Genetic Analysis of Unmarked Juvenile Chinook Salmon in Nearshore Habitats of the San Juan Islands

David Teel, Kurt Fresh, Anna Kagley,

Todd Sandell, Bruce Brown, David Kuligowski, and Eric Beamer

Northwest Fisheries Science Center, NOAA Fisheries

Skagit River System Cooperative

Presentation Outline

- **Background on Methods**
  - Genetic Stock Identification (GSI)
  - Collection of Microsatellite DNA Data
  - GAPS Genetic database
- **Analyses of San Juan Island Samples**
  - Estimates of Stock Proportions
  - Regional Stock Composition Patterns
  - Sub-regional Stock Compositions

Genetic Stock Identification

- Uses natural genotypic “markers”

  - established, peer reviewed methods; fishery applications since 1970’s
  - protein (allozymes), DNA (microsatellites, SNPs)
  - marks are inherited
  - wild and hatchery fish are marked
  - no tagging is required
  - marks remain stable over time
  - differences among populations reflect evolutionary history
    longer isolation = better discrimination

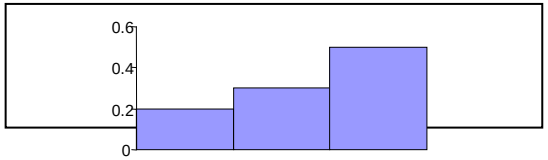
- Probability estimates of fish origins

  - not determined, as with tags
  - estimates are of genetic lineage, not necessarily geographic origin
  - recent / ongoing interbreeding among populations erodes differences;
    intensive monitoring required to accurately discriminate

Genetic Stock Identification (GSI)

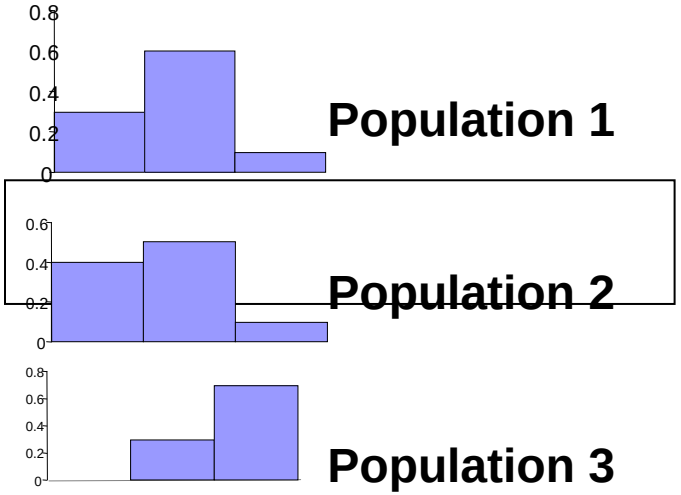
Frequency of Genotype

In Mixture Sample



AA AB BB

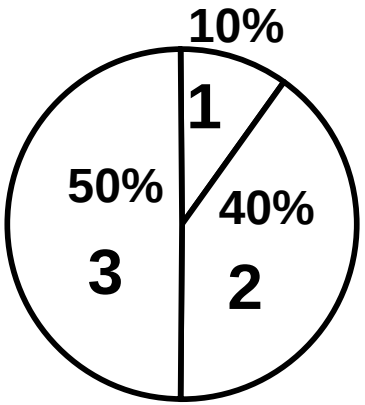
In Contributing Populations



AA AB BB

Estimation of most likely composition of mixture

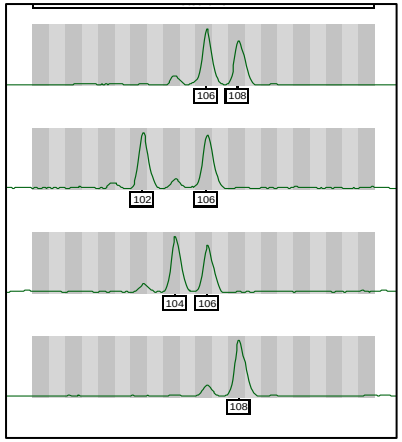
Contribution Estimates



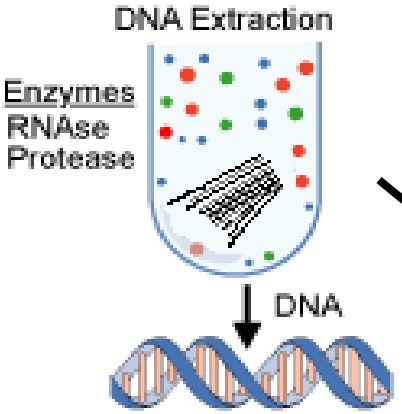
From Milner et al. 1985

Microsatellite DNA Data Collection

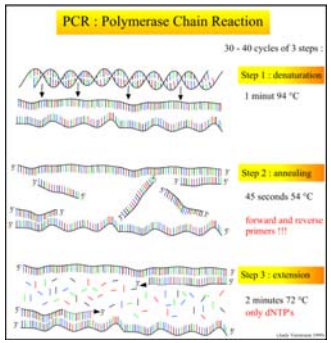
Fin Clip

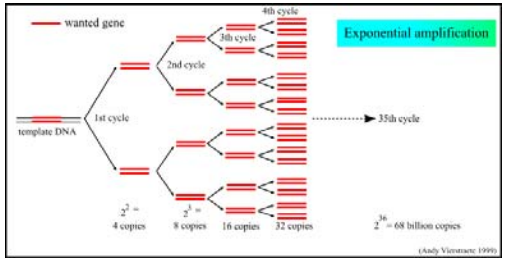


Fragment Analysis



Polymerase Chain Reaction
(PCR amplification)

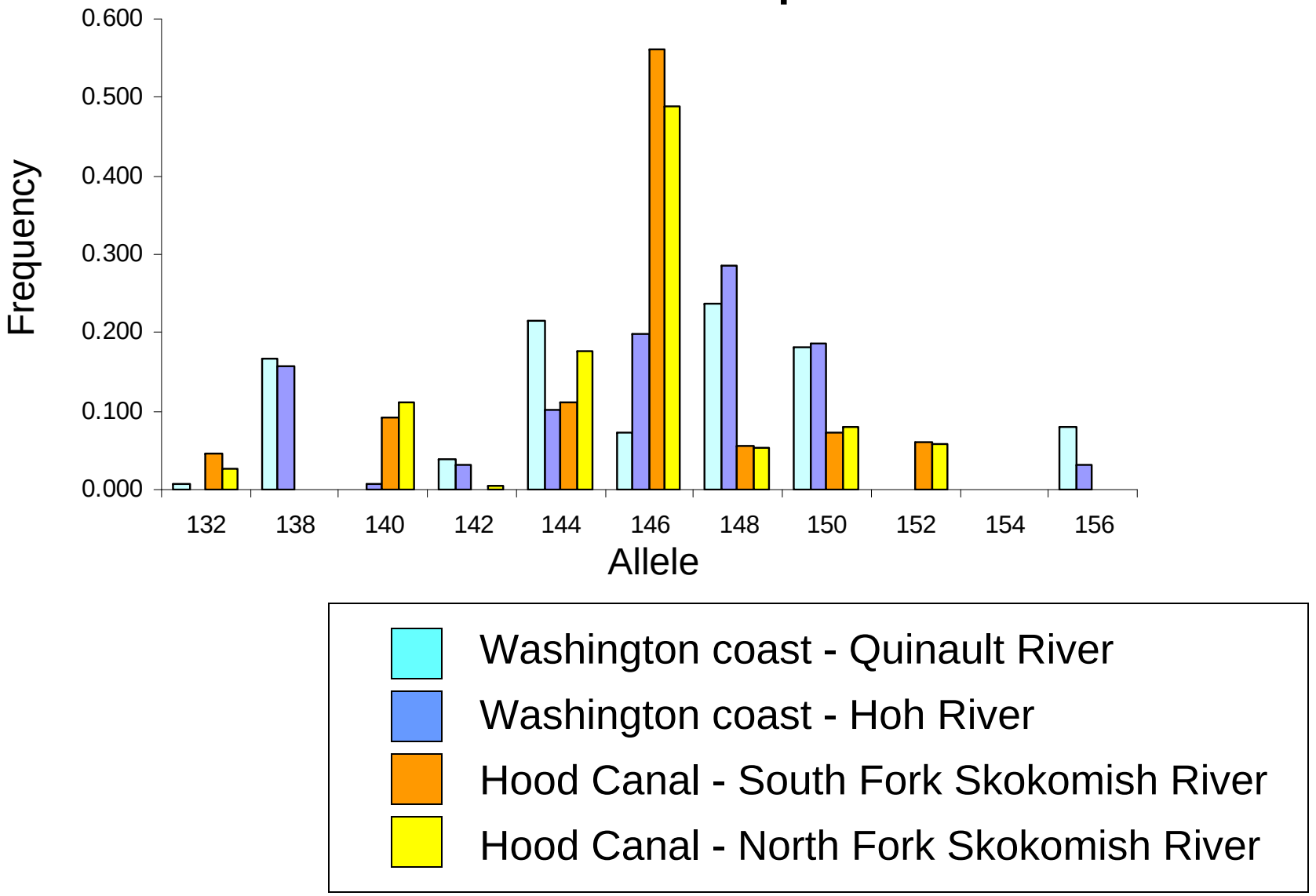




Microsatellite Repeats

108	CA CA CA CA CA CA
106	CA CA CA CA CA
104	CA CA CA CA
102	CA CA CA

Ots3M Allele Frequencies



Data Source: Scott Blankenship WDFW

Interbreeding among populations limits genetic discrimination a natural phenomenon (straying) – but

A Century of Hatchery Releases of South Sound Fall Stock in Rivers Throughout Puget Sound and Hood Canal

- Green River Hatchery established in 1907
- Green River Fall Chinook stock released in

