

The Chesapeake Atlantis Model:

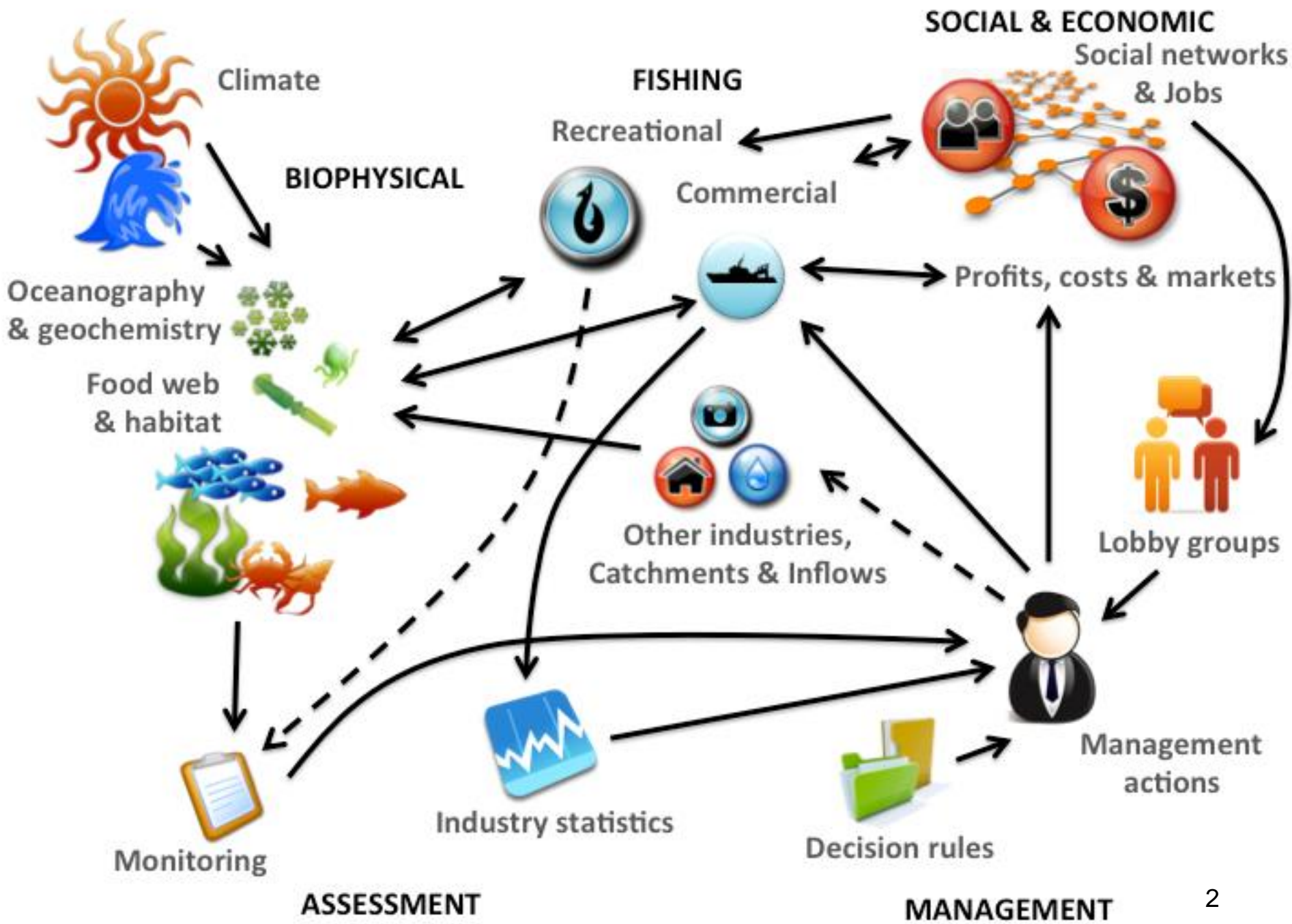
An Adaptive Management Tool for Visualizing Productivity Changes Expected from Workgroup Outcomes & Key Actions



