Climate Change and the Estuary

Adapted from:
Salinity in the Willamette River? Seriously?!?
Columbia River Estuary Conference 2016

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Presented at ***Future of Our Salmon Conference 2016***

Context

- The estuary is highly variable in response to river flow, tides and coastal winds
- This variability is critical to ecosystem function and salmon habitat, and is frequently accounted for in policy and management
- Less understood are the responses of the estuary to future in-basin stresses, coastal subsidence, and climate change

Estuary's response to climate change

Challenges

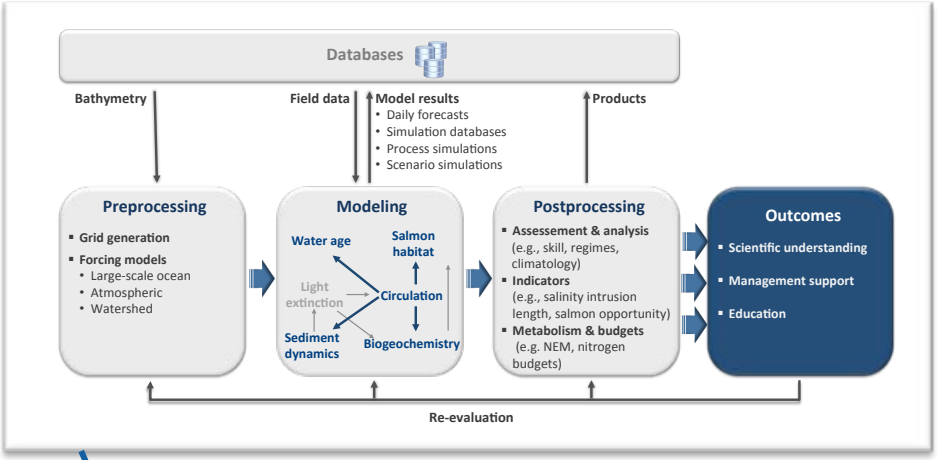
- Uncertainty in global climate change scenarios
- Tools to downscale global change into the estuary

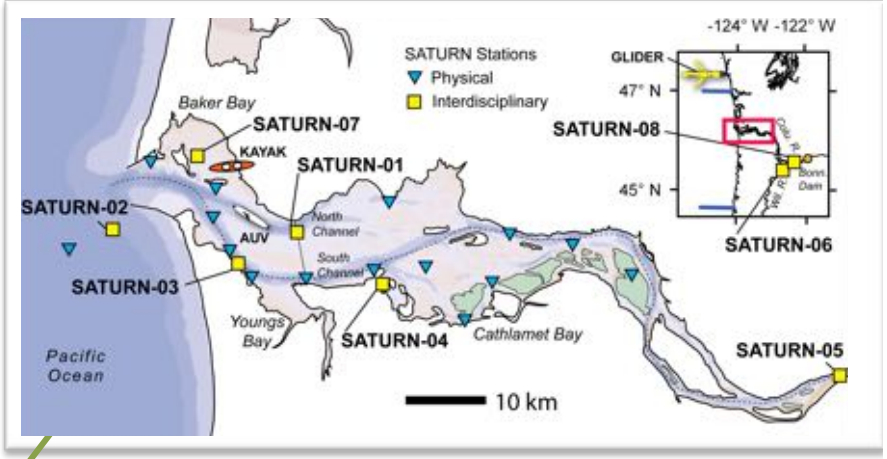
Overcoming the challenges. Today's example:

- What would the impacts of sea level rise (SLR) be?
  - Are there threshold behaviors of note?
  - How do SLR impacts compare with other effects?

Methods

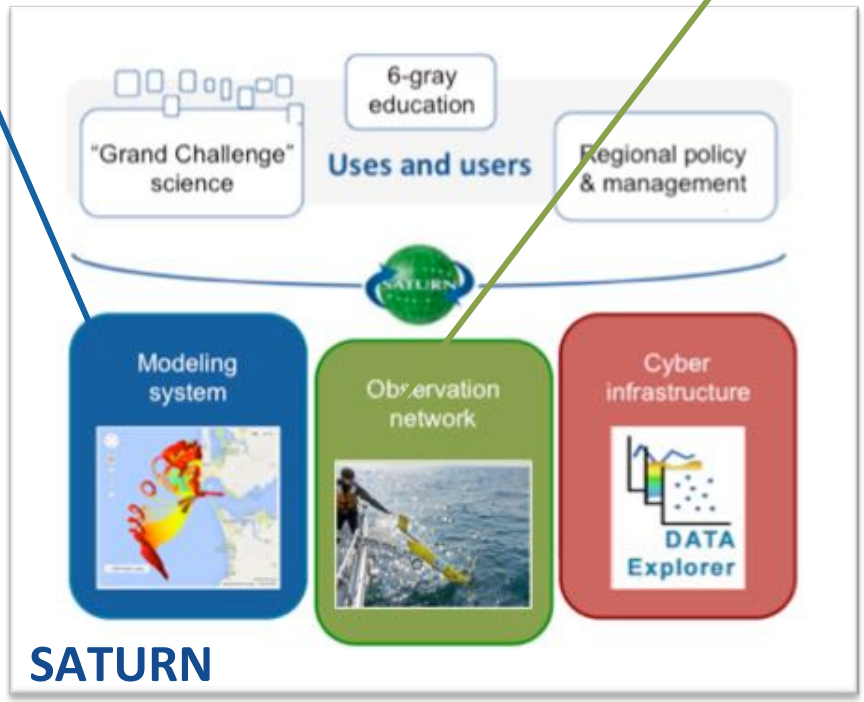
Baptista et al. 2015, *FES*





Modeling system: Virtual Columbia River

Observation network



To address these questions, we use the Virtual Columbia River, which is a modeling system built for collaborative science and management

