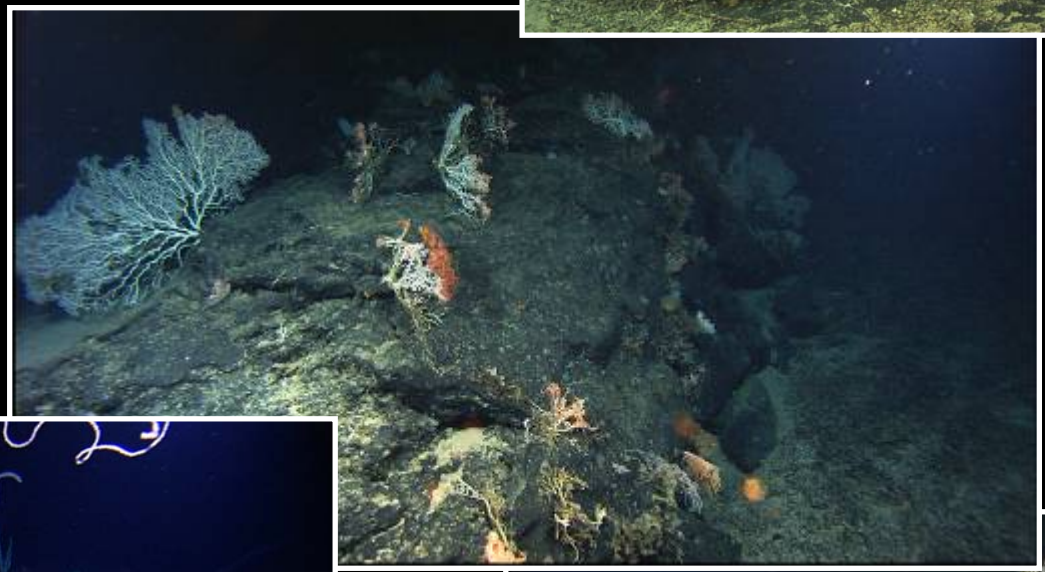
- Cowen et al., 2007

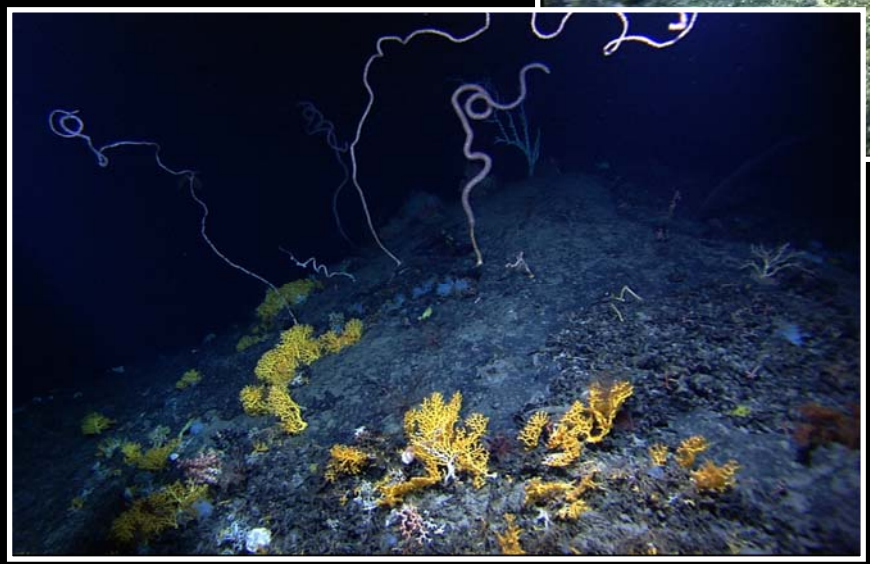
Population Connectivity-

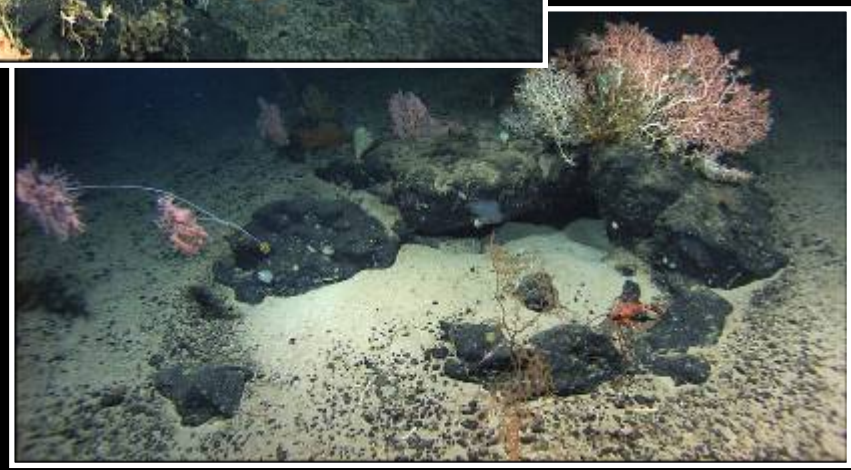
"the dispersal, survival, and reproduction of migrants, so that they contribute to the local gene pool"

