Tustumena Lake
Sockeye Salmon Smolt
Progress Report
2013

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The 2013 Tustumena Lake Sockeye Salmon Smolt Project was made possible through enhancement taxes paid by the commercial fishermen in Area H, Cook Inlet and associated waters.

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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 2013 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.

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ACKNOWLEDGEMENTS

Many individuals and agencies contributed to the success of the 2013 Tustumena Lake sockeye salmon smolt monitoring project. Appreciation is extended to Cook Inlet Aquaculture Association (CIAA) Seasonal Assistants Jeff Gipson and Derek Sugden. Appreciation is also extended to CIAA Project Technician Ron Carlson who spent many hours assisting in the field. Special thanks go out to the Alaska Department of Fish and Game, and Alaska State Parks for their support during this project.

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ABSTRACT

The 2013 Tustumena Lake smolt migration was enumerated from 24 May and continued daily until 10 July. During this time field personnel captured and identified 149,230 sockeye salmon smolt (*Oncorhynchus nerka*), 4,092 coho salmon smolt (*O. kisutch*), 1,386 Chinook salmon smolt (*O. tshawytscha*), 2,156 pink salmon fry (*O. gorbuscha*), and 179 juvenile Dolly Varden (*Salvelinus malma*). Numerous ninespine stickleback (*Pungitius pungitius*), eulachon (*Thaleichthys pacificus*), unspecified lamprey, and slimy sculpin (*Cottus cognatus*) were also captured but only recorded as being present. Recorded trap mortality during the enumeration was 398 sockeye salmon smolt. A mark-recapture stratified sampling design was used to estimate the abundance of the migrating sockeye salmon smolt population in which the estimated weekly capture probability, or trap efficiency, ranged from 1.32% to 3.52%. The mark-recapture analysis concluded the total sockeye salmon smolt migration was estimated to be 7,087,000 (±2,697,000).

Age, weight, and length (AWL) samples (N=592) were collected from 28 May through 3 July on 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 57% (±0.1%) and age-2 class 43% (±0.1%). Sockeye salmon smolt in the age-1 class had an average weight and length of 5.4 g (±0.3 g) and 85 mm (±1.0 mm). Sockeye salmon smolt in the age-2 class had an average weight and length of 9.6 g (±0.2 g) and 106 mm (±0.7 mm).

General environmental conditions were measured for accumulated precipitation, water level fluctuations, water temperature, and air temperature. From 27 May through 8 July personnel recorded accumulated precipitation at 61 mm, water level fluctuated +1.73 feet, water temperature averaged 13°C, and air temperature averaged 16°C.

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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.

Initial 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 as the smolt migration estimates were used by ADF&G to forecast future adult sockeye salmon returns to Tustumena Lake.

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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. 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 17.4 miles to Cook Inlet. Kasilof River is documented under the Anadromous Waters Catalog code 244-30-10050 (Johnson and Blanche, 2010). The 2013 salmon smolt enumeration occurred between river miles 6.3 and 7.1.

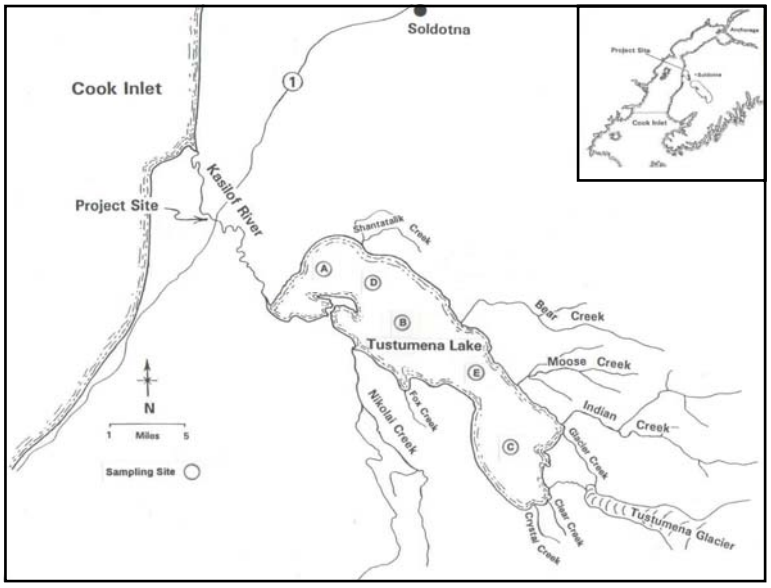

Figure 1. Area Map of Tustumena Lake in relation to Cook Inlet

Tustumena Lake is oligotrophic with mean open-water season total 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 glacikal silt and light penetration is limited to the upper two meters. 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).

