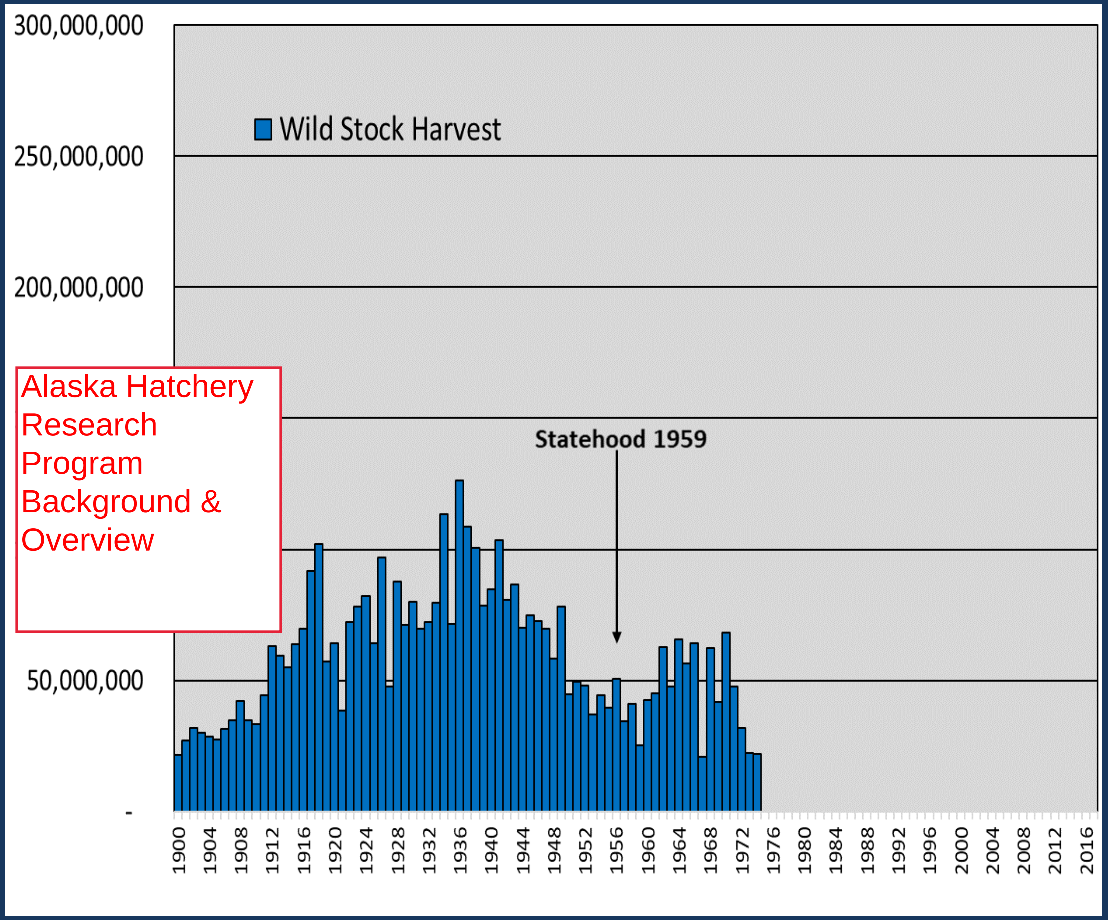
Alaska Hatchery Research Program

- Why the program was initiated
- Program structure
- Key questions addressed
- Study design

AHRP

Background

- Alaska salmon fisheries were severely depressed at statehood, and reached their nadir in 1973 and 1974, when statewide harvest of all species was 22 M



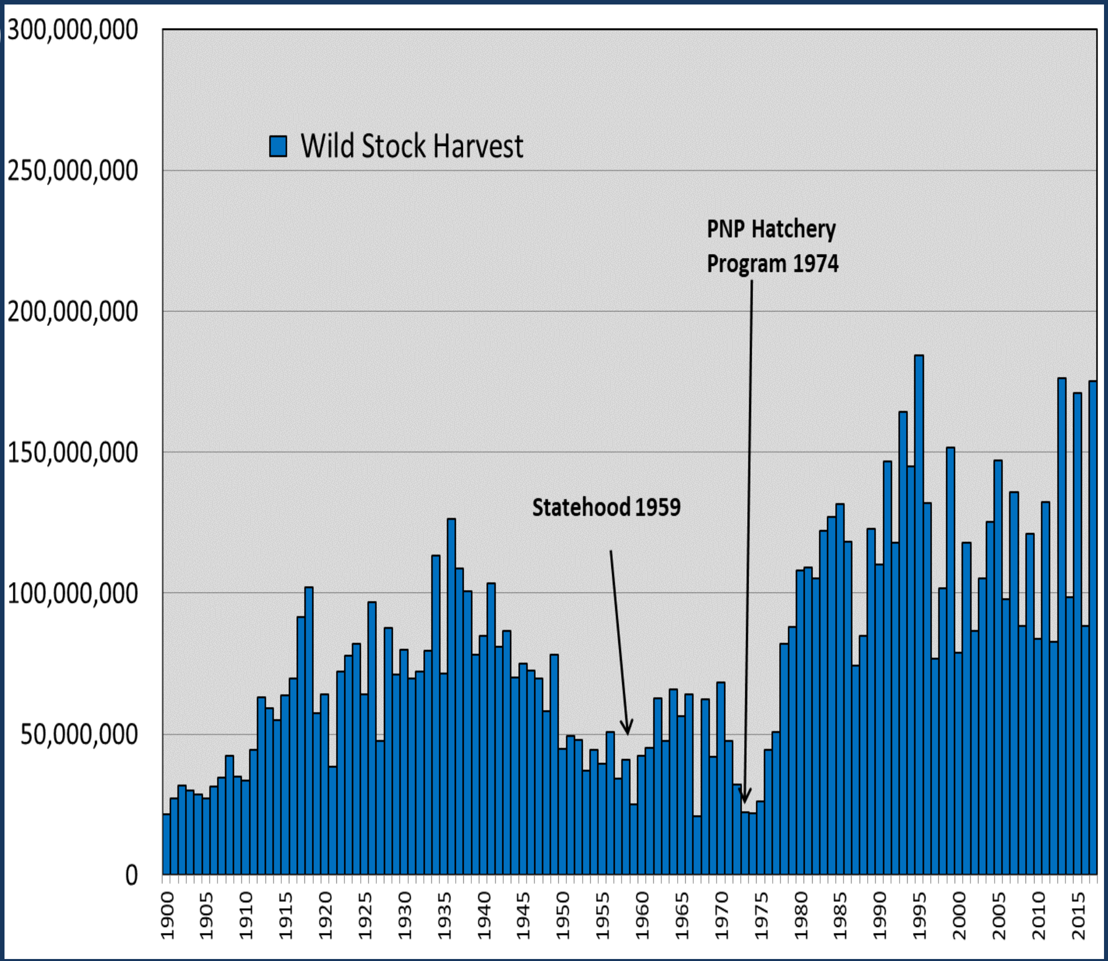
Alaska commercial salmon harvest
1900-1974
Stopha (2018)

Background

- Alaska initiated State (1971) and PNP (1974) hatchery programs to support the recovery and enhancement of Alaska salmon fisheries.

- Remarkable renaissance of Alaska salmon following 1977 "regime" shift and in response to improved management practices.

