

# Studying complexity of Mesozoic Tethyan food webs to understand ecosystem restructuring

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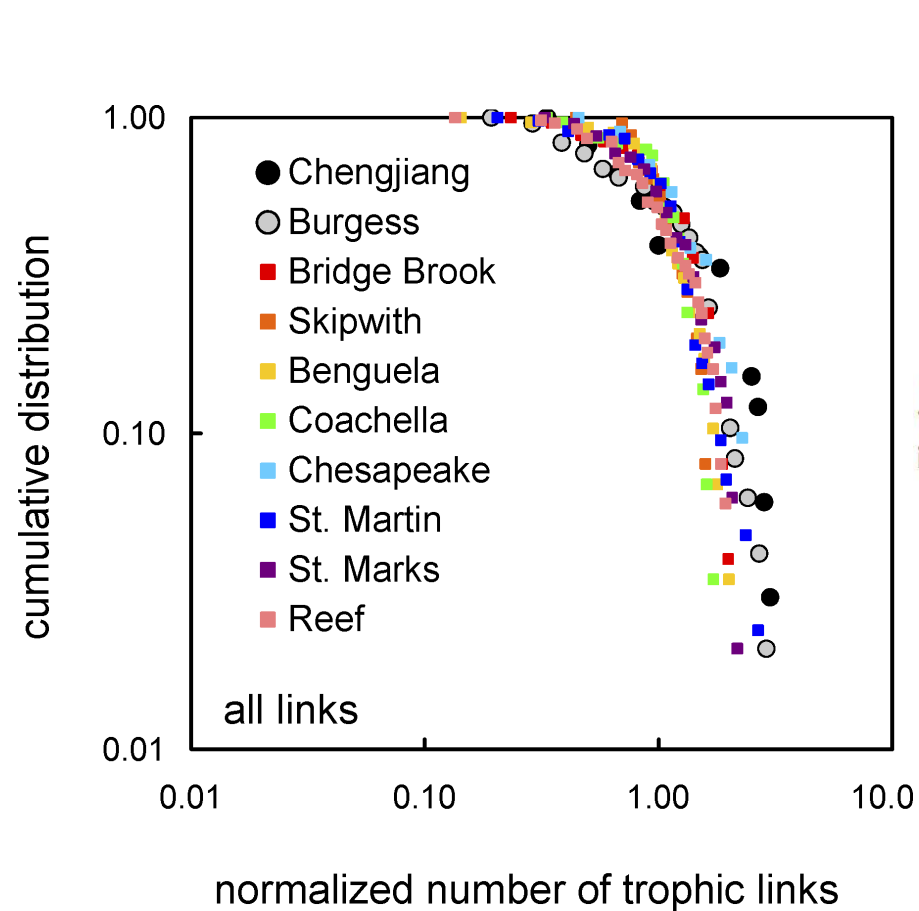
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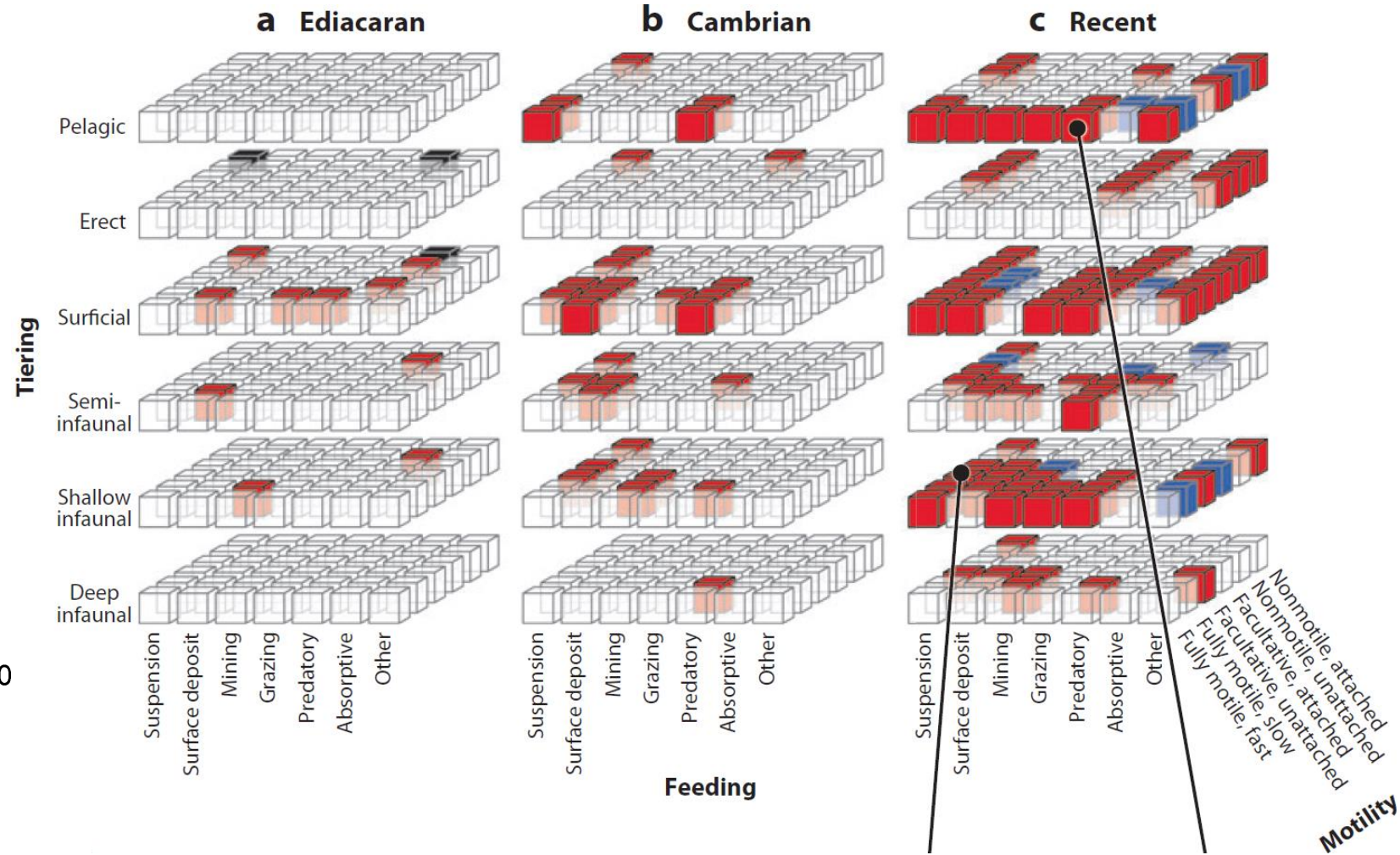




# Does Ecosystem Structure Change Through Time?



*Dunne et al., 2008*



*Bush and Bambach, 2011*

# Mesozoic Marine Revolution (MMR)

- Abrupt ecosystem reorganization due to increasing predation pressure
- Changes in community structure
  - Diversification of predators
  - New modes of life
  - Greater ecosystem complexity?

