NGOMEX: Effects of moderate hypoxia on benthic organisms in the Gulf of Mexico

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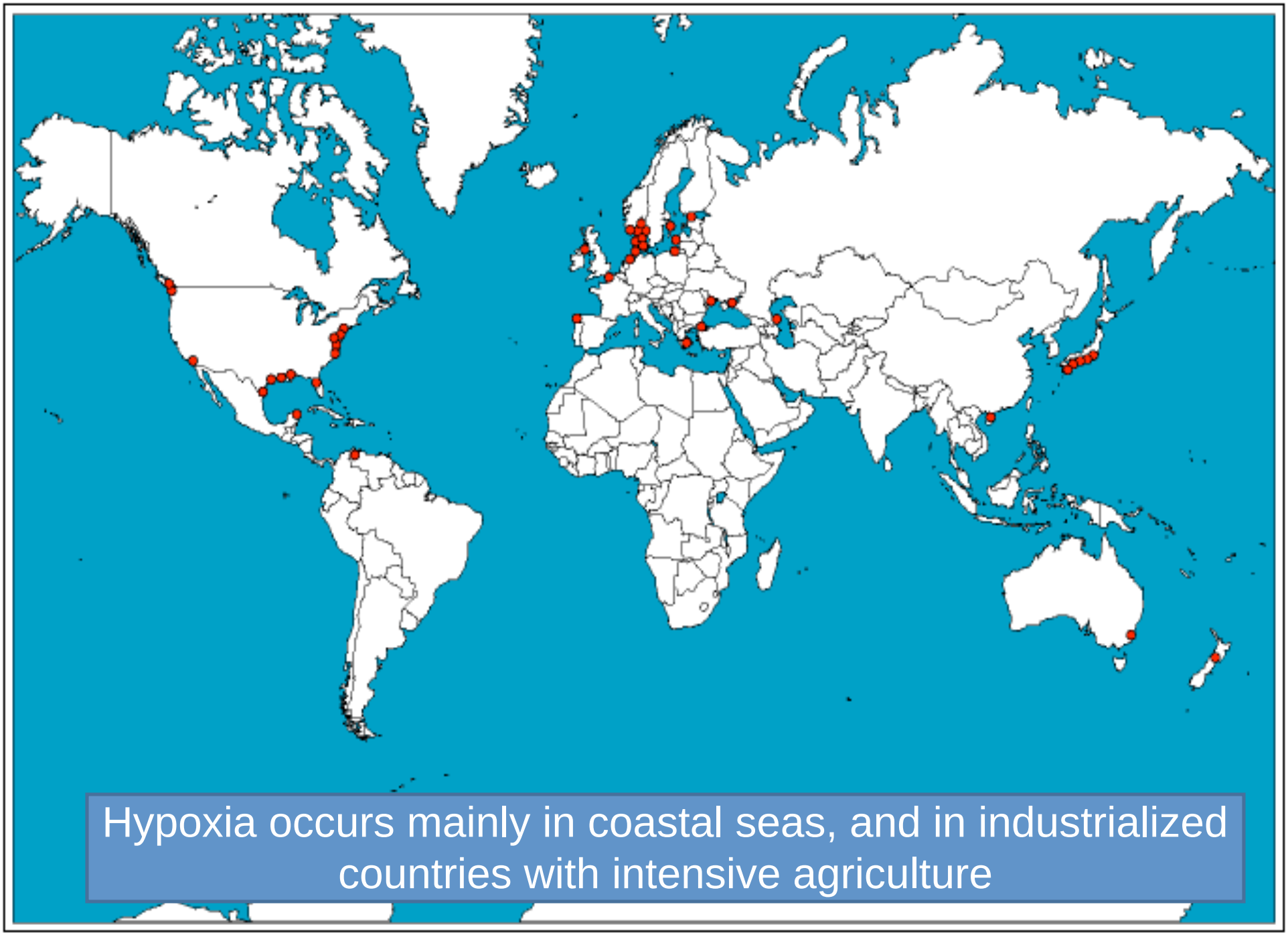
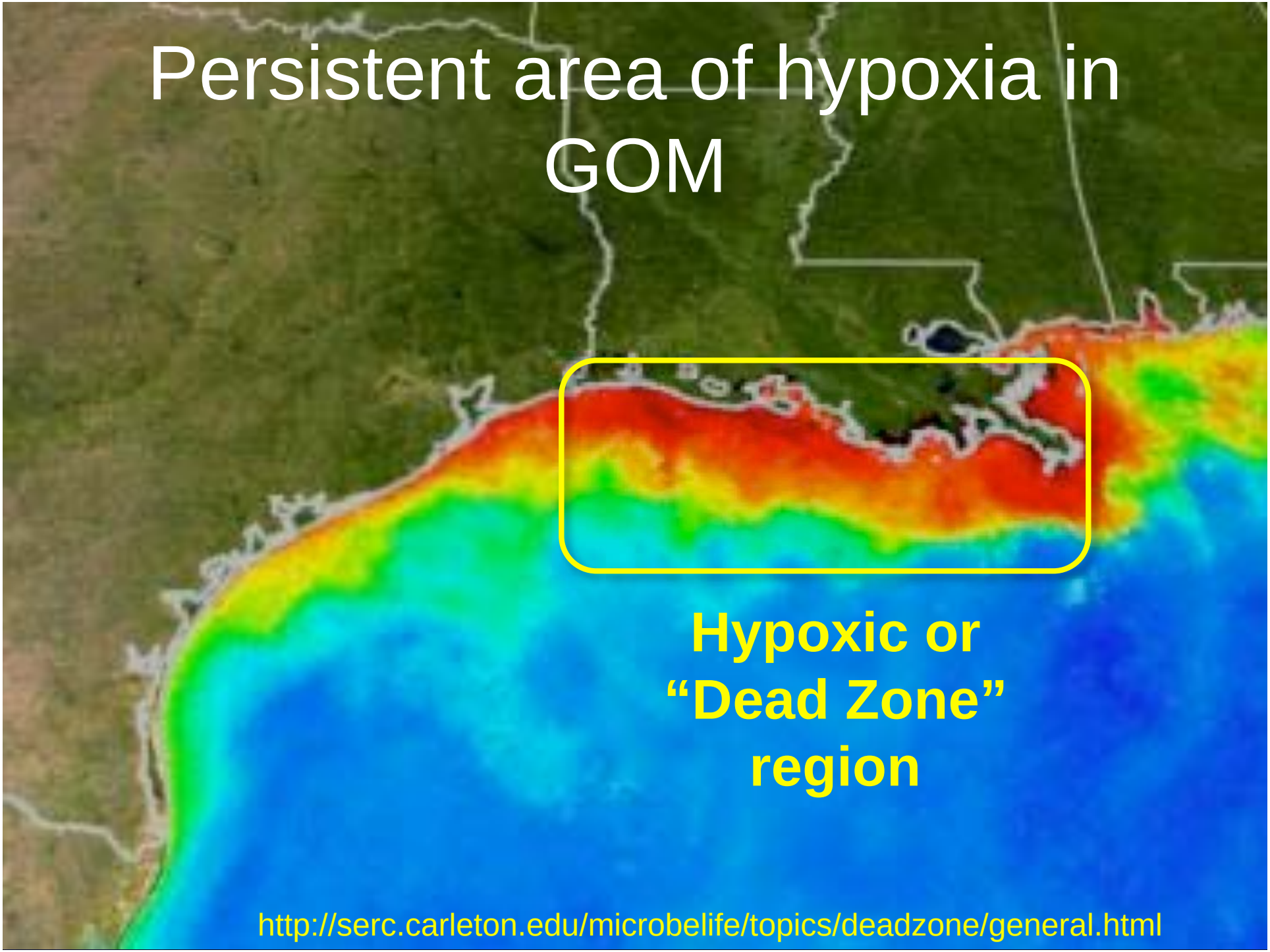
What is hypoxia?

- Hypoxia occurs when bottom waters have less than 2 mg oxygen per liter (max 6-8 mg/L)
- Increasing temperature and increasing salinity both decrease the amount of dissolved gases in seawater
- The major sources of oxygen in seawater are exchange with the atmosphere and photosynthesis, mainly from phytoplankton
- Both occur in near surface waters



Data from Diaz and Rosenberg, 1995.

