PACIFIC SALMON FOUNDATION

SALMON AND SEAL INTERACTIONS

Marine Science Program Newsletter

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Photo by Jamieson Atkinson

LOG BOOMS, SEALS, AND ADULT CHINOOK IN COWICHAN BAY

The coastline of the Salish Sea has an extensive history of log storage, which, unfortunately, is not without consequence to the environment. Log storage activities, such as the presence of log booms in our BC waters, cause cumulative effects which can alter ecosystem dynamics. Log storage has left a legacy of habitat degradation, which lasts long after sites are decommissioned. Protected bays and estuaries are ideal for log booms but are also critical migratory corridors for juvenile salmon during their spring outmigration and as adults returning to spawn; thus we must understand the impacts of log booms and manage these areas in a way that supports Pacific salmon and other species which utilize estuaries and bay ecosystems. This newsletter highlights a project that has received support from the Pacific Salmon Foundation, and is being carried out to assess whether the presence of log booms increases predation on adult salmon that are returning to spawn. A subsequent newsletter will detail results of a second project that investigated how the legacy of log boom activities affects eelgrass restoration potential in estuaries.

Photo by Jamieson Atkinson

Cover photos: Top, Ryan Miller; Left, Danny Swainson; Right, Jamieson Atkinson

DO LOG BOOMS MAKE MIGRATING SALMON MORE VULNERABLE?

The Salish Sea Marine Survival Project (SSMSP) identified predation by Pacific harbour seals as a critical threat to struggling salmon populations. Since harbour seals and other pinnipeds (e.g. sea lions) received protection under the Marine Mammal Protection Act of 1972, their numbers have exploded along our coasts. Although salmon only contribute a small proportion of a seal's overall diet, the sheer number of these opportunistic predators can result in real consequences. Studies done under the SSMSP estimated that up to 43% of juvenile wild and hatchery Chinook are consumed as they pass through the Strait of Georgia. At the same time, adult salmon are also targeted by seals when they return to coastal areas and estuaries on their way to spawn. Overall, the productivity of Chinook is negatively correlated with harbour seal density along our coastlines.[1]

1. Nelson, B.W., Pearson, S.F., Anderson, J.H., Jeffries, S.J., Thomas, A.C., Walker, W.A., Acevedo-Gutiérrez, A., Kemp, I.M., Lance, M.M., Louden, A., and Voelker, M.R. 2021. Variation in predator diet and prey size affects perceived impacts to salmon species of high conservation concern. Can. J. Fish. Aquat. Sci. 78(11): 1661–1676. NRC Research Press. doi:10.1139/cjfas-2020-0300.

Although salmon and seals would have coexisted in equilibrium in the past, human activities have shifted this balance. Now, salmon must contend with several anthropogenic pressures from habitat degradation to climate change. Another factor that may be further tipping the balance is the presence of human-made structures, such as bridges[2] or log booms, that can amplify predation efficiency. These artificial structures can affect salmon behaviour as they pass by, and can provide a convenient refuge for their predators, making the salmon highly vulnerable in crucial migration corridors.

As the seal population has grown in the Salish Sea, so has their use of log booms as haul-outs. Seals favour hunting in areas with abundant prey that are in close proximity to their haul-outs, and log booms are often located right where juvenile and adult salmon aggregate during their migrations. Furthermore, because the rafts of logs float up and down with the tides, seals are never forced off at high tide — when salmon are moving into the river mouths during adult migrations. Therefore log booms provide refuge for the seals and their pups from predators and during prime hunting times when their natural rocky haulouts would become submerged. In addition, juvenile and adult salmon often seek refuge under these structures. While the impact of log boom presence on salmon has not been well studied, this line of evidence has led experts to suspect that log booms have facilitated seal predation on salmon.

