

- Juvenile salmon use of estuaries
- Functional performance of restoring and natural habitats
- Ecological effects of shoreline modifications

Jason Toft



wetland

E C O S Y S T E M T E A M

UNIVERSITY OF WASHINGTON AQUATIC & FISHERY SCIENCES

- It's my birthday!



Jason Toft

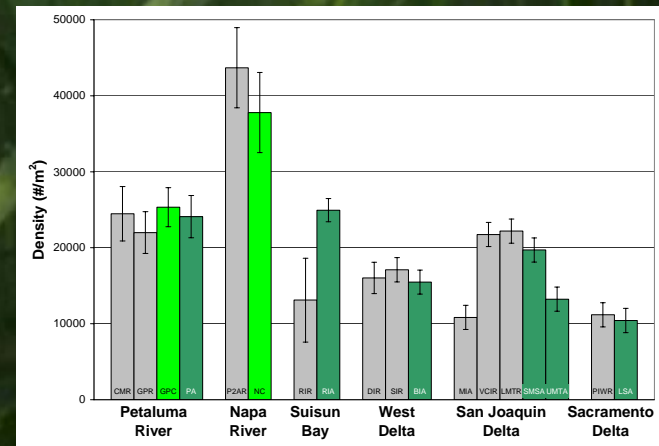


wetland

ECOSYSTEM TEAM

UNIVERSITY OF WASHINGTON AQUATIC & FISHERY SCIENCES





Fish Distribution, Abundance, and Behavior at Nearshore Habitat Types in Puget Sound, WA, USA

Jason Toft

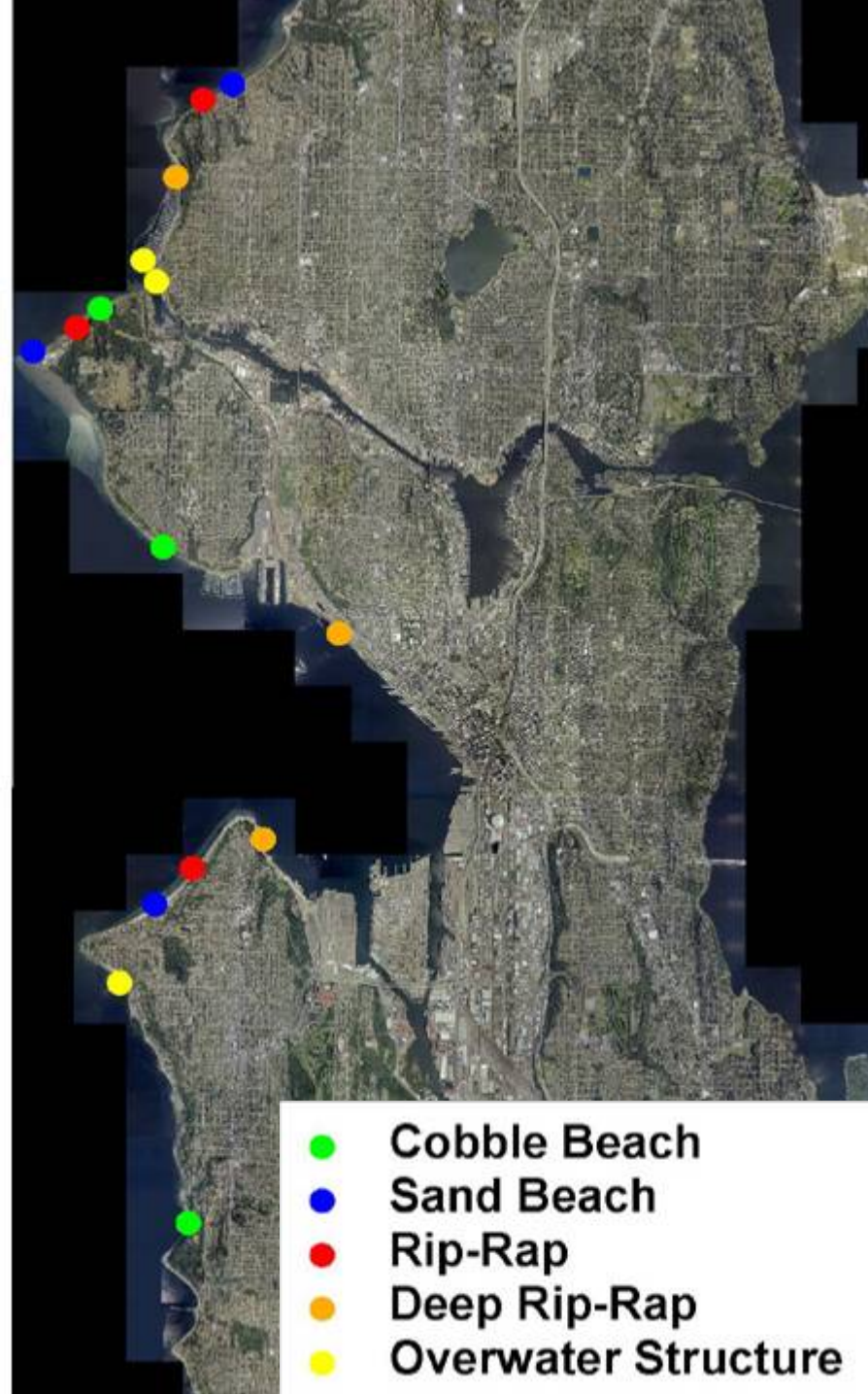
Wetland Ecosystem Team
School of Aquatic and Fishery Sciences
University of Washington
Seattle, WA, USA

Charles Simenstad

Jeff Cordell

Lia Stamatiou

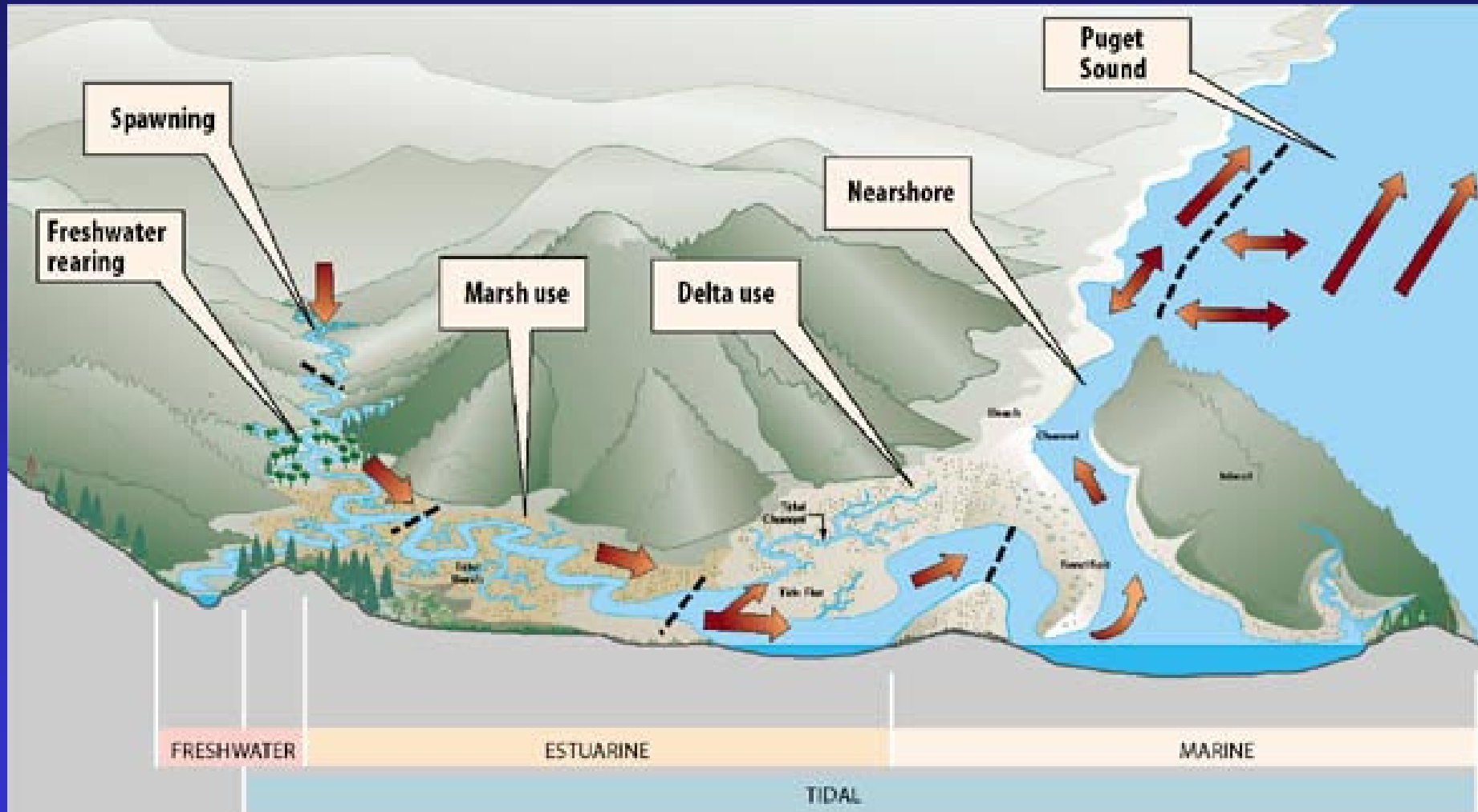
Funded by the Seattle Public Utilities
Department



- Cobble Beach
- Sand Beach
- Rip-Rap
- Deep Rip-Rap
- Overwater Structure

PACIFIC SALMON ECOSCAPE, Puget Sound

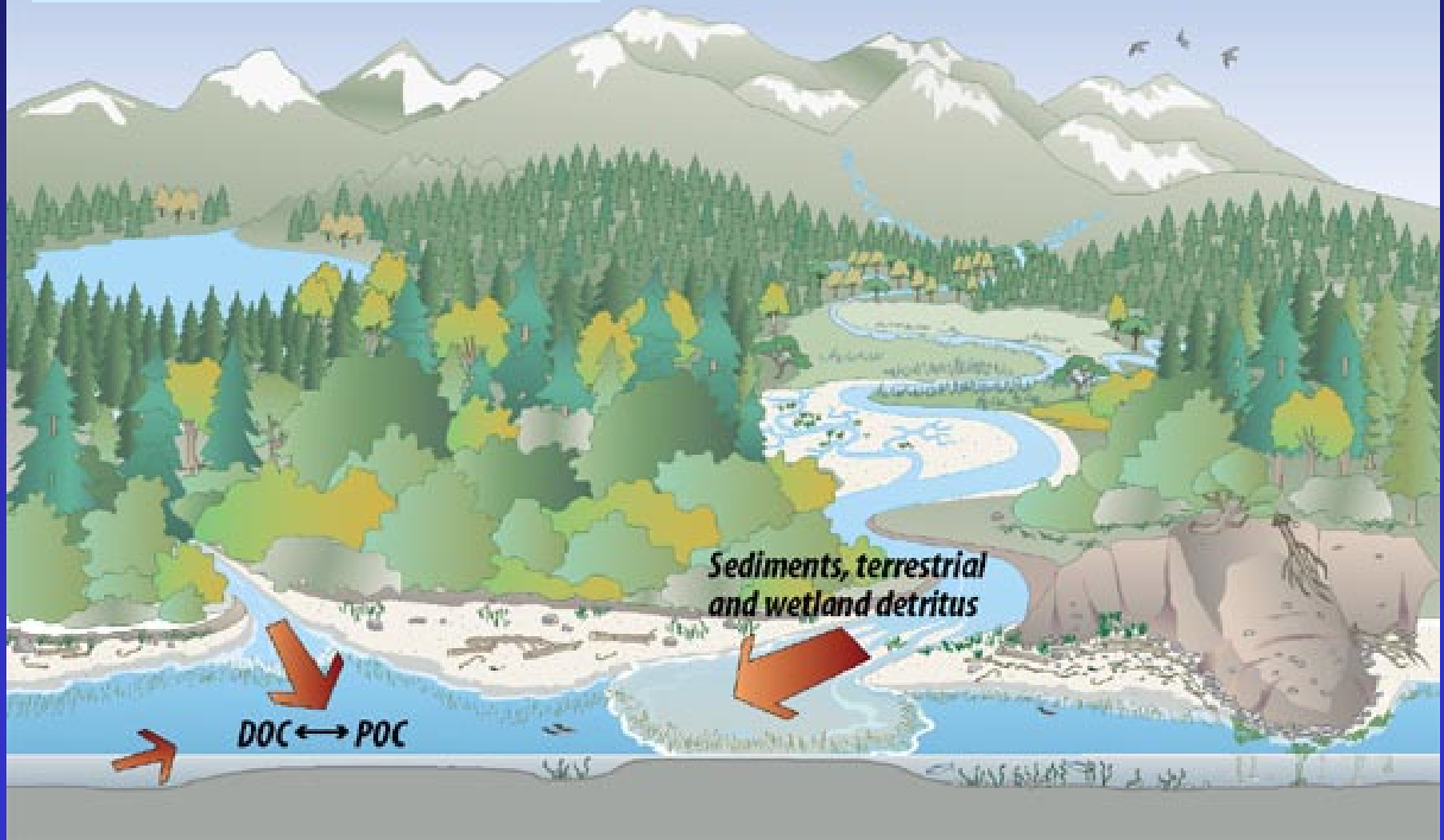
denoting freshwater, estuarine and nearshore habitat continuum



Adapted by C. Simenstad from an original illustration by the GIS & Visual Communications Unit, King County Department of Natural Resources

THE WATERSHED-ESTUARY-NEARSHORE CONTINUUM

Adapted by C. Simenstad from an original illustration by the GIS & Visual Communications Unit, King County Department of Natural Resources



