"Balancing Marine and Freshwater Survival Rates When Managing Anadromous Fish Passage"

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KINTAMA

Or: "The Thinking Fish's Guide to Where to Spend Life"

Pre-Migration:

- Egg
- Fry
- Pre-Smolt

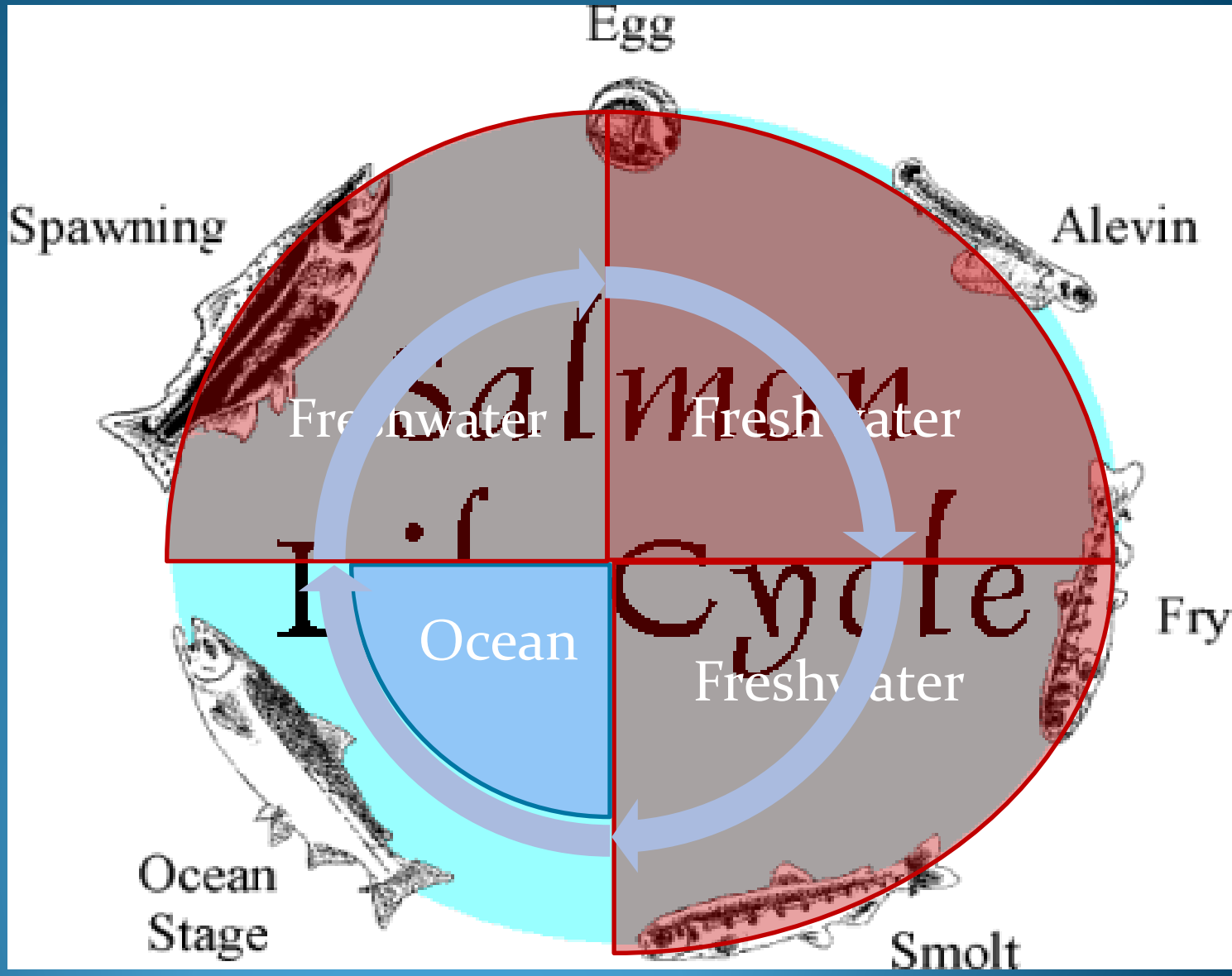
Migratory Phase:

- Smolt (Freshwater)
- Juvenile (Early Ocean)
- Immature (Ocean Years 2+)
- Returning Adult (Last Few Months)

Reproductive Phase:

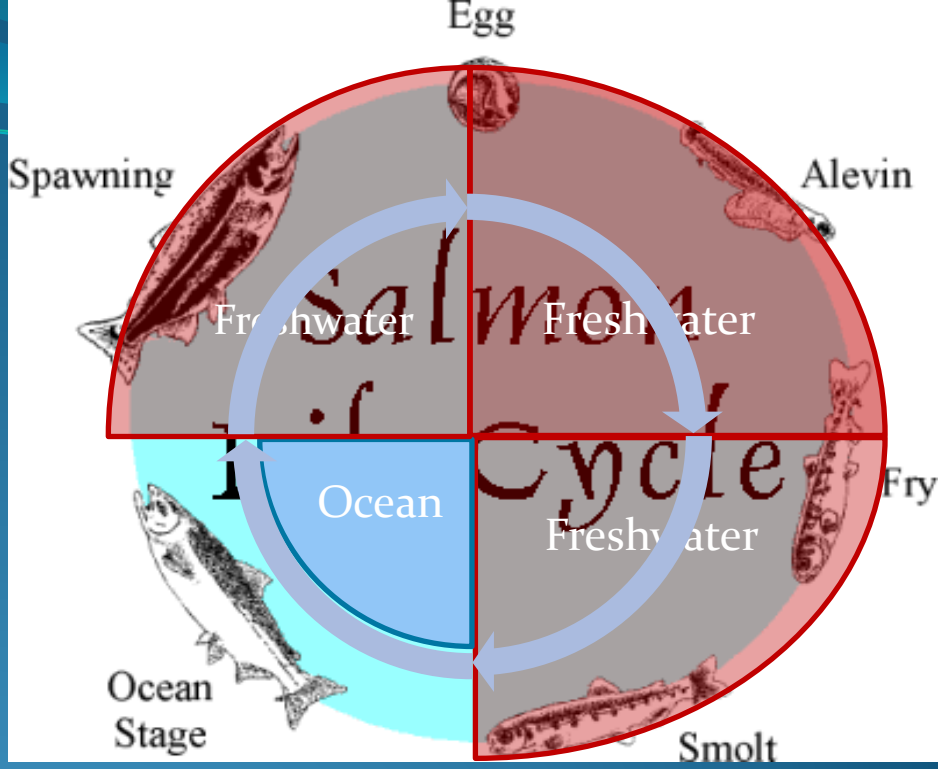
- Spawn & Die

The Salmon Life Cycle



Credit: Lakelse Watershed Society

The Salmon Life Cycle



Credit: Lakelse Watershed Society

TIME

- FW: 0.5~1.5 yrs
- Ocean: 1.5~4 yrs

GROWTH

- 99% in ocean

SURVIVAL

- "Most" determined in ocean
- (About 6/7^{ths} of migratory survival is determined in the ocean)

