Tustumena Lake
Sockeye Salmon Smolt
Progress Report
2018

Prepared by:
Emily Heale, Biologist
Revised February 2019

The 2018 Tustumena Lake Sockeye Salmon Smolt Project was made possible through funding by provided enhancement taxes paid by commercial fishermen in Area H, Cook Inlet and associated waters.

This page intentionally left blank

DISCLAIMER

The Cook Inlet Aquaculture Association (CIAA) conducts salmon enhancement and restoration projects in Cook Inlet (Area H) and associated waters. As an integral part of these projects a variety of monitoring and evaluation studies are conducted. The following progress report is a synopsis of the monitoring and evaluation activities conducted for the 2018 Tustumena Lake sockeye salmon smolt monitoring project.

The purpose of these progress reports is to provide a vehicle to distribute the information produced by the monitoring and evaluation activities. Data collected each year are presented with a summary of the information previously collected for comparative purposes. These reports are intended to provide a general description of project activity and are not an exhaustive evaluation of any fisheries project. The information presented in each report has not undergone an extensive review. As reviews are completed, the information may be updated and presented in later progress reports.

Cook Inlet Aquaculture Association maintains a strong policy of equal employment opportunity for all employees and applicants for employment. We hire, train, promote, and compensate employees without regard for race, color, religion, sex, sexual orientation, national origin, age, marital status, disability or citizenship, as well as other classifications protected by applicable federal, state or local laws.

Our equal employment opportunity philosophy applies to all aspects of employment with CIAA including recruiting, hiring, training, transfer, promotion, job benefits, pay, dismissal, and educational assistance.

This page intentionally left blank

ACKNOWLEDGEMENTS

Many individuals and agencies contributed to the success of the 2018 Tustumena Lake sockeye salmon smolt monitoring project. Appreciation is extended to Cook Inlet Aquaculture Association (CIAA) Seasonal Assistants Ronnie Minter and Jeff Kasowski as well as regular staff who invested many hours in planning and executing this project. Special thanks go out to the Alaska Department of Fish and Game and Alaska State Parks for their support during this project.

This page intentionally left blank

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

This page intentionally left blank

ABSTRACT

The 2018 Tustumena Lake smolt migration was enumerated from May 14 and continued daily until July 6. Field personnel captured and identified 156,759 sockeye salmon smolt (*Oncorhynchus nerka*), 3,038 coho salmon smolt (*O. kisutch*), 606 Chinook salmon smolt (*O. tshawytscha*), 447 pink salmon fry (*O. gorbuscha*), and 185 juvenile Dolly Varden (*Salvelinus malma*) using an inclined plane smolt trap. Numerous ninespine stickleback (*Pungitius pungitius*), eulachon (*Thaleichthys pacificus*), unspecified lamprey, and slimy sculpin (*Cottus cognatus*) were also captured and recorded as being present. A mark-recapture stratified sampling design was used five times throughout the season to estimate the abundance of the migrating sockeye salmon smolt population in which the estimated weekly capture probability, or trap efficiency, ranged from 1.22% to 5.62% with a season average of 3.05%. Through mark-recapture analysis the total sockeye salmon smolt migration was estimated to be 4,406,731 (±722,844).

Age, weight, and length (AWL) samples (N=277) from migrating sockeye salmon smolt were collected throughout the run to determine age structure and physical characteristics of the population. Age structure was analyzed by scale evaluation to classify the proportion of migrating smolt into the following age classes: age-1 class 69.4% (±0.14%) and age-2 class 30.6% (±0.47%). Sockeye salmon smolt in age-1 class had an average weight and length of 5.9 g (±0.2 g) and 91.5 mm (±0.8 mm). Sockeye salmon smolt in the age-2 class had an average weight and length of 11.4 g (±0.4 g) and 114.6mm (±1.4 mm).

General environmental conditions were recorded daily for accumulated precipitation, water level fluctuations, water temperature, and air temperature. From May 14 through July 6 personnel recorded accumulated precipitation at 53 mm, water level fluctuated +1.8 feet, water temperature averaged 12.1°C, and air temperature averaged 17.2°C.

This page intentionally left blank

INTRODUCTION AND PURPOSE

The Alaska Department of Fish and Game (ADF&G) began the Tustumena Lake sockeye salmon enhancement program in 1974. Fry stocking into Tustumena Lake began in 1976 from the resultant broodstock collection. Gamete collection occurred in Bear Creek, Glacier Flats Creek, and Seepage Creek in varying combinations over the development of the program. Over the years, the program progressed in such a manner that as many as 23.6 million eggs were collected and 17.1 million fry were released into Tustumena Lake. Up to eight other lakes were stocked with fry of Tustumena origin.

Initially, Tustumena Lake sockeye salmon enhancement activities were conducted at Crooked Creek Hatchery (CCH) and in July 1993, ADF&G transferred operation of CCH to Cook Inlet Aquaculture Association (CIAA). Under CIAA operation, CCH focused solely on sockeye salmon releases to Tustumena Lake, several lower Cook Inlet lakes, and Resurrection Bay. ADF&G continued to conduct enumeration activities associated with the Tustumena Lake smolt and adult sockeye salmon migrations while CIAA accepted responsibility to oversee and conduct the broodstock collection, incubation and rearing, and fry releases.

In November 1996, CIAA terminated operations at CCH, suspended stocking activities at five lower Cook Inlet lakes, and transferred the remaining stocking programs to its Trail Lakes Hatchery and Eklutna Salmon Hatchery. In 1998, CIAA became responsible for limnological sampling at Tustumena Lake and smolt monitoring in the Kasilof River.

In 2002, issuance of a permit for the Tustumena enhancement project was legally challenged. In 2004, the United States Fish and Wildlife Service was no longer able to provide CIAA with a permit to continue operations on Tustumena Lake and all enhancement activities were suspended; however, CIAA continued to enumerate the Tustumena Lake smolt migration in the Kasilof River, the outlet of Tustumena Lake. Hatchery-incubated sockeye salmon released as fry in 2004 were projected to migrate out of Tustumena Lake through 2006. Sampling procedures to estimate the hatchery contribution to the smolt migration were discontinued after 2006, but smolt enumeration activities continued in subsequent years because the smolt migration estimates were used by ADF&G to forecast future adult sockeye salmon returns to Tustumena Lake.

This report provides data from the 2018 smolt enumeration, as well as historical data.

