Alaska Hatchery Research Program: Study Question 1: Population Structure

Sara Gilk-Baumer

Gene Conservation Laboratory

Alaska Department of Fish and Game

BOF Hatchery Committee Meeting

March 23, 2022

Outline

- Background
- Chum results
- Pink results

Alaska Hatchery Research Program

1) What is the genetic structure of pink and chum in PWS and SEAK?
2) What is the extent and annual variability of straying?
3) What is the impact on fitness (productivity) of natural pink and chum stocks due to straying hatchery pink and chum salmon?

Understanding Genetic Structure

- Differences between populations:
  - Influenced by: selection, mutation, genetic drift, migration

Understanding Genetic Structure

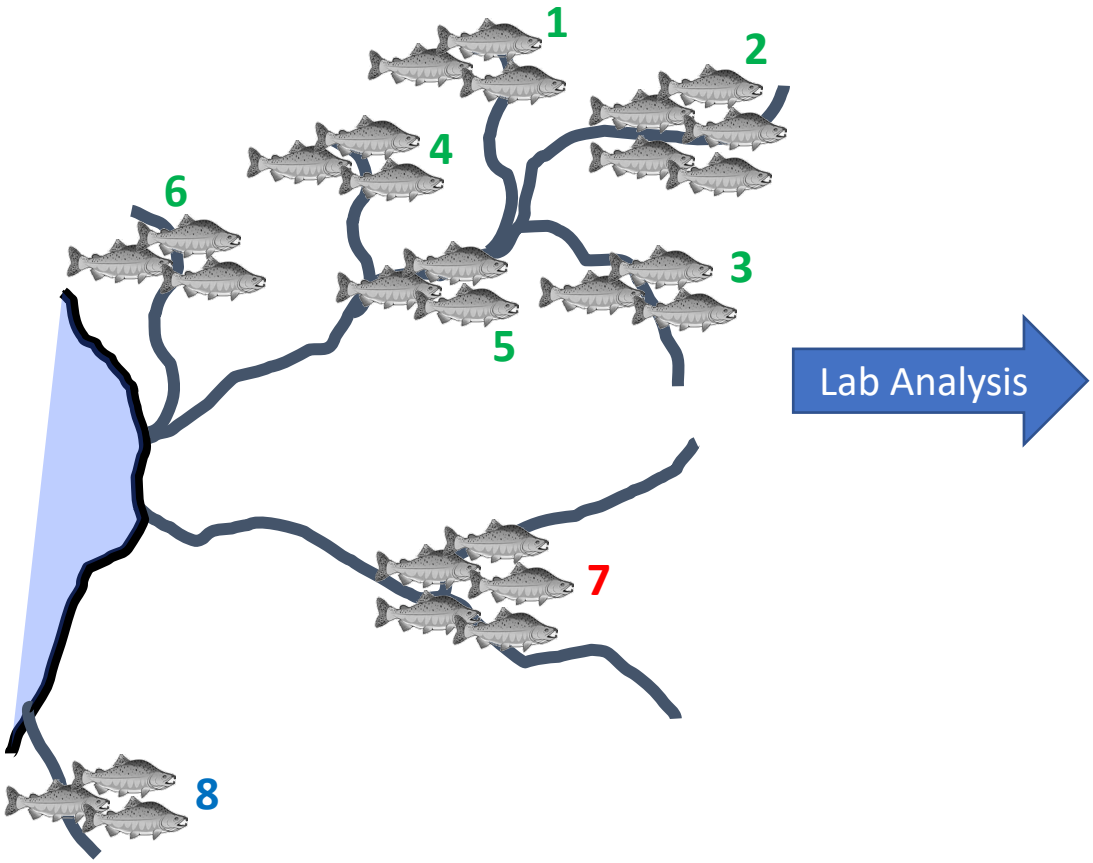
- Differences between populations:
  - Influenced by: selection, mutation, *genetic drift*, *migration*

genetic drift ~ ***homing***

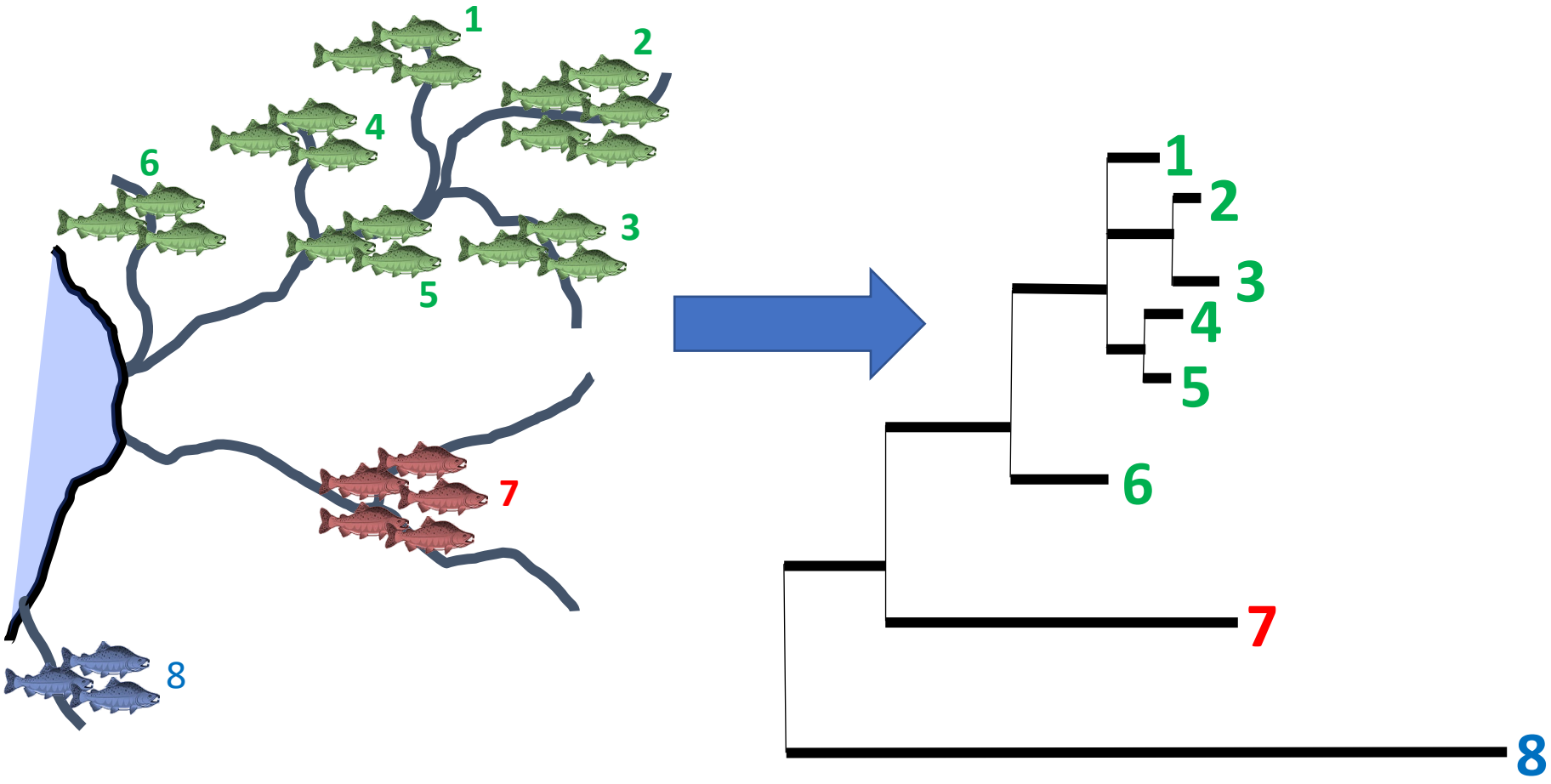
migration ~ ***straying***

    - *Measuring the <u>balance</u> between these within a species across an area*
  - Measured by quantifying pairwise genetic differences
  - Visualize using genetic trees

Population Structure: An example



Population Structure: An example



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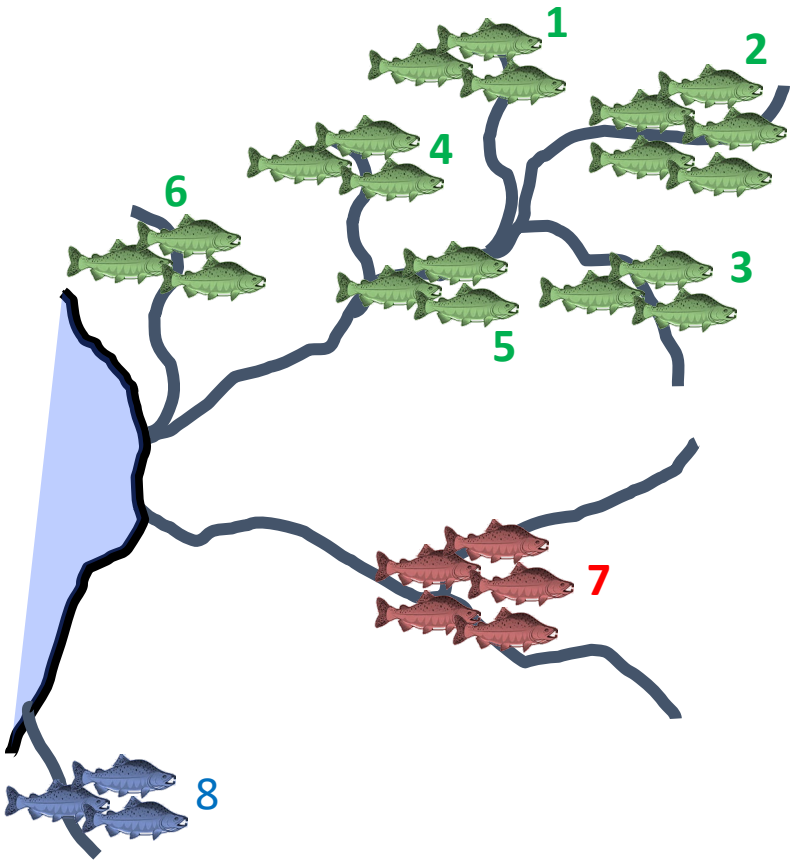
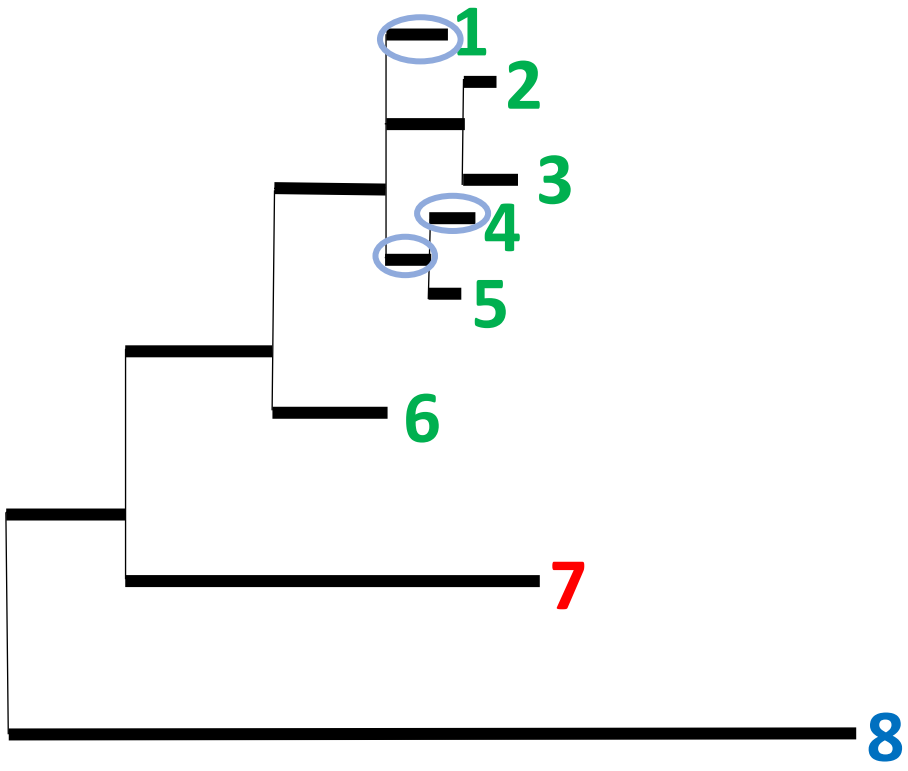
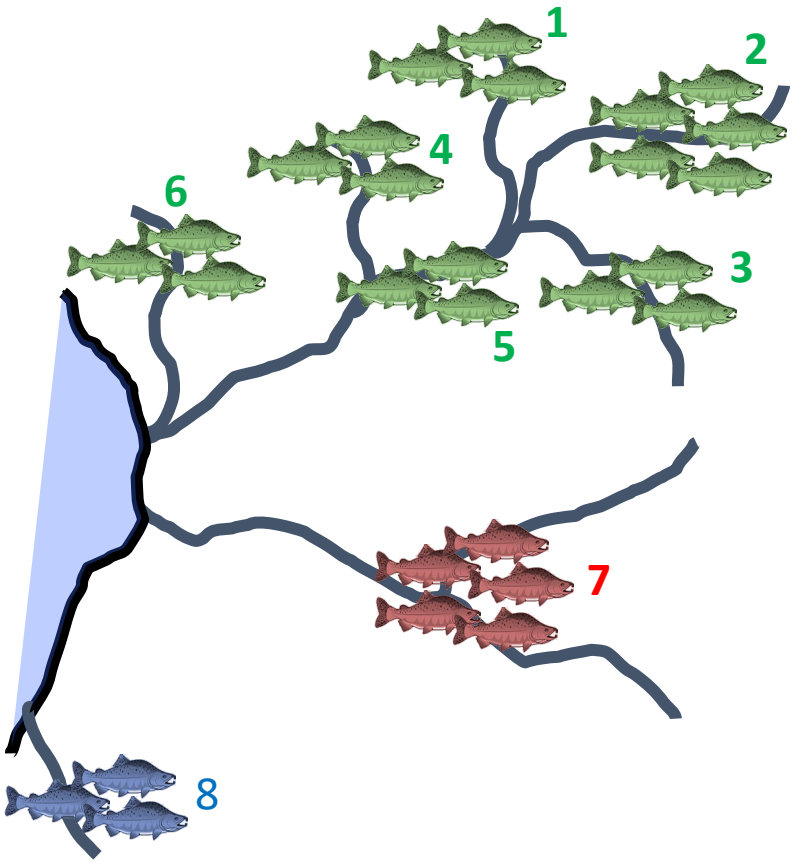
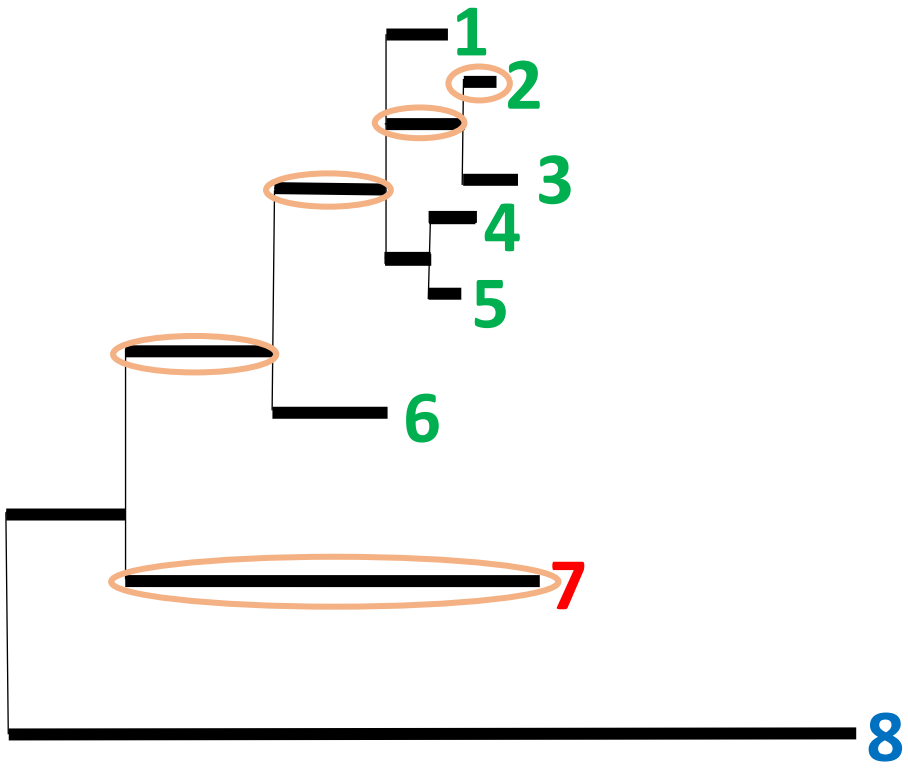




