ANNUAL REPORT

1997 SAMMAMISH RIVER SOCKEYE SALMON FRY PRODUCTION EVALUATION

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INTRODUCTION

The numbers of adult sockeye salmon returning to the Lake Washington system are estimated as they pass the Ballard Locks, and as spawners in the Cedar River, primary tributaries to the Sammamish system, and on certain beaches. The majority of the spawning has occurred in the Cedar River, but in three recent years (1992, 1994, and 1996), biologists have estimated that a quarter to a third of the Lake Washington Basin sockeye have spawned in the Sammamish River Basin (*Egan and Ames WDFW memo, 1997*) . Over the other twelve of the last fifteen years for which escapement estimates are available for all areas, the Cedar River accounts for an average of 88% of the total spawners (range = 82% to 98%). This interannual variation may result from differential survival as a function of spawning and emergence timing relative to stream specific hydrology. In addition to run timing differences, recent electrophoretic analysis indicates that the sockeye which spawn in the Sammamish system are genetically distinct from the larger Cedar River population.

In 1992, as part of a multi-agency effort to determine the cause(s) of the decline in the Lake Washington sockeye run, we began enumerating sockeye fry production from the Cedar River. Measuring the population at this lifestage and location separates freshwater survival into its two major components; spawning which takes place in the river and rearing which occurs in the lake. Over the past six broods, natural spawners in the Cedar River have produced fry populations to the lake of 0.7 to 27.1 million. We have determined that the severity of peak flows is the primary factor controlling survival from spawning to fry emigration in this system. Annual estimates of the numbers of fry entering the lake are also needed to understand the complex ecological relationships which regulate juvenile sockeye survival during their year in the lake. Because the Sammamish system may account for a significant portion of the fry entering Lake Washington in some years, an estimate of this production component is also needed to understand the dynamics of the combined population.

GOALS AND OBJECTIVES

1. Estimate the number of sockeye fry migrating from the Sammamish River into Lake Washington.
2. Define the migration timing of this fry migration.
3. Determine where juveniles produced from spawners in this system rear; Lake Sammamish or Lake Washington?

METHODS

While the spawning areas are well known in the Sammamish River system, it was not known where the fry produced from the spawners using these tributaries rear; Lake Sammamish, Lake Washington or a combination of both. Selection of the trapping location was a critical decision for determining where the fry produced within the Sammamish system rear. Initially, we planned to measure fry production within Big Bear Creek, the tributary in which the majority of spawning occurs. Enumerating fry production from this tributary, which also is closest to Lake Sammamish, however, would provide no insight into the rearing areas used by these juveniles as it is possible that they could ascend the slough to rear in Lake Sammamish. To estimate the migration into Lake Washington from all the tributaries, we elected to locate the trap as low in the Sammamish River as possible. In addition to our estimate, a University of Washington graduate student sampled for upstream migrating fry above the mouth of Bear Creek. Lake Sammamish was also sampled with seines during the spring to further investigate its role in rearing sockeye.

Our approach to estimating sockeye fry migration from the Sammamish River closely resembled the trapping operation we developed and have successfully used in the Cedar River each year since 1992. This operation involves trapping throughout the sockeye fry migration and calibrating the efficiency of this gear over the range of flows experienced. The initial challenge in trapping sockeye fry in the slow-moving Sammamish River was selecting a trapping location with sufficient velocity and access. Estimating the total number of sockeye fry entering Lake Washington from the Sammamish River required locating the trap downstream of all the tributaries. Velocities downstream of Swamp Creek, the lowermost tributary, however, were too slow. The nearest location with marginally-adequate velocity that we found was near the left bank, just below the foot bridge at the Bothell Station Condominiums (R.M. 4.0). Velocity at this point increases somewhat due to the curve of the river bank and the slight channel constriction.

