

Juvenile and Adult Fish Passage at the Hiram M. Chittenden Locks

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with

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Purpose: Provide an Overview of Monitoring at the Locks During 2000 and 2001

- 1. Fish Passage Monitoring of Juvenile Salmon – 2000-2001**
 - a. Entrainment into the large lock filling culverts.**
 - b. Smolt passage flume counts.**
 - c. Fish guidance efficiency – percent of smolts using one of two pathways – the flumes or large lock culverts.**
 - d. Other pathways – saltwater drain and a spillway bay.**
- 2. Monitoring of Adult Chinook Salmon in 2000.**
 - a. Coolwater refuge – area immediately above the large locks.**
 - b. Acoustic tag tracking of adult chinook in the refuge area.**



SALMON BAY

Large Lock
Waiting Pier

Culvert Intake
Hydroacoustic Transducers
Strobe Lights

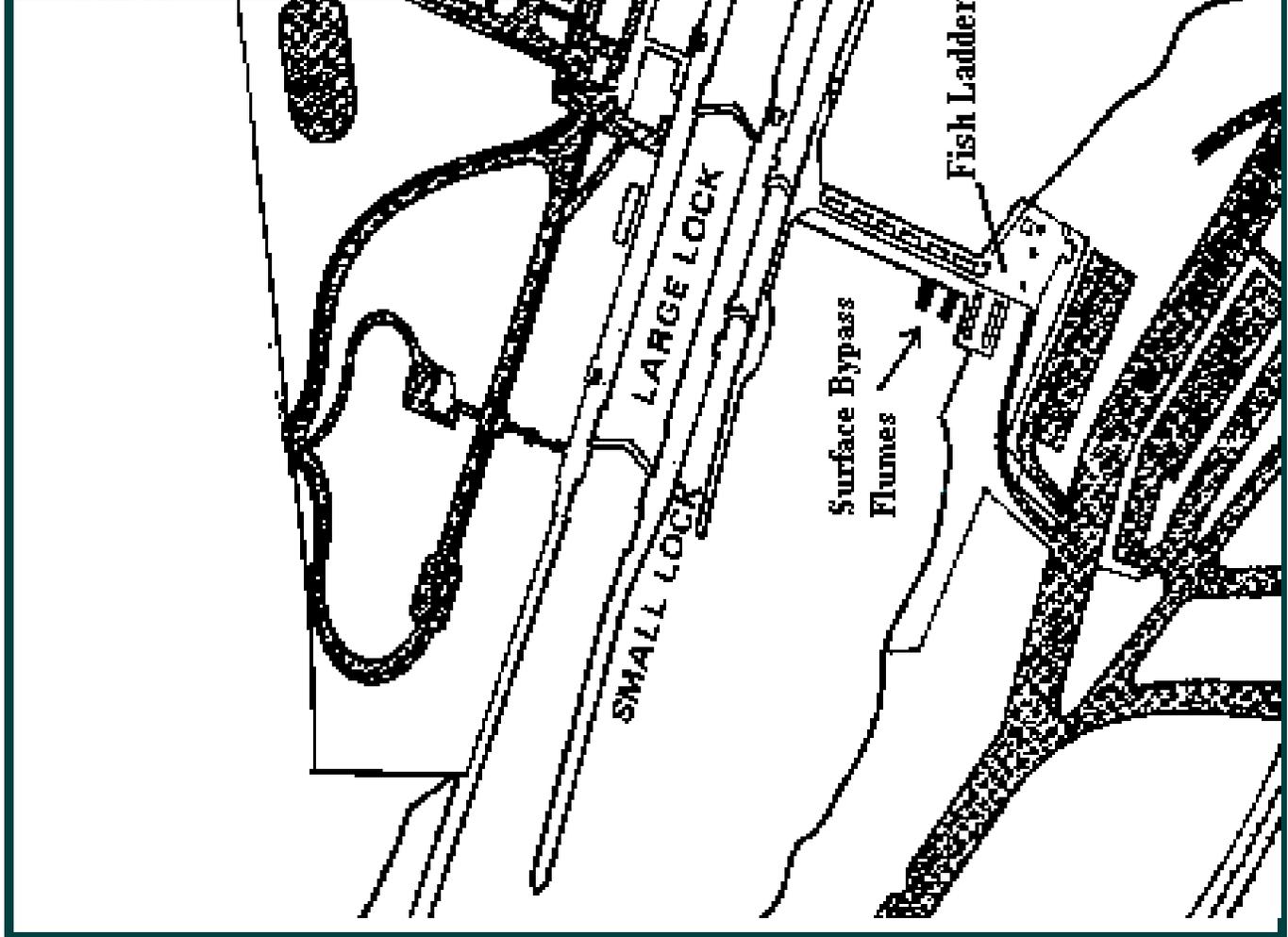
80' x 825'

30' x 150'

Fish Ladder

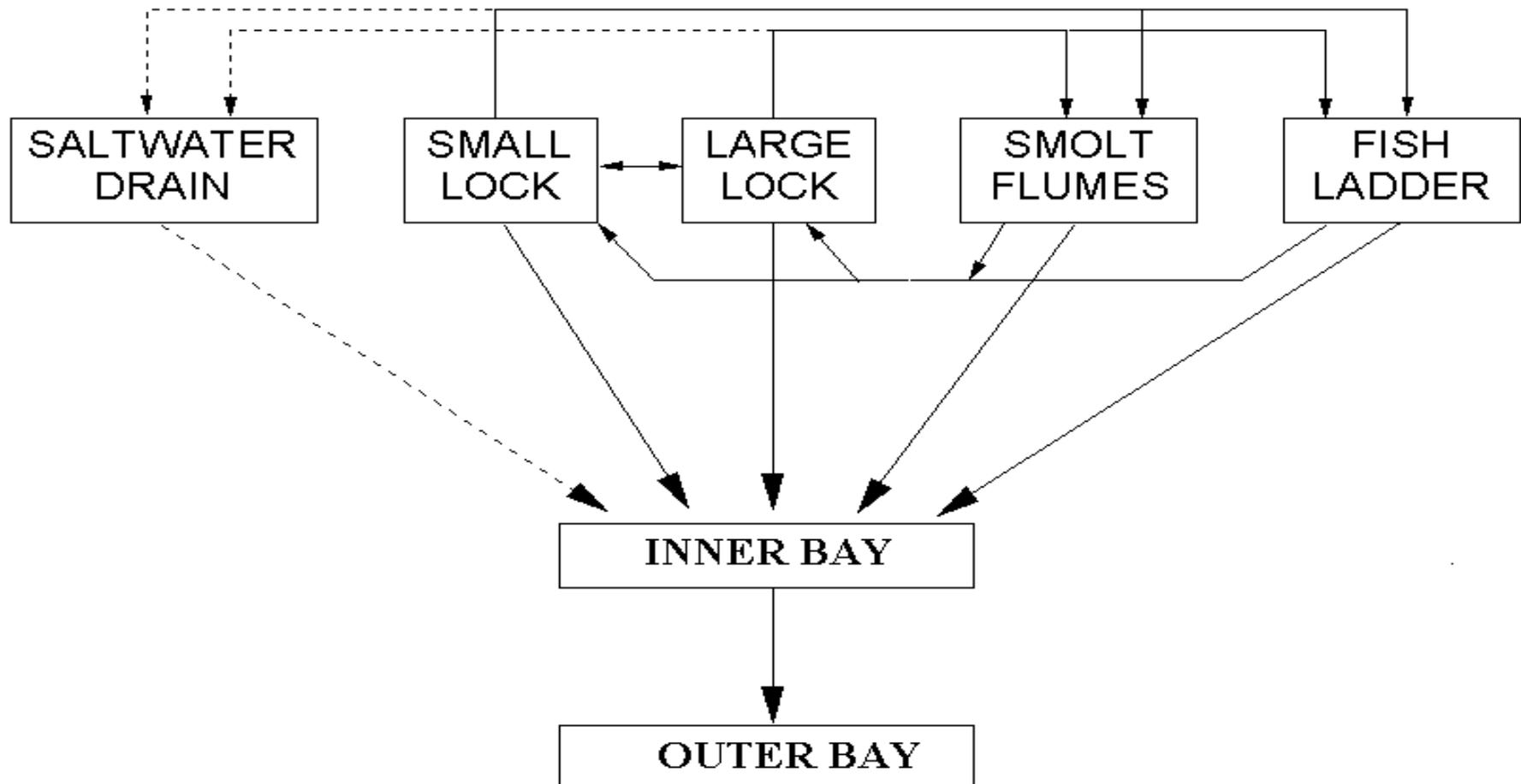
Surface Bypass
Flumes

SMALL LOCK
LARGE LOCK



Conceptual Model of Fish Passage Routes

LAKE UNION SYSTEM



Smolt Passage Project Objectives:

- 1. Increase juvenile salmon (smolt) use of the spillway.**
- 2. Reduce the entrainment of salmon and steelhead smolts into the filling culverts of the large lock chamber. Field test and evaluate various behavioral guidance techniques.**
- 3. If entrainment reduction is not completely successful, reduce the injury and mortality of entrained smolts.**

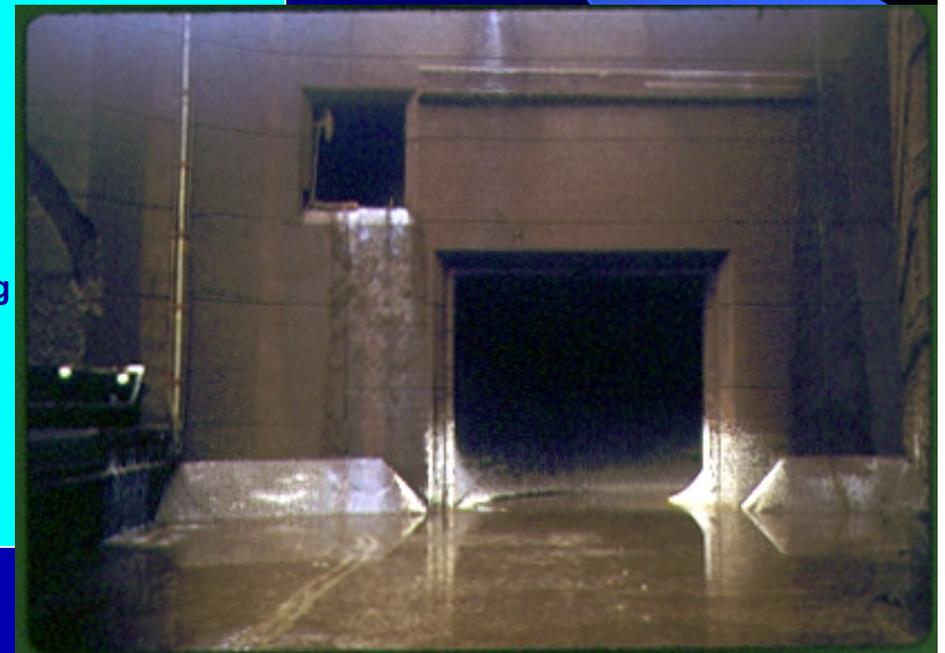
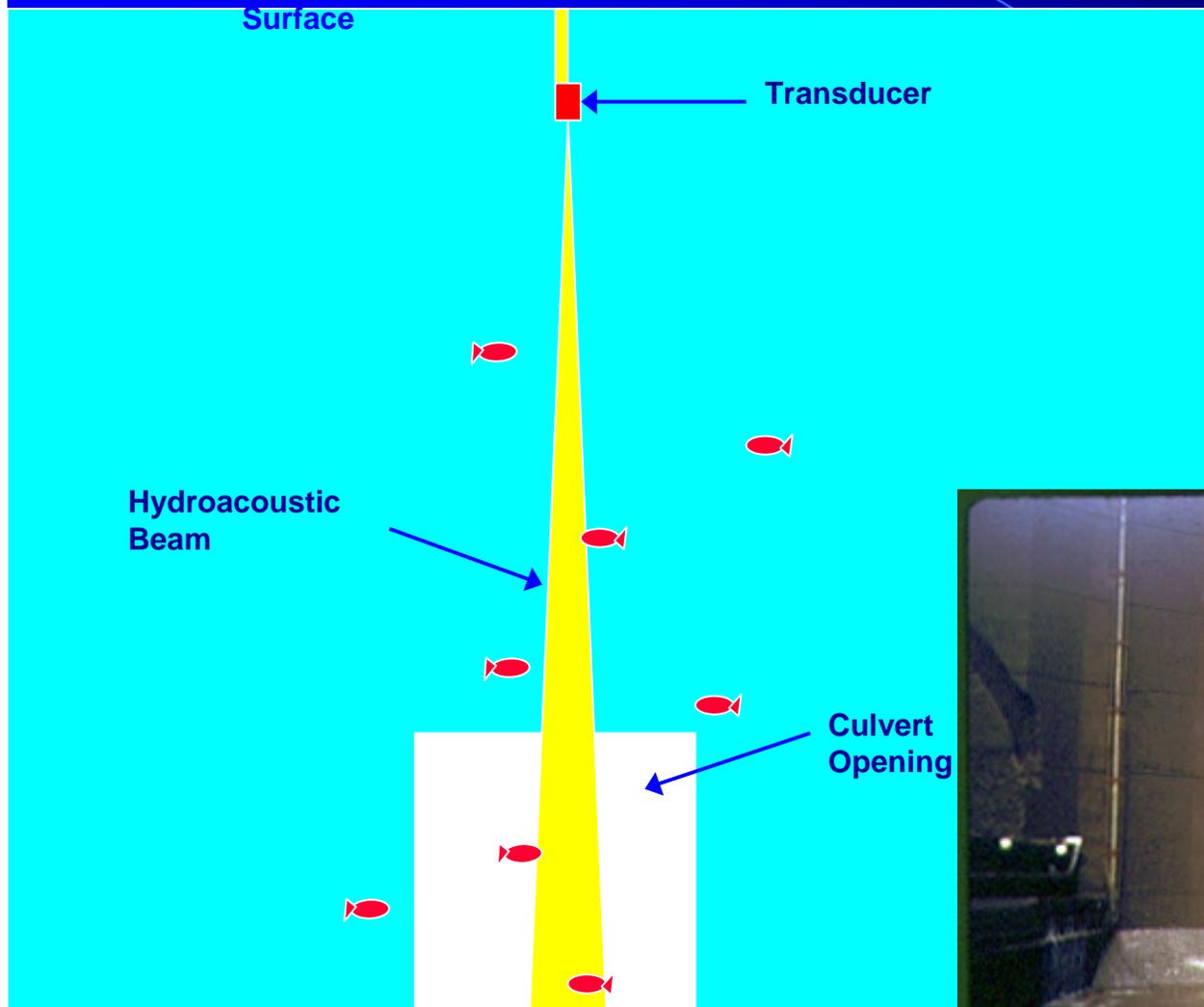
History of Passage Experiments

- * 1994 Slow Fill Experiment by Lockmasters
- * 1995 Prototype Low flow Flume @ 80 cfs
- * 1996 Begin Monitoring Entrainment in L. Lock
- * 1997 Experiment with Low Frequency Sound
- * 1997 Netpen Testing of Sound and Light
- * 1998 Monitor Slowfill in L. Lock
Test Strobe Lights
- * 2000 4 New Flumes @ 400 cfs; Slowfill as SOP;
Removed Barnacles; installed Strobe
Lights; Begin use of Passive integrated
transponders
- * 2002 Begin use of Strobe Lights
- * 2003 Testing of Micro-acoustic tags