This page intentionally left blank

PROJECT AREA

Tustumena Lake is located on the Kenai Peninsula in Southcentral Alaska (Figure 1). The lake is the largest on the Kenai Peninsula and the fifth largest lake in the state of Alaska. It is a glacial lake with a surface area of 294.5 km^2 (73,942 acres). It is approximately 40 km long and 8 km wide. The mean depth is 24 m, and the maximum depth is 320 m. The lake is fed by several clear water streams and two glacial streams originating in the Harding Icefield. The lake outlet is the Kasilof River, which flows 28 km to Cook Inlet. Kasilof River is listed under the Anadromous Waters Catalog code 244-30-10050 (Johnson and Blanche, 2010), which indicates the river is recognized by ADF&G as an important stream for salmon spawning and migration. The 2018 salmon smolt enumeration occurred 450 m above the confluence of Crooked Creek and Kasilof River.

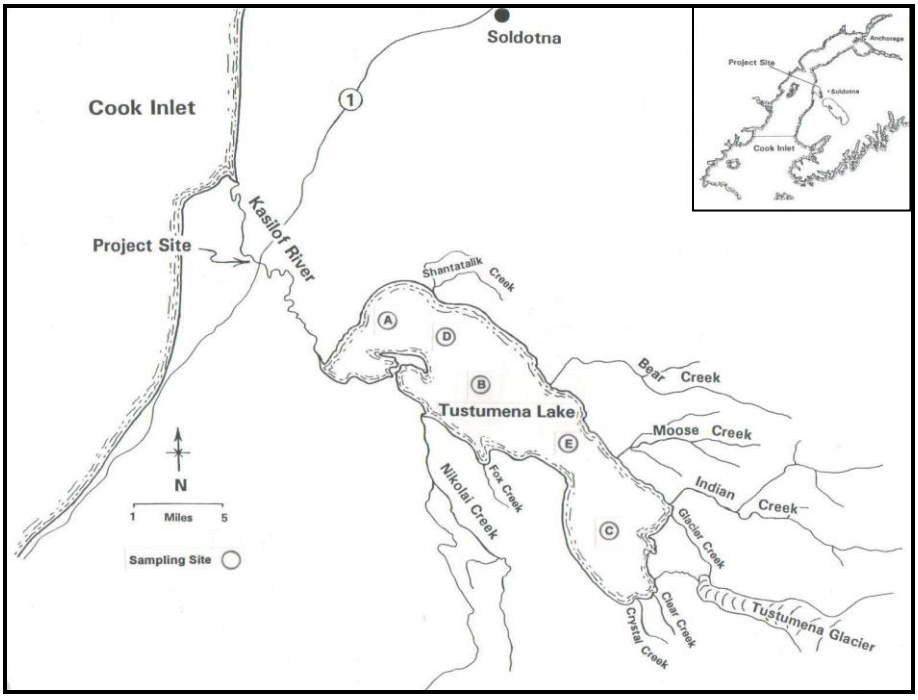

Figure 1. Tustumena Lake in relation to Cook Inlet
The circled letters are zooplankton sampling sites.

In 1992, Kyle characterized Tustumena Lake as oligotrophic with mean open-water season total phosphorus (corrected for turbidity and inorganic phosphorus), total Kjeldahl nitrogen and chlorophyll a concentrations of 3.7 μ/L, 155 μ/L, and 0.45 μ/L, respectively. The lake is turbid with glacial silt and light penetration is limited to the upper two meters and the euphotic zone is less than 1% of the lake's volume. The zooplankton community consists of two copepods, *Diaptomus pribilofensis* and *Cyclops columbianus.* Sockeye salmon (*O. nerka*), coho salmon (*O. kisutch*), Chinook salmon (*O. tshawytscha*), pink salmon (*O. gorbuscha*), and chum salmon (*O.*

keta) are found in the Tustumena Lake system; however, it is mainly sockeye salmon that use the limnetic area of the lake. Resident fish species include rainbow trout (*O. mykiss*), lake trout (*Salvelinus namaycush*), Dolly Varden char (*S. malma*), threespine stickleback (*Gasterosteus aculeatus*), coastrange and slimy sculpin (*Cottus aleuticus* and *C. cognatus*), and round whitefish (*Prosopium cylindraceum*) (Kyle, 1992).

METHODS

Environmental Conditions

To assess the environmental conditions during the sockeye salmon smolt migration personnel recorded estimated percent cloud cover, water level measured to the nearest hundredth of a foot, precipitation measured to the nearest millimeter, and water and air temperatures measured to the nearest degree centigrade. All measurements were recorded at 5:00 PM each day (CIAA Staff, 2018).

Zooplankton samples were collected by CIAA staff at the designated sample sites (Figure 1) in 2014, 2015 and 2016 for future reference. If there are any changes with the salmon population at Tustumena Lake, the zooplankton samples may be analyzed to help understand any anomalies. No samples were taken in 2017 or 2018.

Smolt Enumeration

To conduct the Tustumena Lake sockeye salmon smolt enumeration project, one inclined plane smolt trap, or collection facility, was placed 450 meters up river from Crooked Creek at mile 7.8 on the Kasilof River. The trap consisted of a double compartment live box (Figure 2) supported by a twin pontoon raft (Todd, 1994). The trap was operational on May 14 and was the focal point for enumeration of smolt/species, sub-sampling for smolt characteristics, and for determining trap efficiency until July 6.

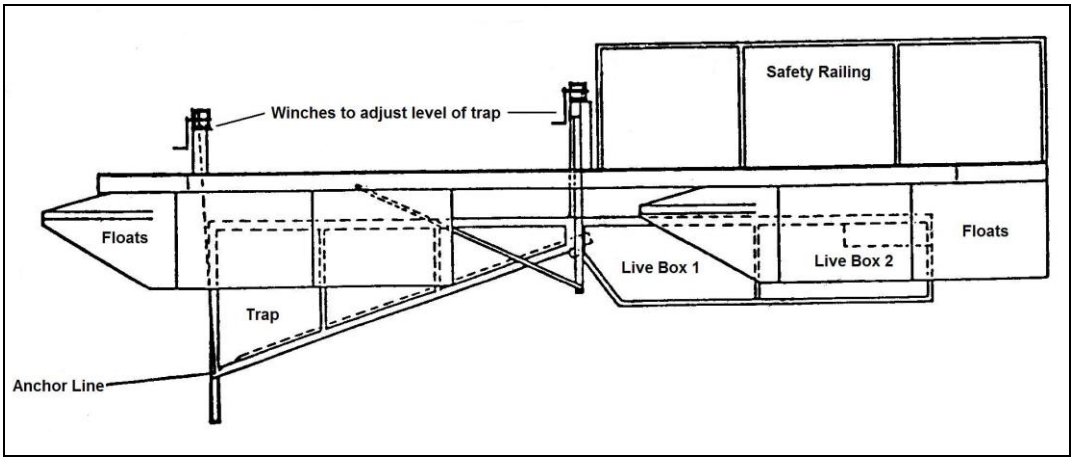

Figure 2. Schematic diagram of the Kasilof River smolt trap

Field personnel physically identified each fish by species and released the fish unharmed downstream of the trap to continue their migration. The daily capture count was used with trap efficiencies to determine the total estimated sockeye salmon smolt out-migration.

