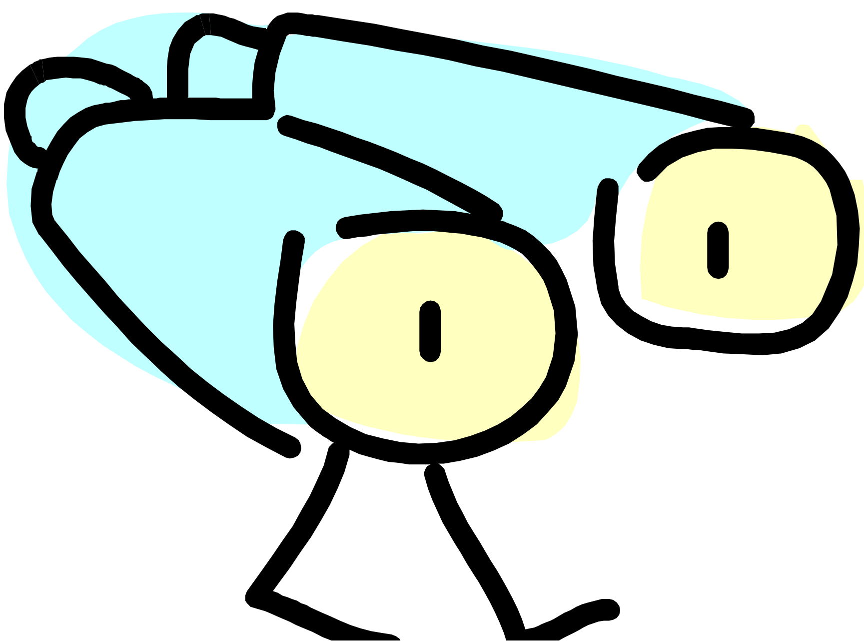
What Does Biodiversity Tell You?

First, What is biodiversity?

Let’s look it up in the scholarly



Wikipedia
The Free Encyclopedia

According to Wikipedia
The Free Encyclopedia

Biodiversity is the degree of variation of life. This can refer to genetic variation, species variation, or ecosystem variation within an area, biome, or planet.

Well, not so fast!

Actually…..

It is really species variation, which more and more is defined by genetic variation.

In biology, a **species** (pl. species) is one of the basic units of biological classification and a taxonomic rank. A species is often defined as a group of organisms capable of interbreeding and producing fertile offspring.

But then, there is this confusing thing about subspecies. Aaaaaargh!

And with genomics, how different does something need to be to be a different species?

Stone Crabs - *Menippe*

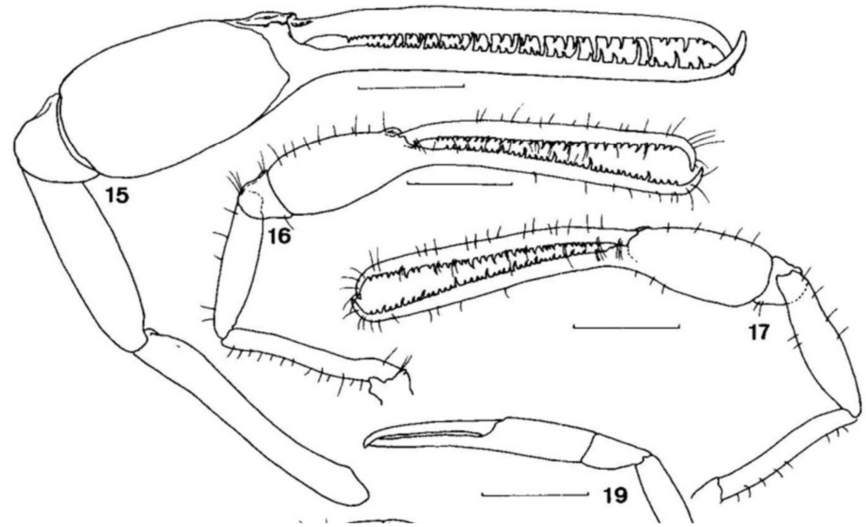
Extensive interbreeding of the two species occurs in the panhandle region of Florida and specimens taken from that area exhibit a variety of phenotypes.

Because of the extensive hybridization, Bert (1986) concluded that the two species warrant taxonomic recognition only at the semispecies level.

Menippe adina Williams and Felder, 1986

Menippe mercenaria Say, 1818

Ctenocheles leviceps Rabalais, 1979



Rabalais, N.N. (1979) A new species of *Ctenocheles* (Crustacea: Decapoda: Thalassinidea) from the northwestern Gulf of Mexico. Proceedings of the Biological Society of Washington, 92, 294-306.

Diversity of [some] Microbes along a Gradient of Dissolved Oxygen Concentrations

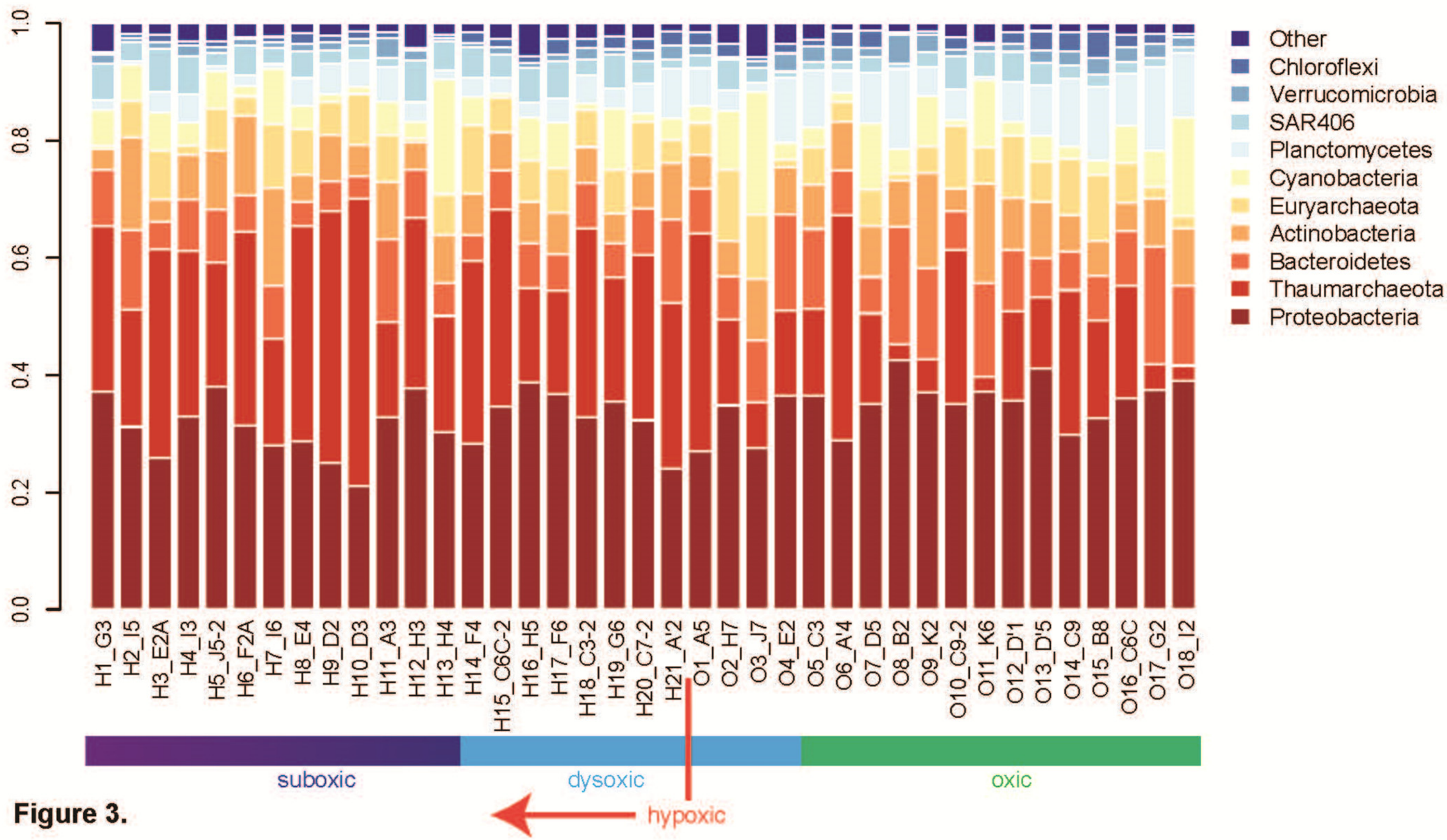


Figure 3.

True or False?

T F

Terrestrial biodiversity tends to be highest near the equator, which seems to be the result of the warm climate and high primary productivity.

Marine biodiversity tends to be highest along coasts in the Western Pacific, where sea surface temperature is highest and in mid-latitudinal band in all oceans.

Biodiversity generally tends to cluster in hotspots.

Common features of habitats with highest biodiversity

Coral reefs are among the most diverse ecosystems on earth.

