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Proposal No: 1235 **Submitted:** Dec 04, 2015
Proposal Title: Relative productivity of hatchery pink salmon in a natural stream
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Priority: Mariculture and wild-hatchery interactions
Summary of Proposed Work: Extensive ocean-ranching aquaculture of Pacific salmon is practiced by private non-profit (PNP) sector corporations in Alaska. Most of the 1.8B juvenile salmon that PNP hatcheries release annually are pink salmon (*Oncorhynchus gorbuscha*) in Prince William Sound and chum salmon (*O. keta*) in Southeast Alaska. Returns from these releases provide 51-97 million adult salmon to harvests, contributing up to 25% of the exvessel value of the statewide commercial common property harvest. While policies exist to reduce risk to wild stocks, the scale of these programs has raised concerns that hatchery-produced fish may detrimentally impact the productivity and sustainability of wild stocks of Alaska salmon. Loss of productivity caused by straying of hatchery fish into wild populations has been demonstrated in other salmonids throughout the Pacific Northwest. However, none of these studies examined pink salmon (shorter hatchery residence) or occurred in Alaska where the purpose and scale of hatchery programs differ, broodstock origin is local, and freshwater habitat is largely intact. The Alaska Department of Fish and Game and PNP corporations developed the Alaska Hatchery Research Program (AHRP) to address uncertainty about straying and genetic interactions between hatchery and wild stocks. AHRP will use genetic parentage analysis to estimate the relative reproductive success of hatchery-origin pink salmon in natural streams to investigate the potential for a reduction in fitness due to hatchery straying. Samples of parents were collected in 2013 and 2014 and offspring have been or will be collected in 2015 and 2016. Existing funding is available to analyze one stream. This project would fund analysis of parents and offspring from even- and odd-lineages from a second stream and provide a critical set of replicates. The proposed research will inform resource management decisions regarding hatchery production and improve the management and sustainable use of marine resources.
Community & Stakeholder Involvement: The proposed project is a collaborative effort between industry, government agencies and academia. The guiding body of this research is the Alaska Hatchery Research Program's Science Panel, composed of current and retired scientists from ADFG, University of Alaska, PNP Aquaculture Corporations, and the National Marine Fisheries Service. Sampling for the project was contracted to the Prince William Sound Science Center with subcontractor Sitka Sound Science Center. As a result, the research program is guided and conducted by a broad range of community and stakeholder representatives. The project and interim results have been presented in a wide range of venues, including AFS Alaska chapter

meetings, the 2015 National meeting, Pink and Chum workshops, and a special meeting in December 2014 in Anchorage to present draft results to the public. Interactions between project staff and the public will continue. There have also been presentations to regional plan team meetings in PWS and SEAK, Seine and Gillnet Task Force Meetings, Fisherman preseason meetings in PWS. In addition progress reports are available on the ADFG web site.

Additional collaboration with NOAA fishery biologist and Science Panel member Dr. Jeff Hard will continue. Dr. Hard is participating as a project partner, offering his expertise on the genetic effects of hatchery-wild interactions. Collaborators at the Prince William Sound Science Center have expressed interest in coordinating outreach efforts upon project completion, and we intend to partner with them and other community organizations to disseminate project findings to the public. As findings of the proposed study will inform future hatchery permitting by ADFG, it is highly valuable to have aquaculture and industry representatives serving on the Science Panel and vested in the design and implementation of the project before results shape policy.

Outreach Overview: Our outreach and education plan centers around conveying study results and important implications to local communities, vested stakeholders and relevant fishery agencies. We propose to communicate our findings via community and conference presentations, a public display, public school curriculum development, news media, primary publications, the ADF&G website and workshop participation.

Local communities and vested stakeholders

We plan to summarize our proposed study findings as an educational tool for middle and high school students via the Data Nugget format (http://datanuggets.org/). Data Nuggets are an innovative approach to bring cutting edge research into the classroom in a simple and flexible format available to K-12 students. While we will target students in Cordova, the local community our proposed research most closely impacts, the Data Nugget educational vehicle will facilitate dissemination to global STEM teachers.

Collaboration with a local non-governmental research institution will improve the local impact of our outreach efforts. The Prince William Sound Science Center publishes an annual natural history and science publication highlighting research in the region. *Delta Sound Connections* is distributed throughout southcentral Alaska and is available online, providing an efficient avenue to communicate our proposed study findings to local communities and interested stakeholders (http://www.pwssc.org/dsc/). The marker discovery component of the Alaska Hatchery Research Program has already been highlighted in the 2014 edition (http://www.pwssc.net/dsc/DSC-FINAL2014.pdf), providing an example of how this medium successfully communicates our research to the public. Similarly, we will approach PWSSC to utilize their Discovery Room (http://pwssc.org/educate/k12-education/discovery-room/) and Lecture Series (http://pwssc.org/educate/community-2/) programs to engage with Cordova children and broader public.

We plan to produce a map- and data visualization-centered interpretive display at a public space in Cordova, possibly at the recently opened Cordova Center (http://www.thecordovacenter.org). Collaborators at Prince William Sound Science Center (http://www.pwssc.org) employ outreach specialists that we will consult to shape our display efforts. We envision an informative and interpretive display communicating the importance of hatchery salmon to Prince William Sound fisheries and the impact of hatchery pink salmon on wild populations that we propose to estimate. While we include $1,000 for the contracting of display construction to commercial vendors, we anticipate our display will be similar to those used to educate public visitors to the William Jack Hernandez Sport Fish Hatchery in Anchorage, Alaska (http://www.adfg.alaska.gov/index.cfm?adfg=fishingSportStockingHatcheries.williamjackhernandez). Such a permanent display would provide lasting outreach value.

Lastly, we will present study findings at meetings of interested local community members, stakeholders, government agencies and scientific peers. Mr. Dann will present key findings of our proposed research to a meeting of stakeholders and the public in Cordova in spring of 2018. The Alaska Hatchery Research Program regularly hosts meetings in Cordova to communicate program research to the public, private non-profit hatchery operators, commercial fishermen and interested non-governmental organizations and seafood sustainability certifying bodies. We anticipate such a meeting to occur in spring 2018. Mr. Shedd will present study findings to the American Fisheries Society Alaska Chapter annual meeting in 2018. Locations and dates for these meetings are to be announced. Anticipated audiences at these oral presentations include representatives from: fishing industry, aquaculture industry, environmental non-governmental organizations, and scientists (including the AHRP Science Panel). NPRB will be acknowledged as the funding source for this project in all reports and presentations.

Fishery agencies

The overarching goal of this study is to help management agencies (i.e., ADF&G) and interested stakeholders understand the impact of hatchery pink salmon on populations of wild pink salmon in PWS. As such, this project is focused on protecting the natural resources role in the ecosystem and, importantly, is a collaborative effort that includes natural resource users, managers and the interested public (e.g., AHRP Science Panel).

We will publish written reports that describe project findings in detail via two outlets. The findings of this study will be relevant to resource management, future hatchery permitting, and evaluation of fishery sustainability by third-party organizations (e.g., Marine Stewardship Council); publication in ADF&G report series provides direct and accountable public access to project findings. Publication in peer-reviewed literature such as *Evolutionary Applications* adds credibility to our study findings and extends outreach to the broader scientific community.

Links to NPRB Projects: The objectives of the proposed project are novel to NPRB. Projects funded by NPRB that use genetic information have focused on species differentiation, population structure, stock composition analyses of mixed-stock catches, migratory pathways, estimating population size, and natural selection. No projects involving hatcheries or artificial propagation have been funded.

Total Funding Requested From NPRB: $289,435

1. Alaska Department of Fish and Game: $289,435

Total Other Support: $0

Authorizing Signature:

Signature	Title
Printed Name	Organization

Research Classification and Keywords

Species

Oncorhynchus gorbuscha, pink salmon

Large Marine Ecosystem(s)

Gulf of Alaska

Places

Hogan Bay, Prince William Sound

Topical Areas(s)

Fishery Management & Industry, New technology, Population Ecology

Ecosystem Component(s)

Fish and Invertebrates, Humans, Other Prominent Issues (Contaminants, Harmful Algal Blooms, Invasive Species, Aquaculture)

Research Approach

Monitoring, Process Studies

Keywords

fitness, genetics, hatchery-wild interaction, parentage analysis, pink salmon, relative reproductive success

Other Research Priorities Relevant to the Proposal

- Other fish, invertebrate, and fish habitat research
- Social sciences applied to management, policy and communities
- Human-ecosystem interactions
- Molecular and laboratory-based technology development

Objectives

1. Genotype 8,000 pink salmon collected in 2013-2016 from odd- and even-lineages from Hogan Bay at 192 genetic markers to allow assignment of offspring to parent via parentage analysis.
2. Identify number of offspring attributable to each parent and calculate relative return per spawner (RRS) for hatchery- and natural-origin pink salmon by sex.
3. Evaluate the power to detect differences in RRS between hatchery- and natural-origin pink salmon given final sample sizes.

4. Communicate study findings to stakeholders, local communities and relevant management agencies and develop educational tools from them.

Research Design and Approach

<u>Project background</u>

The State of Alaska began salmon enhancement in the 1970’s with the intent to enhance fisheries, provide economic opportunity to local communities, and reduce variation in annual harvests of salmon. In contrast to the mitigation hatcheries of the Pacific Northwest that were built to replace wild production diminished by widespread habitat degradation and dams, the Alaska hatchery program was developed to supplement and enhance wild production. The protection and natural productivity of wild stocks was and remains a priority.

Alaska’s salmon fishery enhancement program recognized from its onset that salmon stray, and that hatchery stocks would stray, so it adopted policies and regulations to mitigate concerns associated with straying. The potential for detrimental effects of hatchery production on wild stocks was recognized by policy makers early in the development of the State’s hatchery programs (reviewed by Heard 2012, McGee 2004). In 1986 representatives from aquaculture associations and state and federal scientists formalized concerns regarding straying in the Alaska Department of Fish and Game Genetics Policy. Other policies pertinent to salmon enhancement include the Disease Policy and Fish Transport Permitting Policy.

Wild populations are likely impacted by hatcheries despite sound policy, given the scale of Alaska’s enhancement programs. This likelihood raises concern that hatchery-produced fish may detrimentally impact the productivity and sustainability of wild stocks of Alaska salmon. The risks posed to natural populations by hatcheries include genetic (consequences of interbreeding between hatchery-bred and wild salmon); disease (introduction or amplification of pathogens); ecological (competition for resources); and harvest mortality (Naish et al. 2007). While potential positive effects exist, such as reducing harvest pressure on low-production stocks, the potential for detrimental effects is the greatest concern for meeting the goals of conservation and sustained yields from wild stocks.

