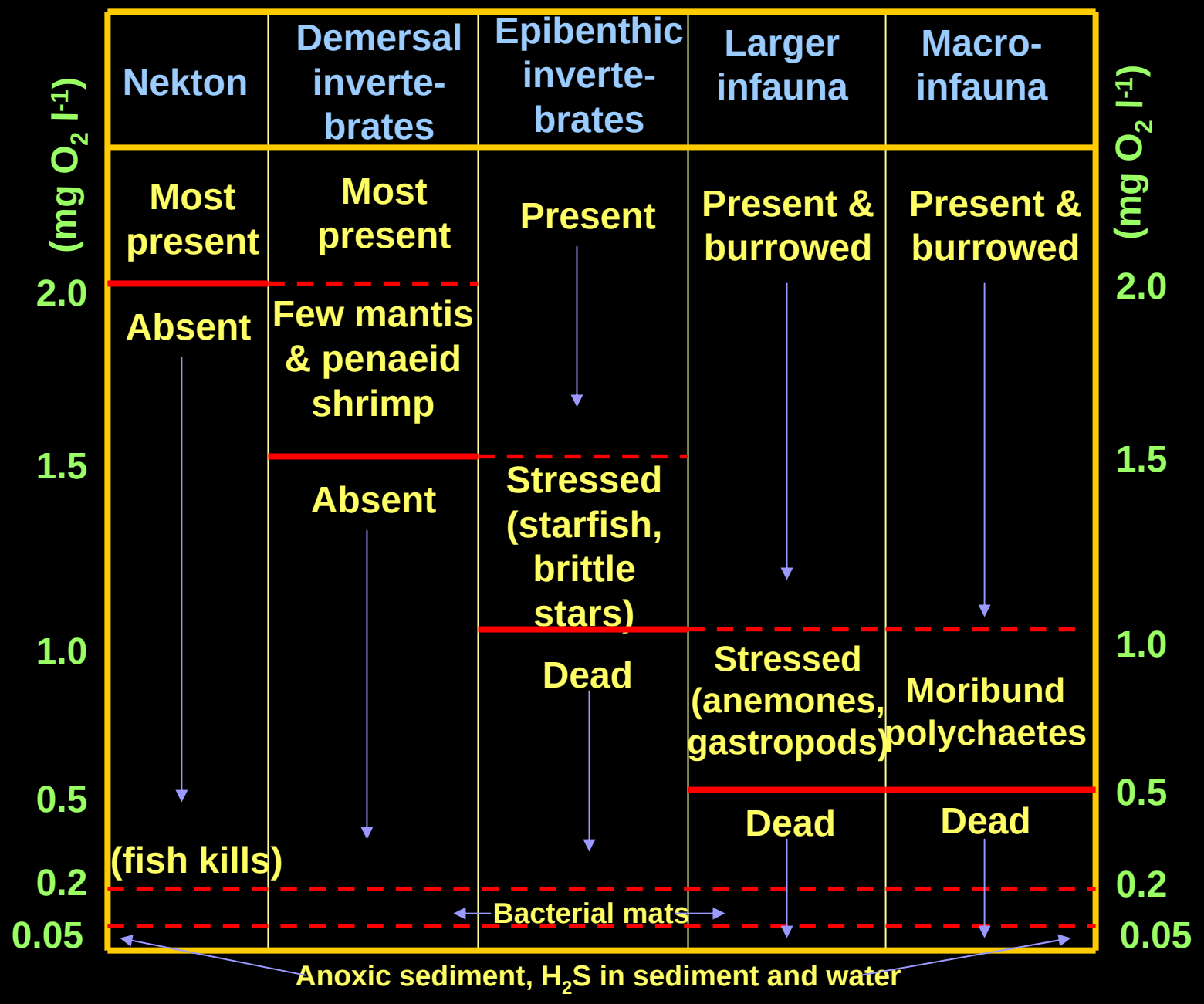
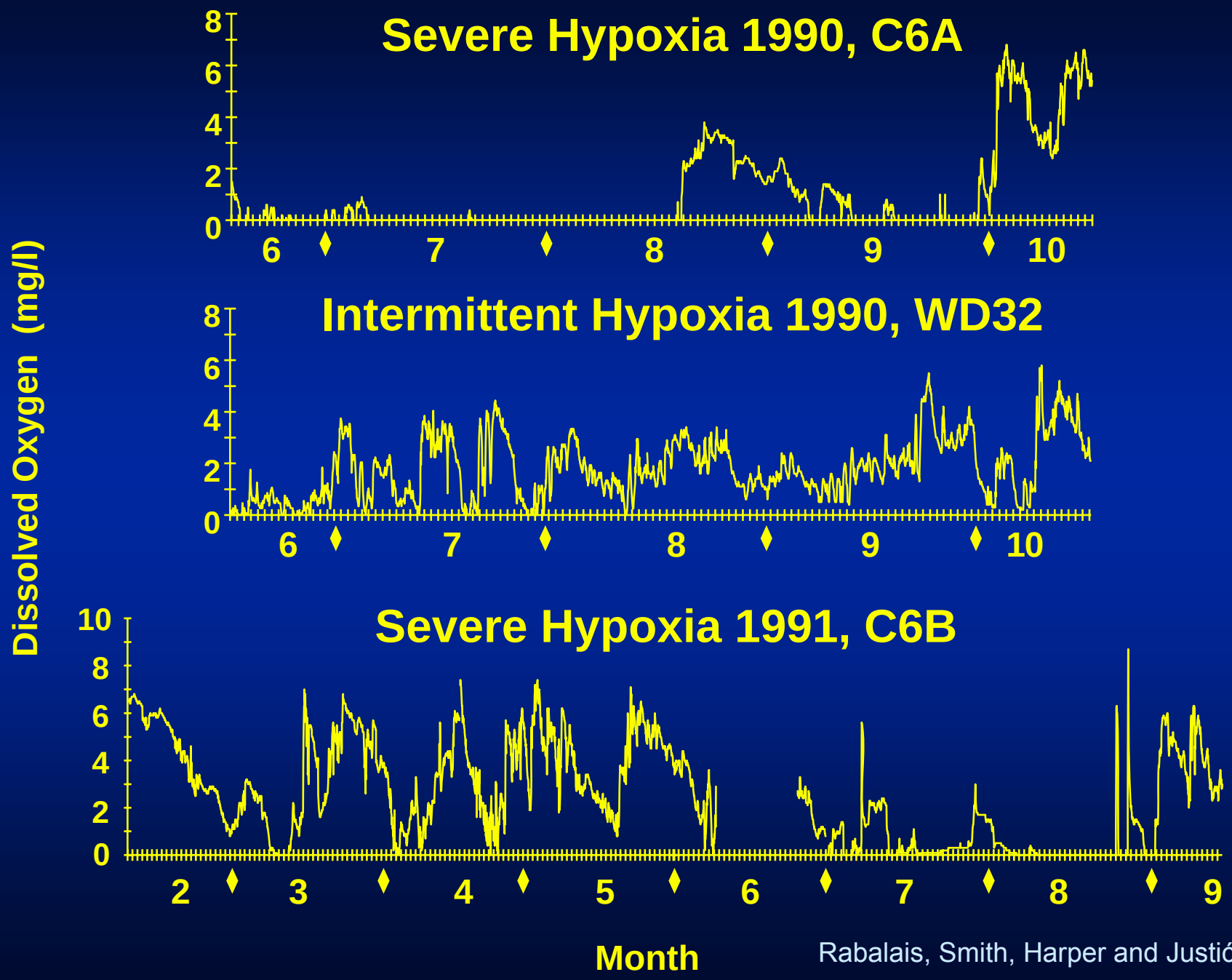
# Benthic Communities and the Effects of Hypoxia in Louisiana Coastal Waters

Nancy N. Rabalais

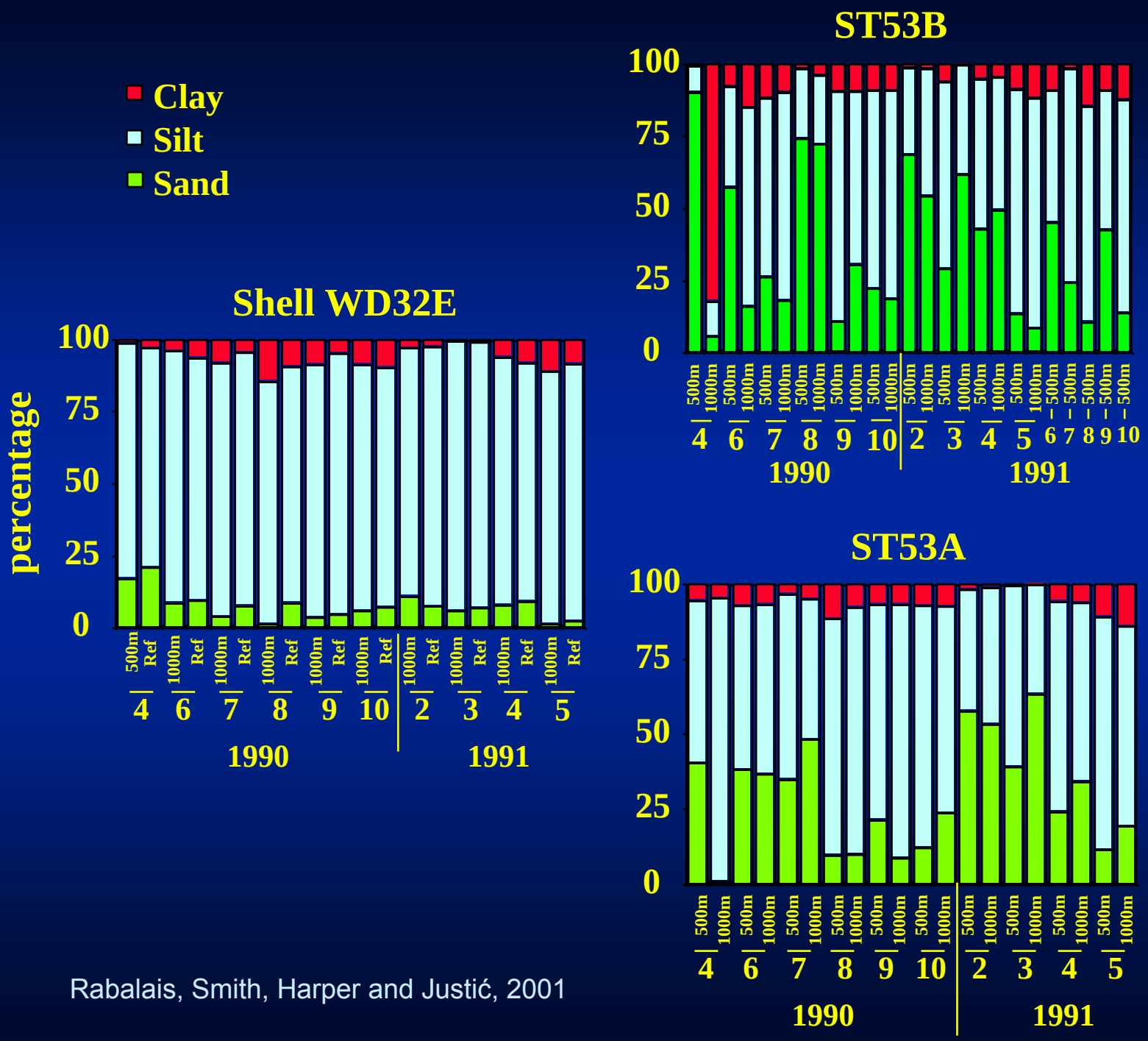
Louisiana Universities Marine Consortium




(Rabalais, Harper & Turner, 2001)