The mark-recapture technique used in this project involved a stratified sampling design in which approximately 1,000 sockeye smolt were color marked with dye and released from mile 7.1 (Figure 3).

Figure 3. Smolt trap and release site, Kasilof River

Personnel conducted the mark-recapture tests weekly. Once the smolt were collected for the mark-recapture test, personnel transferred the fish into a container containing the dye solution Bismarck Brown Y (1 gram of dye per 47.0 liters of water) and monitored the health of the fish for approximately 45 minutes (Figure 4). Upon release, approximately 10–15 dyed smolt were set aside in a smaller container and monitored for an additional hour to record the quality of dye retention as well as vitality. Personnel monitored the number of daily recaptured dyed sockeye smolt at the trap for five days following release of dyed fish at mile 7.1. Any sockeye smolt mortality was not included in the total number released. The number of smolt recaptured in the trap was then used to estimate the proportion of migrating smolts captured (the trap capture efficiency) and the total estimated smolt migration.

Figure 4. Dyed sockeye salmon smolt for trap efficiency test

Statistical procedures for estimating the population of migrating smolts (*N*) followed the *simple stratified M-R design* for One-Site sampling experiments described by Carlson et al. (1998) where:

U = total unmarked population size;
N = total population size;
N_h = total population size in stratum h;
u_h = total number of unmarked smolts captured in stratum h;
M_h = number of marked smolts released in stratum h;
m_h = number of marked smolts recaptured in stratum h;
L = number of strata or periods; and

$$\hat{U} = \sum_{h=1}^{L} \hat{N}_h - M_h = \sum_{h=1}^{L} \frac{u_h\left(M_h + 1\right)}{m_h + 1}$$

The variance of the population estimate $v(N)$ and the 95% confidence interval (CI) were estimated as:

$$v(\hat{N}) = \sum_{h=1}^{L} v(\hat{N}_h) = \sum_{h=1}^{L} \frac{(M_h + 1)(n_h + 1)(M_h - m_h)(n_h - m_h)}{(m_h + 1)^2 (m_h + 2)};$$

And,

$$(CI) = \hat{N} \pm 1.96\sqrt{v(\hat{N})}\,.$$

This method assumes:

- All marked fish released upstream pass the trap before the next release of marked fish;
- The probability that a dyed or unmarked fish enters the trap equals the trap efficiency for all dyed or marked fish;
- Fish are captured or not captured in the trap independently of the fate of other fish;
- All fish entering the trap are counted, and;
- Trap efficiencies do not change substantially during the mark-recapture period.

The proportions of age-1, age-2, and age-3 smolt were calculated using the data computed from the aforementioned notations and formulas with the following notations and formulas:

U_i = total unmarked population size for age class = *i*;
U_h = total unmarked population size for stratum = *h*;
U_{hi}= total unmarked population size for age class *i*, in stratum = *h*;
P_i = proportion of unmarked smolt for age class = *i*;
P_h = proportion of unmarked smolt for stratum = *h*;
P_{hi}= proportion of unmarked smolt for age class = *i*, in stratum = *h*;
a_i = total number of samples of age class = *i;*

The estimated number of migrating age = i smolt was calculated as:

$$U_i = \sum U_h P_{hi}$$

Proportion of age = i smolt was calculated as:

$$P_i = \frac{1}{U} \sum U_h P_{hi}$$

The variance of the proportion of age = i smolt in stratum = h was calculated as:

$$v(P_{hi}) = \frac{P_{hi}(1 - P_{hi})}{a_h - 1}$$

The variance of the number of age = i smolt in stratum = h was calculated as:

$$v(U_{hi}) = U_h^2 v(P_{hi}) + P_{hi}^{\ 2}(U_h) - v(U_h)(P_{hi})$$

Therefore, the variance of the estimated number of age = i smolt was calculated as:

$$v(U_i) = \sum v(U_{hi})$$

Confidence intervals (95%) estimates for number of age = *i* smolts are:

$$U_i \pm 1.96\sqrt{v(U_i)}$$

Smolt Characteristics

To evaluate sockeye smolt characteristics, personnel collected a sample of sockeye smolt migrating from the lake to determine age, weight, and length characteristics of the population. Samples were collected daily by collecting every 500th sockeye smolt counted from the trap. Each sockeye smolt collected for evaluation was first measured to the nearest millimeter for fork length[1] and then weighed to the nearest 0.1 gram. Several scales were removed from the primary growth area[2] and mounted on a glass slide for subsequent age determination. Sockeye smolt characteristics (average weight and length) for captured smolt were estimated with the following notations and formulas.

If:

y = weight or length of fish

c_i = number of age = i smolts sample

Mean weight or length was calculated as:

$$\bar{y}_i = \frac{\sum y_i}{c_i}$$

The standard deviation for weight and length of each age class was calculated as:

$$\sigma_{y_i} = \sqrt{\frac{c_i \sum y_i - \left(\sum y_i\right)^2}{c_i\left(c_i - 1\right)}}$$

Confidence intervals (95%) for the mean weight and length are, therefore:

$$\bar{y}_i = \pm 1.96\left(\frac{\sigma_{y_i}}{\sqrt{c_i}}\right)$$

1. Standard fork length was measured from the tip of the snout to the fork of the tail.
2. Located above the lateral line on a diagonal from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin.

This page intentionally left blank

RESULTS AND DISCUSSION

Environmental Conditions

Environmental conditions were monitored daily from May 14 to July 6, 2018. During this period, water level fluctuated +1.8 feet (Figure 5); river temperatures ranged from 6.0 to 17.0°C and averaged 12.1°C. Air temperatures ranged from 10.0 to 25.0°C and averaged 17.2°C (Table 1). Nineteen percent of the days were clear, 46% were partly cloudy, and 35% were completely overcast. There was measurable precipitation 19 out of 52 days or 37% of the time; a total of 53 mm of rain fell during this period.

