CORCORAN GRANT REPORT
COHO PRE-SPAWN MORTALITY ON LONGFELLOW CREEK

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The Longfellow Creek Watershed drains 2,685 acres of West Seattle, WA. Unidentified chemical contaminants in the stormwater runoff that flow into the creek negatively impact the physiology of Coho Salmon (*Oncorhynchus kisutch*). Affected individuals exhibit a suite of symptoms including disorientation, loss of swimming ability, gaping of the mouth, and usually death within hours of symptom onset. To document this phenomenon, community volunteers trained by Puget Soundkeeper performed daily surveys on Longfellow Creek from October to December 2016, recording sightings of live Coho Salmon and noting their behavior. Volunteers also performed necropsies on 50 Coho carcasses and noted the spawning condition of females. Results suggested 48% of the female salmon died prematurely before spawning, compared to less than 1% in a non-urban stream.

BACKGROUND

Ongoing restoration efforts began on Longfellow Creek in West Seattle in the 1990s (Scholz et al. 2011). Longfellow Creek drains 2,685 acres (King County 2000) and suffers from "urban stream syndrome," a condition marked by frequent flooding after rain-fall events (Figures 1a and 1b), channelization, and reduced species richness and diversity (Meyer et al. 2005). From 2002 to 2009, federal and state agencies conducted surveys on Coho, Chinook Salmon (*O. tshawytscha*), and Chum Salmon(*O. keta*) that use Longfellow Creek as well as other urban creeks in Puget Sound to gauge the effectiveness of stream restoration efforts (Scholz et al. 2011). They observed that Coho Salmon uniquely suffered from exposure to urban stormwater runoff. Chinook and Chum salmon did not appear to experience the same distress (Scholz et al. 2011). When public funding was no longer available to continue survey efforts, Puget Soundkeeper trained community volunteers to collect salmon run data and continue to monitor trends in salmon spawning success and survival.

Photos by the author unless otherwise indicated.

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URBAN SALMON MIGRATIONS

Wild salmon migrate to their natal streams using currents and chemical cues (Johnsen and Hasler 1980). Most of the Coho that migrate to Longfellow Creek, however, are from hatchery stock and do not have a natal stream. Instead they navigate to Longfellow as one of the first freshwater inputs they encounter. To access Longfellow Creek, salmon swim through a grated culvert near the mouth of the Duwamish River and follow an underground pipeline for approximately 800 meters before daylighting. From there, the fish have access to a short stretch of viable spawning habitat.

STORMWATER TOXICITY AND COHO PRE-SPAWN MORTALITY

Migrating salmon in urban areas such as Seattle are exposed to a toxic cocktail of pollutants called stormwater runoff. This refers to water that washs off of paved surfaces and into storm drains when it rains. This mixture is not treated and instead flushes into nearby creeks and streams. Stormwater runoff collects any materials deposited on pavement including petroleum products such as oil and gasoline, trash, rubber from tires, copper from automotive brake pads, fertilizers, pathogens from dog feces and sewage. This mixture of contaminants causes a unique set of symptoms in Coho (Figure 2), including disorientation, loss of swimming ability, gaping of the mouth, and usually death within hours of exposure (Scholz et al. 2011). To see an example of these symptoms in Longfellow Creek, follow the link https://vimeo.com/111234620.

Figure 1a and 1b. Longfellow Creek (A) at base level flow and (B) in flooded conditions.

Coho Salmon affected by urban stormwater runoff often die before reproducing, resulting in a phenomenon called prespawn mortality (PSM), which is alarmingly high in urban waterways. In surveys conducted from 2002 to 2009, PSM in female Coho was 67 to 100% in Longfellow Creek (Figure 3), compared to 1% in a non-urban stream (Scholz et al. 2011).

Collaborative research efforts conducted by Washington State University, Washington Department of Fish and Wildlife, and NOAA suggest the contaminants in urban stormwater runoff are lethal to juvenile Coho (McIntyre et al. 2015) as well as adult spawners (Scholz et al. 2011; Spromberg et al. 2016; Washington State University 2016). Exposure to stormwater runoff during Coho Salmon development has also been linked to an inability to hatch or delayed hatching, smaller body size, atypical bleeding in the brain, smaller eye size, accumulation of fluid around the heart, and deformities in the head and the heart (Washington State University 2016).