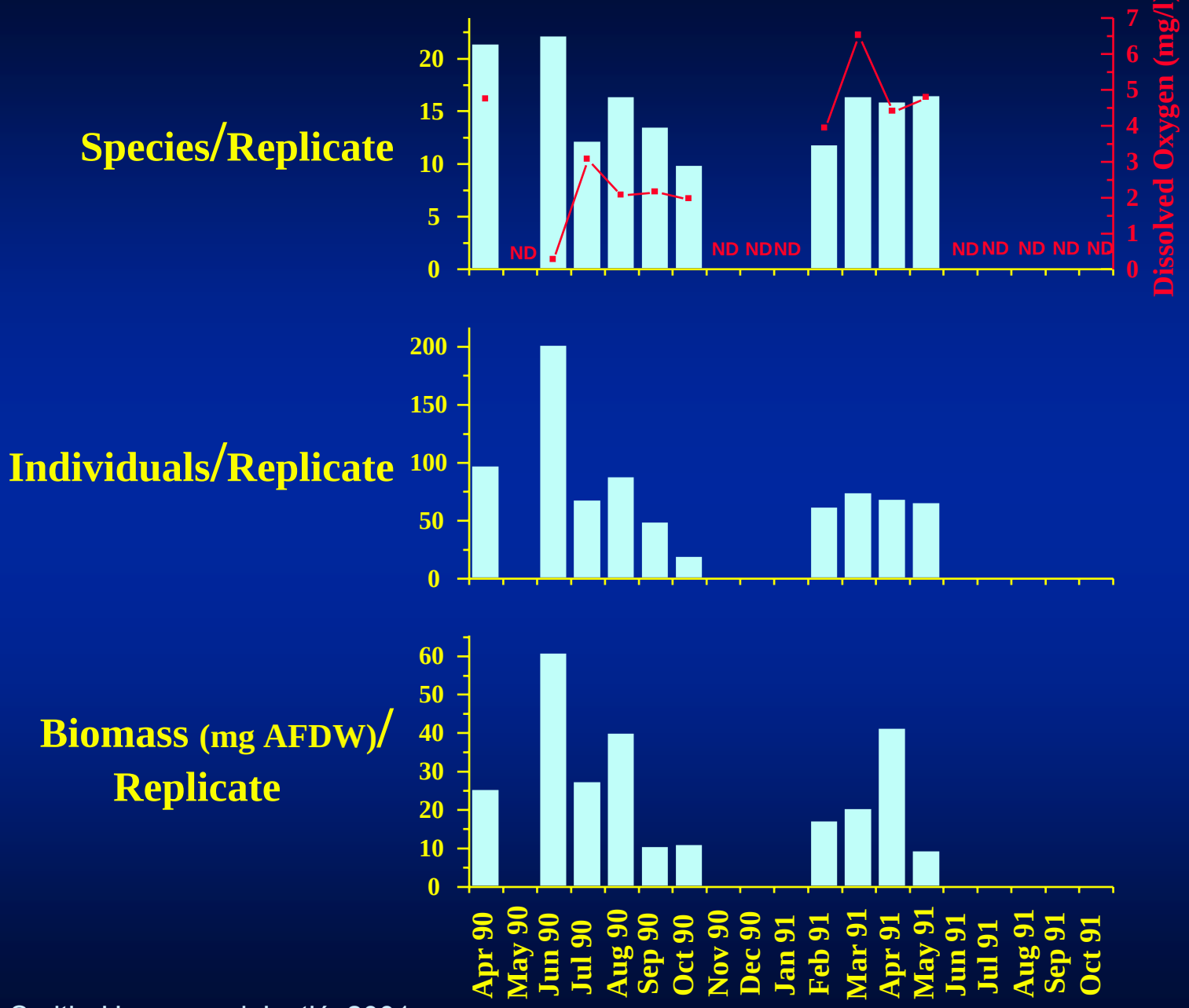



Rabalais, Smith, Harper and Justić, 2001



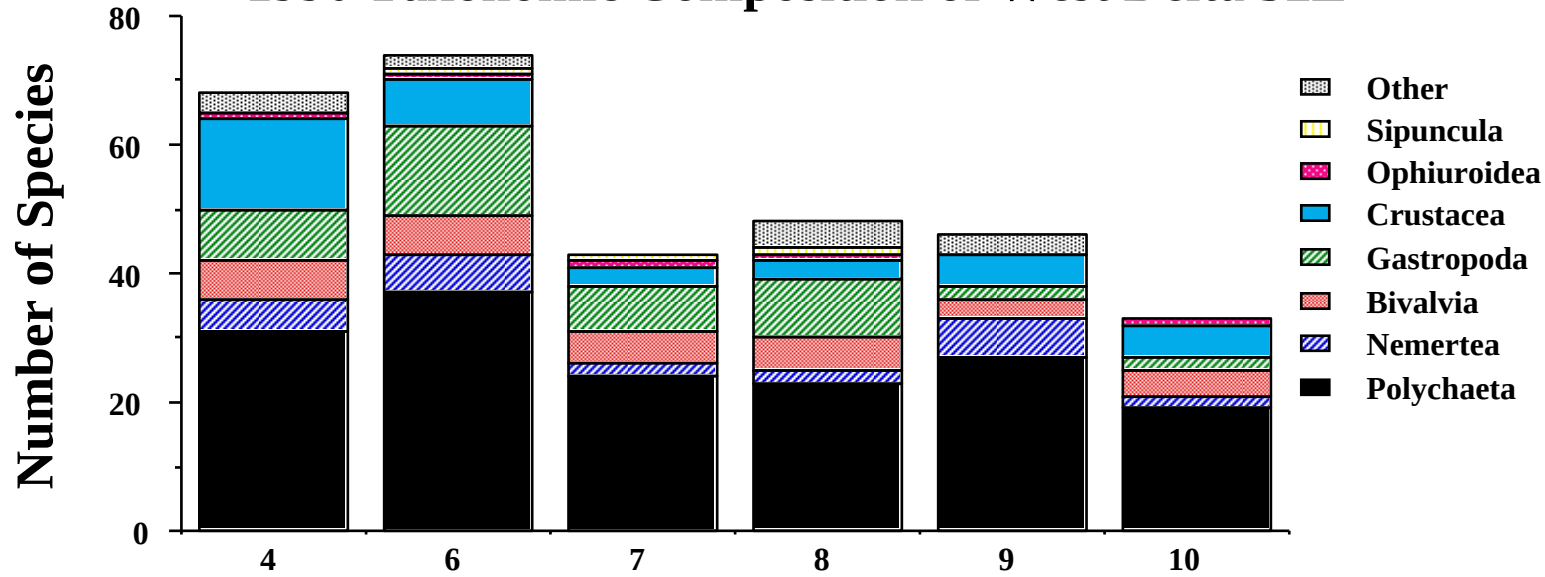

Rabalais, Smith, Harper and Justić, 2001

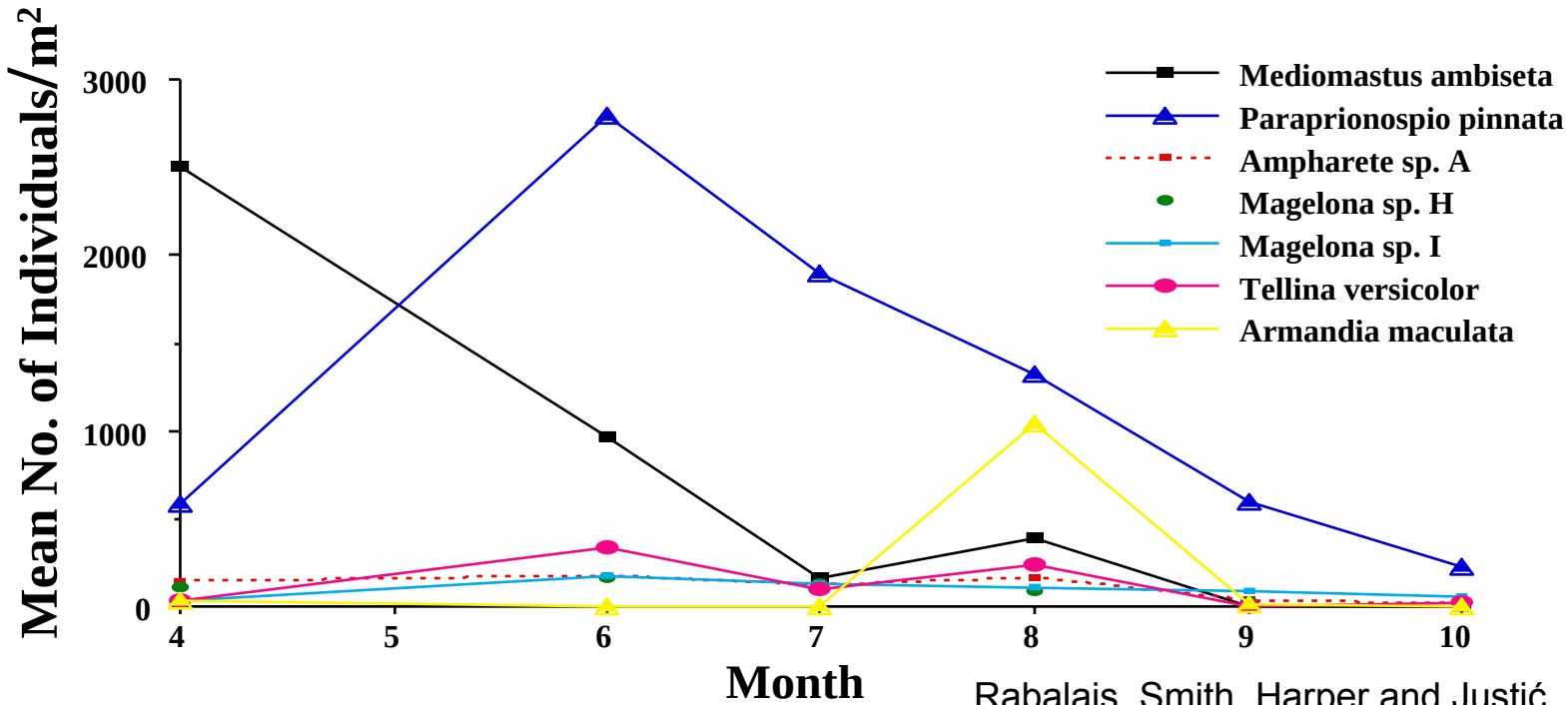
# West Delta 32E




Rabalais, Smith, Harper and Justić, 2001

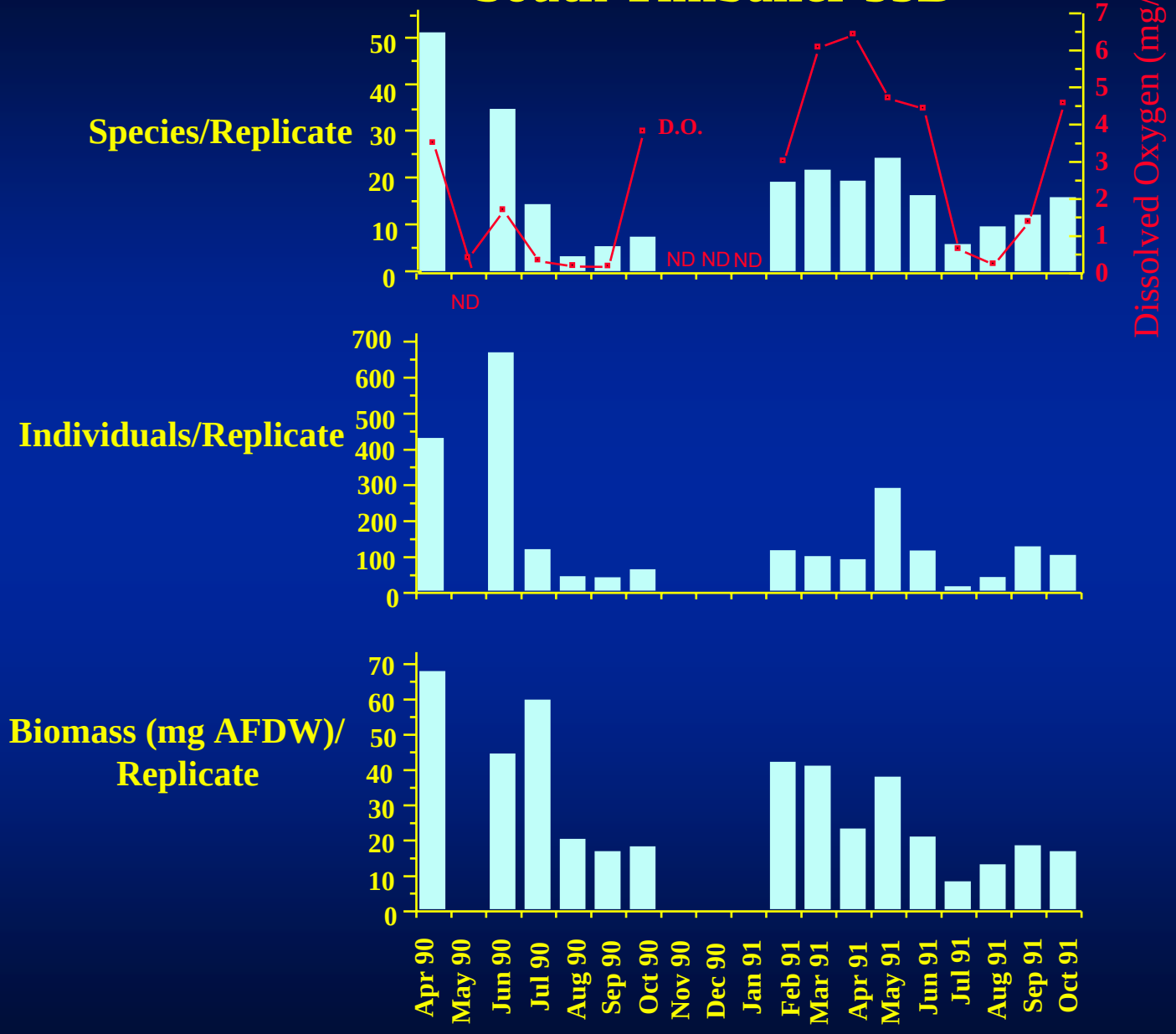
# 1990 Taxonomic Composition of West Delta 32E



