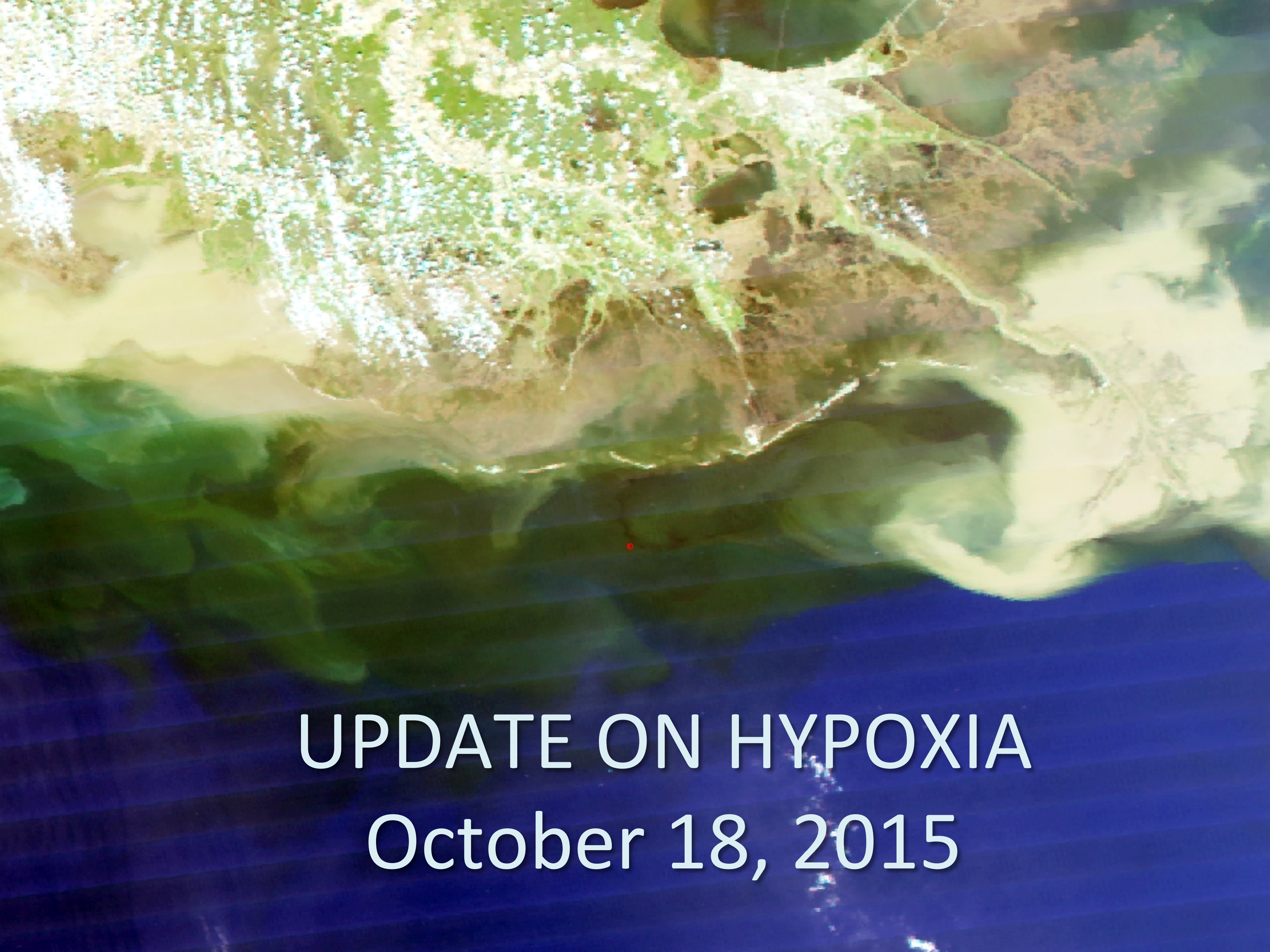
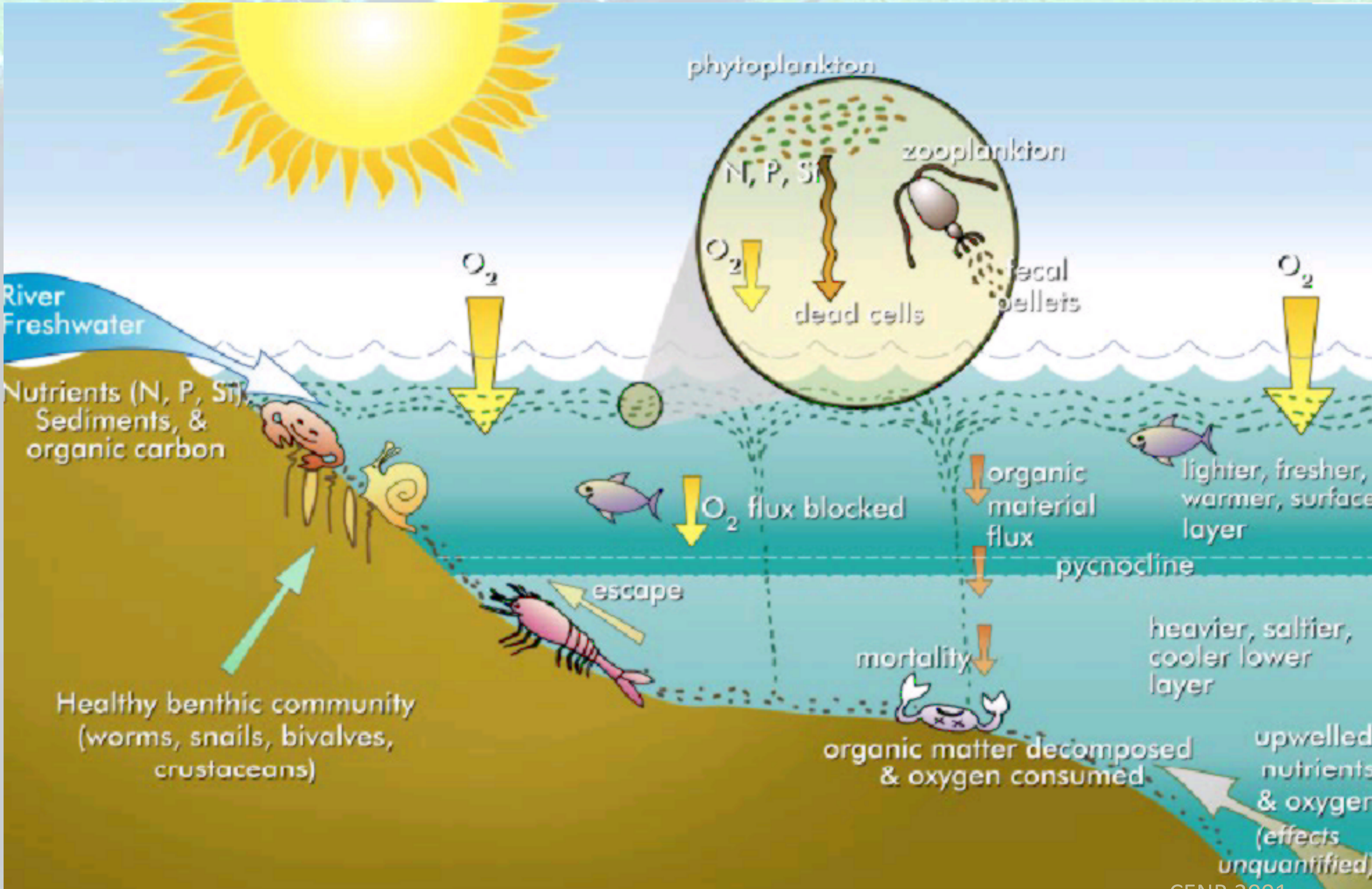


UPDATE ON HYPOXIA
October 18, 2015

Nutrients, Increased Growth, Low Oxygen



CENR 2001

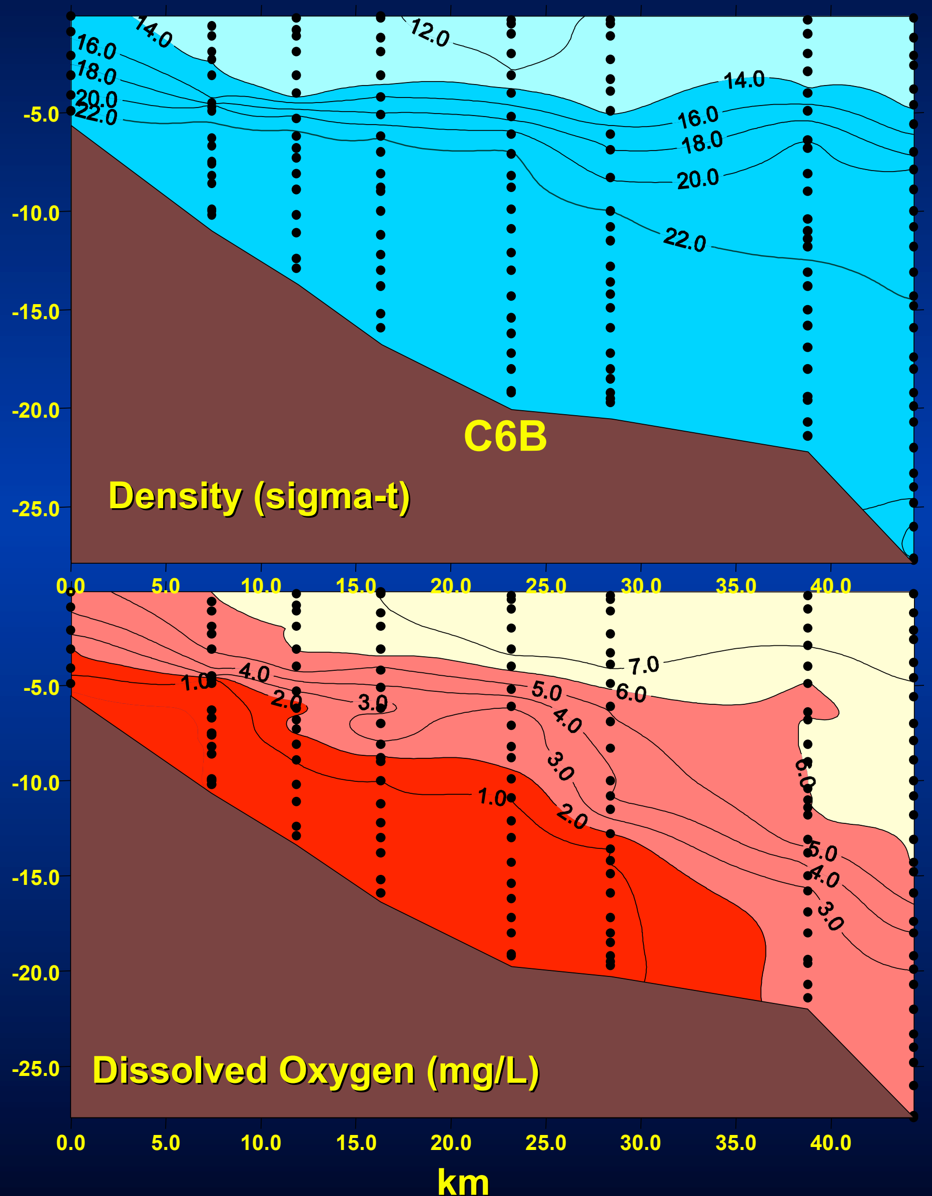
Effects are more far reaching than suspended sediment plume, esp. N & somewhat P

