The Chesapeake Atlantis Ecosystem Model:

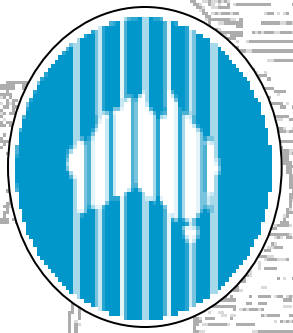
Demonstrating the Importance of Habitat to Chesapeake Forage Fish

Tom Ihde - Versar, Inc.
Howard Townsend - NMFS
NOAA Chesapeake Bay Office

F-GIT Meeting
4 December, 2013

The Commonwealth Scientific and Industrial Research Organisation

Atlantis



Beth Fulton

The Atlantis Model

A Holistic Ecosystem Model

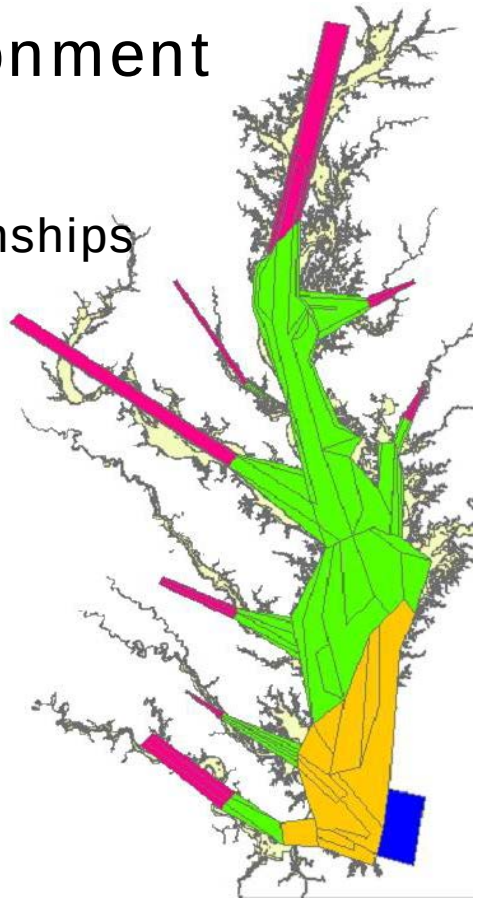
Incorporating:

Biological environment

- ✓Primary production
- ✓Trophic interactions
- ✓Recruitment relationships
- ✓Age structure
- ✓Size structure
- ✓Life History
- ✓Refuge Habitat

Fisheries

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



Physical environment

- ✓Geology
- ✓Chemistry
- ✓Circulation & currents
- ✓Temperature
- ✓Salinity
- ✓Water clarity
- ✓Climate variability

Nutrient Inputs

- ✓Currency is Nitrogen
- ✓Oxygen
- ✓Silica
- ✓3 forms of detritus
- ✓Bacteria-mediated recycling

Goals

Atlantis:

- To model important populations in context of their ecosystem
  - Predators & Prey
  - Water quality, habitat
  - Management change of other species
  - Ecosystem change (e.g., habitat loss, migration patterns)
  - Cumulative effects of multiple stressors (Nye et al. 2012)
- Complements single species assessments
- Strategic not tactical
- Understand ecosystem function

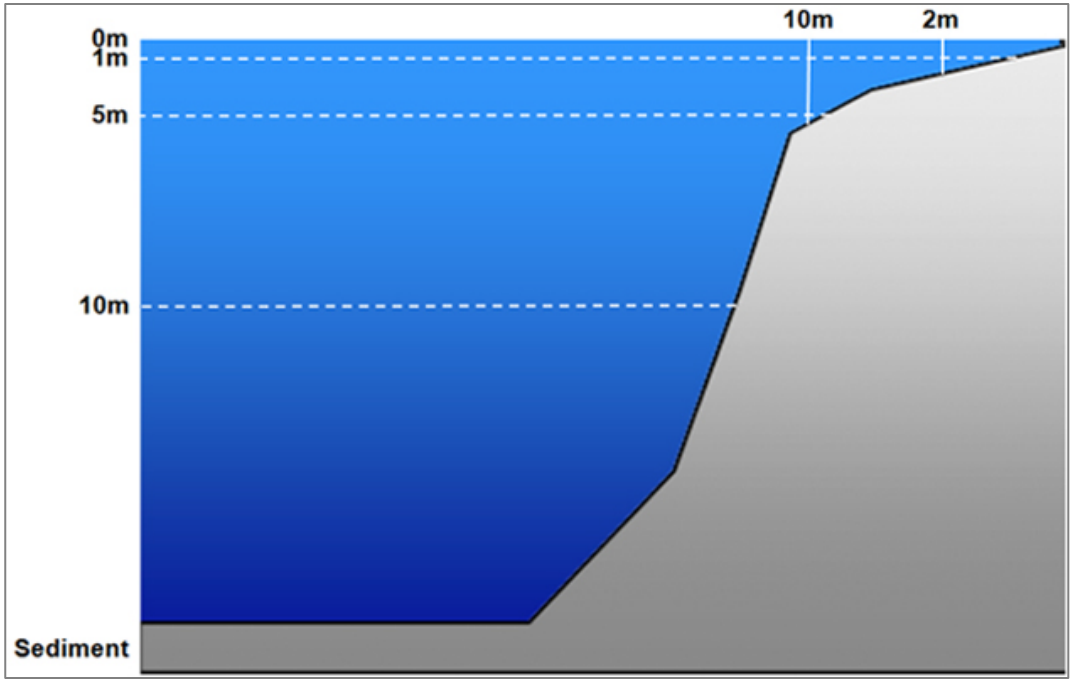
Chesapeake Atlantis Model (CAM):

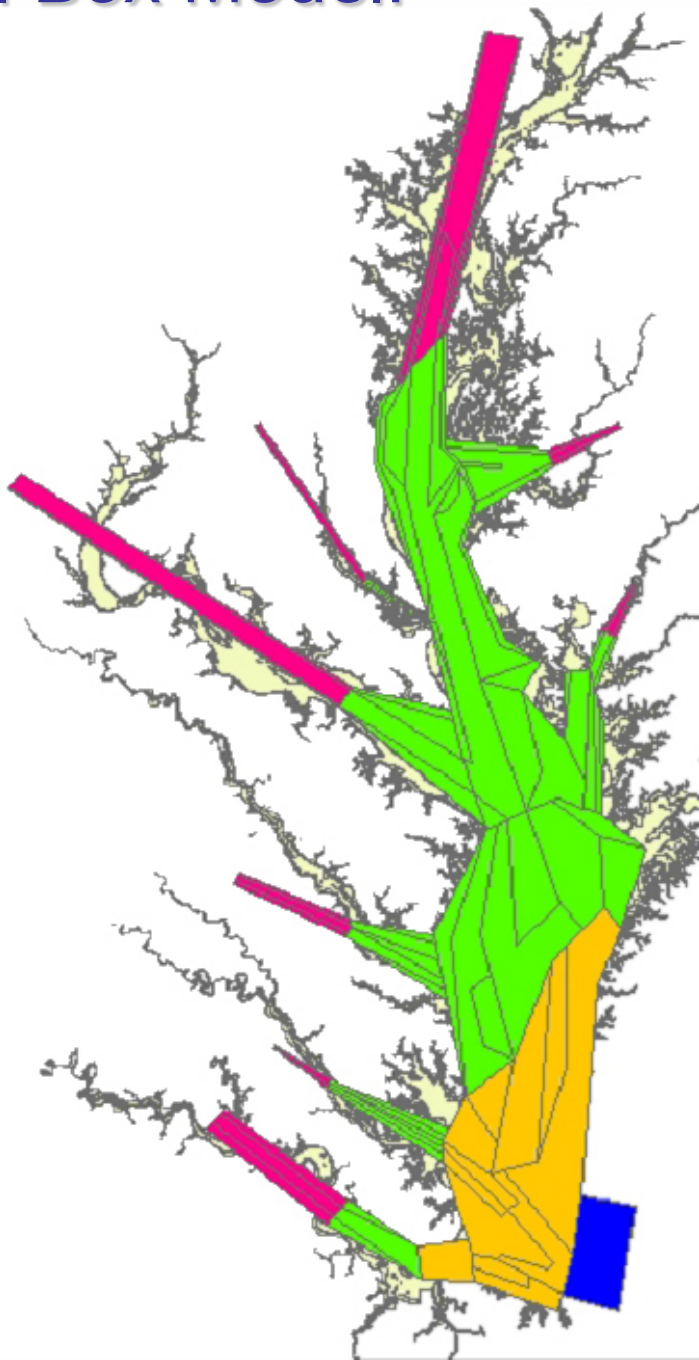
- A virtual Chesapeake for managers & biologists to explore questions
- Integrates best available data - multiple disciplines & scales
- Identify tipping points, data gaps & research priorities
- Compare trade-offs of multiple management options

