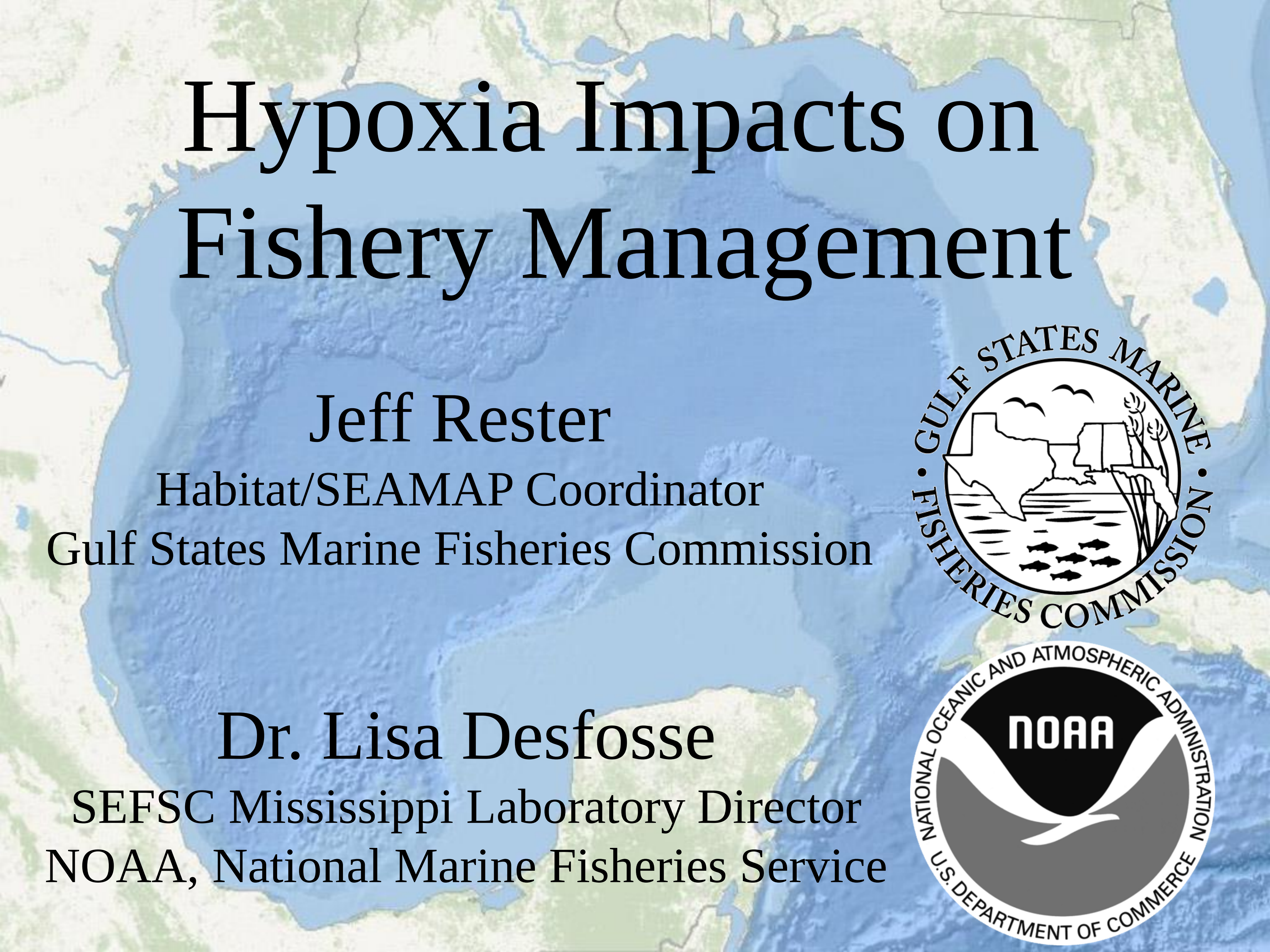

Hypoxia Impacts on Fishery Management

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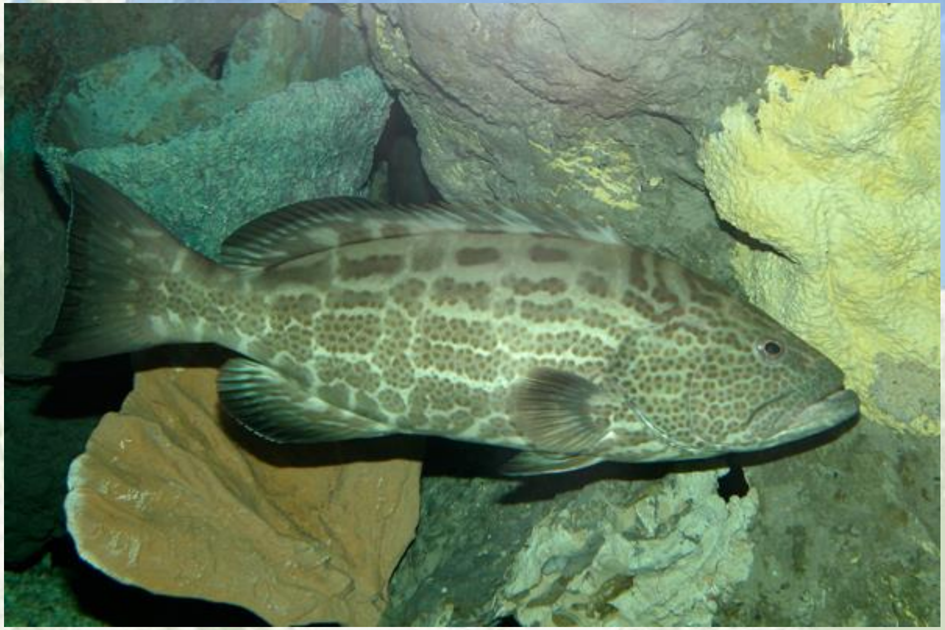
Fisheries

The northern Gulf of Mexico commercial ($10.1 billion) and recreational fisheries ($25.8 billion) generated billions in 2014 in sales, income, and value added impact to the Gulf of Mexico economy. Fishermen in the Gulf of Mexico landed 1.2 billion pounds of finfish and shellfish in 2014 with Louisiana accounting for approximately 72% of the landings.



