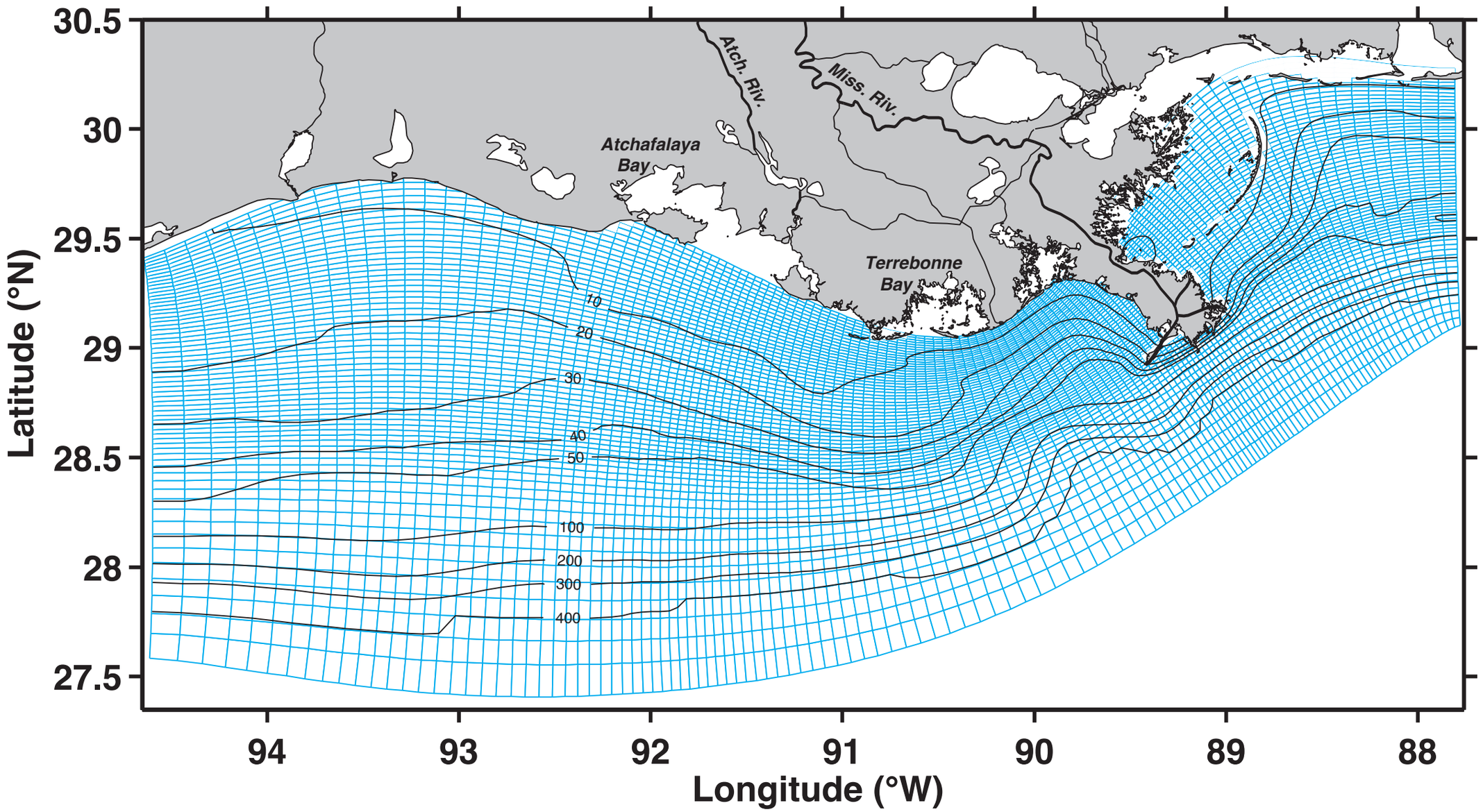
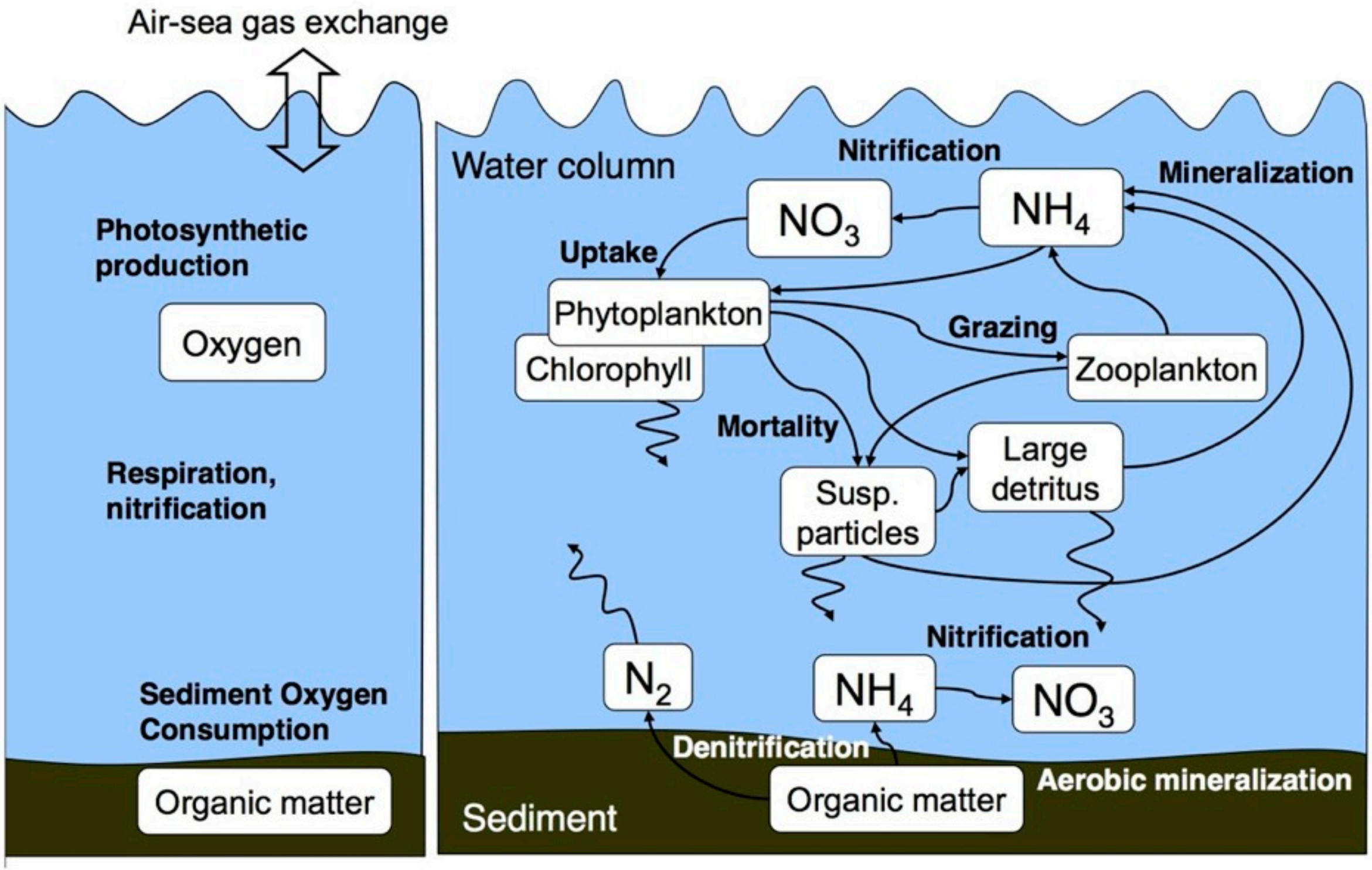
# Sensitivity of hypoxia predictions for the Texas-Louisiana Shelf to sediment oxygen consumption and model nesting

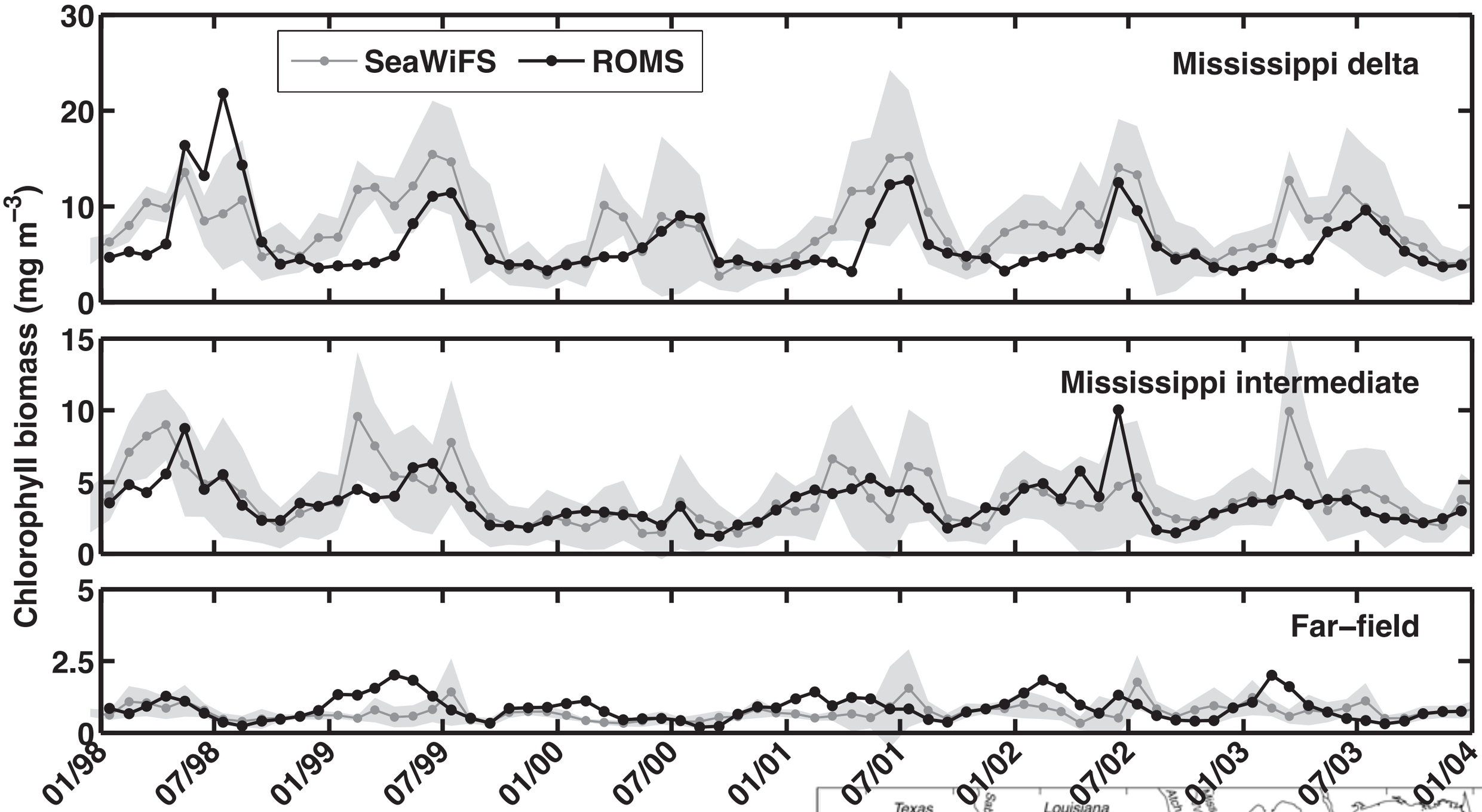
**Katja Fennel,**
**Jiatang Hu, Arnaud Laurent,**
**Martinho Marta-Almeida, Rob Hetland**

