

**Tustumena Lake
Sockeye Salmon Smolt
Data Report
2012**

**Prepared by:
Nathan Weber, Biologist
March 2013**

The 2012 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 and through a State Legislative Grant (12-DM-629).

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 data report is a synopsis of the monitoring and evaluation activities conducted for the 2012 Tustumena Lake sockeye salmon smolt monitoring project. This report was prepared by CIAA under award of a State Legislative Grant (12-DM-629).

The purpose of these data 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 data 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 2012 Tustumena Lake sockeye salmon smolt monitoring project. Appreciation is extended to Cook Inlet Aquaculture Association (CIAA) Seasonal Assistants Rodney Hobby and Elliot Nankervis. 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, Alaska State Parks, and the Alaska State Legislature for their support during this project.

This page intentionally left blank

TABLE OF CONTENTS

DISCLAIMER	iii
ACKNOWLEDGEMENTS	v
TABLE OF CONTENTS	vii
LIST OF FIGURES	ix
LIST OF TABLES	xi
ABSTRACT	1
INTRODUCTION AND PURPOSE	3
PROJECT AREA	5
METHODS	7
Environmental Conditions	7
Smolt Enumeration	7
Smolt Characteristics	10
RESULTS AND DISCUSSION	11
Environmental Conditions	11
Smolt Enumeration	11
Smolt Characteristics	12
RECOMMENDATIONS	15
LITERATURE CITED	17
APPENDICES	19
Appendix 1. Tustumena Lake 2012 - Environmental Conditions	21
Appendix 2. Tustumena Lake 2012 - Smolt Migration	22
Appendix 3. Tustumena Lake 2012 – Mark-recapture Tests and Population Estimate	23
Appendix 4. Tustumena Lake 2012 - Sockeye Salmon Smolt Migration & Hatchery Contribution	24
Appendix 5. Tustumena Lake 2012 - Update	25

This page intentionally left blank

LIST OF FIGURES

Figure 1. Area Map of Tustumena Lake in relation to Cook Inlet	5
Figure 2. 2012 Tustumena Lake Daily Estimated Sockeye Smolt Migration.....	11
Figure 3. Relationship between Trap Efficiency and Water Fluctuation in the Kasilof River	12

This page intentionally left blank

LIST OF TABLES

Table 1. Tustumena Lake Sockeye Salmon Smolt Characteristics, 1998 - 2012.....	13
---	-----------

This page intentionally left blank

ABSTRACT

The 2012 Tustumena Lake sockeye salmon (*Oncorhynchus nerka*) smolt migration recorded the highest total captured sockeye salmon smolt (451,433), the second highest average trap efficiency (5.29%), and the third highest total estimated sockeye smolt migration (7,776,976) since Cook Inlet Aquaculture Association began monitoring the smolt migration in 1998. The highest recorded single day capture was on 6 June when field personnel identified 58,804 sockeye salmon smolt. The peak of the total daily migration was reached by 8 June when 249,749 sockeye salmon smolt were captured and identified.

The 2012 Tustumena Lake smolt migration was enumerated from 19 May and continued daily until 30 June. During this time field personnel captured and identified 451,433 sockeye salmon smolt (*O. nerka*), 5,865 coho salmon smolt (*O. kisutch*), 2,273 Chinook salmon smolt (*O. tshawytscha*), 5 pink salmon fry (*O. gorbuscha*), and 443 juvenile Dolly Varden (*Salvelinus malma*). Numerous ninespine stickleback (*Pungitius pungitius*) and slimy sculpin (*Cottus cognatus*) were also captured but only recorded as being present. Recorded trap mortality during the enumeration was 88 sockeye salmon smolt. A mark-recapture stratified sampling design was used to estimate the abundance of the migrating sockeye salmon smolt population from 27 May through 30 June. The estimated weekly capture probability, or trap efficiency, of the collection facility ranged from 2.31% to 8.18%. The mark-recapture analysis concluded the total sockeye salmon smolt migration was estimated at 7,776,976 ($\pm 1,107,197$).

