

# The Chesapeake Atlantis Model:

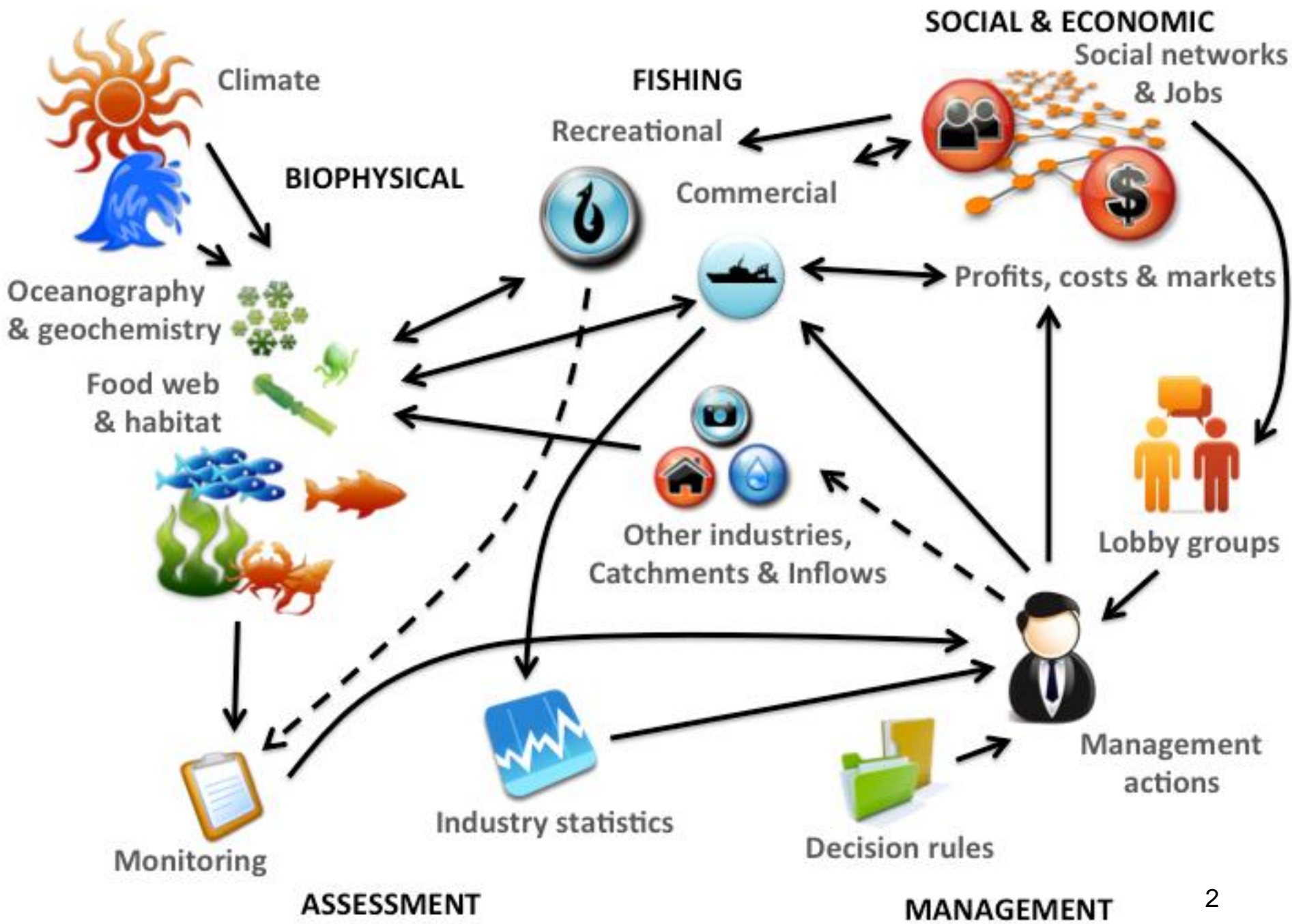
*An Adaptive Management Tool for Visualizing  
Productivity Changes Expected from Workgroup Efforts*