Difference between 1 and 4: ▬ + ▬ + ▬ = ▬▬

Population Structure: An example

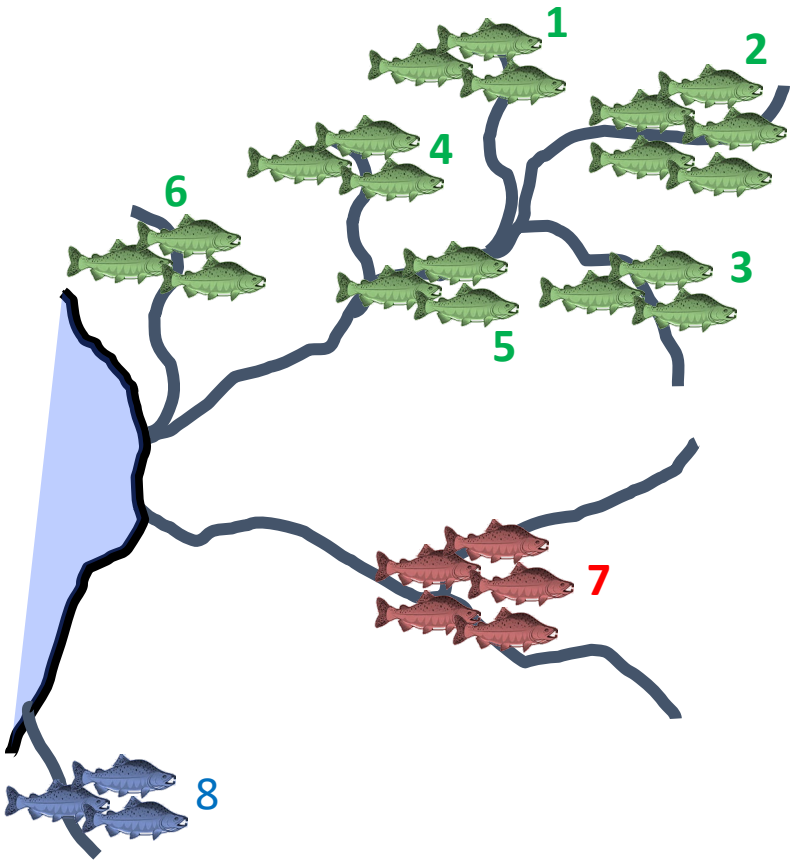


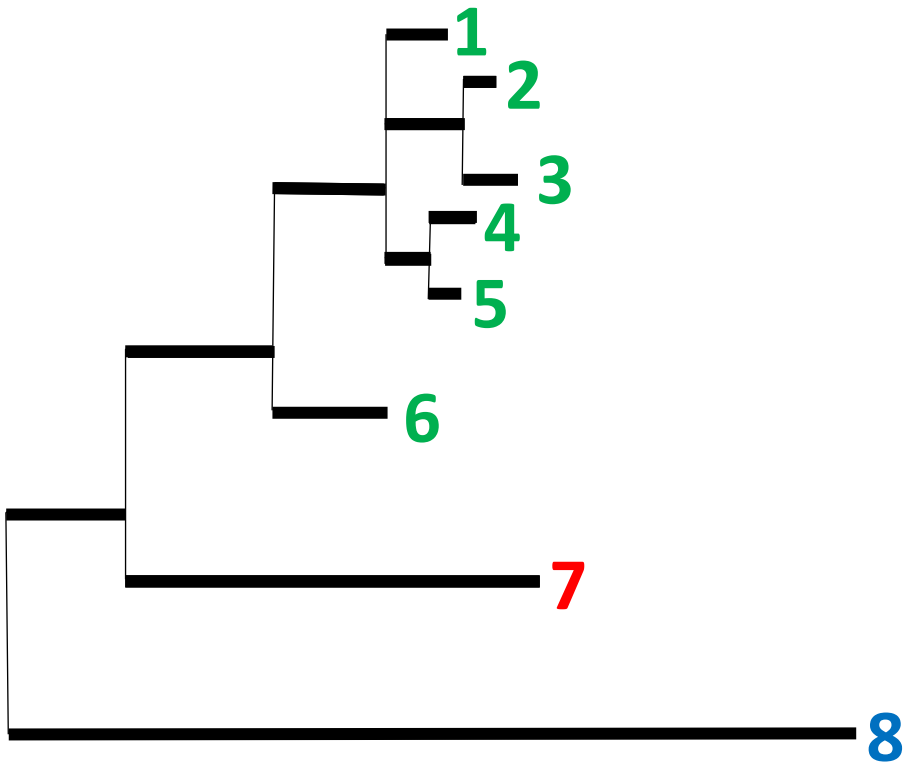


Difference between 1 and 4:

Difference between 2 and 7:

Population Structure: An example





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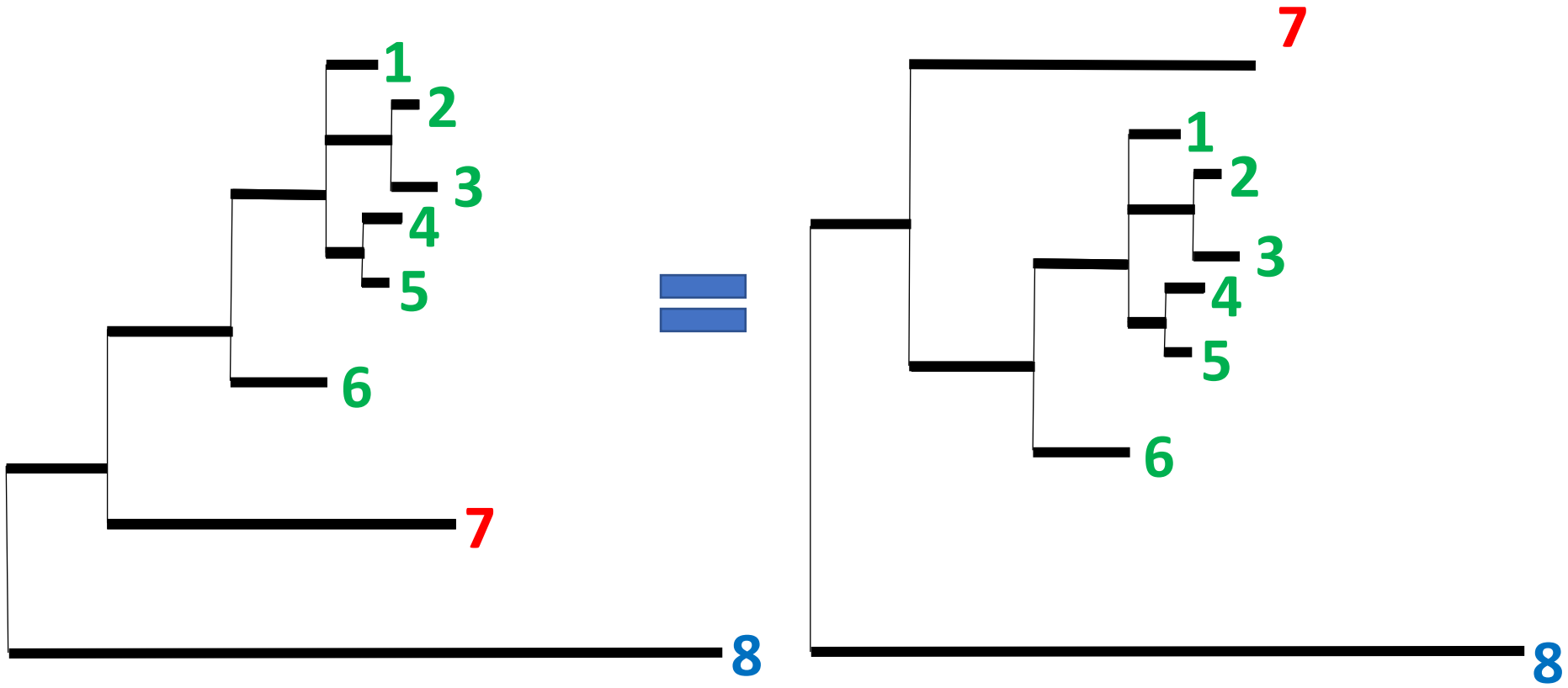
Population Structure: An example



Population structure of chum salmon in Prince William Sound and Southeast Alaska

Sara Gilk-Baumer, Chris Habicht, Andy Barclay, William Templin

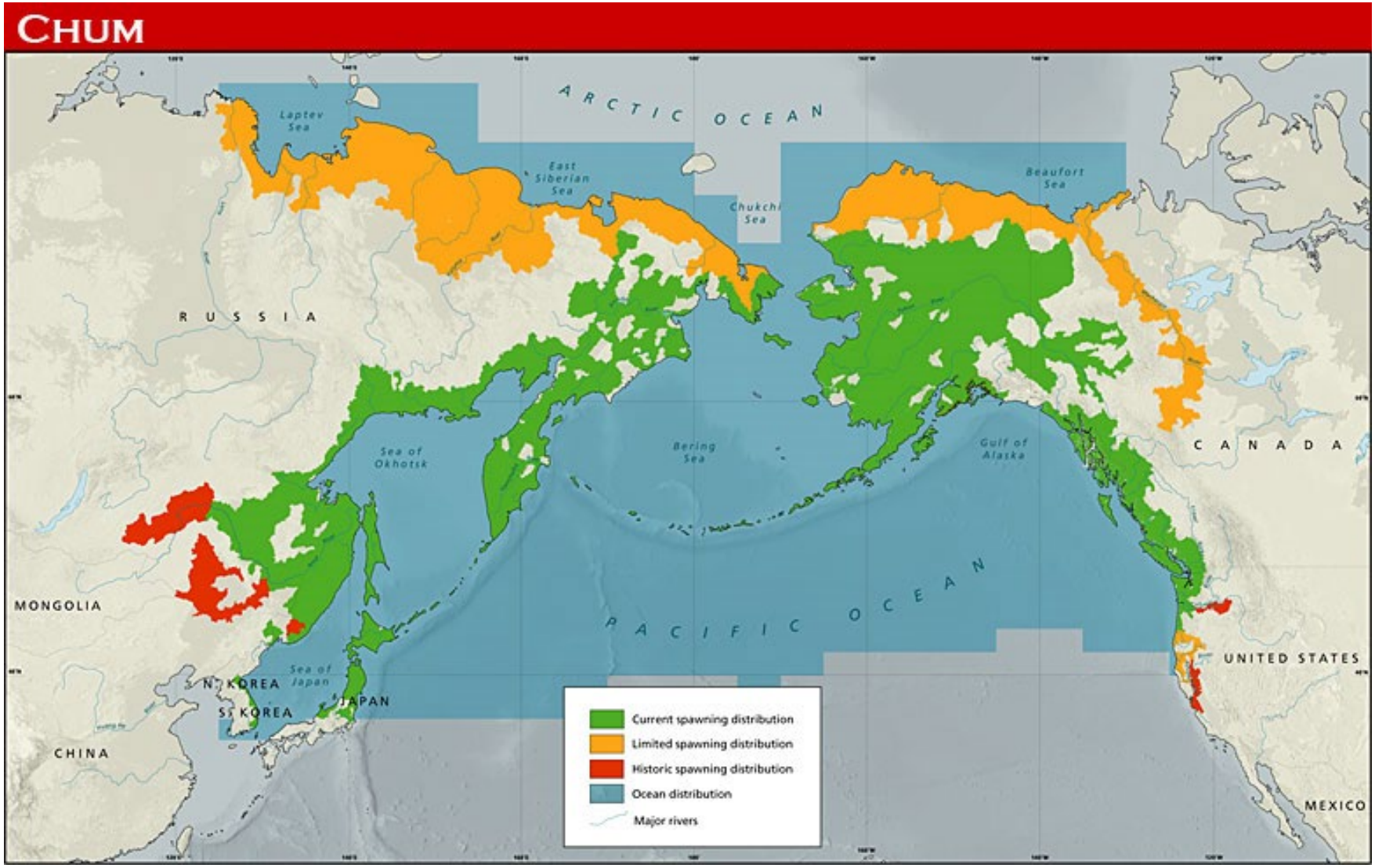
Gene Conservation Laboratory

Alaska Department of Fish and Game

Life History of Chum Salmon

- Migrate as juveniles to ocean
- Typically 2-4 years spent at sea
- Two run timings: summer & fall

