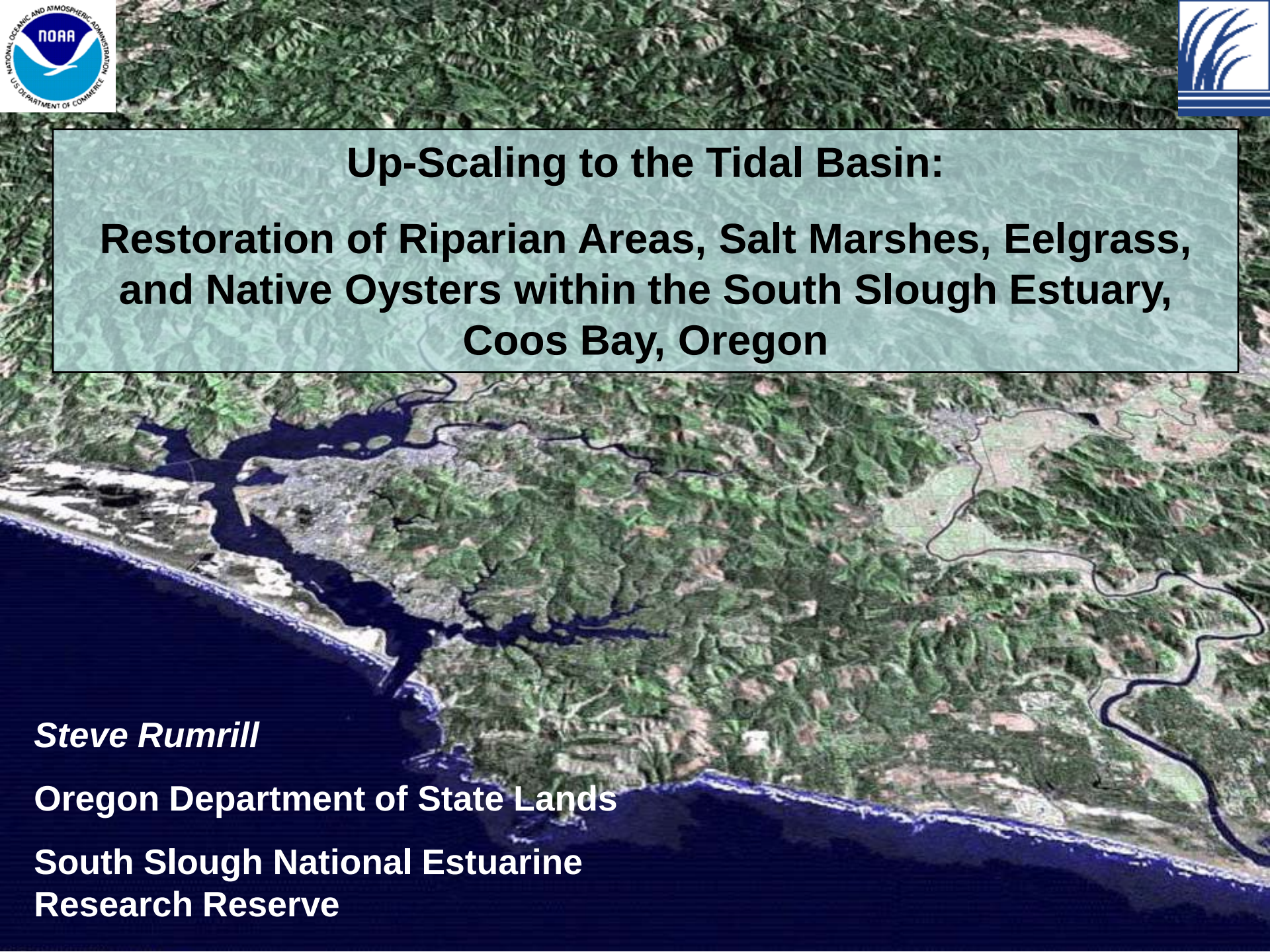
Up-Scaling to the Tidal Basin:

Restoration of Riparian Areas, Salt Marshes, Eelgrass, and Native Oysters within the South Slough Estuary, Coos Bay, Oregon



Steve Rumrill

Oregon Department of State Lands

South Slough National Estuarine Research Reserve

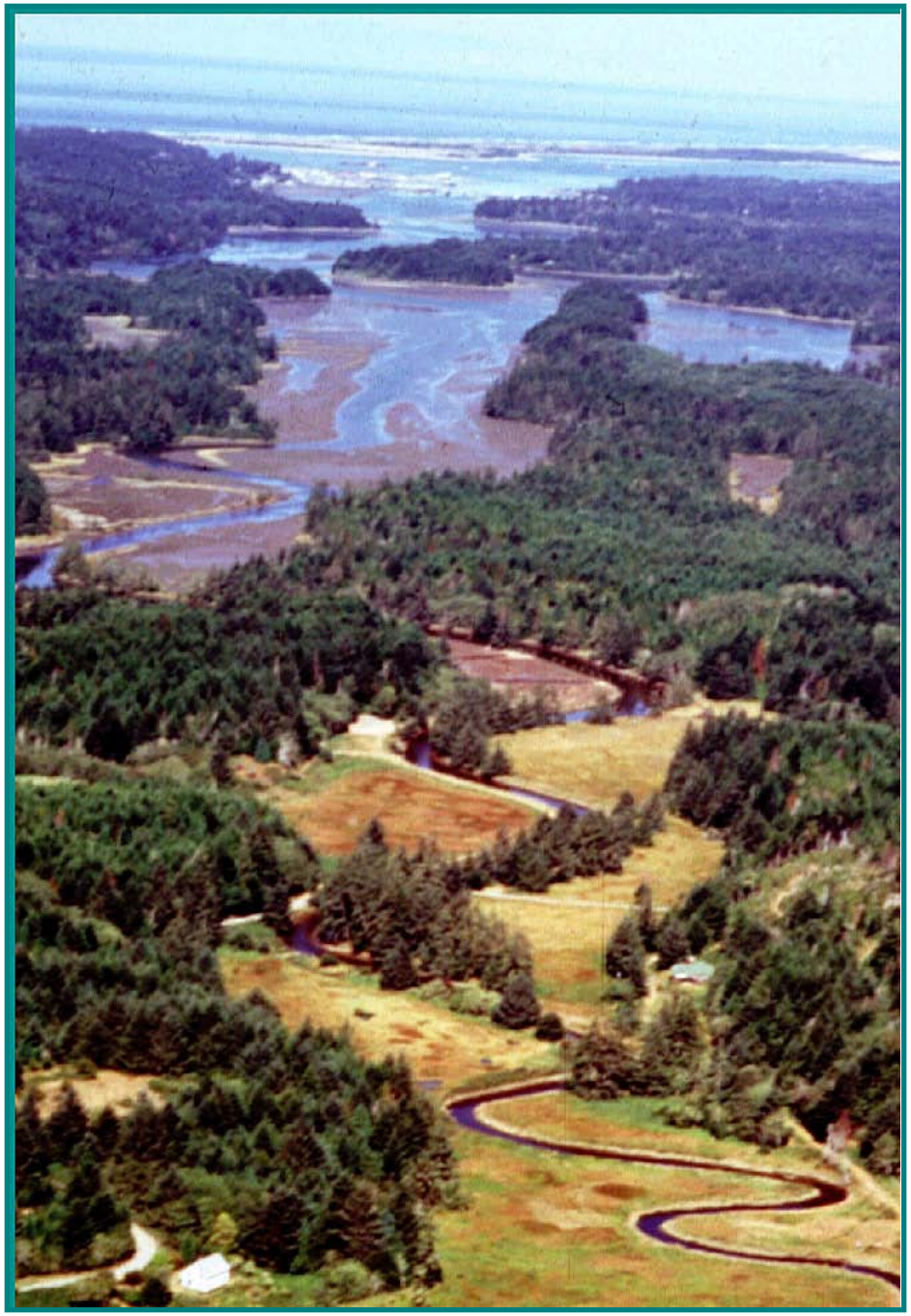
Outline:

Coos Bay Estuary & South Slough Tidal Basin

South Slough National Estuarine Research Reserve

Habitat Restoration within the Linked Components of the South Slough Estuarine Ecosystem

- **Tidal wetlands**
- **Eelgrass Beds**
- **Olympia oysters**
- **Riparian Areas**
- **Upland Forest**
- **Non-indigenous Aquatic Species**



NATIONAL ESTUARINE RESEARCH RESERVES

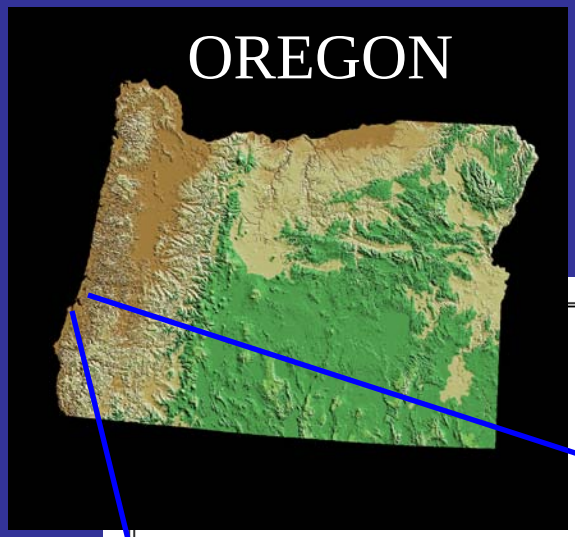
A network of 27 protected areas

Mission: *"promote stewardship of the nation's estuaries through science and education using a system of protected areas"*

Programs: Research, Monitoring, Education, Coastal Training, Resource Stewardship

1. Wells, Maine
2. Great Bay, New Hampshire
3. Waquoit Bay, Massachusetts
4. Narragansett Bay, Rhode Island
5. Hudson River, New York
6. Jacques Cousteau, New Jersey
7. Delaware
8. Chesapeake Bay, Maryland
9. Chesapeake Bay, Virginia
10. North Carolina
11. North Inlet-Winyah Bay, South Carolina
12. ACE Basin, South Carolina
13. Sapelo Island, Georgia
14. Guana Tolomato Matanzas, Florida
15. Rookery Bay, Florida
16. Apalachicola, Florida
17. Weeks Bay, Alabama
18. Grand Bay, Mississippi
19. Mission-Aransas, Texas
20. Tijuana River, California
21. Elkhorn Slough, California
22. San Francisco Bay, California
23. South Slough, Oregon
24. Padilla Bay, Washington
25. Old Woman Creek, Ohio
26. Proposed—St. Lawrence River, New Y
27. Kachemak Bay, Alaska
28. Jobos Bay, Puerto Rico

Coos Bay & South Slough: A Pacific Northwest Drowned River Mouth Estuary



Digitial Elevation Model

Coos Watershed

608 mi² / 158,645 ha

Estuary

21 mi² / 5,010 ha

Wet surface ratio

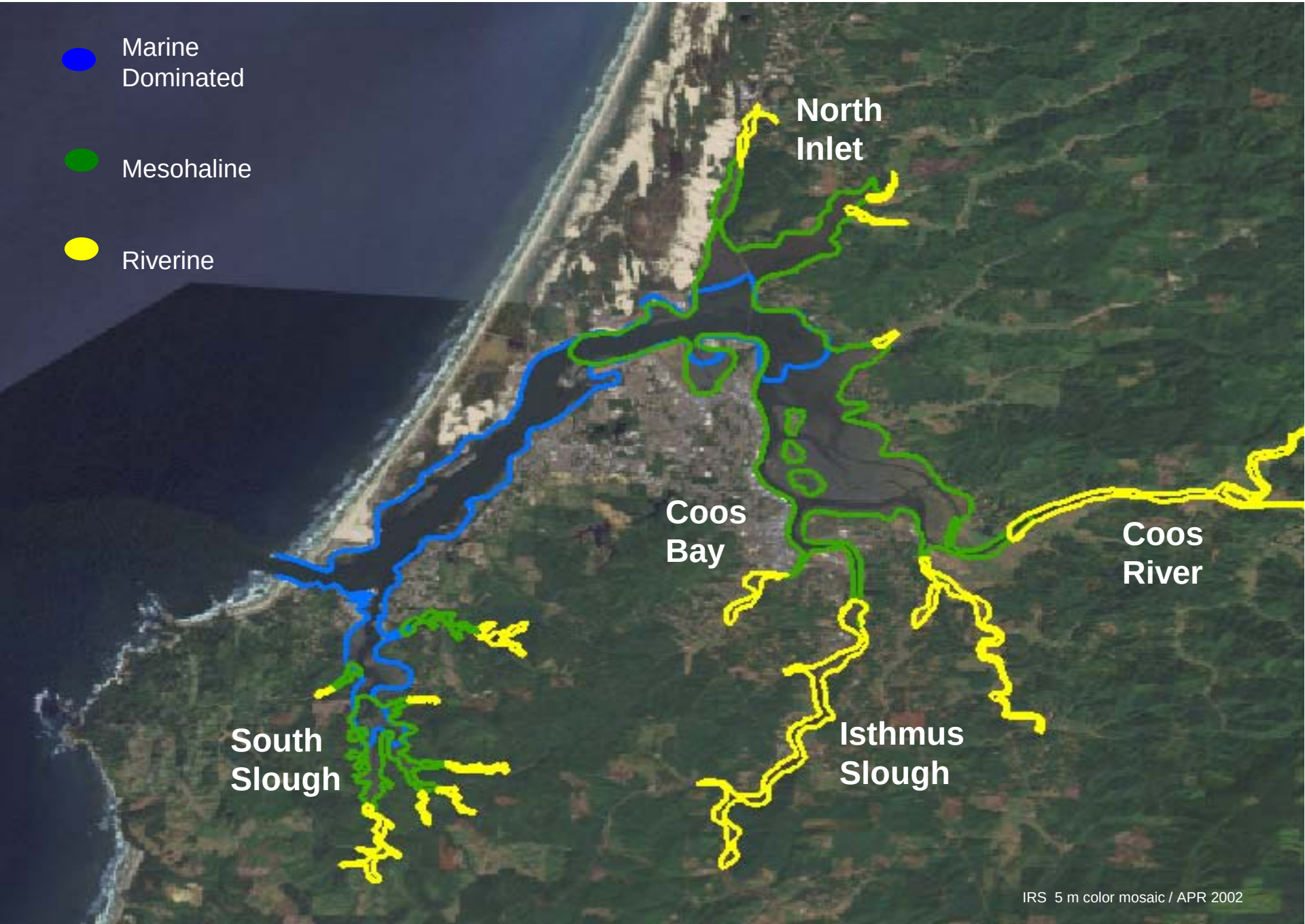
3.5%

N
W
E
S

10 0 10 20 Kilometers

South Slough Tidal Inlet

COOS ESTUARY, OR Hydrologic Regions within the Tidal Basin



South Slough National Estuarine Research Reserve

Designated 1974

4,800 ac research natural area

Habitats:

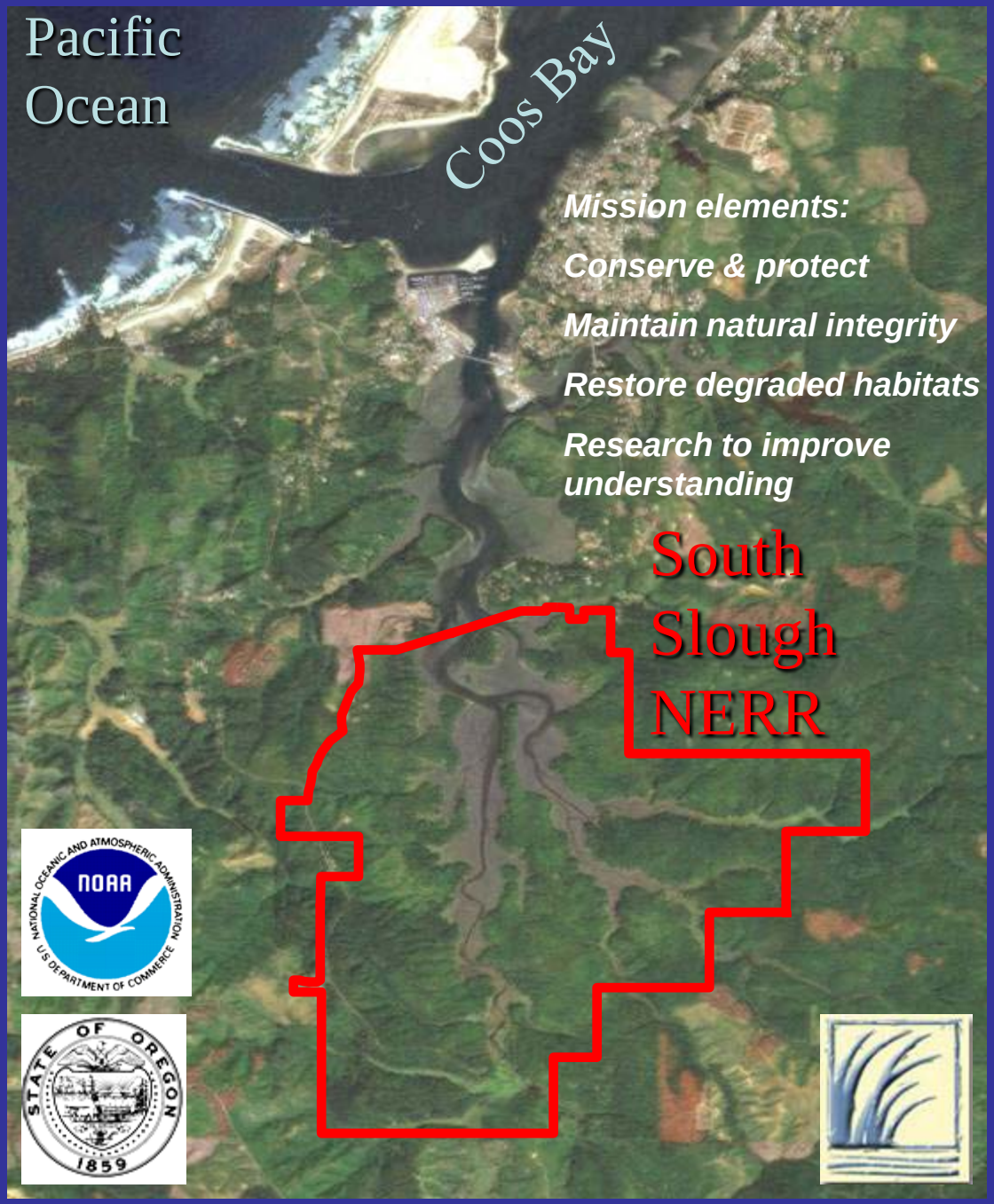
- estuary
- wetlands / riparian
- coastal forest

