Title

Hyperabundance of a native species: Pink Salmon in Sitka National Historical Park

Abstract

Hyperabundance of native species within their natural range can pose a difficult management challenge. Whether due to direct human influence on their environments, or from indirect human influence due to shifting climate regimes, hyperabundance of native species can be as perilous to an ecosystem as incursion from an invasive species. This study examines the case of Pink Salmon (*Oncorhynchus gorbuscha,* Sti’moon, cháas’) in Sitka National Historical Park’s Indian River. Though native to the river, numbers of Pink Salmon returning to spawn in late summer have grown exponentially in recent decades, putting other fish species that are reliant on the river at risk. This is of concern to park managers, as the National Park Service mandates the maintenance of conditions such as they would occur “absent human domination over the landscape.” Some observers believe that the activity of a nearby hatchery, which releases 3 million Pink Salmon fry each year, is directly contributing to the abundance of Pink Salmon seen at Indian River. Using Pink Salmon escapement data collected by the Alaska Department of Fish & Game, this study seeks to determine whether the increased numbers of Pink Salmon observed at Indian River are typical of trends in the wider region, or whether hatchery operations are driving the hyperabundant runs in recent years.

Authors:

Brian McGreal

Quantitative Ecology and Resource Management

University of Washington

Seattle, WA

Scott Gende

U.S. National Park Service

Alaska Regional Office

Juneau, AK

Mark Scheuerell

U.S. Geological Survey Washington Cooperative Fish and Wildlife Research Unit

School of Aquatic and Fishery Sciences

University of Washington

Seattle, WA

Thomas Quinn

School of Aquatic and Fishery Sciences

University of Washington

Seattle, WA

This draft manuscript is distributed solely for purposes of scientific peer review. Its content is deliberative and predecisional, so it must not be disclosed or released by reviewers. Because the manuscript has not yet been approved for publication by the U.S. Geological Survey (USGS), it does not represent any official USGS finding or policy.

Acknowledgements:

The work presented would not have been possible without support from Sitka National Historical Park management and biologists. Mary Miller, Olivia Magni, Jordan Tanguay, and Zachary Jones have provided substantial guidance in understanding the ecological and cultural history of the park and its neighbors. Lauren Bell, Bill Coltharp, and Haley Jenkins of the Sitka Sound Science Center have likewise offered invaluable perspectives and background regarding the history and current state of hatchery operations. Finally, collaboration from Alaska Department of Fish and Game biologists Aaron Dupuis and Justin Priest has enabled this work to compare Indian River Pink Salmon abundances to those seen elsewhere in the vicinity of Sitka, a vital component of this research. Finally, this work has been undertaken with the approval of the Sitka Tribe of Alaska,

Since its inception, the National Park Service (NPS) has operated under a mandate to “preserve unimpaired the natural and cultural resources” under its stewardship. For fish, wildlife, and other natural resources, this mandate calls for maintaining abundances within a “natural range of variation” (National Park Service 2025a). Pursuant to this, park managers are often confronted with either the scarcity of native plant or animal species or an abundance of non-native (exotic, invasive) species that may damage park ecosystems. However, ecosystems can also experience the hyperabundance (i.e., abundance far beyond the established range of densities) of a native species, due to shifting regional trends in habitat suitability, direct (and often anthropogenic) intervention, or a combination of the two.

For example, in Yellowstone National Park, native Mountain Pine Beetles (*Dendroctonus ponderosae*) have recently decimated coniferous forests due to a lack of cold winter temperatures, which have traditionally limited the insects’ numbers and, by extension, their impacts on forests (Gibson et al. 2008). Likewise, in many Midwestern and Eastern NPS units, habitat alterations and the extirpation of natural predators outside park boundaries have led to unprecedented densities of White-Tailed Deer (*Odocoileus virginianus*), capable of intense foraging on vegetation and the depletion of resources on which other species depend (Miller et al. 2023).

