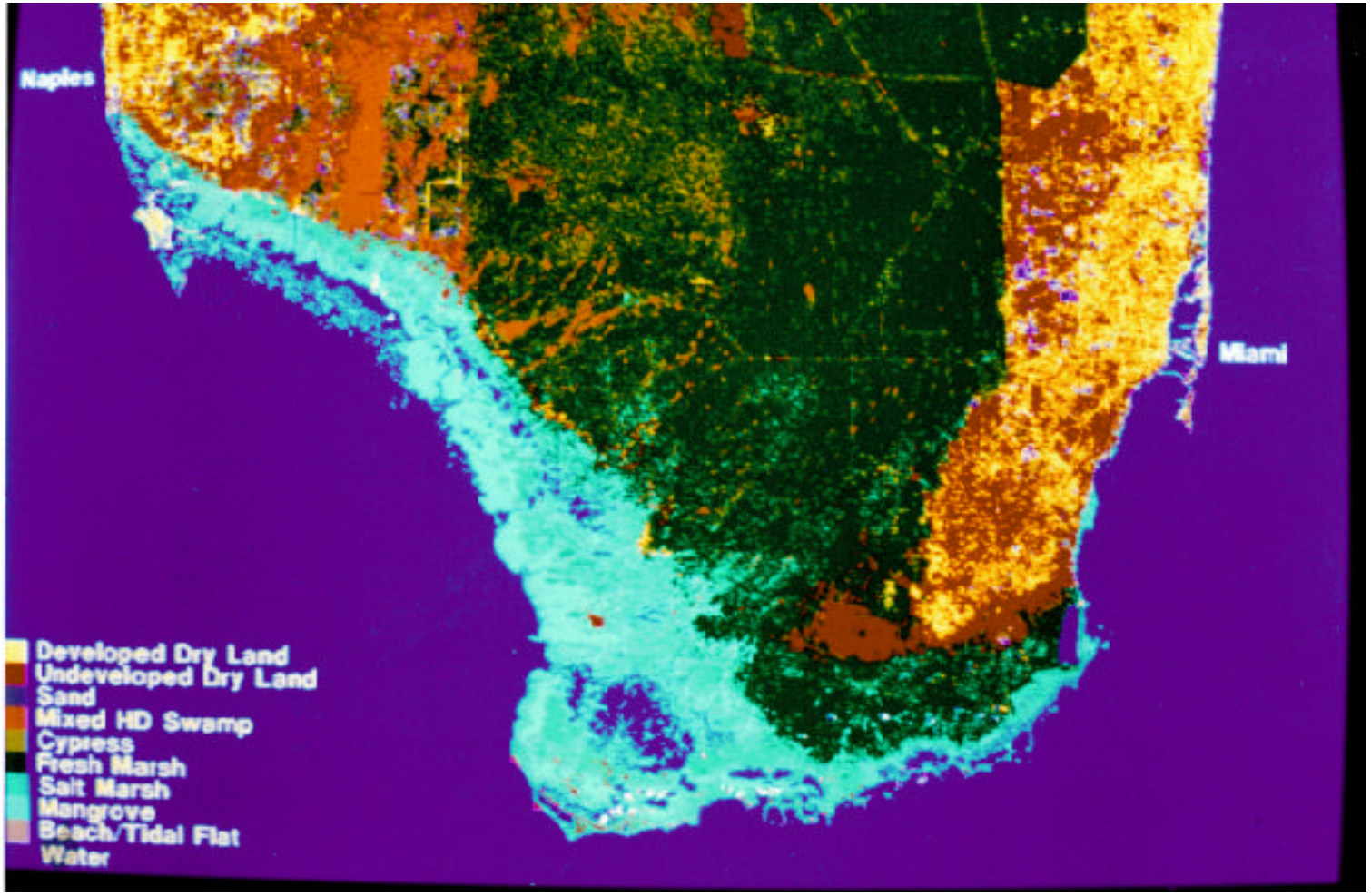
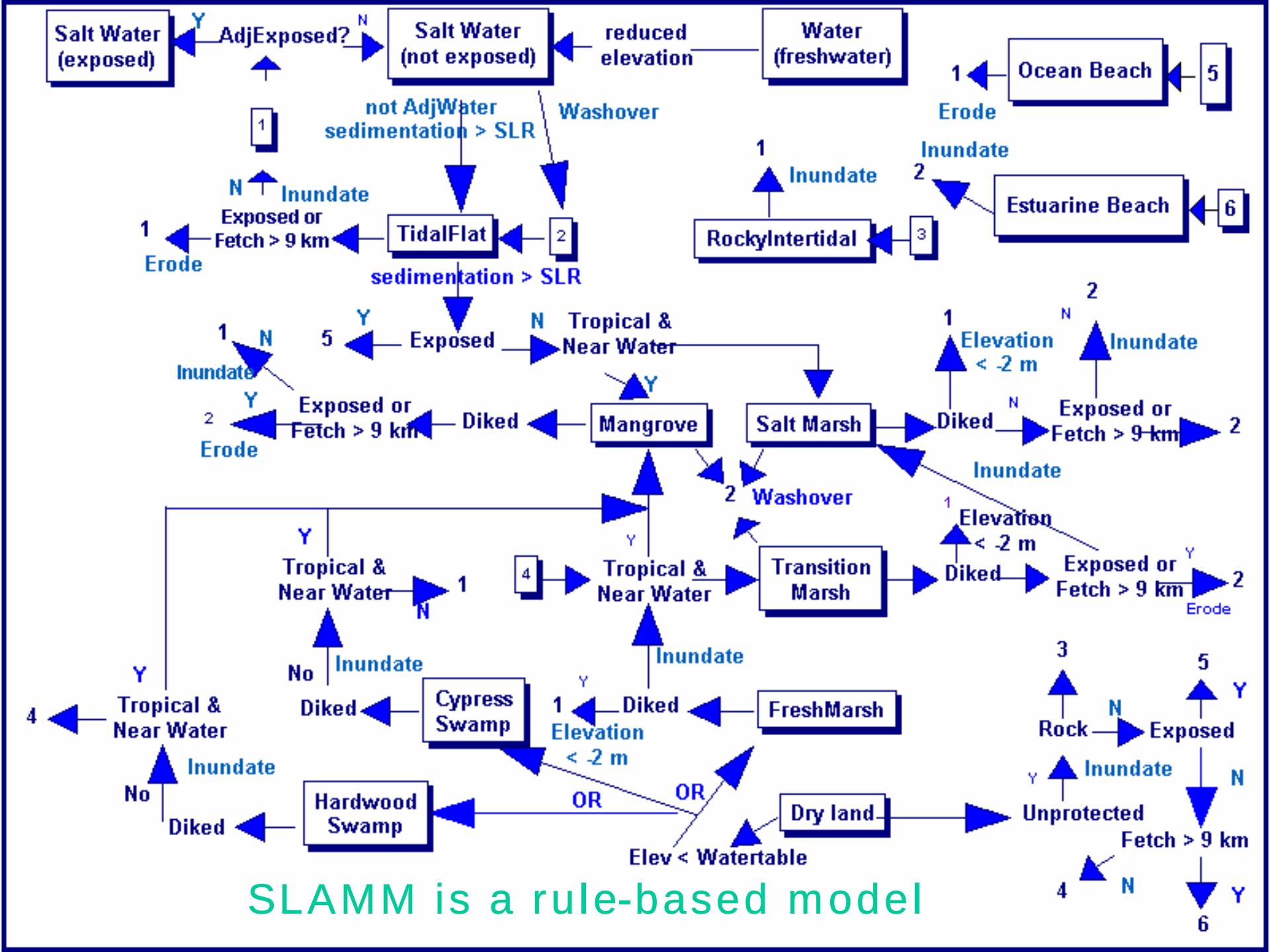
Modeling the Impacts of Sea-level Rise



Richard A. Park, Eco Modeling, Diamondhead MS

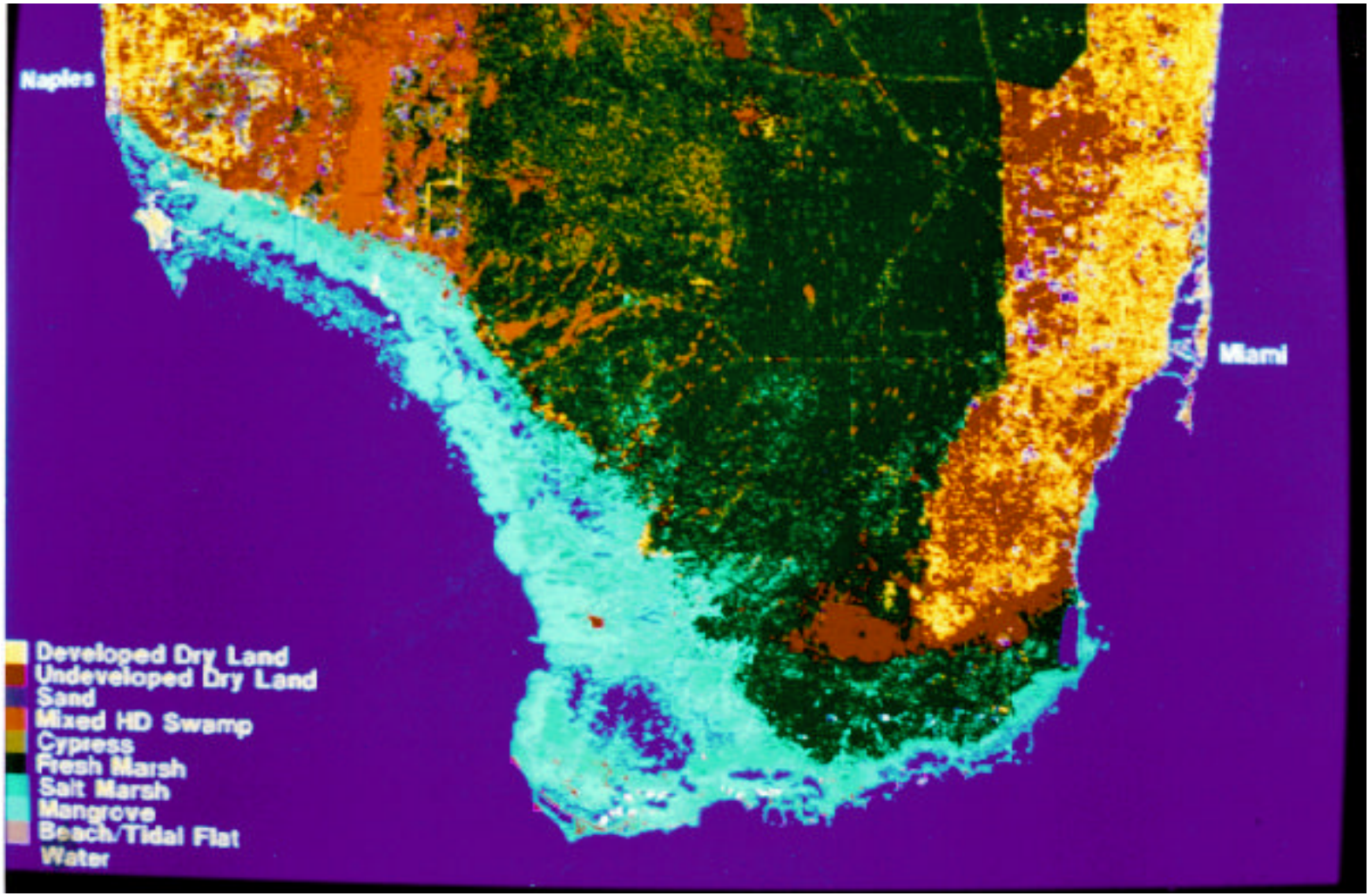
SLAMM (Sea Level Affecting Marshes Model)

- Rule-based spatial model for coastal areas
- Model 1st developed in 1985 for EPA
- SLAMM2 used to predict impacts of sea level rise on 20% coast of U.S. for 1989 Report to Congress on Climate Change
  ("an area = size of MA could be lost by 2100")
- SLAMM3 used for case studies in Puget Sound and South Florida
- SLAMM4 used to predict impacts in WA, CA, TX, & DE, especially on migratory birds (with Hector Galbraith)

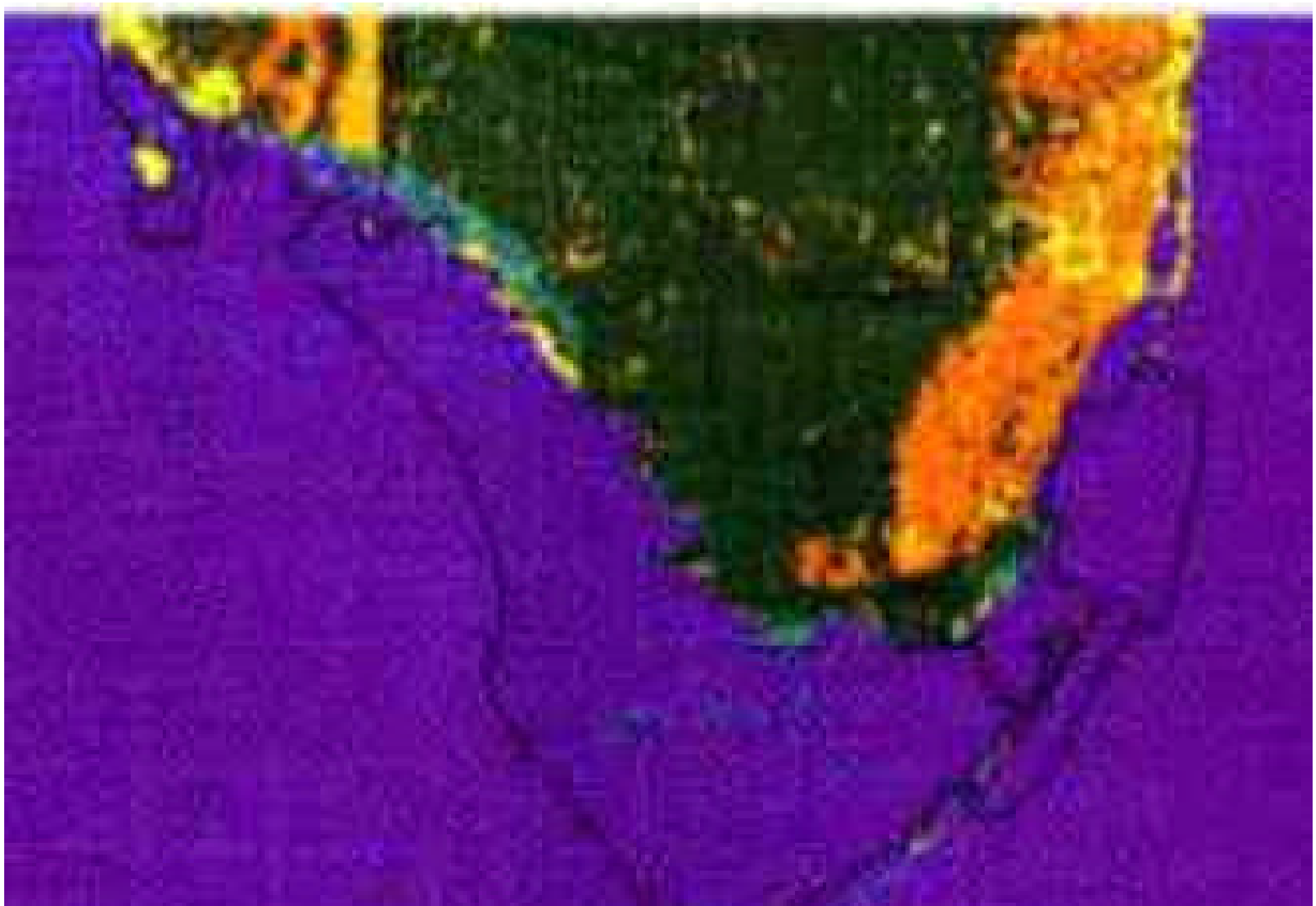


SLAMM is a rule-based model

SLAMM3 initial conditions in 1980 based on Landsat imagery for South FL



Coastal retreat by 2100 with 0.5 m rise in sea level and no additional dikes



SLAMM4
Data from Internet:

