Hiram M Chittenden Locks

Fish injury and predation

LWSC water quality study

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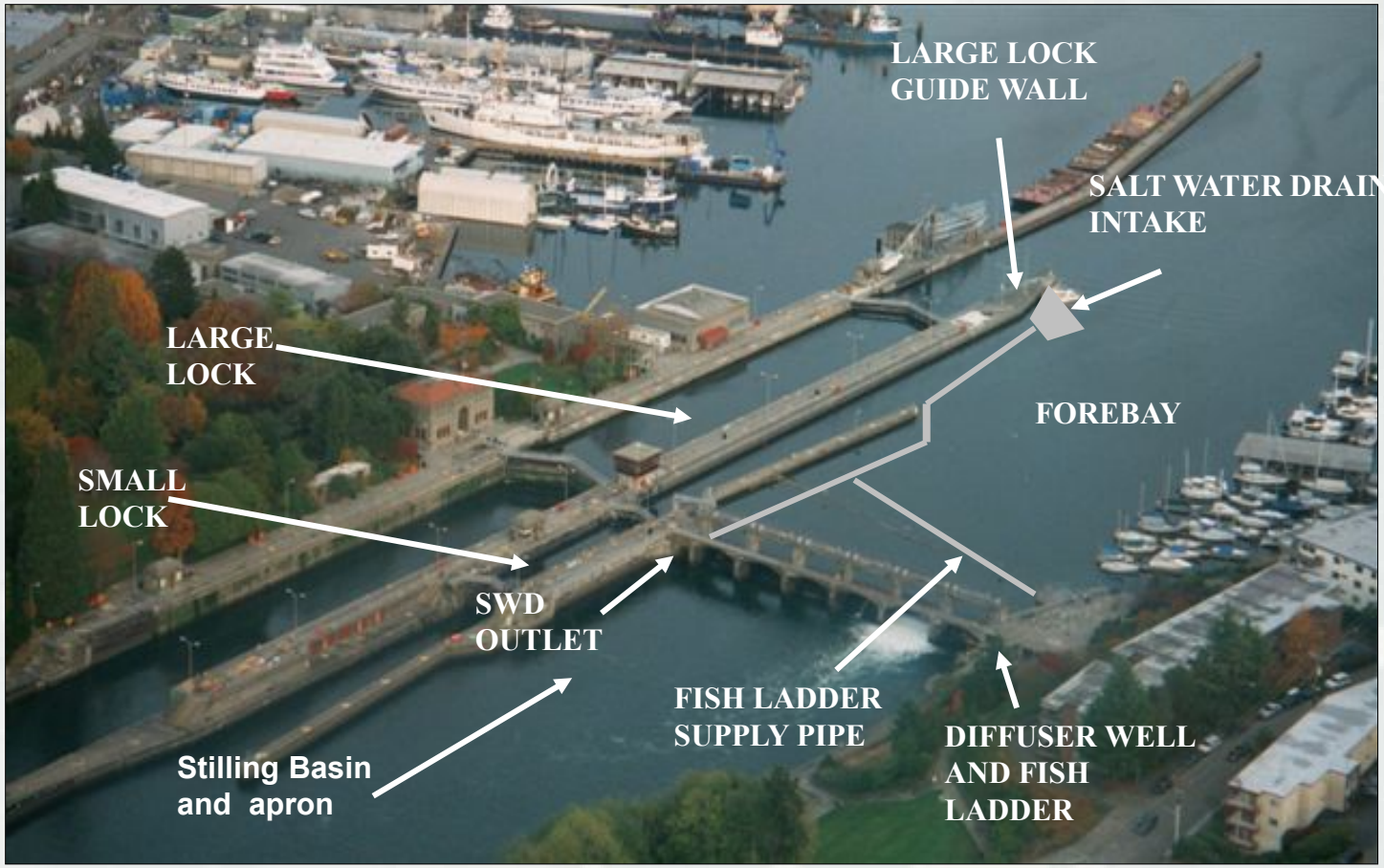
US Army Corps of Engineers
BUILDING STRONG®

Topics

1. Overview
2. Large lock and filling culverts
3. Saltwater drain and diffuser well
4. Predation
5. LWSC water quality study

Locks overview



Locks exit pathway - Chinook salmon

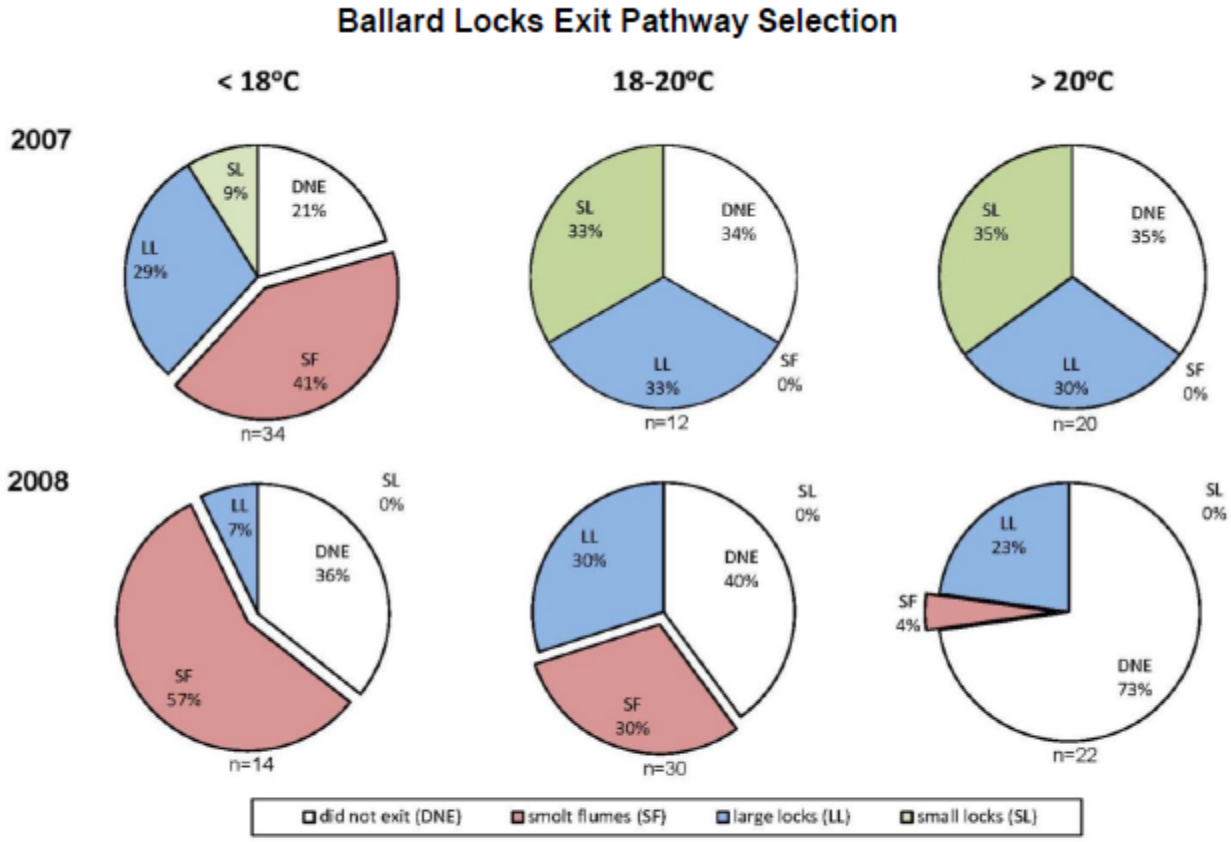
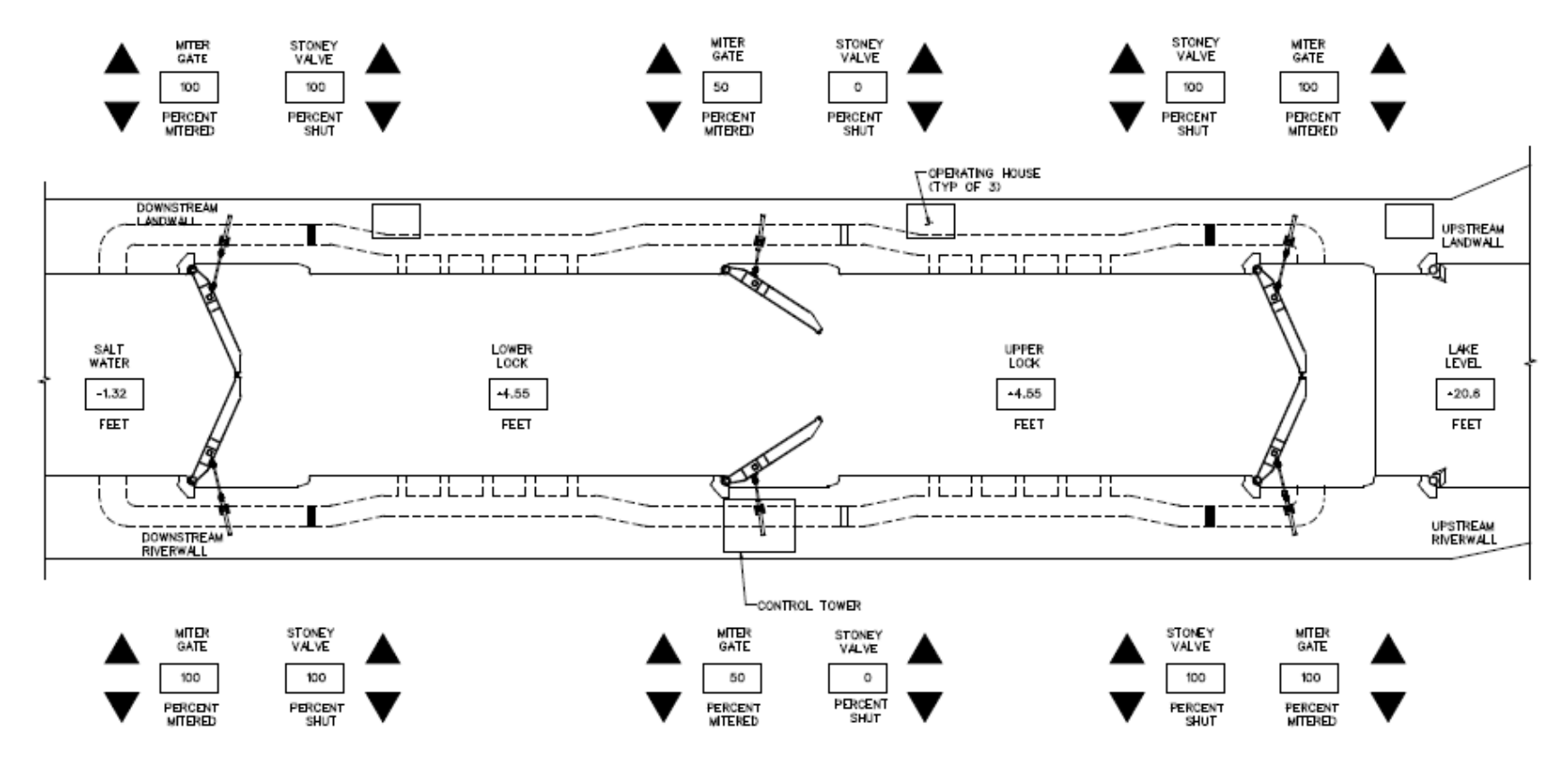


