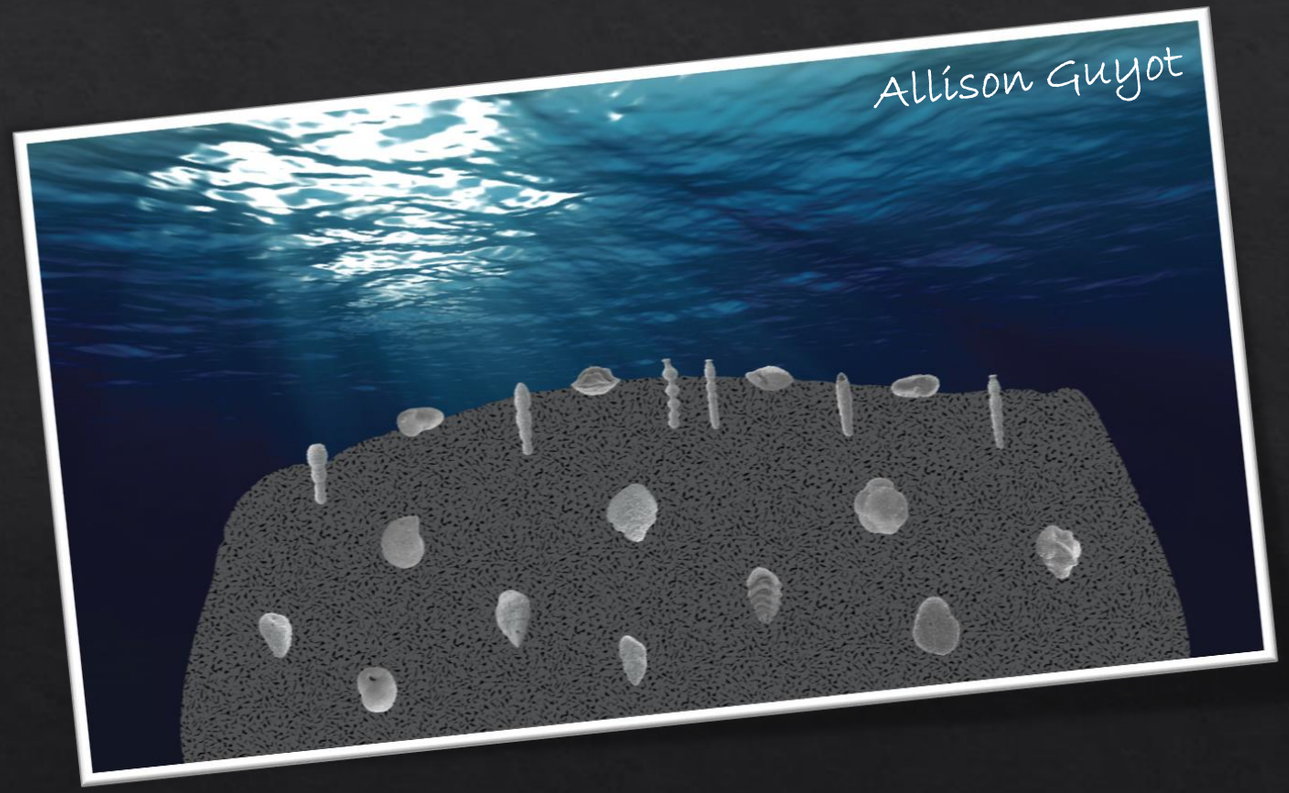
THE GEOLOGICAL SOCIETY OF AMERICA®

NE Section – 51st Annual Meeting 2016

Benthic foraminifera from an equatorial Pacific seamount during greenhouse climate



Gabriela J. Arreguín-Rodríguez, Laia Alegret & Ellen Thomas

Session T3 – Tropical Climate and Paleoclimate

Main points:

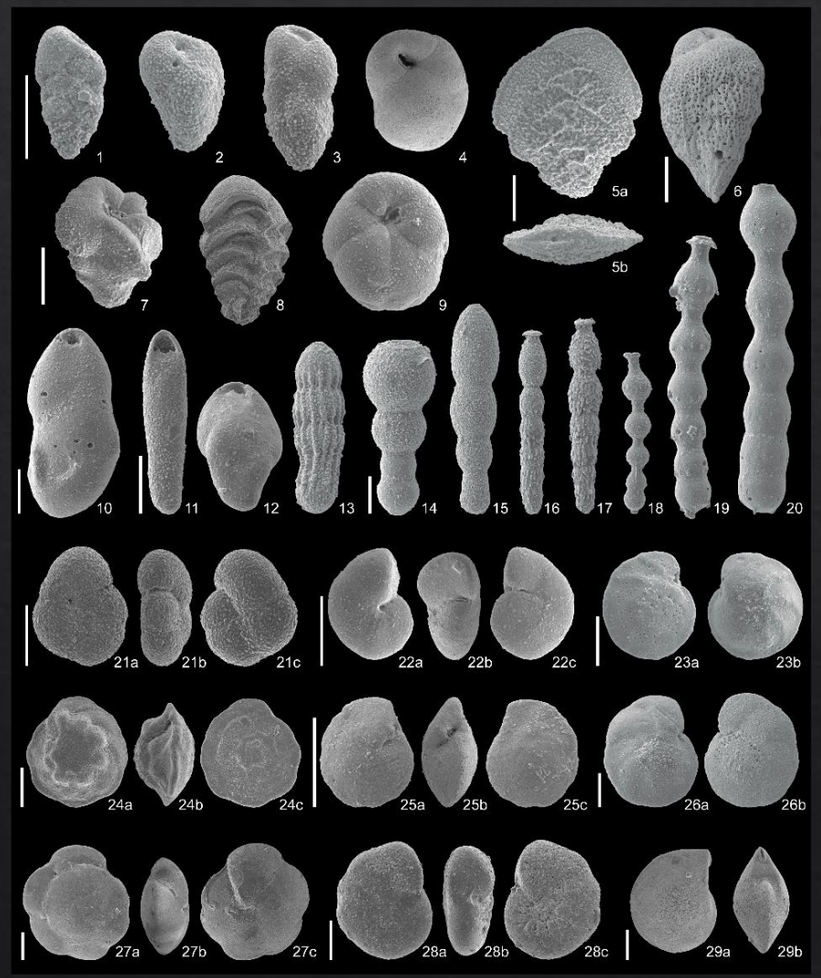
- Composition of benthic foraminiferal assemblages on a Pacific seamount, an unusual setting.

- Which factors influence them:
  - Primary productivity
  - Transfer to seafloor
  - Current activity

  } Food

- Response of the assemblages to warming events of different magnitude superimposed on a greenhouse climate.

Why study benthic foraminifera?



1

Eukaryote, heterotroph, unicellular organisms. Some make multi-chambered $CaCO_3$ or agglutinated-sediment shells.

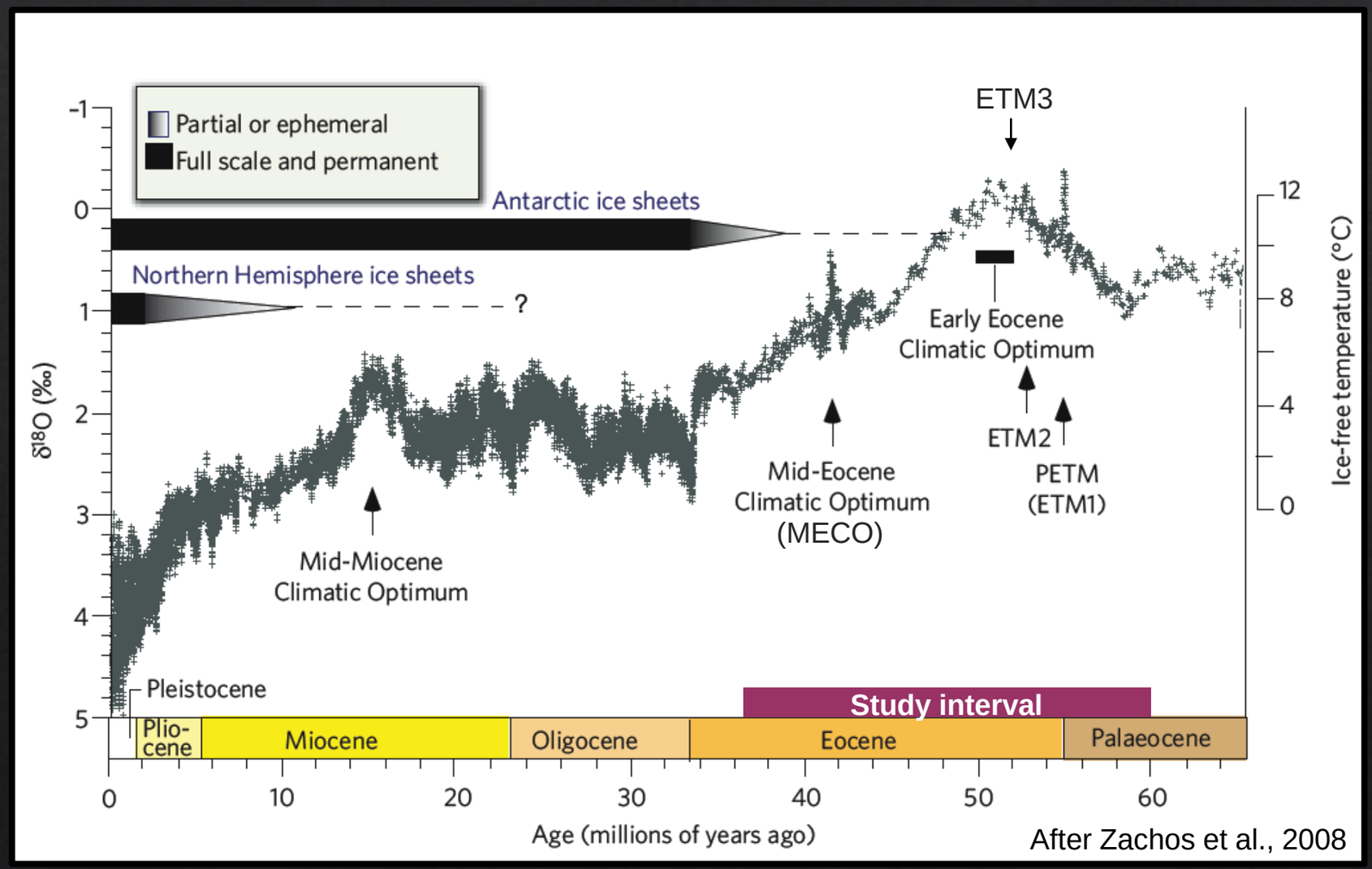
$CaCO_3$ used for trace elements/isotope studies to reconstruct environmental parameters

2

Biota most commonly represented in the microfossil record from the deep sea floor.

