A Risk-Based Approach to Managing Intentional Introduction of Non-Native Species

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Intentionally Introduced Species

- Introduced species have caused great harm
  - e.g., Mongoose, Game fish, Eucalyptus trees, Purple loosestrife
- Non-natives also provide benefits
  - Agricultural Crops & Livestock
  - Ornamental plants
  - Household pets
- Prohibition undesirable & unsuccessful
- Careful planning is essential

Approach

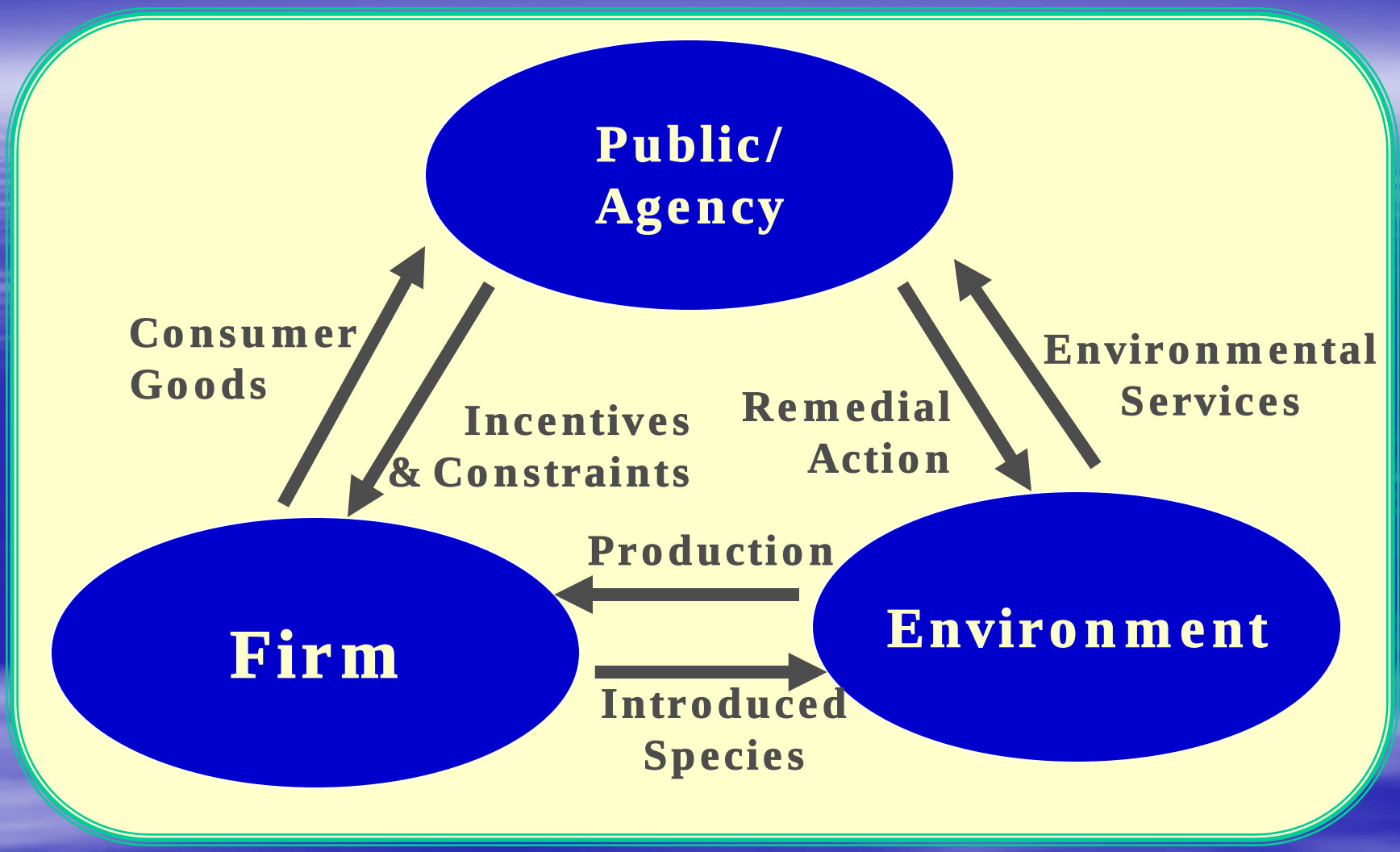
- Risk-based framework
- Balance benefits of intro vs risks of invasives
- Phased introduction w/intervention points

Multiple Tiers of Risk

- Introduced Species Becomes Invasive,
- Invasive “Hitchhiker” Species
- “Rogue” Introduction
- Financial Risks of Profitability

Project Framework

- Spatially Explicit
- Principal-Agent Model
  - Gov. Agency is Principal
  - Introducing Firms are Agents
- Multi-agent Simulation Modeling

