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Office of Subsistence Management
Fisheries Resource Monitoring Program

Abundance and Run Timing of Adult Salmon in Long Lake in the Wrangell-St. Elias National Park and Preserve, 2007

Annual Report for Project 07-505

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INTRODUCTION

The upper Copper River drainage provides spawning habitat for sockeye salmon *Oncorhynchus nerka*, coho salmon *O. kisutch*, and Chinook salmon *O. tshawytscha*. Significant numbers of adult salmon are harvested in commercial drift gillnet operations near the mouth of the Copper River from mid-May to September. Salmon escapement into the upper Copper River system contributes to federal and state subsistence fishing through September each year. The monitoring and evaluation of these runs is essential to ensure that Wrangell - St. Elias National Park and Preserve (WRST) maintains natural and healthy populations of fish as required by the Alaska National Interest Lands Conservation Act (ANILCA).

Accurate assessment of yearly run strength and migratory timing in tributaries to the Copper River is essential to the development of a management strategy that meets the mandates of ANILCA. The upper Copper River sockeye salmon populations are of particular importance to both federally qualified and state subsistence users. The primary assessment of inriver abundance for Copper River sockeye salmon occurs at the Miles Lake sonar site. However, migratory timing of sockeye salmon into the Copper River is prolonged (May-August), and subsequent assessment of escapement into some tributaries is needed to determine spawning distribution. The sonar equipment at the Miles Lake site is typically shut down on August 15 each year, after the majority of the sockeye salmon have migrated through. A portion of the Long Lake sockeye salmon run enters the Copper River after the sonar has been pulled from the Miles Lake site.

Thirty-four years of weir data show annual variations in abundance of Long Lake runs ranging from 4,400 to over 50,000 sockeye salmon (Table 1). This is the longest running data set of salmon weir counts in the Copper River drainage. The sockeye salmon stock that spawns within Long Lake is the largest salmon stock within the Chitina River drainage. The magnitude of escapement, and its contribution to the total inriver return of the Copper River, is widely variable (Table 1). The largest measured escapement (50,000) into Long Lake occurred in 2002, and comprised six percent of the estimated total inriver return. During the period 1978-1980, inriver returns to the Copper River were very low, and Long Lake escapements comprised 14-19% of the total. Since 1981, escapements into Long Lake have comprised no more than 6% of the total inriver return. There does not appear to be a relationship between the magnitude of inriver return and escapement into Long Lake during this 25-year period, which demonstrates the need for stock specific monitoring sites in addition to broad scale sonar sites estimating mixed stock returns.

Background

The Long Lake population has the longest known annual spawning duration (August through April) of any sockeye salmon population in North America. (Ken Roberson, personal communication) Throughout the winter, sockeye salmon spawn in the northwest corner of the lake since this portion of the lake rarely freezes (Figure 1).

Table 1. Long Lake weir and Miles Lake sonar sockeye salmon counts, 1974-2007. Miles Lake sonar counts obtained from Alaska Department of Fish and Game.

	Number of Sockeye Salmon		
Year	Miles Lake Sonar	Long Lake Weir	Long Lake as % of Sonar Estimates
1974		4,684	
1975		6,768	
1976		24,689	
1977		8,624	
1978	107,011	15,458	14.5
1979	237,173	46,110	19.4
1980	276,538	39,038	14.1
1981	535,263	12,659	2.4
1982	467,306	28,047	6.0
1983	545,724	28,133	5.2
1984	536,806	10,637	2.0
1985	436,313	21,131	4.8
1986	509,275	16,997	3.3
1987	483,478	13,633	2.8
1988	488,398	7,543	1.5
1989	607,797	14,981	2.5
1990	581,895	21,664	3.7
1991	579,435	11,511	2.0
1992	601,952	10,091	1.7
1993	797,902	16,101	2.0
1994	715,181	18,289	2.6
1995	599,265	17,923	3.0
1996	906,867	6,309	0.7
1997	1,148,079	4,443	0.4
1998	866,957	8,441	1.0
1999	848,921	12,922	1.5
2000	587,592	8,645	1.5
2001	833,569	26,999	3.2
2002	819,000	49,747	6.1
2003	695,233	4,604	0.7
2004	669,646	19,215	2.9
2005	854,268	7,770	0.9
2006	959,731	9,239	1.0
2007	926,438	7,846	0.9

Figure 1. Salmon spawning in Long Lake in April, 2004.