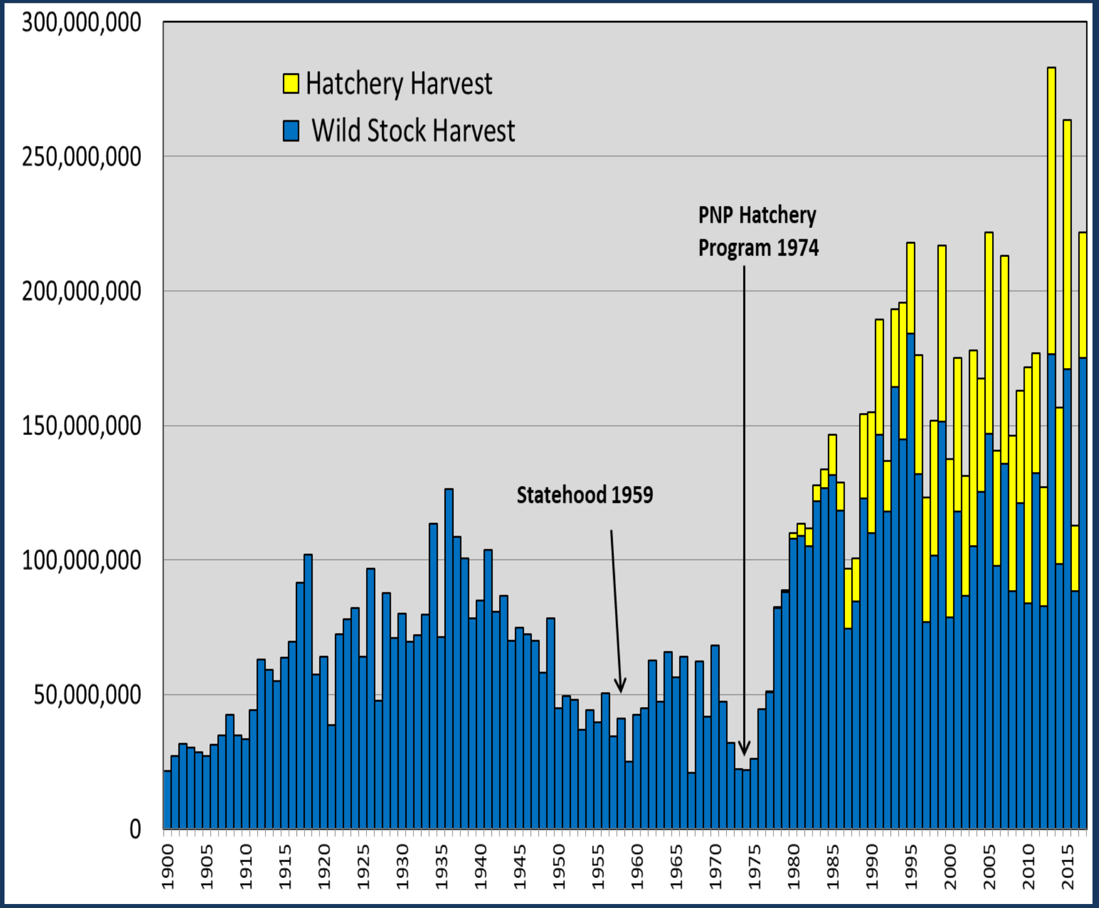
- Wild stock harvest exceeded 100 M in 1980, averaged > 100 million since 1980



Alaska commercial harvest of wild salmon 1900-2017.
Stopha (2018)

Background

- Hatcheries began making substantial contributions to harvest in 1980's
- Statewide harvests (wild and hatchery) have averaged 175 M annually for 2008-2017
- Hatcheries produced an annual average of 67 M, 33% of the harvest, 2008-2017



Alaska commercial harvest of wild and hatchery salmon, 1900-2017.
Stopha (2018)

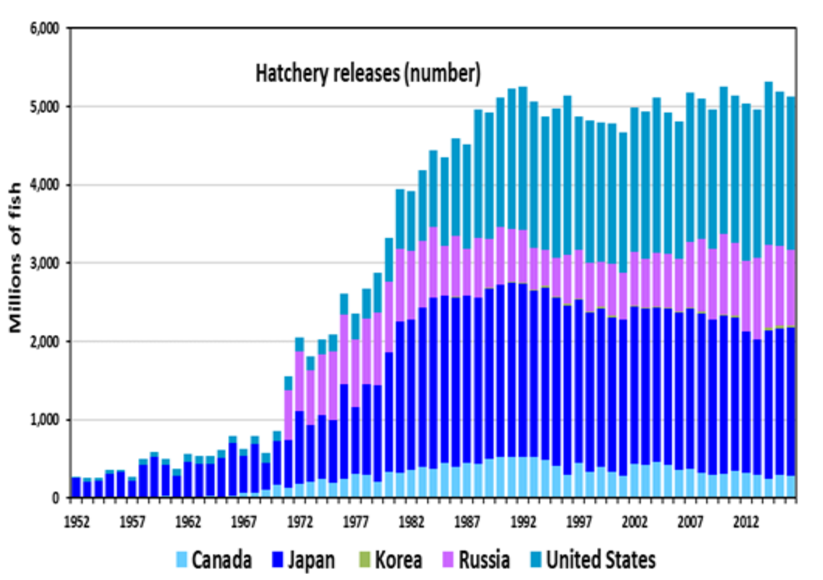
- Hatchery production now dominates the harvest of pink and chum salmon in PWS and chum salmon in SEAK

AHRP

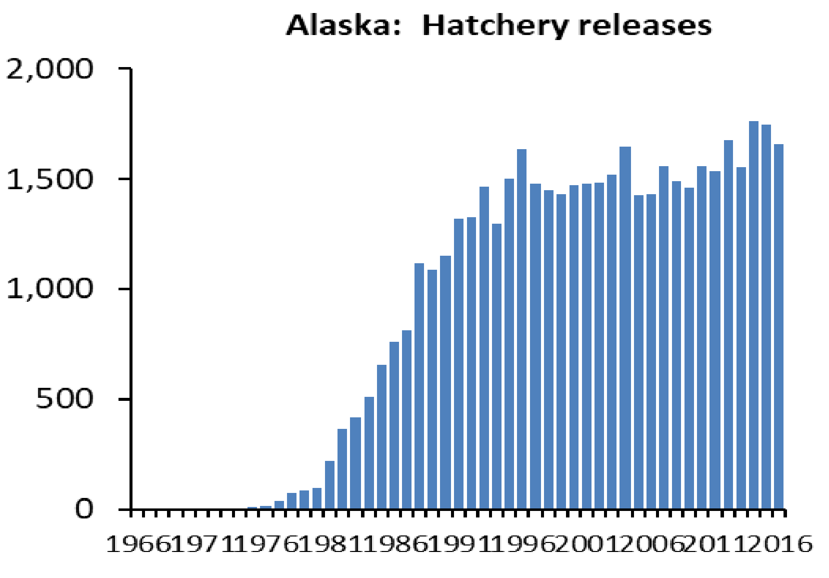
BACKGROUND

Large-scale salmon releases raise concerns for wild stock impacts

- Do hatchery fish detrimentally affect productivity and sustainability of wild stocks?
- Alaska policy mandates sustainable productivity of wild stocks
- Not a new concern: Alaska first state to have a Genetics Policy in 1985



Data Source: North Pacific Anadromous Fish Commission (NPAFC). 2017. NPAFC Pacific salmonid hatchery release statistics (updated 31 July 2017). North Pacific Anadromous Fish Commission, Vancouver. Accessed July, 2017. Available: www.npafc.org