Deep sea ecosystems are the largest habitat on Earth

Greenhouse climate and hyperthermal events

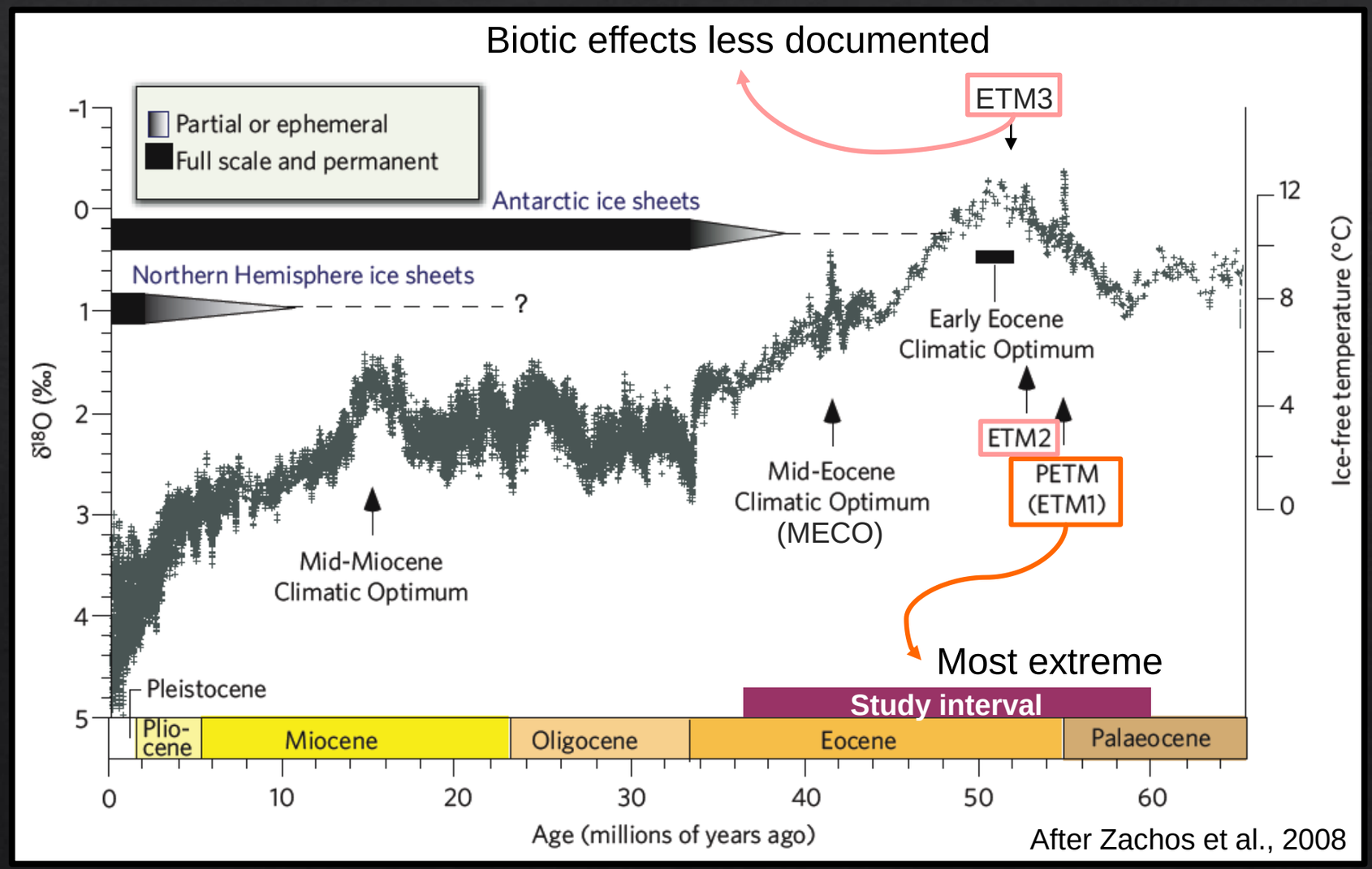


After Zachos et al., 2008

Greenhouse

Early Paleogene characterized by long-term global warming trend

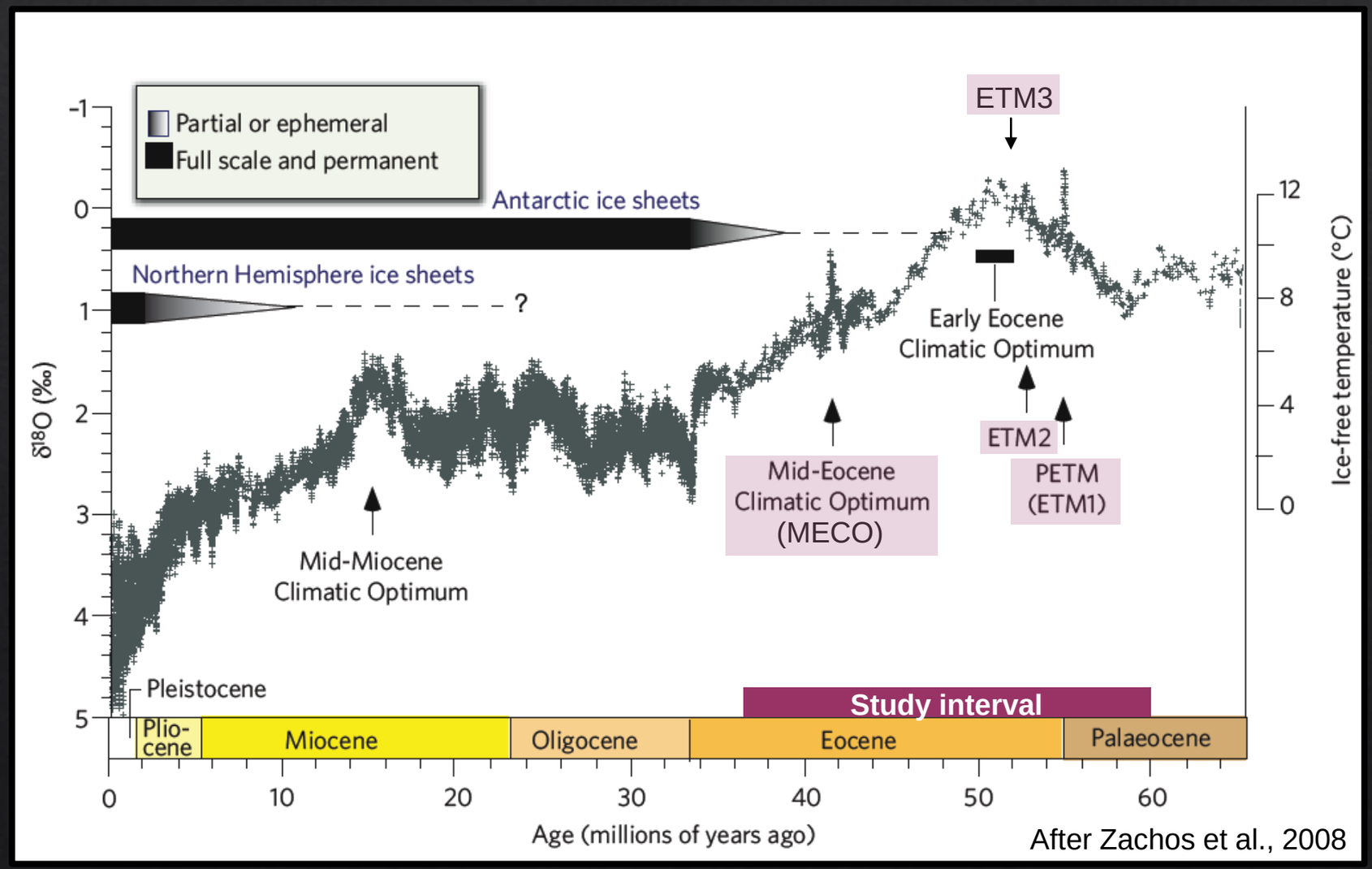
Greenhouse climate and hyperthermal events



Hyperthermals

- Oxygen isotope excursions:
  - ↳ warming
- Negative carbon isotope excursions (CIEs):
  - ↳ emission of isotopically light carbon
- Dissolution of $CaCO_3$:
  - ↳ ocean acidification
- Continental weathering
- Biotic perturbations

Greenhouse climate and hyperthermal events

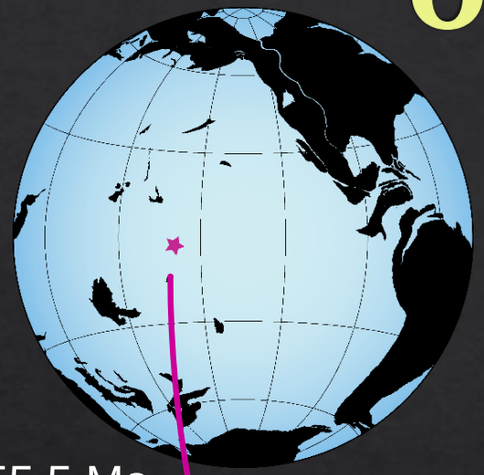


After Zachos et al., 2008

Objective

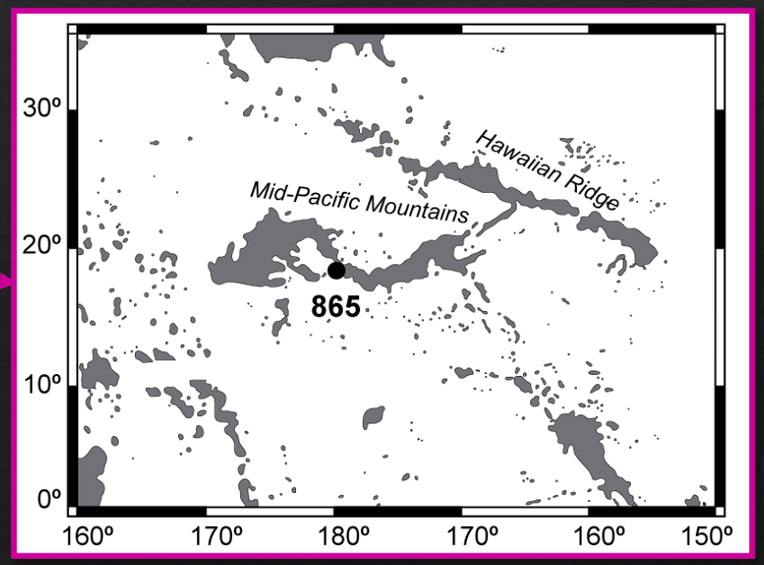
To compare the biotic turnover across the PETM and less intense hyperthermal events

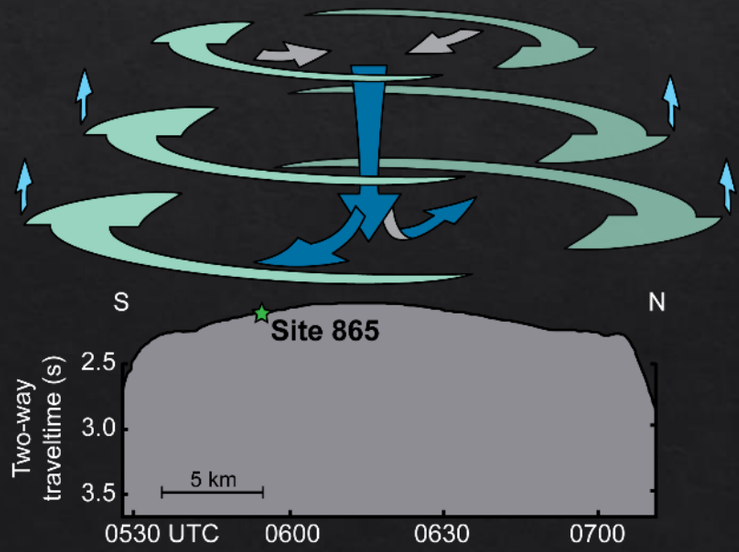
Ocean Drilling Program Site 865



55.5 Ma

- Paleocene – middle Eocene
- Allison Guyot, a seamount in the equatorial Pacific
- Foraminiferal nannofossil ooze
- $CaCO_3$ content: 92-98%
- Paleodepth: upper lower bathyal (~1300-1500 m)