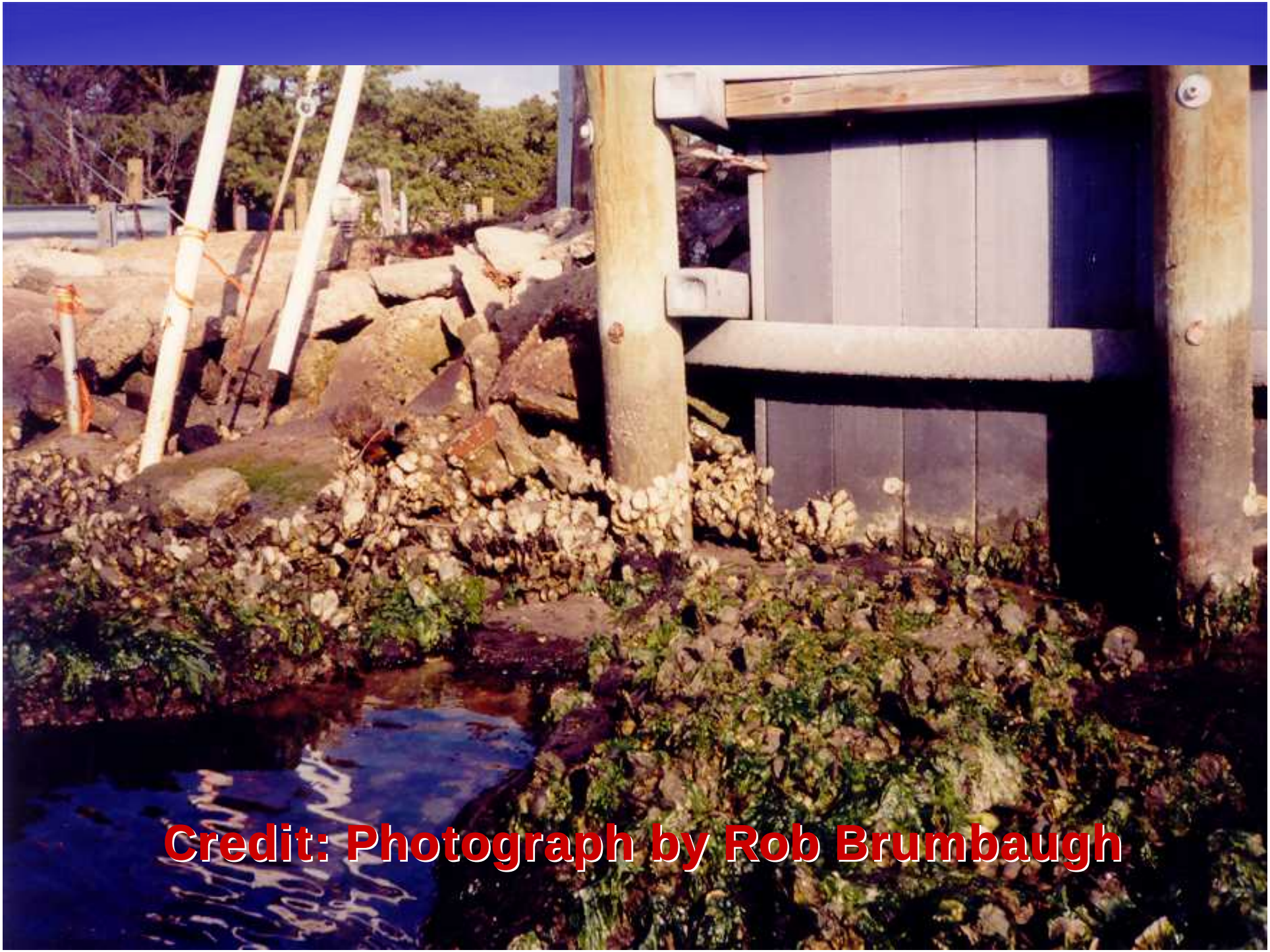


Depiction of Key Relationships

Application: Introducing Non-native Oysters in Chesapeake Bay

- Chesapeake is nation's largest estuary
- Dramatic decline in native oysters (C.virginica) in Chesapeake
- Disease Responsible for Recent Declines
- Triploid non-native Suminoe oyster (C.ariakensis) may be solution
- Very Controversial