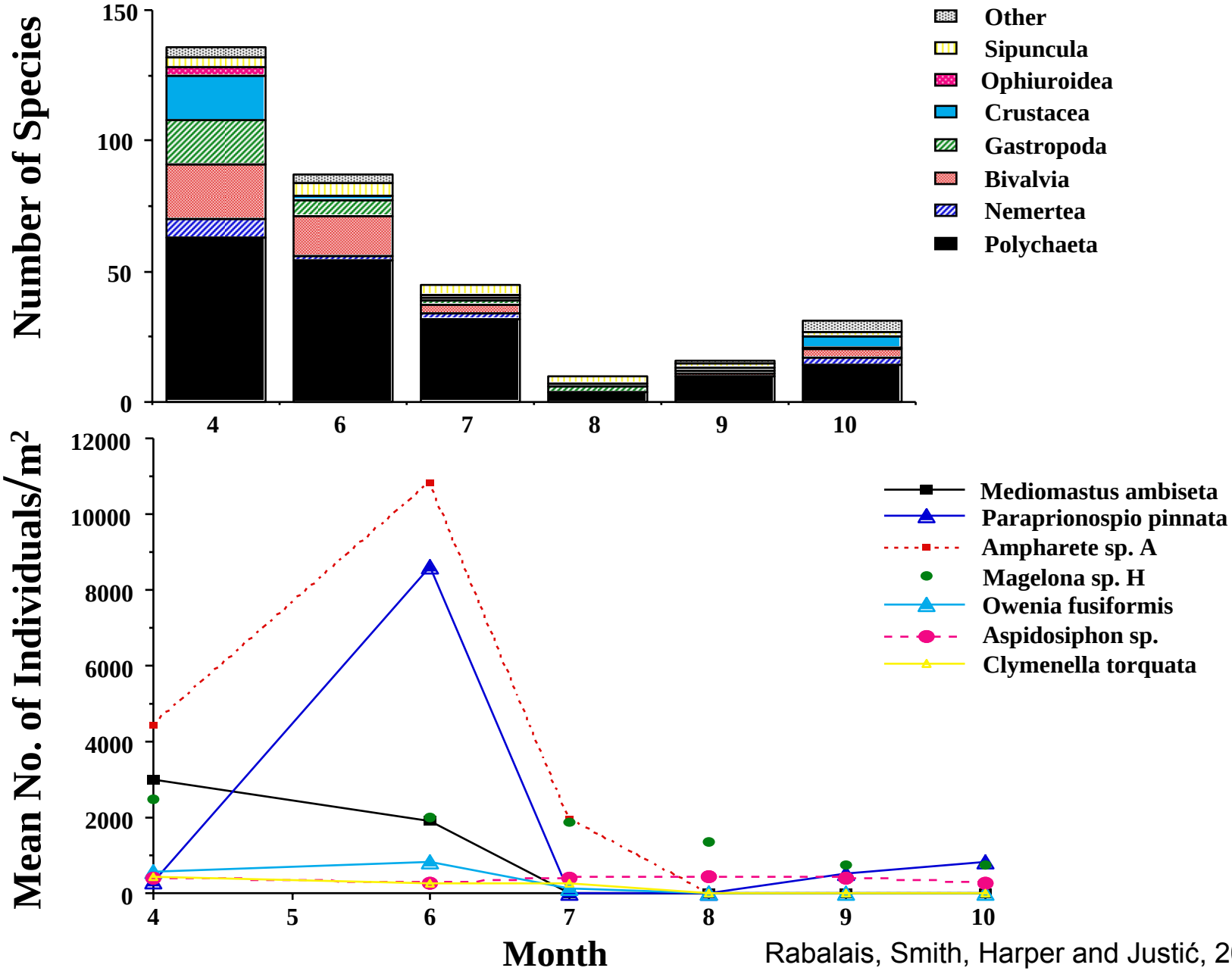

Rabalais, Smith, Harper and Justić, 2001

# South Timbalier 53B



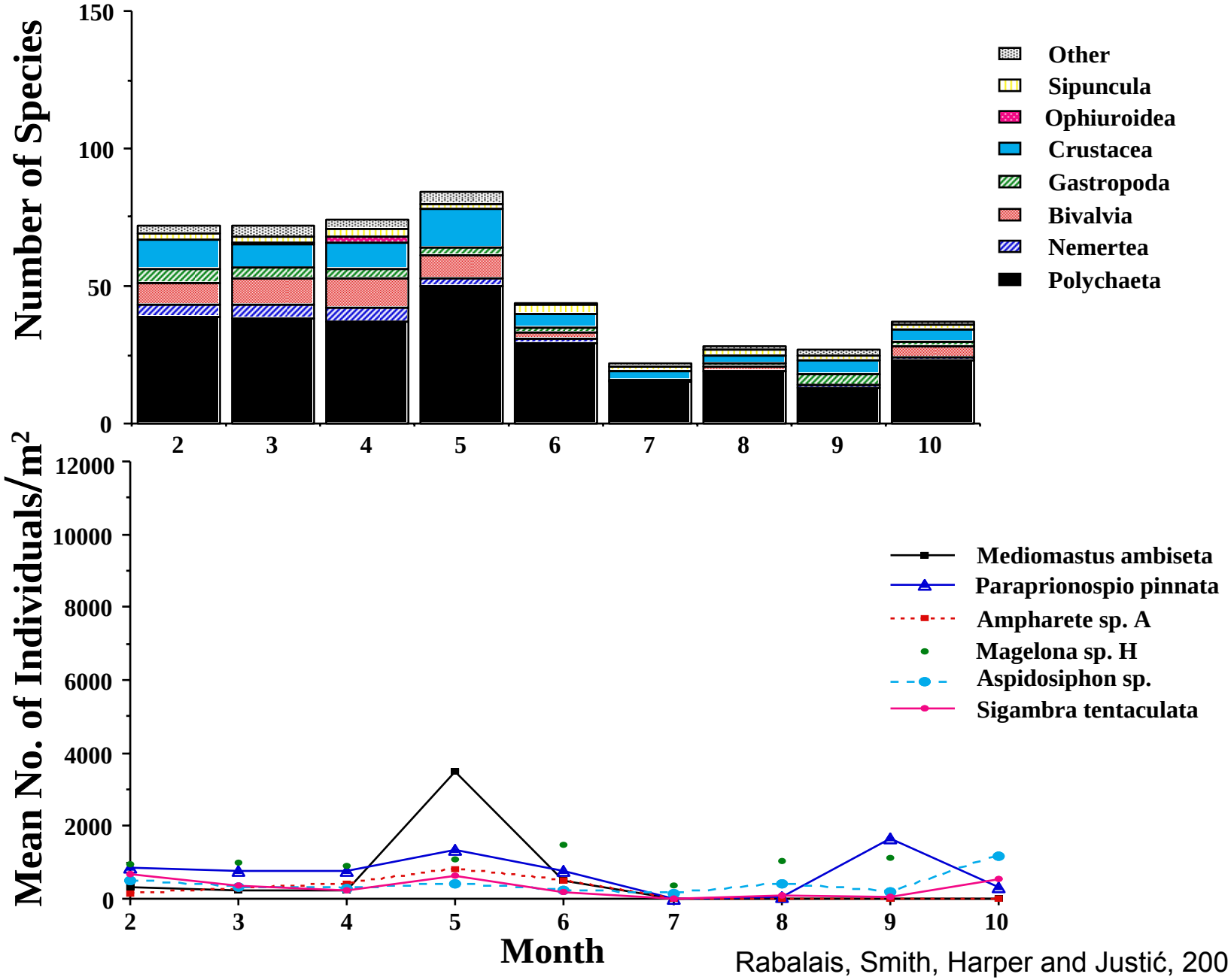

Rabalais, Smith, Harper and Justić, 2001

# 1990 Taxonomic Composition of South Timbalier 53B

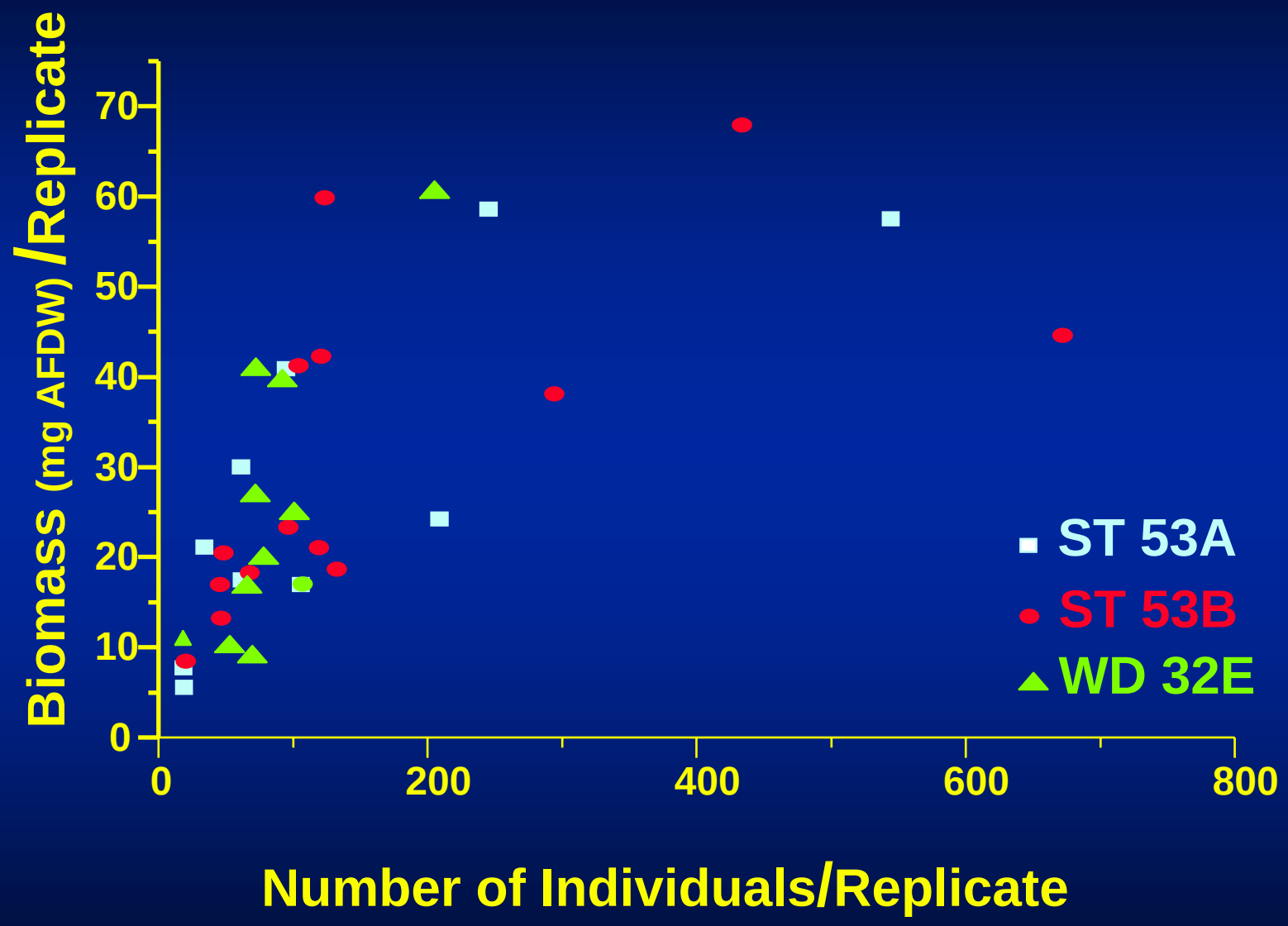



Rabalais, Smith, Harper and Justić, 2001

# 1991 Taxonomic Composition of South Timbalier 53B



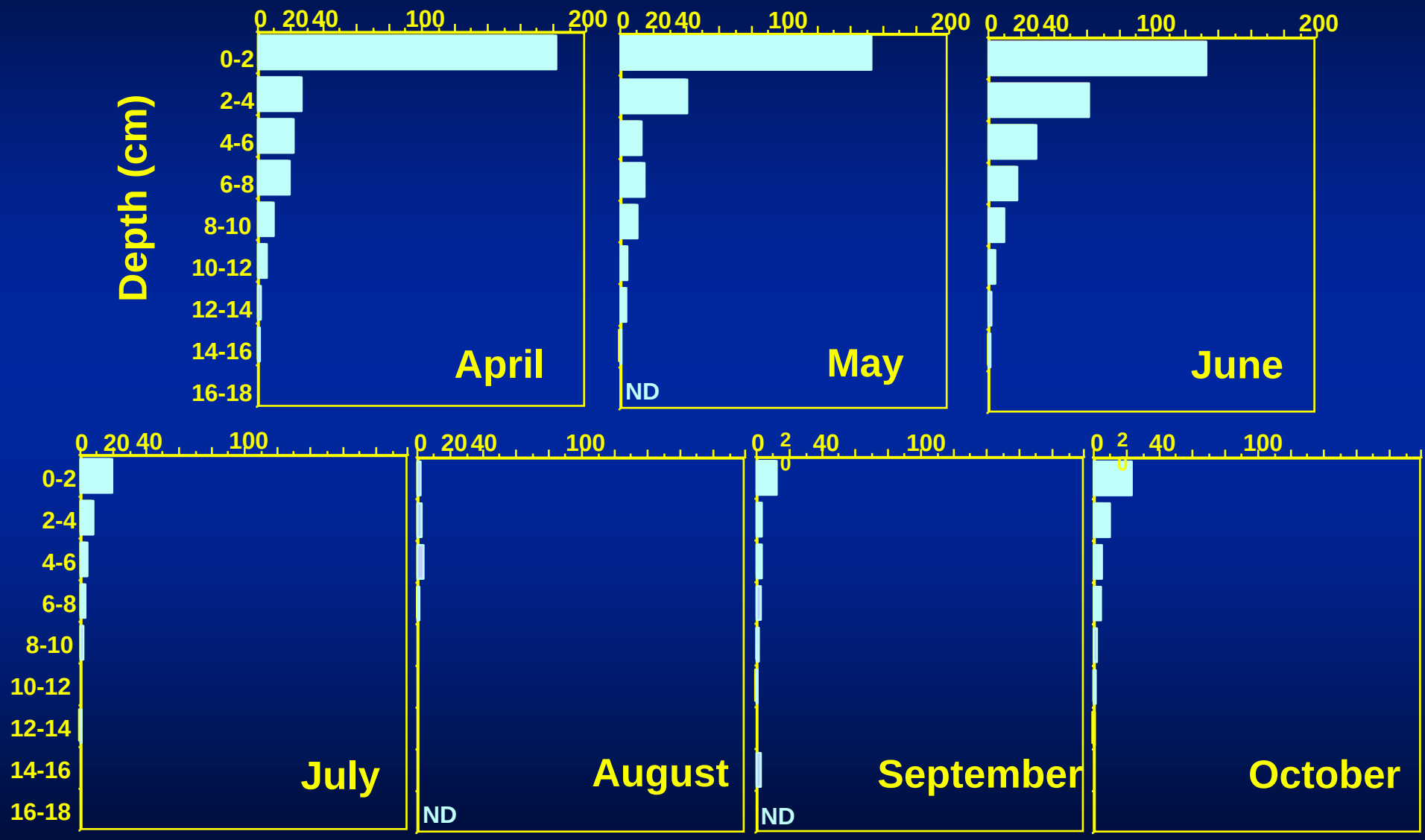

Rabalais, Smith, Harper and Justić, 2001




Rabalais, Smith, Harper and Justić, 2001

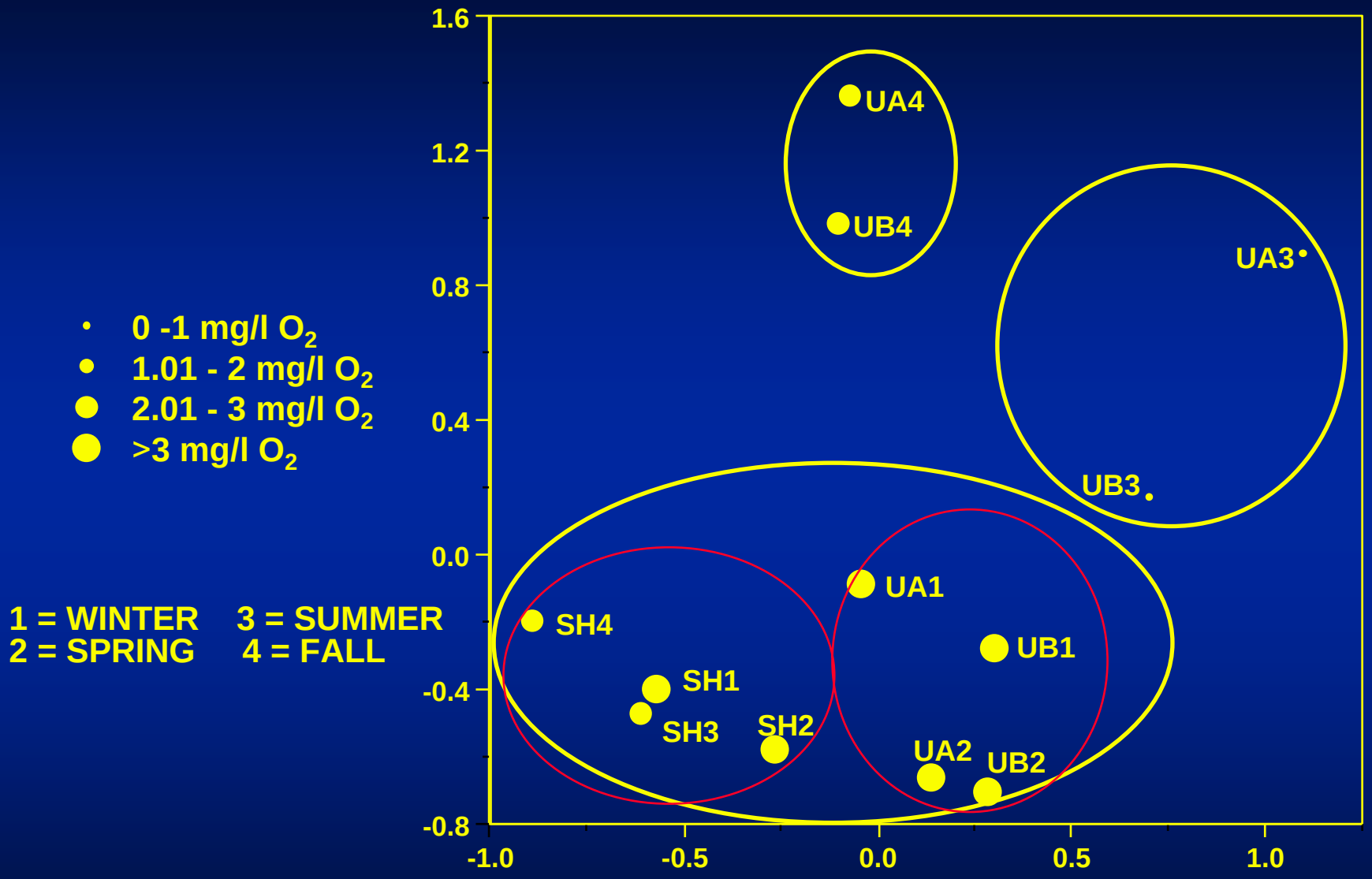
1990

# Mean Number of Individuals




Rabalais, Smith, Harper and Justić, 2001

Results of the nonlinear multidimensional scaling analysis on matrix 'SEASON' with superimposed bottom dissolved oxygen (mg/l).




Rabalais, Smith, Harper and Justić, 2001

# Comparison of benthic communities from hypoxia-affected environments

| Dauer et al. (1992) | Chesapeake Mainstem | | Tributaries | |
|---|---|---|---|---|
| | Polyhaline | Hypoxic | Mesohaline | Hypoxic |
| Density (no. $m^{-2}$) | 1,978 | 1,723 | 3,065 | 902 |
| Biomass (g AFDW $m^{-2}$) | 9.9 | 1.7 | 2.5 | 1.1 |
| Species (no. $sample^{-1}$) | 10.3 | 6.0 | 8.8 | 4.3 |

| Rabalais et al. (1993) | Louisiana Shelf Periodic Hypoxia | | Louisiana Shelf Seasonally Severe Hypoxia | |
|---|---|---|---|---|
| | Spring | | Spring | Hypoxic |
| | April 1990 | | April 1990 | Jul-Aug 1990 |
| Density (no. $m^{-2}$) | 8,637 | | 18,437 | 730 |
| Biomass (g AFDW $m^{-2}$) | 2.59 | | 2.92 | 0.23 |
| Biomass (g C $m^{-2}$) | 1.30 | | 1.46 | 0.10 |
| Species (no. $sample^{-1}$) | 22.1 | | 51.4 | 3.6 |
| | Feb-May 1991 | | Feb-May 1991 | Jul-Aug 1991 |
| Density (no. $m^{-2}$) | 2,873 | | 6,486 | 1,346 |
| Biomass (g AFDW $m^{-2}$) | 0.93 | | 1.55 | 0.46 |
| Biomass (g C $m^{-2}$) | 0.46 | | 0.77 | 0.23 |
| Species (no. $sample^{-1}$) | 16.2 | | 21.5 | 8.1 |

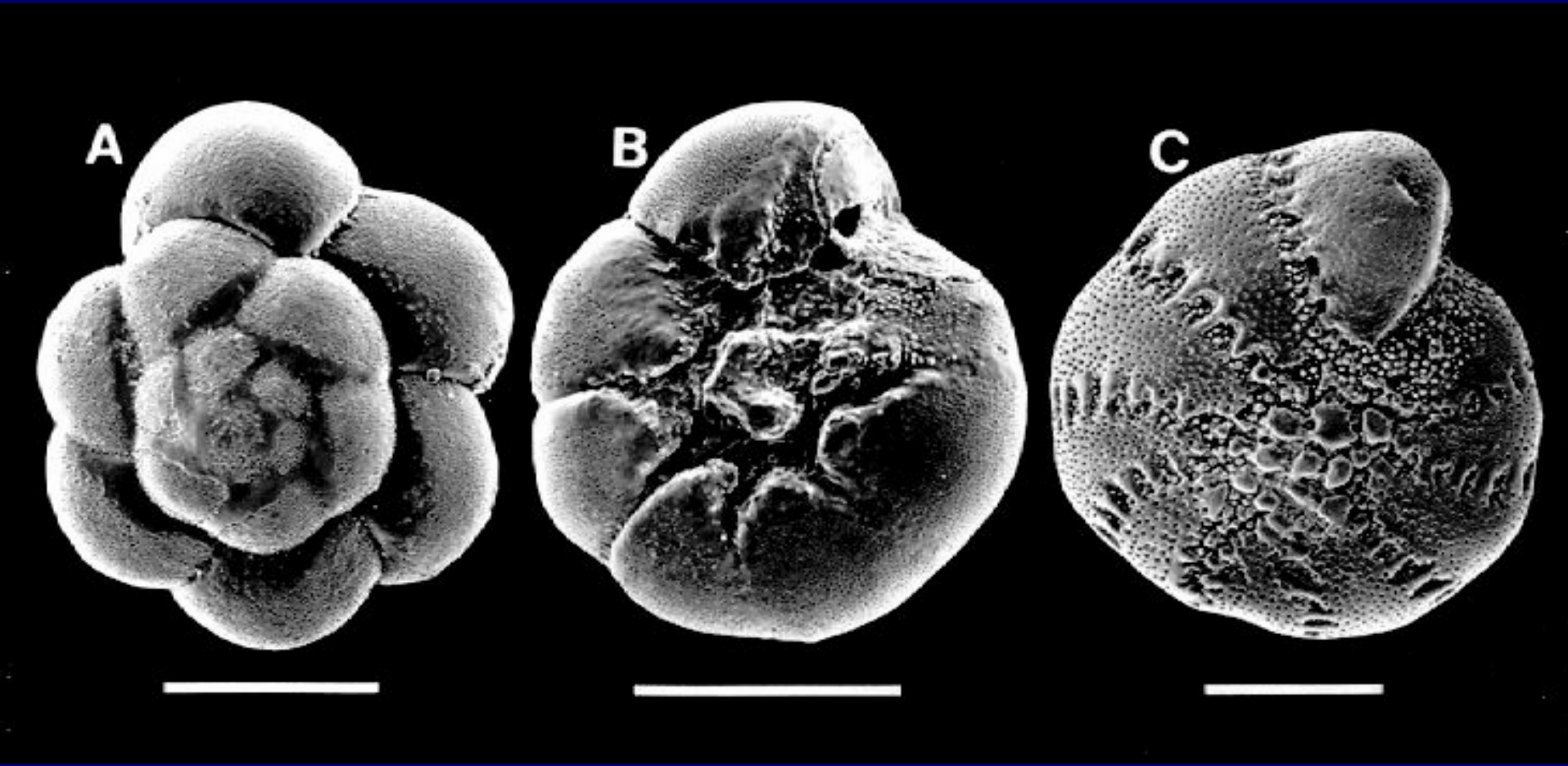
Rabalais, Smith, Harper and Justić, 2001

# Characteristics of Louisiana Shelf Benthos Subjected to Seasonally Severe Hypoxia

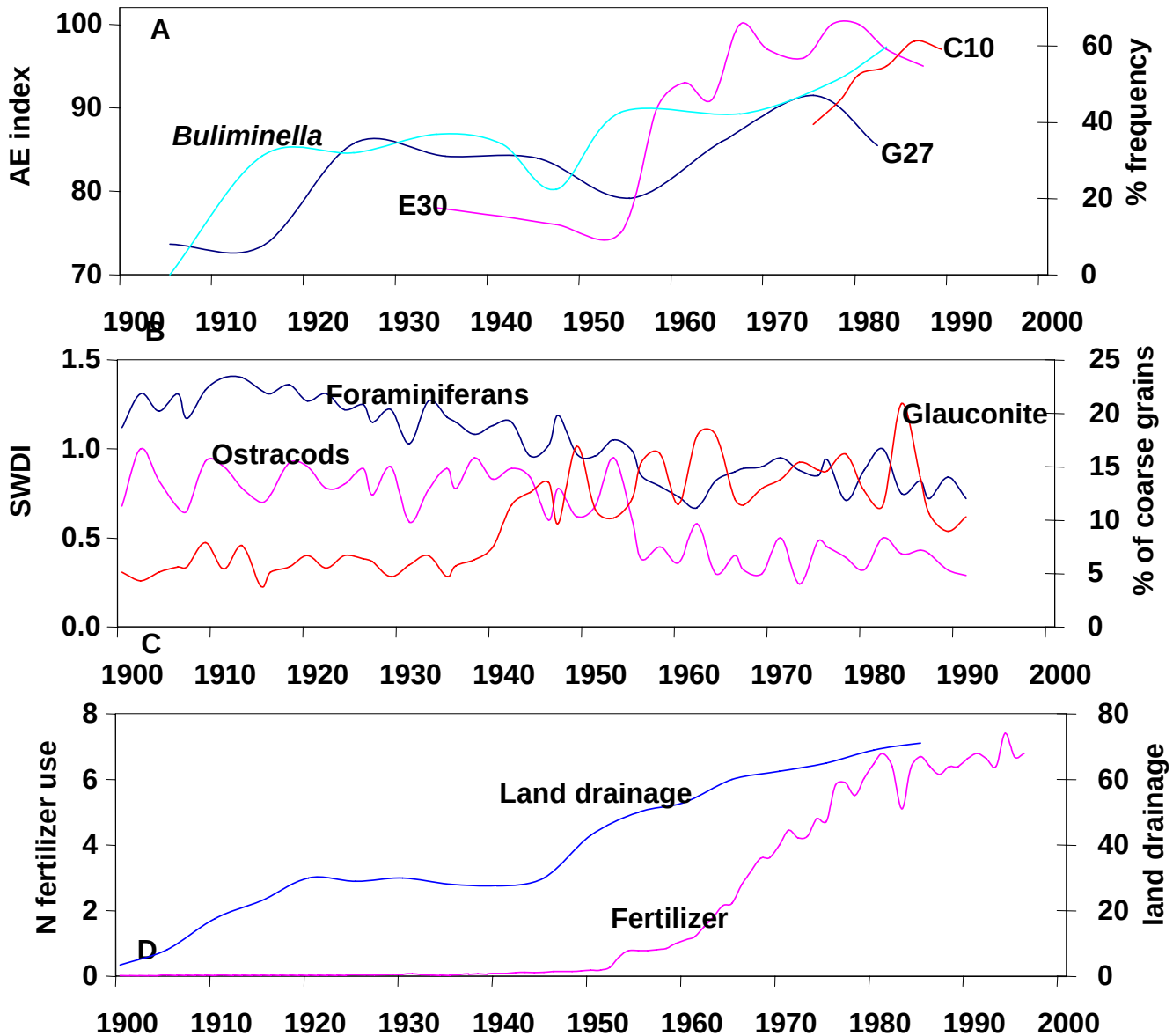
- Reduced species richness
- Severely reduced abundances (but never azoic)
- Low biomass
- Limited fauna (none with direct development)
- Characteristic resistant infauna (e.g., a few polychaetes and sipunculans)
- Limited recovery following abatement of oxygen stress

