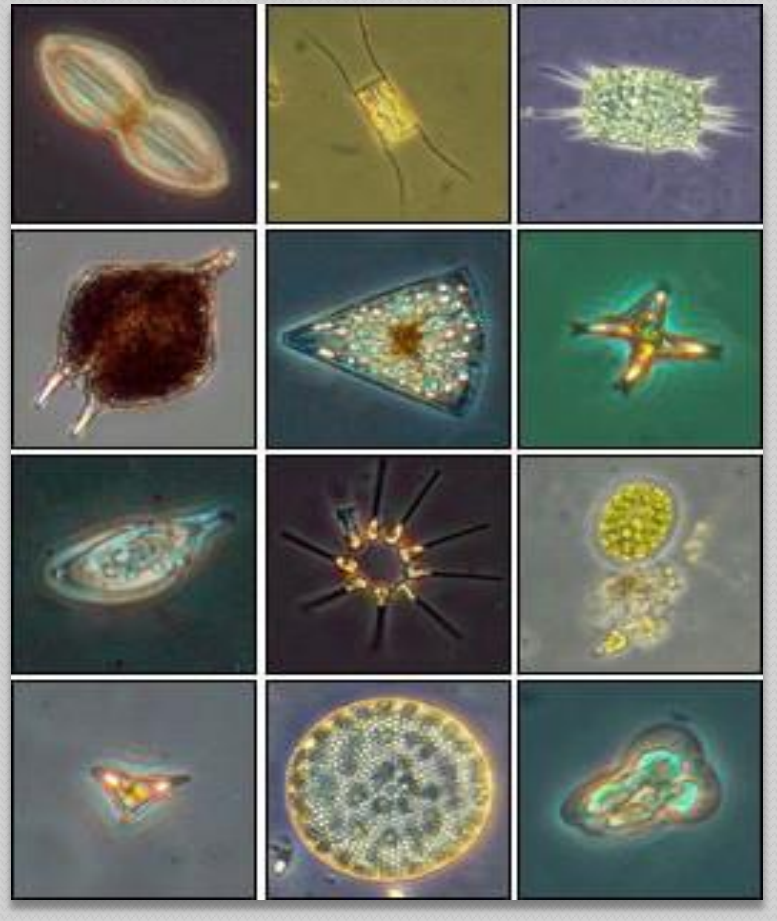
Consequences of Hypoxia in the Gulf of Mexico

Spreading Dead Zones and the Consequences for Marine Ecosystems

- The most serious threat from eutrophication (an increase in the concentration of chemical nutrients in an ecosystem to an extent that increases in the primary production of the ecosystem) is the unseen decrease in dissolved oxygen (DO) levels.
- Any area that has less than 2 milligrams of dissolved oxygen per liter of seawater is hypoxic – "dead".
- The key to reducing dead zones will be to keep fertilizers on the land and out of the sea.



Spreading Dead Zones and the Consequences for Marine Ecosystems

- Research into marine “dead zones” around the world suggests that crustaceans (which consists of crabs, lobsters, crayfish, shrimp, krill and barnacles) are the first to gasp for air when oxygen levels get low.
- Findings based on a review of 872 published studies of 206 ocean-floor dwelling species.

Spreading Dead Zones and the Consequences for Marine Ecosystems

- The minimum oxygen level varies widely among species.
- American oyster (*Crassostrea virginica)* is able to survive in water that are entirely devoid of oxygen.
- Larvae of the rock crab (*Cancer irroratus)* die if there is any less than 8.6 mg/l.

Spreading Dead Zones and the Consequences for Marine Ecosystems

- Oxygen levels need to be 4.6 mg/l or higher
- By the time you get to 2 mg/l, you start to see really serious effects.
- At 2.8 mg/l behavioral mechanisms start to kick in.

Spreading Dead Zones and the Consequences for Marine Ecosystems

http://www.youtube.com/watch?v=YKkdIIRmwwQ

Spreading Dead Zones and the Consequences for Marine Ecosystems

Spreading Dead Zones and the Consequences for Humans

- At least half of the oxygen we breathe comes from phytoplankton.
- All oil comes fossilized plankton
- Diatomaceous earth is made from the skeletons of plankton
- Chalk, Chicken noodle soup, juices, etc. are all made from plankton
- Fish we eat depend on plankton ultimately for their food (base of food web in ocean)
- Shrimp we eat depend on plankton