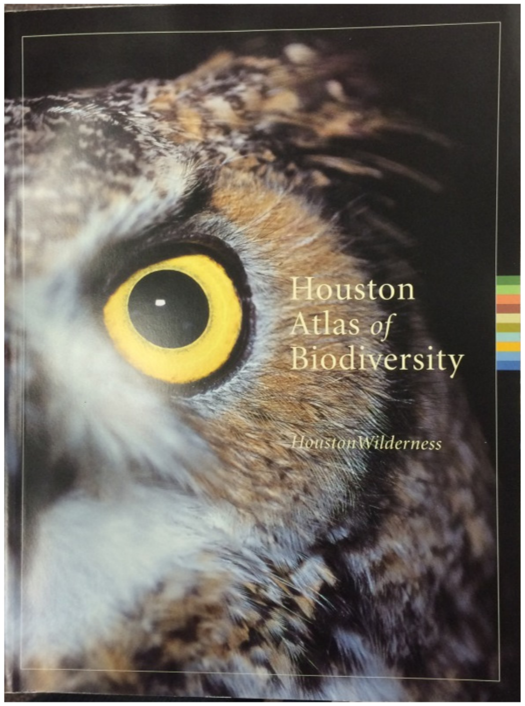
Rainforests are an example of high biodiversity.

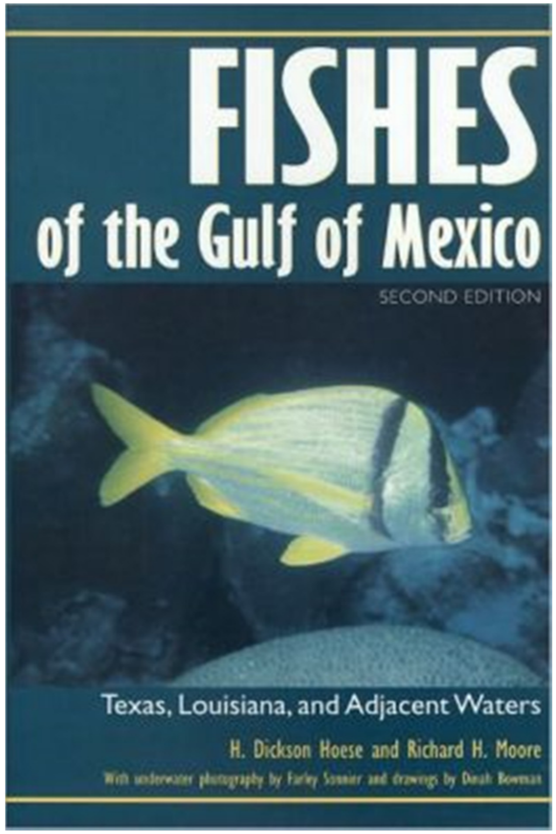
Higher productivity is correlated with higher temperatures as long as essential nutrients are not limiting.

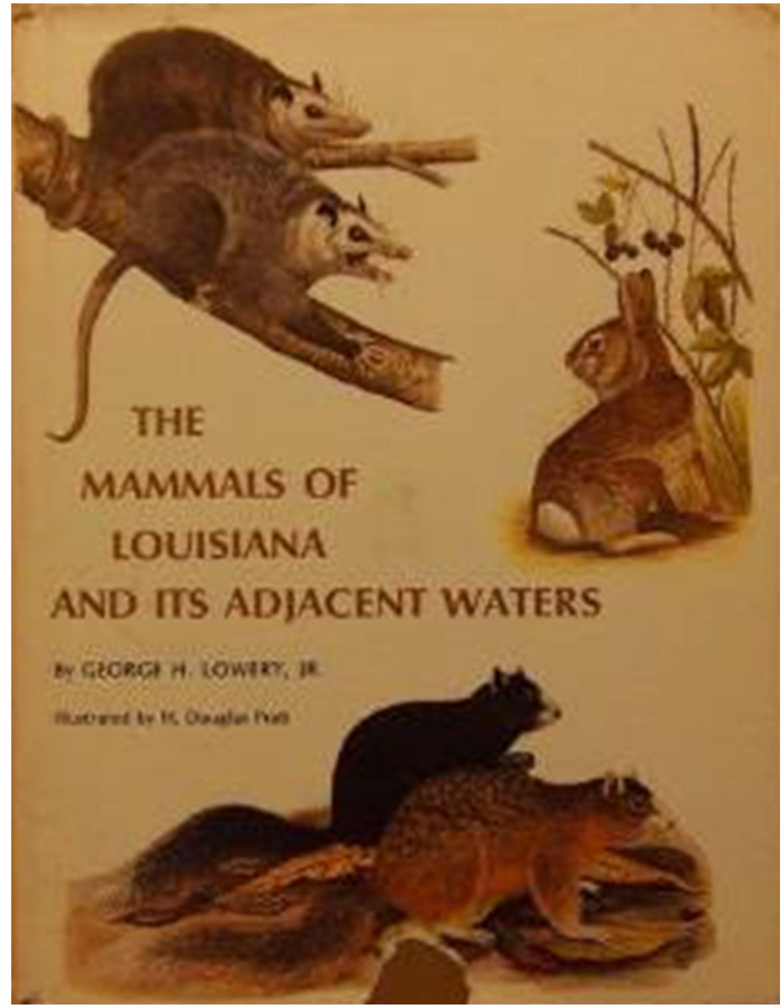
More stable habitats tend to have higher diversity, e.g., deep-sea.

Bioherms – biologically produced habitat features, e.g., coral reefs and tropical forests, are likely to have greater diversity.

Availability of diverse habitats.







Compendia of Species

Biodiversity

Number of species in an area or habitat

Shannon-Weiner diversity index

based on the weighted geometric mean of the proportional abundances of the types, and that it equals the logarithm of true diversity as calculated with q = 1:[3]

$$H' = -\sum_{i=1}^{R} p_i \ln p_i = -\sum_{i=1}^{R} \ln p_i^{p_i}$$

$$H' = -(\ln p_1^{p1} + \ln p_2^{p2} + \ln p_3^{p3} + \cdots + \ln p_R^{pR})$$

Simpson's diversity index

is the number of entities belonging to the *i*th type and *N* is the total number of entities in the dataset.

$$l = \frac{\sum_{i=1}^{R} n_i(n_i - 1)}{N(N-1)}$$

What Does It Mean?