Land-Margin Ecosystem

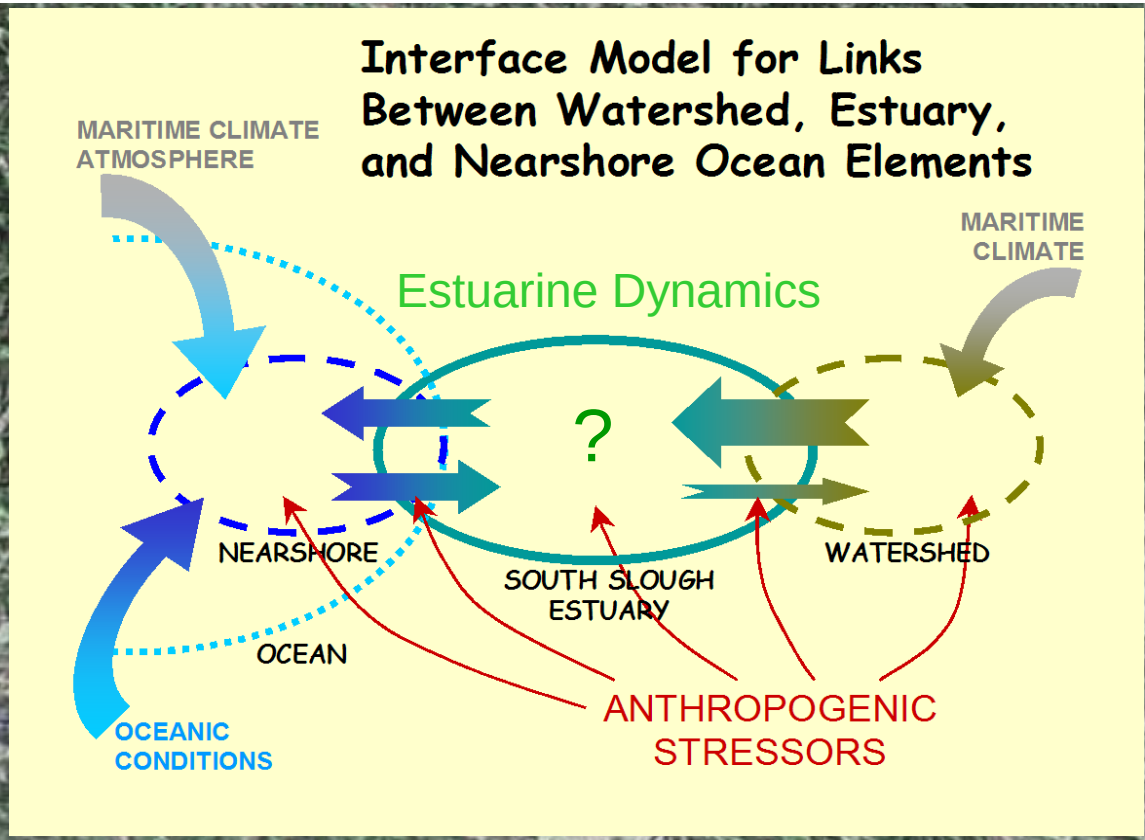
Ocean

↳ Estuary

↳ Creeks



Application of the Interface Model to the South Slough Estuarine Sub-System

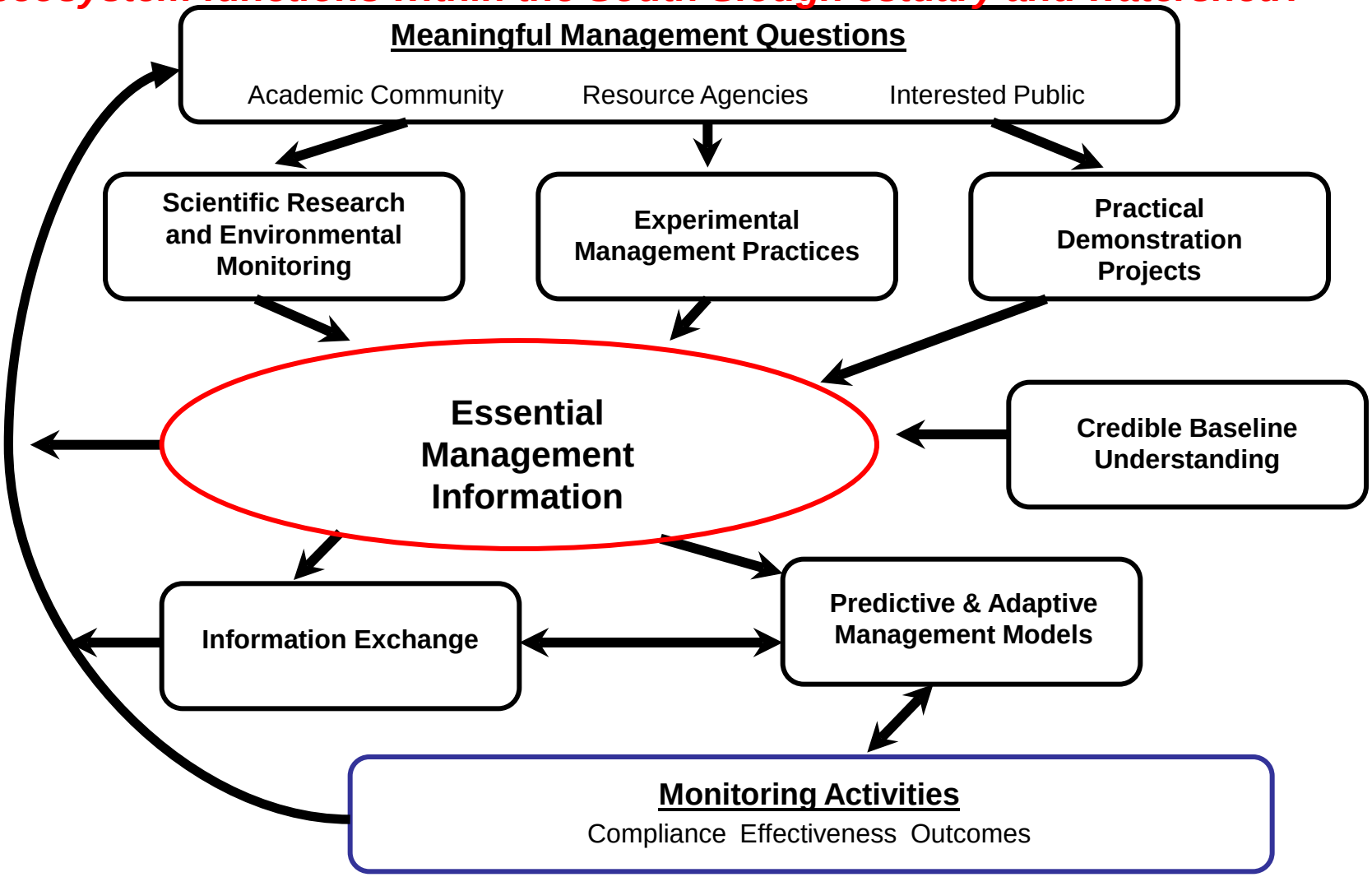


Nearshore

Estuary

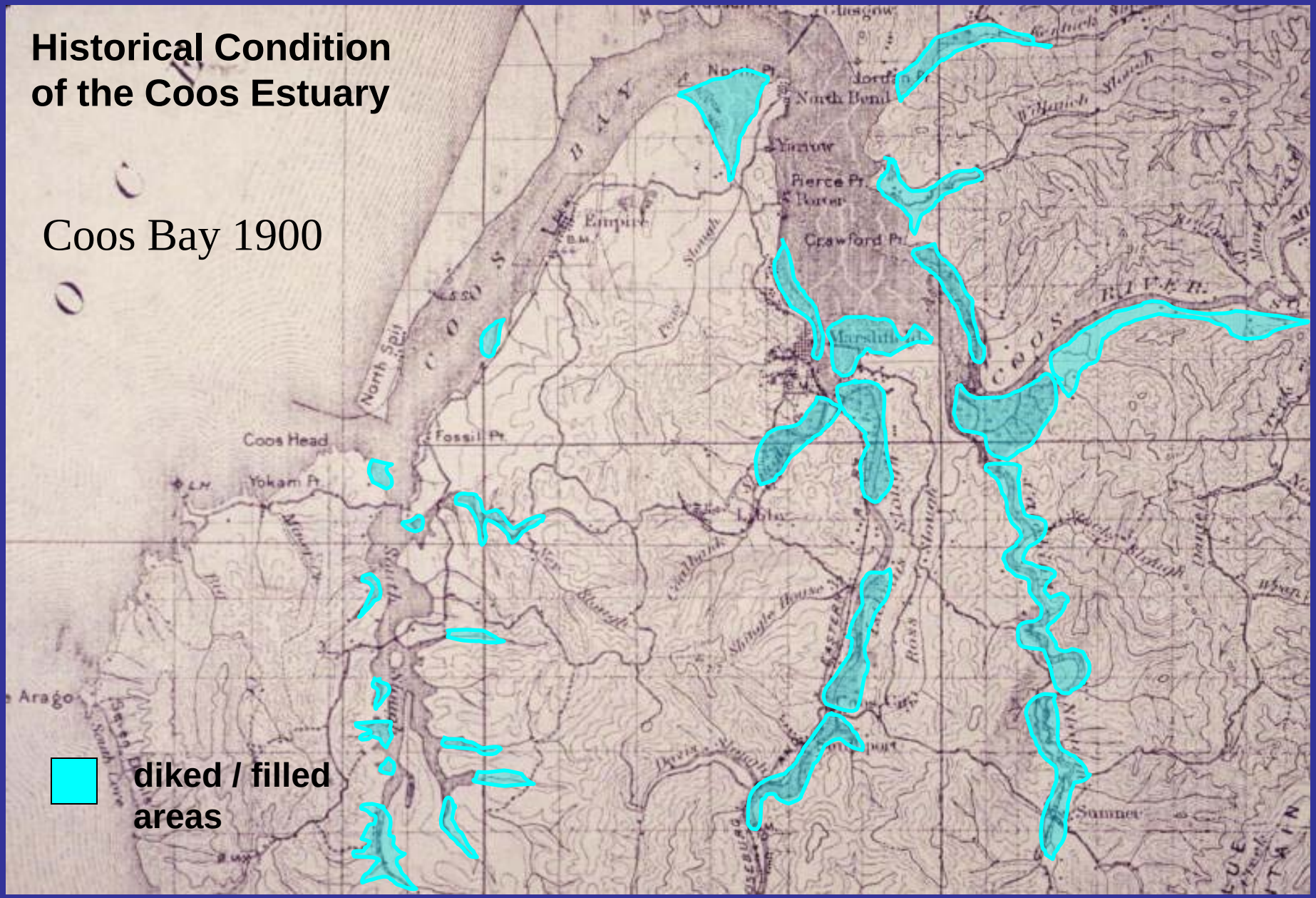
Watershed

"To what extent can restoration of ecosystem structure serve to regain lost ecosystem functions within the South Slough estuary and watershed?"



Adaptive Coastal and Estuarine Ecosystem Management Approach for the South Slough Estuary

Historical Condition of the Coos Estuary

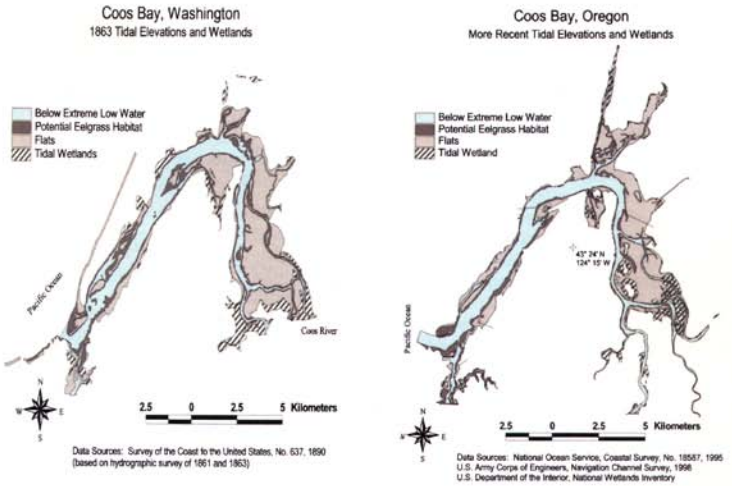


Estuaries Vol. 26, No. 4B, p. 1104–1116 August 2003

Geospatial Habitat Change Analysis in Pacific Northwest Coastal Estuaries

Amy B. Borde[1,*], Ronald M. Thom[1], Steven Rumrill[2], and Lee M. Miller[1]

[1] *Battelle Marine Sciences Laboratory, 1529 West Sequim Bay Road, Sequim, Washington 98382*
[2] *South Slough National Estuarine Research Reserve, P. O. Box 5417, Charleston, Oregon 97420*



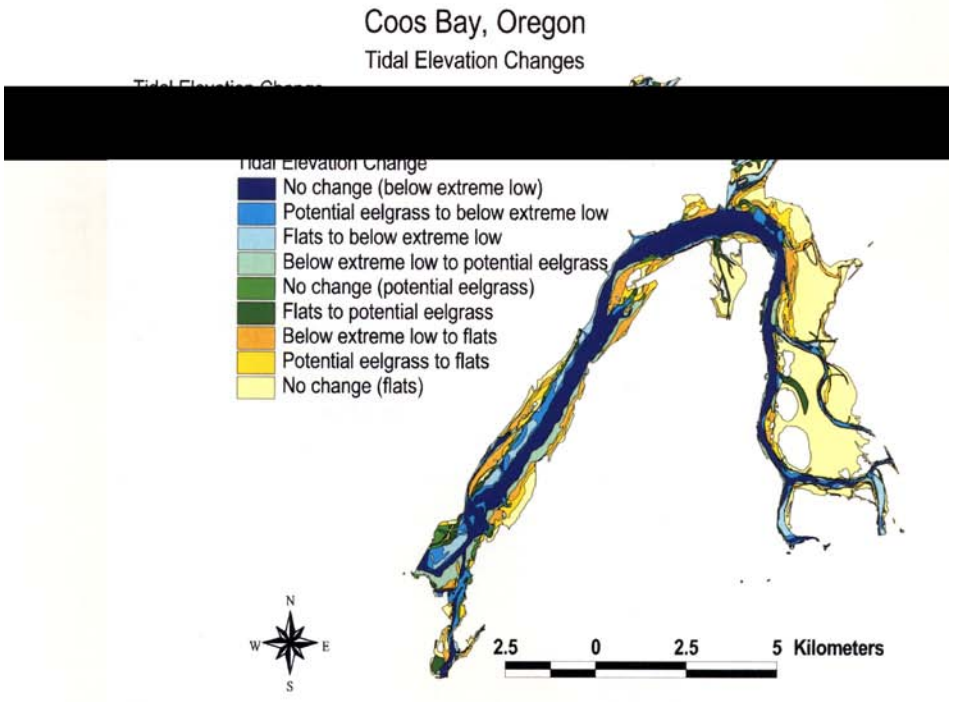
Primary Alterations:

25 % loss of wet estuary surface area

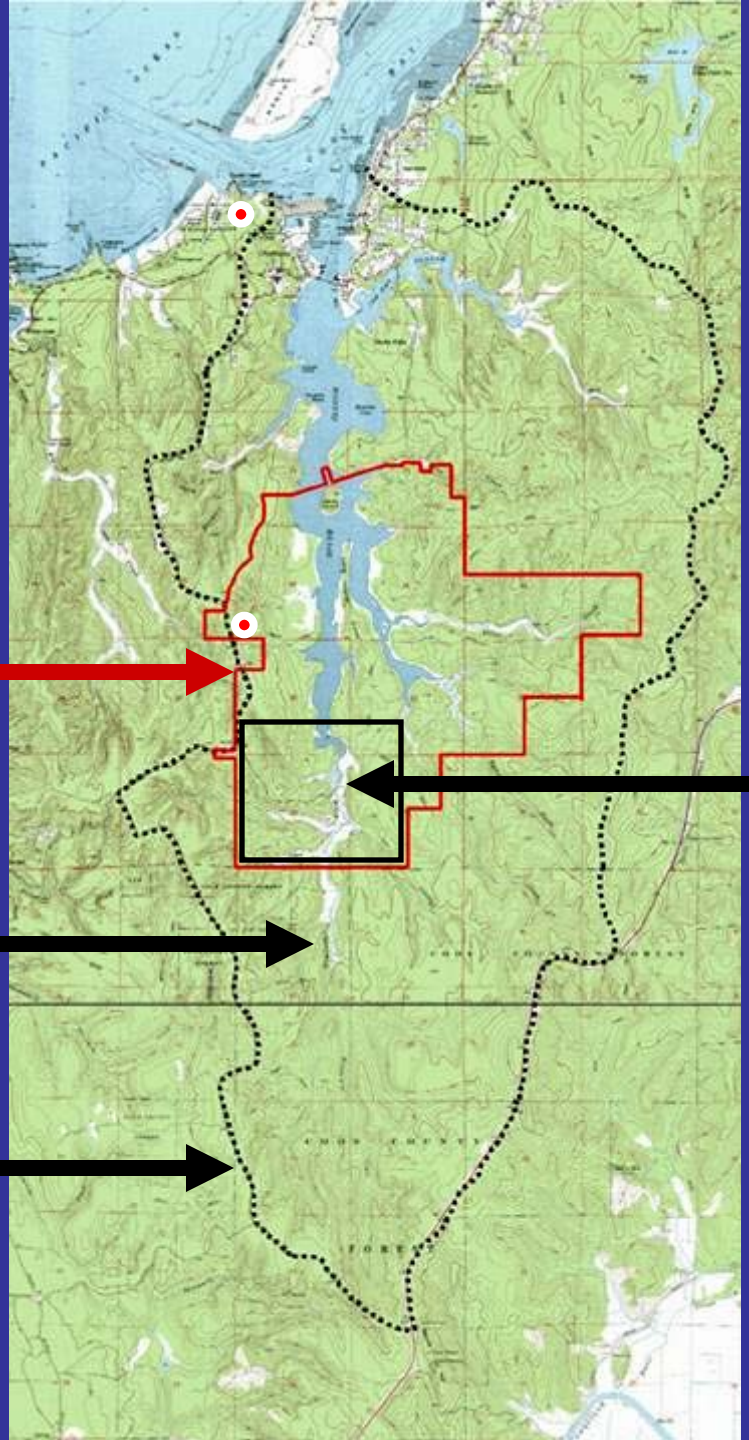
84 % loss of tidal wetlands

- **1892: 8,400 ac**
- **1995: 1,300 ac**
- **Wetlands converted for agriculture, filled for cities, residences, & industry**

