

TIDAL NETWORK STRUCTURE AND CHINOOK SALMON USE

#22-1494

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SKAGIT RIVER SYSTEM
COOPERATIVE



Estuary Restoration and Chinook Recovery

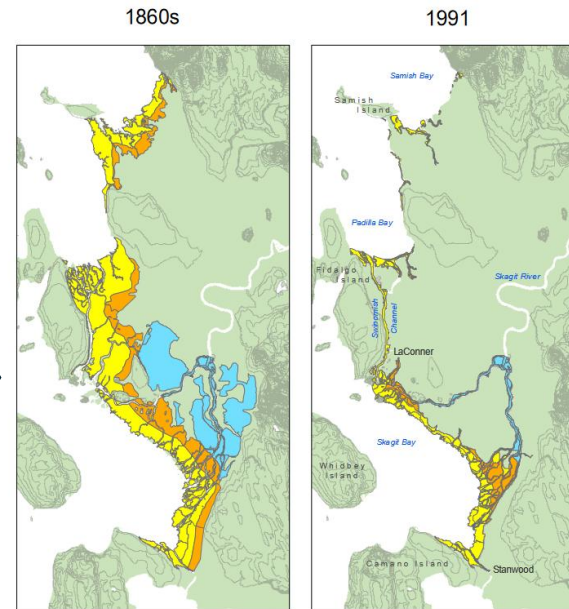
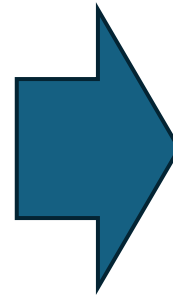
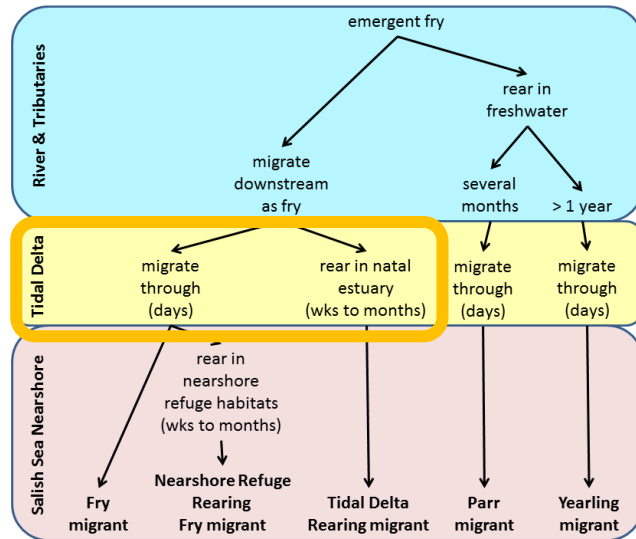
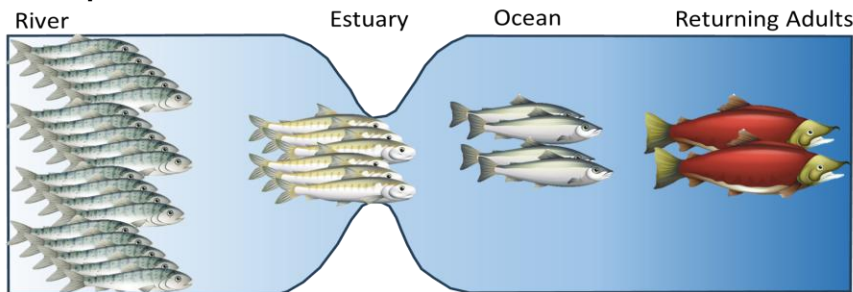
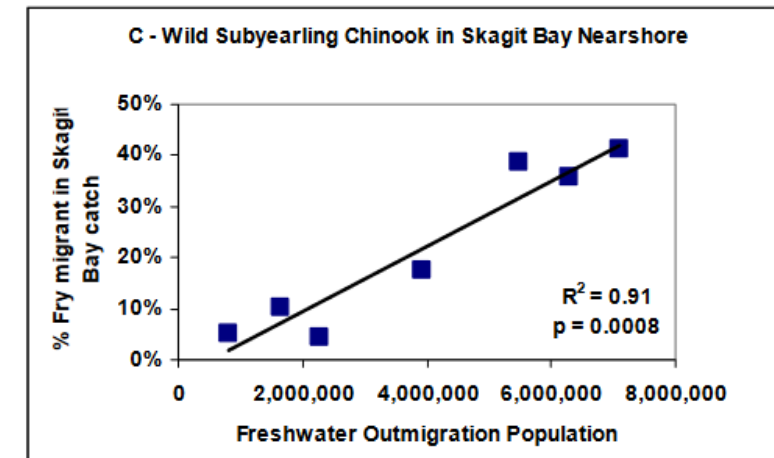
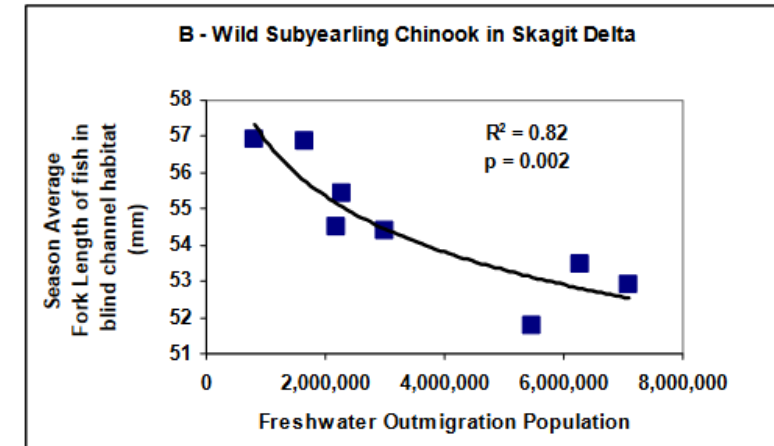
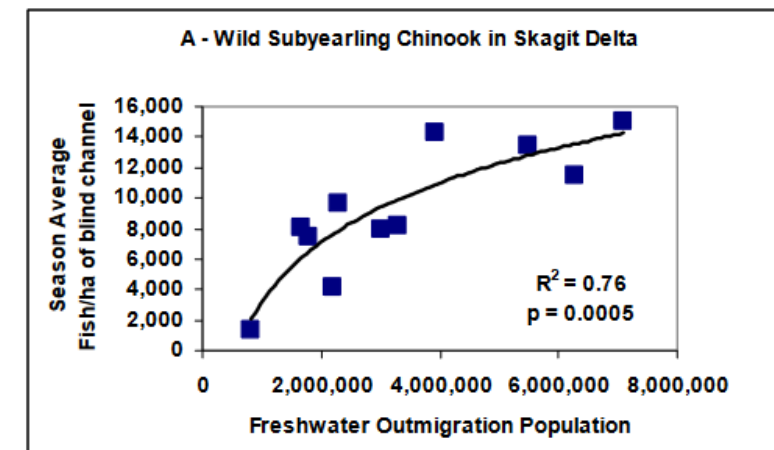