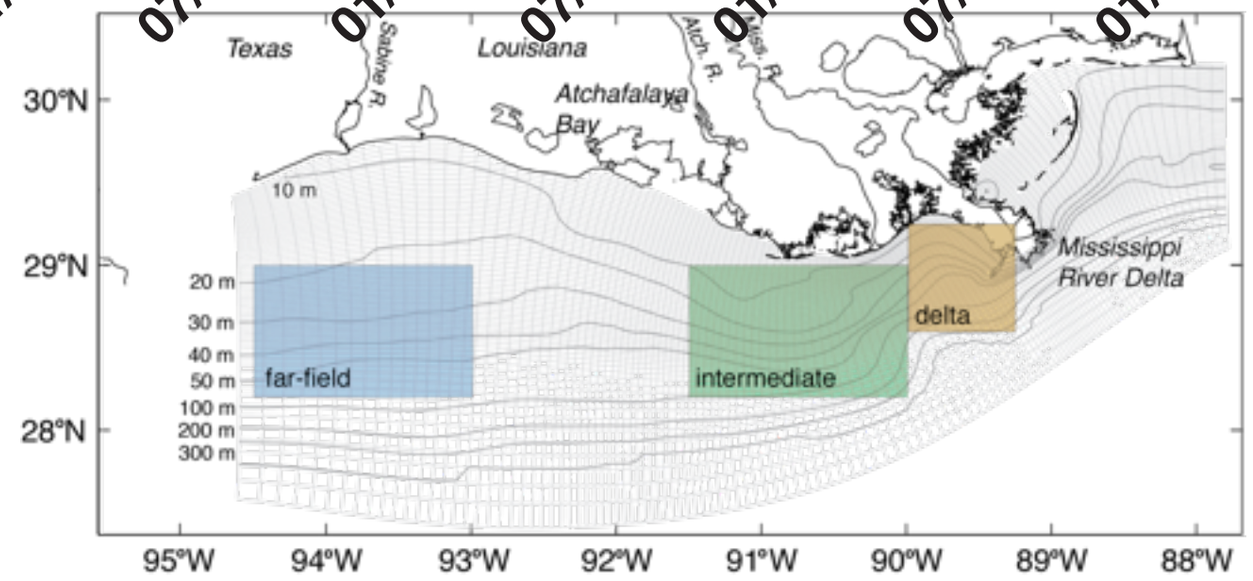

**NOAA NGOMEX**
**and**
**U.S. IOOS COMT**




**Physical model:** ROMS v3.0
**Biological model:** BIO_FENNEL with OXYGEN
**Resolution:** 1-20 km in horizontal, 20 or 30 vertical layers
**Forcing:** 3-hourly NCEP NARR winds; climatological surface heat and freshwater fluxes
**River inputs:** daily measurements of FW input by U.S. Army Corps of Engineers; monthly estimates of nutrient and particulate matter loads from USGS
**Horizontal b.c.s:** climatology, operational HYCOM or IASNFS for physics; climatology for biology


Air-sea gas exchange
Photosynthetic production
Oxygen
Respiration, nitrification
Sediment Oxygen Consumption
Organic matter
Water column
Nitrification
Mineralization
$NO_3$
$NH_4$
Uptake
Phytoplankton
Chlorophyll
Grazing
Zooplankton
Mortality
Large detritus
Susp. particles
$N_2$
Nitrification
$NH_4$
$NO_3$
Denitrification
Organic matter
Aerobic mineralization
Sediment




**Fennel et al. *Biogeosciences* (2011)**
**Laurent et al. *Biogeosciences* (2012)**

| Run | SOC treatment | # vertical layers | horizontal boundaries |
|---|---|---|---|
| **A20clim** | IR | 20 | climatological |
| **B20clim** | H&D | 20 | climatological |
| **C20clim** | M&L | 20 | climatological |
| **A30clim** | IR | 30 | climatological |
| **B30clim** | H&D | 30 | climatological |
| **A30HYC** | IR | 30 | HYCOM |
| **B30HYC** | H&D | 30 | HYCOM |
| **A30IAS** | IR | 30 | IASNFS |
| **B30IAS** | H&D | 30 | IASNFS |

## Coastal & Ocean Modelling Testbed

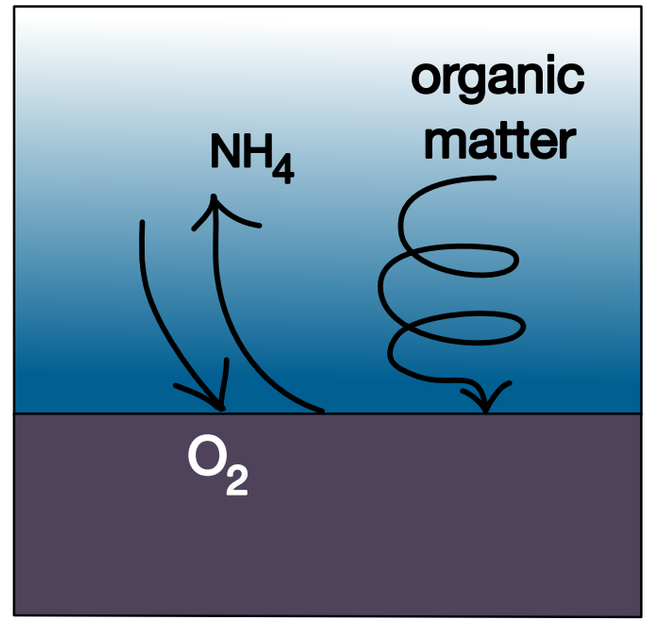
http://testbed.sura.org

Shelf Hypoxia Team incl. collaborators from TAMU, NRL, FSU, NOAA CSDL, UDel, Dal

IOOS®
INTEGRATED OCEAN OBSERVING SYSTEM

# Three treatments of Sediment Oxygen Consumption (SOC):

**(A) Instantaneous Remineralization** or IR
(depends only on organic matter flux)



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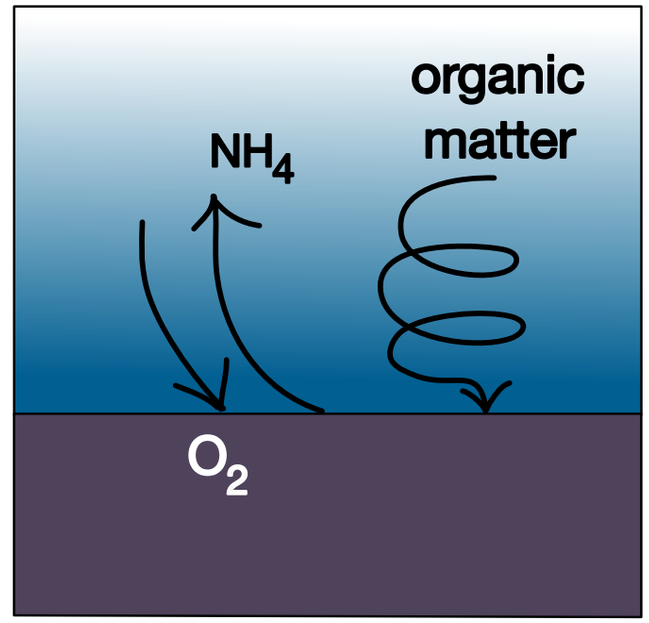
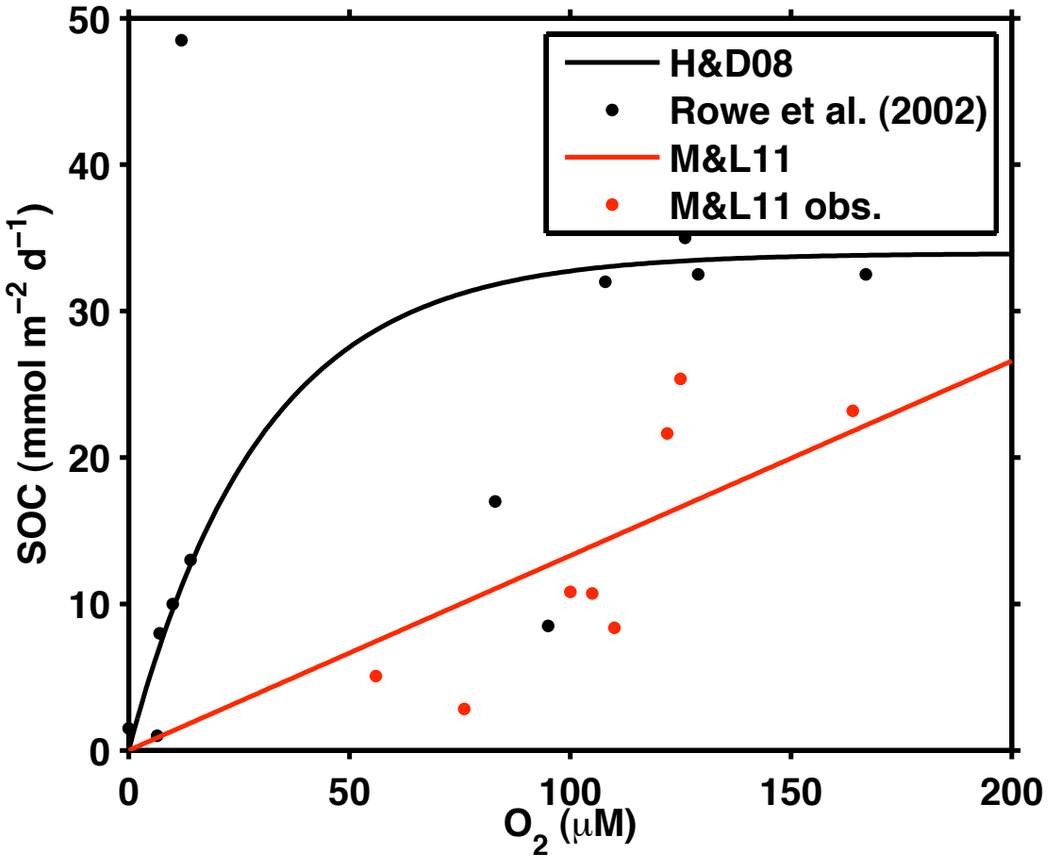
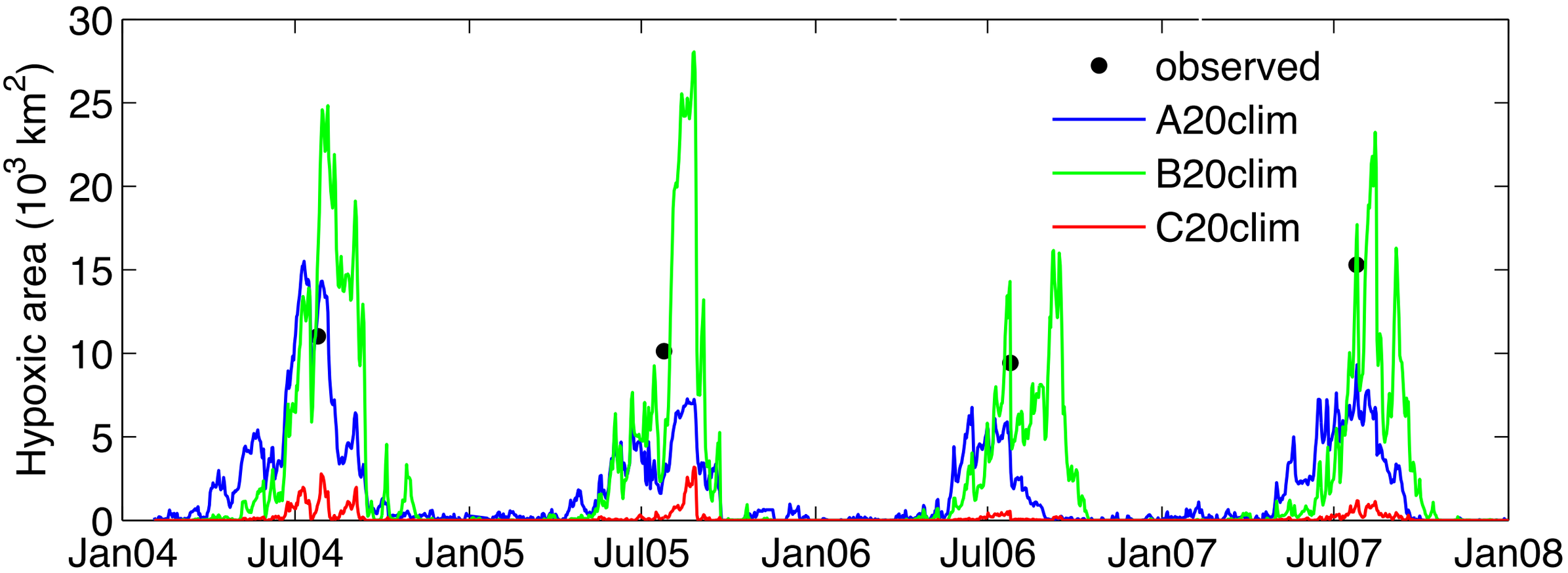