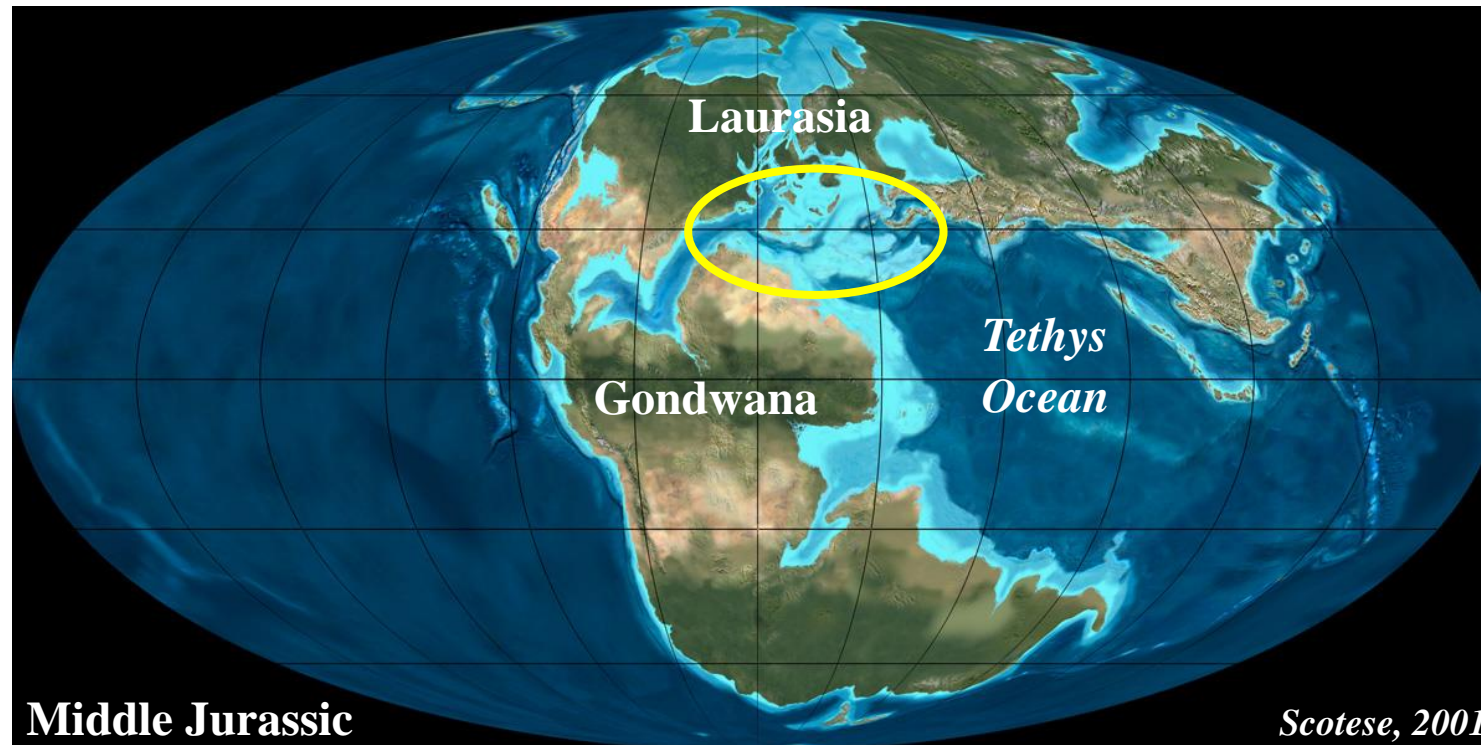


*Duria Antiquior - Beche*



# Hypothesis

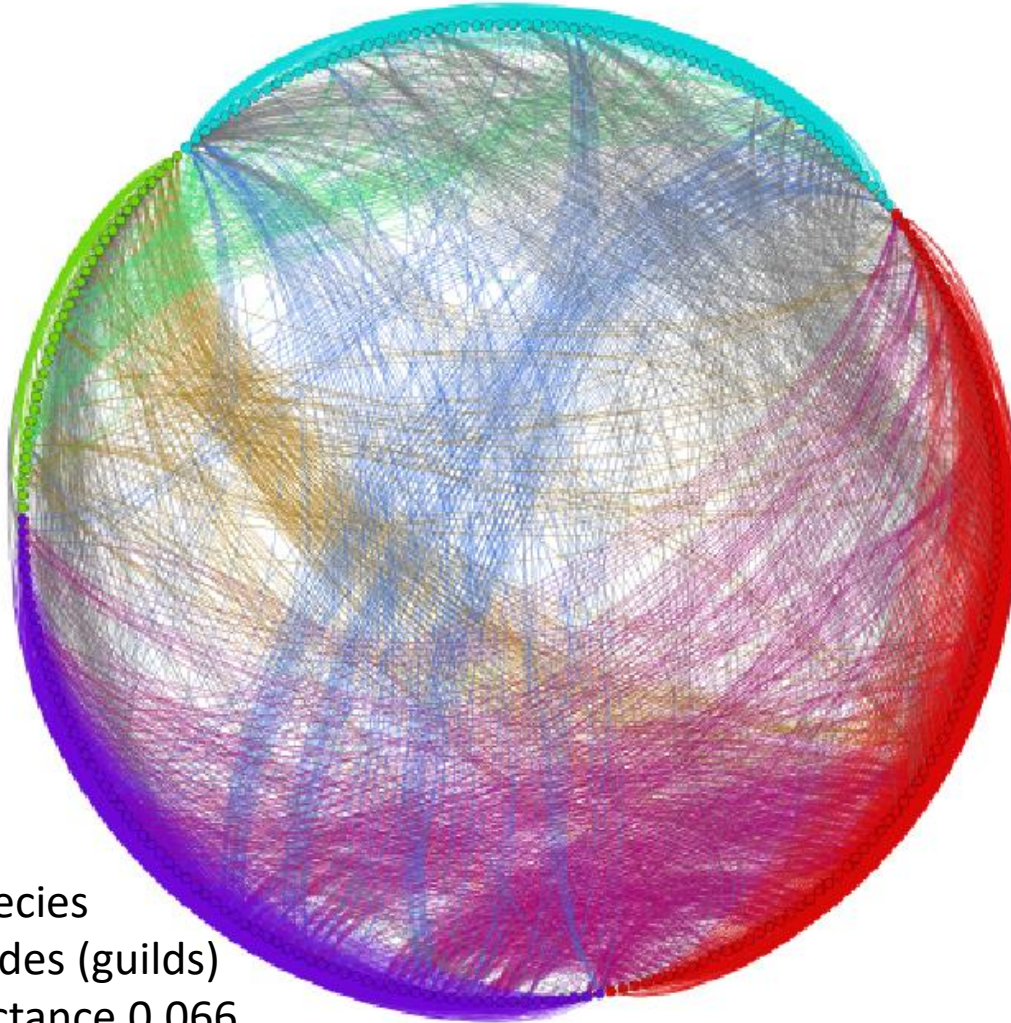
- Middle Triassic and Jurassic networks
- Testing effects of increasing predation pressure on marine communities by comparing trophic organization of both networks
- **Does ecological complexity increase or change across the MMR?**



