Connecting Stressors, Ocean Ecosystem Services and Human Health

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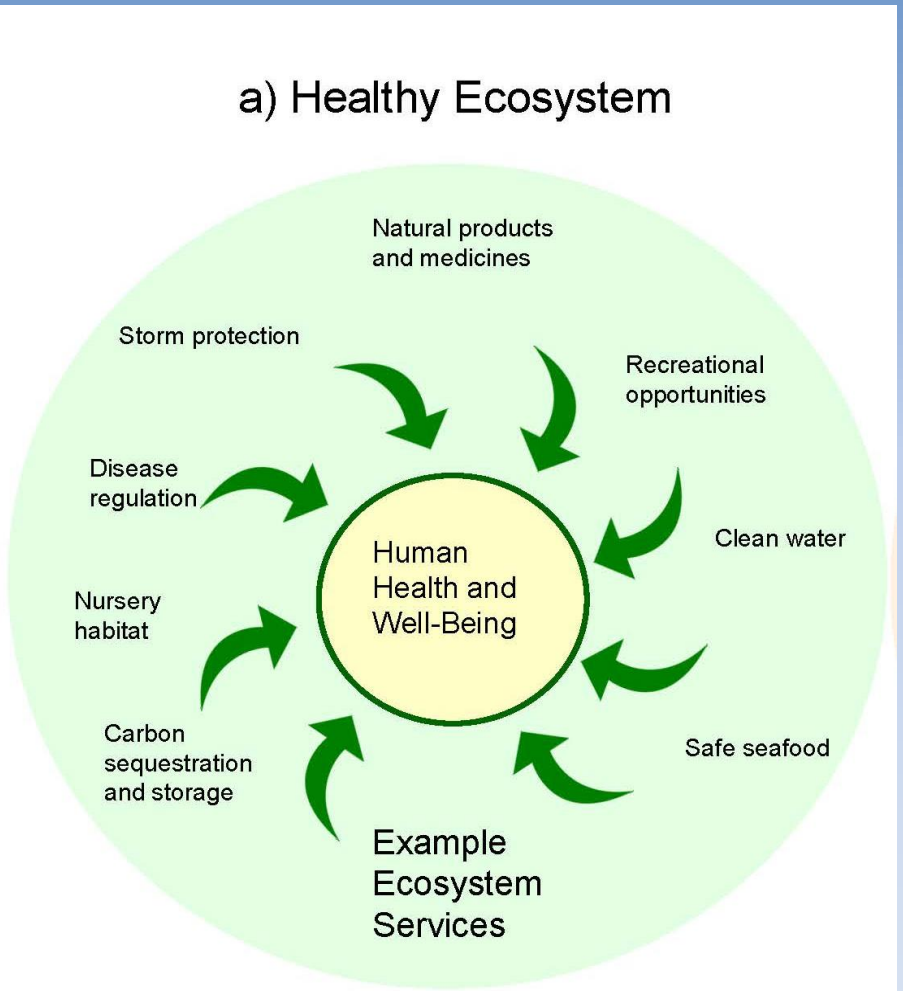
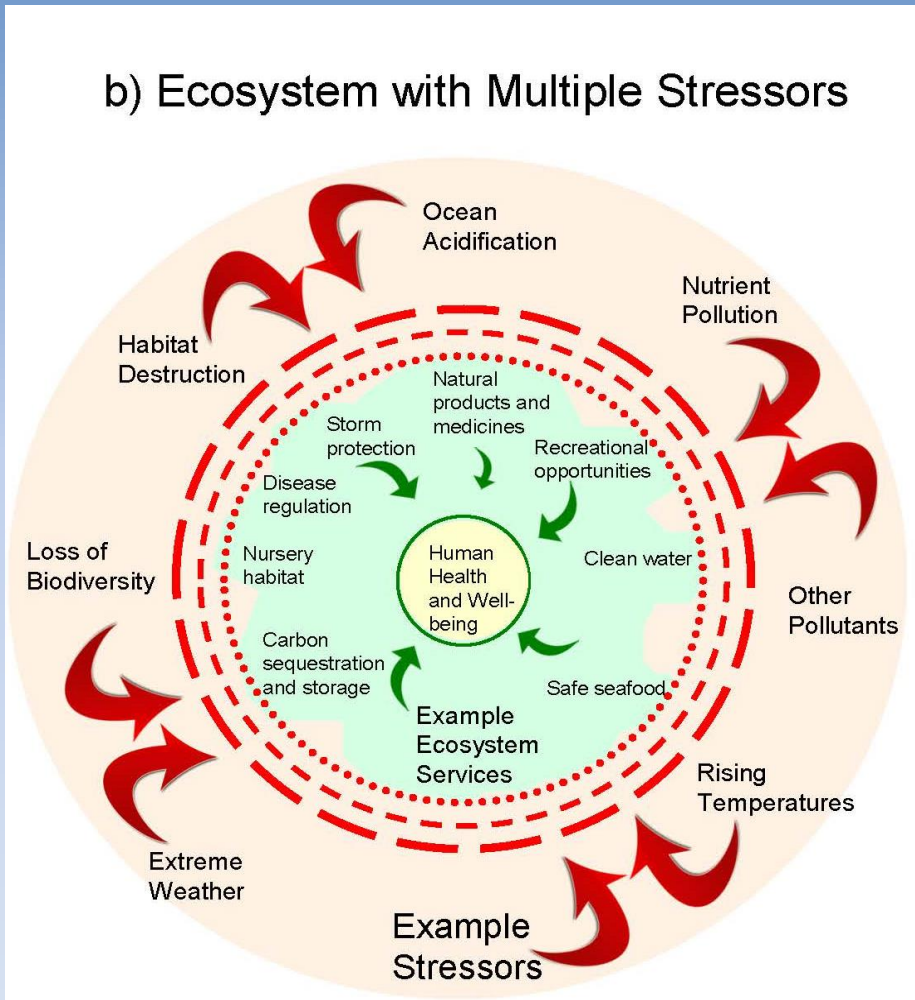
Conceptual Representation of Human Health as Cumulative Ecosystem Service in Healthy and Stressed Ecosystems