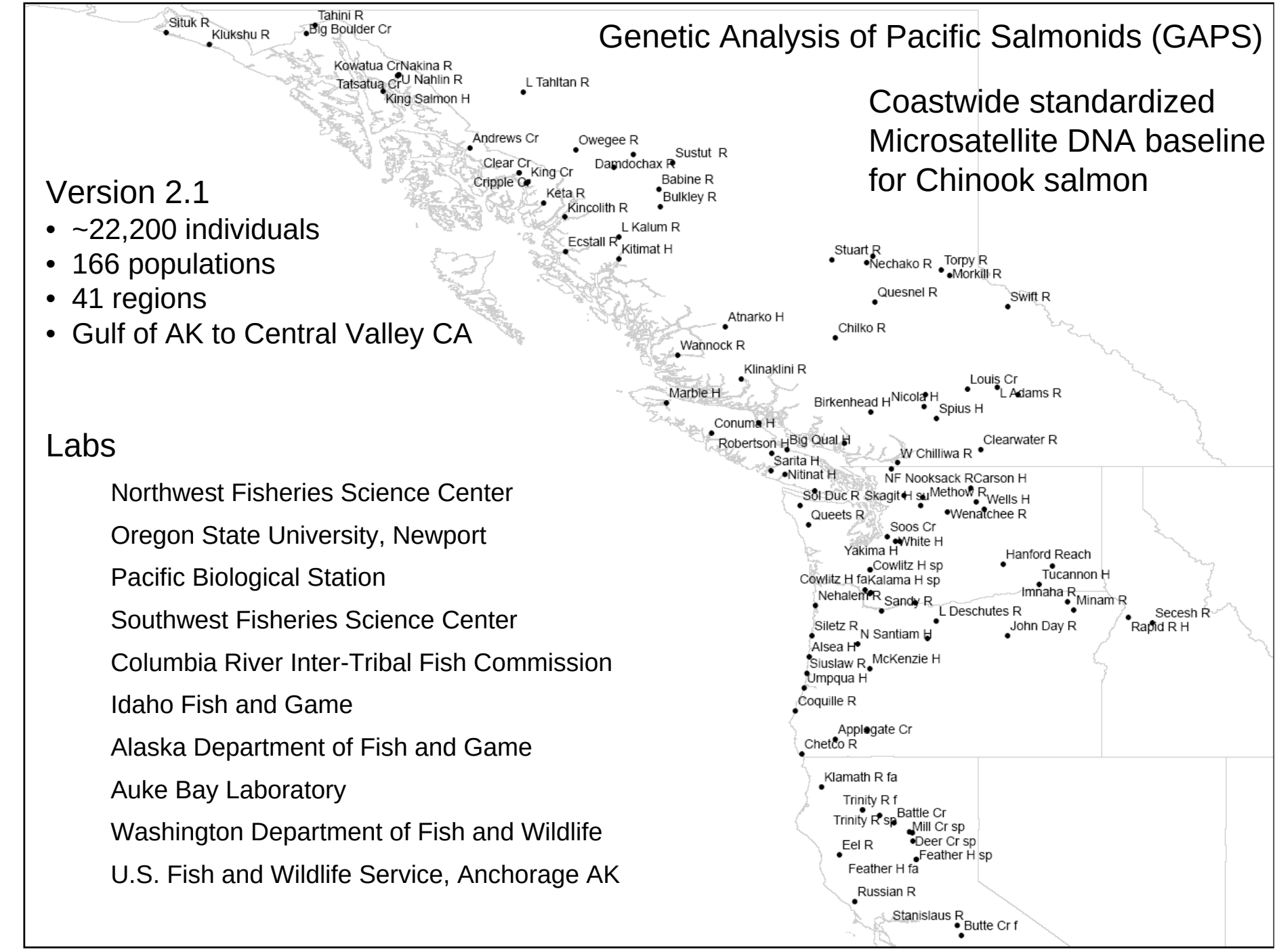
  Nooksack, Samish, Skagit, Stilliguamish, Skykomish, Snoqualmie, Snohomish, Lake Washington, Duwamish, Puyallup, Nisqually, Deschutes, throughout Hood Canal, etc
- Many hatchery programs throughout the region were founded using Green River stock or hatchery populations developed from Green River (e.g., Glenwood Springs H via Samish H)
- As recently as 1995, 20 hatcheries and10 net-pen programs regularly released Green River fall Chinook

Puget Sound Stock Transfers Continued

- All Puget Sound Chinook populations have *not* been homogenized
- Genetic differentiation and structure among populations exists
- But, there is high genetic similarity among populations throughout south Puget Sound
- Populations in Hood Canal are genetically similar to those in south Puget sound
- Fall Chinook from several populations in other regions of Puget Sound are genetically “South Sound Fall Stock”
  Samish fall run (hatchery and naturally produced)
  Nooksack fall run
  Snoqualmie fall run
- Chinook juveniles in our marine-caught sampling that are identified genetically as South Sound Fall stock may not originate in south sound
- Additional information is needed: potential source population sizes, proximity to capture, migration routes

Genetic Analysis of Pacific Salmonids (GAPS)

Coastwide standardized Microsatellite DNA baseline for Chinook salmon



Version 2.1

- ~22,200 individuals
- 166 populations
- 41 regions
- Gulf of AK to Central Valley CA

