**Project Title**

Estimating the natural range of abundance of pink salmon in the Indian River, Sitka National Historical Park

**ABSTRACT**

Salmon are considered a keystone species in small coastal streams in Alaska, naturally influencing stream geomorphology, water chemistry, and a myriad of trophic dynamics both within the stream and in adjacent riparian areas. However, the population of pink salmon returning to spawn in the Indian River, located within Sitka National Historical Park, has grown exponentially over the past several decades due largely to strays from a nearby hatchery. Although state fish and game managers view this increase in population as a management success, biologists within the park are concerned about the effects on the natural population of pink salmon, as well as other fishes and animals within the park. The objective of this study is to better understand the contribution of hatchery fish to the abundance of salmon in the Indian River and identify a possible range of “natural abundance” of pink salmon based on the habitat to help the park establish management targets for “natural” runs of the species.

**STATEMENT OF WORK**

**Background**

Preserving resources within their natural range of variation is a fundamental mandate for national parks in Alaska. Both ANILCA and the NPS Management Policies of 2006 have language that requires parks to manage resources “...at levels they would occur absent human domination over the landscape” and in their “natural” condition. While concern over ‘unnatural’ abundances of park resources often focus on rare or depleted resources (endangered wildlife, rare fish, soundscape, wilderness), it is equally important to manage overabundant resources, even if they are a natural component of park ecosystems. For example, while white-tailed deer are a naturally occurring, keystone species in many Midwestern national parks (e.g., Waller and Alverson 1997), wide-scale habitat alteration and reduction of natural predators by humans outside park boundaries have resulted in an overabundance of deer within park boundaries. The overabundance of deer negatively impacts plant community diversity, resulting in cascading, multi-species impacts (e.g., Frerker et al. 2013).

Sitka National Historical Park (SITK) faces a similar threat from an unnaturally abundant pink salmon (*Oncorhynchus gorbuscha*) in the Indian River. The Indian River is the predominant aquatic resource in the park, and supports diverse biological and riparian communities typical of a small coastal river ecosystem. The river supports populations of resident and anadromous rainbow trout (steelhead) and Dolly Varden charr, cutthroat trout, and other common coastal fish species including threespine stickleback and coastrange sculpin. The river also supports a suite of anadromous salmon (*Oncorhynchus* spp), including native runs of pink and coho salmon, and a small natural run of chum and sockeye salmon.

Like white-tailed deer in Midwestern parks, salmon are considered a keystone species in small coastal streams in Alaska (Gende et al. 2002), naturally influencing stream geomorphology (Moore et al. 2010), water chemistry (Holtgrieve and Schindler 2011), and a myriad of trophic dynamics both in the stream (Gende et al. 2002, Schindler et al. 2003) and in adjacent riparian areas (Gende et al. 2001, Gende et al. 2004, Gende et al. 2007). However, the population of pink salmon returning to spawn in the Indian River has grown exponentially over the past several decades. In the 1980s, peak abundance estimates, conducted by the Alaska Department of Fish and Game (ADF&G) varied between several hundred and 20,000 fish. In the mid-1990s, however, peak spawner abundances regularly exceeded 100,000 and have regularly exceeded 400,000 pink salmon, three orders of magnitude higher than peak runs in the 1970s.

Several lines of evidence suggest that the operations of a salmon hatchery, originally part of the Environmental Science Program at the now-defunct Sheldon Jackson College and more recently operated by the Sitka Sound Science Center, have contributed to the contemporary abundances of pink salmon. First, the exponential increase in pink salmon returns to the Indian River coincided with hatchery operations. The hatchery, located immediately adjacent to the park boundary, has produced, and released large numbers of pink salmon since 1975. From 1990-2000, when pink salmon abundance in the Indian River increased dramatically, the hatchery released over 53 million pink salmon fry. The hatchery has been producing pink salmon for 39 years and thus contributed spawning salmon to the area for over 20 pink salmon generations.