Trapping Gear and Operation

The trap barge consists of two 30 ft x 3 ft x 3 ft steel pontoons outfitted with 15 ft wide decks fore and aft, two five ton anchor winches, two “horseshoe” davits with lifting winches, safety railings, and an 8 ft x 8 ft house on the aft deck. Initially, we placed one inclined-plane screen trap in the opening between the pontoons, but after just two nights of trapping we added a second unit to double our fishing power. Each trap measures 3 ft wide by 2 ft deep at the entrance, and the inclined ramp is 9 ft long. Captured fish are retained in a livebox located at the end of each inclined screen. All surfaces of the trap and livebox are covered with perforated plate aluminum (33 ⅛ inch holes/sq. inch).

To minimize the deceleration of flow through these traps we fished them at a depth of 16 inches rather than the maximum depth of 24 inches. At this depth the incline angle is reduced and more screen surface area is presented relative to the flow volume entering the trap. Each trap fished a cross-sectional area of 4 square ft. Velocity at this location was dependent on discharge. Flows varied six-fold over the period we trapped, from around 300 cfs to over 1,900 cfs. At the lowest flows, velocity at the trap entrance was less than two feet per second. At 1,700 cfs, the highest flow we trapped, velocity measured around four ft/second. We estimate that combined, the traps screened around 10 cfs at the lowest flows to over 30 cfs at the highest.

Trapping began on the night of February 14, and continued every other night until March 2, when we began continuous trapping. We trapped each night through April 25, after which we resumed trapping alternate nights through May 1, our last night. High flows precluded trapping on three nights (March 18,19, and 20) and part of another (April 19).

Trapping commenced each night at dusk and continued through dawn. We also operated the traps during daylight hours for portions of three days (February 24, March 2, and March 21). Hourly, throughout each night, captured fish were removed, identified, and enumerated by trap.

Trap Calibration

Trap efficiency was estimated throughout the season via releasing groups of marked sockeye fry upstream of the traps. Fry retained from the previous night were dyed in a solution (0.014 g/l) of Bismark Brown dye for 1½ hours. Marked fry were released at various times during the middle of the night but generally around midnight. We released the first nine mark groups 300 yds upstream from the trap off both banks. As flows increased, wading out from the steep banks became too dangerous, so we resorted to releasing the mark groups off the bridge over the mouth of North Creek for the remainder of the season. In total, we released 42,414 marked fry in 45 groups over as many nights from March 4 through April 25.

Operating two traps side by side over identical time intervals provides the opportunity to assess the assumption basic to producing unbiased mark and recapture estimates: that marked individuals represent unmarked individuals. For estimating sockeye fry production, fulfilling this assumption requires achieving the same spatial distribution in the stream channel with the marked fry as that of the unmarked population. We compared mark:unmark ratios (m/u) between traps to determine if marked fish were distributed differently than unmarked to assess the effect that release location had on fry distribution.

Fry Estimation

Nightly migrations, N_i, were calculated using the season average trap efficiency (‘)

$$N_i = c_i \div \text{‘}$$

where: c_i = catches during night i

Additional steps used to estimate the total number of sockeye fry migrating from the Sammamish River in 1997 included the following assumptions:

1. The migration began on January 15 and was over on May 15 and, that straight-line extrapolation from the levels estimated when trapping began and ended on February 14 and May 1, respectively, represents the migration before and after trapping.

2. The proportion of the 24 hour migration occurring at night averaged 95.8%. This is the rate projected from our limited sampling of daytime migration.

3. Trap efficiency was lower on the three nights preceding and following the three nights (March 18-20) on which extreme high flows precluded trapping. We reduced the average capture rate by 25% to 5.81% for these six nights. On these nights, up to 50 gallons of debris/hour were removed from the traps. In doing so, we estimate that we also removed (uncounted) around a quarter of the fry.

4. Interpolating from the migrations estimated on March 17 and 21 produced accurate estimates of the migration during the three highwater nights (March 18-20).

RESULTS

Catch

The sockeye fry migration was underway when trapping began on February 14. Catches increased from 50 using one trap on the first night, to peak at 4,080 March 2 (both traps combined). Catches declined through April, and on May 1, our last night of trapping, we caught only 14 sockeye fry. Over the season, catches totaled 51,673 sockeye fry in the 63 nights fished (Table 1).