Figure 3.1. Changes to the estuarine habitat zones within the geomorphic Skagit delta. Historic (circa 1860s) conditions were reconstructed by Collins (2000) using archival maps and survey notes. Current habitat zones were mapped by Beamer et al. (2000b) using 1991 orthophotos.

Population Bottlenecks



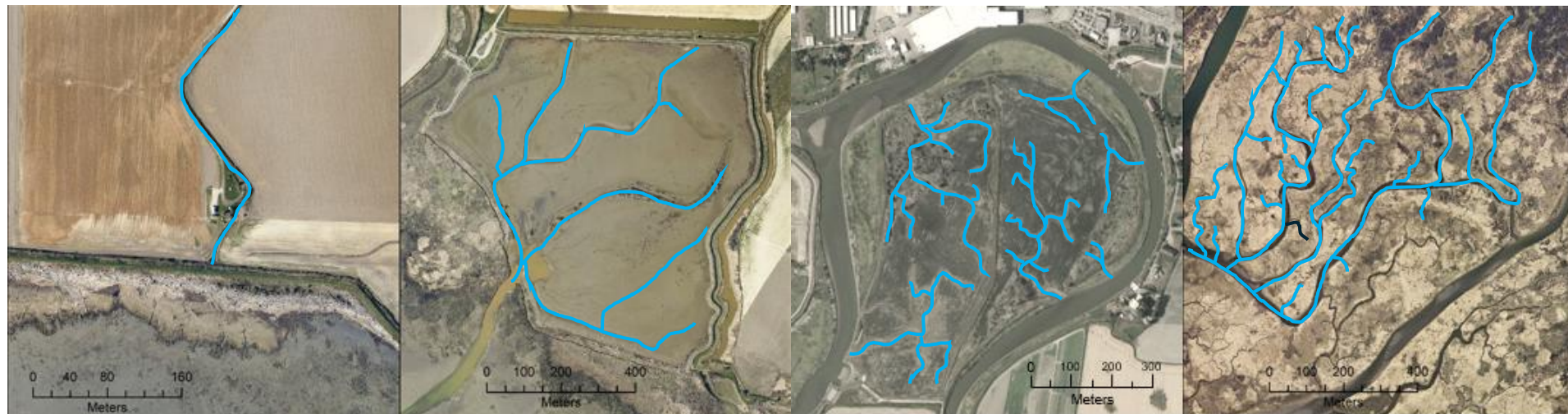
Fresh et al. 2005, Carr-Harris et al. 2014, Greene et al. 2015, Greene et al. 2022, Chamberlin et al. 2022, Beamer et al. 2025, Greene et al. 2025, and others



Estuary Restoration

- Linked to recovery plan actions
 - Estuary habitat loss = reduced capacity → increase habitat (channel) area
 - Connectivity loss = reduced access to habitat → increase pathways

Just increasing habitat enough? Are there aspects about restoration design that can influence fish use?



Estuary Restoration as a Practice

Estuary restoration design guidance changed over time

- Beginning excavation of pilot channels
- Now allometric predictions provide predictive channel metrics based on tidal exchange (Hood 2007 and Hood 2014)
 - # of channel outlets
 - Total channel length
 - Total channel area
 - Cross-sectional area



Clifton-Cardoso 2009



<https://esassoc.com/projects/port-susan-bay-estuary-restoration/>

Tidal Channels are Dendritic networks

Dendritic networks influence species density and distributions

- Confluences can be hotspots
- Distance in large systems can limit access
- Landscape modifiers
 - Estuarine beaver



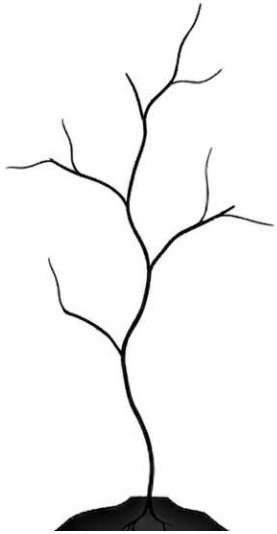
Photo: Jenny Baker, WDFW

Hypotheses

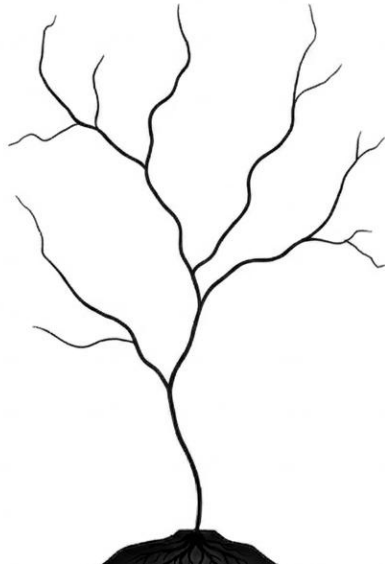
H1: Juvenile Chinook distributions are contingent on tidal channel network attributes.