The Chesapeake Atlantis Model

Design

CAM Design: 3-Dimensional Box Model:





Salinity

1-10

10-18

18-30

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: nannoplankton, 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)

Images courtesy of ian.umces.edu/imagelibrary/

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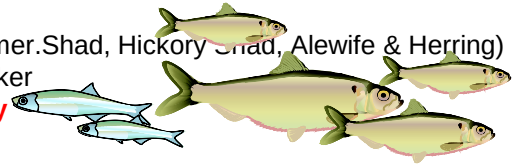
Finfish



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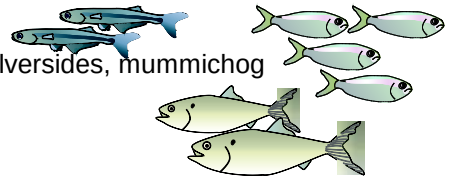

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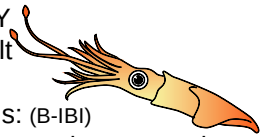

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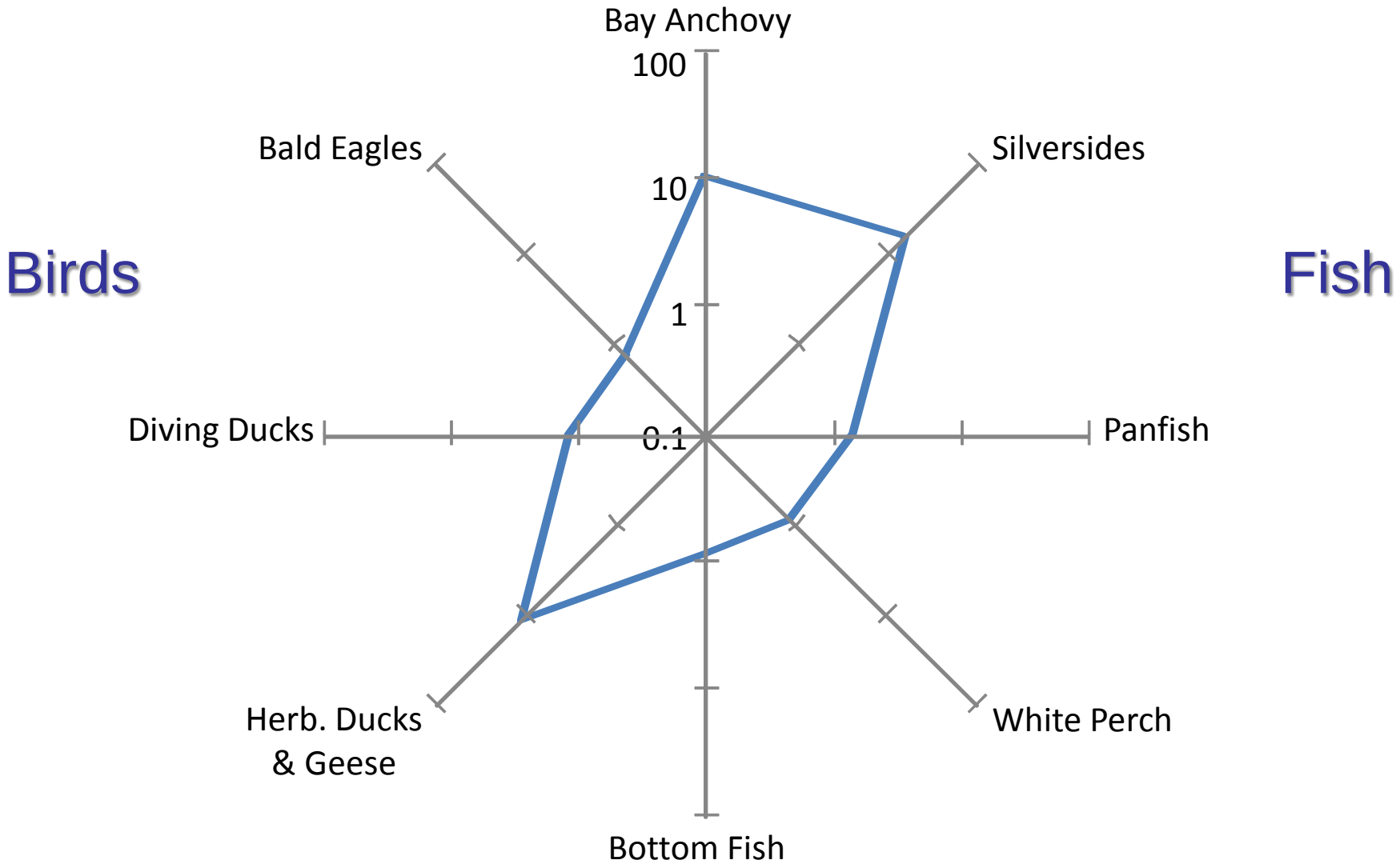
Simple Experimental Plan

Change predicted with habitat loss (marsh)

Results

Groups with the Greatest Reduction in Biomass Due to Marsh Loss

(% Decrease)



Simple Experimental Plan

Change predicted with habitat loss (marsh)

Categories tracked:

(1) Biomass (aggregate)

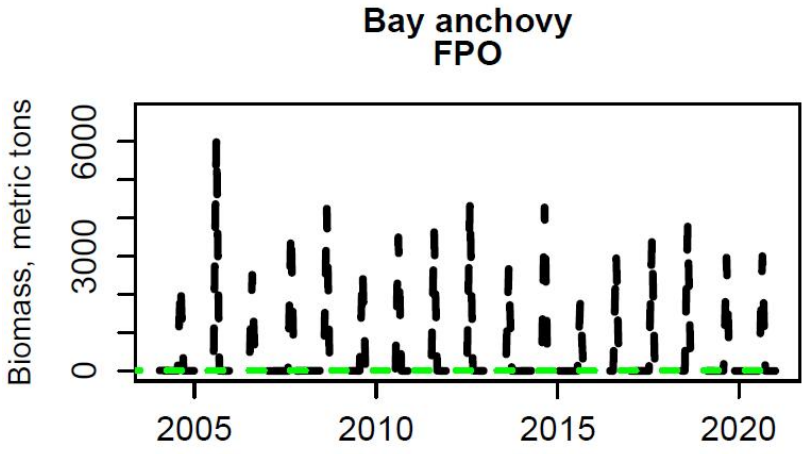
(2) Numbers (by age class)

(3) Physiological condition of individuals (by age class)