Health of an ecosystem

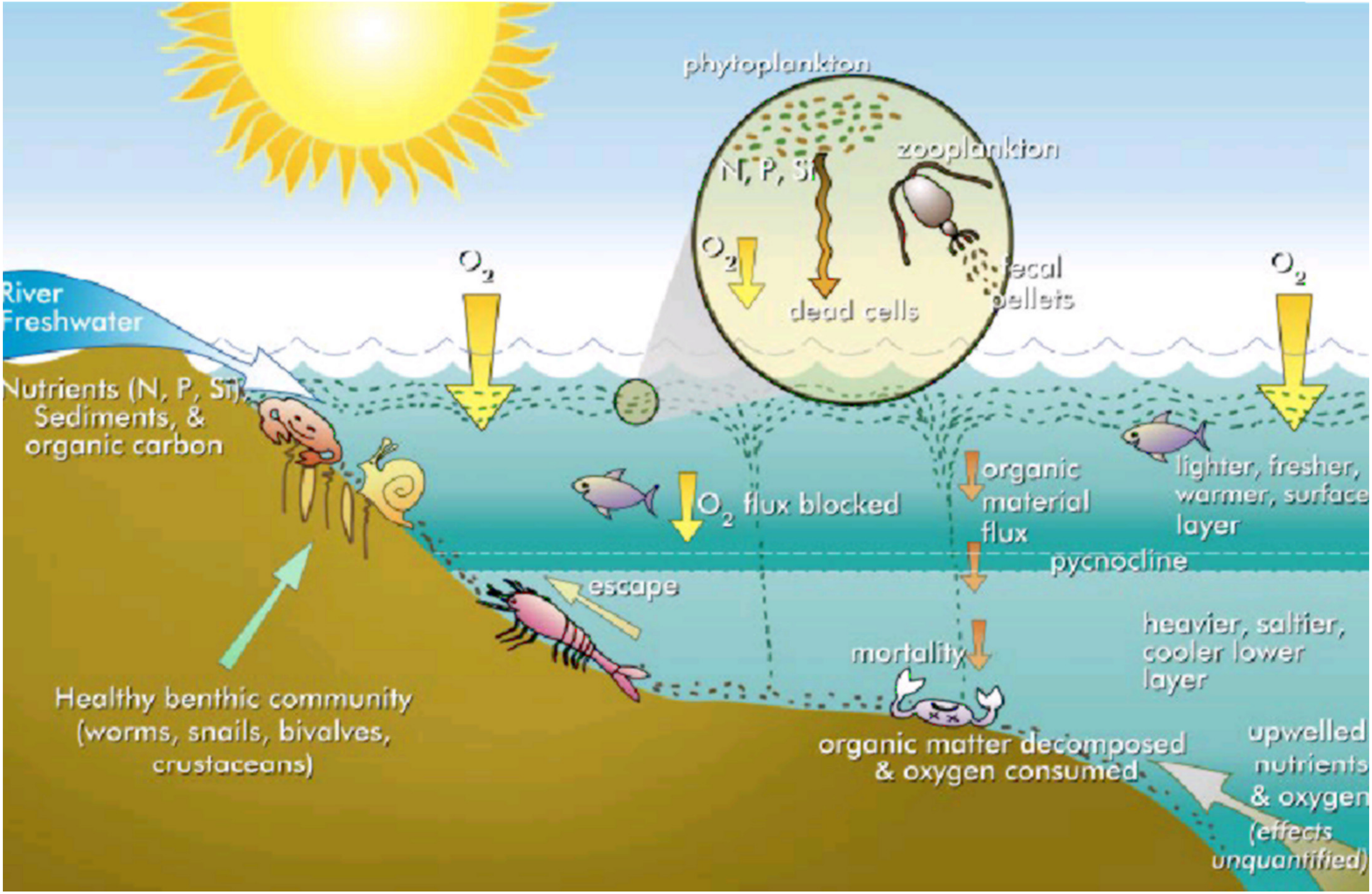
Maintenance of ecosystem functions

Source of recruits

Stability

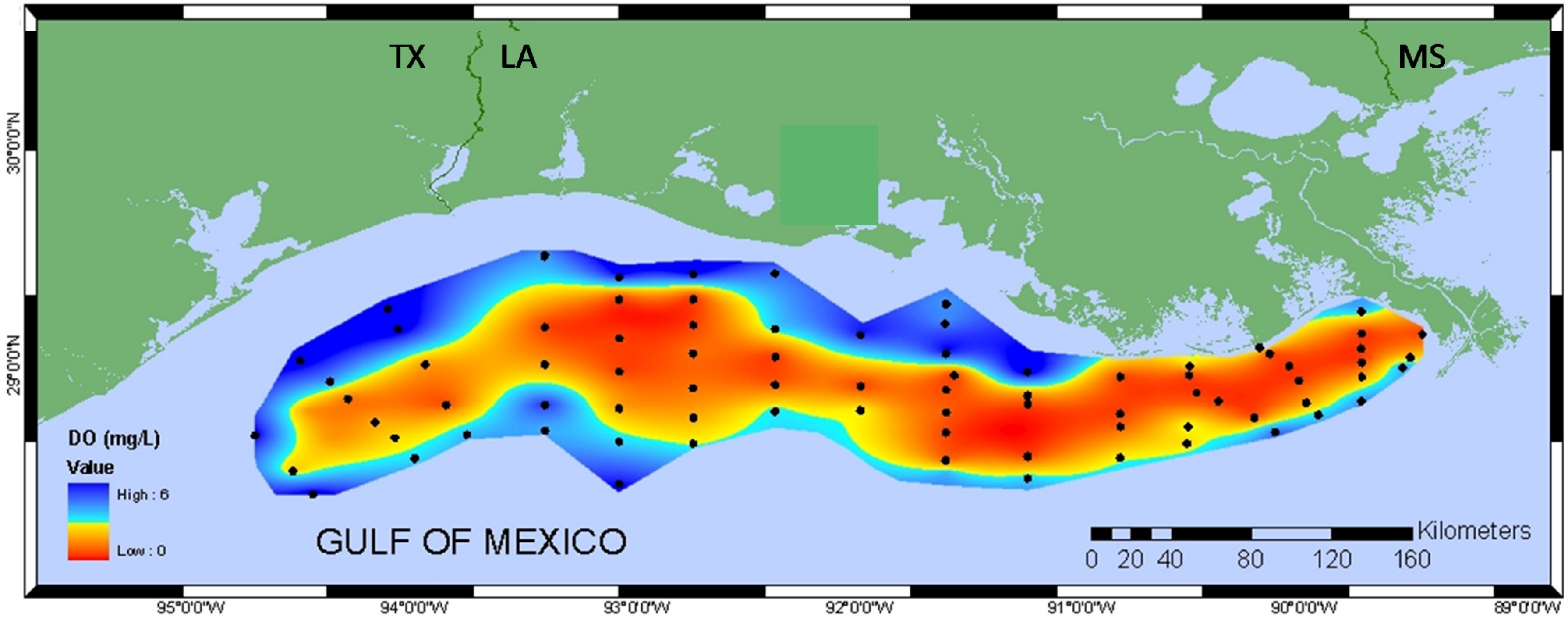
Resilience

We Know What Causes Hypoxia - Globally



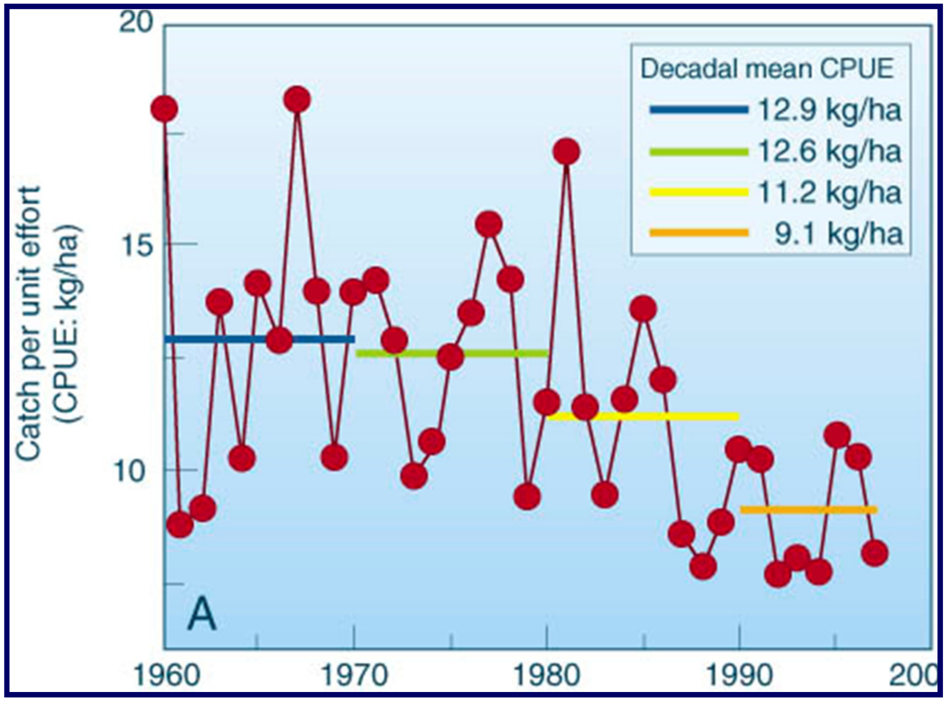
CENR 2001

Extensive, Severe Low Oxygen Waters



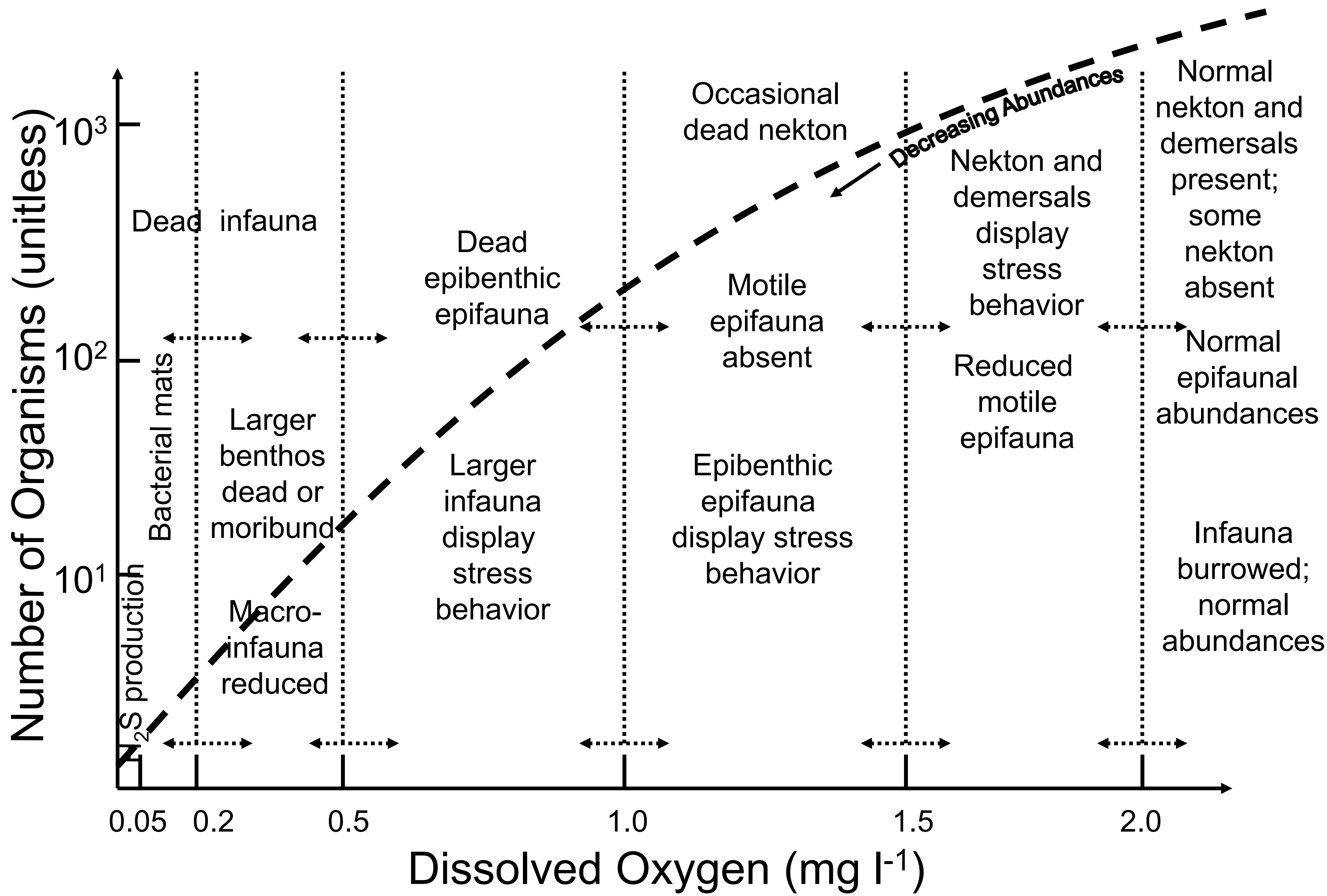
Source: N. Rabalais, LUMCON

- **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**



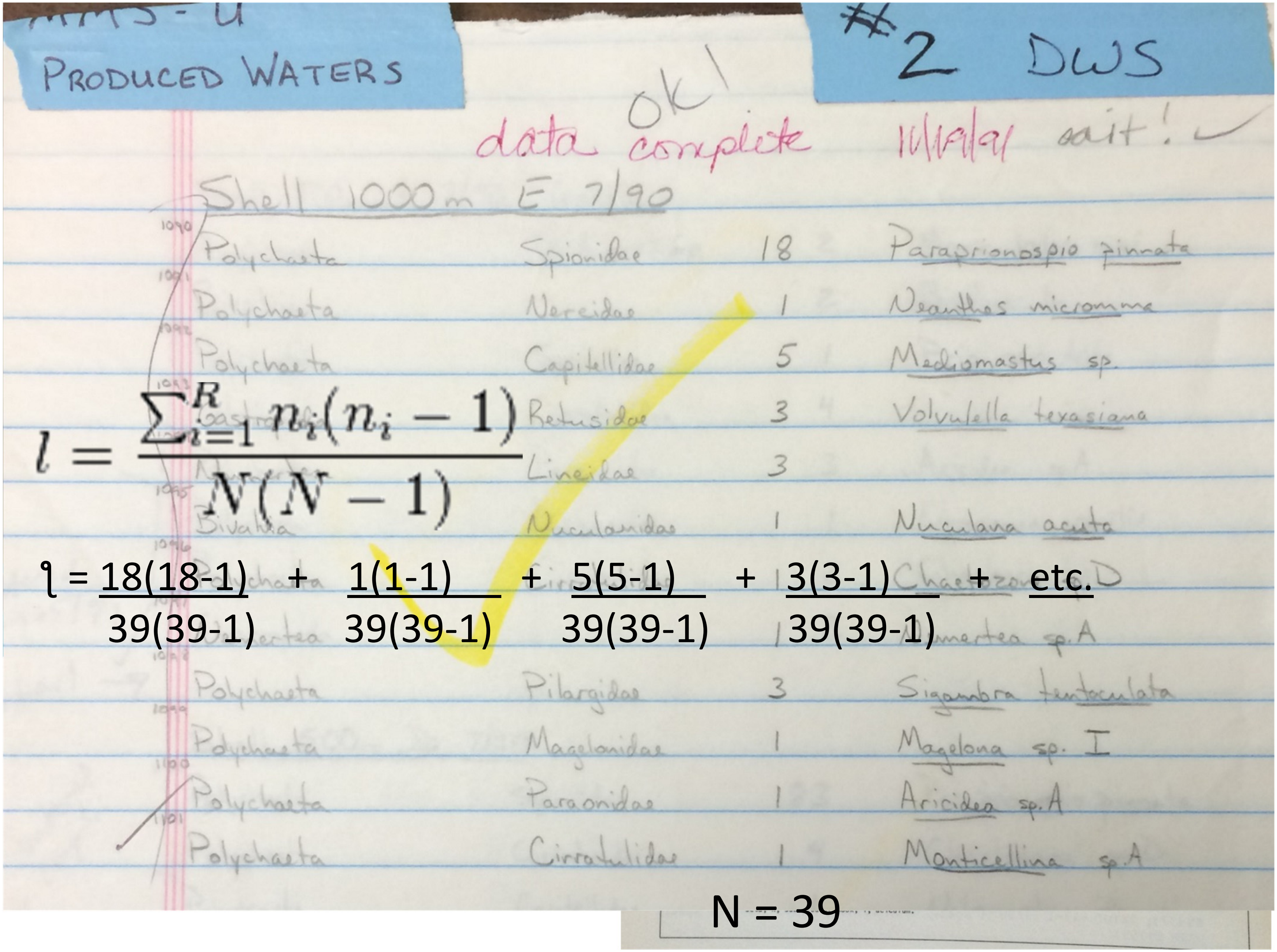
The Consequences

- Fisheries resources at risk
- Altered migration
- Reduced habitat
- Changes in food resources
- Susceptibility of early life stages
