Field Report for the Monitoring of Salmon Abundance, Water Level, and Water Chemistry in the Indian River within Sitka National Historical Park

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Introduction and Problem Statement

Salmon spawning escapement (number of fish "escaping" fisheries to spawn) to a river can directly influence future salmon populations. In the Indian River, continuous release of hatchery salmon from the mid-1970s to present by the Sheldon Jackson College Hatchery---now the Sitka Sound Science Center Hatchery---caused geometric increases in pink and chum salmon escapement to the Indian River (Gende 2016). Such escapement increases can cause ecological effects in the park and in the upstream segments of Indian River.

Drought conditions in Sitka during the summer and early fall of 2019 increased water temperatures and reduced water flows to the Indian River. Such conditions reduce available dissolved oxygen (DO) for fish and can rapidly drop to lethal levels when large escapements occur. Low DO can cause both resident and pre-spawn anadromous fish to suffocate. The park maintains a water quality sonde that continuously monitors water quality parameters (Southeast Alaska Inventory & Monitoring Network). A monitoring program is necessary to understand the relationship between flow, water chemistry (e.g., DO), and the abundance of salmon spawning stock within the Indian River.

Before the addition of the Sheldon Jackson diversion structure in 1914, the Indian River had modest-to-large pink and coho salmon runs, and much smaller chum and king salmon runs. Returning salmon numbers dwindled as the diversion dam blocked most of the Indian River drainage from anadromous fish runs. In the mid-1970s, when the Sheldon Jackson Hatchery was founded, hatchery staff trucked salmon above the diversion structure while they began hatchery operations with a mixed genetic stock of pink, chum, coho, and king salmon (Medley 2012). In 2010, the Sitka Sound Science Center sought and received a permit modification to increase the number of chum salmon reared to 10 million. As those increased numbers of reared fish have returned, increasing numbers of chum salmon have been observed returning to the Indian River alongside pink salmon. Chum are larger than pink salmon and can coarsen streambed substrate more dramatically when constructing their redds due to their ability to move larger gravel and remove more fine sediment (Chapman 1988, Kondolf et al. 1993a, Kondolf et al. 1993b, Montgomery et al. 1996, Quinn 2005). The larger size of chum also allows them to dig deeper redds, which can reduce fine sediment intrusion and disturbance from other females (Quinn 2005). Tracking and assessing the increase in chum salmon returns to Indian River, as well as the stray rate of chum salmon into the river, is of great interest to park managers.

To field staff at the park, chum salmon abundance in the Indian River seemed to be qualitatively larger in 2017 than during 2013-2016. As a result, resource management staff targeted a small number (n=26) of chum salmon to sample for otoliths. The otoliths were submitted to the State of Alaska MARC lab for analysis. Approximately 96% of the sampled salmon were of hatchery origin. The high rate of straying, even given the small sample size, led the resource staff to identify chum salmon straying as an ongoing item of concern for the park due to uncontrolled increases end in hypoxic events and advanced erosion rates. In 2018, overall salmon returns were much lower, and chum salmon were not sampled. In 2019, overall returns of both pink and chum salmon were greater, and the park resource staff requested funds to sample chum salmon for a second time, and in greater numbers.

Project Objectives
The 2019 monitoring focused on the following objectives:

1) To obtain an index of total salmon escapement to the Indian River, Sitka National Historical Park,
2) To monitor river water level, water flow, dissolved oxygen, and water temperature, relative to salmon escapement index, and,
3) To determine stray rate of hatchery chum salmon within the Indian River.

