Effects of peak flows on Chinook (*Oncorhynchus tshawytscha*) spawning success in two Puget Sound River Basins

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INTRODUCTION

Freshwater habitat conditions at the earliest life stage can be a major constraint to salmon (*Oncorhynchus spp.*) productivity in the Puget Sound. Lower egg-to-fry survival rates and smolt production estimates have been correlated to larger flood events. We analyzed the relationship between peak flows during the egg incubation period with six different Skagit and Stillaguamish River chinook stocks to investigate whether the effects of peak flow during egg incubation constrained chinook production at the adult life stage. Our measure of adult production used was a chinook spawning recruitment ratio, which is the number of spawning adult chinook to returning adult chinook for a brood year.

Seiler and others (1998) found a strong negative relationship between peak flows and egg to migrant fry survival estimates for Skagit Chinook. We transformed peak flood events into a flood recurrence interval (years) using a log-Pearson Type III distribution and developed a general model of chinook egg to migrant fry survival from these data. The model was then applied to Stillaguamish River summer chinook data in order to investigate the sensitivity of chinook egg to fry survival to changes in peak flow hydrology.

RESULTS

We found that six different stocks of Skagit chinook and one stock of Stillaguamish chinook were unable to produce enough return spawners to “replace” themselves if peak flow during the egg incubation period was equivalent to a 20-year event or larger (Figure 1). A 20-year flood recurrence interval corresponds to a 5% chinook egg to migrant fry survival rate (Figure 2). Figure 1 also shows an apparent “boundary condition” where chinook recruitment did not exceed

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a certain level for a given peak flow, presumably due to constraints in egg incubation survival. Egg incubation survival limited chinook recruitment over 30% of the time, suggesting that the egg to fry life stage of the chinook life cycle can limit adult production even when flooding is not severe. Factors at other life stages can also limit chinook production. This can include, but is not limited to, the long-term loss of estuary habitat at the juvenile life stage or fishing mortality at the adult life stage.

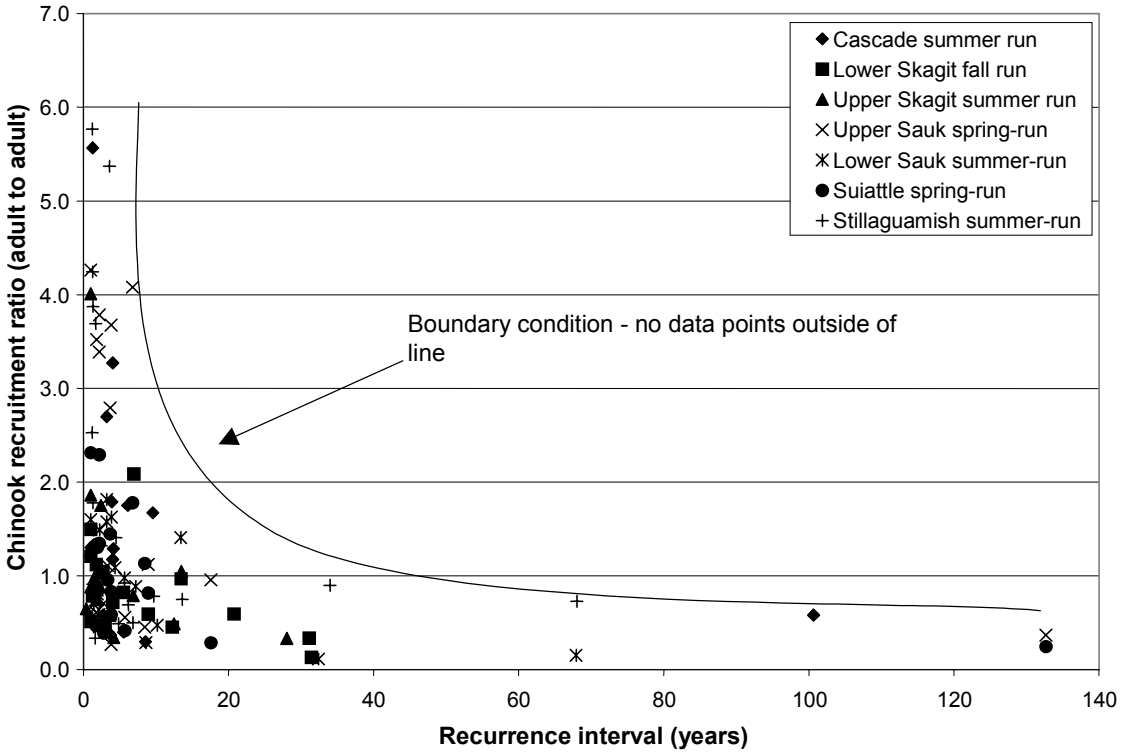

Figure 1. Chinook recruitment ratio as a function of peak flows during the egg incubation period for wild Chinook of the Skagit and Stillaguamish Rivers (Brood years 1974 to 1990).