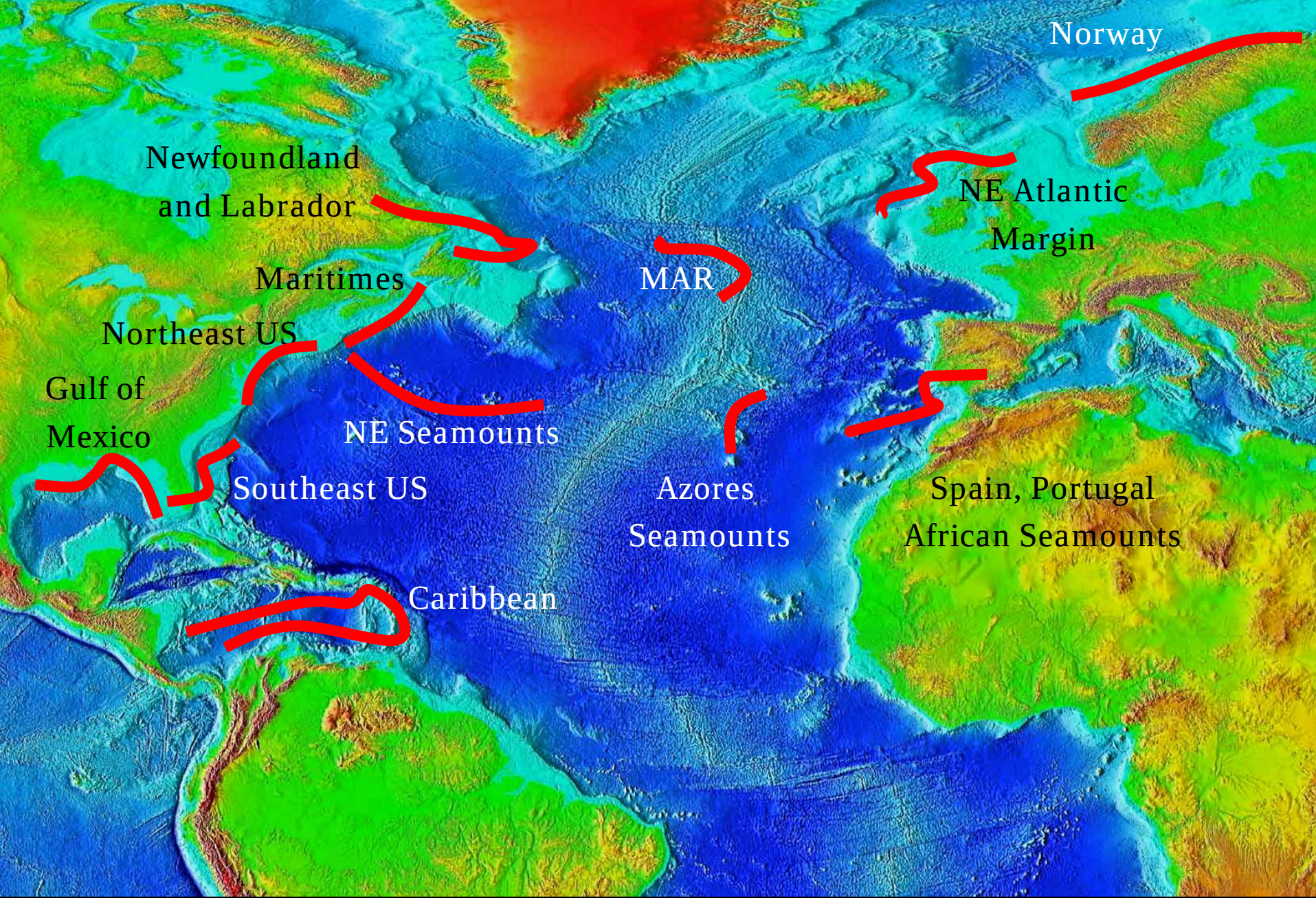
-Cowen et al., 2007

1. Linkages
2. Approaches
3. Challenges





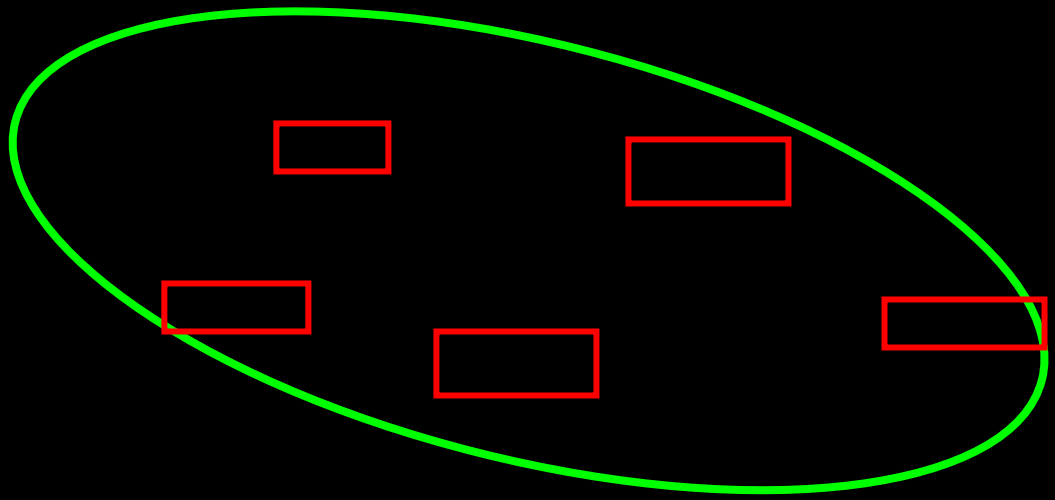




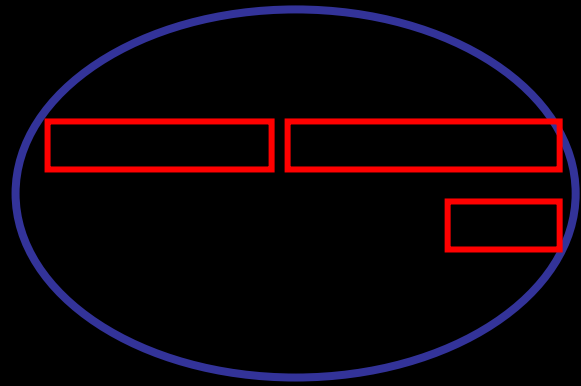
Cold water coral locations in the North Atlantic