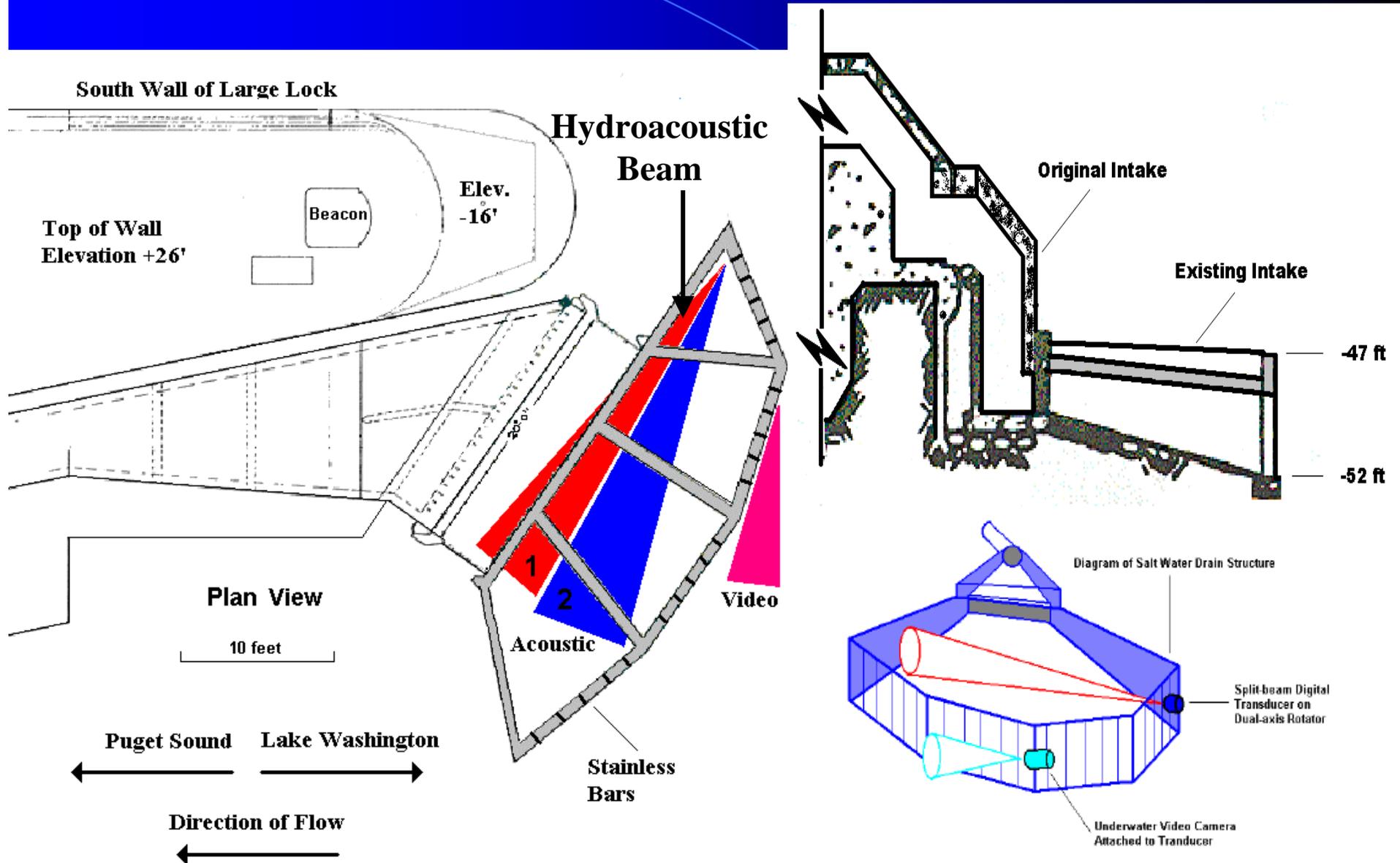
Entrapment/Injury Monitoring: Purse-seining



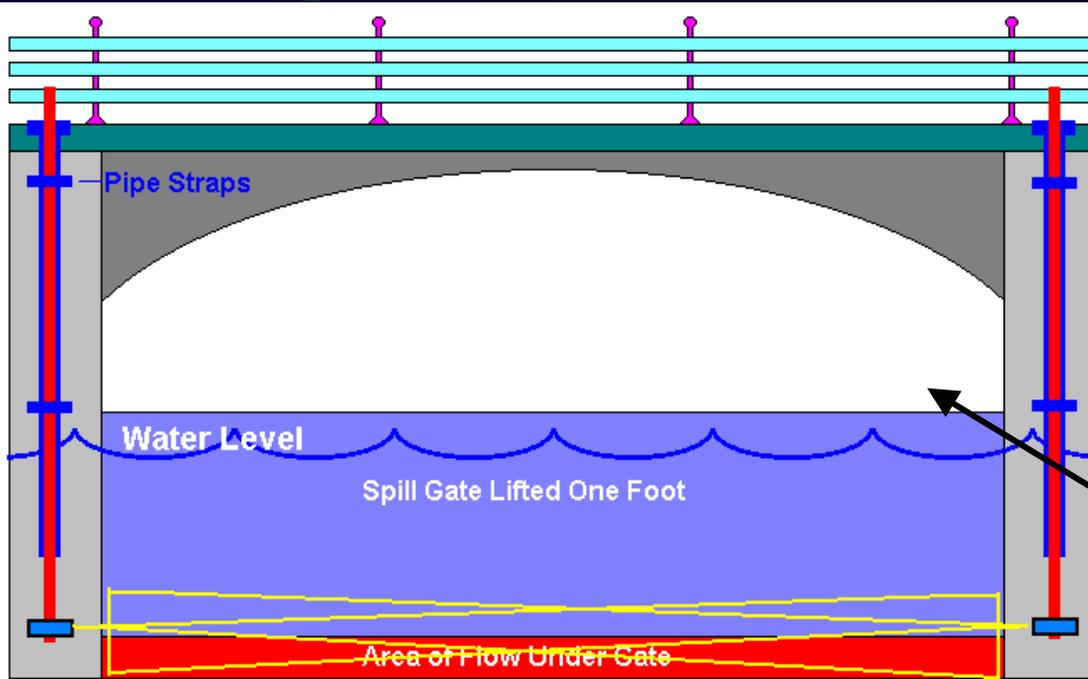
Hydroacoustic Monitoring L. Lock Culvert Opening



Hydroacoustic and Video Monitoring of the Saltwater Drain Intake -- 2000

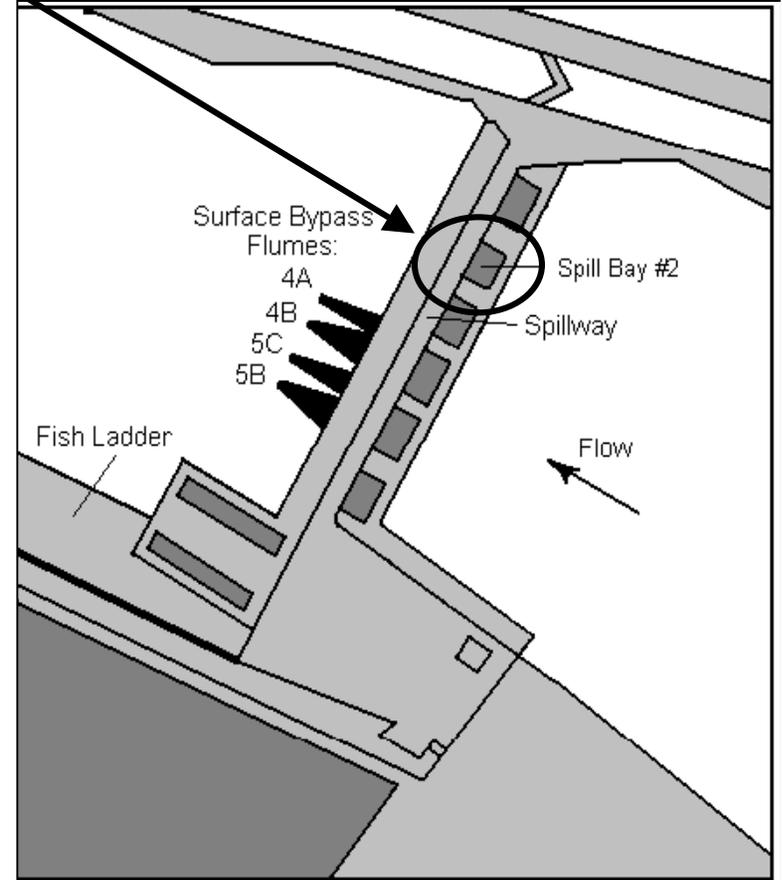
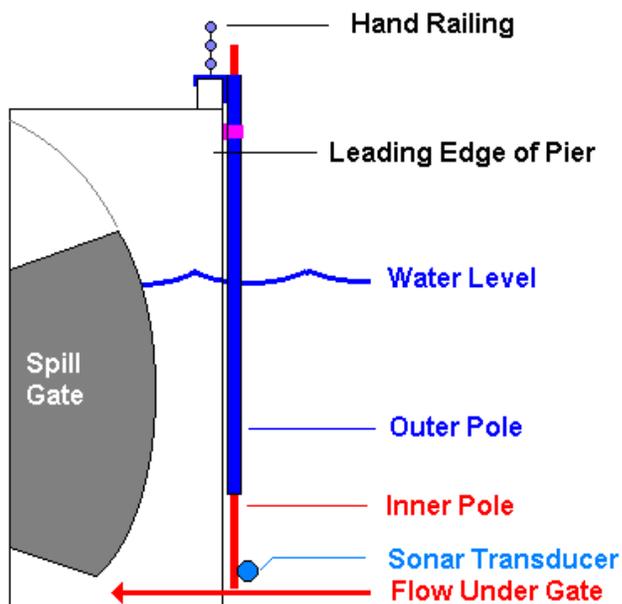


