Hidden Lake
Sockeye Salmon Enhancement
Progress Report
2015

Prepared by:
Andy Wizik, Biologist
&
Caroline Cherry, Hatchery Operations Coordinator

March 2016

The Hidden Lake Sockeye Salmon Enhancement Project was made possible through enhancement taxes paid by the commercial fishermen in Area H, Cook Inlet and associated waters and through the harvest and sale of surplus fish.

This page intentionally left blank

DISCLAIMER

The Cook Inlet Aquaculture Association (CIAA) conducts salmon enhancement and restoration projects in Area H, Cook Inlet 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 studies conducted for the Hidden Lake sockeye salmon enhancement project.

The purpose of the progress report is to provide a vehicle to distribute the information produced by the monitoring and evaluation studies. 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 restoration or enhancement project. The information presented in this report has not undergone an extensive review. As reviews are completed, the information may be updated and presented in later progress reports.

CIAA 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 contributed to the 2015 field season at the Hidden Lake Salmon Enhancement Project. Appreciation is extended to the Cook Inlet Aquaculture Association seasonal assistants and full-time staff who invested many hours in planning and executing this project. Exceptional appreciation is extended to the Cook Inlet Aquaculture Association Board of Directors, the Alaska Department of Fish and Game, the U.S. Fish and Wildlife Service Kenai Field Office, and the Kenai National Wildlife Refuge.

This page intentionally left blank

TABLE OF CONTENTS

DISCLAIMER iii
ACKNOWLEDGEMENTS v
TABLE OF CONTENTS vii
LIST OF FIGURES viii
LIST OF TABLES viii
LIST OF APPENDICES viii
EXECUTIVE SUMMARY 1
INTRODUCTION AND PURPOSE 3
PROJECT AREA 7
METHODS 9
Limnological Sampling and Environmental Conditions 9
Smolt Enumeration 10
Smolt Characteristics and Enhanced Contribution 10
Adult Enumeration and Enhanced Contribution 14
Gamete Collection, Incubation and Rearing 15
Fish Transport and Stocking 16
Evaluation of Adult Sockeye Salmon Fidelity in Hidden Lake at Spawning 16
Straying Study 17
RESULTS AND DISCUSSION 19
Limnology and Environmental Conditions 19
Smolt Enumeration 20
Smolt Characteristics and Enhanced Contribution 21
Adult Enumeration and Enhanced Contribution 22
Gamete Collection, Incubation and Rearing 24
Fish Transport and Stocking 33
Evaluation of Adult Sockeye Salmon Fidelity in Hidden Lake at Spawning 33
Straying Study 34
RECOMMENDATIONS 37
LITERATURE CITED 39
APPENDICES 41

LIST OF FIGURES

Figure 1. Area Map of Hidden Lake, Kenai Peninsula, Southcentral Alaska 7
Figure 2. Morphometric map of Hidden Lake showing the two major basins 8

LIST OF TABLES

Table 1. Average open water season water quality characteristics of Hidden Lake 19
Table 2. Age structure, length and weight characteristics of Hidden Lake sockeye salmon smolt, 1976–2015 26
Table 3. The contribution of enhanced sockeye salmon to the Hidden Lake smolt migrations, 1976–2015 27
Table 4. Summary of Hidden Lake adult sockeye salmon escapement, age distribution, and fish length, 1976–2015 28
Table 5. Summary of enhanced contribution for sockeye salmon smolt and adult migrations 29
Table 6. Historical common property harvests and escapement to Hidden Lake, 1996–2015 30
Table 7. Marine survival by brood year for returns to Hidden Lake, 1988–2011 31
Table 8. Summary of sockeye salmon gamete collection and fry releases at Hidden Lake, 1976–2015 32
Table 9. Distribution of hatchery and natural reared adult sockeye salmon in Hidden Lake, 2015 34
Table 10. Distribution of hatchery and natural reared adult sockeye salmon in Hidden Lake, 2012–2015 34
Table 12. Dates, location, and number of adult sockeye salmon sampled for Hidden Lake straying study, 2015 35
Table 13. Number of fish sampled and percentage of hatchery-produced fish located in areas surrounding Hidden Lake, 2012–2015 35

LIST OF APPENDICES

Appendix 1. Hidden Lake 2015 - Water Quality 42
Appendix 2. Hidden Lake 2015 - Zooplankton (Density) 43
Appendix 3. Hidden Lake 2015 - Zooplankton (Size and Biomass) 44
Appendix 4. Hidden Lake 2015 - Environmental Conditions 45
Appendix 5. Hidden Lake 2015 - Stage Height Changes 46
Appendix 6. Hidden Lake 2015 - Smolt Migration 47
Appendix 7. Hidden Lake 2015 - Adult Migration 48
Appendix 8. Hidden Lake 2015 Adult Sockeye Salmon Escapement Sex Ratio and Size Data 49
Appendix 9. Hidden Lake 2015 - Update 50

EXECUTIVE SUMMARY

This progress report summarizes the 2015 sockeye and coho salmon smolt enumerations, adult sockeye salmon enumeration, and gamete collection at Hidden Lake. The report also summarizes two research studies done on fidelity straying within Hidden Lake and straying outside of the lake.

In 2015, an estimated 335,923 live sockeye salmon smolt migrated from Hidden Lake. Based on otolith sampling, 55.1% (±4.0%) were identified as being of hatchery origin and 94.9% (±2.0) were age 1 and the remaining 5.1% (±2.0)% were age 2. For coho salmon, an estimated 8,970 smolt emigrated from the lake of which 19.3% (±7.6%) and 80.7% (±7.6%) were identified as age 1 and age 2 respectively.

For adult sockeye salmon return to Hidden Lake a total of 18,785 fish were counted through the weir. Otolith analysis indicated that 67.8% (±3.8%) were identified as being of hatchery origin. Age 1.2 were the majority of the return (85.2%), followed by age 1.3 (11.9%) and finally age 2.2 (2.9%).

The fidelity study at Hidden Lake indicated the adult sockeye salmon return to the north side of the western region of the lake and the eastern region of the lake were predominantly hatchery-origin fish at 74.9% and 97.8%, respectively; while the south side of the western region of the lake was 30.0% hatchery origin fish. No Hidden Lake strays were identified at the Kenai-Skilak confluence.

Trail Lakes Hatchery stocked 1,497,000 unfed fry (0.09 gm) into Hidden Lake on May 1. In September, the hatchery staff collected 1,445,598 green sockeye salmon eggs from 635 females and 635 males for release as unfed fry in 2016.

This page intentionally left blank

INTRODUCTION AND PURPOSE

In 1972 and 1973, the Commercial Fisheries Division of the Alaska Department of Fish and Game (ADF&G) conducted biological, chemical, and physical inventories of numerous lakes throughout the Cook Inlet basin (Barton & Barrett, 1973 and Bill, Namtvedt, & Davis, 1972). Based on these investigations it appeared that Hidden Lake had the potential for increased production of sockeye salmon (*Oncorhynchus nerka*).

In 1976, activities to enhance the production of sockeye salmon in Hidden Lake were initiated by the Fisheries Rehabilitation, Enhancement and Development Division (FREDD) of ADF&G. Initial enhancement activities involved the collection of basic fisheries and limnological data and the gathering of a small number of sockeye salmon eggs to evaluate incubation and fry rearing procedures (Kyle, Litchfield, & Todd, 1990).

Between 1976 and 1989, ADF&G collected more information on Hidden Lake. Based on this information, ADF&G was able to conclude that at an adult escapement of 10,000 sockeye salmon, wild smolt production leveled off because the natural spawning area was limited and/or egg-to-fry survival was poor. The Department also concluded the lake's zooplankton community was being underutilized by sockeye salmon fry rearing in the lake. Thus, more sockeye salmon fry could rear in the lake than could be produced by natural spawning.

Since 1976, Hidden Lake has been enhanced by annually collecting eggs from adult sockeye salmon returning to the lake and releasing the resulting fry back to the lake. Enhancement by collecting eggs and releasing fry back to Hidden Lake bypasses some of the critical life stages that occur in the lake and takes advantage of the lake's underutilized zooplankton community.

As the Hidden Lake enhancement project was being developed, it was feared salmon enhancement itself could be detrimental to the fry-rearing environment. The escapement of large numbers of fish may, by increasing the available nutrients, alter the level of primary productivity and shift the zooplankton community to species not utilized by rearing sockeye salmon fry.

Based on the potential of Hidden Lake to rear sockeye salmon fry and the limitations imposed by large adult escapements, the project objective became the production of the maximum number of adult fish while maintaining the fry-rearing environment. To meet this objective, an average adult sockeye salmon escapement of 30,000 fish was considered an appropriate management strategy and could be accomplished by:

1. Annually collecting sockeye salmon eggs and releasing sockeye salmon fry to the lake to target an annual average adult return of 30,000;
2. Monitoring lake water quality through the collection and analysis of representative samples;
3. Enumerating smolt migration from the lake; and
4. Enumerating adult escapement to the lake.

In 1988, the Cook Inlet Aquaculture Association (CIAA) became involved in the Hidden Lake Enhancement Project by conducting the gamete collection, incubation, and fry release activities. In 1989, CIAA, with assistance from ADF&G, also conducted the smolt migration and adult escapement monitoring; and, in 1991, assumed responsibility for conducting the limnological sampling. For data consistency, ADF&G has completed and will continue to complete the water chemistry, plankton, and adult scale analyses.

In March 1999, ADF&G conducted the Hidden Lake Sockeye Salmon Enhancement Project Technical Review (Simpson & Edmundson, 1999). Concerns arose regarding the amount of sockeye salmon entering Hidden Lake. In 2000, CIAA took steps to alleviate this concern by using 4-year floating averages of survival rates (egg-to-fry, fry-to-smolt, and smolt-to-adult) and ADF&G estimated harvests to calculate a stocking rate that would best allow for an annual target escapement of 30,000 sockeye salmon into Hidden Lake. Also based on the technical review, ADF&G recommended that two special studies be conducted: one study to determine if hatchery-incubated fish released to Hidden Lake were straying into other Kenai River system spawning populations and a second study to determine the contribution of hatchery-incubated fish to the sockeye salmon population returning to Hidden Lake.

In 2012, ADF&G, United States Fish and Wildlife Services (USFWS), Kenai Wildlife Refuge and CIAA participated in a review of the Hidden Lake project. Concerns over two conditions in the Special Use Permit were voiced by USFWS that they wanted to address. These two concerns were (1) the ratio of hatchery to natural fish in the spawning population and (2) the straying study had yet to be completed with statistically valid numbers. Based on these concerns all four parties agreed to the following changes to take place starting in 2012:

1. Change the release of hatchery reared unfed fry to the eastern basin of the lake;
2. Change the location of broodstock and egg collection to the western basin-south side of the lake;
3. Collect otoliths during spawning from three regions on the lake (Eastern Basin - new fry release, Western Basin-South Side - new brood and egg collection site, and Western Basin-North Side);
4. Collect otoliths from Skilak Lake (North [n=220] and South [n=220] side), Skilak Lake - Dunes area (n=440) and Kenai River - Jim's Landing to Skilak Confluence (n=220); and
5. Collect otoliths from n=250 residual salmon during egg collection activities.

Items 1, 2, and 3 were changes that would occur each year between 2012 and 2017, while items number 4 and 5 were to be assessed at the end of the 2012 season to determine if further sampling was necessary. Due to flood conditions in 2012, sufficient samples could not be collected for the straying study (item number 4). It was concluded that CIAA would perform this sampling objective again in 2013. CIAA was successful in collecting sufficient samples from the Dunes area in 2013. However, it was agreed that CIAA would sample the other three areas (Kenai-Skilak confluence, north and south shores of Skilak Lake) and the supposed residual sockeye salmon again in 2014 due to discrepancies in reading the age from the otoliths. No samples of residual sockeye were collected in 2015. Additionally, USFWS requested that CIAA collect length from broodstock used to ensure that broodstock selection was indeed random. In 2015, otoliths for the straying project were only taken from the Kenai-Skilak confluence and otolith samples for the fidelity project were taken from all three sites within Hidden Lake.

Details of the above changes can be found in the Hidden Lake Operational Plan 2012 (Cook Inlet Aquaculture Association, United States Fish and Wildlife Service, Kenai Wildlife Refuge, Alaska Department of Fish and Game, 2012).

PROJECT AREA

Hidden Lake is located on the Kenai Peninsula 69 kilometers east of Soldotna, Alaska and lies entirely within the Kenai National Wildlife Refuge. The lake is accessible by the Sterling Highway and the Skilak Lake Loop Road (Figure 1).

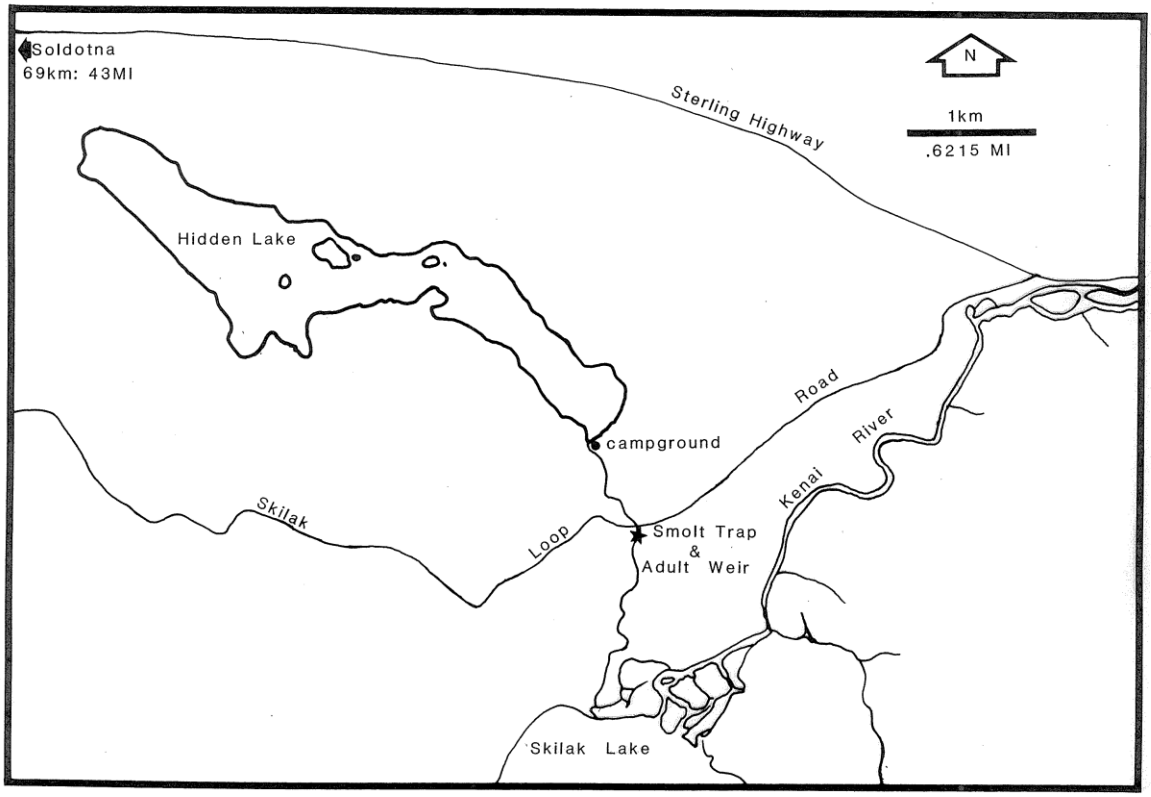


Figure 1. Area Map of Hidden Lake, Kenai Peninsula, Southcentral Alaska

Hidden Lake (Figure 2) is steep sided with two major basins. It has a surface area of 6.8 km^2, a mean depth of 20.1 m, a maximum depth of 45.1 m, and a volume of 138.1 X 10^6 m^3. The mean depth of the euphotic zone is 20 m. There is one outlet, Hidden Creek, which flows 5 km to Skilak Lake, the Kenai River and Cook Inlet (Kyle et al., 1990).

