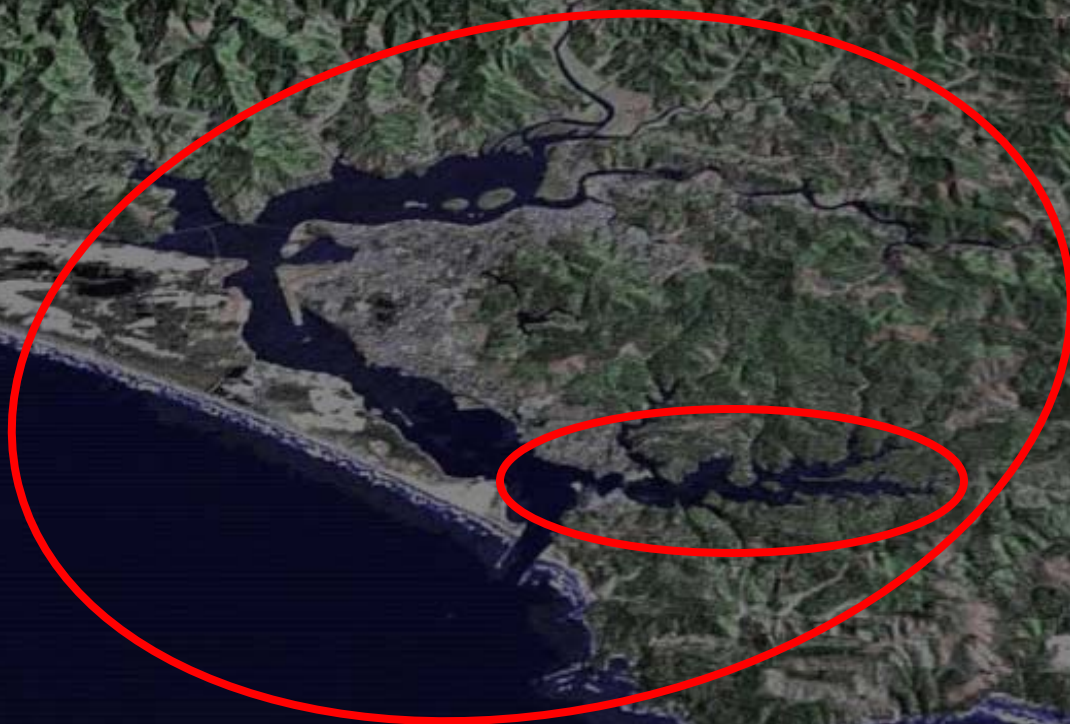




RESTORATION OF NATIVE OLYMPIA OYSTERS

(Ostrea conchaphila)

IN THE SOUTH SLOUGH ESTUARY, OREGON



Steven Rumrill

• South Slough National Estuarine Research Reserve

Olympia oysters
Ostrea conchaphila



- **Native from Alaska to Baja California**
- **Historically extensive in Coos Bay / dredge spoils**
- **Local extinction due to sedimentation / 1800s**
- **Reintroduced from outside source / 1940-50s**
- **Small / growing population in estuary**

Pacific oysters
Crassostrea gigas

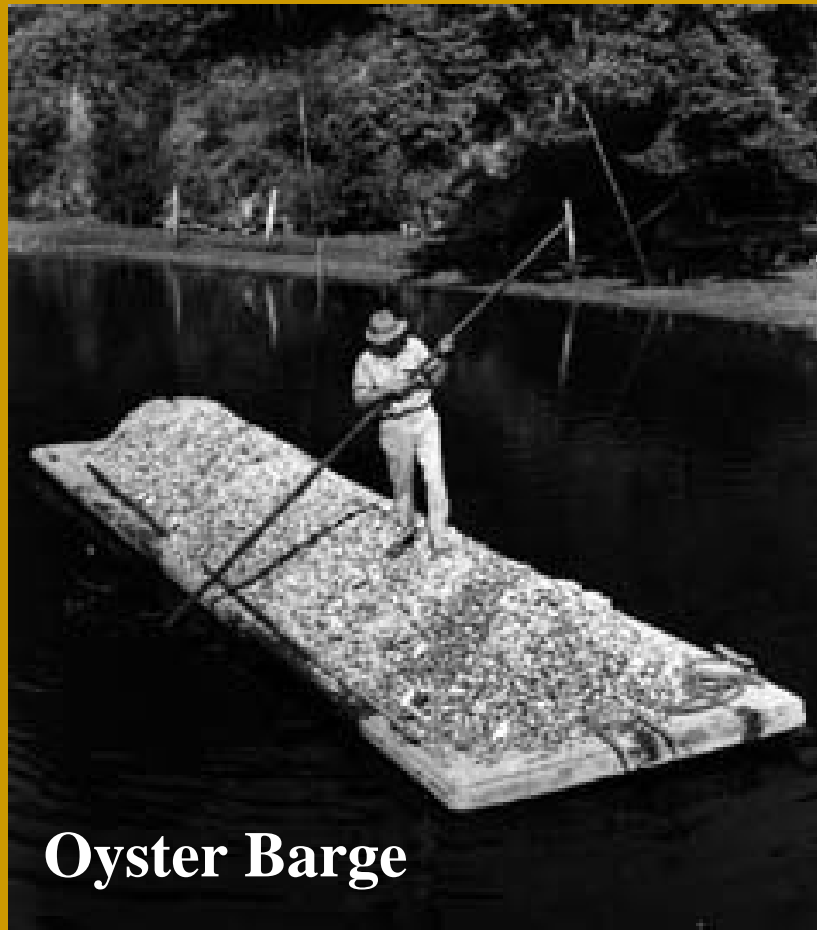


- **Native from Russia to China**
- **Imported to North America from Japan / 1903**
- **Cultured 1910s - present**
- **Mariculture operations include bottom, stake, and rack culture**

Harvest and Culture of Native Olympia Oysters (1850s-1920s)

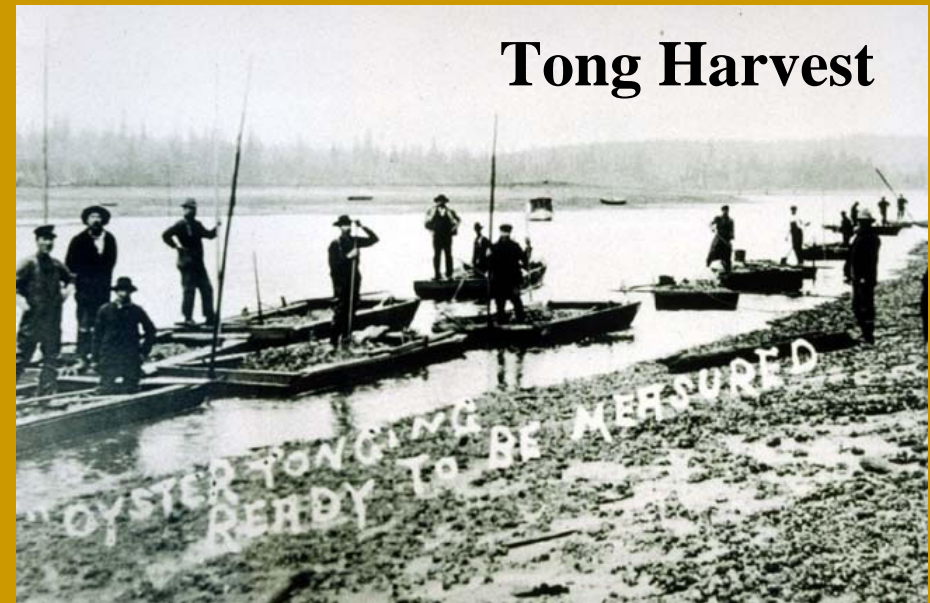
WASHINGTON

Diked Culture Plots

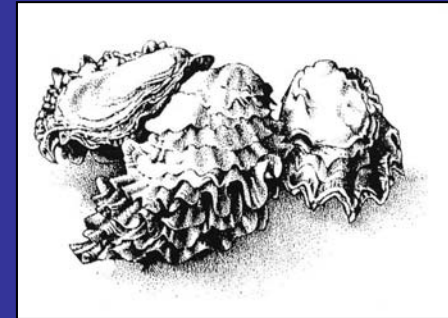
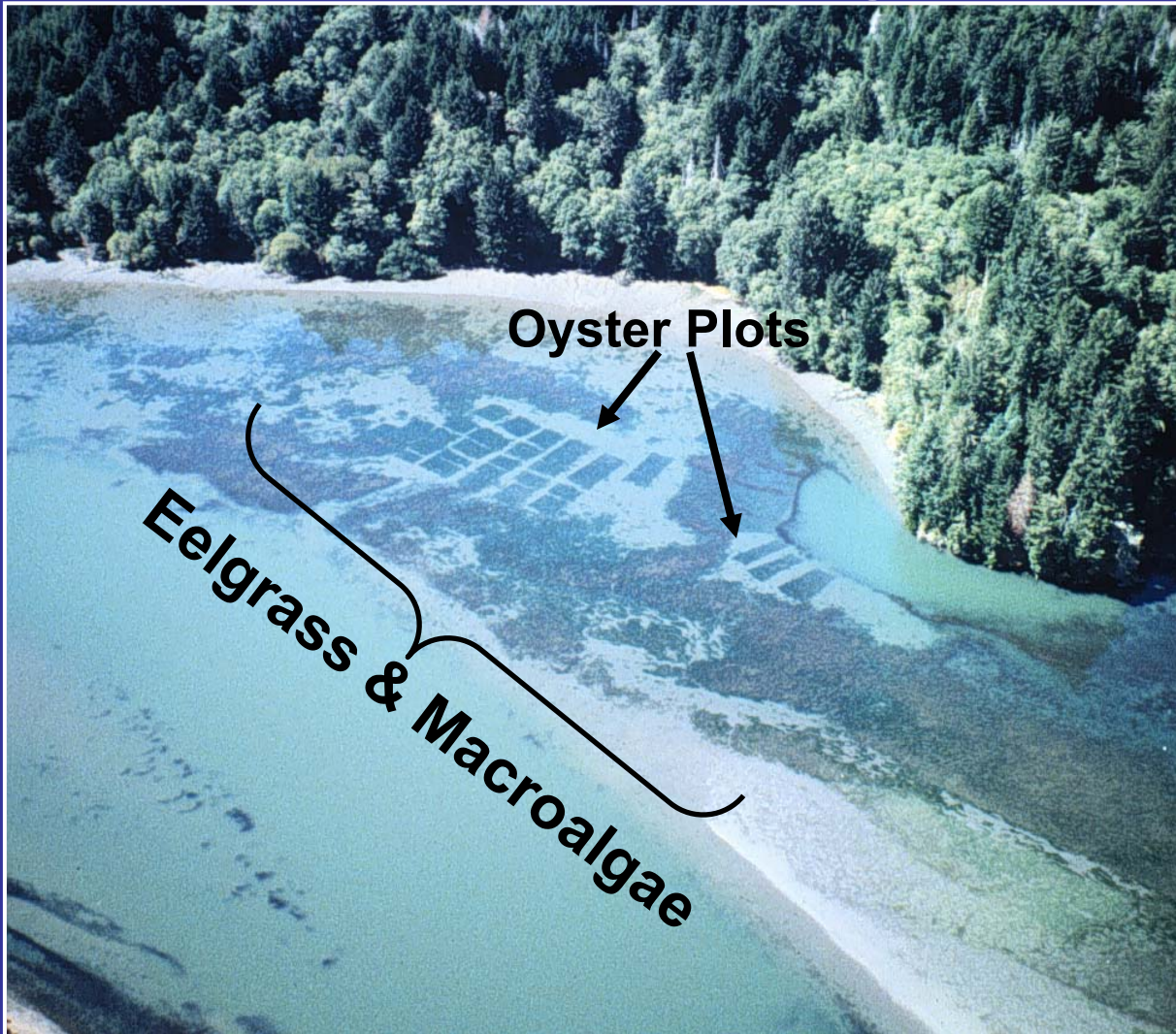


Oyster Barge

Tong Harvest



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

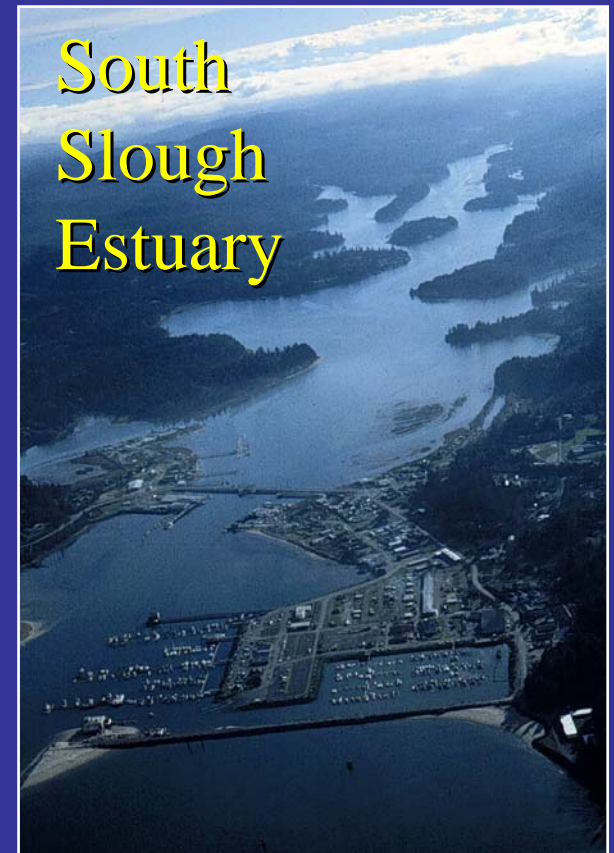
A. Bottom culture

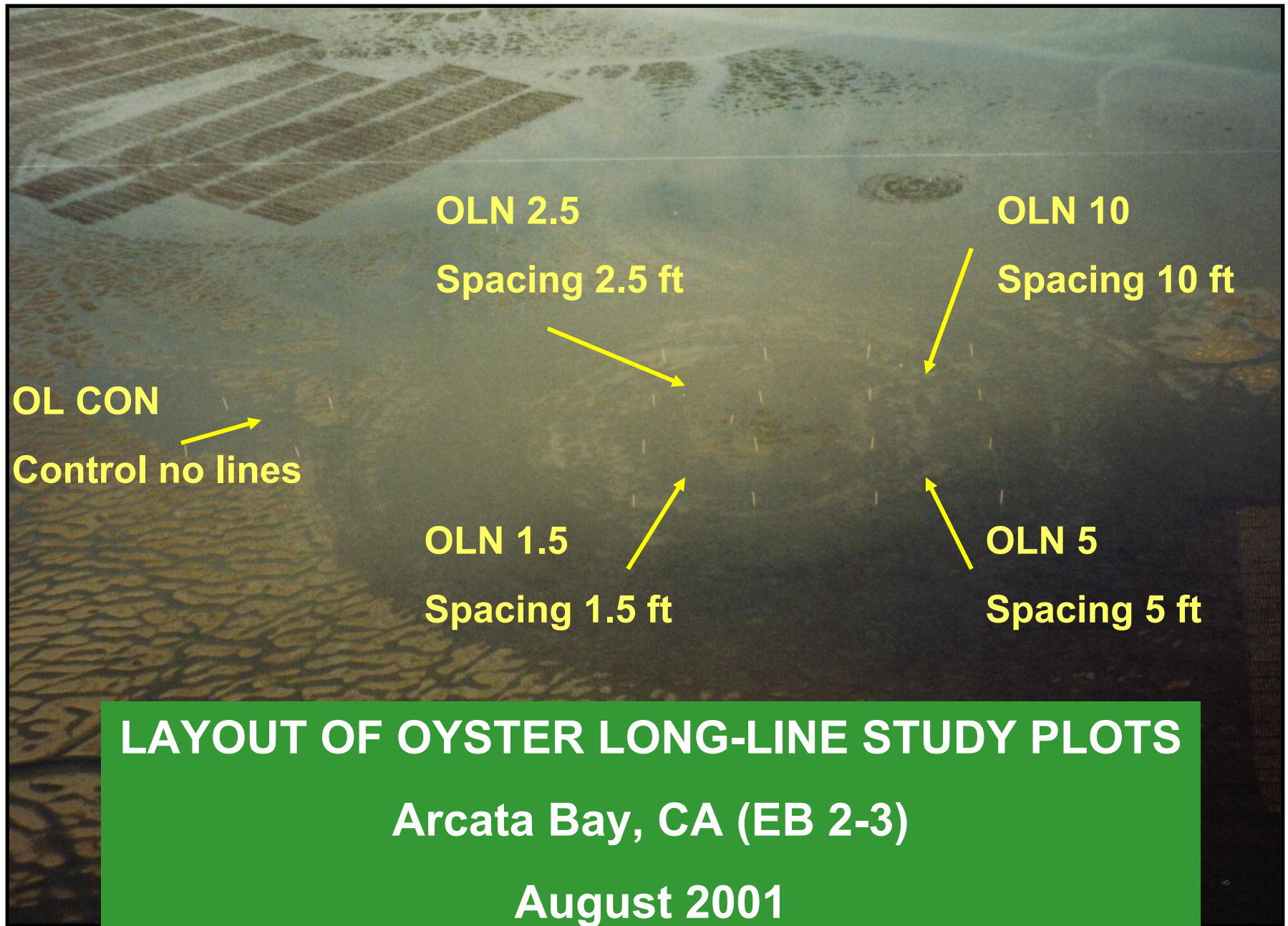


B. Stake culture



C. Rack culture





OLN 2.5
Spacing 2.5 ft

OLN 10
Spacing 10 ft

OL CON
Control no lines

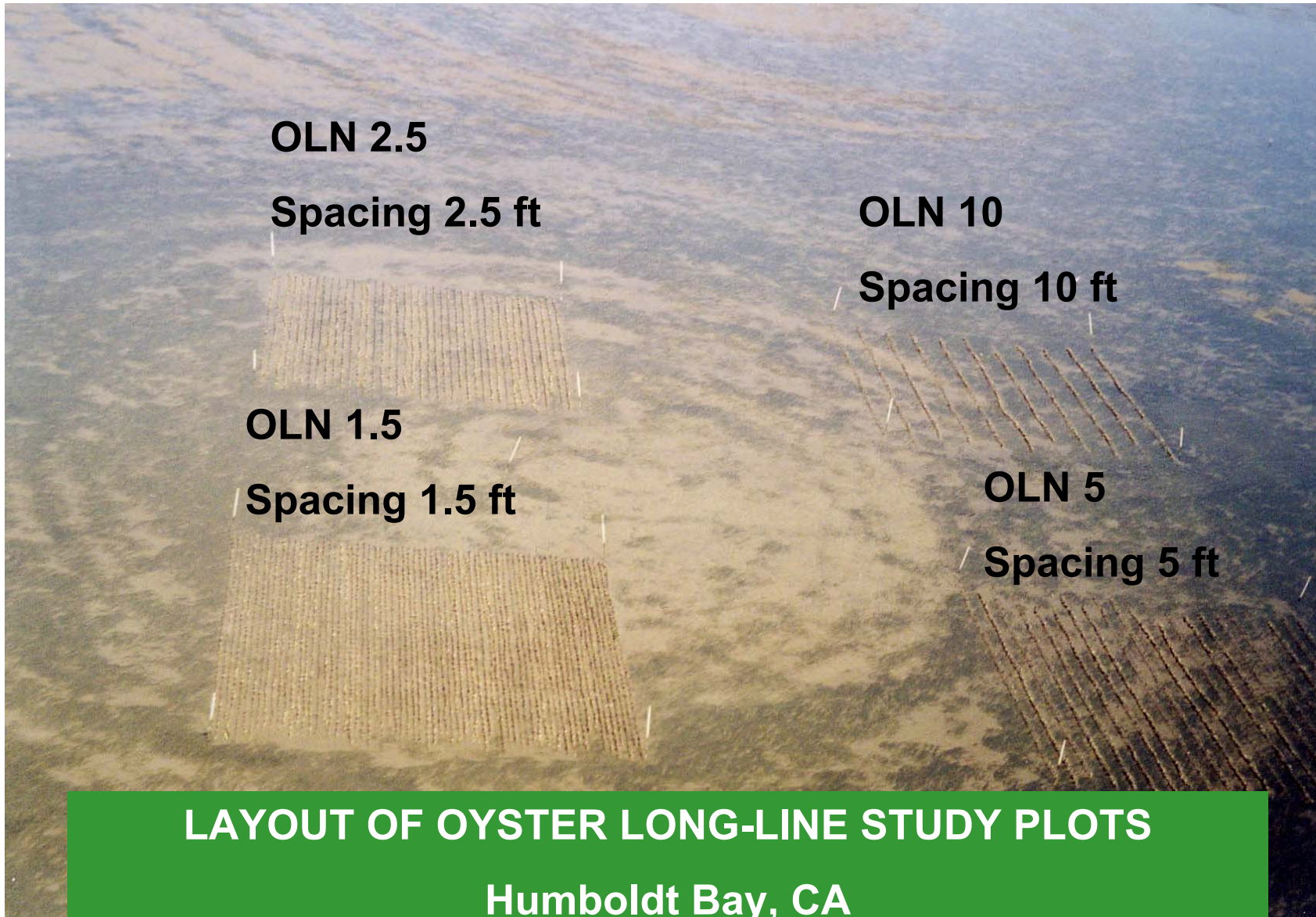
OLN 1.5
Spacing 1.5 ft

OLN 5
Spacing 5 ft

LAYOUT OF OYSTER LONG-LINE STUDY PLOTS

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)

Pacific Oyster / Eelgrass Research in PNW Estuaries

Everett <i>et al.</i> 1995	Impacts of Stakes & Racks	South Slough NERR
Pregnall 1993	Recovery after Removal	South Slough NERR
Trianni 1995	Harvest Dredge Impacts	Humboldt Bay
Rumrill & Christy 1996	Impacts of Bottom Culture	South Slough NERR
Schreffler <i>et al.</i> 1999	Impacts of Bottom Culture	Tillamook Bay
Rumrill & Poulton 2004	Impacts of Long-Line Culture	Humboldt Bay
Dumbauld <i>et al.</i> 2004	Harvest Dredge Impacts	Willapa Bay
Ruesink <i>et al.</i> 2004	Filter-feeding Effects	Willapa Bay
Hosack <i>et al.</i> 2006	Habitat associations & fish use	Willapa Bay
Wisehart <i>et al.</i> 2007	Seed production in eelgrass beds	Willapa Bay

Commercial oyster mariculture has significant and variable impacts on abundance and density of eelgrass beds (*Zostera marina*)

Olympia oysters in Puget Sound ...

What was the historic abundance and distribution of native oysters in Oregon estuaries?