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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 tenth 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, 2013).

Smolt Enumeration

To conduct the Tustumena Lake sockeye salmon smolt monitoring project, two inclined plane smolt traps, or collection facilities, were placed in the thalweg of the Kasilof River near river mile 6.3 and 7.1 Each collection facility consisted of one inclined plane trap and a double compartment live box supported by a twin pontoon raft (Todd, 1994). Trap 1 was positioned near river mile 7.1, near the Kasilof Bridge, and functioned as the marking site. Trap 2 was positioned near river mile 6.3 and functioned as the recapture site.

Trap 1 was operational on 24 May before any significant smolt migration occurred and was used to capture sockeye smolt in the mark-recapture procedure. Trap 2 was operational on 24 May and remained the site of the total count procedure, recapture site, and smolt characteristics sampling for the duration of the enumeration. Field personnel physically identified each fish by species and released the fish downstream of the trap to continue in their migration. The daily capture count was used with trap efficiencies to determine the total estimated sockeye salmon smolt outmigration.

The mark-recapture technique used in this project involved a stratified sampling design in which approximately 1,000 sockeye smolts were color marked with dye and released from Trap 1 once per week. Personnel conducted the mark-recapture tests Monday night each week. Once the sample was collected, personnel transferred the smolt into a container containing the dye solution Bismark Brown Y (1 gram of dye per 30.4 Liters of water) and monitored the health of the fish for approximately 45 minutes. 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 Trap 2 for five days following release of dyed fish at Trap 1. Any sockeye smolt

mortality was not included in the total number released. The number of smolt recaptured in Trap 2 was then used to estimate the proportion of migrating smolts captured (the trap capture efficiency) and the total estimated smolt migration.

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 significantly during the smolt migration.

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 smolt are:

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

Smolt Characteristics

To evaluate sockeye smolt characteristics, CIAA 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 Trap 2. 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 smolts 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.

RESULTS AND DISCUSSION

Environmental Conditions

Environmental conditions were monitored daily from 27 May to 8 July. During this period, water level fluctuated +1.73 feet; river temperatures averaged 13°C and ranged from 4 to 18°C. Air temperatures averaged 16°C and ranged from 8 to 28°C. Twenty-seven percent of the days were clear, 32% were partly cloudy, and 41% were completely overcast. A total of 61 mm of rain fell during this period.

Smolt Enumeration

The smolt migration was monitored from 24 May and continued daily until 10 July. The migration was considered complete when the frequency of migrating smolt had significantly decreased. During this time field personnel captured and identified 149,320 sockeye salmon smolt (*O. nerka*), 4,092 coho salmon smolt (*O. kisutch*), 1,386 Chinook salmon smolt (*O. tshawytscha*), 2,156 pink salmon fry (*O. gorbuscha*), and 179 juvenile Dolly Varden (*S. malma*). Numerous ninespine stickleback (*Pungitius pungitius*), eulachon (*Thaleichthys pacificus*), unspecified lamprey, and slimy sculpin (*Cottus cognatus*) were also captured but only recorded as being present. Recorded trap mortality during the enumeration was 398 sockeye salmon smolt.