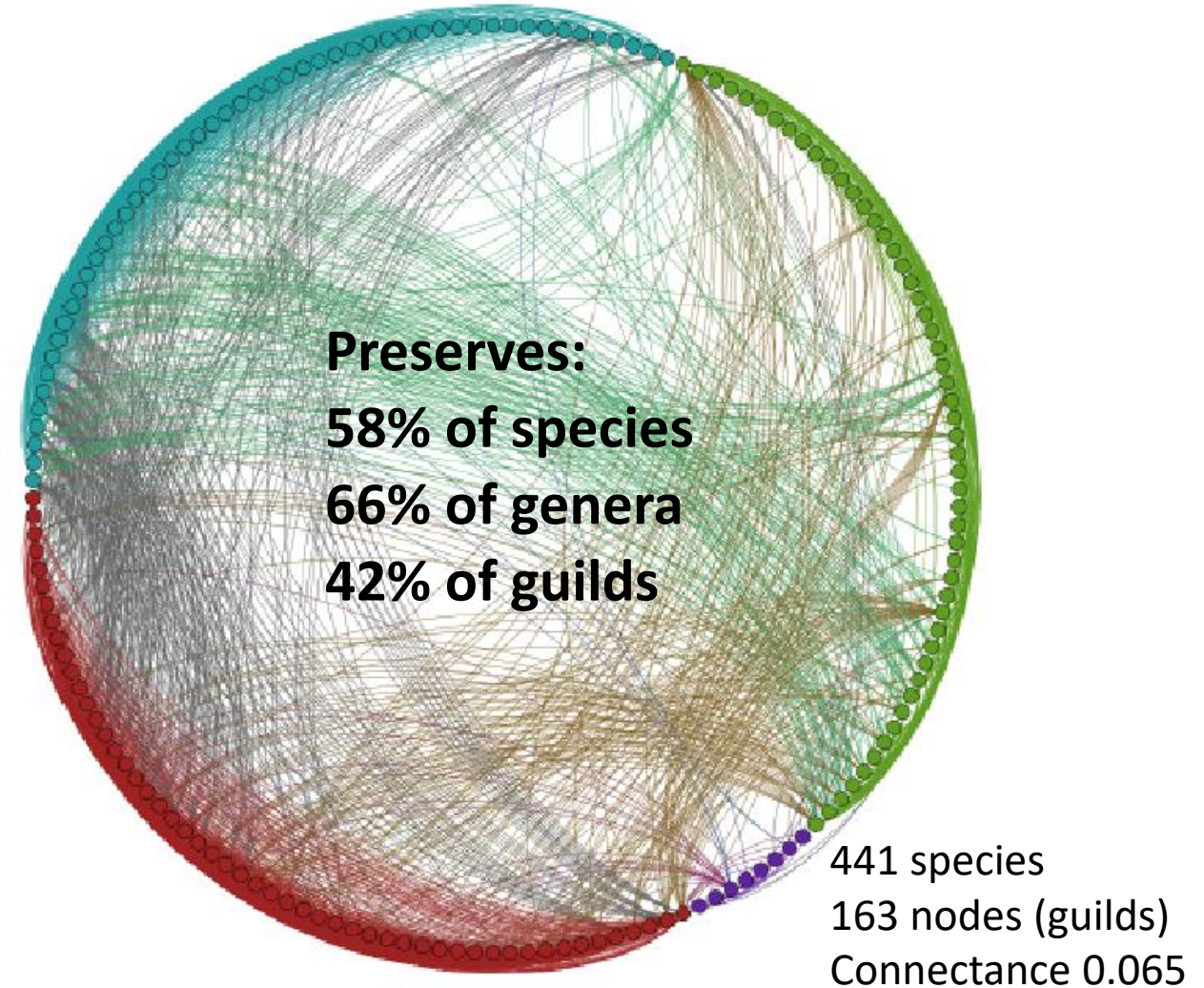


# Integrity of Fossil Food Web Structure

Modern Caribbean Reef



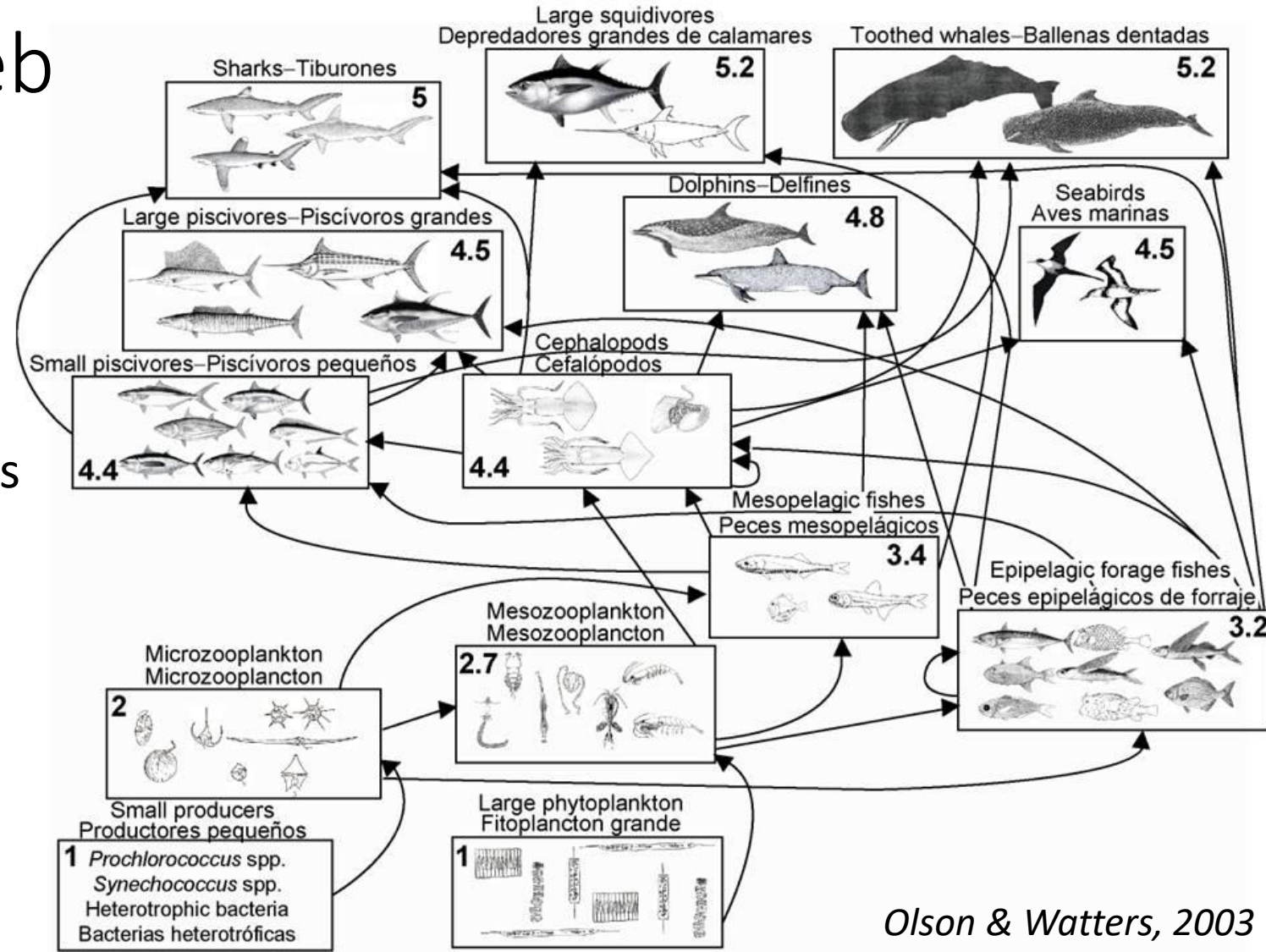
Predicted Fossil Reef





# Constructing a Food Web

- Step 1: Species List
- Step 2: Ecological Parameterization
- Step 3: Guilds and trophic interactions
- Step 4: Metanetwork