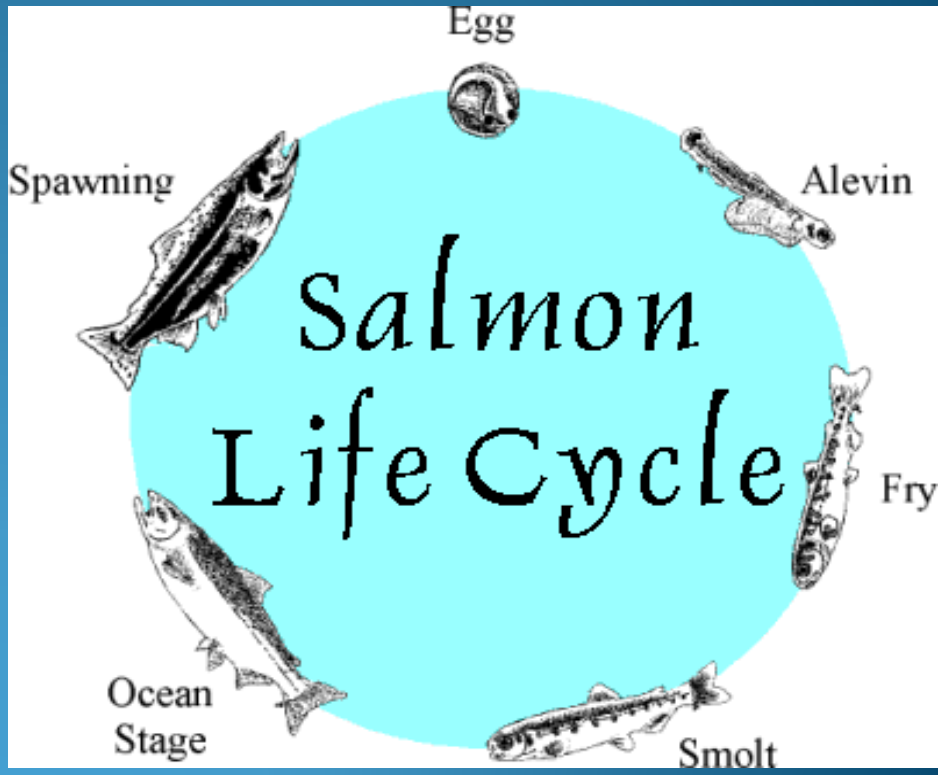
The Salmon Life Cycle

TIME

- Age at maturity is fixed (years are integers), so…

- Less time spent in freshwater ➔ More time spent in the Ocean

- **Let's Explore the Implications**



Credit: Lakelse Watershed Society

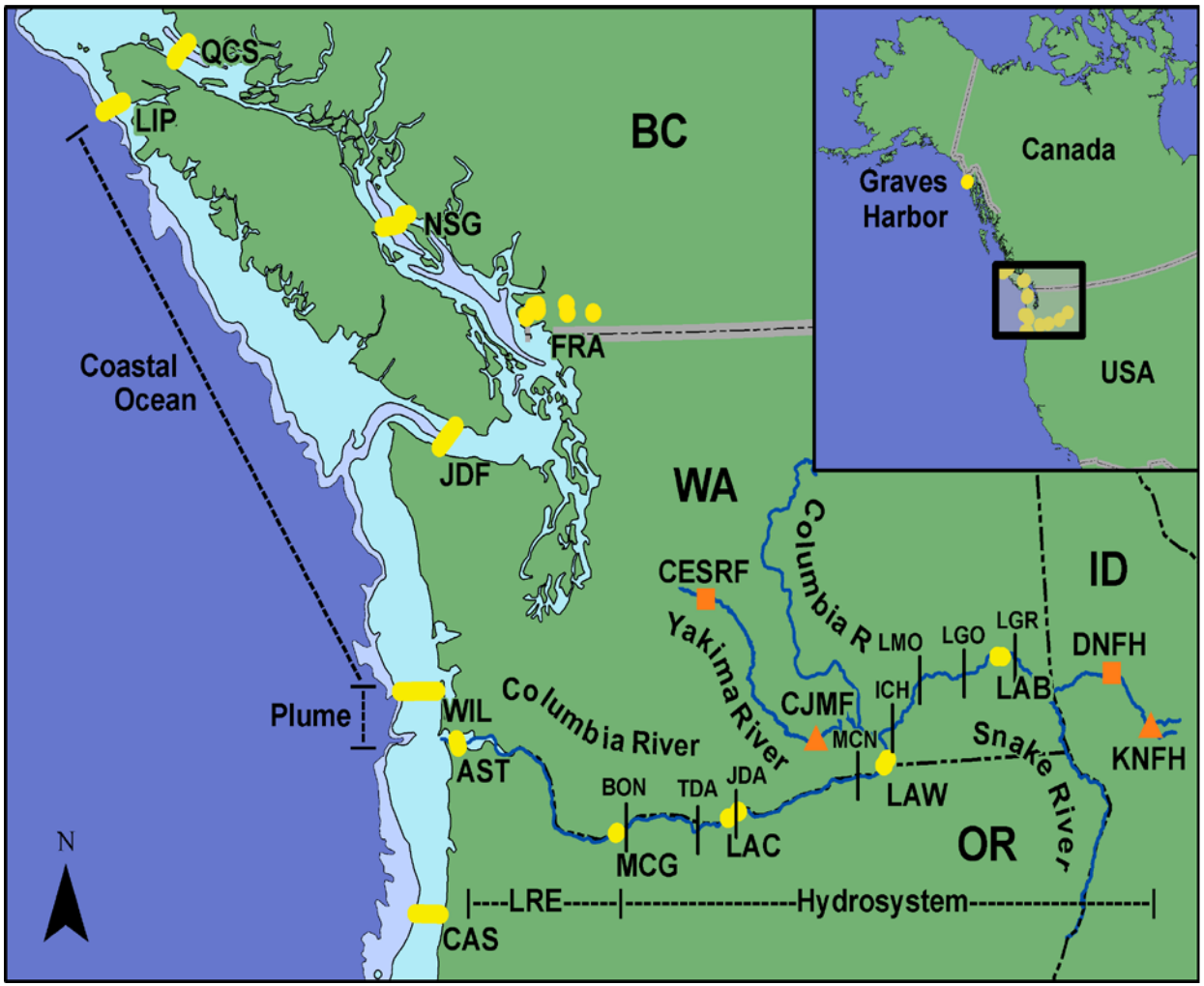
"…Put simply, salmon can remain in freshwater and have a comparatively high survival rate… or they can go to sea and have a lower probability of survival [and a higher growth rate]…"

From: The Behavior and Ecology of Pacific Salmon & Trout, Chapter 12: Downstream Migration: To Sea or Not to Sea? Quinn (2005, p. 209), paraphrasing Mart Gross' (1987) paper

- Virtually all salmon conservation efforts in the Columbia River hydrosystem assume that moving smolts out of the hydrosystem and into the ocean faster improves survival:
  - Spill
  - Barging (Transportation)
  - Reservoir Drawdown
  - Dam Breach
- This makes logical sense only if $S_{Ocean} > S_{FW}$
- So what is the empirical evidence?