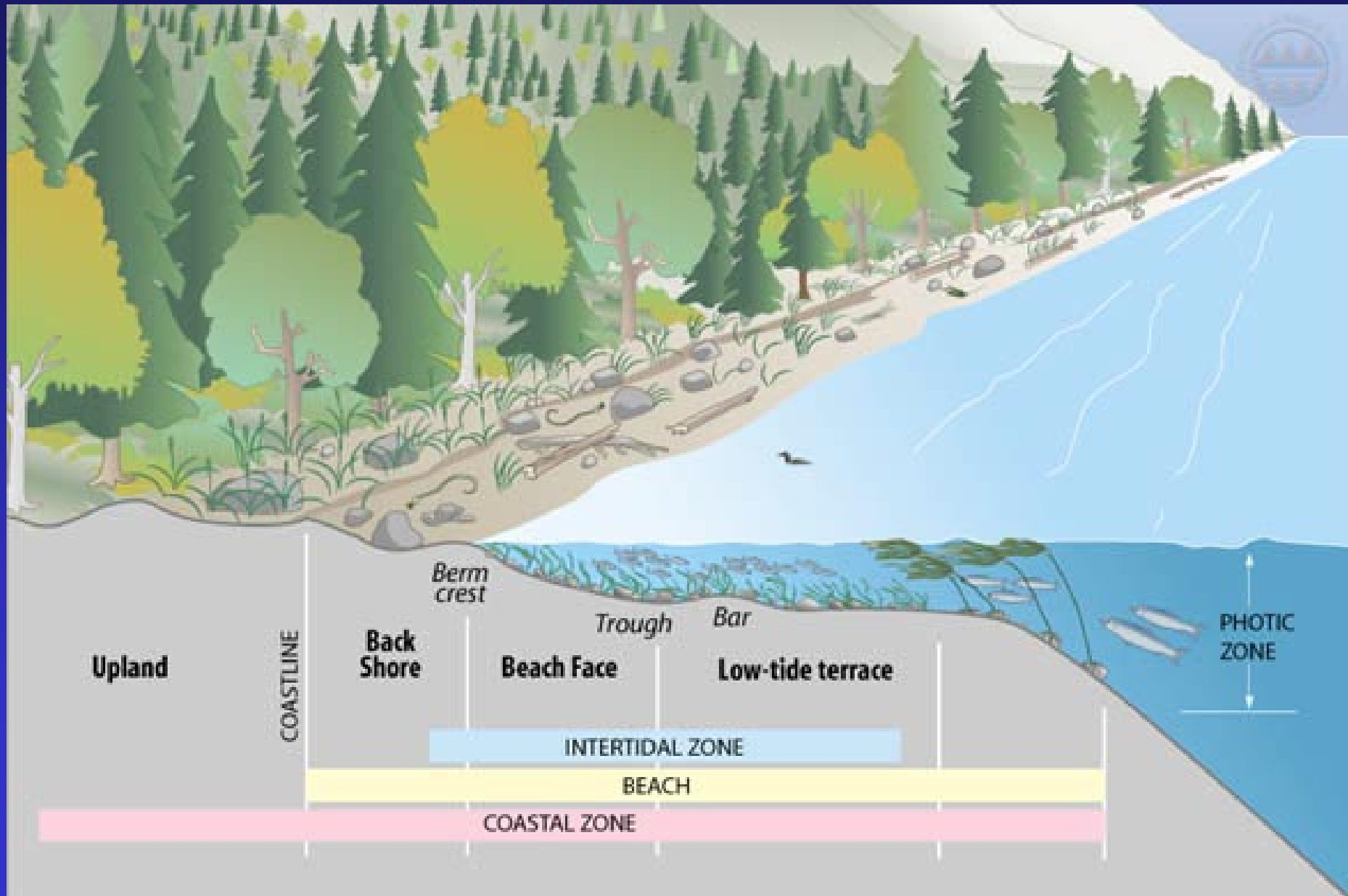
THE WATERSHED-ESTUARY-NEARSHORE CONTINUUM

with watershed and shoreline development

Adapted by C. Simenstad from an original illustration by the GIS & Visual Communications Unit, King County Department of Natural Resources



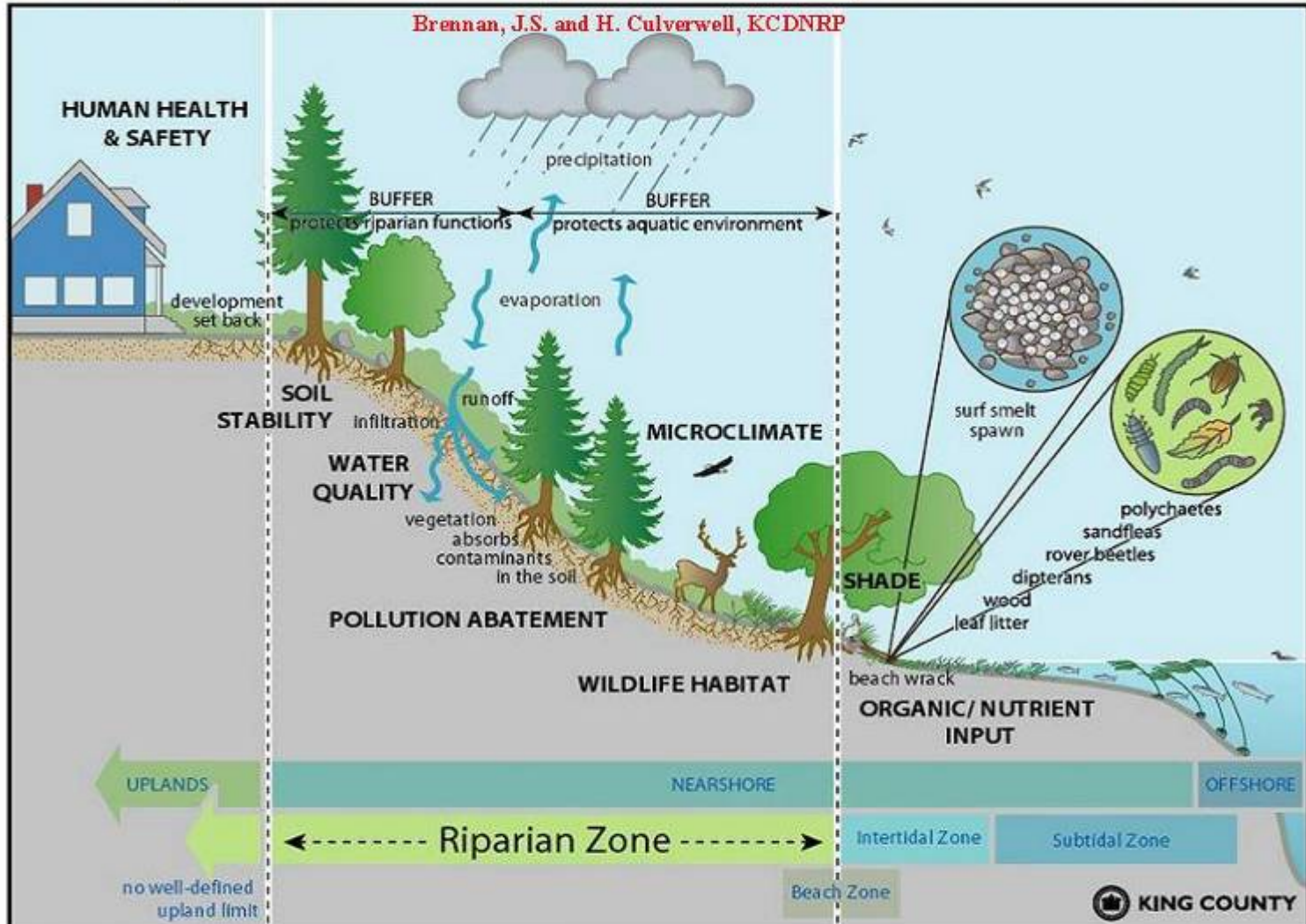
Puget Sound Nearshore

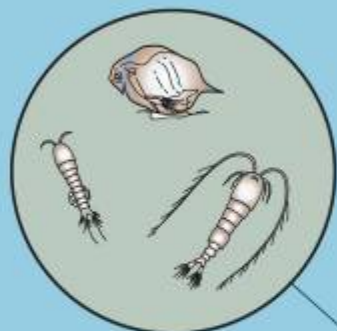


Riparian vegetation in estuarine habitats

Conceptual Model of Marine Riparian Functions

Brennan, J.S. and H. Culverwell, KCDNRP





Zooplankton

**Riparian
Trees and Shrubs**

Higher high water level

Intertidal Marsh

Mid-tide water level

Unvegetated Intertidal

Lower low water level

Shallow Subtidal

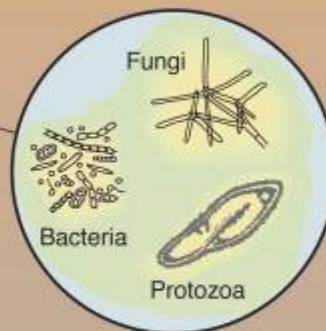
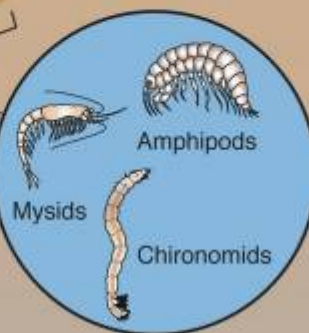
Falling Leaf Litter

Falling Insects

Suspended
Detritus

Deposited
Detritus

**Benthic
Invertebrates**



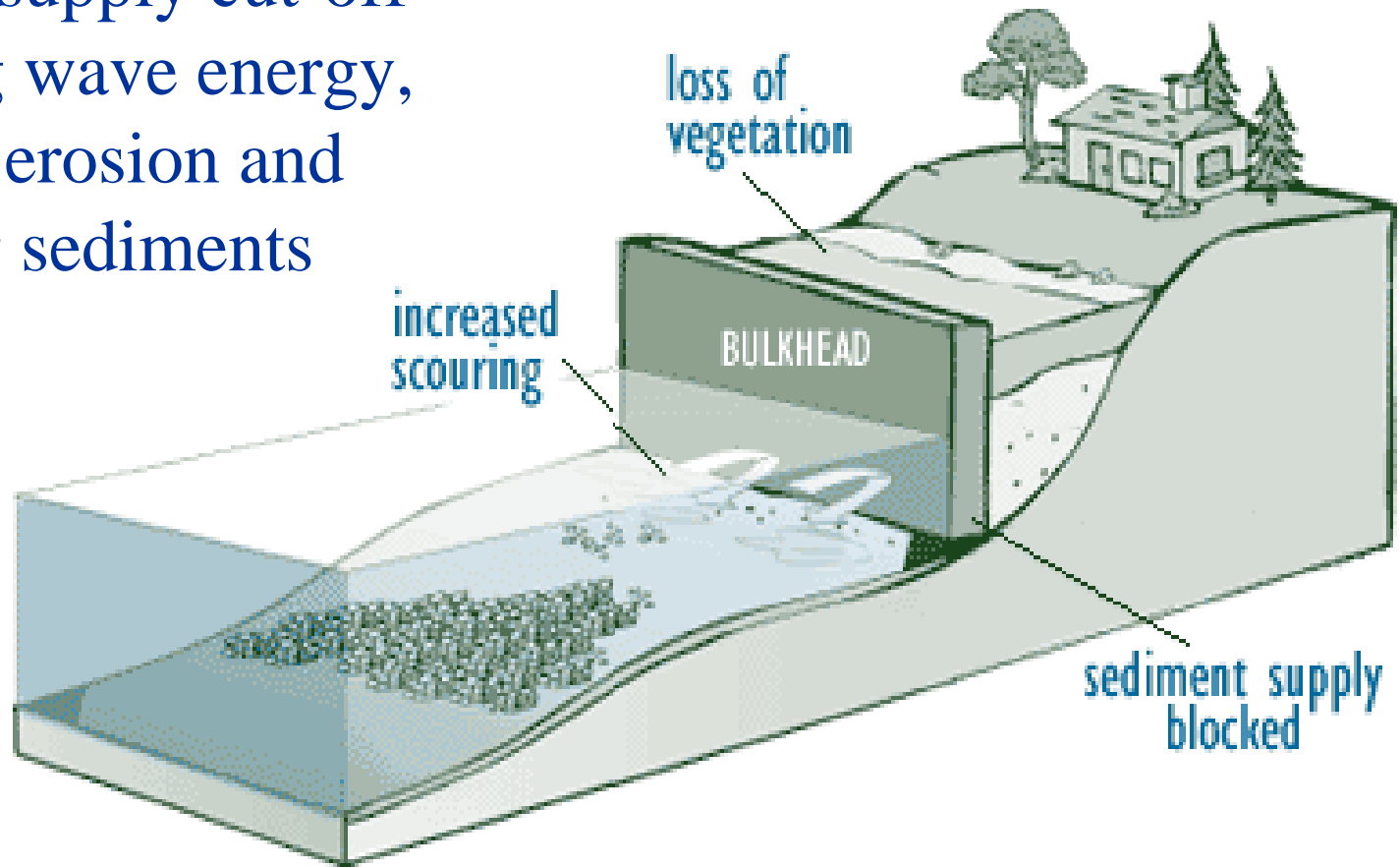
Detritus Particle
(with decomposing
micro-organisms)



**GL Williams
& Associates Ltd.**
Shoreline Management Consulting

Negative impacts of shoreline modifications:

- Degrading of intertidal habitat and shoreline vegetation
- Discontinuity in aquatic-terrestrial interface
- Sediment supply cut-off
- Reflecting wave energy, increasing erosion and coarsening sediments



FUNCTION OF ESTUARIES IN SUPPORT OF JUVENILE SALMON

- **Migration Corridor**
 - gateway between watershed to ocean life histories
- **Physiological Transition**
 - salinity gradient allows physiological adaptation
- **Foraging**
 - sharp transition in prey organisms
- **Refuge from Predation**
 - shallow water, turbidity and structural features that provide refuge from predators