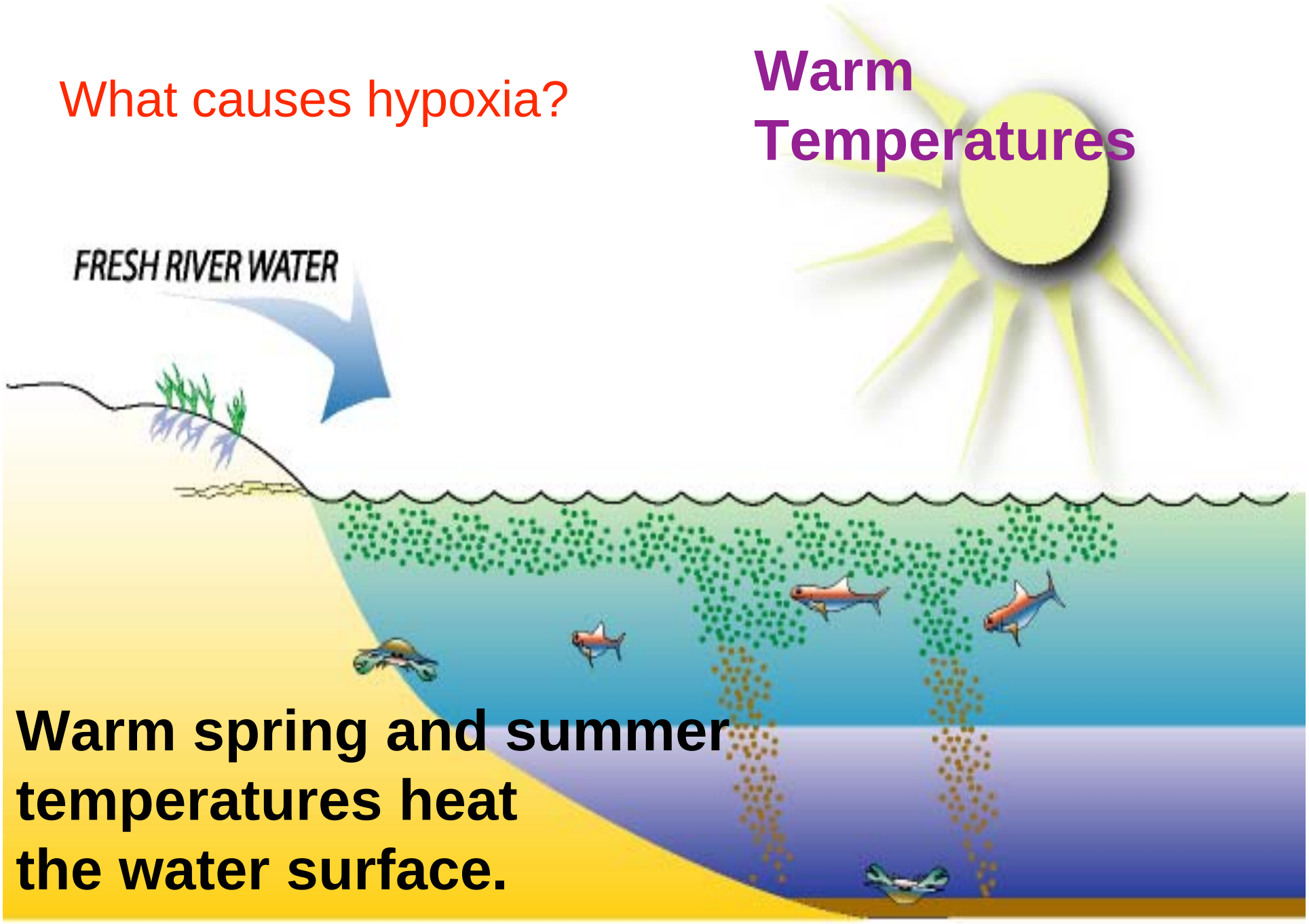
Persistent area of hypoxia in GOM



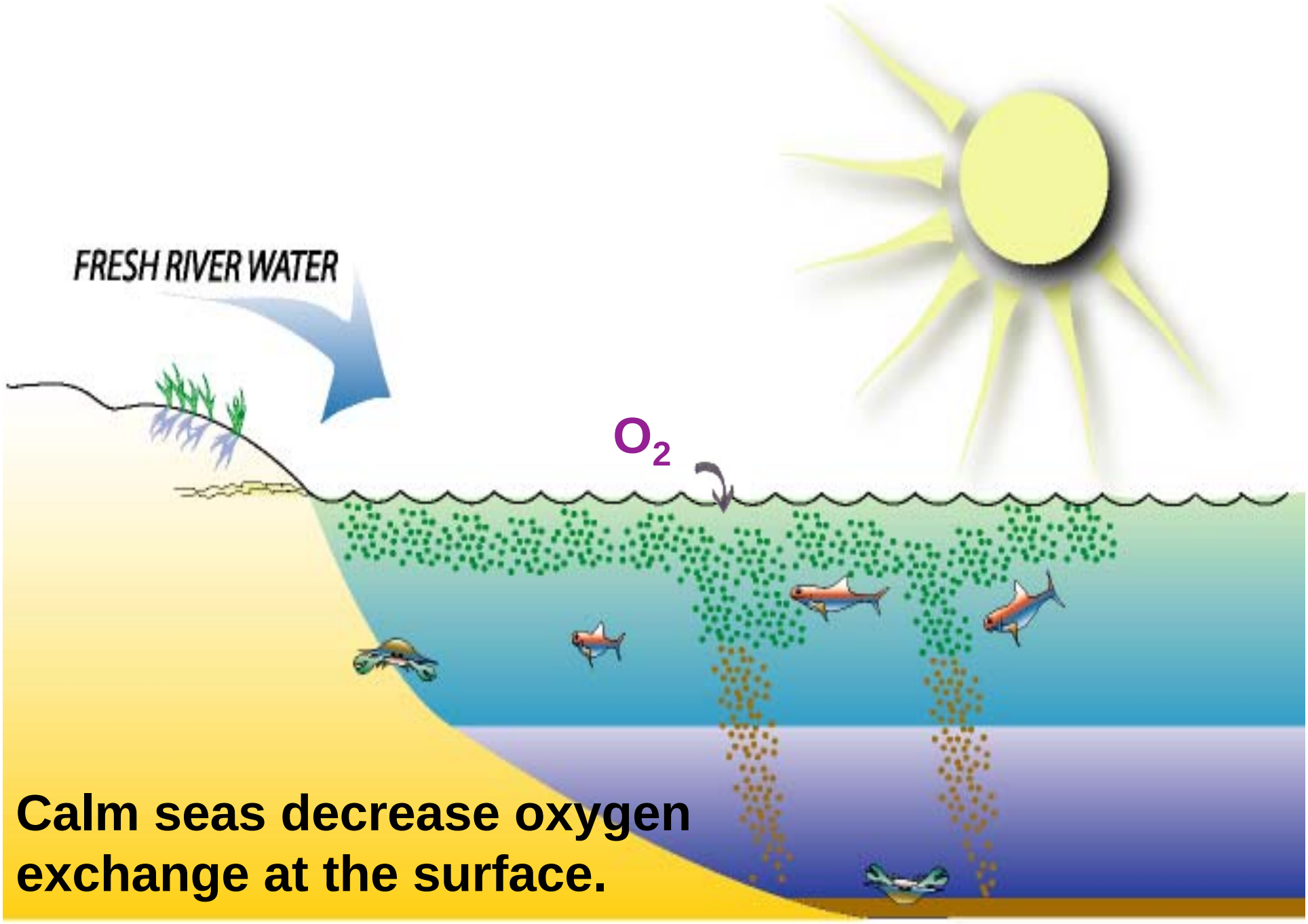
http://serc.carleton.edu/microbelife/topics/deadzone/general.html

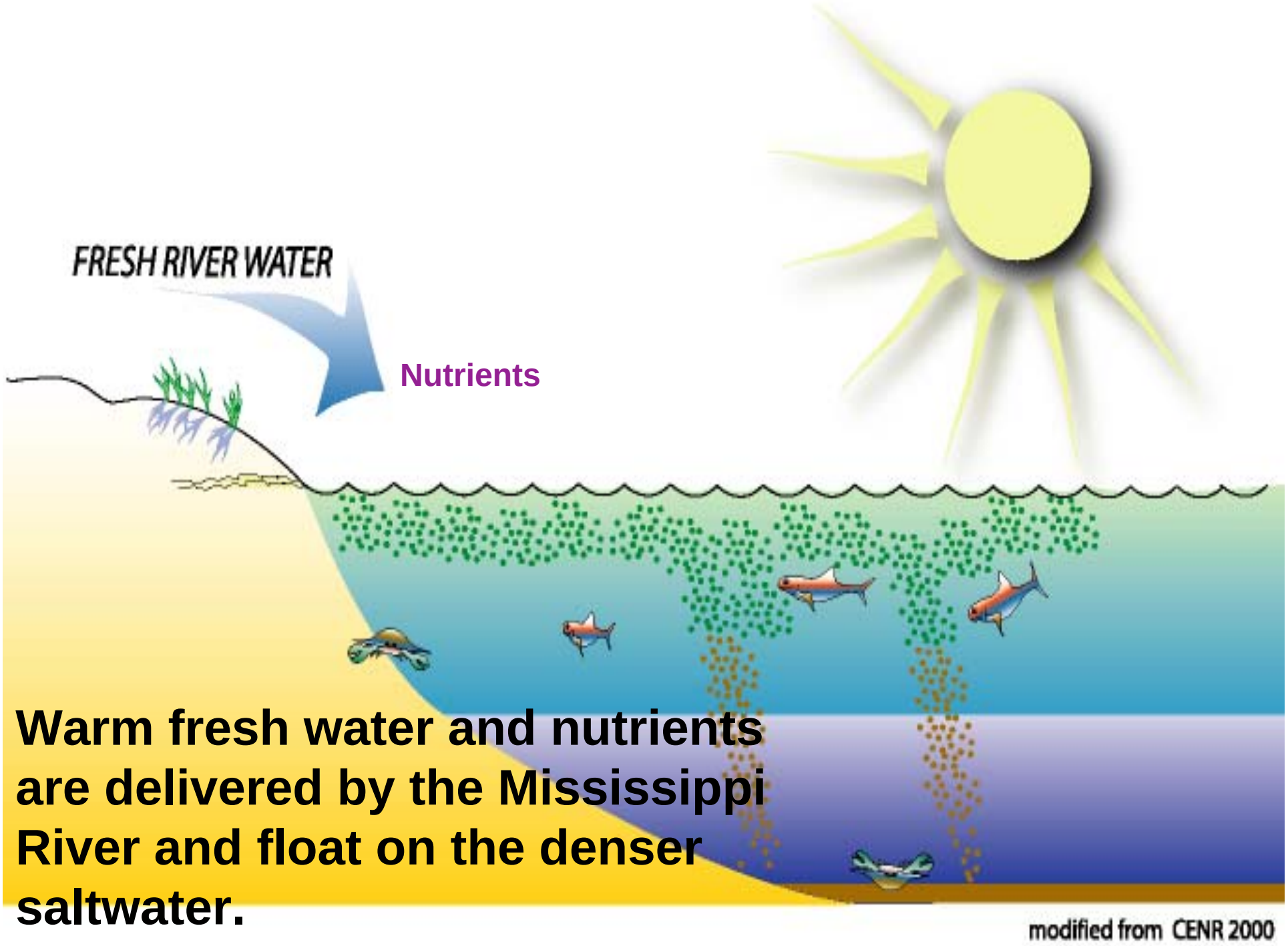
What causes hypoxia?

Warm Temperatures



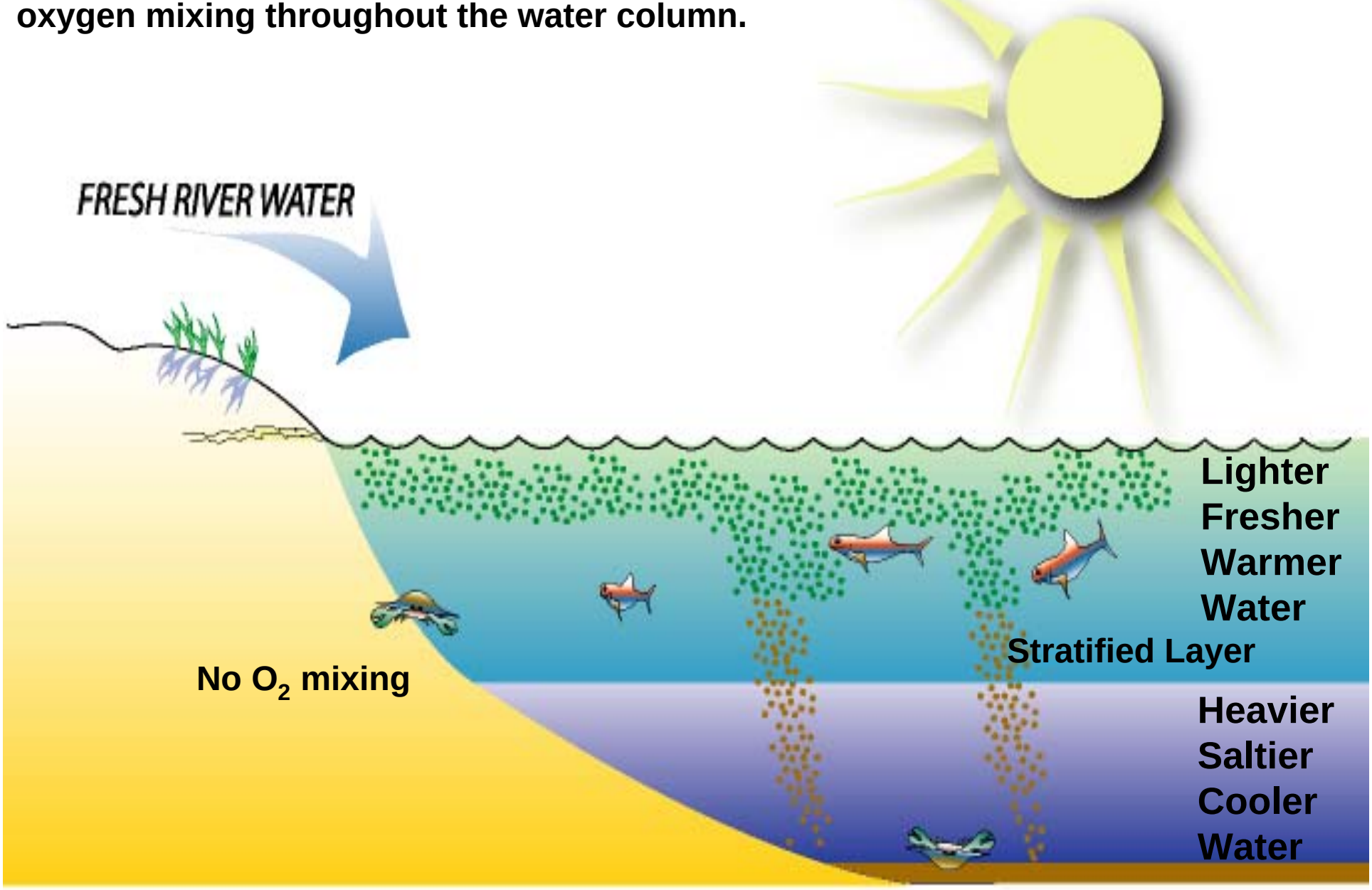
Warm spring and summer temperatures heat the water surface.


