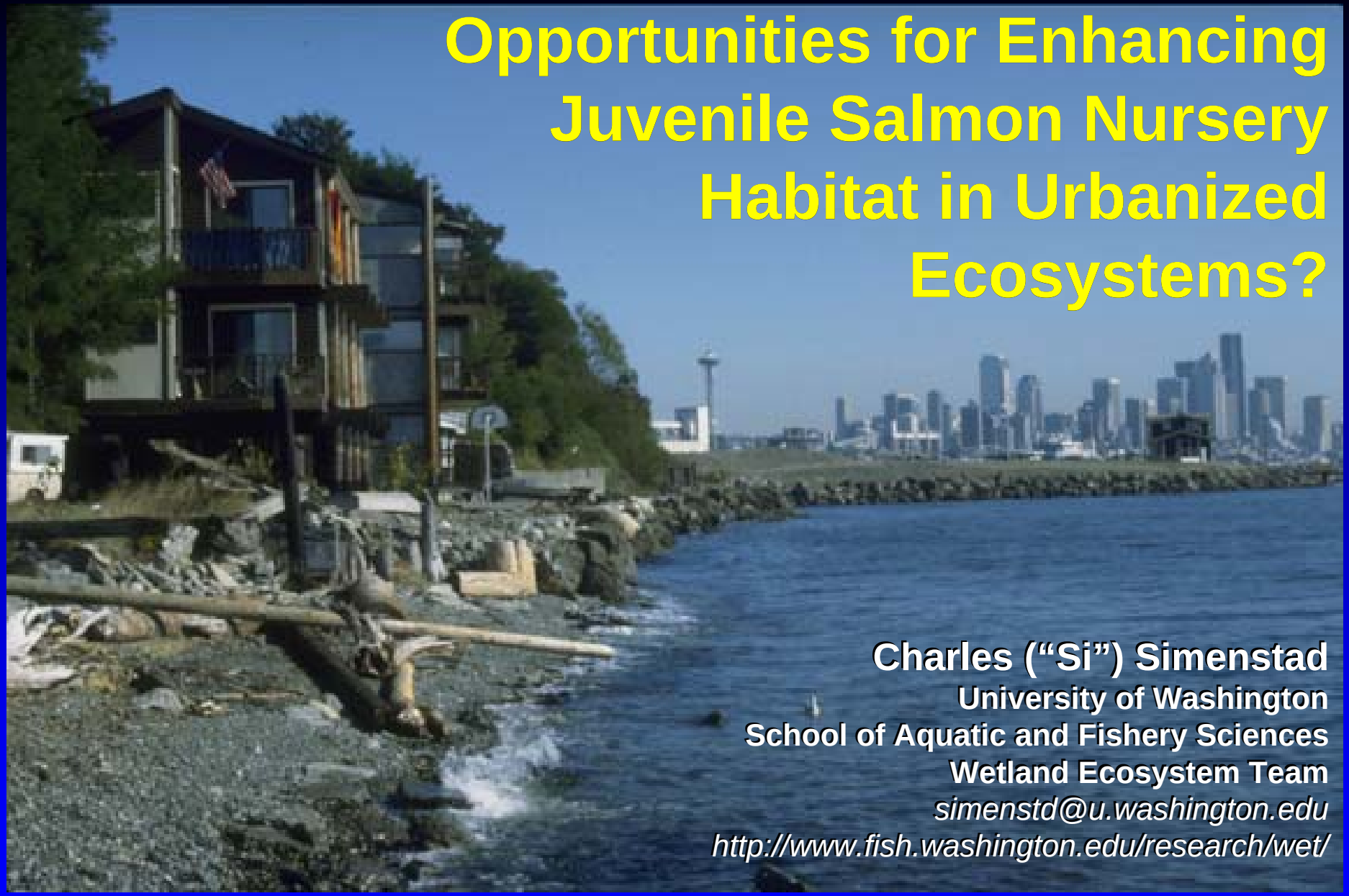
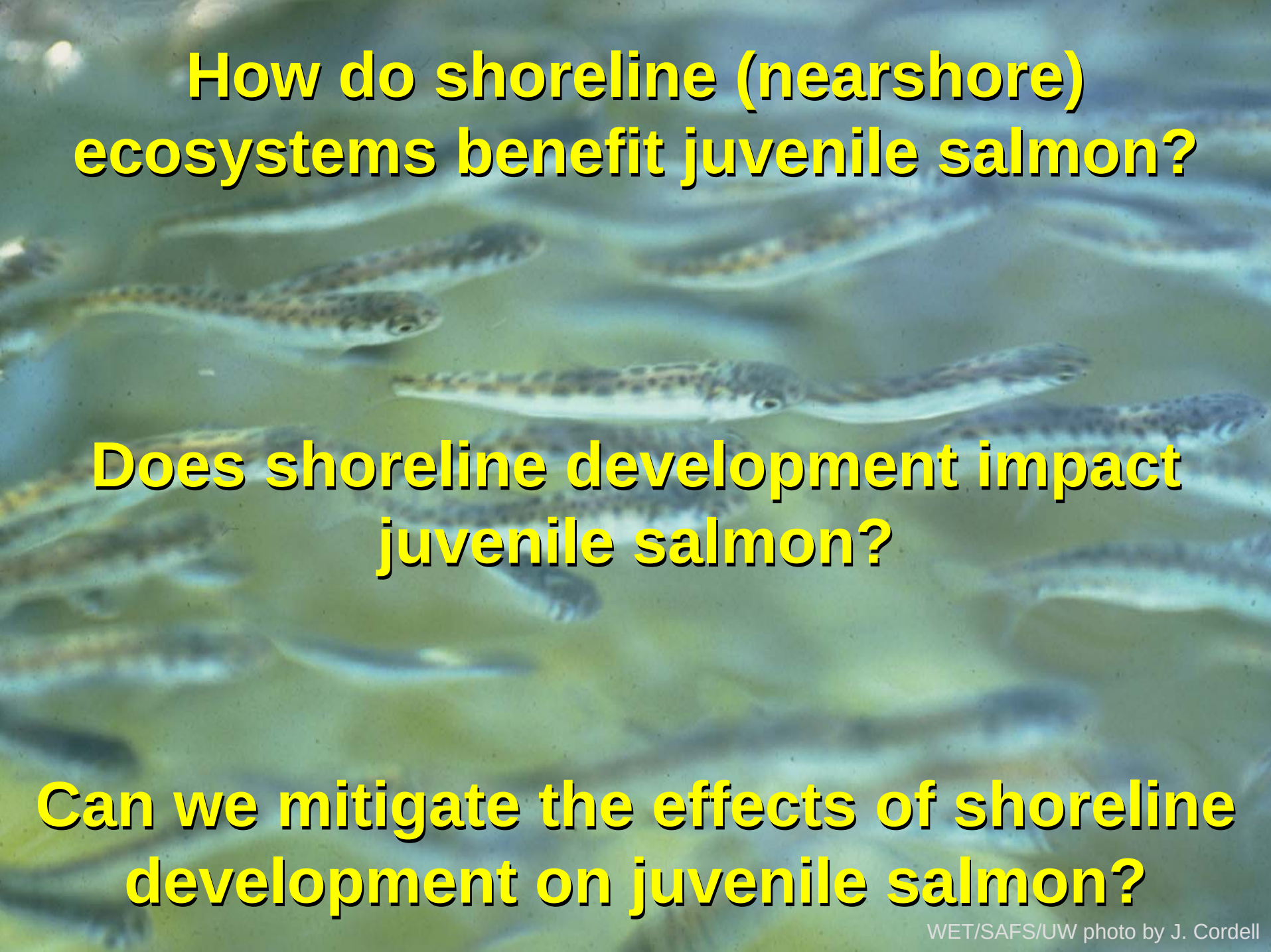
Opportunities for Enhancing Juvenile Salmon Nursery Habitat in Urbanized Ecosystems?



Charles ("Si") Simenstad
University of Washington
School of Aquatic and Fishery Sciences
Wetland Ecosystem Team
simenstd@u.washington.edu
http://www.fish.washington.edu/research/wet/

WET/SAFS/UW photo by C. Simenstad

wetland ECOSYSTEM TEAM
UNIVERSITY OF WASHINGTON AQUATIC & FISHERY SCIENCES



WET/SAFS/UW photo by J. Cordell

ROLE OF ESTUARIES IN SALMON EARLY LIFE HISTORY = "nursery function"?

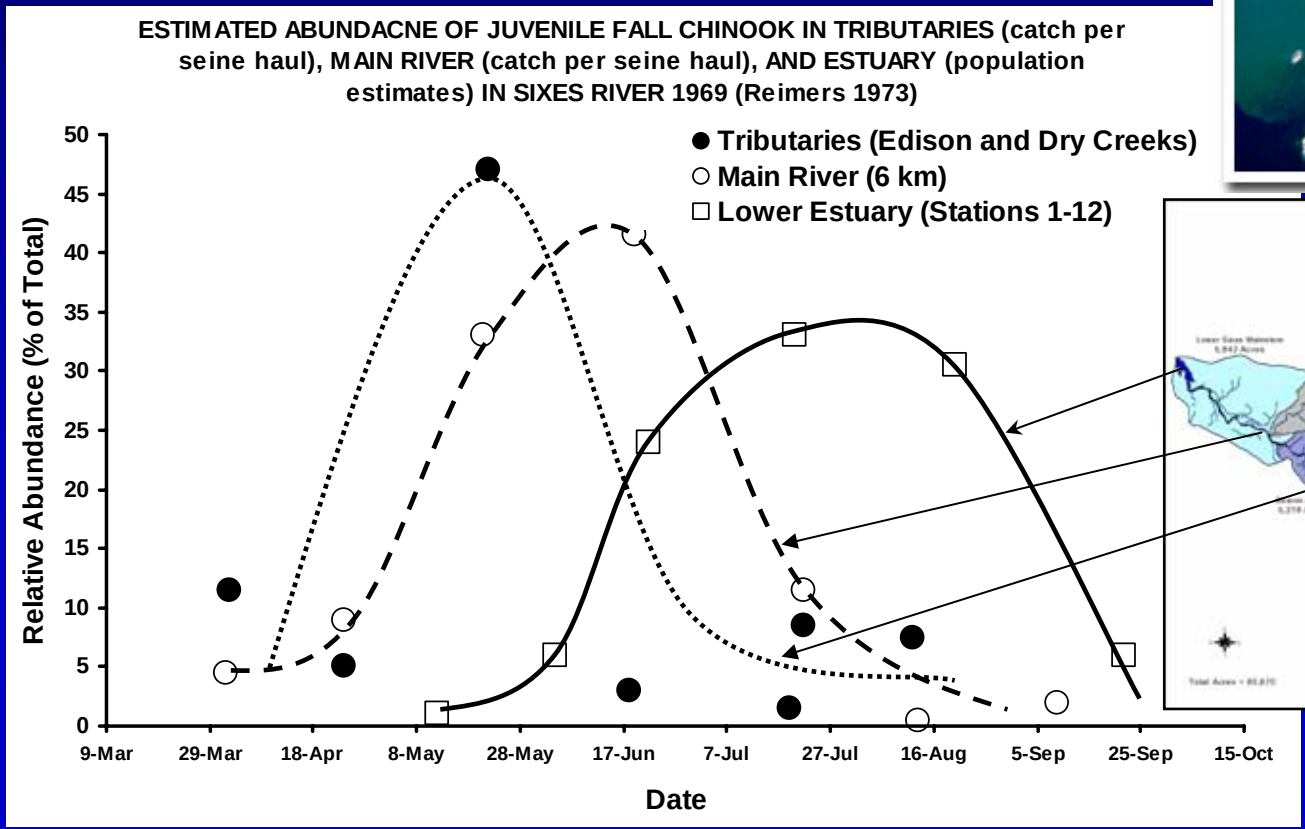
- Juveniles of "ocean-type" salmon, rather than "stream-type" and typical hatchery races, e.g., are the most estuarine dependent on habitat integrity (and frequently in jeopardy?)
- Physiological transition during migration
- Significant shift in feeding and predation regimes
- Site of rapid growth
- Buffer freshwater rearing during extreme events

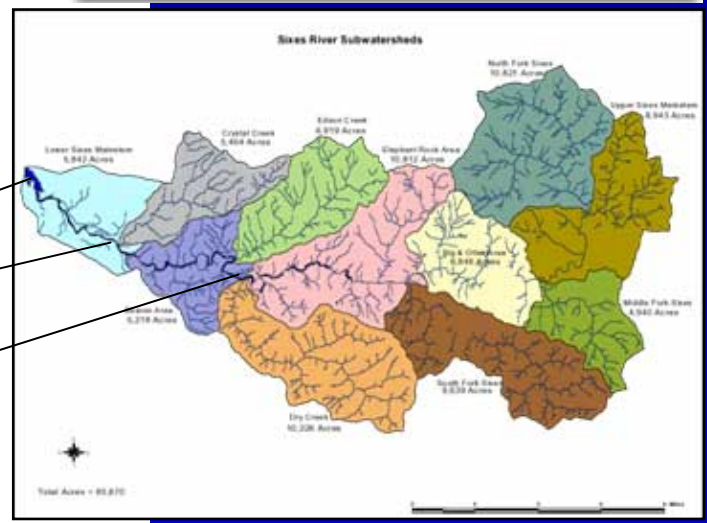
FOR PACIFIC SALMON,
LIFE IS JUST A CONTIMUUM OF BOTTLENECKS!

Species-LH Type	*Freshwater Residence*	*Downstream Migration*	*Estuarine Residence*	*Estuary-Ocean Transition*	*Ocean Residence*	*Possible Life History Types*
PINK	Virtually none	Immediate & rapid, as fry	Short; ~2 weeks	Rapid	Fixed; 2 years	1
CHUM	Virtually none	Immediate, as fry	Short-moderate, 2-3 weeks	Rapid	Variable; 1-5 years	10
SOCKEYE-lake type	Extensive, 1-3 years in lakes	Relatively rapid, as smolts; I-2 weeks	Short; few days	Highly variable	Variable; 1-3 years	9
-ocean type	Short	Rapid, as fry	Often extensive; 1 week-5 months	Unknown	Fixed; 1 years	1
COHO-stream type	Extensive; 1-4 years	Relatively rapid, as smolts; 1-2 weeks	Short; few days	Highly variable	Variable; 1-5 years	11
-ocean type	Virtually none	Rapid, as fry	Long? May involve protracted overwintering, and return upstream to rear?	Unknown?	Fixed; 1 year	1
CHINOOK-stream type	Variable; 1-2 years	Variable; few days to months	Short; few days	Highly variable	Variable; <1 to 6 years	>13
-ocean type	Variable; few days to months	Variable; rapid as fry, longer as fingerlings	Highly variable; days to 6 months	Highly variable; often prolonged	Variable; <1 to 6 years	36

(Simenstad and Fresh, unpubl.)