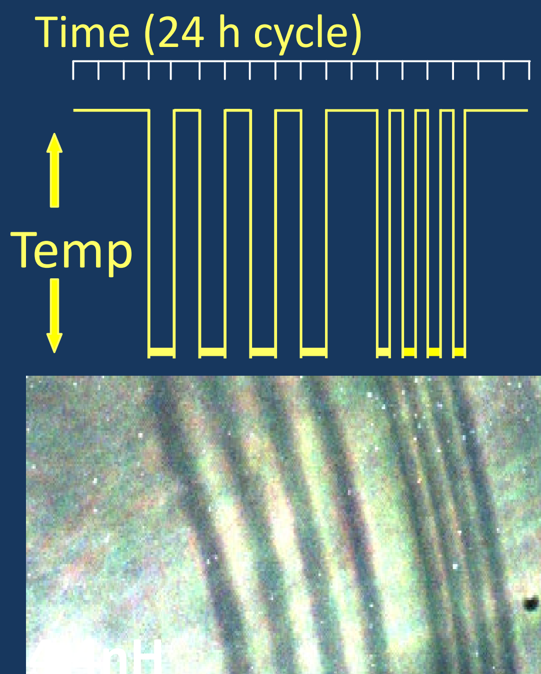
ADF&G Genetic Policy

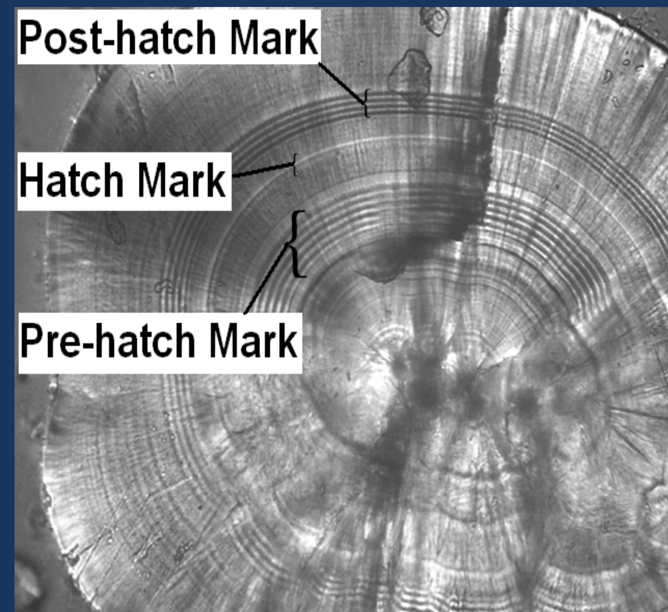
- *Contains protections for wild stocks while allowing increased productivity for enhancement programs.*
- *… priority will be given to protection of wild stocks from possible harmful interactions with introduced stocks.*
- Reduce gene flow from hatchery to wild
  - Minimize introgression of ill-adapted genes
  - Minimize hybrid depression
  - Maintain stock fitness
  - Minimize magnitude of straying
  - Temporal and spatial isolation are important

AHRP

Tool for identifying hatchery fish

Otolith Thermal Marking





Alaska marks > 80% of hatchery fish ~ 1.2 Billion

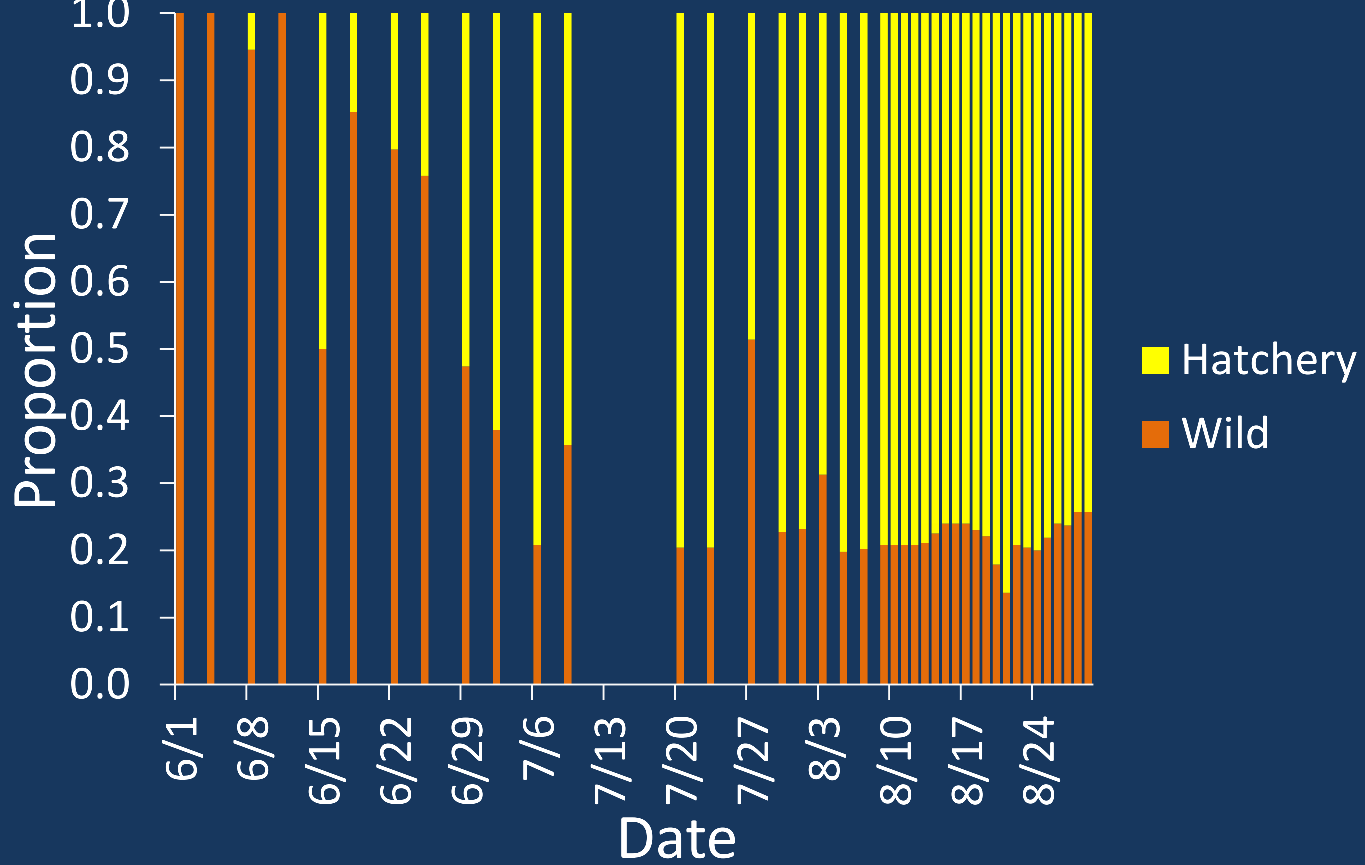
(100% for PWS and SEAK pink and chum)

- NPAFC Voucher DB (Images & Data): http://npafc.taglab.org/MarkSummary.asp

AHRP

Otolith Mark Use 1
In-Season Harvest Monitoring

Example: Pink salmon, PWS SW District, 2015



Haught, S., J. Botz, S. Moffitt, and B. Lewis. 2017. 2015 Prince William Sound area finfish management report. Alaska Department of Fish and Game, Fishery Management Report No. 17-17, Anchorage.

AHRP

Otolith Mark Use 2

Measure Straying

Are hatchery fish straying? If so, how many fish are straying?

