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Relative influences of human nutrient sources, the Pacific Ocean, and climate change on Salish Sea dissolved oxygen through 2070

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Speaker

Mindy Roberts, Teizeen Mohamedali, Brandon S. Sackmann, Tarang Khangaonkar, Wen Long, and Alan F. Hamlet

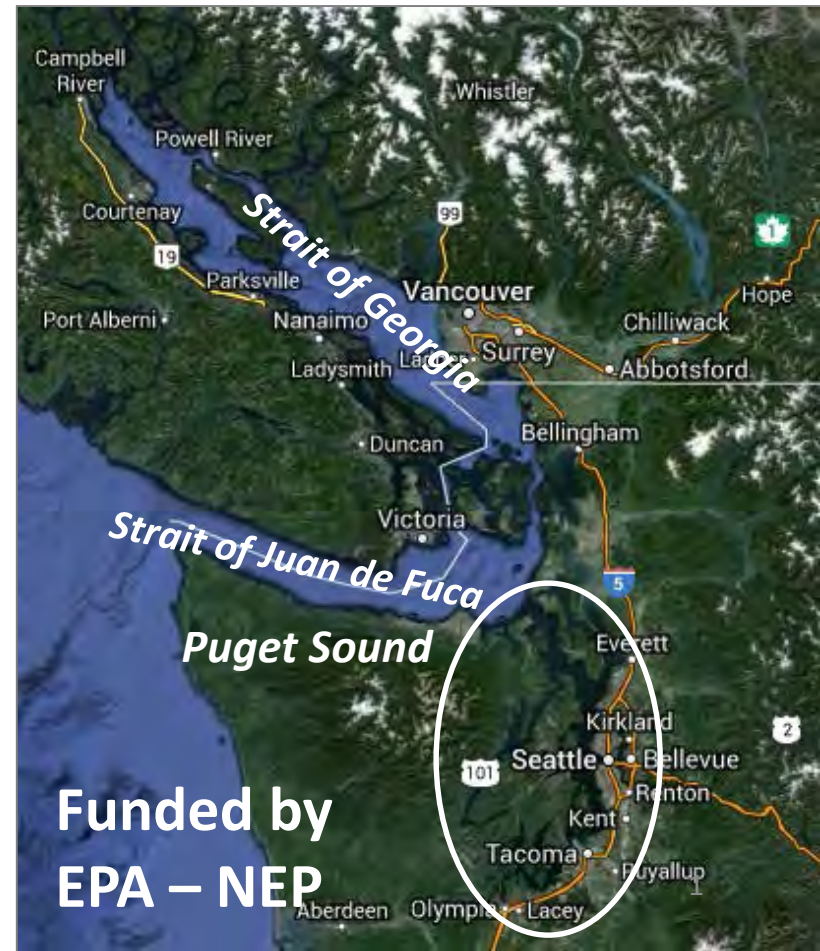
Relative influences of human nutrient sources, the Pacific Ocean, and climate change on Salish Sea dissolved oxygen through 2070

Mindy Roberts¹, Teizeen Mohamedali¹, Brandon Sackmann¹, Tarang Khangaonkar², Wen Long², and Alan Hamlet³

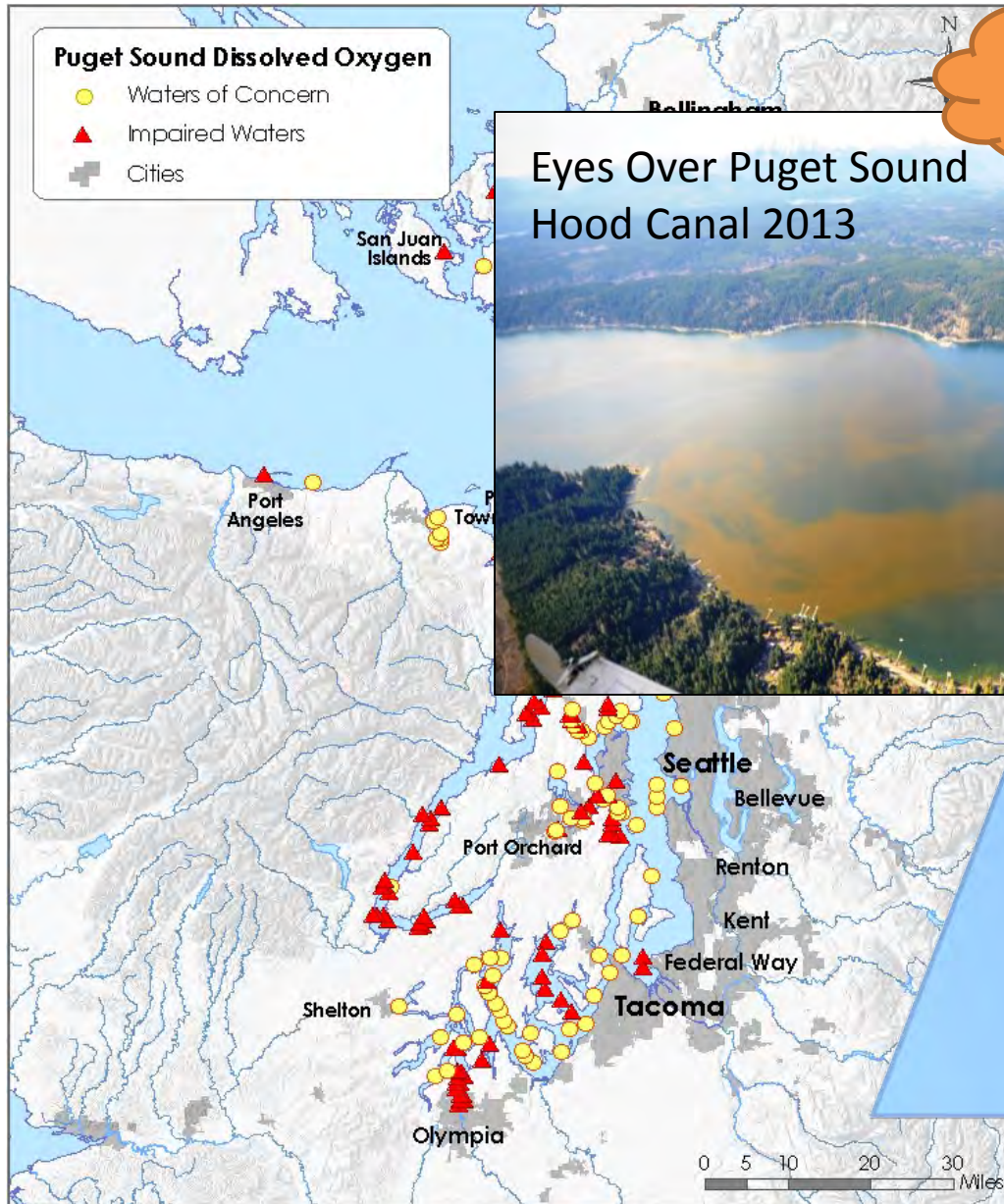
¹ Washington State Department of Ecology