While there is little debate that these issues generate a need for management action, the question of when a species exceeds their natural range of abundance can be difficult to ascertain. In the case of the Mountain Pine Beetle, numbers of the insects are on the rise throughout the Rocky Mountains due to shifting climate patterns (Gibson et al. 2008). Is this then an “unnatural” hyperabundance, or is it representative of a new natural state? Park managers across the NPS are confronted with these issues as they seek to make careful and informed decisions using the best scientific information available to preserve natural resources. These ideas are central to the research presented in this article. At the Indian River in Sitka National Historical Park, recent decades have seen annual abundances of native Pink Salmon (*Oncorhynchus gorbuscha*, Sti’moon, cháas’) increase dramatically. These large salmon runs are capable of putting other resident aquatic species at risk by depleting in-stream dissolved oxygen concentrations. This risk is especially pronounced when these runs coincide with periods of low river flows. An exceptionally large Pink Salmon run in 2013 led to a 37-day period in which dissolved oxygen concentrations in the Indian River were well below the threshold required for healthy physiological function in most freshwater species (Sergeant et al. 2017). Some believe these highly abundant runs are being influenced by the operations of a nearby hatchery which rears and releases millions of Pink Salmon annually. Upon their return as adults, some of these hatchery-origin fish inevitably stray into the Indian River, thereby supplementing the abundance of wild born fish. However, monitoring efforts from the Alaska Department of Fish and Game (ADFG) show Pink Salmon abundances on the rise throughout southeast Alaska, suggesting that the conditions in the Indian River may not be due to the influence of the hatchery and instead may reflect the current state of nature in the wider region. The intention of this study is to parse this question, and to determine what if any impact hatchery releases have had on Indian River Pink Salmon abundances in the context of broader regional trends.

Sitka National Historical Park is a 113- acre coastal park in southeastern Alaska. It was designated a national monument in 1910 and a national park in 1972 to conserve the site of an 1804 battle between native Tlingit peoples and Russian colonizers. The park receives nearly four hundred thousand visitors each year who learn about the history of Sitka and Tlingit culture. Along with the preservation of cultural resources related to the site, the park is also managed to its mature spruce-hemlock forest, riparian ecosystem, and the Indian River, which includes a section of the main reach and the intertidal area that falls within the park boundaries (National Park Service 2025b).

Since time immemorial Kaasda Héen (the Tlingit name for Indian River) has been the location of a fishing camp and harvesting site for the Kiks.ádi clan. The river was particularly valued for its proximity to the clan’s permanent and winter villages, as well as for hosting runs of Pacific salmon species,

including chum (*O. keta,* Gaynii, téel), coho (*O. kisutch*, ÜÜx, l’ook), Chinook (*O. tshawytscha*, Yee, t’á) and Pink Salmon (Thornton 1998). Pink Salmon, the most abundant species of salmon, typically return to spawn in late summer (Ruggerone et al. 2025). When the eggs hatch in the spring, juvenileA river with fish in it

AI-generated content may be incorrect.

*Pink salmon spawning at Indian River, Sitka National Historical Park*

Pink Salmon emerge from the river gravel and immediately migrate to the ocean, with all members of a brood returning to spawn as adults two years later (Quinn 2018). This leads to two genetically distinct runs occurring in even numbered and odd numbered years, each with its own characteristic abundance (Alaska Department of Fish and Game 2024a).

Pink Salmon in southeast Alaska are an important food resource for predators and scavenging wildlife, providing a vector for marine-derived nutrients to make their way into riparian ecosystems (Brandt et al. 2024). Historically, Indian River Pink Salmon held special importance for Kiks.ádi fishers, as they were the first salmon to appear each year (Thornton 1998). Today these fish provide an opportunity for visitors to the park to connect with ideas of stewardship and conservation by observing the spawning salmon from a footbridge that spans the river. Although Pink Salmon have always been abundant in the Indian River, their numbers have increased rapidly in the last several decades. ADFG peak escapement surveys (numbers of fish that have ‘escaped’ the fishery and returned to spawn in the river) demonstrate that, since 1980, Pink Salmon abundance has increased from several thousand to regularly exceeding 100,000 fish annually (Stopha 2015). Moreover, there are indications that the duration of Pink Salmon spawning, formerly limited to August and September, now regularly spans July through October.

High salmon densities in the river are not necessarily a cause for management concern, as they may be naturally occurring phenomena influenced by variation in stream conditions, ocean productivity,

predation intensity, and commercial harvests, among other factors (Manhard et al. 2017). However,

salmon hatcheries can also influence the abundance of salmon (Knudsen et al. 2021). As part of typical

A branch in a stream

AI-generated content may be incorrect.

*Pink salmon spawning in the Indian River, Sitka National Historical Park*

hatchery operations, fish embryos are protected from natural mortality during incubation, and juvenile salmon are reared in relatively low-mortality raceways and net pens before they are released into the ocean to feed, grow, and later return. Due to the natural homing ability of salmon, adult fish, having imprinted on the chemical signatures of the water in which they were reared, return to their hatchery of

A graph showing a graph of a graph

AI-generated content may be incorrect.

