The current state of knowledge on how salmon use the Columbia River estuary and plume

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Today's talk

- Review the science presented at the 2007 science-policy workshop

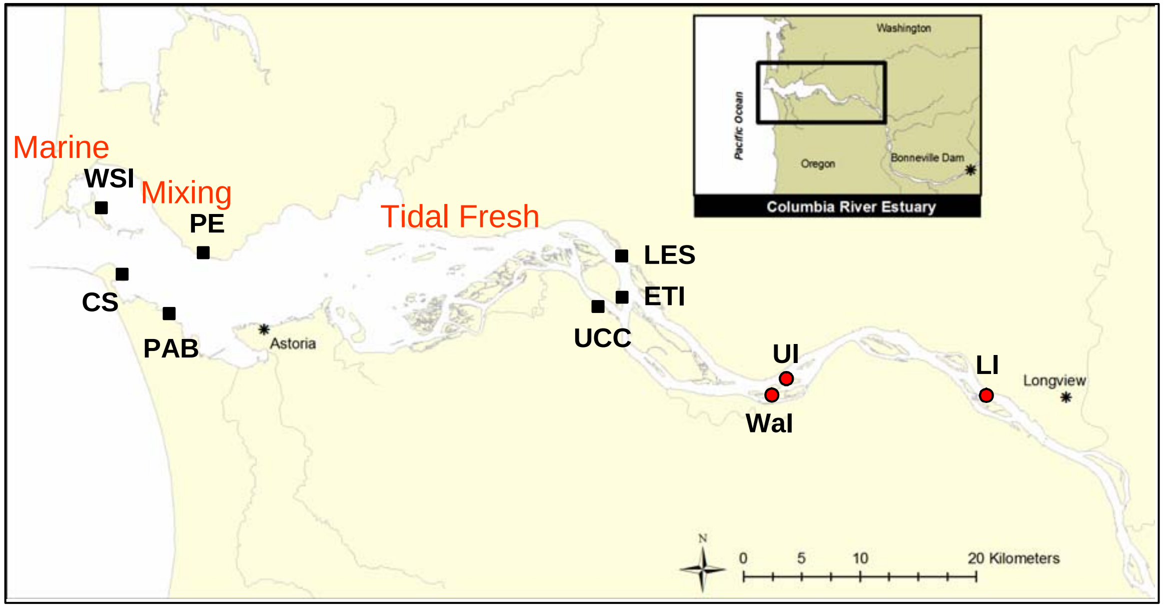
- Identify current uncertainties and data gaps as of 2009 (BiOp, recovery)

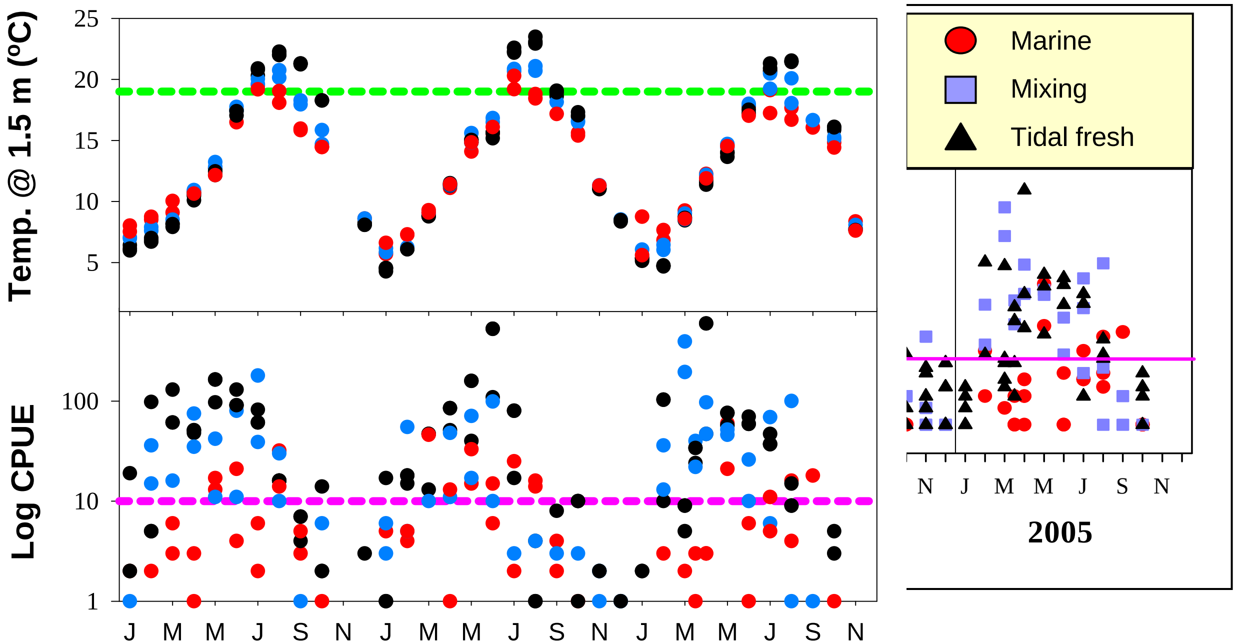
- Discuss the future - what do we need to focus on from here?

2007 Exchange - what did we learn?

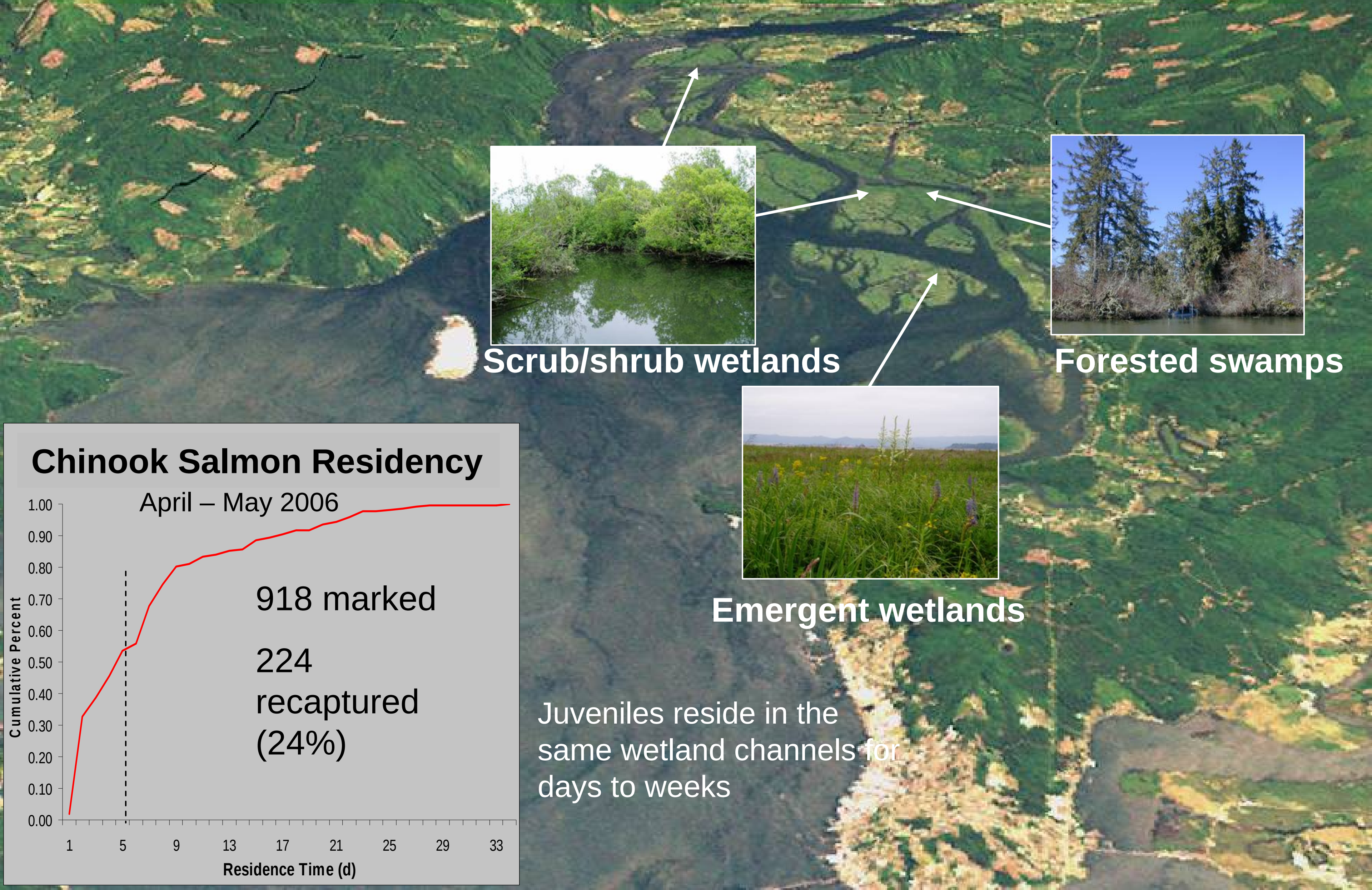
- Fish from throughout the Basin use estuary habitat for varying amounts of time
- River and estuary management should emphasize diversity of life history strategies and habitats, and assume there is no optimum time of residence in the estuary
  - *One size will not fit all*
- Food webs used by juvenile salmon are tightly linked to riparian vegetation in wetland habitats, suggesting the need for a holistic landscape approach to restoration activities

Juvenile Chinook salmon occupy the CR estuary throughout the year





Salmon with subyearling life histories use all wetland types along the tidal gradient



Juveniles reside in the same wetland channels for days to weeks

2007 – bird predation

- Anthropogenic modification of lower river/estuary landscape may have enhanced predators' access to migrating juveniles
- Based on acoustic tag studies, survival through the estuary is lower than previously believed, and not much different than survival through the hydropower system (rate/km)
- Predation might be reduced if barged smolts were released downstream from Astoria
  - this might also affect their adult survival, if rearing and physiological transition time in the mixed saltwater and freshwater environment of the estuary is needed for their maturation and survival
  - 2009 update: Waiting for complete adult returns from 2007 and 2008 releases, to add to 2006 data from Astoria and Skamania releases

2007 – policy implications

- Need to focus on creating more of what the fish need (more acres of wetlands), rather than on quantifying increases and decreases in fish mortality
- Need to look at the estuary as a critical part of the salmon life cycle
- The estuary is an important rearing environment that salmon have adapted to use, and we need to restore it as part of the continuum of habitats salmon require