² Pacific Northwest National Laboratory

³ Notre Dame University



Low oxygen happens ... algae grows ... why?



chemistry

biology

physics

Pacific Ocean dissolved oxygen levels, coastal upwelling, Pacific Decadal Oscillation, other climate cycles, NE Pacific oxygen trends, ocean circulation, residence time, estuarine circulation, stratification, vertical mixing, wind, air temperature, organic matter decay, sediment burial rates, trophic-level dynamics, algae growth, water temperature, human wastewater input, river flows, river nutrient inputs, sediment-water processes, etc. ...

Relative impacts on dissolved oxygen

Increased air
temperature

Changes in circulation due
to changes in freshwater
inflows

Increased
wastewater
from future
population

Sediment-water
exchanges

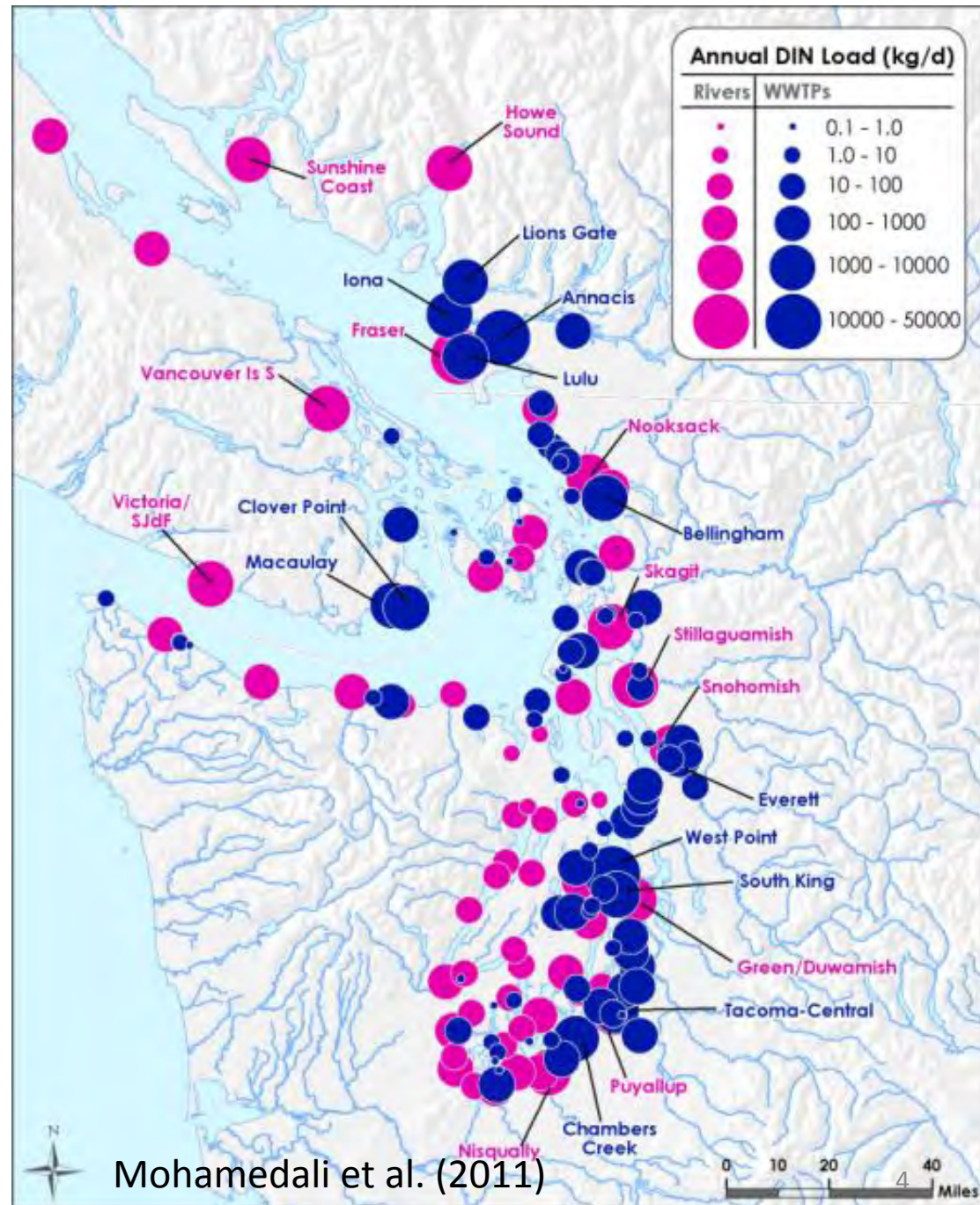
Pacific Ocean trends

Higher river nitrogen
concentrations from
land cover change

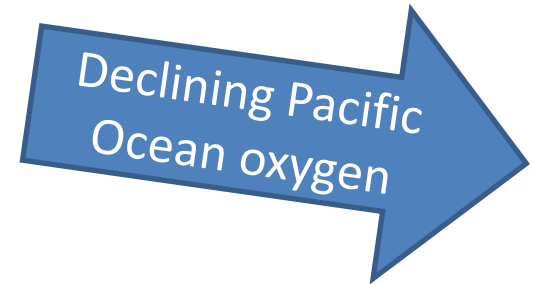
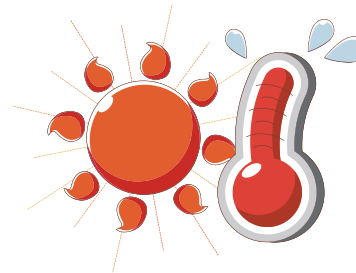
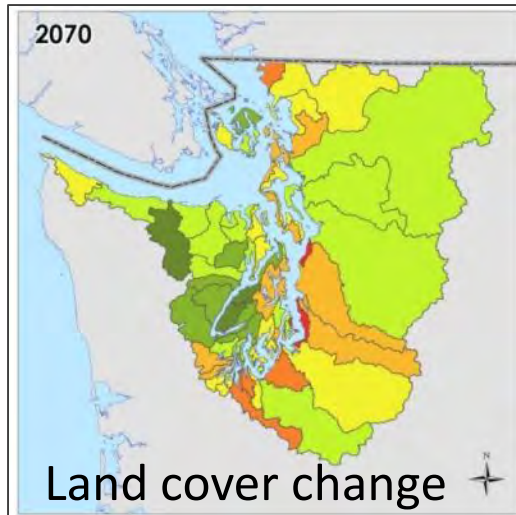
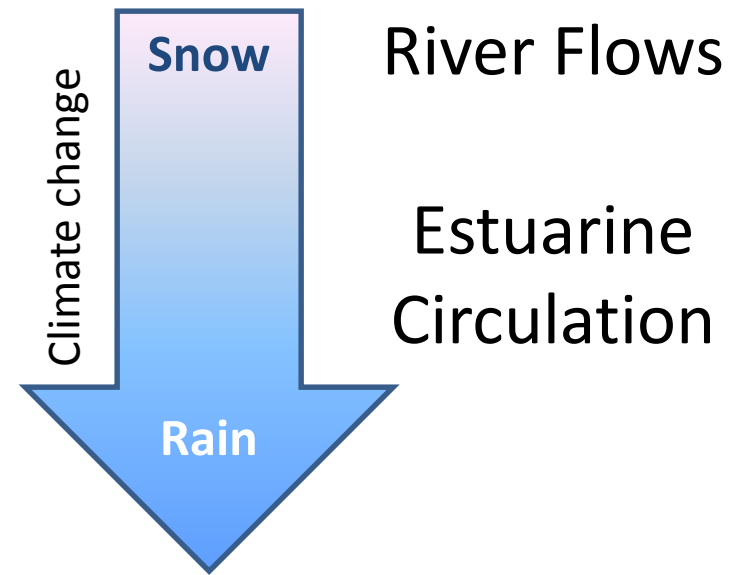
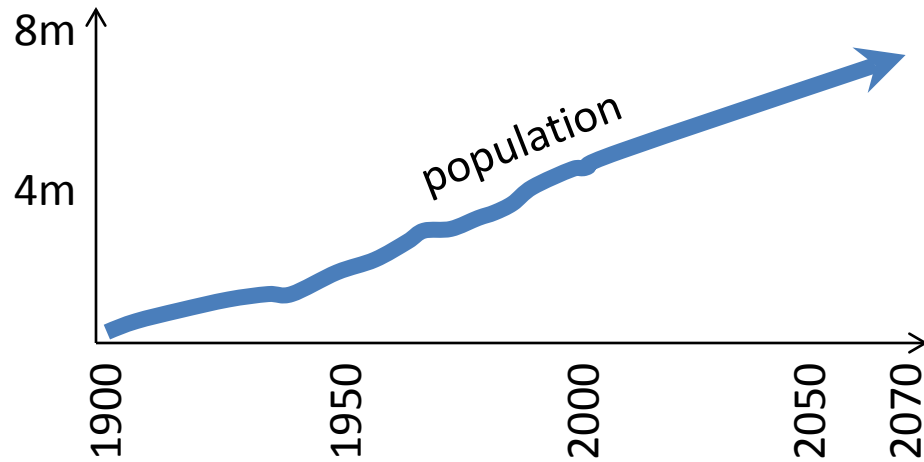
... more study needed.

