Lophelia II: Coral Associates of the Gulf of Mexico

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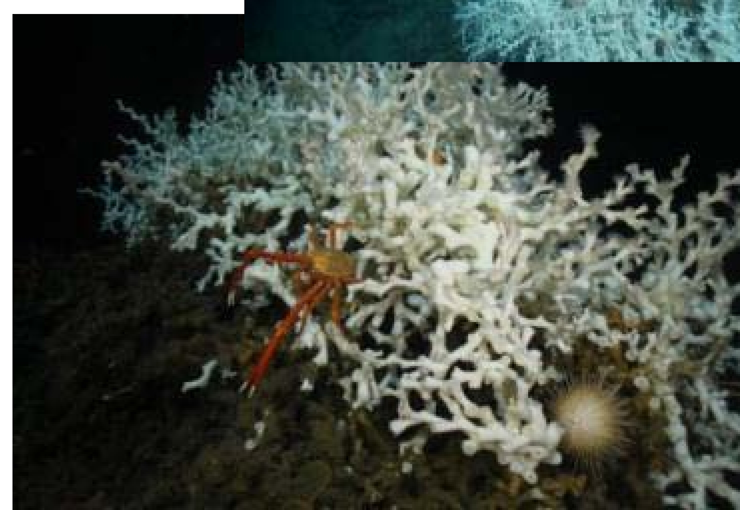
Corals and Their Associates:
Identifying Associations and Their Distributions



Key features of deep-water coral associates:

- Highly diverse (2,300+ spp. span more than 8 phyla)
- Highly specialized for coral habitats
- Associates with varying levels of coral habitat specificity (facultative to obligate)
- Utilize corals in a variety of life-history stages
- Unknown means of (bio-chemical) interactions
  e.g, one per; induce changes in coral growth
- Indicators of coral ecosystem health

Objectives:

- Characterize patterns of diversity, distribution, & genetic connectivity of coral ecosystems in the Gulf of Mexico

Activities:

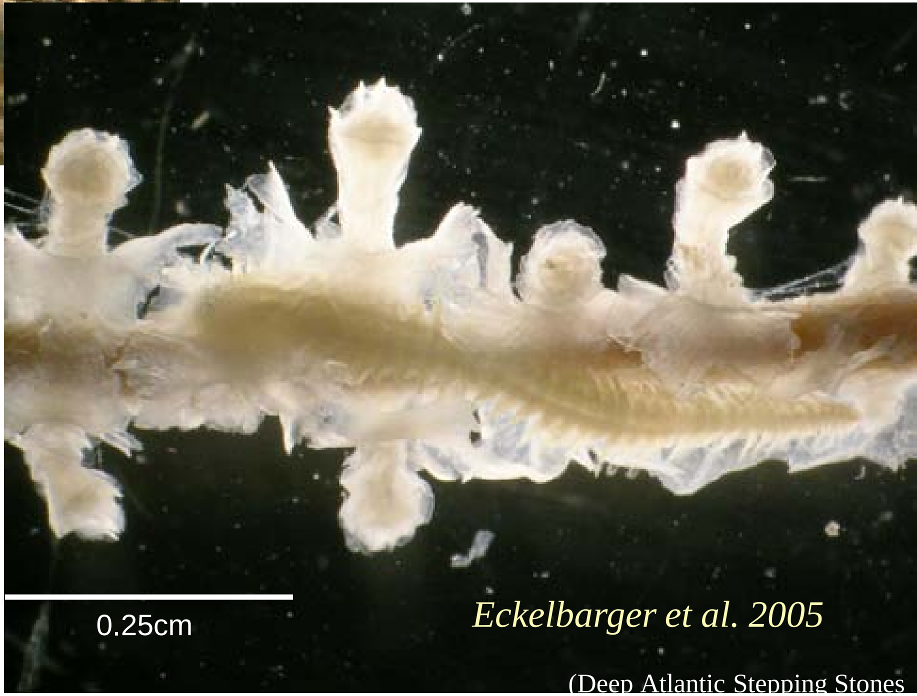
- Identifying associate species via morphological & molecular approaches
- Determining host and epibiont associations and patterns via ROV (HD) imaging
- Assessing population genetic connectivity among coral associates

Chirostylid (*Uroptychus* crab) on host *Parantipathes*

Examples of Coral – Associate Relationships

Candidella imbricata coral associates:

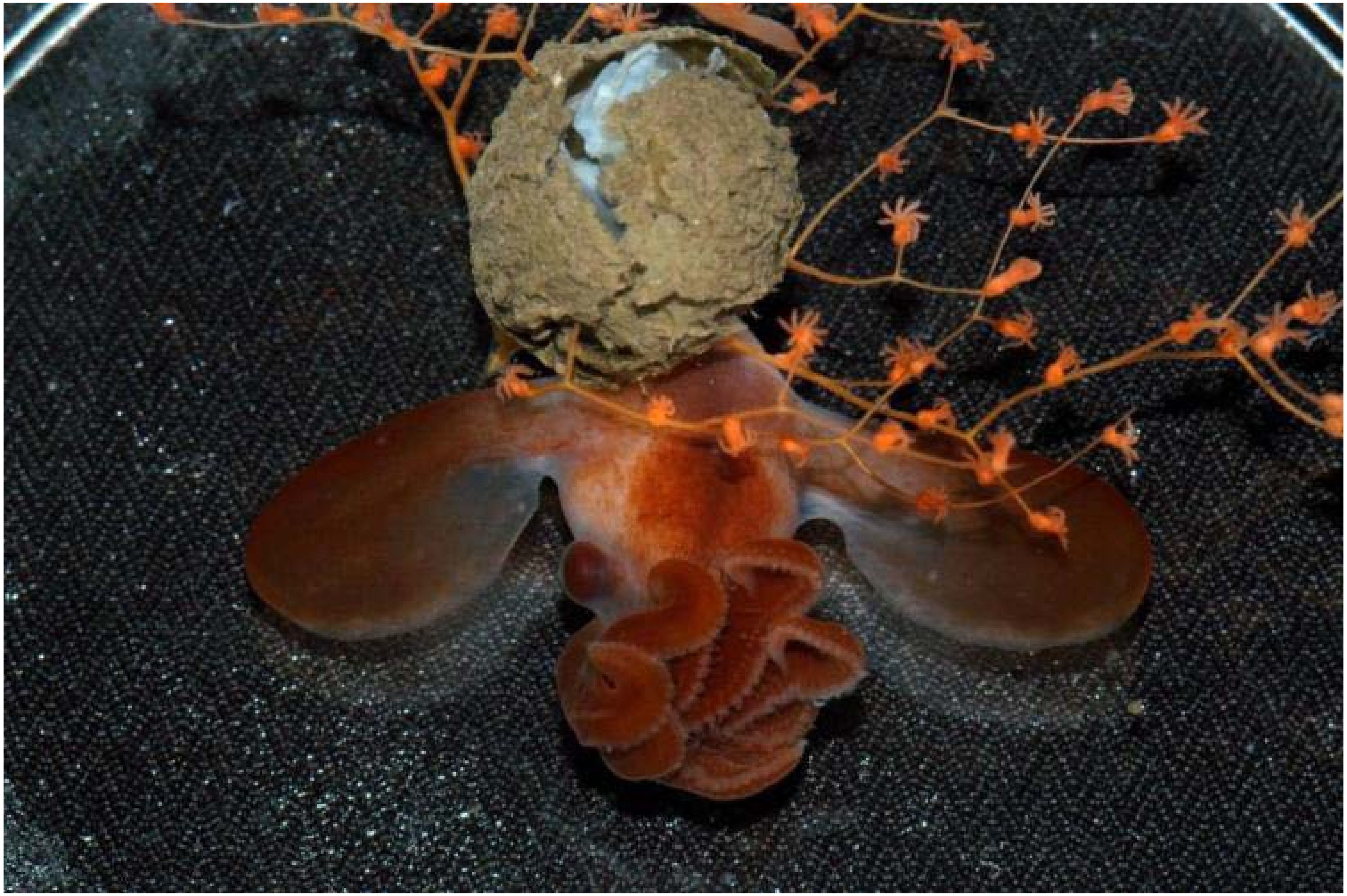
Ophioplinthaca abyssalis



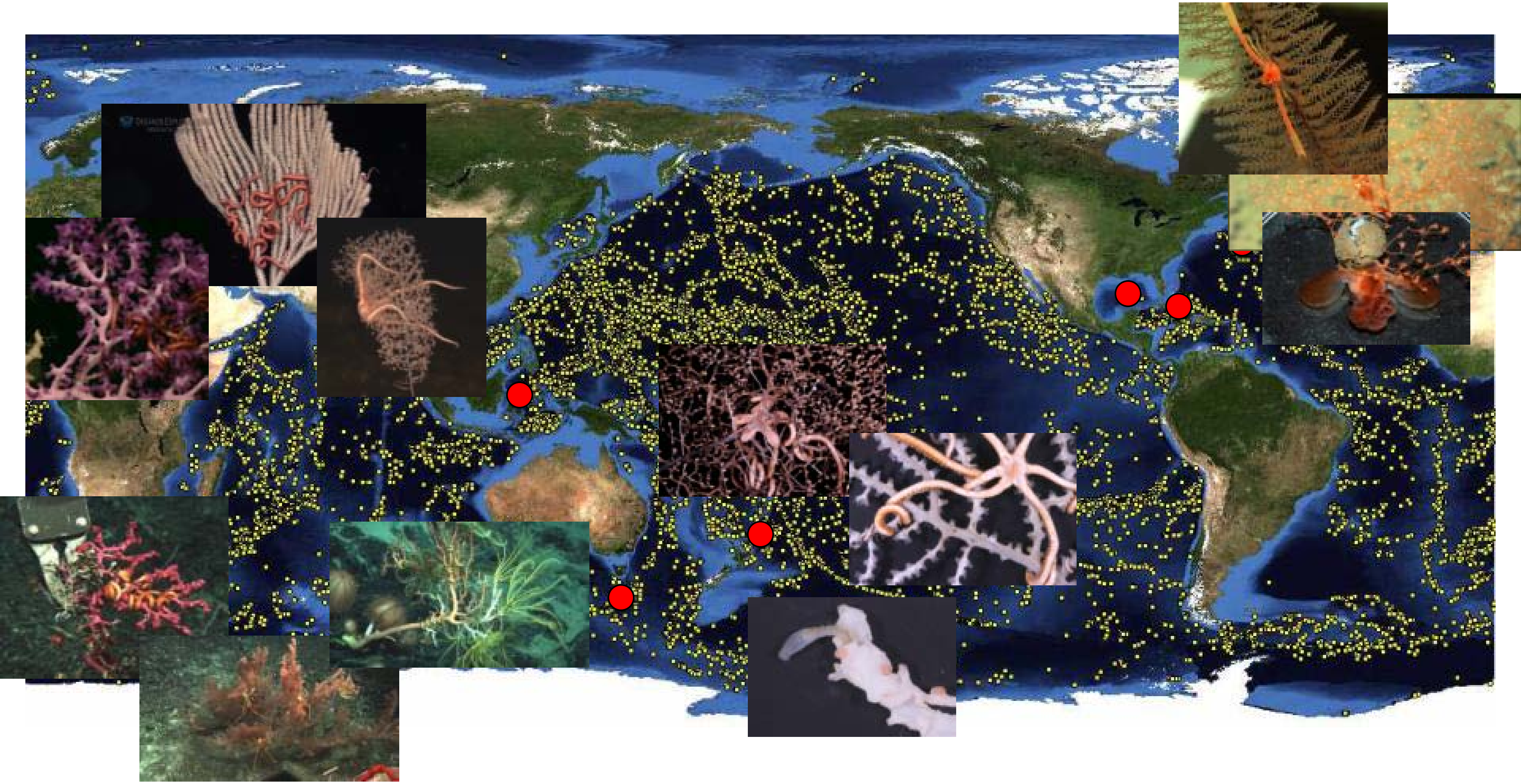
Gorgoniapolynoe caeciliae

Examples of Coral – Associate Relationships

Cirrate octopod species deposits eggs only on octocorals (*Chrysogorgia sp., Acanella sp., Metalagorgia sp.*)



Deep-Sea Coral – Associate Habitats Are Worldwide



MMS/BOEMRE Coral Associate Datasets

	2008	2009	2010
ROV	*SeaEye Falcon*	*Jason II*	*Jason II*
Dives	8	17	16
Sites (total 27)	6	15	14
Dig. Images	>350	>800	>7,300
Video (HD)	Total >170 hours		
Image stations	Total > 196	(19 long-term stations)	
# associates sampled	7	248	619

