Leisure Lake
Sockeye Salmon Enhancement
Progress Report
2015

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February 2016

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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 in 2015 for Leisure Lake. It also includes historical smolt and limnology data collected by Alaska Department of Fish and Game (ADF&G) and CIAA for comparative purposes.

The purpose of the progress report is to provide a vehicle to distribute the information produced by the monitoring and evaluation studies. 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 other reports.

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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.

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ACKNOWLEDGEMENTS

Many individuals and agencies contributed to the success of the Leisure Lake Project. Appreciation is extended to Cook Inlet Aquaculture Association seasonal assistants, and full-time staff who invested many hours in planning and executing this project. Thanks are also extended to the Kachemak State Park staff for their cooperation in accommodating our field camp and fertilizer storage sites, Mako's Water Taxi for crew and equipment transportation, and to Alaska West Air and Northwind Aviation for flight services and fertilizer delivery.

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ABSTRACT

The 2015 Leisure Lake smolt migration was enumerated between May 6–8, and then from May 11 to June 22, 2015. An estimated 461,818 (±12,543) sockeye salmon smolt were enumerated as they emigrated from Leisure Lake. A sample of n=600 smolt were collected throughout the run of which the otoliths from n=593 were readable. Sampled smolt were assessed for fork length, weight, and aged; and thermal mark determined via otolith analysis. Sampled smolt ranged in freshwater age from 1–3 years with age-1 comprising 61.4% of the 2015 migration. Based on otolith data, the age-1 sockeye salmon smolt were determined to be from the 2014 stocking of 1,353,000 English Bay Lakes stock fry (0.24 g/fry; BY 13). The age-2 fish leaving in 2015, which comprised 38.4% of the outmigration, resulted from the stocking of 1,800,000 Hidden Lake fry (BY 12) in 2013 at 0.18 g/fry. An additional 0.2% of the outmigration was made up of age-3 Hidden Lake smolt stocked as fry in 2012. To estimate marine survival, adult sockeye salmon returns will be monitored and otoliths will be checked for thermal marking in 2016 and 2017. Marine survival will be assessed via sampling of harvests in the commercial, cost recovery, and sport fisheries.

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INTRODUCTION AND PURPOSE

Leisure Lake has been stocked with sockeye salmon (*Onchorynchus nerka*) beginning with the Alaska Department of Fish and Game (ADF&G) release of Tustumena Lake sockeye salmon fry from the Crooked Creek Hatchery in 1976. In 1993, Cook Inlet Aquaculture Association (CIAA) took over the Crooked Creek Hatchery as well as stocking operations at Leisure Lake, and since then has used three different stocks to supply an average of 1.7 million sockeye salmon fry to support this terminal fishery on an annual basis. The Tustumena Lake stock was used through brood year (BY) 2003 when the 9th Circuit Court of Appeals deemed the Tustumena project as incompatible with the wilderness designation of Tustumena Lake and CIAA subsequently lost the ability to use that stock as a brood source. In 2004, CIAA released the last fish from Tustumena Lake into Leisure Lake. After this, CIAA used the Hidden Lake stock from BY 2004–2012 and transitioned to the English Bay Lakes stock for BY 2013. The purpose of this study will be to determine freshwater and marine survivals of the sockeye salmon fry stocked in this system, as well as provide a comparison on the performance of the Hidden Lake and English Bay Lakes stocks.

Data regarding sockeye salmon adult returns to Leisure Creek gathered by ADF&G between 1979 and 1984 have been widely variable and were based on commercial and personal use dip net catches from China Poot Bay. Returns for those years ranged from a high of 117,360 in 1984 to a low of 3,400 in 1982 (Bechtol and Dudiak, 1988) (appendices 6 and 7). However, no analysis was done to determine if these harvests were solely the result of Leisure Lake stocking or fish intercepted from other systems. Yearly variations in environmental conditions (e.g., wind) could lead sockeye salmon from other stocks such as Hazel Lake or Upper Cook Inlet to China Poot Bay and could skew the estimated return of Leisure Lake sockeye salmon. Beginning in 2016, CIAA plans to remove otoliths from a representative sub-sample of adult sockeye salmon harvested in the commercial and cost recovery fisheries in China Poot Bay. Pending funding, CIAA also plans to collect samples from the personal use fishery as well. This will allow CIAA staff to determine the origin of the sockeye salmon and estimate the marine survival of the sockeye smolt migrating from Leisure Lake.

In addition to the stocking program, ADF&G and CIAA have been applying liquid fertilizer to Leisure Lake. This fertilization program has been an important element of the enhancement project. The fertilizer is applied throughout the growing season to the pelagic area of the lake to stimulate algae growth, increase the zooplankton community, and bolster the food chain from the bottom up.

This report provides data from the 2015 smolt enumeration, limnology and fertilization projects, as well as historical data regarding stocking numbers and limnological sampling.

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PROJECT AREA

Leisure Lake is located at 59º32’ N latitude and 151º12’ W longitude in Kachemak Bay State Park, approximately 13 kilometers southeast of Homer, Alaska (Figure 1). It has a surface elevation of 51 meters and a surface area of 1.05 x $10^6 m^2$ (Figure 2) (Bechtol and Dudiak, 1988). There are three small unnamed tributaries to Leisure Lake located on the north-east, east, and south-west sides of the lake, and several vernal streams. The lake’s discharge forms Leisure Creek, which flows 1.5 km into the China Poot Bay. A barrier falls near China Poot Bay prevents adult salmon from returning to the lake.