*Pink salmon population abundance at 35 streams in southeast Alaska (even year runs), Indian River highlighted*

*(Alaska Department of Fish and Game)*

origin when they are prepared to spawn. Therefore, if all salmon reared in a hatchery returned to that hatchery as adults, then population dynamics of salmon in adjacent stream systems would be independent of hatchery operations. In practice however, homing by salmon isn’t perfect, and some fish produced in the hatchery will inevitably ‘stray’ into nearby streams and rivers when returning as adults. While it is difficult to infer whether straying is more or less likely in hatchery-origin fish, homing imperfection is likely an evolved trait as it allows a few fish to colonize new habitats when they become suitable for spawning (Quinn 2018). Nevertheless, hatchery and fishery managers typically aim to minimize straying rates, both to maximize the returns to the hatchery and to reduce the chances of hybridizing hatchery and wild fish, as hybridization can produce offspring that are less adapted to local conditions and thus have lower fitness (May and Westley 2024).

A map of a park

AI-generated content may be incorrect.At Sitka National Historical Park, the possibility of hatchery Pink Salmon straying into the Indian River is particularly high. The not-for-profit Sitka Sound Science Center operates a hatchery immediately adjacent to the park boundary, less than a mile from the Indian River estuary. In general, the likelihood of hatchery raised Pink Salmon straying into nearby streams is influenced by the spatial proximity of those streams to the hatchery. The closer a hatchery is to a stream, the greater the chance hatchery fish will stray into that stream (Knudsen et al. 2021). Sitka Sound Science Center’s hatchery has been in A close-up of a circular object

AI-generated content may be incorrect.operation since 1975, a timeline which coincides with the increases in Indian River Pink Salmon

*Location of Indian River mouth (red circle) and Sitka Sound Science Center (red square)*

*(National Park Service)*

*Otolith of a pink salmon fry from Wally Noerenberg Hatchery in Prince William Sound showing the regular rings produced by systematic changes in temperature to mark the fish.*

*(Dion Oxman – Alaska Department of Fish and Game)*

abundances observed in the 1980s. The hatchery initially was permitted to rear and release 1 million

Pink Salmon annually, a number that was increased to 3 million in 2010. The hatchery utilizes

the Indian River, via a diversion upriver of the park’s boundary, as the source of water for operations.

This water is used to rear salmon fry, which imprint on its chemical signature, and is also released into the bay near the hatchery to attract returning adult fish, only a few hundred meters from the mouth of the Indian River. Some portion of returning adults are retained each year by hatchery technicians as

broodstock, from which the eggs that will grow into the next year’s cohort of juveniles are extracted. Initial broodstock at the onset of hatchery operations came from the Indian River (even years) and nearby Starrigavan Creek (odd years) (Stopha 2015).

Fisheries managers and biologists are able to identify hatchery-produced salmon through otolith marking, a process in which small carbonate bodies located in the inner “ears” of fish are marked with a distinct pattern produced during incubation. To produce these markings hatchery technicians expose salmon eggs to carefully controlled regimes of dry periods and periods submerged in water (Alaska Department of Fish and Game 2024b; Stopha 2015). When salmon return to spawn as adults, the otoliths from the carcasses can be collected and sent to a lab to determine whether the adult fish sampled are of hatchery or wild origin. Not surprisingly, surveying efforts in Indian River have at times noted high numbers of stray Pink Salmon from the hatchery, however these rates vary depending on year and sampling period. For example, in 2015 hatchery strays made up approximately 33% of all individuals Pink Salmon sampled, while in 2011 hatchery strays represented less than 5%. (Gende and Carter 2015). Likewise, sampling of fish returning to the hatchery has recorded large percentages of wild-born fish, and while these wild fish with no otolith marks cannot be said to have conclusively originated in the Indian River the proximity and linkages between the two sites makes this the most likely scenario.

Assuming that hatchery and Indian River fish have been straying for decades, and that both these lineages come from similar genetic stock, there is little (if any) concern about preserving the distinct genetic lineage of salmon that are adapted to the conditions of the Indian River. Instead, the concern is that the abundance of Pink Salmon originating from the hatchery but spawning in the river may be contributing to such high densities of salmon that they may deleteriously impact the river’s ecosystem. When salmon spawn, they remove dissolved oxygen from the water both through the direct consumption of oxygen while alive and through the respiration of decomposing microbes following their death (Sergeant et al. 2023). High salmon abundances occurring during periods of low river flows can reduce dissolved oxygen concentrations to levels below what is needed for resident fish and other aquatic life to survive, especially if these low flows coincide with warm temperatures (Sergeant et al. 2017). In stream systems free of hatchery influence, there are natural regulators (density-dependence) that bring the population back into balance when the number of returning spawners exceeds a stream’s carrying capacity. For example, at very high densities, females arriving later in a spawning season dig up nests (redds) made by early arriving females, so the stream has a natural limit to production. Hypoxia events are also not limited to stream systems in which natural abundances are supplemented by hatchery strays. In such an instance, females may die before spawning due to lowered oxygen levels (Tillotson and Quinn 2017). In either of these scenarios, the numbers of spawners returning in subsequent years would be subsequently constrained. These constraints weaken with the introduction of straying fish from hatcheries, and the question becomes whether these natural processes, and resulting swings in salmon abundance, are exaggerated by strays from nearby hatcheries to the point where the stream ecosystem is disturbed.

