Recent Discoveries (Challenges) at the Land-Receiving Water Interface

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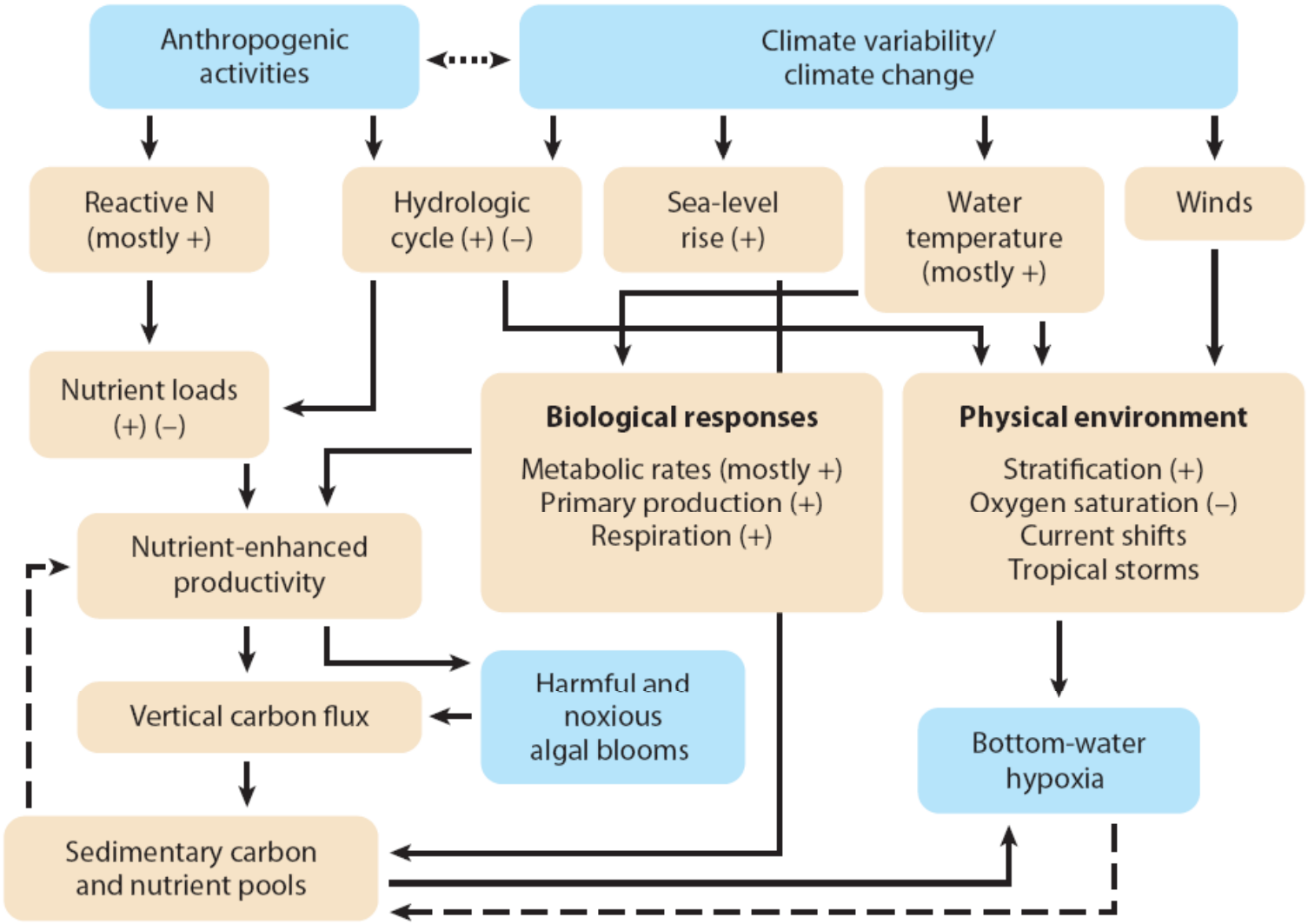
Photo: John White, LSU

Increasing Human Population and Resource Requirements

Some of the Challenges these ecosystems are facing…



Rabalais et al. 2010

Significance of River Drainage Basins

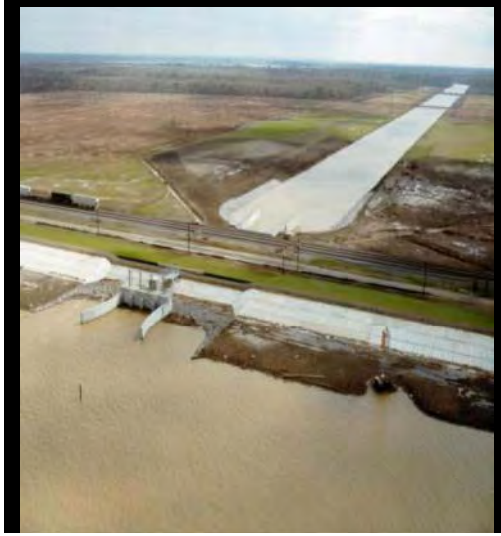
- **60% world population**
  - More than 50% of the world's population lives in Asia and most of Asia's population live in deltaic areas
- **2/3 middle/large size cities**

A. Watershed Alterations

Levees: Protection from Flooding

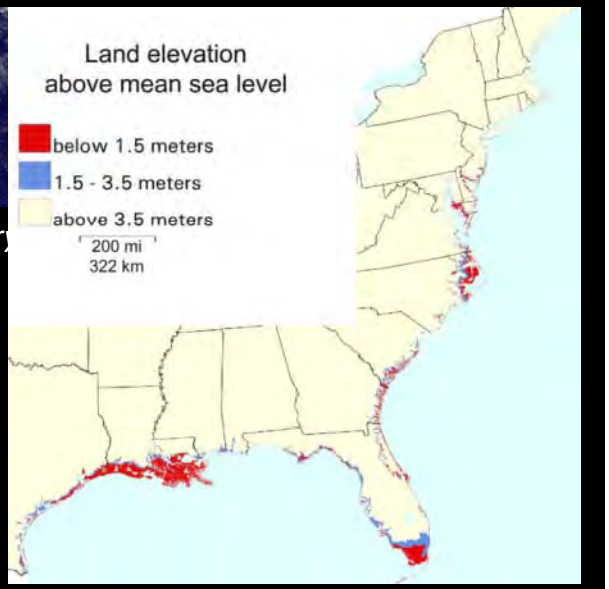
- **ALTERED RIVER FLOW**
- **FEW NUTRIENTS AND LESS SEDIMENTS TO WETLANDS**
- **WETLAND LOSS**

Diversions: Reconnect the River with the Marsh



Sea Level Rise and Subsidence

By NASA Earth Observatory



COASTAL MORPHOLOGY CHANGES
SALINITY INTRUSION
WETLAND LOSS

B. Nutrient Enrichment

Excess off Nutrients seems to be the main driver at this interface in many places