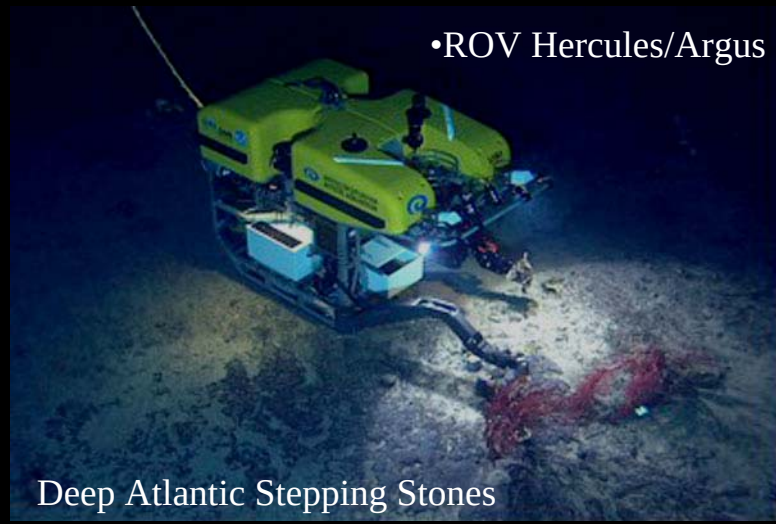
North Atlantic Seamounts

New England Seamount Chain



Corner Rise Seamounts



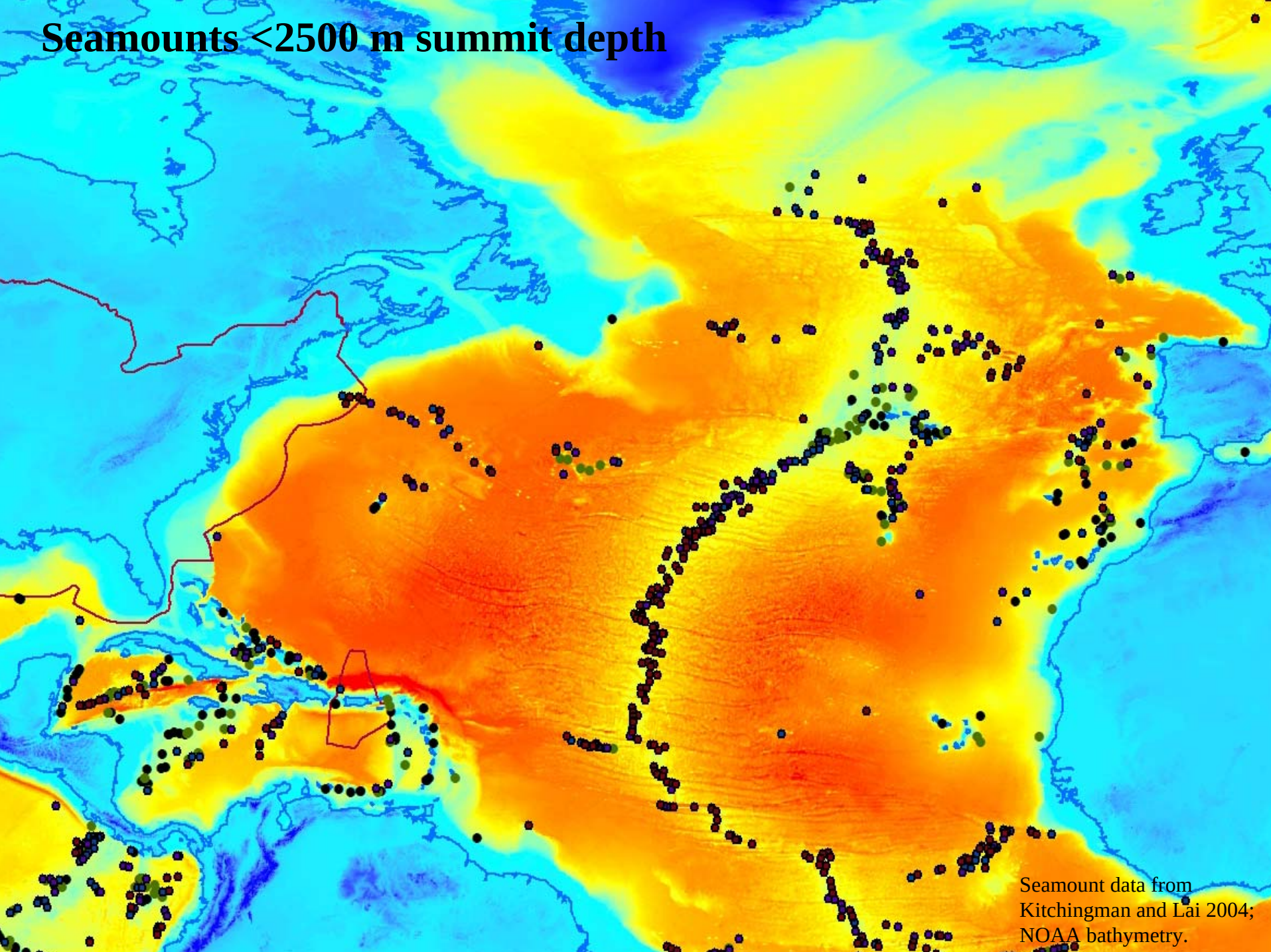


Quick Survey Summary of the New England and Corner Rise Seamounts

- Total of 61,714 observations
- 270 species, dominated by sponges, corals, echinoderms
- 60 species found only on the New England Smts
- 75 species found only on the Corner Rise Smts
- 135 species found at both the New England Smts & the Corner Rise Smts
- Host associate relationships- “facultative to obligate”

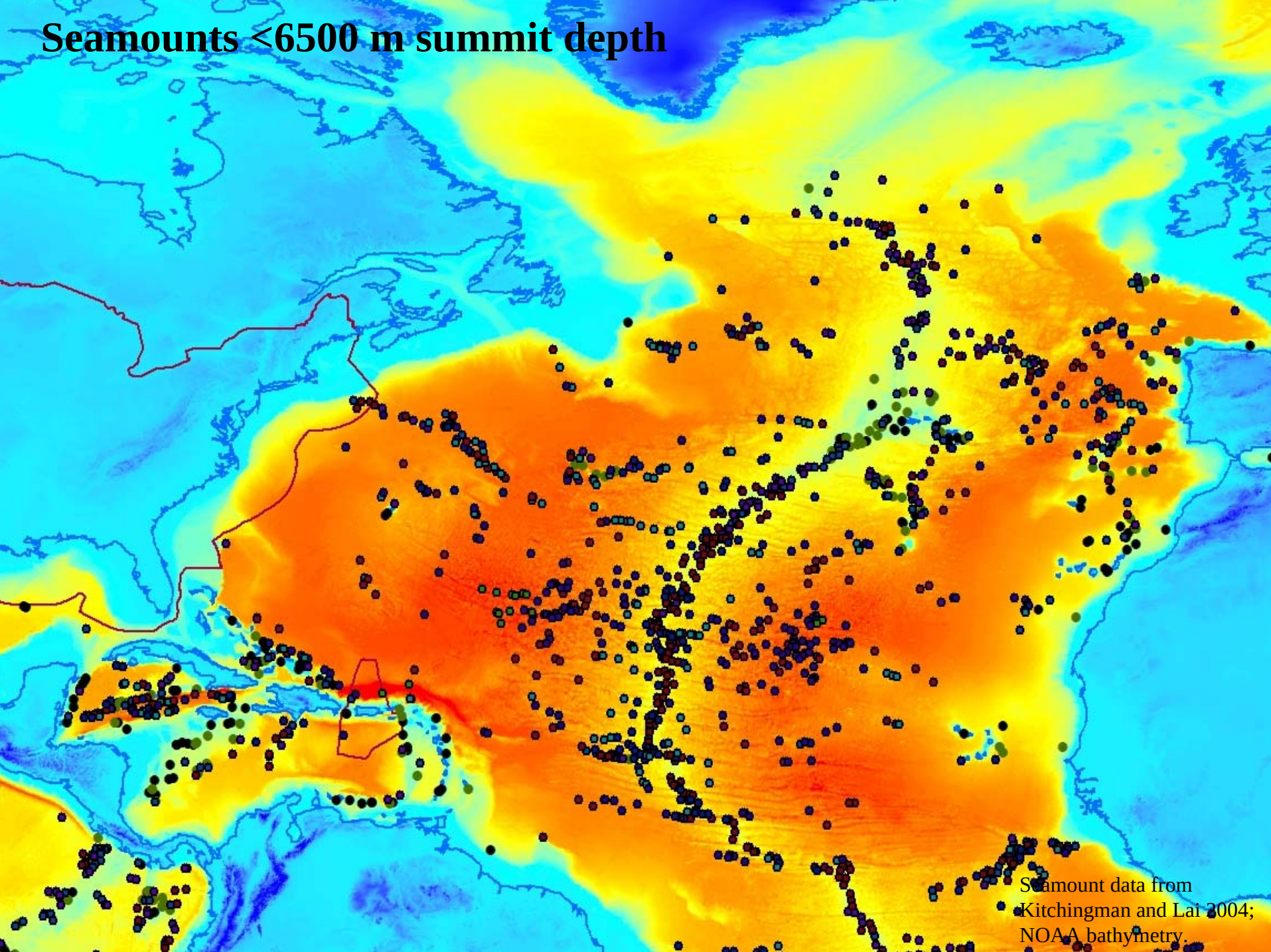
Cho and Shank, in prep

Seamounts <2500 m summit depth



Seamount data from Kitchingman and Lai 2004; NOAA bathymetry.