FRESH RIVER WATER
O_2
Calm seas decrease oxygen exchange at the surface.
modified from CENR 2000

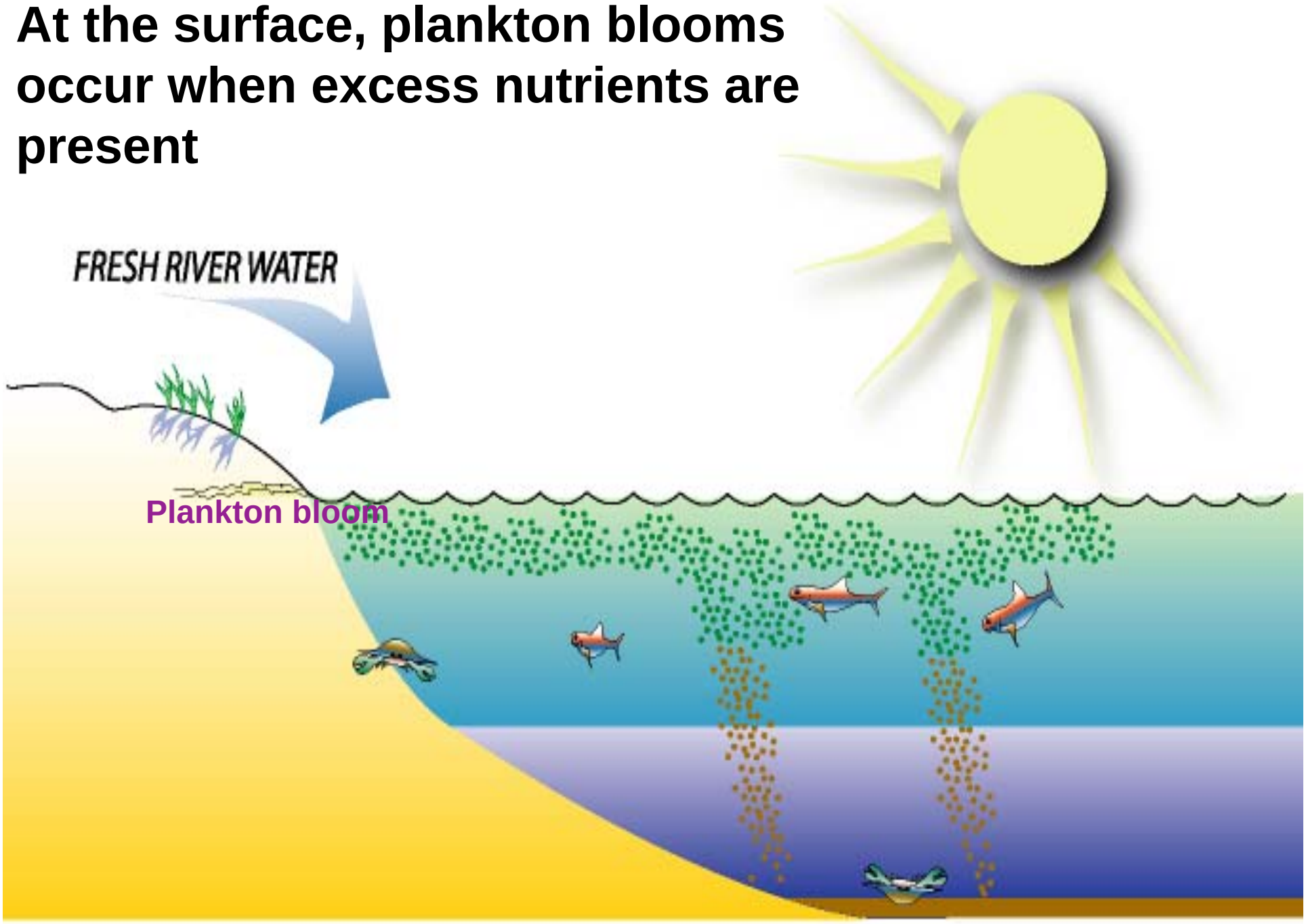


Warm fresh water and nutrients are delivered by the Mississippi River and float on the denser saltwater.

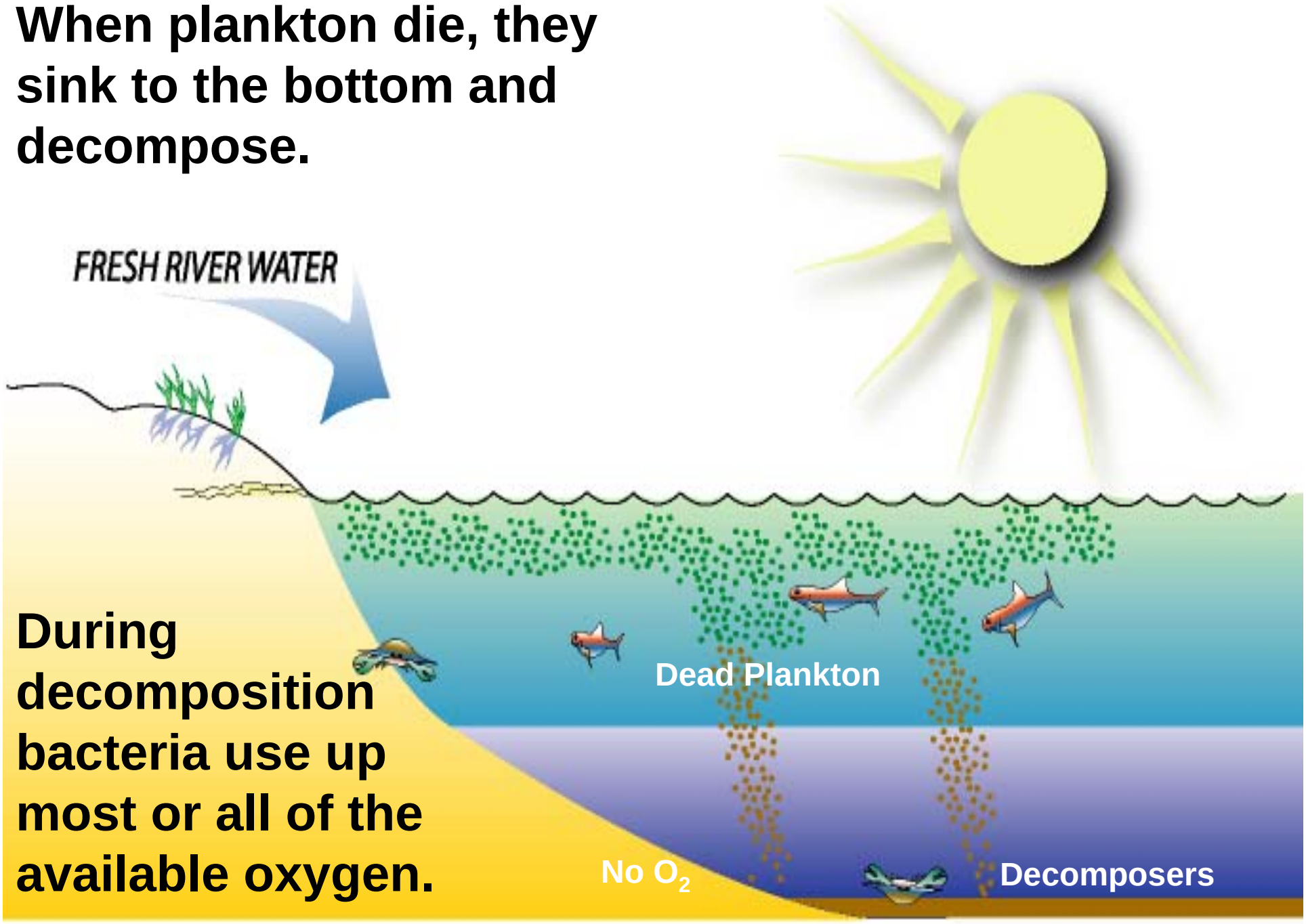
A stratified layer is formed with lighter, fresher, warmer water at the surface and heavier, saltier, cooler water near the bottom limiting oxygen mixing throughout the water column.



At the surface, plankton blooms occur when excess nutrients are present

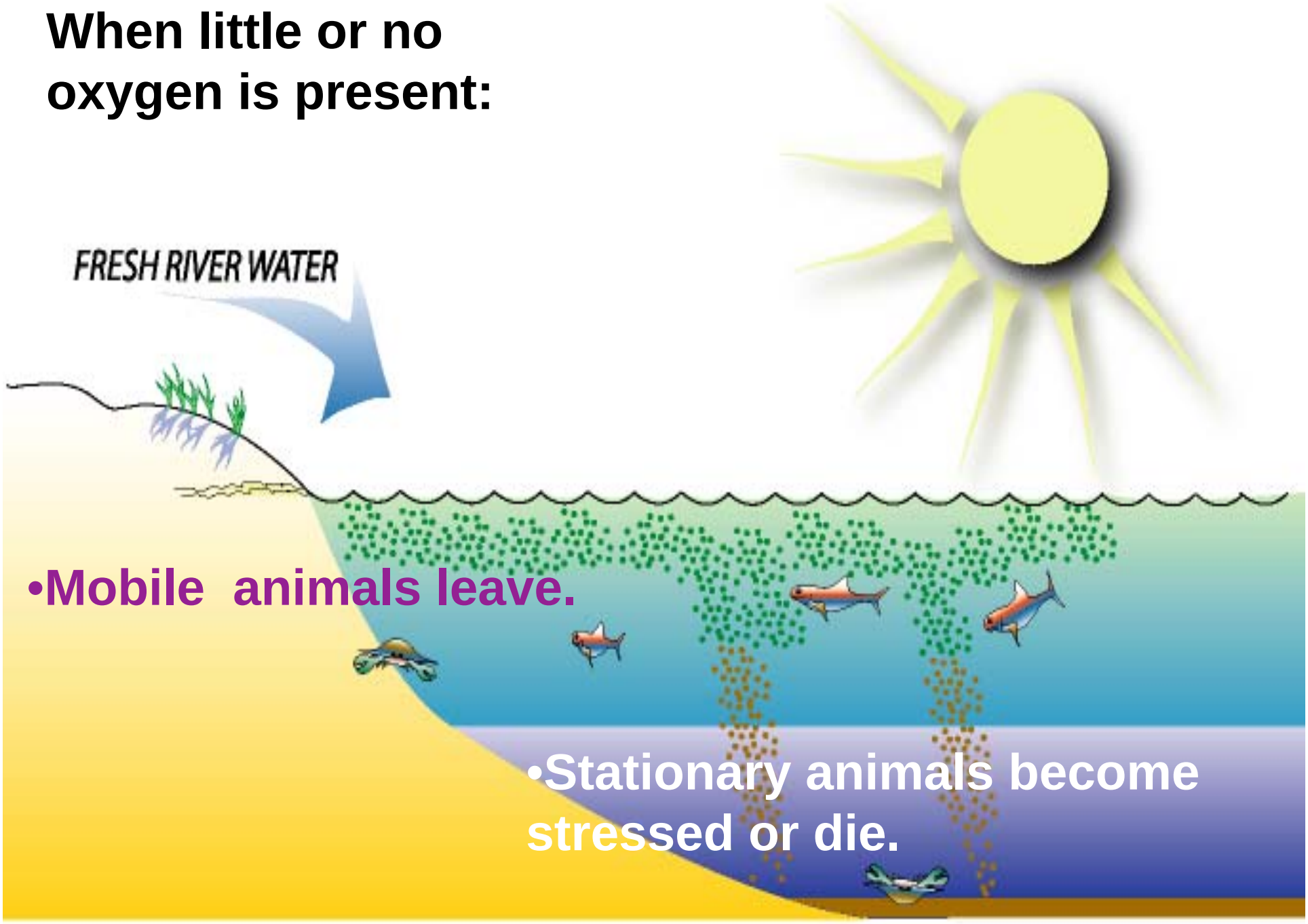


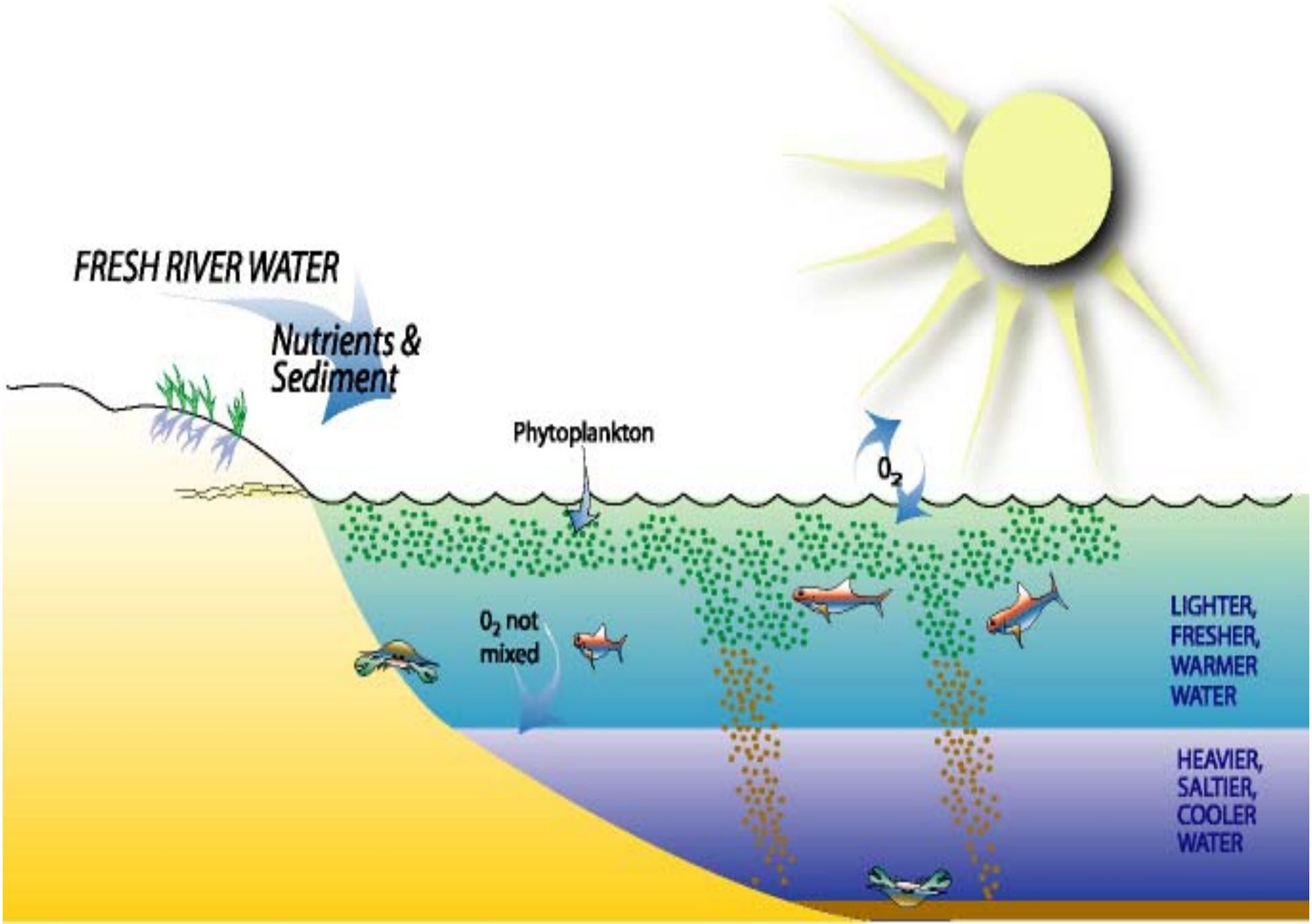
When plankton die, they sink to the bottom and decompose.