H2: Impounded water (low tide pools and beaver impoundment) increase Chinook Presence.

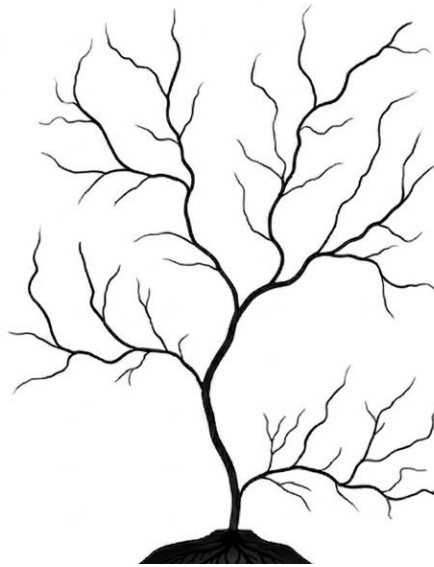
SIMPLE (LOW COMPLEXITY)



INTERMEDIATE (MEDIUM COMPLEXITY)

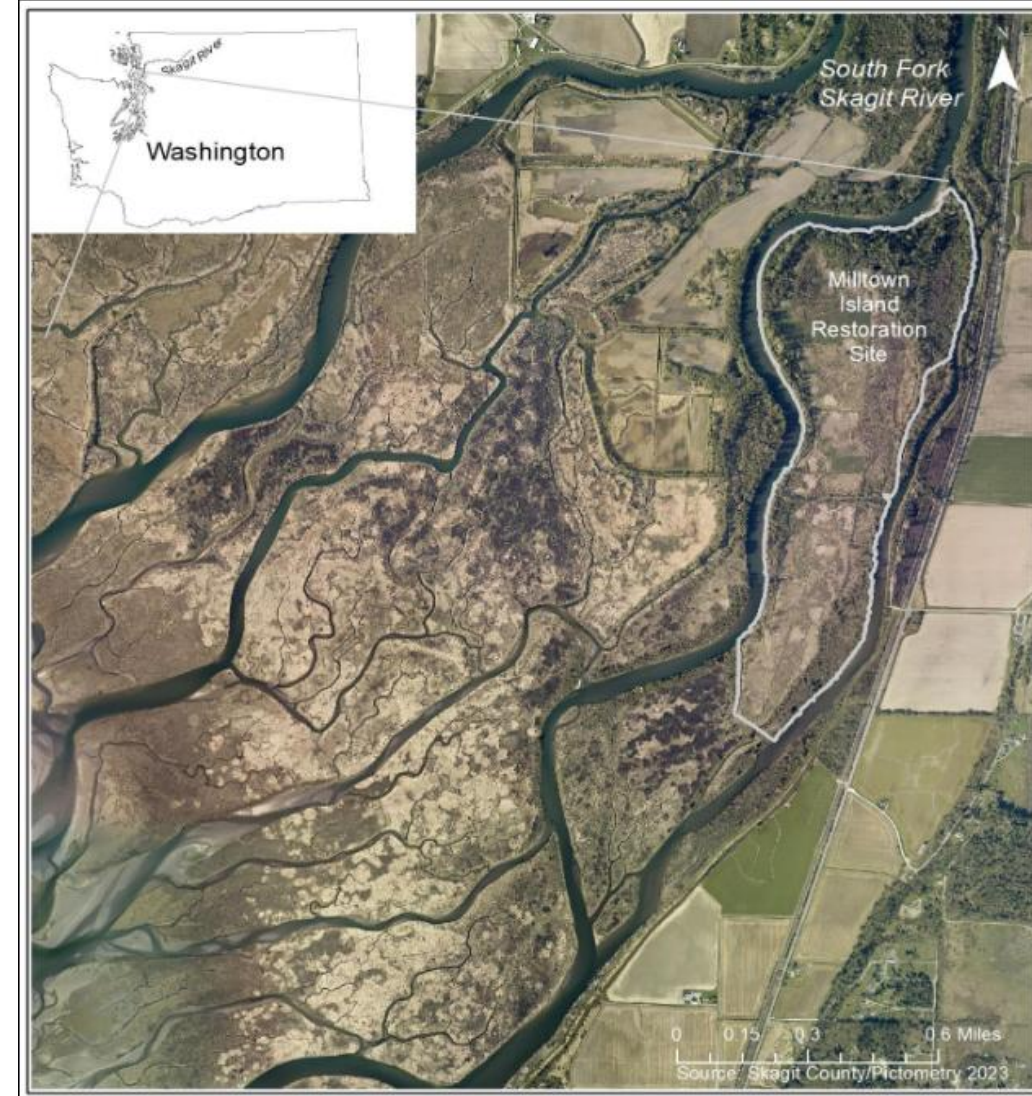


COMPLEX (HIGH COMPLEXITY)



