

## Managing Incidental and Agricultural runoffs in Coastal Areas

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## Connection of Agriculture to Eutrophication and Dead Zones

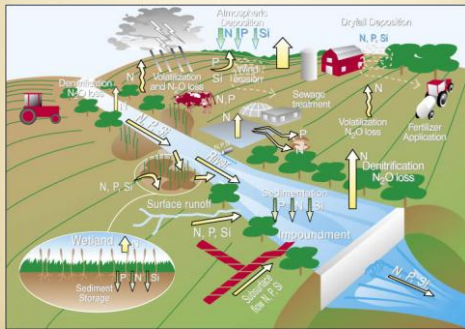
Green Lands → → → Blue Waters

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



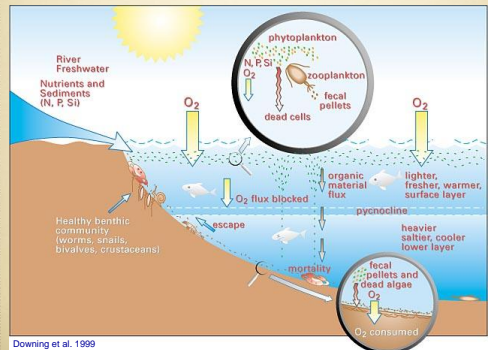
(Photo: N. Rabalais, LUMCON)

## Agriculture Connected to Eutrophication:



Downing et al. 1999

## Eutrophication and Formation of Hypoxia:



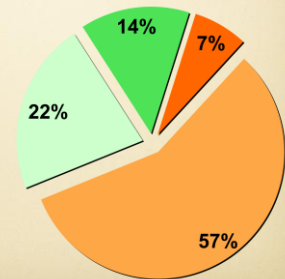
Downing et al. 1999

Seriousness of low Dissolved Oxygen  
is best expressed by motto of  
American Lung Association:

**“When You Can’t Breathe,  
Nothing Else Matters.”**

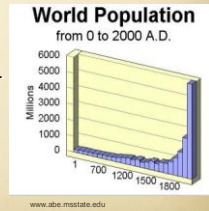
## What is at stake? Coastal and Continental Shelf Habitats, Aquaculture and Capture Fisheries

- Aqua. Inland
- Aqua. Marine
- Capture Inland
- Capture Marine



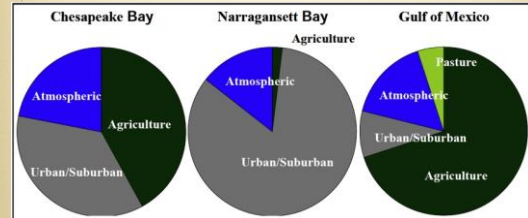
## How Eutrophication/Hypoxia Became a Global Problem

- The increasing input of nutrients to coastal areas over the last 60 years resulted in system overload.
- Strong correlation through time between:
  - Population growth.
  - Increased nutrient discharges.
  - Increased primary production.
  - Increased occurrence of hypoxia/anoxia.



## How Eutrophication/Hypoxia Became a Global Problem

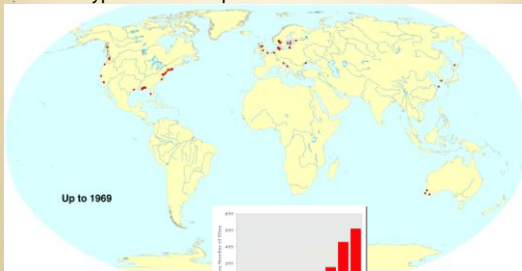
Source of nutrients varies by system, but system response is similar.



Jewett et al. 2009

## Spread of Hypoxia

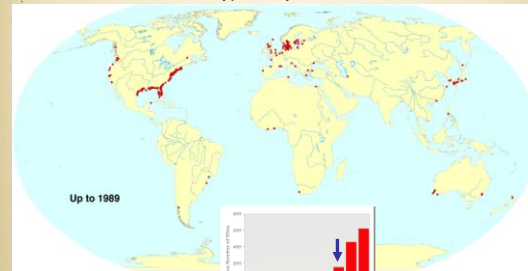
In the 1960s the number of systems with reports of hypoxia-related problems started to increase.



Diaz & Rosenberg 2008  
Updated by Rabalais et al. 2010

## Spread of Hypoxia

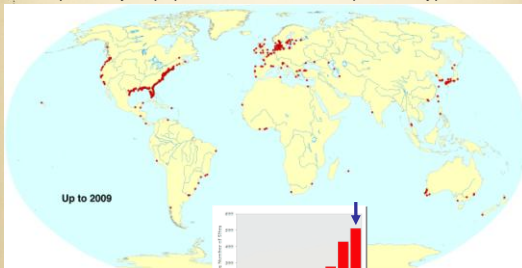
By the 1980s there was an explosive increase in the number of hypoxic systems.



