Genetics: Science and Implications in Salmon Management

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Director, Alaska Fisheries Science Center
NMFS

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Genetics Program Manager, Auke Bay Laboratories
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Bill Templin
Principle Geneticist, Gene Conservation Laboratory
ADF&G

August 25, 2015
Salmon Genetics
Caught
Impact?
Timeline

8-8:10 AM  Doug DeMaster – Director, Alaska Fisheries Science Center

8:10-8:35 AM  Bill Templin – Alaska Department of Fish and Game Alaska State Fisheries

8:35-9:00 AM  Jeff Guyon – National Marine Fisheries Service Alaska Federal Fisheries (marine)

9-9:30 AM  New technologies and panel discussion
Alaska’s Genetics Program

Genetics applications for fisheries management

Gene Conservation Laboratory
Division of Commercial Fisheries
Alaska Department of Fish and Game
Why does ADF&G have a genetics lab?

Alaska Department of Fish and Game uses genetic information to achieve its mission to …

*protect, maintain, and improve the fish, game, and aquatic plant resources of the state, and manage their use and development in the best interest of the economy and the well-being of the people of the state, consistent with the sustained yield principle.*
Why does ADF&G have a genetics lab?

Alaska Department of Fish and Game uses genetic information to achieve its mission to …

protect, maintain, and improve the fish, game, and aquatic plant resources of the state, and manage their use and development in the best interest of the economy and the well-being of the people of the state, consistent with the sustained yield principle.

The activities of the Gene Conservation Laboratory fall into 4 main categories:

1. Basic research to understand the resource
2. Development of capabilities
3. Inform/Assess management actions
4. Research to inform human activities
Questions that use genetic information

- Did exposure to mutagens cause genetic injury?
  - EVOS oiling experiments

- What species of salmon is this?
  - Atlantic salmon escapees

- Is this crab a hybrid?
  - Snow/tanner crab hybrids

- Which broodstock are these unmarked salmon from?
  - DIPAC broodstock

- What is the structure of these populations?
  - Sockeye salmon in Bristol Bay lakes

- Where are these fish going?
  - Chinook salmon in SE Alaska
  - Sockeye salmon in the Bering Sea

- Who’s fish are being harvested?
  - Bering Sea salmon bycatch
Applications: Understanding the Resource

Example: Red king crab population structure
Applications: Understanding the Resource

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Example: Red king crab population structure
Applications: Understanding the Resource
Example: Red king crab population structure

Pattern of heterozygosity
Applications: Understanding the Resource

Example: Red king crab population structure

Post-glacial Colonization Routes
Applications: Understanding the Resource
Example: Red king crab population structure

Implications

• Gene flow and ice-age isolations

• Red king crab might be managed on a small geographic scale in some regions

• Guidance for possible stock enhancement
Applications: Develop Capabilities
Example: Chinook salmon coastwide baseline

Alaska Department of Fish and Game

NOAA Fisheries

University of Washington
Applications: Develop Capabilities
Example: Chinook salmon coastwide baseline

North Pacific Anadromous Fish Commission Partners
Applications: Develop Capabilities

Example: Chinook salmon coastwide baseline

Pacific Salmon Commission Partners
Applications: Develop Capabilities
Example: Chinook salmon coastwide baseline

172 Populations
42 SNPs
Applications: Develop Capabilities
Example: Chinook salmon coastwide baseline

Neighbor Joining based on $F_{ST}$
Applications: Develop Capabilities
Example: Chinook salmon coastwide baseline

Stock-specific migration in the Bering Sea

Murphy et al. 2009
Stock-Structured Distribution of Western Alaska and Yukon Juvenile Chinook Salmon from United States BASIS surveys, 2002-2007
Applications: Develop Capabilities
Example: Chinook salmon coastwide baseline
Stock-specific migration in the Bering Sea
Applications: Develop Capabilities
Example: Chinook salmon coastwide baseline
Stock-specific migration in the Bering Sea
Applications: Inform/Assess Management

Example: Stock composition of harvest
Port Moller Test Fishery - Inseason
Applications: Inform/Assess Management
Example: Port Moller Test Fishery - Inseason

http://vimeo.com/110201354
Applications: Inform/Assess Management
Example: Port Moller Test Fishery - Inseason

Ugashik 2012

June 28 – July 6
8 days

Cumulative abundance

Date
Applications: Inform/Assess Management

Example: Stock composition of harvest

Western Alaska Salmon Stock Identification Program – Post season
Applications: Inform/Assess Management