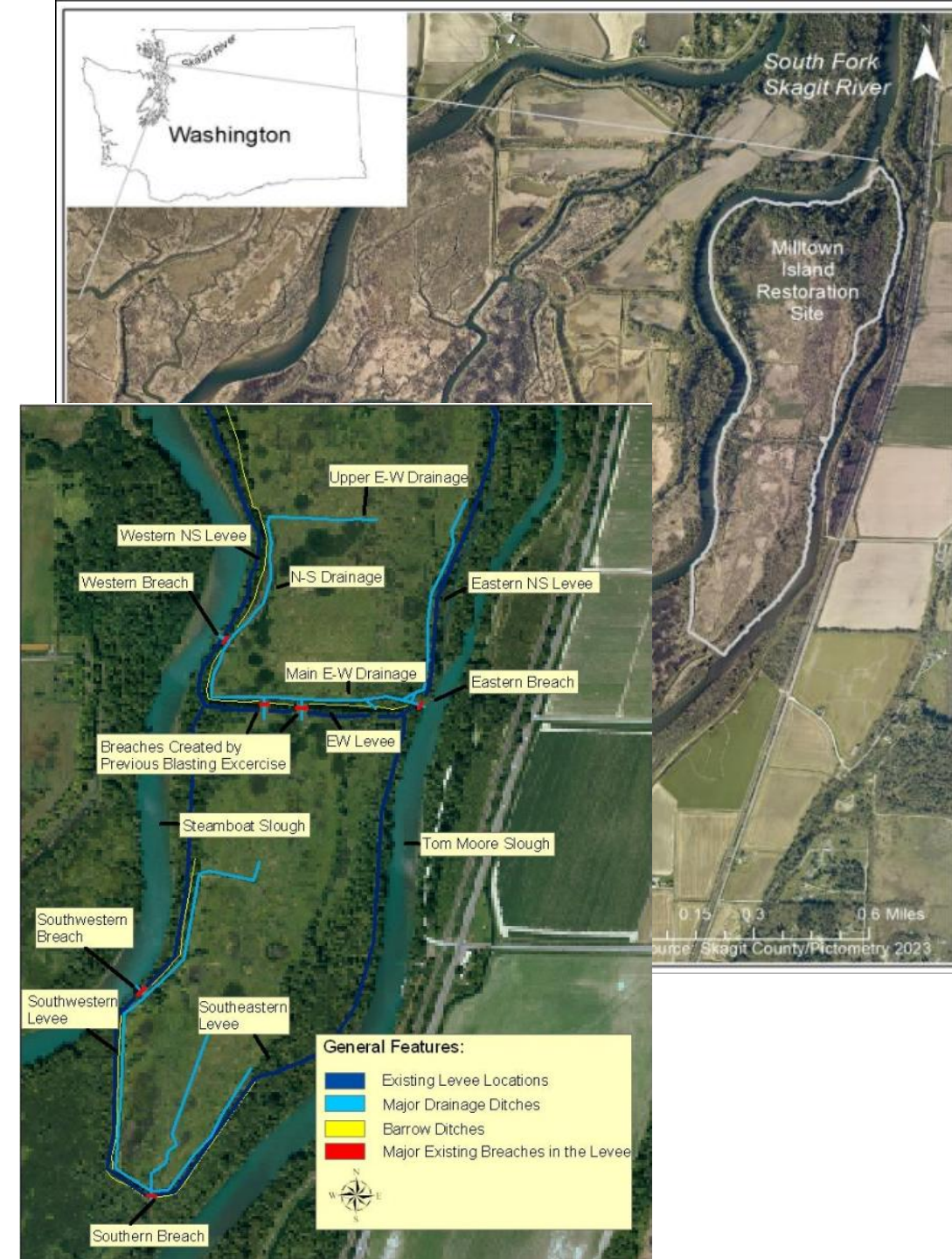
Milltown Island

- Approx 220 acre site in SF Skagit River



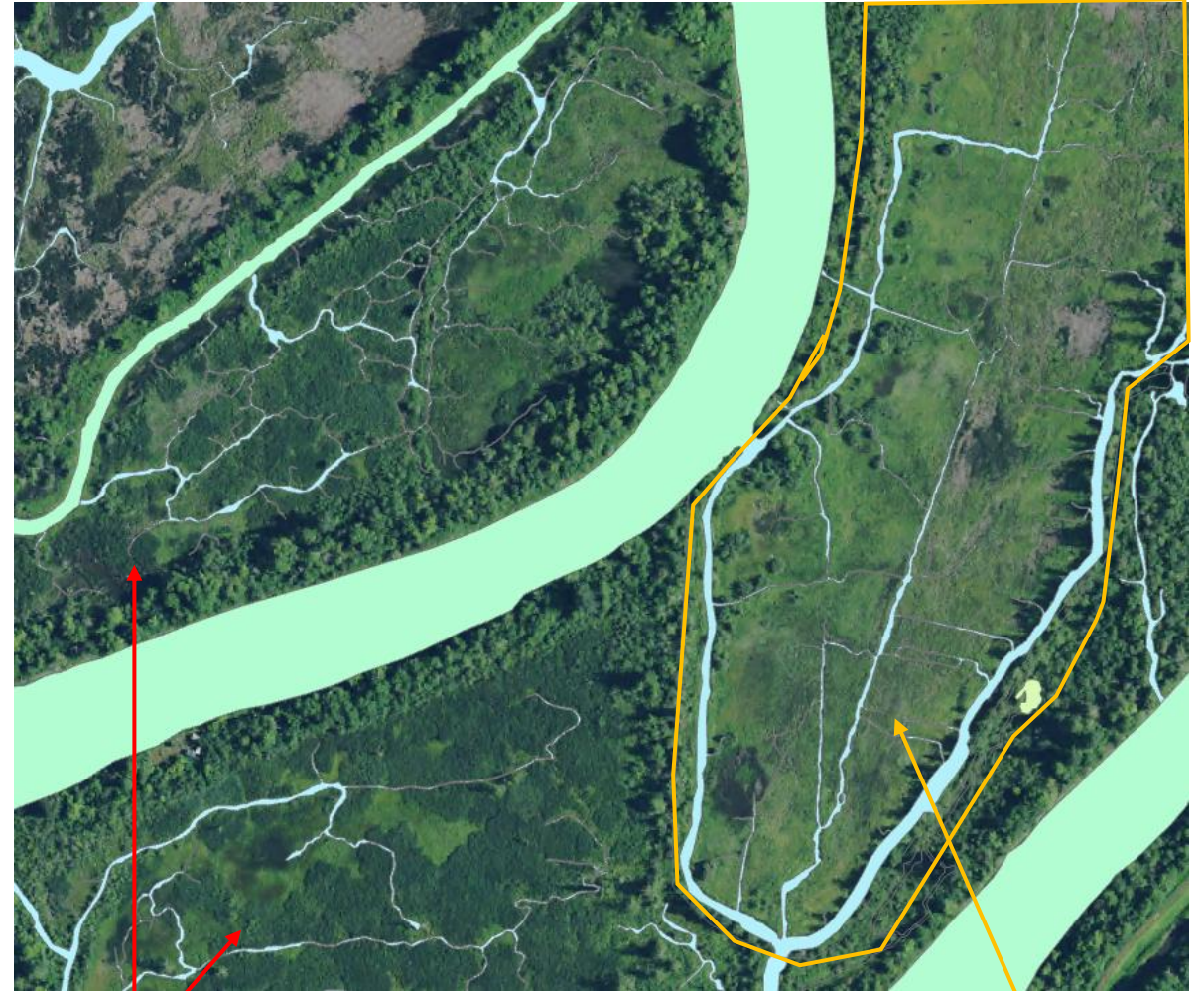
Milltown Island

- Approx 220 acre site in SF Skagit River
 - North and South Lobe
- Site has received various actions
 - Explosive breaching leveraging existing borrow ditches for network***
 - 1999 dike breaching
 - 2006 244 m of dike breached
 - 2007 92 m of dike breached
 - *Excavation in 2024*
 - *Remove 823 m of dike*
 - *Excavate 2,460 m of new channel*



Milltown 2023

- Restoration Site
 - Met allometric predictions, but
 - Channels lack sinuosity
 - Channel coverage low interior to the site