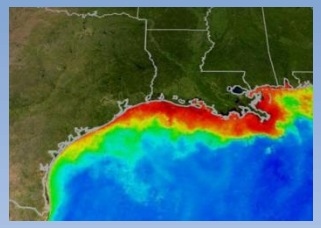




Sandifer and Sutton-Grier. 2014. Natural Resources Forum

Five Stressor Examples

Rising Temperatures



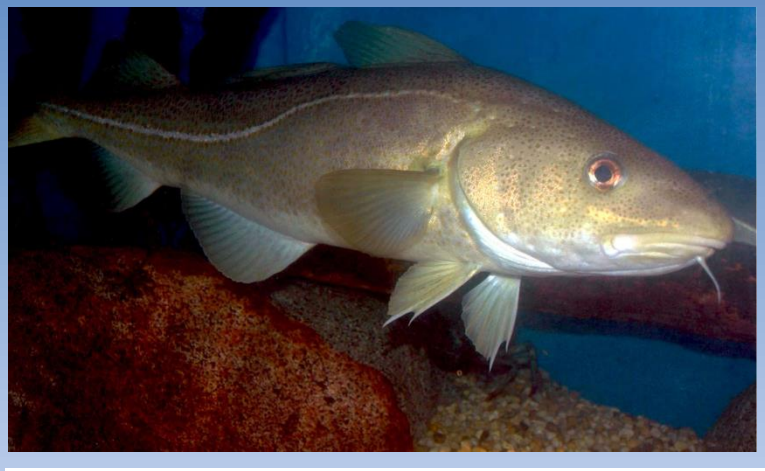
Nutrient Pollution (Harmful Algal Blooms and Hypoxia)

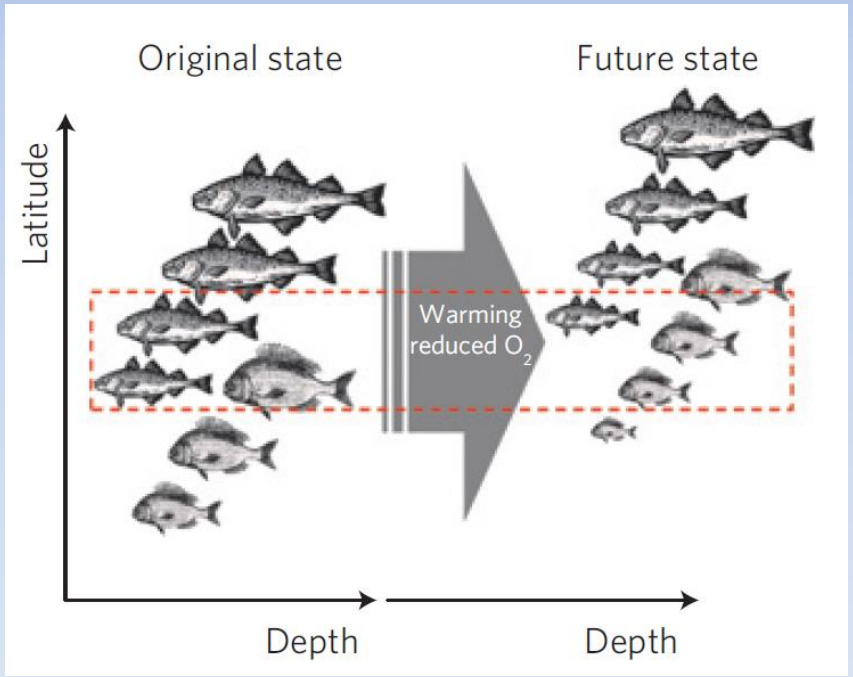
Ocean Acidification

Habitat Destruction and Loss of Biodiversity

Extreme Weather Events

Rising Temperatures





Cheung et al. 2012 and 2013 Nature Climate Change and Nature

- Changes in distribution, phenology, and productivity
- Evidence of reduced body size
  - Less dissolved oxygen in warmer water
  - Average body size could contract by 14-24% by 2050 for many species
  - At higher latitudes, more of catch is now warm water species

Vibrios: Naturally Occurring Pathogens

Vibrio cholerae

Vibrio parahaemolyticus
Vibrio vulnificus

- Rising temperatures may influence distribution and abundance of disease-causing organisms along coasts
- Seafood poisoning caused by *Vibrio* bacteria
- Outbreaks in numerous areas of US including 1st time in Alaska (~1,000 km range extension)
- *Vibrio v.* can cause would infections and can lead to death: ~ 200 deaths in the Gulf from 1989 – 2004
- Regular reporting to CDC only began in 2007
- **Bacteria most prevalent at high temperatures→ good chance infections may increase with increased temp**

Zoonotics

- Lacaziosis (formerly called Lobomycosis)
  —Previously only in tropics but now in temperate waters of US, Europe and Asia

- *Cryptococcus gattii*
  —Previously found only in tropics outside US
  —Emerged in Pacific Northwest around 1999; first case in US in porpoise, then epidemic in domestic animals and people in Canada, WA, OR

- Not sure if movement of these diseases is due to climate change, but diseases are now showing up in places and species not previously seen

Relationship between Rising Temperature, Ecosystem Services, and Human Health

Rising Temperatures

Changes in Ecosystem Services

- Decreases in average fish biomass
- Increases in disease and pest population abundance and geographic distribution
- Changes in Species distributions
  - Changes in what is present to harvest or where diseases or vectors can survive