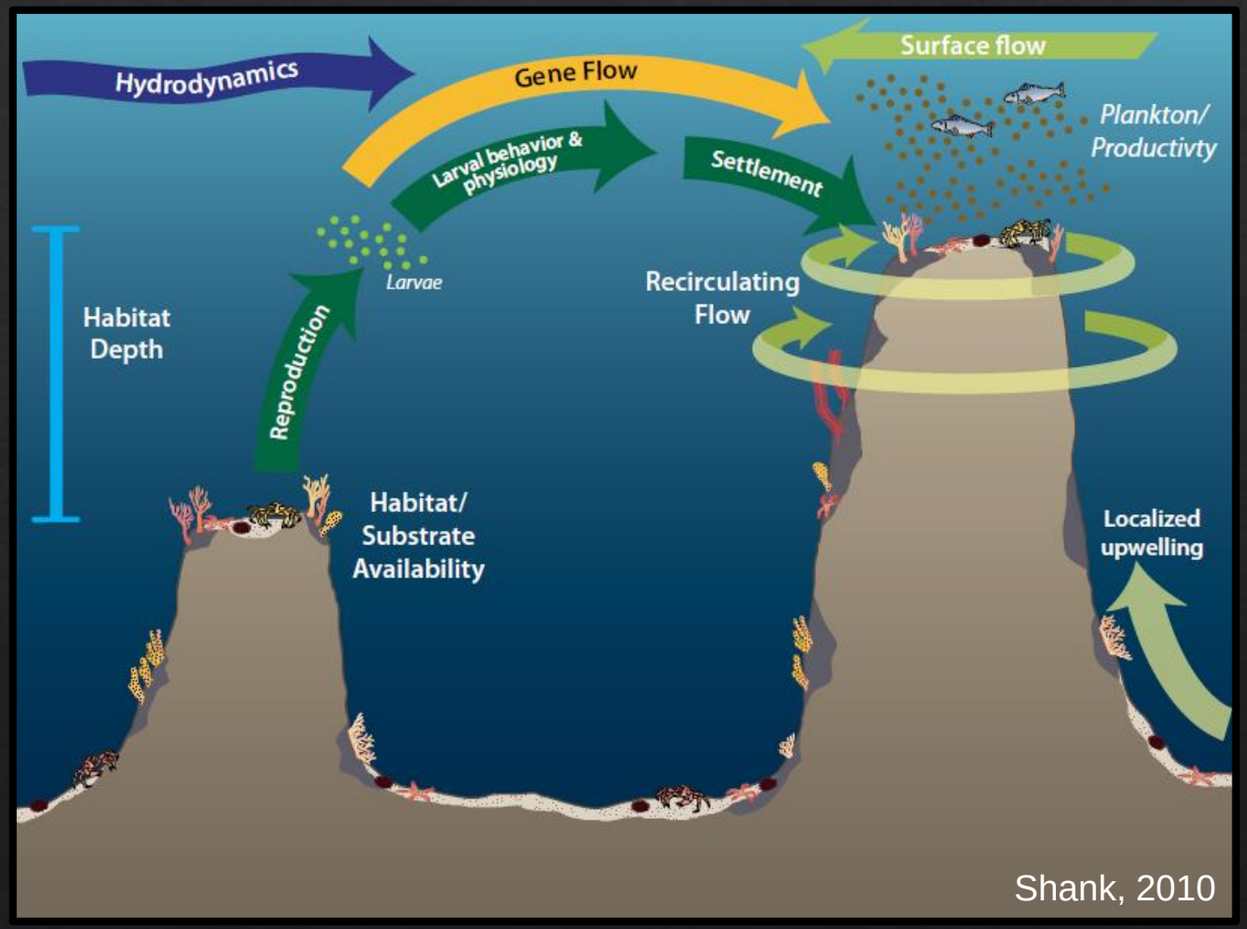
Core 865B-10H-3

Seamounts

Factors
- Geological
- Oceanographic
- Biological

Unusual ecological settings

Commonly dominated by suspensión feeders

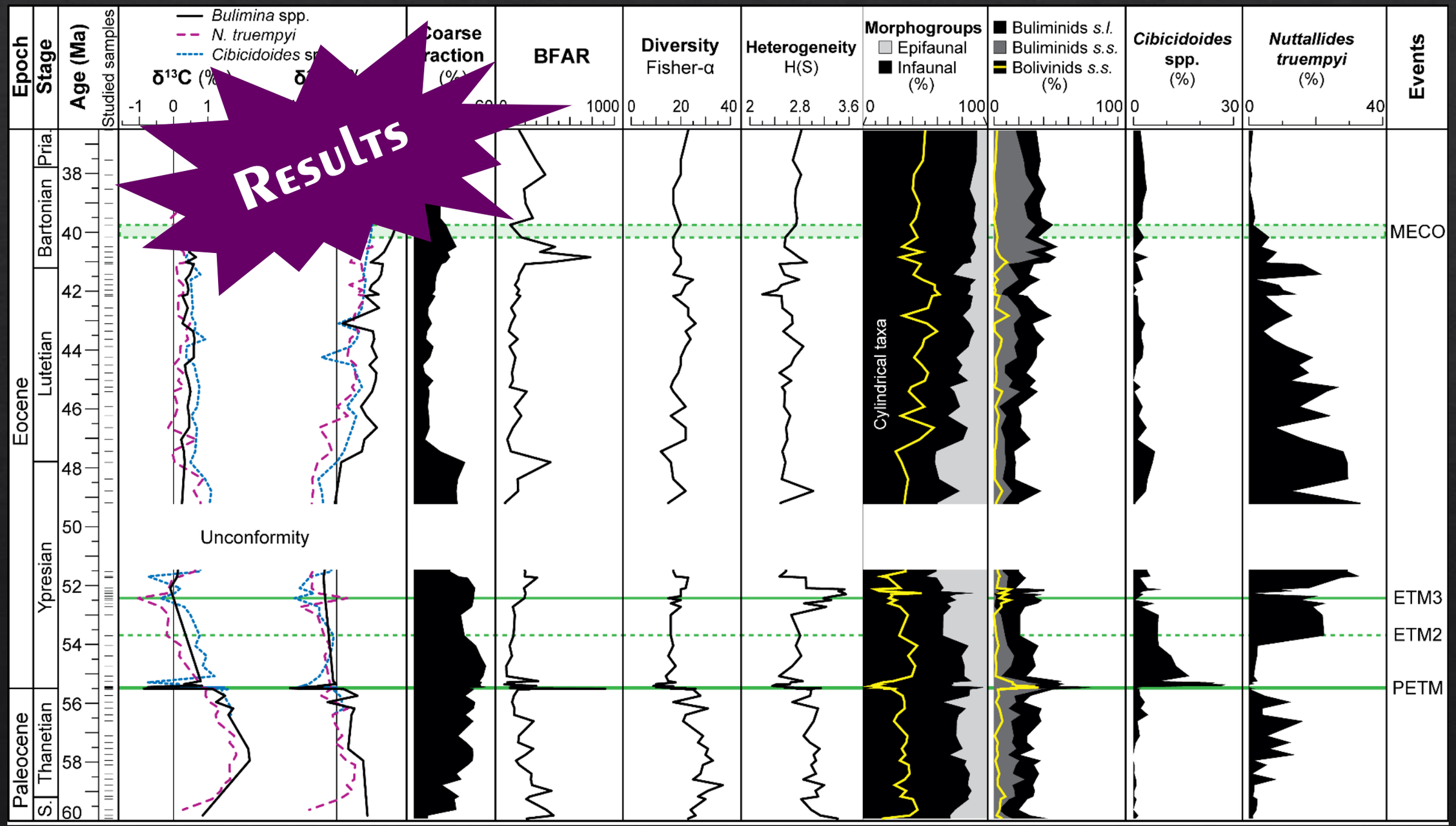


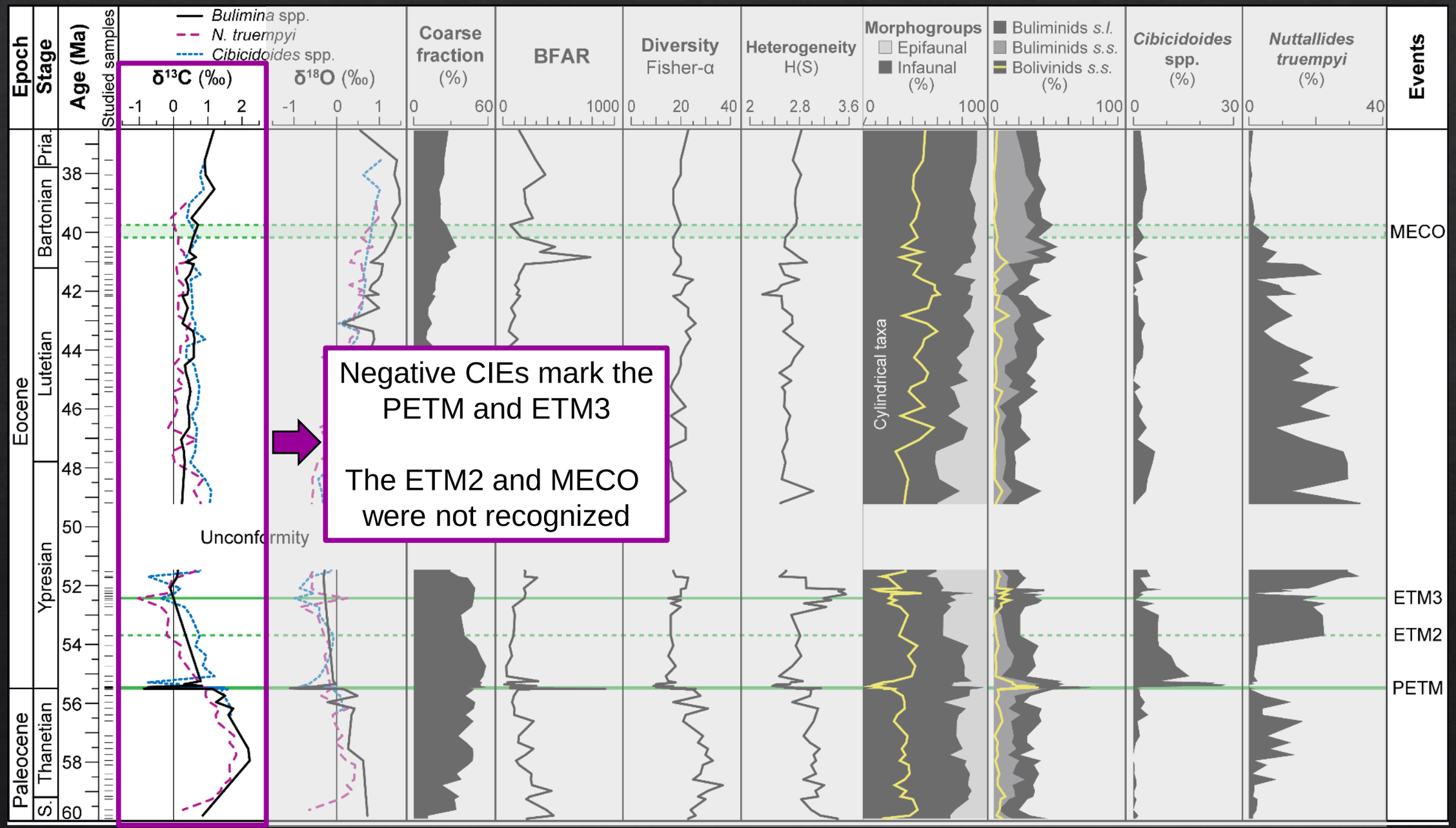
Currents are intensified

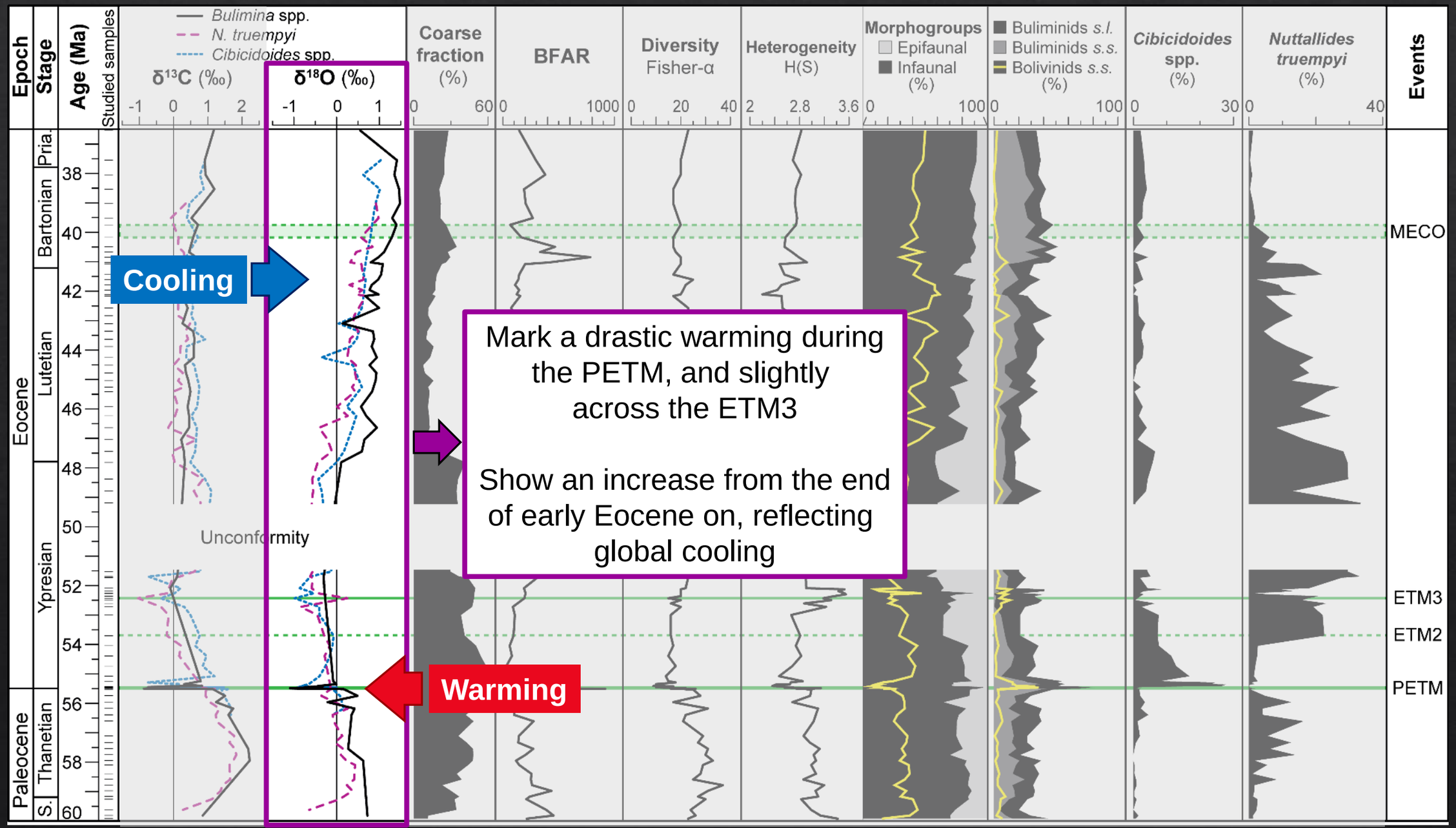
Winnow fine particles

Trap organisms and food particles (larger)

The link between primary productivity and arrival of food to the seafloor (bentho-pelagic coupling) may be broken


Epoch
Stage
Age (Ma)
Studied samples
Bulimina spp.
N. truempyi
Cibicidoides sp.
δ13C (‰)
δ18O (‰)
-1 0 1
Coarse fraction (%)
BFAR
0 1000
Diversity Fisher-α
0 20 40
Heterogeneity H(S)
2 2.8 3.6
Morphogroups
Epifaunal
Infaunal
(%)
0 100
Buliminids s.l.
Buliminids s.s.
Bolivinids s.s.
(%)
0 100
Cibicidoides spp. (%)
0 30
Nuttallides truempyi (%)
0 40
Events
Eocene
Paleocene
Pria.
Bartonian
Lutetian
Ypresian
S.
Thanetian
38
40
42
44
46
48
50
52
54
56
58
60
Unconformity
Cylindrical taxa
MECO
ETM3
ETM2
PETM
Results