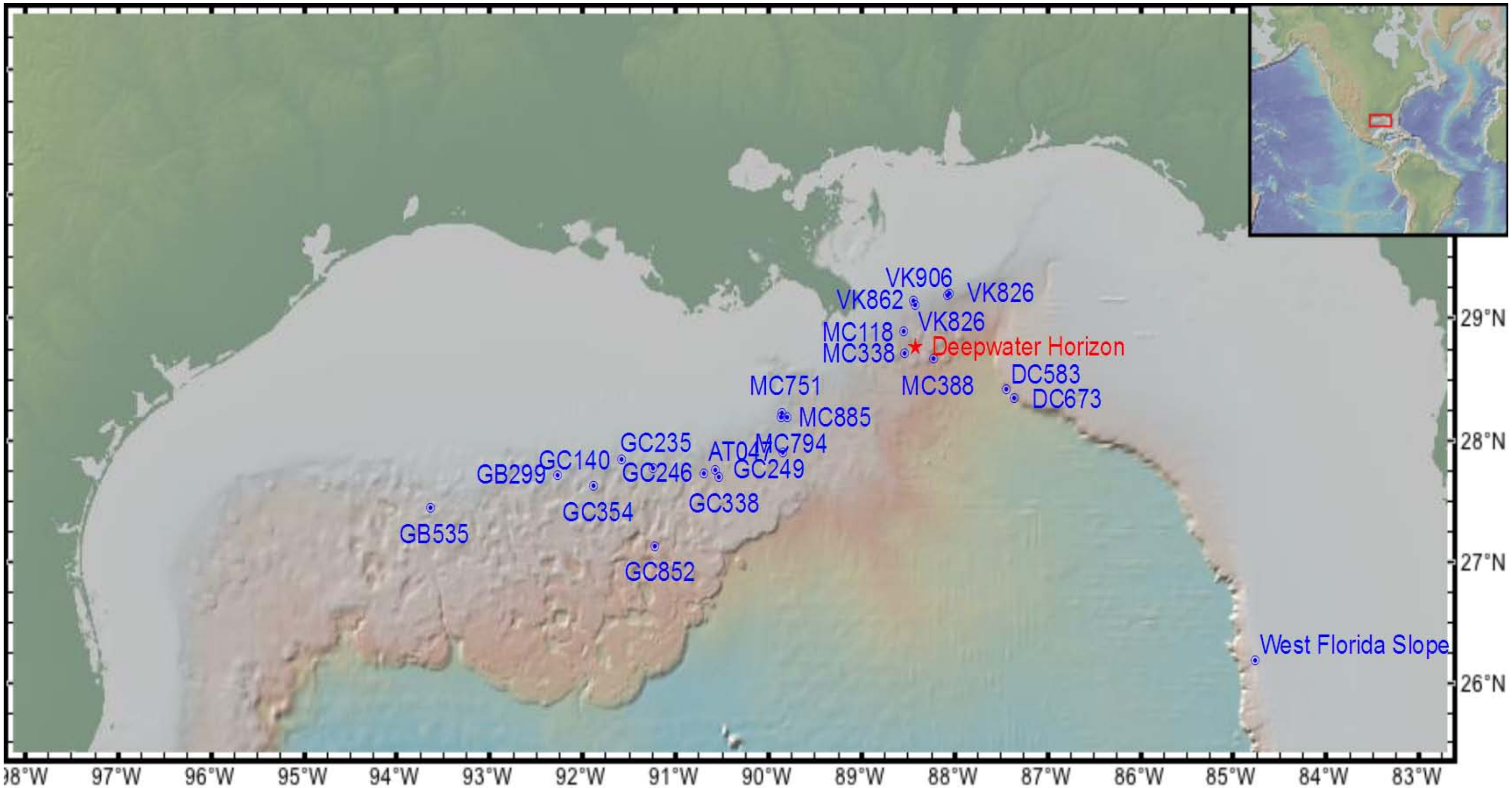


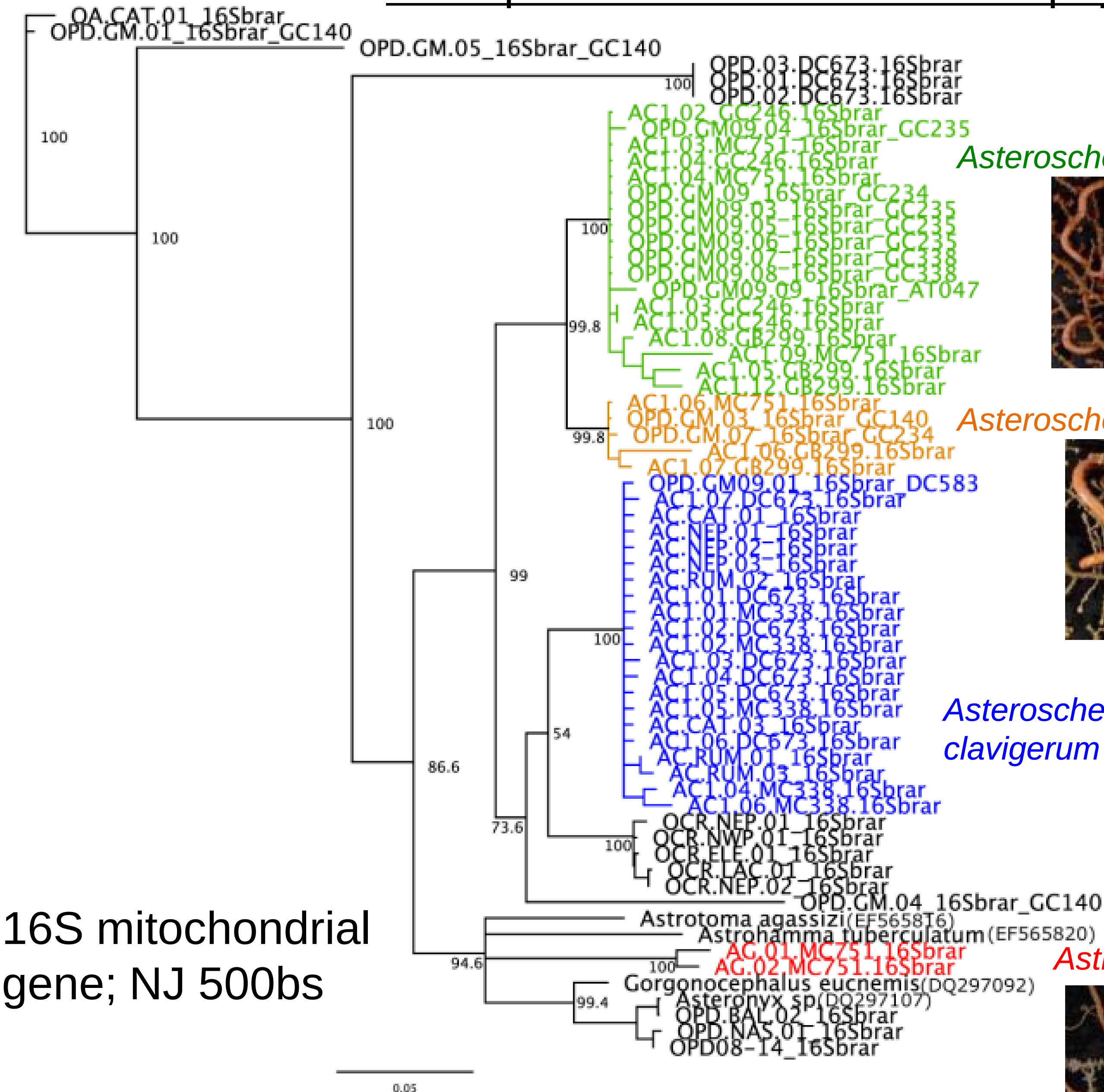
Image Station 41 MC751 in Oct 2010

Callogorgia americanus with
Asteroschema brittle stars

Gulf of Mexico Coral Associates

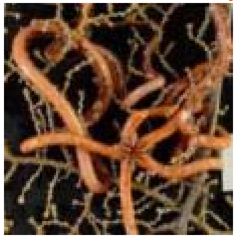
Lopelia II *expedition, NOAA-OER/ BOEMRE*

Example: brittle star associates: phylogenetic identification

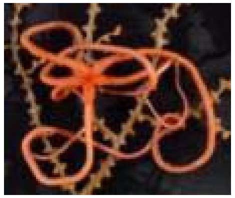


Asteroschematidae sp. 1

Asteroschematidae sp. 2



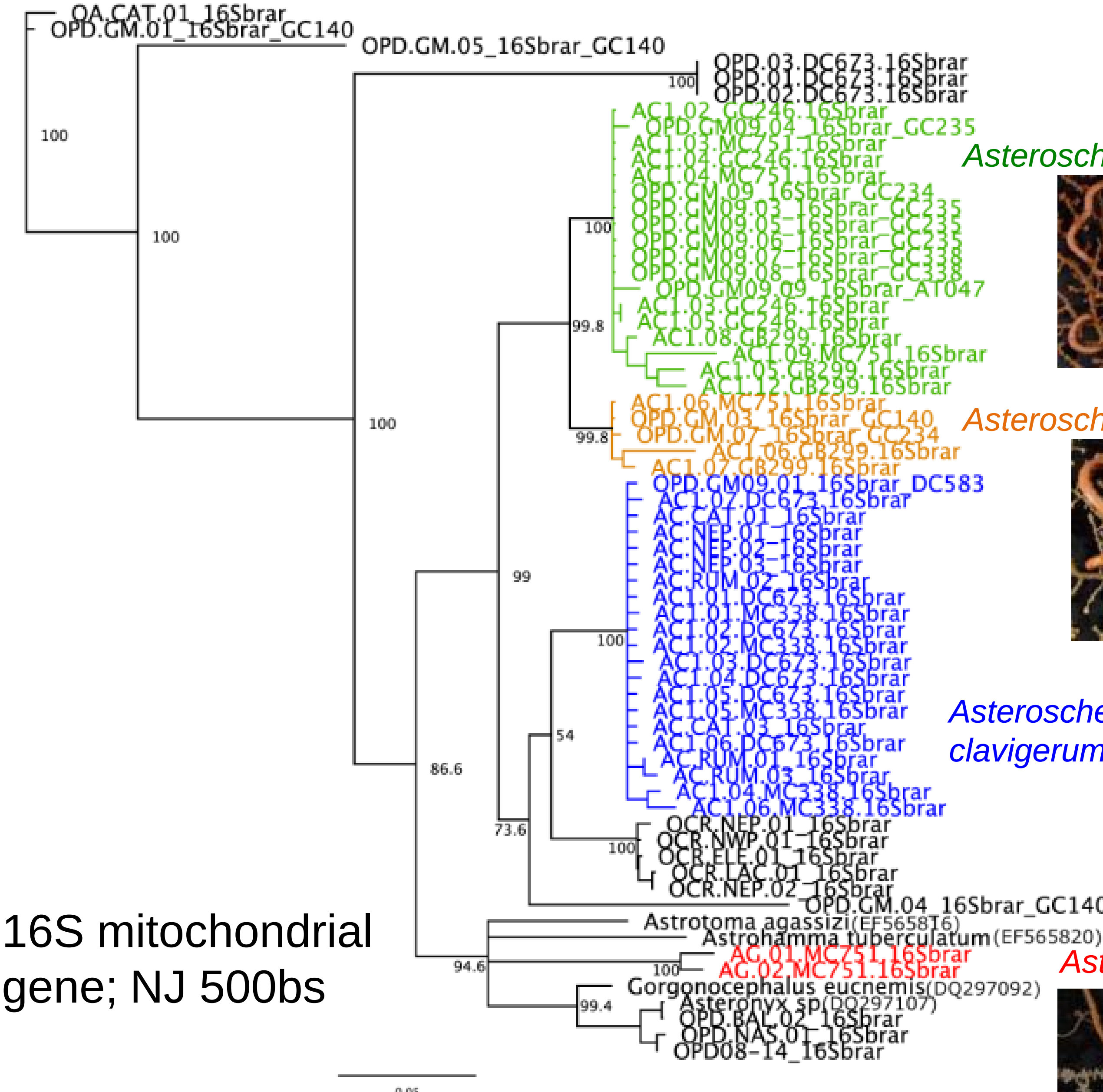
Asteroschema clavigerum



Astrogomphus sp.

16S mitochondrial gene; NJ 500bs

<u>Host Coral</u>



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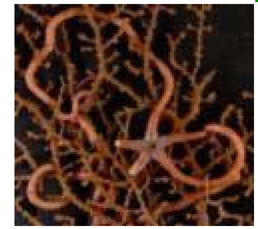
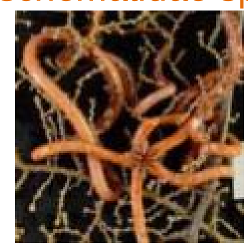


Callogorgia sp.
Paragorgia sp.
Paramuricea sp.
Primnoidae sp.

Asteroschematidae sp. 2

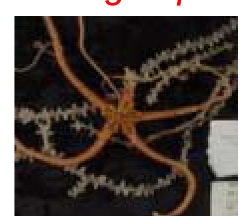


Paragorgia sp.
Paramuricea sp.

Asteroschema clavigerum

Paragorgia sp.
Paramuricea sp.
Plexaurid

Astrogomphus sp.



Callogorgia sp.
Paramuricea sp.
Muriceides sp.
Keratoisis sp.
Isidid sp.
Lophelia sp.

Patterns of Coral Host – Invertebrate Associations in the Gulf of Mexico

	Annelida	Arthropoda	Cnidaria			Echinodermata	Mollusca		Porifera	Total
	Polychaeta	Crustacea	Anemones	Hydroids	Zoanthids	Ophiuroidea	Aplacophora	Gastropoda	Sponges	Species
Alcyonacea										
Bamboo coral			D			D				2
Callogorgia		T	F, G			A, C, D, F, K, L, M		B, C, E		13
Chrysogorgidae		E, M				B				3
Corallium		F		B						2
Keratoisis		D, J, P, S, X				D, L				7
Muriceides?		C		B		D	A			4
Nicella white			A			C				2
Paragorgidae						C, G				2
Paramuriceidae		A, G, I, L	B, H	B	B, C	B,C, D, G, M	A, B	B		17
Plexauridae							A			1
Primnoidae						C, K				2
Purple gorgonian						C, G				2
Antipatharia										
Antipatharian		G, I, J, L, AA				H, I, N				8
Dead Antipatharian	A	H			C					3
Leiopathes		G, I, J, K, M, AA	C, F	B	C	E				11
Tanacetipathes		D, O, Q		B						4
Scleractinia										
Dead Lophelia	B, C, E			A		J				5
Lophelia	D, F, G, H, I	B, D, O, R, U, V, W, Y, Z	A, C, E	B	A, F	D, O		A, B, C, D,	A, B, C, D, E, F, G	23
Total Species	**9**	**27**	**11**	**2**	**4**	**15**	**2**	**5**	**7**	**80**