FIGURE 34. Proportion of tagged fish using different exit pathways at the Ballard Locks at three temperature regimes, June-July, 2007-2008. Temperature regimes were established using predominant surface water temperature at 1-2 m depth. See Table 1 for dates corresponding with each temperature regime.

0%: fish ladder & saltwater drain

from Caledonia et al. 2011

Large Lock


MITER GATE
100
PERCENT MITERED
STONEY VALVE
100
PERCENT SHUT
MITER GATE
50
PERCENT MITERED
STONEY VALVE
0
PERCENT SHUT
STONEY VALVE
100
PERCENT SHUT
MITER GATE
100
PERCENT MITERED
OPERATING HOUSE (TYP OF 3)
DOWNSTREAM LANDWALL
UPSTREAM LANDWALL
SALT WATER
-1.32
FEET
LOWER LOCK
+4.55
FEET
UPPER LOCK
+4.55
FEET
LAKE LEVEL
+20.8
FEET
DOWNSTREAM RIVERWALL
UPSTREAM RIVERWALL
CONTROL TOWER

Large lock issues

- Attracts juvenile salmon and other fish species into filling culverts
  - ▶ High velocity, sharp turns, narrow openings, gates, and barnacles
  - ▶ 'Mini-flushing' procedure (ended 1990s)
  - ▶ Strobe light failure
- Results in injured and dead smolts
  - ▶ Predators (seagulls, others?) capture injured fish

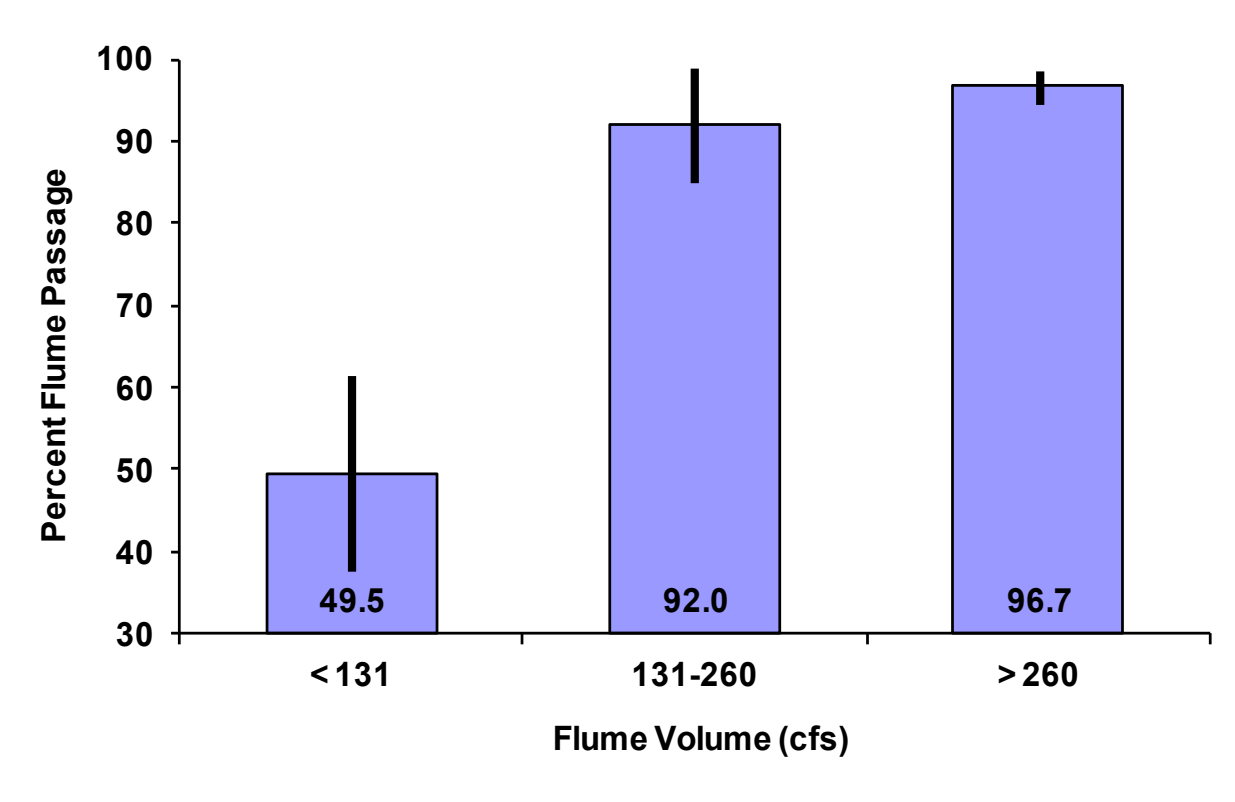
Filling culverts

Smolt flumes

- Installed in 2000
- Attracts smolts away from the large lock
- Provides a surface water outlet

- Conserves water relative to spillway use which allows for surface oriented fish passage during smolt emigration season
- Since 2013 began to maximize use of available water by using entire authorized lake elevation