Epoch
Stage
Age (Ma)
Studied samples
Bulimina spp.
N. truempyi
Cibicidoides spp.
δ13C (‰)
δ18O (‰)
Coarse fraction (%)
BFAR
Diversity Fisher-α
Heterogeneity H(S)
Morphogroups
Epifaunal
Infaunal
(%)
Buliminids s.l.
Buliminids s.s.
Bolivinids s.s.
(%)
Cibicidoides spp. (%)
Nuttallides truempyi (%)
Events
Eocene
Paleocene
Pria.
Bartonian
Lutetian
Ypresian
Thanetian
S.
Cylindrical taxa
Unconformity
MECO
ETM3
ETM2
PETM
Negative CIEs mark the PETM and ETM3
The ETM2 and MECO were not recognized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δ18O (‰)
Coarse fraction (%)
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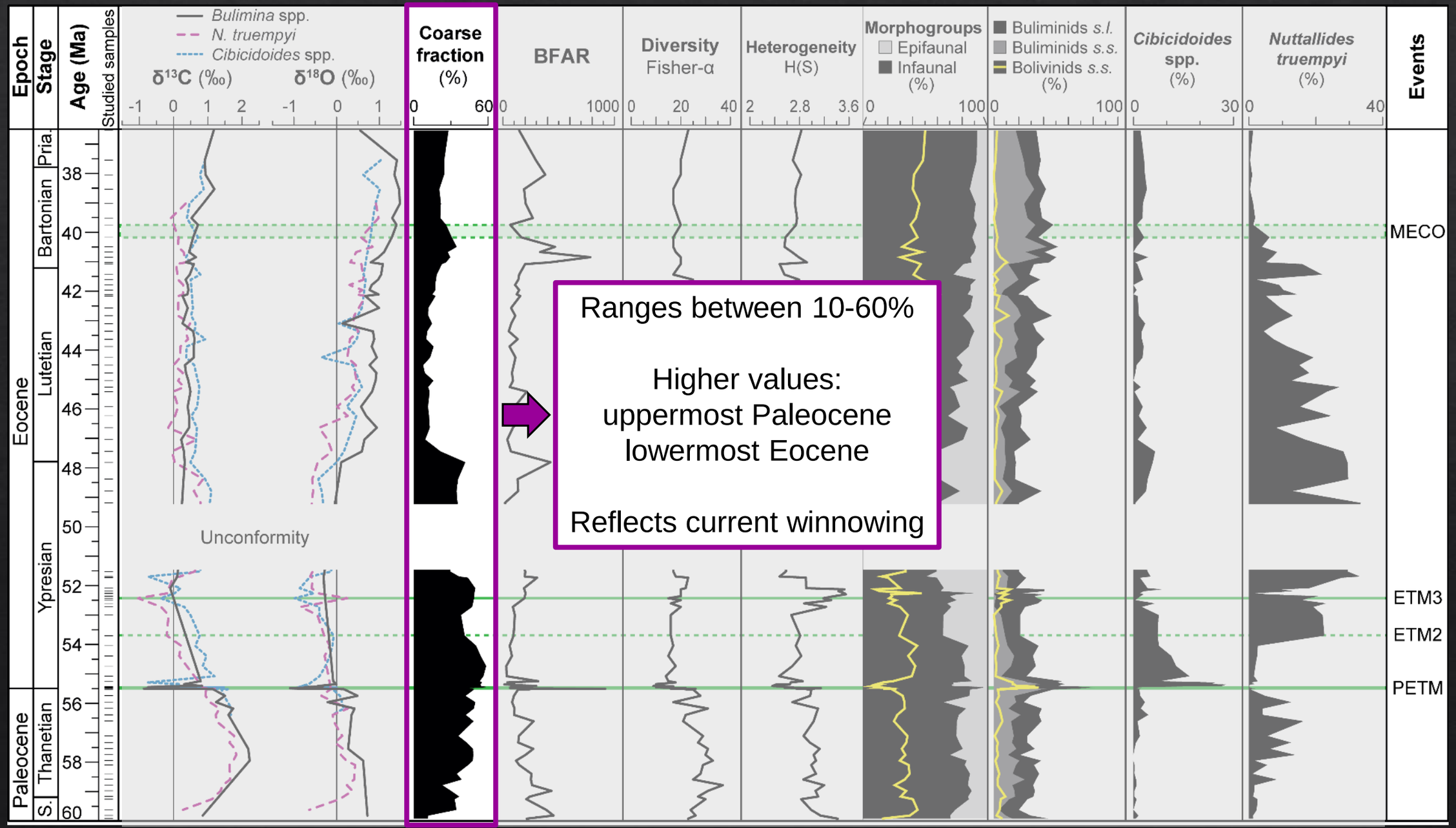
Diversity Fisher-α
Heterogeneity H(S)
Morphogroups
Epifaunal
Infaunal
(%)
Buliminids s.l.
Buliminids s.s.
Bolivinids s.s.
(%)
Cibicidoides spp. (%)
Nuttallides truempyi (%)
Events
Eocene
Paleocene
Pria.
Bartonian
Lutetian
Ypresian
S.
Thanetian
Unconformity
MECO
ETM3
ETM2
PETM
Cooling
Warming
Mark a drastic warming during the PETM, and slightly across the ETM3
Show an increase from the end of early Eocene on, reflecting global cooling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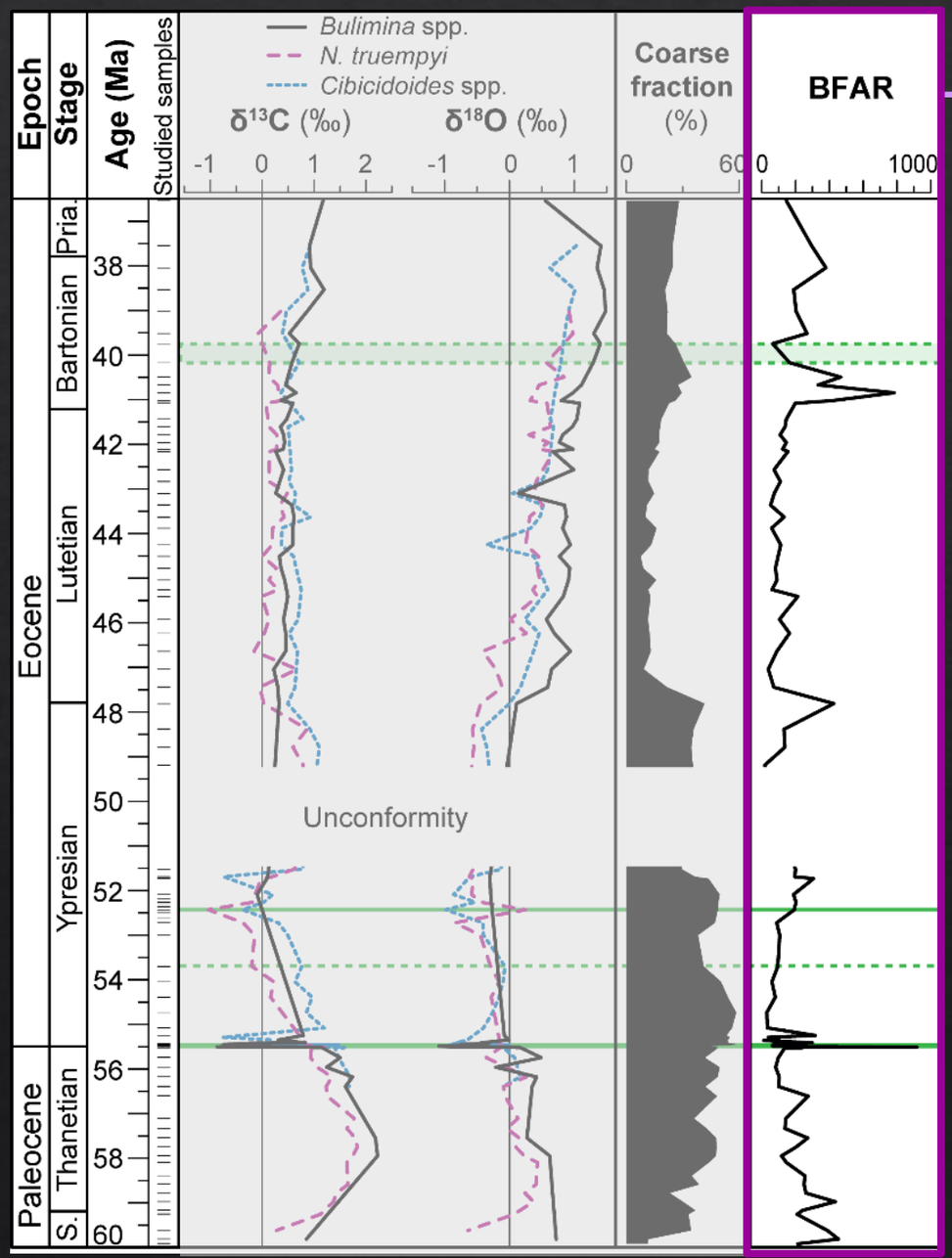
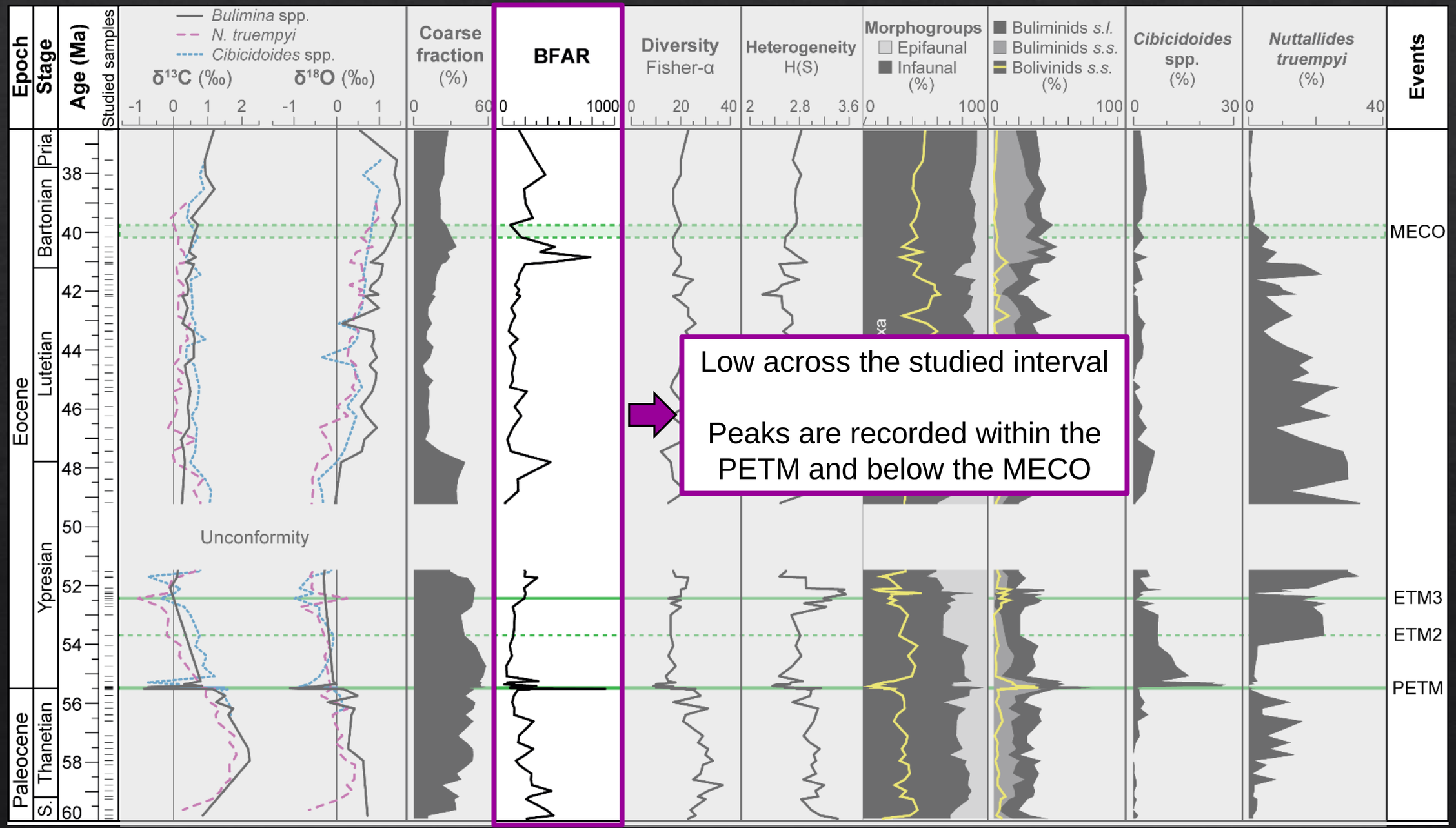
N. truempyi
Cibicidoides spp.
δ13C (‰)
δ18O (‰)
Coarse fraction (%)
BFAR
Diversity Fisher-α
Heterogeneity H(S)
Morphogroups
Epifaunal
Infaunal
(%)
Buliminids s.l.
Buliminids s.s.
Bolivinids s.s.
(%)
Cibicidoides spp. (%)
Nuttallides truempyi (%)
Events
Eocene
Paleocene
Pria.
Bartonian
Lutetian
Ypresian
S.
Thanetian
Unconformity
MECO
ETM3
ETM2
PETM
Ranges between 10-60%
Higher values:
uppermost Paleocene
lowermost Eocene
Reflects current winnowing



Benthic Foraminiferal Accumulation Rates

Number of benthic foraminifera per cm^2 per thousand years

Proxy for export productivity (higher numbers indicating more organic carbon reaching the seafloor)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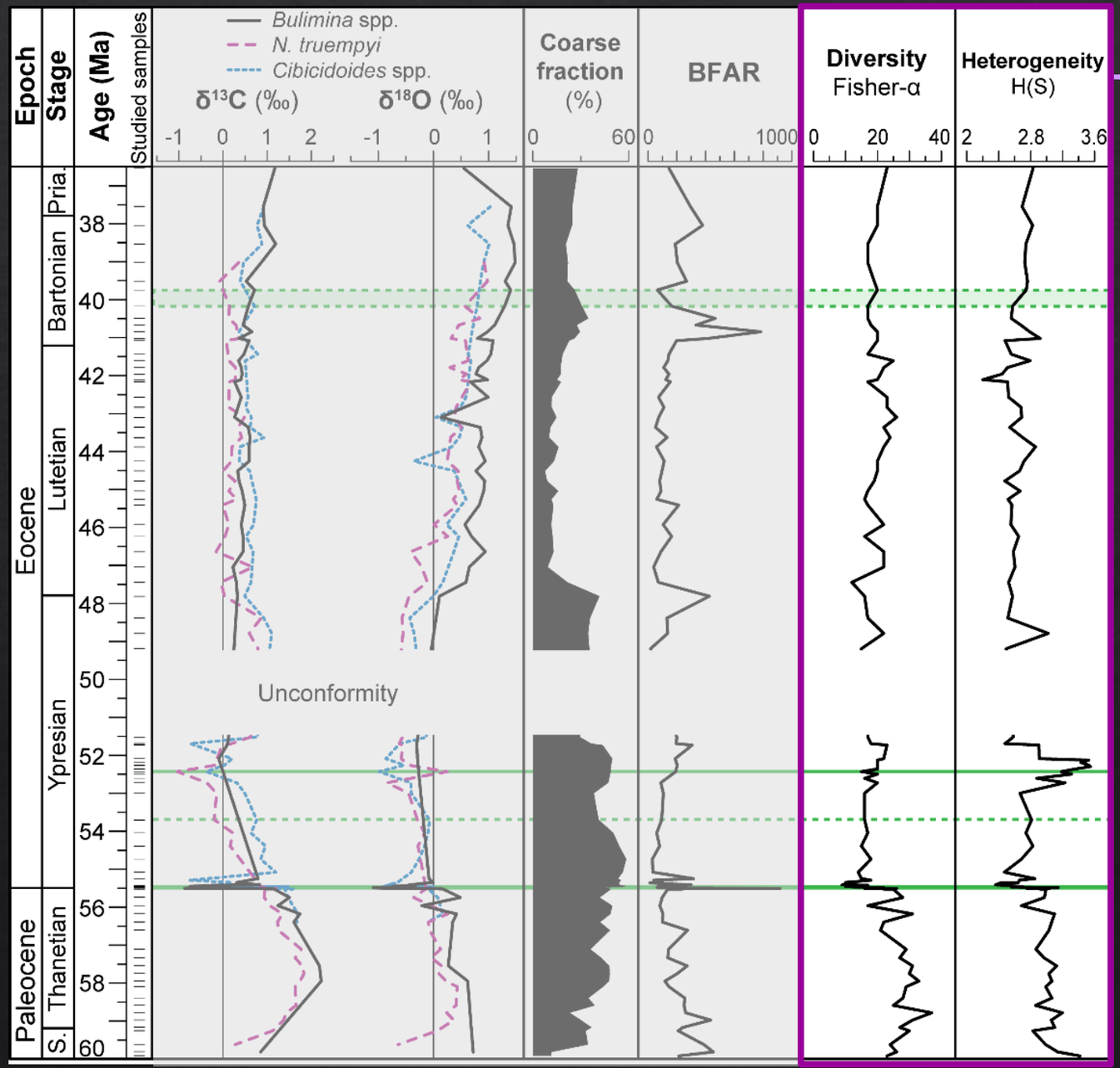
N. truempyi
Cibicidoides spp.
δ13C (‰)
δ18O (‰)
Coarse fraction (%)
BFAR
Diversity Fisher-α
Heterogeneity H(S)
Morphogroups
Epifaunal
Infaunal
(%)
Buliminids s.l.
Buliminids s.s.
Bolivinids s.s.
(%)
Cibicidoides spp. (%)
Nuttallides truempyi (%)
Events
Eocene
Paleocene
Pria.
Bartonian
Lutetian
Ypresian
S.
Thanetian
Unconformity
MECO
ETM3
ETM2
PETM
Low across the studied interval
Peaks are recorded within the PETM and below the MECO