Harbour seals resting on log booms. Are these artificial platforms helping seals hunt for salmon? Photo by Mitch Miller

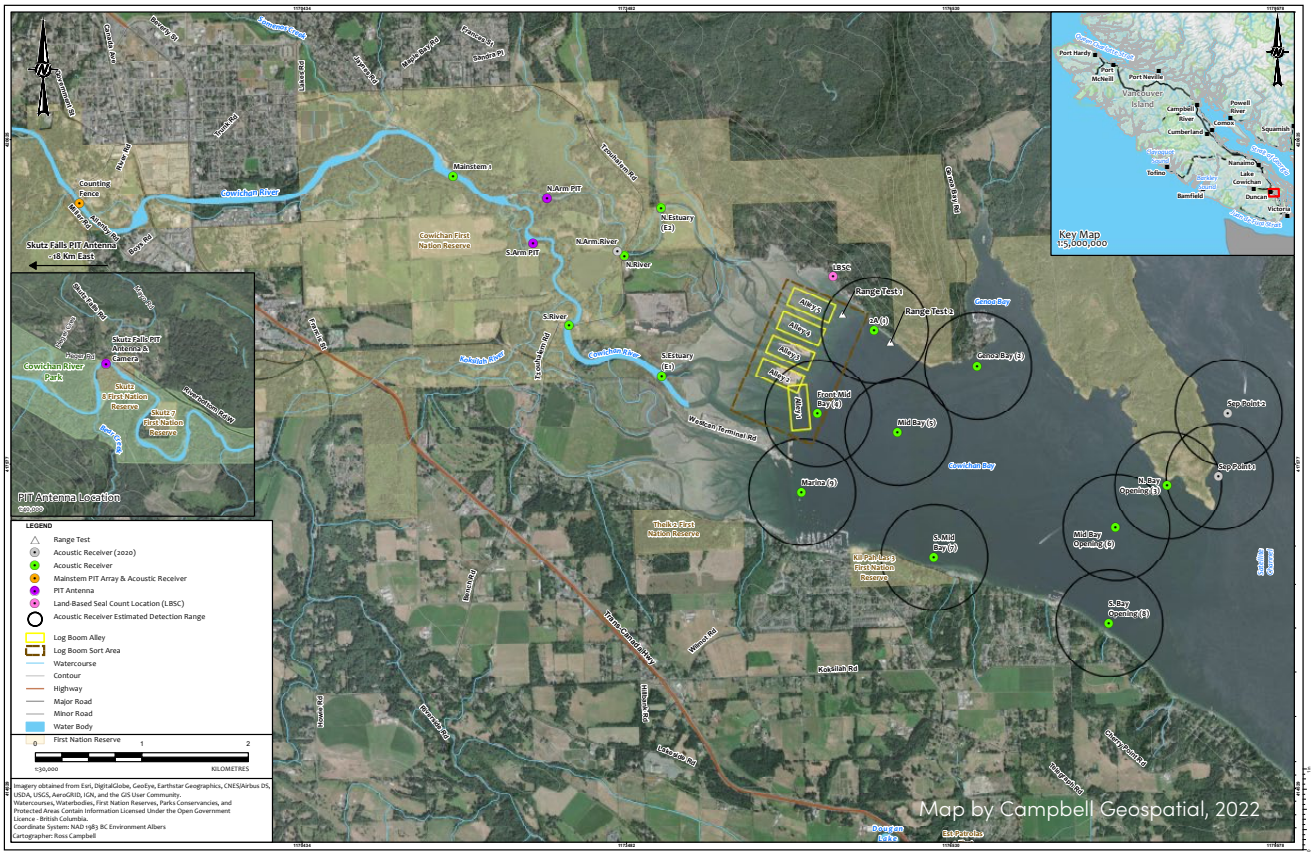

Figure 1. Map of Cowichan Bay and lower river system showing the location of log boom storage areas (yellow rectangles), acoustic receivers (green dots, and 2020 only locations – grey dots), PIT antenna arrays (purple dots), and mainstem (7 km) PIT array and acoustic receiver (orange dot).

2. Moore M, BA Berejikian, and EP Tezak. 2013. A floating bridge disrupts seaward migration and increases mortality of steelhead smolts in Hood Canal, Washington State. PLoS ONE 8(9): e73427. doi: 10.1371/journal.pone.0073427