Second, the hatchery and its operations produce conditions that are favorable for high rates of ‘straying’, i.e., juvenile pink salmon produced in the hatchery and released into the ocean “stray” into the Indian River when returning to spawn as adults. Pink salmon can stray at very high rates from hatcheries into nearby streams (Brenner et al. 2012) and as a result, substantially increase the number of spawning salmon in rivers (Zhivotovsky et al. 2012). In addition to this general tendency, the hatchery diverts water for salmon rearing directly from the Indian River just upstream from the park boundary. This diversion, located approximately 1.3 km upstream from the estuary (Paustian and Hardy 1995), functions through a 42-inch diameter pipe and is allowed because the hatchery is allocated 30 cubic feet per second of water rights from the Indian River. Moreover, original hatchery brood stock of pink salmon, i.e., the individuals whose gametes were extracted to begin production, was taken predominantly from the Indian River. Thus, in simplest terms, the hatchery is producing pink salmon that are nearly identical (genetically) to ‘wild’ Indian River fish. The hatchery-raised fish are released near the mouth of the Indian River and are imprinted on olfactory cues identical to the Indian River.

Owing to concerns about the impacts of the hatchery on the wild stock of Indian River fish, the ADF&G required the hatchery to initiate an effort to estimate the straying rate as part of their operations permit. In 2012, otoliths were extracted from a number of spawned adult pink salmon to check for thermal marks, which are produced when the hatchery fish are subjected to dramatic water temperature shifts during production. In 2012, the percentage of spawned-out pink salmon collected in the Indian River that had thermal marks, i.e., “straying rate”, varied between 3% and 8% based on sampling in late September and mid-October. From 2013 to 2015 the NPS supplemented this sampling by collecting otoliths throughout the summer in the Indian River. The results demonstrated a straying rate >24% and appeared to be higher earlier in the summer. Stray rates averaged 33.7%, 30.1%, and 3.7% for otoliths collected during the 14-day periods of August 26-September 9th, September 10th – September 24th, and September 25th – October 9th, respectively (years pooled) (Gende and Carter, unpublished data).

While the target goal for straying by ADF&G is 2% or less, even these small rates of straying have the potential to cumulatively increase the number of fish in the Indian River over subsequent generations. Salmon are subject to myriad sources of mortality that varies with their life-history. During the freshwater component of their life-history salmon eggs, alevins, and fry are subject to scour, environmental varying dissolved oxygen (DO) levels, disease due to fungus and viral outbreaks, and predation, all of which can dramatically influence the number of juvenile fish that enter the ocean. Once in the ocean they are further subject to predation, suboptimal feeding conditions, and, as adults, commercial harvest, further reducing the percentage of offspring that successfully return to spawn.

The hatchery, by definition, produces millions of offspring with the intent of effectively eliminating mortality during the freshwater stage. Thus the hatchery will buffer against these impacts in years when the ‘wild’ number of fish produced may be reduced significantly due to conditions that naturally act on the population in freshwater. The additional returning fish then reproduce (including hybridize) thereby further increasing the number of fish year after year. After 15+ generations (30+ years of hatchery production of pink salmon with 2-year life cycle), it’s likely that the number of fish in the Indian River has been significantly supplemented by the hatchery.

While this unnaturally abundant resource can have positive impacts on visitor experience, especially for those who hike to the footbridge over the river, there is some evidence that the high densities of pink salmon are adversely impacting the Indian River and resources therein. In August 2013, as part of an otolith collection effort, 89% of dead female pink salmon sampled in the Indian River had died before spawning (S. Gende, unpublished data). The extraordinarily high density of salmon in the river, which can significantly decrease dissolved oxygen (DO) levels and thus impact stream respiration (Holtgrieve and Schindler 2011), occurred coincident with low flow and resulted in DO levels averaging 5.48 mg/L during August, including periods when levels dropped to 1.74 mg/L with 16% saturation, levels well below lethal limits for salmonids. These levels are also far lower than the 7 mg/L minimum levels of DO recommended for supporting anadromous salmon. During opportunistic surveys during this period, a large number of dead Dolly Varden charr, cutthroat trout, and juvenile coho salmon were discovered.