*Olson & Watters, 2003*

# Metrics to Study MMR Structural Changes

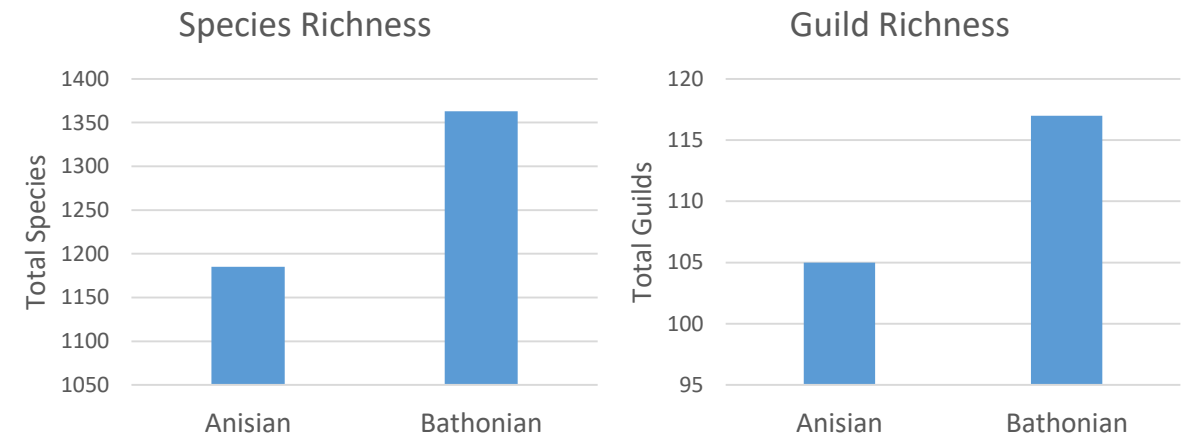
Structural Metrics	Anisian	Bathonian
Species Richness	1185	1363
Guild Richness	105	117
Number of Trophic Links	1006	1000
Linkage Density	9.57	8.55
Connectance	0.0912	0.0731
Number of Trophic Levels	4.88	5.01
Modularity	0.341	0.369
Average Path Length	1.81	1.91

- Trends characteristic of the MMR
  - Diversification of predators
  - Increased infaunalization
  - Larger body sizes
  - Increased richness

# Functional Diversity

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- Species and guild richness increase
- Suggests MMR led to an increase in functional richness

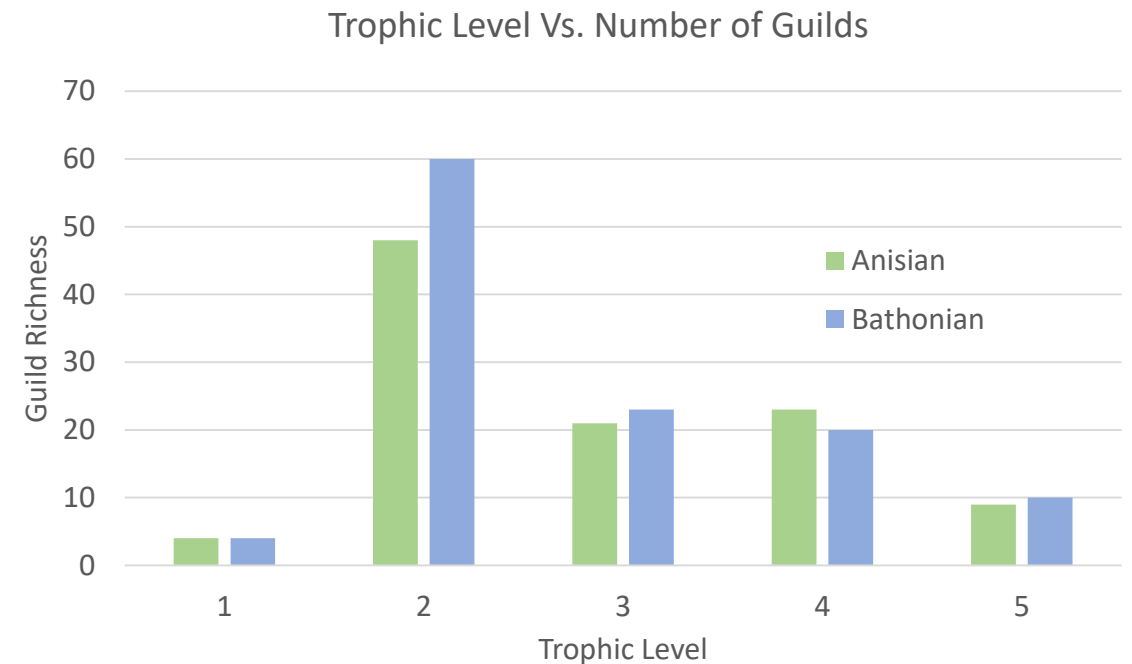




# Trophic Levels

- Slight increase in number of trophic levels
- Distribution of trophic levels similar
- Increased suspension feeders in 2<sup>nd</sup> trophic level
  - More higher trophic levels (depend on increased primary productivity)