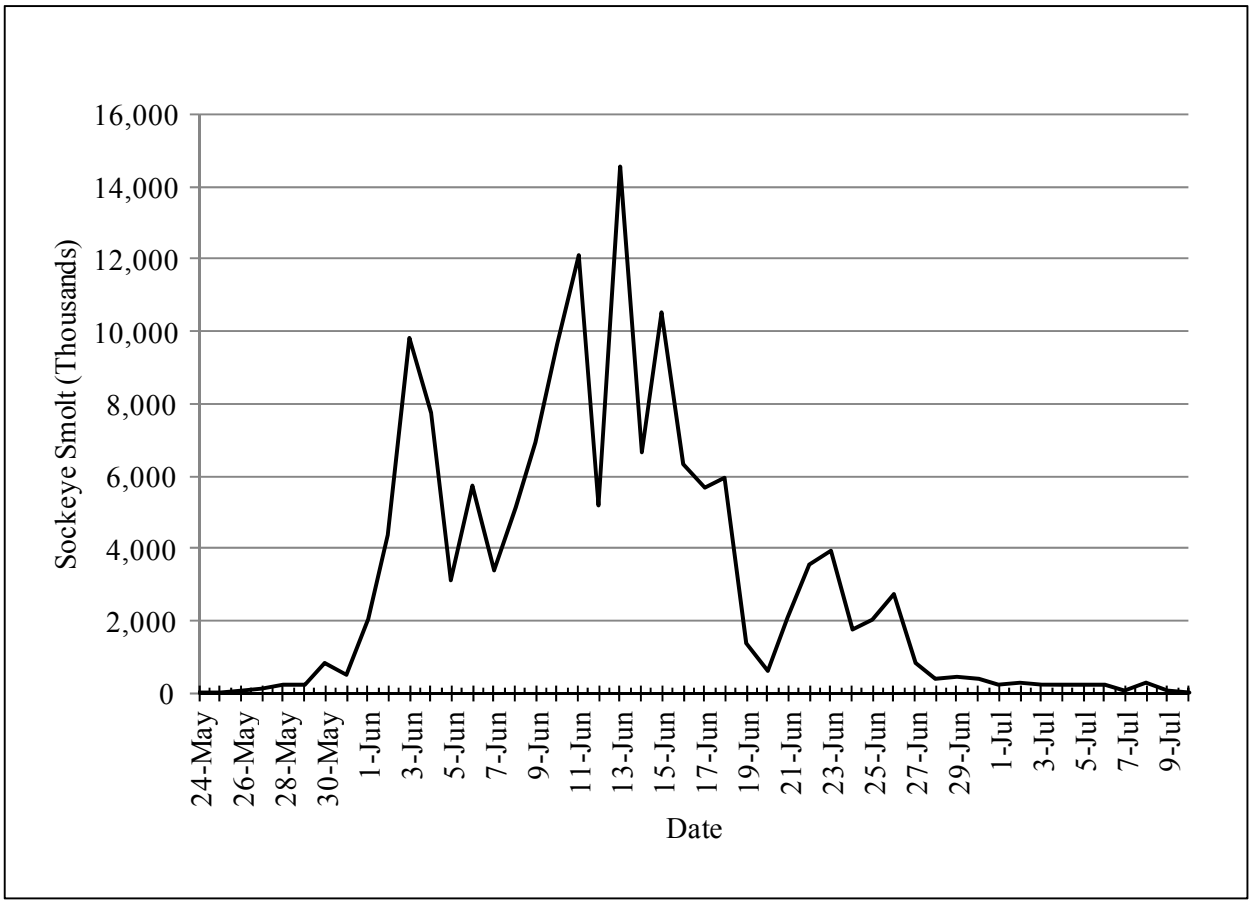

Figure 2. 2013 Tustumena Lake Daily Sockeye Smolt Trap Capture

The highest recorded single day capture was on 13 June when field personnel counted and identified 14,578 sockeye salmon smolt (Figure 2). The peak of the total daily migration was reached by 12 June when a total of 77,240 sockeye salmon smolt were counted and identified. From 4 June through 30 June, four mark-recapture tests were conducted estimating weekly trap efficiency ranging from 1.32% to 3.52%. The mark-recapture analysis concluded the total sockeye salmon smolt migration from 24 May through 10 July was an estimated 7,087,000 (±2,697,000) sockeye salmon smolt (Table 1).