During decomposition bacteria use up most or all of the available oxygen.

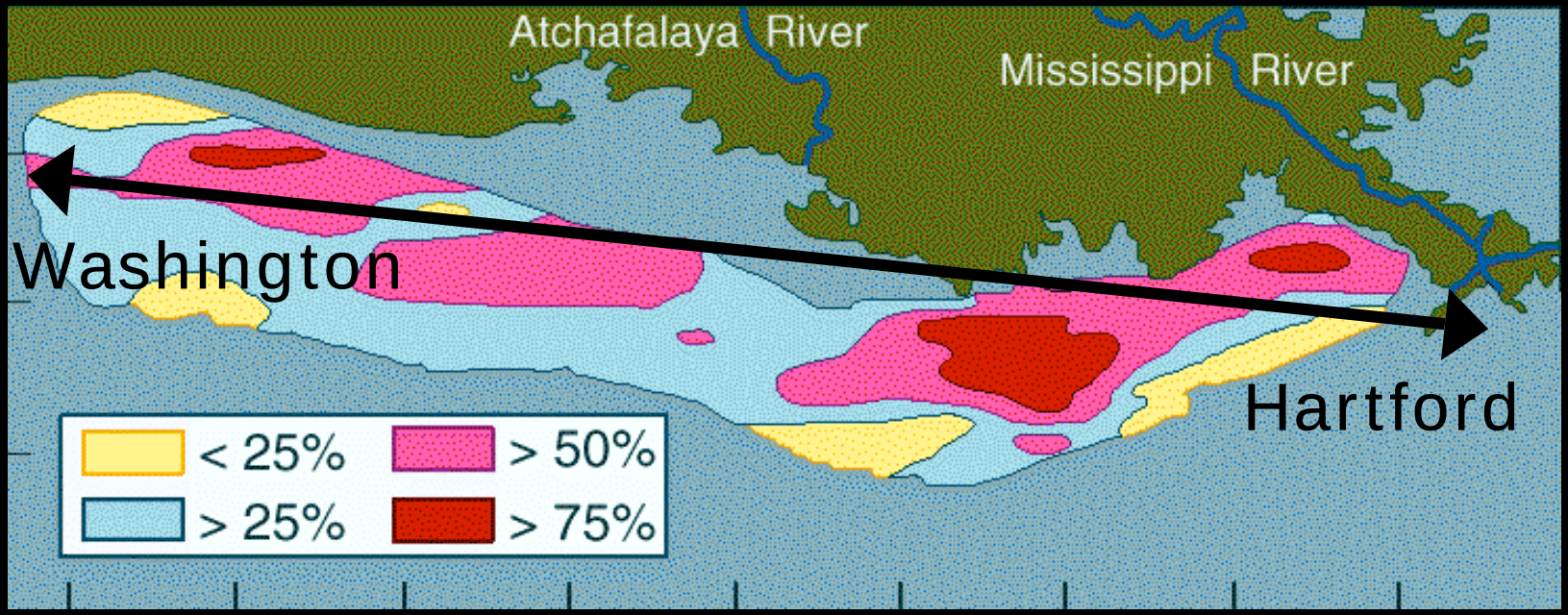
When little or no oxygen is present:





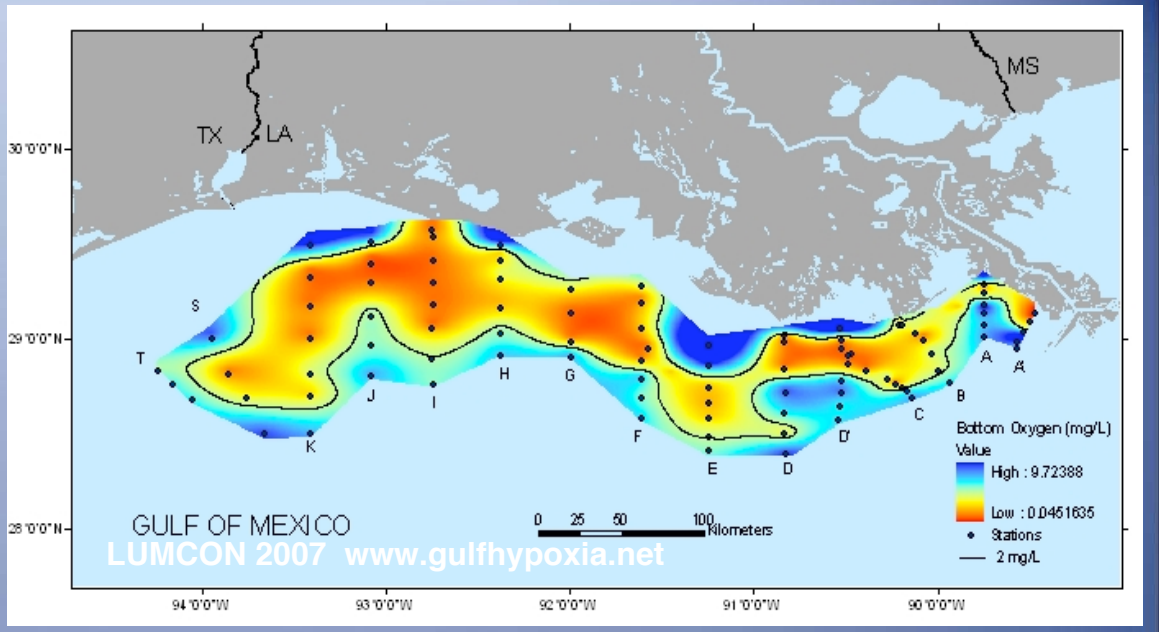
modified from CENR 2000

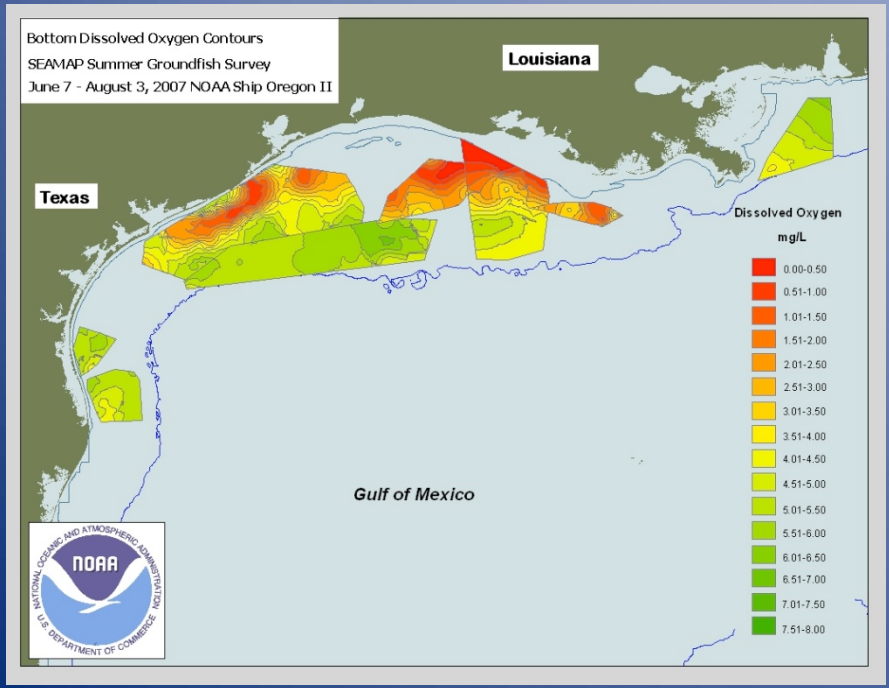
Gulf of Mexico Hypoxia



Rabalais, et al.

Gulf of Mexico Hypoxia





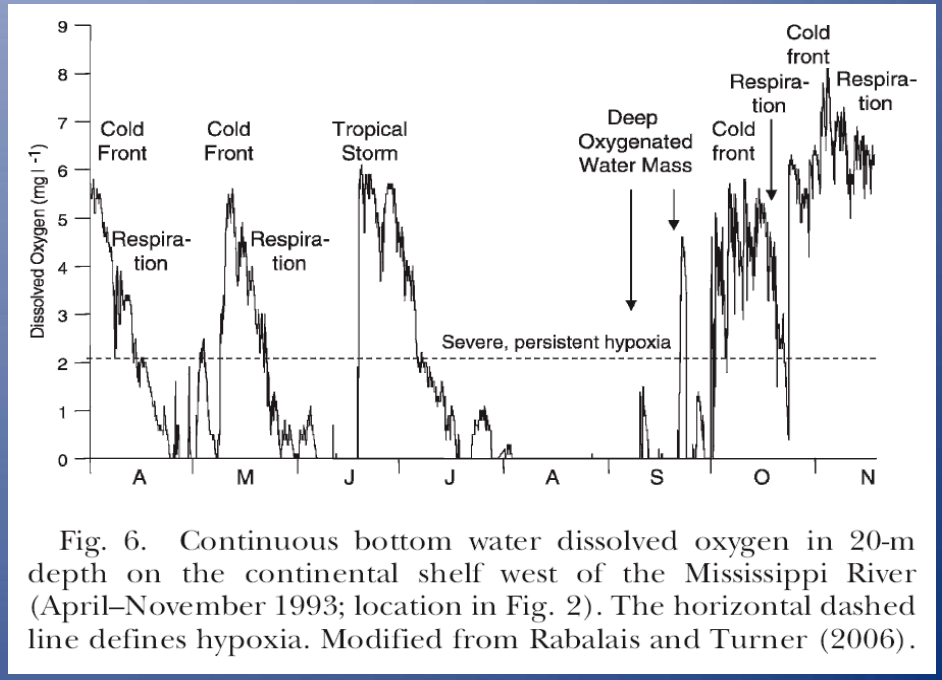
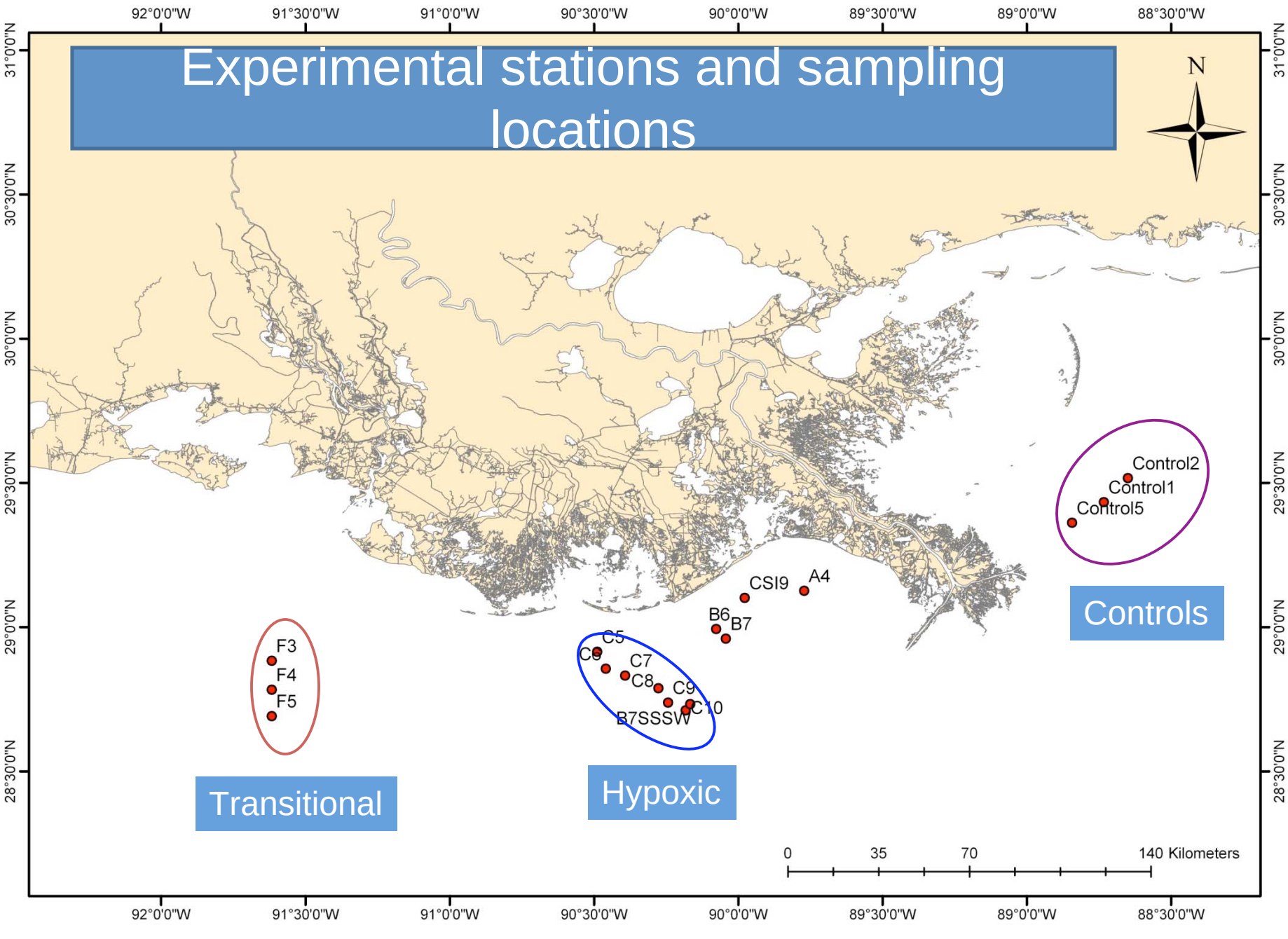


