Estuaries as nursery habitats for salmon: from science to stewardship

Jonathan Moore

jwmoore@sfu.ca

www.jonwmoore.org

SFU

SIMON FRASER UNIVERSITY

Salmon Watersheds Lab

APPROACH

- Big Data Analyses
- Field Research
- Collaboration

Salmon Watersheds Lab

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Estuary resilience

Nature Trust British Columbia

Hakai Science on the Coastal Margin

British Columbia

Canada

Ducks Unlimited Canada

Habitat Conservation Trust Foundation

Salmon Watersheds Lab

CCIRA

Haida Nation

K'ómoks First Nation

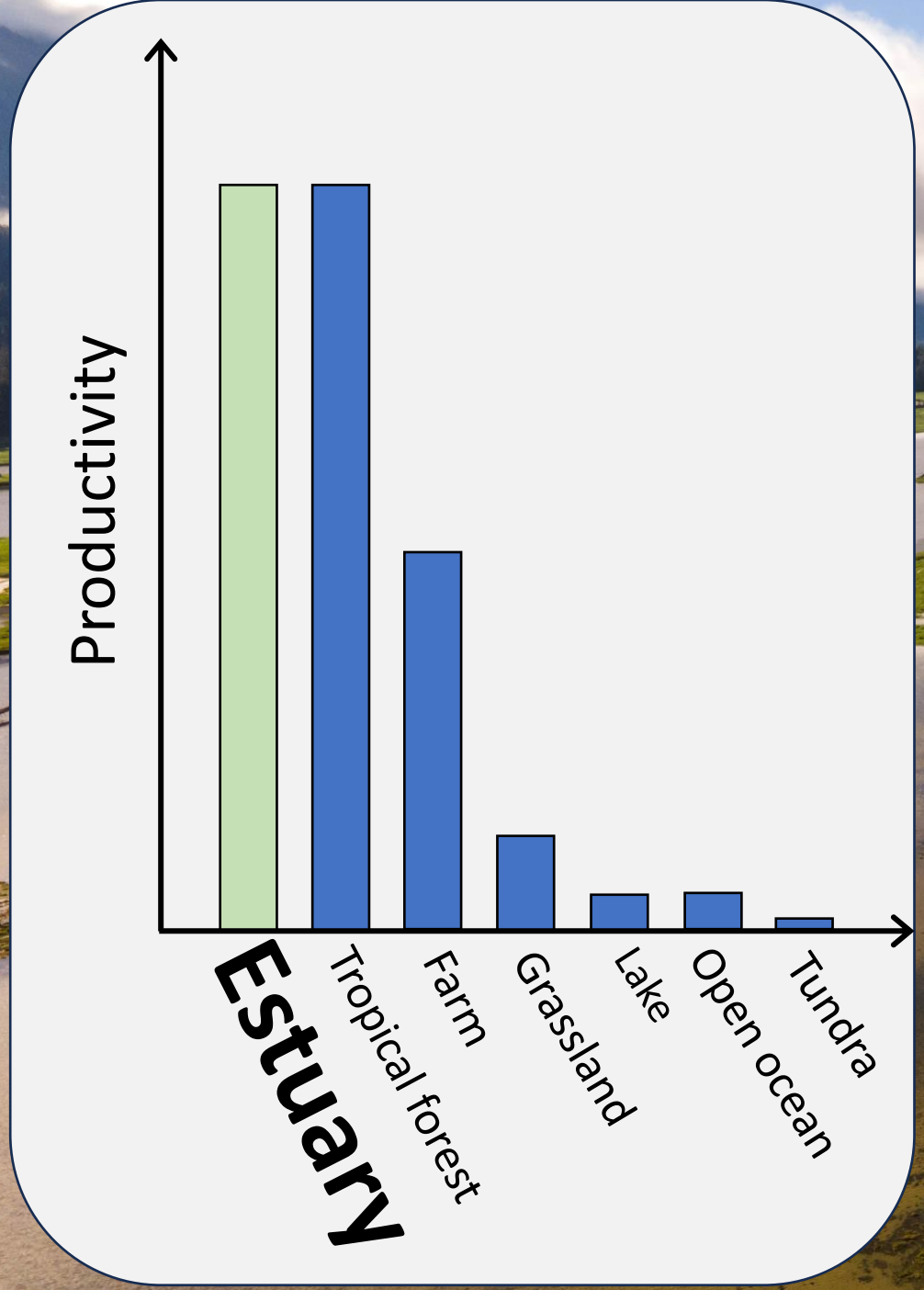
Kwakiutl First Nation

Ngnwakolas Council

Tlowitsis Nation

Uu-a-thluk Taking Care Of

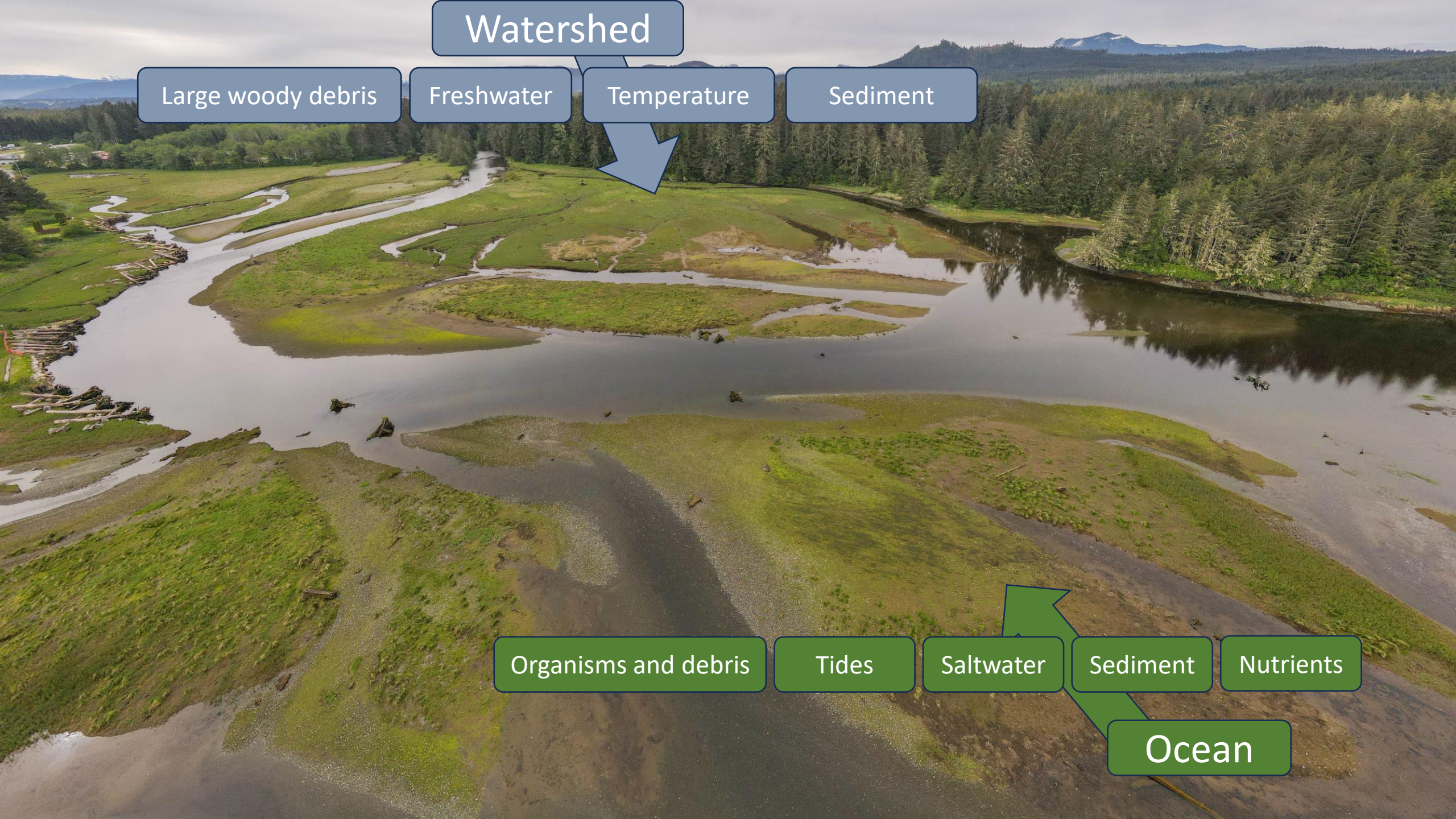

ESTUARIES AS COMPLEX SYSTEMS
ESTUARIES IN THE SALMON LIFE CYCLE
STRESSORS—EMERGING AND PAST
KEY TAKE-HOMES

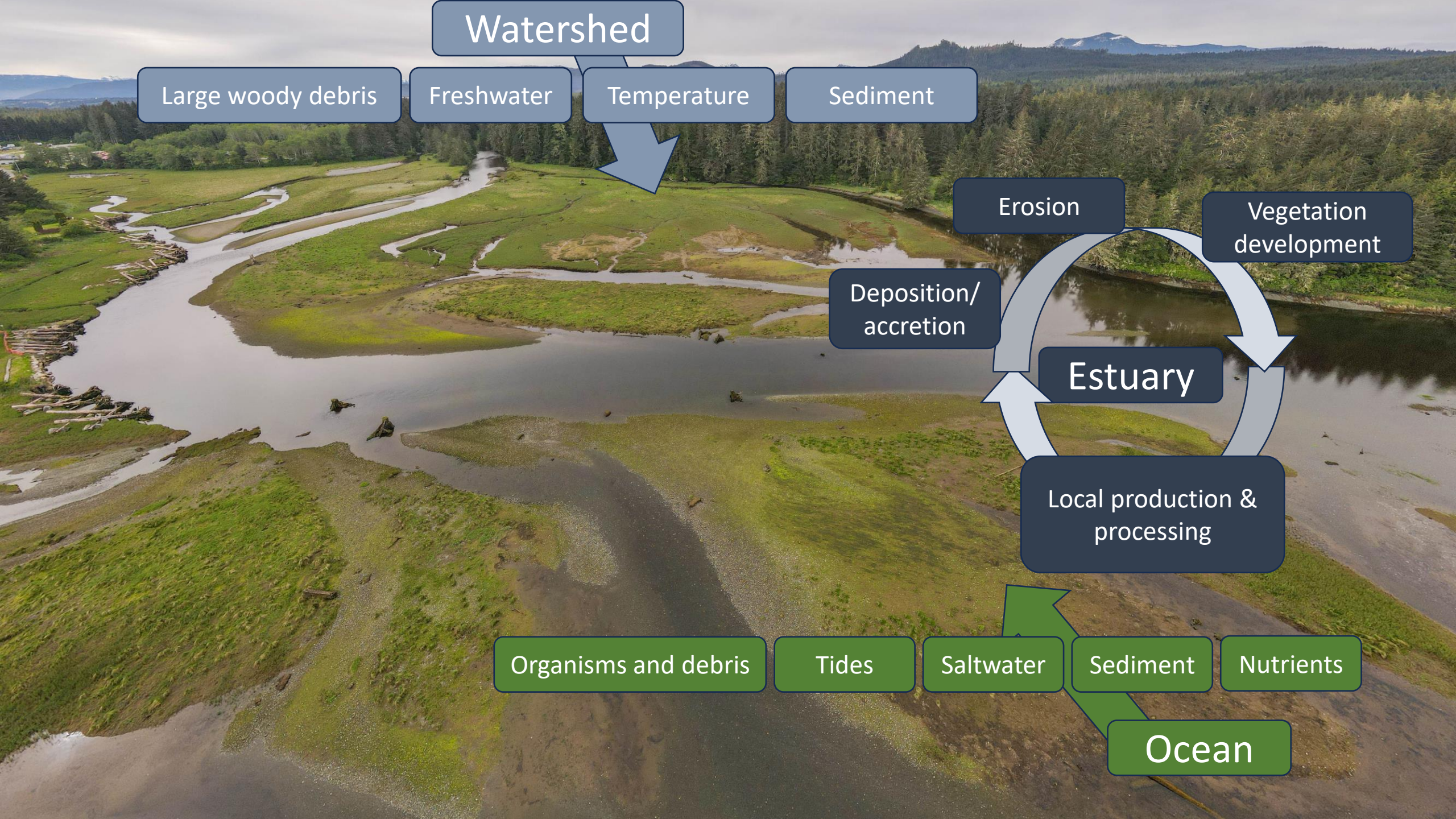


Estuaries are among most productive habitats on Earth

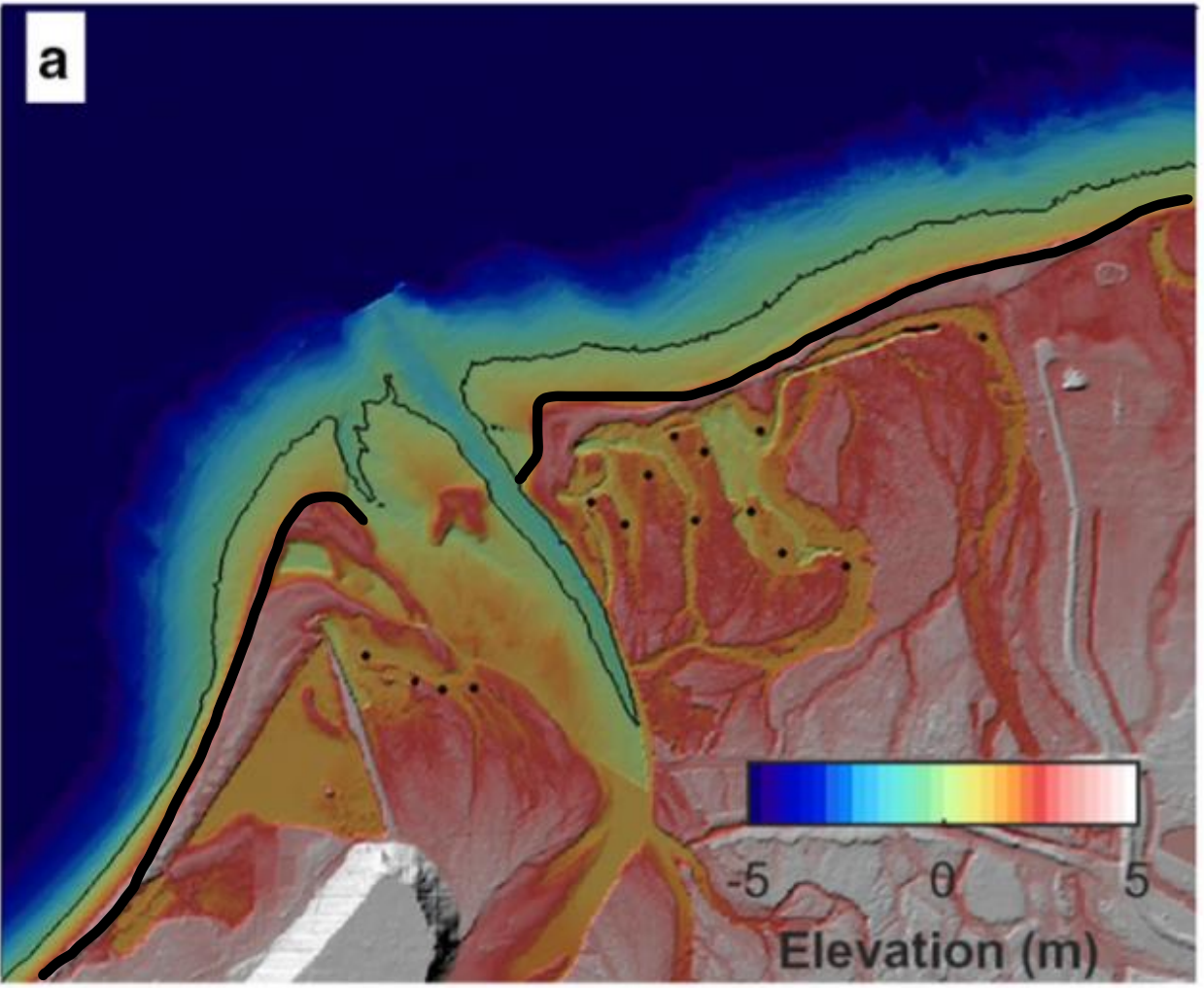
Estuaries are among most degraded habitats on Earth

