

Impacts of Saltwater Intrusion into an Urban Freshwater Lake

Tim Clark

King County

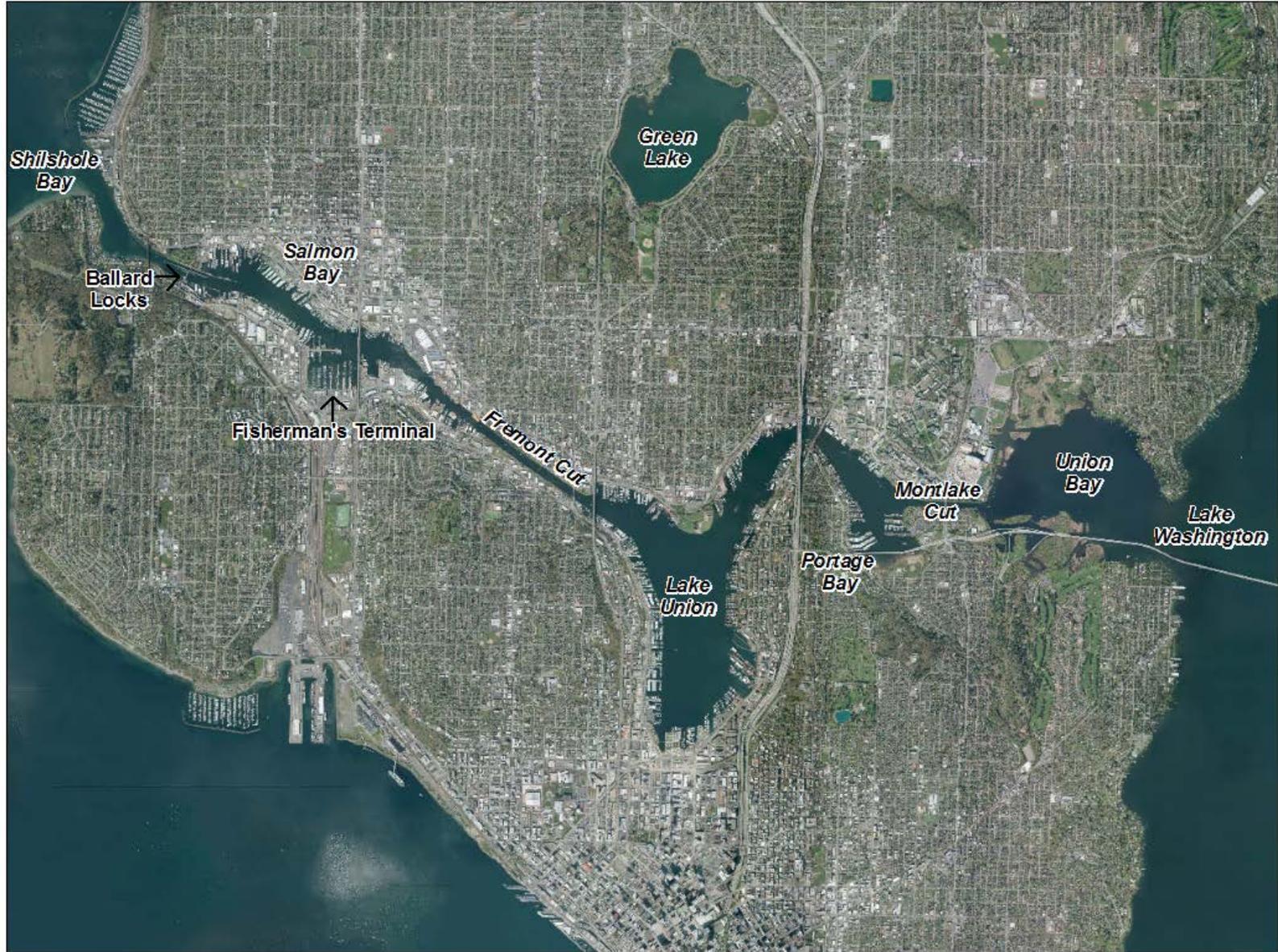
Department of Natural Resources

Water and Land Resources Division

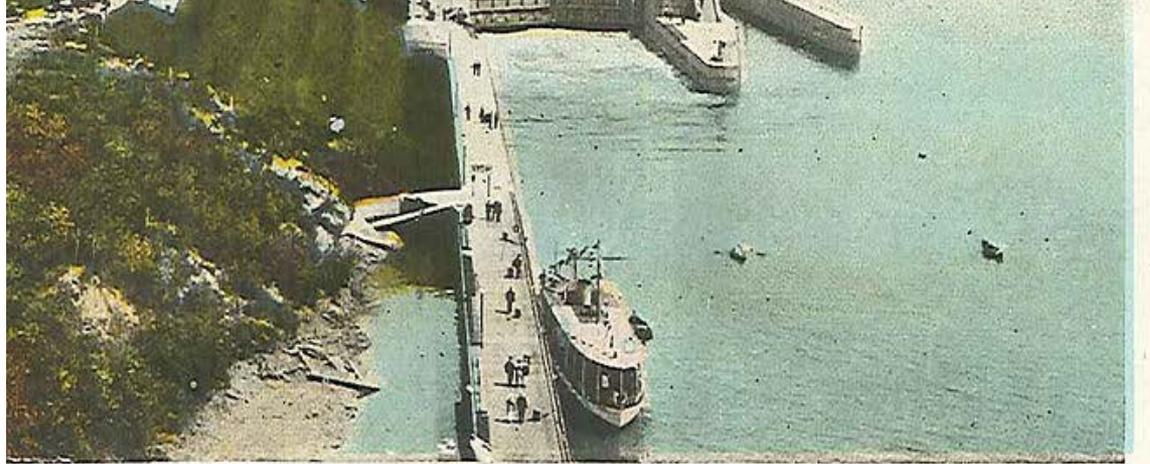
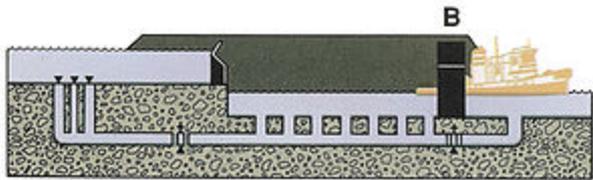
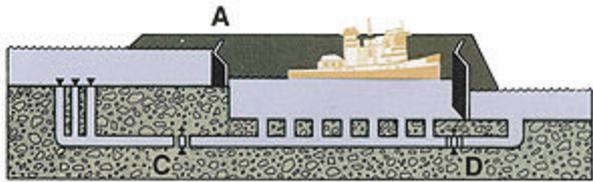
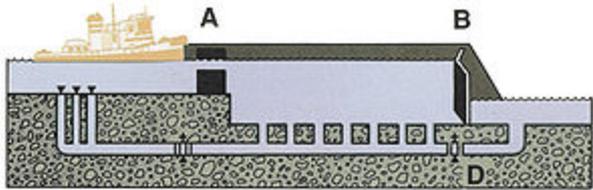
Lake Union/Ship Canal - Yesterday



Lake Union/Ship Canal - Today







MA.