Both the Foundation Statement (2012) and Sitka’s General Management Plan (1998) identify the Indian River and its salmon resources as an important and significant park resource. While SITK is considered a historical park, the GMP specifically identifies the need to “preserve the Indian River and the biologically rich ecosystems” because “they are critical to understanding the historical events” that represent the foundation of the park’s establishment. The GMP further states that research should be aimed at “...achieving a more comprehensive resource program to detect potentially harmful changes to the Indian River as early as possible, particularly to... in-stream flows and freshwater organisms” and that a foundational goal for resource management “…will pursue cooperative management of resources not fully protected within the park boundary particularly the Indian River and its resources...”.

Given the differing objectives of park managers at Sitka National Historical Park and hatchery managers, a meeting was convened in 2011, which included the ADF&G, the Sitka Sound Science Center, the hatchery manager, and several other NPS personnel. The numerical abundance of pink salmon in the Indian River were a source of contention during the meeting. The hatchery manager viewed the abundance as healthy (more = better) while NPS managers viewed abundances within “natural” ranges as healthier. When confronted with the question of “how much is too much” by the ADF&G, NPS staff could not clearly define what constitutes “natural” ranges of pink salmon abundance, and thus their management goals could not be implemented.

**Objectives**

The objective of this study is to better understand the contribution of hatchery fish to the abundance of salmon in the Indian River and identify a possible range of “natural abundance” of pink salmon based on the habitat to help the park establish management targets for “natural” runs of the species. Absent robust estimates of abundance and better understanding of the contribution of hatchery straying to the abundance of pink salmon in the Indian River, park managers will continue to struggle with management goals consistent with their founding mandate and management plans. We will develop and apply a combination of population and habitat models to help describe how the influx of straying salmon can influence abundance in the Indian River, and if the habitat attributes related to the Indian River watershed can help identify a natural range of abundance. In doing so, the project will advance the understanding of the implications for the high abundance of pink salmon present in river reaches within the park, and further clarify some management targets from the perspective of “natural” abundances.

**Description of Work**

Information is available through the Alaska Department of Fish and Game (ADF&G) Commercial Fish Division which estimates escapement (number of fish that “escape” the fishery to spawn in the streams and rivers) in Southeast Alaska as to generate harvest guidelines and fishery management targets. To do so, ADFG divides all of southeast Alaska into four sub-regions, and has management areas within each of these sub-regions. Each summer, each of the index streams within the sub-regions is visually surveyed from fixed wing aircraft, approximately 1-8 times with relative abundance estimates generated for each stream. The peak abundance estimates are then used to ‘roll up’ to regional level abundance estimates. While each of these surveys are index surveys and have factors that influence their precision on any given survey (visibility, turbidity, tree cover, etc.), the total number of streams and the long time series make possible estimates of whether individual streams are generally commensurate with trends across the region or among streams with similar characteristics. Note that the Indian River, while serving as an important source of pink salmon for the seine fishery and thus surveyed using the same methods as other streams, is not an index stream because of concern over its proximity to the hatchery (D. Gordon, ADF&G Biologist, personal communication, December 5th, 2013). Owing to the ability to survey many streams using this method, ADFG has estimated peak abundances for over 600 streams across southeast Alaska since 1960, though not all streams are surveyed in every year.

The productivity of salmon streams can vary dramatically among systems owing to fundamental differences in stream size and habitat quality. Fortuitously, most of the 600 index streams also have some data on habitat attributes which can be related to salmon carrying capacity including total watershed size, length of spawning habitat, location of barriers, among other attributes (Liermann et al. 2010). These data are available in several different databases, such as the Anadromous Waters Catalog (AWC), as they are collected by different agencies including both the ADF&G and the US Forest Service.