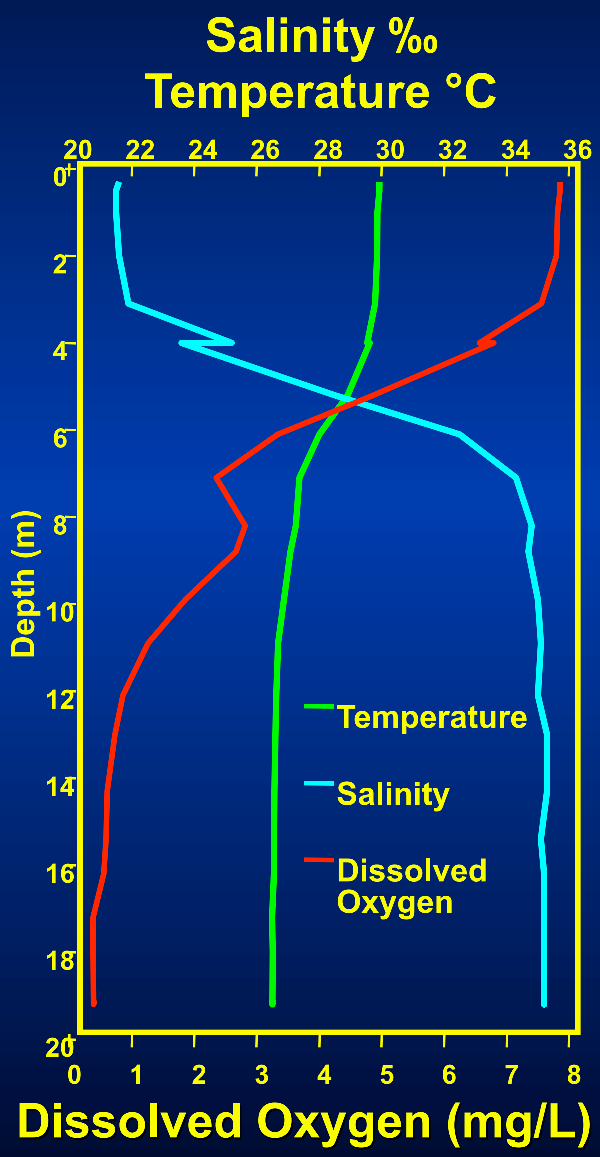
dominant wind direction

Source: N. Rabalais, LUMCON

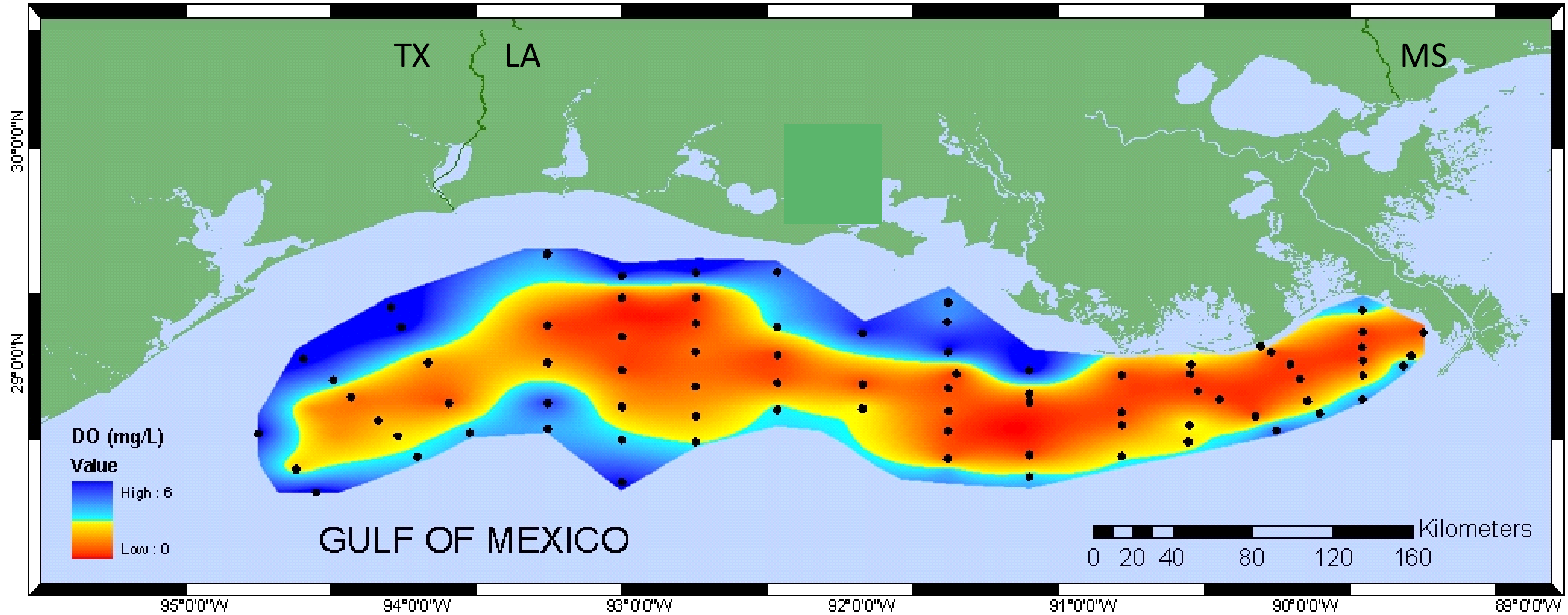
Stratification

(mid-summer)





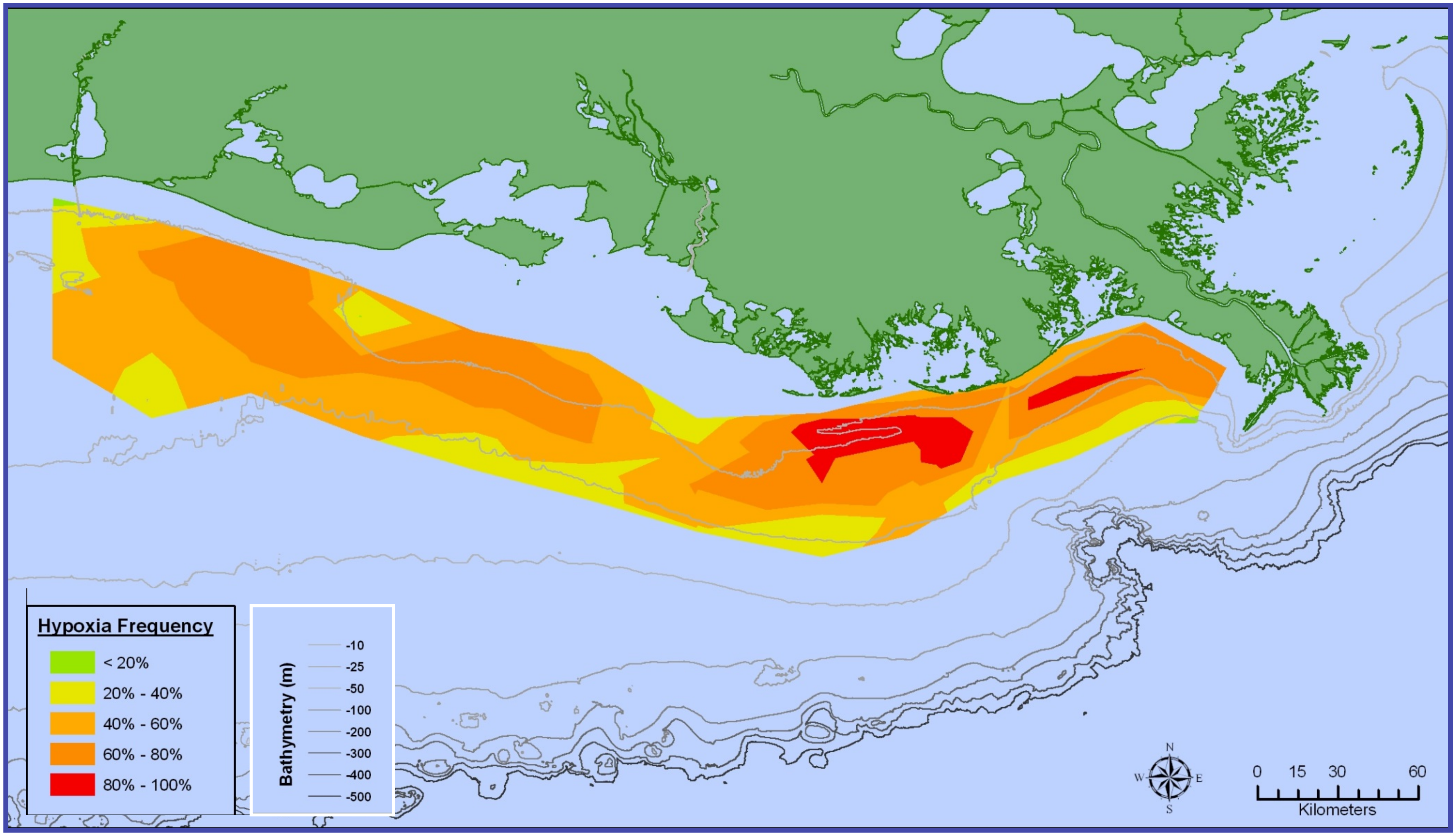
Extensive, Severe Low Oxygen Waters



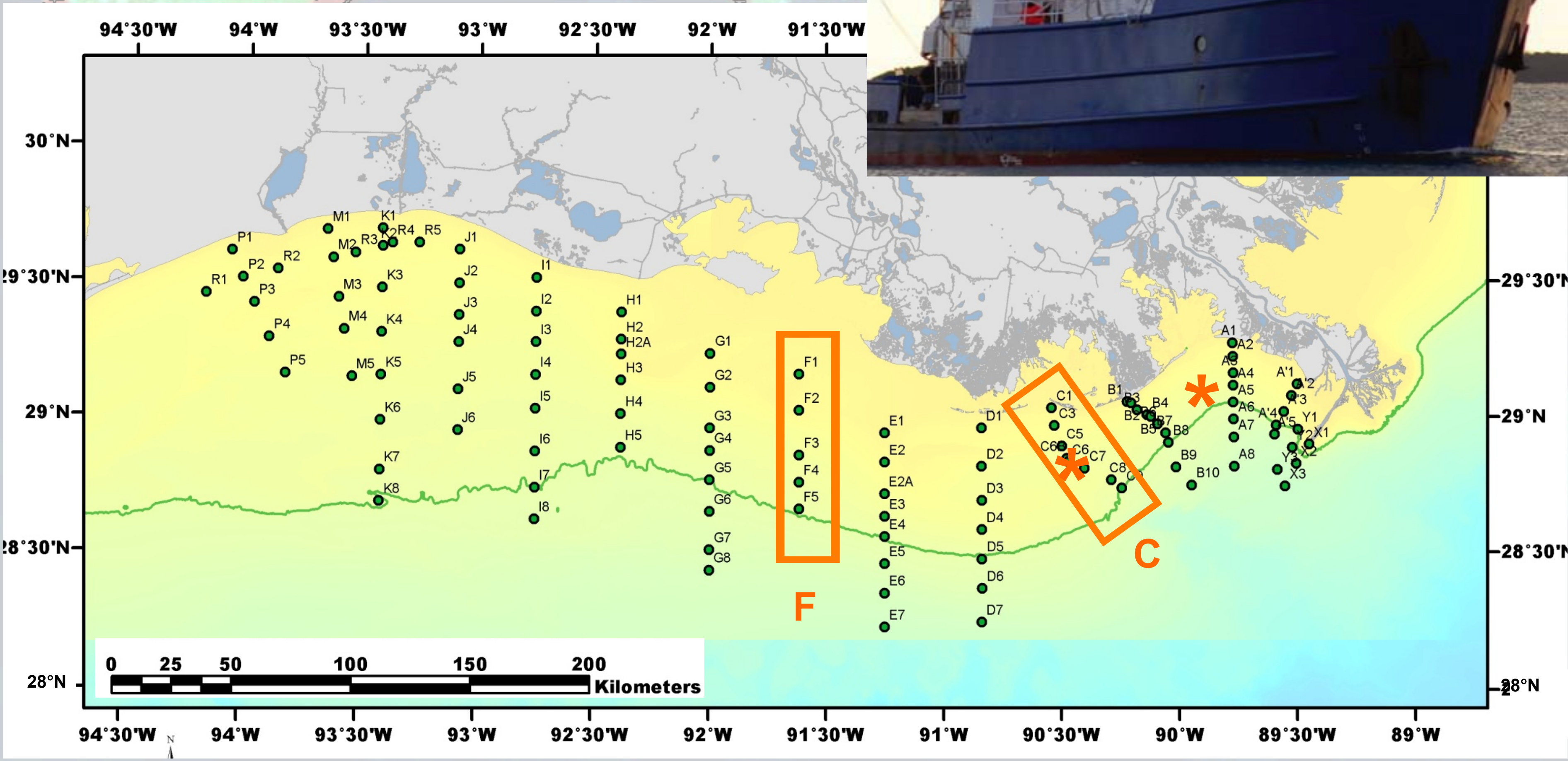
Source: N. Rabalais, LUMCON

- **up to 22,000 km^2**
- **4 - 5 m nearshore to 35 - 45 m offshore**
- **0.5 km nearshore to 100$^+$ km offshore**
- **widespread and severe in Jun – Sep**