5 % loss of eelgrass habitat



South Slough National Estuarine Research Reserve

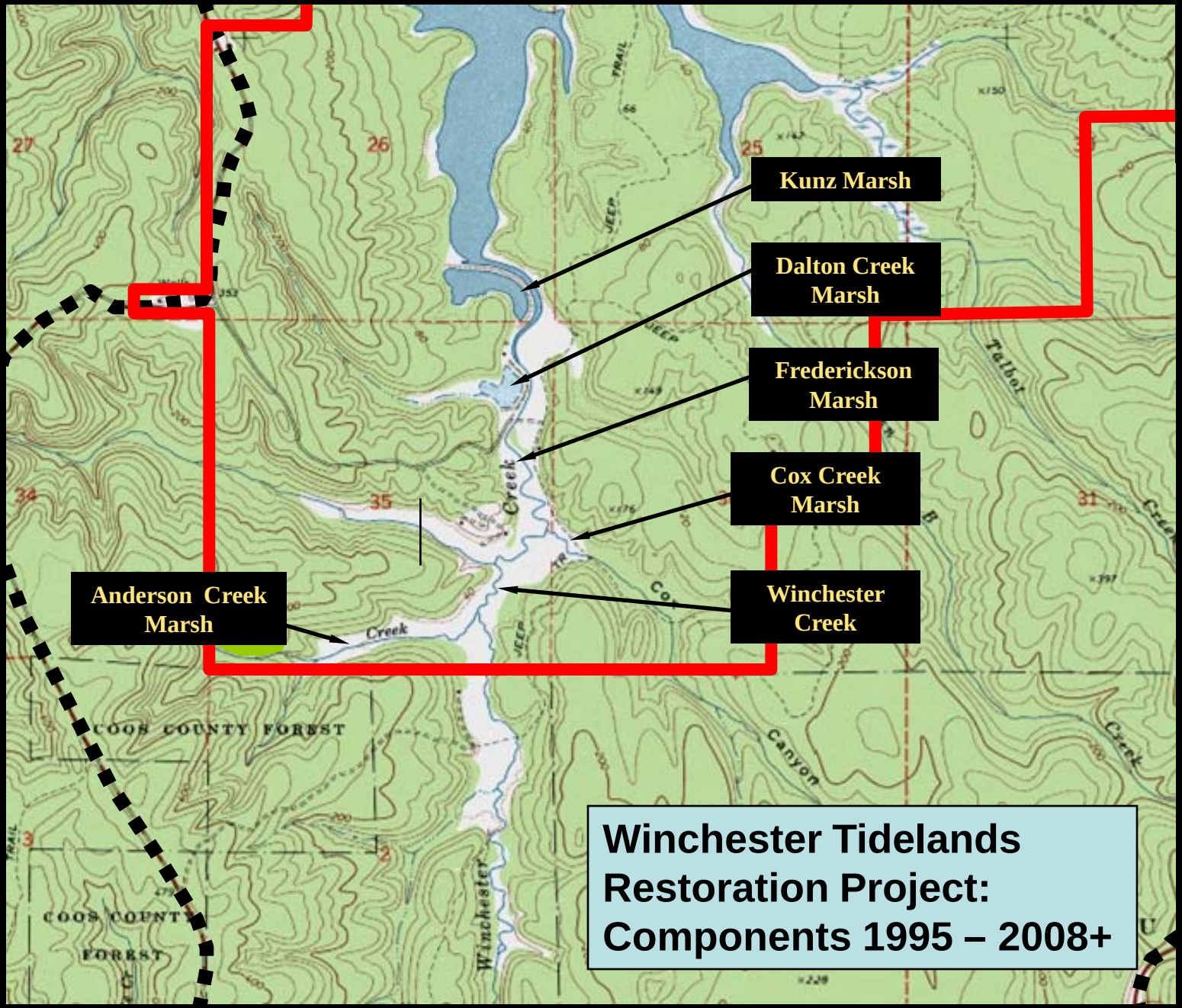


South Slough NERR Admin. Boundary

Winchester Creek

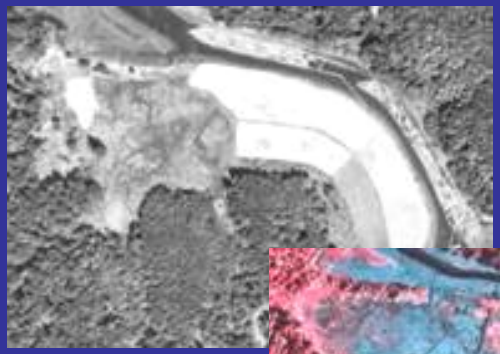
South Slough Watershed

Winchester Tidelands Restoration Project (1995-2008+)

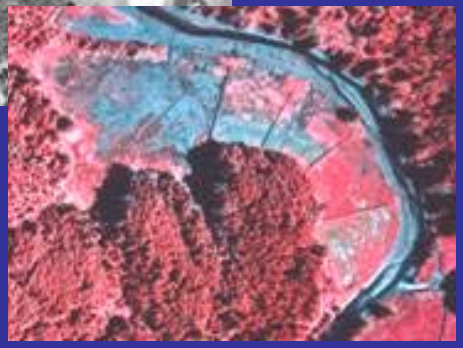

Kunz Marsh
Dalton Creek Marsh
Frederickson Marsh
Cox Creek Marsh
Winchester Creek
Anderson Creek Marsh
Winchester Tidelands Restoration Project: Components 1995 – 2008+

1996: diked FW wetland subsided 80 cm

1997: dikes removed, create mid & low elevation salt marsh cells

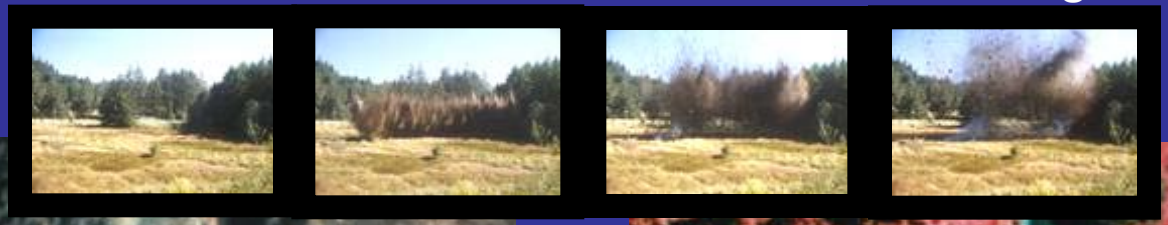


2003 salt marsh



1939 pasture

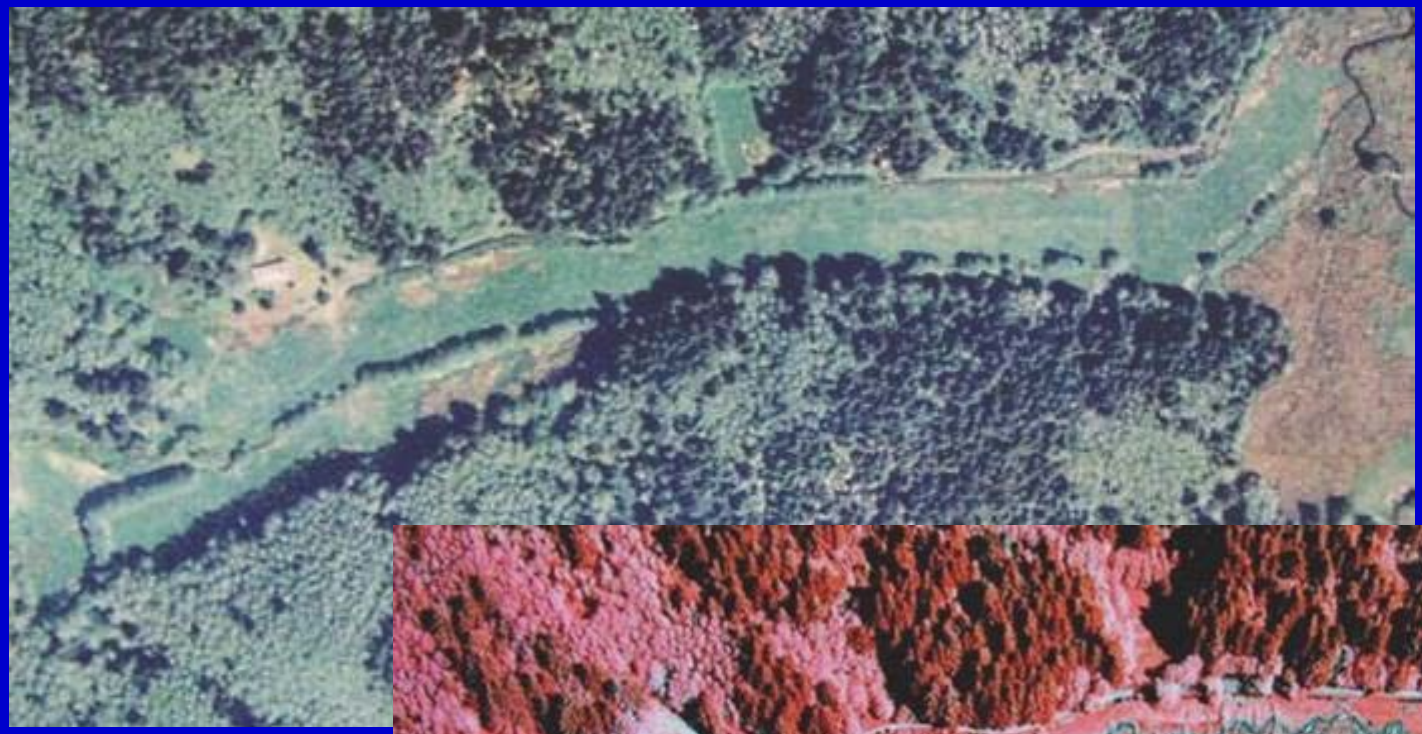
Dalton Creek: Dike Removal and Channel Re-configuration



Dalton Creek Marsh 1991

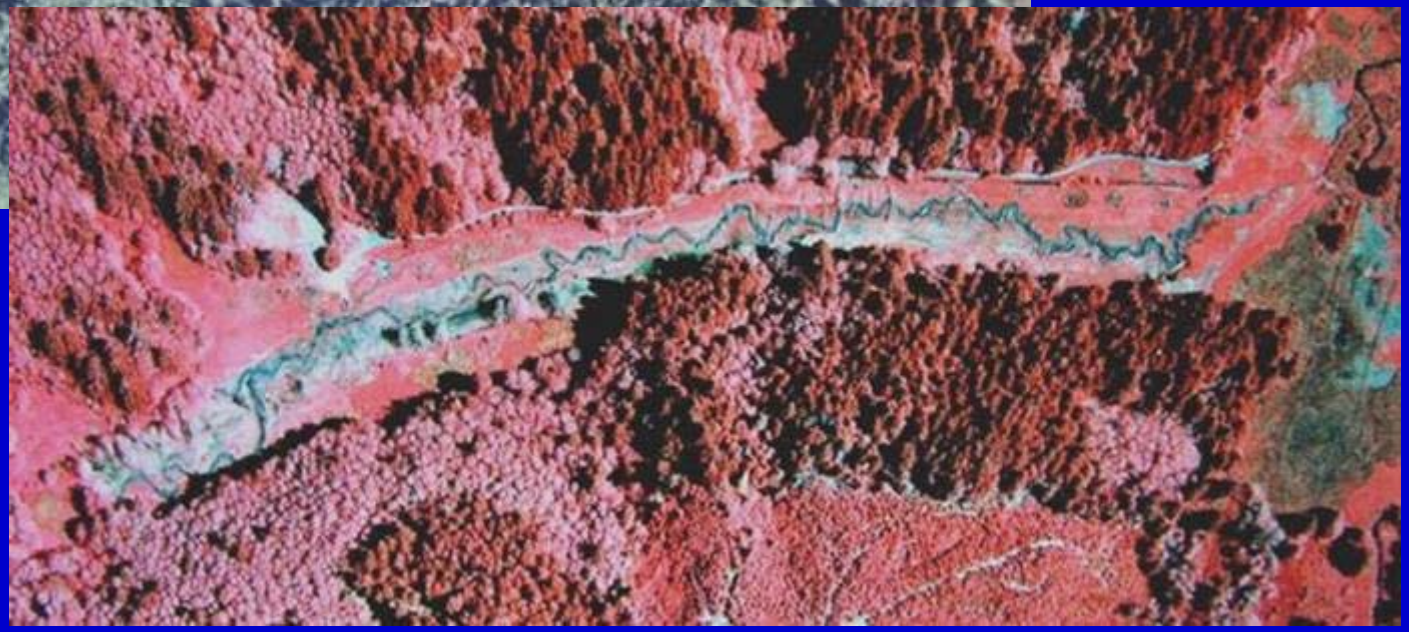
Dalton Creek Marsh 2003

Re-construction of the Anderson Creek Channel and Marsh



N

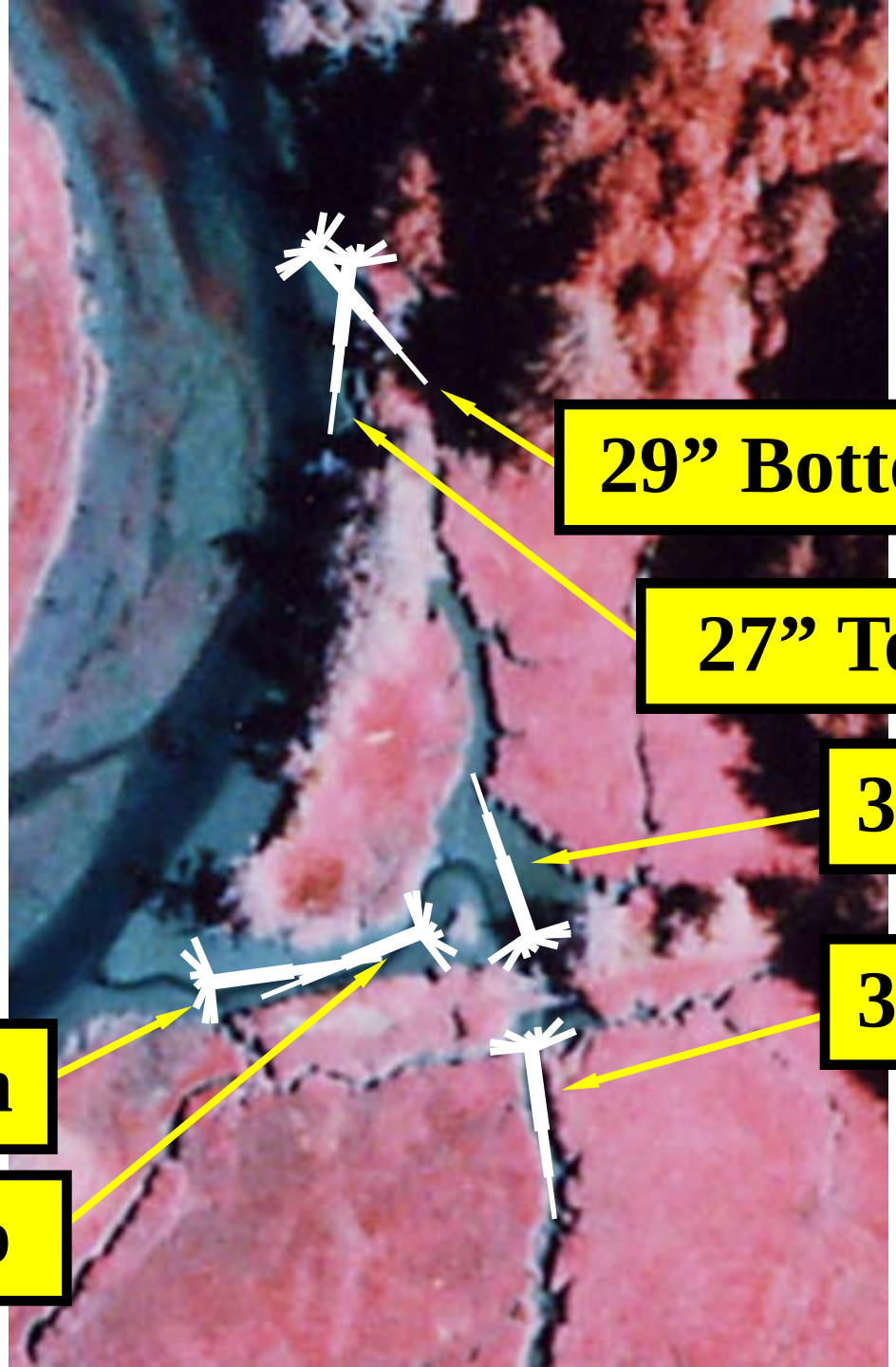
Anderson Creek Marsh 1991



Anderson Creek Marsh 2003

South Slough Estuary: Addition of Large Wood & Root-wads to the Winchester Creek Tidal Channel

2005-06



A1

6 Trees

38”

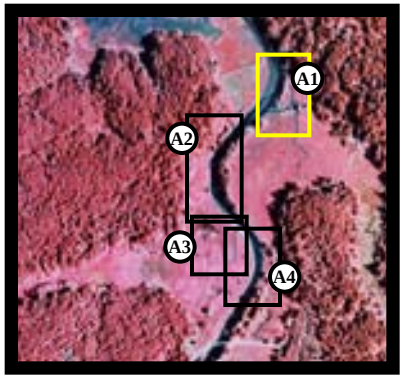
36”

35”

29”

27”

25”



N

Journal of Coastal Research	SI	55	121–134	West Palm Beach, Florida	Summer 2008

Concurrent Assessment of Eelgrass Beds (*Zostera marina*) and Salt Marsh Communities along the Estuarine Gradient of the South Slough, Oregon

Steven S. Rumrill[†] and Derek C. Sowers[‡]

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South Slough National Estuarine Research Reserve
P.O. Box 5417
Charleston, OR 97420, U.S.A.
Steve.Rumrill@state.or.us

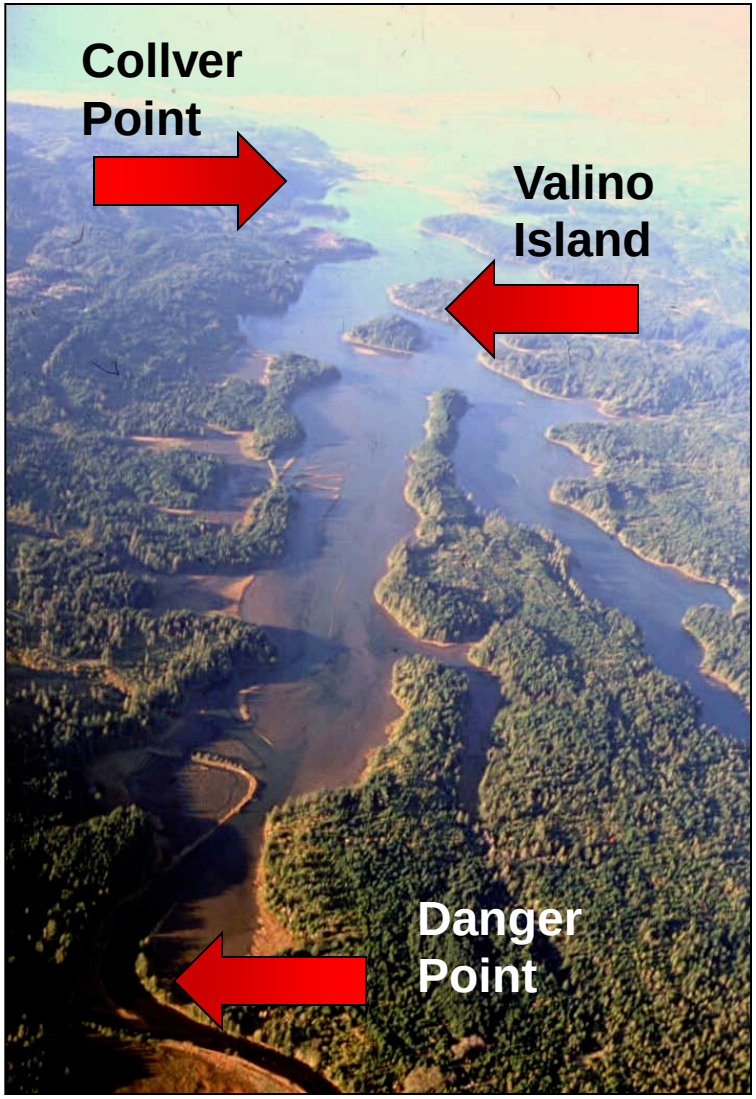
[‡]University of New Hampshire—Marine Program
New Hampshire Estuaries Project
Nesmith Hall
Durham, NH 03824, U.S.A.

Questions:

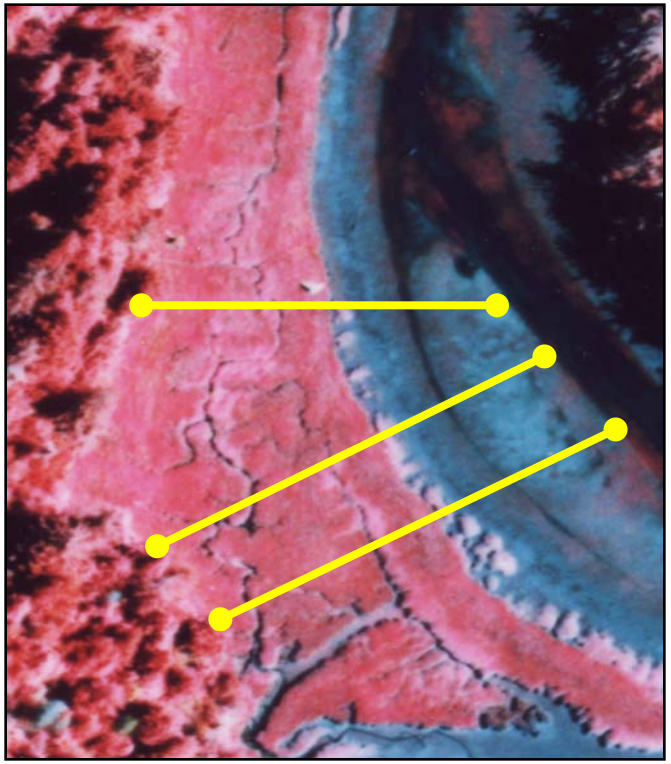
How do the dynamics of salt marshes and eelgrass beds differ within the marine-dominated, mesohaline, and riverine regions of the South Slough estuary?

