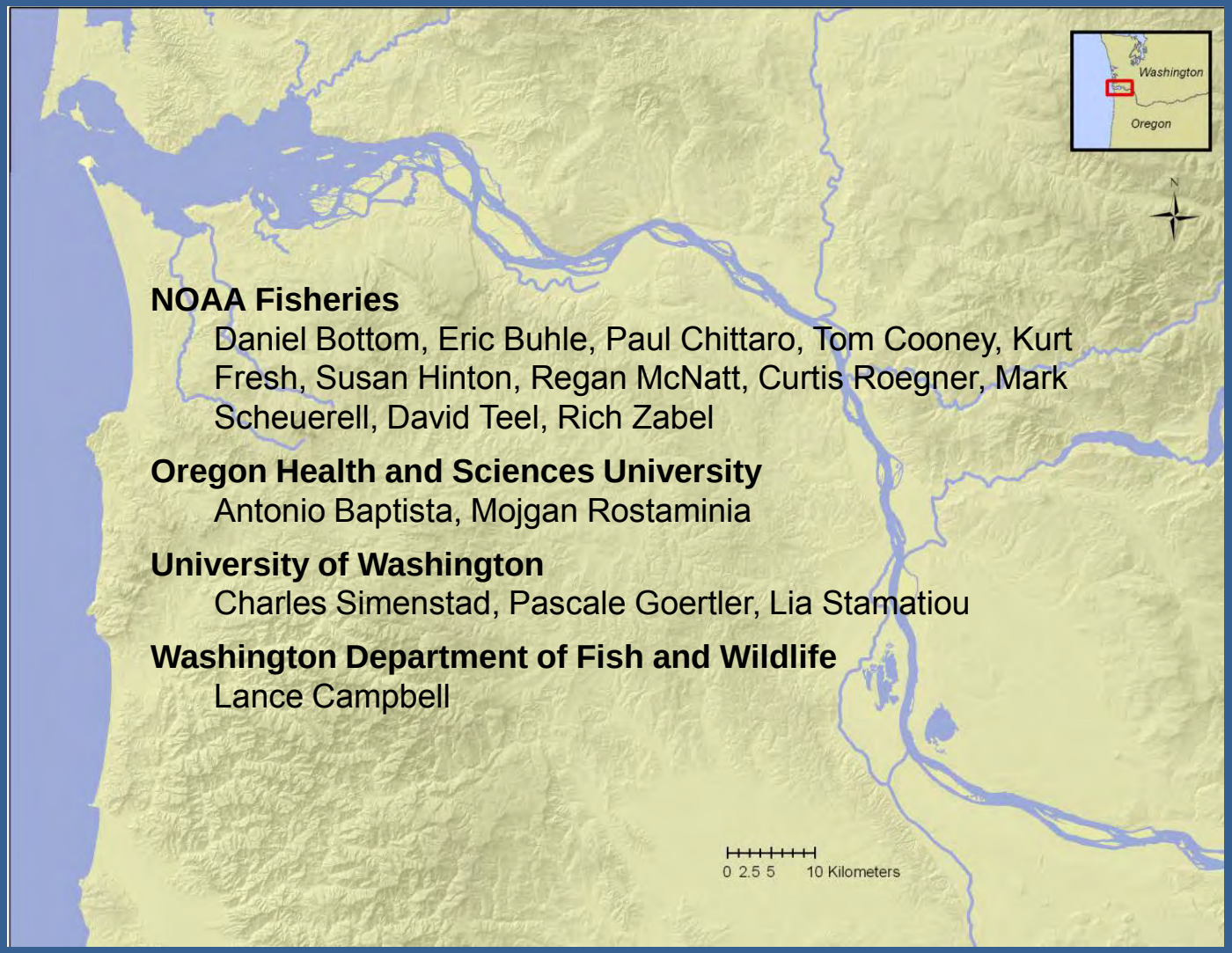
Estuary Habitat and Recovery of At-Risk Columbia River Salmon



NOAA Fisheries

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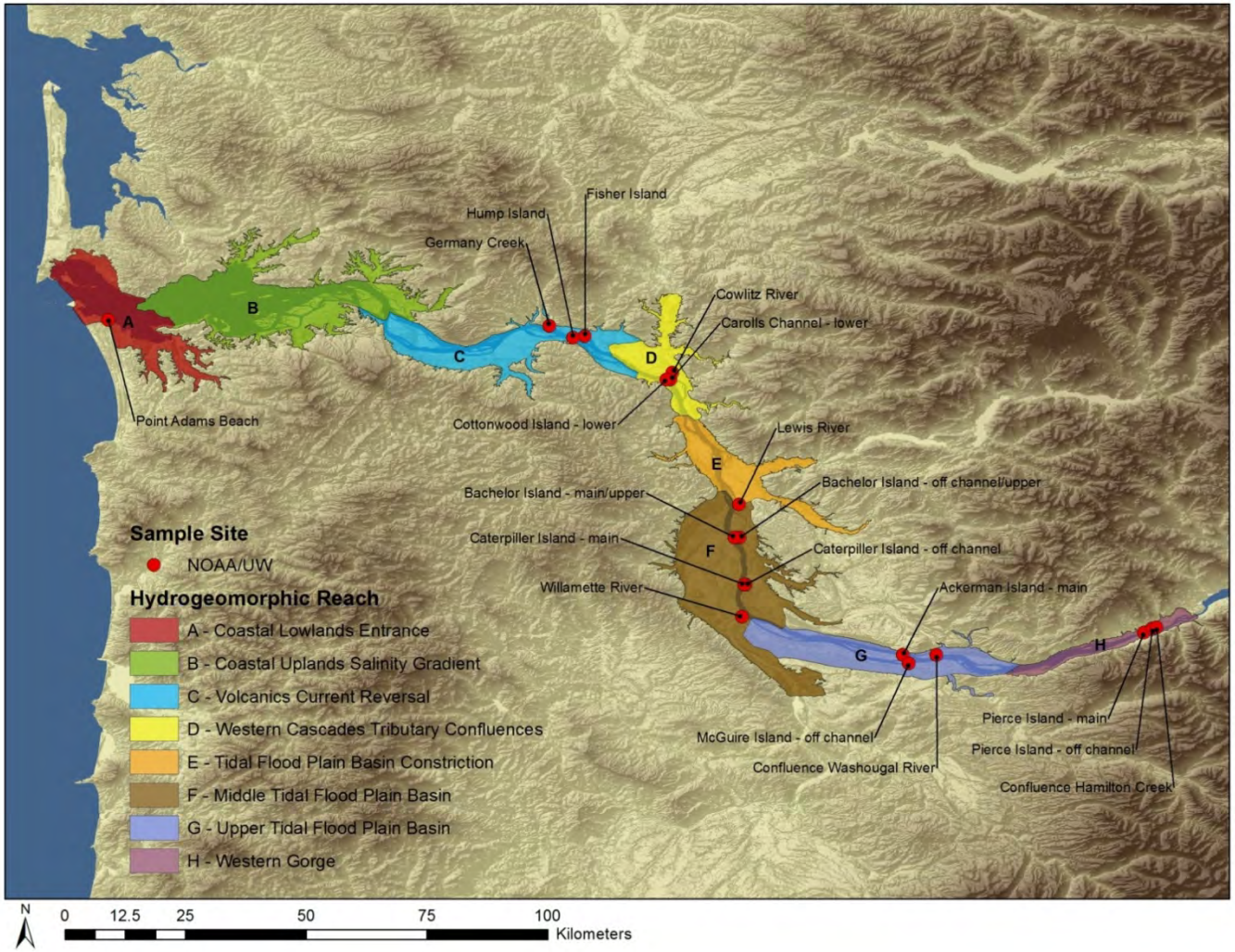
BONNEVILLE POWER ADMINISTRATION