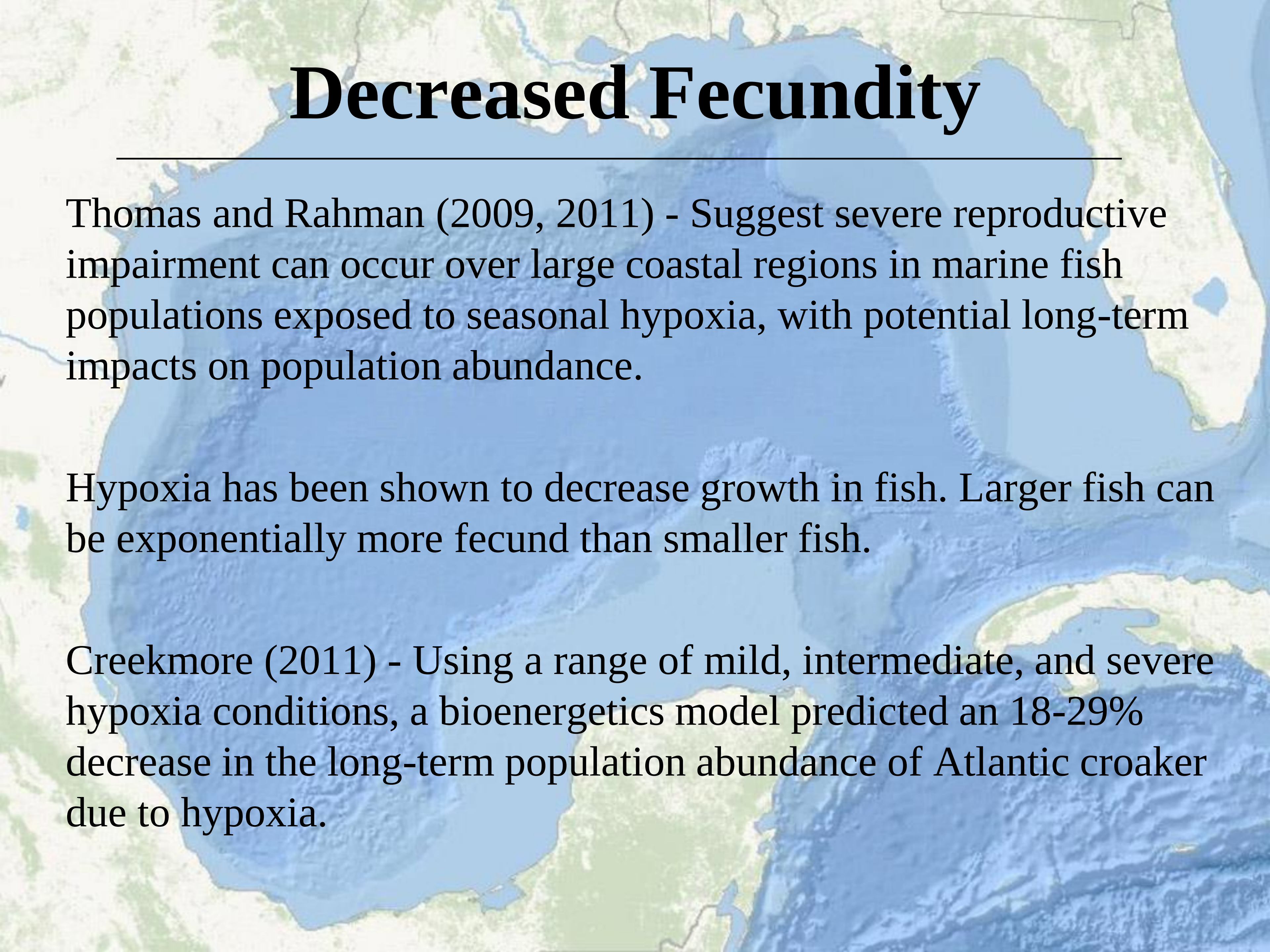
Fisheries

These fisheries are directly impacted by hypoxia. Fishery resources are affected by direct mortality of managed species and their prey, decreased fecundity, loss of habitat, decreased feeding and growth, and increased susceptibility to predation.

Direct Mortality

Mobile species will usually move away from hypoxic waters unless hypoxic waters trap organisms near land.

Benthic species that cannot escape hypoxic waters usually die thereby reducing the amount of prey available to managed species.