Recent studies have demonstrated large proportions of hatchery-origin salmon in some wild-spawning populations in PWS (Brenner et al. 2012) and SEAK (Piston and Heinl 2012). These results raised important questions: (1) Are hatchery-bred salmon interbreeding with wild salmon to the extent that fitness and productivity are being diminished?; (2) Is the annual assessment of wild stocks (which is largely based on visual observation) biased by the presence of hatchery salmon?; and (3) Is the presence of hatchery-origin salmon causing density interactions that diminish the productivity of wild salmon?

Any potential effect of these programs on wild stocks must be considered in the context of both benefits from enhancement programs and costs to wild stocks that the agency is mandated to protect. It has been argued that hatchery stocks have simply replaced the productivity of wild stocks of pink salmon in PWS so that no net gain realized (Hilborn and Eggers 2000). However, Wertheimer et al. (2004) estimated that an annual average production of 24 million hatchery pink salmon was associated with a yield loss of around 1 million wild fish. Harvest and escapement indices of wild stocks in PWS and SEAK have been consistent with historical levels during 30 years of large-scale hatchery production, suggesting that enhanced production has been compatible with sustained wild stock productivity (Wertheimer et al. 2001). Faced with evidence of straying and uncertainty about its extent and effect, ADFG must act with caution when considering requests by PNP hatchery corporations for permit alterations. Coincident with requests for increased production, salmon fisheries in PWS have recently been identified as not sustainable by third-party sustainability certifying organizations due to uncertainty of the effects of hatcheries on wild populations.

ADFG and the PNP hatchery corporations developed a research program to investigate concerns about straying and genetic interactions between hatchery and wild stocks. In 2011, ADFG convened a Science Panel of current and retired scientists with broad experience in salmon enhancement, management, and wild and hatchery interactions from ADFG, University of Alaska, PNP Aquaculture Corporations, and NOAA-Fisheries. The Panel addressed three priority questions:

- I. *What is the genetic stock structure of pink and chum salmon in each region*?
- II. *What is the extent and annual variability in straying of hatchery pink salmon in PWS and chum salmon in PWS and SEAK*?
- III. *What is the impact on fitness (productivity) of natural pink and chum salmon stocks due to straying of hatchery pink and chum salmon*?

The Panel developed the Alaska Hatchery Research Program (AHRP) to address these questions (http://www.adfg.alaska.gov/index.cfm?adfg=fishingHatcheriesResearch.main) in 2013 with funding from the State of Alaska, the PNP operators, and industry representatives. Efforts concentrated on providing information to answer questions I (population structure) and II (extent of straying) during the first three years of the program.

Further research is needed to answer question III and evaluate potential changes in natural populations of Alaskan pink and chum salmon due to straying of hatchery-origin fish. The main concern is that hatchery-origin fish interbreeding with natural-origin fish may reduce the fitness of wild populations. Fitness is a measure of an organism's ability to survive, reproduce and pass genetic information to future generations. Fitness and can be measured as the contribution to the next generation by an average individual of a given type. Relative fitness is the ratio of fitness between one type and another, for example, hatchery-origin versus natural-origin salmon. For salmon, fitness is often measured as the number of adult offspring produced per spawner of each sex. If hatchery-origin fish are less fit and interbreed with natural-origin fish, natural-spawning populations may lose productivity as a consequence of hatchery strays in the breeding population.

<u>Concept</u>

In order to investigate the potential for fitness impacts of hatchery-origin strays on natural-origin pink salmon populations in PWS, we need to know the origin and pedigree of each fish captured in select streams across multiple generations. Origin refers to the type of early life-history habitat (hatchery or natural) that a fish experienced. Pedigree refers to the family relationship among parents and offspring. 'Ancestral origin' refers to the origin of an individual's ancestors (e.g., two parents of a single origin [hatchery/hatchery or natural/natural] or two parents of mixed origin [hatchery/natural]). These ancestral origins can be determined by combining information from two sources: identification of hatchery origin from otolith marks (all hatchery salmon in PWS have thermally marked otoliths) and pedigree reconstruction from genetic data. By pairing these data within fish and across generations, we can estimate reproductive success of origin groups. Survival of both hatchery- and natural-origin fish and their adult-to-adult relative reproductive success (RRS) are needed to evaluate whether fitness differences exist between the two types of salmon spawning in the wild. The AHRP is using the relative reproductive success of hatchery-origin fish to natural-origin fish as the measure of fitness in this study.

The initial design of the fitness study was based on:

1. Six streams in PWS with pink salmon spawning populations of about 3,000 fish each; three with a low proportion of strays (less than 20%) and three with a high proportion of strays (around 50%); and

2. Four streams in SE Alaska with chum salmon spawning populations of about 3,000 fish each; two streams that have a low portion of strays and two streams that have a high proportion of strays.

In each of these 10 "fitness" streams, about 500 adult post-spawning salmon were to be collected, their otoliths sampled to determine their origin (hatchery or wild), and genetic samples taken to identify them as potential parents of the next generation (F_0). Sampling of returning adult offspring occurs when offspring (F_1) of the originally sampled parents return to spawn. As part of the analysis, it will be determined if these fish are offspring of F_0 males or females of known origin (either hatchery strays or natural-origin fish) or are offspring of unsampled F_0. These data were to be used to estimate survival rates and the reproductive success to the adult stage for hatchery-versus natural-origin fish in each stream as well as provide data for comparisons between low and high stray rates for each of the two species with replication.

Fish spawning in these streams were to be sampled for two complete generations. For pink salmon, sampling in each stream would occur in each of six years over two brood years for each brood line, and for chum salmon, sampling in each stream was planned to occur in each of 11 years over two brood years. Pink salmon sampling was scheduled to occur annually from 2013-2018 and chum salmon sampling from 2013-2023. Data and statistics obtained from this robust experiment would provide information needed to evaluate fitness of natural-origin versus hatchery-origin stray salmon spawning in the wild in streams of PWS and SE Alaska.

Preliminary power analyses of the original design called for greater sampling in all fitness study streams (Dann et al. 2014b). These analyses indicated low power to detect differences in fitness between hatchery- and natural-origin salmon with the original design described above. The Science Panel chose to increase the frequency of sampling resulting in tens of thousands more samples than originally planned. At the same time, funding declines limit the scope of the study that can be completed and thus the program's ability to answer these important questions to inform future resource management decisions.

Offspring (F_1) of the pink salmon parents sampled in 2013 returned to the streams and were sampled in 2015 while offspring of parents sampled in 2014 will be sampled in 2016. Matching of the F_1 individuals to F_0 parents will provide the first estimates of relative reproductive success of hatchery-origin pink salmon in natural streams. Available funds allow for analysis of samples from a single stream (Stockdale Creek) of the six sampled; this analysis will be completed by fall of 2017. We propose analysis of samples from another system with potential for high statistical power in both lineages to provide replicate estimates of relative reproductive success in both space and time. Such a replicate study will greatly improve our ability to make inferences from the research program to inform future hatchery permitting policy.

Estimates of RRS from both odd- and even-year lineages serve as highly valuable replicates and lend credibility to inferences and decisions based upon study findings. The two lineages experience the same environment and selective pressures in alternating years but respond with isolated and distinct pools of standing genetic variation. Furthermore, the two lineages are managed differently, with separate escapement goals within the same district. Most importantly, having more than one estimate of RRS from a system is a much stronger experimental design from a statistical perspective and lends credibility to any inferences based upon the results of the experiment.

Experimental design

This study will utilize samples collected under AHRP. The original experimental design for field collections is detailed in the AHRP Request for Proposals (http://www.adfg.alaska.gov/static/fishing/PDFs/hatcheries/research/rfp_hatchery_fish_interaction.pdf) and in the Prince William Science Center Proposal (http://www.adfg.alaska.gov/static/fishing/PDFs/hatcheries/research/pwssc_h-w_proposal_6-29-12.pdf).

By September 2016, the AHRP will have sampled parents (F_0) and offspring (F_1) from a complete generation of both odd- and even-year pink salmon in PWS. This will be the first opportunity to reconstruct genetic pedigrees in order to directly compare the RRS of hatchery-origin spawners to natural-origin spawners in natural streams for both odd- and even-year pink salmon in PWS. This information will help determine: 1) if hatchery-origin salmon spawn with natural-origin salmon and 2) if hatchery-origin salmon result in a change in fitness of wild populations (i.e. a decline in natural-origin productivity).

The original target sample size for each of the 6 pink salmon pedigree streams in PWS under this study (Figure 1) was 500 adults (F_0) and 500 offspring (F_1) from a stream with an average escapement ~3,000 salmon, with the goal to have adequate statistical power to detect a 50% reduction in fitness of hatchery-origin spawners as compared to natural-origin spawners (i.e. RRS = 0.5). Further investigation involving extensive power analyses (Shedd et al. 2014, Shedd and Habicht In prep) concluded that the best way to maximize statistical power to detect potential differences in reproductive success between natural- and hatchery-origin spawners is to sample as many parents of both origin groups as possible and a high proportion of returning adult offspring. Partly based on this information, the AHRP Science Panel modified the study design to increase the sampling numbers and proportions in 2014 and onward. Given the increase in the number of samples collected and declining funding, the AHRP has decided to focus initial pedigree reconstruction to a subset of streams in order to maximize statistical power by taking a “depth” approach (intensively investigate fewer streams), rather than a “breadth” approach (limited understanding of many streams).

For this study we propose to analyze 8,000 individuals from one stream in both lineages. Hogan Bay (Figure 1) is a moderate-sized stream in the southwest corner of Prince William Sound with moderate escapements in the mid- to tens of thousands and a relatively high observed stray rate (50-90%). We selected Hogan Bay based upon anticipated power to detect differences in RRS over a wide range of potential distributions of reproductive success (Shedd et al. in prep; Figure 2), sample sizes, and escapement estimates from 2013-2015 and expected returns and stray rate in 2016 (Table 1; Figure 3). For the odd-year lineage, we plan to analyze all potential parents collected in 2013 regardless of origin, and all of the potential offspring collected in 2015 (i.e. only natural-origin offspring as determined by otolith analysis) in order to compare distributions of reproductive success by origin and sex. For the even-year lineage, we intend to follow a similar plan except that we will subsample from the hatchery-origin parents collected in 2014 in order to bring the total number of fish analyzed to this project to 8,000 individuals. Approximately 2,400 hatchery-origin parents were collected in 2014, far more than is statistically required to adequately characterize the distribution of reproductive success among hatchery-origin parents, so we chose this experimental group to subsample from in order to design a cost-effective research program. The exact number of hatchery-origin parents sampled in 2014 that will be subsampled will depend on how many natural-origin offspring are sampled in 2016.

Methods

Stream Sampling

Field crews visited PWS pedigree streams at least once every three days throughout the 2013 and 2014 field seasons to collect samples from the F_0 generation (i.e. potential parents) throughout the entire run (Knudsen et al. 2015). Paired otolith and genetic samples were collected into a cell of a 48-well deep well plate and preserved in 95% ethanol to prevent DNA degradation. Additional phenotypic data such as sex and fork length along with date and GPS location data were also collected.