While fish originating from the hatchery may be contributing to the great abundance of Pink Salmon observed in recent decades at Indian River, it is also possible that the relatively low numbers of spawning Pink Salmon observed before 1980 may themselves have been historically atypical, and current densities are within the natural range. During World War II, US Navy contractors began dredging sand and gravel from the riverbed, as well as from a wooded island at the river’s mouth, to build fortifications and an airport on nearby Japonski Island. Park Service officials at the time believed that the removal of gravel contributed to several severe floods between 1940 and 1960 (Antonson and Hanable 1987). Even with the completion of those fortifications, gravel removal continued in the Indian River delta intermittently until 1960, and anecdotal accounts suggest the river may at times have been restocked with fish from other streams during this period. This gravel removal and the accompanying floods profoundly affected the geomorphology of the reaches of Indian River in what is now Sitka National Historical Park, shifting the mouth of the river and stripping away lowlands near the river’s banks, impacting the quality of riparian habitat. Kiks.ádi Elders have recalled that, before these dredging operations, the Pink Salmon runs at Indian River were so numerous that “it seemed like you should just be able to walk across the river on the humpies [Pink Salmon]” (Thornton 1998). It is altogether possible that high Pink Salmon abundances observed in recent years are not an exception but a return to historic levels.

With all this in mind, how might park managers determine whether the abundances of Pink Salmon observed in recent years at Indian River are within some natural range of variation? Building a baseline picture of Pink Salmon abundance in the wider region could provide a useful basis of comparison. ADFG has monitored Pink Salmon streams in southeast Alaska as far back as 1960 in order to manage escapement and regulate fisheries. It is worth nothing that 1960 is the first year following the banning of salmon fish traps in Alaska, suggesting that salmon abundance may have been at a historical low point throughout the region (Colt 1999). This monitoring effort surveys 714 Pink Salmon index streams annually throughout southeastern Alaska via fixed-wing aircraft. A random subset of these streams surveyed are selected each year for validation by foot counts to ensure the accuracy of ADFG’s aerial survey efforts (A. Dupuis, personal communication, August 19, 2024). Of these 714 index streams, ADFG places 35 within the “Northern Southeast – Outside” subregion - the ocean-facing coasts of Chichagof and Baranof islands (where Sitka is located), as well as a few smaller islands in the vicinity.

In 2023, the NPS entered into a partnership with USGS and the University of Washington to evaluate Indian River Pink Salmon populations in the context of the broader region. Using statistical modeling, it is possible to estimate the annual abundance of Pink Salmon in the Indian River and to compare those estimates to Pink Salmon abundance in neighboring streams. The project will also explore the Indian River system in greater detail, with the goal of identifying what if any measurable impact hatchery releases have on abundances of spawning Pink Salmon entering the stream each year.

Part of the management challenge when confronted with hyper-abundant native species is assessing whether or not the abundances observed occur within some natural range of variation. The cases of the pine mountain beetle and white-tailed deer illustrate that many factors both local and global may drive the proliferation of native species within a national park. Pink Salmon have returned to Indian River in large numbers every summer since time immemorial, but whether the density of spawning salmon observed recently is exceptional requires understanding both the general behavior of Pink Salmon in the region as well as the potential impact of direct influences such as hatchery releases. Taken together, we hope to provide context and clarity to park officials regarding the Pink Salmon population in the Indian River and the ability to maintain the healthy riverine ecosystem on which so many other resident species depend.

References

Alaska Department of Fish and Game. 2024a. Commercial Salmon Fisheries – Southeast Alaska & Yakutat Research: Pink Salmon. Available at: <https://www.adfg.alaska.gov/index.cfm?adfg=commercialbyareasoutheast.salmon_research_pink> (accessed December 14, 2024)

Alaska Department of Fish and Game. 2024b. Mark Recovery Laboratory – Otolith Marking. Available at: <https://mtalab.adfg.alaska.gov/OTO/marking.aspx> (accessed December 14, 2024)

Antonson, J. M. and W. S. Hanable. 1987. *An Administrative History of Sitka National Historical Park*. National Park Service. Available at: <https://www.nps.gov/parkhistory/online_books/sitk/adhi/index.htm> (accessed December 17, 2024).