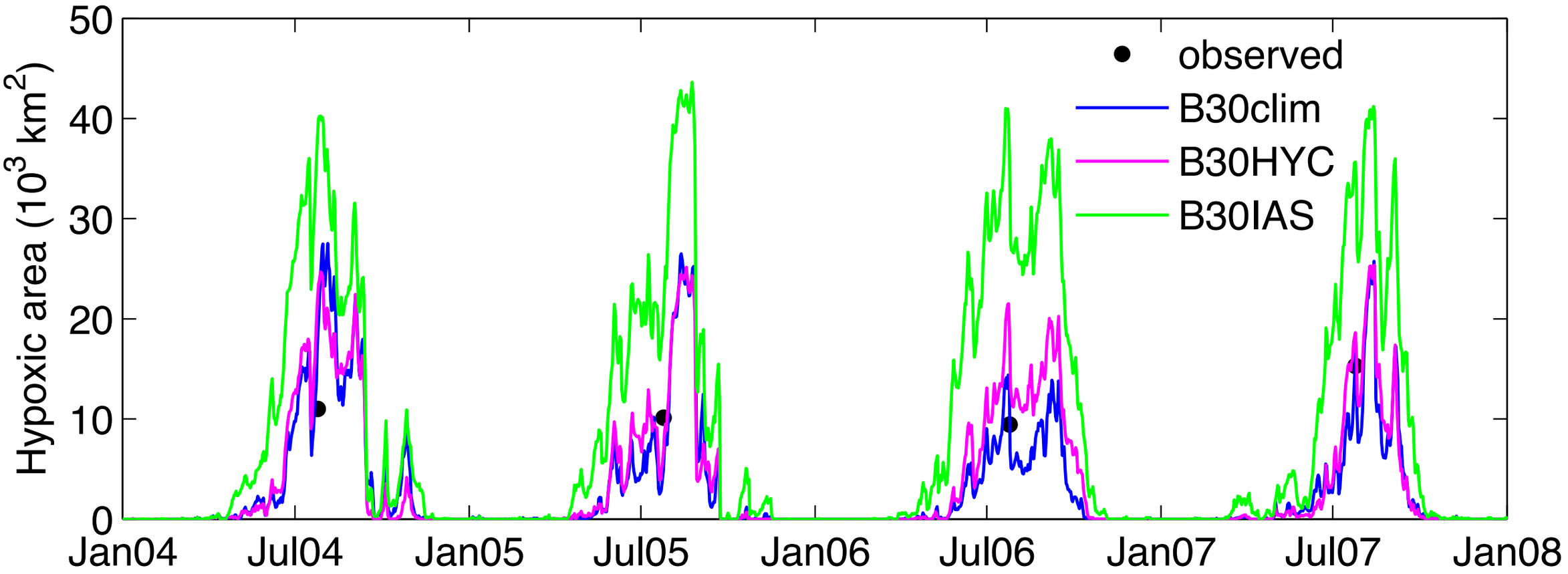

SOC parameterizations (depend on bottom water T and DO, but not organic matter flux)
**(B) Hetland and DiMarco (2008)** or H&D
**(C) Murrell and Lehrter (2011)** or L&M






**A: Instantaneous Remineralization**
**B: Hetland & DiMarco (2008)**
**C: Murrell & Lehrter (2011)**

**Fennel et al. *JGR-Oceans* (2013)**

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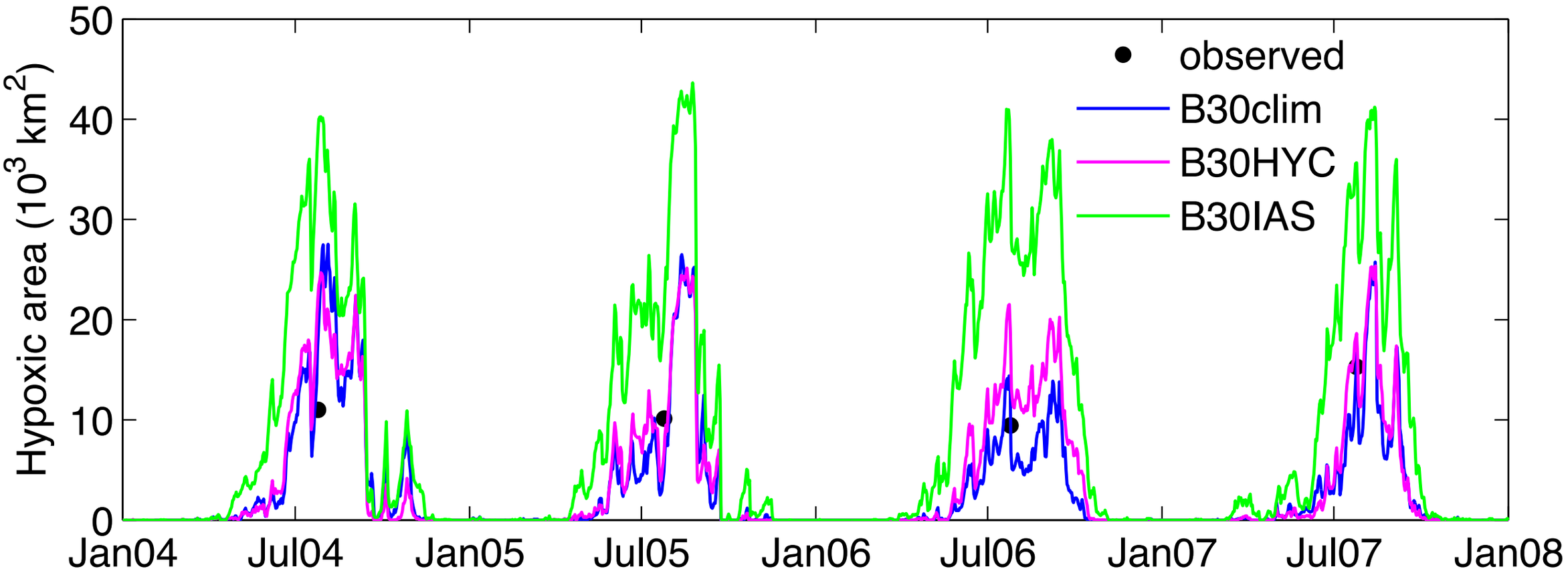
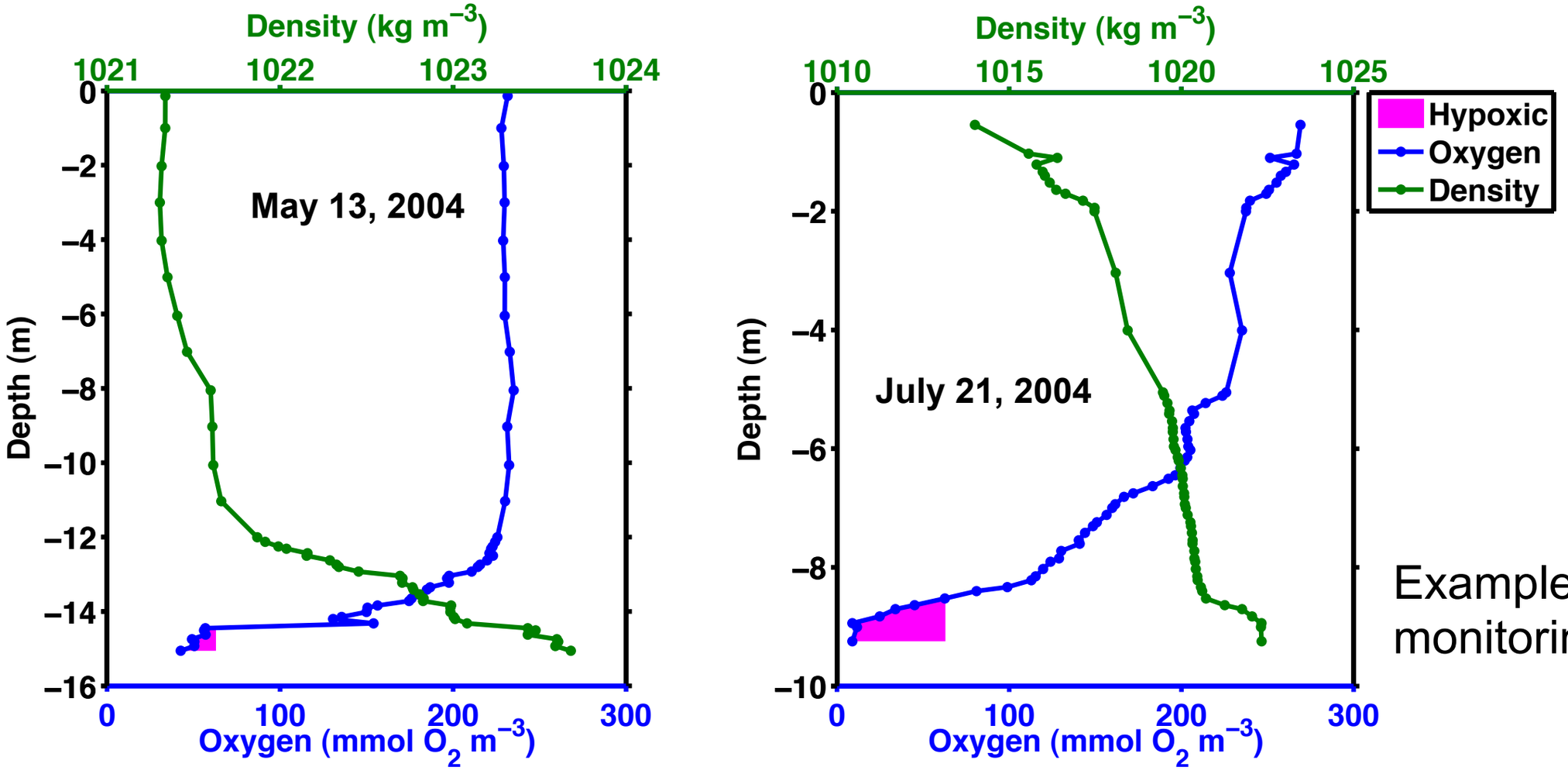


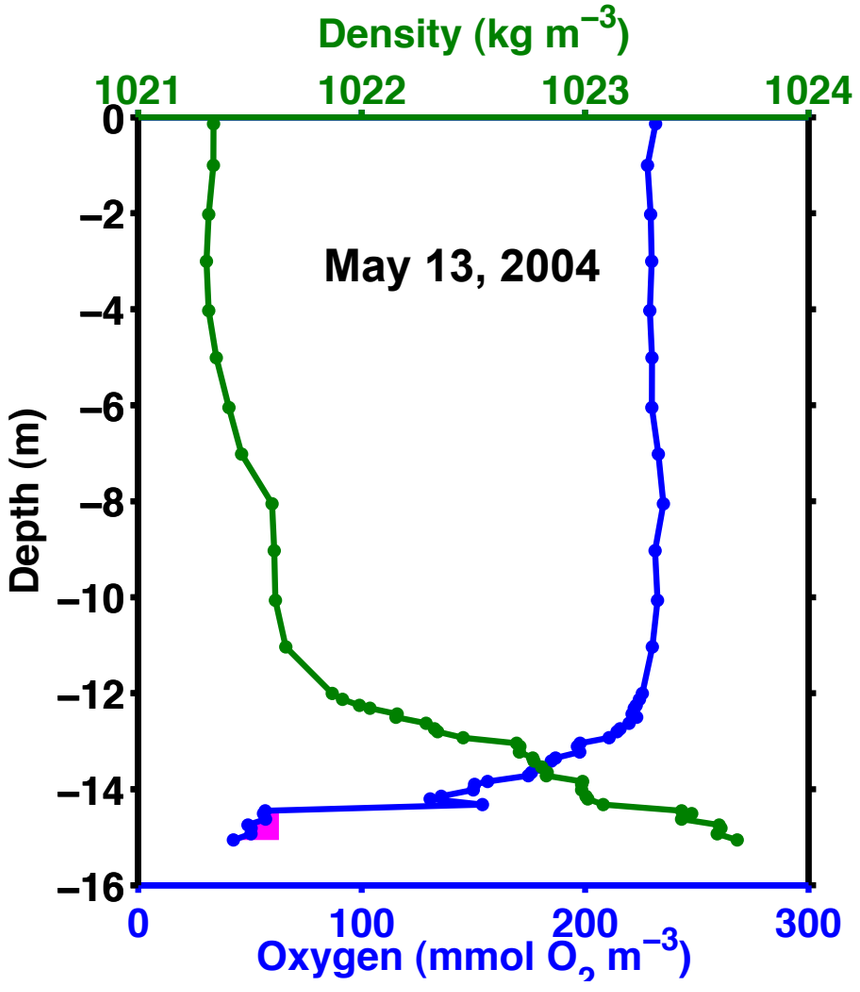

Why are hypoxia predictions so sensitive to SOC treatment?