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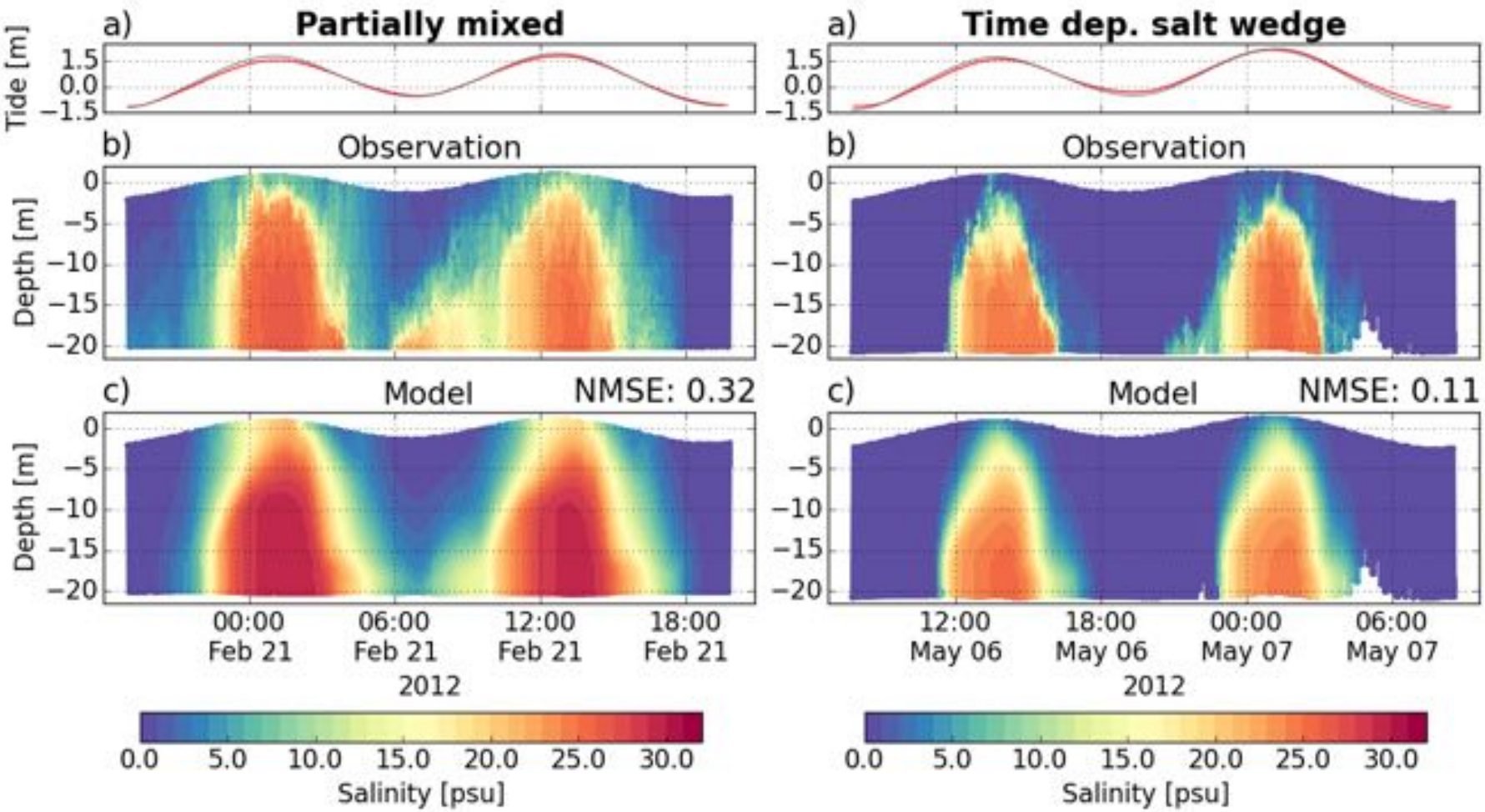
Methods

The circulation model of the Virtual Columbia River has been skill assessed against an extensive set of contemporary observations



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Kärnä et al. 2015 & Kärnä and Baptista, 2016; *OM*

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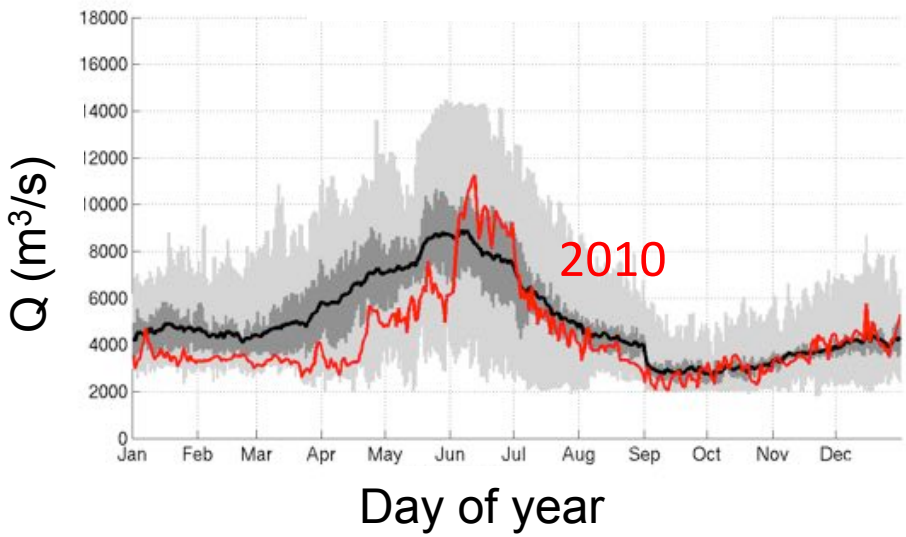
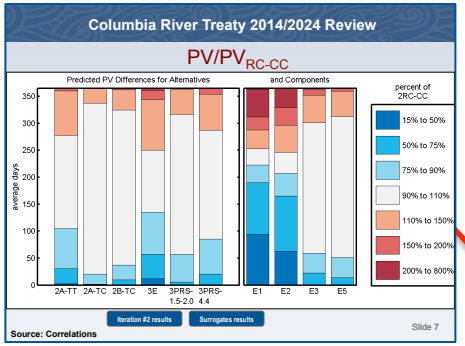
Approach

Using a year-long simulation for “2010” as reference, we contrast contemporary conditions against multiple scenarios of SLR



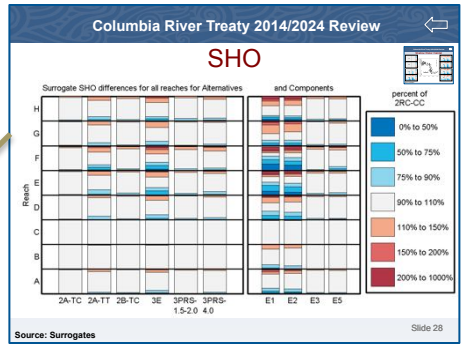
Contrasts are based on metrics commonly used to support salmon-relevant regional decisions

Physically-based metrics …



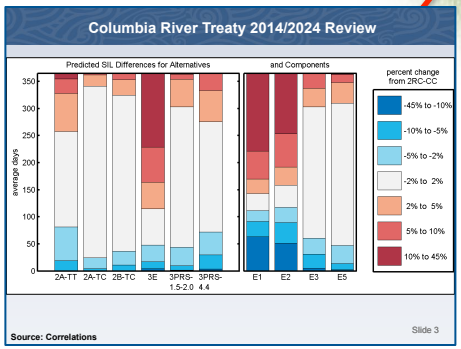
Plume volume (PV)

Relevance: ocean entry conditions (Miller et al. 2013, 2014)



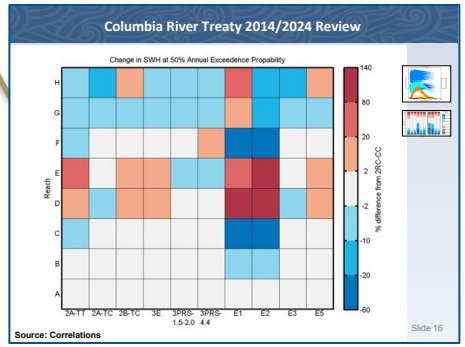
Salmon Habitat (SH)

Relevance: salmon-favorable habitat (Bottom et al. 2005, others)



Salinity Intrusion Length (SIL)

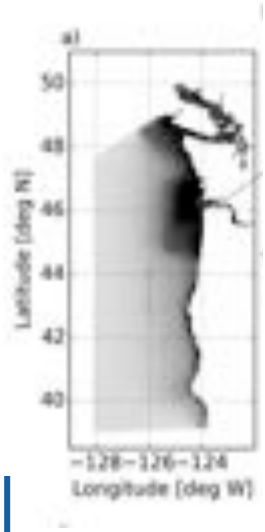
Relevance: extent of ocean influences, including estuarine hypoxia and acidification