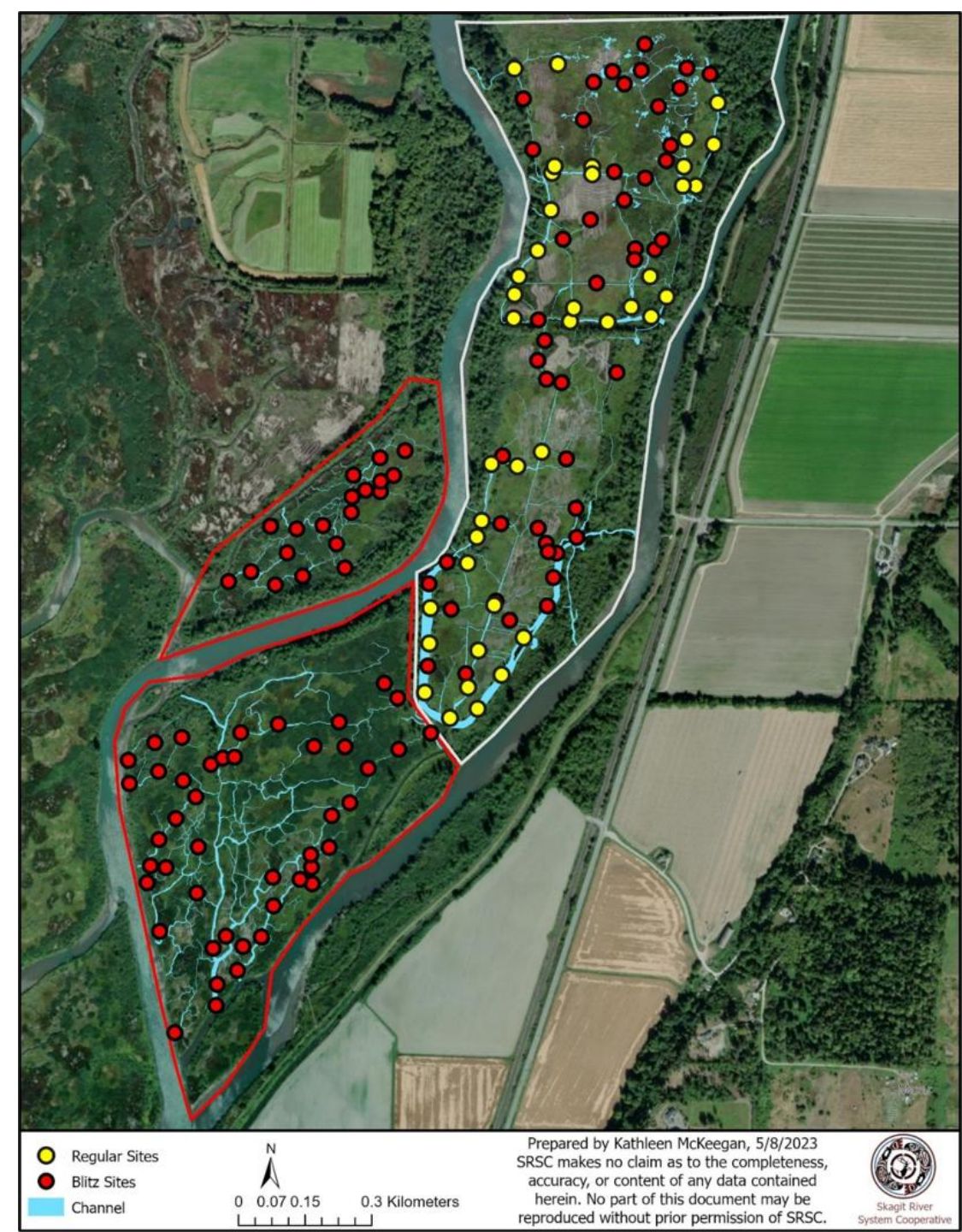


Reference Marsh

Milltown

Field Sampling

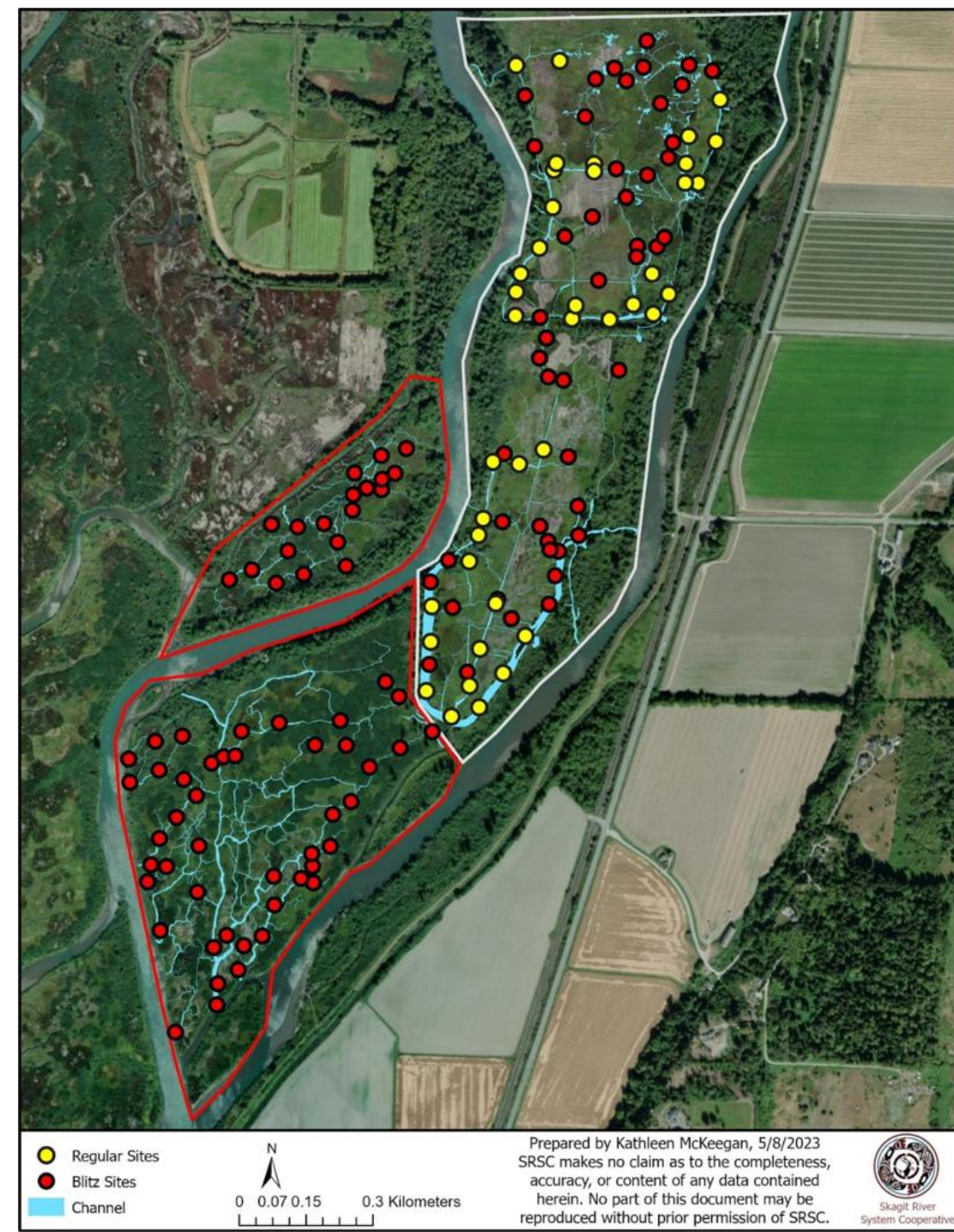
- Conducted a short term “Blitz” in 2023 prior to last phase of restoration
- Restoration/Reference stratified random design
- 4 Days during neep tide
- Focus on NoR Chinook subyearlings <100 mm



Field Sampling

- Site Covariates at each location

Covariate	Units
Water Temperature	°C
Salinity	psu
Dissolved Oxygen	mg/L
Water Velocity	m/s
Water Depth	m
Habitat Type	pond or channel
Channel Depth	m
Channel Width	m
Hydrologic Distance	m
Distance to nearest node	m
Beaver Habitat modification present	present or absent
Marsh type	Reference or Restoration