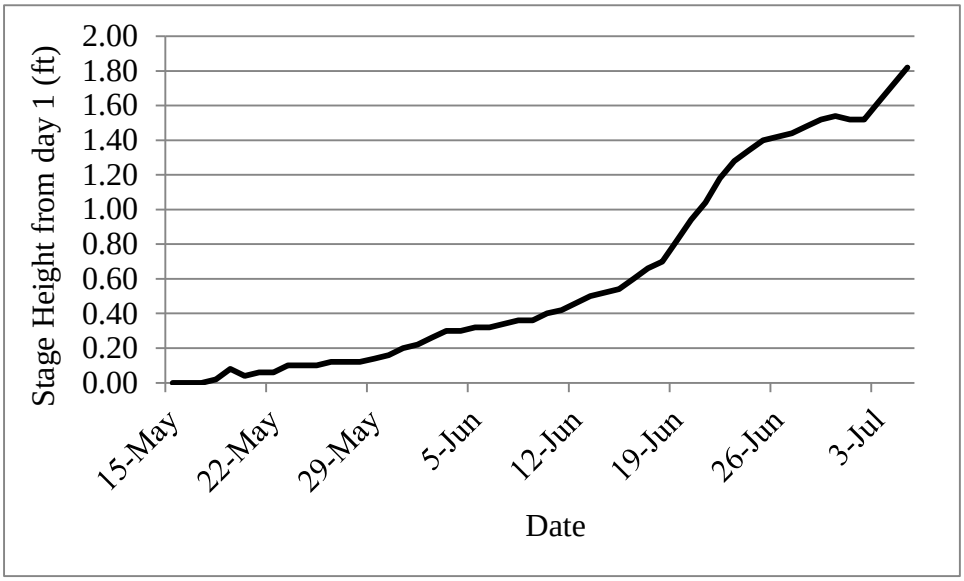

Figure 5. River stage, Kasilof River, 2018

Table 1. Environmental summary, Kasilof River, 2018

	Precipitation (mm)	Water Level (ft)	Water Temperature (°C)	Air Temperature (°C)
Total	53			
Average	1	0.91	12.1	17.2
Minimum	0	0.28	6.0	10.0
Maximum	22	2.10	17.0	25.0

Smolt Enumeration

The smolt migration was monitored daily from May 14 through July 6. During this time, field personnel captured and identified 156,759 sockeye salmon smolt (*O. nerka*), 3,038 coho salmon smolt (*O. kisutch*), 606 Chinook salmon smolt (*O. tshawytscha*), 447 pink salmon fry (*O. gorbuscha*), and 185 juvenile Dolly Varden (*S. malma*). Numerous ninespine stickleback (*Pungitius pungitius*), eulachon (*Thaleichthys pacificus*), unspecified lamprey, and slimy sculpin (*Cottus cognatus*) were also captured and recorded as being present. Recorded mortality during the dye testing and trap efficiency tests was 177 sockeye salmon smolt.

The highest recorded single day of capture was on June 6 when field personnel counted and identified 33,207 sockeye salmon smolt (Figure 6).

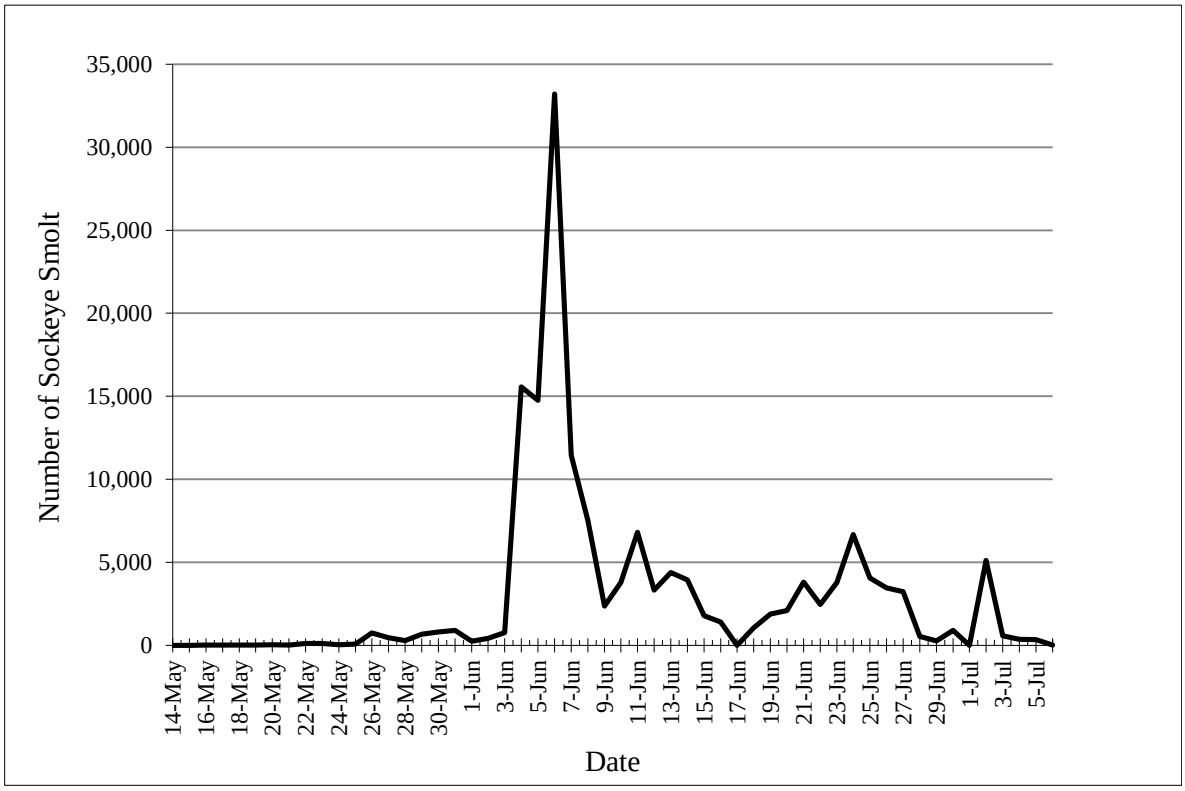

Figure 6. Daily trap capture, sockeye smolt, Tustumena Lake, 2018

From May 14 through July 6, five mark-recapture tests were conducted to estimate trap efficiency, which ranged from 1.22% to 5.62% with an average of 3.05%. Through mark-recapture analysis, the total sockeye salmon smolt migration from May 14 through July 6 was an estimated 4,406,731 (±722,844) sockeye salmon smolt (Figure 7). Table 2 shows the smolt outmigration including hatchery contribution since CIAA took over the counting in 1998.