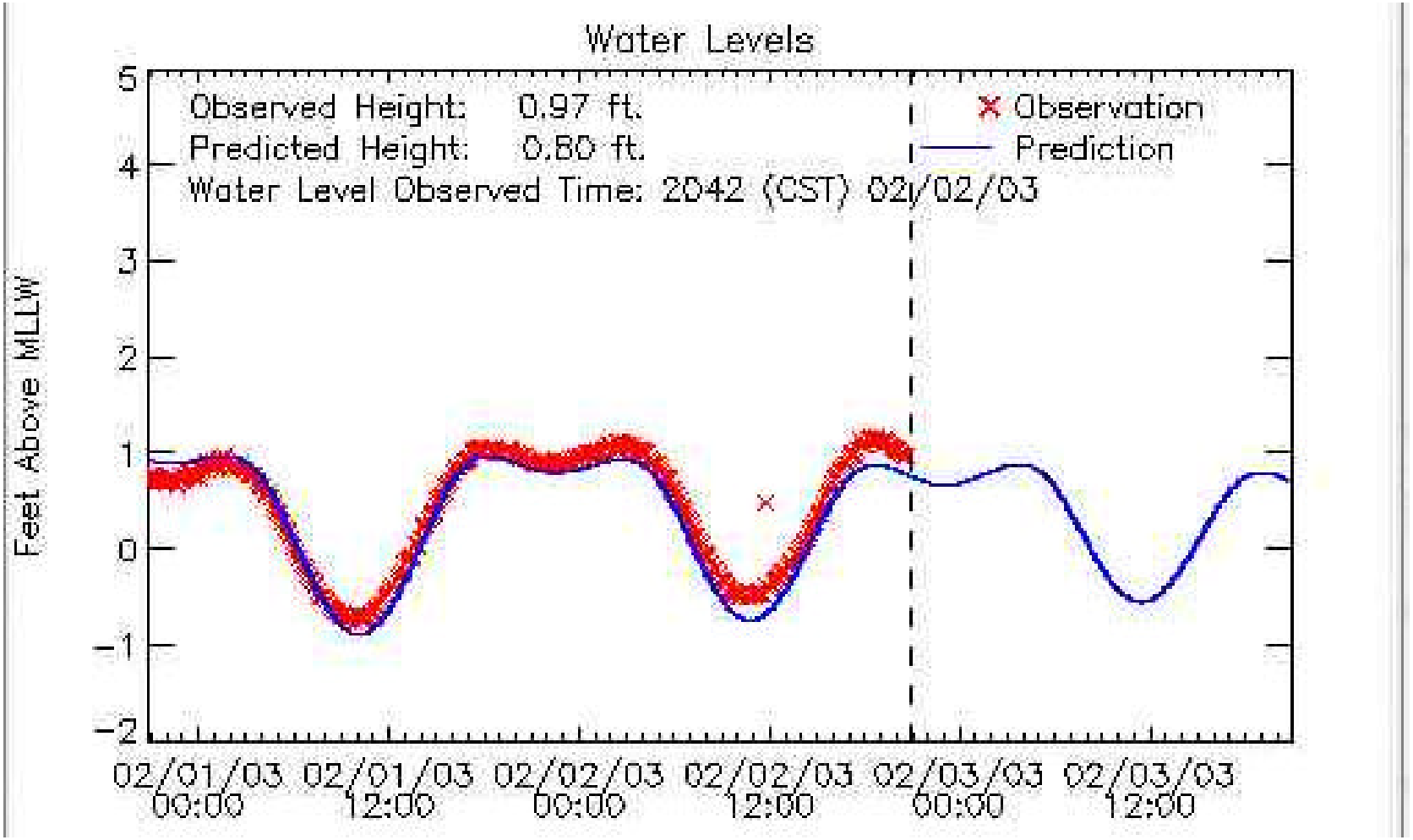
- **NOAA tidal data (ex.: Galveston Bay)**
- **NOAA sea level trends**
- **EPA sea-level rise scenarios**
- **USGS Digital Elevation Model (30 m X 30 m)**
- **US F&WS National Wetland Inventory**

Mean and spring tide ranges determine vulnerability to sea-level rise

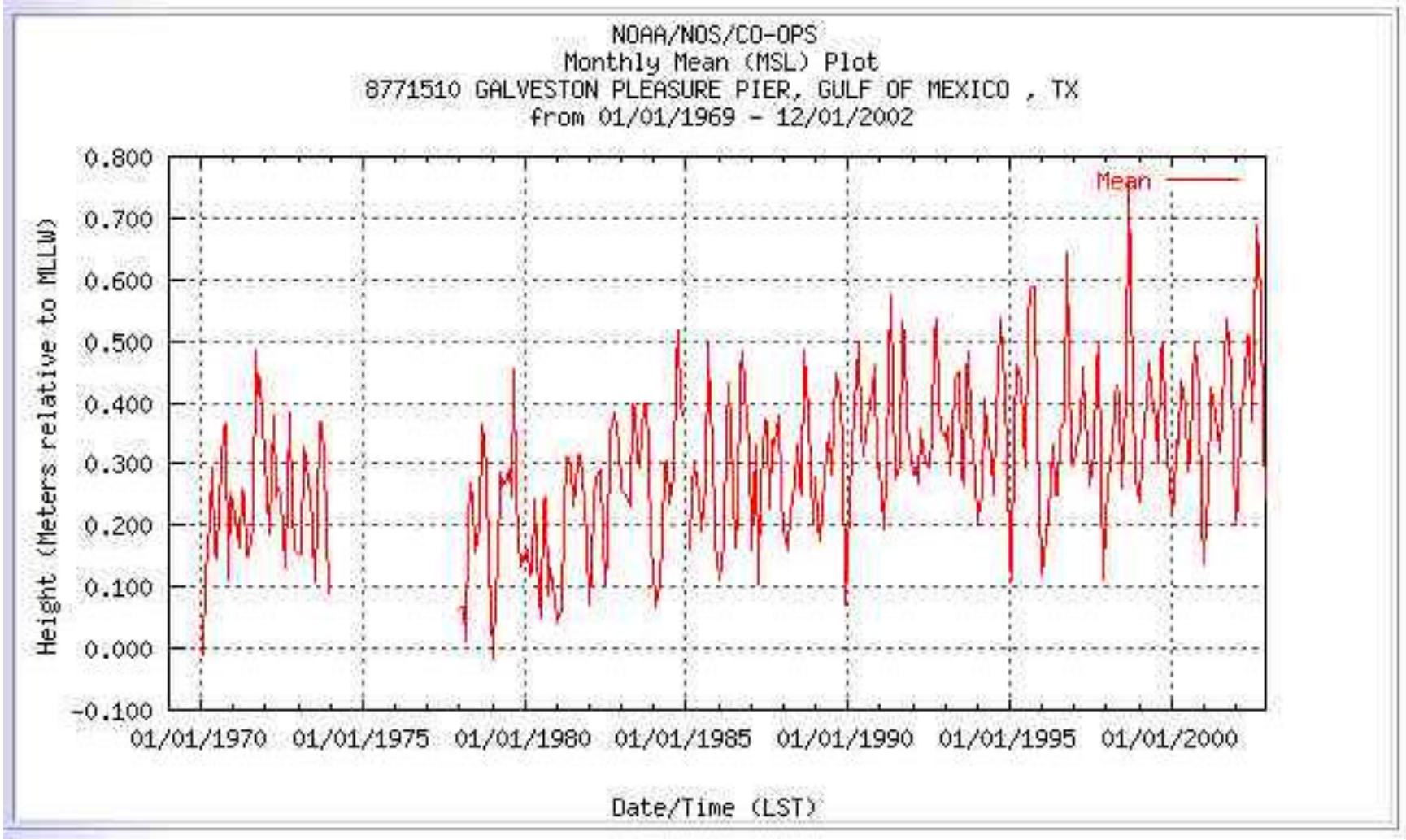
TEXAS

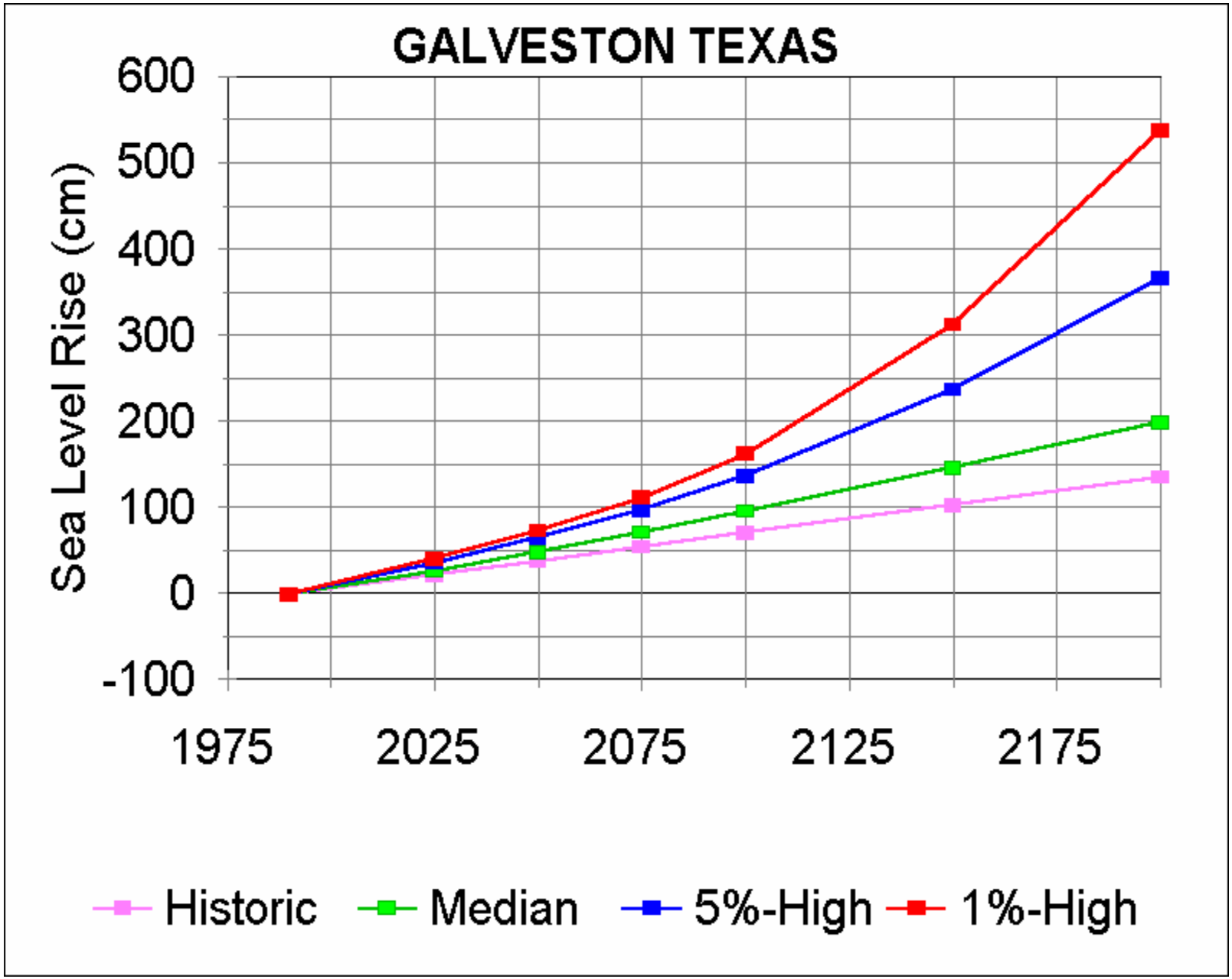
Station	Latitude	Longitude		Mean Range (ft)	Spring Range (ft)	
Sabine Bank Lighthouse	29° 28'	93° 43'	- -	2.8	1.4	
Sabine Pass (jetty)	29° 39'	93° 50'	- -	2.5	1.2	
Sabine Pass	29° 42'	93° 51'	- -	1.9	1.0	
Mesquite Point, Sabine Pass	29° 46'	93° 54'	- -	1.3	0.6	
Galveston Bay entrance, south jetty	29° 20'	94° 42'	- -	2.0	1.0	
Port Bolivar	29° 22'	94° 47'	- -	1.4	0.7	
GALVESTON, Galveston Channel	29° 19'	94° 48'	- -	1.4	0.7	
Galveston Bay						
Texas City, Turning Basin	29° 23'	94° 53'	- -	1.4	0.7	
Eagle Point#20	29° 30'	94° 55'	- -	1.0	0.5	
Clear Lake#20	29° 34'	95° 04'	- -	0.9	0.4	
Morgans Point#20	29° 41'	94° 59'	- -	1.0	0.5	
Round Point, Trinity Bay#20	29° 44'	94° 42'	- -	1.0	0.5	
Point Barrow, Trinity Bay	29° 44'	94° 50'	- -	1.1	0.5	
Gilchrist, East Bay	29° 31'	94° 29'	- -	1.2	0.6	
Jamaica Beach, West Bay	29° 12'	94° 59'	- -	1.0	0.5	
Alligator Point, West Bay	29° 10'	95° 08'	- -	0.9	0.4	
Christmas Point, Christmas Bay	29° 05'	95° 10'	- -	0.9	0.4	
Galveston Pleasure Pier	29° 17'	94° 47'	- -	2.1	1.1	
San Luis Pass	29° 05'	95° 07'	- -	1.2	0.6	
Freeport Harbor	28° 57'	95° 19'	- -	1.8	0.9	
Pass Cavallo	28° 22'	96° 24'	- -	1.4	0.7	
PORT O'CONNOR, MATAGORDA BAY	28° 27'	96° 24'	- -	0.5	0.2	
PADRE ISLAND (south end)	26° 04.1'	97° 09.4'	1.31	1.58	0.86	
Port Isabel	26° 03.6'	97° 12.9'	- -	1.40	0.76	

Galveston wetlands vulnerable because of low tidal range relative to sea level rise



Local sea level trend
(note substantial subsidence)





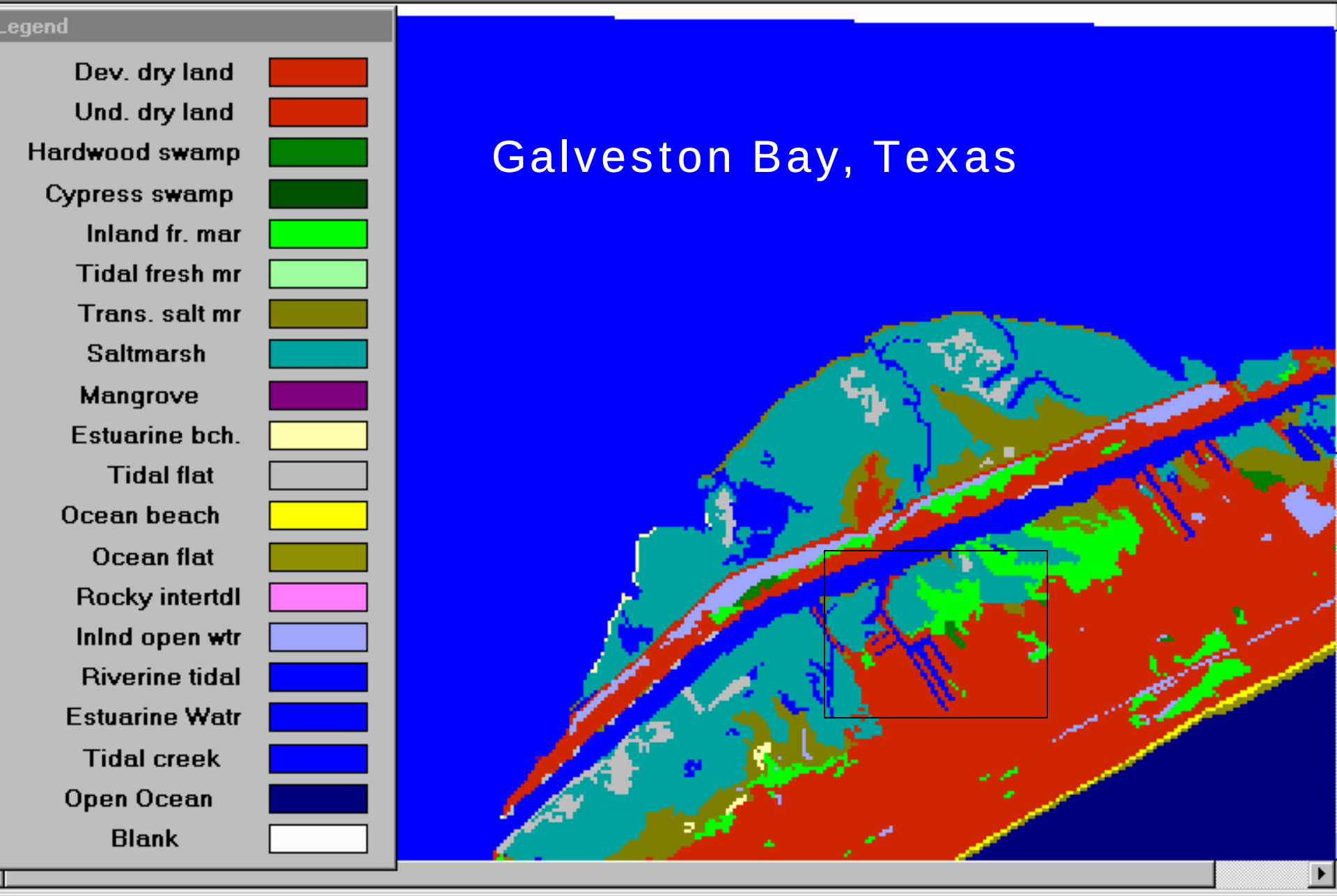
Probabilistic sea-level rise model: Titus and Narayanan, 1995
corrected for local subsidence