Age, weight, and length (AWL) samples (N=1,735) were collected and analyzed from 27 May through 30 June 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 68.4% ($\pm 0.02\%$), age-2 class 31.1% ($\pm 0.07\%$), and age-3 class 0.5% ($\pm 0.9\%$). Sockeye salmon smolt in the age-1 class had an average weight and length of 5.8 g (± 0.2 g) and 87 mm (± 0.3 mm). Sockeye salmon smolt in the age-2 class had an average weight and length of 8.7 g (± 0.1 g) and 101 mm (± 0.6 mm). Sockeye salmon smolt in the age-3 class had an average weight and length of 12.3 g (± 2.5 g) and 112 mm (± 8.2 mm).

General environmental conditions were measured for accumulated precipitation, water level fluctuations, water temperature and air temperature. From 22 May through 30 June personnel recorded accumulated precipitation at 52 mm, water level fluctuated +2.34 feet, water temperature averaged 8°C, and air temperature averaged 13°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. The program progressed over the years that lead to as many as 23.6 million collected eggs and 17.1 million fry 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 the 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 Crooked Creek Hatchery, 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 and smolt monitoring at Tustumena Lake.

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.

This page intentionally left blank

PROJECT AREA

Tustumena Lake is located on the Kenai Peninsula in South-central 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 km². 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 2012 salmon smolt enumeration occurred between river miles 6.3 and 7.1.

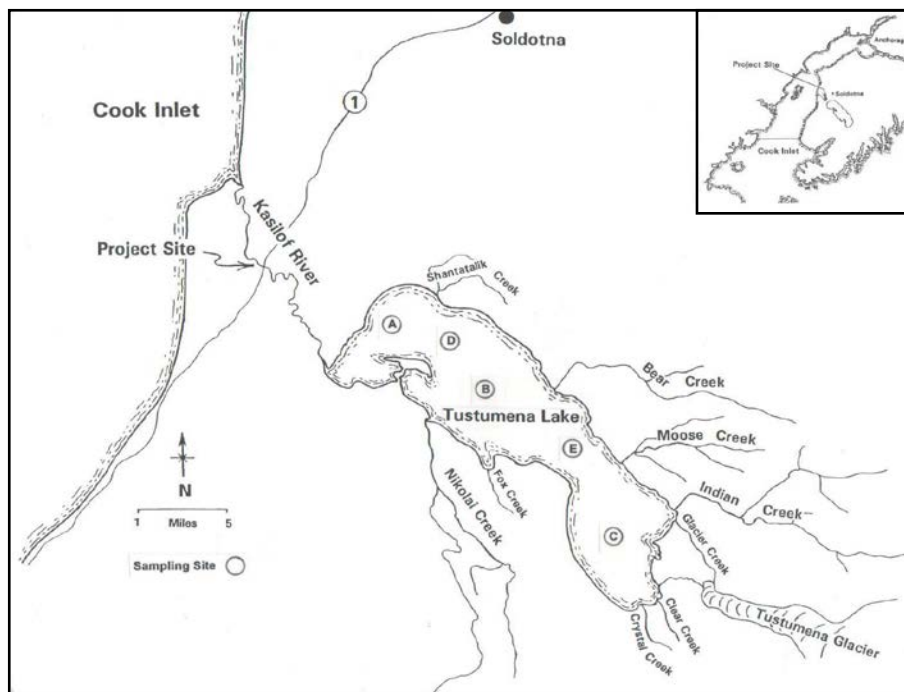


Figure 1. Area Map of Tustumena Lake in relation to Cook Inlet

Tustumena Lake is oligotrophic with mean open-water season total phosphorus, total Kjeldahl nitrogen and chlorophyll *a* concentrations of 3.7 μL , 155 μL , and 0.45 μL , respectively. The lake is turbid with glacial silt and light penetration is limited to the upper two meters. The zooplankton community consists of two copepods, *Diaptomus pribilofensis* and *Cyclops columbianus*. Sockeye (*O. nerka*) salmon, coho (*O. kisutch*) salmon, Chinook (*O. tshawytscha*) salmon, pink (*O. gorbuscha*) salmon, and chum (*O. keta*) salmon are found in the Tustumena Lake system; however, it is mainly sockeye that utilize 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).

This page intentionally left blank

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, 2012).

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 and operated from 19 May through 30 June. 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 at river mile 7.1, near the Kasilof Bridge, and functioned as the marking site. Trap 2 was positioned at river mile 6.3 and functioned as the recapture site.