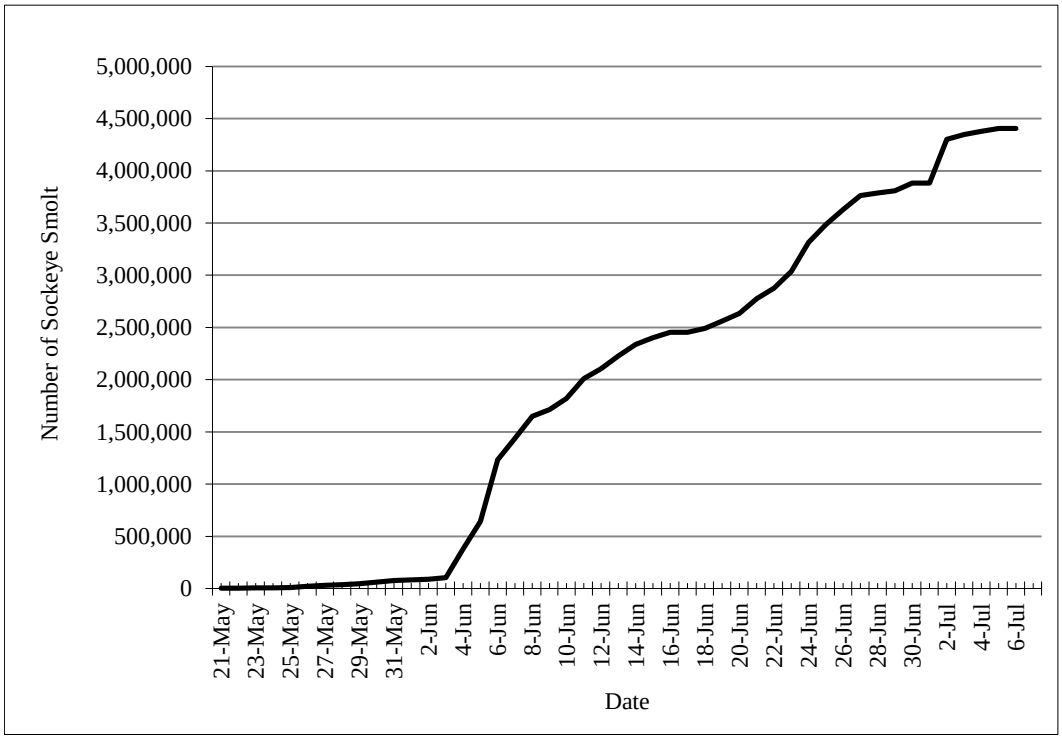

Figure 7. Mark-Recapture cumulative estimated population, sockeye salmon smolt, Kasilof River, 2018

Table 2. Sockeye smolt migrations & hatchery contribution, Tustumena Lake, 1998–2018

Year[a]	Total (million)	95% C.I.	Wild	Hatchery[d]	% Hatchery[d]	95% C.I.
1998	4.6	(±395,000)	3,872,000	727,000	15.8	(±2.2)
1999	4.5	(±461,000)	3,555,000	945,000	21.0	(±2.5)
2000	4.3	(±526,000)	3,986,000	316,000	7.4	(±1.8)
2001	5.3	(±612,000)	5,155,500	105,000	1.9	(±1.0)
2002	3.5	(±618,000)	3,474,000	0	0	0
2003[b]	12.9	(±2,437,000)	10,619,000	2,329,000	18.0	(±4.6)
2004	6.4	(±997,000)	3,155,000	3,140,000	49.9	(±12.6)
2005	11.1	(±2,152,000)	7,631,000	3,592,000	32.0	(±7.4)
2006	2.8	(±756,000)	2,833,000	10,600	0.4	(±0.5)
2007	3.2	(±832,000)	3,231,000			
2008	5.4	(±2,149,000)	5,418,000			
2009	3.6	(±885,000)	3,614,000			
2010	1.9	(±885,000)	1,949,000			
2011	ND	ND	8,282[c]			
2012	7.3	(±1,026,115)	7,383,018			
2013	7.0	(±2,697,000)	7,087,523			
2015	9.8	(±1,809,261)	9,832,522			
2017	3.7	(±574,029)	3,756,102			
2018	4.4	(±722,844)	4,406,731			
Average	5.7		5,053,216	1,240,511	16.3	

ND = No Data
a. The project was not operated in 2014 or 2016.
b. CIAA discontinued the stocking program at Tustumena Lake in 2003 and remaining enhanced fish out-migrated by 2006.
c. This was the actual number of smolt counted; there were no results from the mark-recapture study.
d. Hatchery averages are calculated from data collected 1998–2006. No hatchery fish were present after 2006.

Smolt Characteristics

Age, weight, and length (AWL) samples (N=277) were collected from May 14 through July 6 from migrating sockeye salmon smolt to determine age structure and physical characteristics of the population. Age structure was analyzed by scale evaluation to classify the proportion of migrating smolt into the following age classes: age-1 class 69.4% (±0.14%) and age-2 class 30.6% (±0.47%) (Table 3). Sockeye salmon smolt in the age-1 class had an average weight and length of 5.9 g (±0.2 g) and 91.5 mm (±0.8 mm). Sockeye salmon smolt in the age-2 class had an average weight and length of 11.4 g (±0.4 g) and 114.6 mm (±1.4 mm). No measurements were collected on any other species.