Credit: Photographs by Rob Brumbaugh
Chesapeake Bay Foundation


Credit: Photograph by Rob Brumbaugh

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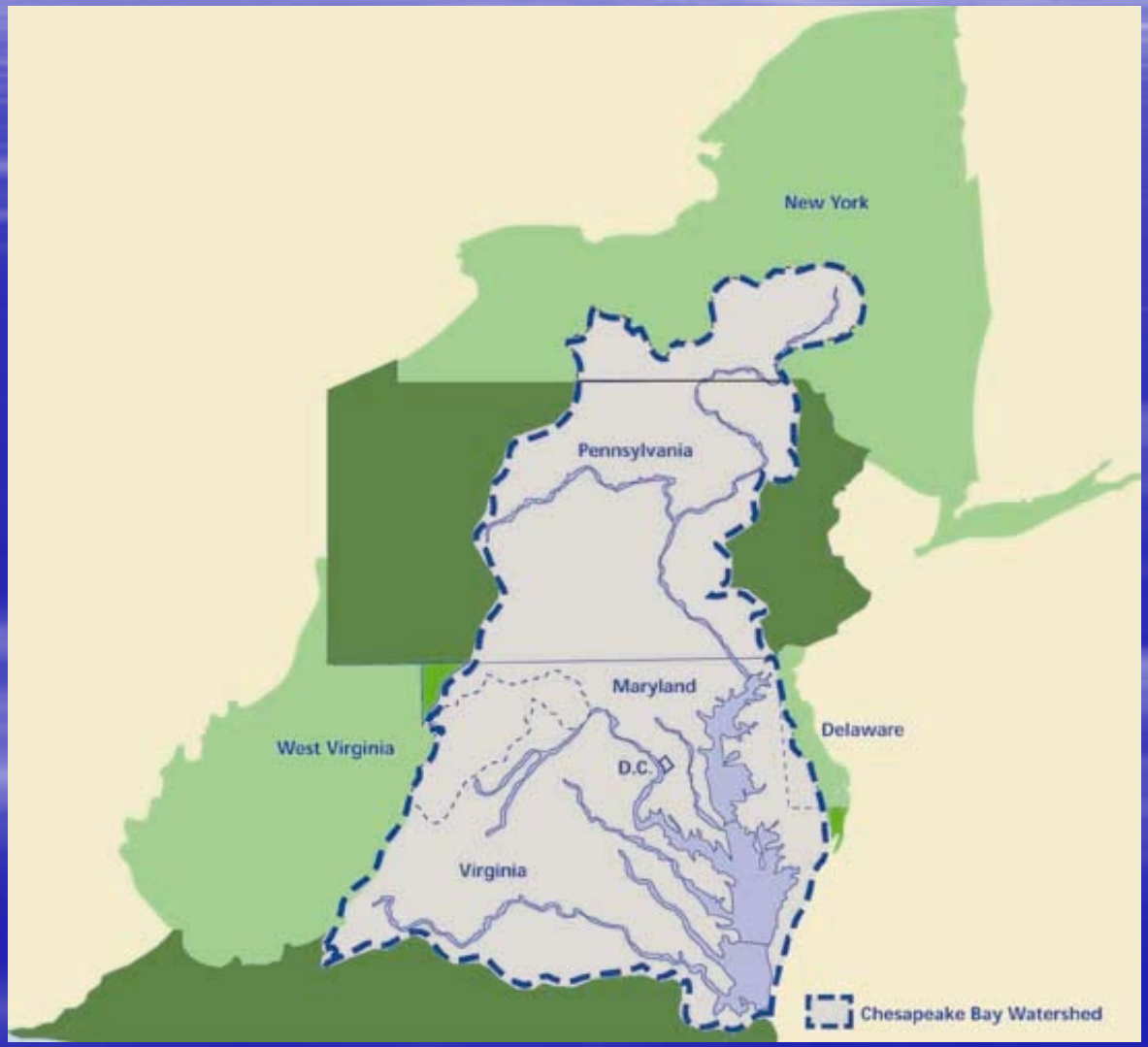
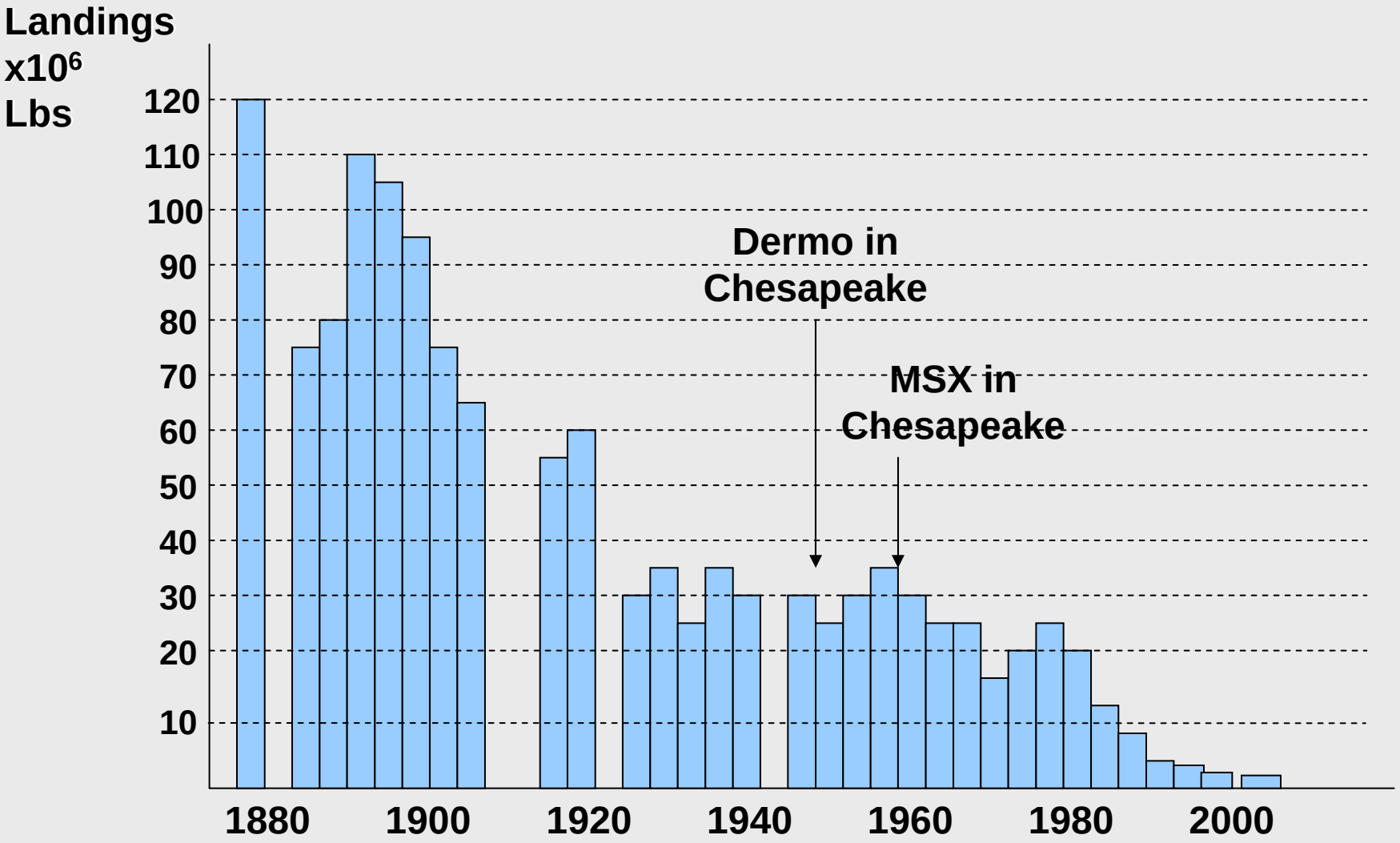
Chesapeake Bay Foundation

Chesapeake Bay Watershed





Time Series of Oyster Landings in Chesapeake Bay

Sources: Data from Chesapeake Bay Program & National Marine Fisheries Service

Interesting Application

- Important and controversial issue
- Illustrates problems common to other introductions
- Extensive Data Available

Attributes of Ariakensis

- Faster growing than native oysters,
- Tolerated MSX and Dermo disease;
- Indistinguishable taste from native oysters

Invasive Risk Management

- Biological Controls

Biological Controls

- Triploids unable to reproduce
- But probability of reverting to diploids (mosaics), capable of reproducing
- Fear of becoming invasive