Fig. 6. Continuous bottom water dissolved oxygen in 20-m depth on the continental shelf west of the Mississippi River (April–November 1993; location in Fig. 2). The horizontal dashed line defines hypoxia. Modified from Rabalais and Turner (2006).

NOAA SEAMAP 2007

Rabalais et al. 2007

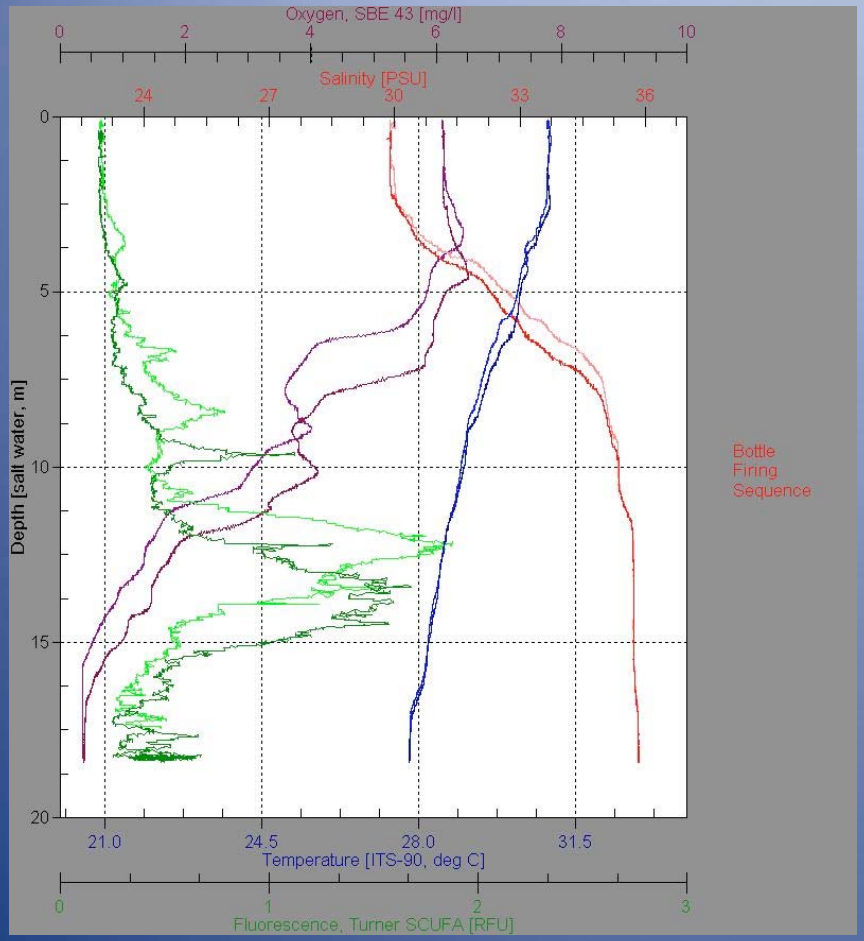

Experimental stations and sampling locations
N
92°0'0"W
91°30'0"W
91°0'0"W
90°30'0"W
90°0'0"W
89°30'0"W
89°0'0"W
88°30'0"W
31°0'0"N
30°30'0"N
30°0'0"N
29°30'0"N
29°0'0"N
28°30'0"N
Control2
Control1
Control5
Controls
CSI9
A4
B6
B7
C5
C6
C7
C8
C9
C10
B7SSSW
F3
F4
F5
Transitional
Hypoxic
0
35
70
140 Kilometers

Cruises on R/V Pelican

- Operations
  - CTD casts to locate hypoxic areas along transects
  - Trawls to collect bottom fish and invertebrates (Peter Thomas Lab)
  - Sediment cores to study nutrient regeneration (Wayne Gardner) and small invertebrates (meiofauna) (Buskey Lab)

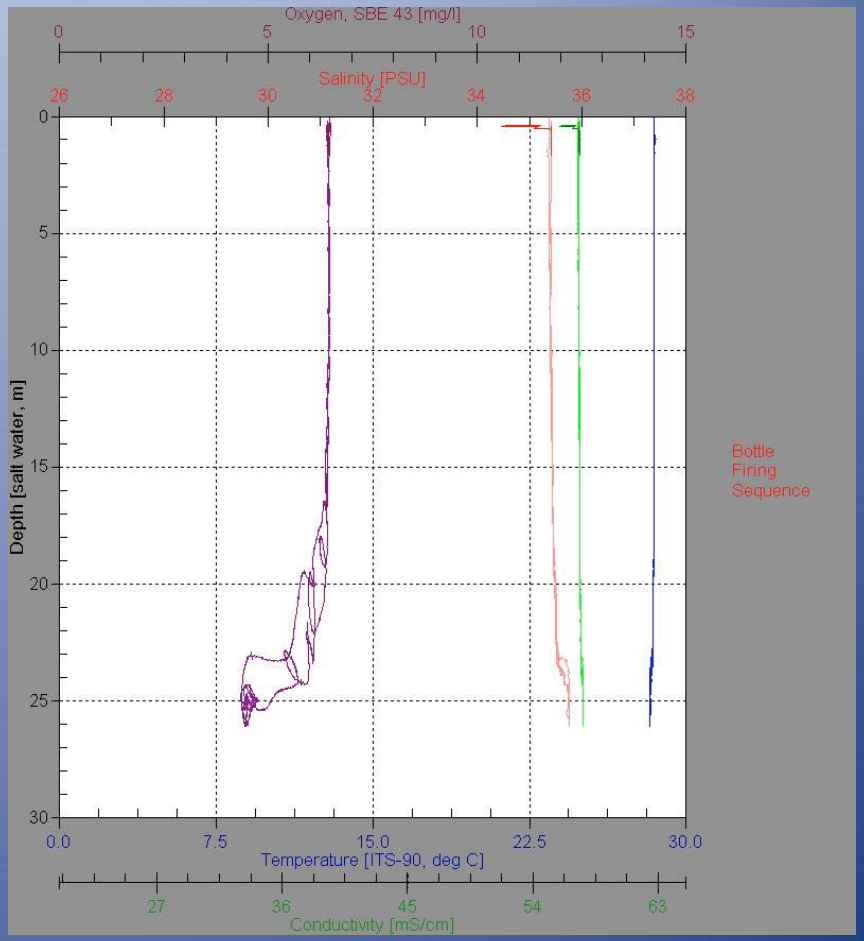
CTD Casts

CTD profiles



Hypoxia (nearly anoxia)