Diaz & Rosenberg 2008  
Updated by Rabalais et al. 2010

## Spread of Hypoxia

By the 1990s and 2000s most estuarine and marine systems in close proximity to population centers had reports of hypoxia/anoxia.



Diaz & Rosenberg 2008  
Updated by Rabalais et al. 2010

## Ecosystem Services:

- Provisioning (Food, Fiber)
- Regulating (Water Purification, Trophic Structure)
- Supporting (Biodiversity, Nutrient Cycling)
- Cultural (Aesthetic, Recreation)

### Ecosystem Services Needed by Aquaculture:

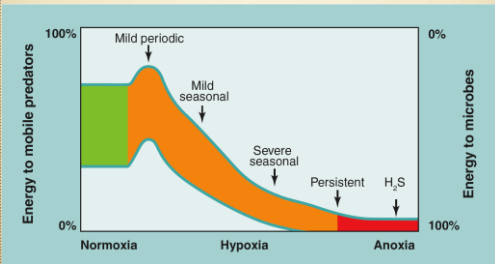
- **Regulating Services:**
  - Water purification and waste treatment
  - Biological control, trophic structure
- **Supporting Services:**
  - Nutrient cycling
  - Habitat

### Eutrophication Effects on Ecosystem Services:

- **Regulating Services:**
  - Water purification and waste treatment (**Loss**)
  - Biological control, trophic structure (**Loss, Altered**)
- **Supporting Services:**
  - Nutrient cycling (**Loss, Altered**)
  - Habitat (**Loss**)

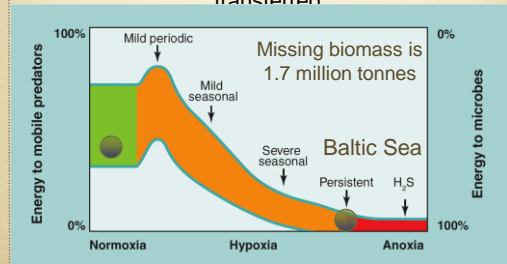
### Altered Trophic and Energy Pathways

Processes and pathways favored by hypoxia taking larger portions of ecosystem's energy. Ultimately, microbes dominate.



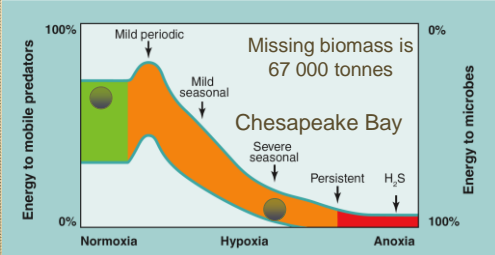
### Altered Trophic and Energy Pathways

Normal oxygen conditions 40% of benthic biomass is transferred to higher trophic levels. Under persistent hypoxia/anoxia 0% is transferred



### Altered Trophic and Energy Pathways

Normal oxygen conditions 60% of benthic biomass is transferred to higher trophic levels. Severe seasonal hypoxia about 1-5% is transferred



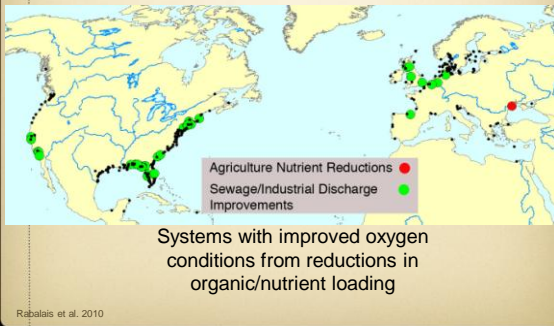
### Global Loss of Ecosystem Services from Eutrophication Hypoxia

Habitat	Value Lost to Hypoxia (Million USD)	Hypoxic Area (Km <sup>2</sup> )	% Habitat Hypoxic	Global Flow Lost to Hypoxia
Shelf	26 000	170 000	0.6%	0.1%
Estuaries	151 000	70 000	3.9%	0.4%

Total value of all ecosystem services in 1994:  
33 000 000 000 000 USD

Costanza et al. 1997, Diaz and Rosenberg 2008

## For Coastal Areas Managing Agriculture Impacts has been Difficult.



## Managing Agriculture Impacts, Gulf of Mexico Moving from Science to Policy.

**Goals**

**Coastal:** Reduce hypoxic area to <5 000 km<sup>2</sup> over 5-year running average.

**Inland:** Restore and protect water quality.

**Social:** Improve social and economic conditions in Basin.

Estimated Nitrogen reduction required:

- 30% 2001 Action Plan
- 35-45% 2008 Action Plan

## Managing Agricultural Impacts on Aquaculture

- Developing sustainability in agriculture through ecosystem-based management approach that considers land-sea interactions.
- Multiculture of species that can lessen impacts of land based activities
  - Offsetting declines ecosystem services (water quality)
  - Increasing ecosystem services (nutrient cycling)

## Two Part Key to Future Hypoxia