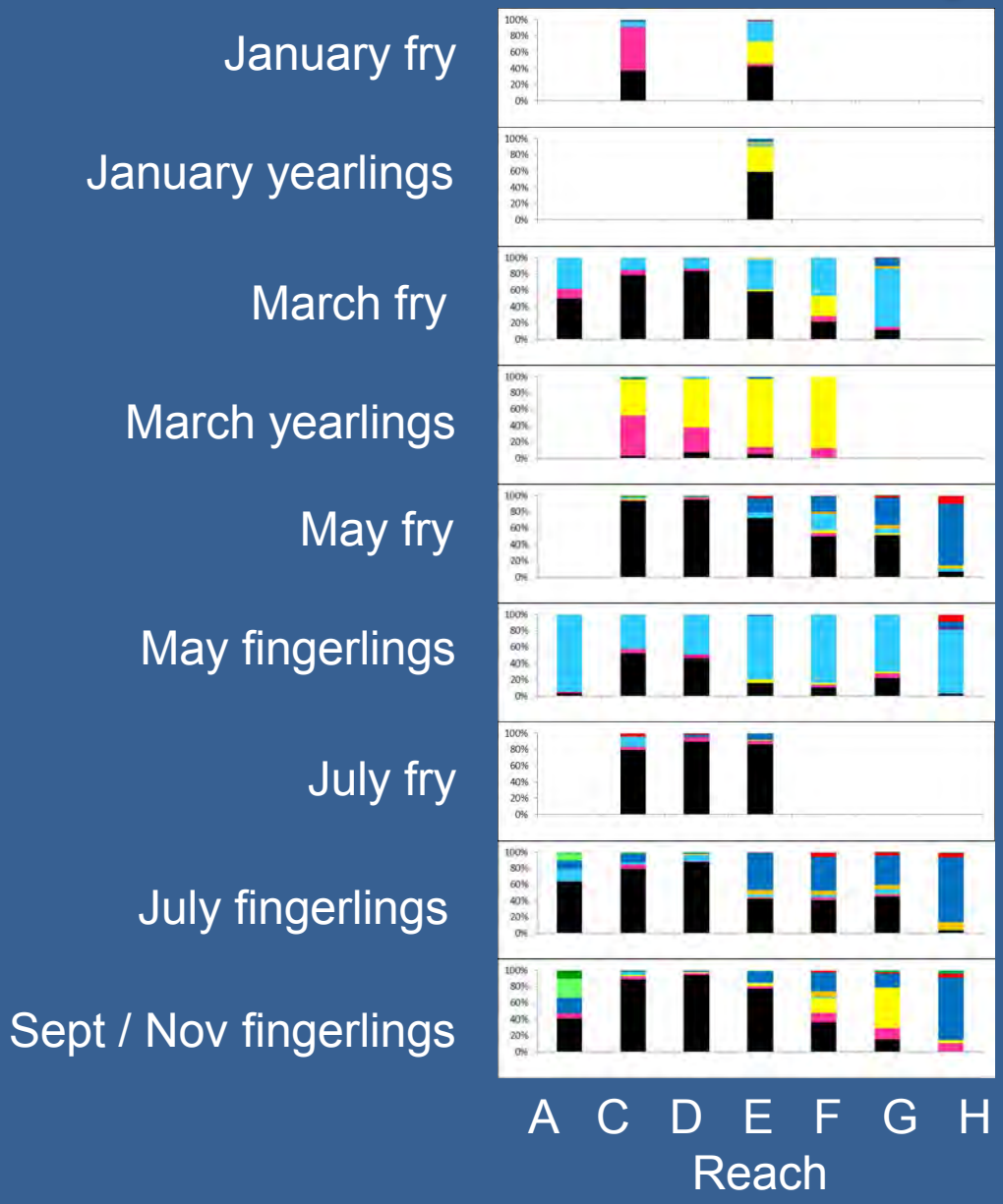
NOAA

Genetic Stock Distribution Survey
March 2010 - March 2012



- Bimonthly, up to 30 samples/site
- 3 habitats/reach (C-H):
  --trib. confluence
  --backwater
  --main stem
- Outmigrants biweekly to monthly at PAB (reach A)

Chinook Stock Compositions by Month and Life History, 2010-11



Fry ≤ 60mm

Fingerling > 60mm

Yearling by size and month

- Coastal
- Rogue
- Snake spring/summer
- Snake fall
- Upper CR summer/fall
- Mid & Upper CR spring
- Deschutes fall
- Spring Creek Group fall
- Willamette spring
- West Cascade spring
- West Cascade fall

Unpublished data D. Teel

ESA-listed Interior Stocks

	Dominant Juv. Migrant	
	Subyearling	Yearling
• Chinook		
– Snake R. Fall	☑	
– Snake R. Spr/Su		☑
– Upper CR Spr		☑
• Steelhead		
– Snake R.		☑
– Mid CR		☑
– Upper CR		☑
• Sockeye		
– Snake R.		☑

Conventional Wisdom
Interior-Basin Stocks

Restoration of estuary habitat will not benefit recovery objectives for interior-basin stocks because these stocks:

- produce only large subyearling or yearling migrants
- move rapidly through the estuary
- do not uitilize shallow-water habitats

Recovery Assumptions

- Only stocks whose dominant life histories reside for extended periods in the estuary (and also enter shallow-water habitats) will benefit from estuary restoration
- Recovery is measured by improvements in survival/productivity of the dominant LH type in each ESU
- Improvements in spatial structure and diversity do not benefit survival/productivity

Outline

- Research approach and context
- Results and Implications for interior salmon stocks
- RME needs and future research plans

Estuary Research Goal

Determine the estuary's contribution to the spatial structure and life history diversity of Columbia River salmon stocks and the implications for estuary restoration and salmon recovery.

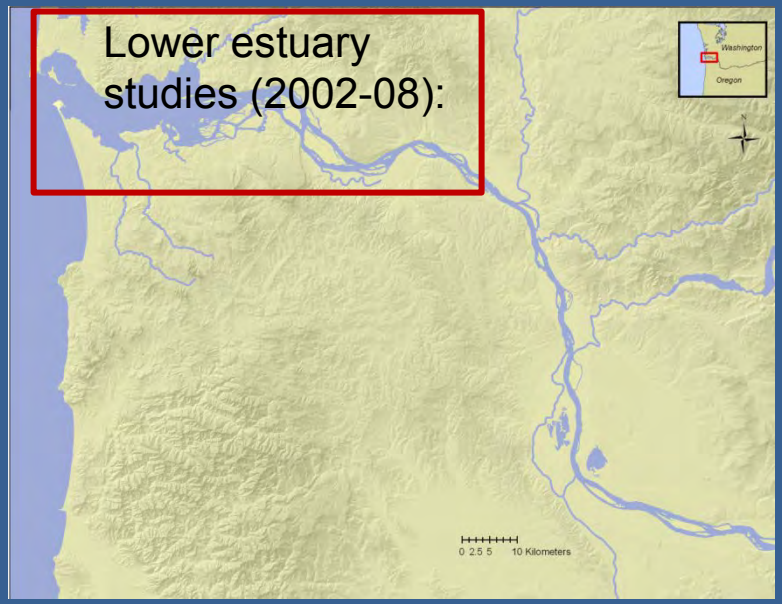
Site selection

Are genetic stock groups uniformly distributed such that all stocks will benefit similarly from habitat restoration?

Contribution to adults

Will improvements in the estuary performance of juvenile salmon increase adult survival and promote salmon recovery?