Fish passage
smolt flumes vs large lock

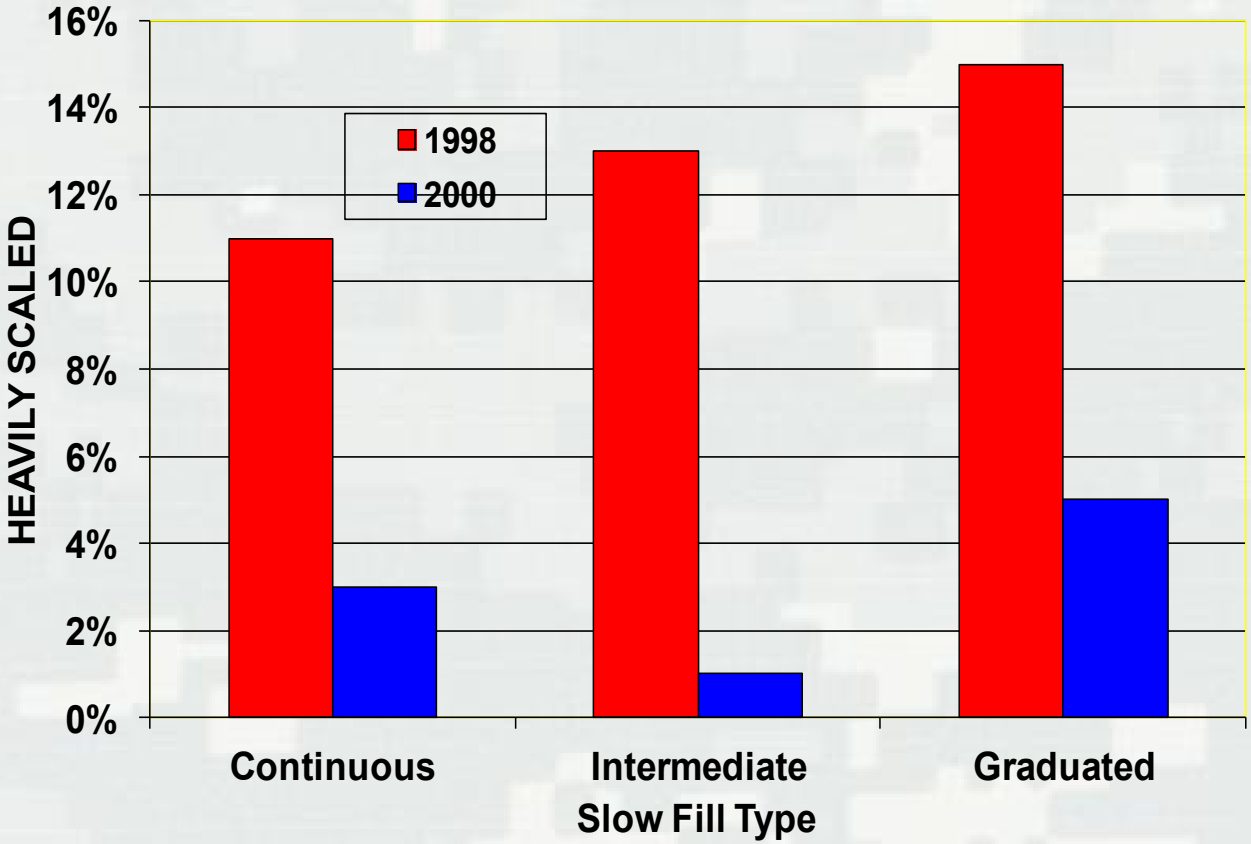


2000 & 2001 data combined

Annual barnacle removal from filling culverts

- Conducted annually since 2000 in November during large lock maintenance dewatering
- Investigating use of antifouling paint

Barnacle removal effectiveness



Comparison of Heavy (greater than 10%) Descaling of Fish Captured in the Large Lock Before (1998) and Following (2000) Barnacle Removal, Percent of purse seine catch

Filling Culvert Valve Replacement

DESCRIPTION AND CONDITION

- "Stoney Gate Valves" are original (1916)
- Total of six valves (two at each miter gate)
- Valves raise or lower lock chamber water elevation
- Valve speed cannot be adjusted.
- Fast velocities, 90 degree bends, and narrow openings result in fish injury and mortality

STATUS

- Anticipate completed design by fall of 2016
- Construction anticipated 2018 or 2019 (funding dependent)
- Cedar River Instream Flow Commission contributed $100k in design costs (Thank You!)
- Cost $3M-$11M depending on # of valves replaced. Plan on replacing #3 valves and control system first

FUTURE IMPACTS or BENEFITS

- New valves w/ hydraulic controls will reduce water velocity entraining less juvenile salmon

Maintenance dewatering activities

- Large lock
  - Late November timing minimizes catching salmon species
  - Crowd fish out before begin dewatering
  - Conduct fish rescue
- Small lock
  - February-March timing - very few fish captured
  - Conduct fish rescue
- Fish ladder
  - May timing; fish generally not captured

Diffuser Well & ASES

CONDITION

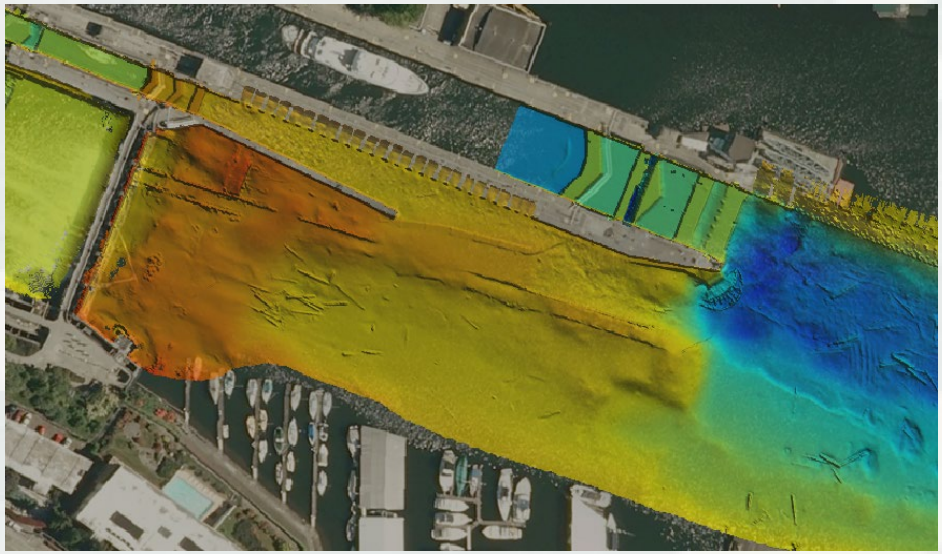
- Temporary structure to prevent adult salmon from entering the saltwater drain and becoming trapped in the diffuser well was installed in 2008
- Still functional and routinely inspected

IMPACTS

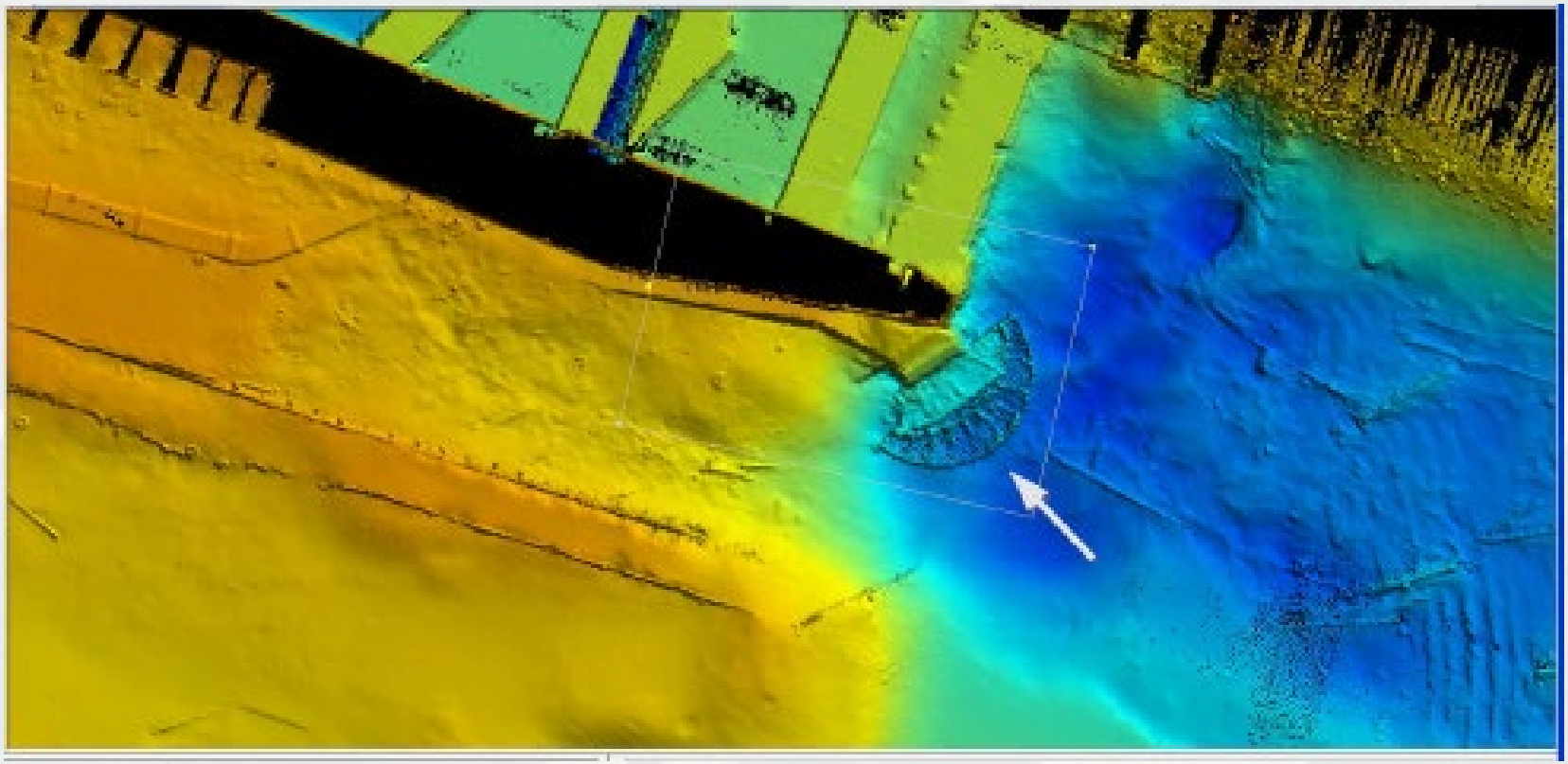
- Failure of the temporary structure would allow fish in the diffuser well