Distribution of Chum Salmon



http://www.salmonnation.org/fish/meet_species.html

Previous work (a sampling)

Determining Continent of Origin of Chum Salmon (*Oncorhynchus keta*) Using Genetic Stock Identification Techniques: Status of Allozyme Baseline in Asia

Gary A. Winans and Paul B. Aebersold
Northwest Fisheries Science Center, National Marine Fisheries Service, Seattle, WA 98112-2097, USA
Shigehiko Urawa
Hokkaido Salmon Hatchery, Fisheries Agency of Japan, Sapporo 062, Japan
and Nataly V. Varnavskaya
Kamchatka-TINRO, Petropavlovsk, Russia

Population structure and stock identification of chum salmon (*Oncorhynchus keta*) from British Columbia determined with microsatellite DNA variation

Terry D. Beacham, Brian Spilsted, Khai D. Le, and Michael Wetklo

Genetic Relationships Among Chum Salmon Populations in Southeast Alaska and Northern British Columbia

C.M. Kondzela, C.M. Guthrie, S.L. Hawkins, C.D. Russell, and J.H. Helle
Auke Bay Laboratory, Alaska Fisheries Science Center, National Marine Fisheries Service, National Oceanographic and Atmospheric Administration, 11305 Glacier Highway, Juneau, AK 99801-8626, U.S.A.
and A.J. Gharrett
School of Fisheries and Ocean Sciences, University of Alaska Fairbanks, 11120 Glacier Highway, Juneau, AK 99801, U.S.A.

Microsatellite Stock Identification of Chum Salmon on a Pacific Rim Basis

TERRY D. BEACHAM,* JOHN R. CANDY, AND C. WALLACE
Fisheries and Oceans Canada, Pacific Biological Station, 3190 Hammond Bay Road, Nanaimo, British Columbia V9T 6N7, Canada
SHIGEHIKO URAWA[1] AND SHUNPEI SATO
National Salmon Resources Center, Fisheries Research Agency, Toyohira-ku, Sapporo 062-0922, Japan
NATALIA V. VARNAVSKAYA
Kamchatka Fishery and Oceanography Research Institute, 18 Naberezhnaya Street; Petropavlovsk-Kamchatsky 683000, Russia
KHAI D. LE AND MICHAEL WETKLO
Fisheries and Oceans Canada, Pacific Biological Station, 3190 Hammond Bay Road, Nanaimo, British Columbia V9T 6N7, Canada

Environmental Biology of Fishes **69**: 37–50, 2004.

Chum Salmon Genetic Diversity in the Northeastern Pacific Ocean Assessed with Single Nucleotide Polymorphisms (SNPs): Applications to Fishery Management

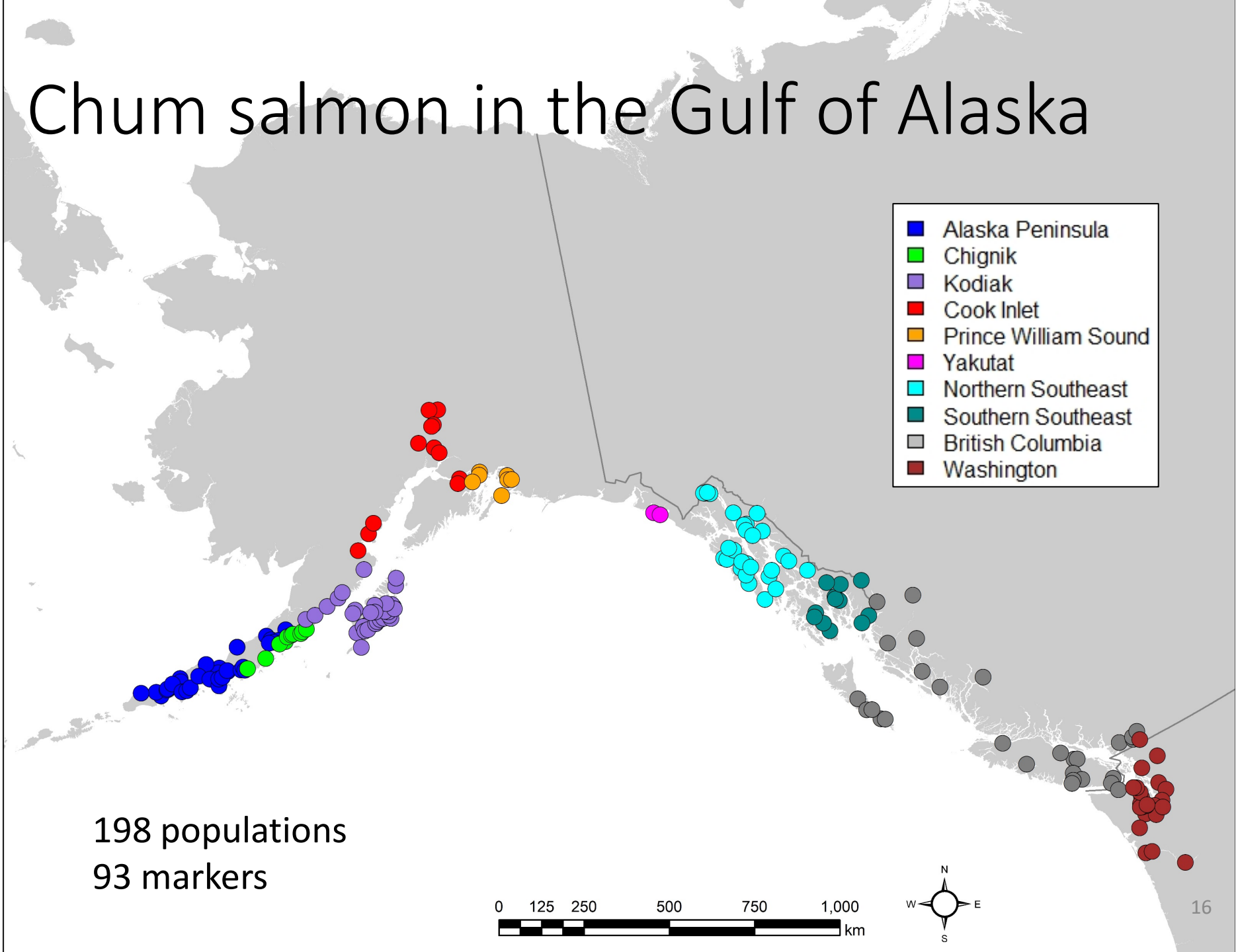
Maureen P. Small*
Washington Department of Fish and Wildlife, Molecular Genetics Lab, 1111 Washington Street Southeast, Olympia, Washington 98501, USA
Serena D. Rogers Olive
Alaska Department of Fish and Game, Division of Commercial Fisheries, Gene Conservation Laboratory, 333 Raspberry Road, Anchorage, Alaska 99518, USA
Lisa W. Seeb, James E. Seeb, and Carita E. Pascal
School of Aquatic and Fishery Sciences, University of Washington, 1122 Northeast Boat Street, Box 355020, Seattle, Washington 98195, USA
Kenneth I. Warheit
Washington Department of Fish and Wildlife, Molecular Genetics Lab, 1111 Washington Street Southeast, Olympia, Washington 98501, USA; and School of Aquatic and Fishery Sciences, University of Washington, 1122 Northeast Boat Street, Box 355020, Seattle, Washington 98195, USA
William Templin
Alaska Department of Fish and Game, Division of Commercial Fisheries, Gene Conservation Laboratory, 333 Raspberry Road, Anchorage, Alaska 99518, USA

Genetic population structure of chum salmon in the Pacific Rim inferred from mitochondrial DNA sequence variation

Shunpei Sato[a], Hiroyuki Kojima[b], Junko Ando[a], Hironori Ando[a], Richard L. Wilmot[c], Lisa W. Seeb[d], Vladimir Efremov[e], Larry LeClair[f], Wally Buchholz[g], Deuk-Hee Jin[h], Shigehiko Urawa[i], Masahide Kaeriyama[b], Akihisa Urano[a,j] & Syuiti Abe[k,l]
[a]*Division of Biological Science, Graduate School of Science, Hokkaido University, Sapporo 060-0810, Japan*
[b]*Graduate School of Science and Engineering, Hokkaido Tokai University, Sapporo 005-8601, Japan*
[c]*Auke Bay Laboratory, Alaska Fisheries Science Center, NOAA, Juneau, U.S.A.*
[d]*Alaska Department of Fish and Game, Anchorage, U.S.A.*
[e]*Russian Academy of Science, Vladivostok, Russia*
[f]*Washington Department of Fish and Wildlife, Olympia, Washington, U.S.A.*
[g]*U.S. Fish and Wildlife Service, Anchorage, AK, U.S.A.*
[h]*Kangnung National University, Kangnung, Korea*
[i]*Salmon Resources Center, Sapporo 062-0922, Japan*
[j]*Field Science Center, Hokkaido University, Sapporo 060-0811, Japan*
[k]*Laboratory of Animal Cytogenetics, Center for Advanced Science and Technology, Hokkaido University, Sapporo 060-0810, Japan (e-mail: sabe@ees.hokudai.ac.jp)*
[l]*Laboratory of Breeding Science, Graduate School of Fisheries Sciences, Hokkaido University, Hakodate 041-8611, Japan*