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# Bathonian Trophic Levels

## Taxa

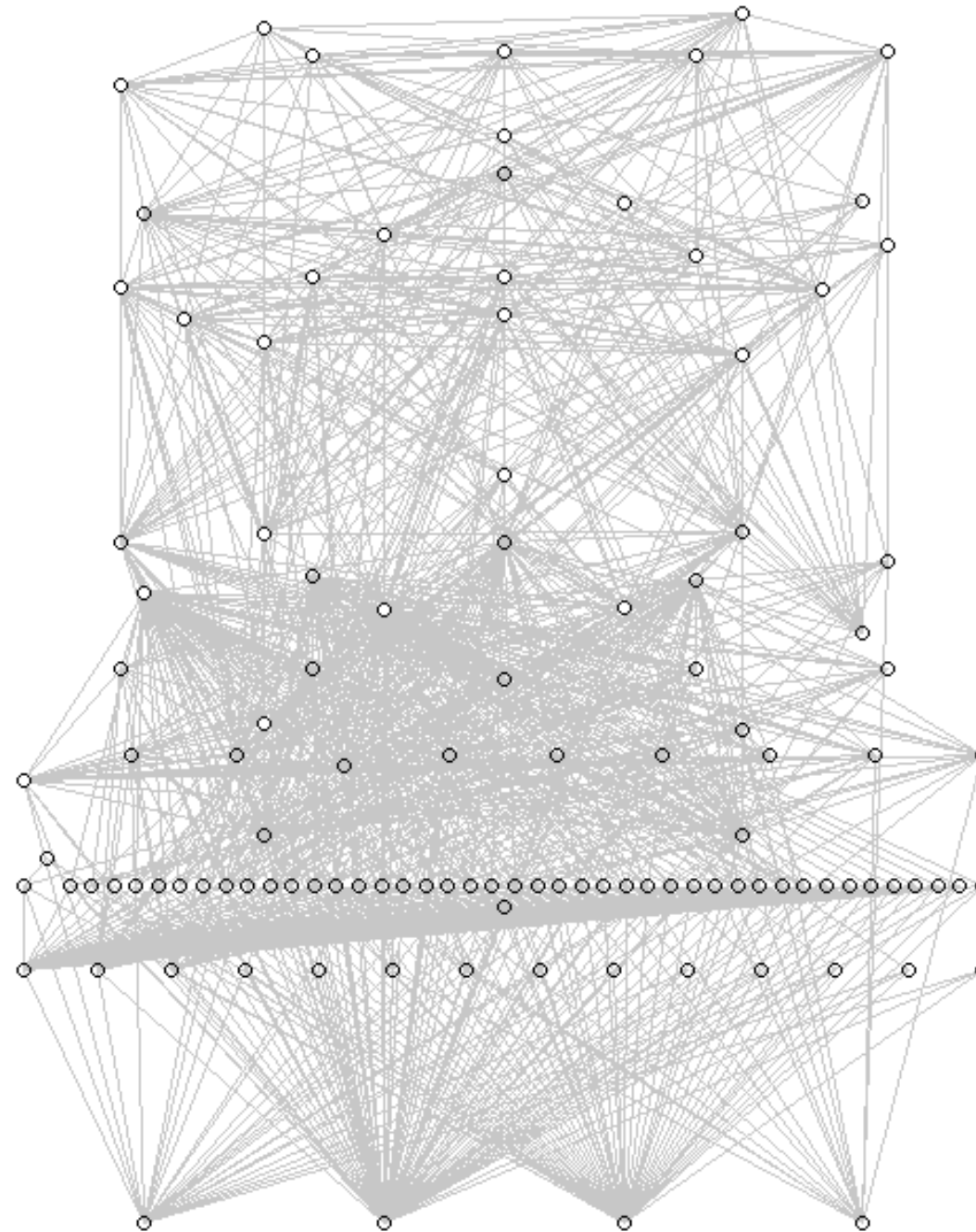
Pliosaurus, ichthyosaurs,  
plesiosaurs

Durophagous sharks/rays,  
cephalopods

Lobsters/crabs, deposit  
feeders, grazers, benthic  
carnivores

Suspension feeders,  
detritivores,  
microzooplankton

Bacteria, detritus,  
dinoflagellates, macroalgae

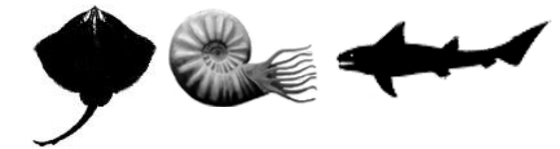


## Trophic Level

5



4



3



2

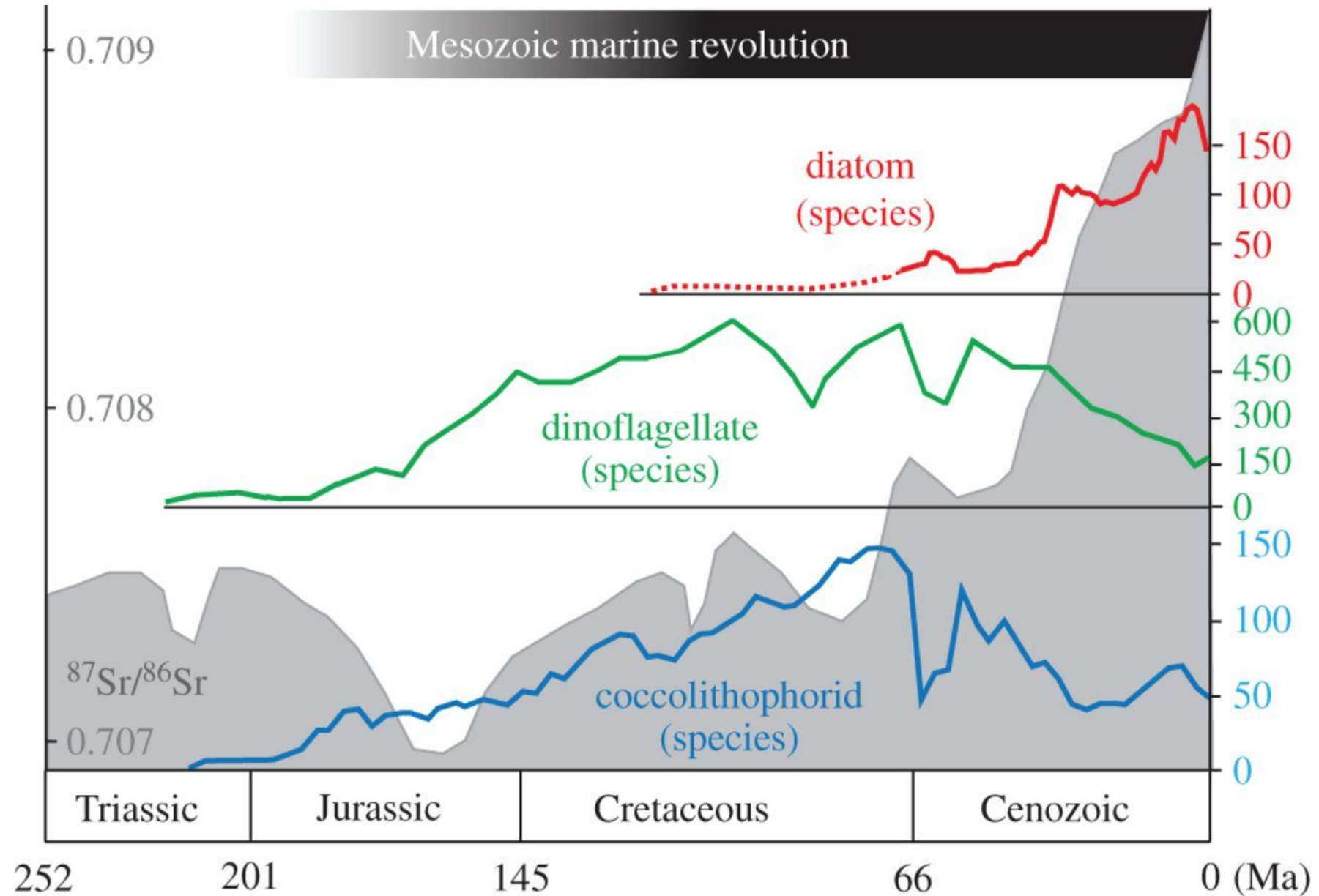


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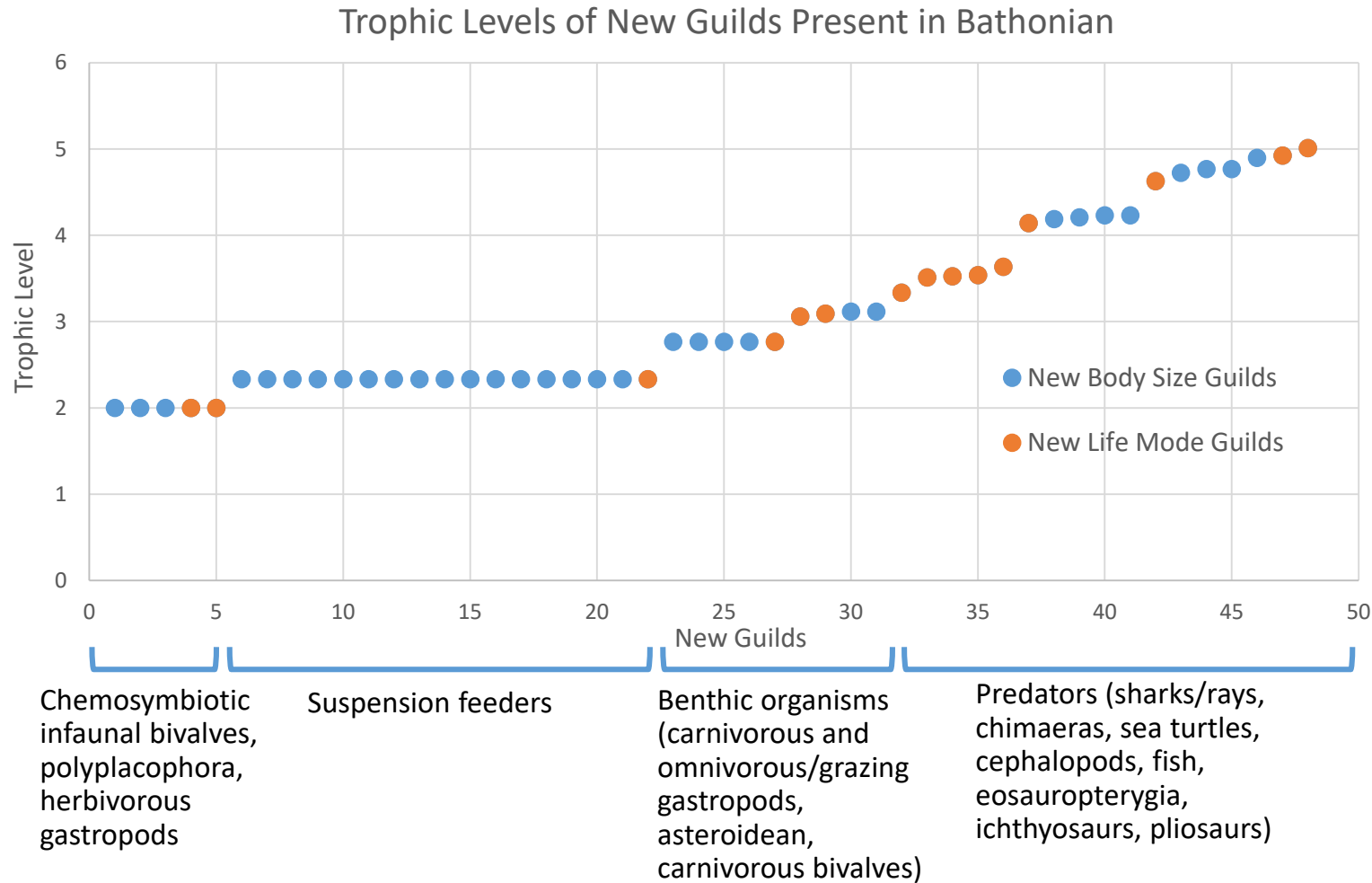