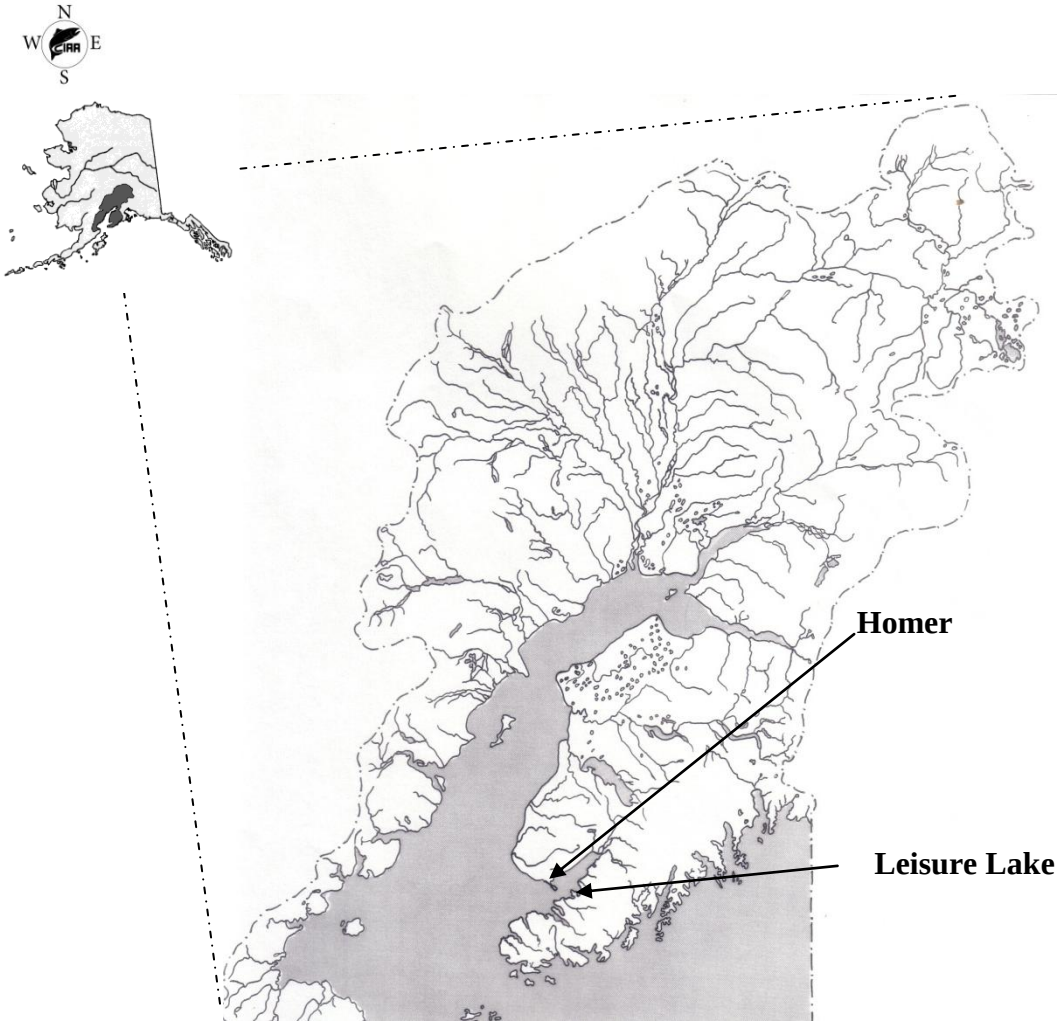

Figure 1: Leisure Lake in Relation to Cook Inlet and Alaska

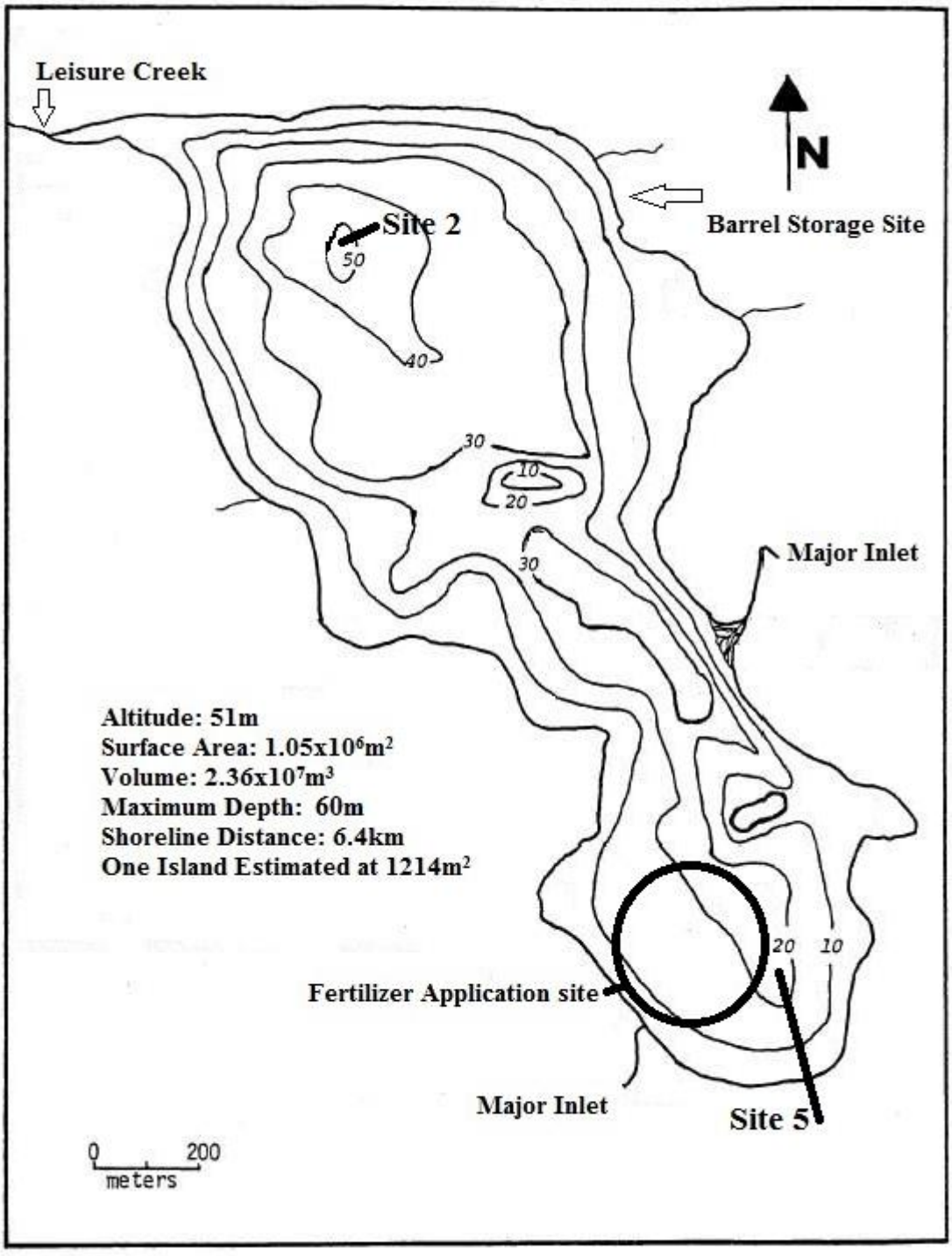

Figure 2: Bathymetric Map of Leisure Lake

METHODS

Limnological Sampling & Environmental Conditions

During 2015, water quality samples were collected four times during the open water season on May 26, June 30, August 3, and September 8. Two primary sites, Stations 2 and 5 (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.

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 Leisure Lake, percent cloud cover was visually estimated, water level in the creek recorded to the nearest 0.1 foot, precipitation measured to the nearest millimeter, and water and air temperatures (Celsius) were recorded at 5:00 PM daily. Standard CIAA procedures were followed for collecting these observations (CIAA, 2015).