STATUS

- Budget requested for design and/or replacement temporary structure
- Temporary structure cost estimate is $500K- $1M;



Adult Salmon Exclusion Structure



Fish kill without ASES

Mammal Predation

Mammal deterrence

- Noise deterrence installed in mid-90s.
- 150 -180 dB in stilling basin, along pier nose & waiting pier

- Uncertain effectiveness
- Naïve animals likely dissuaded from approaching ladder.
- Some animals not discouraged – may be deaf

Bird predation

Fish predation???

- No data at the Locks
- Upstream in ship canal: number of studies, ongoing work
- No data for stilling basin downstream of the locks

Unknowns

- Fish injury related to small lock operation
- Large lock filling culvert use/injury over time and by species (juveniles and adults)
- Predation effect – quantitative (u/s & d/s)

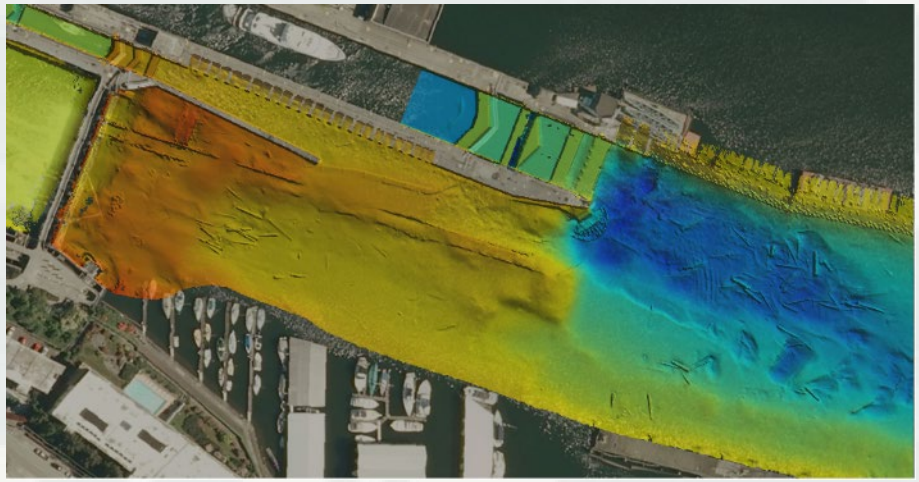
False Locking Study

Current conditions

- occasional high temp, low dO near Locks where adult Chinook salmon hold
- thermal migration barrier in ship canal; low dO/anoxic conditions at bottom

Study purpose

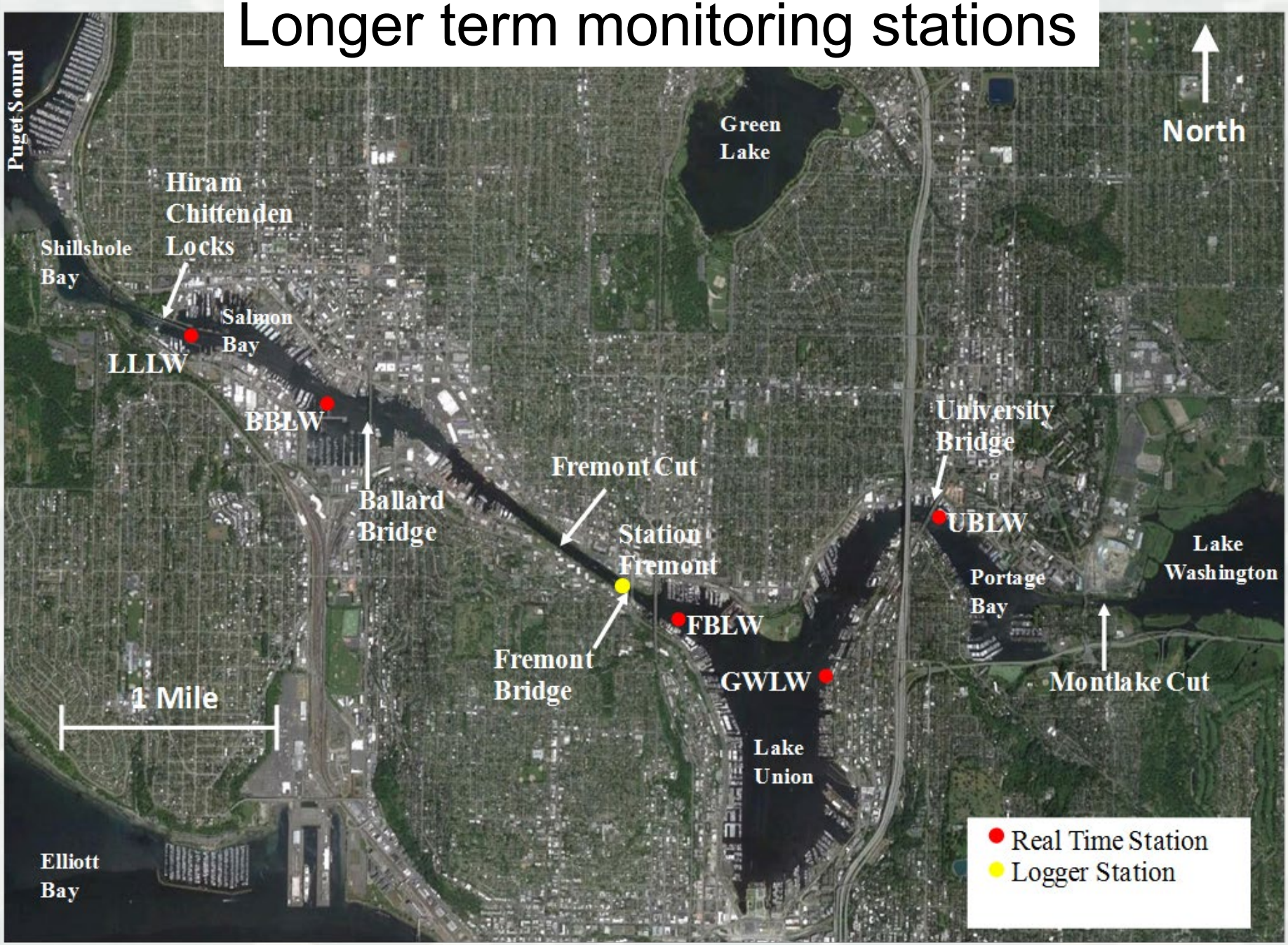
- decrease water temperature by adjusting operations to allow more salt water u/s of the Locks
- comply with BiOps

