

Including Hypoxia in Ecosim and Ecospace

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Hypoxia Forum
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Goals

- Determine the effect of the hypoxic zone in the Northern Gulf of Mexico on the biomass of living marine resources
- Determine impact on fisheries: should the hypoxic zone be considered in fishing regulation?

Ecopath with Ecosim

Widely used for construction of mass-balance trophic models of ecosystems

Simulates response of fish to fishing and environmental change; accounts for ecological interactions

Has three main components:

- Ecopath – a static snapshot of ecosystem trophic structure
- Ecosim – a time dynamic simulation module
- Ecospace – a spatial and temporal dynamic module



Coastal Northern Gulf of Mexico Ecopath model

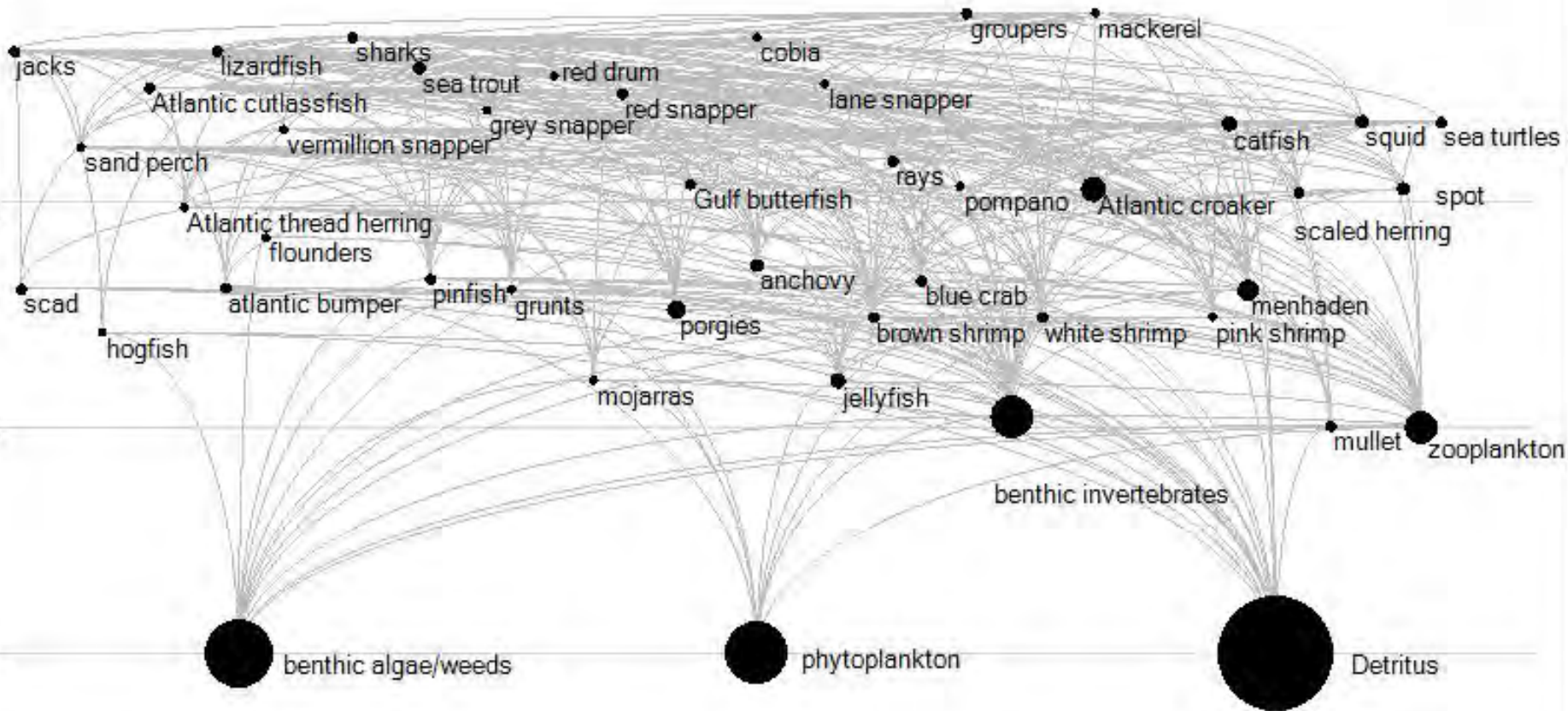
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1



Including environmental drivers

- No end-to-end modeling; including time series as forcing function that affects producer and/or consumer biomass
- Time series (could be hypoxia model output or empirical DO data) in combination with species specific response curves
- Time-step: 1 month
- No feedback loop; programming language and time-step does not have to be compatible
- Running time in the order of years (20-50)