Smolt Enumeration and Characteristics

To enumerate the smolt migration, a collection facility was temporarily placed in Leisure Creek, approximately 50 meters upstream from the mouth of the creek. A trap installed in early May, which was comprised of a modified fyke net attached to a double compartment live box, was positioned in the main flow of the creek. There were 2 leads composed of vexar® paneling, which were anchored upstream to each bank and functioned by directing smolts into the trap. The use of the paneling enabled staff to sample the entire width of the creek to ensure a total smolt count.

Typically, staff checked the trap at least four times daily and all smolts were enumerated. Age (otolith), weight, and length (AWL) data were collected from a random sample of the migrating smolts. The CIAA procedures manual sets forth a protocol for the collection of random AWL and otolith samples in an attempt to sample 0.2% of the smolt outmigration, or every 500th smolt throughout the run. The smolt crew did not reach the goal of sampling 0.2% of the 2015 smolt emigration. Six-hundred sockeye smolt otoliths and AWL measurements were collected throughout the run. Of the otoliths collected, n=593 were readable, or 0.13% of the total outmigration. Each smolt sacrificed for evaluation was first anesthetized with a lethal dose of

MS-222, then measured for fork length[1] to the nearest millimeter and weighed to the nearest gram. Otoliths were removed from the smolt and placed in an ethyl alcohol solution for subsequent age determination at the CIAA lab (Glick and Shields, 1993). The Leisure Lake Smolt Procedures Manual outlines the AWL procedures (CIAA, 2015).

On May 9–10 no smolt counts were made due to a staffing issue. Using a straight line between existing data points it is estimated that approximately 10,036 smolt were missed during this time period or 2.2% of the total estimated outmigration. For the purposes of this report, this estimate was not included in the smolt count for 2015 because 2.2% of the population would not significantly affect the marine survival estimates in future studies at Leisure Lake.

The sockeye smolt characteristic data regarding weight and length, and the proportion of age 1, and 2 sockeye smolt in the migrating population, were estimated with the following notations and formulas provided by ADF&G, since no wild stock exists in Leisure Lake, q_h=0. No-wild produced smolt were detected in any of the samples from 2014–2015.

If:

N = total number of migrating smolts,

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

n = total number of smolts sampled,

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

a = total number of enhanced smolts sampled,

a_h = number of enhanced smolts sampled in stratum h, $\left(a = \sum a_h\right)$,

$p_h = a_h / n_h$, The proportion of enhanced smolts in stratum h,

$q_h = 1 - p_h$, The proportion of wild smolts in stratum h,

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

[1] Fork length is defined as the length from the tip of the snout to the fork of the tail.

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

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

$m_{hi} = 1 - l_{hi}$, The proportion of other than age $= i$ smolts 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.

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

$$\hat{L}_i = c_i \big/ n; \qquad \text{with a variance of} \qquad v(\hat{L}_i) = (1 - f)\frac{1}{n}\sum_h W_h l_{hi} m_{hi};$$

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

$$\hat{C}_i = N(\hat{L}_i); \qquad \text{with a variance of} \qquad v(\hat{C}_i) = N^2 v(\hat{L}_i).$$

Confidence interval (90%) estimates for age-class proportion and abundance, assuming 2 age-classes, are:

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

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:

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

The confidence interval (95%) estimate for the mean weight and length is:

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

A total count of smolt migrating from Leisure Lake was made until the migration of fish exceeded 1,000 to 2,000 fish per hour. At migrations 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 was used to enumerate the fish.

To enumerate migrating smolt with the 10% sub-sampling procedure, the counting day was divided into 20-minute intervals. During each 20-minute interval, migrating fish were directed into the live-box for two minutes and counted. The two-minute interval used for counting was taken from a list of random numbers (1–20) generated in Microsoft Excel™. The order of the list determines which two-minute block of time will be counted within the 20-minute period. For the first 10% count the field crew would count the two-minute period within the 20-minute block, which corresponds with the first random number on the list and follow down the list for any subsequent 10% counts. During the remaining 18 minutes, migrating smolt passed through the trap uncounted. To estimate the number of smolt migrating during the 20-minute interval, the two-minute smolt count was multiplied by 10.

Assuming the two-minute sampling intervals were randomly distributed throughout the 20-minute sampling period and smolt moved through the weir randomly, the total smolt migration was estimated as follows:

If:

T_c = number of fish counted with the total count procedure,

$\hat{T}_s$ = number of fish counted with the 10% sub-sampling procedure,

$\hat{T}$ = the total smolt migration,

y = the number of fish counted in each two minute sub-sampling interval,

n = the number of two minute sub-sampling intervals sampled, and

N = the number of possible two minute sub-sampling intervals,

Then, the total smolt migration ($\hat{T}$) is:

$$\hat{T} = T_c + \hat{T}_s;$$

with a variance of:

$$v\left(\hat{T}_s\right) = N^2\left((N-n)/N\right)\sum\left(y_i - \bar{y}\right)^2 / \left(n(n-1)\right);$$

and 95% confidence limits of:

$$\hat{T}_s \pm 2\sqrt{v\left(\hat{T}_s\right)}.$$

The variance about the estimated smolt migration, $\hat{T}$, is equal to the variance about $\hat{T}_s$, because T_c is a total count with 0 variance.

Fertilization

To enhance the food source of juvenile salmon in Leisure Lake, liquid fertilizer composed of 20% nitrogen, 5% phosphorus, and 0% potassium was mixed with lake water and sprayed from the back of a small skiff. A 12 volt Bean® pump and a sprayer manifold attached to the stern of the skiff were used to mix and deliver the fertilizer. To assure that the nutrients were evenly distributed, spatially and temporally, several transects were run over the application area, i.e., the southern portion of the lake (Figure 2). To ensure that CIAA is applying the appropriate dosage of fertilizer to Leisure Lake, ADF&G provided the results of the May 26 limnological sampling to CIAA in June so adjustments could be made to the amount of fertilizer applied to the lake if needed. Calculations made using the total phosphorus from this in-season analysis indicated no change in fertilizer dosage was needed. Approximately 300 gallons of fertilizer were applied weekly for nine weeks from June–August. During that time frame, 96 barrels totaling 2,880 gallons or approximately 15 tons of fertilizer were applied to Leisure Lake.