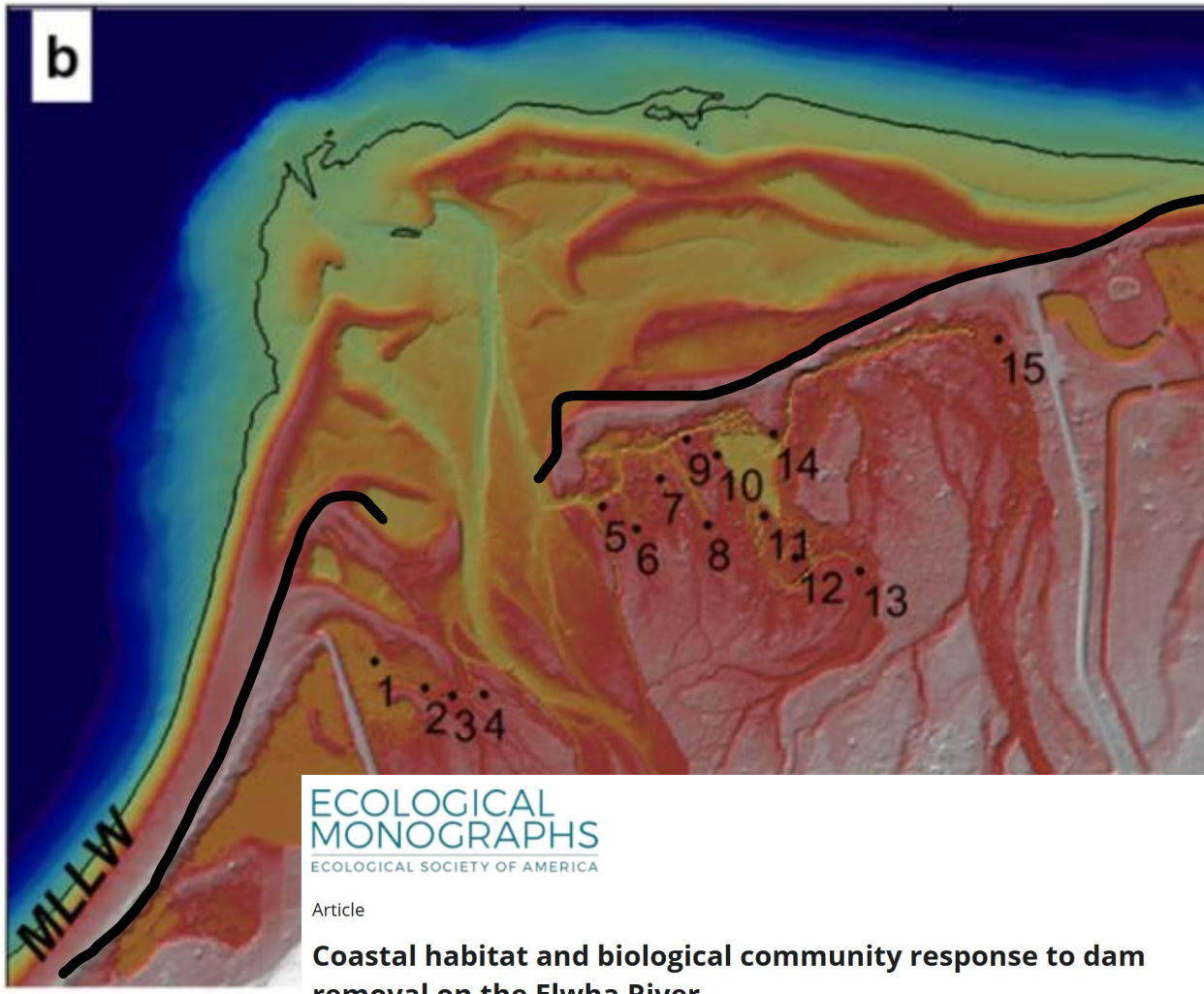
Data from Horne and Goldman 1994


Watershed
Large woody debris
Freshwater
Temperature
Sediment
Organisms and debris
Tides
Saltwater
Sediment
Nutrients
Ocean


Watershed
Large woody debris
Freshwater
Temperature
Sediment
Erosion
Vegetation development
Deposition/ accretion
Estuary
Local production & processing
Organisms and debris
Tides
Saltwater
Sediment
Nutrients
Ocean

Dam removals on Elwha (WA) added 3 M m^3 of sediment and increased estuary habitat area by 300,000 m^2





ECOLOGICAL MONOGRAPHS
ECOLOGICAL SOCIETY OF AMERICA

Article

Coastal habitat and biological community response to dam removal on the Elwha River

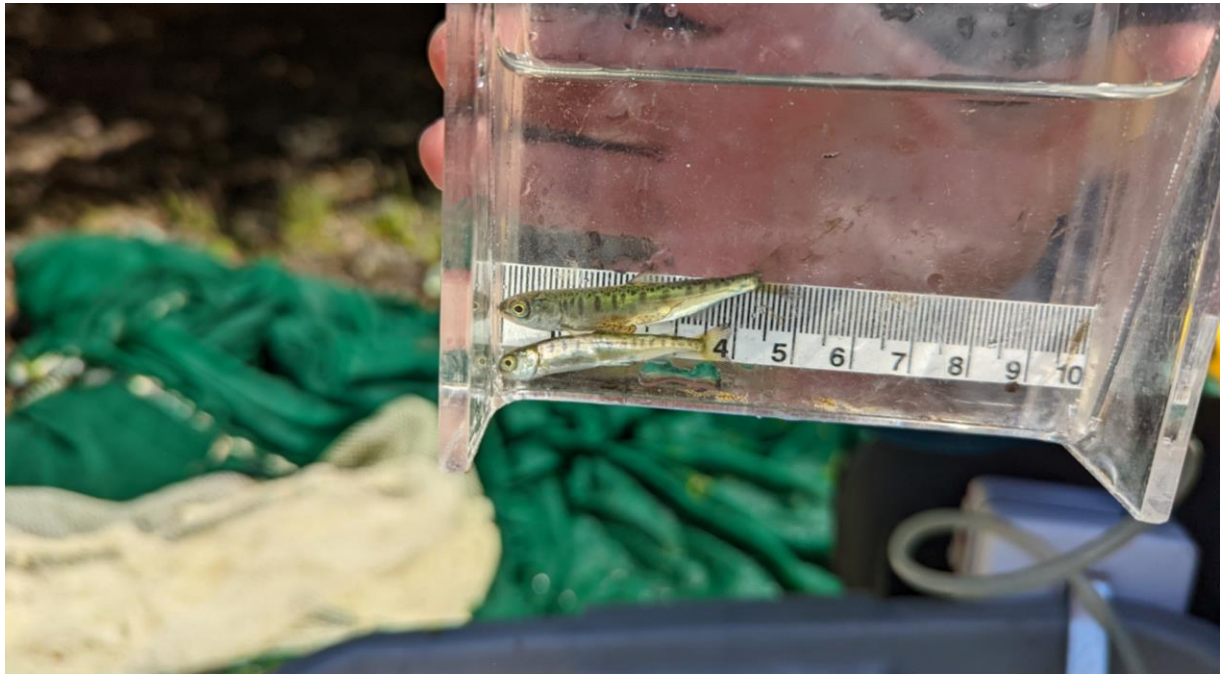
Melissa M. Foley, Jonathan A. Warrick, Andrew Ritchie, Andrew W. Stevens, Patrick B. Shafroth, Jeffrey J. Duda, Matthew M. Beirne, Rebecca Paradis, Guy Gelfenbaum, Randall McCoy, Erin S. Cubley

First published: 21 June 2017 | https://doi.org/10.1002/ecm.1268 | Citations: 50


1 2 3 4 5 6 7 8 9 10


centimetres-10centimetres(cm)


3 4 5 6


4 5 6 7 8 9 10


I am not a juvenile salmon


ESTUARIES AS COMPLEX SYSTEMS
ESTUARIES IN THE SALMON LIFE CYCLE
STRESSORS—EMERGING AND PAST
PATHS FORWARD

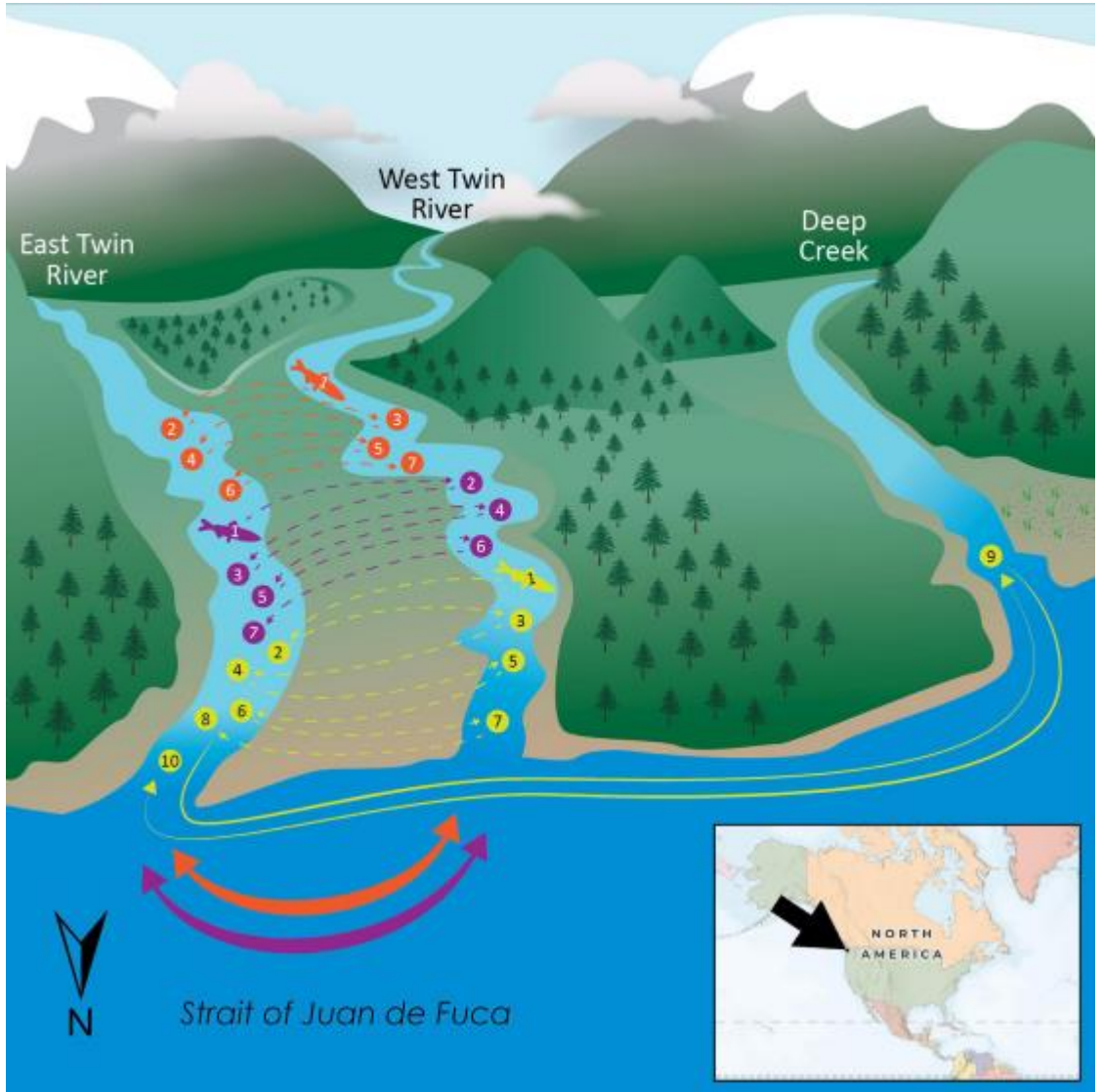
Estuaries and the salmon life cycle

1. Regional

2. Estuary

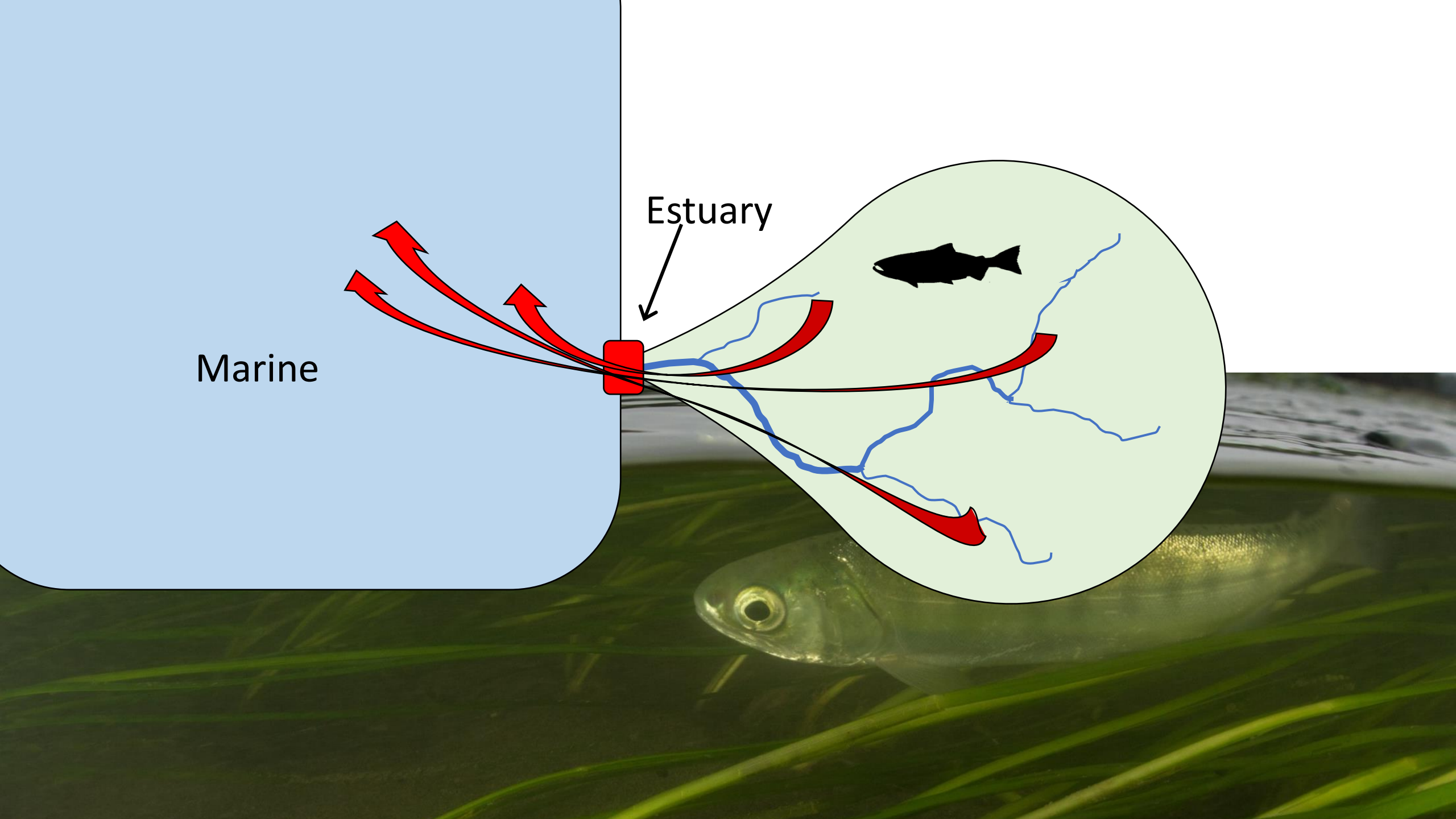
3. Within estuary

Migrating salmonids can use multiple estuaries



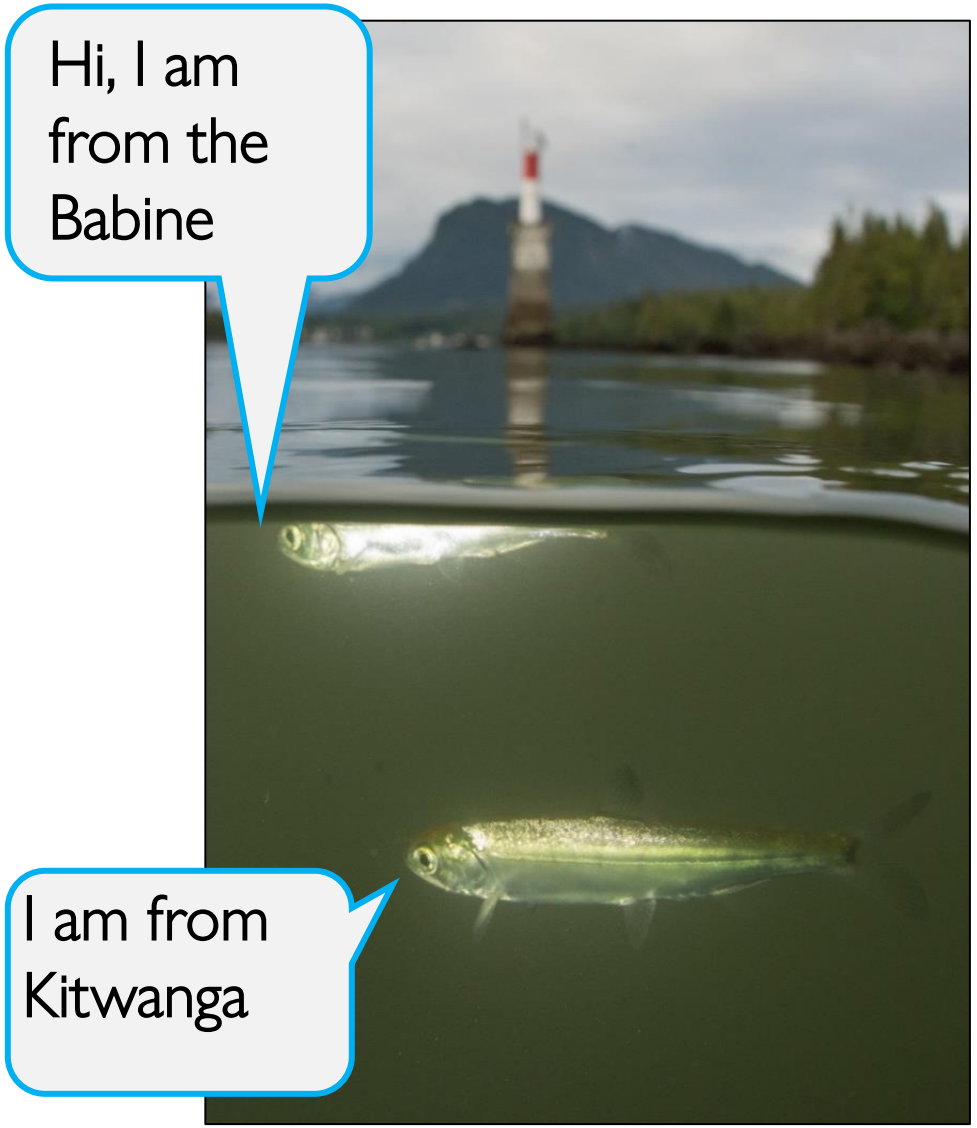
Juvenile salmonids traverse coastal meta-nurseries that connect rivers via the sea