Field crews plan to visit PWS pedigree streams at least every other day throughout the 2016 field season to collect samples from the F_1 generation (i.e. potential offspring) throughout the entire run following methods used in 2014 (Knudsen et al. 2015). Sampling effort in 2016 is expected to parallel that of 2014 and 2015; given that expectation and assuming similar run sizes and straying rates, we expect approximately 6,045 individuals will be sampled from Hogan Bay and that 72.9% will be hatchery strays. This would result in 1,638 natural-origin offspring of 2014 parents (Table 1).

Otoliths and genetic tissue are separated at the Gene Conservation Laboratory (GCL) in Anchorage maintaining pairing integrity. Otoliths are sent to the ADFG Cordova Otolith Laboratory where they are subsequently polished and inspected under a light microscope for the presence of hatchery thermal marks (Volk et al. 2005). All trained otolith readers had previously been tested with randomized blind tests of known origin fish to assess accuracy (Joyce and Evans 1999).

Heart tissue was selected as the genetic tissue for collections and single nucleotide markers (SNPs) were selected as the genetic marker. DNA decay in dead fish is affected by time, temperature, chemical environment, and solar radiation (Cadet et al. 1997). We therefore chose to sample heart tissue (bulbus arteriosus) because (1) it is one of the last tissues to die, (2) it is protected from the solar radiation that can damage DNA, and (3) tests of this tissue type from both live and dead (non-rotten) salmon indicated high genotyping success (Dann et al. 2014a). SNPs were chosen because they lend themselves to high-throughput genotyping and have been successfully used for parentage analysis in salmonids (Anderson and Garza 2006, Hauser et al. 2011).

Previous studies documented that DNA from poor quality tissues can produce unreliable genotypic data and questionable estimates of stock composition in mixed stock analyses (Paetkau 2003; ADF&G unpublished data). Data reliability is even more important for parentage analyses due to the large influence that missing or incorrect genotypes can have on parentage assignments relative to stock of origin assignments. Poor-quality DNA samples will be excluded from analyses by implementing the "80% Rule", whereby individuals missing genotypes for 20% or more of screened markers are removed from further analysis (Dann et al. 2009).

Laboratory Analysis

DNA extraction and genotyping will generally follow Genotyping-in-Thousands by sequencing (GT-seq) methods (Campbell et al. 2014). While 5' exonuclease genotyping methods have been efficient and cost-effective for projects involving < 96 SNPs (Dann et al. 2012, Seeb et al. 2009), the newly developed GT-seq method allows for massively parallel sequencing reactions that is transformational for obtaining high quality genotypes for ≥ 200 SNPs. Briefly, genomic DNA will be extracted from individual tissue samples using DNeasy 96 Tissue kits (QIAGEN, Valencia, CA). Extracted DNA from individuals will be combined with a PCR cocktail for multiplex PCR of ~ 200 SNP amplicons currently being developed specifically for parentage analysis under contract to the University of Washington. This amplicon panel will be selected from among thousands of SNPs discovered using restriction site associated DNA sequencing of PWS pink salmon collected in 2013 and 2014. SNPs with high minor allele frequency in both broodlines (odd- and even-year) will be selected. High minor allele frequency markers maximize discriminatory power in parentage analysis and pedigree reconstruction (Anderson and Garza 2006). Following multiplex PCR, individual samples will be labeled with unique DNA barcode adapters, normalized, and pooled into a single sequencing library for next generation sequencing (NGS). Post-sequencing, reads from individual samples will be split based on the unique barcodes and genotypes will be called according to counts of amplicon-specific alleles (Campbell et al. 2014). Genotypes will be imported and archived in the Gene Conservation Laboratory Oracle database, *LOKI*.

A quality control analysis (QC) will be conducted to identify laboratory errors and to measure the background discrepancy rate of the genotyping process. The QC analyses will be performed by staff not involved in the original genotyping (Dann et al. (2012). Briefly, the method will consist of re-extracting 8% of project fish and genotyping them for the same SNPs assayed in the original genotyping process following the same methods. Discrepancy rates will be calculated as the number of conflicting genotypes, divided by the total number of genotypes compared. These rates will describe the difference between original project data and QC data for all SNPs and are capable of identifying extraction, assay plate, and genotyping errors. Assuming that discrepancies among analyses are due equally to errors during the original genotyping and during quality control and assuming that one of these genotypes is correct, error rates in the original genotyping will be estimated as half the rate of discrepancies.

Statistical Analysis

Genotypes in the *LOKI* database will be imported into the statistical package *R* for analysis (R Core Team 2015). Two statistical quality control analyses will be performed to ensure only high-quality genotypic data are used in subsequent analyses. First, individuals that are missing a substantial number of genotypes will be identified and removed from further analyses. We will use what we refer to as the 80% rule, which excludes individuals missing genotypes for 20% or more of loci, because these individuals likely have poor-quality DNA. The inclusion of individuals with poor quality DNA might introduce genotyping errors and reduce the accuracies of parentage analyses. The second statistical quality control analysis will identify individuals with duplicate genotypes and remove them from further analyses. Duplicate genotypes can occur as a result of sampling or extracting the same individual twice, and will be defined as pairs of individuals sharing the same genotype in 95% of markers screened. The individual with the most complete genotypes from each duplicate pair will be retained for further analyses.

Once statistical quality control is complete for genetic data, all other sampling data including otolith origin will be queried from ADFG's Alaska Salmon Biological Data Warehouse and joined to individuals based on the plate barcode and individual position. Collection year and sex will be used to create input files for pedigree reconstruction program FRANz (Riester et al. 2009). Briefly, FRANz uses a Bayesian framework and a Metropolis-Hastings coupled Markov Chain Monte Carlo (MCMC) algorithm to assign parentage based on phenotypic data (brood year and sex) and multilocus genotypes. Likelihood- or Bayesian-based parentage analysis has been shown to perform better than exclusion-only techniques (Anderson and Ng 2014, Harrison et al. 2013, Hauser et al. 2011, Jones et al. 2010, Steele et al. 2013). Additionally, a full-probability Bayesian model for pedigree reconstruction is better suited for studies that are not able to sample all potential parents and offspring, as the model accounts for this and can use sibships and other close relationships among sampled individuals to infer parental genotypes from progeny to assist in filling out sparse pedigrees (Jones et al. 2010, Riester et al. 2009). Final parentage assignment will be limited to those parent-offspring pairs or parent-pair-offspring trios that have a posterior probability > 95%.

The reproductive success of each origin group (hatchery- and natural-origin) will be calculated separately for each sex, as we anticipate that most offspring will be assigned to single-parent-offspring pairs since only a proportion of potential parents are being sampled, and this provides a method to account for parents that produce zero sampled offspring (Araki and Blouin 2005, Christie et al. 2014). Reproductive success is the number of F_1 offspring assigned to F_0 parents.

Hypothesis testing:

H_0: Reproductive success does not differ between hatchery- and natural-origin pink salmon in the Hogan Bay drainage.

1) Differences in reproductive success will be tested using a non-parametric one sample permutation test ("oneway.test" function in the "coin" package in R), as testing for differences in RS is equivalent to testing if RRS < 1 (Araki and Blouin 2005). Results of the permutation test will provide a mean estimate of RRS along with 90% confidence interval (based on the permutation distribution).

2) To compliment the analysis of RS, we will also use a generalized linear model (GLM; negative binomial distribution with a log link function; "glm.nb" in "MASS" package in R) to investigate the effects of covariates such as length, timing, and origin, on individual reproductive success (Ford et al. 2012).

Project Management

The ADFG Gene Conservation Laboratory has many years of experience providing researchers and fishery managers with genetic information to inform fisheries management and policy. ADFG Administrative procedures provide for immediate invoice payment and tracking of expenses. The principal investigators are funded through other sources and both have successful track records in preparing projects, participating in data collection and analysis and producing reports in a timely fashion.

GCL plays an integral role in the AHRP advising the Science Panel on genetic and statistical methods. GCL is also charged with receiving, separating tissues from otoliths, and inventorying and archiving samples for the AHRP. AHRP Science Panel has encouraged GCL to secure outside funding to complete the objectives of the program. Since the field components of this project are under the purview of the AHRP, no additional permits are required to complete this project.

The project and interim results will be presented in a wide range of venues, such as American Fisheries Society (AFS) Alaska chapter and national meetings, Pink and Chum workshops, and AHRP public meetings. There have also been presentations to regional plan team meetings in PWS and SEAK, Seine and Gillnet Task Force Meetings, Fisherman preseason meetings in PWS. In addition progress reports are available on the ADFG web site (2013 and 2014 results will soon be posted; http://www.adfg.alaska.gov/index.cfm?adfg=fishingHatcheriesResearch.main). Finally, results will be published in peer-reviewed literature such as Evolutionary Applications.

Tyler Dann – ADFG, Gene Conservation Laboratory, Fisheries Geneticist II, Southcentral and Southwest Alaska Genetics Project leader. Mr. Dann will act as the PI, budget coordinator, and will be in charge of all aspects of project implementation. Mr. Dann will ensure that work is completed and accurately reported in a timely fashion and will finalize all data reporting.