LIFE HISTORY TYPES OF JUVENILE CHINOOK SALMON FRESHWATER AND ESTUARINE REARING IN SIXES RIVER (Reimers 1973)





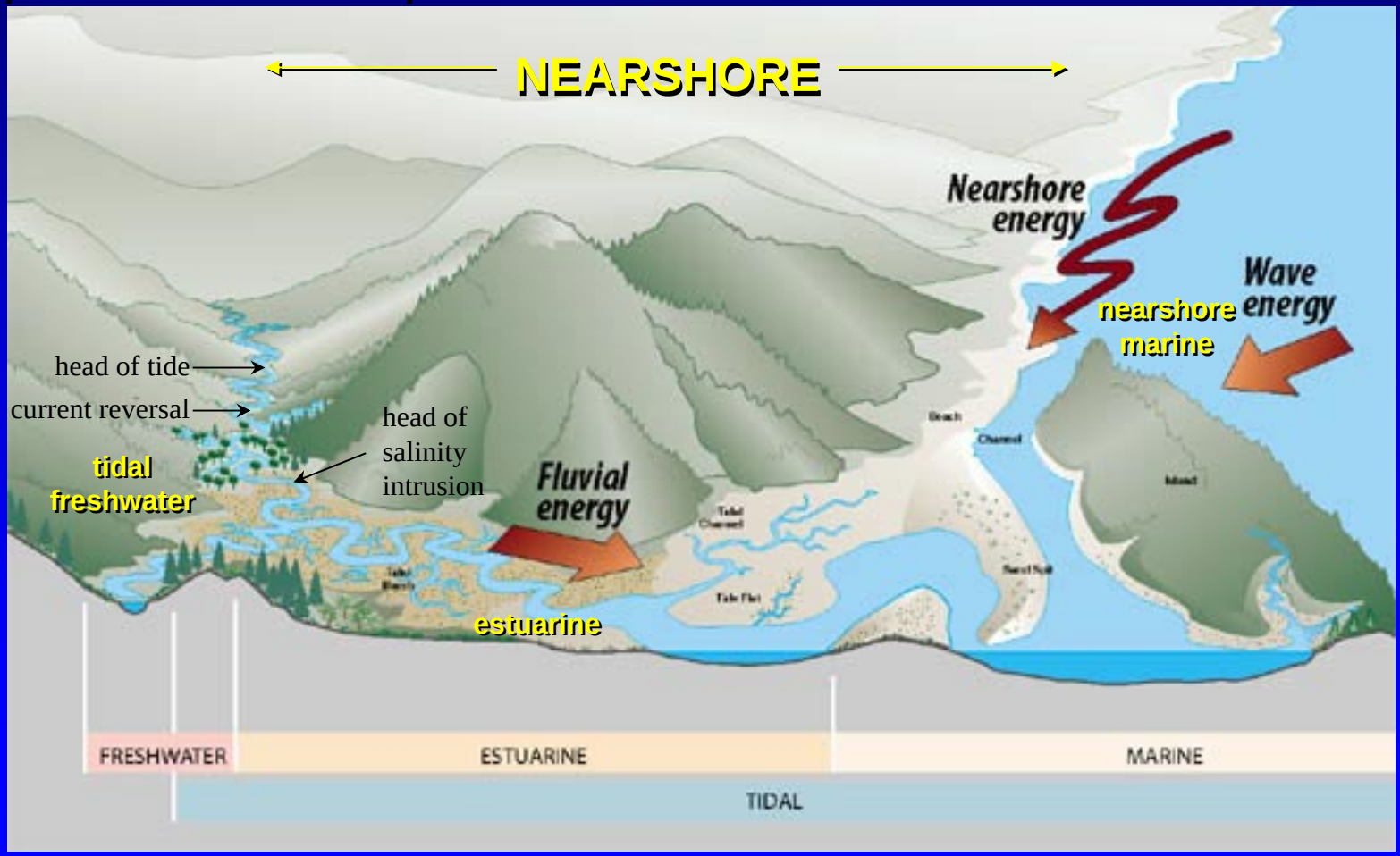
CONDITIONS OF THE NURSERY HABITAT CONCEPT

- "*The underlying premise of most studies that examine nursery-role concepts is that some nearshore, juvenile habitats contribute disproportionally to the production of individuals that recruit to adult populations*." (Beck *et al.* 2001)
- Support greater contributions to adult recruitment from any combination of four factors:
  - density
  - growth
  - survival of juveniles
  - movement to adult habitats
- Advantage/disadvantage of Beck et al. (2001) perspective:
  - focus on *mechanism* of contribution to recruitment
  - focus only on production

KNOWLEDGE NEEDS TO UNDERSTAND SCALE(S) AFFECTING HABITAT REQUIREMENTS

- resolution relevant to organism's interactions with landscape….what defines "habitat"?
- factors affecting spatial pattern:
  - life history/autecology (reproduction, dispersal)
  - disturbance
  - biological interactions (herbivory)
  - physiology (stressors, disease)
- scales of processes controlling spatial organization of landscape patterns
- MUST consider not only direct, but also indirect, habitat support

Definition: *downstream from the upstream limits of tidal influence of any river or stream entering Puget Sound, to the western limit of the Strait of Juan de Fuca, including those adjacent uplands that directly affect nearshore processes, and encompassing intertidal and subtidal areas, extending to the depth limits of the photic zone*



THE ESTUARINE-NEARSHORE CONTINUUM OF PHYSICS, CHEMISTRY AND ECOLOGY=MOSAIC

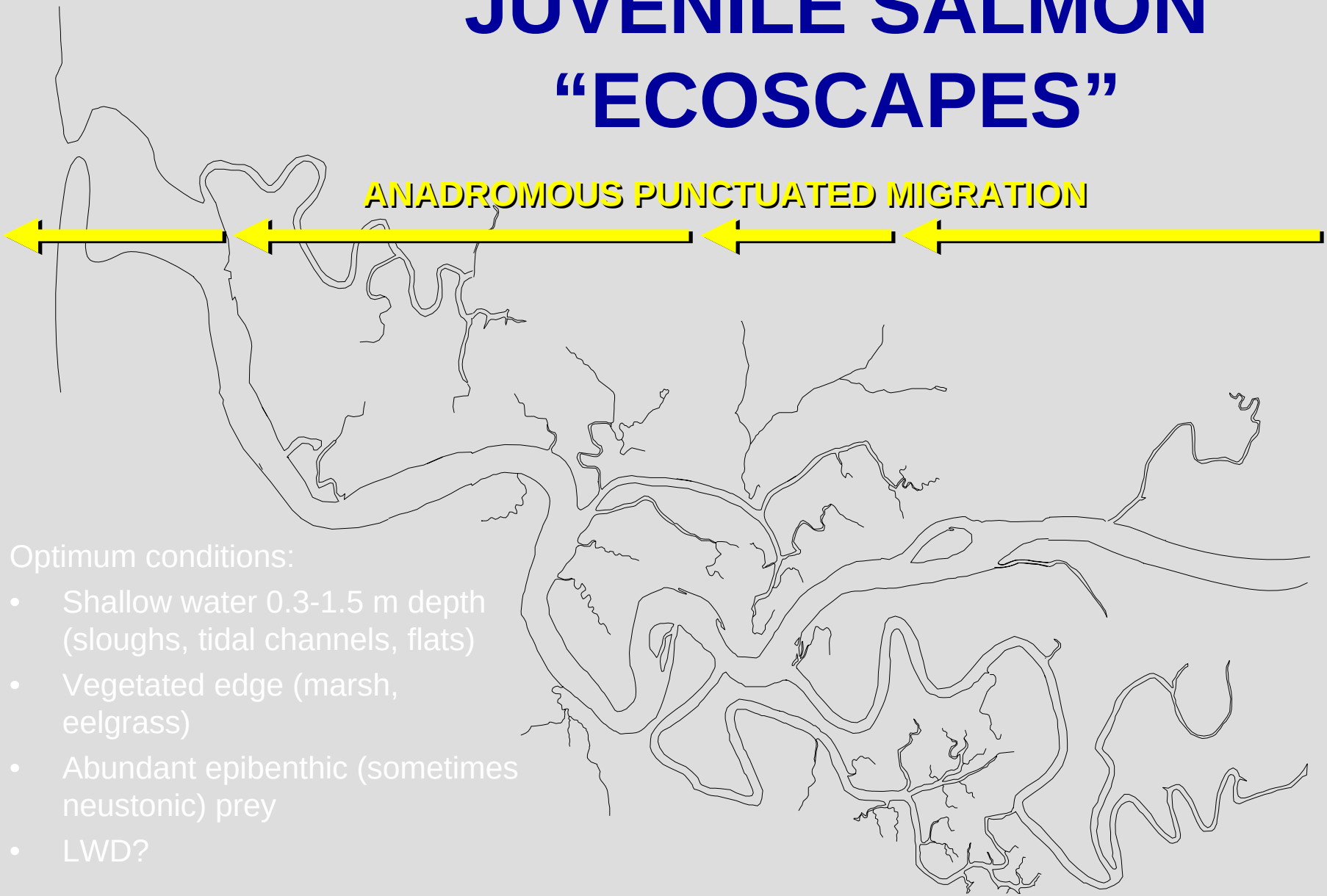









JUVENILE SALMON "ECOSCAPES"



Optimum conditions:

- Shallow water 0.3-1.5 m depth (sloughs, tidal channels, flats)
- Vegetated edge (marsh, eelgrass)
- Abundant epibenthic (sometimes neustonic) prey
- LWD?

euhaline-euryhaline brackish-oligohaline tidal-freshwater

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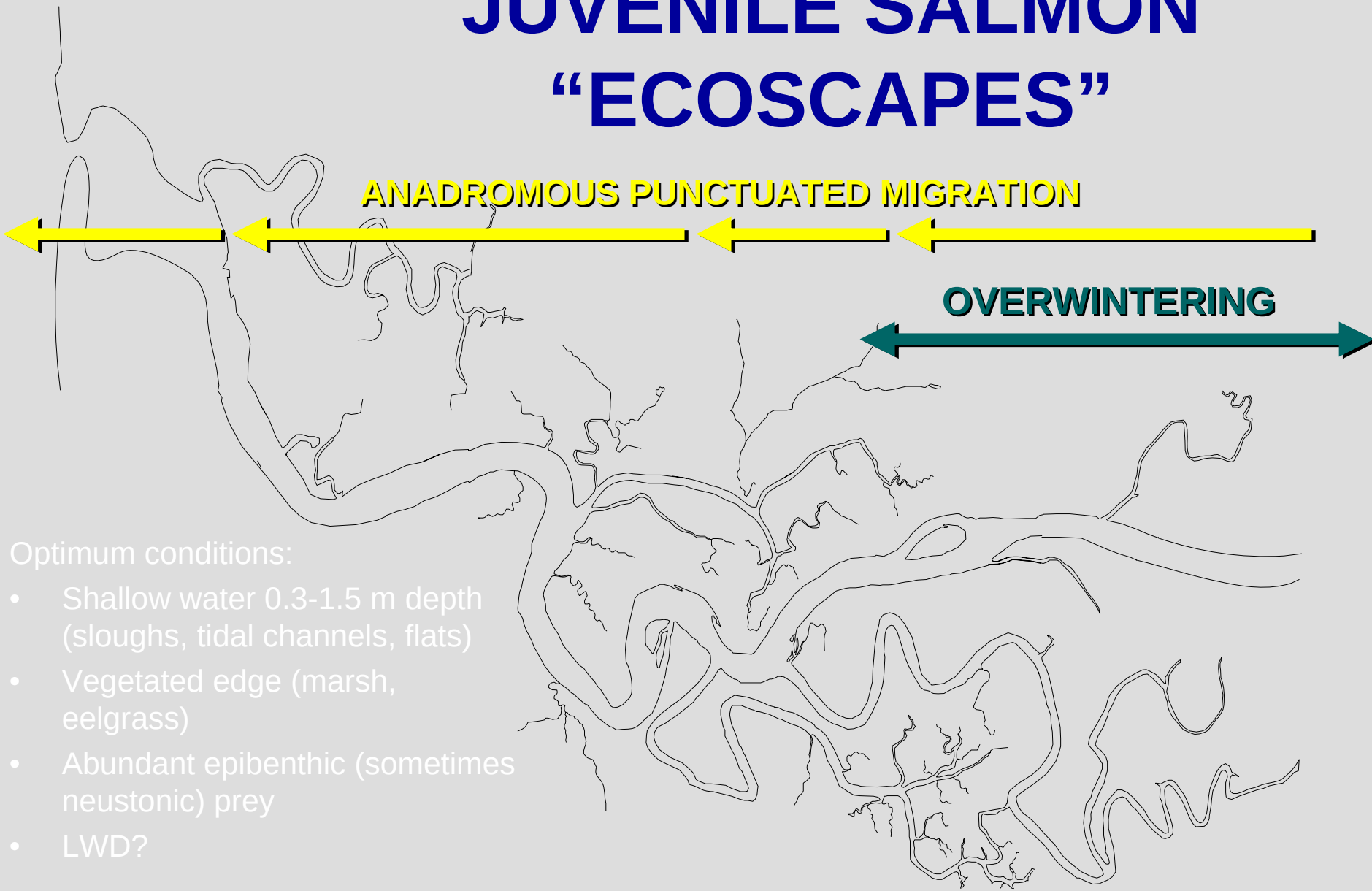