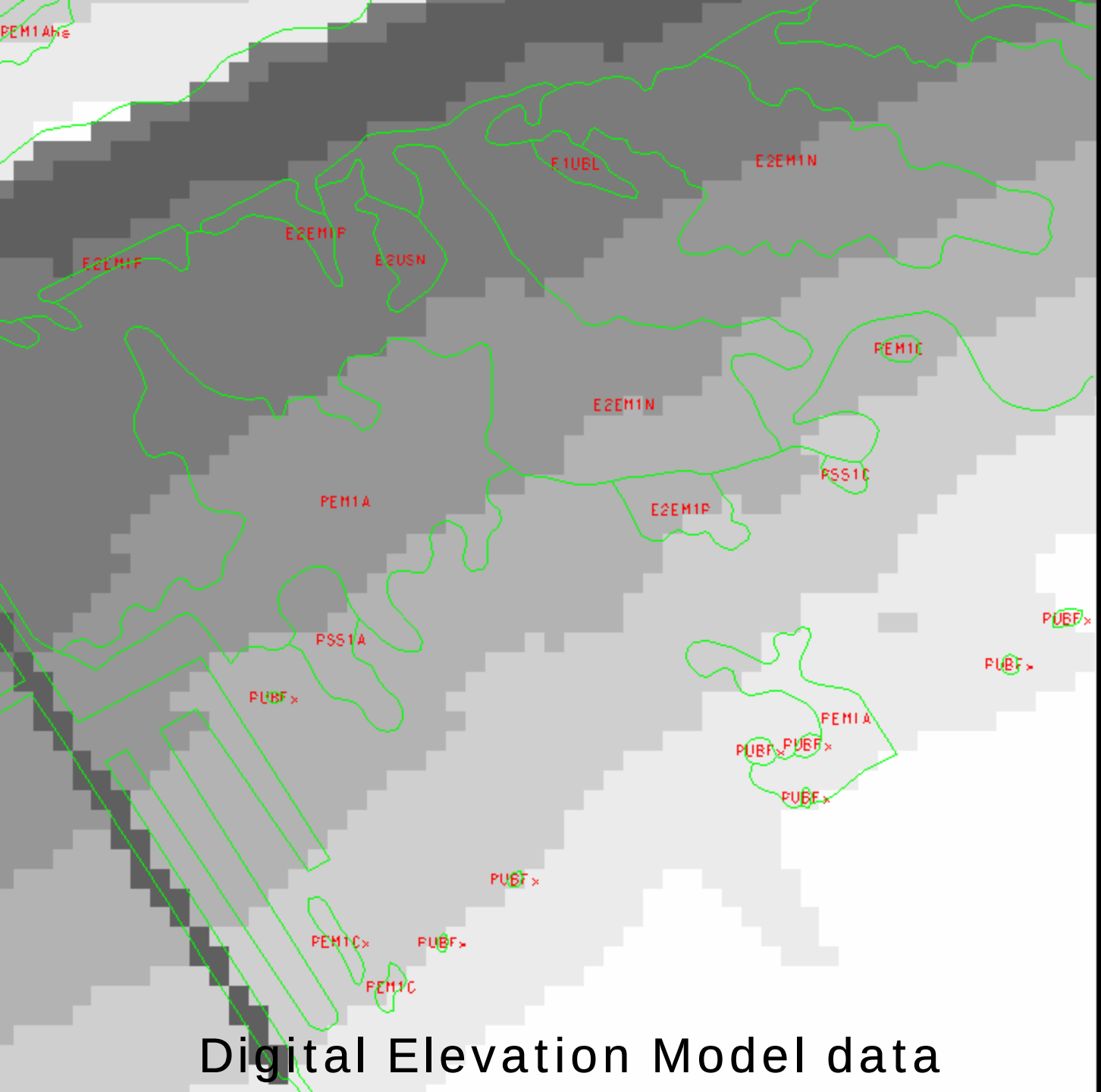
Galveston Bay, Texas

Photo Courtesy NASA Johnson Space Center

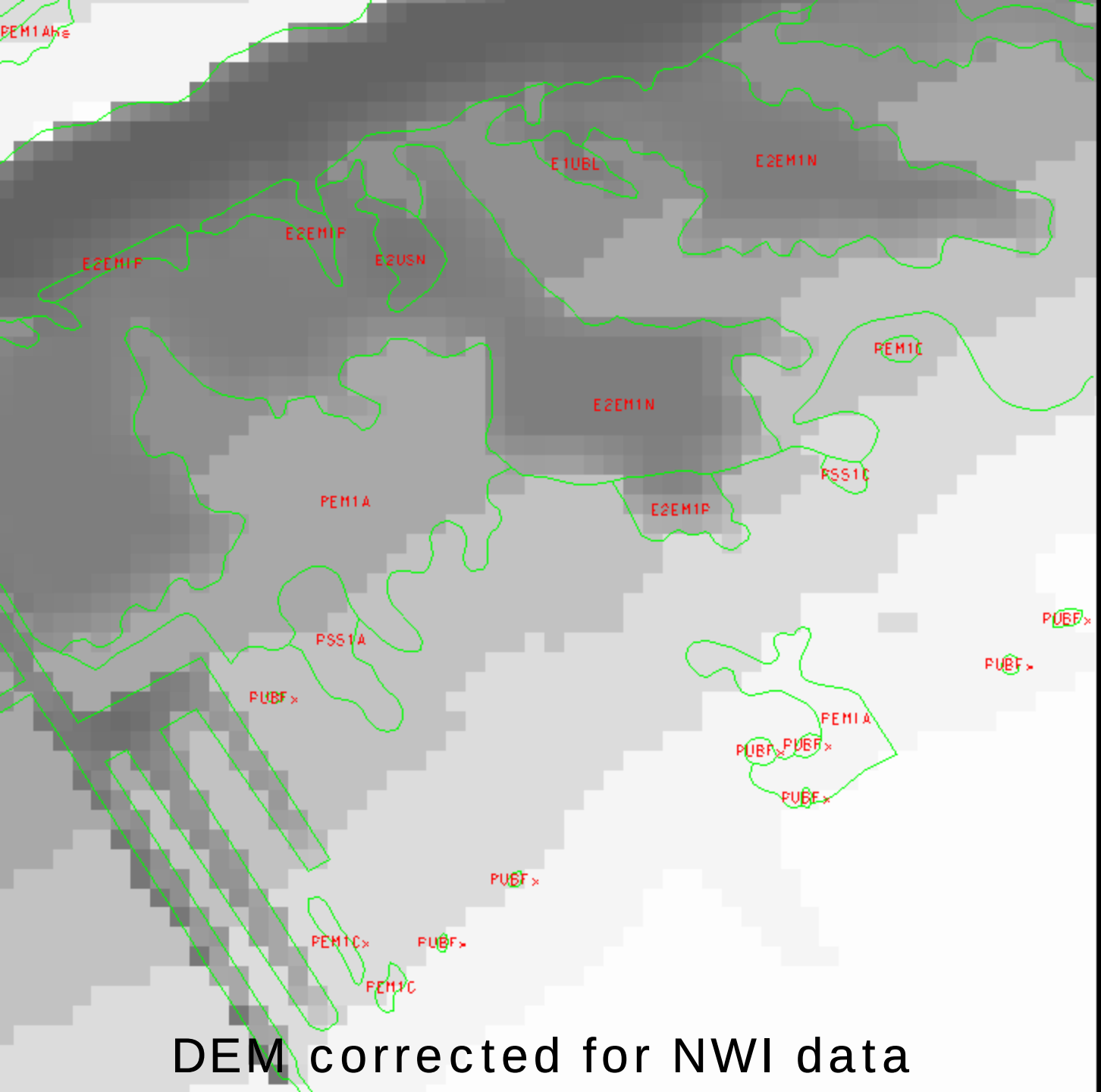
SLAMM 4.0 In Progress

Halt Execution | Hide Map | Hide Legend | Pixel Size: 1 2 3 4





Digital Elevation Model data

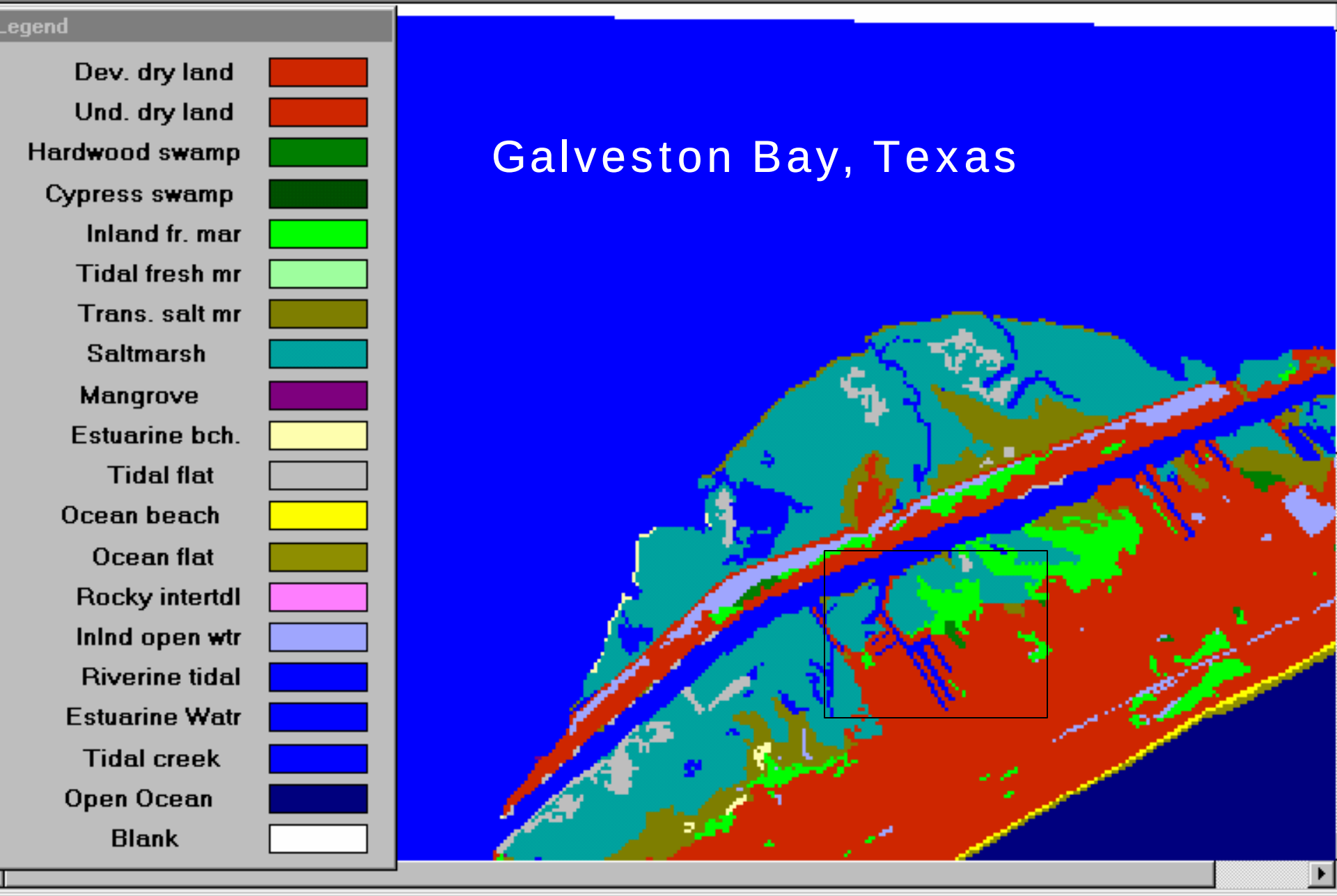


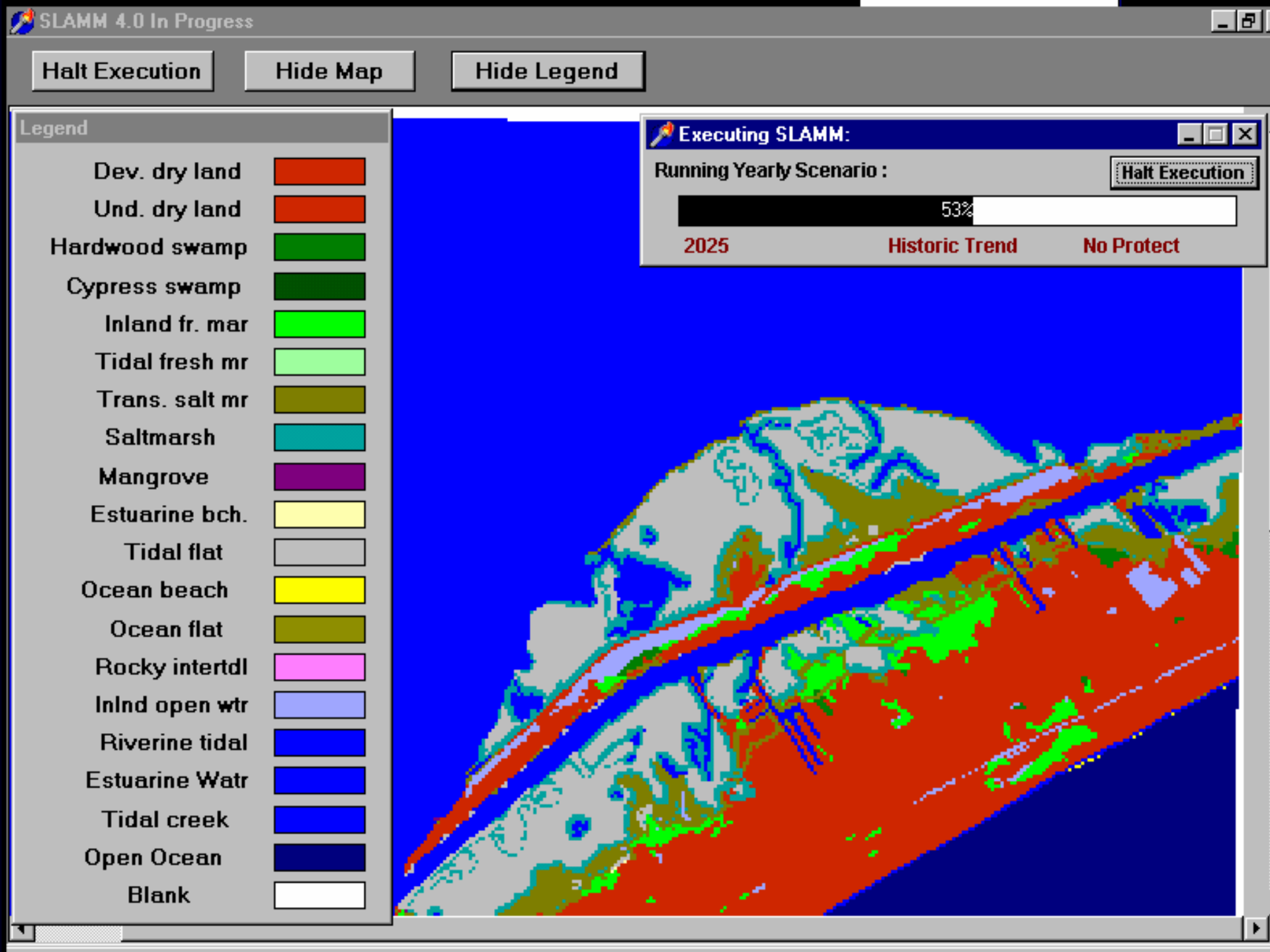
DEM corrected for NWI data


E1UBLx
EZBI1P
EZBI1N
PBI1A
PBI1C
PSS1A
PUBFx
PUBGx
PBI1Cx
PBI3C
U

SLAMM 4.0 In Progress

Halt Execution | Hide Map | Hide Legend | Pixel Size: 1 2 3 4

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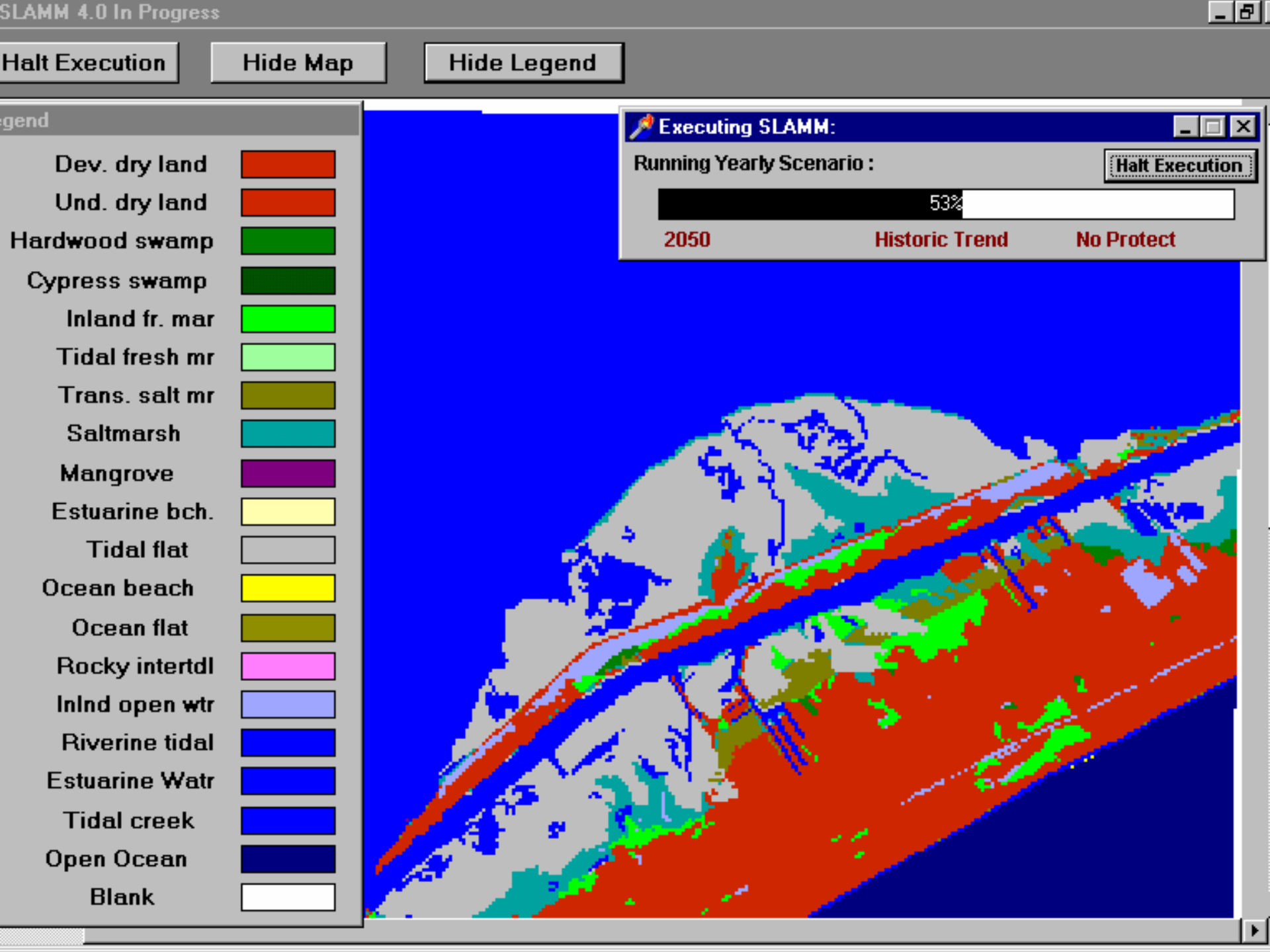
Hide Legend
Legend
Dev. dry land
Und. dry land
Hardwood swamp
Cypress swamp
Inland fr. mar
Tidal fresh mr
Trans. salt mr
Saltmarsh
Mangrove
Estuarine bch.
Tidal flat
Ocean beach
Ocean flat
Rocky intertdl
Inlnd open wtr
Riverine tidal
Estuarine Watr
Tidal creek
Open Ocean
Blank
Executing SLAMM:
Running Yearly Scenario :
Halt Execution
53%
2025
Historic Trend
No Protect