Research Approach



Salmon Performance Measures:

- Foraging success
- Growth
- LH variation (residency, timing & size)

- Estuary overall
- Within a habitat
- Particular stock
- Particular LH type
- Particular population

Salmon habitat use and performance in the lower estuary (2002-08)

↓

Genetic composition/distribution surveys (2010-12)

↓

Salmon habitat use and performance in the upper estuary (2012–16)

↓

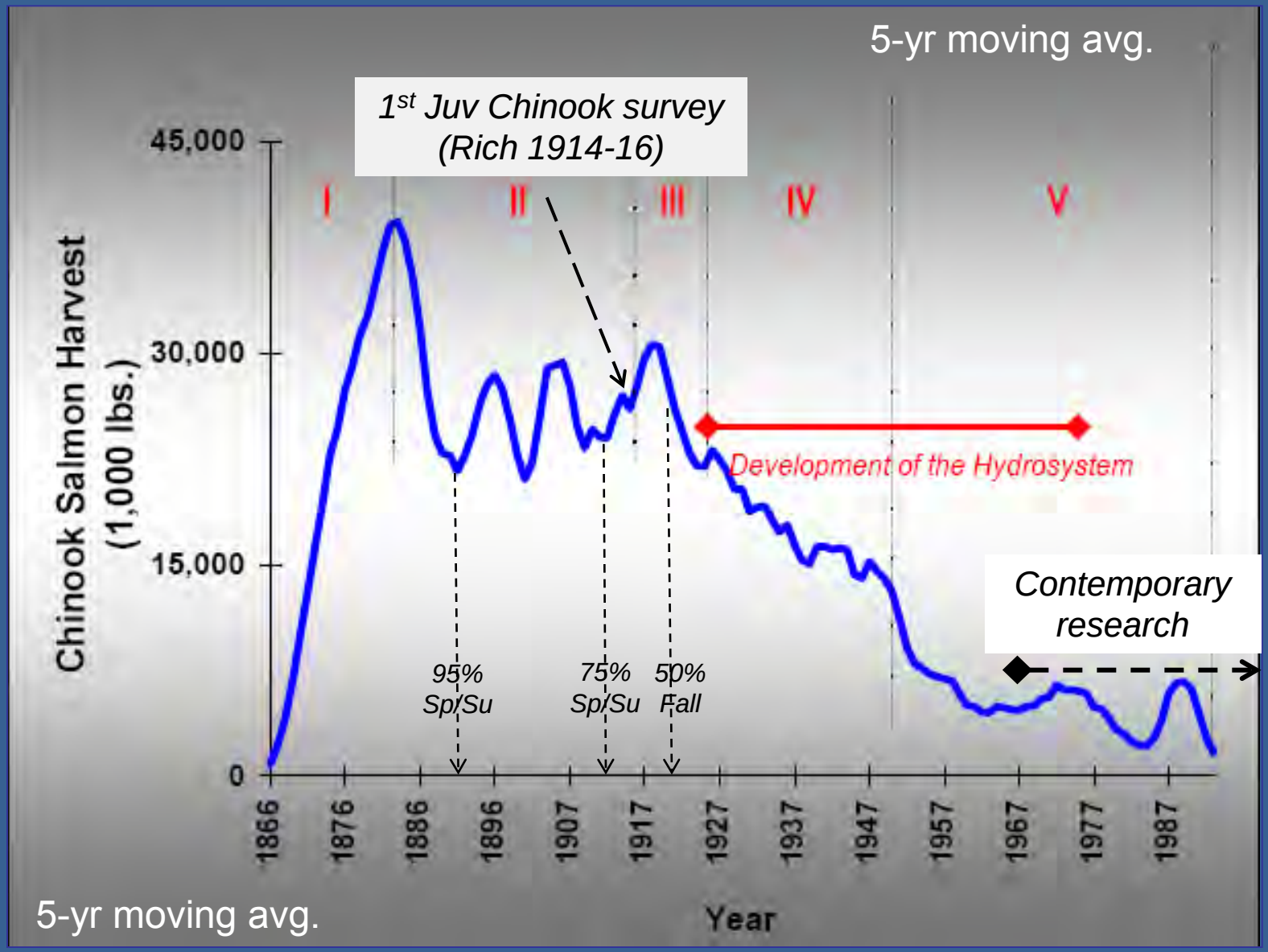
Effects of estuary restoration on population performance and salmon recovery (2011-18)

Gear Types & Sampling Caveats

- Comparing results using different gear types is difficult (e.g. variable catch efficiency)
- Each gear depicts a different habitat and life history
- Sampling effort has been greatest in the lower estuary
- Relative stock abundance in the estuary may reflect upriver abundances, estuary habitat preferences, or both
- Genetic interpretations are influenced by
  - Stock transfers and interbreeding (gene flow)
  - Logistical constraints (i.e., obtaining baseline samples)

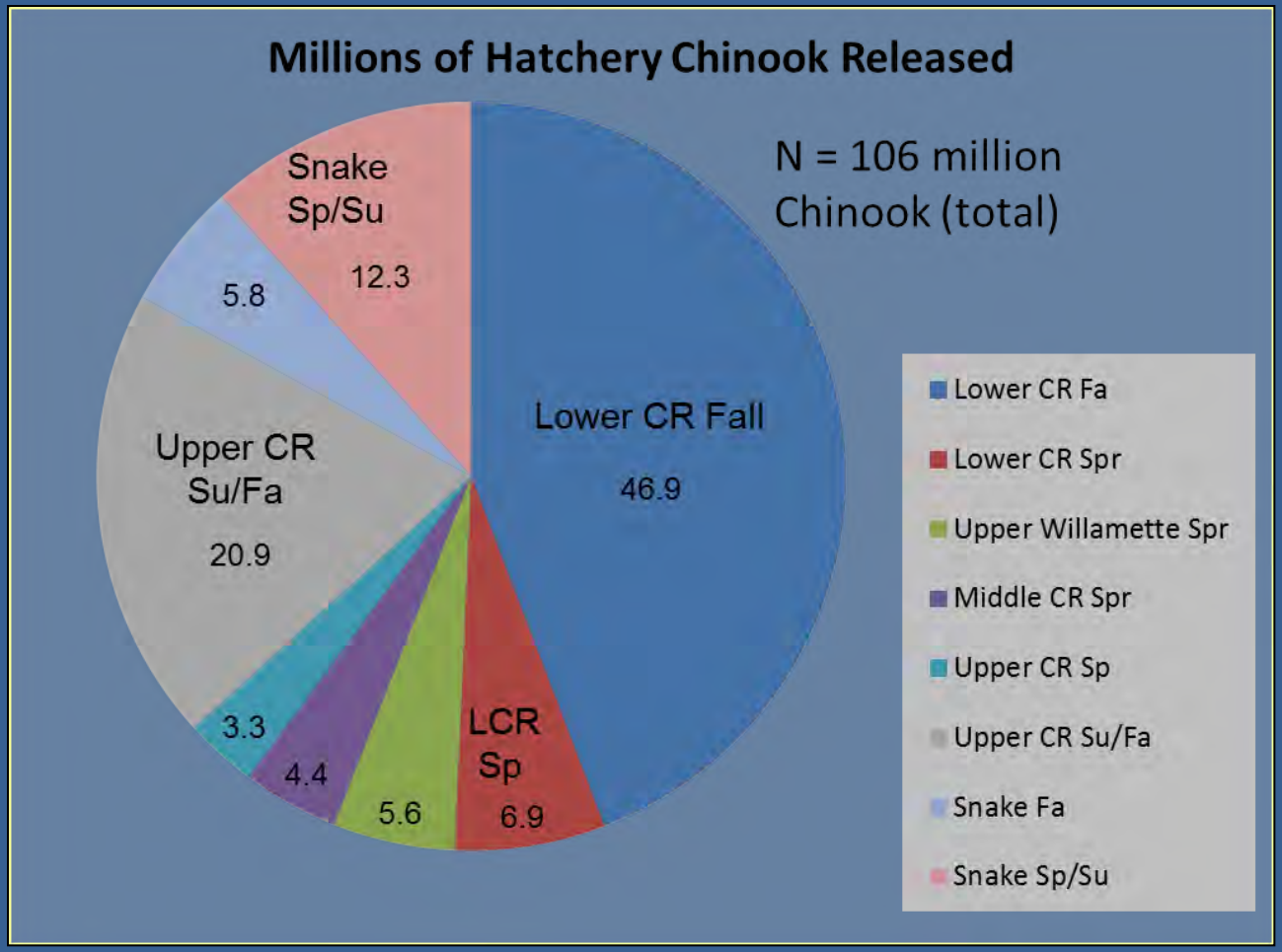
Historical Context

Adapted from Mundy (2005)



Hatchery Scientific Research Group (2009)