Example: Stock composition of harvest
Western Alaska Salmon Stock Identification Program – Post season

- Political support to fund large scale, collaborative genetic stock identification study

IF

- Stakeholders agree on necessary information, study design and results

WASSIP Advisory Panel

Alaska Fish and Game
Aleut Corp
Aleutians East Borough
Assoc. Village Council Presidents
Bering Sea Fishermen’s Association
Bristol Bay Native Association
Concerned Area M Fishermen
Kawerak Inc.
Lake and Peninsula Borough
Tanana Chiefs Conference
Yukon River Drainage Fisheries Assoc.
Applications: Inform/Assess Management
Example: Western Alaska Salmon Stock Identification Program

Chum salmon

35,921 Individuals
302 Populations
96 SNPs
Applications: Inform/Assess Management
Example: Western Alaska Salmon Stock Identification Program

Sockeye salmon

North of Kuskokwim River
Kuskokwim Bay
Bristol Bay
North Peninsula
South Peninsula
Chignik
East of WASSIP

294 Populations
96 SNPs
Applications: Inform/Assess Management

Example: Western Alaska Salmon Stock Identification Program

~3,300 km of coastline
Applications: Inform/Assess Management

Example: Western Alaska Salmon Stock Identification Program
Chum salmon:
- 278 fishery strata sampled
- 194 fishery strata analyzed
- 143,258 individuals sampled
- 74,445 individuals genotyped

Sockeye salmon:
- 307 fishery strata sampled
- 216 fishery strata analyzed
- 182,523 individuals sampled
- 81,932 individuals genotyped

Applications: Inform/Assess Management
Example: Western Alaska Salmon Stock Identification Program
What stocks are caught in my fishery?

Applications: Inform/Assess Management
Example: Western Alaska Salmon Stock Identification Program
Applications: Inform/Assess Management
Example: Western Alaska Salmon Stock Identification Program

How may fish of each stock were caught in my fishery?
Applications: Inform/Assess Management

Example: Western Alaska Salmon Stock Identification Program

What fishery catches my stock?
Applications: Inform/Assess Management
Example: Western Alaska Salmon Stock Identification Program

What fishery catches my stock?
Applications: Inform Human Activities

Example: Chum salmon hatchery/wild interaction
Applications: Inform Human Activities

Example: Chum salmon hatchery/wild interaction

Straying Definitions

Adult

Stray (dies)

Genetic stray (spawns)

Introgression (successful hybridization)

Not Home Stream (uncommitted)
Applications: Inform Human Activities

Example: Chum salmon hatchery/wild interaction

Idealized natural system

No straying
Applications: Inform Human Activities

Example: Chum salmon hatchery/wild interaction

Reality natural system

Straying/drift equilibrium
Applications: Inform Human Activities

Example: Chum salmon hatchery/wild interaction

Reality natural system

Equilibrium
Applications: Inform Human Activities

Example: Chum salmon hatchery/wild interaction
Applications: Inform Human Activities

Example: Chum salmon hatchery/wild interaction
Applications: Inform Human Activities

Example: Chum salmon hatchery/wild interaction
Applications: Inform Human Activities

Example: Chum salmon hatchery/wild interaction

Equilibrium  Hatchery  Hatchery straying

Time
Applications: Inform Human Activities

Example: Chum salmon hatchery/wild interaction

Equilibrium Hatchery Hatchery straying
Applications: Inform Human Activities

Example: Chum salmon hatchery/wild interaction

Equilibrium

Hatchery

Hatchery straying
Applications: Inform Human Activities

Example: Chum salmon hatchery/wild interaction
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Equilibrium Hatchery Hatchery straying

Historical (pre-hatchery scales)

Contemporary samples
Applications: Inform Human Activities

Example: Chum salmon hatchery/wild interaction
Applications: Inform Human Activities

Example: Chum salmon hatchery/wild interaction

One-way migration model
2% stray rate

Contemporary vs. Hatchery

Historical vs. Hatchery

6 generations
Applications: Inform Human Activities

Example: Chum salmon hatchery/wild interaction
Applications: Inform Human Activities

Example: Chum salmon hatchery/wild interaction

Implications

• Population structure not visibly eroded

• Introgression rates are highly variable among locations

• Distance from the hatchery and life history affect introgression rates
Genetic stock composition analysis of salmon caught in Alaska federal groundfish trawl fisheries