Mississippi River No_x flux forces primary productivity

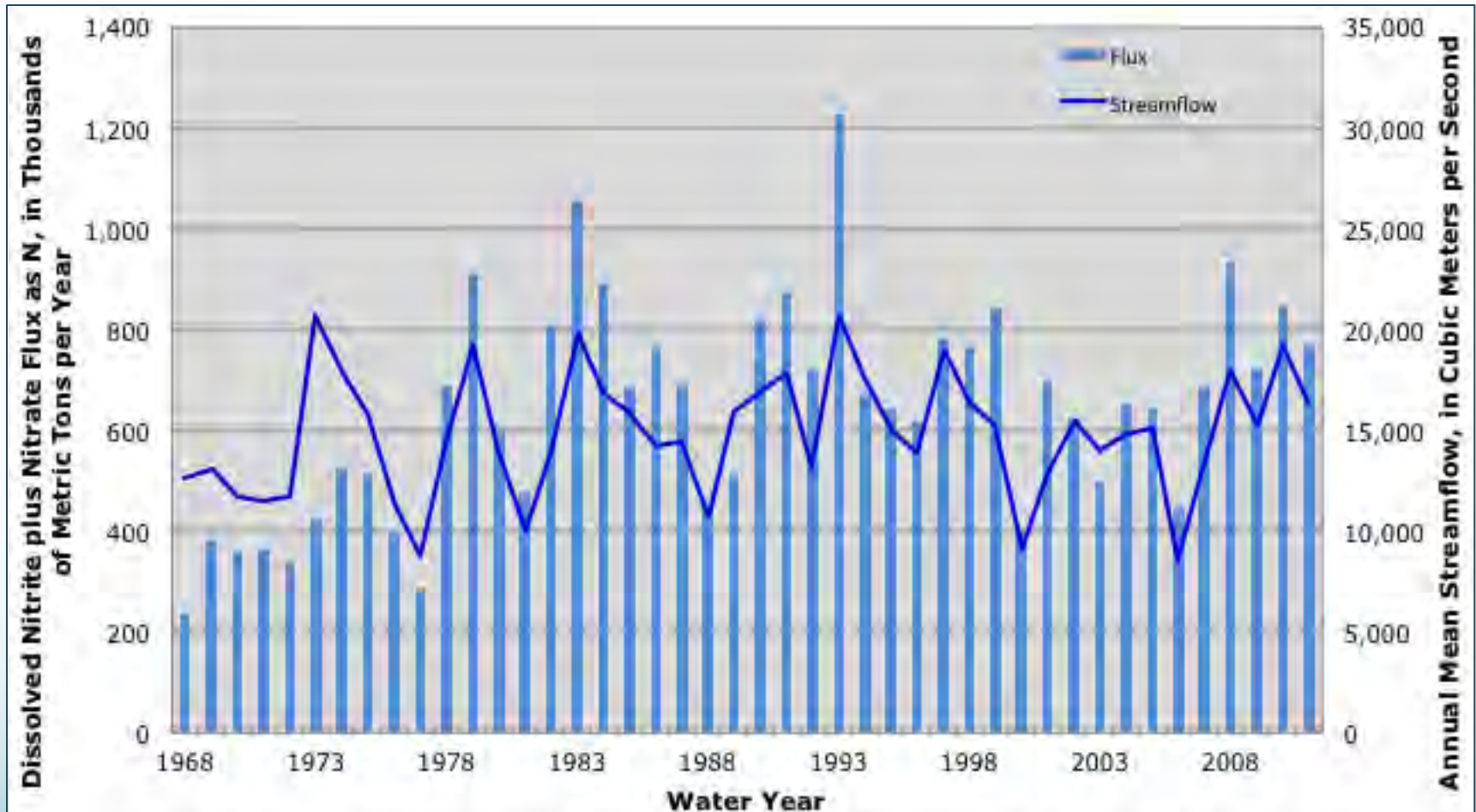
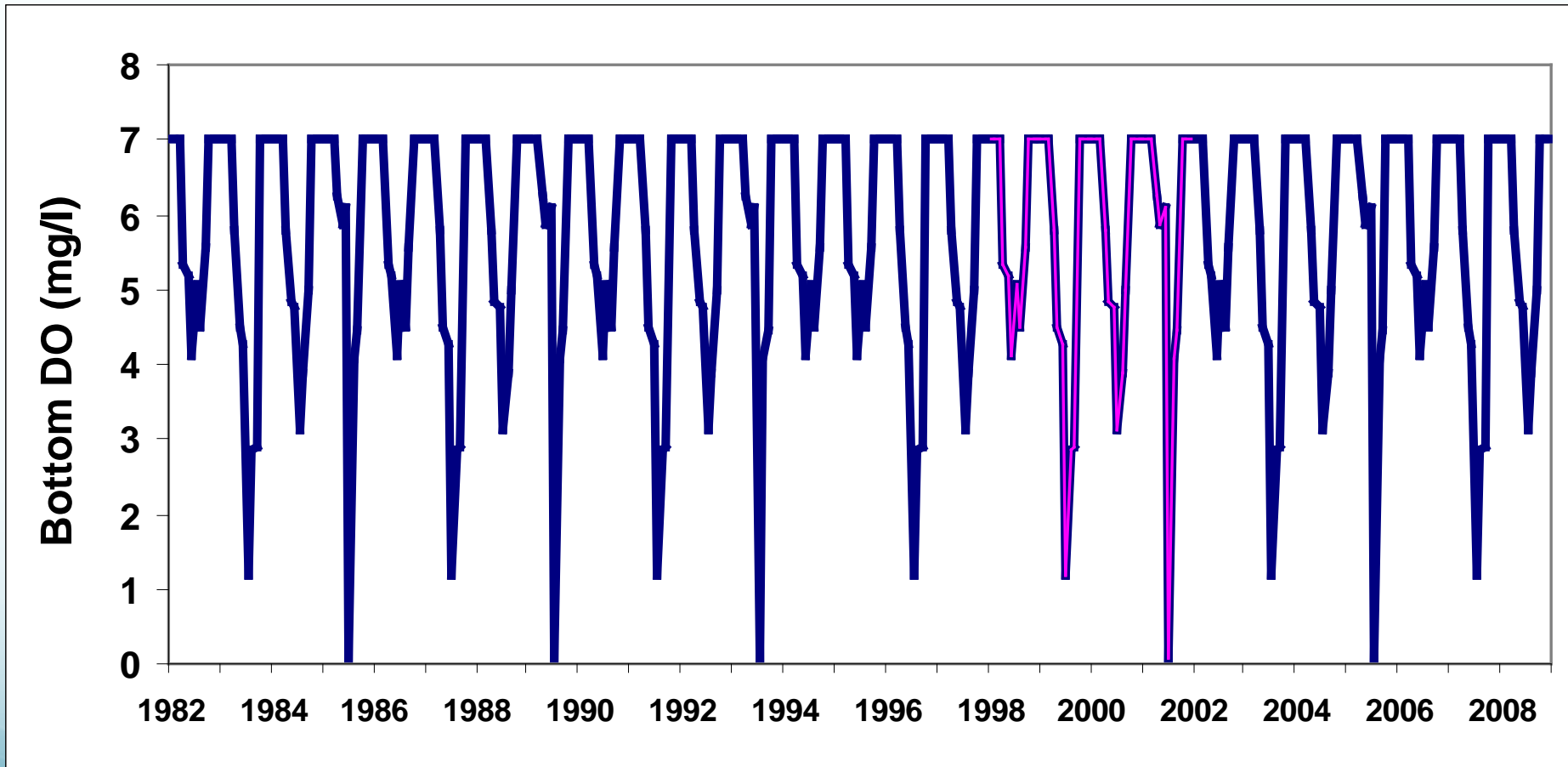


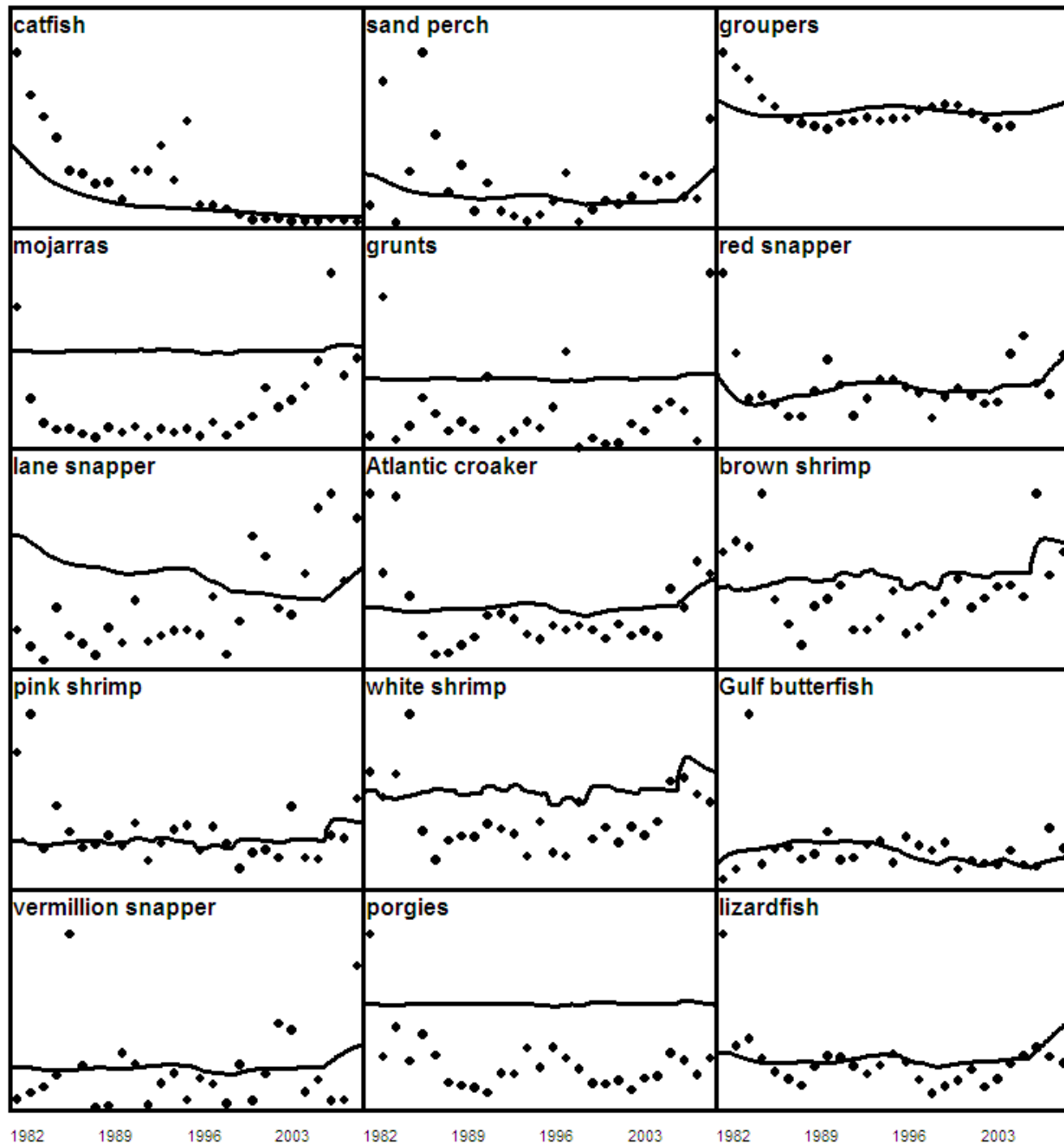
Figure 1. Annual dissolved nitrite plus nitrate flux at Mississippi River near St. Francisville, Louisiana. Annual streamflow data from Mississippi River at Tarbert Landing, Mississippi (USACE Station ID 01100).