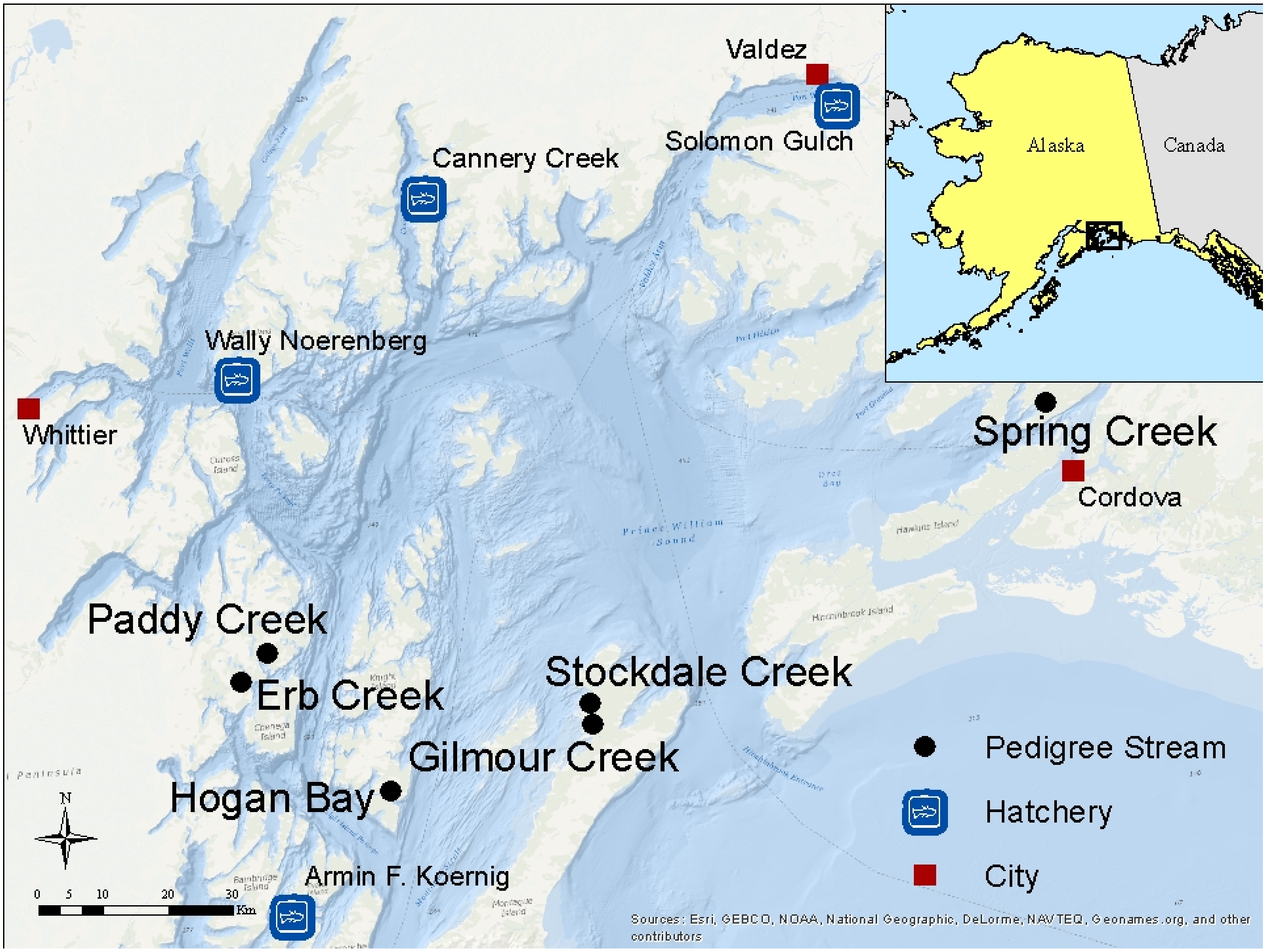
Kyle Shedd – ADFG, Gene Conservation Laboratory, Fisheries Geneticist I, Hatchery Research and Westward Region Analyst. Mr. Shedd will oversee data collection, analysis and report preparation.

Relative productivity of hatchery pink salmon in a natural stream
September, 2016 - June, 2018

	Responsible Party	2016		2017				2018	
		Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
Alaska Marine Science Symposyum	Dann, Tyler			X				X	
Final Report	Dann, Tyler								X
Data and Metadata Transfer	Dann, Tyler								X
Progress Report	Dann, Tyler	X		X		X		X	
Objective# 1 Genotype 8,000 pink salmon collected in 2013-2016 from odd- and even-lineages from Hogan Bay at 192 genetic markers to allow assignment of offspring to parent via parentage analysis.	Shedd, Kyle			X	X				
Objective# 2 Identify number of offspring attributable to each parent and calculate relative return per spawner (RRS) for hatchery- and natural-origin pink salmon by sex.	Shedd, Kyle					X			
Objective# 3 Evaluate the power to detect differences in RRS between hatchery- and natural-origin pink salmon given final sample sizes.	Shedd, Kyle					X			
Objective# 4 Communicate study findings to stakeholders, local communities and relevant management agencies and develop educational tools from them.	Dann, Tyler						X	X	X
Deliverable# 1 Data Nugget educational tool	Dann, Tyler						X		
Deliverable# 2 Article describing study findings to local stakeholders and community in the Prince William Sound Science Center's annual natural history and science publication, Delta Sound Connections.	Dann, Tyler							X	
Deliverable# 3 Map- and data visualization-centered interpretive display at a public space in Cordova.	Dann, Tyler								X
Deliverable# 4 Presentation of study findings to stakeholders and local community members.	Dann, Tyler								X
Deliverable# 5 Presentation of study findings at the American Fisheries Society Alaska Chapter annual meeting.	Shedd, Kyle								X
Deliverable# 6 Publication of study findings for policy makers, third-party sustainability certification organizations and the public in ADF&G report series.	Dann, Tyler								X
Deliverable# 7 Publication of study findings in peer-reviewed journal such as Evolutionary Applications.	Shedd, Kyle								X

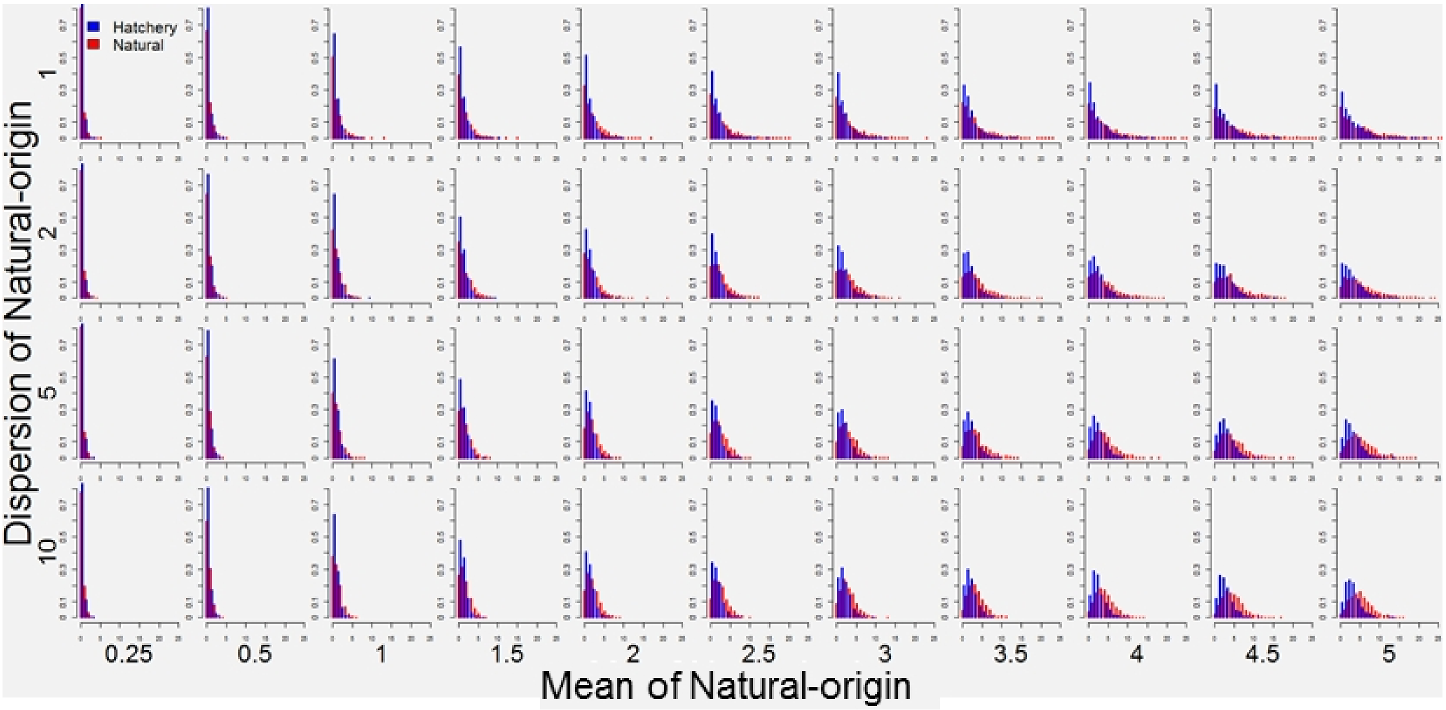
Figures

Figure: 1



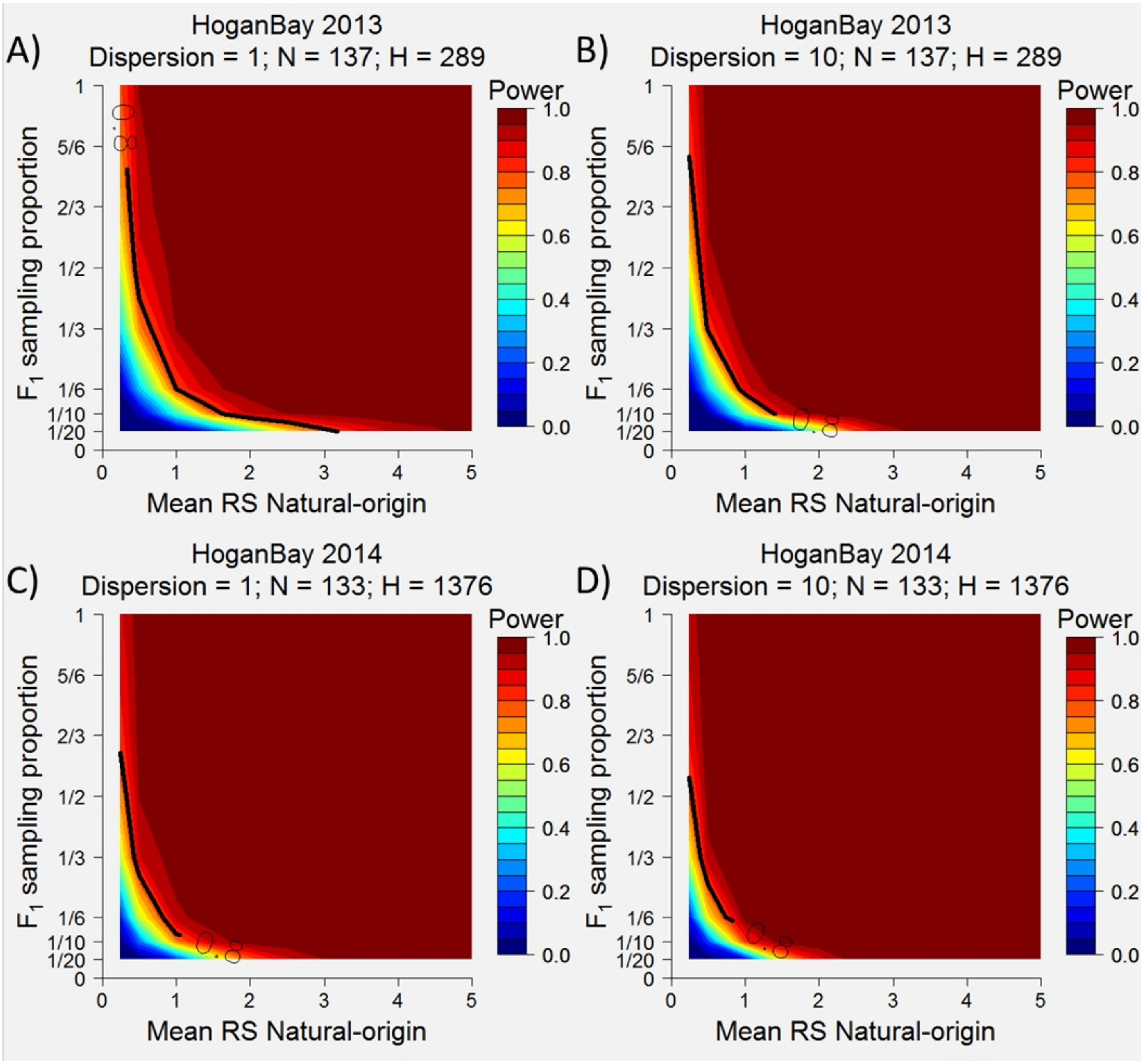
Location of six pink salmon pedigree streams in Prince William Sound for the Alaska Hatchery Research Program.