Seamounts <6500 m summit depth



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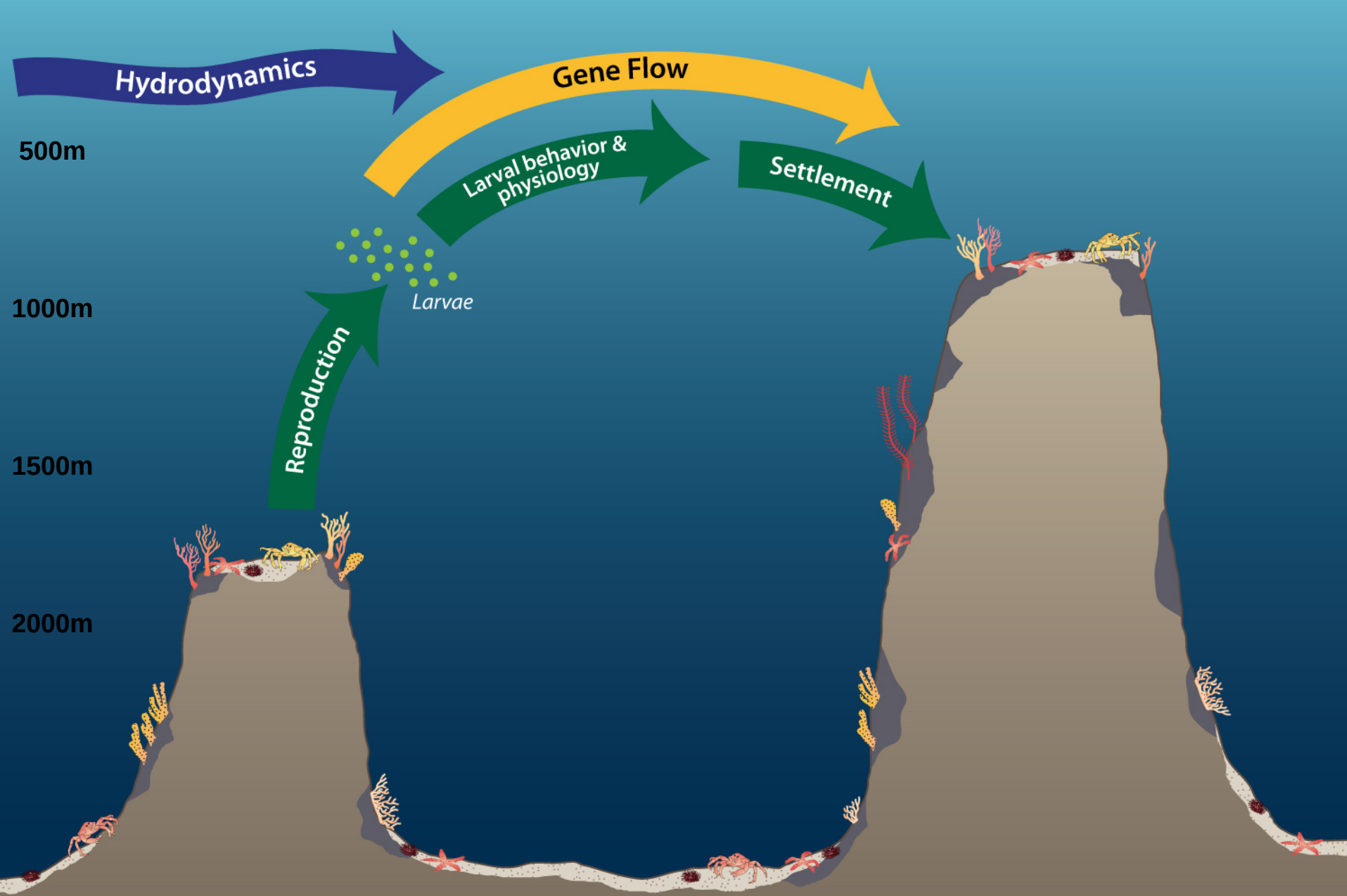
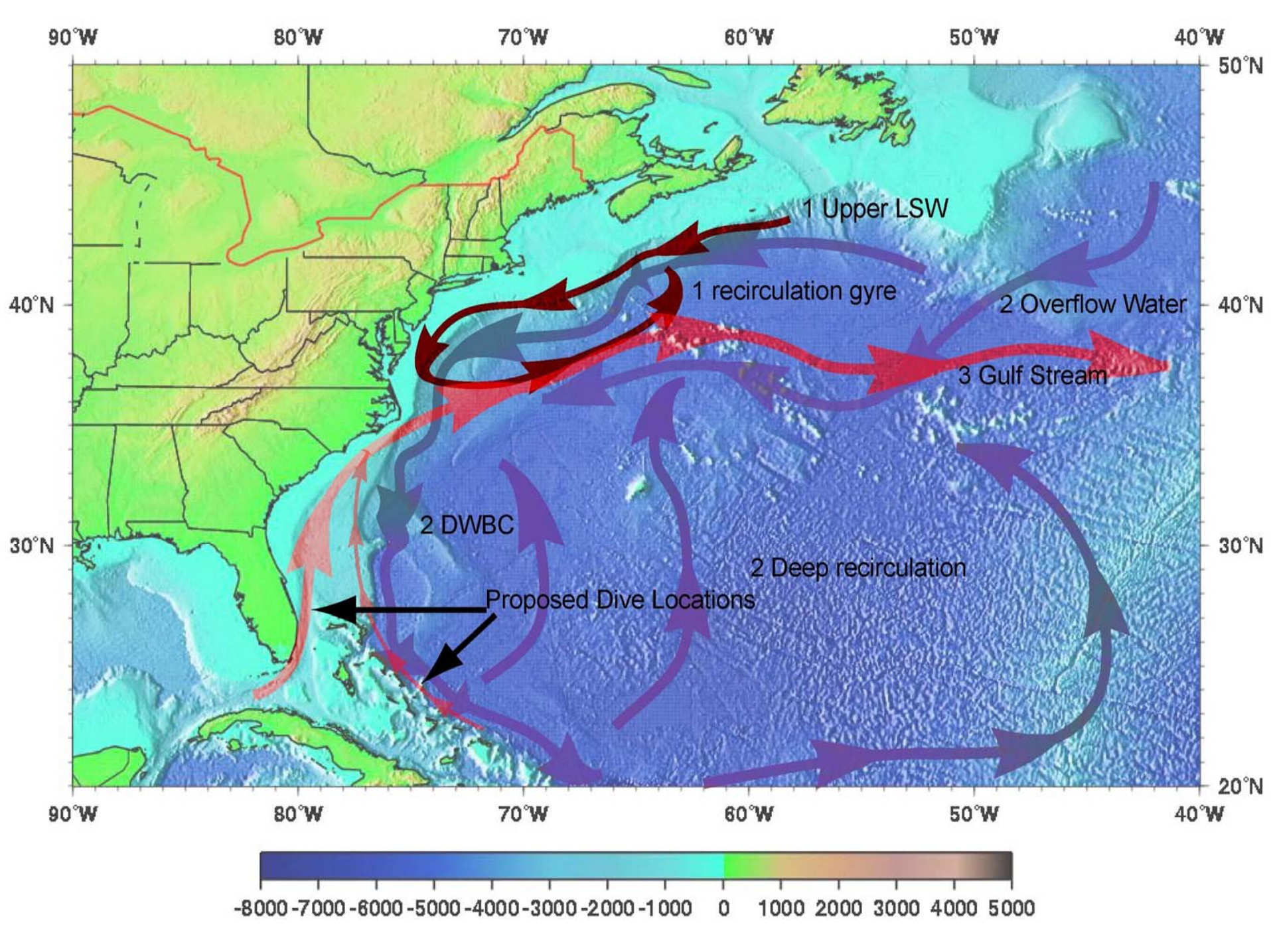
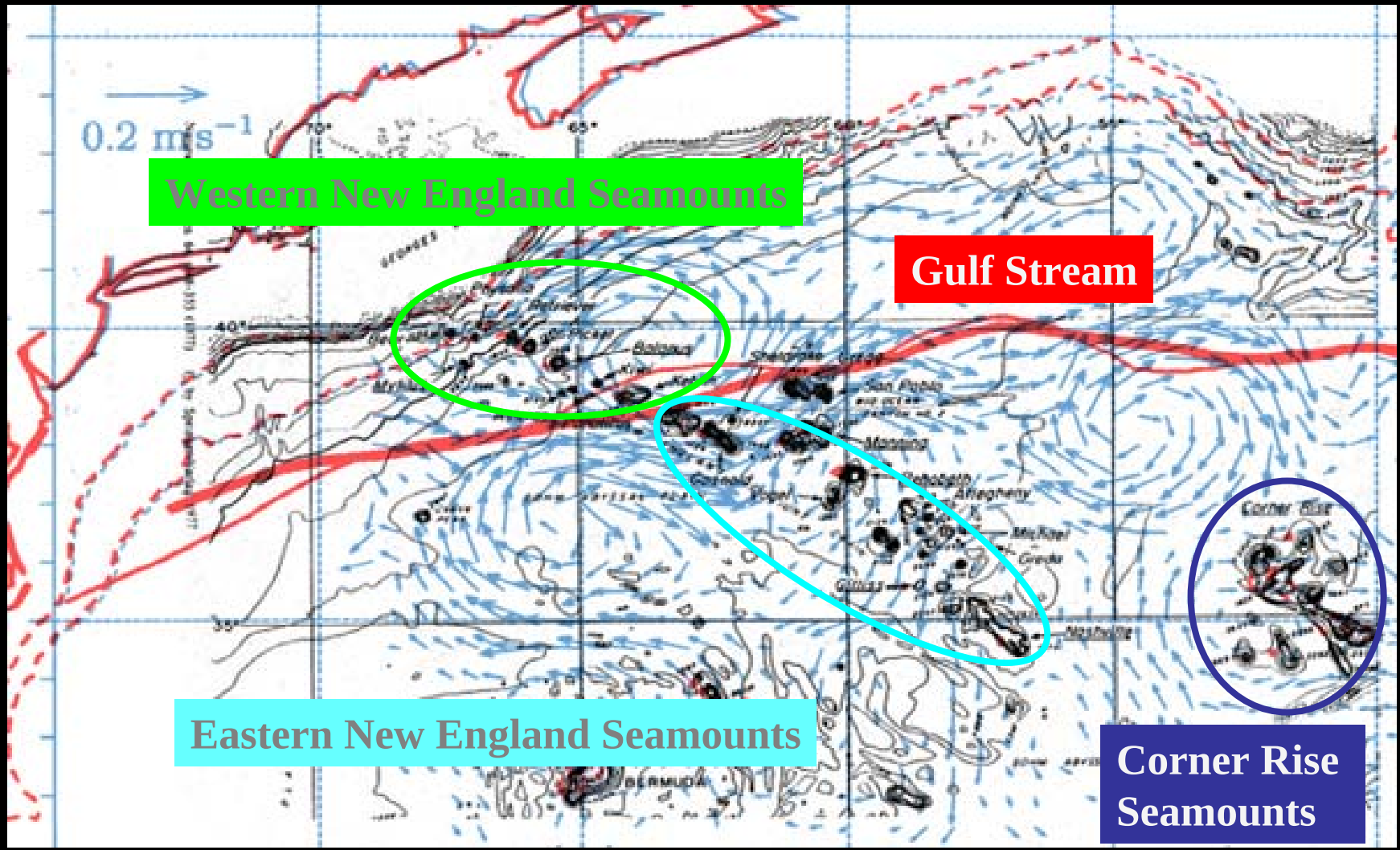