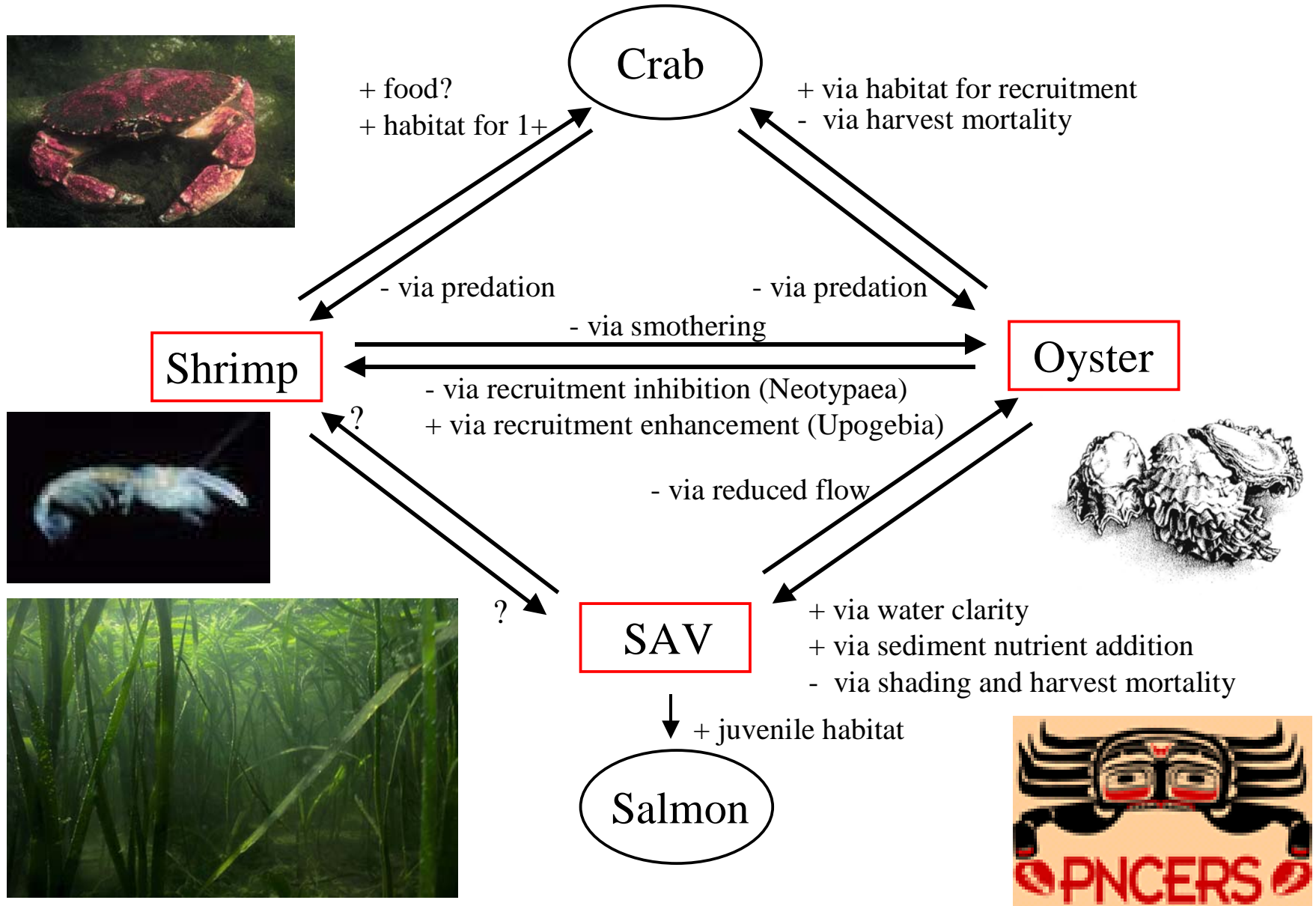
What were the structural characteristics of native oyster beds in Oregon estuaries?

What was the historic functional ecological role of oysters in Coos Bay and South Slough?

Poster: Jefferson County, WA

NOAA / Northwest Straits Marine Conservation Initiative

Pacific Northwest Estuarine* Ecosystem - Biotic Interactions



Recovery and Restoration of Olympia oysters in Coos Bay and the South Slough Estuary

Vision: Successful establishment of self-sustaining populations of *Ostrea conchaphila* throughout the South Slough and Coos Bay, to the extent that native oysters can provide habitat and contribute to improved ecological functions

Project Goal: Increased understanding of intrinsic and ecological factors to facilitate and encourage recovery of self-sustaining populations in the estuarine tidal channels and tideflats

Objectives:

- Monitor the location, status and recovery of *Ostrea* populations in Coos Bay
- Determine the genetic identity of existing oyster populations in Coos Bay and identify appropriate broodstock sources (2006-07)
- Establish an experimental population and conduct an on-site assessment of oyster survivorship, growth, and reproduction in South Slough (2007-09)

Coos Bay – South Slough Estuary, OR



COOS ESTUARY, OR Hydrologic Regions and Oyster Mariculture Operations

- Marine Dominated
- Mesohaline
- Riverine

**Pacific oyster:
Commercial mariculture**



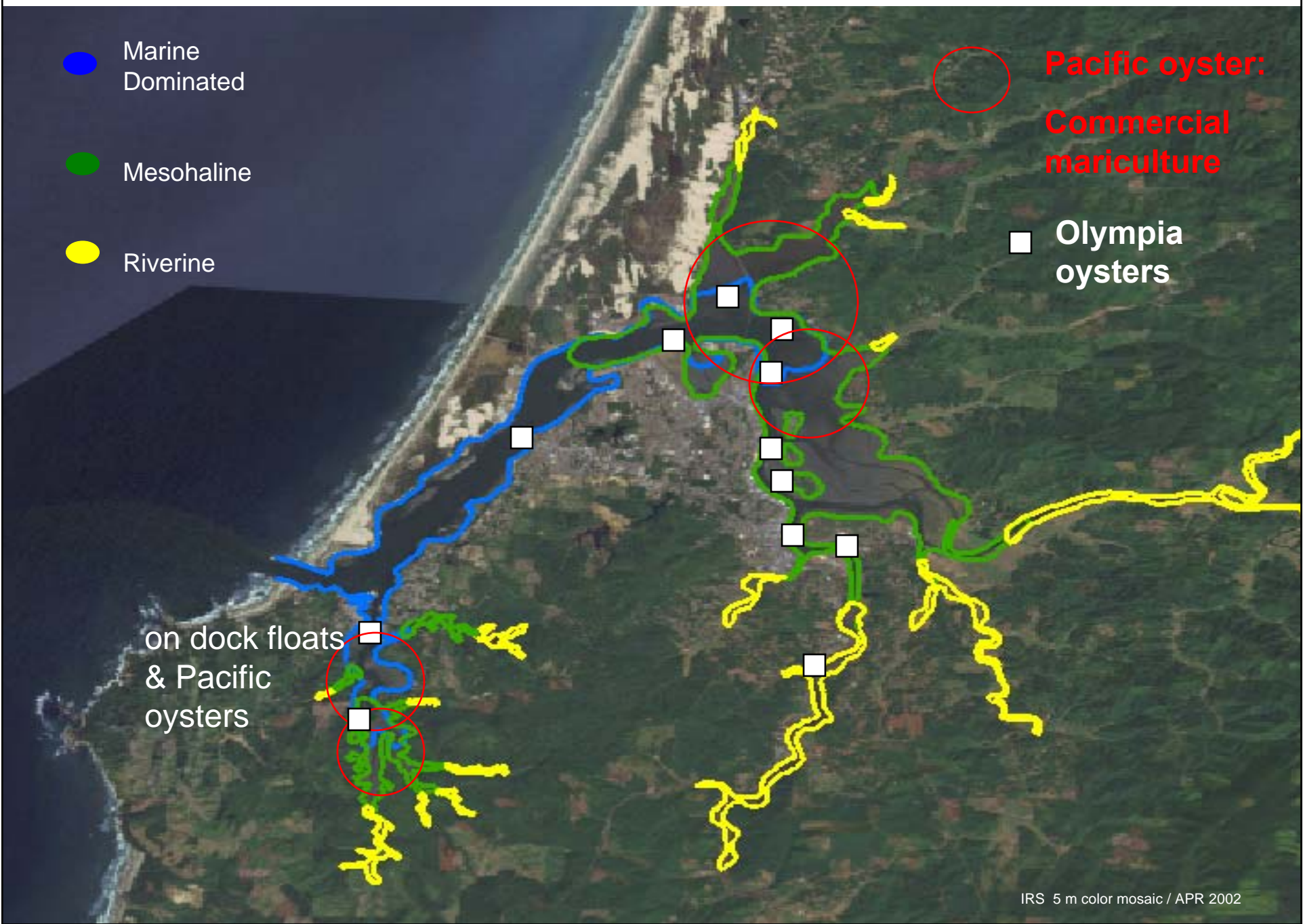
COOS ESTUARY, OR Hydrologic Regions and Distribution of Olympia Oysters

- Marine Dominated
- Mesohaline
- Riverine

Pacific oyster:
Commercial mariculture

■ Olympia oysters

on dock floats
& Pacific oysters



What factors may limit the recovery of Olympia oysters in the South Slough estuary?

- Larval supplies (growth, survival, retention)
- Availability of appropriate substratum for larval settlement
- Recruitment of post-larvae into established populations
- Survival and growth of adult oysters
- Predation by crabs and snails
- Overgrowth by non-indigenous tunicates



South Slough Estuary Olympia Oyster Restoration Project: 2006-2010

- **History of Native Oysters in Oregon Estuaries**

Oregon Dept. Fish & Wildlife / SSNERR (S. Groth, S. Rumrill / 2006)

- **Genetic Identity of Broodstock Oysters**

Oregon State University (M. Camara, C. Langdon, D. Stick / 2006)

- **Distribution and Recovery of Olympia Oysters in Coos Bay**

Oregon Dept. Fish and Wildlife (S. Groth / 2005-06)

- **Recruitment of Olympia Oysters to Fouling Panels and Shells**

SSNERR / SERC (C. deRivera, S. Rumrill / 2004-05)

- **Characterization of Estuarine Water Quality Conditions**

SSNERR (S. Rumrill, A. Helms, A. DeMarzo / 2005-2010)

- **Culture, Settlement, and Out-planting of Juvenile Oysters**

SSNERR / TNC (S. Rumrill, D. Vander Schaaf / 2007)

- **Monitor Oyster Survival, Growth, and Reproduction (2007-2010)**

SSNERR (S. Rumrill & ? / 2007)

- **Ecological Interactions with Competitors, Predators, and Eelgrass (2008-2010)**

- **Estimation of Larval Production, Retention, Export, and Settlement (2008-2010)**



History of Native Olympia Oysters in Oregon Estuaries

Netarts Bay:

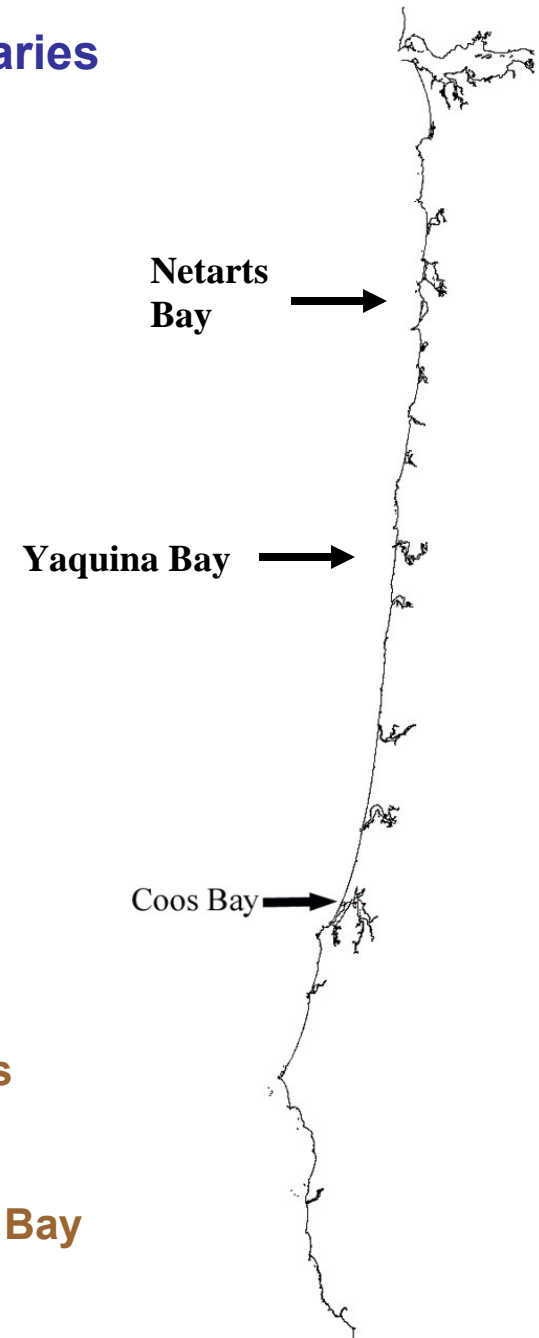
- Extensive commercial fishery 1860's
- Low numbers by 1930's
- Exotic snail predator 1957 (*Ocenebra*)
- Absent in 1992
- Restoration work in 2006-07

Yaquina Bay:

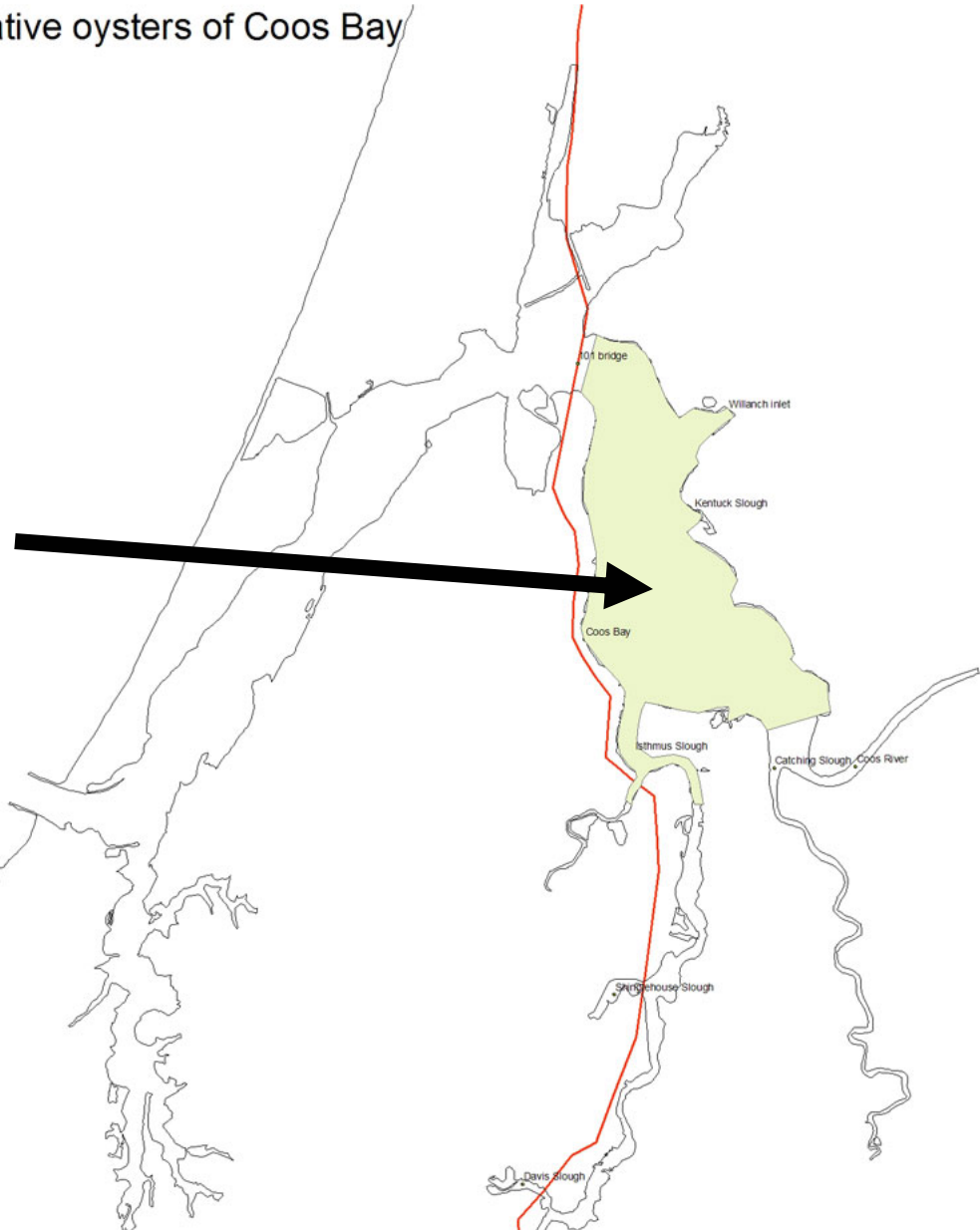
- Extensive commercial fishery 1860's to 1890's
- Commercial harvest ended by 1940's
- Slow recovery of natural populations 2006

Coos Bay:

- Extensive historic populations and shell deposits
- Local extinction prior to European settlement
- Reintroduction with Pacific oysters from Willapa Bay 1950's
- Natural populations re-established 1987-2007



Fossil deposits of native oysters of Coos Bay



**Extensive
Olympia
oyster shells
in dredge
spoils**

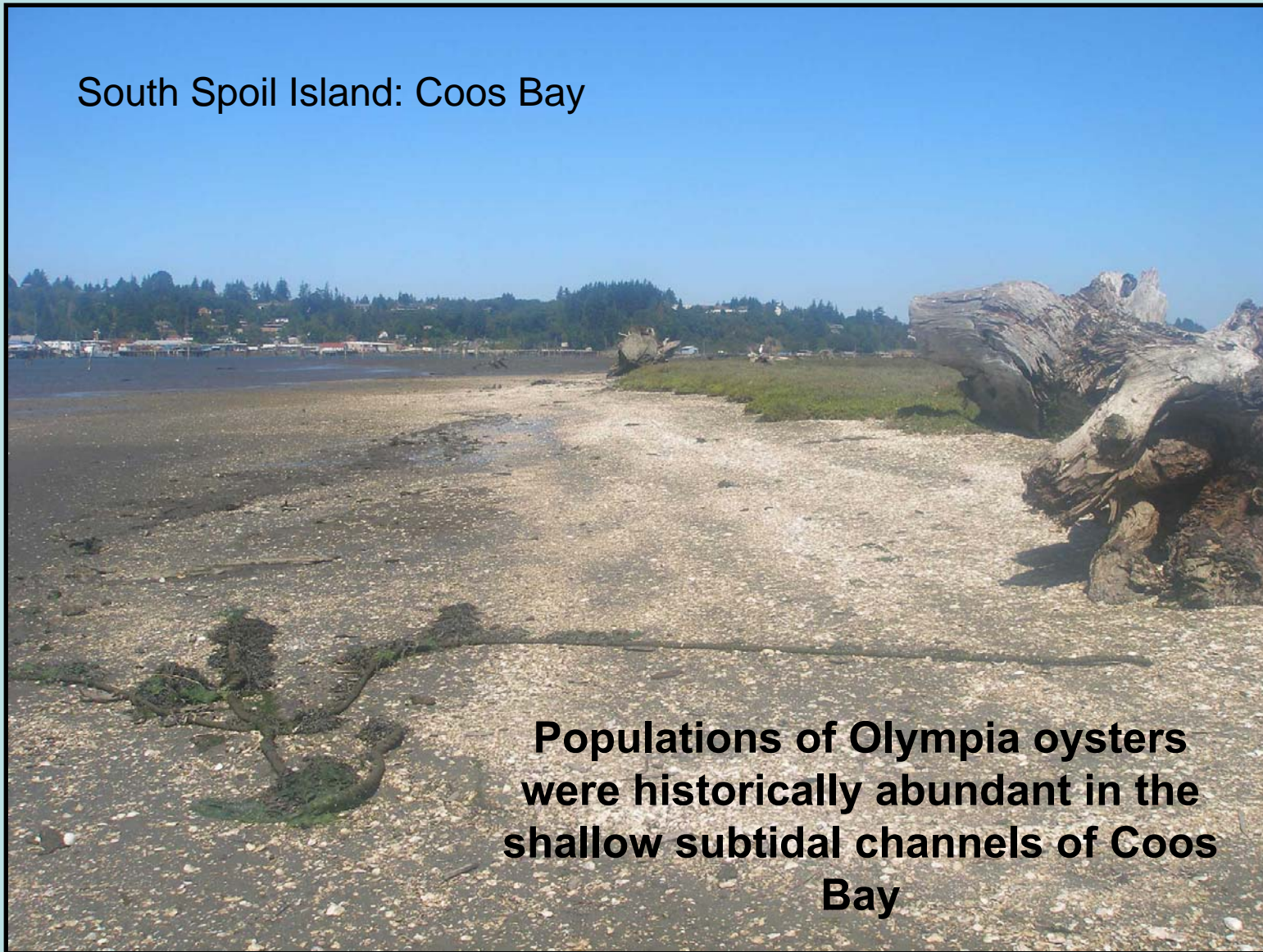
from S. Groth / ODFW

Coos Bay, OR: Shell deposits of Olympia oysters embedded in dredge spoils and in subtidal channels throughout upper regions of the Coos Bay Estuary



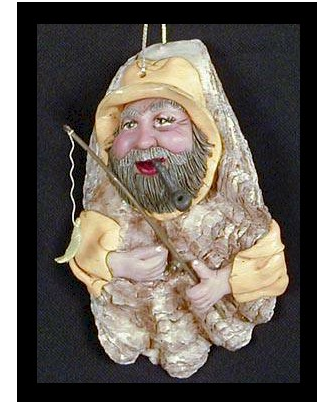
Coos Bay, OR: Shell deposits (*Ostrea conchaphila*) eroded from dredge spoil islands in the upper region of the Coos Bay Estuary

South Spoil Island: Coos Bay



Populations of Olympia oysters were historically abundant in the shallow subtidal channels of Coos Bay

Where did the Olympia oysters that currently inhabit Coos Bay come from?



Genetic Identity of Broodstock Oysters:

Sample Collections from Coos Bay Populations

North Bend, Coos Bay, Isthmus Slough, Shinglehouse Slough / (D. Stick, S. Rumrill, S. Groth, D. Sowers / 2005)

Genetic Analysis / DNA Microsatellites

M. Camara, C. Langdon, D. Stick / 2006



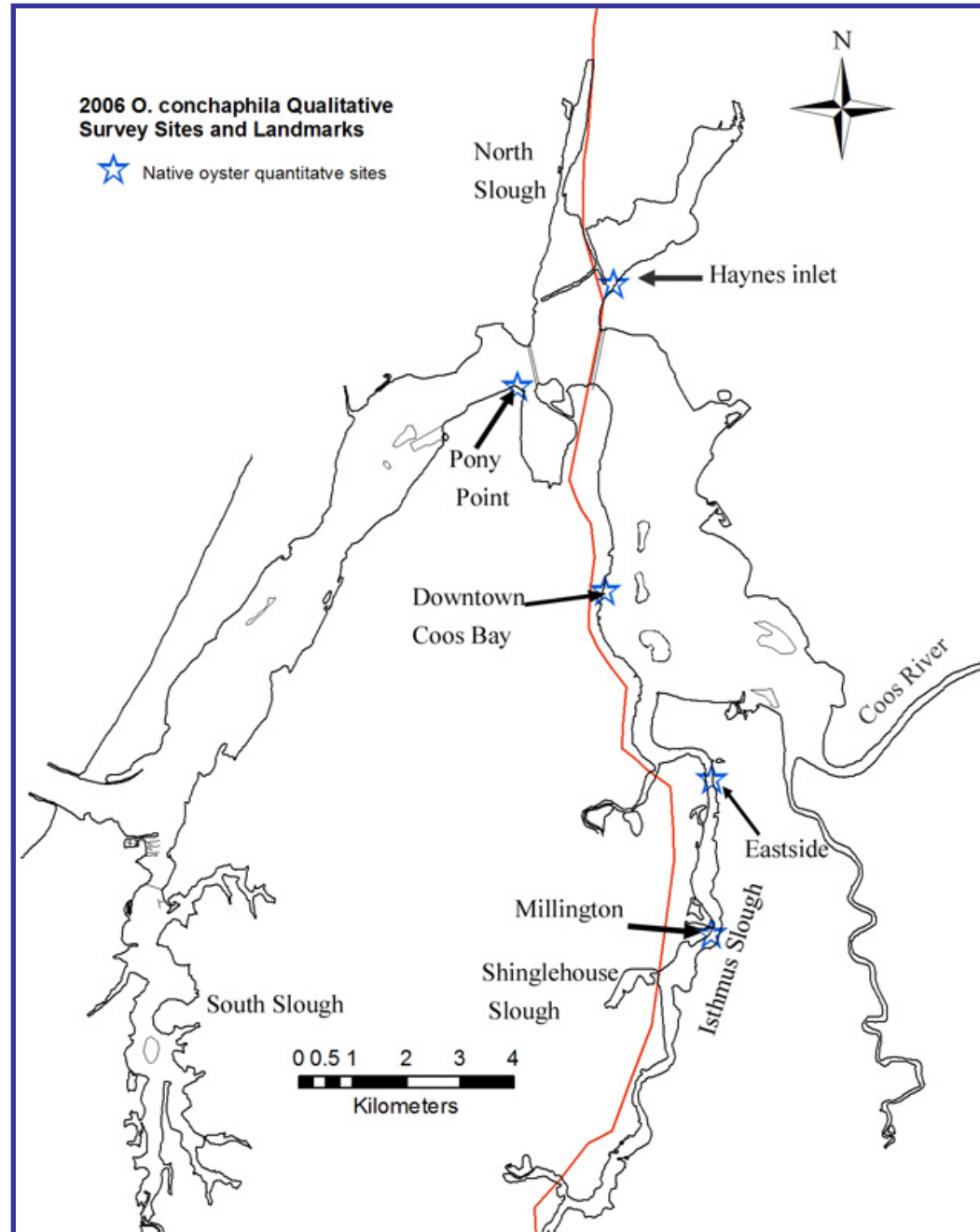
Preliminary findings so far (2007) ...