Received 17 April 2003 Accepted 27 April 2003

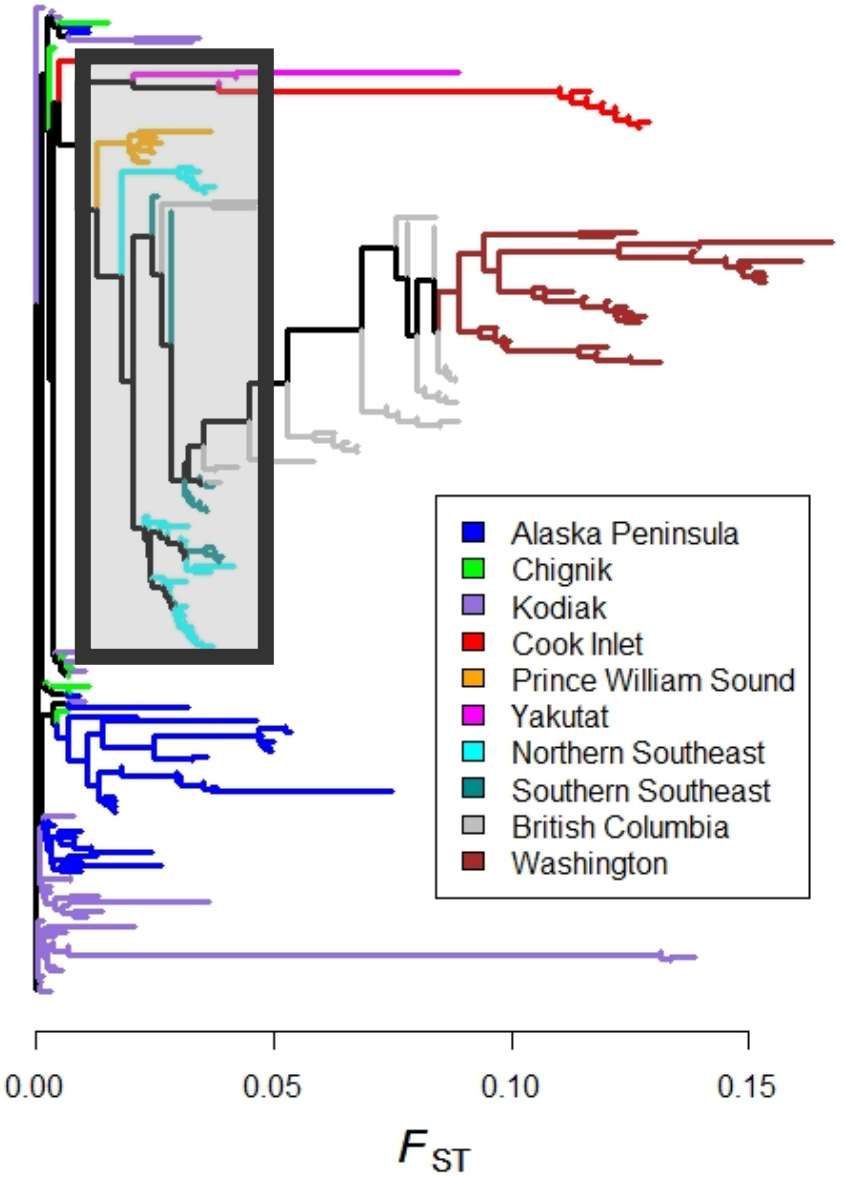
Chum salmon in the Gulf of Alaska



198 populations
93 markers

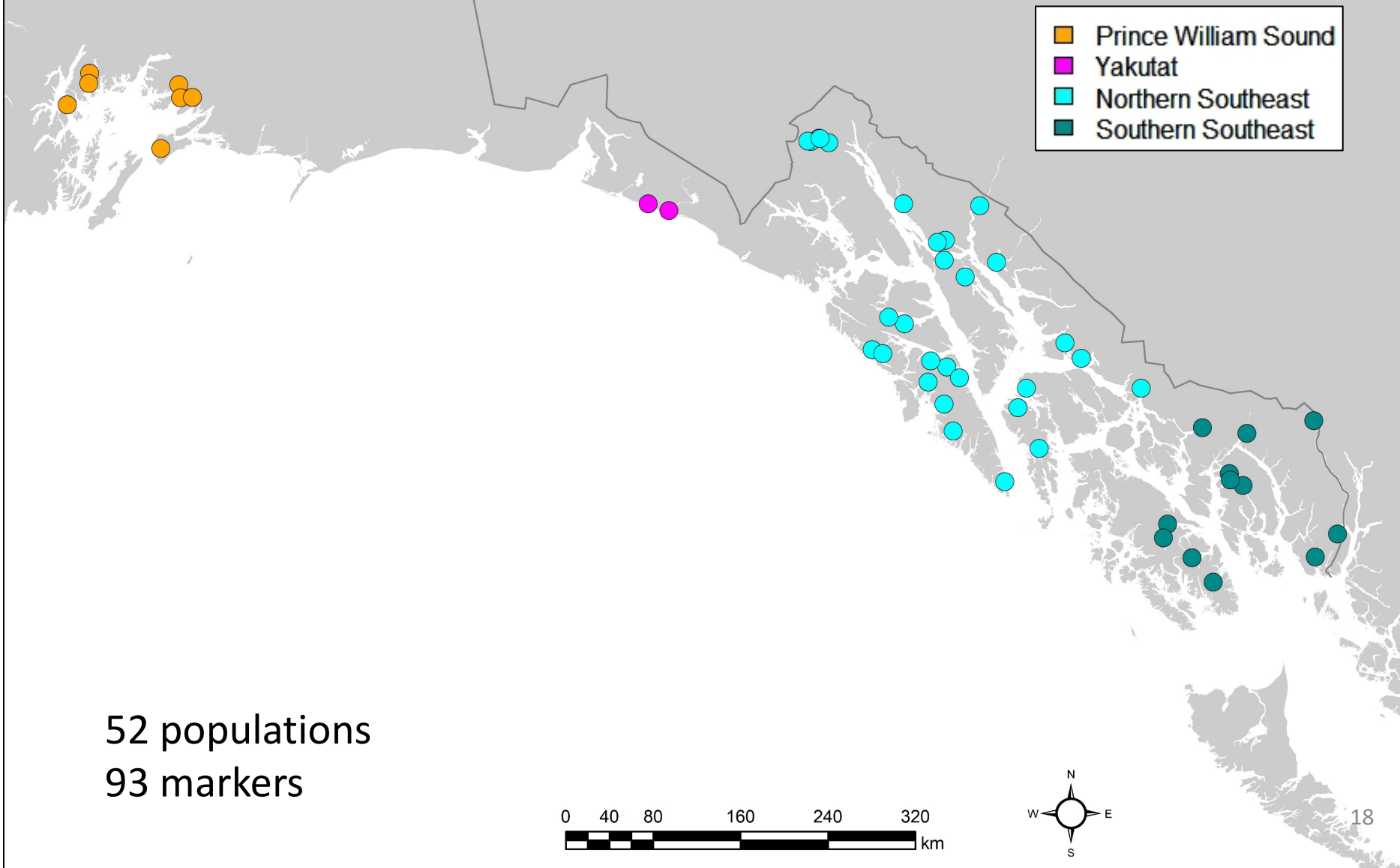
Chum salmon in the Gulf of Alaska

198 populations
93 markers



PWS to SEAK

Chum salmon in PWS and SEAK



52 populations
93 markers

Chum salmon in PWS and SEAK

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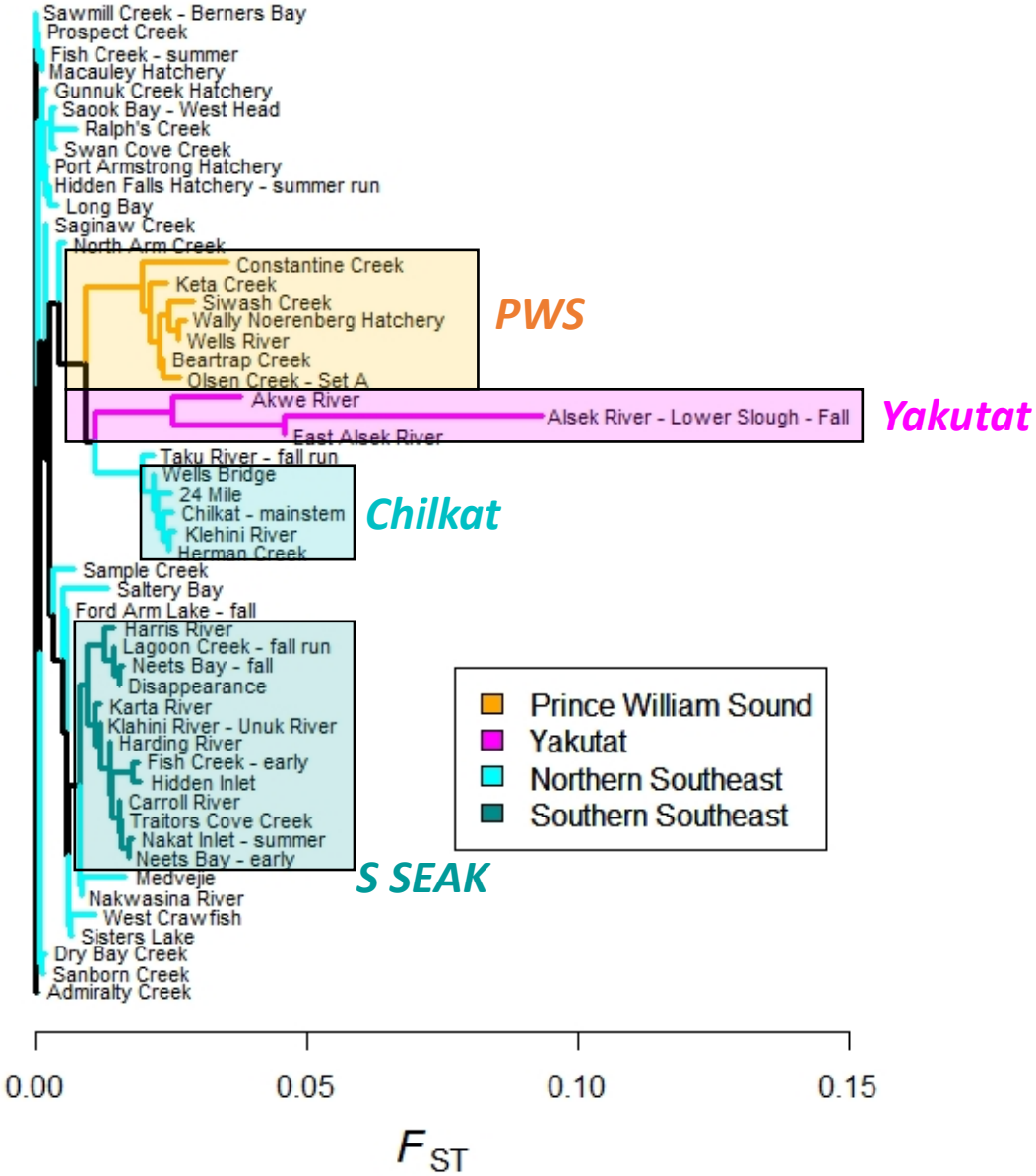
93 markers



Chum salmon in PWS and SEAK

52 populations
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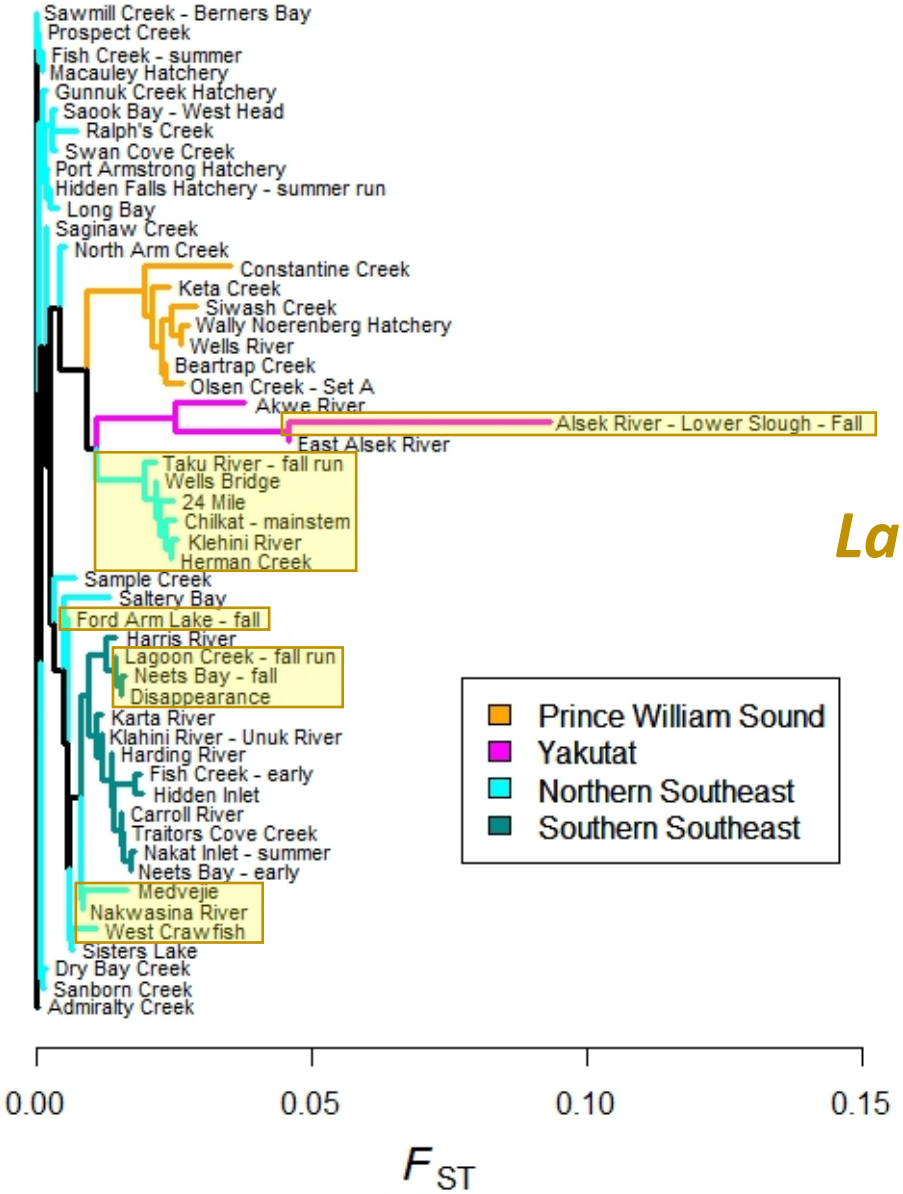


Late run timing

Conclusions: Chum salmon structure in AHRP study area

- Generally correlated with geography
- Some differentiation by run timing
- Similar to other studies

J. Hyde

Contemporary Population Structure of Pink Salmon from Prince William Sound, Alaska

Wei Cheng[1,2], Christopher Habicht[1], William D. Templin[1], Zachary D. Grauvogel[1], and Anthony J. Gharrett[2]