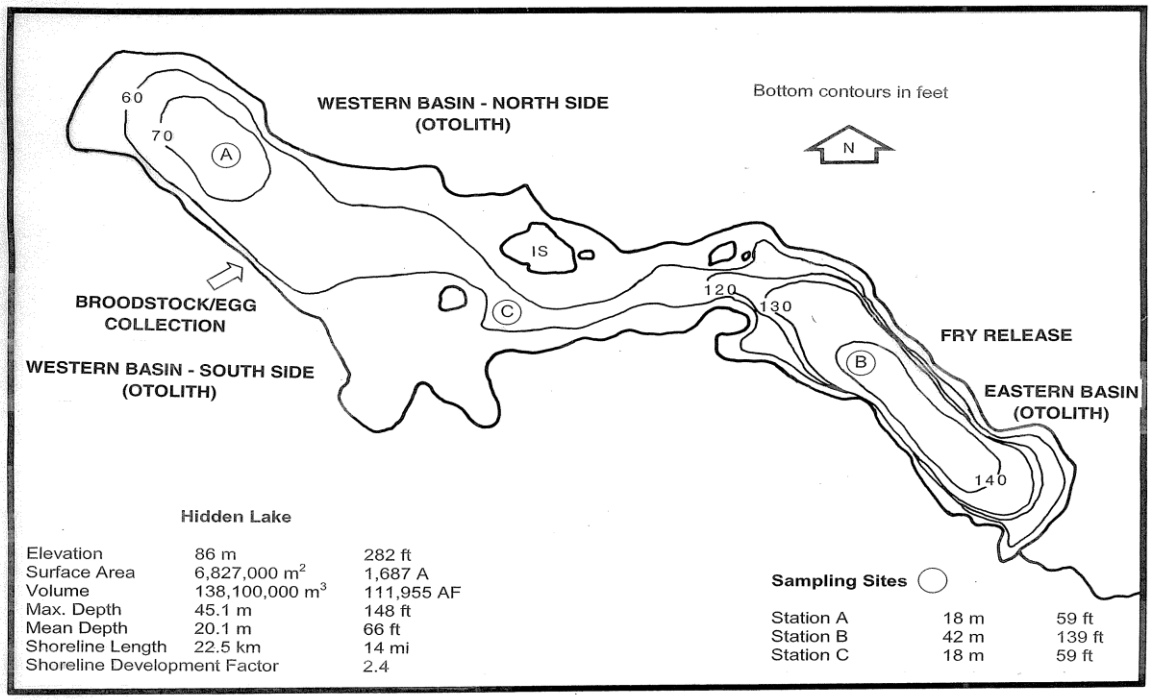


Figure 2. Morphometric map of Hidden Lake showing the two major basins

The lake's watershed area is 37.4 km^2 and has an average annual precipitation of 44 cm. The estimated water residence time is 11.7 years. Historically, during the open water season, the total phosphorus concentration averaged 7 μg/l, the total nitrogen concentration was 178 μg/l and the chlorophyll a concentration was 0.6 μg/l (Kyle et al., 1990). Based on these concentrations, Hidden Lake is considered an oligotrophic-mesotrophic system.

Two cladocerans, (*Bosmina longirostris* and *Daphnia longiremus*), two copepoda (*Epischura nevadensis*, and *Cyclops columbians*), and numerous species of rotifers make up the zooplankton community of Hidden Lake. Historically, fish present in the lake include five species of Pacific salmon (*O. nerka*, *O. kisutch*, *O. tshawytscha*, *O. gorbuscha*, and *O. mykiss*), lake trout (*Salvelinus namaycush*), Dolly Varden char (*S. malma*), threespine stickleback (*Gaserosteus aculeatus*), and coastrange sculpin (*Cottus aleuticus*) (Kyle et al.,1990).

METHODS

In general, Hidden Lake limnological sampling, salmon egg collection, hatchery incubation, fry rearing, smolt enumeration, and adult escapement monitoring follow procedures recommended by ADF&G.

Limnological Sampling and Environmental Conditions

During 2015, water quality samples were collected four times during the open water season in June, July, August, and September.

Two primary sites, Stations A and B (Figure 2) were sampled for dissolved oxygen, temperature and light transmission profiles, Secchi disk transparency, and zooplankton densities. Samples for analysis of phosphorus, carbon, chlorophyll *a*, phaeophytin *a*, nitrogen, calcium, magnesium, iron, conductivity, pH, alkalinity, turbidity, and color were also collected with a horizontal Van Dorn beta sampler one meter below the surface and from the midhypolimnion. In addition to the two primary sites, one secondary site, Station C, was sampled (Figure 2). Measurements at the secondary site were limited to the zooplankton community and Secchi disk transparency.

The water sample procedures followed are described in the Limnology Field and Laboratory Manual: Methods for Assessing Aquatic Production (Koenings et al., 1986). Analysis was completed by ADF&G.

In addition to the limnological samples collected from Hidden Lake, percent cloud cover was estimated and precipitation measured to the nearest millimeter at 5:00 pm each day. Hidden Creek water and air temperatures were recorded using a data logger (Hobo®) that recorded water and air temperature every four hours. Recordings were then averaged over a 24-hour period to provide a daily average air and water temperature. Previous to 2013, water and air temperatures were measured using a thermometer at 5:00 pm each day, and therefore results prior to this date may not be comparable to subsequent years.

Smolt Enumeration

To enumerate the smolt migration, a smolt trap was temporarily placed in Hidden Creek approximately 50 meters downstream of Skilak Lake Loop road. The smolt trap consisted of a modified fyke net with nylon mesh leads and a double compartment live-box. The leads and fyke net funneled migrating smolt into the live-box. A swing gate remotely controlled by the trap operators directed smolt into one of two live-box compartments where they were enumerated and a smolt sample was collected.

A total count of smolt migrating from Hidden Lake was made until the migration of fish exceeded 1,000 to 2,000 fish per hour. At migration rates greater than 2,000 fish per hour, fish densities in the trap become too great and the fish become stressed. To avoid stressing the fish during periods of peak migration, a 10% sub-sampling procedure could be used to enumerate the fish. In 2015, the rate of fish migration was such that the 10% sub-sampling procedure was not required. From June18–20, the smolt trap was left open and smolt went uncounted due to the need to evacuate the crew because of a nearby wildfire. Estimates based on the smolt counts from before and after the missed days indicate that the number of smolt missed during this three day period range from 500–2,000 smolt. The missed smolt—constituting less than 0.5% of the total migration—will be ignored for the remainder of this report and all smolt counts will be listed as estimates.

A detailed description of smolt enumeration procedures is available in CIAA's 2015 Hidden Lake Smolt Enumeration Procedures Manual (CIAA, 2015a).

Smolt Characteristics and Enhanced Contribution

During the smolt enumeration CIAA analyzed age, weight, and length characteristics of emigrating sockeye and coho salmon smolts. Hatchery contribution was also assessed by collecting otolith samples from sockeye salmon smolt. Since 1991, CIAA has marked the otolith of all sockeye salmon fry released to Hidden Lake with a thermal mark. A thermal mark is a hatchery induced thermal band produced by controlled temperature changes during incubation.

No otolith sampling was conducted on any other species. However, scale samples for age determination were collected from the coho smolt.

During the 2015 smolt migration, smolt samples were collected in proportion to the projected emigration. This was accomplished by attempting to collect every 500th sockeye salmon smolt and every 75th coho salmon smolt that was counted and passed through the smolt trap. In 2015, 0.2% of the migrating sockeye salmon were sampled (every 500th fish) and 1.3% of the migrating coho salmon were sampled (every 75th fish). The numbering sequence began when the first fish passed through the trap and continued consecutively until the smolt migration was complete. A total of 113 coho salmon were sampled and all samples were readable. Of the 601 sockeye smolt otoliths collected at the weir, 596 were readable. Mean smolt lengths are presented in this report plus or minus one standard deviation of the sample mean.

The fish collected for sampling were placed in a plastic container filled with a diluted solution of 99.5% pure Tricaine Methanesulfonate Finquel® MS-222® and water to anesthetize the fish during the sampling event. Sockeye and coho salmon smolts were first measured to the nearest millimeter for fork length[1] and then weighed to the nearest 0.1 gram. Up to 10 scales were removed from the primary growth area[2] and mounted on a glass slide for subsequent age determination for coho salmon only. The otoliths from sockeye salmon smolt were extracted following procedures by Glick and Shields (1993) and placed in a labeled one-dram vial. A dilute ethanol solution was added to the vial to cover the otoliths.

Statistical analysis of coho characteristics follows the same equation used to assess sockeye salmon smolt. Since there is no hatchery component to the Hidden Lake coho population, α and α_h=0.

Sockeye salmon smolt characteristics, the proportion of hatchery incubated sockeye salmon smolt, and the proportion of age 1 and 2 sockeye salmon smolt in the migrating population, were estimated with the following notations and formulas provided by ADF&G.

[1] Standard fork length was measured from the tip of the snout to the fork of the tail.
[2] The primary growth area is located above the lateral line on a diagonal from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin.

If:

N = total number of migrating smolt,

N_h = number of smolt in stratum h, $\left(N = \sum N_h\right)$,

n = total number of smolt sampled,

n_h = number of smolt sampled in stratum h, $\left(n = \sum n_h\right)$,

a = total number of hatchery incubated smolt sampled,

a_h = number of hatchery incubated smolt sampled in stratum h, $\left(a = \sum a_h\right)$,

$p_h = a_h / n_h$, the proportion of hatchery incubated smolt in stratum h,

$q_h = 1 - p_h$, the proportion of wild smolt in stratum h,

c_i = number of age $= i$ smolt sampled,

c_{hi} = number of age $= i$ smolt sampled in stratum h, $\left(c_i = \sum c_{hi}\right)$,

$l_{hi} = c_{hi} / n_{hi}$, the proportion of age $= i$ smolt in stratum h,

$m_{hi} = 1 - l_{hi}$, the proportion of other than age $= i$ smolt in stratum h,

$f = n / N$, the sampling fraction (assumed equal in all strata),

$W_h = N_h / N$, the stratum weight, and

y = the weight or length of the smolt.

Then, the proportion of hatchery incubated smolt, $\hat{P}$, is:

$$\hat{P} = a / n;$$

with a variance of:

$$v\left(\hat{P}\right) = \left(1 - f\right)(1/n)\sum W_h p_h q_h;$$

which, under proportional allocation, is like the usual simple random sample estimate. And, the total number of hatchery incubated smolt, $\hat{A}$, is:

$$\hat{A} = N(a/n) = N\hat{P};$$

with a variance of:

$$v\left(\hat{A}\right) = N^2\left(1 - f\right)(1/n)\sum W_h p_h q_h = N^2 v\left(\hat{P}\right).$$

Since samples sizes are large and $\hat{P}$ is not extreme, the normal approximation without a correction for continuity, can be used to develop the relative error. Thus, the 95% confidence interval estimates for $\hat{P}$ and $\hat{A}$ are:

$$\hat{P} \pm 1.96\sqrt{v(\hat{P})} \quad \text{and} \quad \hat{A} \pm 1.96\sqrt{v(\hat{A})};$$

with relative errors of:

$$\left(1.96\sqrt{v(\hat{P})}/(\hat{P})\right)100 \quad \text{and} \quad \left(1.96\sqrt{v(\hat{A})}/(\hat{A})\right)100.$$

The proportion of age $= i$ smolt in the migration was also estimated as:

$$\hat{L}_i = c_i / n;$$

with a variance of:

$$v(\hat{L}_i) = (1 - f)\frac{1}{n}\sum_h W_h l_{hi} m_{hi};$$

and, the total number of age $= i$ smolt was estimated as:

$$\hat{C}_i = N(\hat{L}_i);$$

with a variance of:

$$v(\hat{C}_i) = N^2 v(\hat{L}_i).$$

Confidence intervals (95%) estimates for age-class proportion and abundance, assuming 2 age-classes, are:

$$\hat{L}_i \pm 2.24\left(\sqrt{v(\hat{L}_i)}\right) \quad \text{and} \quad \hat{C}_i \pm 2.24\left(\sqrt{v(\hat{C}_i)}\right).$$

Mean weight or length of age $= i$ smolt was also estimated as:

$$\bar{y}_i = \frac{\sum_h \sum_j y_{hij}}{c_i};$$

with an approximate variance estimate of:

$$v(\bar{y}_i) \cong \frac{1}{\hat{C}_i^2}\sum_h \frac{N_h^2(1-f)}{n_h(n_h-1)}\left[\sum_j (y_{hij} - \bar{y}_{hi})^2 + c_{hi}(1 - c_{hi}/n_h)(\bar{y}_{hi} - \bar{y}_i)^2\right];$$

and 95% confidence interval estimates of:

$$\bar{y}_i \pm 1.96\left(\sqrt{v(\bar{y}_i)}\right).$$

Adult Enumeration and Enhanced Contribution

The 2015 Hidden Lake adult escapement was monitored to assess the returning fish population. To enumerate and sample returning salmon, an adult counting weir was temporarily installed in Hidden Creek. The weir was constructed of 1.9 cm galvanized pipe and 7.6 cm aluminum channel. The galvanized pipe was picketed through 1.9 cm holes in the aluminum channel spaced 2.54 cm apart. The weir consisted of an upper and lower half that were erected perpendicular to the flow and positioned at an approximate distance of 5 yards of each other creating a trap between the two halves. The double weir configuration comfortably held fish for a short period while field personnel safely operated the weir. During day time hours, field personnel passed fish upstream or downstream through both sections of the weir. As the number of fish ascending Hidden Creek increased, counts were made more frequently to prevent fish from accumulating behind the weir.

The returning adult population's characteristics were assessed by collecting a sample of the migrating sockeye salmon adults to determine age, sex, and length characteristics. To obtain a representative sample for determining age, sex, and length of the returning adult sockeye salmon population, scale samples were collected along with weights and lengths from every 50^{th} adult sockeye salmon that passed through the weir and sex was recorded. The mean adult lengths are presented in this report plus or minus one standard deviation of the sample mean.

For 2015, 1.9% of the returning adult salmon were sampled. Adult sockeye salmon were captured at the weir, measured for standard fork length to the nearest millimeter, sex determined, and a scale was removed from the primary growth area. The fish were released upstream unharmed. Reading and statistical analysis of adult sockeye salmon scales were conducted by ADF&G.