The Alaska Department of Fish and Game (ADF&G) initially operated the Long Lake weir in 1974 and 1975. Cliff Collins, a local private citizen who owned the land where the weir is located, voluntarily took over operation of the weir in 1976 when ADF&G was no longer able to fund its operation (Figure 2). He operated the weir continuously from 1976 through 2003. In 2003, when Mr. Collins, at age 93, was no longer able to operate the weir, a cooperative agreement was formed between the Collins' Family Trust, Wrangell-St. Elias National Park/Preserve and the Copper River Watershed Project to keep the weir operating. Since 2004, funding has been provided under the Subsistence Fisheries Resource Monitoring Program[1]. Starting in 2003 the weir operators began sampling sockeye salmon for age, sex, and length composition according to a sampling protocol established by ADF&G.

The physical structure of the weir has changed little since 1974. A small sampling box was constructed on the upstream side of the middle of the weir in 2003. In 2004 a larger sampling box was constructed against the west bank of the creek on the upstream side of the weir. This larger box has been used since 2004.

[1] Administered by U.S. Fish and Wildlife Service, Office of Subsistence Management.

Figure 2. Cliff Collins at the weir at age 93 with Karelian bear dog in 2003.

OBJECTIVES

1) Monitor annual abundance and timing of sockeye and other salmon in Long Lake.
2) To enumerate the number of sockeye salmon entering Long Lake from July 1 to mid-September, thereby continuing a data set initiated in 1974.
3) To measure the entry pattern of sockeye salmon to Long Lake and compare the entry pattern to the historic entry pattern data set to test for change in the interannual run timing.
4) To estimate age-sex-length composition of the Long Lake sockeye salmon population.
5) To compare the numbers of sockeye salmon entering Long Lake with similar data from the Miles Lake sonar.

METHODS

Site Description

Long Lake is 480 m above sea level, at latitude 61 deg 23’ 1.68” N and longitude 143 degrees 17’ 15.89” W (Figure 2). Long Lake is located adjacent to the McCarthy Road and is 0.5 km wide and 8.5 km long. The outlet stream (called Salmon Creek by the Collins family) runs 2.1 kilometers through nearly level terrain to the Lakina River, a tributary of the Chitina River that flows into the Copper River. Willows, alders, mosses and sedges dominate the vegetation.

Forested areas consist mainly of white spruce interspersed with stands of paper birch and quaking aspen. The soils are poorly drained. Average annual precipitation is 40.11 cm, and average annual temperature is 22° C with extremes of 13.39° C and -27.06° C (USDA 1979).