VARIABILITY IN ESTUARINE AND NEARSHORE DEPENDENCE BY PACIFIC SALMON

high dependence



low dependence

ocean type chinook
chum

ocean type coho (?)
pink

stream type chinook
stream type coho
sockeye

Salmon Species with Juveniles utilizing the nearshore:

- **Chinook (Endangered)**



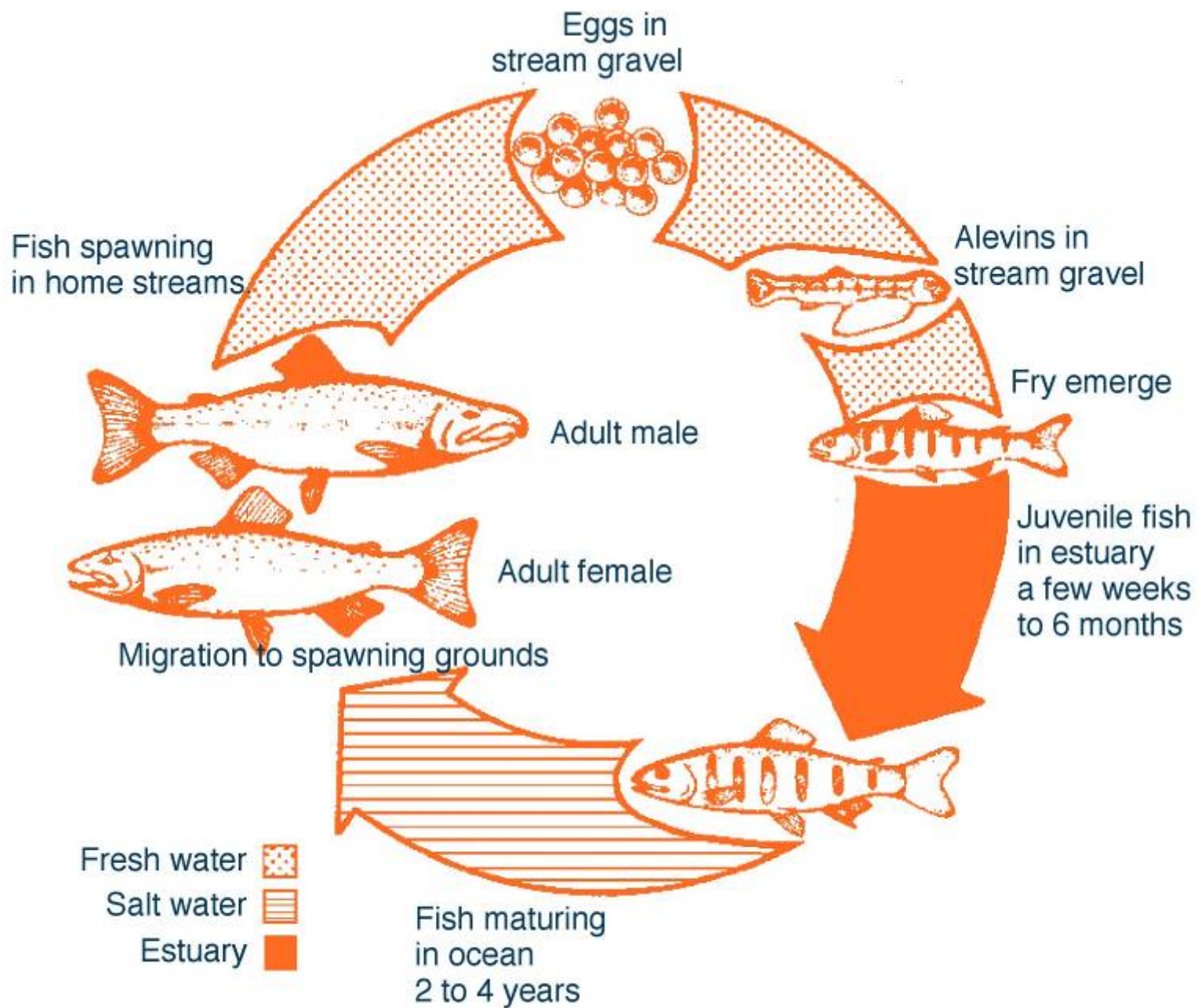
- **Coho**



- **Chum**



- **Pink, Sockeye, Steelhead trout, Cutthroat trout, bull trout**
- **Issues of Hatchery versus Wild fish**



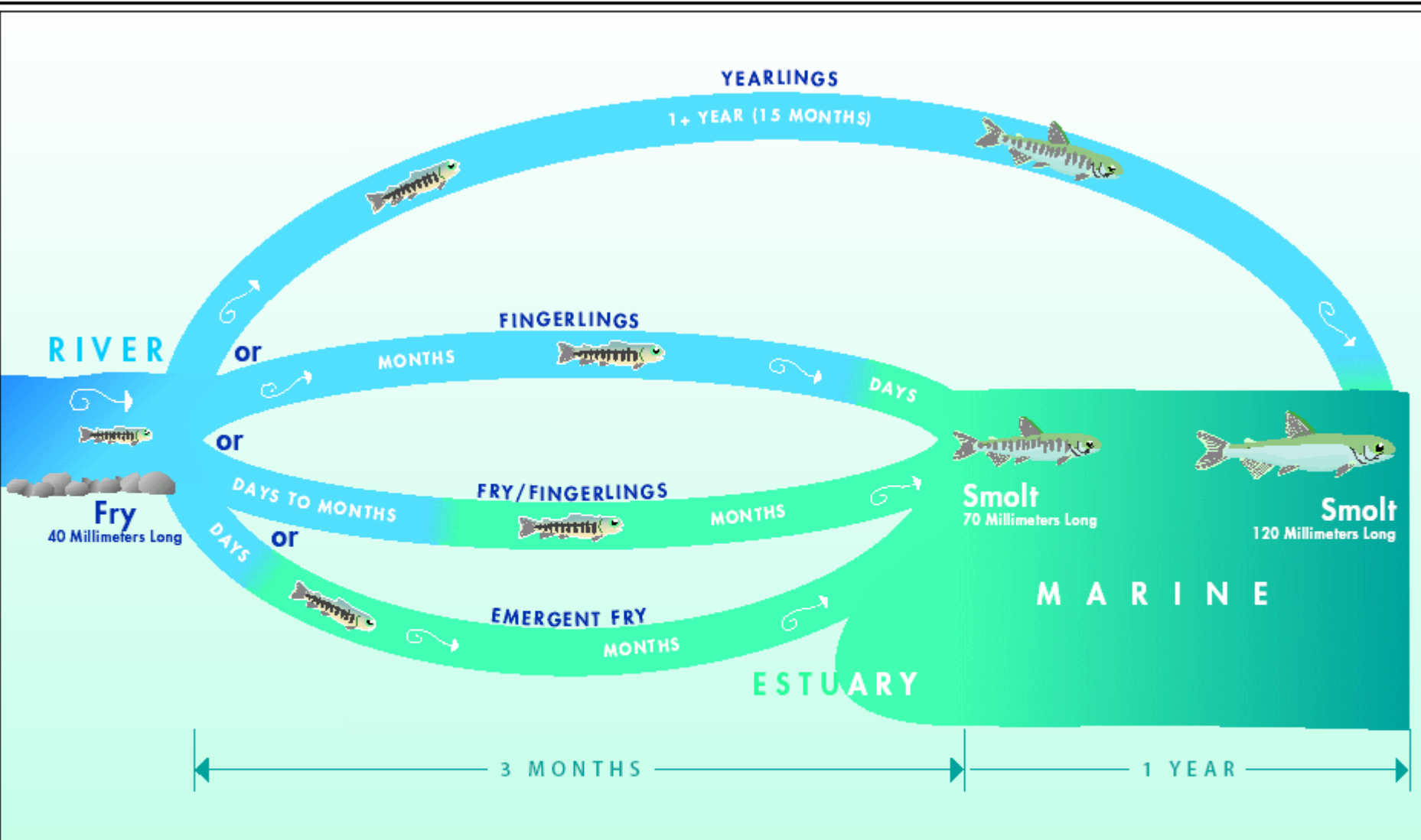


Figure 1-12
**Green/Duwamish River Chinook
Juvenile Rearing Trajectories**

*WRIA 9 Juvenile Salmonid
Survival Studies 2001*

Produced by: King County DNRP GIS & Visual Communications Unit
0404_W0J55_CHINOOKRear.d WGAB, LPRE

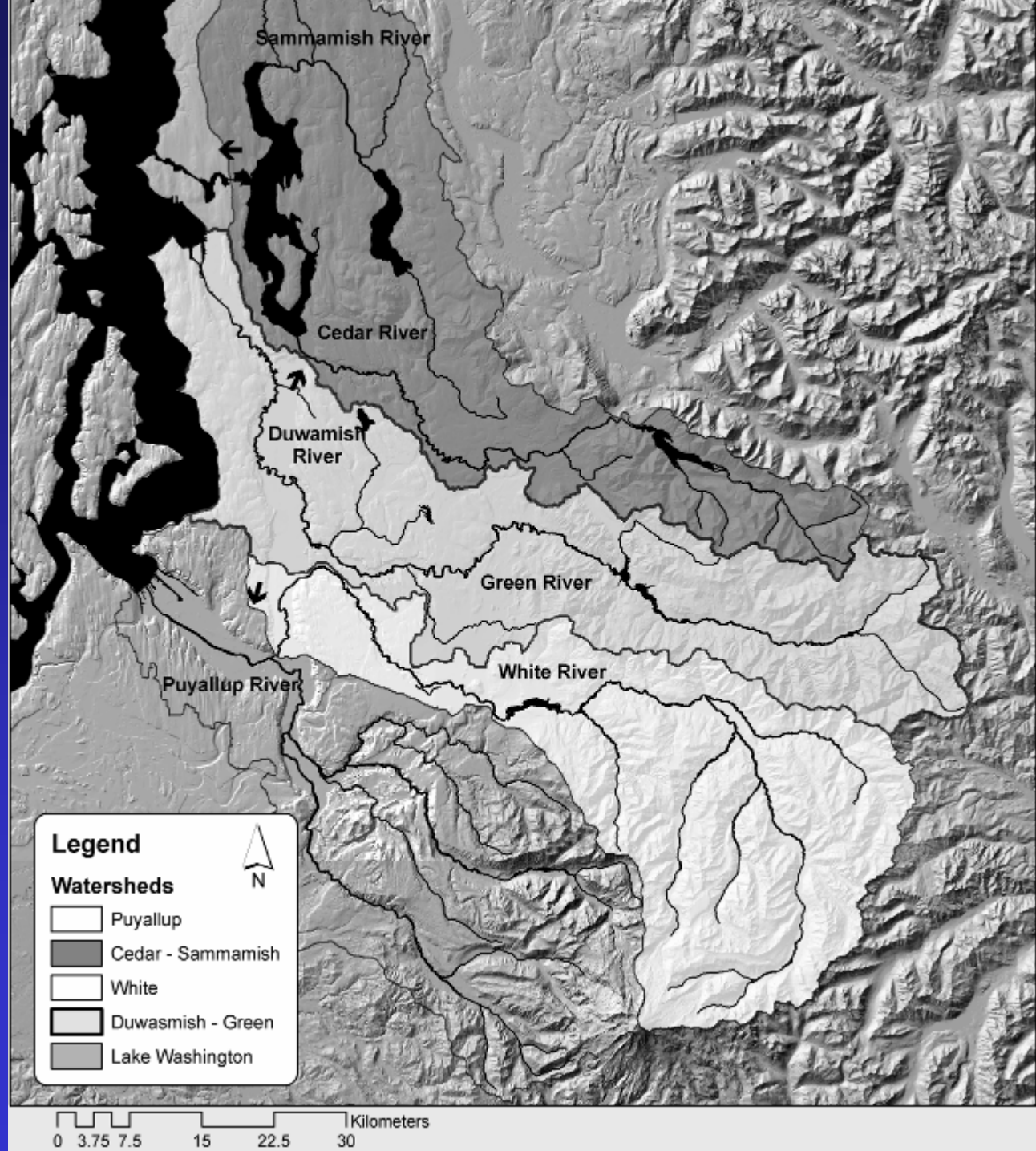


Historical Perspective

- Increased urban development leading to the degradation of natural habitats.
- 84-97% of the current shoreline is modified by retaining structures.
- Chinook Salmon listed under the Endangered Species Act.
- Nearshore important to juvenile salmon as a rearing and migration corridor to the ocean.