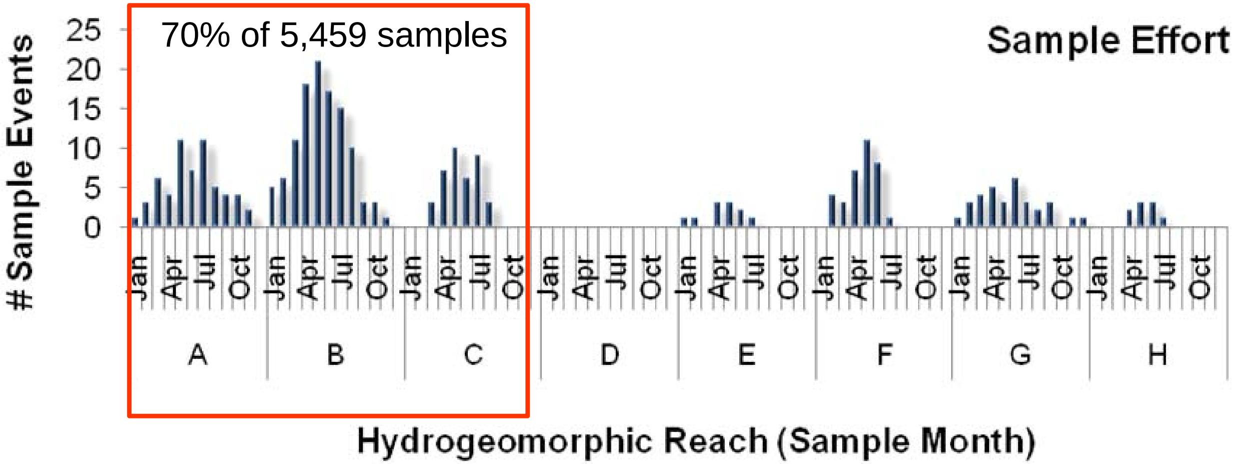
2007 - Summary

- Policies should connect the (upriver) hydropower system to the (lower river) estuary, synthesizing scientific knowledge in order to direct future research and policy-making
  - This knowledge could inform policy decisions on hydropower operations that influence salmon travel time and habitat conditions in the estuary
- 2009 update: Conclusions from the 2007 S-P exchange are largely in tact!

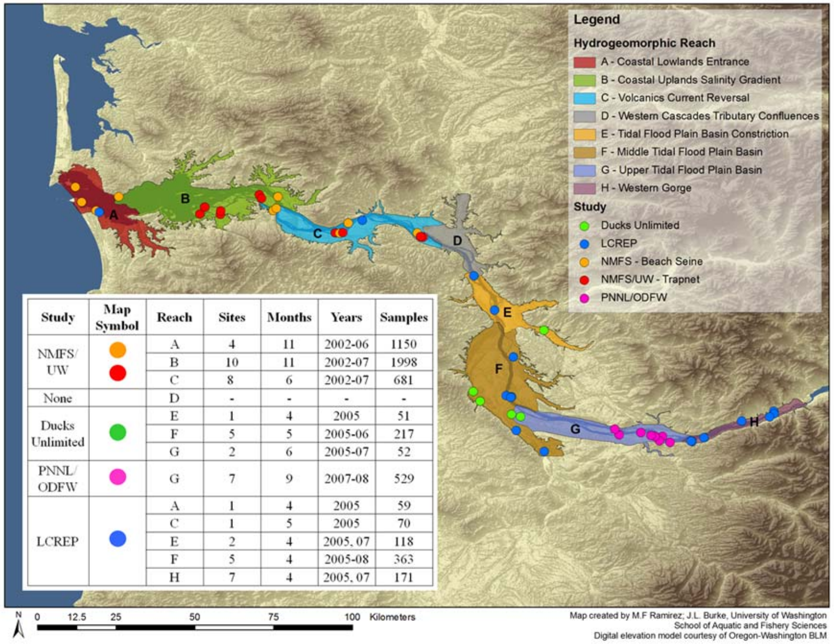
2009 – Habitat uncertainties and data gaps

- Does the tidally influenced reach (RM 40 to Bonneville Dam) function in the same manner as the lower reach for juvenile salmon ?

2009 - Chinook salmon genetic sampling has been very opportunistic and uneven in both space and time



- Methods, frequencies, and intensities vary among surveys
- Upriver sample sizes are small except in reach G (Sandy Delta)
- Temporal/spatial breadth of sampling is inadequate to interpret estuary-wide stock distributions

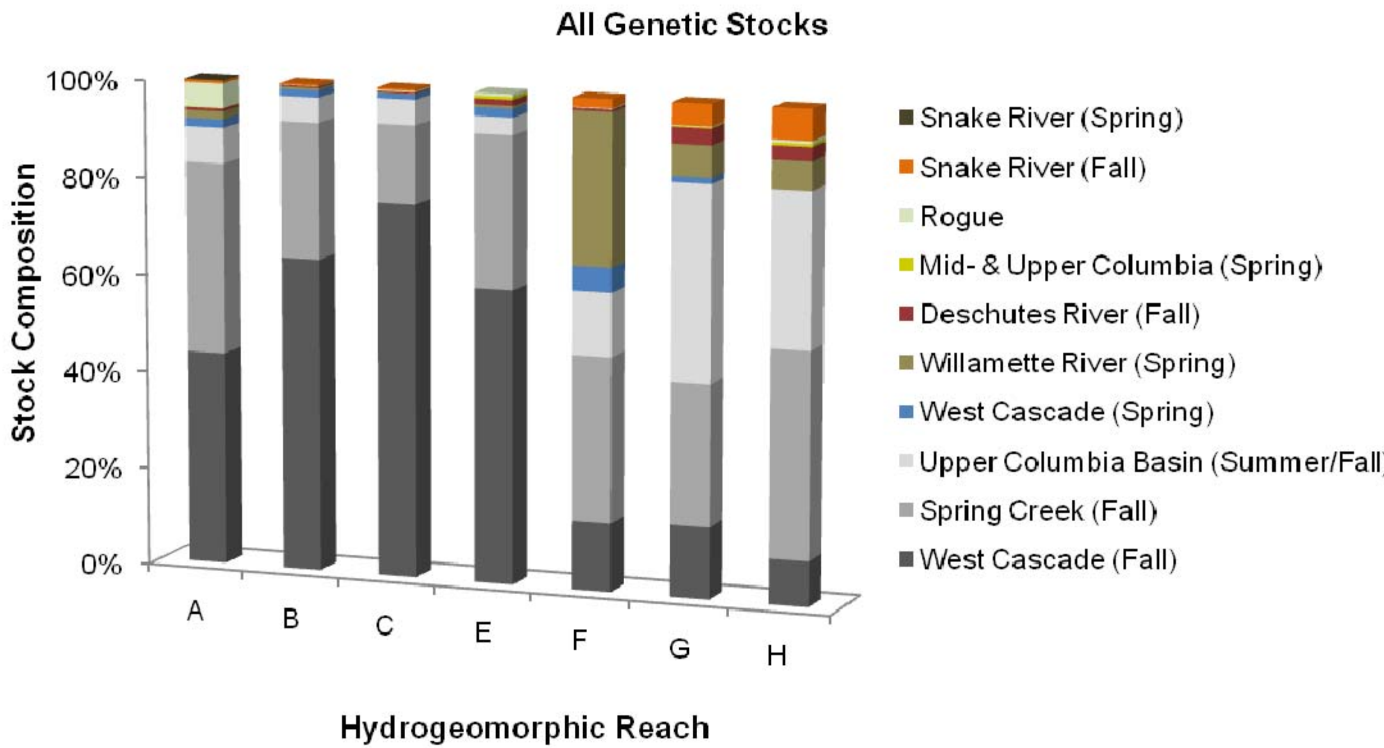


Study	Map Symbol	Reach	Sites	Months	Years	Samples
NMFS/ UW		A	4	11	2002-06	1150
		B	10	11	2002-07	1998
		C	8	6	2002-07	681
None		D	-	-	-	-
Ducks Unlimited		E	1	4	2005	51
		F	5	5	2005-06	217
		G	2	6	2005-07	52
PNNL/ ODFW		G	7	9	2007-08	529
LCREP		A	1	4	2005	59
		C	1	5	2005	70
		E	2	4	2005, 07	118
		F	5	4	2005-08	363
		H	7	4	2005, 07	171

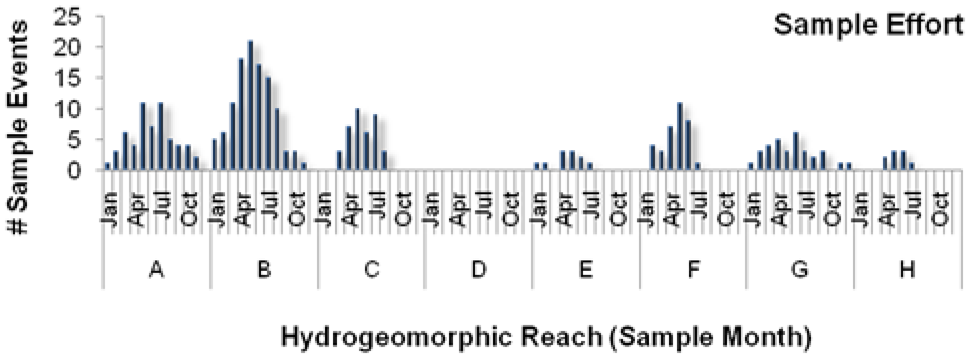
2009 – Habitat uncertainties and data gaps

- Stock-specific information on use of upper estuary
- Eg.: Interior basin fall Chinook spend up to a year in the estuary, but where?
  - We know from PIT tagged fish that a large proportion of returning adults entered seawater as yearlings