The first objective was developed to provide complementary Indian River escapement estimates to the annual aerial escapement indices collected by the Alaska Department of Fish and Game (ADF&G) which biologists conduct annually on streams that surround Sitka Sound. Both aerial surveys and foot surveys have weaknesses when they are used to estimate salmon abundance (Jones et al. 1998, Knudsen 2000). However, foot surveys can be more accurate when aerial visibility is limited due to overhanging vegetation or undercut banks (Jones et al. 2007), which is the case for the Indian River in the middle of summer. Streamside counts can complement aerial indices surveys and serve as the next type of count used to improve escapement estimation. Using the streamside counts and abundance estimates in Indian River in conjunction with sonde data for dissolved oxygen and temperature allows biologists to examine the relationships among the three and provides an indication of overall stream and fish health during return periods (Pentec Environmental, Inc. 1991; Sergeant et al. 2017). The third objective allows biologists to estimate the stray rate of hatchery fish into stream systems and provide that data to permitting agencies and hatchery managers.

Methods
The authors estimated an index of salmon escapement by first establishing five 20-meter long river reaches within Sitka National Historical Park (Figure 1; Figure 2), then, two people counted live salmon within each reach to realize 3-6 total counts. Counts were conducted on both 31 August 2019, and on 6 September 2019. Videos were captured at each observation site.

We downloaded river height and discharge for the Indian River (site number 15087700) before, during, and after salmon escapement (23 August – 13 September 2019) from the online USGS stream gage data repository (USGS 2019; Figure 1). Dissolved oxygen concentration and water temperature were recorded hourly with an YSI 6500 sonde calibrated monthly. Extending the observation window by one week before and after the collection of streamside live salmon counts allowed us to observe environmental conditions over time and understand how conditions related to salmon escapement at study sites.

To estimate hatchery contribution, we collected 53 chum salmon otoliths from the five survey sites. The sex of each carcass was determined, the skull dissected, and the otoliths retrieved. We checked female chum carcasses for eggs to determine the percentage of pre-spawn mortality. Otoliths were sent to State of Alaska MARC laboratory (https://mtalab.adfg.alaska.gov/OTO/Default.aspx) to verify if fish were thermally marked and thus, of hatchery origin.