A Global Response to Anthropogenic Loadings

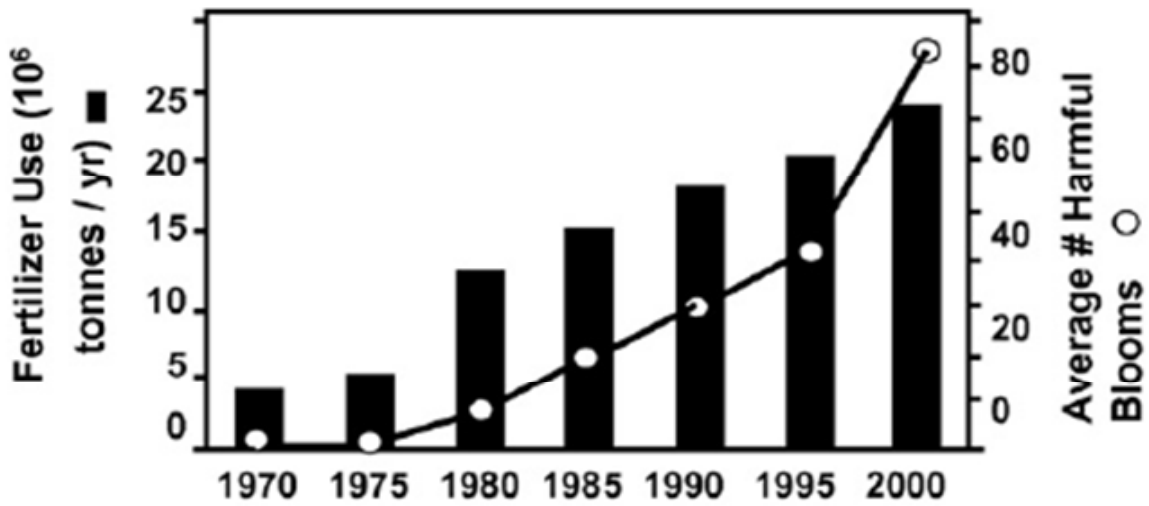
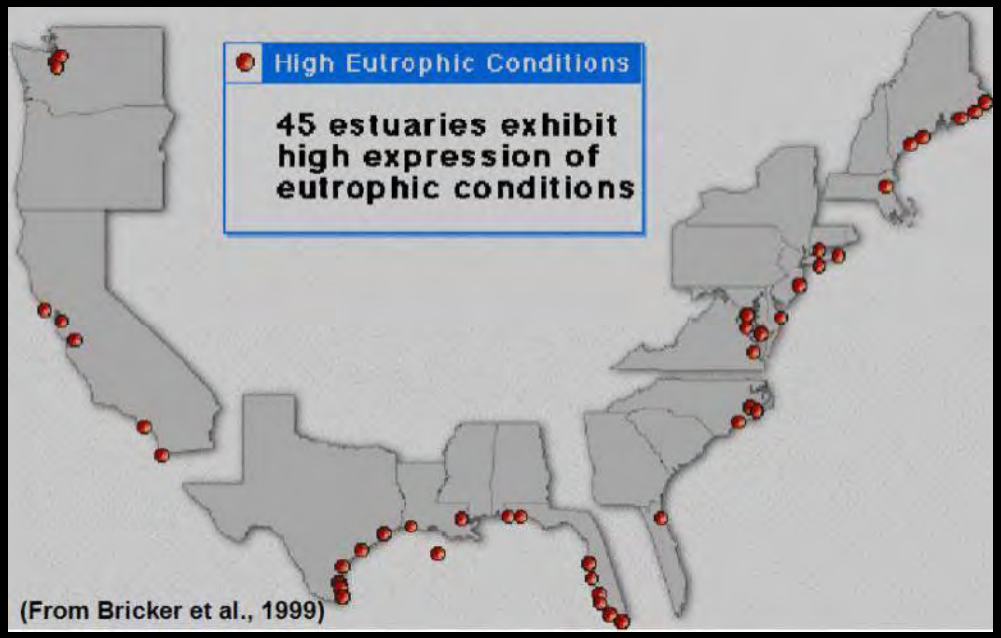


Fig. 3. Long-term trends in the use of nitrogen-based fertilizers and the number of occurrences of red tide blooms in Chinese coastal waters (modified and redrawn from Anderson et al., 2002; Zhou, 2005).