Tom Ihde, ERT, Inc.  
for the NOAA Chesapeake Bay Office



CBP STAR, 28 July, 2016



# Atlantis Applications



*Figure from Weijerman et al., 2016*

# The Atlantis Model

## "End-to-End" Approach

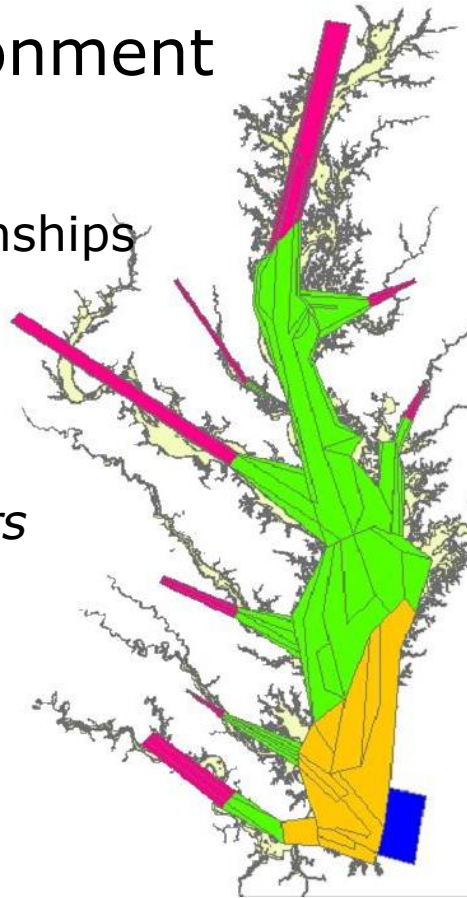
### *Factors Influencing Included:*

#### Biological environment

- ✓ Primary production
- ✓ Trophic interactions
- ✓ Recruitment relationships
- ✓ Age structure
- ✓ Size structure
- ✓ Life History
- ✓ Habitat also refuge  
*SAV, Marsh, Oysters*

#### Fisheries

- ✓ Multiple sectors
- ✓ Gears
- ✓ Seasons
- ✓ Spatially explicit



#### Physical environment

- ✓ Chemistry
- ✓ Circulation & currents
- ✓ Temperature
- ✓ Salinity
- ✓ Water clarity
- ✓ Climate change

#### Nutrient Inputs

- ✓ Currency is Nitrogen
- ✓ Oxygen
- ✓ Silica
- ✓ 3 forms of detritus
- ✓ Bacterial nutrient cycling



# Management Strategy Outcomes & Key Actions

## STAR:

- ✓ Development and testing of ecological indicators
- ✓ Integrative tool for multiple datasets – visualize data trends & effects on common scale

## *Water Quality-Goal Implementation Team (GIT):*

- ✓ Visualize, improve understanding of ecosystem services of attainment of TMDL or a range of levels of attainment
- ✓ The simulation of all other Outcomes in the context of the TMDL conditions for the Bay
- ✓ Demonstrate and quantify the benefit of improved monitoring, and filling of data gaps

## *Climate Resiliency & Adaptation:*

- ✓ Visualize likely impacts of expected temperature increase and salinity change
- ✓ Support development of research agenda – identify most critical data or research gaps
- ✓ Visualize future realizations for public, stakeholder, and local engagement
- ✓ Simulate implementation of priority adaptation actions
- ✓ Develop and test climate resilience indicators to assess adaptation action effectiveness

## *Habitat-GIT:*

- ✓ Visualize range of attainment for SAV Outcome: acreage benefits, water clarity benefits and restoration benefits
- ✓ Fish Passage: Visualize benefits (& ecosystem services) of restored populations
- ✓ Wetlands outcome – range of attainment, simulate ecosystem services

## *Sustainable Fisheries-GIT:*

- ✓ Blue crab – ecosystem effects of varying abundance; harvest sectors allocation
- ✓ Oyster restoration – visualize benefits of restoration
- ✓ Fish habitat – visualize effects of loss or gain
- ✓ Forage – simulate predator population effects of loss or gain of forage groups

# Management Strategy Outcomes & Key Actions

STAR: ✓ In the context of the TMDL attainment and expected Climate Change

- ✓ Development and testing of ecological indicators
- ✓ Integrative tool for multiple datasets – visualize data trends & effects on common scale

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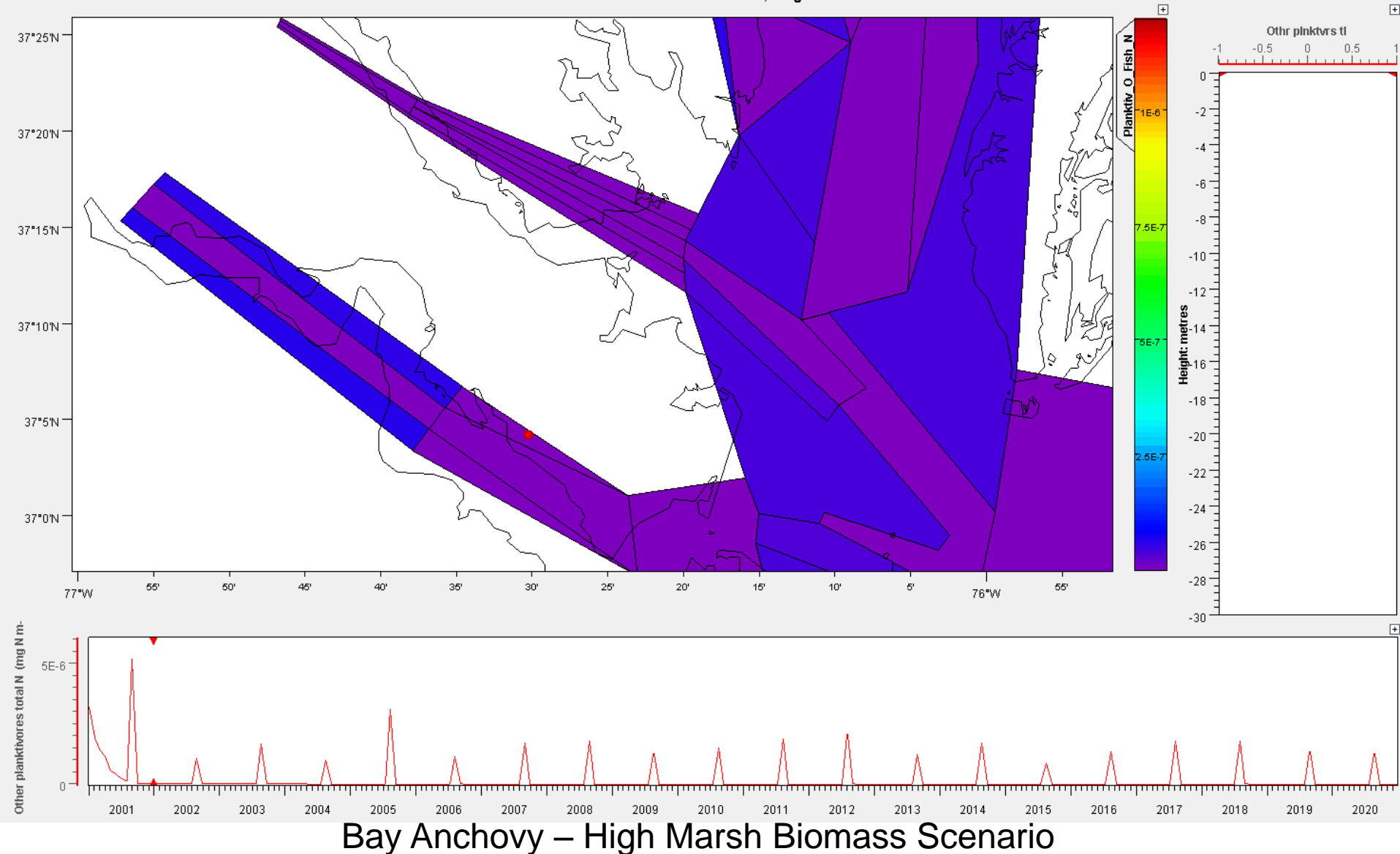
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# The Chesapeake Atlantis Model