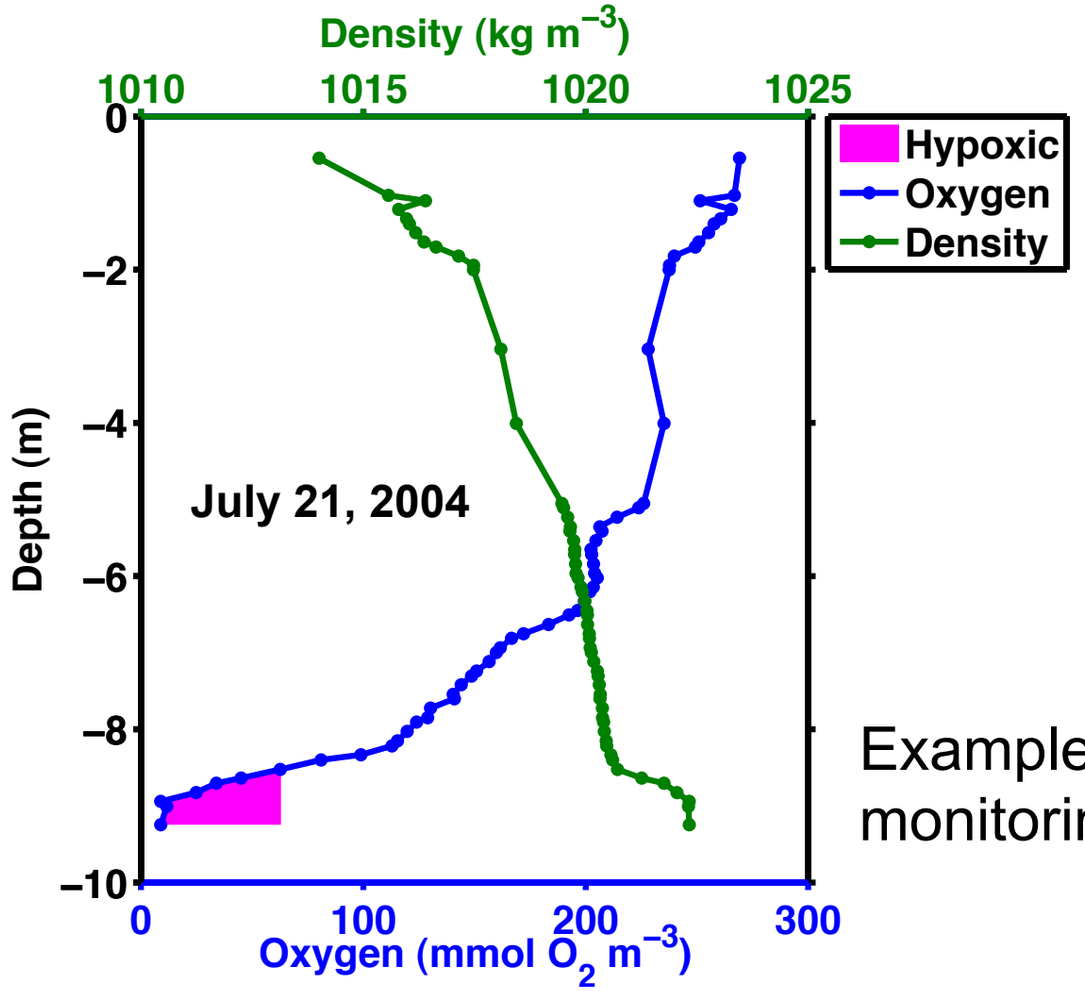
Why systematically higher for IASNFS boundaries?

**Fennel et al. *JGR-Oceans* (2013)**




Examples of LUMCON monitoring observations

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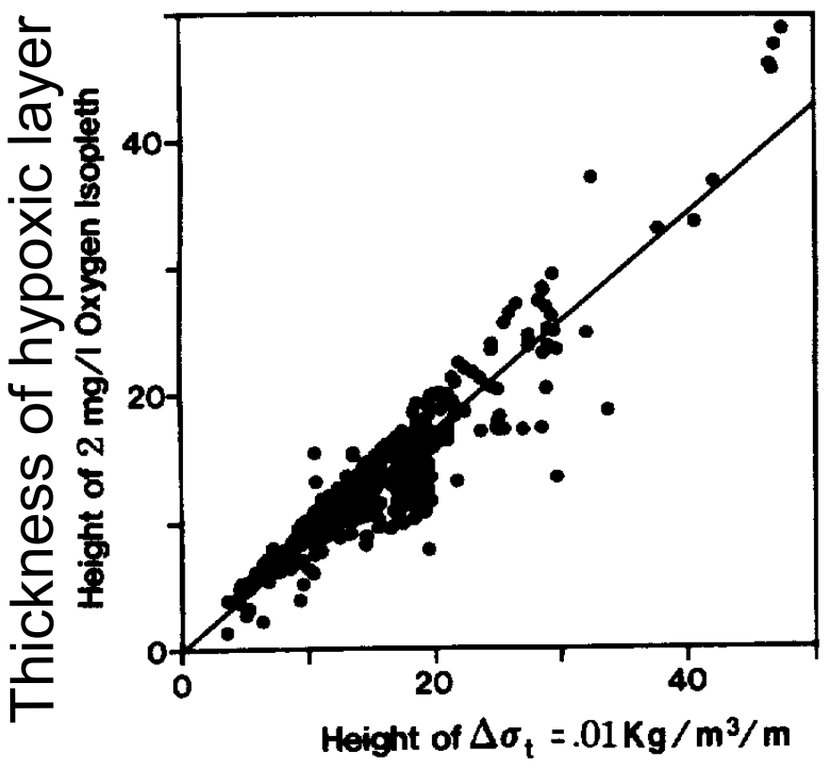
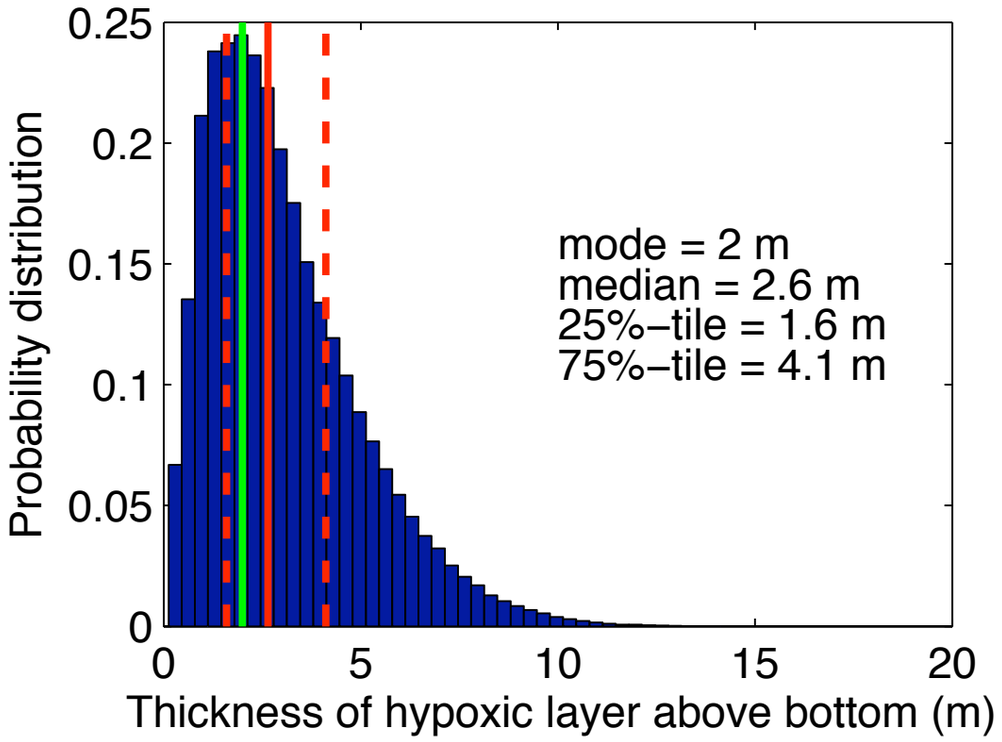
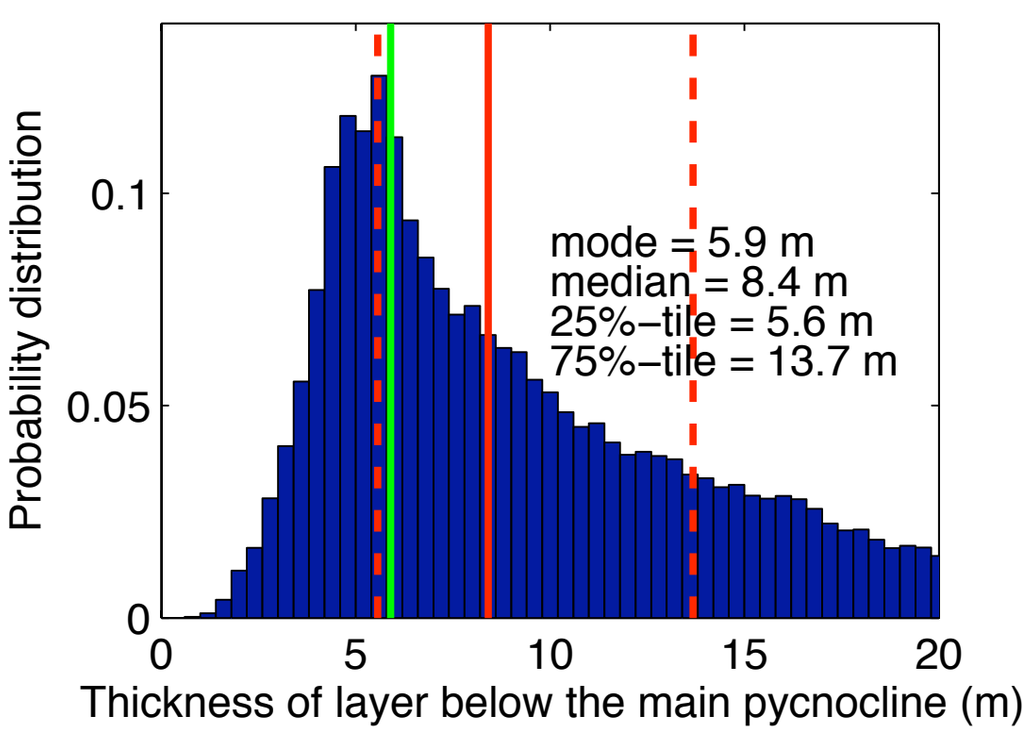


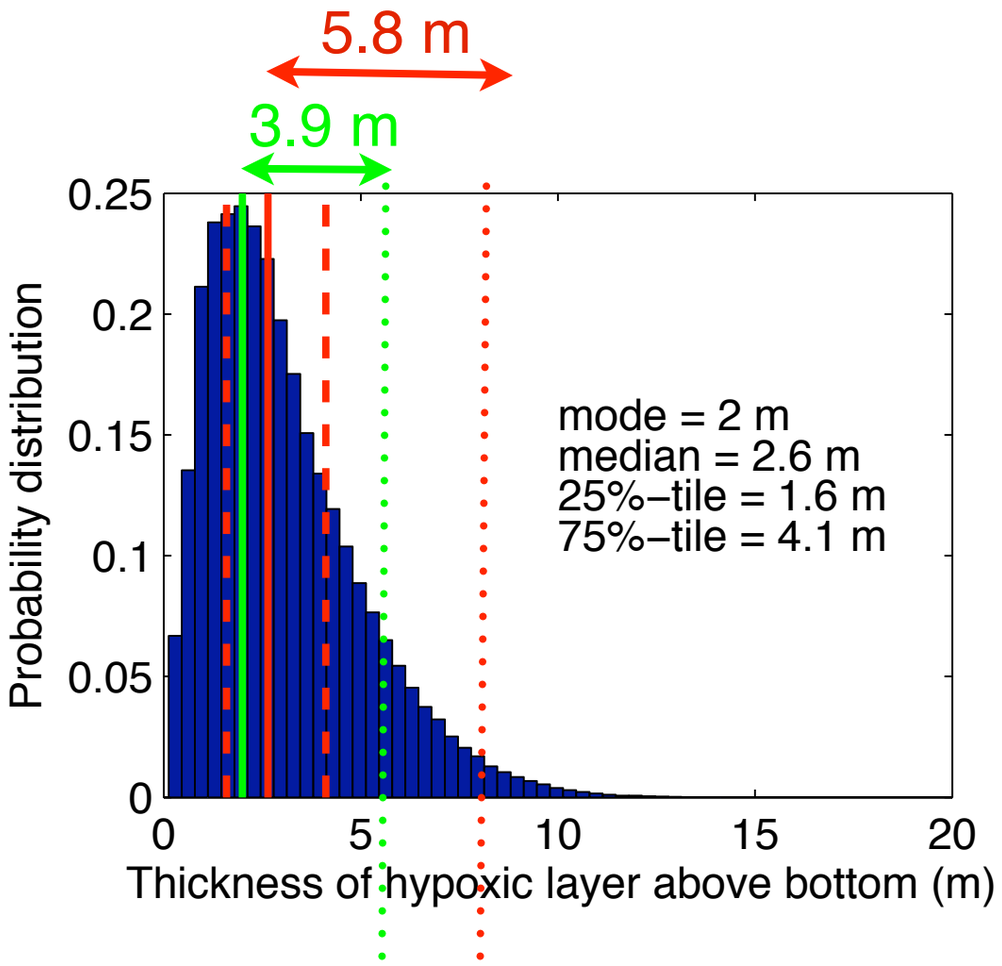

Wiseman et al., JMS (1997)

Thickness of the bottom boundary layer

Hypoxia is essentially constrained to bottom boundary layer (BBL).