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RESULTS AND DISCUSSION

Limnological & Environmental Conditions

During the 2015 smolt migration, staff monitored environmental conditions at 5:00 PM from May 6 through June 22. Water levels in the creek were monitored for the same time period and water levels fluctuated 0.34 ft during that time period (Figure 3). Stream temperatures averaged 9.1ºC (±2.4ºC) [mean ± standard deviation] and ranged from 5.0 to 13.0ºC (Table 1). Air temperatures averaged 13.6ºC (±3.5 ºC) and ranged from 7.0 to 20.0ºC. Forty-two percent of the days were clear, 10% were less than 50% cloudy, 15% were more than 50% cloud covered, 17% were completely overcast and 17% had measured rainfall (Table 2). A total of 56.6 mm of rain fell during that period.

Table 1: Environmental Summary, Leisure Lake, 2015

	Precip. (mm)	Stage Height (ft)	Water Temp. (◦C)	Air Temp. (◦C)
Total	56.6			
Avg.	1.2	1.1	9.1	13.6
Min.	0.0	0.9	5.0	7.0
Max.	12.7	1.2	13.0	20.0

Table 2: Summary of Cloud Cover, Leisure Lake, 2014–2015

Year	Total Days	Clear	<50% Cloud Cover	>50% Cloud Cover	100% Overcast	Rain	Days Meas. Precip	Precip (mm)	Temperature (C) Air Avg	Air Range	Water Avg	Water Range
2014	50	22%	26%	20%	24%	8%	18	52.6	13.7	10.0–17.0	10.2	8.0–12.0
2015	48	33%	17%	17%	15%	10%	16	56.6	13.6	7.0–20.0	9.1	5.0–13.0

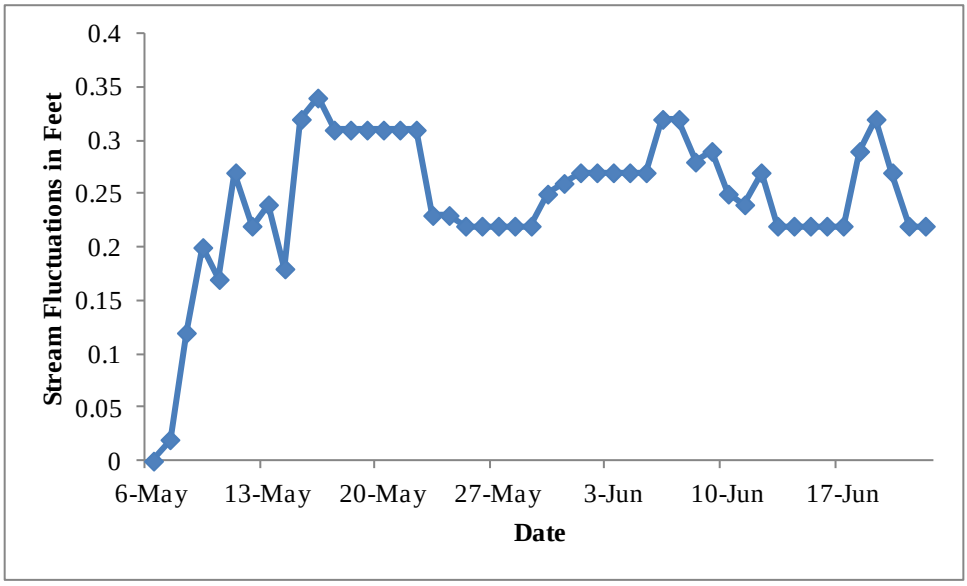

Figure 3: Stream Stage, Leisure Lake, 2015

Water samples were analyzed by ADF&G staff in the ADF&G lab in Soldotna (tables 3 and 4). Limnological results and zooplankton information is presented in appendices 3–5.

Table 3: Nutrients and Primary Productivity, Leisure Lake, 2015

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)	Site	EZD (m)
5/26/2015	2	1	2.6	1.1	0.7	120.0	11.2	592.3	111.7	:1	2,919	181	1.25	0.28	2	18.6
5/26/2015	2	40	2.2	1.2	1.0	121.0	13.5	551.4	135.4	:1	2,961	64	0.47	0.23		
5/26/2015	5	1	2.1	1.0	0.6	161.2	14.6	582.2	185.4	:1	2,934	138	0.94	0.29	5	16
5/26/2015	5	18	2.9	1.1	1.2	150.8	14.0	565.3	125.8	:1	3,006	136	1.23	0.40		
6/30/2015	2	1	13.1	4.6	1.7	218.3	18.5	356.6	40.0	:1	2,371	411	6.80	1.20	2	13.1
6/30/2015	2	40	1.9	2.2	0.8	94.0	11.2	572.2	122.6	:1	2,834	80	0.43	0.30		
6/30/2015	5	1	10.9	3.7	1.3	182.6	16.0	388.7	40.3	:1	2,410	361	4.19	1.24	5	11.2
6/30/2015	5	13	6.0	2.2	1.2	122.3	11.7	483.6	49.5	:1	2,774	265	3.31	1.38		
8/3/2015	2	1	10.6	5.4	1.5	213.6	15.7	252.2	47.9	:1	915	393	5.39	1.09	2	8.3
8/3/2015	2	43	2.0	1.8	1.0	81.6	9.7	579.7	101.1	:1	2,890	42	0.49	0.27		
8/3/2015	5	1	26.7	11.0	8.4	338.9	17.0	278.0	29.5	:1	909	593	13.24	2.17	5	10.3
8/3/2015	5	17	5.5	2.3	1.7	138.7	36.4	479.8	70.5	:1	3,135	129	2.06	1.24		
9/8/2015	2	1	6.0	4.6	1.4	237.7	14.9	177.5	93.2	:1	1,120	251	8.96	0.90	2	17.7
9/8/2015	2	40	6.6	7.2	4.9	128.8	9.6	589.2	46.4	:1	3,119	51	0.52	0.58		
9/8/2015	5	1	11.4	4.9	1.5	284.1	15.9	168.7	58.3	:1	1,147	309	17.40	1.16	5	13.3
9/8/2015	5	18	4.1	3.8	1.0	162.0	9.5	498.0	92.6	:1	3,601	93	0.72	0.70		
Mean	1 - Meter		10.4	4.5	2.1	219.6	15.5	349.5	75.8	:1	1,841	330	7.27	1.04	Mean	13.6
Min			2.1	1.0	0.6	120.0	11.2	168.7	29.5	:1	909	138	0.94	0.28	Min	8.3
Max			26.7	11.0	8.4	338.9	18.5	592.3	185.4	:1	2,934	593	17.40	2.17	Max	18.6
Mean	Hypolimnion		3.9	2.7	1.6	124.9	14.5	539.9	93.0	:1	3,040	108	1.15	0.64		
Min			1.9	1.1	0.8	81.6	9.5	479.8	46.4	:1	2,774	42	0.43	0.23		
Max			6.6	7.2	4.9	162.0	36.4	589.2	135.4	:1	3,601	265	3.31	1.38		