[1]Alaska Department of Fish and Game Gene Conservation Laboratory

[2]University of Alaska Fairbanks
College of Fisheries and Ocean Sciences

Alaska Hatchery Research Program Informational Meeting
March 9, 2022

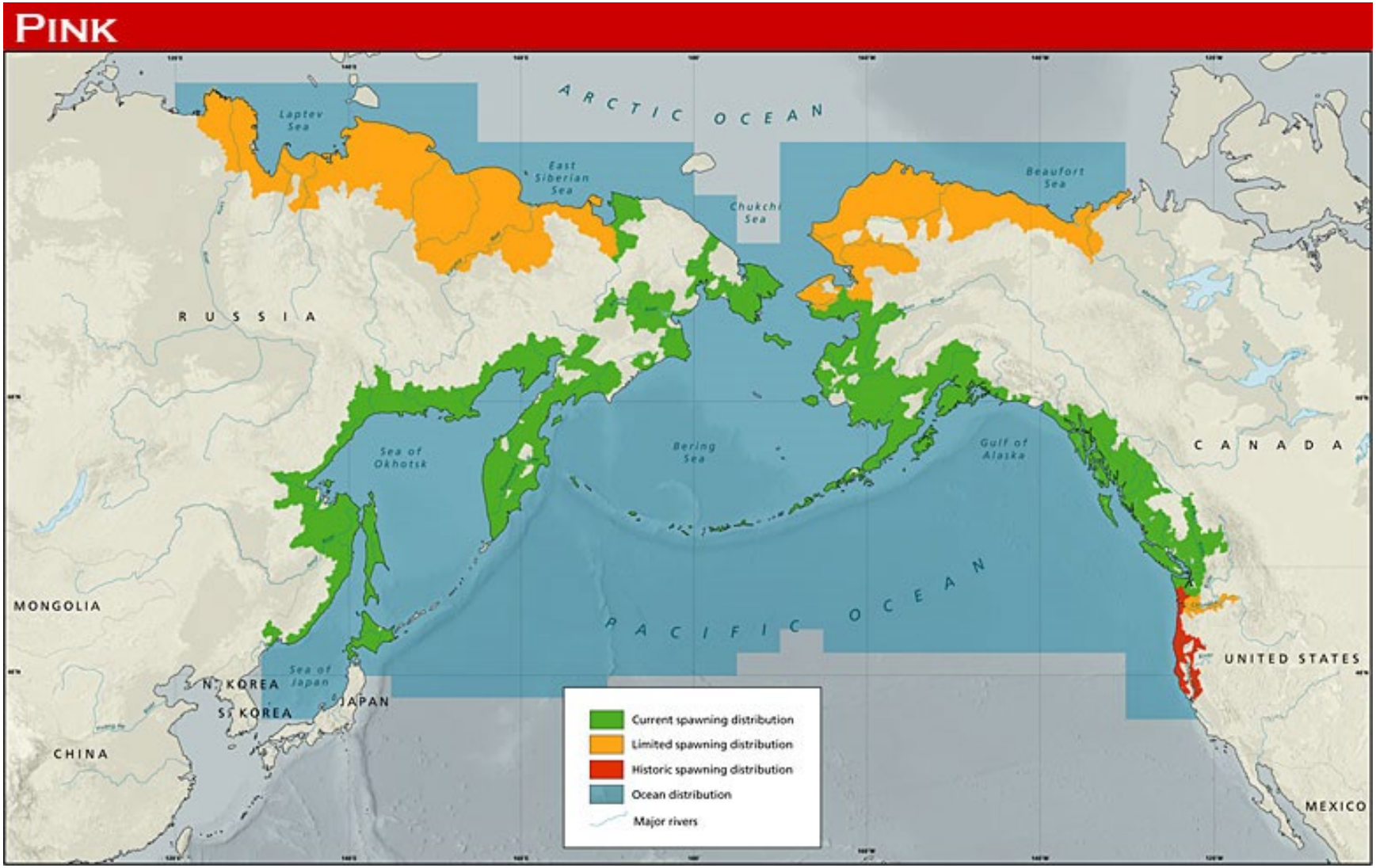
Life History of Pink Salmon

- Two-year life cycle
  - Odd year
  - Even year

- Limited freshwater life history

https://www.n-sea.org/pink-salmon

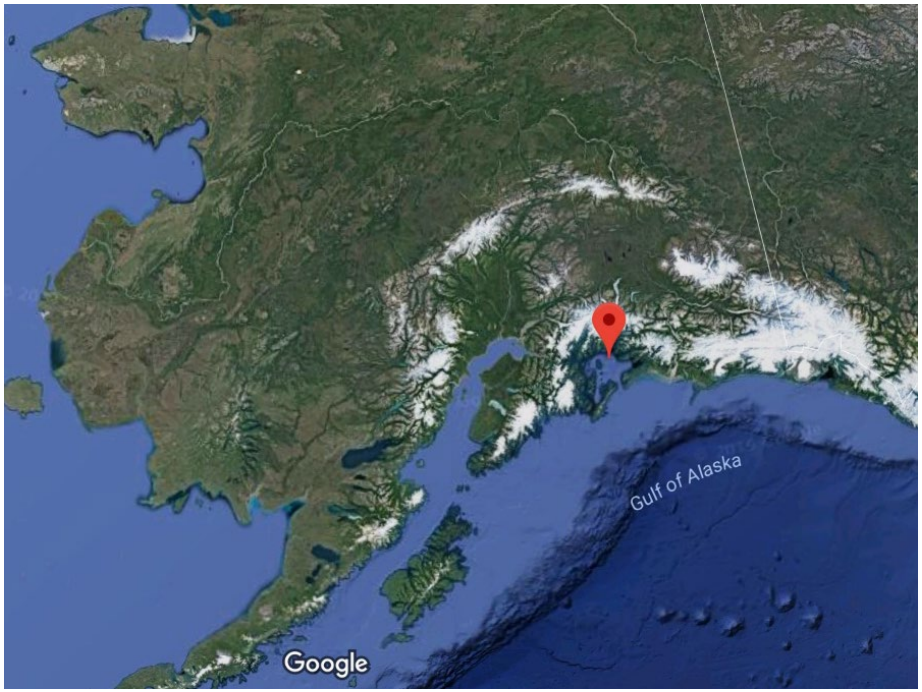
Distribution of Pink Salmon



http://www.salmonnation.org/fish/meet_species.html

PWS Pink Salmon

- **Over 800 streams in Prince William Sound (PWS)**
- **Variation in run timing**



Variability in spawning habitat

Previous Studies

Genetic Characterization of Prince William Sound
Pink Salmon Populations

Report
to
Alaska Department of Fish and Game
Feb. 15, 1977
by
Jim Seeb
and
Lisa Wishard

INFORMATIONAL LEAFLET NO. 181

SEPARATION OF SOME PINK SALMON (Oncorhynchus gorbuscha Walbaum) SUB-POPULATIONS IN PRINCE WILLIAM SOUND, ALASKA BY LENGTH-WEIGHT RELATIONSHIPS AND HORIZONTAL STARCH GEL ELECTROPHORESIS

By
Richard B. Nickerson

Ecology of Freshwater Fish 1999: 8: 122–140
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ECOLOGY OF FRESHWATER FISH
ISSN 0906-6691

Allozyme and mitochondrial DNA variation describe ecologically important genetic structure of even-year pink salmon inhabiting Prince William Sound, Alaska

Seeb JE, Habicht C, Templin WD, Seeb LW, Shaklee JB, Utter FM. Allozyme and mitochondrial DNA variation describe ecologically important genetic structure of even-year pink salmon inhabiting Prince William Sound, Alaska.
Ecology of Freshwater Fish 1999: 8: 122–140. © Munksgaard, 1999

Abstract – Allozyme and mitochondrial DNA (mtDNA) data were obtained from pink salmon throughout Prince William Sound, Alaska, from two hatchery, five upstream, and 20 tidal locations distributed among five management regions collected during 1994. Screening for allozymes included 66 loci for 92 to 100 fish per sample. Thirty-four loci had variant allele frequencies >0.01 in one or more collections and were used for population analyses. Eight haplotypes were detected after screening 40 fish per collection for variation at the ND5/ND6 region of mtDNA using six restriction enzymes. Significant and apparently stable differences detected by both data sets permit rejecting a null hypothesis of panmixia and support managing native populations in Prince William Sound at the regional level. Distinctions between upstream and tidal collections were detected within Lagoon Creek (allozymes) and Koppen Creek (mtDNA). Significant regional heterogeneity was detected within upstream (allozymes and mtDNA) and tidal (allozymes) collections; however, upstream collections were more divergent from each other than were tidal collections. The absence of distinction of Armin F. Koernig Hatchery from almost all regions was consistent with multiple origins of this stock. Conversely, Solomon Gulch Hatchery in the East Region was distinct from all regions but East, consistent with a more restricted origin and influence.

J. E. Seeb[1], C. Habicht[1], W. D. Templin[1], L. W. Seeb[1], J. B. Shaklee[2], F. M. Utter[3]

[1]Alaska Department of Fish & Game, Commercial Fisheries Division, Anchorage, Alaska, [2]Washington Department of Fish & Wildlife, Olympia, [3]School of Fisheries, University of Washington, Seattle, Washington, USA

Key words: allozyme; mtDNA; genetics; pink salmon

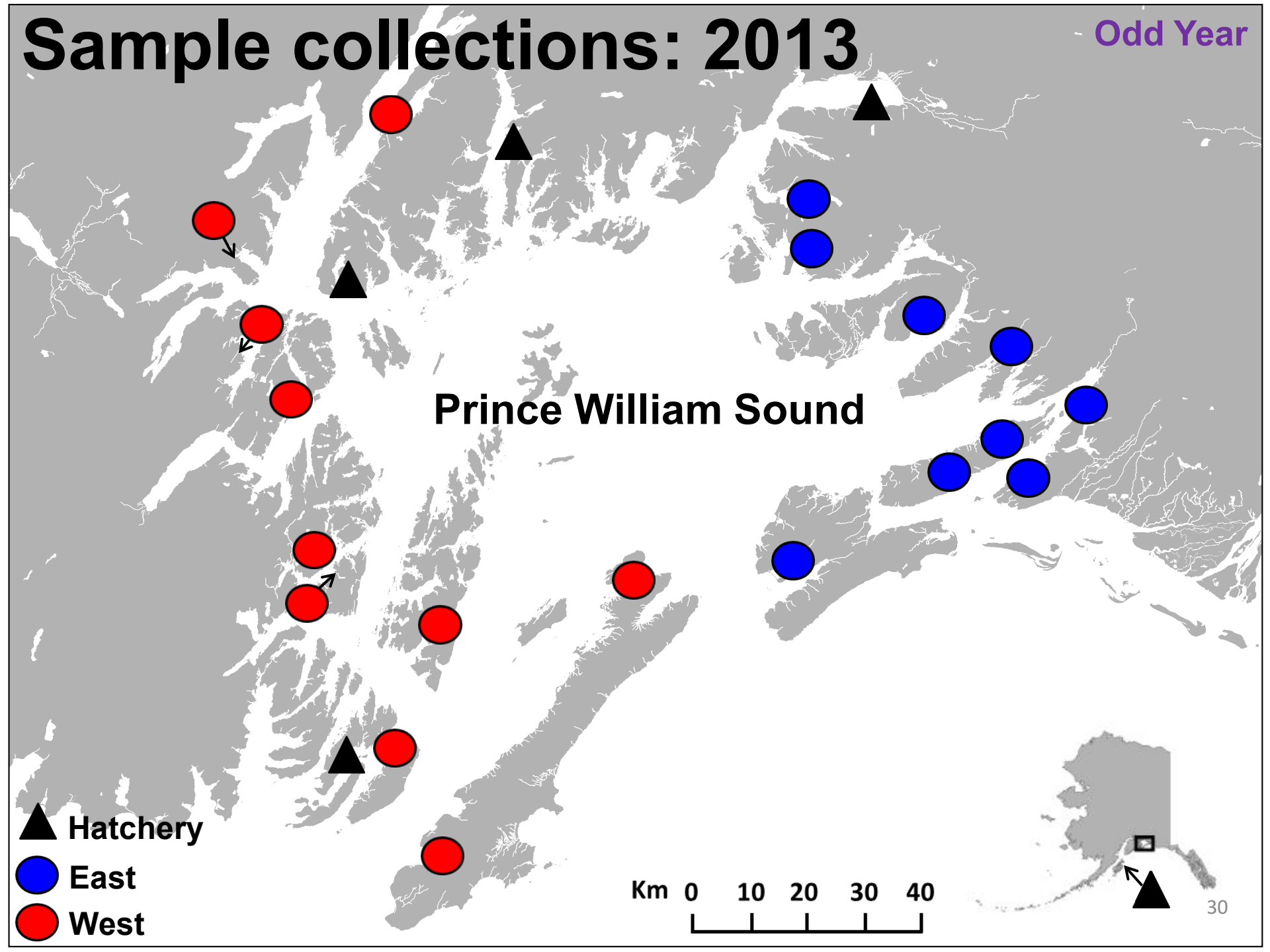
J. E. Seeb, Alaska Department of Fish & Game, Commercial Fisheries Division, Anchorage, AK 99518, USA

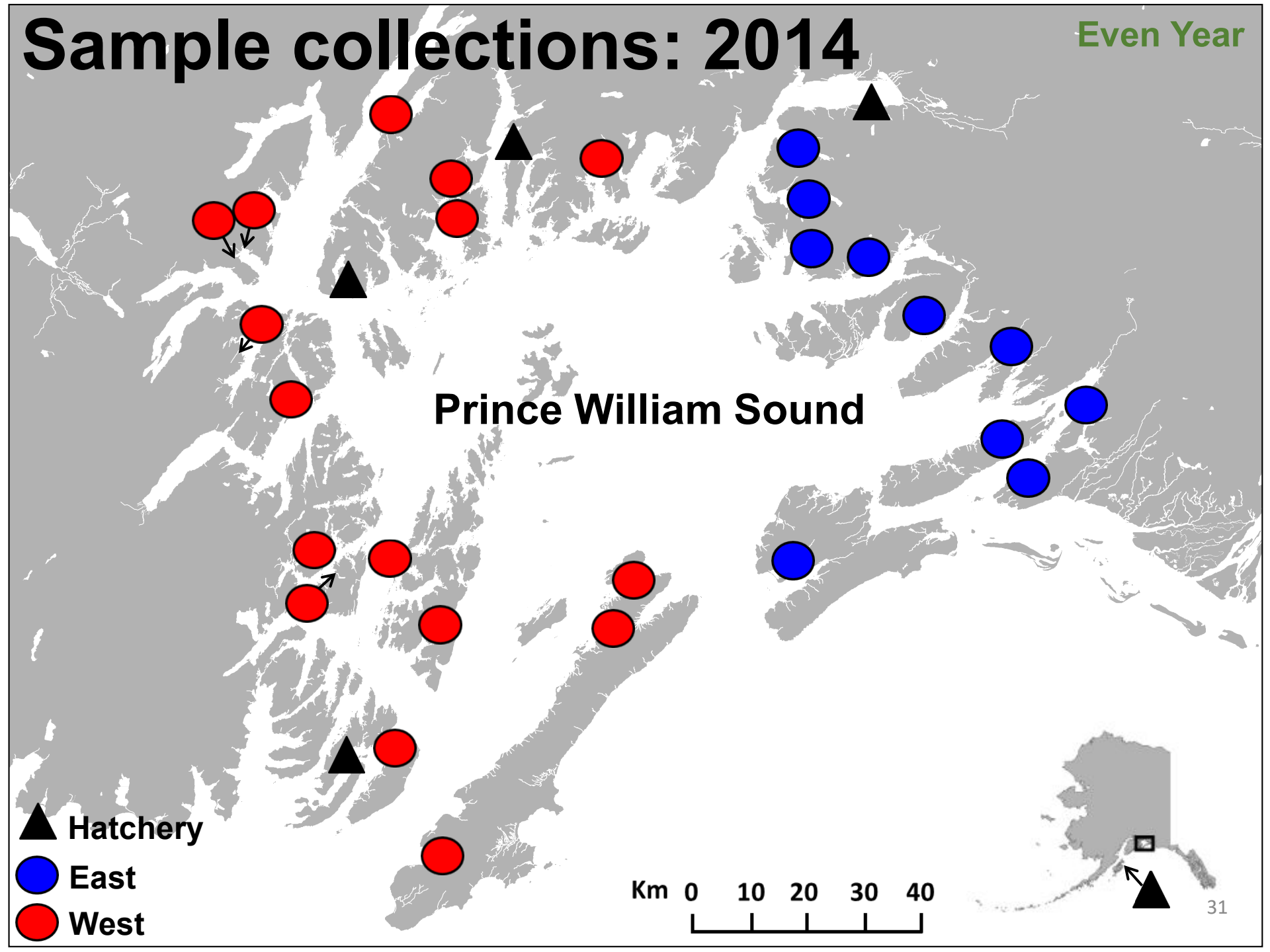
Accepted for publication April 9, 1999

Un resumen en español se incluye detrás del texto principal de este artículo.