Decreased Fecundity

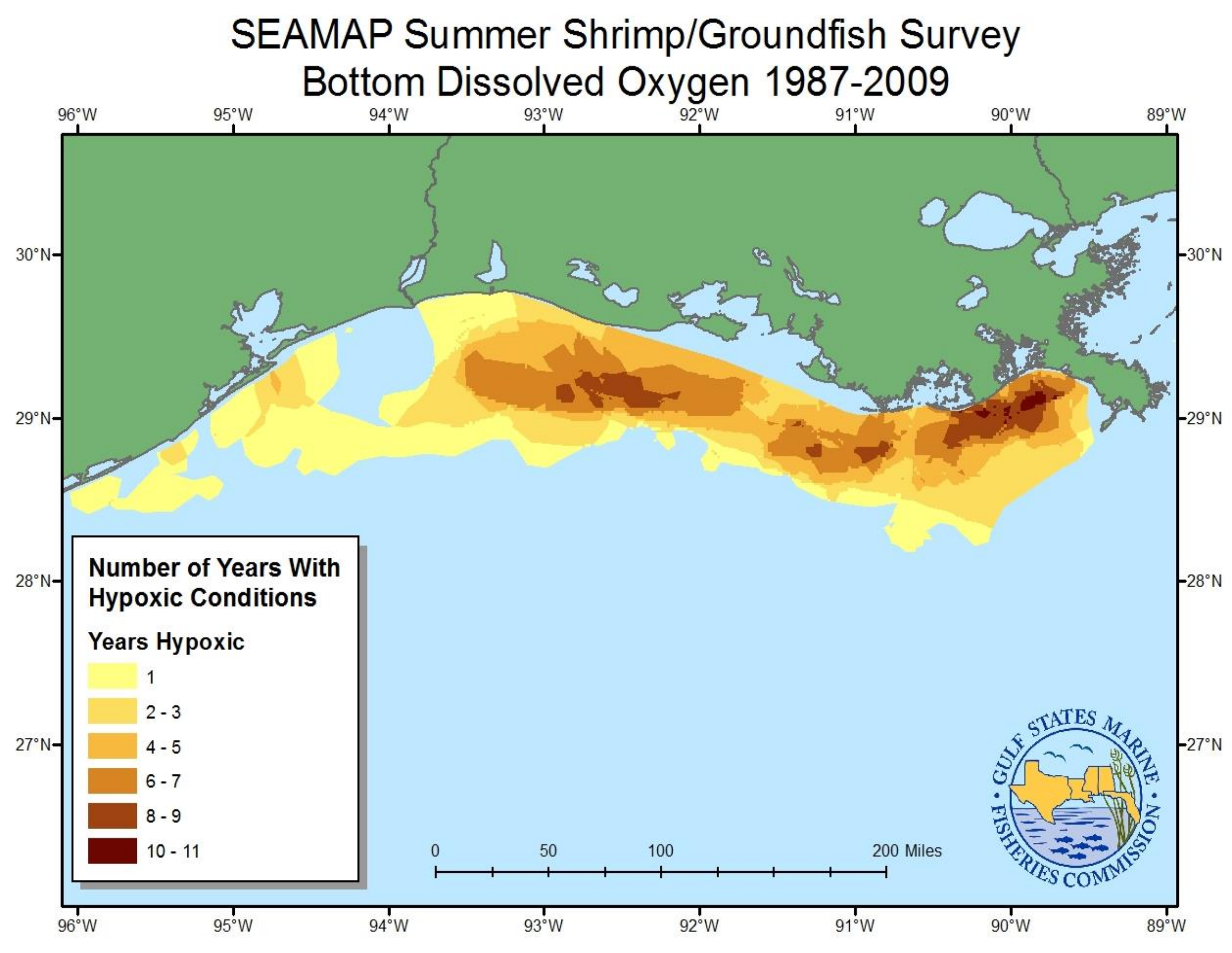
Thomas and Rahman (2009, 2011) - Suggest severe reproductive impairment can occur over large coastal regions in marine fish populations exposed to seasonal hypoxia, with potential long-term impacts on population abundance.

Hypoxia has been shown to decrease growth in fish. Larger fish can be exponentially more fecund than smaller fish.

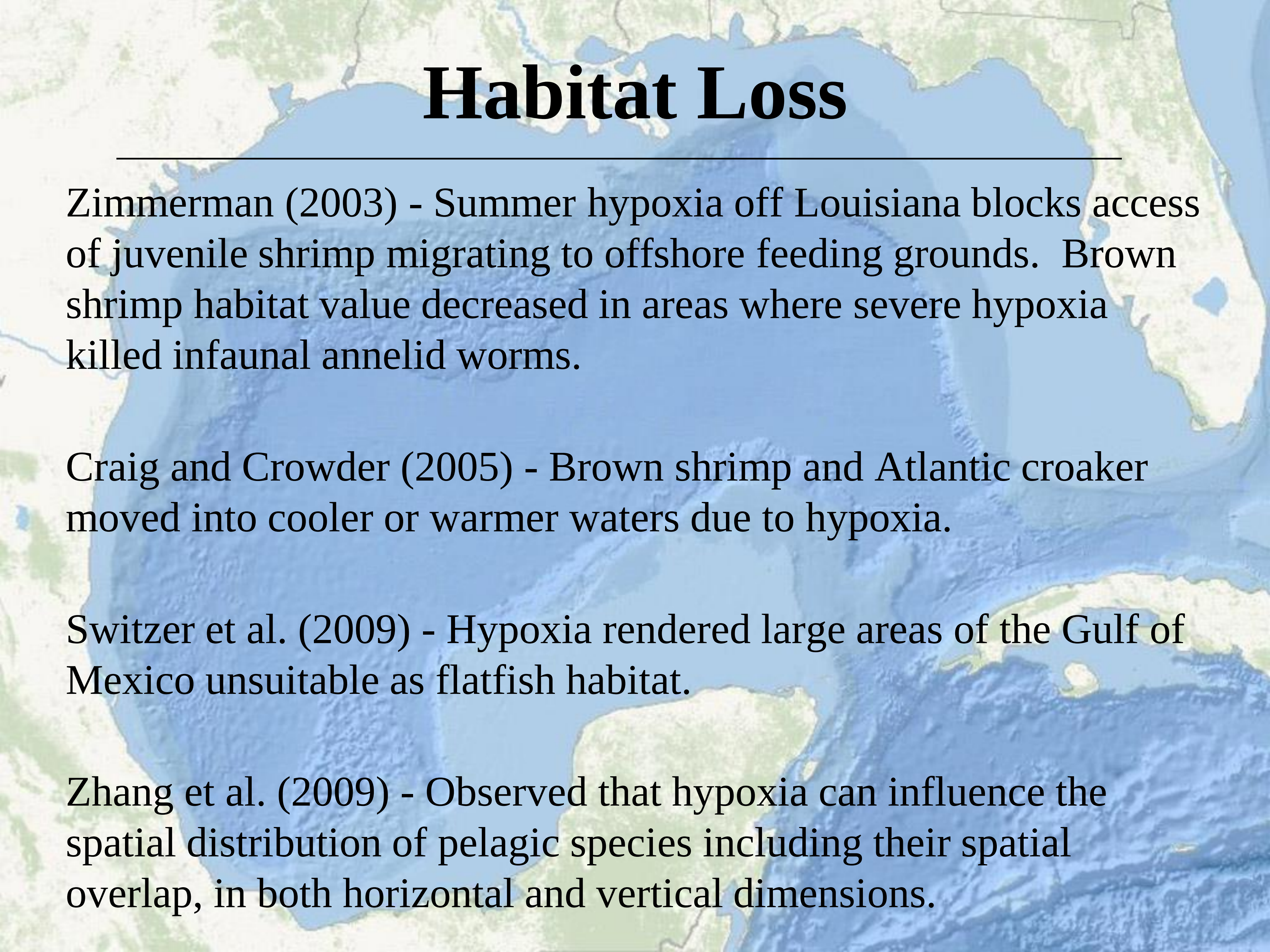
Creekmore (2011) - Using a range of mild, intermediate, and severe hypoxia conditions, a bioenergetics model predicted an 18-29% decrease in the long-term population abundance of Atlantic croaker due to hypoxia.