Hatchery contribution was assessed by collecting otoliths from returning adult sockeye salmon to identify the hatchery induced thermal band. Staff attempted to collect a total of 600 readable otolith pairs for evaluation with equal number of samples (n=200) collected over the beginning,

middle, and end of the escapement. For 2015, 550 otolith samples were collected of which 546 were readable. The otolith pairs were analyzed by CIAA staff to estimate hatchery contribution.

Marine survival for all fish (hatchery and natural production) was determined for each complete brood year by dividing the total adult return (for all age classes by a particular year class) by the number of migrating smolts for that same year class. The total adult return was determined by dividing the number of fish that were counted at the weir by 1 minus the harvest rate (as provided by ADF&G) for that return year.

A detailed description of adult escapement enumeration procedures is available in the 2015 CIAA Hidden Lake Adult Enumeration Procedures Manual (CIAA, 2015b).

Gamete Collection, Incubation and Rearing

Gamete collection occurred three times between September 16 and 21, 2015. Adult sockeye salmon were collected using a beach seine from the spawning area located in the western basin on the north shore, checked for ripeness, and placed into net pens. This collection location is different from previous years (before 2012) and is part of the changes implemented in 2012 to the Hidden Lake Operational Plan. This location was selected because it showed the lowest proportion of hatchery produced sockeye through otolith analysis in 2014.

During the gamete collection, those fish used as broodstock for the first two eggtakes were measured for length following similar procedures used for measuring the length at the weir. A total of 380 fish were sampled (176 males and 204 females). Gamete collection followed the Alaska Sockeye Salmon Culture Manual (McDaniel et al., 1994). Equipment was disinfected between each fish. Iced coolers of eggs and milt in individual containers were transported to Trail Lakes Hatchery. Containers were disinfected prior to admission to the facility. Single family delayed fertilization and water hardening disinfecting techniques were used. Newly-fertilized eggs were water hardened in iodophor solution for 2 hours before being placed into Kitoi incubators. Once eggs reached the eyed stage, eggs were shocked, picked, and inventoried. Resulting live eggs were placed into Kitoi incubators for hatching and emergence. The sockeye

salmon eggs collected in 2015 are currently being incubated at Trail Lakes Hatchery. Incubation followed standard hatchery procedures and water temperature has been regulated to thermally mark the otoliths of fish scheduled for release in 2016 (thermal mark is 3,2,1H).

Fish Transport and Stocking

Prior to the 2015 fish release, a sample of surviving unfed fry collected from adult sockeye salmon in 2014 was sent to ADF&G Pathology Lab for disease screening. A sample of the surviving unfed fry was also measured for weight to the nearest 0.01 gram. The remaining unfed fry were transferred to fish transport tanks and transported to Hidden Lake. Staff transported the sockeye salmon fry via boat to the east basin of the lake and released the fry near the north shore. This location is different from previous years (prior to 2012) and is part of the changes implemented in 2012 to the Hidden Lake Operational Plan.

Evaluation of Adult Sockeye Salmon Fidelity in Hidden Lake at Spawning

Continuing an evaluation on spawning fidelity by ADF&G (2008 through 2010), which indicated that the hatchery-reared fish have returned to their release location at a higher proportion than to other areas of the lake (Habicht et al., 2013), CIAA attempted to collect the otoliths from 250 spawning fish from each of three different spawning locations. These three locations were the western basin at the (1) north (Western Basin-North Side) and (2) south side of the lake (Western Basin-South Side) and (3) an aggregate of the eastern basin (Eastern Basin). The aggregate of the eastern basis corresponds to the new fry release site. The north side of the western basin corresponds to the gamete collection site in 2015.

In 2015, 223 otoliths were collected from fish from the Eastern Basin, 219 from the Western Basin-North Side, and 245 from Western Basin-South Side. Dead sockeye were collected along the shoreline in each spawning location. Otoliths were analyzed for age structure and presence of thermal mark.

Straying Study

Based on the genetic mapping, which was summarized in a ADF&G report (Barclay et al., 2010), three populations were identified as possible concerns for straying (1) Skilak Lake Outlet, (2) Kenai River between Skilak and Kenai lakes, and (3) Skilak Lake beach spawners (north and south side of the lake). Along with ADF&G, KNWR, and USFWS, CIAA agreed to analyze the straying rate of enhanced fish from Hidden Lake into other populations based on the entire stock-complex (i.e., the entire Kenai River stock complex excluding Hidden Lake). The parameters under which this analysis will occur are: 2% overall stray rate at a precision of 35% with a 90% confidence interval. Due to the excessive samples that would be required to have statistical validation of these three key populations (1,100/population; 3,300 total samples), all parties agreed to monitor the aggregate of these populations, therefore requiring 1,100 samples to be collected in total, distributed among the four areas surveyed. These four areas and number of samples to be collected are (1) Skilak Lake - South (n=220), (2) Skilak Lake - North (n=220), (3) Kenai River - Jim's Landing to Skilak Lake confluence (n=220) and (4) Skilak - Dunes (n=440).

The Skilak - Dunes area sampling goal was met by CIAA in 2013 and hence this area was not sampled in 2014–2015. Two of the three remaining areas (Skilak North and South) were not sampled during field season 2015 due to low numbers of fish being present in those areas and the excessive financial resources that would be required to meet the sampling goal. The decision not to sample these areas was agreed upon by USFWS and ADF&G. Otoliths from carcasses found in the Kenai-Skilak confluence were collected by CIAA on four different occasions between September 11 and 23. A total of 422 samples were collected from Kenai-Skilak confluence and 415 of those samples were readable.

This page intentionally left blank

RESULTS AND DISCUSSION

Limnology and Environmental Conditions

Limnology sampling at Hidden Lake has been completed by CIAA since 1992. In 2015, water quality, and zooplankton samples were collected four times (June, July, August, and September). Water quality and zooplankton analysis was completed by ADF&G and are summarized in Table 1.

Table 1. Average open water season water quality characteristics of Hidden Lake

	AVERAGE WATER QUALITY - 1 METER										AVERAGE WATER QUALITY - HYPOLIMNION						
Year	Sp. Cond (umhos/cm)	pH (SU)	Alk (mg/l)	Turb. (NTU)	TP (ug/l)	TKN (ug/l)	Chl a (ug/l)	EZD (m)	Secchi (m)	Zooplankton (mg/m2)	Sp. Cond (umhos/cm)	pH (SU)	Alk (mg/l)	Turb. (NTU)	TP (ug/l)	TKN (ug/l)	Chl a (ug/l)
1980	145	7.8	66		6.8	120	2.1				146	7.8	69		6.1	140	1.8
1981	117	7.0	73		6.6	171	0.6			2,381	116	7.0	74		6.5	175	0.5
1982	137	8.1	70		8.6	174	0.4			1,619	136	8.0	71		7.2	172	0.5
1983	144	8.1	72		6.9	176	0.5			3,285	148	7.8	73		9.2	193	0.8
1984	146	7.9	71		6.7	172	0.7			2,248	149	7.7	72	0.6	6.3	168	0.6
1985	147	7.9	78	0.7	7.2	177	0.9			1,967	147	7.7	79	0.7	8.2	179	0.7
1986	144	7.8	72	0.4	7.5	185	0.3			2,420	146	7.7	71	0.3	7.6	180	0.3
1987	147	8.0	70	0.2	6.9	188	0.5			1,390	150	7.8	70	0.3	8.3	191	0.5
1988	146	7.8	67	0.6	6.8	197	0.6			2,466	150	7.6	67	0.4	7.0	195	0.6
1989	146	8.0	67	0.4	7.8	198	0.4			3,437	149	7.9	67	0.4	8.0	196	0.4
1990	147	8.0	73	0.4	7.8	193	0.8			2,258	148	7.8	73	0.4	8.5	187	0.7
1991	152	8.0	72	0.7	6.7	171	0.8	20.2	7.3	2,222	154	7.8	73	0.7	8.2	189	0.6
1992	145	8.0	66	0.7	7.4	231	1.3	15.2	5.0	1,030	147	7.7	69	0.6	9.5	218	1.1
1993	150	7.8	68	0.5	7.0	198	1.5	14.0	6.4	2,030	156	7.6	71	0.4	8.0	203	1.3
1994	156	7.8	70	0.5	7.4	210	1.6	19.6	6.7	847	157	7.6	70	0.6	7.3	188	0.9
1995	153	7.8	71	0.7	5.7	197	1.8	20.0	7.6	1,520	159	7.6	72	0.7	6.5	189	1.6
1996	152	7.8	71	0.7	5.6	188	0.9	19.6	8.4	1,338	159	7.7	73	0.7	6.3	190	2.6
1997	153	7.8	73	0.4	6.6	186	0.7	20.2	9.7	2,111	153	7.8	73	0.5	9.0	201	1.2
1998	150	8.0	72	0.8	6.4	205	0.8	21.0	7.2	2,358	153	7.8	72	0.1	6.6	194	0.6
1999	149	7.6	72	0.7	7.3	234	0.8	18.7	6.7	2,474	153	7.5	72	0.7	7.4	221	0.5
2000	150	7.8	69	0.8	7.2	234	1.6	20.4	8.7	3,896	151	7.7	70	0.7	7.9	245	1.5
2001	150	7.6	68	0.7	7.8	231	1.1	19.4	7.1	3,398	152	7.5	69	0.7	7.5	222	0.9
2002	147	7.7	73	0.4	8.6	257	1.1	17.9	5.9	2,447	150	7.6	73	0.5	9.1	239	0.7
2003	148	7.3	70	0.4	8.4	229	2.8	17.1	7.0	959	149	7.3	68	0.5	8.9	224	1.5
2004	141	7.5	70	0.3	11.7	286	1.0	17.1	6.6	1,450	151	7.7	71	0.5	13.1	302	1.0
2005	149	7.2	68	0.3	9.8	273	0.5	17.5	7.0	1,693	149	7.2	68	0.1	11.8	277	0.5
2006	147	7.3	67	0.1	8.2	237	0.5	23.4	8.0	1,445	148	7.4	68	0.2	8.5	216	0.6
2007	151	7.8	71	0.6	8.4	218	0.7	21.4	9.0	1,589	154	7.7	71	0.5	9.9	222	0.9
2008	149	7.4	68	0.3	12.4	217	0.6	20.6	7.8	1,373	152	7.3	69	0.2	8.8	202	0.5
2009	151	7.4	69	0.3	8.8	229	0.5	20.0	8.1	1,515	151	7.3	68	0.2	8.1	219	0.6
2010	154	7.5	66	0.2	7.7	NA	0.6	20.2	7.4	955	152	7.5	66	0.6	7.5	NA	0.9
2011	160	8.0	73	0.8	6.5	NA	0.9	24.0	8.5	1,313	162	7.9	72	0.3	12	NA	2.4
2012	160	7.9	69	0.4	6.5	NA	1.0	20.6	7.7	1,419	163	7.7	70	0.5	6.2	NA	1.0
2013	160	7.8	65	0.3	6.7	NA	0.9	23.2	8.3	1,874	165	7.6	67	0.3	7.7	NA	1.1
2014	158	7.5	70	0.2	7.4	NA	1.0	17.7	6.6	1,423	160	7.4	72	0.2	7.2	NA	0.6
2015	158	7.9	76	0.2	8.0	236	1.0	20.0	7.9	1,239	160	7.7	77	0.2	7.5	220	0.6

Averages prior to 1992 compiled by ADF&G.
EZD and Secchi provided by CIAA.
Open water season only.
Zooplankton data was corrected for 2008 onward.

Environmental conditions during the Hidden Lake smolt migration were monitored from May 18 to June 28, 2015. Stream stage measurements generally increased over the course of the smolt

migration but were variable because of beaver activity near the outlet of Hidden Lake. The average change in stage height over this time period was +0.21 ft (±0.12 ft). During the period of smolt migration, stream temperatures averaged 13.2°C (±2.3°C). Air temperatures averaged 13.7°C (±2.9°C). Twenty-four percent of the days were clear, 16% had less than 50% cloud cover, 18% had more than 50% cloud cover, and 42% were completely overcast. Measurable rain was recorded on 9 days (21%) during the smolt migration. A total of 12 mm of rain fell during this period.

Environmental conditions during the Hidden Lake adult sockeye salmon migration were monitored from July 10 to September 20, 2015. Stream stage measurements were fairly stable during adult monitoring. The average change in stage height over this time period was 0.55 ft (±0.05 ft). Stream temperatures averaged 15.0°C (±2.2°C) and air temperatures averaged 12.5°C (±3.1°C). Eighteen percent of the days were clear, 25% had less than 50% cloud cover, 22% had more than 50% cloud cover, and 33% were completely overcast. Measurable rain was recorded on 42 days (58%) during the adult migration. A total of 8 mm of rain fell during this period.

Smolt Enumeration

The Hidden Lake smolt migration was enumerated from May 18 and continued daily until June 28 except for the days from June 18–20 when the smolt crew was evacuated from the site due to a wildfire. A straight line interpolation was made to estimate the smolt missed during the evacuation which was estimated at 500–2,000 smolt. For the remainder of the report this estimate of missed smolt was ignored due to the small percentage of smolt that was estimated to be missed. Thus, the total estimated number of smolt at the trap was 336,971sockeye and 8,970 coho salmon smolt. The 2015 Hidden Lake sockeye salmon smolt migration was above the four-year average smolt emigration of 276,487 (Table 3). Sockeye salmon smolt mortalities were 447 and 601 fish were sacrificed for otolith collection resulting in 335,923 live sockeye salmon smolt migrating out of the lake. The live smolt migration for the coho salmon smolt is the same as the total migration. Other fish counted included 269 rainbow trout (*O. mykiss*), and 189 Dolly Varden (*S. malma*). The 10% sub-sampling procedure was not used.

Field staff collected the carcasses of the 447 sockeye smolt that appeared to have succumbed to natural mortality at the weir site for analysis at the ADF&G pathology lab. Due to improper handling, no conclusive results from pathology were made. Similar mortality patterns have been observed in the past (2006, 2004, and 2002). These mortalities are believed to be mainly due to IHN (infectious hemorrhagic necrosis), which is a disease innate to sockeye salmon. The prevalence of IHN is exacerbated by warm temperature and hence mortalities tend to peak toward the tail-end of the run. As sockeye salmon are carriers of the IHN virus, there is not much that can be done to control the disease. Prior to stocking the unfed fry from the hatchery, samples are submitted to ADF&G Pathology Lab for IHN screening. For the 2015 stocking, no IHN was detected. However, once the fish are stocked the disease can be transferred from the natural stock to the hatchery fish.

Smolt Characteristics and Enhanced Contribution

Otolith, weight, and length measurements were collected and analyzed on 601 sockeye salmon smolt of which 586 samples were readable. Based on the otolith samples collected, 55.1% (±4.0%) of the migrating sockeye salmon smolt were incubated at Trail Lakes Hatchery. An estimated 94.9% (±2.0%) were age 1 and 5.1% (±2.0%) were age 2. The average length and weight of the age 1 sockeye salmon smolt were 129.1mm (±0.5 mm) and 23.7 g (±1.1 g). The average length and weight of the age 2 sockeye salmon smolt were 153.4 mm (±27.3 mm) and 37.7 g (±9.0 g).