DO data as hypoxia forcing function



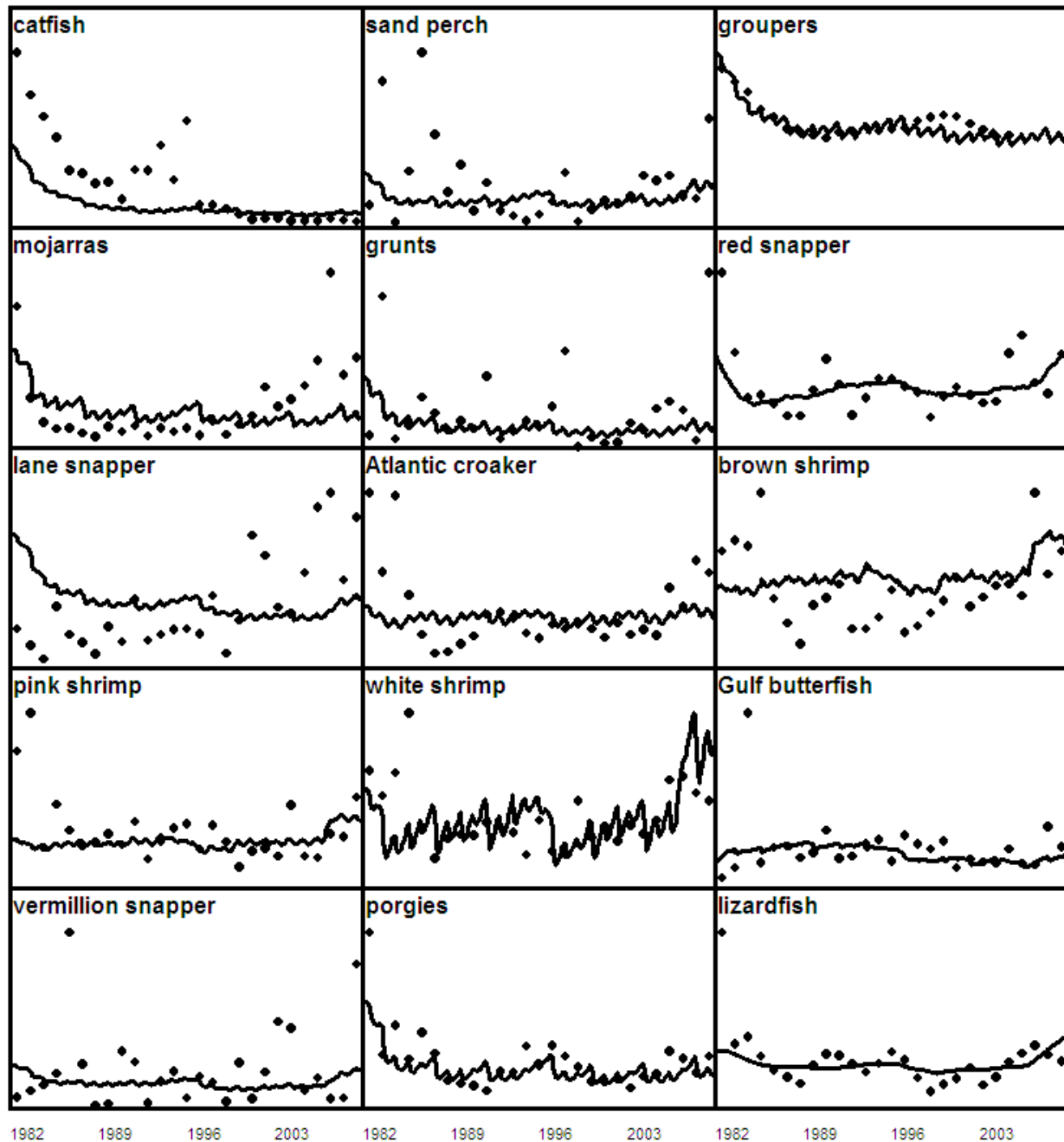
Ecosim model runs versus absolute biomass time series

No DO forcing
SS = 780



Ecosim model runs versus absolute biomass time series

With DO forcing
SS = 670



Ecospace: temporal and spatial dynamic simulations

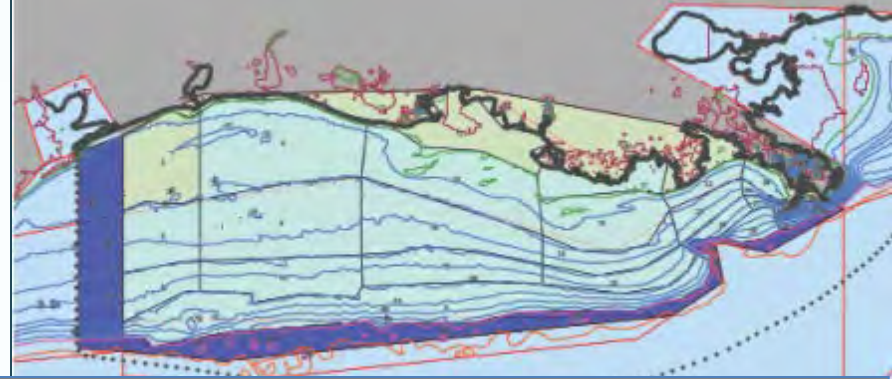
- Ecosim in each cell in a raster grid, while accounting for cell connectivity and fish movement explicitly
- Movement modified by whether a cell has preferred habitat/environmental conditions
- User-defined increased predation risk and reduced feeding rate in non-preferred cells
- Fishing effort in each cell is proportional to the overall profitability of fishing in that cell

Ecospace renewed: Foraging habitat capacity model

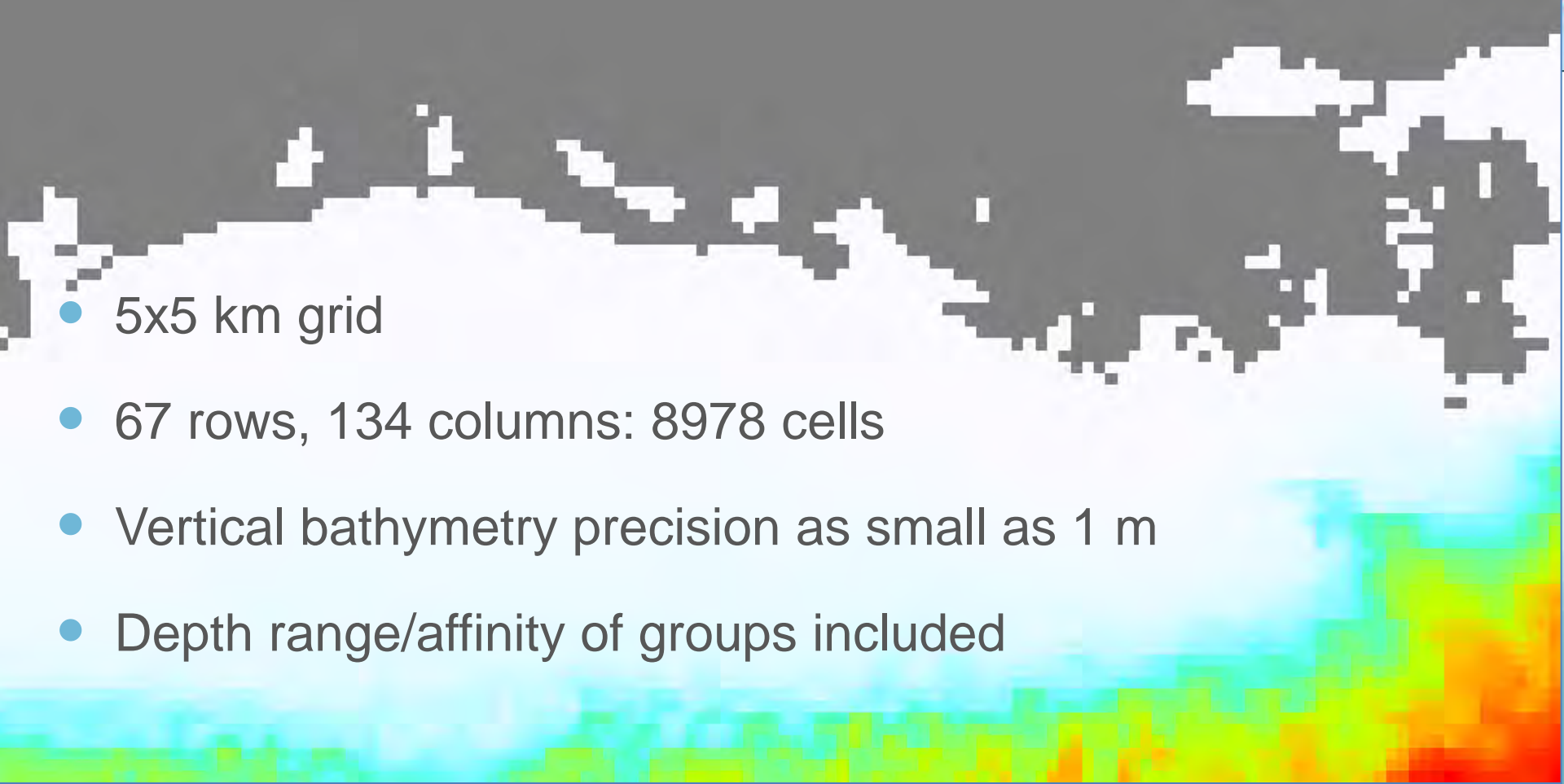
- The portion of a cell suitable for a species can be restricted
- Habitat as well as environmental factors (hypoxia) can affect the area of a cell that a species can utilize for foraging (species-specific capacity of a cell)
- Habitat preferences and environmental tolerance ranges are directly converted to a *habitat capacity map* for each species/group