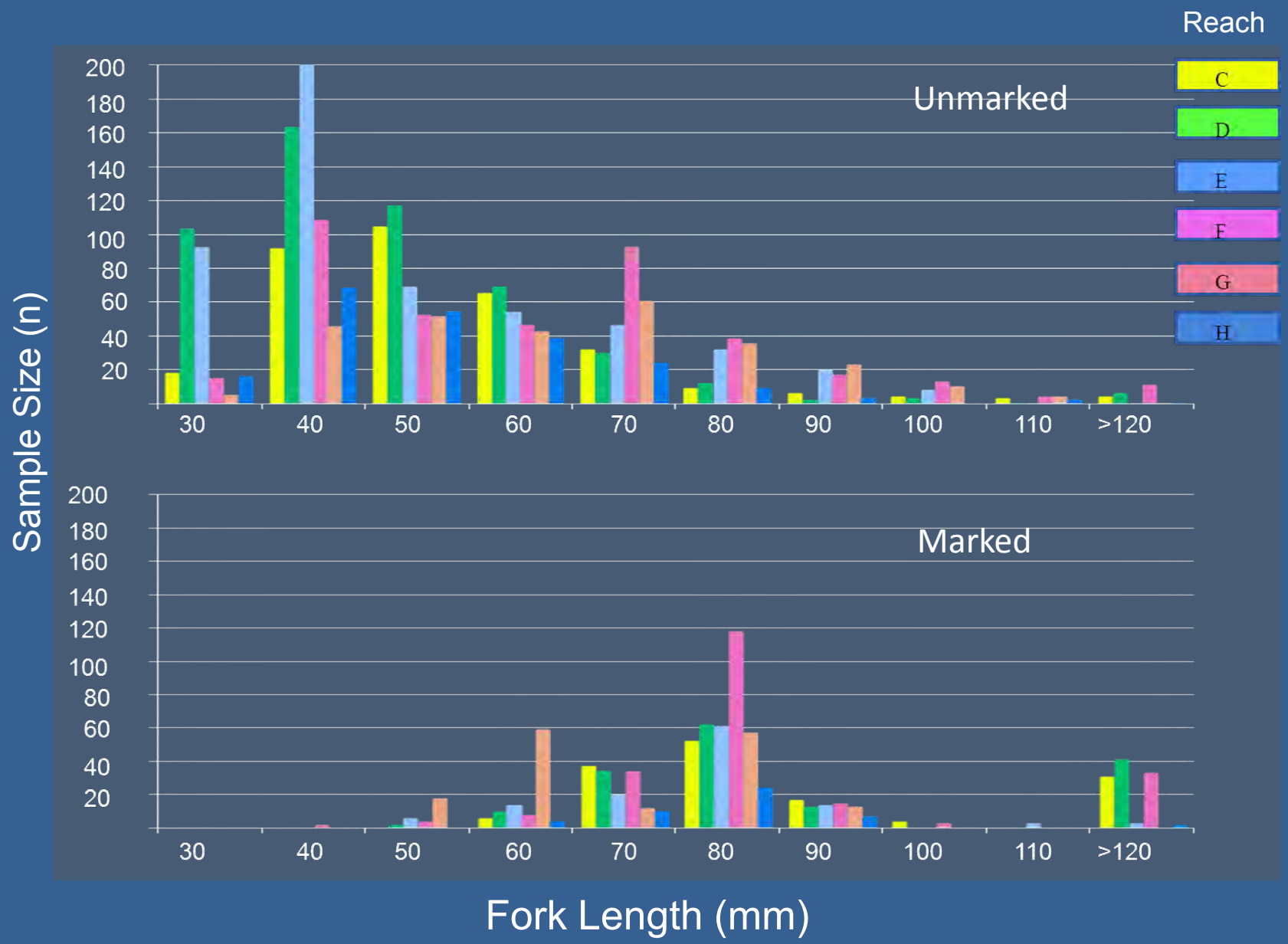
Hatchery Context



- ~2/3 of all releases from two ESUs
- ~1/2 of all releases are Lower CR ESU
- One hatchery responsible for ~¼ (15-47%) of all subyearlings released in the basin

Chinook Size Distribution (2010)

Hinton, unpublished data



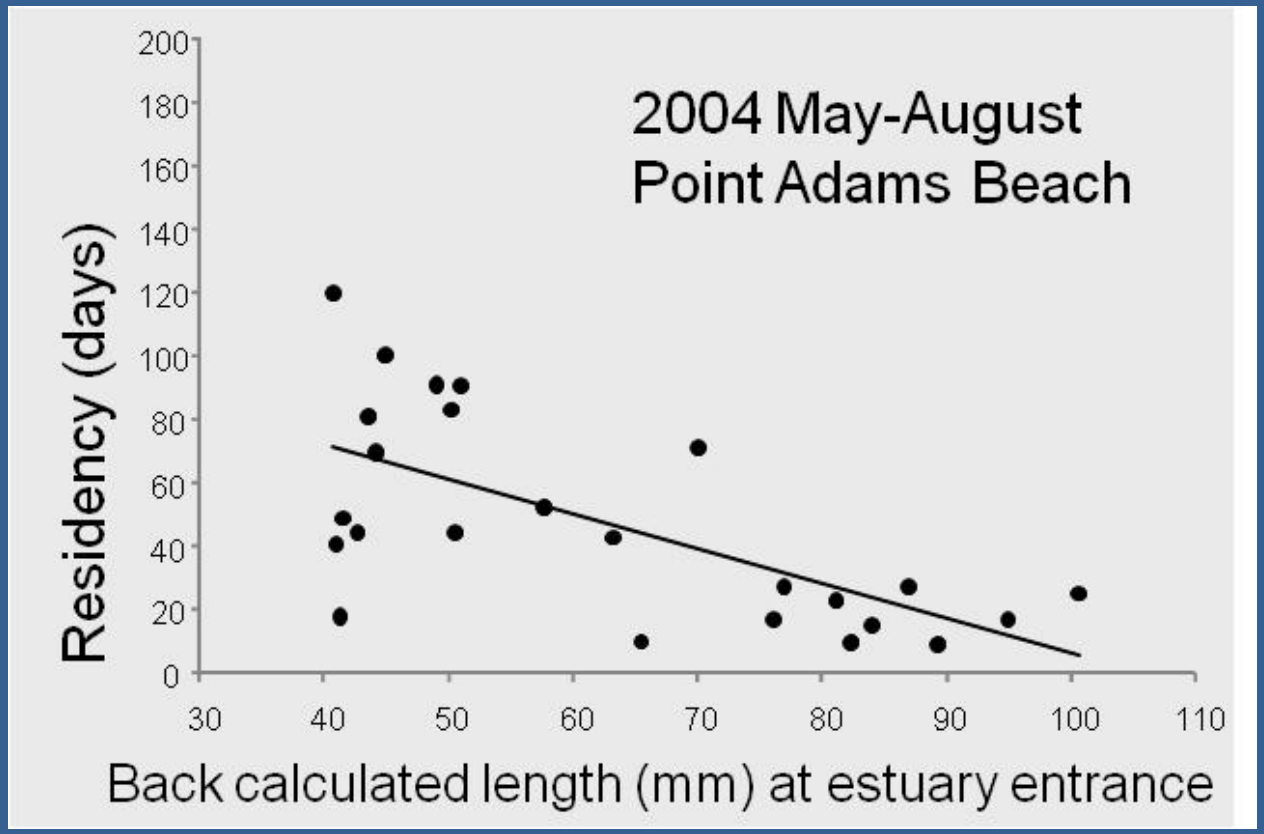
Fish Size and Estuarine Habitat Use

- Small juveniles frequent shallow habitats near shore
- Larger juveniles frequent deeper channel areas further from shore
- Mean fish size increases toward the estuary mouth and from nearshore to offshore areas
- Hatcheries release relatively large fish

Campbell, 2010

Chinook Size and Estuary Residency (2004)