Do salt marshes and eelgrass beds respond similarly to their location along the estuarine gradient?

Which marshes and eelgrass beds can best serve as reference sites for comparison with restoration sites in other areas of the estuary?



Concurrent Assessment of Salt Marshes and Eelgrass Beds in the South Slough Estuary



Continuous transects:

- **3X per site**
- **high marsh to eelgrass**
- **SET installations**
- **ground-water wells**

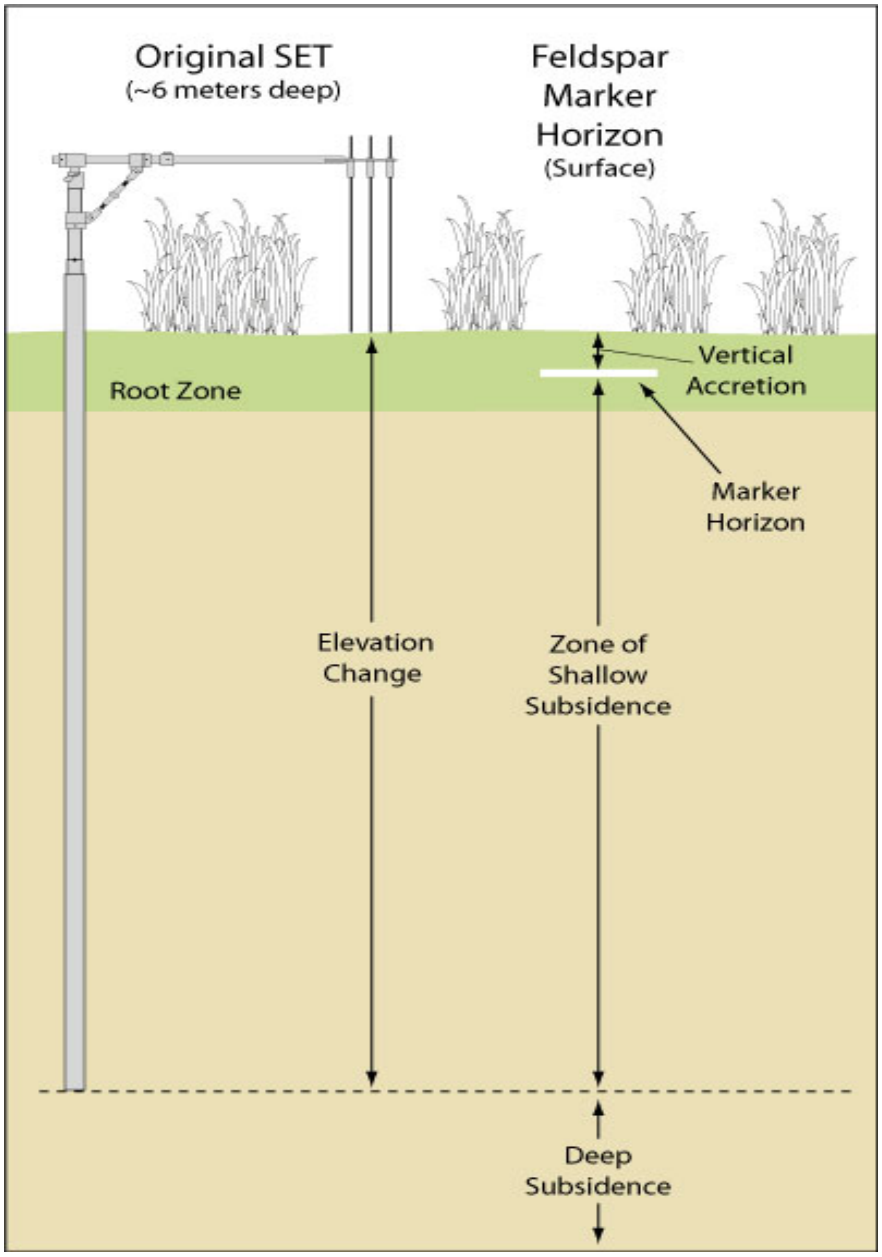
Salt Marshes:

- **plant species**
- **% cover & density**
- **canopy height**
- **above-ground biomass**
- **archival photo**

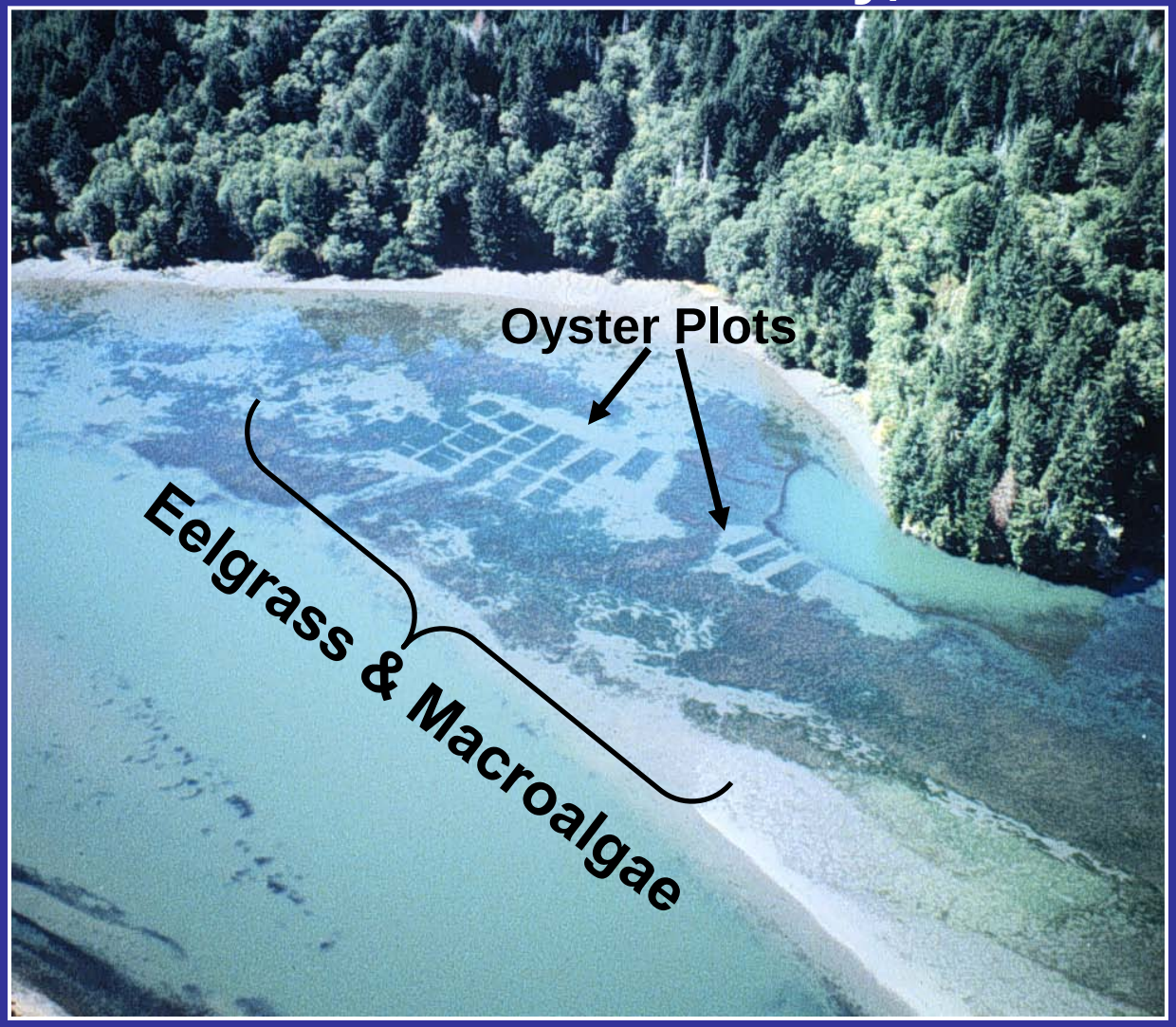
Eelgrass:

- **% cover & density**
- **canopy height**
- **above & below ground biomass**
- **sediment core**
- **archival photo**

Sediment Elevation Tables: SET



ANTHROPOGENIC STRESSOR: Commercial Oyster Mariculture within the South Slough Estuary, OR



OBSERVATION:

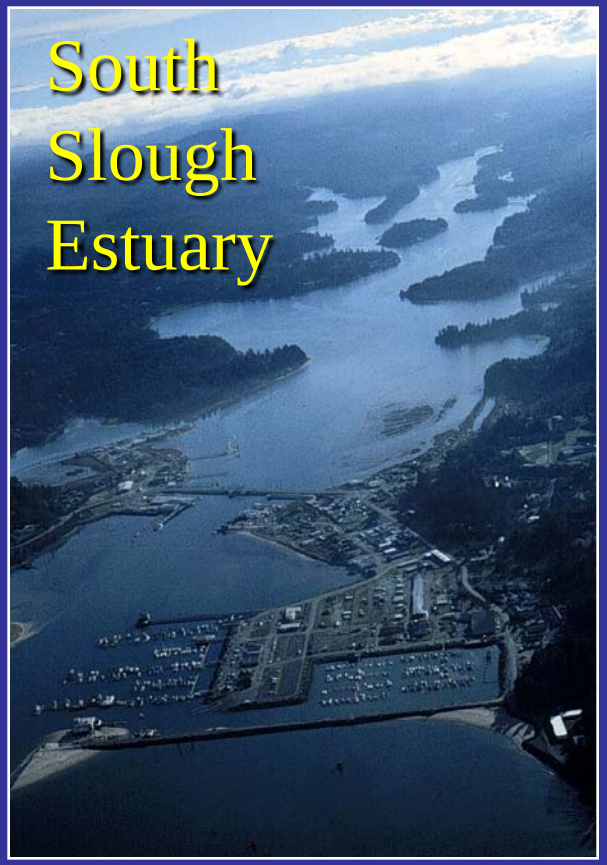
Dense cultivation of *Crassostrea gigas* (a non-indigenous species) results in displacement and fragmentation of eelgrass beds (*Zostera marina*)

Commercial Mariculture of Pacific Oysters in South Slough NERR, OR

A. Bottom culture

B. Stake culture

C. Rack culture



Eelgrass (*Zostera marina*): Tideflat Ecological Engineer and Essential Functions in Pacific Northwest Estuaries

Primary Production & Detritus

Sediment Trap & Nutrient Exchange

Water Quality Improvement

Habitat for Juvenile Fish & Shellfish

Recovery of Eelgrass Beds following Removal of Commercial Oyster Stakes

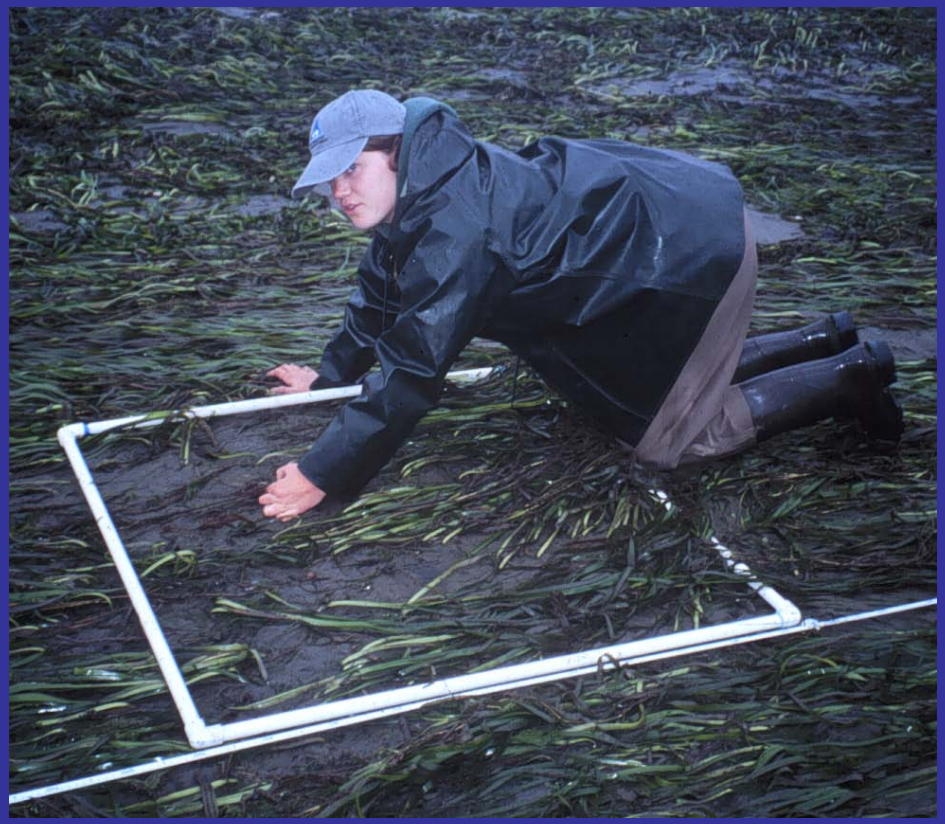
Pregnall, M. 1993

Time after oyster stake removal:

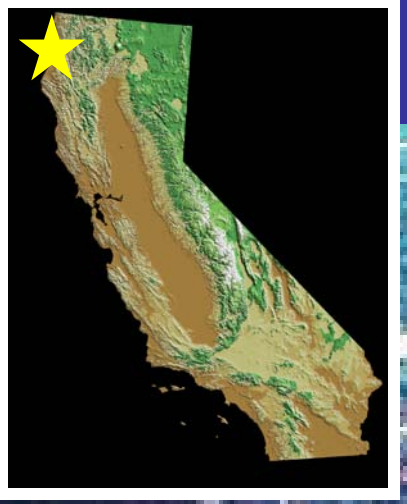
5 months / Eelgrass density significantly lower than control

1 year / Eelgrass density not significantly different, but still visually lower than control

2 years / Full recovery of eelgrass beds



HUMBOLDT BAY, CA



Drowned Tidal Basins

Mad River

Jacoby Creek

Eel River

Freshwater Creek

Elk Creek

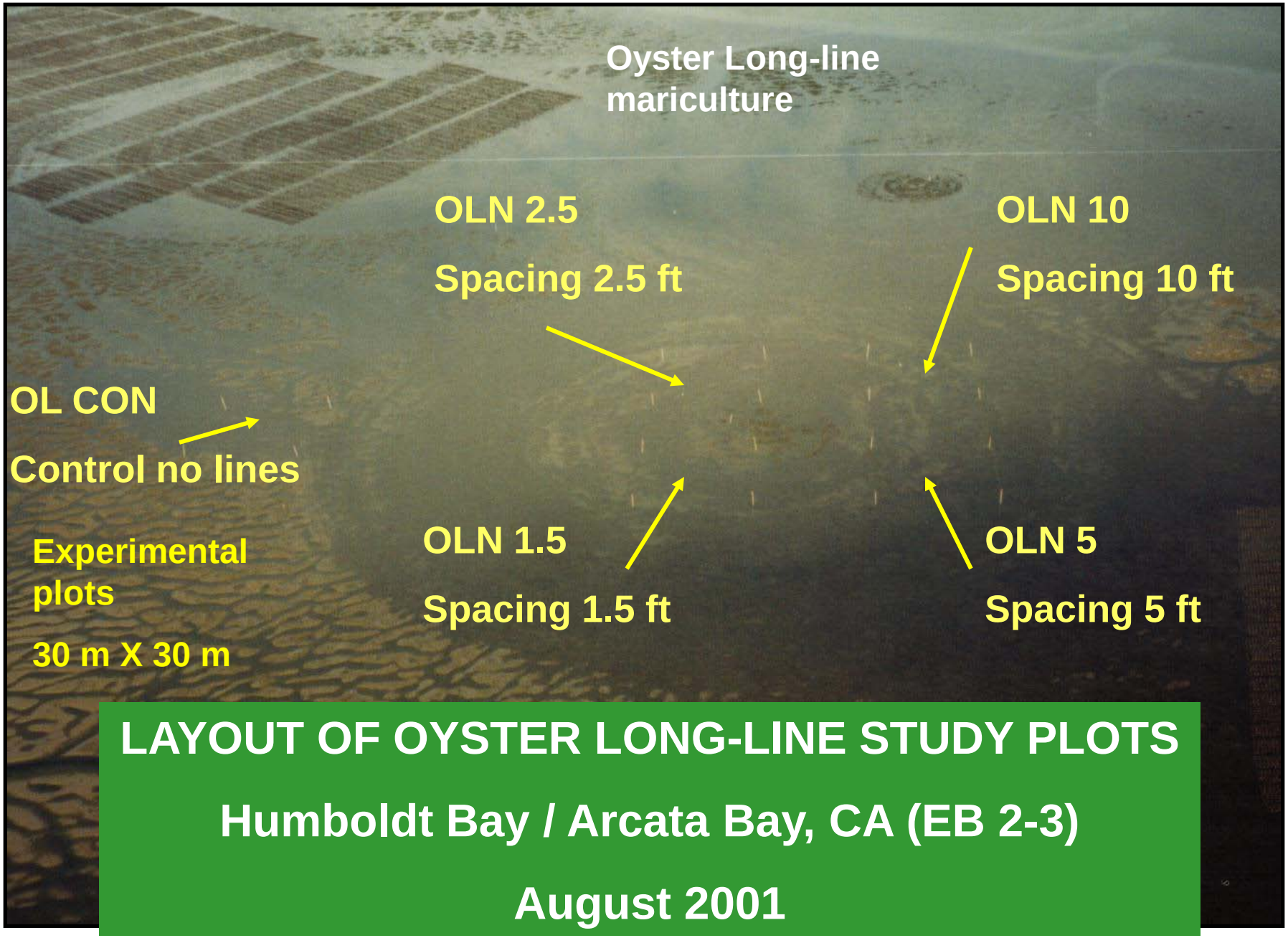
Arcata Bay

Salmon Creek

Entrance Bay

South Bay

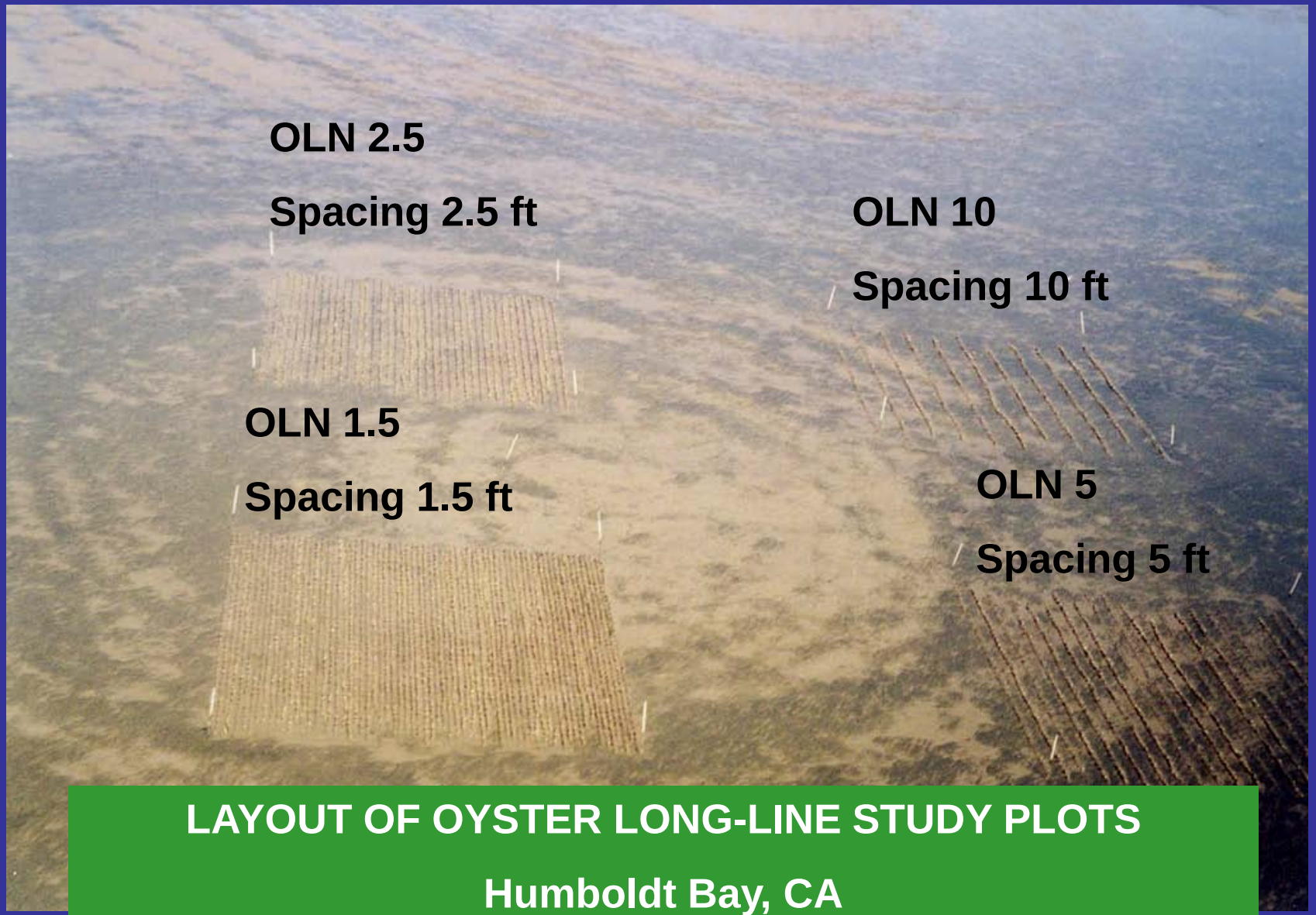
Pacific Ocean



LAYOUT OF OYSTER LONG-LINE STUDY PLOTS

Humboldt Bay / Arcata Bay, CA (EB 2-3)