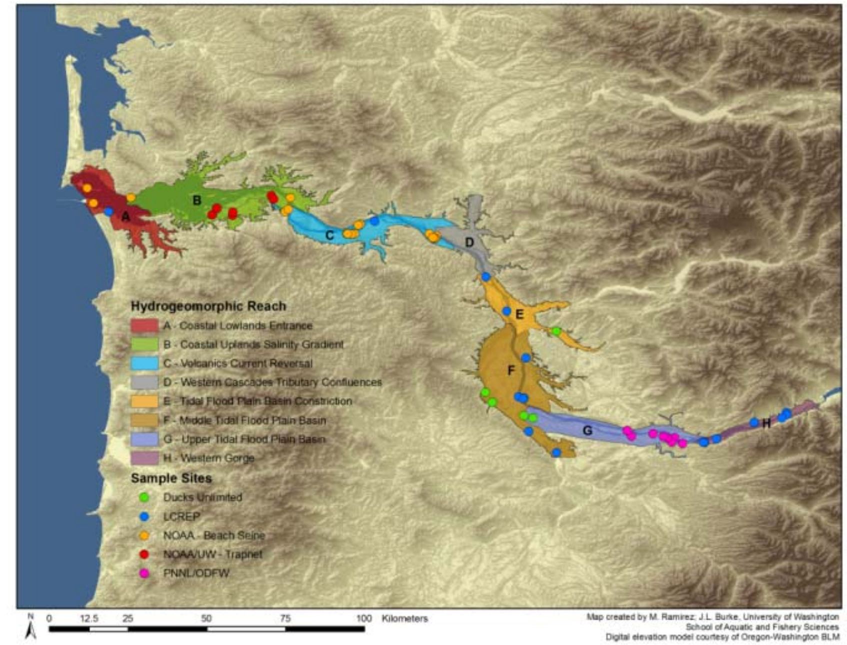
Chinook salmon genetic stock groups may not be distributed uniformly



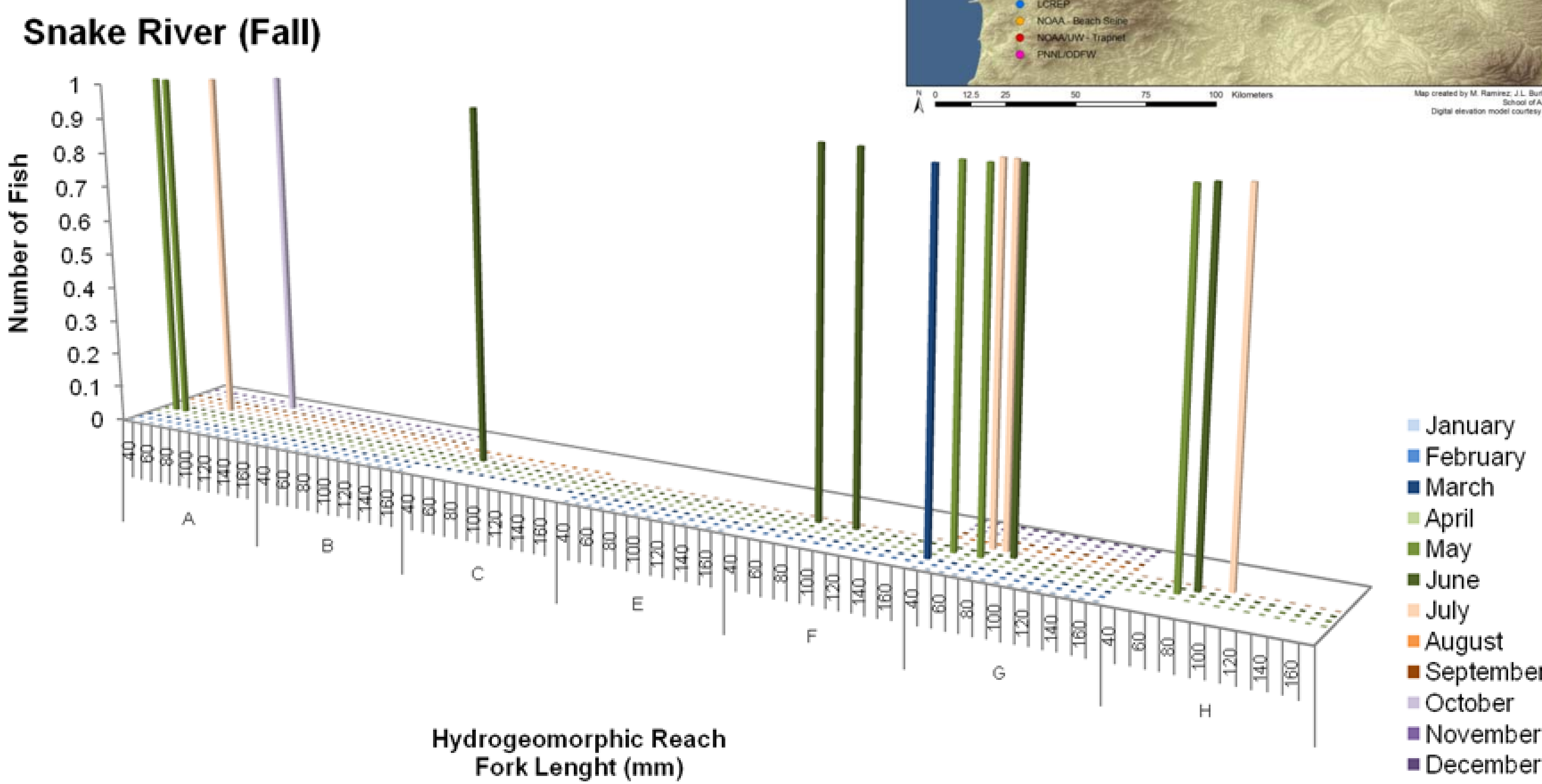
- Upper CR stocks appear more prevalent in upper-estuary collections
- Restoration activities are concentrated in the lower estuary



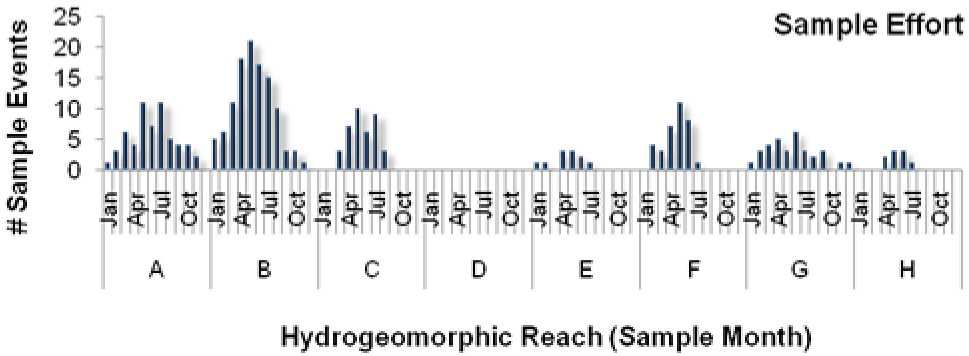
Sample Effort
Sample Events
Hydrogeomorphic Reach (Sample Month)
A
B
C
D
E
F
G
H

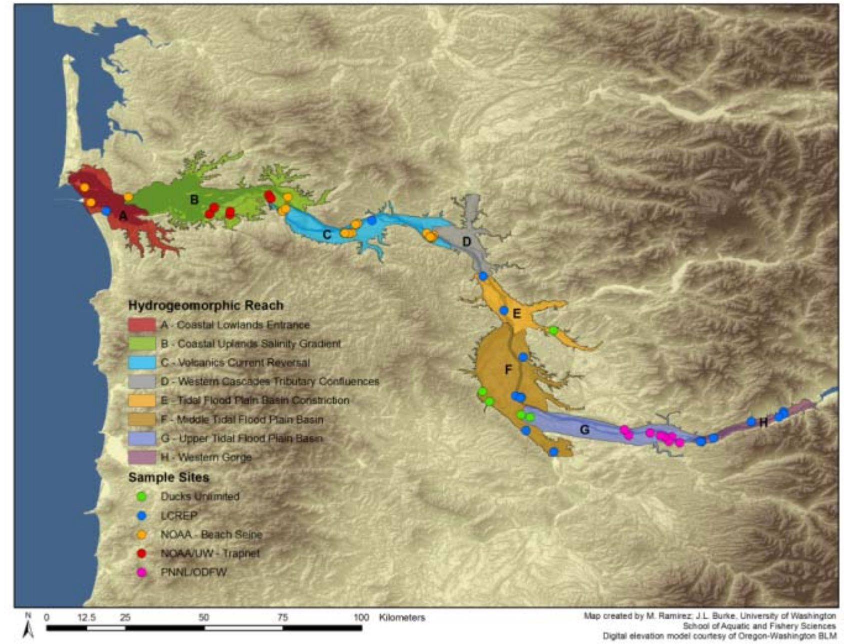


Hydrogeomorphic Reach
A - Coastal Lowlands Entrance
B - Coastal Uplands Salinity Gradient
C - Volcanics Current Reversal
D - Western Cascades Tributary Confluences
E - Tidal Flood Plain Basin Constriction
F - Middle Tidal Flood Plain Basin
G - Upper Tidal Flood Plain Basin
H - Western Gorge
Sample Sites
Ducks Unlimited
LCREP
NOAA - Beach Seine
NOAA/UW - Trapnet
PNNL/ODFW
Kilometers
Map created by M. Ramirez; J.L. Burke, University of Washington
School of Aquatic and Fishery Sciences
Digital elevation model courtesy of Oregon-Washington BLM