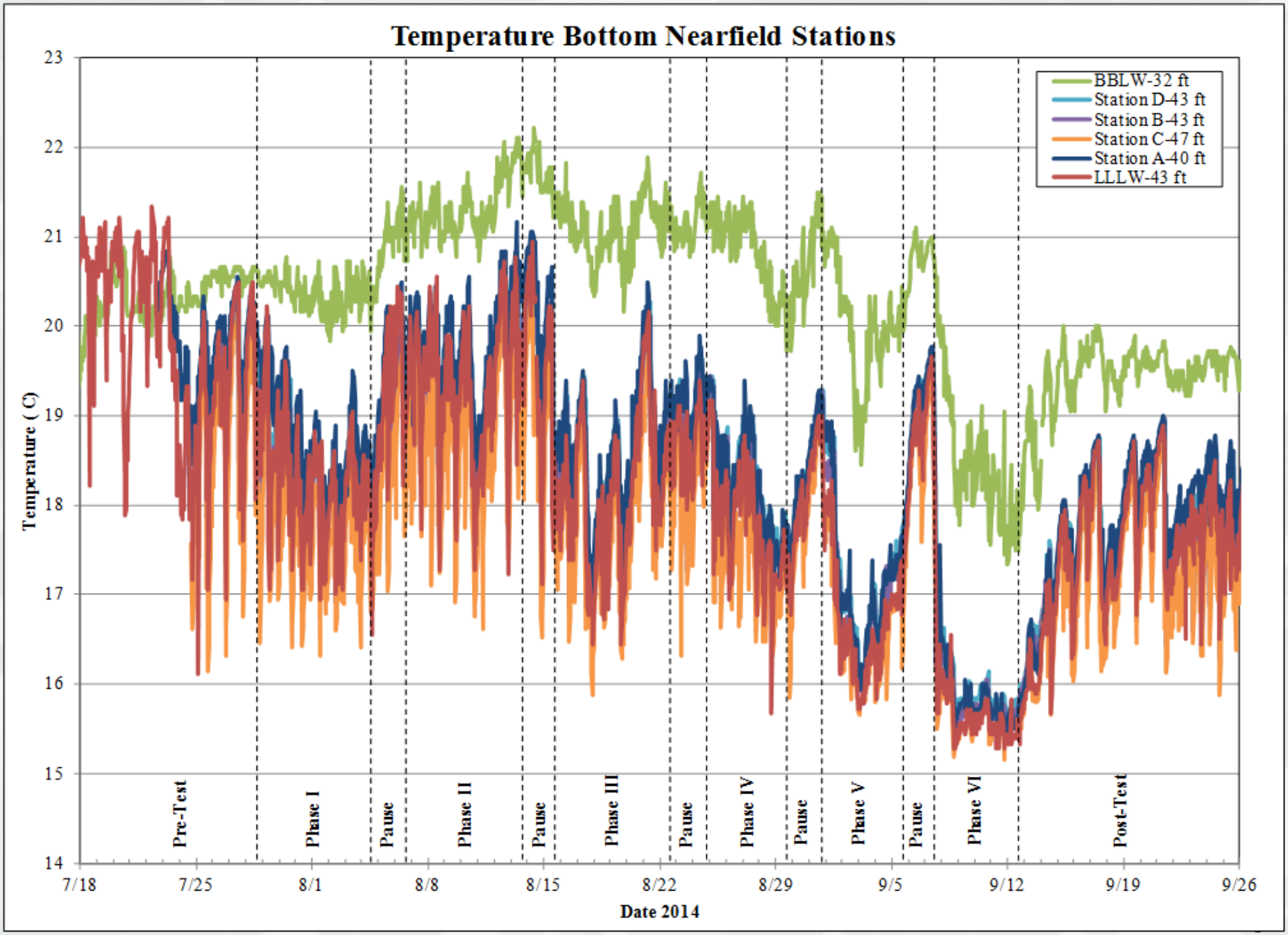


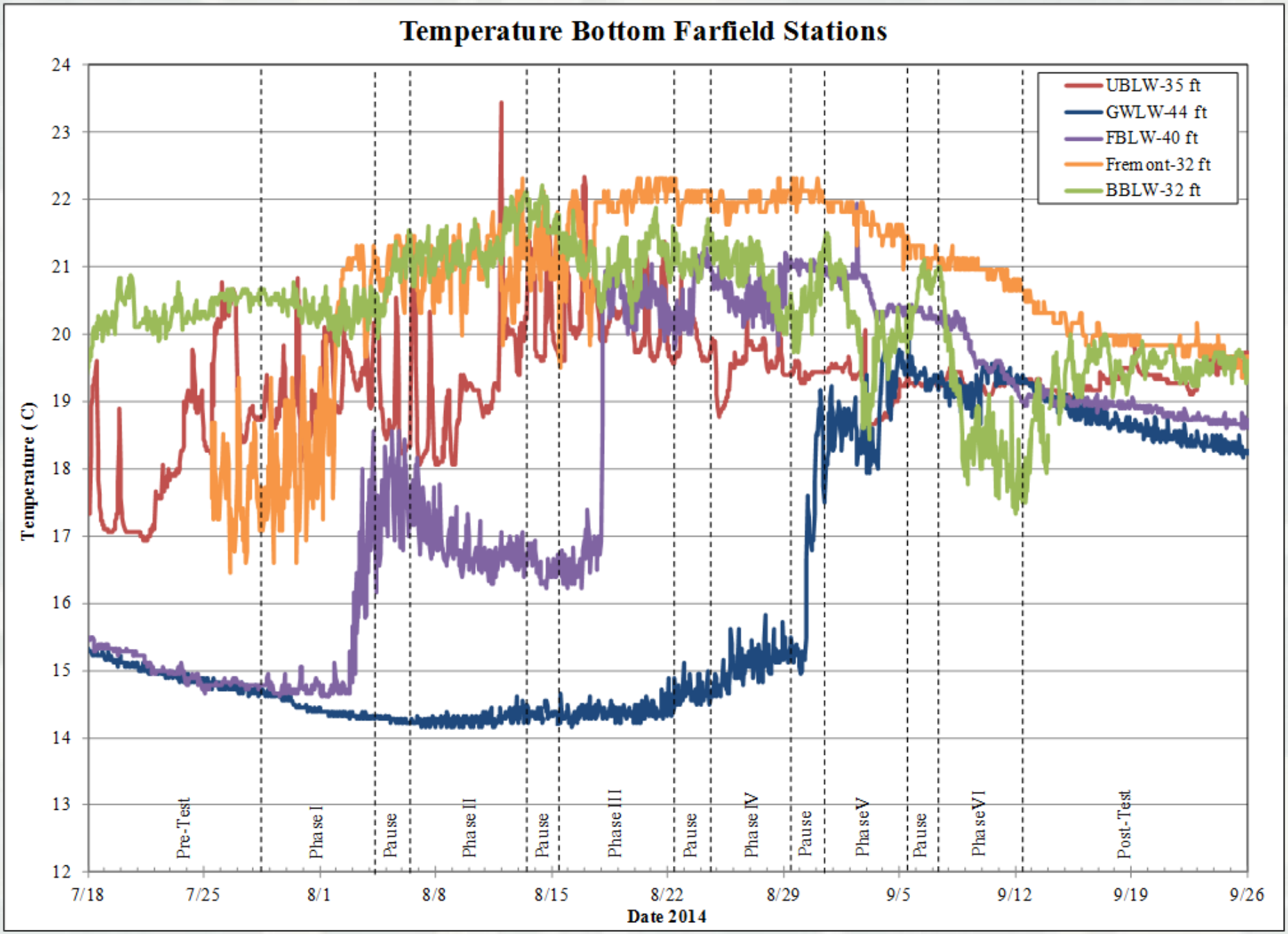
Actions

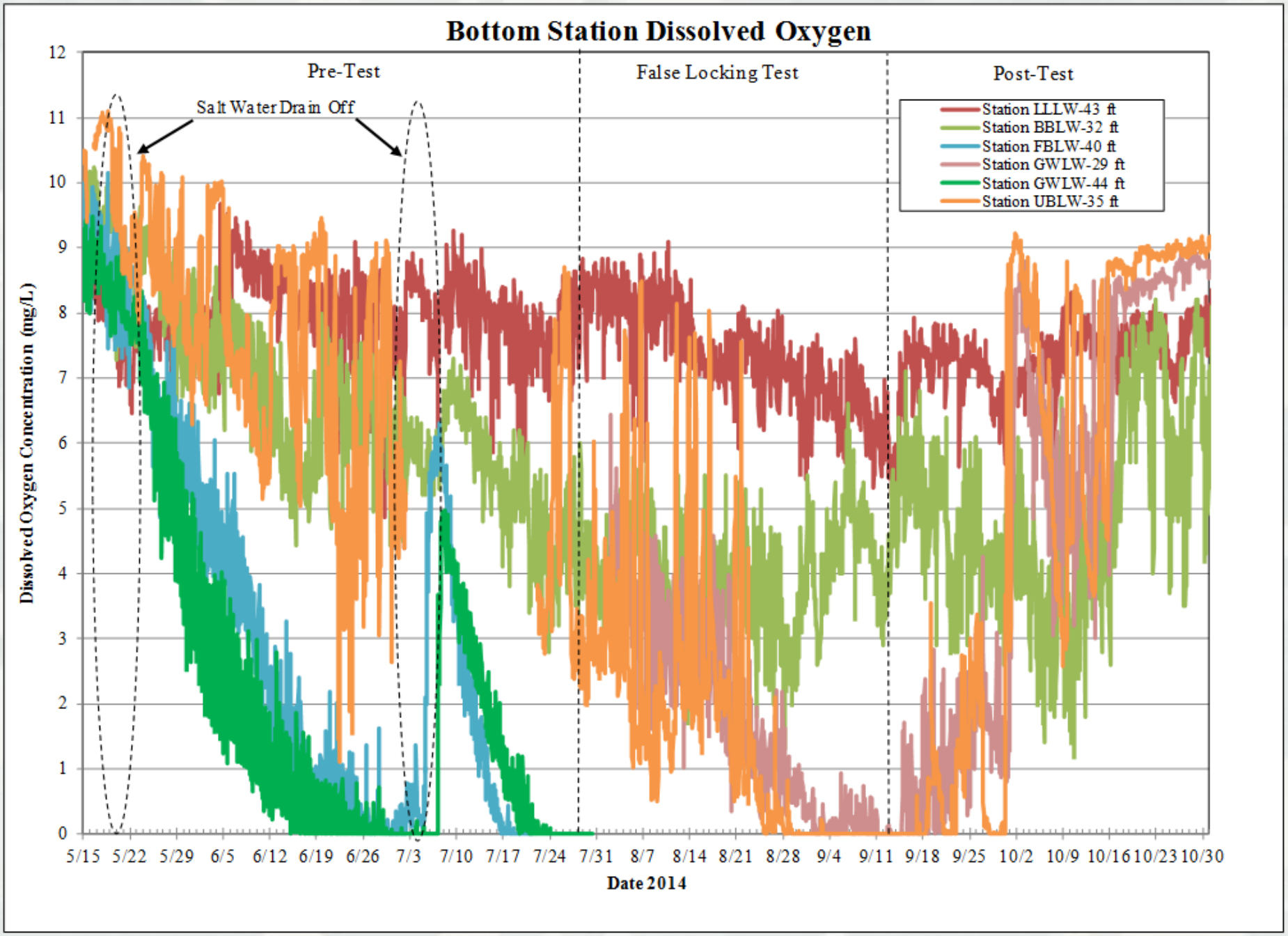
- adjust lockage frequency; lockage volume; saltwater barrier; saltwater drain;
- gradually increase saltwater u/s with each study phase