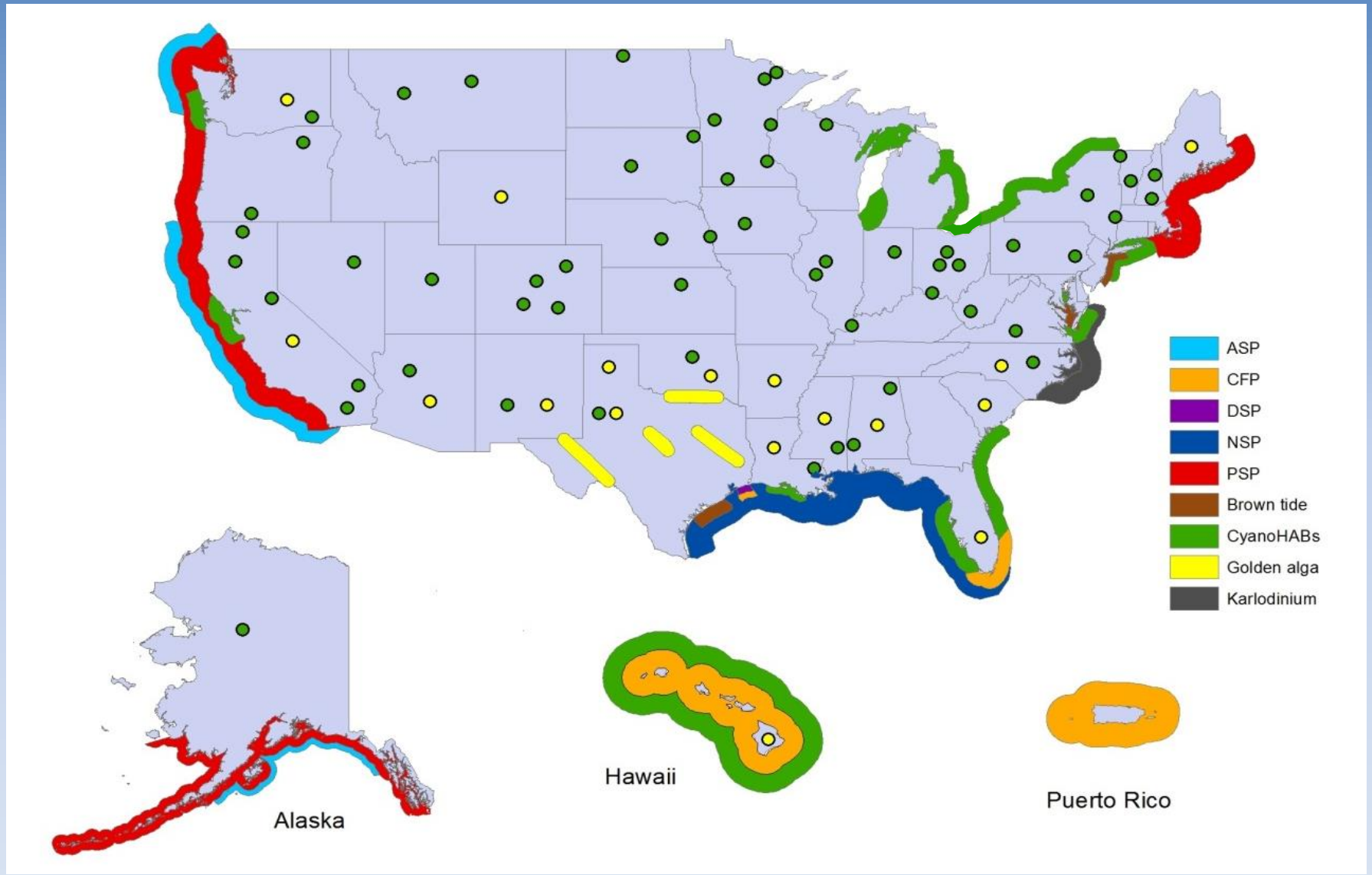
Impacts on Human Health

- Less seafood biomass and changes in species distributions → less food security and food diversity in some areas
- More disease exposure (*Vibrios*, zoonotics, etc.)
- More heat stress

Nutrient Pollution (Harmful Algal Blooms and Hypoxia)

- Both hypoxia and HABs are growing problems worldwide
- Eutrophication leads to hypoxia and increases the occurrence of HABs in some cases
- Human (and other animal) health risk, even death
- Significant economic losses

Distribution of HABs in the U.S.



Economic cost of HABs over the last decade is conservatively ~$1billion, but cost of illness and lost productivity problem mean costs much greater.

Texas, western Gulf of Mexico, *Karenia brevis* (“Texas red tide”)

Padre Island National Seashore Closes Park to Dogs (December 9, 2009)

Climate Change and Harmful Algal Blooms

Climate Change Affects Harmful Algal Blooms

Scientists Connect Global Warming and Nutrient Runoff to HABs

© Nina Munteanu

Aug 29, 2008

Changes in climate may be creating a marine environment particularly suited to HAB (harmful algal bloom)-forming species of algae, according to a team of scientists.

- **Warming temperatures contribute to increases in frequency, duration, and geographic extent of HABs (e.g., *Alexandrium*, *Pseudo-nitzschia*)**

Increases in CO_2 and reduction of P (which occur in acidified waters) can increase HAB production(e.g., *Pseudo-nitzchia*)

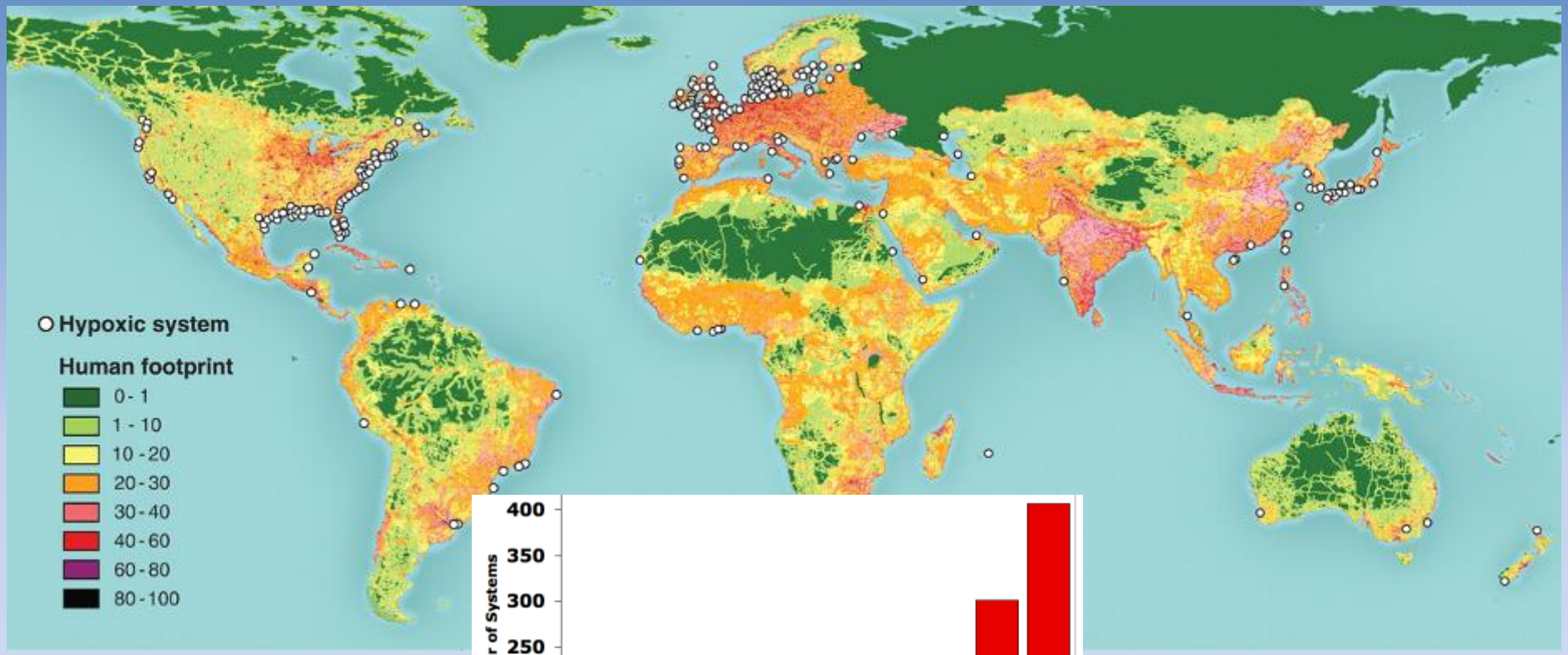
- **Domoic acid production increases with low P and high CO2**
- **(Sun et al. 2011)**