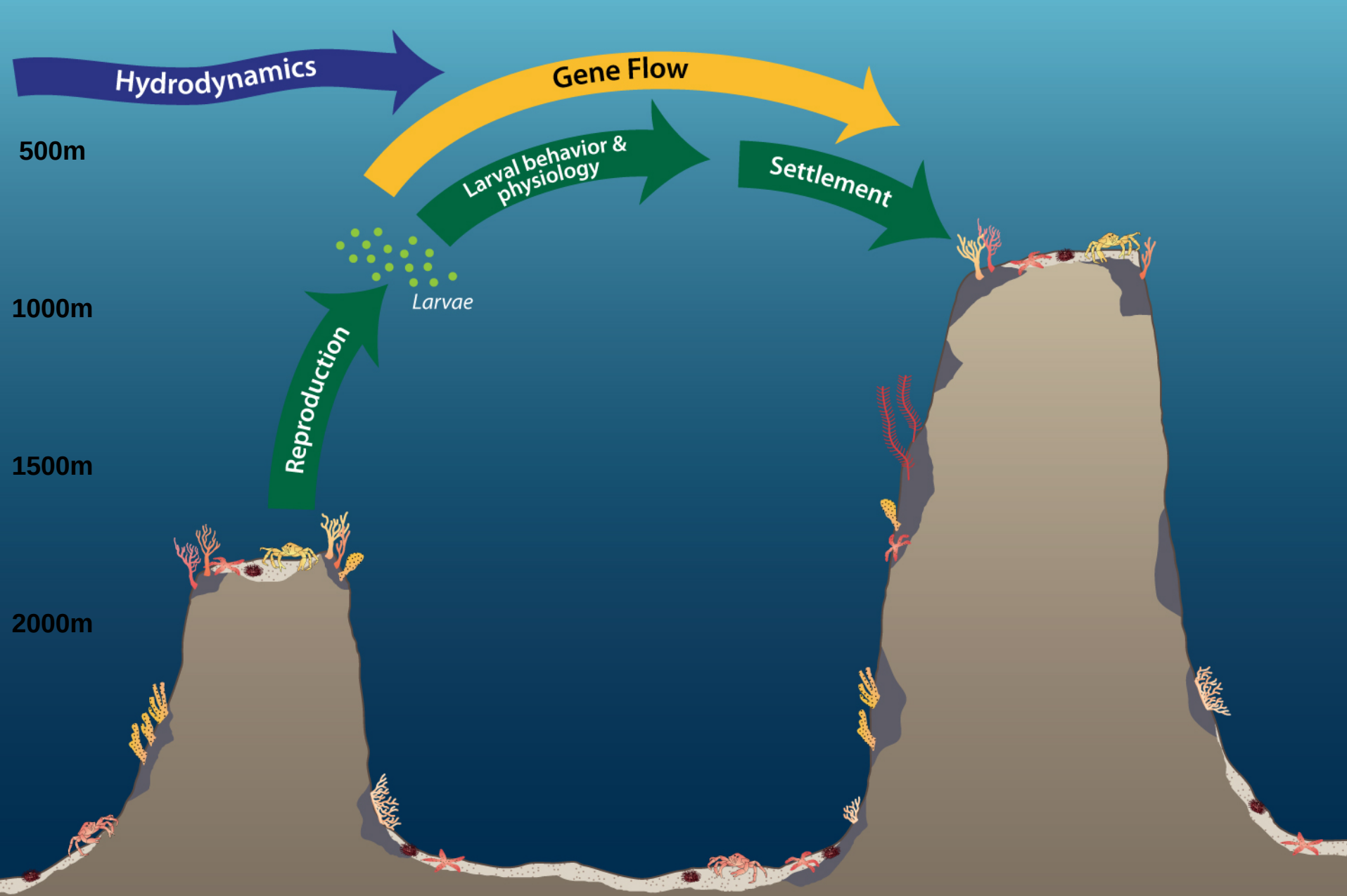
Seafloor morphology, Habitat availability(abiotic/biotic), Depth, Reproduction/Settlement, Hydrodynamics