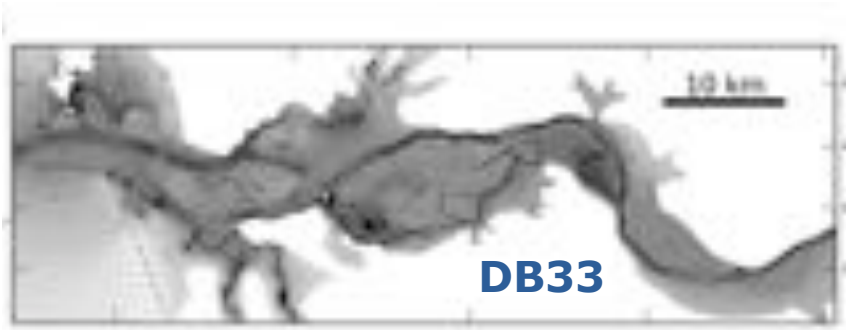


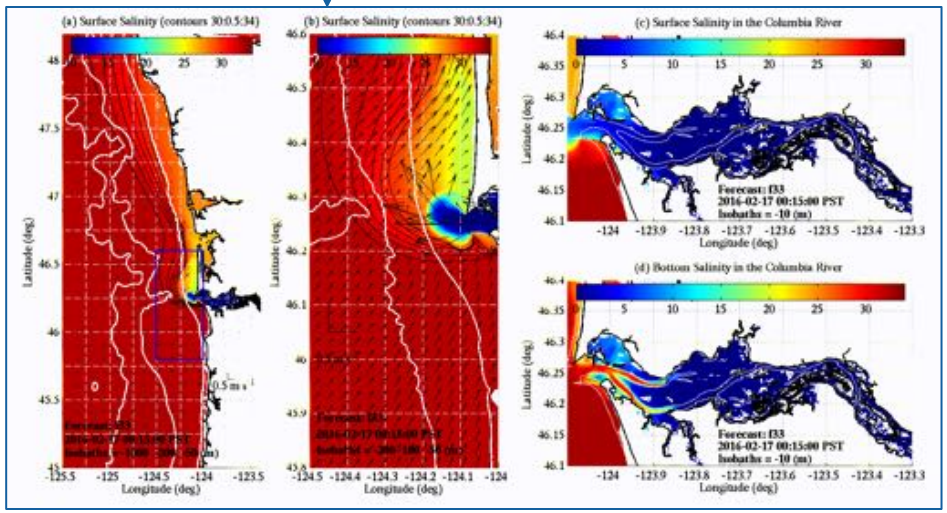
Shallow Water Habitat (SWH)

Relevance: shallow water habitat (USACE metric)

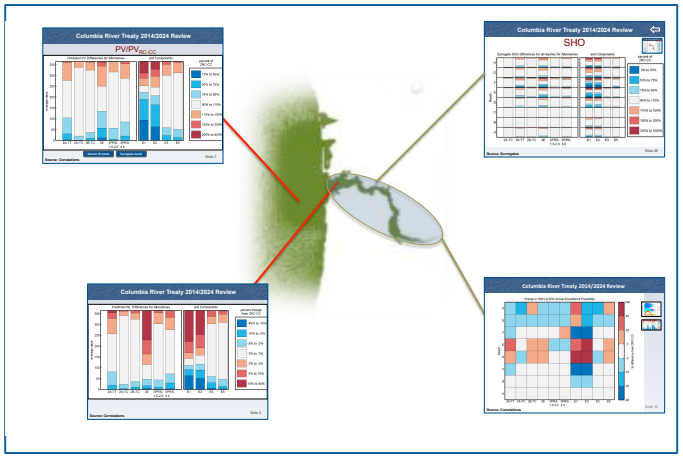
… obtained by filtering circulation fields







Filters



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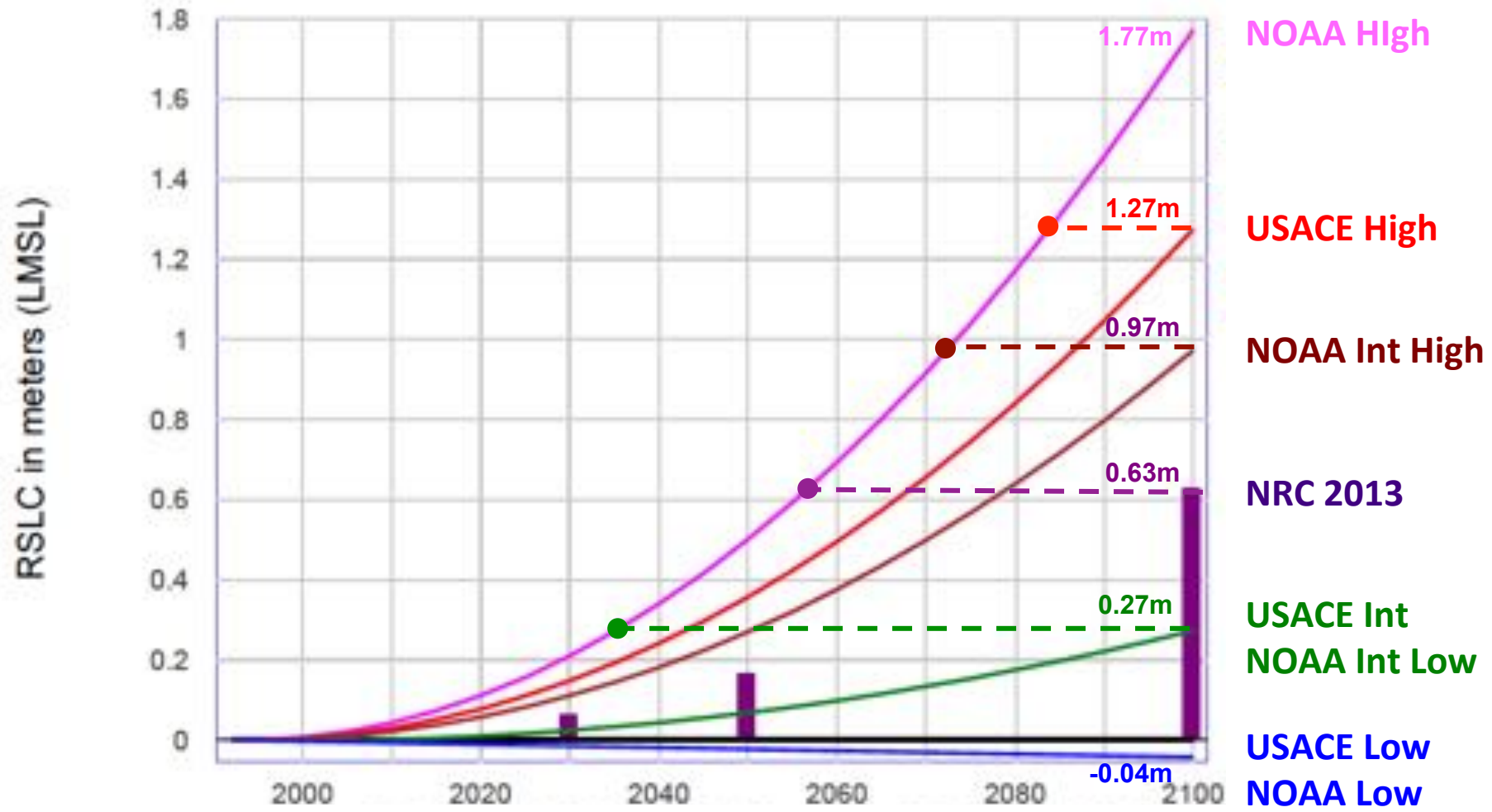
Sea level rise scenarios