Impact of Dead Zones on Fisheries

Martha M. Gomez Sapiens

Dead zones effects on fisheries

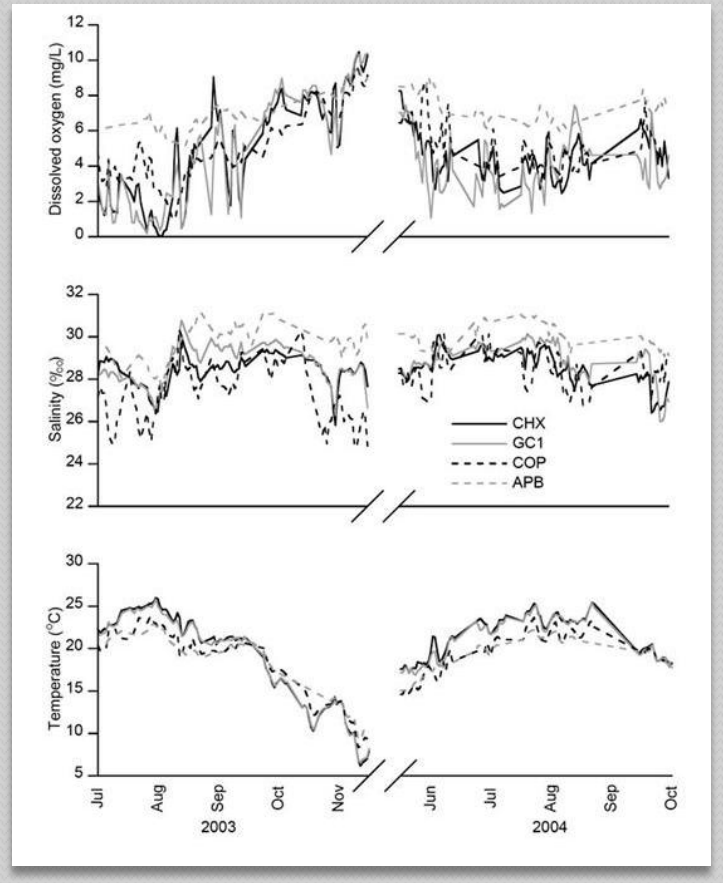
Ecological Effects:

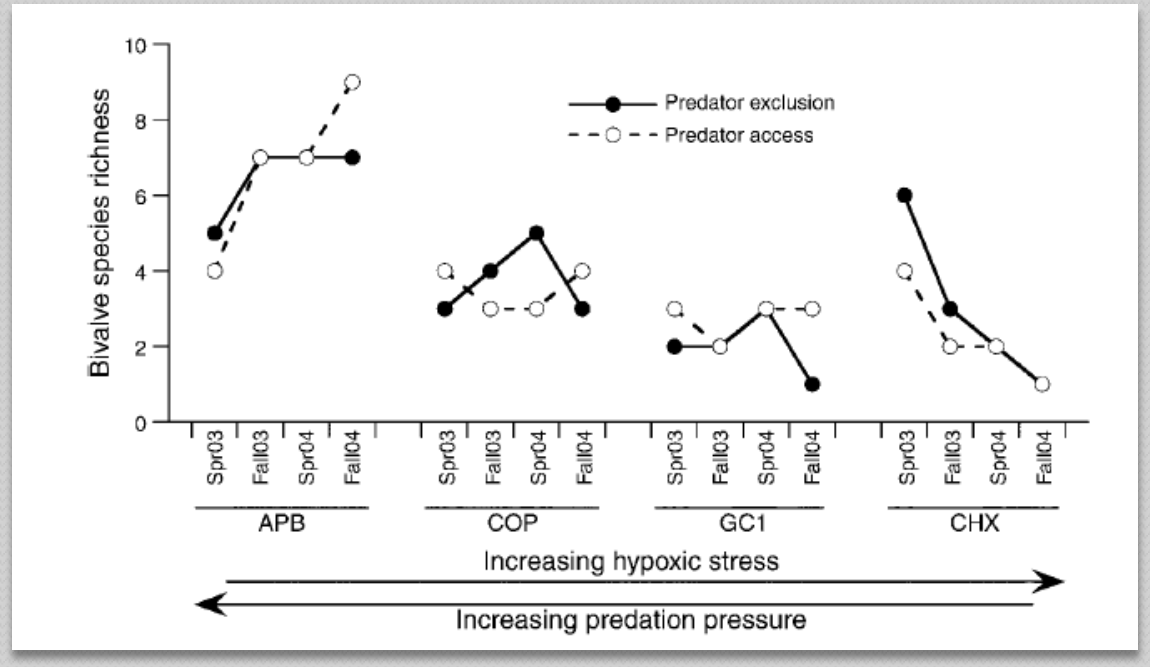
- Alteration of predator-prey interactions.
- Alteration of competition interactions.
- Habitat compression and the loss of fauna.
- Diversion of energy flows into microbial pathways that are detrimental for higher trophic levels.
- Only within a narrow range of conditions hypoxia will facilitate trophic transfer to higher levels in the food chain.

Enhancement of key fisheries species or a “silver lining in a very dark cloud.”

- Some species could benefit from the harsh conditions of degraded habitats.
- Case of study in Rhode Island, USA- Chronic-Hypoxic estuary of Narrangansett.
- Clam fishery *Mercenaria mercenaria* with a landed value *of* $8.4 million on 2007, is one of Rhode Island’s dominant fisheries.
- Questions about predation rates, net survivorship and predation rates and stress tolerance interacts to generate higher abundances but lower diversity of bivalves