Degradation of Water Quality
EUTROPHICATION

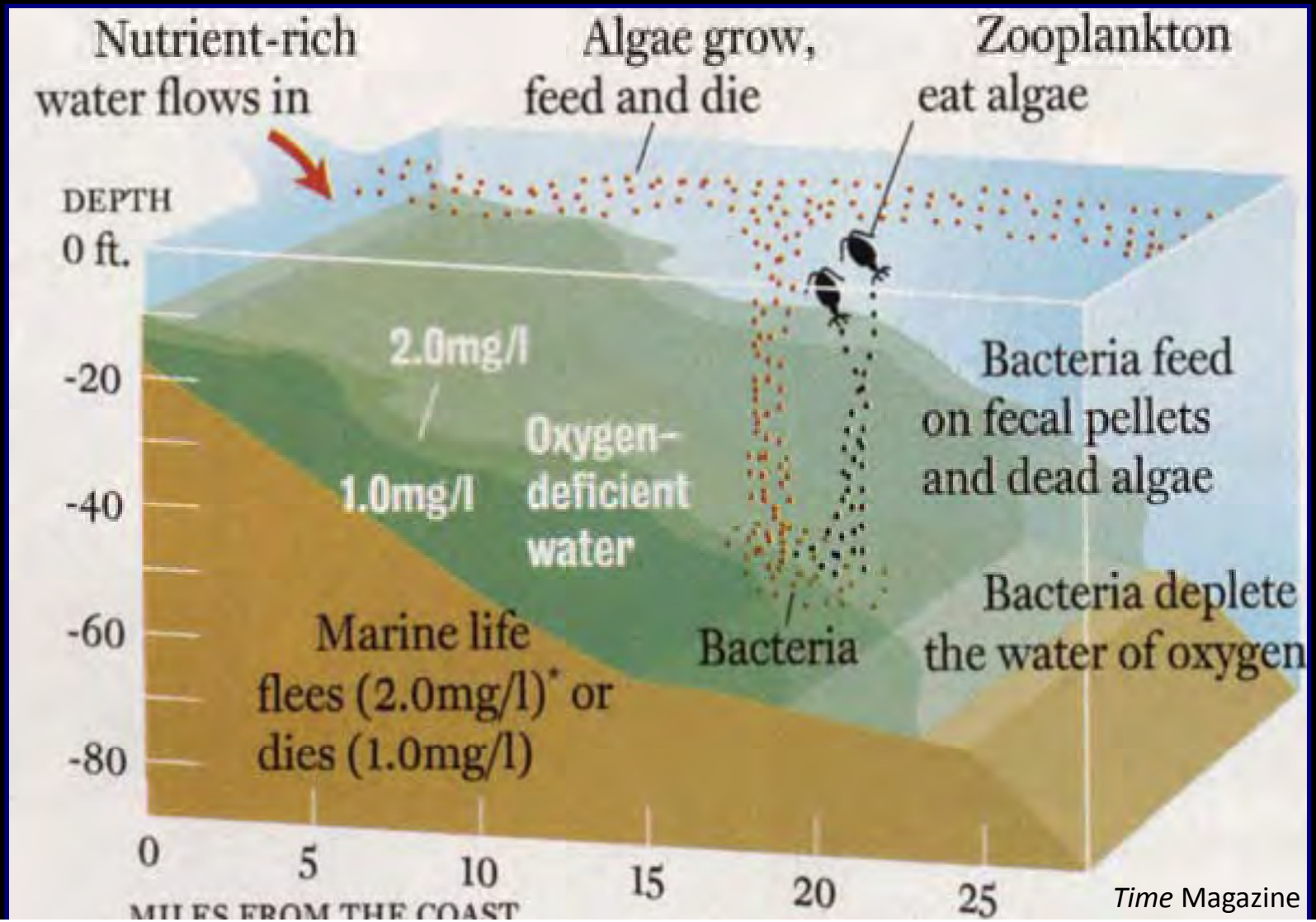


http://www.redtide.whoi.edu/hab/

- Hypoxia
- Harmful algal blooms
- Reduced benthic biomass and biodiversity.
- Fishery and seafood industries.
- Fishermen and coastal state economies