Visualization *of*  
Management Strategy  
Outcomes

# System Changes Over Space and Time

Date: 26 Dec 2001 14:00:00 UTC, Height 0 m

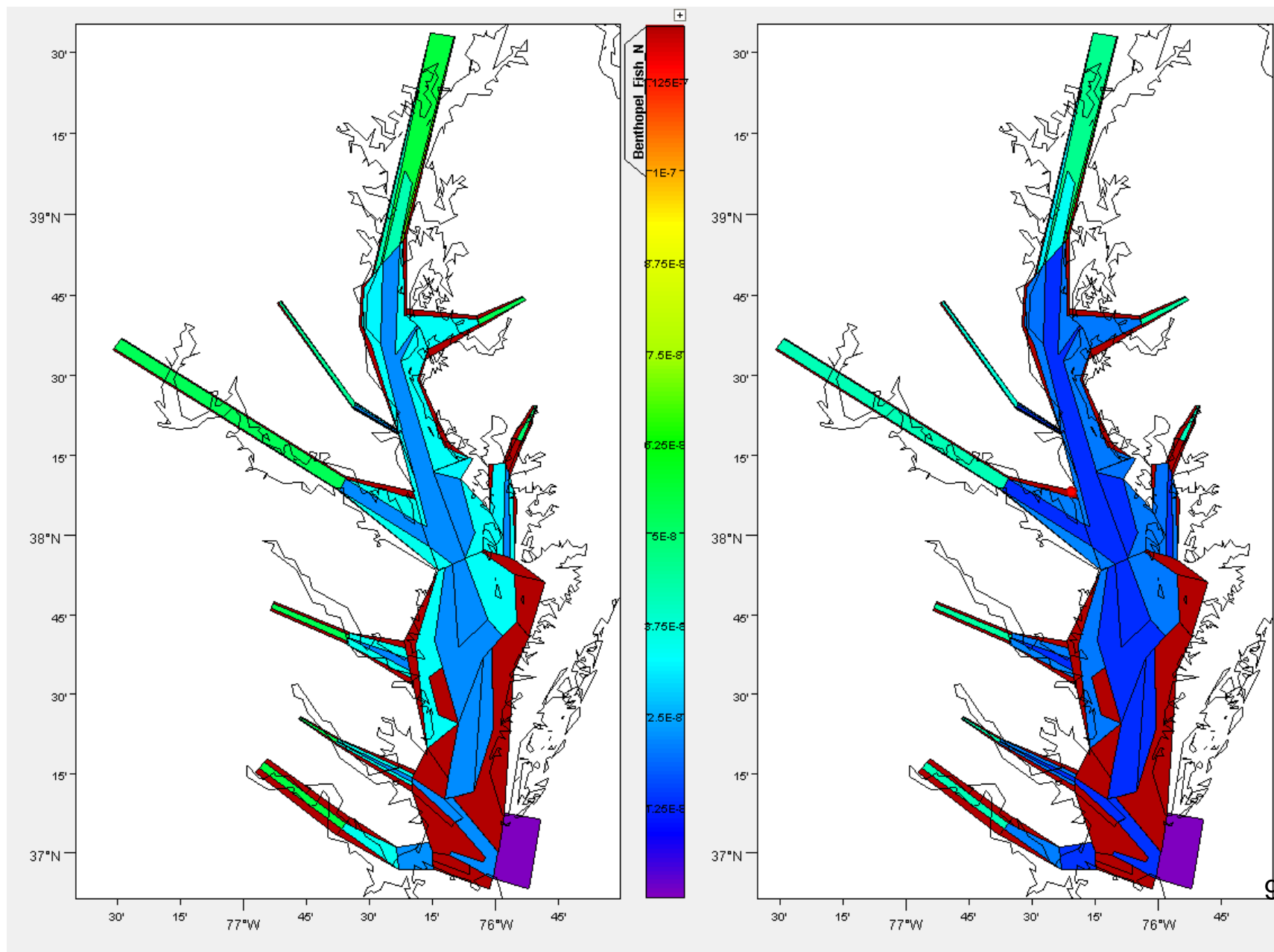


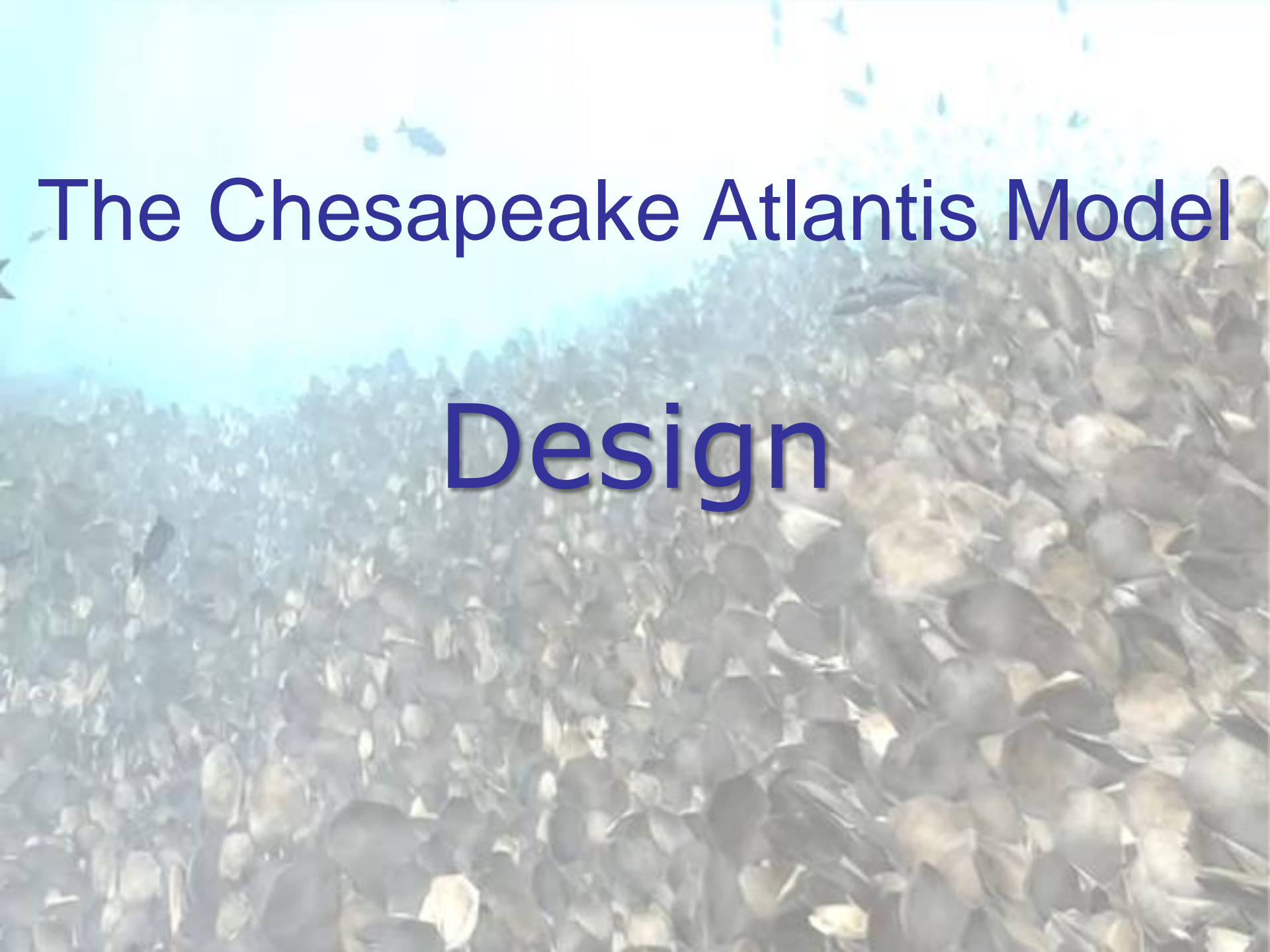


Current Conditions

# Striped Bass

Temperature increase  
& Habitat Loss

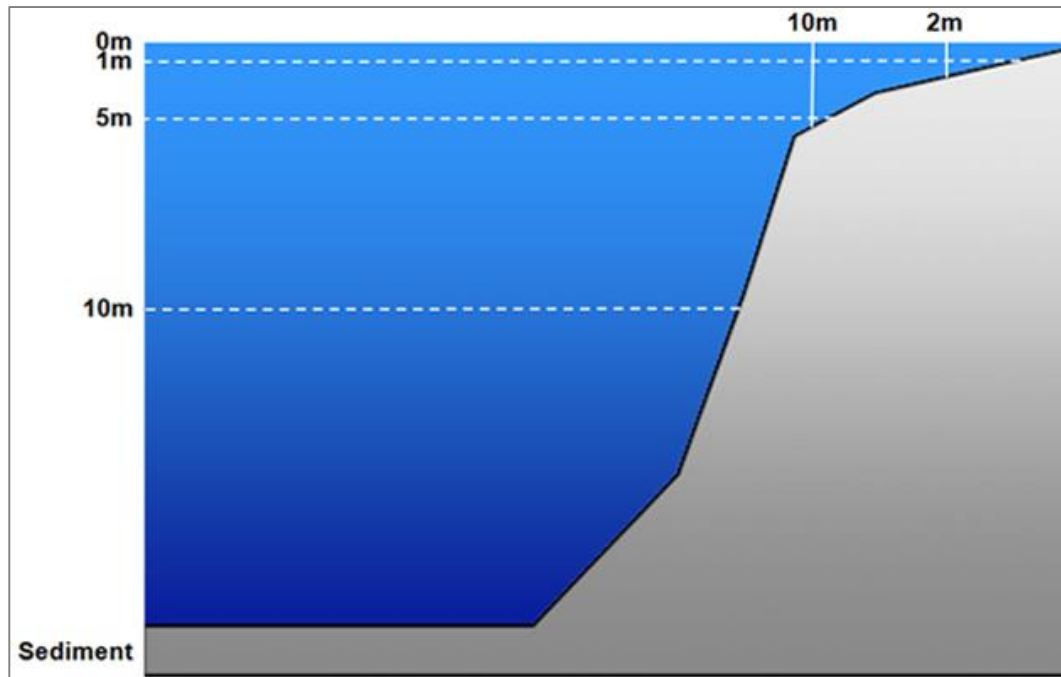




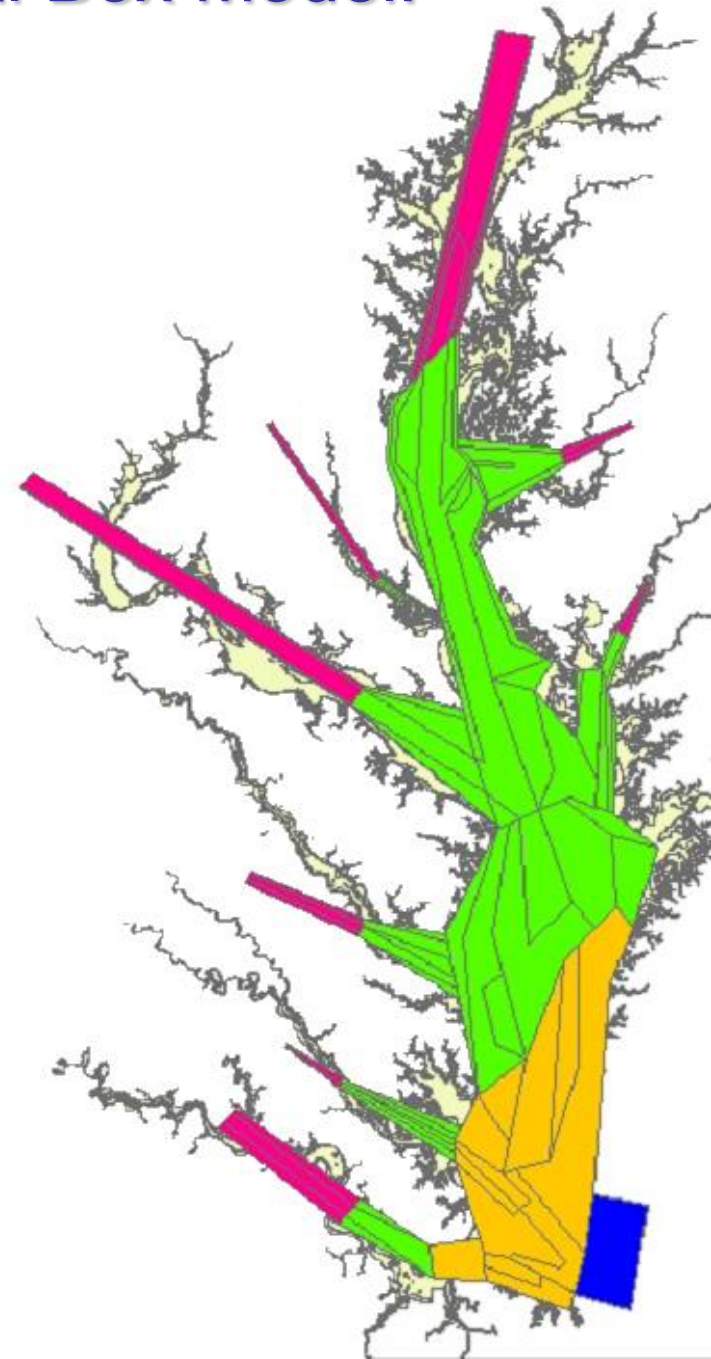