Kintama Acoustic Telemetry Overview

Map of the 2006-09 Array



- Coastal ocean sub-arrays extended offshore to 200 m depth (Edge of Continental Shelf)
- Sub-array added at Astoria in 2008
- Sub-array added at Cascade Head, OR in 2009

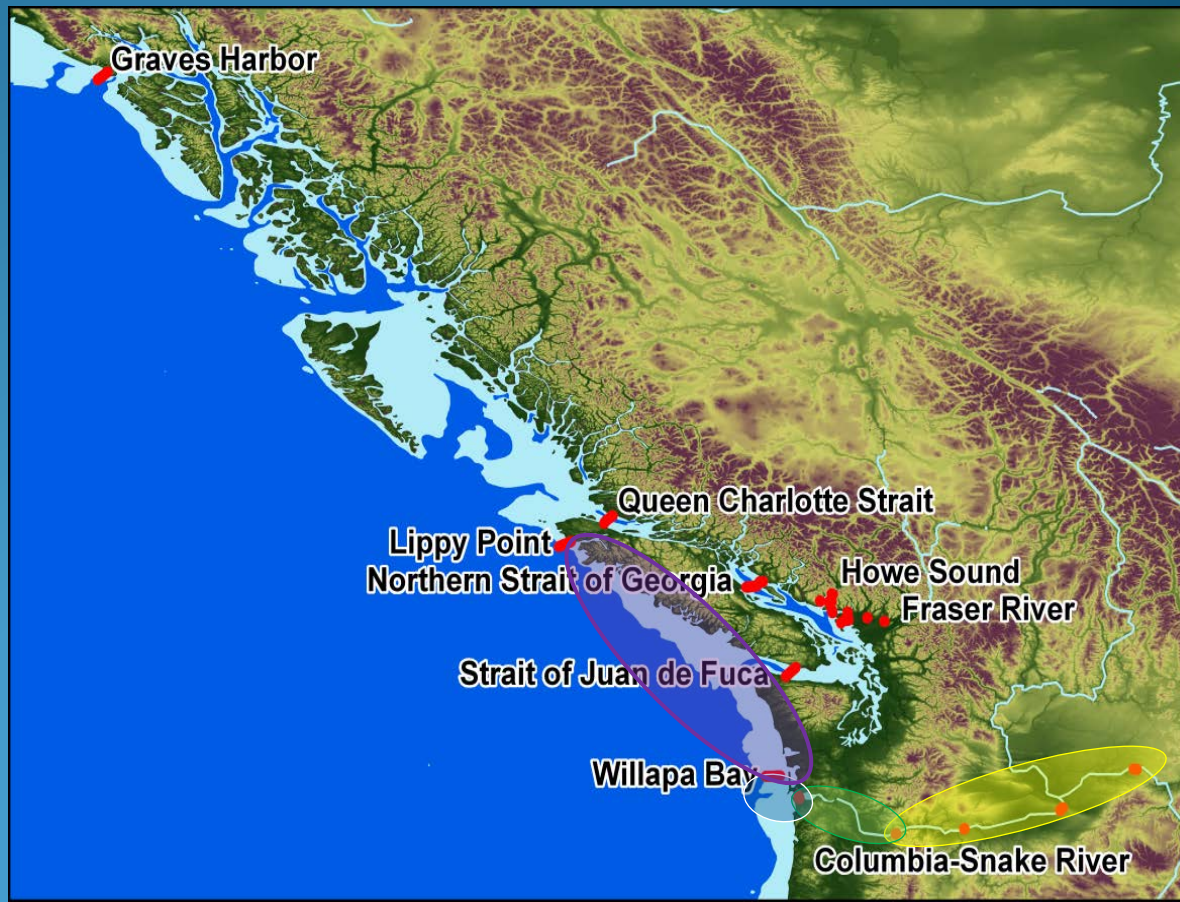
Acoustic sub-array
Hatchery origin
Release site

LAB= Lake Bryan
LAW- Lake Wallula
LAC= Lake Celilo
MCG=McGowans Channel
AST=Astoria Bridge
WIL=Willapa Bay
LIP= Lippy Point
CAS=Cascade Head
Graves Harbor