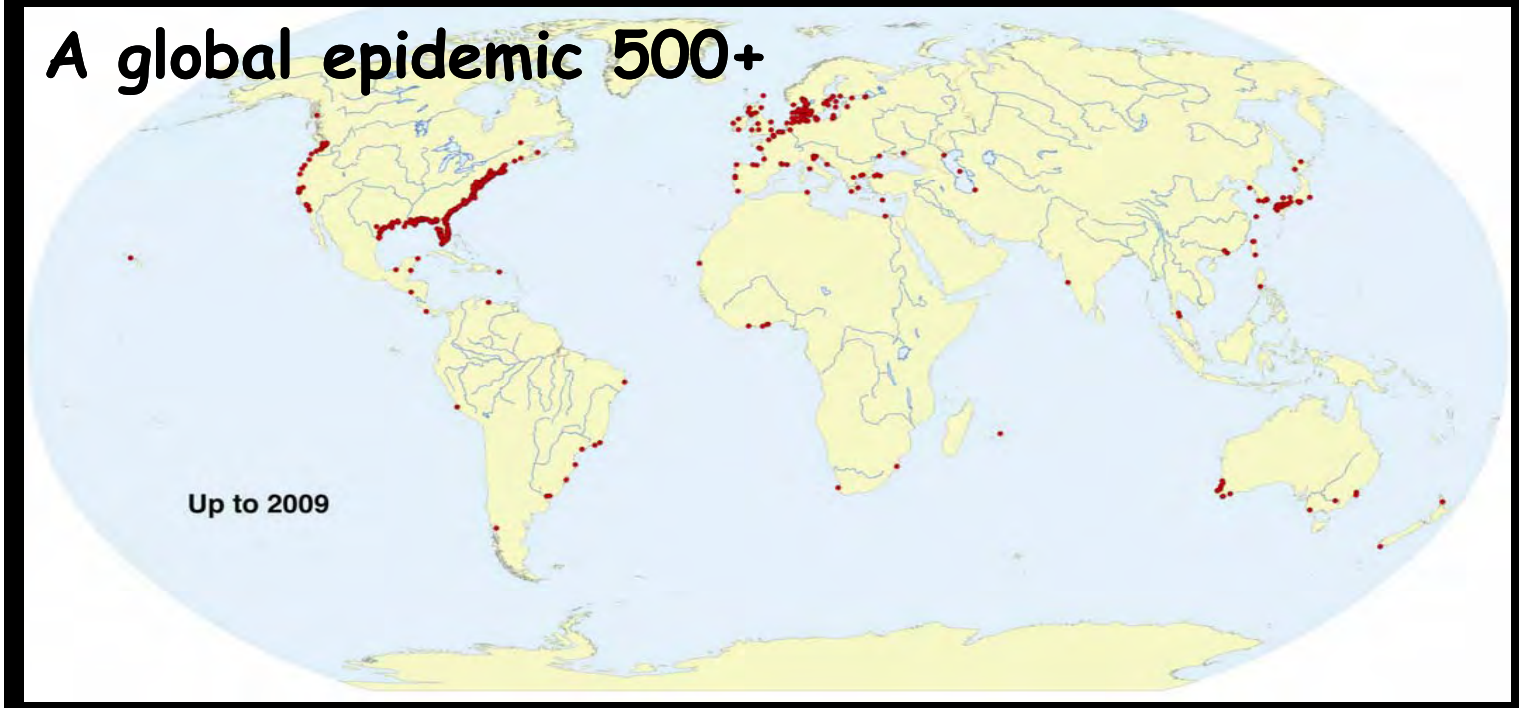
HYPOXIA

Nutrients, Increased Growth, Low Oxygen…

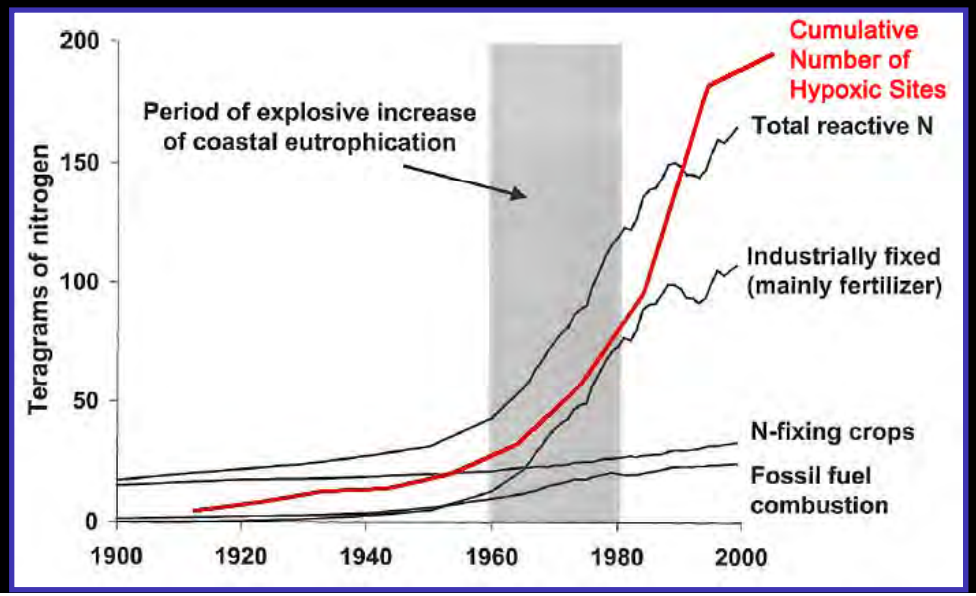


Time Magazine

A global epidemic 500+

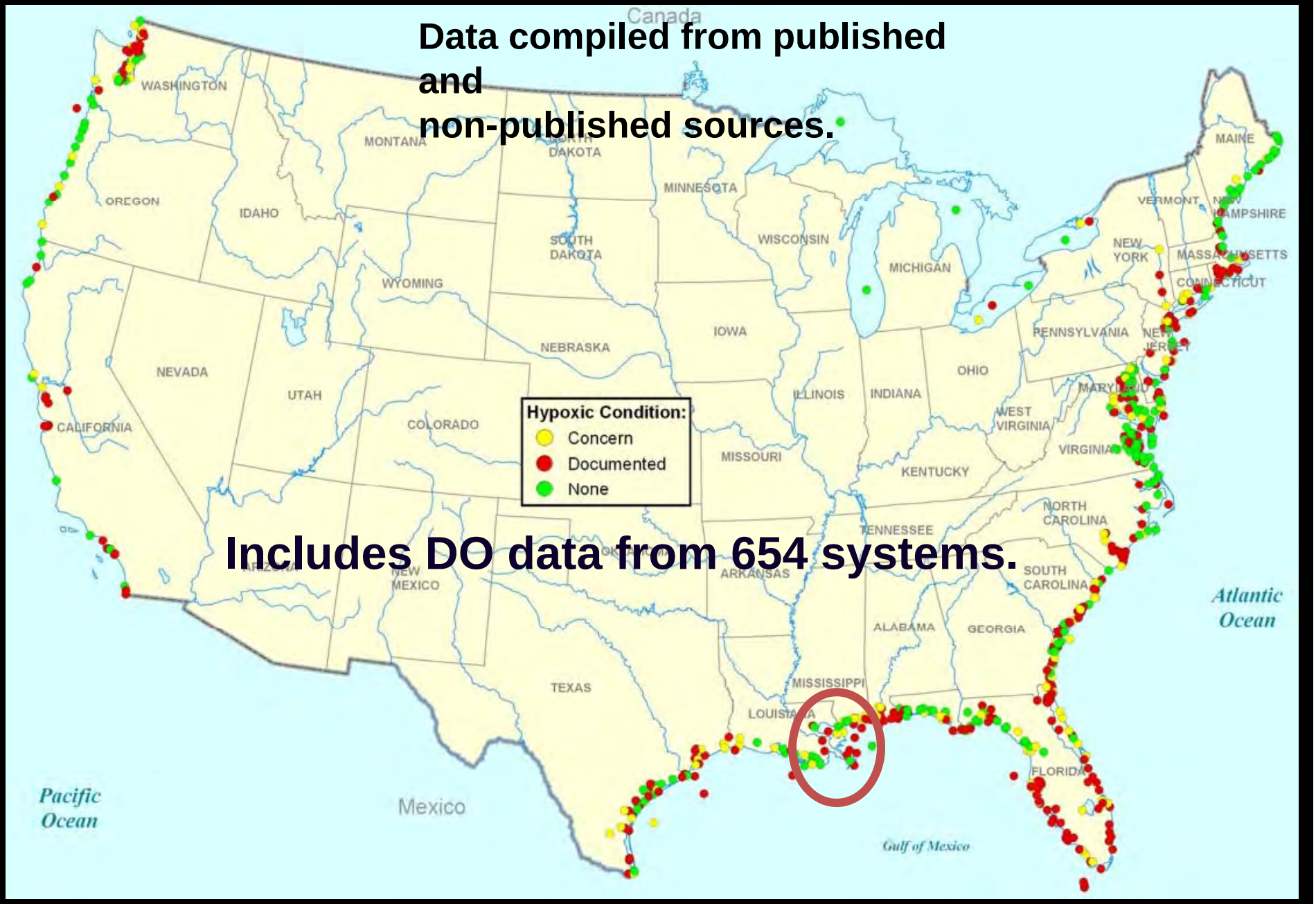


Rabalais et al. 2010; modified from Díaz and Rosenberg 2008

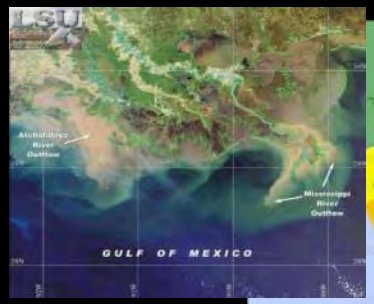


Boesch 2002 & Diaz unpubl.

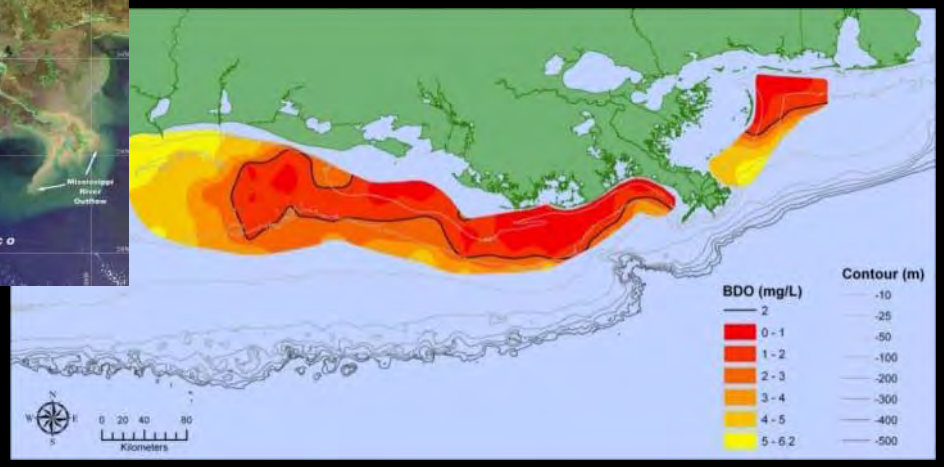
U.S. Hypoxic Trends for Estuarine and Coastal Systems



The drainage basin of Mississippi River

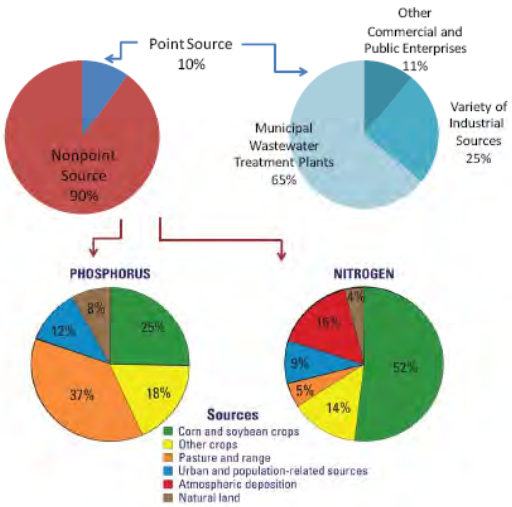


Bottom-Water Dissolved Oxygen July 18-21, 24-30, 2011



Data source: N.N. Rabalais, Louisiana Universities Marine Consortium, R.E. Turner, LSU

- **The Mississippi River is the largest river system in North America and among the largest in the world**
- **by length 6,300 km, it is the forth longest**
- **Discharge—seventh in the world** (530 km3/y)
- **Sediment—tenth in the world** (210 million t/y)



The "Dead Zone" is ……. not completely 'dead.'