Genetic identity (DNA microsatellite variability) and phenotypic evidence (oyster body size and shape) indicate that specimens from Coos Bay are distinct from populations in other locations (i.e. Willapa Bay, WA and Yaquina Bay, OR), and suggest that the existing populations in Coos Bay may be locally adapted or truly native remnants.

Recommendation: Use local adults from Coos Bay as broodstock for larval cultures and outplanting

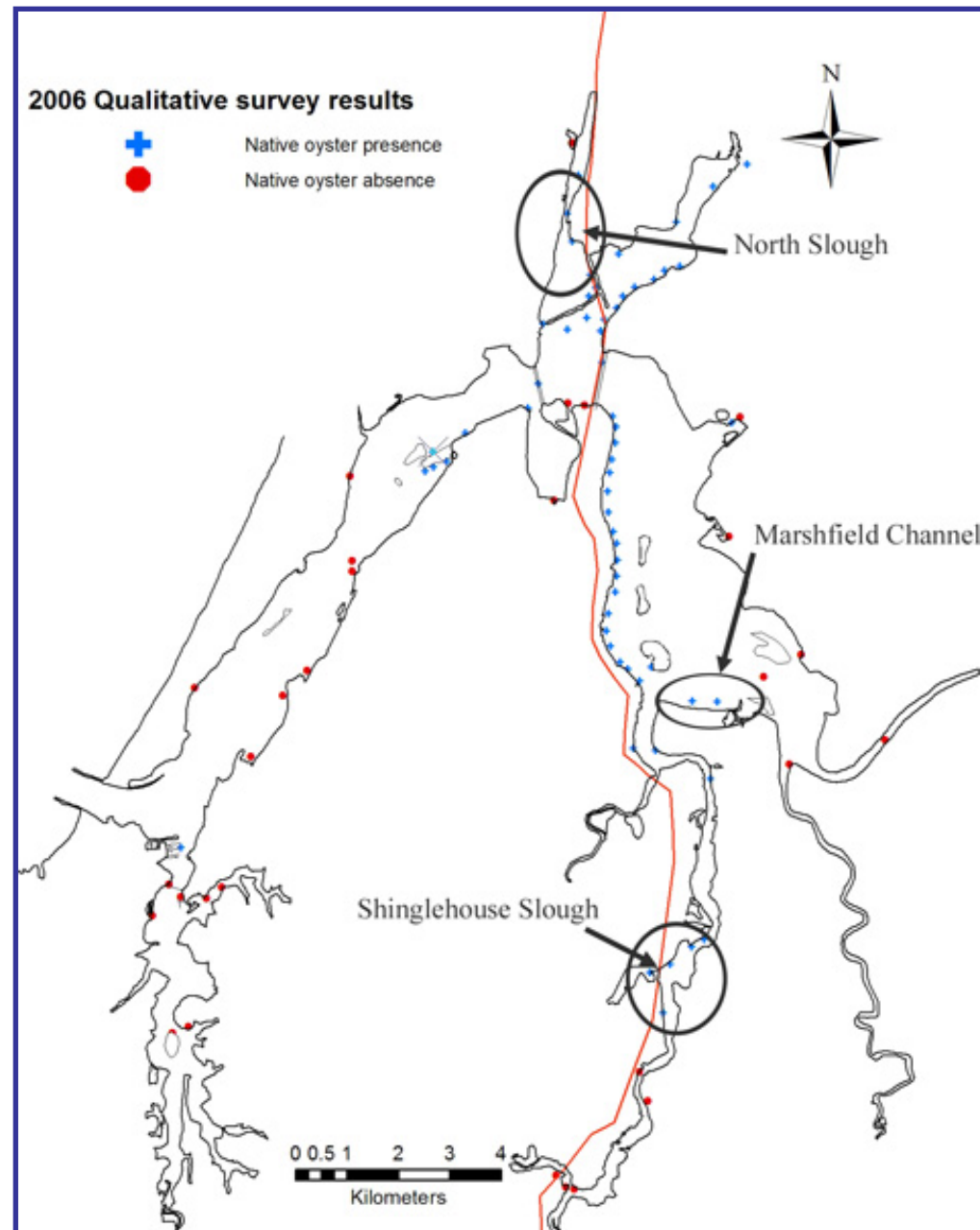
Distribution and Recovery of Olympia Oysters in Coos Bay

Coos Bay, OR: Map indicates the location of local landmarks and five study sites examined in 2006 during quantitative surveys of *Ostrea conchaphila* populations.



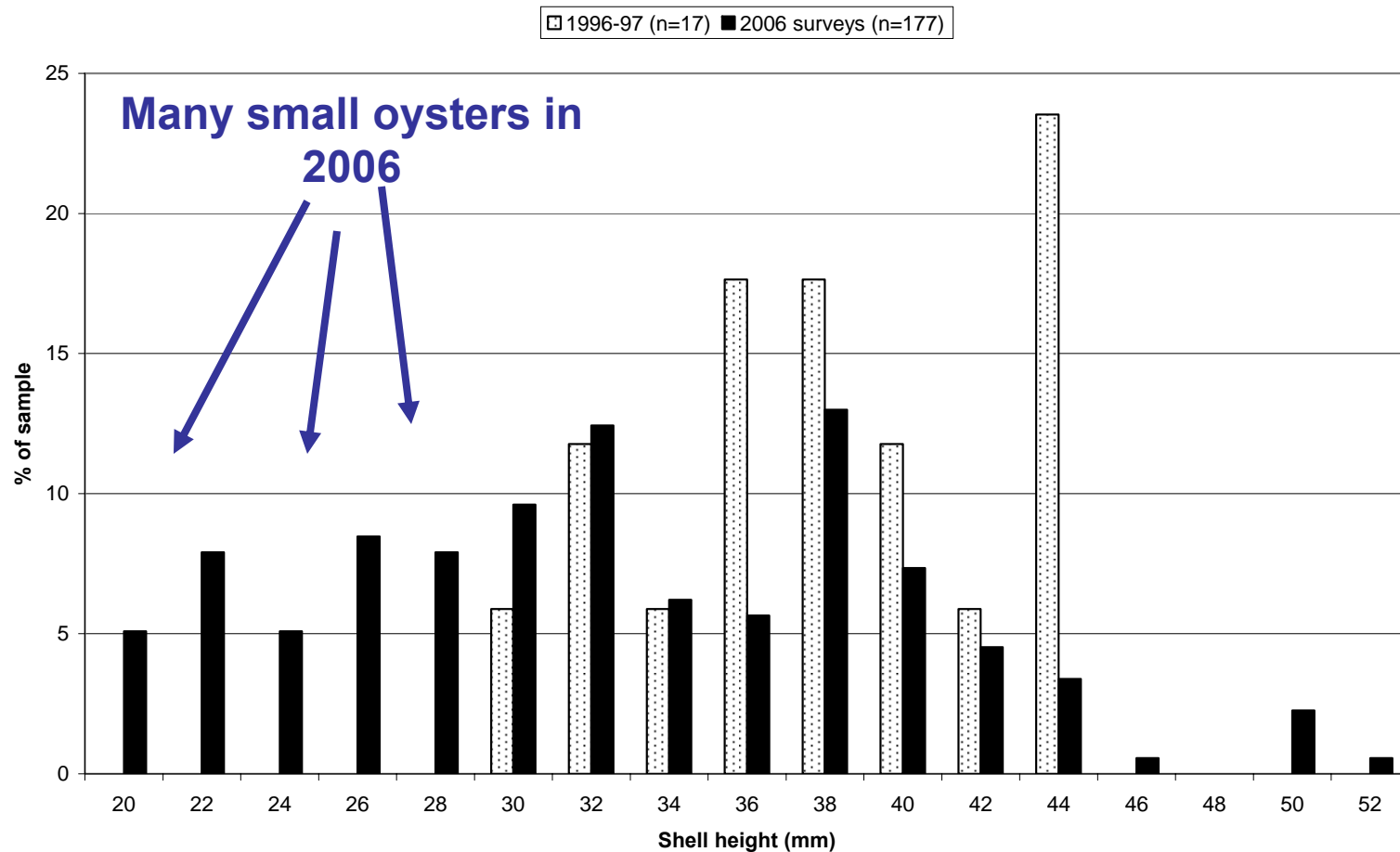
Coos Bay, OR:

Distribution of *Ostrea conchaphila* observed during qualitative surveys in 2006. Circles indicate locations where substantial changes in distribution were observed from 1996-97 surveys.



Coos Bay, OR: Comparison of size distribution of adult *Ostrea conchaphila* from surveys conducted in 1997 and 2006. Oyster sizes for the 1997 surveys are adapted from Baker *et al.* (2000).

Intertidal *O. conchaphila* survey comparison (≥ 20 mm)





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*)



Ecology of Olympia oysters (*Ostrea conchaphila*):

Appearance: Small (4-7 cm) epibenthic bivalves, non-motile with left valve typically cemented to shell or other hard substrata.

Reproduction & Growth: Protandric hermaphrodite, multiple spawning in spring and summer, internal fertilization with brooded embryos, release of planktonic veliger larvae.

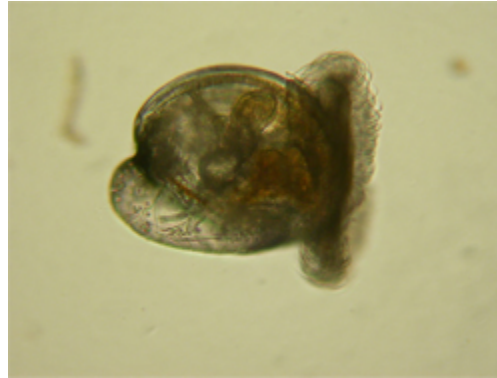
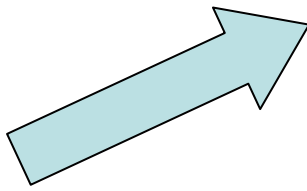
Habitat: Lower intertidal to shallow subtidal, attachment to hard surfaces in sheltered waters, often on adult shells. Forms sparse to dense clusters or beds on bottom.

Feeding: Filter-feeder / suspension-feeder, consumes phytoplankton and protists.

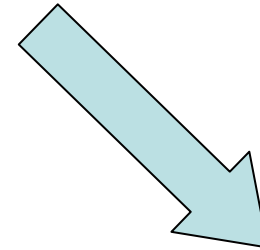
Predators: Seastars, crabs, boring gastropods, polychaetes, fish, birds, humans.



Recruitment of Olympia Oysters to Fouling Panels and Oyster Shells



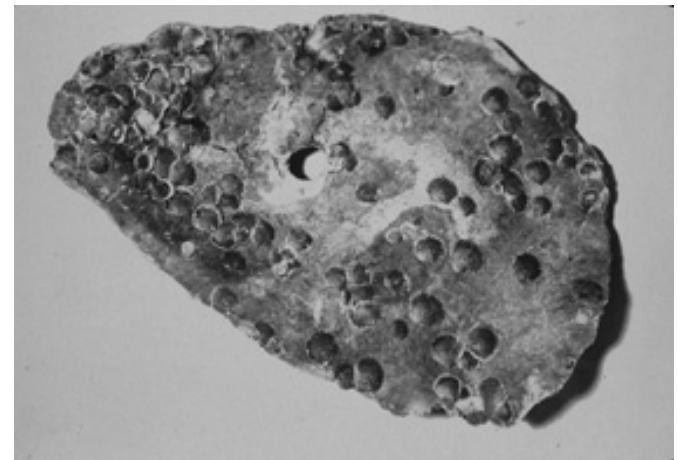
Planktonic veliger larva swims and feeds for about 8-10 days



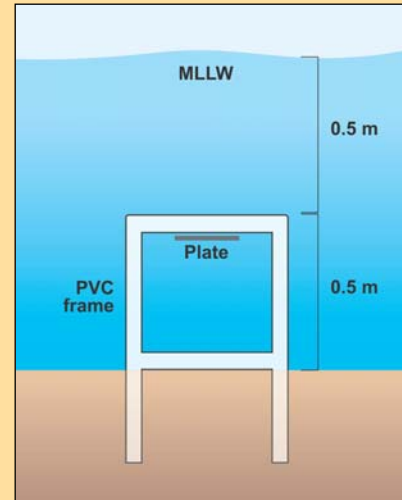
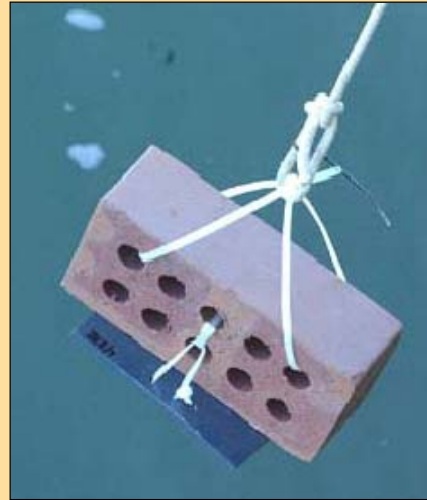
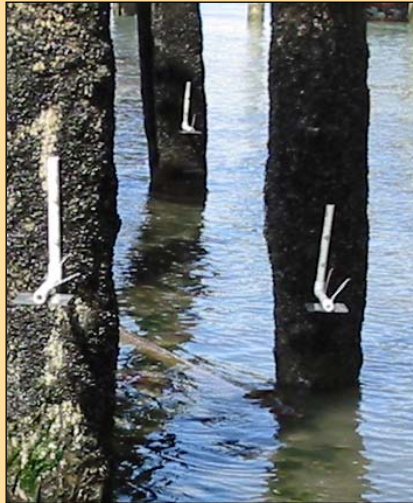
Female oysters brood larvae about 10-12 days



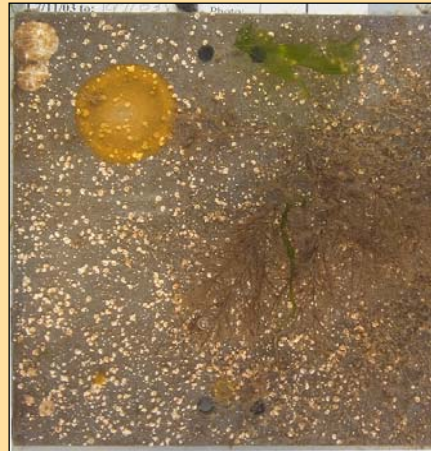
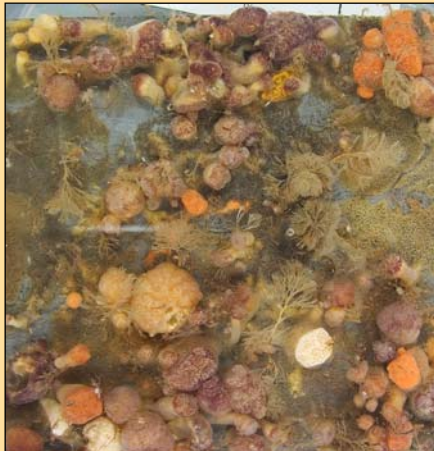
Larvae settle and attach to shells as surface for growth



Broad-Scale Assessment of Estuarine Invasive Species in Coos Bay



Fouling panel deployment from docks, piers, and on soft-sediment frames throughout estuarine habitats (2004)



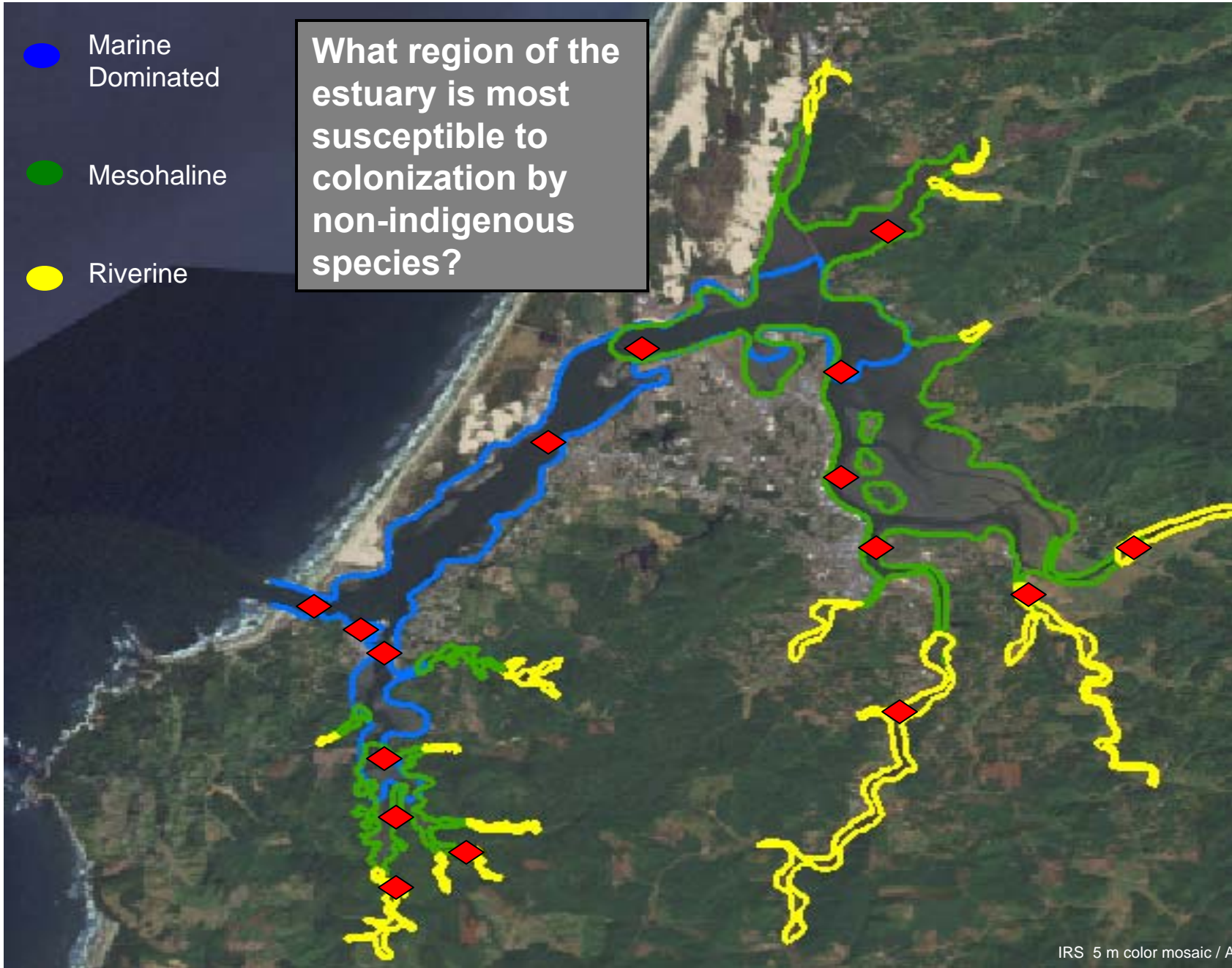
Recovery of panels after 90-100 days, followed by digital photos, preservation, and taxonomic identification



COOS ESTUARY, OR Monitoring Stations for Epifaunal Invasive Invertebrates ◆

- Marine Dominated
- Mesohaline
- Riverine

What region of the estuary is most susceptible to colonization by non-indigenous species?

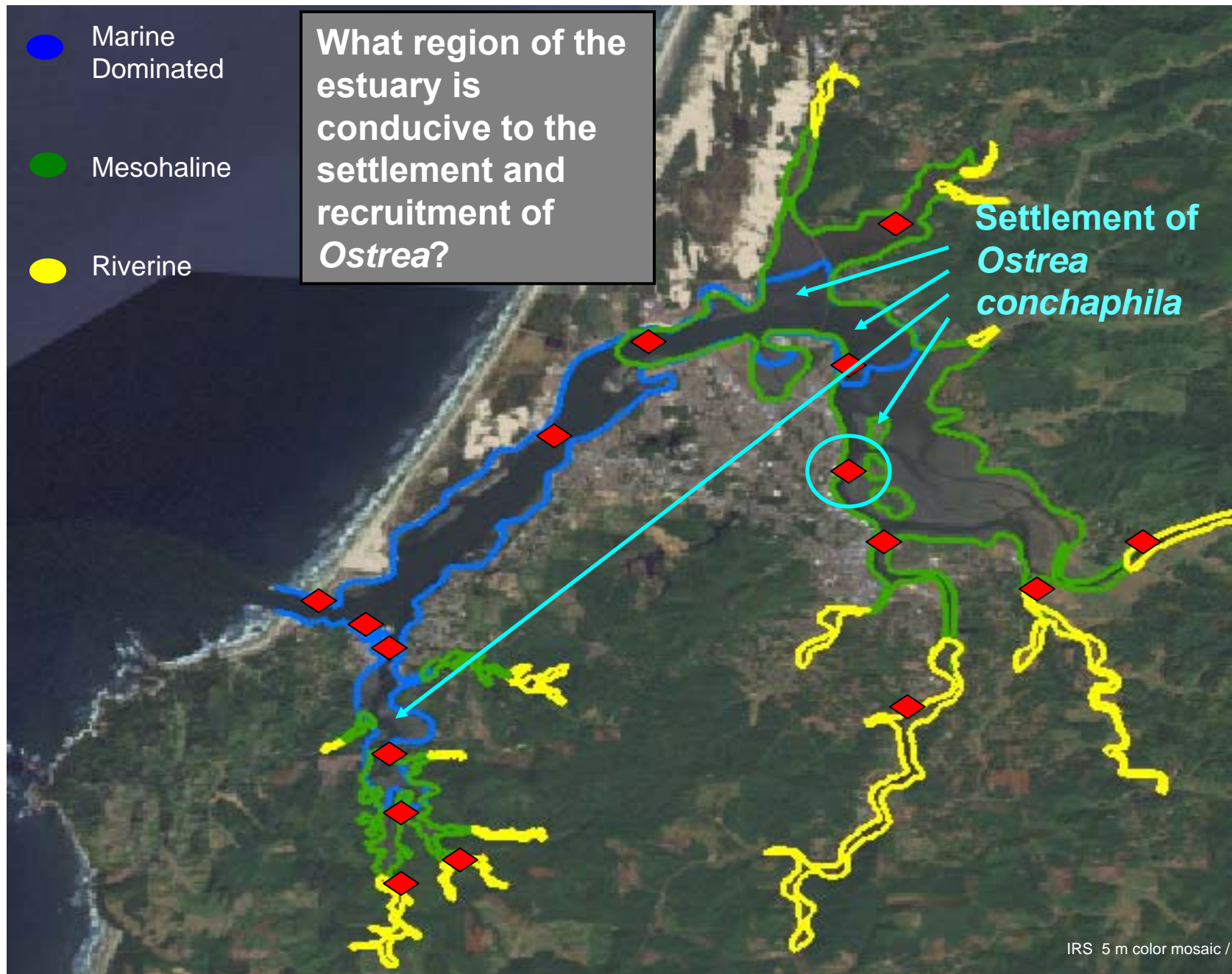


COOS ESTUARY, OR Monitoring Stations for Epifaunal Invasive Invertebrates ♦

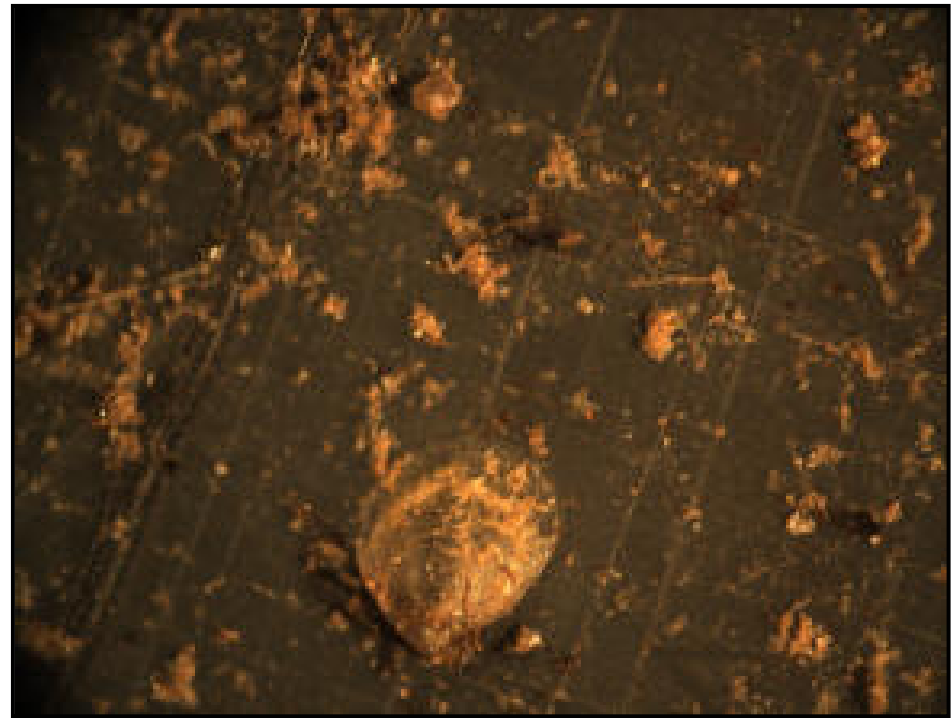
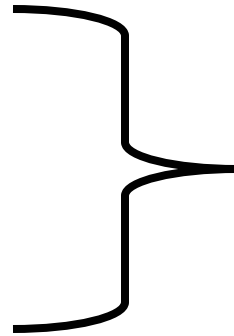
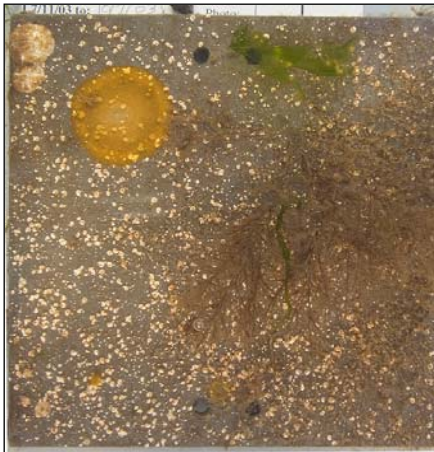
- Marine Dominated
- Mesohaline
- Riverine

What region of the estuary is conducive to the settlement and recruitment of *Ostrea*?