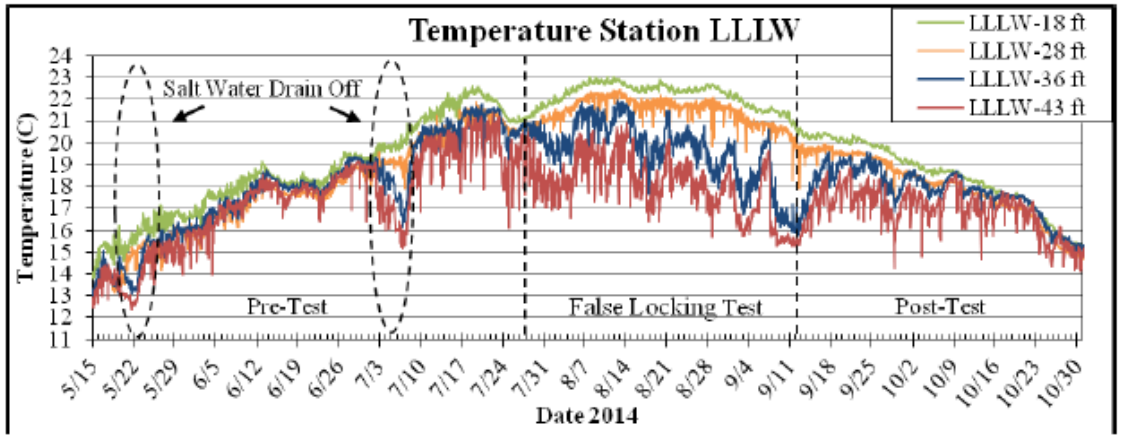
Longer term monitoring stations

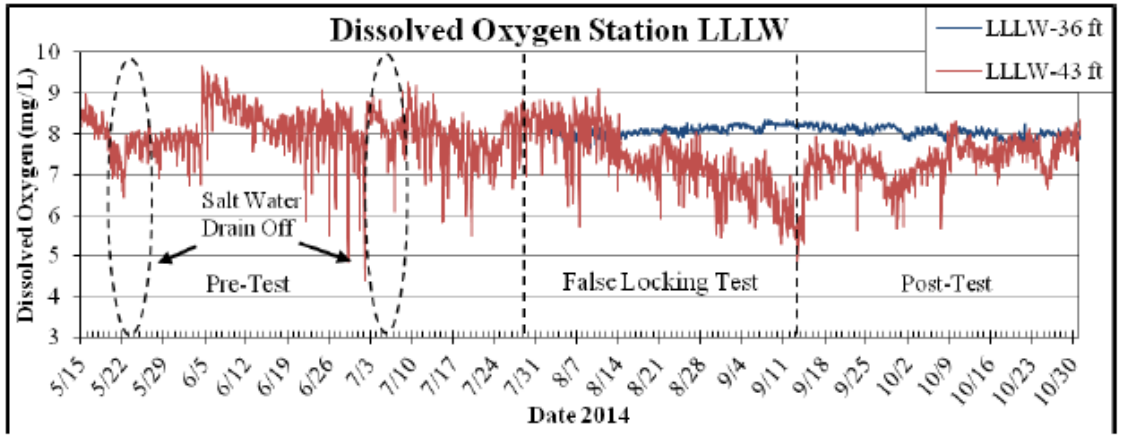


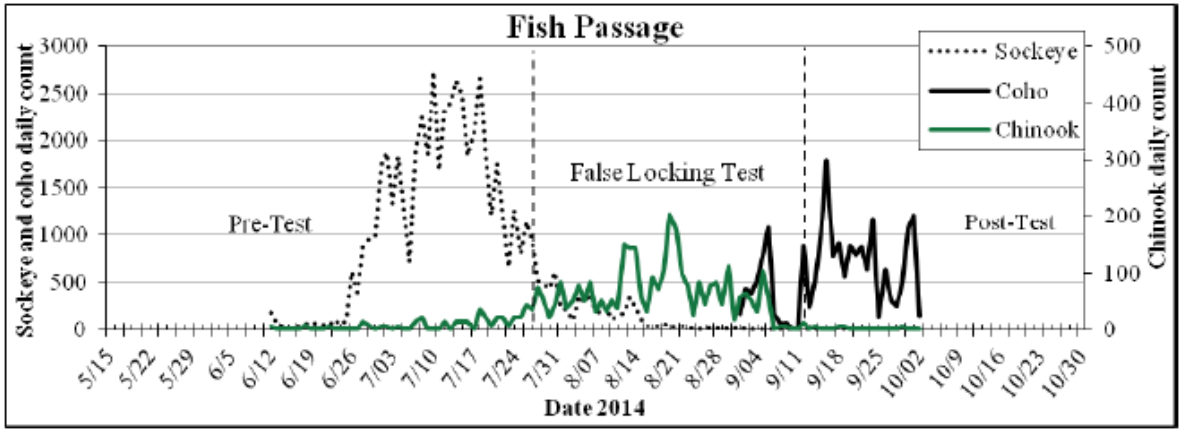

Temperature Bottom Nearfield Stations
BBLW-32 ft
Station D-43 ft
Station B-43 ft
Station C-47 ft
Station A-40 ft
LLLW-43 ft
Temperature (C)
23
22
21
20
19
18
17
16
15
14
Pre-Test
Phase I
Pause
Phase II
Pause
Phase III
Pause
Phase IV
Pause
Phase V
Pause
Phase VI
Post-Test
7/18
7/25
8/1
8/8
8/15
8/22
8/29
9/5
9/12
9/19
9/26
Date 2014

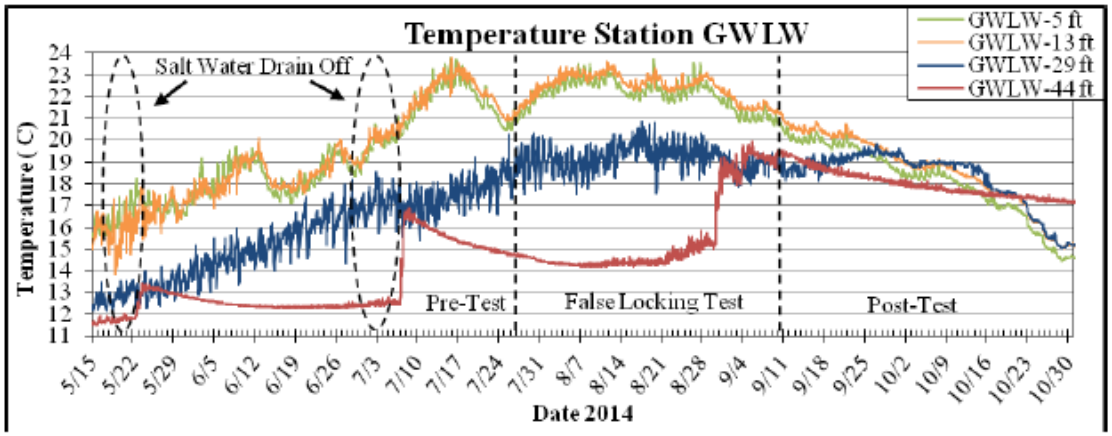

Temperature Bottom Farfield Stations
UBLW-35 ft
GWLW-44 ft
FBLW-40 ft
Fremont-32 ft
BBLW-32 ft
Temperature (C)
24
23
22
21
20
19
18
17
16
15
14
13
12
Pre-Test
Phase I
Pause
Phase II
Pause
Phase III
Pause
Phase IV
Pause
Phase V
Pause
Phase VI
Post-Test
7/18
7/25
8/1
8/8
8/15
8/22
8/29
9/5
9/12
9/19
9/26
Date 2014