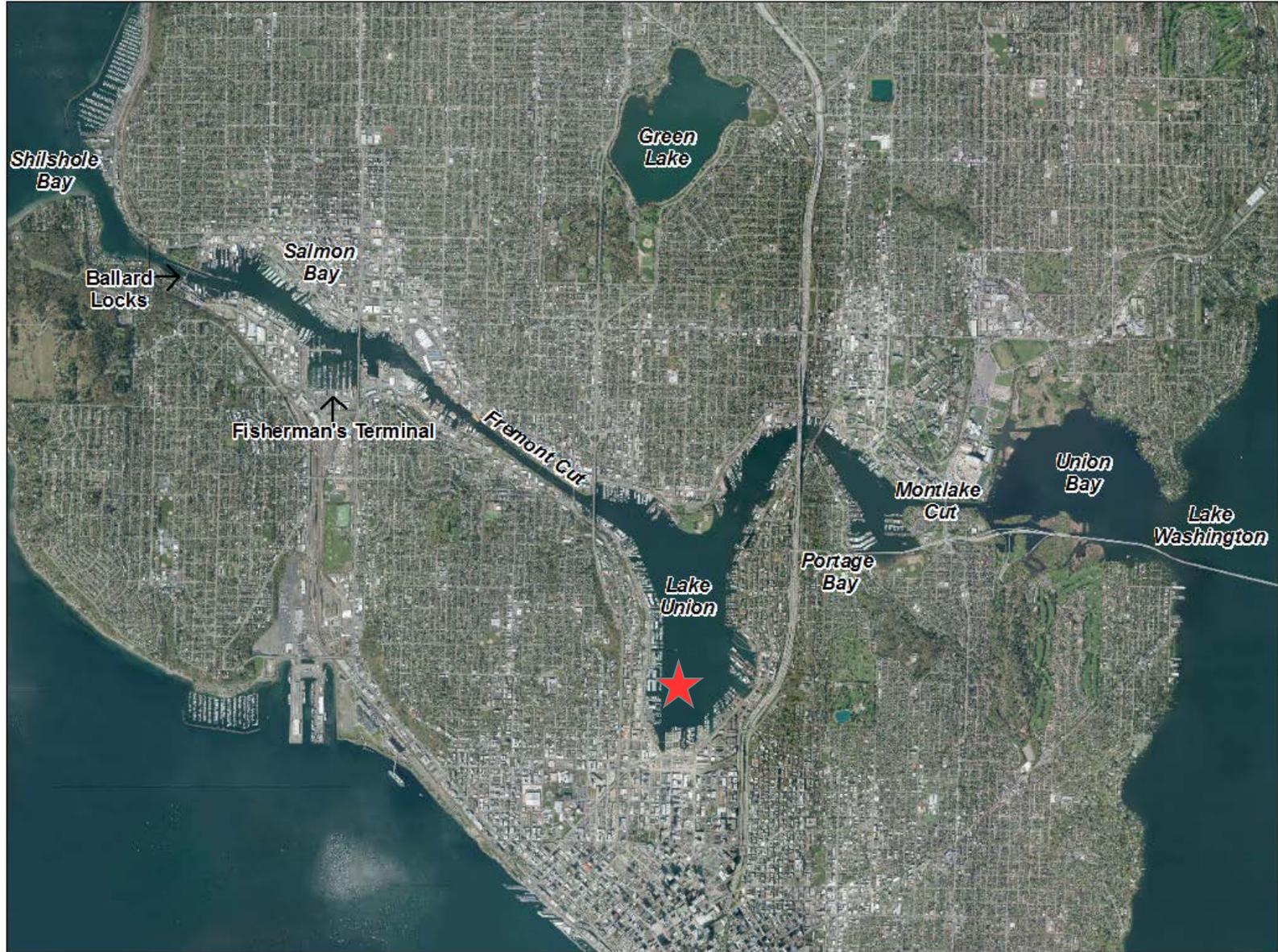
Following Ship Canal Construction

- Level of Lake Washington dropped by 8.8 ft (2.7 m)
- Lake Washington's outlet switched from the Black River to the Montlake Cut
- Due to lockages, saltwater could