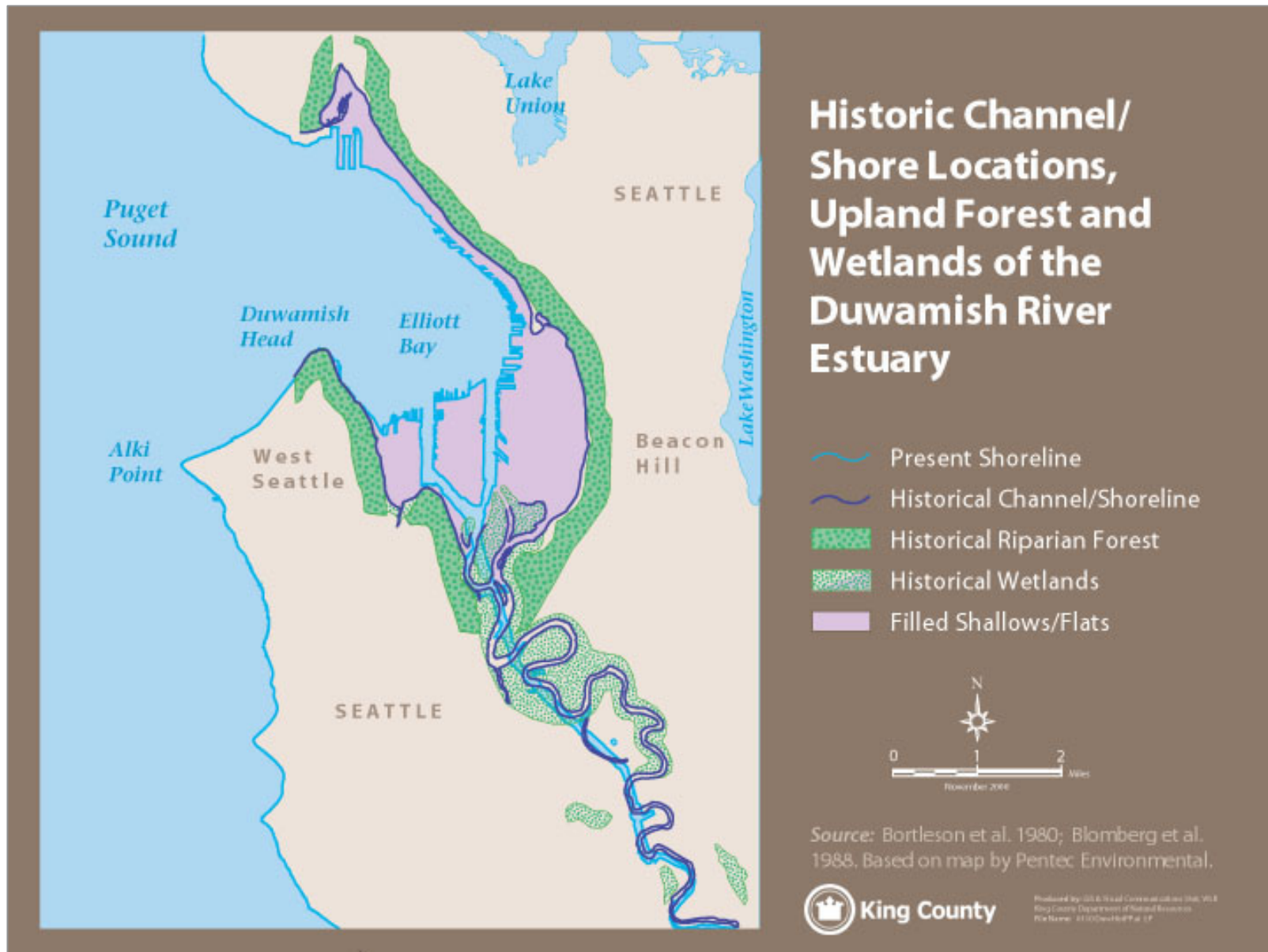


Major River Alterations





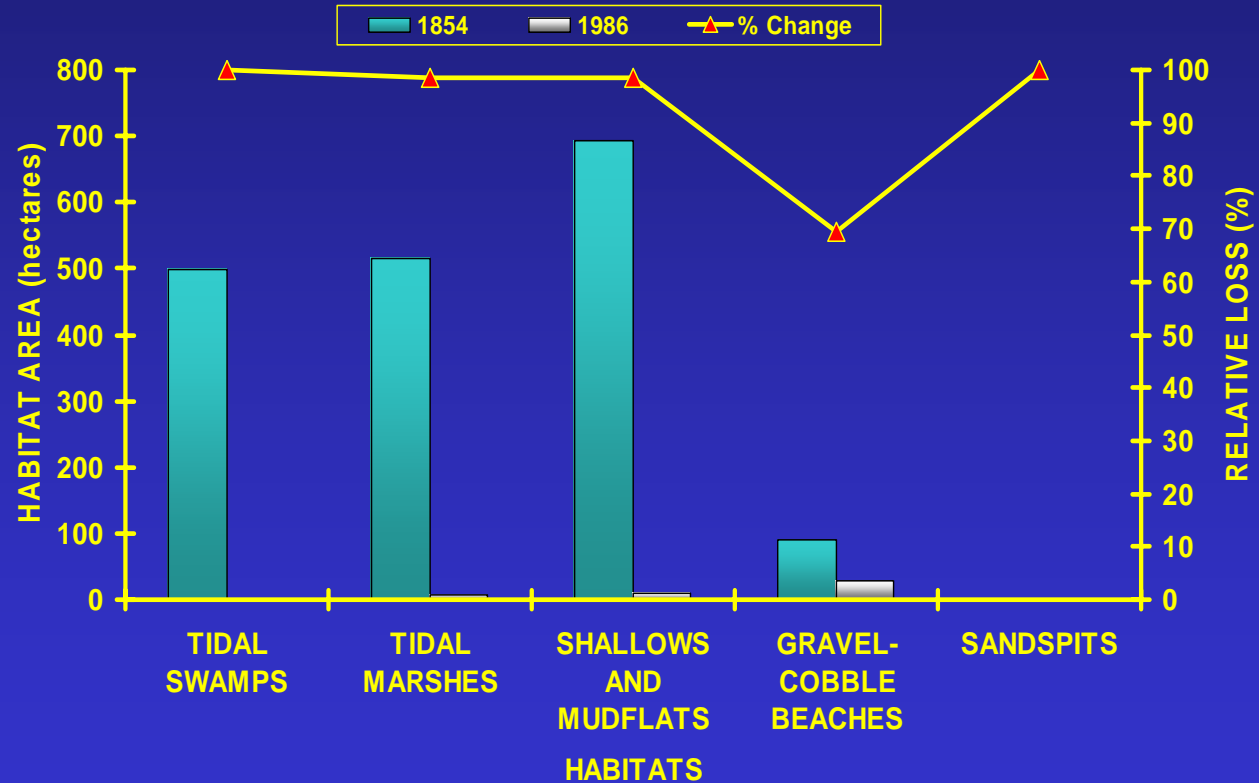
The Duwamish River Estuary – historically



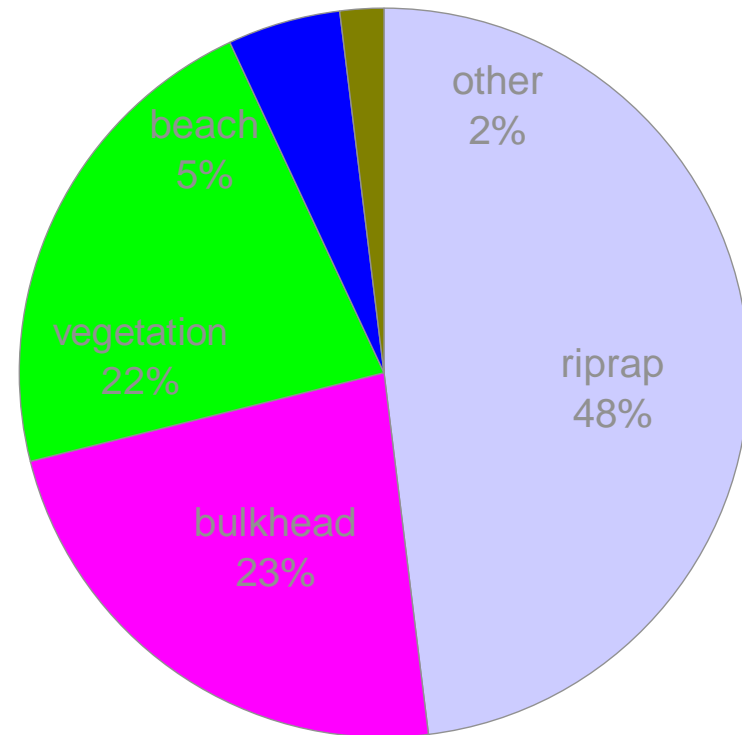
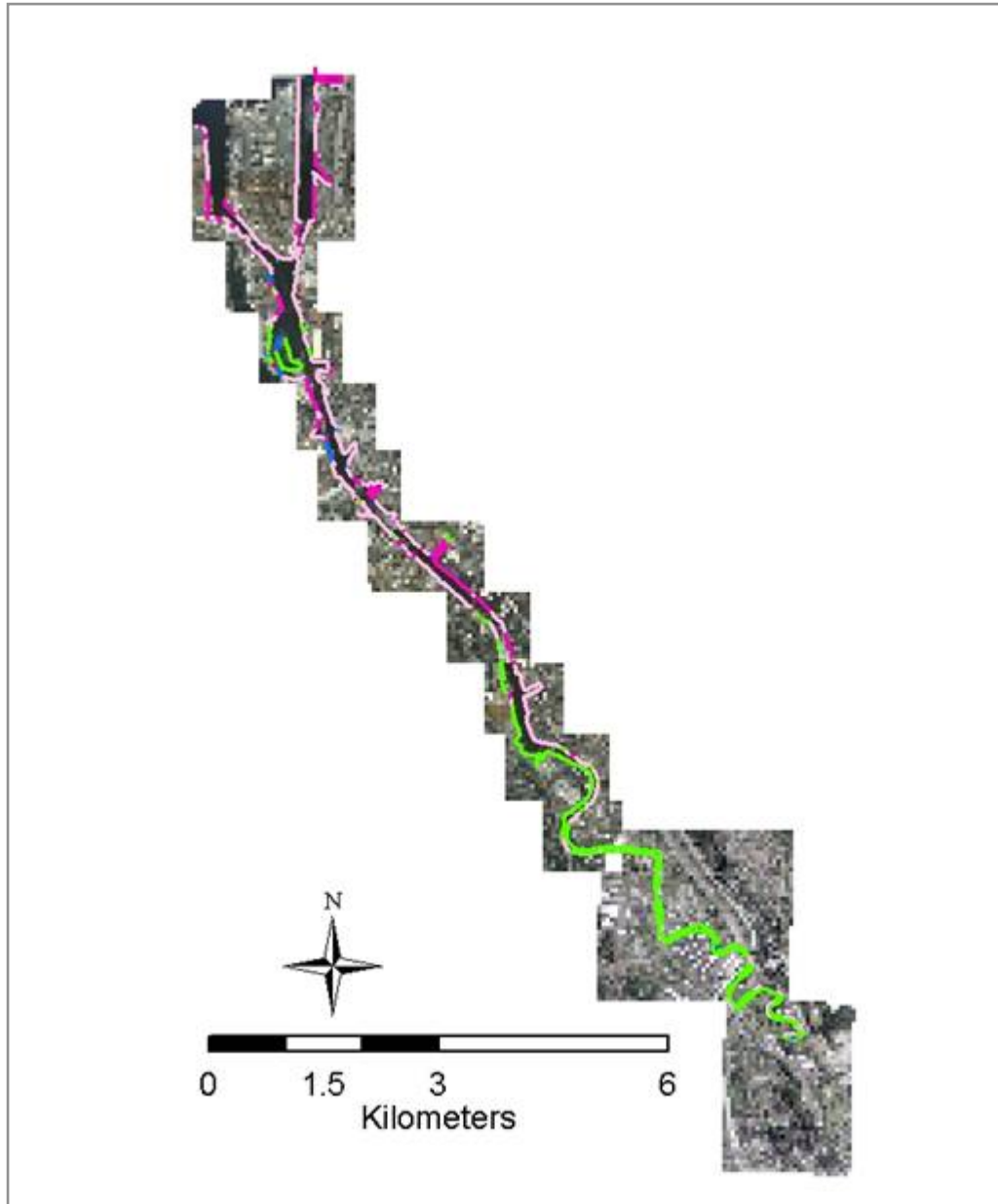
HISTORIC DREDGING AND FILLING OF THE DUWAMISH RIVER ESTUARY



**DUWAMISH RIVER / ELLIOTT BAY ESTUARINE
HABITAT LOSS 1854-1986**



Shoreline Mapping - Duwamish



Marine Nearshore



Shoreline Armoring

Unarmored

Armored

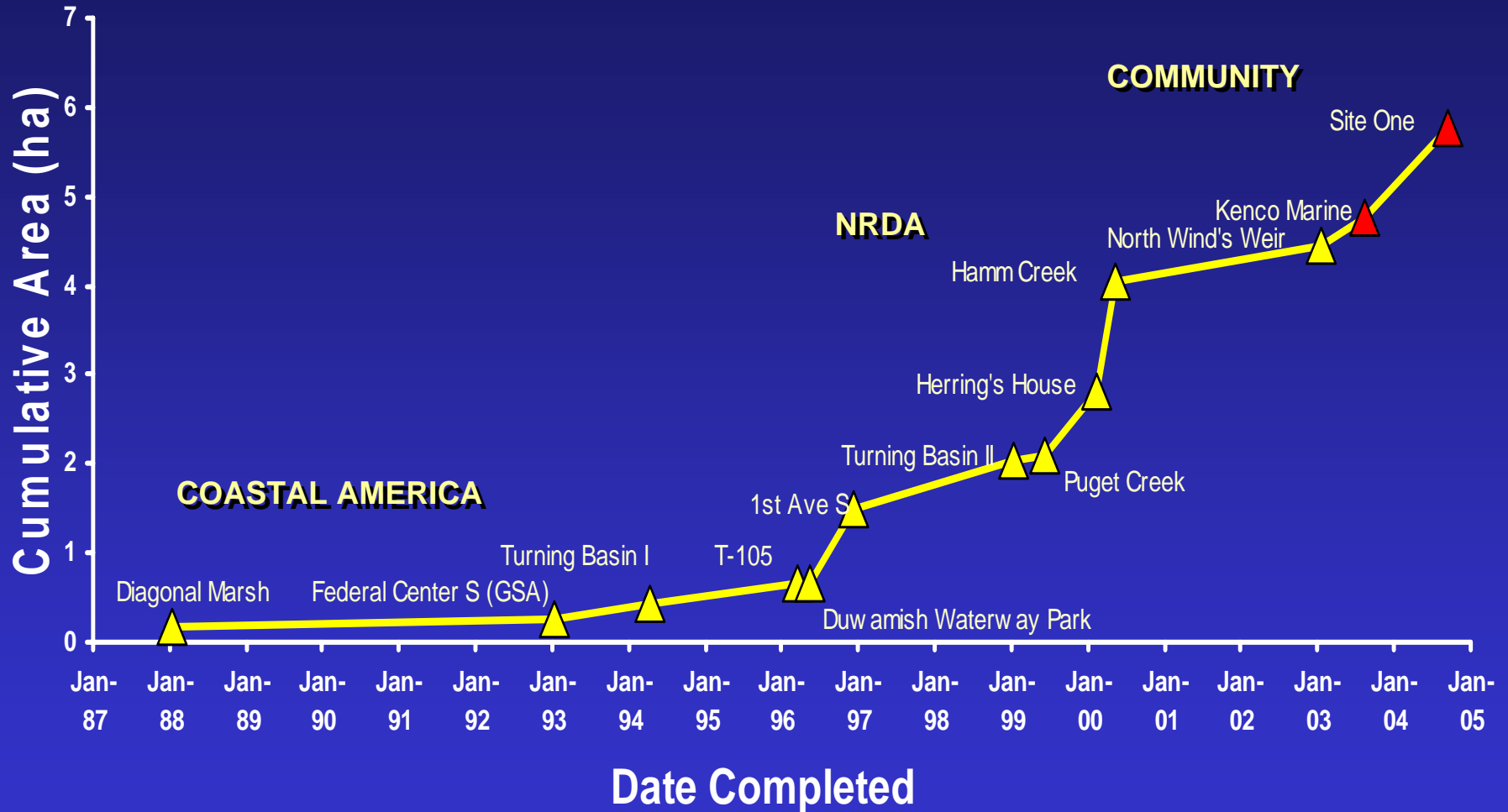
Waterbody

Cities



2 0 2 4 Miles

DUWAMISH RIVER ESTUARY RESTORATION SINCE 1988



COMPLETE AND ANTICIPATED DUWAMISH RIVER ESTUARY PROJECTS



Study design – “natural” vs. modified



vs.