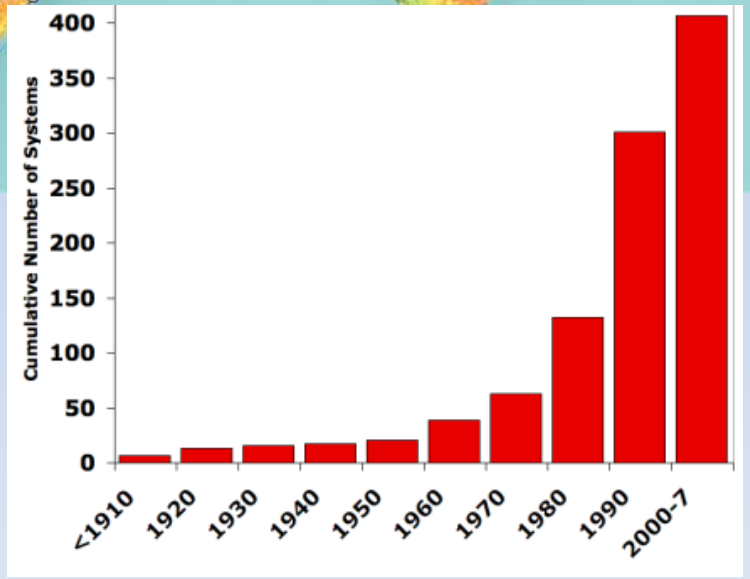
Environ Health. 2008; 7(Suppl 2): S4. PMCID: PMC25867
Published online 2008 November 7. doi: 10.1186/1476-069X-7-S2-S4.

Impacts of climate variability and future climate change on harmful algal blooms and human health

Stephanie K Moore,[1,2] Vera L Trainer,[2] Nathan J Mantua,[3] Micaela S Parker,[4] Edward A Laws,[5] Lorraine C Backer,[6] and Lora E Fleming[7]

Hypoxia: Increasing Global Problem





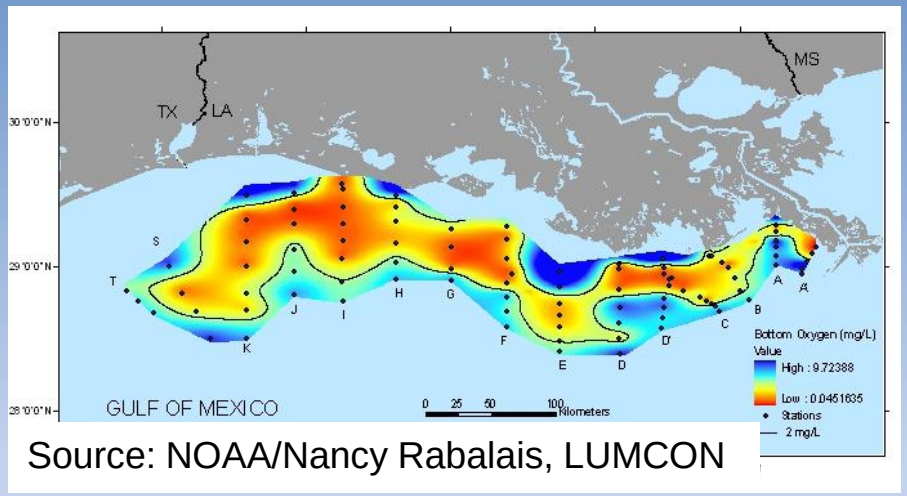
78% of US coasts and 65% of Europe's Atlantic coast exhibit eutrophication