But…. effects of hypoxia on fisheries resources are big

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

Photo credit: Kerry St. Pe

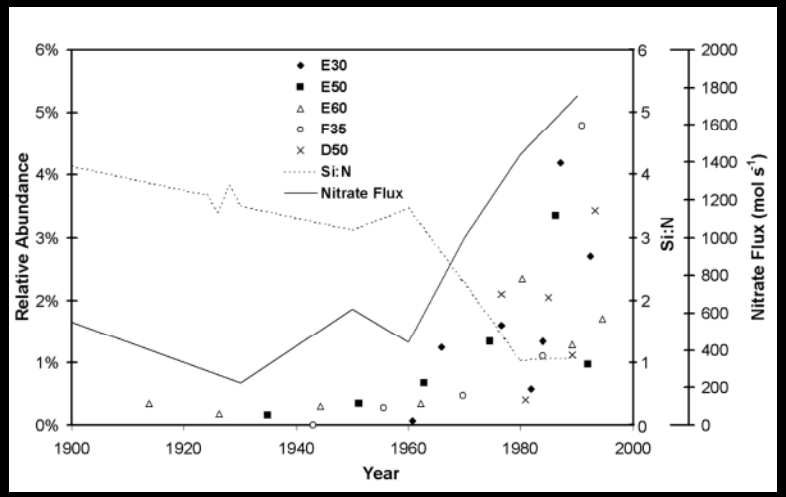
Photo credit: Franklin Viola

Food Web Alterations

Officer and Ryther's Hypothesis and "Redfield" ratios

C:Si:N:P = 106:15:16:1

(Photo: Q. Dortch)



A shift from heavily silicified to less silicified, including the HAB *Pseudo-nitschia* (indicates less silica availability but competitive advantage with increased nitrogen)