Study Design

		Contemporary	Historical
Odd Year	Natural	√	*(pending)*
	Hatchery	√	*(pending)*
Even Year	Natural	√	*(pending)*
	Hatchery	√	*(pending)*

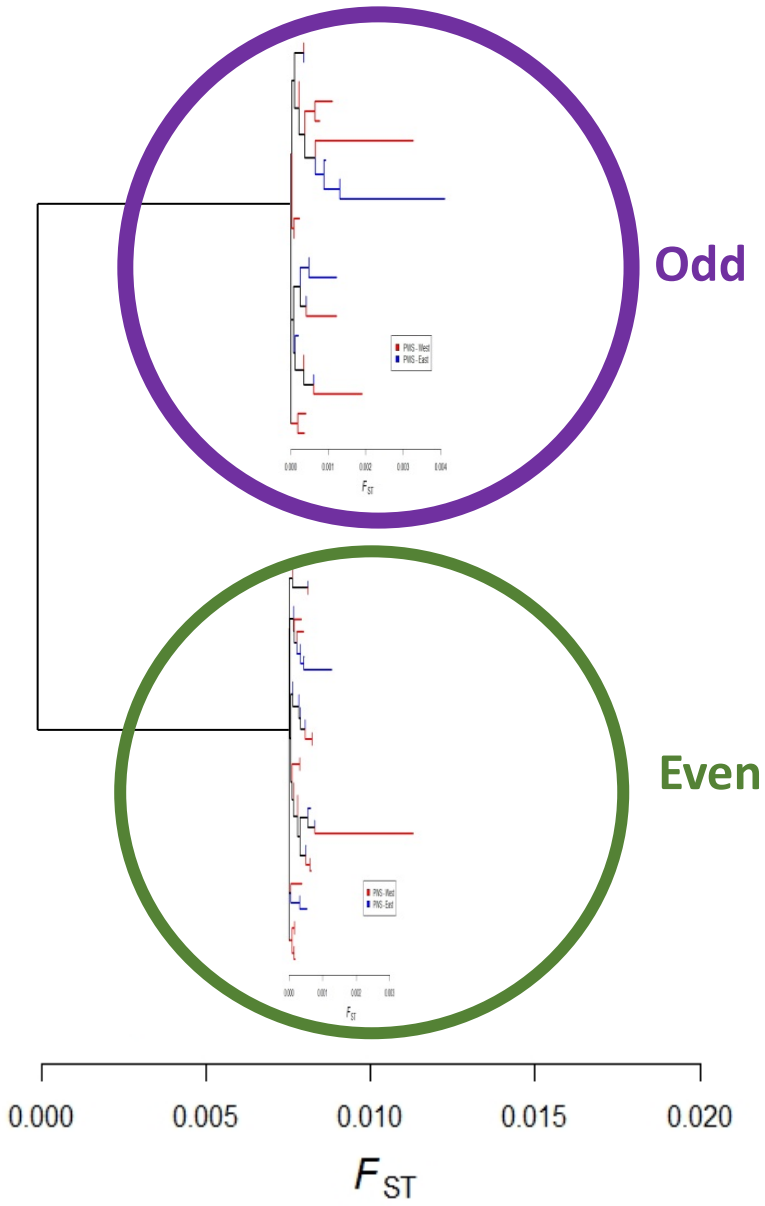

Sample collections: 2013
Odd Year
Prince William Sound
Hatchery
East
West
Km 0 10 20 30 40


Sample collections: 2014
Even Year
Prince William Sound
Hatchery
East
West
Km 0 10 20 30 40

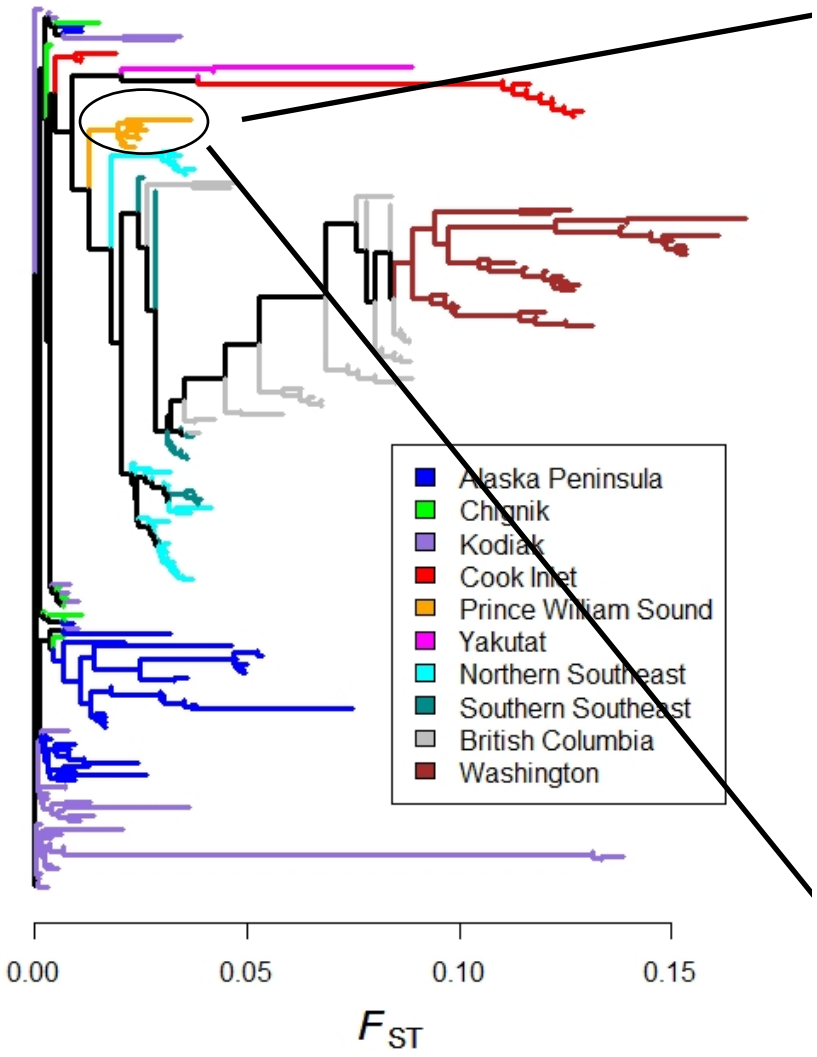
Population Structure Analyses

- **Calculate genetic differences among collections**
- **Test for significance of these differences**
- **Visualize the relationships among collections**