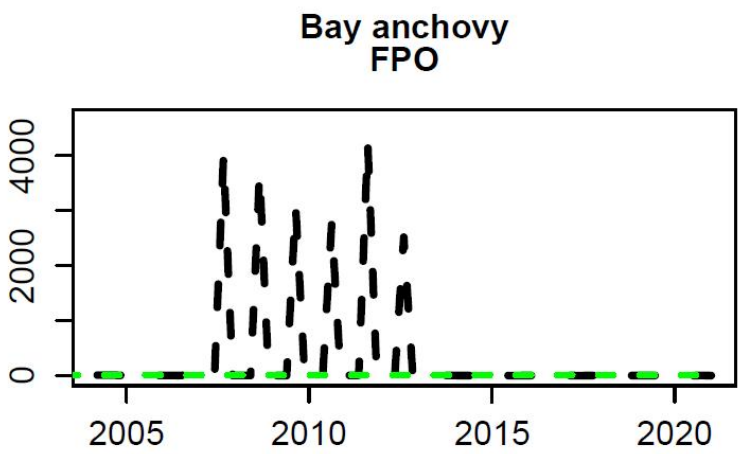
Change predicted with Marsh loss

Biomass

Full Marsh Biomass



Reduced Marsh

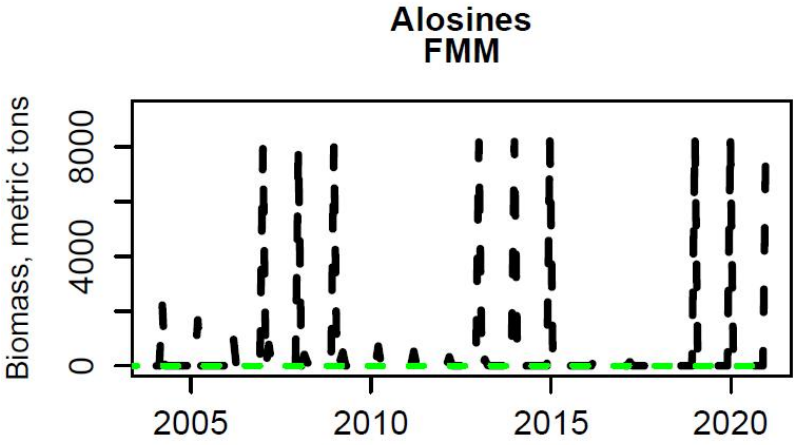


Year

Change predicted with Marsh loss

Biomass

Full Marsh Biomass



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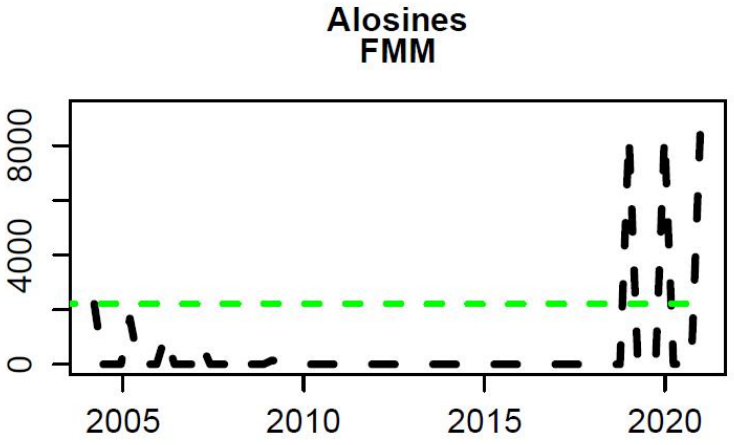

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Change predicted with Marsh loss

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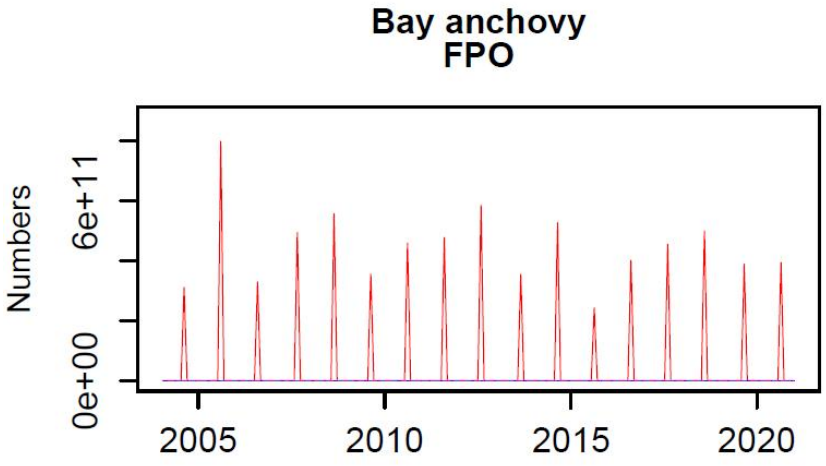

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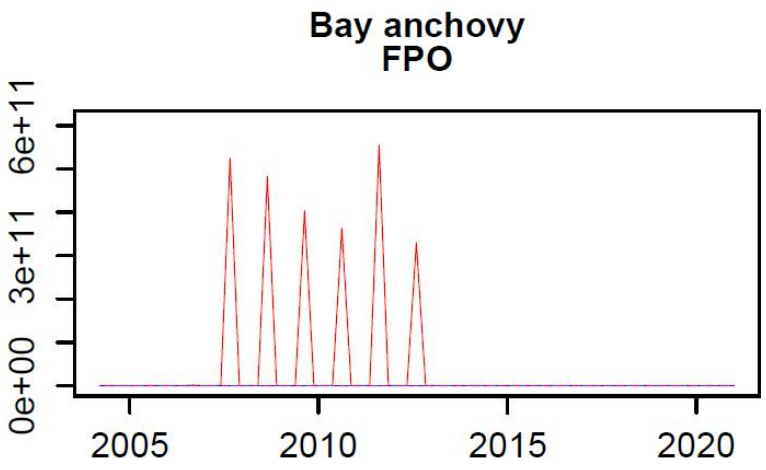
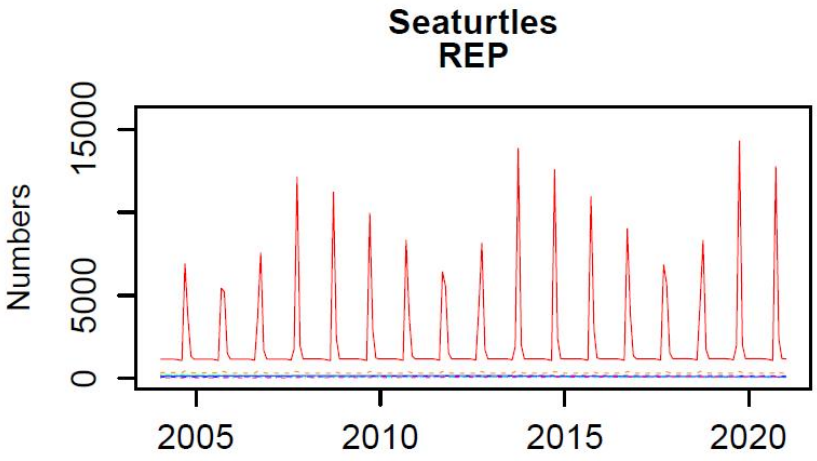