We will develop a statistical modeling framework for estimating the peak abundance of spawning pink salmon across the index streams in SE Alaska based upon habitat attributes (e.g., watershed size, average slope), harvest data, and estimates of hatchery stray rates. By comparing estimates from index streams without hatchery influences, we can compare the predicted number of adult spawners in the Indian River to the observed numbers. In addition, we will use the estimated escapement and harvest of adults, the number of juveniles released from the hatchery, and hatchery stray rates to develop an integrated population model for estimating the optimal escapement under different reference points (e.g., maximum sustained yield; Scheuerell et al. 2021).

All data analysis will be conducted in an open science environment using the R statistical software, with reproducible workflows being written in R Markdown, and copies of all scripts will be synced to a GitHub cloud repository created specifically for this project.

**Educational and training component**

A postdoctoral scholar, advised by Dr. Mark Scheuerell, will conduct the analyses and produce a written report. The postdoc will also be a coauthor on publications generated from the work.

**Work Location**

All data analyses and final report preparation will be conducted at the School of Aquatic and Fishery Sciences, University of Washington, Seattle, WA.

**Period of performance**

Date of signature of government contracting officer through December 31, 2024.

**Reports/Deliverables**

The following will be provided to Dr. Scott Gende, National Park Service:

1. Data files or database of collated information.
2. Copies of all software code/scripts used for analyses.
3. Final report that includes all results and documentation of methodology.
4. One or more manuscripts prepared for submission to a peer-reviewed journal.

**BUDGET JUSTIFICATION AND BUDGET**

A graduate student will be supported on this project for the full length of the project at a total cost of $132,950 in salary, and benefits at 23.2% for a total of $30,392. Salary and benefits together will be $163,342. Services have been projected to cost $624. Travel is estimated at $10,000. Supplies will be for the purchase of one computer, $3500. Per the Washington Cooperative Fish and Wildlife Research Unit’s Cooperative Agreement, indirect cost is fixed at 15% on total direct costs and will equal $26,328, bringing the project costs at the UW to $202,184. The USGS indirect cost is fixed at 6% of the total costs at the UW, bringing the total cost of this agreement to $213,954.

**Budget**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Year 1 | Year 2 | Total |
| Postdoc salary | $65,000 | $67,950 | $132,950 |
| Postdoc benefits (23.2%) | $15,080 | $15,312 | $30,392 |
| Services | $310 | $314 | $ 624 |
| Travel | $5,000 | $5,000 | $10,000 |
| Supplies | $3,500 | $0 | $3,500 |
| Subtotal | $88,890 | $88,576 | $177,466 |
| Overhead at UW (15%) | $13,334 | $12,994 | $26,328 |
| Project costs at UW | $102,224 | $99,960 | $202,184 |
| Overhead at USGS (6%) | $6,133 | $5,977 | $12,110 |
| **Total Project Cost** | **$108,357** | **$105,597** | **$213,954** |

*Budget Notes:*

*Postdoctoral scholar benefits include health insurance*

*Services includes publication fees*

**Project Timeline**

2020/2021 **-** Work with agency partners to select and start MS student at University of Washington. Student takes courses and contacts agency partners to discuss goals and obtain data sharing agreements.

2022 -Student takes courses, defends proposal, conducts analyses.

2023 **-** Student finished analyses and writing; defends thesis.

**Terms**

(1) To modify, cancel, or terminate the agreement:

Either party may propose modifications to this agreement. This agreement is binding when the Service Representative signs it. Requests for extension of the period of performance must be sent to the Service Representative 60 days before the last day of the period of performance. After the agreement expires, the Service Representative will not grant requests for extension. Other modification requests must be sent to the Service Representative no less than 30 days before required execution.

(2) Alternative dispute resolution clause:

If a disagreement arises on the interpretation of the provisions of this agreement, or amendments or revisions to the agreement that the parties cannot resolve at the operational level, each party must state in writing the area(s) of disagreement and give the statement to the other party for consideration. If the parties do not reach agreement on interpretation within 30 days, they must send the written description of the disagreement to their respective higher officials for appropriate resolution.

(3) Order cancellations:

The Buyer may cancel or terminate the agreement with written notice. If the Buyer cancels or terminates this agreement, the Buyer is liable only for payment for services rendered before the effective date of the cancellation or termination.