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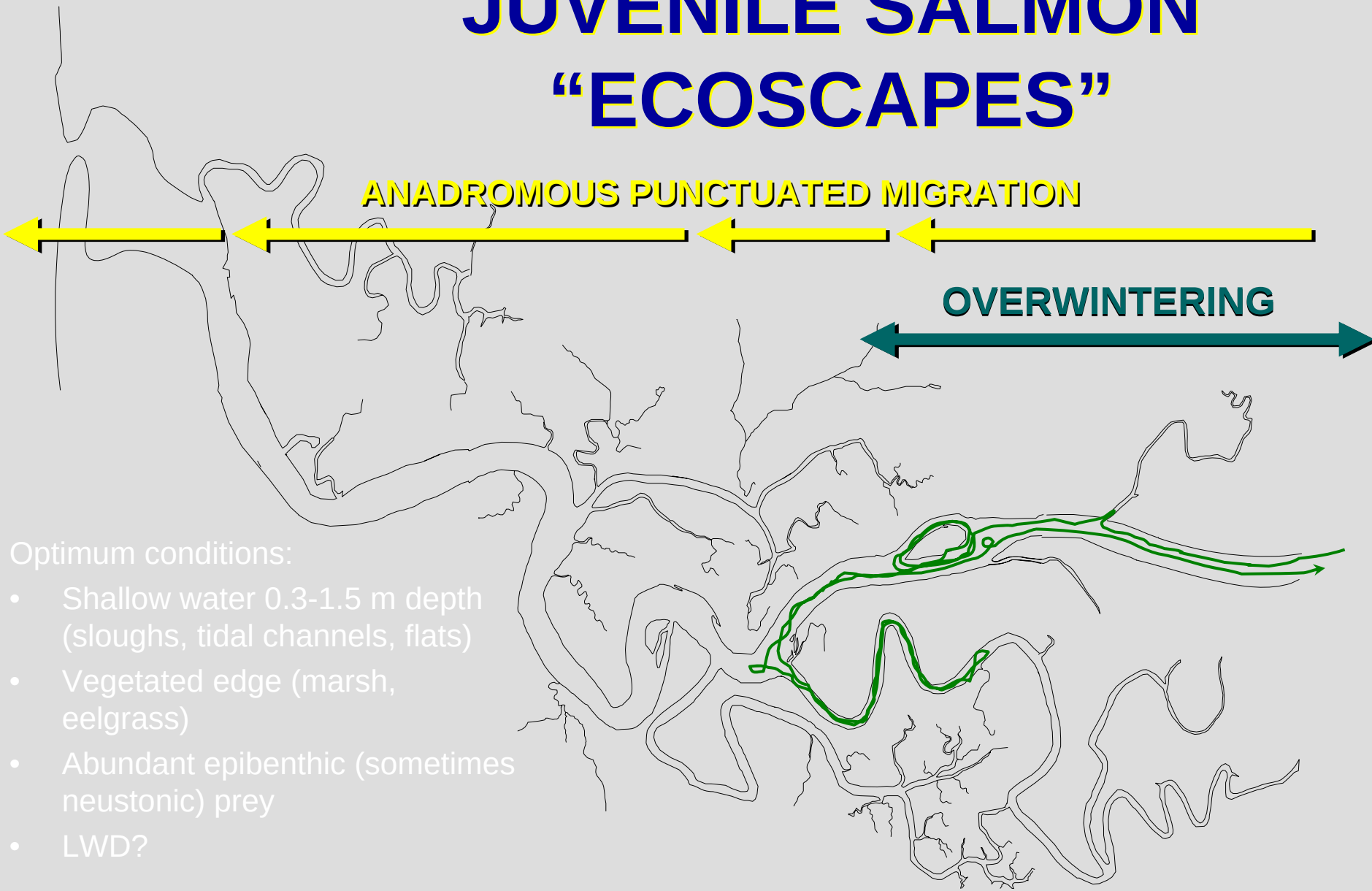

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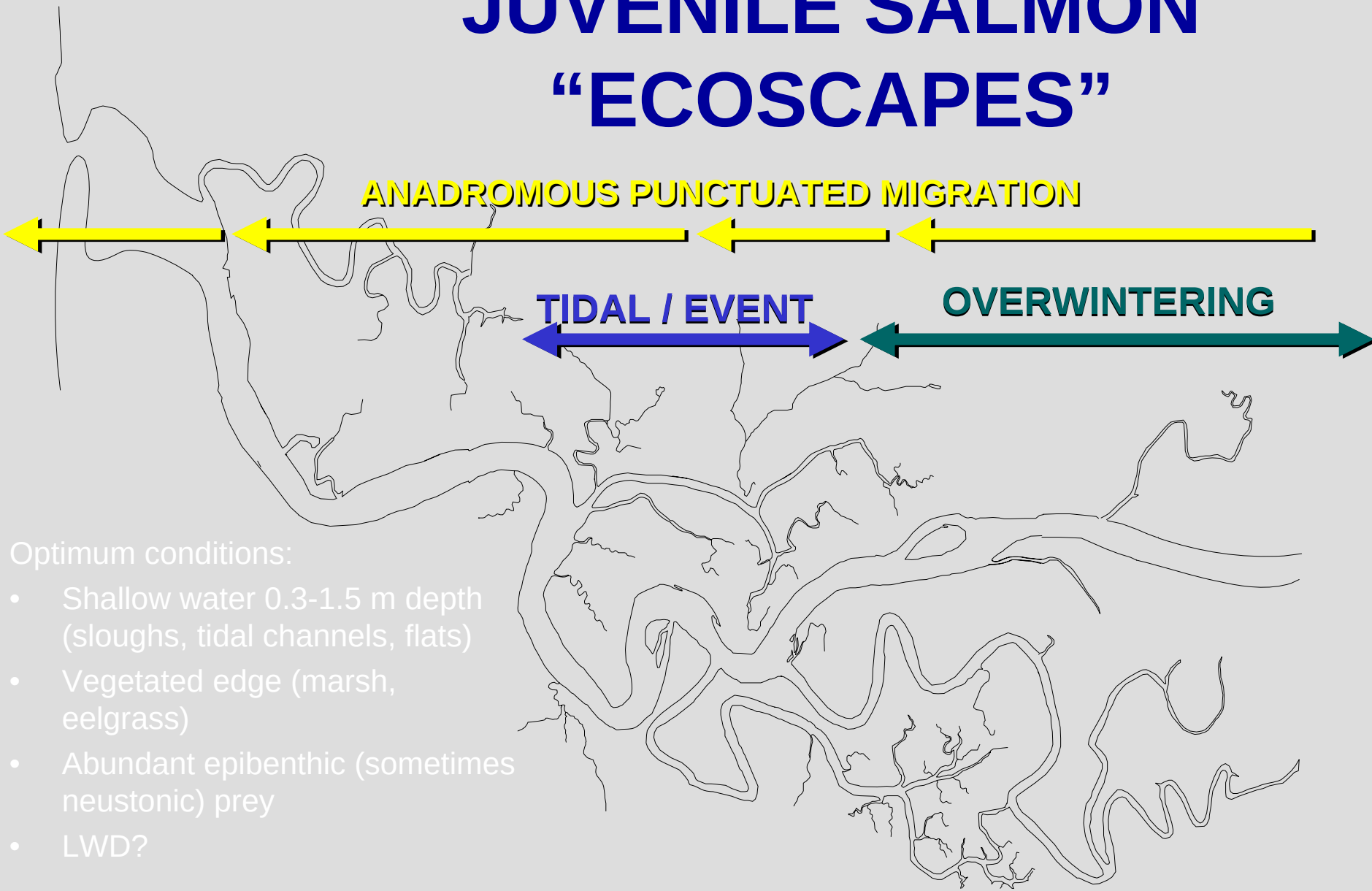

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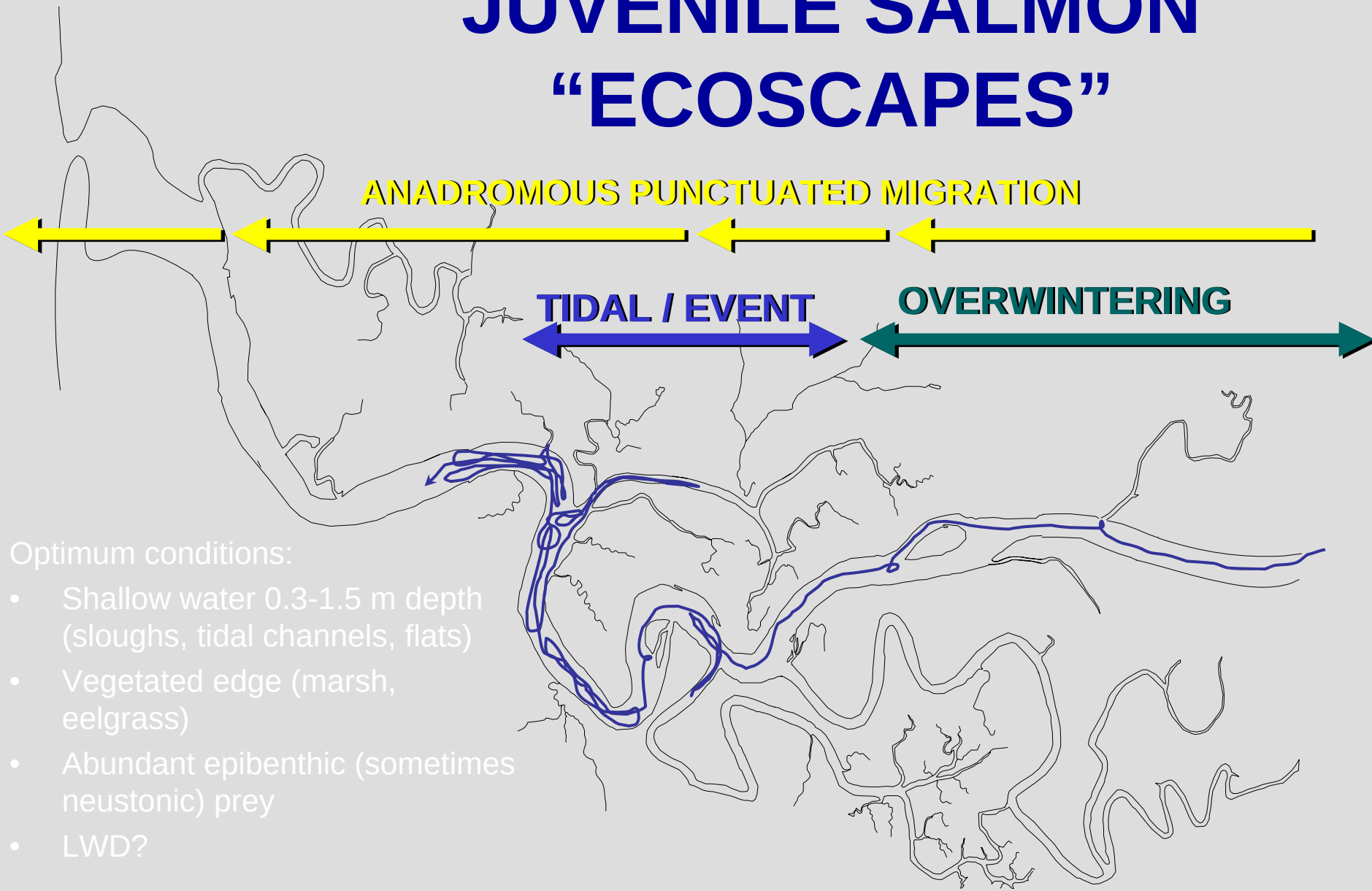

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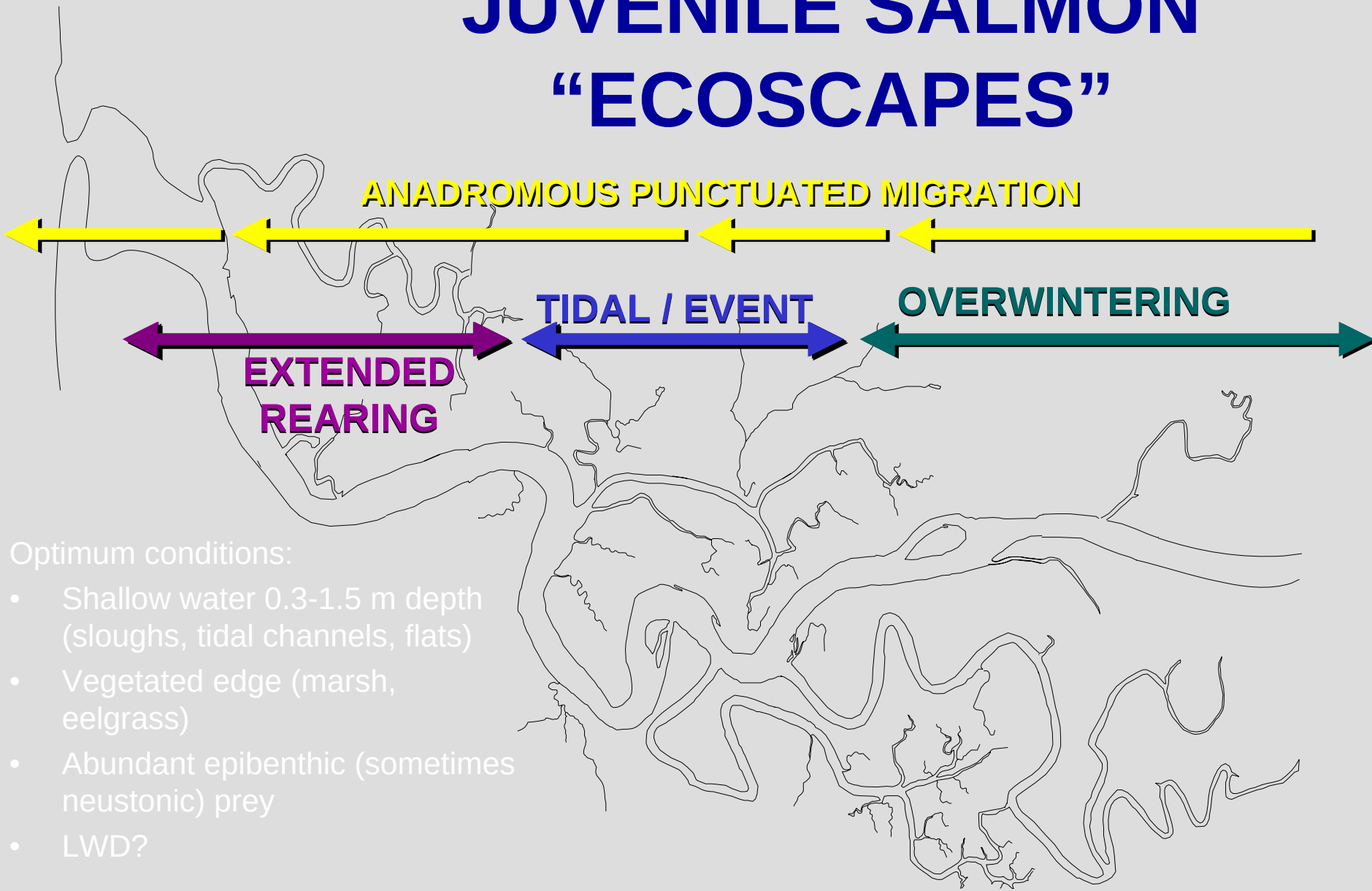