- Growth & reproduction



Number of Organisms (unitless)
10^3
10^2
10^1
Dissolved Oxygen (mg l^{-1})
0.05
0.2
0.5
1.0
1.5
2.0
Decreasing Abundances
H_2S production
Bacterial mats
Dead infauna
Larger benthos dead or moribund
Macro-infauna reduced
Dead epibenthic epifauna
Larger infauna display stress behavior
Occasional dead nekton
Motile epifauna absent
Epibenthic epifauna display stress behavior
Nekton and demersals display stress behavior
Reduced motile epifauna
Normal nekton and demersals present; some nekton absent
Normal epifaunal abundances
Infauna burrowed; normal abundances

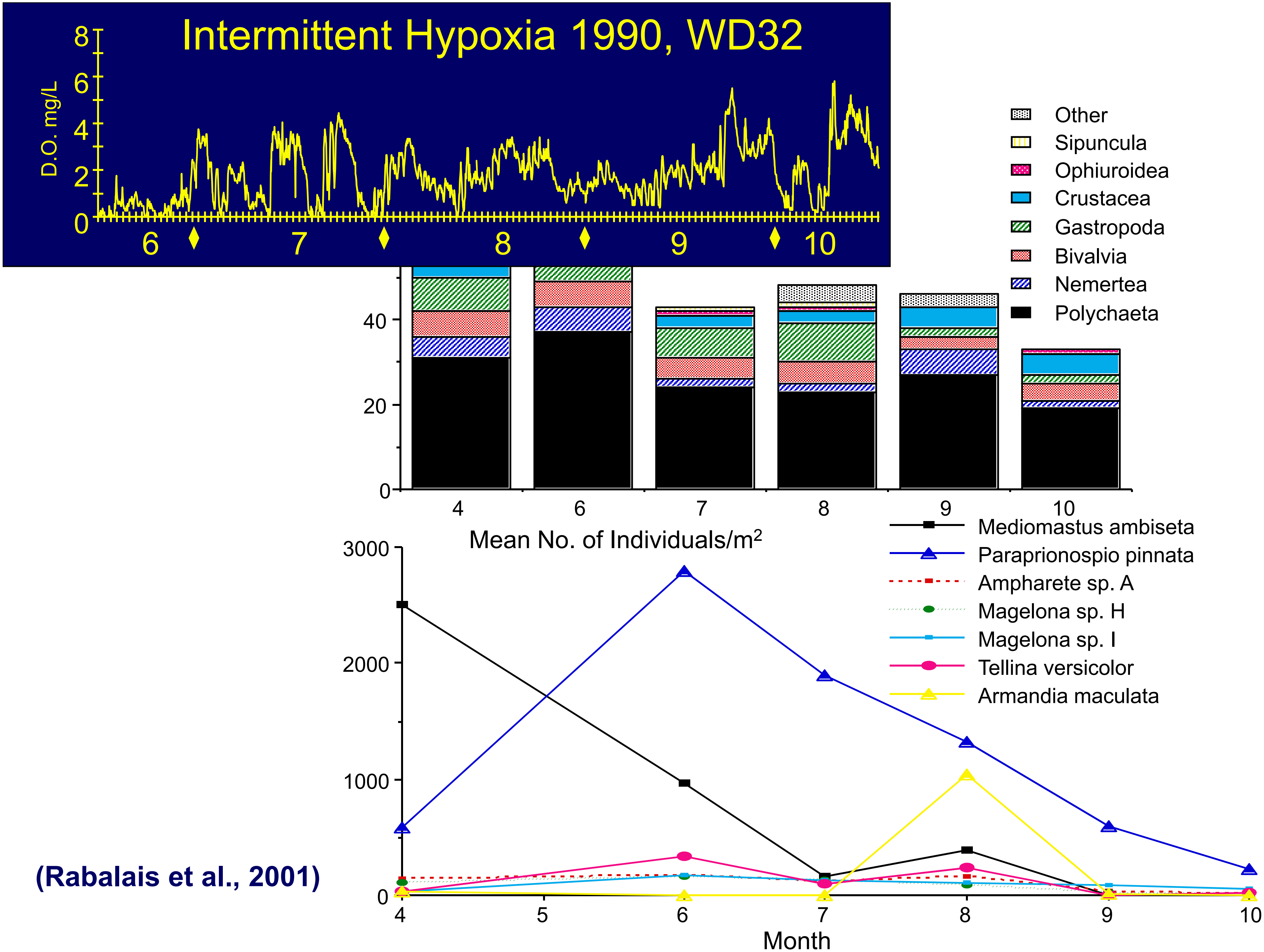
So, How Is This Done?