Table 4: General Tests and Metals, Leisure Lake, 2015

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)
5/26/2015	2	1	84	7.1	32.3	0.2	6	14.2	0.3	7	2	6.0
5/26/2015	2	40	81	6.9	32.2	0.1	6	14.1	0.4	4		
5/26/2015	5	1	81	7.3	32.8	0.2	6	13.7	0.3	8	5	7.0
5/26/2015	5	18	80	7.2	32.6	0.2	9	13.9	0.4	7		
6/30/2015	2	1	91	7.9	32.2	0.4	3	13.7	0.7	11	2	3.8
6/30/2015	2	40	91	7.0	31.8	0.0	4	13.6	0.7	1		
6/30/2015	5	1	91	8.1	31.9	0.2	4	13.7	0.7	16	5	3.8
6/30/2015	5	13	89	7.3	32.4	0.0	4	13.9	0.5	1		
8/3/2015	2	1	86	8.4	32.2	0.9	4	13.8	1.1	8	2	4.0
8/3/2015	2	43	78	6.9	32.9	0.2	6	14.1	0.7	2		
8/3/2015	5	1	84	8.4	32.8	0.5	6	14.3	0.9	7	5	2.5
8/3/2015	5	17	96	6.9	31.2	0.2	5	13.9	0.6	4		
9/8/2015	2	1	100	8.5	33.1	0.3	4	13.4	0.7	10	2	3.0
9/8/2015	2	40	93	6.9	31.7	0.3	4	13.7	0.8	6		
9/8/2015	5	1	100	8.5	34.3	0.2	4	13.6	0.6	6	5	2.5
9/8/2015	5	18	95	6.7	31.8	0.2	3	13.7	1.3	2		
Mean	1 - Meter		90	8.0	32.7	0.4	5	13.8	0.7	9	Mean	4.1
Min			81	7.1	31.9	0.2	3	13.4	0.3	6	Min	2.5
Max			100	8.5	34.3	0.9	6	14.3	1.1	16	Max	7.0
Mean	Hypolimnion		88	7.0	32.1	0.2	5	13.9	0.7	3		
Min			78	6.7	31.2	0.0	3	13.6	0.4	1		
Max			96	7.3	32.9	0.3	9	14.1	1.3	7		

Smolt Enumeration and Characteristics

The Leisure Lake smolt migration was enumerated from May 9 through June 22, 2015. During that time, an estimated 461,818(±12,543) sockeye salmon smolt were enumerated while migrating from Leisure Lake (figures 4 and 5). The peak migration was 31,096 smolt, which occurred on May 21. Ten percent sub-sampling was performed on 8.4% of the run (38,990 fish). The daily and cumulative smolt migration for 2015 is depicted (in red) in figures 4–5 along with the smolt migration data from 2014 (in black) for comparative purposes.

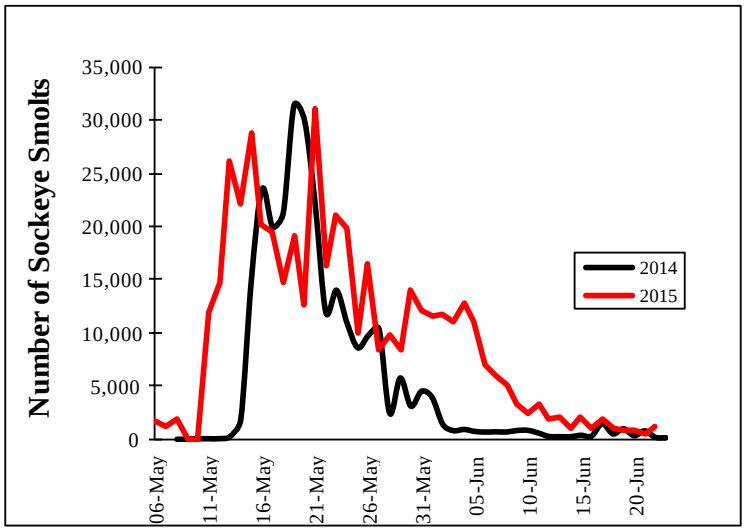

Figure 4: Daily Smolt Migration, Leisure Lake, 2014–2015

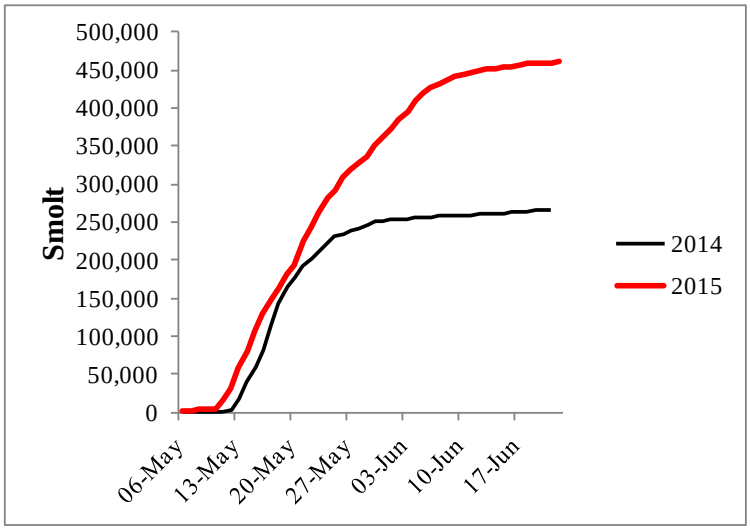

Figure 5: Cumulative Smolt Migration, Leisure Lake, 2014–2015

Throughout the migration, staff collected 600 sockeye salmon smolt (0.13% of total estimated population), and took otolith samples, weight, and measurements for fork length. Based on the

593 otolith samples that were readable, there were 3 age classes observed during the migration. Within the sample, age-1 was the most abundant age class comprising 61.4% of the outmigration, age-2 smolt accounted for 38.4% and age-3 smolt (only one sample) accounted for 0.2%. The average length of the sampled age-1 sockeye salmon smolt was 79.9 mm (±0.3 mm) and the average weight was 4.70 g (±0.05 g). The average length of the age-2 sockeye salmon smolt was 98.9 mm (±0.8 mm) and the average weight was 7.95 g (±0.15 g) (Table 5).

The high proportion of two-year smolt in migrating from Leisure Lake in 2014 is atypical for Hidden Lake stock that generally migrates as one-year-olds from Hidden Lake. Additionally, the smolt size was much smaller than what typically migrates from Hidden Lake. Smolt enumeration in 2015 was comprised primarily of the final outmigration of the Hidden Lake stock as two-year smolt with all one-year smolt being from English Bay Lakes stock.

