Assessment of Gulkana Hatchery Sockeye Straying into Upper Copper River Tributaries

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Abstract
Since the inception of the Gulkana Hatchery in 1973 in the upper Copper River Basin, there has been no effort to address the question of whether or not enhanced fish are straying into tributaries of the Copper River, or what effect this may have on the unique spawning stocks of this region. In 2008 we surveyed six sites in sub-drainages of the upper Copper River to document any occurrence of marked sockeye salmon from the Gulkana Hatchery that had strayed into and died in wild salmon spawning streams. A microscopic analysis of recovered otoliths from spawned-out carcasses revealed no evidence of hatchery-marked fish in surveyed wild salmon streams and lakes.

Introduction
To insure the long term sustainability of wild sockeye salmon (*Oncorhynchus nerka*) stocks in the Copper River, managers need to know whether hatchery-produced salmon are straying into, and spawning in, wild salmon streams. Interactions between wild and hatchery fish may lead to changes in physical and behavioral traits of wild salmon, and may ultimately lead to the decline of wild populations (Naish et al., 2008; NRC 1996). Concerns regarding changing wild salmon populations and impacts of supplemented salmon have been raised by basin residents in the Ecotrust-sponsored Copper River Salmon Workshops I and II (Ecotrust, 2005 & 2006). Furthermore, information concerning occurrence and rates of straying was emphasized as a condition for the sustainability certification of the Copper River by the Marine Stewardship Council in its five year re-assessment of Alaska salmon fisheries (Marine Stewardship Council, 2007). In a first attempt to examine this issue, we sampled sub-drainages of the upper Copper River to document any occurrence of strontium-marked sockeye salmon from the Gulkana Hatchery that have strayed into and died in wild salmon spawning streams.

The Copper River is renowned for its production of wild sockeye salmon. Subsistence uses of salmon in the Copper River date back hundreds if not thousands of years (Simeone and Kari, 2002.). Contemporary subsistence fisheries operate at the river's mouth, along the main stem of the upper Copper, and at the headwaters tributary of Tanada Creek. These fisheries, combined with the upriver sport fishery and the personal use fishery operating near Chitina, harvest around 200,000 fish per year (Somerville, 2008). Additionally, a commercial fishery has operated at the river's mouth for over 100 years, and Copper River salmon are highly prized in fish markets throughout the United States. Commercial harvests of Copper River sockeye salmon have been as high as three million fish in 1997, and have averaged 1.5 million annually over the past decade (Botz et al., 2008).

Since 1973 the Gulkana Hatchery, located on the Gulkana River (Figure) has been releasing sockeye salmon fry into the Copper River watershed. This facility, owned by the State of Alaska, is operated by Prince William Sound Aquaculture Corporation (PWSAC). The hatchery consists of two spring-fed incubation facilities. Broodstock is taken at the hatchery site, and fry are released in the spring either volitionally into Paxson and Summit Lakes (from Gunn Creek) or stocked into Crosswind Lake where they rear to the smolt stage. Annual fry releases from this facility increased from less than 200,000 in

1973 to over 30 million in 1996 (PWSAC, 2007). Over the past decade, adult sockeye salmon returns to the Copper River from Gulkana Hatchery production were estimated to be as high as 1,119,000 salmon in 1999, and have averaged 422,301 per year (Botz et al., 2008), or 21.5% of the total upper Copper River sockeye run.

Evaluation of the enhanced fish returning to the Copper River has been ongoing since the hatchery's inception. Coded wire tagging was used through 2003; however, this technique had limitations because it required tagging smolts a year after their release from the facility. In 2000 strontium chloride was evaluated as a mass marking technique for Gulkana Hatchery sockeye salmon (Oxman et.al., 2004). By immersing fry into a bath of strontium chloride, a mark was left on the otolith that could be detected on the adult fish using scanning electron microscopy. Starting in 2001, 100% of the Gulkana Hatchery fry have received strontium marks. In 2003, the Alaska Department of Fish and Game (ADF&G) began using the otolith marking program to estimate the proportion of the commercial and personal use harvests that are made up by Gulkana Hatchery enhanced fish. These estimates assume that 100% of the marks are detectable; however, vouchers of known marked fry have not been tested at this time. According to recent ADF&G estimates, Gulkana Hatchery fish comprised on average 20.6% of the Copper River commercial, subsistence, personal use and sport catch between 1997 and 2006, (Botz et al., 2008).