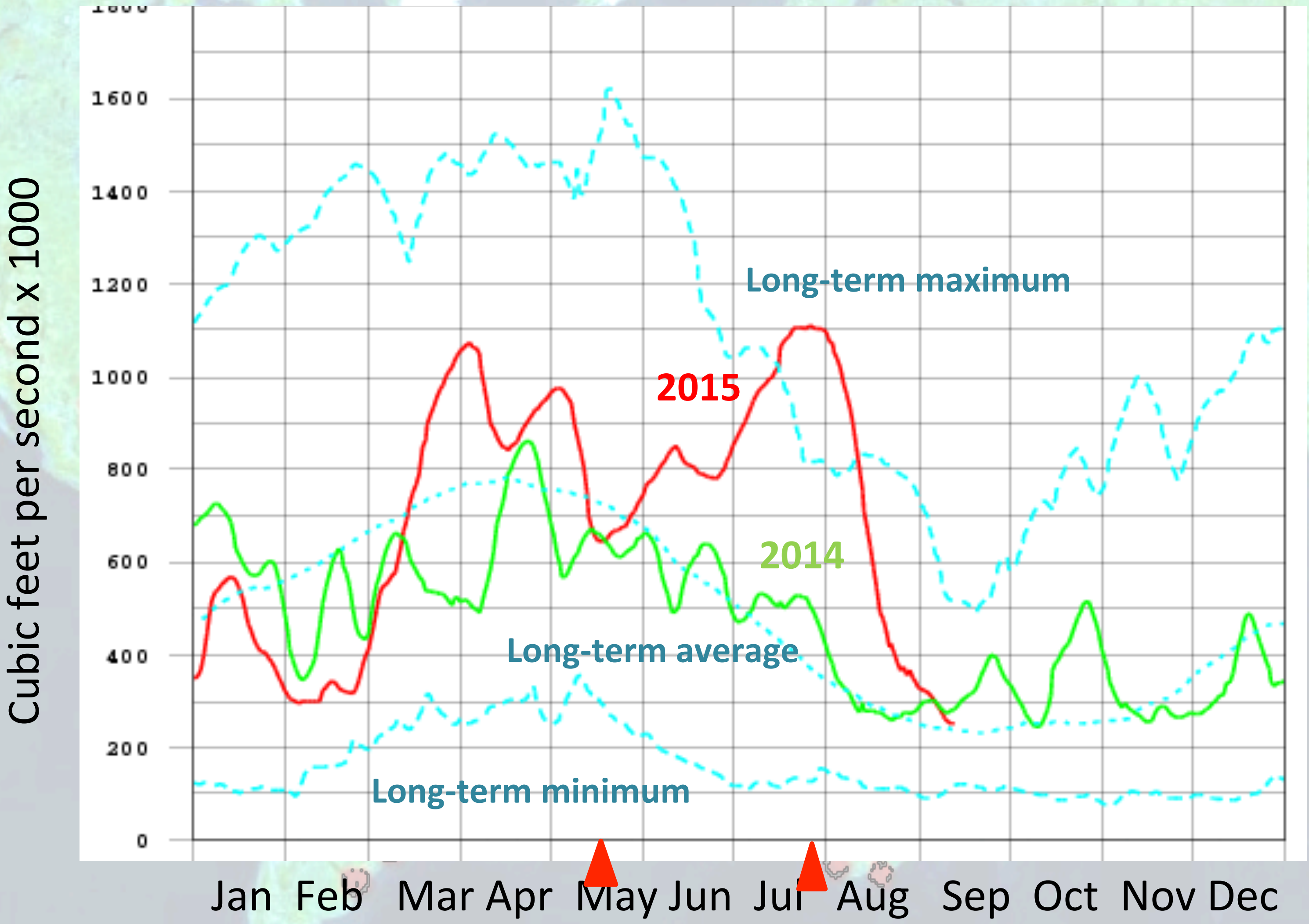
Frequency of Bottom-Water Dissolved Oxygen Distribution in Mid-Summer



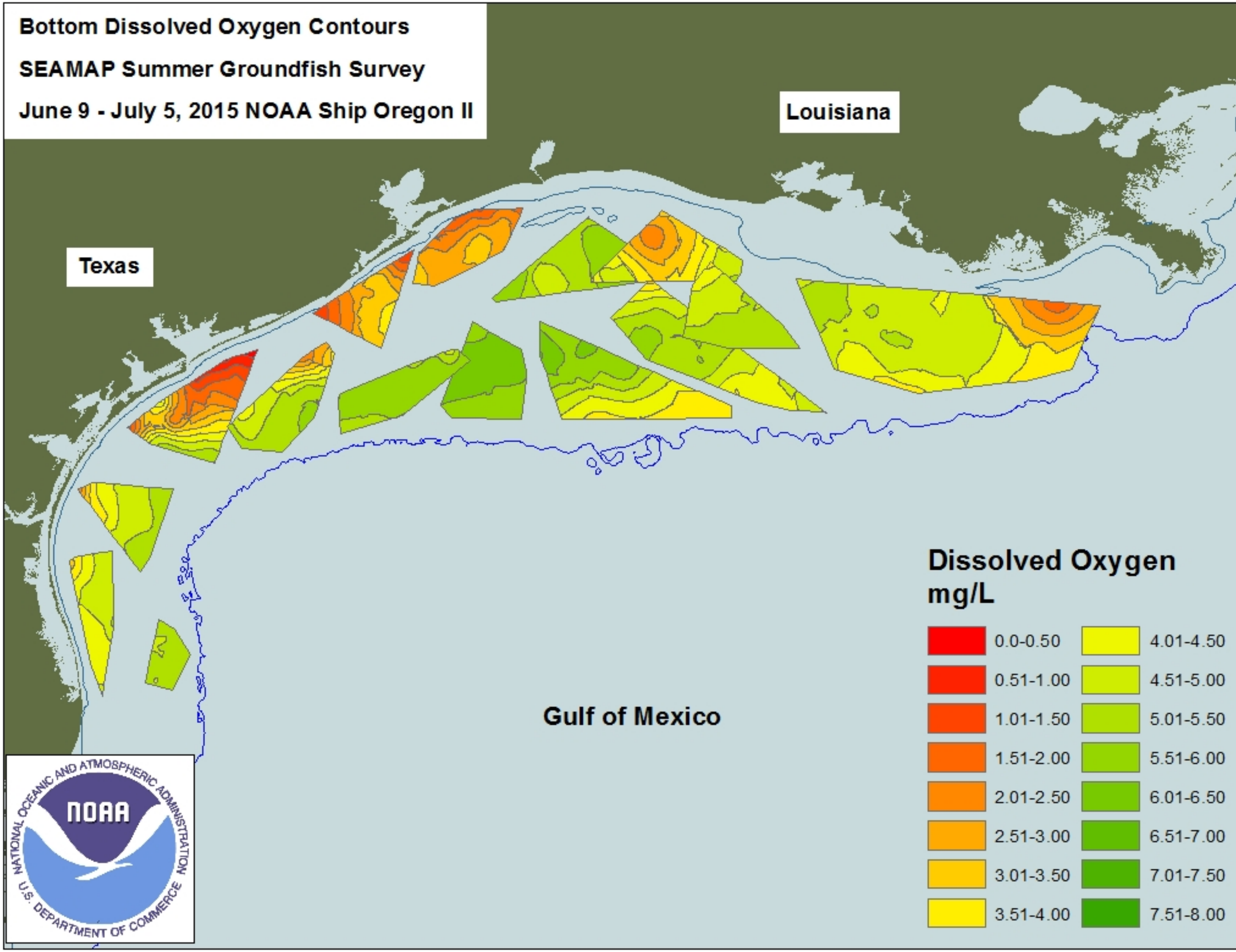
- Mid-summer shelfwide cruise
- Monthly lines C and F
- Deployed oxygen meters



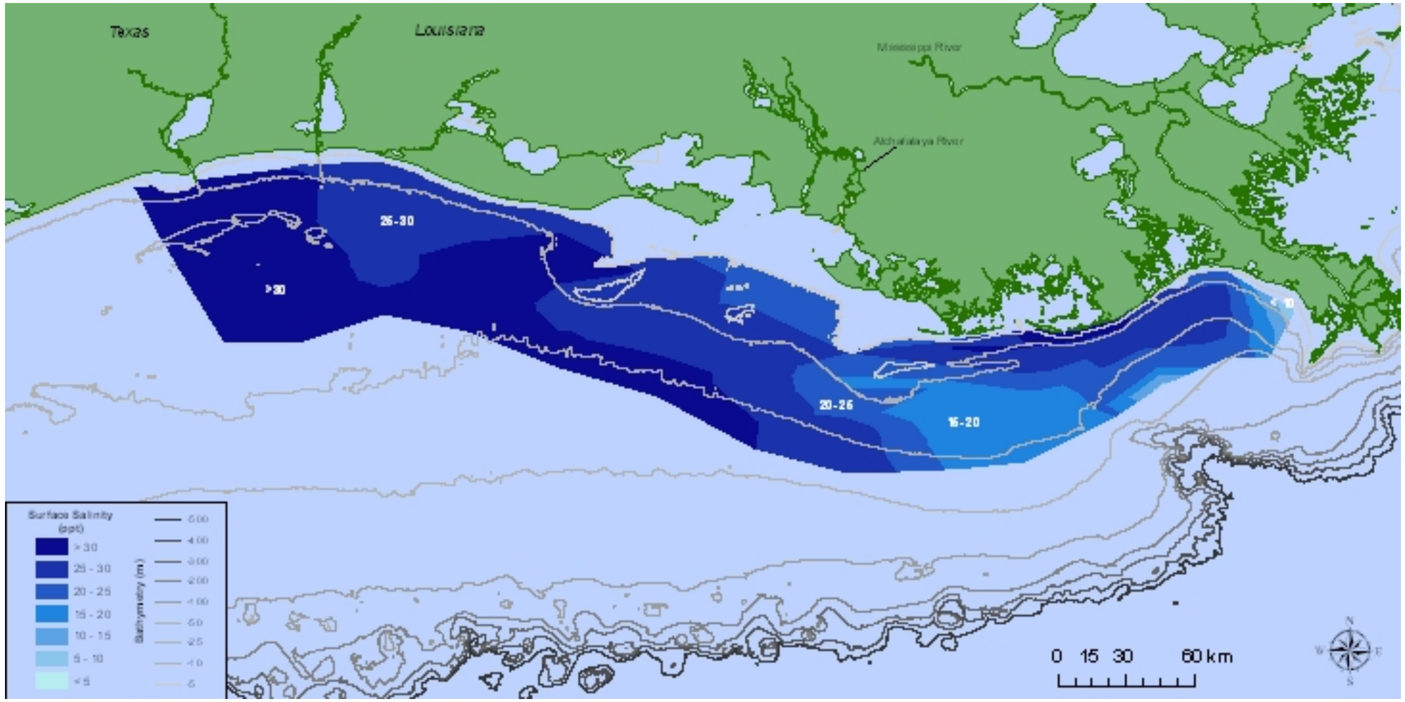
Mississippi River Discharge at Tarbert Landing, 1935-Sep 10, 2015