Stuart H Munsch[1*], Todd R Bennett[2], Jimmy Faukner[3], Madison J Halloran[4], Karrie M Hanson[2], Martin C Liermann[2], Michael L McHenry[5], John R McMillan[6], Raymond E Moses[5], Bob Pagliuco[7], George R Pess[2], Katherine R Stonecypher[4], and Darren M Ward[4]

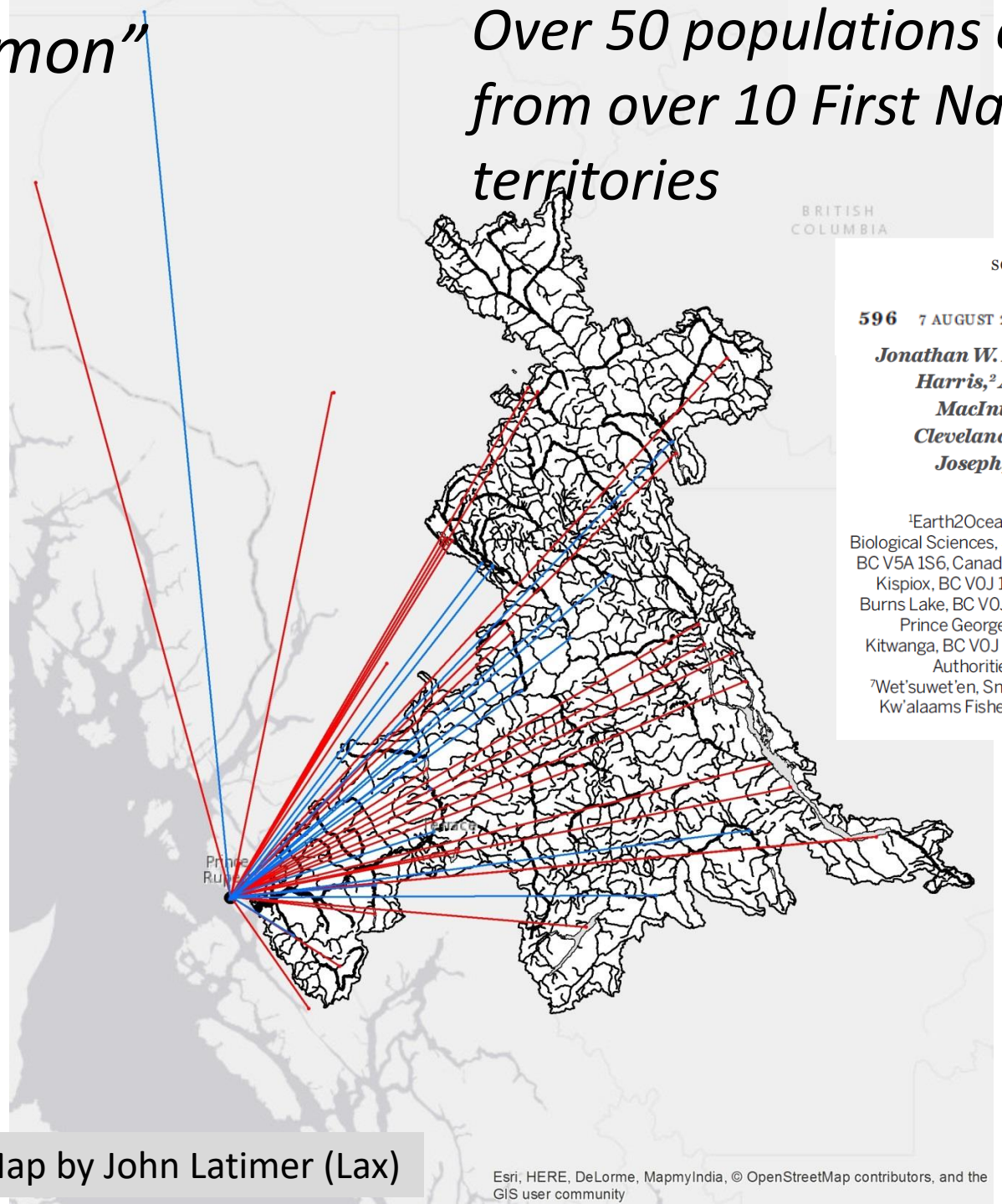

Estuary
Marine

"Grand Central Station for salmon"

Allen Gottesfeld, Skeena Fisheries Commission



Over 50 populations of salmon from over 10 First Nation territories



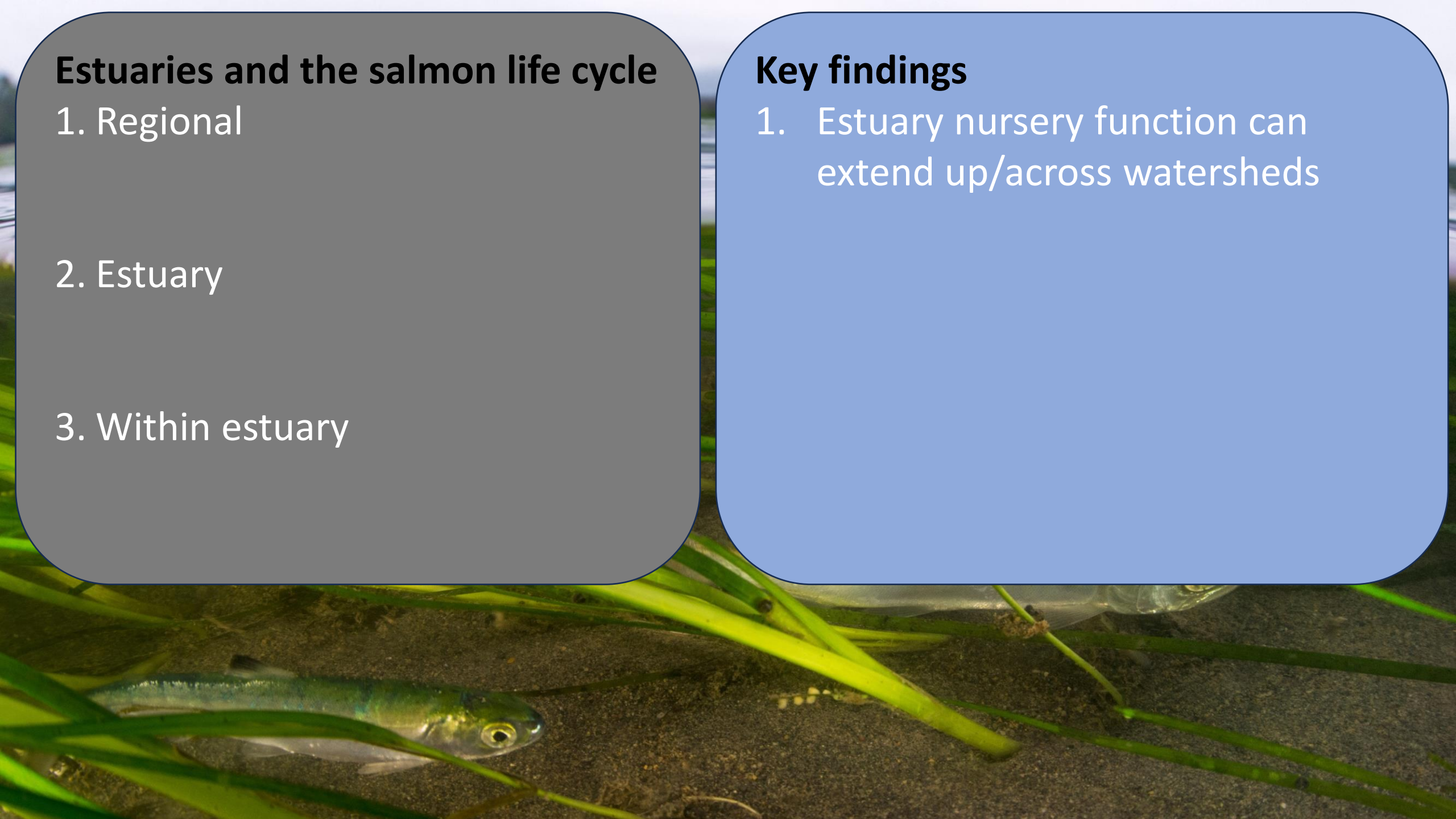
Map by John Latimer (Lax)

sciencemag.org **SCIENCE**

596 7 AUGUST 2015 • VOL 349 ISSUE 6248

Jonathan W. Moore,[1] Charmaine Carr-Harris,[2] Allen S. Gottesfeld,[2] Donna MacIntyre,[3] David Radies,[4] Mark Cleveland,[5] Chris Barnes,[2,6]† Walter Joseph,[7] Glen Williams,[5] Jennifer Gordon,[8] Bill Shepert[8]*

[1]Earth2Ocean Research Group, Department of Biological Sciences, Simon Fraser University, Burnaby, BC V5A 1S6, Canada. [2]Skeena Fisheries Commission, Kispiox, BC V0J 1Y4, Canada. [3]Lake Babine Nation, Burns Lake, BC V0J 1E0, Canada. [4]Takla Lake Nation, Prince George, BC V2L 2Y9, Canada. [5]Gitanyow, Kitwanga, BC V0J 2A0, Canada. [6]Gitxsan Watershed Authorities, Hazelton, BC V0J 1Y0, Canada. [7]Wet'suwet'en, Smithers, BC V0J 2N1, Canada. [8]Lax Kw'alaams Fisheries, Lax Kw'alaams, BC V0V 1H0, Canada.



Estuaries and the salmon life cycle

1. Regional

2. Estuary

3. Within estuary

Key findings

1. Estuary nursery function can extend up/across watersheds

Survival of Chinook salmon is lower in more degraded estuaries

Estuaries Vol. 26, No. 4B, p. 1094–1103 August 2003

Estuarine Influence on Survival Rates of Coho (*Oncorhynchus kisutch*) and Chinook Salmon (*Oncorhynchus tshawytscha*) Released from Hatcheries on the U.S. Pacific Coast

A. Magnusson* and R. Hilborn

Estuaries as critical habitats for young salmon

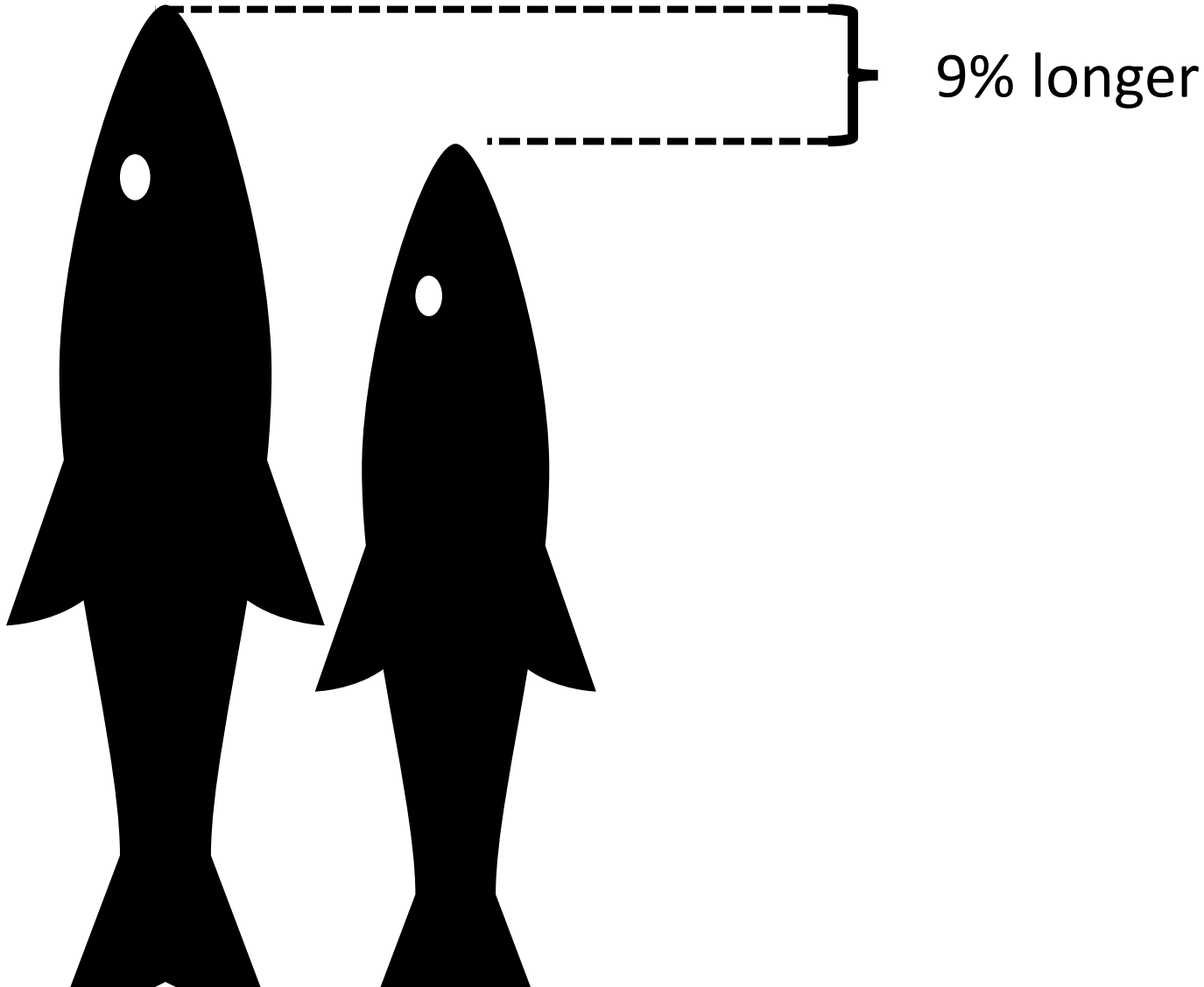
- Extensive estuary residency (up to 40 days)
- Fast estuary growth rates (upwards of 5X typical freshwater growth)
- 9% increase in body size prior to ocean entry

Hakai
Science on the Coastal Margin

Heiltsuk Nation

Sawyer et al. 2023. Ecosphere

Growth benefits of estuary nursery habitat



Growth benefits of estuary nursery habitat

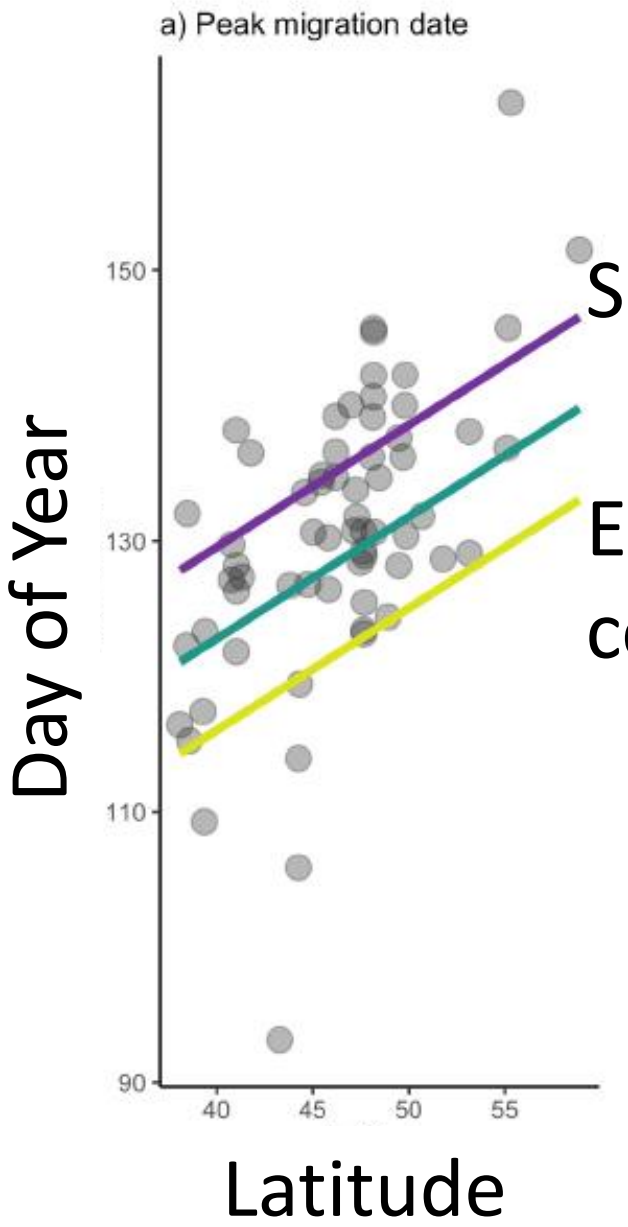
Lebron James: 6’ 7” Luka Doncic = 6’ 6” Jon Moore = 6’ 1” (on a tall day)