SLAMM 4.0 In Progress
Halt Execution
Hide Map
Hide Legend
egend
Dev. dry land
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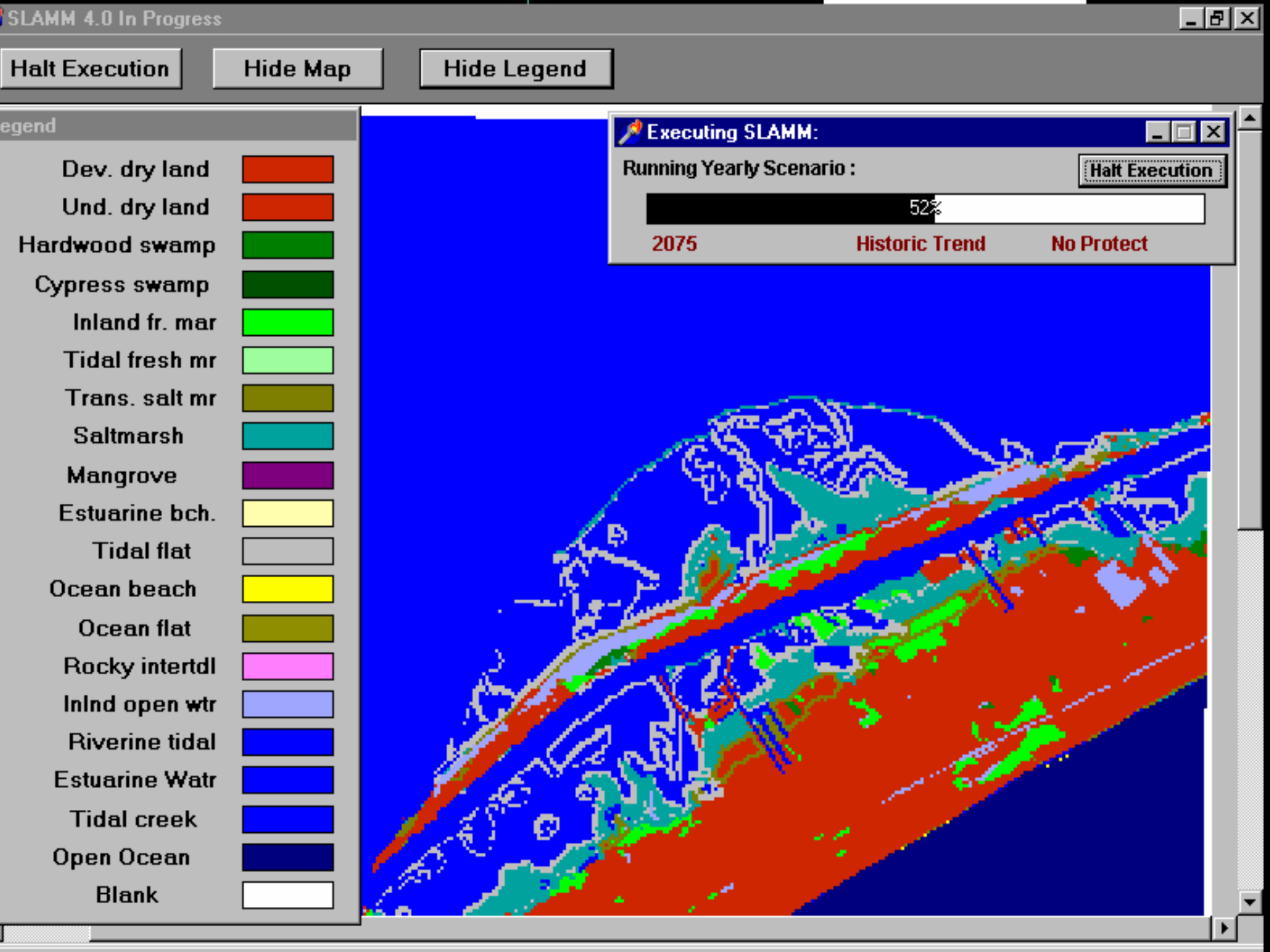
Inlnd open wtr
Riverine tidal
Estuarine Watr
Tidal creek
Open Ocean
Blank
Executing SLAMM:
Running Yearly Scenario :
Halt Execution
53%
2050
Historic Trend
No Protect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Halt Execution
Hide Map
Hide Legend
egend
Dev. dry land
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Hardwood swamp
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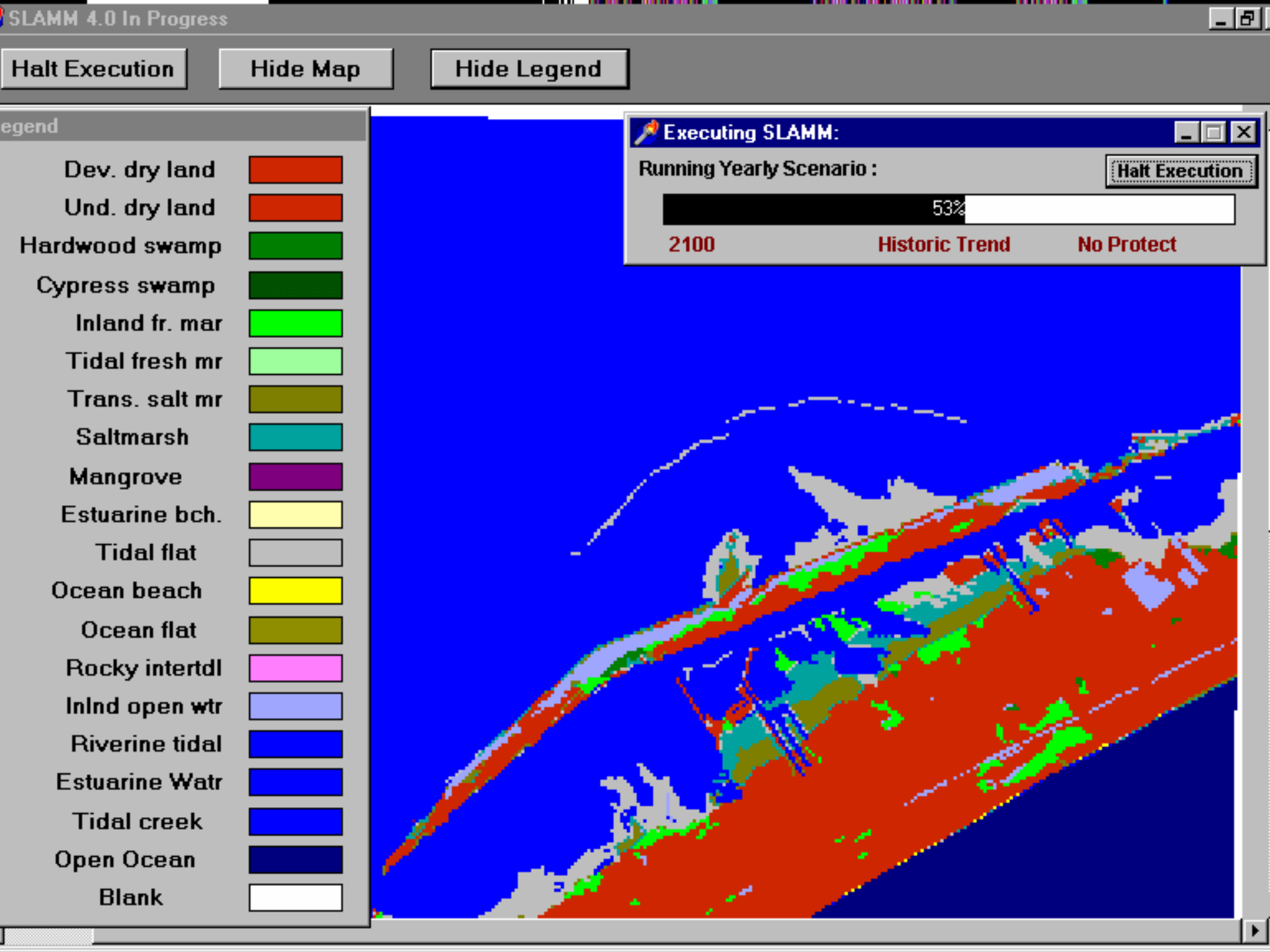
Ocean flat
Rocky intertdl
Inlnd open wtr
Riverine tidal
Estuarine Watr
Tidal creek
Open Ocean
Blank
Executing SLAMM:
Running Yearly Scenario :
Halt Execution
52%
2075
Historic Trend
No Protect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Halt Execution
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Dev. dry land
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Hardwood swamp
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Ocean flat
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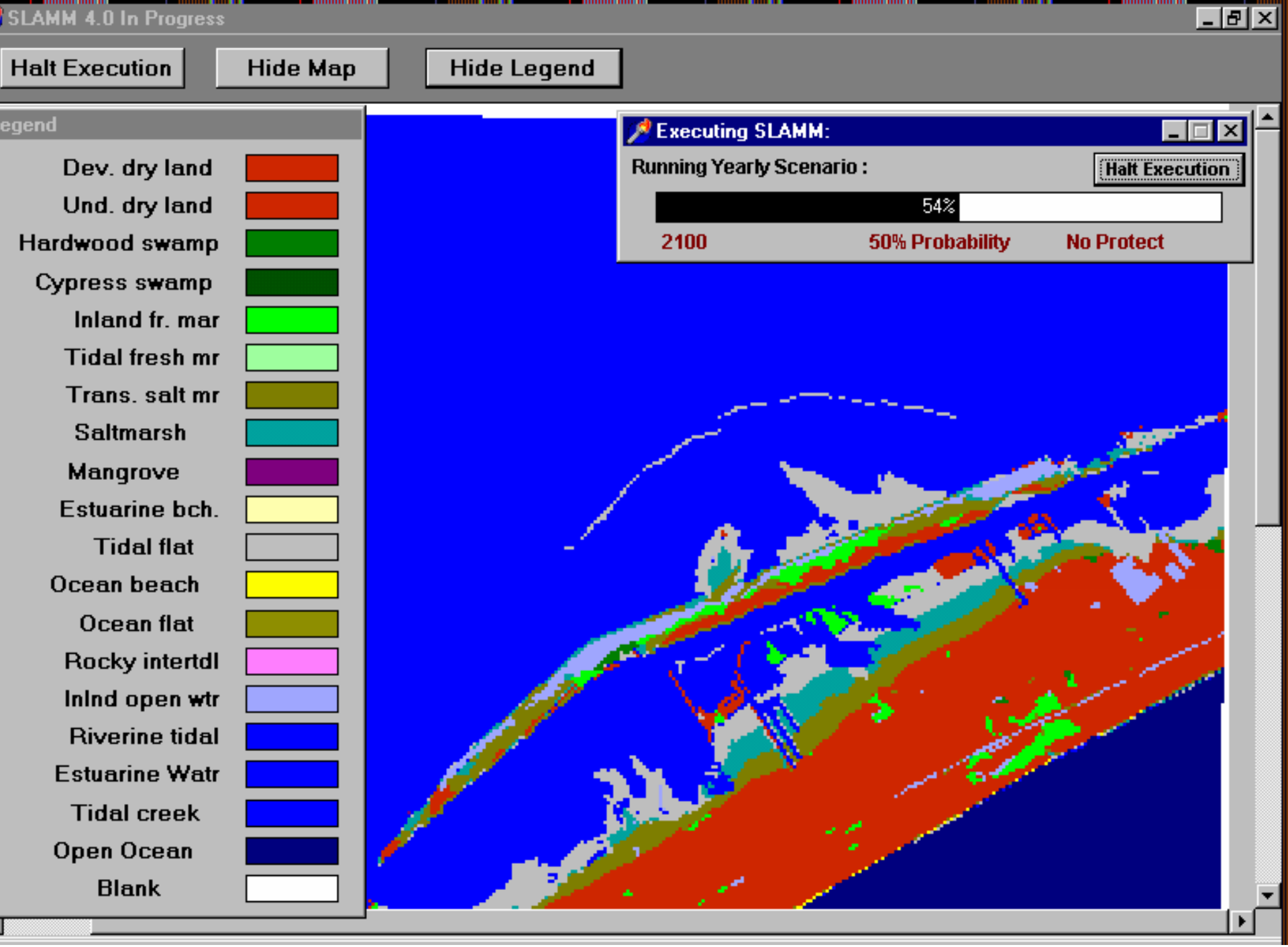
Inlnd open wtr
Riverine tidal
Estuarine Watr
Tidal creek
Open Ocean
Blank
Executing SLAMM:
Running Yearly Scenario :
Halt Execution
53%
2100
Historic Trend
No Protect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Halt Execution
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egend
Dev. dry land
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Hardwood swamp
Cypress swamp
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Tidal fresh mr
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Tidal flat
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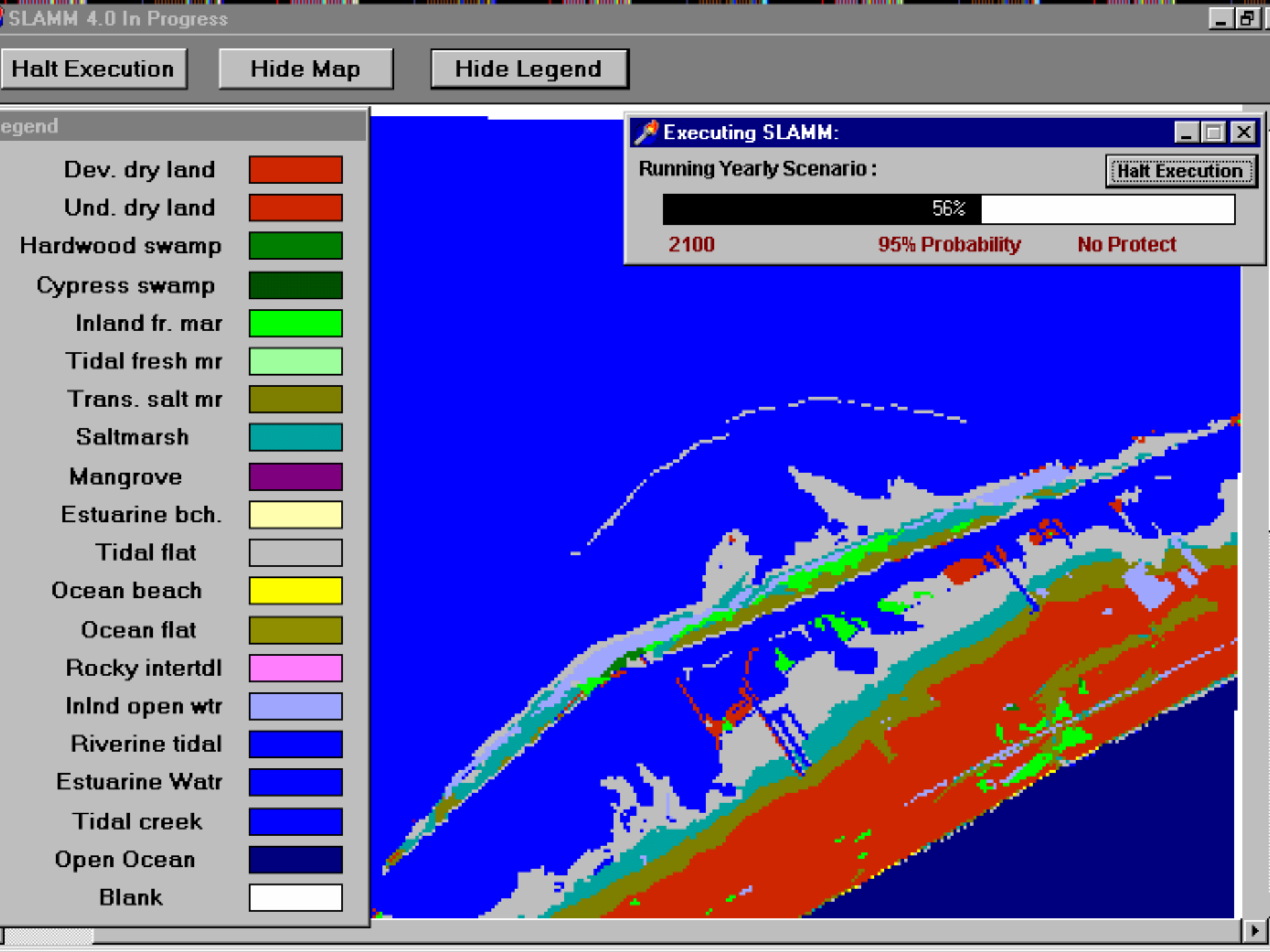
Ocean flat
Rocky intertdl
Inlnd open wtr
Riverine tidal
Estuarine Watr
Tidal creek
Open Ocean
Blank
Executing SLAMM:
Running Yearly Scenario :
Halt Execution
54%
2100
50% Probability
No Protect