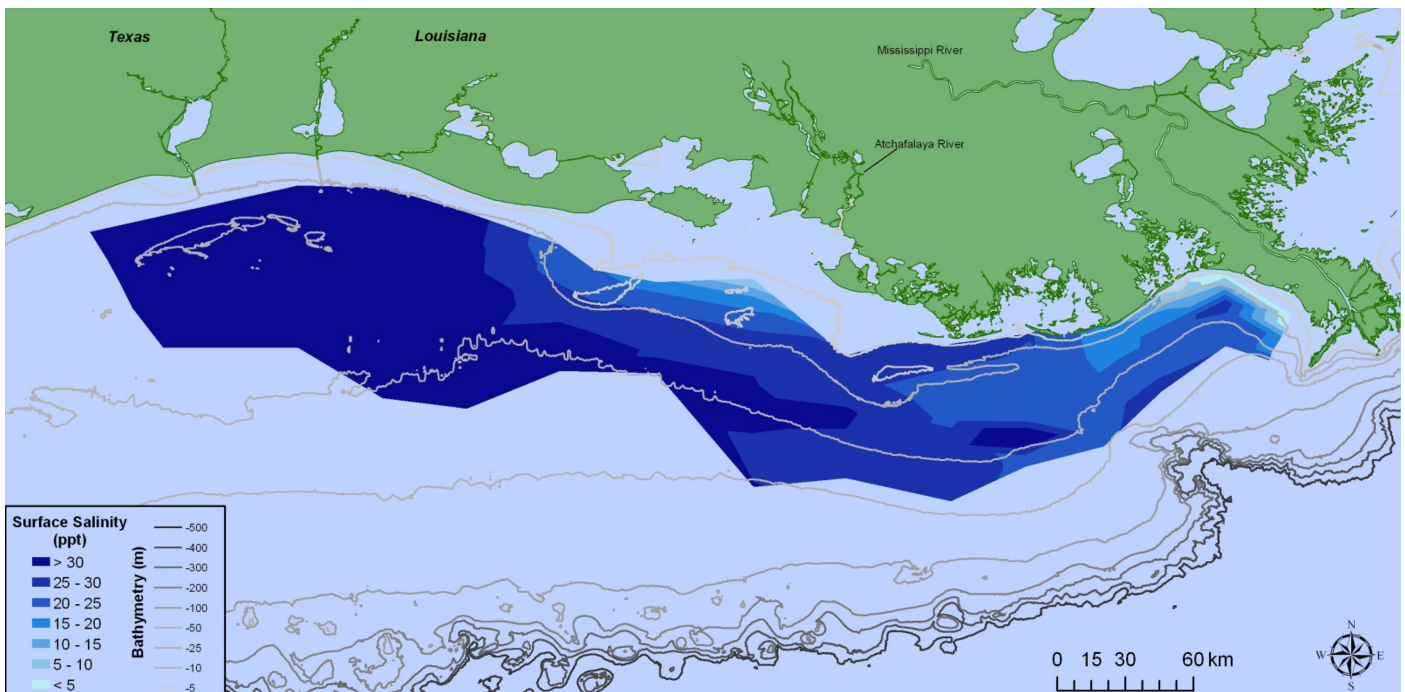
http://rivergages.mvr.usace.army.mil/WaterControl/Districts/MVN/tar.gif

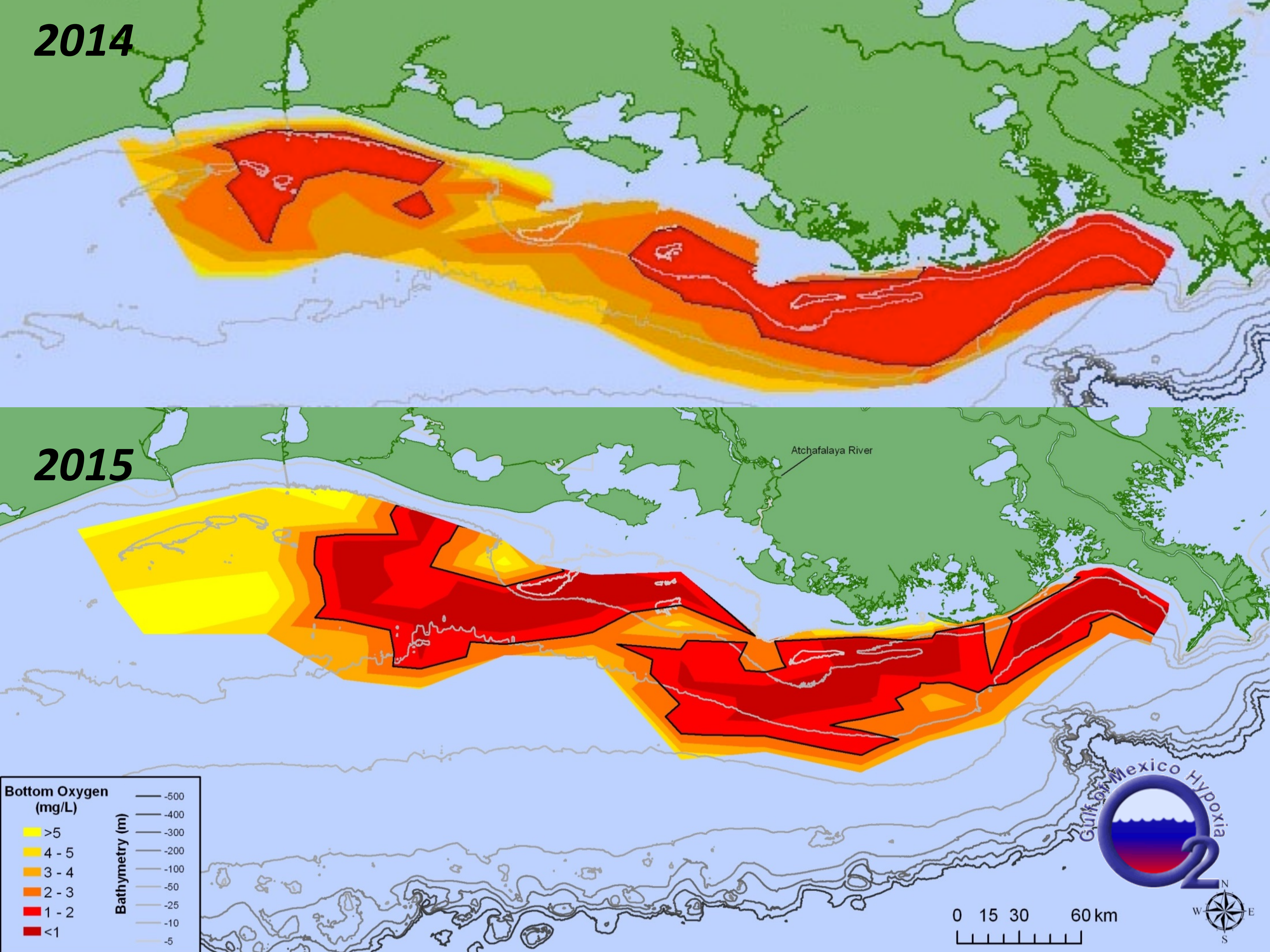

Bottom Dissolved Oxygen Contours
SEAMAP Summer Groundfish Survey
June 9 - July 5, 2015 NOAA Ship Oregon II
Louisiana
Texas
Gulf of Mexico
Dissolved Oxygen mg/L
0.0-0.50
0.51-1.00
1.01-1.50
1.51-2.00
2.01-2.50
2.51-3.00
3.01-3.50
3.51-4.00
4.01-4.50
4.51-5.00
5.01-5.50
5.51-6.00
6.01-6.50
6.51-7.00
7.01-7.50
7.51-8.00
NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

