State of Alaska Hatchery Research Project:

A study of the interactions between hatchery and natural pink and chum salmon in Southeast Alaska and Prince William Sound streams

Progress Synopsis December 2019

Alaska Hatchery Priority Research Questions – In 2011, the Alaska Department of Fish and Game (ADF&G) organized a science panel composed of current and retired scientists from ADF&G, University of Alaska, aquaculture associations, and National Marine Fisheries Service to discuss ways to systematically evaluate the interaction between wild and hatchery-produced salmon in Alaska. The science panel designed a long-term research project to address three top priority research questions:

1. What is the genetic stock structure of pink salmon in Prince William Sound (PWS) and chum salmon in Southeast Alaska (SEAK)?
2. What is the extent and annual variability in straying of hatchery pink salmon in PWS and chum salmon in PWS and SEAK?
3. What is the impact on fitness (productivity) of wild pink and chum salmon stocks due to straying of hatchery pink and chum salmon?

The following is a short description of progress made to through 2019 to provide answers to these questions.

Population Structure – Laboratory analysis of the genetic stock structure for both the odd-year and even-year runs of pink salmon populations in PWS using DNA microsatellites has been completed. A report of the current population structure of odd-year lineage (2013, 2015) is available online and the results on the even-year population structure (2014) was presented in May 2018 at the American Fisheries Society meeting in Anchorage; the report is under review. As observed elsewhere in their range, variation among odd-year populations was larger than among even-year populations. In preliminary comparisons of historic (mid-1990's) and contemporary samples, populations are genetically similar across time (10+ generations), but not identical. Among odd-year collections, early and late spawners within some creeks showed genetic differences. Population structure in PWS is comparable to structure found in wild pink salmon elsewhere in its geographic range. A similar analysis of even-year pink salmon collections is currently in progress and should provide more historic perspective on population structure in the presence of hatchery production.

Straying Studies – In a systematic manner, following a robust design, the project sampled otoliths from spawned-out fish in representative chum salmon streams in SEAK, and pink and chum salmon streams in PWS, to estimate the hatchery fraction in natural spawning populations on a district scale. Previous studies have documented strays in SEAK and PWS streams, but this is the first study designed to provide an unbiased estimate for an entire region.

Three years of field work focused on the variability and extent of hatchery pink and chum salmon straying in PWS, and chum salmon straying in SEAK were completed in 2015. The sample results are available online and two separate manuscripts have been completed in 2019 to publish results (Table 1 and Figure 1) in peer-reviewed journals.

Table 1. Updated estimates of the region-wide proportions of hatchery-origin spawners in streams.

	Hatchery Proportion		
PWS	2013	2014	2015
Pink salmon	4%	14%	10%
Chum salmon	3%	3%	9%
SEAK	2013	2014	2015
Chum salmon	3%	3%	6%