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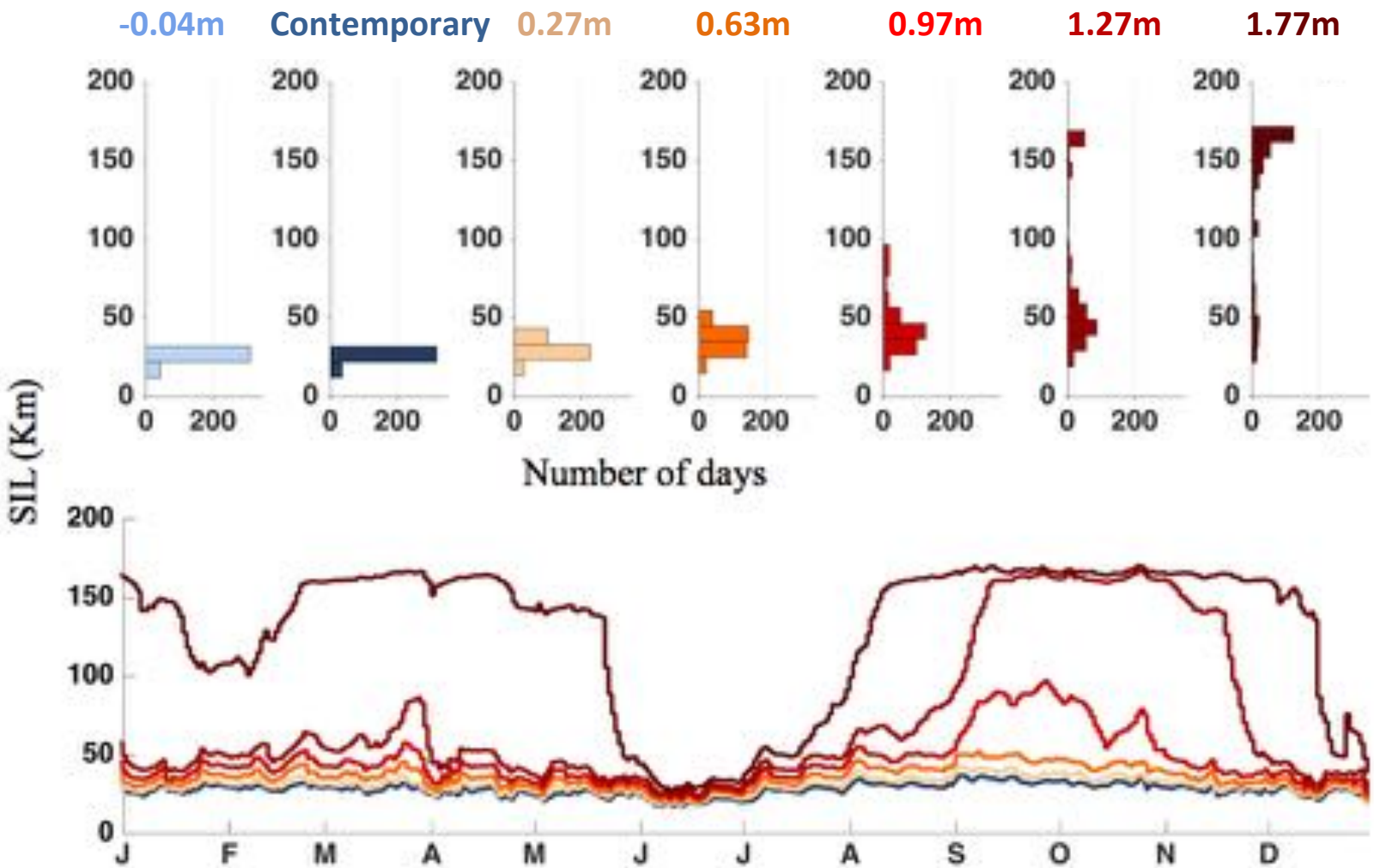
Salinity Intrusion Length, SIL (Km)



Rostaminia et al., in prep

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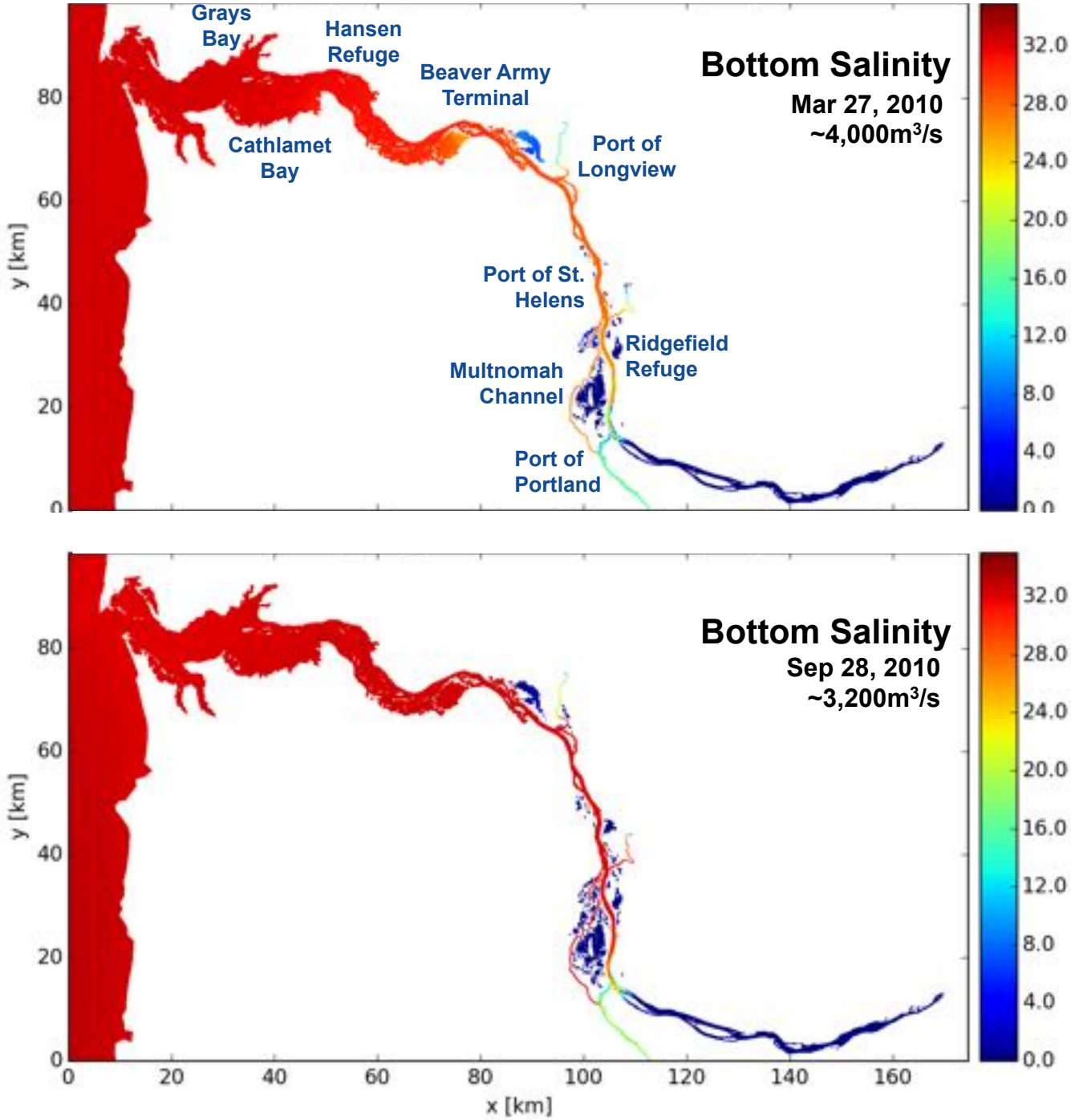

