Definitions

- **Hypoxia** is a term meaning low oxygen levels – usually defined as < 2 mg/L dissolved oxygen
- Ocean water saturated with air typically contains >5 mg/L dissolved oxygen
- The press sometimes calls hypoxic areas “dead zones”
- **Anoxia** is a term meaning absence of oxygen

Hypoxia in the Headlines

Dead Zone Keeps Getting Bigger

By Mark Schlehldin

The entire Florida Keys area, located from the south end of Miami to the northern tip of Key West, is running out of oxygen.
Things to Keep in Mind

- Human activities, particularly fertilizer use, contribute to hypoxia
- Decisions on land use, agriculture, and alternative energy may all have an effect on hypoxia.
- What should society do to limit hypoxia?

Topics for Discussion

- Buoyancy and floatation
- Eutrophication – effect of excess nutrients on water bodies
- Hypoxia – low oxygen concentrations in natural water bodies
- Harmful algal blooms – another effect of excess nutrients
- Fertilizer use
- What can be done about hypoxia?

Buoyancy and the Ocean Environment

- Positive buoyancy allows a ship to float
- Negative buoyancy sinks an anchor
- Buoyancy of water can impact large areas of the sea itself
Relative Densities Determine Buoyancy

- Salt water is more dense than fresh water
- Cold water is more dense than warm water
- In the ocean, warmer, fresher water floats on colder, saltier water

Salinity and temperature determine seawater density

Rivers Discharge Buoyant Fresh Water into the Gulf of Mexico

- Fresh water enters the Gulf and is swept to the west by ocean currents
- The fresh water forms a floating layer on top of more salty ocean waters

General direction of ocean current

Will It Float?

- Ocean water is about 3% salt
- What happens when fresh river water flows into the ocean?

“I think as adults, we all know what floats and what doesn’t float. We all kinda can guess within a fairly close percentage what’s gonna float.” — David Letterman, February 28, 2002
How Does Layering Impact the Ocean Environment?

Warm fresh water and nutrients are delivered by rivers and float on the denser, cooler saltwater. This keeps oxygen in the air from getting to the bottom.

Solar Heating Helps Stabilize Layers

Warm spring and summer temperatures heat the water surface - making the water even more buoyant.

Calm Weather Also Stabilizes Layers

Calm seas decrease oxygen exchange at the surface and inhibit vertical mixing.
Microscopic algae or phytoplankton use excess nutrients to grow rapidly or “bloom”.

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

When plankton die, they sink to the bottom, decompose, and use up oxygen.
Hypoxia: When little or no oxygen is present near the sea bottom

- Mobile animals leave.
- Stationary animals become stressed or die.

Gulf of Mexico Hypoxia

- Every summer, bottom waters from the Mississippi River west to Texas become hypoxic
- Hypoxia typically occurs in waters 5 – 30 m deep
- Normal marine life cannot remain in hypoxic areas

In Louisiana, the hypoxic zone occurs west of the Mississippi and Atchafalaya rivers
What do we need to know about hypoxia?

- How big is the hypoxic region in the Gulf?
- What causes it?
- How much of a problem is it?
- Where else does it occur?
- If it is a problem - what could be done about it?

Size of Hypoxic Zone Varies From Year to Year

Hypoxic Area Roughly Follows River Flow Rate
In the U.S., hypoxia occurs in coastal waters in New York, Maryland, North Carolina, Florida, Alabama, Texas and Louisiana.

The Gulf of Mexico is not the only region with hypoxic areas.

Hypoxia in Long Island Sound - August 2007

- Nutrient-rich waters from East River and other smaller rivers
- Restricted mixing in relatively confined area
When does hypoxia occur?

- Gulf of Mexico hypoxia occurs from late spring until late summer.
- Fall and winter storms mix up the water and the dead zone disappears.
- Demonstration - let's see what happens when we stir up the fresh water floating on the salt water.