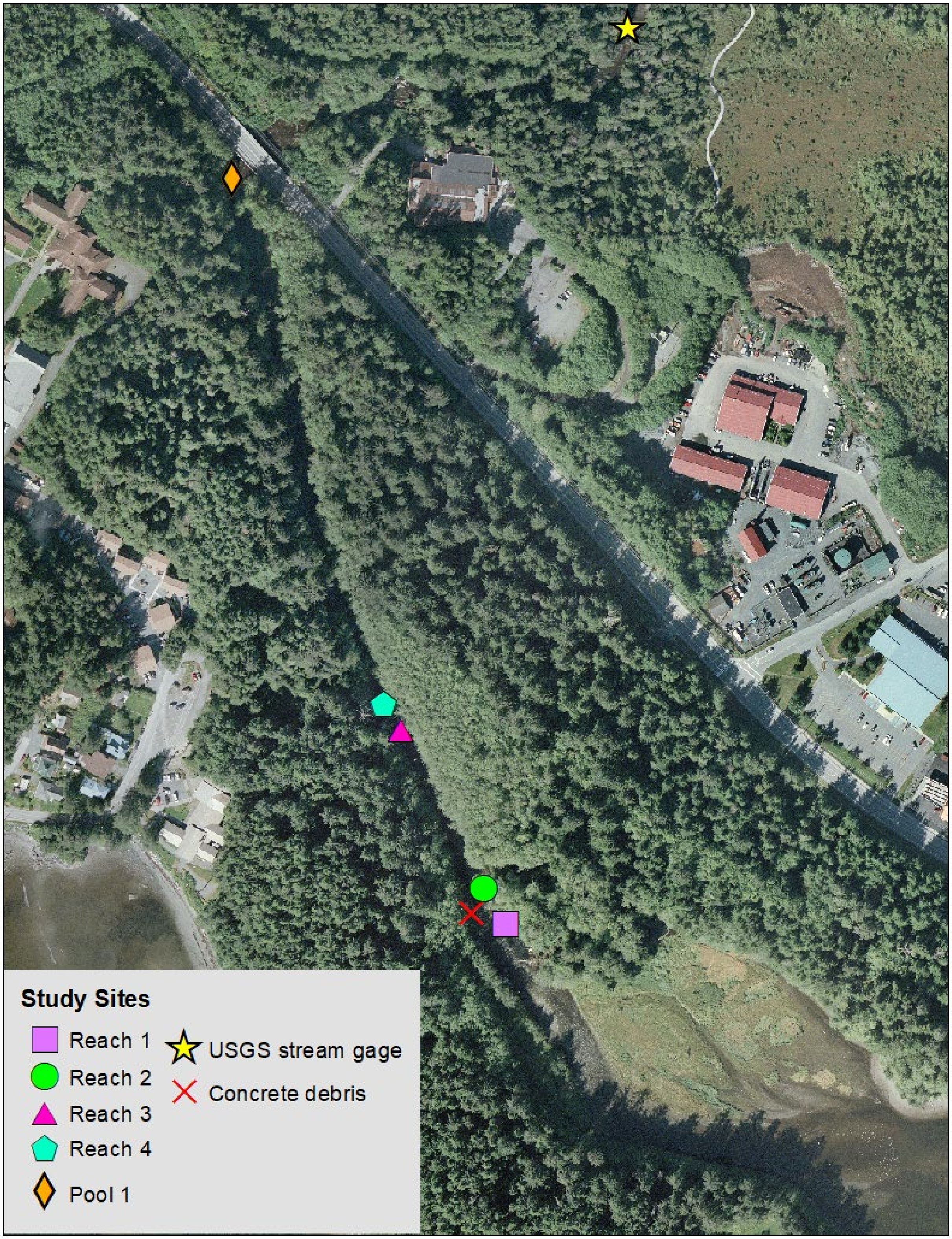

Figure 1. Map of study area including site locations (Reach 1, Reach 2, Reach 3, Reach 4, and Pool 1), USGS stream gage, and concrete debris site marker.