Invasive Risk Management

- Biological Controls
- Technology-based standards

Technology Based Standard

High Harvest Certainty

Source: Dew, Berkson, Hallerman and Allen, "Demographic Simulation Model for Assessing and Managing Risks Posed by Proposed Deployment of Triploid Suminoe Oysters in the Chesapeake Bay"

Invasive Risk Management

- Biological Controls
- Technology-based standards
- Best management practices
  - e.g., Locations where oysters are planted
- Performance standards
  - e.g., Maximum escapement rates
- Incentives
  - e.g., Liability for response costs & damages

Institutions

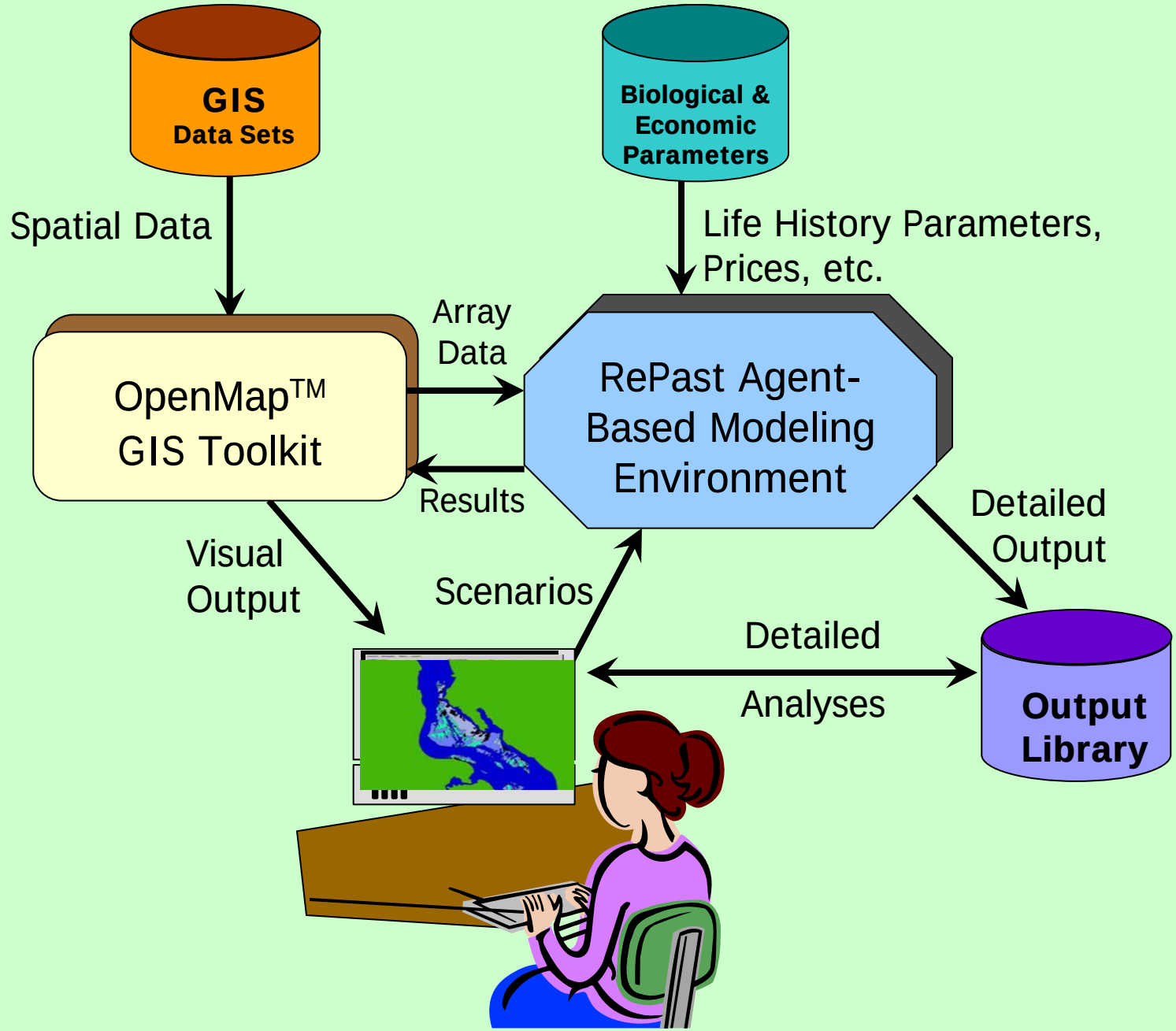
- States play major role
- Md. plants beds, and licenses harvesters
- Va. leases oyster beds to private parties