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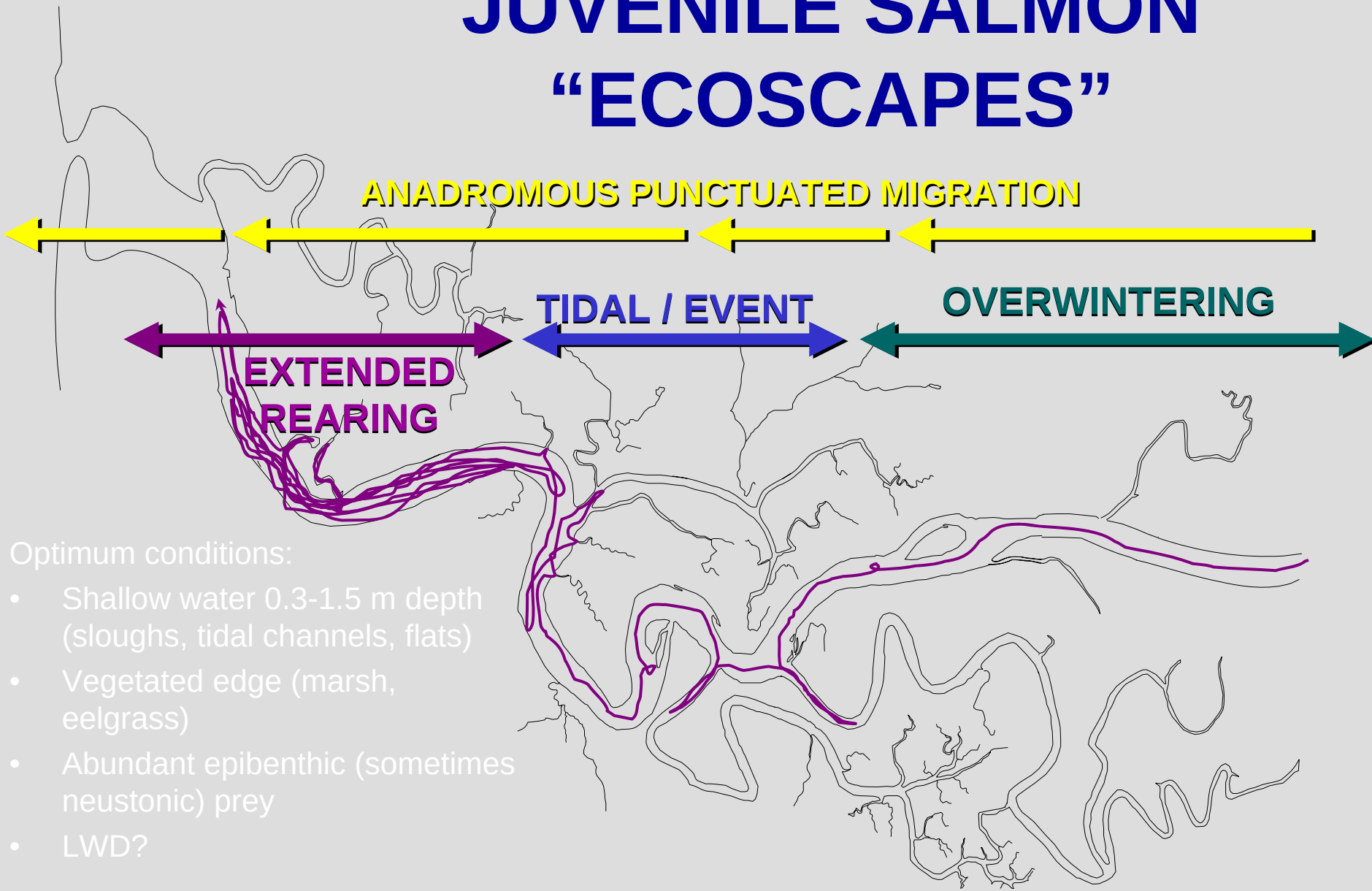

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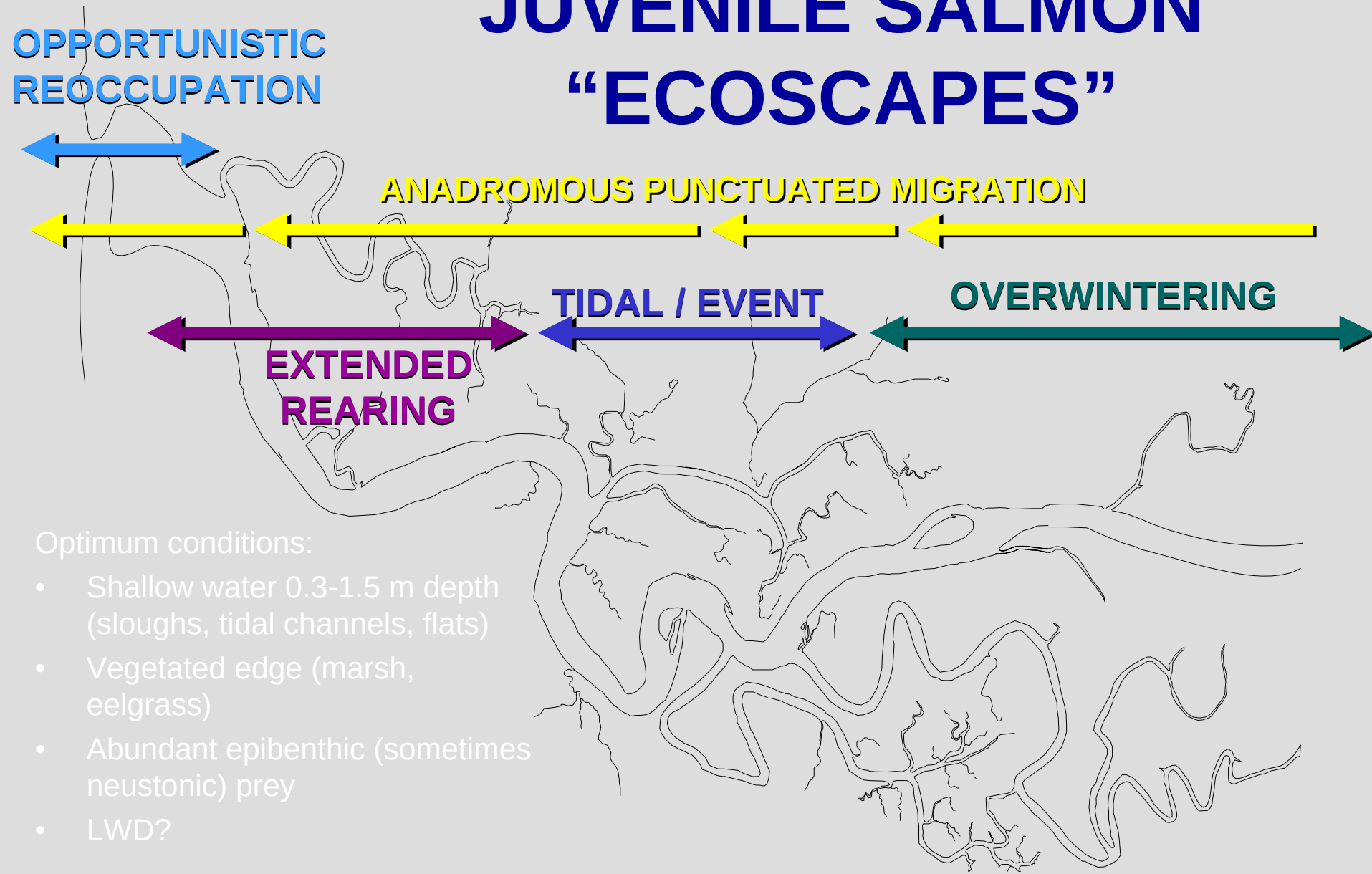

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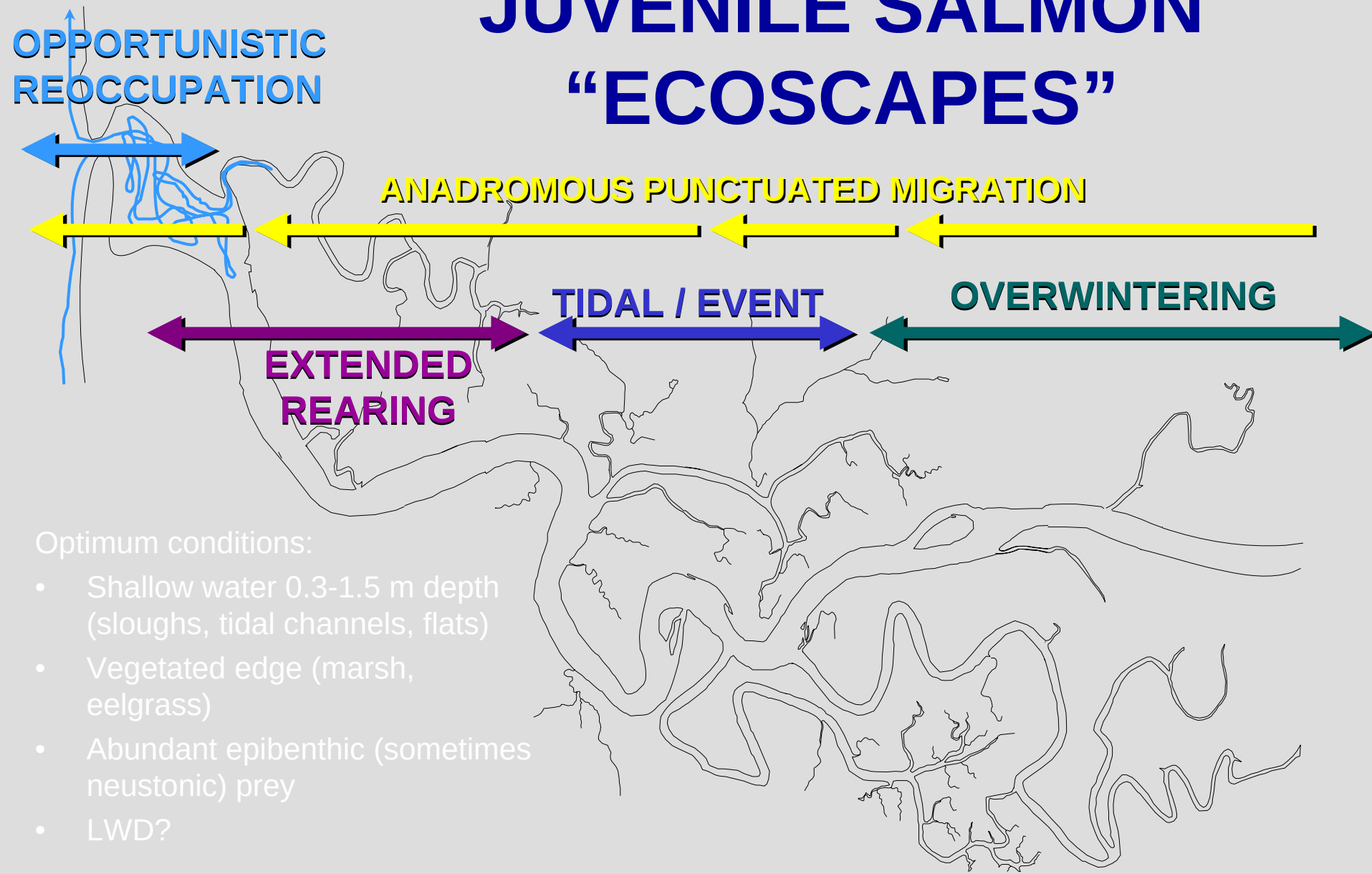

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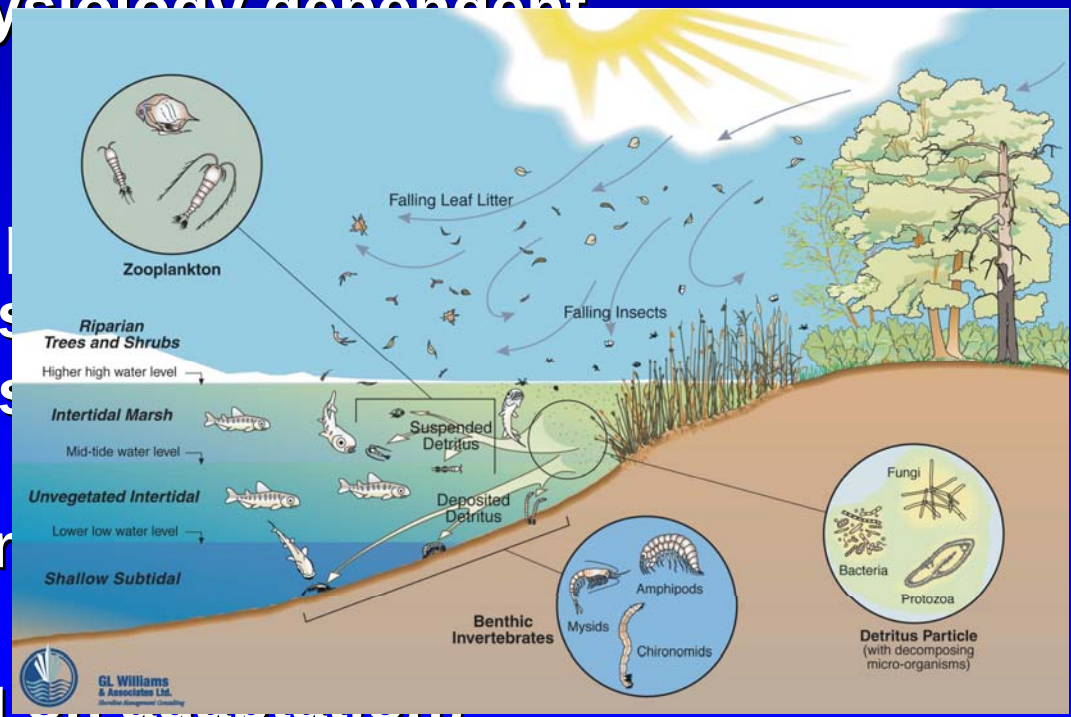
ECOSCAPE IMPLICATIONS

- Sequencing of fish pathways through ecoscape with ontogenetic development and environmental change
- Importance of mosaic structure and ecoscape connectivity as migratory corridors among habitats
- Inherent problems:
  - ✓ conceptual: dynamic, rather than traditional static view of habitat
  - ✓ tools: haven't had readily available technology to assess salmon ecoscape at appropriate resolutions
  - ✓ management, and particularly restoration, continues to be piecemeal, both within and across ecosystems…….needs to become integrated!
- How can the composition and organization of estuarine ecoscapes benefit juvenile salmon…..whether natural or build?