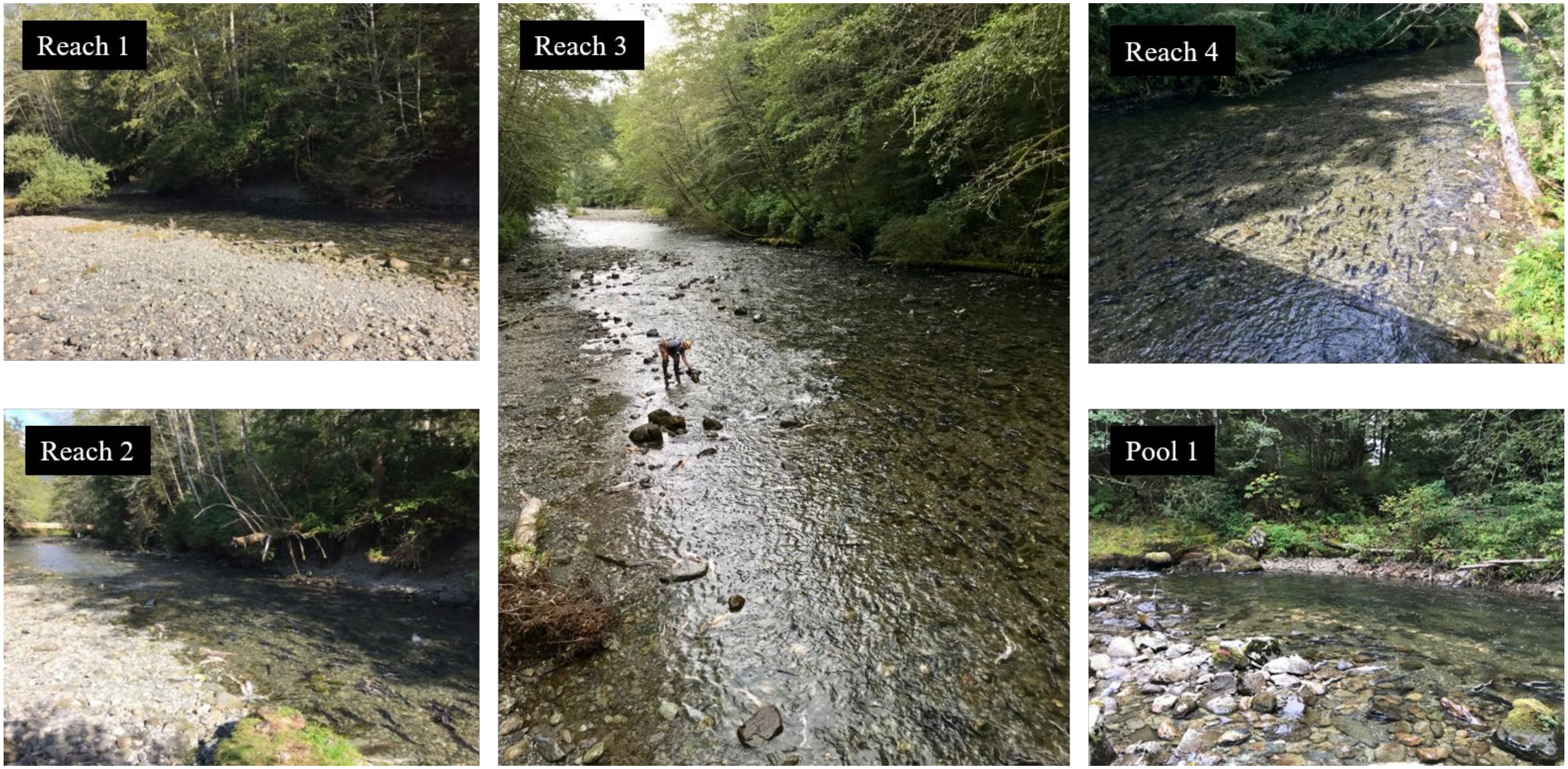

Figure 2. Study sites within Sitka National Historical Park. Each site is a 20-meter stretch of the Indian River. Reach 1 and Reach 2 are downstream and upstream, respectively, of a large piece of concrete debris. Reach 3 and Reach 4 are downstream and upstream, respectively, from the Sitka National Historical Park trail system's Pedestrian Bridge. Pool 1 is downstream of the Sawmill Creek Road bridge.

Results

At the five observation sites, the mean live salmon counts from both dates and all sites ranged from 414 to 1850 (Table 1). The highest salmon abundance estimates were at Reach 1 and Reach 4 and the lowest estimate was at Pool 1 (Table 1).

Table 1. Streamside live salmon counts (pink/chum combined), Indian River, Sitka NHP.

Count ID	Date	Reach 1	Reach 2	Reach 3	Reach 4	Pool 1
SG1	8/31/19	3400	780	1406	2200	900
SG2	8/31/19	2800	825	1200	1980	1100
SG3	8/31/19	2350	690	1310	2460	970
BC1	8/31/19	875	520	2000	No Count	900
BC2	8/31/19	800	561	No Count	No Count	865
BC3	8/31/19	875	532	No Count	No Count	790
KH1	9/6/2019	1242	848	1138	948	421
KH2	9/6/2019	1217	872	1048	908	445
KH3	9/6/2019	1178	945	1039	886	399
BC1	9/6/2019	1056	635	No Count	No Count	380
BC2	9/6/2019	1068	739	No Count	No Count	415
BC3	9/6/2019	1263	738	No Count	No Count	424
Average Count	8/31/2019	1850	651	1479	2213	921
Average Count	9/6/2019	1171	796	1075	914	414