now enter Salmon Bay, Lake Union, and even Lake Washington
- Tactics to prevent intrusion:
 - Saltwater drain (improved pumping in late '50s)
 - Dredging
 - Barrier (1966)

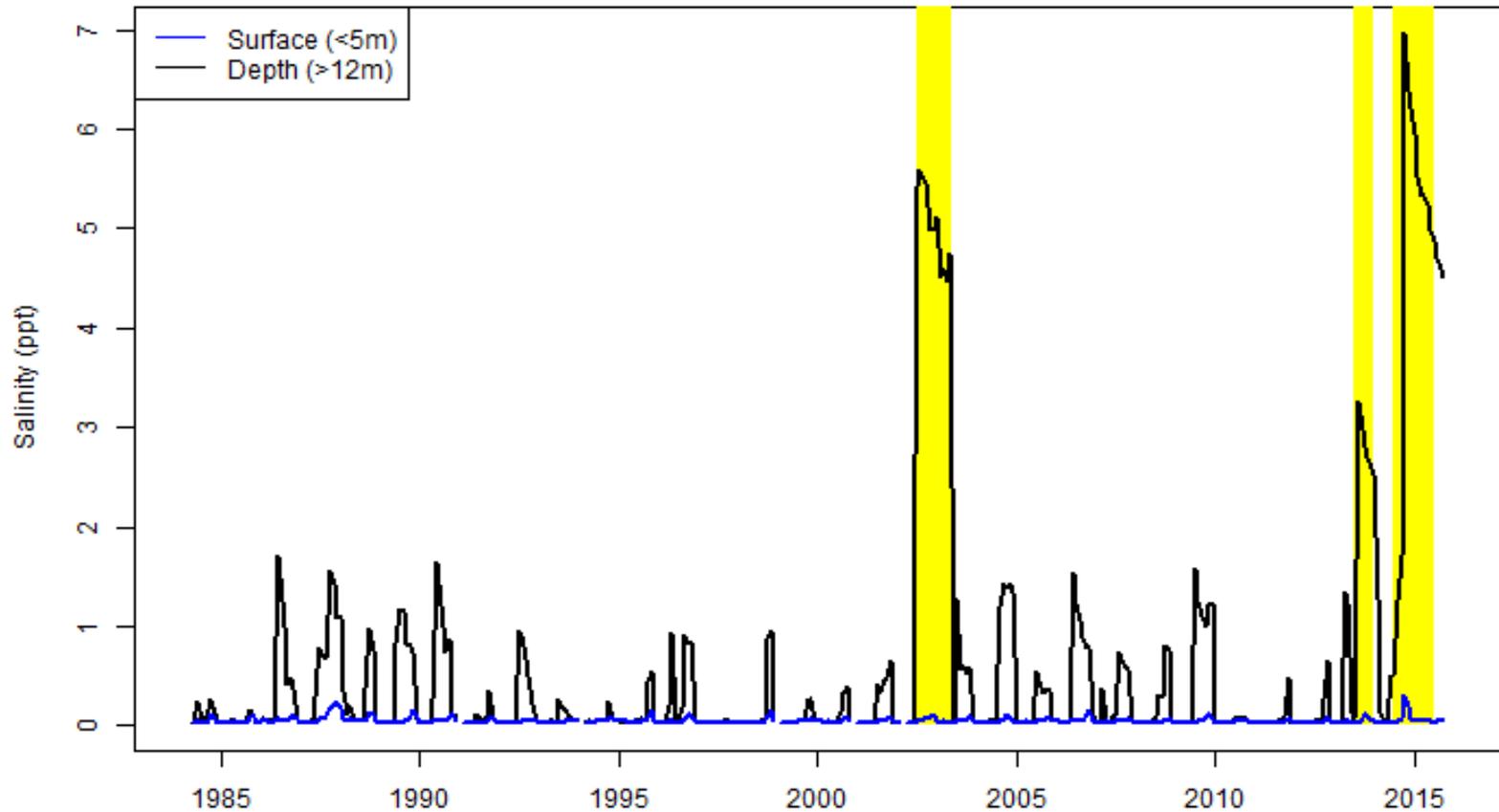
What's the Problem with Salt?