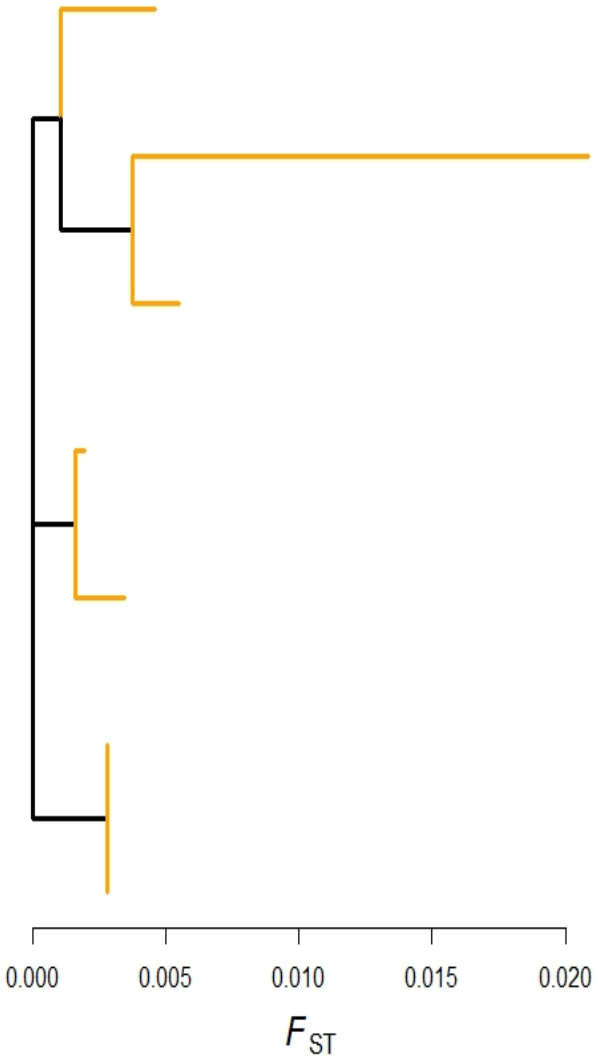
PWS Pink Salmon



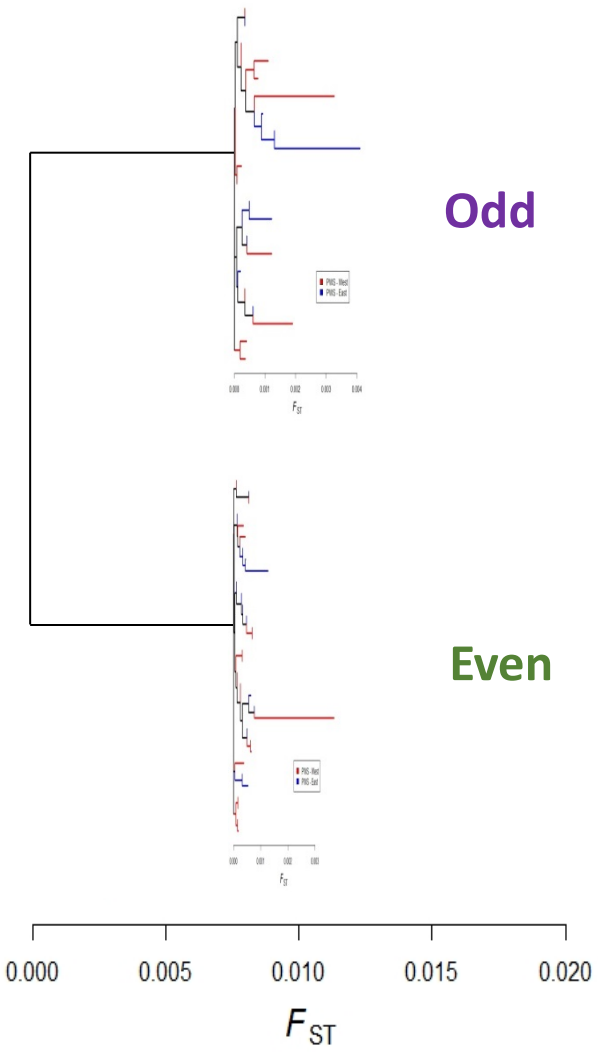
GOA Chum Salmon



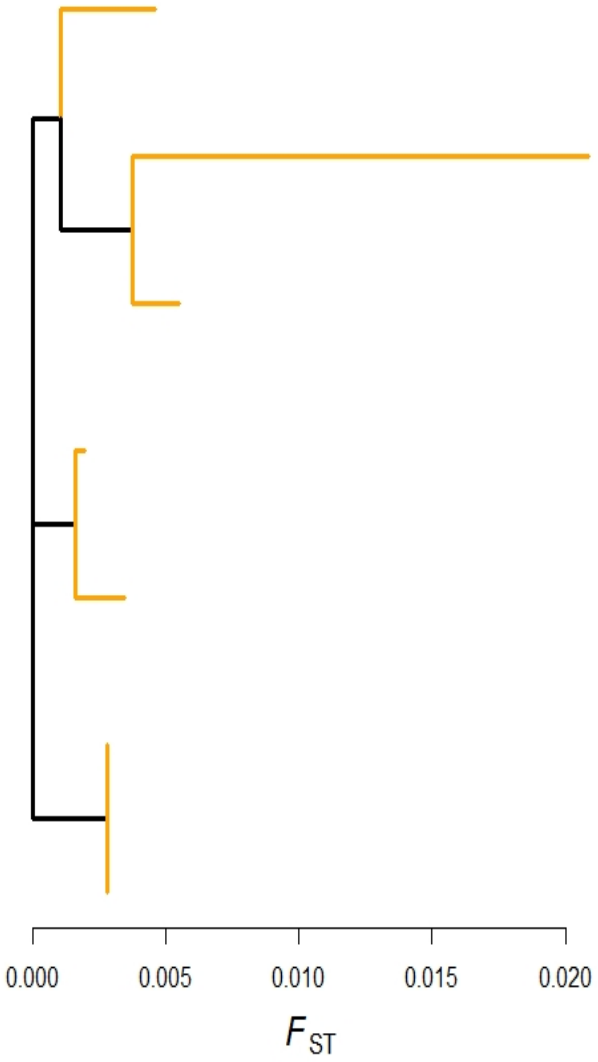
PWS Chum Salmon



PWS Pink Salmon



PWS Chum Salmon

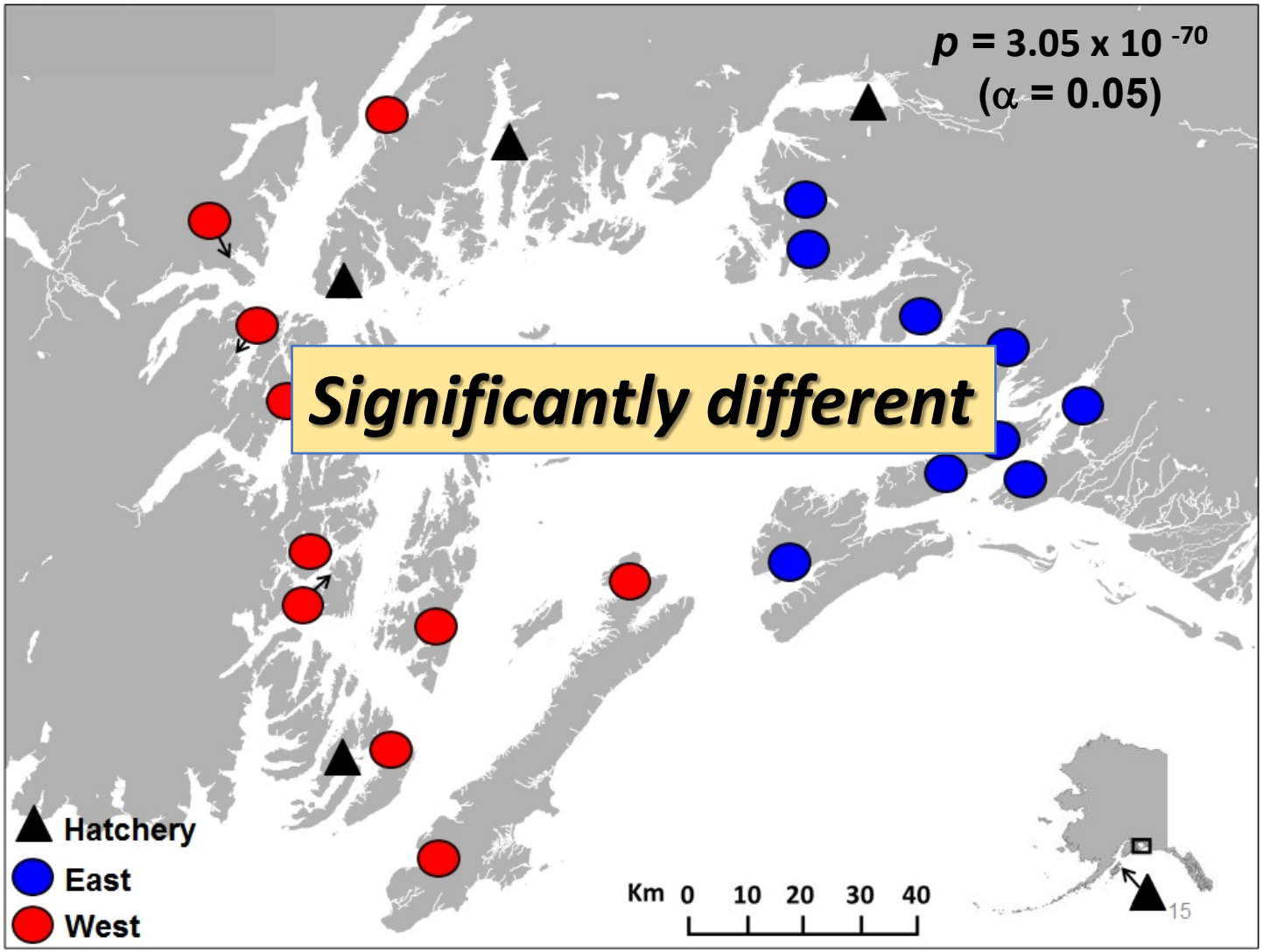


Population Structure Analyses

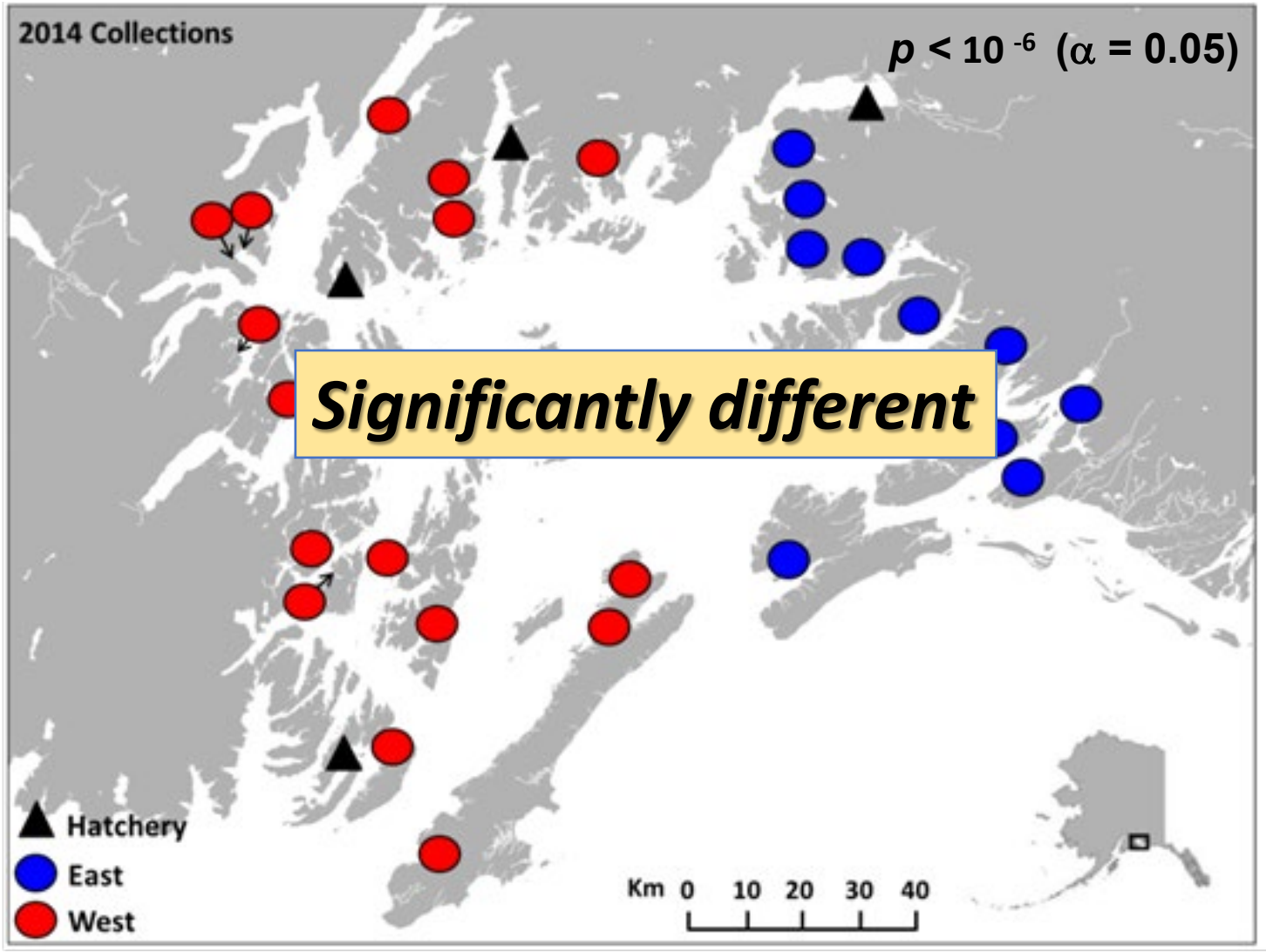
- Calculate genetic differences among collections

- **Test for significance of these differences**

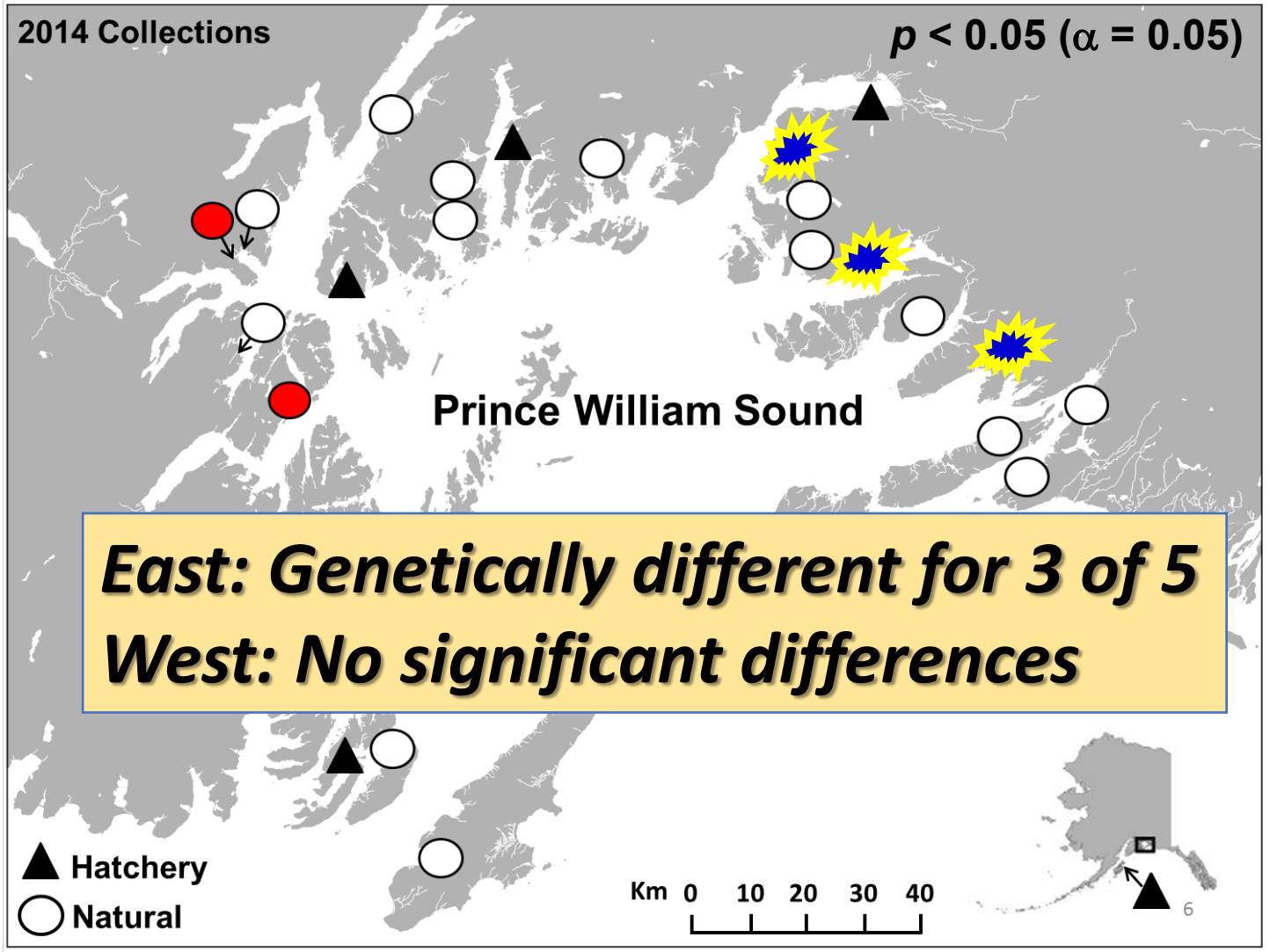
Testing for Differences: Among Prince William Sound



Testing for Differences: Among Prince William Sound



Testing for Differences: Between Early and Late

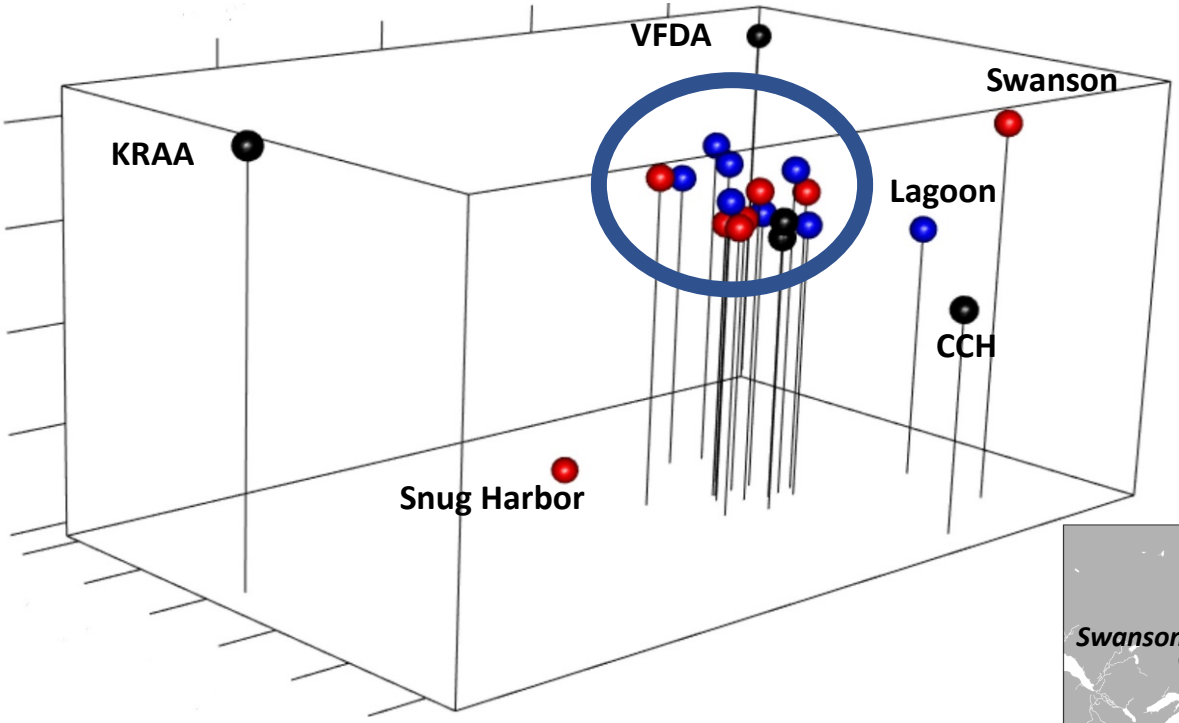


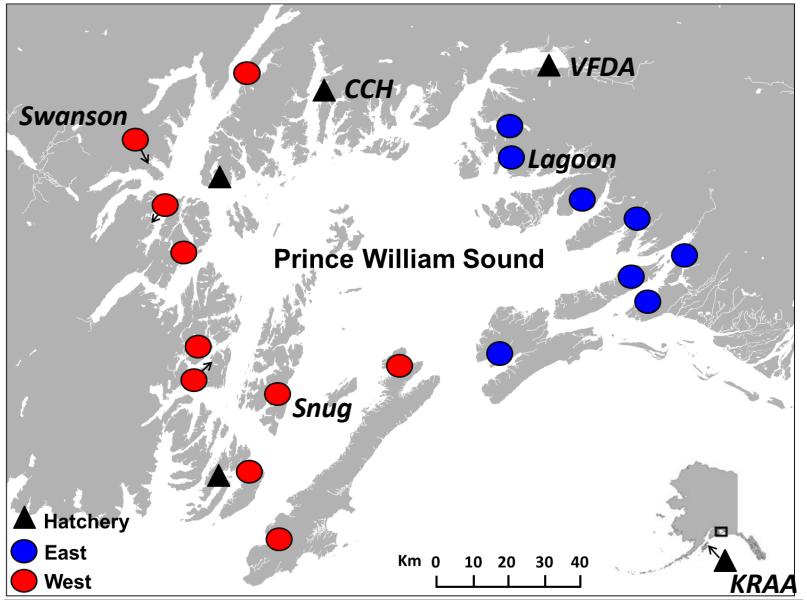
Population Structure Analyses

- Calculate genetic differences among collections
- Test for significance of these differences
- **Visualize the relationships among collections**