0.25
0.2
0.15
0.1
0.05
0
Probability distribution
mode = 2 m
median = 2.6 m
25%–tile = 1.6 m
75%–tile = 4.1 m
0
5
10
15
20
Thickness of hypoxic layer above bottom (m)


0.1
0.05
0
Probability distribution
mode = 5.9 m
median = 8.4 m
25%–tile = 5.6 m
75%–tile = 13.7 m
0
5
10
15
20
Thickness of layer below the main pycnocline (m)


5.8 m
3.9 m
0.25
0.2
0.15
0.1
0.05
0
Probability distribution
mode = 2 m
median = 2.6 m
25%–tile = 1.6 m
75%–tile = 4.1 m
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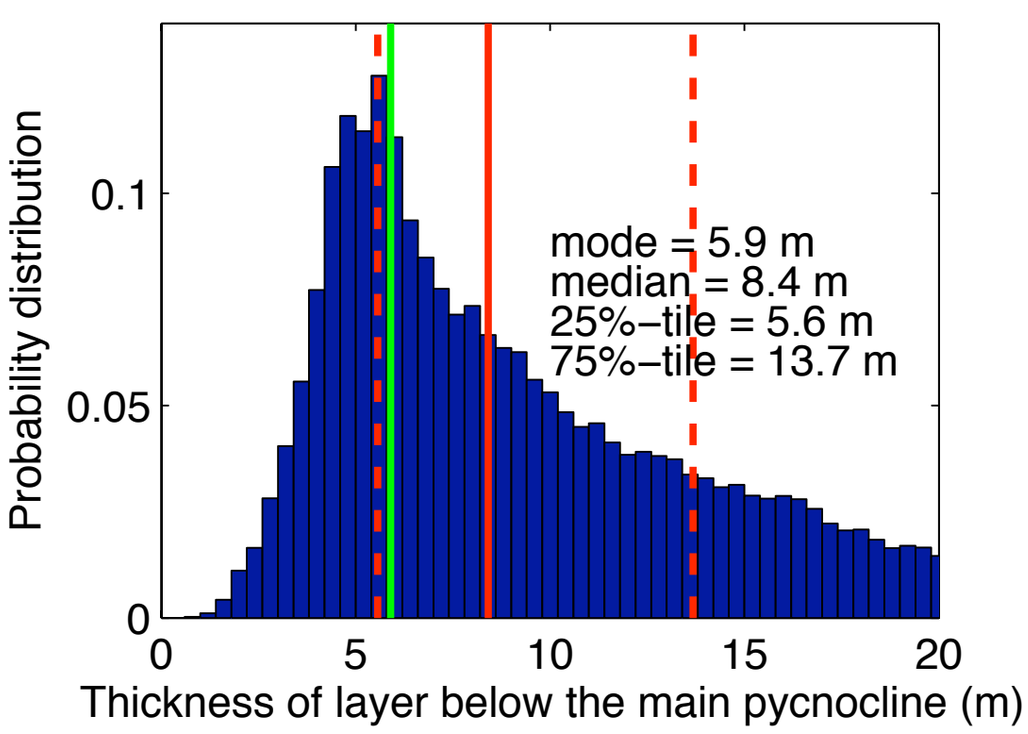
Thickness of hypoxic layer above bottom (m)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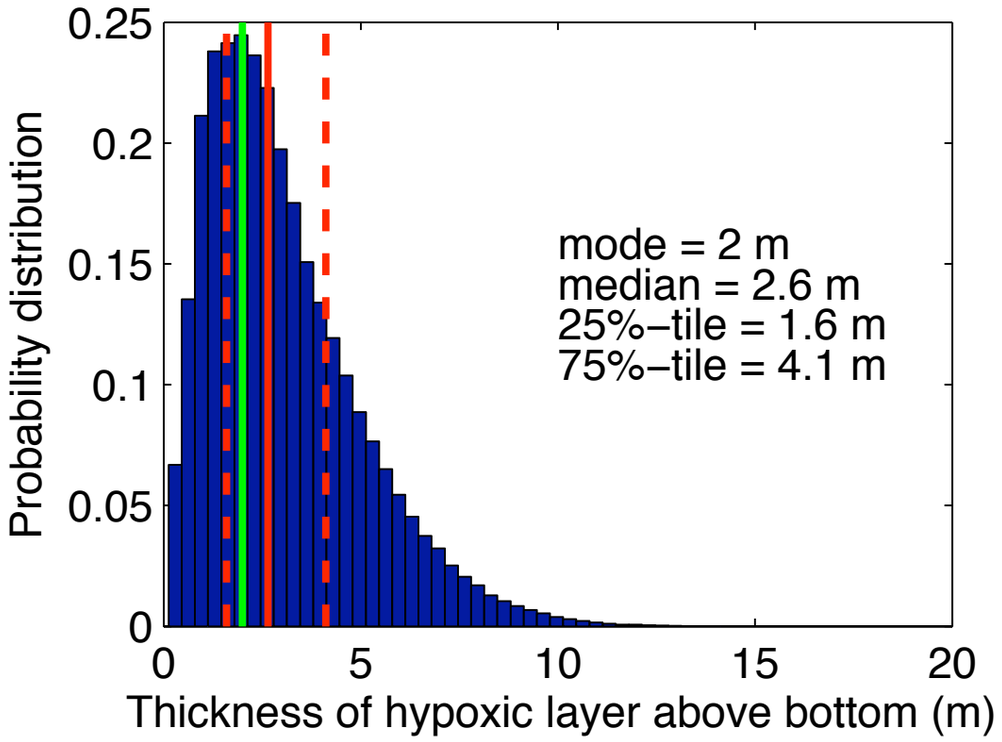
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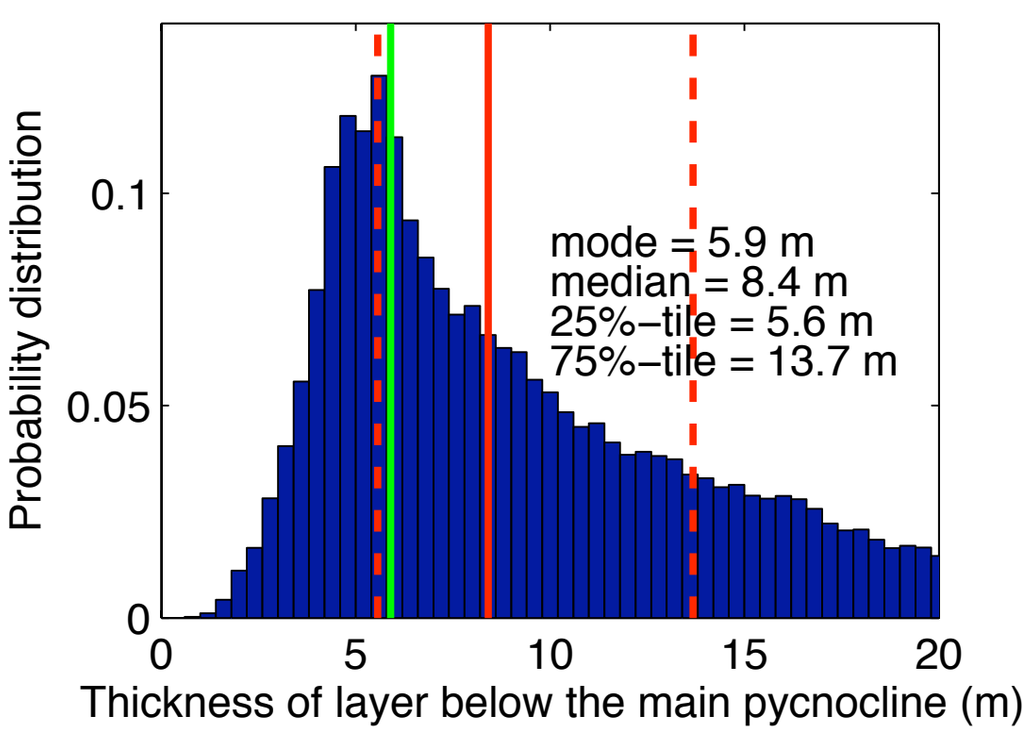