Diaz and Rosenberg: Science, 2008

Worldwide > 400 marine/estuarine systems with reports of hypoxia as of 2007

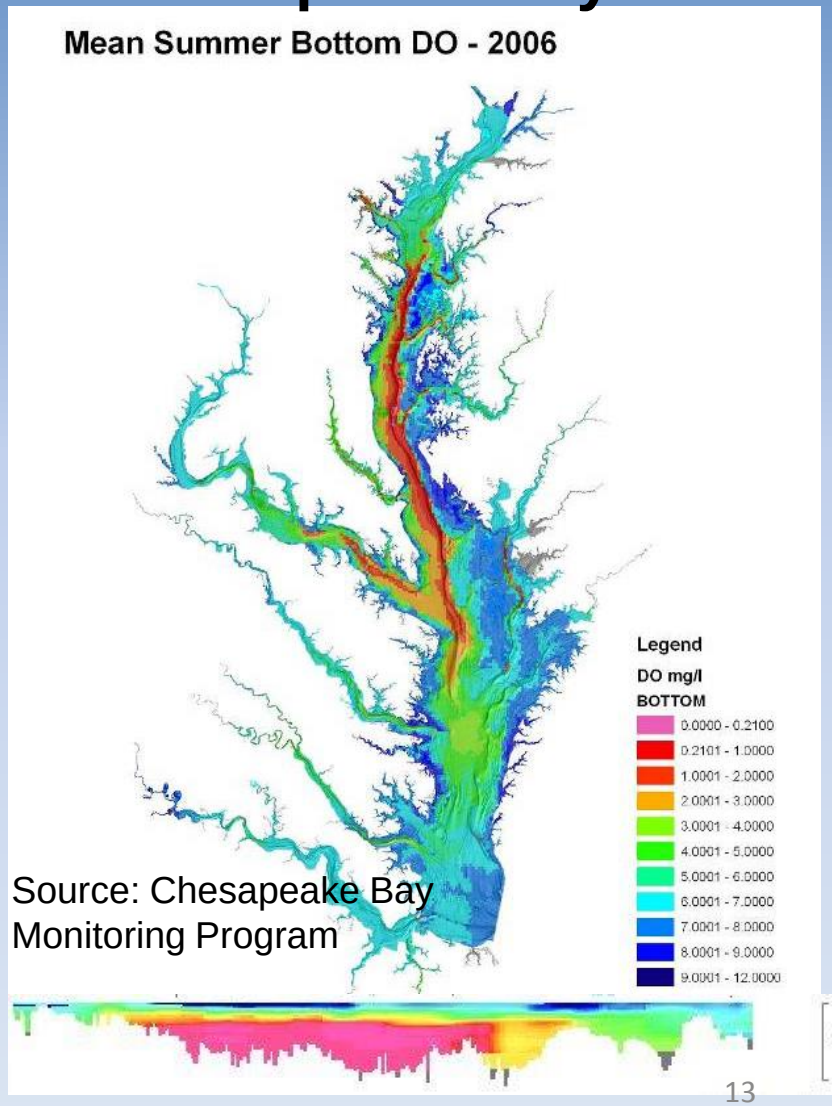
Three Largest Hypoxic Zones in US

Gulf of Mexico



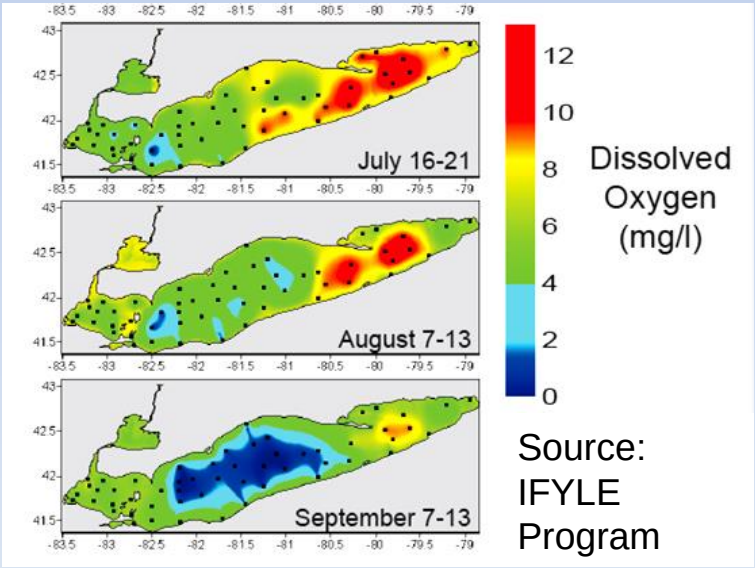
Source: NOAA/Nancy Rabalais, LUMCON

Chesapeake Bay



Source: Chesapeake Bay Monitoring Program

Lake Erie



Source: IFYLE Program

Relationship between Nutrient Pollution, Ecosystem Services, and Human Health

Nutrient Pollution (HABs and Hypoxia)

Changes in Ecosystem Services

Decreases in
- Clean drinking water
- Safe seafood
- Air quality near beaches
- Coastal recreational opportunities

Increases in
- Fish & wildlife kills
- Fish & wildlife susceptibility to other disease factors

Impacts on Human Health
- Lack of clean drinking water→ health risks
- Impaired quality of seafood impacts the shellfish industry in entire regions and can last a whole season→ less job security and more stress
- Inability to access coastal areas without respiratory problems and health risks→ more stress and less recreation possible
- Wildlife loss and risks to pets → decreased mental health

Ocean Acidification and Human Health

- Ocean 30% more acidic than pre-industrial levels
- **Recent meta-analysis indicates negative effect of ocean acidification on corals and other calcifying coral reef species**
  - Threatens numerous ecosystem services – reef-associated fisheries, tourism, coastal protection, natural products and drugs
- **Edible molluscs also exhibit overall negative responses to ocean acidification**
  - Threatens availability and economic benefits of seafood
  - People/communities which rely heavily on bivalves for protein source will be especially vulnerable

(Kroeker et al. 2010. *Ecology Letters* and Cooley et al. 2011. *Fish and Fisheries*)

Ocean Acidification

- Major economic impacts possible
- Example: Pacific Northwest oyster industry
  - 2005 hatcheries near collapse
  - $84 million industry (3,000 jobs)
  - Determined acidic water was killing oyster larvae
  - Monitor seawater so hatcheries can schedule production when seawater less acidic or treat water that is too acidic

Relationship between Ocean Acidification, Ecosystem Services, and Human Health

Ocean Acidification

Changes in Ecosystem Services

Decreases in

- Shellfish production
- Coral reef production and area
- Nursery habitat for other species (loss of keystone species)
- Resilience of the community to other stressors like extreme weather, nutrient pollution, or overfishing
- Aesthetics of reefs and ecotourism opportunities

Impacts on Human Health

- Fewer coastal jobs (both fisheries and tourism)→ More stress from unemployment and depressed coastal economies
- Less shellfish biomass → less food security
- Fewer or decreased quality of coral reef snorkeling and diving opportunities→ decreases in mental health and relaxation

Habitat Destruction and Loss of Biodiversity

- Coastal habitats some of most threatened in the world
- Most loss is due to either sea level rise or coastal development
- Loss of biodiversity of these ecosystems
- Loss of many ecosystem services




Examples of Ecosystem Services Provided By Coastal Habitats

Oyster Reef

Ecosystem Services

- **Seafood – commercial and recreational fisheries**
- **Filtration services – water quality/quantity**
- **Shoreline protection & stabilization**
- **Building materials & buffering capacity**
- **Nutrient balance**
- **Aesthetics & recreation**
- **Science & education**

Examples of Ecosystem Services Provided By Coastal Habitats

Coral Reef

Ecosystem Services

- Food, medicinal, ornamental, & other products
- Nursery & refuge – numerous species
- Aesthetics, recreation, tourism, cultural and spiritual values
- Shoreline protection/stabilization
- Science & education

Examples of Ecosystem Services Provided By Coastal Habitats

Dunes/Beaches

Ecosystem Services

- Aesthetics, recreation, tourism, cultural and spiritual values
- Shoreline protection & stabilization
- Soil & sediment balance
- Water quality/quantity
- Science & education

Relationship between Habitat Loss, Ecosystem Services, and Human Health

Habitat and Biodiversity Loss

Changes in Ecosystem Services

Decreases in

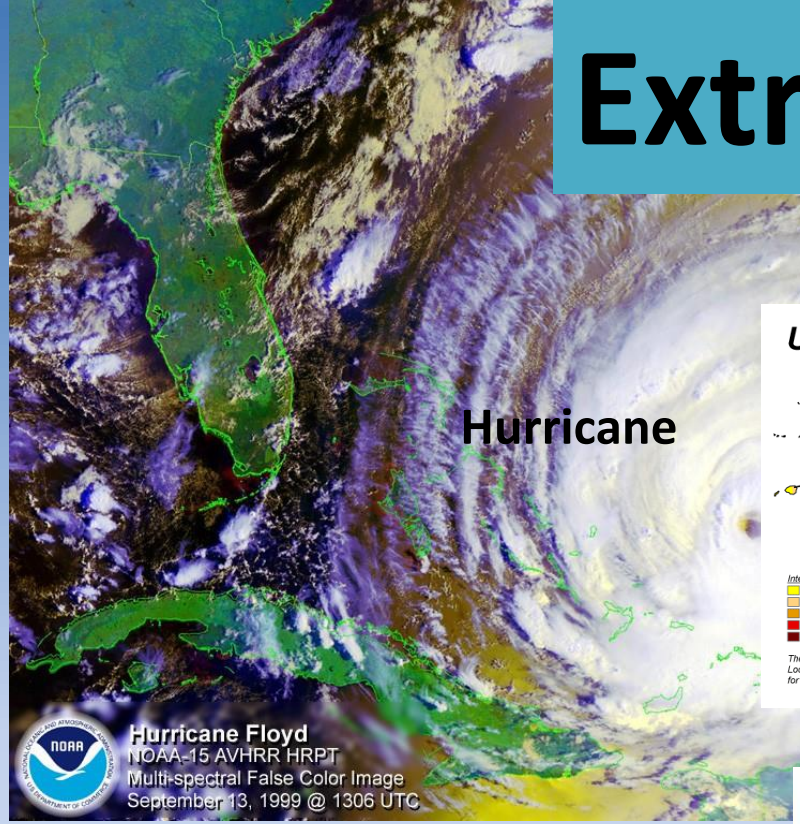
- Storm surge protection and shoreline stabilization
- Seafood abundance
- Nutrient balance
- Aesthetics, recreation, and education opportunities
- Resilience of the ecosystem to other stressors like nutrient pollution and extreme weather
- Loss of biodiversity & natural products