Visualizing Relationships Among Collections

Odd Year

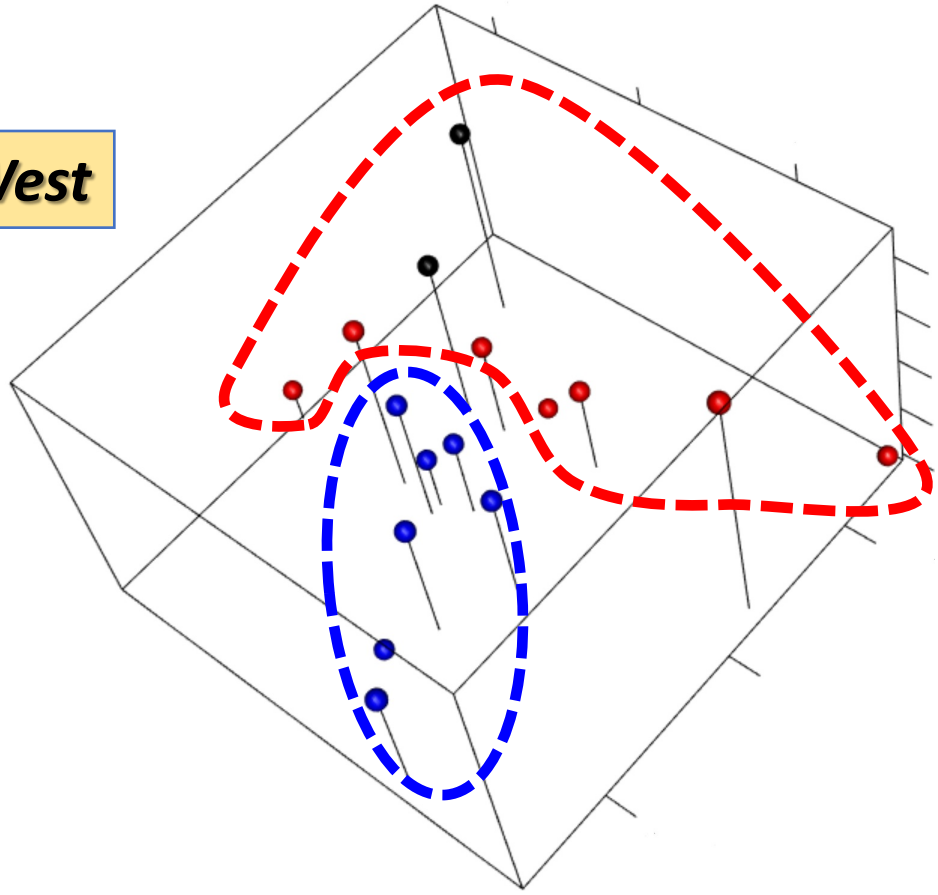


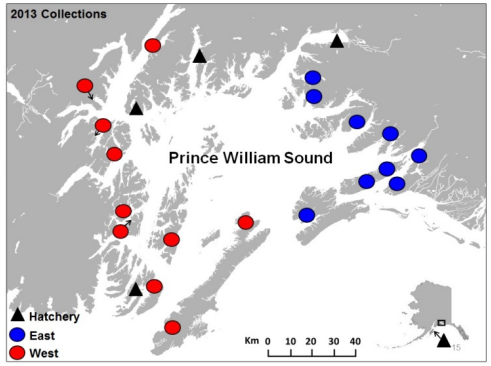


Visualizing Relationships Among Collections – Zooming In

Odd Year

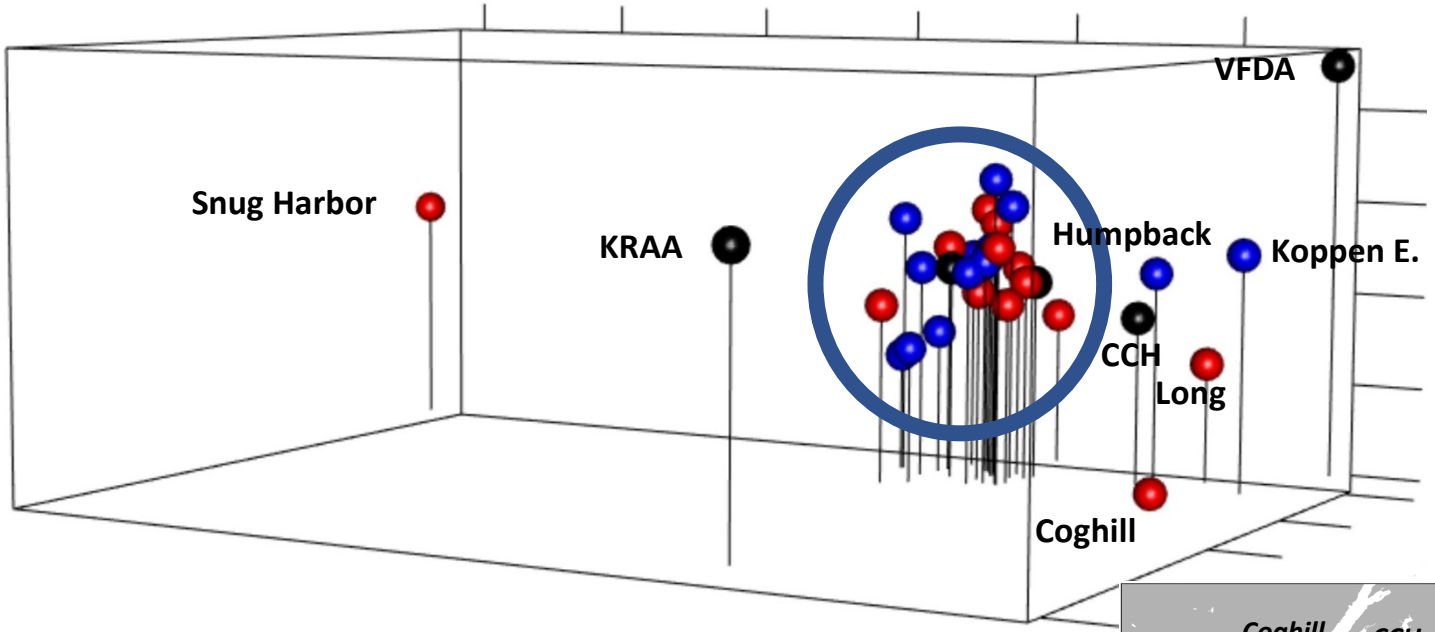
East vs. West

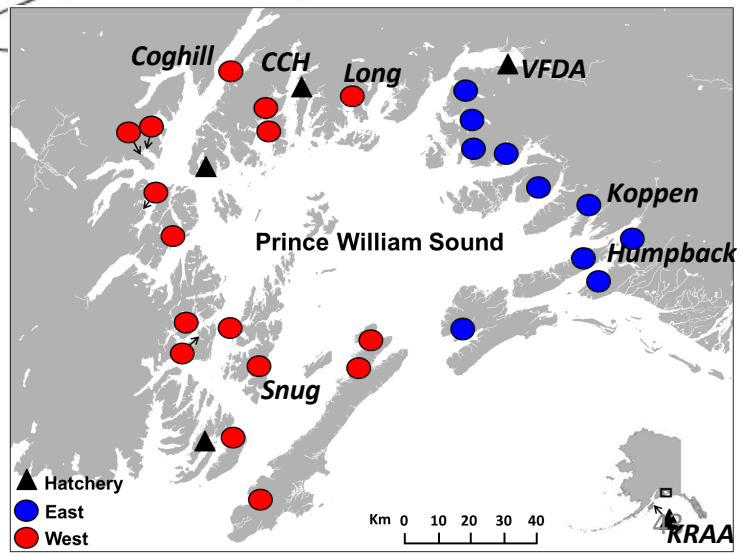




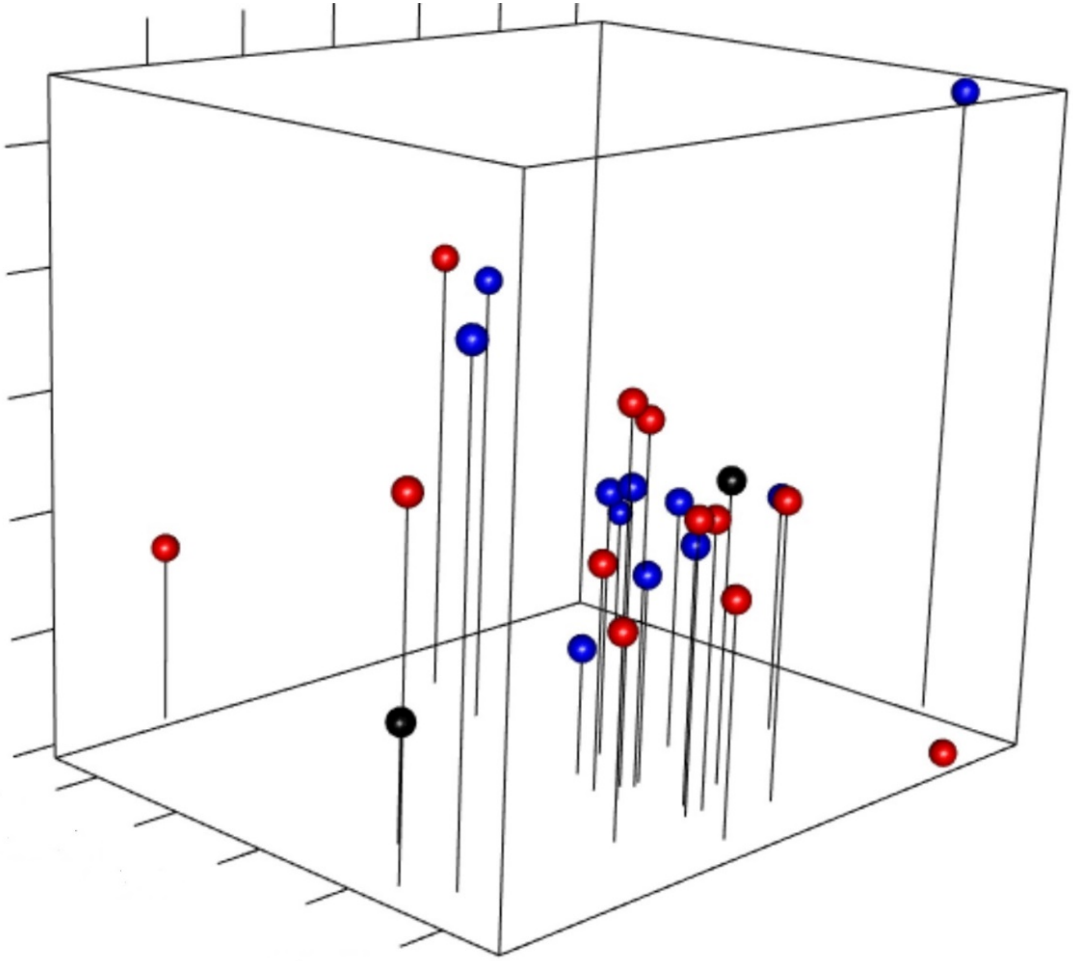
Even Year

Visualizing the Relationships among Collections





Visualizing the Relationships among Collections



Summary to date

- **Kodiak vs. Prince William Sound (PWS)**
  - **Significantly different in both lineages** [data not shown]

- **Genetic variation among pink salmon populations in PWS is very small**
  - **Odd year – small**
  - **Even year – even smaller**

- **Within lineage patterns**
  - **Odd year:**
    - **East vs. West**
    - **Early vs. Late?**
  - **Even year:**
    - **Early vs. Late (eastern side only)**

Future Work

- Historical samples
  - 1991 – 1997
  - No otolith information

- Investigate mechanisms driving the structure

Acknowledgements

- Hatcheries
  - PWSAC, VFDA, KRAA
- Prince William Sound Science Center
- Fisheries and Oceans Canada
  - Pacific Biological Station
- Alaska Department of Fish and Game
- Alaska Hatchery Research Program Science Panel
- University of Alaska Fairbanks