2015 High Discharge



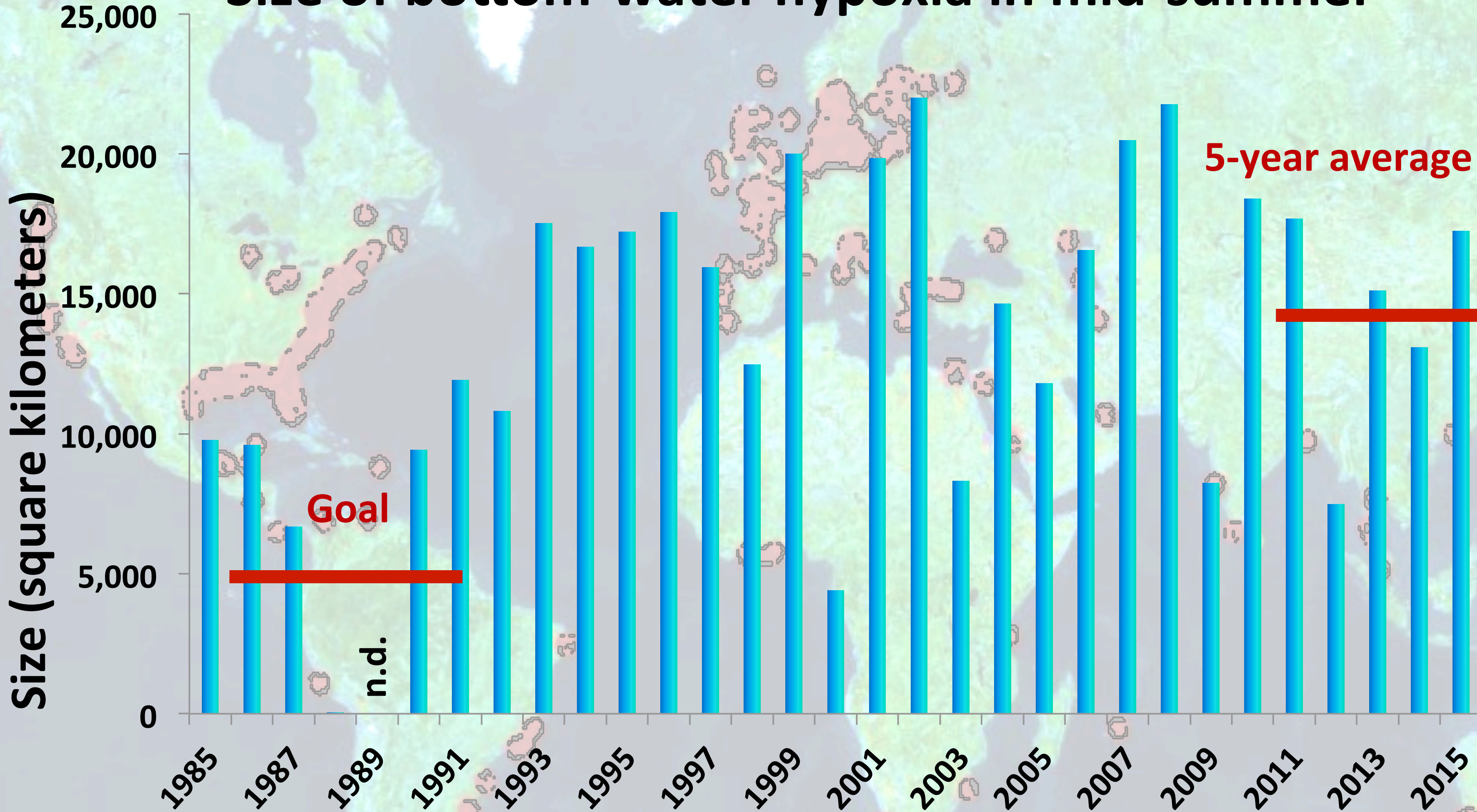
2014 Medium Discharge



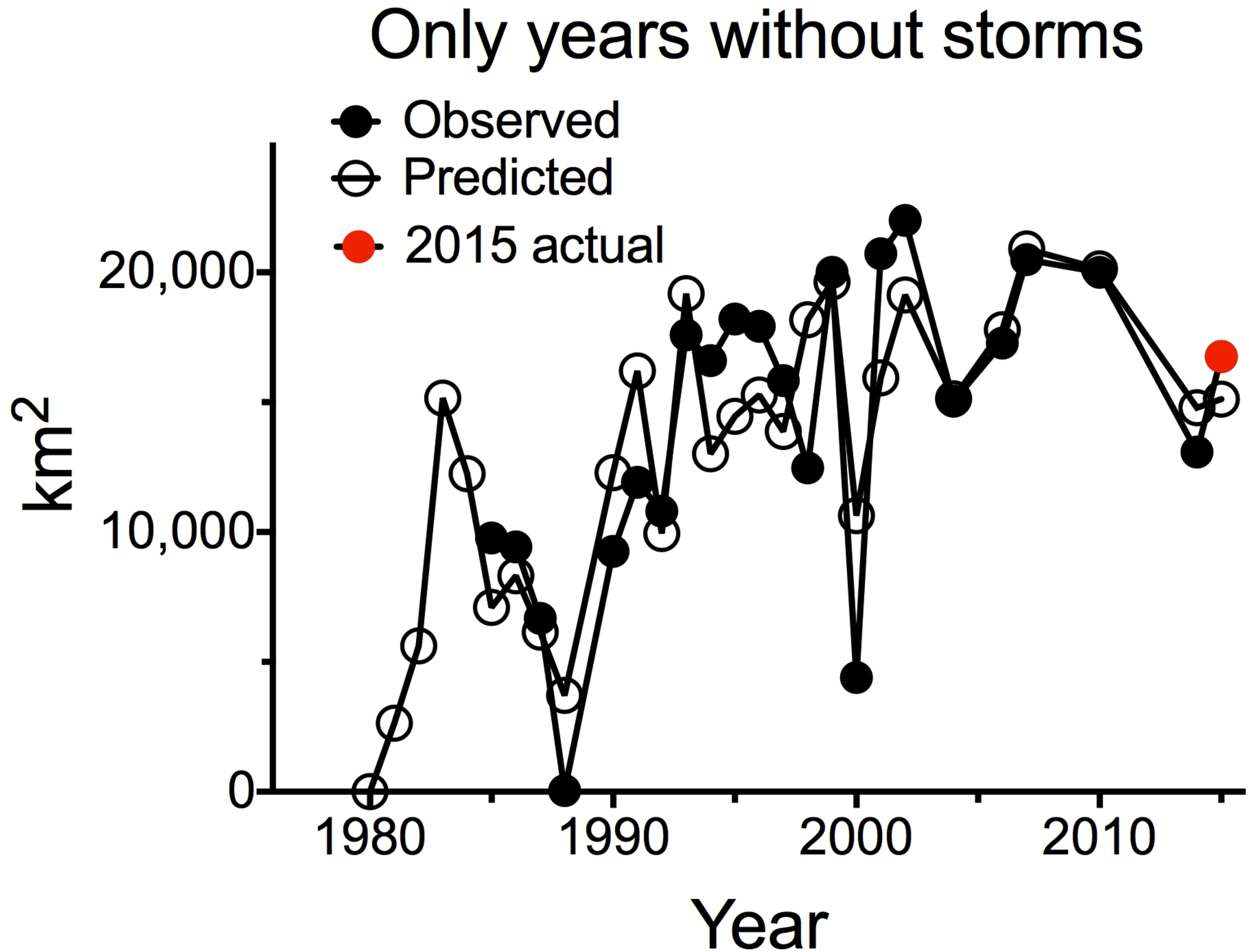


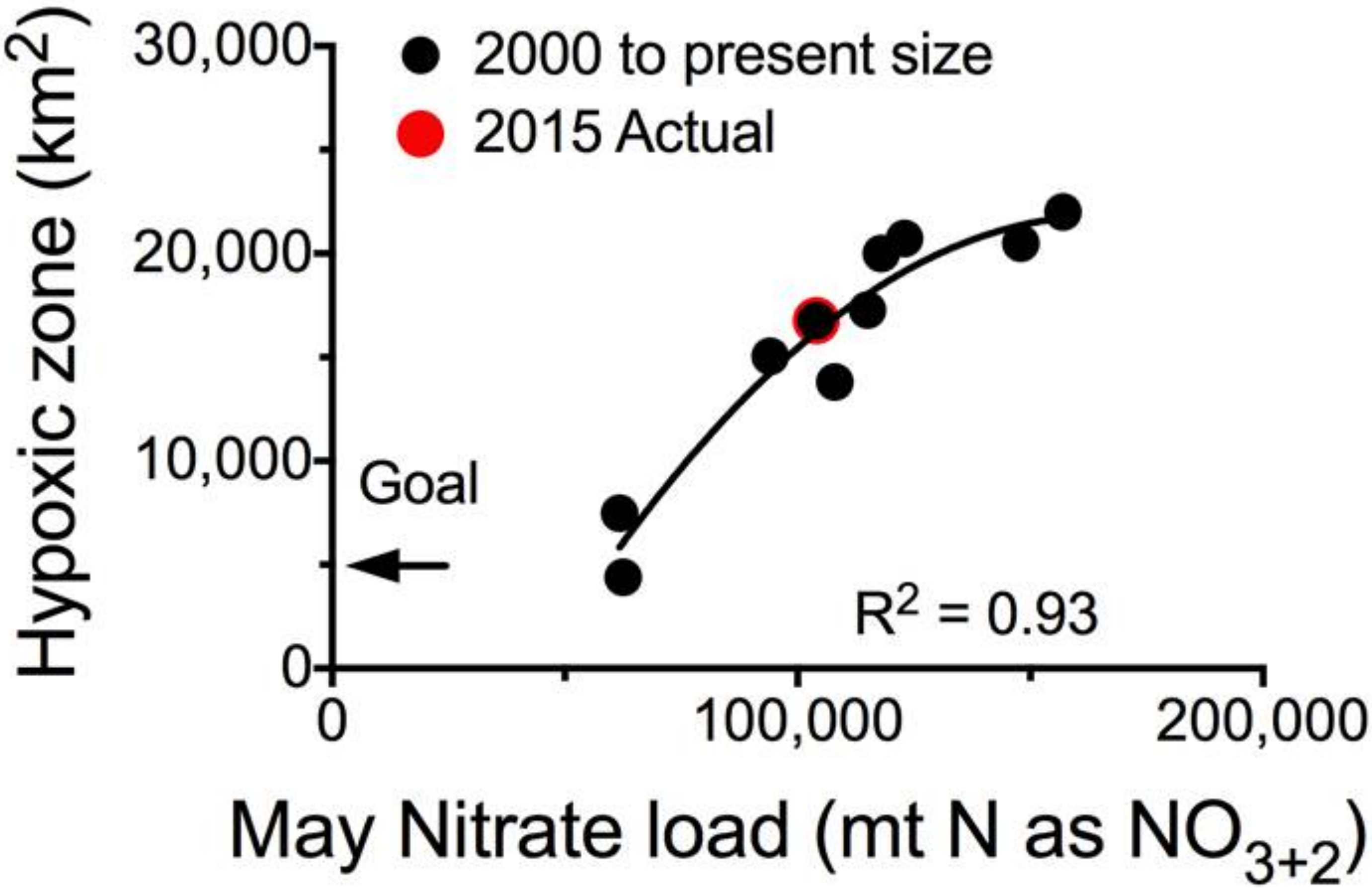
2014
2015
Atchafalaya River
Bottom Oxygen (mg/L)
>5
4 - 5
3 - 4
2 - 3
1 - 2
<1
Bathymetry (m)
-500
-400
-300
-200
-100
-50
-25
-10
-5
Gulf of Mexico Hypoxia
0 15 30 60 km
N
W
E
S

Size of bottom-water hypoxia in mid-summer

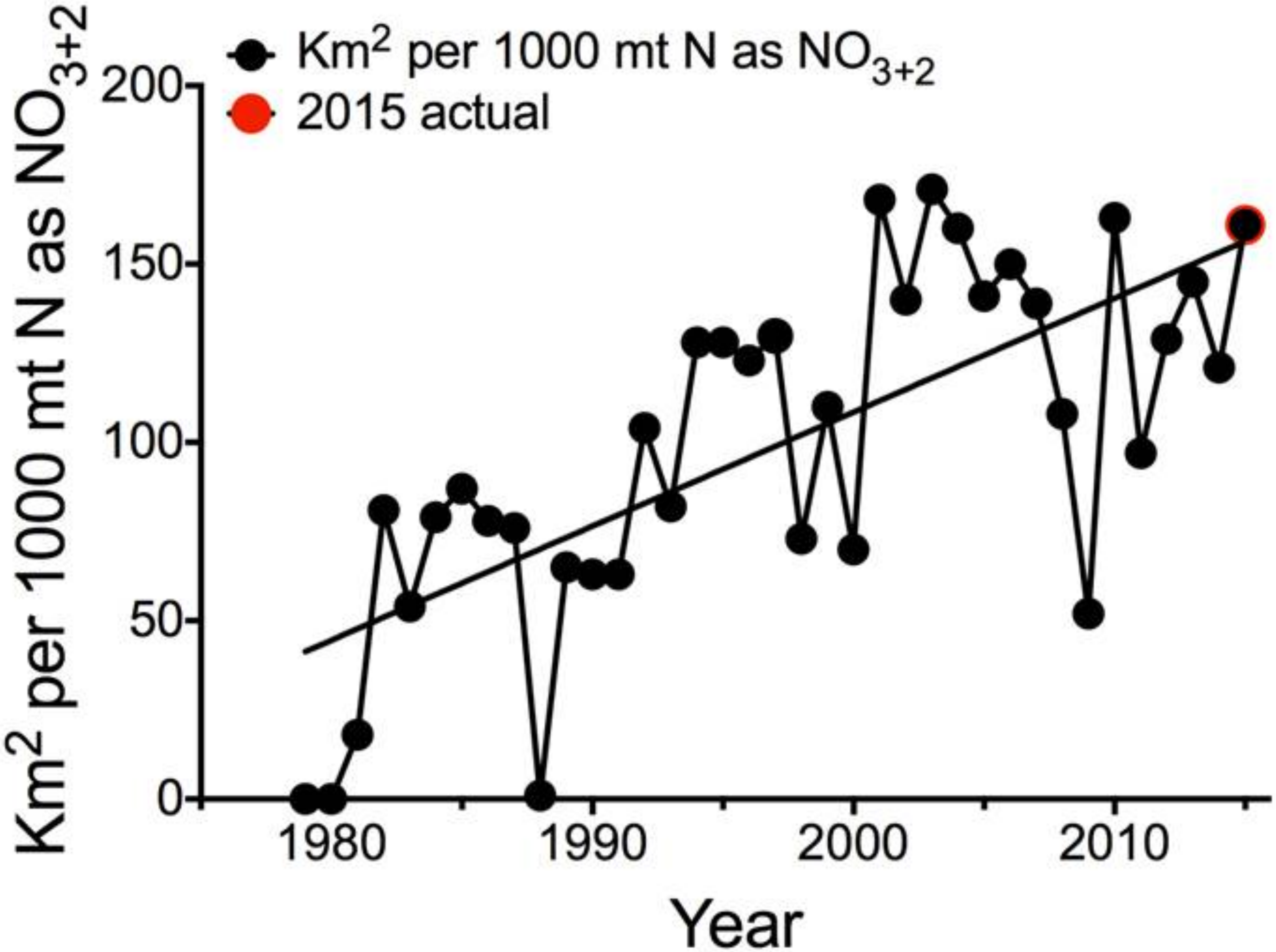


Data source: Nancy N. Rabalais, LUMCON, and R. Eugene Turner, LSU
Funding sources: NOAA Center for Sponsored Coastal Ocean Research and U.S. EPA Gulf of Mexico Program