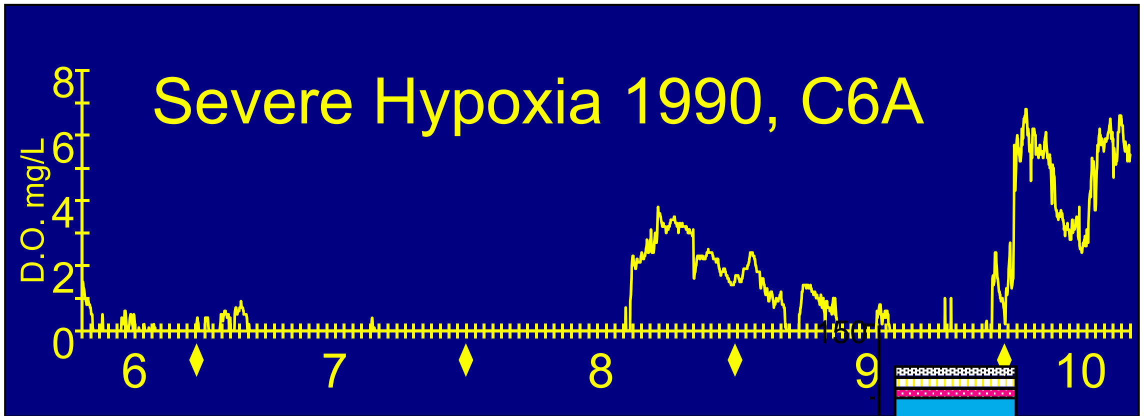
$$l = \frac{\sum_{i=1}^{R} n_i(n_i - 1)}{N(N-1)}$$

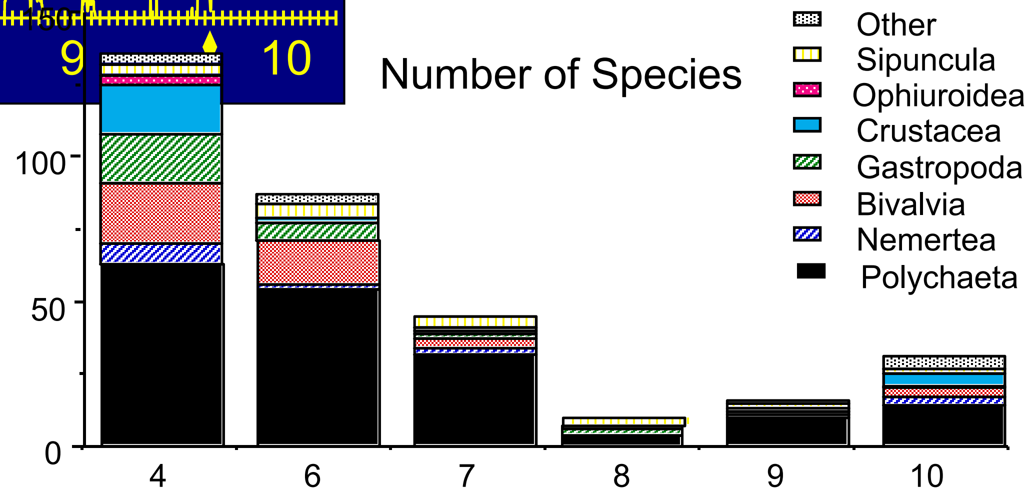
$$l = \frac{18(18-1)}{39(39-1)} + \frac{1(1-1)}{39(39-1)} + \frac{5(5-1)}{39(39-1)} + \frac{3(3-1)}{39(39-1)} + \text{etc.}$$

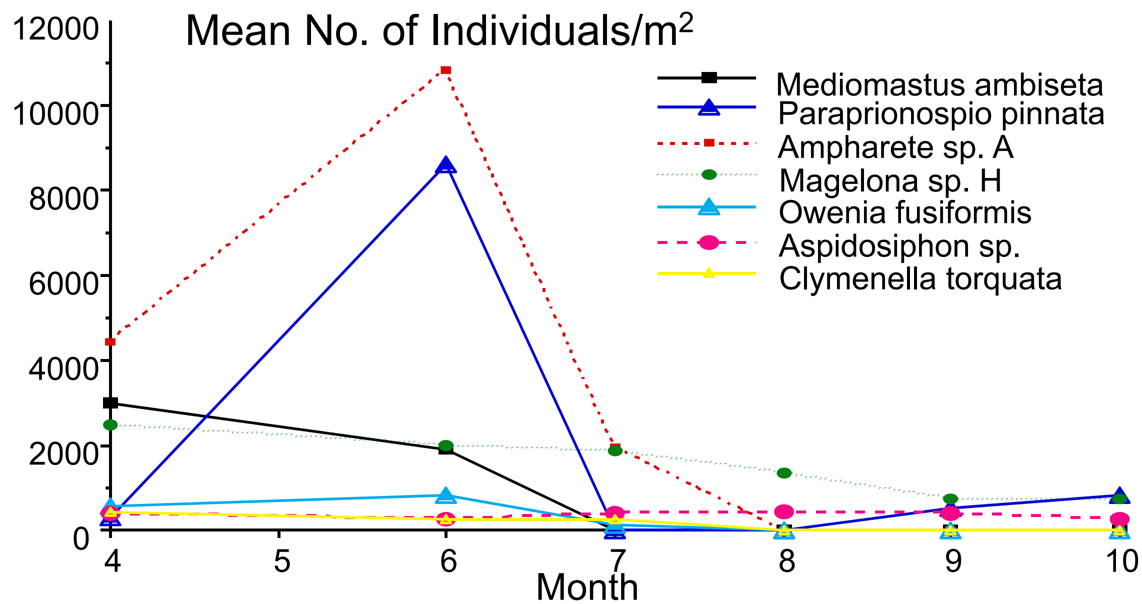
$N = 39$



(Rabalais et al., 2001)