THE STUDY

After the BC Government signed in a 15-year lease renewal permitting log storage in Cowichan Bay without consultation with Cowichan Tribes, there was an impetus to better understand the suspected consequences of log booms on the local Chinook population. Led by Cowichan Tribes together with British Columbia Conservation Foundation (BCCF) and with funding from FLNRORD, a pilot study was undertaken in 2017 to estimate returning adult Chinook survival in the lower river and estuary while log booms were present. Using PIT (Passive Integrated Transponder) tags and a system of antenna arrays, the journeys of a number of returning Cowichan Chinook (identified genetically) were tracked as they passed by tag detection points along the river. The study results suggested high losses of adult Chinook were occurring in Cowichan Bay and the lower Cowichan River, with only 34% of the returning adults making it past the mainstem PIT array at river kilometer 7. What was the cause of this dismal survival rate? Was it a result of the log boom presence? A better understanding was needed, and so, after a gap in funding for 2018, in 2019, PSF and British Columbia Conservation Foundation (BCCF), Cowichan Tribes and the University of Victoria, initiated a more comprehensive multi-year study.

The current study, slated to run through 2022, tracks four additional years of Cowichan Chinook survival during the fall migration season. Similar to the pilot study, Chinook staging in the Cowichan Bay were captured, PIT-tagged genetically sampled for stock identification, and returned to the water. A more extensive PIT array network was established to track fish passage (Fig. 1), and, in 2019 and 2020, a subset of PIT-tagged fish was also outfitted with an acoustic tag. The acoustic tags provide active tracking of a fish's movement in the bay, via a suite of listening receivers, while also documenting depth (pressure) and acceleration of each fish outfitted. The aim was to provide a clearer picture of how log booms impact returning Chinook and make meaningful recommendations to improve their survival.

SURVIVAL RESULTS

When Chinook returned to Cowichan Bay in the fall of 2019, log booms were not situated in the bay and overall survival of tagged fish past the lower river was higher than in 2017, at about 54%. Subsequently, in 2020 and 2021, log booms were again present, allowing for additional comparisons of survival rates with the influence of log boom presence. However, as often occurs when studying a system in a dynamic natural environment, an additional confounding factor was a high pulse of water through the estuary that enabled the returning Chinook to move more quickly up the river in 2020 and 2021. Despite the presence of log booms, those years had higher survival rates among the fish tagged at 60% and 68%, respectively, making it past the lower river (Table 1).

It is well known that river flow conditions are important for migrating salmon. Returning Chinook will stage in estuaries during the late summer as they wait for suitable conditions to move up the river to spawn. In years of late summer/fall droughts, they can be delayed for weeks to months, increasing the time spent in the estuaries and nearshore areas. In 2017 and 2019, river flow rates and conditions were similar (Fig. 2 on the next page), with a flow pulse not occurring until around mid October. In 2020 and 2021, however, large pulses of water occurred nearly a month earlier. Unsurprisingly, the earlier flows in 2020 and 2021 coincided with shorter migration times (e.g. less time spent in the estuary staging) and higher survival rates (Table 1).

Looking at the survival rate across all years in a spatial context, there is strong evidence that the bay and estuary represent a survival bottleneck where the Chinook are susceptible to predation. Once the fish moved successfully beyond the lower river and out of the reach of seals, the vast majority of the tagged Chinook (95%, CI 83, 98) were detected on the mainstem array, 7km up the river.

Table 1: Survival rates (% moving beyond the lower river) and average migration times (AMT) of Cowichan Chinook tagged in Cowichan Bay and Cowichan River flow conditions (mean point discharge (MDP)) by year and log boom presence. Statistical differences ($p<0.05$) in migration times (AMT) and flow rate by year are indicated by superscript letters.

YEAR	LOG BOOM PRESENT (Y/N)	TAGGED CHINOOK (n)	SURVIVAL RATE (%) (LOWER, UPPER 95% CI)	AMT (DAYS) (LOWER, UPPER 95% CI)	MDP* (M^3/S) (LOWER FLOW, UPPER FLOW)
2017	Y	29	34% (21, 54)	29.12^{a} (24.5, 33.7)	5.62^{a} (4.91, 60.90)
2019	N	41	56% (40, 69)	$22.4^{a,b}$ (19.4, 25.3)	5.26^{ab} (2.85, 51.70)
2020	Y	42	60% (46, 74)	13.7^{c} (12.0, 15.4)	14.57^{c} (5.26, 55.89)
2021	Y	25	68% (51, 85)	$16.92^{b,c}$ (14.3, 20.0)	13.44^{bc} (2.81, 113.58)

* MDP is the weighted average daily discharge throughout the study period August 1 to November 1.