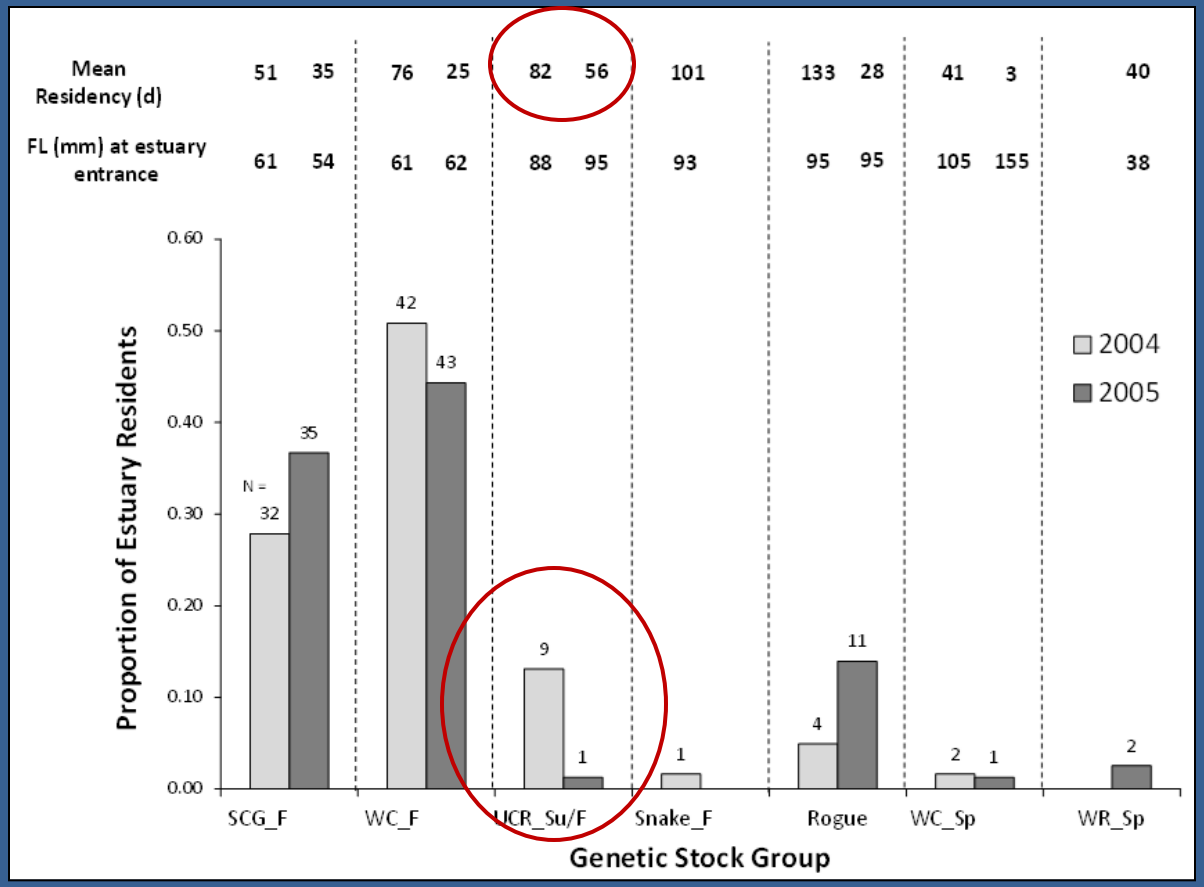
In 2003-05 >half of all hatchery fish >90 mm at release



Bottom et al. 2011

Stock-Specific Residency (2004-05)

Back-calculated size at entry and estimated residency in the salt-influenced portion of the estuary based on otolith chemsitry



- Even some upper CR stocks reside in the estuary for weeks or months
- Otolith-derived residency values do not include time spent in tidal fresh-water areas

Size at Estuary Entry

Campbell, unpublished data

Back-calculated fork lengths at salt-water entry from adult otoliths

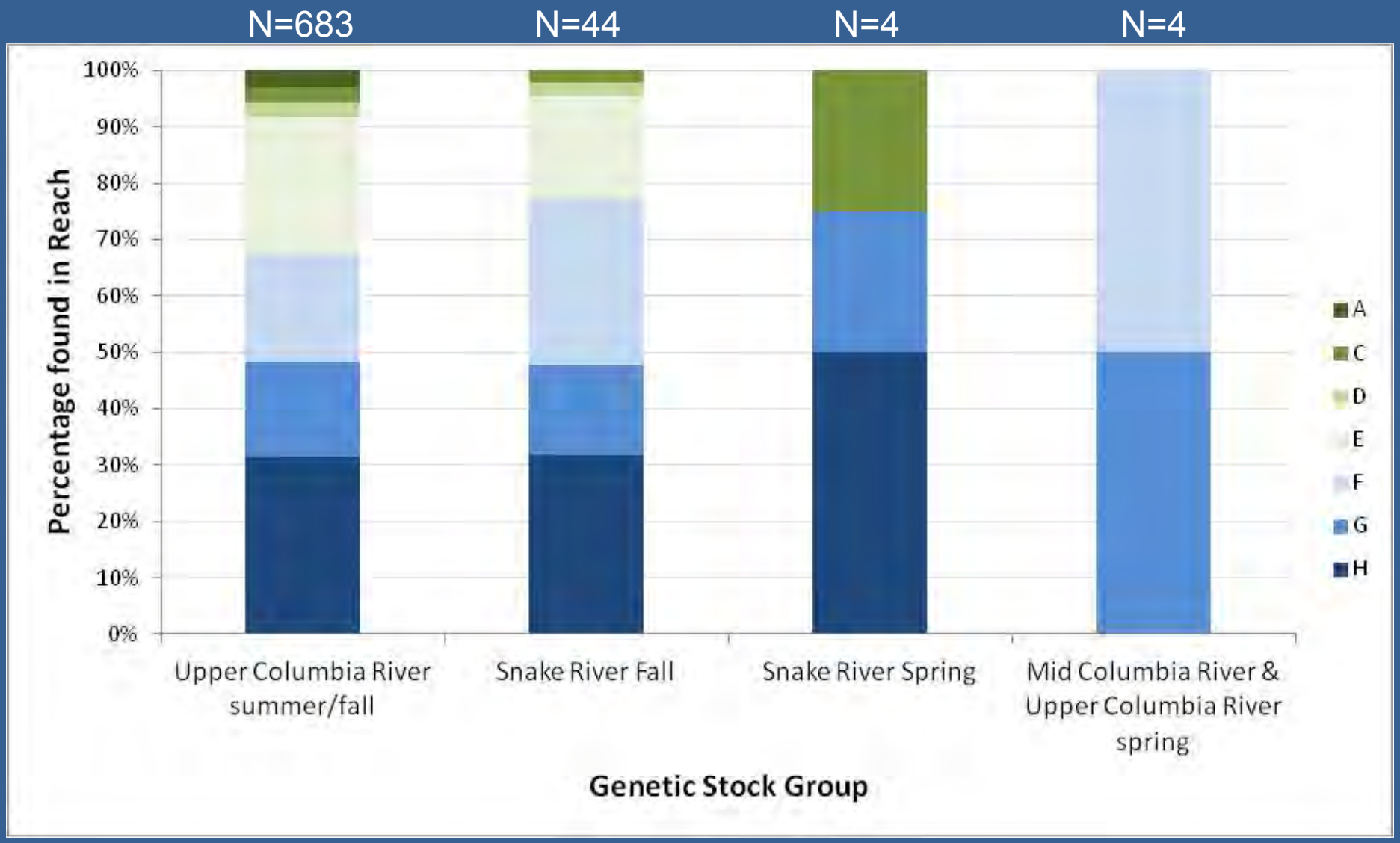
	BC size at estuary/ocean entrance (mm)					Average	
	<60	61-90	91-120	>121	n	Fl (mm)	SD
Coweeman Ch F 2009	0.01	0.42	0.51	0.06	106	94	15.43
Coweeman Ch F 2010	0.00	0.29	0.59	0.12	41	100	14.74
NFK Lewis Ch F 2011	0.10	0.27	0.56	0.08	52	95	23.72
Hanford Reach Ch Su/F 2011	0.02	0.74	0.25	0.00	53	82	13.94
Methow Ch Su 2011	0.00	0.06	0.64	0.30	49	116	21.14
Methow Ch Sp 2011	0.00	0.02	0.40	0.57	42	126	17.29

- Spawners from Lower CR fall stocks entered the brackish estuary over a range of sizes, but averaged 94–100mm
- 74% of returning adults sampled in the Hanford Reach area (Upper CR Su/Fa) were from individuals that entered the estuary at sizes <90mm
- Estuary entry sizes of returning Su (subyearlings) and Sp (yearlings) Chinook in the Methow R. were relatively similar (116 vs 126 mm) despite differences in migration age
- Do juvenile life histories of surviving adults vary from year to year?