In the North Fork Stillaguamish River, increases in peak flows over the last 70 years have changed the flood frequency curve (see Figure 3). By applying our model of chinook egg to migrant fry survival (Figure 2) we hypothesize chinook egg to fry survival has been reduced from 10% to 5% for the two-year flood event (Figure 4). This means that every brood year of spawning chinook has a 50% chance, rather than a 10% chance, of being exposed to flow events that correspond to egg to fry survival rates where the stock does not replace itself. Possibly not by coincident, naturally spawning North Fork Stillaguamish chinook have been unable to replace themselves over 70% of the time since 1980 (Figure 1).

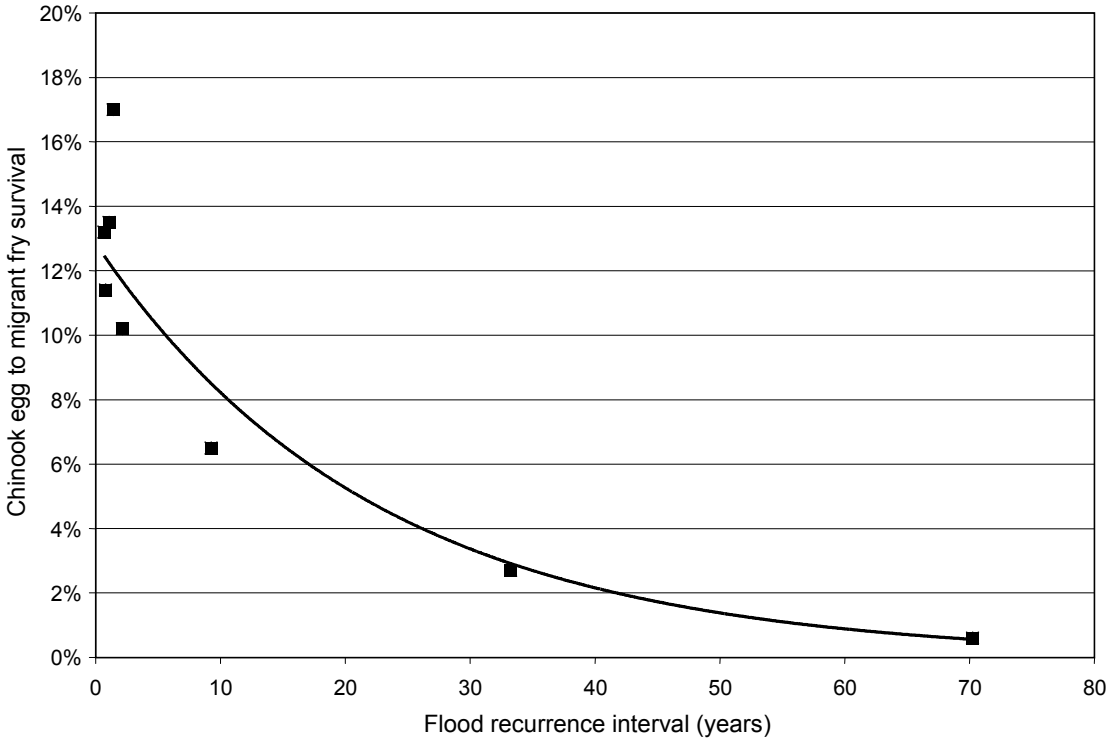

Figure 2. Egg to migrant fry survival as a function of peak flow during egg incubation (at Mt. Vernon) in the Skagit River basin (1989 to 1996) ($y=0.1285e^{-0.0446x}$, $R^2=0.97$).