Hydro-acoustic Monitoring of Spillway Bay No. 2 -- 2000

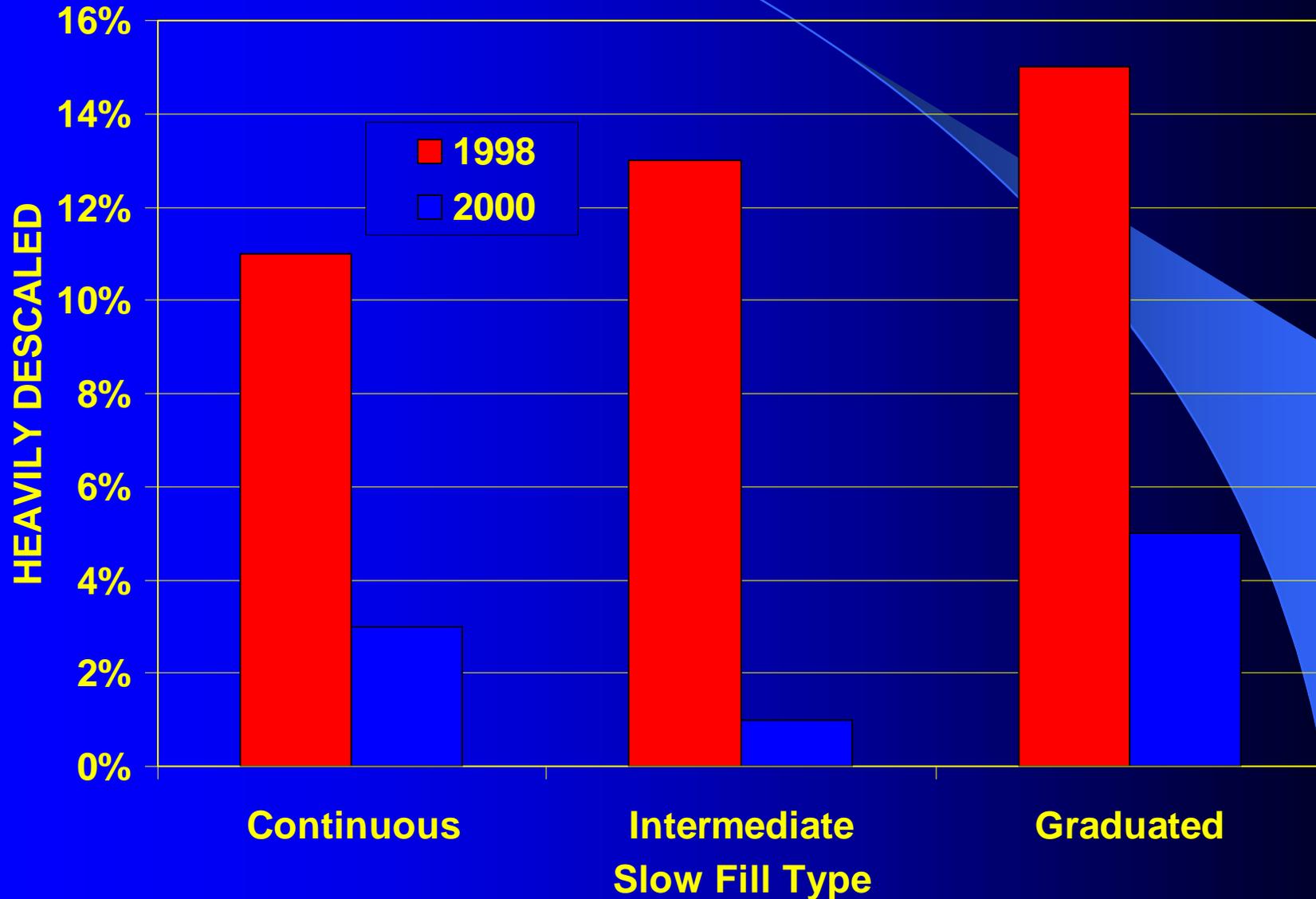


Transducer #108
Cable 141-95-899

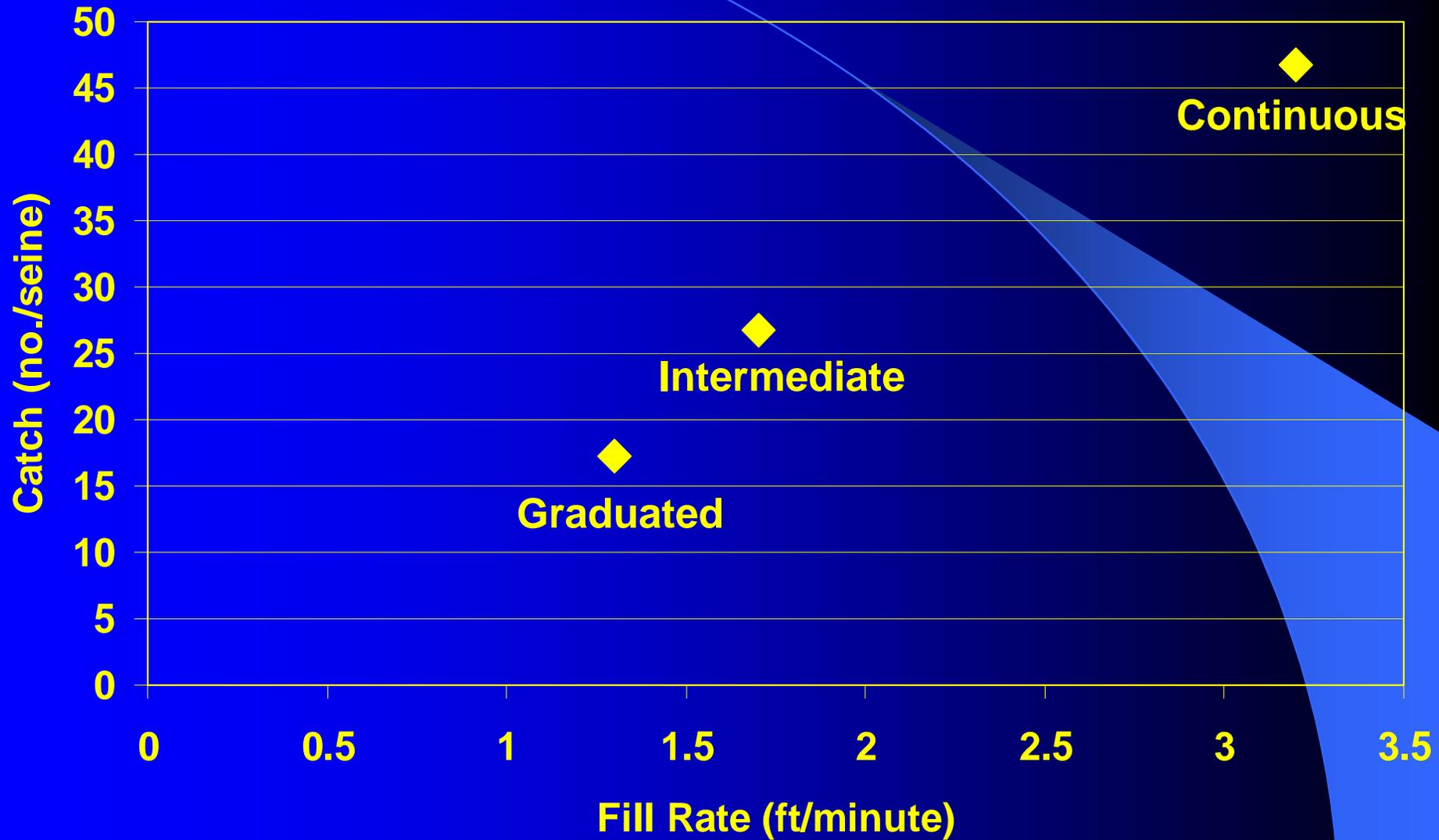
Transducer #106
Cable 141-96-1062



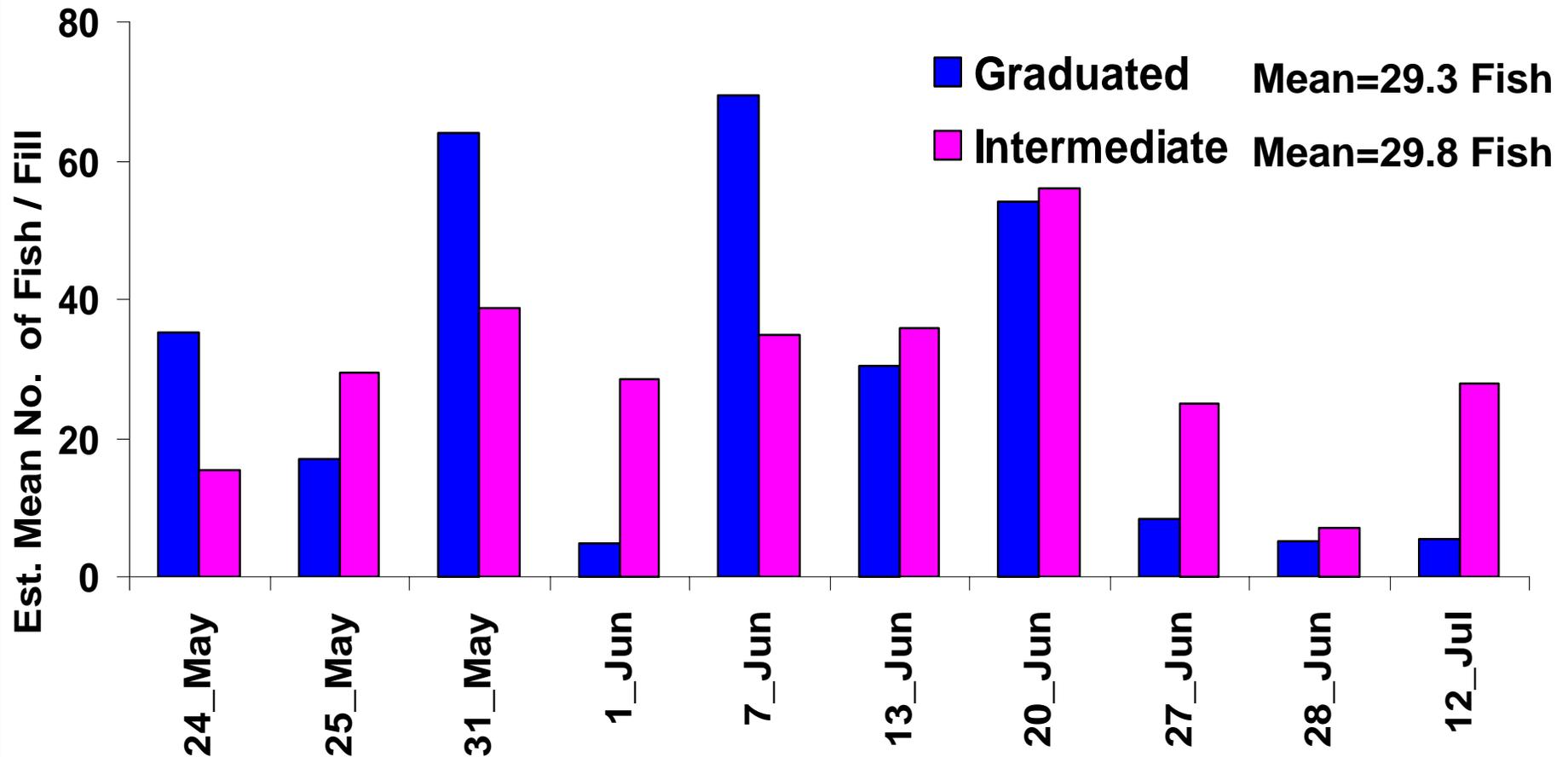
Barnacle Removal: Comparison of Heavy Descaling Before (1998) and After (2000)



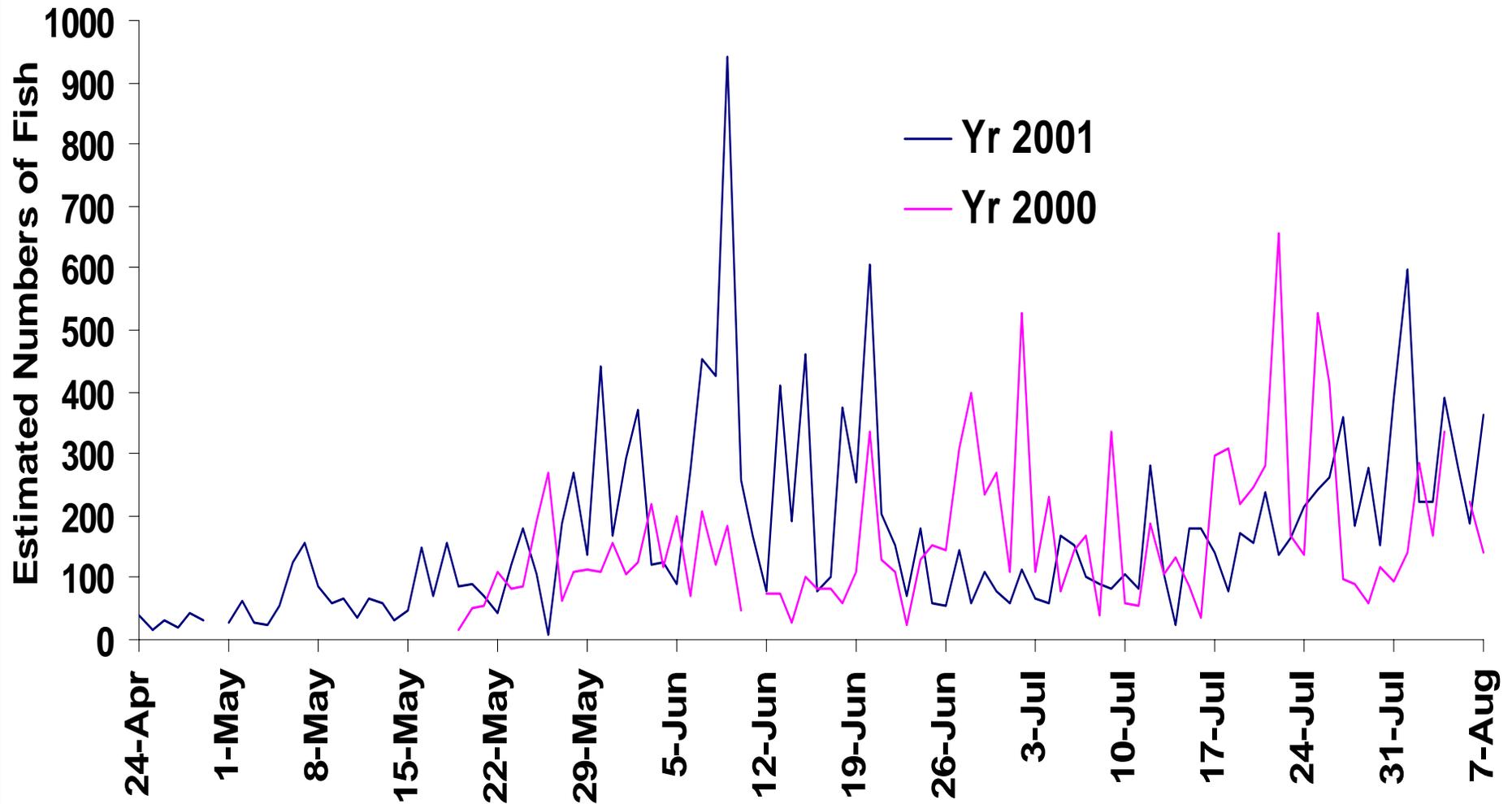
Slow Fill: Comparison of Fill Rate vs Purse-Seining Catch Per Unit Effort -- 2000

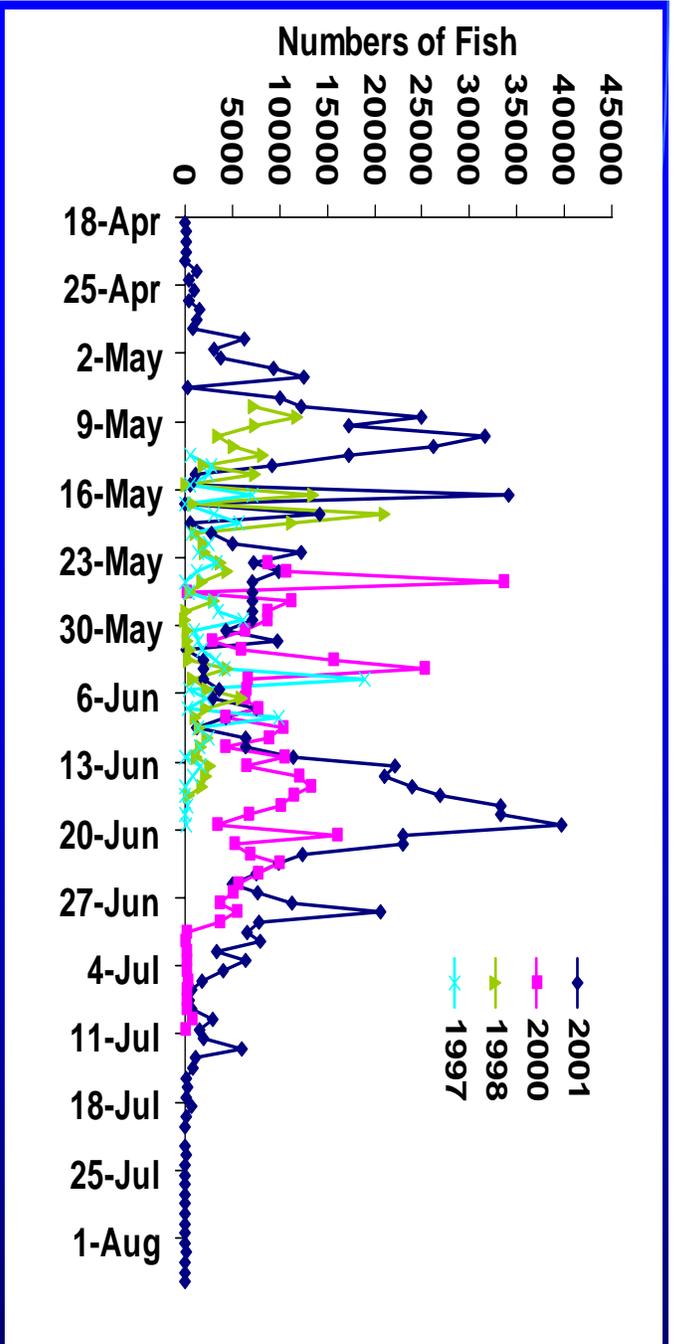
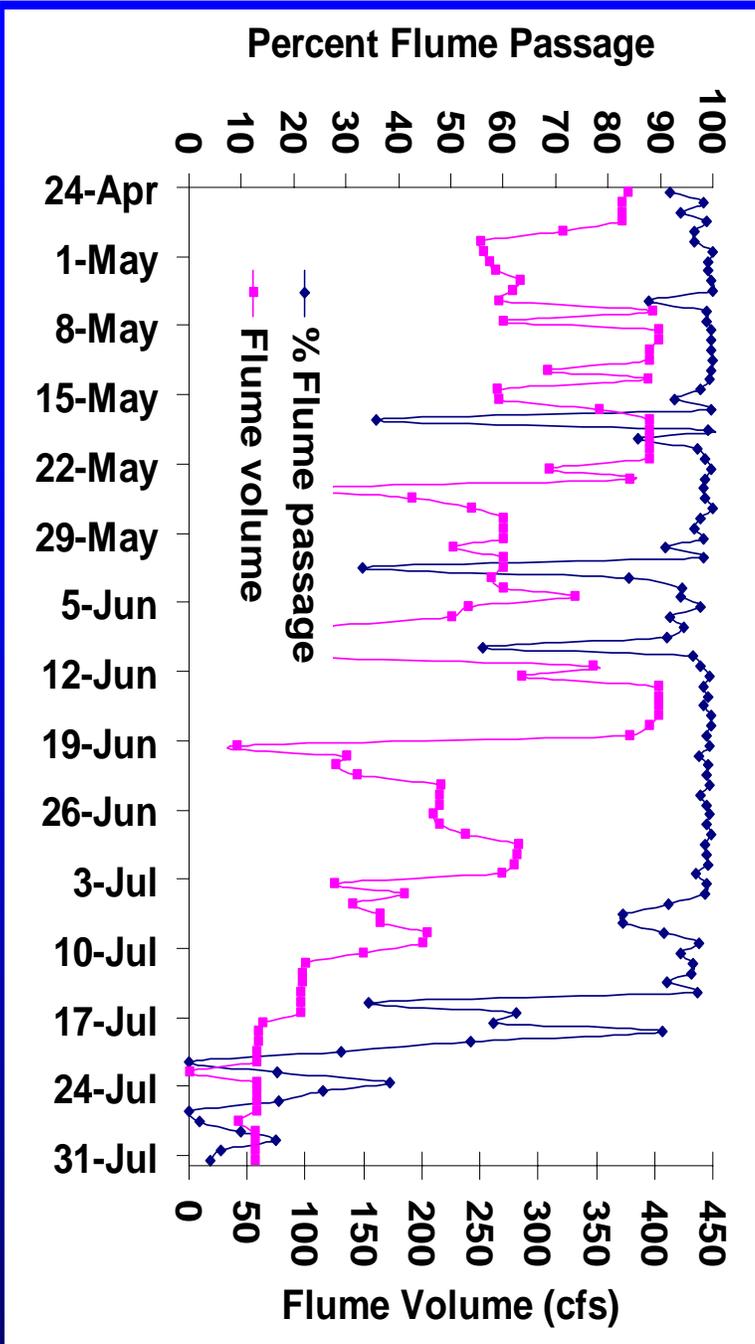