Blood analyses of Coho Salmon exposed to urban stormwater runoff suggest the toxicity causes hypoxia, a condition where the fish are unable to use the oxygen in their tissues for respiration (Washington State University 2016). Interestingly, the level of dissolved oxygen in the water in Longfellow Creek is normal, but the Coho are unable to use this oxygen in respiration (Washington State University 2016).

SURVEY PROCEDURE AND RESULTS

Volunteers trained by Puget Soundkeeper, using the protocol created by NOAA's Northwest Fisheries Science Center and the Department of Fish and Wildlife, surveyed a quarter-mile stretch of Longfellow Creek, beginning east of the Dragonfly Pavilion on 28th Avenue SW and SW Dakota Street, Seattle, WA, and ending just before the bridge on SW Genesee Street and the West Seattle Golf Course. Daily surveys began on October 10th and finished on December 15th, 2016.

Figure 2. A Coho Salmon in Longfellow Creek exhibiting signs of stress.

Figure 3. King 5 News filming salmon survey volunteers as they examine a deceased female Coho.

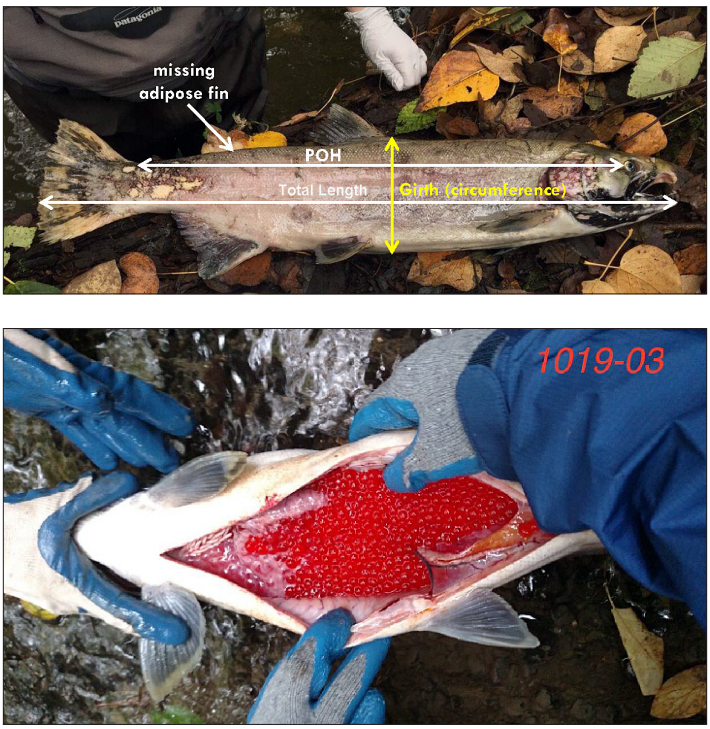

Figure 4. Top: necropsy measurements recorded for each deceased Coho. Bottom: a female Coho marked as a pre-spawn mortality (PSM) case.

Volunteers recorded sightings of live fish, noting their species and behavior. They also recorded whether or not each individual fish had an adipose fin, a small fin located behind the dorsal fin. If the fin was clipped, the fish was assumed to be from hatchery stock. Volunteers also performed necropsies on dead Coho found in the creek, which included measuring, dissecting, and evaluating the spawning condition of each salmon. Necropsy procedure is outlined in Figure 4.

The measurements taken for each Coho carcass included the total length (length from the tip of the jaws to the end of the tail), the post-orbital to hypural plate length (POH, from behind the eye to the point at which the tail bends), and the girth (circumference just in front of the dorsal fin). The abdomen of each Coho was slit to determine spawning condition. Male spawning condition was always marked as unknown, as there was not sufficient evidence to determine whether or not the males had released their sperm. Female Coho were marked as pre-spawn mortality cases (PSM) if ≥50% of eggs remained after death. If the female's body cavity was empty or contained <50% eggs, she was marked as a post-spawn mortality (POST) case. Any individuals that showed signs of predation were marked as having an unknown (UNK) spawning condition at the time of death. Table 1 shows the spawning condition assessment for the 98 specimens examined in the 2016 survey.

