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 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. The U.S. National Park Service mandates the maintenance of population densities such as they would occur within a “natural range of variation.” A nearby hatchery, which releases 3 million pink salmon fry each year, may be contributing to the abundance of pink salmon in Indian River. Using pink salmon escapement data collected by the Alaska Department of Fish and 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 may be driving the hyperabundant runs in recent years.

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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” (NPS 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 parks, 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).

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 Alaska’s Sitka National Historical Park, recent decades have seen annual abundances of native pink salmon (*Oncorhynchus gorbuscha*, Cháas’ [Tlingit]) increase dramatically. These large salmon runs can put 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. A 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). These highly abundant runs may be 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 (May and Westley 2024). However, monitoring efforts from the Alaska Department of Fish and Game (ADFG) show pink salmon abundances on the rise throughout Southeast Alaska, indicating 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 (ADFG 2025). The intention of this study is to parse this question, and to determine if hatchery releases effect Indian River pink salmon abundances in the context of broader regional trends.

Sitka National Historical Park is a 113-acre coastal park in southeast Alaska. It was designated a national monument in 1910 and a national historical park in 1972 to conserve the site of an 1804 battle between the Native Tlingit Tribe and Russian settlers. The park receives nearly 400,000 visitors each year who learn about the history of the Sitka Tribe of Alaska and Tlingit culture. Along with the preservation of cultural resources related to the site, the park is also managed to conserve 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 (NPS 2025b).

For perhaps 5,000 years, the Indian River (Kaasda Héen [Tlingit]) has been the location of a fishing camp and harvesting site for one of the Tlingit clans (Thornton 1998). 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 A river with fish in it

AI-generated content may be incorrect.species, including chum (*Oncorhynchus keta,* Téel [Tlingit]), coho (*O. kisutch*, L’ook [Tlingit]), chinook (*O. tshawytscha*, T’á [Tlingit]), 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, juvenile 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 (ADFG 2024a).

*Pink salmon spawning at Indian River, Sitka National Historical Park, Alaska. Credit: Brian McGreal, University of Washington.*

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 Tlingit 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. The 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 A branch in a stream

AI-generated content may be incorrect.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.

*Pink Salmon spawning in the Indian River, Sitka National Historical Park, Alaska. Credit: Brian McGreal, University of Washington.*

High salmon densities in the river 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 A graph showing a graph of a graph

AI-generated content may be incorrect.salmon (Knudsen et al. 2021). As part of typical 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 (Stopha 2015). 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 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 is not perfect, and some fish produced in the hatchery will inevitably stray into nearby streams and rivers when returning as adults. Although 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).

*Figure 1: Pink salmon population abundance at 35 index streams in southeast Alaska and Indian River (even year runs). Data is sourced from Alaska Department of Fish and Game. Abundance estimates are scaled by stream length and statistically standardized for ease of comparison. Therefore, a positive value is above a particular stream’s average abundance, and a negative value is below. Indian River highlighted in pink.*

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 (Sitka Sound Science Center 2025). 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 A close-up of a circular object

AI-generated content may be incorrect.Science Center’s hatchery has been in operation since 1975, a timeline which coincides with the increases in Indian River pink salmon 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 uses 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).

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

*Credit: National Park Service (National Park Service 2025c), modified.*

*Otolith of a pink salmon fry from Wally Noerenberg Hatchery in Prince William Sound, Alaska, showing the regular rings produced by systematic changes in temperature to mark the fish. Credit: Dion Oxman – Alaska Department of Fish and Game*

Fisheries managers and biologists identify hatchery-produced salmon by 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 (ADFG 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. 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, large percentages of fish sampled returning to the hatchery are wild born, and, based on the proximity and linkages between the two sites, it is likely that these wild fish with no otolith marks may have originated in the Indian River.

Given the proximity of Sheldon Jackson Hatchery to Indian River, and given pink salmon’s propensity for straying, the question of whether pink salmon originating from the hatchery but spawning in the Indian River are significantly contributing to the high densities observed in recent years becomes germane. 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 (McNeil 1964). 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 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.

Although 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 have been historically atypical, and current densities are within the natural range. During World War II, U.S. 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. National 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 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. Tlingit 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 possible that high pink salmon abundances observed in recent years are not an exception but a return to historical 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 to manage escapement and regulate fisheries. It is worth noting that 1960 was 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 Southeast Alaska via fixed-wing aircraft. A subset of these streams surveyed are subject to validation by foot counts to assess the accuracy of ADFG’s aerial survey efforts (A. Dupuis – Alaska Department of Fish and Game, oral 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 the city of Sitka is located), as well as a few smaller islands in the vicinity. Abundances of pink salmon observed both in these 35 index streams as well as in the Indian River are displayed in Figure 1.

In 2023, the NPS entered into a partnership with U.S. Geological Survey 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 the abundances observed occur within some natural range of variation. The cases of the pine mountain beetle and white-tailed deer indicate that both local and global factors may drive the proliferation of native species within a park. Understanding whether the density of spawning pink salmon observed in recent years at Indian River 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. The intent of this research is to provide context and clarity to park officials regarding the pink salmon population in the Indian River to help maintain the healthy riverine ecosystem on which so many other resident species depend.

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