Slow Fill: Comparison of Fill Rate vs. Hydroacoustic Estimate of Fish/Fill -- 2001



Daily Entrainment Estimates for the Large Lock Culverts -- 2000 and 2001

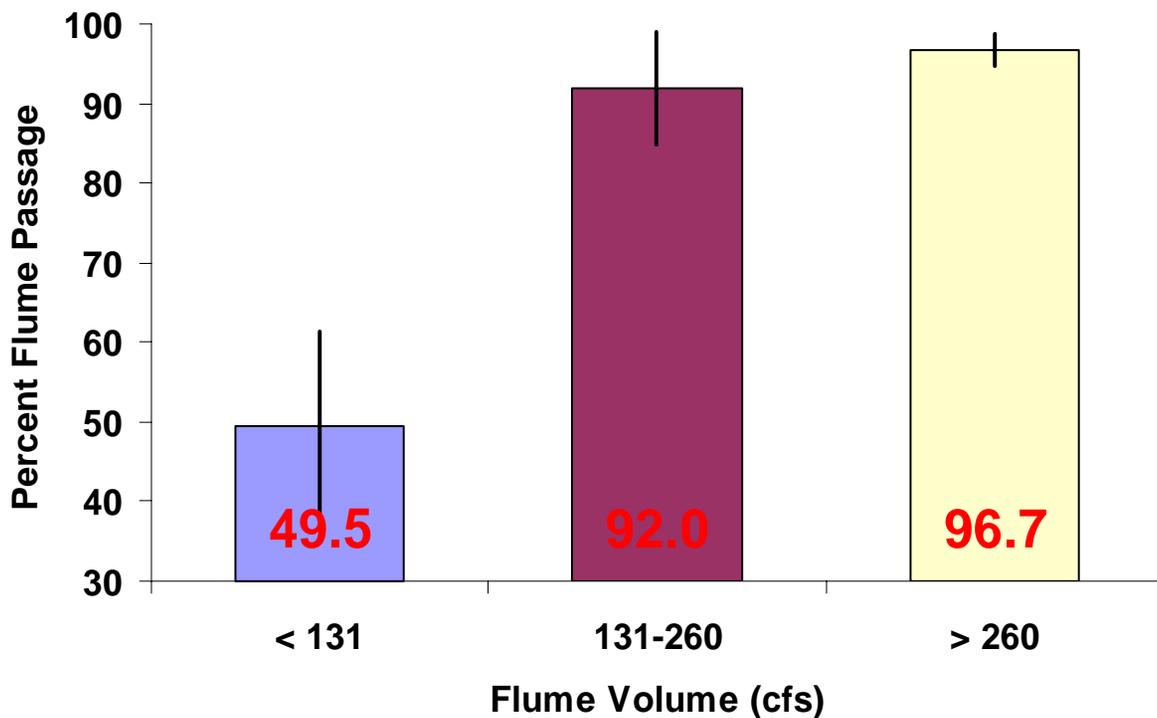
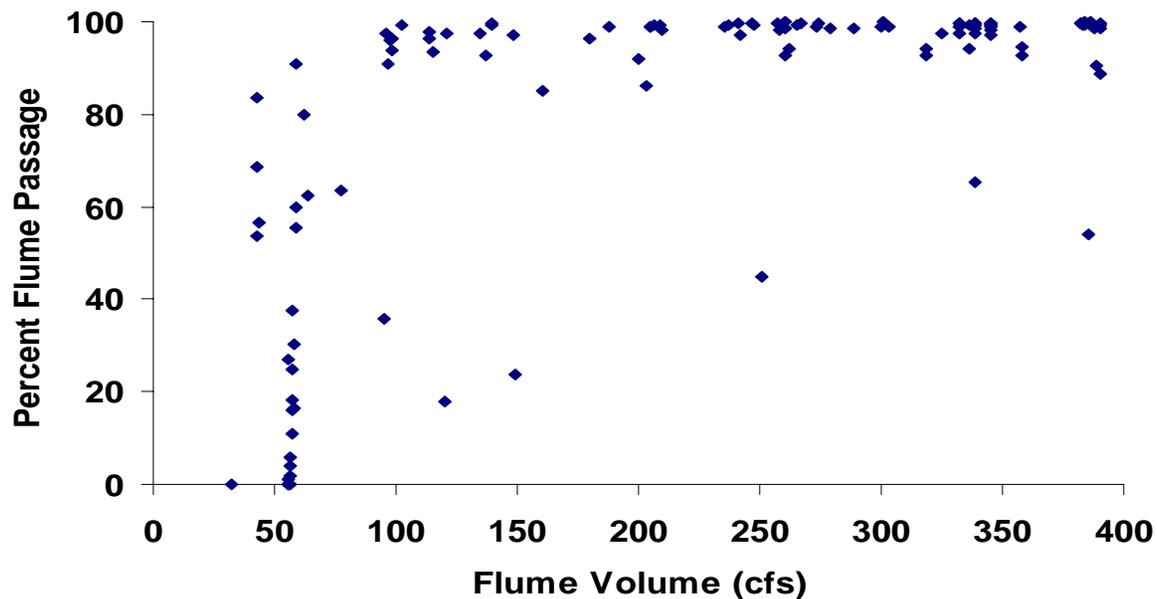




Flume Counts

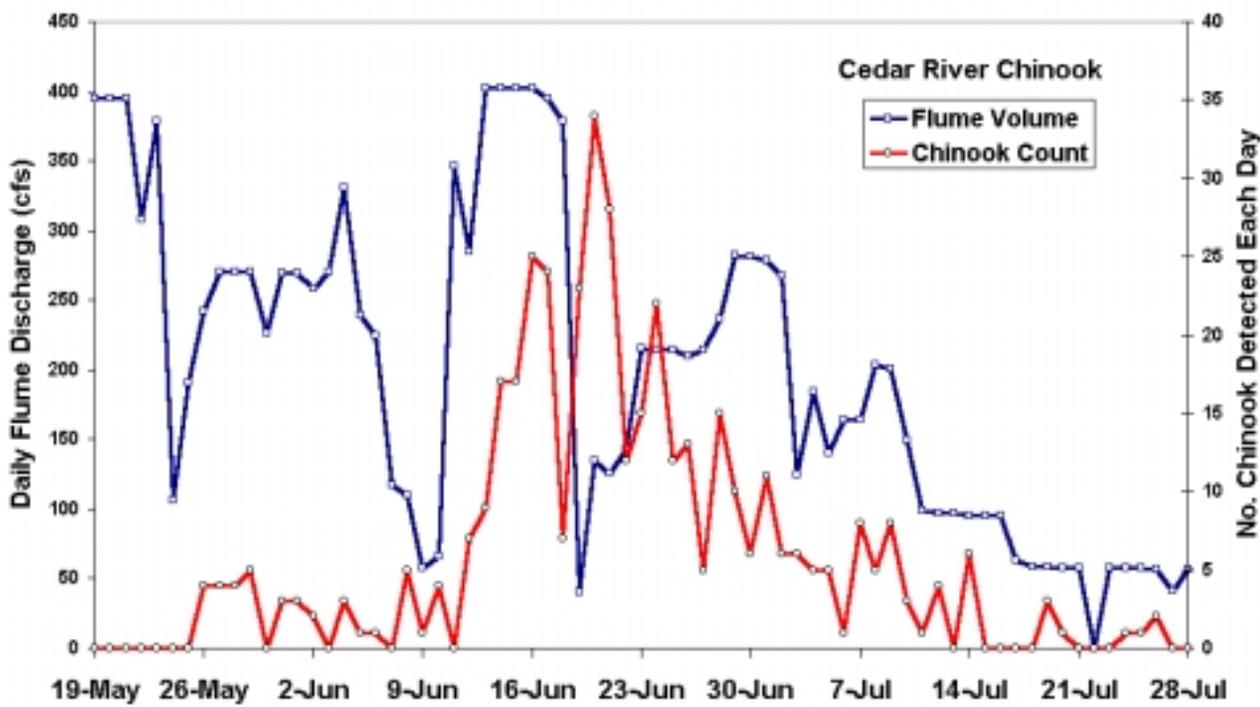
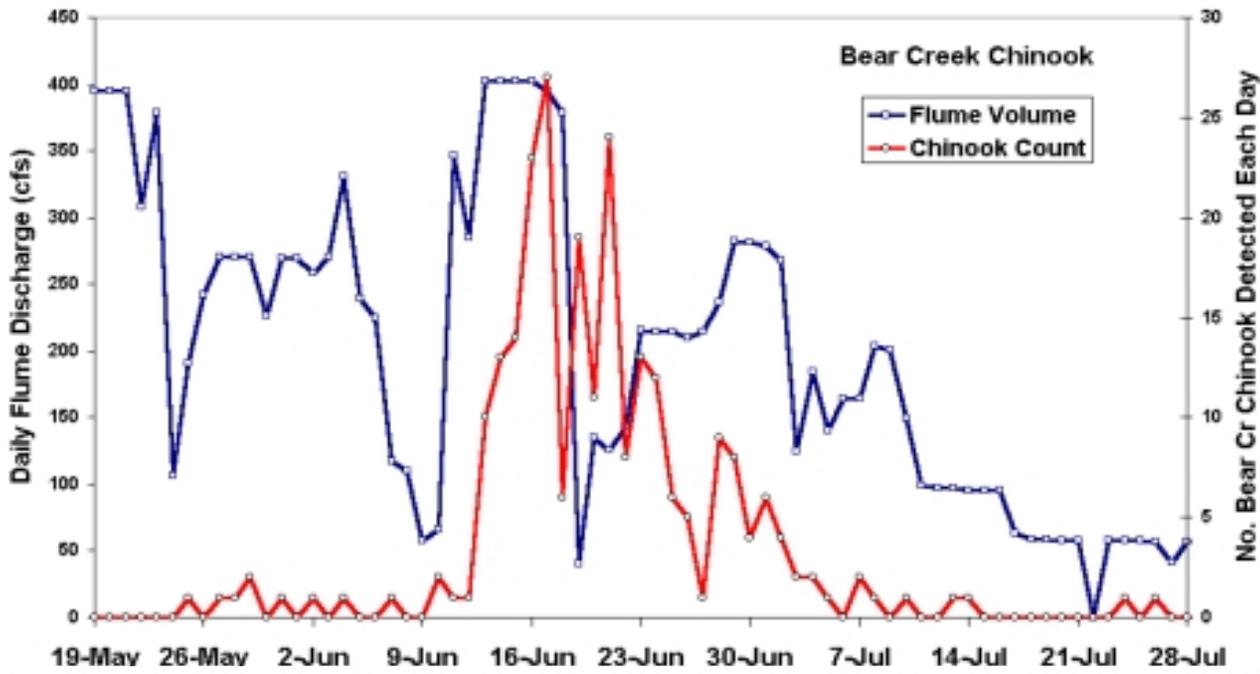
Fish Guidance Efficiency (FGE) – 2001

Flume Count and Entrainment



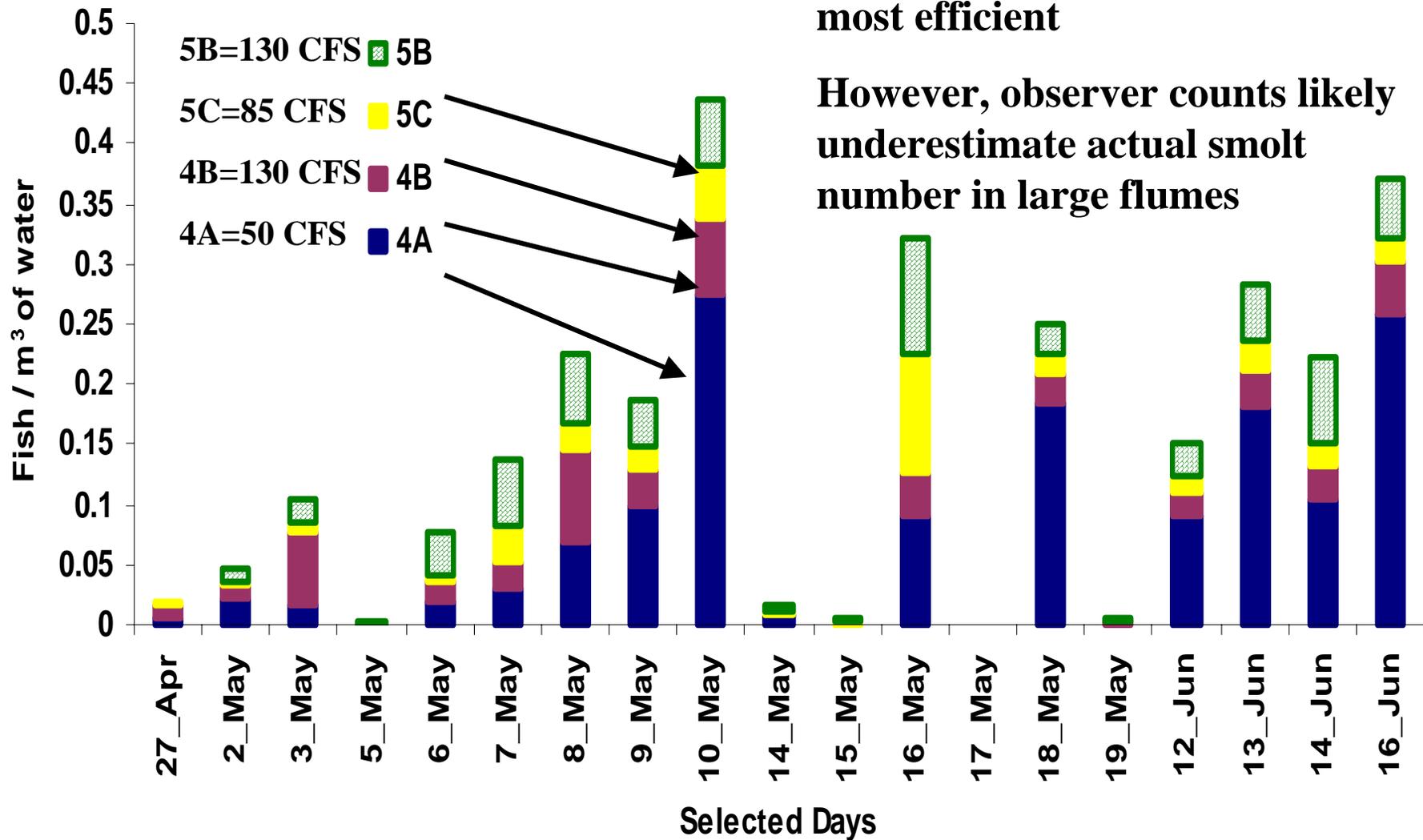
**Fish Guidance
Efficiency (FGE)
2000 and 2001**