# Bottom-up Cascades



# New Guilds Present in Bathonian

- 48 new guilds
- Increased primary producer and predator guilds

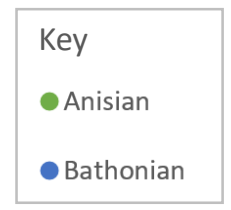
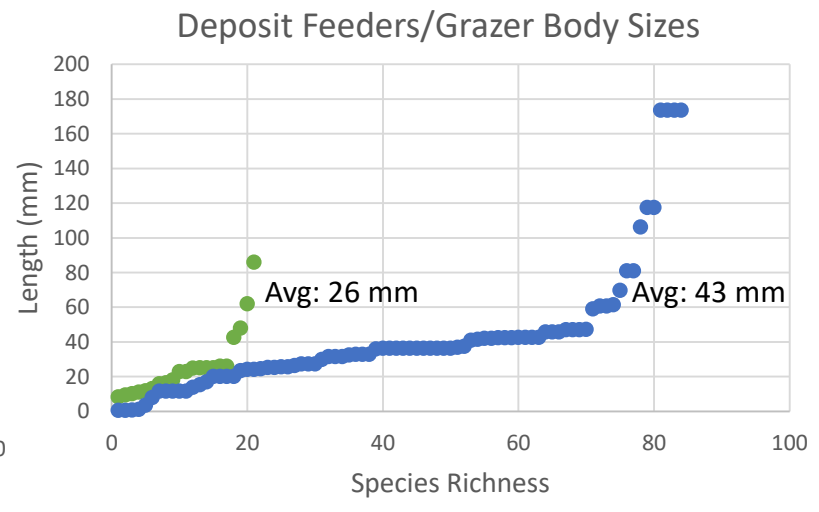
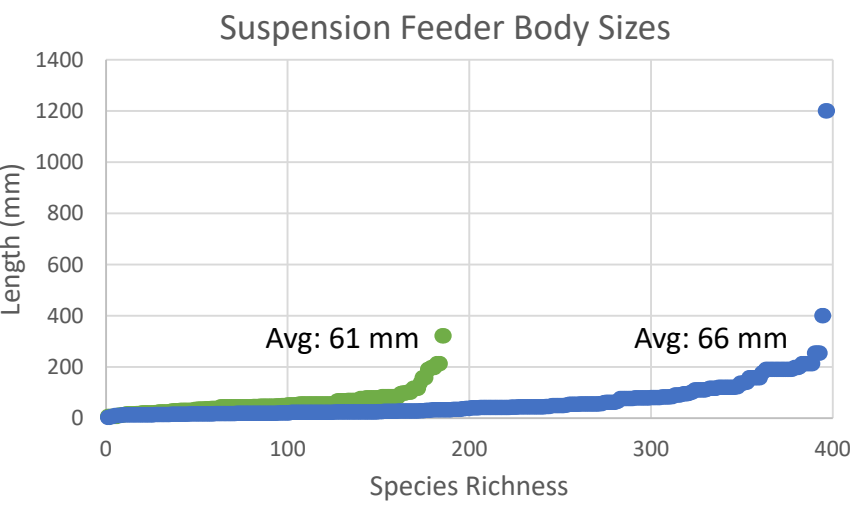
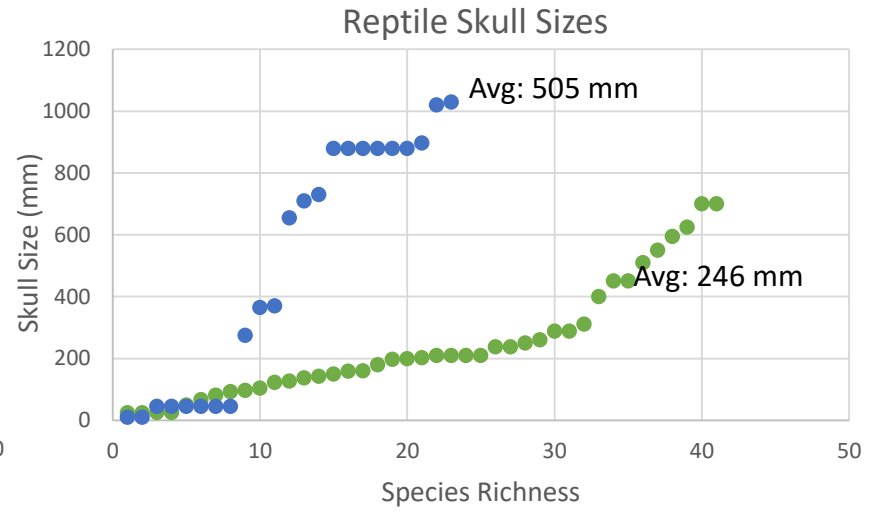
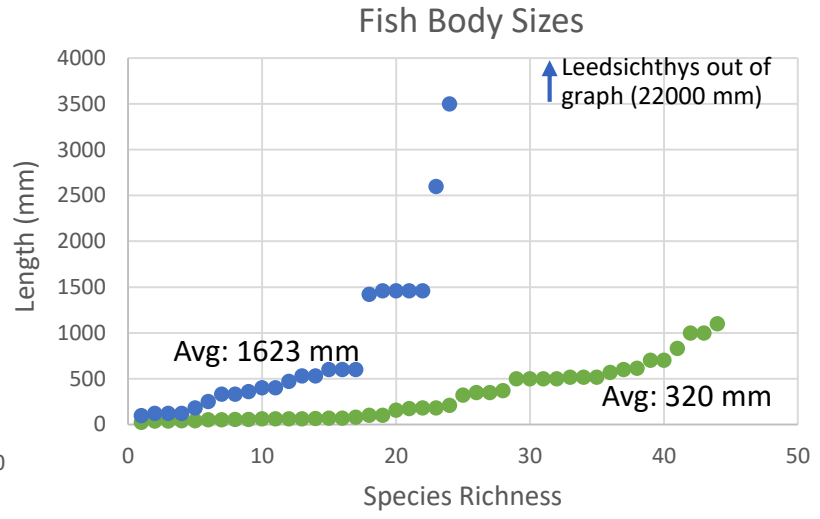
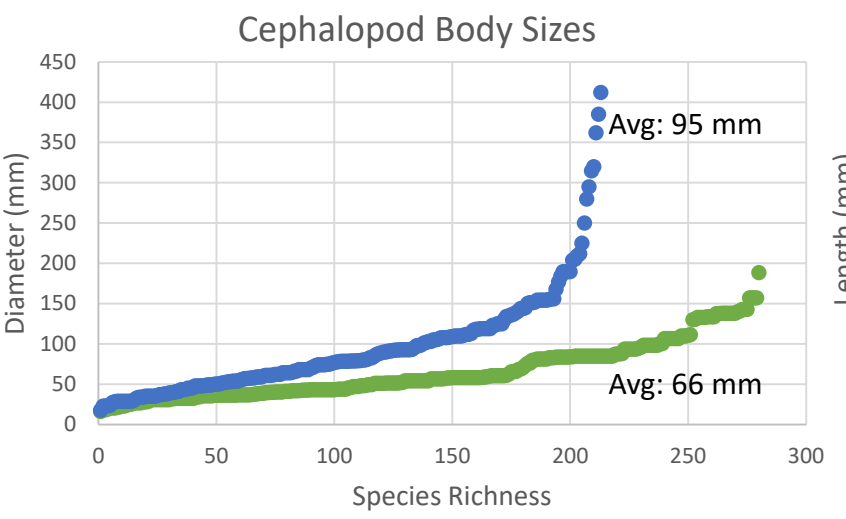