Current condition
CSZ-XXL1
Current condition
SLR -0.04 m
SLR 0.27 m
SLR 0.63 m
SLR 0.97 m
SLR 1.27 m
SLR 1.77 m

Rostaminia et al., in prep

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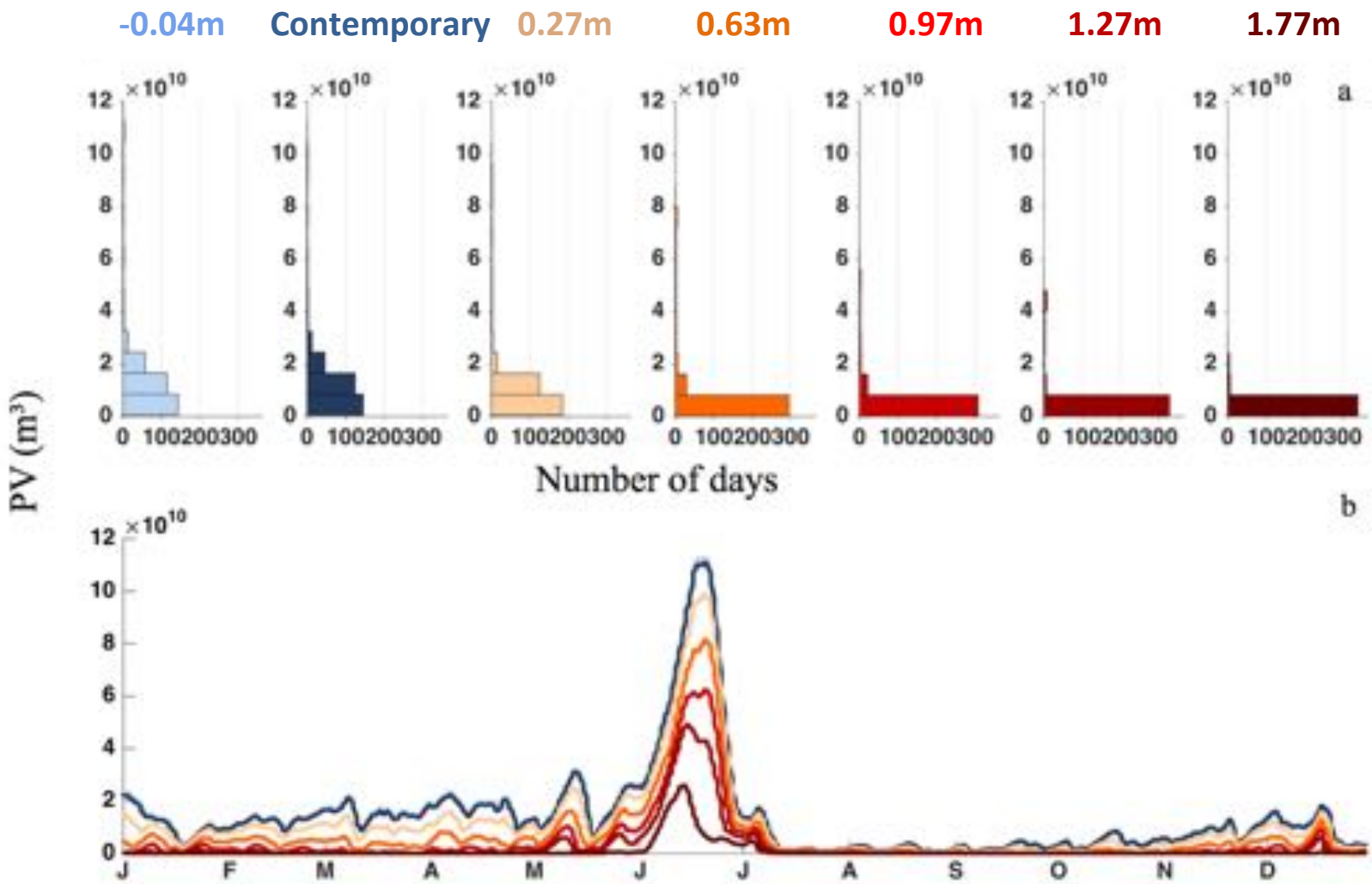
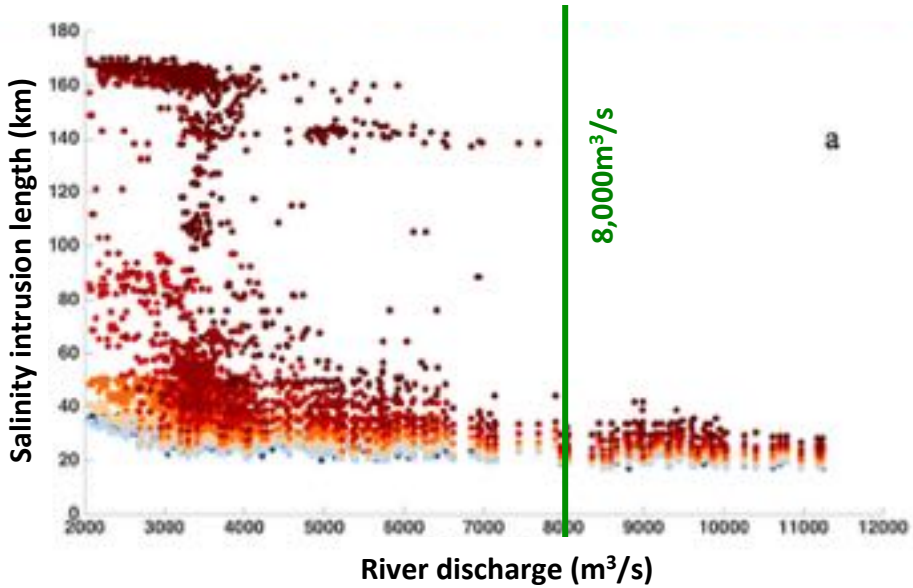
Plume volume, PV (m^3)