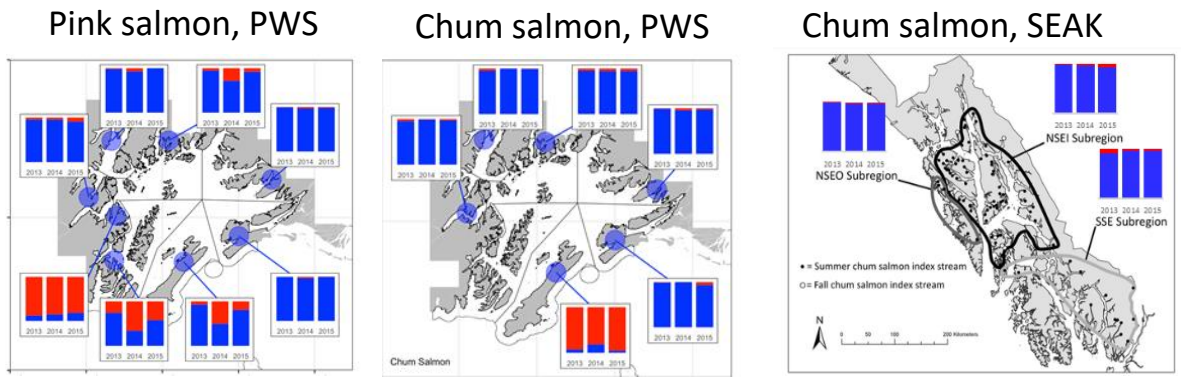

Figure 1. Estimated fractions of hatchery- (red) and naturally-origin (blue) for pink and chum salmon in spawning streams within ADF&G commercial fishing districts in Prince William Sound (PWS) and for summer chum salmon in subregions in Southeast Alaska (SEAK), 2013 – 2015.

Things that we can infer from work to date:

1. Hatchery proportions of pink salmon in streams across PWS ranged from 4 to 10% in the two odd years and was 14% in the even year and was highly variable among streams and districts. The distribution of hatchery fish across districts was consistent across years, with higher proportions near hatcheries similar to previous observations.
2. Hatchery proportions of chum salmon in streams across PWS ranged from 3 to 9% across the three years and was highly variable among streams and districts. The distribution of these hatchery fish across districts was fairly consistent across years, with higher proportions in the districts where fish are remotely released and/or few wild fish spawn.
3. Hatchery proportions of chum salmon in streams across SEAK ranged from 3 to 6% across the three years. The stream with the highest hatchery proportion (87% in one year) was proximate to a hatchery, while more distant streams had hatchery proportions below 2%.

Estimating Production in PWS – Ocean sampling in the entrances to PWS has provided an un-biased estimate of the hatchery fraction in the total return of pink and chum salmon. This information, when combined with estimates from the streams and known removals through harvest and hatchery take provided a means to estimate: 1) the number of natural-origin salmon spawning in streams, 2) the number of hatchery salmon spawning naturally (Hatchery strays), 3) total production of hatchery salmon (including strays; Hatchery run), and 4) total production of natural salmon (excluding hatchery strays; Natural run). With knowledge of the total number of fish spawning in streams and the total return of natural fish, it is possible to estimate the return per spawner, an important measure of productivity and fitness (Table 2). It is also possible to estimate the proportion of the hatchery return that spawned naturally. These results were included in the manuscript submitted to a peer-reviewed journal in 2019.

Table 2. Estimated production of pink and chum salmon in Prince William Sound, 2013-2015.

	Estimated Run sizes		Estimated Harvest Rates	
Species Year	Hatchery	Natural	Hatchery	Natural
Pink salmon				
2013	69,890	33,100	0.99	0.53
2014	42,760	6,960	0.98	0.26
2015	77,340	63,530	0.95	0.40
Chum salmon				
2013	3,010	1,140	0.98	0.22
2014	1,230	1,180	0.96	0.21
2015	2,480	1,130	0.95	0.21

Things that we can infer from work to date:

1. Between 1% and 5% of the pink salmon hatchery returns, and 2% and 5% of the hatchery chum salmon returns (Table 2) in PWS during the three study years spawned naturally. Preparations are underway to publish run reconstruction and straying results.
2. These results indicate that natural populations in PWS continue to be productive in the presence of over 18 generations of straying from large scale hatchery production.
3. The natural production of PWS pink salmon has been particularly robust in the three brood years represented in the work so far: 17 million spawners in 2013 produced an estimated natural run of just under 64 million return, a 4 to 1 return-to-spawner ratio.

Comparison of harvest rates indicates that ADF&G achieved its policy of preferential harvest of hatchery-produced fish (>90%) and sustainable harvest of naturally produced fish (<60%) in 2013-205.

Fitness Studies – This ground-breaking work is based on first identifying the origin (hatchery/natural using otolith marks) and genotype of potential parents spawning in study streams and subsequently identifying parental origin (hatchery/natural) of returning fish using genetic pedigree reconstruction. This information will allow estimation of the relative reproductive success (fitness) of hatchery and naturally produced fish spawning in streams. Evaluation at this scale is important because it will provide insight into the ecological and genetic consequences of hatchery strays on fitness of natural spawners at the drainage scale.