Observing Hypoxia From Oil and Gas Platforms

http://wavcis.csi.lsu.edu

Long term measurements:
- Temperature and Salinity
- Currents and waves
- Dissolved oxygen

Hurricane Katrina Stirs Up the Gulf

- Measurements of dissolved oxygen (y-axis) over time (x-axis)
- Surface remains oxygenated throughout
- Passage of hurricane oxygenates middle and bottom waters

Figures provided by Nancy Rabalais, LUMCON
Hypoxia can affect:

- Benthos – organisms living on the seabed
- Fisheries – adult and larval fish that would otherwise inhabit the lower water column
- People who depend on the living resources in hypoxic areas

How Big a Problem is Hypoxia?

- Research to date has not shown that the occurrence of hypoxia reduces overall fish and shrimp catches in the Gulf
- Difficult to sort out effects of hypoxia from other environmental stresses, e.g. overfishing
- Effects could become more apparent if the hypoxic zone gets much larger
- Scientists and policymakers are concerned in many areas of the world

Harmful Algal Blooms

- Also related to nutrient over-enrichment.
- Certain species of algae bloom and then cause a range of adverse effects on humans and fish
Harmful Algal Blooms

- Harmful algal blooms (HABs) are blooms of species of algae that have negative impacts on humans, marine environments, and/or coastal economies.
- HABs include blooms of both microalgae (microscopic, single celled) and macroalgae (seaweeds).
- HABs are a natural feature in coastal ecosystems.
- Human activities may be contributing to increased frequency.

Locations of HAB Events in the US

Economic effects of HABs in the U.S.: $82 million/year *

- Commercial Fisheries Impacts: $38 million/year
- Public Health Costs of Illnesses: $37 million/year
- Recreation and Tourism Impacts: $4 million/year
- Coastal Monitoring & Management: $3 million/year

Nutrients are compounds that contain:

- Phosphorus
- Nitrogen
- Silica

What Do We Mean by Nutrients?

Excess nutrients from runoff are carried to the Gulf of Mexico.

Excess nutrient inputs lead to eutrophication - over-enrichment of any water body with nutrients, resulting in excessive growth of organisms and depletion of oxygen concentration.

Nutrients carried by the river come from a variety of sources.
Where do nutrients come from?

Human activities contribute to nutrient inputs

- Land use practices
- Location and intensity of fertilizer use
- Loss of wetlands

Fertilizer Use Driving Increased Nitrogen Inputs Mississippi and Atchafalaya Rivers

Taken from CENR publication "Draft: Integrated Assessment of Hypoxia in the northern Gulf of Mexico."
Fertilizer: Your Lawn Versus the Amber Waves of Grain

![Graph showing nitrogen levels for different types of grass and crops.]

Just How Much Lawn Do We Have?

- NASA satellite imagery analysis estimates lawns cover 3X more US area than irrigated corn.
- 5-20% of fertilizer sold for non-agricultural use.

Fertilizers Boost Agricultural Productivity

![Bar charts showing yield increase with nitrogen application for various crops.]

<table>
<thead>
<tr>
<th>Crop</th>
<th>Yield (bushel/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>Without Nitrogen</td>
</tr>
<tr>
<td>Rice</td>
<td>Without Nitrogen</td>
</tr>
<tr>
<td>Barley</td>
<td>Without Nitrogen</td>
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<td>Wheat</td>
<td>Without Nitrogen</td>
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<tr>
<td>Soybeans</td>
<td>Without Nitrogen</td>
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<tr>
<td>Peanuts</td>
<td>Without Nitrogen</td>
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Does the increasing price of corn make more fertilizer use an economic sure thing for farmers?
Topics for Discussion

- One solution? Reduce nutrient loading
  - Change flood control practices
  - Use fertilizers more efficiently on farms and at home
  - Create and restore wetlands
- Need to consider effectiveness, cost, impacts
- What will options mean for society?
  - Cost of food and biofuel production
  - Limitations on agricultural or development activities

Acknowledgements

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  http://www.lamer.lsu.edu/classroom/deadzone/index.htm

- WAVCIS pictures and data used by permission Nancy Rabalais, Louisiana State Universities Marine Consortium