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	Annelida Polychaeta	Arthropoda Crustacea	Cnidaria Anemones	Hydroids	Zoanthids	Echinodermata Ophiuroidea	Mollusca Aplacophora	Gastropoda	Porifera Sponges	Total Species
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Bamboo coral			D			D				2
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Nicella white			A			C				2
Paragorgidae						C, G				2
Paramuriceidae		A, G, I, L	B, H	B	B, C	B,C, D, G, M	A, B	B		17
Plexauridae							A			1
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Antipatharian		G, I, J, L, AA				H, I, N				8
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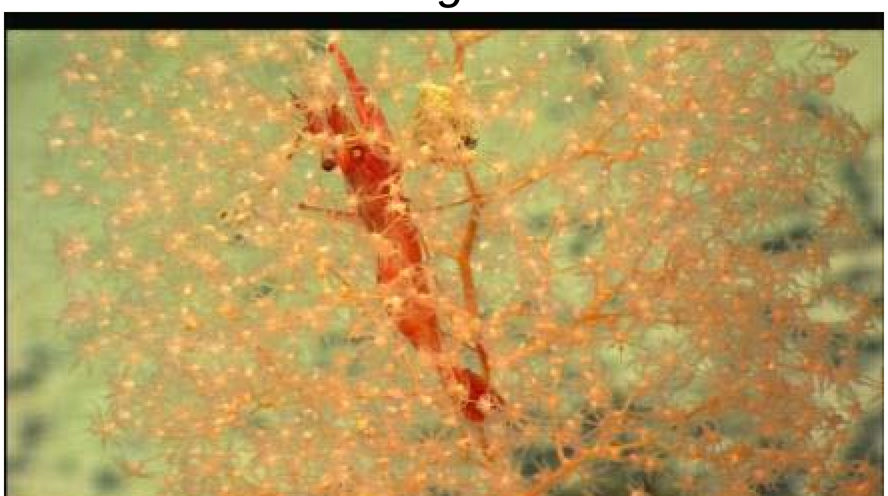
Scleractinia										
Dead Lophelia	B, C, E			A		J				5
Lophelia	D, F, G, H, I	B, D, O, R, U, V, W, Y, Z	A, C, E	B	A, F	D, O		A, B, C, D,	A, B, C, D, E, F, G	23
Total Species	**9**	**27**	**11**	**2**	**4**	**15**	**2**	**5**	**7**	**80**

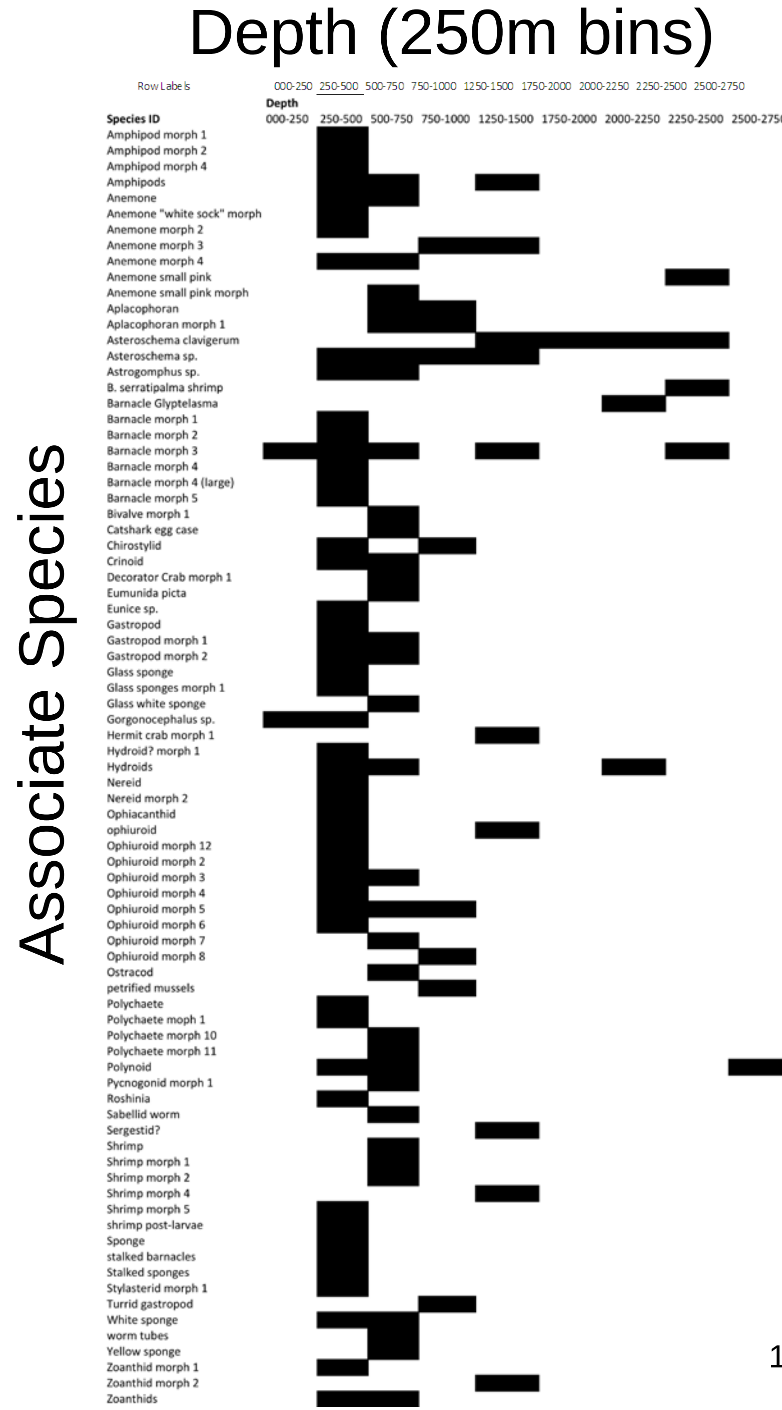
Are depth differences structuring host and associate patterns?

Patterns of Coral Host Associations with Depth

Paramuricea sp. host MC338 –1370m
Asteroschema clavigerum associate

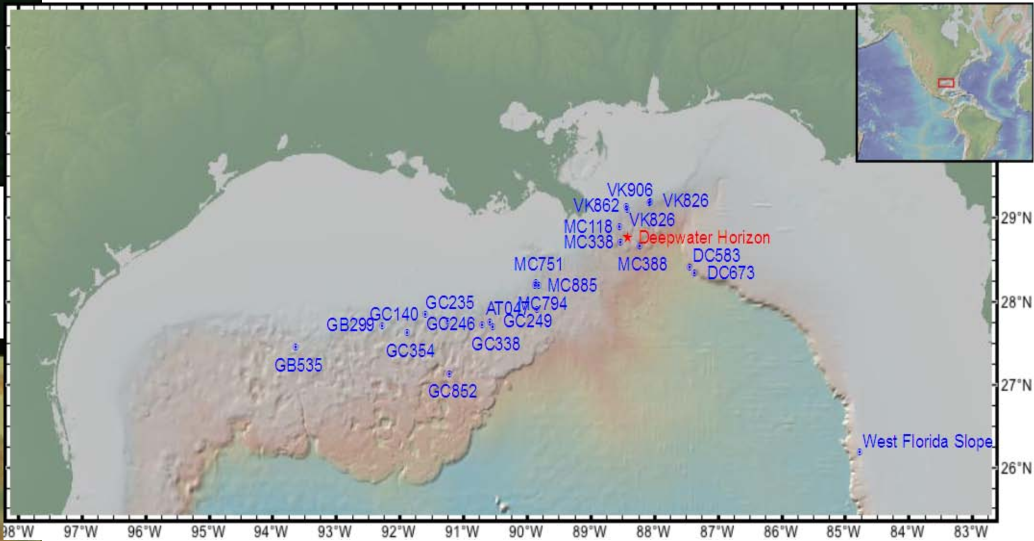


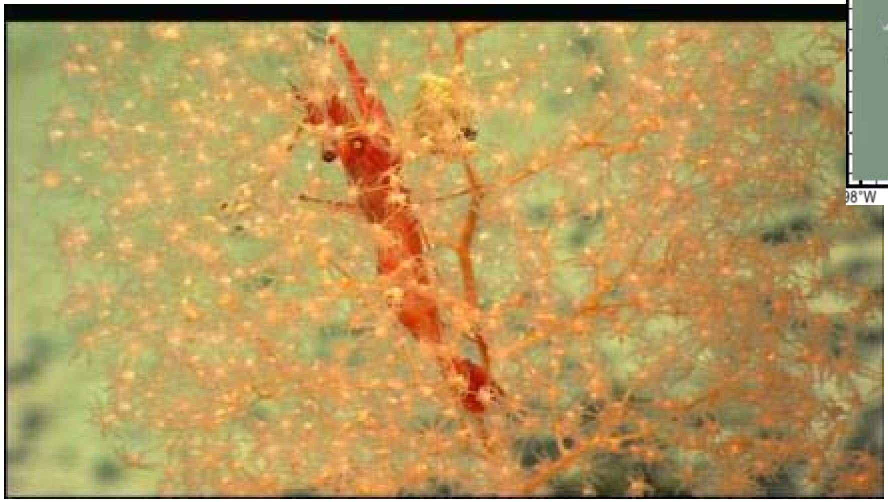
Chrysogorgia host DC673 – 2,420m
B. serratipalma shrimp associate