- SE Alaska - chum

  Heinl and Piston (2008-2010)

- Prince William Sound - pink, chum & sockeye

  Joyce and Evans (1997-1999)

  Brenner and Moffitt (2004-2010)

- These studies found widespread distribution of hatchery strays in their respective regions, and high rates of hatchery strays in streams near hatchery release sites

Recognition of need to examine extent and impact of hatchery strays on wild stock fitness and productivity

- PNP operators proposed that ADF&G organize a science panel of experts to design and implement a long term research project to inform future resource management decisions

- Funding partnership: State, Operators & Industry

- Fundamental questions aimed at examining extent and potential impacts of hatchery straying on fitness of wild stocks
  - Pink and chum salmon PWS
  - Chum salmon SEAK

AHRP Science Panel

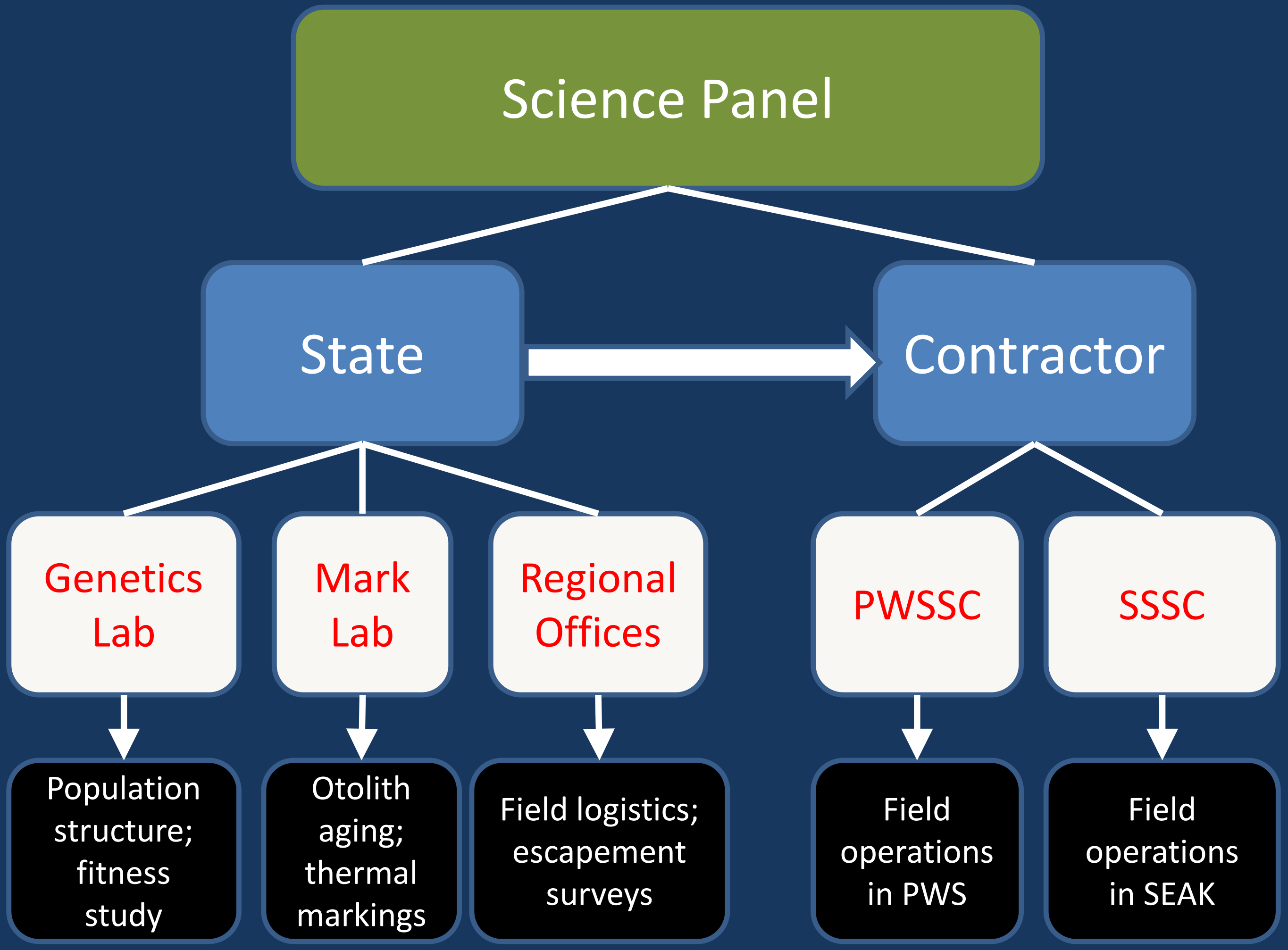
Panel Charge –

Identify priority research questions and develop a framework for research that could be used to address these questions.

Panel Makeup – 13 members:

- Alaska Department of Fish and Game
- National Marine Fisheries Service
- University of Alaska
- Aquaculture associations

AHRP Structure



AHRP Research Questions

1) What is the genetic stock 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?

AHRP Research Questions

1) What is the genetic stock structure of pink and chum in PWS and SEAK?

- Hatchery broodstocks are all derived from stocks within their respective regions as per the Alaska Genetics Policy
- Broodstocks are necessarily large because of the scale of the program, and brood fish are spawned non-selectively from throughout the duration of the spawning run.
- As a result, broad-scale genetic variability is maintained, but the distribution of genotypes may differ from wild spawning populations which are smaller and potentially adapted to localized environmental conditions.
- Policy makers and resource managers need an improved understanding of the hierarchical genetic structure of the populations, and the degree of genetic differentiation at and within the level of harvest management resolution.

AHRP Research Questions

1) What is the genetic stock structure of pink and chum in PWS and SEAK?

Pink salmon in PWS

Ecologically important, but shallow, structure observed in even and odd years (1990s)

Re-examine structure with new samples and new markers (2013-2015)

Compare 1990s structure to present structure

Chum salmon in PWS and SEAK

Temporal and regional structuring observed within SEAK and PWS (1990s & 2013).

Collect additional samples to supplement baseline collections

Examine fine-scale structure using updated methods

AHRP Research Questions

1) What is the genetic stock structure of pink and chum in PWS and SEAK?

- Research directed by the ADF&G Gene Conservation Laboratory
- Collaborative effort with University of Alaska, NOAA Auke Bay Laboratories, University of Washington, Prince William Sound Science Center and Sitka Sound Science center
- Results to provide perspective on degree of heterogeneity across different geographic scales, insight into temporal changes associated with hatchery production, and improved capacity to track future changes.

AHRP Research Questions

2) What is the extent and annual variability of straying?

- Stray Rate (1) : Proportion of a spawning population that spawns in a stream other than its natal stream
- Stray Rate (2) : Proportion of a stream's escapement that is composed of strays from other streams (or hatcheries)
- Estimation of hatchery stray rate (2):
  Proportion of spawning composed of hatchery-origin fish at the stream, management district, and region level for pink salmon and chum salmon in PWS and chum salmon in SEAK

AHRP Research Questions

2) What is the extent and annual variability of straying?