Table 3. Sockeye salmon smolt characteristics, Tustumena Lake, 1998–2018

	Age Class (%)				Mean Length (mm)				Mean weight (g)			
Smolt Year	Age 1.0	95% C.I.	Age 2.0	95% C.I.	Age 1.0	95% C.I.	Age 2.0	95% C.I.	Age 1.0	95% C.I.	Age 2.0	95% C.I.
1998	80	(±2.8)	21	(±2.8)	75	(±0.36)	85	(±1.03)	3.8	(±0.05)	5.4	(±0.16)
1999	78	(±9.6)	22	(±3.8)	77	(±0.34)	89	(±0.66)	3.9	(±0.05)	5.8	(±0.13)
2000	81	(±11.5)	19	(±4.2)	73	(±0.32)	86	(±0.73)	3.2	(±0.05)	5.0	(±0.12)
2001	61	(±9.5)	38	(±6.3)	72	(±0.39)	84	(±0.53)	3.3	(±0.05)	5.1	(±0.08)
2002	39	(±24.1)	61	(±24.8)	74	(±0.42)	82	(±0.64)	3.7	(±0.06)	5.2	(±0.11)
2003	74	(±16.2)	25	(±6.4)	78	(±0.42)	91	(±0.15)	4.8	(±0.07)	7.2	(±0.15)
2004	65	(±13.3)	35	(±8.1)	79	(±0.42)	92	(±0.57)	4.3	(±0.07)	6.6	(±0.12)
2005	91	(±19.0)	9	(±2.3)	76	(±0.25)	91	(±0.74)	3.9	(±0.72)	6.4	(±1.19)
2006	91	(±26.3)	9	(±3.6)	82	(±0.86)	98	(±2.26)	4.5	(±0.08)	7.4	(±0.58)
2007	81	(±19.0)	19	(±6.0)	75	(±0.5)	90	(±1.3)	3.5	(±0.1)	5.9	(±0.4)
2008	79	(±32.0)	21	(±19.0)	78	(±0.8)	96	(±1.4)	3.9	(±0.09)	7.1	(±0.31)
2009	58	(±15.0)	42	(±12.0)	81	(±0.6)	92	(±1.4)	4.7	(±0.09)	6.8	(±0.19)
2010	88	(±27.0)	12	(±42.0)	83	(±0.7)	103	(±2.2)	5.0	(±0.1)	9.0	(±0.5)
2011	98	(±0.02)	2	(±14.0)	87	(±1.4)	113	(±1.0)	5.9	(±0.3)	12.0	(±0.1)
2012	68	(±0.02)	31	(±0.07)	87	(±0.3)	101	(±0.6)	5.8	(±0.15)	12.3	(±2.5)
2013	57	(±0.1)	43	(±0.1)	85	(±0.4)	106	(±0.7)	5.4	(±0.4)	9.6	(±0.2)
2015	54	(±0.1)	46	(±0.1)	85	(±1.5)	99	(±1.5)	5.2	(±0.2)	7.6	(±0.2)
2017	76	(±0.1)	24	(±0.4)	84	(±0.4)	96	(±1.2)	4.6	(±0.1)	6.6	(±0.2)
2018	69	(±0.14)	31	(±0.47)	92	(±0.8)	115	(±1.4)	5.9	(±0.15)	11.4	(±0.4)
15-year Average*	73		27		82		98		4.7		8.1	
10-year Average*	73		27		84		101		5.0		8.8	
5-year Average*	65		35		87		103		5.4		9.5	

Note: 2001 smolt migration included 1.1% (±0.07) age class 3 smolt.
Note: 2003 smolt migration included 1% (±0.8) age class 3 smolt.
Note: 2012 smolt migration included 0.5% (±0.9) age class 3 smolt.
Note: No funding for the smolt migration project in 2014 and 2016.
*15, 10, and 5 year averages do not include years without funding (2014, 2016).

Alternate Methods

Tustumena Lake is a significant sockeye salmon producer in the Cook Inlet watershed. Over 30 years of sockeye salmon smolt enumeration data have been collected on the system—the data are used by ADF&G to help generate adult return predictions and harvest limits. Enhanced fish have not been introduced into the lake by CIAA since 2004, and those fish all emigrated by 2006.

In the past hydroacoustic and townet surveys have taken place in Tustumena Lake in conjunction with the incline plane trap to help determine smolt abundance (Todd and Kyle, 1994). Currently ADF&G uses similar hydroacoustic techniques to determine juvenile sockeye salmon population estimates in Skilak and Kenai Lakes (DeCino and Willette, 2014). Using these methods ADF&G staff could generally survey Tustumena Lake in 4–5 days (weather permitting).

The Kasilof River is a swift glacial river and can be difficult to operate in for both the smolt monitoring staff and for other users of the river. Table 4 summarizes recent accidents that have occurred involving the trap (causes are varied but include human error as well as natural forces). To ensure recreational boaters know about the trap CIAA has signs posted at the boat launch, on the trap, on the east bank adjacent to the trap and on the west bank above the blind corner upstream of the trap. Though any waterbody can present dangers at any time, the majority of incidents on the Kasilof River have occurred near the end of counting operations in early July when the river is usually near its highest level.

Table 4. Tustumena Smolt Trap Accidents, 2013–2018

Year	Incident Description
2013	Sport drift boat hit the trap and capsized
2014	During trap removal CIAA staff was injured—needed stitches—delayed trap removal
2015	Sport motor boat hit a trap cable and pulled it loose, sinking the boat in the process
2018	CIAA boat capsized during trap removal process, delayed trap removal
*This table does not mention the amount trees and other large debris that gets caught in the trap and anchor cables yearly (sometimes daily).	

RECOMMENDATIONS

Because Tustumena Lake is no longer an enhanced system and in light of the safety incidents that have occurred on the Kasilof River it is recommend that the board examine CIAA's role in evaluating the Tustumena smolt migration and whether it makes sense to continue to enumerate smolt or look into funding ADF&G hydroacoustic and townet surveys in the fall. The fall hydroacoustic and townet surveys are inherently safer based on the time that the crew would be on the water and the flexibility to choose good weather days; less than a week for the lake survey compared to two months for the smolt trap, which is situated in a high-traffic area. A determination would have to be made as to whether enough information about the juvenile sockeye population could be obtained to help generate adult return statistics, and a cost-benefit analysis should be conducted to determine whether CIAA funds are better spent funding the incline plane trap or ADF&G hydroacoustic surveys.

This page is intentionally left blank

LITERATURE CITED

Carlson, S. R., Coggins, L. G. and C. O. Swanton. 1998. A simple stratified design for mark-recapture estimation of salmon smolt runs. Alaska Fishery Research Bulletin. 5(2):88–102.

CIAA Staff, 2018. Kasilof river smolt enumeration procedures manual. Cook Inlet Aquaculture Association, 40610 Kalifornsky Beach Road, Kenai, Alaska 99611.

DeCino, R. D., and T. M. Willette. 2014. Juvenile sockeye salmon population estimates in Skilak and Kenai lakes, Alaska, by use of split-beam hydroacoustic techniques, 2005 through 2010. Alaska Department of Fish and Game, Fishery Data Series No. 14–17, Anchorage.

Johnson, J. and P. Blanche. 2010. Catalog of waters important for spawning, rearing, or migration or anadromous fishes – southcentral region, effective June 1, 2010. Alaska Department of Fish and Game, Special Publication No. 10-06, Anchorage.