Patterns of Coral Host Associations with Depth

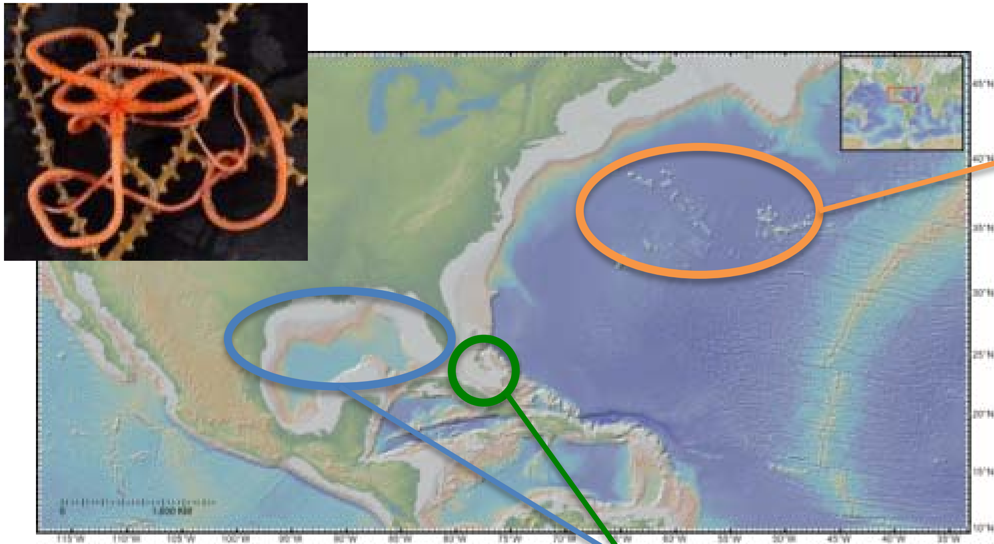
Metallogorgia host DC673 2,400m
Ophiocreas oedipus associate