Year

Change predicted with Marsh loss

Numbers

Full Marsh Biomass



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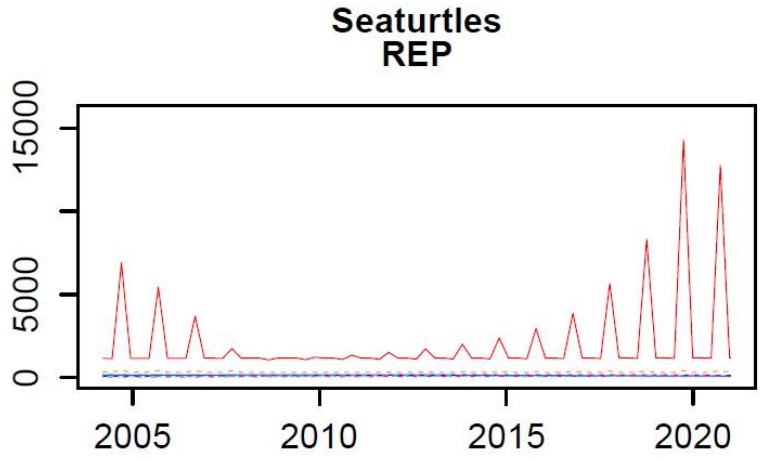
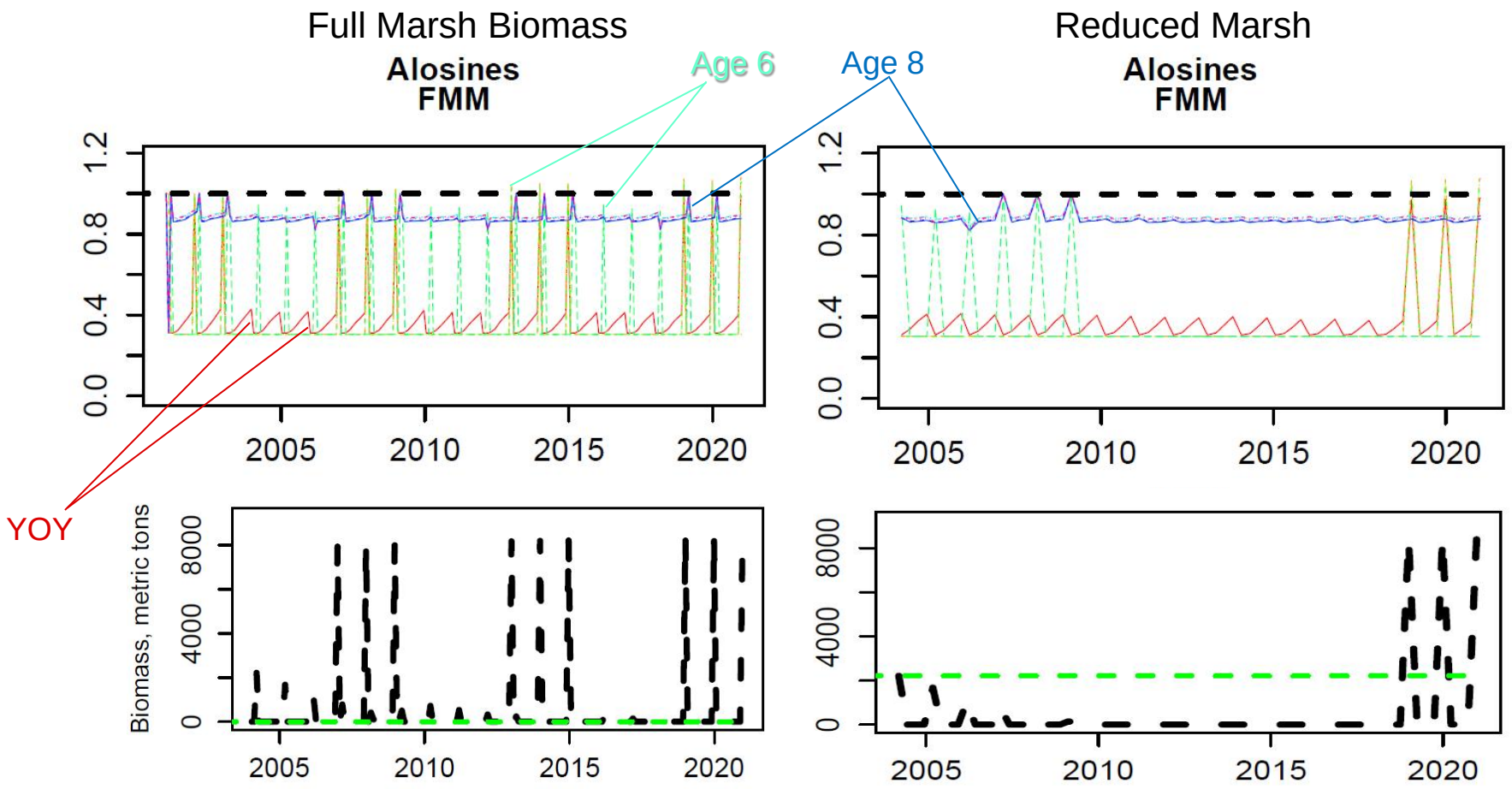