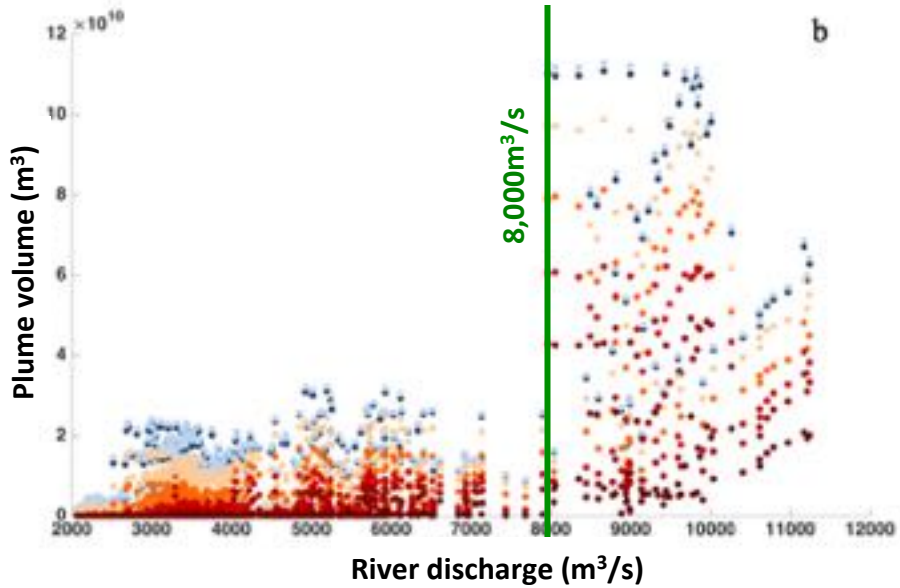


Rostaminia et al., in prep

Discharge threshold

-0.04m Contemporary 0.27m 0.63m 0.97m 1.27m 1.77m





Rostaminia et al., in prep

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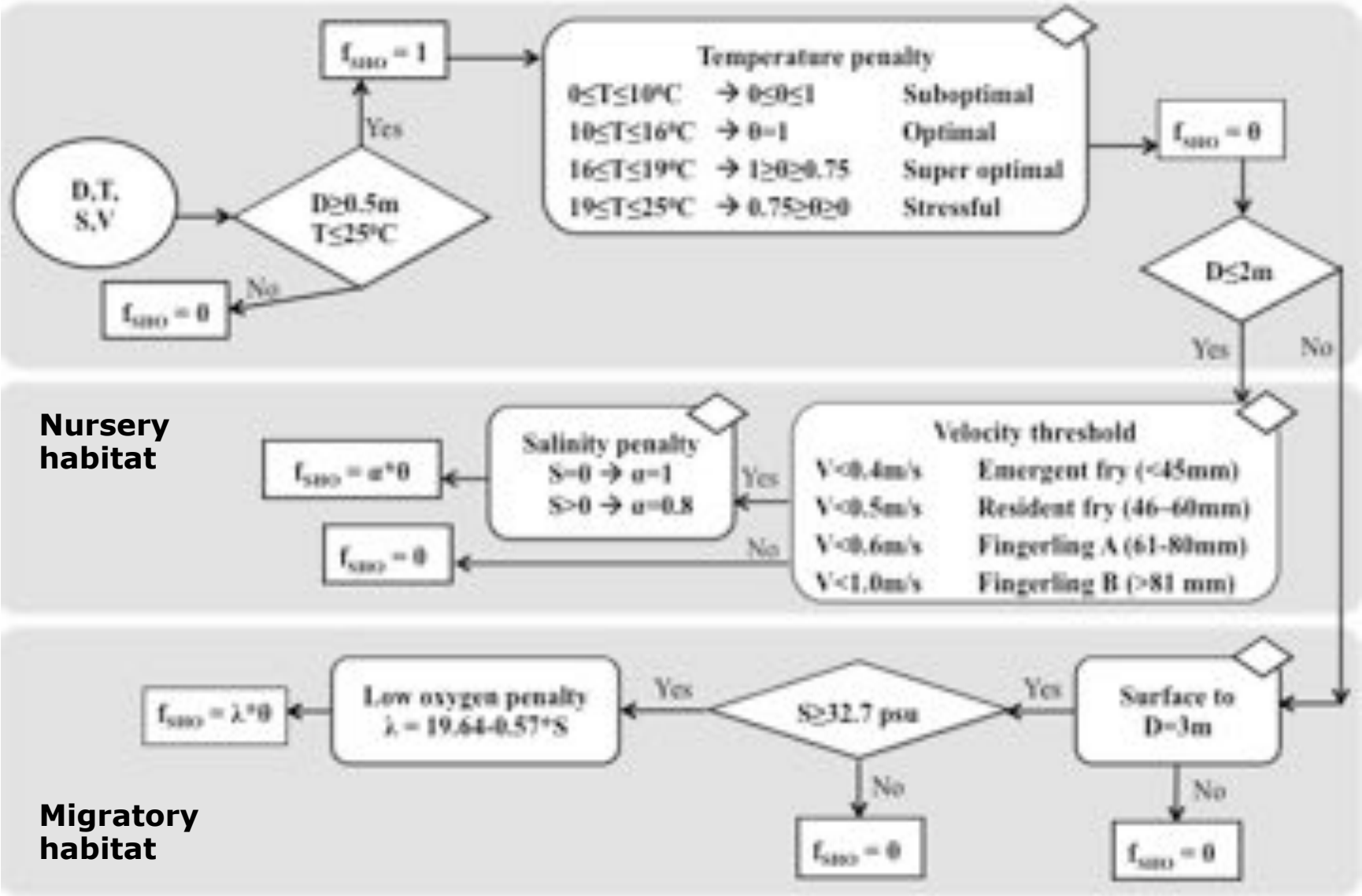
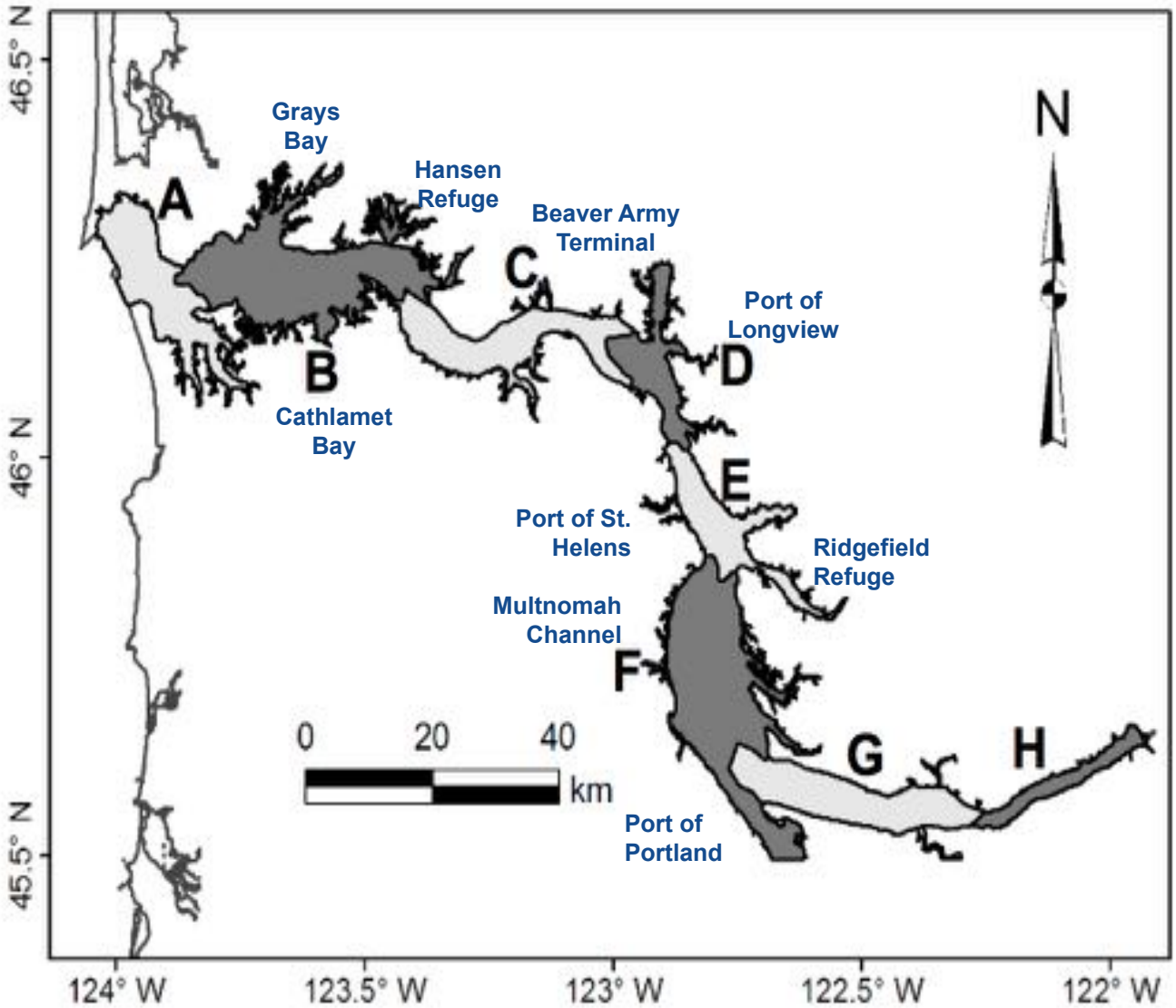
Juvenile Chinook salmon habitat (SH)