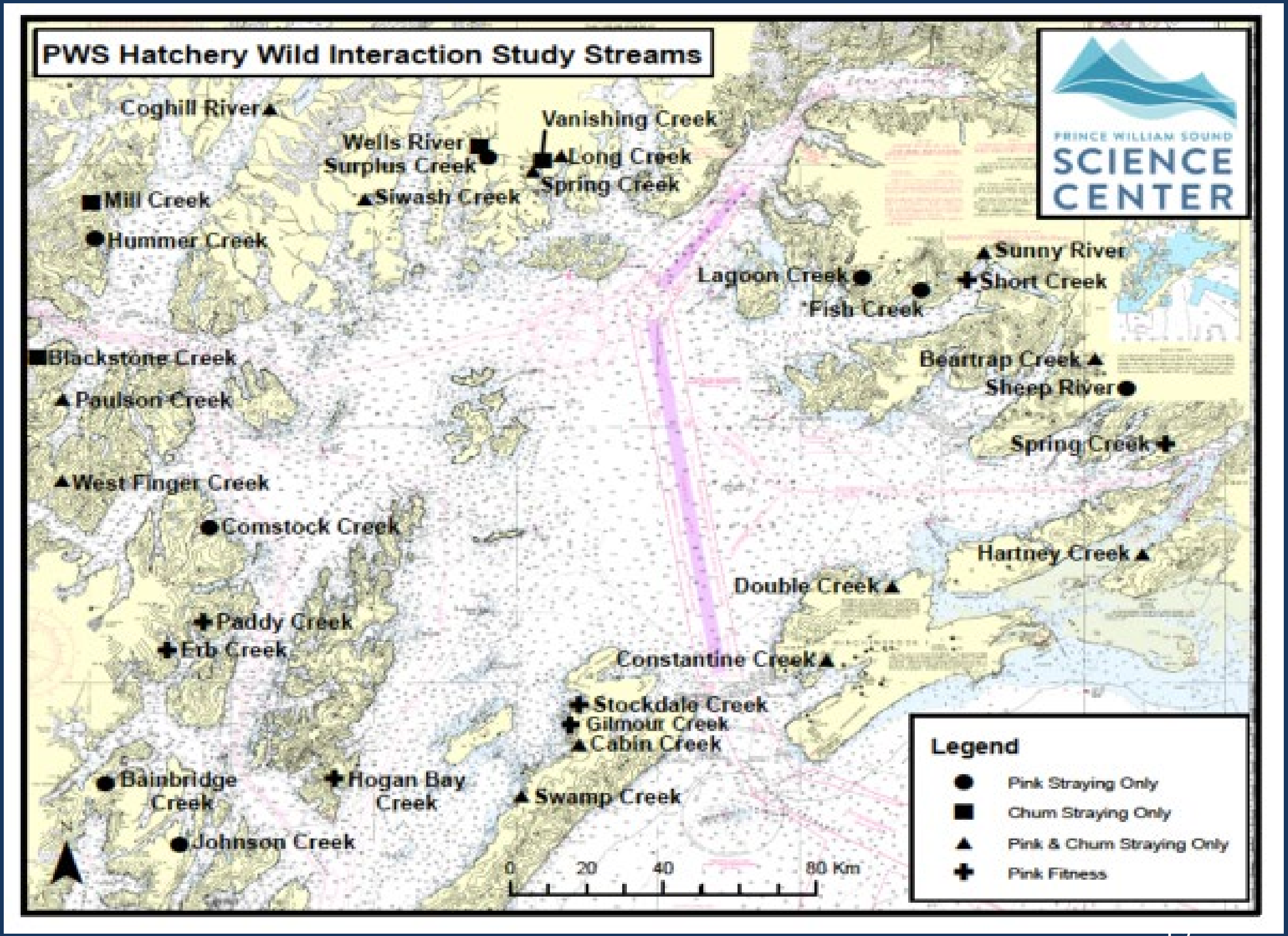
- Randomly select streams with selection weighted for escapement within and between management districts so that stray rates in streams can be used to accurately estimate district and regional rates
- Initial target of 384 fish per stream to estimate stray rate within 5% with 95% confidence
- Sample otoliths from carcasses throughout run, weighting samples in calculating hatchery proportion by the carcass counts at each sampling event

AHRP Research Questions

2) What is the extent and annual variability of straying?

- PWS Pinks:
  27 streams
  8 districts

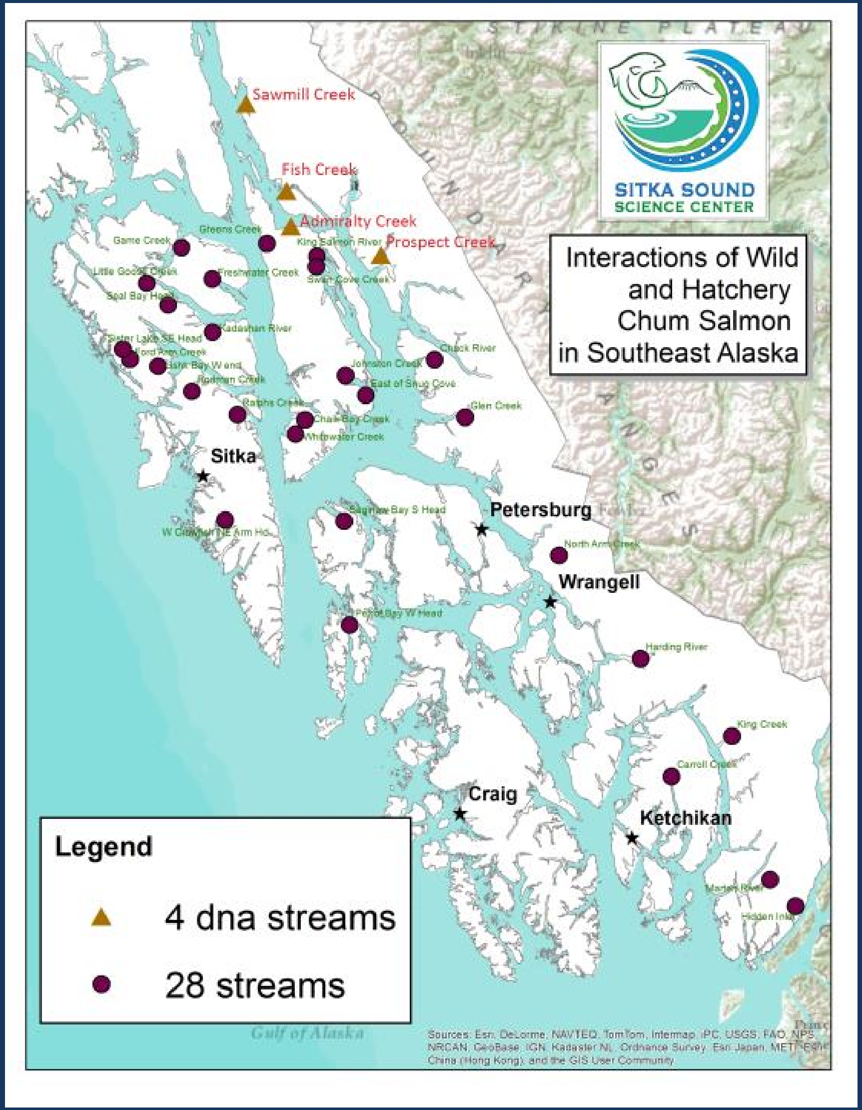
- PWS Chums:
  17 streams
  6 districts



AHRP Research Questions

2) What is the extent and annual variability of straying?

- SEAK Chums:
  32 streams
    3 sub-regions



AHRP Research Questions

2) What is the extent and annual variability of straying?