Si:N > 1:1

diatoms as prey

↓

zooplankton as Grazer

↓

desirable fish community

Si:N<1:1

flagellated algae, incl. harmful algal blooms

↓

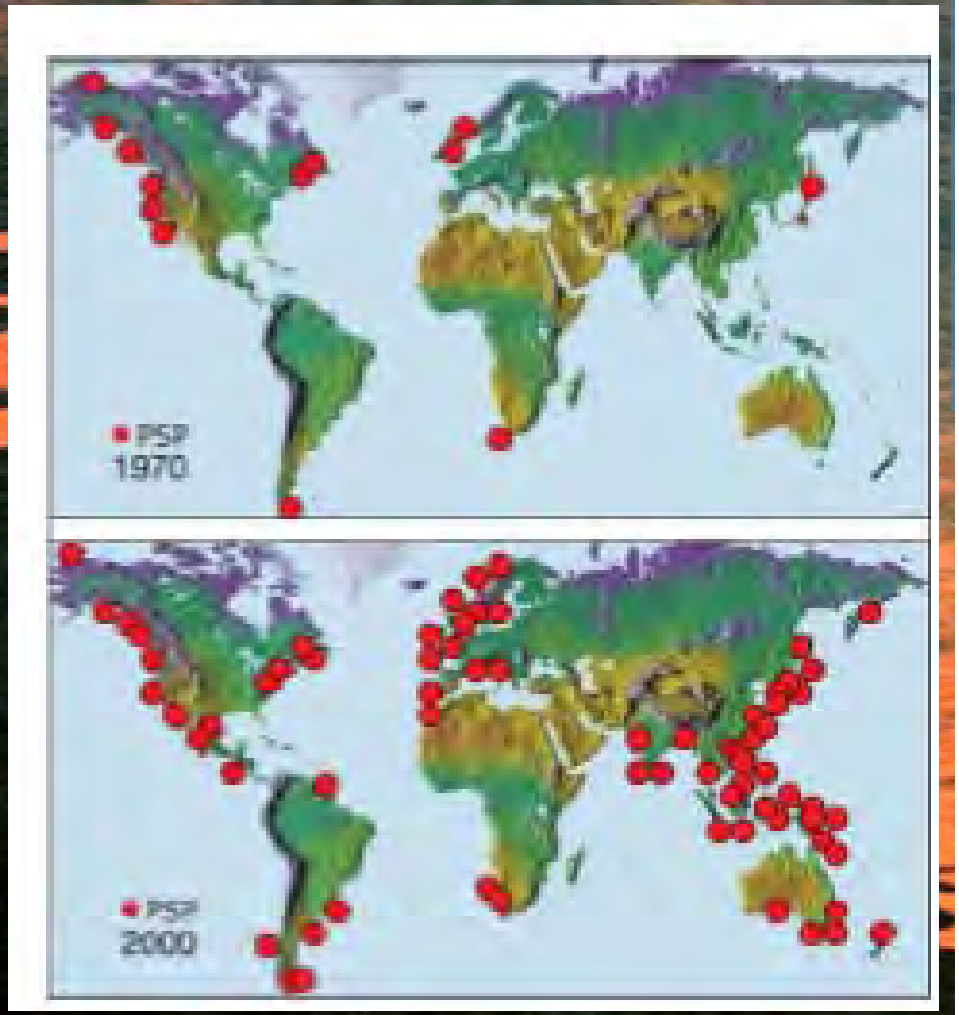
zooplankton reduced

↓

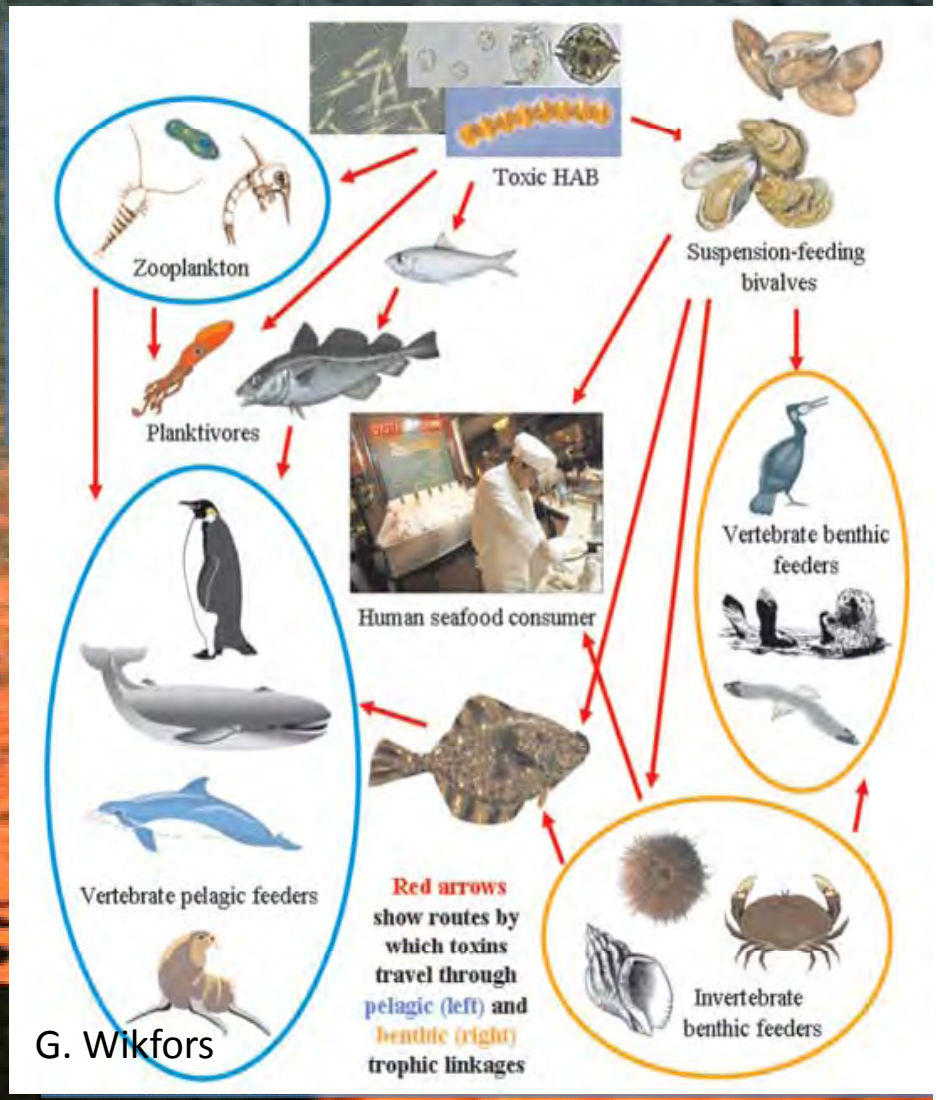
undesirable or reduced fish stocks

Richardson et al. 2009

Harmful/Toxic Algal Blooms (HABs)



@ PJS Franks

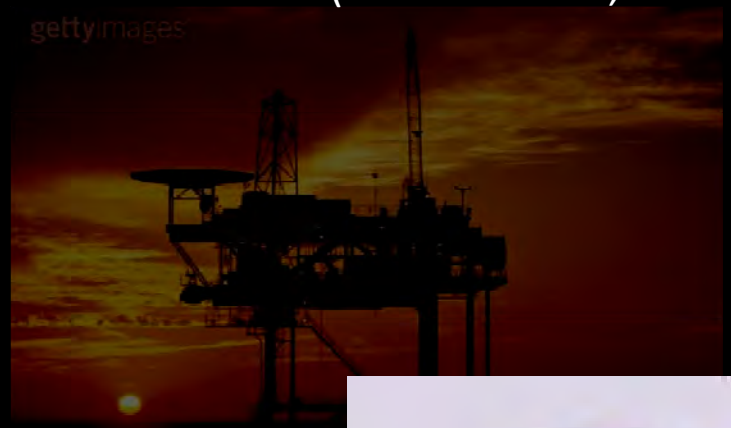


G. Wikfors

Ciguatera Fish Poisoning can be a threat: *Gambierdiscus toxicus*

"The *sea-surface temperature rise*, increased *industrial creation of hard substrate* and *fish-attracting structures*, petroleum production platforms, and probable *habitat/range expansion of both Gambierdiscus and toxic fish* in the future suggests that the risk is unlikely to diminish and could increase." (Villareal et al., 2007)

terragalleria.com



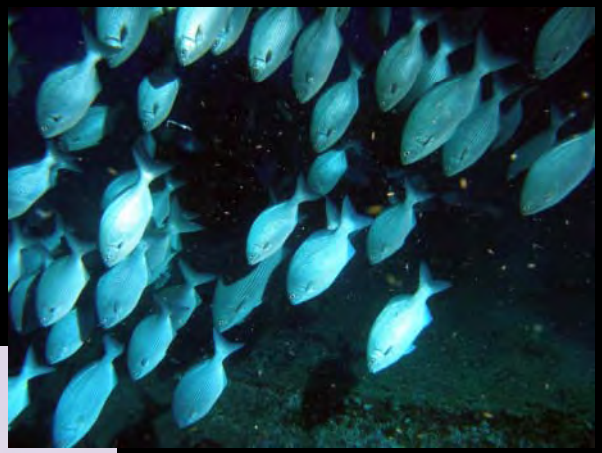


Photo: Mark Benfield, LSU

rst.gsfc.nasa.gov

http://www8.nos.noaa.gov

Local News

Mechanism of alga

Sunday, September 20 | 12:14 a.m.

BY ERIK ROBINSON

COLUMBIAN STAFF WRITER

Another summer, another lake closure.

Clark County health authorities closed Lacamas and Round lakes to swimming and wading last week

INSIDE ENVIRONMENT with The Oregonian

• Environmental News

Breaking News, East Multnomah County »

Algae blooms on increase in state; officials cite changing conditions, better monitoring

retriever died after frolicking in the

osures of Vancouver Lake have

?

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lsureveille.com

THE DAILY REVEILLE

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Daily Reveille > News

Algae poses potential health risk

By The Associated Press

Muskegon Chronicle

• Subscribe to Muskegon Chronicle

• Today's Paper & More

Lakes' toxic algae blooms know no boundaries

arian suspected cyanob

Algae bloom closes Halfmoon Pond

Scientists Study Whether There's Any Link Between Lou Gehrig's Disease and Water Quality

By Amy Quinton on Monday, June 15, 2009.

algal bloom of blue-green algae.

Fond du Lac County, Wis.