8.2% taller

Estuaries as critical habitats for young salmon

- Extensive estuary residency (up to 40 days)
- Fast estuary growth rates (upwards of 5X freshwater growth)
- 9% increase in body size prior to ocean entry

Estuaries shape salmon life-histories



Simple, open

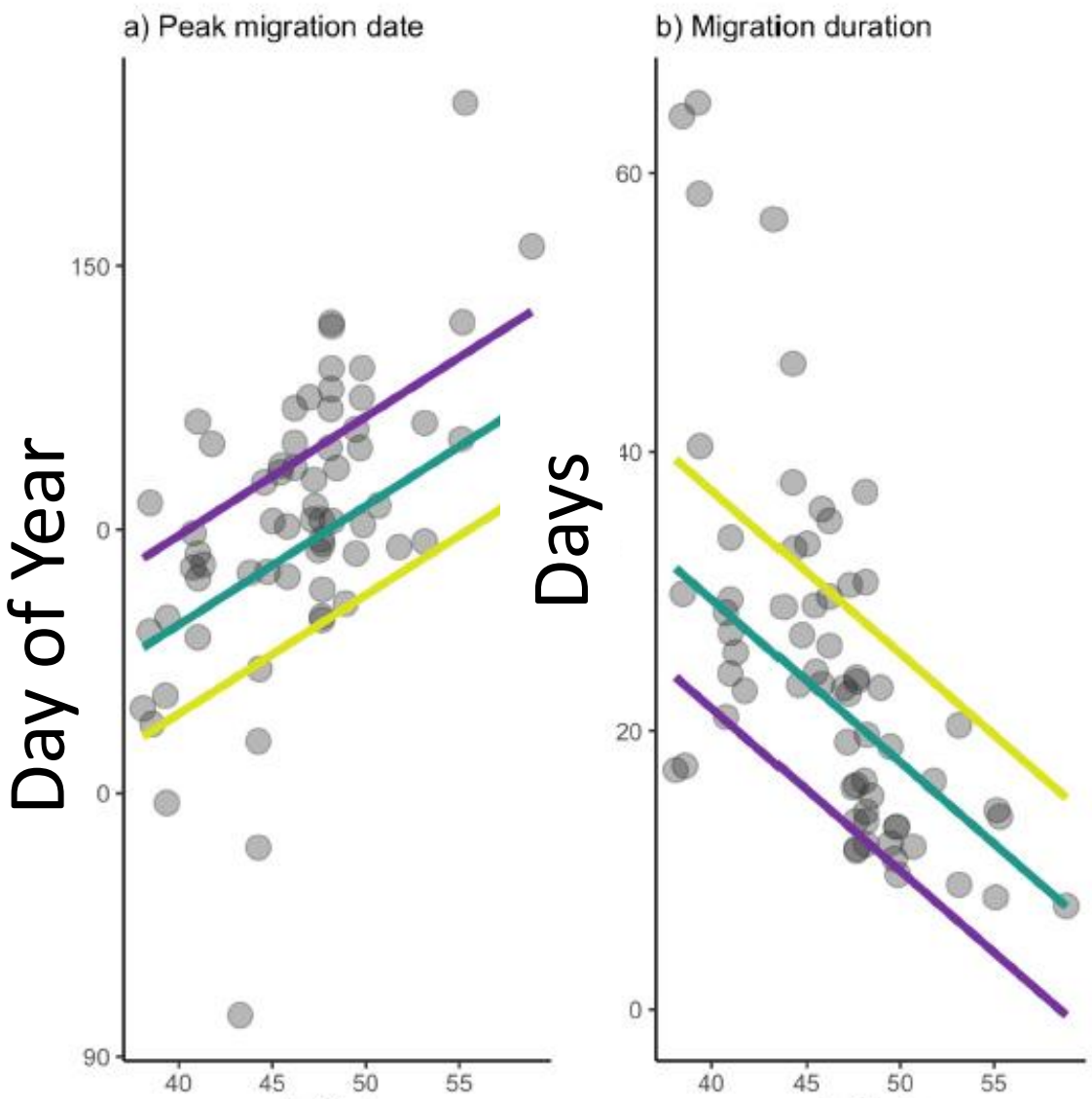
Enclosed, complicated

With more enclosed and complicated estuaries . . .

coho migrate earlier

Sawyer, Masters Thesis

Estuaries shape salmon life-histories



With more enclosed and complicated estuaries . . .

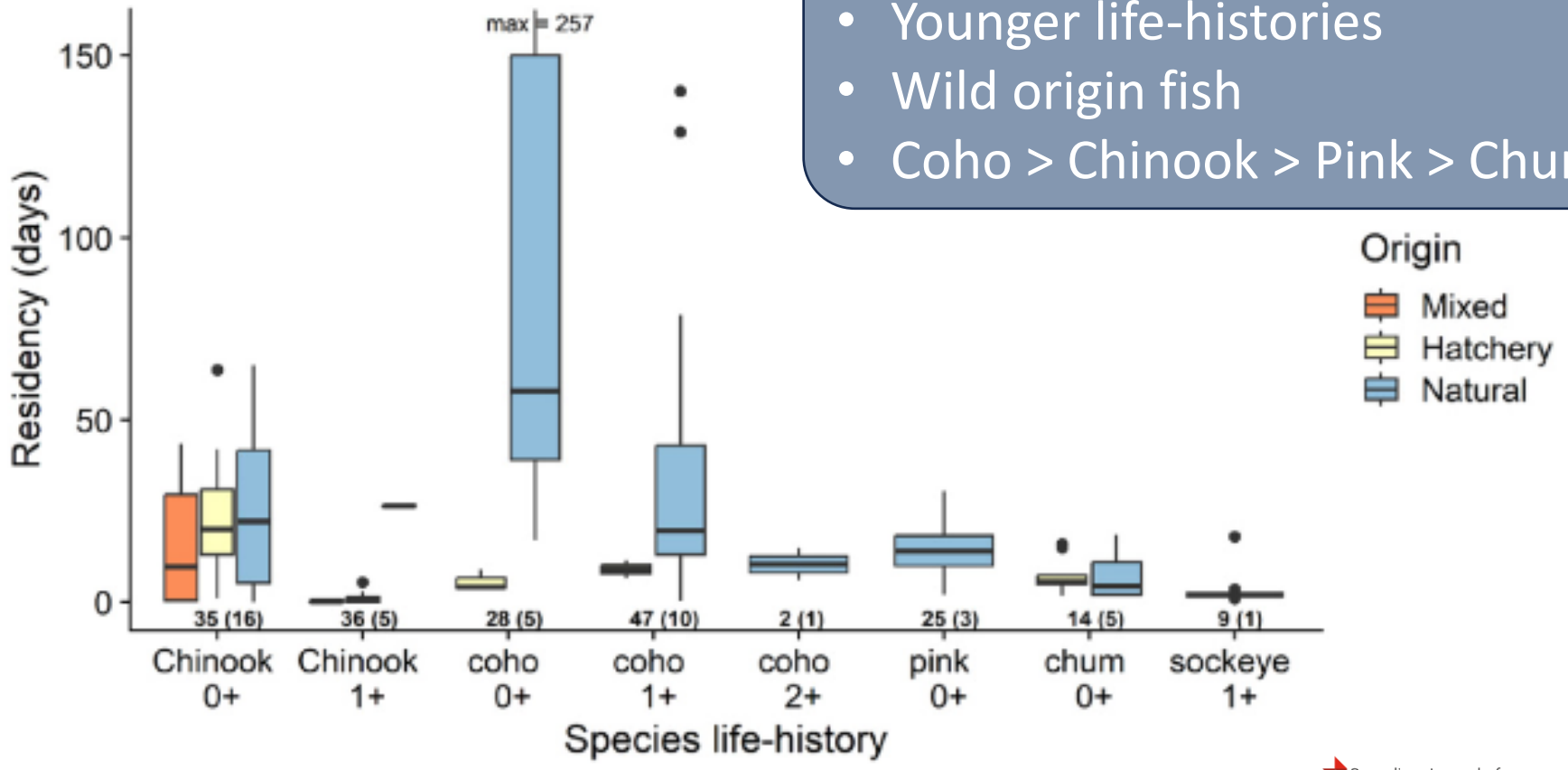
coho migrate earlier & over a longer duration

Sawyer, Masters Thesis

Estuary use varies across species, population

Estuary residency longer:

- Younger life-histories
- Wild origin fish
- Coho > Chinook > Pink > Chum > Sockeye



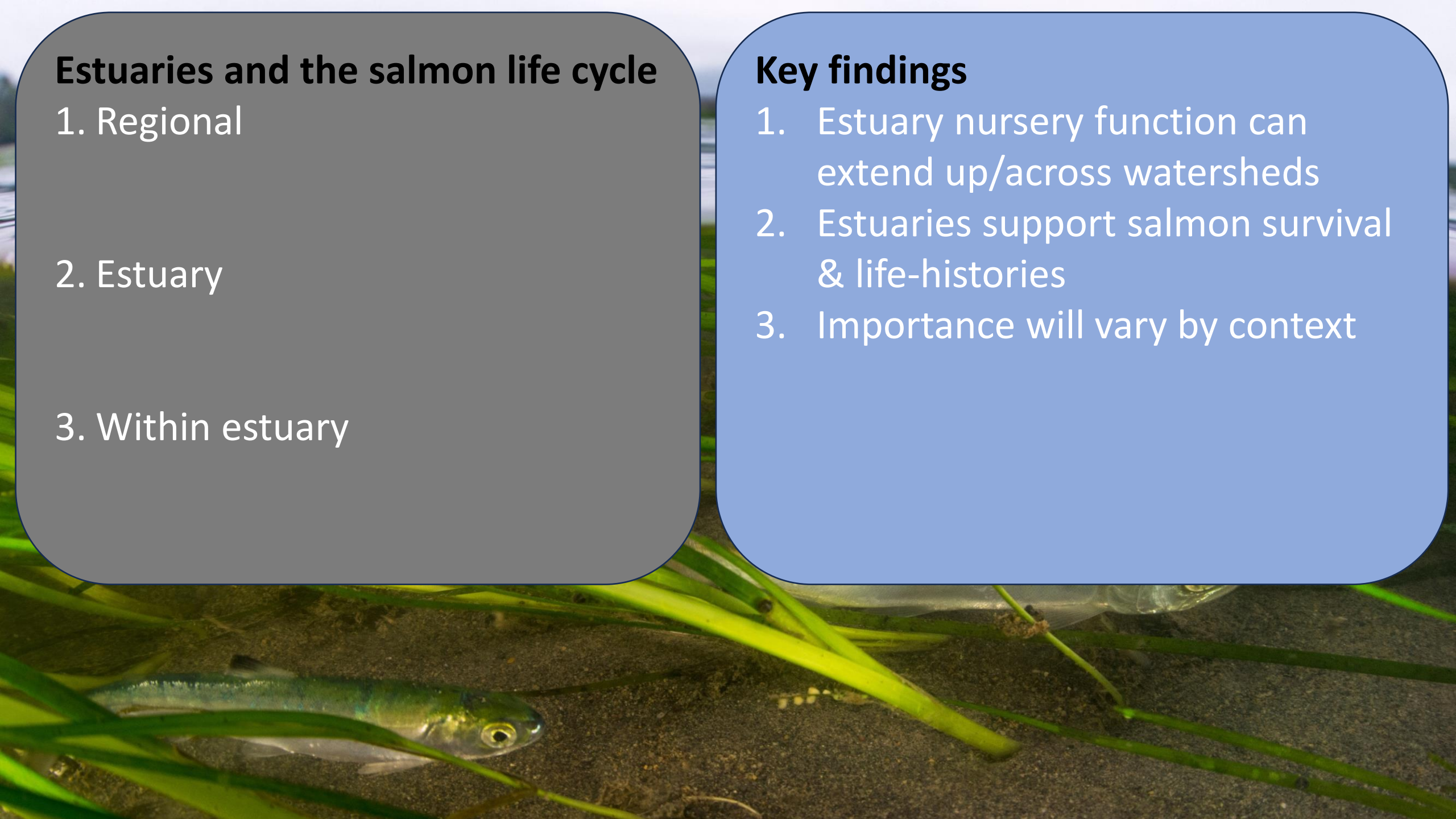
Canadian Journal of Fisheries and Aquatic Sciences

OPEN ACCESS | Article

The estuarine growth and residency of juvenile Pacific salmon in North America: a compilation of empirical data

Michael Arbeider[a], Violaine Pemberton-Renaud[b], Emma E. Hodgson[b], and Jonathan W. Moore[a]

[a]Earth to Ocean Research Group, Simon Fraser University, Burnaby, BC V5A 1S6, Canada; [b]Cultus Lake Salmon Research Laboratory, Freshwater Ecosystems Section, Fisheries and Oceans Canada, Cultus Lake, BC V2R 5B6, Canada