The field crews have completed 7 years of intensive sampling directed toward studies of the relative fitness of hatchery and natural fish in 5 pink salmon study streams in PWS and 4 chum salmon study streams in SEAK. Collectively 237,145 salmon have been sampled for this research through 2019. The laboratory analysis using single nucleotide polymorphism (SNP) genetic markers to determine pedigrees for pink salmon in PWS began in 2018. The first step in this analysis was refining methods to use cost-effective sequencing technology to screen samples taken from carcasses. Pedigree data for two full generations (2 brood years for both odd and even-year runs) in 2 streams completed in spring of 2019. Generally, hatchery fish produced fewer progeny than natural fish during this first generation, but variation was observed by sex, stream, and year. Modeling has been employed to better understand how differences in where and when hatchery- and natural-origin fish spawn affect fitness. Results were reported in the summer of 2019 to the funding entities that supported this portion of the project. This program encompasses additional years from these streams, additional streams, and an additional generation (grandparents), all of which will provide a better understanding of what is driving the observed variation and how to assess the impact on fitness of hatchery fish in the wild.

Funding – In 2015, a finance committee was formed comprised of hatchery operators, a processor representative, and the ADF&G commissioner's office and aquaculture section. This team has focused attention on maintaining the funding to meet the targeted research costs of $16.7 million necessary to complete the work intended to answer the fundamental questions about spawner fitness. The current State of Alaska budget precludes additional state funds, however 7 of Alaska's largest hatchery corporations (SSRAA, NSRAA, DIPAC, PWSAC, VFDA, KRAA, and CIAA) have combined to provide $353,500 for the coming year's work. Those funds in concert with existing funds, and the processor's requested contribution of $500,000 will provide for this year's field work. ADF&G will continue to provide considerable in-kind support. In 2016, ADF&G successfully secured funding from NOAA's Saltonstall-Kennedy Grant Program ($250,000) and North Pacific Research Board ($289,000) to genetically analyze adult and offspring pink salmon from 2 streams in PWS over 2 brood years as part of the fitness study. In addition, NSRAA has received $275,000 in grants from the Pacific Salmon Commission to support sampling of chum salmon in the fitness streams in SEAK. To date, funding received in support of the project totals $10.263 million. Of this, the Seafood Processors Association has provided $2.994 million, PNP operators combined have provided $3.003 million, the State of Alaska appropriated $3.5 million, and $0.447 million is from grants. In 2019, $2.5 million from the 2016 Pink Salmon Disaster funds have been awarded to this project and this funding is earmarked to replace contributions, rather than adding to the total available.

Future –Field work for Questions 1 and 2 has been completed and portions have been submitted for publication in peer-reviewed scientific journals. While, the scope of work for the research project to address the fitness question (Question 3) was narrowed, there are still significant costs. The science panel considers the fitness studies to be the most important to long term understanding of hatchery-wild fish interactions. Some funding has been secured from federal grants (NPRB, SK, Northern Fund of the Pacific Salmon Commission, and the 2016 Disaster Relief) but continued funding for the remaining portion of this component of the project is currently being provided by fishermen through the hatcheries via additional cost recovery, as well as the processor community through a consensus agreement.

It is particularly important that hatchery operators and processors continue their support of the project, both for financial reasons as well as showing a commitment to maintaining this ground-breaking research that is designed to directly address questions about the Alaska salmon hatchery program. Processors had initially committed to 5 years; we hope they will continue their same level of support for the remainder of the project.

This project is expected to end in 2023 with the conclusion of the fitness analysis of chum salmon in SEAK.

This study provided Marine Stewardship Council and Alaska Seafood Marketing Institute information helpful for their certification programs.

Additional information on this project is available at:
http://www.adfg.alaska.gov/index.cfm?adfg=fishingHatcheriesResearch.main