Chrysogorgia host DC673 - 2,420m
B. serratipalma shrimp associate

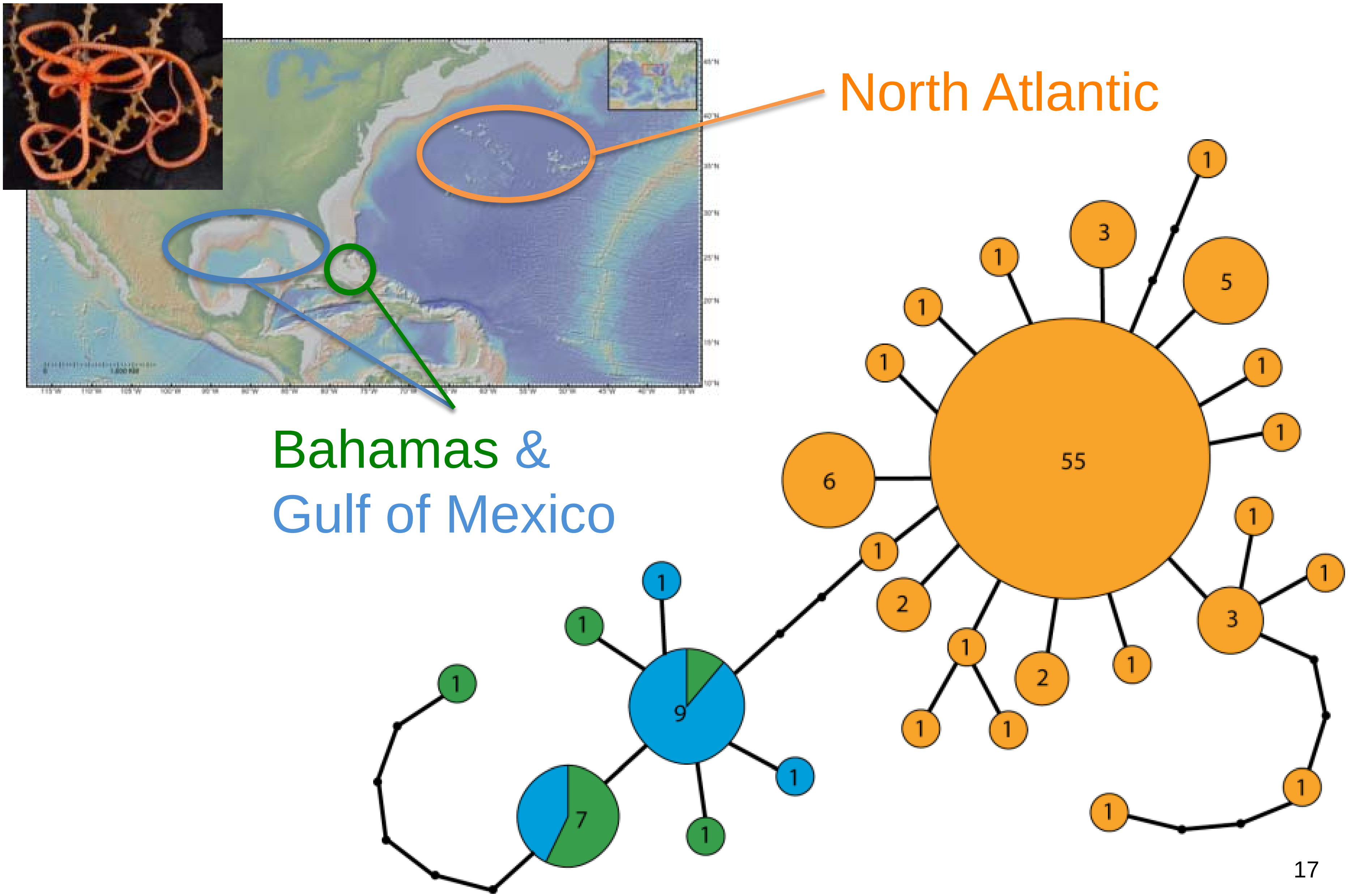
Asteroschema clavigerum



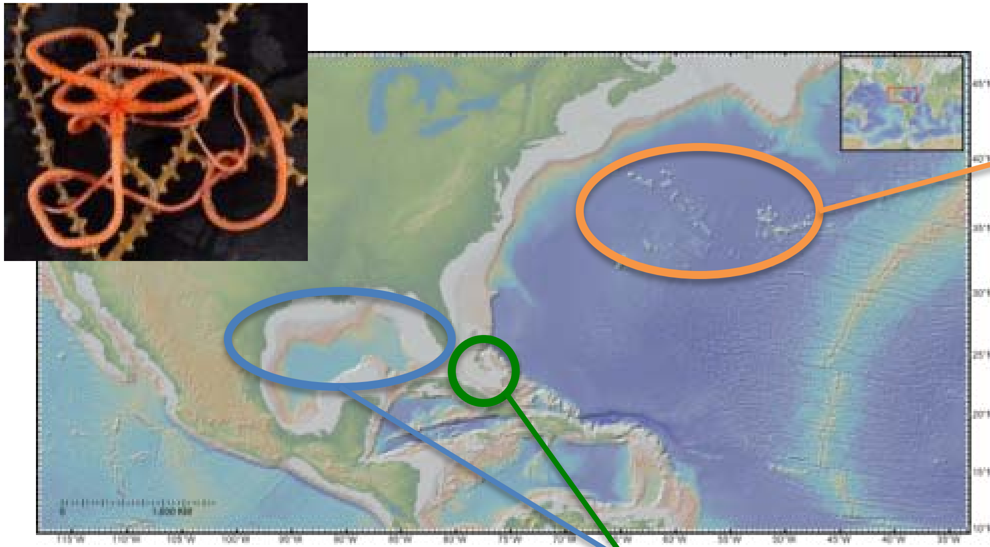
North Atlantic

Bahamas & Gulf of Mexico

Asteroschema clavigerum Haplotype Network

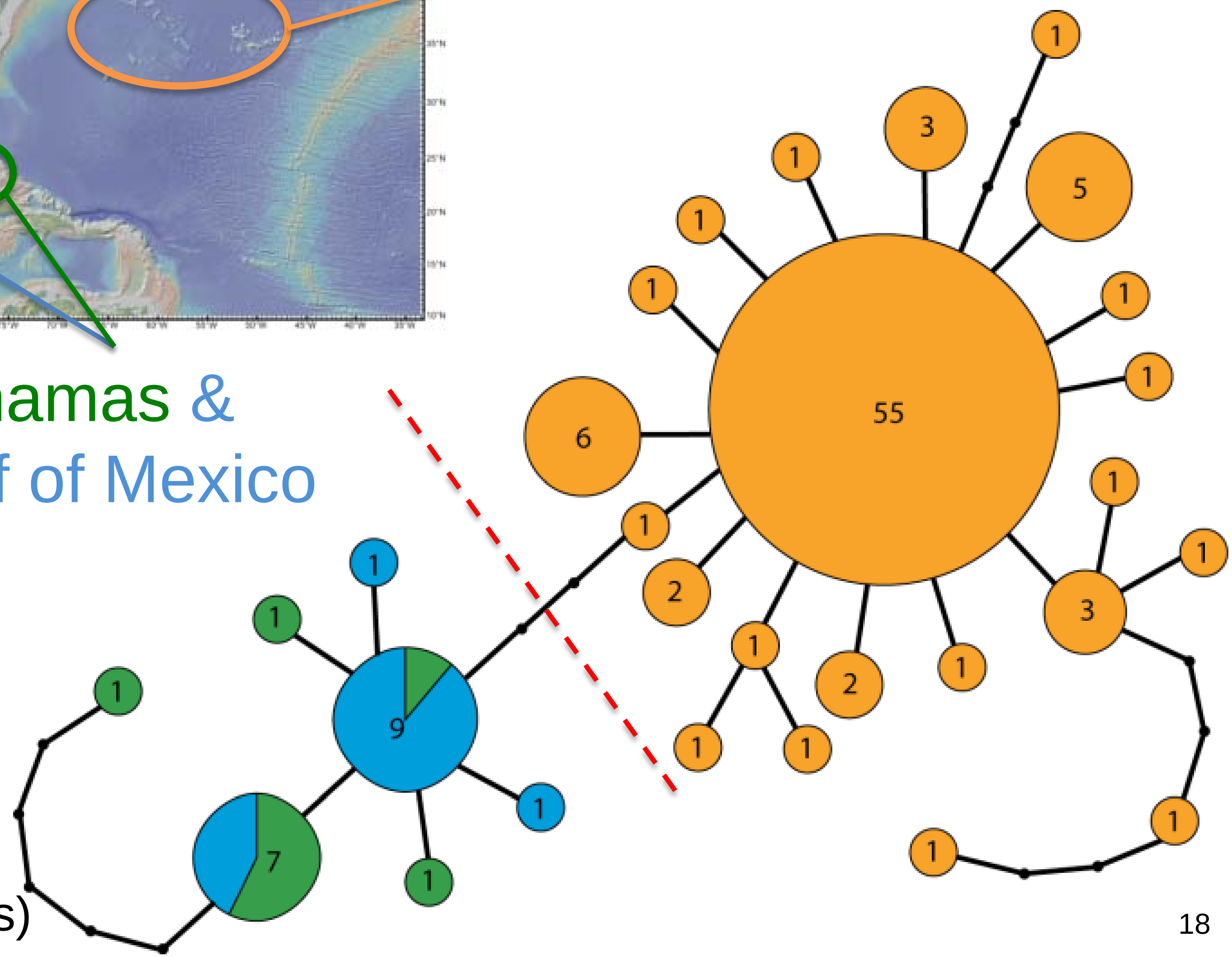


Asteroschema clavigerum Haplotype Network



North Atlantic

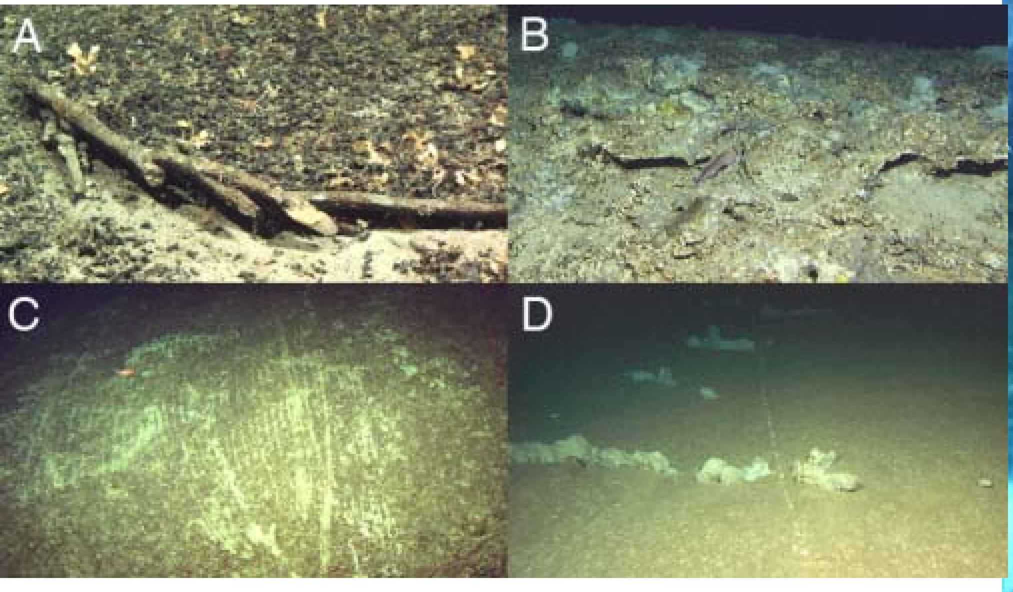
Bahamas & Gulf of Mexico



Significant population structure between the North Atlantic populations and the Bahamas and Gulf of Mexico populations (no shared haplotypes)

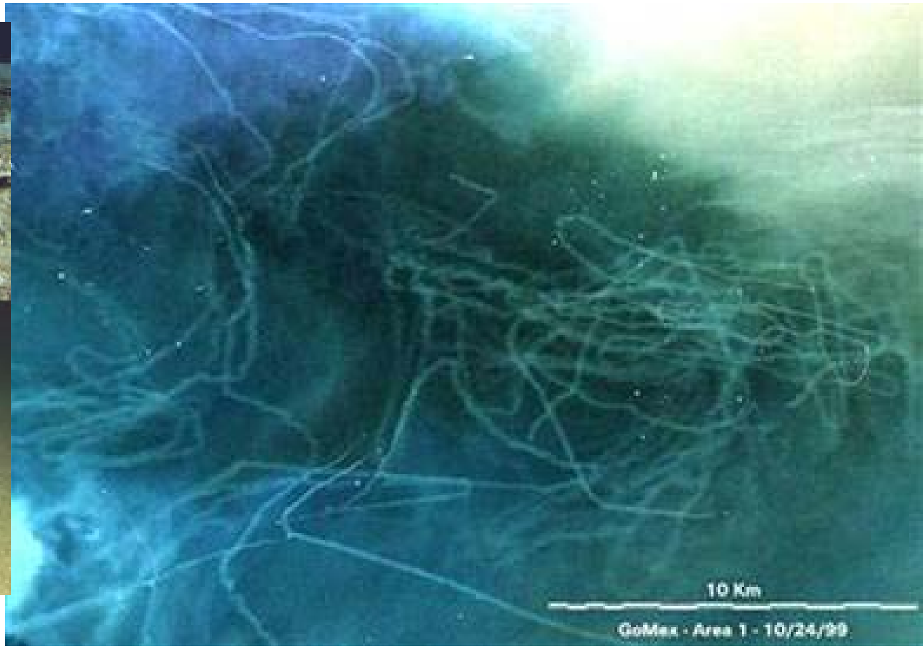
Strategic management requires an understanding of diversity and connectivity of vulnerable marine ecosystems

1) key force structuring and maintaining biodiversity and biogeography
2) mechanism to identify isolated and vulnerable populations and species
3) key for ecosystems under unprecedented stress from human activities (e.g., fisheries, mining, acidification, climate change) as well as those that are slow (unknown) rates of colonization, growth and ecosystem recovery



Fisheries-related habitat damage on North Atlantic Seamounts
(Deep Atlantic Stepping Stones Research Group/IFE/URI/NOAA)

"Globally each year, bottom trawlers drag an area equal to twice the lower 48 states" (Watling and Norse 1998)



Sediment plumes left in the wake of trawling nets across the floor of the Gulf of Mexico
(Image from space; Science News, Feb. 28, 2008)

Lophelia II Work: Well Poised for Assessing Associates as Indicators of Coral Ecosystem Health

Mississippi Canyon 338 – 1,370m
Observations over Time

- ASSOCIATE COLORATION:
  - 47% of ophiuroids were tan to red
  - 44% had pale arms
  - 9% were mostly pale
- CHANGES/MOVEMENT:
  - 78% ophiuroids moved very little or not at all
  - 22% noticeably shifted position (but often very slightly)
  - 1 ophiuroid appeared
  - 1 ophiuroid disappeared
- BEHAVIOR:
  - 10 ophiuroids went from tightly to loosely coiled
  - 2 ophiuroids went from tightly or loosely coiled to splayed out

Lopelia II *expedition, NOAA-OER/ BOEMRE*
NSF Rapid Response

Coral Associates in the Gulf of Mexico
Next Steps: Future Integrative Work

- Exploration of deeper sites hosting corals and their associates
- Establishment of temporal HD imaging stations, including time-lapse camera imaging to monitor the temporal and spatial interactions of corals and their associates
- Connectivity of coral and associate populations among different regions and depths within and outside of the Gulf of Mexico
- The role of larvae in genetic connectivity to maintain species via temporal analysis of sediment trap larvae

- To examine the strength of resilience and recovery of these ecosystems by examining the fidelity of associates to their coral host – gene expression analysis