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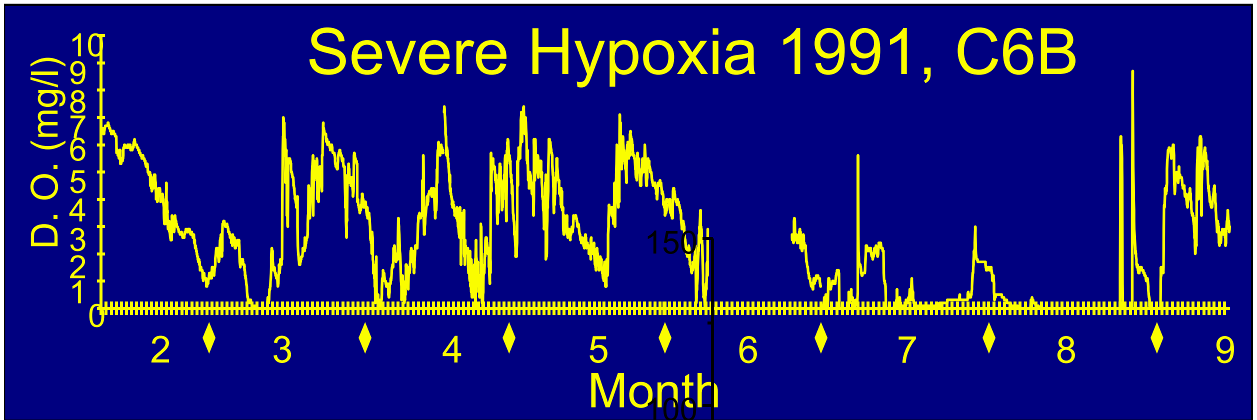
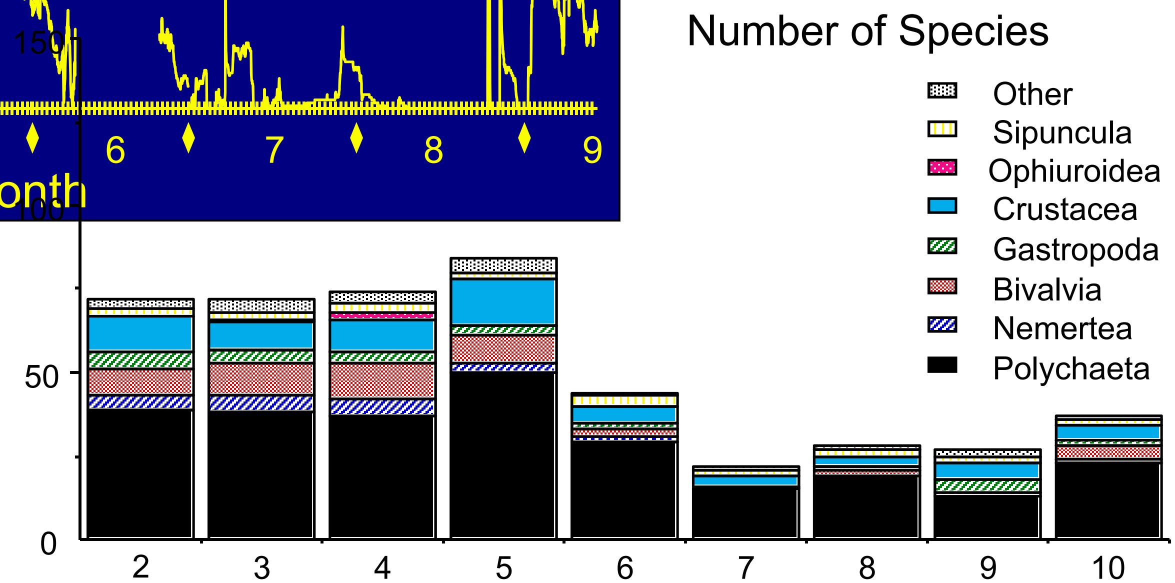
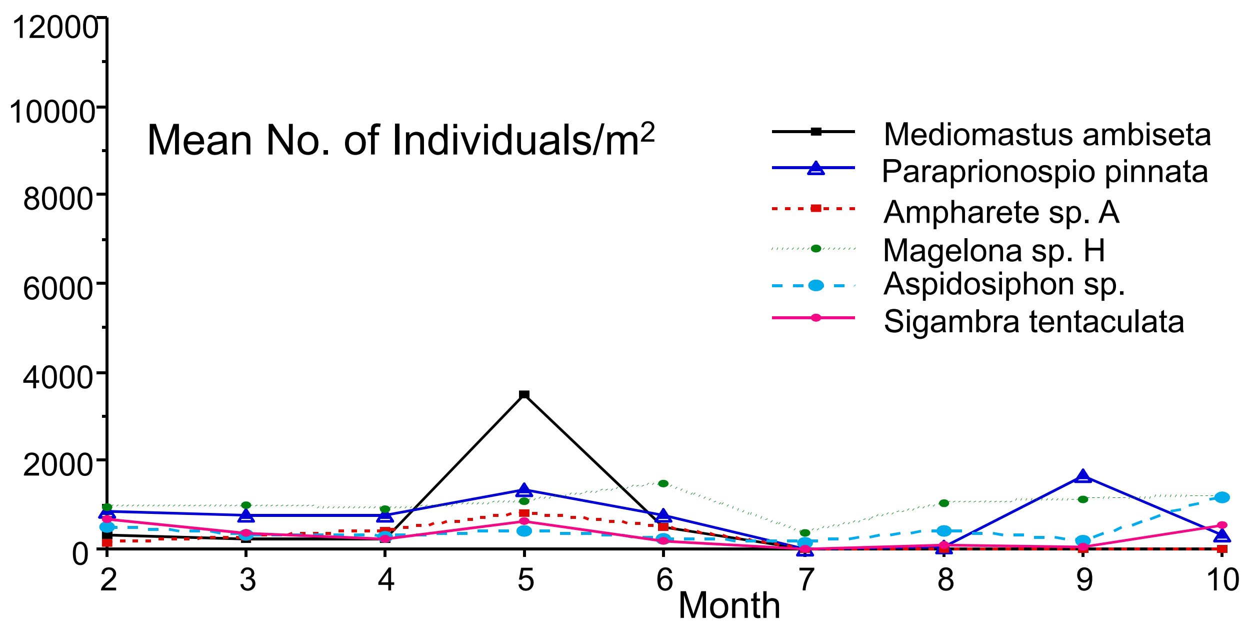
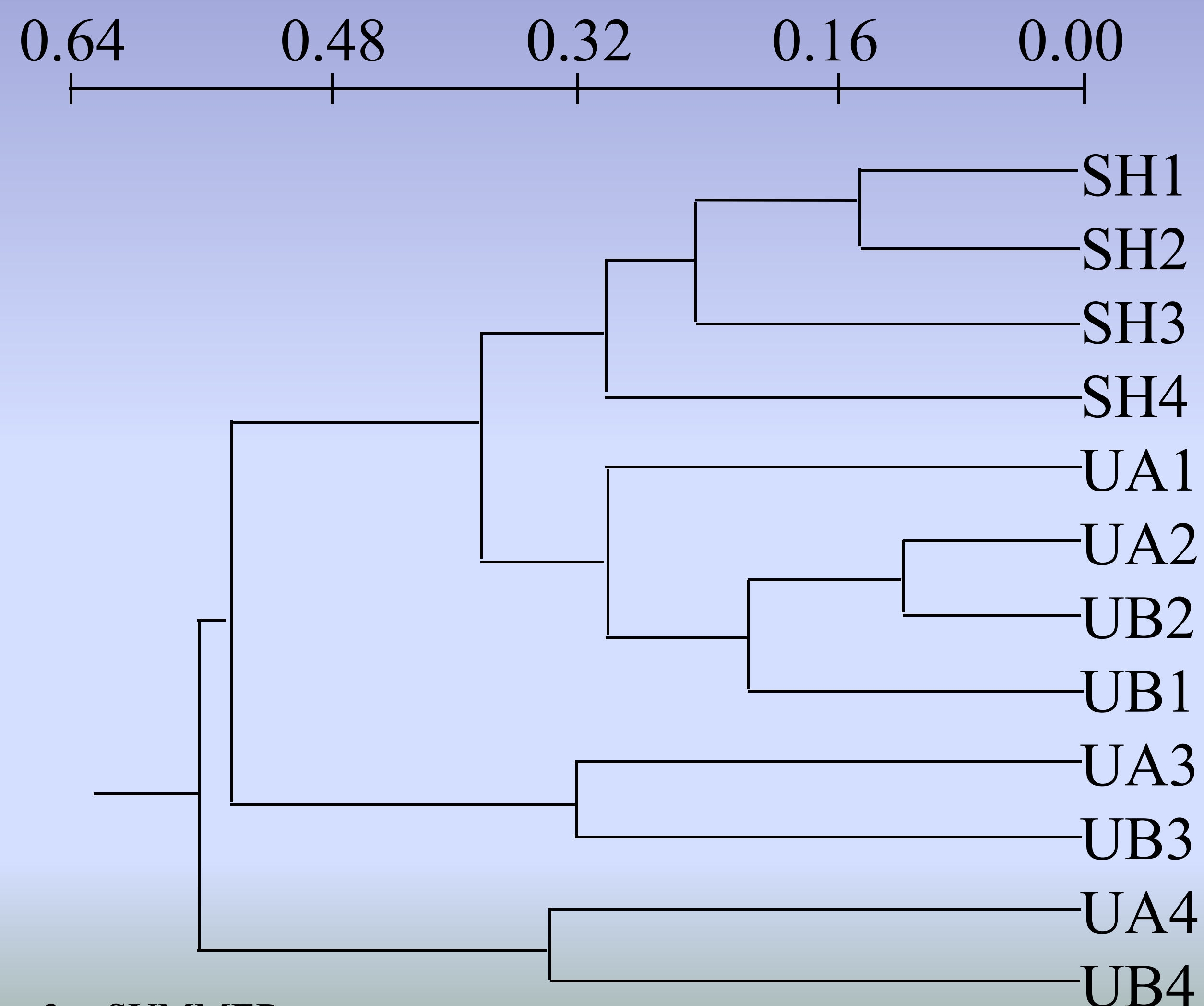