Scale age, weight, and length measurements were made on 113 coho salmon smolt, of which 109 scale samples were readable. Based on the scale samples collected, an estimated 19.3% (±7.6%) of the migrating coho salmon smolt were age 1. An estimated 80.7% (±7.6%) were age 2. The average length and weight of the age 1 coho smolt were 122 mm (±2.9 mm) and 22.2 g (±8.6 g). The average length and weight of the age 2 coho salmon smolt were 138 mm (±0.5 mm) and 29.8 g (±1.3 g). Table 2 summarizes the age structure, average length, and weight measurements since 1976.

Prior to 1988, estimates of the enhanced contribution to the Hidden Lake sockeye salmon smolt

migration were based on coded wire tag studies. Estimates of the proportion of hatchery fish ranged from 3 to 78% (Kyle et al., 1990). Since 1991, the otoliths of all hatchery-incubated fry released to Hidden Lake were thermally marked. These hatchery marks have been used to apportion migrating sockeye salmon smolt between wild and enhanced fish since 1993.

In 2015, the proportion of hatchery-incubated salmon in the sockeye salmon smolt migration was 55.1% (±4.0%) (Table 3). The 2015 hatchery contribution is less than the 1993–2015 average of 66% and with the most recent 4-year average of 63%. Without knowing the success of natural spawning within the system (i.e., green egg number; survival to eyed stage; survival to emergence), no comparison of survival between the two groups can be made. Fry-to-smolt survival for hatchery fish can be determined on a year class basis. For the most recent completed year class (BY2010), the fry-to-smolt survival is estimated at 14.1%. It should be noted that as the hatchery fish are stocked as unfed fry and they are subject to the same environmental conditions as the naturally produced fish. Therefore, if there is a lower survival of naturally-produced fish, it is most likely occurring between the green egg to emergence stage.

Adult Enumeration and Enhanced Contribution

The Hidden Lake adult salmon escapement was enumerated from July 10 to September 20, 2015. During this time, a total of 19,385 adult sockeye salmon (*O. nerka*) and 7 adult coho salmon (*O. kisutch*) returned to Hidden Creek. No other fish were reported. Six hundred were sampled for otolith collection leaving a live escapement of 18,785 to the lake. There were no living adult sockeye salmon sampled as part of the fidelity study (because all of the fish sampled were collected after natural mortality occurred in the lake) but 1,313 were used for hatchery brood stock, leaving 17,472 fish as potential spawners. Twenty-three females and 9 males were deemed unusable for brood stock and another 11 fish succumbed to holding mortality leaving 635 mating pairs used for brood stock.

Personnel collected scales from 361 adult sockeye salmon at the weir, of which 341 samples were readable. The percentage of adult male and adult female sockeye salmon returning to Hidden Lake was 45.7% and 54.3%, respectively. Male fish averaged 501 mm (±23.0 mm) in

length and the females averaged 490 mm (±19.9 mm) (Table 4). An estimated 86.5% were age 1.2, 9.4% were age 1.3, 4.1% were age 2.2, 0.0% were age 2.3, and 0.0% were age 1.4. Table 4 provides length data over the last 40 years for each age class.

To determine the contribution of hatchery-incubated fish to the population of adult sockeye salmon returning to Hidden Lake, CIAA staff collected 550 otolith pairs from Hidden Creek on August 10, 18, and 27, 2015, of which 546 pairs were readable. Based on otolith marks, an estimated 67.8% (±3.8%) adult sockeye salmon were incubated at Trail Lakes Hatchery.

Prior to 1999, the hatchery contribution of adult sockeye returns was not evaluated. The Hidden Lake adult hatchery contribution of adult returns from 1999–2015 was 62%. Hatchery contribution could not be assessed in 2005 and 2006 due to inconsistency in daily escapement that created an unpredictable sampling technique and rendered statistically inconclusive results. Looking at the most recent 4-year average, the number of adult sockeye attributable to the hatchery program was 68%. Table 4 summarizes historical sockeye salmon escapements and major age classes based on calendar year and Table 5 also summarizes AWL data but on a brood year basis and for enhanced contribution only. On a brood year basis, the enhanced characteristics of smolts are a predictor of what the adult returns will be for that same year class.

The 2015 estimated commercial fishery harvest of Hidden Lake sockeye salmon (enhanced and wild) was 11,700. Personal use and sport fishery combined was estimated at 11,404 (M. Willette, Commercial Fisheries Biologist, ADF&G, Soldotna, personal communication, 2015). Common property harvest was estimated to be 55.2% and escapement to Hidden Lake was 44.8% (Table 6).

Based on information collected from migrating sockeye salmon smolt and returning sockeye salmon adults, it is possible to provide an estimate of the survival of each brood year in the marine environment (Table 7).

Gamete Collection, Incubation and Rearing

Since 1976, the collection of sockeye salmon gametes and the release of hatchery-incubated fry have been used to enhance the sockeye salmon population in Hidden Lake, Tutka Bay Lagoon, Leisure (China Poot) Lake, Hazel Lake, and Kirschner Lake. To date, a total of 93,361,598 eggs have been collected for incubation at Crooked Creek, Big Lake, and Trail Lakes Hatcheries. Since 1983 all Hidden Lake sockeye egg incubation has taken place at Trail Lakes Hatchery. As of 2009, CIAA is no longer using the Hidden Lake sockeye salmon population to enhance systems other than Hidden Lake. The annual gamete collections conducted since 1976 are summarized in Table 8.

Between September 16 and 21 2015, an estimated 1,445,598 eggs were collected from 635 female sockeye salmon and shipped to Trail Lakes Hatchery for fertilization. This involves mixing the eggs from each female with the milt from one male and activating the sperm with a 0.7% saline solution. An estimated 1,266,663 eggs (88%) have survived to the eyed stage. Average length of the male broodstock was 499 mm (±27.8 mm) and the female broodstock was 497 mm (±24.7 mm).

The objective of the Hidden Lake Sockeye Salmon Enhancement Project is to achieve an average adult sockeye salmon escapement of 30,000 fish. The number of gametes to collect each year to meet this objective is calculated based on the most recent 4-year average natural sockeye salmon smolt emigration (101,400 Table 3), brood year average green egg-to-fry survival (89.0%, Table 8), fry-to-smolt survival (16.8%, Table 8), smolt-to-adult survival (18.2%, Table 7), and the average common property harvest rate (57.2%, Table 6). Based on these averages, to meet a projected adult return of 30,000 adult sockeye salmon to Hidden Creek, CIAA projects 1,899,853 eggs must be collected in 2016 to supplement the Hidden Lake return.

<u>Calculations:</u>

Equation 1: Natural Return (Total Fishery Return)

4-year avg. natural smolt * smolt-to-adult survival = est. 2015 natural return (total fishery return)

101,400* 18.2% = 18,455

Equation 2: Natural Return (Hidden Lake)

2015 total fishery return (Equation 1) * (1 - Common Property %) = est. natural return to lake

18,455* (1-0.572) = 7,899

Equation 3: Enhanced Return (Hidden Lake)

return goal – est. natural return to lake (Equation 2) = est. enhanced return to lake

30,000 – 7,899 = 22,101

Equation 4: Enhanced Green Egg Collection Requirement

est. enhanced return to lake/green-to-eyed surv./fry-to-smolt surv./smolt-to-adult surv/escape.%

22,101/0.890/0.168/0.182/0.428 = 1,897,569

However, due to space limitations at the hatchery, only 1,250,000 eggs will be collected.

Table 2. Age structure, length and weight characteristics of Hidden Lake sockeye salmon smolt, 1976–2015

		Age Class 1.0			Age Class 2.0			Mean Length (mm)				Mean weight (g)			
Smolt	#		95%			95%		Age	95%	Age	95%	Age	95%	Age	95%
Year	Live Migr.	%	C.I.	#	%	C.I.	#	1.0	C.I.	2.0	C.I.	1.0	C.I.	2.0	C.I.
1976	29,639	80		23,711	20		5,928	130		146		NA		NA	
1977	17,670	83		14,666	17		3,004	144		199		NA		NA	
1978	111,466	88		98,090	12		13,376	133		190		22.4		79.3	
1979	94,347	85		80,195	15		14,152	145		177		30.7		57.2	
1980	81,748	90		73,573	10		8,175	143		200		27.3		83.9	
1981	161,522	98		158,292	2		3,230	144		198		28.5		81.4	
1982	222,673	99		220,446	1		2,227	145		174		27.3		55.3	
1983	235,233	94		221,119	6		14,114	132		186		21.3		66.1	
1984	419,376	95		398,407	5		20,969	144		170		28.7		49.2	
1985	396,000	97		384,120	3		11,880	141		185		26.3		63.7	
1986	651,889	96		625,813	4		26,076	134		180		22.4		55.6	
1987	68,980	81		55,874	19		13,106	143		175		28.0		54.3	
1988	471,625	94		443,328	6		28,298	128		179		18.7		59.1	
1989	719,527	94		676,355	6		43,172	126		163		17.6		43.5	
1990	231,300	78		180,414	21		48,573	140		191		30.0		71.6	
1991	208,500	93		193,905	6		12,510	140		205		25.4		88.9	
1992	191,900	95		182,305	5		9,595	133		172		21.5		47.1	
1993	388,500	89		345,765	10		38,850	130		183		20.4		61.2	
1994	414,400	94		389,536	6		24,864	130		179		18.1		49.8	
1995	293,700	86		252,582	13		38,181	128		181		18.3		56.5	
1996	427,400	95	(±2.1)	406,030	5	(±2.1)	21,370	135	(±0.5)	190	(±4.5)	19.1	(±0.3)	59.4	(±6.5)
1997	228,400	96	(±2.7)	219,264	4	(±2.7)	9,136	123	(±0.6)	190	(±15.9)	15.9	(±0.3)	72.7	(±19.7)
1998	384,800	91	(±2.9)	350,168	9	(±2.9)	34,632	129	(±0.7)	203	(±5.8)	20.0	(±0.4)	82.3	(±6.5)
1999	312,644	86	(±3.6)	268,874	14	(±3.6)	43,770	132	(±0.6)	173	(±5.1)	23.0	(±0.3)	51.1	(±4.8)
2000	474,900	93	(±2.2)	441,657	8	(±2.2)	37,992	138	(±0.5)	182	(±7.3)	25.0	(±0.3)	64.0	(±7.8)
2001	324,400	94	(±2.6)	304,936	6	(±2.5)	19,464	134	(±0.5)	165	(±8.6)	22.3	(±0.3)	45.0	(±8.0)
2002	366,600	86	(±2.2)	315,276	13	(±2.2)	47,658	134	(±0.8)	165	(±6.0)	22.2	(±0.4)	45.0	(±4.8)
2003	308,500	94	(±2.2)	289,990	6	(±2.2)	18,510	140	(±0.5)	179	(±0.8)	24.7	(±0.2)	60.5	(±6.5)
2004	180,600	64	(±3.7)	115,584	36	(±3.7)	65,016	140	(±0.8)	179	(±3.6)	24.7	(±0.8)	60.5	(±3.7)
2005	289,300	91	(±1.8)	263,263	9	(±1.9)	26,037	140	(±0.5)	179	(±3.6)	24.7	(±2.0)	60.5	(±3.7)
2006	200,000	91	(±2.4)	182,000	9	(±2.4)	18,000	140	(±0.9)	179	(±10.3)	24.7	(±0.5)	60.4	(±8.7)
2007	216,000	86	(±2.8)	185,760	16	(±3.0)	34,560	135	(±0.9)	167	(±3.1)	24.7	(±1.0)	47.4	(±4.8)
2008	349,600	97	(±1.8)	339,112	3	(±1.7)	10,488	123	(±0.9)	170	(±16.3)	18.0	(±0.3)	49.5	(±12.2)
2009	315,200	88	(±2.4)	277,376	12	(±2.4)	37,824	131	(±0.5)	175	(±3.0)	22.9	(±0.5)	55.7	(±3.7)
2010	283,300	84	(±3.4)	237,972	16	(±3.4)	45,328	120	(±7.0)	188	(±13.0)	17.0	(±2.5)	67.8	(±5.9)
2011	298,700	70	(±4.2)	207,895	30	(±4.2)	90,805	137	(±5.0)	197	(±2.5)	24.5	(±0.9)	77.8	(±2.9)
2012	312,100	95	(±2.1)	296,495	5	(±2.1)	15,605	122	(±0.7)	181	(±4.8)	16.6	(±0.6)	53.5	(±9.3)
2013	184,300	96	(±2.3)	177,568	4	(±2.3)	7,399	130	(±1.0)	172	(±12.9)	20.7	(±0.5)	53.0	(±11.0)
2014	272,900	97	(±1.7)	267,863	3	(±1.7)	8,724	142	(±0.6)	178	(±11.1)	28.6	(±0.4)	61.9	(±12.5)
2015	335,923	95	(±2.0)	318,726	5	(±2.0)	17,197	129	(±0.7)	153	(±27.4)	23.7	(±1.1)	37.7	(±9.0)
Mean	286,889	90			10			135		181		21.9		57.7	

Table 3. The contribution of enhanced sockeye salmon to the Hidden Lake smolt migrations, 1976–2015

Smolt Year	Total # Live Migr.	95% C.I.	Wild	Hatchery	% Hatchery %	95% C.I.
1976	29,639		29,639	0	0	
1977	17,670		17,670	0	0	
1978	111,466		52,745	58,721	53	
1979	94,347		46,828	47,519	50	
1980	81,748		79,458	2,290	3	
1981	161,522		161,522	0	0	
1982	222,673		222,673	0	0	
1983	235,233		235,233	0	0	
1984	419,376		175,876	243,500	58	
1985	396,000		98,000	298,000	75	
1986	651,889		140,965	510,924	78	
1987	68,980		68,980	0	0	
1988	471,625					
1989	719,527					
1990	231,300					
1991	208,500					
1992	191,900					
1993	388,500	(±21,100)	62,200	326,300	84	(±4.8)
1994	414,400	(±40,400)	53,900	360,500	87	(±3.9)
1995	293,700	(±33,400)	79,300	214,400	73	(±6.5)
1996	427,400	(±15,700)	94,000	333,400	78	(±3.6)
1997	228,400	(±0)	66,200	162,200	71	(±5.1)
1998	384,800	(±45,000)	84,700	300,100	78	(±3.7)
1999	312,644	(±13,400)	93,800	218,900	70	(±4.2)
2000	474,900	(±52,600)	109,200	365,700	77	(±3.2)
2001	324,400	(±0)	94,100	230,300	71	(±4.4)
2002	366,600	(±51,400)	132,000	234,600	64	(±4.4)
2003	308,500	(±17,300)	64,800	243,700	79	(±3.1)
2004	180,600	(±0)	131,800	48,800	27	(±3.9)
2005	289,300	(±15,500)	69,400	219,900	76	(±2.6)
2006	200,000	(±17,900)	106,000	94,000	47	(±3.6)
2007	216,000	(±70,700)	64,800	151,200	70	(±3.4)
2008	349,600	(±58,500)	139,800	209,800	60	(±4.3)
2009	315,200	(±9,000)	154,400	160,800	51	(±3.4)
2010	283,300	(±13,530)	140,200	143,100	51	(±4.1)
2011	298,700	(±17,639)	157,400	141,300	47	(±3.8)
2012	312,100	(±11,000)	109,600	203,100	65	(±4.0)
2013	184,300	(±0)	81,400	102,900	56	(±5.1)
2014	272,900	(±0)	64,000	208,900	76	(±3.6)
2015	335,923	(±0)	150,764	185,159	55	(±4.0)
Mean	311,400		100,200	211,300	66	
4-Year mean	276,300		101,400	175,000	63	

Prior to 1993, estimates of smolts originating from hatchery fry releases based on CWT studies.