Settlement of *Ostrea conchaphila*



Coos Bay, OR: Juvenile Native Oysters Recruited to PVC Fouling Panels Deployed off the Port of Coos Bay – Citrus Dock in the Mesohaline Region of the Estuary



**PVC plate
deployed in
Coos Bay for 90-
100 days in 2004**

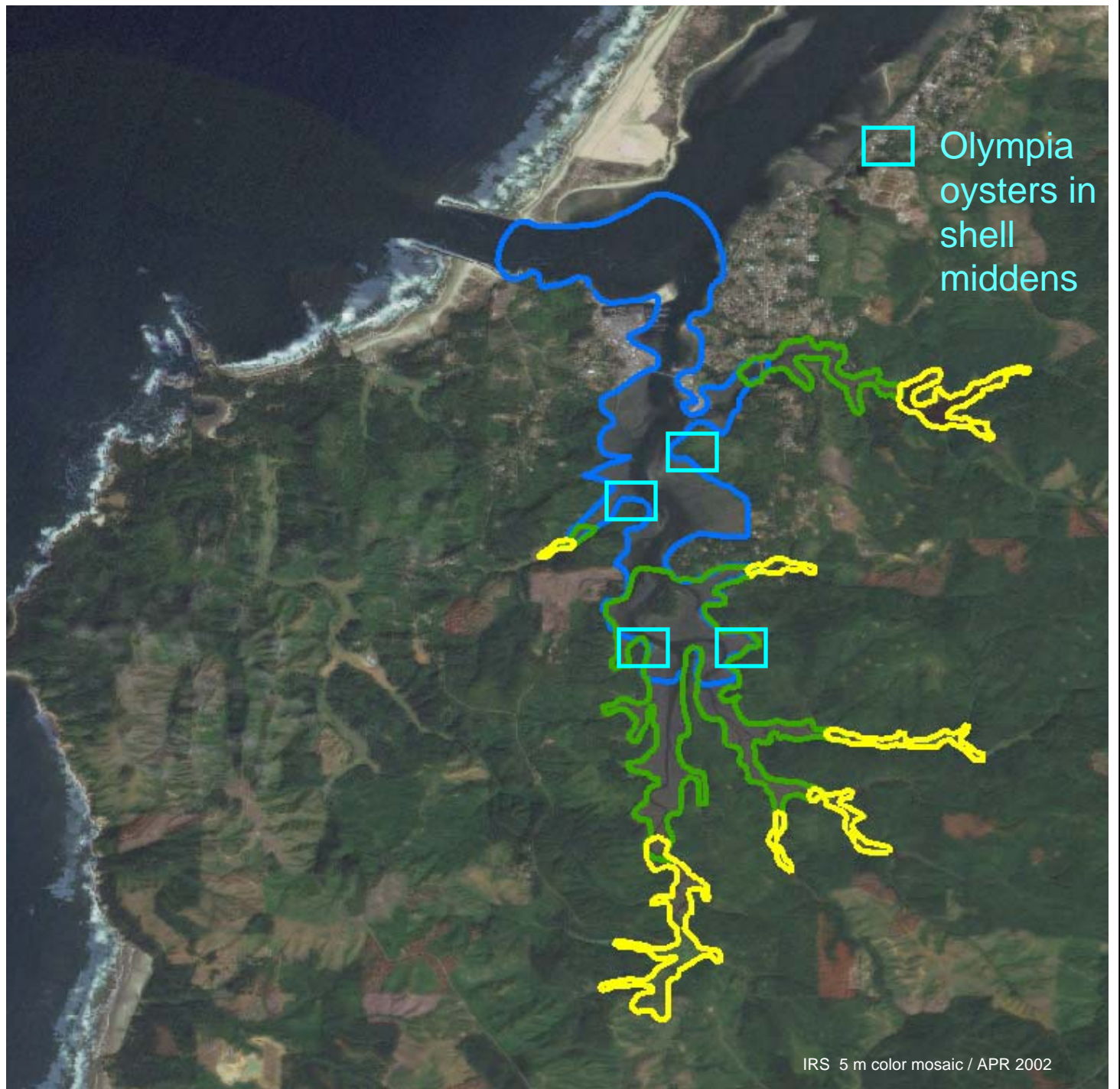
**Juvenile *Ostrea conchaphila*
attached to PVC plate**



SOUTH SLOUGH ESTUARY, OR

Location and spatial extent of three distinct hydrographic regions located along the estuarine gradient of the South Slough tidal basin

- Marine-Dominated
31-20 psu
- Mesohaline
28-15 psu
- Riverine
21-0 psu



South Slough Estuary:

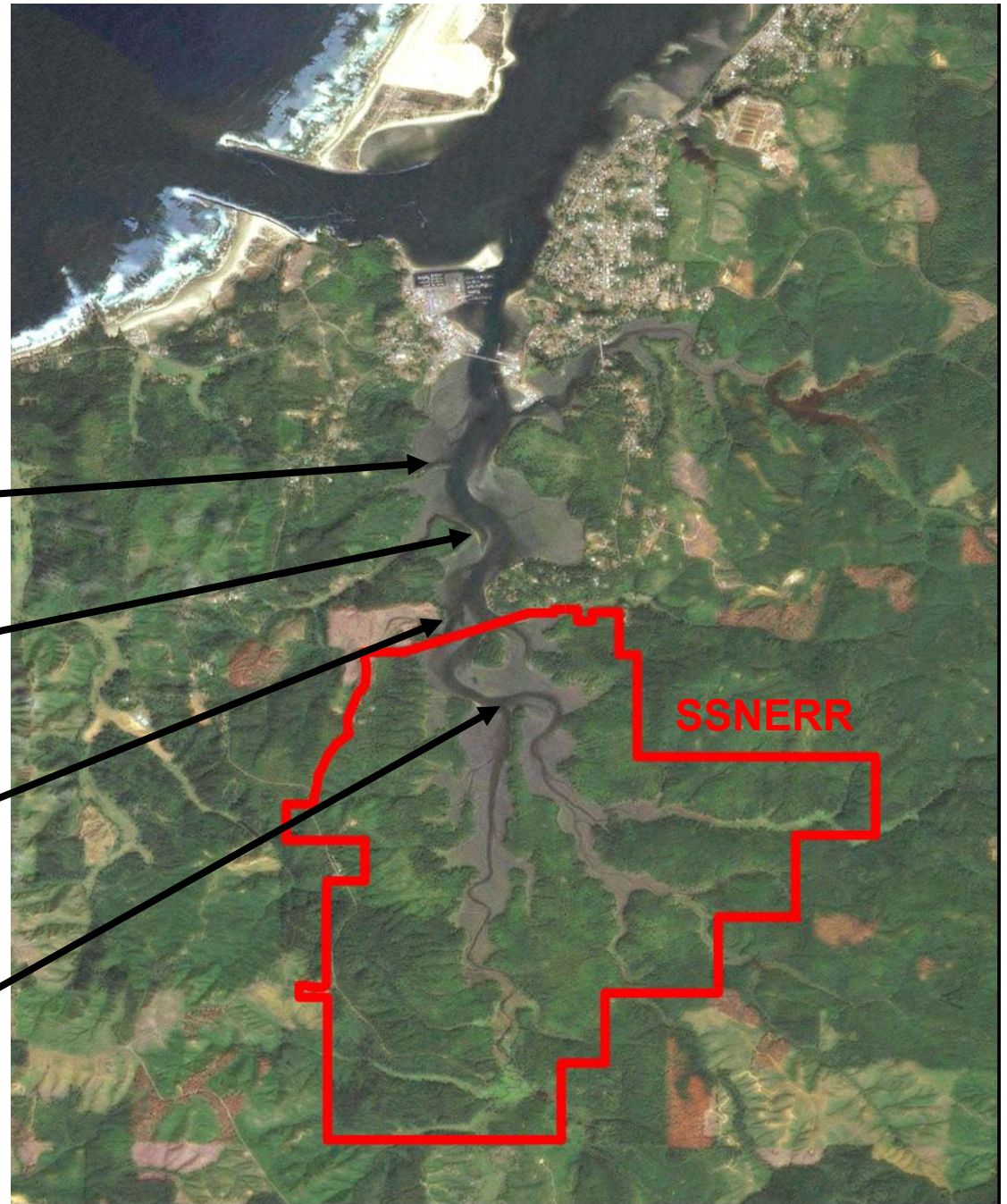
Location of Potential Out-planting Sites for Olympia Oysters

1. Collver Point

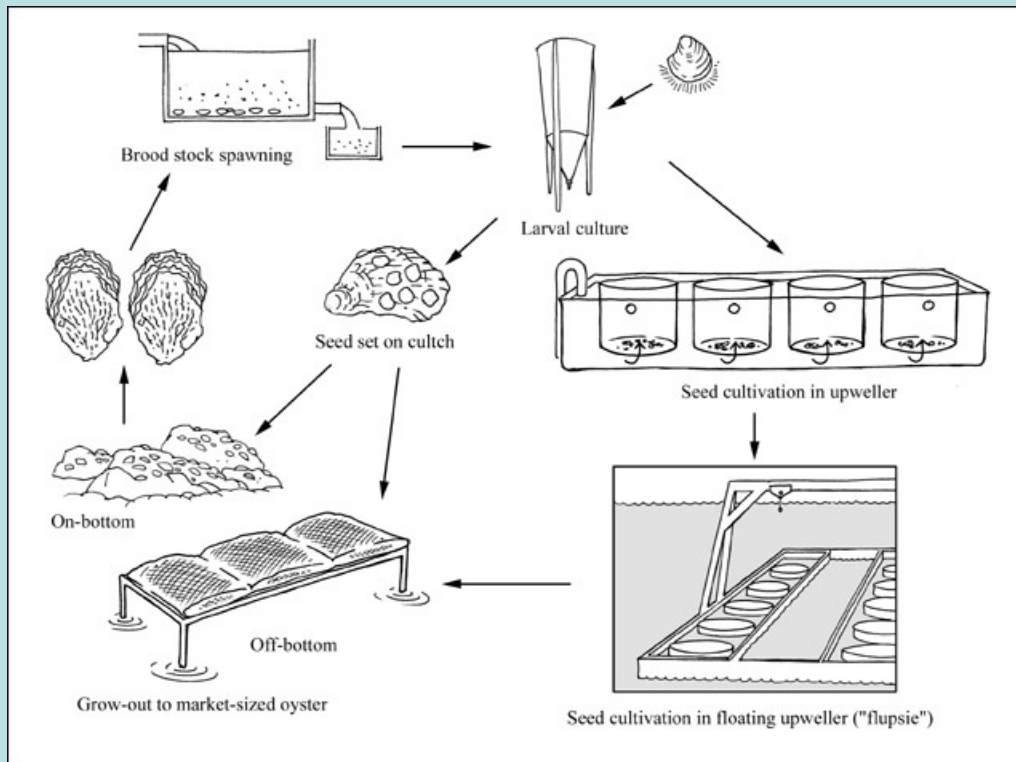
2. Younker Point

3. Graveyard Point

4. Ferrei Head / Long Island Point / Bronx Point



Workplan for Oyster Transplants:



**Adult oysters collected
in Coos Bay**

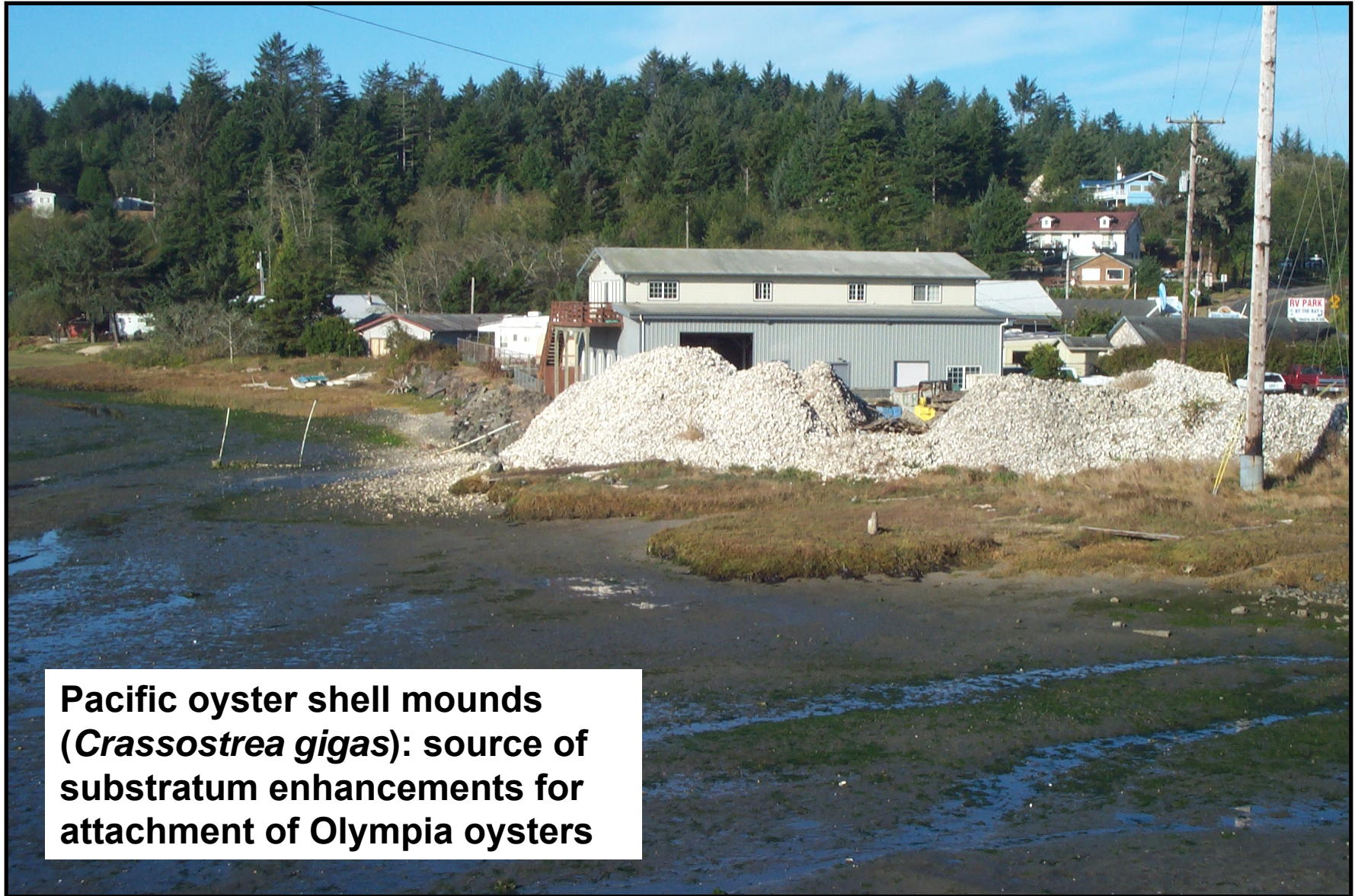
**Larval culture and
settlement on shells in
commercial hatchery in
Netarts Bay**



**Bags with shells and living
juvenile Olympia oysters
(cultch) transported back
to Coos Bay**

**Outplanting of cultch bags
into the lower intertidal
zone of South Slough**

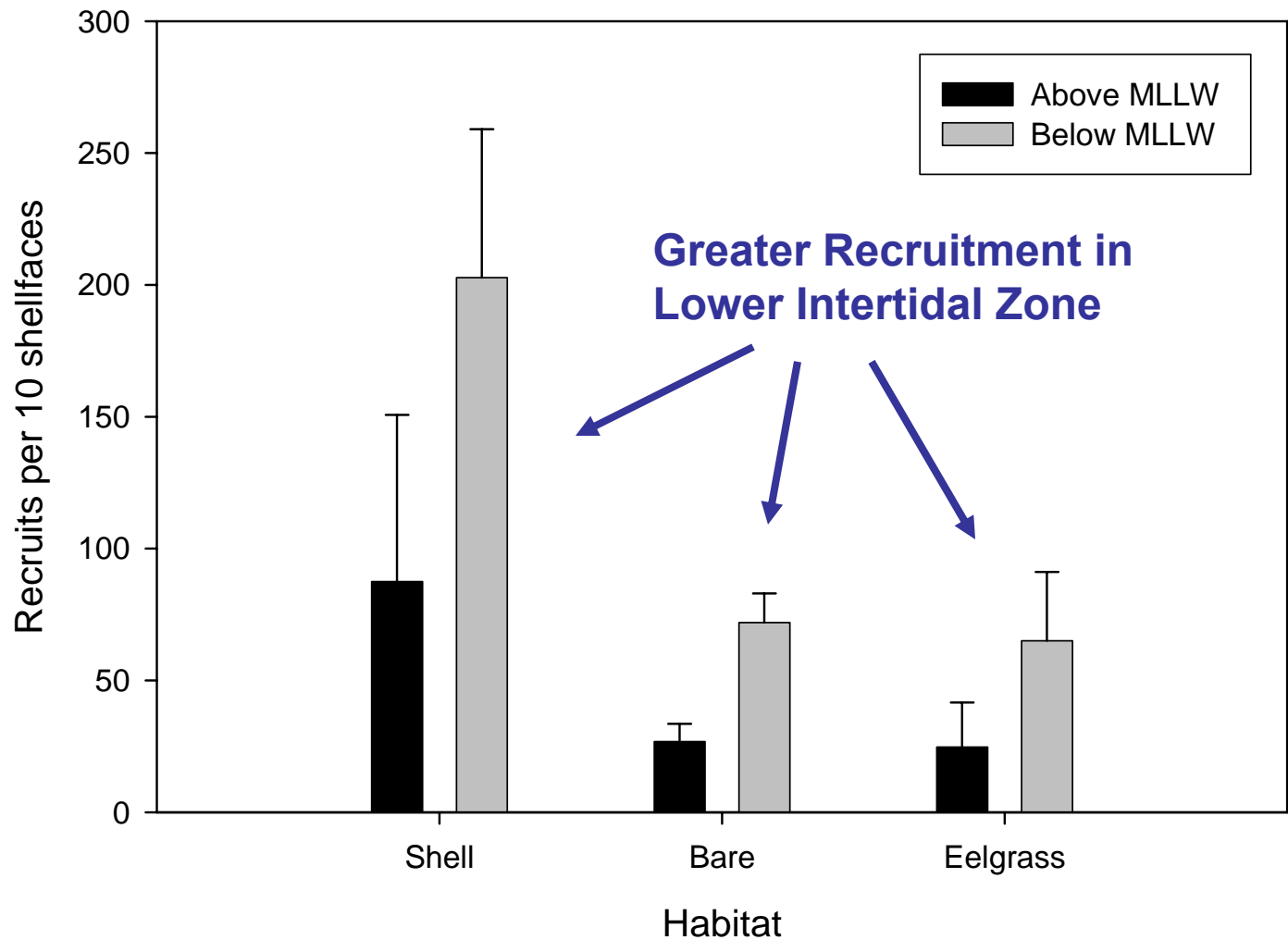
note: workplan requires ODFW oyster transfer permit

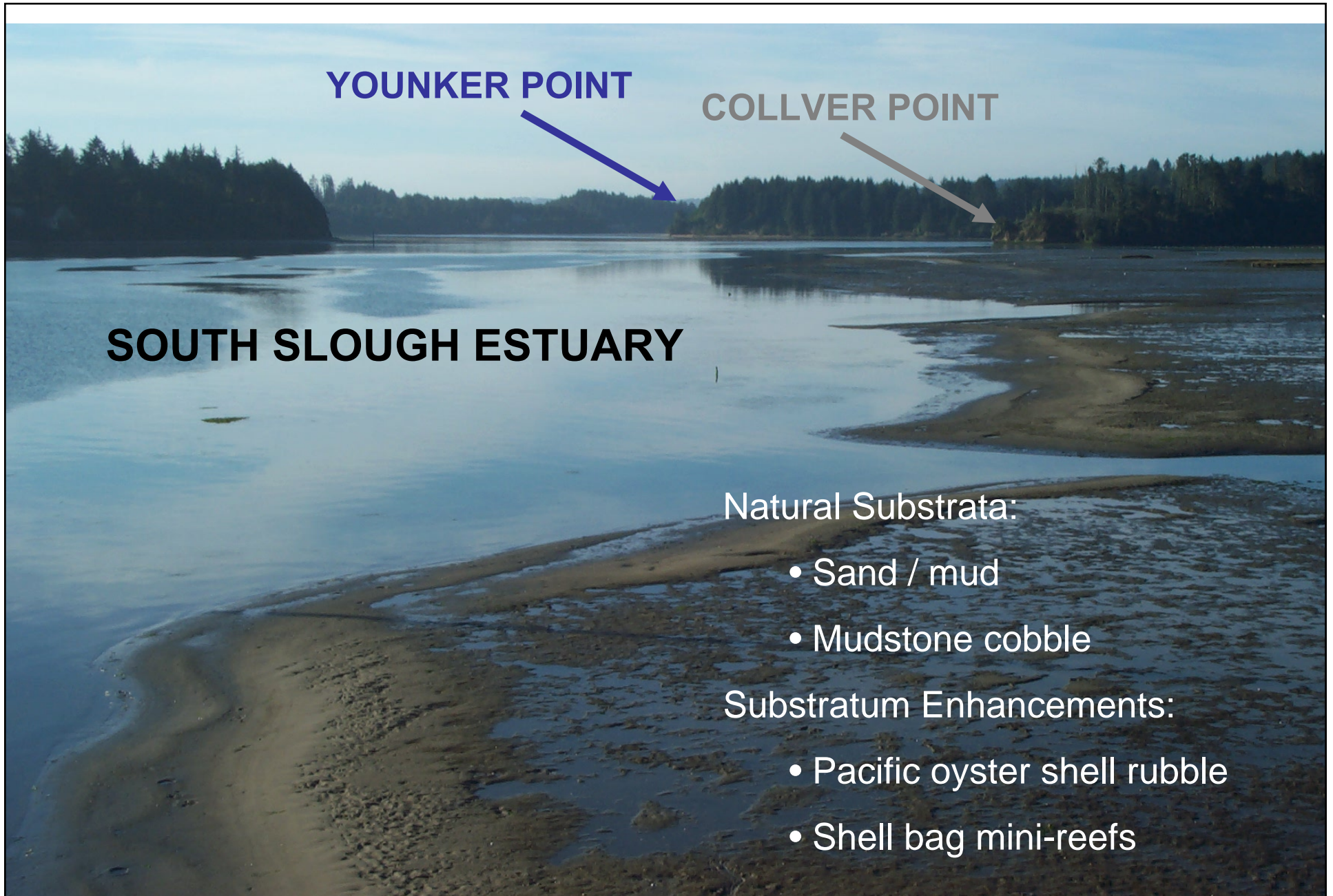


**Pacific oyster shell mounds
(*Crassostrea gigas*): source of
substratum enhancements for
attachment of Olympia oysters**

Willapa Bay, WA: Variation in recruitment of Olympia oysters to shell substrate in three habitat types (from A. Trimble, 2006).