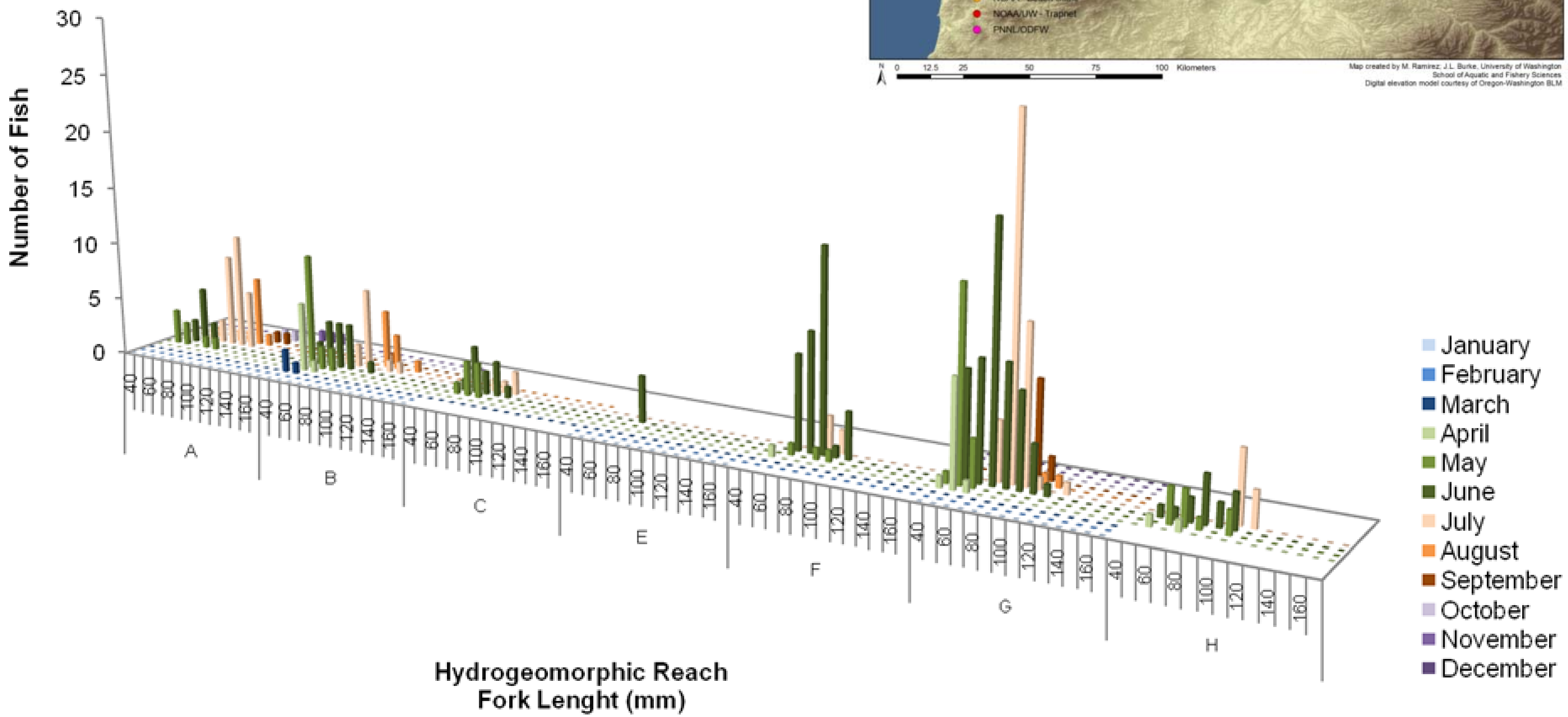


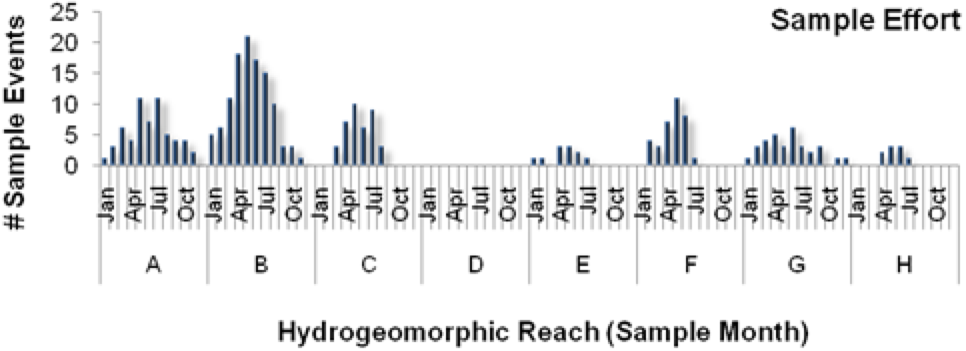
Snake River (Fall)
Number of Fish
Hydrogeomorphic Reach
Fork Lenght (mm)
January
February
March
April
May
June
July
August
September
October
November
December

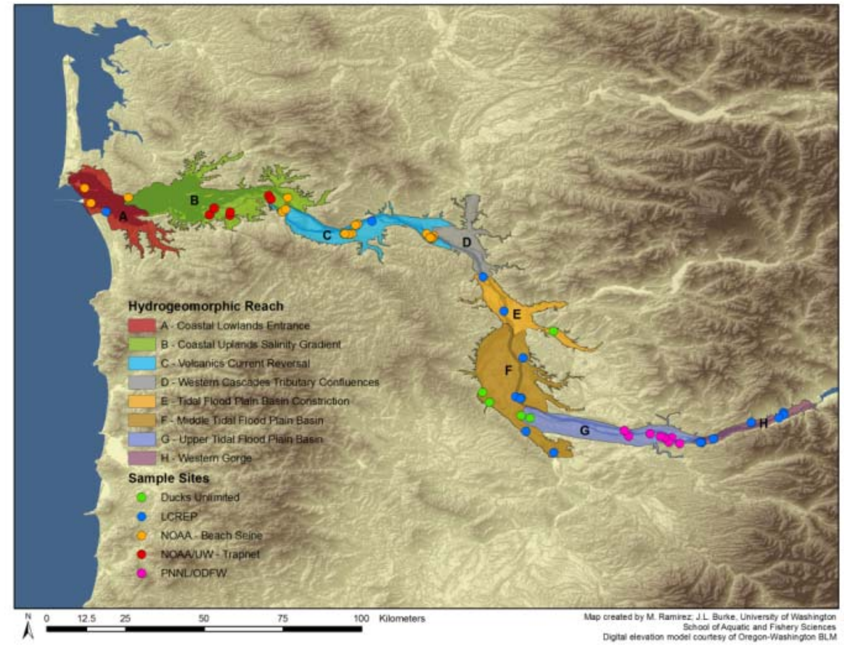




Upper Columbia Basin (Summmer/Fall)




Sample Effort
Sample Events
Hydrogeomorphic Reach (Sample Month)
Jan Apr Jul Oct
A B C D E F G H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Sample Sites
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PNNL/ODFW
0 12.5 25 50 75 100 Kilometers
Map created by M. Ramirez; J.L. Burke, University of Washington
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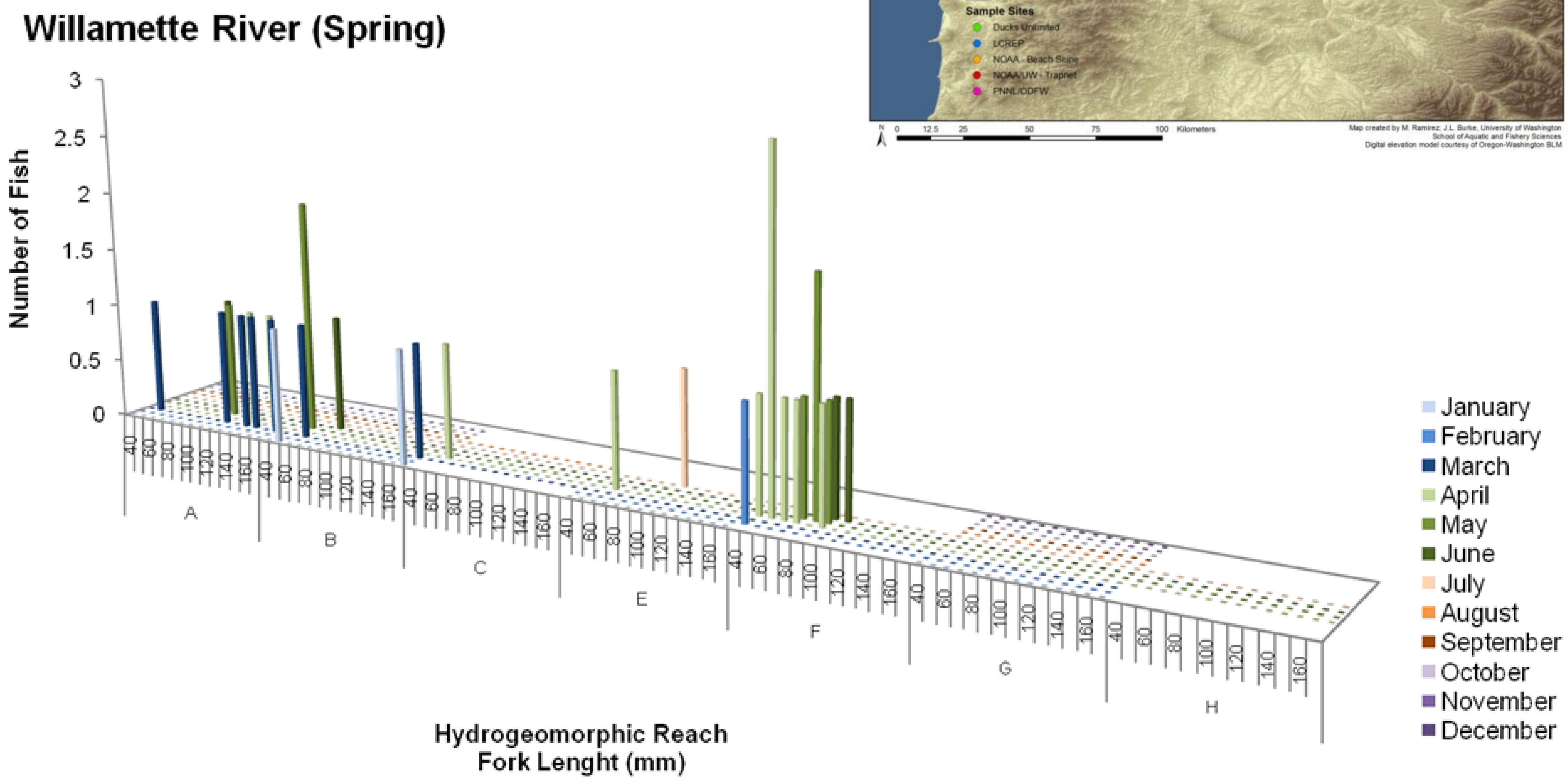
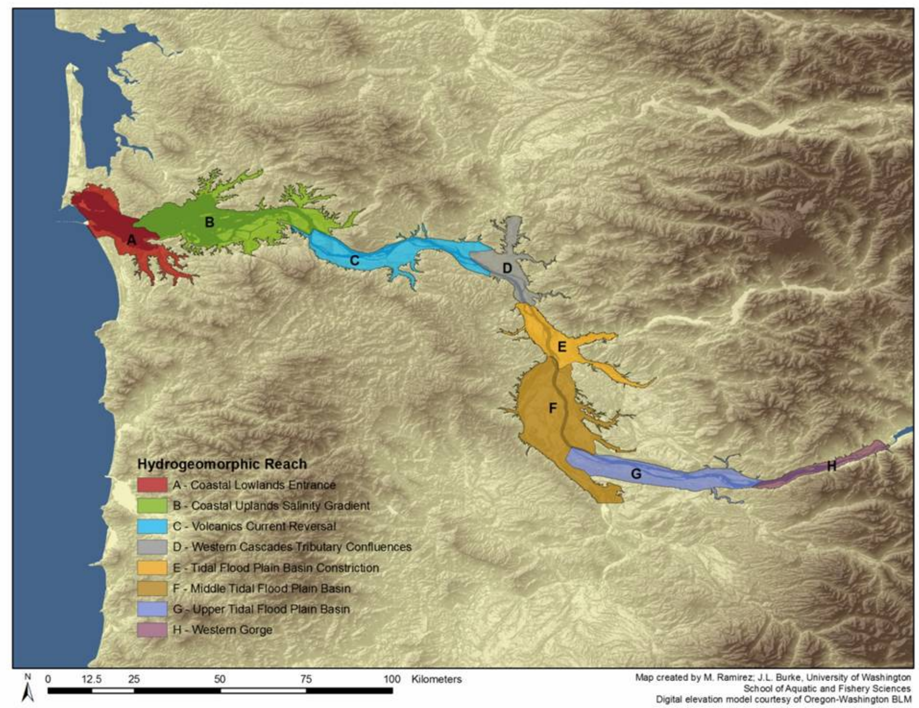