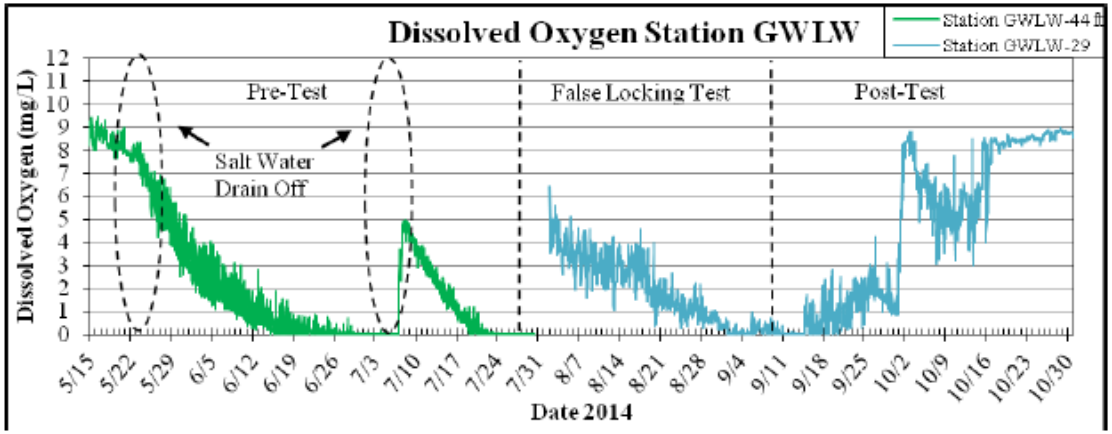

Bottom Station Dissolved Oxygen
Pre-Test
False Locking Test
Post-Test
Salt Water Drain Off
Station LLLW-43 ft
Station BBLW-32 ft
Station FBLW-40 ft
Station GWLW-29 ft
Station GWLW-44 ft
Station UBLW-35 ft
Dissolved Oxygen Concentration (mg/L)
0
1
2
3
4
5
6
7
8
9
10
11
12
5/15 5/22 5/29 6/5 6/12 6/19 6/26 7/3 7/10 7/17 7/24 7/31 8/7 8/14 8/21 8/28 9/4 9/11 9/18 9/25 10/2 10/9 10/16 10/23 10/30
Date 2014

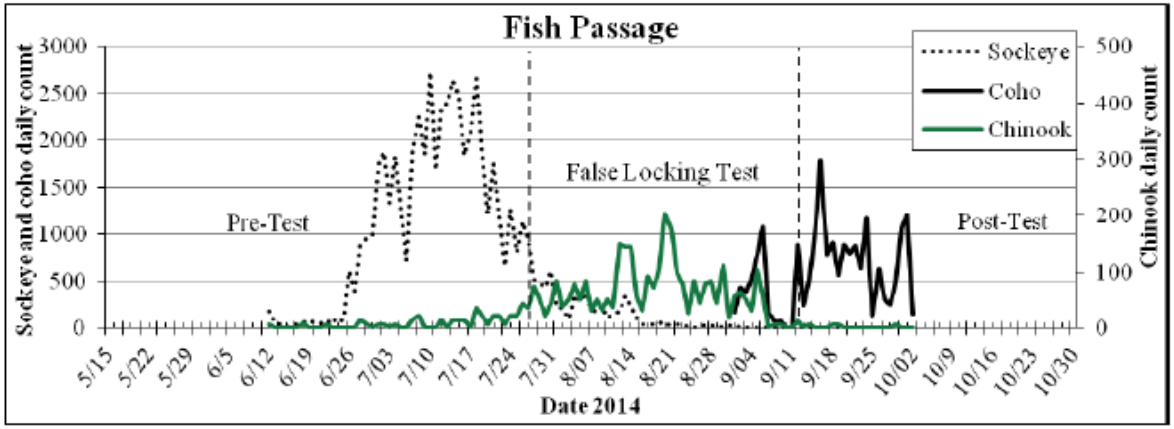

Temperature Station LLLW
LLLW-18 ft
LLLW-28 ft
LLLW-36 ft
LLLW-43 ft
Temperature (C)
Salt Water Drain Off
Pre-Test
False Locking Test
Post-Test
Date 2014

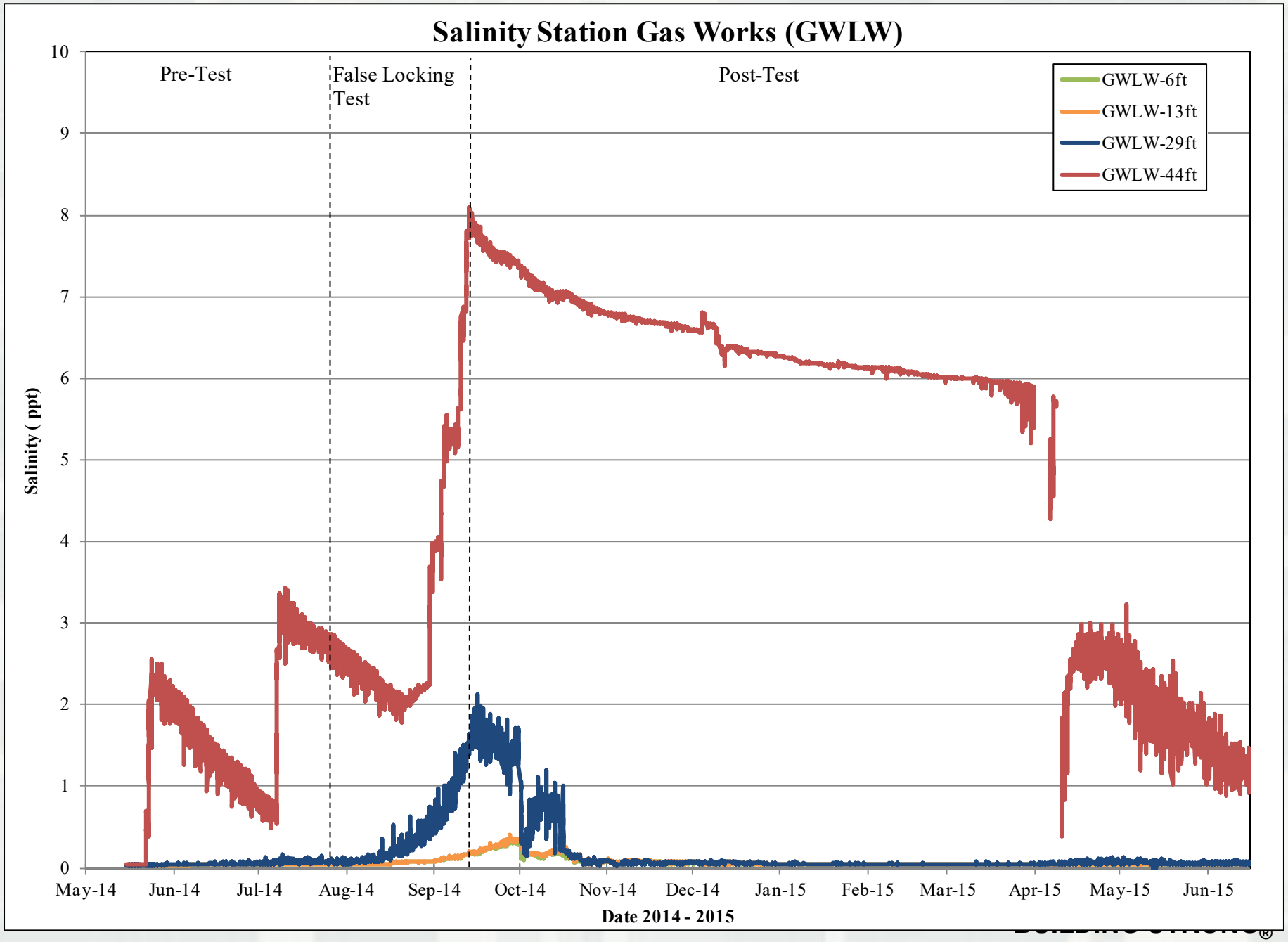

Dissolved Oxygen Station LLLW
LLLW-36 ft
LLLW-43 ft
Dissolved Oxygen (mg/L)
Salt Water
Drain Off
Pre-Test
False Locking Test
Post-Test
Date 2014