ARE THERE "RULES" FOR JUVENILE SALMON USE OF ESTUARINE-NEARSHORE SHORELINES?

- Size dependent
  - ✓ the bigger the fish, the less "d
  shallow water
  - ✓ however, doesn't mean that th
  shallow water
- Shallow water is relative to tide!
- Species-life history/phys
  - ✓ salinity
  - ✓ turbidity
- Varying 'selectivity' for
in nearshore ecosystems
- Behavioral changes ass
features
  - disturbance (sudde
  etc.)
  - shading (depending



THE ESTUARINE-NEARSHORE CONTINUUM OF PHYSICS, CHEMISTRY AND ECOLOGY=MOSAIC









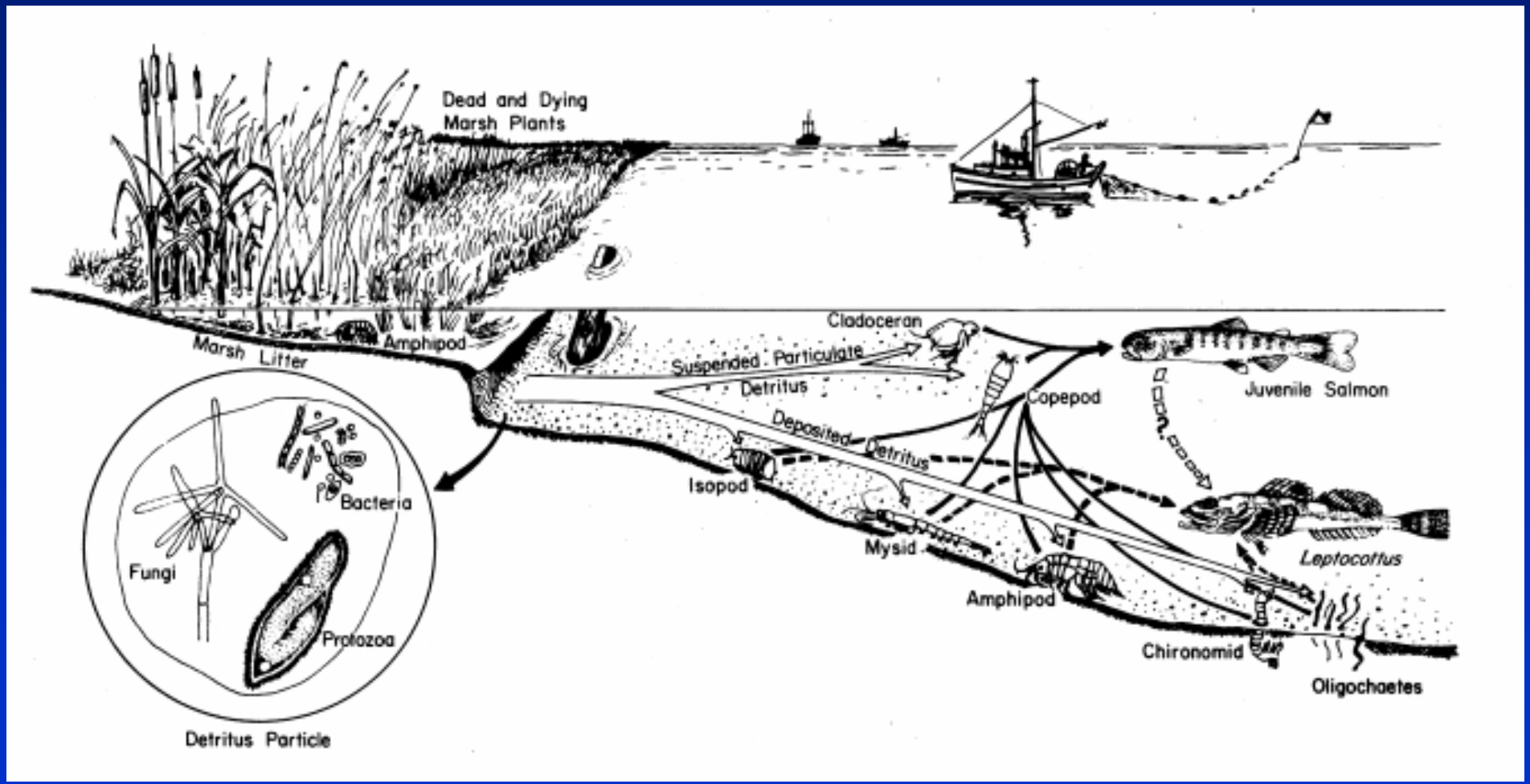

SCALES OF SHORELINE FUNCTION

- Internal
  - Within marine riparian ecosystem
- Ecosystem
  - Exchanges between ecosystems
- Ecotone-Landscape
  - Across land-margin
  - Landscape element
- Cultural
  - Traditional use
- Recreational/aesthetic
  - Anthropogenic value

SCALES OF SHORELINE FUNCTION -- Internal

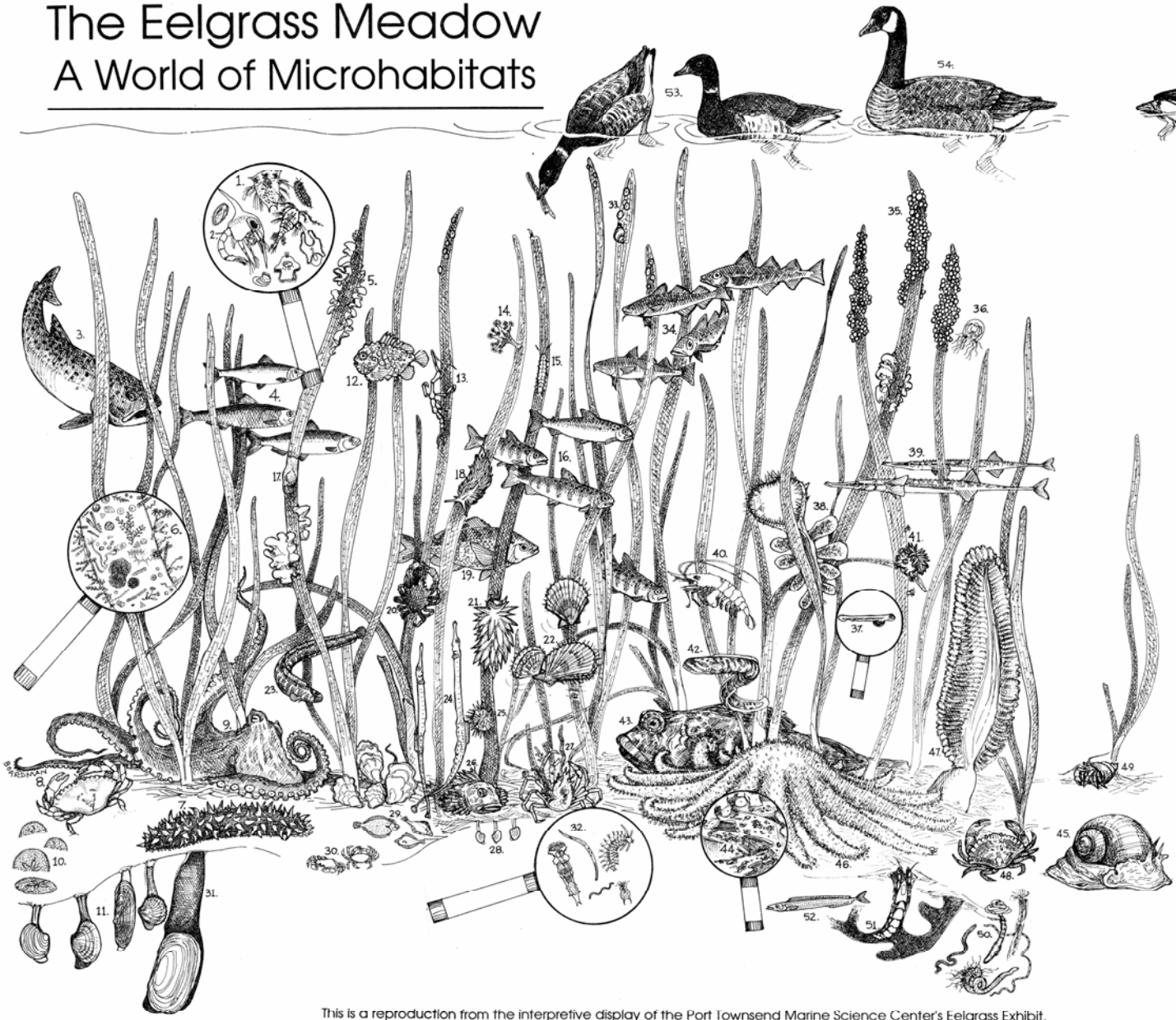
- Primary production
  - sources of OM to direct herbivory and detritus pool
  - habitat for resident non-fisheries species
- Secondary production
  - consumers and prey
- Decomposition, detritus production
  - OM entrainment
  - environments conducive to physical, chemical and biological decomposition
- Nutrient cycling
  - plant uptake

CONCEPTUAL DIAGRAM OF DETRITUS-BASED FOOD WEB OF ESTUARINE AND NEARSHORE ECOSYSTEMS OF PUGET SOUND AND WASHINGTON COASTAL ESTUARIES



(modified from Dorsey et al. 1978)

EELGRASS ECOSYSTEM



This is a reproduction from the interpretive display of the Port Townsend Marine Science Center's Eelgrass Exhibit.
For more information, call, write or visit the Port Townsend Marine Science Center, Fort Worden State Park, Port Townsend, WA 98368 – (206) 385-5582.

SCALES OF SHORELINE FUNCTION--Ecosystem

- Sediment and water flux to nearshore
- Food web contributions
  - export of organic matter and nutrients
  - potential prey organisms (e.g., insects, amphipods)
- Modulation of ecosystem processes
  - temperature (shading)
  - humidity
  - shoreline geomorphology
- Surface and groundwater modification
  - mechanical filtration
  - soil/plant uptake and transformation
  - contaminant removal

SEDIMENT FLUX TO SHORELINE

- chronic, high frequency, low intensity
- episodic, low frequency, high intensity

courtesy Hugh Shipman, WDOE

WATER FLUX TO SHORELINE

- non-estuarine delta features
- meso-scale low salinity plumes
- OM and prey export
- nutrient mediation

NATURAL AND ALTERED SHORELINE GEOMORPHOLOGY

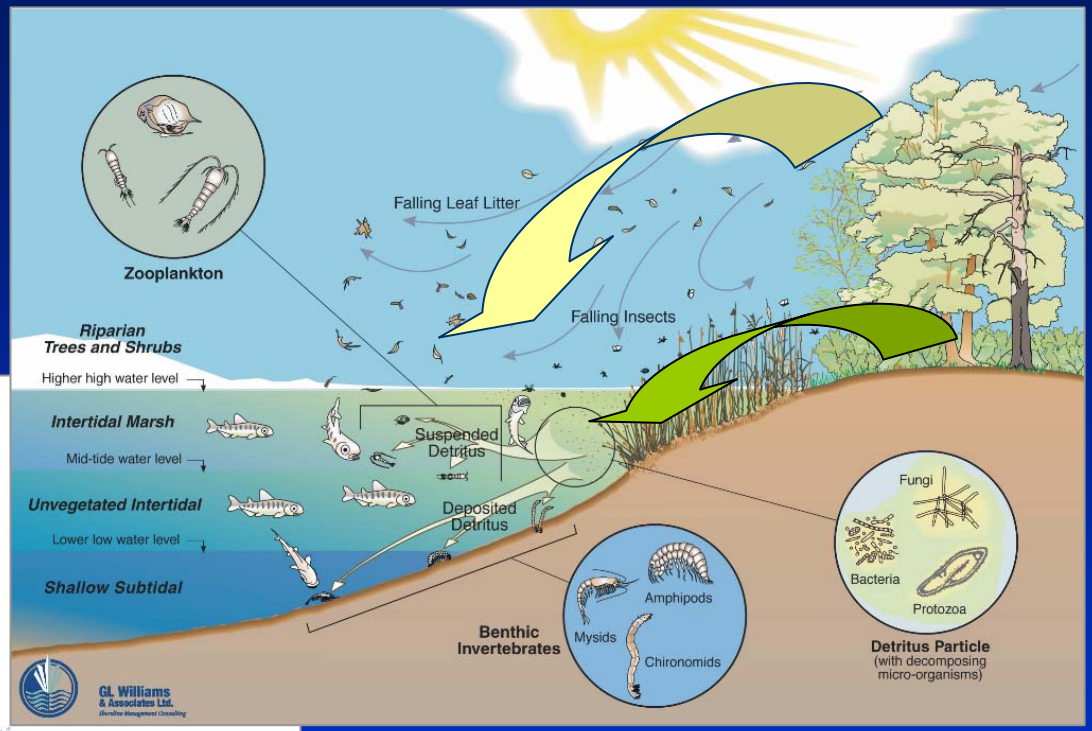
- Loss of littoral sediment
- Wave reflection/scour
- Hydrological impacts
- Loss of riparian vegetation
- Passive erosion
- Cumulative impact

courtesy Hugh Shipman, WDOE

PREY OF JUVENILE SALMON IN ESTUARIES AND NEARSHORE MARINE HABITATS

- epibenthic crustaceans
- aquatic insect larvae and pupae
- neustonic/drift adult insects
- plankton and other free-swimming invertebrates