Ecospace base map

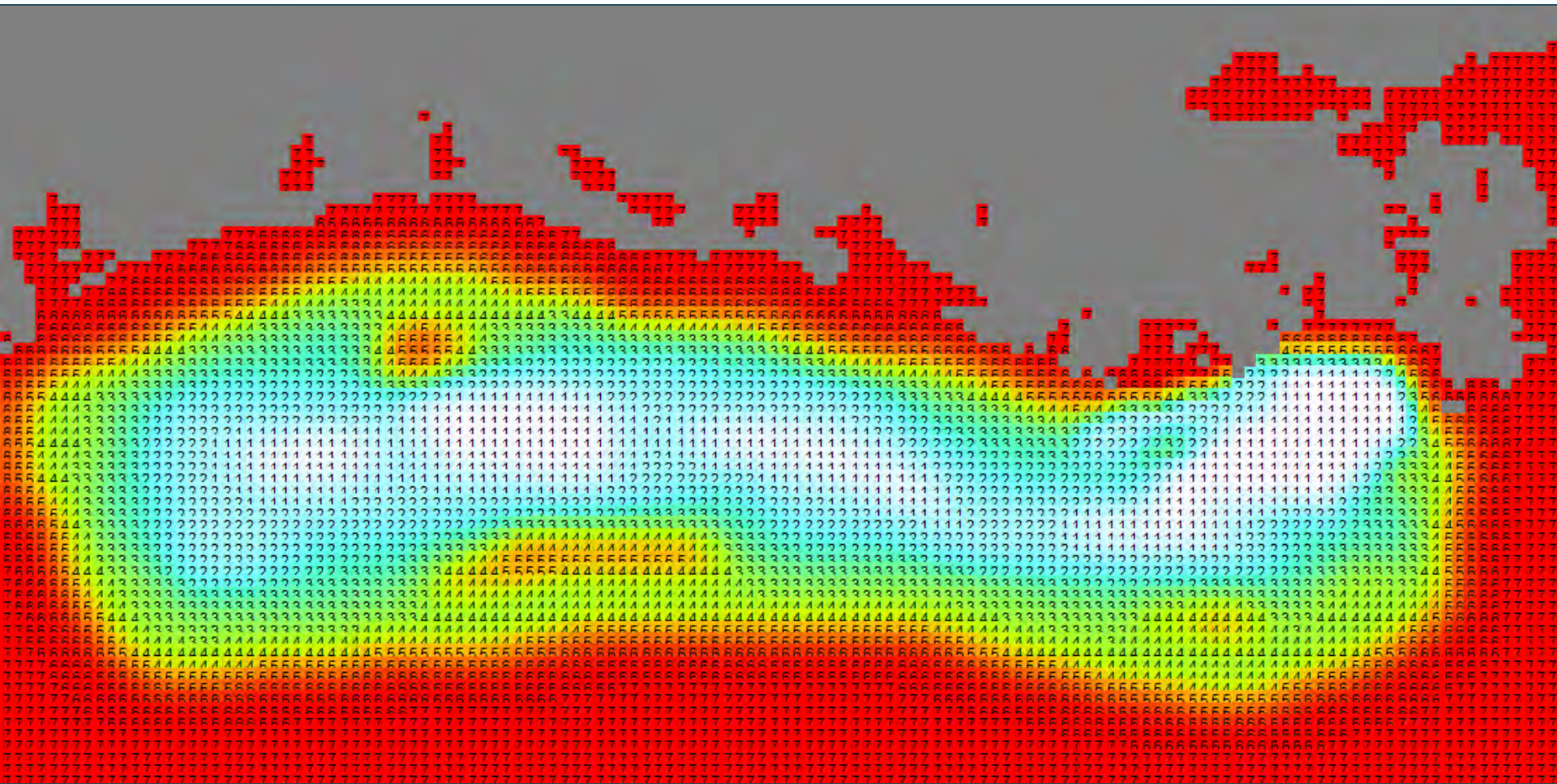
ATLANTIS base map



- 5x5 km grid
- 67 rows, 134 columns: 8978 cells
- Vertical bathymetry precision as small as 1 m
- Depth range/affinity of groups included