Since 1993, estimates of smolts originating from hatchery fry releases based on otolith thermal marks.

Mean calculated from 1993 to present.

Prior to 1990, data summary is from Kyle et al. (1990).

This summary is total migration minus the mortalities.

4-Year mean calculated from 2012–2015

Table 4. Summary of Hidden Lake adult sockeye salmon escapement, age distribution, and fish length, 1976–2015

						Major Age Classes								
						1.2			1.3			2.2		
Year	Lake Escapement	Hatchery Return (%)	(C.I.)	Hatchery	Wild	(%)	#	Lth(mm)	(%)	#	Lth(mm)	(%)	#	Lth(mm)
1976	4,860					79	3,839	540	1	49	530	20	972	550
1977	1,055					64	675	550	2	21	600	34	359	570
1978	4,647					88	4,089	530	10	465	540	2	93	540
1979	5,762					90	5,186	540	4	230	560	6	346	550
1980	27,488					92	25,289	530	1	275	560	1	275	530
1981	15,939					78	12,432	530	15	2,391	560	7	1,116	555
1982	9,790					70	6,853	520	23	2,252	560	4	392	520
1983	11,297					87	9,828	530	11	1,243	550	2	226	530
1984	27,784					92	25,561	520	3	834	570	5	1,389	550
1985	24,784					77	19,084	520	13	3,222	570	9	2,231	580
1986	17,530					85	14,901	530	9	1,578	570	6	1,052	540
1987	43,487					96	41,748	530	3	1,305	540	0	0	540
1988	50,907					94	47,853	540	4	2,036	570	2	1,018	570
1989	7,770					44	3,419	550	41	3,186	580	15	1,166	540
1990	77,959					86	67,045	507	2	1,559	565	12	9,355	516
1991	35,576					90	32,018	512	7	2,490	557	3	1,067	521
1992	32,912					82	26,988	505	13	4,279	551	5	1,646	513
1993	11,582					80	9,266	529	9	1,042	568	11	1,274	536
1994	6,086					60	3,652	493	31	1,887	557	6	365	507
1995	7,542					63	4,751	514	12	905	559	21	1,584	525
1996	55,526					83	46,087	539	7	3,887	587	9	4,997	540
1997	56,053					77	43,161	514	18	10,090	566	3	1,682	536
1998	67,727					83	56,213	510	14	9,482	556	3	2,032	516
1999	49,406	69%	(±3.7%)	34,288	15,118	89	43,971	455	6	2,964	549	5	2,470	502
2000	45,685	62%	(±3.6%)	28,325	17,360	82	37,462	519	9	4,112	560	8	3,655	530
2001	42,462	58%	(±4.0%)	24,585	17,877	63	26,827	525	20	8,548	564	12	5,282	544
2002	71,983	62%	(±3.1%)	44,629	27,354	73	52,548	537	18	12,957	582	7	5,039	544
2003	11,734	58%	(±5.2%)	6,794	4,940	70	8,214	517	24	2,816	568	6	704	570
2004	18,172	77%	(±2.7%)	13,956	4,216	67	12,175	521	19	3,453	568	12	2,181	540
2005	13,000	ND	ND	ND	ND	79	10,270	ND	12	1,560	ND	9	1,170	ND
2006	38,535	ND	ND	ND	ND	89	34,296	502	4	1,541	547	7	2,697	506
2007	16,735	57%	(±7.9%)	9,489	7,246	63	10,618	537	23	3,864	562	11	1,888	520
2008	15,072	41%	(±1.5%)	6,104	8,968	86	12,962	511	8	1,206	573	6	904	517
2009	11,002	67%	(±1.8%)	7,338	3,664	65	7,151	518	21	2,310	553	8	880	518
2010	40,503	56%	(±1.7%)	22,560	17,943	91	36,781	500	1	522	543	8	3,196	496
2011	17,771	51%	(±3.8%)	9,117	8,654	84	14,887	506	8	1,441	546	7	1,290	496
2012	30,466	53%	(±3.9%)	16,100	14,366	79	24,068	500	13	3,961	547	7	2,133	521
2013	21,157	77%	(±3.3%)	16,179	4,978	71	14,979	514	19	3,978	555	8	1,756	527
2014	21,838	72%	(±3.5%)	15,788	6,050	79	17,263	500	11	2,498	552	9	1,910	514
2015	18,785	68%	(±3.8%)	12,730	6,055	87	16,770	492	9	1,819	524	4	796	490
Mean	27,425	62%		18,232	11,338	79	22,780	520	12	3,608	560	8	2,312	532
4 Year Avg	23,062	68%		15,199	7,862	79	18,270	501	13	3,064	544	7	1,649	513
Min	1,055	41%		6,104	3,664	63	7,151	455	1	21	524	0	704	490
Max	77,959	77%		44,629	27,354	91	52,548	550	41	12,957	600	34	5,282	580

Data prior to 1990 from Kyle, et al. 1990.
ND = No Data Collected or Calculated.
Note: Total is escapment to the lake and not fish returning to weir (morts and sampled fish).
1991 - Total sockeye return to weir was 112,792. Personal use-dipnet fishery harvested 72,060. 5,156 were donated to charity.
2005 - A hole was detected in the weir, CIAA counted 6,745 sockeye salmon. 13,000 is based on prior counts and ADF&G fish wheel estimates.
2008 - Total estimated return includes 1,500 sockeye estimated due to high bear activity.

Table 5. Summary of enhanced contribution for sockeye salmon smolt and adult migrations by brood year, 1991–2012

Brood Year	Smolt Migration		Adult Migration	
	% Hatchery	% Wild	% Hatchery	% Wild
1991	84	16	Incomplete Brood Years	
1992	86	14		
1993	73	27		
1994	78	22		
1995	72	28	68	32
1996	77	23	61	39
1997	71	29	60	40
1998	77	23	62	38
1999	70	30	64	36
2000	65	35	Incomplete Brood Years	
2001	69	31		
2002	36	64		
2003	74	26	55	45
2004	51	49	46	54
2005	69	31	63	37
2006	59	41	56	44
2007	51	49	51	49
2008	50	50	57	43
2009	49	51	75	25
2010	65	35	72	28
2011	57	43		
2012	74	26		
4-year average	61	39	64	36

*4-year average is for complete brood years only

Table 6. Historical common property harvests and escapement to Hidden Lake, 1996–2015

Year	% Harvest	% Escapement
1996	75%	25%
1997	55%	45%
1998	50%	50%
1999	50%	50%
2000	52%	48%
2001	71%	29%
2002	71%	29%
2003	69%	31%
2004	65%	35%
2005	72%	28%
2006	43%	57%
2007	67%	33%
2008	61%	39%
2009	58%	42%
2010	56%	44%
2011	51%	49%
2012	63%	37%
2013	57%	42%
2014	54%	46%
2015	55%	45%
Average	60%	40%
4-year average	57%	42%

Table 7. Marine survival by brood year for returns to Hidden Lake, 1988–2011

BY	Marine Survival (%)
1988	51.2%
1989	23.0%
1990	9.6%
1991	13.7%
1992	48.7%
1993	45.1%
1994	29.7%
1995	42.6%
1996	31.7%
1997	50.1%
1998	41.1%
1999	10.6%
2000	10.0%
2001	12.8%
2002	50.8%
2003	13.8%
2004	18.9%
2005	13.1%
2006	23.6%
2007	14.8%
2008	24.0%
2009	19.9%
2010	14.1%
2011	20.1%
2012	
4-year average	18.2%

*4-year average is for complete brood years

*Red numbers indicate incomplete brood years

Table 8. Summary of sockeye salmon gamete collection and fry releases at Hidden Lake, 1976–2015

Brood Year	No. eggs taken	No. females used	Fecundity	Receiving hatchery	Egg-to-fry survival (%)	No. fry released Hidden Lk.	No. Hatchery Smolt Migrated	Fry-to-smolt survival (%)	No. fry Released LCI Lakes	No. fry Held for Smolt	No. Smolt Released Tutka Lagoon	Hatchery Fry-to-smolt survival (%)
1976	832,880	274	3,091	Crooked Cr.	39.6%	330,228	59,076	17.89%				
1977	406,878	200		Big L.	75.9%	308,704	40,342	13.07%				
1978	311,808	100	3,118	Crooked Cr.	27.0%	8,258	2,207	26.73%				
1979												
1980												
1981												
1982		576	2,741	Trail L.	68.8%	1,086,000	250,633	23.08%				
1983	1,928,000	639	3,017	Trail L.	64.2%	1,236,900	49,148	3.97%				
1984	3,766,000	1,310	2,875	Trail L.	47.9%	1,805,792	488,134	27.03%				
1985	7,019,000	2,330	3,012	Trail L.		0	No otolith					
1986	4,740,000	1,580	3,000	Trail L.	78.5%	3,718,311	No otolith					
1987	7,000,184	2,434	2,876	Trail L.	86.9%	6,085,307	No otolith					
1988	2,718,853	891	3,046	Trail L.	91.0%	2,470,012	No otolith					
1989	2,220,467	647	2,669	Trail L.	79.0%	1,747,900	No otolith					
1990	2,189,000	956	2,290	Trail L.	64.6%	1,600,000	No otolith					
1991	2,652,000	1,119	2,370	Trail L.	64.7%	1,716,000	317,634	18.51%				
1992	2,293,000	1,007	2,277	Trail L.	82.9%	1,901,000	369,549	19.44%				
1993	2,200,000	934	2,355	Trail L.	81.8%	1,800,000	201,475	11.19%				
1994	2,156,000	1,017	2,120	Trail L.	78.8%	1,700,000	331,201	19.48%				
1995	1,893,000	849	2,230	Trail L.	84.5%	1,600,000	182,930	11.43%				
1996	2,048,000	817	2,507	Trail L.	73.3%	1,501,000	304,170	20.26%				
1997	2,166,000	936	2,314	Trail L.	47.8%	1,035,000	217,783	21.04%				
1998	2,303,000	859	2,681	Trail L.	65.4%	1,507,100	354,418	23.52%				
1999	2,297,000	954	2,408	Trail L.	54.1%	1,242,000	247,614	19.94%				
2000	1,486,000	607	2,448	Trail L.	60.9%	905,500	218,330	24.11%				
2001	1,326,000	504	2,631	Trail L.	73.9%	980,200	249,711	25.48%				
2002	1,118,000	433	2,582	Trail L.	56.3%	628,900	53,455	8.50%				
2003	893,000	371	2,481	Trail L.	89.4%	646,000	210,499	32.58%		100,000	96,000	96.0%
2004	5,445,000	2,045	2,663	Trail L.	89.5%	573,000	111,447	19.45%	4,126,000	284,000	260,000	91.5%
2005	2,027,000	1,045	1,940	Trail L.	78.6%	582,000	136,827	23.51%	680,000	193,000	144,000	74.6%
2006	5,640,000	2,340	2,450	Trail L.	89.9%	658,000	223,452	33.96%	3,980,000	570,000	483,000	84.7%
2007	5,686,000	2,231	2,549	Trail L.	85.0%	917,000	165,098	18.00%	4,880,000	317,000	301,000	95.0%
2008	4,004,000	1,543	2,595	Trail L.	90.4%	911,000	164,166	18.02%	2,411,000	290,000	278,000	95.9%
2009	5,140,000	1,849	2,780	Trail L.	92.4%	880,000	108,633	12.34%	3,406,000	410,000	192,000	46.8%
2010	1,241,000	500	2,517	Trail L.	84.1%	1,044,000	197,234	18.89%				
2011	1,119,600	445	2,516	Trail L.	84.7%	948,000	105,025	11.08%				
2012	964,000	370	2,606	Trail L.	89.2%	860,000	213,368	24.81%				
2013	1,685,000	728	2,315	Trail L.	91.4%	1,540,000	160,603					
2014	1,647,600	710	2,321	Trail L.	90.8%	1,497,000						
2015	1,445,598	635	2,277	Trail L.	87.6%							
Total	94,009,000	36,785				46,473,000	5,734,000		19,483,000	2,164,000	1,754,000	
Mean			2,462		77.3%	1,226,677	212,910	19.80%				83.50%
4-yr Avg.			2,605		89.0%	933,000	156,065	16.78%				

The 1977 sockeye salmon were taken from anadromous and residual fish.
BY 1978 eggs suffered high mortality due to complications with the hatchery source water.
The 1985 hatchery broodstock (fry) became infected with IHN virus and were destroyed.
Egg collection data prior to 1989 is from on Kyle, et al. 1990.
Mean caculation is based on broodyear 1988 to present.
2003-Survival from eyed egg to emergent fry was 89%. Only 646,000 fry released, 152,000 kept for smolt.
Survival from eyed egg to emergent fry was 89%. Only 573,000 fry released to Hidden, 4,126,000 fry released to Lower Inlet Lakes, 174,000 kept for smolt.
***Survival from eyed egg to emergent fry was 79%. Only 582,000 fry released to Hidden, 680,000 fry released to Lower Inlet Lakes, 193,000 kept for smolt.

incomplete broodyear

Fish Transport and Stocking

On May 1, 2015, an estimated 1,497,000 unfed sockeye salmon fry at approximately 0.09 g from gametes collected in 2014 were released into Hidden Lake. The unfed fry released to Hidden Lake were transported by truck in oxygenated tanks from Trail Lakes Hatchery to Hidden Lake, transferred to oxygenated fish transport tanks on board a small skiff, and motored to the east end of the lake (Figure 2) where they were released along the north shoreline. All fry were screened for diseases prior to release. There was no detection of infectious hematopoietic necrosis virus (IHNV). None of the released fry were externally marked or tagged; however, the otoliths of all the released fry were marked with thermal bands [Hatch Code: 2,1,2H]. Since 1977, over 46 million fry have been released to Hidden Lake (Table 8).

Evaluation of Adult Sockeye Salmon Fidelity in Hidden Lake at Spawning

It is hypothesized that by imprinting hatchery-reared sockeye salmon fry to the eastern basin of the lake where spawning conditions are marginal, returning F1 hatchery-origin adults will not be successful at spawning and subsequent egg and fry survival will be lower, thus decreasing the number of F2 smolts and adults. Releasing hatchery-reared sockeye salmon fry to the eastern basin of the lake will also reduce F1 hatchery-origin adult influence at the two primary spawning areas located in the western basin of the lake and the number of hatchery-produced fish spawning with naturally-produced fish will be reduced.

During September 2015 otoliths were collected and analyzed for thermal marks from dead spawned adult sockeye salmon in the Eastern Basin (223), Western Basin-North Side (219), and Western Basin-South Side (243) sampling locations. Table 9 summarizes the results. The Eastern Basin had the highest percentage of hatchery-reared fish at 97.8%, followed by the Western Basin-North Side (74.9%), and Western Basin-South Side (30.5%). Table 10 summarizes the results over the last 4 years.