SLAMM 4.0 In Progress
Halt Execution
Hide Map
Hide Legend
egend
Dev. dry land
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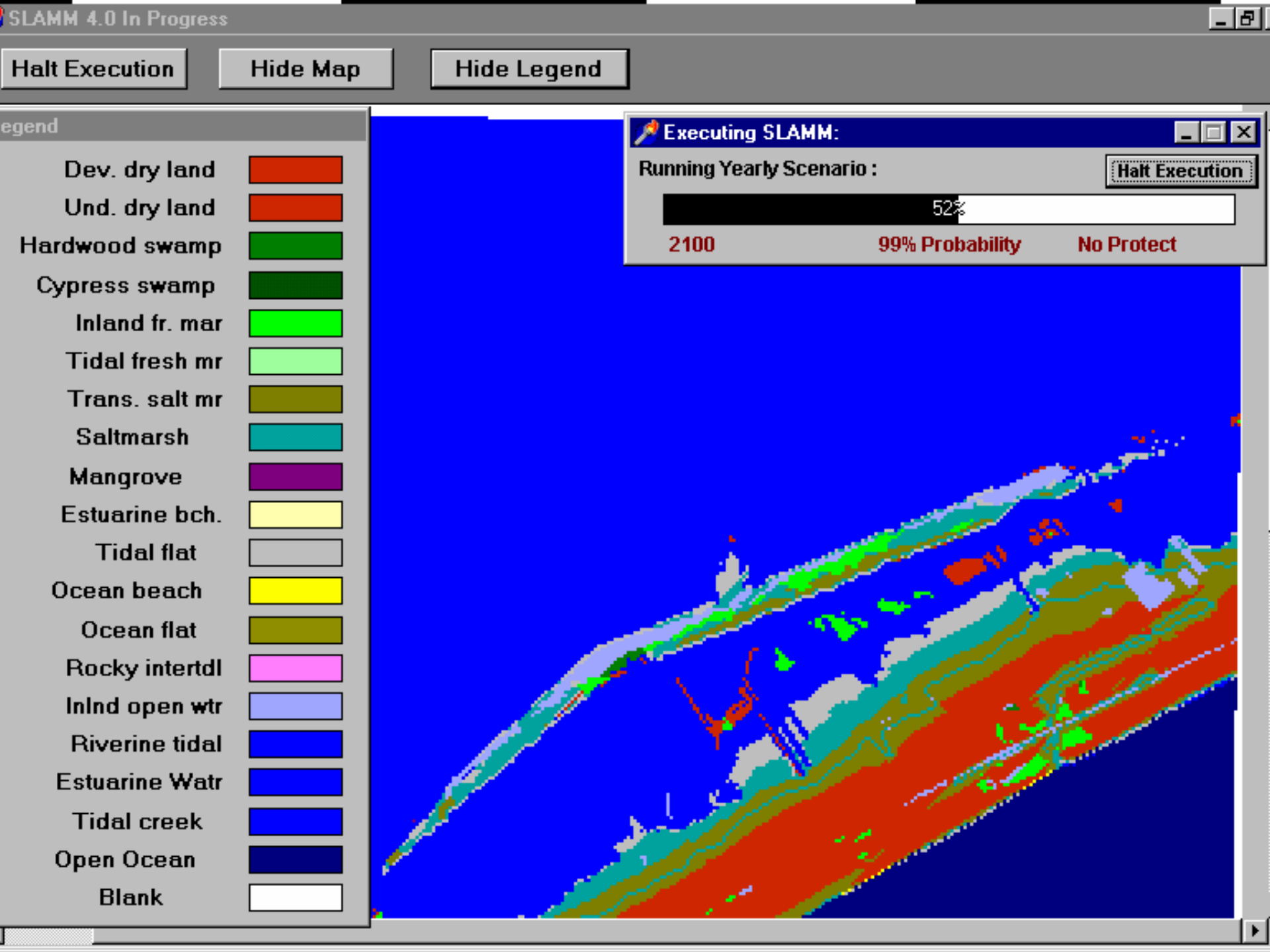
Ocean flat
Rocky intertdl
Inlnd open wtr
Riverine tidal
Estuarine Watr
Tidal creek
Open Ocean
Blank
Executing SLAMM:
Running Yearly Scenario :
Halt Execution
56%
2100
95% Probability
No Protect


SLAMM 4.0 In Progress
Halt Execution
Hide Map
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egend
Dev. dry land
Und. dry land
Hardwood swamp
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Estuarine bch.
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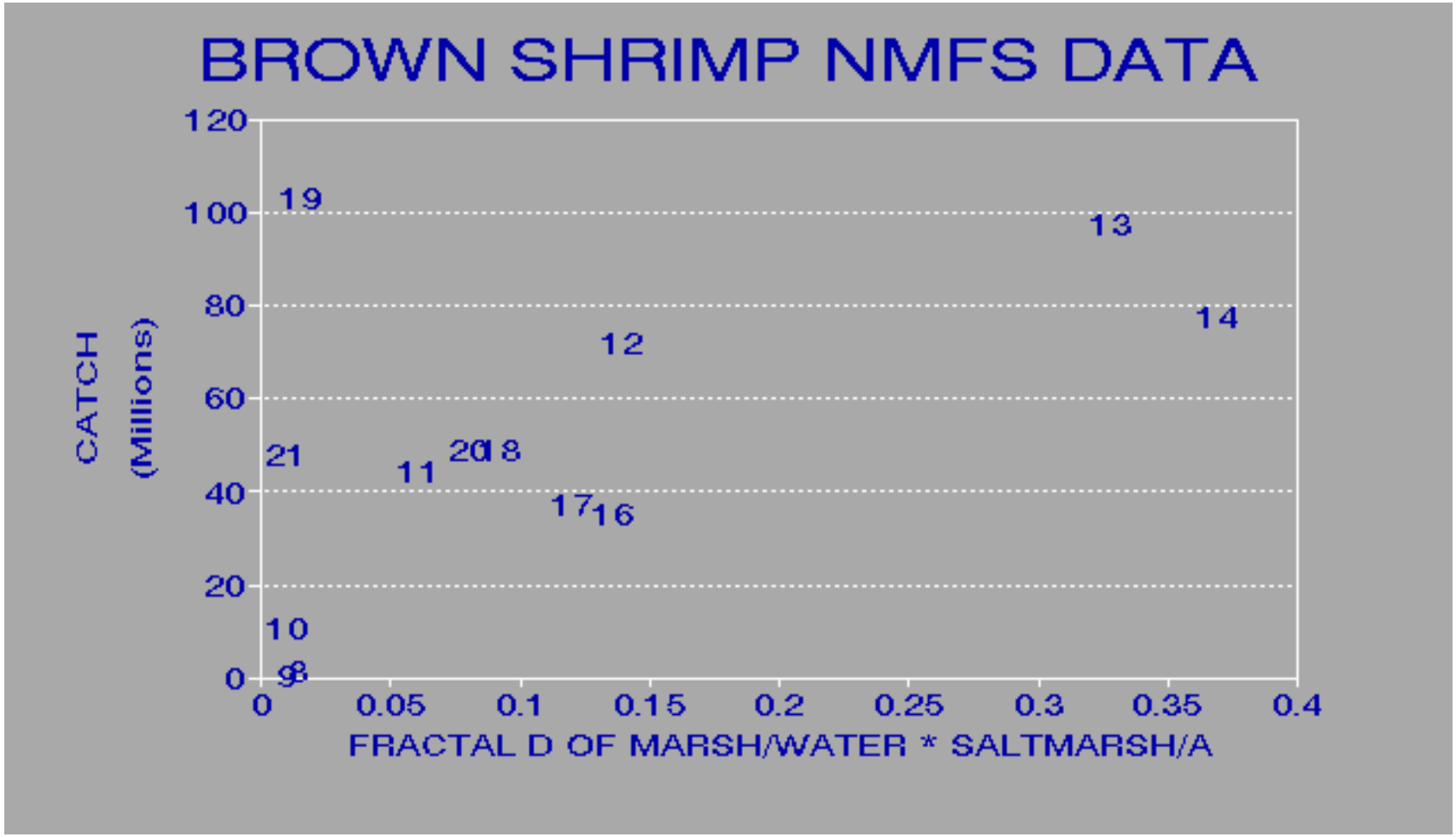
Ocean beach
Ocean flat
Rocky intertdl
Inlnd open wtr
Riverine tidal
Estuarine Watr
Tidal creek
Open Ocean
Blank
Executing SLAMM:
Running Yearly Scenario :
Halt Execution
52%
2100
99% Probability
No Protect

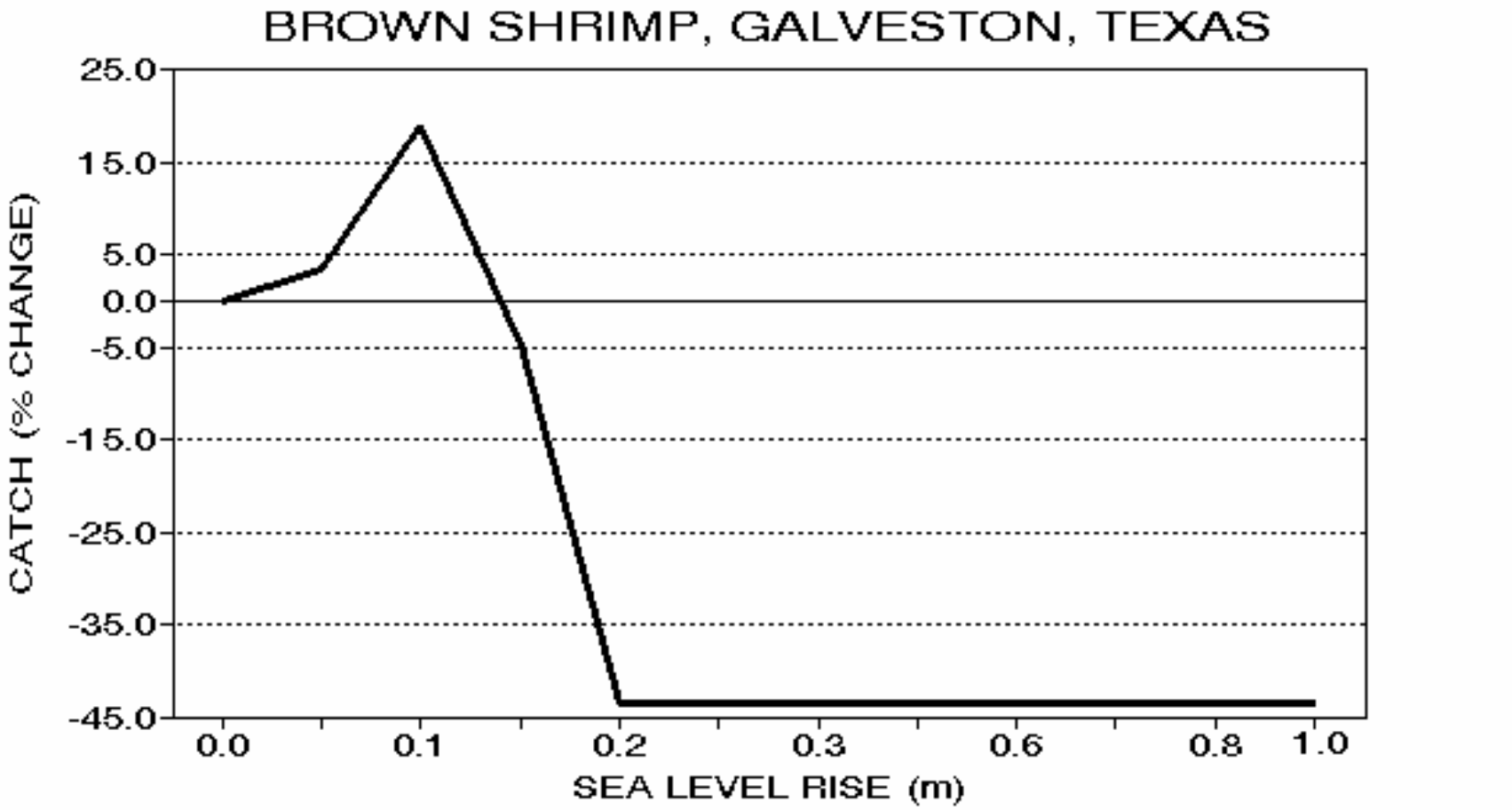
Impacts on coast

- Developments, especially finger-fill canal estates, flooded
- Vulnerability to storm surges increases
- Habitat for migratory shorebirds is lost
- Nursery areas for shrimp and other fisheries increase as marshes break up, then crash as areas are lost

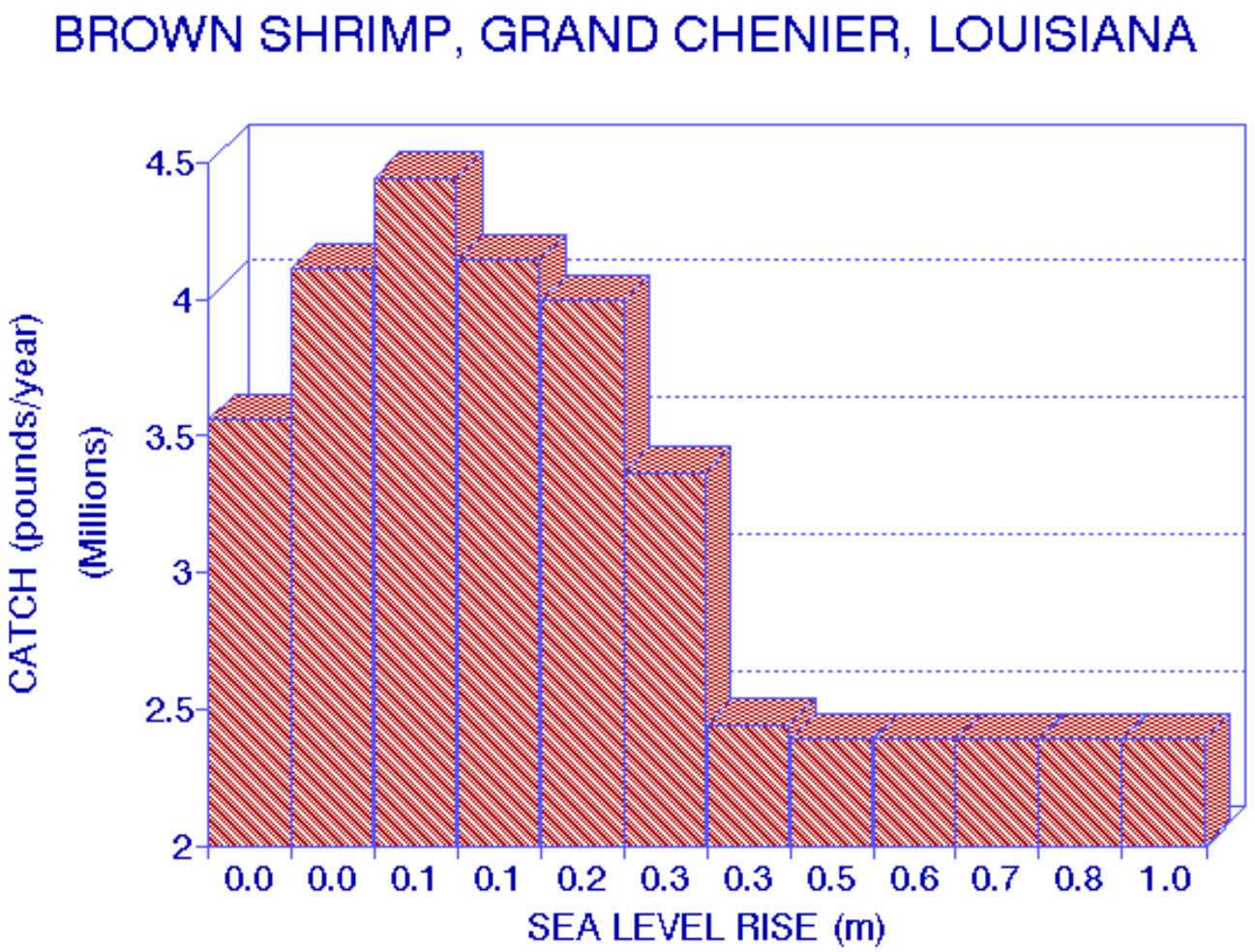
Shrimp catch was regressed on the fractal dimensions of adjacent marshes for Gulf statistical areas