Rabalais, Smith, Harper and Justić, 2001

# Benthic Foraminiferans: Tolerant or Intolerant of Low Oxygen




(Photo Source: Barun Sen Gupta)




**Hypoxia Index ↑**

**Reducing Envt. ↑**
**Benthic Diversity ↓**

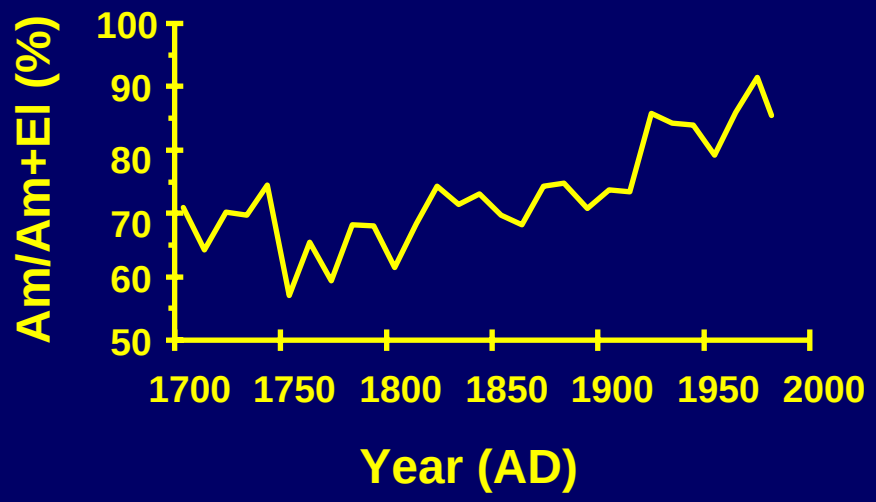
**N Inputs &**
**Land Drainage ↑**

Rabalais et al. (2002)

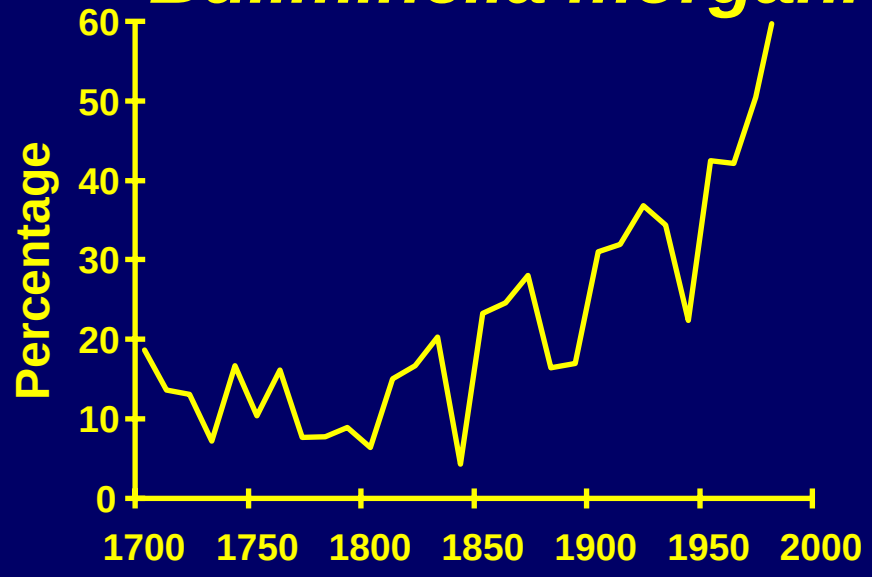
# Core G27

## *Ammonial*

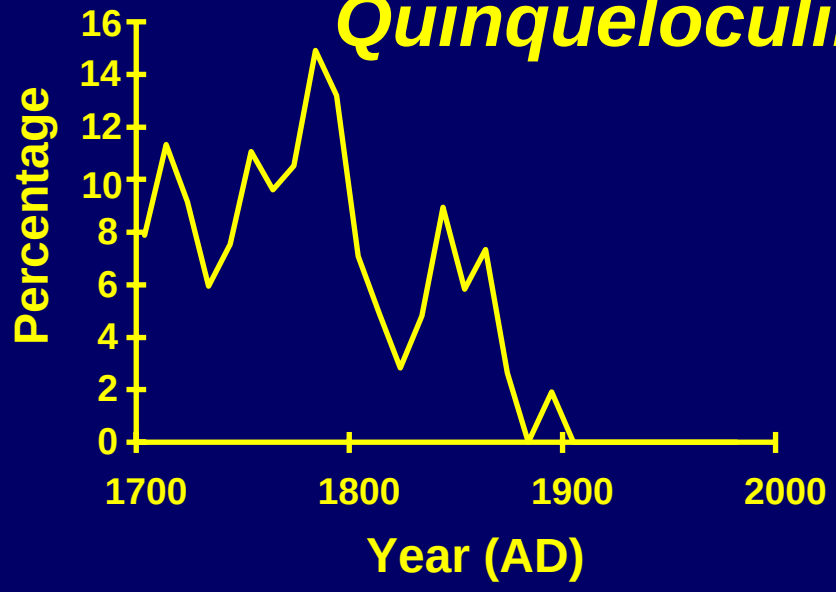
(*Ammonia* +*Elphidium*)x100




## *Buliminella morgani*




## *Quinqueloculina*




Rabalais et al. 2006, Sen Gupta et al. 2006)

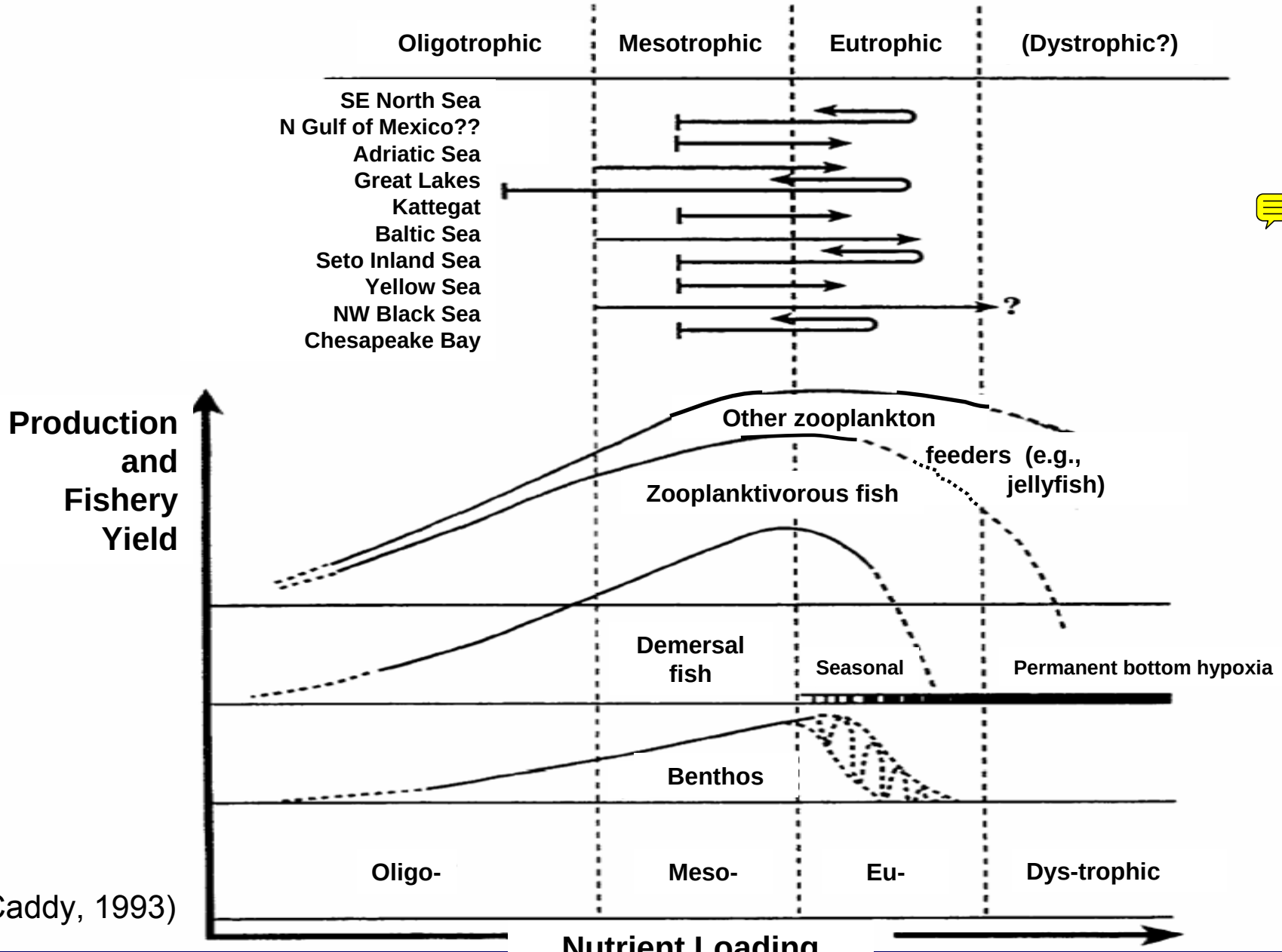
# Session 4:

# Hypoxia Effects on Ecosystems

# General Discussion

# More Nutrients
# More Fish
# Up to a Point….

(Photo: Kevin Craig)


Oligotrophic
Mesotrophic
Eutrophic
(Dystrophic?)
SE North Sea
N Gulf of Mexico??
Adriatic Sea
Great Lakes
Kattegat
Baltic Sea
Seto Inland Sea
Yellow Sea
NW Black Sea
Chesapeake Bay
?
Production and Fishery Yield
Other zooplankton feeders (e.g., jellyfish)
Zooplanktivorous fish
Demersal fish
Seasonal
Permanent bottom hypoxia
Benthos
Oligo-
Meso-
Eu-
Dys-trophic
Nutrient Loading

(Caddy, 1993)

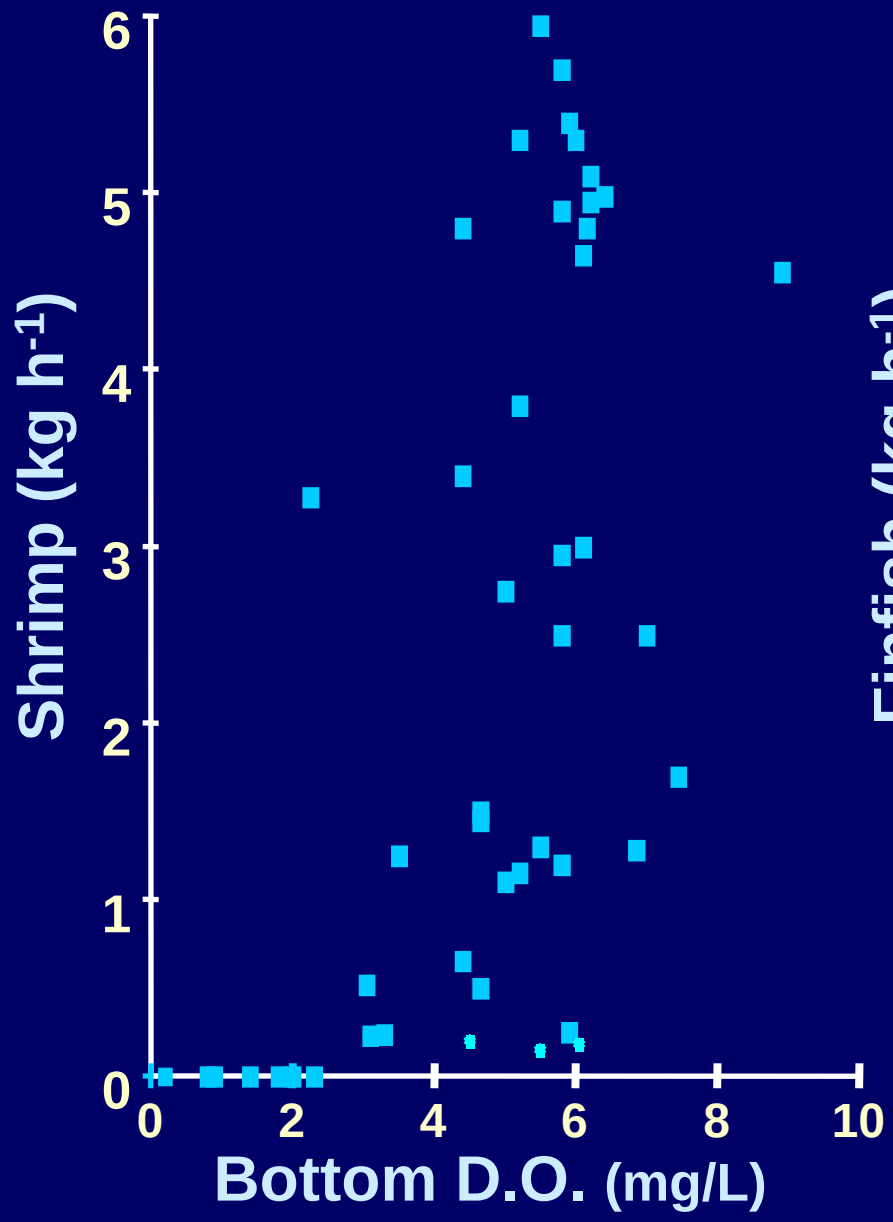
# 2° Production in Benthos Implications for Fisheries

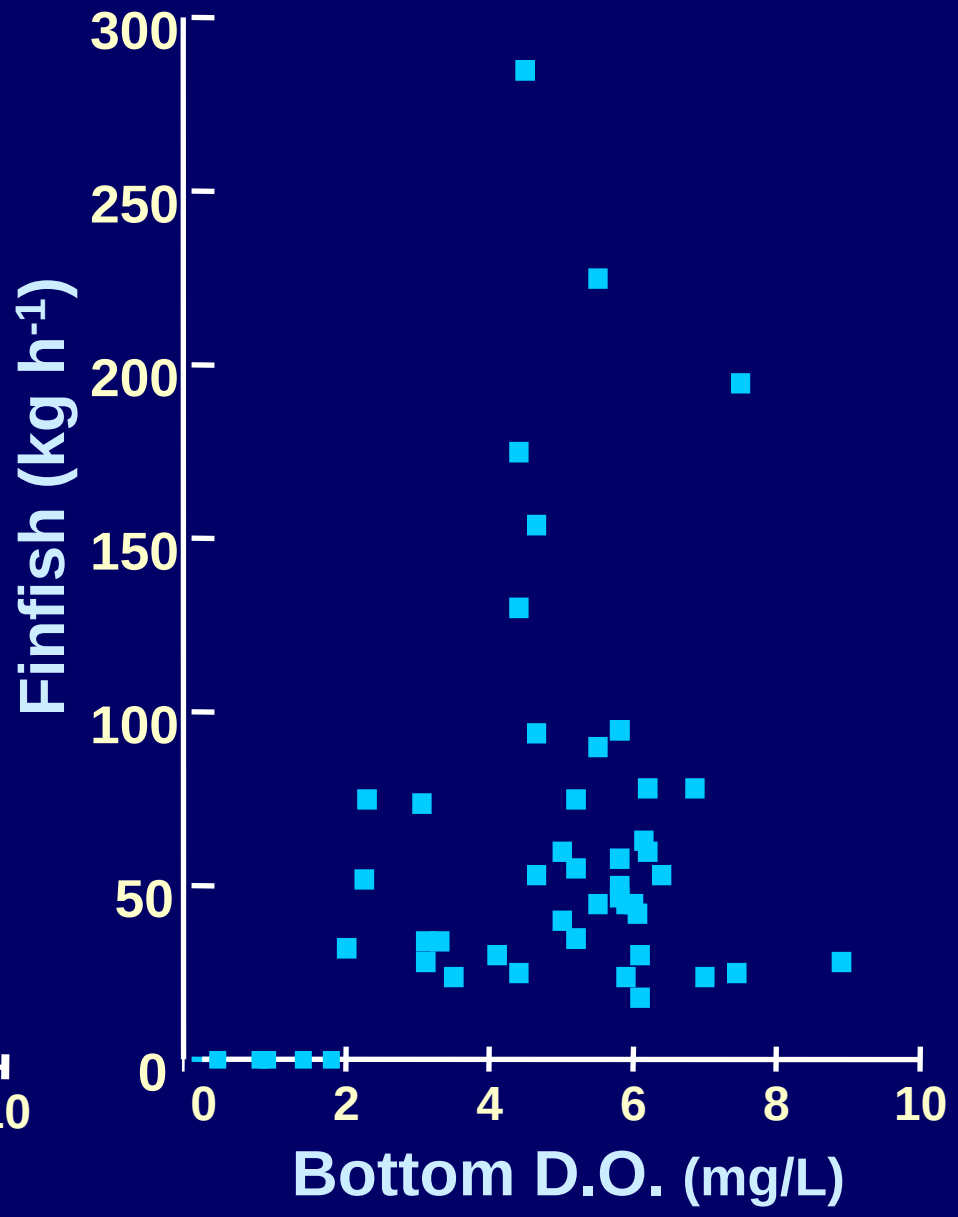
- Temporally & spatially enhanced
- Enhanced predation
  - Marginally
  - As stress increases
- High post-hypoxia recruitment
- High turnover rates & ultimately higher production
- Higher yield

- Prolonged, severe faunal depression, large areas
- Predators excluded
  - Stressed fauna intact
  - Suitable habitat absent
- Low post-hypoxia recruitment
- Turnover rates similar, biomass less, overall production lower
- Lower yield