- How does it get in?
 - Up-lockages mix marine water from Shilshole Bay with freshwater from Lake Union
- When does it get into Lake Union and Lake Washington?
 - High lockages
 - Low inflow and runoff
 - (Summer months)

Lake Union/Ship Canal - Today



1985 - 2015 Salinity

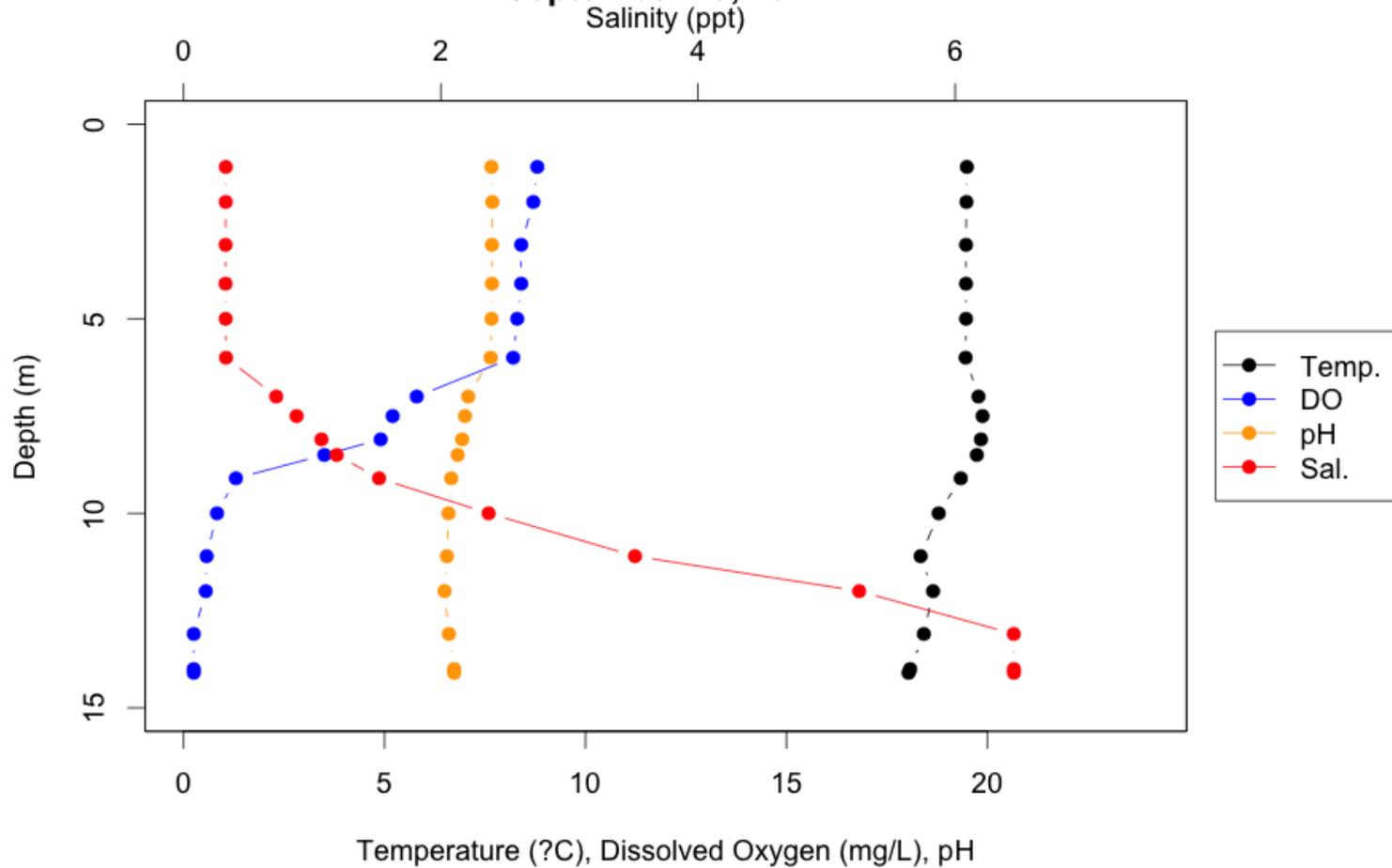


King County site in SW Lake Union (A522) –
max depth: 16 m

What Happened in 2014?