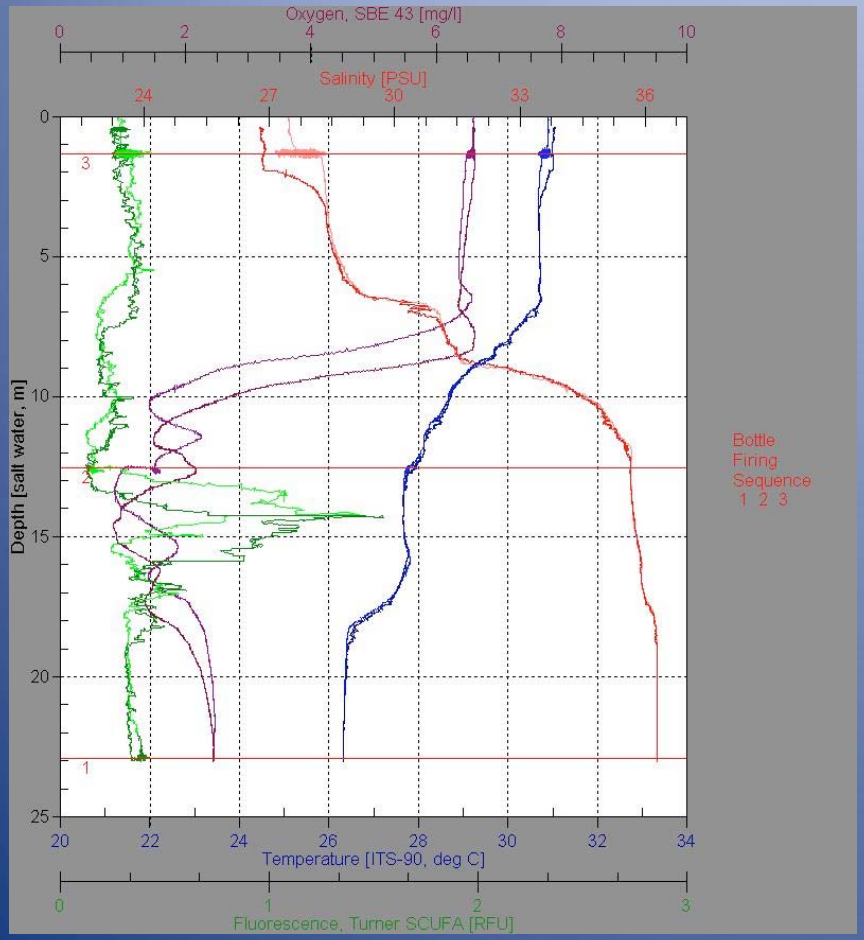
C6, August 2007



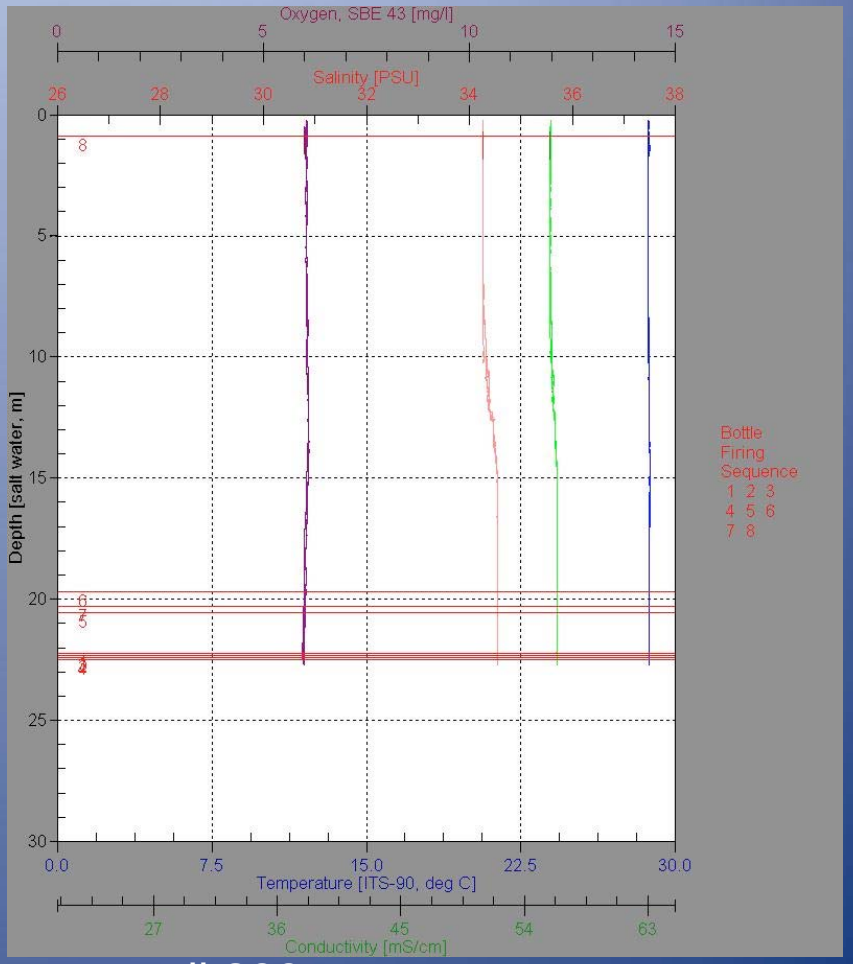
Normoxic

Control 2, Fall 2007

CTD casts at station F4

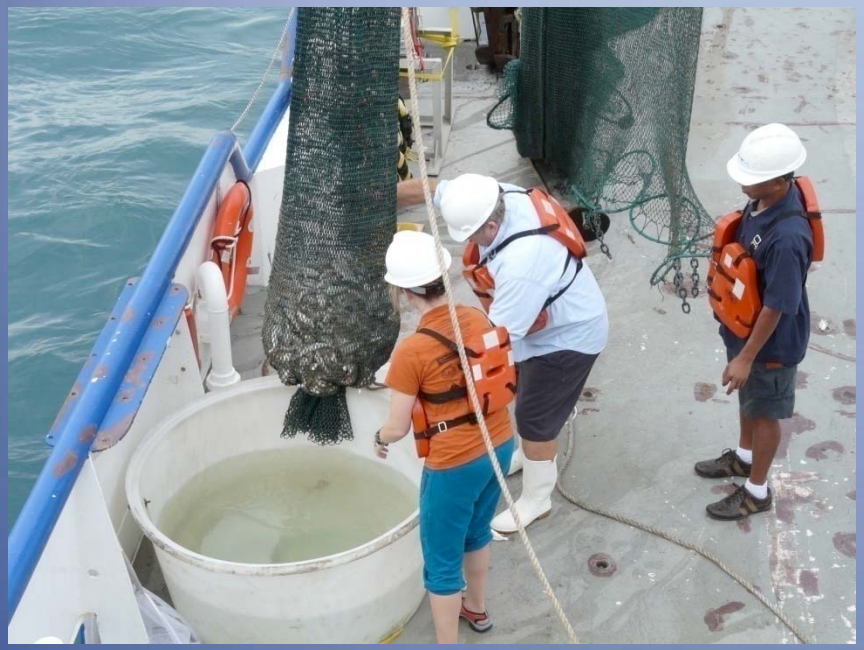


August 2007

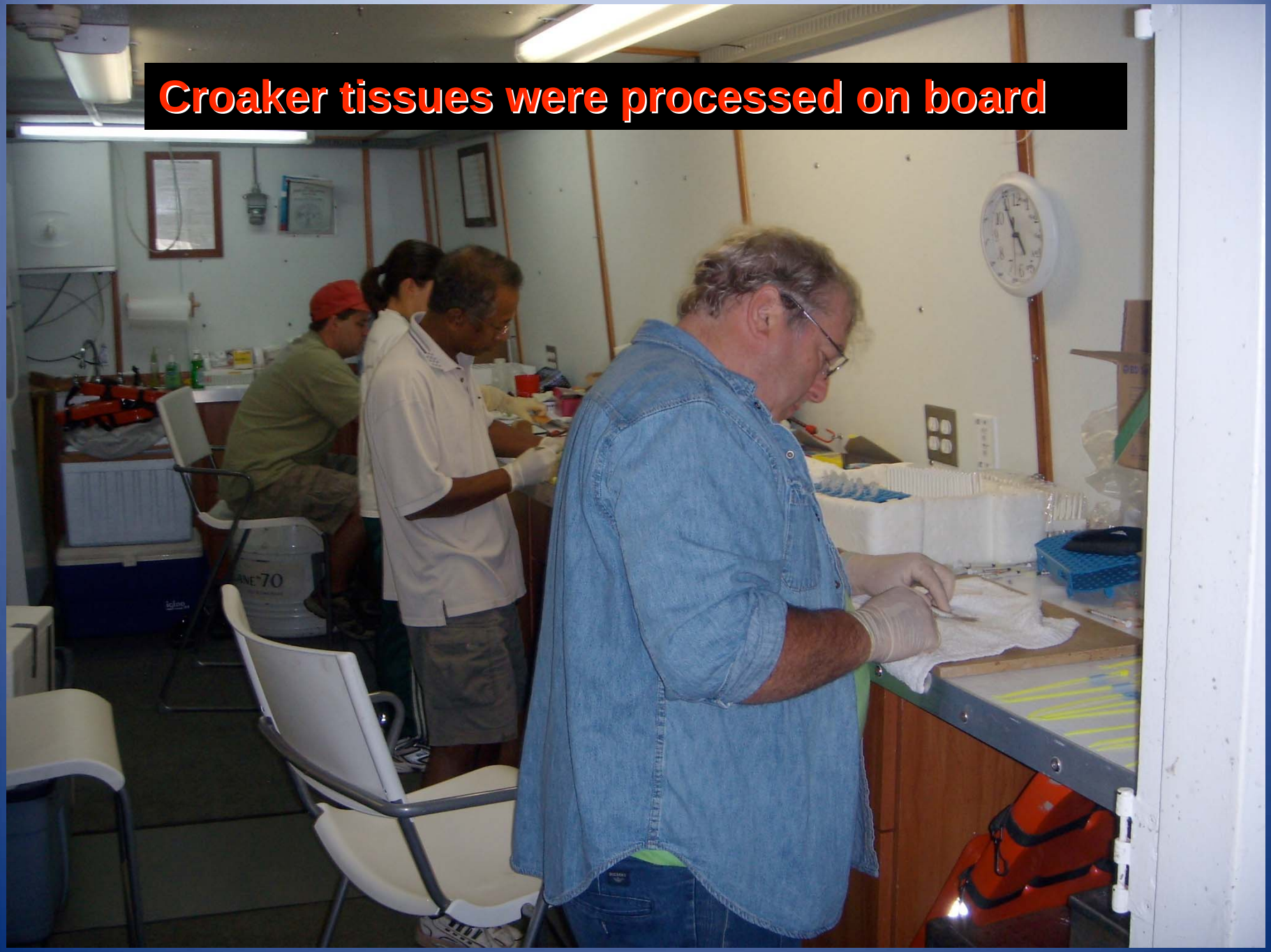


Fall 2007

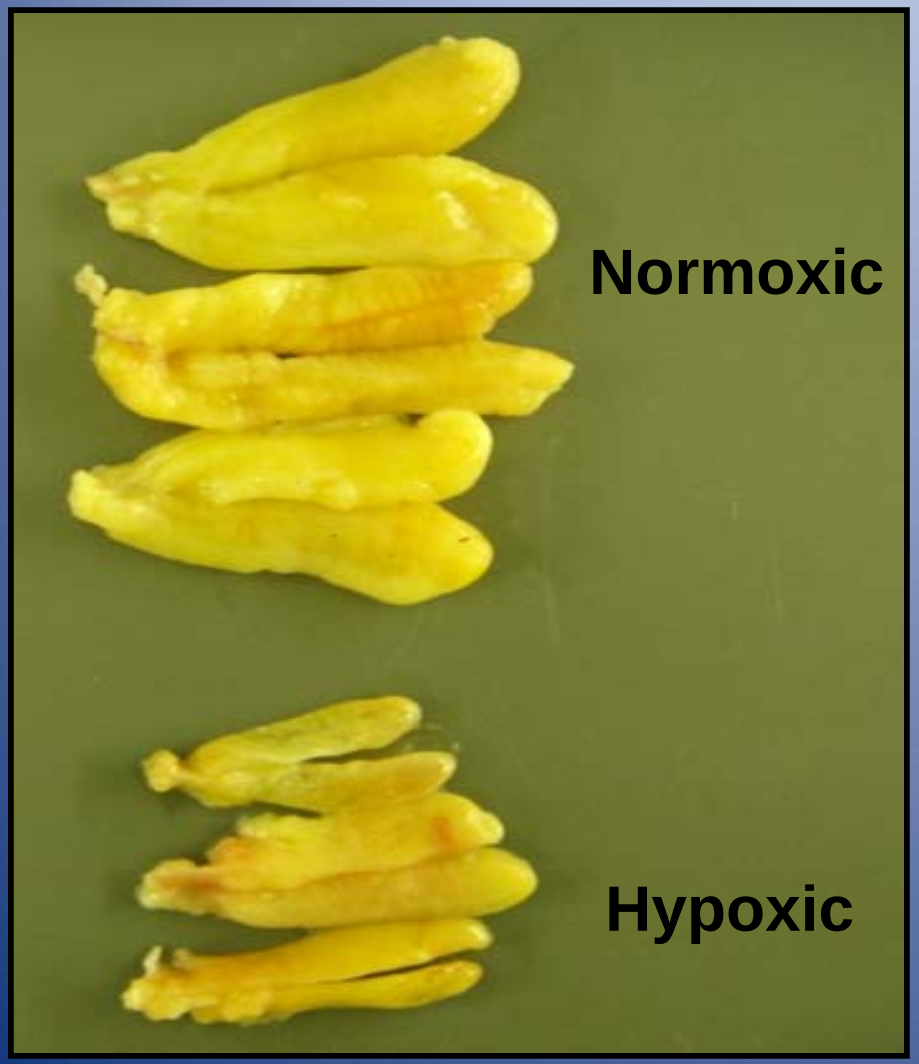
Studies of fish reproduction



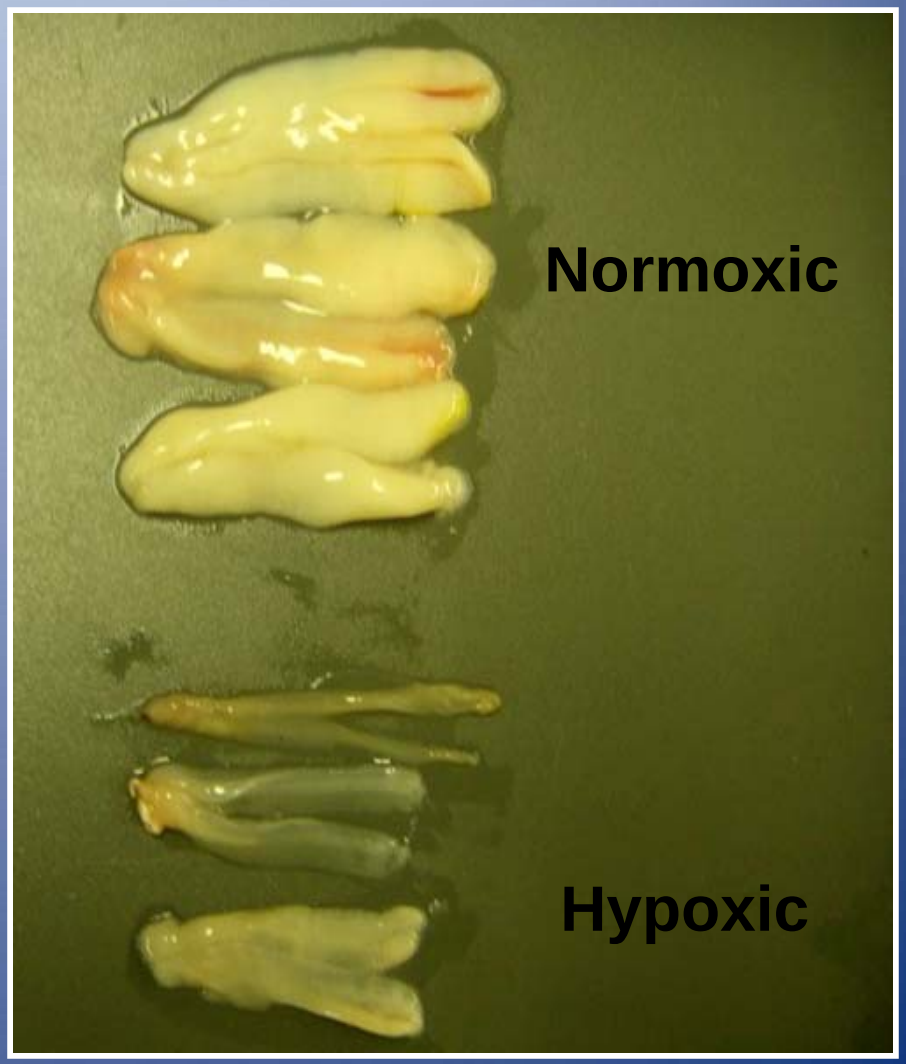
- Thomas lab performs studies of effects of hypoxia on Atlantic croaker reproduction
- Hypoxia causes development of smaller reproductive organs and reduced reproductive potential


Croaker tissues were processed on board

Atlantic croaker ovary and testis collected from normoxic and hypoxic sites in the Gulf of Mexico in September 2007