Willamette River (Spring)
Number of Fish
Hydrogeomorphic Reach
Fork Lenght (mm)
A B C E F G H
January
February
March
April
May
June
July
August
September
October
November
December

2009 - Need to characterize the <u>temporal</u> and <u>spatial</u> distribution of Chinook salmon genetic stock groups throughout the estuary

- Synoptic genetics surveys, stratified by reach
- Emphasize poorly studied habitats & time periods
- Assign genetic stock-group membership
- Reconstruct life history



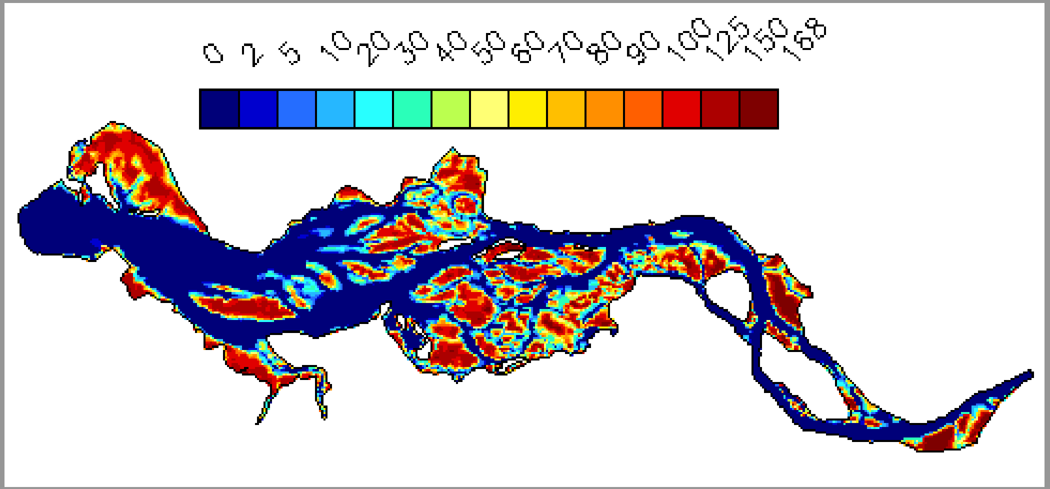
Hyrdogeomorphic reach classification (Simenstad et al. 2005)

2009 – Need to establish criteria for site selection and restoration project design, with emphasis on the tidal fluvial region of the estuary

- Offer provisional criteria from present understanding of stock distributions and habitat use
- Incorporate results of new stock-distribution surveys
- Use hydrological modeling to evaluate alternative restoration strategies

Habitat opportunity for subyearling salmon:

- Depth
- Water velocity
- Temperature



Physical Habitat Opportunity (hr/wk)

Key habitat questions

Estuary Restoration:

1. How are genetic stock groups distributed throughout the estuary? (synoptic genetics surveys)
2. Do salmon life history, habitat use, and performance vary by stock? (key habitats, tidal fluvial reaches)
3. What restoration strategies would most benefit the diversity of Columbia River stocks? (site selection criteria)

Salmon Recovery:

4. Which juvenile life histories contribute to adult returns, and does restoration benefit <u>population resilience/recovery</u>? (tributary populations)

5. How much restoration is needed to <u>insure stock persistence</u>? (life-cycle modeling)

2009 – Other juvenile salmon uncertainties and data gaps

- Determine whether <u>contaminant</u> loadings affect juvenile salmon health, especially growth and survival, through the estuary

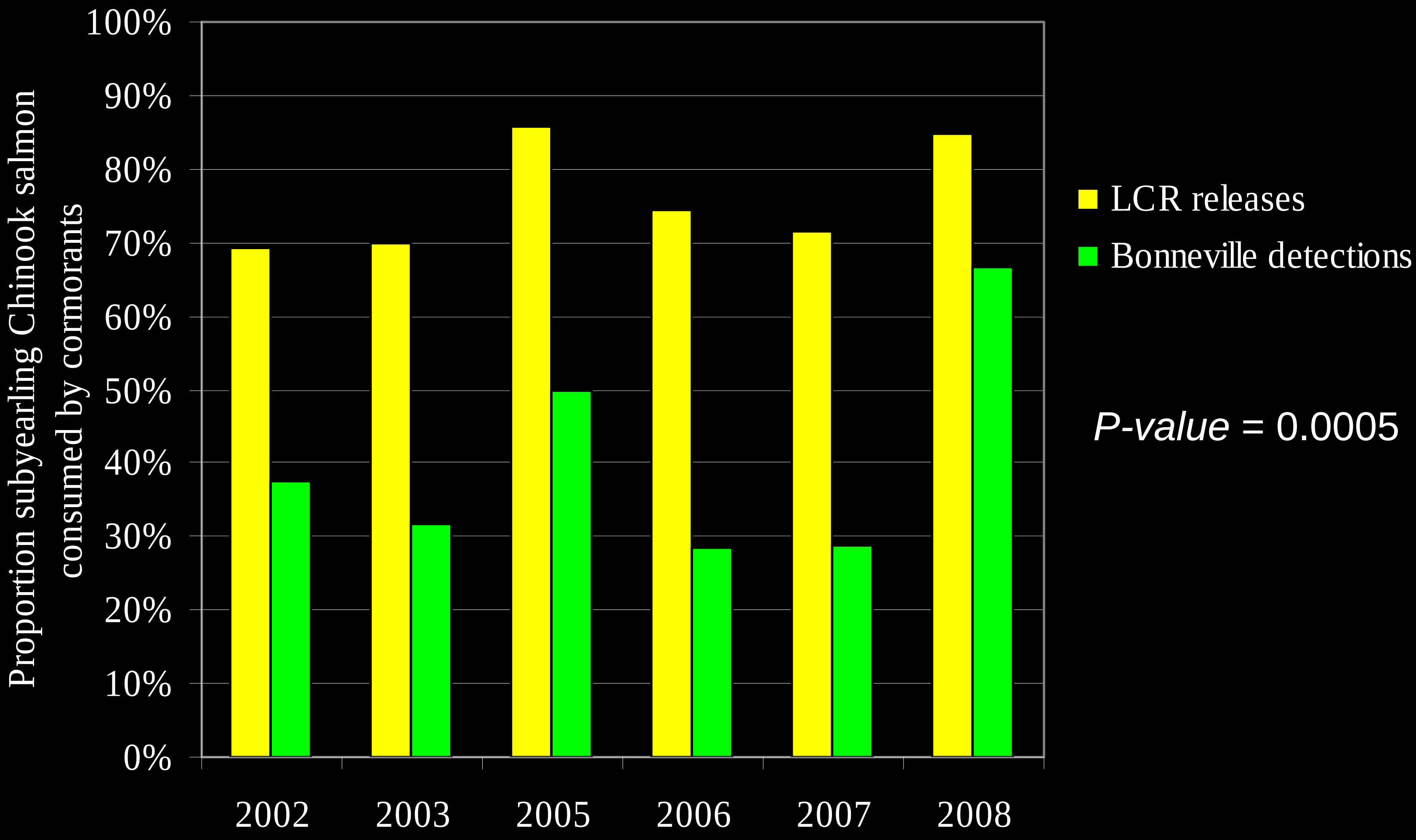
- Apparent increased <u>predation</u> by cormorants and pelicans

2009 – What is the role of cormorant predation?