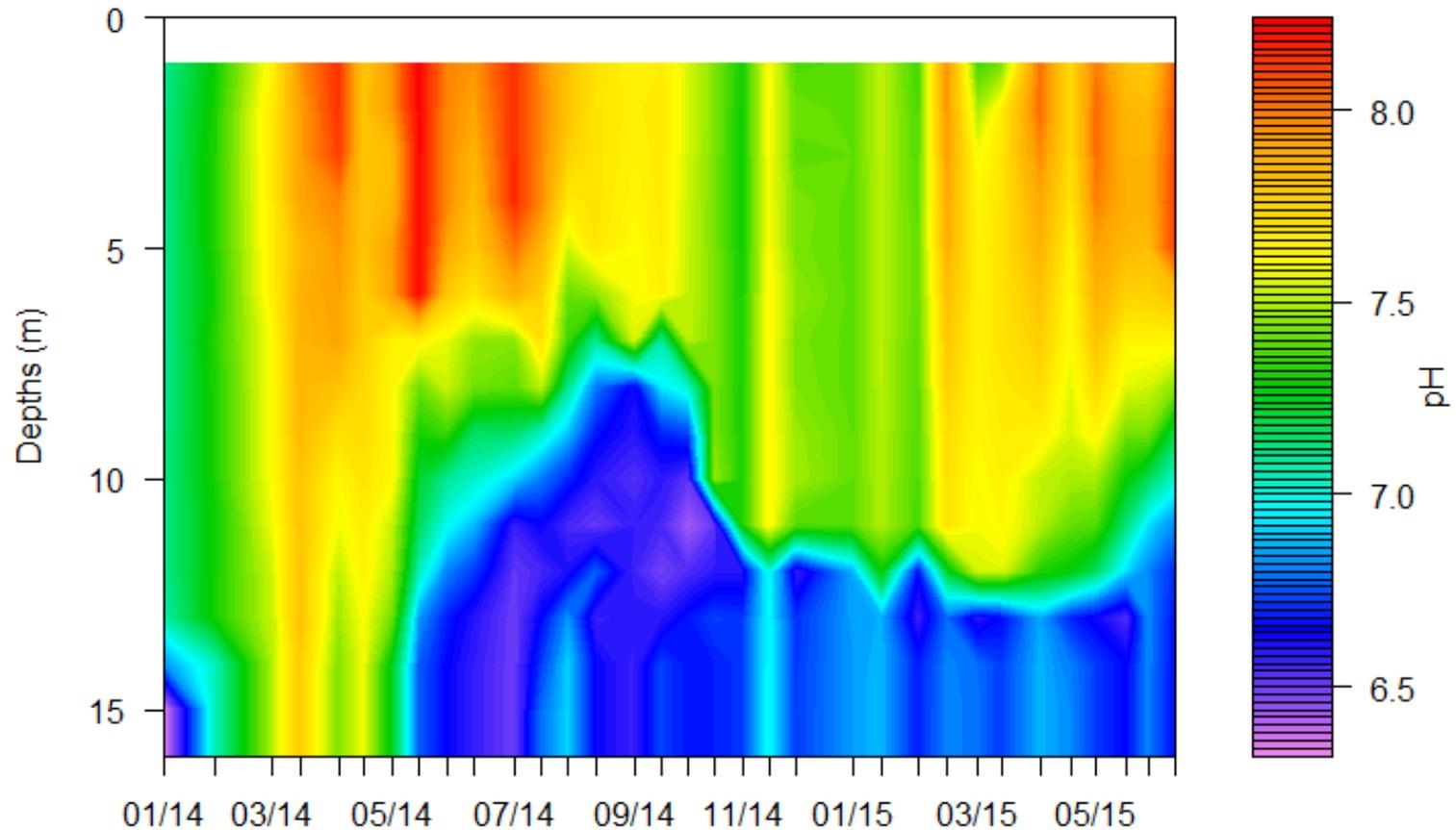
- Army Corps False Lockings Experiment
 - Lake Union is too warm for migrating salmon in summer ($>20^{\circ}$ C)
 - Cool Salmon Bay with cooler marine water ($\sim 14^{\circ}$ C)
 - How?
 - Increase the number of lockages
 - Lower the barrier
 - Turn off the saltwater drain
 - Essentially, undo all the measures made to prevent the intrusion.

September 29, 2014



What's the Problem with Salt?

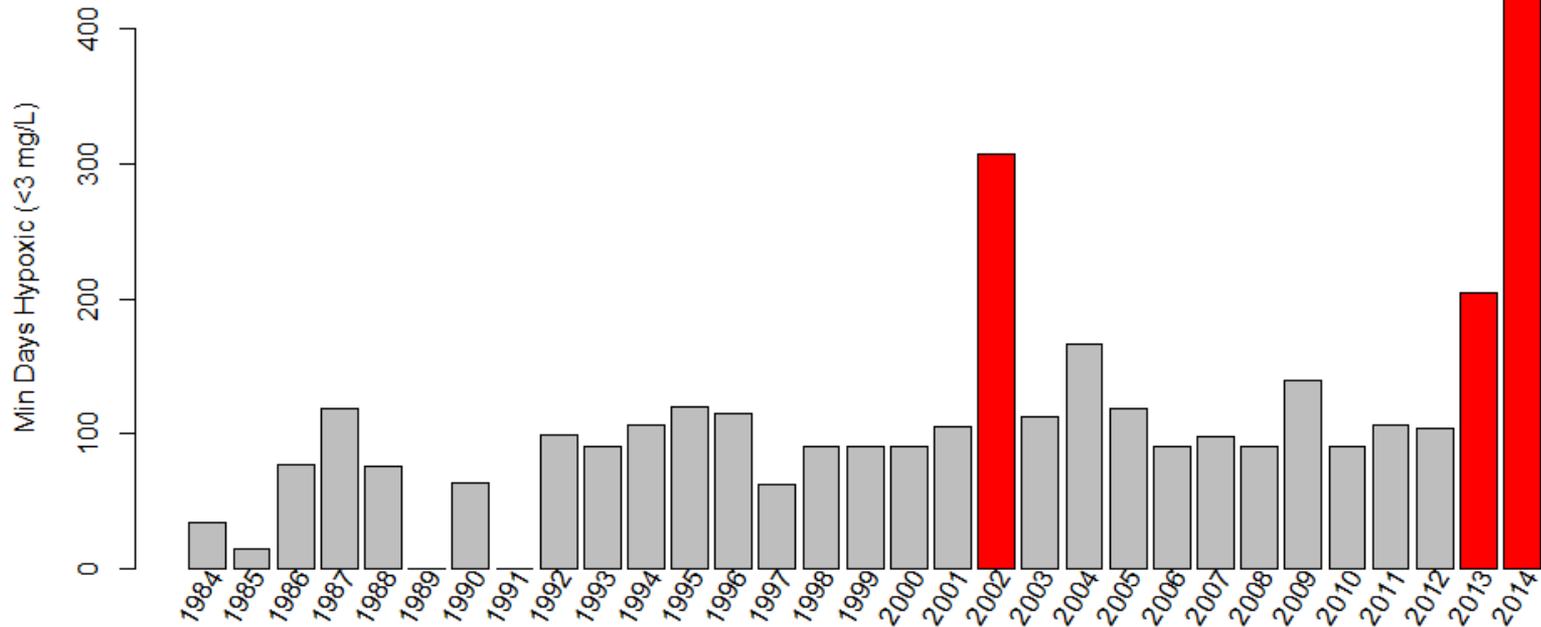
It just sits there...