(Source: Nancy Rabalais, LUMCON)

# Hypoxia = Dissolved $O_2$ < 2 mg/L (=2 ppm)




(data from Leming and Stuntz, 1984; SW Louis. Coast, June 1982)

# Effects of Hypoxia on Fisheries Resources

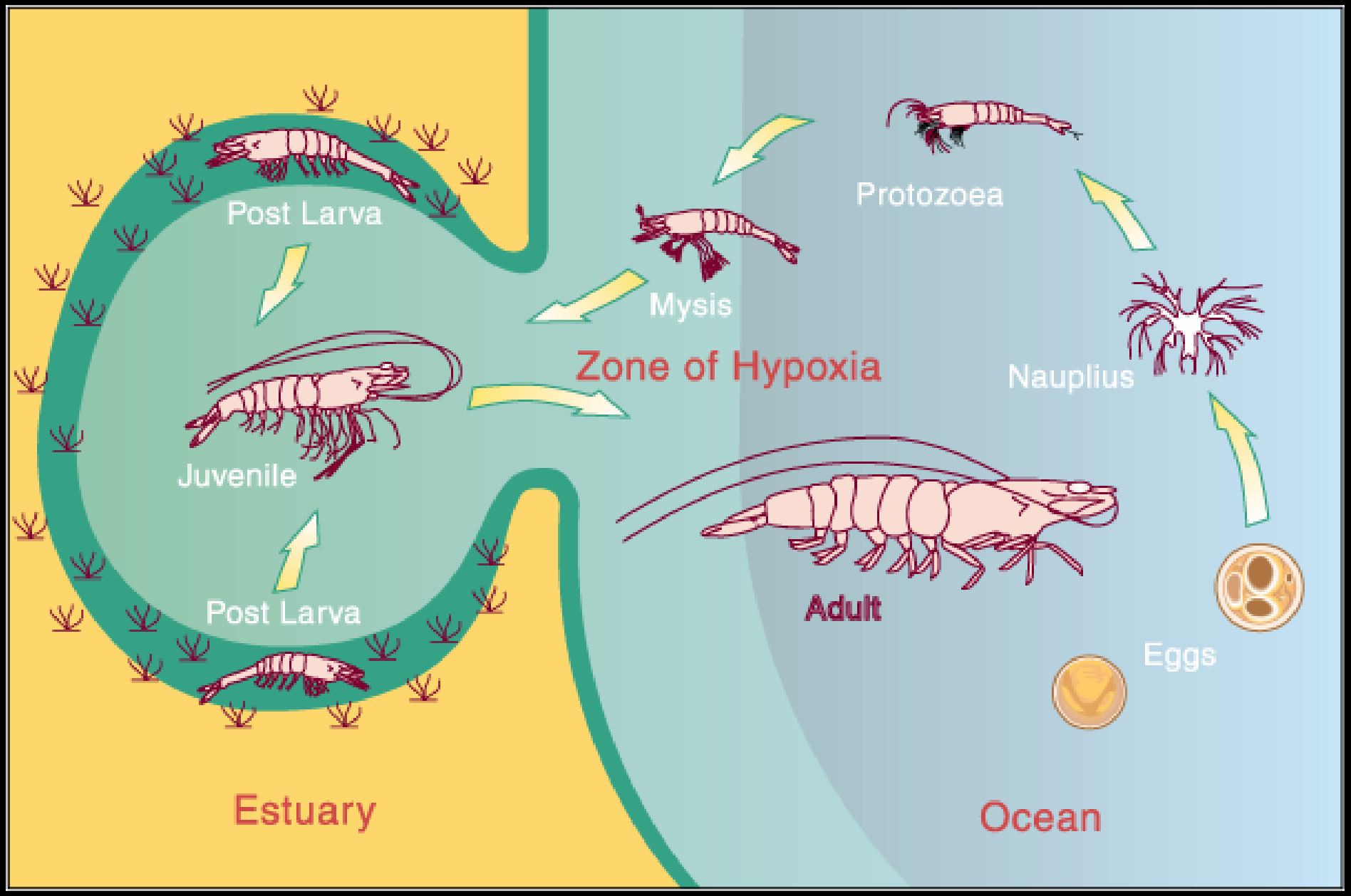
- Direct mortality
- Altered migration
- Reduction in suitable habitat
- Increased susceptibility to predation
- Changes in food resources
- Susceptibility of early life stages

(Photo: Kerry M. St. Pe)

Photo Dead Polychaete

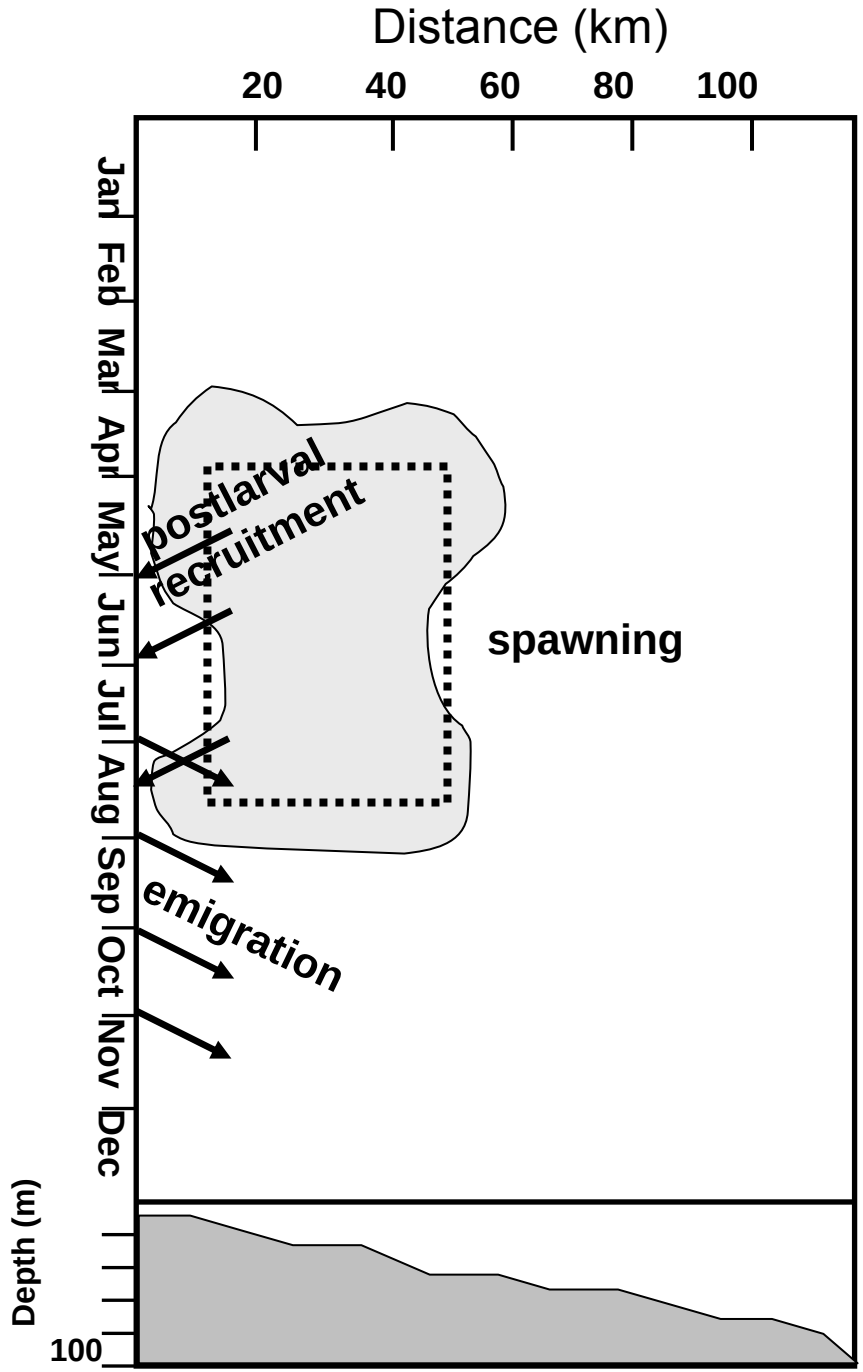
Photo Dead Spider Crab

(Rabalais et al., 2001)



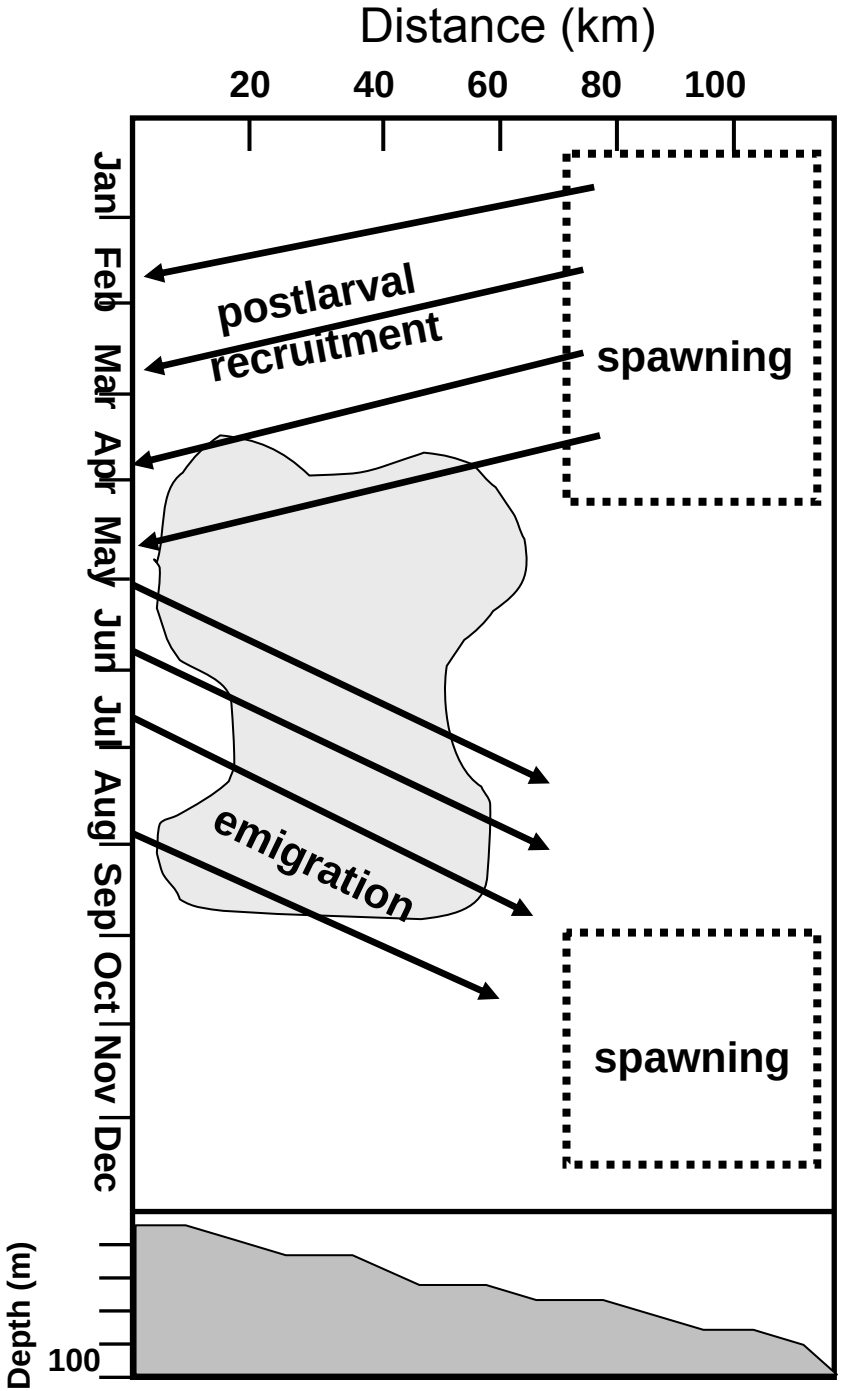

(Downing et al., 1999)

***Litopenaeus setiferus***
**White Shrimp**



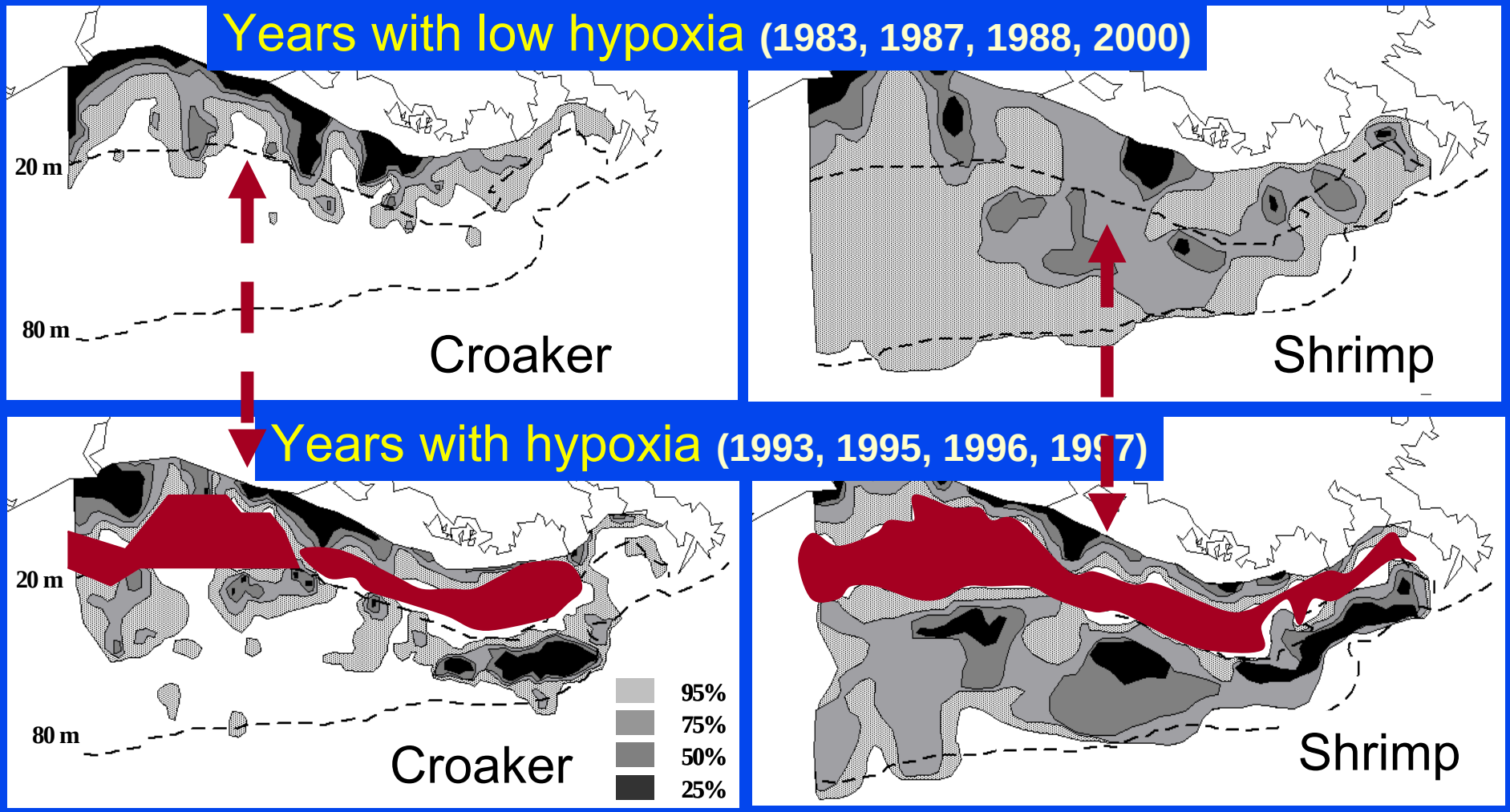

**(Source: Nancy Rabalais, LUMCON)**

***Farfantepenaeus aztecus***
**Brown Shrimp**




**(Source: Nancy Rabalais, LUMCON)**

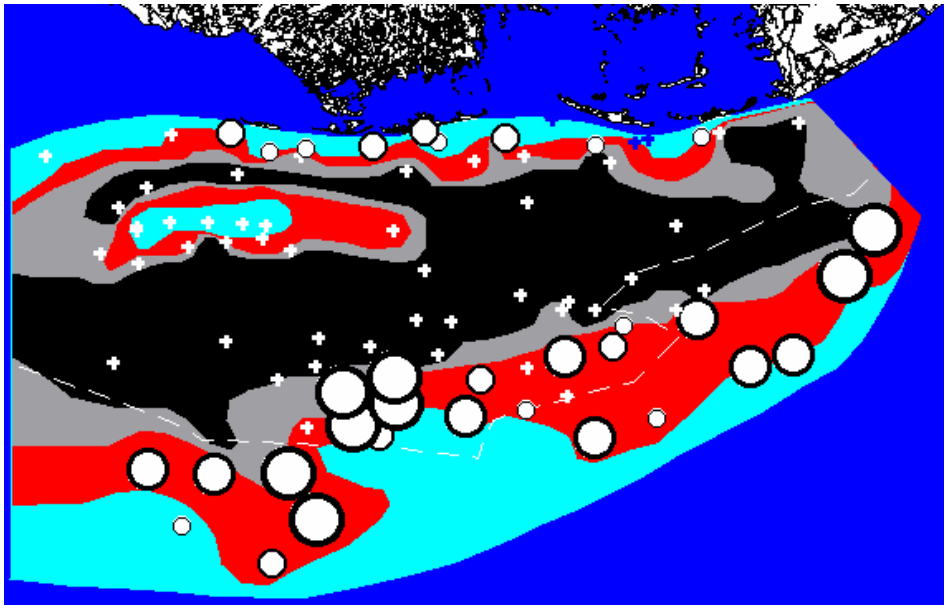
# Fisheries: bottom-feeding fish (croaker) and shrimp densities