22,000 cormorants

20,000 terns

Mean annual proportion of PIT-tagged subyearling Chinook salmon known to be consumed in the Columbia estuary by cormorants



P-value = 0.0005

Mobile Tracking

Migration Pathways, Baker Bay, 2008

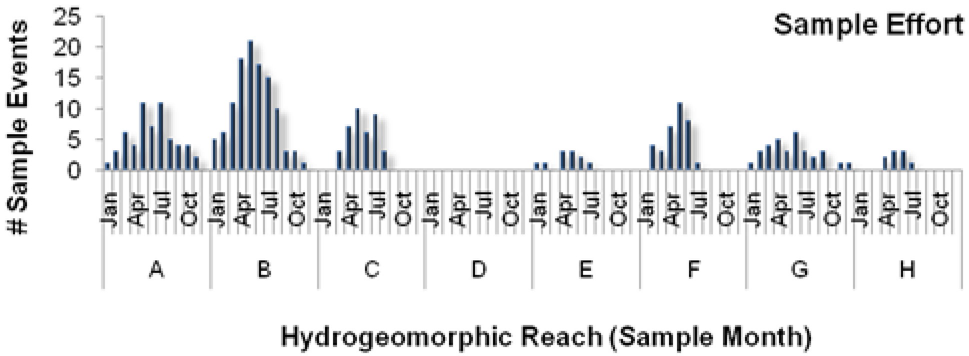
NOAA Fisheries
National Marine Fisheries Service

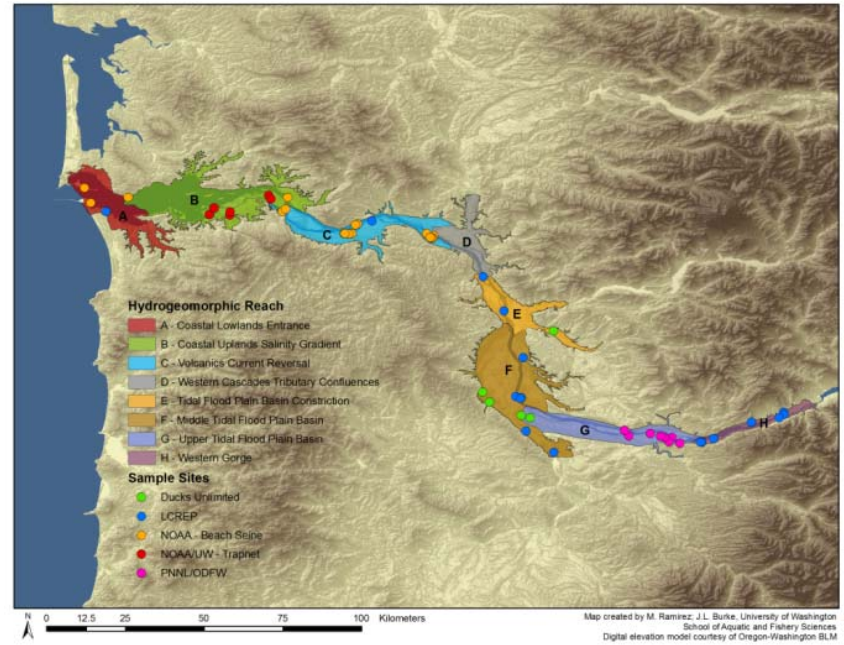
2009 – uncertainties and data gaps -- broader topics (#1)

- Can we use the POST array to inform the issue of delayed hydropower system mortality?
- Welch et al. 2008 (PLoS) found no evidence through Willipa Bay line, based on 2006 only

2009 – uncertainties and data gaps -- broader topics (#2)

- Relatively high proportion of spawners in some tule fall Chinook populations have been from out-of-ESU hatchery origin fish (PFMC, recovery plans)


Sample Effort
Sample Events
0
5
10
15
20
25
Jan
Apr
Jul
Oct
A
B
C
D
E
F
G
H
Hydrogeomorphic Reach (Sample Month)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0
12.5
25
50
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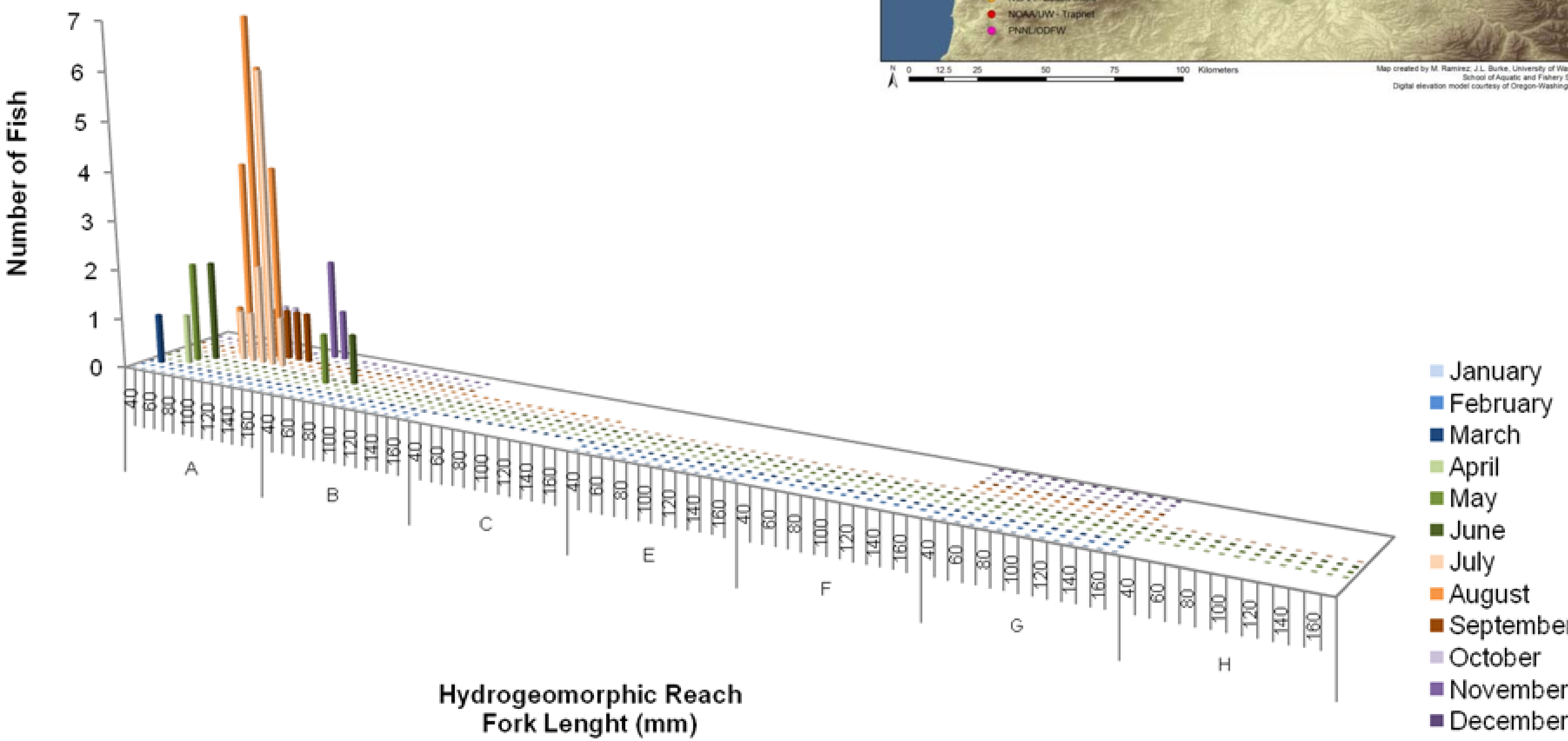
Digital elevation model courtesy of Oregon-Washington BLM