Jeff Guyon, PhD
Genetics Program
Auke Bay Laboratories
Juneau, AK

August 25, 2015
Chinook Salmon
Genetic Stock Composition Analysis of Chum Salmon Bycatch from the 2013 Bering Sea Walleye Pollock Trawl Fishery

J. A. Whittle, S. C. Vulstek, C. M. Kondzela, and J. R. Guyon
Genetics Program
Auke Bay Laboratories
Juneau, AK
1994: Scales (Patton et al., 1998) - 1,204 samples


1996: Allozymes (Seeb et al., 2004) – Eastern shelf

Map of the Pacific Rim indicating the general geographic regions where chum salmon (*Oncorhynchus keta*) from 381 populations were surveyed. The regions are listed in Table 1.

Beacham et al., 2009
Map of the Pacific Rim indicating the general geographic regions where chum salmon (*Oncorhynchus keta*) from 381 populations were surveyed. The regions are listed in Table 1.
Principal Coordinate Analysis
11 microsatellites, CSE

Upper/Middle Yukon
Southwest Alaska
Western Alaska
Northeast Asia
Southeast Asia
Eastern GOA - PNW
CIAP-WASC chum salmon collections

Goal II

Objective 1
– Genotype 144 samples from each of 32 collections at pre-existing and new microsatellite markers.

Objective 2
– Genotype mixture samples from lower Yukon and Kuskokwim rivers.
2013 Chum Salmon Bering Sea Bycatch

Graph showing bycatch and genetic samples over statistical weeks.
2013 Chum Salmon Bering Sea Bycatch

Correlation coefficient, $r > 0.99$
# 2013 Chum Salmon Bering Sea Bycatch

## Area 517

<table>
<thead>
<tr>
<th>Reporting area</th>
<th>Time period</th>
<th>Number of samples</th>
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<tbody>
<tr>
<td>517</td>
<td>Early</td>
<td>304</td>
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<tr>
<td>517</td>
<td>Middle</td>
<td>1,004</td>
</tr>
<tr>
<td>517</td>
<td>Late</td>
<td>473</td>
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</table>

### Stock proportion

- **SE Asia**
- **NE Asia**
- **Western AK**
- **Upper/Middle Yukon**
- **SW Alaska**
- **Eastern GOA/PNW**
Genetic Stock Composition Analysis of the Chinook Salmon Bycatch from the 2013 Bering Sea Walleye Pollock (Gadus chalcogrammus) Trawl Fishery

C.M. Guthrie, H. T. Nguyen, and J.R. Guyon
Genetics Program
Auke Bay Laboratories
Juneau, AK

August 25, 2015
1979-1982: Scales (Myers and Rogers, 1988)

1997-1999: Scales (Myers et al., 2004)

2005 “B” - 2006: SNPs (ADF&G, Chinook Salmon EIS)

2013 Chinook Salmon Bering Sea Bycatch

2013 BSAI Bycatch/Sample Distribution

- Total Bycatch
- Genotyped Samples

Bycatch vs Statistical Week
Extension of Genetic Stock Composition Analysis to the Chinook Salmon Bycatch in the Gulf of Alaska Walleye Pollock (*Gadus chalcogrammus*) Trawl Fisheries, 2013

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Anchorage, AK

August 25, 2015

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NMFS AKSSF NPFRF
New Genetic Technologies
Genetic tools and their uses for management are increasing
RAD Sequencing
RAD Sequencing/Genomics – Example from UW and ADFG
Parentage Analysis

Fragment Size

<table>
<thead>
<tr>
<th>Locus 1</th>
<th>Locus 2</th>
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<td>F0 (male1)</td>
<td>F0 (male1)</td>
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<tr>
<td>F0 (male2)</td>
<td>F0 (male2)</td>
</tr>
<tr>
<td>F1 (sample)</td>
<td>F1 (sample)</td>
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</tbody>
</table>
Hatchery programs with current broodstock sampling

Steelhead: Russian River; Central Valley (four programs)

Coho salmon: Klamath River-Iron Gate; Russian River

Chinook salmon: Trinity River- spring and fall run; Feather & San Joaquin River- spring run; Sacramento- winter run
A National Forensics Program for NOAA

Provide genetic and morphological analyses

Serve all regions of the Office of Law Enforcement (OLE)
Collect water sample
Isolate residual DNA from sloughed cells
Sequence DNA for species ID

eDNA (metagenomics)