Oyster Population Dynamics

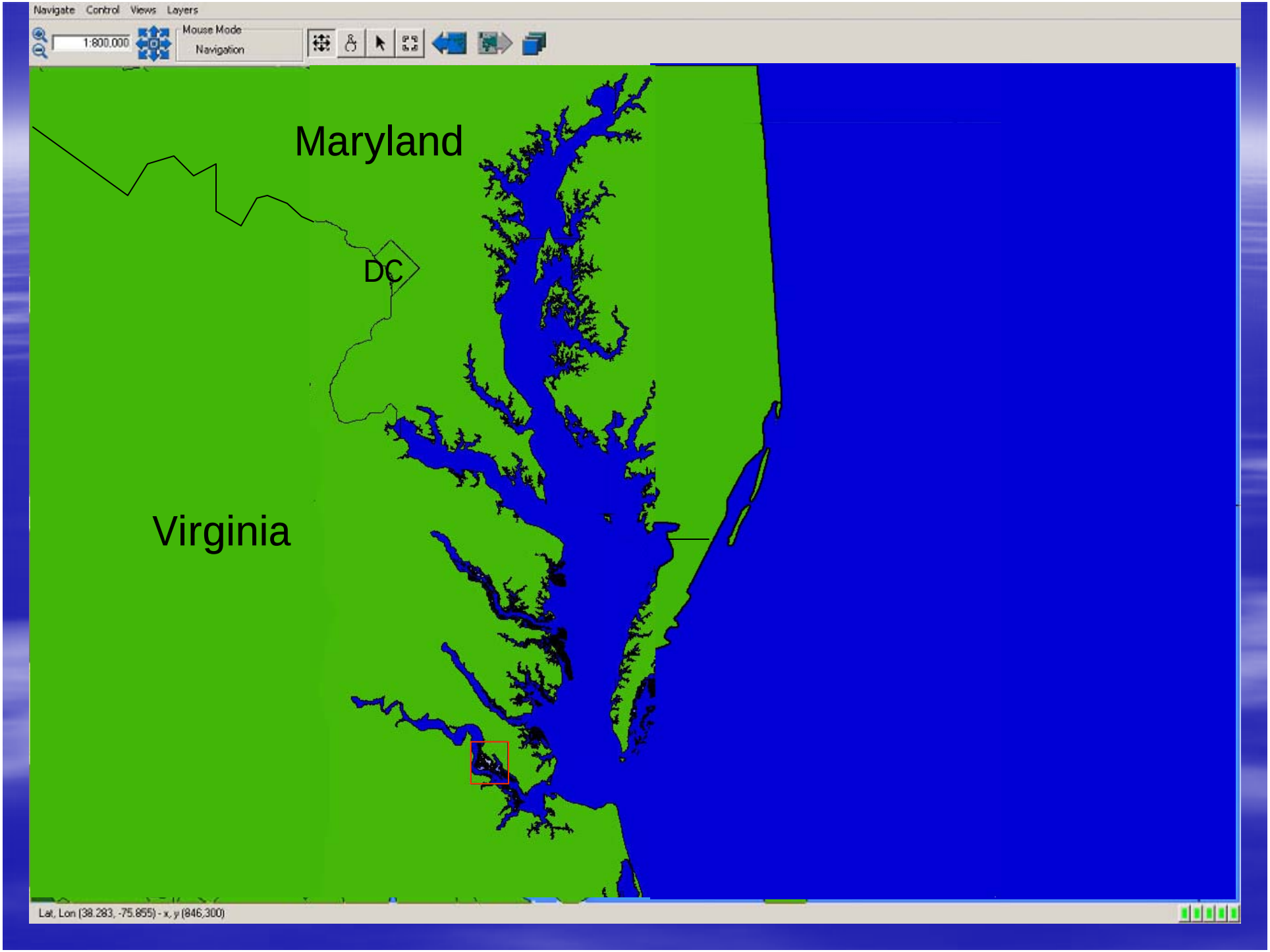
- Cohort-Based Model (Dew et al. 2005)
- Spatially Explicit Agent-Based Model
- Adult Oysters Sedentary
- Transport Only During Reproduction
- Detailed Modeling of Early Life Stages

Larval Modeling

- Gamete Production
- Fertilization
  - Density Dependent
  - Gamete Sink
- Survival
  - Depends up environmental conditions (e.g., Salinity)
- Transport and Setting on Habitat