Trap 1 and Trap 2 were operated simultaneously from 19 May through 26 May before any significant smolt migration occurred. During this time a combined total trap count was recorded with no capture probability estimates. As of 27 May when the migration increased, Trap 1 was utilized only in the facilitation of capturing samples to conduct the mark-recapture releases. Trap 2 remained the site of the total count procedure, recapture site and smolt characteristics sampling for the duration of the enumeration. Field personnel used the total count procedure by physically identifying and recording each fish by species then releasing the fish on the downstream side of the trap. 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 mixture Bismark Brown Y (concentration) and 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 colored sockeye smolt at Trap 2 for five days following release of dyed fish at Trap 1. Any mortality sockeye smolt 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;
- Nh = total population size in stratum h ;
- uh = total number of unmarked smolts captured in stratum h ;
- Mh = number of marked smolts released in stratum h ;
- mh = number of marked smolts recaptured in stratum h ;
- L = number of strata or periods; and

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

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 smolts 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 smolts was calculated as:

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

Proportion of age = i smolts was calculated as:

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

The variance of the proportion of age = i smolts 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 smolts 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 smolts 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, CIAA personnel collected a sample of sockeye smolts migrating from the lake to determine age, weight, and length characteristics of the population. Samples were collected daily by collecting a sample per every 500th sockeye smolt captured by Trap 2. Each sockeye smolt collected for evaluation was first measured to the nearest millimeter for fork length¹ and then weighed to the nearest 0.1 gram. Several scales were removed from the primary growth area² 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:

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

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

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

¹Standard fork length was measured from the tip of the snout to the fork of the tail.

²Located 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 22 May to 30 June. During this period, water level fluctuated +2.34 feet, river temperatures averaged 8°C and ranged from 0 to 21°C. Air temperatures averaged 13°C and ranged from 2 to 23°C. Ten percent of the days were clear, 33% were partly cloudy, and 58% were completely overcast. A total of 52 mm of rain fell during this period.

Smolt Enumeration

The smolt migration was enumerated from 19 May and continued daily until 30 June. The migration was considered complete when the frequency of migrating smolt had significantly decreased. During this time field personnel captured and identified 451,433 sockeye salmon smolt (*O. nerka*), 5,865 coho salmon smolt (*O. kisutch*), 2,273 Chinook salmon smolt (*O. tshawytscha*), 5 pink salmon fry (*O. gorbuscha*), and 443 juvenile Dolly Varden (*S. malma*). Numerous ninespine stickleback (*Pungitius pungitius*) and slimy sculpin (*Cottus cognatus*) were also captured but only recorded as being present. Recorded trap mortality during the enumeration was 88 sockeye salmon smolt.

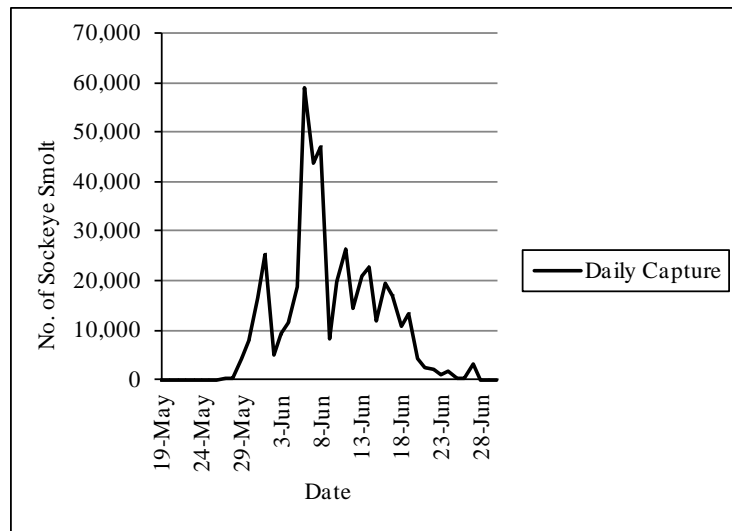


Figure 2. 2012 Tustumena Lake Daily Estimated Sockeye Smolt Migration

From 27 May through 30 June, five mark-recapture tests were conducted that estimated weekly trap efficiency which had ranged from 2.31% to 8.18%. General observations noted the weekly trap efficiency was inversely related to the water level though no analysis was made for a statistical relationship. The mark-recapture analysis concluded the total sockeye salmon smolt migration from 27 May through 30 June was an estimated 7,776,976 ($\pm 1,107,197$) sockeye salmon smolt.