Local sources of nitrogen (US and Canada)

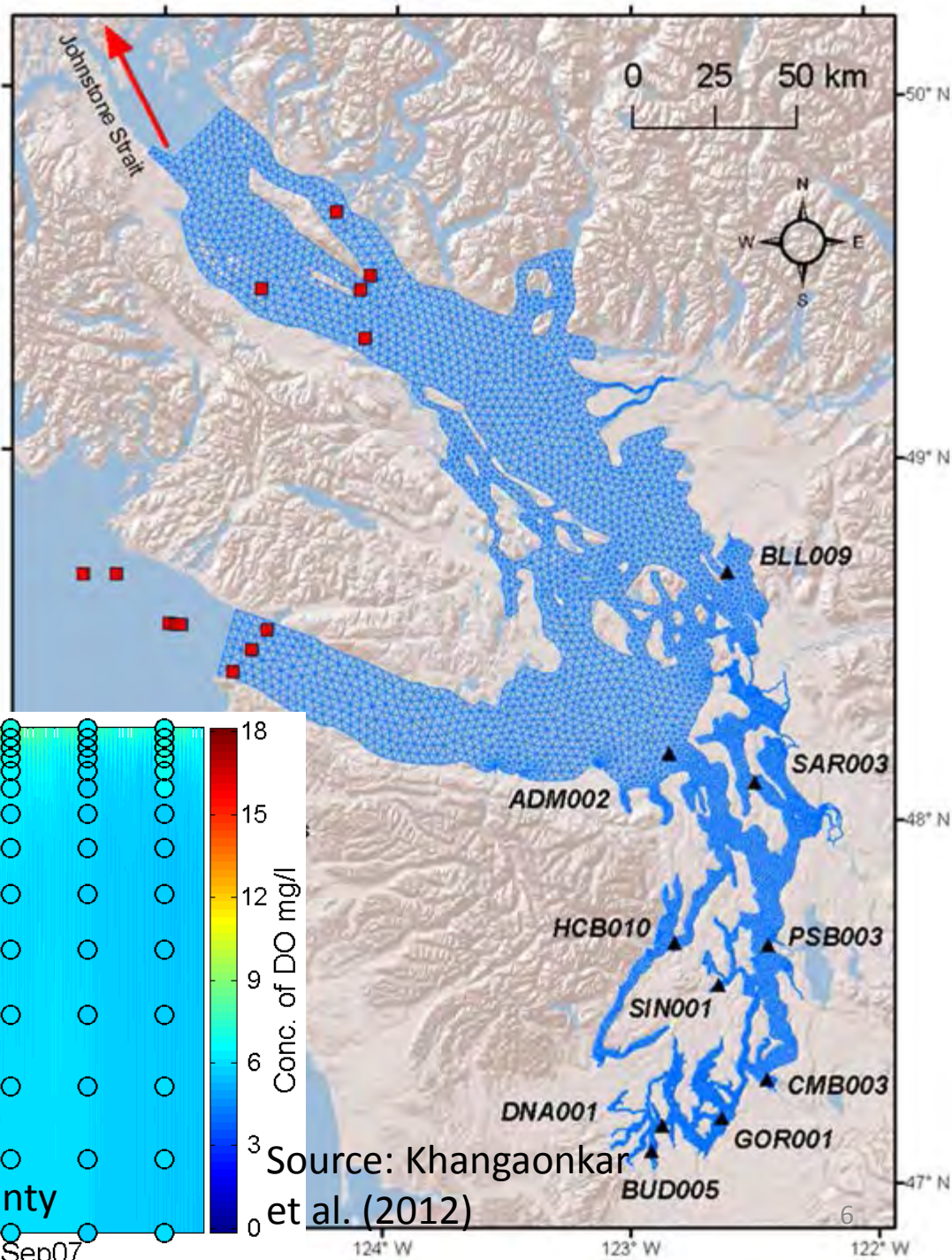
- Pacific Ocean is the largest source of nitrogen
- Sediment-water exchanges highly influential



Current and Future Scenarios (2020s, 2040s, 2070s)



- 3D model (circ, WQ)
- 10,000s of elements
- 1,000,000,000s of outputs
- *See me for modeling details...*