Labs

Northwest Fisheries Science Center

Oregon State University, Newport

Pacific Biological Station

Southwest Fisheries Science Center

Columbia River Inter-Tribal Fish Commission

Idaho Fish and Game

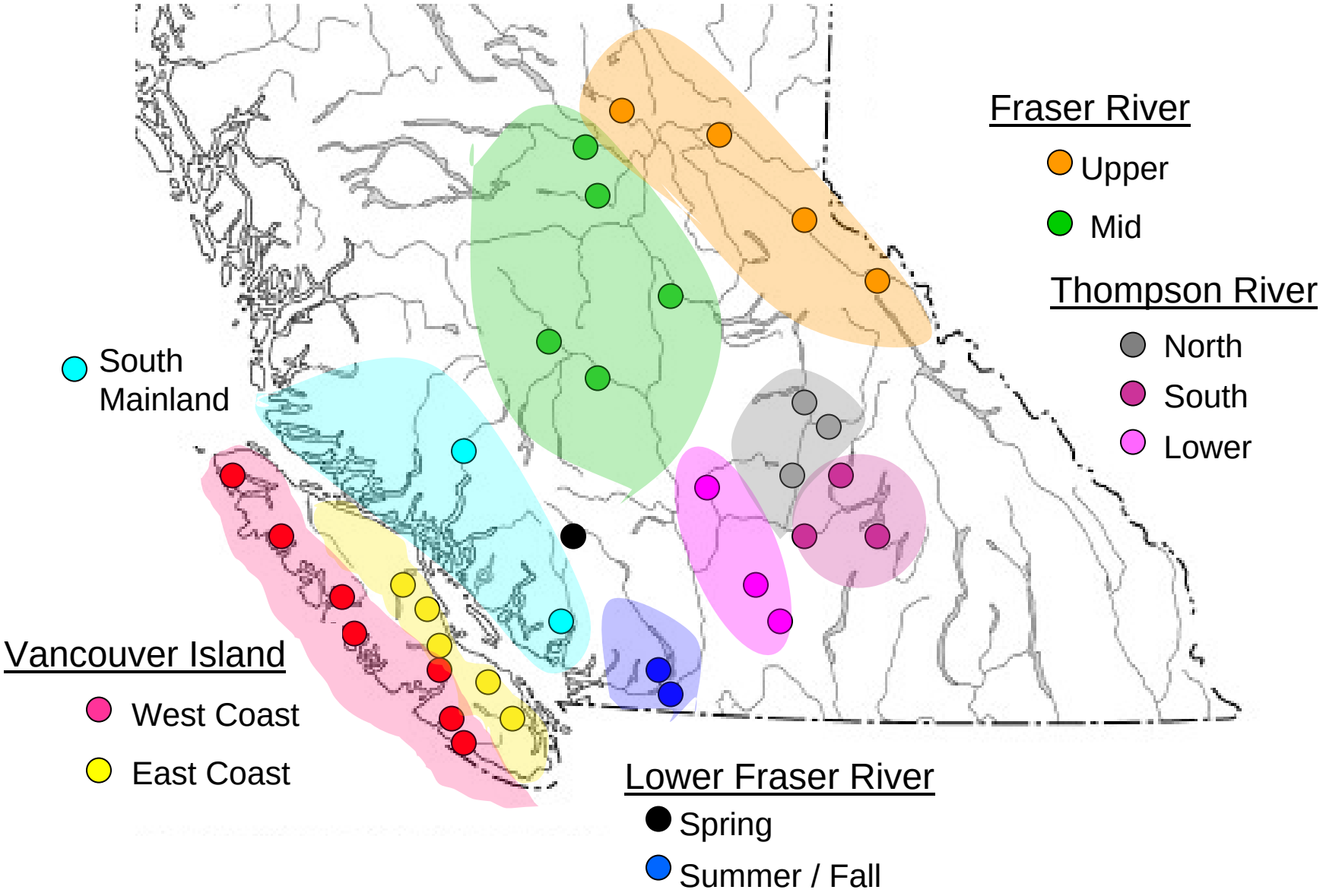
Alaska Department of Fish and Game

Auke Bay Laboratory

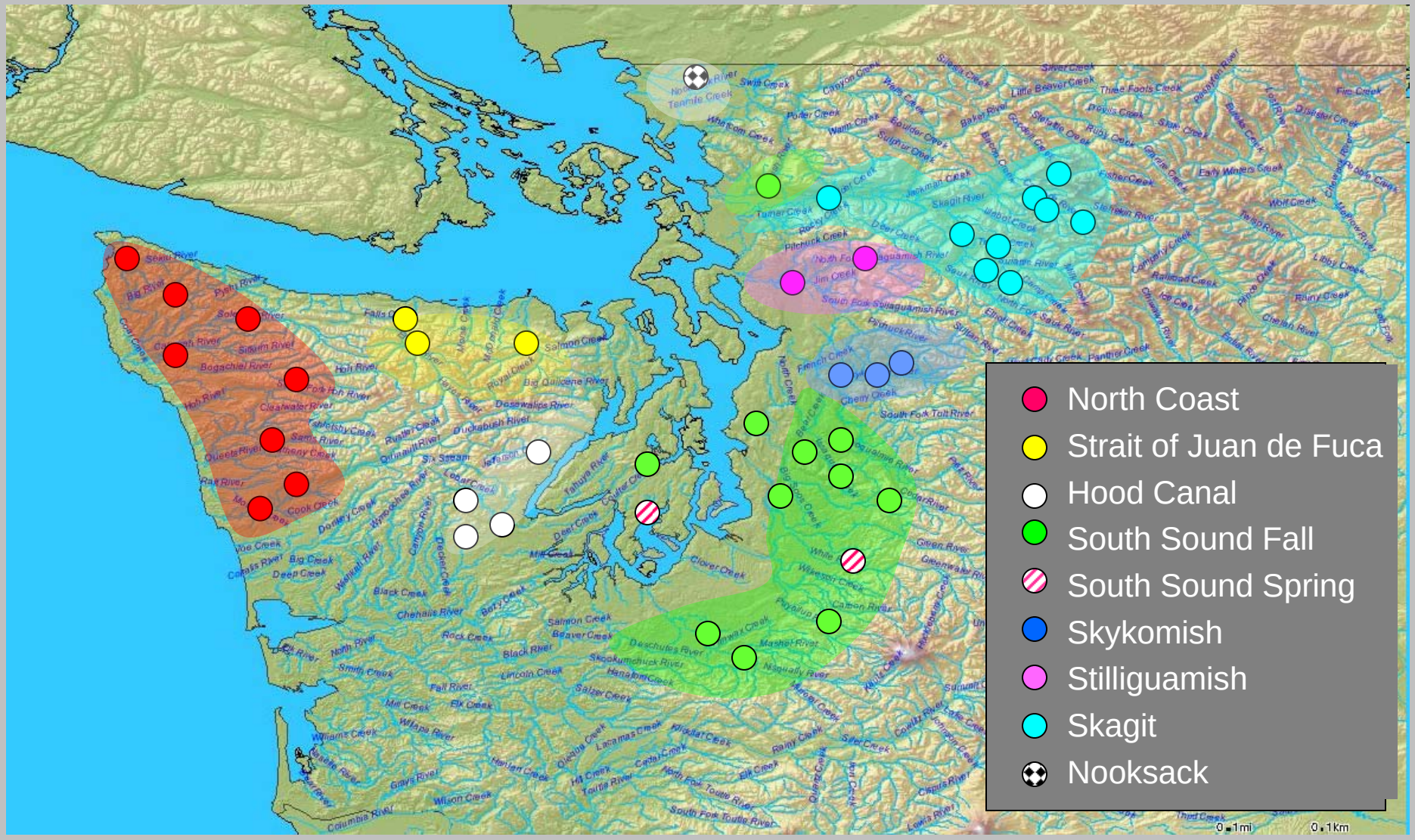
Washington Department of Fish and Wildlife

U.S. Fish and Wildlife Service, Anchorage AK

Genetic Groups in British Columbia



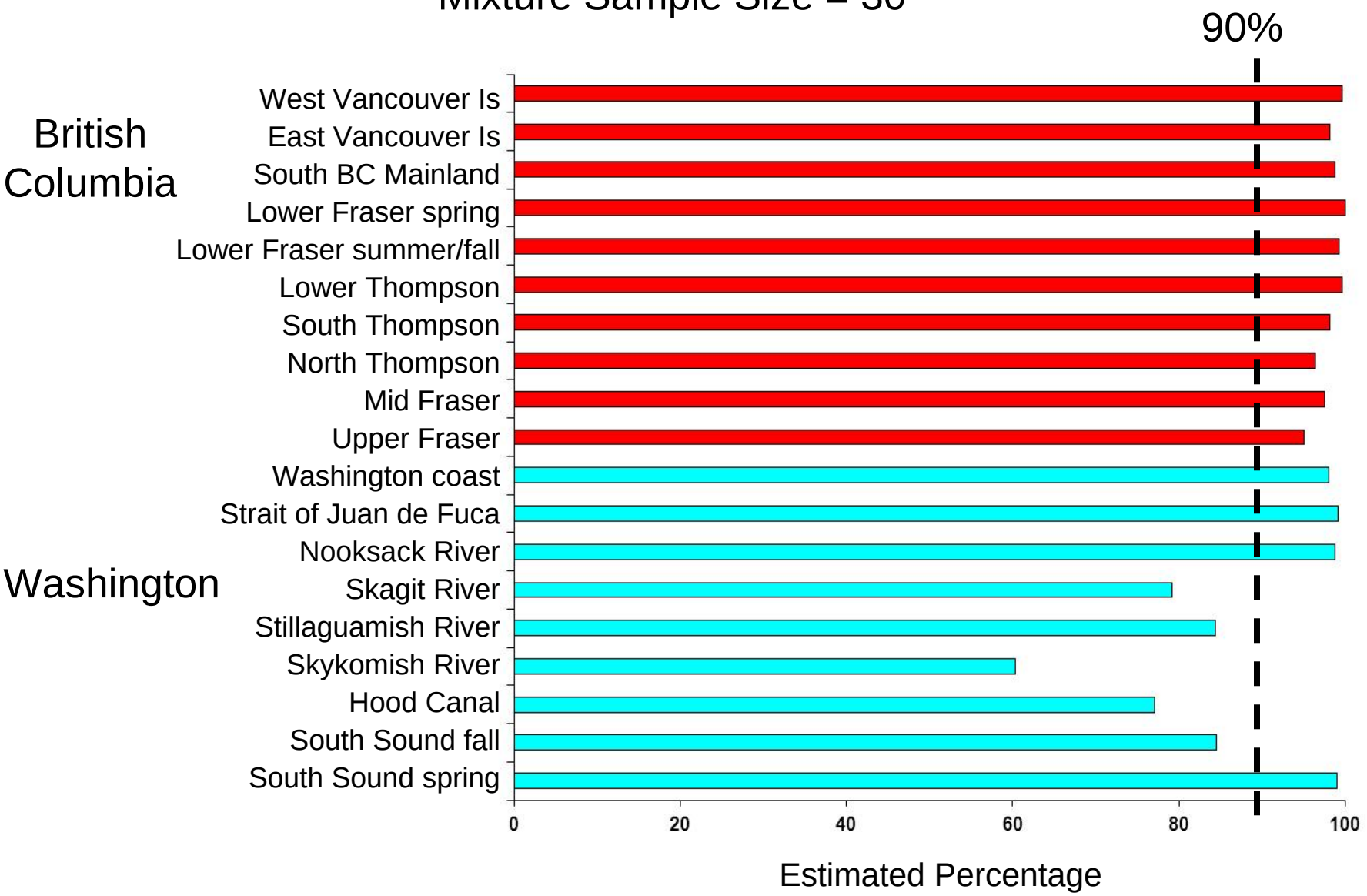
Genetic Groups in Northwest Washington



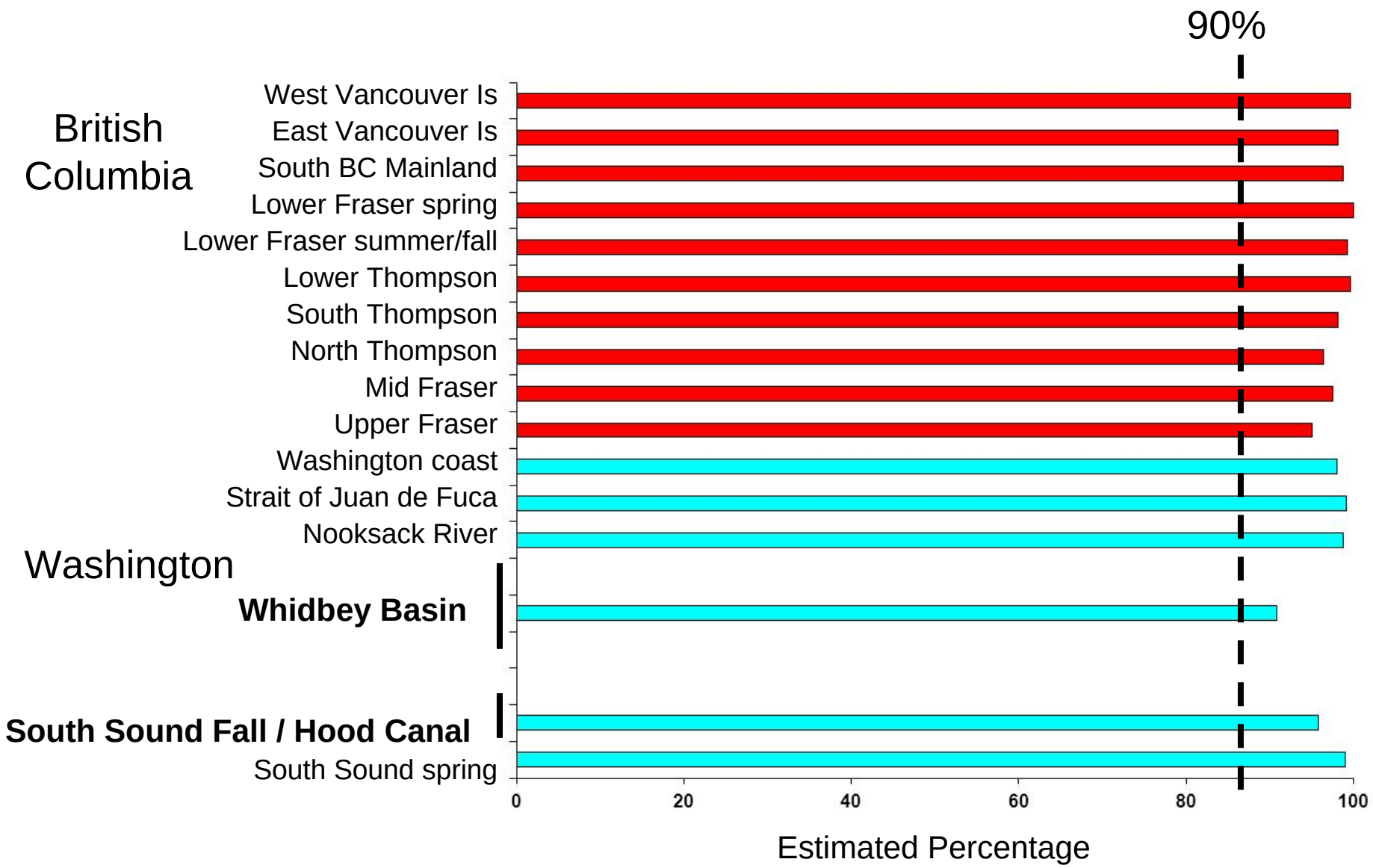
Analysis of Samples of Known Origin

Computer Simulations of “100% Mixtures”

Mixture Sample Size = 30



90% accuracy when lower accuracy populations are combined



Methods Summary

- Mixture samples: Juveniles of unknown origin caught in San Juan Island marine habitats