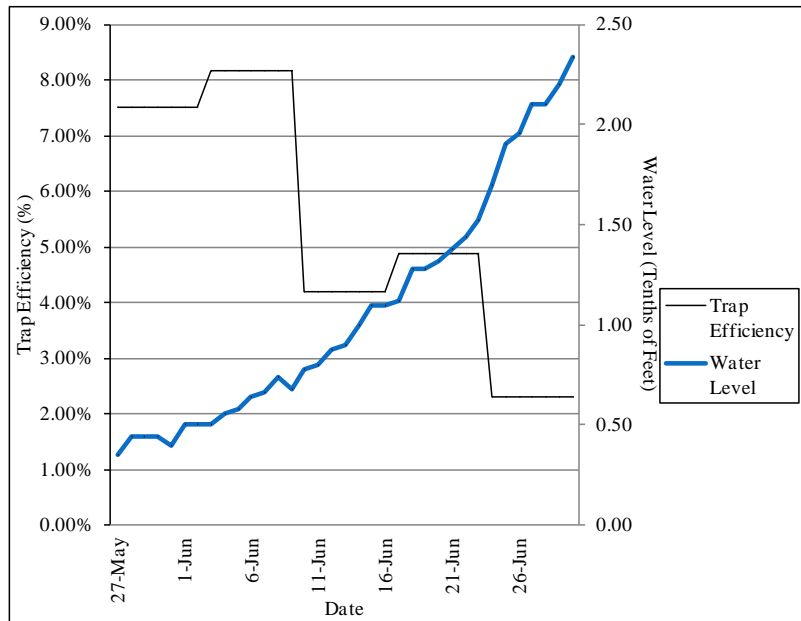


Figure 3. Relationship between Trap Efficiency and Water Fluctuation in the Kasilof River

The 2012 Tustumena Lake sockeye salmon smolt migration recorded the highest total captured sockeye salmon smolt (451,433), the second highest average trap efficiency (5.29%), and the third highest total estimated sockeye smolt migration (7,776,976) since Cook Inlet Aquaculture Association began monitoring the smolt migration in 1998. The highest recorded single day capture was on 6 June when field personnel identified 58,804 sockeye salmon smolt. The peak of the total daily migration was reached by 8 June when 249,749 sockeye salmon smolt were captured and identified.

Smolt Characteristics

Age, weight, and length (AWL) samples (N=1,735) were collected and analyzed from 27 May through 30 June 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 68.4% ($\pm 0.02\%$), age-2 class 31.1% ($\pm 0.07\%$), and age-3 class 0.5% ($\pm 0.9\%$). Sockeye salmon smolt in the age-1 class

had an average weight and length of 5.8 g (± 0.2 g) and 87 mm (± 0.3 mm). Sockeye salmon smolt in the age-2 class had an average weight and length of 8.7 g (± 0.1 g) and 101 mm (± 0.6 mm). Sockeye salmon smolt in the age-3 class had an average weight and length of 12.3 g (± 2.5 g) and 112 mm (± 8.2 mm). No measurements were made on any other species. Sockeye salmon smolt weight and length characteristics in 2012 were generally similar to the most recent 5 year average of age-1 and age-2 classes. Age proportion for age-1 class (68%) in 2012 was slightly lower than the most recent 5 year average of 78% and the age-2 class (31%) was slightly higher than the most recent 5 year average of 22%.