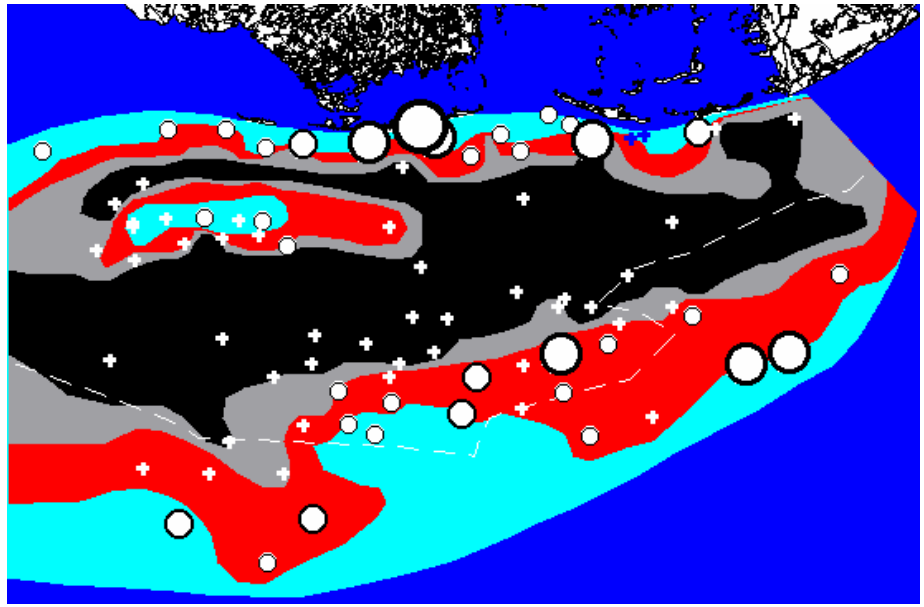

(Craig et al. 2005)

# NGOMEX02 Cruise

## Atlantic croaker



## Brown shrimp



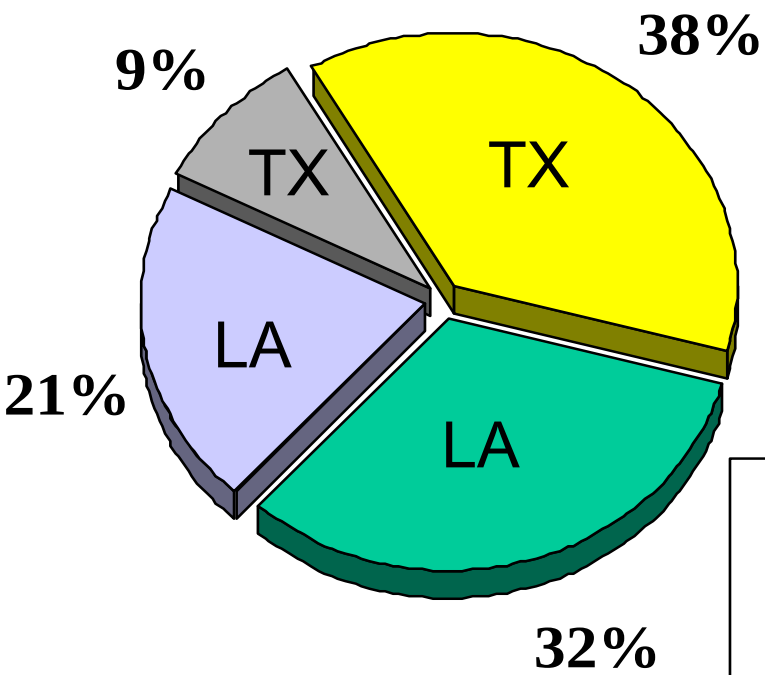
**Dissolved oxygen (mg/l)**

- 0-1
- 1-2
- 2-4
- >4

**Catch percentiles**

- + 0
- 1-25%
- 25-50%
- 50-75%
- 75-100%

(Craig et al., 2005)




Inshore = the area from the beach inland, e.g., bays and wetlands.

Offshore = the area from the beach out.

- **Texas Offshore $\overline{X}$= 25.2**
- **Louisiana Offshore $\overline{X}$ =22.2**
- **Louisiana Inshore $\overline{X}$ = 14.3**
- **Texas Inshore $\overline{X}$ =6.31**

Western Gulf of Mexico Brown Shrimp Landings in Millions of Pounds 1986 -2003.

**(Source: Roger Zimmerman, NMFS)**

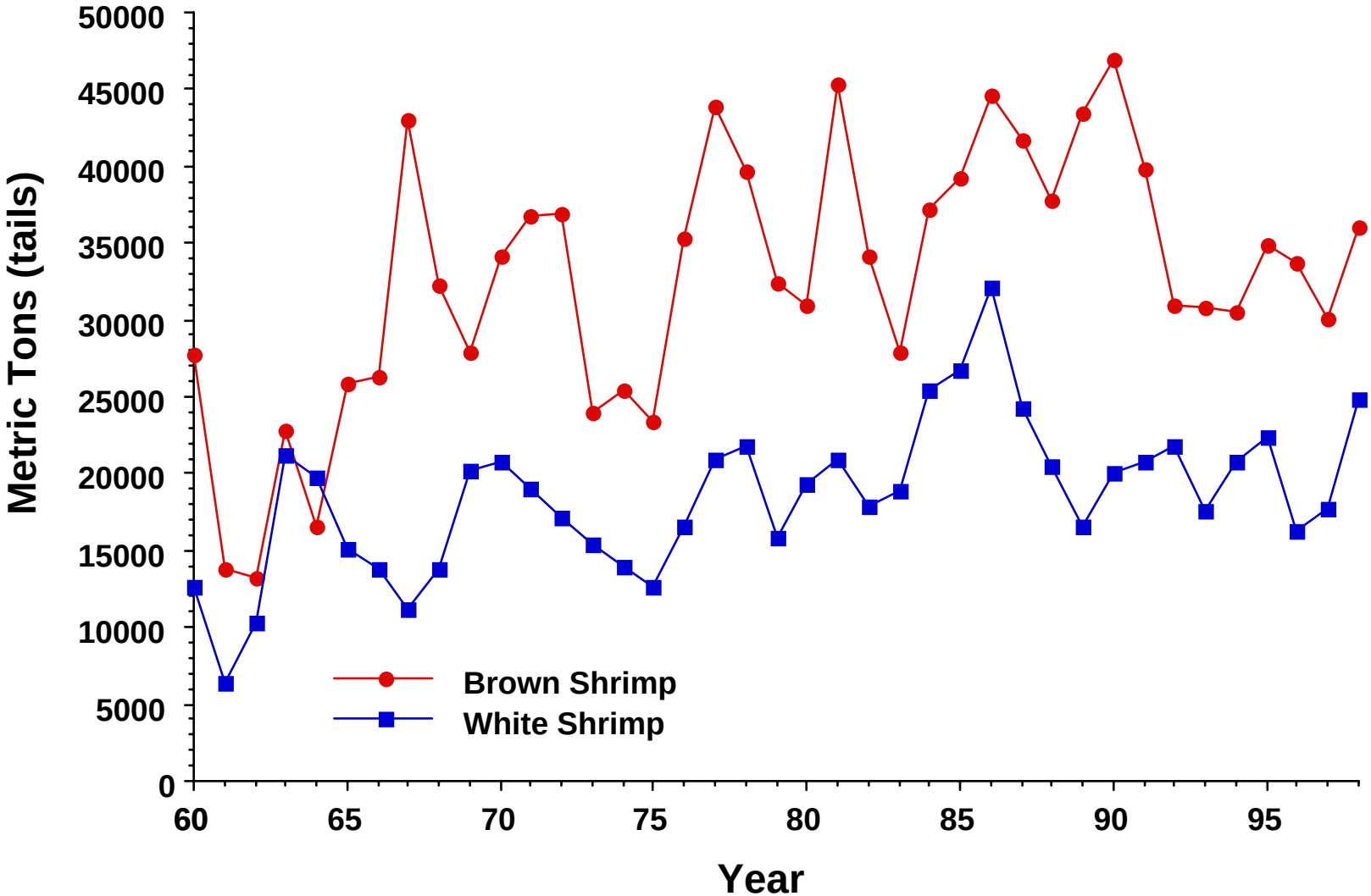



Figure 3. Trends in annual catch of brown shrimp and white shrimp in the western Gulf of Mexico, 1960-1998 (total weight of shrimp tails caught in Texas and Louisiana waters).

**(Zimmerman and Nance, 2001)**

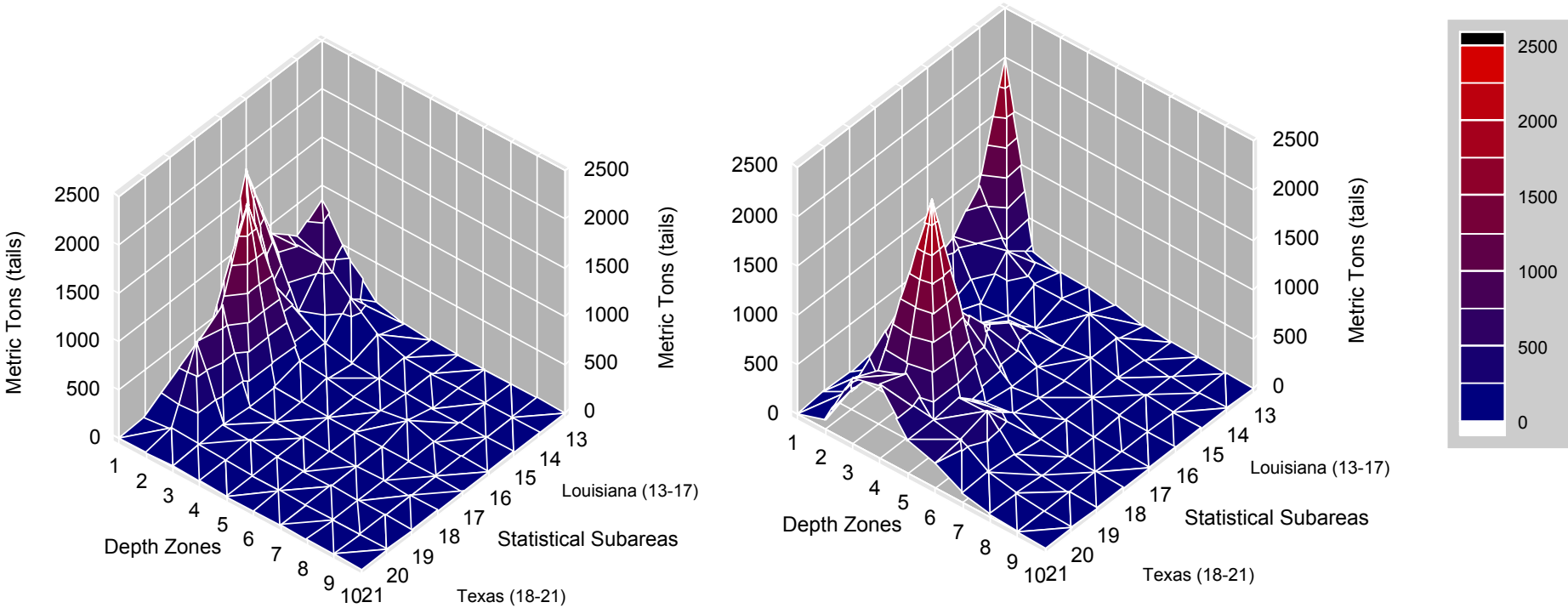



Figure 4a. Mean annual catch of white shrimp (L) and brown shrimp )R) by subarea/depth location cell in the western Gulf of Mexico, during the 1992-1998 interval of expanded hypoxia on the Louisiana shelf. Subarea designations extend from the mouth of the Mississippi (Subarea 13) to the mouth of the Rio Grande (Subarea 21). Depth zones are in 5-fm (9-m) increments.

**(Zimmerman and Nance, 2001)**

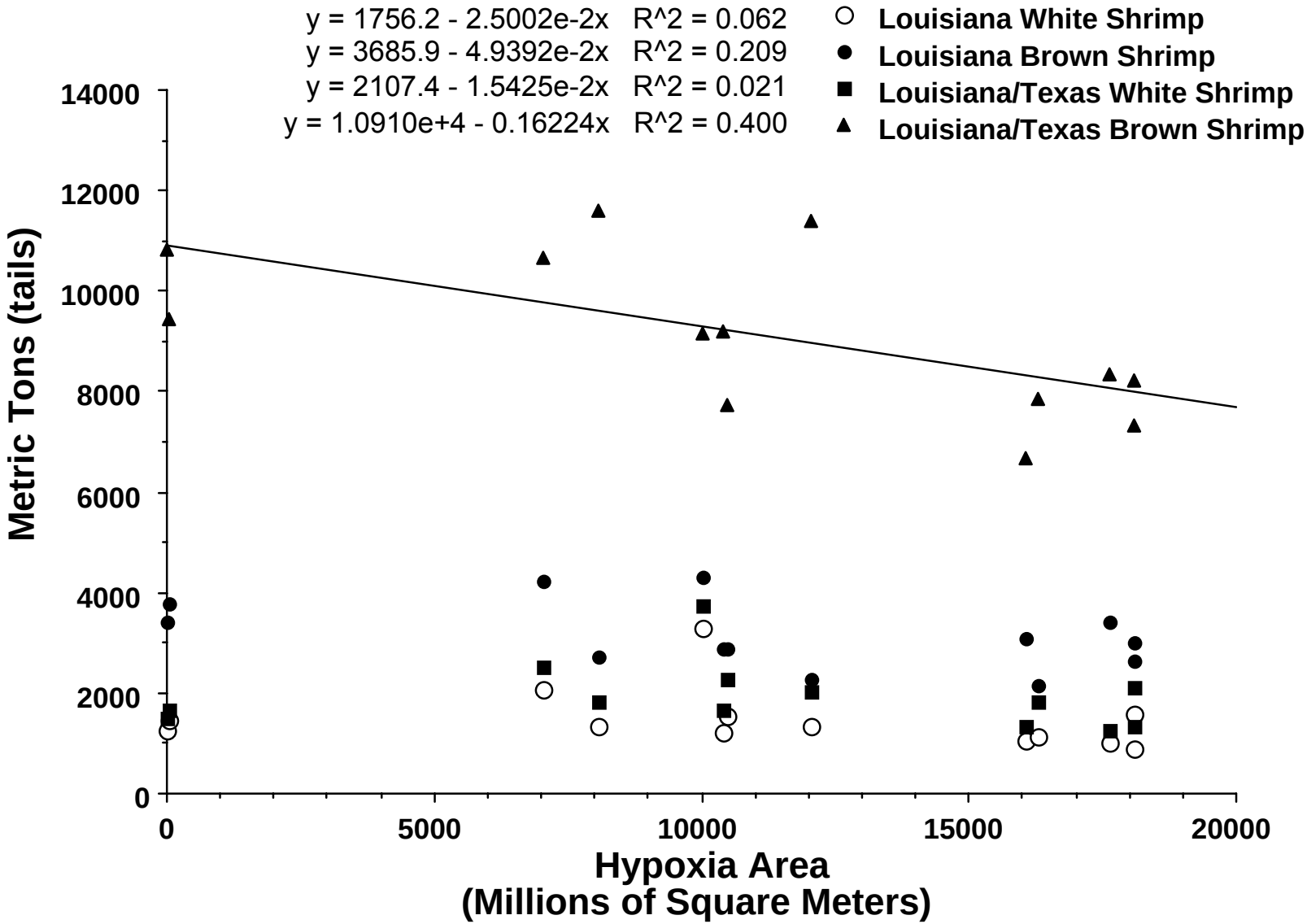
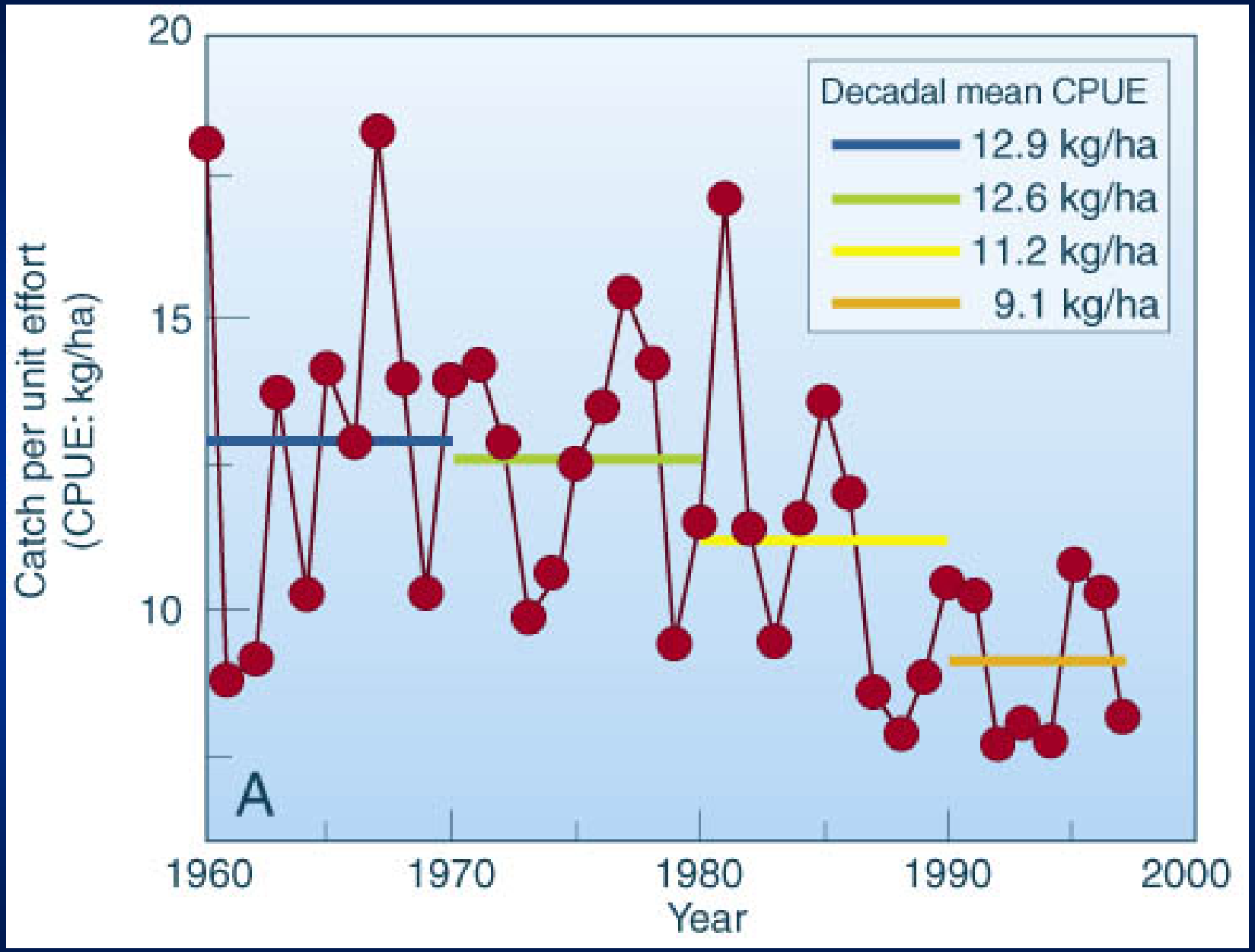