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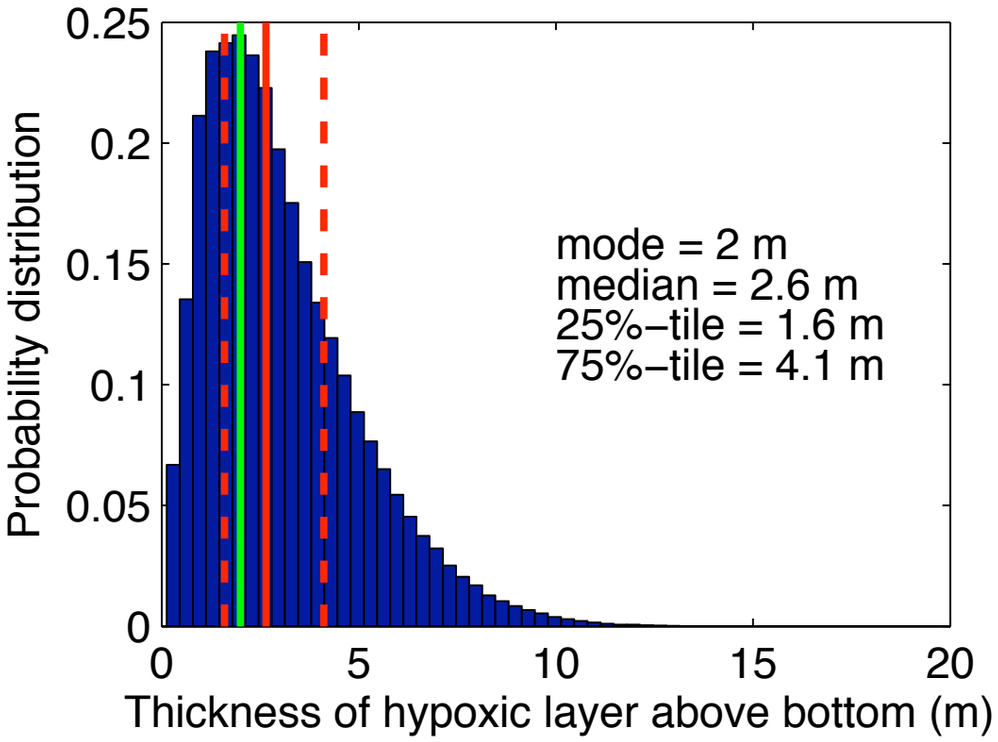
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Probability distribution
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5
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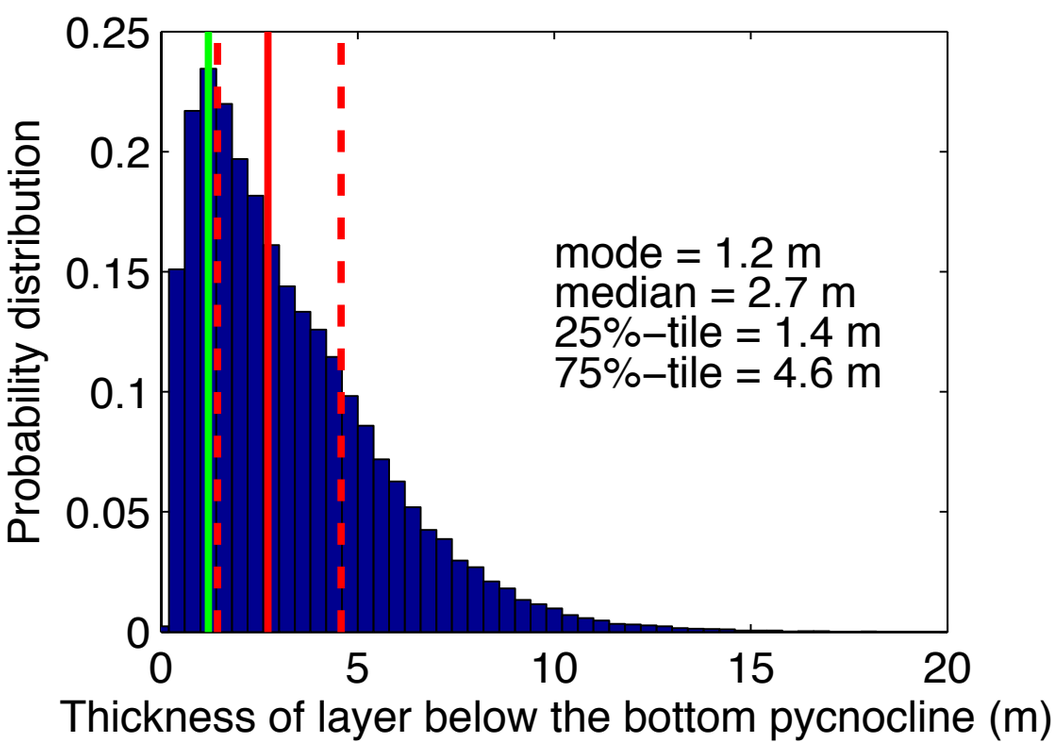
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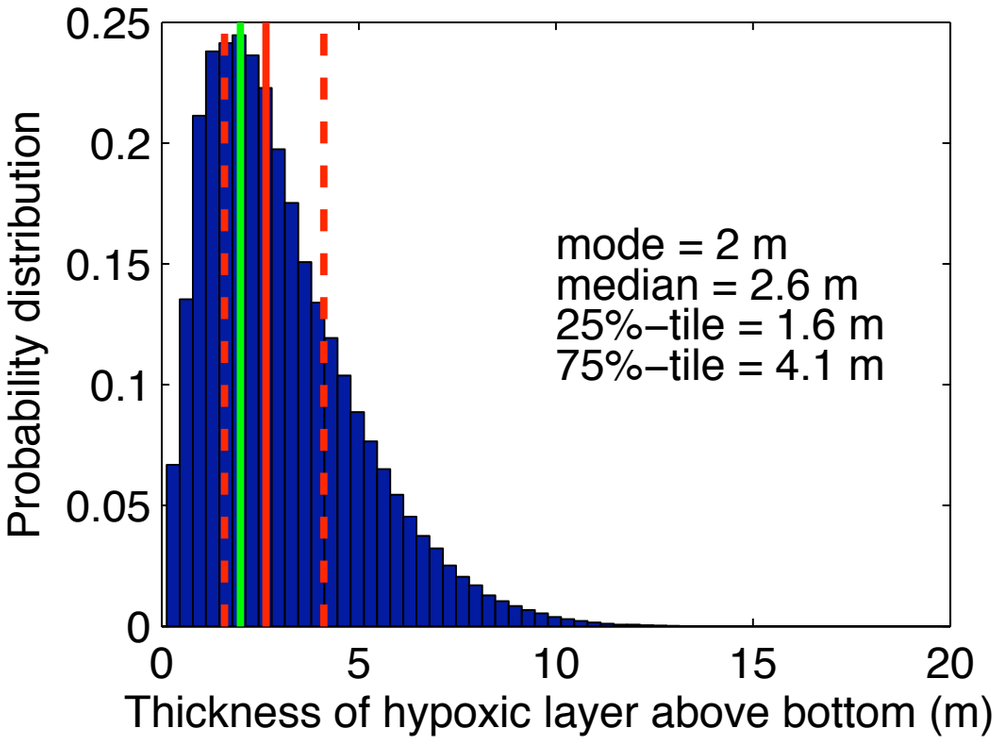
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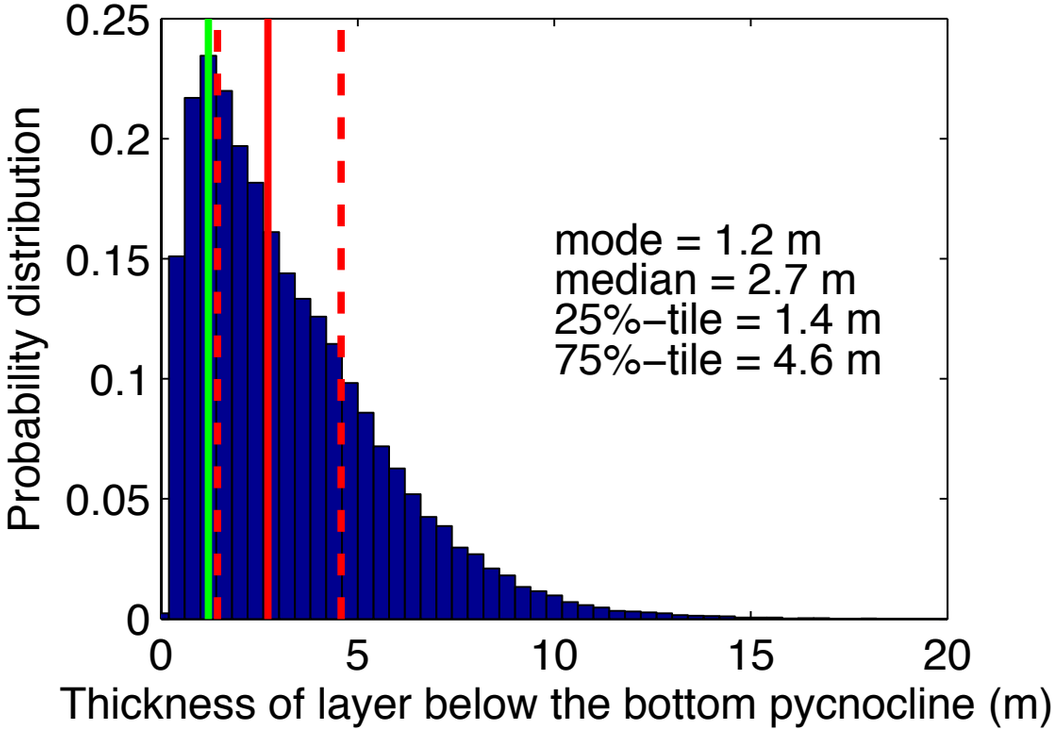
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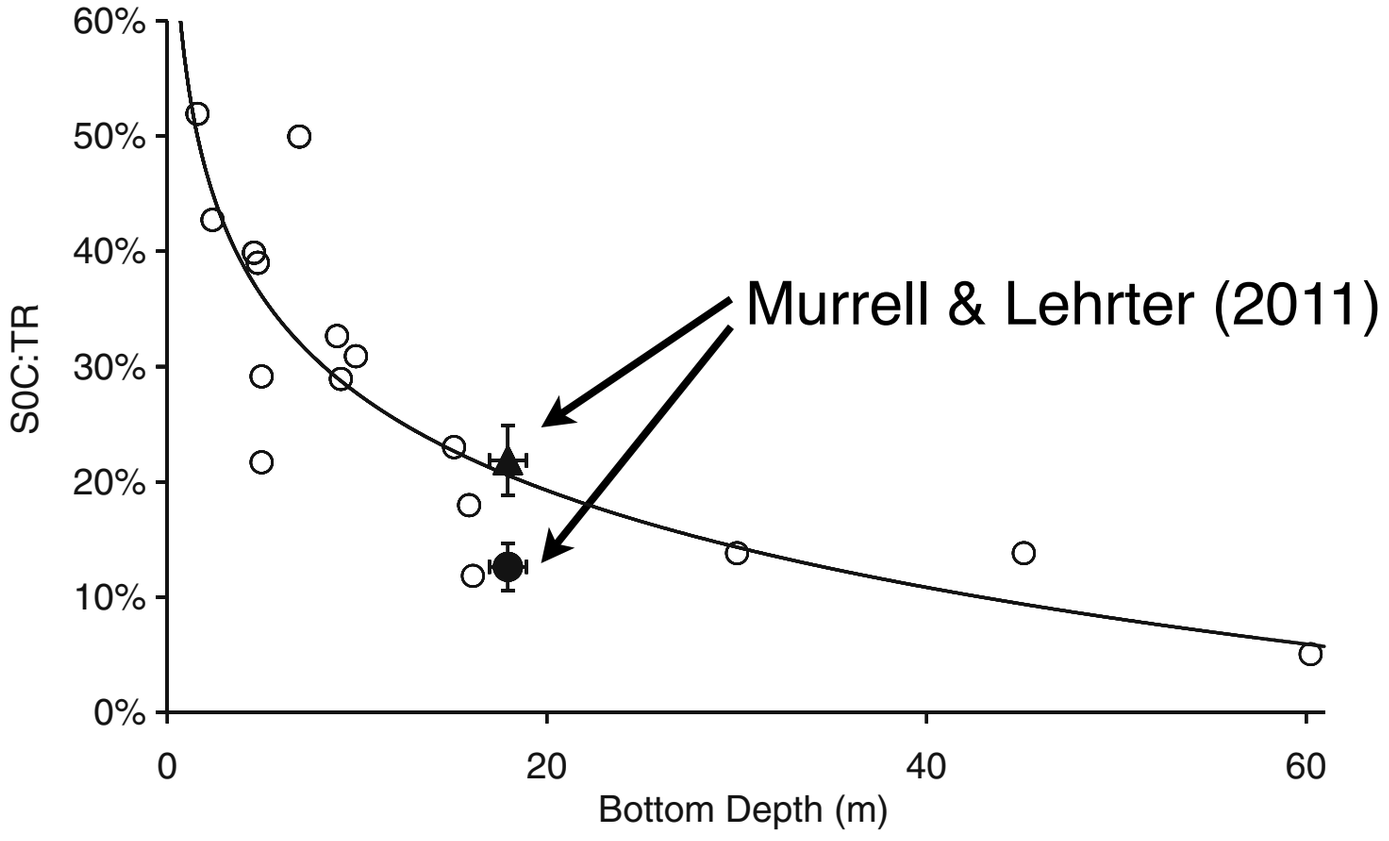
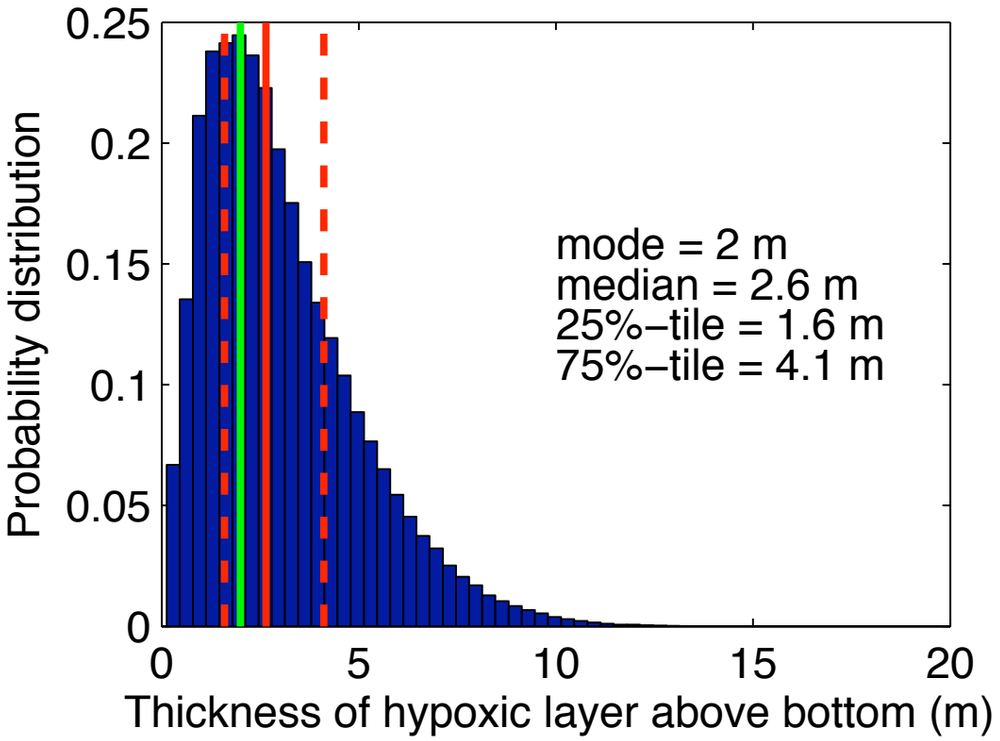
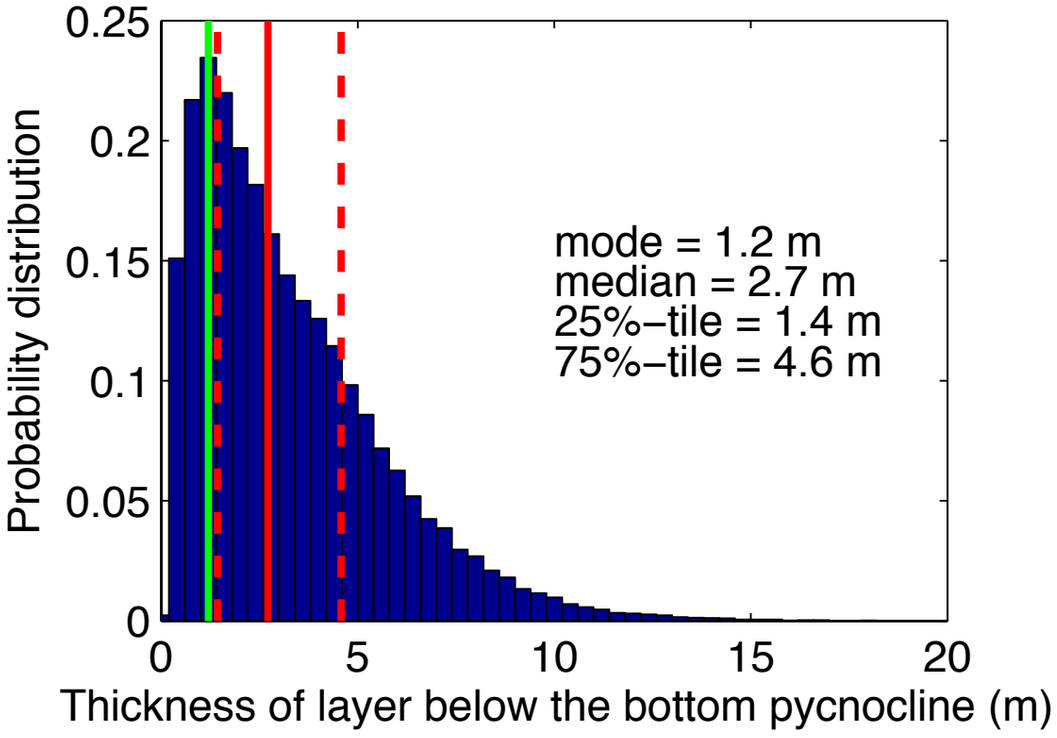