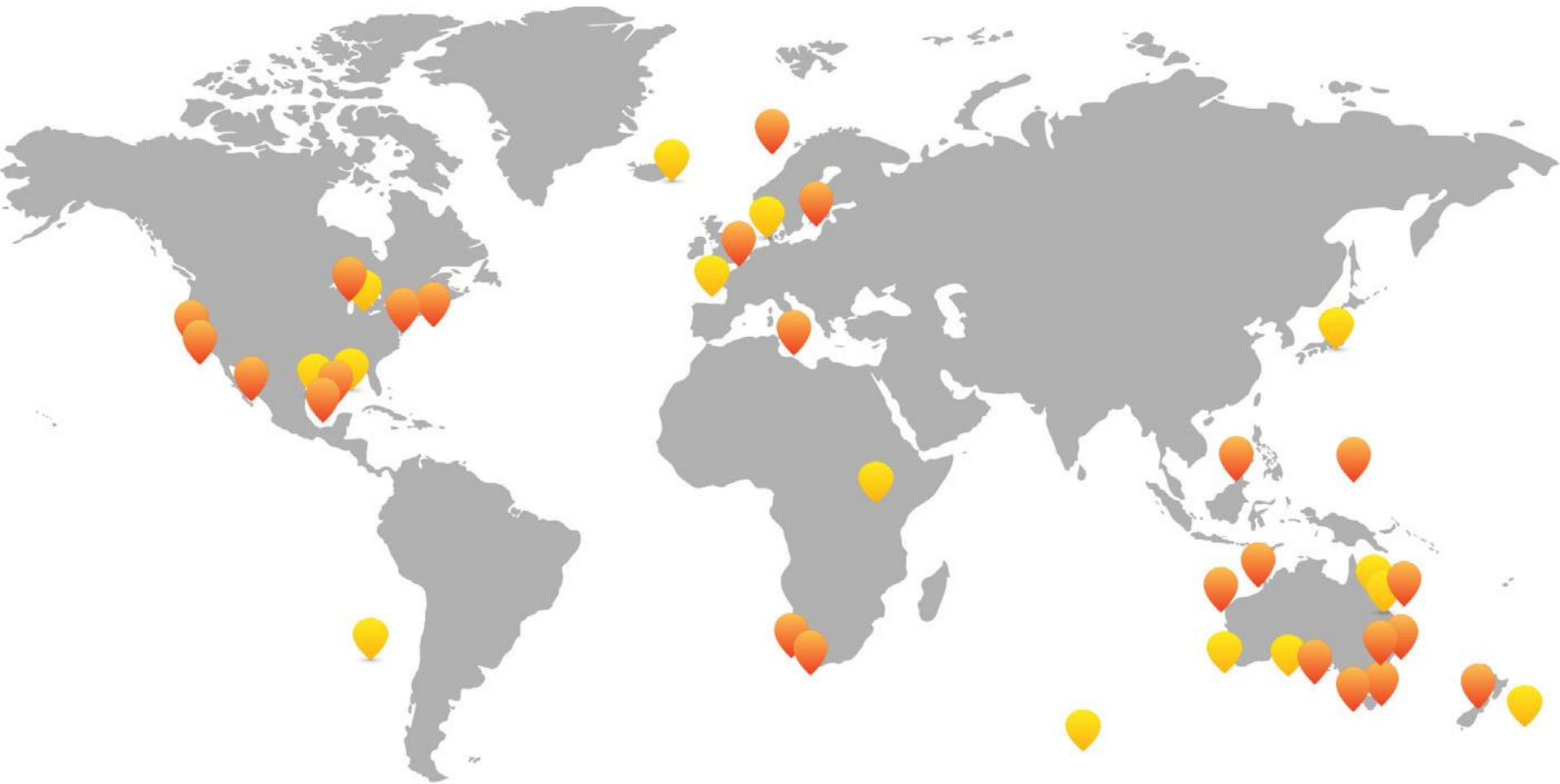
Tom Ihde, ERT, Inc.
for the NOAA Chesapeake Bay Office