Table 1. Tustumena Lake Sockeye Salmon Smolt Migrations and Hatchery Contribution, 1998–2013

Year	Total (million)	95% C.I.	Wild	Hatchery	% Hatchery	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)	5,155,000	105,000	1.9	(±1.0)
2002	3.5	(±618,000)	3,474,000	0	0	0
2003	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	11.2	(±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	3.7	(±832,000)	3,231,000	0	0	
2008	5.4	(±2,149,000)	5,418,000	0	0	
2009	3.6	(±885,000)	3,614,000	0	0	
2010	2.0	(±885,000)	1,949,000	0	0	
2011	0.008	ND	8,282	0	0	
2012	7.7	(±1,026,115)	7,383,018	0	0	
2013	7.0	(±2,697,000)	7,087,523	0	0	
Avg	5.3		4,920,000	1,240,511	16.3	
CIAA discontinued stocking program at Tustumena Lake in 2003 and remaining enhanced fish outmigrated by 2006.						

Smolt Characteristics

Age, weight, and length (AWL) samples (N=592) were collected from 28 May through 3 July on 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 57% (±0.1%) and age-2 class 43% (±0.1%). Sockeye salmon smolt in the age-1 class had an average weight and length of 5.4 g (±0.3 g) and 85 mm (±1.0 mm). Sockeye salmon smolt in the age-2 class had an average weight and length of 9.6 g (±0.2 g) and 106 mm (±0.7 mm) (Table 2). No measurements were collected on any other species.

Table 2. Tustumena Lake Sockeye Salmon Smolt Characteristics, 1998–2013

	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		21		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%)	19	(±6%)	75	(±0.5)	90	(±1.3)	3.5	(±0.1)	5.9	(±0.4)
2008	79	(±32%)	21	(±19%)	78	(±0.8)	96	(±1.4)	3.9	(±0.09)	7.1	(±0.31)
2009	58	(±15%)	42	(±12%)	81	(±0.6)	92	(±1.4)	4.7	(±0.09)	6.8	(±0.19)
2010	88	(±27%)	12	(±42%)	83	(±0.7)	103	(±2.2)	5.0	(±0.1)	9.0	(±0.5)
2011	98	(±0.02%)	2	(±14%)	87	(±1.4)	113	(±1)	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)
15 Yr Avg	74		26		79		94		4.4		7.4	
10 Yr Avg	78		22		81		98		4.7		8.3	
5 Yr Avg	74		26		85		103		5.4		9.9	

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

RECOMMENDATIONS

Tustumena Lake is an important sockeye salmon producer in the Cook Inlet watershed. Pending funding, the sockeye salmon smolt enumeration project should continue in Kasilof River consistent with previous monitoring efforts in order to provide further comparative data and to compliment adult salmon monitoring performed by the Alaska Department of Fish and Game.

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APPENDICES

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Appendix 1. Tustumena Lake 2013 - Environmental Conditions

Date	Sky	Precip. (mm)	Water Level (ft)	Water Temp. (◦C)	Air Temp. (◦C)
27-May	1	0.51	0.05	13	14
28-May	1	0	0.16	13	17
29-May	1	0	0.20	13	17
30-May	2	0	0.22	13	11
31-May	3	0.0	0.26	13	10
1-Jun	4	0.0	0.30	4	8
2-Jun	2	1.5	0.35	10	14
3-Jun	ND	ND	ND	ND	ND
4-Jun	5	1.5	0.4	10	10
5-Jun	2	2.8	0.42	11	12
6-Jun	2	0.0	0.46	13	12
7-Jun	2	0	0.48	15	13
8-Jun	1	0	0.48	15	13
9-Jun	1	0.0	0.5	14	22
10-Jun	1	0.0	0.54	15	21
11-Jun	1	0.0	0.56	14	18
12-Jun	1	0.0	0.60	14	14
13-Jun	2	0.0	0.62	14	15
14-Jun	1	0.0	0.68	14	19
15-Jun	3	0.0	0.70	15	16
16-Jun	2	0.0	0.76	16	22
17-Jun	1	0.0	0.82	18	28
18-Jun	1	0.0	0.90	17	18
19-Jun	4	0.3	1.02	13	13
20-Jun	4	0.3	1.08	12	12
21-Jun	4	0.3	1.10	12	18
22-Jun	4	0.3	1.10	12	18
23-Jun	4	0.8	1.20	13	20
24-Jun	2	0.5	1.20	14	21
25-Jun	3	0.0	1.26	13	23
26-Jun	5	1.0	1.32	14	19
27-Jun	2	0.0	1.32	11	18
28-Jun	4	0.0	1.40	12	19
29-Jun	2	0.0	1.42	14	19
30-Jun	4	0.0	1.46	10	10
1-Jul	4	15.2	1.52	12	14
2-Jul	4	15.2	1.52	12	14
3-Jul	5	1.5	1.58	11	12
4-Jul	4	0.3	1.60	12	11
5-Jul	ND	ND	ND	ND	ND
6-Jul	5	10.2	1.70	12	17
7-Jul	4	1.0	1.74	11	15
8-Jul	5	8.1	1.78	11	11
Total		61			
Avg.		1		13	16
Min.		0	0.05	4	8
Max.		15	1.78	18	28