Ostreola conchaphila





YOUNKER POINT

COLVER POINT

SOUTH SLOUGH ESTUARY

Natural Substrata:

- Sand / mud
- Mudstone cobble

Substratum Enhancements:

- Pacific oyster shell rubble
- Shell bag mini-reefs

Location of Olympia oyster out-planting sites in the South Slough estuary / 2007

Outplanting of Juvenile Olympia Oysters in South Slough

Juvenile Olympia oysters settle and grow on adult oyster shells (*O. conchaphila* preferred / *C. gigas* acceptable) contained in nylon mesh cultch bags.



Cultch bags with juvenile Olympia oysters placed into the lower intertidal zone of the South Slough estuary tidal channel.

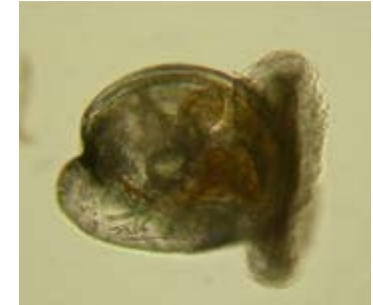


Restoration of Native Olympia Oysters in the South Slough Estuary: Monitoring and Evaluation Criteria

- **Genetic Identity of Broodstock**
- **Survivorship of Out-planted Oysters**
- **Growth of Out-planted Oysters**
- **Reproduction & Reproductive Output**
- **Larval Settlement and Recruitment onto Shells**
- **Structural Formation of Shell Clusters**
- **Processing of Estuarine Waters**
- **Ecological Interactions / Habitat Use by Invertebrates & Fish**

Restoration of Native Olympia Oysters in the South Slough Estuary: Monitoring and Evaluation Criteria

Broodstock Objectives:



- Parameter:** Genetic identity of broodstock oysters
units = % similarity of *Ostrea* from Coos Bay to populations from other estuaries (Willapa, Netarts, Yaquina)
- Technique:** DNA microsatellite analysis (M. Camara / USDA-ARS)
- Baseline:** Genetic ID & phenotype indicate Coos Bay populations are distinct and may be locally adapted or truly native
- Target:** *Ostrea* outplanted to South Slough will have high similarity to genetic signature of existing populations in Coos Bay

Restoration of Native Olympia Oysters in the South Slough Estuary: Monitoring and Evaluation Criteria

Survivorship Objectives:

- Parameter:** Survivorship of out-planted oysters
units = # of out-planted *Ostrea* that persist and survive following placement into South Slough
- Technique:** Quarterly counts of living & dead oysters in cultch bags
- Baseline:** Measureable populations do not currently exist in South Slough / only rare individuals on artificial substrata)
- Target:** *Ostrea* outplanted to South Slough will have 30-50% survivorship and will be comparable to oyster survival in Coos Bay

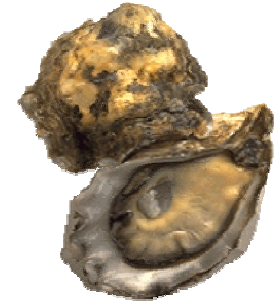
Restoration of Native Olympia Oysters in the South Slough Estuary: Monitoring and Evaluation Criteria

Growth Objectives:

- Parameter:** Growth of out-planted oysters
units = mm shell length & width added per month
- Technique:** Field measurements of marked individuals and sub-sets of population
- Baseline:** Initial size of out-planted oysters about 2mm in length
- Target:** *Ostrea* outplanted to South Slough will have growth rates that are similar to growth rates for existing populations in Coos Bay

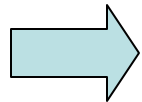
Restoration of Native Olympia Oysters in the South Slough Estuary: Monitoring and Evaluation Criteria

Reproduction Objectives:

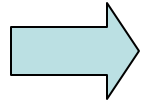


- Parameter:** Reproduction of out-planted oysters
units = oyster gonad tissue index, gonad condition, number & viability of brooded embryos, output of larvae
- Technique:** Lab measurements of sacrificial individuals
- Baseline:** Onset of reproduction anticipated at about 20 mm shell length
- Target:** *Ostrea* outplanted to South Slough will have gonad indices and metrics of reproductive output that are similar for existing populations in Coos Bay

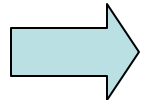
Restoration of Native Olympia Oysters in the South Slough Estuary: Monitoring and Evaluation Criteria



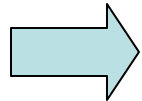
- **Genetic Identity of Broodstock**



- **Survivorship of Out-planted Oysters**



- **Growth of Out-planted Oysters**



- **Reproduction & Reproductive Output**

- **Larval Settlement and Recruitment onto Shells**

- **Structural Formation of Shell Clusters**

- **Processing of Estuarine Waters**

- **Ecological Interactions / Habitat Use by
Invertebrates & Fish**

South Slough Estuarine Gradient

MARINE / BAY

Boathouse

MARINE
DOMINATED

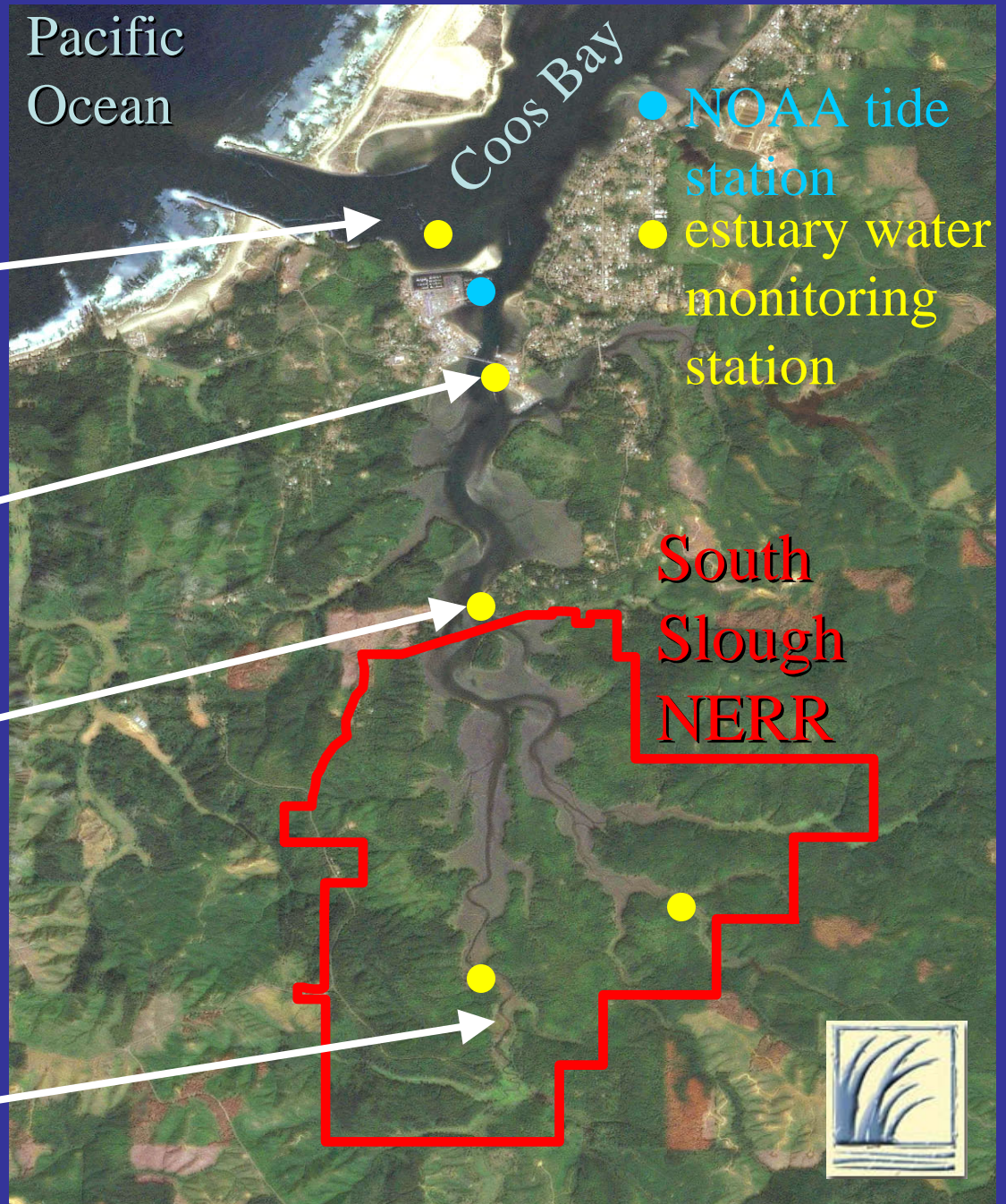
Charleston

MESOHALINE

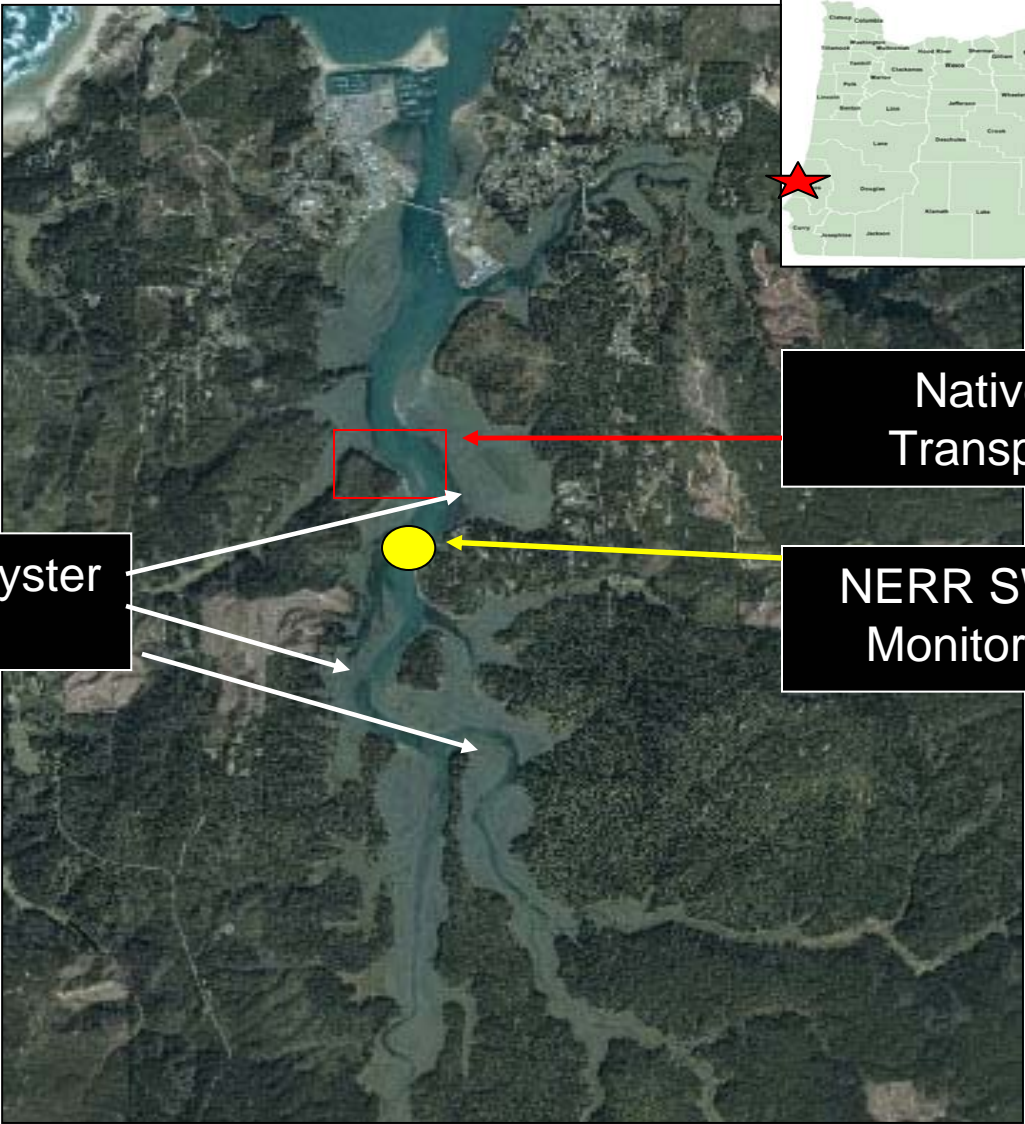
Valino Island

RIVERINE

Winchester Creek



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



Native Oyster Transplant Area

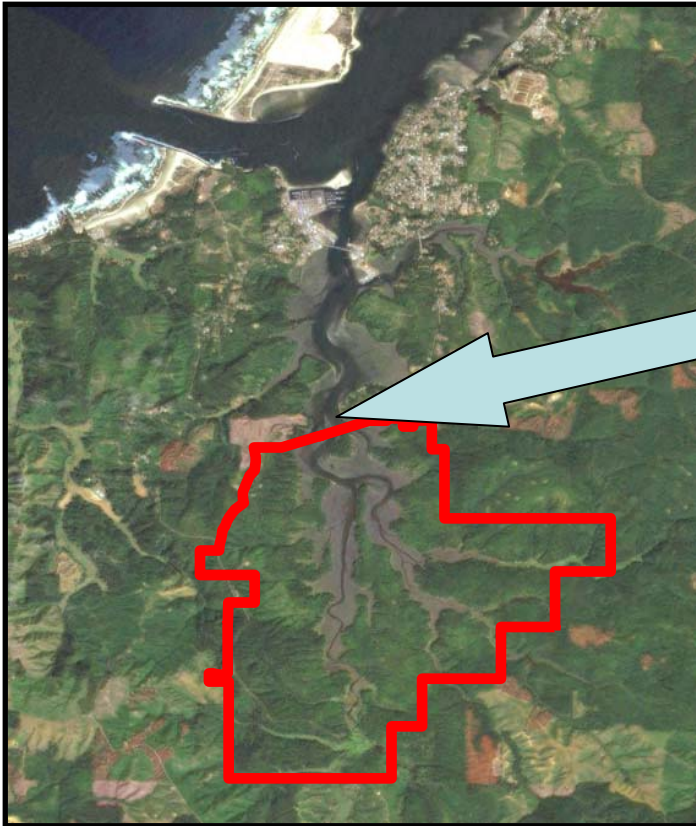
Commercial Oyster Plots

NERR SWMP Water Monitoring Station

South Slough NERR / SWMP Water Quality Monitoring Station

Valino Island (SOS-VA)

GOES Satellite
Transmission System



YSI 6600-EDS Datasondes / Extended Deployment System



Estuarine Tidal Channel (0.5 m off-bottom):

NERR SWMP Parameters (30 min intervals):



- time (PST)
- water level (m)
- temperature (°C)
- conductivity (mS/cm/s)
- salinity (psu)
- dissolved oxygen (mg/L)
- pH
- turbidity (NTU)
- Chl / fluorescence (ug/L)



Nutrient analysis conducted by the South Slough NERR (monthly plus diel tidal forcing):

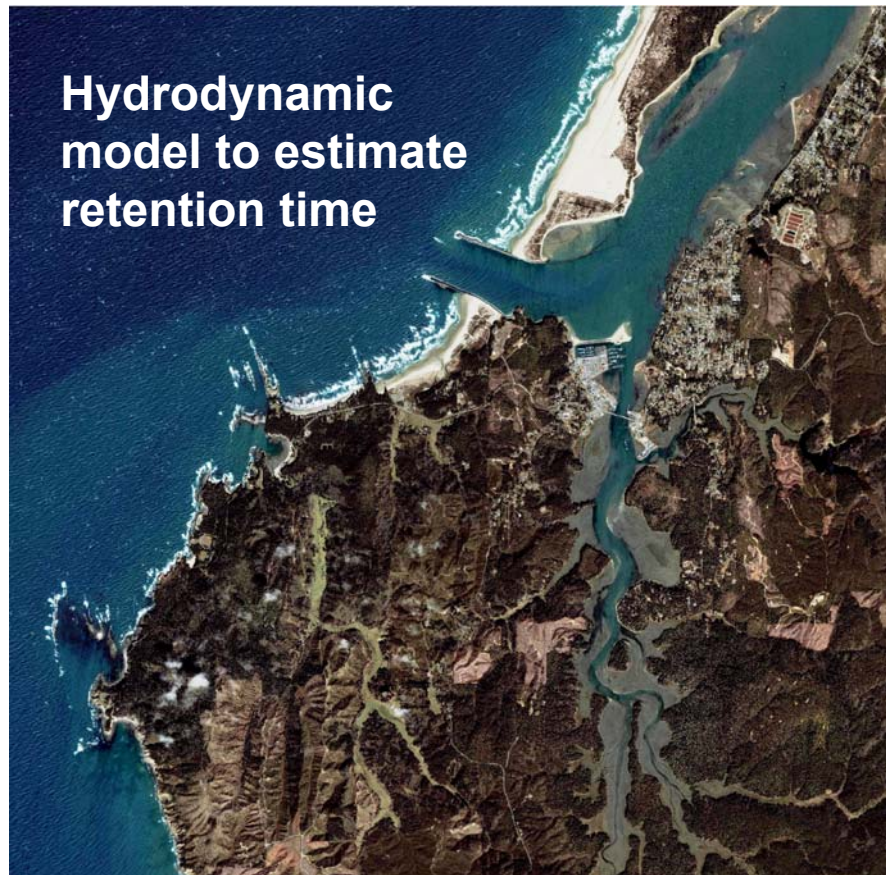
- Chlorophyll a
- Phaeopigments
- Nitrate
- Nitrite
- Ammonia
- Ortho-phosphate

NERR System-Wide Monitoring Program / SWMP



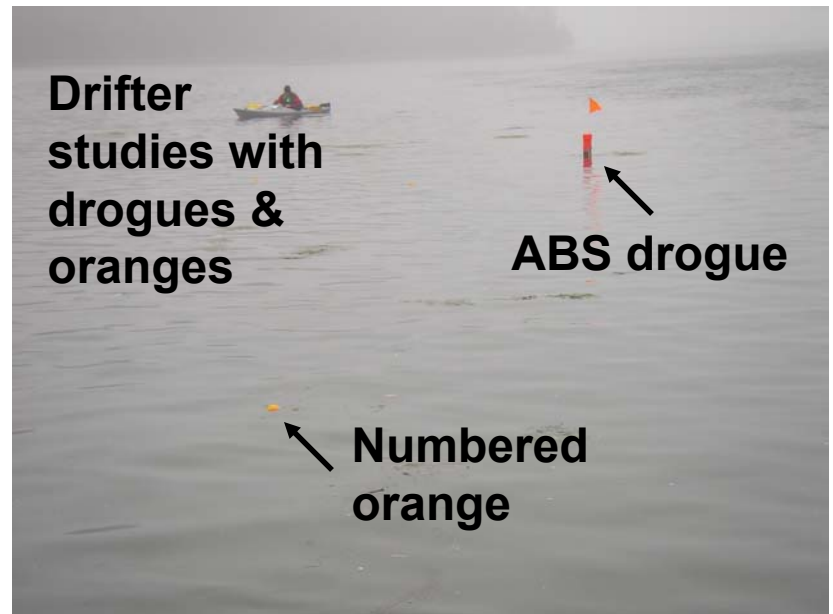
Are *Ostrea* larvae retained or exported from Coos Bay and the South Slough estuary?

Laboratory and field behavior of pediveliger larvae



Hydrodynamic model to estimate retention time

Dispersion and tidal current studies with Rhodamine WT dye and ADCP deployment



Drifter studies with drogues & oranges

ABS drogue

Numbered orange

COOS ESTUARY, OR Hydrologic Regions and Oyster Mariculture Operations

● Marine Dominated

● Mesohaline

● Riverine

Source – Sink Hypothesis

○ Pacific oyster:
Commercial mariculture

Production of native Olympia oyster larvae occurs from recovering populations in Coos Bay.

Do the shells of commercial oysters provide a settlement site in the mid intertidal zone that is fatal for juvenile Olympia oysters?

Conclusions:

1. New project to initiate restoration and recovery of *Ostrea conchaphila* populations in the South Slough estuary
2. Genetic identification of an appropriate source of broodstock in 2006-07
3. Culture, settlement, and out-planting of 15,000 to 22,000 oysters will occur in 2008
4. Field assessments to determine survival, growth, and reproduction in 2008-2010
5. Future work to determine larval export, retention, and interactions with predators, competitors, and eelgrass



**Community
Restoration
Program**

LARGE-SCALE RESTORATION OF OLYMPIA OYSTERS IN PUGET SOUND, WA

Over 7 million oysters spread out at 80 sites (1999-2006)

Survivorship rate at 29-95%

Re-establishment of naturally spawning populations at 8 sites



Biotic Interactions between Oysters and Eelgrass in Pacific Northwest Estuaries

Olympia Oysters

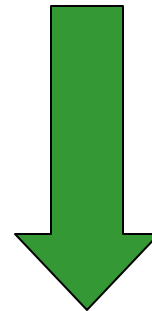
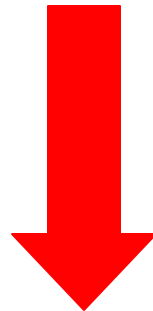
?



- Reduced plant biomass
- Shading
- Blade damage and desiccation
- Harvest impacts

-

Ostrea conchaphila



+



?