Oceanographic conditions and diversity of bivalves at Narragansett Bay

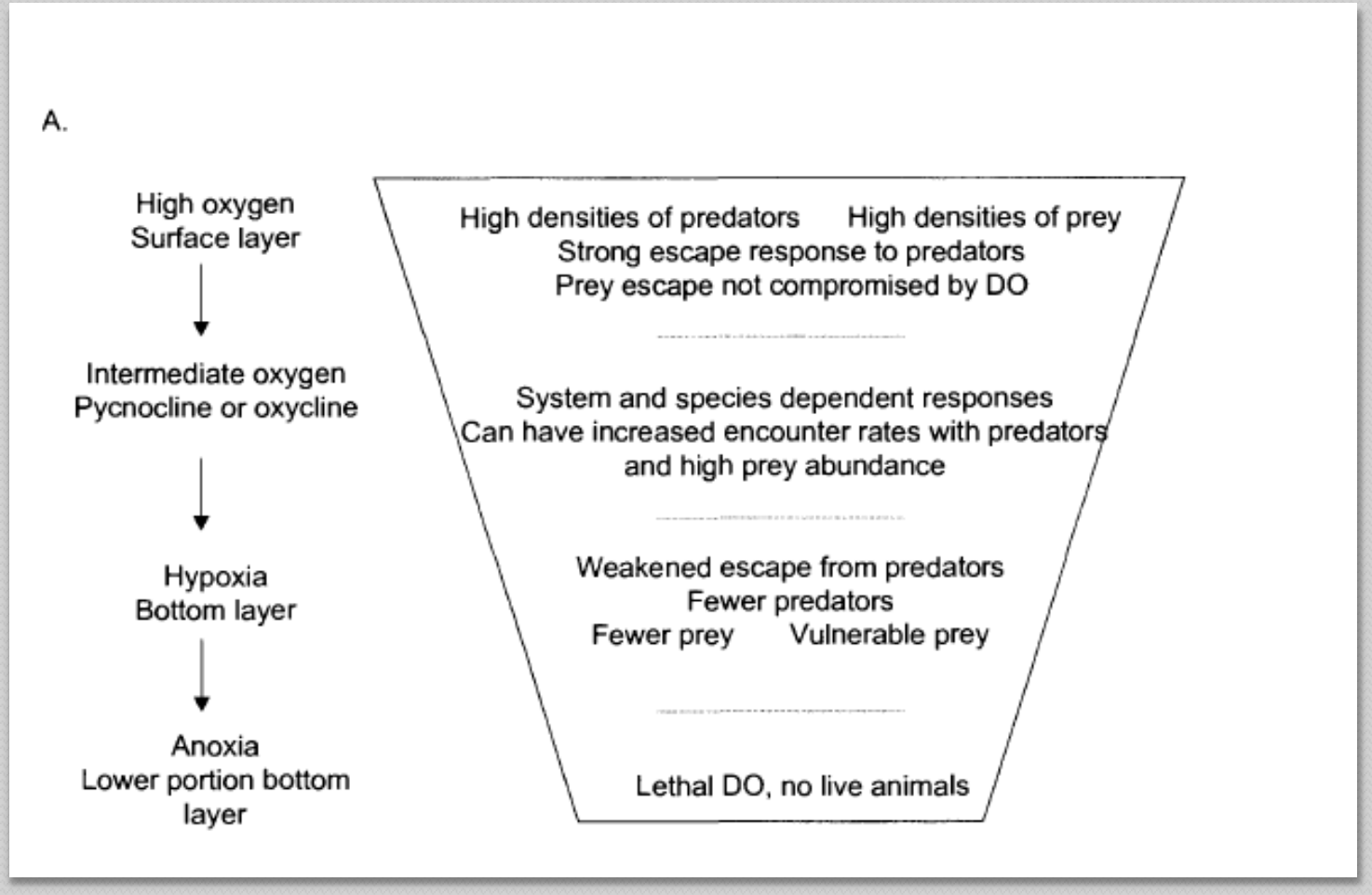




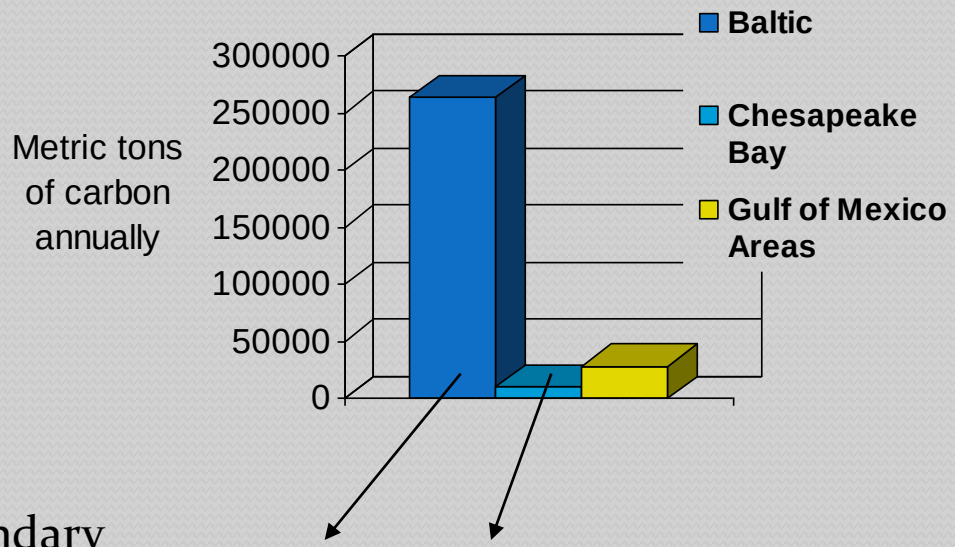
Some examples of Hypoxic areas linked to eutrophication and the fishery response