Depiction of the Modeling System Architecture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DC
Virginia
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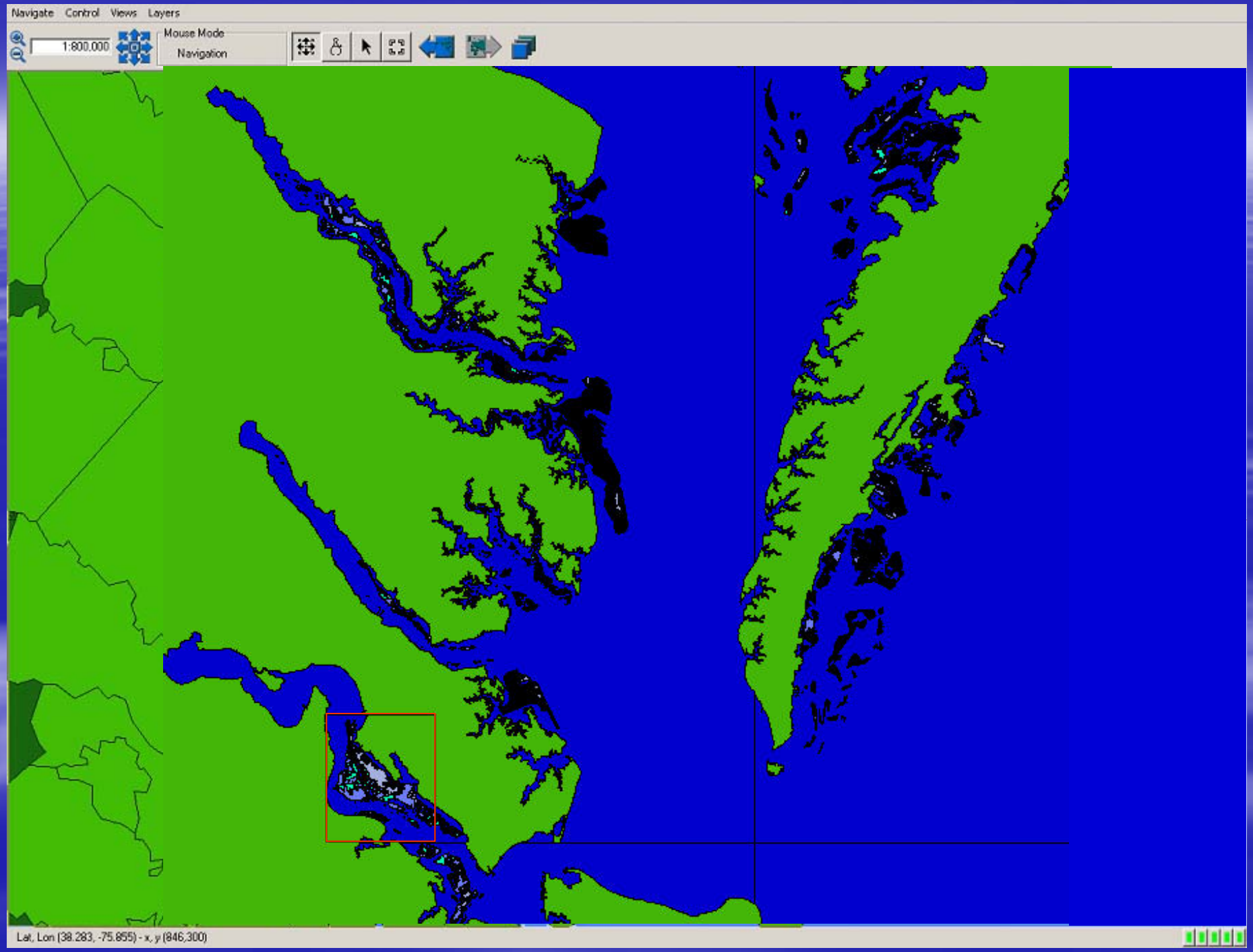
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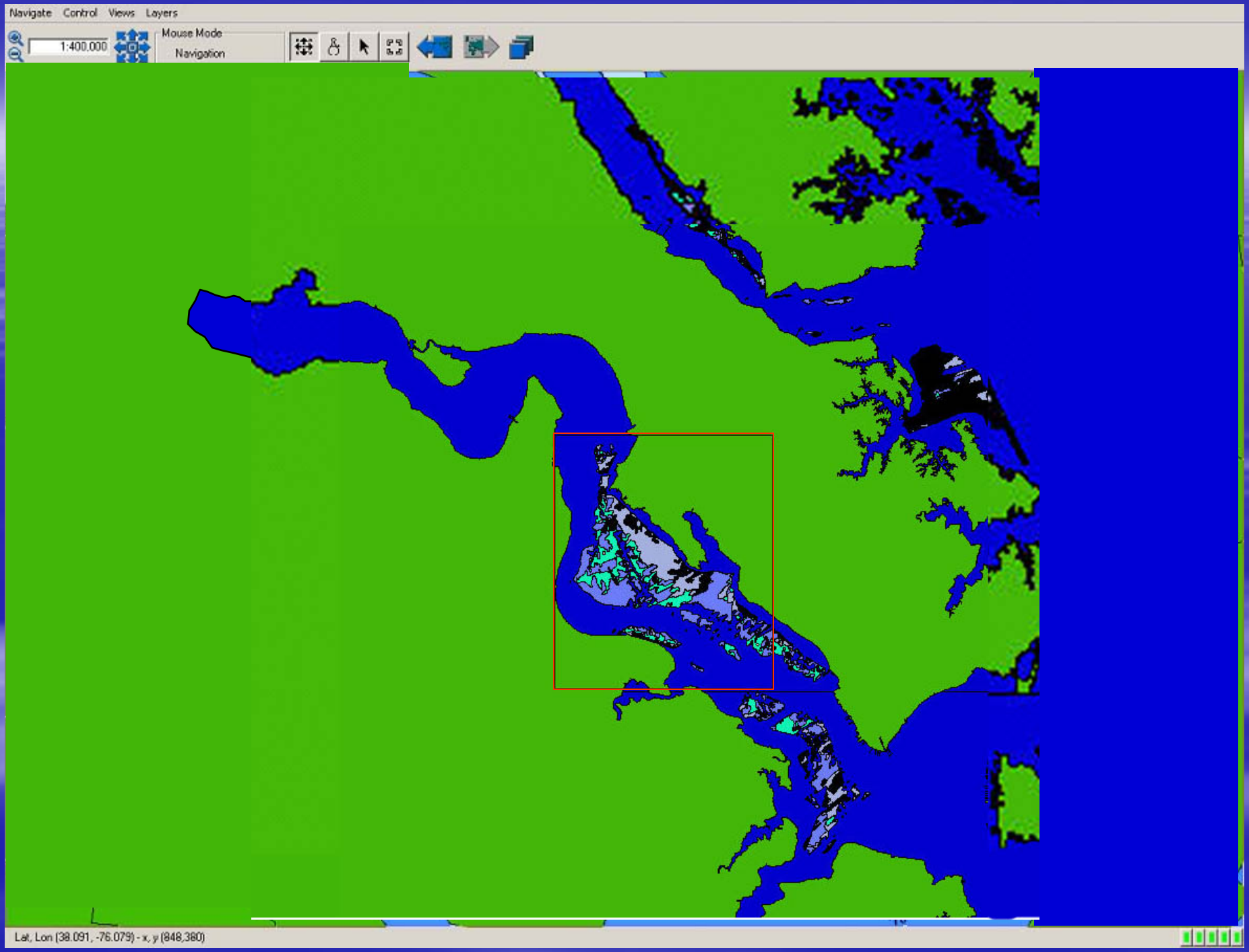
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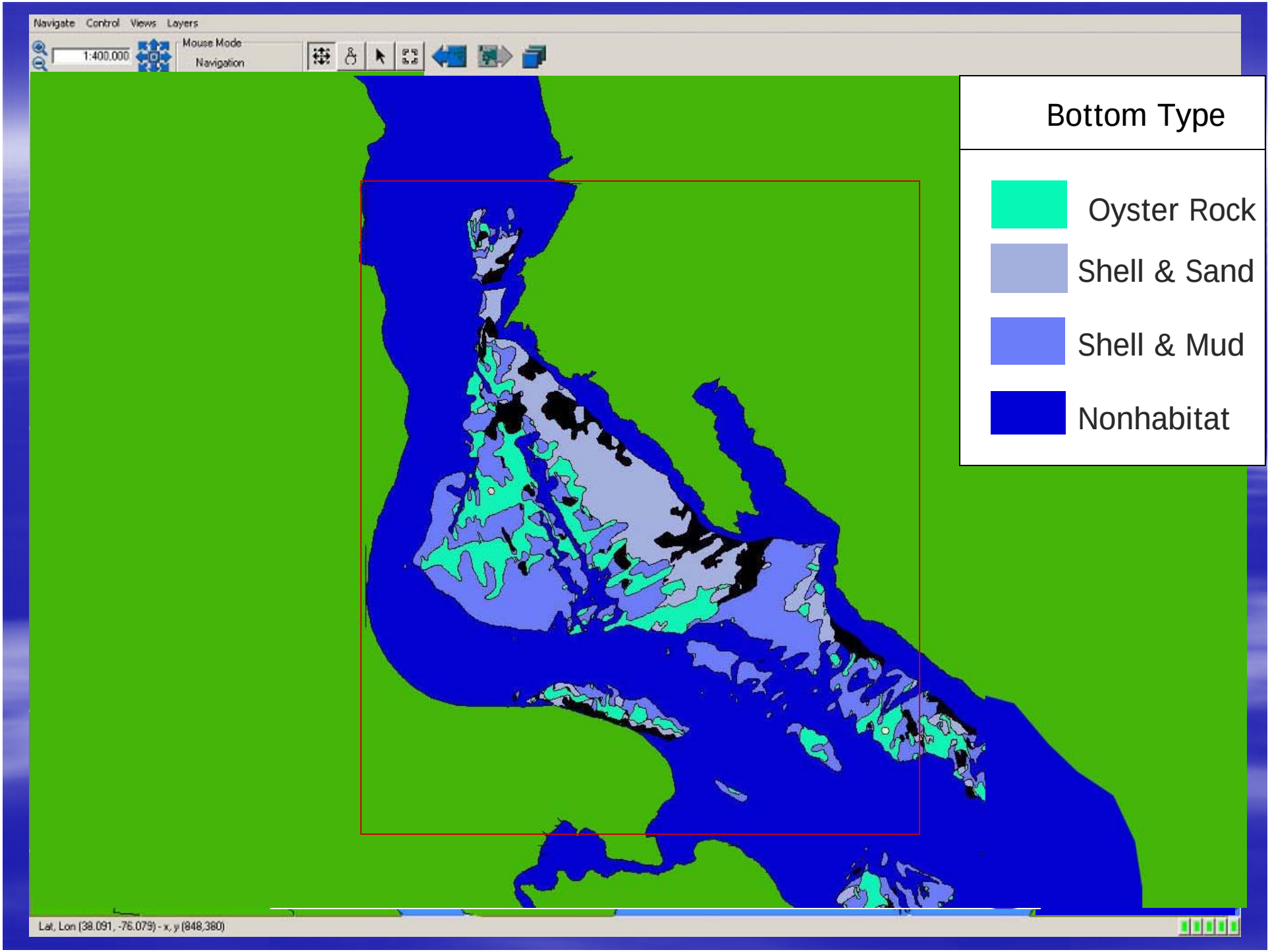
Navigate Control Views Layers
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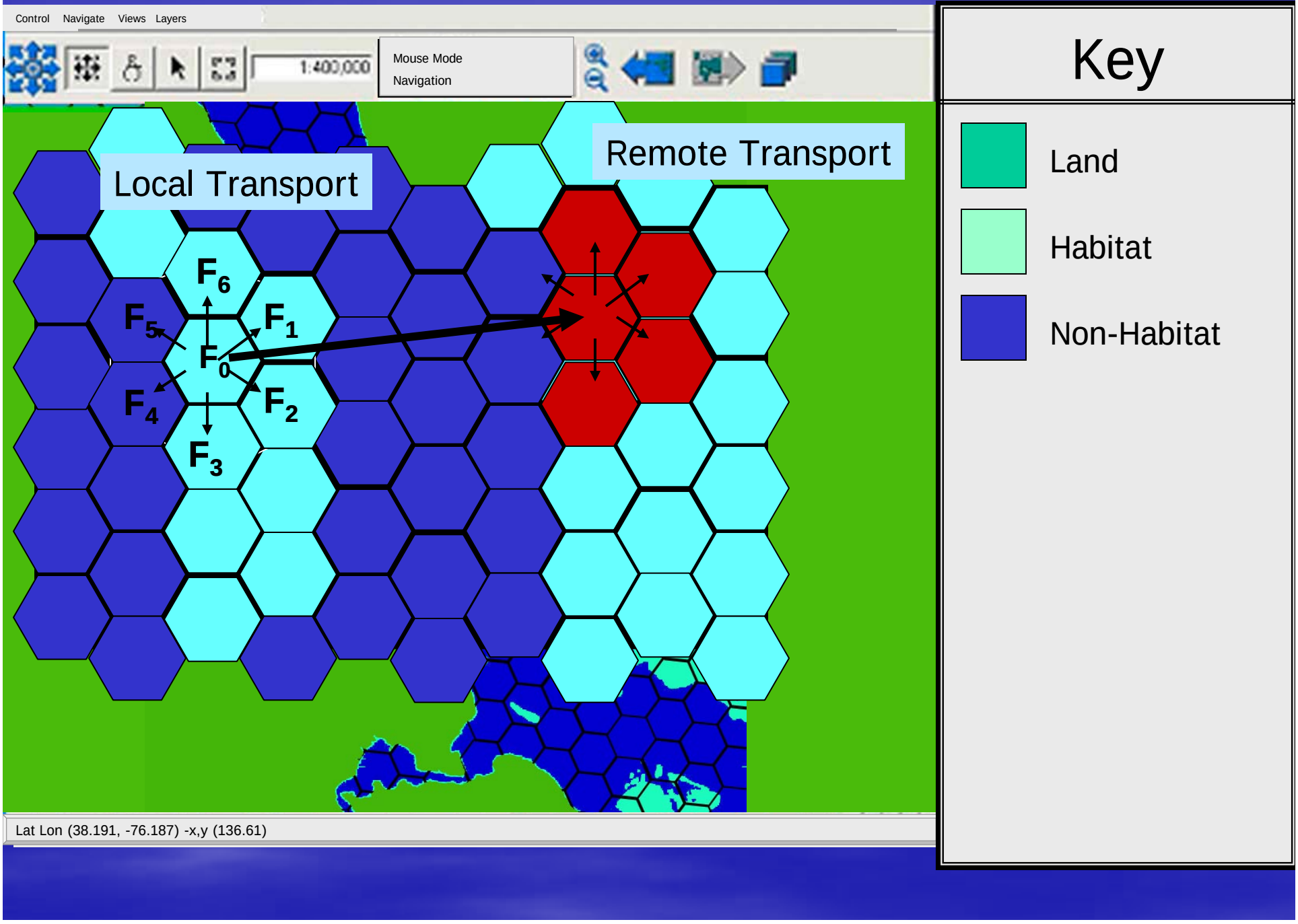