**SUMMARY
FGE
2000 and 2001**

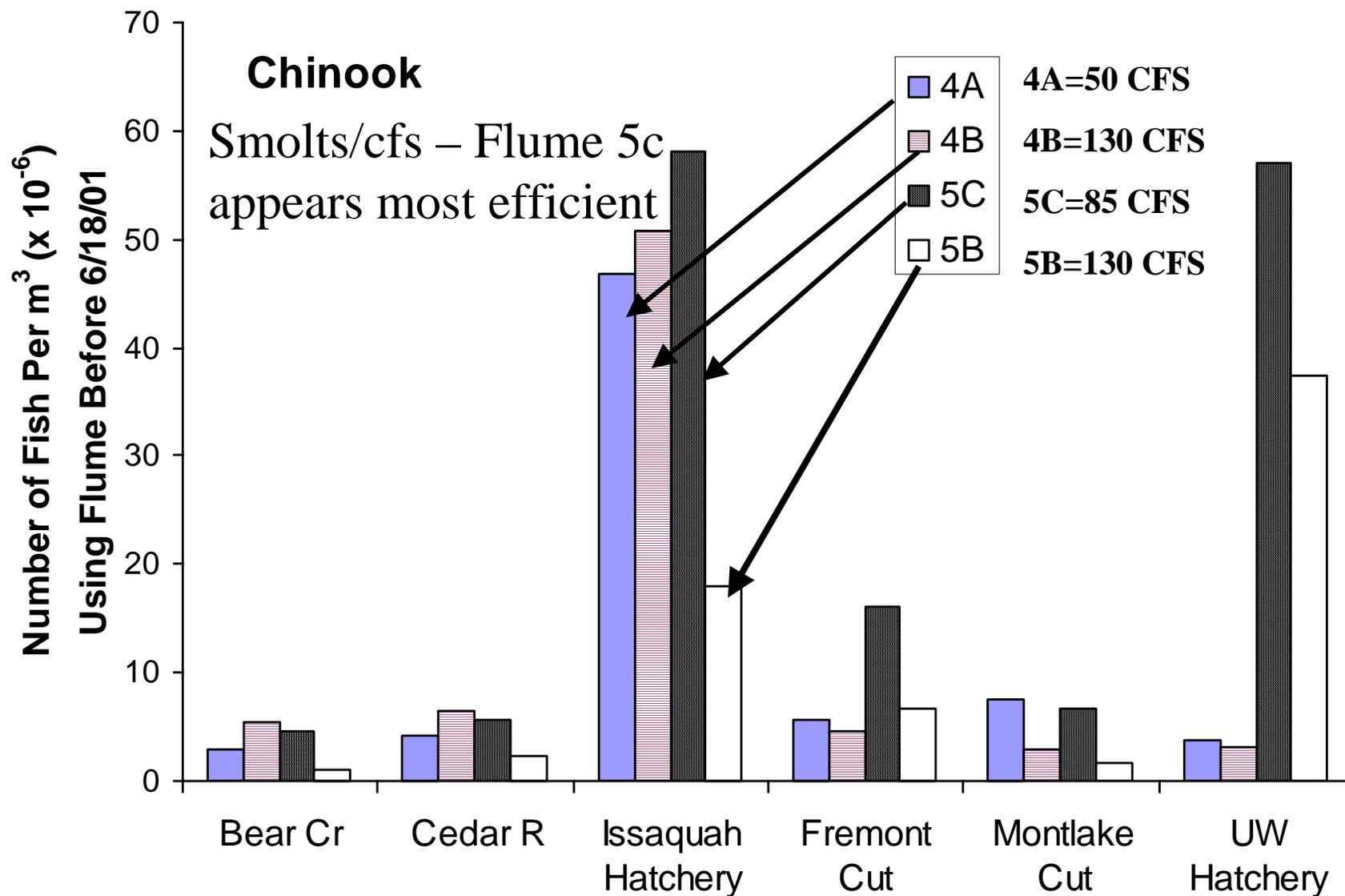


Flume Discharge & Chinook Passage

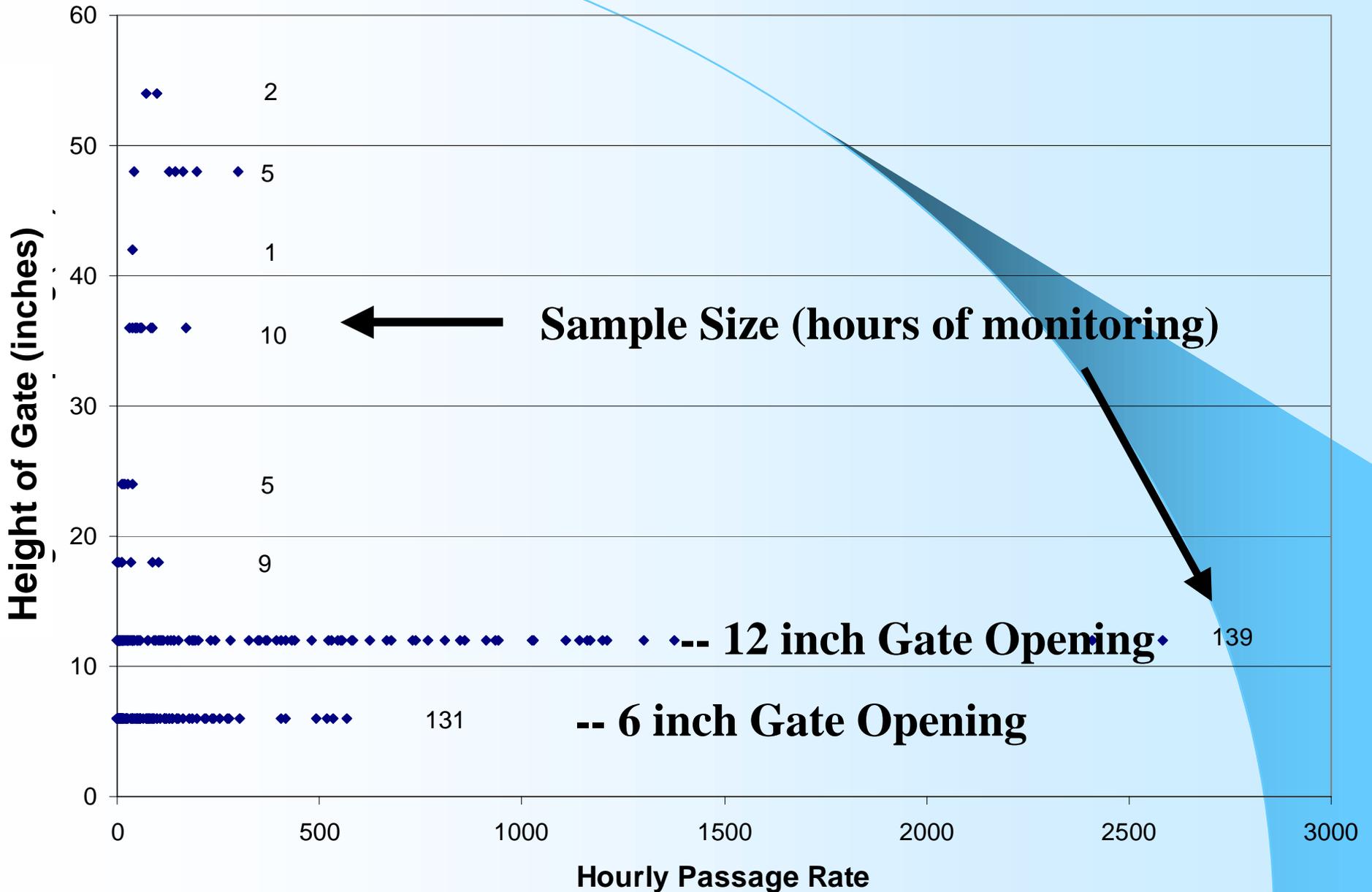
Flume Comparisons – Observer Counts



Flume Comparisons – PIT-TAG Chinook Data

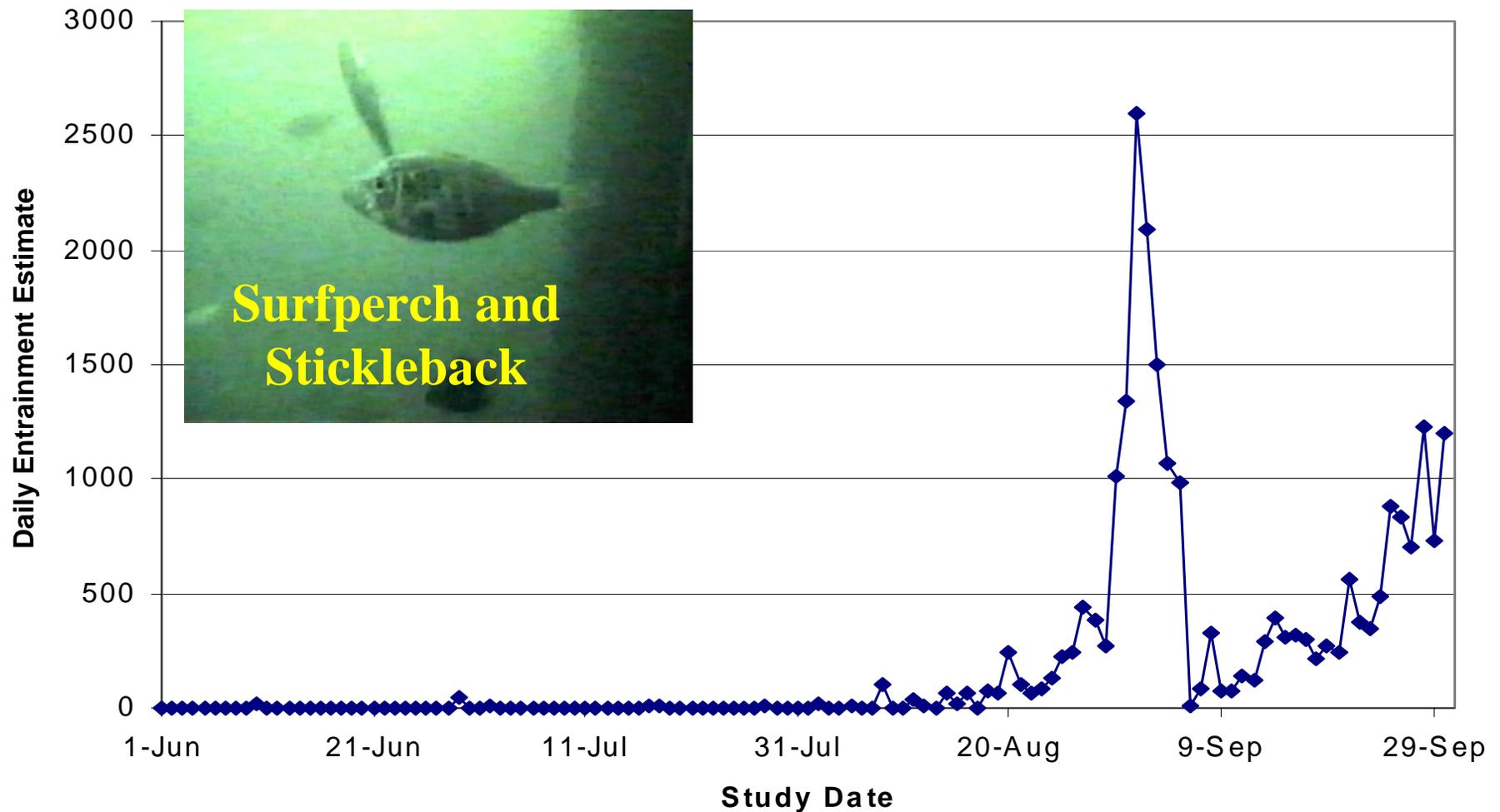


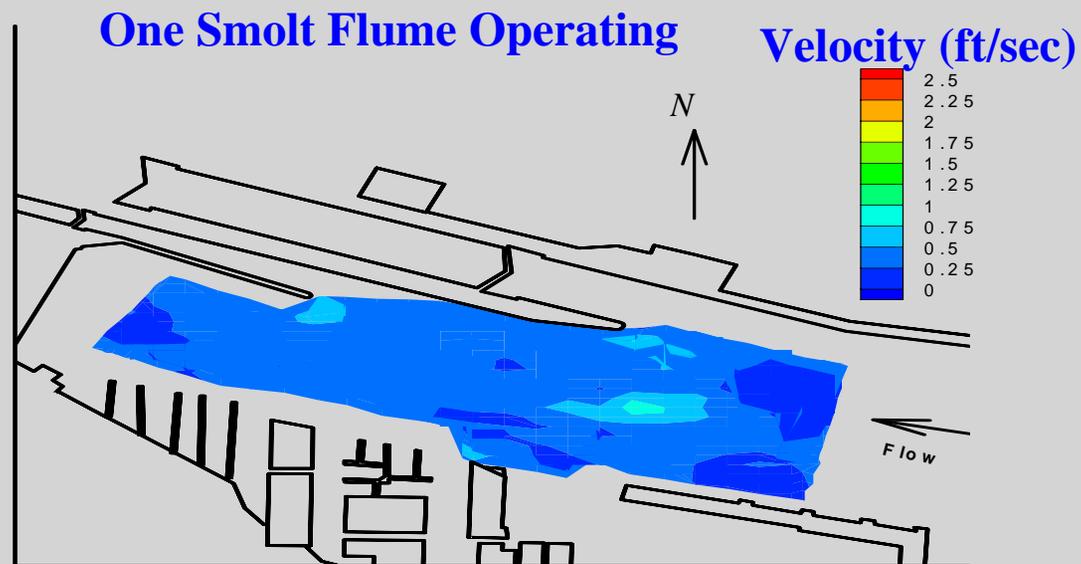
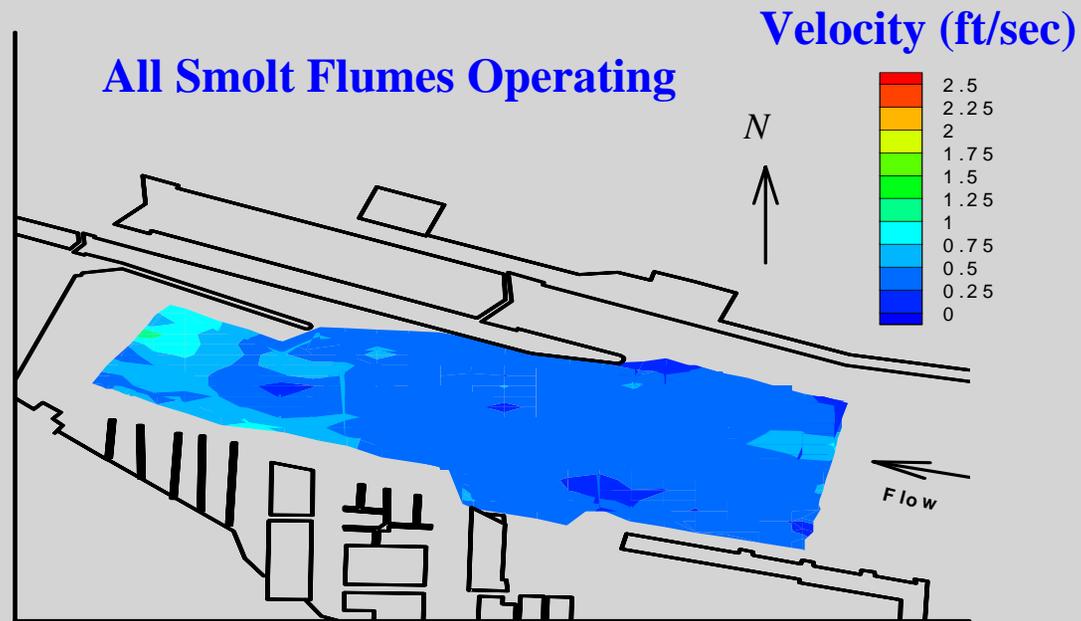
Hourly Passage Rate Samples vs Spillway Gate Opening (inches)



Monitoring of Saltwater Drain

Daily Entrainment Estimates -- 2000





**Acoustic
Current
Measurement
Water Velocity
at 4 ft Depth**

Juvenile Fish Passage Summary

- **Entrainment Reduction by Slow Fill.** Purse seine catch suggests a trend with lower entrainment rates with slowest fill rates. Hydroacoustic estimates show no discernable difference between two slowest fill types (mean value of 28 fish/fill).
- **Fish Guidance Efficiency.** Adequate flow volume through the flumes is largely responsible for reduced entrainment rate. Over 95% of counted smolts pass over the flumes when flow volumes are greater than 260 cfs. Flows less than 130 cfs result in an almost even passage rate with 50% of smolts using the flumes and 50% entrained in the large lock culverts.
- **Smolt Passage.** Observer counts likely underestimate actual smolt number in larger flumes. Smolt capture below the flumes offers the potential for a wide range of new data. Smolt capture methods require feasibility assessment.