Gage height ranged from 20.29 to 22.31 ft (6.18 – 6.8 m) and total discharge ranged from 11.20 - 462 cfs (0.32 – 13.08 m^3/s) within the four-week study period from 23 August – 13 September 2019 (Table 2). Dissolved oxygen concentration ranged from 6.98 to 11.48 mg/L and water temperature ranged from 8.67° to 11.3°C (Table 2). All four parameters spiked on 27 August, 3, and 13 September 2019 (Figure 3) after precipitation events (The Weather Channel, 2019). Dissolved oxygen concentration dropped to 6.98 mg/L (62 % saturation), threshold hypoxic condition, between 23 – 26 August 2019. This low DO event occurred while gage height and river discharge were also low at 20.4 ft and 17.2 cfs respectively. Dissolved oxygen concentration and water temperature showed diel cycles (Figure 3), with an overall declining DO trend after the spike on 27 August (Figure 3). Dissolved oxygen leveled out between ~10.5-11.5 mg/L after the 3 September spike (Figure 3). The live salmon streamside counts was conducted 4 and 3 days after low oxygen events (Figure 3).

Table 2. Summary of Indian River water conditions during 23 Aug. – 13 Sept. 2019.

Variable	Mean	Median	Standard Deviation	Minimum	Maximum
Gage Height (ft)	20.57	20.49	0.31	20.29	22.31
River Discharge (cfs)	40.06	23.90	56.24	11.20	462
Dissolved Oxygen (mg/L)	9.90	10.51	1.25	6.98	11.48
Temperature (°C)	9.79	9.73	0.58	8.67	11.30

A total of 53 chum carcasses were dissected for otolith samples over the course of this study. Thirty-two chum carcasses were dissected for otolith samples on 30 August 2019. Of these fish, 15 were male and the other 17 were female. One female carcass showed evidence of pre-spawn mortality. Twenty-one chum carcasses were dissected for otolith samples on 6 September 2019. Of these fish, 14 were male and 7 were female. Four of the females died before spawning.