Hypoxia type	Fishery/other response	System and country
Episodic	Decline of Mantis shrimp	Tokyo Bay, Japan.
Episodic	Collapse of Cockle fishery	Baie de Somme, France.
Episodic	Absence of fish and pelagic invertebrates	Coyote Creek, California, US.
Episodic	Common finfish species had skin lesions and signs of bacterial infections	Pamlico Sound, North Carolina, US.
Periodic	Fish kill	Patos Lagoon, Brazil.
Seasonal	Killed crabs in crab pots	Chesapeake Bay, Maryland-US

Effect of Oxygen concentration on various aspects of predator-prey interactions



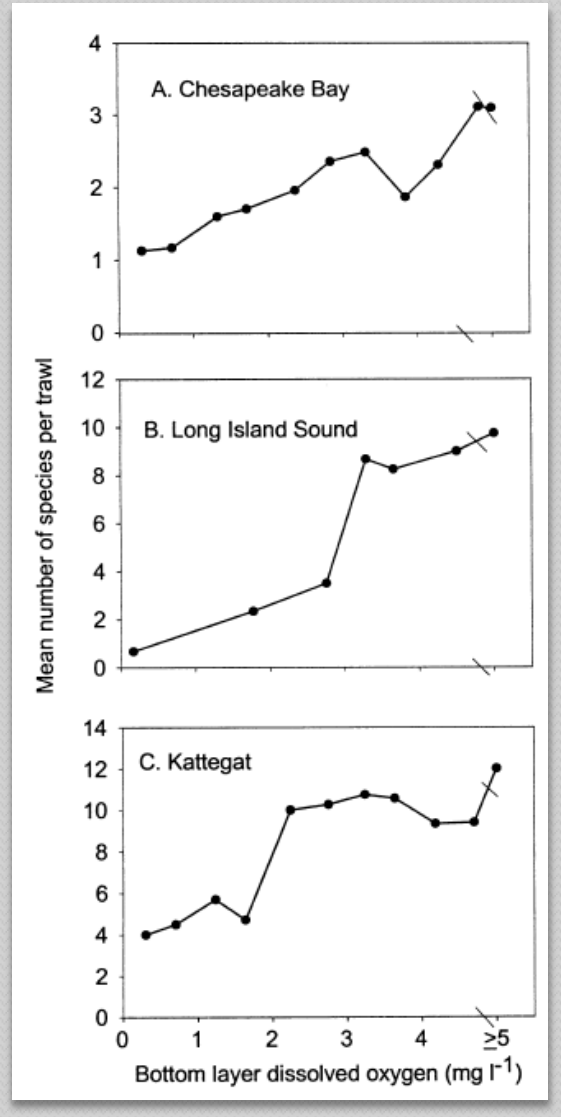
How much biomass and diversity is lost?



Secondary production

30%

5%



Some facts about the Hypoxia effects on fisheries

- There is not clear signal of hypoxia in fishery landings statistics.
- Reduction in demersal fisheries can be the result of hypoxia in conjunction with other factors associated to nutrient loadings.
- Economic and social cost (Fishers may need to travel farther increasing the costs and risk of fishing efforts, reduction of recreational fishing activities.

References

- Altieri, A., 2008. Dead zones enhance key fisheries species by providing predation refuge. Ecology, 89:2808-2818.
- Breitburg, D. 2002. Effects of hypoxia, and the balance between hypoxia and enrichment, on Coastal fishes and fisheries. Estuaries, 25:767-781.
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Natural Dead Zones

Dead Zone: Hypoxic areas in the ocean/lakes

- Hypoxia:
  - Water with concentration < 2 ppm oxygen
- Fish/animals can't survive
- Nutrients derived from various sources

Nutrients come from….

- Erosion
- Sewage Discharge
- Fertilizer

Natural Stuff….

- Erosion
- Stagnant Water
  - Oxygen loss / not replaced
  - Fjords/Black Sea

Question

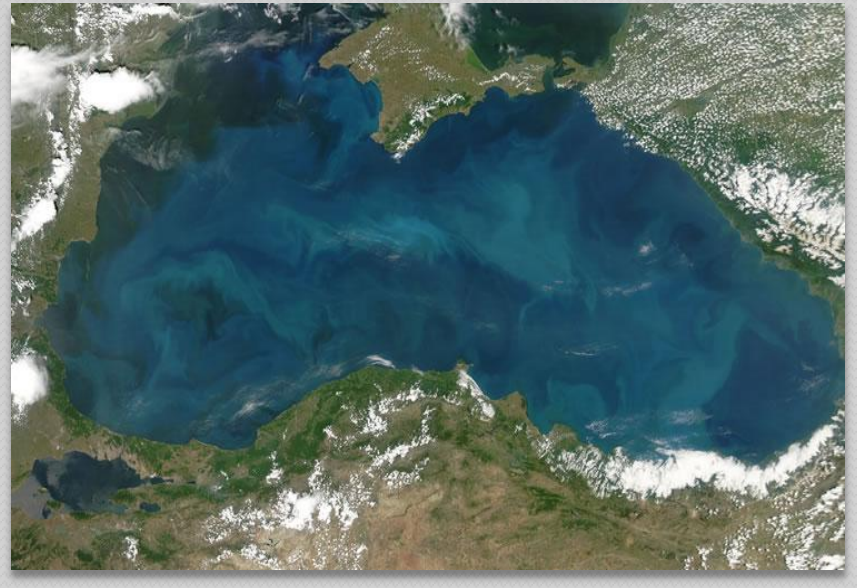
- Are there any natural dead zones?