Rostaminia et al., in prep; evolved from Bottom et al. 2005

Reaches



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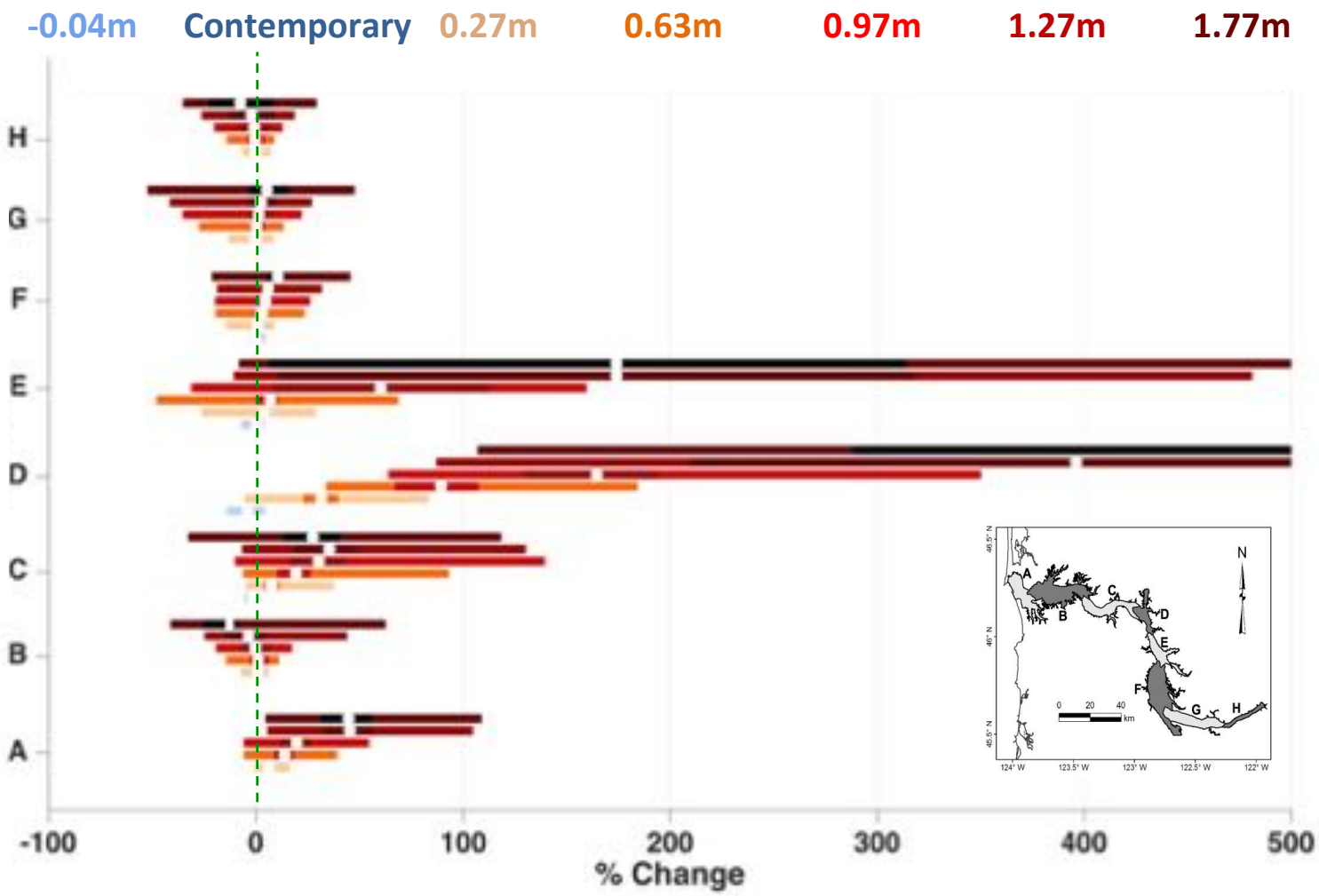
Change in salmon habitat