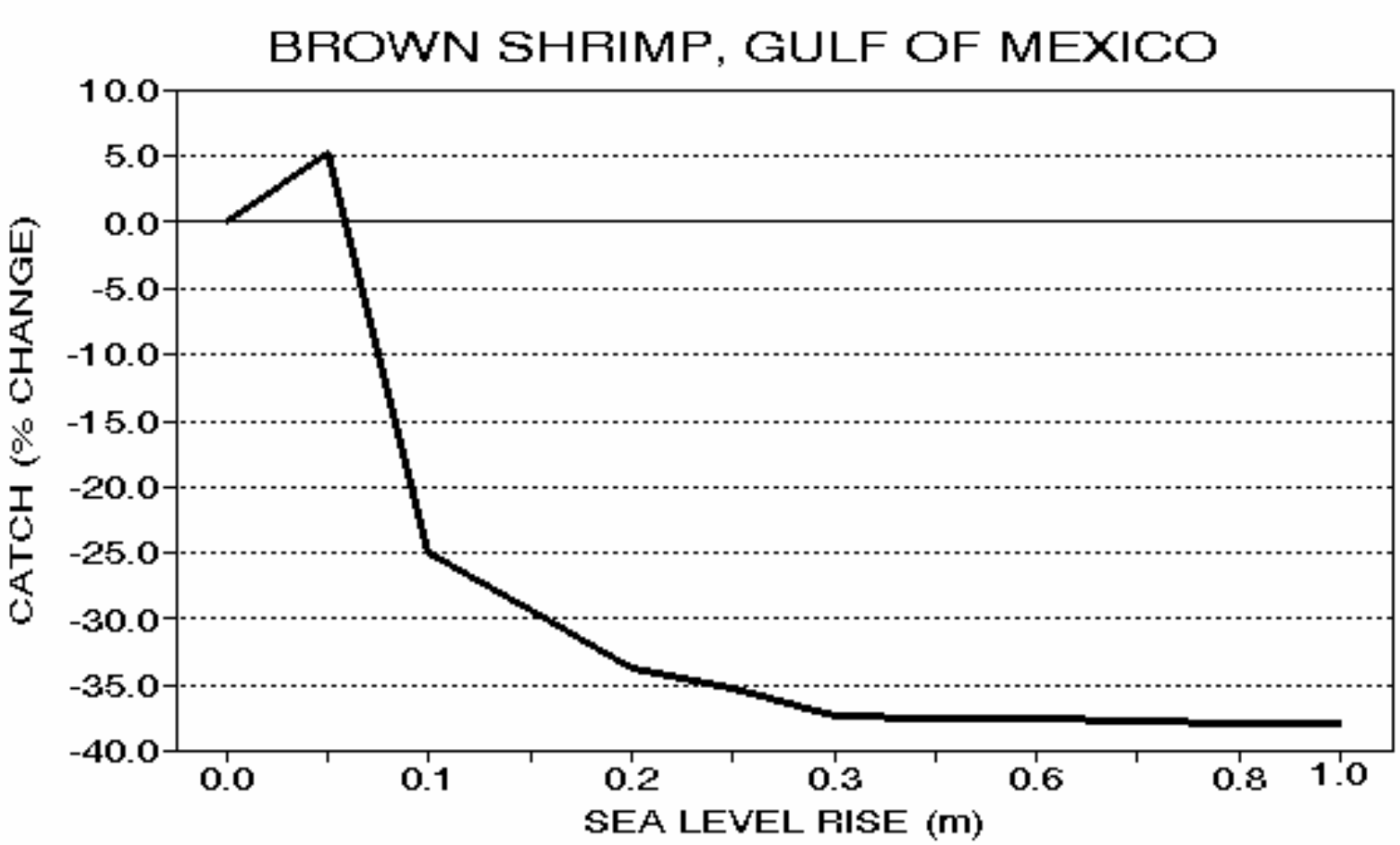
Predicted change in TX shrimp catch with sea-level rise (based on SLAMM2)



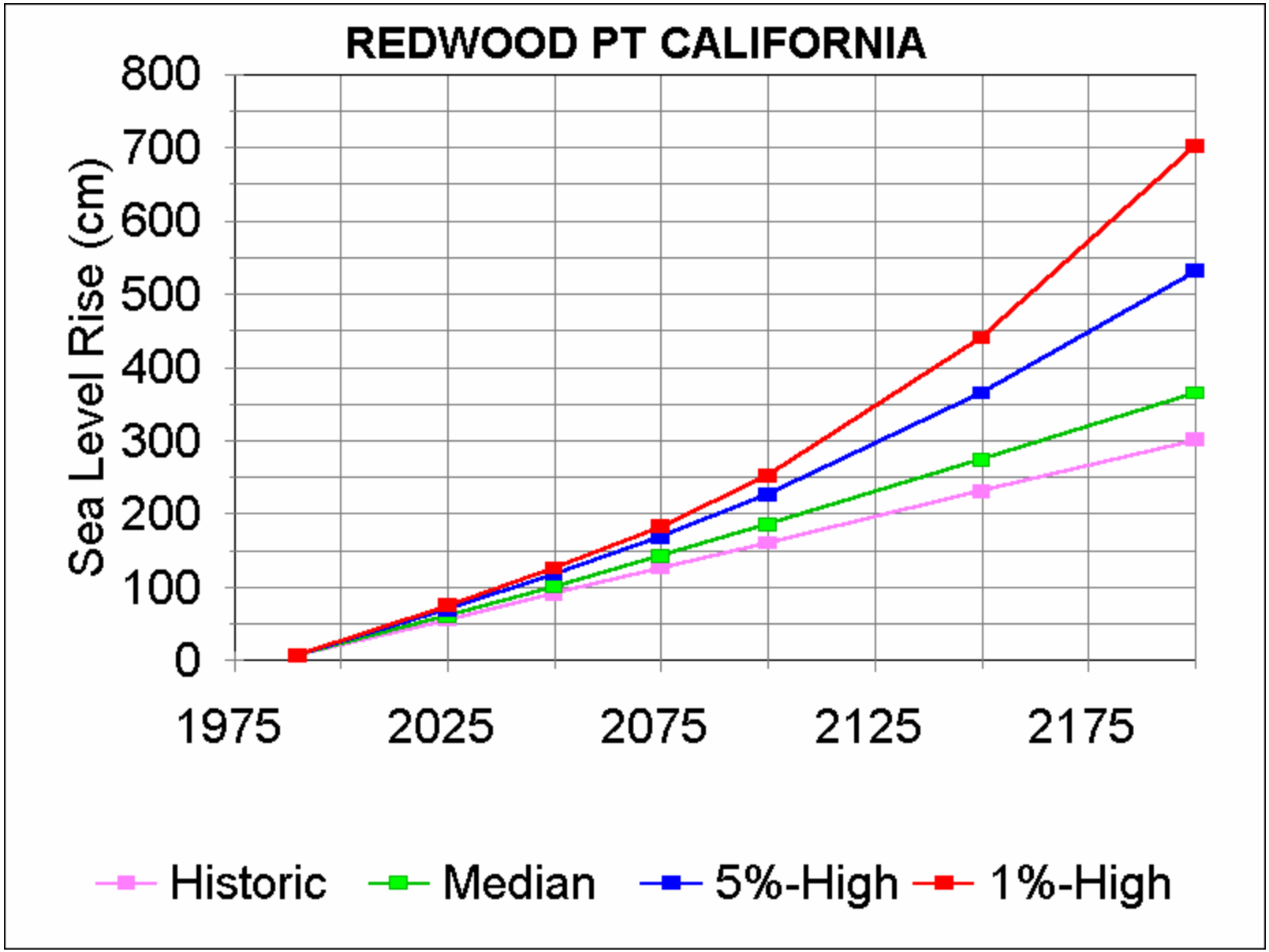
Louisiana catch could increase significantly before declining



Predicted change in Gulf shrimp catch with sea-level rise (based on SLAMM2)



South San Francisco Bay--even > subsidence



SLAMM 4.0 In Progress

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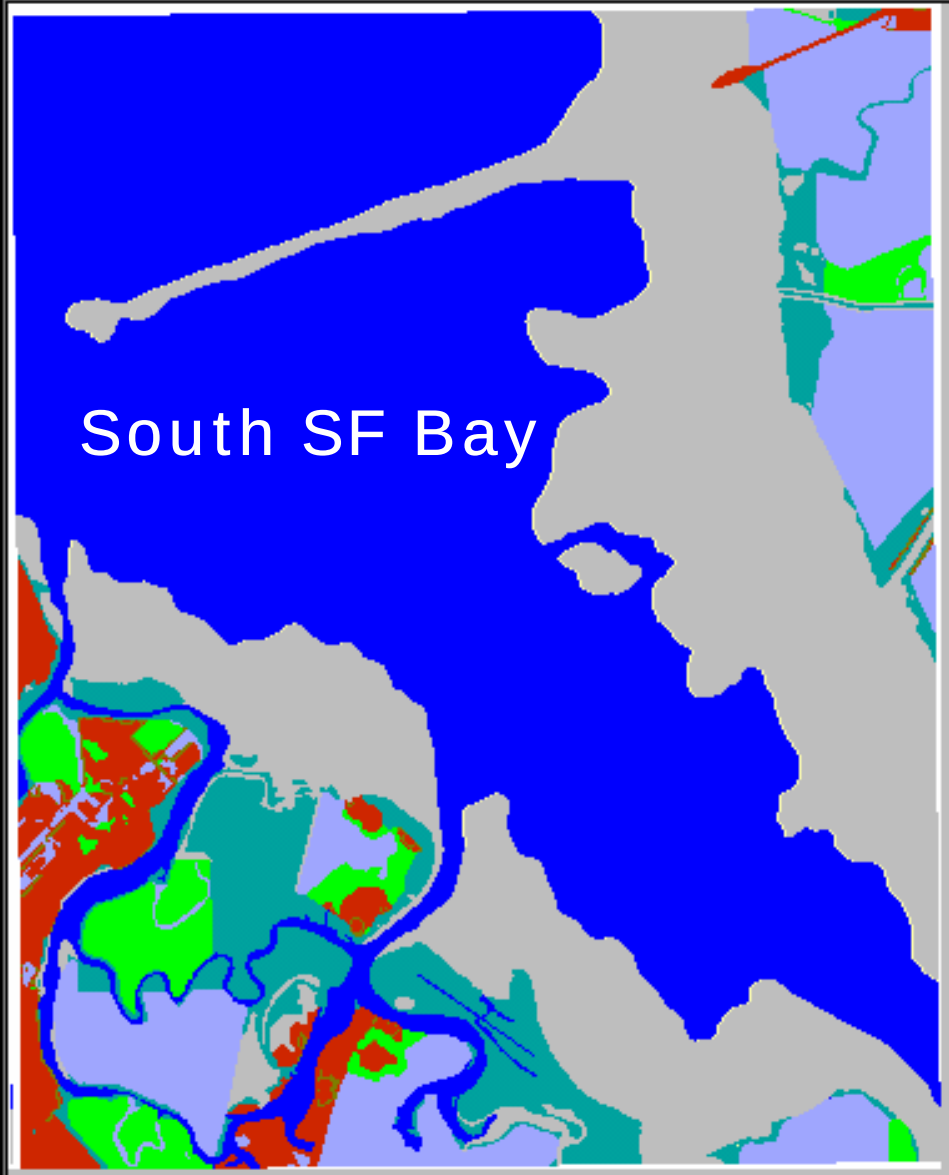


Legend

- Dev. dry land
- Und. dry land
- Hardwood swamp
- Cypress swamp
- Inland fr. mar
- Tidal fresh mr
- Trans. salt mr
- Saltmarsh
- Mangrove
- Estuarine bch.
- Tidal flat
- Ocean beach
- Ocean flat
- Rocky intertdl
- Inlnd open wtr
- Riverine tidal
- Estuarine Watr

Executing SLAMM:

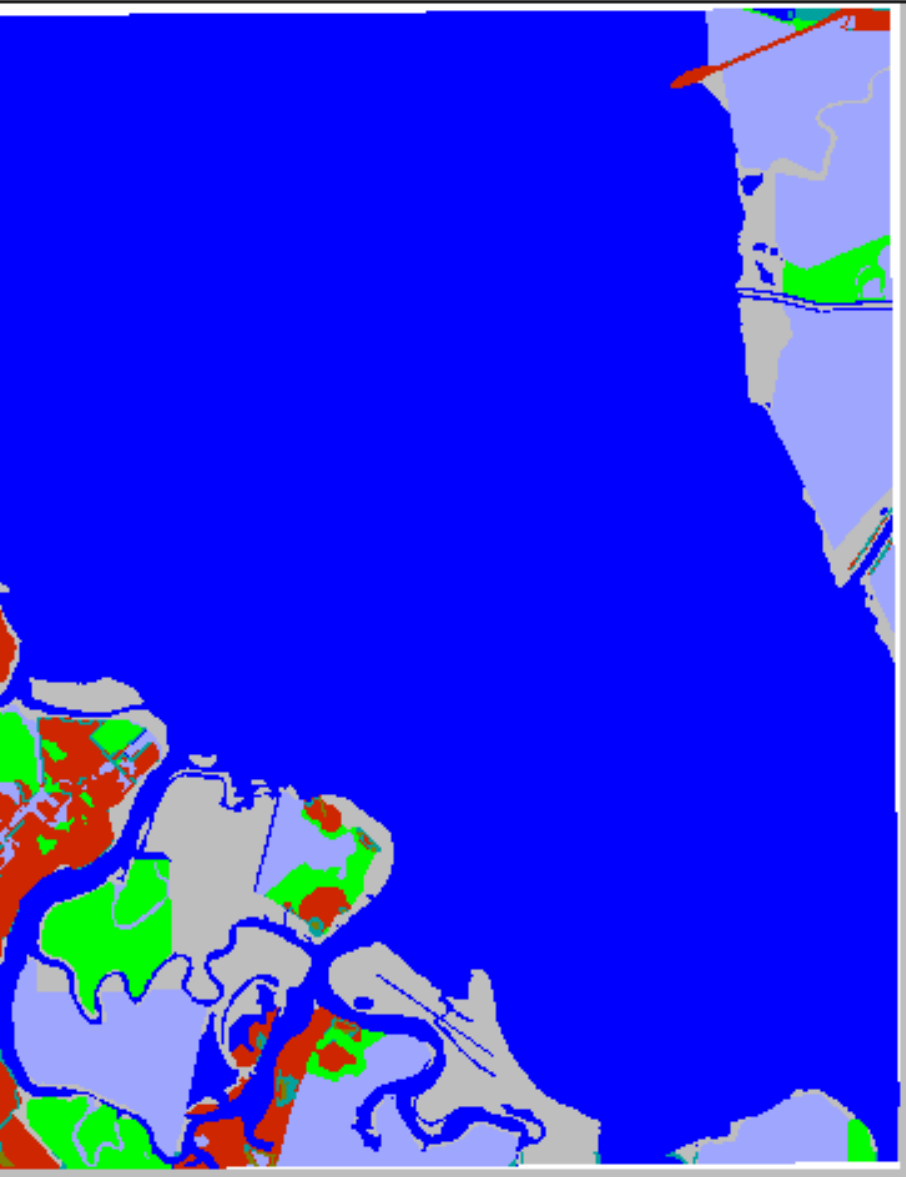
Running First Year

95%

1985 Historic Trend

SLAMM 4.0 In Progress

Halt Execution | Hide Map | Hide Legend



Legend

Dev. dry land	
Und. dry land	
Hardwood swamp	
Cypress swamp	
Inland fr. mar	
Tidal fresh mr	
Trans. salt mr	
Saltmarsh	
Mangrove	
Estuarine bch.	
Tidal flat	
Ocean beach	
Ocean flat	
Rocky intertdl	
Inlnd open wtr	
Riverine tidal	
Estuarine Watr	

Executing SLAMM:

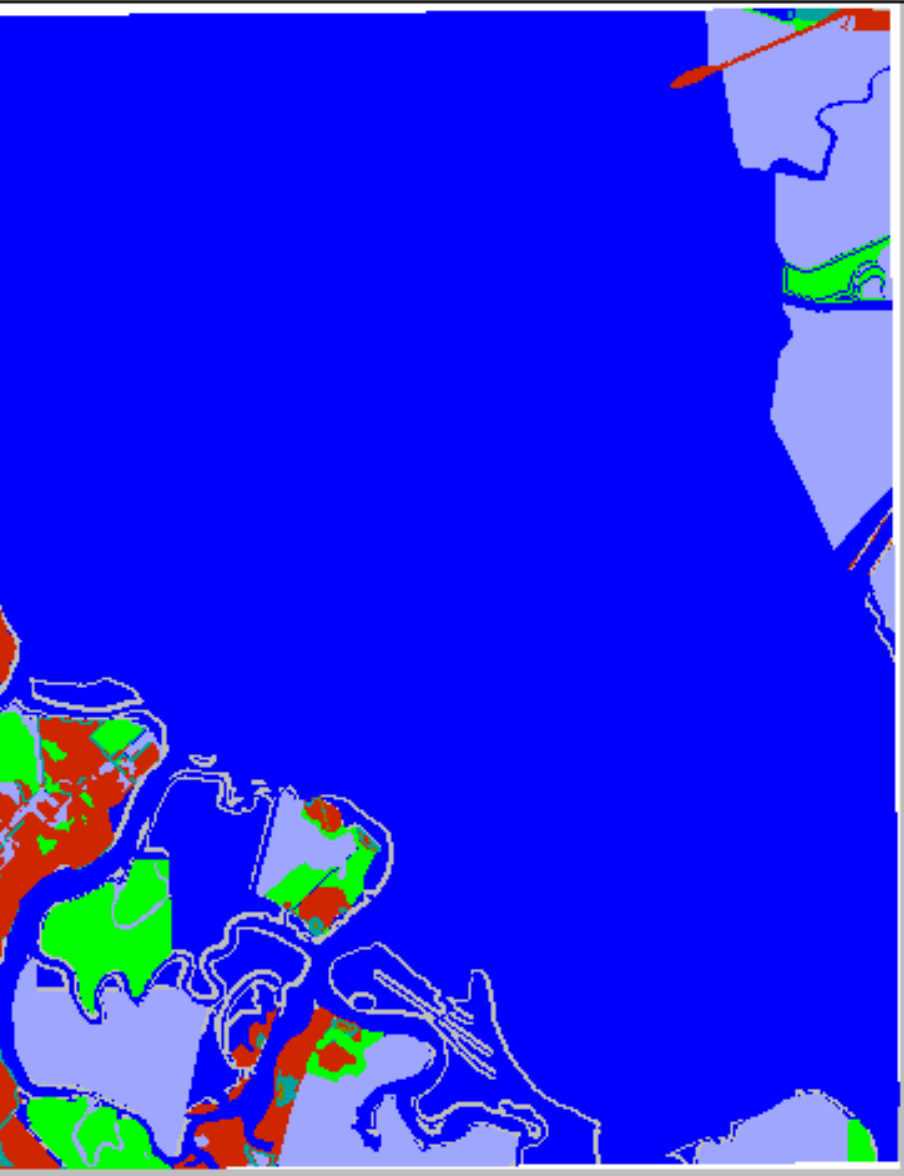
Running Yearly Scenario :

98%

2050 Historic Trend

SLAMM 4.0 In Progress

Halt Execution | Hide Map | Hide Legend



Legend

- Dev. dry land
- Und. dry land
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- Cypress swamp
- Inland fr. mar
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- Trans. salt mr
- Saltmarsh
- Mangrove
- Estuarine bch.
- Tidal flat
- Ocean beach
- Ocean flat
- Rocky intertdl
- Inlnd open wtr
- Riverine tidal
- Estuarine Watr