New Life Mode Guilds (N: 15)	
Benthic grazing polyplacophora	
Benthic herbivorous gastropods	
Nektobenthic carnivorous chimaeras	
Nektobenthic carnivorous durophagous rays	
Boring suspension feeding bivalves	
Deposit feeding/grazing sea stars	
Mobile infaunal carnivorous bivalves	
Hermit crabs	
Pliosaurs	
Sea turtles	
Nektobenthic carnivorous sharks/rays	
Nektobenthic carnivorous fast predatory fish	
Heteromorph ammonites	
Suspension feeding fish	
New Body Size Guilds (N: 33)	
Chemosymbiotic (Infaunal)(1)	
Chemosymbiotic (Infaunal)(3)	
Chemosymbiotic (Infaunal)(7)	
Suspension Feeder IX Epibiont Epifaunal(2)	
Suspension Feeder IX Epibiont Epifaunal(3)	
Suspension Feeder IX Epibiont Epifaunal(4)	
Suspension Feeder IX Epibiont Epifaunal(5)	
Suspension Feeder V Mobile Infaunal(10)	
Suspension Feeder V Mobile Infaunal(4)	
Suspension Feeder V Mobile Infaunal(5)	
Suspension Feeder V Mobile Infaunal(6)	
Suspension Feeders III Stationary Epifaunal(13)	
Suspension Feeders III Stationary Epifaunal(20)	
Suspension Feeders III Stationary Epifaunal(8)	
Suspension Feeders III Stationary Epifaunal(9)	
Suspension Feeders VII Epibiont SemiInfaunal(1)	
Suspension Feeders VII Epibiont SemiInfaunal(2)	
Suspension Feeders VII Epibiont SemiInfaunal(5)	
Suspension Feeders VII Epibiont SemiInfaunal(60)	
Benthic Omnivore/Grazers I(3)	
Benthic Omnivore/Grazers I(4)	
Benthic Omnivore/Grazers I(5)	
Benthic Omnivore/Grazers I(9)	
Benthic Carnivores III Epifaunal Gastropods(4)	
Benthic Carnivores III Epifaunal Gastropods(9)	
Nektonic Carnivores V Ammonites(3)	
Nektonic Carnivores III Fast Predatory Fish(4)	
Nektonic Carnivores V Ammonites(4)	
Nektonic Carnivores V Ammonites(5)	
Marine Reptiles II Piercing Predatory Reptiles(11)	
Marine Reptiles II Piercing Predatory Reptiles(8)	
Marine Reptiles II Piercing Predatory Reptiles(9)	
Marine Reptiles III Smash/Crunch Predatory Reptiles(8)	



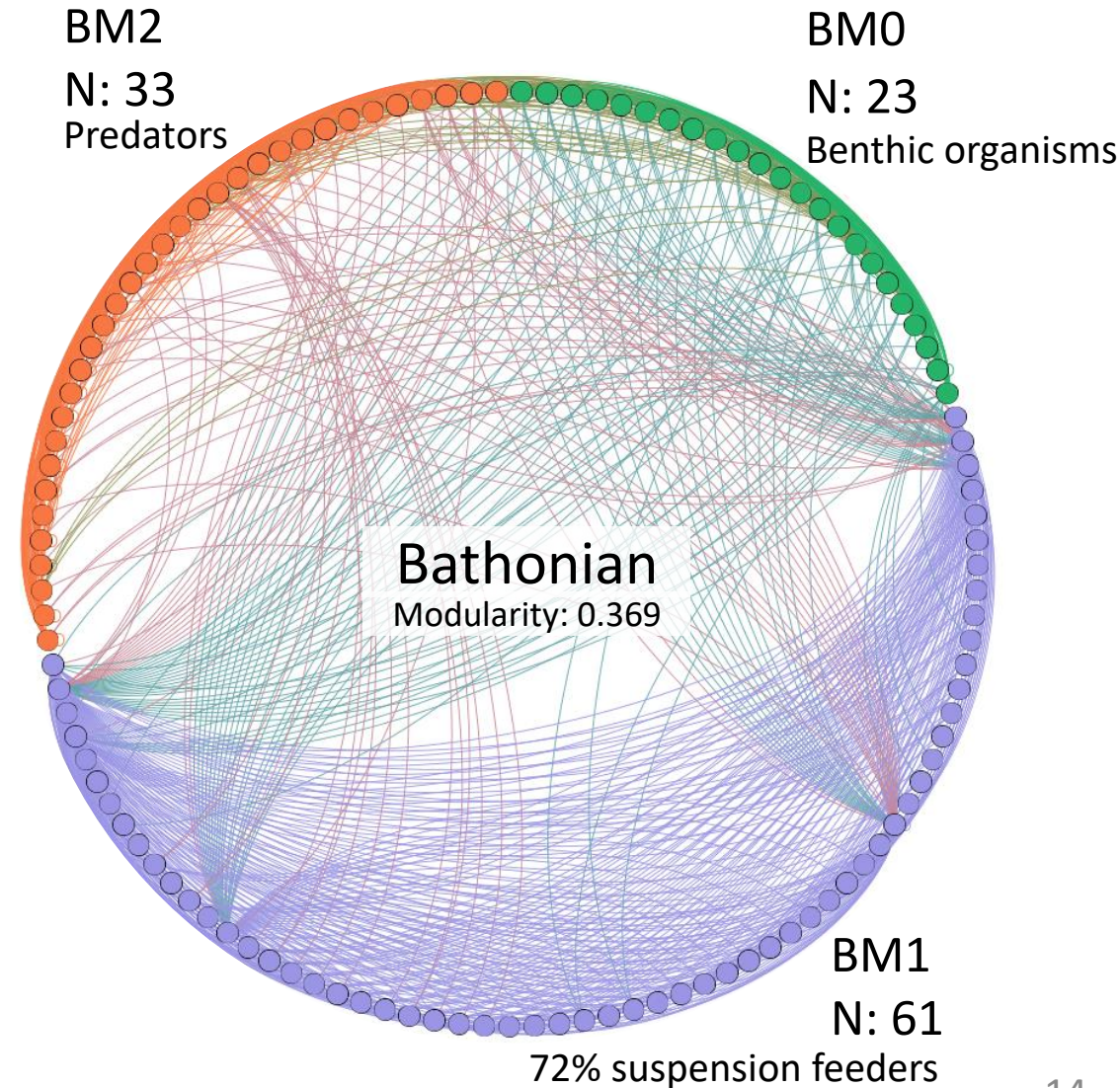
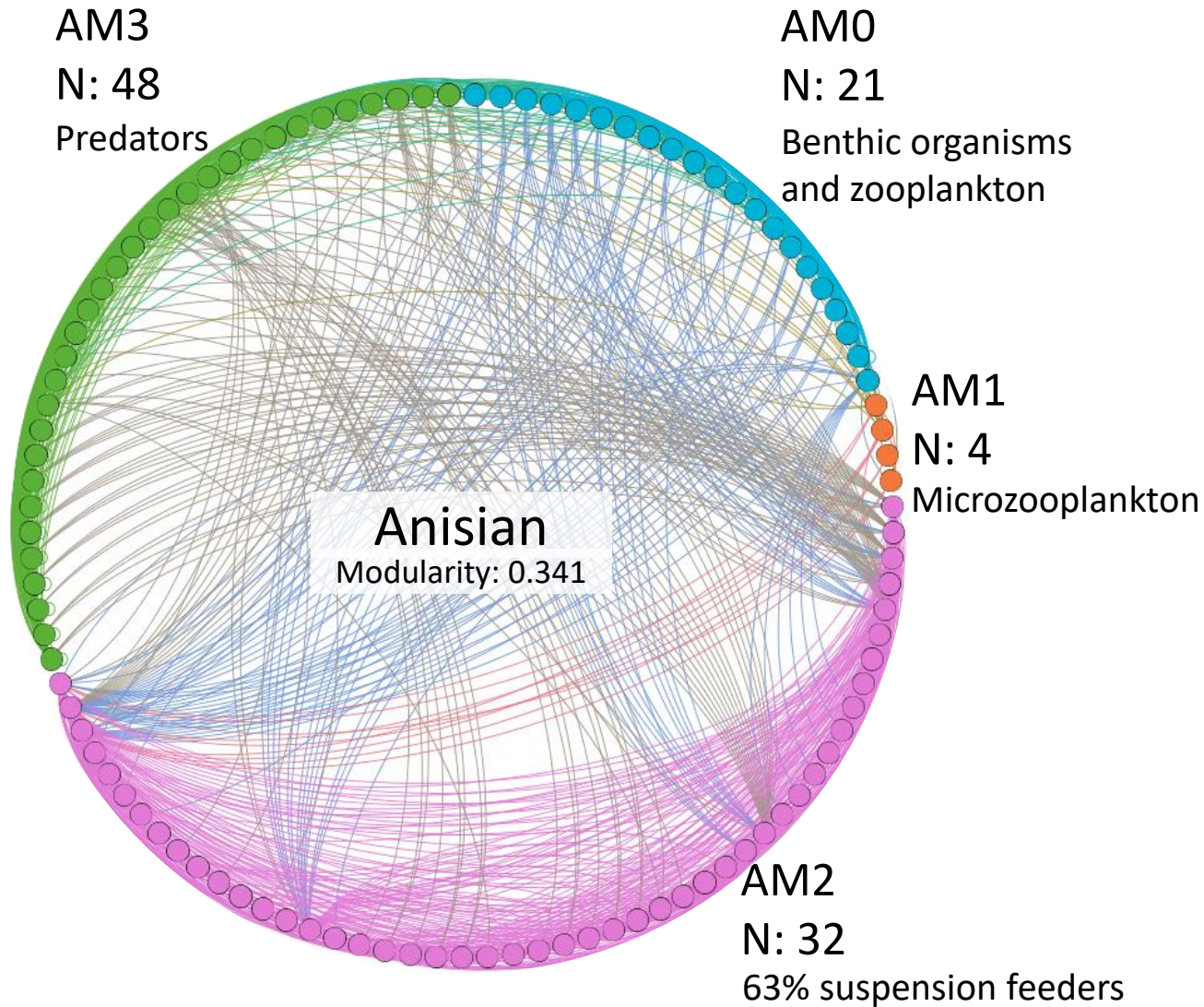
# Body Sizes