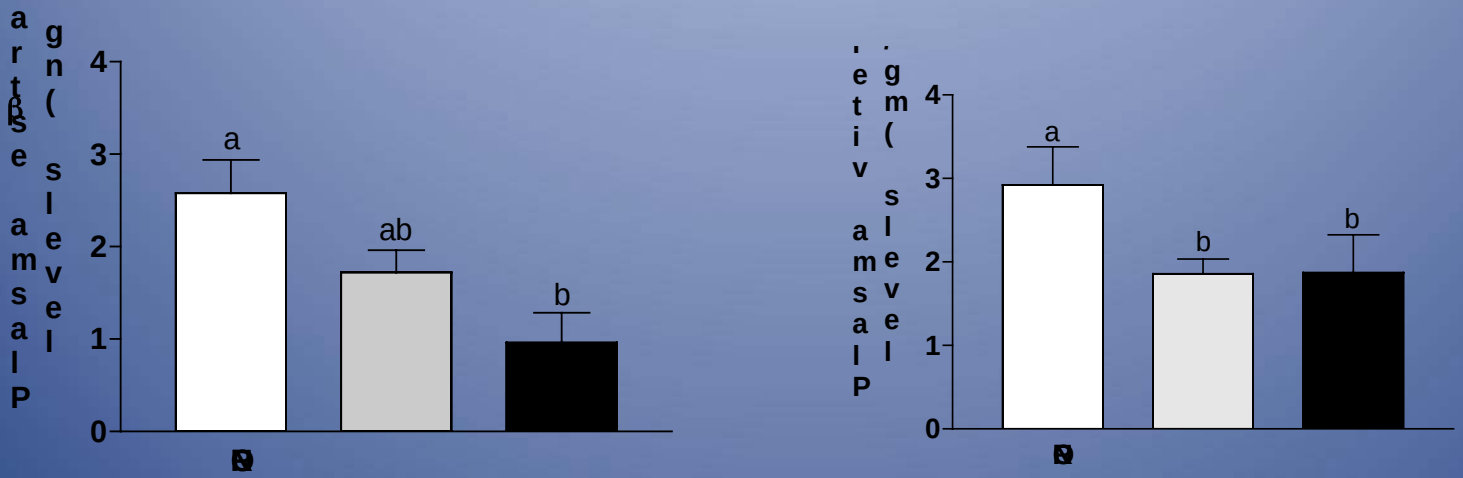
Ovary



Testis

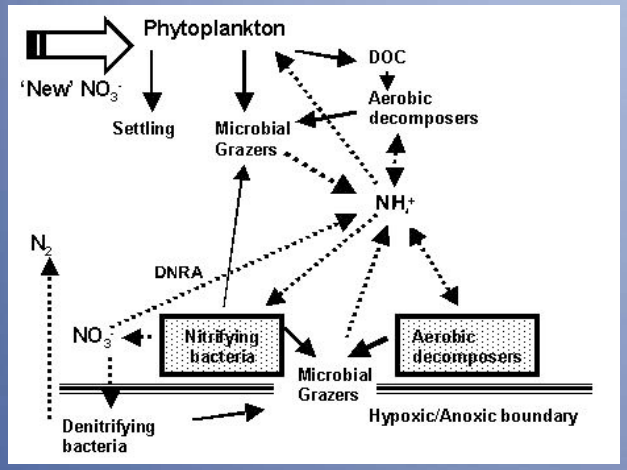
Preliminary data-Gulf of Mexico

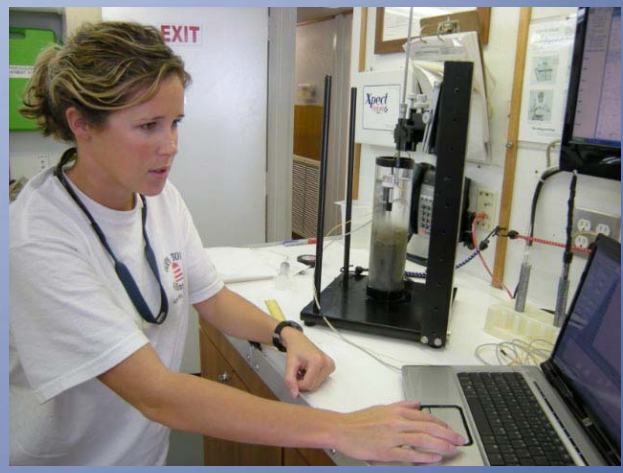
Plasma levels of both estradiol and vitellogenin were lowest in female croaker collected from the hypoxic sites



Conclusion: Preliminary evidence to support hypothesis that endocrine and reproductive functions are also impaired by hypoxia in croaker offshore in the northern Gulf of Mexico

Studies of sediment chemistry





- Gardner Lab performs studies of nutrient transformations and oxygen uptake in sediments
- Collects undisturbed cores with overlying water
- Performs incubations aboard ship to

Studies of benthic copepods

To determine if there are measurable sub-lethal effects of hypoxia on reproductive measures in harpacticoid copepods.

Harpacticoids are abundant small crustaceans; fed on by juvenile fish

Brood their eggs, making studies of reproduction easier

Effects of Hypoxia on Reproduction

Maintenance

Increased energy for respiration

Changes in behavior

Growth

Reduced growth

Changes in development times & population structure

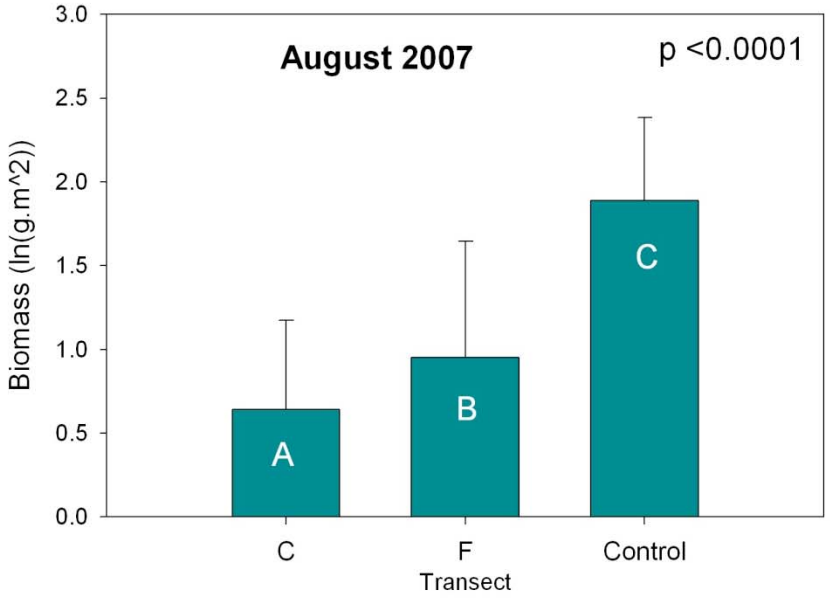
Reproduction

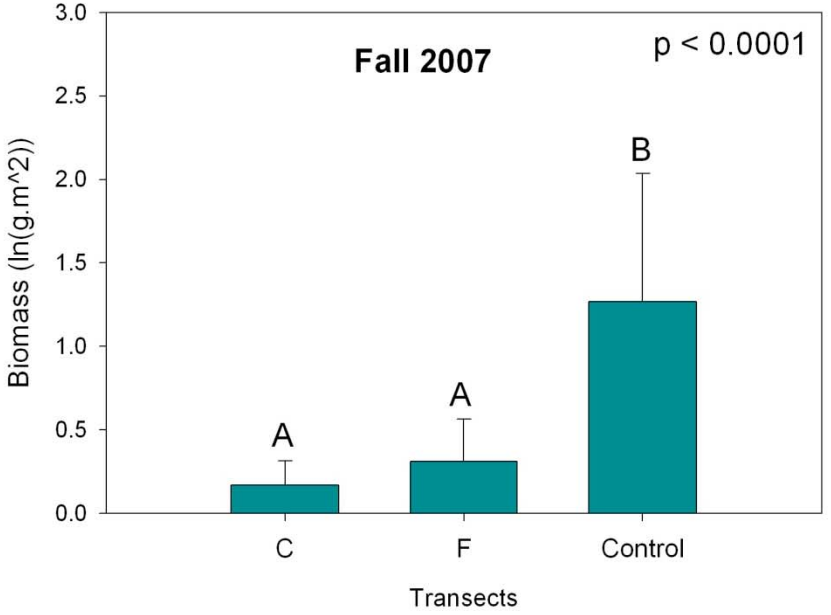
Reduced egg mass & egg size
Abundance of gravid females

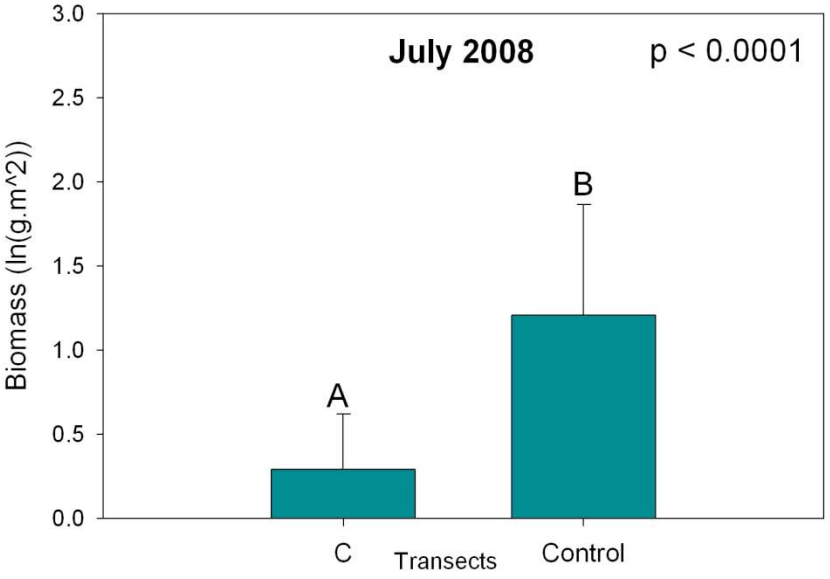
Sampling Methods

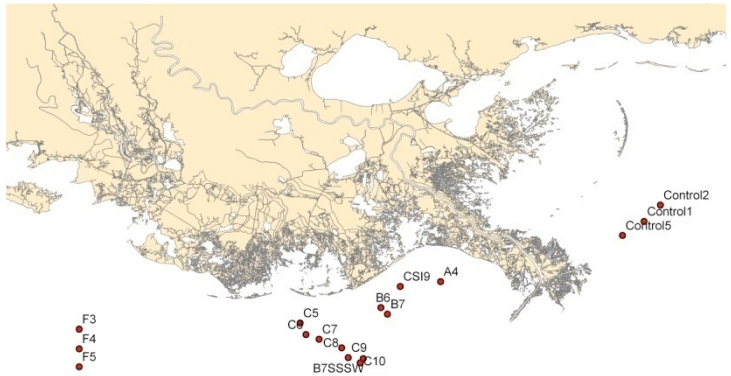
- Sediment cores
  - Collect preserved cores for later study of copepods
  - Density separation of copepods from mud using colloidal silica
  - Grain size, CHN

Biomass

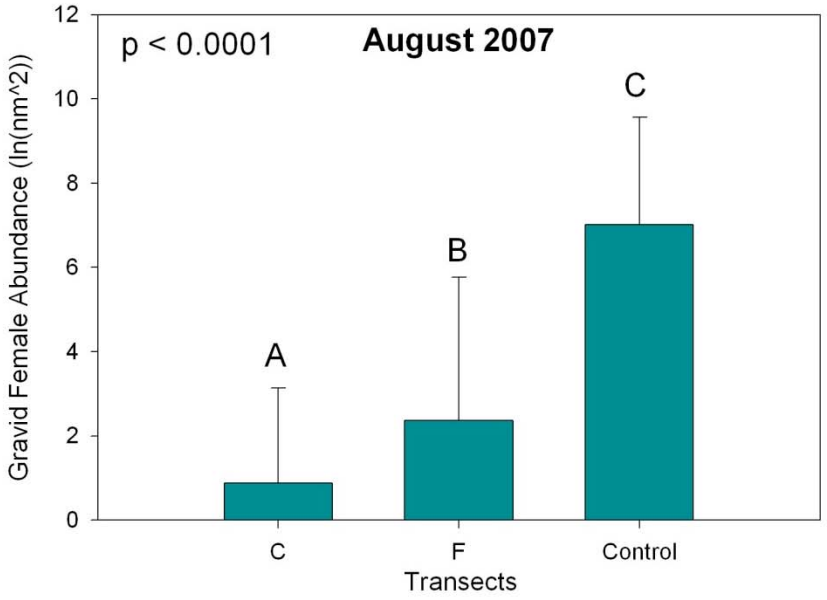

August 2007
p <0.0001
Biomass (ln(g.m^2))
3.0
2.5
2.0
1.5
1.0
0.5
0.0
A
B
C
C
F
Control
Transect