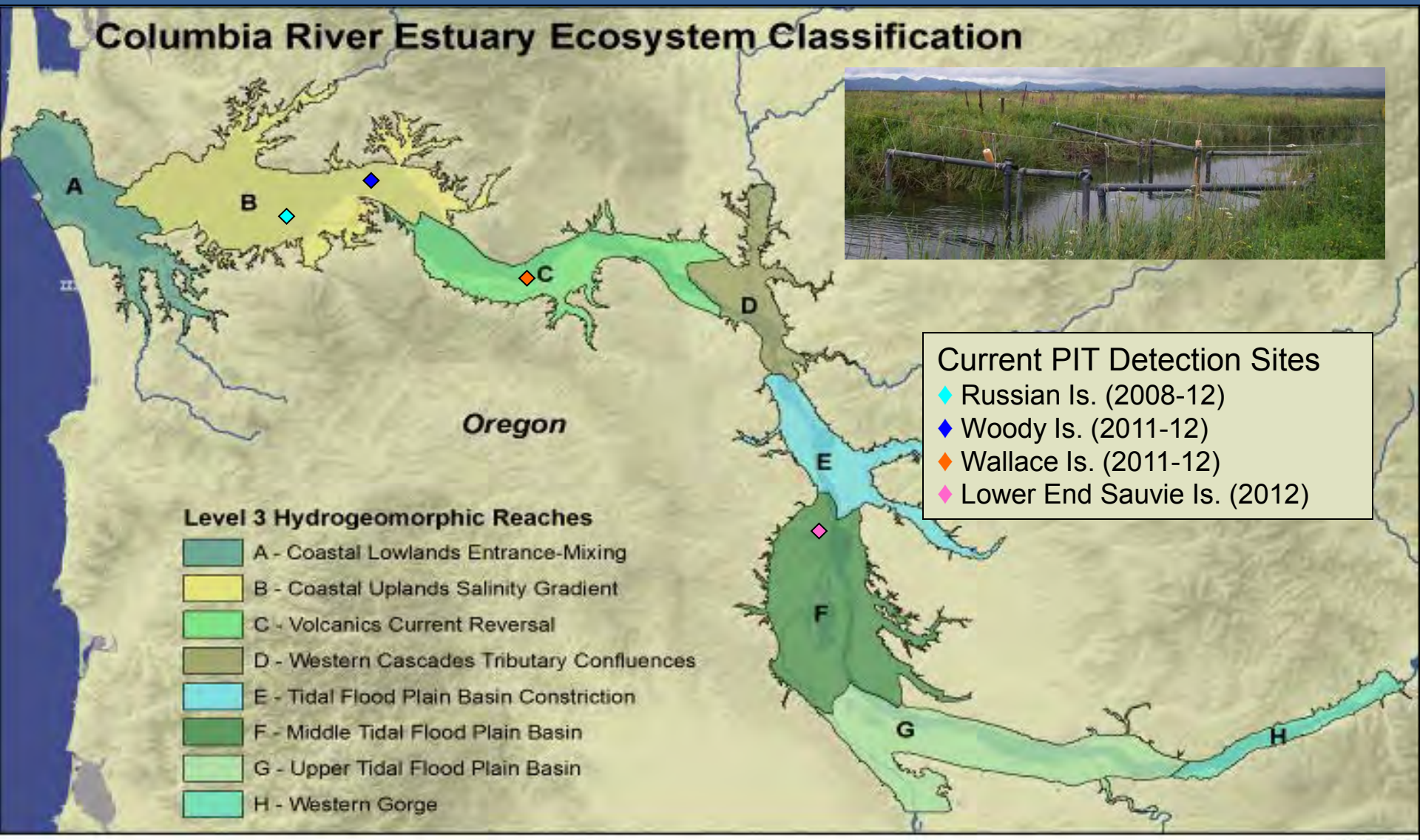
Teel, unpublished data

Genetics Survey (2010-12)

Shallow Water Habitat



PIT Studies: Sources of salmon in off-channel habitats



McNatt, unpublished data

PIT Monitoring At-Risk Stocks (2008-12)

			Russian Island (Reach B)			All Sites
Species	**ESU**	**ESA Status**	**Naturally Produced (n)**	**Hatchery (n)**	**Reported Sizes at Tagging (mm FL)**	**Total PIT Detections (n)**
Chinook	Upper CR Spring	E	1	1	97-98	2
	Lower CR	T	0	121	61-84	174
	Snake R Spring/Summer	T	0	1	--	4
	Snake R Fall	T	1	1	72-122	4
	Upper Willamette R	T	1	2	65-162	4
Coho	Lower CR	T	6	4	67-139	15
Steelhead	Snake R	T	1	4	210	7
	Upper CR	T	0	1	124	2
	Middle CR	T	0	0	--	3

McNatt, unpublished data

Expanded Estimates for Tagged Releases of Interior Stocks*

Species	ESU	ESA Status	Wetland Site	Year	Total PIT Detections (N)	N expanded
Chinook	Upper CR Spring	E	Russian Is.	2011	1	7
	Snake R Spring/Summer	T	Russian Is.	2011	1	48
			Lower Sauvie Is.	2012	1	48
	Snake R Fall	T	Woody Is.	2011	2	27
Steelhead	Snake R	T	Russian Is.	2009	3	109
	Upper CR	T	Russian Is.	2011	1	13
	Middle CR	T	Woody Is.	2011	1	10

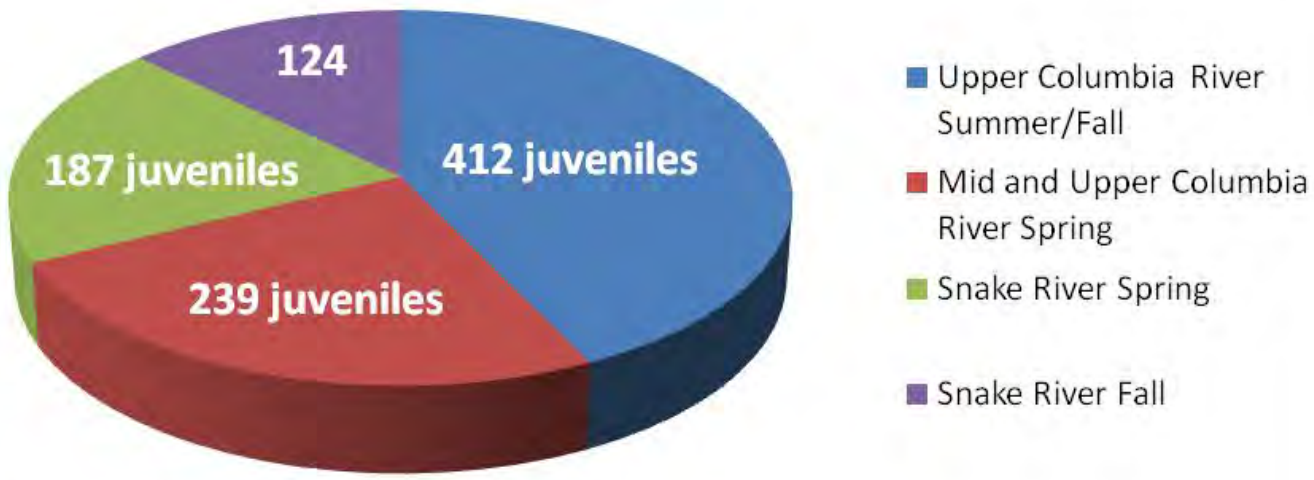
*Data from large hatchery releases that also included large PIT tagged groups.
N expanded = % of PIT group detected x total hatchery release

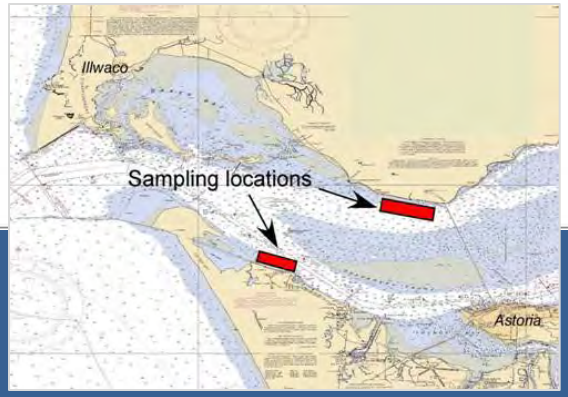
Teel & Weitkamp, unpublished data

NOAA Purse Seine Surveys (2007-11)