In addition to the nightly trapping we also operated the traps for limited intervals during the daylight on three days. On February 24, March 2, and March 21 we fished a total of 9.2 hours during mid-day and caught a total of 23 sockeye fry. Catch/hour rates were expanded to the total hours of daylight to project a daily catch. Combined with respective nightly catches, these estimates accounted for an average of 4.2% of the 24 hour total. (Table 2).

While sockeye fry were our target species, we also caught the following numbers of incidental salmonids; 354 coho fry, 102 chum fry, 20 chinook fry, 13 coho smolts, one adult steelhead kelt (hatchery male), one rainbow trout, and one steelhead smolt. Non-salmonids captured included juvenile lampreys, sticklebacks, cyprinids, sculpins, perch, sunfish, bass, frogs and pollywogs (Table 3).

Efficiency and Flow

Recapture rates of the 45 release groups ranged from 2.5% to 17.5%, and averaged 7.75% for both traps combined (Table 4). On the dates that we conducted efficiency tests, flows (measured at Woodinville-USGS) ranged from 309 to 1,490 cfs. Correlation of efficiency on flow indicated a weak relationship ($R^2 = 25\%$) for both traps combined (Figure 1). Flows exceeded 1,490 cfs, the highest flow experienced during a calibration test, on three nights, March 19-21.

We attribute the poor relationship between flow and efficiency to two factors: channel shape and turbulence upstream of the traps. The Sammamish Slough is contained by steep banks. Consequently, as flows increase so do depth and velocity, but width changes very little. Because sockeye fry migrate near the surface, despite depth, the cross-sectional area of fish-bearing water in the slough changes primarily with the width increment, which is relatively small. As the traps fish a constant area, capture rate is largely a function of the proportion of fish-bearing water sampled. We believe that the variation in capture rates that we observed, even at relatively constant flows, resulted from turbulence in the form of large boils emanating from the banks upstream of the trap. These boils which occurred frequently, but with no apparent pattern, undoubtedly affected the lateral distribution of marked and unmarked sockeye fry and thereby, the instantaneous capture rate.

Analysis of m/u ratios by trap indicates that over all calibration tests, the distribution of marked fry was significantly different than that of unmarked fry. Marked:unmarked ratios in the port and starboard traps over the 45 nights that calibration tests were conducted averaged 8.2% and 6.9%, respectively (Table 5). Although, differences in m/u ratios were observed for the groups released from the various sites, only the North Creek Bridge (NCB) releases (n=36) and the first nine releases (pooled) which were made from both banks and mid-channel, were numerous enough to allow statistical analysis. Marked to unmarked ratios for the first nine releases pooled were identical between both traps indicating that these marked groups had the same distribution as the unmarked fry. The NCB releases, which had significantly higher m/u ratios in the port trap than in the starboard trap (9.00% vs 7.39%) accounted for all of the bias in the over all release groups. Apparently, the marked fry released from the NCB maintained a distribution closer to the right bank than that of the unmarked fry.

Although the m/u analysis indicated that releasing marked fry from the NCB resulted in a biased distribution, this finding cannot be used to adjust the releases or recaptures to produce an unbiased estimate of capture rate. The direction of the bias indicates that the NCB releases underestimated the actual capture rate. However, the fact that NCB releases were captured at a higher rate than the first nine releases pooled (8.3% vs 5.6%), which we determined were unbiased, suggests that the effect of the bias on NCB recapture rates was negligible. Some of the difference between these two recapture rates results from flow. During the first nine releases flows averaged 722 cfs, while the average over the NCB releases was 611 cfs. The flow-efficiency analysis over all of the calibration tests indicates that this difference in flows would explain around a third of the discrepancy in these average recapture rates (0.8% of the 2.7%) (Figure 1).

Given the slight, if any, effect that the release bias had on capture rates and the poor correlation between flow and capture rates, we elected to use the average capture rate estimated over all tests of 7.75% for estimating sockeye fry migration from the Sammamish River.

Fry Production

We estimate that 953,000 sockeye fry migrated down the Sammamish River at Bothell (Figure 2).