# The Chesapeake Atlantis Model

## Design

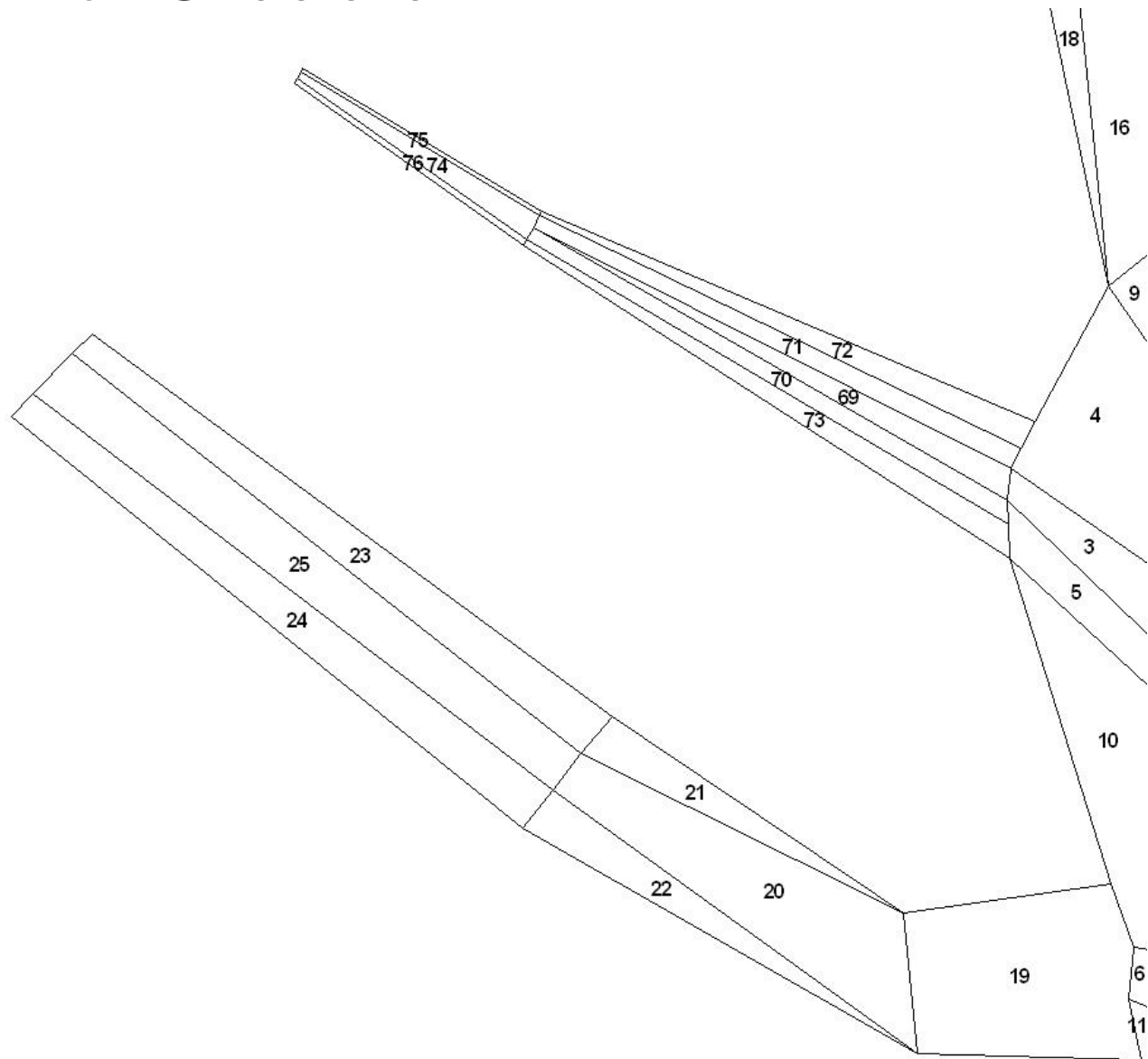
# CAM Design: 3-Dimensional Box Model:



## Salinity



# CAM: River Box Structure





# Ecological Groups: **Federal fisheries**, **Forage**, **Protected**, **Habitat**

## Finfish

- **Alosines** (Amer. Shad, Hickory Shad, Alewife & Herring)
- Atlantic Croaker
- **Bay anchovy**
- Black drum
- **Bluefish**
- **Butterfish**, harvestfish ("Jellivores")
- Catfish
- Gizzard shad
- **Littoral forage fish**, silversides, mummichog
- **Menhaden**
- Striped bass
- **Summer flounder**
- Other flatfish (hogchoker, tonguefish, window pane, winter flounder)
- **Panfish:**  
Euryhaline: Spot, silver perch; FW to 10ppt: yellow perch, bluegill
- **Reef assoc. fish:** spadefish, tautog, **black seabass**, toadfish
- Spotted hake, lizard fish, northern searobin
- Weakfish
- White perch

## Elasmobranchs

- Cownose ray
- Dogfish, smooth
- **Dogfish, spiny**
- Sandbar shark

## Birds

- **Bald Eagle**
- Piscivorous birds (osprey, great blue heron, brown pelican, cormorant)
- Benthic predators (diving ducks)
- Herbivorous seabirds (mallard, redhead, Canada goose, & swans)