Estuaries and the salmon life cycle

1. Regional

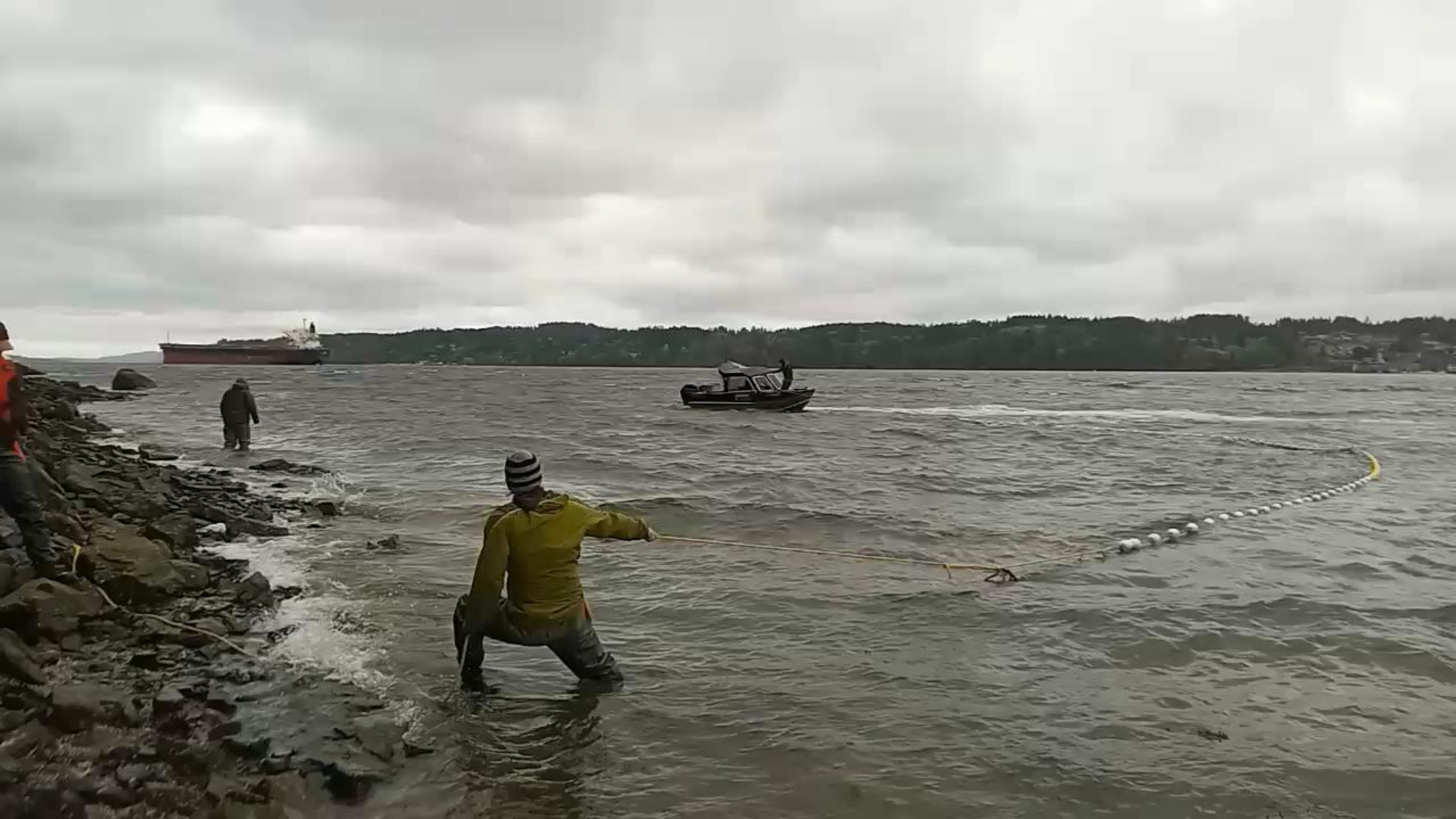
2. Estuary

3. Within estuary

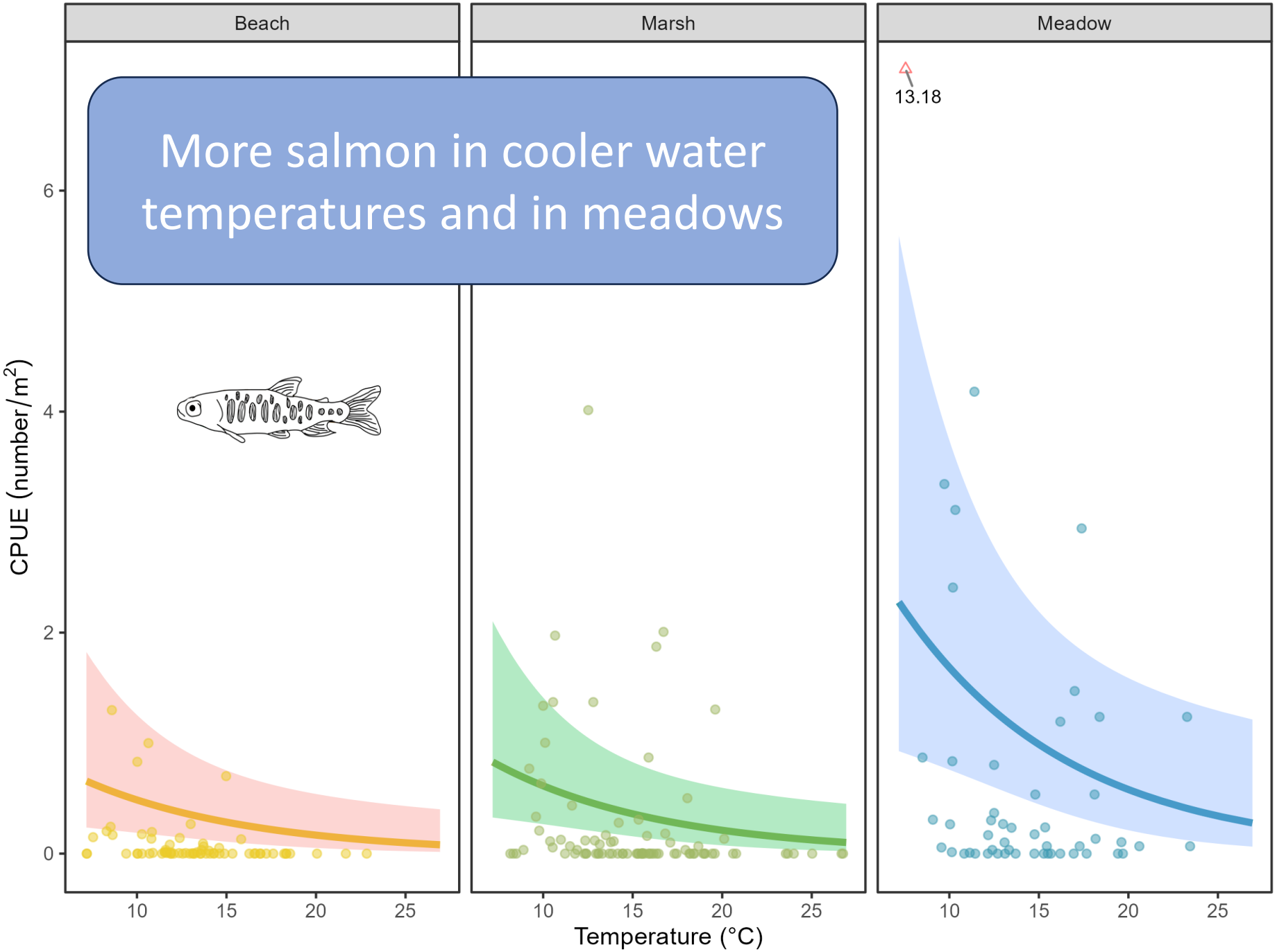
Key findings

1. Estuary nursery function can extend up/across watersheds
2. Estuaries support salmon survival & life-histories
3. Importance will vary by context

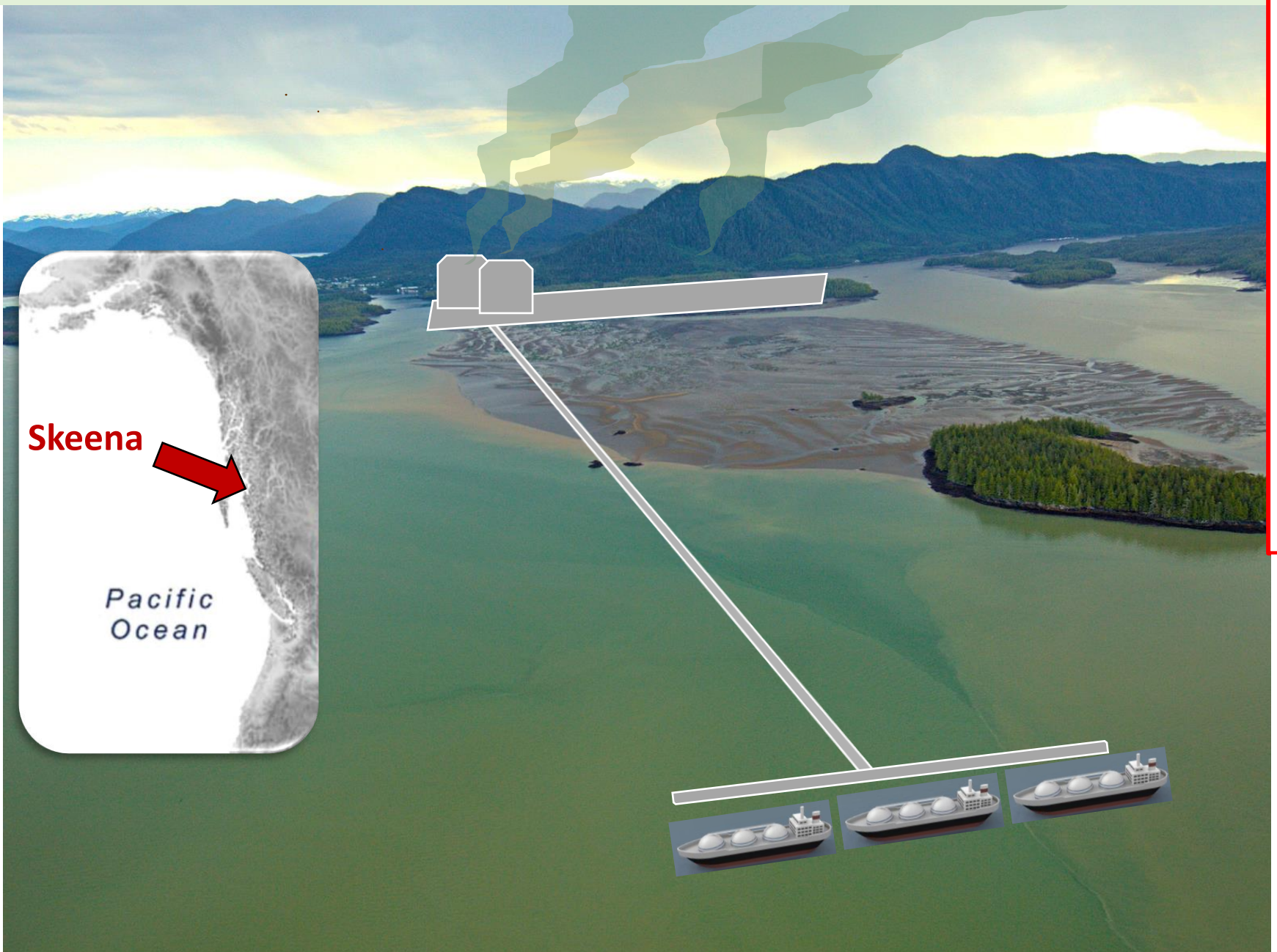

River
Marsh
Mudflat
Eelgrass
Beach

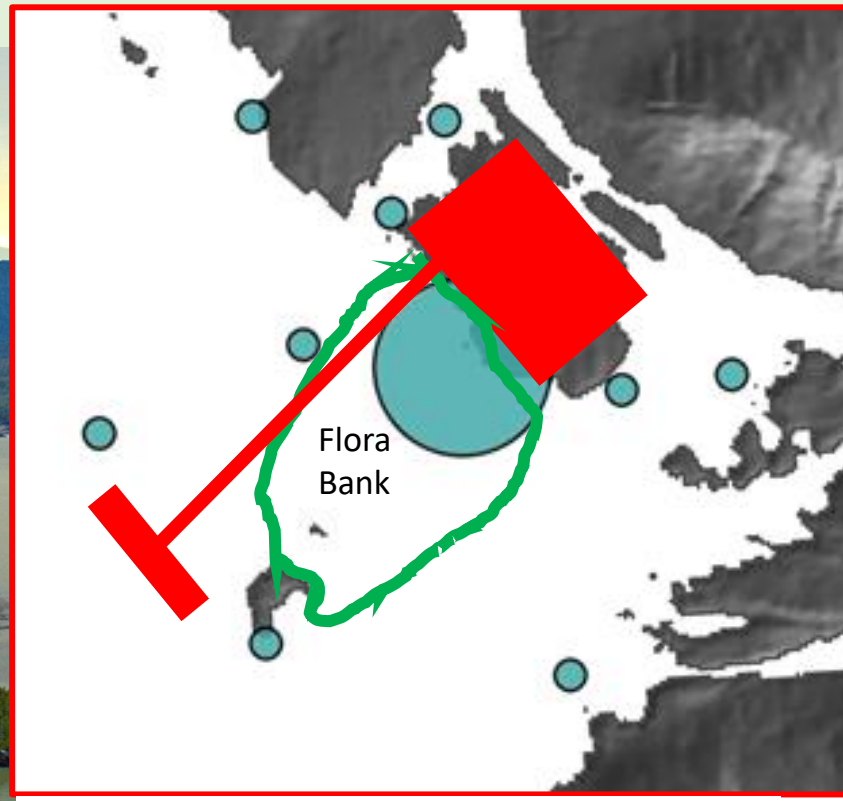


More salmon in cooler water temperatures and in meadows



Use of habitats varies within estuaries

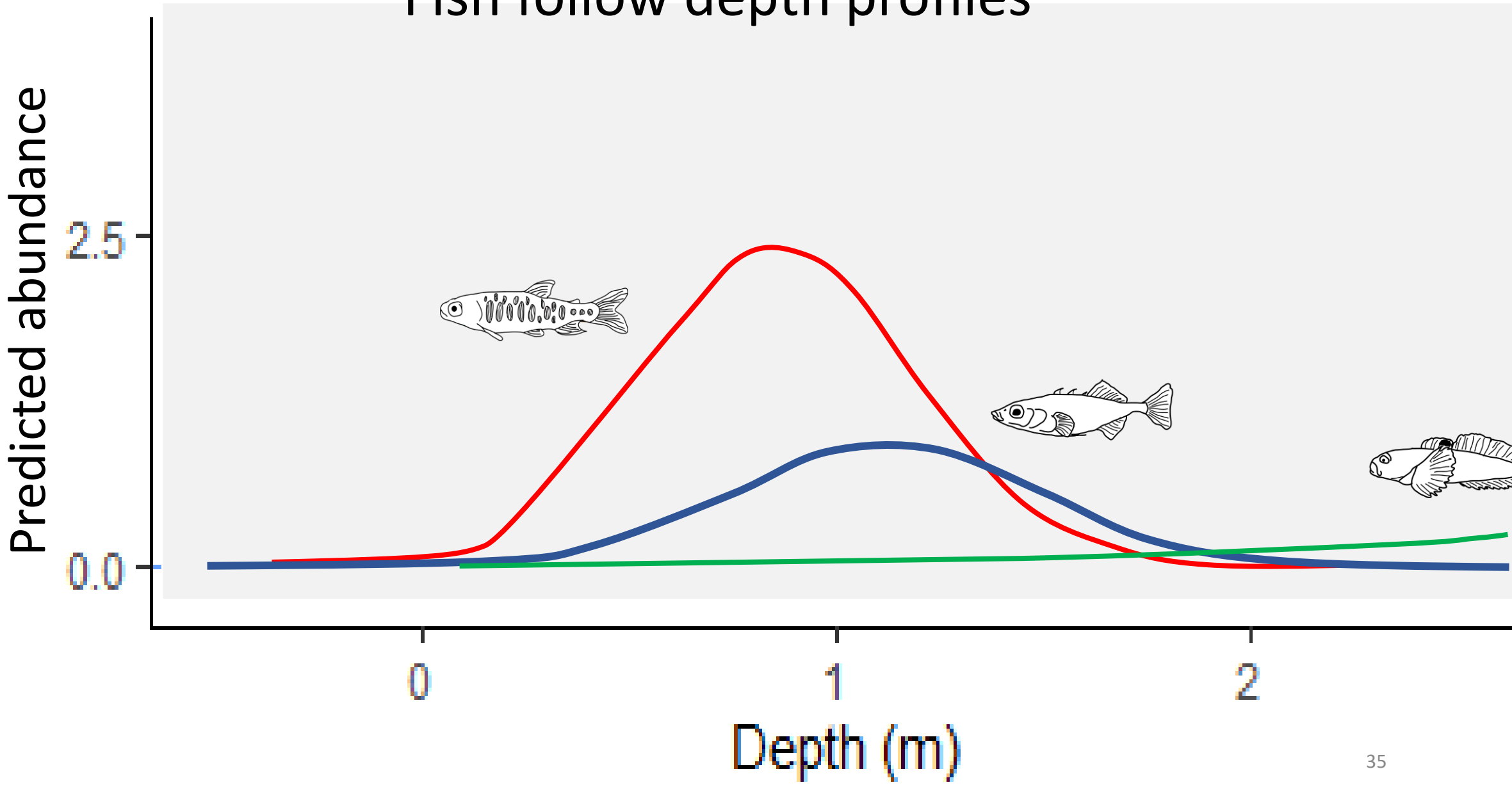




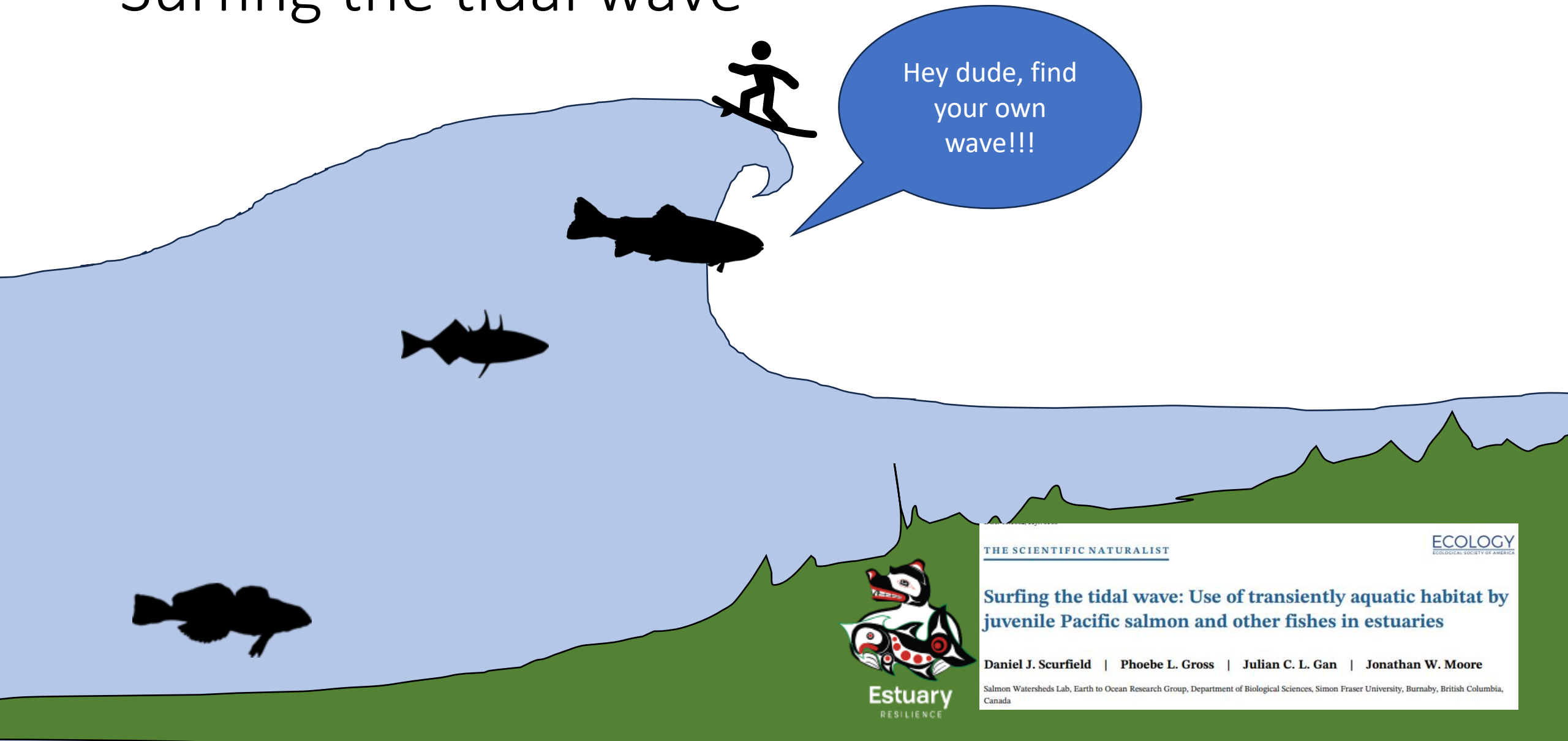
Eelgrass in Flora Bank region contained ~25X more salmon than other eelgrass habitats.