Table 5: Sockeye Salmon Smolt AWL Summary, Leisure Lake, 2014–2015

	Age Class (%)				Mean length (mm)				Mean weight (g)			
Smolt	Age 1	95% C.I.	Age 2	95% C.I.	Age 1	95% C.I.	Age 2	95% C.I.	Age 1	95% C.I.	Age 2	95% C.I.
2014	3.4%	1.4%	96.6%	1.4%	77.1	3.3	94.5	0.8	4.09	0.56	6.85	0.18
2015	61.4%	4.4%	38.4%	4.4%	79.9	0.3	98.9	0.8	4.70	0.05	7.95	0.15

Fish Stocking

On June 9, 2015 CIAA released fed sockeye salmon fry into Leisure Lake. Stocking information from 2012–2015 is summarized in Table 6.

Table 6: Stocking Summary, Leisure Lake, 2012–2015

Brood Year	Brood Source	Species	Weight (g)	Number Released	Thermal Mark	Release Date
2011	Hidden Lake	Sockeye	0.18	2,074,000	2,2H	6/29/2012
2012	Hidden Lake	Sockeye	0.18	1,800,000	H2,2	6/25/2013
2013	English Bay Lake	Sockeye	0.24	1,353,000	1,3H	6/7/2014
2014	English Bay Lake	Sockeye	0.20	1,051,000	2,2H	6/9/2015

Though the data set is incomplete there is a marked increase in fry to smolt survival for the smolt stocked from English Bay Lakes. Brood year survival is summarized in Table 7.

Table 7: Brood Year Survival Comparison, Leisure Lake, 2011–2014

Hidden Lake Smolt

Brood Year 2011	Smolt Age	Smolt Total	Fry Released	**Brood Year 2012**	Smolt Age	Smolt Total	Fry Released
2012	0.0	ND		2013	0.0	ND	
2013	1.0	ND		2014	1.0	9,060	
2014	2.0	258,203		2015	2.0	177,332	
2015	3.0	778		2016	3.0	IC	
Total		258,981	2,074,000	Total		186392	1,800,000
Fry to Smolt Survival		**12.5%**		Fry to Smolt Survival		**10.4%**	

English Bay Lakes Smolt

Brood Year 2013	Smolt Age	Smolt Total	Fry Released	**Brood Year 2014**	Smolt Age	Smolt Total	Fry Released
2014	0.0	0		2015	0.0	0	
2015	1.0	283,109		2016	1.0	IC	
2016	2.0	IC		2017	2.0	ND	
2017	3.0	ND		2018	3.0	ND	
Total		283,109	1,353,000	Total		0	1,051,000
Fry to Smolt Survival		**20.9%**		Fry to Smolt Survival		**0.0%**	

ND=No data are available for that year

IC=Data are incomplete but planned for completion

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RECOMMENDATIONS

The smolt outmigration at Leisure Lake will be monitored again in 2016. These data will provide another data point for the characteristics of the English Bay Lakes stock. Additionally, CIAA will begin the monitoring of adult returns in 2016–2018 to estimate the marine survival of smolts counted between 2014 and 2016. Because all of the salmon leaving Leisure Lake and nearby Hazel Lake are thermally marked with unique patterns, CIAA will be able to determine the source of the fish returning to China Poot Bay.

In 2015 CIAA received water quality data during the season to aid in the adjustment of fertilizer calculations. While no adjustment was needed, CIAA would like to continue receiving these data in season to ensure that the fertilizer applications are appropriate for Leisure Lake.

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APPENDICES

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Appendix 1: Environmental Conditions, Leisure Lake 2015

Date	Sky	Precip. (mm)	Staff Height (ft)	Stage Change (ft)	Water Temp. (◦C)	Air Temp. (◦C)
6-May	4	0.0	0.9	0.0	5	10
7-May	5	0.0	0.9	0.0	6	11
8-May	4	10.5	1.0	0.1	6	12
9-May	5	6.5	1.1	0.2	7	11
10-May	3	3.5	1.1	0.2	6	12
11-May	3	1.3	1.2	0.3	5	7
12-May	2	0.9	1.1	0.2	5	8
13-May	4	0.2	1.1	0.2	6	10
14-May	4	0.3	1.1	0.2	6	8
15-May	4	0.2	1.2	0.3	7	9
16-May	1	0.0	1.2	0.3	9	13
17-May	1	0.0	1.2	0.3	8	14
18-May	3	0.0	1.2	0.3	7	8
19-May	1	0.0	1.2	0.3	8	11
20-May	3	0.0	1.2	0.3	8	11
21-May	4	0.0	1.2	0.3	7	11
22-May	1	0.0	1.2	0.3	7	10
23-May	5	6.4	1.1	0.2	7	10
24-May	4	0.0	1.1	0.2	8	10
25-May	5	12.7	1.1	0.2	7	11
26-May	1	0.0	1.1	0.2	7	10
27-May	1	0.0	1.1	0.2	8	11
28-May	1	0.0	1.1	0.2	9	12
29-May	1	0.0	1.1	0.2	10	15
30-May	1	0.0	1.1	0.3	10	15
31-May	1	0.0	1.1	0.3	10	14
1-Jun	1	0.0	1.2	0.3	10	16
2-Jun	3	0.1	1.2	0.3	10	17
3-Jun	2	0.0	1.2	0.3	10	15
4-Jun	1	0.0	1.2	0.3	10	14
5-Jun	3	0.0	1.2	0.3	11	16
6-Jun	5	6.4	1.2	0.3	11	15
7-Jun	5	5.1	1.2	0.3	10	15
8-Jun	5	1.3	1.2	0.3	11	16
9-Jun	5	1.3	1.2	0.3	10	17
10-Jun	4	0.0	1.1	0.3	10	16
11-Jun	2	0.3	1.1	0.2	11	16
12-Jun	1	0.0	1.2	0.3	12	18
13-Jun	1	0.0	1.1	0.2	11	18
14-Jun	1	0.0	1.1	0.2	13	20
15-Jun	1	0.0	1.1	0.2	13	20
16-Jun	1	0.0	1.1	0.2	13	20
17-Jun	3	0.0	1.1	0.2	12	16
18-Jun	1	0.0	1.2	0.3	12	17
19-Jun	1	0.0	1.2	0.3	12	19
20-Jun	2	0.0	1.2	0.3	12	15
21-Jun	2	0.0	1.1	0.2	12	16
22-Jun	1	0.0	1.1	0.2	12	17
Total		56.6				
Avg.		1.2	1.1	0.2	9.1	13.6
Min.		0.0	0.9	0.0	5.0	7.0
Max.		12.7	1.2	0.3	13.0	20.0