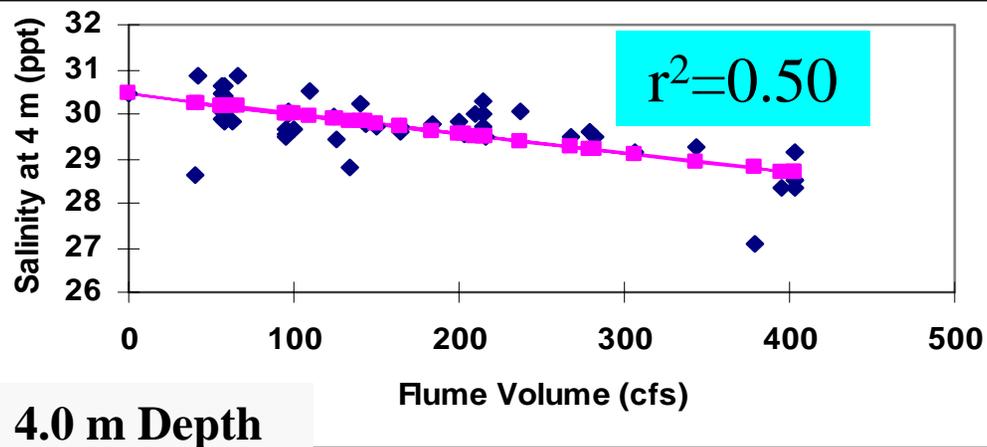
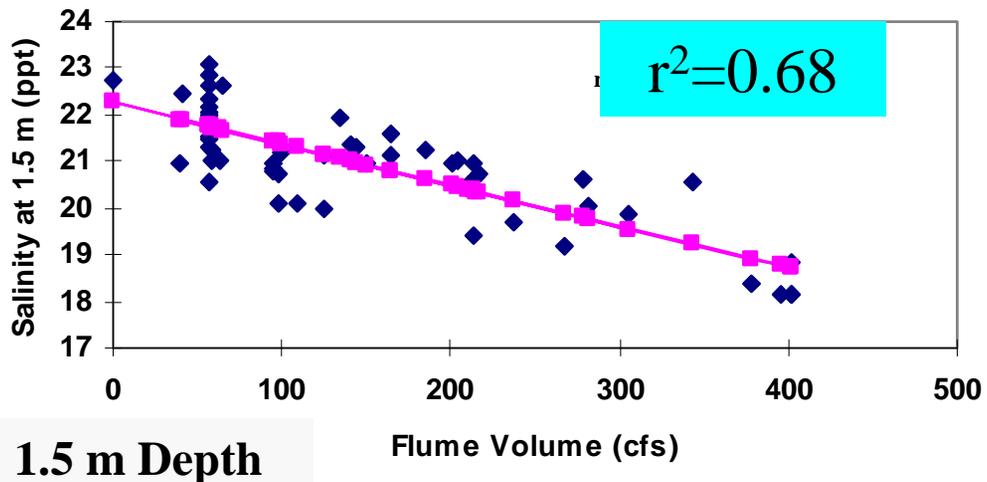
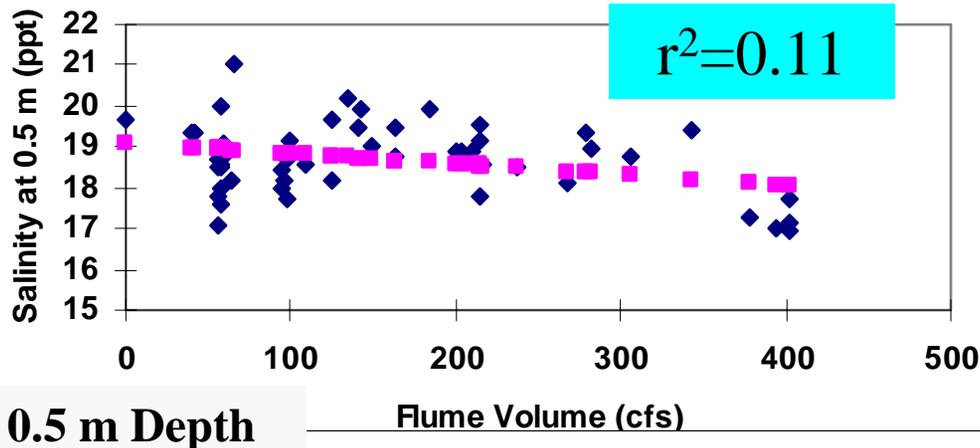
Juvenile Fish Passage Summary Cont'd

- Barnacle Removal. Injury rate for heavily descaled smolts is 75% lower since barnacle removal and 65% lower for lightly descaled.
- Saltwater Drain. Few smolts are entrained during periods of spill or smolt passage flume operation. Estuarine fish are the most entrained fish. Adult chinook enter the intake and hold but are able to swim-out during normal summer conditions.
- Spillway Gate. The estimates of fish passage suggest increased passage at a 12-inch gate height vs. 6 inch. Estimates were 100 to 150% higher for the 12-inch gate opening, requires conversion to fish/cms.

Preliminary Estuary Stuff

Can the functional value of the “neoestuary” be improved.

What happens when you spill more freshwater?



Continuous CTD Monitoring Below the Locks – *Daily Values*

**Increasing Spill Volume
increases the depth of
the Freshwater Lens at
1.5 m and 4.0 m**

Adult Chinook Passage

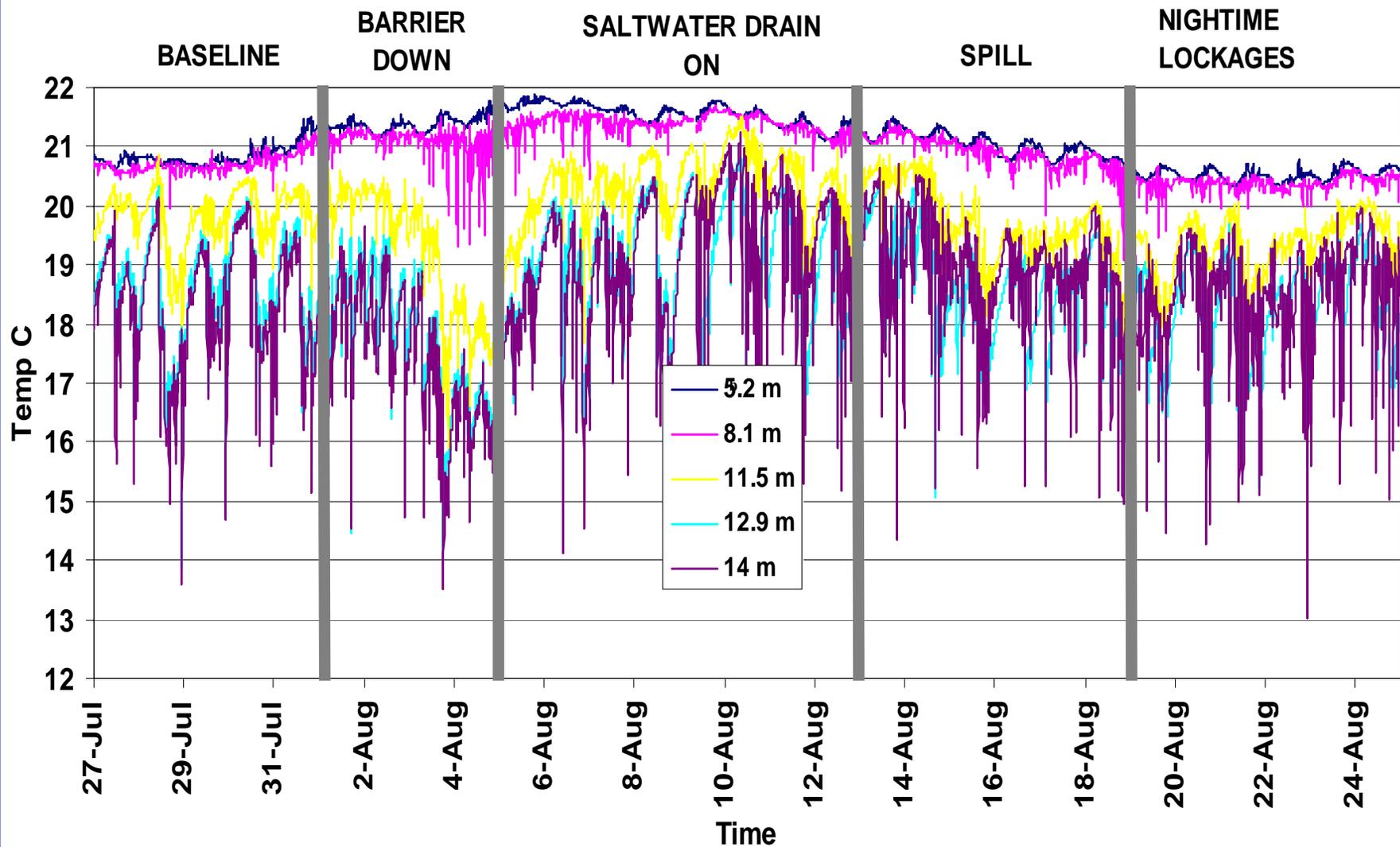
Adult Issues

Can we improve holding conditions above the Locks. Mid-summer migrants reside in a small, localized area above the Locks for up to 50 days. Monitoring and evaluation are being used to develop concept of “coolwater refuge.”

Fish Passage Monitoring Objective

Develop individual behavior model of adult chinook salmon holding in the coolwater refuge. Link fish vertical position to changes in water quality and water velocity.

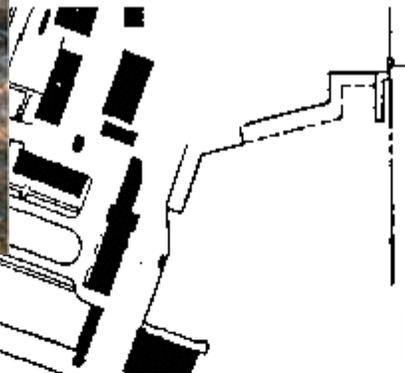
Monitoring of Temperature within the Coolwater Refuge Area



Acoustic Tag Study: Linked Hydrophones

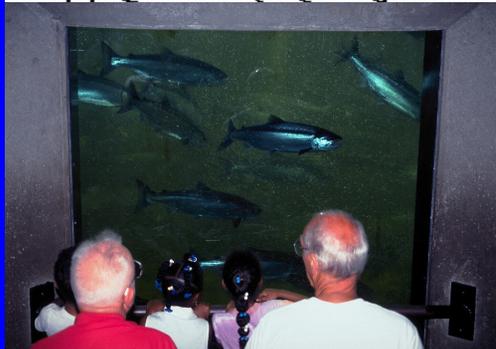
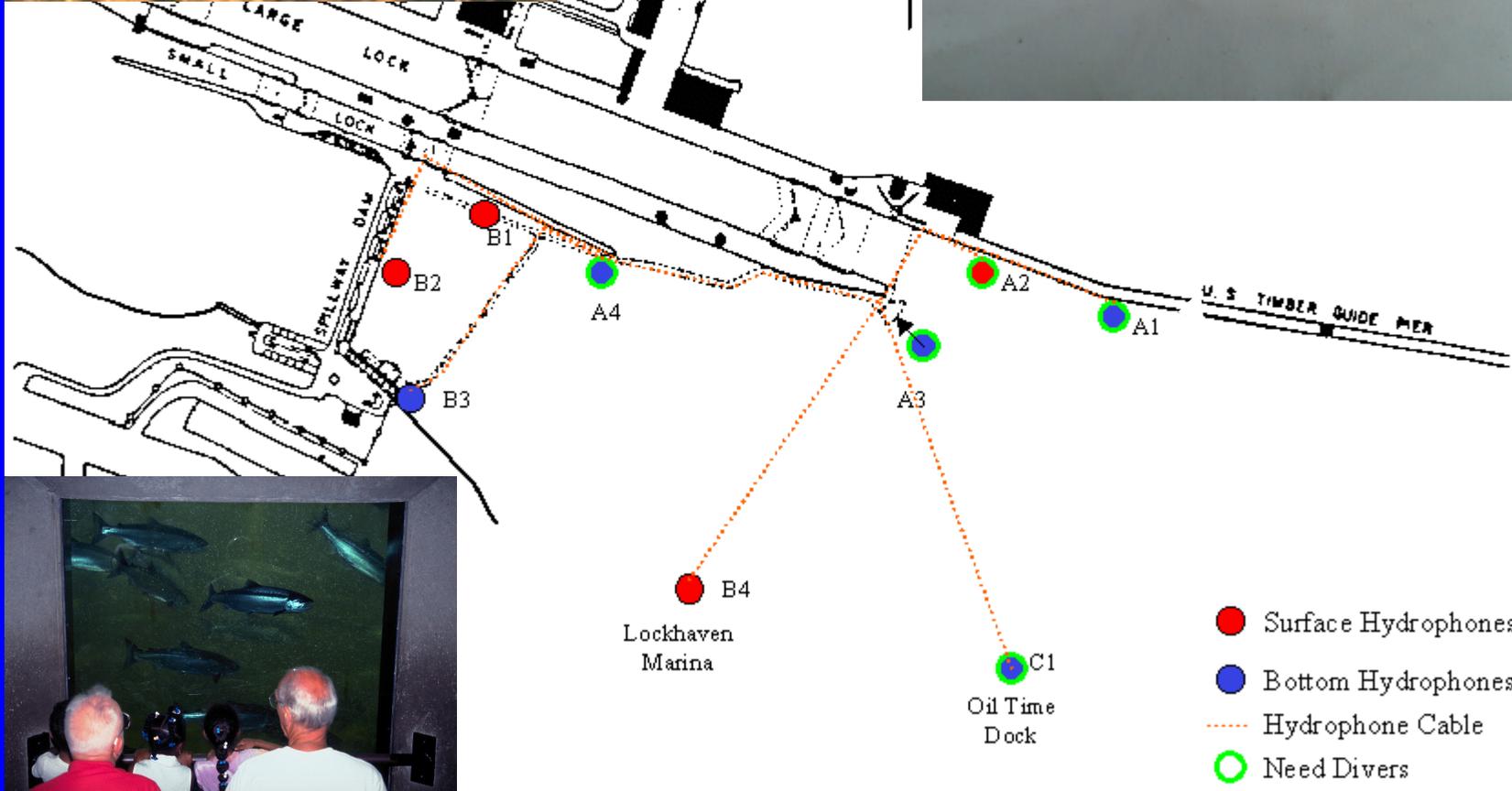