STAC, 13 September, 2016



Atlantis Applications



 In development  Extant

The Atlantis Model

“End-to-End” Approach

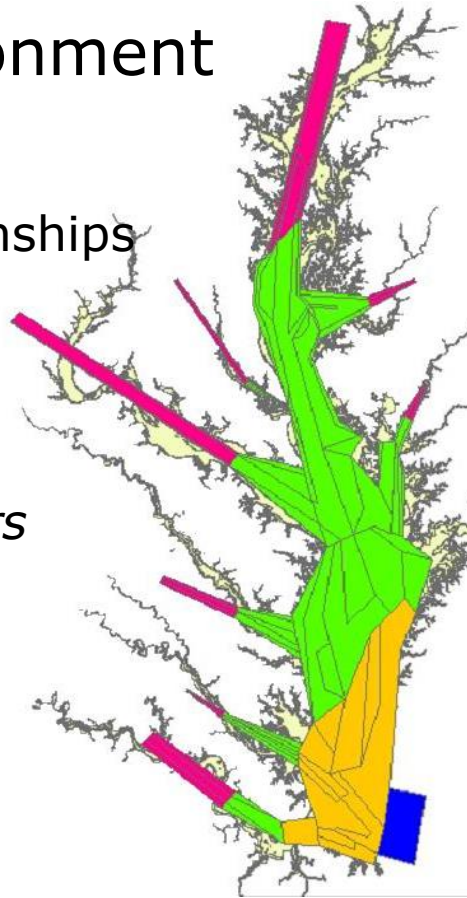
Factors Influencing Included:

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 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
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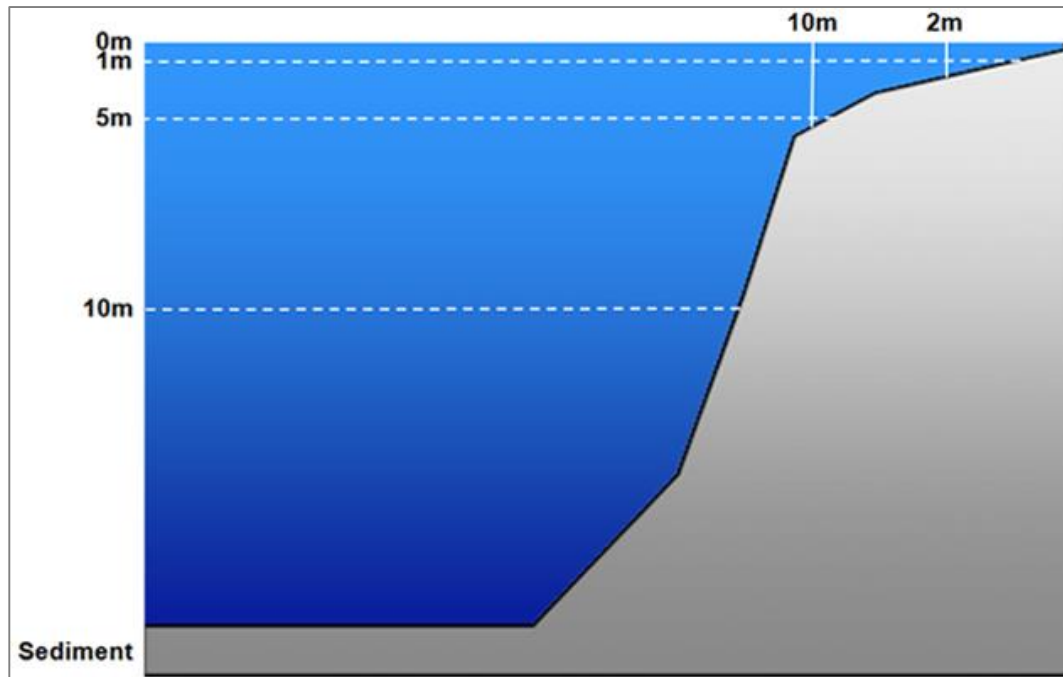
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An underwater photograph showing a vast, dense bed of mussels covering the seabed. The mussels are dark brown and grey, with some showing lighter, yellowish interiors. In the background, the water is a clear, light blue, and several small fish are visible swimming near the surface.