Appendix 2: Daily Sockeye Smolt Migration, Leisure Lake 2015

	Sockeye Smolt			
Date	Daily	Otoliths	Total	% of Total Run
06-May	1,754	3	1,751	0%
07-May	1,181	8	2,924	1%
08-May	1,930	12	4,842	1%
09-May	ND	ND	4,842	1%
10-May	ND	ND	4,842	1%
11-May	11,967	19	16,790	4%
12-May	14,721	26	31,485	7%
13-May	26,125	20	57,590	12%
14-May	22,036	0	79,626	17%
15-May	28,723	18	108,331	23%
16-May	20,255	10	128,576	28%
17-May	19,531	5	148,102	32%
18-May	14,742	0	162,844	35%
19-May	19,192	0	182,036	39%
20-May	12,579	5	194,610	42%
21-May	31,096	5	225,701	49%
22-May	16,301	0	242,002	52%
23-May	20,994	0	262,996	57%
24-May	19,796	8	282,784	61%
25-May	10,055	9	292,830	63%
26-May	16,564	4	309,390	67%
27-May	8,368	6	317,752	69%
28-May	9,781	11	327,522	71%
29-May	8,385	20	335,887	73%
30-May	13,945	5	349,827	76%
31-May	12,115	19	361,923	78%
01-Jun	11,604	38	373,489	81%
02-Jun	11,703	20	385,172	83%
03-Jun	11,045	20	396,197	86%
04-Jun	12,879	22	409,054	89%
05-Jun	10,952	20	419,986	91%
06-Jun	7,012	20	426,978	92%
07-Jun	5,852	18	432,812	94%
08-Jun	5,142	20	437,934	95%
09-Jun	3,351	17	441,268	96%
10-Jun	2,401	23	443,646	96%
11-Jun	3,304	20	446,930	97%
12-Jun	1,965	20	448,875	97%
13-Jun	2,100	20	450,955	98%
14-Jun	1,021	20	451,956	98%
15-Jun	2,064	20	454,000	98%
16-Jun	1,096	20	455,076	99%
17-Jun	1,807	20	456,863	99%
18-Jun	990	10	457,843	99%
19-Jun	882	5	458,720	99%
20-Jun	872	5	459,587	100%
21-Jun	503	4	460,086	100%
22-Jun	1,137	5	461,218	100%
Total	461,818	600	461,218	

*ND indicates no count was made

Appendix 3: Historical Limnological Data, Leisure 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)
1981	72.5	6.2	19.5		2.1	43	0.1				69	6.2	24.0		2.5	36.5	0.2
1982	78.4	7.3	26.4		5.9	95	0.3			102	79	7.2	26.6		4.7	90.0	0.4
1983	87.1	7.4	29.6		3.1	56	0.4			45	87	7.3	31.2		3.6	66.4	1.0
1984	80.6	7.4	30.0	1.2	6.9	98	0.9			66	85	7.1	28.0	1.0	4.5	73.7	0.6
1985	88.3	7.8	31.4	4.0	7.2	147	4.7			501	83	7.2	31.4	1.8	6.4	95.2	1.4
1986	80.4	7.9	29.1	2.3	9.5	140	2.3			615	85	7.0	28.1	1.2	4.2	71.3	0.5
1987	80.3	7.9	26.7	1.2	9.2	145	5.6			181	80	7.3	25.9	0.6	4.5	81.8	0.8
1988	77.8	7.6	23.7	1.6	7.1	101	5.4			318	81	7.2	25.1	0.9	6.3	67.4	2.7
1989	83.5	7.8	27.3	1.7	8.1	171	2.7			826	85	7.2	27.2	0.9	6.4	119.3	1.4
1990	84.6	7.7	28.9	1.6	6.3	101	0.5			966	85	7.3	27.9	0.8	3.7	62.6	0.5
1991	90.7	7.8	27.8	0.8	7.3	146	1.0			421	94	7.2	28.7	0.6	5.2	99.8	0.5
1992	91.4	7.5	27.2	1.4	8.5	150	3.0			1151	95	7.1	27.5	0.9	5.5	108.9	1.5
1993	93.6	7.5	27.9	1.1	9.9	171	3.4			615	95	7.1	29.0	0.8	7.0	116.2	2.6
1994	95.9	7.0	28.0	1.3	5.6	100	1.6			895	96	6.8	29.0	0.8	4.0	88.2	1.3
1995	91.3	7.7	29.0	1.9	10.1	133	2.0			1315	94	7.0	29.7	1.4	4.9	92.3	0.8
1996	98.5	7.5	31.5	1.0	7.4	123	2.2			1611	99	7.0	31.7	0.8	4.7	90.0	1.6
1997	96.5	7.9	32.4	0.8	8.7	135	2.3			1174	100	7.2	33.9	0.9	5.7	88.3	1.5
1998	88.3	7.5	28.9	1.3	7.2	155	1.9			817	90	7.2	29.1	1.7	6.0	145.9	1.0
1999	86.3	7.2	26.3	1.2	5.1	107	0.3			307	89	7.2	27.8	1.1	3.0	96.4	0.4
2000	92.3	7.2	27.6	1.1	8.3	126	2.4			447	94	7.0	28.2	1.0	3.8	85.4	3.0
2001	86.4	7.0	25.6	0.8	3.0	78	0.4			681	89	6.9	25.5	0.6	3.0	80.1	0.6
2002	83.5	7.1	28.2	0.7	10.9	123	3.7			327	88	7.0	28.9	0.6	7.8	125.4	2.6
2003	89.8	6.8	27.3	0.9	4.4	82	0.6	16.6	7.5	457	87	6.8	26.6	0.8	7.5	130.4	0.6
2004	85.0	7.1	27.9	1.0	18.5	209	1.7	20.3	6.4	713	85	6.9	27.9	7.5	35.0	300.3	1.9
2005	93.2	6.7	27.1	0.4	7.7	128	1.1	18.8	6.5	1399	92	6.8	27.0	0.9	9.2	147.7	1.1
2006	92.2	6.5	26.4	0.4	4.9	113	0.5	19.4	7.5	1217	93	6.6	26.7	0.4	5.2	116.0	0.5
2007	91.6	6.7	28.2	0.4	8.8	107	1.0	19.3	6.0	700	93	6.6	28.7	0.3	5.8	81.2	0.7
2008	86.2	7.2	27.6	0.8	10.1	83	0.5	14.8	6.7	228	87	7.1	27.6	1.1	6.5	74.7	0.8
2009	90.7	7.1	28.8	0.5	6.9	111	0.5	16.7	8.0	187	91	6.9	28.7	0.4	6.8	137.1	7.6
2010	87.9	7.1	26.0	0.6	4.7	ND	0.8	17.2	5.8	157	91	6.8	27.4	0.4	5.2	ND	5.0
2011	93.4	7.7	30.0	0.7	5.7	ND	2.3	17.0	5.3	254	93	7.4	30.4	0.5	6.5	ND	2.5
2012	92.6	7.5	28.5	0.6	6.0	ND	2.3	20.7	5.8	319	95	7.4	29.5	0.5	4.4	ND	1.3
2013	91.1	8.0	26.8	0.6	11.2	ND	4.5	15.2	4.8	304	93	7.0	27.6	0.5	4.5	ND	1.4
2014	85.0	6.7	27.0	0.5	9.1	ND	2.3	18.5	3.7	587	92	7.0	28.5	0.8	4.7	ND	1.5
2015	90	7.2	27.5	0.7	6.6	220	1.3	17.9	4.1	142	88	7.0	28.6	0.7	5.9	109	1.9