Data courtesy of King County

Source: Khangaonkar et al. (2012)

Average DO
depletion
(mg/L)



Oxygen depletion – current sources (wastewater, watersheds)

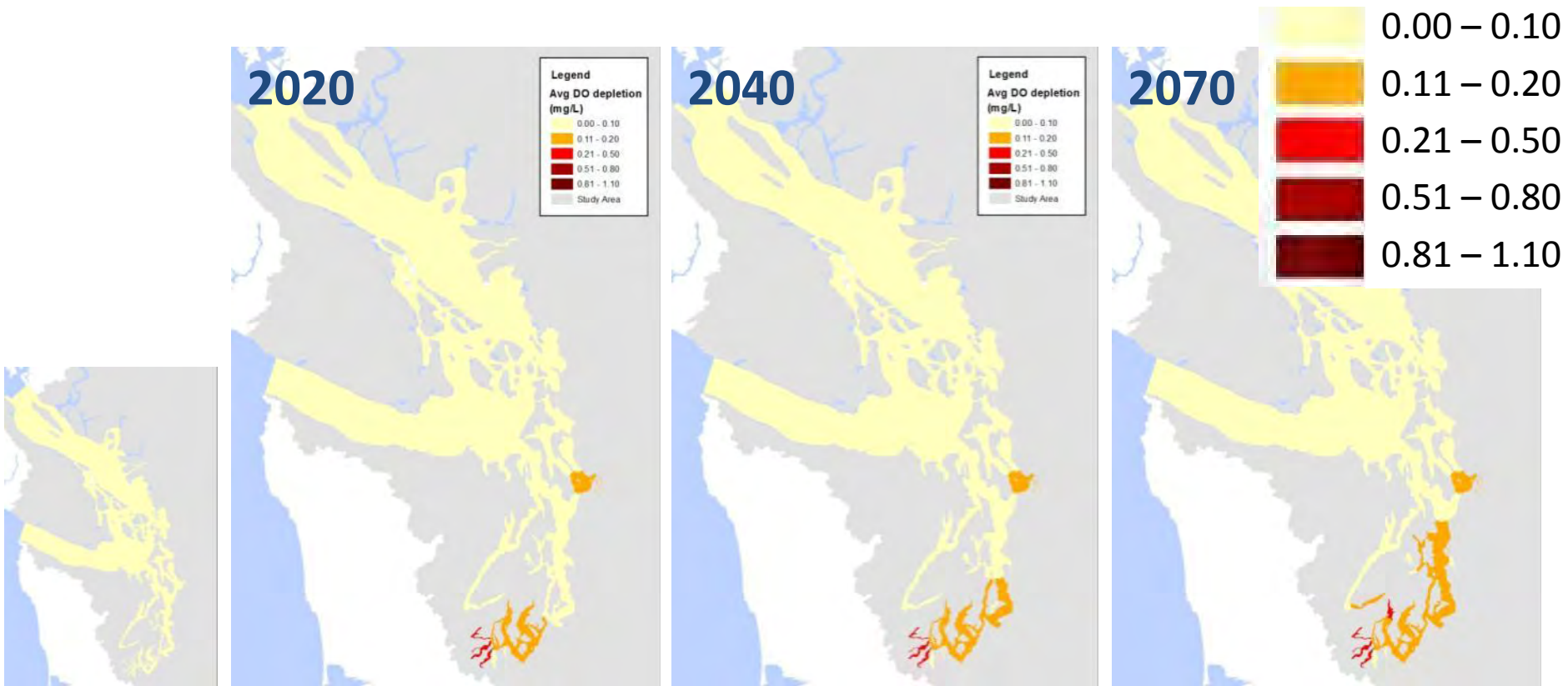
- *Biggest impacts in South and Central Puget Sound*
- *Not directly applicable to State of WA water quality standards*

Average regional and seasonal oxygen deficit:

- Oxygen inventory
- Below pycnocline
- September - October

Oxygen depletion – future marine point sources and watershed inflows

Average DO depletion (mg/L)