What's the Problem with Salt?

- **Extended anoxic and acidic period for near-bottom water**
- Extended release and build-up of nutrients near bottom
- Potential contaminated sediment resuspension

Increased Period of Hypoxia

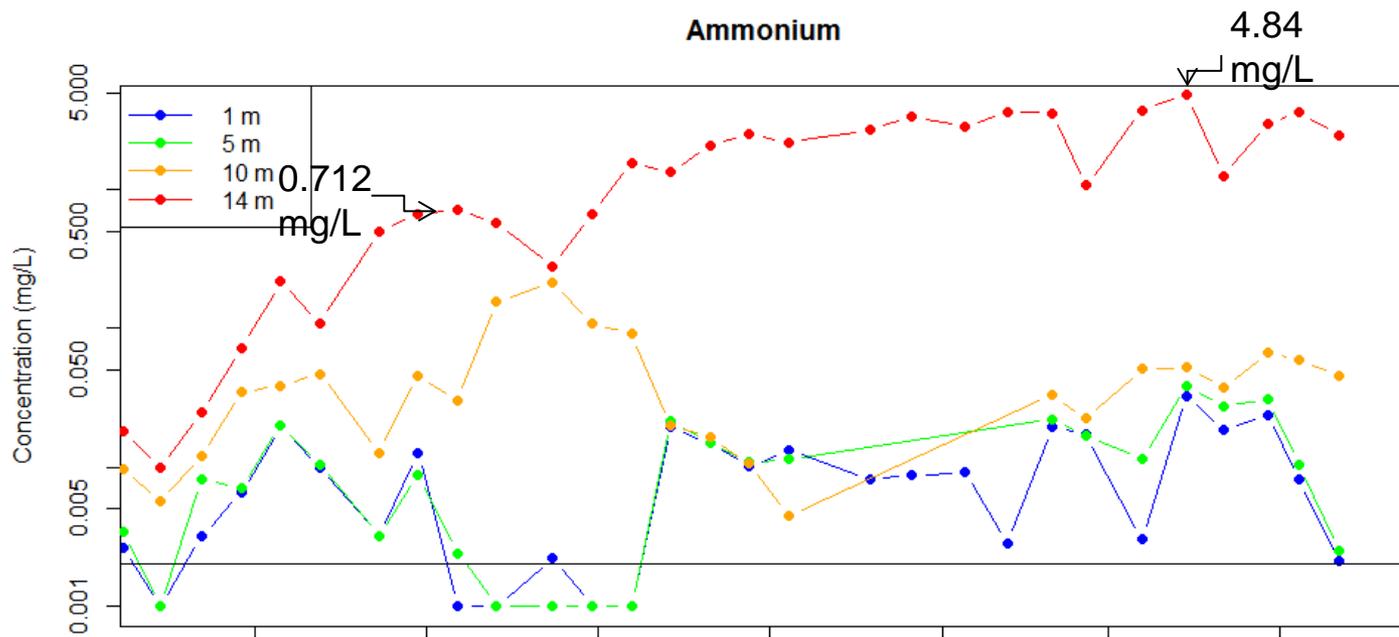


Days hypoxic calculated as first day of summer hypoxia observed through last day hypoxia (may include the following year)