New Zealand

Next Article: Starship reluctant to give back cash

Councils, health agencies warn of toxic algae blooms this summer

; social problem

TOXIC CYANOBACTERIA BLOOMS

Hydrobiologia (2011) 661:377–389
DOI 10.1007/s10750-010-0545-8

PRIMARY RESEARCH PAPER

Effects of freshwater input on nutrient loading, phytoplankton biomass, and cyanotoxin production in an oligohaline estuarine lake

Sibel Bargu · John R. White · Chunyan Li · Jessica Czubakowski · Robinson W. Fulweiler

Received: 20 August 2010 / Revised: 21 October 2010 / Accepted: 1 November 2010 / Published or
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Abstract Pulsed river water events can increase nutrient levels potentially translating into enhanced primary production, phytoplankton community shifts, and bloom formation. The Bonnet Carré Spillway is a managed river diversion which can be used to redirect

gradually mixed togethe
closed, indicated by the
salinity gradient. The riv
nitrate and dissolved reac
tions to more than five ti

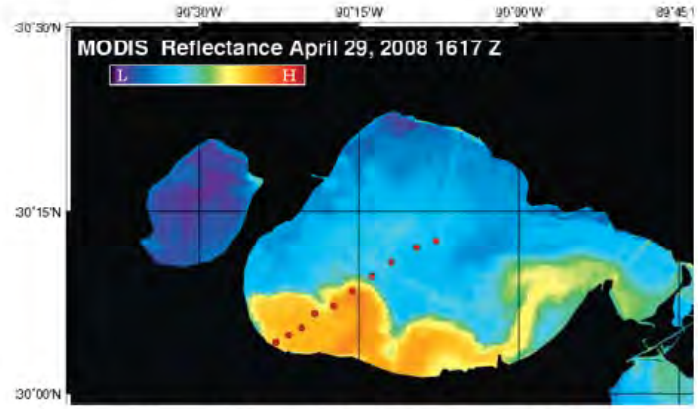
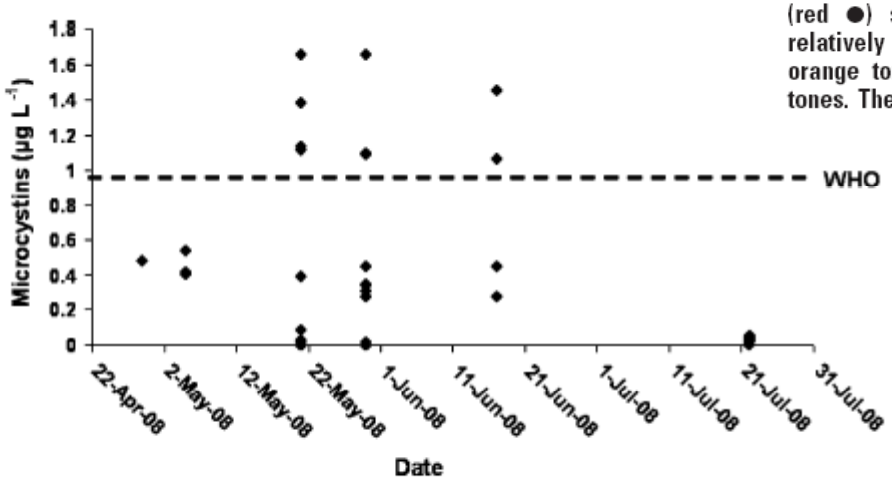
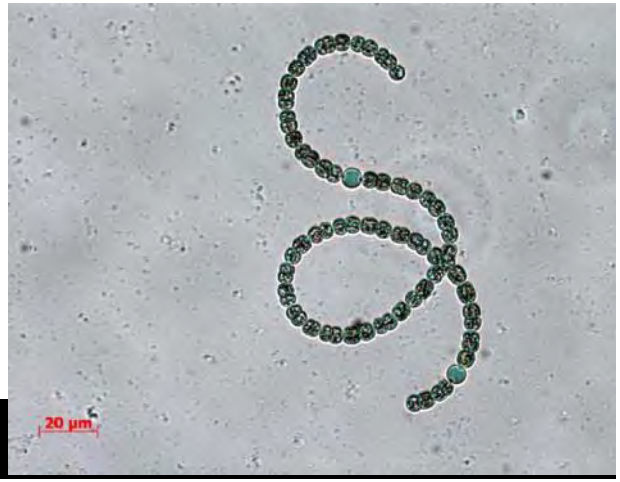


FIGURE 2. Terra-1 MODIS band 1 (red) reflectance data obtained on April 29, 2008 at 1017 CST with sampling stations (red ●) superimposed. Sediment-laden river waters exhibit relatively high red band reflectance values and are depicted in orange tones. Low reflectance values are depicted with blue tones. The land has been colored black.

Fig. 5 Concentration of microcystins (μg MC l^{-1}) ($n = 19$) in surface water of sampling stations. *Dashed horizontal line* represents World Health Organization (WHO) advisory limit for tolerable daily intake (TDI) of 1.0 μg MC l^{-1}

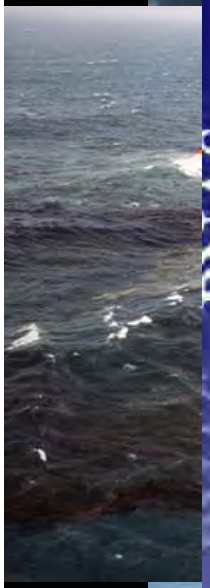




Impairments from nutrients are significant, but are not the only stressor

http://theaterturtle.glogster.com/plastic-pollution/

OIL SPILLS



www.cnbc.c

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PNAS

SPECIAL FEATURE

Genomic and physiological footprint of the *Deepwater Horizon* oil spill on resident marsh fishes

Andrew Whitehead[a,1], Benjamin Dubansky[a], Charlotte Bodinier[a], Tzintzuni I. Garcia[b], Scott Miles[c], Chet Pilley[d], Vandana Raghunathan[e], Jennifer L. Roach[a], Nan Walker[e], Ronald B. Walter[b], Charles D. Rice[f], and Fernando Galvez[a]

Departments of [a]Biological Sciences, [c]Environmental Sciences, and [d]Oceanography and Coastal Sciences, and [e]Coastal Studies Institute, Louisiana State University, Baton Rouge, LA 70803; [b]Department of Chemistry and Biochemistry, Texas State University, San Marcos, TX 78666; and [f]Department of Biological Sciences, Clemson University, Clemson, SC 29634

Edited by Paul G. Falkowski, Rutgers, The State University of New Jersey, New Brunswick, NJ, and approved September 1, 2011 (received for review June 13, 2011)

The biological consequences of the *Deepwater Horizon* oil spill are unknown, especially for resident organisms. Here, we report results from a field study tracking the effects of contaminating oil across space and time in resident killifish during the first 4 mo of the spill event. Remote sensing and analytical chemistry identified exposures, which were linked to effects in fish characterized by genome expression and associated gill immunohistochemistry, despite very low concentrations of hydrocarbons remaining in water and tissues. Divergence in genome expression coincides with contaminating oil and is consistent with genome responses that are predictive of exposure to hydrocarbon-like chemicals and indicative of physiological and reproductive impairment. Oil-contaminated waters are also associated with aberrant protein expression in gill tissues of larval and adult fish. These data suggest that heavily weathered crude oil from the spill imparts significant biological impacts in sensitive Louisiana marshes, some of which remain for over 2 mo following initial exposures.