August 2001

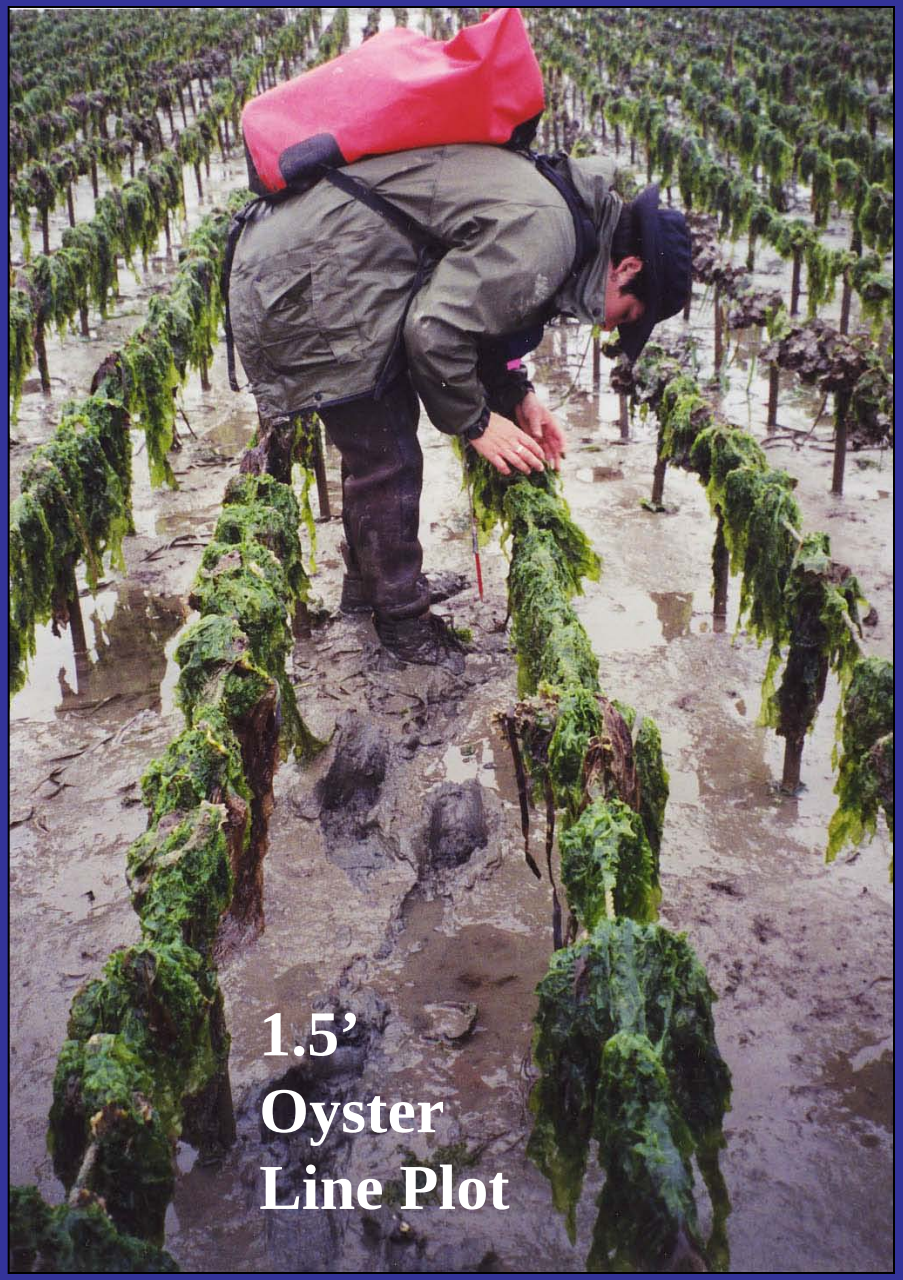


LAYOUT OF OYSTER LONG-LINE STUDY PLOTS

Humboldt Bay, CA

May 2003 (20 months of oyster grow-out)

Eelgrass within Experimental Oyster Line and Control Plots



History of Olympia Oysters in Oregon Estuaries

Netarts Bay:

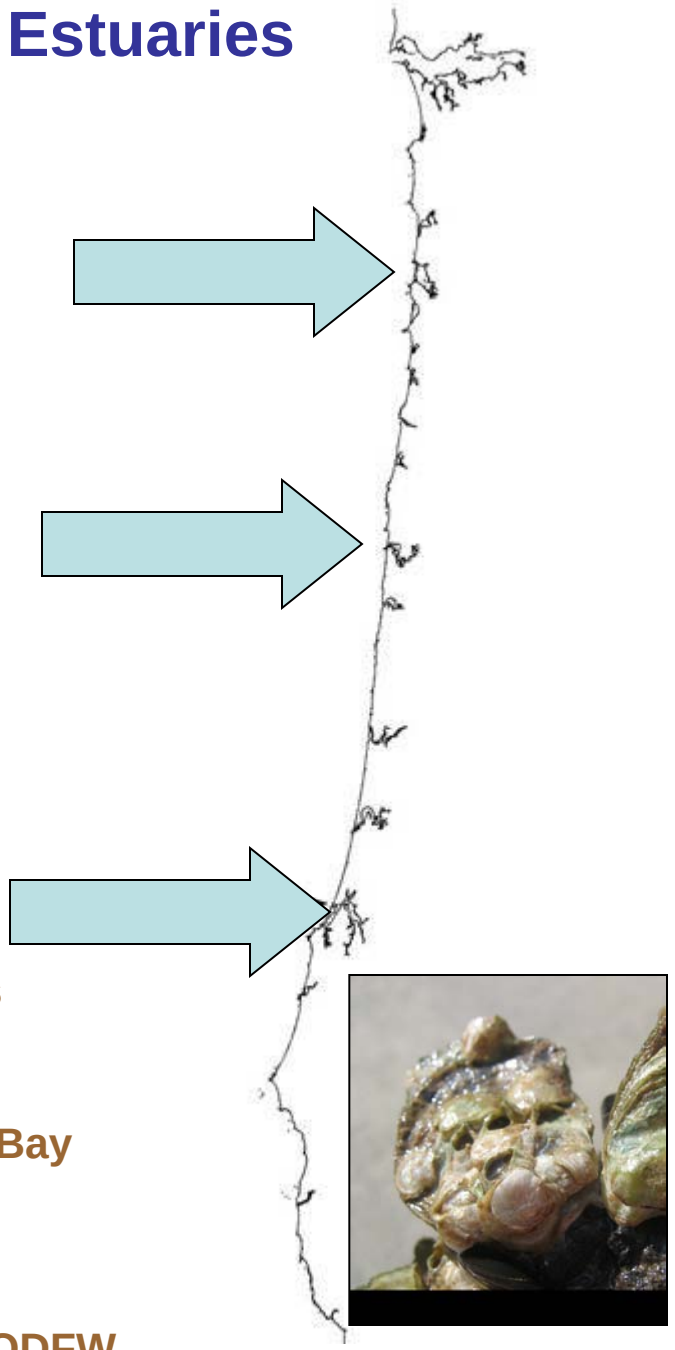
- Extensive commercial fishery 1860's
- Low numbers by 1930's
- Exotic snail predator 1957 (*Ocenebra*)
- Absent in 1992
- Restoration work in 2006-09 by TNC

Yaquina Bay:

- Extensive commercial fishery 1860's to 1890's
- Commercial harvest ended by 1940's
- Slow recovery of natural populations 2006-08

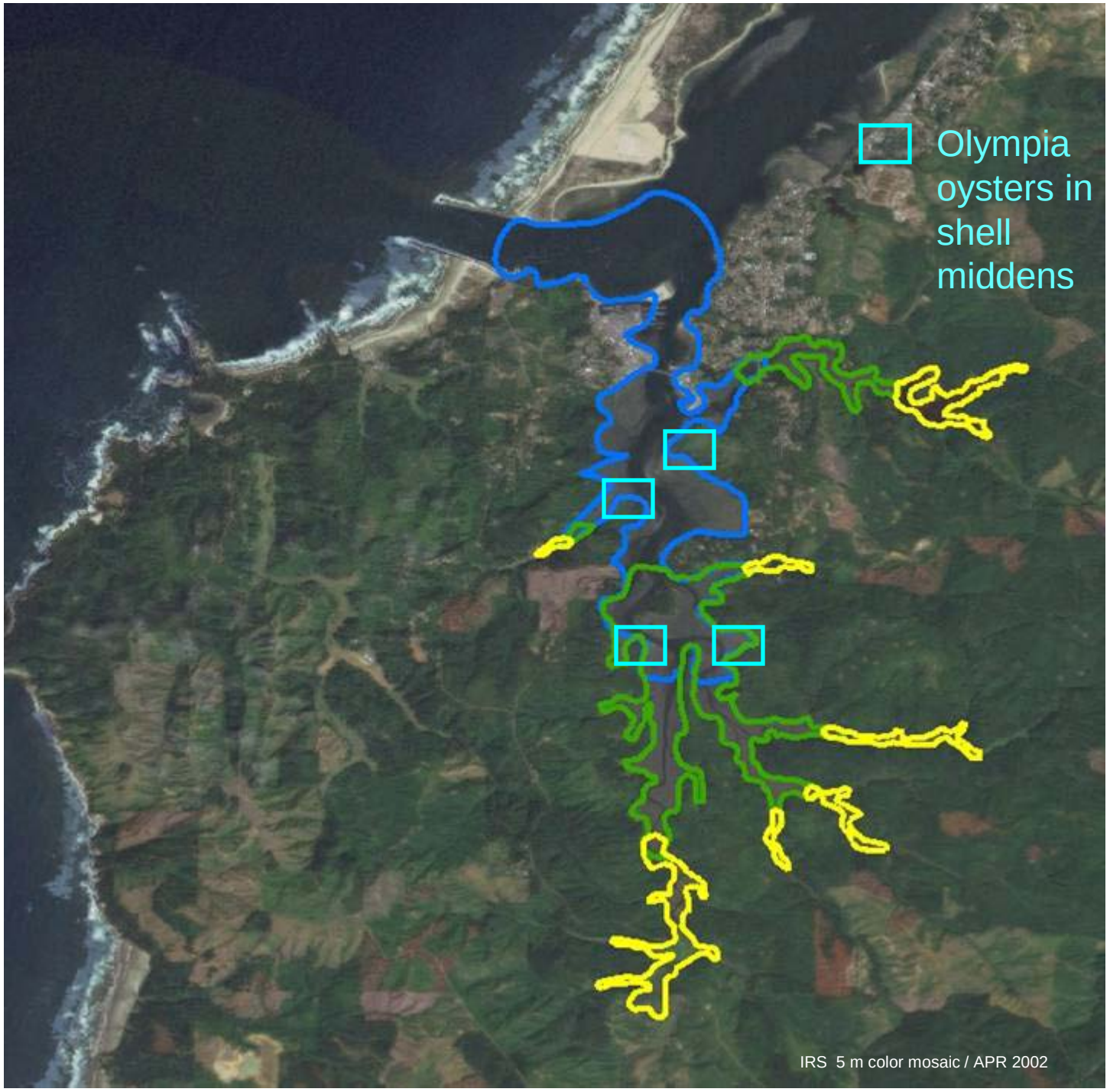
Coos Bay:

- Extensive historic populations and shell deposits
- Local extinction prior to European settlement
- Reintroduction with Pacific oysters from Willapa Bay 1950's
- Slow recovery of natural populations 1987-2008
- Restoration work initiated in 2008 by SSNERR & ODFW



SOUTH SLOUGH ESTUARY, OR

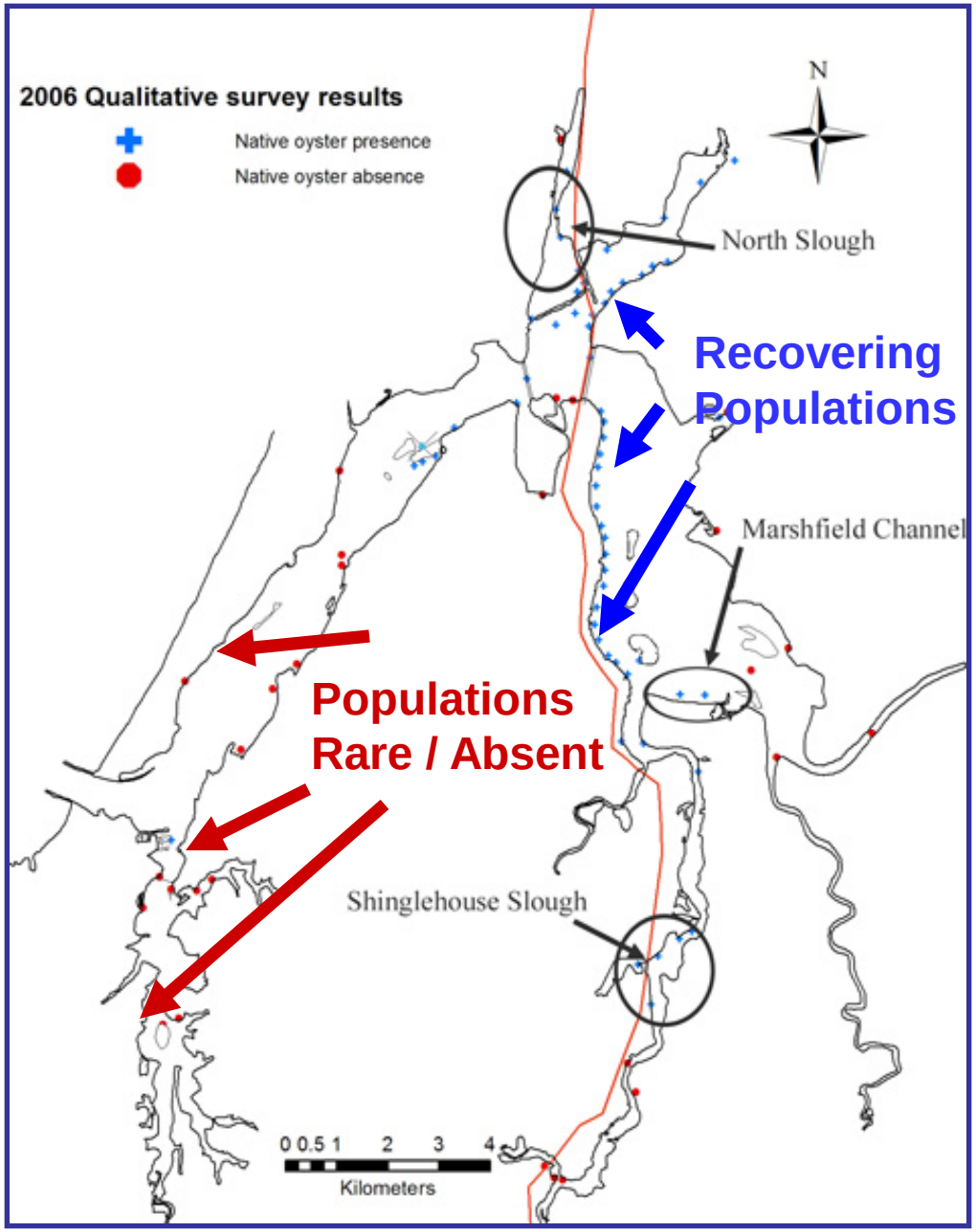
Hydrographic regions located along the estuarine gradient of the South Slough tidal basin



Coos Bay, OR:

Distribution of *Ostrea lurida* populations (2006). Circles indicate substantial changes between 1996-97 and 2006.