Impacts on Human Health

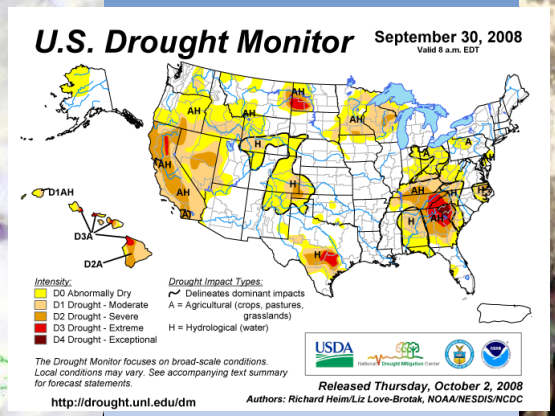
- Less climate adaptation and storm protection→ bigger risk of loss of property and lives
- Less seafood → fewer jobs and food security
- Issues with water quality and clean drinking water → health risks
- Fewer or decreased quality of recreational opportunities
- Impacts to mental health

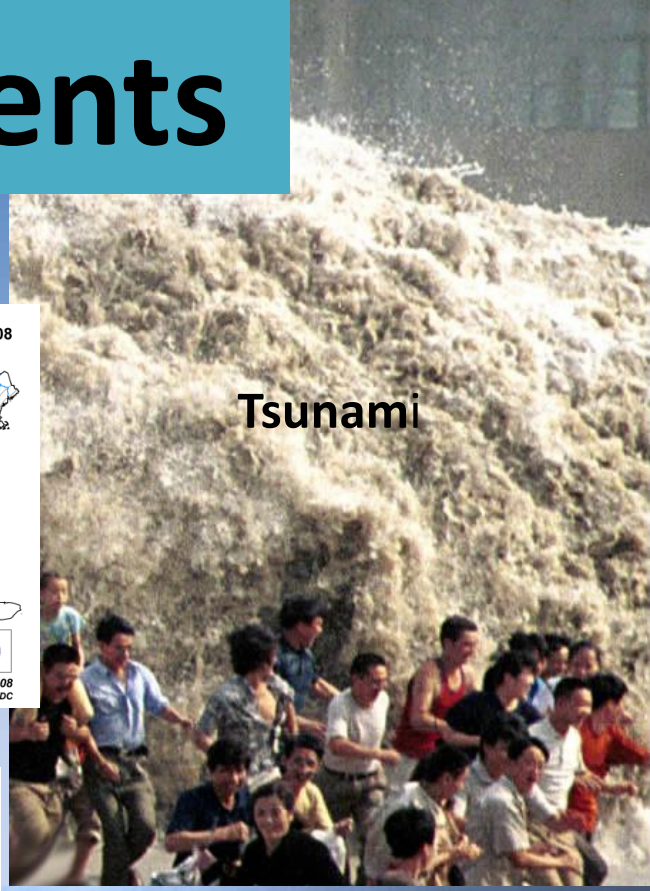
Sandifer and Suttton-Grier, Nature and Biodiversity Exposure Impacts on Human Health: Thurs, 2:55-3:15pm, Salon F-G