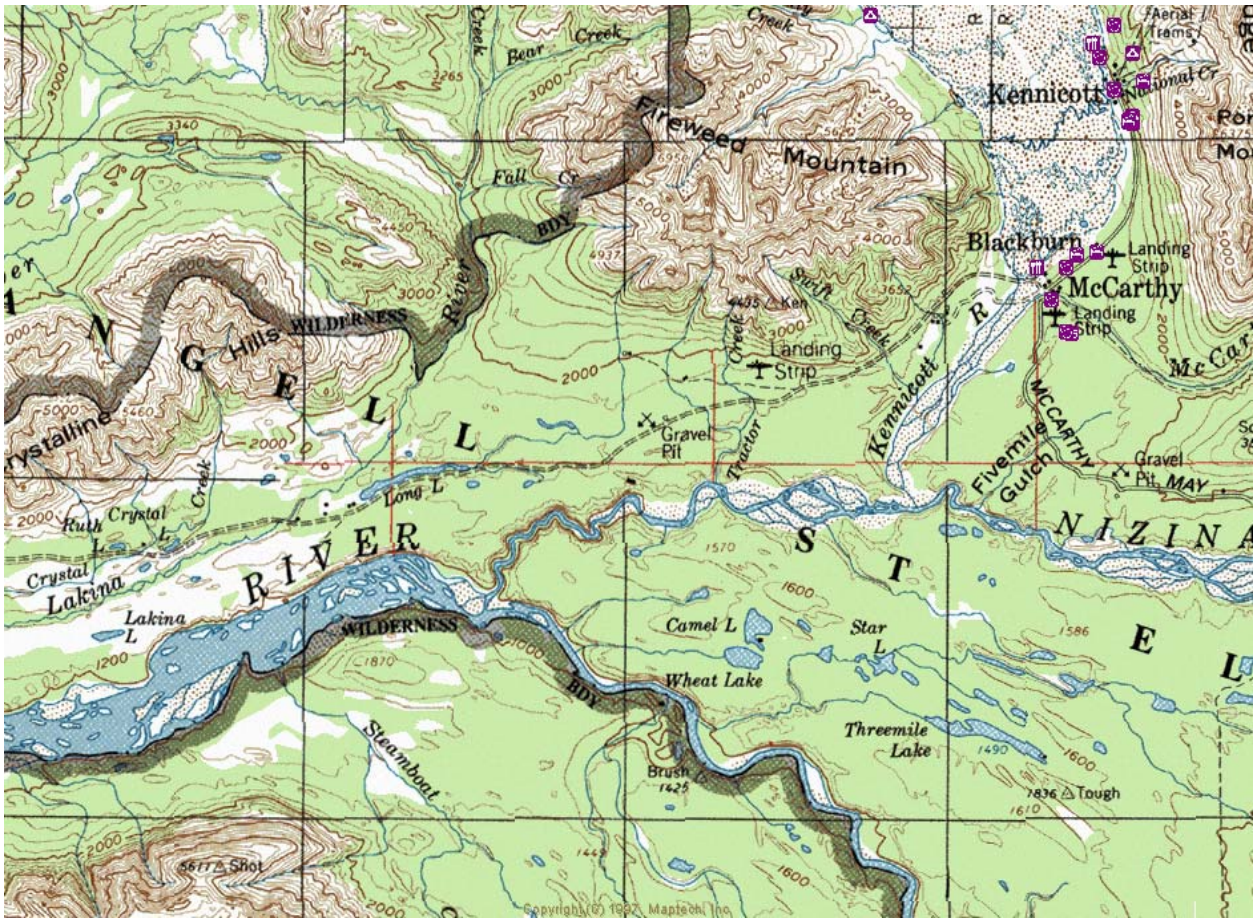

Figure 3. Long Lake weir site.

Weir Operation

The project uses a rigid picket weir to enumerate the number of salmon migrating into Long Lake and to estimate the age, sex and length composition of the run by sampling sockeye salmon migrating through the weir. The weir site is on Collins Family Trust land and is located within a few hundred meters of the Collins family residence, at mile 45 on the McCarthy Road (Figure 3). The weir is installed operated at the outlet of the lake and pickets are spaced 3.75 cm apart (Figure 4). To count fish, one or two pickets are removed to allow the fish to swim through the opening as they are enumerated. Counting is done daily, and all pickets are kept in place to that fish cannot pass through when it is not monitored.

The site is extremely conducive to the operation of a rigid picket weir. Flows fluctuate only slightly, water velocity is always low, and the stream is shallow and easily waded. A walkway lays across the stream immediately upstream of the weir where a weir operator can stand and count migrating salmon simply by removing one or two pickets from the weir.

Figure 4. Long Lake weir site, 2007.

There is a large sampling box with a funnel-shaped entry trap on the northwestern bank, approximately 2.1 m x 3.1 m in size, with the bank of the creek used as one side of the box. There is a table at one end that is used to sample fish (Figure 5). Fish are allowed to enter the sampling box by removing one or two pickets on the west side of the weir. When the box has 20-50 fish in it, the pickets are replaced, trapping the fish within the box. In 2007 the weir and sampling box were installed on July 15. Work at the weir ended on October 16, when the weir pickets were removed for the winter. Sampling was typically performed with a crew of three people.

Bears are frequently a problem at the weir and further downstream in the creek. The Collins family has several Karelian bear dogs (Figure 2) that are staked out near the weir when fish are being sampled or enumerated. An electric fence was installed around the weir and sampling box for the entire 2007 field season to prevent bears from damaging the weir and eating salmon captured in the box.

Both water temperature and water level were monitored throughout the summer: monitoring started on August 4. A *HOBO® TEMP* data logger was placed in a submersible case to collect water temperature data, and a staff gauge was installed on the weir to measure water level (by observation) each day (Figure 6).

Figure 5. Sampling box and weir, Long Lake weir**,** 2007.

Figure 6. Staff gauge at Long Lake weir, 2006.

Biological Data

Fish migrating through the weir were counted and identified to species. This was done by removing 1 or 2 pickets in the weir and visually counting the salmon as they passed through. Sockeye salmon were sampled according to the same used by the ADF&G, Division of Commercial Fisheries in Cordova, Alaska. This required sampling 10 percent of the average total return of sockeye salmon to estimate the age, sex and length of the population. To do this, 100 to 700 sockeye salmon were sampled each week, with up to 100 sockeye salmon being sampled each day (or as many as were present if less than 100 were available).

Each sockeye salmon sampled was measured to the nearest millimeter from mid-eye to fork length (MEF). One scale was collected from the preferred area, located on the left side of the fish and two rows above the lateral line on a diagonal from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin, according to ADF&G sampling protocols. Scales were later analyzed by ADF&G Commercial Fisheries Division staff based in Cordova. Ages were adjusted for resorbed scale margins using an age-length relationship developed for Copper River sockeye salmon. Age, sex, and length sampling at the weir occurred from August 18 through September 22, 2007. Additionally, age, sex, and length data were collected from 125 sockeye salmon carcasses sampled from the lake and shore between October 1 and 19, 2007 (Figure 7).. Otoliths were removed from these carcasses, for future analysis.