ecological genomics | ecotoxicology | microarray | RNA-seq | toxicogenomics

Following the *Deepwater Horizon* (DWH) drilling disaster on April 20, 2011, in the Gulf of Mexico, acute oiling and the resulting mortality of marine wildlife were evident. In contrast, the sublethal effects, critically important for predicting long-term population-level impacts of oil pollution (1), have not been well described following the DWH disaster. Here, we report the results of a 4-mo field study monitoring the biological

spatially and temporally comprehensive but of low resolution and chemistry data are of high resolution but patchy in space and time. Ocean surface oil was remotely detected through the analysis of images from synthetic aperture radar (SAR) (14). Proximity of the nearest oil slick to each field site (e.g., Fig. S1) was measured for each day that SAR data were available, from May 11 through August 13, 2010, to approximate the location, timing, and duration of coastal oiling (Fig. 1*C*). Although surface oil came close to many of our field sites in mid-June, only the Grande Terre (GT) site was directly oiled (Fig. 1 *B* and *C*). Although the GT site had been clearly contaminated with crude oil for several weeks before our sampling (Fig. 1*C* and Fig. S2) and retained much oil in sediments (Dataset S2), only trace concentrations of oil components were detected in subsurface water samples collected from the GT site on June 28, 2010, and tissues did not carry abnormally high burdens of oil constituents at any site or time point (Dataset S2). Despite a low chemical signal for oil in the water column and tissues at the time of sampling, we detected significant biological effects associated with the GT site postoil.

We sampled multiple tissues from adult Gulf killifish (average weight of 3.5 g) from each of six field sites for each of three time points [only the first two time points for the Mobile Bay (MB) site] spanning the first 4 mo of the spill event (Fig. 1*C*). We compared biological responses across time (before, at the peak, and after oiling) and across space (oiled sites and sites not oiled) and integrated responses at the molecular level using genome expression profiling with complimentary protein expression and

ENVIRONMENTAL SCIENCES

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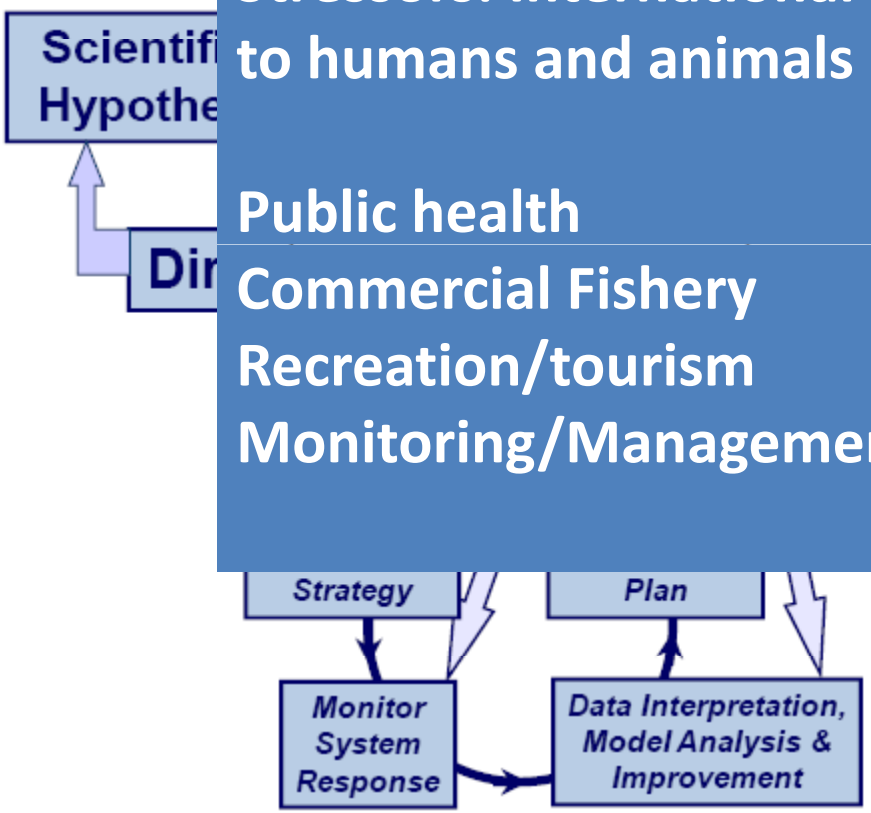
lie Riedel

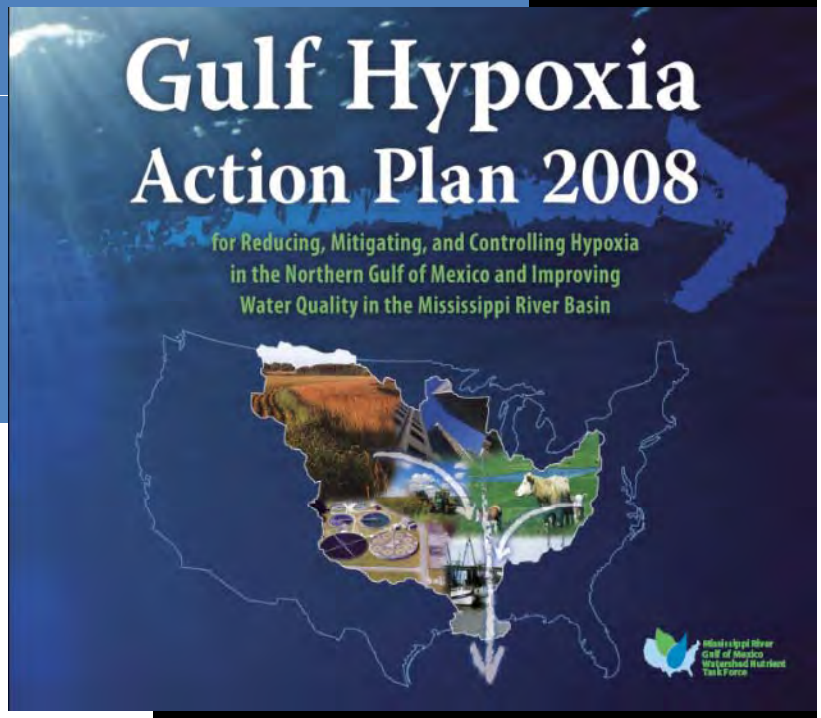
April 20, 2010 Deepwater Horizon drilling rig explosion

Socio-economic losses and Collaborative Efforts in Communication

Stressors: International aquatic hazards to humans and animals

Public health
Commercial Fishery
Recreation/tourism
Monitoring/Management





Adaptive management framework that connects monitoring, analysis, and management actions with continuous feedback for improvement. Research and management needs are a continual input to the adaptive management scheme. (Rabalais et al. 2002).