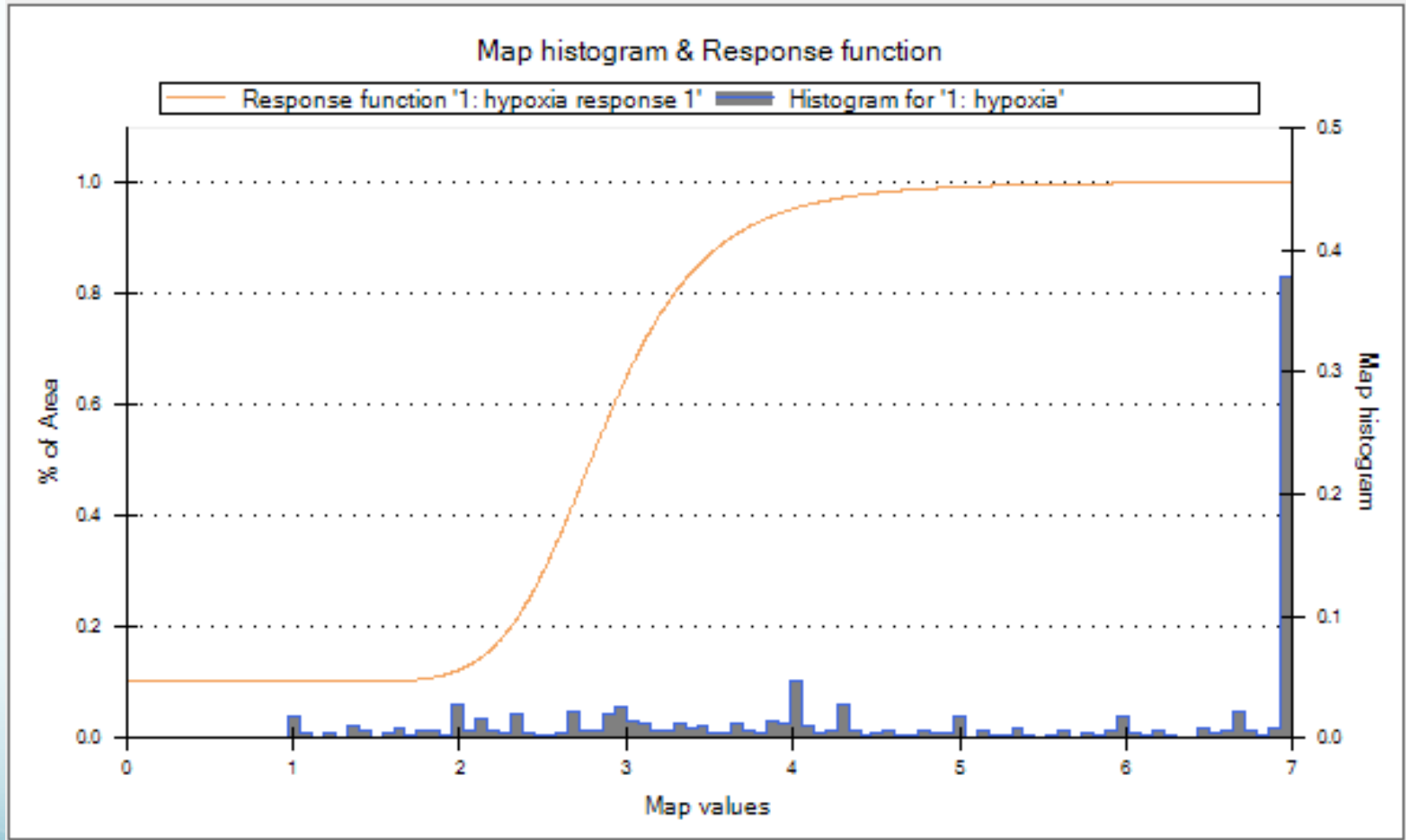


Environmental driver: summer hypoxia

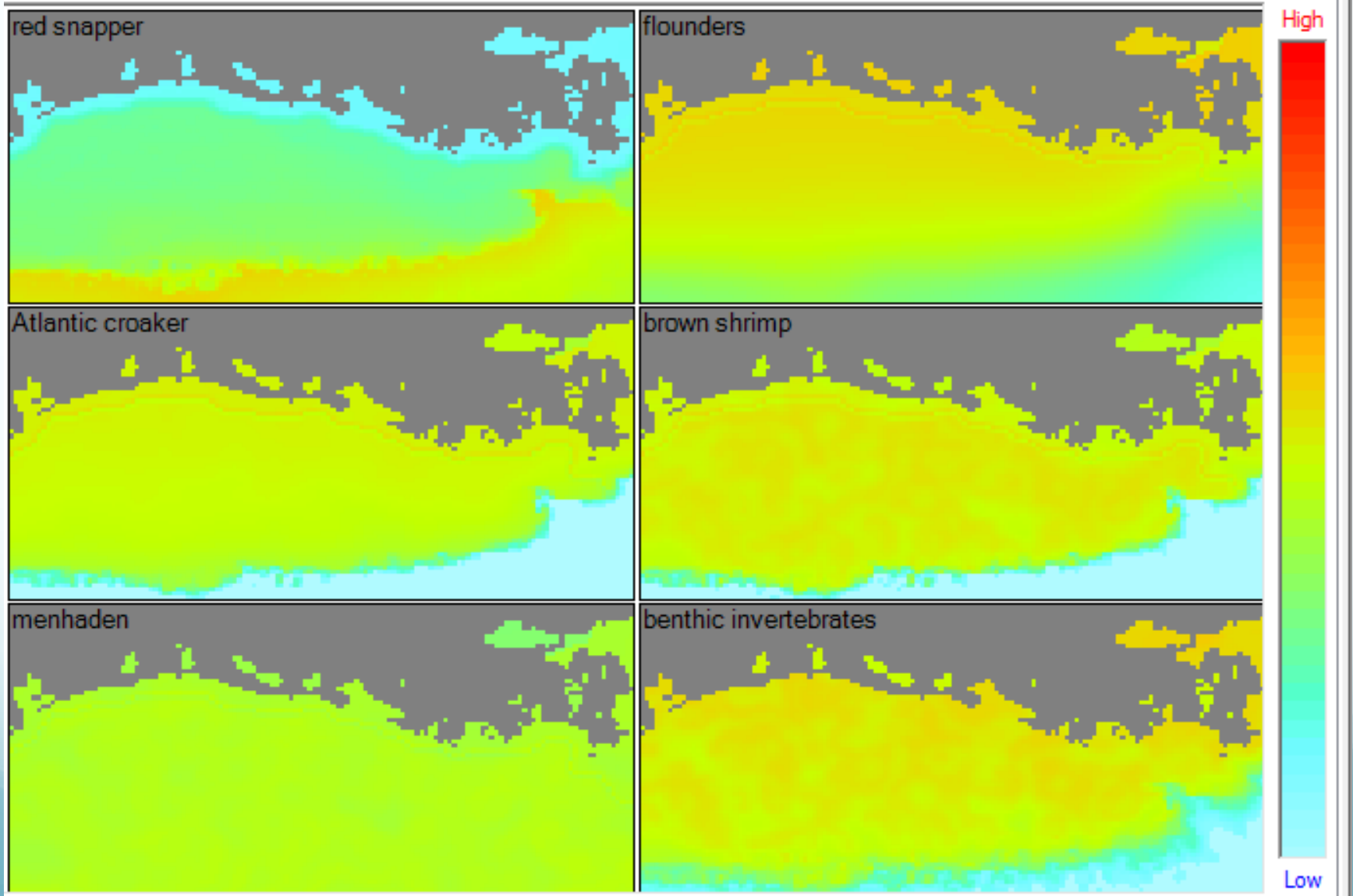


*Warmer (red) is higher DO; blue & white indicate hypoxia

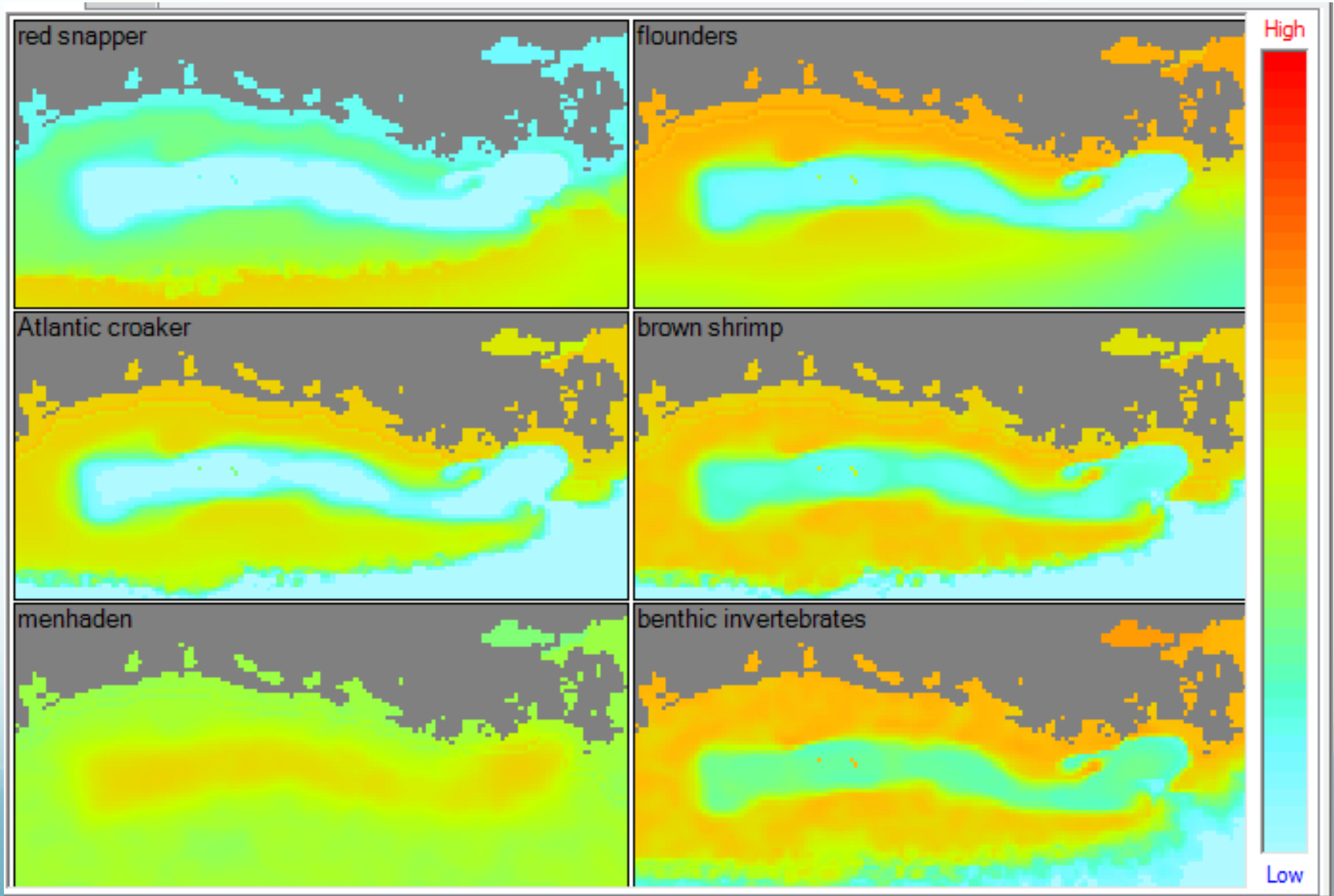
Species-specific foraging response curves