Rostaminia et al., in prep

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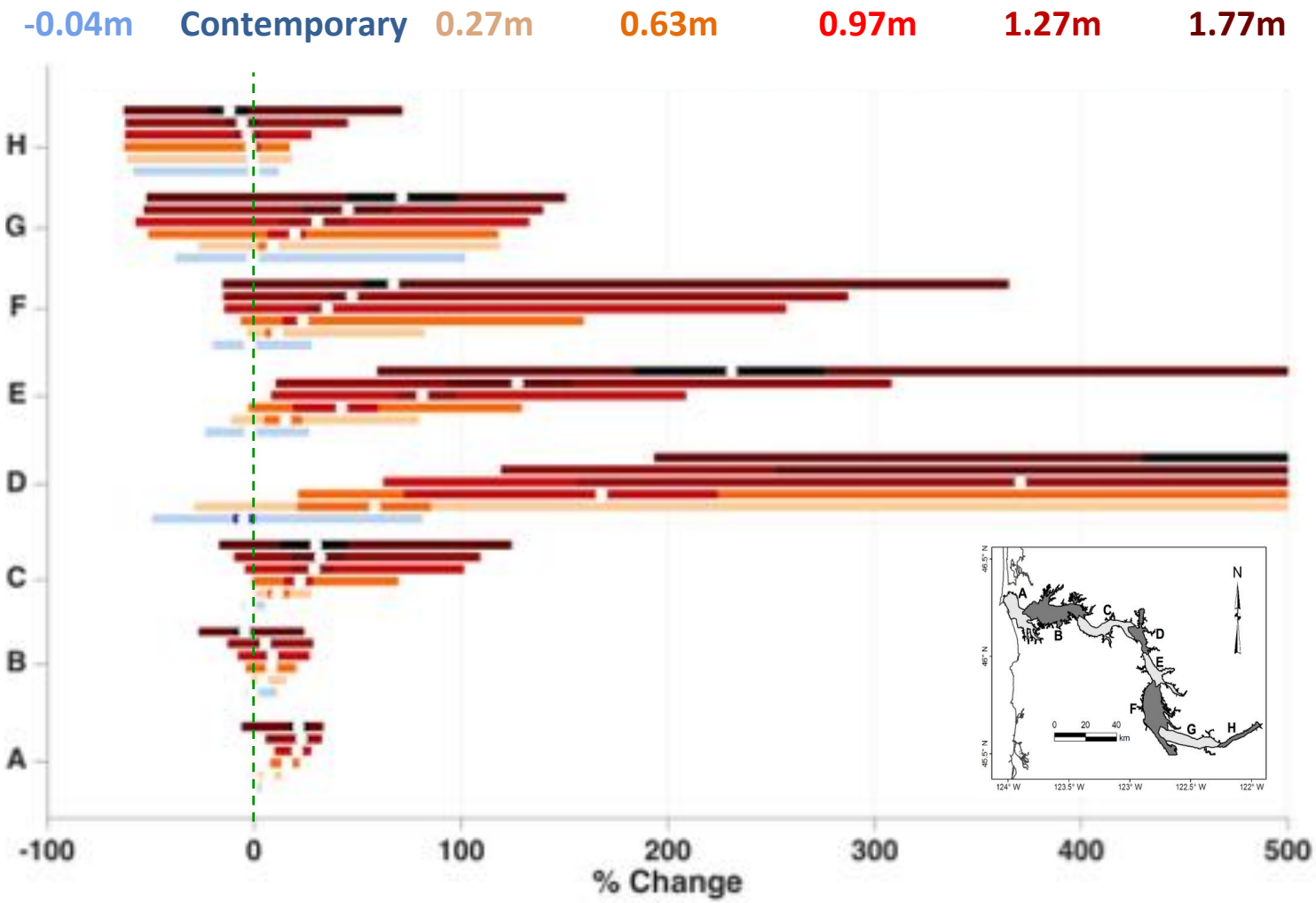
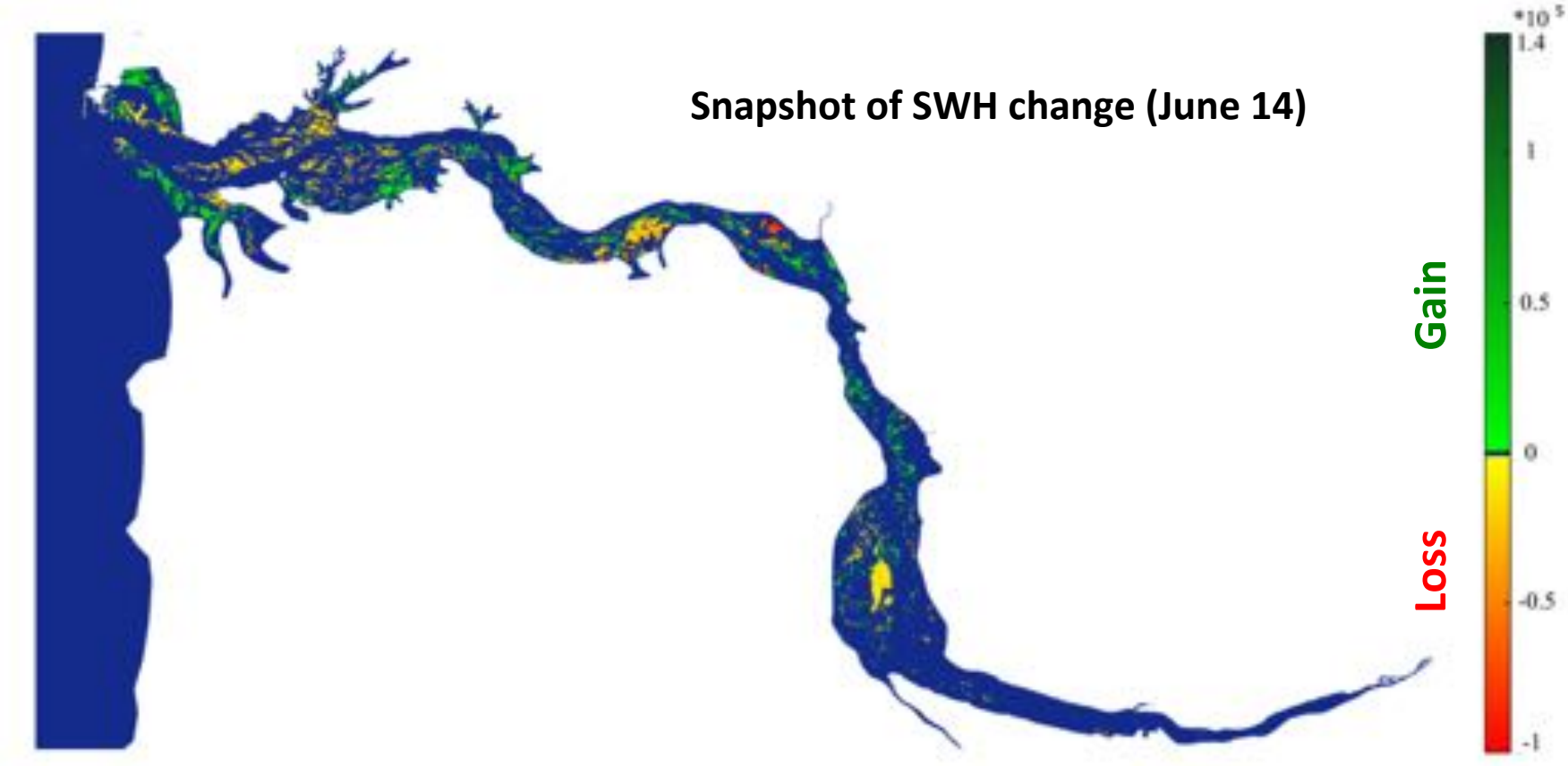
Change in shallow water habitat



Rostaminia et al., in prep

Site-specific gains and losses



Summary and conclusions

- The Virtual Columbia River is a powerful tool to anticipate effects of climate change. In our example:
  - SLR matters to the estuary
  - If certain SLR thresholds (~1m?) are crossed, a vastly transformed estuary will emerge (deeper salinity intrusion, smaller plumes, gains and losses of habitat)
  - Changes will affect both mean states and temporal variability
  - Changes will have deep implications on ecosystem function and salmon populations—with both "winners" and "losers"

Summary and conclusions

- Uncertainties remain in (especially) the definition and (also) the simulation of scenarios of change
- Results presented today should be further refined:
  - Need to continue to carefully review results, both scientifically and via stakeholder scrutiny
  - Need to be expanded to account for simultaneous change in multiple forcing (SLR, river flows, CSZ, etc.)
  - Need to be placed in site-specific context
- But the results show a potential for drastic change that is too clear to ignore, and that should be incorporated into regional thinking now