- Baseline (reference) samples: Spawning populations in Washington and British Columbia likely to contribute to the mixed-stock sample of juveniles

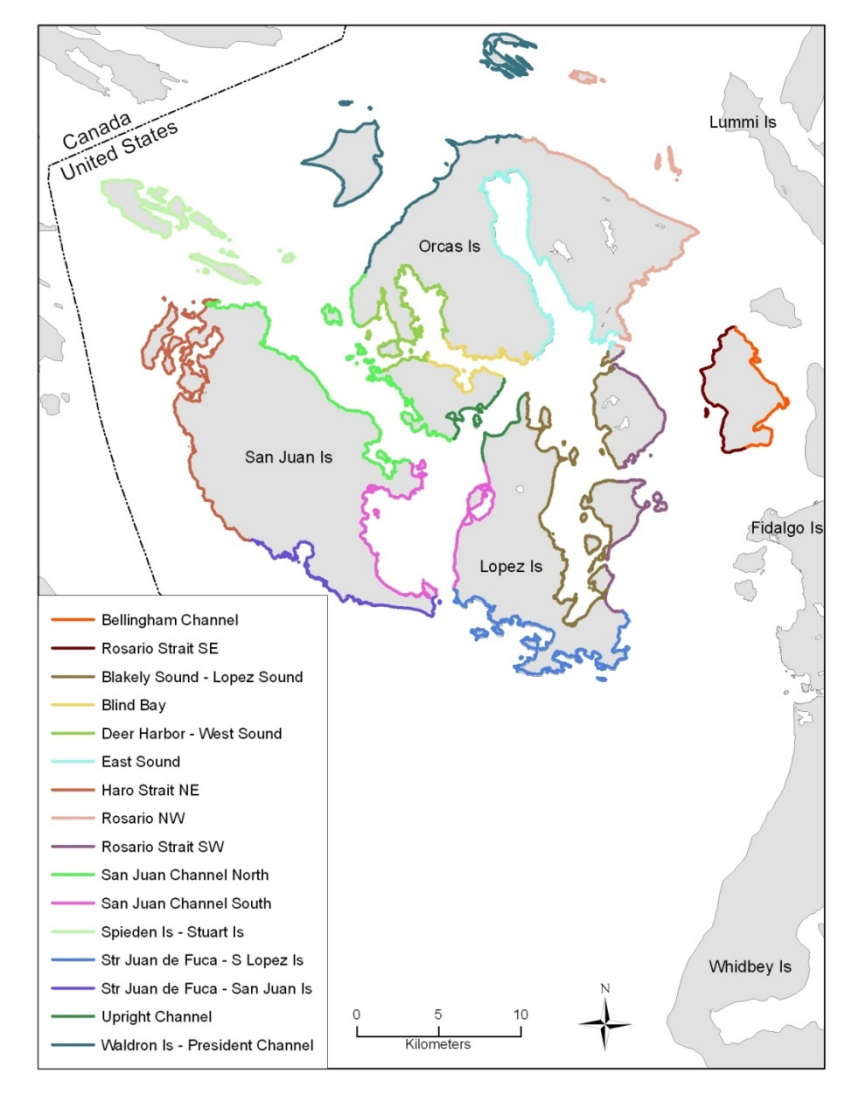
- Data collection: 13 GAPS Microsatellite DNA loci

- Analysis: Allocate and sum method using ONCOR software (Kalinowski 2007) / Ranalla & Mountain (1997) algorithm

- Stock composition estimates: Proportion of each genetic group in the mixture samples (with 95% Confidence Intervals)

- Estimates of stock origins of individual fish in mixture samples
  (we used only Individuals with high probability estimates - > 0.90)
  - to identify stocks that were rare in our San Juans samples
  - in a multivariate habitat and spatial analysis

San Juans Sampling Areas



Genetic Analysis

Number of Unmarked Juvenile Chinook Salmon Samples

Region	Offshore	Shoreline	Total
San Juans	343	661	1004
Admiralty	28	37	65
Bellingham - Samish	80	89	169
Whidbey Basin	163	1495	1658

Unmarked Genetics Samples: San Juans Region

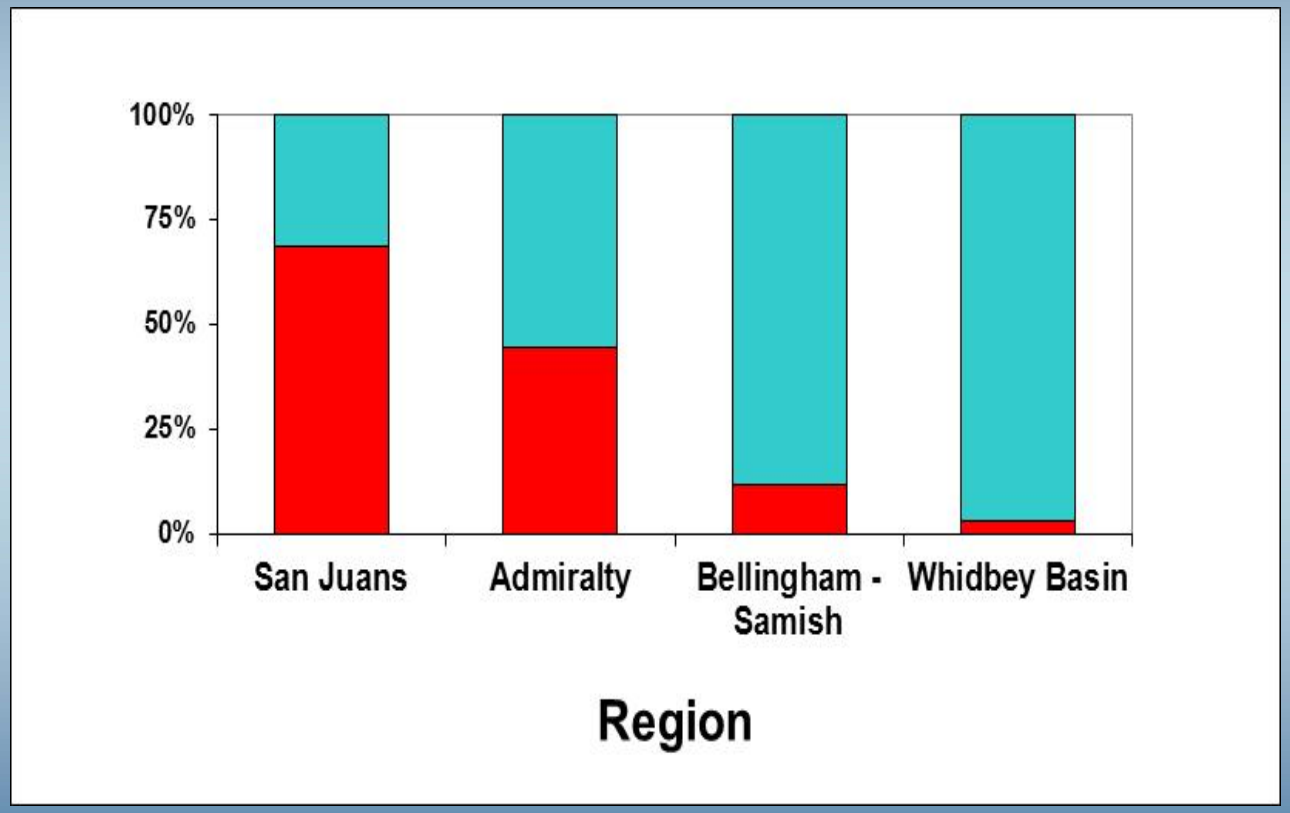
Sub-region	Offshore	Shoreline
Bellingham Channel	0	**50**
Rosario Strait SE	0	17
Blakely Sound – Lopez Sound	11	1
Deer Harbor – West Sound	**44**	2
East Sound	**46**	8
Haro Strait NE	10	4
Rosario NW	**138**	**55**
Rosario Strait SW	13	**40**
San Juan Channel North	7	8
San Juan Channel South	1	3
Str Juan de Fuca – S Lopez Is	**59**	**168**
Str Juan de Fuca – San Juan Is	0	32
Waldron Is – President Channel	14	**273**

Unmarked Hatchery Releases in 2008 and 2009

Southern British Columbia	2008	2009
No Mark	29.0 M	30.4 M
Total Release	31.2 M	33.0 M
% not identifiable	91.3%	91.9%

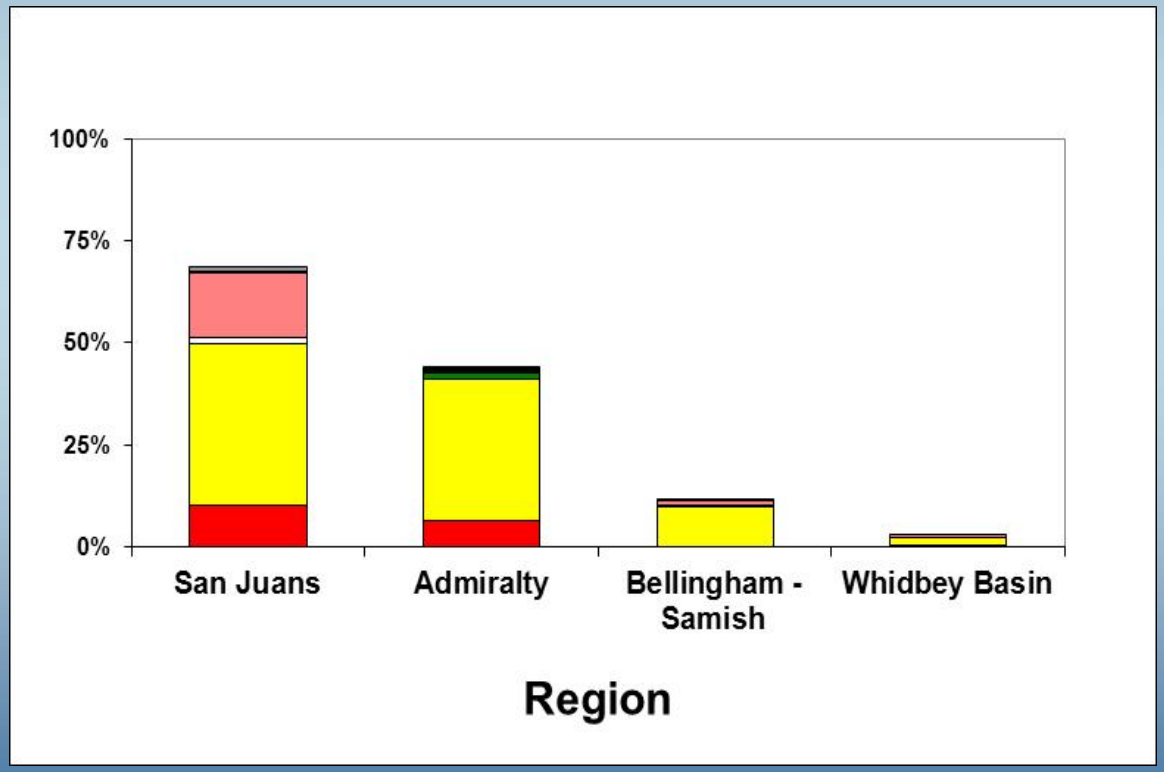
Puget Sound Region	2008	2009
No Mark	5.2 M	5.1 M
Total Release	42.5 M	43.2 M
% not identifiable	12.3%	11.8%