Better question:

- What do we know about the sea?

Changing, Harsh, Untamable

- 30 years ago ~ 1970's
- No one knows if cause is only human contamination
- Effects have been altered
  - Seasonal hypoxia
  - Black Sea
    - Change after Soviet Union collapse



Location of Black Sea

Gulf of Mexico

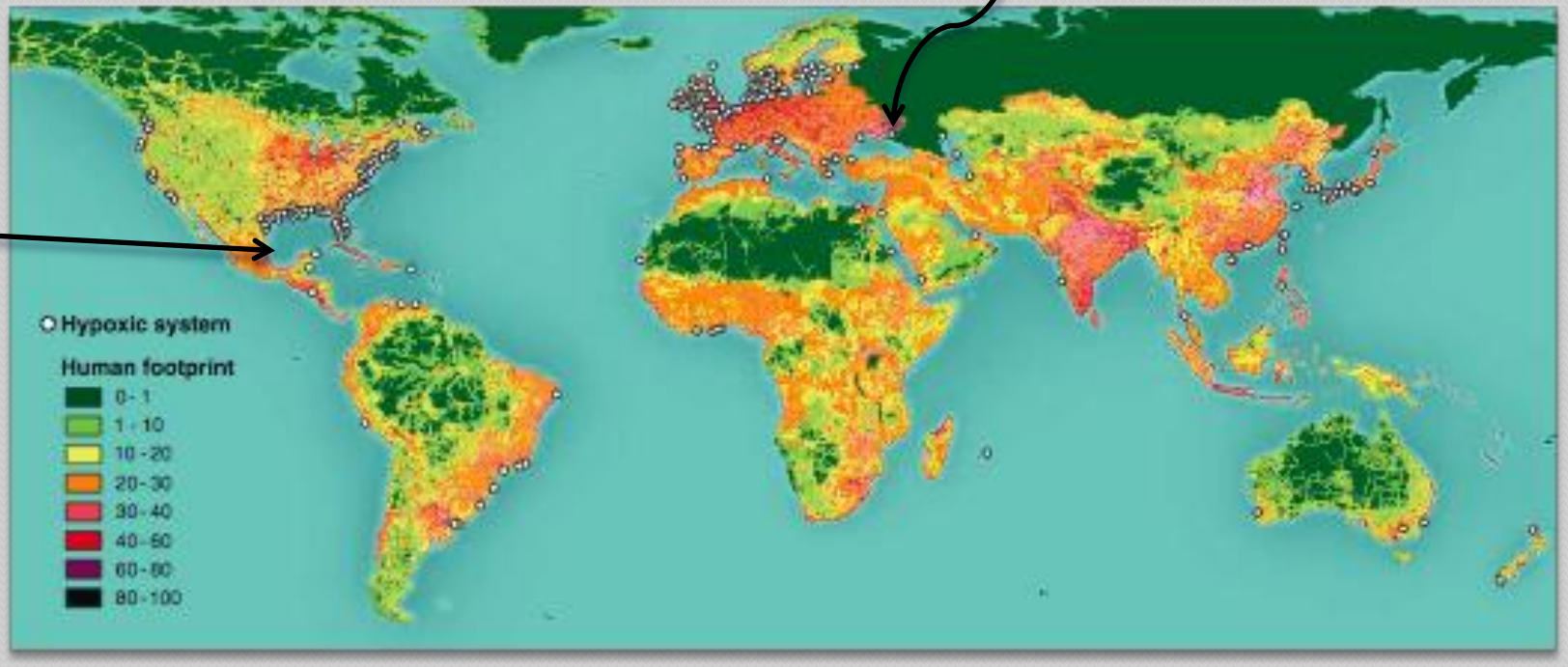
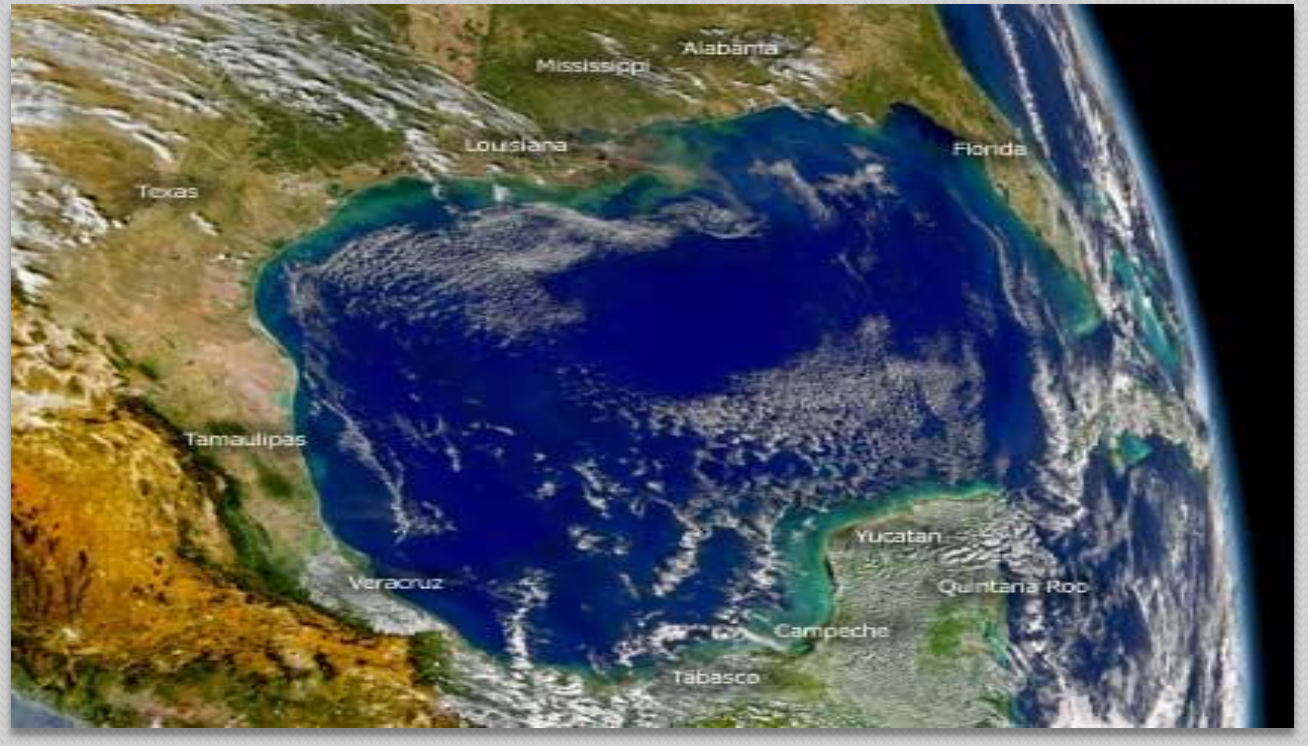