- In addition to estimation of proportion of hatchery strays in spawning escapement, the study was designed to estimate:
  -Number of wild spawners
  -Number of hatchery strays
  -Production (total run) of wild and hatchery fish

- Can be calculated from catch numbers (known), hatchery broodstock numbers (known), proportion hatchery fish in spawning escapement (estimated), and PROPORTION OF HATCHERY FISH IN TOTAL RUN

- Estimate in PWS with ocean sampling as fish enter Sound

- Estimate in SEAK from chum salmon incidental catch in pink salmon seine fishery: not feasible due to data resolution in fishery

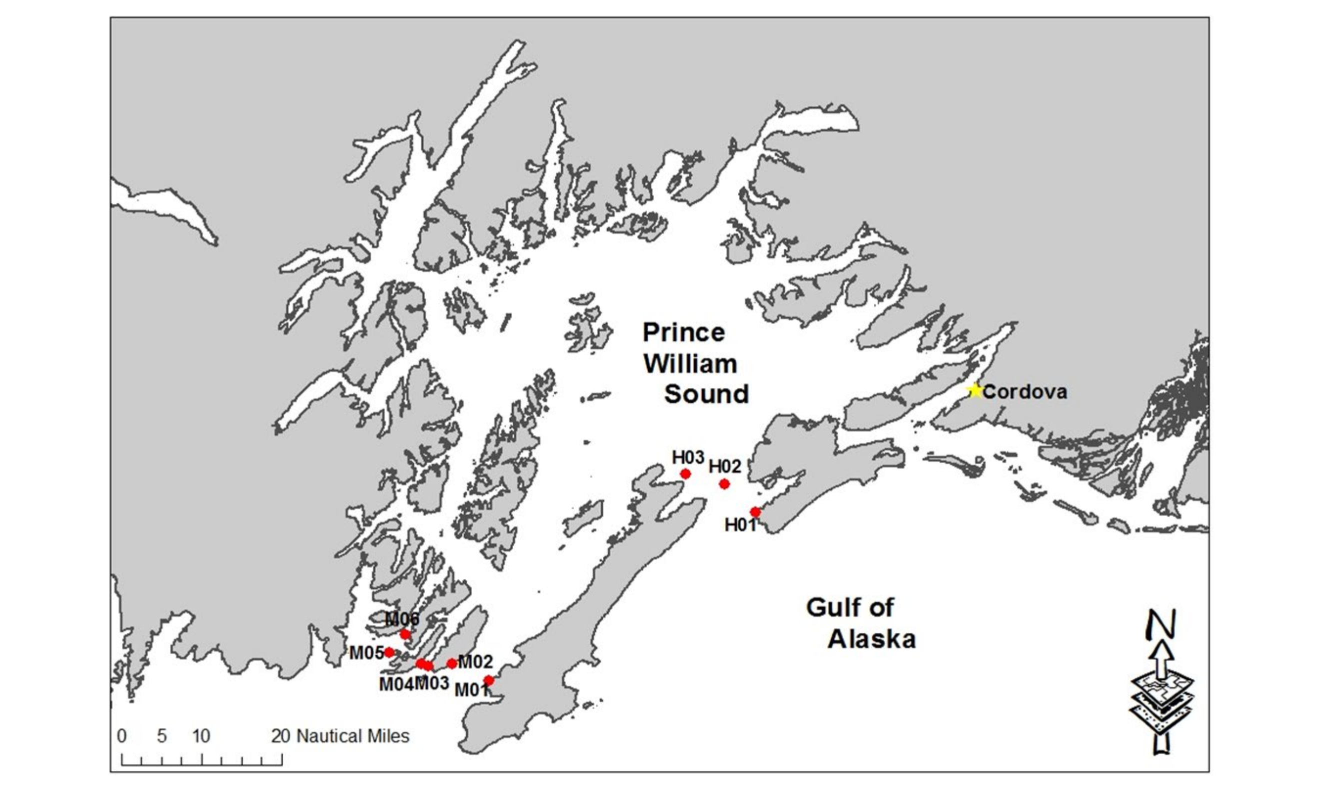
AHRP

AHRP Research Questions

2) What is the extent and annual variability of straying?

Ocean sampling 2013–2015 (PWS only)

- Fish entering PWS sampled at 9 stations
- Multi-mesh panel gillnet fished from contracted gillnet vessel
- Twice weekly sampling from mid-May until the end of August



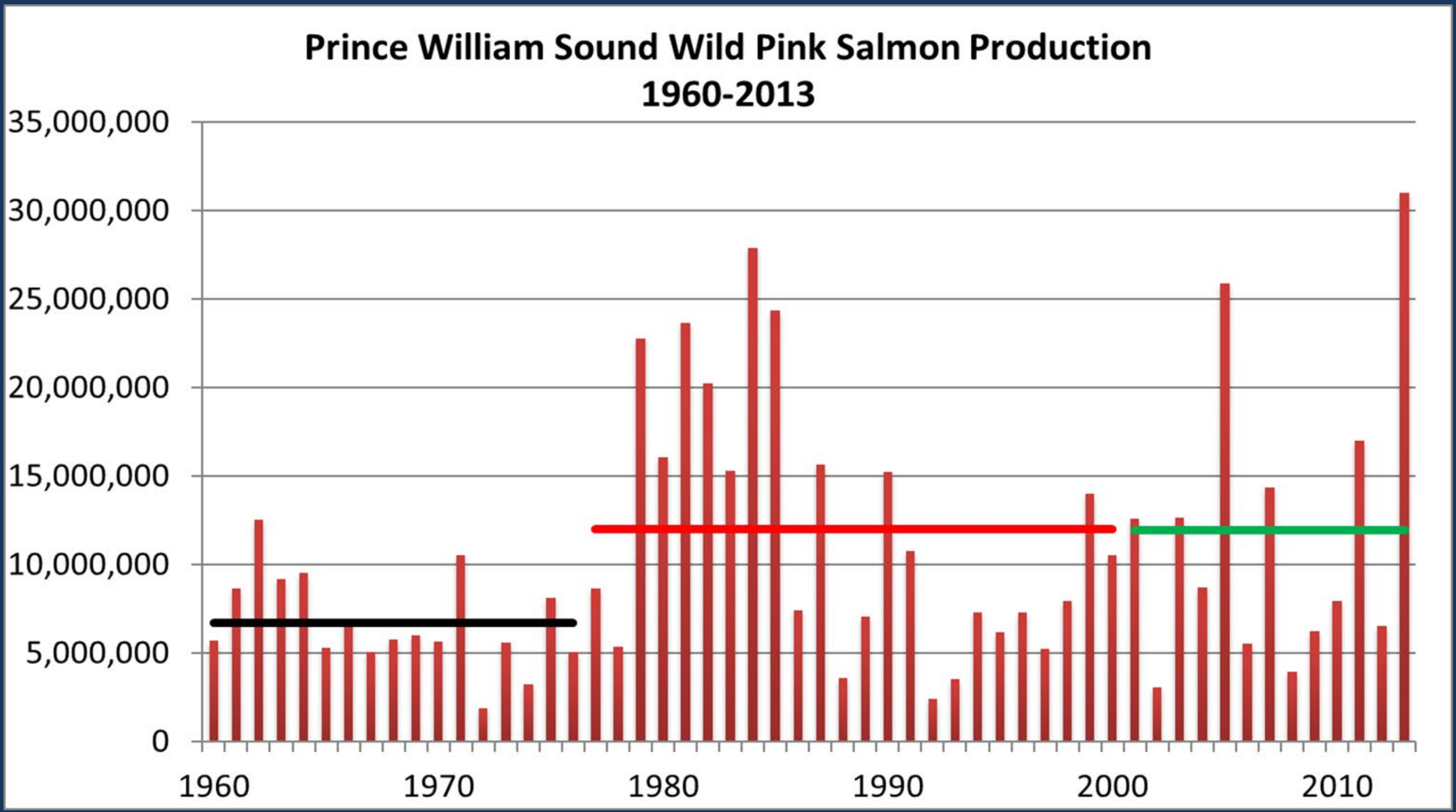
AHRP Research Questions

2) What is the extent and annual variability of straying?