Period	Dates	Estimate
Before trapping	January 15 - February 13	19,531
During trapping	February 14 - May 1	932,500
After trapping	May 2 - 15	1,229
Total		953,260

Migration Timing

The sockeye fry migration increased from under 2,000 fry/night in mid-February, to peak at over 70,000 fry on March 21, then declined through April, to less than 200 on May 1 (Figure 2). March 21 is also the median date for this estimated migration.

Egg-to-Migrant Fry Survival

Survival from potential egg deposition (P.E.D.) to lake entry as fry is estimated at 1%. This rate which represents an over all average value for this brood is the ratio of our estimate of 0.9 million fry to a P.E.D. of 89.5 million. The P.E.D. is based on the following estimates and assumptions:

1. A spawning population in the Sammamish system (downstream of the lake) of 60,000 sockeye in 1996.;
2 An even sex ratio; and
3. average fecundity of 3,000 eggs per female.

This survival rate is only a fraction of the value (7%) that we estimated in 1997 from the sockeye that spawned in the Cedar River in 1996. We attribute this seven-fold difference in survival to the differences between these watersheds and their peak flows. The storm which produced the highest flows occurred around January 1, 1997, and is regionally referred to as the “ice storm”. It was a classic rain on snow event that hit low elevation systems particularly hard. In such urbanized watersheds as the Sammamish, the runoff rate was exacerbated by the large proportion of impervious surfaces. This event produced the highest single day flow (2,830 cfs) ever recorded in the 157 sq. mile Sammamish River Basin (USGS at Woodinville) since 1966 when flow monitoring began. In comparison, flows from the larger (184 sq. mile) Cedar River system also peaked at 2,830 cfs. This flow is only a fraction of the highest flow ever recorded at Renton, 10,600 cfs on November 24, 1990. The difference in runoff response between these two watersheds resulted from several factors: the Cedar River watershed originates at much higher elevations, is less developed than the Sammamish; and during this event the Seattle Water Department did not spill any additional water from Chester Morse Dam, which forms the storage reservoir.

To assess the effect of minimum peak flows during incubation on sockeye survival in the Sammamish system we approximated fry production from the 1992 brood, which experienced the lowest peak flow on record (492 cfs), by applying the survival rate that we measured in the Cedar River to the spawning escapement estimated in the Sammamish system (Table 6). Flows during incubation for this brood were also the lowest of the six broods (1991-1996) that we have assessed in the Cedar River. We estimated that 18% of the eggs deposited in the Cedar River in 1992 survived to become fry that migrated into the lake. At this egg to migrant fry survival rate, the escapement of 30,000 sockeye estimated for the Sammamish system in 1992 produced 8.1 million fry (Table 6). Assuming the same age distribution at return as the Cedar, this production resulted in the majority (age 4) of the estimated 1996 return of 60,000, a spawner:fry ratio of 0.74%. Because this rate is the same as we estimated for the Cedar River population (0.79%; 230,000 adults returning in 1996 from 29 million fry produced in 1993), it indicates that survival to fry migration in the Sammamish system is also controlled by the severity of peak flows during egg incubation and may have a similar functional relationship.

Rearing Area Determination

In the foregoing, we have discussed fry survival for the Sammamish River System with the inherent assumption that all fry produced downstream of Lake Sammamish migrate down the slough to rear in Lake Washington. While we believe this is the case, given our low estimates of fry production for this first year, we cannot confirm this assumption. Although results from the sampling in Lake Sammamish will most directly assess its role in the freshwater rearing phase, this work will not identify the origin of the fry because spawning also occurs in Issaquah Creek. Additional trapping/fry estimation in the slough should provide us the opportunity to verify this assumption if moderate flows occur during the incubation period.

LITERATURE CITED

Egan, R. and J. Ames. 1997. **1996 Lake Washington Basin Sockeye Escapement**. WDFW memo.

Seiler, D., S. Neuhauser, and M. Ackley. 1981. Upstream/Downstream Salmonid Trapping Project 1977-1980. WA Dept. of Fish. Prog. Rpt. No. 144. 195pp.

Volk, E.C., S.L. Schroder, and K.L. Fresh. 1990. Inducement of unique otolith banding patterns as a practical means to mass-mark juvenile Pacific salmon. Am. Fish. Soc. Symposium **7**:203-215.