Extreme Events



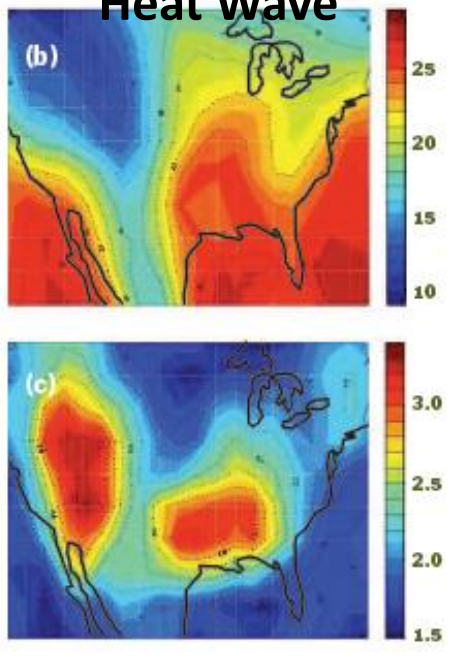
Hurricane





Tsunami

Heat Wave



Flooding

Tornado

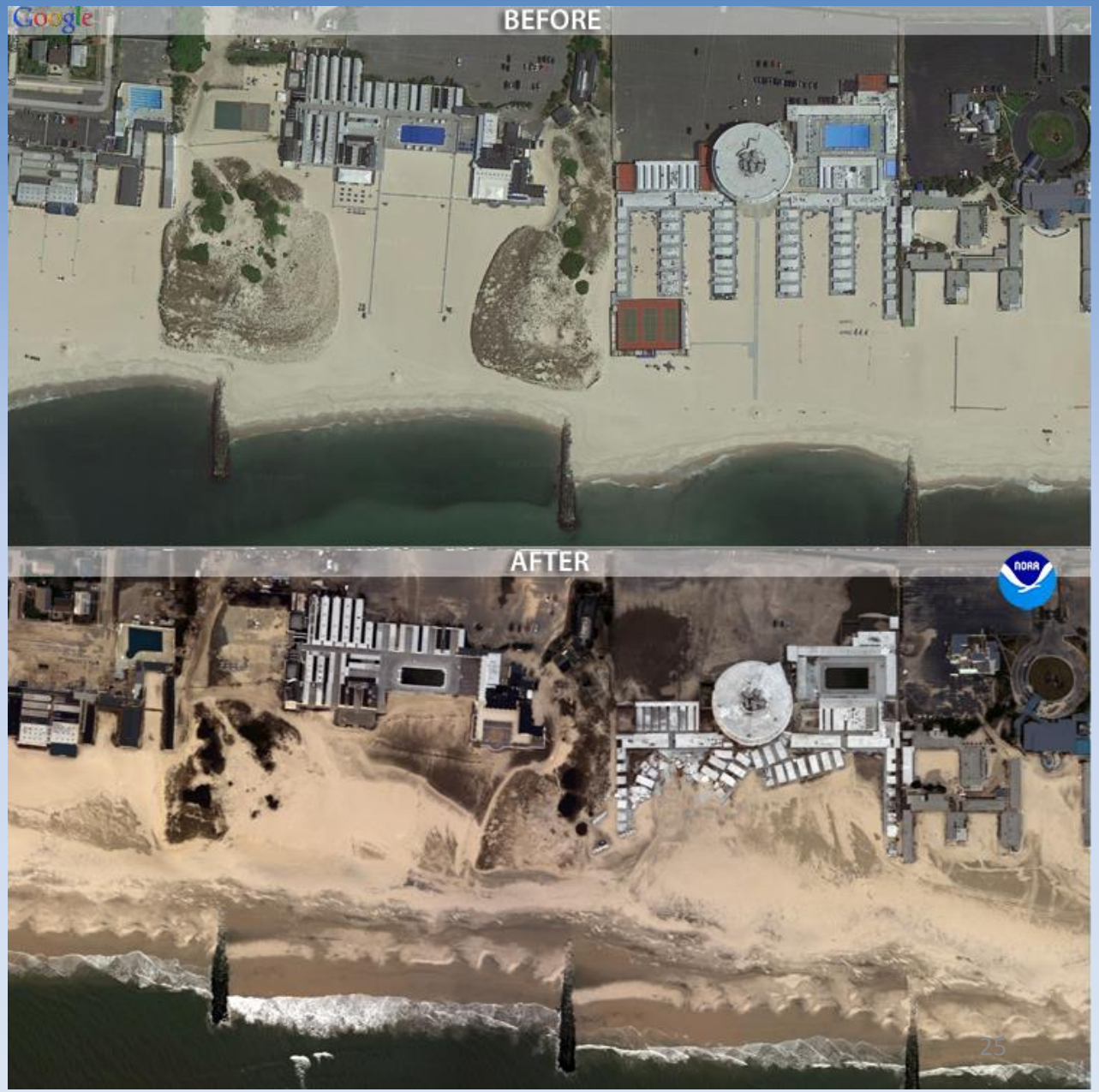
Extreme Weather

In 2011 Alone…

Fourteen $1 Billion Disasters

Hurricane Sandy Impacts

- Long Beach, NY



Extreme Weather

- Storm damage to:
  - coastal habitats; loss of coastal habitats and loss of future storm surge protection
  - Human infrastructure including sewer systems (impacting drinking water) and other infrastructure leading to contaminants in water
- Loss of clean water means losses in ecosystem services:
  - Decreases in water quality
  - Loss/degradation of housing, sanitation, security
  - Decreases in seafood safety (radiation, oil, sewage)
  - Losses of wildlife
  - Loss of recreational opportunities

Relationship between Extreme Weather, Ecosystem Services, and Human Health

Extreme Weather

Changes in Ecosystem Services

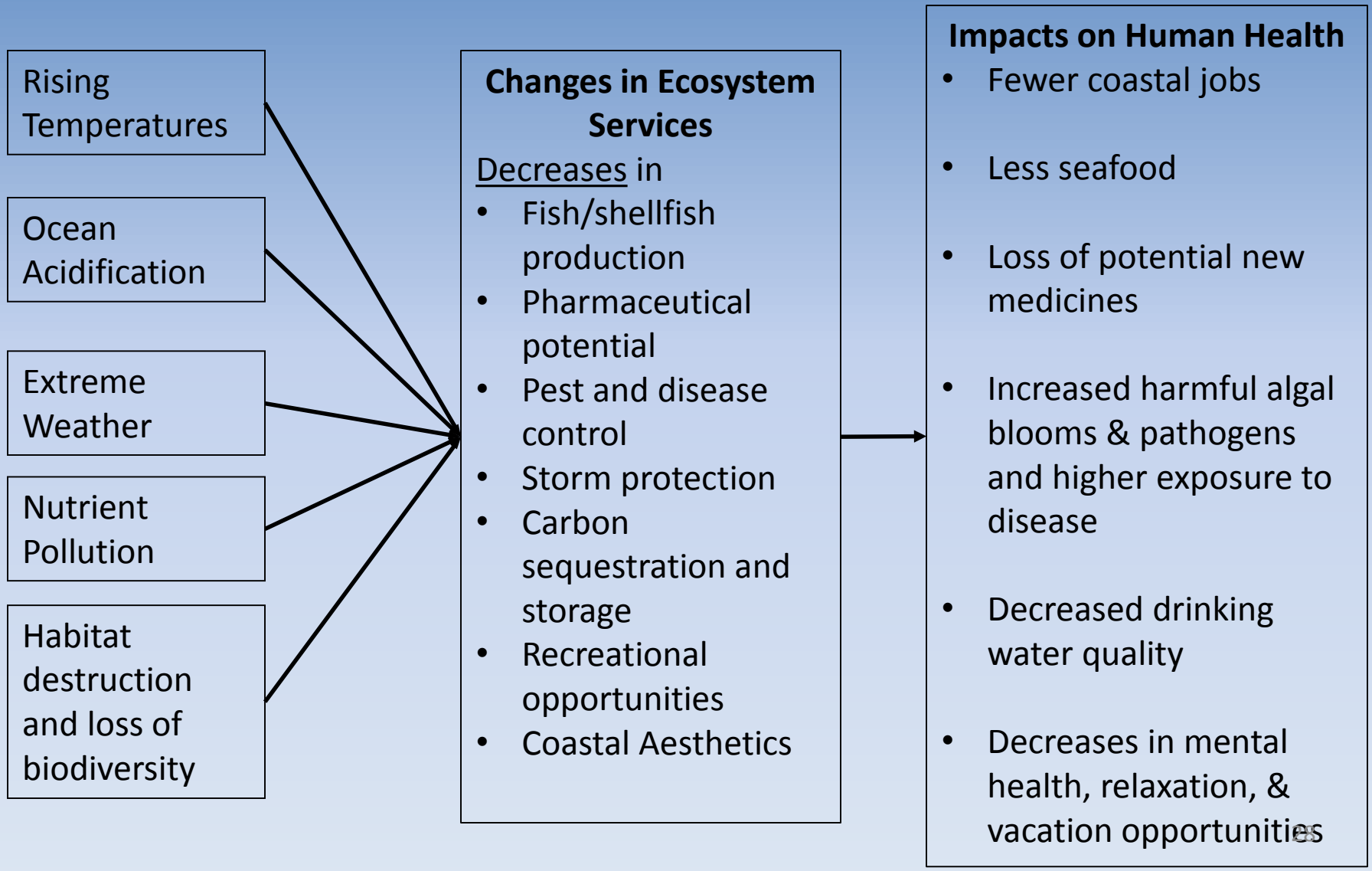
Decreases in

- Clean water
- Safe seafood
- Storm surge protection (due to loss of marsh and beach habitat)
- Coastal aesthetics
- Coastal recreational opportunities
- Suitable human habitat