Fig. 1. Global distribution of 400-plus systems that have scientifically reported accounts of being eutrophication-associated dead zones. Their distribution matches the global human footprint [the normalized human influence is expressed as a percent (41)] in the Northern Hemisphere. For the Southern Hemisphere, the occurrence of dead zones is only recently being reported. Details on each system are in tables S1 and S2.

Gulf of Mexico

- Largest Dead Zone in Western Hemisphere
- Mississippi River dumps high nutrient enriched water



Gulf of Mexico Alliance

Environmental Awareness Campaign

Represented States

- Alabama
- Florida
- Louisiana
- Mississippi
- Texas

Priority Issues

- Wetland and coastal restoration and conservation
- Environmental education
- Improve water quality
  - Emphasis on healthy beaches and shellfish beds

Priority Issues continued…

- Identification and characterization of Gulf habitats
  - Help inform management decisions

- Coastal community resiliency

Limitations

- Focused on GOMA states
  - No data from upstream populations
  - No data from Mexico

- Focused mainly on fertilizer use

Major Priorities for this publication

- Reduce nutrient loading
- Develop branding to improve community participation
  - Increased visibility = better position among partner groups

Qualitative Data

- Residents of the GOMA states
- Policy makers
- Environmental advocates
- Other opinion makers

General Public Consultants

- 10 focus group interviews
  - 7 in English and 3 in Spanish
  - Total of 74 individuals
  - 3 individual interviews
- 56 key informant interview
- Other consultants were interviewed individually

APPENDIX A. GOMA BEHAVIORAL AND BRANDING PANEL SURVEY

I. INTRODUCTION

We are conducting a short public opinion poll to find out how people care for their lawns and feel about the Gulf of Mexico. All of the answers given today will remain anonymous.

Please complete all of the questions appearing on each page. Always scroll down to make sure you have answered all of the questions provided before moving to the next page. When you are ready to move on to the next page, click the "Next" button located in the lower portion of the screen.

II. SCREENER

Let's begin by asking a few questions to see if this survey applies to you.

1. What state do you live in? [terminate if not in Alabama, Florida, Mississippi, Louisiana, Texas]

1. Alabama [n=150]	18. Kentucky	36. Ohio
2. Alaska	19. Louisiana [n=150]	37. Oklahoma
3. Arizona	20. Maine	38. Oregon
4. Arkansas	21. Maryland	39. Pennsylvania
5. California	22. Massachusetts	40. Rhode Island
6. Colorado	23. Michigan	41. South Carolina
7. Connecticut	24. Minnesota	42. South Dakota
8. Delaware	25. Mississippi [n=150]	43. Tennessee
9. District of Columbia	26. Missouri	44. Texas [n=150]
	27. Montana	45. Utah
10. Florida [n=150]	28. Nebraska	46. Vermont
11. Georgia	29. Nevada	47. Virginia
12. Hawaii	30. New Hampshire	48. Washington
13. Idaho	31. New Jersey	49. West Virginia
14. Illinois	32. New Mexico	50. Wisconsin
15. Indiana	33. New York	51. Wyoming
16. Iowa	34. North Carolina	
17. Kansas	35. North Dakota	
52.		