current

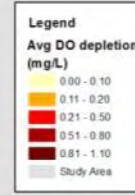
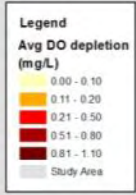
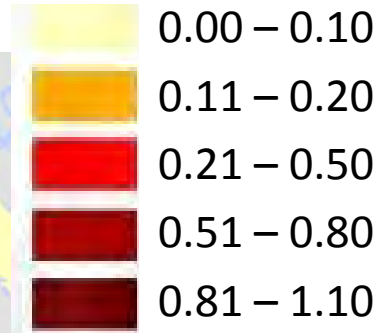
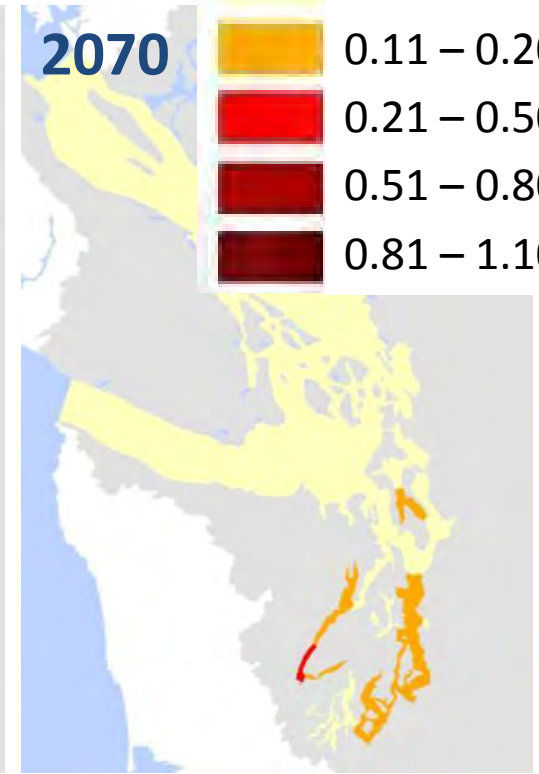
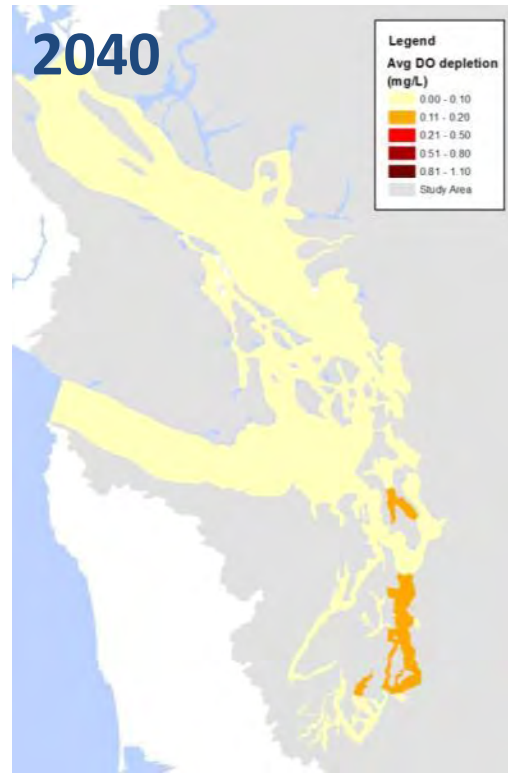
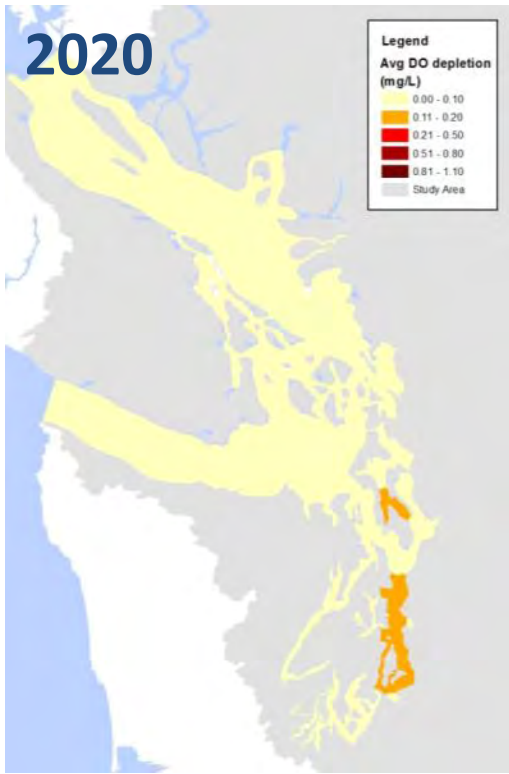
2020 loads, current circ, current ocean

2040 loads, current circ, current ocean

2070 loads, current circ, current ocean

Oxygen depletion – future human loads and future circulation

Average DO depletion (mg/L)



