Climate Change and the Estuary

Adapted from:
*Salinity in the Willamette River? Seriously?!?*
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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?
To address these questions, we use the Virtual Columbia River, which is a modeling system built for collaborative science and management.
Methods

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

Salinity Intrusion Length (SIL)
Relevance: extent of ocean influences, including estuarine hypoxia and acidification

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

Shallow Water Habitat (SWH)
Relevance: shallow water habitat (USACE metric)
... obtained by filtering circulation fields
Sea level rise scenarios

NOAA High
USACE High
NOAA Int High
NRC 2013
USACE Int
NOAA Int Low
USACE Low
NOAA Low
Salinity Intrusion Length, SIL (Km)

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

Rostaminia et al., in prep
Bottom Salinity
Mar 27, 2010
~4,000m³/s

Bottom Salinity
Sep 28, 2010
~3,200m³/s

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
Plume volume, PV (m³)

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

Rostaminia et al., in prep
Discharge threshold

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

Salinity intrusion length (km)

Rostaminia et al., in prep
Juvenile Chinook salmon habitat (SH)

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

- Grays Bay
- Hansen Refuge
- Cathlamet Bay
- Beaver Army Terminal
- Port of Longview
- Port of St. Helens
- Ridgefield Refuge
- Multnomah Channel
- Port of Portland
- Port of Longview
- Port of Portland
Change in salmon habitat

Rostaminia et al., in prep
Change in shallow water habitat

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

Rostaminia et al., in prep
Site-specific gains and losses

Snapshot of SWH change (June 14)
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