Kemp et al. MEPS (1992)
60%
50%
40%
30%
20%
10%
0%
SOC:TR
Murrell & Lehrter (2011)
0
20
40
60
Bottom Depth (m)

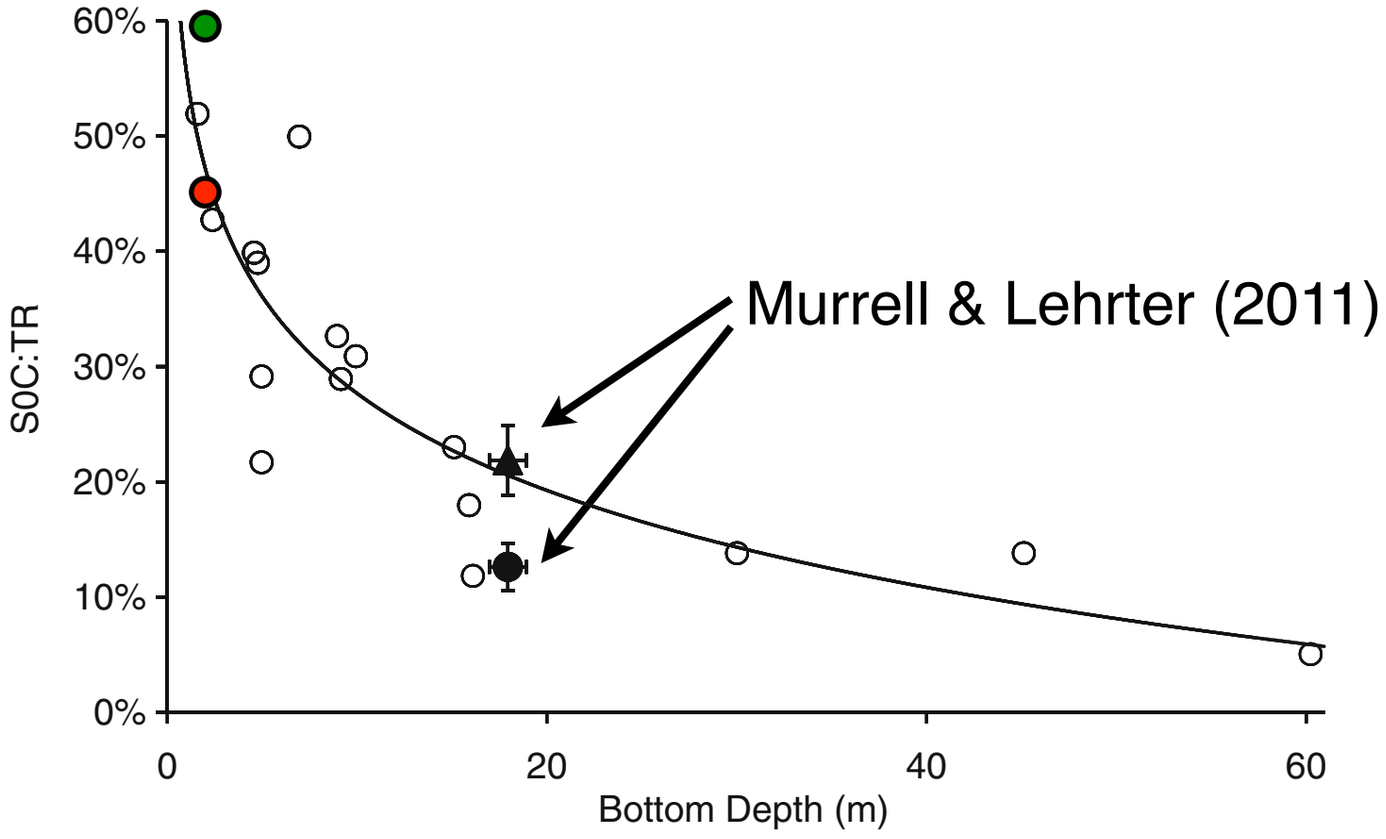


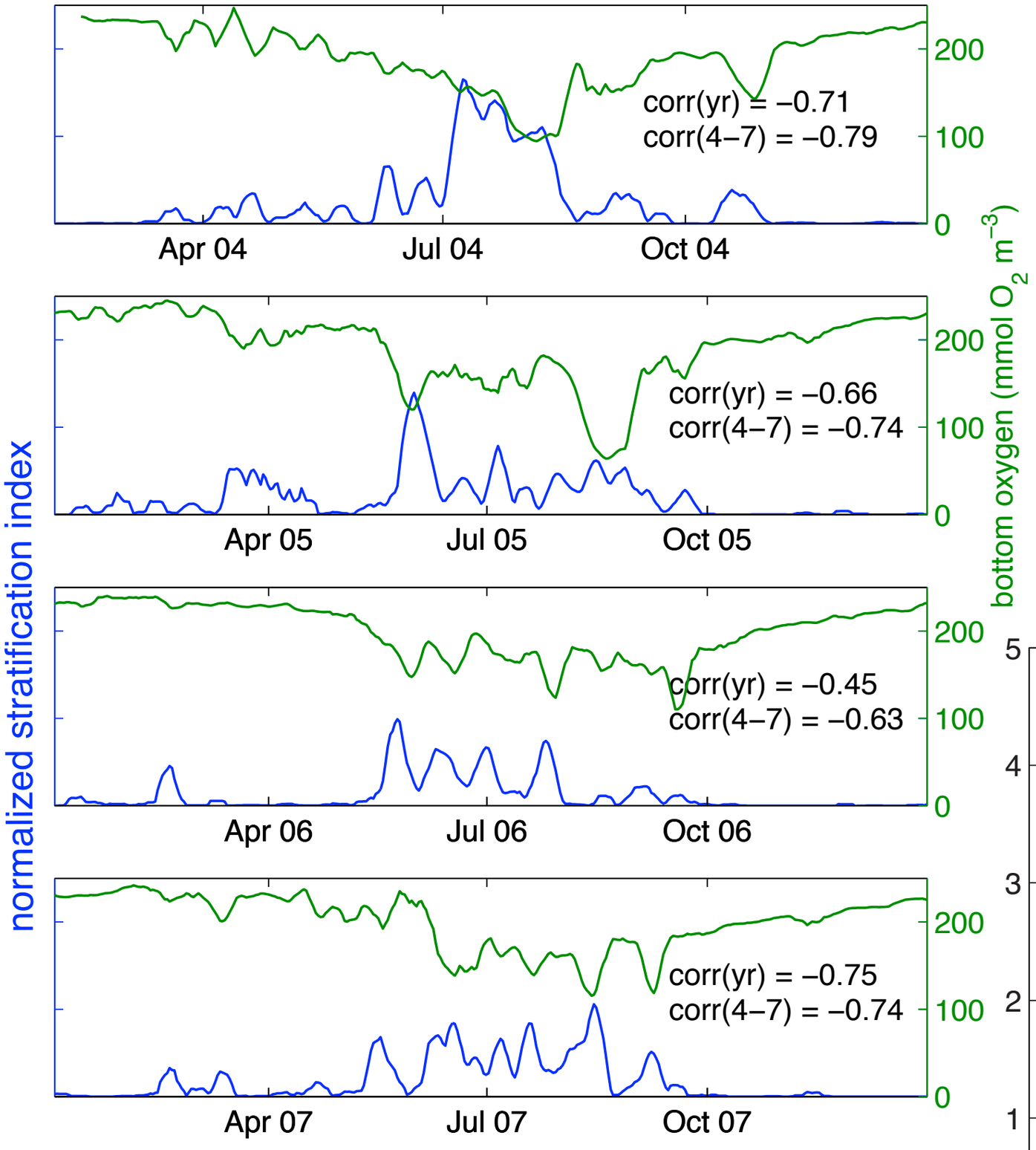



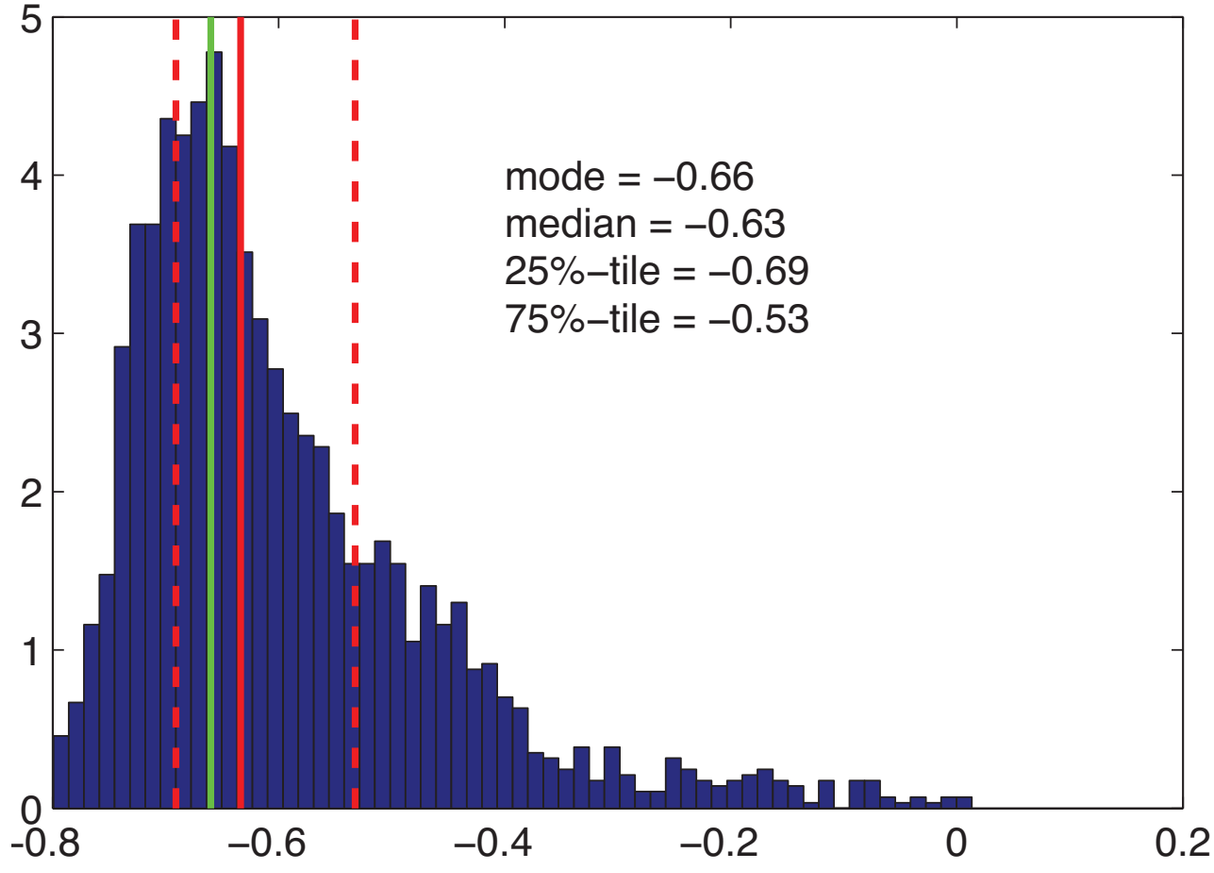

WR and SOC from M&L, 2 m BBL

WR from M&L, SOC from Rowe et al. (2002)