Habitat Loss

Craig et al. (2005) - Hypoxia has caused an approximately 25% loss of brown shrimp habitat on the Louisiana continental shelf with shifts in distribution and associated high densities both inshore and offshore of the hypoxic region.



Habitat Loss



Zimmerman (2003) - Summer hypoxia off Louisiana blocks access of juvenile shrimp migrating to offshore feeding grounds. Brown shrimp habitat value decreased in areas where severe hypoxia killed infaunal annelid worms.

Craig and Crowder (2005) - Brown shrimp and Atlantic croaker moved into cooler or warmer waters due to hypoxia.

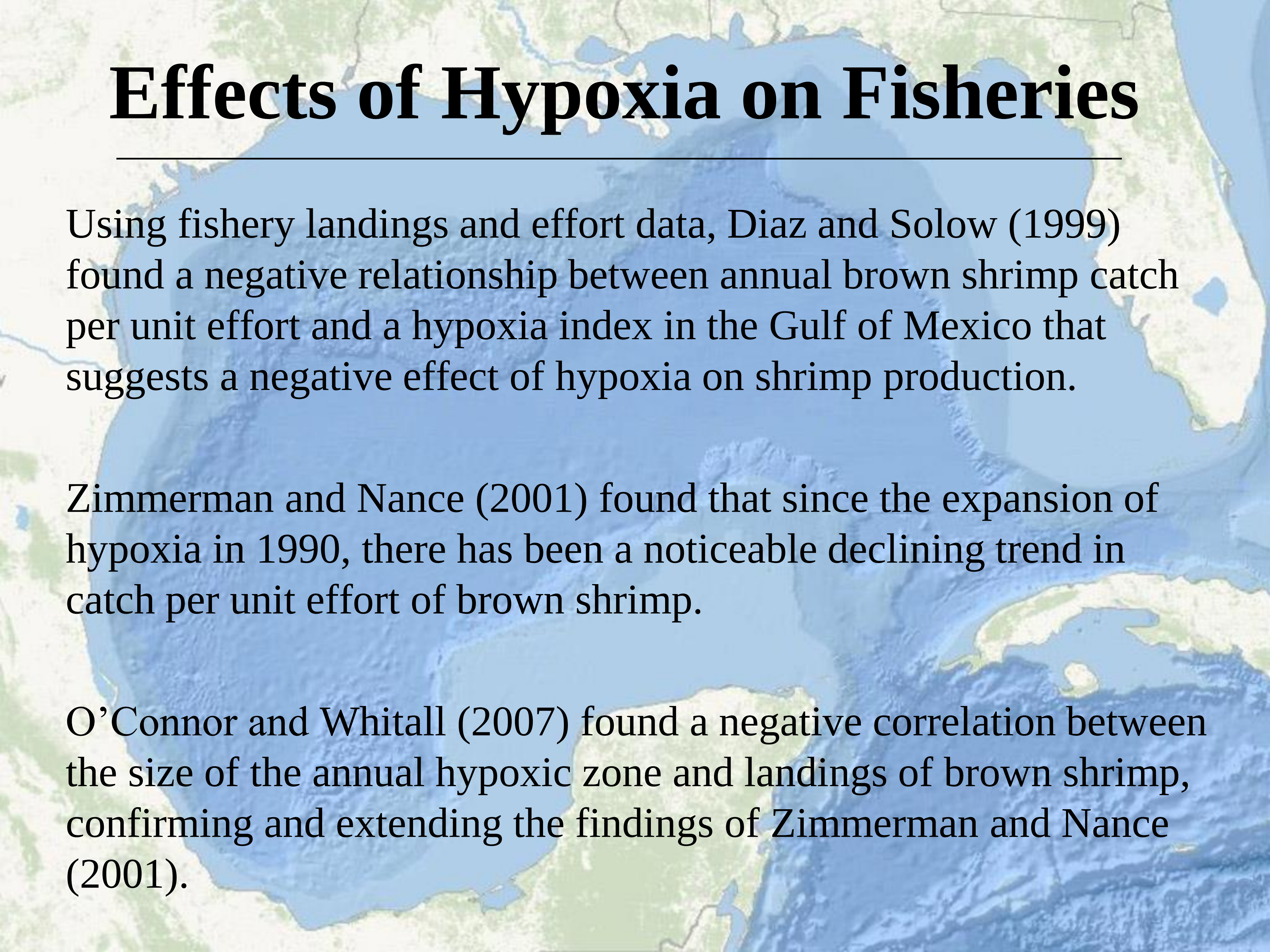
Switzer et al. (2009) - Hypoxia rendered large areas of the Gulf of Mexico unsuitable as flatfish habitat.