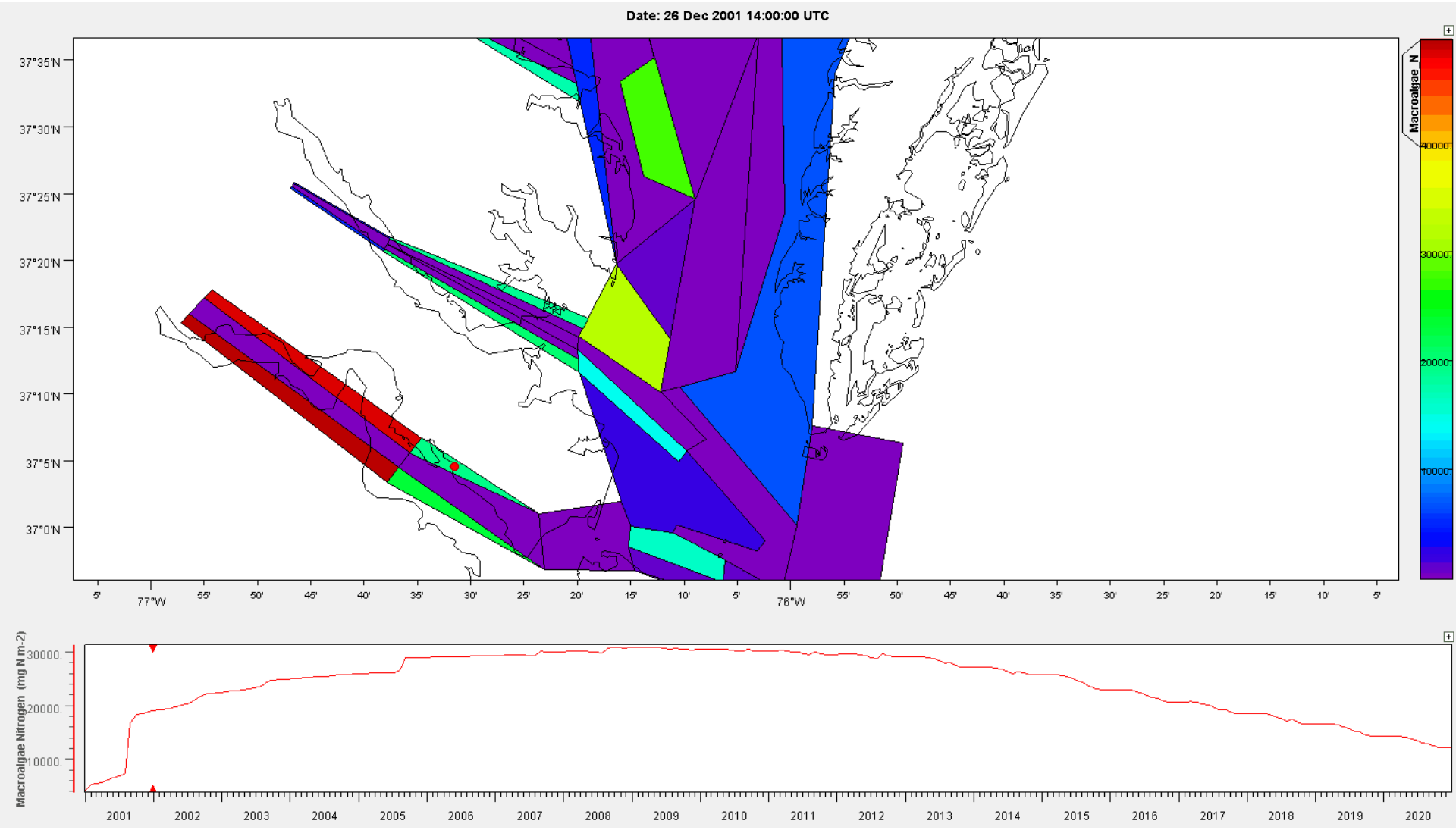
Year

Change predicted with Marsh loss

Physiological Condition

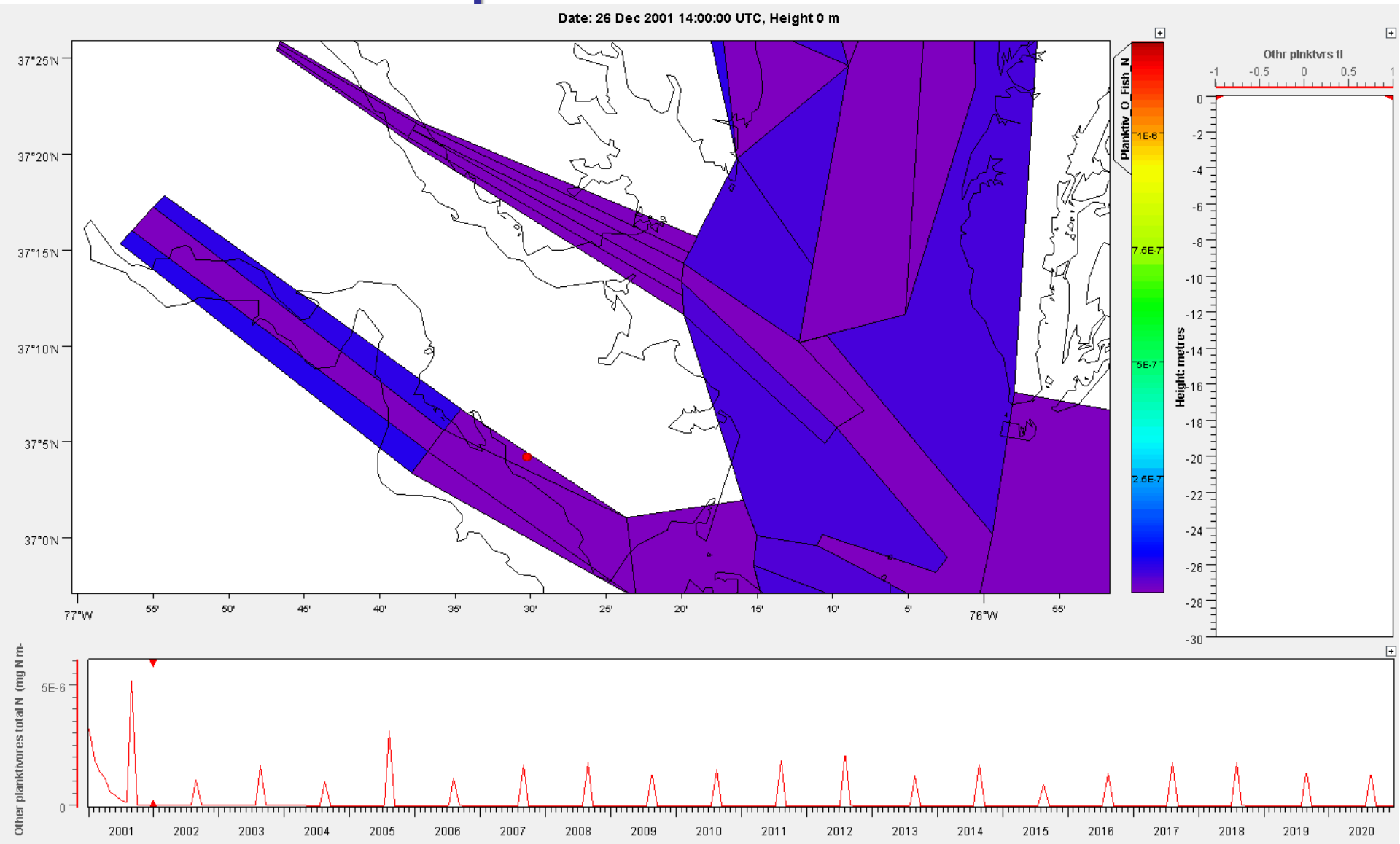


System Changes Over Space and Time



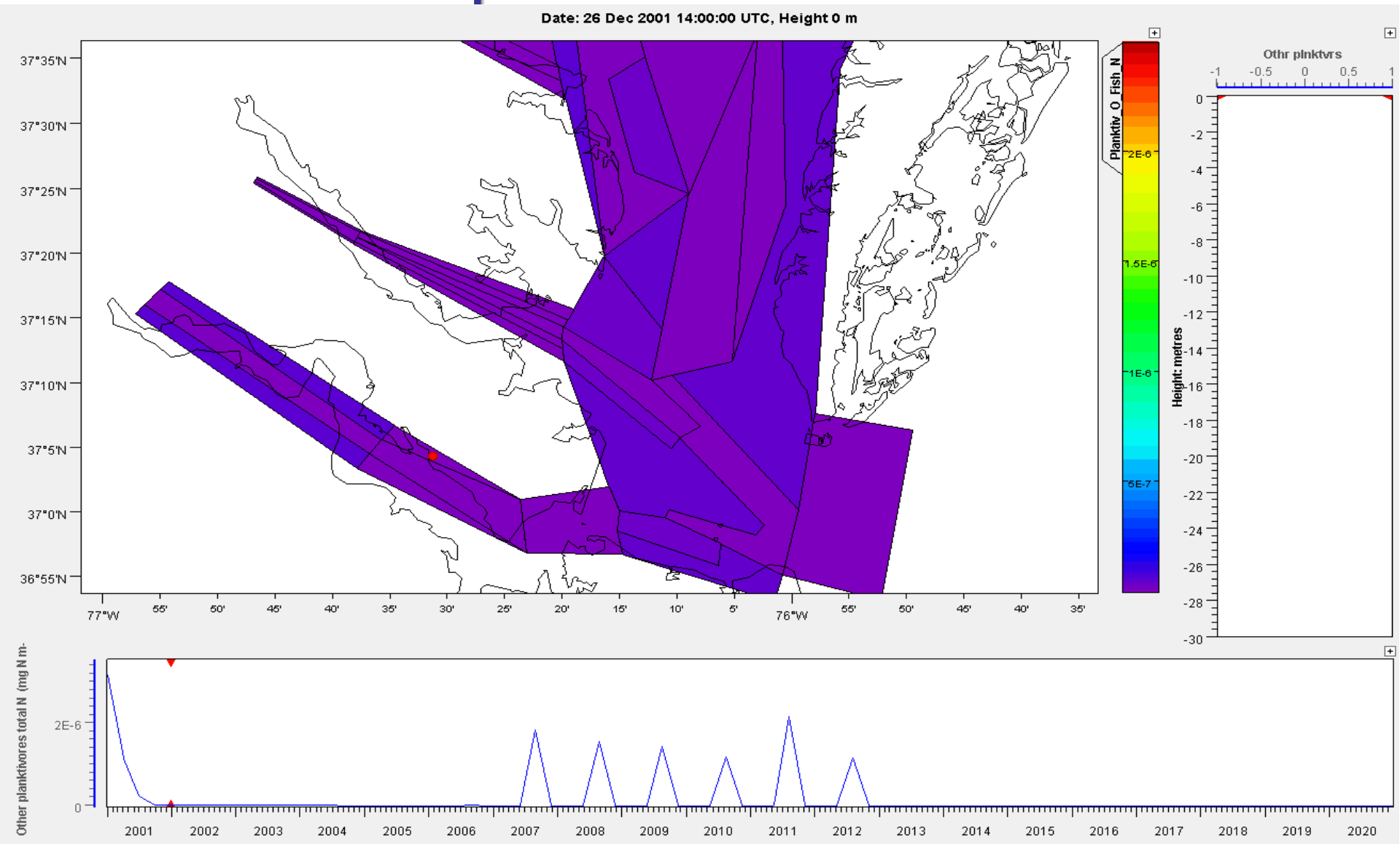
Current Marsh Biomass

System Changes Over Space and Time



Bay Anchovy – High Marsh Biomass Scenario

System Changes Over Space and Time



Bay Anchovy – Reduced Marsh Biomass Scenario

Summary

General:

- Atlantis – tool for integrating a wide variety of data across disciplines & scales
- 3D box model – CAM spatially structured by salinity & depth characteristics
- Exploratory tool for planning for system change/ management change in the Chesapeake system

Summary

Habitat Scenario:

- CAM predicts marsh loss negatively affects forage fish & herbivorous ducks & geese most strongly
- Effects on forage fish likely due to recruitment failure
- Model captures non-intuitive effects of ecosystem change
- Likewise, model captures unintended consequences of management change that might otherwise surprise us

Closing Thoughts:

- *Though funded to look at habitat connections to fish production, CAM enables us to address a much broader range of questions*
- *The approach underscores the importance of state and local management decisions (e.g., marsh, land use, fish harvest, water quality), and highlights the effects of those decisions on a regional scale*

Thanks to:

CSIRO **Marine and Atmospheric Research**

NOAA *Northwest Fisheries Science Center*
NOAA Fisheries Service

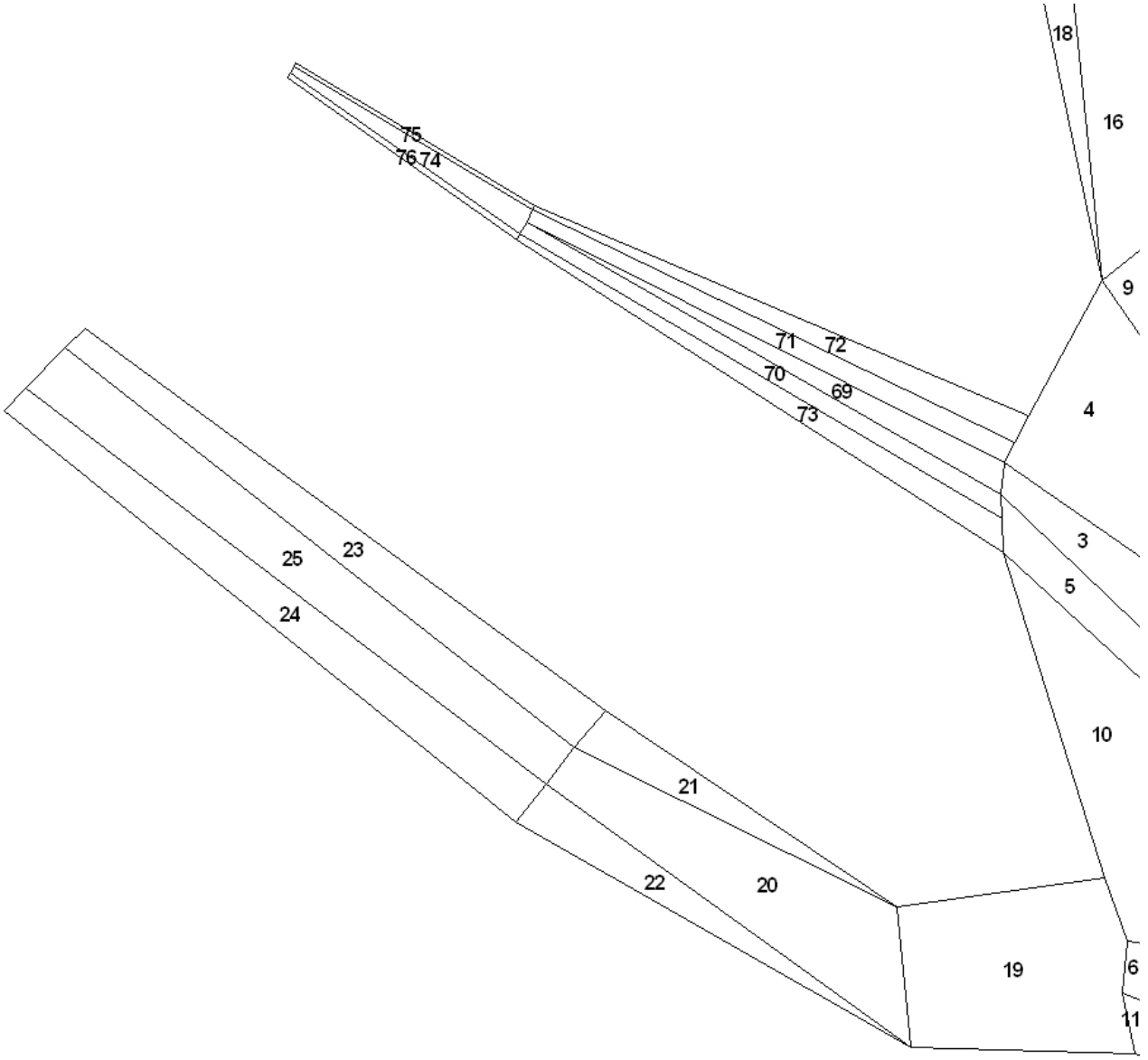
Northeast Fisheries Science Center

NOAA OFFICE OF SCIENCE AND TECHNOLOGY
NATIONAL MARINE FISHERIES SERVICE

NOAA HABITAT CONSERVATION
NATIONAL MARINE FISHERIES SERVICE

EXTRA SLIDES

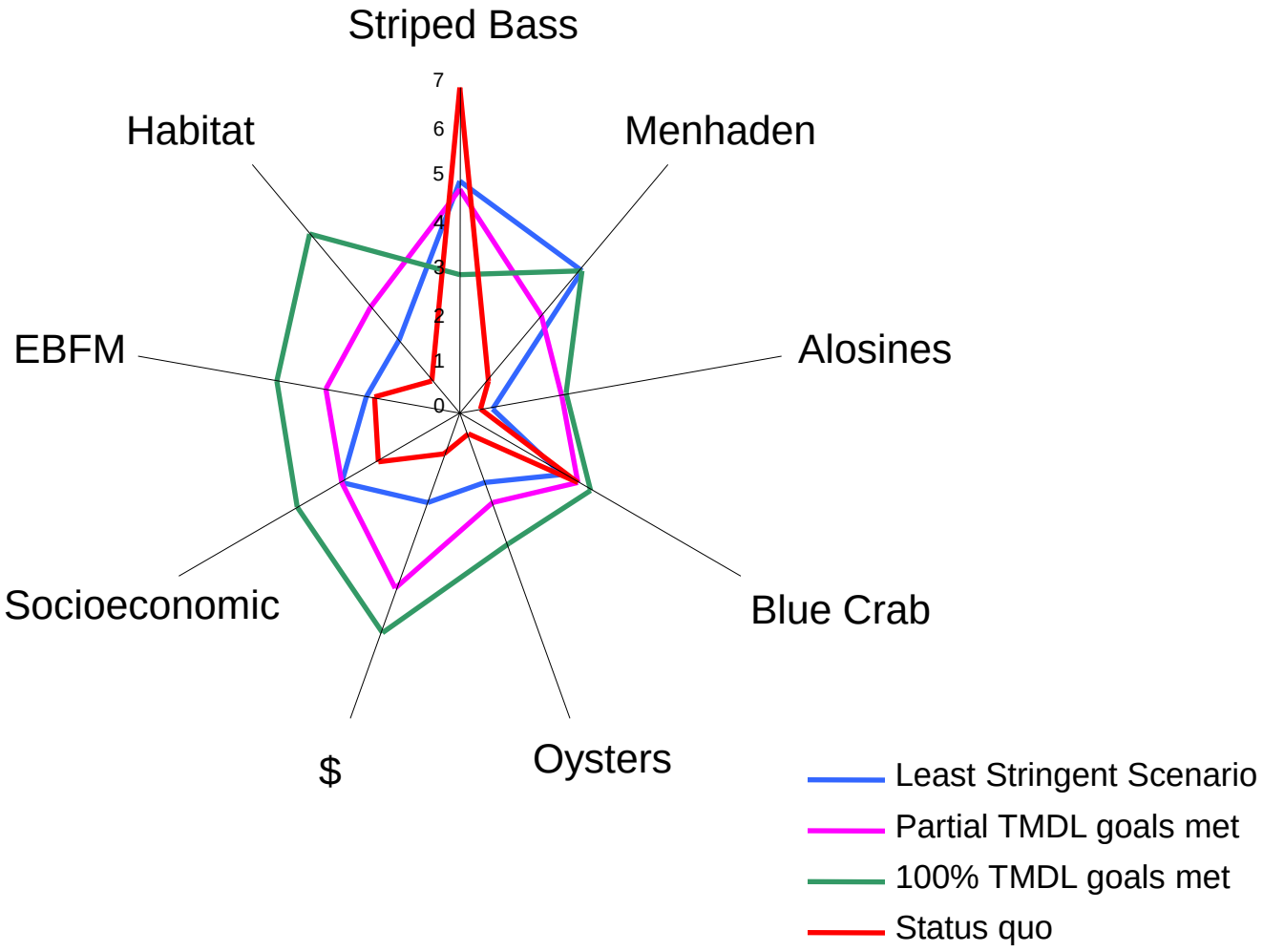
CAM: River Box Structure



Tradeoffs - *Hypothetical*

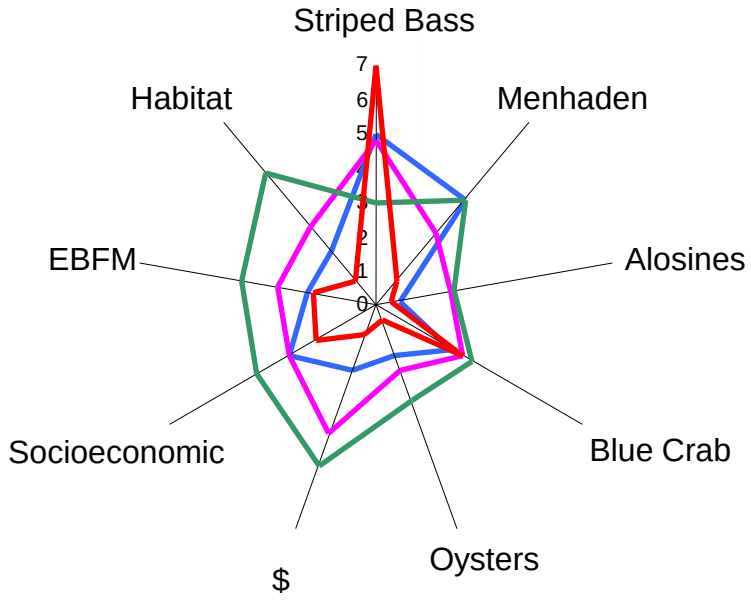
CAM Output

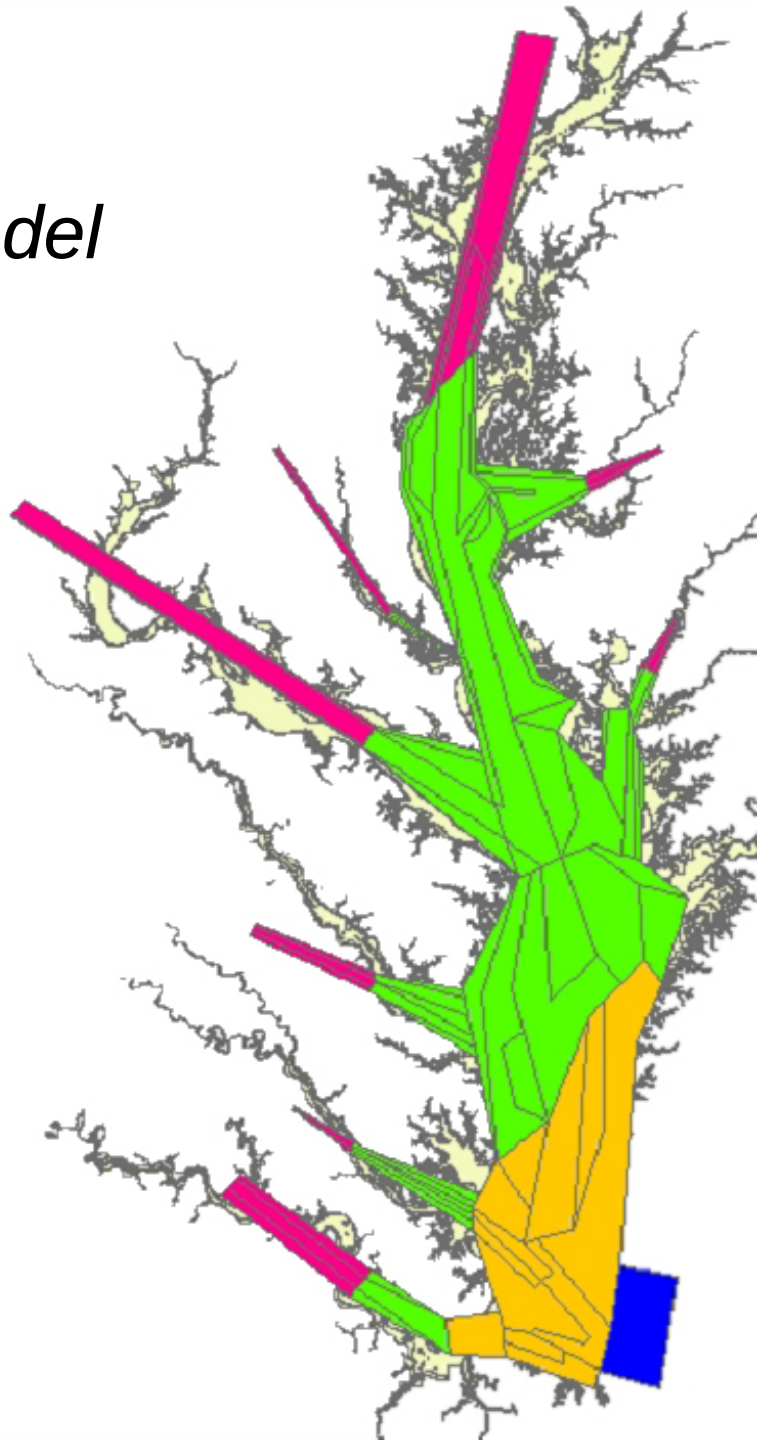
20 year Simulation



For Illustrative Purposes Only -- Not Based on Actual Modeling Results

Chesapeake Atlantis Model





Tradeoffs

CAM Output

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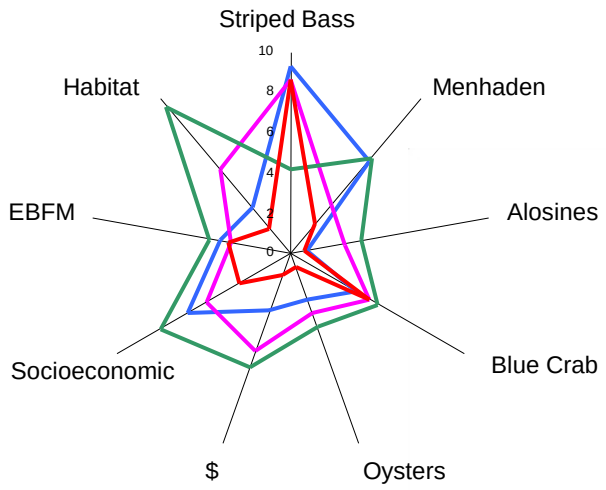
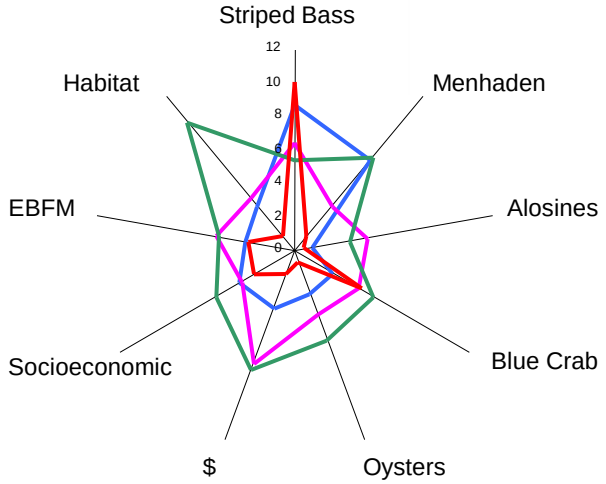
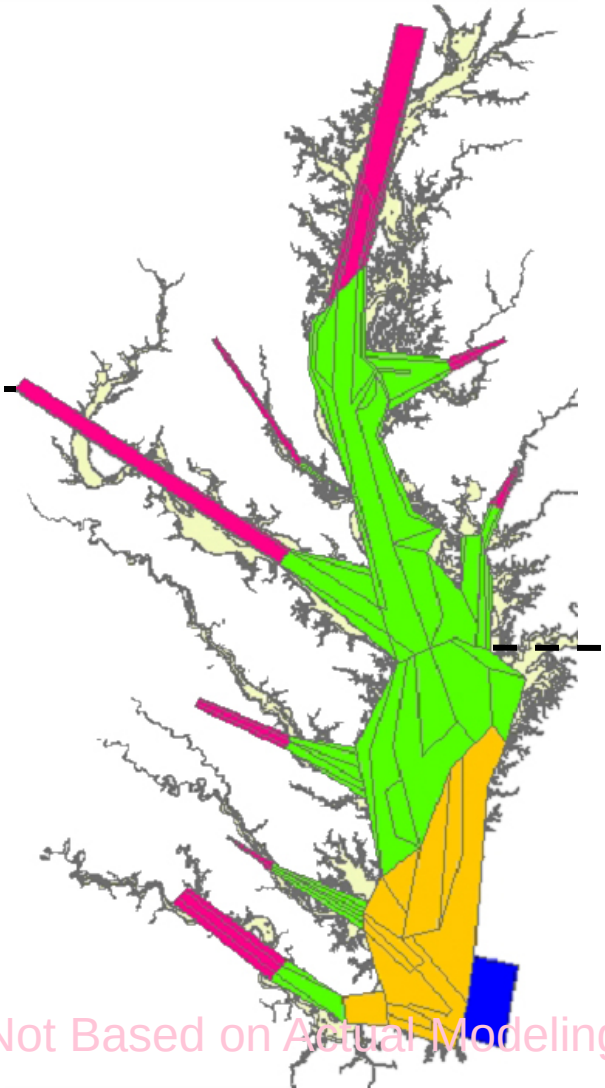
MD



VA





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Tradeoffs

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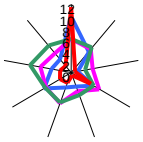