Smolt Year	Age Class (%)				Mean length (mm)				Mean weight (g)			
	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	($\pm 9.6\%$)	22	($\pm 3.8\%$)	77	(± 0.34)	89	(± 0.66)	3.9	(± 0.05)	5.8	(± 0.13)
2000	81	($\pm 11.5\%$)	19	($\pm 4.2\%$)	73	(± 0.32)	86	(± 0.73)	3.2	(± 0.05)	5.0	(± 0.12)
2001	61	($\pm 9.5\%$)	38	($\pm 6.3\%$)	72	(± 0.39)	84	(± 0.53)	3.3	(± 0.05)	5.1	(± 0.08)
2002	39	($\pm 24.1\%$)	61	($\pm 24.8\%$)	74	(± 0.42)	82	(± 0.64)	3.7	(± 0.06)	5.2	(± 0.11)
2003	74	($\pm 16.2\%$)	25	($\pm 6.4\%$)	78	(± 0.42)	91	(± 0.15)	4.8	(± 0.07)	7.2	(± 0.15)
2004	65	($\pm 13.3\%$)	35	($\pm 8.1\%$)	79	(± 0.42)	92	(± 0.57)	4.3	(± 0.07)	6.6	(± 0.12)
2005	91	($\pm 19.0\%$)	9	($\pm 2.3\%$)	76	(± 0.25)	91	(± 0.74)	3.9	(± 0.72)	6.4	(± 1.19)
2006	91	($\pm 26.3\%$)	9	($\pm 3.6\%$)	82	(± 0.86)	98	(± 2.26)	4.5	(± 0.08)	7.4	(± 0.58)
2007	81	($\pm 19\%$)	19	($\pm 6\%$)	75	(± 0.5)	90	(± 1.3)	3.5	(± 0.1)	5.9	(± 0.4)
2008	79	($\pm 32\%$)	21	($\pm 19\%$)	78	(± 0.8)	96	(± 1.4)	3.9	(± 0.09)	7.1	(± 0.31)
2009	58	($\pm 15\%$)	42	($\pm 12\%$)	81	(± 0.6)	92	(± 1.4)	4.7	(± 0.09)	6.8	(± 0.19)
2010	88	($\pm 27\%$)	12	($\pm 42\%$)	83	(± 0.7)	103	(± 2.2)	5.0	(± 0.1)	9.0	(± 0.5)
2011	98	($\pm 0.02\%$)	2	($\pm 14\%$)	87	(± 1.4)	113	(± 1)	5.9	(± 0.3)	12.0	(± 0.1)
2012	68	($\pm 0.02\%$)	31	($\pm 0.07\%$)	87	(± 0.3)	101	(± 0.6)	5.8	(± 0.15)	12.3	(± 2.5)
5 Yr Avg	78		22		83		101		5.1		9.4	
10 Yr Avg	79		21		81		97		4.6		8.1	
15 Yr Avg	75		24		79		93		4.3		7.1	

Note: 2001 smolt migration included 1.1% ($\pm 0.07\%$) age class 3 smolt
Note: 2003 smolt migration included 1% ($\pm 0.8\%$) age class 3 smolt
Note: 2012 smolt migration included 0.5% ($\pm 0.9\%$) age class 3 smolt

Table 1. Tustumena Lake Sockeye Salmon Smolt Characteristics, 1998 - 2012

This page is intentionally left blank

RECOMMENDATIONS

The 2013 Tustumena Lake sockeye smolt monitoring project should continue efforts to increase the average trap efficiency to 10% in order to more accurately estimate the migration.

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, 2012. *Tustumena Lake Procedures Manual*. Cook Inlet Aquaculture Association 40610 Kalifornsky Beach Road Kenai, Alaska 99611.
- 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.

This page is intentionally left blank

APPENDICES

This page is intentionally left blank

Appendix 1. Tustumena Lake 2012 - Environmental Conditions

Date	Sky	Precip. (mm)	Water Level (ft)	Water Temp. (°C)	Air Temp. (°C)
22-May	2	0	0	0	9
23-May	1	0	0	0	15
24-May	4	ND	0.20	0	8
25-May	4	0	0.25	0	8
26-May	5	0.5	0.30	0	7
27-May	5	0.5	0.35	0	7
28-May	4	0.0	0.44	0	6
29-May	4	0.0	0.44	0	6
30-May	4	0.0	0.44	0	5
31-May	4	0.0	0.40	2	2
1-Jun	3	0.0	0.50	8	13
2-Jun	5	ND	0.50	8	12
3-Jun	5	ND	0.50	5	8
4-Jun	3	0.0	0.56	7	20
5-Jun	4	0.0	0.58	8	12
6-Jun	4	0.0	0.64	10	12
7-Jun	4	0.0	0.66	12	15
8-Jun	4	0.0	0.74	9	18
9-Jun	4	0.0	0.68	8	13
10-Jun	4	0.0	0.78	11	13
11-Jun	2	0.0	0.80	12	18
12-Jun	5	1.0	0.88	8	10
13-Jun	5	1.5	0.90	9	13
14-Jun	5	1.0	1.00	9	18
15-Jun	2	0.0	1.10	12	16
16-Jun	2	0.0	1.10	14	17
17-Jun	2	0.0	1.12	16	22
18-Jun	2	0.0	1.28	11	16
19-Jun	2	0.0	1.28	12	22
20-Jun	2	0.0	1.32	12	12
21-Jun	1	0.0	1.38	16	20
22-Jun	1	0.0	1.44	16	21
23-Jun	1	0.0	1.52	15	23
24-Jun	5	5.6	1.70	10	11
25-Jun	5	26.4	1.90	8	10
26-Jun	5	10.0	1.96	8	14
27-Jun	3	0.0	2.10	10	18
28-Jun	5	5.3	2.10	6	12
29-Jun	3	0.0	2.20	12	17
30-Jun	3	0.0	2.34	21	12
Total		52			
Avg.		1		8	13
Min.		0	0.00	0	2
Max.		26	2.34	21	23