Only years without storms
Observed
Predicted
2015 actual
20,000
10,000
0
km2
1980
1990
2000
2010
Year



Area size of dissolved oxygen less than 2 mg l^{-1} in mid summer as a function of Mississippi River nitrate load in May; graphic by R. E. Turner

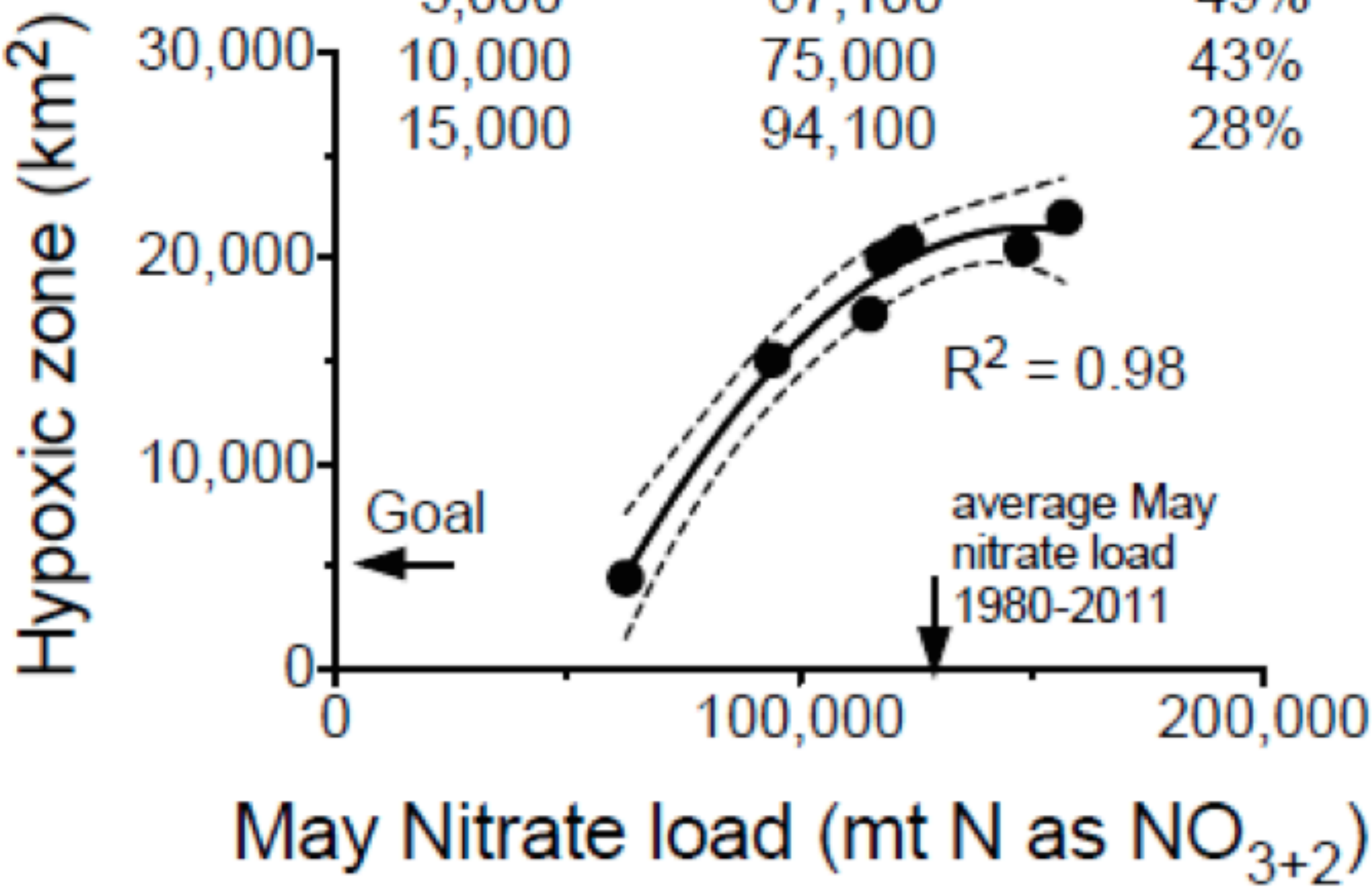


The area of bottom-water dissolved oxygen less than 2 mg l^{-1} in mid summer as a function of Mississippi River nitrate load in May has increased over the period from 1979 to 2015; graphic by R. E. Turner

More Nutrients >>>
More Phytoplankton >>>
More Carbon Reaches the Bottom >>>
More Oxygen Consumed >>>
More Hypoxia

Photo: N. Rabalais, LUMCON

Target size (km^2)	Nitrate Load (mt N)	Reduction required (% 1980-2011)
5,000	67,100	49%
10,000	75,000	43%
15,000	94,100	28%

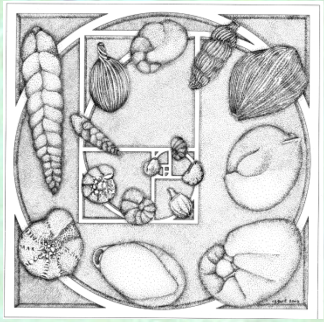


But, this system must have been hypoxic forever!

Always high discharge, long residence time, warming surface waters in summer, seasonally strong stratification

No, not so!

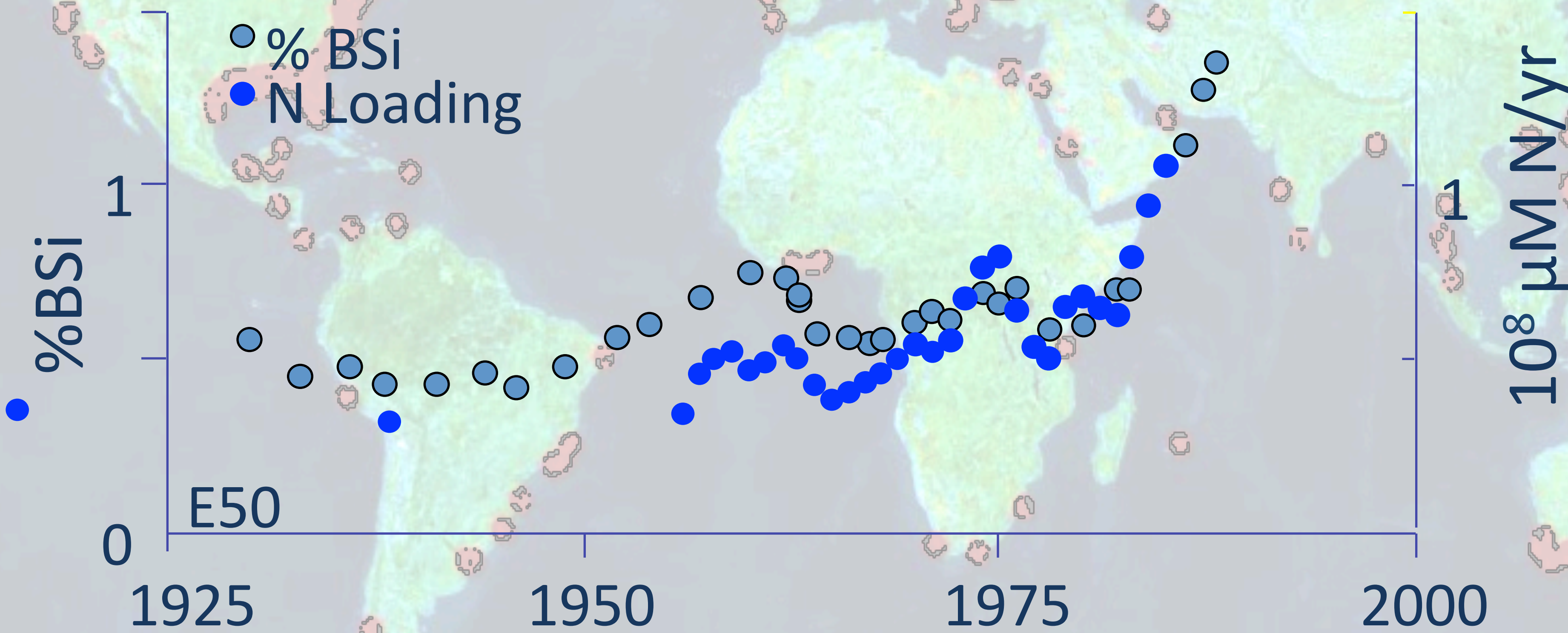
Verified by paleoindicators from sediment cores across the continental shelf



Gulf of Mexico Hypoxia

O2

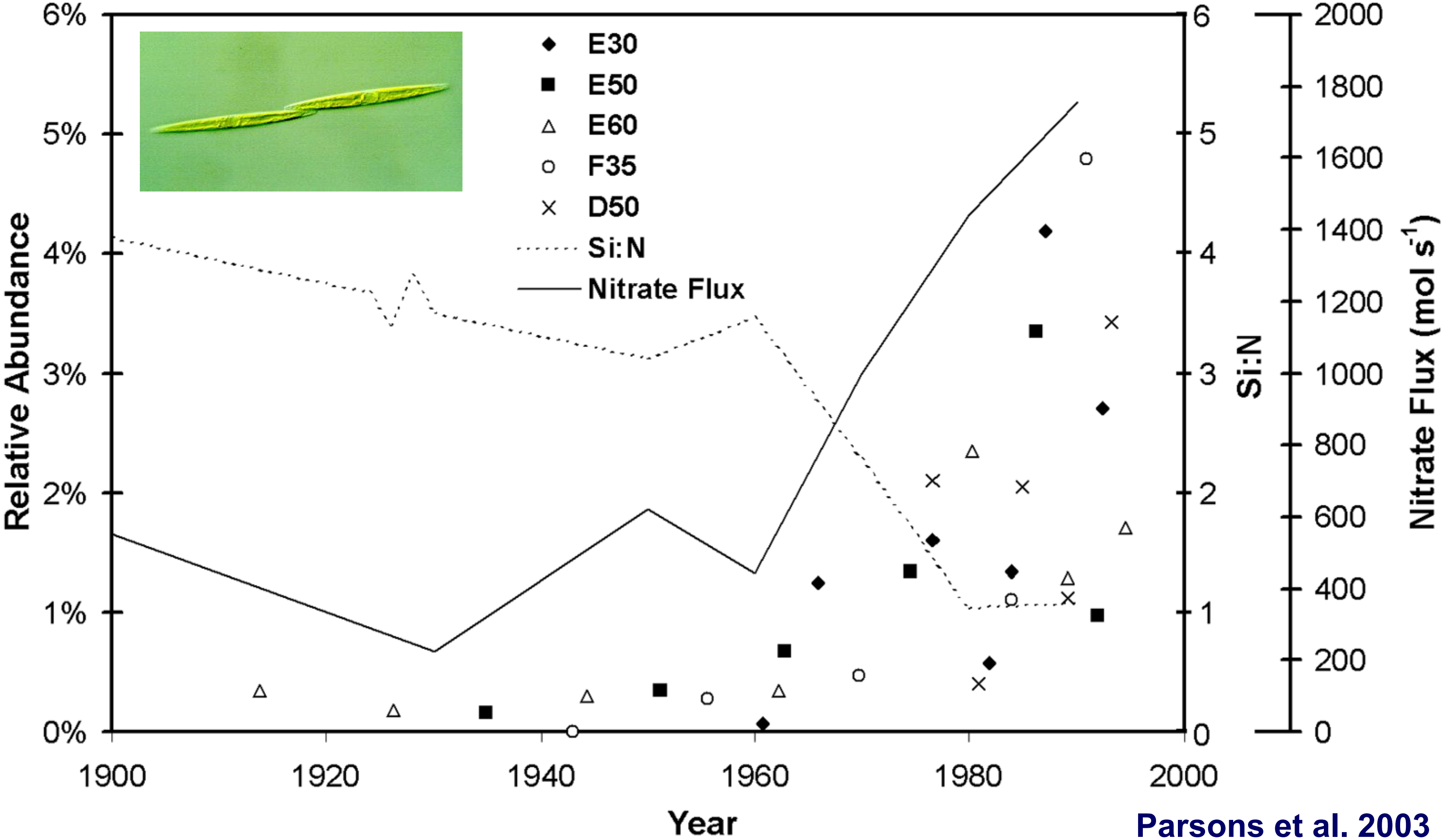
Relationship Between Biogenic Silica and Nutrient Loading