Summary of Cloud Cover - Percent of Days

No. Days	Meas. Rain	Overcast	Partly Cloudy	Clear
41	44%	41%	32%	27%

ND = No Data

1 = Clear
2 = Cloud Cover <50%
3 = Cloud Cover>50%
4 = Overcast
5 = Rain

Appendix 2. Tustumena Lake 2013 - Smolt Migration

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

	Sockeye						Coho	King	Pink	Chum	Dolly Varden
Date	Daily Capture	Total Capture	Daily Mortality	Trap Efficiency	Daily Estimate	*Cumulative Outmigration	No. Caught	No. Caught	No. Caught	No. Caught	No. Caught
24-May	11	11	0	ND	11	11	1	0	0	0	4
25-May	20	31	0	ND	20	31	0	0	60	0	5
26-May	63	94	0	ND	63	94	1	0	56	0	2
27-May	113	207	0	ND	113	207	11	0	68	0	11
28-May	220	427	0	ND	220	427	1	0	26	0	11
29-May	238	665	0	ND	238	665	3	0	141	0	10
30-May	862	1,527	0	ND	862	1,527	2	0	252	0	10
31-May	521	2,048	0	ND	521	2,048	0	0	271	0	2
1-Jun	2,021	4,069	0	ND	2,021	4,069	12	2	295	0	17
2-Jun	4,374	8,443	2	ND	4,374	8,443	11	2	3	0	21
3-Jun	9,811	18,254	12	ND	9,811	18,254	5	2	81	0	32
4-Jun	7,732	25,986	3	3.39%	228,083	246,337	6	14	26	0	10
5-Jun	3,150	29,136	2	3.39%	92,920	339,257	10	6	458	0	13
6-Jun	5,730	34,866	20	3.39%	169,027	508,283	10	3	102	0	6
7-Jun	3,386	38,252	2	3.39%	99,882	608,166	29	10	251	0	10
8-Jun	5,117	43,369	9	3.39%	150,944	759,109	74	1	27	0	4
9-Jun	6,943	50,312	3	3.39%	204,808	963,918	155	60	27	0	1
10-Jun	9,659	59,971	124	1.32%	731,742	1,695,660	167	160	2	0	2
11-Jun	12,082	72,053	13	1.32%	915,303	2,610,963	76	29	1	0	0
12-Jun	5,187	77,240	9	1.32%	392,955	3,003,918	21	12	1	0	0
13-Jun	14,578	91,818	15	1.32%	1,104,394	4,108,312	36	17	1	0	1
14-Jun	6,657	98,475	13	1.32%	504,318	4,612,630	36	18	2	0	1
15-Jun	10,514	108,989	5	1.32%	796,515	5,409,145	42	10	0	0	1
16-Jun	6,342	115,331	15	1.32%	480,455	5,889,600	163	31	2	0	2
17-Jun	5,665	120,996	15	2.36%	240,042	6,129,642	285	52	2	0	1
18-Jun	5,969	126,965	9	2.36%	252,924	6,382,566	259	45	0	0	0
19-Jun	1,369	128,334	2	2.36%	58,008	6,440,574	256	28	0	0	1
20-Jun	615	128,949	2	2.36%	26,059	6,466,633	440	19	1	0	0
21-Jun	2,073	131,022	6	2.36%	87,839	6,554,472	346	29	0	0	0
22-Jun	3,578	134,600	26	2.36%	151,610	6,706,083	150	8	0	0	0
23-Jun	3,920	138,520	17	2.36%	166,102	6,872,184	150	11	0	0	0
24-Jun	1,759	140,279	6	3.52%	49,972	6,922,156	126	16	0	0	0
25-Jun	2,063	142,342	11	3.52%	58,608	6,980,764	112	24	0	0	0
26-Jun	2,740	145,082	5	3.52%	77,841	7,058,605	141	30	0	0	0
27-Jun	864	145,946	6	3.52%	24,545	7,083,150	188	264	0	0	1
28-Jun	431	146,377	3	3.52%	12,244	7,095,395	83	136	0	0	0
29-Jun	460	146,837	8	3.52%	13,068	7,108,463	69	96	0	0	0
30-Jun	382	147,219	0	3.52%	10,852	7,119,315	124	104	0	0	0
1-Jul	255	147,474	3	ND	255	7,119,570	97	55	0	0	0
2-Jul	287	147,761	6	ND	287	7,119,857	109	27	0	0	0
3-Jul	249	148,010	0	ND	249	7,120,106	67	11	0	0	0
4-Jul	240	148,250	6	ND	240	7,120,346	48	23	0	0	0
5-Jul	218	148,468	0	ND	218	7,120,564	47	9	0	0	0
6-Jul	264	148,732	3	ND	264	7,120,828	34	6	0	0	0
7-Jul	93	148,825	0	ND	93	7,120,921	33	1	0	0	0
8-Jul	281	149,106	5	ND	281	7,121,202	45	10	0	0	0
9-Jul	94	149,200	12	ND	94	7,121,296	0	5	0	0	0
10-Jul	30	149,230	0	ND	30	7,121,326	11	0	0	0	0
Total	149,230		398				4,092	1,386	2,156	0	179