Stock Proportions by Region



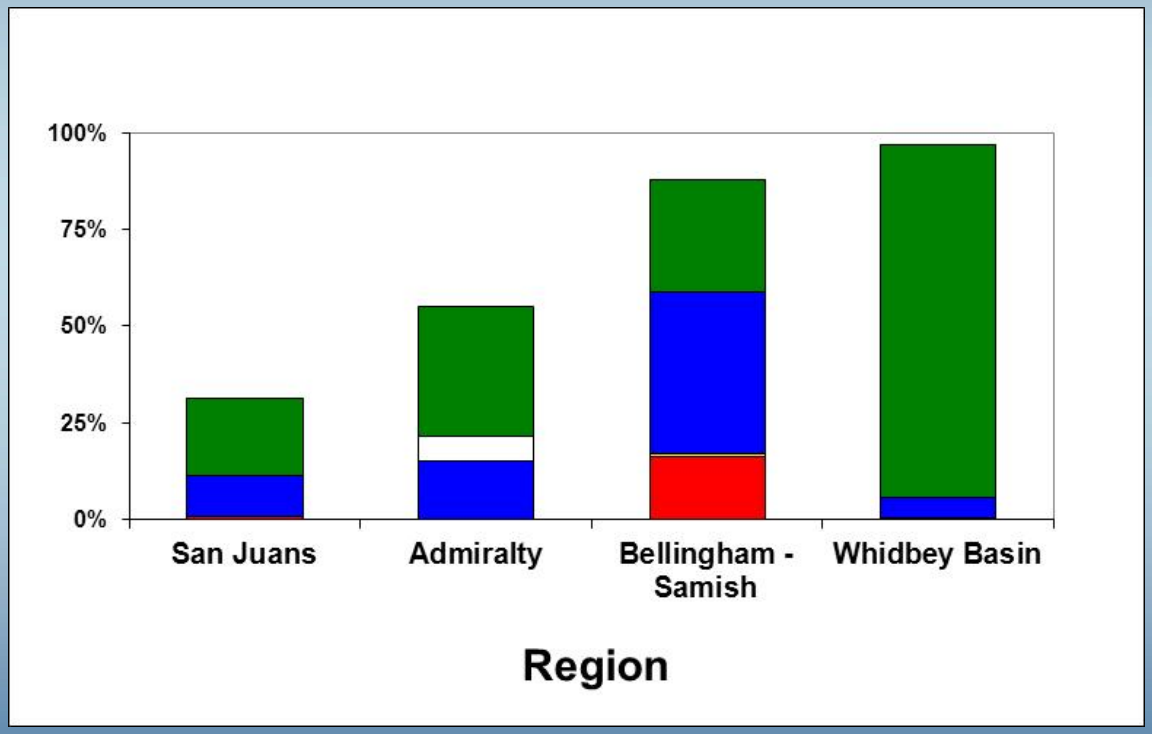
Stock Proportions by Region

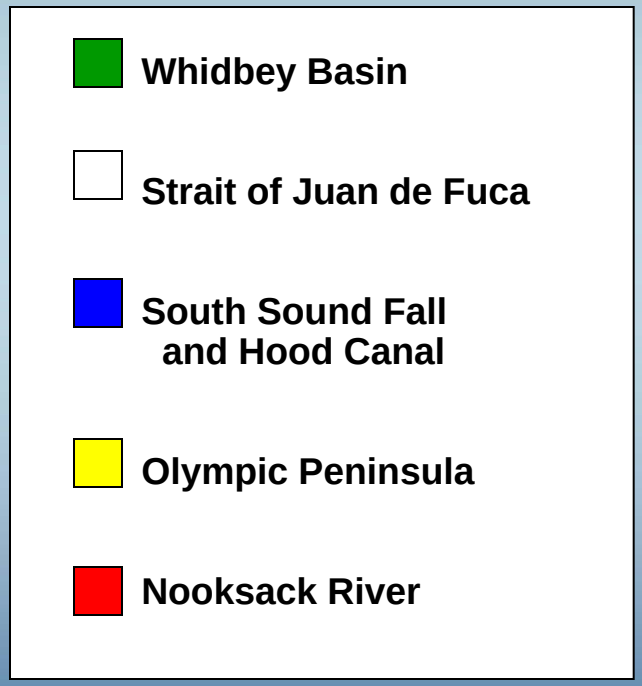
British Columbia Stocks Only



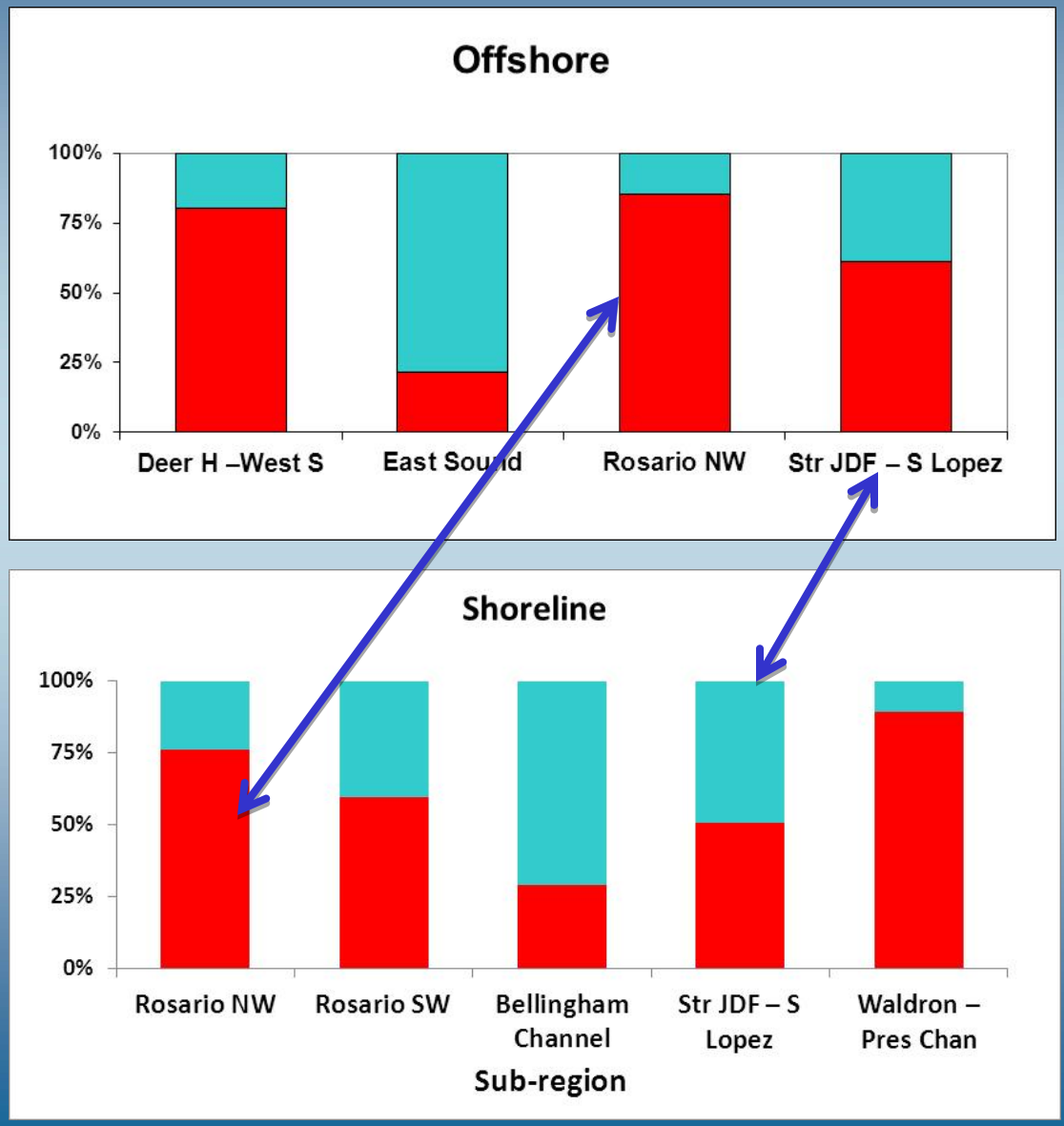
Stock Proportions by Region

Washington Stocks Only

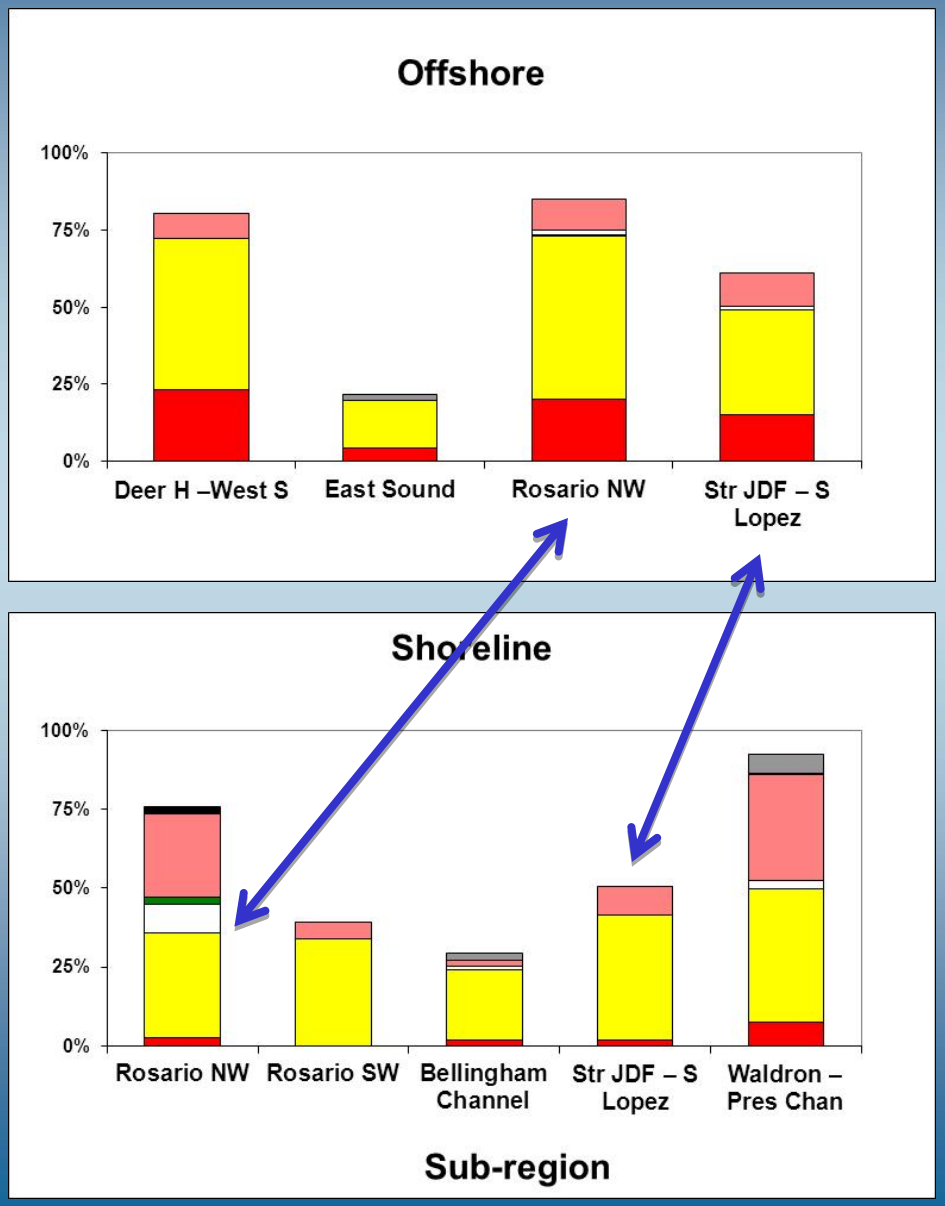