Camera 4, Site Elevation: 3.20m
Salmon Estuary, N. Vancouver Island BC

Fish follow depth profiles



Surfing the tidal wave



Estuary
RESILIENCE

THE SCIENTIFIC NATURALIST

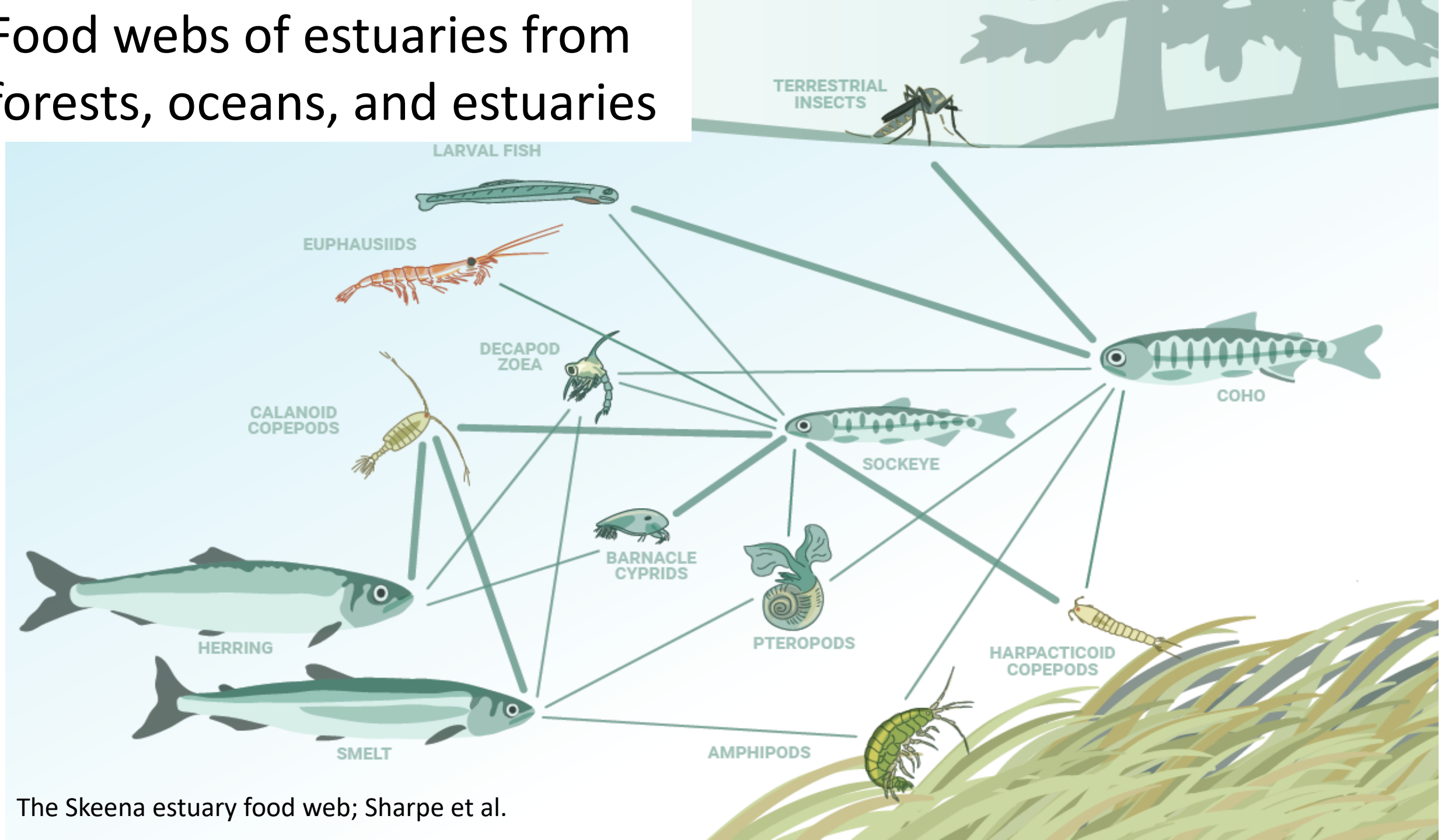
ECOLOGY
ECOLOGICAL SOCIETY OF AMERICA

Surfing the tidal wave: Use of transiently aquatic habitat by juvenile Pacific salmon and other fishes in estuaries

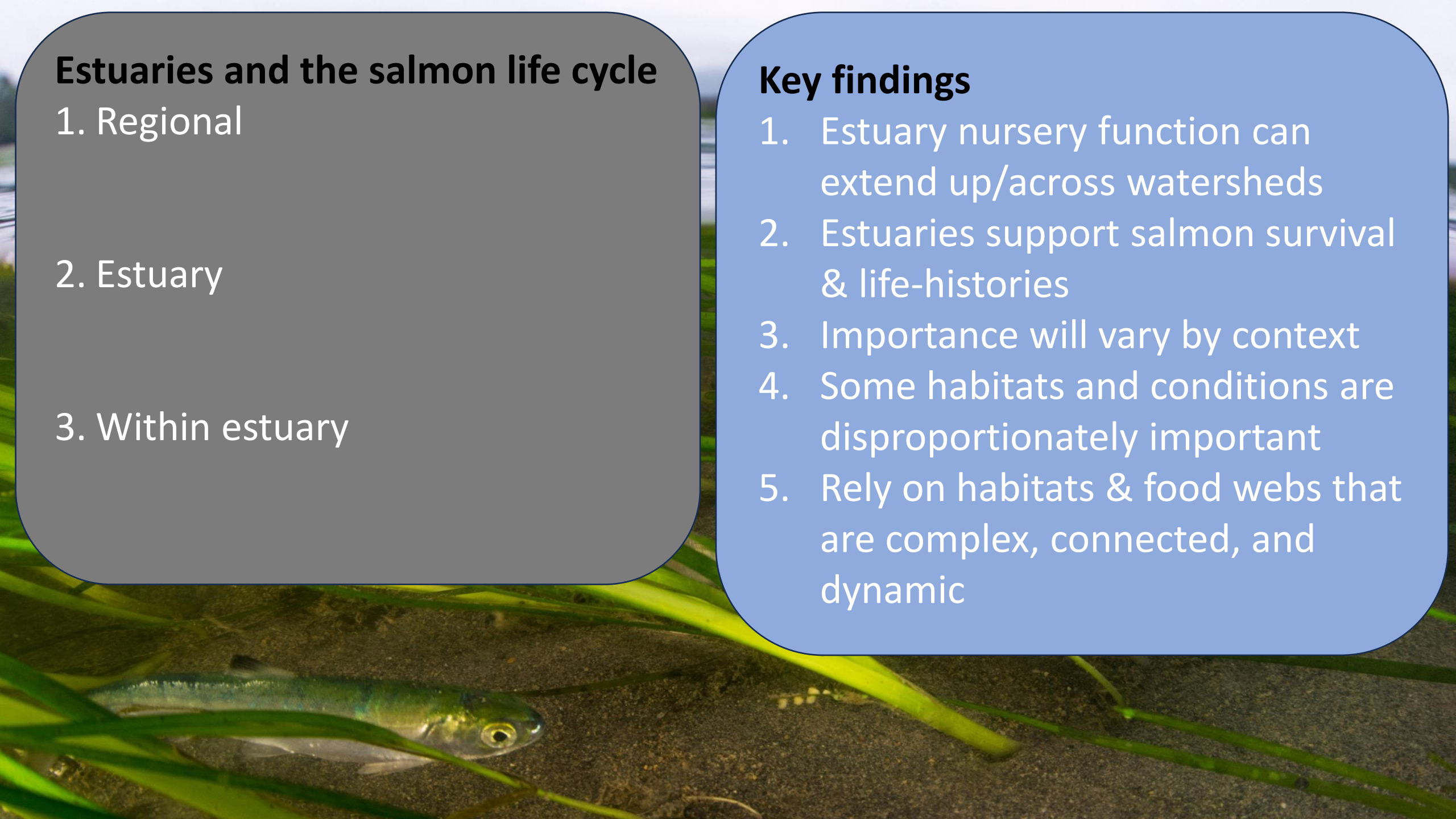
Daniel J. Scurfield | Phoebe L. Gross | Julian C. L. Gan | Jonathan W. Moore

Salmon Watersheds Lab, Earth to Ocean Research Group, Department of Biological Sciences, Simon Fraser University, Burnaby, British Columbia, Canada

Food webs of estuaries from forests, oceans, and estuaries



The Skeena estuary food web; Sharpe et al.



Estuaries and the salmon life cycle

1. Regional

2. Estuary

3. Within estuary

Key findings

1. Estuary nursery function can extend up/across watersheds
2. Estuaries support salmon survival & life-histories
3. Importance will vary by context
4. Some habitats and conditions are disproportionately important
5. Rely on habitats & food webs that are complex, connected, and dynamic