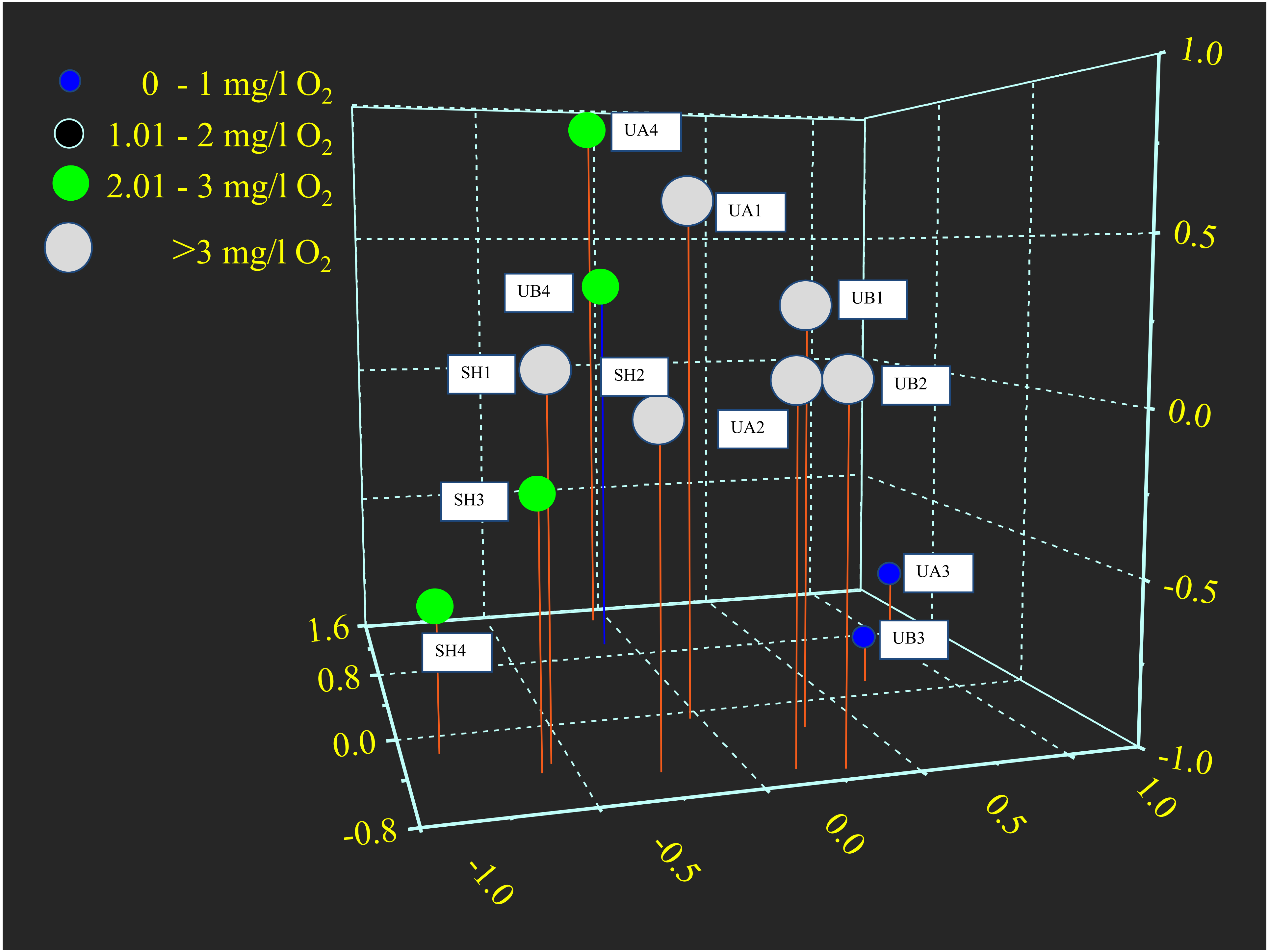


(Rabalais et al., 2001)

Results of unweighted pair-group method, arithmetic average clustering analysis of species abundance by site and season for Bray-Curtis Dissimilarity Index



1 = WINTER 3 = SUMMER
2 = SPRING 4 = FALL



0 - 1 mg/l O_2
1.01 - 2 mg/l O_2
2.01 - 3 mg/l O_2
>3 mg/l O_2
UA4
UA1
UB4
UB1
SH1
SH2
UB2
UA2
SH3
UA3
SH4
UB3
1.0
0.5
0.0
-0.5
-1.0
1.6
0.8
0.0
-0.8
-1.0
-0.5
0.0
0.5
1.0

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
	Louisiana Shelf		Louisiana Shelf	
Rabalais et al. (1993)	Periodic Hypoxia		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
Species (no. $sample^{-1}$)	16.2		21.5	8.1

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 et al., 2001)

Nonindigenous species - Definition

Variously called: exotics, transplants, non-natives, introduced species, alien species, invasive

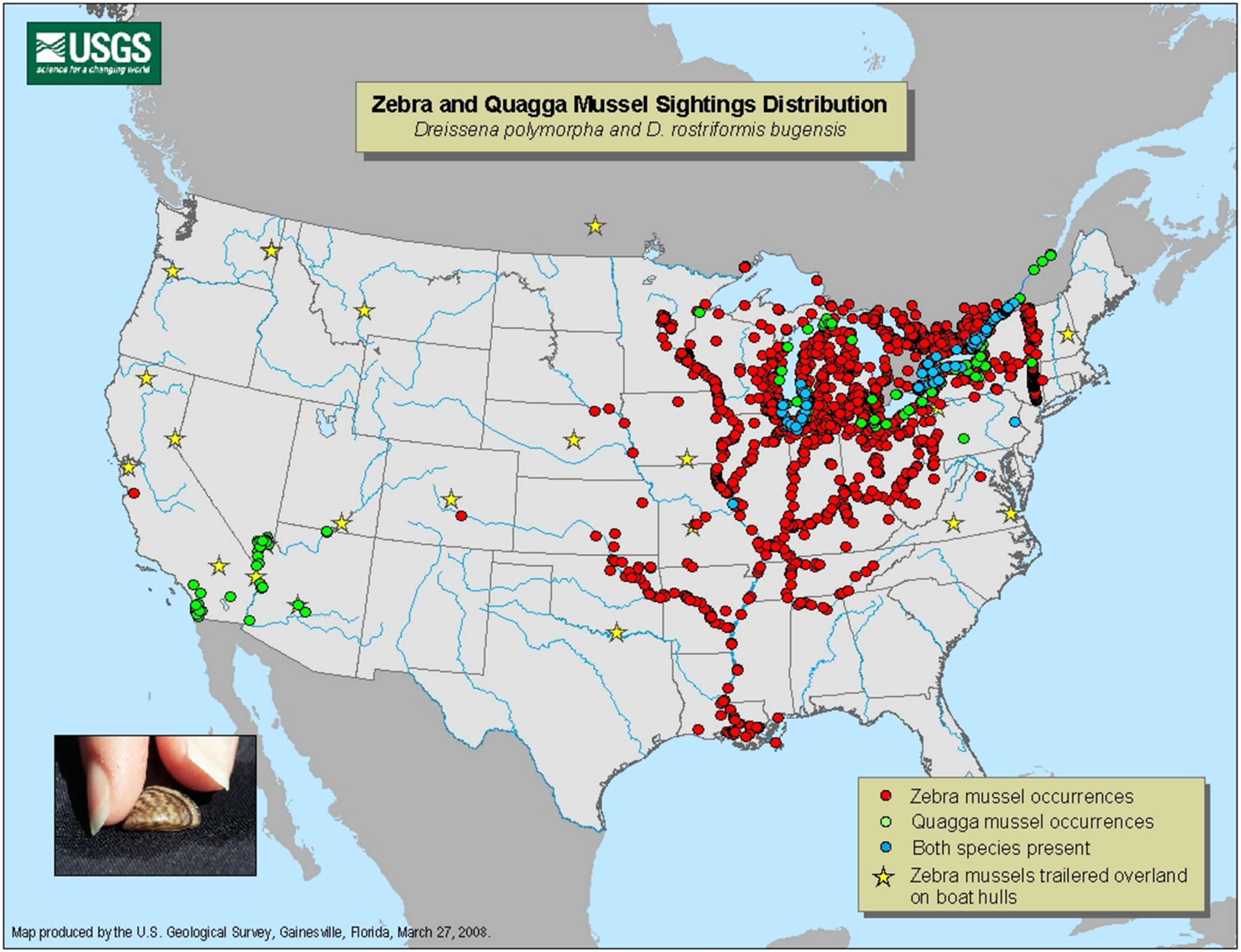
Def: An individual, group, or population of a given taxon that is introduced, as the result of human activities, into an area or ecosystem outside its historic or native geographic range.

Includes foreign (introduced) and transplants.

Zebra musssel
Dreissena polymorpha

Why are they a problem?