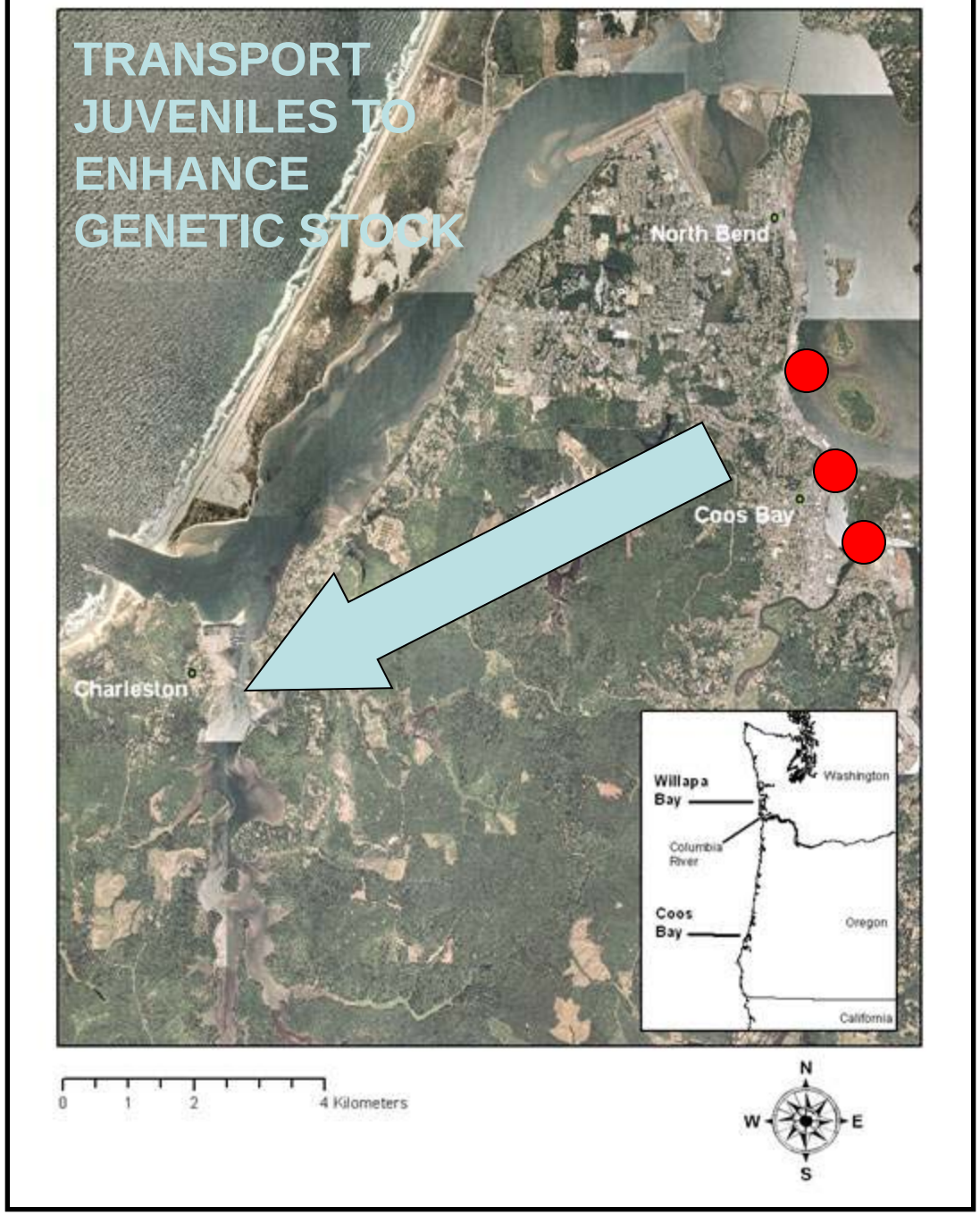
Why are *Ostrea* populations slow to recover in South Slough?



Oyster surveys 1996-97 from Baker *et al*. (2000); 2006 surveys by S. Groth / ODFW

Settlement Collector Bags (n=200) deployed at 3 locations in Coos Bay to provide substratum for larvae produced by locally-adapted adult Olympia oysters (2008+)

● **Settlement Collector Bags**



Re-establishment of Olympia Oysters in the South Slough Estuary: Common Garden Experiment

Evidence for local adaptation?

Broodstock Source

A. Willapa Bay, WA

B. Coos Bay, OR

Oyster Cultch

(shell with juveniles)

Outplants in South Slough:

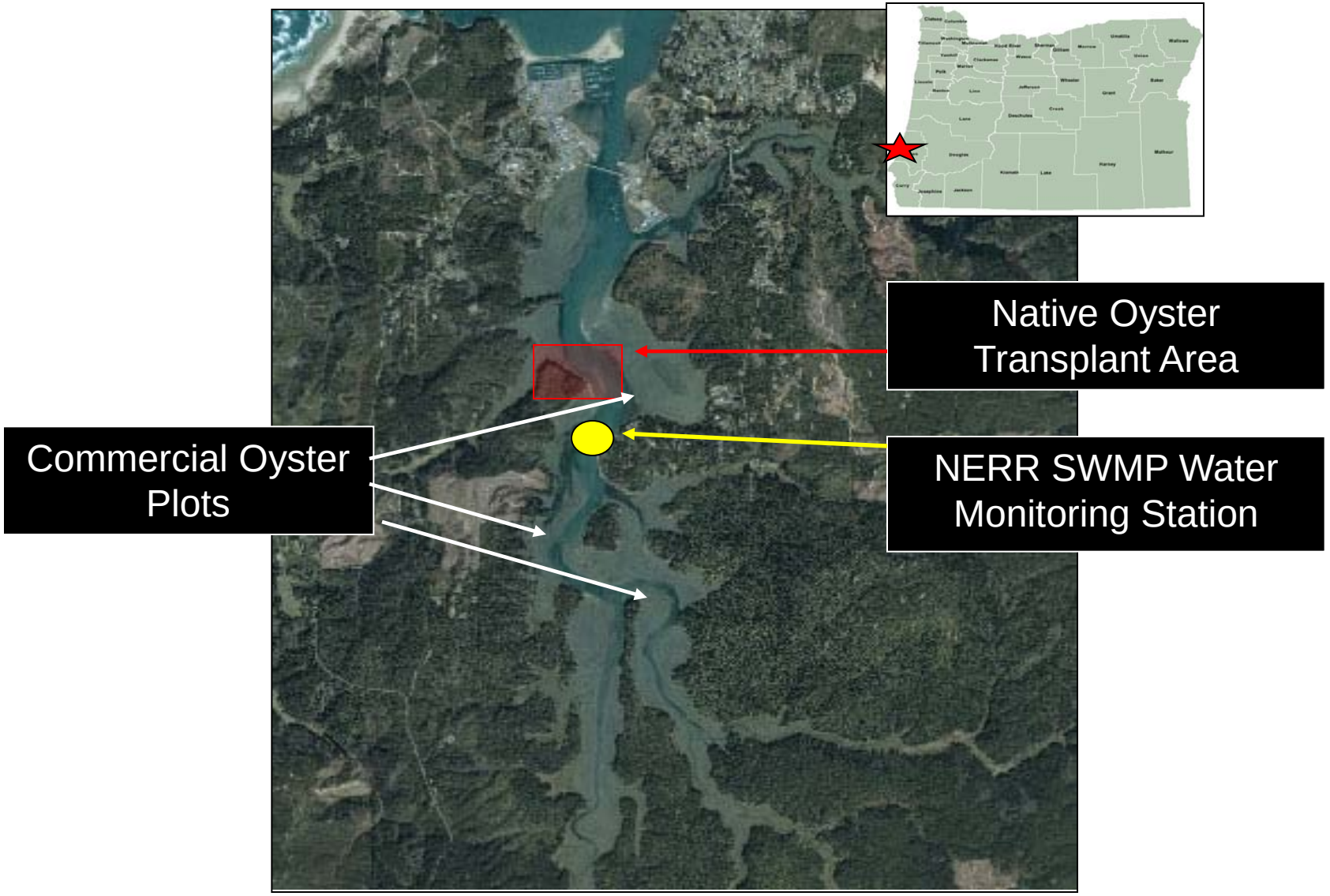
2008 / 22 Oyster bags

2009 / 300 Oyster bags

Ecological Performance

- **Survival**
- **Growth**
- **Onset of Reproduction**
- **Reproductive Output**
- **Susceptibility to:**
  - **predation**
  - **overgrowth competition**
  - **sedimentation**

Project Area: Restoration of Native Olympia Oysters Within The South Slough Estuary, Oregon



Take-Home Messages:

1. The South Slough NERR is engaged in an active restoration program that encompasses a diversity of habitats located throughout the coastal watershed-estuarine ecosystem.

2. Restoration work and effectiveness monitoring has been completed for multiple habitat components of the Winchester Tidelands Restoration Project (1996-present).

3. Re-establishment of tidal hydrology and re-construction of tidal channels has facilitated rapid recovery of salt marsh communities, including sedimentation, vegetation, invertebrates, fish, and shorebirds.

4. Removal of experimental small-scale oyster plots has been followed by successful re-planting of eelgrass, but commercial oyster mariculture will continue as a source of eelgrass disturbance.

5. A new program has been initiated to re-establish populations of native Olympia oysters in South Slough and accelerate recovery in Coos Bay.

6. Adaptive Ecosystem Management and the EBM approach will be followed to explore connectivity between nearshore, estuarine, and watershed elements of the South Slough coastal land-margin ecosystem. New work is needed to address colonization by non-native species and to establish restoration trajectories for the adjacent coastal forest habitats.

South Slough Estuarine Gradient

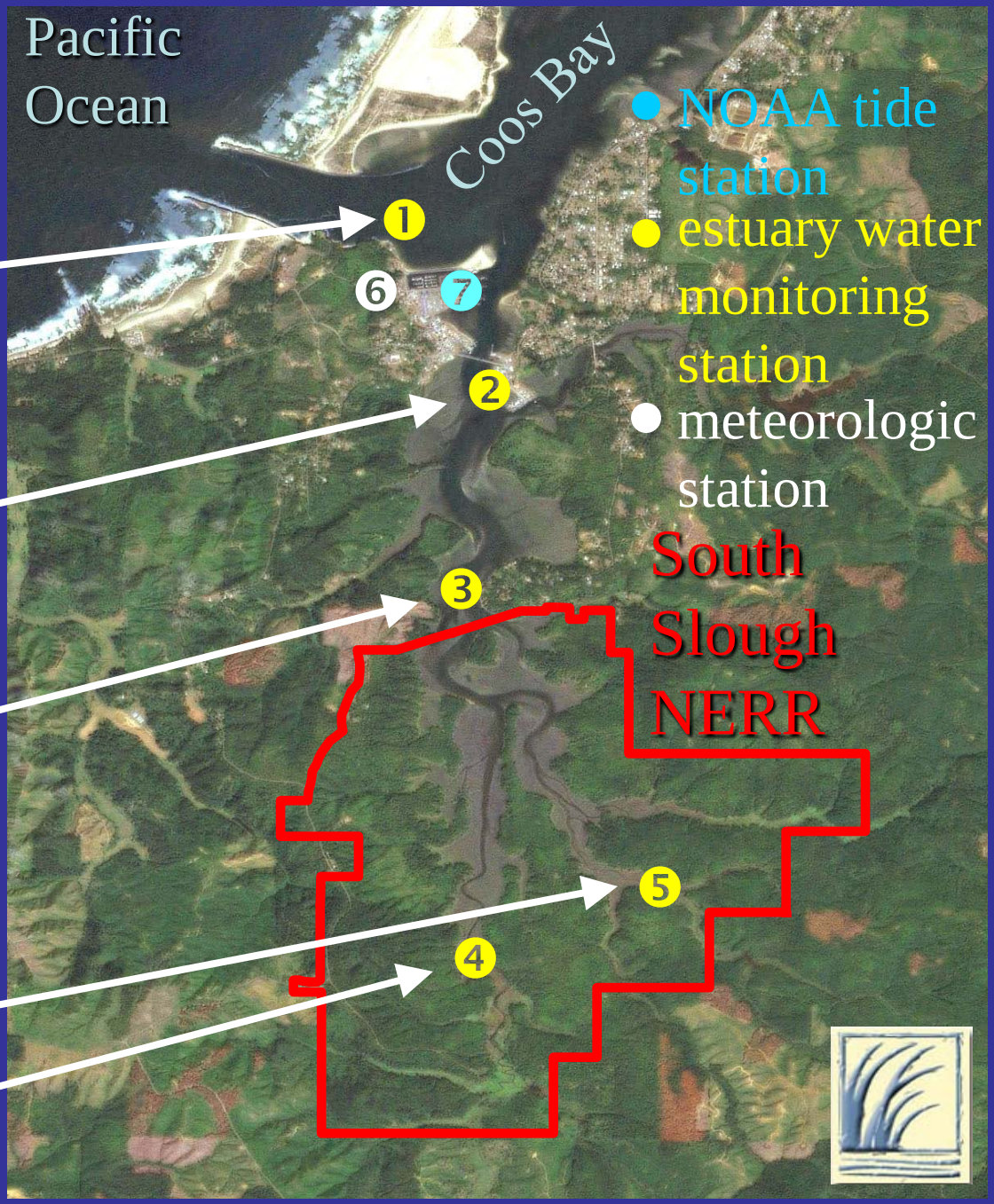
MARINE / BAY
Boathouse

MARINE DOMINATED
Charleston

MESOHALINE
Valino Island

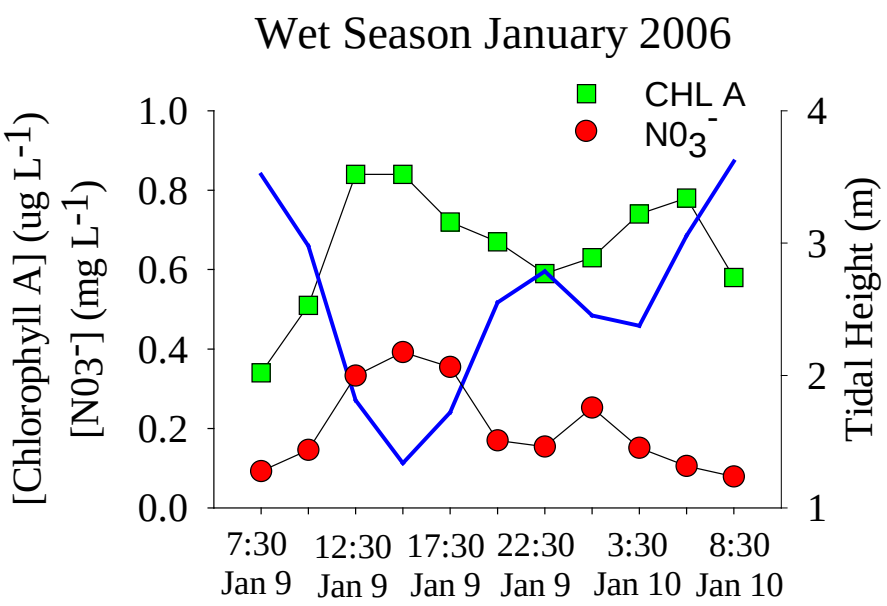
RIVERINE
Sengstacken Arm

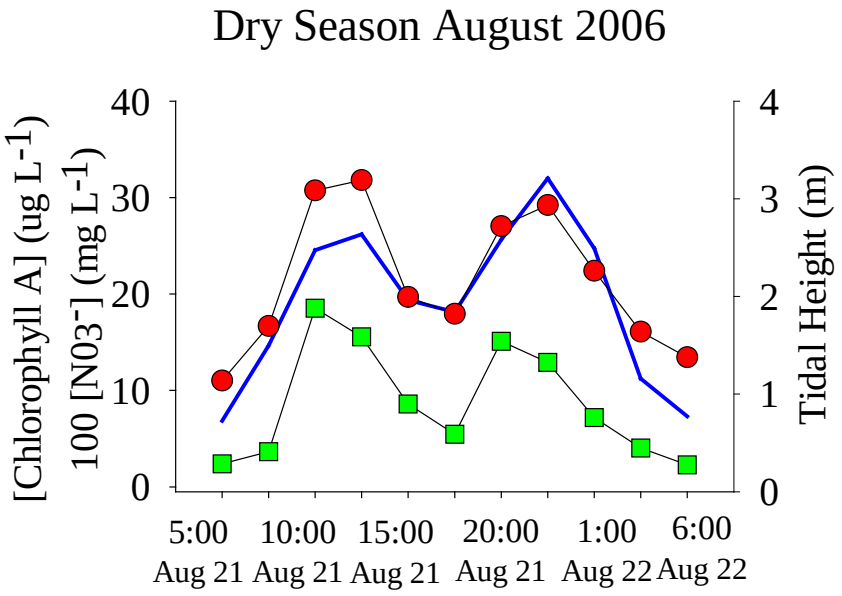
Winchester Creek



Tidal Changes in Nitrate and Chlorophyll-a Concentrations at the Charleston Bridge SWMP Station during the Wet and Dry Seasons

note: dry season nitrate scaled up 100X





Out-of-Phase with Tide: ⟺ **In-Phase with Tide:**

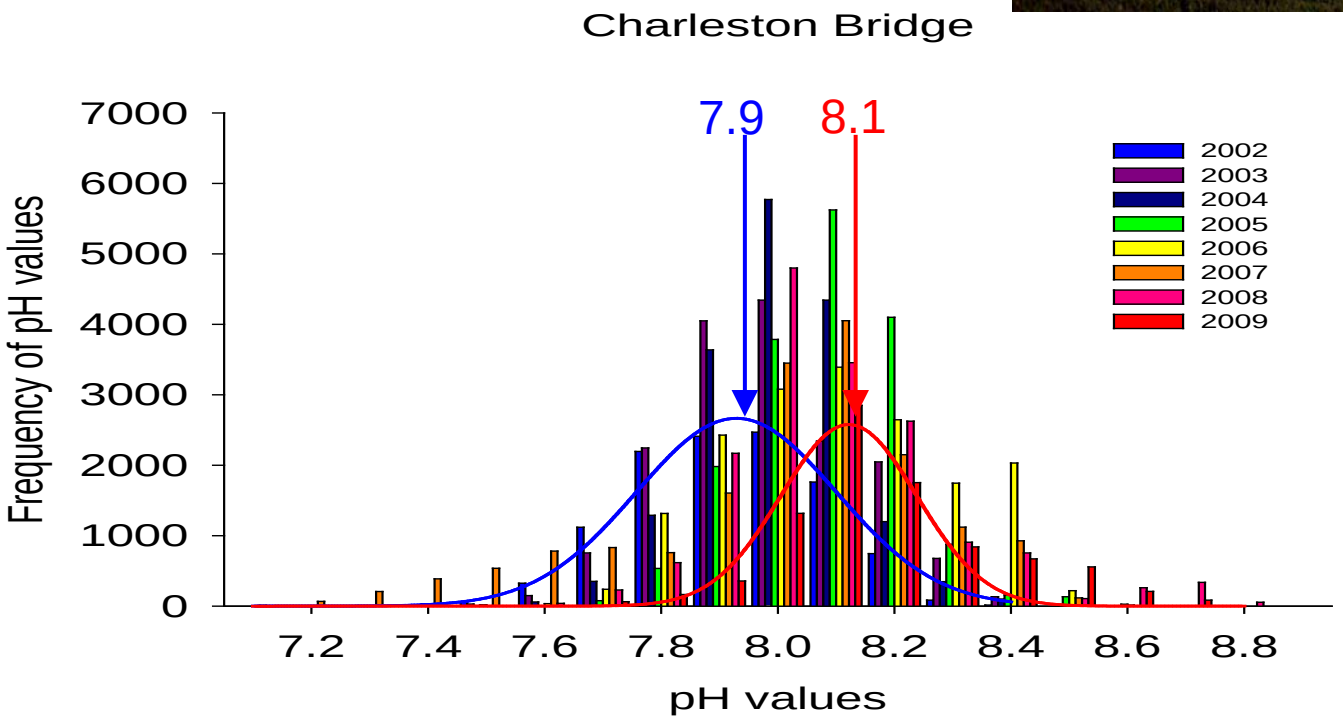
- **Peak Chl-a & NO3 values at low tide**
- **Watershed delivery of nutrients**
- **Peak Chl-a & NO3 values at high tide**
- **Ocean delivery of nutrients**

Time-series data reveal a long-term shift in pH values within the marine-dominated region of the South Slough

Annual averages:

2002 / pH 7.9

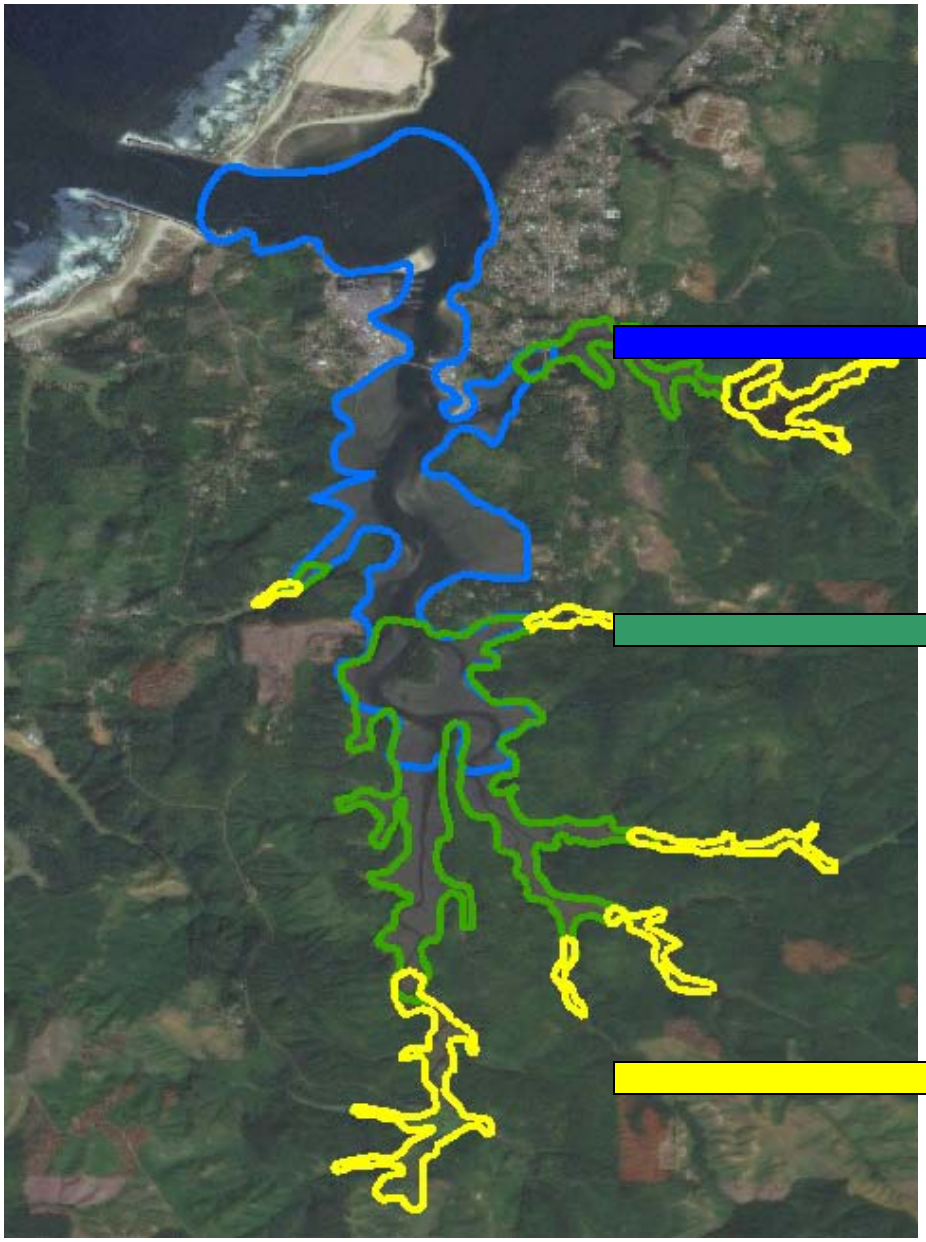
2009 / pH 8.1

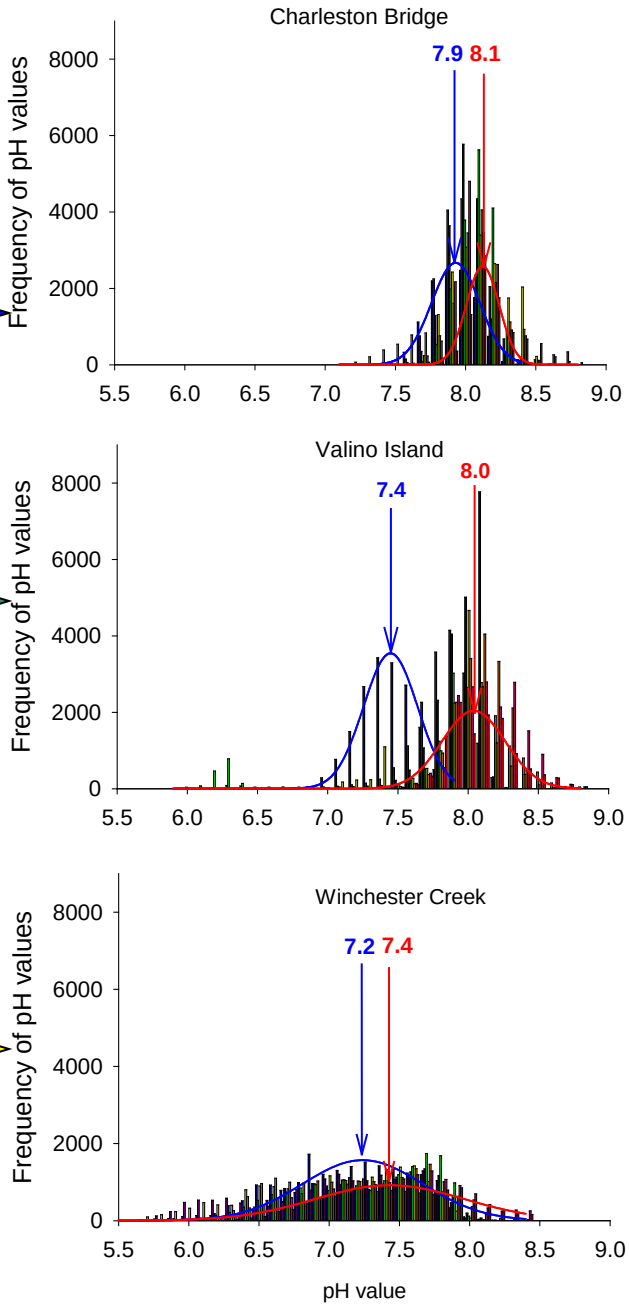


YSI-6600 EDS Datalogger

Total n = 208,400 pH measurements

South Slough: Changes in pH Values along the Estuarine Gradient

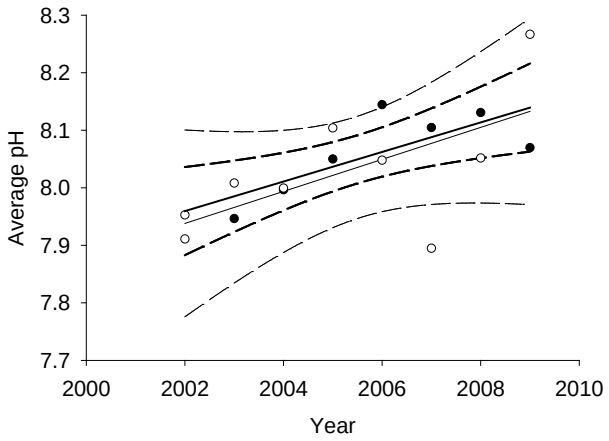


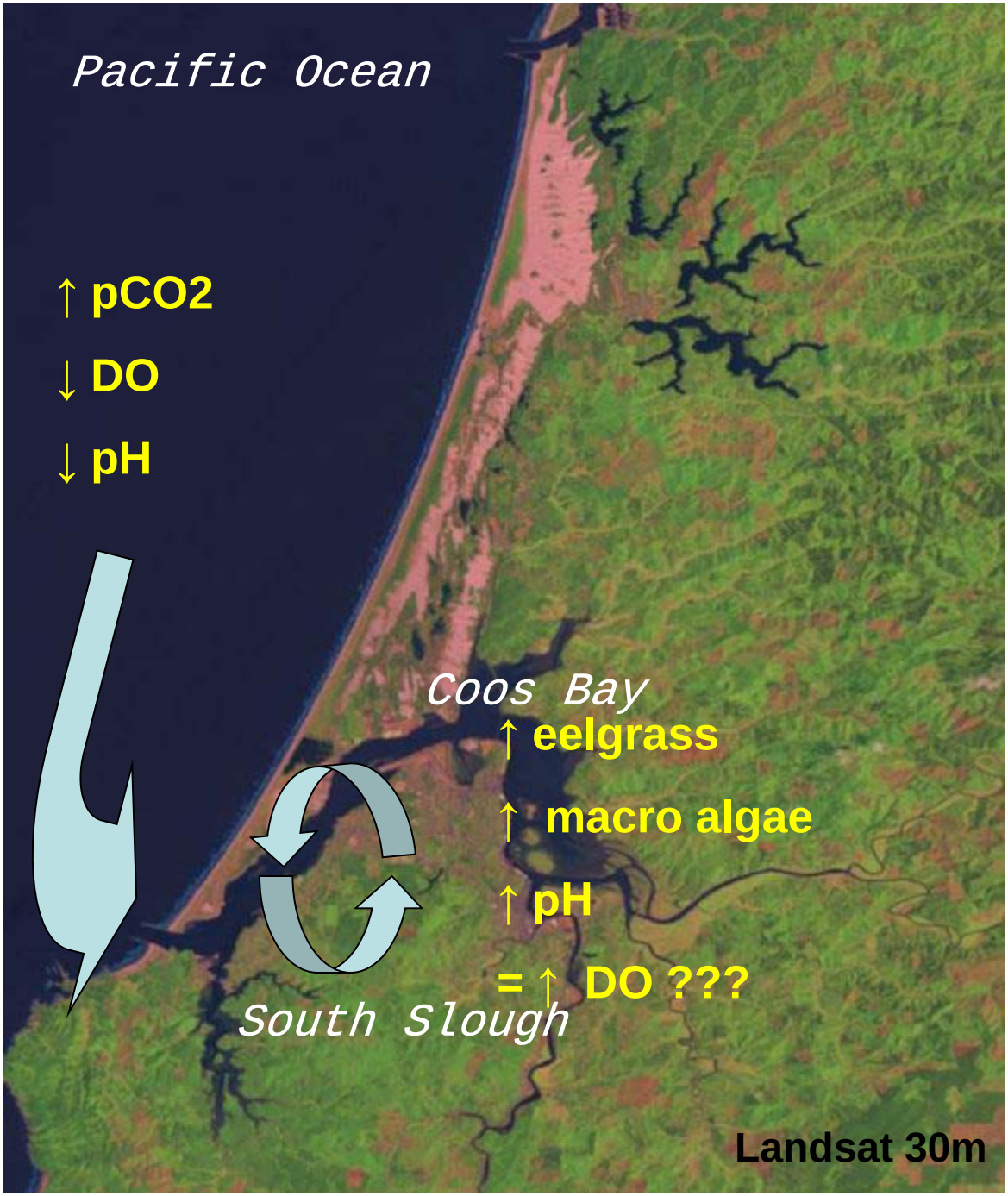


Coos Bay / South Slough Estuary

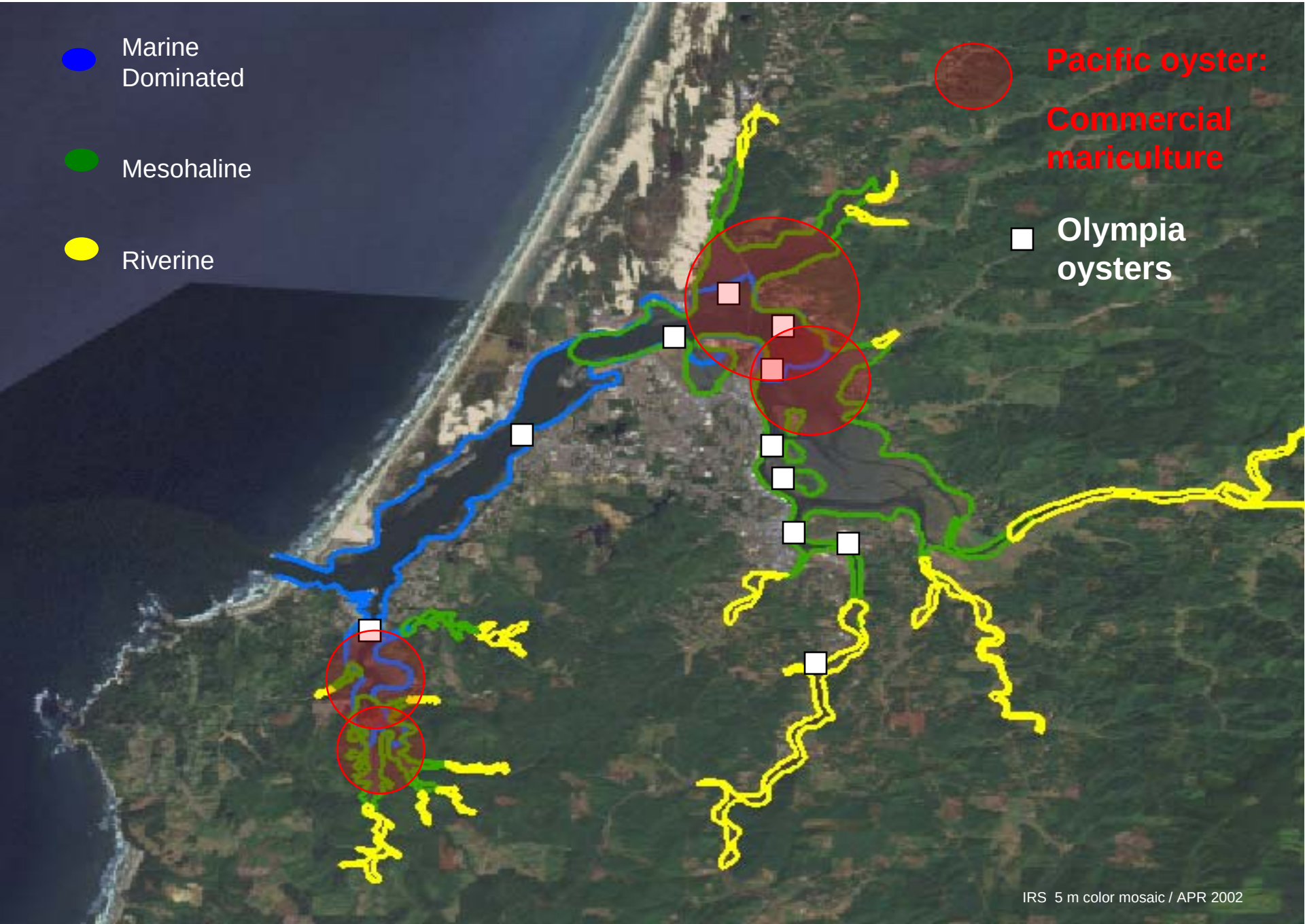
Working Hypothesis:

Observed long-term (8 yr) trend toward increased pH values is due to localized increases in biotic production (*i.e.*, eelgrass and macrobenthic algae) coupled with increases in the intensity of upwelling and ocean delivery of nutrients





COOS ESTUARY, OR Hydrologic Regions and Distribution of Olympia Oysters

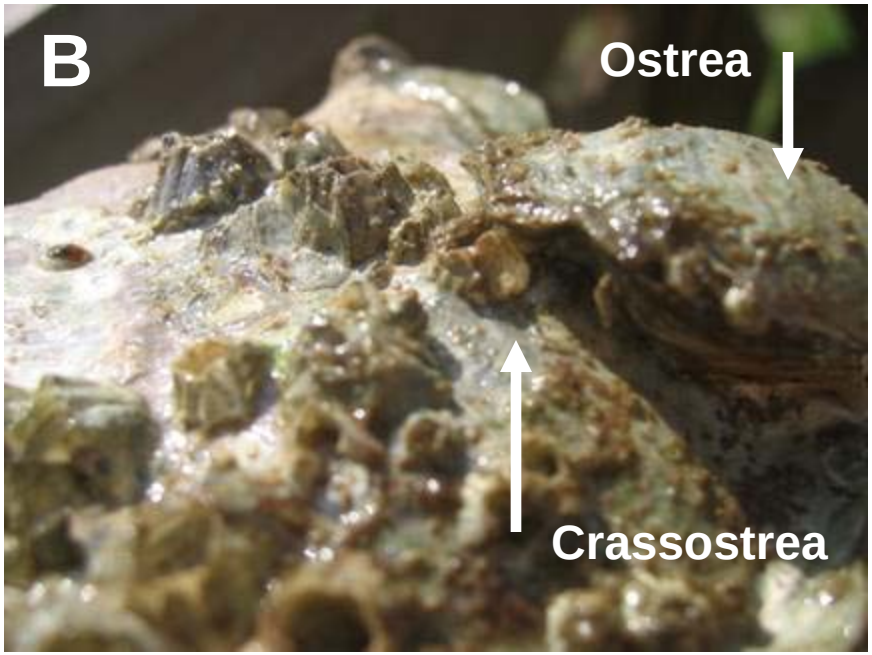


Ostrea lurida: Larval Settlement and Recruitment on Shells of Living Pacific Oysters (*Crassostrea gigas*)

Juvenile recruitment on adult Olympia oysters / *Ostrea*

<u>Outcome</u>: Good / Successive Generation

Juvenile recruitment on adult Pacific oysters / *Crassostrea*



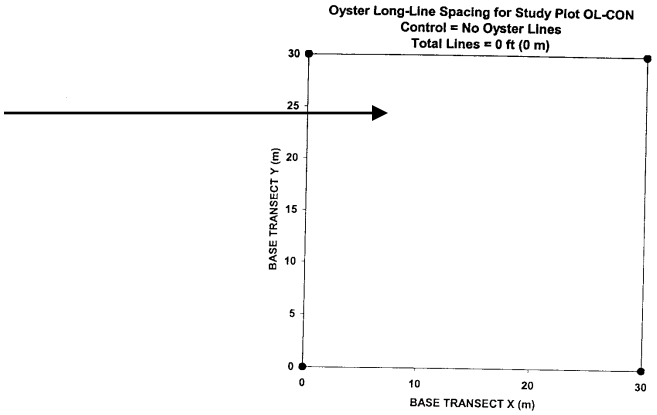
<u>Outcome</u>: Good / Available Substrate

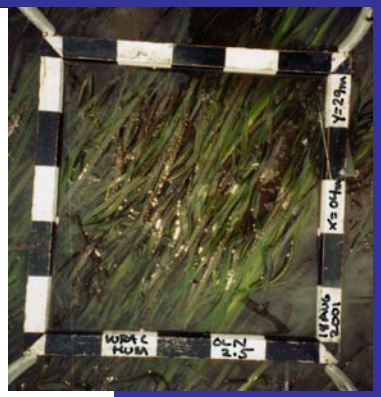
Bad / Harvested and Removed from Population