Sub-region Stock Proportions by Habitat

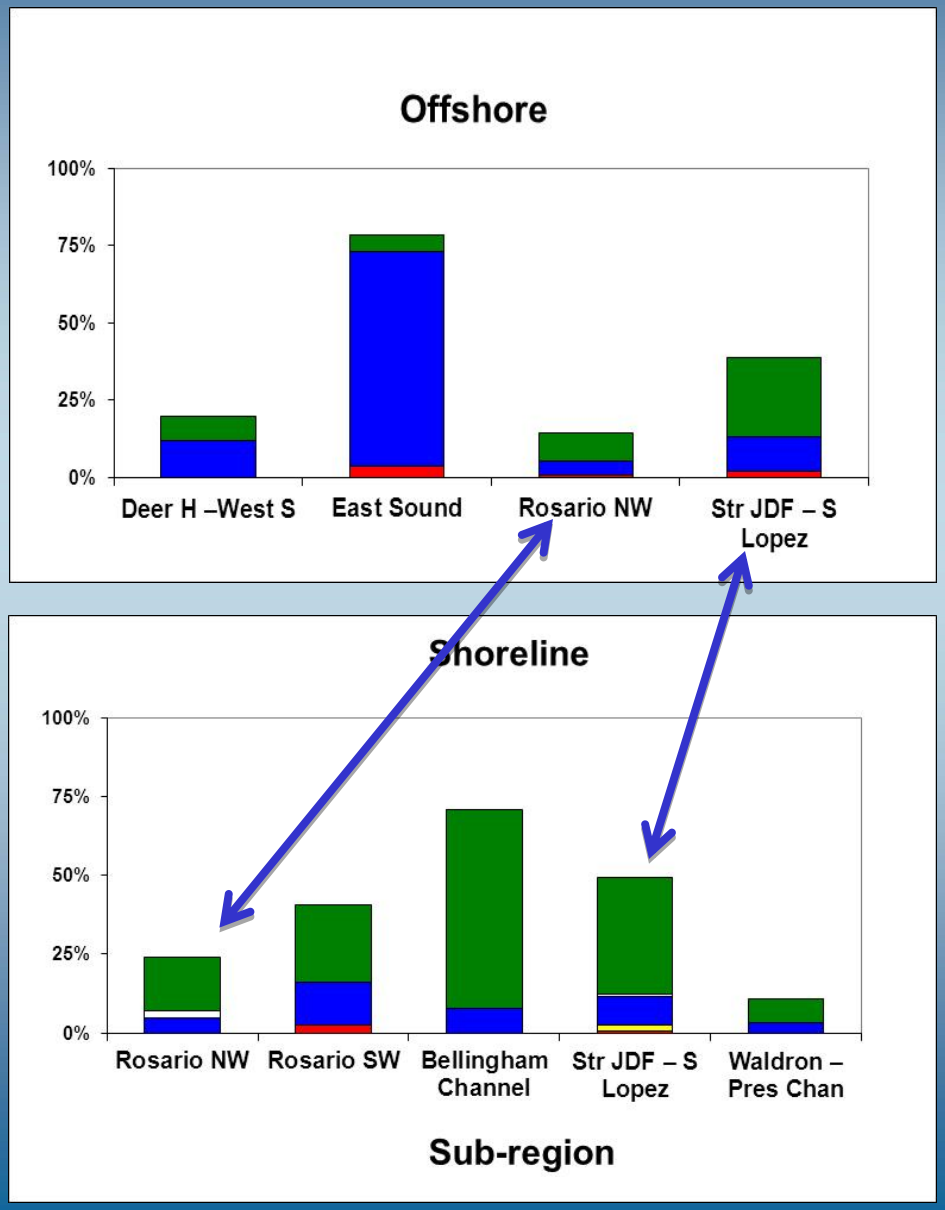


Sub-region Stock Proportions by Habitat
British Columbia Stocks Only



Sub-region Stock Proportions by Habitat

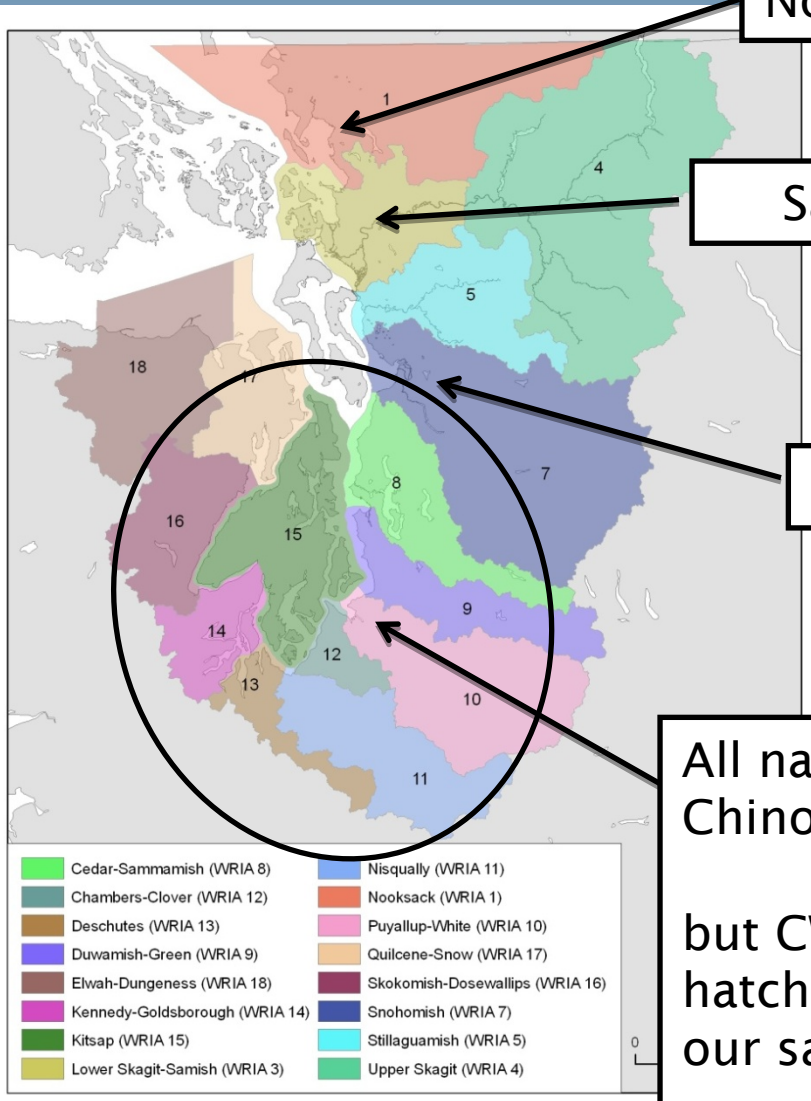
Washington Stocks Only



What are the sources of the South Sound Fall stock in these samples?