Figure 6. July and August brown shrimp catch from Texas and Louisiana versus relative size of the hypoxic zone on the Louisiana shelf during the years from 1985 through 1997. **(Zimmerman and Nance, 2001)**




(Downing et al., 1999)

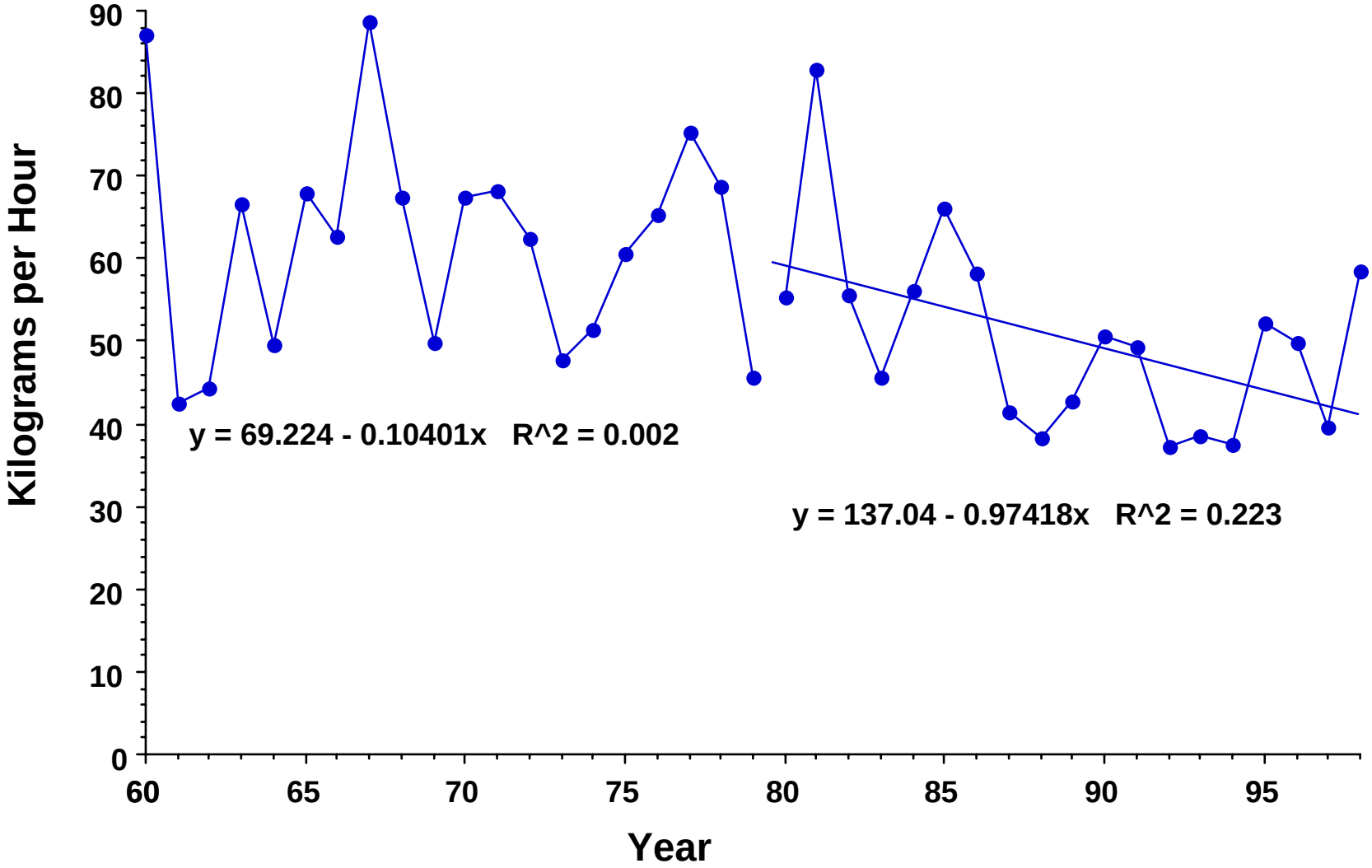
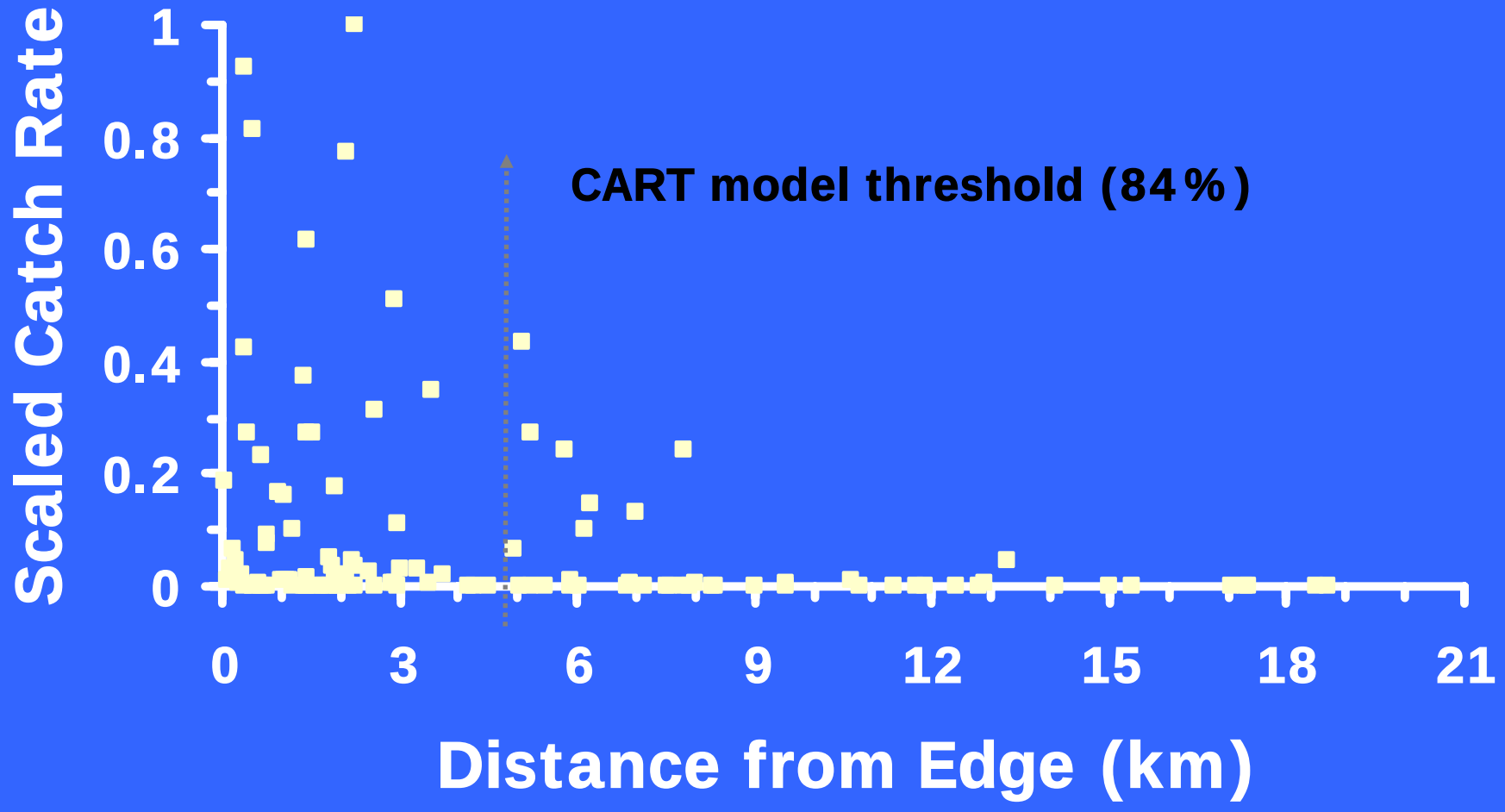



Figure 7. Trend in annual brown shrimp catch per unit effort (CPUE) from Texas and Louisiana from 1960 through 1998. **(Zimmerman and Nance, 2001)**

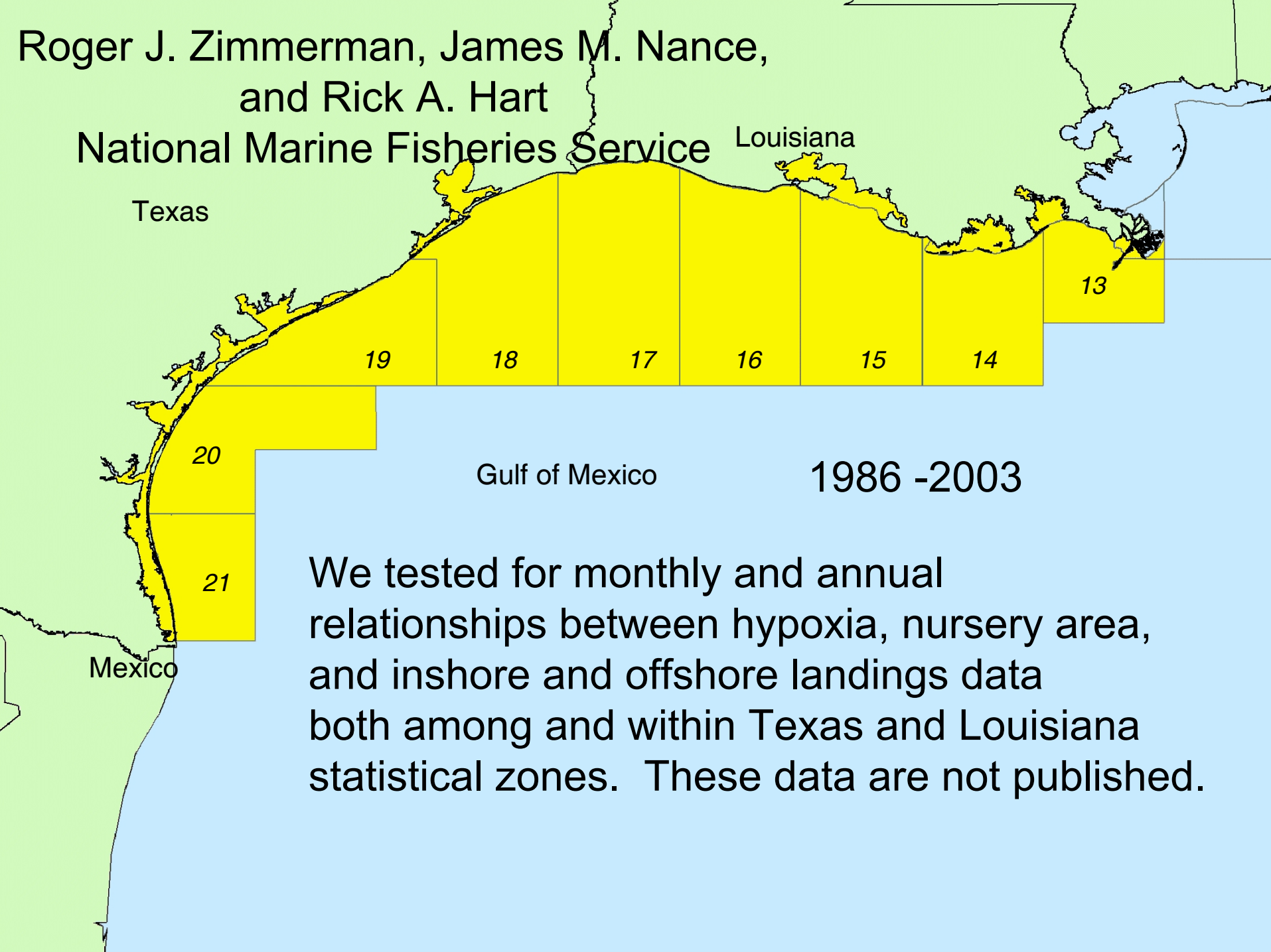
# Hypoxia Edge Effects




(Kevin Craig, unpubl. data)

**Neutral lipids in the hepatopancreas of brown shrimp is lower when the dissolved oxygen in low in 2002 data, but there was no difference in the 2003 data. (Kevin Craig, unpubl. data)**

Roger J. Zimmerman, James M. Nance,
and Rick A. Hart
National Marine Fisheries Service

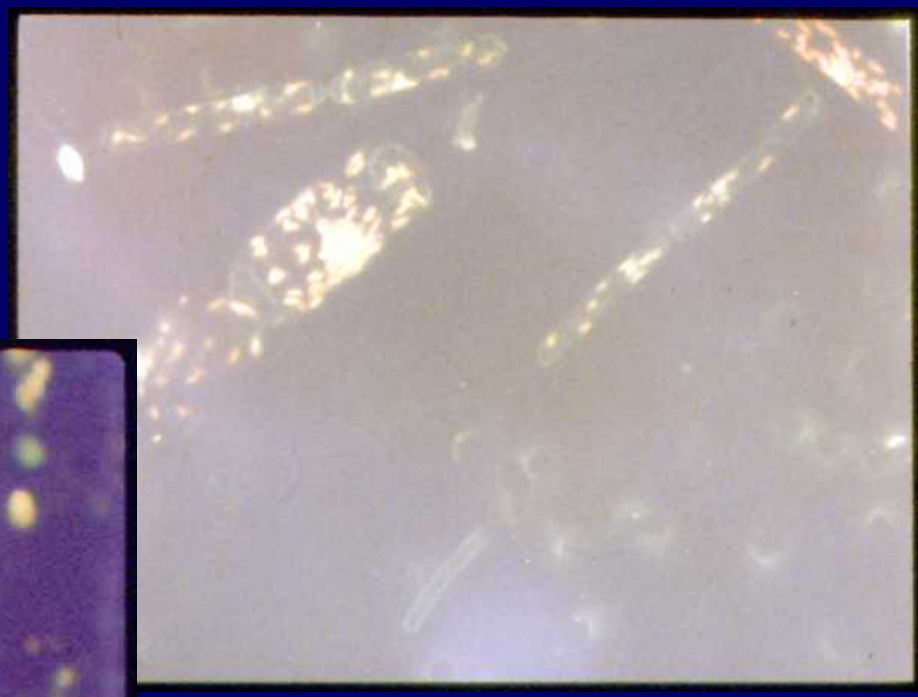


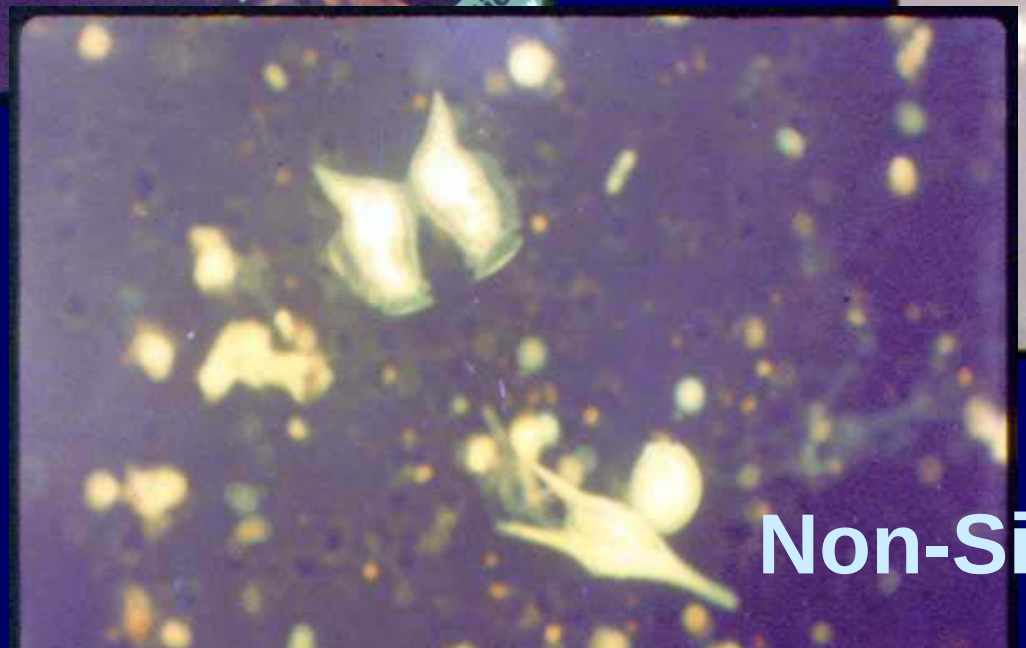

1986 -2003

We tested for monthly and annual relationships between hypoxia, nursery area, and inshore and offshore landings data both among and within Texas and Louisiana statistical zones. These data are not published.