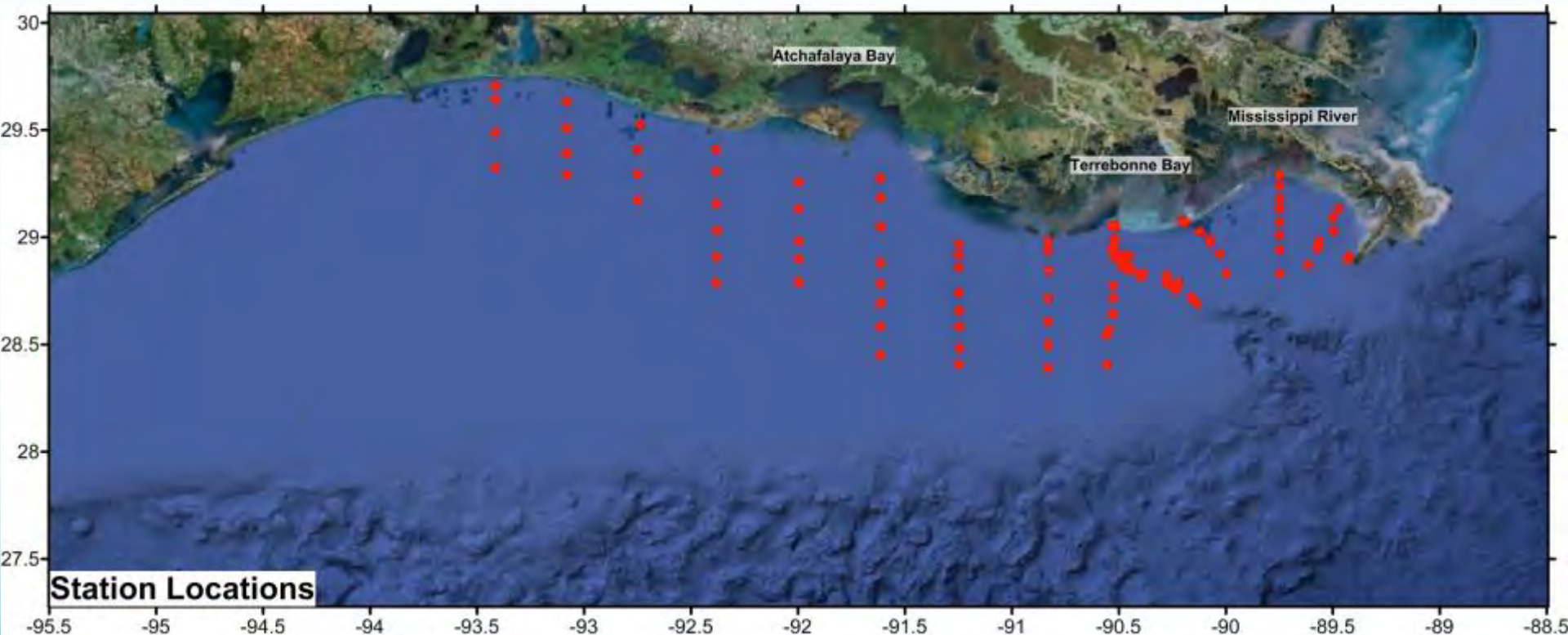
Output selected species without hypoxia



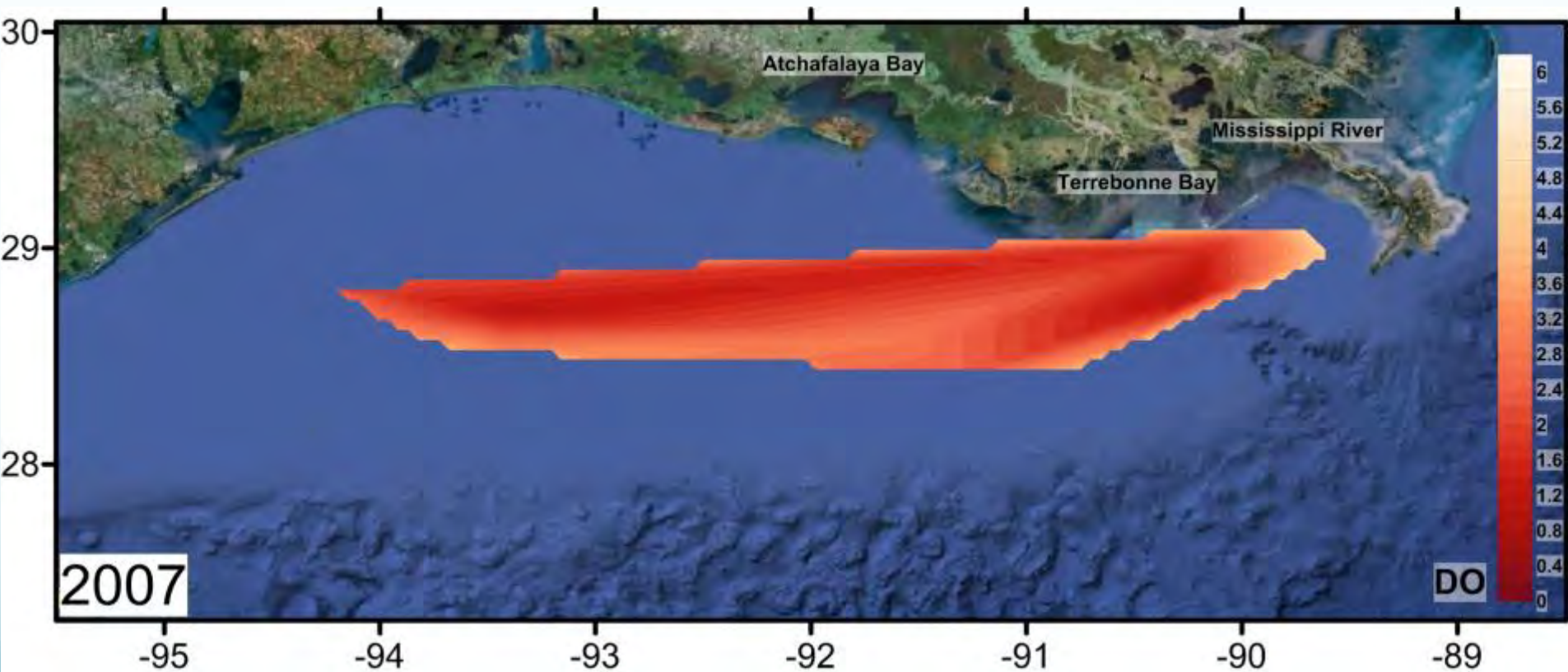
Output selected species with hypoxia

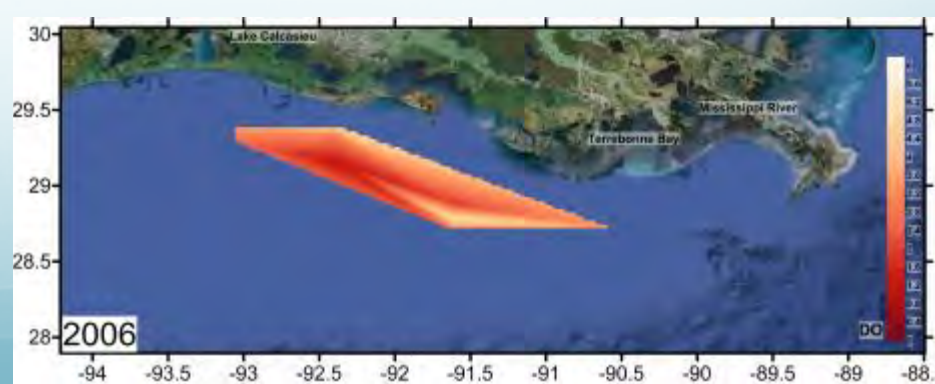
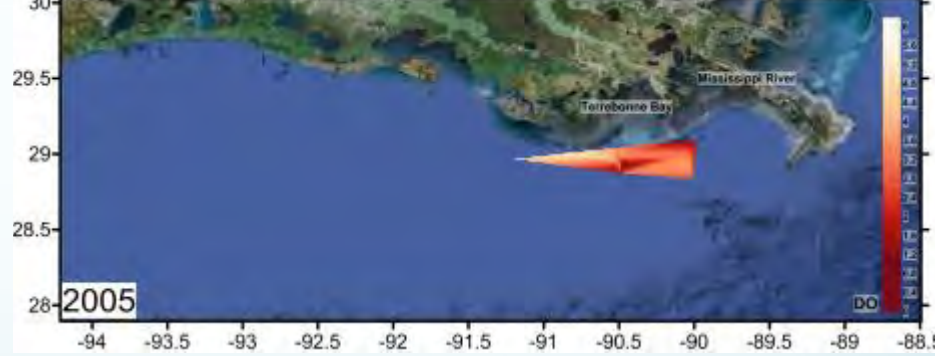