Hiram M. Chittenden Locks



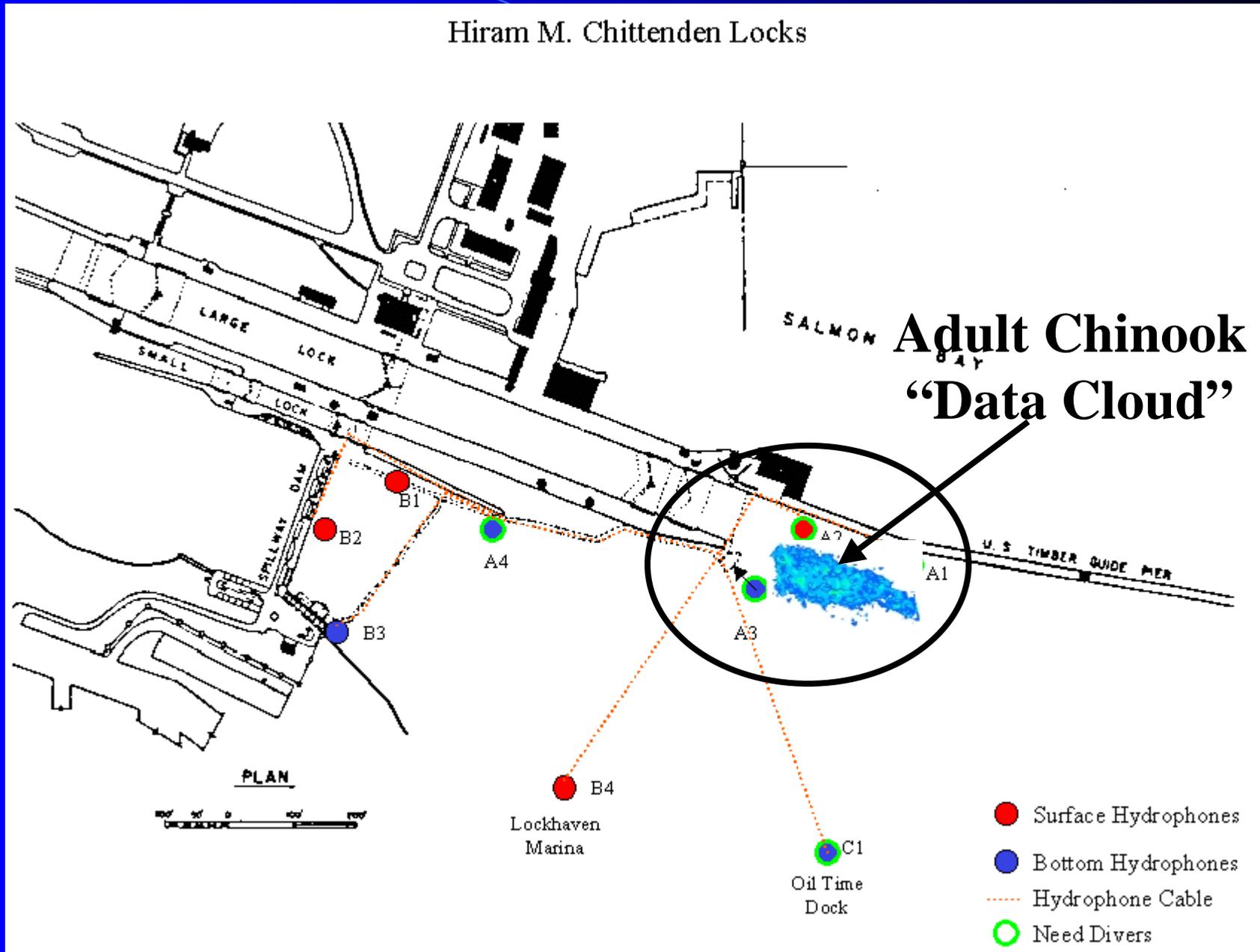
Vemco Tag

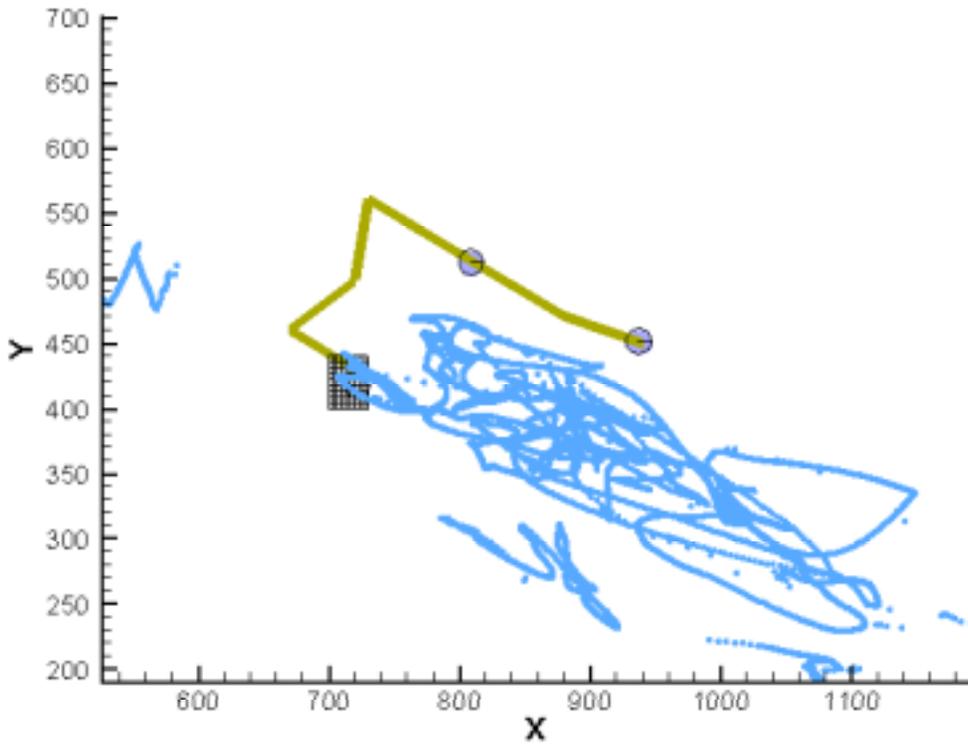
HTI Acoustic Tag



Planview of "Data Cloud" or Horizontal Position

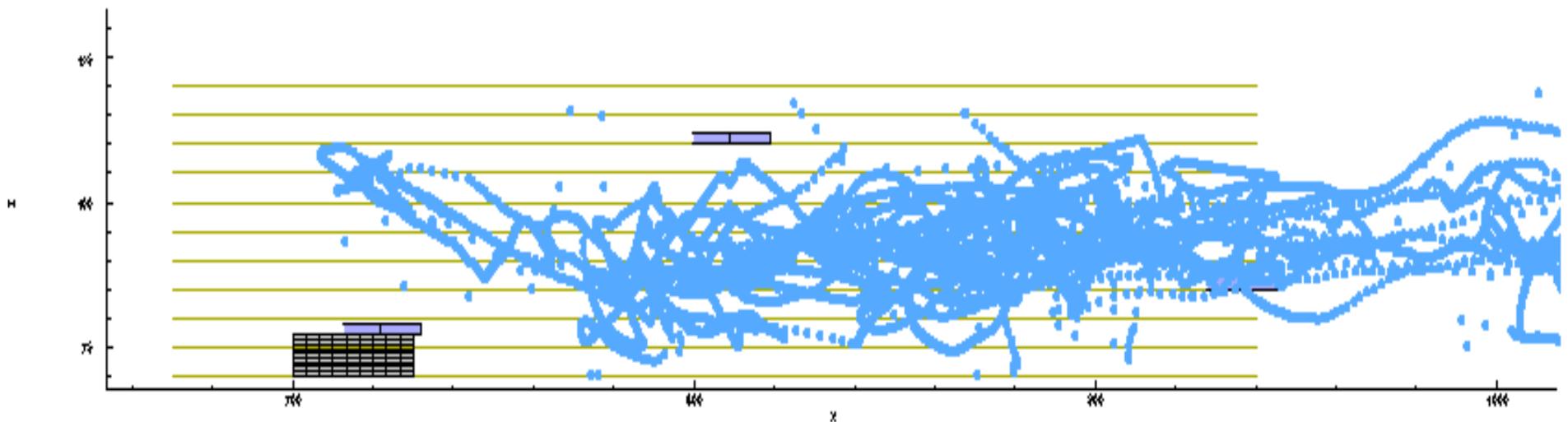
Hiram M. Chittenden Locks

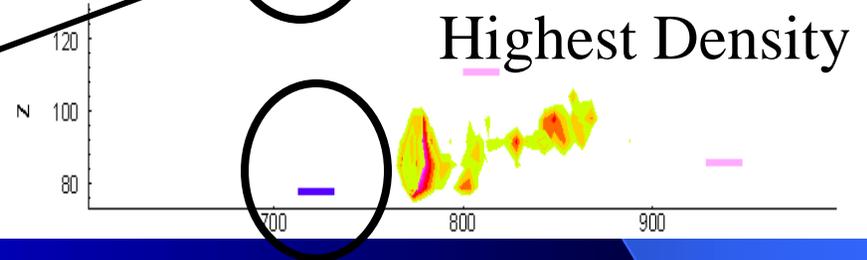
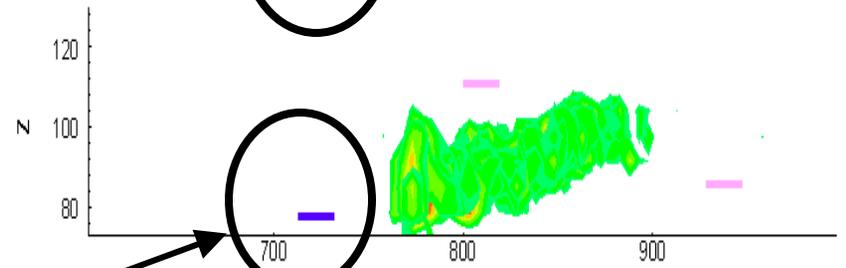
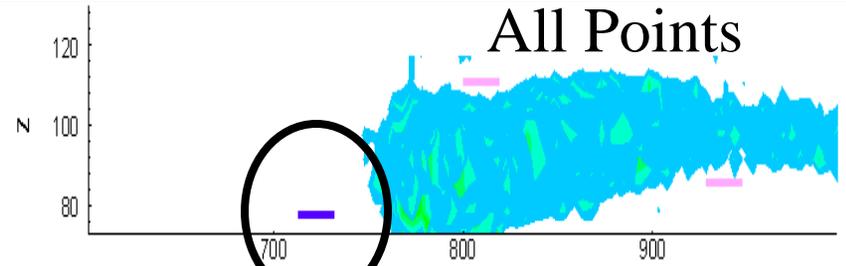
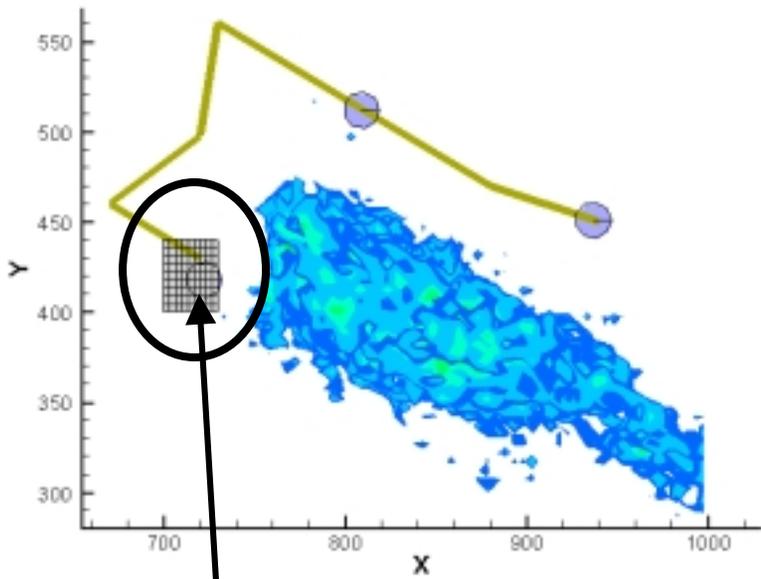