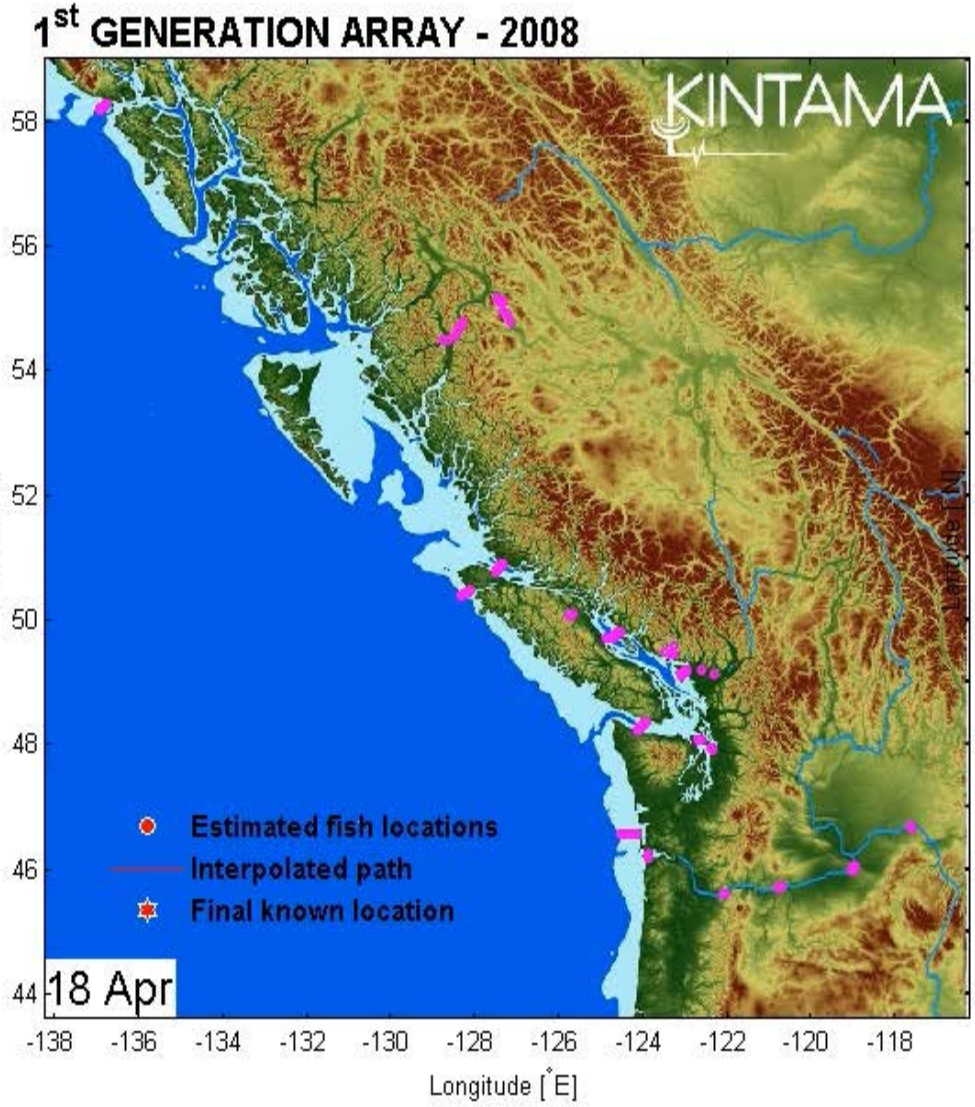
Acoustic Measurements of Survival

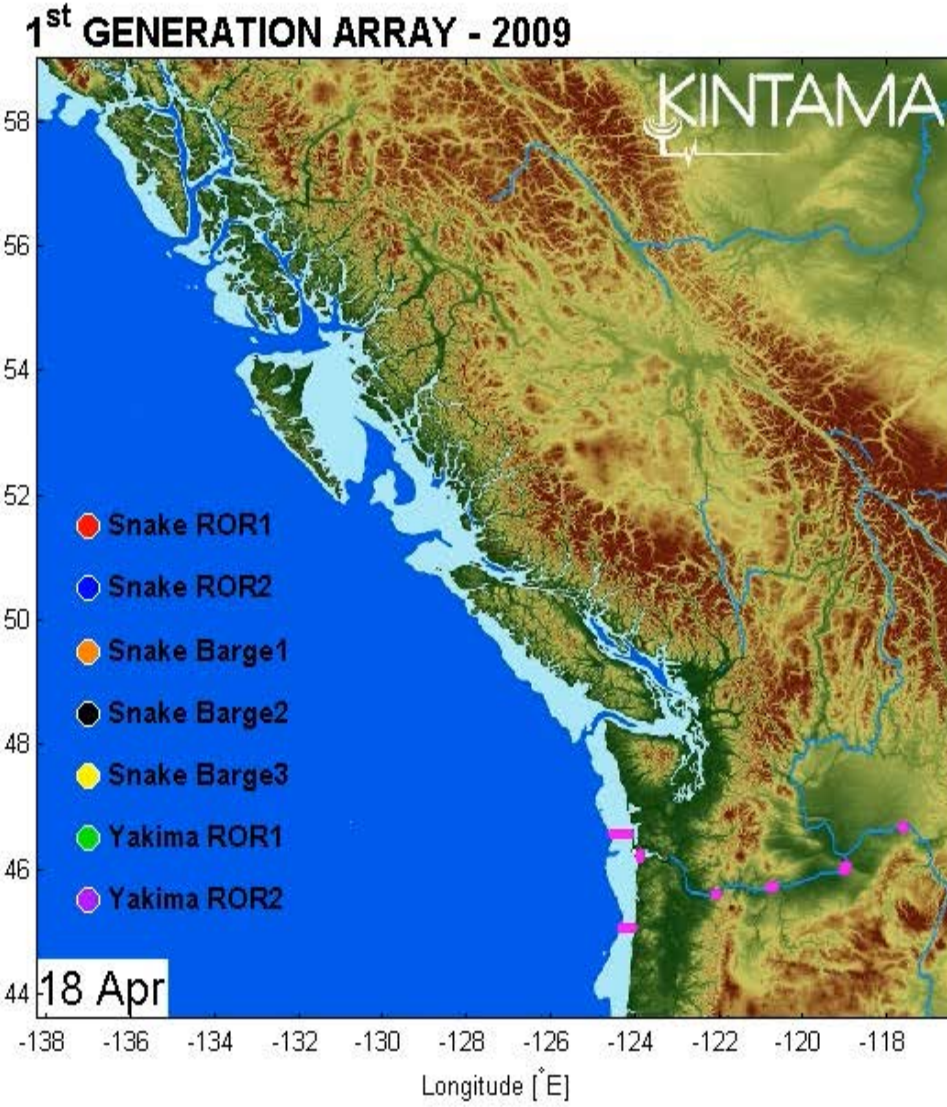
Telemetry array (Vemco equipment) used to measure Snake River Spring Chinook survival in 4 habitats:

- Hydrosystem
- Estuary
- Plume
- Coastal Ocean



2008 & 2009 Juvenile Migration-Animation



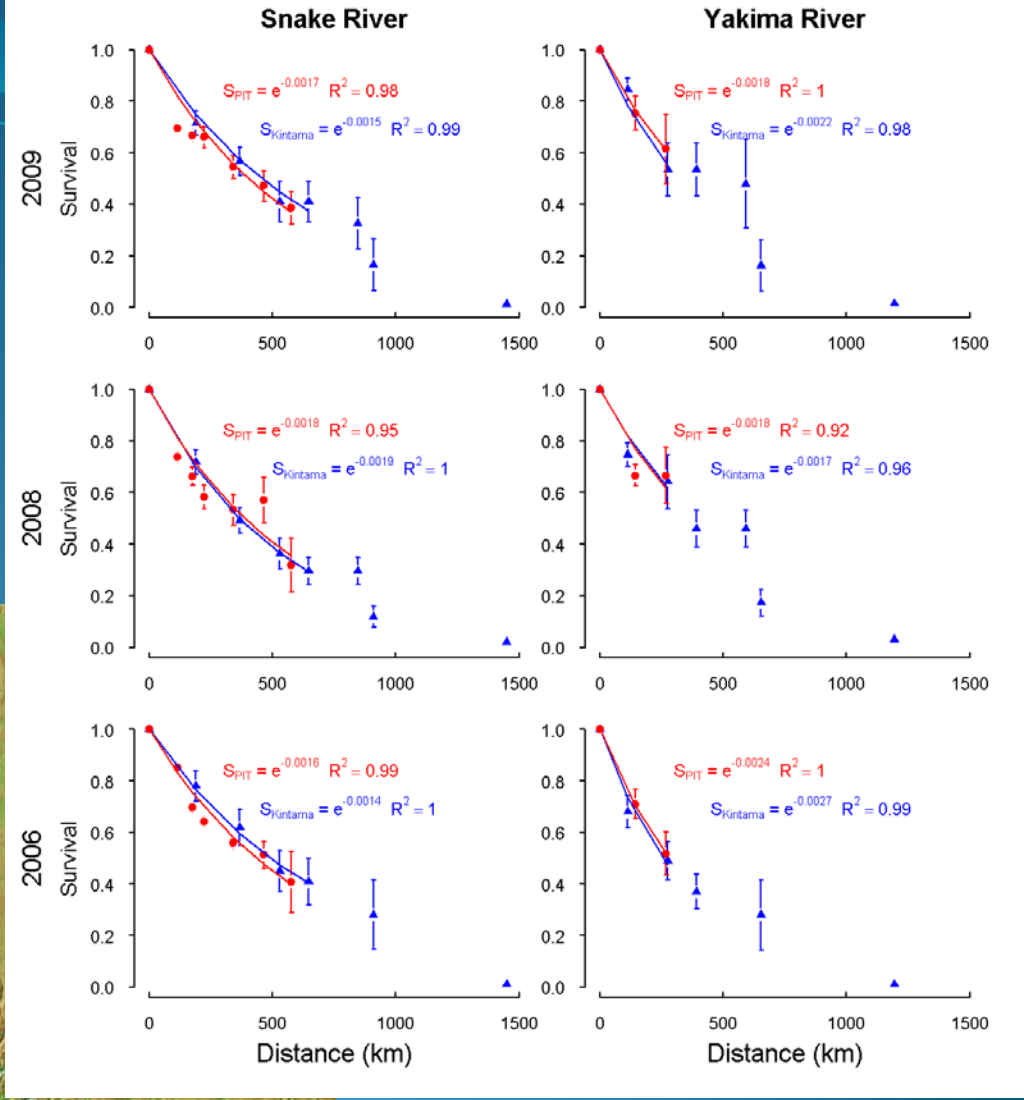


IS THE DATA RELIABLE?

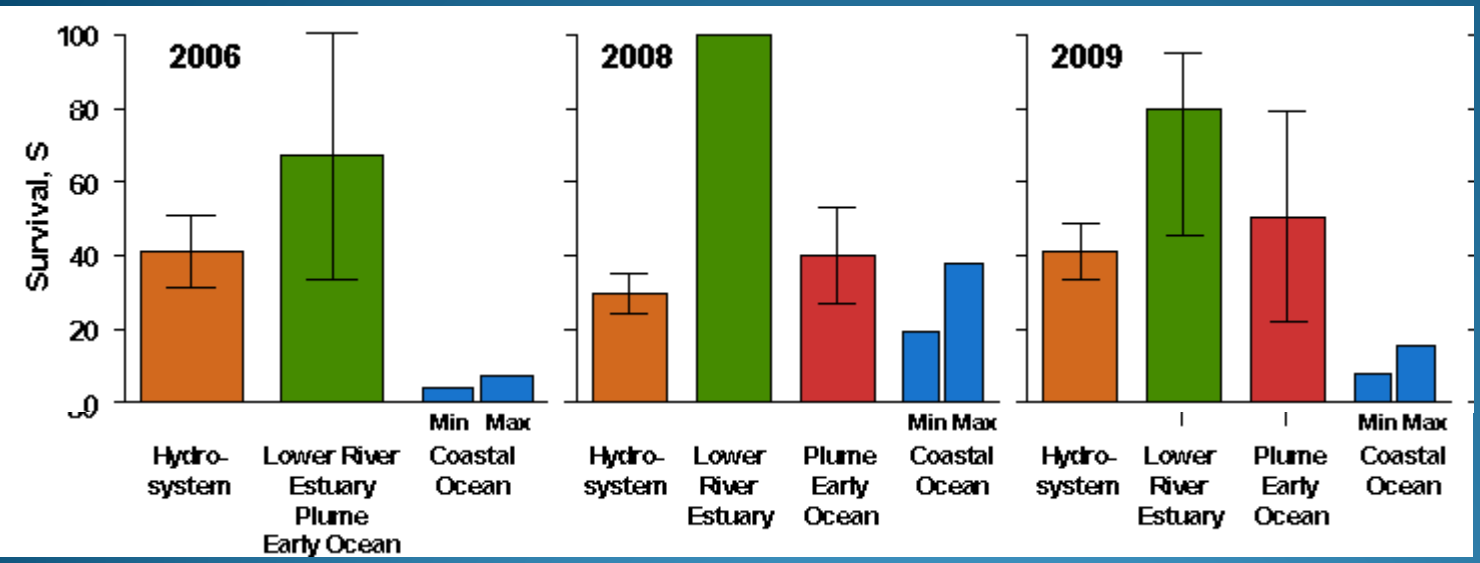
Acoustic-Tagged Smolts: Adult Return Rates (SARs)

IS THE DATA RELIABLE?

PIT vs Acoustic-Tagged Smolts: Columbia River Chinook Survival (Freshwater Comparison)