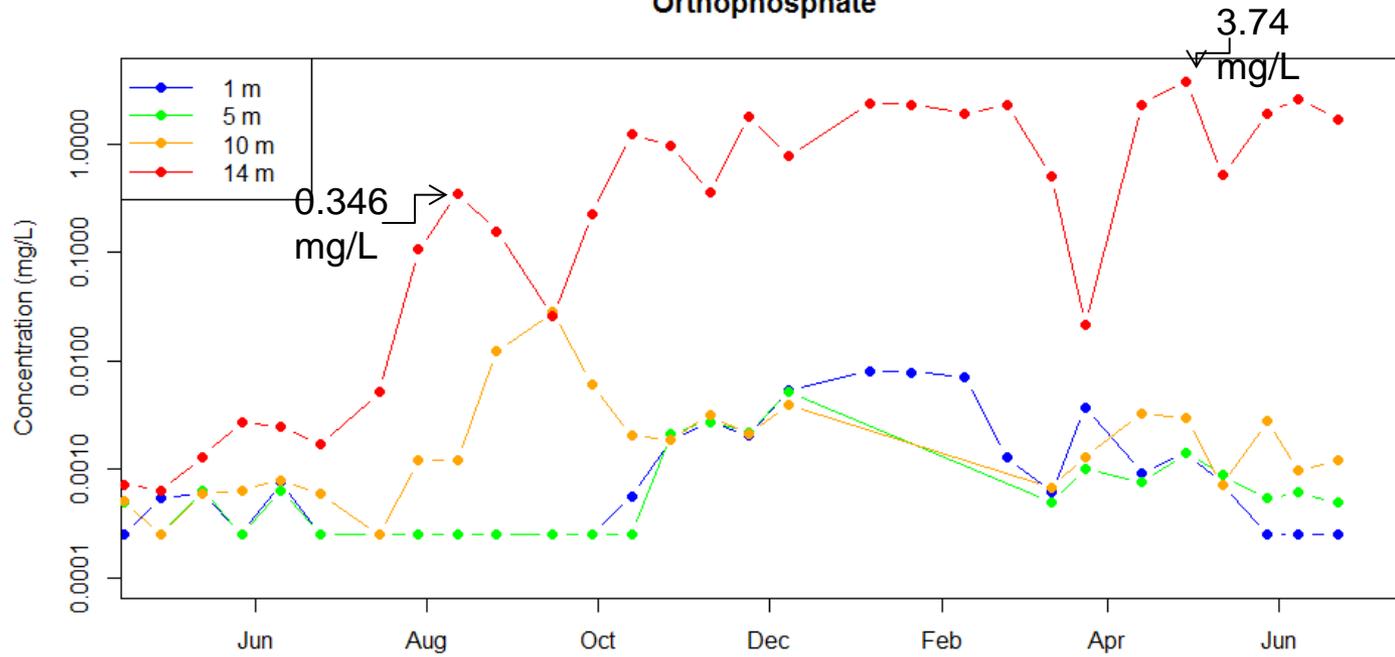
What's the Problem with Salt?

- Extended anoxic and acidic period for near-bottom water
- **Extended release and build-up of nutrients near bottom**
- Potential contaminated sediment resuspension

Ammonium



Orthophosphate



What's the Problem with Salt?

- Extended anoxic and acidic period for near-bottom water
- Extended release and build-up of nutrients near bottom
- **Potential resuspension of contaminated sediments**

What's the Problem with Salt?

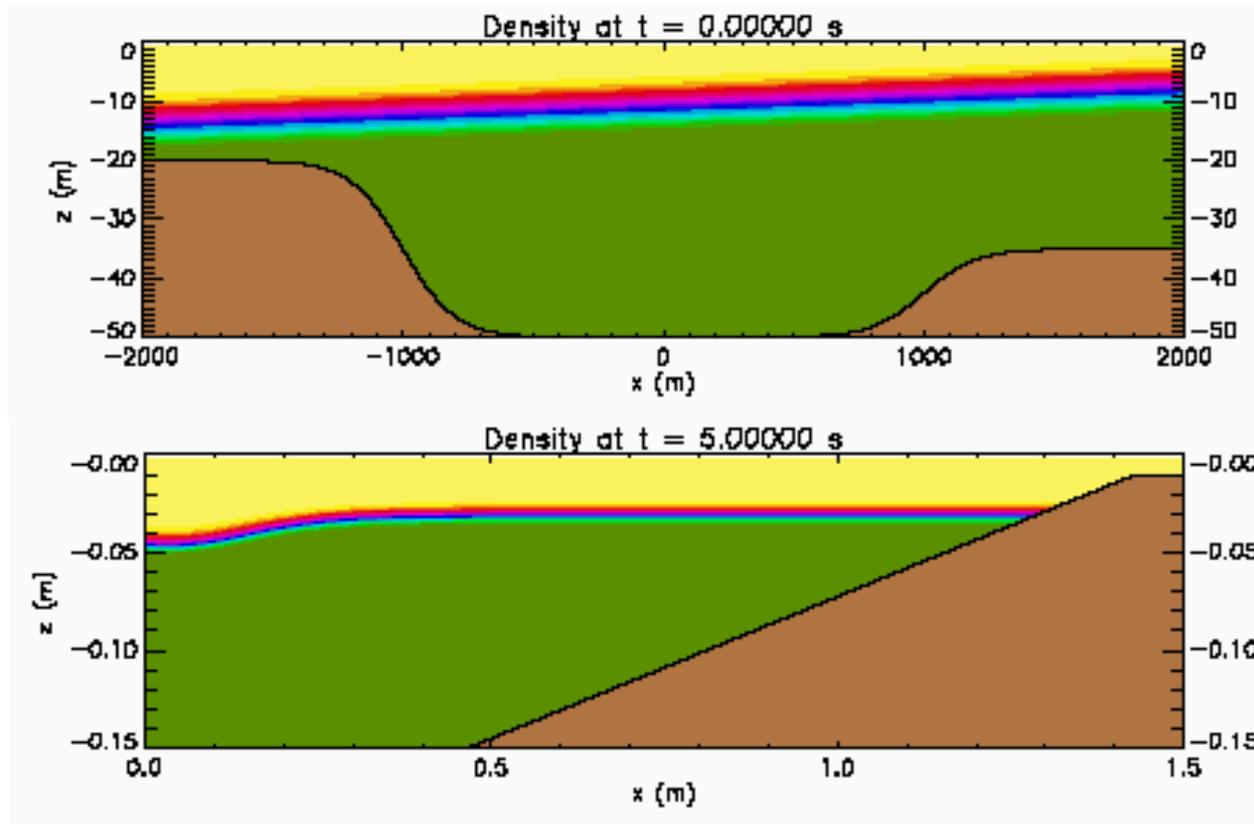
- In saltwater layer (compared to surface waters), we observed
 - Increased levels of PAHs
 - Increased levels of TSS
- Due to internal seiching?
- Due to slowed settling?