ORGANIC MATTER AND INSECT PRODUCTION



SCALES OF SHORELINE FUNCTION—Ecotone/Landscape

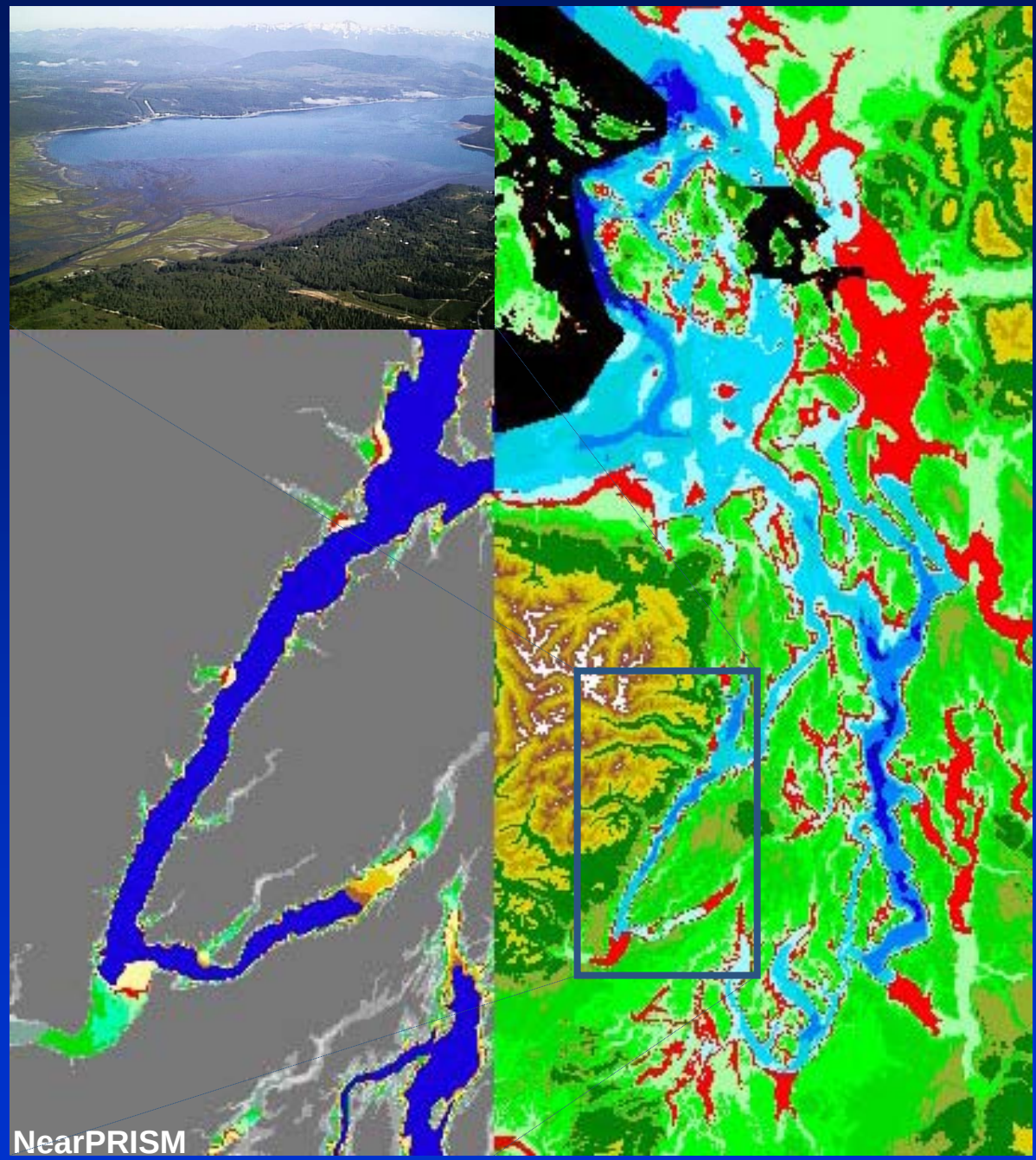
- Migratory corridors and transitional habitats
  - upland and marine consumers
- Mediate flux of material and energy
  - erosion from winds and waves
  - mass wastage
- Disturbance
  - maintain ecosystem diversity and complexity
- Sustain longshore sediment transport that maintains diverse, distant shoreforms

SHORELINES AS MIGRATORY CORRIDORS AND ECOTONES

- anadromous fishes
- small mammals
- avifauna

Eelgrass (*Zostera marina*) as fundamental nearshore segment in habitat continuum ("ecoscape") of juvenile chum salmon in Hood Canal:

- migratory corridor
- refuge from predation
- foraging habitat



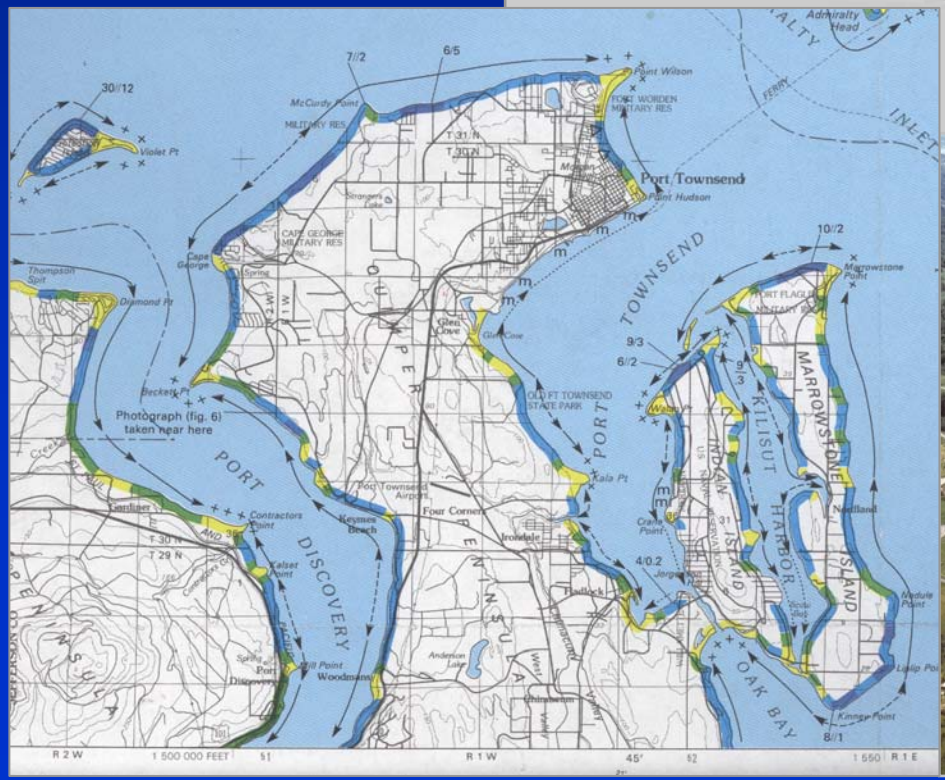
LIKELY FACTORS CONTRIBUTING TO THE "VALUE" OF EELGRASS LANDSCAPE STUCTURE TO JUVENILE SALMON

	Migration Corridor	Refuge from Predation	Foraging Success
extent		✓	✓
connectivity	✓	✓	
core			✓

MASS WASTAGE, VEGETATED SHORELINES AND DISTURBANCE

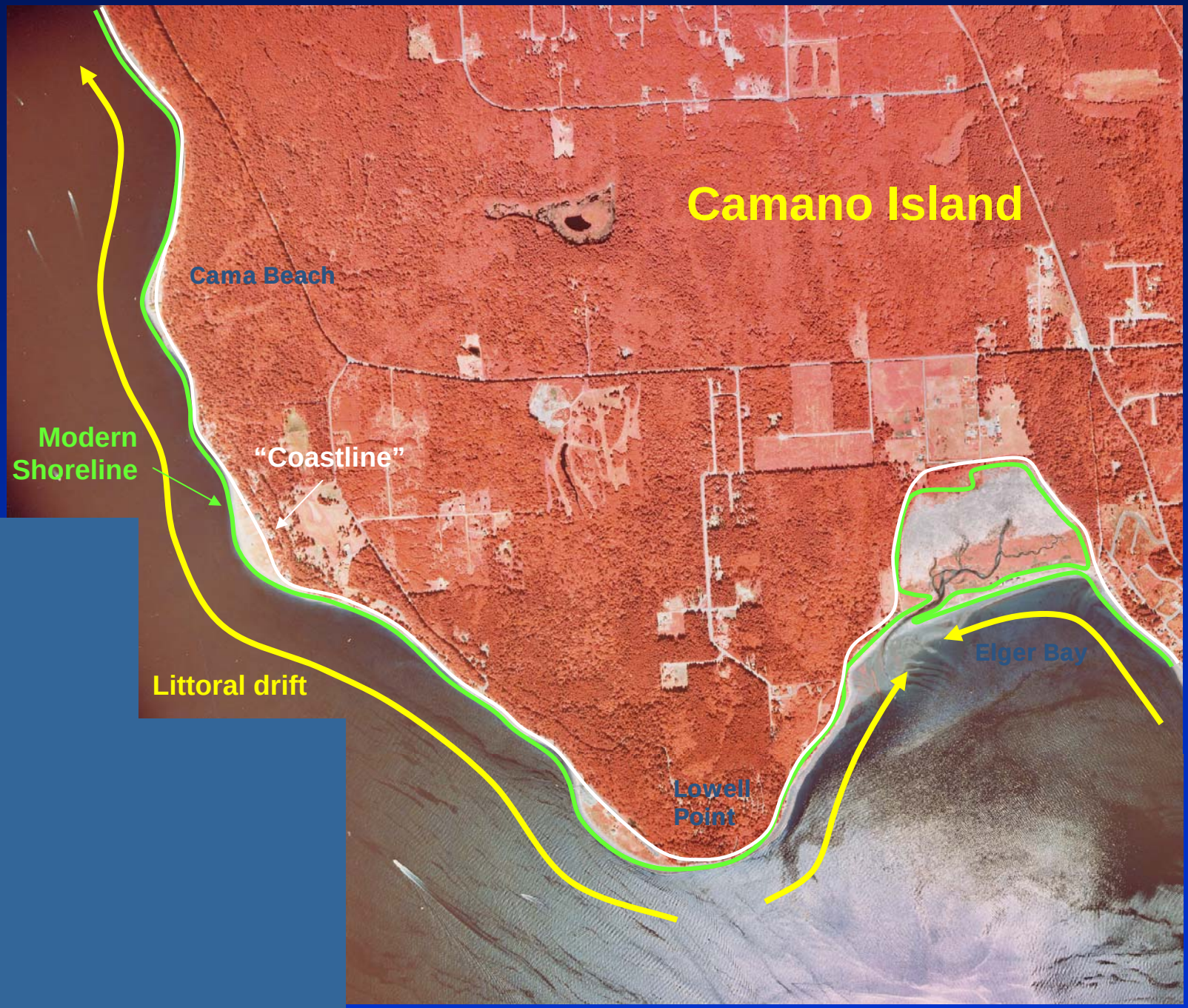
courtesy Hugh Shipman, WDOE

LANDSCAPE GEOMORPHIC PROCESSES



SAND SPITS, BARRIER BEACHES AND LAGOONS

courtesy Hugh Shipman, WDOE



courtesy Hugh Shipman, WDOE

SCALES OF SHORELINE—Cultural

- Habitation
  - permanent occupation
  - seasonal sites
- Resource harvest
  - shoreline resources
  - subsistence and cultural materials, e.g., ethobotanical harvest for baskets, and other products

NORTHWEST NATIVE AMERICANS AND THE SHORELINE

Van Olinda, O. S., ca 1902-1905; Skagit potlatch house with people gathered outside, Whidbey Island. Canoes pulled up onto beach in front of house, and canoes and other boats moored in water. ; UW Libraries Special Collection, NA832.

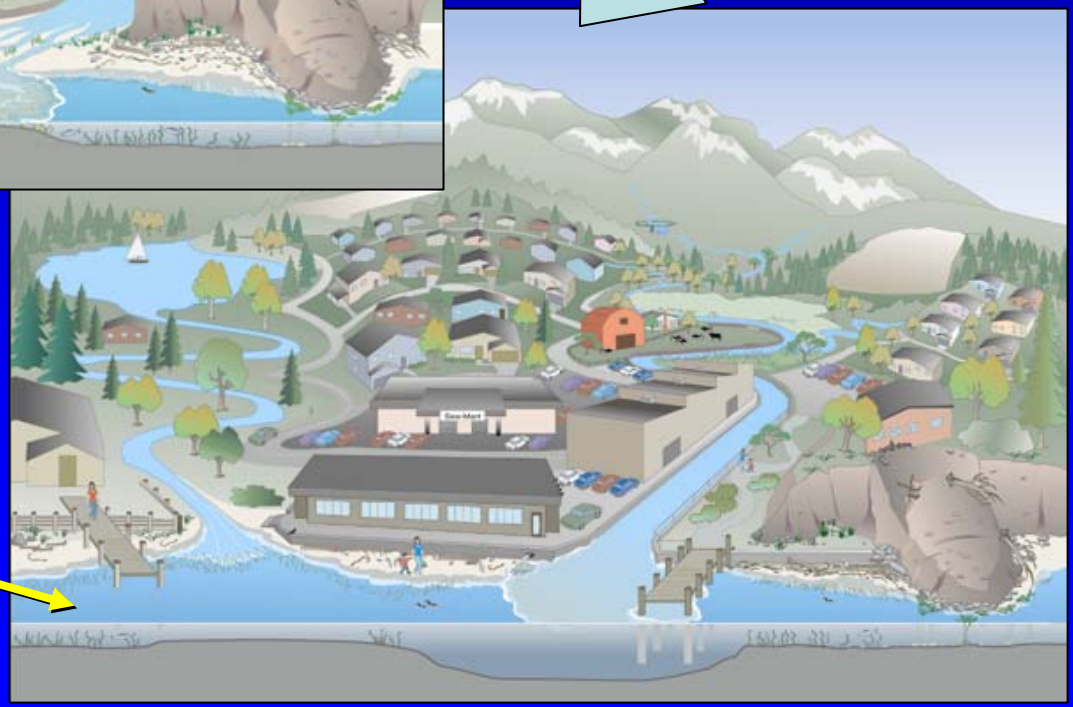
ca 1900; Lushootseed man, woman, older woman and five children (and the dogs) pose in front of tents, 1895-1905. Drying in front of them are clams & fish; UW Libraries Special Collection, NA849.