2. Do you own or rent your home?
1. Own
2. Rent
3. Live with a family member
4. Refused [THANK AND TERMINATE]

3. Does your home have a lawn?
1. Yes
2. No [THANK AND TERMINATE]

4. Who cares for your lawn?
1. I do
2. Spouse

3. Someone else in the home
4. Lawn service/gardener paid by household
5. Lawn service/gardener paid by others (landlord, apartment manager, maintenance fees etc.) [THANK AND TERMINATE]
6. No one [THANK AND TERMINATE]

5. Do you live in a community with a home owners association that has rules about lawn maintenance?
1. Yes
2. No [Go to Q8]

6. Does your home owners association determine how often your yard is fertilized?
1. Yes
2. No
3. Don't Remember

7. On a scale from 1 to 5 where 1 represents "not at all difficult" and 5 represents "very difficult," how difficult would it be to get your home owners association to change its rules about fertilizer use?

1. 1 (not at all difficult)
2. 2
3. 3
4. 4
5. 5 (very difficult)
6. They do not have fertilizer rules

III ATTITUDE & BEHAVIOR QUESTIONS

8. **In what month or months, did your lawn service or gardener apply fertilizer to your lawn in 2007?**
[Check all that apply]
1. January
2. February
3. March
4. April
5. May
6. June
7. July
8. August
9. September
10. October
11. November
12. December
13. I'm not sure
1. Never/Not at all [Do we terminate here?]

9. **Which of these comes closest to describing how you determine the amount of fertilizer to apply to your lawn?** [ROTATE CHOICES]
   1. Ask the salesperson where I bought the fertilizer
   2. My lawn service or landscaper determines the amount
   3. Ask a friend or neighbor
   4. Use directions on the package
   5. Guess
   6. Fill the container of the equipment I use to spread the fertilizer
   7. Divide the bag evenly on my yard and discard the bag
   8. Other: [Write in response]

10. **What statement best describes how you determine when to fertilize your lawn?**
   1. Condition of the lawn
   2. Specific time of year
   3. Reminders from an outside source (newspapers, TV, radio, local organizations)
   4. People in your neighborhood are fertilizing
   5. Your family or friends are fertilizing
   6. When I see sales and advertising for fertilizers
   7. Other: [Write in response]

11. **Thinking about how you or your gardener/lawn service care for your lawn, please rate on a scale from 1 to 5, where 5 is STRONGLY AGREE and 1 is STRONGLY DISAGREE, how much you agree with the following statements.** [ROTATE CHOICES]

	FACTOR	*RATING*
A	I find it very difficult to determine how much fertilizer to put on my lawn.	
B	Purchasing fertilizer can be very confusing.	
C	As long as my lawn looks good, I don't care about how fertilizer works.	
D	It is impossible to have an attractive lawn without using fertilizers.	
E	It's important to keep fertilizer off of hard-top surfaces like sidewalks, driveways and streets.	
F	I generally understand the directions on fertilizer labels.	
G	Keeping my lawn attractive is important to me.	
H	I feel pressure from my neighbors or homeowners' association to keep my lawn attractive.	
I	I know many people who treat their lawns with non-chemical pesticides.	
J	I care what my neighbors think of my property.	
K	[if answered YES on Q6] I would support changes to my home owners association rules to reduce the amount of fertilizers used on my lawn.	

12. **On a scale from 1 to 5 where 5 is EXTREMELY IMPORTANT and 1 is NOT IMPORTANT AT ALL, how important are the following factors when deciding how you landscape and care for your lawn?** [ROTATE CHOICES]

	FACTOR	*RATING*
A	How much it will cost	
B	How difficult it will be to keep up	
C	How the yard will look; its overall appearance	
D	What neighbors will think	
E	The impact on property value	
F	The impact on local water sources	
G	How long it will take to do	
H	The amount of fertilizer it will require	
I	The impact on the Gulf of Mexico	
J	[if answered YES on Q6] Rules of my homeowners' association	

13. **Using a scale from 1 to 5 where 5 is ABSOLUTELY TRUST and 1 is NOT TRUST AT ALL, rate how much you would trust each of the following about proper fertilizer use for your lawn?** [ROTATE CHOICES]

	FACTOR	*RATING*
A	Someone like me	
B	County extension office	
C	University or community college	
D	Gulf of Mexico Alliance	
E	Local government	
F	Homeowners' association	
G	A big box store (e.g., Home Depot, Lowes)	
H	A local garden shop	
I	[if answered 4 on Q4] Landscaper who cares for your yard	
J	The Governor of your state	
K	The Federal Government	

14. **How willing would you be to participate in each of the following activities on a scale where 1 represents "very unwilling" and 5 represents "very willing."** [ROTATE CHOICES]

	FACTOR	*RATING*
A	Attend a fertilizer educational expo	
B	Attend a neighborhood program that promotes healthy and environmentally friendly yards and landscaping	
C	Visit a website about proper fertilizer use	

D	Talk to a salesperson about proper fertilizer use	
E	Read a brochure about environmentally friendly yards and landscaping	
	Add in more as necessary – This is where we said we'd coordinate with Lee to see what was doable– NO MORE THAN 3 MORE	

Now we'd like to ask you a few questions about your views of the Gulf of Mexico.