Field season 2015 had the first returns from the new stocking location at the eastern region of the lake. As predicted based on fidelity studies performed by Habicht et al. (2013), there was an increase in the ratio of hatchery fish at this new release location.

Table 9. Distribution of hatchery and natural reared adult sockeye salmon in Hidden Lake, 2015

Location	No. of Samples	No. of Readable Samples	No. Readable Marked	Percent Hatchery Marked	Percent Wild
Eastern	227	223	218	97.8%	2.2%
Western-North	225	219	164	74.9%	25.1%
Western-South	250	243	74	30.5%	69.5%

Table 10. Distribution of hatchery and natural reared adult sockeye salmon in Hidden Lake, 2012–2015

	Eastern Region		Western-North		Western-South	
Year	% Hatchery	% Wild	% Hatchery	% Wild	% Hatchery	% Wild
2012	94.1	5.9	73.0	27.0	51.7	48.3
2013	85.5	14.5	84.4	15.6	56.0	44.0
2014	90	10	84.1	15.9	91.8	8.2
2015	97.8	2.2	74.9	25.1	30.5	69.5
Average	91.9	8.2	79.1	20.9	57.5	42.5

Straying Study

Based on the 2013–2014 efforts to collect spawned sockeye carcasses, there is limited spawning located on the south and north sides of Skilak Lake. To attempt to collect 220 samples from these two locations was considered a futile effort and was not conducted in 2015 as per an agreement between CIAA, ADF&G and USFWS. The Kenai River confluence however, does have fish and survey efforts continued in this area for the 2015 field season.

Between September 11 and 23, 2015, staff sampled carcasses on 4 separate occasions at the Kenai River-Skilak Confluence (Table 12). Based on the samples that were collected, no hatchery-reared fish were detected at this location. Table 12 presents the results for 2015, and Table 13 summarizes the results from 2012 through 2015.

Table 11. Dates, location, and number of adult sockeye salmon sampled for Hidden Lake straying study, 2015

Date	Kenai River Confluence
11-Sep	44
15-Sep	141
22-Sep	96
23-Sep	164
Total	445

Table 12. Number of fish sampled and percentage of hatchery-produced fish located in areas surrounding Hidden Lake, 2012–2015

	Kenai-Skilak Confluence		Skilak South		Skilak North		Skilak Dunes	
Year	# Fish	% Hatchery	# Fish	% Hatchery	# Fish	% Hatchery	# Fish	% Hatchery
2012	ND	ND	ND	ND	69	0.0	100	0.0
2013	10	0.0	16	0.0	5	0.0	434	0.0
2014	51	0.0	1	0.0	0	0.0	not required	
2015	413	0.0	not required		not required		not required	
Total	474		17		74		534	
Average		0.0		0.0		0.0		0.0

Flood events in 2012 & 2013 limited sampling efforts.

This page is intentionally left blank

RECOMMENDATIONS

In 2012, CIAA changed the stocking location to the eastern basin of Hidden Lake. The first return of adult sockeye salmon to this new stocking location occurred in 2015. As hypothesized and based on the fidelity characteristics of sockeye salmon, the number of fish in the eastern region that are of hatchery origin increased, while in the western basin the hatchery contribution decreased at both the south and north locations.

The new fry release site should continue to be used in 2016 and the 2016 egg take should be from the western basin south side because this is the site that held the lowest proportion of hatchery produced sockeye in 2015.

Since 1999, CIAA has spent significant resources documenting the possible straying of the Hidden Lake stock to nearby lakes, streams, creeks and rivers. In that time period, no strays from the Hidden Lake stocking program have been documented. Because the attainable goals of this study have been met and the consideration for the fiscal and personnel resources necessary to complete further straying studies, CIAA recommends that straying sampling be discontinued.

This page is intentionally left blank

LITERATURE CITED

Barclay, A.W., Habicht, C., Templin, W.D, Hoyt, H.A, Tobias, T and Willette, T.M. (2010). Genetic Stock Identification of Upper Cook Inlet Sockeye Salmon Harvest, 2005–2008. Alaska Department of Fish and Game, Fishery Manuscript No. 10-01, Anchorage, Alaska.

Barton, L., & Barrett, B. (1973). Cook Inlet Inventory Report. Soldotna: Alaska Department of Fish and Game, Commercial Fisheries Division.

Bill, D., Namtvedt, T., & Davis, A. (1972). Cook Inlet Lake and Stream Inventory Report. Anchorage: Alaska Department of Fish and Game, Commercial Fisheries Division.

Cherry, C. (2014). Bear Lake Salmon Enhancement Progress Report 2013. Kenai: Cook Inlet Aquaculture Association.

CIAA, USFWS (KWR) and ADFG (2012). Hidden Lake Operational Plan 2012–2017.

CIAA. (2015a). Hidden Lake Smolt Enumeration Procedures Manual. Kenai: Cook Inlet Aquaculture Association.

CIAA. (2015b). Hidden Lake Adult Enumeration Procedures Manual. Kenai: Cook Inlet Aquaculture Association.

Habicht, C., Tobias, T., Fandrei, G., Webber, N., Lewis, B and Grant, W.G. (2013). Homing of Sockeye Salmon within Hidden Lake, Alaska, Can Be Used to Achieve Hatchery Management Goals. North American Journal of Fisheries Management Volume 33: 777-782.

Glick, W., & Shields, P. (1993). Juvenile Salmonid Otolith Extraction and Preparation Techniques for Microscopic Examination. Soldotna: Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development.

Koenings, J., Edumndson, J., Edumndson, J., & Kyle, G. (1986). Limnology Field and Laboratory Manual: Methods for Assessing Aquatic Production. Soldotna: Alaska Department of Fish and Game, Division of Fisheries Rehabilitation, Enhancement, and Development.

Kyle, G., Litchfield, D., & Todd, G. (1990). Enhancement fo Hidden Lake sockeye salmon (*Oncorhynchus nerka*): Summary of fisheries production (1976–1989). Soldotna: Alaska Department of Fish and Game, Division of Fisheries Rehabilitation, Enhancement, and Development.

McDaniel, T.R., Pratt, K.M., Meyers, T.R., Ellison, T.D. Follett, J.E., Burke, J.A. (1994). Alaska Sockeye Salmon Culture Manual. Special Publication Number 6. Alaska Department of Fish & Game: Commercial Fisheries Management and Development Division.

Simpson, E., & Edmundson, J. (1999). Hidden Lake Sockeye Enhancement Project Technical Review. Soldotna: Alaska Department of Fish and Game, Division of Commercial Fisheries.

APPENDICES

Appendix 1. Hidden Lake 2015 - Water Quality
Nutrients and Primary Productivity

Date	Sta	Depth (m)	TP (ug/l)	TFP (ug/l)	FRP (ug/l)	TKN (ug/l)	NH3+NH4 (ug/l)	NO2+NO3 (ug/l)	TN:TP	RSi (ug/l)	Org C (ug/l)	Chla (ug/l)	Phaeo (ug/l)	EZD (m)	
5/27/2015	A	1	5.8	2.5	1.2	254.1	ND	ND	ND :1	3192	149	0.60	0.14	A	13.7
5/27/2015	A	14	8.1	2.7	0.9	214.5	ND	ND	ND :1	2960	175	0.63	0.20		
5/27/2015	B	1	4.8	6.6	6.1	230.0	ND	ND	ND :1	2957	181	0.76	0.21	B	18.8
5/27/2015	B	28	7.6	3.0	2.4	197.1	ND	ND	ND :1	2987	146	0.98	0.33		
7/1/2015	A	1	5.0	3.9	1.1	218.2	ND	ND	ND :1	2827	132	0.86	0.14	A	13.5
7/1/2015	A	15	6.8	4.0	1.4	224.9	ND	ND	ND :1	2902	132	0.97	0.42		
7/1/2015	B	1	4.5	4.0	1.2	264.3	ND	ND	ND :1	2786	129	0.57	0.18	B	16.3
7/1/2015	B	25	7.2	5.3	3.0	184.8	ND	ND	ND :1	2955	91	0.30	0.41		
8/4/2015	A	1	4.0	4.0	1.9	213.1	ND	ND	ND :1	2660	178	0.44	0.20	A	20.9
8/4/2015	A	15	6.9	4.7	1.7	253.0	ND	ND	ND :1	2777	132	0.59	0.29		
8/4/2015	B	1	4.0	4.0	1.2	219.4	ND	ND	ND :1	2764	117	0.65	0.15	B	ND
8/4/2015	B	30	6.8	7.1	6.8	247.3	ND	ND	ND :1	3134	106	0.22	0.14		
9/10/2015	A	1	6.2	4.8	1.0	235.4	ND	ND	ND :1	2986	149	1.14	0.47	A	23.8
9/10/2015	A	15	7.1	4.4	0.6	239.8	ND	ND	ND :1	2916	152	1.06	0.45		
9/10/2015	B	1	7.1	5.2	0.9	219.2	ND	ND	ND :1	2924	155	1.37	0.48	B	22.7
9/10/2015	B	30	9.6	8.0	4.5	195.4	ND	ND	ND :1	3519	97	0.16	0.16		
Mean	1 - Meter		5.2	4.4	1.8	232	ND	ND	ND :1	2887.0	148.8	0.8	0.2	Mean	18.5
Min			4.0	2.5	0.9	213	ND	ND	ND :1	2660.0	117.0	0.4	0.1	Min	13.5
Max			7.1	6.6	6.1	264	ND	ND	ND :1	3192.0	181.0	1.4	0.5	Max	23.8
Mean	Hypolimnion		7.5	4.9	2.7	220	ND	ND	ND :1	3,019	129	0.6	0.3		
Min			6.8	2.7	0.6	185	ND	ND	ND :1	2,777	91	0.2	0.1		
Max			9.6	8.0	6.8	253	ND	ND	ND :1	3,519	175	1.1	0.5		

*Nitrogen data provided by ADF&G was not reliable due to a possible contamination or equipment failure.
** ND indicates no data for that field

General Tests and Metals

Date	Sta	Depth (m)	Sp. Cond (umhos/cm)	pH (SU)	Alk (mg/l)	Turb (NTU)	Color (Pt)	Ca (mg/l)	Mg (mg/l)	Fe (ug/l)	Secchi Sta	Secchi (meters)
5/27/2015	A	1	144	7.8	77.0	0.1	8	22.6	2.6	2	A	8.0
5/27/2015	A	14	144	7.8	77.2	0.1	5	23.1	2.5	1		
5/27/2015	B	1	141	7.9	77.2	0.1	9	23.3	2.5	3	B	8.0
5/27/2015	B	28	142	7.8	77.5	0.1	6	23.5	2.6	1		
7/1/2015	A	1	154	8.0	76.1	0.2	12	23.1	2.3	0	A	8.0
7/1/2015	A	15	158	7.7	76.4	0.1	9	23.2	2.4	0		
7/1/2015	B	1	155	8.0	75.6	0.1	12	23.0	2.4	0	B	10.0
7/1/2015	B	25	160	7.6	76.8	0.1	6	23.4	2.4	0		
8/4/2015	A	1	162	7.9	76.9	0.2	13	22.8	2.0	2	A	9.0
8/4/2015	A	15	172	7.5	75.5	0.2	9	23.4	2.2	0		
8/4/2015	B	1	167	7.9	72.8	0.3	11	23.3	1.9	0	B	11.0
8/4/2015	B	30	176	7.4	78.7	0.2	10	23.5	2.0	2		
9/10/2015	A	1	171	7.8	75.9	0.2	4	22.1	2.3	2	A	5.0
9/10/2015	A	15	169	7.9	74.5	0.2	5	21.9	2.5	0		
9/10/2015	B	1	167	7.8	75.6	0.3	5	22.0	2.6	0	B	4.0
9/10/2015	B	30	162	7.6	77.4	0.2	4	22.2	2.7	2		
Mean	1 - Meter		158	7.9	75.9	0.2	9	22.8	2.3	1	Mean	7.9
Min			141	7.8	72.8	0.1	4	22.0	1.9	0	Min	4.0
Max			171	8.0	77.2	0.3	13	23.3	2.6	3	Max	11.0
Mean	Hypolimnion		160	7.7	76.8	0.2	7	23.0	2.4	1		
Min			142	7.4	74.5	0.1	4	21.9	2.0	0		
Max			176	7.9	78.7	0.2	10	23.5	2.7	2		

Appendix 2. Hidden Lake 2015 - Zooplankton (Density)

Macrozooplankton Density - Site A - Depth 18m - 21m
(No/m2)

	27-May	1-Jul	4-Aug	10-Sep		Mean (No/m2)	Seasonal Mean (No/m2)
Ergasilus							
Ovig Ergasilus							
Epischura	17,771	6,115	29,299	637		13,456	13,456
Ovig Epischura							
Diaptomus							
Ovig Diaptomus							
Cyclops	135,669	12,611	7,962	764		39,252	39,252
Ovig. Cyclops	2,675					2,675	669
Bosmina	54,841	263,694	370,382	478		172,349	172,349
Ovig. Bosmina	573	2,293	3,822	96		1,696	1,696
Daphnia l.	14,713	52,357	34,076	1,369		25,629	25,629
Ovig. Daphnia l.	5,924	41,656	15,924	318		15,956	15,956
Daphnia g.	1,146	3,057	6,051	159		2,603	2,603
Ovig. Daphnia g.		1,529	2,866			2,198	1,099
Chydorinae				64			
Polyphemus							
Total:	233,312	383,312	470,382	3,885	0	275,812	272,707
Ave:	29,164	47,914	58,798	486		30,646	30,301
STDEV:	46,576	89,330	126,447	438		54,665	54,870

Macrozooplankton Density - Site B - Depth 38m - 40m
(No/m2)

	27-May	1-Jul	4-Aug	10-Sep		Mean (No/m2)	Seasonal Mean (No/m2)
Ergasilus							
Ovig Ergasilus							
Epischura	10,987	6,369	17,834	9,682		11,218	11,218
Ovig Epischura							
Diaptomus							
Ovig Diaptomus							
Cyclops	356,369	550,955	459,618	140,892		376,959	376,959
Ovig. Cyclops	5,732	25,478	4,076	255		8,885	8,885
Bosmina	432,325	133,758	231,847	283,057		270,247	270,247
Ovig. Bosmina	10,032	1,274	5,605	6,624		5,884	5,884
Daphnia l.	21,975	24,841	81,529	7,643		33,997	33,997
Ovig. Daphnia l.	12,420	5,732	11,720			9,957	7,468
Daphnia g.	5,255	3,822	9,682	4,331		5,773	5,773
Ovig. Daphnia g.				764		764	191
Chydorinae							
Polyphemus							
Total:	855,095	752,229	821,911	453,248	0	723,683	720,621
Ave:	106,887	94,029	102,739	56,656		80,409	80,069
STDEV:	178,655	189,762	163,796	103,170		140,743	140,941

Macrozooplankton Density - Site C - Depth 12m - 18m
(No/m2)