Volunteers conducted 60 daily surveys from October 10 to December 15, 2016, weather permitting. Volunteers recorded 113 sightings of live Coho. PSM was 48% in female Coho .

Table 1. Coho Salmon necropsy results.

Sex of Coho	Necropsy Totals	Spawning Condition			
		PSM	% PSM	POST	UNK
Female	21	10	48	11	0
Male	28	---	---	---	28
Unknown	1	---	---	---	1
TOTALS	**50**	**10**	**48**	**11**	**29**

For the 50 necropsied fish, the average total length was 60 cm, average POH length was 44 cm, and average girth was 30 cm. All necropsied Coho were from hatchery stock. The Coho Salmon examined in 2016 had a larger average body size than those dissected in 2015, with a 16 cm longer average total length and 6 cm larger average girth (Figure 5).

CONCLUSIONS

The number of Coho recorded in Longfellow Creek in 2016 was encouraging, especially after the Coho Salmon run was predicted to be low and fishing for this species was initially restricted. These numbers contrast with results gathered by Puget Soundkeeper and volunteers in 2015, when only 31 necropsies performed (22 male, 9 female with 1 PSM case). Additionally, most of the males necropsied in 2015 were "jack" (juvenile) males, whereas only one jack male was recorded in 2016, likely explaining the larger average body size of the 2016 run.

A pre-spawn mortality level of 48% in female Coho was lower than that seen in previous years, but it would be premature to suggest any sort of permanent downward trend in PSM in Longfellow Creek. Interestingly, rainfall was 12.3 cm above average in October through December for this year with an especially rainy October. Increased rainfall has been qualitatively correlated with decreased PSM on Longfellow Creek (Scholz et al. 2011), perhaps because the chemical contaminants in stormwater are more frequently flushed through the watershed and do not have the chance to accumulate to levels that are toxic to Coho. Additionally, ongoing restoration efforts at Longfellow Creek continue to improve the local ecology of this urban ecosystem and may also have contributed to a decreased toxicity in the area's stormwater runoff during the survey season. For example, Delridge Neighborhood Development Association's Wetlands and Stewardship Project constructed a one-acre wetland to help filter runoff before it flows into Longfellow Creek. The City of Seattle has developed a number of programs and policies directed at filtering and reducing stormwater flow to streams. The Nature Consortium also works with volunteers to remove invasive species like Himalayan Blackberry from the banks of the creek and replace them with native, shade-providing species. The collective ef-

Figure 5. A salmon survey volunteer analyzing a Coho carcass.

forts of these groups and others to improve Longfellow Creek may also be partially responsible for the decreased level of PSM and reduced toxicity symptoms observed in Coho in 2016.

Past research also suggests that installing simple systems to filter urban stormwater runoff can have a significant impact on Coho survival (McIntyre et al. 2015; Spromberg et al. 2016; Washington State University 2016). In laboratory studies, filtering urban stormwater runoff through a mixture of 60% sand and 40% compost with a topping of mulched bark reduced Coho Salmon mortality from 100% to 0% in both adults (Spromberg et al. 2016) and juveniles (McIntyre et al. 2015). Adopting similar filtration methods on a larger scale, called Green Stormwater Infrastructure (GSI), includes systems like rain gardens, swales, and permeable pavement. Installing GSI on a biologically relevant scale in the Longfellow Creek Watershed has the potential to drastically reduce Coho PSM.

This research provides an example of community-based education and outreach, as well as a visually impactful way to spread awareness around urban stormwater runoff and its ecological effects. Puget Soundkeeper would not have been able to gather these data without the help of dedicated volunteers, who committed their time and resources every week to document the plight of Coho Salmon in this urban environment.

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