- Whidbey Basin
- Strait of Juan de Fuca
- South Sound Fall and Hood Canal
- Olympic Peninsula
- Nooksack River

Sources of Natural Production of South Sound / Hood Canal Fall Stock



Nooksack R fall

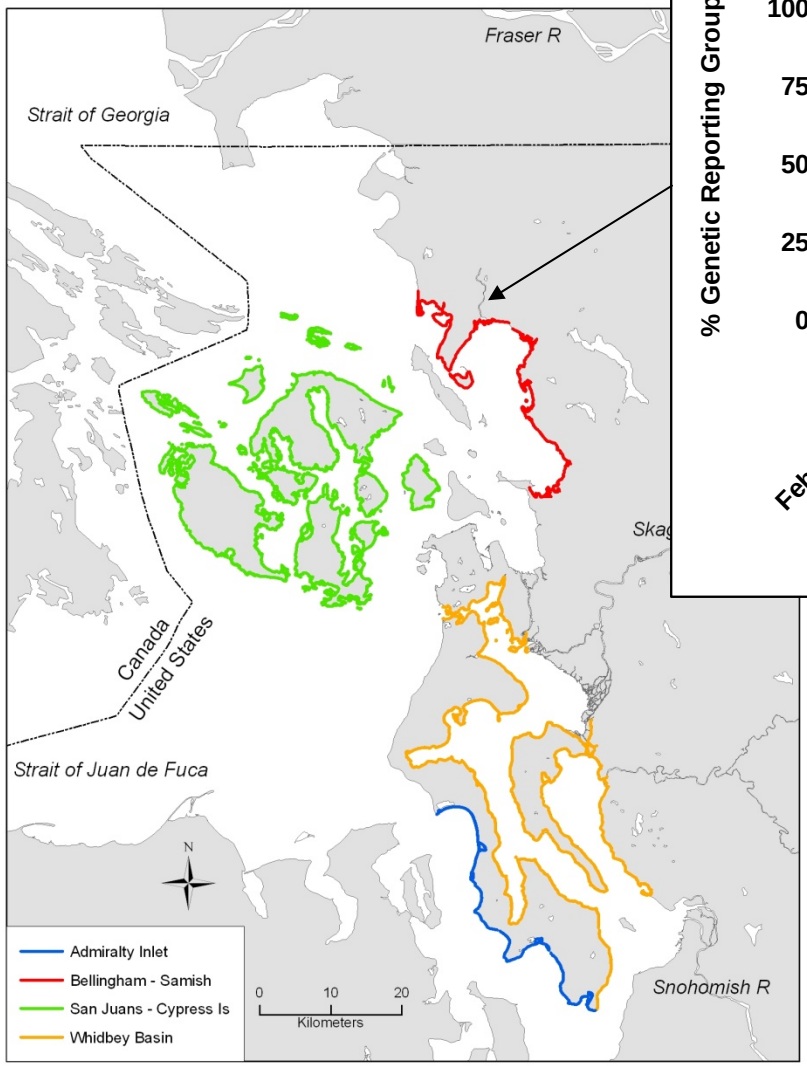
Samish R fall

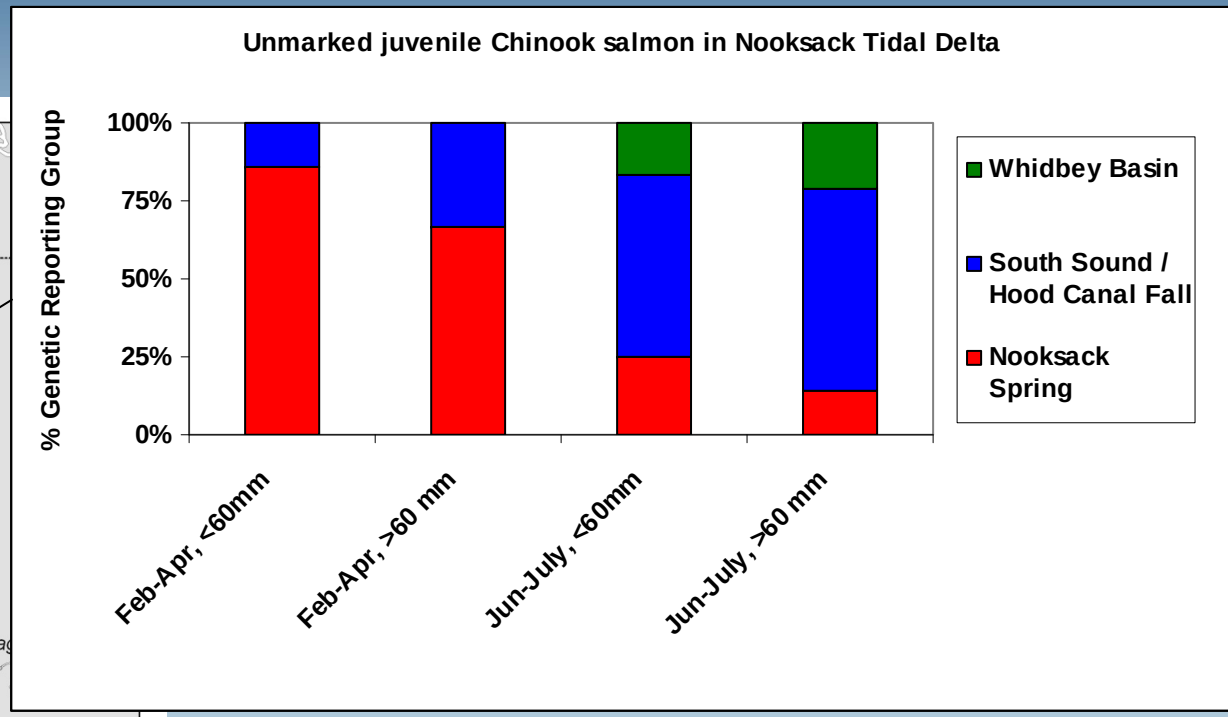
Snoqualmie R fall

All natural production of fall Chinook in these WRIAs;

but CWT data shows almost no hatchery fish from these areas in our samples

Origin of unmarked juvenile Chinook in the Nooksack Tidal Delta

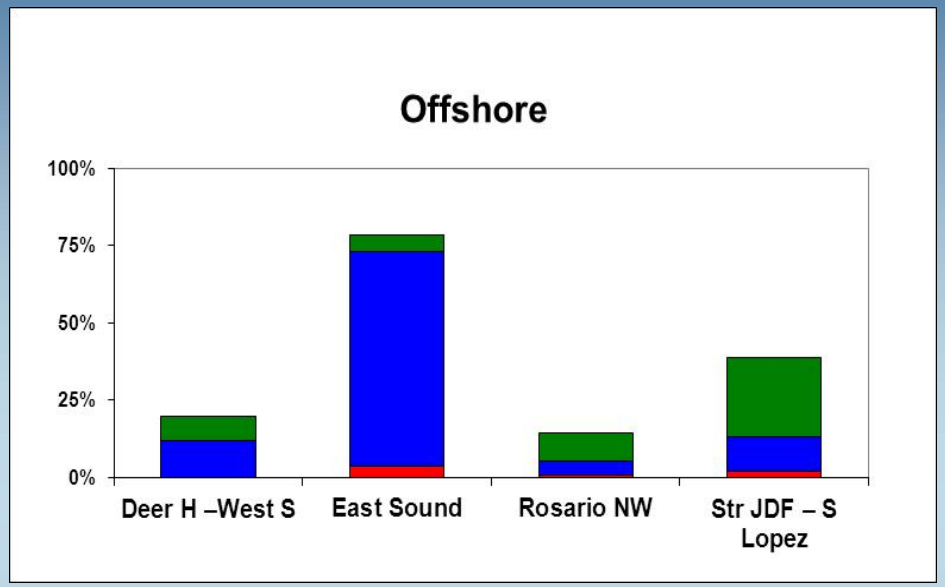


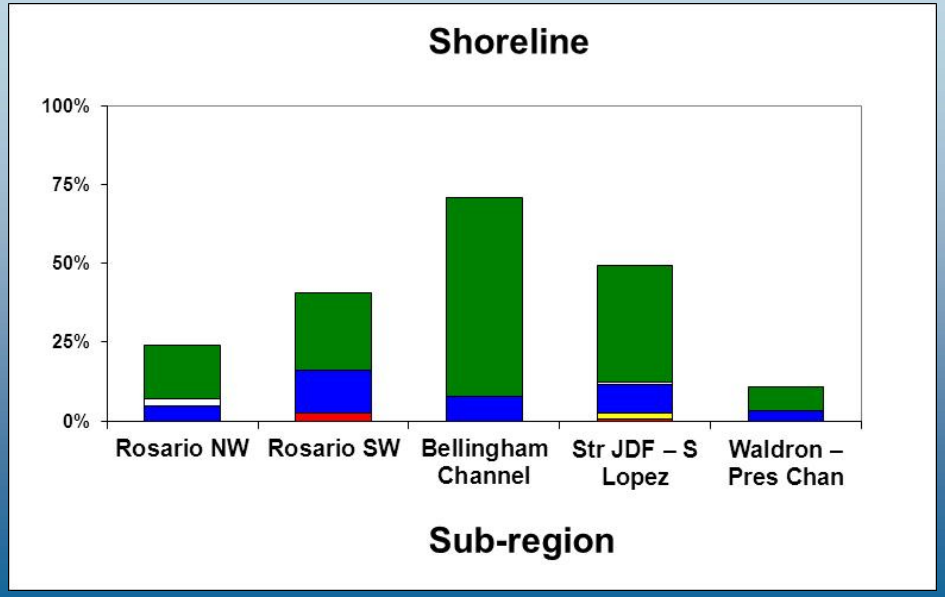


- South Sound / Hood Canal genetics are present in wild (or natural origin) fish within the Nooksack River Basin

Sub-region Stock Proportions by Habitat

Washington Stocks Only





What are the hatchery sources of the South Sound Fall stock in these samples?