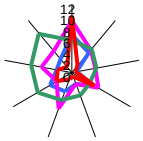
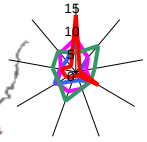
Focus areas:



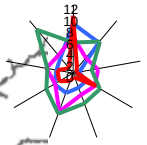
Susquehanna/
Upper-Bay



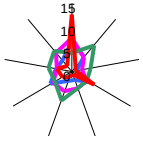
Potomac



Choptank

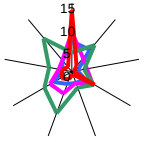


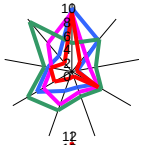
Nanticoke



Rappahannock

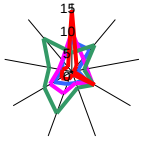
Mid-Bay

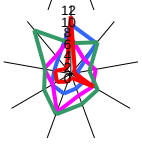




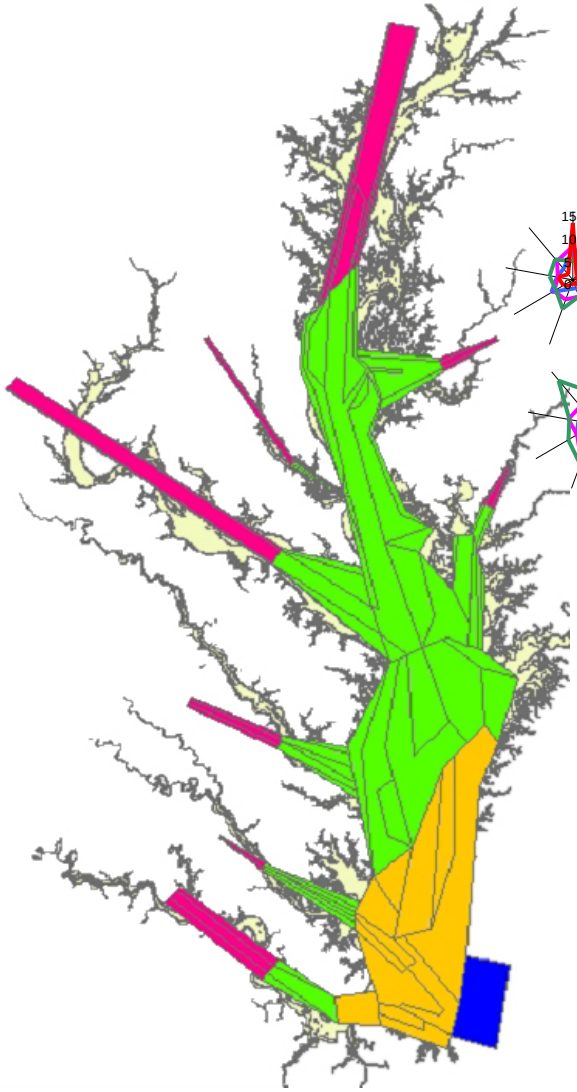
York

Lower-Bay





James



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Atlantis

Management Strategy Evaluation (MSE)

Manager Roles

DEFINE OBJECTIVES

PERFORMANCE MEASURES

Simulation Cycle

Biophysical

Industry

Monitoring

Implementation

Assessment

Management

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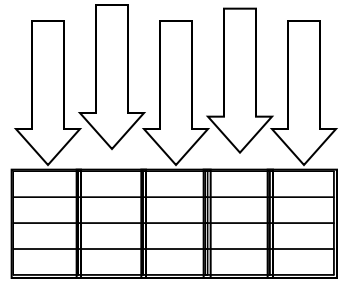

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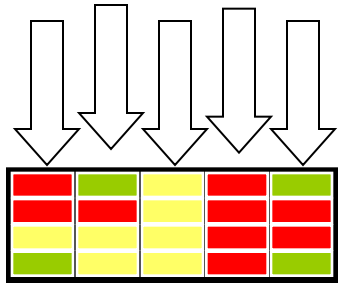

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