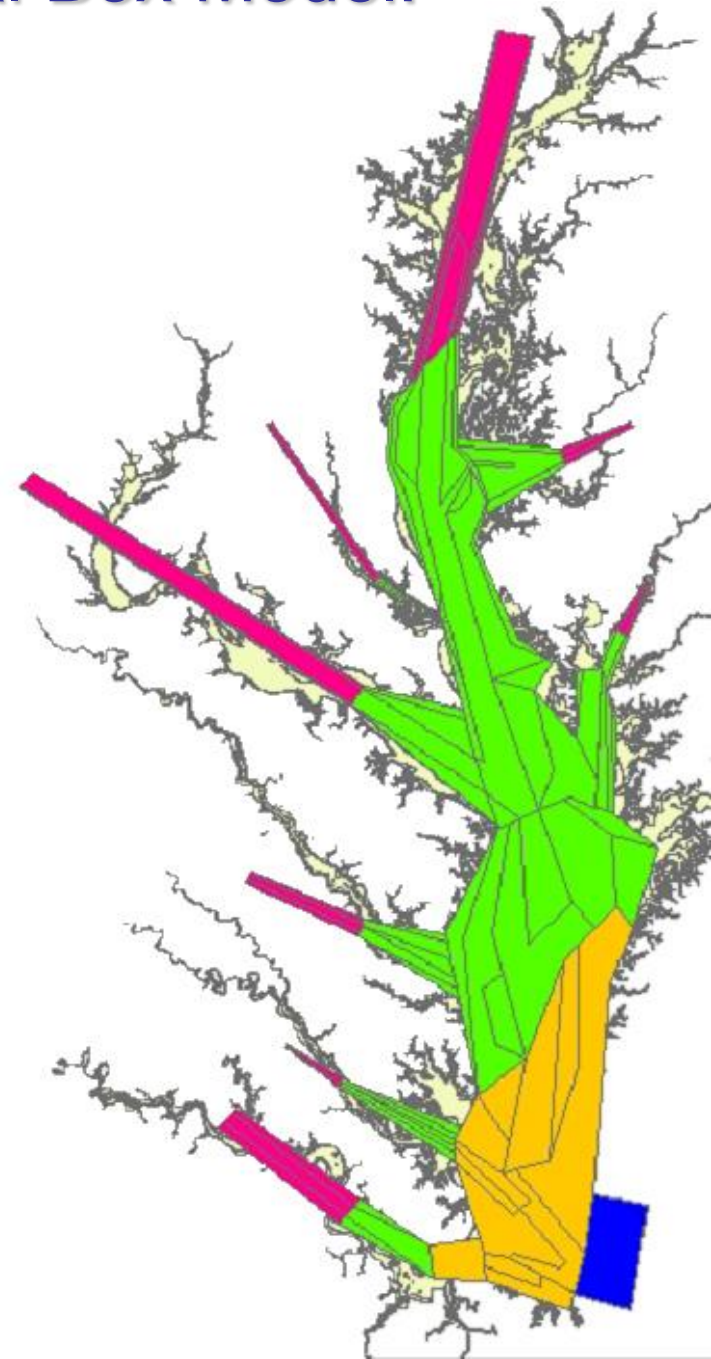
The Chesapeake Atlantis Model

Design

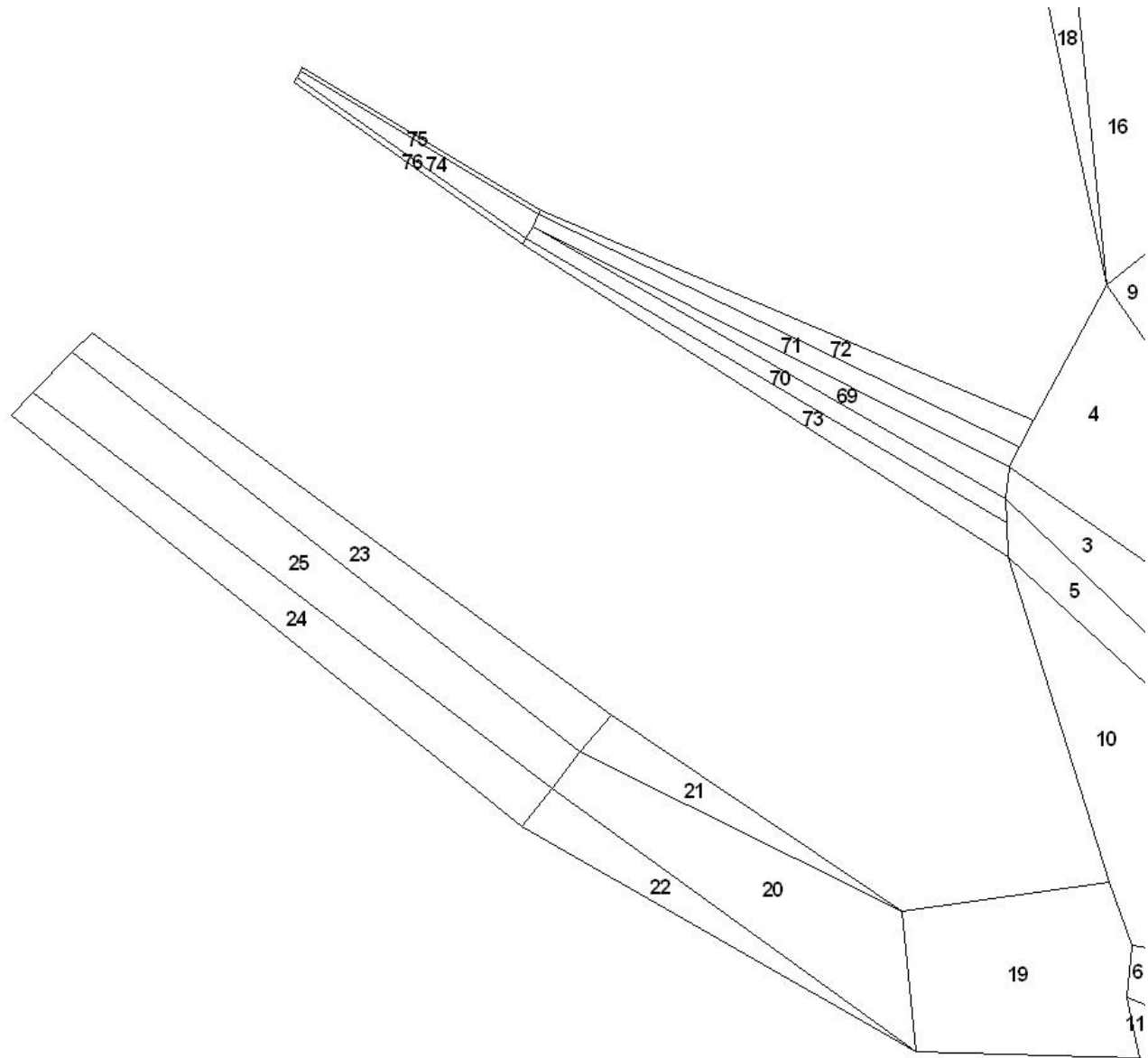
CAM Design: 3-Dimensional Box Model:



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**



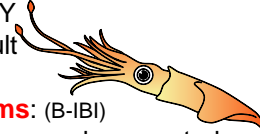
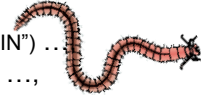
Reptiles

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



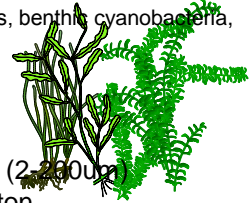
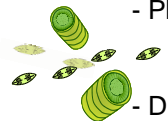
Invertebrates

- **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**



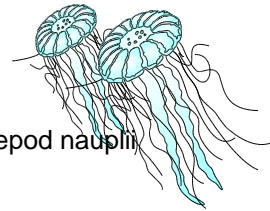
Primary Producers

- Benthic microalgae ("microphytobenthos" benthic diatoms, benthic cyanobacteria, & flagellates)
- **"Grasses:"**
 - SAV** – type varies with salinity
 - **Marsh grass**
- Phytoplankton – Large: diatoms & silicoflagellates (2-200um)
- Phytoplankton – Small: nanoplankton, ultraplankton, aka "picoplankton" or "picoalgae" (0.2-2um), cyanobacteria included (2um)
- Dinoflagellates (mixotrophs) (5-2,000um)