	27-May	1-Jul	4-Aug	10-Sep		Mean (No/m2)	Seasonal Mean (No/m2)
Ergasilus							
Ovig Ergasilus							
Epischura	25,637	7,643	255	446		8,495	8,495
Ovig Epischura							
Diaptomus							
Ovig Diaptomus							
Cyclops	66,879	10,828	1,561	573		19,960	19,960
Ovig. Cyclops	669		64			367	183
Bosmina	145,350	364,968	1,561	350		128,057	128,057
Ovig. Bosmina	5,127	2,866	64			2,686	2,014
Daphnia l.	18,503	50,637	382	796		17,580	17,580
Ovig. Daphnia l.	5,796	24,522	32	64		7,604	7,604
Daphnia g.	1,783	3,503				2,643	1,322
Ovig. Daphnia g.	446	318				382	191
Chydorinae							
Polyphemus							
Total:	270,190	465,285	3,919	2,229	0	187,773	185,406
Ave:	30,021	58,161	560	446		20,864	20,601
STDEV:	48,155	125,073	695	271		40,824	40,961

Appendix 3. Hidden Lake 2015 - Zooplankton (Size and Biomass)

	Body Size - Site A - Depth 18m - 21m (mm)				Seasonal Means				
	12-Jun	**14-Jul**	**12-Aug**	**16-Sep**	Mean Length (mm)	Weighted Length (mm)	Biomass (mg/m2)	Weighted Biomass (mg/m2)	% by Species
Ergasilus									
Ovig Ergasilus									
Epischura	1.21	1.66	1.46	0.71	1.26	1.32	52.8	60.5	13%
Ovig Epischura									
Diaptomus									
Ovig Diaptomus									
Cyclops	0.92	0.97	1.01		0.97	0.94	174	166	36%
Ovig. Cyclops	1.29	1.23	1.14		1.22	1.26	7	8	2%
Bosmina	0.52	0.57	0.55	0.36	0.50	0.55	121	147	31%
Ovig. Bosmina	0.81	0.66	0.64	0.42	0.63	0.67	5	5	1%
Daphnia l.	0.87	1.25	1.09	0.67	0.97	1.09	35	45	10%
Ovig. Daphnia l.		1.41	1.39		1.40	1.41	23	24	5%
Daphnia g.	1.41	1.13	1.23		1.17	1.17	12	12	3%
Ovig. Daphnia g.	1.22	1.66	1.43		1.44		6		
Chydorinae									
Polyphemus									
TOTAL:							436	468	100%

	Body Size - Site B - Depth 38m - 40m (mm)				Mean Length (mm)	Weighted Length (mm)	Biomass (mg/m2)	Weighted Biomass (mg/m2)	% by Species
	12-Jun	**14-Jul**	**12-Aug**	**16-Sep**					
Ergasilus									
Ovig Ergasilus									
Epischura	1.40	1.56	1.19	1.48	1.41	1.26	189	137	4%
Ovig Epischura									
Diaptomus									
Ovig Diaptomus									
Cyclops	0.99	1.01	1.00	1.00	1.00	1.00	2,396	2,399	76%
Ovig. Cyclops	1.28	1.27	1.17	1.15	1.22	1.25	55	58	2%
Bosmina	0.52	0.53	0.52	0.46	0.51	0.52	297	311	10%
Ovig. Bosmina	0.70	0.71	0.62	0.54	0.64	0.64	16	16	1%
Daphnia l.	0.88	1.17	1.02	1.02	1.02	0.96	110	96	3%
Ovig. Daphnia l.	1.11	1.47	1.22	1.21	1.25	1.19	32	28	1%
Daphnia g.	1.11	1.21	1.04	0.89	1.06	1.08	70	74	2%
Ovig. Daphnia g.	1.44	1.75	1.26	1.19	1.41	1.46	42	47	1%
Chydorinae									
Polyphemus									
TOTAL:							3,207	3,166	100%

	Body Size - Site C - Depth 12m - 18m (mm)				Mean Length (mm)	Weighted Length (mm)	Biomass (mg/m2)	Weighted Biomass (mg/m2)	% by Species
	12-Jun	**14-Jul**	**12-Aug**	**16-Sep**					
Ergasilus									
Ovig Ergasilus									
Epischura	1.30	1.37	0.89	0.77	1.08	1.25	56	85	13%
Ovig Epischura									
Diaptomus									
Ovig Diaptomus									
Cyclops	0.96	1.00	1.01	0.79	0.94	0.98	66	71	11%
Ovig. Cyclops	1.26	1.28	1.19		1.24	1.27	5	5	
Bosmina	0.51	0.54	0.45	0.40	0.48	0.53	255	324	51%
Ovig. Bosmina	0.67	0.66	0.60		0.64	0.66	5	5	1%
Daphnia l.	0.94	1.02	0.84	0.64	0.86	0.98	35	47	7%
Ovig. Daphnia l.	1.16	1.28		0.82	1.09	1.23	12	16	3%
Daphnia g.	0.92	1.16	0.89		0.99	1.14	33	53	8%
Ovig. Daphnia g.		1.46			1.46	1.46	30	30	5%
Chydorinae									
Polyphemus									
TOTAL:							497	636	100%

Appendix 4. Hidden Lake 2015 - Environmental Conditions

Smolt Migration

Date	Sky	Precip. (mm)	Stage (ft)	Stage Change (ft)	Water Temp. (°C)	Air Temp. (°C)
18-May	4	0.0	0.36	0.00	ND	19.696
19-May	3	0.0	0.36	0.00	11.525	11.451
20-May	2	0.0	0.42	0.06	10.952	11.062
21-May	1	0.0	0.48	0.12	11.490	13.21
22-May	3	0.0	0.48	0.12	11.422	12.707
23-May	4	0.0	0.48	0.12	11.414	11.446
24-May	3	0.0	0.36	0.00	10.792	11.565
25-May	2	2.0	0.36	0.00	11.137	11.368
26-May	4	0.0	0.38	0.02	10.678	10.151
27-May	1	0.0	0.80	0.45	10.081	10.598
28-May	1	0.0	0.75	0.39	12.712	12.395
29-May	1	0.0	0.66	0.30	13.867	14.13
30-May	1	0.0	0.51	0.15	14.923	14.799
31-May	1	0.0	0.71	0.35	15.817	16.42
1-Jun	4	0.0	0.64	0.28	14.913	14.22
2-Jun	4	3.4	0.60	0.24	11.039	12.536
3-Jun	4	0.6	0.71	0.35	10.843	10.234
4-Jun	4	1.0	0.69	0.33	10.748	9.999
5-Jun	4	0.3	0.69	0.33	10.908	10.775
6-Jun	4	0.0	0.65	0.29	10.516	11.265
7-Jun	4	3.4	0.48	0.12	11.164	10.996
8-Jun	4	0.3	0.66	0.30	11.862	10.384
9-Jun	4	0.5	0.67	0.31	10.045	9.812
10-Jun	4	0.0	0.51	0.15	10.642	11.629
11-Jun	2	0.0	0.68	0.32	10.922	11.201
12-Jun	2	0.0	0.68	0.32	12.164	13.099
13-Jun	1	0.0	0.59	0.23	13.914	14.628
14-Jun	2	0.0	0.65	0.29	14.288	15.942
15-Jun	1	0.0	0.65	0.29	15.244	18.099
16-Jun	3	0.0	0.62	0.27	15.358	18.222
17-Jun	ND	ND	ND		15.581	19.969
18-Jun	ND	ND	ND		16.392	18.996
19-Jun	ND	ND	ND		15.886	17.28
20-Jun	ND	ND	ND		13.197	13.53
21-Jun	4	0.0	0.61	0.25	14.836	13.247
22-Jun	1	0.0	0.62	0.26	16.090	16.325
23-Jun	4	0.0	0.59	0.23	16.822	14.981
24-Jun	2	0.0	0.59	0.23	17.013	17.046
25-Jun	3	0.0	0.56	0.20	16.998	17.027
26-Jun	3	0.5	0.54	0.18	15.552	14.381
27-Jun	3	0.0	0.54	0.18	15.250	14.009
28-Jun	4	0.0	0.52	0.16	14.468	13.054
Total		12.0				
Avg.		0.3	0.57	0.21	13.2	13.7
Min.		0.0	0.36	0.00	10.0	9.8
Max.		3.4	0.80	0.45	17.0	20.0
SD		0.8	0.12	0.12	2.3	2.9

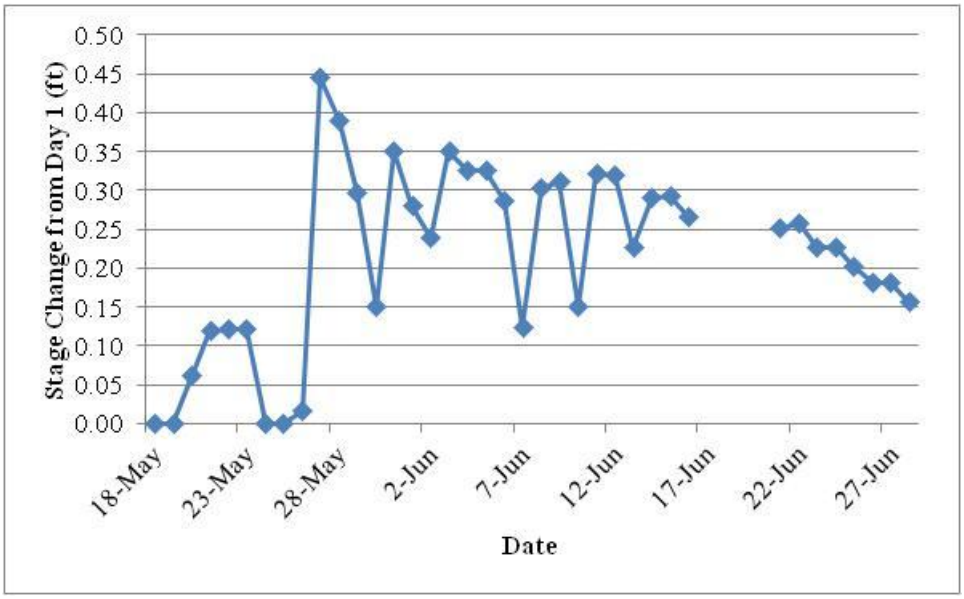
Adult Migration

Date	Sky	Precip. (mm)	Stage (ft)	Stage Change (ft)	Water Temp. (°C)	Air Temp. (°C)
10-Jul	3	0.0	0.41	0.00	15.980	14.967
11-Jul	3	0.0	0.56	0.02	16.393	15.618
12-Jul	3	0.1	0.521	0.05	16.347	15.018
13-Jul	4	0.0	0.502	0.02	15.011	14.239
14-Jul	3	0.0	0.5	0.00	14.722	13.52
15-Jul	4	0.0	0.483	0.02	14.770	13.949
16-Jul	5	0.0	0.526	0.02	14.070	14.435
17-Jul	2	0.0	0.525	0.01	14.292	15.695
18-Jul	3	0.0	0.522	0.00	14.782	15.361
19-Jul	2	0.0	0.515	0.00	15.962	15.739
20-Jul		0.0	0.464	0.00	16.535	15.888
21-Jul	1	0.0	0.431	0.00	16.473	14.744
22-Jul	4	0.1	0.522	0.05	15.823	12.742
23-Jul	3	0.3	0.532	0.34	15.409	13.431
24-Jul	1	0.0	0.523	0.00	16.550	15.988
25-Jul	2	0.0	0.498	0.00	17.617	15.68
26-Jul	4	0.6	0.5	0.60	16.030	12.654
27-Jul	5	0.1	0.481	0.07	16.028	12.974
28-Jul	4	0.5	0.578	0.48	16.490	13.375
29-Jul	4	0.1	0.586	0.07	16.616	15.063
30-Jul	3	0.0	0.548	0.01	16.776	15.428
31-Jul	1	0.0	0.515	0.00	16.870	15.215
1-Aug	2	0.0	0.589	0.00	17.997	15.825
2-Aug	1	0.0	0.572	0.02	18.505	17.43
3-Aug	1	0.0	0.574	0.00	18.505	16.43
4-Aug	1	0.0	0.562	0.00	17.775	17.218
5-Aug	2	0.0	0.559	0.00	16.998	14.307
6-Aug	4	0.0	0.582	0.00	16.933	15.177
7-Aug	2	0.0	0.581	0.00	18.204	16.95
8-Aug	4	0.0	0.558	0.00	17.998	15.228
9-Aug	4	0.1	0.558	0.12	16.776	14.724
10-Aug	2	0.1	0.562	0.13	16.855	14.287
11-Aug	2	0.1	0.554	0.05	17.108	13.957
12-Aug	1	0.0	0.562	0.00	16.440	12.54
13-Aug	3	0.0	0.566	0.00	16.949	13.933
14-Aug	2	0.0	0.582	0.00	16.870	13.863
15-Aug	5	0.2	0.59	0.15	16.252	11.704
16-Aug	5	0.2	0.578	0.22	16.062	12.75
17-Aug	5	0.4	0.598	0.40	15.887	12.576
18-Aug	2	0.3	0.604	0.28	16.775	15.519
19-Aug	1	0.0	0.58	0.00	16.075	12.828
20-Aug	1	0.0	0.58	0.00	15.645	11.526
21-Aug	4	0.2	0.561	0.23	15.807	11.873
22-Aug	2	0.0	0.571	0.00	15.391	12.472
23-Aug	2	0.0	0.574	0.02	15.438	12.675
24-Aug	2	0.0	0.562	0.00	15.438	13.166
25-Aug	2	0.0	0.563	0.00	16.521	15.699
26-Aug	2	0.1	0.578	0.11	16.363	13.349
27-Aug	5	0.3	0.584	0.26	15.855	12.973
28-Aug	1	0.1	0.58	0.10	13.474	9.561
29-Aug	2	0.0	0.559	0.00	13.122	6.918
30-Aug	3	0.0	0.557	0.00	12.608	8.198
31-Aug	1	0.0	0.5	0.00	12.334	8.919
1-Sep	1	0.0	0.5	0.00	11.957	7.484
2-Sep	1	0.0	0.5	0.00	12.116	8.453
3-Sep	5	0.6	0.501	0.61	13.252	9.898
4-Sep	4	0.4	0.506	0.44	12.979	10.255
5-Sep	4	0.1	0.558	0.05	13.860	12.138
6-Sep	5	0.2	0.50	0.20	13.893	11.312
7-Sep	3	0.0	0.50	0.00	13.700	11.354
8-Sep	5	0.1	0.57	0.10	13.413	11.473
9-Sep	4	0.0	0.57	0.03	13.140	12.117
10-Sep	5	0.1	0.57	0.08	12.432	10.667
11-Sep	3	0.2	0.60	0.15	11.608	8.839
12-Sep	3	0.2	0.60	0.20	11.997	9.299
13-Sep	3	0.0	0.56	0.00	10.516	7.42
14-Sep	3	0.5	0.58	0.48	11.330	8.502
15-Sep	5	0.9	0.66	0.88	12.126	9.01
16-Sep	3	0.4	0.66	0.38	12.029	8.028
17-Sep	4	0.3	0.62	0.28	11.560	6.146
18-Sep	3	0.1	0.62	0.09	10.891	5.799
19-Sep	2	0.0	0.62	0.02	10.728	5.252
20-Sep	2	0.0	0.62	0.02	11.088	5.527
Total		7.8				
Avg.		0.1	0.55	0.09	15.03	12.54
Min.		0.0	0.41	0.00	10.52	5.25
Max.		0.9	0.66	0.61	18.51	17.43
SD		0.2	0.05	0.15	2.15	3.09