Figure: 2



Potential distributions of reproductive success as characterized by the negative binomial distribution for 11 mean reproductive success values (natural-origin) and 4 dispersion factor values (i.e. variance component). The hatchery-origin group has a distribution with equal variance, but a mean value half that of the natural-origin group (RRS of 0.5).

Figure: 3



Color contour plots of expected statistical power to detect RRS of 0.5 based on the productivity of the system (x-axis), the proportion of F_1 offspring sampled (y-axis), and different variances in reproductive success for the odd- (A & B) and even-year (C & D) lineages of pink salmon from Hogan Bay.

Table 1. Summary of information guiding the experimental design of relative reproductive success analyses of pink salmon from Hogan Bay. Information includes numbers of sampled individuals, estimated stray rates and abundance estimates by broodyear, expected number of natural-origin offspring for F_1 broodyears, and proposed numbers to genotype by origin and broodyear. Proposed numbers to genotype are based upon maximizing power to detect differences in relative reproductive success and so include all 2013 individuals (F_0), all natural-origin F_0 sampled in 2014, all natural-origin F_1 sampled in 2015 and 2016, and the number of hatchery-origin F_0 from 2014 that bring the total number of individuals to genotyped to 8,000. Note that final sample sizes to be genotyped will depend upon actual 2016 sampling and observed stray rate; estimates included are simply the average of 2014 and 2015, years believed to be representative of 2016 sampling effort.

			Abundance estimate			# to genotype by origin	
Broodyear	Sampled Individuals	Stray Rate	Aerial survey	Stream survey	# natural origin	Natural	Hatchery
2013	829	56.4%	46,968	8,613		361	468
2014	2,649	89.4%	9,238	6,655		281	1,136
2015	9,441	56.4%	18,998	9,958	4,116	4,116	-
2016	6,045	73%			1,638	1,638	-
Total	18,964		75,204	25,226	5,754	6,396	1,604

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Outreach Plan

Our outreach and education plan centers around conveying study results and important implications to local communities, vested stakeholders and relevant fishery agencies. We propose to communicate our findings via community and conference presentations, a public display, public school curriculum development, news media, primary publications, the ADF&G website and workshop participation.

Local communities and vested stakeholders

We plan to summarize our proposed study findings as an educational tool for middle and high school students via the Data Nugget format (http://datanuggets.org/). Data Nuggets are an innovative approach to bring cutting edge research into the classroom in a simple and flexible format available to K-12 students. While we will target students in Cordova, the local community our proposed research most closely impacts, the Data Nugget educational vehicle will facilitate dissemination to global STEM teachers.

Collaboration with a local non-governmental research institution will improve the local impact of our outreach efforts. The Prince William Sound Science Center publishes an annual natural history and science publication highlighting research in the region. *Delta Sound Connections* is distributed throughout southcentral Alaska and is available online, providing an efficient avenue to communicate our proposed study findings to local communities and interested stakeholders (http://www.pwssc.org/dsc/). The marker discovery component of the Alaska Hatchery Research Program has already been highlighted in the 2014 edition (http://www.pwssc.net/dsc/DSC-FINAL2014.pdf), providing an example of how this medium successfully communicates our research to the public. Similarly, we will approach PWSSC to utilize their Discovery Room (http://pwssc.org/educate/k12-education/discovery-room/) and Lecture Series (http://pwssc.org/educate/community-2/) programs to engage with Cordova children and broader public.

We plan to produce a map- and data visualization-centered interpretive display at a public space in Cordova, possibly at the recently opened Cordova Center (http://www.thecordovacenter.org). Collaborators at Prince William Sound Science Center (http://www.pwssc.org) employ outreach specialists that we will consult to shape our display efforts. We envision an informative and interpretive display communicating the importance of hatchery salmon to Prince William Sound fisheries and the impact of hatchery pink salmon on wild populations that we propose to estimate. While we include $1,000 for the contracting of display construction to commercial vendors, we anticipate our display will be similar to those used to educate public visitors to the William Jack

Hernandez Sport Fish Hatchery in Anchorage, Alaska (http://www.adfg.alaska.gov/index.cfm?adfg=fishingSportStockingHatcheries.williamjackhernandez). Such a permanent display would provide lasting outreach value.

Lastly, we will present study findings at meetings of interested local community members, stakeholders, government agencies and scientific peers. Mr. Dann will present key findings of our proposed research to a meeting of stakeholders and the public in Cordova in spring of 2018. The Alaska Hatchery Research Program regularly hosts meetings in Cordova to communicate program research to the public, private non-profit hatchery operators, commercial fishermen and interested non-governmental organizations and seafood sustainability certifying bodies. We anticipate such a meeting to occur in spring 2018. Mr. Shedd will present study findings to the American Fisheries Society Alaska Chapter annual meeting in 2018. Locations and dates for these meetings are to be announced. Anticipated audiences at these oral presentations include representatives from: fishing industry, aquaculture industry, environmental non-governmental organizations, and scientists (including the AHRP Science Panel). NPRB will be acknowledged as the funding source for this project in all reports and presentations.

Fishery agencies

The overarching goal of this study is to help management agencies (i.e., ADF&G) and interested stakeholders understand the impact of hatchery pink salmon on populations of wild pink salmon in PWS. As such, this project is focused on protecting the natural resources role in the ecosystem and, importantly, is a collaborative effort that includes natural resource users, managers and the interested public (e.g., AHRP Science Panel).

We will publish written reports that describe project findings in detail via two outlets. The findings of this study will be relevant to resource management, future hatchery permitting, and evaluation of fishery sustainability by third-party organizations (e.g., Marine Stewardship Council); publication in ADF&G report series provides direct and accountable public access to project findings. Publication in peer-reviewed literature such as *Evolutionary Applications* adds credibility to our study findings and extends outreach to the broader scientific community.

Audience

- Interested Public
- Scientific Community
- Alaska Community Stakeholders
- Fisheries Management
- Industry Stakeholders
- Policy Makers
- Formal educators
- Students (secondary or post-secondary)

Education & Outreach Products

1. **Quantity**: 1
   Data Nugget educational tool
2. **Quantity**: 1
   Article describing study findings to local stakeholders and community in the Prince William Sound Science Center's annual natural history and science publication, *Delta Sound Connections*.
3. **Quantity**: 1
   Map- and data visualization-centered interpretive display at a public space in Cordova.

4. **Quantity**: 1
   Presentation of study findings to stakeholders and local community members.
5. **Quantity**: 1
   Presentation of study findings at the American Fisheries Society Alaska Chapter annual meeting.
6. **Quantity**: 1
   Publication of study findings for policy makers, third-party sustainability certification organizations and the public in ADF&G report series.
7. **Quantity**: 1
   Publication of study findings in peer-reviewed journal such as *Evolutionary Applications*.

Assessment Goals

1. Number of stakeholder and local community members that participate in public presentation of study findings.
2. Number of fishery science community members that participate in public presentation of study findings at Alaska AFS meeting.
3. Number of STEM teachers that download and use the Data Nugget educational tool we propose to develop.
4. Number of times the agency report we propose to write is used to make hatchery permitting decisions.

Links to Previous NPRB Projects Section

The objectives of the proposed project are novel to NPRB. Projects funded by NPRB that use genetic information have focused on species differentiation, population structure, stock composition analyses of mixed-stock catches, migratory pathways, estimating population size, and natural selection. No projects involving hatcheries or artificial propagation have been funded.

Management or Ecosystem Implication

This project leverages samples collected from a collaboratively-funded program to directly assist in management of fisheries and permitting of hatchery operations. This project will broaden the number and type of streams examined for relative reproductive success (RRS) under the Alaska Hatchery Research Program. This program is funded to collect samples from six streams from Prince William Sound over four years. Currently, we anticipate funding to genetically analyze for RRS in one stream (Stockdale Creek) with intermediate straying rates (~10-20%). This project would expand this examination to another stream (Hogan Creek) with high straying rates (~50%). This expansion of analyses will reduce uncertainty when extrapolating results to other streams within Prince William Sound.

Data collected under this project will provide key information to build stock-recruitment relationships, a foundation to managing under the sustained yield principal codified by the Alaska State Constitution and the Alaska Sustainable Salmon Fisheries Policy. Combining relative reproductive fitness of hatchery and natural-origin fish along with proportions of hatchery-origin fish in streams will allow for adjustments to the spawner-recruit relationship. This relationship is used to establish escapement goals and expected escapement curves. In season, observed escapement is compared to the expected escapement curves to determine when and where fishery openings should occur to harvest fish in excess to escapement needs. Currently, managers assume that the relative reproductive fitness of hatchery- and wild-origin fish is the same within streams. If this assumption is violated, escapement goals to streams may be more or less than ideal.

This project will provide information key to assessing hatchery permit requests. This program is the first to provide information on the relative reproductive fitness of pink salmon in Alaska. Pink salmon have a very large impact on the ecosystem of the North Pacific (Ruggerone and Connors 2015; Springer and van Vliet 2014) and increased hatchery production in a localized region may impact distant communities. Information from the proposed research will be used when assessing local impacts from hatchery-proposed activities. Under Alaska Administrative Code, hatchery operators must apply for Fish Transport Permits and file Basic and Annual Management Plans. These documents are subject to department review. Faced with evidence of straying and uncertainty about its extent and effect, the ADFG must act with caution when considering requests by hatchery operations for permit alterations. Any potential effect of these programs on wild stocks must be considered in the context of both benefits from enhancement programs and costs to wild stocks that the agency is mandated to protect. This project will provide information that will allow ADFG to manage the fishery and assess aquaculture permits with more certainty in striving to meet Alaska Constitution, Alaska Administrative Code, Alaska Statute, and Genetic Policy directives including:

1) Alaska Constitution Section Article 8, Section 8.4: “Fish, forests, wildlife, grasslands, and all other replenishable resources belonging to the State shall be utilized, developed, and maintained on the sustained yield principle, subject to preferences among beneficial uses.”

2) Alaska Administrative Code (AAC) 5.40.005.c: “Where hatchery returns enter a segregated location near the release site and can be harvested without significantly affecting wild stocks, a special harvest area may be designated by regulation adopted by the board, within the hatchery permit, or by emergency orders issued by the commissioner.”