- Larger organisms in Bathonian
- Coincides with radiations of phytoplankton



# Modules

- Bathonian is partitioned into fewer subcommunities
- Suspension feeders form the largest subcommunity

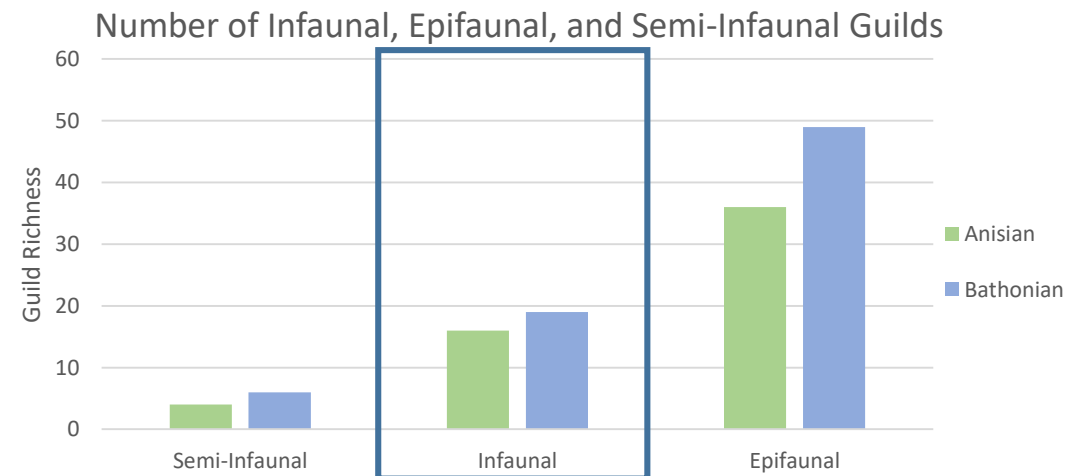
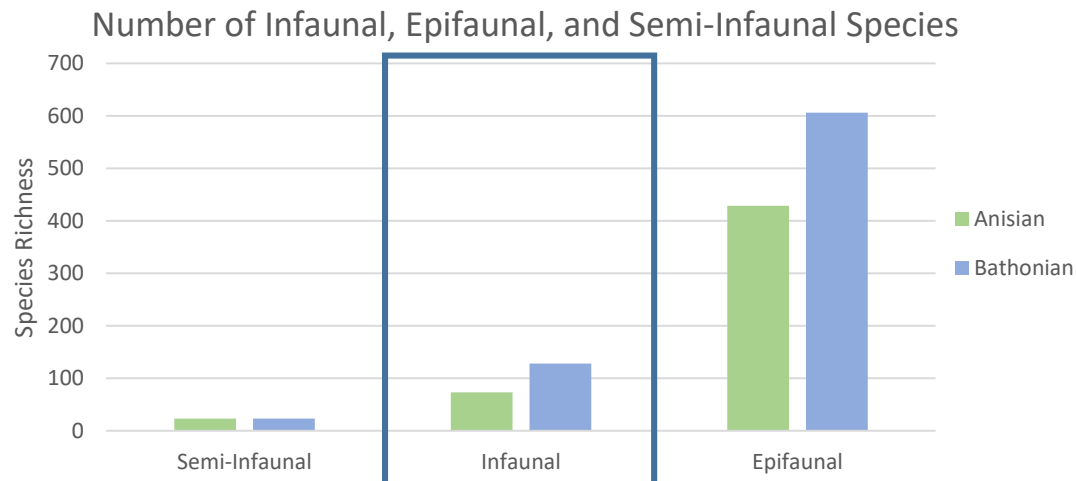




# Infaunal and Epifaunal Life Modes

- Increased predation and bioturbation in MMR
  - Shift to deeper waters or infaunalization
- Increase in infaunalization in both species and guild richness

	Anisian	Bathonian
Total Semi-Infaunal Species	23	23
Number of Semi-Infaunal Guilds	4	6
Total Infaunal Species	73	128
Number of Infaunal Guilds	16	19
Total Epifaunal Species	429	606
Number of Epifaunal Guilds	36	49



# Average Path Length

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- Bathonian has longer trophic chains
- More complex and inefficient!
- Makes sense given ecosystem restructuring



# Conflicting Metrics

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- Higher values of linkage density and connectance may lead to increased complexity
- Not supported here

# Conclusions

- MMR: increased predation pressure changes ecosystems
- Anisian to Bathonian: Increase in primary productivity led to increased energy transfer and higher trophic levels
- Triggered ecosystem restructuring and changes in energy transfer pathways, facilitated by radiation of phytoplankton
- Ecosystem structure has changed



# Acknowledgments

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