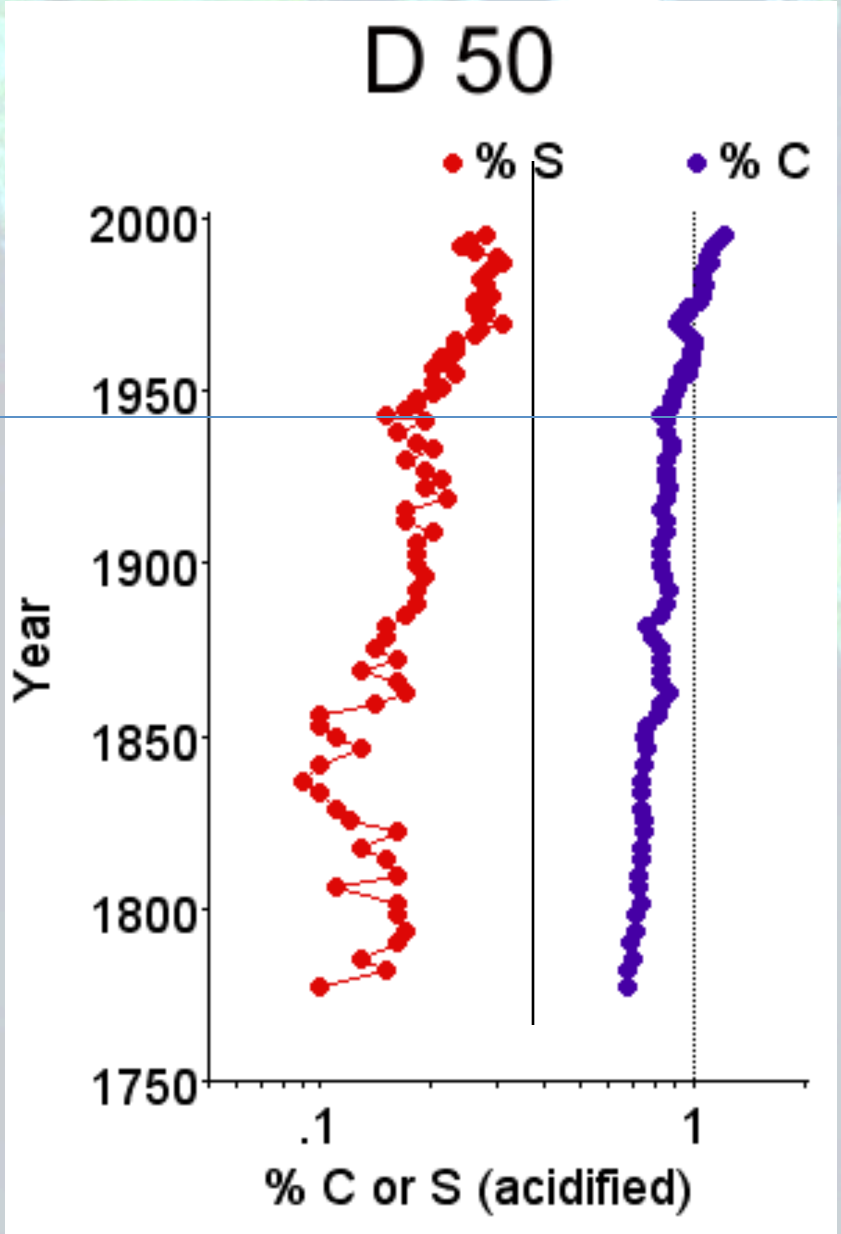
Turner and Rabalais 1994

A shift from heavily silicified to less silicified, including the HAB *Pseudo-nitzschia*

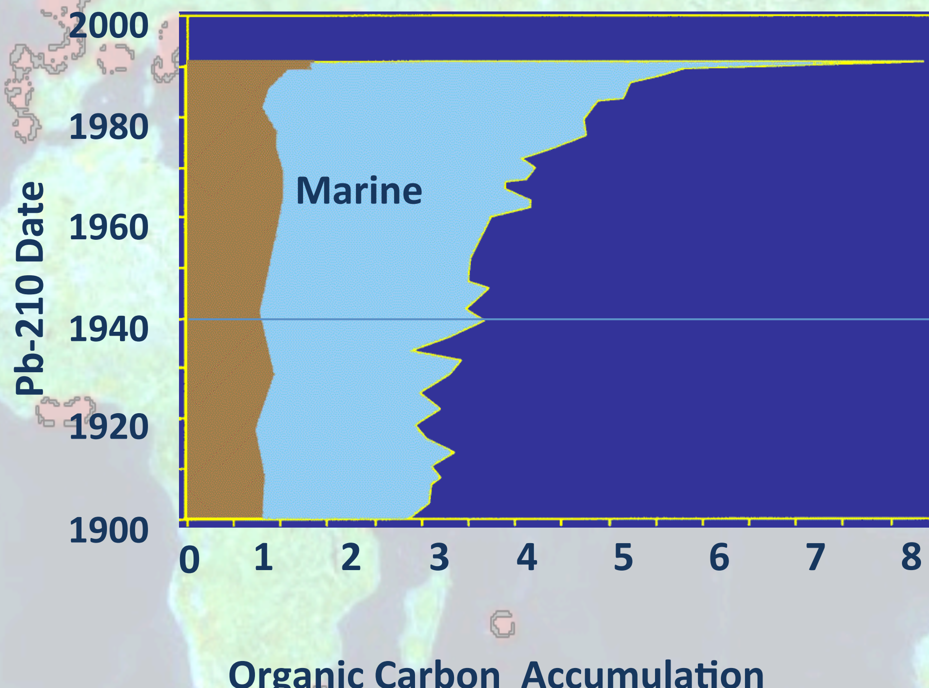
(indicates potential Si limitation but competitive advantage of *Pseudo-nitzschia* with increased nitrogen)