Acknowledgments

LOPHELIA II Team

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Dr. Peter Etnoyer (NOAA)
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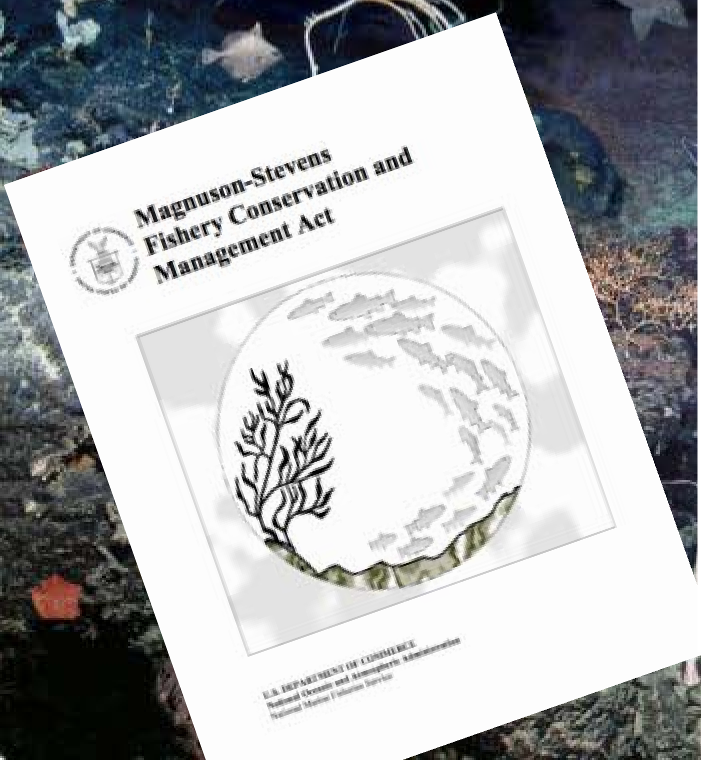
R/V *Nancy Foster*, R/V *Cape Hatteras*
Pilots & Crew of ROV *Jason*, *Global Explorer*, and *SeaEye Falcon*

Why Is Understanding Coral Ecosystem Connectivity Important?

1) mechanism to identify isolated and vulnerable populations and species
2) key structuring and maintaining biodiversity and biogeography
3) ecosystems under unprecedented stress from human activities (e.g., fisheries, mining, acidification, climate change)
4) slow (unknown) rates of colonization, growth and ecosystem recovery

Calls for management approaches to counter anthropogenic impacts & ensure conservation of naturnal resources


Magnuson-Stevens Fishery Conservation and Management Act


Report to Congress on the

Implementation of the Deep Sea Coral Research and Technology Program

U.S. Department of Commerce

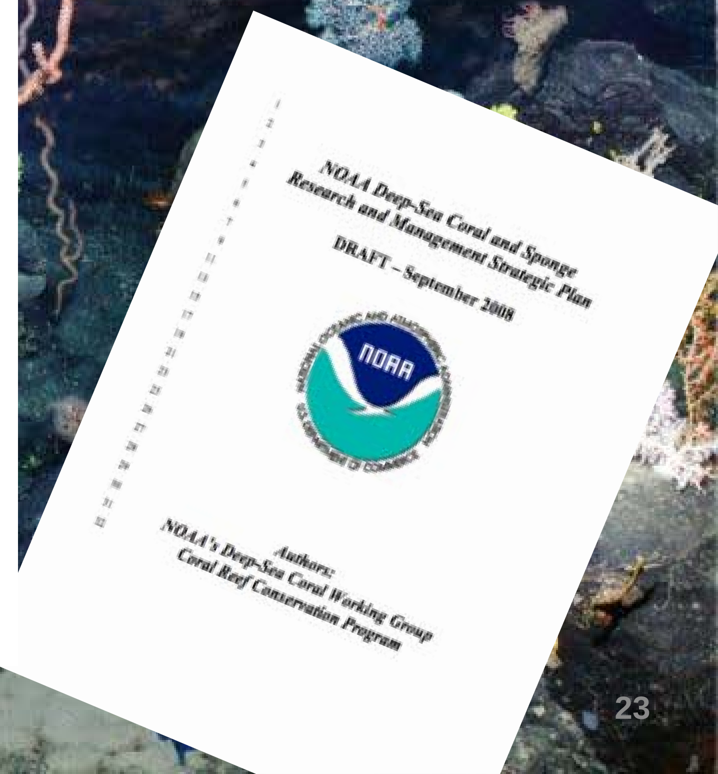
National Oceanic and Atmospheric Administration

National Marine Fisheries Service

Coral Reef Conservation Program

March 2008

Silver Spring, Maryland


NOAA Deep-Sea Coral and Sponge Research and Management Strategic Plan

DRAFT – September 2008

Authors:

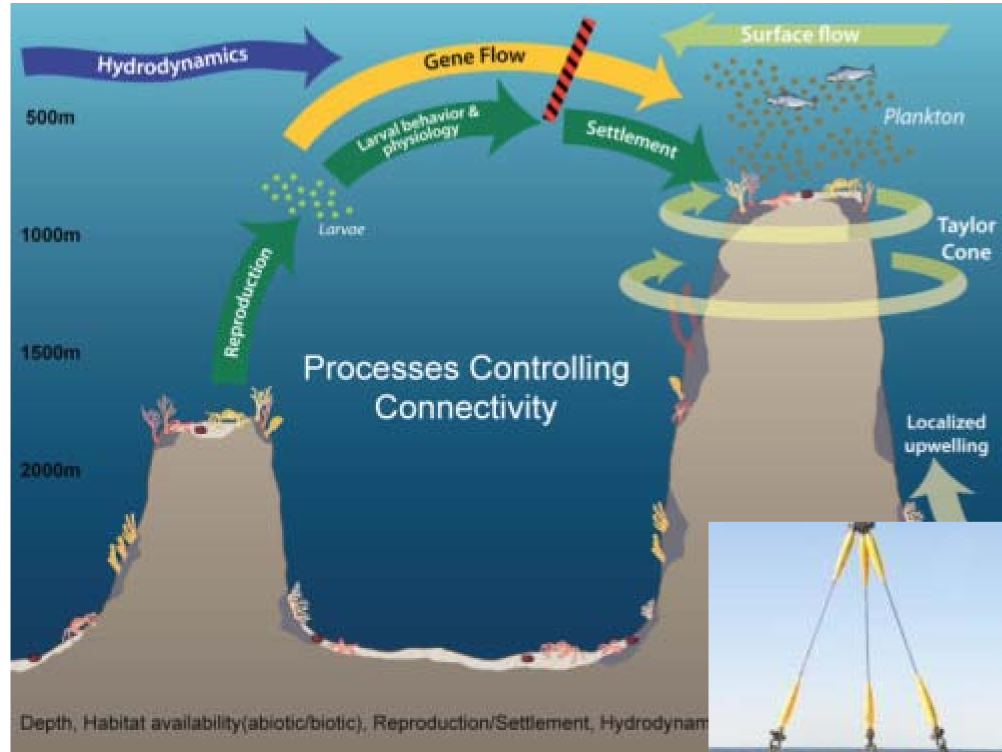
NOAA's Deep-Sea Coral Working Group

Coral Reef Conservation Program

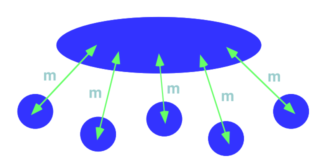
Characterize Patterns of Diversity, Distribution, & Genetic Connectivity of Coral Ecosystems in the Gulf of Mexico

- Phylogenetic identification
    - To identify and characterize the diversity and association of coral and associates
- Genetic Connectivity
    - “the dispersal, survival, and reproduction of migrants, so that they contribute to the local gene pool“

      Hedgecock et al. 2007
    - To assess patterns of gene flow among populations within and beyond the Gulf of Mexico
- Enumeration of Larvae from sediment traps
    - Molecular identification of larvae
    - Provide estimates of connectivity, direction of migration, source/sink dynamics