Impacts on Human Health

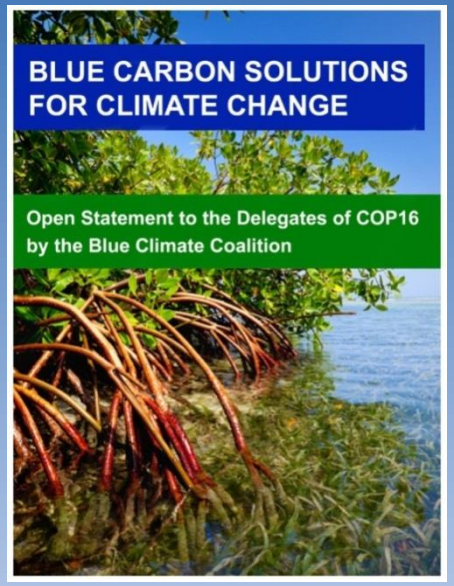
- Lack of clean drinking water, health risks
- Impaired quality of seafood → cascading negative impact on fishery jobs (more locations than impacted area) leading to less job security and more stress of unemployment
- Fewer or decreased quality of coastal relaxation opportunities; increased stress and anxiety → decreases in mental health and relaxation

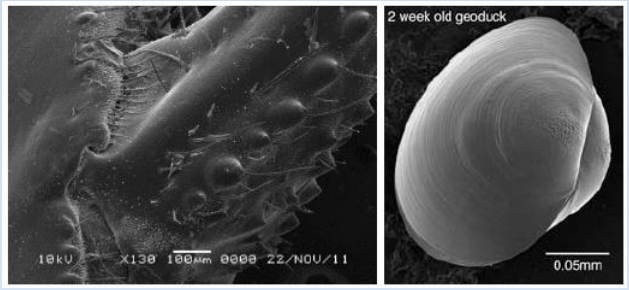
Relationship between stressors, E.S., and Human Health



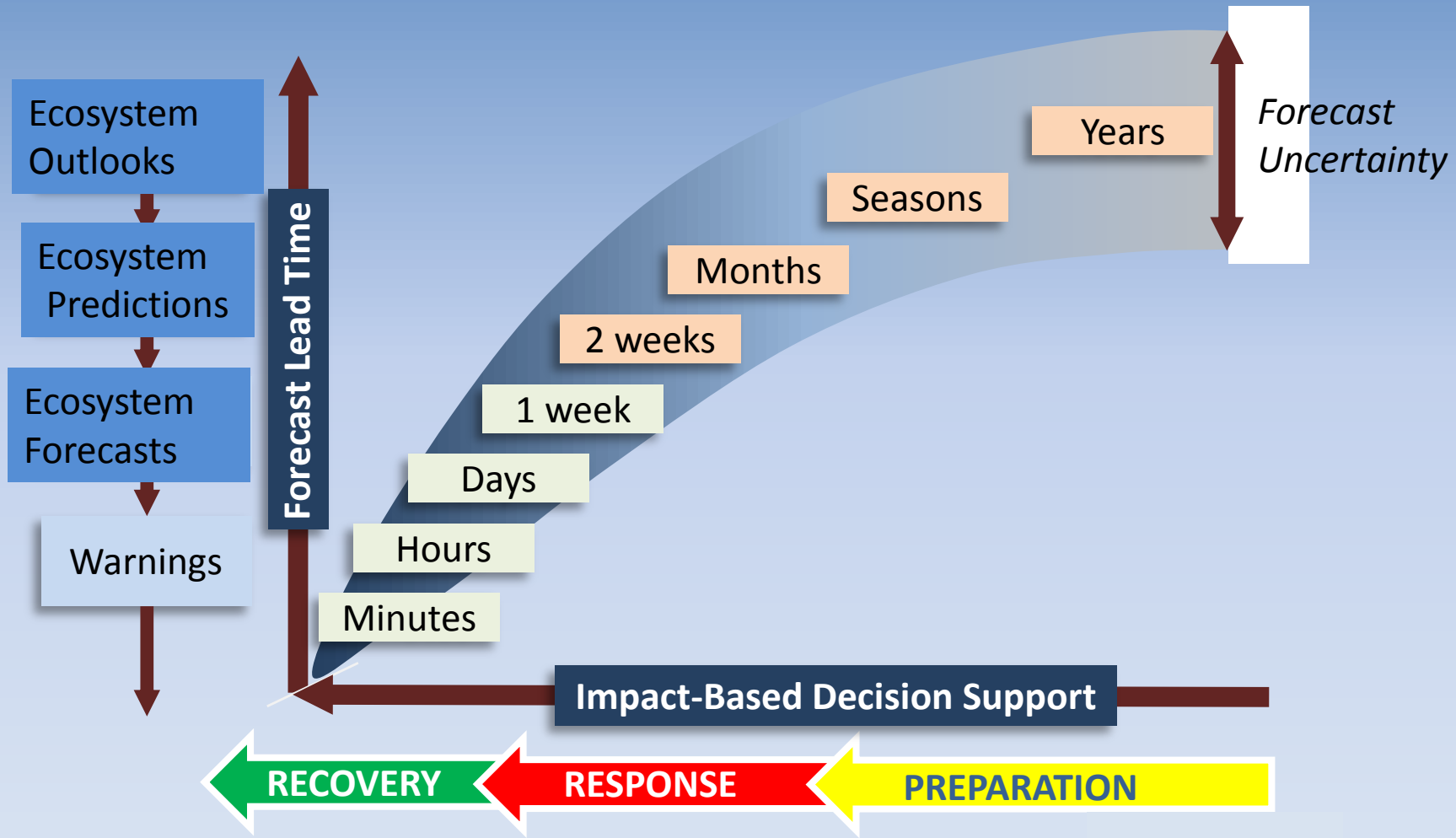
What can we do?

- Account for ecosystem services in our policies and decision-making
- Protect and restore “green infrastructure” (coastal ecosystems) to provide natural storm surge protection and climate adaptation benefits
- Conduct research to understand the impacts of these stressors and potential adaptation options
- Monitor and warn





Enhance Ecological Forecasting



Questions?

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