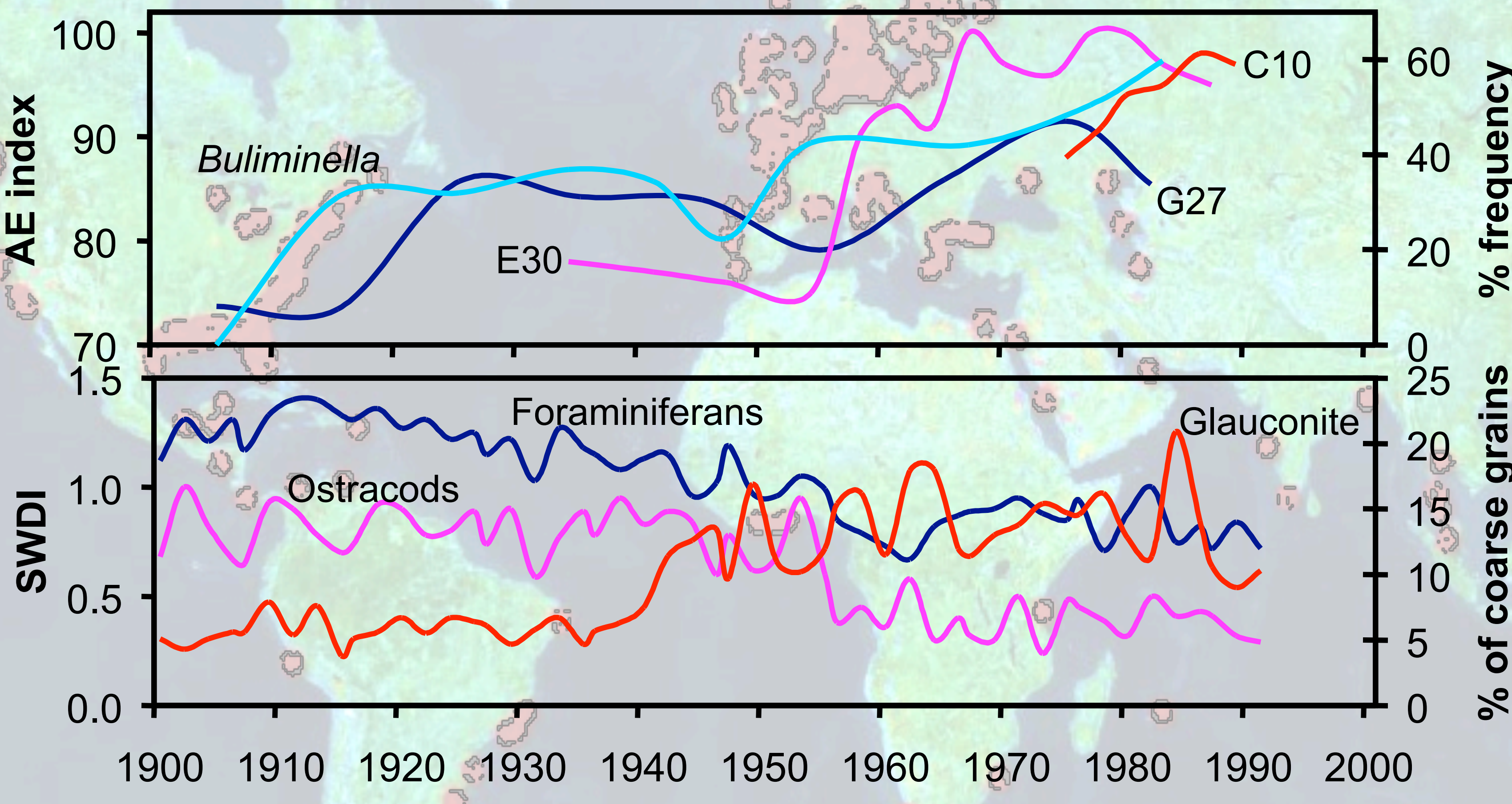


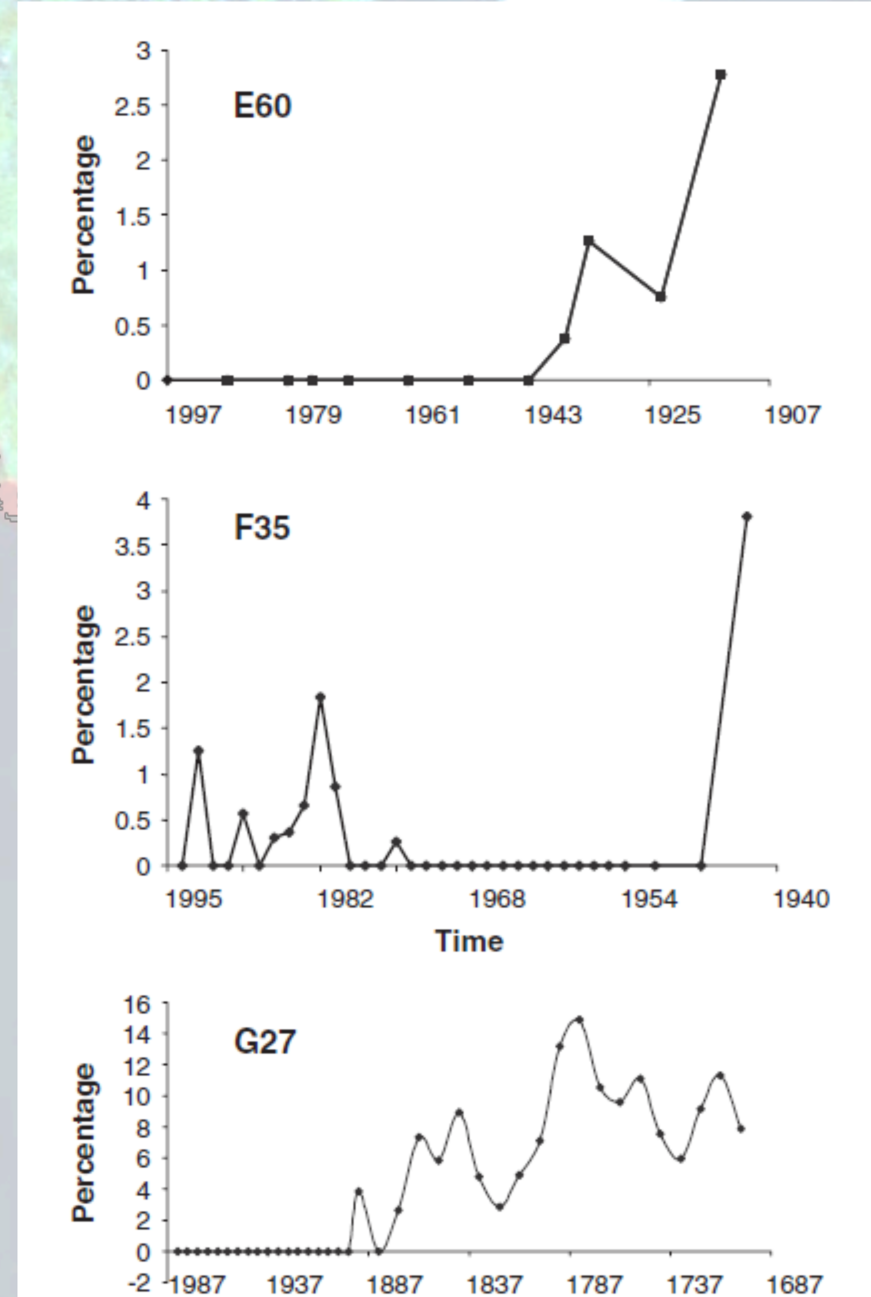
Parsons et al. 2003



del ^{13}C Stable Isotopes




AE index
100
90
80
70
Buliminella
E30
G27
C10
% frequency
60
40
20
0
SWDI
1.5
1.0
0.5
0.0
Foraminiferans
Ostracods
Glauconite
% of coarse grains
25
20
15
10
5
0
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000



Quinquenoculina

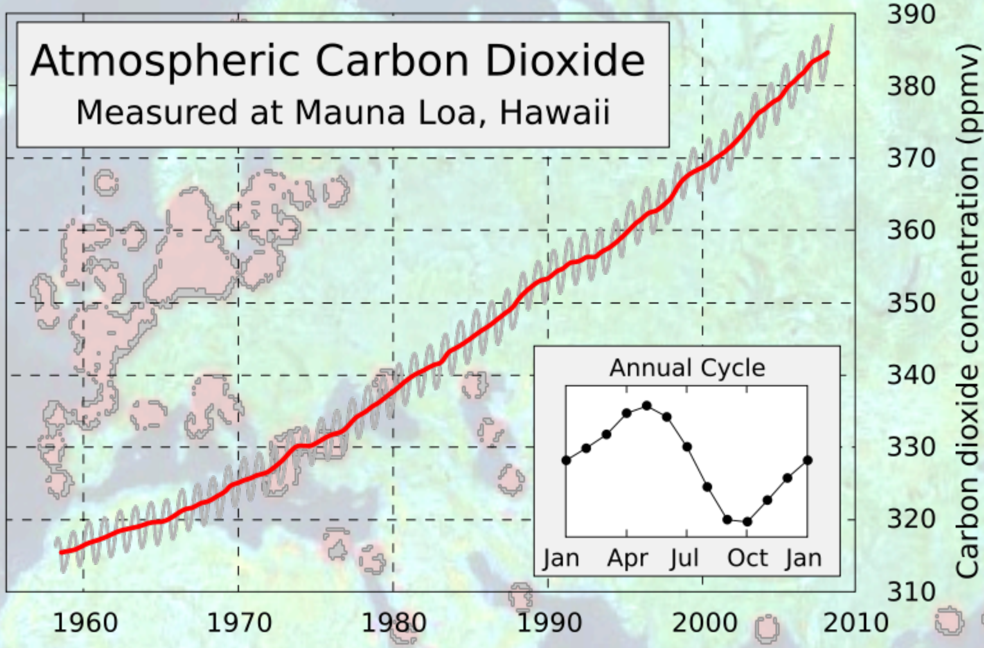
Not an abundant species but a definite decline

1945 in 60 m
1950 in 35 m
1900 in 27 m

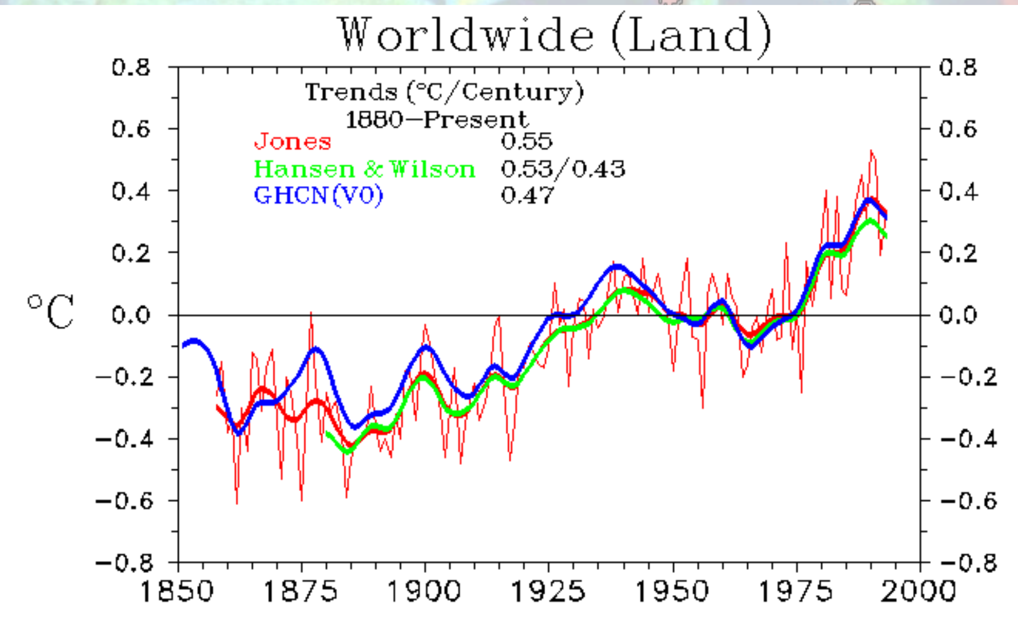
An increase of hypoxia in time with depth?

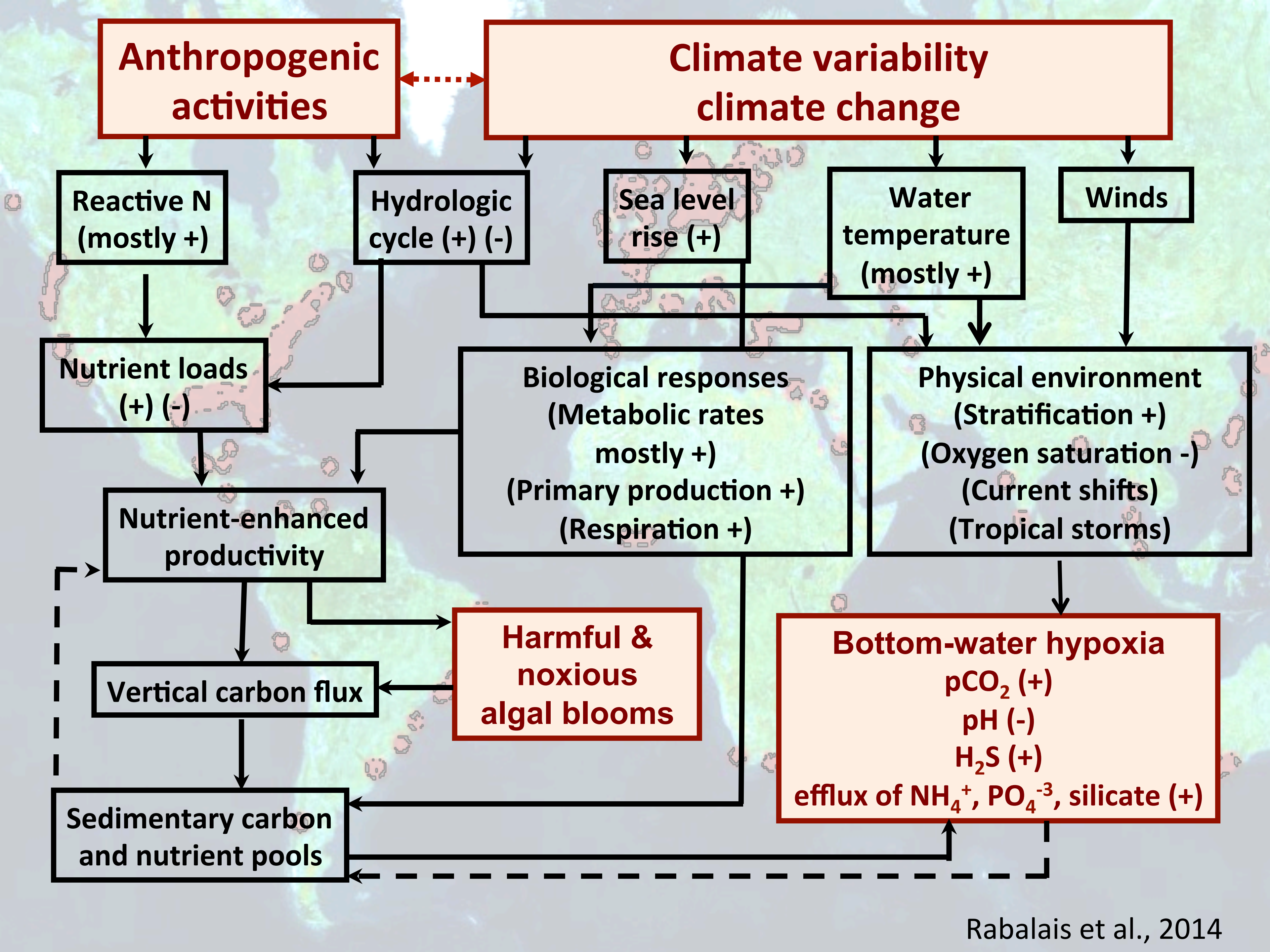
Platon et al. 2005

Increasing human population drives the increasing need for food, fuel and fiber, leading to increases in $N_{reactive}$ and CO_2 emissions.



Excess $N_{reactive}$ often leads to eutrophication, hypoxia and harmful algal blooms. Increasing CO_2 leads to increased temperatures.




Anthropogenic activities
Climate variability climate change
Reactive N (mostly +)
Hydrologic cycle (+) (-)
Sea level rise (+)
Water temperature (mostly +)
Winds
Nutrient loads (+) (-)
Biological responses (Metabolic rates mostly +) (Primary production +) (Respiration +)
Physical environment (Stratification +) (Oxygen saturation -) (Current shifts) (Tropical storms)
Nutrient-enhanced productivity
Harmful & noxious algal blooms
Vertical carbon flux
Bottom-water hypoxia
pCO_2 (+)
pH (-)
H_2S (+)
efflux of NH_4^+, PO_4^{-3}, silicate (+)
Sedimentary carbon and nutrient pools
Rabalais et al., 2014

A Global Issue