90°W
80°W
70°W
60°W
50°W
40°W
50°N
40°N
30°N
20°N
1 Upper LSW
1 recirculation gyre
2 Overflow Water
3 Gulf Stream
2 DWBC
2 Deep recirculation
Proposed Dive Locations
-8000 -7000 -6000 -5000 -4000 -3000 -2000 -1000 0 1000 2000 3000 4000 5000

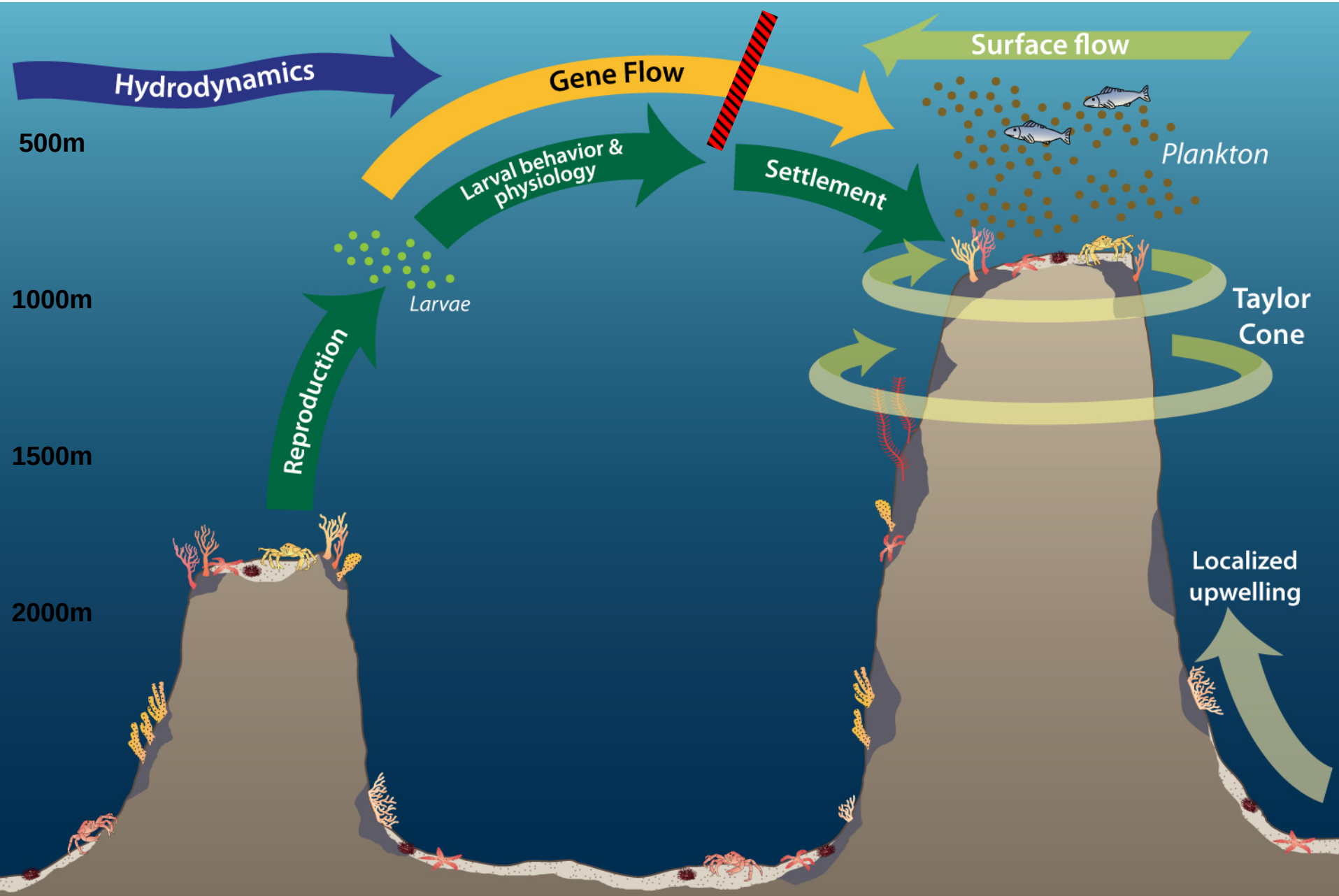


Predicted flow (blue arrows) of the Gulf Stream at 3000m depth (mean flow in solid red) across the New England Seamounts

(calculated from surface to deep water models; modified from Houghton et al., 1977; Qiu, 1994)



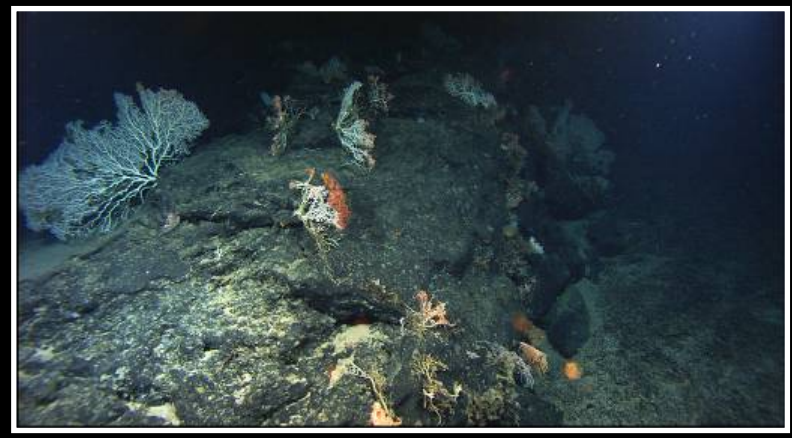
Seafloor morphology, Habitat availability(abiotic/biotic), Depth, Reproduction/Settlement, Hydrodynamics



Seafloor morphology, Habitat availability(abiotic/biotic), Depth, Reproduction/Settlement, Hydrodynamics, Productivity

Population Connectivity-

"the dispersal, survival, and reproduction of migrants, so that they contribute to the local gene pool"
-Cowen et al., 2007