SCALES OF SHORELINE—
Recreational/Aesthetic

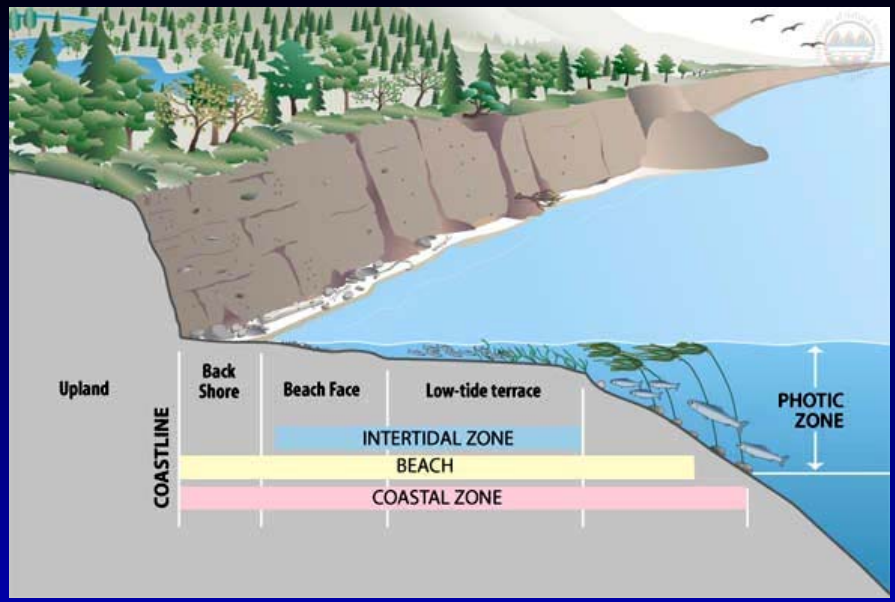
- Buffer landward development
- Contiguous nature
- Perception of integrity

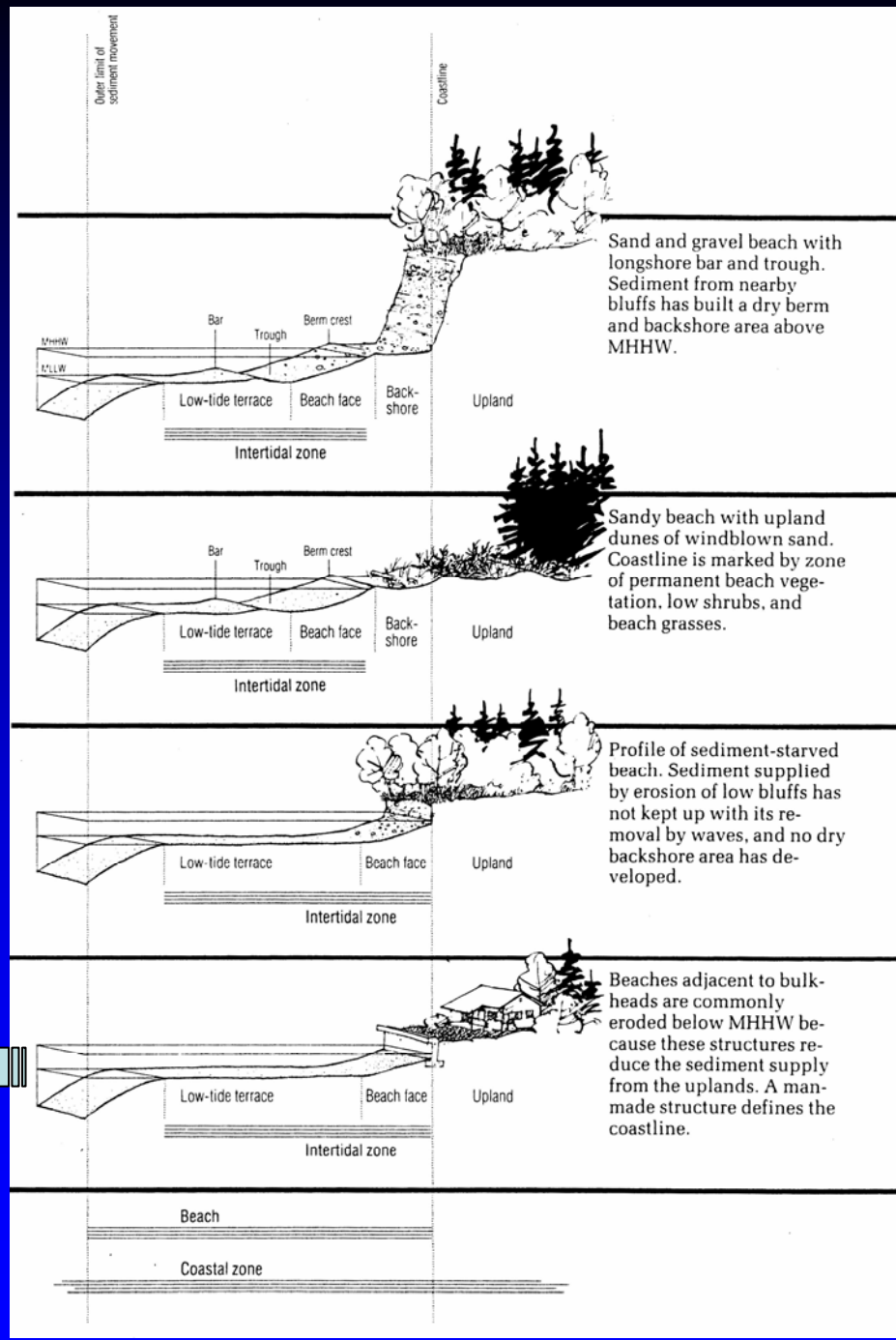
JUVENILE SALMON IN PUGET SOUND: Ghosts of Habitat Past?

- extensive loss of estuarine rearing habitat
- reduced connectivity
- forced transport to marine environments

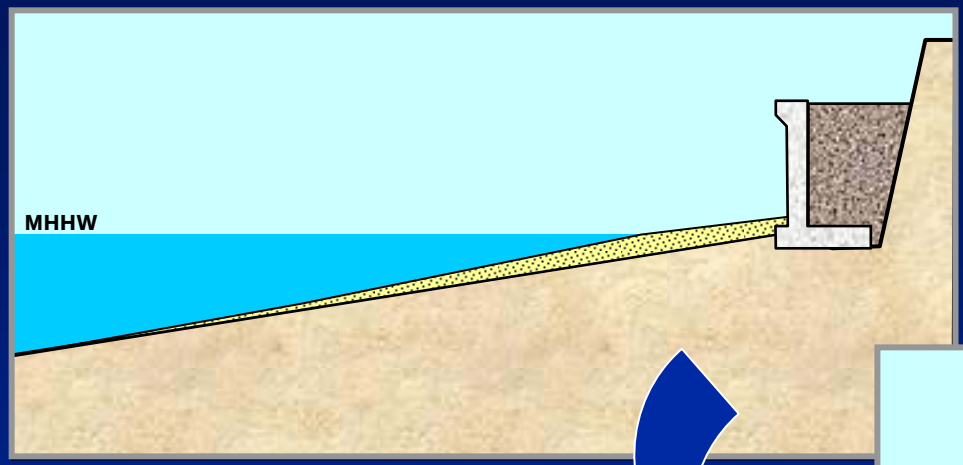


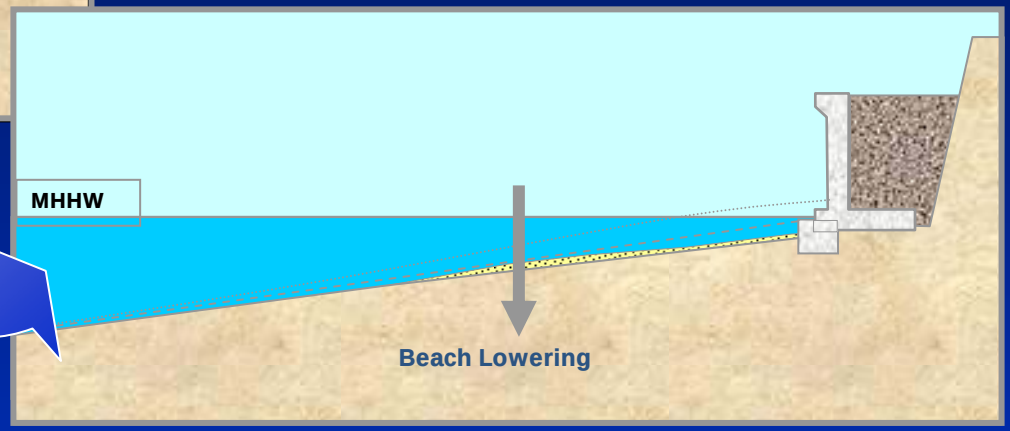
Is the marine nearshore acceptable replacement for estuarine habitat of ocean-type juvenile salmon?


Upland
Back Shore
Beach Face
Low-tide terrace
PHOTIC ZONE
COASTLINE
INTERTIDAL ZONE
BEACH
COASTAL ZONE


Outer limit of sediment movement
Coastline
MHHW
MLLW
Bar
Trough
Berm crest
Low-tide terrace
Beach face
Back-shore
Upland
Intertidal zone
Sand and gravel beach with longshore bar and trough. Sediment from nearby bluffs has built a dry berm and backshore area above MHHW.
Sandy beach with upland dunes of windblown sand. Coastline is marked by zone of permanent beach vegetation, low shrubs, and beach grasses.
Profile of sediment-starved beach. Sediment supplied by erosion of low bluffs has not kept up with its removal by waves, and no dry backshore area has developed.
Beaches adjacent to bulkheads are commonly eroded below MHHW because these structures reduce the sediment supply from the uplands. A man-made structure defines the coastline.
Beach
Coastal zone