*ND means no data was collected for those dates

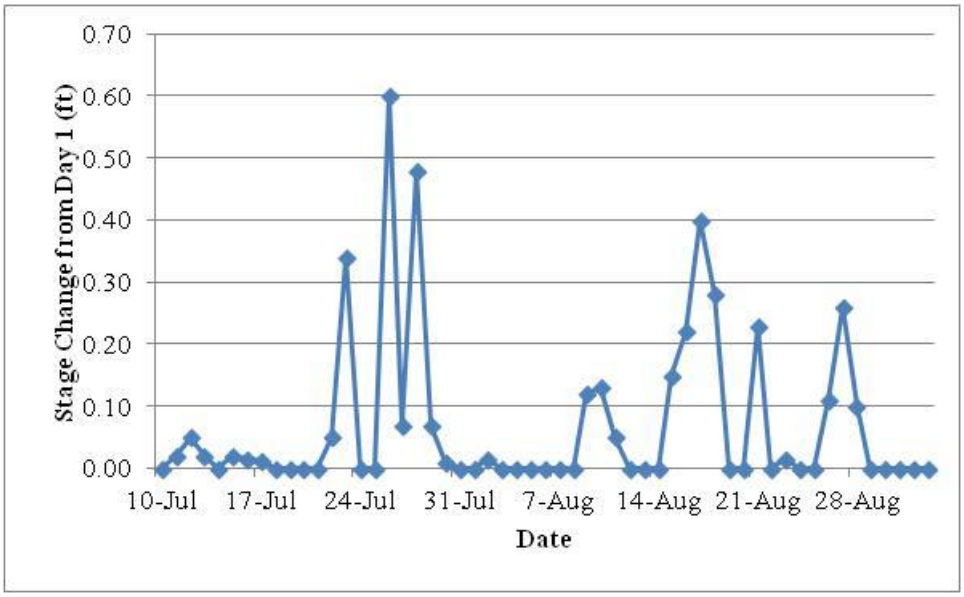
Appendix 5. Hidden Lake 2015 - Stage Height Changes

Smolt Migration



No stream stage readings were taken June 17–20 due to a fire evacuation

Adult Migration



Appendix 6. Hidden Lake 2015 - Smolt Migration

	Sockeye					Coho		Rainbow		Dolly Varden	
Date	Daily	Morts	Otoliths	Total	% Smpl	Daily	Total	Daily	Total	Daily	Total
18-May	0	0		0		8	8	18	18	3	3
19-May	0	0		0		15	23	16	34	3	6
20-May	0	0		0		16	39	0	34	0	6
21-May	0	0		0		26	65	10	44	0	6
22-May	0	0		0		53	118	3	47	0	6
23-May	1	0		1		96	214	2	49	0	6
24-May	7	0		8		225	439	9	58	3	9
25-May	7	0		15		228	667	1	59	3	12
26-May	1	0		16		468	1,135	2	61	5	17
27-May	21,481	0		21,497		320	1,455	46	107	35	52
28-May	23,236	0	47	44,733	0.20%	525	1,980	43	150	19	71
29-May	33,893	0	56	78,626	0.17%	303	2,283	20	170	10	81
30-May	16,455	0	73	95,081	0.44%	281	2,564	11	181	4	85
31-May	49,644	0		144,725	0.00%	745	3,309	18	199	6	91
1-Jun	34,426	0	101	179,151	0.29%	1,676	4,985	21	220	8	99
2-Jun	3,644	0		182,795	0.00%	366	5,351	1	221	3	102
3-Jun	10,487	0	71	193,282	0.68%	475	5,826	9	230	4	106
4-Jun	4,491	0	51	197,773	1.14%	694	6,520	6	236	10	116
5-Jun	4,664	0		202,437	0.00%	337	6,857	1	237	7	123
6-Jun	2,750	0		205,187	0.00%	188	7,045	0	237	3	126
7-Jun	19,489	0		224,676	0.00%	178	7,223	3	240	11	137
8-Jun	9,758	0		234,434	0.00%	407	7,630	4	244	3	140
9-Jun	4,715	0		239,149	0.00%	225	7,855	2	246	2	142
10-Jun	9,609	45		248,758	0.00%	50	7,905	1	247	4	146
11-Jun	33,998	44	41	282,756	0.12%	198	8,103	4	251	7	153
12-Jun	23,219	6		305,975	0.00%	185	8,288	3	254	11	164
13-Jun	9,145	65	134	315,120	1.47%	235	8,523	7	261	10	174
14-Jun	10,214	68		325,334	0.00%	171	8,694	4	265	3	177
15-Jun	5,987	72		331,321	0.00%	140	8,834	3	268	7	184
16-Jun	3,079	89		334,400	0.00%	46	8,880	1	269	2	186
17-Jun	438	48		334,838	0.00%	16	8,896	0	269	1	187
18-Jun	*	*		334,838		*		*		*	
19-Jun	*	*		334,838		*		*		*	
20-Jun	*	*		334,838		*		*		*	
21-Jun	72	2		334,910	0.00%	7	8,903	0	269	0	187
22-Jun	181	5		335,091	0.00%	39	8,942	0	269	0	187
23-Jun	567	2		335,658	0.00%	7	8,949	0	269	2	189
24-Jun	556	1		336,214	0.00%	12	8,961	0	269	0	189
25-Jun	328	0	27	336,542	8.23%	2	8,963	0	269	0	189
26-Jun	116	0		336,658	0.00%	4	8,967	0	269	0	189
27-Jun	72	0		336,730	0.00%	0	8,967	0	269	0	189
28-Jun	241	0		336,971	0.00%	3	8,970	0	269	0	189
Total	**335,923**	**447**	**601**	**336,971**	**0.18%**	**8,970**	**8,970**	**269**	**269**	**189**	**189**

*Indicates no counts were made for those days due to fire evacuation

Appendix 7. Hidden Lake 2015 - Adult Migration

	Sockeye			Coho		King		Pink		Chum		Rainbow		Dolly Varden	
Date	Daily	Otolith	Total	Daily	Total	Daily	Total	Daily	Total	Daily	Total	Daily	Total	Daily	Total
8-Jul									0						
9-Jul									0						
10-Jul	0		0	0	0	0	0	0	0	0	0	0	0	0	0
11-Jul	0		0	0	0	0	0	0	0	0	0	0	0	0	0
12-Jul	0		0	0	0	0	0	0	0	0	0	0	0	0	0
13-Jul	0		0	0	0	0	0	0	0	0	0	0	0	0	0
14-Jul	0		0	0	0	0	0	0	0	0	0	0	0	0	0
15-Jul	0		0	0	0	0	0	0	0	0	0	0	0	0	0
16-Jul	0		0	0	0	0	0	0	0	0	0	0	0	0	0
17-Jul	0		0	0	0	0	0	0	0	0	0	0	0	0	0
18-Jul	97		97	0	0	0	0	0	0	0	0	0	0	0	0
19-Jul	63		160	0	0	0	0	0	0	0	0	0	0	0	0
20-Jul	0		160	0	0	0	0	0	0	0	0	0	0	0	0
21-Jul	1		161	0	0	0	0	0	0	0	0	0	0	0	0
22-Jul	2		163	0	0	0	0	0	0	0	0	0	0	0	0
23-Jul	3		166	0	0	0	0	0	0	0	0	0	0	0	0
24-Jul	0		166	0	0	0	0	0	0	0	0	0	0	0	0
25-Jul	0		166	0	0	0	0	0	0	0	0	0	0	0	0
26-Jul	8		174	0	0	0	0	0	0	0	0	0	0	0	0
27-Jul	54		228	0	0	0	0	0	0	0	0	0	0	0	0
28-Jul	37		265	0	0	0	0	0	0	0	0	0	0	0	0
29-Jul	356		621	0	0	0	0	0	0	0	0	0	0	0	0
30-Jul	5		626	0	0	0	0	0	0	0	0	0	0	0	0
31-Jul	69		695	0	0	0	0	0	0	0	0	0	0	0	0
1-Aug	193		888	0	0	0	0	0	0	0	0	0	0	0	0
2-Aug	320		1,208	0	0	0	0	0	0	0	0	0	0	0	0
3-Aug	104		1,312	0	0	0	0	0	0	0	0	0	0	0	0
4-Aug	178		1,490	0	0	0	0	0	0	0	0	0	0	0	0
5-Aug	843		2,333	0	0	0	0	0	0	0	0	0	0	0	0
6-Aug	308		2,641	0	0	0	0	0	0	0	0	0	0	0	0
7-Aug	60		2,701	0	0	0	0	0	0	0	0	0	0	0	0
8-Aug	588		3,289	0	0	0	0	0	0	0	0	0	0	0	0
9-Aug	168		3,457	0	0	0	0	0	0	0	0	0	0	0	0
10-Aug	2,221	200	5,678	0	0	0	0	0	0	0	0	0	0	0	0
11-Aug	49		5,727	0	0	0	0	0	0	0	0	0	0	0	0
12-Aug	244		5,971	0	0	0	0	0	0	0	0	0	0	0	0
13-Aug	166		6,137	0	0	0	0	0	0	0	0	0	0	0	0
14-Aug	721		6,858	0	0	0	0	0	0	0	0	0	0	0	0
15-Aug	289		7,147	0	0	0	0	0	0	0	0	0	0	0	0
16-Aug	1,367		8,514	0	0	0	0	0	0	0	0	0	0	0	0
17-Aug	0		8,514	0	0	0	0	0	0	0	0	0	0	0	0
18-Aug	908	200	9,422	0	0	0	0	0	0	0	0	0	0	0	0
19-Aug	40		9,462	0	0	0	0	0	0	0	0	0	0	0	0
20-Aug	18		9,480	0	0	0	0	0	0	0	0	0	0	0	0
21-Aug	207		9,687	0	0	0	0	0	0	0	0	0	0	0	0
22-Aug	653		10,340	0	0	0	0	1	1	0	0	0	0	0	0
23-Aug	546		10,886	0	0	0	0	0	1	0	0	0	0	0	0
24-Aug	502		11,388	0	0	0	0	0	1	0	0	0	0	0	0
25-Aug	433		11,821	0	0	0	0	0	1	0	0	0	0	0	0
26-Aug	80		11,901	0	0	0	0	0	1	0	0	0	0	0	0
27-Aug	540	200	12,441	0	0	0	0	0	1	0	0	0	0	0	0
28-Aug	462		12,903	0	0	0	0	0	1	0	0	0	0	0	0
29-Aug	346		13,249	0	0	0	0	0	1	0	0	0	0	0	0
30-Aug	386		13,635	0	0	0	0	0	1	0	0	0	0	0	0
31-Aug	199		13,834	0	0	0	0	0	1	0	0	0	0	0	0
1-Sep	276		14,110	0	0	0	0	0	1	0	0	0	0	0	0
2-Sep	135		14,245	0	0	0	0	0	1	0	0	0	0	0	0
3-Sep	467		14,712	0	0	0	0	0	1	0	0	0	0	0	0
4-Sep	67		14,779	0	0	0	0	0	1	0	0	0	0	0	0
5-Sep	2,257		17,036	7	7	0	0	0	1	0	0	0	0	0	0
6-Sep	82		17,118	0	7	0	0	0	1	0	0	0	0	0	0
7-Sep	4		17,122	0	7	0	0	0	1	0	0	0	0	0	0
8-Sep	67		17,189	0	7	0	0	0	1	0	0	0	0	0	0
9-Sep	424		17,613	0	7	0	0	0	1	0	0	0	0	0	0
10-Sep	85		17,698	0	7	0	0	0	1	0	0	0	0	0	0
11-Sep	97		17,795	0	7	0	0	0	1	0	0	0	0	0	0
12-Sep	48		17,843	0	7	0	0	0	1	0	0	0	0	0	0
13-Sep	156		17,999	0	7	0	0	0	1	0	0	0	0	0	0
14-Sep	101		18,100	0	7	0	0	0	1	0	0	0	0	0	0
15-Sep	134		18,234	0	7	0	0	0	1	0	0	0	0	0	0
16-Sep	454		18,688	0	7	0	0	0	1	0	0	0	0	0	0
17-Sep	20		18,708	0	7	0	0	0	1	0	0	0	0	0	0
18-Sep	5		18,713	0	7	0	0	0	1	0	0	0	0	0	0
19-Sep	46		18,759	0	7	0	0	0	1	0	0	0	0	0	0
20-Sep	26		18,785	0	7	0	0	0	1	0	0	0	0	0	0
Total	18,785	600	18,785	7		0		1		0		0		0	

Appendix 8. Hidden Lake 2015 Adult Sockeye Salmon Escapement Sex Ratio and Size Data

	Age					
	1.2	1.3	1.4	2.2	2.3	Total
Sample Period:	July 23 - September 9, 2015					
Males (No.)	7,390	910		568		8,868
Percent	83.3%	10.3%		6.4%		45.7%
Sample Size	130	16		10		156
Total Sample Size						
Mean Length (mm)	498	531		492		507
St Dev	19	29		25		24
Females (No.)	9,380	910		227		10,517
Percent	89.2%	8.6%		2.2%		54.3%
Sample Size	165	16		4		185
Total Sample Size						
Mean Length (mm)	486	516		485		496
St Dev	17	19		12		16
Both Sexes (No.)	16,770	1,819		796		19,385
Percent	86.5%	9.4%		4.1%		100.0%
Sample Size	295	32		14		341
Total Sample Size						
Mean Length (mm)	492	524		490		502
St Dev	19	25		22		22

Total means for males, females and both sexes are generated from the total sample size

Appendix 9. Hidden Lake 2015 - Update

Stocking & Misc. Activities

Ice-out:	NA		
Smolt crew on-site:	18-May		
Smolt crew off-site:	28-Jun		
Adult crew on-site:	8-Jul		
Adult crew off-site:	20-Sep		
Fry stocking:	1-May		
Adult Otolith Collection	10-Aug-15	18-Aug	27-Aug

Egg Take

Dates:	16-Sep	to	21-Sep
	No. Female		No. Male
No. of broodstock used:	635		635
Green eggs:	1,445,598		
Fecundity:	2,277		
Eyed eggs:	1,266,663		
Survival	88%		

Smolt Migration

Dates:	23-May	to	28-Jun
		No.	%
Sockeyes:	**335,923**		
Mortalities:		447	0.13%
Age 1:		318,726	95%
Age 2:		17,197	5%
Hatchery:		185,159	55%
Coho:	**8,970**		
Dolly Varden:	**189**		
Rainbow:	**269**		

Adult Migration

Dates:	8-Jul	to	20-Sep
		No.	%
Sockeye total return:	**41,889**		
Hidden Creek return:		19,385	46.3%
Commercial Harvest:*		11,700	27.9%
Personal Use/Sport Fish Harvest:*		11,404	27.2%
Otolith Collection:		600	1.4%
Lake otolith collection:		702	
Mortalites:			
Lake Escapement:	**18,785**		
Hatchery broodstock:		1,313	
Lake broodstock:		17,576	
Lake otolith collection:		496	
Coho:	**7**		

** Commercial, sportfish and personal use harvests provided by ADF&G.*