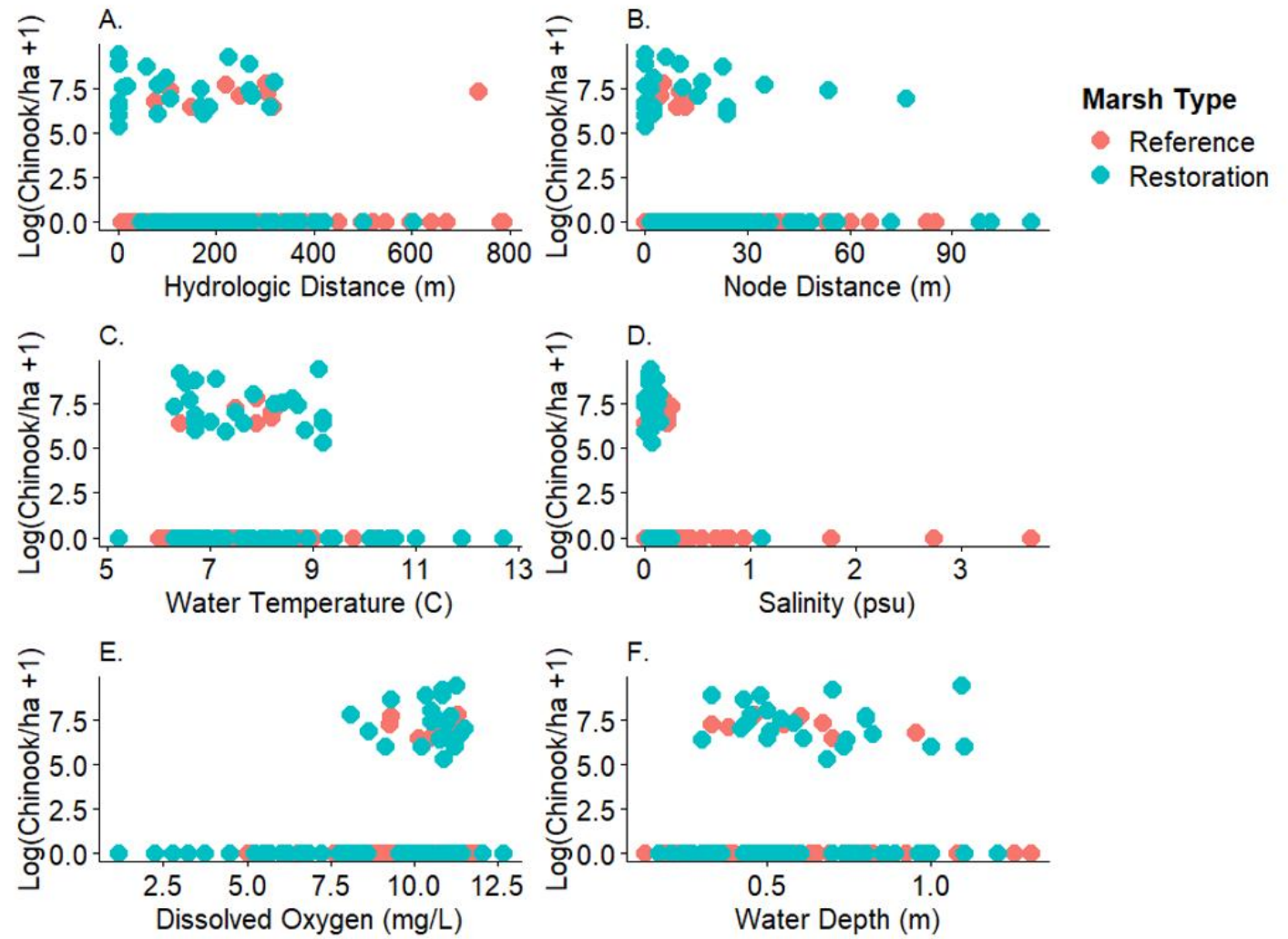
Results

- 116 locations, Chinook present in 32 locations

Category	# of Sites with Chinook	
	Absent	Present
Reference	53	9
Restoration	63	23
Channel	100	30
Pond	16	2
No Beaver	94	27
Beaver	22	5

Results

- Juvenile Chinook tended