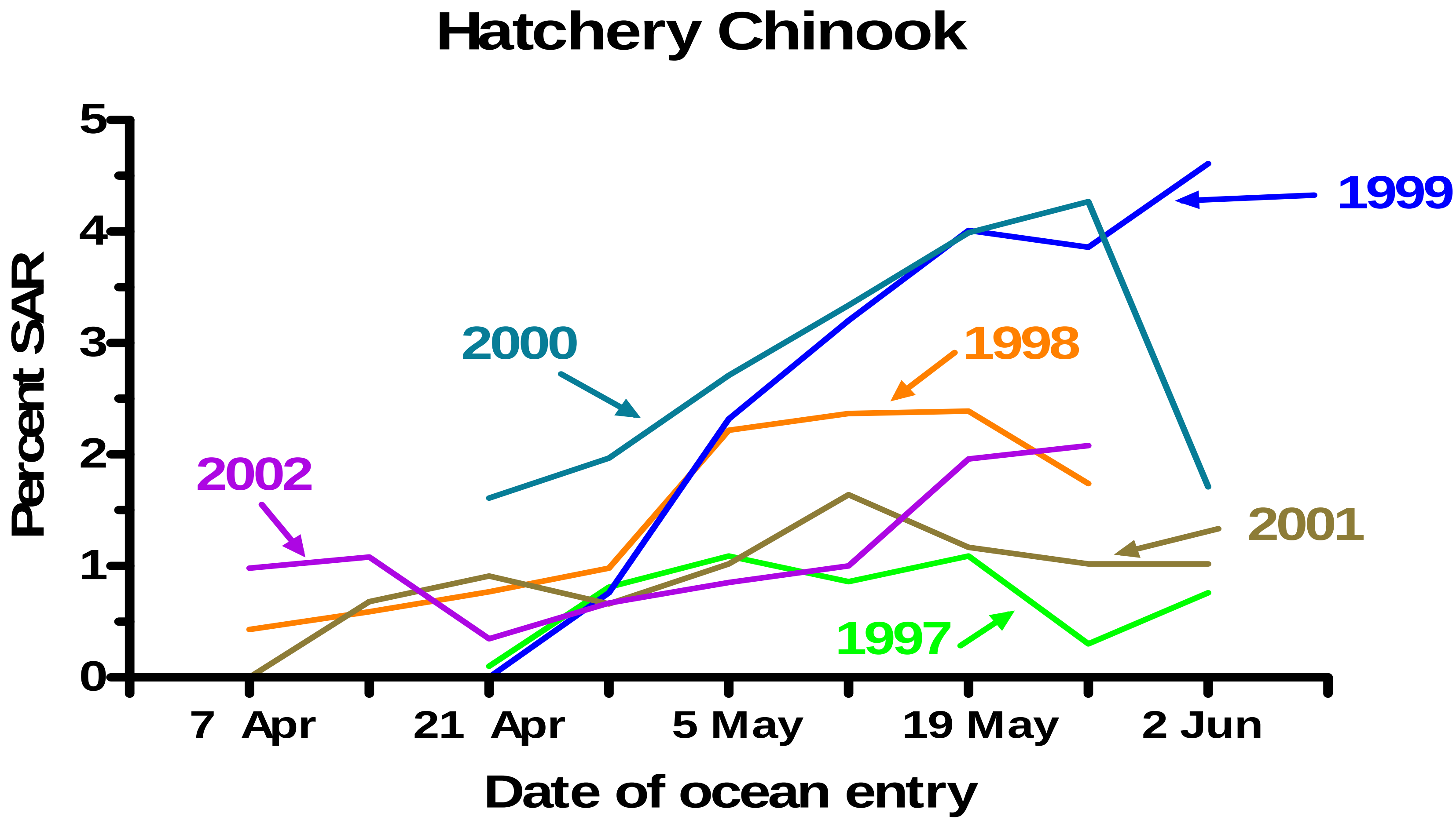
Rogue

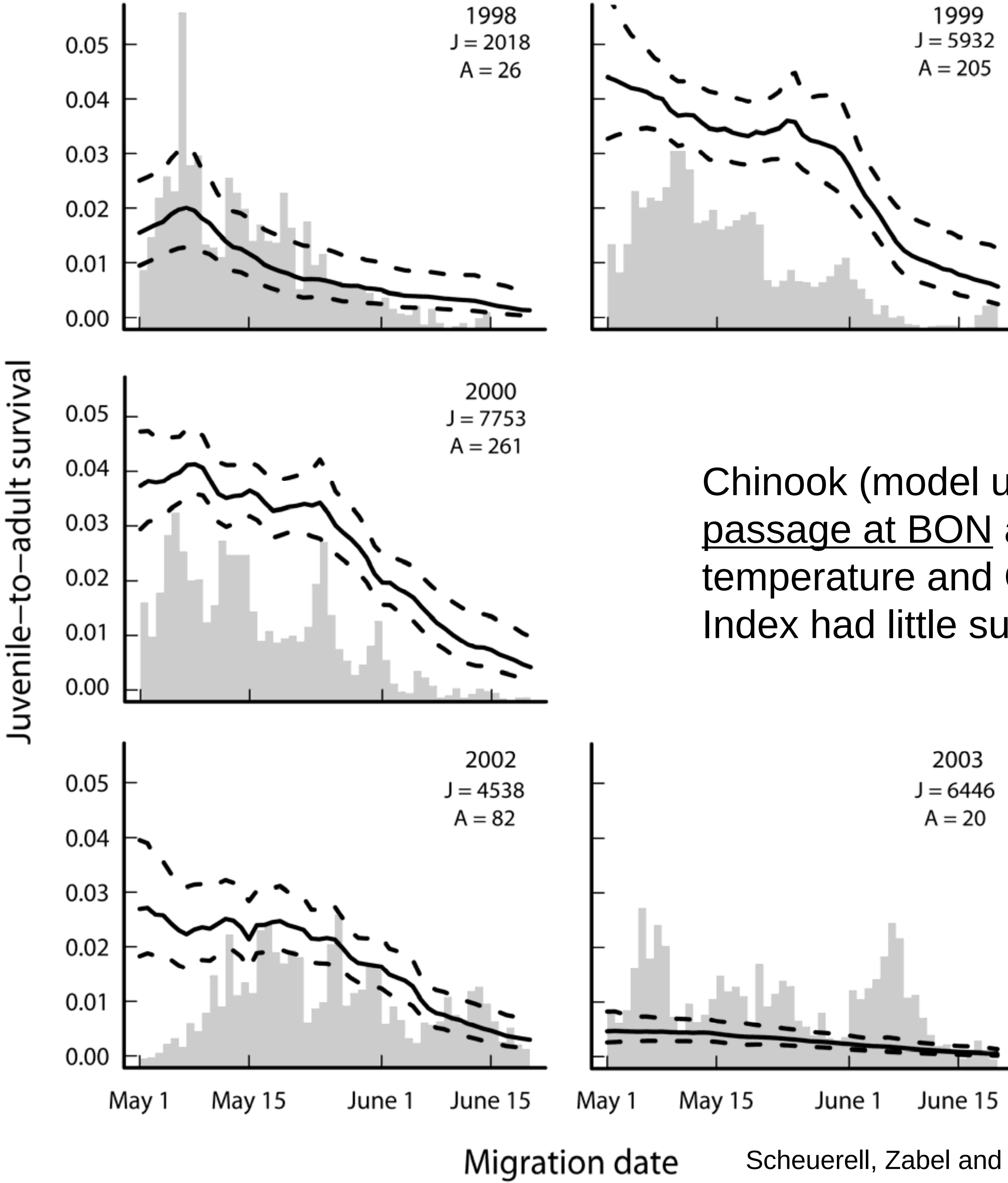

Number of Fish
0
1
2
3
4
5
6
7
40
60
80
100
120
140
160
A
B
C
E
F
G
H
Hydrogeomorphic Reach
Fork Lenght (mm)
January
February
March
April
May
June
July
August
September
October
November
December

2009 – uncertainties and data gaps -- broader topics (#3)

- SARs (SR spring Chinook, steelhead) vary greatly with ocean entry timing
- Why? What conditions in the plume lead to improved survival that can be measured and used to adjust actions taken in freshwater (e.g., transportation, hatchery release timing, flow timing and volume)?

2009 – What is the role of ocean entry timing?





Chinook (model using date of passage at BON and year; water temperature and Coastal Upwelling Index had little support from the data)

Scheuerell, Zabel and Sandford 2009 J. of Appl. Ecol.

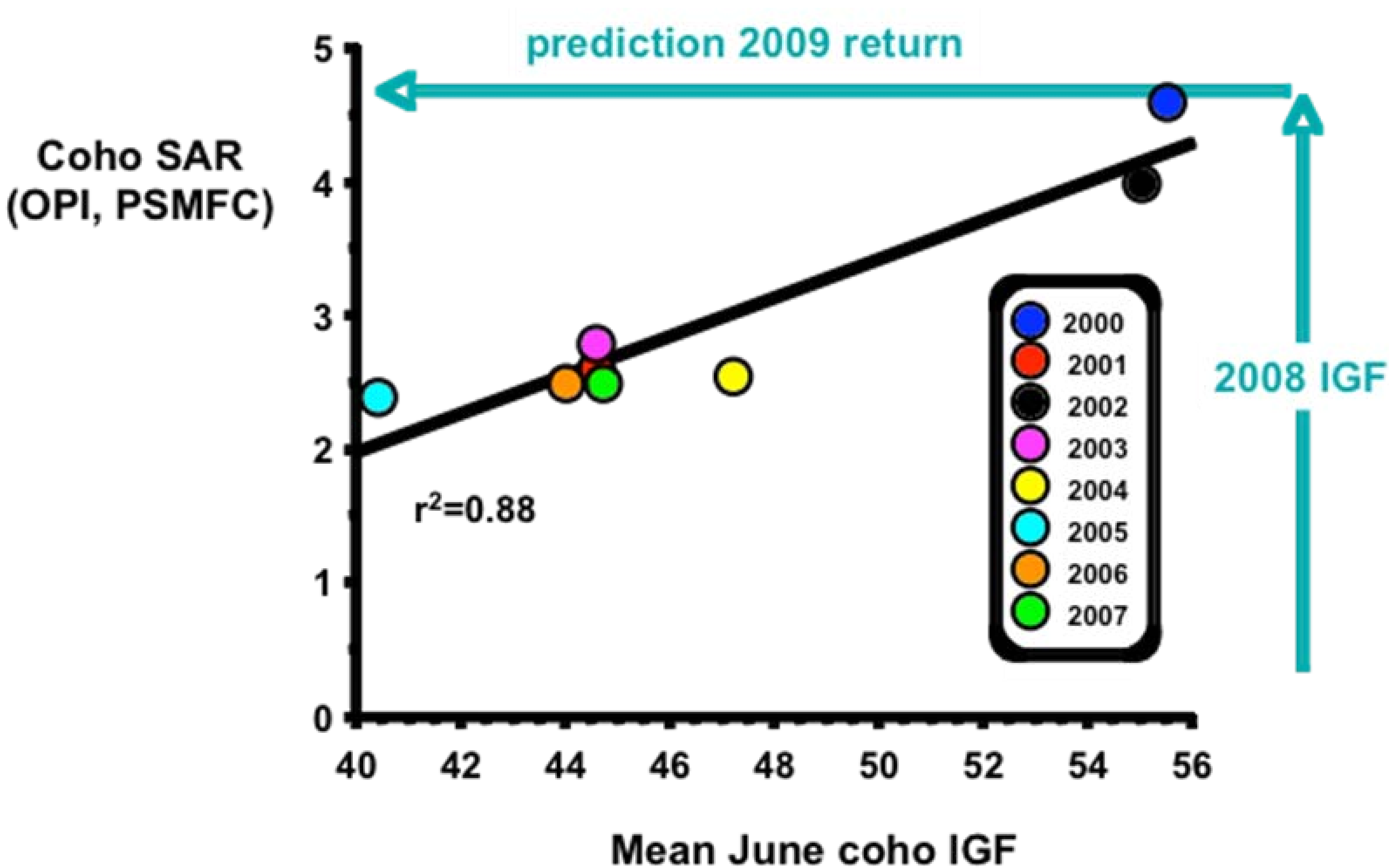
Entry timing research needed.....

- Our current ocean sampling schedule can not resolve variability in ocean productivity on short time scales (May, June, and September)
- Previous slide: Using CUI as a surrogate was not instructive
- We tentatively proposed the idea of increased sampling of the ocean ecosystem to BPA, with the goal of identifying what aspects of the ecosystem smolts are responding to that results in increased SARs
- To guide FW actions: flow volume, timing, hatchery release timing, and transportation