ESTUARIES AS COMPLEX SYSTEMS
ESTUARIES IN THE SALMON LIFE CYCLE
STRESSORS—EMERGING AND PAST
PATHS FORWARD

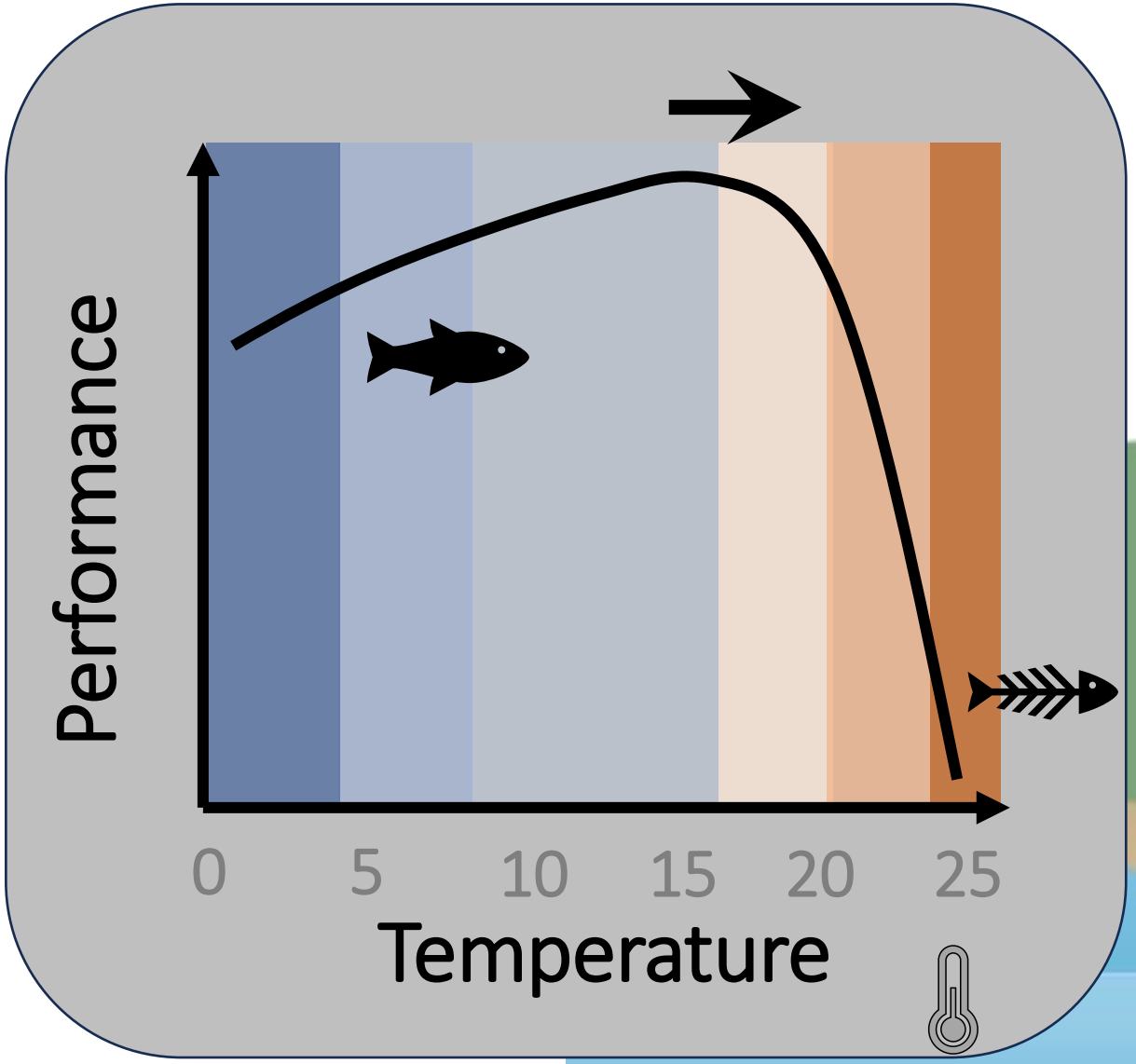
RESEARCH REVIEW

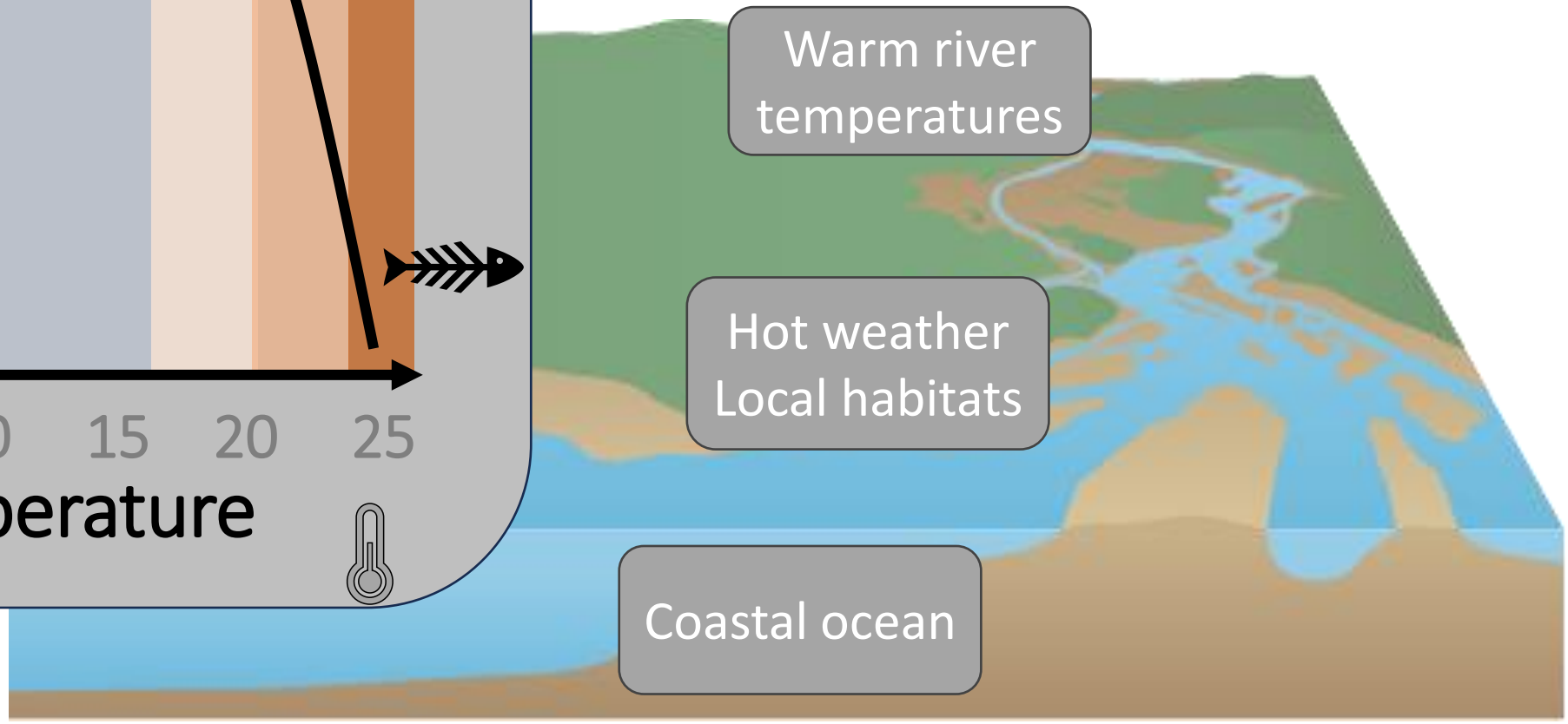
Global Change Biology

Changing estuaries and impacts on juvenile salmon: A systematic review

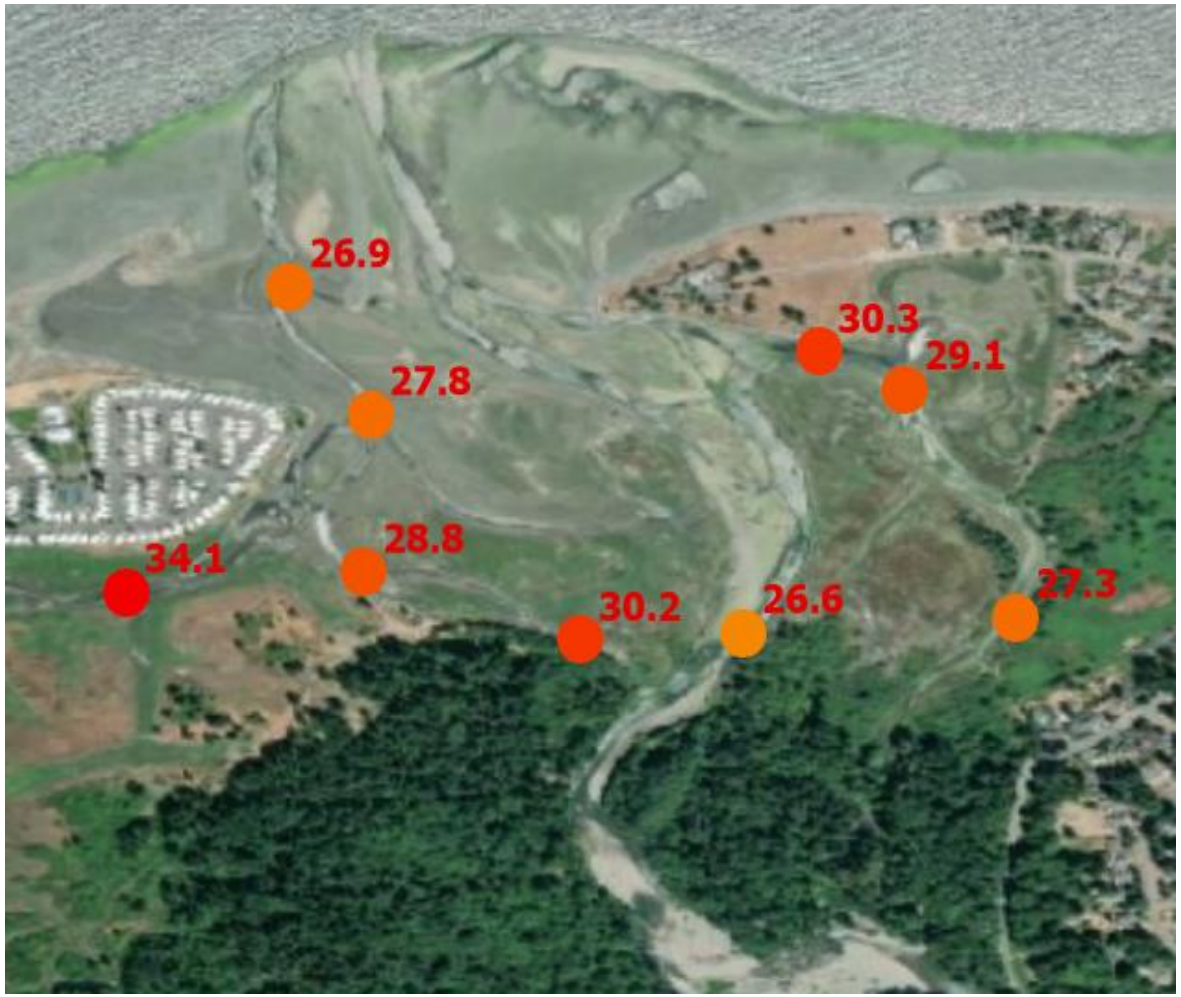
Emma E. Hodgson | Samantha M. Wilson | Jonathan W. Moore

Water temperature





Water temperatures



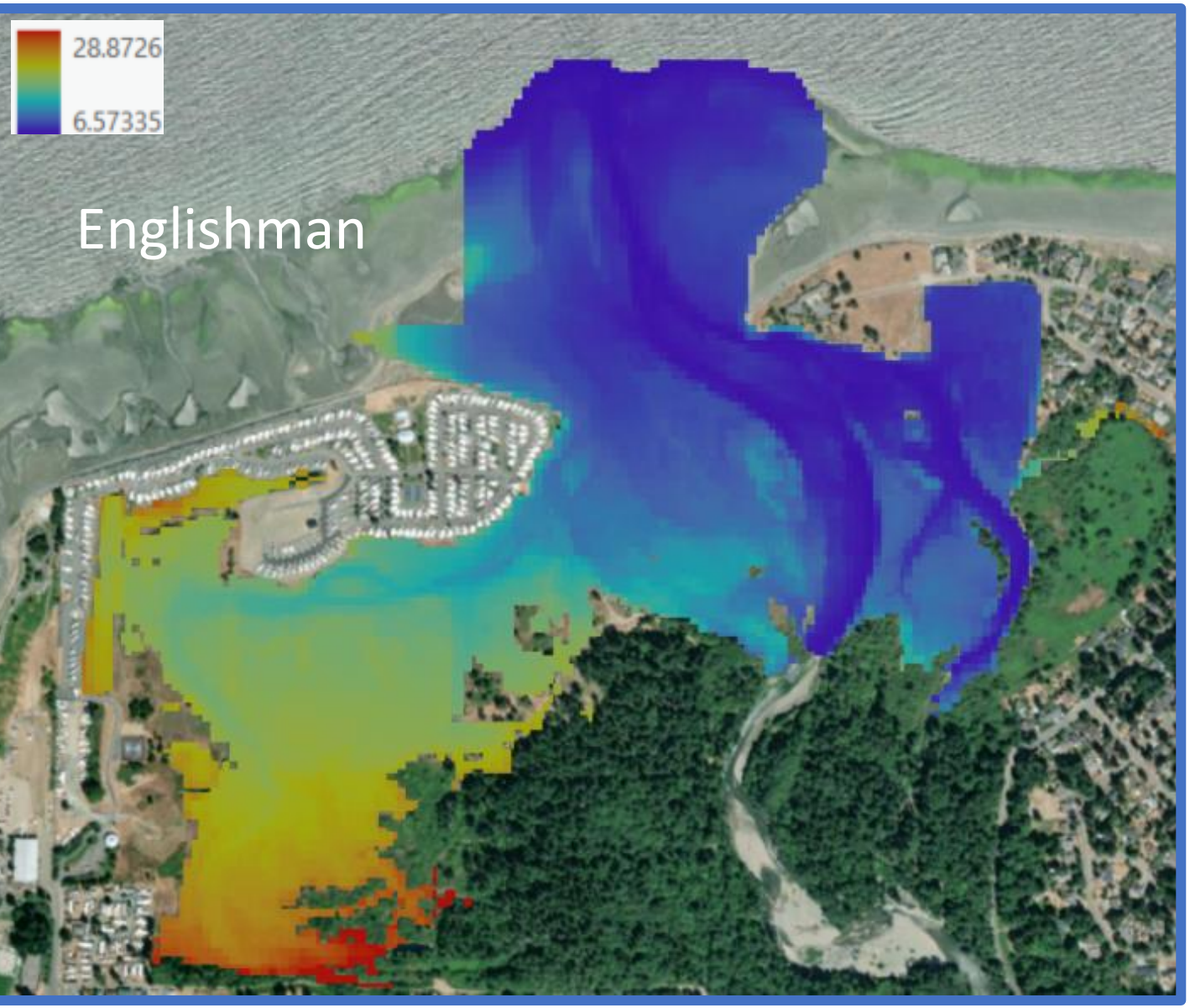
During 2021 Heat Dome

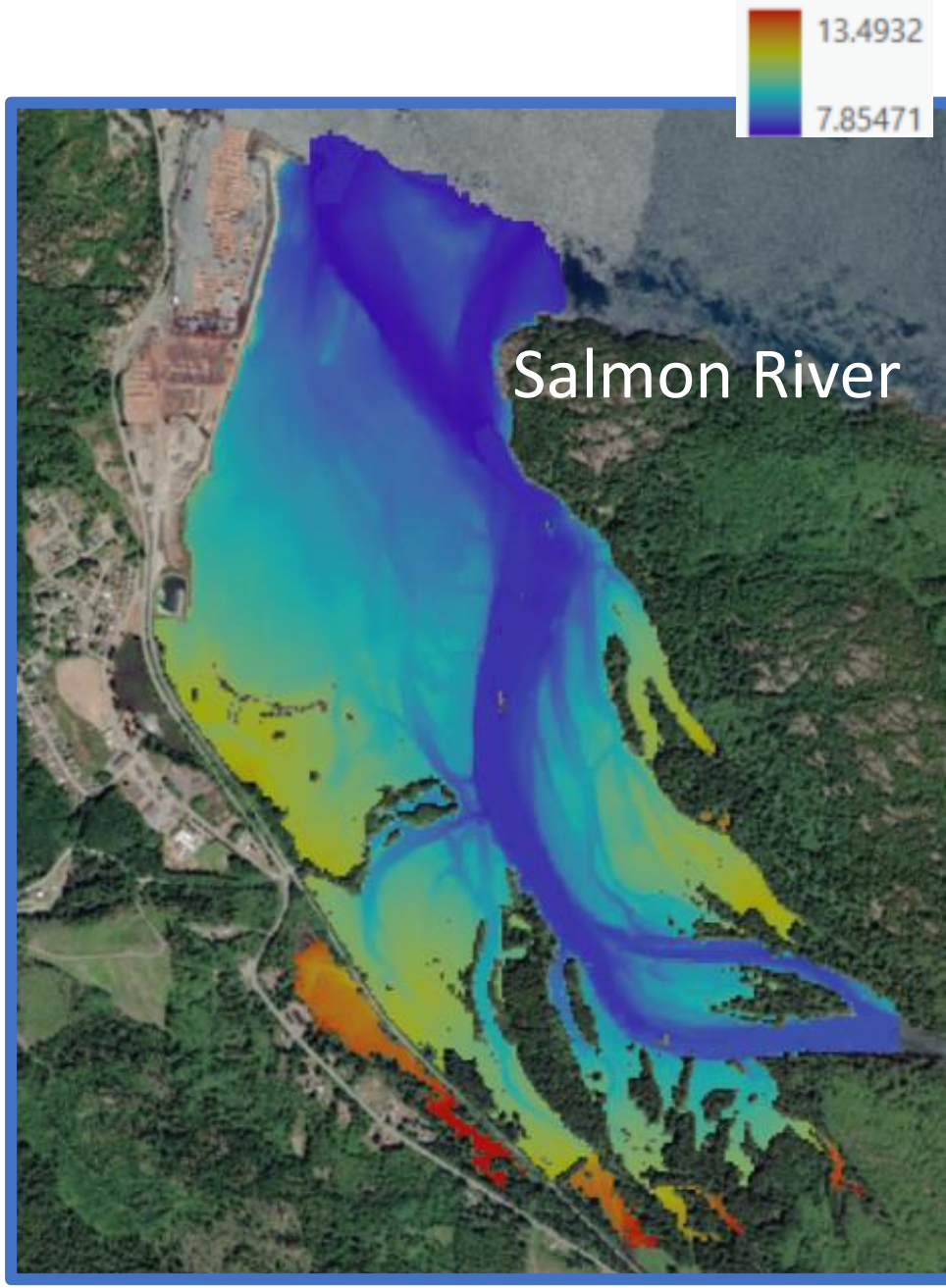
- Extensive monitoring across estuaries
- Temperatures governed by tides, flows, weather
- Emerging seasonal constraints on habitat use?

Complex temperature mosaics across space and time in estuaries: implications for current and future nursery function for Pacific salmon

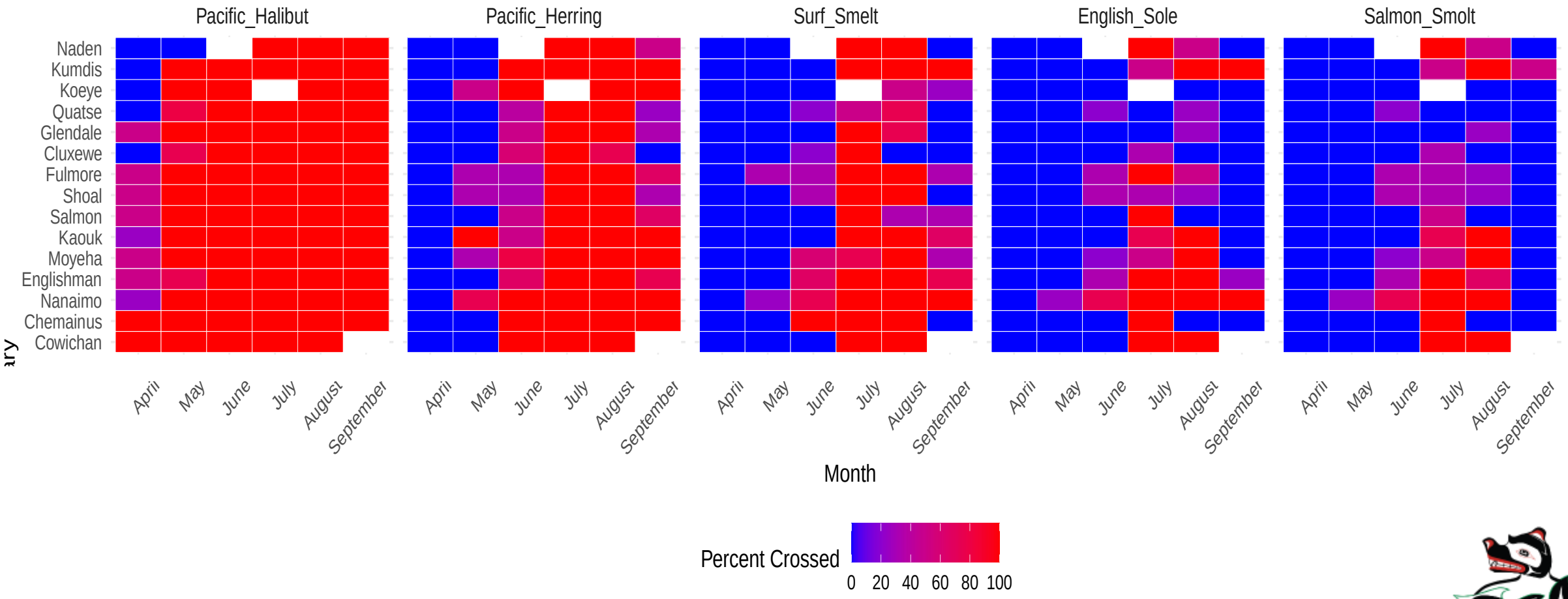
Phoebe L. Gross[1*], Julian C.L. Gan[1], Daniel J. Scurfield[1], Cory Frank[2], Cedar Frank[2], Caelan McLean[2], Chris Bob[3] and Jonathan W. Moore[1]