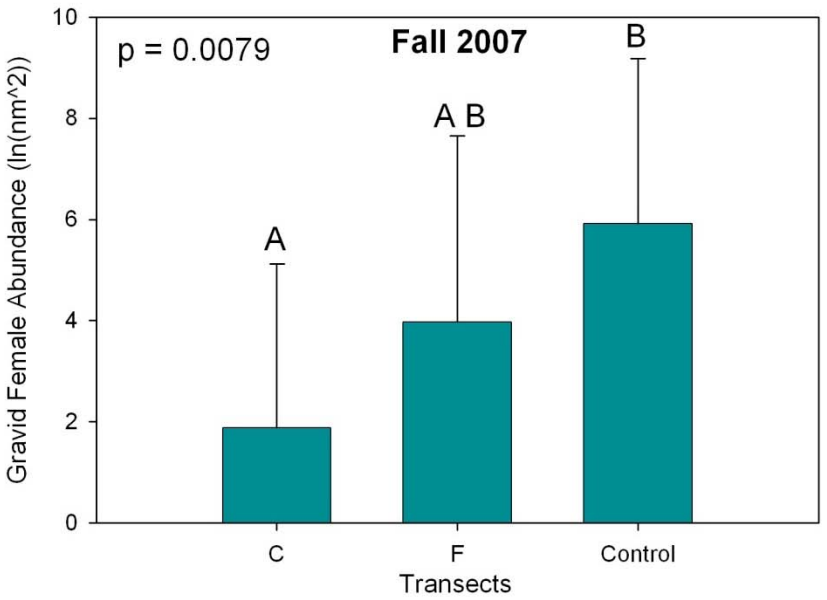

Fall 2007
p < 0.0001
Biomass (ln(g.m^2))
3.0
2.5
2.0
1.5
1.0
0.5
0.0
A
A
B
C
F
Control
Transects

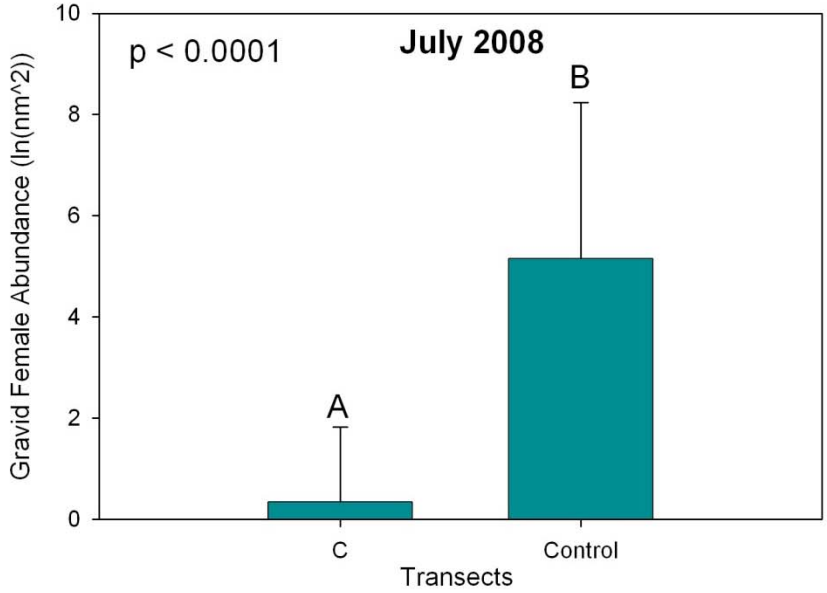

July 2008
p < 0.0001
Biomass (ln(g.m^2))
3.0
2.5
2.0
1.5
1.0
0.5
0.0
A
B
C
Transects
Control

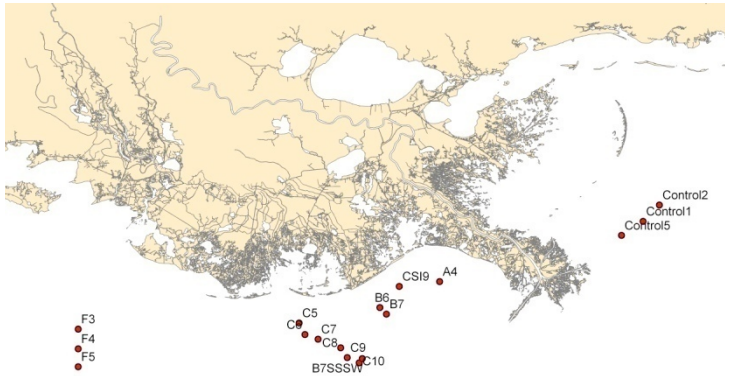

Control2
Control1
Control5
CSI9
A4
B6
B7
C5
C6
C7
C8
C9
C10
B7SSSW
F3
F4
F5

Gravid Female Abundance

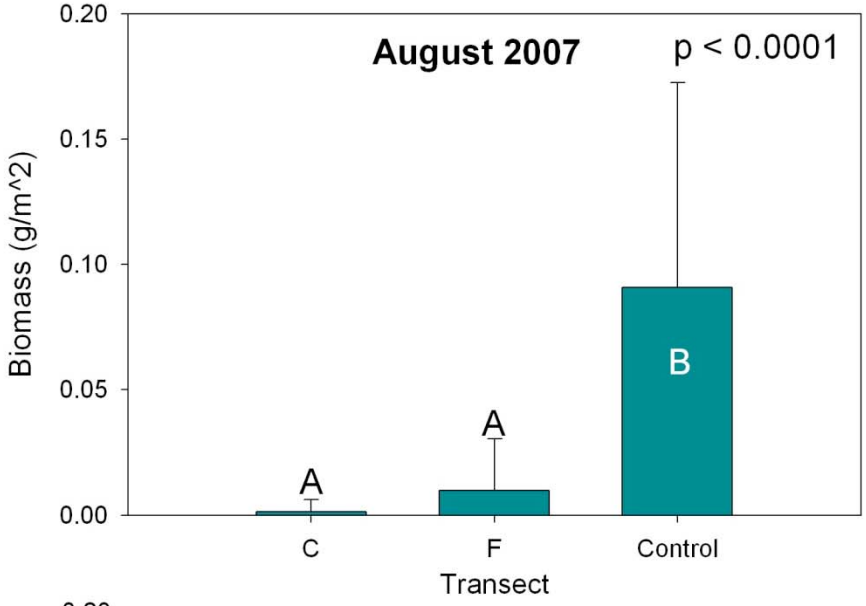


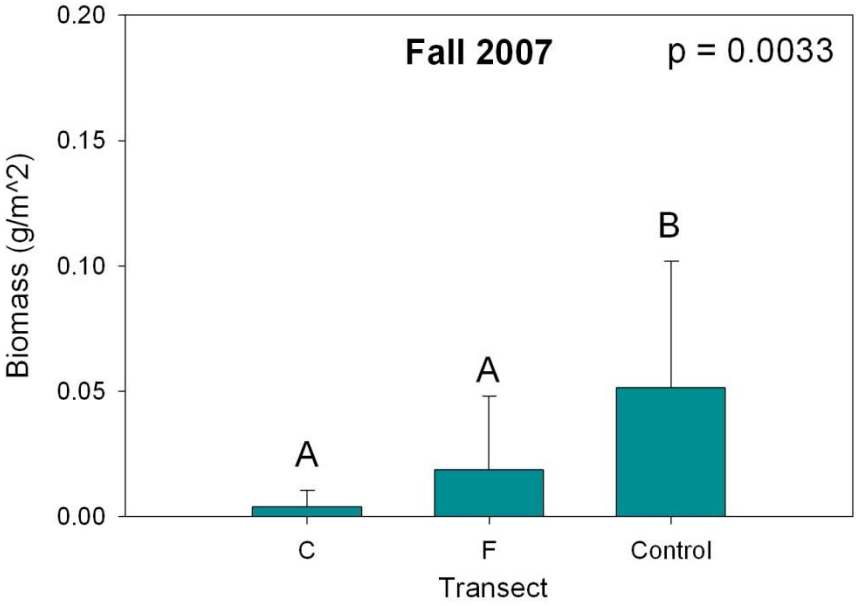


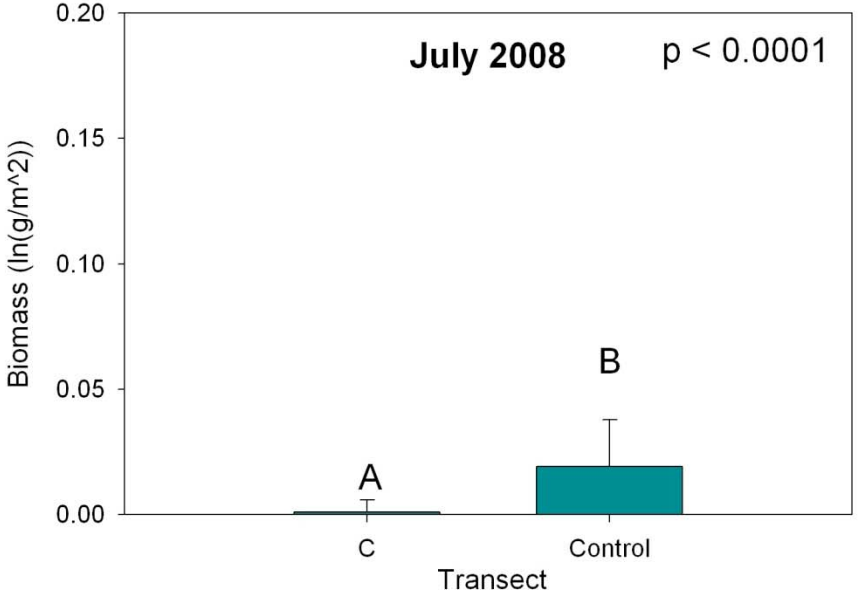




Egg Mass Biomass

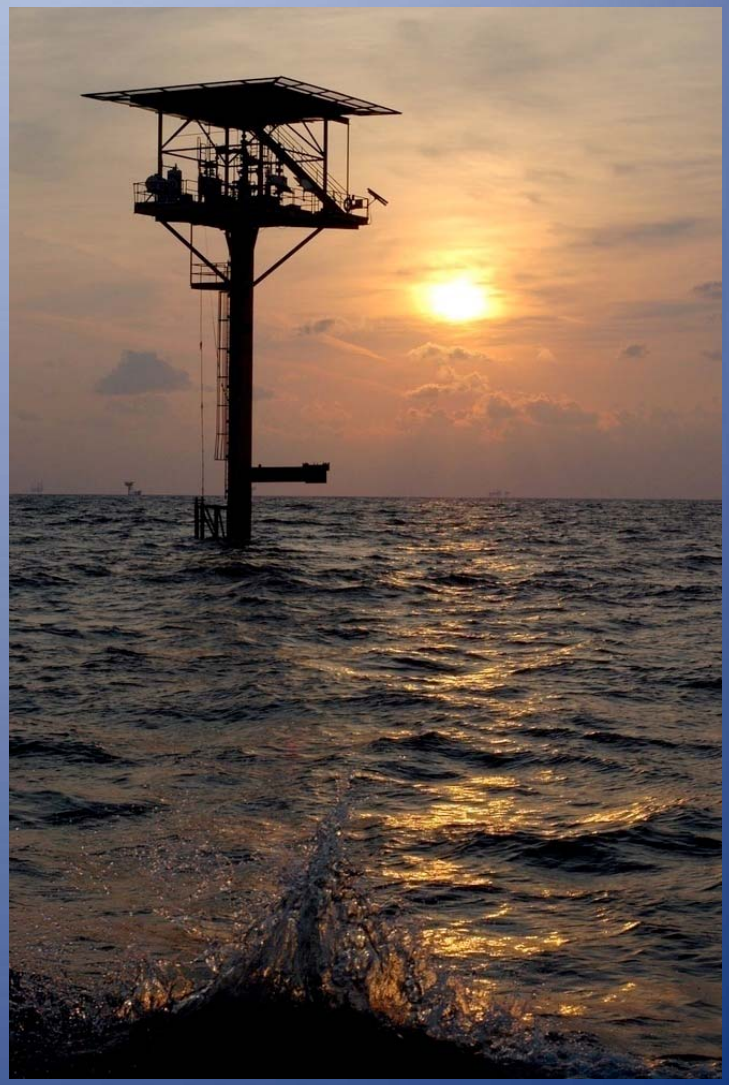






Conclusions

- Areas of moderate hypoxia (low oxygen) can have important effects on populations of marine organisms
- In both groups of organisms studied, exposure to low oxygen lead to significant reduction in reproductive capacity



Any questions?

Last cruise of the R/V Longhorn