15. **Think about the part of the Gulf of Mexico that you are most familiar with. Below is a list of word pairs that can be used to describe the Gulf. From each pair, pick the word that you think best describes the Gulf.** [ROTATE CHOICES]

	FACTOR	*Word Choice*
A	Stressful or Tranquil	
B	Unpredictable or Predictable	
C	Boring or Fun	
D	Stormy or Calm	
E	Unhealthy or Healthy	
F	Polluted or Clean	
G	Unimportant or Important	
H	Vulnerable or Resilient	

16. **Have you been to the Gulf of Mexico (e.g., to the beach)?**
    1. Yes
    2. No

17. **For each of the following recommended actions, how likely you would be to do it if it was recommended as a way to protect the Gulf. So on a scale form 1 to 5 with 1 representing "NOT AT ALL LIKELY TO DO IT" and 5 representing "VERY LIKELY TO DO IT" how likely would you be to:** [ROTATE CHOICES]

	Statement	*RATING*	Already do it	Unsure/Not applicable
A	Fertilize your yard only at specified times of the year			
B	Fertilize your yard with only a specific amount			
C	Write or call local legislators or policymakers to ask for their support of environmentally friendly policies			
D	Vote for legislators or policymakers that support environmentally friendly policies			
E	Support local ordinances that regulate littering and polluting			
F	Join a local environmental organization			

18. **Please rate each of the following statements below on a scale from 1 to 5, where 5 is STRONGLY AGREE and 1 is STRONGLY DISAGREE.** [ROTATE CHOICES]

	FACTOR	*RATING*
A	My livelihood depends on the Gulf of Mexico.	
B	The Gulf of Mexico is an important part of my community	
C	I feel strongly about preserving the environment	
D	I have a basic understanding of environmental science	
E	The health of the Gulf of Mexico interests me	
F	I know what to do to protect the Gulf of Mexico	
G	The Gulf of Mexico is healthy.	
H	The health of the Gulf of Mexico depends on location.	
I	I'm unaware of the health of the Gulf of Mexico.	
J	Trying to encourage policy makers (e.g., representatives, Governors) to protect the health of the Gulf would be a waste of my time.	
K	I would volunteer for local activities (e.g., beach clean-up) designed to improve the health of the Gulf of Mexico.	
L	Everyone's actions on land affect the health of the Gulf of Mexico.	
M	I can help protect the Gulf of Mexico	
N	The Gulf of Mexico is so large that it can absorb pollution	
O	It's my responsibility to protect the health of the Gulf of Mexico.	
P	We should protect the Gulf of Mexico for future generations	
Q	The local economy depends on a healthy Gulf of Mexico	
R	Putting too much fertilizer on my yard hurts the Gulf of Mexico	
S	Fertilizing my yard at the wrong time of year hurts the Gulf of Mexico	
T	Feeling a personal connection to the Gulf would motivate me to protect it.	
U	Receiving more information on how to protect the Gulf would motivate me to protect it.	
V	Receiving economic incentives would motivate me to protect the Gulf of Mexico.	
W	Being personally affected by pollution in the Gulf would motivate me to protect it.	
X	Thinking of my kids or grandkids' future would motivate me to protect the Gulf of Mexico.	
Y	Protecting the Gulf of Mexico would enhance the local economy.	
Z	The way I landscape my yard has a direct affect on the Gulf of Mexico.	
AA	I am an environmentalist.	
BB	I am often influenced by my friends and family.	

General Public

- View the Gulf of Mexico as an “important, powerful asset in their lives”

- Feelings and images associated:
  - Beauty
  - Nature
  - Relaxation
  - Tranquility

- Most participants have a strong sense of place, identity and personal connection to the Gulf of Mexico

Policy Makers and Opinion Leaders

- Emotional and economic lens

- Resources seen as valuable:
  - Oil production
  - Maritime transportation
  - Fisheries
  - Tourism
- They fear these resources will be affected

Policy Makers and Opinion Leaders

- Perceive lack of citizen support due to:
  - Ignorance of the problem
  - Feeling of powerlessness
  - Discomfort with advocating for change
  - Unsure as to what to recommend
    - Solid evidence desired to justify advocacy

Policy Challenges

- Political turn over
  - Incentive for short term policies and results
- Lack of funding

Recommendations

- More collaboration between local organizations
- More transparency
- Enhance policy development activities
- Involve state agencies
- Enhance lobbying at the national level
- Engage the environmental/economic connection
- Collaboration between involved scientific and industrial parties

Environmental Advocates

- Improve information dissemination
- Promote hands on experiences and a sense of connectedness with the gulf

- Utilize an engaged spokesperson
  - Fishermen
  - Environmentalists
  - Community leaders

Home Owners Associations

- Critical part of the local lifestyle
  - The “lifeblood” of their city
- Maintain current lifestyle
- Maximize property values

- On the ground organization with direct access

Media Representatives

- Similar emotional associations
  - All encompassing, cultural and economic feature

Conclusions

- People expressed more willingness to adopt helpful behaviors when they see the benefits locally
  - Frame issues in local terms
  - Simple everyday language is needed
  - Solid scientific evidence
  - Also frame issues in economic terms

Conclusions

- Focus education on children
- Build on the view of the Gulf as an impact on all facets of life
  - Incorporate personal connections

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