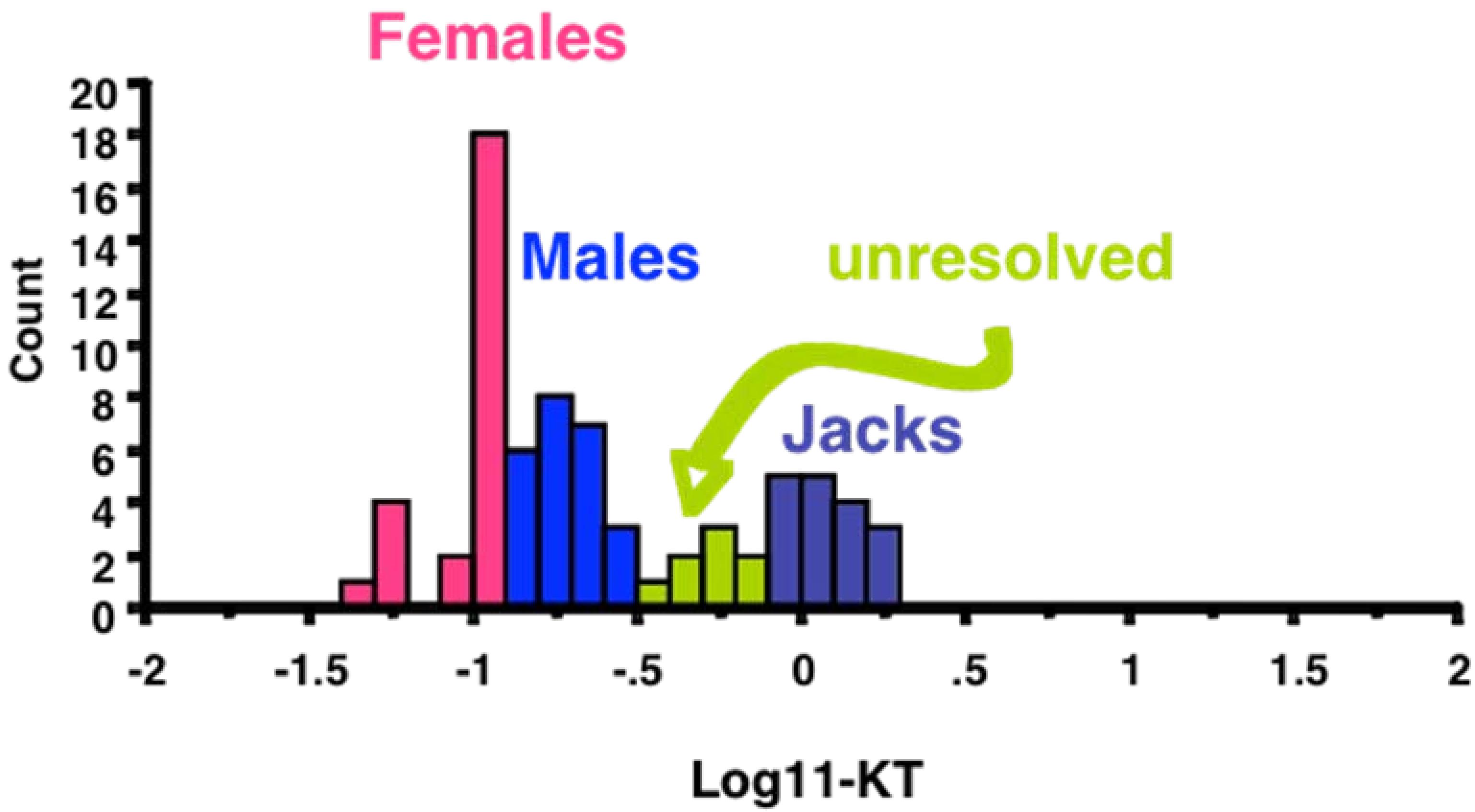
2009 – uncertainties and data gaps -- broader topics (#4)

- Can early ocean data on smolt condition be used to predict jack rates?
- If so, TAC would have a much improved spring Chinook forecasting tool

Coho – Insulin-like growth factor (IGF) in post smolts predicts adult return rates



Spring Chinook: IGF is not a good indictor, but the hormone 11-ketatestosterone shows promise



2009 – Other uncertainties and data gaps –- adult survival from mouth to Bonneville Dam (#5)

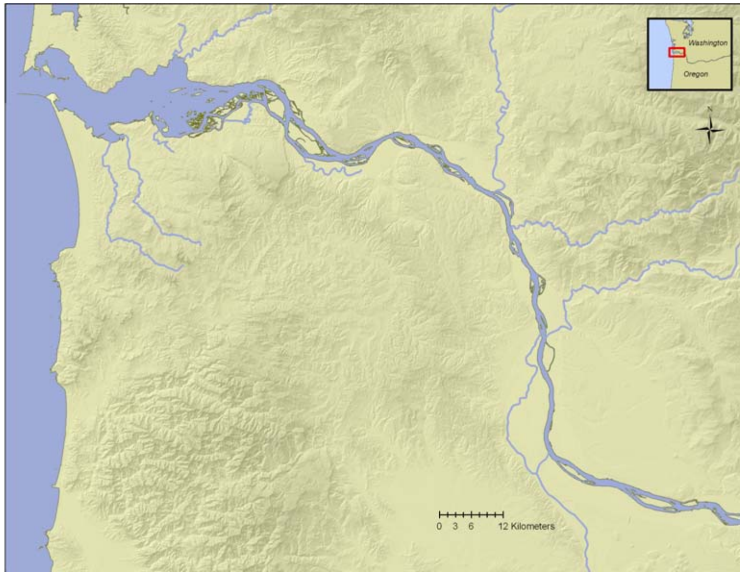
- Pinniped population estimated at 7,000
  - *CA* sea lions; Steller sea lions; harbor seals
  - Pinnipeds at BON preyed upon 3.2% of run in 2008 (93% spring Chinook) (Tackley et al. 2008)
- In 2007, a task force estimated that predation in the 10 miles below BON by *CA* sea lions ranged from 12,160 to 32,960 salmon (based on *n* = 500 sea lions)
- In 2009, NOAA-F calculated predation by 1,500 pinnipeds in entire estuary would range from 9,120 to 24,720 salmon, if diet was 25% salmon

Summary

- The freshwater tidal reach is an unknown and an obvious research priority (extend sampling spatially and temporally)
- Quantitative goals should be considered for habitat restoration, with outputs linked to VSP criteria through life cycle modeling; measuring survival alone is insufficient
- Intensively monitored watersheds might include estuary sites to better understand how fish use these habitats, inform recovery and harvest management actions
- Need to explore why SARs vary over very short time periods
- Adult survival from mouth and BON needs to be verified

2009 - Key Questions and Research Objectives

Estuary Restoration:



1. How are genetic stock groups distributed throughout the estuary? (synoptic surveys)
2. Do salmon life history, habitat use, and performance vary by stock? (key habitats)
3. What restoration strategies will benefit the full diversity of Columbia River stocks? (site selection criteria)

2009 - Need to determine stock-specific habitat use, life histories, and performance of juvenile salmon in key habitat complexes to fill data gaps in the tidal fluvial reaches of the estuary

- Select key complexes & habitats (based on hierarchical classification)
- Compare stock-specific life history, prey resources, and performance
- Compare with previous lower-estuary results, 2002-07

2009 – Habitat uncertainties and data gaps

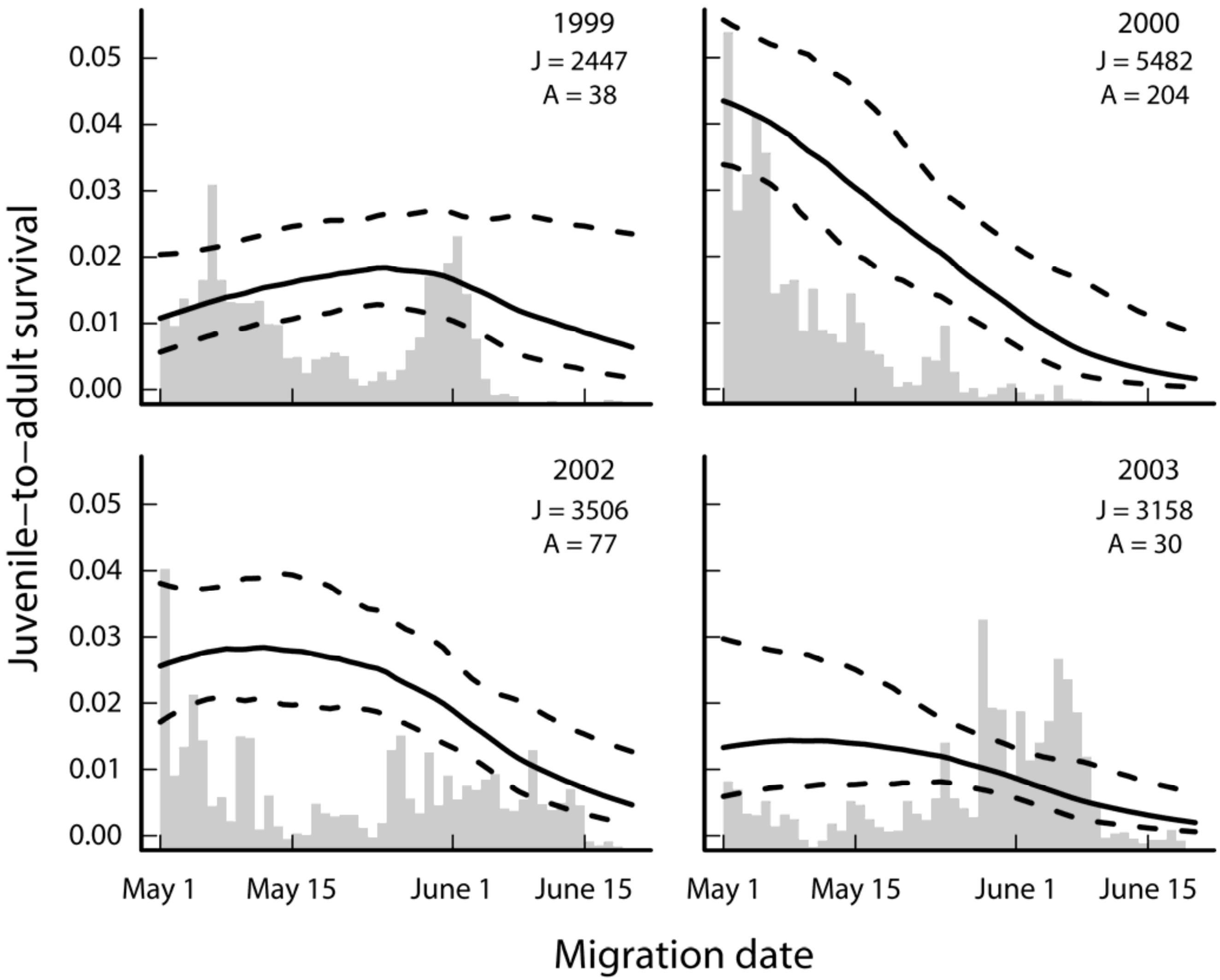
- From the acoustic tag work: Mortality of larger juveniles occurs primarily in the lower 40 km
  - But the benefit of the estuary is for smaller juveniles using wetland habitats throughout the estuary; can eradicating mortality be the goal and measure of success?

- If estuarine habitat restoration is a goal to success, how do we determine how much needs to be done?

Concluding habitat thoughts…..

- Because one size does not fit all stocks with respect to habitat, we need to:
  - Identify the restoration sites with the greatest potential to recover at-risk salmon stocks
  - Improve the performance of fish (i.e., feeding, growth, and increased life history diversity) to promote the recovery and persistence of at-risk salmon populations

Steelhead (model using date of passage at BON and year;
water temperature and Coastal Upwelling Index had little support from the data)



Scheuerell, Zabel and Sandford 2009 J. of Appl. Ecol.