## Mammals

- **Bottlenose dolphin**

## Reptiles

- **Diamond-back Terrapin**
- **Seaturtles**

## Invertebrates

- **Benthic feeders:** (B-IBI "CO"+"IN") ...
- **Benthic predators:** (B-IBI "P") ...
- **Benthic suspension feeders:** (B-IBI "SU")
- Blue crab YOY
- Blue crab adult
- **Brief squid**
- **Macoma clams:** (B-IBI)
- **Meiofauna:** copepods, nematodes, ...
- **Oysters**

## Primary Producers

- Benthic microalgae ("microphytobenthos" benthic diatoms, benthic cyanobacteria, & flagellates)
- **"Grasses:"**  
**SAV** – type varies with salinity
- **Marsh grass**
- Phytoplankton – Large: diatoms & silicoflagellates (2-2000µm)
- Phytoplankton – Small: nanoplankton, ultraplankton, aka "picoplankton" or "picoalgae" (0.2-2µm), cyanobacteria included (2µm)
- Dinoflagellates (mixotrophs) (5-2,000µm)

## ZooPlankton

- Ctenophores
- Sea nettles
- Microzooplankton (.02-.2mm): rotifers, ciliates, copepod nauplii
- Mesozooplankton (.2-20mm): copepods, etc.

## Detritus

- Carrion
- Carrion (sediment)
- Labile
- Labile (sediment)
- Refractory
- Refractory (sediment)

## Bacteria (.2-2 µm [.002 mm] - feed microzooplankton food chain)

- Benthic Bacteria (sediment)
- Pelagic Bacteria: (free-living)



# Application *Outline*

## Stressors / system changes:

- Habitat loss:
  - Marsh, SAV
- Water column factors:
  - Nitrogen & Total Suspended Solids
- Climate forcing:
  - Temperature increase

Simulation results

Next Steps

# Habitat Scenario Assumptions

- 50% loss of Marsh  
(area & biomass)

Due to multiple, interacting factors:

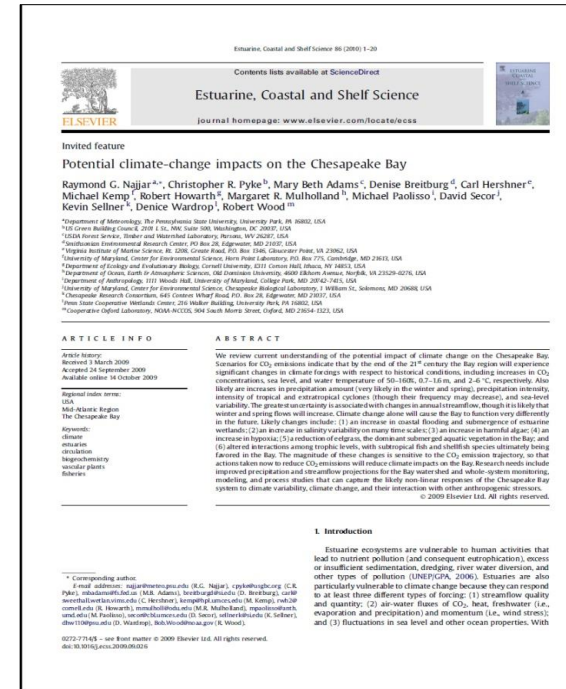
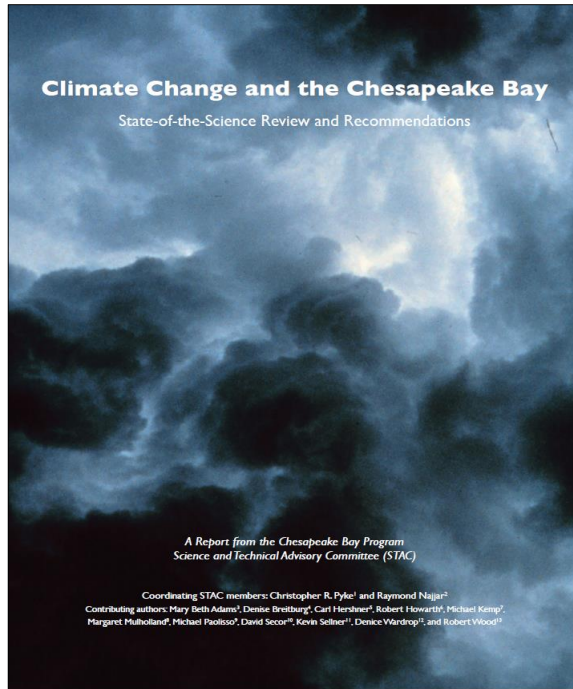
- shoreline armoring
  - subsidence
  - sea level rise
- 50% loss of Seagrass

# Water Column Habitat Assumptions

“TMDL” = Total Maximum Daily Loads of  
Nitrogen & turbidity – full attainment:

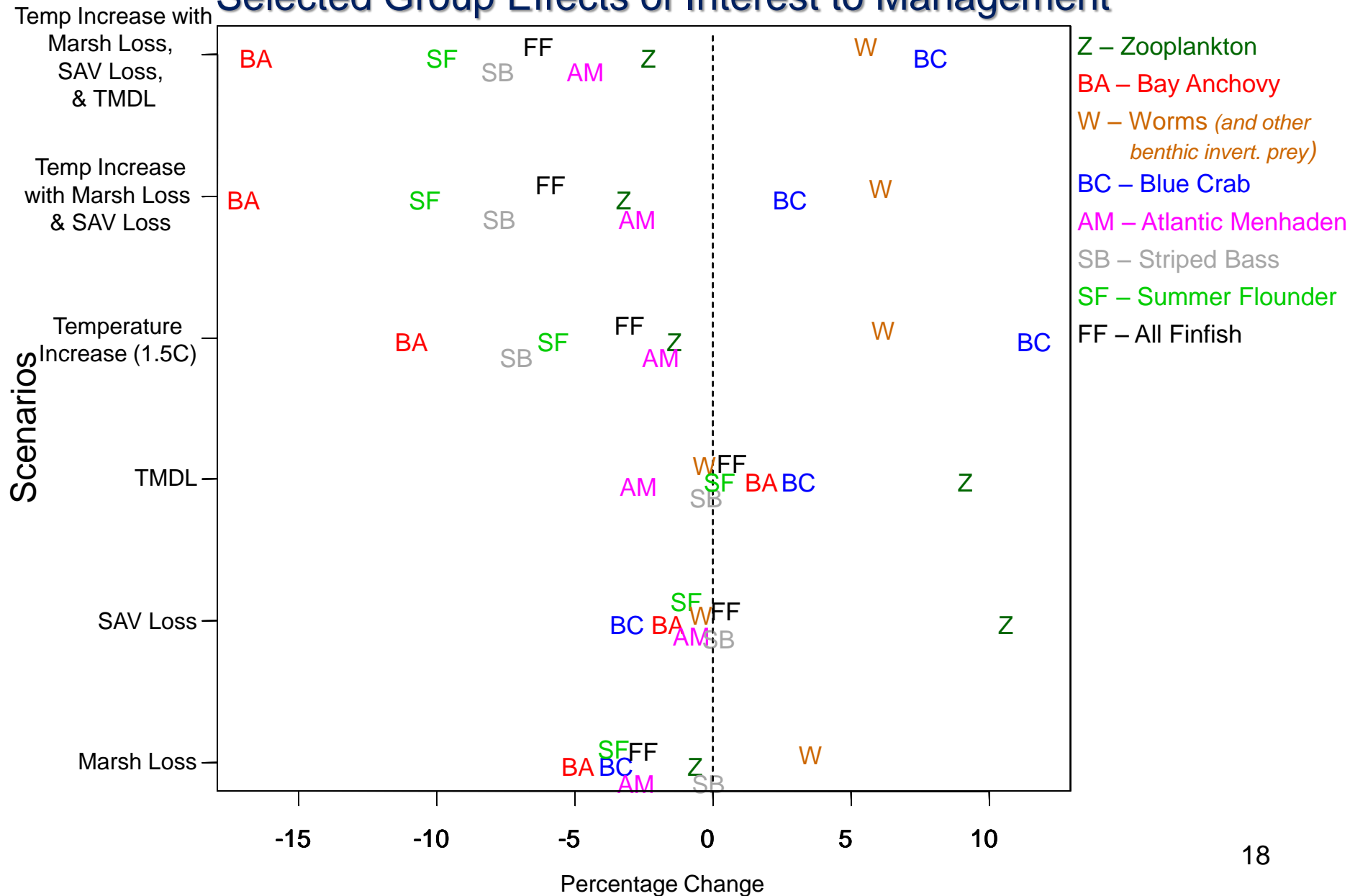
- Nitrogen
  - 25% reduction
- Turbidity (total suspended solids)
  - 20% reduction

# Climate Change Assumptions



- Najjar et al. (2010); IPCC AR4 (2007)
- 50 years from now:
  - ✓ Increased water temperature (1.5°C)
  - ✓ Salinity (+/- 2 ppt)

# Sensitivity To Factors Influencing Selected Group Effects of Interest to Management





# Summary

- CAM is a readily available tool able to support many of the critical needs of the CBP Workgroups Outcomes and Key Actions not directly focused on water quality
- Temperature increase produces relatively strong effects on production compared to losses of marsh, SAV, or the TMDL water quality improvements
  - *Modeling other stressors without expected temperature increase could be misleading*
- Reasonable trends can be predicted modeling a single stressor *if you happen to choose the dominant stressor*
  - *Risk is relatively large if workgroups miss the dominant stressor - for some important Chesapeake managed fish (~10 % loss in production)*

# Next...

- ✓ Test sensitivities, explore current hypotheses: pred-prey mismatches; shifts in state of system; DO
- ✓ Verify trends with other models where possible
- ✓ Add other effects of climate change:
  - allow movement preferences for changing climate conditions (temperature, salinity)
  - shifts in timing of migration & spawning
- ✓ Acidification effects

# Thanks to:



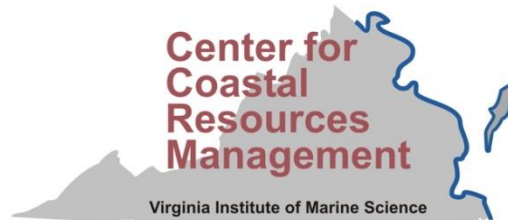
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