Kyle, G. B. 1992. Summary of sockeye salmon (*Oncorhynchus nerka)* investigations in Tustumena Lake, 1981-1991. Alaska Department of Fish and Game Division of Fisheries Rehabilitation, Enhancement and Development No. 122. Juneau, AK. Pages 4–6.

Todd, G. L. 1994. A lightweight, inclined-plane trap for sampling smolts in rivers. Alaska Fishery Research Bulletin. 1(2):179–186.

Todd, G. L. and G. B. Kyle. 1994. Tustumena Lake project report: sockeye salmon investigations (Fall 1992–1993). Regional Information Report No. 5J94–11. Alaska Department of Fish and Game, Juneau, Alaska.

This page is intentionally left blank

APPENDICES

Appendix 1. Environmental Conditions, Tustumena Lake, 2018

Date	Sky	Precip. (mm)	Water Level (ft)	Water Temp. (◦C)	Air Temp. (◦C)	Stage Change (ft)
15-May	5	3.50	0.28	6.0	10.0	0.00
16-May	4	1.75	0.28	7.0	10.0	0.00
17-May	4	2.00	0.28	8.0	10.0	0.00
18-May	3	1.50	0.30	9.0	11.0	0.02
19-May	4	4.00	0.36	10.0	13.0	0.08
20-May	4	0.25	0.32	9.0	11.0	0.04
21-May	3	0.00	0.34	9.0	15.0	0.06
22-May	2	0.00	0.34	10.0	13.0	0.06
23-May	2	0.00	0.38	11.0	20.0	0.10
24-May	2	0.00	0.38	11.0	17.0	0.10
25-May	3	0.00	0.38	11.0	20.0	0.10
26-May	2	0.00	0.40	11.0	21.0	0.12
27-May	1	0.00	0.40	13.0	22.0	0.12
28-May	1	0.00	0.40	12.0	16.0	0.12
29-May	4	0.00	0.42	9.0	10.0	0.14
30-May	3	0.00	0.44	10.0	14.0	0.16
31-May	3	0.00	0.48	11.0	16.0	0.2
1-Jun	1	0.25	0.50	13.0	18.0	0.22
2-Jun	1	0.00	0.54	13.0	25.0	0.26
3-Jun	2	0.00	0.58	12.0	16.0	0.3
4-Jun	3	0.00	0.58	11.0	13.0	0.3
5-Jun	3	0.00	0.60	10.0	15.0	0.32
6-Jun	2	0.00	0.60	10.0	16.0	0.32
7-Jun	2	0.00	0.62	12.0	18.0	0.34
8-Jun	2	0.00	0.64	12.0	20.0	0.36
9-Jun	2	0.00	0.64	12.0	16.0	0.36
10-Jun	2	0.00	0.68	15.0	20.0	0.4
11-Jun	2	0.00	0.70	13.0	22.0	0.42
12-Jun	3	0.00	0.74	14.0	21.0	0.46
13-Jun	2	0.00	0.78	14.0	23.0	0.5
14-Jun	1	0.00	0.80	15.0	22.0	0.52
15-Jun	5	22.00	0.82	12.0	12.0	0.54
16-Jun	4	3.75	0.88	13.0	18.0	0.6
17-Jun	5	4.25	0.94	13.0	15.0	0.66
18-Jun	4	1.50	0.98	14.0	16.0	0.7
19-Jun	4	0.50	1.10	14.0	16.0	0.82
20-Jun	4	0.25	1.22	15.0	22.0	0.94
21-Jun	5	1.00	1.32	13.0	16.0	1.04
22-Jun	5	2.00	1.46	13.0	18.0	1.18
23-Jun	3	0.00	1.56	14.0	17.0	1.28
24-Jun	3	0.00	1.62	12.0	21.0	1.34
25-Jun	3	0.00	1.68	12.0	15.0	1.4
26-Jun	4	0.25	1.70	12.0	17.0	1.42
27-Jun	4	0.50	1.72	13.0	18.0	1.44
28-Jun	5	3.00	1.76	13.0	17.0	1.48
29-Jun	4	1.00	1.80	13.0	15.0	1.52
30-Jun	2	0.00	1.82	12.0	17.0	1.54
1-Jul	1	0.00	1.80	15.0	22.0	1.52
2-Jul	1	0.00	1.80	16.0	23.0	1.52
3-Jul	1	0.00	1.90	17.0	22.0	1.62
4-Jul	1	0.00	2.00	17.0	22.0	1.72
5-Jul	1	0.00	2.10	15.0	23.0	1.82
Total		53	47.16			
Avg.		1	0.91	12.1	17.2	0.63
Min.		0	0.28	6.0	10.0	0
Max.		22	2.10	17.0	25.0	1.82

Sky Key: 1 = Clear, 2 = Cloud Cover <50%, 3 = Cloud Cover >50%, 4 = Completely Overcast, 5 = Rain