Summary of Cloud Cover - Percent of Days					
	No. Days	Meas. Rain	Overcast	Partly Cloudy	Clear
Smolts	40	23%	57.5%	32.5%	10.0%
ND = No Data 1 = Clear 2 = Cloud Cover <50% 3 = Cloud Cover >50% 4 = Overcast 5 = Rain					

Appendix 2. Tustumena Lake 2012 - Smolt Migration

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

Date	Sockeye						Coho	King	Pink	Chum	Dolly Varden
	Daily Capture	Total Capture	Daily Mortality	Trap Efficiency	Daily Estimate	*Cumulative Outmigration	No. Caught	No. Caught	No. Caught	No. Caught	No. Caught
19-May	2	2	0	ND	2	2	2	0	0	0	15
20-May	8	10	0	ND	8	10	4	0	0	0	12
21-May	8	18	0	ND	8	18	0	0	1	0	16
22-May	15	33	0	ND	15	33	0	0	0	0	10
23-May	16	49	0	ND	16	49	0	1	0	0	12
24-May	26	75	0	ND	26	75	0	1	0	0	16
25-May	33	108	0	ND	33	108	0	1	0	0	14
26-May	71	179	0	ND	71	179	0	0	0	0	13
27-May	279	458	0	7.52%	3,710	3,889	0	3	0	0	10
28-May	360	818	0	7.52%	4,787	8,676	0	1	0	0	14
29-May	4,335	5,153	2	7.52%	57,646	66,323	0	0	0	0	11
30-May	7,972	13,125	66	7.52%	106,011	172,333	5	7	0	0	15
31-May	16,679	29,804	0	7.52%	221,795	394,128	56	15	0	0	27
1-Jun	25,321	55,125	0	7.52%	336,715	730,844	22	4	0	0	6
2-Jun	5,194	60,319	0	7.52%	69,069	799,913	27	0	1	0	22
3-Jun	9,338	69,657	0	8.18%	114,156	914,070	115	0	0	0	23
4-Jun	11,693	81,350	0	8.18%	142,946	1,057,016	108	407	0	0	20
5-Jun	18,840	100,190	0	8.18%	230,318	1,287,334	105	1176	0	0	22
6-Jun	58,804	158,994	0	8.18%	718,875	2,006,209	124	232	0	0	20
7-Jun	43,655	202,649	0	8.18%	533,680	2,539,889	90	72	0	0	17
8-Jun	47,100	249,749	0	8.18%	575,795	3,115,683	53	29	0	0	30
9-Jun	8,287	258,036	0	8.18%	101,308	3,216,991	13	21	0	0	19
10-Jun	19,925	277,961	0	4.19%	475,537	3,692,528	41	14	0	0	22
11-Jun	26,386	304,347	0	4.19%	629,737	4,322,266	37	19	1	0	18
12-Jun	14,532	318,879	0	4.19%	346,826	4,669,092	206	16	0	0	3
13-Jun	21,084	339,963	0	4.19%	503,198	5,172,290	433	2	0	0	4
14-Jun	22,837	362,800	0	4.19%	545,036	5,717,325	28	4	0	0	4
15-Jun	11,943	374,743	0	4.19%	285,036	6,002,361	18	21	0	0	2
16-Jun	19,439	394,182	0	4.19%	463,938	6,466,299	95	68	0	0	3
17-Jun	17,056	411,238	0	4.87%	350,226	6,816,525	300	26	0	0	6
18-Jun	10,900	422,138	0	4.87%	223,819	7,040,344	433	24	1	0	1
19-Jun	13,482	435,620	0	4.87%	276,838	7,317,182	642	5	0	0	2
20-Jun	4,434	440,054	0	4.87%	91,047	7,408,229	527	4	0	0	1
21-Jun	2,425	442,479	0	4.87%	49,795	7,458,024	207	4	1	0	1
22-Jun	2,056	444,535	0	4.87%	42,218	7,500,242	108	6	0	0	2
23-Jun	1,072	445,607	0	4.87%	22,012	7,522,254	107	17	0	0	1
24-Jun	1,650	447,257	0	2.31%	71,429	7,593,683	602	40	0	0	8
25-Jun	408	447,665	0	2.31%	17,662	7,611,345	718	17	0	0	0
26-Jun	422	448,087	0	2.31%	18,268	7,629,613	349	16	0	0	0
27-Jun	3,163	451,250	20	2.31%	136,926	7,766,540	134	0	0	0	1
28-Jun	97	451,347	0	2.31%	4,199	7,770,739	142	0	0	0	0
29-Jun	80	451,427	0	2.31%	3,463	7,774,202	12	0	0	0	0
30-Jun	6	451,433	0	2.31%	260	7,774,462	2	0	0	0	0
Total	451,433		88				5,865	2,273	5	0	443