Zhang et al. (2009) - Observed that hypoxia can influence the spatial distribution of pelagic species including their spatial overlap, in both horizontal and vertical dimensions.

Habitat Loss

Hazen et al. (2009) – While pelagic habitat is usually not directly impacted by hypoxia, hypoxia can induce vertical or horizontal displacement of fish causing potential indirect bioenergetic or trophic interactions potentially leading to changes in growth, exposure to predators, and foraging behavior.

Roman et al. (2014) found zooplankton shifted their vertical distribution while Langseth et al. (2014) found vertical shifts in Gulf menhaden that may affect their susceptibility to harvest.



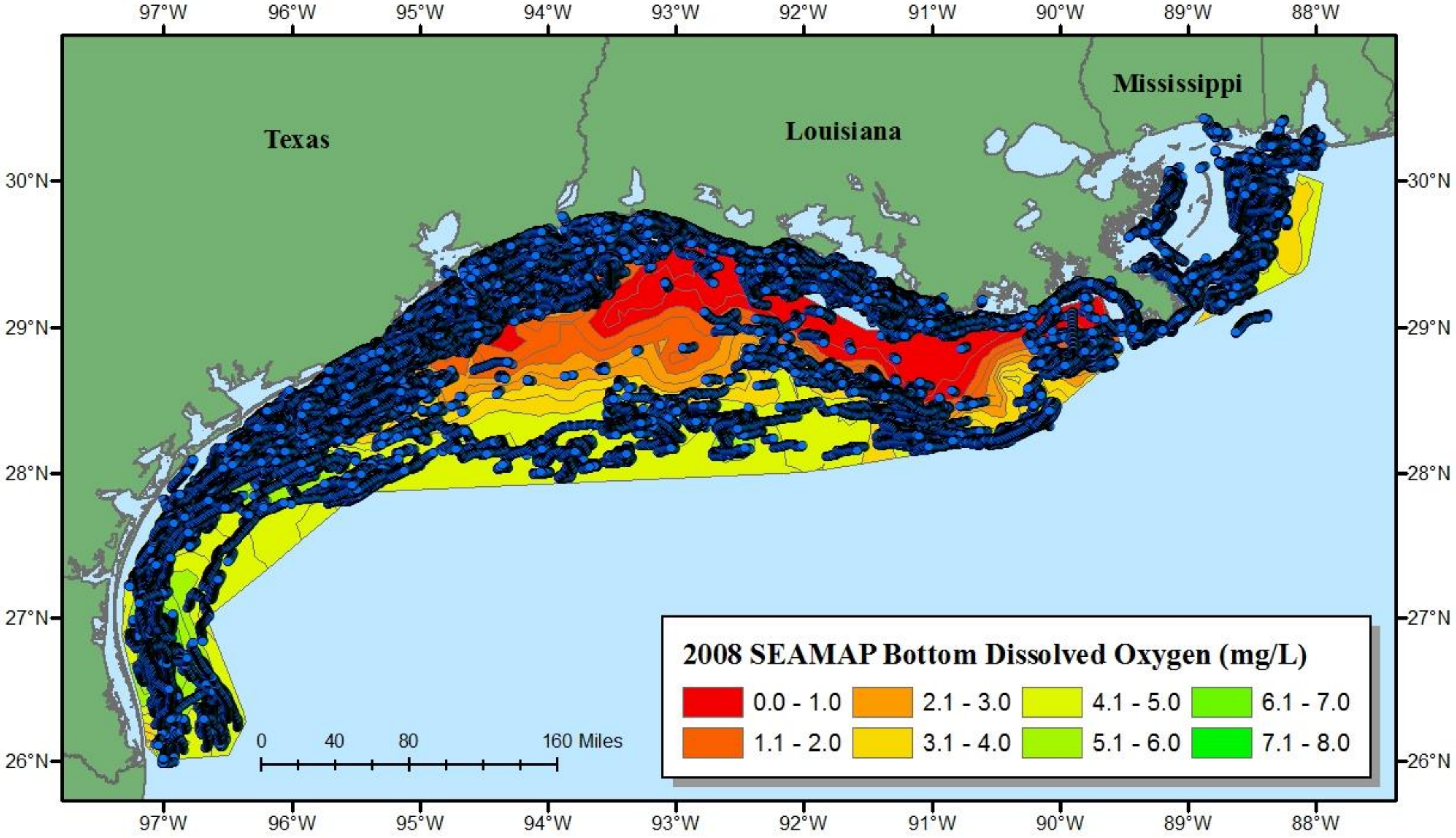
Effects of Hypoxia on Fisheries

Using fishery landings and effort data, Diaz and Solow (1999) found a negative relationship between annual brown shrimp catch per unit effort and a hypoxia index in the Gulf of Mexico that suggests a negative effect of hypoxia on shrimp production.