OL CON

Control no lines

Length 0 ft

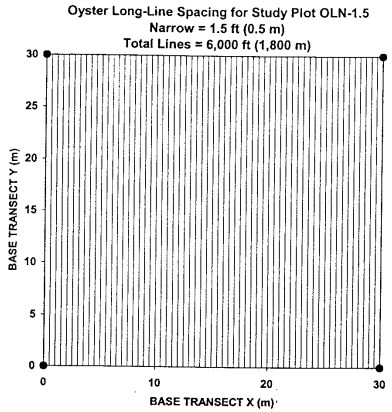


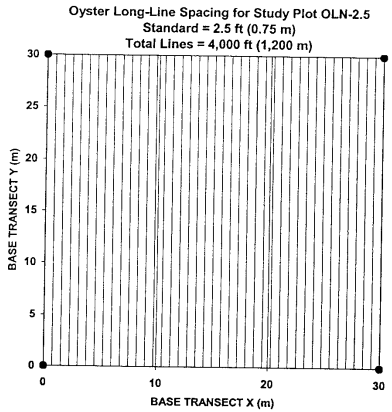


OLN 1.5

Spacing 1.5 ft

Length 6,000 ft





OLN 2.5

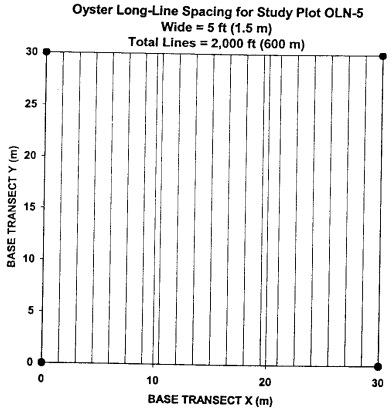
Spacing 2.5 ft

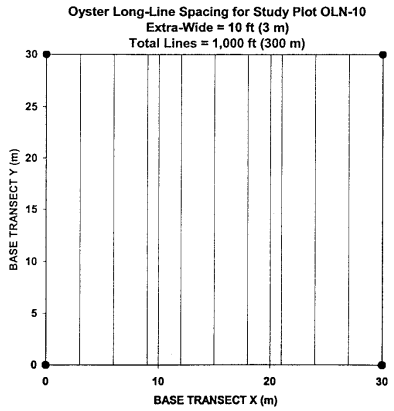
Length 4,000 ft

OLN 5

Spacing 5 ft

Length 2,000 ft





OLN 10

Spacing 10 ft

Length 1,000 ft

Coos Bay / South Slough Olympia Oyster Restoration Project: 2008-2015

Components:

Common-Garden Experiment to Investigate Local Adaptation (2008-2014)

Monitor Oyster Survival, Growth, and Reproduction (2008-2010)

Ecological Interactions with Predators and Competitors (2008-2010)

Alteration of Hydrodynamics by Oyster Clusters (2008-09)

Estimation of Larval Production, Retention, Export, and Settlement (2009-2015)

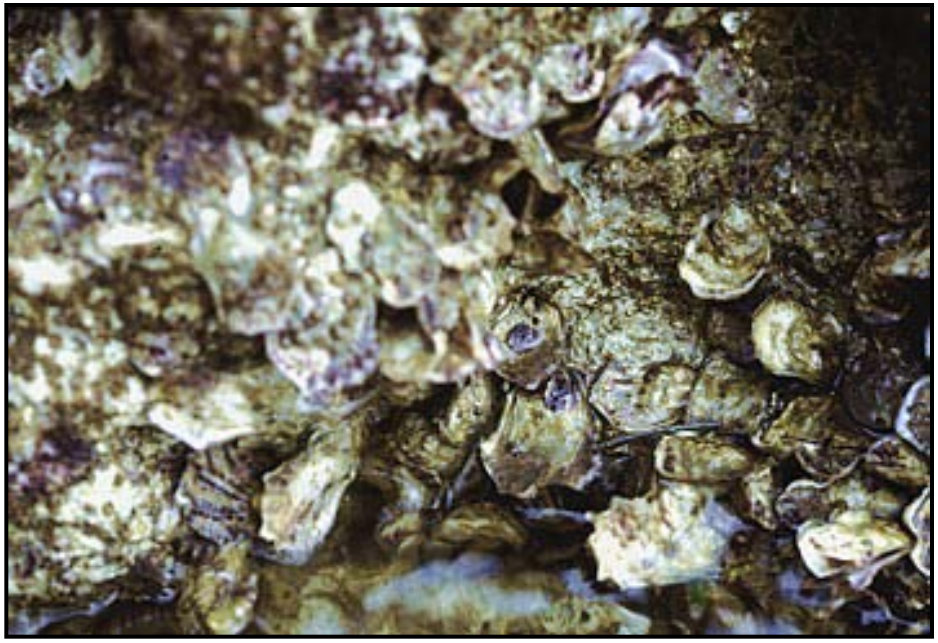
Initiation of Larger-scale Oyster Restoration Study Areas (2009-15)

Populations of Native Olympia Oysters are Making a Slow Recovery in the Middle and Upper Regions of Coos Bay

Salinity range 10 to 30 psu (mesohaline to polyhaline hydrographic region)

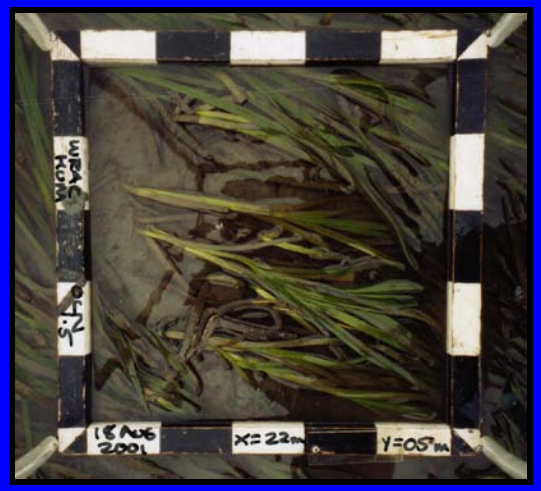
Availability of Suitable Surfaces for Settlement and Growth Appears to be an Important Limiting Factor

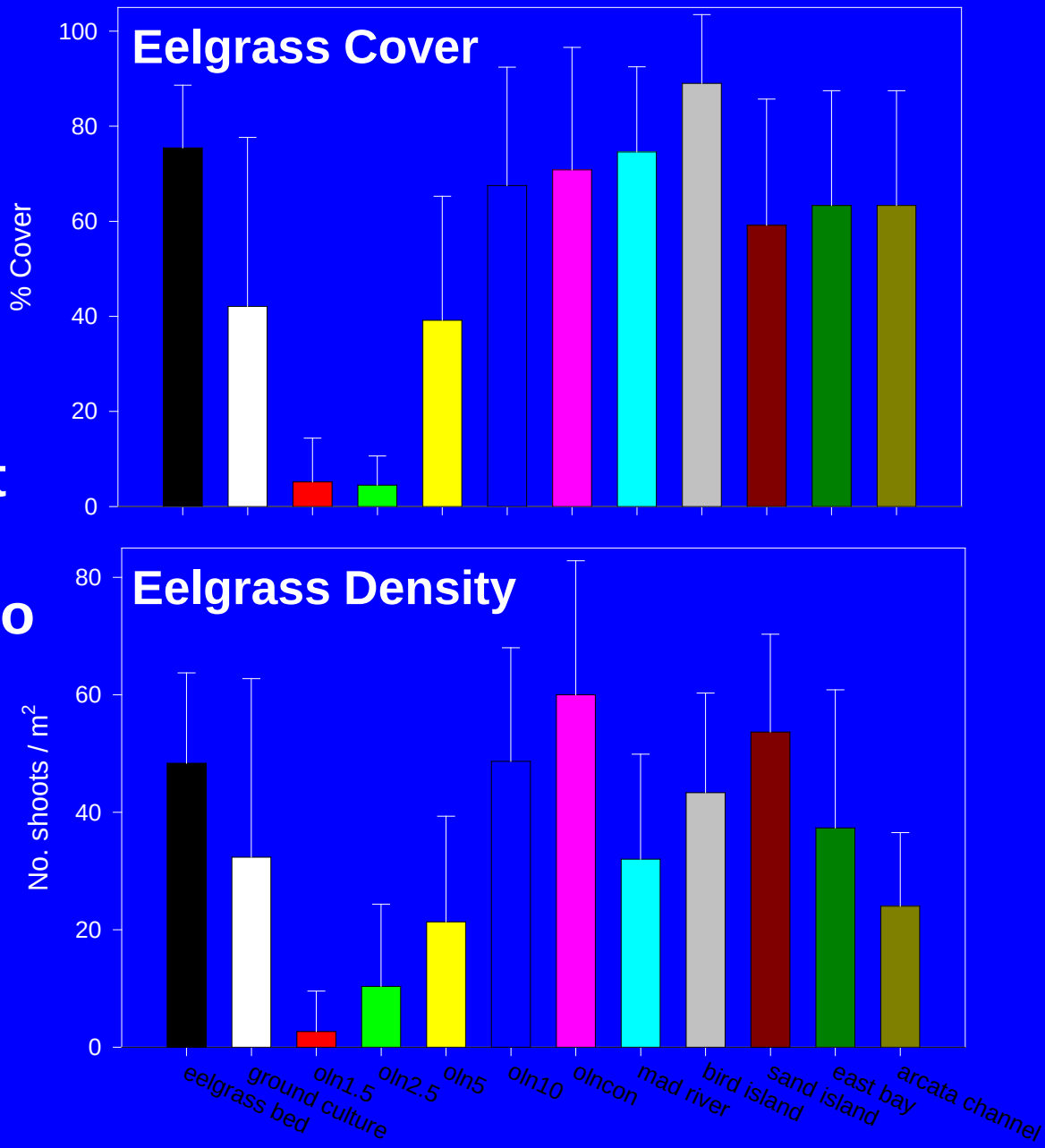
Suitable Hard Surfaces include Shell Rubble, Rocks, Gravel, Pilings, Rip-Rap, and Living Pacific Oysters (*Crassostrea gigas*)



After 22 months (Sep 01 – Jul 03):

- Eelgrass % cover and shoot density increase with wider long-line spacing
- Eelgrass in 5- and 10-ft line spacing plots is generally comparable to reference areas





Zostera marina: Conceptual model of controlling factors (from Thom *et al.*, 2003)

CONTROLLING FACTORS ⇨ ***STRUCTURE*** ⇨ ***FUNCTIONS***

PRIMARY:

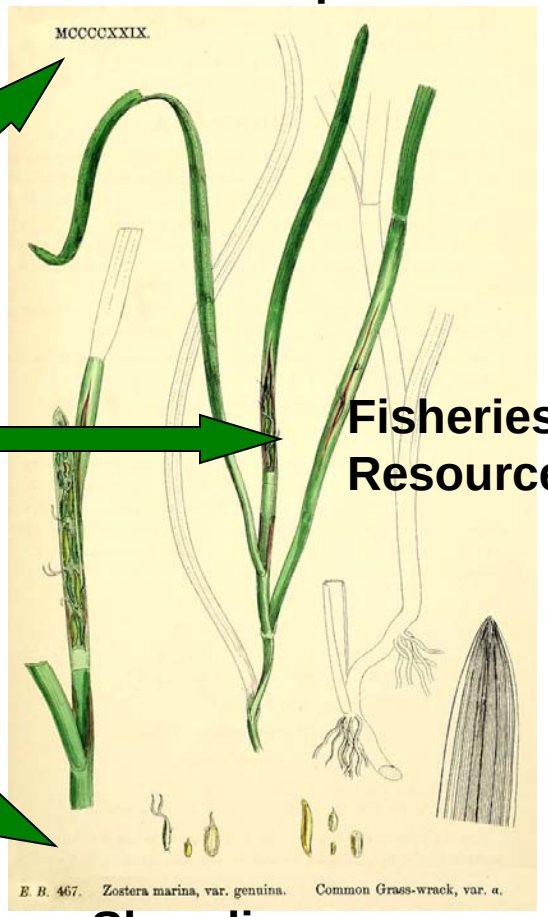
- **Light**
  (3 moles PAR d^{-1})
- **Temperature**
  (7-13 °C)
- **Substratum**
  (sand/mud/gravel)
- **Nutrients**
  (mod soil / low water col.)
- **Water Motion**
  (3 m s-1 tidal / 80 cms-1 burst)

SECONDARY:

- **Bioturbation**
- **Dessication**
- **Mechanical Damage**
- **Plant Competition**
- **Disease/Herbivory**

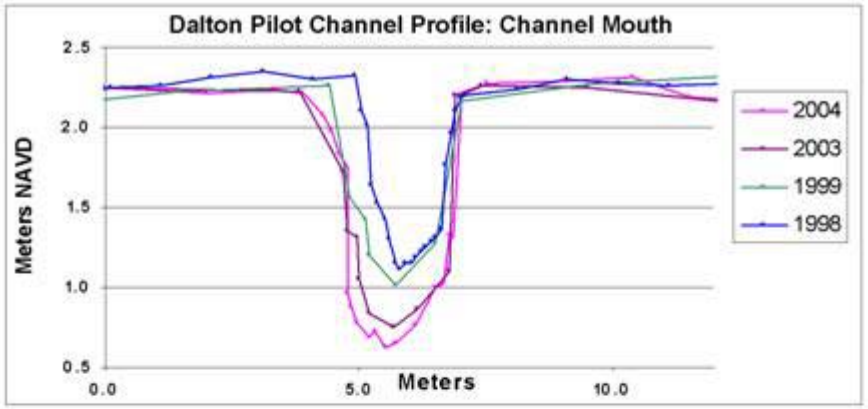
Eelgrass Biomass (& associated community)

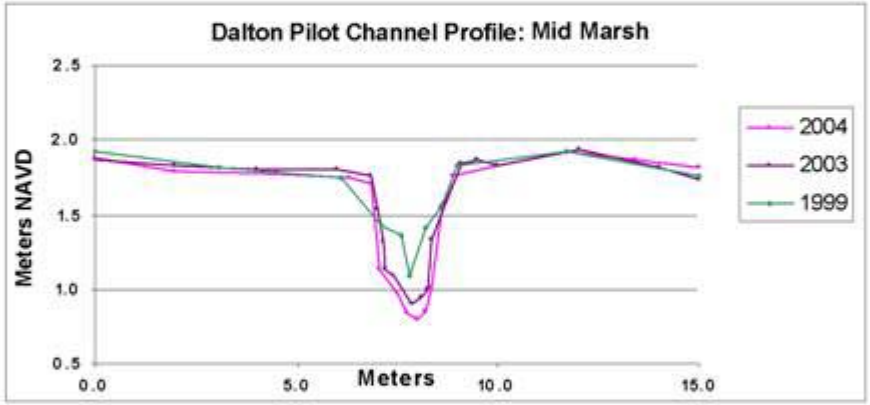
Carbon Export

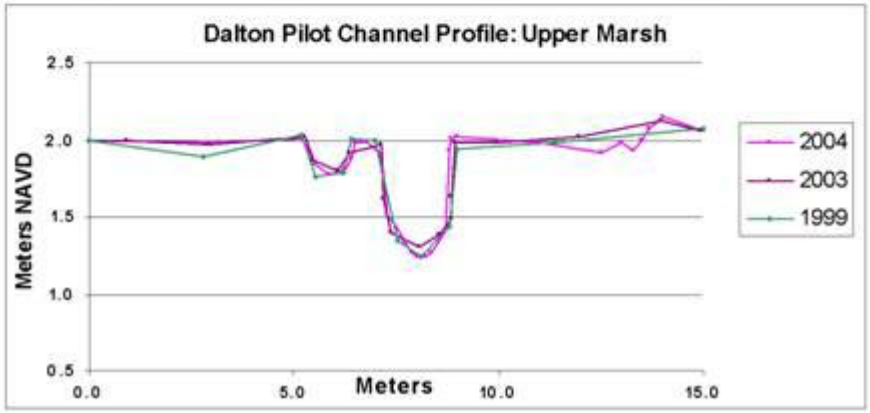


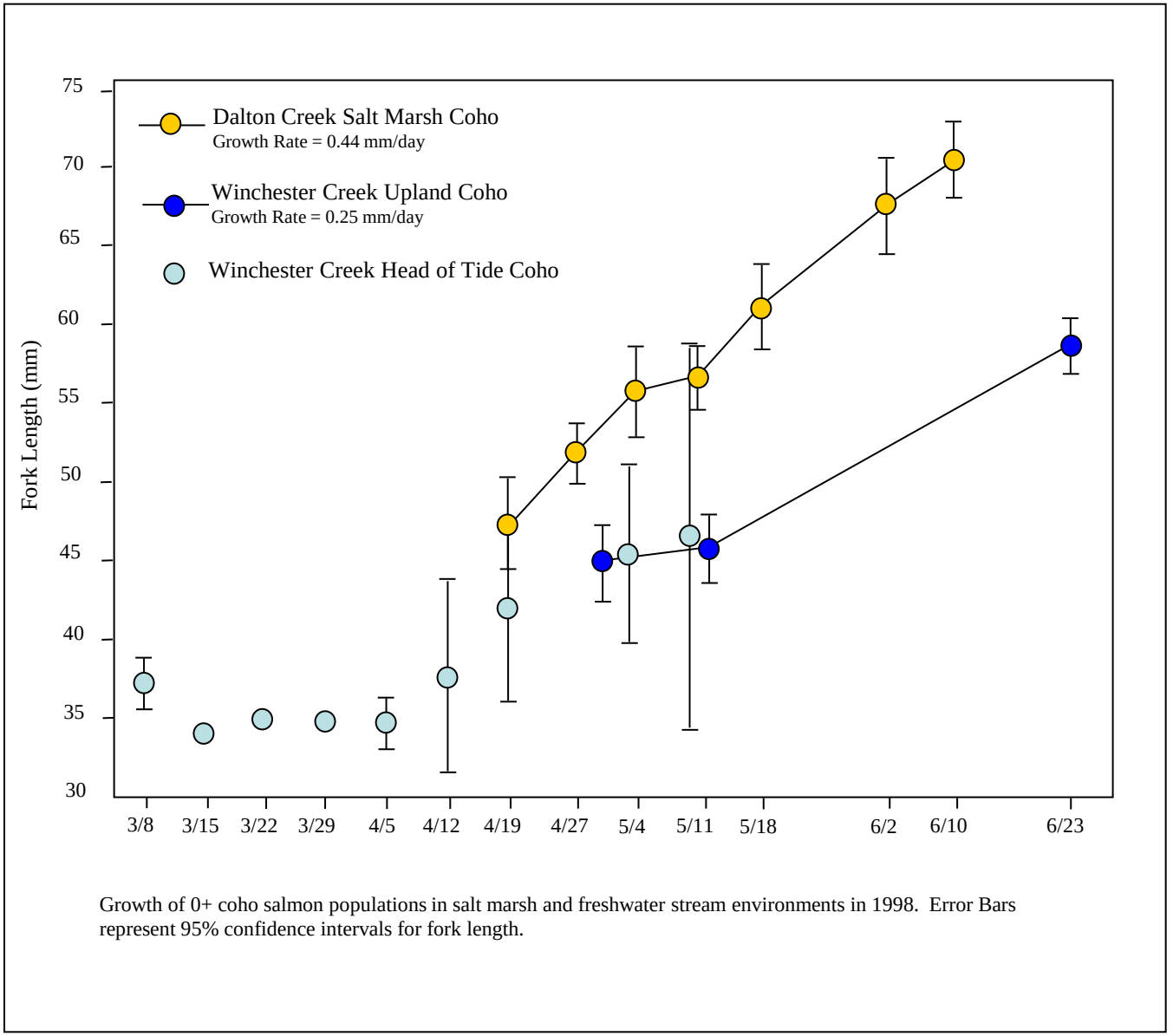
Fisheries Resources

Shoreline Stabilization


Dalton Pilot Channel Profile: Channel Mouth
Meters NAVD
2.5
2.0
1.5
1.0
0.5
0.0
5.0
10.0
Meters
2004
2003
1999
1998


Dalton Pilot Channel Profile: Mid Marsh
Meters NAVD
2.5
2.0
1.5
1.0
0.5
0.0
5.0
10.0
15.0
Meters
2004
2003
1999


Dalton Pilot Channel Profile: Upper Marsh
Meters NAVD
2.5
2.0
1.5
1.0
0.5
0.0
5.0
10.0
15.0
Meters
2004
2003
1999



Growth of 0+ coho salmon populations in salt marsh and freshwater stream environments in 1998. Error Bars represent 95% confidence intervals for fork length.

Juvenile coho salmon growth rates in the constructed Dalton tidal creek and Winchester Creek

National Estuarine Research Reserve System

Existing Reserves Proposed Reserves