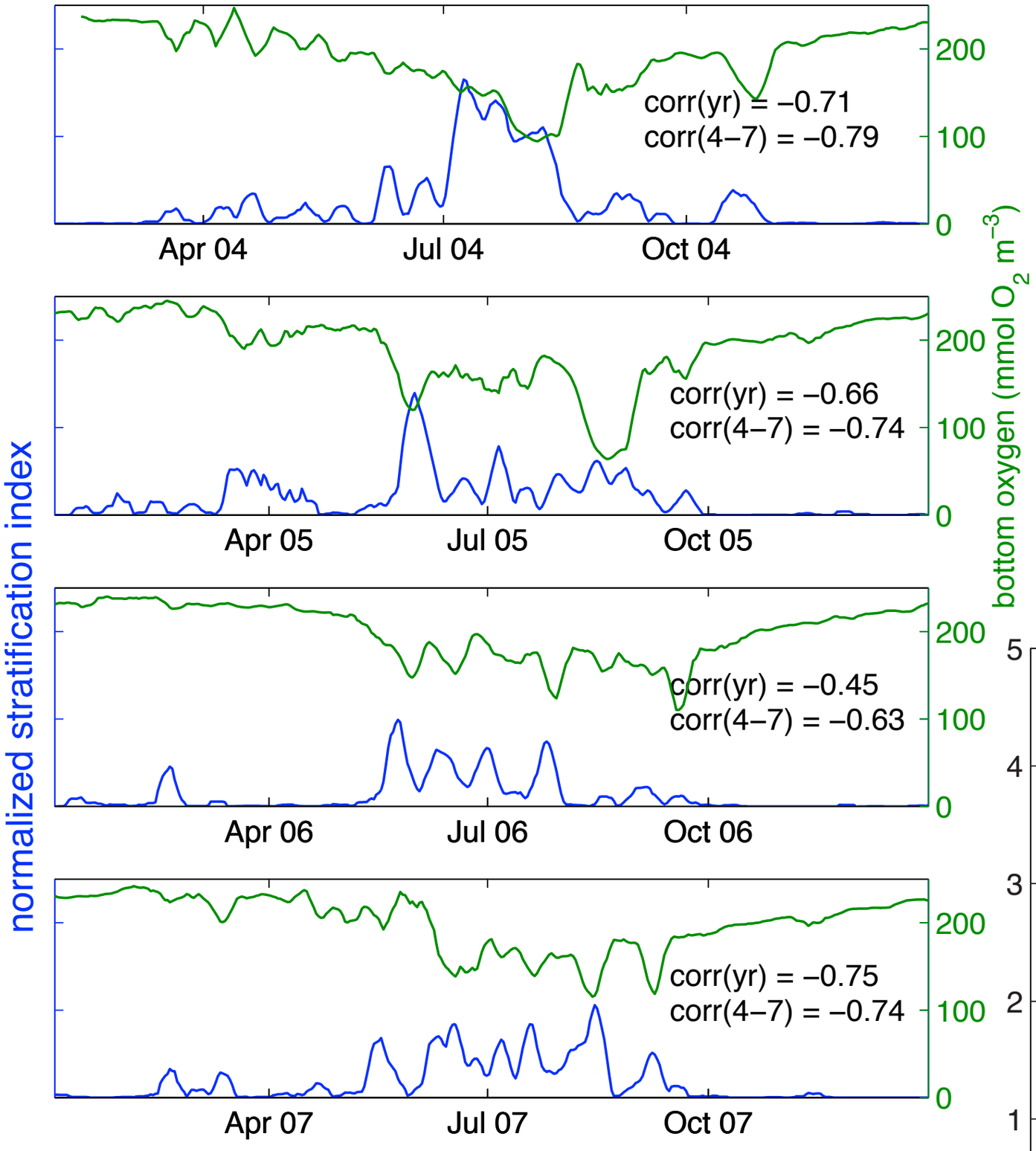
Kemp et al. MEPS (1992)



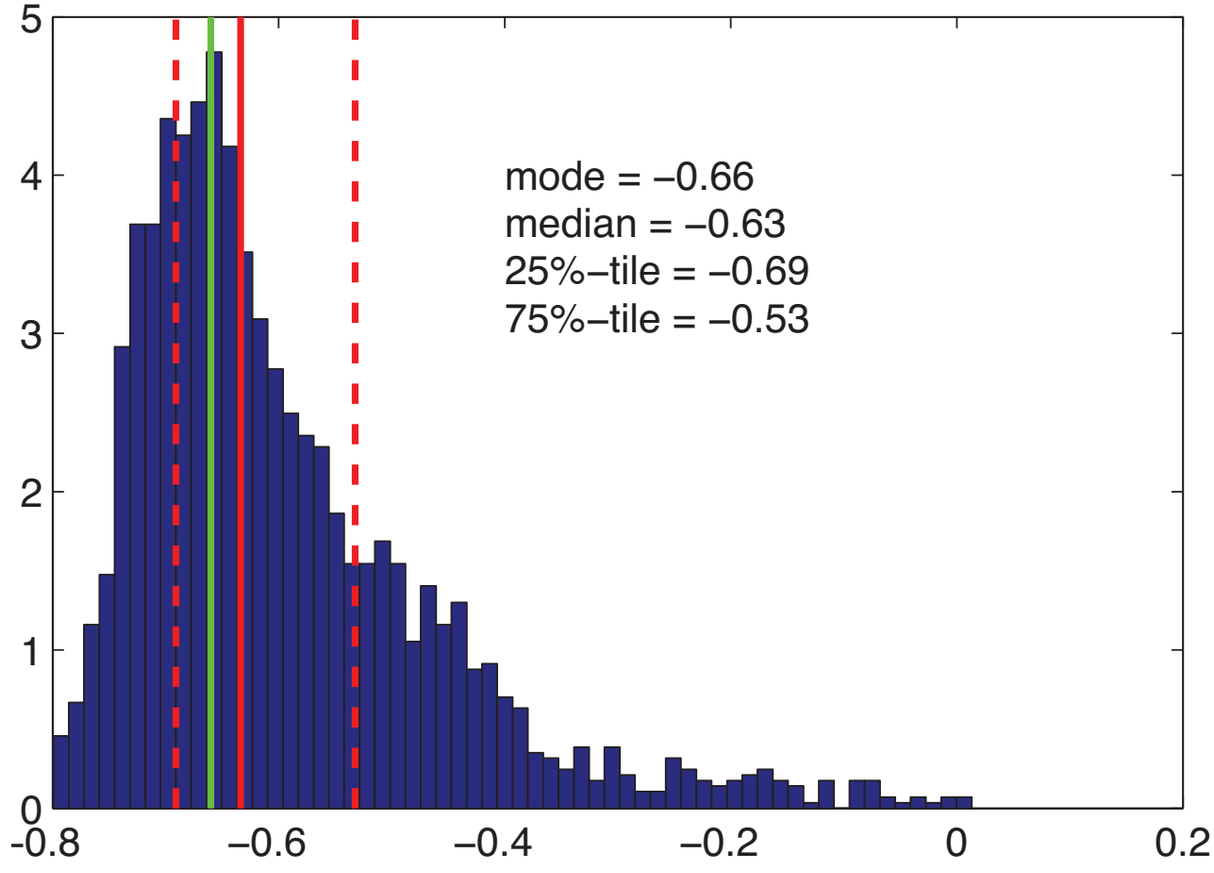



PDF of temporal correlation between stratification index and bottom oxygen




Can this explain differences between B30HYC and B30IAS?

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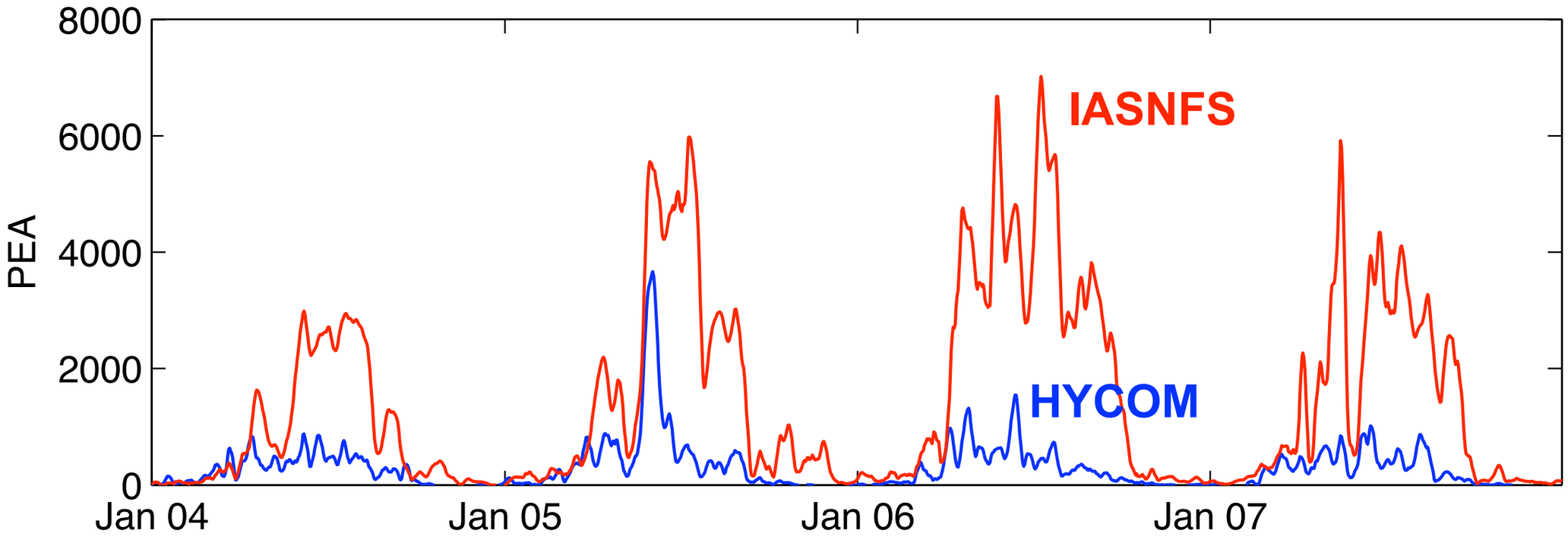
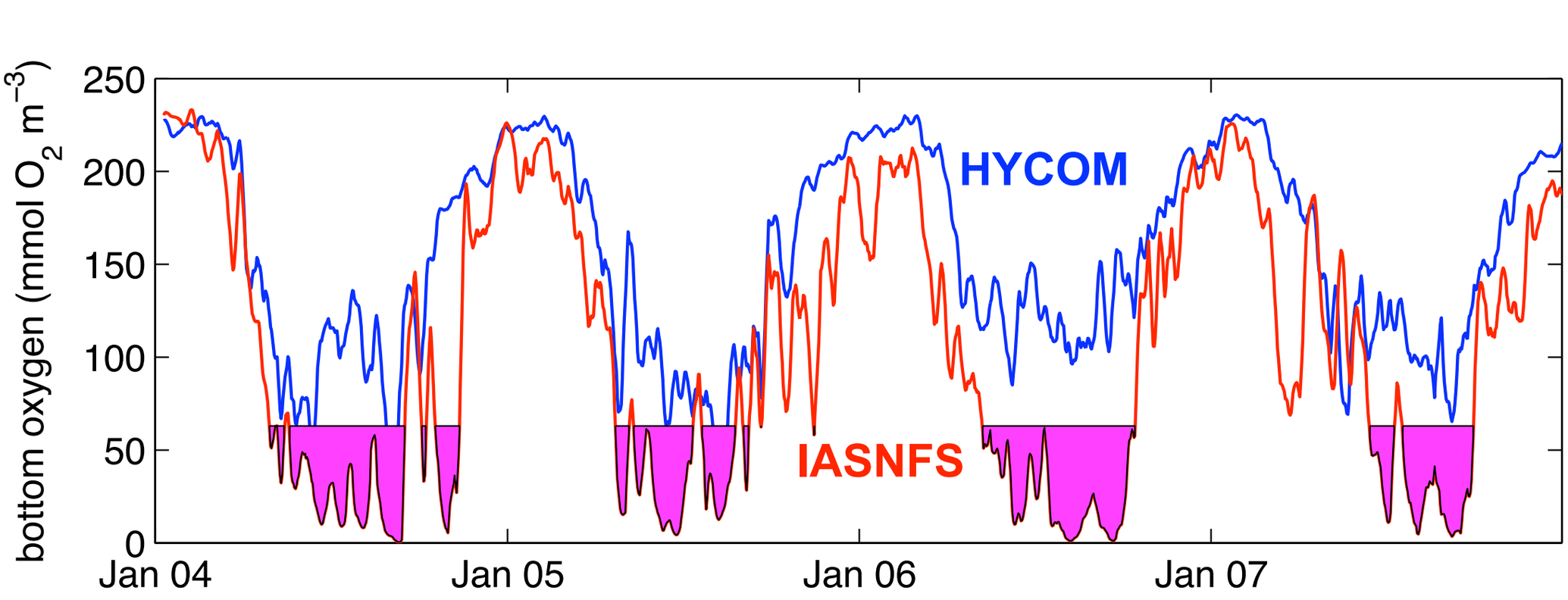

8000
6000
4000
2000
0
PEA
IASNFS
HYCOM
Jan 04
Jan 05
Jan 06
Jan 07


250
200
150
100
50
0
bottom oxygen (mmol O2 m−3)
HYCOM
IASNFS
Jan 04
Jan 05
Jan 06
Jan 07

# Conclusions

**Hypoxia predictions are very sensitive to the parameterization of SOC.**

**Results because hypoxic conditions are restricted to a relatively thin layer above the bottom over most of the shelf.**

**Strength of vertical stratification is an important predictor of oxygen in bottom waters.**

**Modification of physical horizontal boundary conditions can have a large effect on hypoxia predictions.**