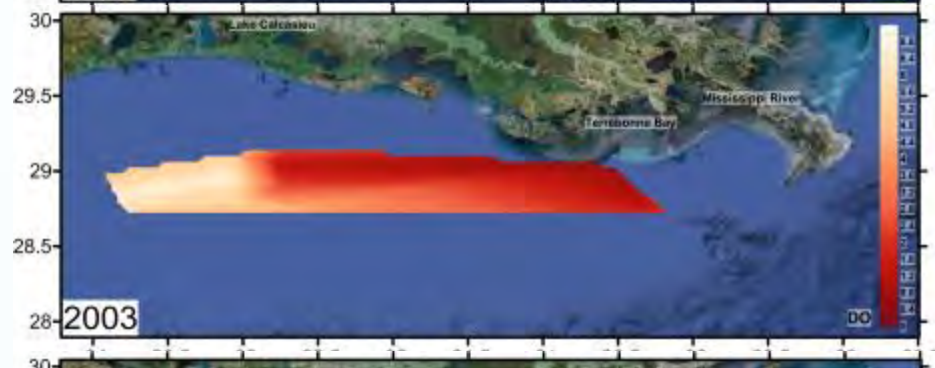
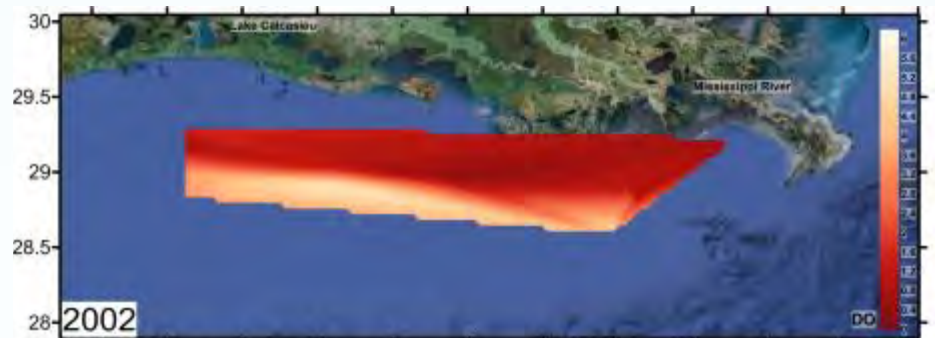
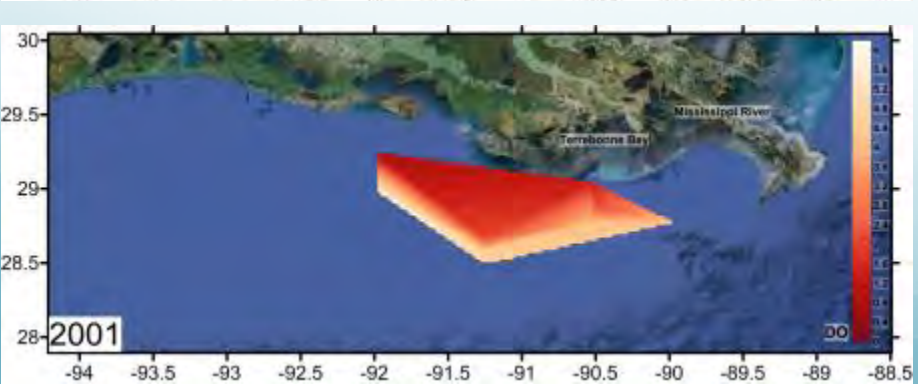
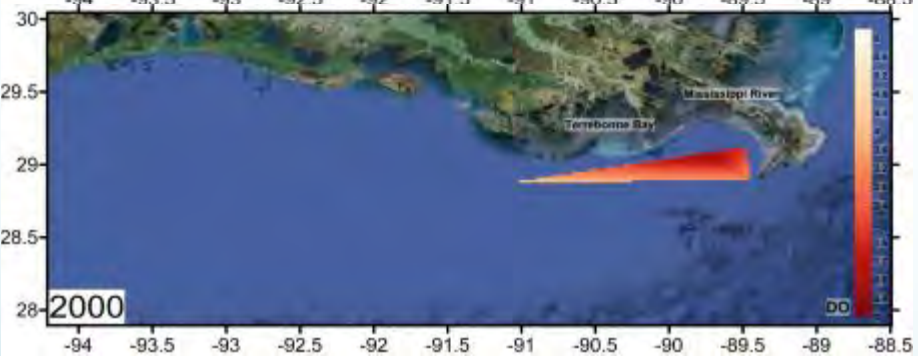
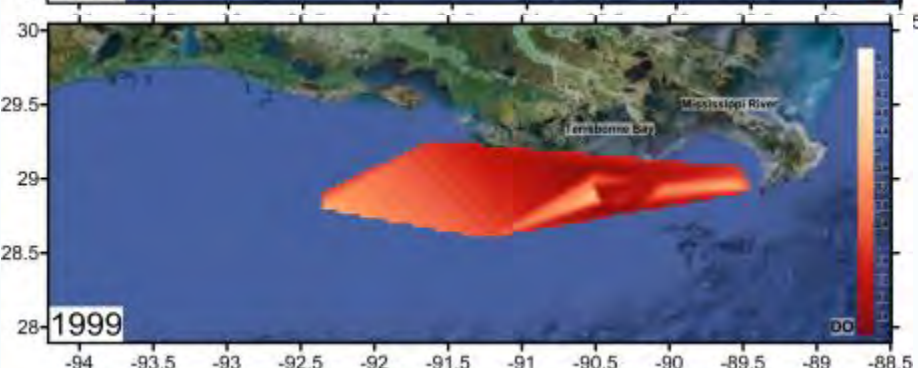
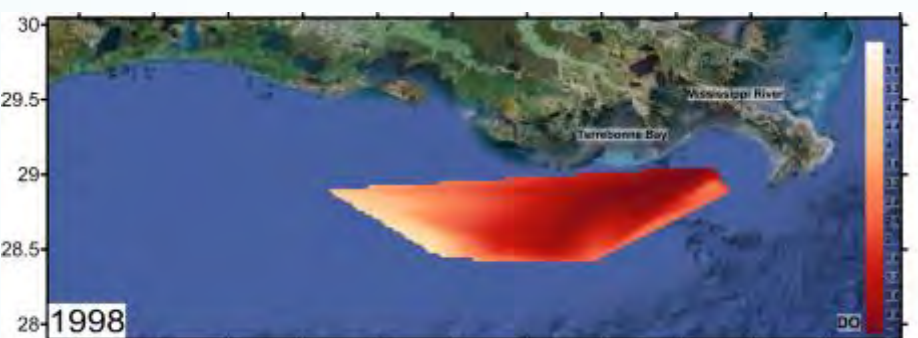


Empirical data (LUMCON cruises)