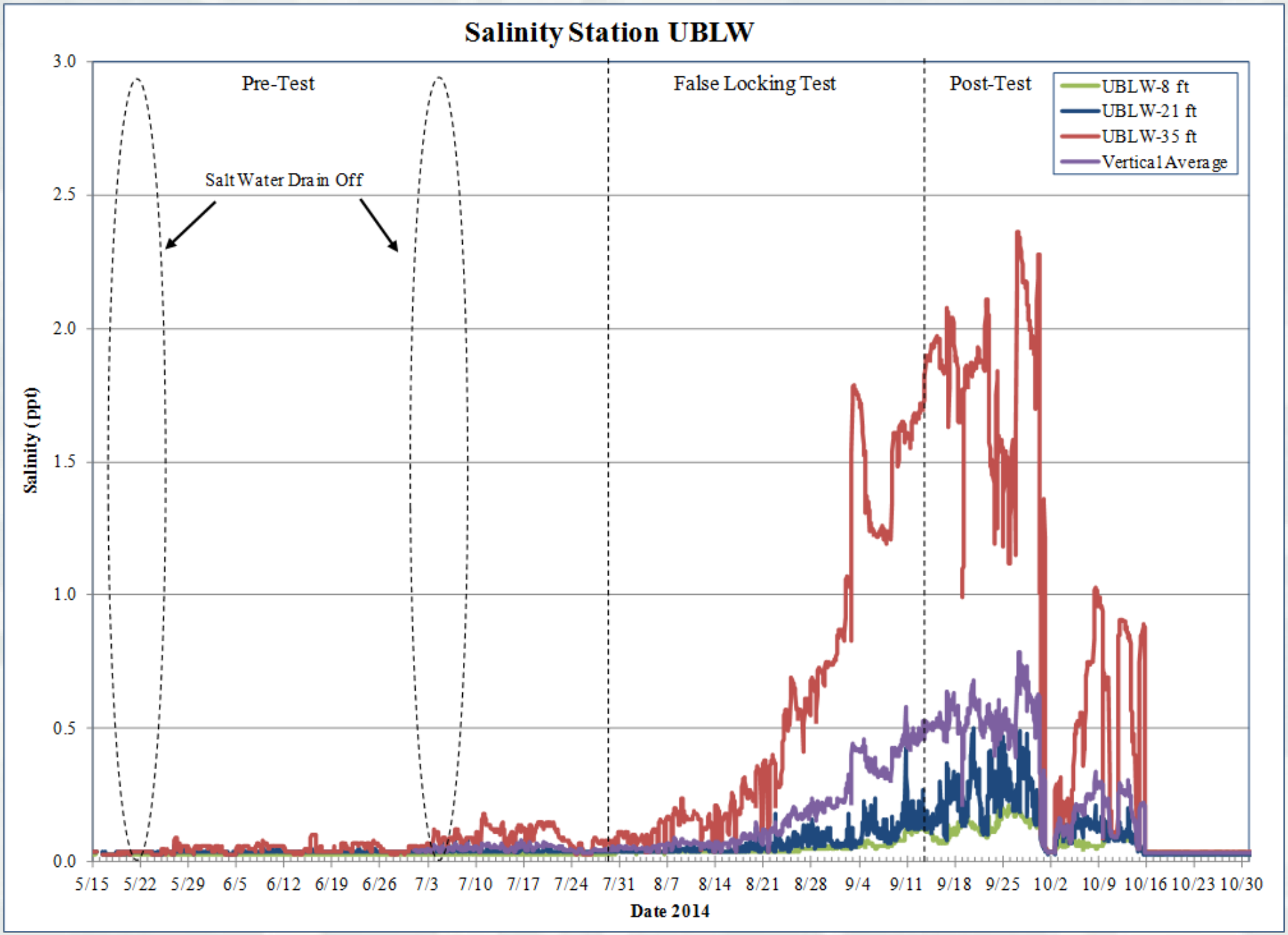

Fish Passage
Sockeye
Coho
Chinook
Sockeye and coho daily count
Chinook daily count
Pre-Test
False Locking Test
Post-Test
Date 2014


Temperature Station GWLW
GWLW-5 ft
GWLW-13 ft
GWLW-29 ft
GWLW-44 ft
Salt Water Drain Off
Pre-Test
False Locking Test
Post-Test
Temperature (C)
Date 2014


Dissolved Oxygen Station GWLW
Station GWLW-44 ft
Station GWLW-29
Pre-Test
False Locking Test
Post-Test
Salt Water
Drain Off
Dissolved Oxygen (mg/L)
Date 2014


Fish Passage
Sockeye
Coho
Chinook
Pre-Test
False Locking Test
Post-Test
Sockeye and coho daily count
Chinook daily count
Date 2014

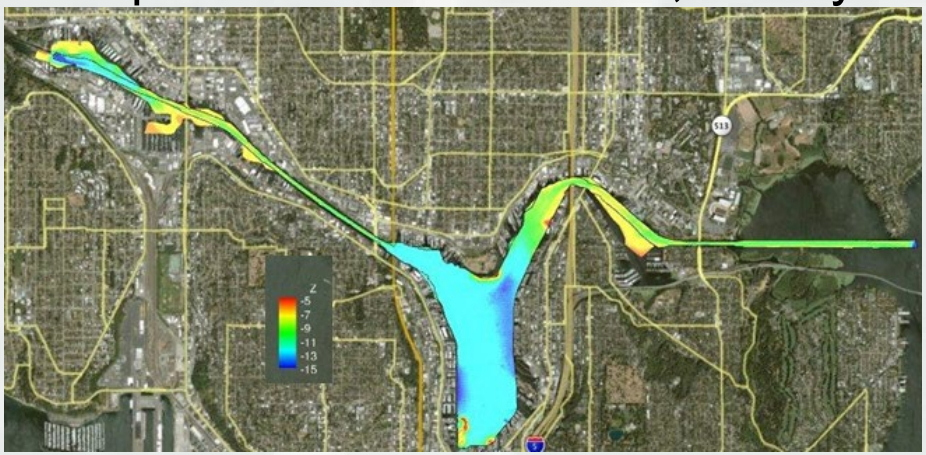

Salinity Station Gas Works (GWLW)
Pre-Test
False Locking Test
Post-Test
GWLW-6ft
GWLW-13ft
GWLW-29ft
GWLW-44ft
Salinity (ppt)
0
1
2
3
4
5
6
7
8
9
10
May-14
Jun-14
Jul-14
Aug-14
Sep-14
Oct-14
Nov-14
Dec-14
Jan-15
Feb-15
Mar-15
Apr-15
May-15
Jun-15
Date 2014 - 2015


Salinity Station UBLW
Pre-Test
False Locking Test
Post-Test
Salt Water Drain Off
UBLW-8 ft
UBLW-21 ft
UBLW-35 ft
Vertical Average
Salinity (ppt)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
5/15 5/22 5/29 6/5 6/12 6/19 6/26 7/3 7/10 7/17 7/24 7/31 8/7 8/14 8/21 8/28 9/4 9/11 9/18 9/25 10/2 10/9 10/16 10/23 10/30
Date 2014

False Locking Study Summary

Results

- limited salt input→ minor temp decrease near Locks, steady dO
- aggressive salt input→
  - significant temp decrease near Locks
  - increased temp in Lake Union
  - persistent more widespread salt, anoxic conditions in ship canal



Conclusions

- WQ near Locks can be substantially improved but may result in negative WQ effects elsewhere in ship canal
- migration conditions cannot be improved with operational changes
- WQ can be slightly improved near Locks w/o negative effects elsewhere

END

FWS BiOp RPMs

- 2(b): Efforts are to be made to partner with one or more local entities (Tribal, State, County, City, and Federal) to seek a change from the Washington State Department of Ecology water quality standard to allow higher salinity in the LWSC at the University Bridge.
- 3(a): expert panel will be constituted to address DO, salinity and temperature issues.
- 3(d) The expert panel recommendation with the greatest likelihood of improving water quality conditions shall be implemented if need be via a temporary trial before permanent implementation. The recommendation may be tested prior to permanent implementation.
- 3(f) In conjunction with Ecology, the maximum amount of cold, high DO, saltwater will be allowed into the LWSC, east of the lock complex in late summer and early fall, while simultaneously meeting the saltwater standard at the University Bridge.
- 3(g) The COE shall attempt to partner with one or more local agencies (Tribal, State, County, City, and Federal) to seek a change from the Washington State Department of Ecology water quality standard to allow higher salinity at the University Bridge.

NMFS BiOp RPM

- 1a. The COE currently allows the maximum amount of salt water into the LWSC that does not exceed the limit imposed by Ecology at the University Bridge. If the Ecology standard is modified, the COE shall increase the amount of salt water in the LWSC to the maximum allowed, east of the lock complex, and simultaneously meet the modified saltwater standard at the University Bridge in late summer and early fall.