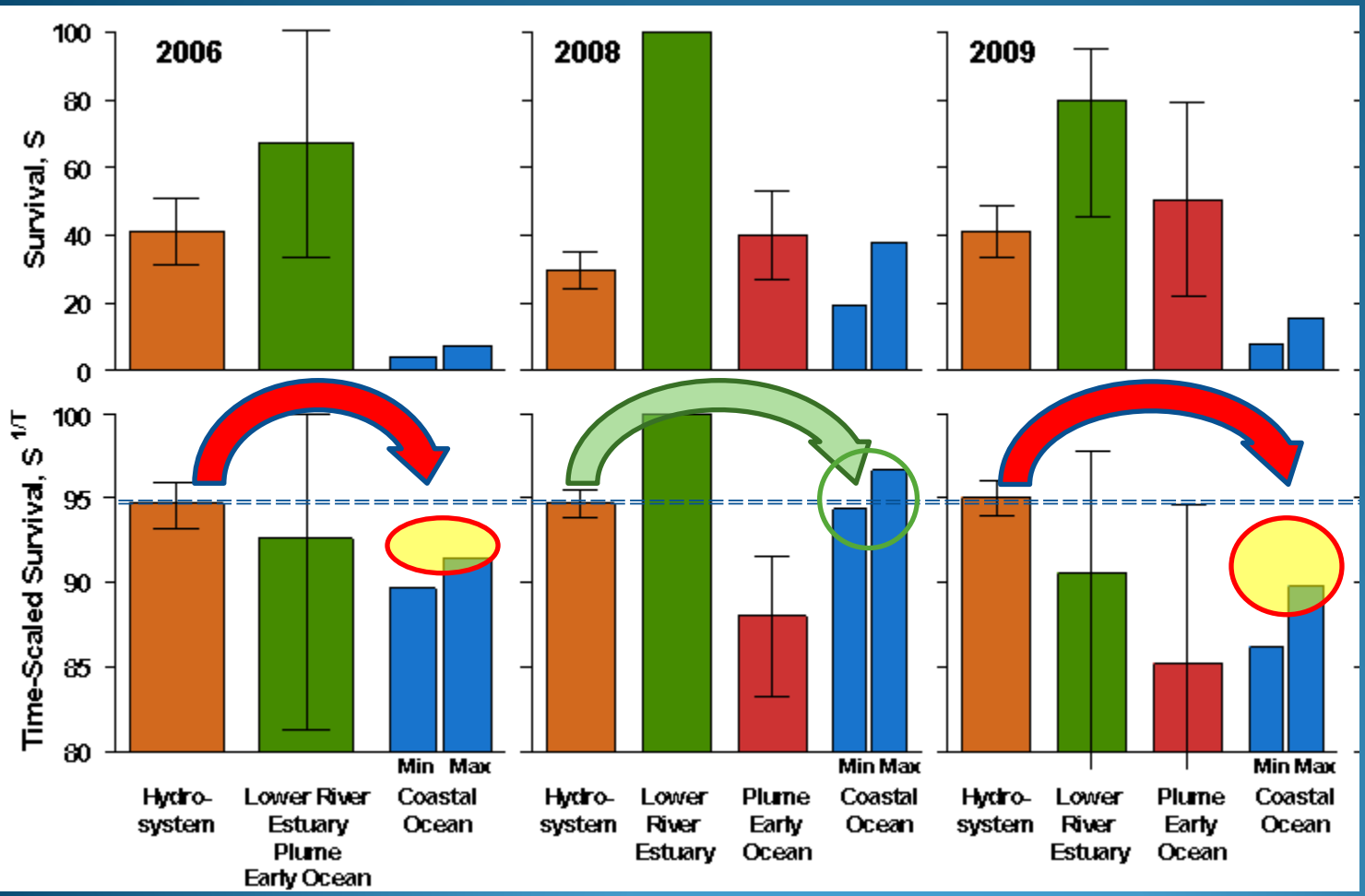
Continental shelf Chinook Survival



Data based on: *(i)* Rechisky, Welch, *et al.* Nature Sci. Reports (2012), *(ii)* Proc. U.S. National Academy of Sciences(2013), & *(iii)* In Prep.

Estimated CJS survival ± 95% CI; Coastal survivals assume NWVI sub-array detection efficiencies of 50 & 100%

Continental shelf Chinook Survival



Estimated CJS survival ± 95% CI; Coastal survivals assume NWVI sub-array detection efficiencies of 50 & 100%

SUMMARY

- Reducing freshwater residence time ***necessarily increases*** survival in the hydrosystem
  - First, because freshwater observation time is shorter. (!)

- However, ***only if survival rates are better in the ocean than freshwater*** does reducing ***freshwater residence time*** improve adult returns.

- A Decision Rule:

RULE	**EFFECT OF CURRENT MANAGEMENT APPROACHES**
$S_{Ocean} > S_{FW}$	Improves adult returns
$S_{Ocean} \approx S_{FW}$	No Effect
$S_{Ocean} < S_{FW}$	Reduces adult returns

Conclusions

- Management actions reducing smolt residence time in the river increase time spent in the ocean
- Under the poor ocean conditions predicted in future (similar to what occurred in the 1990s) ocean survival rates could well be lower than in the hydrosystem
- Current approaches to river conservation should be assessed to see if they are appropriate under such conditions