Appendix 3. Tustumena Lake 2013 - Mark-Recapture Tests and Population Estimate

Event	Sample Period	Release Date & Time	Total Captured	Total Mortality	Total Dyed Released	Total Dyed Recaptured
1	6/4 to 6/9	6/6/13 1:15 AM	1,020	17	1,003	33
2	6/10 to 6/16	6/10/13 12:20 AM	1,020	115	905	11
3	6/17 to 6/23	6/19/12 2:45 AM	1,020	2	1,018	23
4	6/24 to 6/30	6/25/13 3:15 AM	1,032	10	1,022	35

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	4-Jun	9-Jun	32,058	1,003	33	3.39%	946,682	24,712,613,592	157,202	308,117
2	10-Jun	16-Jun	65,019	905	11	1.32%	4,909,009	1,828,831,284,228	1,352,343	2,650,592
3	17-Jun	23-Jun	23,189	1,018	23	2.36%	984,608	37,825,665,118	194,488	381,197
4	24-Jun	30-Jun	8,699	1,022	35	3.52%	247,224	1,587,171,136	39,839	78,085
		Total	**128,965**	**3,948**	**102**	**2.58%**	**7,087,523**	**1,892,956,734,074**	**1,375,848**	**2,696,661**

Appendix 4. Tustumena Lake 2013 - Update

Dates:	24-May to 10-Jul	No.	%	C.I.
Sockeye:				
Total Capture:		149,230		
Trap Efficiency Range:		1.32% to 3.52%		
Total Estimated Migration:		7,087,000	100%	(±2,697,000)
Mortalities:		398	0.006%	
Estimated Age 1:		4,022,351	57%	(±0.1%)
Estimated Age 2:		3,064,649	43%	(±0.1%)
Coho:		4,092		
King:		1,386		
Pink:		2,156		
Dolly Varden:		179