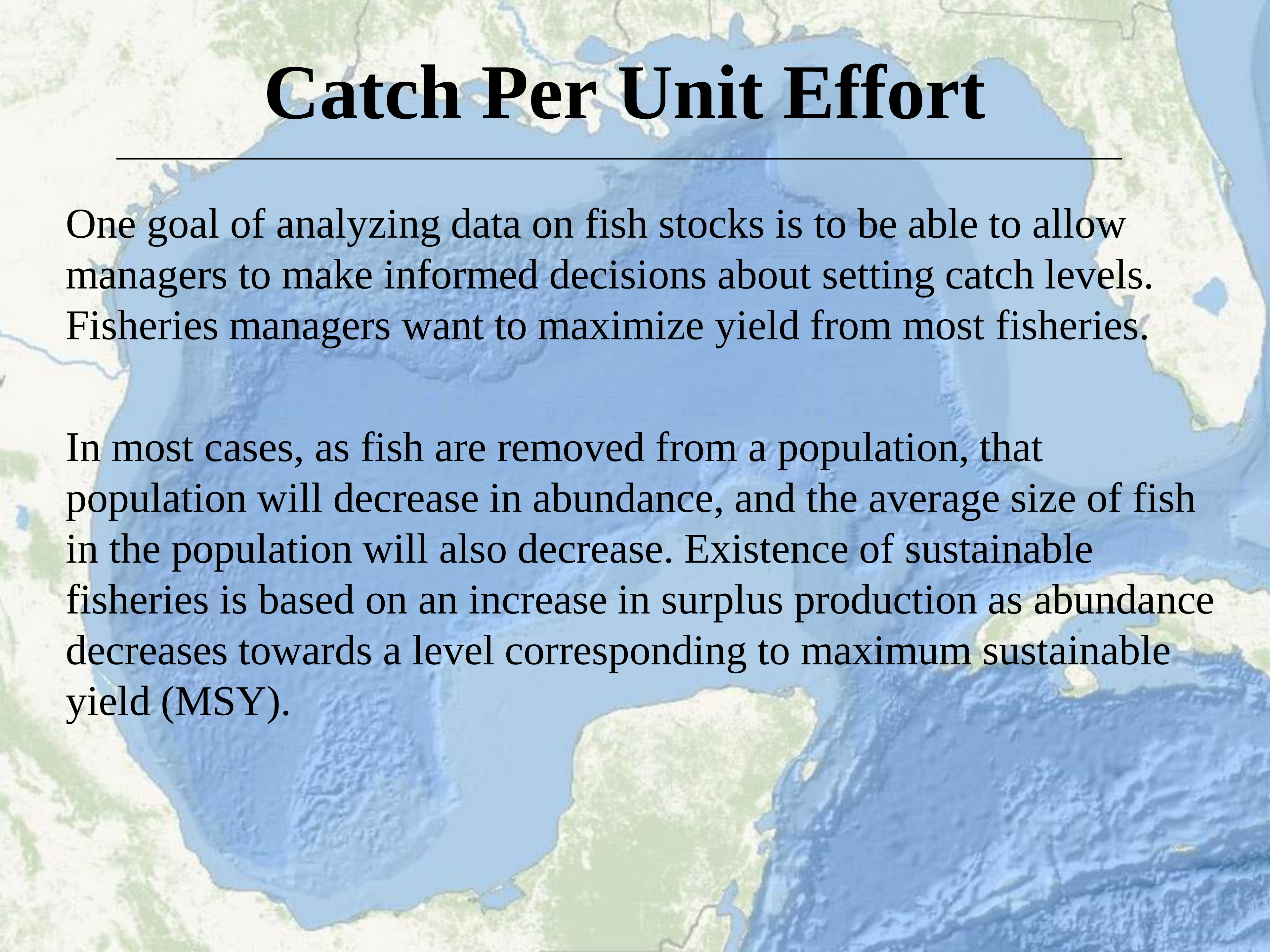
Zimmerman and Nance (2001) found that since the expansion of hypoxia in 1990, there has been a noticeable declining trend in catch per unit effort of brown shrimp.

O’Connor and Whitall (2007) found a negative correlation between the size of the annual hypoxic zone and landings of brown shrimp, confirming and extending the findings of Zimmerman and Nance (2001).