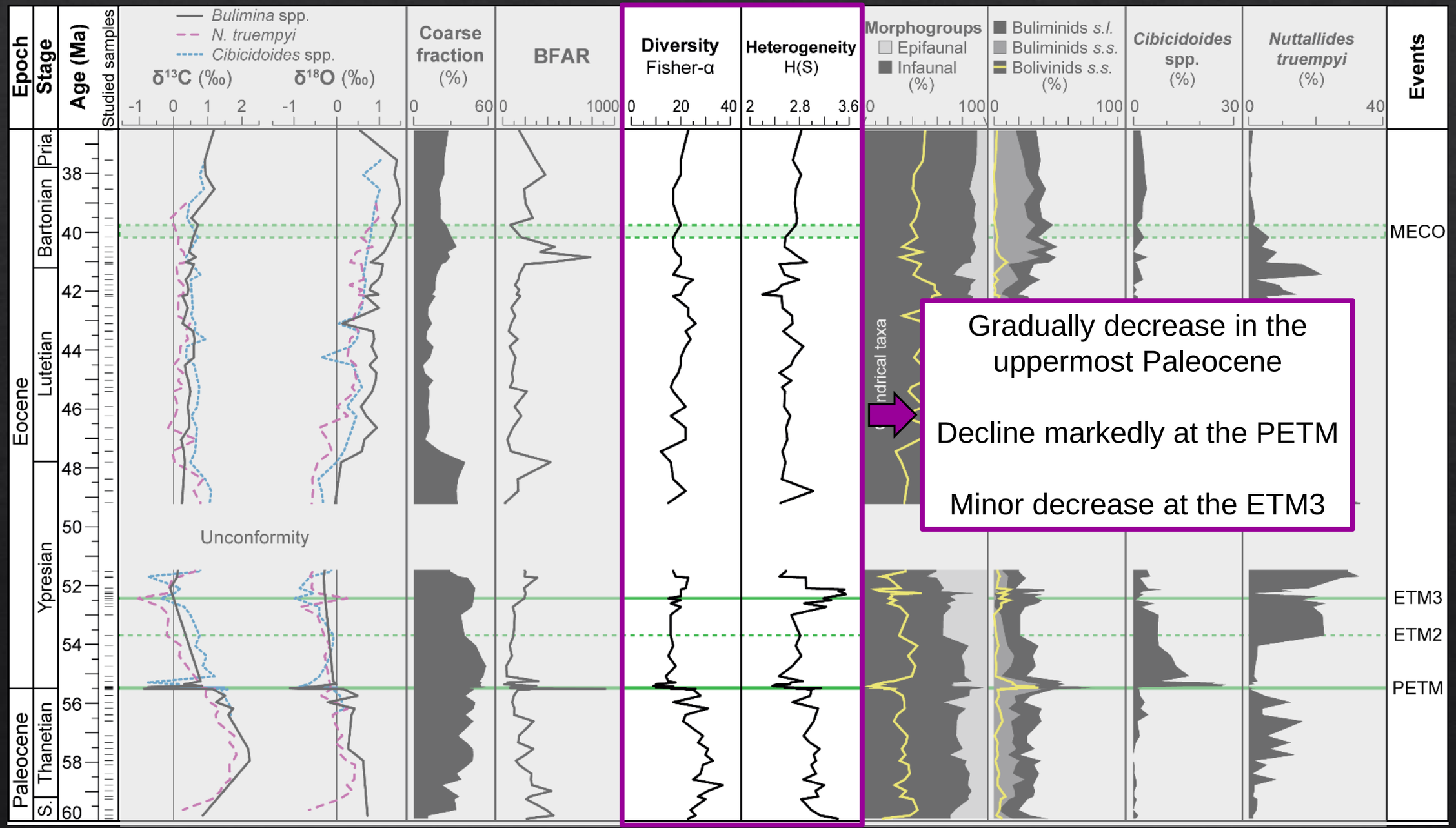


Fisher-α diversity

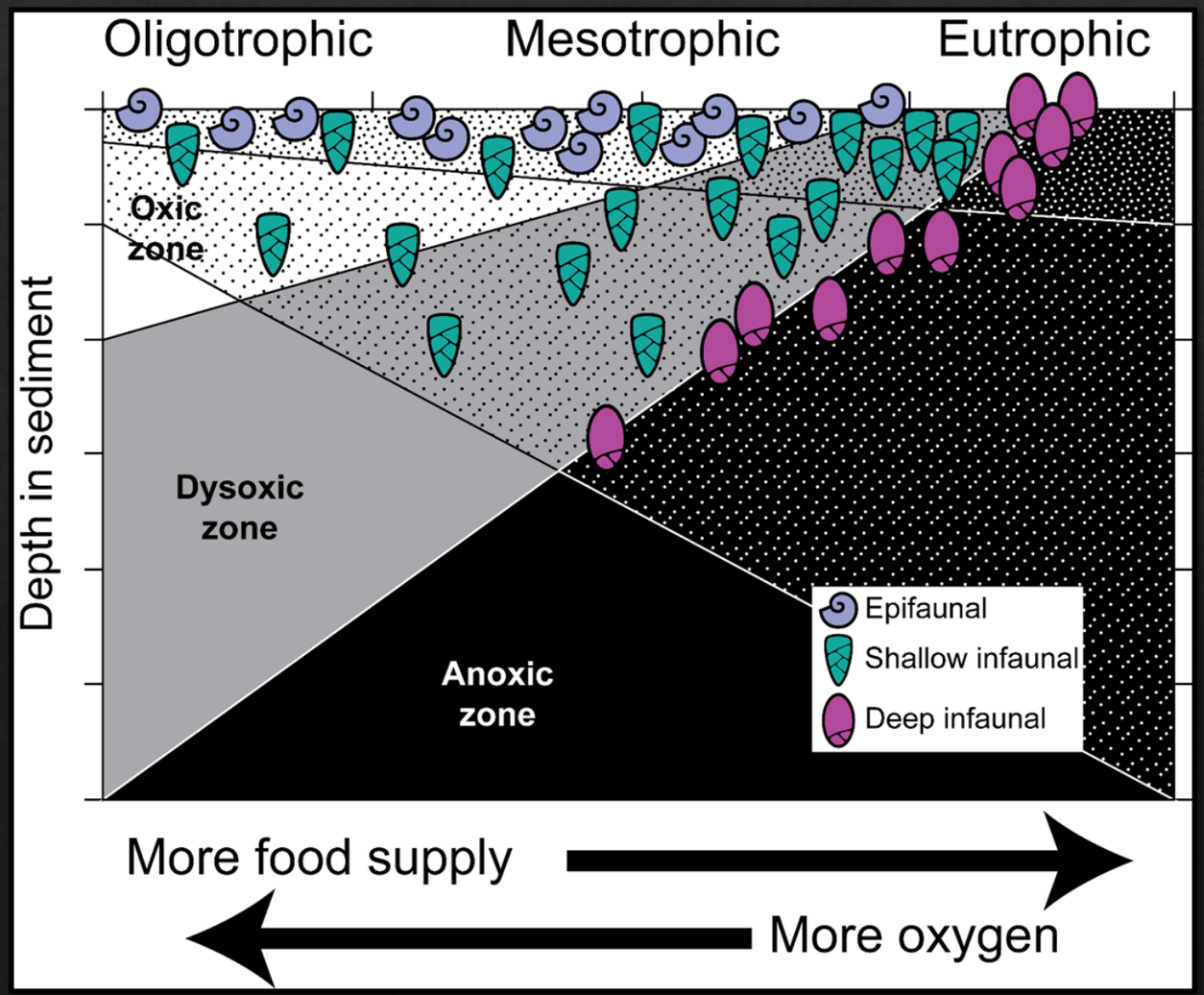
Correlates the number of species and the number of individuals in each sample

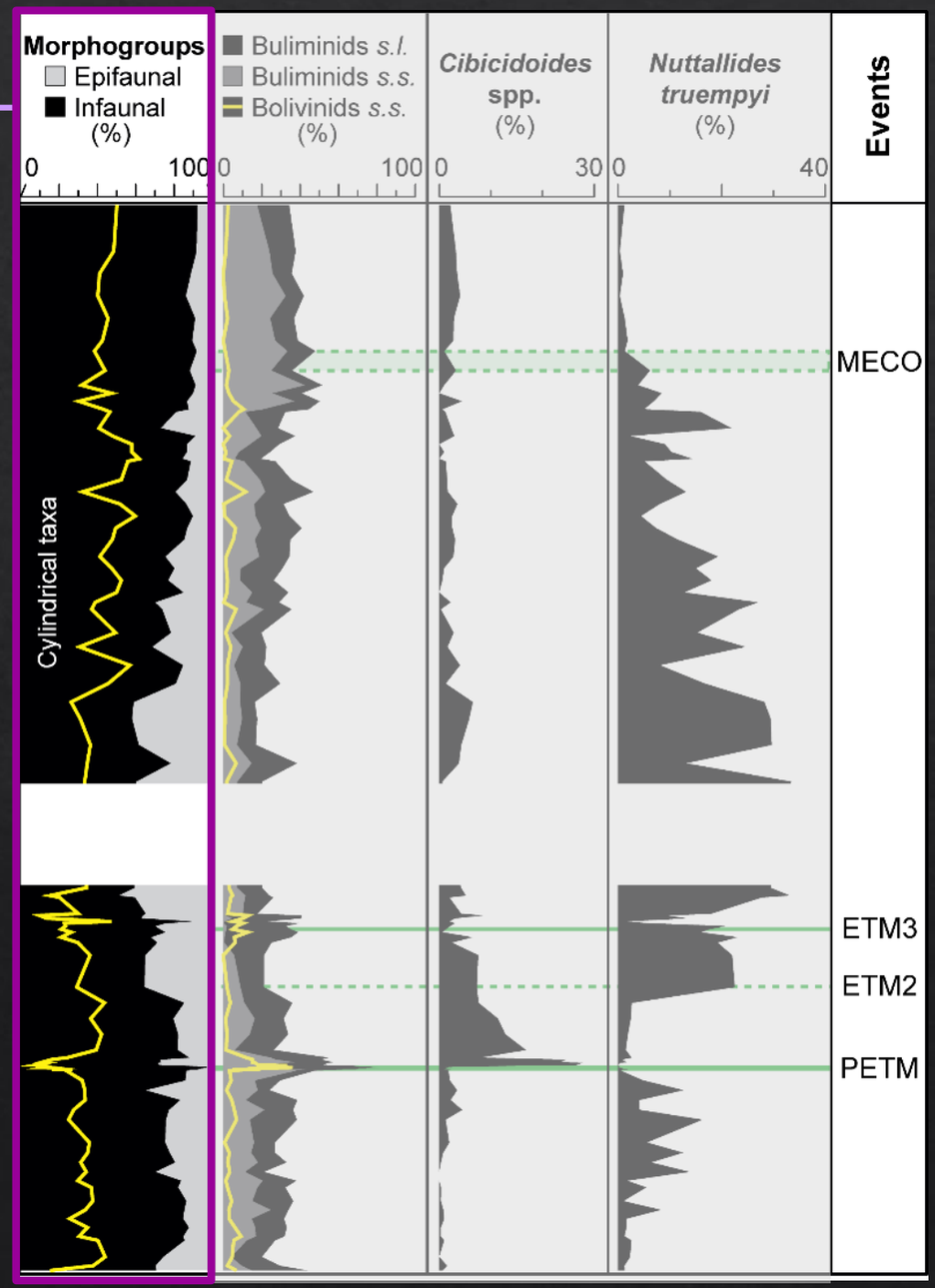
Shannon-Weaver heterogeneity

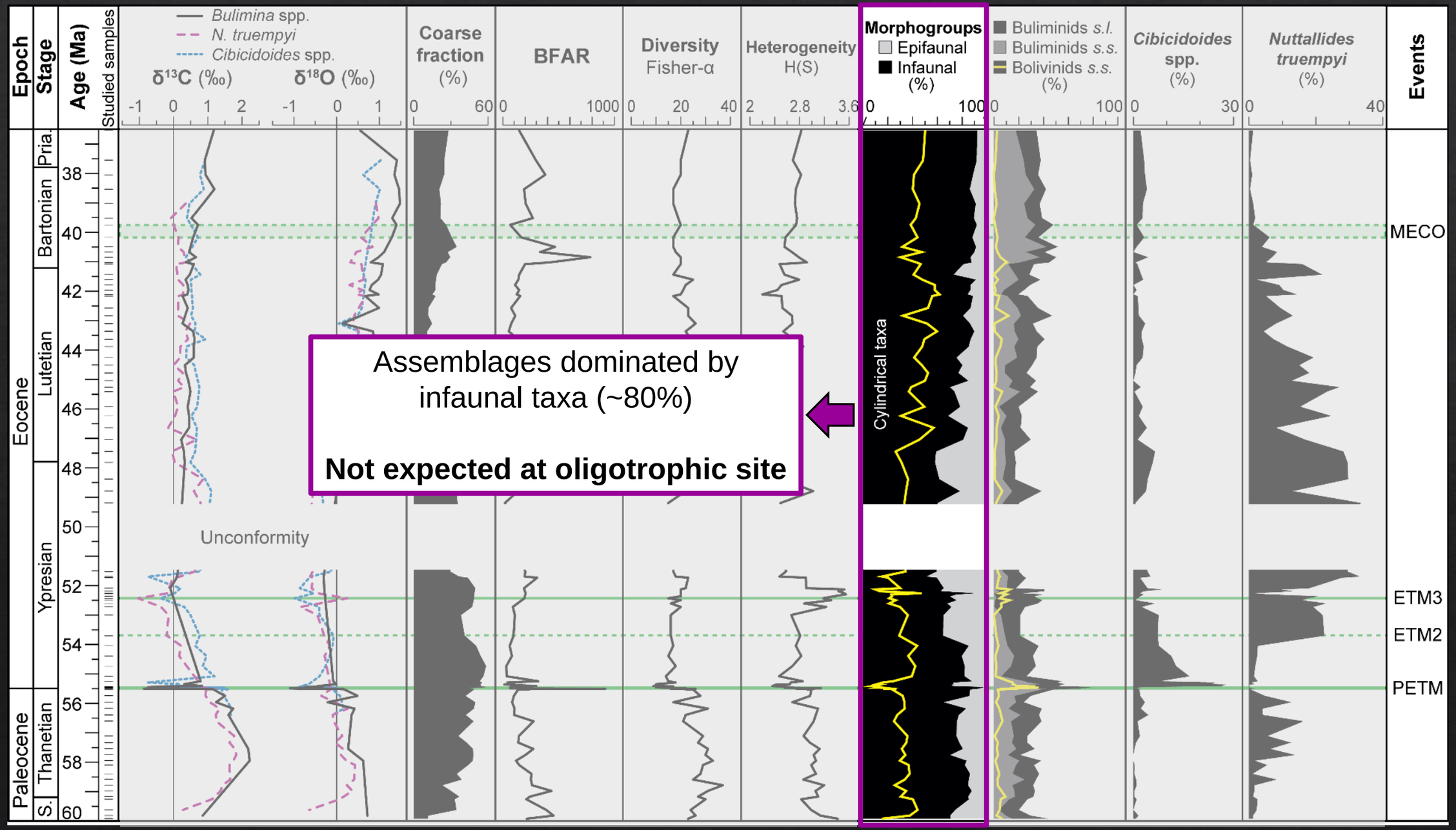
Depends on the relative abundance, the number of taxa and the distribution of specimens over taxa


Epoch
Stage
Age (Ma)
Studied samples
Bulimina spp.
N. truempyi
Cibicidoides spp.
δ13C (‰)
δ18O (‰)
Coarse fraction (%)
BFAR
Diversity Fisher-α
Heterogeneity H(S)
Morphogroups
Epifaunal
Infaunal
(%)
Buliminids s.l.
Buliminids s.s.
Bolivinids s.s.
(%)
Cibicidoides spp. (%)
Nuttallides truempyi (%)
Events
Eocene
Paleocene
Pria.
Bartonian
Lutetian
Ypresian
S.
Thanetian
Unconformity
MECO
ETM3
ETM2
PETM
Gradually decrease in the uppermost Paleocene
Decline markedly at the PETM
Minor decrease at the ETM3

TROX model
(Jorissen et al., 1995)