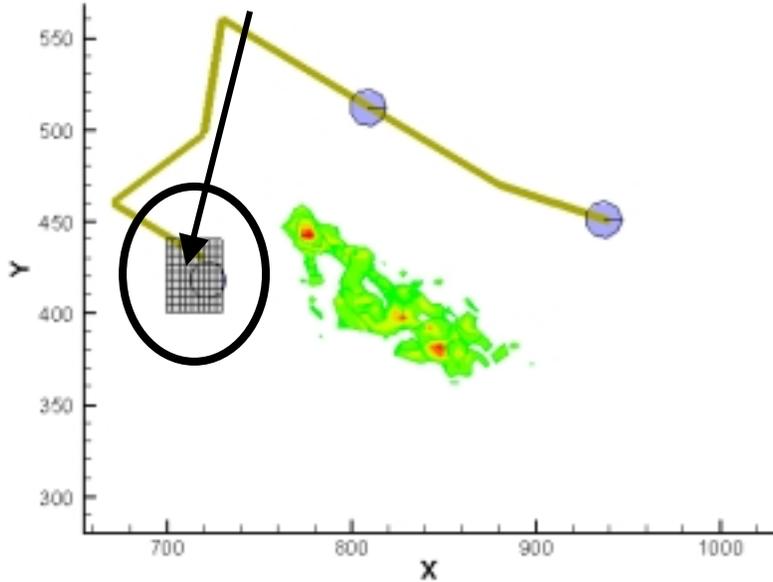
**Make-up of the
Data Cloud**

**Horizontal and
Vertical Fish Tracks**



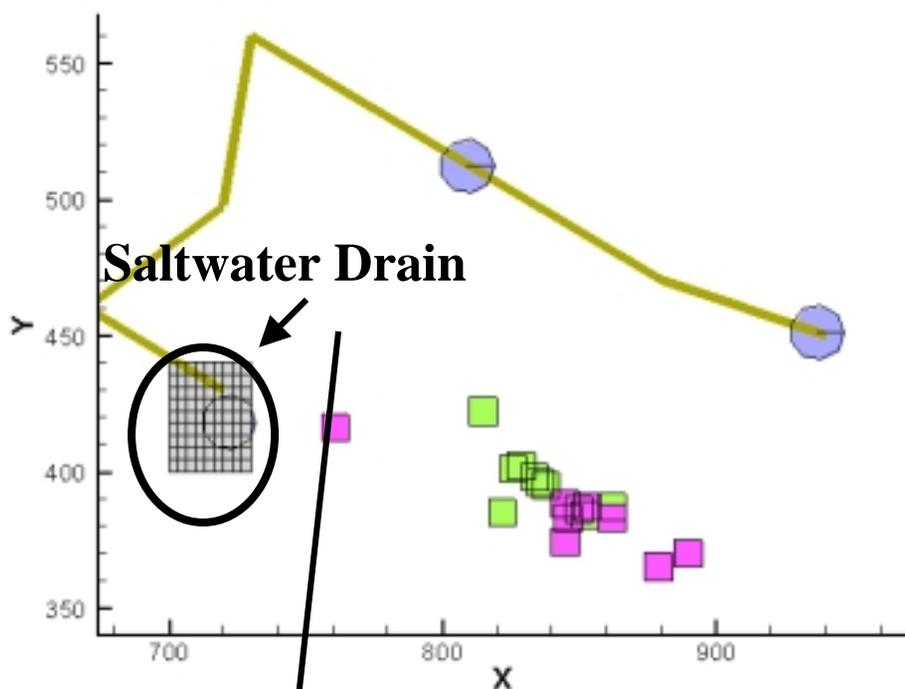


Saltwater Drain



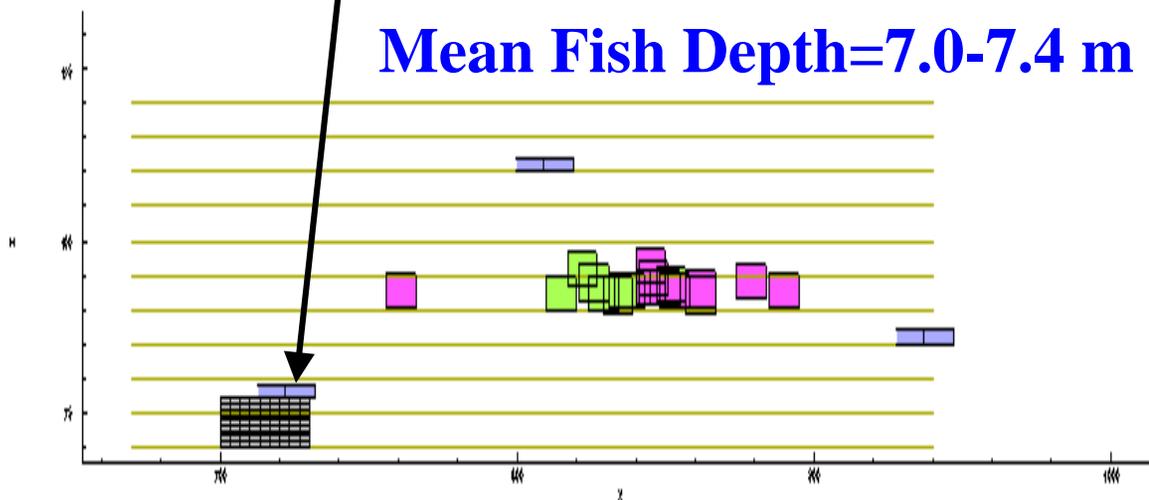
**Data Cloud
Horizontal and Vertical
Position**

Acoustic Tag Study Vertical Position



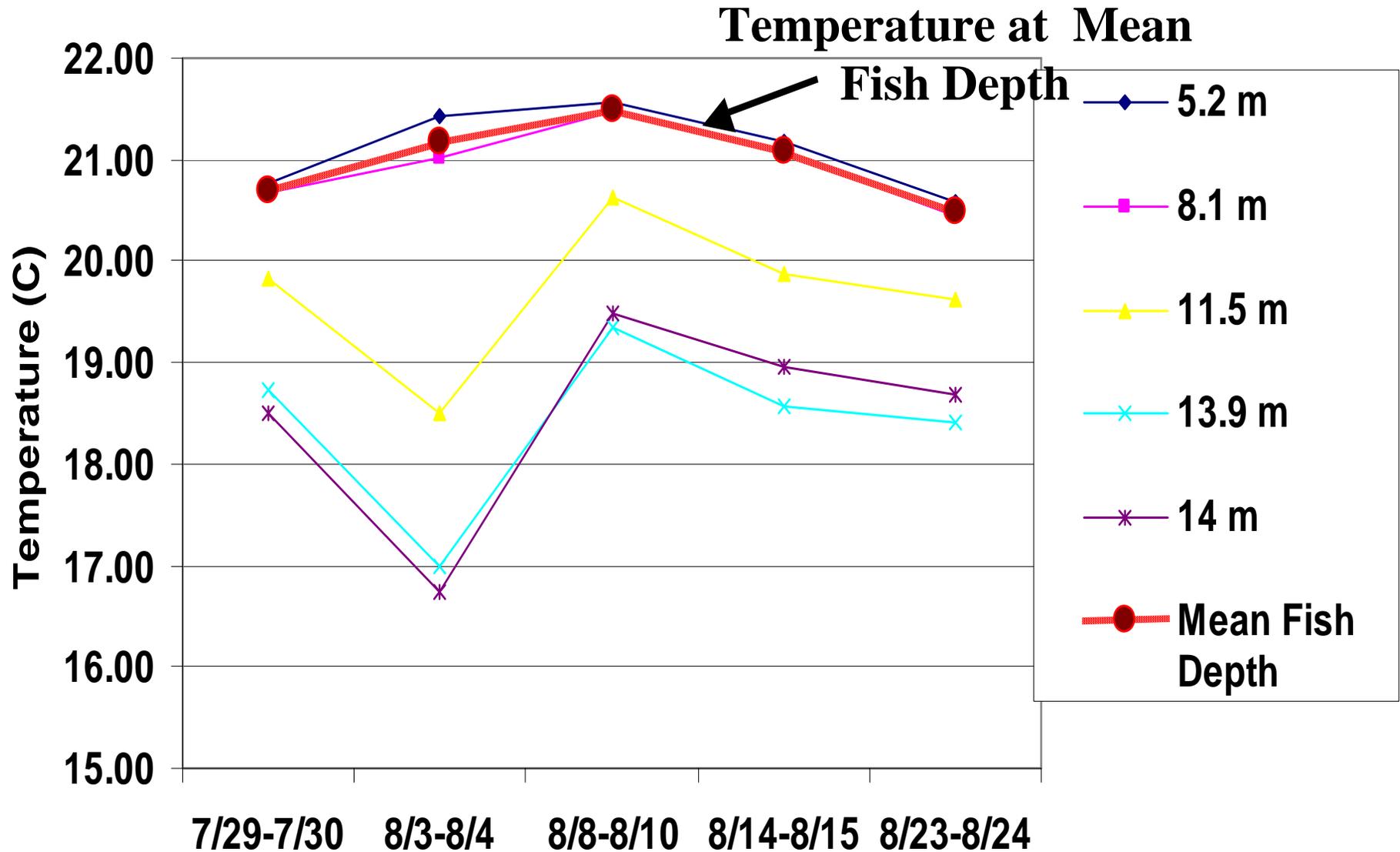
- Mean position of all echoes
- Mean position of echoes in close proximity to saltwater drain

Mean Fish Depth=7.0-7.4 m

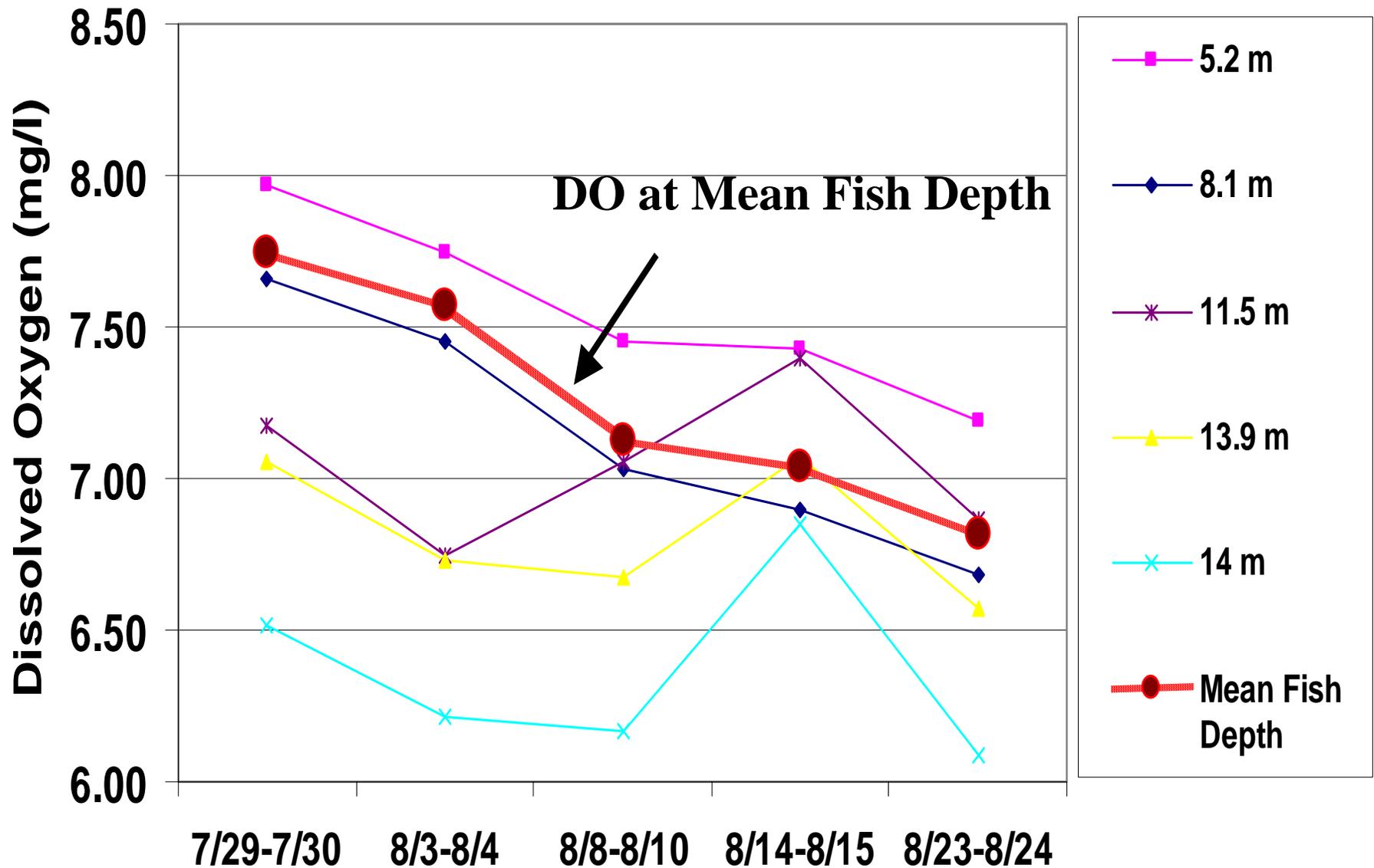


**Next,
integration with
temperature,
salinity, and
dissolved O₂**

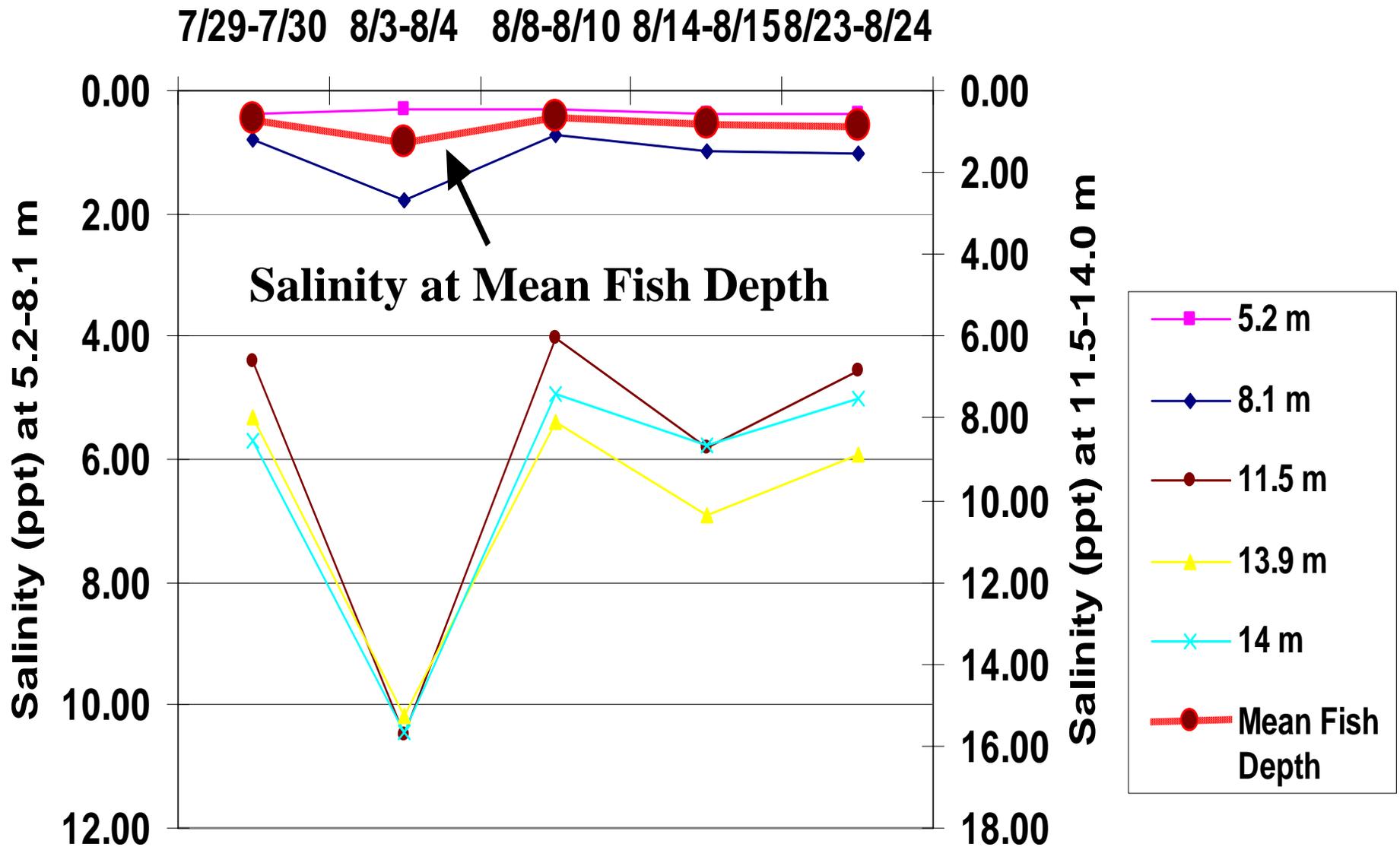
Vertical Fish Position vs. Water Temperature



Vertical Fish Position vs. Dissolved Oxygen



Vertical Fish Position vs. Salinity



Adult Chinook Passage Summary

- **Monitoring utilized new technology, linked hydrophones, to estimate fish position with a high level of accuracy (± 1 -m)
-- assessing habitat use within the navigation channel/SW return.**
- **Adult salmon behavior has not been studied before in such an unusual pseudo-estuary. Preliminary results are unexpected – 1) fish holding in high water temperatures, 21 C (reported elsewhere as beyond the selected range of adult chinook), and 2) the possibility that adult holding behavior may be a function of acclimation to freshwater. What does this long-term temperature exposure mean to reproductive success?**
- **Preliminary results as yet do not show that the coolwater refuge is a necessary habitat feature explaining fish location and behavior. Further analysis will include water velocity tracks and analysis of fish position during Locks operations.**
- **Lastly, we have asked Waterways Experiment Station to further evaluate fish behavior by investigating development of a computational fluid dynamics model.**