Executing SLAMM:

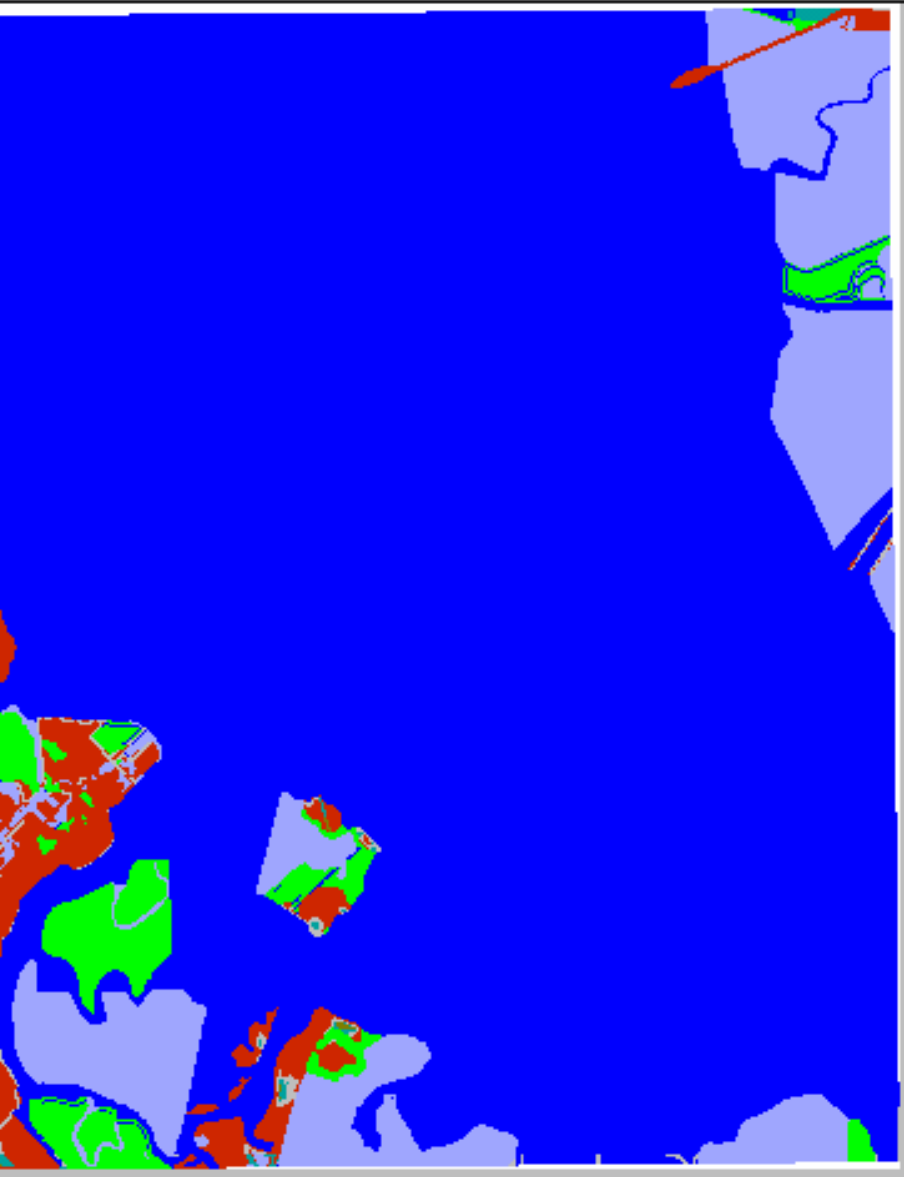
Running Yearly Scenario :

50%

2100 Historic Trend

SLAMM 4.0 In Progress

Halt Execution | Hide Map | Hide Legend



Legend

Dev. dry land	
Und. dry land	
Hardwood swamp	
Cypress swamp	
Inland fr. mar	
Tidal fresh mr	
Trans. salt mr	
Saltmarsh	
Mangrove	
Estuarine bch.	
Tidal flat	
Ocean beach	
Ocean flat	
Rocky intertdl	
Inlnd open wtr	
Riverine tidal	
Estuarine Watr	

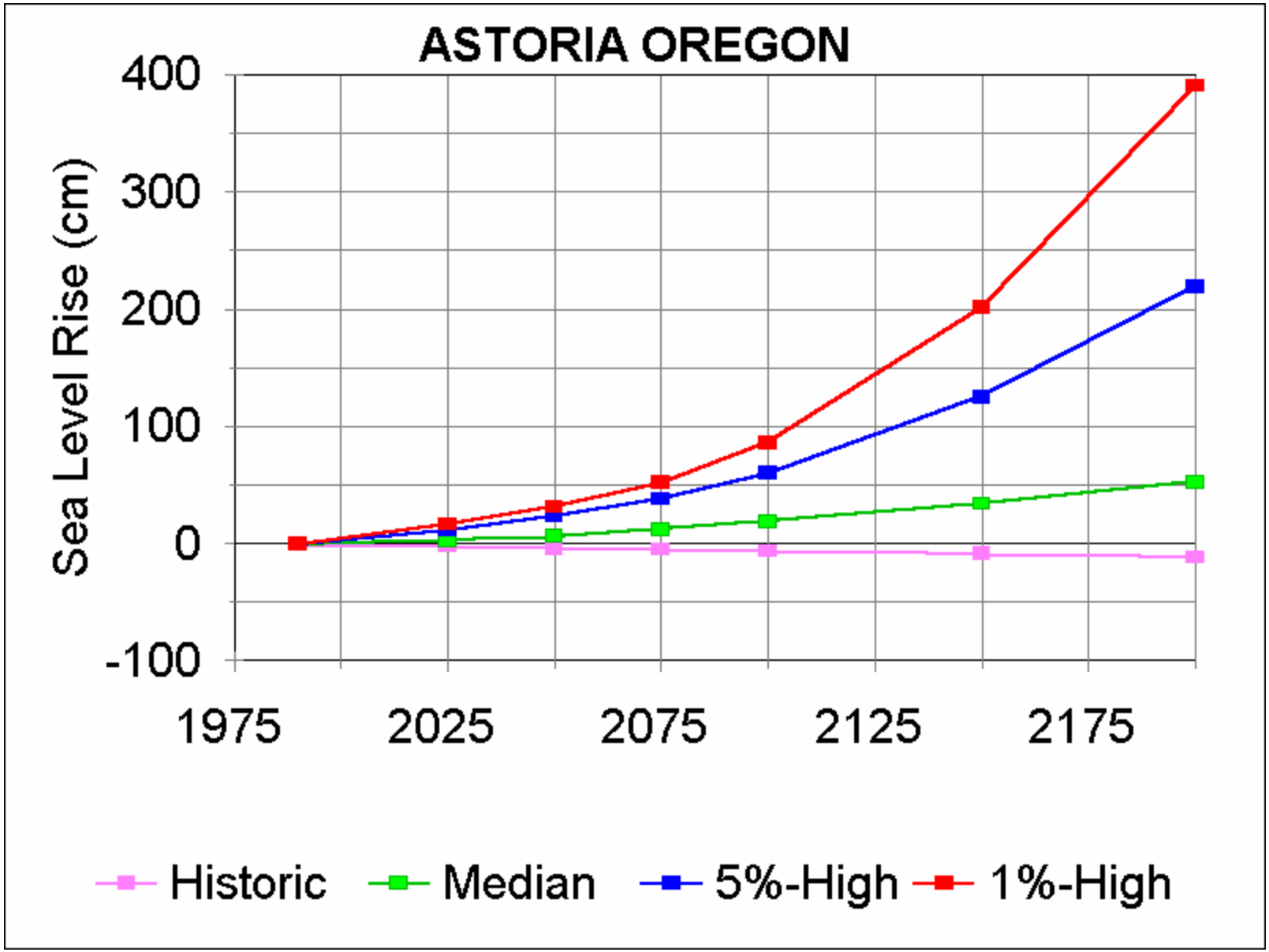
Executing SLAMM:

Running Yearly Scenario :

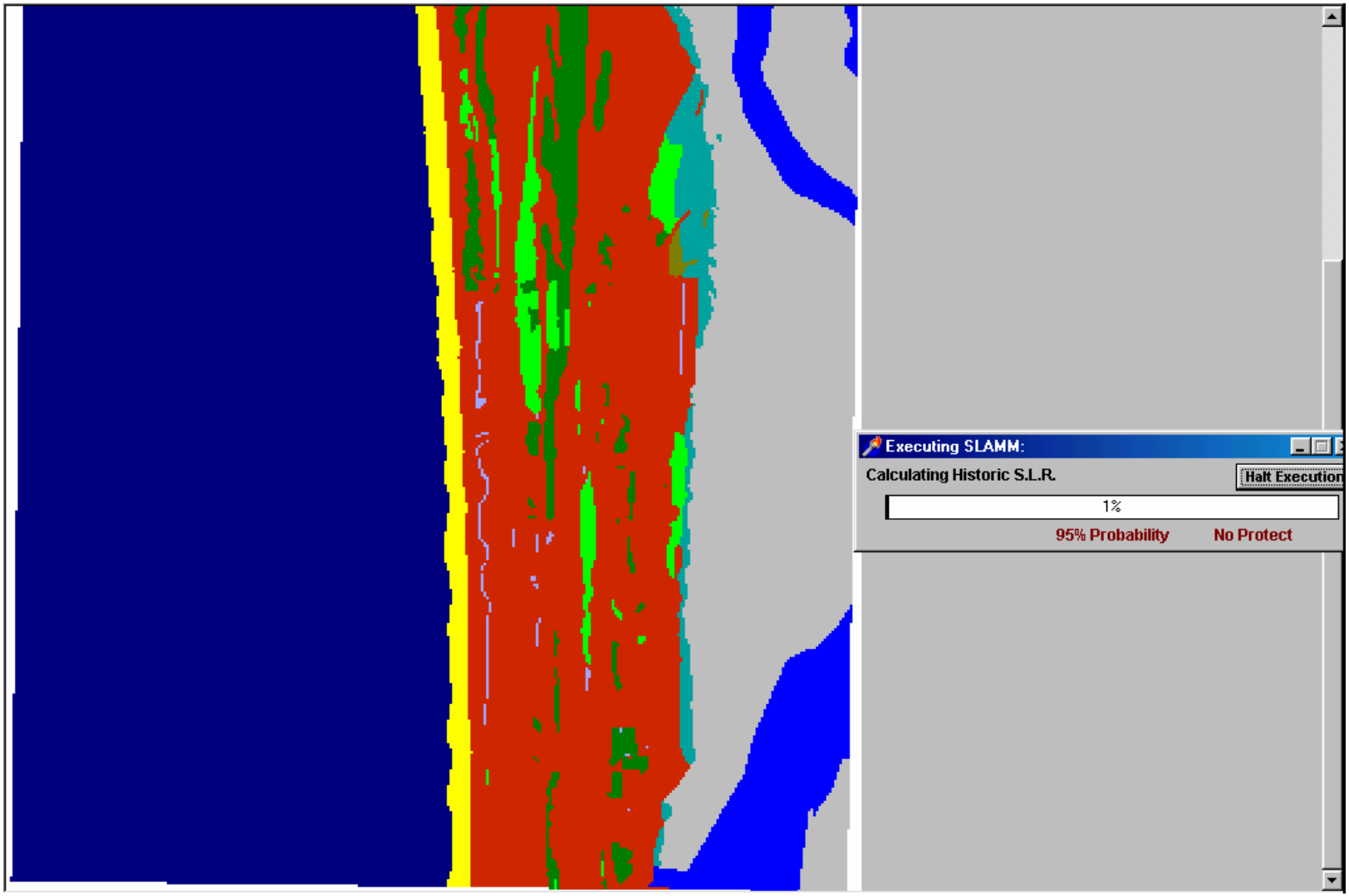
98%

2100 Historic Trend

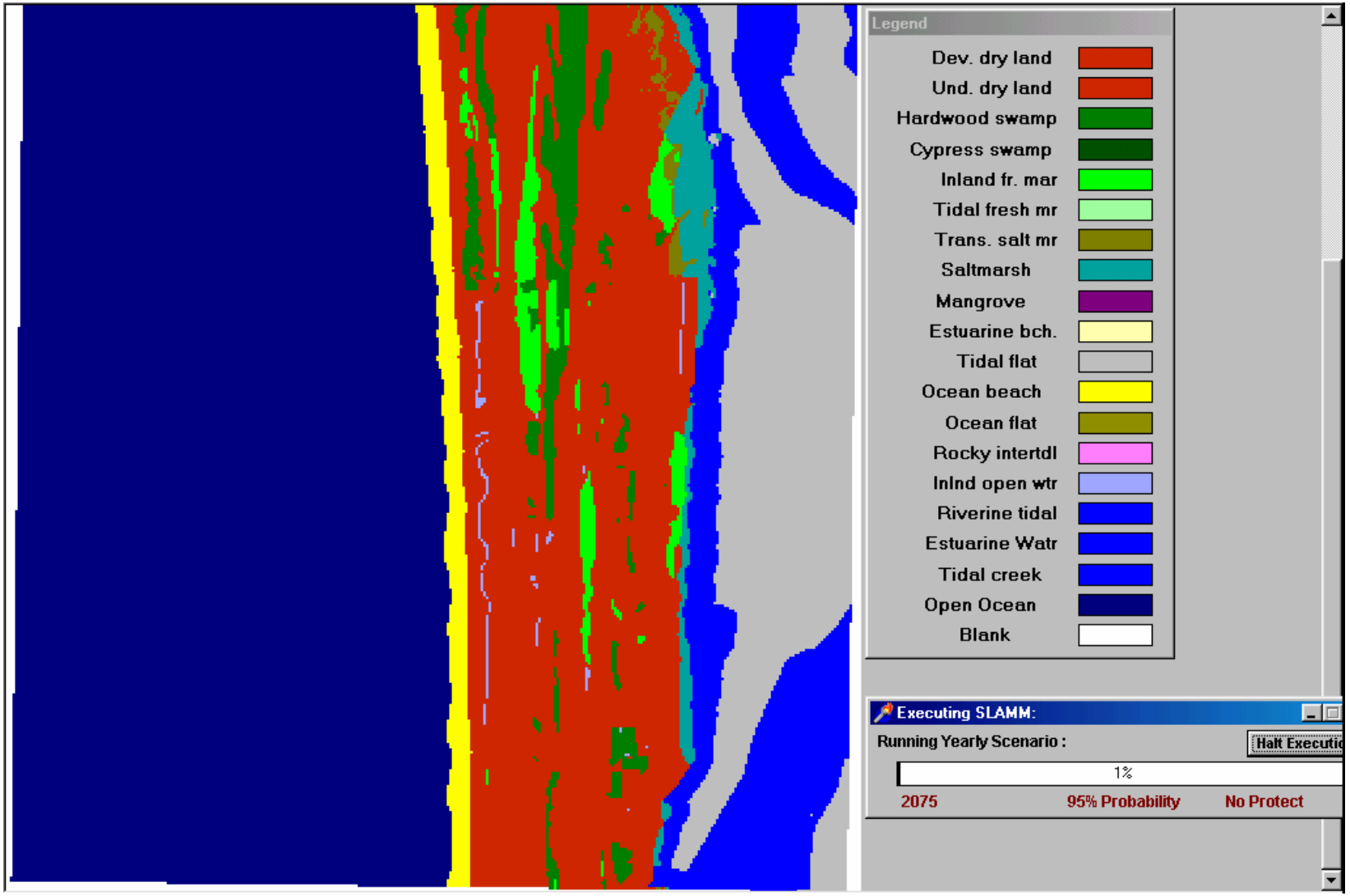
Parts of Pacific Northwest are rising but can still be affected by sea-level rise