BEACH LOWERING

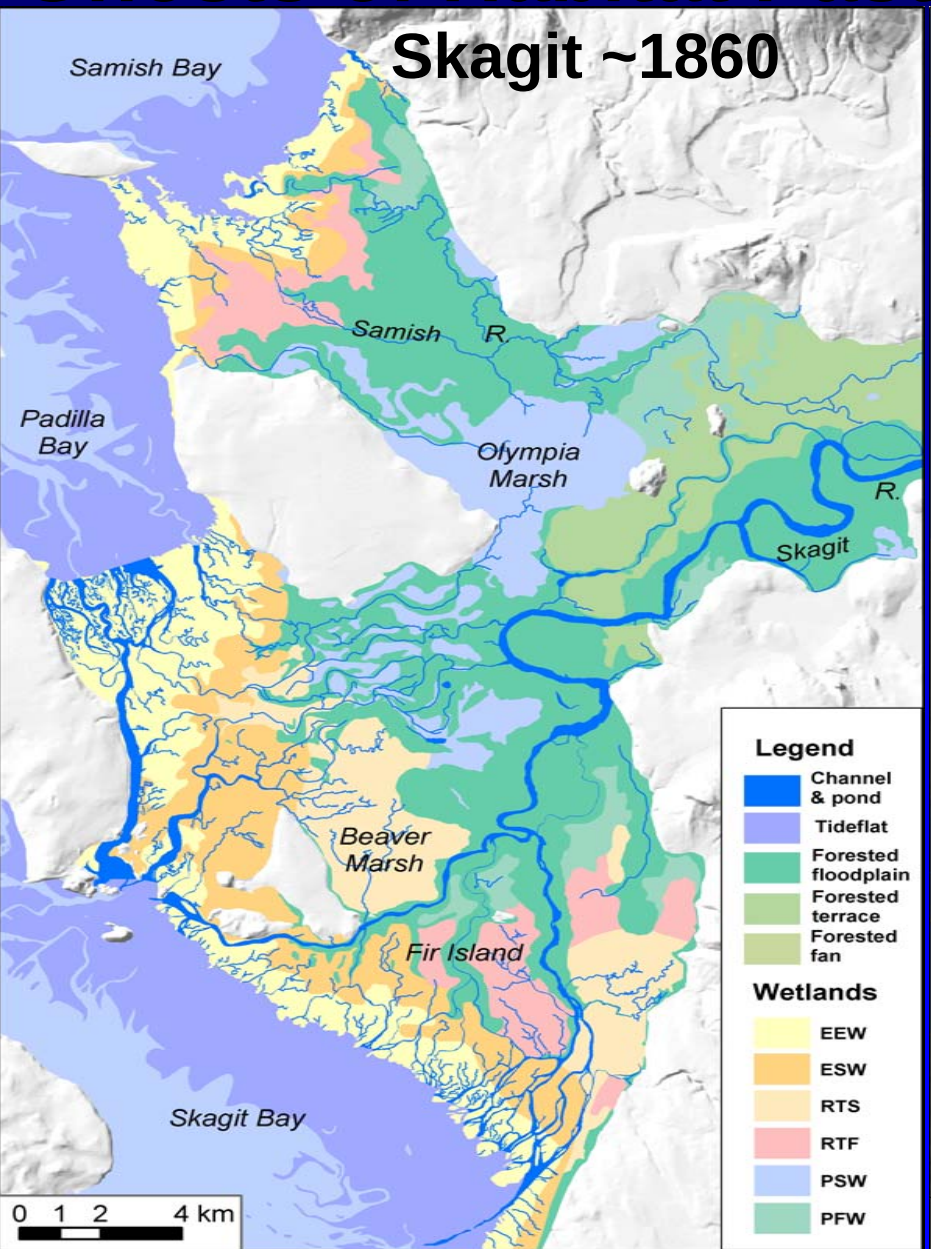


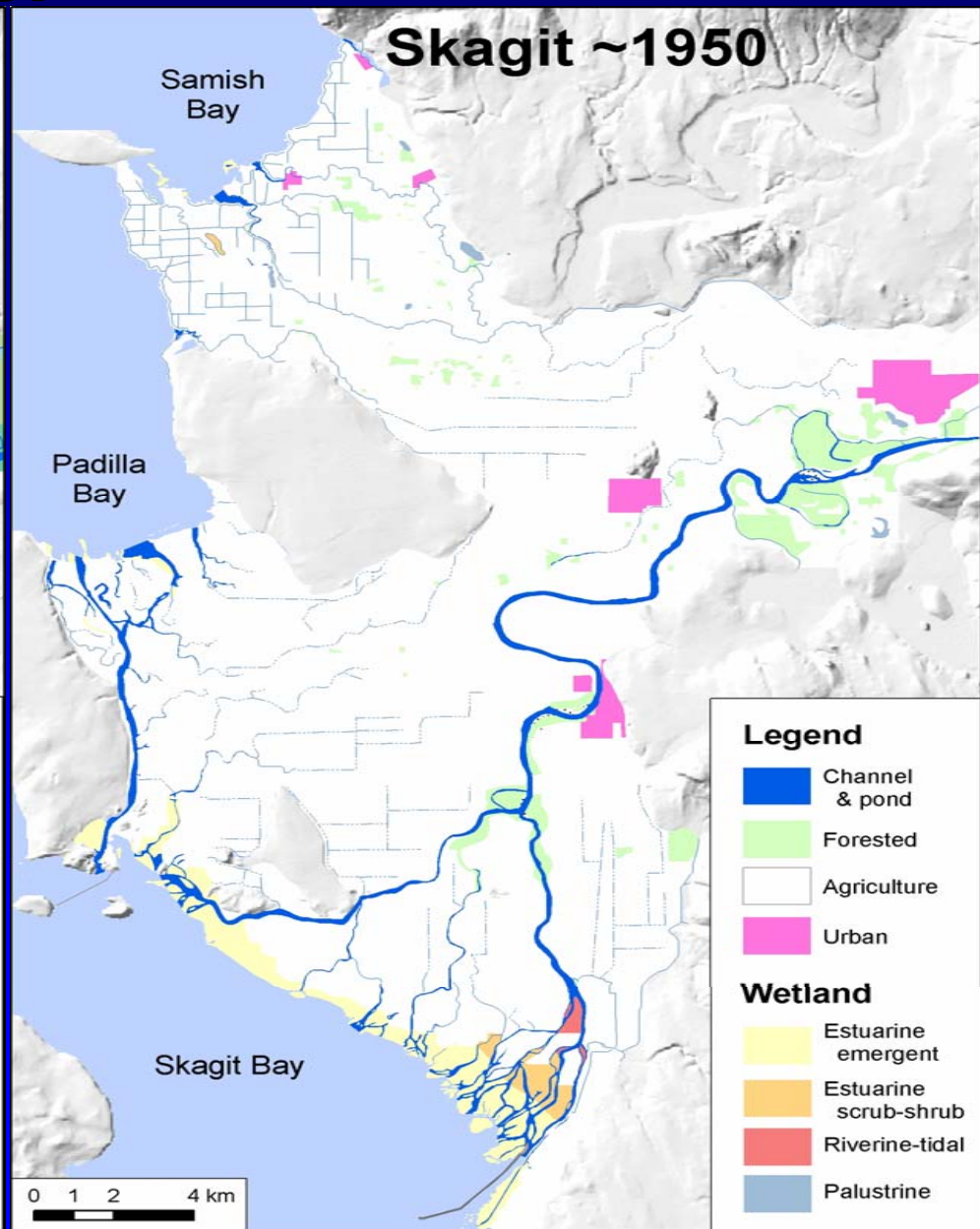


courtesy Hugh Shipman, WDOE

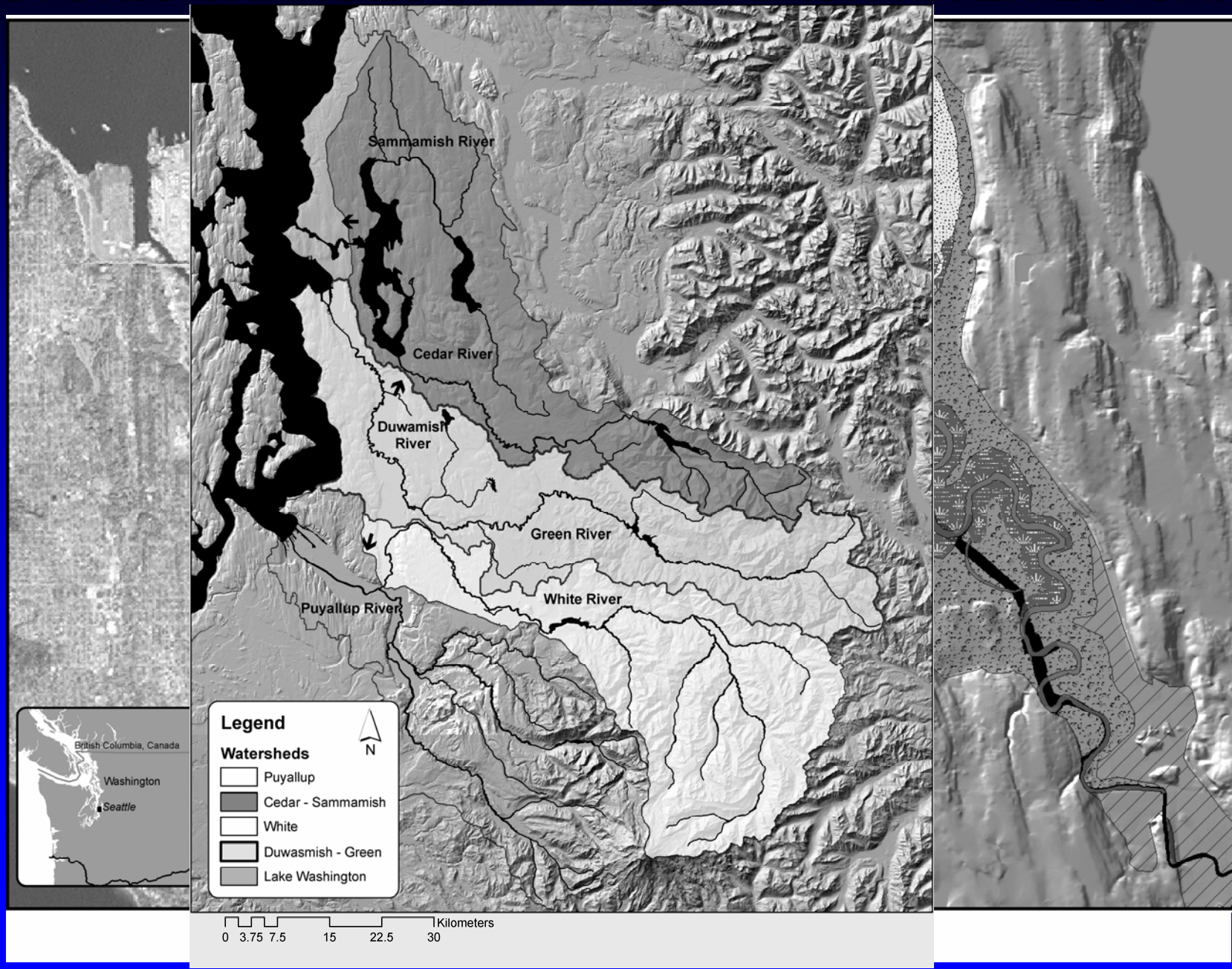
JUVENILE SALMON IN PUGET SOUND: Ghosts of Habitat Past?

Skagit



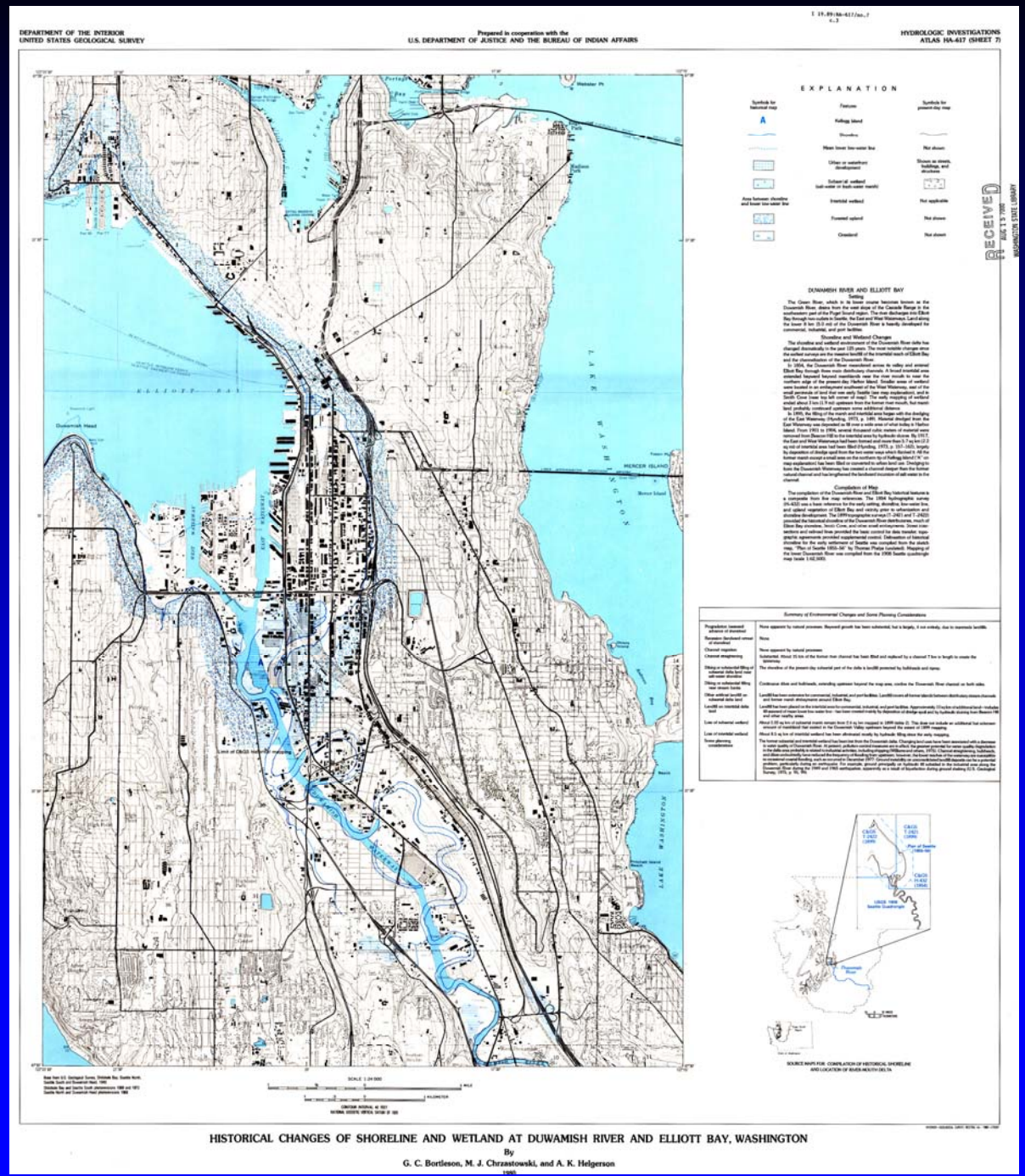


HISTORIC CHANGES IN THE DUWAMISH RIVER ESTUARY

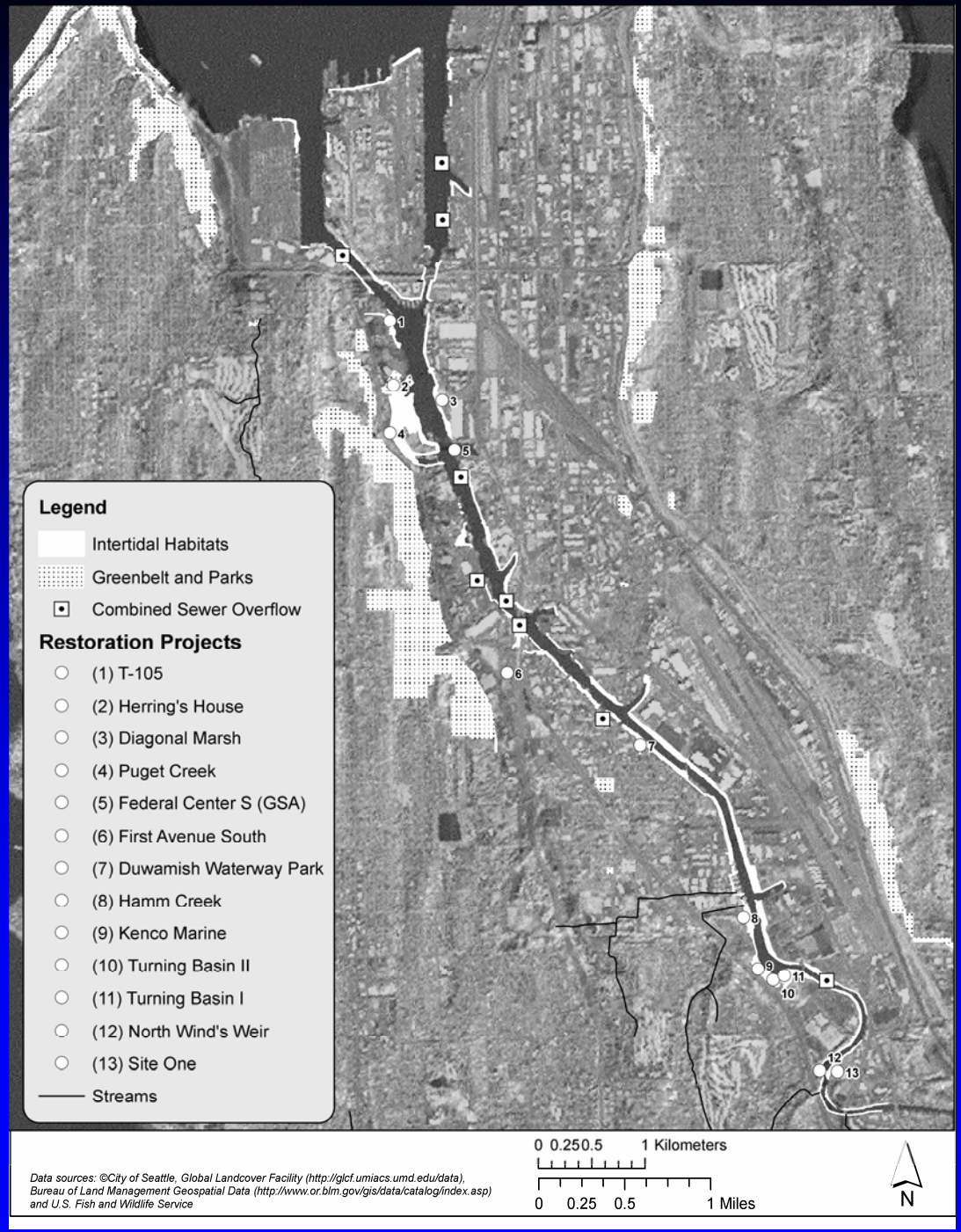


WET/SAFS/UW figure by J. Burke

HISTORIC DUWAMISH RIVER-ELLIOTT BAY ESTUARY AS ECOSCAPE



RESTORATION PROJECTS IN THE DUWAMISH RIVER ESTUARY



WET/SAFS/UW figure by J. Burke

RESTORATION PROJECTS IN THE DUWAMISH RIVER ESTUARY

TAKE-HOME MESSAGE

- consider nearshore landscape….from watershed to nearshore marine
- anything will contribute…..the challenge will be how to cumulatively make a difference
- be strategic…..where are the gaps (literally and figuratively)?
- provide a “habitat ecoscape” with integrity and sustainability
- not only incorporate human dimensions (can’t avoid it in urban setting) but take advantage of it!


Let’s not lose the concept of what salmon need in the way of habitat!
Photo: 2001 Harley Soltes, Seattle Times