 - To not swim far into networks
 - Stay close to nodes
 - In waters <11 C
 - DO > 7 mg/L
 - Water depths 0.4m to 1.1m

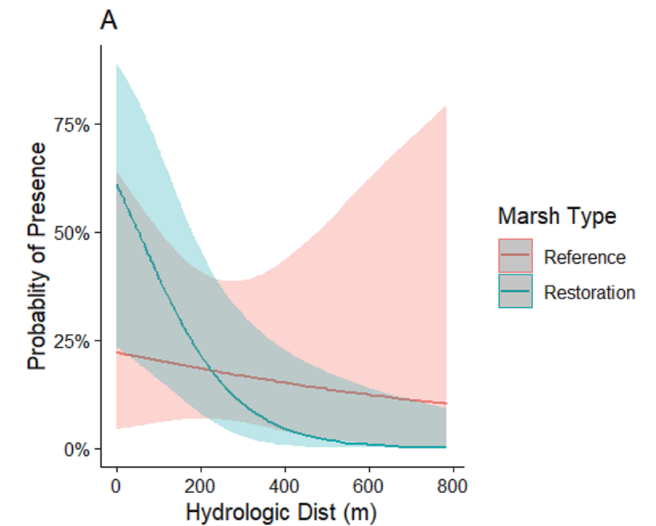
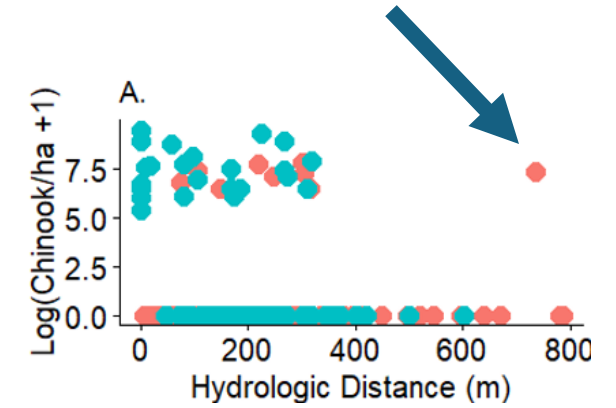
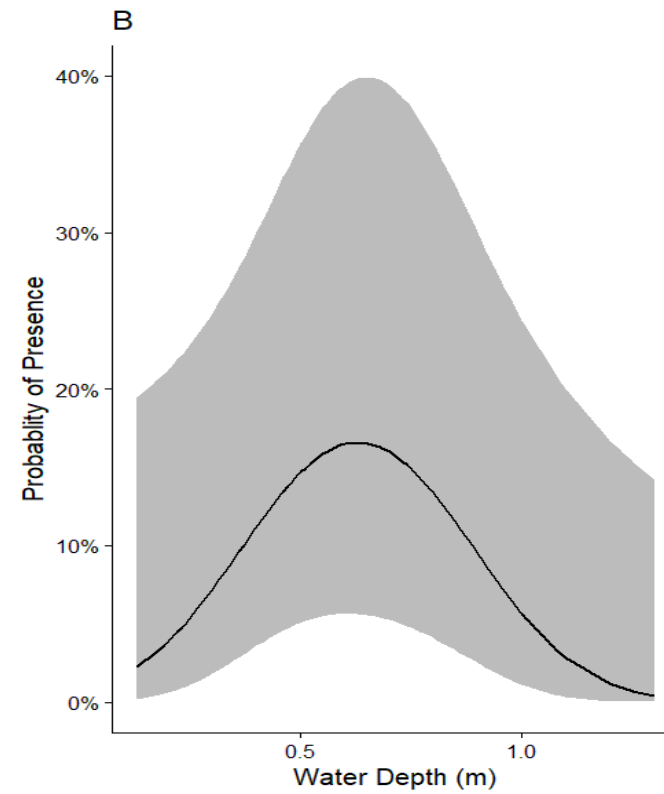
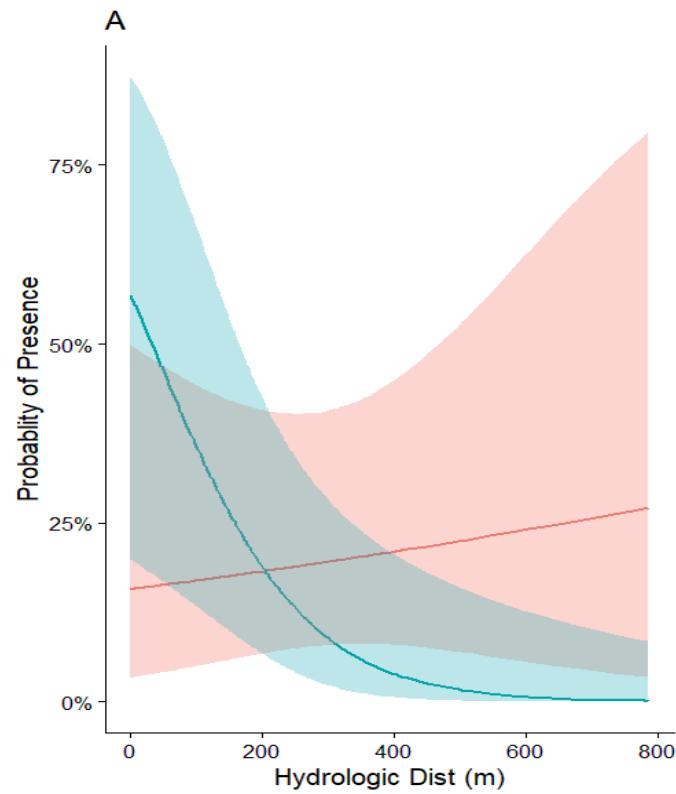