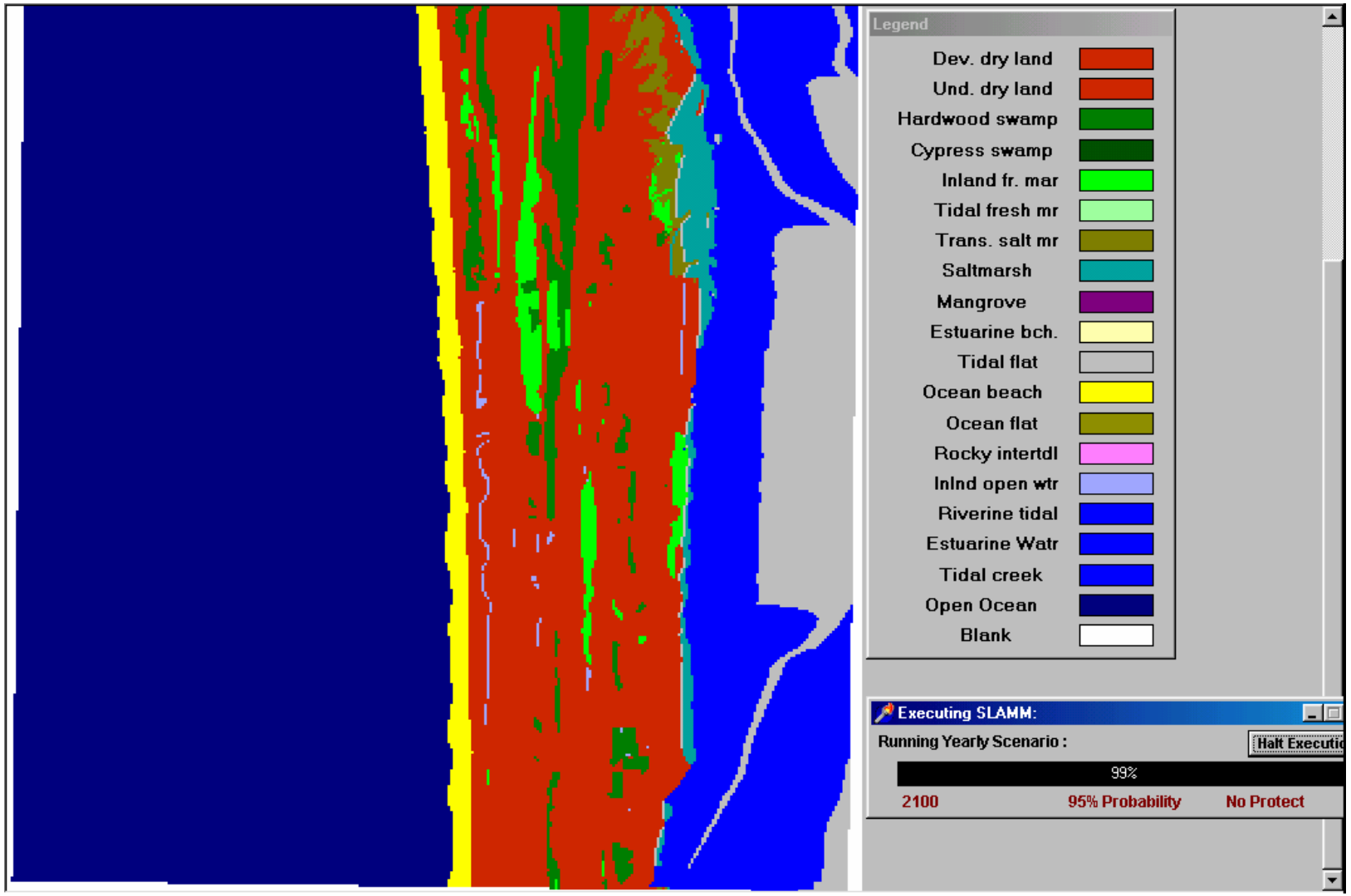
Oysterville, Washington, Initial Conditions



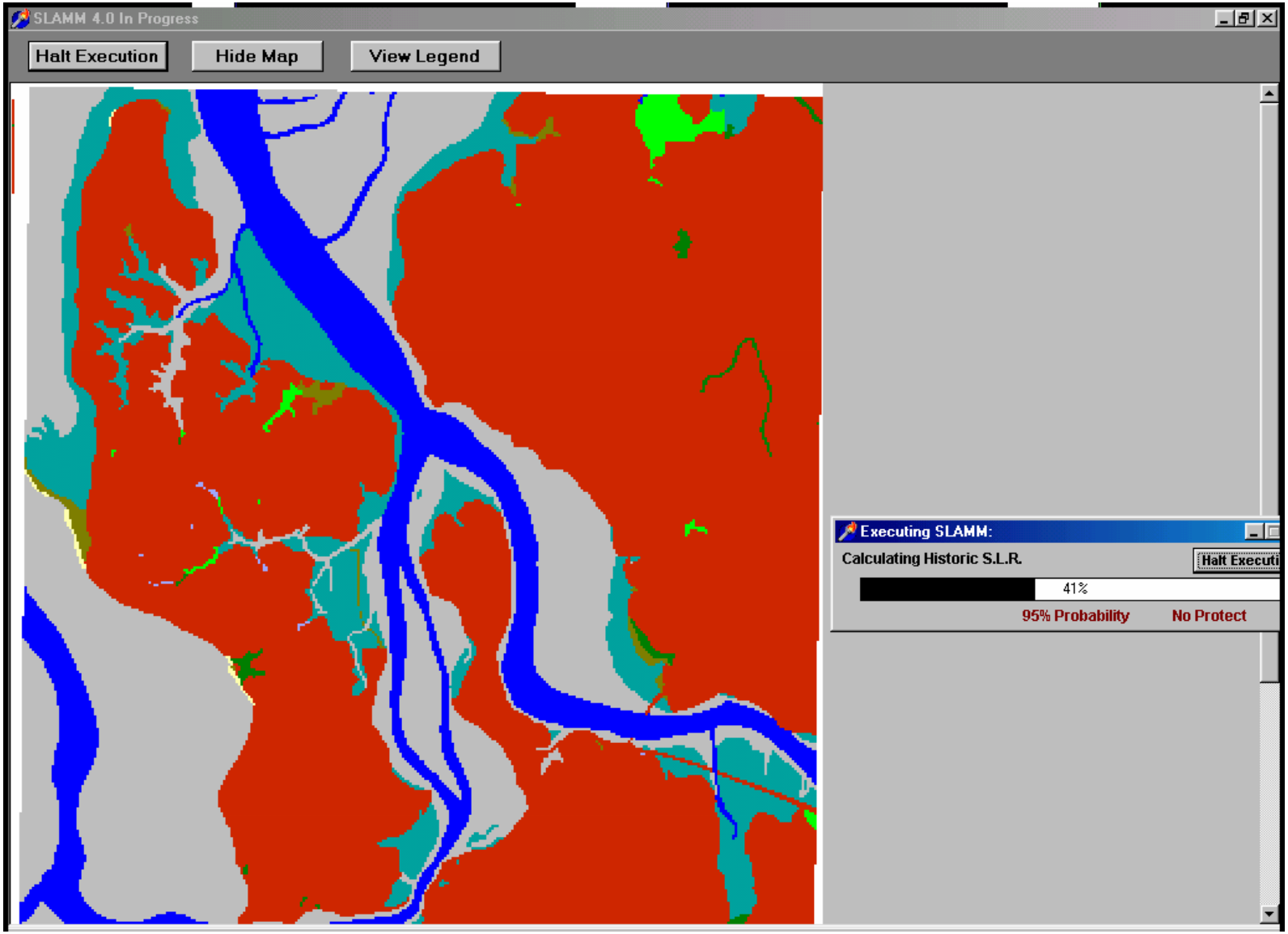
Oysterville, WA, 2050 High SLR



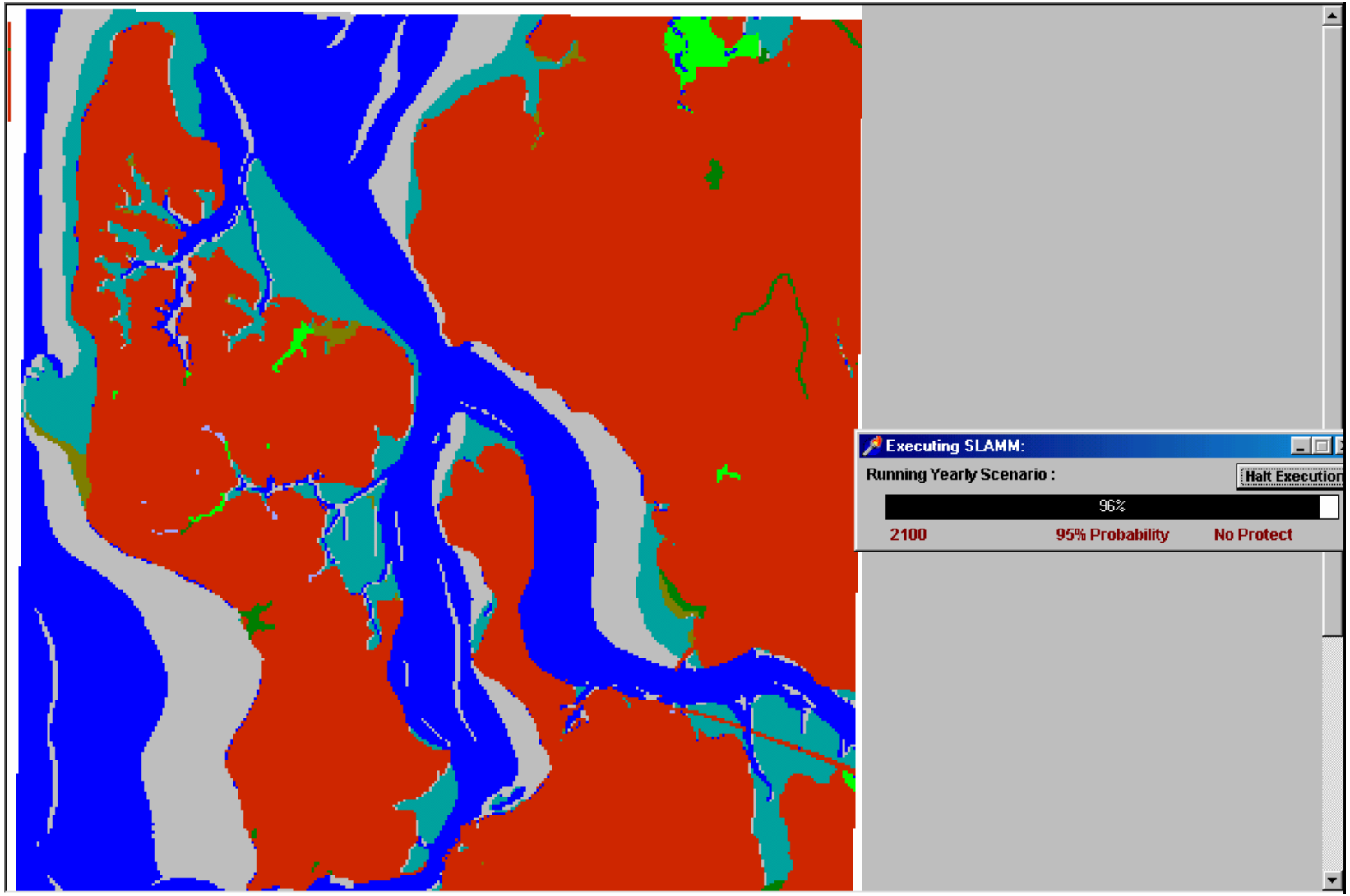
Oystervill, WA, 2100 High SLR



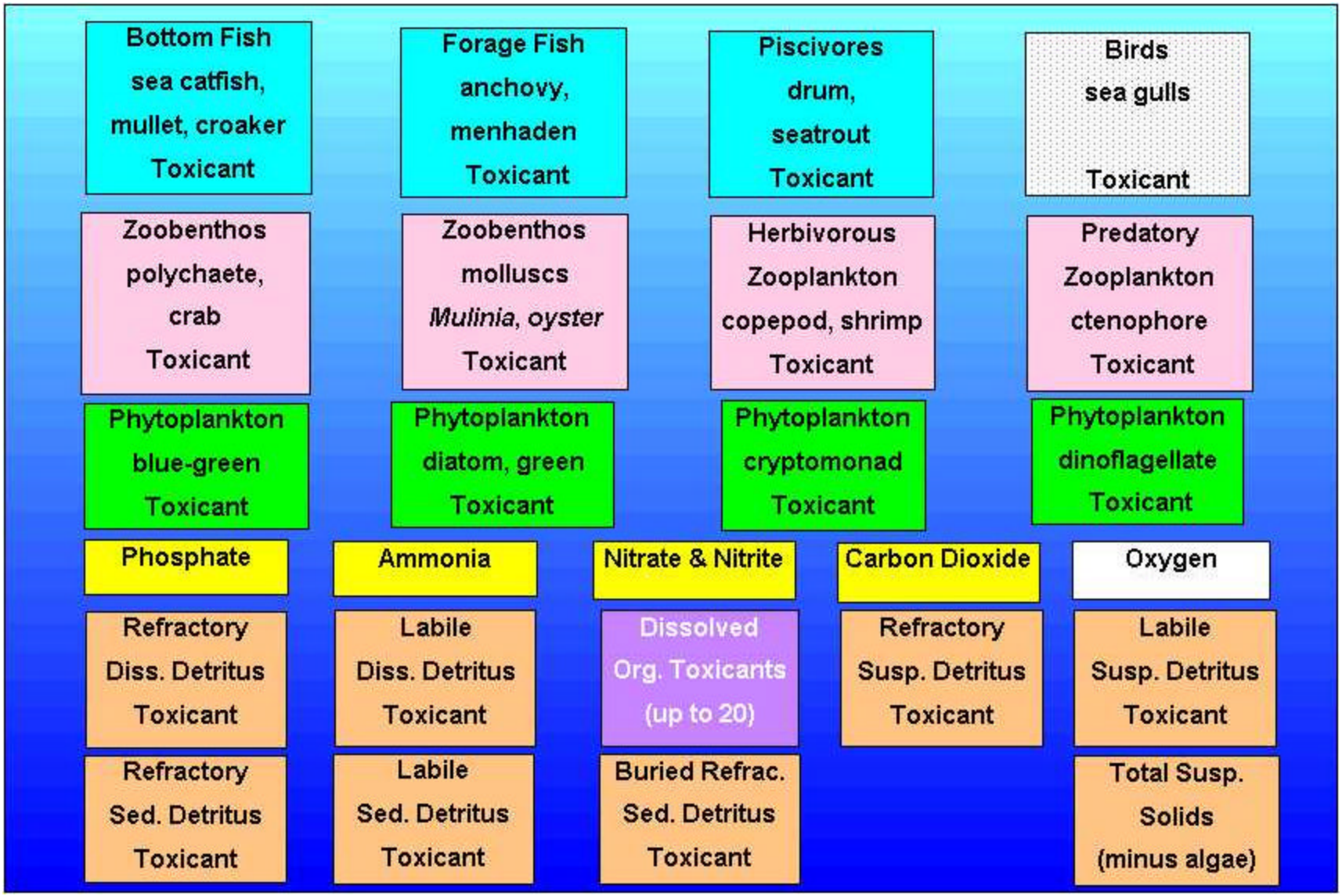
E. Willapa Bay, WA, Initial Conditions (area of high relief, poor elev. data)



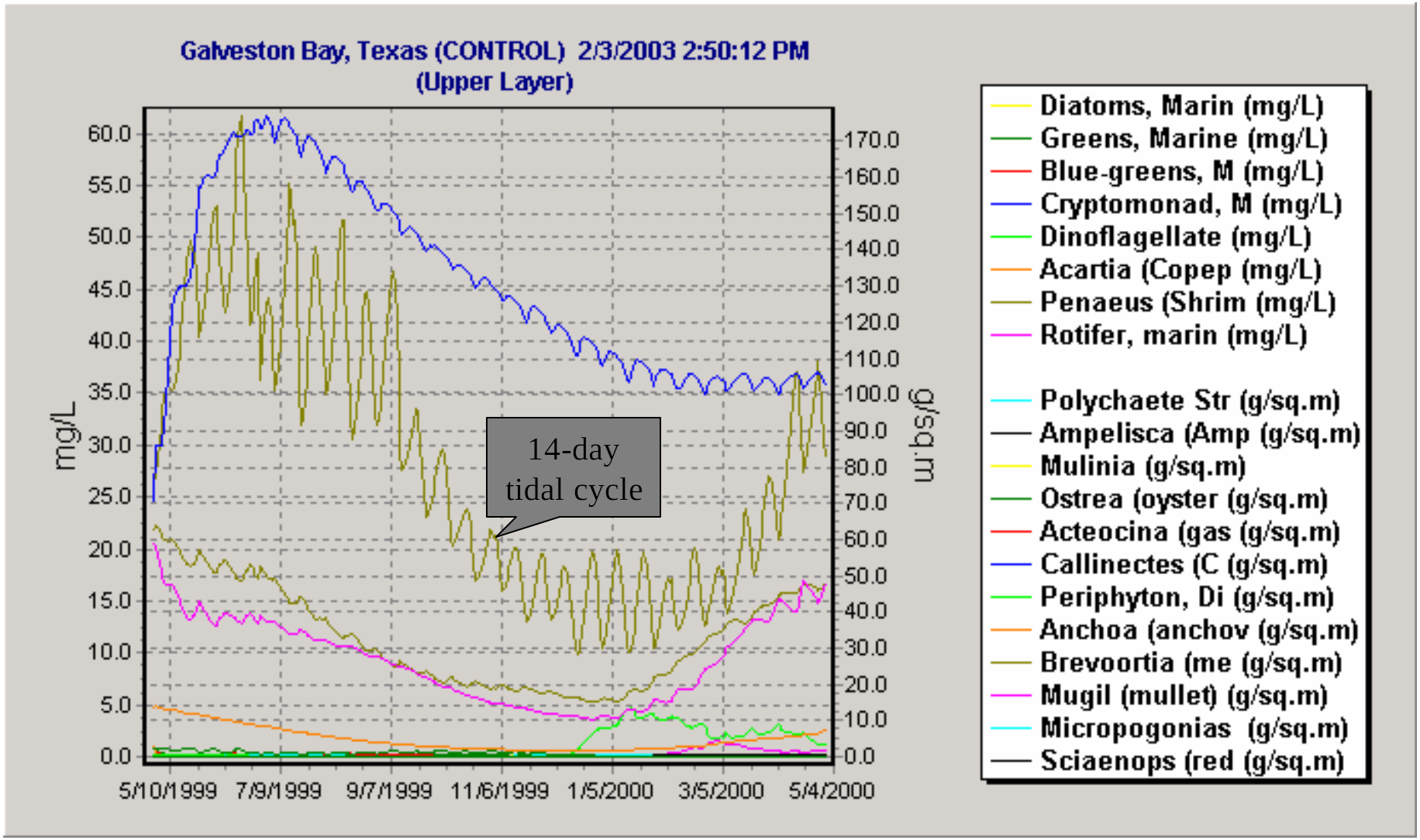
E. Willapa Bay, WA, 2100, High SLR



Galveston Bay, Texas, AQUATOX compartments



AQUATOX can model biomass of commercial and other species in upper and lower layers



What's next?

- High-resolution elevational data for coastal areas likely to be inundated
- Subsidence trends over time (not linear)
- Include seagrasses/macrophytes (subtidal habitat)
- Model Alaskan coast?
- Link to an ecosystem model such as AQUATOX (now able to simulate Galveston Bay)
- http://myweb.cableone.net/dickpark/