- **Whidbey Basin**
- **Strait of Juan de Fuca**
- **South Sound Fall and Hood Canal**
- **Olympic Peninsula**
- **Nooksack River**

Genetic Stock and Unmarked Rate of 2008 and 2009 Hatchery Releases in Puget Sound

South Sound Fall
31.5% - 0.0%

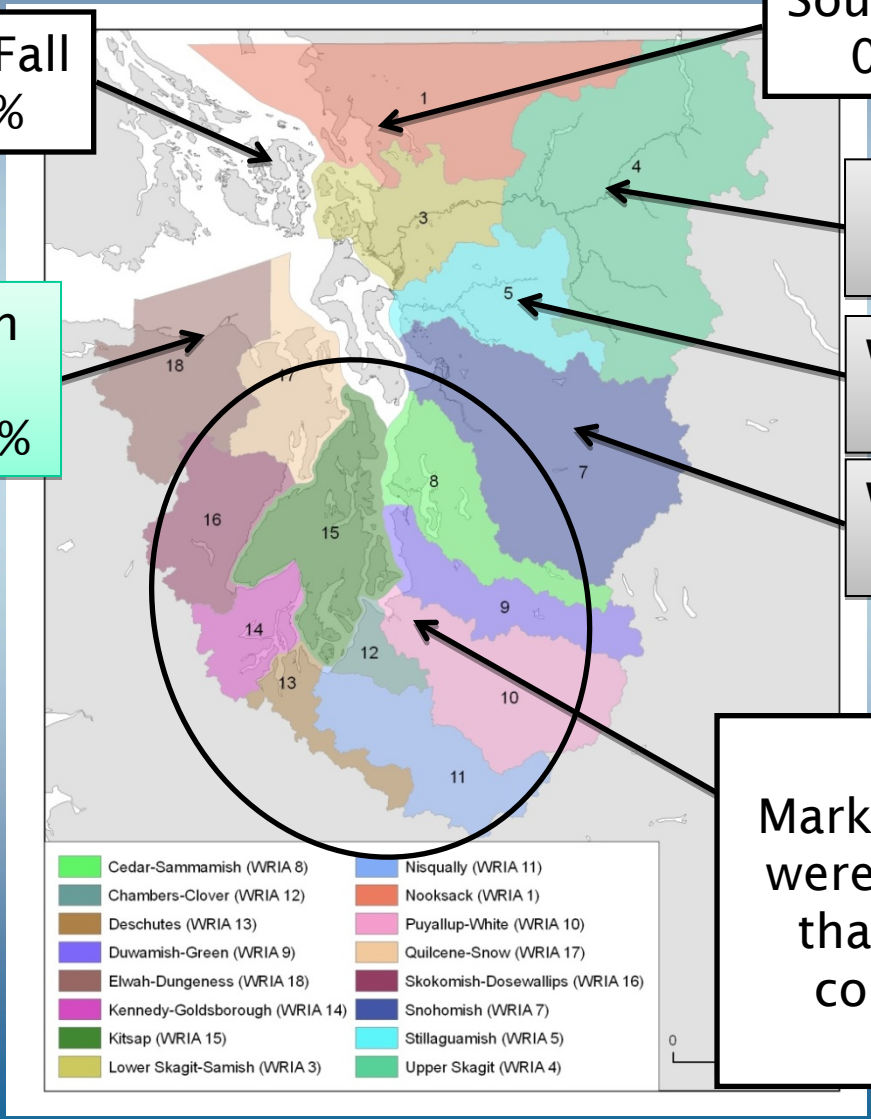
South Sound Fall
0.1% - 0.4%

Whidbey Basin
0.5% - 0.0%

Strait of Juan de Fuca
73.1% - 78.6%

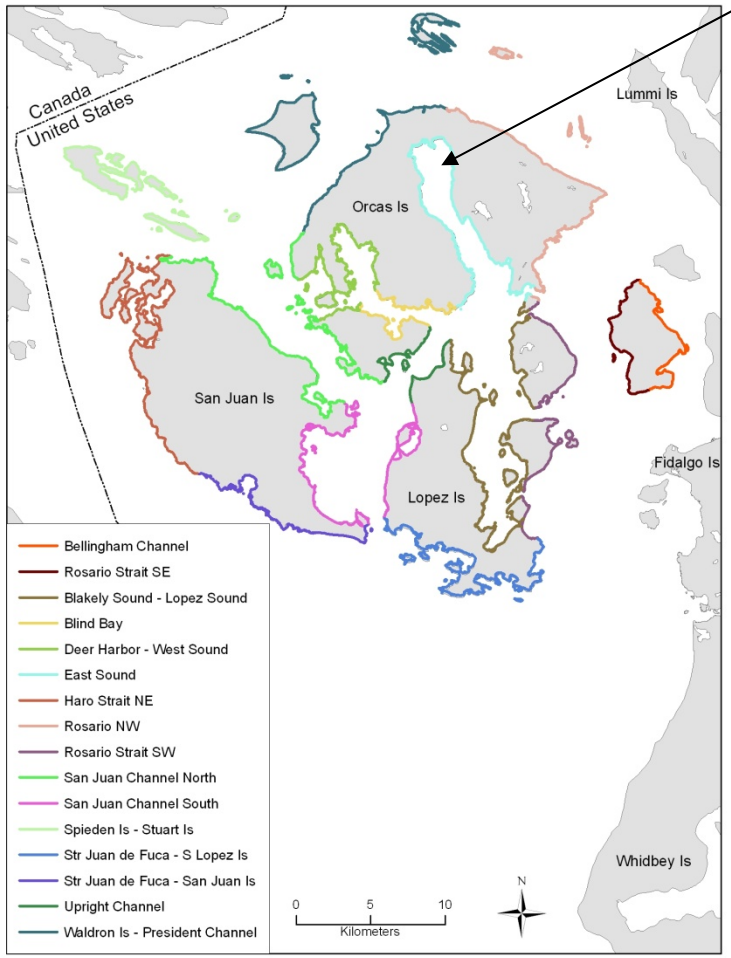
Whidbey Basin
0.0%- 0.2%

Whidbey Basin
10.8% - 11.7%



South Sound Fall
Marking rates for these WRIAs were variable. CWTs indicate that these releases did not contribute to our catches

Hatchery releases within East Sound are South Sound Fall / Hood Canal Genetics

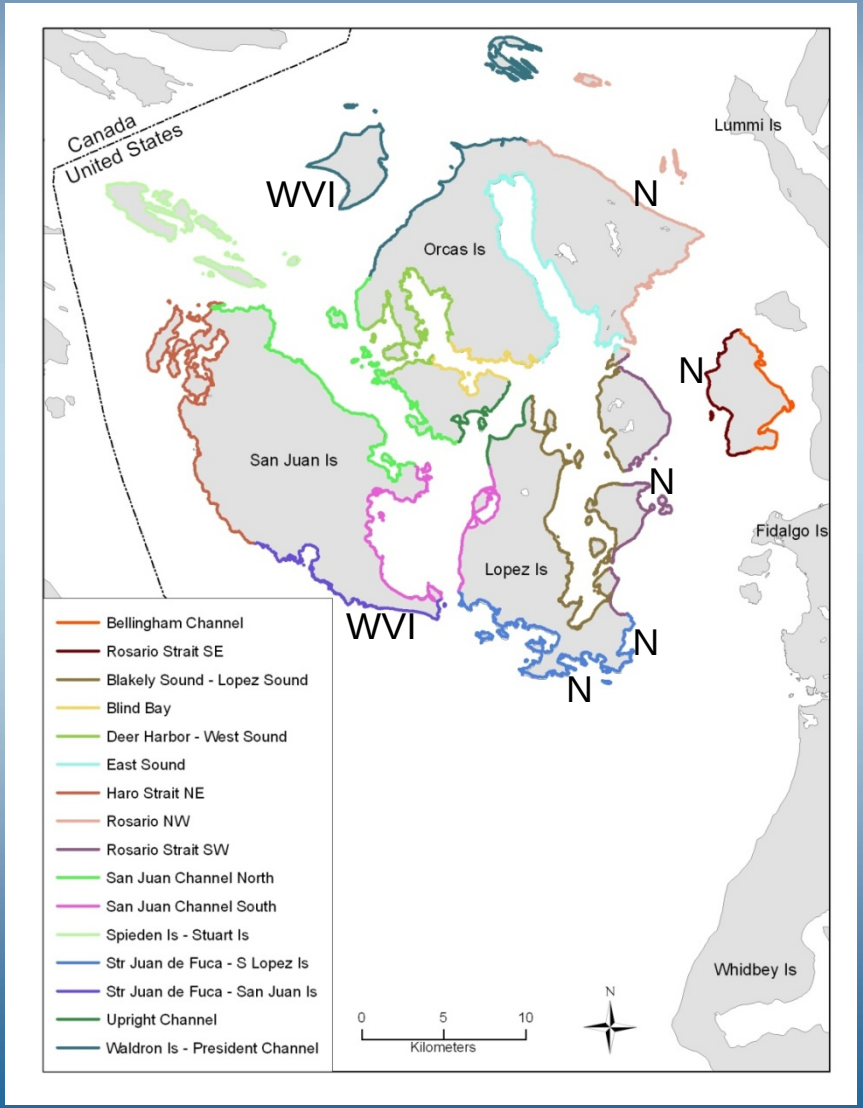


Reported Chinook Releases (RMIS):

- **Year 2008: 571,076 (180,000 not marked)**
- **Year 2009: 565,829 (0 not marked)**

- Unmarked hatchery releases from East Sound were a source of South Sound Fall / Hood Canal genetics found in the San Juan's in 2008 but not 2009

Capture Locations of “Rare” Stocks



<u>Nooksack spring run</u>
(A low abundance population)

Rosario NW
Rosario SE
Rosario SW
Str Juan de Fuca – S Lopez

<u>West Vancouver Island stock</u>
(Only evidence of migration from the west)

Waldron – President Channel
Str Juan de Fuca – San Juan Is

Conclusions

- Origins of juvenile Chinook salmon in San Juan Islands nearshore marine habitats are different than in other North Puget Sound Regions

- San Juan Islands have a diverse group of stocks

- Juveniles are primarily from Fraser River, East Vancouver Island, Whidbey Basin, and Nooksack / Samish

- Very few BC hatchery fish are marked; our samples likely contain Canadian hatchery fish

- The contribution of fish from South Puget Sound sources is likely minimal

  The absence of CWTs from South Sound and the legacy of stock transfers indicate that fish identified as South Sound fall are from sources such as Samish (H or R), Nooksack R falls and Glenwood Springs Hatchery

Conclusions continued

- Nooksack spring run fish (a low abundance population) were detected in our samples from eastern Sub-regions

- Little evidence of fish from western sources; but we identified a few from West Vancouver Island

- Several stock groups were not detected (no individuals ID'd with high probability)

  Olympic Peninsula, Strait of Juan de Fuca, South Sound spring run

  South BC Mainland, Lower Fraser spring run

- Origins of juvenile Chinook salmon in the San Juan Islands nearshore marine habitats are not uniform across sub-regions or habitats (offshore vs shoreline)

Acknowledgements

Collection of samples for genetic analysis

Thanks to all who contributed to the sampling effort!

Russel Barsh, Madrona Murphy, Anne Beaudreau, Anne Harmann, and Audrey Thompson from Kwiaht: Center for the Historical Ecology of the Salish Sea provided tissue samples from their collections.

GAPS Genetic Baseline

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John Candy

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