Results GLM-Binomial

Parameter	Est	St. Error	p
Int	-1.46	0.55	0.008**
Temperature	-0.05	0.28	0.867
Salinity	-2.13	1.55	0.171
Dissolved Oxygen	0.74	0.48	0.126
Node Distance	-0.63	0.36	0.082*
Water Depth	0.29	0.34	0.400
Water Depth^2	-0.6	0.28	0.033**
Habitat	-1.15	0.93	0.214
Beaver	-0.57	0.69	0.412
Marsh Type	-0.17	0.64	0.787
Hydrologic Distance	0.14	0.36	0.692
Marsh Type:Hydrologic Distance	-1.53	0.63	0.014**

** p = 0.05, * p = 0.10

Results GLM-Binomial



Density Dependence

Mean density and (standard error) in fish per hectare

Species	Reference		Restoration	
	Southern Marsh	Western Marsh	North Lobe	South Lobe
Chinook Salmon	222.7	161.7	641.3	906.4
	(85.1)	(129.4)	(284.6)	(384.9)

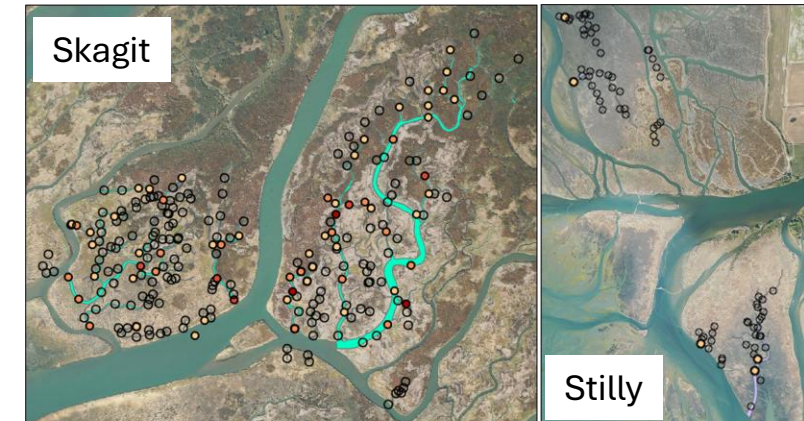
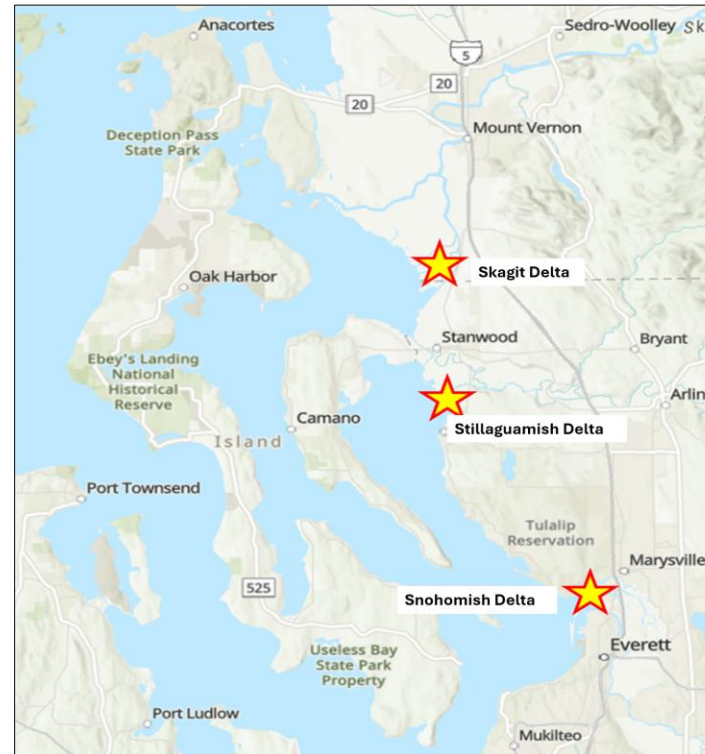
Greene et al. 2020 notes density dependent affects at 250 fish/ha

Conclusions

- The importance of considering dendritic network structure in estuaries was described early by Simenstad et al. 2000.
- Much work has been developed to describe the variation of natural channel network structure (e.g. channel allometry, Hood 2007).
- Juvenile Chinook distributions may be influenced by network topology attributes that may reduce the efficacy of increasing capacity
- Additional work is needed
 - Continue improving our understanding of reference network structures and juvenile Chinook distributions within them
 - Link channel network observations with Restoration Practicioners

Looking Forward

- 2027 Blitz sampling in Milltown
- WDFW HSIL Tidal Channel Geometry Project



Thank You – Questions mlemoine@skagitcoop.org

Skagit Delta