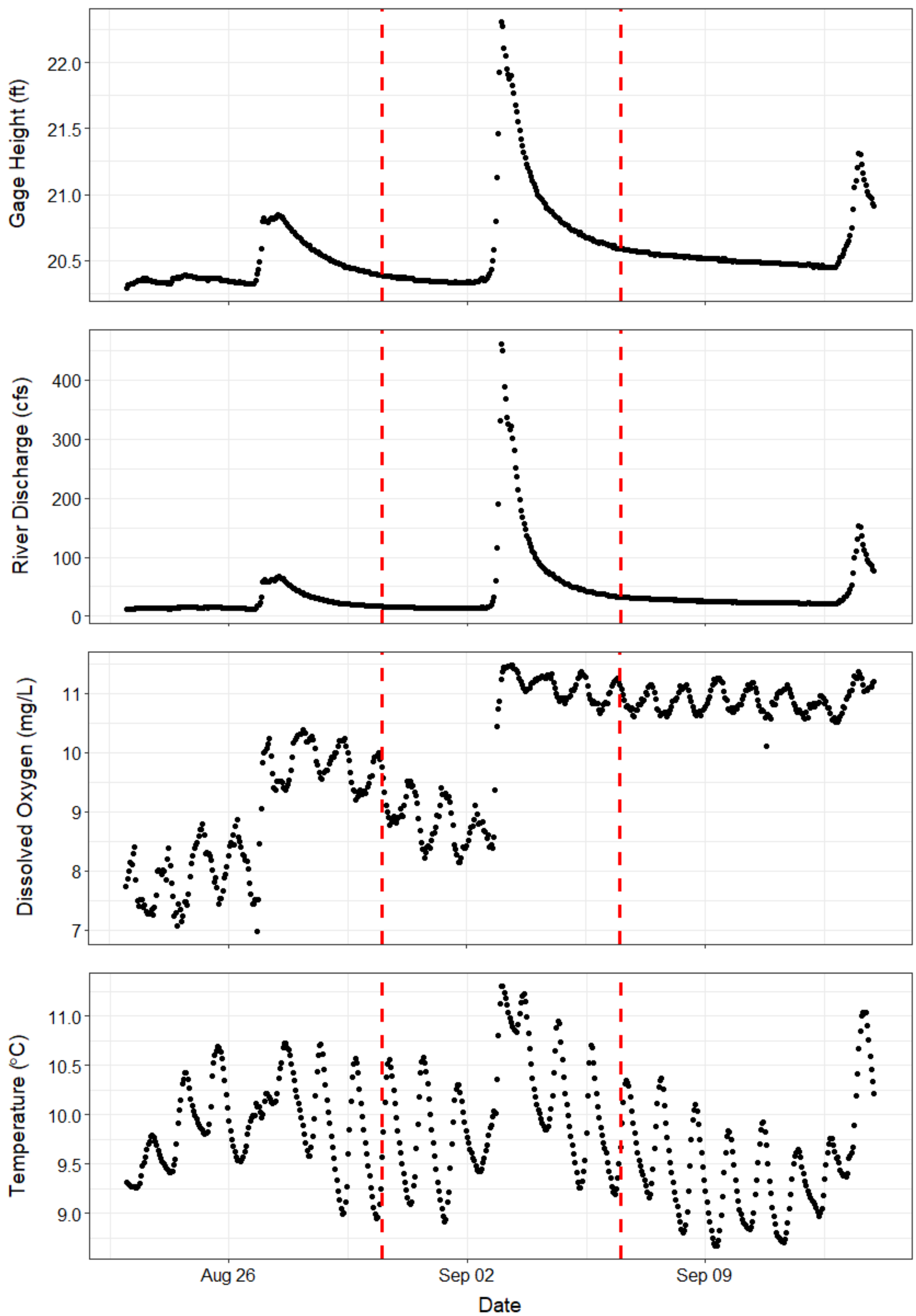

Figure 3. Hourly (dots) Indian River water conditions during 12 Aug. - 23 Sept. 2019. Red lines denote dates of streamside live salmon index counts. Precipitation events occurred on 27 August, 3, and 13 September 2019. Note different scales (y-axis) of each parameter.

Straying Rates

Of the 53 sampled chum salmon, XX% (n=YYY) originated from the Sheldon Jackson Hatchery, (SUMMARIZE MARC LAB DATA)…..

Discussion

The high variability in streamside counts at Reach 1 was due to a discrepancy between observers' understanding of the boundaries of the reach. The variability in salmon abundance estimates between river sections is due to location characteristics such as water depth, section width, and stream flow. The high variability between sections should be considered when estimating overall salmon return abundance within the Indian River.

Between 21-26 August 2019, DO dropped below the threshold for hypoxic conditions that can cause physiological stress on Pacific salmon (*Oncorhynchus* spp.; Sergeant et al. 2017; Figure 3). These low DO levels occurred during a period of low stream flow and increased water temperature, which agrees with the findings of Sergeant et al. (2017) and Pentec Environmental, Inc. (1991). The DO measurements in this study were only recorded at one location within the Indian River, and due to high variability of water quality within riverine systems, we cannot make inferences about the entire Indian River system. However, the data from this one multi-parameter sonde does provide some insight into the water conditions to which returning salmon are exposed.

Although only a small sample size (n = 24) of female chum carcasses were checked for pre-spawn mortality, the 21% overall female pre-spawn mortality rate observed in our sample is still cause for concern. Since flow rate, water level, dissolved oxygen concentrations, and salmon abundance are connected to the rate of pre-spawn mortality (Pentec Environmental, Inc. 1991, Sergeant et al. 2017), the drought conditions observed during this study have an impact on the reproductive success of salmon within the Indian River.

Enough data was collected from these two short field visits to warrant some concern about continued augmentation of the Indian River drainage with hatchery strays, and to point to the need to continue sampling chum salmon in the river to document one effect of the ongoing chum rearing occurring adjacent to the river, using river water as the rearing source.

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