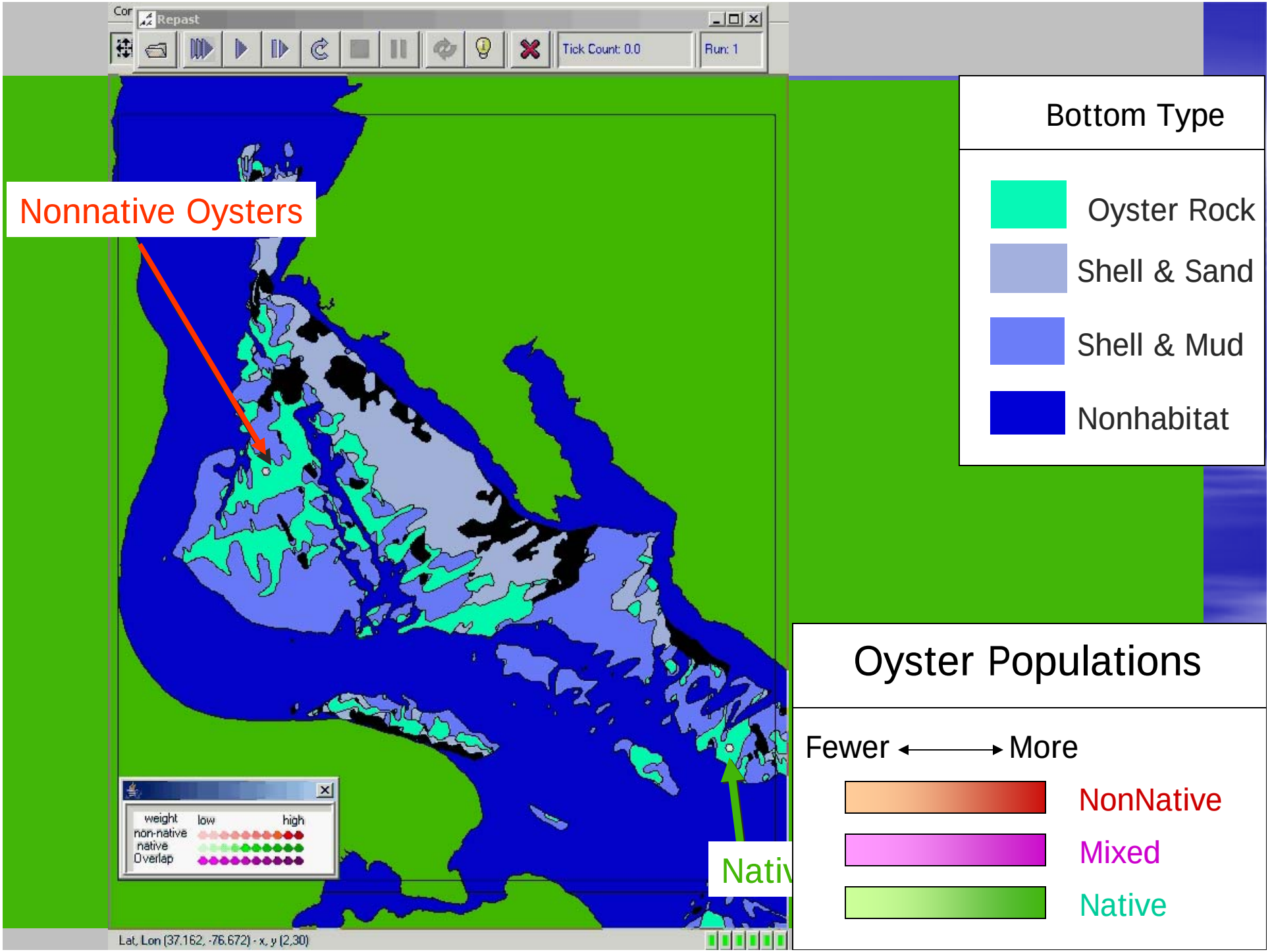
Mouse Mode
Navigation
Bottom Type
Oyster Rock
Shell & Sand
Shell & Mud
Nonhabitat
Lat, Lon (38.091, -76.079) - x, y (848,380)

Transport Mechanisms

- Transport Occurs During Reproduction
- Broadcast Spawners
- Hybrid CA Model
- Local Transport
  - Virtually All Larval Transport
- Remote Transport
  - Rare, Stochastic Influences
- Transport to be calibrated to North et al. (2005)


Control
Navigate
Views
Layers
1:400,000
Mouse Mode
Navigation
Local Transport
Remote Transport
F6
F5
F1
F0
F4
F2
F3
Lat Lon (38.191, -76.187) -x,y (136.61)
Key
Land
Habitat
Non-Habitat


Repast
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Run: 1
Nonnative Oysters
weight
low
high
non-native
native
Overlap
Nativ
Lat, Lon (37.162, -76.672) - x, y (2,30)
Bottom Type
Oyster Rock
Shell & Sand
Shell & Mud
Nonhabitat
Oyster Populations
Fewer
More
NonNative
Mixed
Native

Next Steps

- Refine Model of Open Access Fishery
- Develop Principal-Agent Model of Sole Owner
- Calibrate Transport to Science Studies
- Incorporate Hydrology into Transport