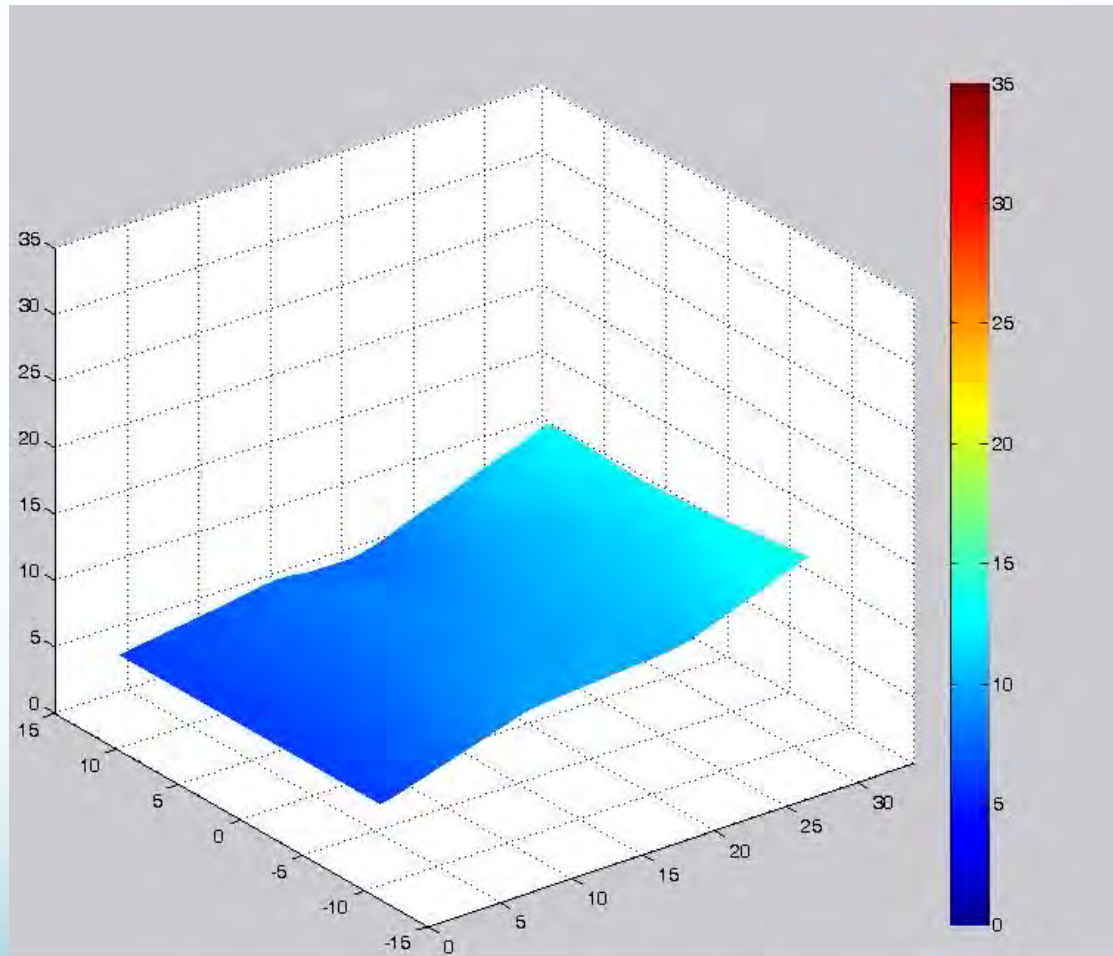


Empirical data (Bottom DO July and August)



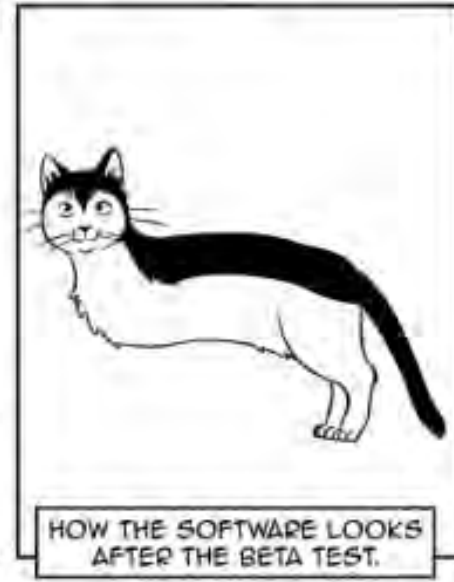
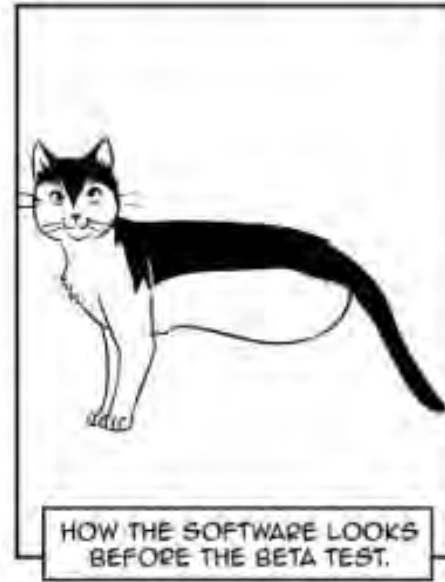
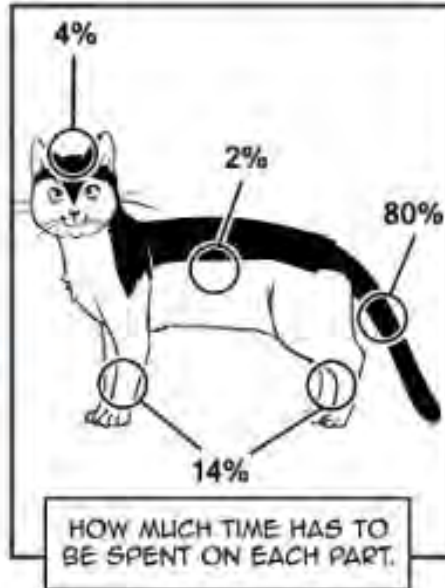


Developing time-dynamic spatial forcing functions



This was possible in EwE 5...

Richard's guide to software development



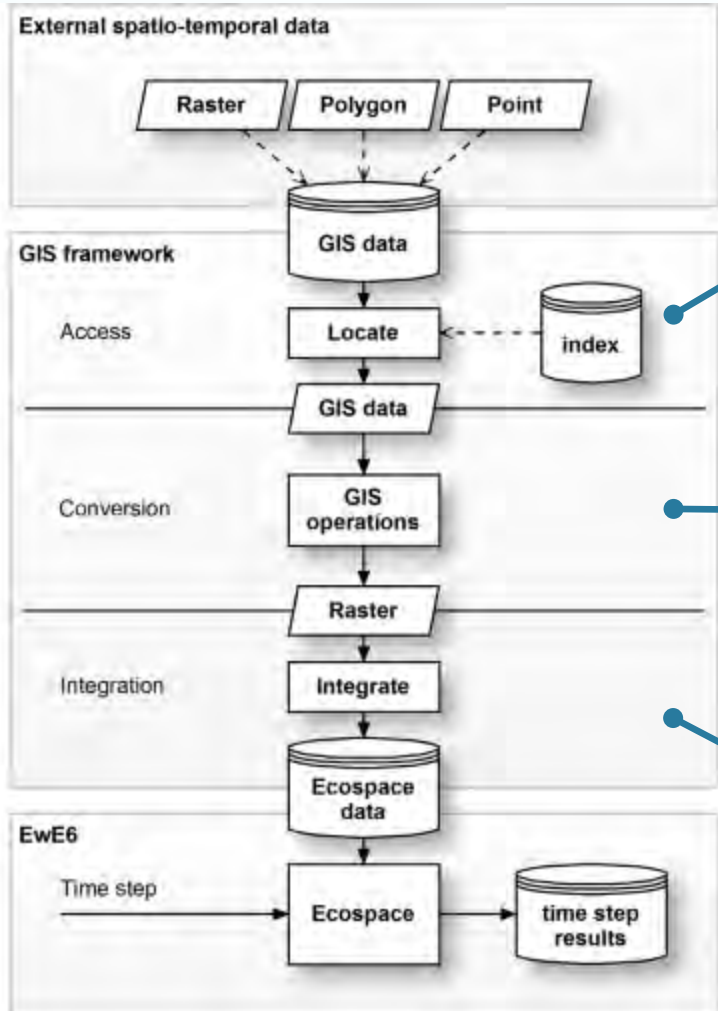
Using external spatial/temporal data

Ecospace needs a system to dynamically insert external spatial and temporal data into Ecospace map layers

Requirements

- Create map from true GIS data
- Import GIS data into Ecospace timesteps
- Export Ecospace results as GIS data
- Use a wide range of GIS data formats
- Potentially access a wide range of GIS data sources such as files, databases, web services, and running models (!)

Data exchange framework - design



Access modules can be added to connect to different sources of spatial/temporal data

Conversion modules can be added to perform any combination of GIS operations

Integration modules ensure data is properly nested in Ecospace

Next steps

- Week-long EwE programming workshop next week
- Create and insert time-dynamic spatial forcing function (Monthly LUMCON data from 1998-2007)
- ANY hypoxia model output that can be converted to GIS data (or just lat-long-bottom DO) can serve as forcing function
- For Ecosim, any hypoxia output that can be converted to bottom DO/month; run-time needs to be in the order of years
- Programming language will become important when true coupling (end-to-end modeling) becomes possible; EwE 6 written in Visual Basic .NET