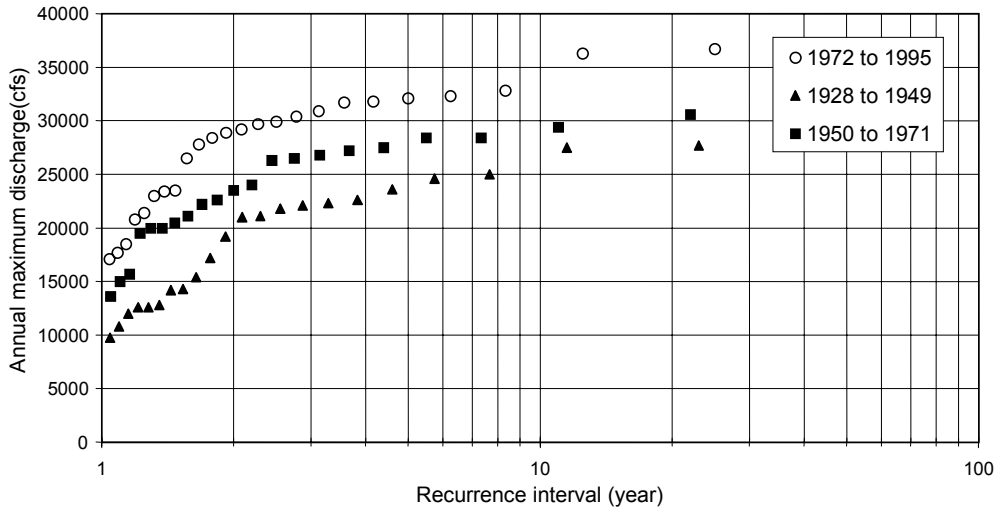

Figure 3. North Fork Stillaguamish flood recurrence interval

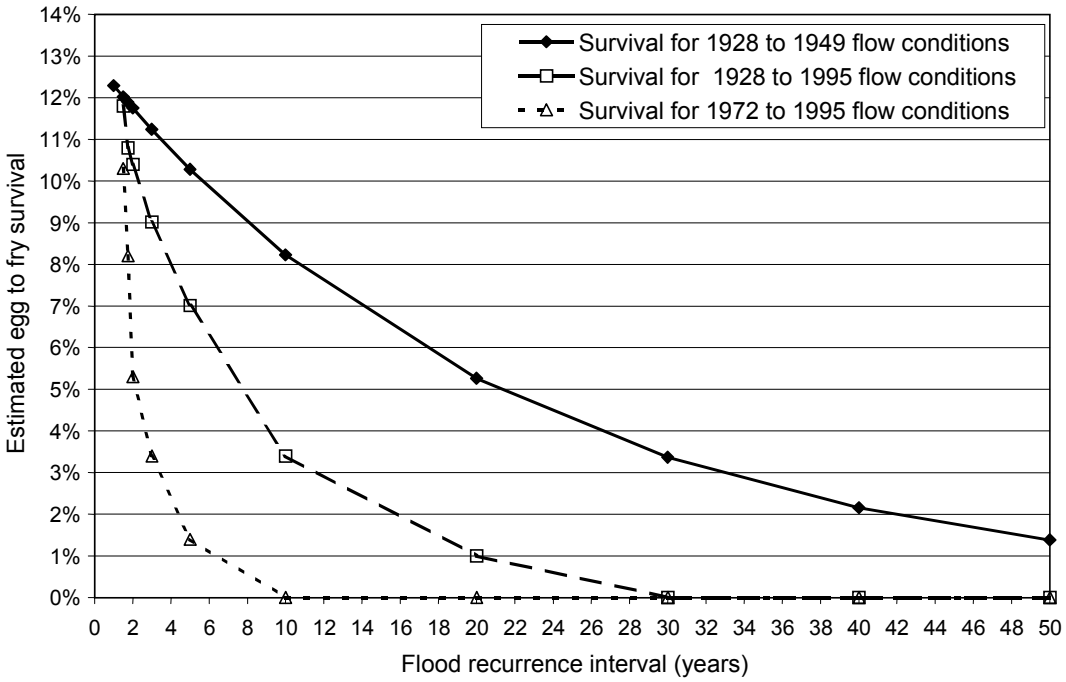

Figure 4. Estimated egg to fry survival v. flood recurrence interval for the North Fork Stillaguamish.

CONCLUSIONS

Peak flows can constrain adult chinook production even in years where flooding is not severe. Freshwater habitat conditions at the egg to fry life stage can therefore be a “bottleneck” to production of chinook stocks. Because of the exponential decay shape of the curve (see Figure 2), egg to fry survival is sensitive to changes in peak flow. A change in peak flows can reduce egg to fry survival levels to the point where one generation of chinook cannot produce enough returning adults to replace themselves. This information is important in predicting run sizes for fisheries harvest management, and also has significant landscape management implications when considering how to protect and restore chinook stocks.

REFERENCES

Seiler,D., L.Kishimoto, and S.Neuhauser. 1998. 1997 Skagit River wild 0+ Chinook production evaluation. Washington Department of Fish and Wildlife, Olympia, WA. 57 pp.