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 um [.002 mm] - feed microzooplankton food chain)

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

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:

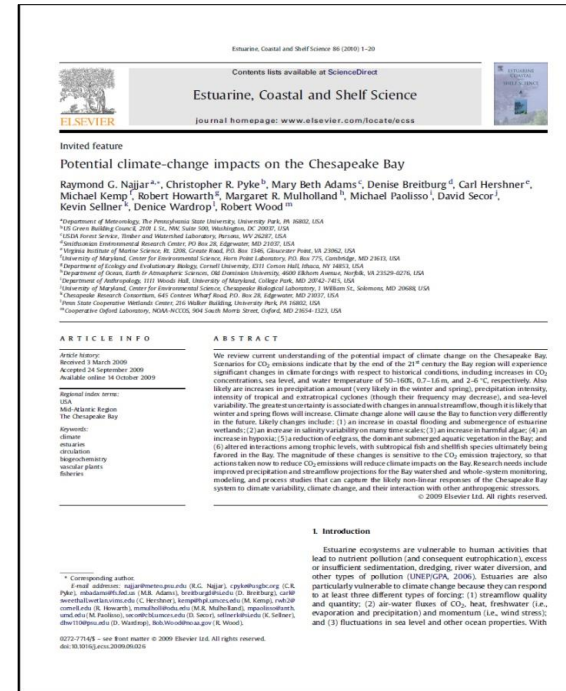
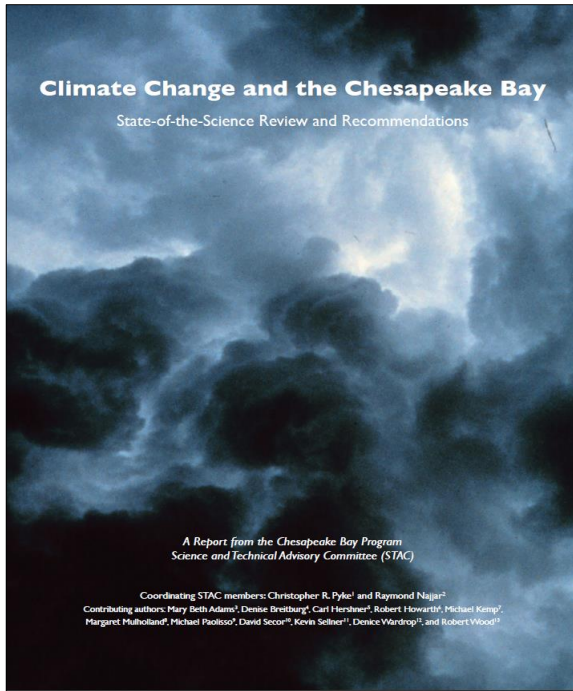
- shoreline armoring
 - subsidence
 - sea level rise
- 50% loss of Seagrass