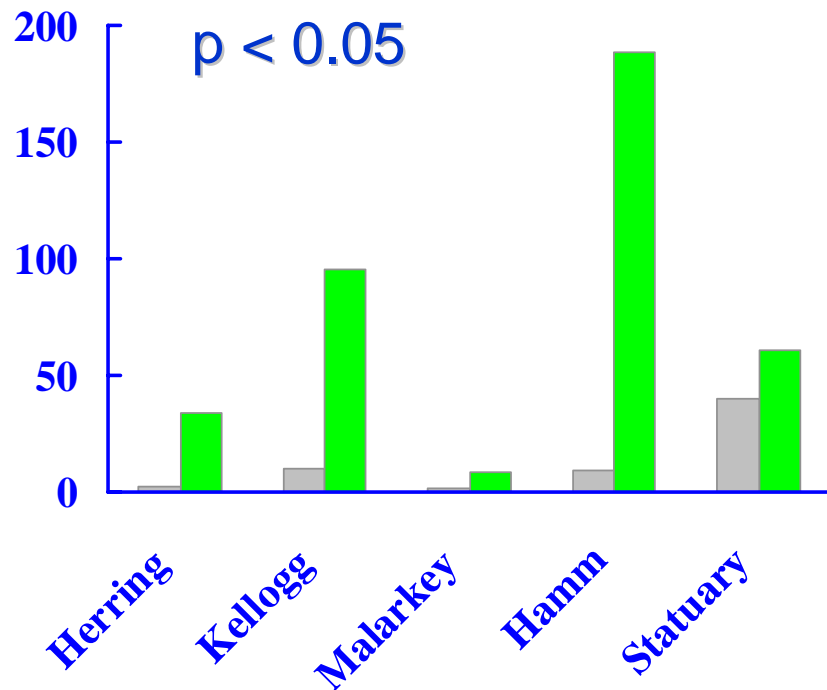
“vegetated”

“riprap”

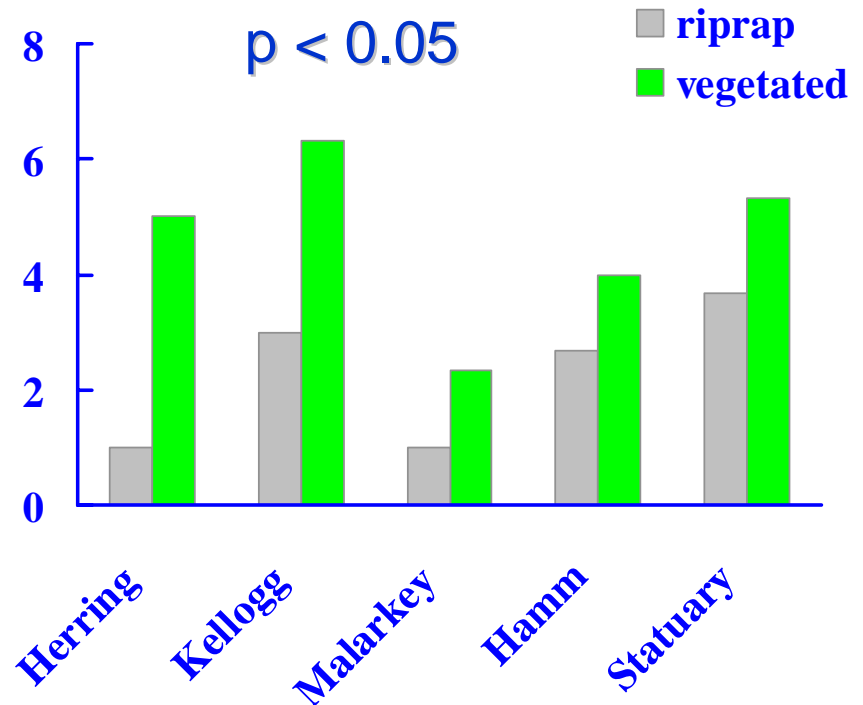
Q: How do isolated patches of “natural” nearshore habitat differ from extensively modified reaches?

Preliminary results – beach seining 2004

mean fish abundance



mean fish taxa richness



paired t-test, 2-sided, $n = 5$



Main Objective:

Quantify the abundance and behavior of juvenile salmonids and other fishes directly along marine shoreline habitat types.



Sampling Techniques

Typical beach seines can be problematic



...better for quantifying directly along shore



Enclosure Nets



Snorkel Surveys



Sampling Methods: High tides 5/12 - 8/1/03

Spring Tides: Enclosure nets and snorkeling - sand, cobble, riprap

Neap Tides: Snorkeling - all sites

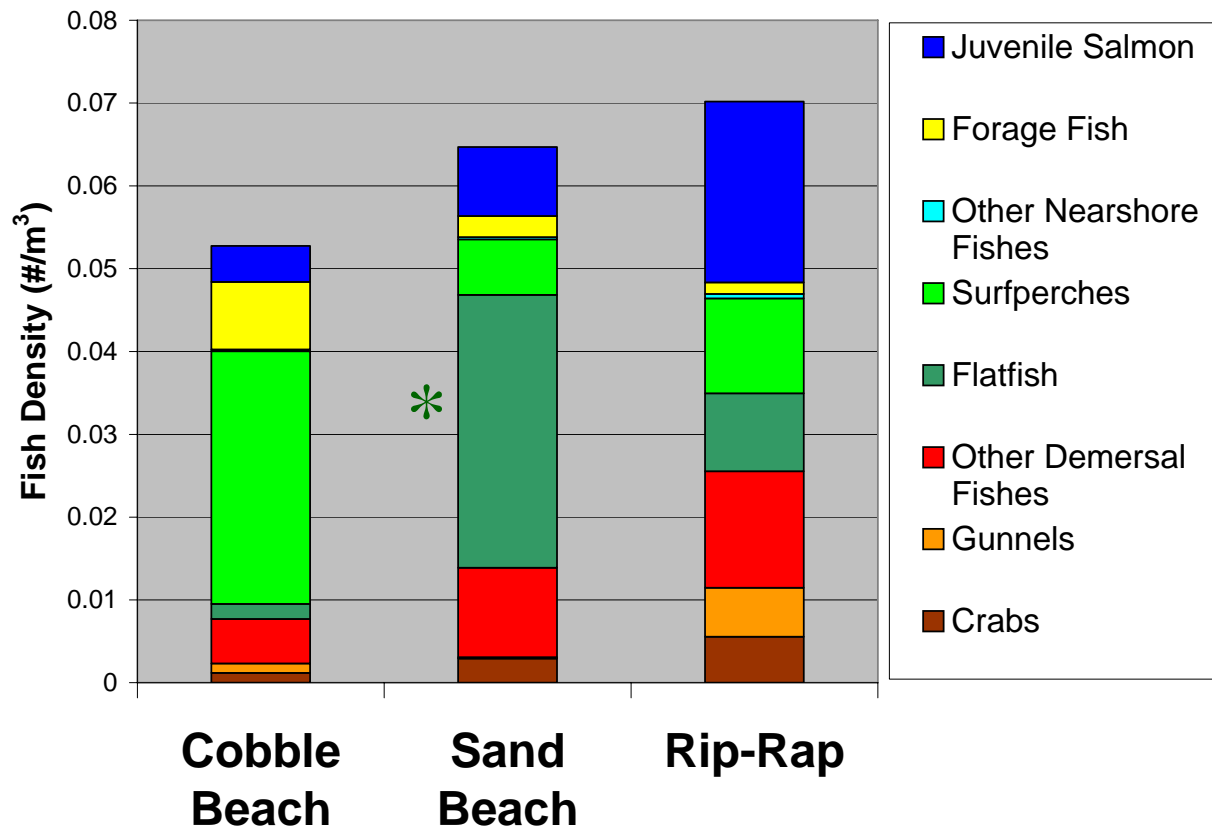


Fish Densities:

Between cobble beaches, sand beaches, and rip-rap that ends at the high intertidal, we see minimal differences - all in bottom fishes.



Enclosure Nets: ↑ Flatfish (juv. English Sole) at Sand Beaches



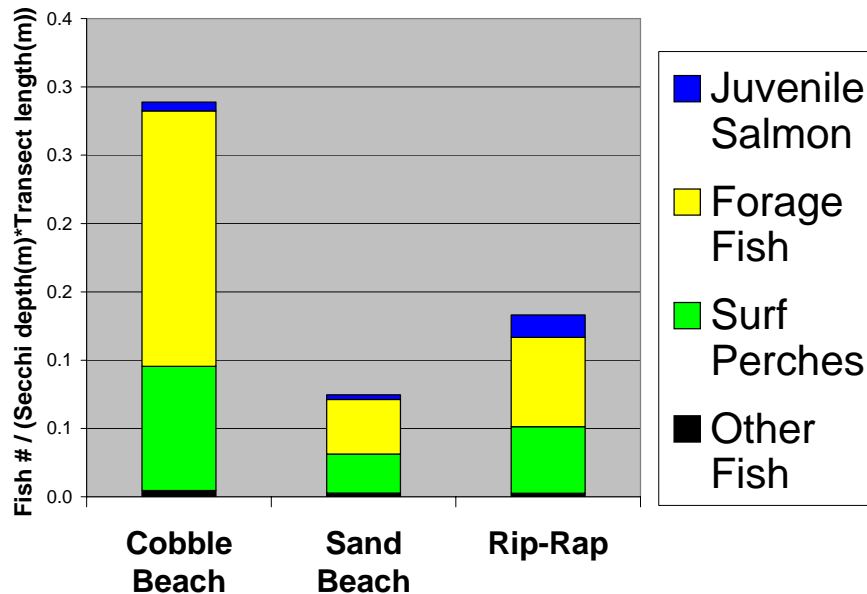
Fish Densities:

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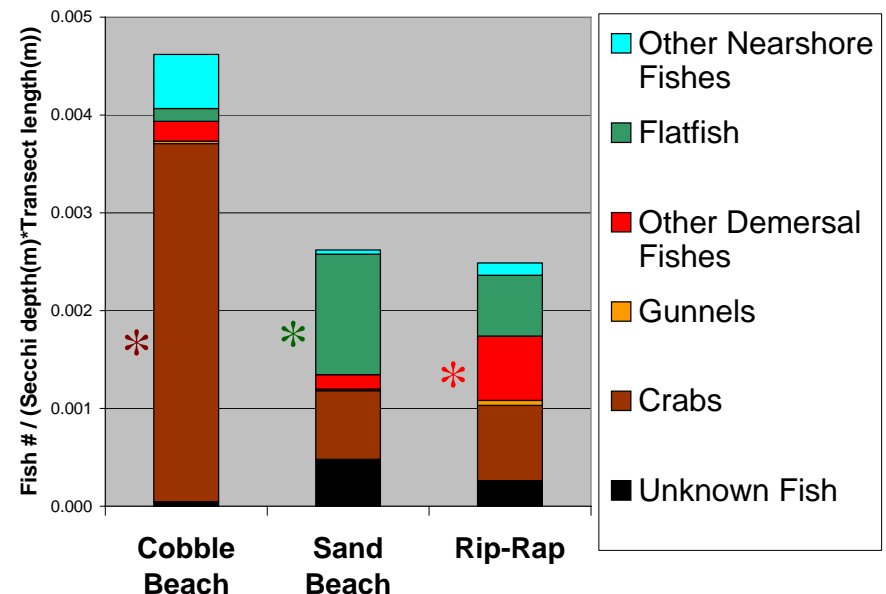


Snorkeling: ↑ Crabs at Cobble Beaches, ↑ Sculpins at Rip-Rap

Abundant Fish



Less Abundant Fish



Fish Densities:

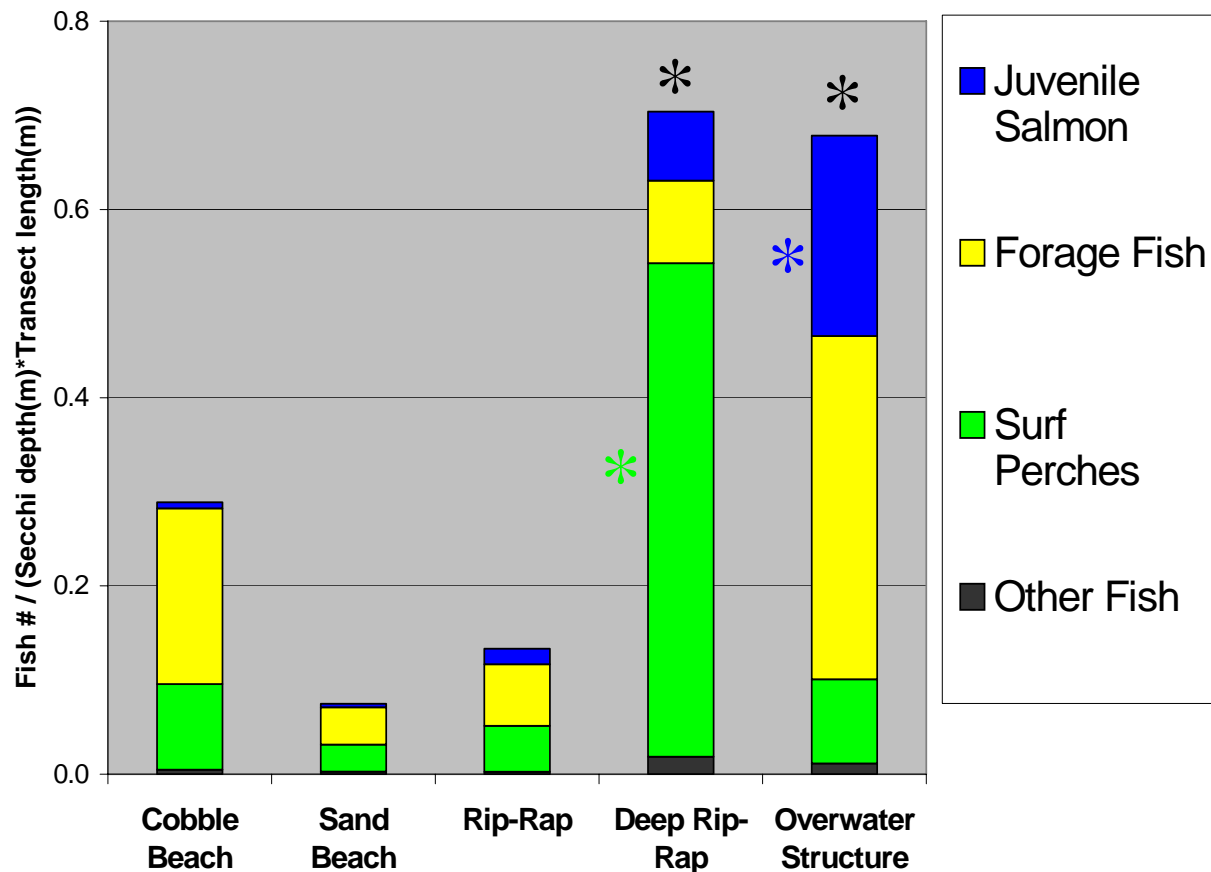
When shoreline modifications extend into the subtidal, we see more differences - in pelagic fishes.



Snorkeling: ↑ Overall at Overwater and Deep Rip-Rap,
↑ Juvenile Salmonids at Overwater, ↑ Surfperches at Deep Rip-Rap



Abundant Fish



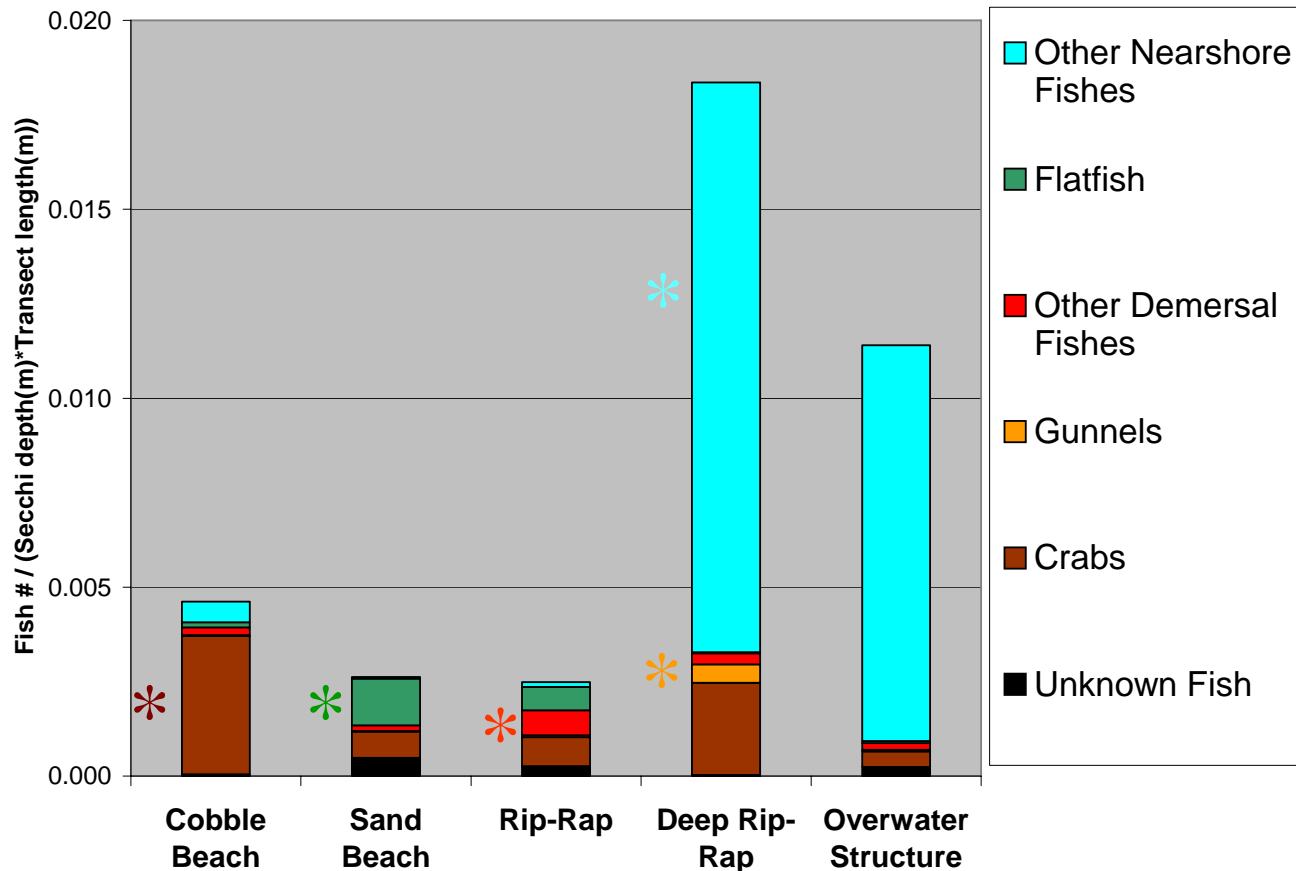
Fish Densities:

When shoreline modifications extend into the subtidal, we see more differences - in pelagic fishes.

Snorkeling: ↑ Other Nearshore Fishes and Gunnels at Deep Rip-Rap



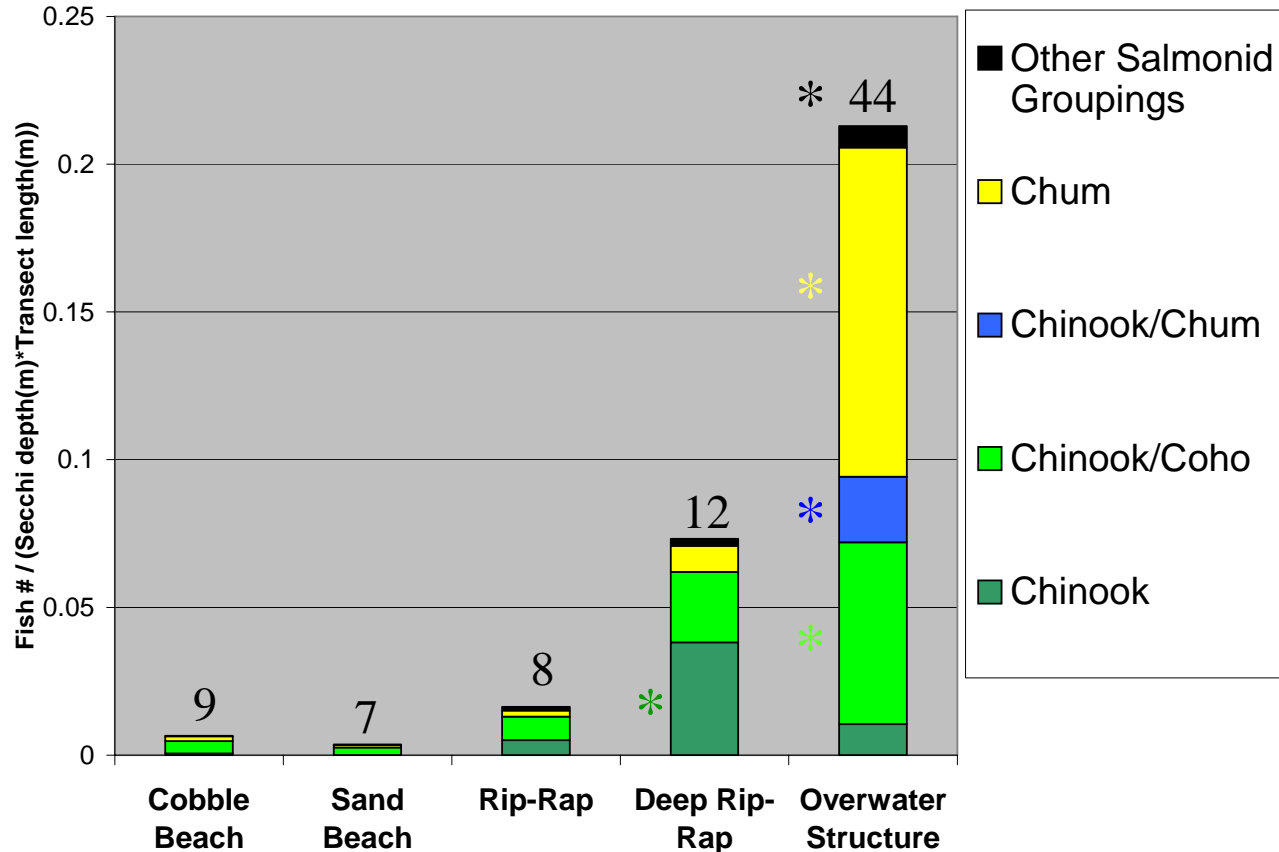
Less Abundant Fish



Salmon Densities and School Sizes:

When shoreline modifications extend into the subtidal, we see differences in juvenile salmonids.

Snorkeling: ↑ Juvenile Salmonid species groupings at Overwater and Deep Rip-Rap, also greater school sizes at Overwater (numbers above bars)



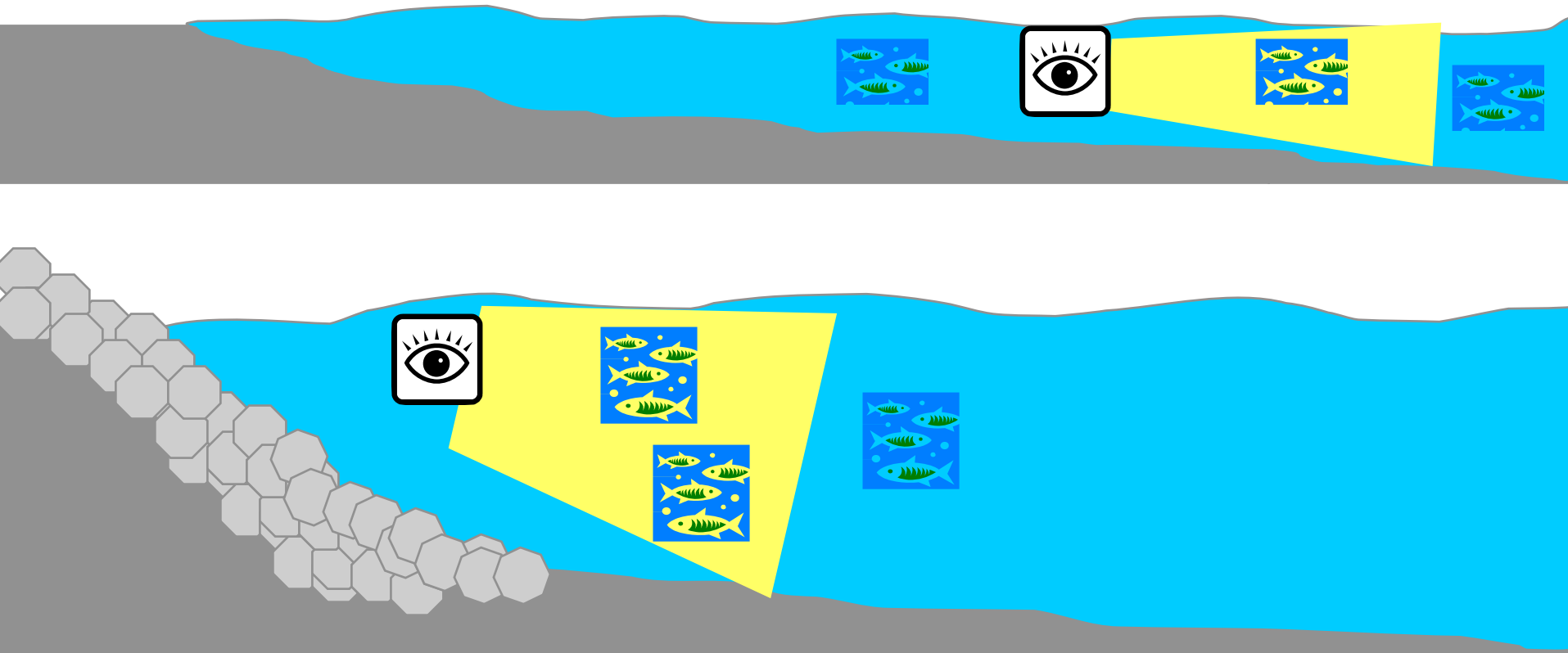
Fish Location:

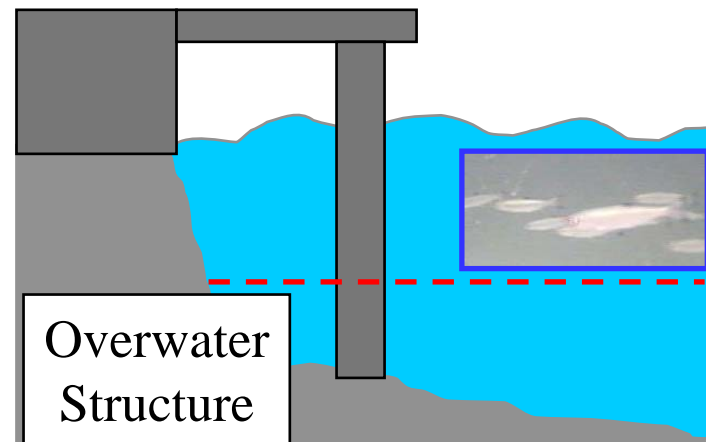
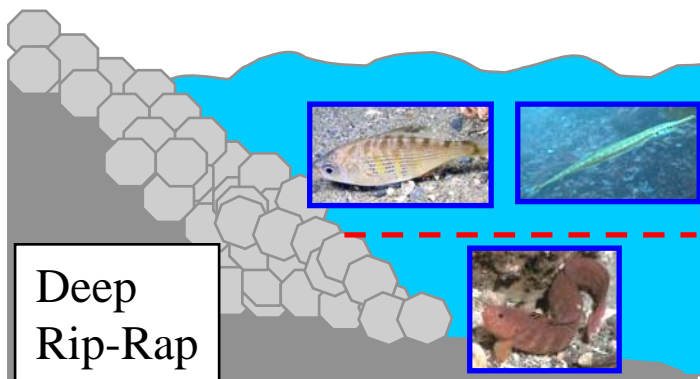
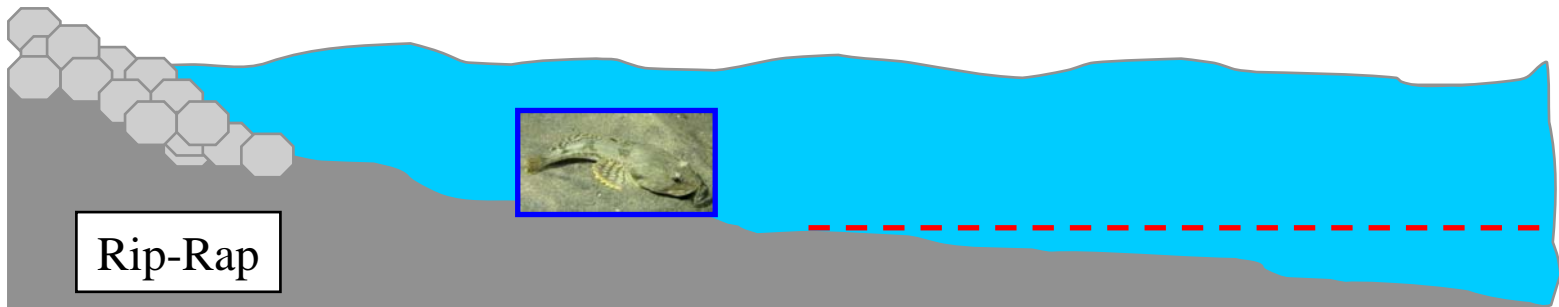
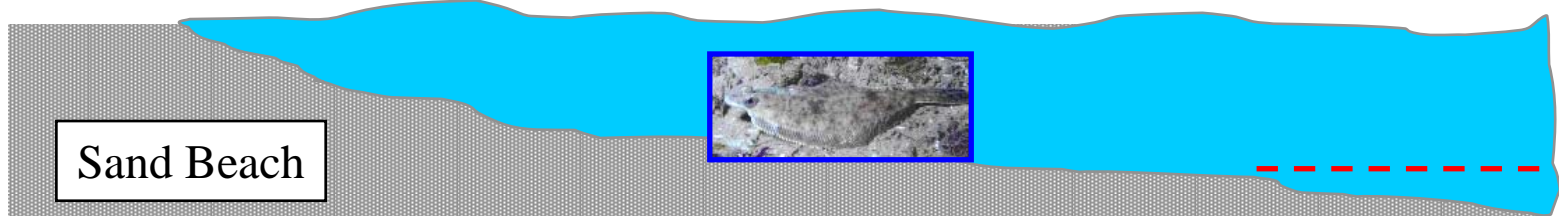
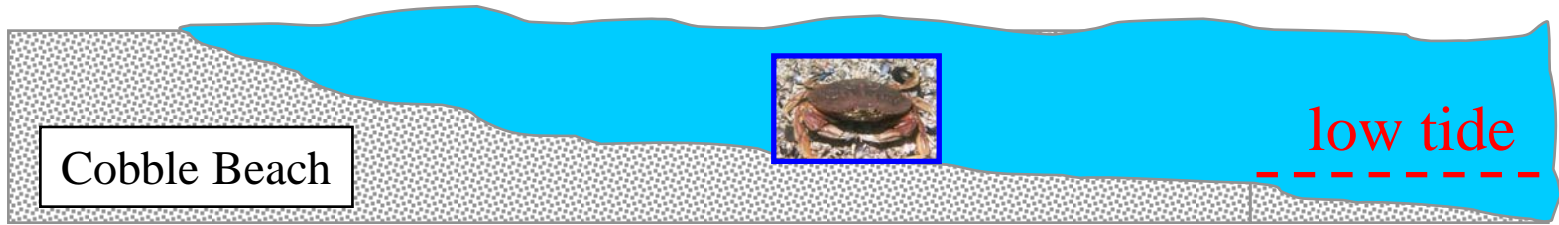
**Juvenile salmonids found 70% > 1m away from edge,
or 30% at edge, rare underneath Overwater Structures.**



Habitat Measurements:

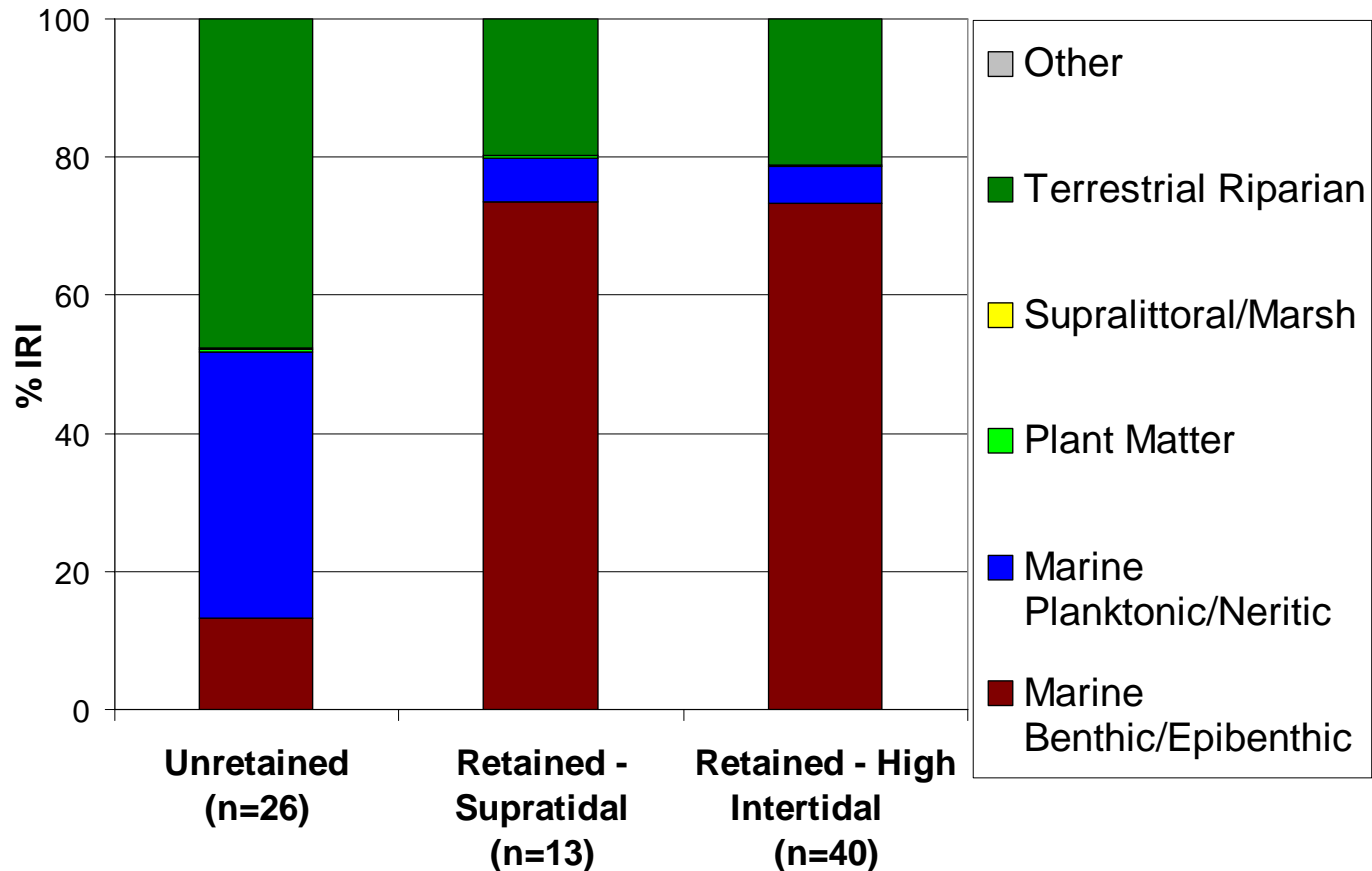
Shoreline modifications truncate the shallow water zone, gradual slope is lost. Pelagic fish that are typically spread-out along a large area may be forced to inhabit deep water directly along shore.





Diet Analysis:

Gastric lavage of juvenile chinook shows less terrestrial/riparian input (insects) at sites with retaining structures at intertidal or supratidal.



Common Juvenile Chinook Prey Items:



INSECTS: Chironomidae



Amphipods, *Corophium* sp.