Appendix 3. Tustumena Lake 2012 – Mark-recapture Tests and Population Estimate

Event	Sample Period	Release Date & Time	Total Captured	Total Mortality	Total Dyed Released	Total Dyed Recaptured
1	5/27 to 6/3	5/29/12 11:40 PM	1,051	2	1,049	78
2	6/4 to 6/9	6/5/12 12:56 AM	1,500	0	1,014	82
3	6/10 to 6/16	6/12/12 1:10 AM	1,050	0	1,050	43
4	6/17 to 6/23	6/19/12 1:20 AM	2,500	0	1,046	50
5	6/24 to 6/30	6/28/12 12:15 AM	3,163	20	1,080	24

No. (=h)	Sample Periods		Total Caught During Sample Periods (nh)	Total Dyed Smolts Released M_h	Total Dyed Smolts Recovered m_h	Trap Efficiency e_h (%)	Migration Estimate of Unmarked Smolts N_h	Variance Estimate $v(U_h)$	SE(U_h)	95% C.L.
	begin	end								
1	27-May	2-Jun	60,140	1,049	78	7.52%	799,341	7,376,235,843	85,885	168,335
2	3-Jun	9-Jun	197,717	1,014	82	8.18%	2,417,876	63,878,770,808	252,742	495,375
3	10-Jun	16-Jun	136,146	1,050	43	4.19%	3,252,056	225,107,566,972	474,455	929,932
4	17-Jun	23-Jun	51,425	1,046	50	4.87%	1,055,745	20,370,275,591	142,724	279,740
5	24-Jun	30-Jun	5,826	1,080	24	2.31%	251,958	2,374,974,710	48,734	95,518
		Total	451,254	5,239	277	5.29%	7,776,976	319,107,823,924	564,896	1,107,197

Appendix 4. Tustumena Lake 2012 - Sockeye Salmon Smolt Migration & Hatchery Contribution

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	ND	ND	
2008	5.4	(±2,149,000)	5,418,000	ND	ND	
2009	3.6	(±885,000)	3,614,000	ND	ND	
2010	2.0	(±885,000)	1,949,000	ND	ND	
2011	0.008	ND	8,282	ND	ND	
2012	7.7	(±1,026,115)	7,383,018	ND	ND	
Avg	5.2		4,920,000	1,240,511	16.3	

ND = No Data
 CIAA discontinued stocking program at Tustumena Lake in 2003 and remaining enhanced fish outmigrated by 2006.

Appendix 5. Tustumena Lake 2012 - Update

Smolt Migration			
Dates:	19-May to 30-Jun		
	No.	%	C.I.
Sockeye:			
Total Capture:	451,433		
Trap Efficiency Range:	2.31% to 8.18%		
Total Estimated Migration:	7,776,976	100%	
Mortalities:	88	0.0%	
Age 1:	5,316,135	68.4% (±0.02%)	
Age 2:	2,420,500	31.1% (±0.07%)	
Age 3:	40,342	0.5% (±0.9%)	
Coho:	5,865		
King:	2,273		
Pink:	5		
Dolly Varden:	443		