Water Column Habitat Assumptions

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

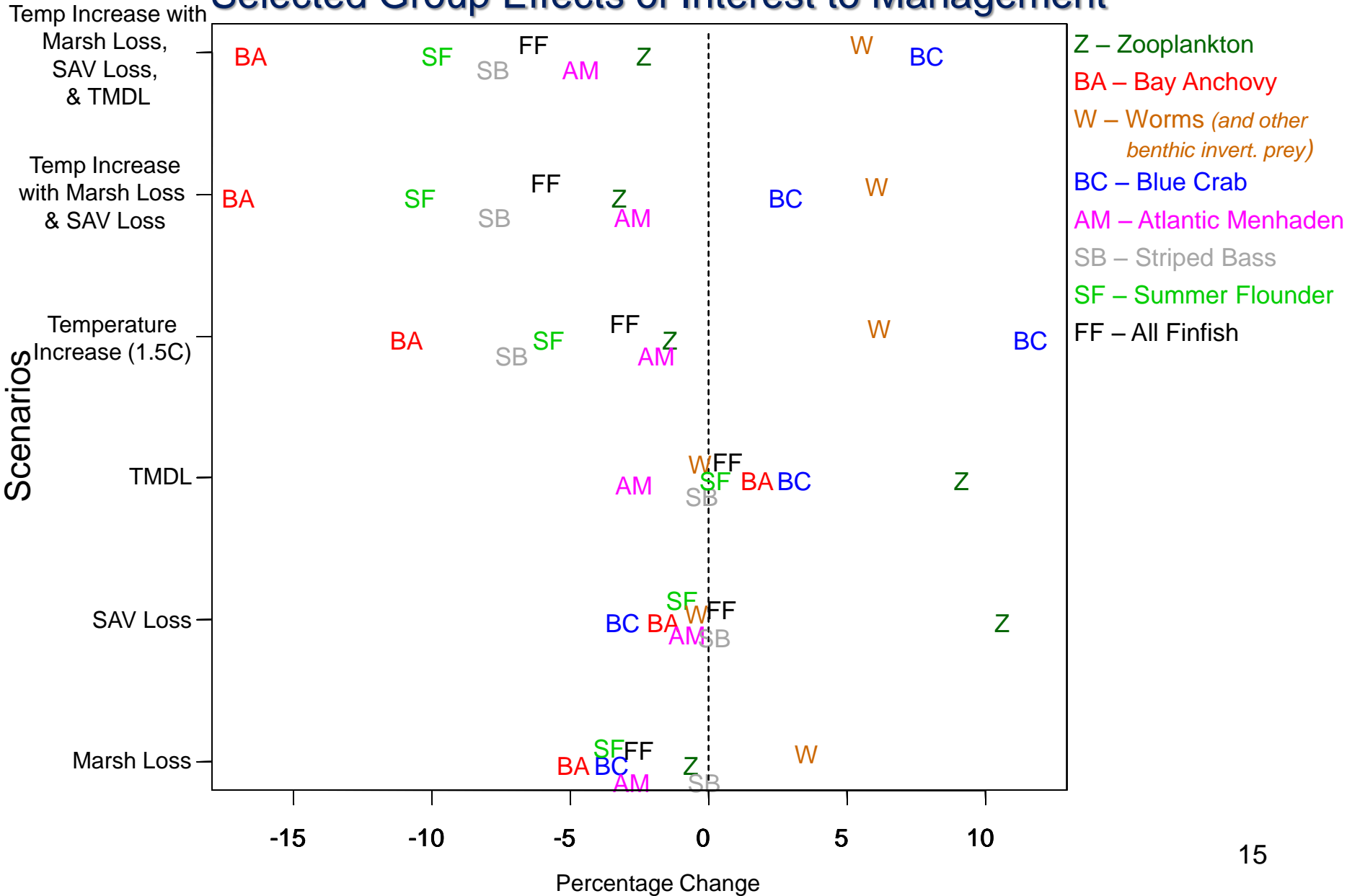
- Nitrogen
 - 25% reduction
- Turbidity (total suspended solids)
 - 20% reduction

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...

- ✓ Need to move project under CBP
- ✓ Urgent need to prioritize use of model by specific Workgroups
- ✓ Each “v” will require ~ a quarter (FY) of focused activity to support an individual question from a workgroup

Thanks to:



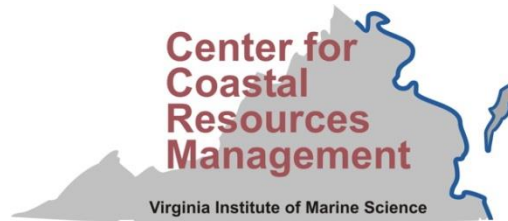
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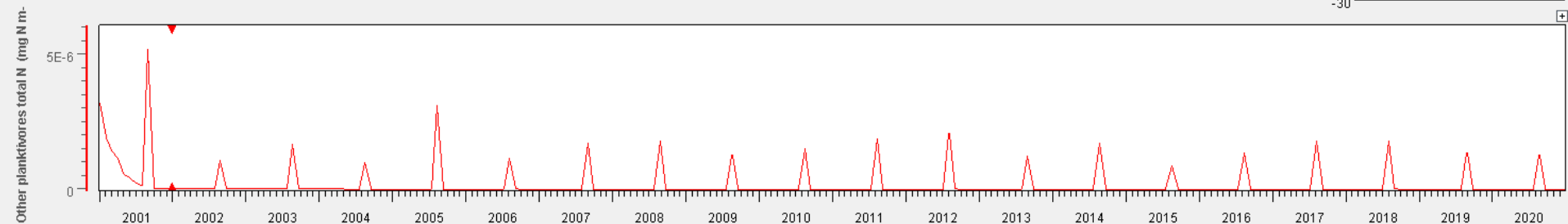
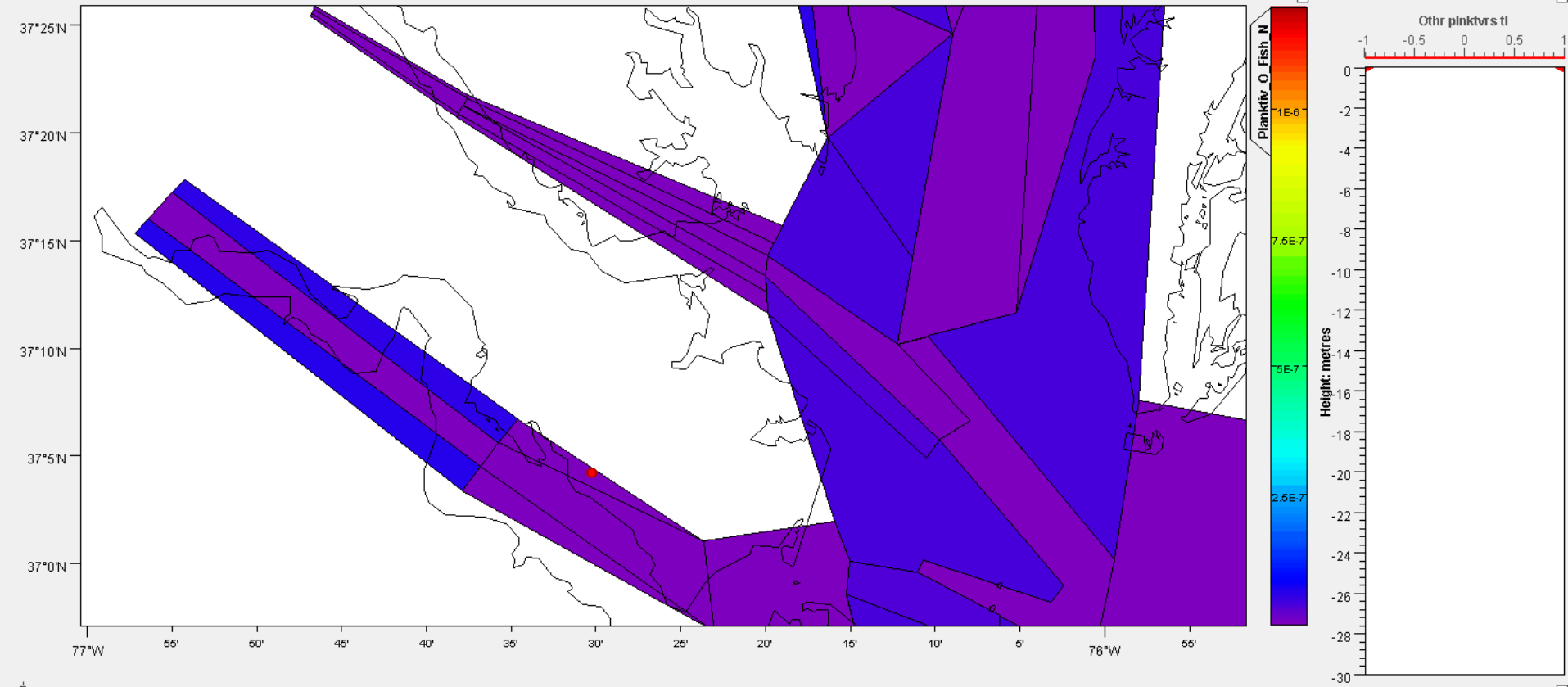


The Chesapeake Atlantis Model

Visualization *of*
Management Strategy
Outcomes

System Changes Over Space and Time

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



Bay Anchovy – High Marsh Biomass Scenario

Striped Bass

Current Conditions Temperature increase & Habitat Loss