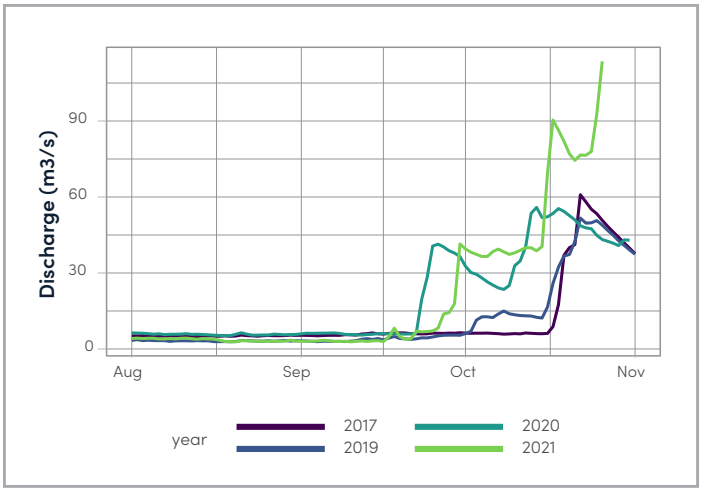

Figure 2. Flow rates of Cowichan River by year. The years 2020 and 2021 experienced high flow conditions approximately a month earlier than the drier years of 2017 and 2019. The earlier flows coincided with shorter migration times and greater survival of the returning Chinook.

MODEL PREDICTIONS

A generalized linear mixed-effect model was developed to tease out the relative influence of the log boom presence on Chinook survival. A number of different variables (size of fish, degree of bleeding from tagging, river flow (MDP), log boom presence) were tested for inclusion in the model. The best model fit included river flow and log boom presence. Results showed a significant relationship between Chinook survival past the lower river and river flow conditions (p=0.01). Given environmental variability, the low number of study years (n=4) and only a single year in which log booms were not present, the relationship between log boom presence on survival was not as clear and lacked statistical significance. However, due to the predicted effect size reported in the logistic models, log boom presence was considered a biologically significant negative influence on survival[3]. The model predicts that the log boom presence has a predicted mean probability of reducing survival by 0.18 (CI 0.11, 0.21)(i.e. reduce rate of survival by 18%) in an average year. During an average flow year (9.72 m^3/s), the estimated survival probability with log booms present would be on average 0.49, whereas without log booms, it was estimated to be 0.67.

NEXT STEPS AND CONCLUSIONS

Continued research into the impacts of anthropogenic activities on the survival and behaviour of Chinook stocks will support evidence-based management suggestions to increase survival and help to regrow declining populations. This study is set to continue for an additional year, and will use acoustic tags for a third year, enabling model refinements and higher precision for survival estimates and the impact of environmental and anthropogenic effects. Parameters will be expanded to include river temperature.

Inserting a PIT tag into an adult Chinook in Cowichan Bay. With the tag in place, migration of this fish was tracked to see whether it survived its time in the estuary and made its way up the river. Photos by Danny Swainson

3. Ronald L. Wasserstein, Allen L. Schirm & Nicole A. Lazar (2019) Moving to a world beyond "P<0.05", The American Statistician. 73:sup1, 1-19, DOI:10.1080/00031305.2019.1583913"

The result of river flow conditions as a significant influence on terminal Chinook survival in the Cowichan system is an essential finding in and of itself. Cowichan River flows are regulated by a dam located at the outlet of Cowichan Lake and are managed by Paper Excellence with all levels of government (First Nation, Federal and Provincial). Ensuring adequate river flow during late summer and early fall spawn migrations is critical to spawner success, particularly during prolonged summer drought conditions, which are projected to occur more regularly. This study provides further evidence of the negative impact of low flow conditions.

A Best Management Practices document for log booming activities in Cowichan Bay is being developed to reduce the negative impacts log booms have on returning Chinook and, importantly, ecosystem health of the entire estuary. Recommendations such as removing log booms during the fall migration period and maintaining river flow above certain thresholds will improve Chinook terminal survival. Given that drought conditions and the management of river flows, habitat alterations in estuaries, log booming, dredging, and other industrial activities are concerns for many estuaries in British Columbia, the recommendations from this work will be applicable in other systems as well.

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