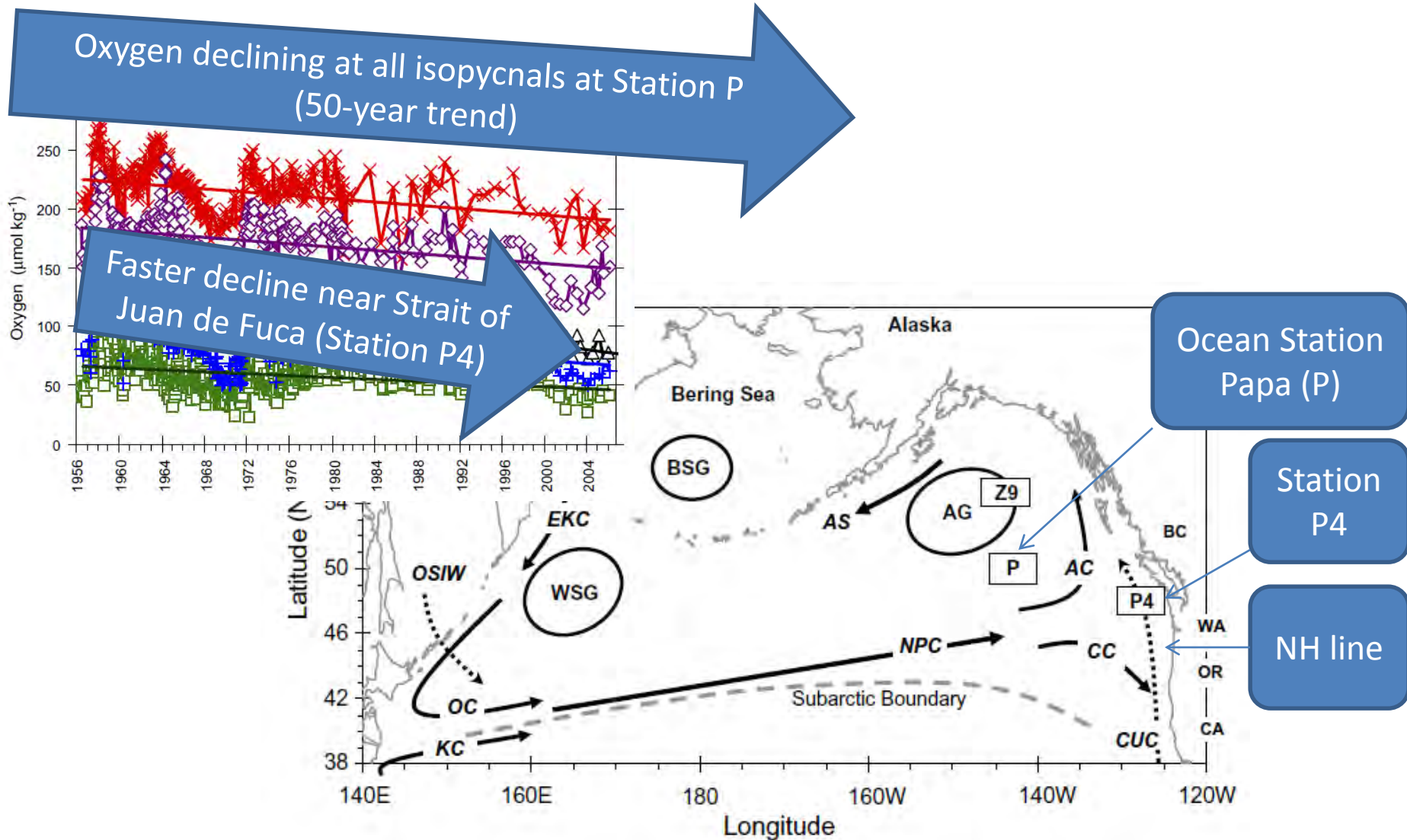
current

2020 loads, future circ, current ocean

2040 loads, future circ, current ocean

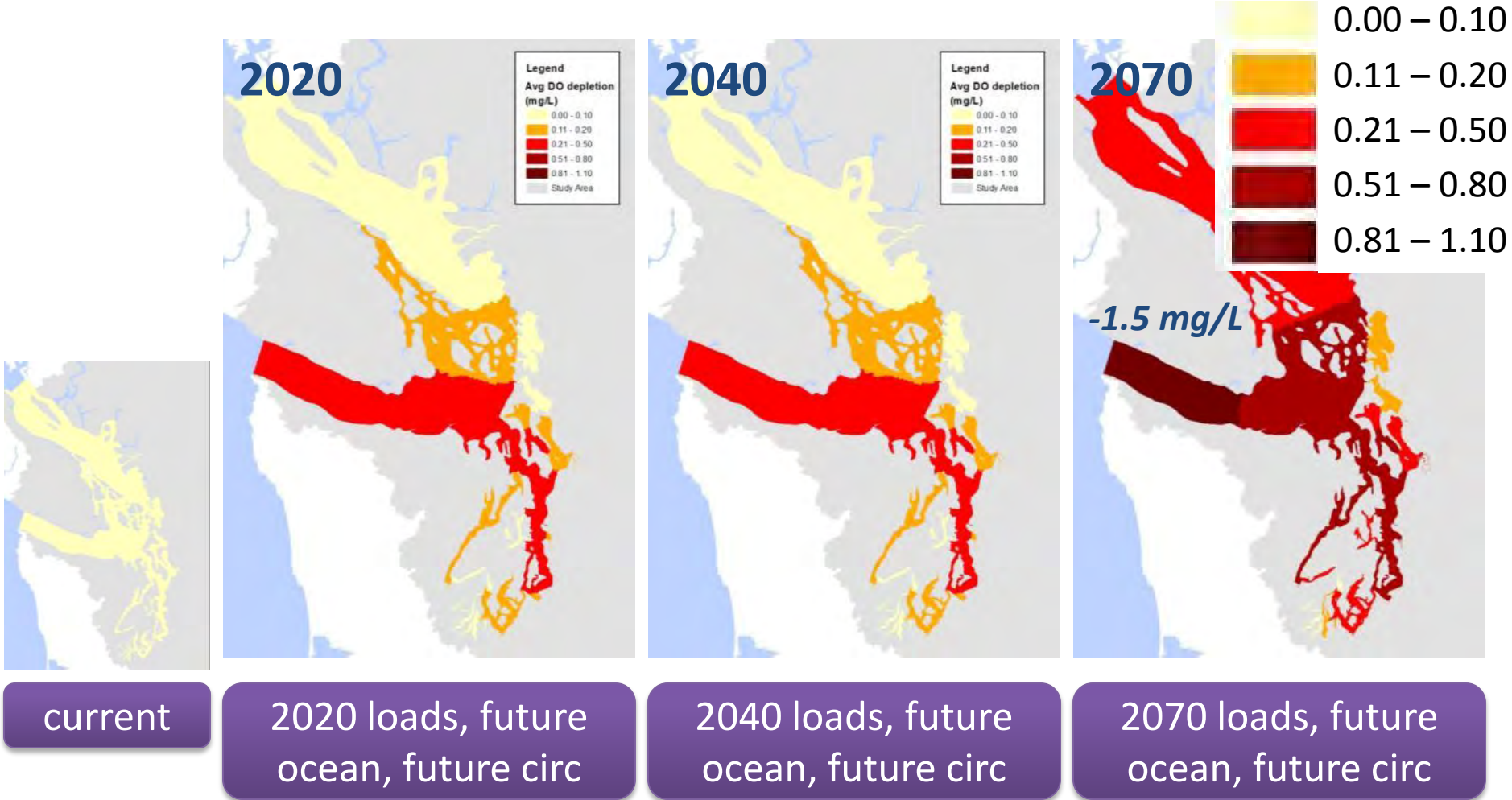
2070 loads, future circ, current ocean

Future scenarios – Pacific Ocean trends

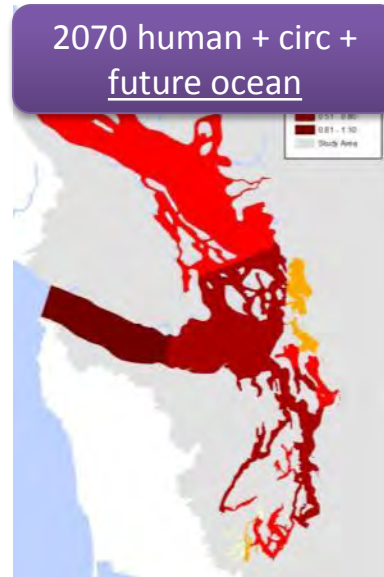
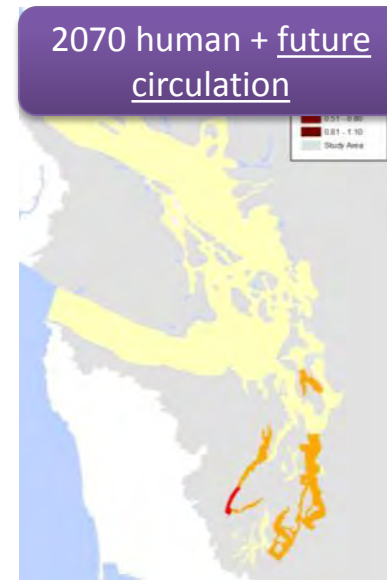
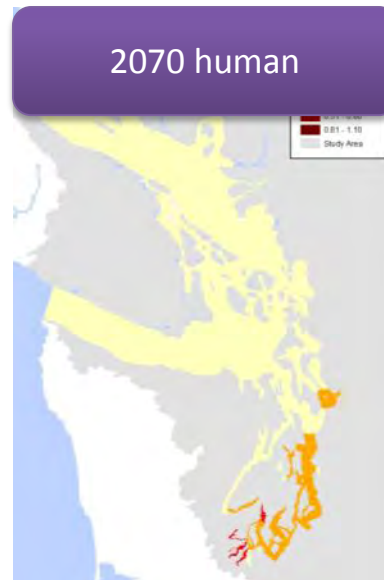


Oxygen depletion – future human loads, circulation, and ocean

Average DO depletion (mg/L)

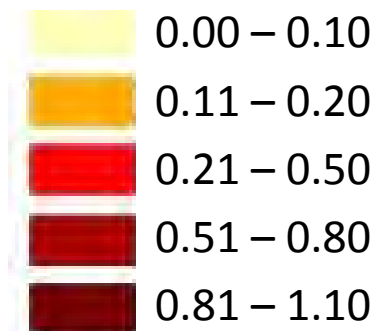


Future population growth will increase oxygen impacts; ocean trends would make it worse



Average depletion

(mg/L of oxygen decline compared with current conditions)



Relative impacts on dissolved oxygen

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temperature

Changes in circulation due
to changes in freshwater
inflows

Increased
wastewater
from future
population

Sediment-water
exchanges

Pacific Ocean trends

Higher river nitrogen
concentrations from
land cover change

... more study needed.

Influence

HIGHER

LOWER

Future ocean conditions

HIGHER

Future marine community shifts

Future climate

(air temperature, precipitation, hydrology)

Future sediment-water exchanges

Future watershed concentrations
(land cover)

Future watershed inflows

LOWER

Future marine point source concentrations

Future marine point source flows

Current sediment-water exchanges

Current ocean conditions

Current watershed inflows

Current marine point sources 14

Next steps (2015):

Pacific Ocean trends?

Sediment diagenesis

Revisit scenarios

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Pacific
Ocean

Report:

www.ecy.wa.gov/programs/wq/PugetSound/DOModel.html

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