## Heavily Silicified Diatoms

## Lighlty Silicified Diatoms





## Non-Silicified, Flagellates

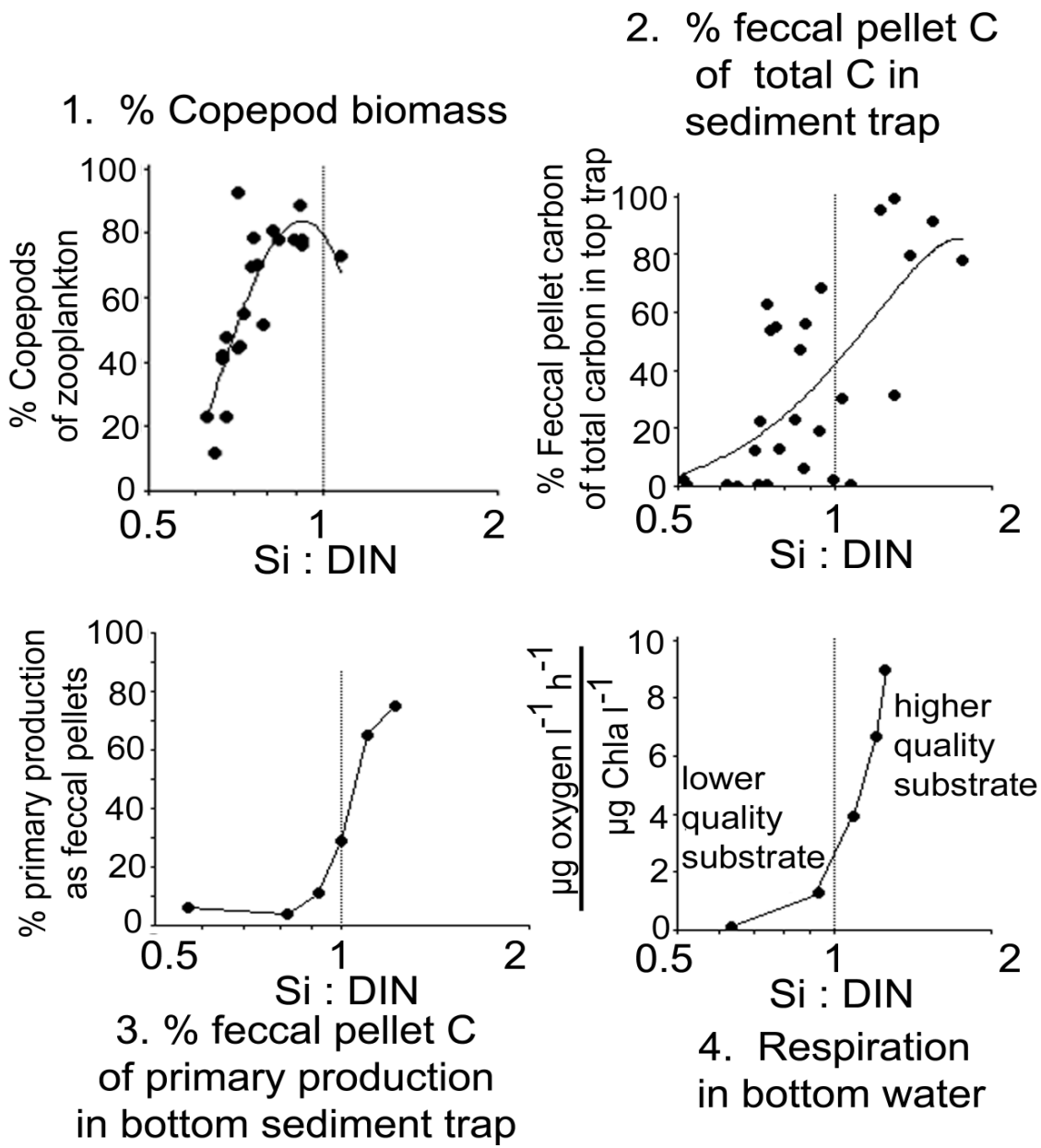
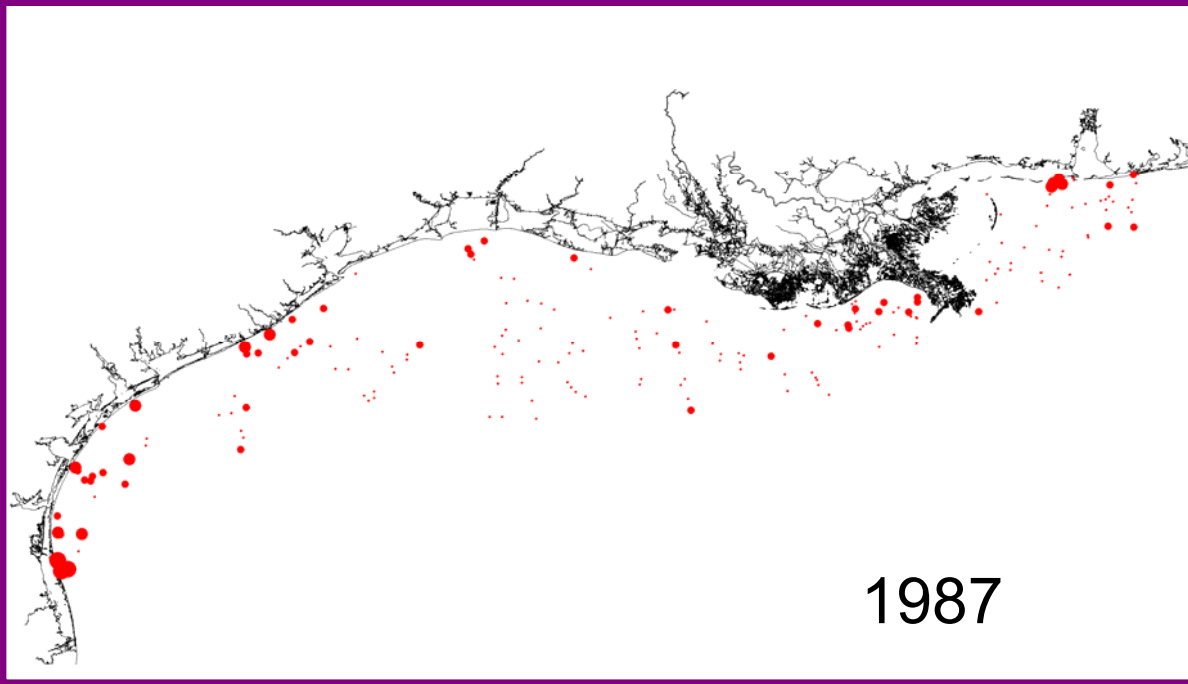


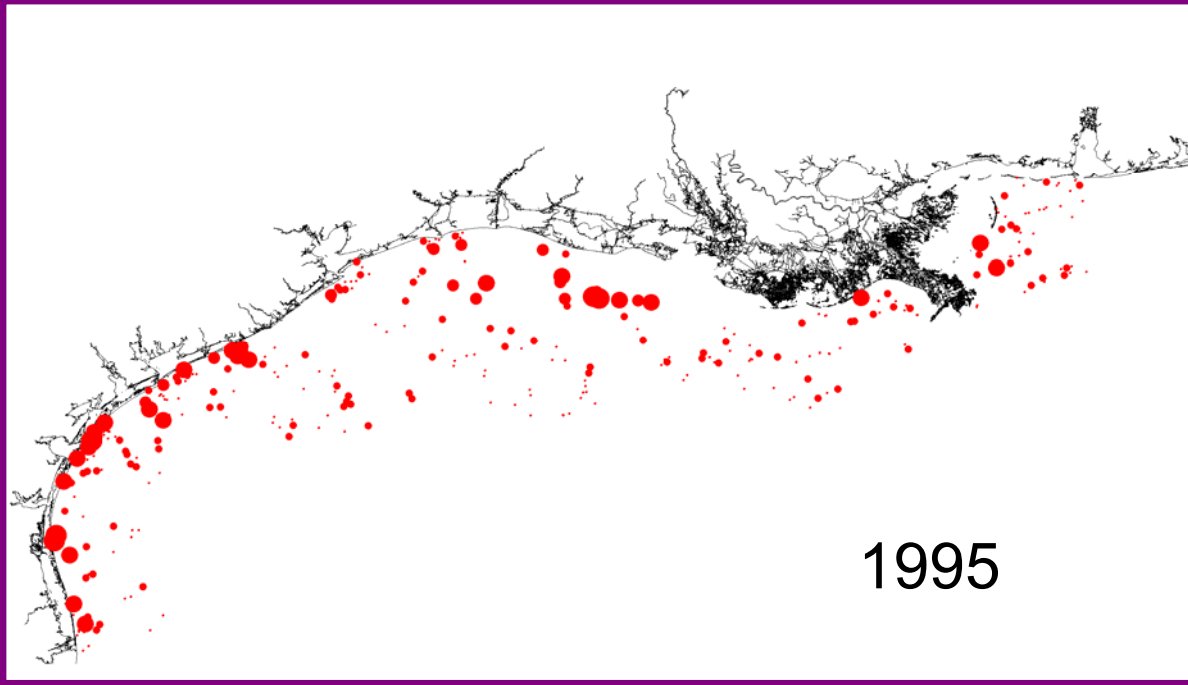

Fig. 16. Relationships between the average Si:DIN ratio for the preceding 90 d and 1: the percentage of zooplankton that were copepods; 2: the percent of carbon collected in the surface sediment trap that was fecal pellets; 3: the percentage of estimated water column phytoplankton production captured in a sediment trap as fecal pellets at 15 m (total depth = 20 m); and 4: the respiration rate per total Chl *a* in bottom water (adapted from Turner et al. 1998).

**(Turner et al., 1998)**

# Jellyfish abundance: an indicator of altered food webs

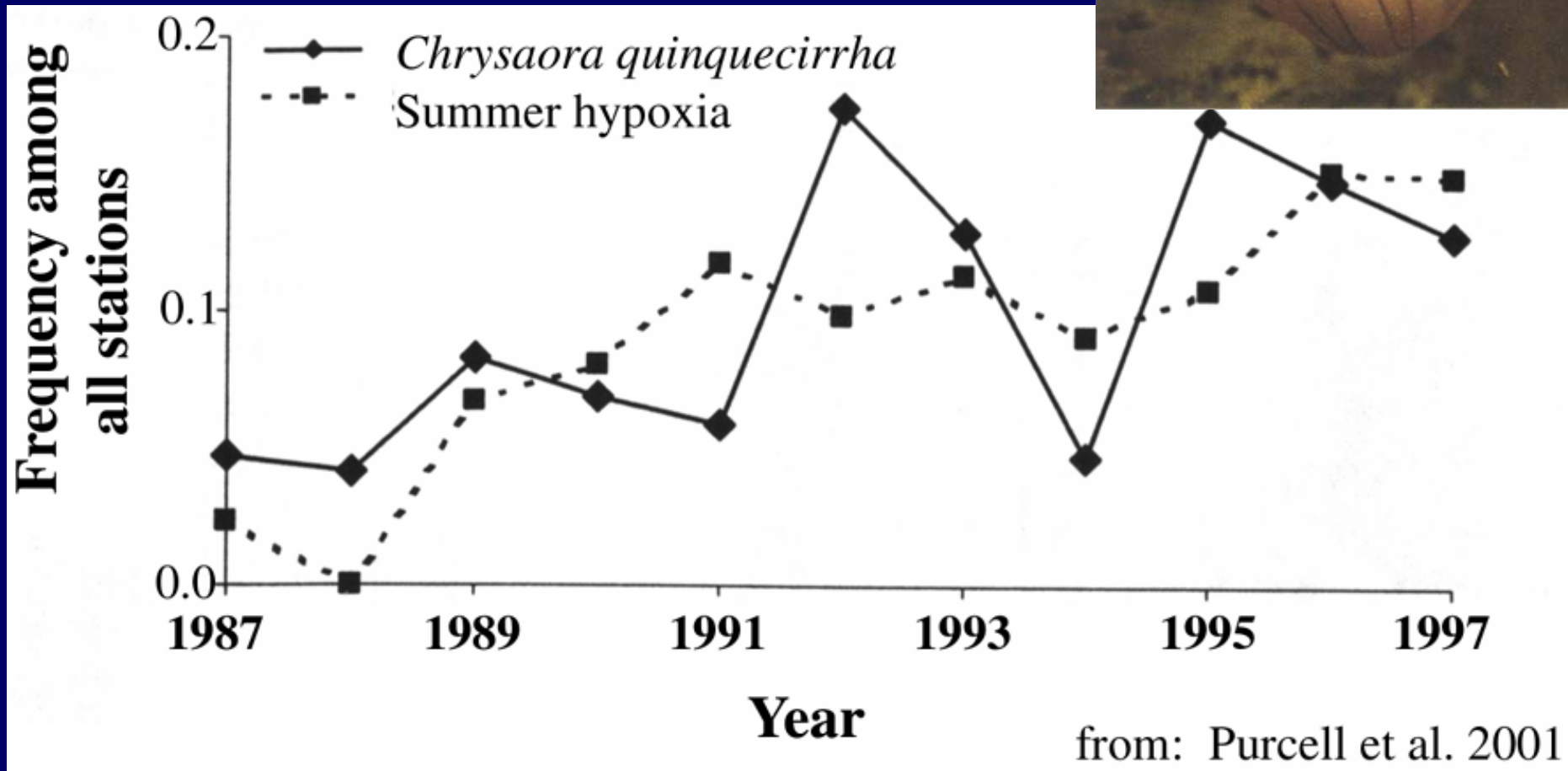
***Aurelia* moon jelly**



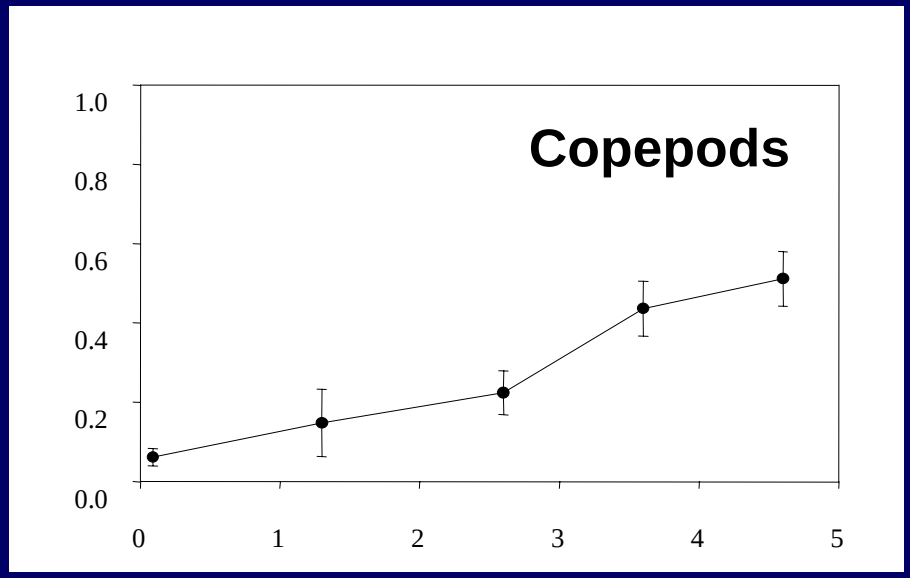



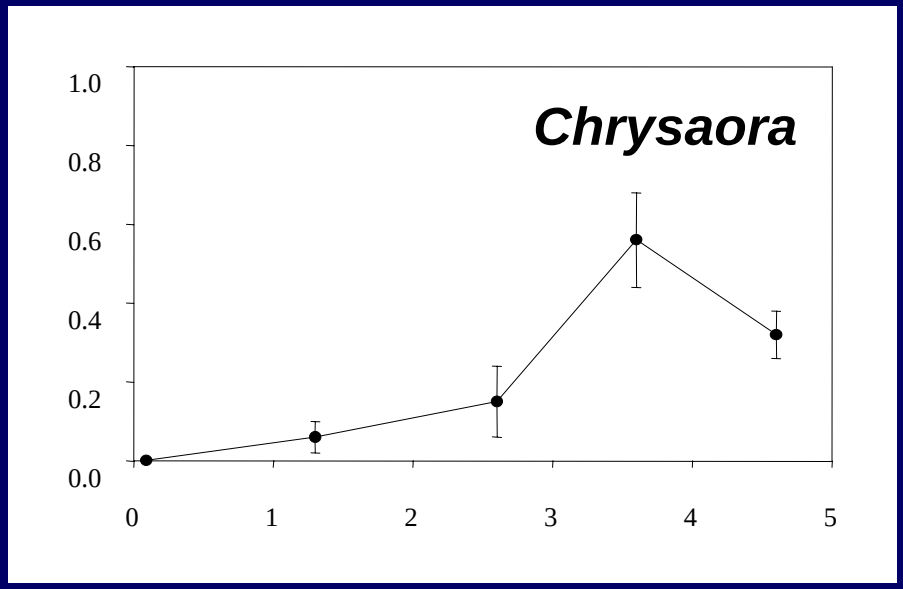

**Source: M. Graham, DISL**

# Jellyfish abundance: an indicator of altered food webs

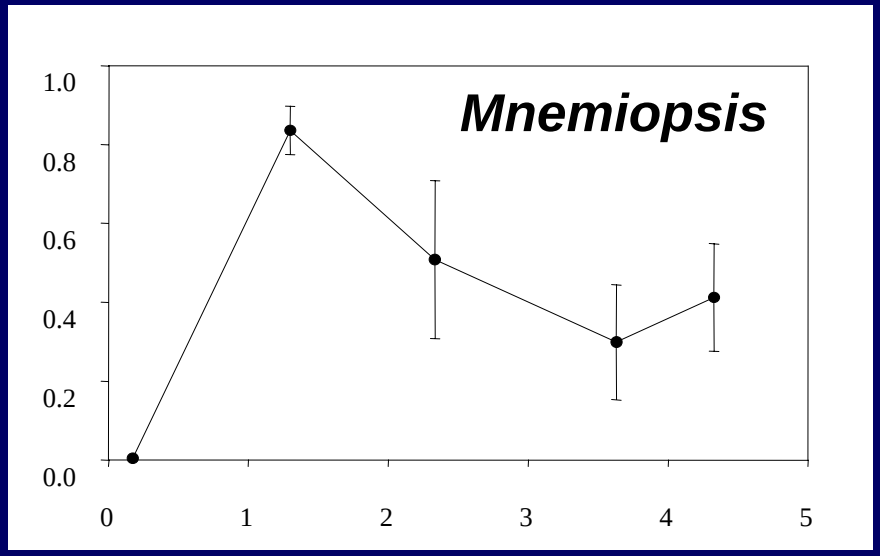



from: Purcell et al. 2001




Proportional Density in Bottom Layer




**Bottom Water Dissolved Oxygen (mg/l)**

**(Purcell et al. 2001)**