Sediment Contamination



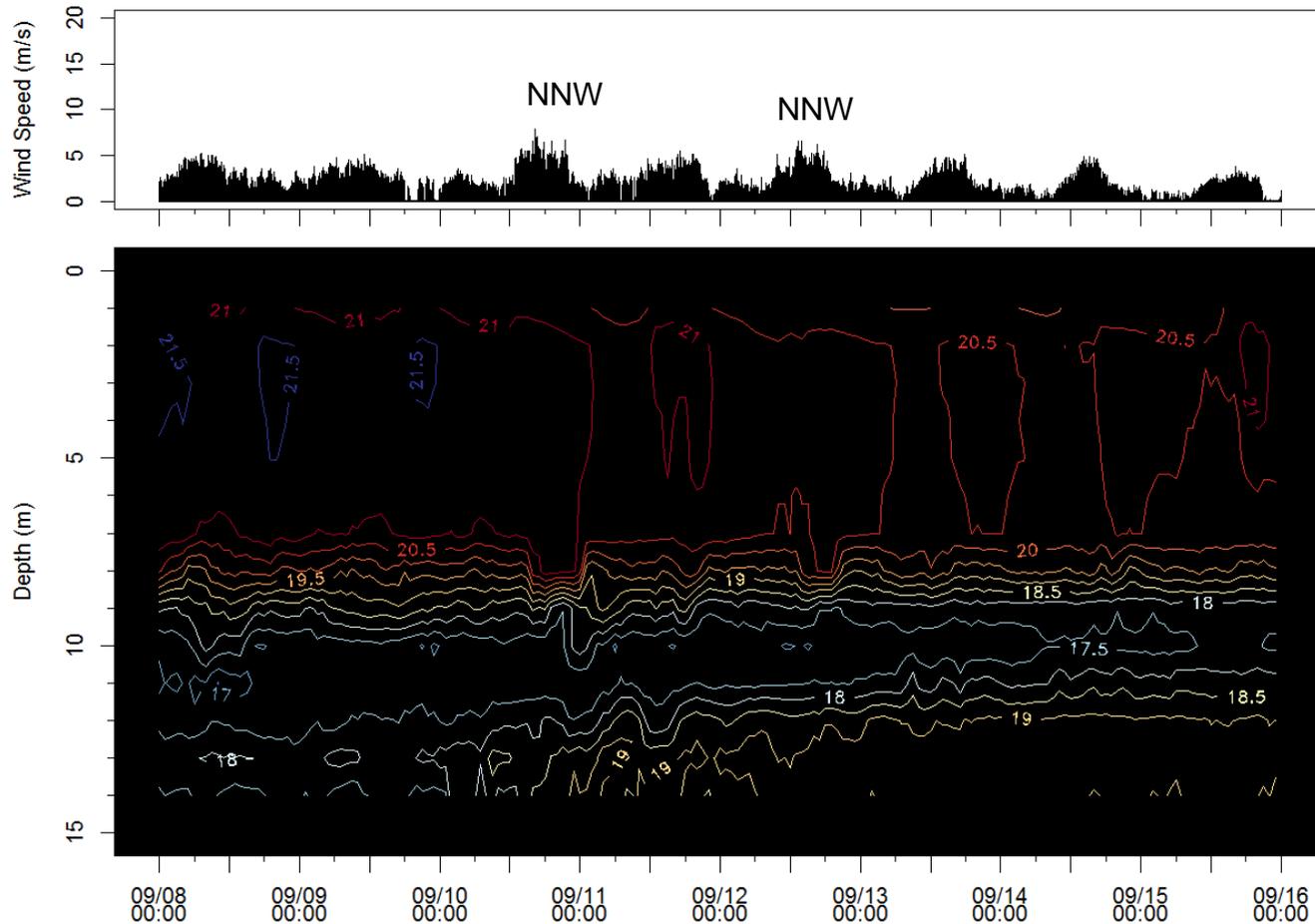
What's the Problem with Salt?

It doesn't just sit there...



What's the Problem with Salt?

It doesn't just sit there...



Outcomes of 2014/15 Saltwater Intrusion

- As of latest sampling (September), turnover has not occurred
- Army Corps data suggests whole-lake mixing occurred in early October during storm event.
- Army Corps do not plan on turning off the saltwater drain
 - Did not find substantial temperature decreases
 - May complete locking to cause mixing and increase bottom DO if sensors indicate hypoxia

QUESTIONS?