Blank cells = no data were gathered for that parameter during the time specified.
Averages based off data from both sampling sites.
Water quality data for 2014 has been amended to correct errors
Numbers reported from previous years have also been corrected to reflect an accurate number of significant figures

Appendix 4: Zooplankton Density Site 2, Leisure Lake, 2015

Macrozooplankton Density - Site 2 - Depth 60m
(No/m2)

					Mean	Seasonal Mean
	26-May	**30-Jun**	**3-Aug**	**8-Sep**	(No/m2)	(No/m2)
Ergasilus						
Ovig Ergasilus						
Epischura						
Ovig Epischura						
Diaptomus	96	2,580	2,229	955	1,465	1,465
Ovig Diaptomus						
Cyclops	2,389	5,637	10,350	5,255	5,908	5,908
Ovig. Cyclops		191	318	318	276	207
Bosmina	318	4,108	48,885	26,115	19,857	19,857
Ovig. Bosmina	446	2,389	10,987	1,911	3,933	3,933
Daphnia l.	414	3,631	30,732	70,064	26,210	26,210
Ovig. Daphnia l.	96	3,057	9,395	25,637	9,546	9,546
Daphnia g.						
Chydorinae				637	637	159
Ovig. Chydorinae						
Scapholeberis						
Total:	3,759	21,593	112,896	130,892	67,832	67,285
Ave:	627	3,085	16,128	16,362	8,479	8,411
STDEV:	877	1,682	17,486	24,317	9,638	9,703

Blank cells indicate that the species indicated was not detected in the sample

Appendix 5: Zooplankton Density Site 5, Leisure Lake, 2015

Macrozooplankton Density - Site 5 - Depth 27m
(No/m2)

					Mean	Seasonal Mean
	26-May	**30-Jun**	**3-Aug**	**8-Sep**	(No/m2)	(No/m2)
Ergasilus						
Ovig Ergasilus						
Epischura						
Ovig Epischura						
Diaptomus	96	1,624	1,146		955	717
Ovig Diaptomus						
Cyclops	2,898	3,439	28,917	6,210	10,366	10,366
Ovig. Cyclops			510		510	128
Bosmina	287	7,452	25,096	57,643	22,620	22,620
Ovig. Bosmina	255	4,299	13,248	1,592	4,849	4,849
Daphnia l.	446	2,197	26,497	94,745	30,971	30,971
Ovig. Daphnia l.	127	1,146	9,172	31,051	10,374	10,374
Daphnia g.						
Chydorinae						
Ovig. Chydorinae						
Scapholeberis						
Total:	4,109	20,157	104,586	191,241	80,645	80,023
Ave:	685	3,360	14,941	38,248	11,521	11,432
STDEV:	1,091	2,320	12,019	38,697	11,413	11,512

Blank cells indicate that the species indicated was not detected in the sample

Appendix 6: Stocking and Adult Returns, Leisure Lake 1976–1989

Year	Fish Stocked (millions)[a]	Source	Age	Smolt Migration[b]	Age 1[c]	Age 2[c]	Age 3[c]	Adult Return[d]
1976	0.06	Glacier	Presmolt					
1977	0.092	Glacier	Presmolt	31,316	31,316			
1978	0.077	Glacier	Presmolt	49,900-66,900	48,000-65,000	1,900		
1979		Glacier	Fry	58,826	54,061	1,353	3,412	650
1980	0.53	Glacier	Fry	3,857	ND	3,857		14,000
1981	1.09	TUSTUMENA LK	Fry	240,659	240,658		1	11,500
1982	1.53	TUSTUMENA LK	Fry	319,502	315,176	4,326		3,400
1983	2.1	TUSTUMENA LK	Fry	416,940	326,643	90,297		90,420
1984	2.1	TUSTUMENA LK	Fry	229,222	177,678	51,544		117,360
1985	2	TUSTUMENA LK	Fry	178,100	46,500	131,600		65,930
1986	2.2	TUSTUMENA LK	Fry	372,000	220,000	152,000		18,800
1987	2	TUSTUMENA LK	Fry		861,000			23,700
1988	2.1	TUSTUMENA LK	Fry	>650,000	642,880			93,915
1989	2	TUSTUMENA LK	Fry					89,000

Blank cells indicate that: a=Fish were not stocked, b=No migration occurred or no count was made, c=Year class was not detected in samples, d=No adult return for that year

Appendix 7: Salmon Stocking, Leisure Lake 1990–2015

Brood Year	Release Year	No. Released (Millions)	Brood Source	Age
1989	1990	2.0	Tustemena Lake	Fry
1990	1991	2.0	Tustemena Lake	Fry
1991	1992	2.0	Tustemena Lake	Fry
1992	1993	2.0	Tustemena Lake	Fry
1993	1994	1.6	Tustemena Lake	Fry
1994	1995	1.5	Tustemena Lake	Fry
1995	1996	2.0	Tustemena Lake	Fry
1996	1997	1.9	Tustemena Lake	Fry
1997	1998	0.3	Tustemena Lake	Fry
1998	1999	1.7	Tustemena Lake	Fry
1999	2000	0.1	Tustemena Lake	Fry
2000	2001	2.2	Tustemena Lake	Fry
2001	2002	2.2	Tustemena Lake	Fry
2002	2003	2.0	Tustemena Lake	Fry
2003	2004	2.3	Hidden Lake	Fry
2004	2005	0.7	Hidden Lake	Fry
2005	2006	2.3	Hidden Lake	Fry
2006	2007	2.1	Hidden Lake	Fry
2007	2008	1.2	Hidden Lake	Fry
2008	2009	1.9	Hidden Lake	Fry
2009	2010	1.4	Hidden Lake	Fry
2010	2011	NA	No Fish Released	
2011	2012	2.1	Hidden Lake	Fry
2012	2013	1.8	Hidden Lake	Fry
2013	2014	1.4	English Bay Lakes	Fry
2014	2015	1.1	English Bay Lakes	Fry