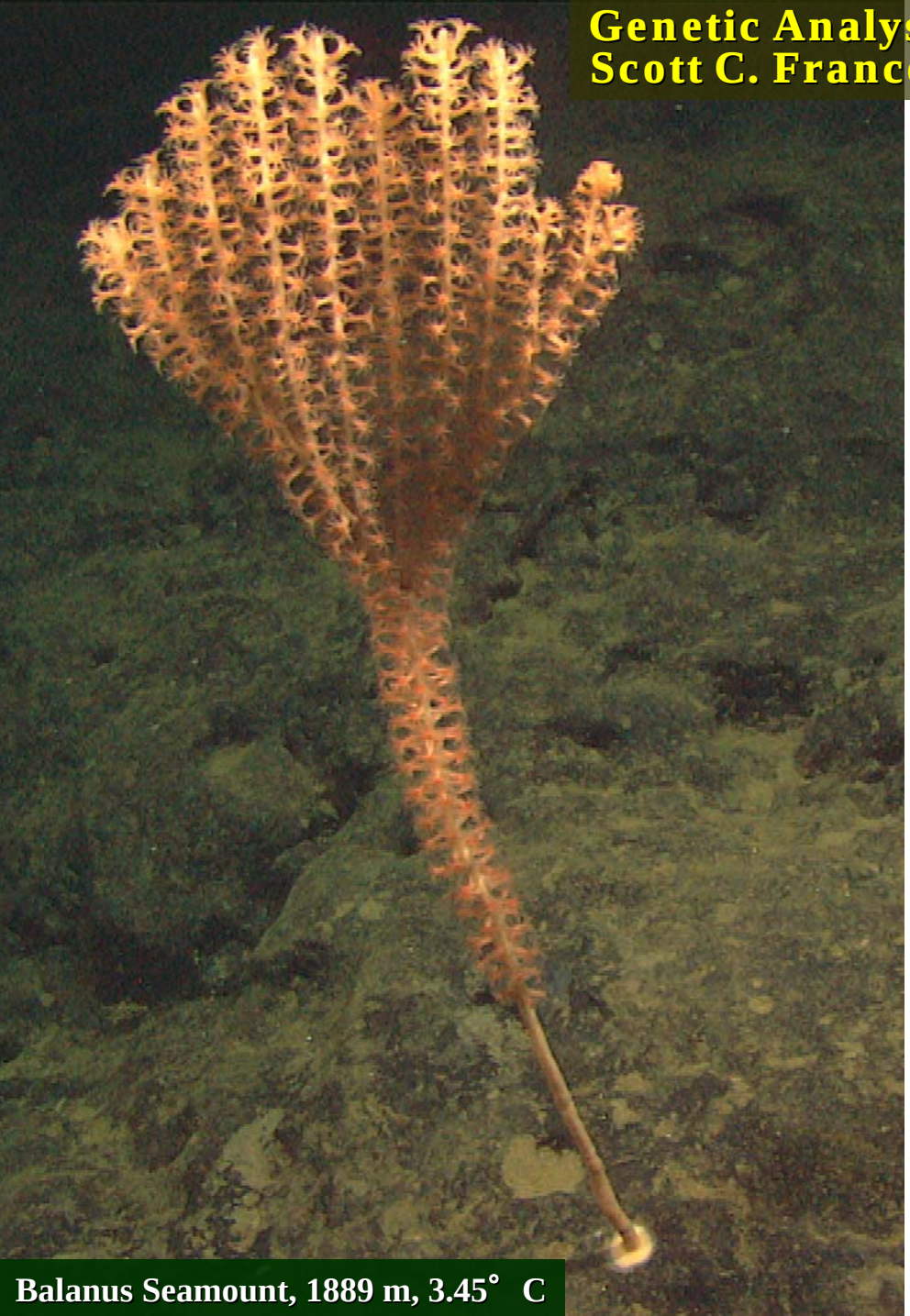
Basic approaches to inferring connectivity:

1) indirect (inferring effective migration)
   - Genetic methods to estimate gene flow from genetic differences among populations (Slatkin et al., 2003; Benzie 1999); different gene regions evolve at different rates so must pick markers yield appropriate scale

2) direct (assigning sources populations, natal origins, or parents)
   - Larval and adult tags (Jones et al., 1999; Alamay et al., 2007)
   - Fish otilith chemistry (Thorrold et al., 2001)
   - Genetic markers for assignment of individuals to populations
     (Mantel et al., 2005; Jones et al., 2005)

Genetic Analyses of Octocorals and Black Corals

Scott C. France, University of Louisiana, Lafayette



Balanus Seamount, 1889 m, 3.45° C

First things first:

Must identify what a species is…

- DNA sequences reveal cryptic species
  Species morphologically indistinguishable
  DNA data assists with taxonomy
  - France (2007): example in bamboo corals

- DNA sequence data
  - octocorals: *msh1* gene*
  - black corals: mitochondrial intergenic*

- sequenced the complete mitochondrial genomes of 2 bamboo corals and discovered novel 5-gene inversion
  - Brugler & France (in review)

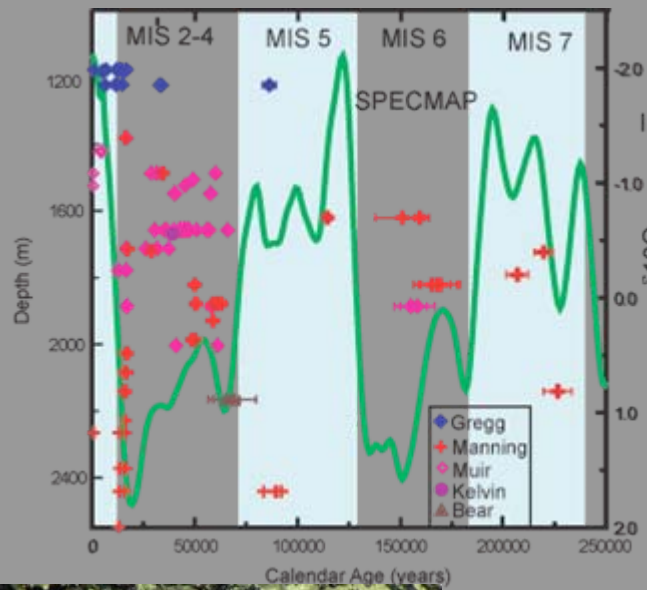
* The standard mtCOI barcode is not sufficiently variable in corals.

Phylogeographic analyses of abundant taxa
- ***Paramuricea* spp. (octocoral)**
- ***Metallogorgia melanotrichos* (octocoral)**
- ***Parantipathes* spp. (black coral)**

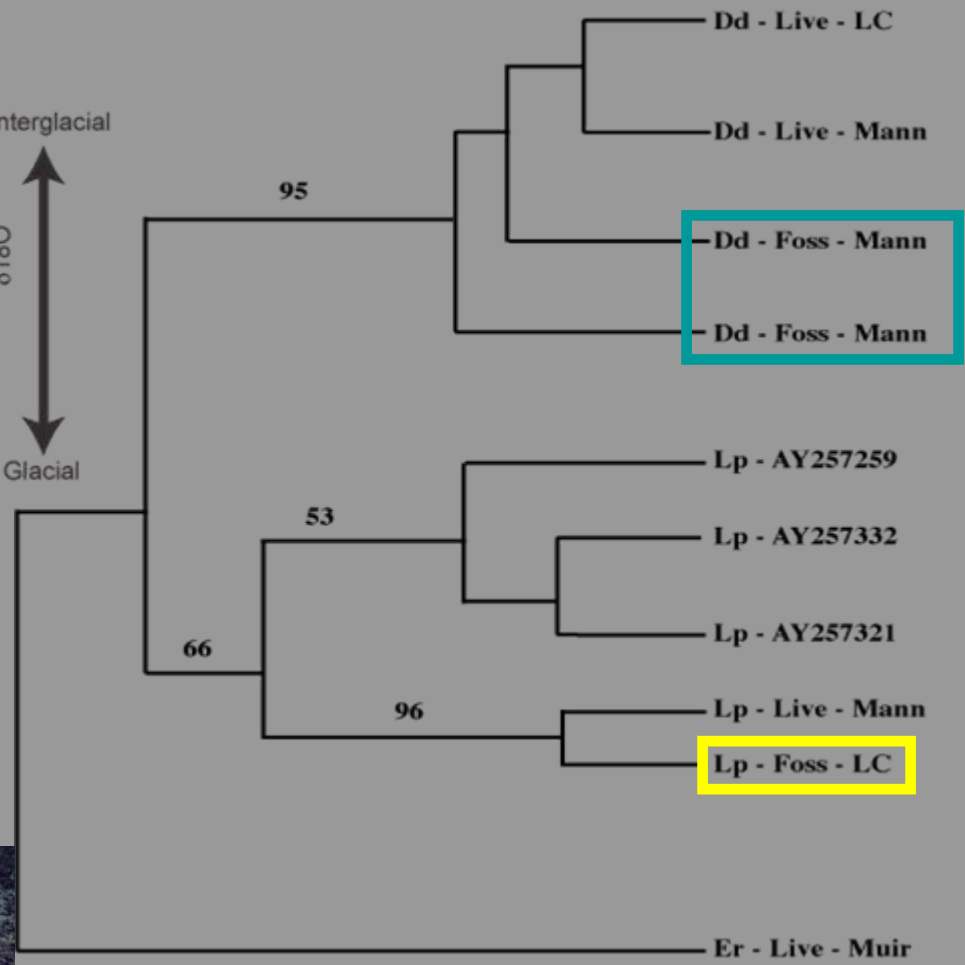
Deep Atlantic Stepping Stones Science Party, IFE, URI-IAO, and NOAA