3) AAC 5.40.220.b.1: “The physical and environmental nature of the proposed location must be suitable for enhancing runs or for establishing new runs, and must have the potential to make a reasonable contribution to the common property fishery. The proposed hatchery returns may not unreasonably or adversely affect management of natural stocks. The returns for the proposed hatchery may not require significant alterations in traditional fishery time, area, gear type, or user group allocations.”

4) AAC 5.40.860.b.4: “The commissioner will, in his or her discretion, consider a permit alteration, suspension, or revocation in accordance with AS 16.10.430 . If the commissioner decides to consider a permit alteration, suspension, or revocation, the coordinator will notify the appropriate regional planning team. The regional planning team may make a written recommendation to the commissioner on the proposed alteration, suspension, or revocation. The regional planning team shall use the following performance standards in their review, evaluation, and recommendation to the commissioner, including whether: the hatchery does not significantly impact wild stocks in a negative manner;”

5) Alaska Statute (AS) 16.05.020.2: “The commissioner shall manage, protect, maintain, improve, and extend the fish, game and aquatic plant resources of the state in the interest of the economy and general well-being of the state.”

6) AS 16.05.050.16: “The commissioner has, but not by way of limitation, the following powers and duties to permit and regulate aquatic farming in the state in a manner that ensures the protection of the state's fish and game resources and improves the economy, health, and well-being of the citizens of the state.”

7) AS 16.05.730: Management of wild and enhanced stocks of fish.

(a) Fish stocks in the state shall be managed consistent with sustained yield of wild fish stocks and may be managed consistent with sustained yield of enhanced fish stocks.

(b) In allocating enhanced fish stocks, the board shall consider the need of fish enhancement projects to obtain brood stock. The board may direct the department to manage fisheries in the state to achieve an adequate return of fish from enhanced stocks to enhancement projects for brood stock; however, management to achieve an adequate return of fish to enhancement projects for brood stock shall be consistent with sustained yield of wild fish stocks.

(c) The board may consider the need of enhancement projects authorized under AS 16.10.400 and contractors who operate state-owned enhancement projects under AS 16.10.480 to harvest and sell fish produced by the enhancement project that are not needed for brood stock to obtain funds for the purposes allowed under AS 16.10.450 or 16.10.480(d). The board may exercise its authority under this title as it considers necessary to direct the department to provide a reasonable harvest of fish, in addition to the fish needed for brood stock, to an enhancement project to obtain funds for the enhancement project if the harvest is consistent with sustained yield of wild fish stocks. The board may adopt a fishery management plan to provide fish to an enhancement project to obtain funds for the purposes allowed under AS 16.10.450 or 16.10.480(d).

(d) In this section, "enhancement project" means a project, facility, or hatchery for the enhancement of fishery resources of the state for which the department has issued a permit.

8) AS 16.10.750(a): “The legislature finds that the state is committed to maintaining and enhancing its wild stocks of salmon by careful management, by initiating a 20-year rebuilding program, and by investing in the fishing industry.”

9) Genetic Policy,

(a) Introduction: “The genetic policy contains restrictions that will serve to protect the genetic integrity of important wild stocks. Certainly in Alaska where wild stocks are the mainstay of the commercial fishery economy, it is necessary to protect these stocks through careful consideration of the impacts of enhancement activities.

(b) Protection of Wild Stocks: “Gene flow from hatchery fish straying and intermingling with wild stocks may have significant detrimental effects on wild stocks. First priority will be given to protection of wild stocks from possible harmful interactions with introduced stocks. Stocks cannot be introduced to sites where the introduced stock may have significant interaction or impact on significant or unique wild stocks.”

(c) II. Protection of Wild Stocks, C. Stock Rehabilitation and Enhancement:1. “A watershed with a significant wild stock can only be stocked with progeny from the indigenous stocks.”

Reviewer Expertise

- Fields of Expertise
    - Physical Science
    - Biological Science
        - Biochemistry
        - Ecology
        - Genetics
        - Evolution
        - Population Biology
        - Aquaculture
    - Socio/Economic
        - Resource Management
- Professional Activity
    - Field Research & Data Collection
    - Fishery Management
    - Data Management
    - Laboratory Research

- Ecosystems
    - Freshwater – Rivers/Streams
- Ecosystem Components
    - Fish
        - Species Groups
            - Anadromous Salmonids
                - Pink
        - Specific Research Issues
            - Population Structure, Dynamics, & Modeling
            - Genetics and Stock Identification
            - Hatcheries
    - Humans
- Geographic Regions
    - Gulf of Alaska
    - Prince William Sound
- Technological Expertise/Lab Methods
    - Technology
        - Tagging- Other (Pit, CWT, Archival, etc.)
    - Laboratory Methods
        - Genetic Analysis
        - Hardpart Analysis
- Modeling
    - Modeling method(s)
        - Analytical - Deterministic (i.e. Solving PDEs ODEs)
        - Analytical – Probabilistic (Stochastic)
        - Inference (i.e. function fitting, Bayesian)
    - Modeling type(s)
        - Population
        - Distribution
- Management/Policy/Social
    - Policy
    - Commercial Fisheries
    - Aquaculture

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RESEARCH INTERESTS

Population genetics of Pacific salmon
Commercial fisheries management and effect on community development
Life history and landscape influences on genome structure

EDUCATION

Expected 2016	PhD	Fisheries, University of Washington, Seattle
2009	M.S.	Fisheries, University of Alaska Fairbanks, Juneau
2000	B.A.	Politics/Env. Studies, Whitman College, Walla Walla

RELEVANT EXPERIENCE

2014- Graduate Research Fellow, Seeb Laboratory, School of Aquatic and Fisheries Sciences, University of Washington, Seattle, Washington. Improved understanding of the genetics of Pacific salmon advances management of commercial fisheries.

2008- Fisheries Geneticist II, Gene Conservation Laboratory, Division of Commercial Fisheries, Alaska Department of Fish and Game, Anchorage, Alaska. Southcentral and Southwestern Alaska Genetics Project leader. Responsible to conduct, interpret and supervise programs studying the genetic structure of commercially important fishes and utilize mixed-stock analysis of fishery mixtures to further sustainable management of the target species.

2005-07 Graduate Research Fellow, Gharrett Laboratory, Fisheries Division, School of Fisheries and Ocean Sciences, University of Alaska Fairbanks, Juneau, Alaska. Outbreeding depression and quantitative genetics in coho salmon.

RELEVANT AWARDS, FELLOWSHIPS, HONORS

2015 Hall Conservation Genetics Research Award

2011 Directors Achievement Award for Outstanding Service, ADF&G Commercial Fisheries Division

PROFESSIONAL AFFILIATIONS AND CERTIFICATIONS

2008- Genetics Section, American Fisheries Society

2005- American Fisheries Society

RELEVANT PUBLICATIONS

Refereed research papers

1. Dann, T.H., C. Habicht, W.D. Templin, G.M. McKinney, L.W. Seeb and J.E. Seeb. In prep. Incorporating genetic legacy of Beringian ancestry improves understanding of the Chinook salmon genome and identifies regions of adaptive divergence useful for conservation. Evolutionary Applications.
2. Dann, T.H., W.D. Templin, D.E. Schindler, L.W. Seeb and J.E. Seeb. In prep. Examining scales of genetic diversity in Bristol Bay sockeye salmon reveals temporal patterns of harvest important to conservation of diversity. Molecular Ecology.
3. Dann, T.H., C. Habicht, S. Raborn, M. Link, F. West, L.W. Seeb, and J.E. Seeb. In prep. Synthesis of genetic and abundance data for Bristol Bay sockeye salmon characterizes stock-specific travels times between a distant test fishery and district of origin. Canadian Journal of Fisheries and Aquatic Sciences.
4. Dann, T.H., C. Habicht, T.T. Baker, and J.E. Seeb. 2013. Exploiting genetic diversity to balance conservation and harvest of migratory salmon. Canadian Journal of Fisheries and Aquatic Sciences 70(5):785-793.
5. Dann, T.H., J.J. Hard, W.W. Smoker, and A.J. Gharrett. 2010. Outbreeding depression after two generations of hybridizing Southeast Alaskan coho salmon populations? Transactions of the American Fisheries Society 139:1292-1305.

Technical reports

1. Habicht, C., A. R. Munro, T. H. Dann, D. M. Eggers, W. D. Templin, M. J. Witteveen, T. T. Baker, K. G. Howard, J. R. Jasper, S. D. R. Olive, H. L. Liller, E. L. Chenoweth and E. C. Volk. 2012. Harvest and harvest rates of sockeye salmon stocks in fisheries of the Western Alaska Salmon Stock Identification Program (WASSIP), 2006-2008. Alaska Department of Fish and Game, Special Publication No. 12-24, Anchorage.
2. Dann, T. H., C. Habicht, S. D. R. Olive, H. L. Liller, E. K. C. Fox, J. R. Jasper, A. R. Munro, M. J. Witteveen, T. T. Baker, K. G. Howard, E. C. Volk and W. D. Templin. 2012. Stock composition of sockeye salmon harvests in fisheries of the Western Alaska Salmon Stock Identification Program (WASSIP), 2006-2008. Alaska Department of Fish and Game, Special Publication No. 12-22, Anchorage.
3. Dann, T. H., C. Habicht, J. R. Jasper, E. K. C. Fox, H. A. Hoyt, H. L. Liller, E. S. Lardizabal, P. A. Kuriscak, Z. D. Grauvogel and W. D. Templin. 2012. Sockeye salmon baseline for the Western Alaska Salmon Stock Identification Project. Alaska Department of Fish and Game, Special Publication No. 12-12, Anchorage.

RELEVANT CONFERENCE AND SYMPOSIA PAPERS

1. 2015 RAD Sequencing of Chinook Salmon in Cook Inlet, Alaska: Discovering Markers Useful for Sustainable Management in a Genomic Context. Annual meeting of the American Fisheries Society, Portland, OR, August 20 (with G.M. McKinney, C. Habicht, W.D. Templin, L.W. Seeb, and J.E. Seeb).