- fouls pipes, pumps, water intakes
- kills native molluscs
- disrupts food chains
- damages boat engines and hulls
- creates foul smells
- create foul tastes and odors in drinking water



USGS
science for a changing world
Zebra and Quagga Mussel Sightings Distribution
Dreissena polymorpha and D. rostriformis bugensis
Zebra mussel occurrences
Quagga mussel occurrences
Both species present
Zebra mussels trailered overland on boat hulls
Map produced by the U.S. Geological Survey, Gainesville, Florida, March 27, 2008.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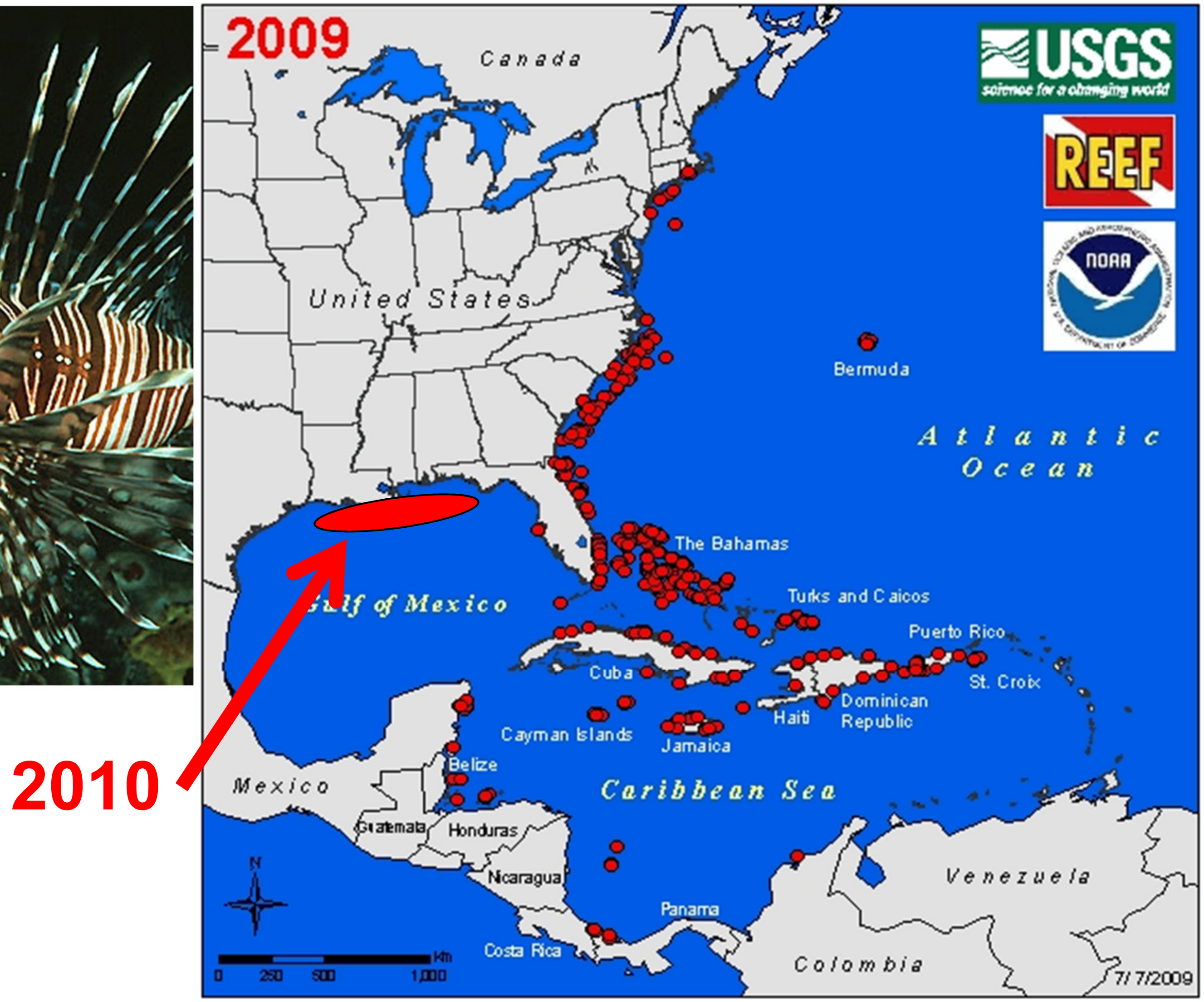
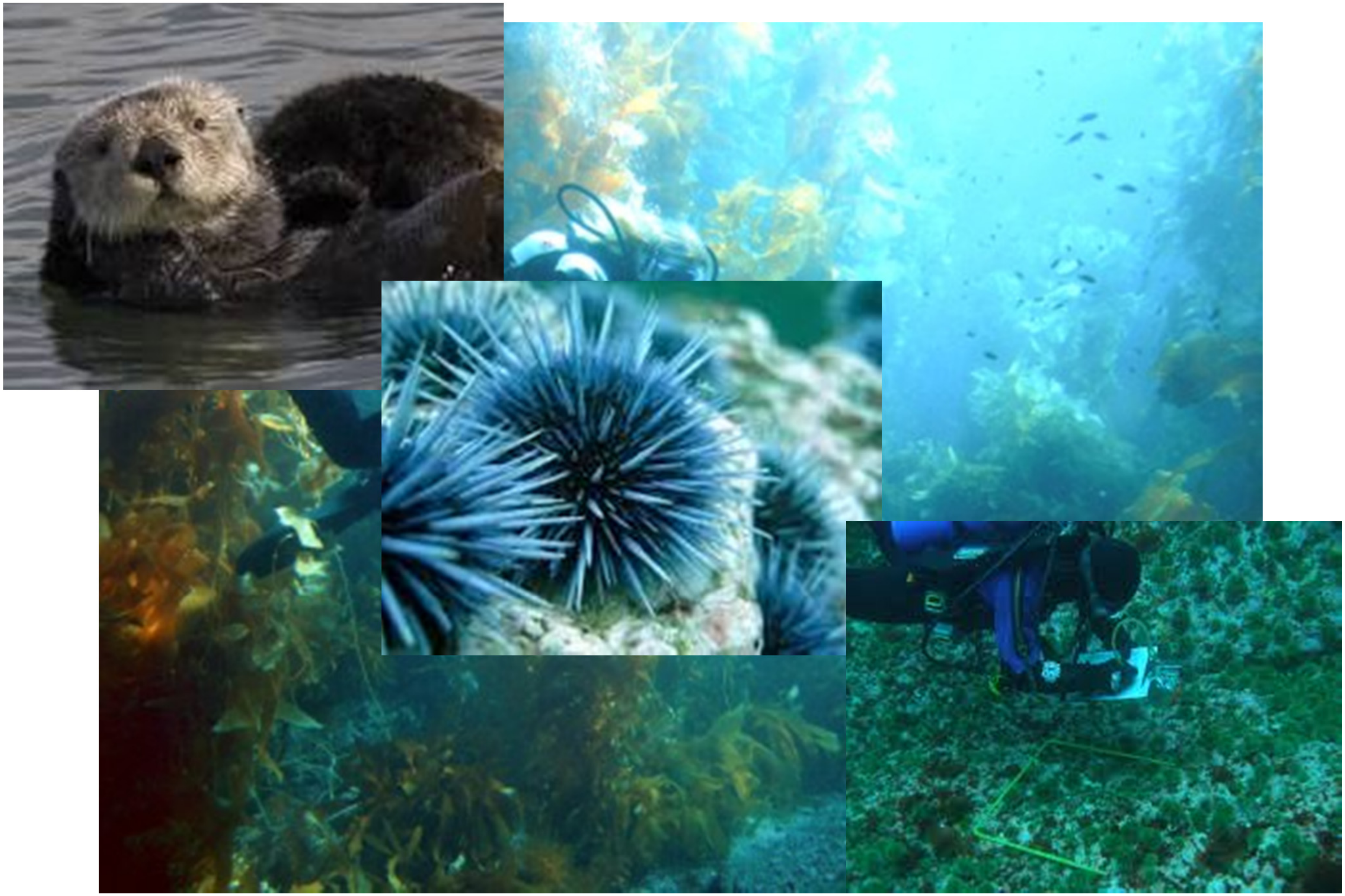
Red Swamp Crayfish (Procambarus clarkii)

In their native range, red swamp crayfish are economically valuable, for instance as the basis of profitable aquaculture in Louisiana, where they are used for Cajun cooking. They have been intentionally introduced outside their native range for aquaculture operations. They are known to be very aggressive, territorial, and are generalist feeders, making them a formidable threat to organisms that rely on the same resources; in California, they may out-compete native crayfish. They are also known to prey upon endangered newts and are thought to be directly responsible for the decline in newt numbers in some areas. The burrowing behavior of this species can compromise the integrity of banks and levees, thereby increasing erosion and causing destruction to important wildlife habitat.



Several fish were introduced into marine waters of Key Biscayne, Florida, just south of Miami. Palm Beach and Boca Raton, Lake Worth Pier in Palm Beach County, St. Augustine and Jacksonville, Treasure Island, Pinellas County, Florida in 2006. A single individual was spotted by a snorkeler off Varadero, Cuba 2005.

A **cascade effect** is a series of secondary extinctions that is triggered by the primary extinction of a key species in an ecosystem.



Rivets
Hold things together