***Paramuricea* sp.**
Goode Peak, Corner Seamount, 1916 m

Paleo-Population Genetics - Connectivity and Climate Change



Fossil *D. dianthus*



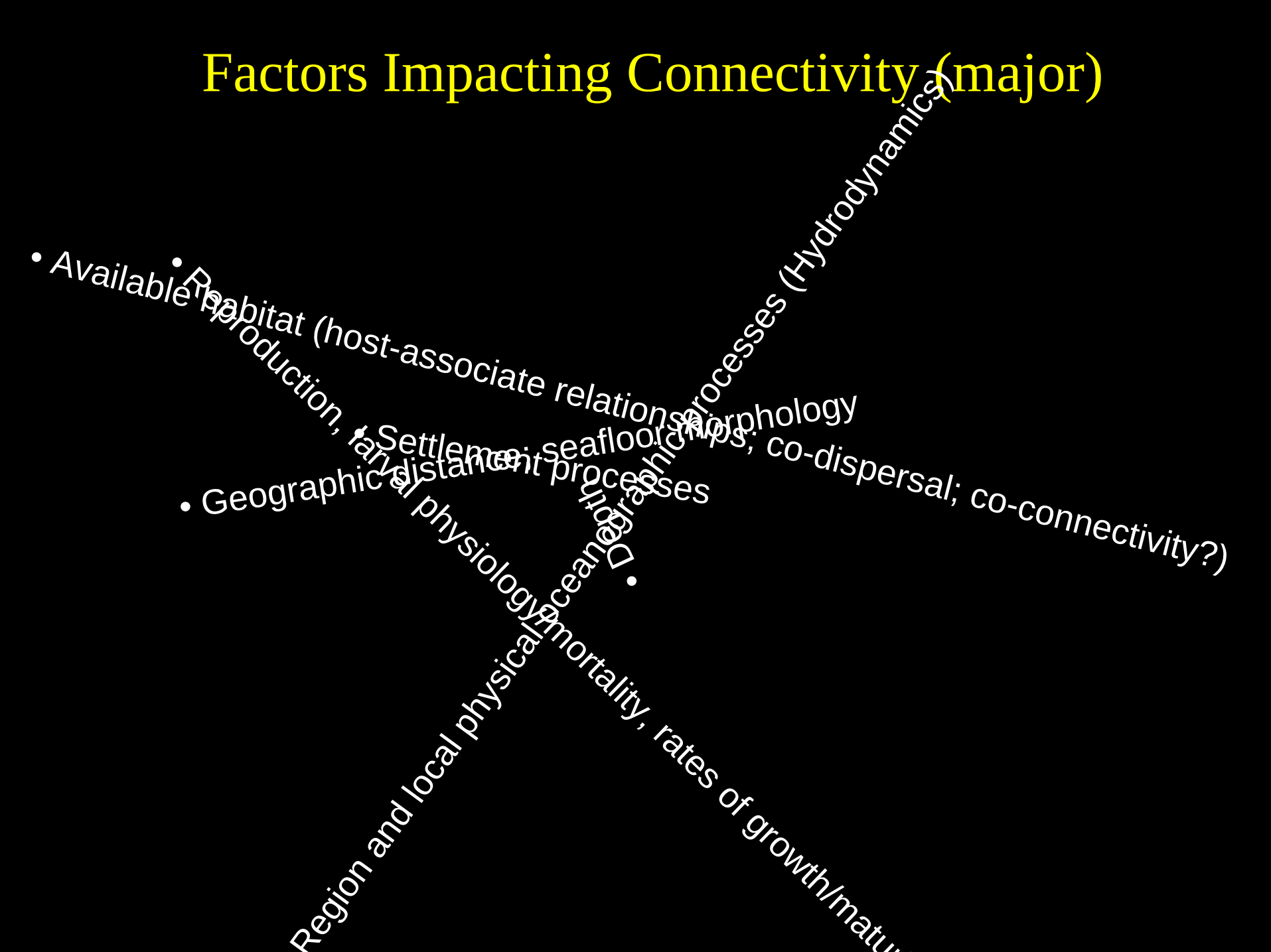
- Preliminary Results -
- ITS1, ITS2 compared to live sequences (~200bp)

Waller, Adkins, Robinson, Shank 2007

Factors Impacting Connectivity (major)

- Geographic distance; seafloor morphology
- Available habitat (host-associate relationships; co-dispersal; co-connectivity?)
- Depth
- Region and local physical oceanographic processes (Hydrodynamics)
- Reproduction, larval physiology/mortality, rates of growth/maturity
- Settlement processes

Factors Impacting Connectivity (major)



Challenges for understanding “Connectivity”

1. Identifying the dynamic temporal and spatial scales over which all of these processes interact
2. Designing the appropriate sampling design to address questions of connectivity on these scales
3. Identifying species through morph. & molecular taxonomy
4. Identifying population/phyologeographic boundaries
5. Obtaining enough samples/individuals for population genetics
6. Finding the appropriate genetic marker for the question
7. Obtaining co-located/co-incident physical and environmental data

Major Research Questions

(Linkages and Connectivity)

- 1. What are the dominant processes that structure differences in connectivity in Atlantic coral ecosystems?
- 2. What are the key temporal and spatial scales over which these processes operate…to cause differences in connectivity in coral ecosystems?
- 3. How do we overcome the key technical (e.g., genetic resolution, sampling designs) problems assessing connectivity and gene flow (over spatial and temporal scales)?
- 4. What are the impacts of fisheries on altering coral ecosystem connectivity?

What Do We Need?

- to realize we can not extrapolate current dispersal/connectivity results of any taxa or seamount to another. For example, from the South Pacific or the Equatorial Pacific

- to realize that species characterized as having “limited larval dispersal” can travel large oceanic distances

- to realize that isolated coral communities are only isolated if larval dispersal and colonization limit the exchange of genetic material (distance ≠ isolation)

- to realize that any plan to assess coral community diversity, endemism, and connectivity “must” include the integrated use of genetic approaches