COLLABORATORS

Chris Habicht, Bill Templin, Jim Seeb, Lisa Seeb, Wes Larson, Garrett McKinney, Tony Gharrett, Andy Barclay, Kyle Shedd, Daniel Schindler, Chuck Brazil, Scott Raborn, Michael Link, Tim Baker, Eric Volk, Fred West, Carolyn Tarpey, Ryan Waples, Morten Limborg

KYLE R. SHEDD
Curriculum Vitae

CONTACT INFORMATION

Alaska Department of Fish and Game
Division of Commercial Fisheries
Gene Conservation Laboratory
333 Raspberry Road, Anchorage, AK 99518
Tel: (907) 267-2531
Fax: (907) 267-2242
E-mail: kyle.shedd@alaska.gov

RESEARCH INTERESTS

Population genetics of Pacific salmon
Commercial fisheries management
Hatchery-wild salmon interactions

EDUCATION

2013	M.S.	Biological Sciences, University of Alaska Anchorage
2006	B.A.	Biological Sciences, Northwestern University, Evanston, IL

RELEVANT EXPERIENCE

2014- Fisheries Geneticist I, Gene Conservation Laboratory, Division of Commercial Fisheries, Alaska Department of Fish and Game, Anchorage, Alaska. Westward Region and Alaska Hatchery Research Program Genetics Project Leader. Responsible for analysis and reporting for programs studying hatchery-wild salmon interactions via parentage reconstruction and fishery mixtures via mixed-stock-analysis to further sustainable management of the target species.

2014 Fisheries Biologist I, Westward Region, Division of Commercial Fisheries, Alaska Department of Fish and Game, Kodiak, Alaska. Supervise, conduct, analyze, and report on a long-term sockeye smolt outmigration study on Chignik River.

2011-13 Graduate Research Fellow, von Hippel Laboratory, Biological Sciences, Environmental and Natural Resources Institute, University of Alaska Anchorage, Anchorage, Alaska. Evolutionary ecology of kokanee in Southwest Alaska.

RELEVANT AWARDS, FELLOWSHIPS, HONORS

2011-13 Alaska INBRE (IDeA Network of Biomedical Research Excellence) Graduate Research Fellowship

PROFESSIONAL AFFILIATIONS AND CERTIFICATIONS

2011- American Fisheries Society

RELEVANT PUBLICATIONS

Refereed research papers

1. Shedd, K.R., F.A. von Hippel, J.J. Willacker, T.R. Hamon, O.L. Schlei, J.K. Wenburg, J.L. Miller, and S.A. Pavey. 2015. Ecological release leads to novel otogenetic diet shift in kokanee (*Oncorhynchus nerka*). Canadian Journal of Fisheries and Aquatic Sciences 72.

Technical reports

1. Shedd, K.R. and C. Habicht. In prep. Stream-specific power analysis of 2013 and 2014 streams. Alaska Hatchery Research Group Technical Document 12.
2. Shedd, K.R., T.H. Dann, S.D. Moffit, and C. Habicht. 2015. Prioritization of pink salmon samples and analyses 2013/2015. Alaska Hatchery Research Group Technical Document 11.
3. Shedd, K.R., T.H. Dann, C. Habicht, J.R. Jasper, and W.D. Templin. 2014. Advanced parentage simulations: the statistical power to measure relative reproductive success. Alaska Hatchery Research Group Technical Document 5.
4. Dann, T.H., K.R. Shedd, C. Habicht, and W.D. Templin. 2014. Effect of sampling proportion of parents on parentage assignment. Alaska Hatchery Research Group Technical Document 4.
5. Dann, T.H., H.L. Liller, C. Habicht, and K.R. Shedd. 2014. Evaluation of tissue quality for pedigree samples collected in 2013. Alaska Hatchery Research Group Technical Document 3.
6. Shedd, K.R., T.H. Dann, C. Habicht, and W.D. Templin. 2014. Parentage SNP selection: SEAK chum. Alaska Hatchery Research Group Technical Document 2.
7. Shedd, K.R., T.H. Dann, C. Habicht, and W.D. Templin. 2014. Defining relative reproductive success: which fish count?. Alaska Hatchery Research Group Technical Document 1.

RELEVANT CONFERENCE AND SYMPOSIA PAPERS

1. 2015 Examining statistical power to detect effects of hatchery strays on relative reproductive success for pink and chum salmon given the experimental design of the Alaska Hatchery Research Program. 2015 Pink and Chum Salmon Workshop, Richmond, BC, February 18 (with T.H. Dann, C. Habicht, and W.D. Templin).

Results of Previous NPRB Projects

Mr. Tyler Dann, Lead PI
This PI has not been involved with any completed NPRB projects.

Using the template below, indicate for the specified PI or co-PI, any ongoing or pending projects that will require time commitments during the course of the proposed project. See the example below. Examples provided below should be deleted in the final document.

Investigator: *Tyler Dann* **Affiliation:** *ADFG - GCL*

Has the current proposal been submitted to any other funding source? **Yes/No: No** **Other Funding Source: Samples from other streams/years have been**

Current Support									
Project Title	Supporting Agency	2016	2017	2018	2019	2020	Start Date	End Date	Location
		PI time (months/ calendar year)					Month/Year	Month/Year	
AHRP - Stockdale odd-year samples	*State of Alaska/AHRP collaborators*	*1.0*	*1.0*				*March 2016*	*August 2016*	*Anchorage*
Fisheries Geneticist II job duties	*State of Alaska*	*10.0*	*10.0*						*Anchorage*

Pending Support									
Project Title	Supporting Agency	2016	2017	2018	2019	2020	Start Date	End Date	Location
		PI time (months/ calendar year)					Month/Year	Month/Year	

Results of Previous NPRB Projects

Mr. Kyle Shedd, Co-PI
This PI has not been involved with any completed NPRB projects.

Using the template below, indicate for the specified PI or co-PI, any ongoing or pending projects that will require time commitments during the course of the proposed project. See the example below. Examples provided below should be deleted in the final document.

Investigator: Kyle Shedd **Affiliation:** *ADFG - GCL*

Has the current proposal been submitted to any other funding source? **Yes/No: No** **Other Funding Source: Samples from other streams/years have been**

Current Support									
Project Title	Supporting Agency	2016	2017	2018	2019	2020	Start Date	End Date	Location
		PI time (months/ calendar year)					Month/Year	Month/Year	
AHRP - Stockdale odd-year samples	*State of Alaska/AHRP collaborators*	*1.0*	*1.0*				*March 2016*	*August 2016*	*Anchorage*
Fisheries Geneticist I job duties	*State of Alaska*	*7.5*	*3.0*						*Anchorage*
Pending Support									
Project Title	Supporting Agency	2016	2017	2018	2019	2020	Start Date	End Date	Location
		PI time (months/ calendar year)					Month/Year	Month/Year	
AHRP - Stockdale even-year samples	*Saltonstall-Kennedy*	*1.5*	*6.0*				*9/2016*	*6/2018*	*Anchorage*

Budget

No	Institution	Requesting Funds	Other Support
1	Alaska Department of Fish and Game	289,435	0

1. Mr. Tyler H Dann [PI, Applicant, Lead-PI]
   Alaska Department of Fish and Game
2. Ms. Rebecca Alt [Grant Manager]
   Alaska Department of Fish and Game

INSTRUCTIONS

Each organization requesting funds must be listed on a separate spreadsheet. If your proposal includes more than four organizations, you may insert additional spreadsheets, but ensure that all inserted spreadsheets are included in the formulas on the "summary" spreadsheet.

Do not add any Cost Categories.

Project Year is dependent on project start date. Year 1 is considered to be the first 12 months after the project start date.

The yellow fields in each spreadsheet will calculate automatically from the information provided.

The summary spreadsheet will be generated automatically from all individual "org" spreadsheets.

Once you have completed your "org" budget spreadsheets and double-checked that the total funds requested on the summary spreadsheet match those of the amount indicated online under Budget Overview, save this file and upload it as your "Budget Summary." A separate "Budget Narrative" is also required.

The details of the Budget Narrative must match exactly to the numbers entered in the Budget Summary.

NPRB BUDGET SUMMARY FORM

PROJECT TITLE	Relative productivity of hatchery pink salmon in a natural stream					
PRINCIPAL INVESTIGATOR	Tyler Dann; Alaska Department of Fish and Game					
	YEAR 1	**YEAR 2**	**YEAR 3**	**YEAR 4**	**TOTAL**	
NPRB Funding	136,407	153,027	0	0	289,435	
Other Support					0	
TOTAL	136,407	153,027	0	0	289,435	

Cost Categories	**NPRB Year 1**	**NPRB Year 2**	**NPRB Year 3**	**NPRB Year 4**	**NPRB TOTAL**	**Other Support TOTAL**
1. Personnel Salaries	68,390	81,299			149,688	
2. Personnel Fringe Benefits					0	
3. Travel	1,690	1,690			3,380	
4. Equipment	0	0			0	
5. Supplies	47,646	47,646			95,292	
6. Contractual/Consultants	4,320	5,320			9,640	
7. Other					0	
Total Direct Costs	**122,045**	**135,955**	**0**	**0**	**258,000**	**0**
Indirect Costs	14,362	17,073			31,435	
TOTAL PROJECT COSTS	**136,407**	**153,027**	**0**	**0**	**289,435**	**0**

NPRB BUDGET SUMMARY FORM

PROJECT TITLE	Short title					
PRINCIPAL INVESTIGATOR	PI and Organization					
	YEAR 1	**YEAR 2**	**YEAR 3**	**YEAR 4**	**TOTAL**	
NPRB Funding	0	0	0	0	0	
Other Support					0	
TOTAL	0	0	0	0	0	

Cost Categories	**NPRB Year 1**	**NPRB Year 2**	**NPRB Year 3**	**NPRB Year 4**	**NPRB TOTAL**	**Other Support TOTAL**
1. Personnel Salaries					0	
2. Personnel Fringe Benefits					0	
3. Travel					0	
4. Equipment					0	
5. Supplies					0	
6. Contractual/Consultants					0	
7. Other					0	
Total Direct Costs	**0**	**0**	**0**	**0**	**0**	**0**
Indirect Costs					0	
TOTAL PROJECT COSTS	**0**	**0**	**0**	**0**	**0**	**0**

NPRB BUDGET SUMMARY FORM

PROJECT TITLE	Short title					
PRINCIPAL INVESTIGATOR	PI and Organization					
	YEAR 1	**YEAR 2**	**YEAR 3**	**YEAR 4**	**TOTAL**	
NPRB Funding	0	0	0	0	0	
Other Support					0	
TOTAL	0	0	0	0	0	

Cost Categories	**NPRB Year 1**	**NPRB Year 2**	**NPRB Year 3**	**NPRB Year 4**	**NPRB TOTAL**	**Other Support TOTAL**
1. Personnel Salaries					0	
2. Personnel Fringe Benefits					0	
3. Travel					0	
4. Equipment					0	
5. Supplies					0	
6. Contractual/Consultants					0	
7. Other					0	
Total Direct Costs	**0**	**0**	**0**	**0**	**0**	**0**
Indirect Costs					0	
TOTAL PROJECT COSTS	**0**	**0**	**0**	**0**	**0**	**0**

NPRB BUDGET SUMMARY FORM

PROJECT TITLE	Short title					
PRINCIPAL INVESTIGATOR	PI and Organization					
	YEAR 1	**YEAR 2**	**YEAR 3**	**YEAR 4**	**TOTAL**	
NPRB Funding	0	0	0	0	0	
Other Support					0	
TOTAL	0	0	0	0	0	