2008 SEAMAP Bottom Dissolved Oxygen and July Shrimping Effort



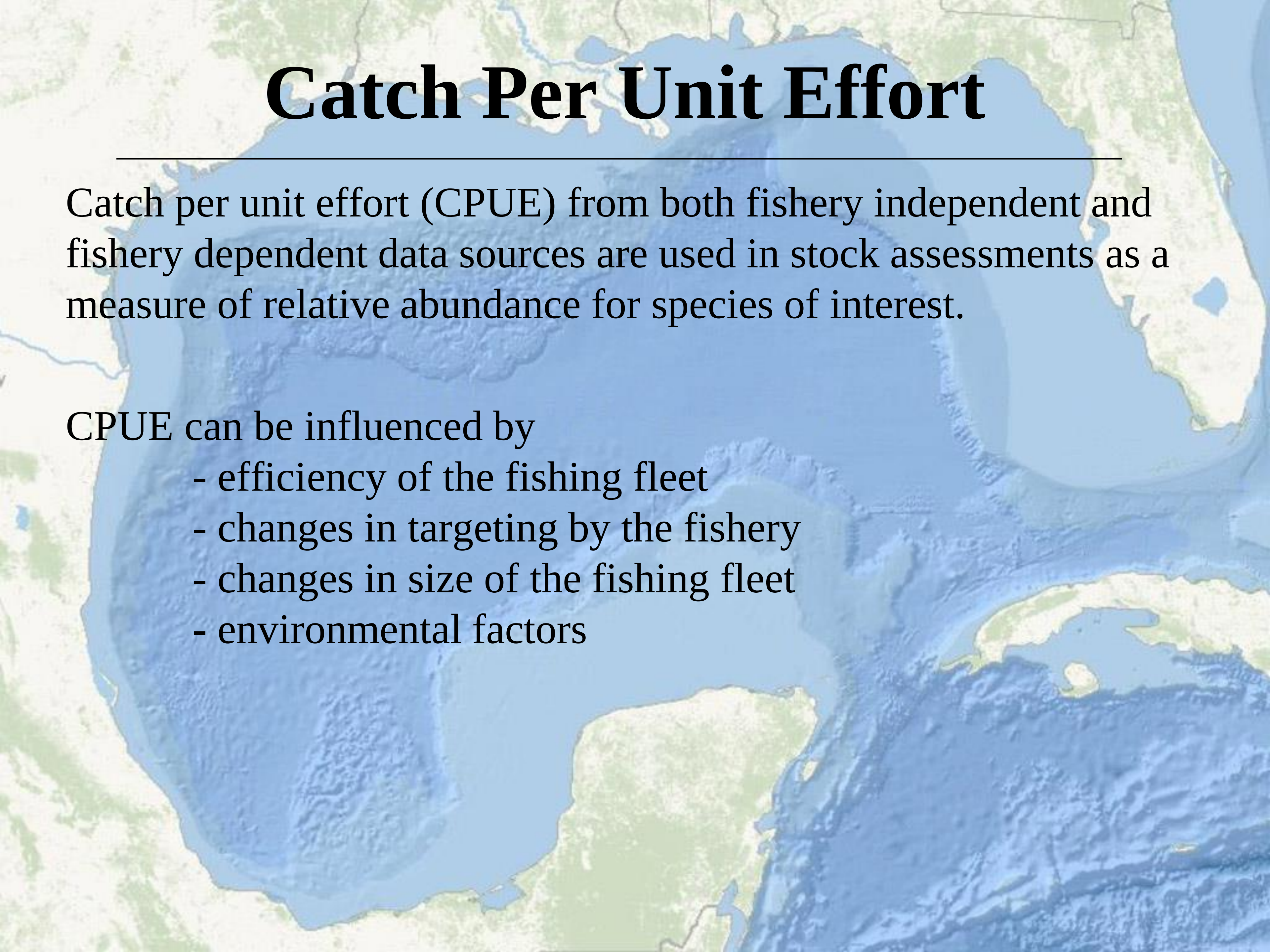
Catch Per Unit Effort



One goal of analyzing data on fish stocks is to be able to allow managers to make informed decisions about setting catch levels. Fisheries managers want to maximize yield from most fisheries.

In most cases, as fish are removed from a population, that population will decrease in abundance, and the average size of fish in the population will also decrease. Existence of sustainable fisheries is based on an increase in surplus production as abundance decreases towards a level corresponding to maximum sustainable yield (MSY).

Catch Per Unit Effort



Catch per unit effort (CPUE) from both fishery independent and fishery dependent data sources are used in stock assessments as a measure of relative abundance for species of interest.

CPUE can be influenced by

- efficiency of the fishing fleet
- changes in targeting by the fishery
- changes in size of the fishing fleet
- environmental factors

Effects of Hypoxia on Fisheries

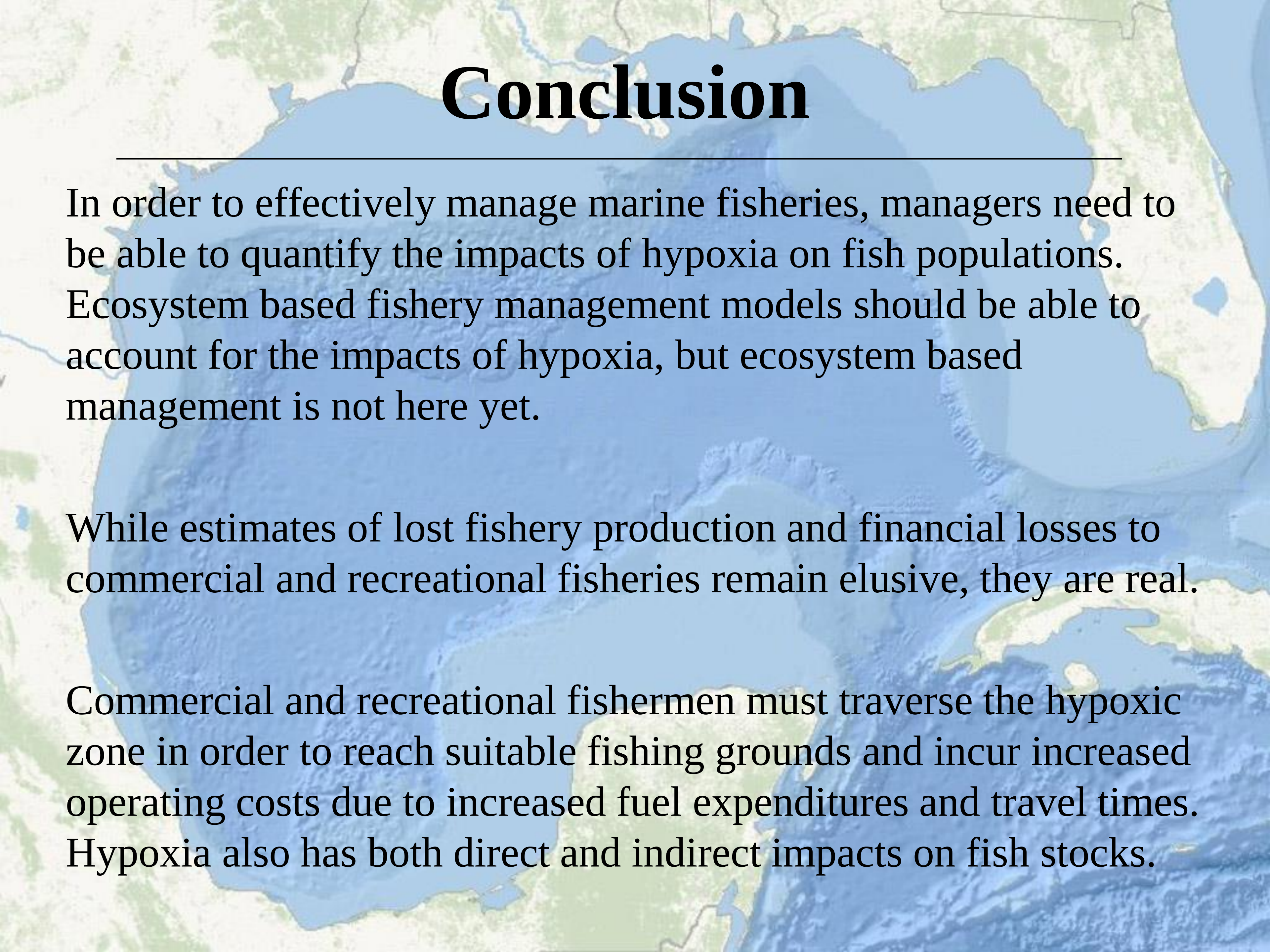
Even though catch per unit effort (CPUE) may increase when hypoxia is present, Kociolek (2011) found that on average, landings of large shrimp decrease in the presence of seasonal hypoxia whereas landing of smaller, less valuable shrimp increase significantly.