Worms: Polychaete

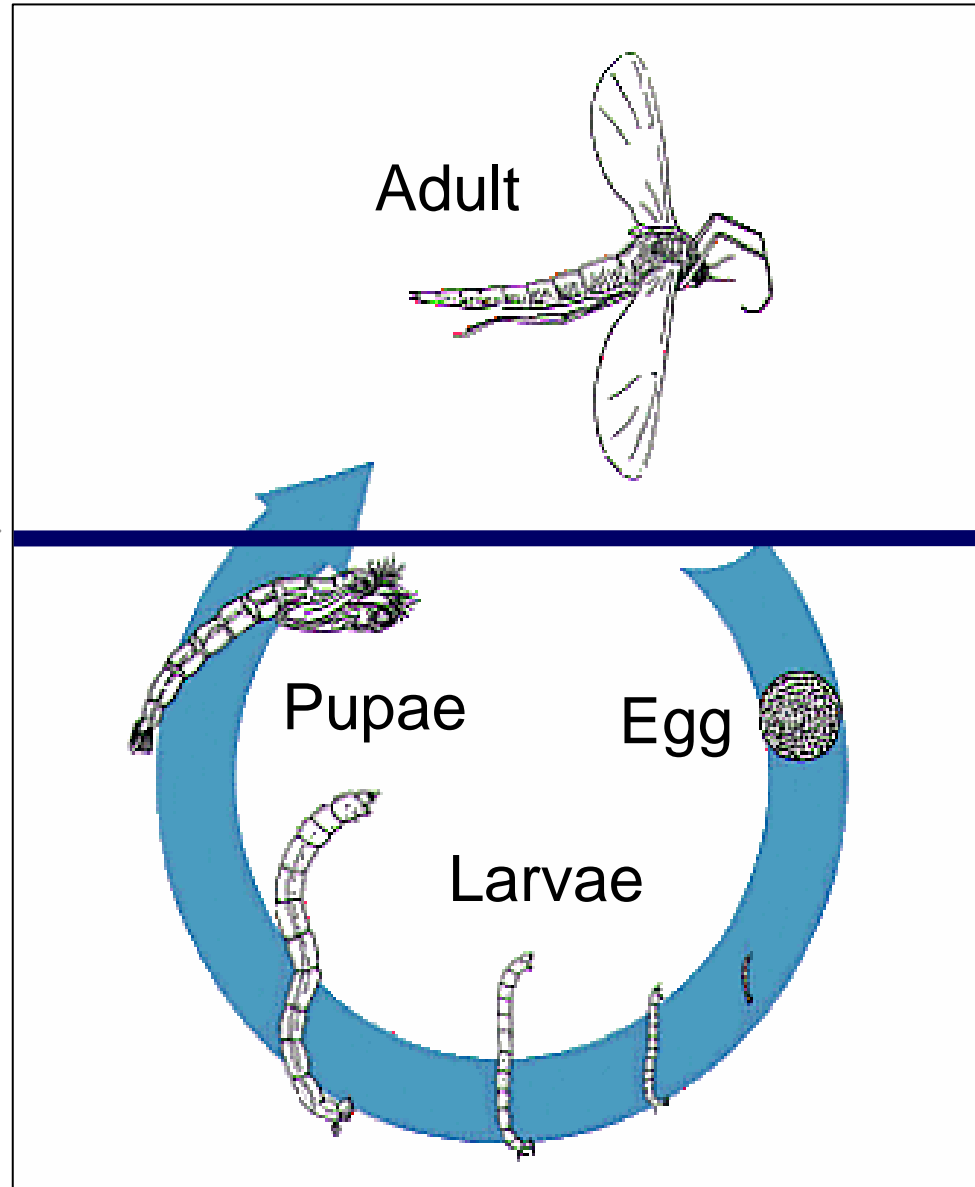


Crustacea: Crab larvae

Chironomid Life Cycle

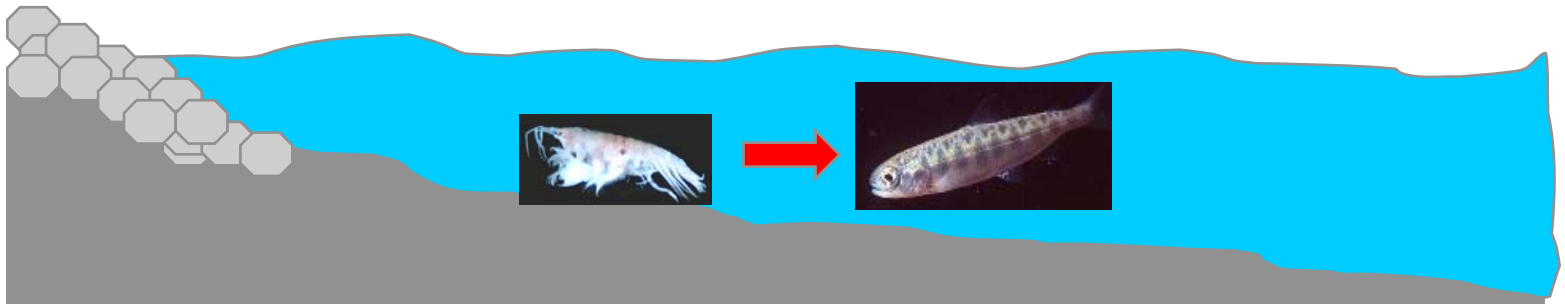
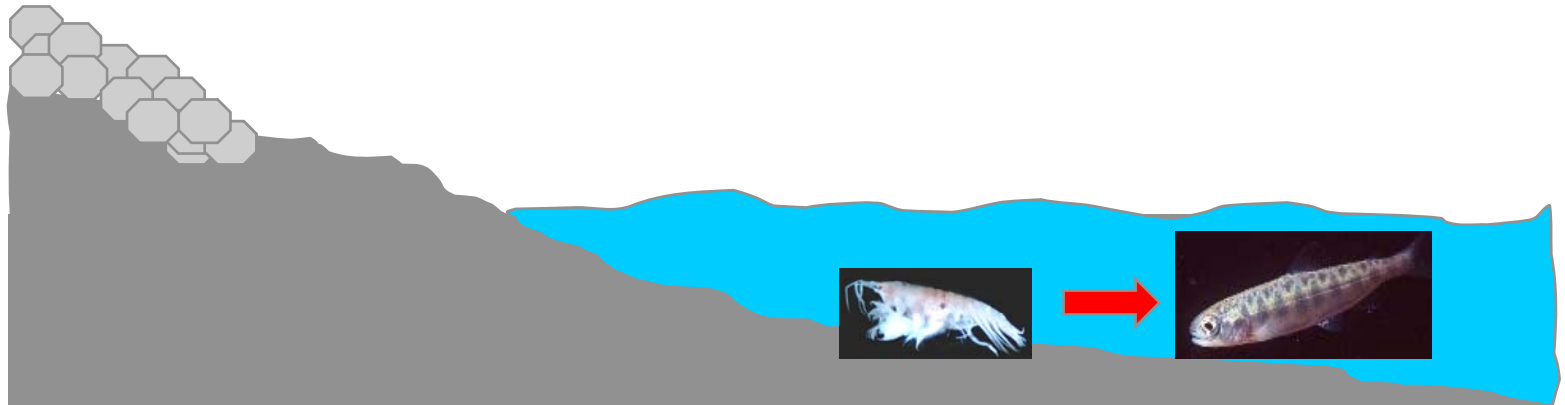
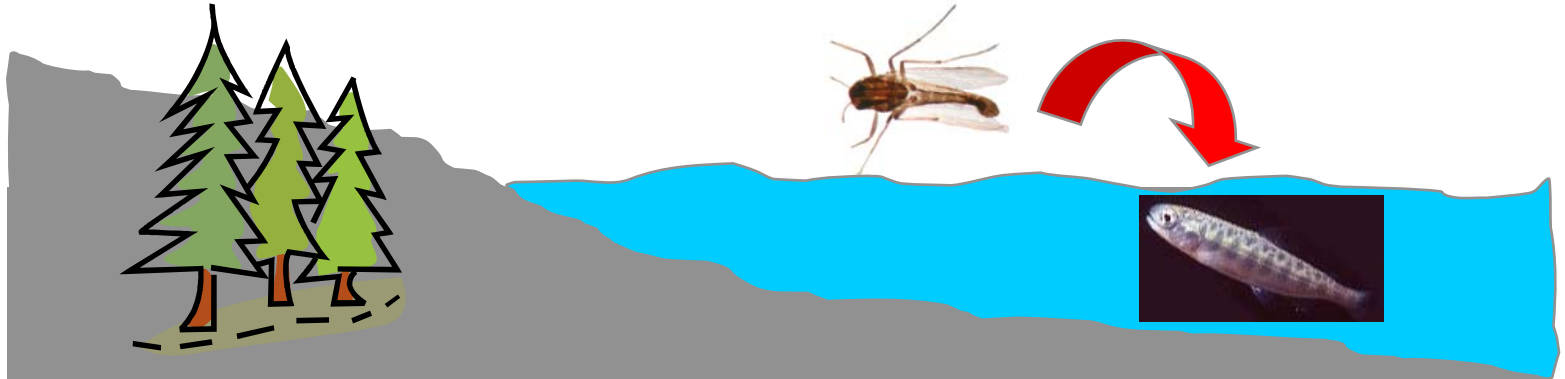
*** Aquatic/Terrestrial Interface ***

Chinook
Feeding



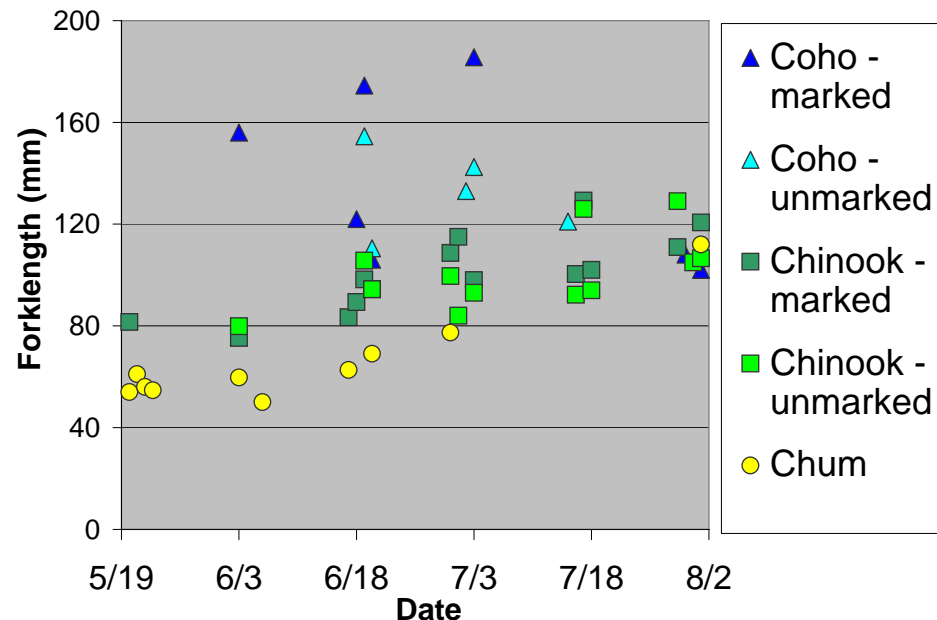
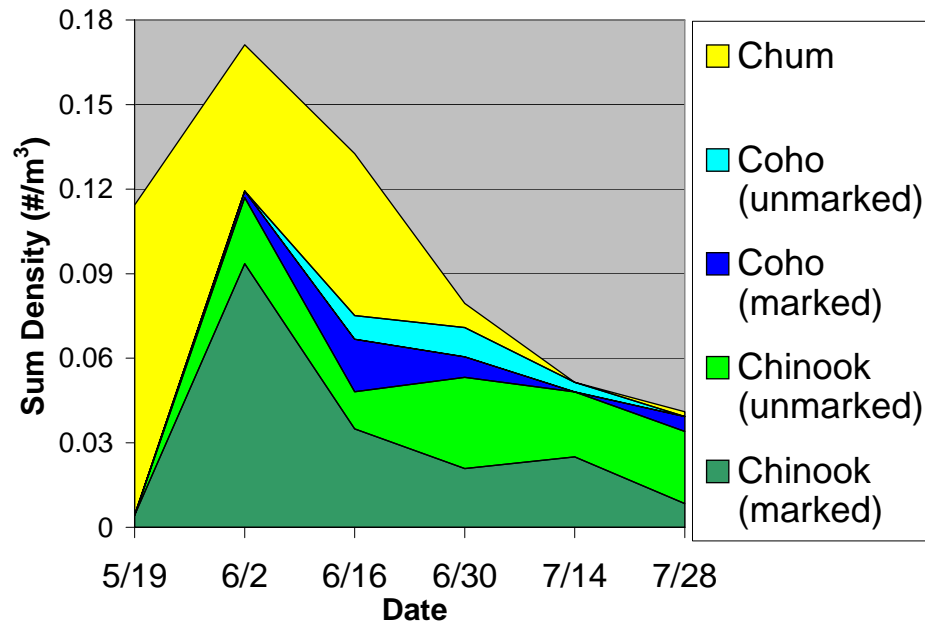
Prey Resources:

Unretained shorelines have a greater input of terrestrial insects into the diets of juvenile chinook salmon.



Timing and Size:

- As compared to Lake Washington: juvenile chinook avoid armored banks.
- Juvenile chinook are larger and more pelagic in marine waters, less dependent on shallow water.
- Differences are related more to indirect rather than direct effects of shoreline modifications, such as changes in water depth, substrate, and shoreline vegetation.



Seahurst Park: Just completed!



Remove Rip-Rap and restore intertidal zone,
with linkages to riparian habitat

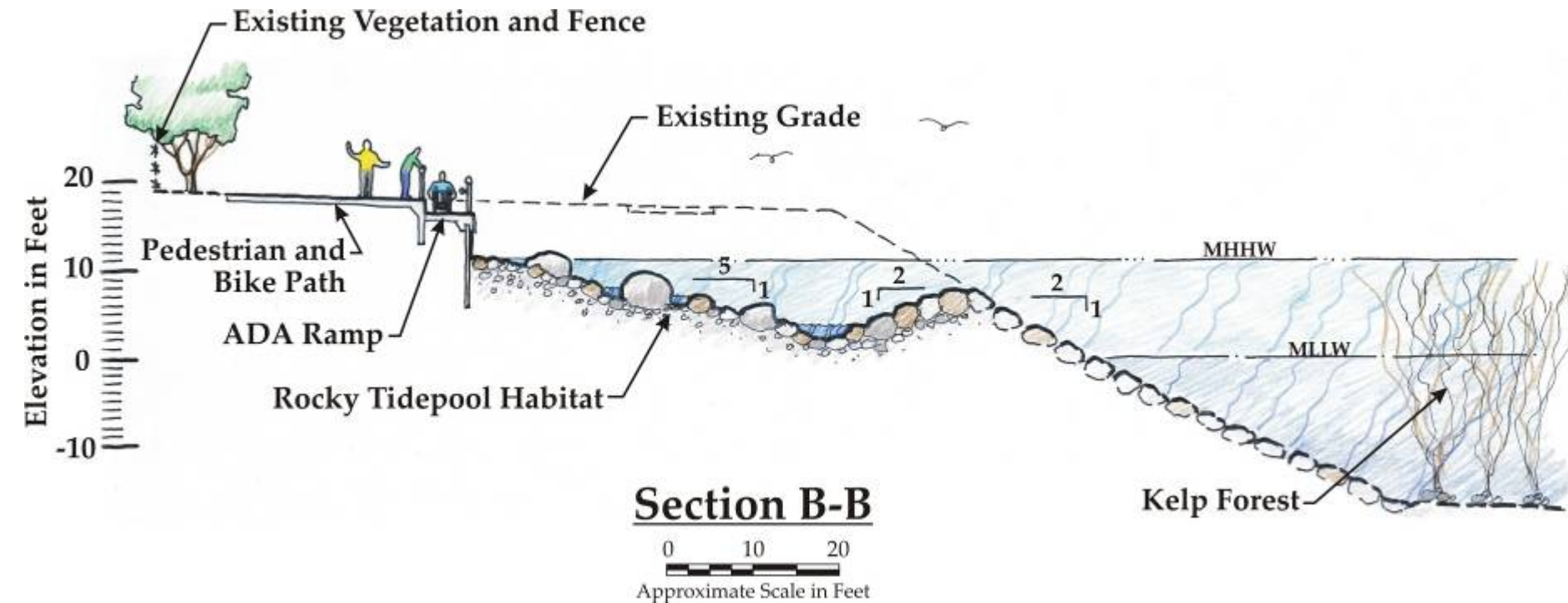
Olympic Sculpture Park: Planned to start this year



Create intertidal and
linkages to riparian habitat



Olympic Sculpture Park: Planned to start this year



Future Seawall Repair:

- **Replace degraded planks, Gribbles!**
- **Opportunity to incorporate better materials and designs to improve habitat.**

Seattle Waterfront Falling to Gribble Invasion

John Roach

for National Geographic News

April 23, 2004

Flea-sized crustaceans with seven sets of legs, four moving mouth parts, and a voracious appetite for wood-borne bacteria could cause the edge of downtown Seattle, Washington, to slip into the Puget Sound.