Epoch
Stage
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Bulimina spp.
N. truempyi
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δ13C (‰)
δ18O (‰)
Coarse fraction (%)
BFAR
Diversity Fisher-α
Heterogeneity H(S)
Morphogroups
Epifaunal
Infaunal
(%)
Buliminids s.l.
Buliminids s.s.
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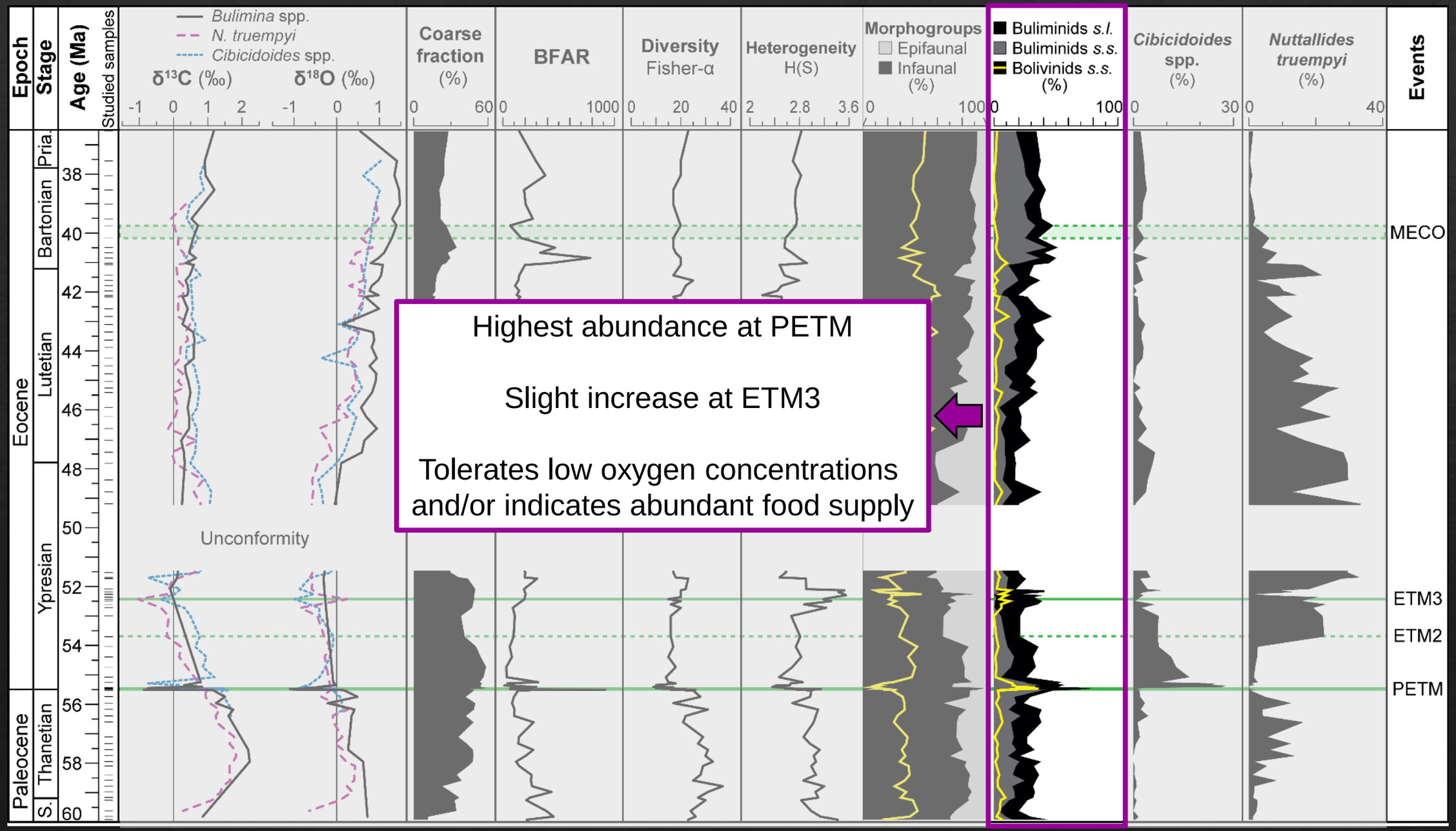
(%)
Cibicidoides spp. (%)
Nuttallides truempyi (%)
Events
Eocene
Paleocene
Pria.
Bartonian
Lutetian
Ypresian
S.
Thanetian
Unconformity
Cylindrical taxa
MECO
ETM3
ETM2
PETM
Assemblages dominated by infaunal taxa (~80%)
Not expected at oligotrophic site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δ13C (‰)
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Coarse fraction (%)
BFAR
Diversity Fisher-α
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Morphogroups
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Buliminids s.l.
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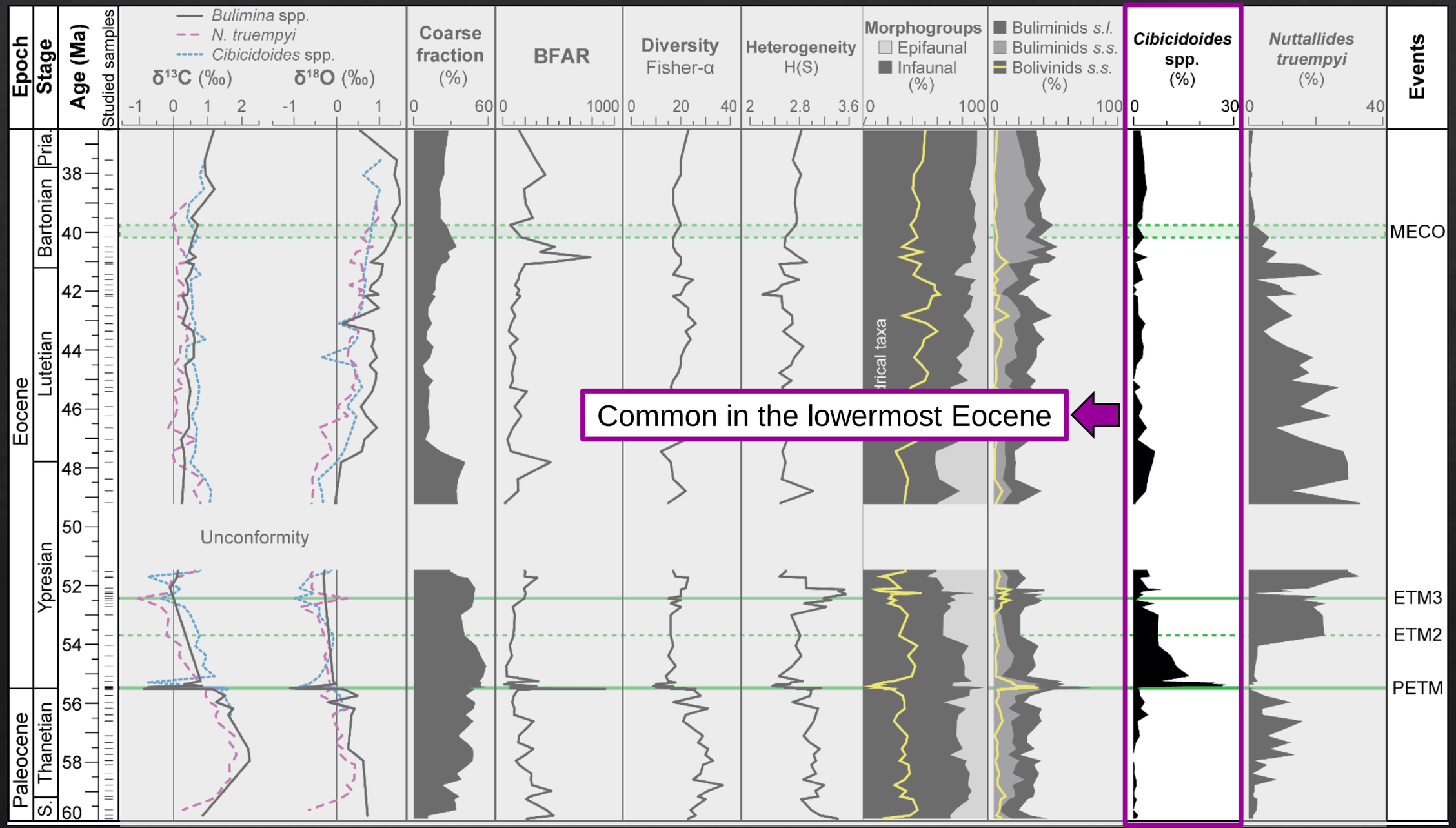
Events
Eocene
Paleocene
Pria.
Bartonian
Lutetian
Ypresian
S.
Thanetian
Unconformity
MECO
ETM3
ETM2
PETM
Highest abundance at PETM
Slight increase at ETM3
Tolerates low oxygen concentrations and/or indicates abundant food supply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Coarse fraction (%)
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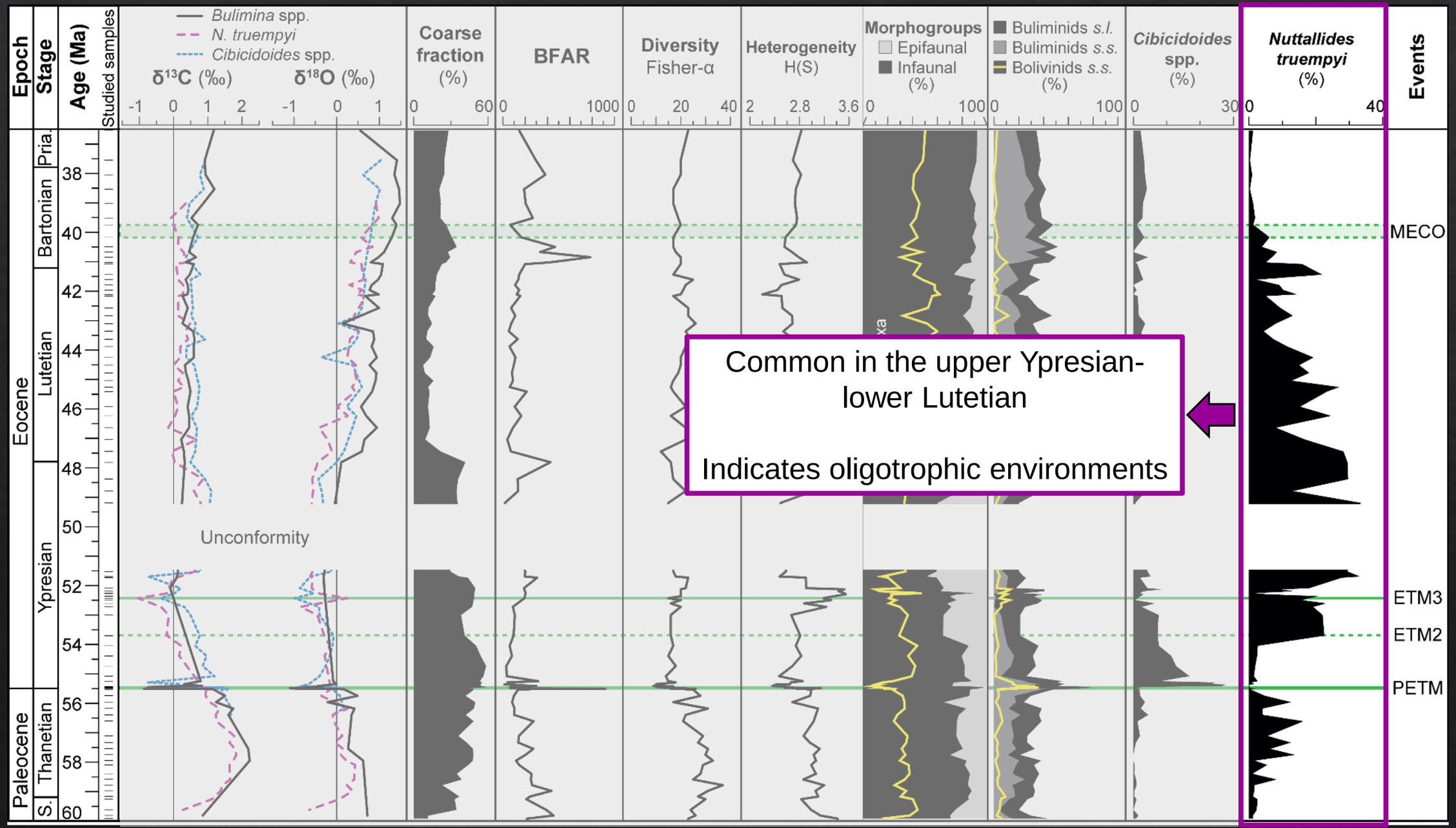
Morphogroups
Epifaunal
Infaunal
(%)
Buliminids s.l.
Buliminids s.s.
Bolivinids s.s.
(%)
Cibicidoides spp. (%)
Nuttallides truempyi (%)
Events
Eocene
Paleocene
Pria.
Bartonian
Lutetian
Ypresian
S.
Thanetian
Unconformity
MECO
ETM3
ETM2
PETM
Common in the lowermost Eocene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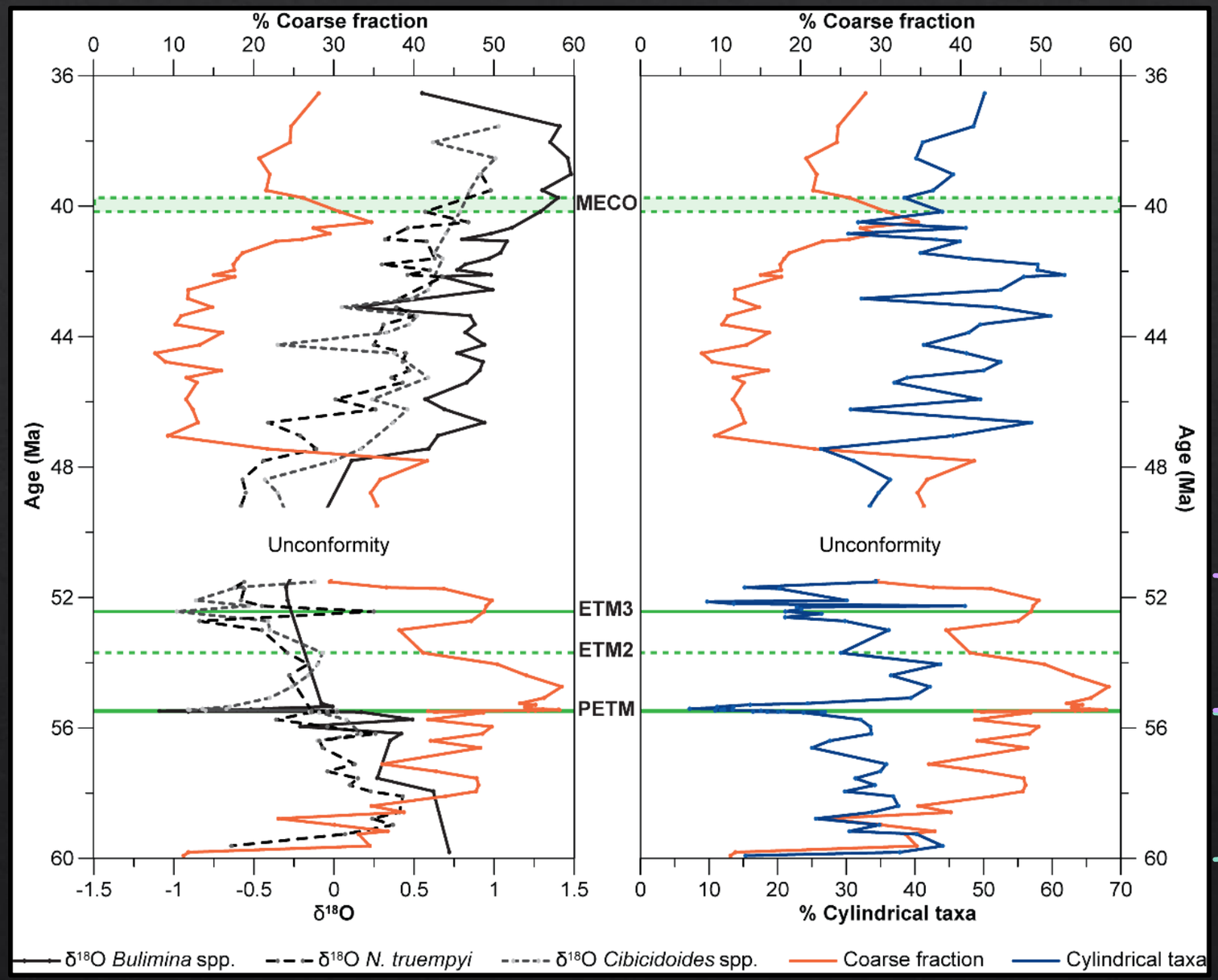
δ13C (‰)
δ18O (‰)
Coarse fraction (%)
BFAR
Diversity Fisher-α
Heterogeneity H(S)
Morphogroups
Epifaunal
Infaunal
(%)
Buliminids s.l.
Buliminids s.s.
Bolivinids s.s.
(%)
Cibicidoides spp. (%)
Nuttallides truempyi (%)
Events
Eocene
Paleocene
Pria.
Bartonian
Lutetian
Ypresian
S.
Thanetian
Unconformity
MECO
ETM3
ETM2
PETM
Common in the upper Ypresian-lower Lutetian
Indicates oligotrophic environments