- Biofiltration to improve water clarity
- Nutrient enrichment
- Complex bottom habitat



Eelgrass

Zostera marina

CRABS

SHRIMP

BIRDS

FISH

INFAUNAL INVERTEBRATES

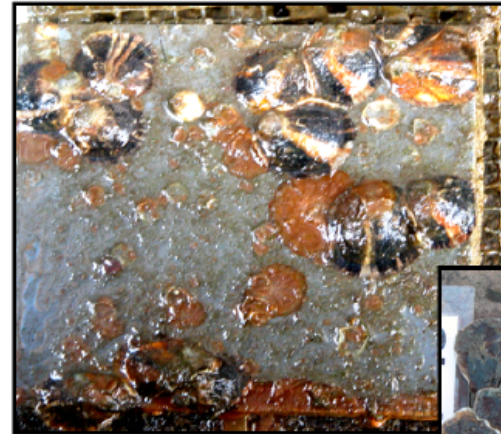
Newport Bay, CA: Placement of Settlement Plates (PVC & Ceramic Tiles) in the Intertidal Zone to Provide Surfaces for Larvae to Attach and Grow (from E. Seale, 2006)



Results: Significant seasonal differences occur in larval settlement with greatest settlement in summer (June 2005 & '06)



Tomales Bay, CA: Assessment of Olympia Oyster Settlement and Survival in Different Regions of the Estuary (from D. Kimbro, 2006)



Oyster sizes and densities differ throughout Tomales Bay.

Consequences for diversity?

Figure 2. Oysters of same age placed at different sites.



Results: Oyster Settlement, Growth, Survival, and Abundance Differ Significantly in Regions of the Bay

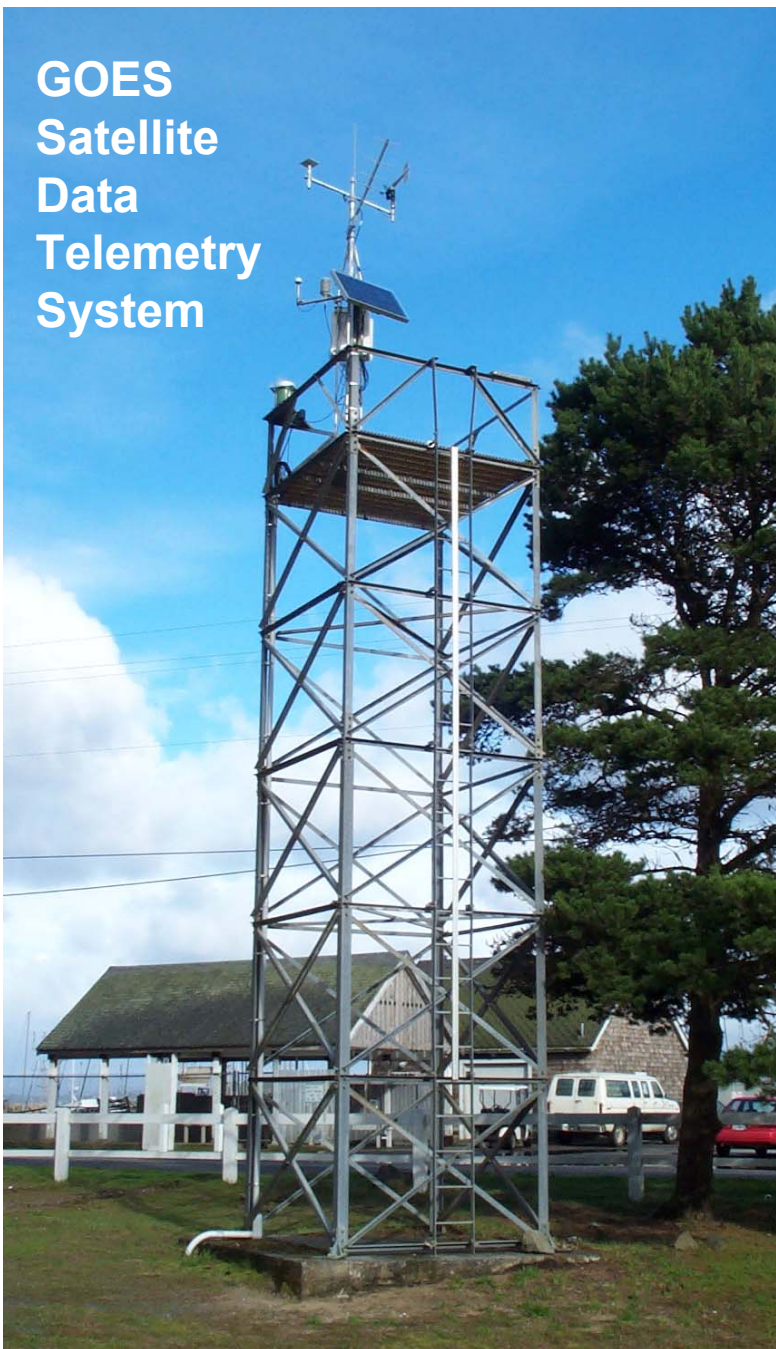
What factors may be limiting the re-establishment and recovery of Native Olympia oysters (*Ostrea conchaphila*) in the South Slough estuary?

Potential Factors:

- Larval supplies (growth, survival, retention)
- Availability of appropriate substratum for larval settlement
- Recruitment of post-larvae into established populations
- Survival and growth of adult oysters
- Predation by crabs and snails
- Overgrowth by non-indigenous tunicates



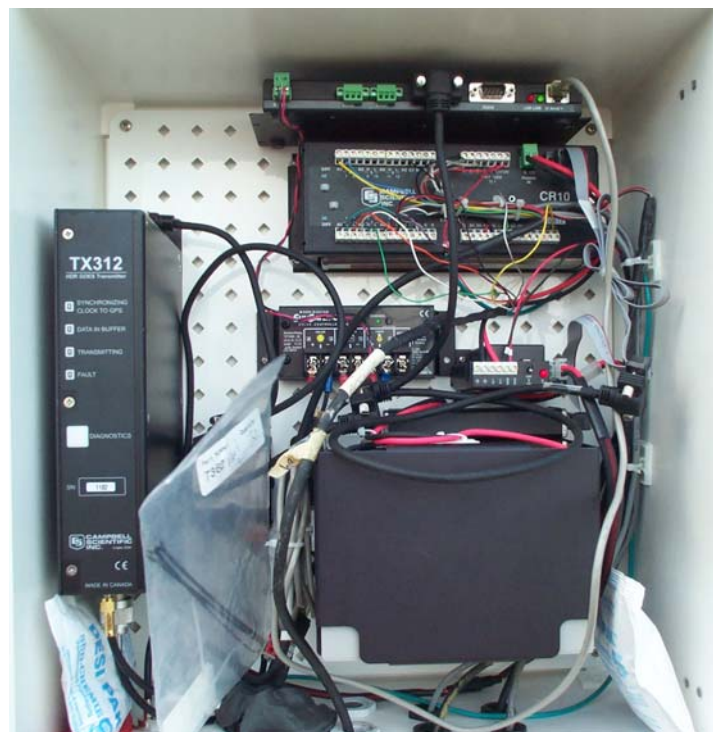
**GOES
Satellite
Data
Telemetry
System**



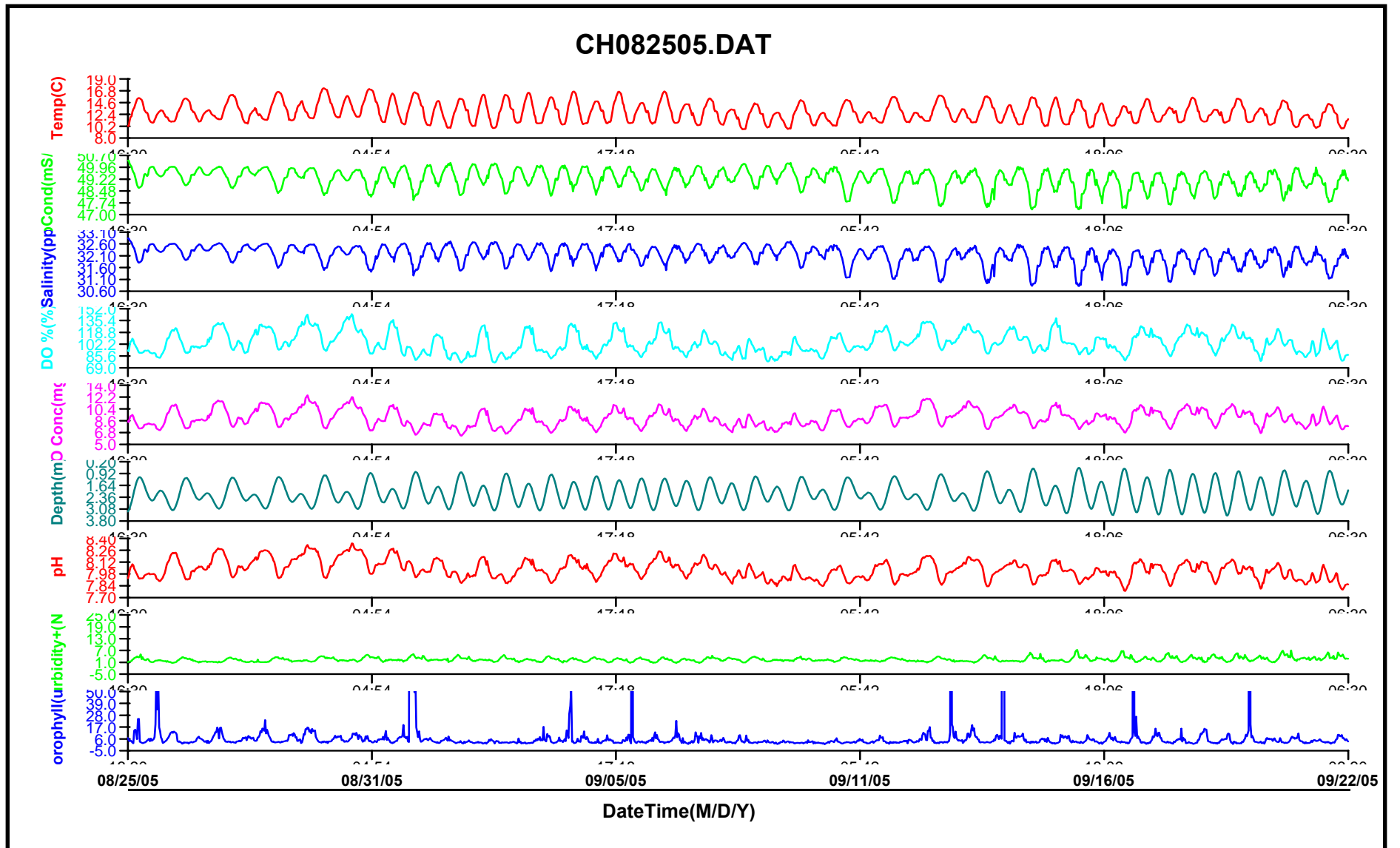
**South Slough
NERR / SWMP
Meteorological
Station**

**Oregon Institute
of Marine
Biology**

Charleston, OR



South Slough Estuary / Charleston SWMP Station (Aug- Sep 2005): Continuous Time-Series Datastream from Multi-parameter Datalogger



Installation of GOES / SatLink telemetry system for near real-time data transmission at the Charleston Dock SWMP station

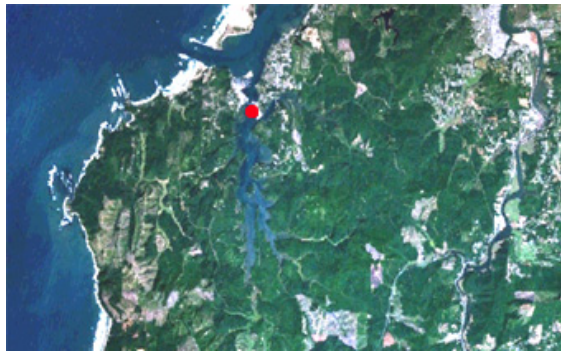




Coos Bay, Charleston Bridge, OR
Observatory: [South Slough NERR](#)



<http://www.ccalmr.ogi.edu/nanoos/network/southslough/sosch>



[NANOOS Station Map](#) [Public Data Access](#)



YSI Estimated depth: depth unavailable

Most recent data:

Temperature: 10.54 °C

Salinity: 15.81 psu

Conductivity: 25.90 mS/cm

Oxygen: 9.61 mg/l

Oxygen Saturation: 95.40 %

pH: 7.86

Turbidity: 12.70

database last updated: 2006-01-30

19:30:00 PST

[2 days](#)

[7 days](#)

[15 days](#)

South Slough NERR System-Wide Monitoring Program / Charleston Dock Station, OR

Near Real-time Data available
on-line:

NERRS Centralized Data
Management Office

<http://cdmo.baruch.sc.edu>

National Weather Service

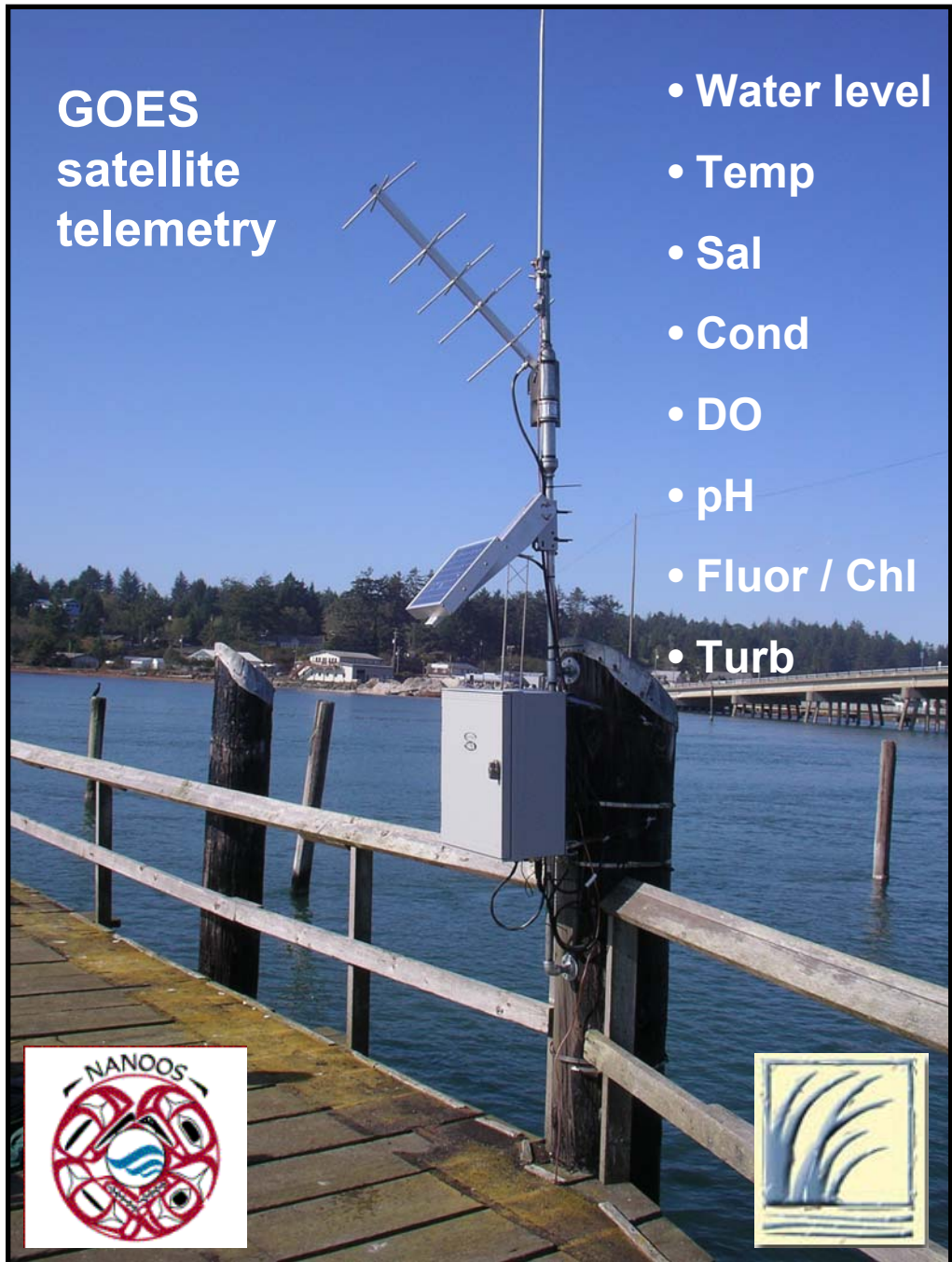
www.weather.gov/oh/hads

Northwest Association of
Networked Ocean Observing
Systems

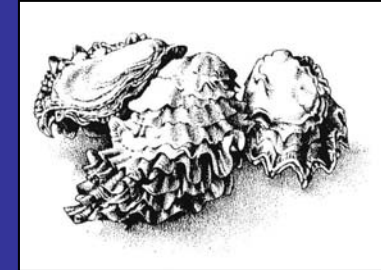
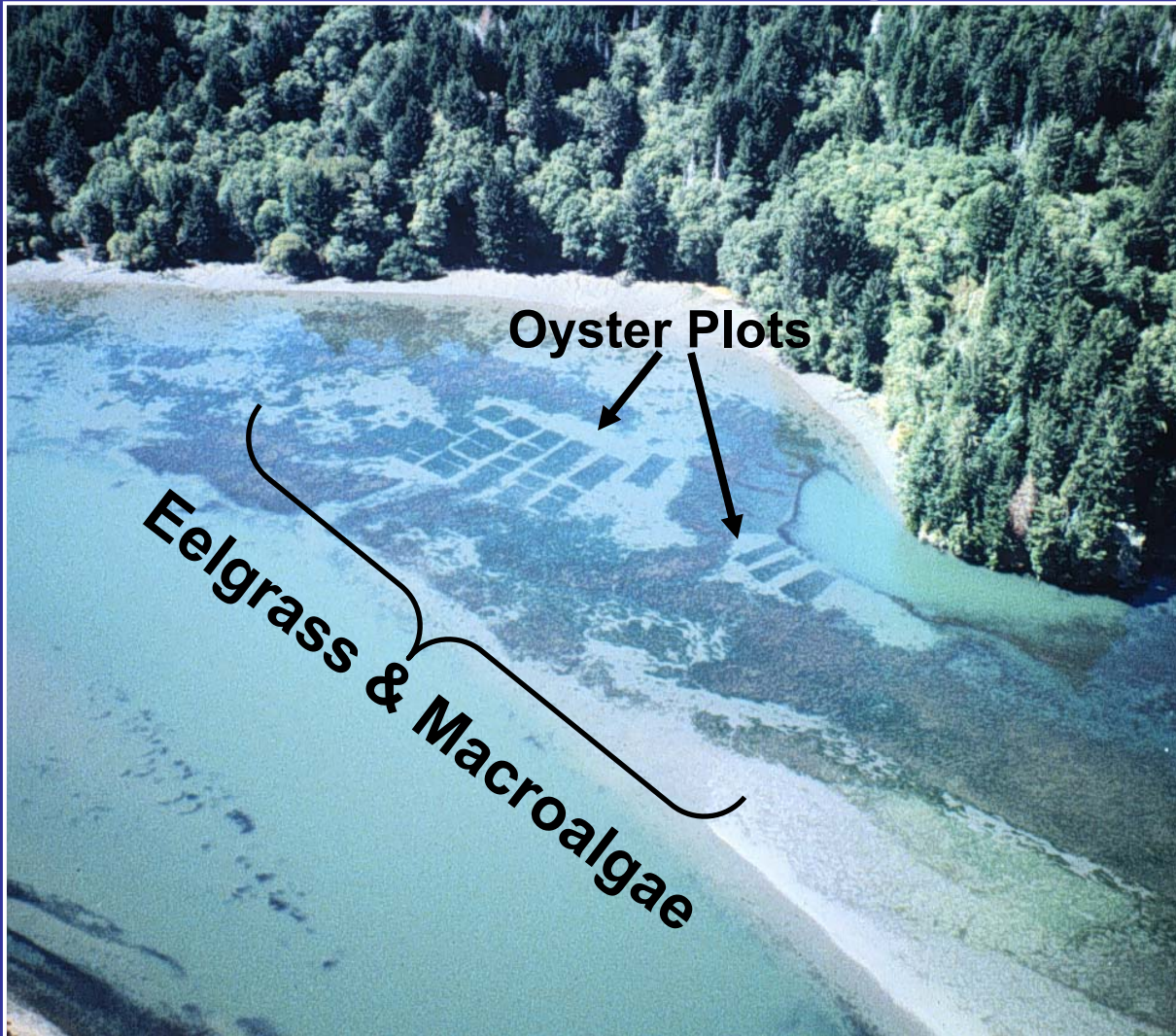
www.nanoos.org

GOES
satellite
telemetry

- Water level
- Temp
- Sal
- Cond
- DO
- pH
- Fluor / Chl
- Turb

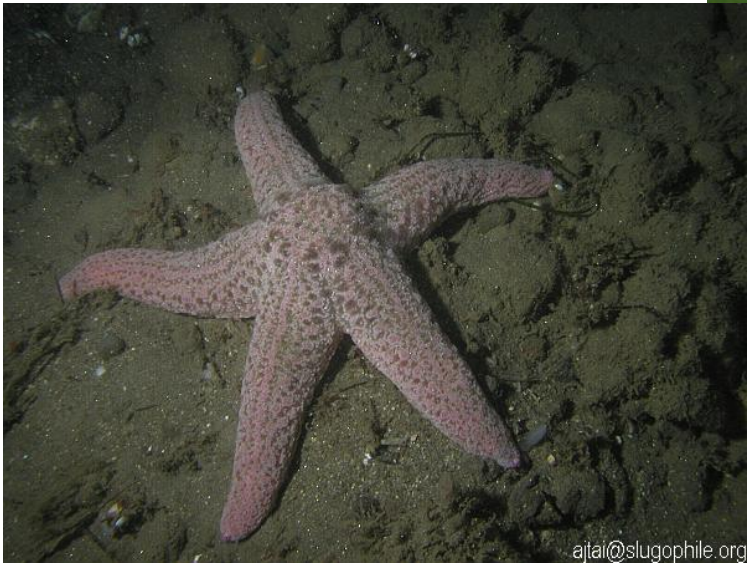


ANTHROPOGENIC STRESSOR: Commercial Oyster Mariculture within the South Slough Estuary, OR



OBSERVATION:

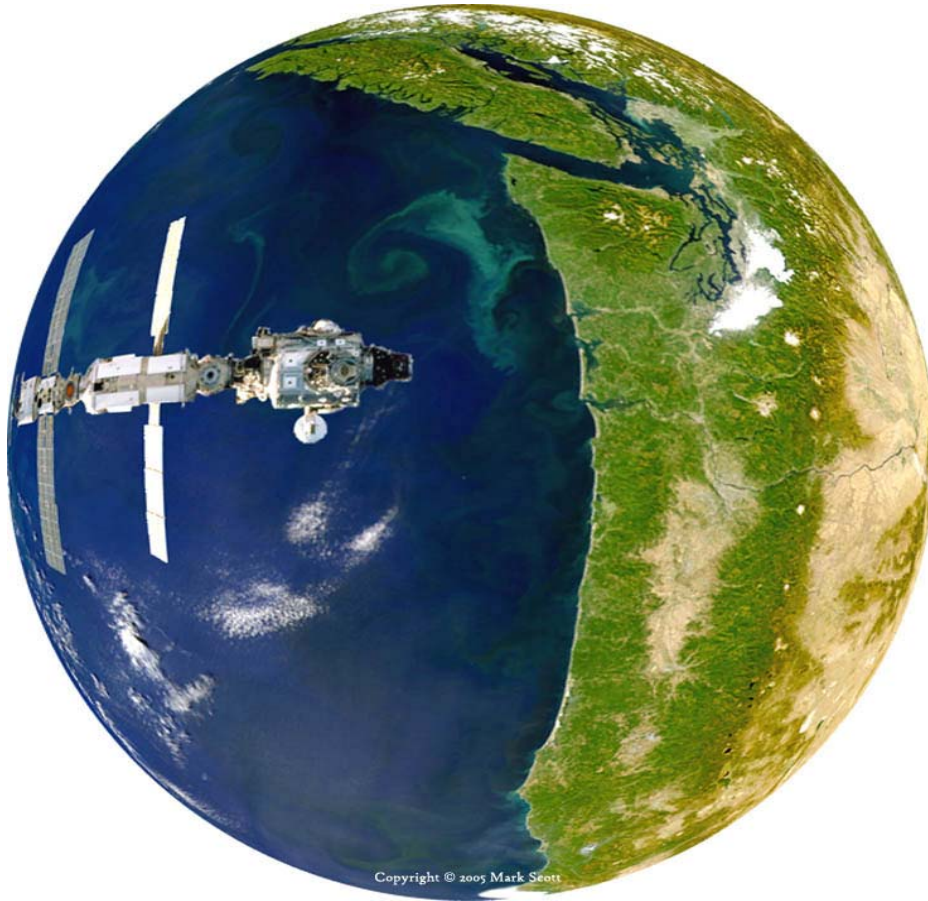
Dense cultivation of *Crassostrea gigas* (a non-indigenous species) results in displacement and fragmentation of eelgrass beds (*Zostera marina*).