Water temperatures



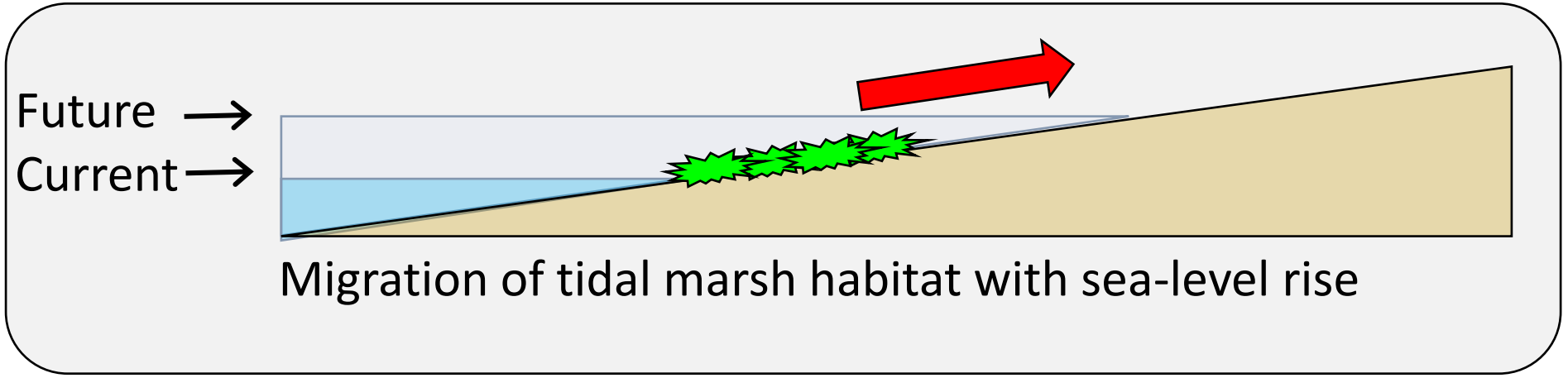


Potential temperature stress across BC estuaries (North -> South) for fishes

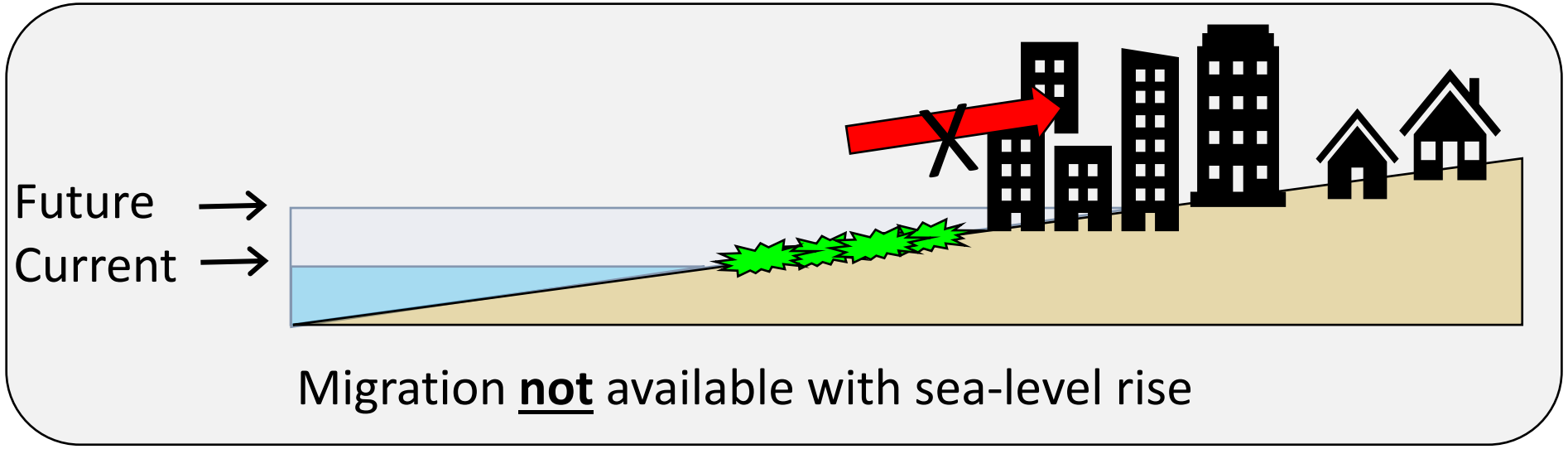


Leah Davis SFU thesis (in prep)

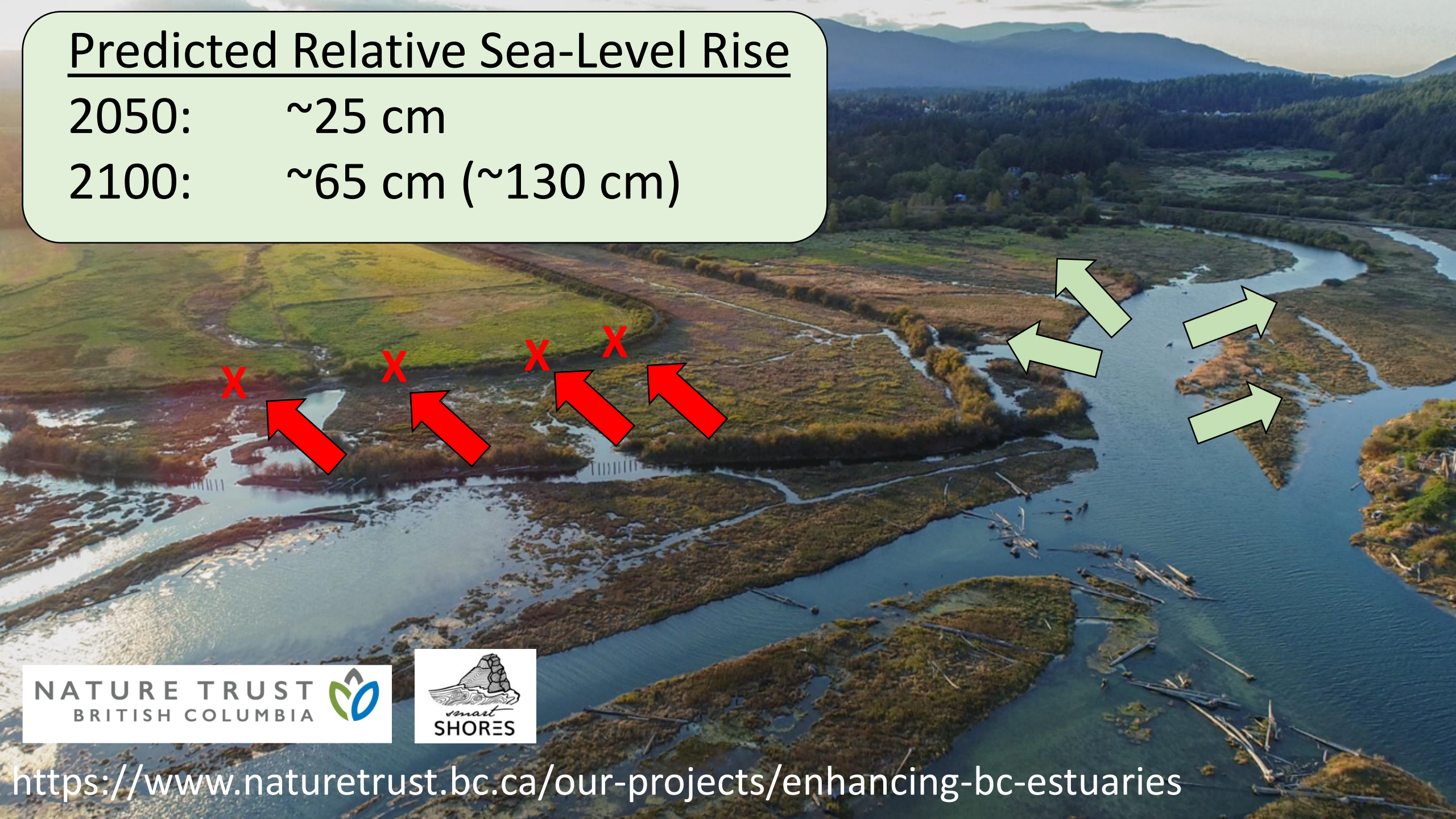
Sea-level rise and coastal squeeze



Migration of tidal marsh habitat with sea-level rise



Migration **not** available with sea-level rise


Predicted Relative Sea-Level Rise
2050: ~25 cm
2100: ~65 cm (~130 cm)
X
X
X
X
NATURE TRUST
BRITISH COLUMBIA
smart
SHORES
https://www.naturetrust.bc.ca/our-projects/enhancing-bc-estuaries


ESTUARIES AS COMPLEX SYSTEMS
ESTUARIES IN THE SALMON LIFE CYCLE
STRESSORS—EMERGING AND PAST
PATHS FORWARD

- Nursery function of estuaries is enabled by connected, diverse, and dynamic estuary habitats (mosaics)
- Ocean, estuary, and watershed processes
- Provide “solution space” for salmon in their complex migratory life cycles

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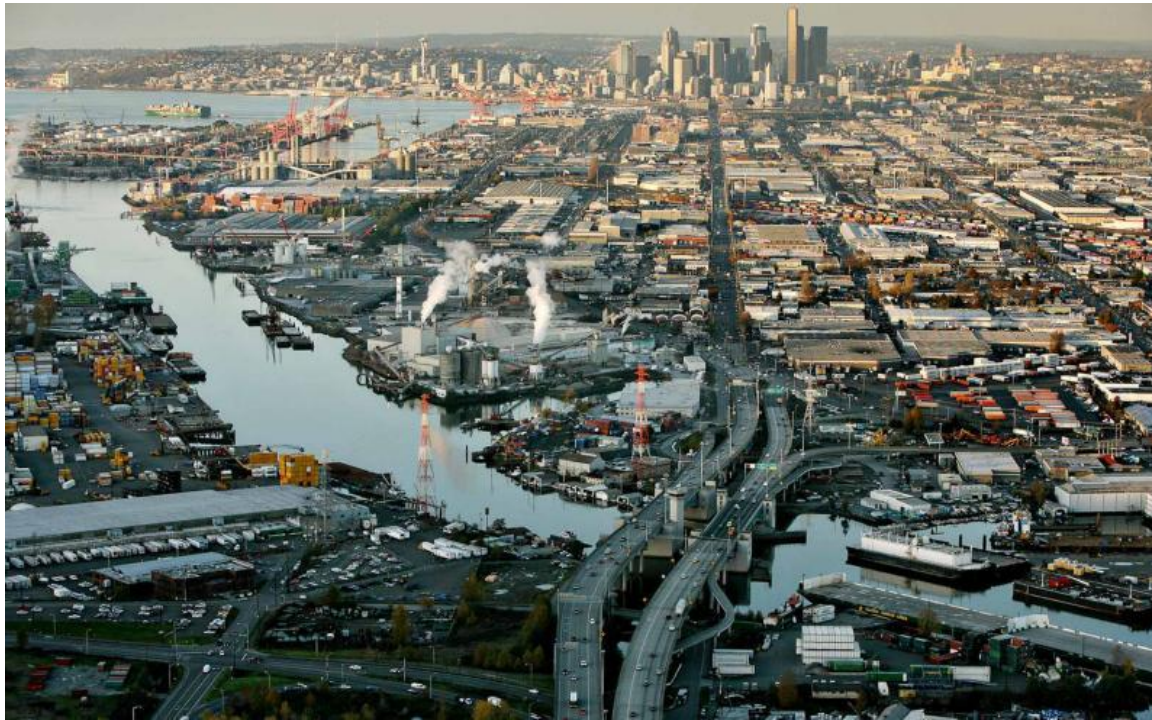
Unaltered

Profoundly impaired



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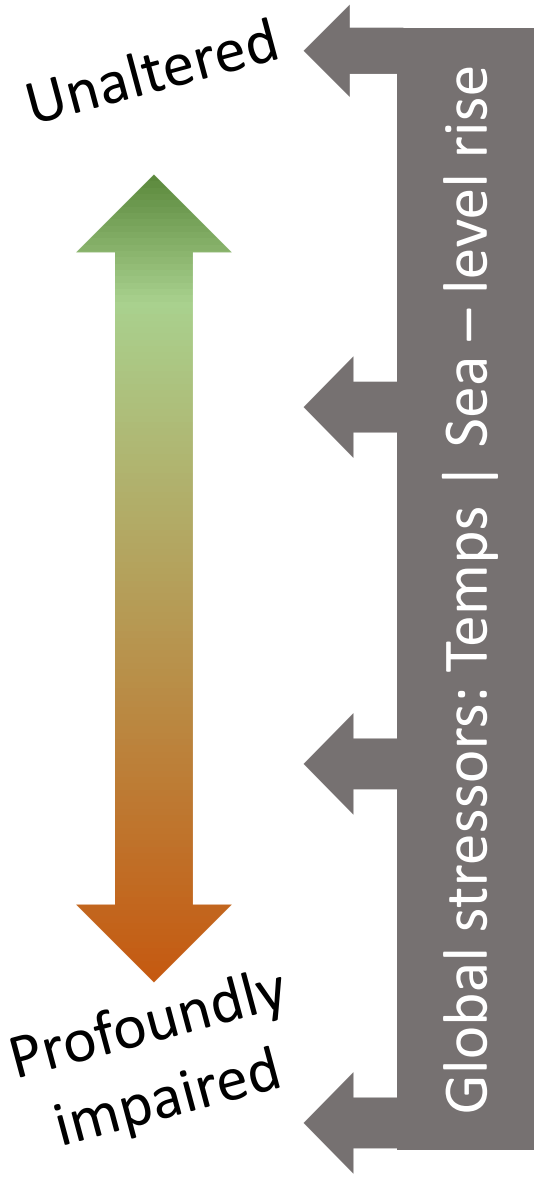

- Nursery function of estuaries is enabled by connected, diverse, and dynamic estuary habitats (mosaics)
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- Provide “solution space” for salmon in their complex migratory life cycles

Unaltered

Profoundly impaired

Global stressors: Temps | Sea – level rise

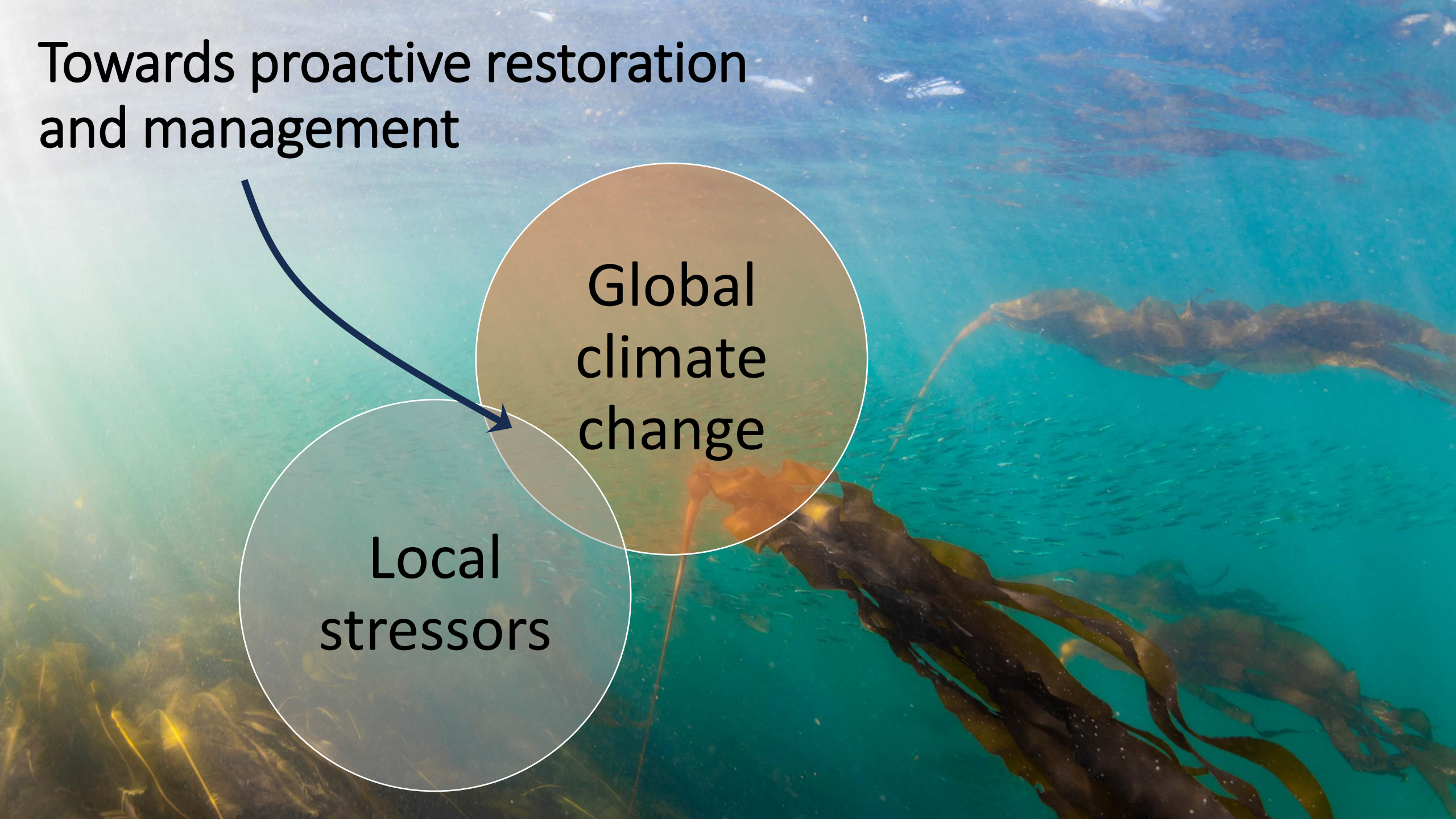
If we want to enhance estuary nursery function. . .

PROTECT
- No industrial development

RESTORE
- Reduce stressors
- Processes (flows of water, sediment)
- Connectivity (current & future

ENHANCE
- Engineering enhancements

MONITOR


Towards proactive restoration and management
Global climate change
Local stressors

Estuary resilience

Jonathan Moore

jwmoore@sfu.ca

www.jonwmoore.org

SFU
SIMON FRASER UNIVERSITY

Salmon Watersheds Lab

Cowichan estuary log booms provide unfair perch for seals to prey on salmon: study

Combined with low river flows caused by drought, it's contributing to declining salmon populations in the beleaguered estuary

Darron Kloster
Jun 13, 2024 4:46 AM