- Ocean sampling allows estimates of total hatchery and wild runs, wild escapement, and number of hatchery strays in the escapement.
- Can compute the hatchery stray rate (1): proportion of hatchery run that strays into spawning streams
- Can contrast production with estimates using index counts to estimate escapement

AHRP Research Questions

2) What is the extent and annual variability of straying?



From Gaudet (2017)

AHRP Research Questions

3) What is the impact on fitness (productivity) of natural pink and chum stocks?

Fitness – the ability to survive and reproduce [average contribution by average individual to next generation]

If hatchery fish are less fit in wild streams, then

1. Hatchery fish will produce fewer offspring

AND

2. Wild fish will produce fewer offspring due to interbreeding.

AHRP Research Questions

3) What is the impact on fitness (productivity) of wild pink and chum stocks?

- Identify number of offspring produced by hatchery- and wild-origin parents
- Follow 2 brood years for 2 generations: replicate for F_1 , potential for F_2
- PWS pink salmon: 6 streams (2013-2018)
- SEAK chum salmon: 4 streams (2013-2023)
- Target streams with high (@50%) and low (@10-20%) hatchery stray rates

Sampling Year

Species		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Chum	BY 1	F_0			F_1	F_1/F_2	F_1/F_2	F_1/F_2	F_2	F_2	F_2	
	BY 2		F_0			F_1	F_1/F_2	F_1/F_2	F_1/F_2	F_2	F_2	F_2
Pink	Odd BY 1	F_0		F_1		F_2						
	Even BY 2		F_0		F_1		F_2					

AHRP

Otolith Mark Use 3

Are there effects of straying on fitness and productivity?

- Use otolith marks to identify hatchery vs. natural origin spawners
- Use parentage analysis to assess fitness of hatchery and wild fish
- Studies in Pacific NW on other species may not apply to AK (king, coho, steelhead)
  - ✓ Freshwater residence time
  - ✓ Life span and age structure
- Different hatchery practices
  - ✓ Local broodstock in AK
  - ✓ 10,000 + parents spawned
  - ✓ Limited holding or feeding for pinks and chums

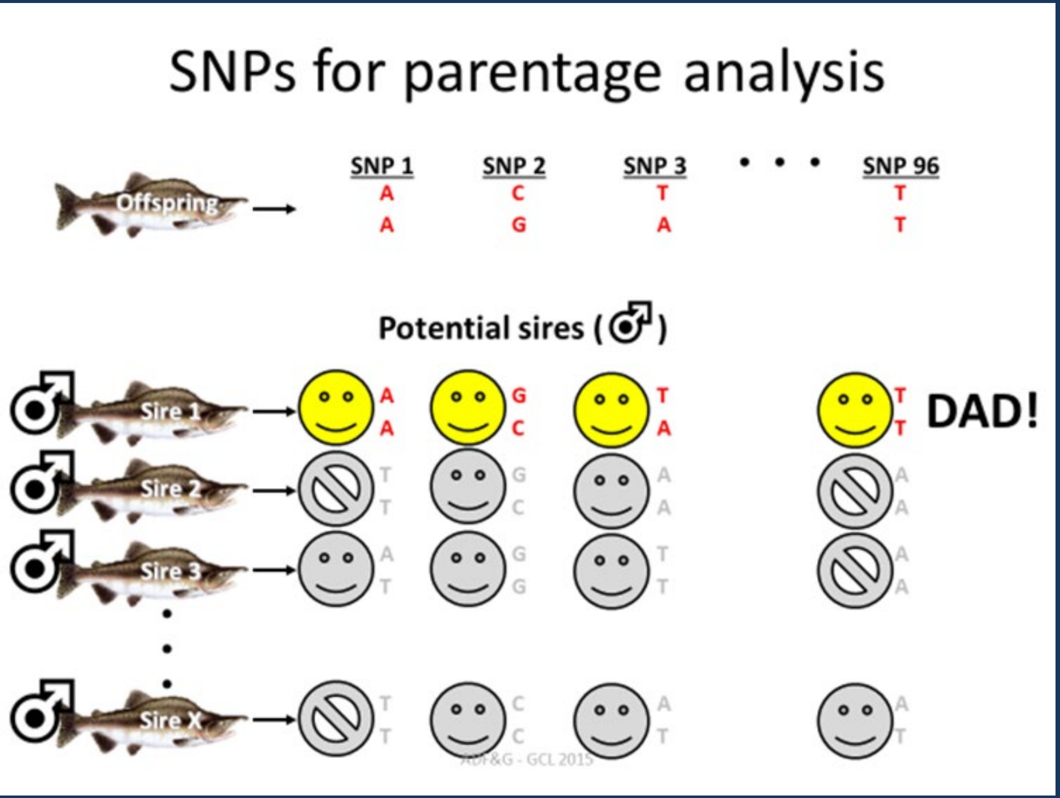
AHRP

AHRP Research Questions

3) What is the impact on fitness (productivity) of natural pink and chum stocks?

Parentage analysis – use genotyping of parents (F_0) for pedigree reconstruction to identify offspring in F_1 (and F_2 if feasible) using single nucleotide polymorphisms (SNPs)

- SNPs available for chum salmon genotyping
- Extensive SNP development required for pink salmon genotyping
- Identify reproductive success **(RS)** of hatchery and wild parents