ajtai@slugophile.org



South Slough NERR: Real-Time Data



Websites:

NERRS CDMO

HADS

NANOOS

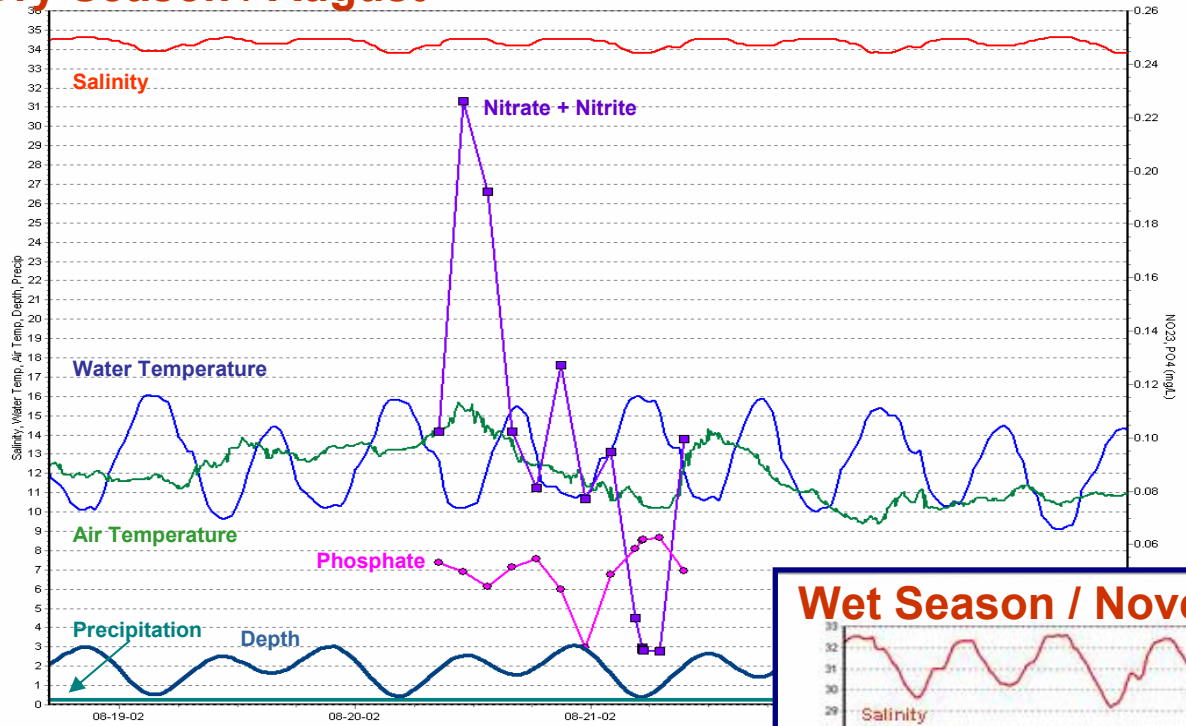
Oly Oyster site

National Estuarine Research Reserve System



● Existing Reserves ● Proposed Reserves

Dry Season / August



Dry Season / Aug '02:

Ocean delivery of nitrate + nitrite by flood tides

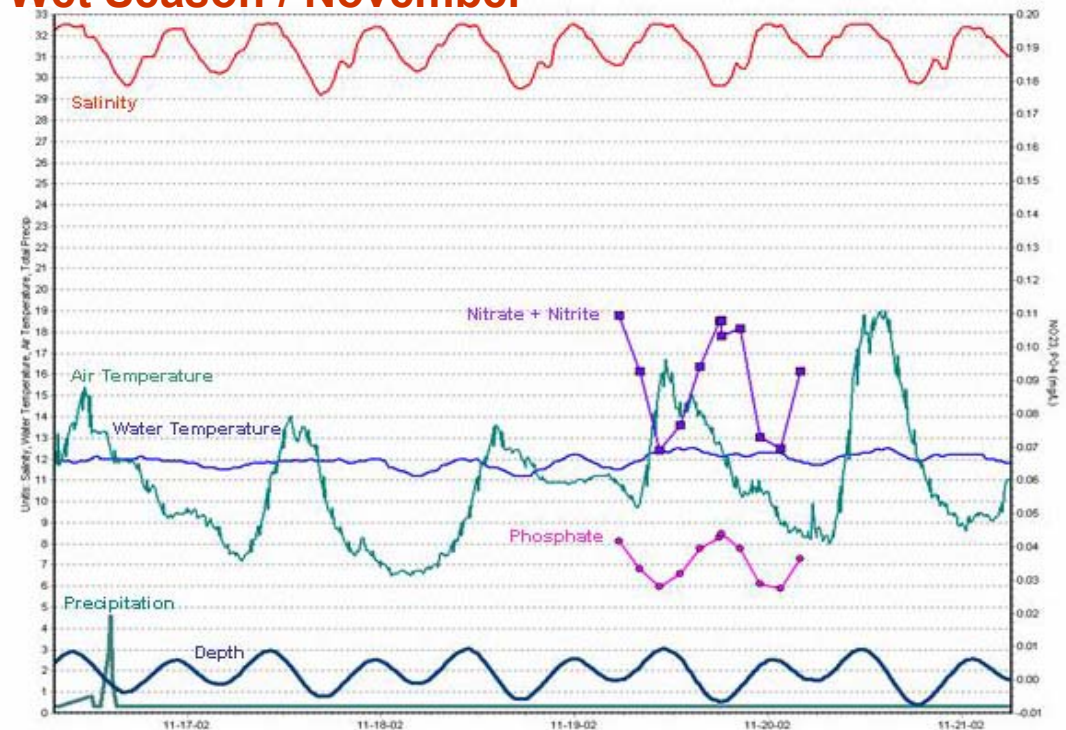


Wet Season / Nov '02:

Watershed input of nitrate + nitrite & phosphate during low tides



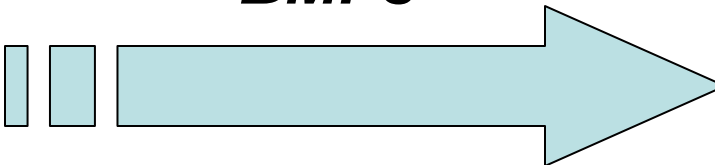
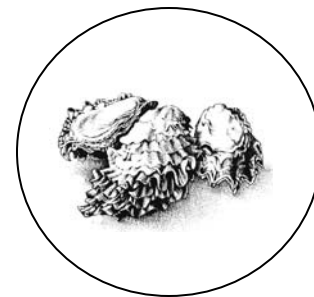
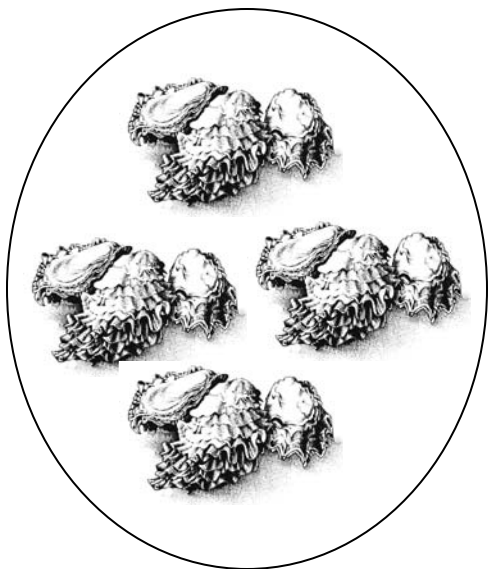
Wet Season / November



Pacific Oysters

Crassostrea gigas

BMPs



**High-Density
Mariculture**

**Low-Density
Mariculture**



Eelgrass

Zostera marina

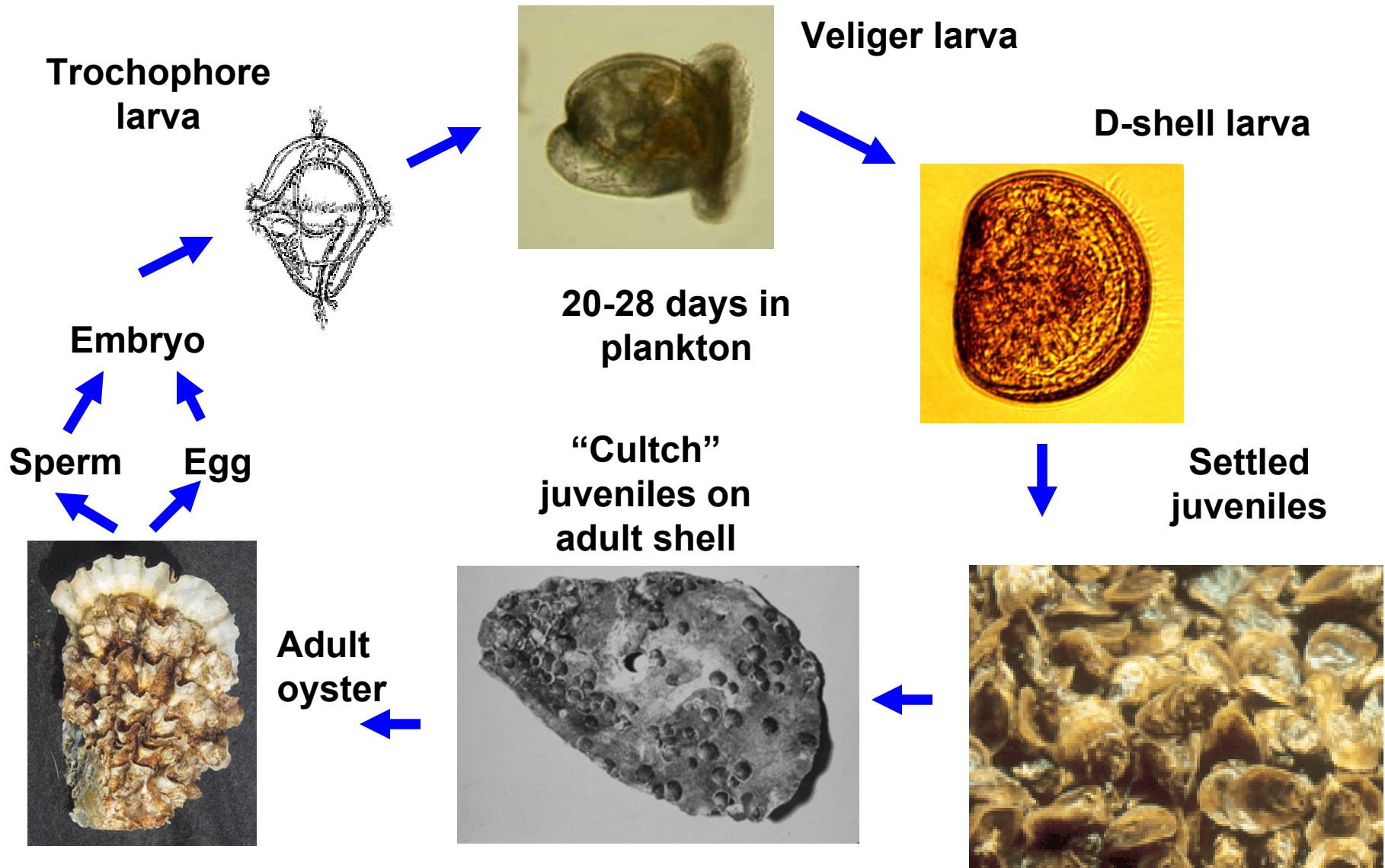
**DEPRESSED
BED
METRICS**

**HEALTHY
BED
METRICS**

Restoration / Enhancement



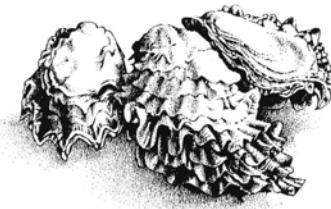
Life History of Pacific Oysters: *Crassostrea gigas*



Biotic Interactions between Oysters and Eelgrass in Pacific Northwest Estuaries

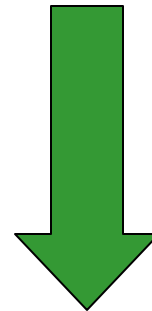
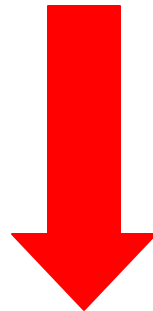


Pacific Oysters
Crassostrea gigas



- **Reduced plant biomass**
- **Shading**
- **Blade damage and desiccation**
- **Harvest impacts**

-



+

- **Biofiltration to improve water clarity**
- **Nutrient enrichment**
- **Complex bottom habitat**



Eelgrass

Zostera marina

CRABS

SHRIMP

BIRDS

FISH

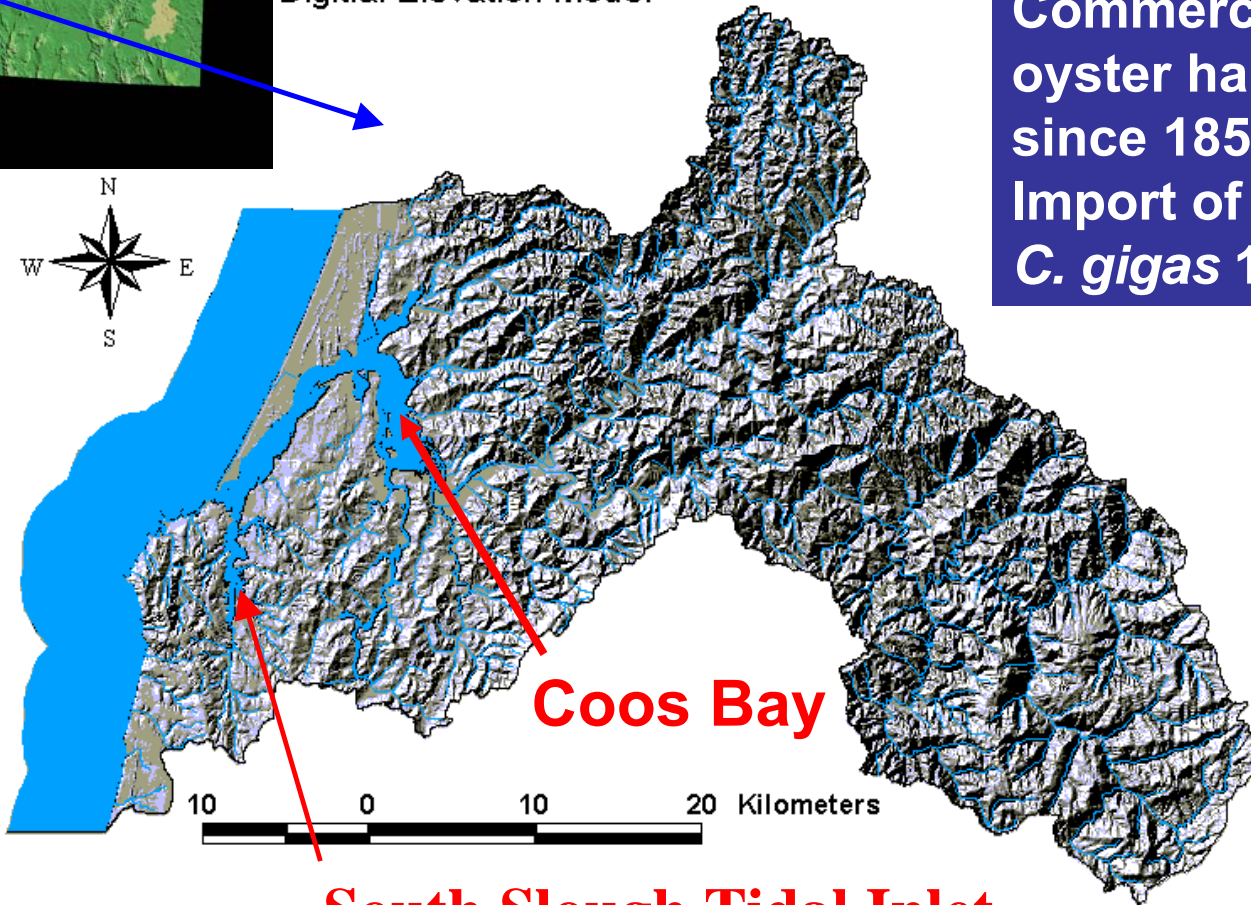
INFAUNAL INVERTEBRATES

OREGON



Coos Bay: A Pacific Northwest Drowned River Mouth Estuary

Digital Elevation Model



Commercial oyster harvest since 1850s / Import of *C. gigas* 1920s



South Slough Tidal Inlet

South Slough National Estuarine Research Reserve

Designated 1974

4,800 ac research natural
area

Habitats:

- estuary
- wetlands / riparian
- coastal forest

Land-Margin
Ecosystem

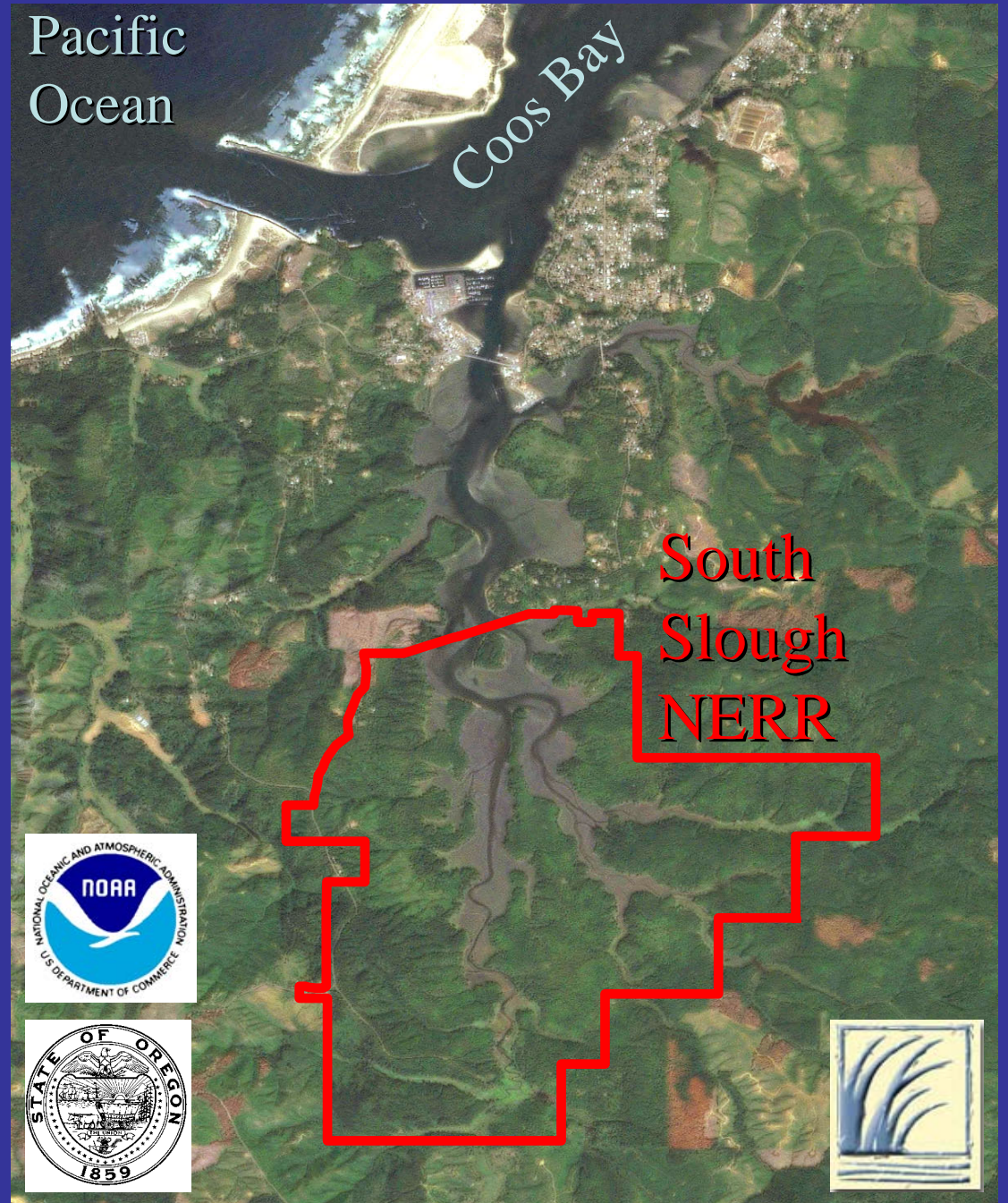
Ocean



Estuary

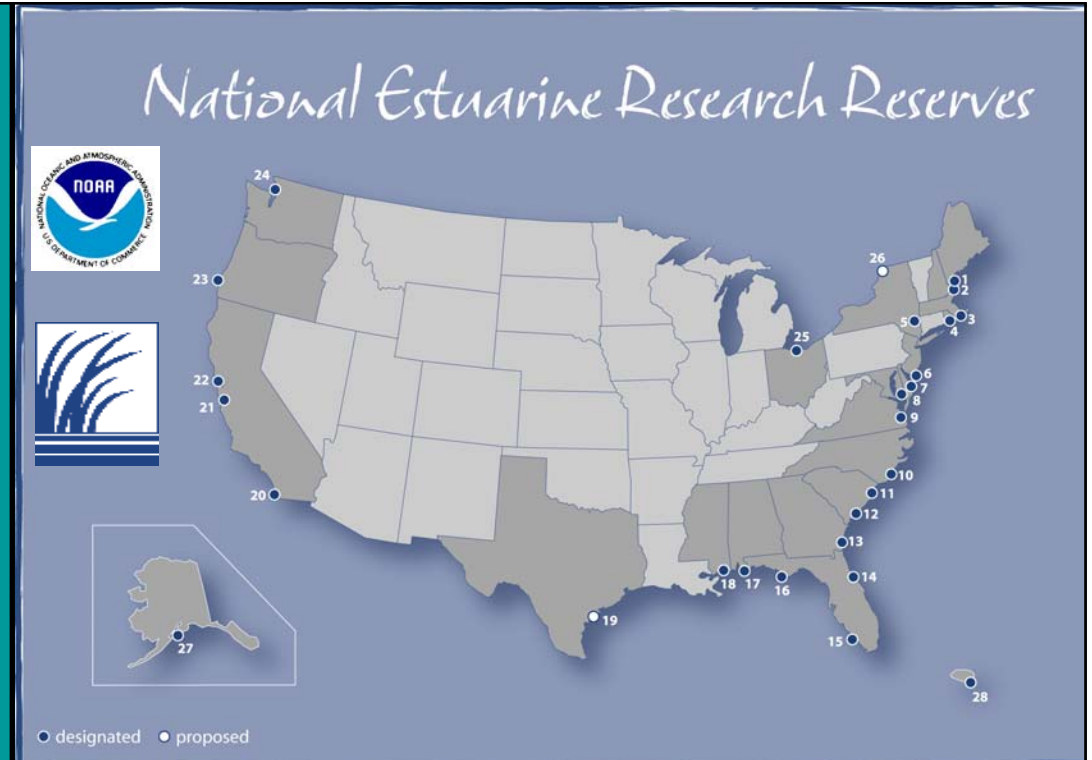


River



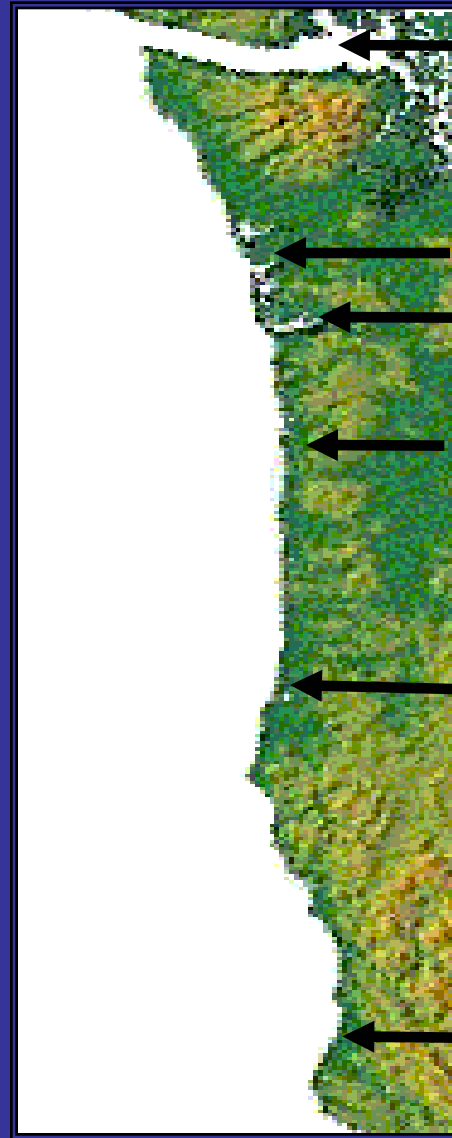
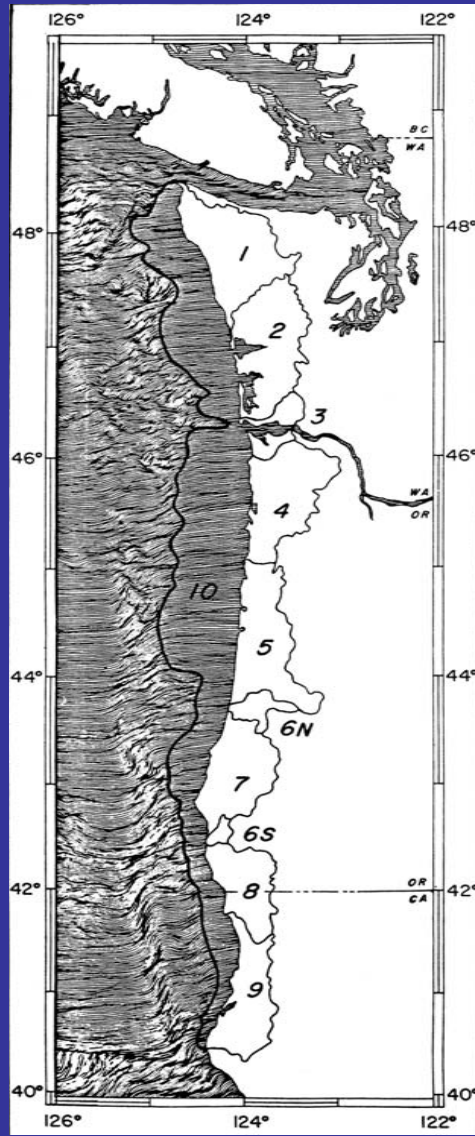
Mission (2005):

“to promote stewardship of the nation’s estuaries through science and education using a system of protected areas”



- Nationwide network of 27 estuarine protected areas
- Designation and long-term protection of over 1,000,000 acres of land and water
- Federal – state partnership program in operation since 1974
- Biogeographic approach to Reserve representation
- Programs for research, monitoring, education, training, & resource stewardship

Ecological Impacts of Commercial Oyster Mariculture in the Pacific Northwest / Columbian Bioregion



Puget Sound

Willapa Bay, WA

Columbia River

Tillamook Bay, OR

Coos Bay, OR

South Slough

Humboldt Bay, CA

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

Restoration of Olympia oysters in the South Slough Estuary

Vision: Successful establishment of self-sustaining populations of *Ostrea conchaphila* throughout the South Slough and Coos Bay, to the extent that native oysters can provide habitat and contribute to improved ecological functions

Project Goal: Increased understanding of intrinsic and ecological factors to facilitate and encourage recovery of self-sustaining populations in the estuarine tidal channels and tideflats

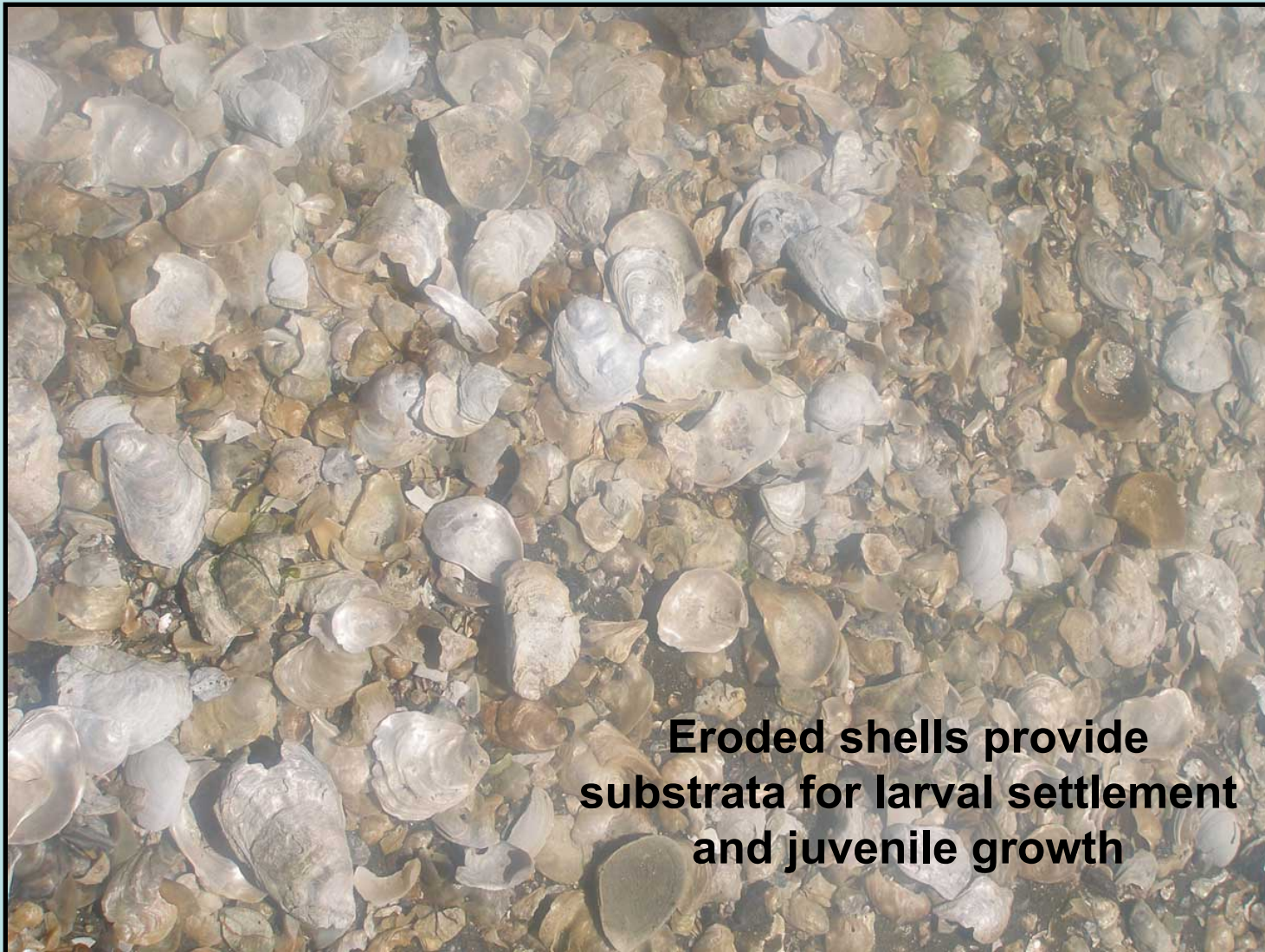
Objectives:

1. Determine the genetic identity of existing oyster populations in Coos Bay and identify appropriate broodstock sources (2006)
2. Establish an experimental population and conduct an on-site assessment of oyster survivorship, growth, and reproduction in South Slough (2007-09)

Poster: Jefferson County, WA

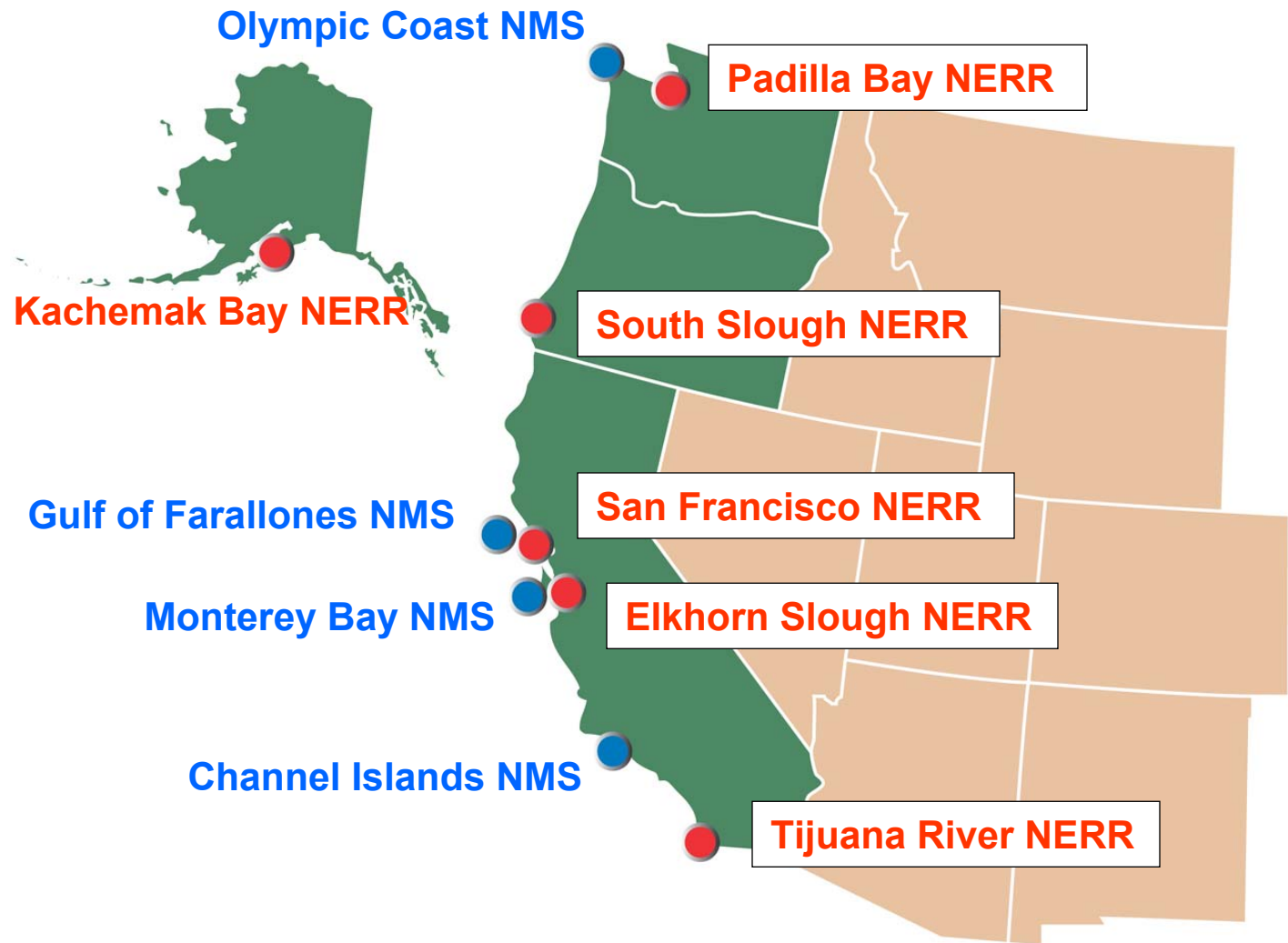
NOAA / Northwest Straits Marine Conservation Initiative

**Coos Bay, OR: Shell deposits of Olympia oysters
(*Ostrea conchaphila*) eroded from dredge spoil islands
in the upper region of the Coos Bay Estuary**



**Eroded shells provide
substrata for larval settlement
and juvenile growth**

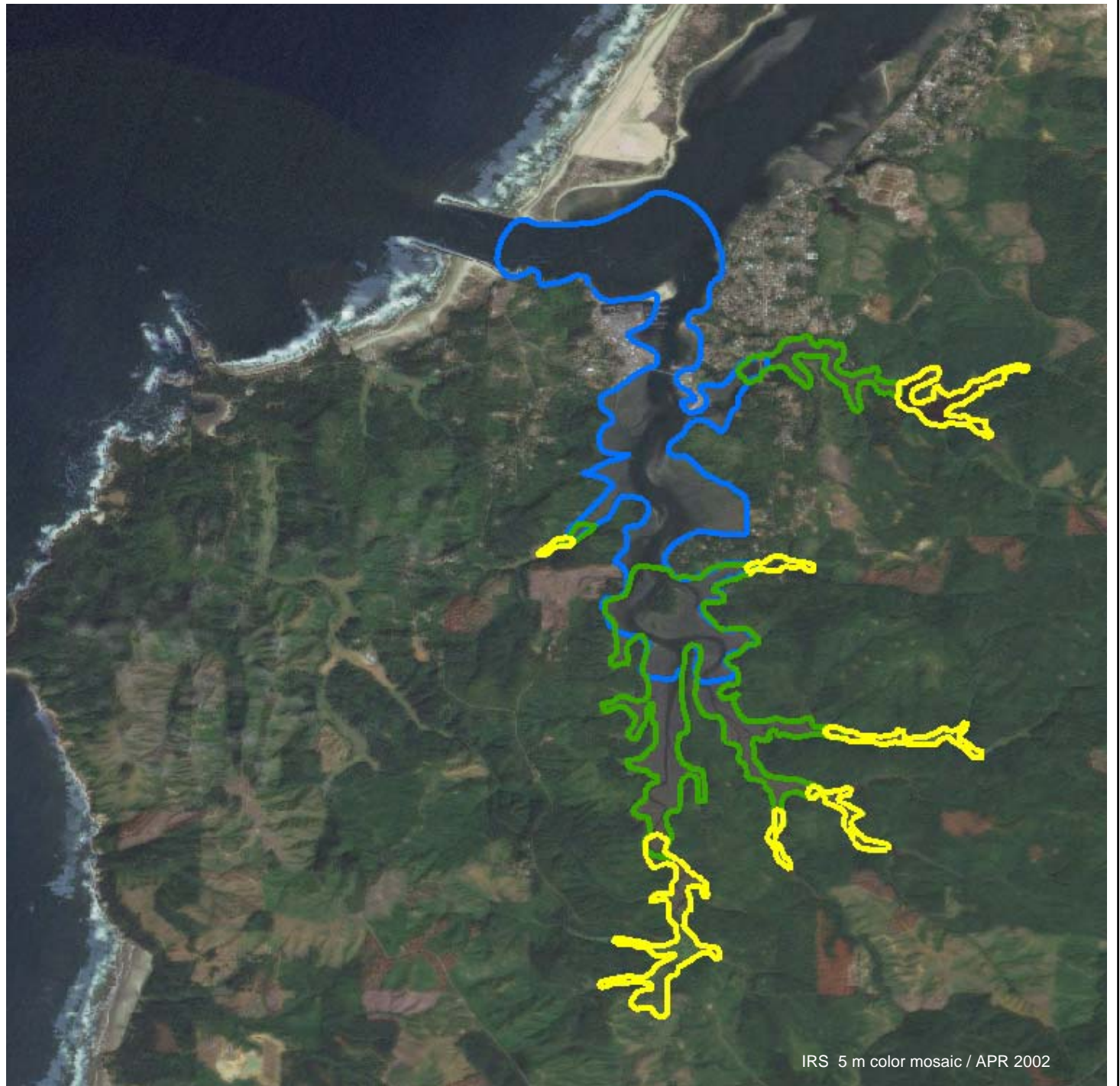
Broad-scale Assessment of Marine and Estuarine Invasive Species within the Pacific Coast National Estuarine Research Reserves and National Marine Sanctuaries



SOUTH SLOUGH ESTUARY, OR

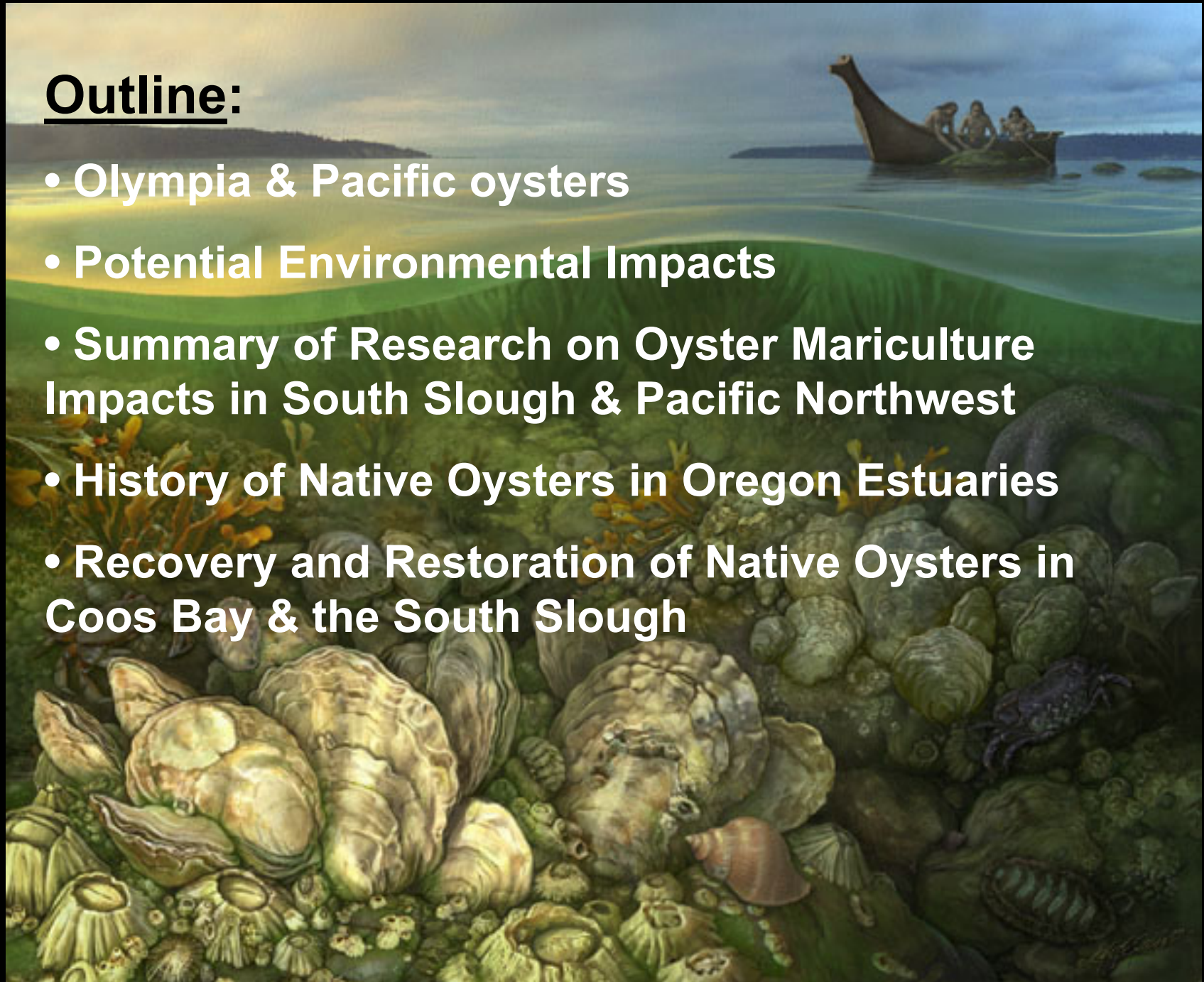
Location and spatial extent of three distinct hydrographic regions located along the estuarine gradient of the South Slough tidal basin

- Marine-Dominated
31-20 psu
- Mesohaline
28-15 psu
- Riverine
21-0 psu



Outline:

- Olympia & Pacific oysters
- Potential Environmental Impacts
- Summary of Research on Oyster Mariculture Impacts in South Slough & Pacific Northwest
- History of Native Oysters in Oregon Estuaries
- Recovery and Restoration of Native Oysters in Coos Bay & the South Slough



Characterization of Local Weather Conditions and Variability in Water Quality Parameters within the South Slough Estuary

National Estuarine Research Reserves: System-Wide Monitoring Program (SWMP)



Ambient Status & Trends: Dynamic Forcing within the South Slough Estuarine Tidal Basin

- **Local Meteorological Conditions**
- **Water Quality Parameters**
- **Inorganic Nutrients & Chlorophyll**



Ecology of Pacific oysters (*Crassostrea gigas*):

Appearance: Large (8-15 cm) epibenthic bivalves, non-motile with left valve typically cemented to substrata.

Reproduction & Growth: Protandric hermaphrodite, spawn in summer, external fertilization with planktonic veliger larvae. Post settlement growth about 25 mm per year.

Habitat: Mid intertidal to shallow subtidal, attachment to hard surfaces in sheltered waters, often on adult shells. Mariculture species.

Feeding: Filter-feeder / suspension-feeder, consumes phytoplankton and protists.

Predators: Seastars, crabs, boring gastropods, polychaetes, fish, birds, humans.





Commercial Mariculture of Pacific Oysters in South Slough NERR, OR

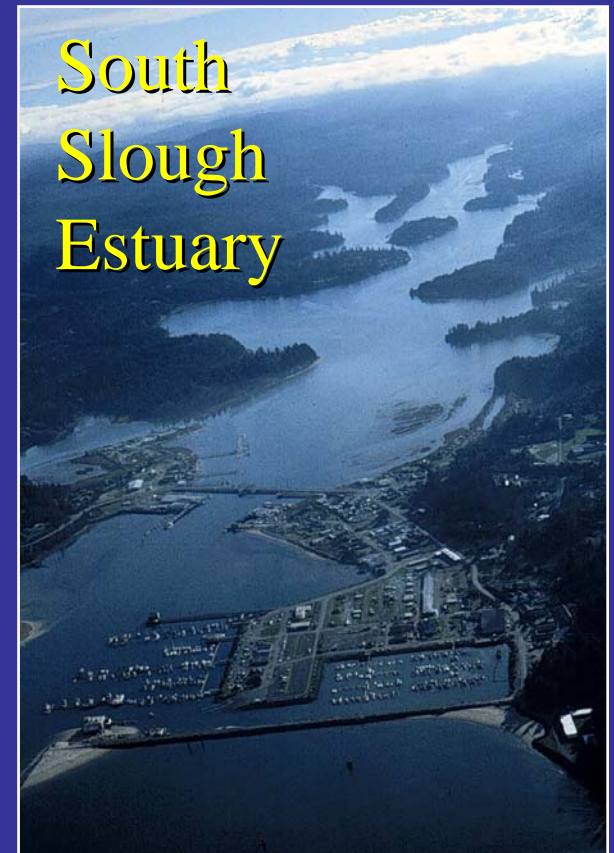
A. Bottom culture



B. Stake culture



C. Rack culture



South Slough Estuary