Coarse fraction negatively corrrelates with oxygen isotopes

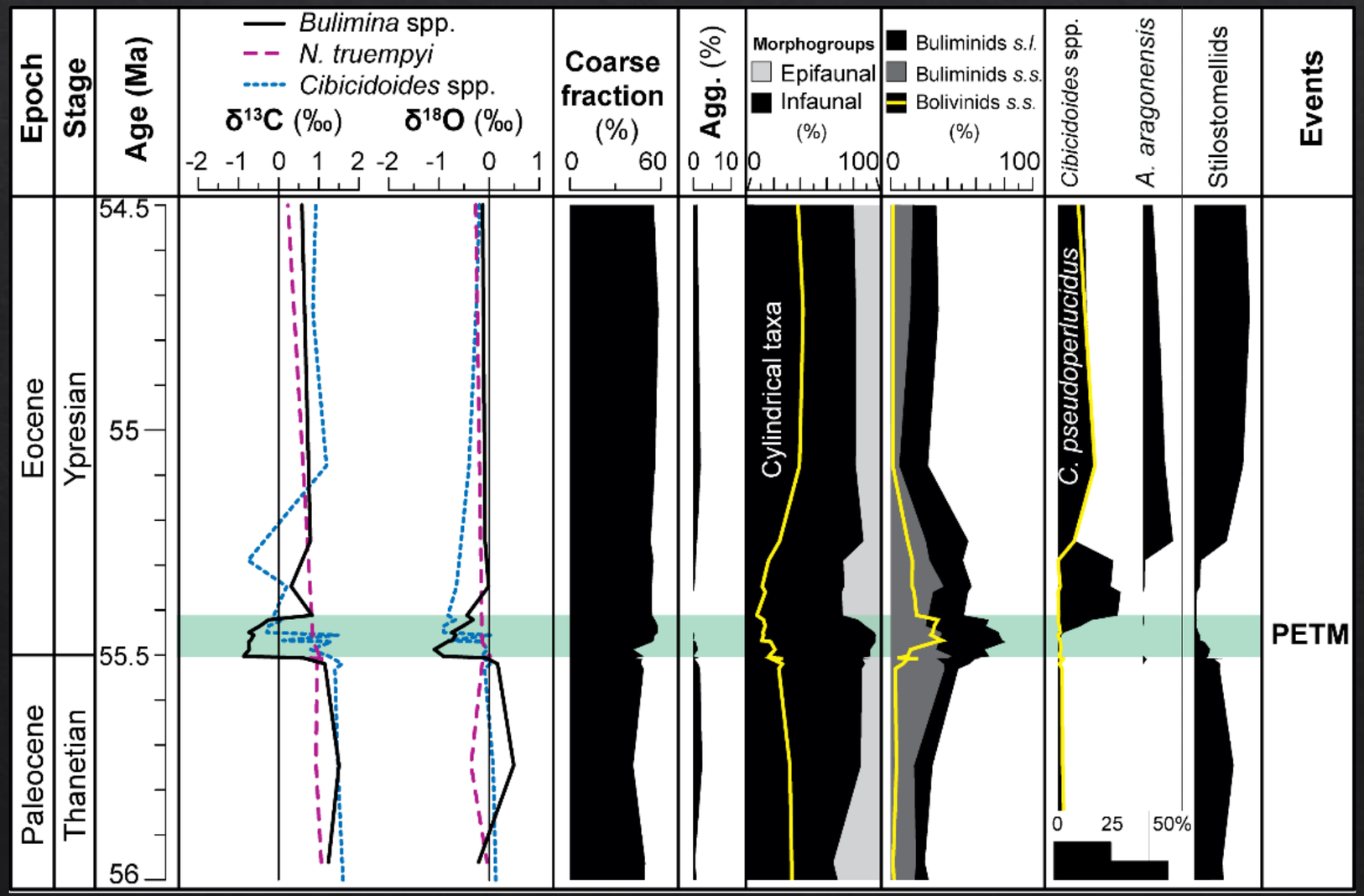
Increased winnowing ocurred during warm periods



Success of cylindrical taxa in current-swept environments

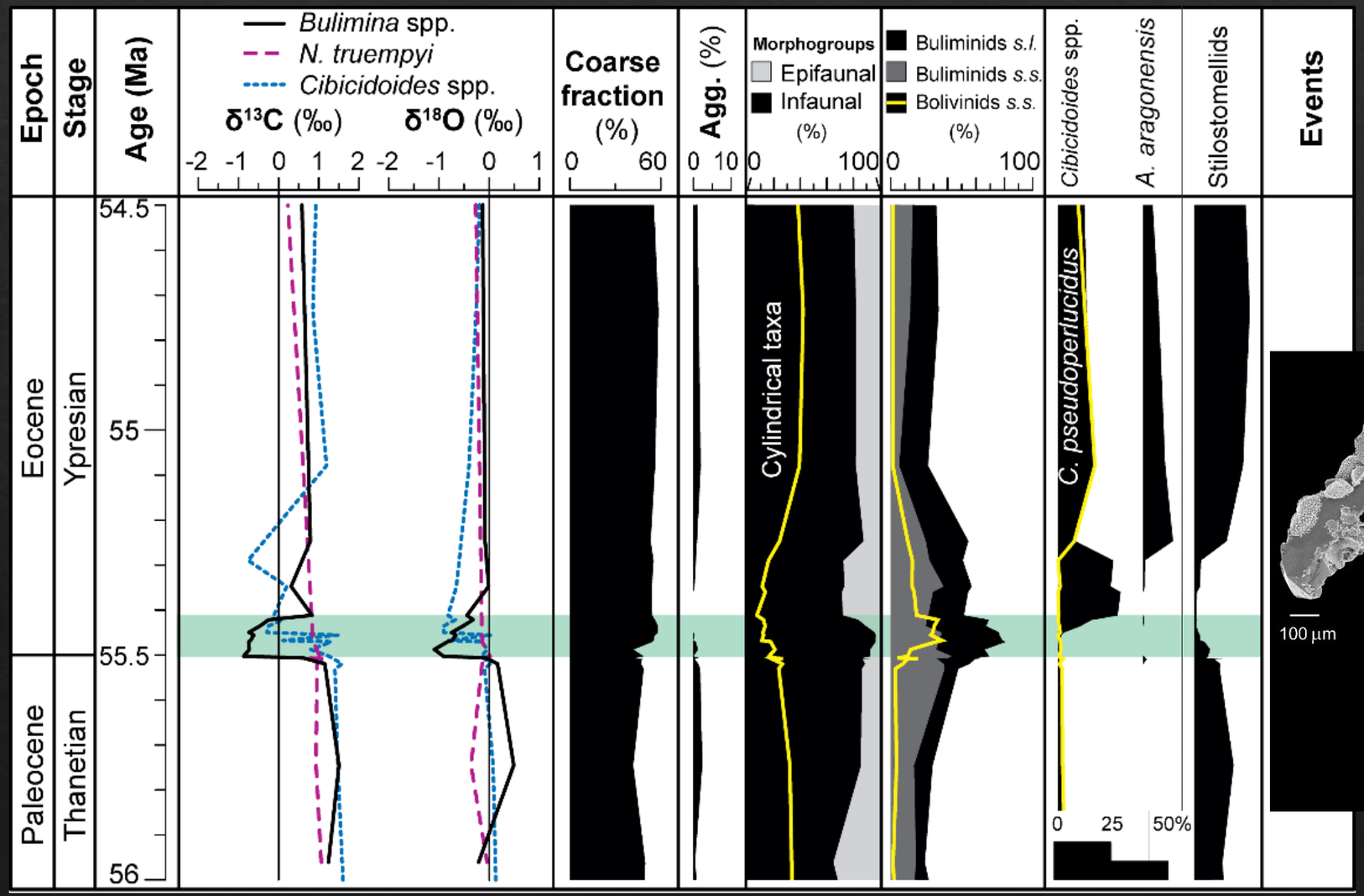
Less food supply

Paleocene – Eocene Thermal Maximum (PETM)



- 33.4% became extinct at the PETM
- Increase in carbonate dissolution
- Infaunal taxa are shielded from corrosive waters
- Increase in coarse fraction values point to increased currents
- *Cibicidoides* probably lived epifaunally attached to hard surfaces

Paleocene – Eocene Thermal Maximum (PETM)



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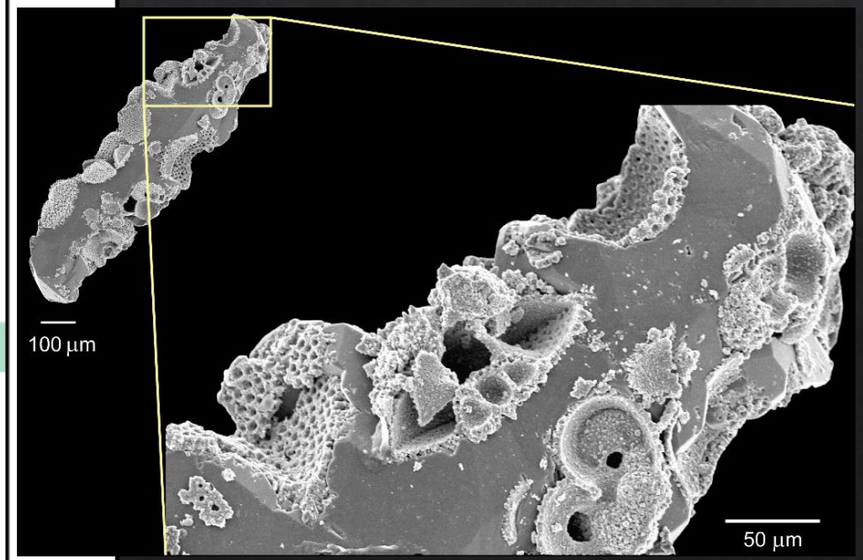
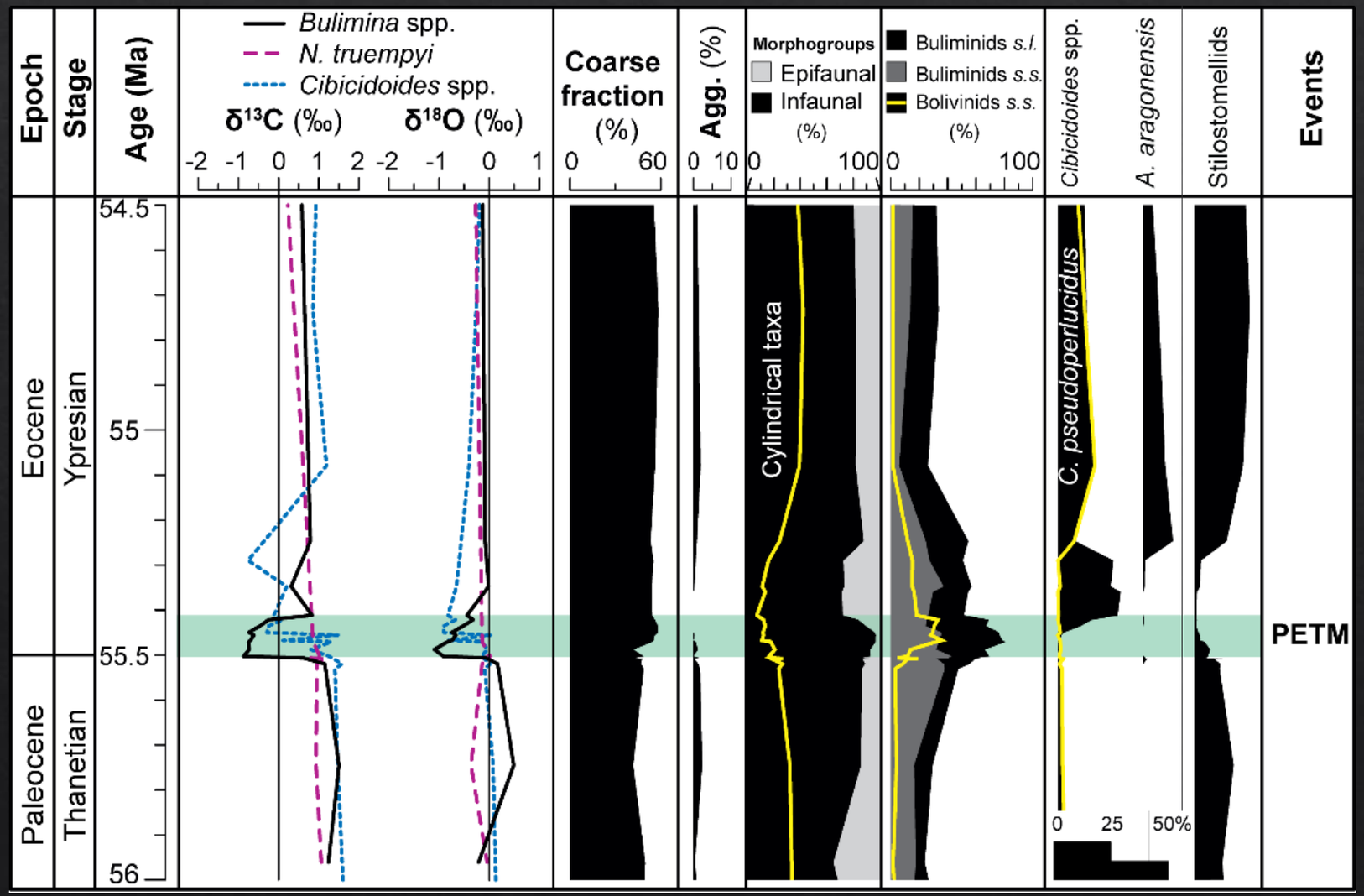
- Increase in carbonate dissolution