Gene Flow Models



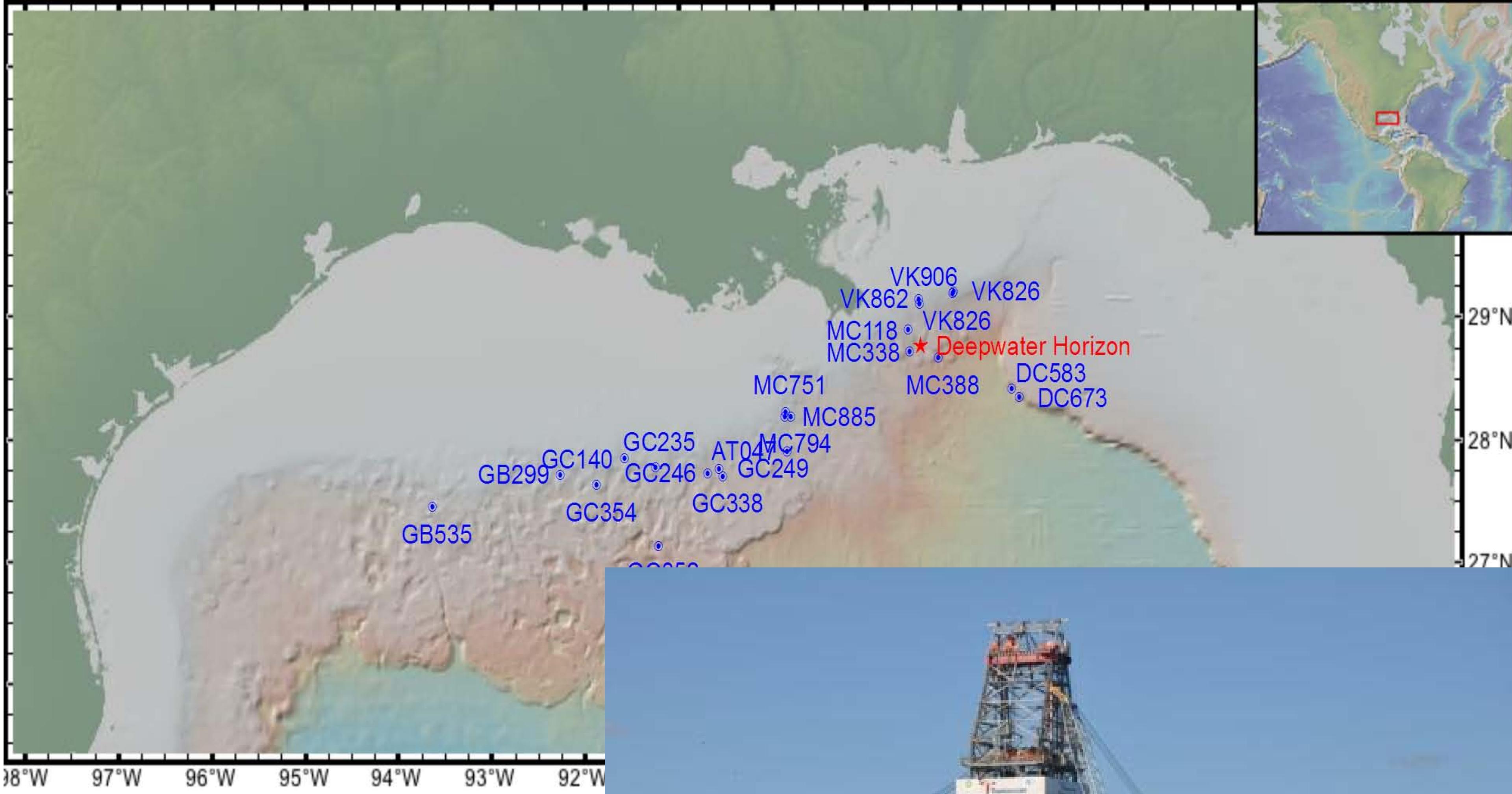
Asteroschema clavigerum

on *Paramuricea sp.*
66% of the observations
on *Paragorgia sp.*
34% of the observations

Ophiocreas oedipus

on *Metallogorgia melanotrichos*
Singly on central branching nodes
100% of the observations

(Deep Atlantic Stepping Stones /IFE/URI/NOAA)


VK906
VK862
VK826
VK826
MC118
MC338
Deepwater Horizon
MC388
DC583
DC673
MC751
MC885
GC235
MC794
AT047
GC140
GB299
GC246
GC249
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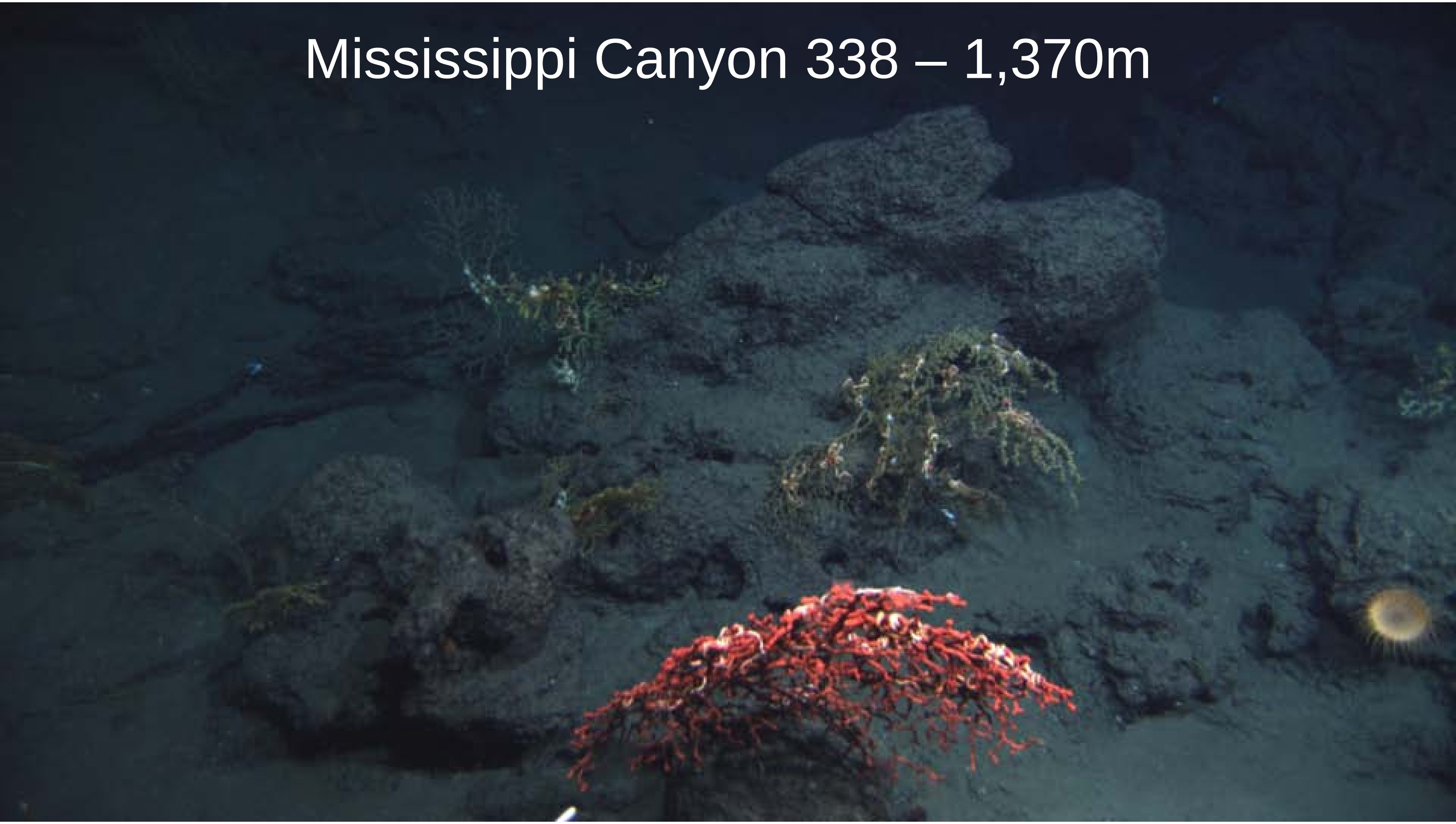
93°W
92°W



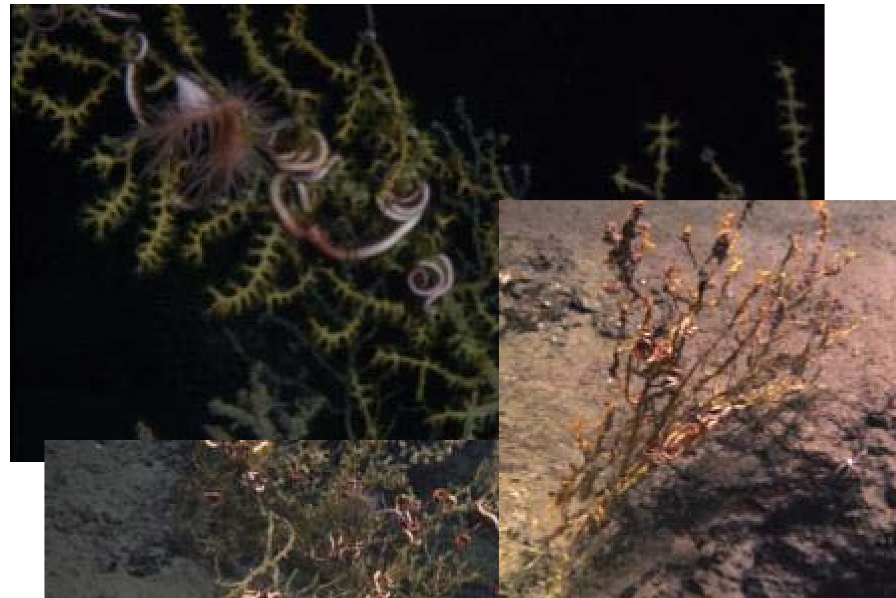
Coral communities, some with no apparent tissue (upper left), to wilting or a loss of tissue biomass (right) to exposed skeleton (upper white section in red foreground coral).

Lopelia II *expedition, NOAA-OER/ BOEMRE*

Assessing Impacts on Coral Associates

- Coral Hosts:
  - 52 corals
    - 75% with ophiuroid and/or anemone associates
    - 25% without associates

- Ophiuroid Associates:
  - 78 *Asteroschema clavigerum*
    - 70% on *Paramuricea* sp.
    - 18% on *Paragorgia* sp.
    - 12% on *Acanthogorgia* sp.?



Lopelia II *expedition, NOAA-OER/ BOEMRE*

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Eckelbarger, K.J., L. Watling, and H. Fourniero. 2005. Reproductive biology of the deep-sea polychaete *Gorgoniapolynoe caeciliae* (Polynoidae), a commensal species associated with octocorals. Journal of the Marine Biological Association of the United Kingdom 85:4933:1–9.

Hedgecock, D., P.H. Barber, and S. Edmands. 2007. Genetic approaches to measuring connectivity. Oceanography 20(3):70–79.

Watling, L. and E.A. Norse. 1998. Disturbance of the seabed by mobile fishing gear: A comparison to forest clearcutting. Conservation Biology 12:1180–1197.