There are numerous spawning stocks of sockeye salmon in the Copper River watershed, each exhibiting unique spatial, temporal, behavioral and physiological adaptations (Wade et.al., 2007). A complex management plan aims to provide harvest allocations to the various fisheries while insuring spawning escapement needs are met to sustain the diverse wild population. Returning Gulkana Hatchery fish add to the complexity of this plan. Hatchery fish are known to stray into wild streams, but the full impact of hatchery fish on wild salmon populations and river ecosystems is still unclear (see Naish et al., 2008 for a review). Interactions between wild and hatchery fish may lead to changes in genetic structure of wild populations resulting from interbreeding and competition (at all life stages, including on the spawning grounds), and may ultimately lead to the decline of wild populations. Since the inception of the Gulkana Hatchery, there has been no effort to address the question of whether or not enhanced fish are straying into tributaries of the Copper River, or what effect this may have on the unique spawning stocks of this region. This project addresses this gap in our knowledge of sockeye salmon management in this system by documenting any presence of hatchery fish in wild salmon streams and lakes in the upper Copper River basin.

Methods

We sampled six known sockeye spawning sites in the upper Copper River Basin: Swede, Dickey, Upper Fish, lower Paxson, and Mentasta lakes were surveyed, as well as Gunn Creek (Figure).

Otolith sampling occurred opportunistically between July and September 2008, based on reports of salmon carcasses seen by Glenn Hollowell of the ADF&G in the course of survey flights in the upper Copper River basin, as well as reports from local residents.

Once carcasses were spotted, all efforts were made to sample these areas before carcasses were washed downstream. Otoliths were taken only from "spawned-out" carcasses, not live fish. Carcasses were sampled randomly, up to 96 fish per site. Both otoliths were recovered where possible, and sex of sampled fish was noted. GPS coordinates of each sample location were recorded.

All collected otoliths were sent to the Advanced Instrumentation Laboratory lab at the University of Alaska Fairbanks for analysis. The strontium mark can only be visualized with a scanning electron microscope (SEM), run by personnel experienced in microscopy and otolith structure and formation. Otoliths were individually mounted, then ground and polished to the proper viewing area for mark determination. All otoliths were inspected through a light microscope for crystalline status, age, and presence of thermal marking (from other hatcheries in Prince William Sound). They were then mounted on another slide, cleaned, and carbon coated in preparation for the SEM. Presence or absence of strontium hatchery mark was recorded and pictures were taken for each sample.

Results and Discussion

We collected otoliths from 448 fish from six sites; otoliths from 426 were readable under the SEM (Table). None of the fish had thermal marks, and there were no strontium marks on otoliths from any sites except Gunn Creek, where 100% of the otoliths examined were marked. We are confident that the strontium otolith results are accurate, within an error rate of approximately three percent. A blind test was conducted in 2009, with the remaining otoliths from 36 previously-run samples being returned to the SEM lab for analysis. Of the 36 samples, 35 matched the previous results (data not shown).

Gunn Creek presents an unusual situation, in that hatchery fry are generally released directly into the creek, and are intercepted on their return as adults by a weir across the creek mouth (Gary Martinek, *pers. comm*.). In 2008, however, no weir was erected, allowing all fish to return upstream. Therefore, these fish are not considered strays. However, it is possible that the wild run in Gunn Creek (thought to be several hundred fish) could have been negatively impacted by these hatchery returns in 2008. The wild run is generally earlier, so any redds laid by these fish may have been disturbed by spawning hatchery fish.

The absence of hatchery-marked fish in drainages was not entirely surprising given the high fidelity to natal sites in sockeye salmon (Quinn et al., 1999). This low straying rate is conducive to hatchery operations that have minimal impact to wild populations, and make sockeye salmon a potentially good choice for hatchery production. The absence of any evidence of hatchery-marked fish in wild salmon streams and lakes in the upper Copper River basin in this study is an encouraging result. The results of this study serve as a baseline, and we recommend that further surveys be conducted in subsequent years to monitor the situation. In addition, ecological interactions between Gunn Creek wild and hatchery fish should be investigated, and any genetic introgression or disease transmission should be evaluated.