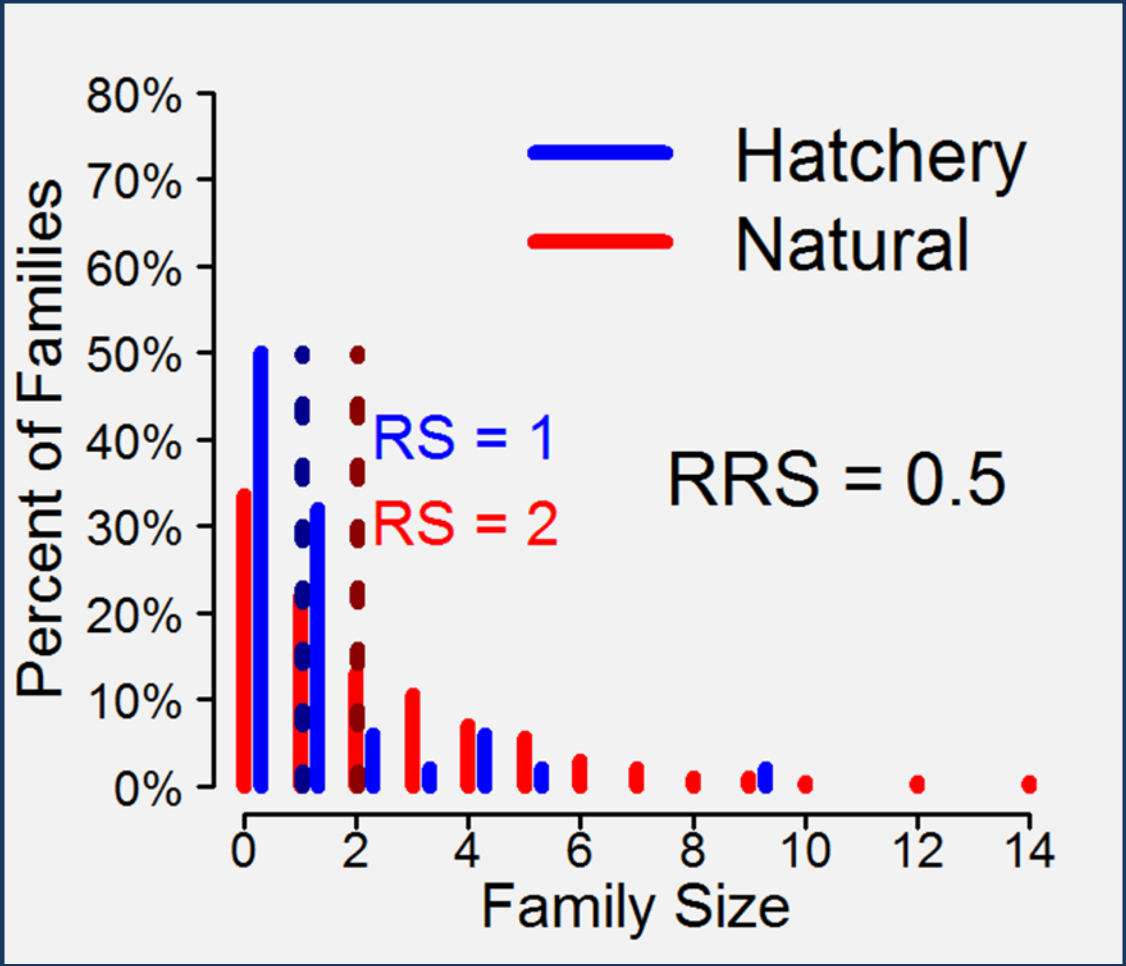
AHRP

AHRP Research Questions

3) What is the impact on fitness (productivity) of natural pink and chum stocks?

Hypothetical distribution of family size for hatchery and wild parents

- Determine RS for hatchery and wild parents for each gender in a stream.
- Calculate the ratio (RRS)= RS(h)/RS(w)
- Differences in fitness must be large in order to detect as statistically significant; use RRS=0.5 for power analysis



AHRP Research Questions

3) What is the impact on fitness (productivity) of wild pink and chum stocks?

Power increases with…

- In our control
  - ↑ Number families
  - Stray rate > 10%
  - ↑ Proportion offspring
- Out of our control
  - Distribution of RS
    - ↑ Mean
    - ↑ Dispersion
  - ↓ True RRS

Depends on:

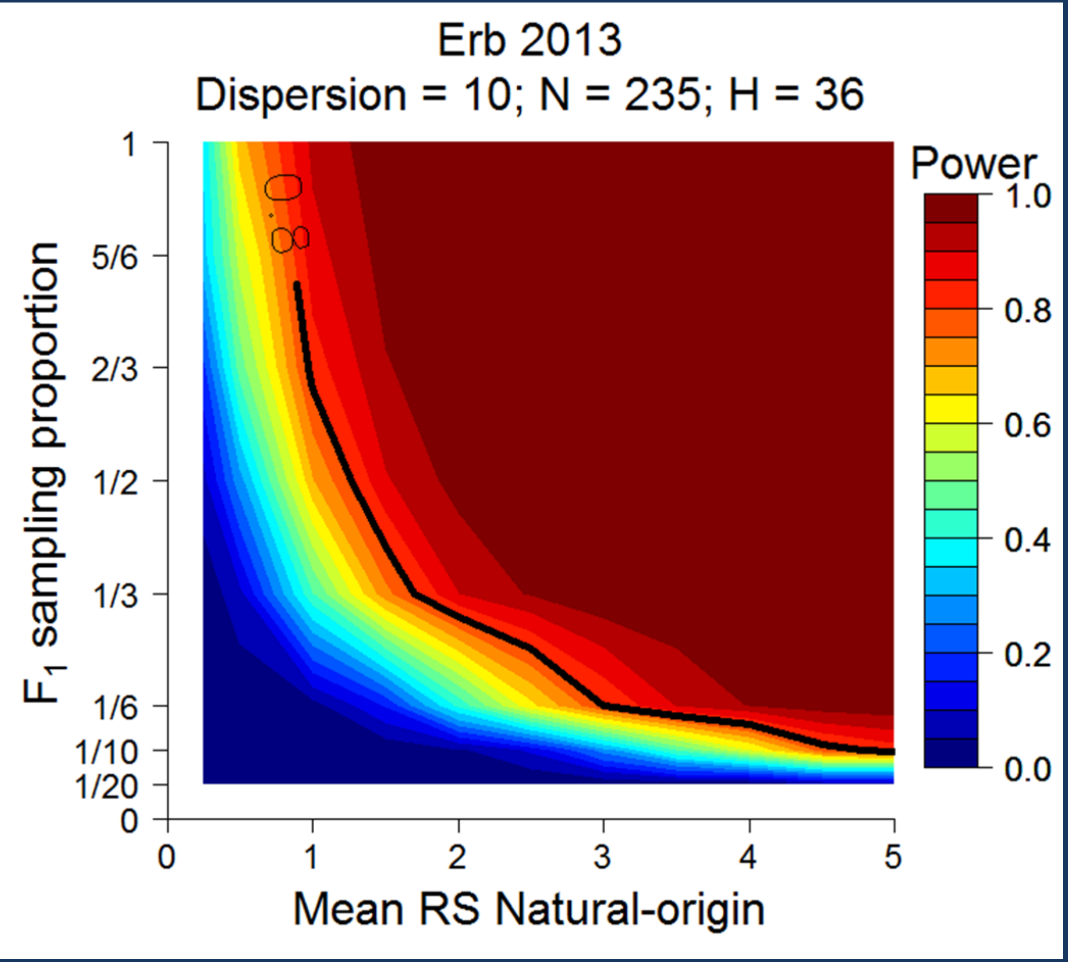
- Number parents (F_0) sampled
  - Hatchery ~ f(stray)
  - Natural
- Proportion offspring (F_1) sampled
- Distribution of RS (productivity)
  - Mean
  - Dispersion
- RRS
  - Difference between Hatchery and Wild
  - Benchmark RRS = 0.5

AHRP

AHRP Research Questions

3) What is the impact on fitness (productivity) of wild pink and chum stocks?

Example of power analysis simulation for accurately estimating RS at different sampling proportions, given observed sample sizes.



Provided by Gene Conservation Lab

AHRP Research Questions

3) What is the impact on fitness (productivity) of wild pink and chum stocks?

Alevin Sampling

- Sampling alevins (post-hatch/pre-emergent larval fish) can provide insight into life-history stage of effects: freshwater versus marine
- Hydraulic pumping in spring to collect alevins that could be progeny of parents sampled after spawning the previous fall
- 250 sample sites distributed in relation to observed spawning abundance, with up to 25 aelvins retained per sample site
- Limit alevin sampling to one pink stream (Stockdale) and one chum stream (Fish Creek) due to budget constraints

AHRP Research Questions

3) What is the impact on fitness (productivity) of wild pink and chum stocks?

Who does the work?

- Sampling of fitness streams contracted to PWSSC for PWS pink salmon, SSSC for SEAK chum salmon
- Otolith samples processed by ADF&G in Cordova (PWS) and Juneau (SEAK)
- SNP development for pink salmon a collaboration with University of Washington and ADF&G Gene Conservation Lab
- Processing and analysis of parentage and offspring samples the responsibility of the ADF&G Gene Conservation Lab

Adaptive Management by Science Panel

Changes to study design due to budget constraints, operational realities (challenging field conditions!)

- Limit stray rate studies to three years to ensure funding for fitness studies
- Drop one of the PWS pink salmon fitness streams because of low stray rate of hatchery fish
- Increase frequency of sampling on fitness streams to increase sample sizes, proportion of run sampled
- Extend sampling in PWS fitness streams until 2019 because of low sample sizes in 2013.
- Prioritize processing of fitness samples due to budget
- Limit alevin sampling to one pink stream (Stockdale) and one chum stream (Fish Creek)