Cost Categories	**NPRB** **Year 1**	**NPRB** **Year 2**	**NPRB** **Year 3**	**NPRB** **Year 4**	**NPRB** **TOTAL**	**Other Support** **TOTAL**
1. Personnel Salaries					0	
2. Personnel Fringe Benefits					0	
3. Travel					0	
4. Equipment					0	
5. Supplies					0	
6. Contractual/Consultants					0	
7. Other					0	
Total Direct Costs	**0**	**0**	**0**	**0**	**0**	**0**
Indirect Costs					0	
TOTAL PROJECT COSTS	**0**	**0**	**0**	**0**	**0**	**0**

NPRB BUDGET SUMMARY FORM – MULTIPLE ORGANIZATIONS

PROJECT TITLE	Relative productivity of hatchery pink salmon in a natural stream				
PRINCIPAL INVESTIGATOR(S)	Tyler Dann; Alaska Department of Fish and Game; PI and Organization; PI and Organization; PI and Organization				
	YEAR 1	**YEAR 2**	**YEAR 3**	**YEAR 4**	**TOTAL**
NPRB Funding	136,407	153,027	0	0	289,435
Other Support					0
TOTAL	136,407	153,027	0	0	289,435

Cost Categories	**NPRB Year 1**	**NPRB Year 2**	**NPRB Year 3**	**NPRB Year 4**	**NPRB TOTAL**	**Other Support TOTAL**
1. Personnel Salaries	68,390	81,299	0	0	149,688	0
2. Personnel Fringe Benefits	0	0	0	0	0	0
3. Travel	1,690	1,690	0	0	3,380	0
4. Equipment	0	0	0	0	0	0
5. Supplies	47,646	47,646	0	0	95,292	0
6. Contractual/Consultants	4,320	5,320	0	0	9,640	0
7. Other	0	0	0	0	0	0
Total Direct Costs	**122,045**	**135,955**	**0**	**0**	**258,000**	**0**
Indirect Costs	14,362	17,073	0	0	31,435	0
TOTAL PROJECT COSTS	**136,407**	**153,027**	**0**	**0**	**289,435**	**0**

Budget Narrative – <u>Alaska Department of Fish and Game</u>

Complete a separate budget narrative for each organization. The Budget Narrative must match exactly to the numbers entered in the Budget Summary (excel template). Flag each line item that fulfills an Education & Outreach deliverable, with a summary at the end of this document.

Supporting spreadsheets may be uploaded in the Documents section.

Instructions and italicized text are provided for example only and should be removed in the final document.

Total Amount requested by Alaska Department of Fish and Game for this project: $289,435

<u>1. Personnel/Salaries:</u>

Tyler Dann will serve as the lead Principal Investigator who will oversee the scientific content, project management, and project completion.

Kyle Shedd will serve as the Principal Investigator who is responsible for the scientific content of the proposal and for the completion of the project.

Zach Pecachek will assemble field kits and split the otoliths from the heart tissues in the lab.

Christy Cupp will manage and archive samples.

Paul Kuriscak will extract tissues and genotype samples.

Heather Hoyt will manage the laboratory and coordinate sample processing.

Bruce Whelan will provide program support.

<u>2. Personnel/Fringe Benefits:</u>
The fringe rate is approximately 38% of the Personnel Cost and is already included in the monthly salaries.

<u>Personnel Expense Details:</u>

Year	**Name**	**Effort (months)**	**Rate ($/month)**	**Personnel cost**	**Fringe Rate**	**Fringe cost**
1	Tyler Dann	1	$9,921	$9,921		
1	Kyle Shedd	2	$8,257	$16,514		
1	Zach Pecachek	2	$5,737	$11,475		
1	Christy Cupp	1	$6,325	$6,325		
1	Paul Kuriscak	1	$8,272	$8,272		
1	Heather Hoyt	1	$7,673	$7,673		
1	Bruce Whelan	1	$8,210	$8,210		
Yr 1 Totals				**$68,390**		
2	Tyler Dann	1	$10,228	$10,228.28		

2	Kyle Shedd	2	$8,513	$17,025.93		
2	Zach Pecachek	2.5	$6,439	$16,098.38		
2	Christy Cupp	2	$6,521	$13,042.57		
2	Paul Kuriscak	1	$8,528	$8,528.19		
2	Heather Hoyt	1	$7,910	$7,910.42		
2	Bruce Whelan	1	$8,465	$8,464.93		
Yr 2 Totals				**$81,299**		

3. Travel:

Year 1: Mr. Dann will present key findings of our proposed research to a meeting of stakeholders and the public in Cordova in spring of 2018. Airfare is estimated at $1,000, lodging at $150/night for three nights (total $400) and per diem at $60/day for four days (total $240). These costs fulfill an Education & Outreach deliverable.

Total travel request in Year 1 **$1,690 (E&O)**

Year 2: Mr. Shedd will present study findings to the American Fisheries Society Alaska Chapter annual meeting in 2018. Airfare is estimated at $1,000, lodging at $150/night for three nights (total $400) and per diem at $60/day for four days (total $240). These costs fulfill an Education & Outreach deliverable.

Total travel request in Year 2 **$1,690 (E&O)**

4. Equipment:

Year 1:

Total equipment funds request in year 1 **$0**

Year 2:

Total equipment funds request in year 2 **$0**

5. Supplies:

Year 1: These costs include laboratory supplies for genotyping 4,320 fish (half of project total plus 8% for quality control). Costs include DNA extraction ($6,480), Illumina flow cells/kit ($10,800), laboratory plastics ($8,640), and biochemical assays ($21,726).

Total supplies funds request in year 1 **$47,646**

Year 2: These costs include laboratory supplies for genotyping 4,320 fish (half of project total plus 8% for quality control). Costs include DNA extraction ($6,480), Illumina flow cells/kit ($10,800), laboratory plastics ($8,640), and biochemical assays ($21,726).

Total supplies funds request in year 2 **$47,646**

6. Contractual/Consultants:

Total Contractual funds requested is $4,000 in Year 1 and $5,000 in Year 2 ($1,000 E&O)

These costs include $1/fish for equipment maintenance contracts and an additional $1,000 for a contract with a currently unknown vendor to construct an interpretive display as part of our outreach and education plan. This $1,000 cost fulfills an Education & Outreach deliverable.

7. Other:

Total Other funds requested is $0 in Year 2

8. Indirect Costs:
Total indirect funds requested is $14,361.82 in Year 1 and $17,072.73 in Year 2
The Alaska Department of Fish and Game has an indirect rate of 21% that applies to all personnel costs.

Education and Outreach Overview:
We will spend $3,380 of travel funds towards outreach with local stakeholders and the scientific community and $1,000 of contractual funds towards the construction of an interpretive display as part of our outreach and education effort.

Other Support for Organization A:

Total Other Support provided by Alaska Department of Fish and Game for this project is: $0.

Cordova District Fishermen United
PO Box 939 | 509 First Street | Cordova, AK 99574
phone. (907) 424 3447 | fax. (907) 424 3430
web. www.cdfu.org

November 30, 2015

Jo-Ann Mellish
Senior Program Manager
North Pacific Research Board
1007 W. 3rd Avenue, Suite 100
Anchorage, AK 99501

To Whom It May Concern:

The purpose of this letter is to offer our support of funding for the project "Relative productivity of hatchery pink salmon in a natural stream" submitted by the Alaska Hatchery Research Program (AHRP). The information gathered from this project will support the long-term health of wild and hatchery salmon stocks in the Prince William Sound region.

Cordova District Fishermen's United (CDFU) is a non-profit membership organization dedicated to preserving, promoting, and perpetuating the commercial fisheries in the PWS area. CDFU is committed to the sustainable management of Alaska's commercial fisheries as a function of the continued health and sustainability of the economies of Prince William Sound communities and the State of Alaska.

The value of the information gathered by this project will be beneficial as we look to the future to ensure healthy salmon resources for all users. Salmon returning to PWS benefit commercial, sport, personal use and subsistence users in the PWS area and throughout the state.

CDFU is dedicated to helping maintain the long-term health of all salmon resources in PWS, and supports the "Relative productivity of hatchery pink salmon in a natural stream" project.

Sincerely,

Alexis Cooper
Executive Director

COPPER RIVER
Wild Alaska King, Sockeye & Coho
www.copperrivermarketing.org
Copper River/Prince William Sound
Marketing Association
PRINCE WILLIAM SOUND
WILD ALASKA SOCKEYE
509 First Street
P.O. Box 199
Cordova, AK 99574
t: 907.424.3459
f: 907.424.3430

November 30, 2015

Jo-Ann Mellish
Senior Program Manager
North Pacific Research Board
1007 W. 3rd Ave., Suite 100
Anchorage, AK 99501

Dear Ms. Mellish,

The purpose of this letter is to support the project "Relative productivity of hatchery pink salmon in a natural stream".

As members of the Alaska salmon industry in the Copper River and Prince William Sound regions, our member fishermen participate in the harvest of Prince William Sound pink and chum salmon. Protecting genetic diversity is critical to preserving our commercial fisheries.

Our member constituents represent more that 540 small owner operated commercial fishing businesses many based out of Cordova, Alaska. As a community, Cordova's economy is intrinsically connected to thriving commercial fisheries including PWS pink and chum salmon.

Long-term health and sustainability of all salmon stocks managed by ADFG is vital to the long-term health and sustainability of our commercial harvests and communities.

Sincerely,

Christa Hoover
Executive Director
Copper River/Prince William Sound Marketing Association

Douglas Island Pink and Chum, Inc.
2697 Channel Dr. • Juneau, Alaska 99801
www.dipac.net • 907.463.5114 • FAX 907.463.3213

December 1, 2015

Jo-Ann Mellish
Senior Program Manager
North Pacific Research Board
1007 W. 3rd Avenue, Suite 100
Anchorage, AK 99501

Dear Jo-Ann,

Douglas Island Pink and Chum, Inc. (DIPAC) strongly supports the Alaska Hatchery Research Program proposal: *Interactions of Wild and Hatchery Pink Salmon and Chum Salmon in Prince William Sound and Southeast Alaska*. This area of research is of particular interest to DIPAC as it relates to establishing interactions between wild and hatchery salmon and to encourage the responsible management for all of Alaska's salmon fisheries.

DIPAC is part of a network of private non-profit hatchery organizations whose primary objective is to enhance the common property salmon fisheries in the state of Alaska and who we are as a corporation is summed up in our corporate mission statement: *The goal of Douglas Island Pink and Chum, Inc. is to sustain and enhance valuable salmon resources of the State of Alaska for the economic, social, and cultural benefit of all citizens, and to promote public understanding of Alaska's salmon resources and salmon fisheries through research, education, and tourism.*

We firmly encourage the support of NPRB for this research. Thank you for your consideration.

Respectfully,

Eric P. Prestegard

Eric Prestegard
Executive Director