Deep estuary channel

Interior juveniles
N= 962





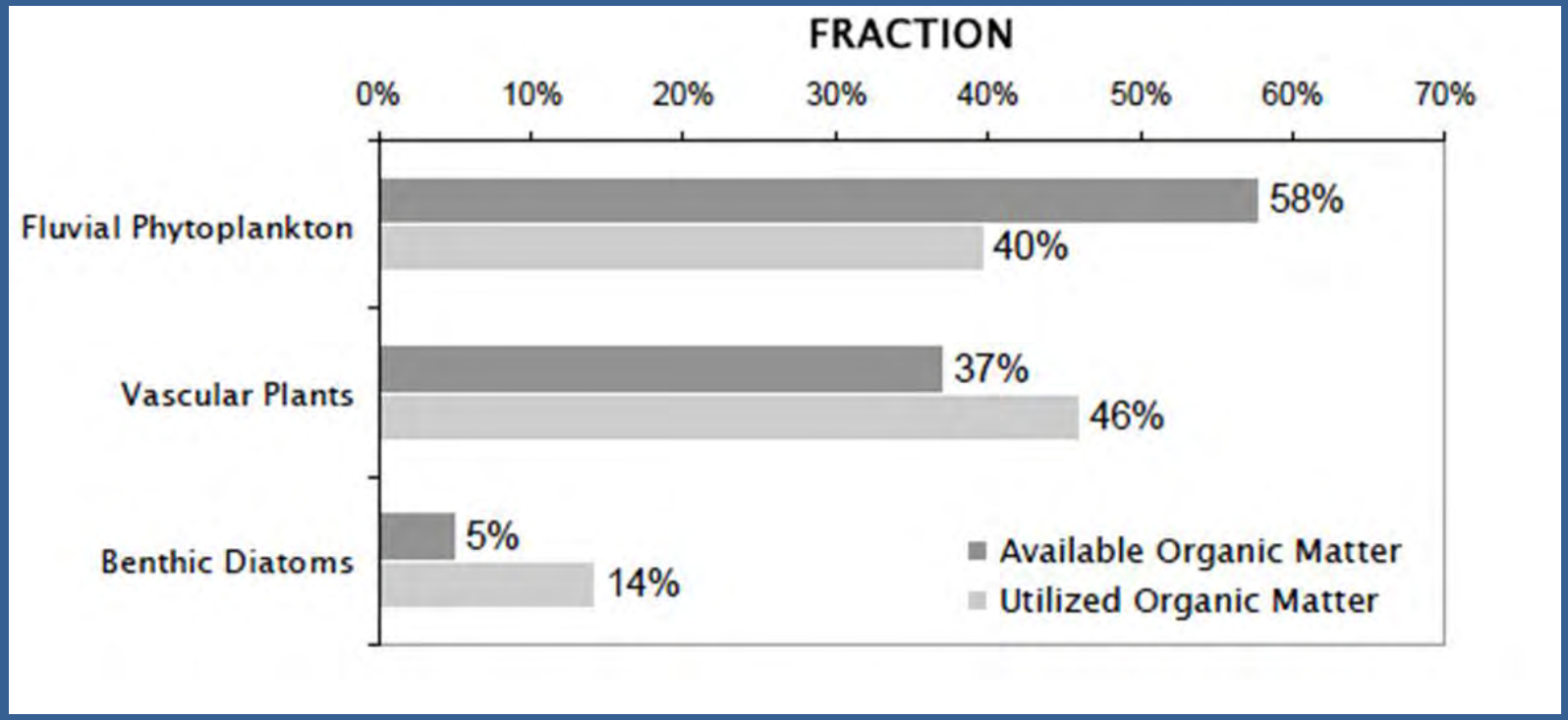
Alternative Estuary Pathways

- Subyearling migrant spring Chinook
  Willamette and Lower CR spring stocks use shallow estuarine habitats; Subyearling and yearling strategies contribute to Willamette R. returns (Schroeder et al. 2007)
- Fry migrant Snake R. spring-summer Chinook?
  Productive fry life history in the Pahsimeroi River may have been a viable LH strategy (Copeland & Venditti 2008)
- Yearling migrant fall Chinook
  Lower and upper CR fall Chinook stocks (Snake R., Spring Cr., Upper CR, West Cascade groups) enter the estuary in the fall and may overwinter near Sandy River delta (G. Johnson et al. 2011)
- Reservoir-type or estuary-type Chinook?
  Some transported Snake R. subyearlings overwinter below Bonneville (Marsh et al. 2010); some apparent “reservoir type” Chinook may be estuary-rearing Chinook

Maier and Simenstad 2009

Food Web Benefits of Shallow Habitats: Macrodetritus

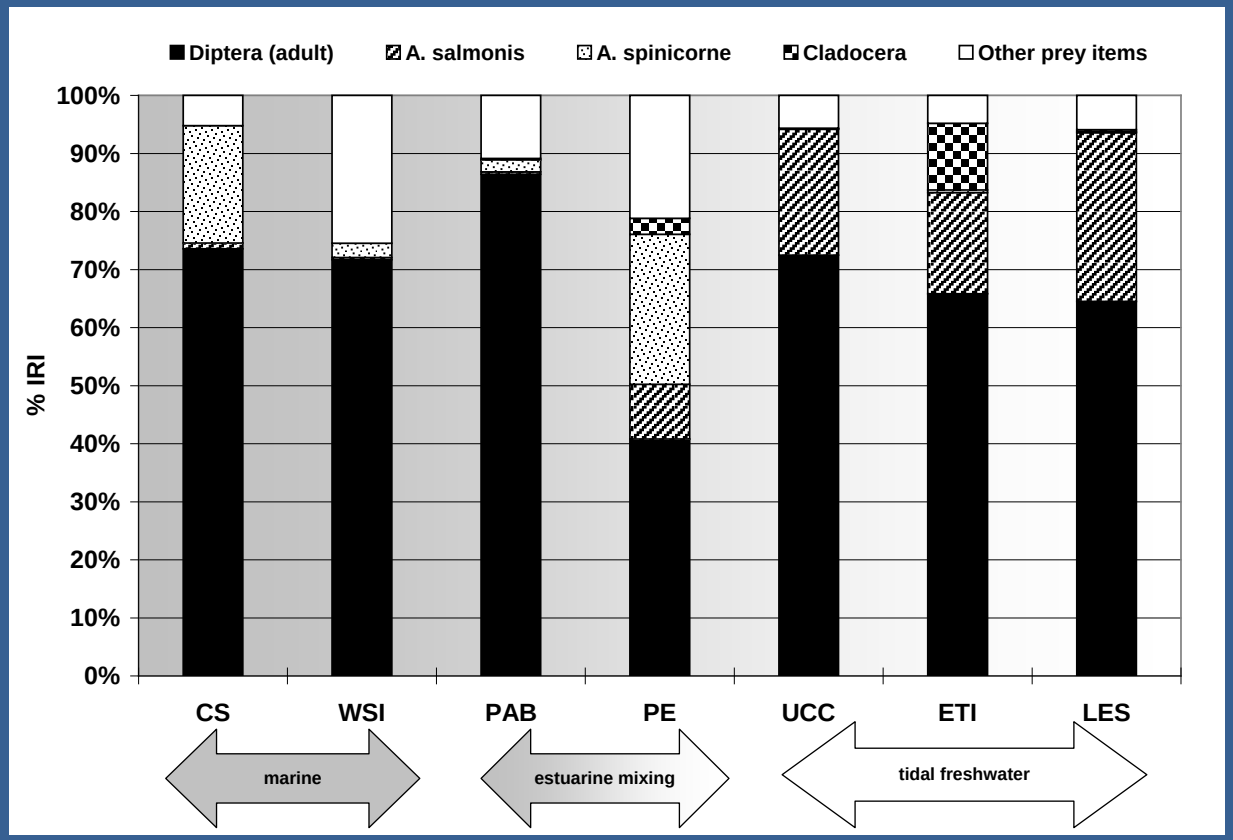
- Wetland losses eliminated ~84% of historical macrodetritus that supported estuarine food webs (Sherwood et al. 1990)
- But salmon select disproportionately for food webs linked to marsh detritus and benthic diatoms
- The food-web linkage is likely through consumption of prey produced in wetlands and other shallow habitats; Wetland losses could limit estuarine rearing capacity