Paleocene – Eocene Thermal Maximum (PETM)



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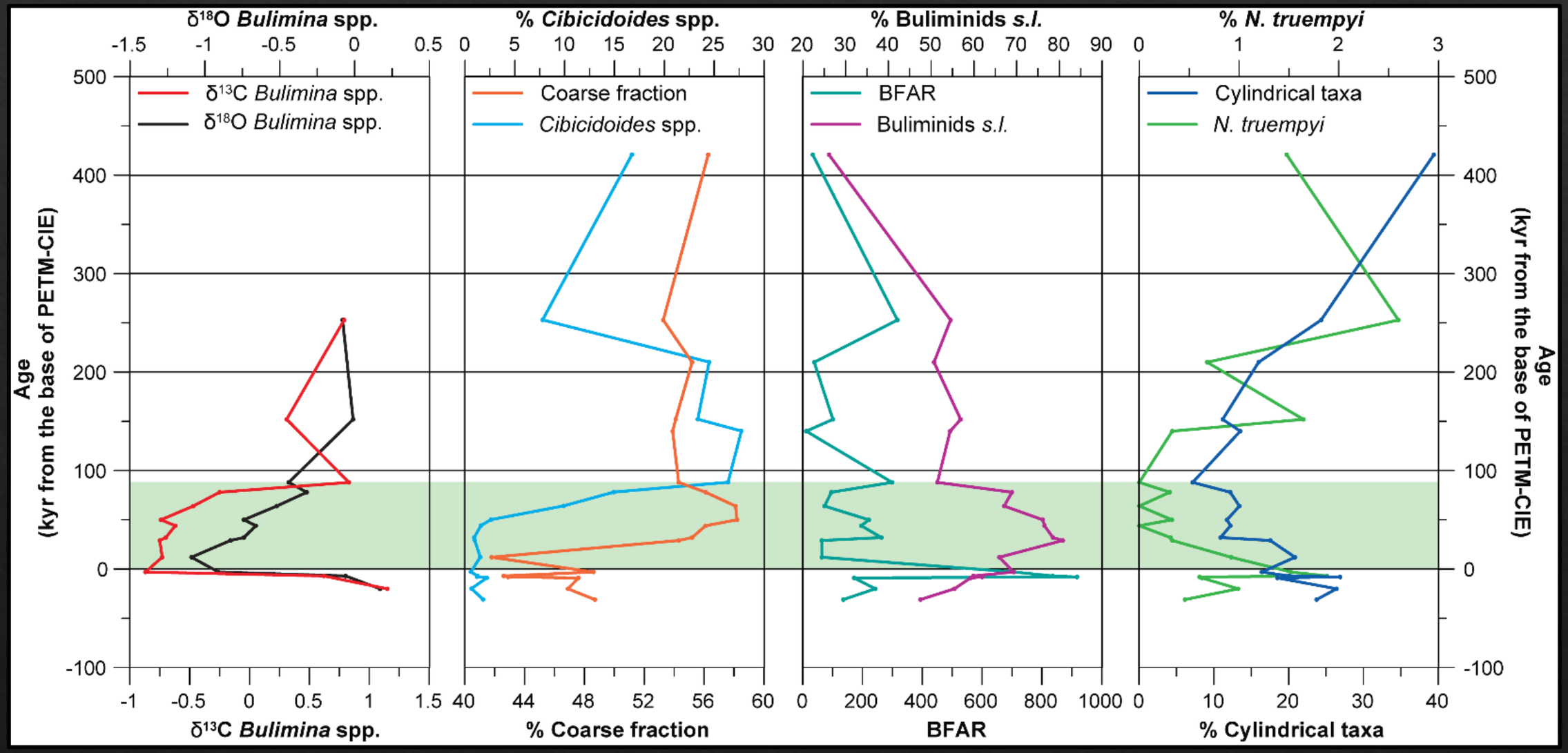
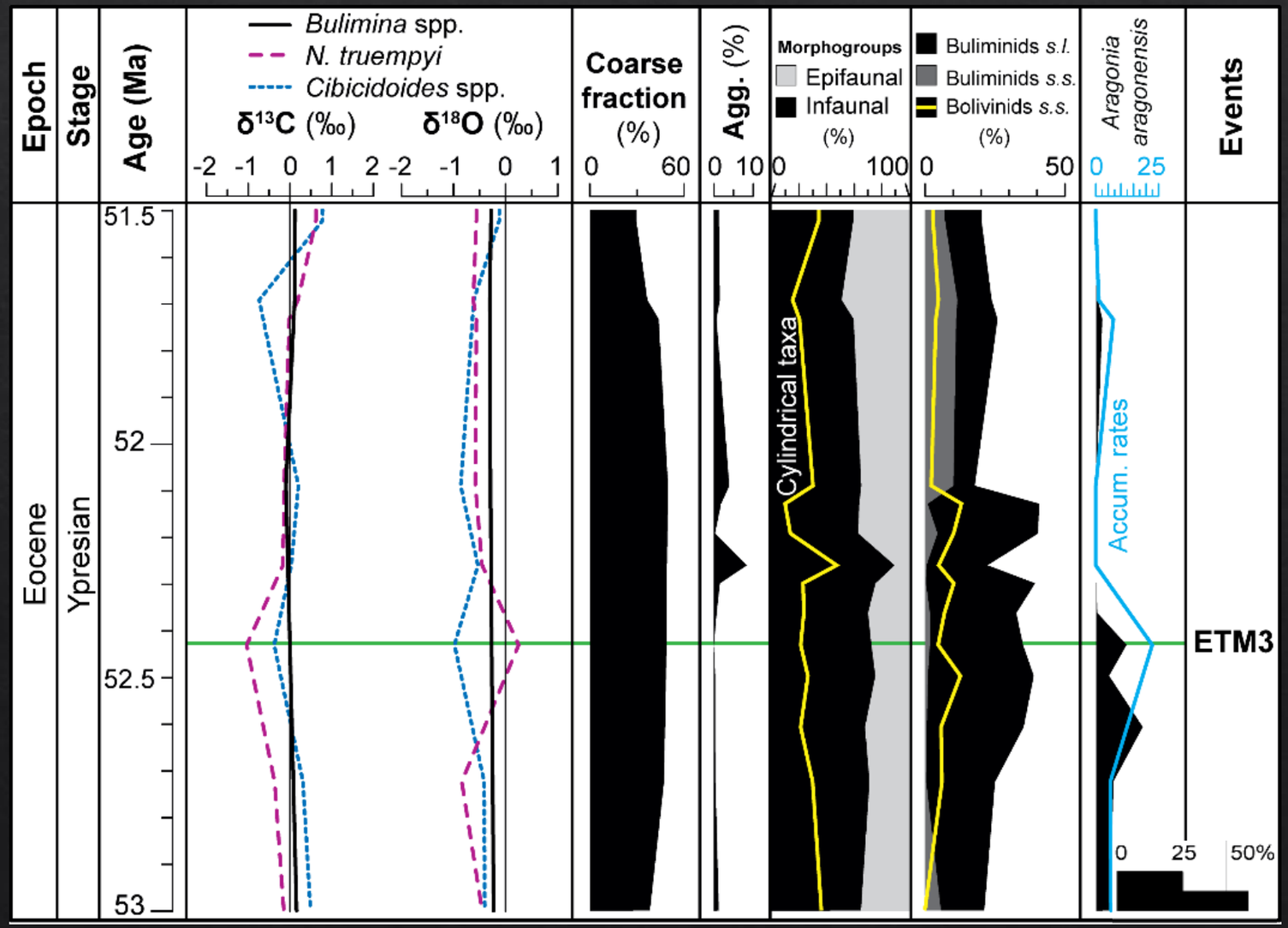
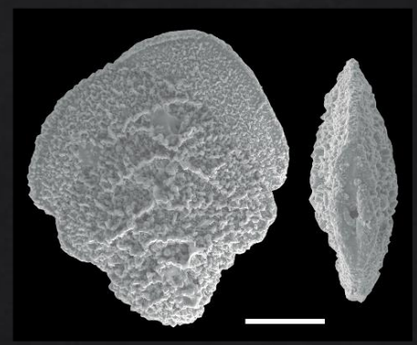

δ18O Bulimina spp.
% Cibicidoides spp.
% Buliminids s.l.
% N. truempyi
δ13C Bulimina spp.
δ18O Bulimina spp.
Coarse fraction
Cibicidoides spp.
BFAR
Buliminids s.l.
Cylindrical taxa
N. truempyi
Age (kyr from the base of PETM-CIE)
δ13C Bulimina spp.
% Coarse fraction
BFAR
% Cylindrical taxa

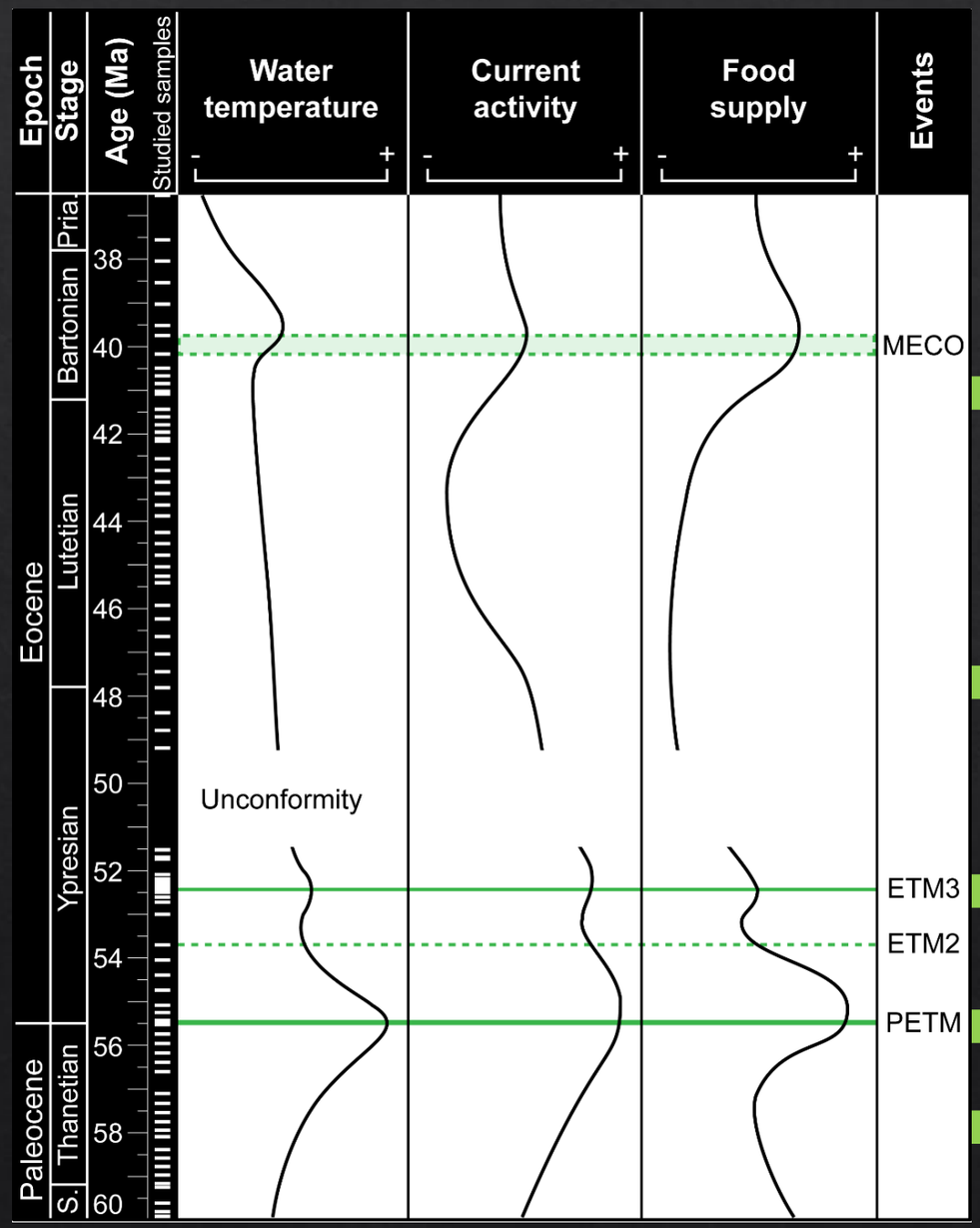
Eocene Thermal Maximum 3 (ETM3)



- No significant extinction has been documented
- Significant dissolution has not occurred
- Increase in buliminids suggests moderate increase in food supply
- *A. aragonensis*: opportunistic species, marker of hyperthermals



Summary



- Current activity gradually increased
- Decrease in current activity
- Food availability moderate
- Food availability at the bottom, and dissolution, suddenly increased
- Progressive increase in current activity and oligotrophic conditions

Conclusions

- Assemblage changes across the PETM and ETM3 were similar.
- Both events possibly associated with increased food availability through trophic focusing due to enhanced current activity.
- Faunas across PETM have been also affected by carbonate dissolution, but not across ETM3.
- The biotic response scales with the magnitude of the event.
- Currents around seamounts may break the bentho-pelagic coupling.

Thank you!!

Universidad Zaragoza
1542

CONACYT
Consejo Nacional de Ciencia y Tecnología

Additional information in:

Arreguín-Rodríguez, G. J., L. Alegret, and E. Thomas (2016), Paleoceanography, 31, doi:10.1002/2015PA002837.