Brandt, J. E., J. S. Wesner, G. T. Ruggerone, T. D. Jardine, C. A. Eagles-Smith, G. E. Ruso, C. A. Stricker, K. A. Voss, and D. M. Walters. 2024. Continental-scale nutrient and contaminant delivery by Pacific salmon. *Nature* 634:875-882.

Colt, S. 1999. *Salmon Fish Traps in Alaska.* University of Alaska Anchorage Institute of Social and Economic Research. Available at: [https://www.iseralaska.org/static/legacy\_publication\_links/fishrep/fishtrap.pdf](https://www.iseralaska.org/static/legacy_publication_links/fishrep/fishtrap.pdf%20) (accessed April 25, 2025)

Gende, S. and B. Carter. 2015. *Straying rates of pink salmon into the Indian River, Sitka National Historical Park. Final Report – ADF&G Permit # SF2015-225.* National Park Service, 11 pp.

Gibson, K., K. Skov, S. Kegley, C. Jorgensen, S. Smith, and J. Witcosky. 2008. *Mountain Pine Beetle Impacts in High-Elevation Five-Needle Pines: Current Trends and Challenges.* USDA Forest Service – Forest Health Protection, 40 pp.

Knudsen, E. E., P. S. Rand, K. B. Gorman, D. R. Bernard, and W. D. Templin. 2021. Hatchery-origin stray rates and total run characteristics for Pink Salmon and Chum Salmon returning to Prince William Sound, Alaska in 2013-2015. *Marine and Coastal Fisheries* 13(1): 41-68.

Manhard, C. V., J. E. Joyce, W. W. Smoker, and A. J. Gharrett. 2017. Ecological factors influencing lifetime productivity of pink salmon (*Oncorhynchus gorbuscha*) in an Alaskan stream. *Canadian Journal of Fisheries and Aquatic Sciences* 74(9): 1325-1336.

May, S. A. and P. A. H. Westley. 2024. The cost of hatchery straying: an economic case study on Alaska pink salmon. *Canadian Journal of Fisheries and Aquatic Sciences* 82: 6pp.

Miller, K. M., S. J. Perles, J. P. Schmit, E. R. Matthews, A. S. Weed, J. A. Comiskey, M. R. Marshall, P. Nelson, N. A. Fisichelli. 2023. Overabundant deer and invasive plants drive widespread regeneration debt in eastern United States national parks. *Ecological Applications* 33: 24pp.

National Park Service. 2025a. Organic Act of 1916. Available at: https://www.nps.gov/grba/learn/management/organic-act-of-1916.htm (accessed March 27, 2025)

National Park Service. 2025b. Sitka National Historical Park. Available at: https://www.nps.gov/sitk/index.htm (accessed March 18, 2025)

Quinn, T. P. 2018. *The Behavior and Ecology of Pacific Salmon and Trout, Second Edition.* University of Washington Press, 547 pp.

Ruggerone, G. T., L. Lowe, K. Binkley, and A. McDonnell. 2025. Long-term biennial patterns in Puget Sound Chinook salmon and Southern Resident killer whales: the role of pink salmon and implications for ecosystem management. *Canadian Journal of Fisheries and Aquatic Sciences* 82: 16pp.

Sergeant, C. J., J. R. Bellmore, C. McConnell, J. W. Moore. 2017. High salmon density and low discharge create periodic hypoxia in coastal rivers. *Ecosphere* 8(6):e01846.

Sergeant, C. J., J. R. Bellmore, R. A. Bellmore, J. A. Falke, F. J. Mueter, and P. A. H. Westley. 2023. Hypoxia vulnerability in the salmon watersheds of Southeast Alaska. *Science of the Total Environment* 896: 165247.

Stopha, M. 2015. *An Evaluation of the Sheldon Jackson Salmon Hatchery for Consistency with Statewide Policies and Prescribed Management Practices.* Alaska Department of Fish and Game, Division of Commercial Fisheries, 42 pp.

Thornton, T. F. 1998. *Traditional Tlingit Use of Sitka National Historical Park*. National Park Service, 170 pp.

Tillotson, M. D., T. P. Quinn. 2017. Climate and conspecific density trigger pre-spawning mortality in sockeye salmon (*Oncorhynchus nerka*). *Fisheries Research* 188: 138-148.