Craig and Bosman (2013) found that hypoxia-induced changes in spatial dynamics have the potential to influence harvest and bycatch interactions in and around the Gulf hypoxic zone.

Effects of Hypoxia on Fisheries

De Mutsert et al. (2016) concluded that an increases in total fish biomass and fisheries landings as a result of an increase in primary production outweigh the decreases as a result of hypoxic conditions, but their results showed that responses were species-specific, and some species such as red snapper did suffer a net loss in biomass.

Switzer et al. (2014) found weak red snapper recruitment off Louisiana during years of severe hypoxia.

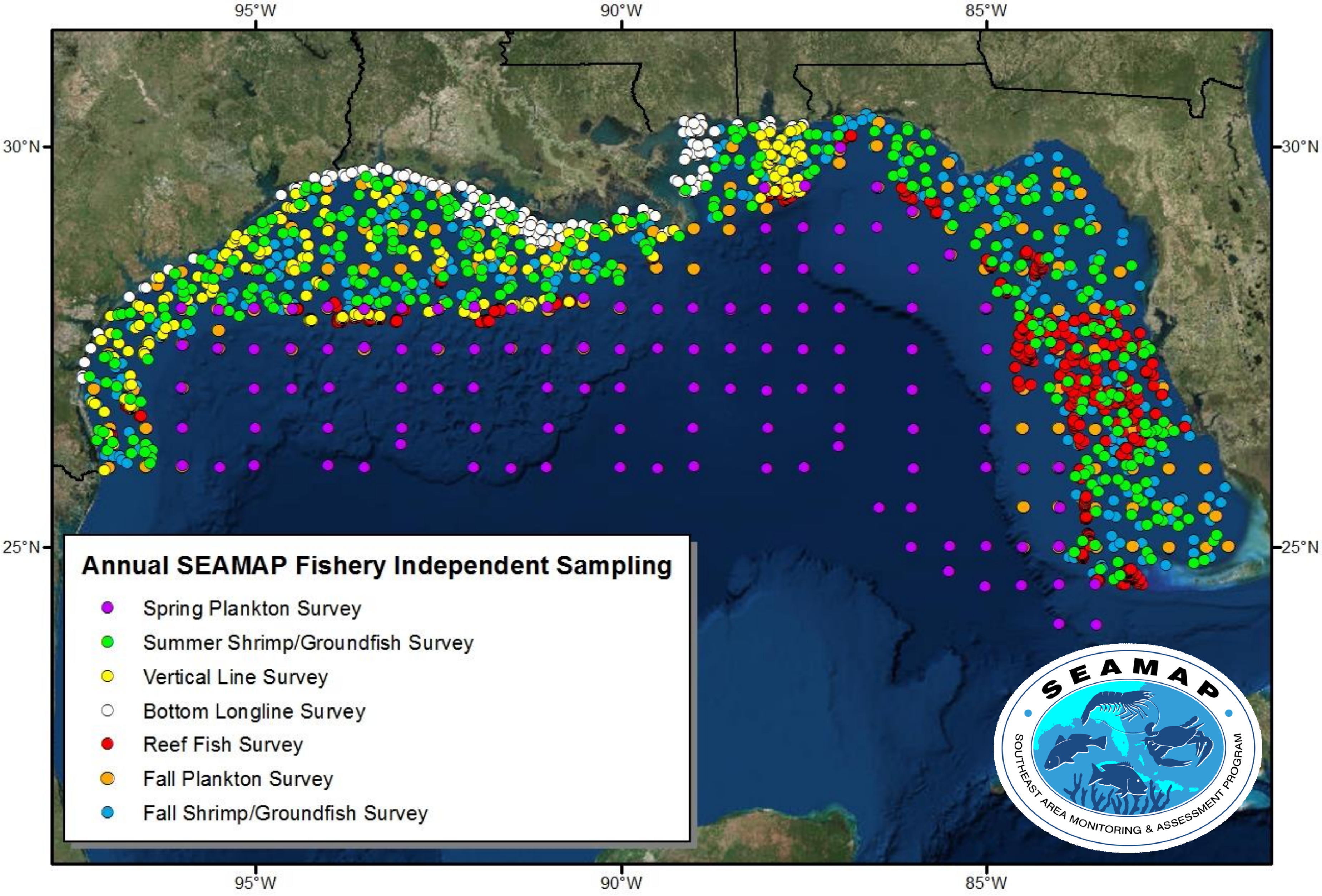


Conclusion

In order to effectively manage marine fisheries, managers need to be able to quantify the impacts of hypoxia on fish populations. Ecosystem based fishery management models should be able to account for the impacts of hypoxia, but ecosystem based management is not here yet.

While estimates of lost fishery production and financial losses to commercial and recreational fisheries remain elusive, they are real.

Commercial and recreational fishermen must traverse the hypoxic zone in order to reach suitable fishing grounds and incur increased operating costs due to increased fuel expenditures and travel times. Hypoxia also has both direct and indirect impacts on fish stocks.


95°W
90°W
85°W
30°N
25°N
Annual SEAMAP Fishery Independent Sampling
● Spring Plankton Survey
● Summer Shrimp/Groundfish Survey
● Vertical Line Survey
○ Bottom Longline Survey
● Reef Fish Survey
● Fall Plankton Survey
● Fall Shrimp/Groundfish Survey
SEAMAP
SOUTHEAST AREA MONITORING & ASSESSMENT PROGRAM

2016 SEAMAP Summer Shrimp/Groundfish Survey
May 30 to July 19, 2016