Bottom et al. 2008

Food Web Benefits of Shallow Habitats: Salmon Diets

Prey composition (Index of Relative Importance) of juvenile Chinook salmon in 3 estuary zones, 2002-05 (n = 1,554)



- Diets dominated by taxa produced in wetlands and other shallow habitats
- Results also include larger juvenile size classes that don't typically enter wetlands
- Estuarine growth rates of juvenile Chinook salmon ~0.5 mm per day

Weitkamp, unpublished data

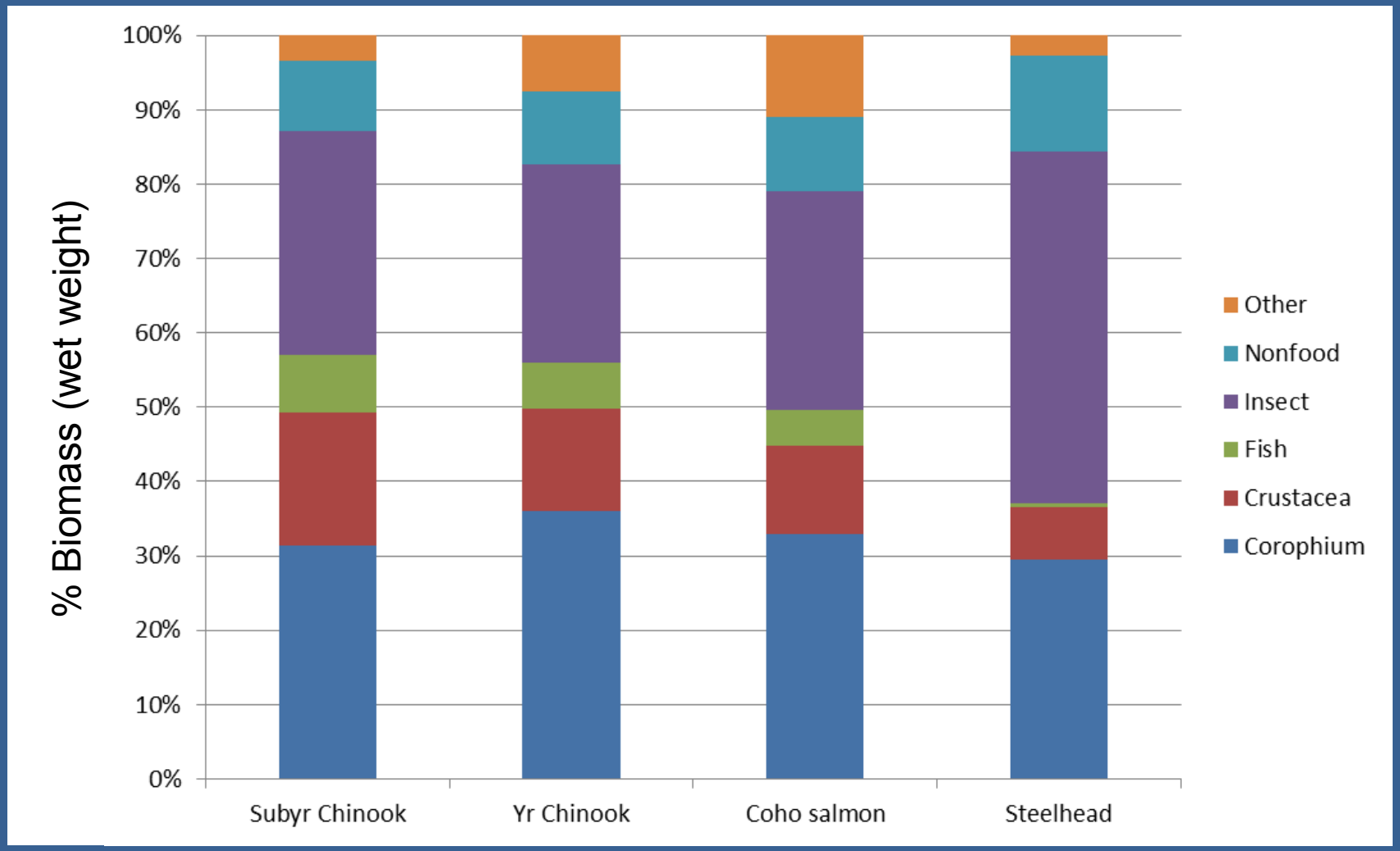
Mean Stomach Fullness of Juvenile Salmon Caught in Deep-Water Habitats

Years 2007-2011, all stocks combined

Spp/age class	Average of % fullness (contents wt/body wt)	n
Subyearling Chinook	0.91	563
Yearling Chinook	0.75	128
Coho salmon	0.68	171
Steelhead	0.19	112

Weitkamp, unpublished data

Diet Composition of Juvenile Salmon Caught in Deep Water



Eaton 2010; Woodruff et al. 2012

Food Web Benefits of Shallow Habitats: Off-site transport

From Eaton (2010):

- Drift invertebrates are flushed from Grays R. wetlands at a higher rate than they drift in
- Chinook diet composition in subsidized areas of the main-stem Grays R. is consistent with the neuston composition exported from the wetlands

From Woodruff et al. (2012):

- 237 acres of restoring sites in Grays R. could be exporting 391 metric tons (dry wt) of marsh macro-detritus annually
- The macro-detritus drift contains insects
- Major pulsed events force major export of OM into estuary
- 50% of the POM export is transported ~7km from the source

Conclusions

- Interior salmon stocks occur estuary-wide; distribution and abundance in shallow habitats differ by stock:
  - Interior stock proportions increase in E – H; overall diversity high in E/F
  - Upper CR Su/Fa and Snake R Fa are widely distributed
  - A few Snake and Mid/upper Cr spring Chinook sampled in near-shore habitats in reaches G,H
- In deep channels of the lower estuary, fish are larger, proportions of hatchery fish are greater, and purse seine catches of interior stocks are higher (relative to sample collections in shallow near-shore habitats)
- Most hatcheries release relatively large fish that tend to use deep habitats and migrate more rapidly to the lower estuary than small fish

Conclusions

- Use of shallow tidal habitats is not confined to small subyearlings from the lower Columbia basin
- Even small numbers of interior basin stocks in shallow habitats may be significant (i.e., T&E stocks are now rare; areas surveyed are small; estuary area is large)
- All size classes benefit from the prey produced and transported from shallow habitats, including large fish that may not enter these habitats
- Present stock composition, abundance, and LH are driven largely by hatchery production practices; focusing recovery on the dominant LH patterns may reinforce the status quo
- Subordinate life histories are alternative “survival pathways” that may contribute to population abundance/productivity
- Some interior basin stocks may rear in upper estuary habitats but additional data are needed

Information Needs (RME)

- Salmon habitat use and stock-specific performance in the upper estuary
- Organic matter and prey transport from upper-estuary floodplains and forested sloughs
- Contributions of estuary LH to adult returns and importance to population viability
- Hatchery effects on estuary LHs, intraspecific interactions, and the performance of naturally produced salmon
- Population and ESU responses to alternative estuary restoration scenarios

Proposed Activities 2013

- Upper estuary habitat surveys (Reach E/F)
- Estuary out-migrant sampling (beach seine, purse seine)
- LH contributions in multiple ESUs (adult otoliths)
- Hydological modeling: flow and temperature effects on habitat opportunities (Reach E/F)
- Life-cycle modeling: sensitivities to estuary survival improvements and recovery benefits of restoration scenarios
- Life-cycle monitoring: Selection of indicator population(s) to quantify juvenile LHs and survival to adult (2014 and after)

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