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Figure. Sample site locations (denoted by stars) and hatchery locations (round fish symbols). Upper inset shows Copper River watershed boundary within State of Alaska. Lower inset shows six survey sites (one furthest right is Mentasta Lake).

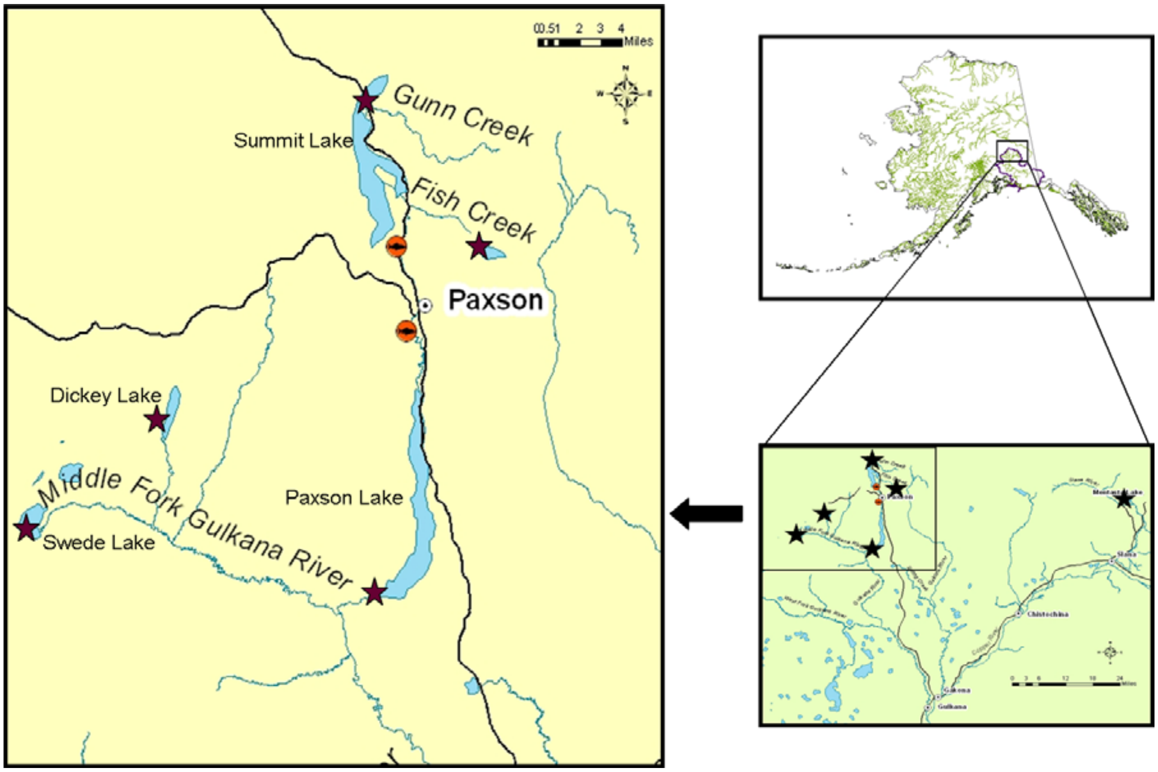

Table. Sample site locations, dates and numbers collected, sex ratio of samples, and otolith markings.

Date Collected	Site Name	Anadromous Stream Number	Total # Samples	# Readable Samples	% Female	% Hatchery Origin
8/22/2008	Swede Lake	212-20-10080-2461-3171-4042-0010	96	94	64	0
8/22/2008	Dickey Lake	212-20-10080-2461-3171-0030	14	14	29	0
8/24/2008	Upper Fish Lake	212-20-10080-2461-3272-0020	72	71	60	0
8/25/2008	Mentasta Lake	212-20-10080-2605-3050-0010	96	94	44	0
9/25/2008	Paxson Lake (South End)	212-20-10080-2461	96	83	50	0
9/26/2008	Gunn Creek	212-20-10080-2461-3292	74	70	66	100
		Total	**448**	**426**		