Appendix 2. Daily smolt migration, Tustumena Lake, 2018

	Sockeye						Coho	Chinook	Pink	Chum	Dolly Varden
Date	Daily Capture	Total Capture	Daily Mortality	Trap Efficiency	Daily Estimate	*Cumulative Outmigration	No. Observed	No. Observed	No. Observed	No. Observed	No. Observed
14-May	4	4	0	5.62%	71	71	5	1	48	0	0
15-May	8	12	0	5.62%	142	214	8	0	53	0	12
16-May	22	34	0	5.62%	392	605	23	2	19	0	16
17-May	17	51	0	5.62%	303	908	18	1	0	0	7
18-May	12	63	0	5.62%	214	1,122	6	4	9	0	13
19-May	17	80	0	5.62%	303	1,424	3	0	20	0	8
20-May	45	125	0	5.62%	801	2,225	4	7	4	0	6
21-May	18	143	0	5.62%	320	2,546	19	3	7	0	2
22-May	121	264	0	5.62%	2,154	4,700	1	23	7	0	4
23-May	108	372	0	5.62%	1,923	6,623	4	11	8	0	8
24-May	46	418	0	5.62%	819	7,442	13	2	3	0	8
25-May	70	488	0	5.62%	1,246	8,688	16	9	12	0	4
26-May	750	1,238	0	5.62%	13,353	22,041	53	28	11	0	6
27-May	466	1,704	0	5.62%	8,296	30,337	47	23	12	0	9
28-May	292	1,996	0	5.62%	5,199	35,536	55	33	23	0	5
29-May	682	2,678	0	5.62%	12,142	47,678	52	20	15	0	11
30-May	807	3,485	0	5.62%	14,367	62,045	46	29	21	0	11
31-May	901	4,386	0	5.62%	16,041	78,086	50	17	19	0	11
1-Jun	252	4,638	0	5.62%	4,487	82,573	40	19	57	0	8
2-Jun	413	5,051	0	5.62%	7,353	89,926	68	15	32	0	2
3-Jun	770	5,821	0	5.62%	13,709	103,635	102	45	46	0	7
4-Jun	15563	21,384	4	5.62%	277,077	380,712	169	24	18	0	5
5-Jun	14753	36,137	0	5.62%	262,656	643,368	111	9	2	0	9
6-Jun	33207	69,344	0	5.62%	591,203	1,234,571	105	17	0	0	7
7-Jun	11439	80,783	0	5.62%	203,655	1,438,226	34	5	0	0	1
8-Jun	7527	88,310	0	3.58%	210,535	1,648,761	40	8	0	0	2
9-Jun	2364	90,674	0	3.58%	66,122	1,714,883	34	7	0	0	0
10-Jun	3795	94,469	0	3.58%	106,148	1,821,031	32	8	0	0	1
11-Jun	6808	101,277	50	3.58%	190,424	2,011,455	33	3	0	0	0
12-Jun	3321	104,598	0	3.58%	92,890	2,104,345	126	6	0	0	0
13-Jun	4385	108,983	0	3.58%	122,651	2,226,996	70	5	0	0	0
14-Jun	3948	112,931	0	3.58%	110,428	2,337,424	108	6	0	0	0
15-Jun	1784	114,715	0	2.76%	64,567	2,401,991	189	4	0	0	0
16-Jun	1406	116,121	0	2.76%	50,886	2,452,878	179	4	0	0	0
17-Jun	0	116,121	0	2.76%	0	2,452,878	104	4	0	0	0
18-Jun	1049	117,170	0	2.76%	37,966	2,490,844	113	3	0	0	0
19-Jun	1889	119,059	23	2.76%	68,367	2,559,211	71	3	0	0	0
20-Jun	2101	121,160	0	2.76%	76,040	2,635,251	64	9	0	0	0
21-Jun	3816	124,976	0	2.76%	138,110	2,773,361	69	4	0	0	0
22-Jun	2460	127,436	0	2.39%	102,985	2,876,345	70	3	0	0	0
23-Jun	3787	131,223	0	2.39%	158,538	3,034,883	131	20	0	0	0
24-Jun	6677	137,900	0	2.39%	279,524	3,314,406	160	44	0	0	0
25-Jun	4057	141,957	80	2.39%	169,841	3,484,247	74	35	0	0	0
26-Jun	3455	145,412	0	2.39%	144,639	3,628,886	96	29	0	0	0
27-Jun	3230	148,642	0	2.39%	135,220	3,764,106	82	19	0	0	0
28-Jun	530	149,172	0	2.39%	22,188	3,786,293	35	13	1	0	0
29-Jun	274	149,446	0	1.22%	22,400	3,808,693	38	7	0	0	0
30-Jun	905	150,351	0	1.22%	73,984	3,882,677	38	7	0	0	0
1-Jul	2	150,353	0	1.22%	164	3,882,840	0	0	0	0	0
2-Jul	5114	155,467	20	1.22%	418,070	4,300,910	12	6	0	0	2
3-Jul	577	156,044	0	1.22%	47,170	4,348,079	10	1	0	0	0
4-Jul	359	156,403	0	1.22%	29,348	4,377,428	3	0	0	0	0
5-Jul	342	156,745	0	1.22%	27,959	4,405,386	5	1	0	0	0
6-Jul	14	156,759	0	1.22%	1,145	4,406,531	0	0	0	0	0
Total	156,759		177				3,038	606	447	0	185

*Cumulative Migration has not been statistically evaluated and only serves as reference.

Indicates mortality during trap efficiency test (after transport and dyeing)

Appendix 3. Mark-recapture test and population estimates, Tustumena Lake, 2018

Event	Sample Period	Release Date & Time	Total Captured	Total Mortality	Total Dyed Released	Total Dyed Recaptured	Trap efficiency
1	5/14–6/7	6/4/18 12:29 AM	1,000	4	996	55	5.62%
2	6/8–6/14	6/11/18 12:07 AM	1,000	50	950	33	3.58%
3	6/15–6/21	6/19/18 12:00 AM	963	23	940	25	2.76%
4	6/22–6/28	6/25/18 12:15 AM	1,000	80	920	21	2.39%
5	6/29–7/6	7/2/18 1:33 AM	1,000	20	980	11	1.22%

Estimate of the Total Smolt Migration for 2018											
Sample Periods			**Total Caught During Sample**	**Total Dyed Smolts Released**	**Total Dyed Smolts Recovered**	**Trap Efficiency eh** (%)	**Migration Estimate of Unmarked Smolts**	**Variance Estimate**		
No. (=h)	**begin**	**end**	**Periods (nh)**	**M_h**	**m_h**	**e_h**	**N_h**	**$v(U_h)$**	**$SE(U_h)$**	**95% C.L.**
1	14-May	7-Jun	80,783	996	55	5.62%	1,438,243	34,228,149,371	185,009	362,617
2	8-Jun	14-Jun	32,148	950	33	3.58%	899,225	22,253,553,457	149,176	292,385
3	15-Jun	21-Jun	12,045	940	25	2.76%	435,972	6,830,422,749	82,646	161,987
4	22-Jun	28-Jun	24,196	920	21	2.39%	1,012,973	43,508,502,074	208,587	408,830
5	29-Jun	6-Jul	7,587	980	11	1.22%	620,318	29,191,353,237	170,855	334,875
6										
		Total	**156,759**	**4,786**	**145**	**3.05%**	**4,406,731**	**136,011,980,888**	**368,798**	**722,844**

Appendix 4. Tustumena Lake 2018 - Update

Smolt Migration				
Dates:	14-May to 6-Jul	No.	%	C.I.
Sockeye:				
Total Capture:		156,759		
Trap Efficiency Range:		1.22%–5.62%		
Total Estimated Migration:		4,406,731	100%	(±722,844)
Mortalities:		177		
Estimated Age 1:		2,650,292	69%	0.14%
Estimated Age 2:		1,168,409	31%	0.47%
Coho:		3,038		
King:		606		
Pink:		447		
Dolly Varden:		185		

Note: Trap efficiency is designated for sockeye salmon, other species are not included.