To determine whether the 1978-2007 time series of sockeye salmon escapements into Long Lake showed linear trends over years, the coefficient of determination (R^2) was calculated to determine the amount of variation explained by the regression, and an F test was used to test the null hypothesis that the slope of the fitted line was equal to zero. Similar statistical analyses were

Figure 7. Otolith sampling, Long Lake**,** 2007.

applied to1978-2007 inriver runs at the Miles Lake sonar site. To determine whether sockeye salmon escapements into Long Lake were correlated with total inriver runs at Miles Lake, the correlation coefficient (R) for 1978-2007 paired estimates was calculated. All statistical significance testing was done at the 95% level.

RESULTS

Weir Operation

In 2007, daily staff gauge readings between August 4 and October 10 varied between 1.4 feet and 2.5 feet, showing a maximum variation of 1.1 feet (Figure 8). The water level was similar to that recorded for the previous two years throughout the summer (Figure 9).

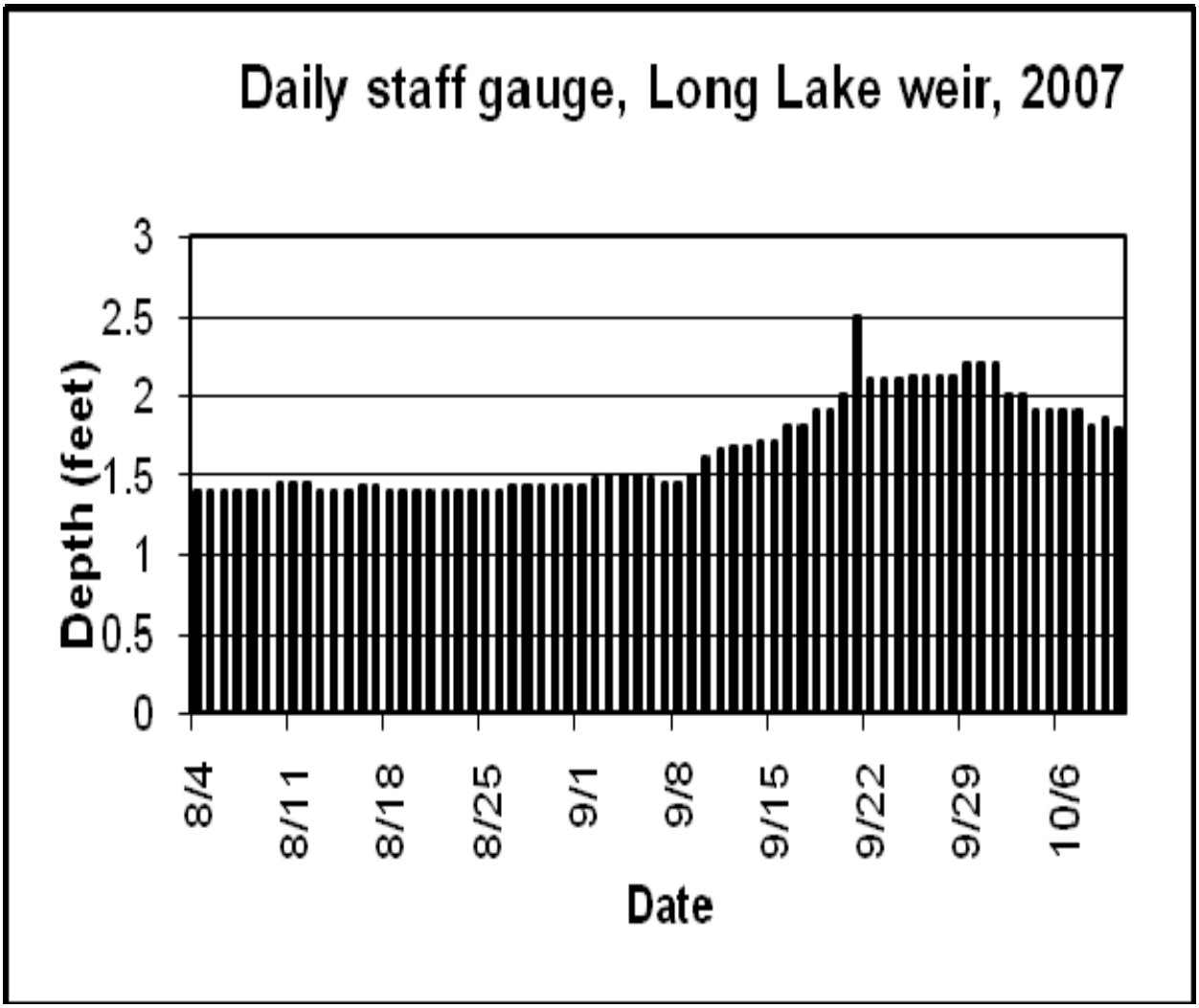

Figure 8. Daily staff gauge readings of water depth, Long Lake weir, 2007.

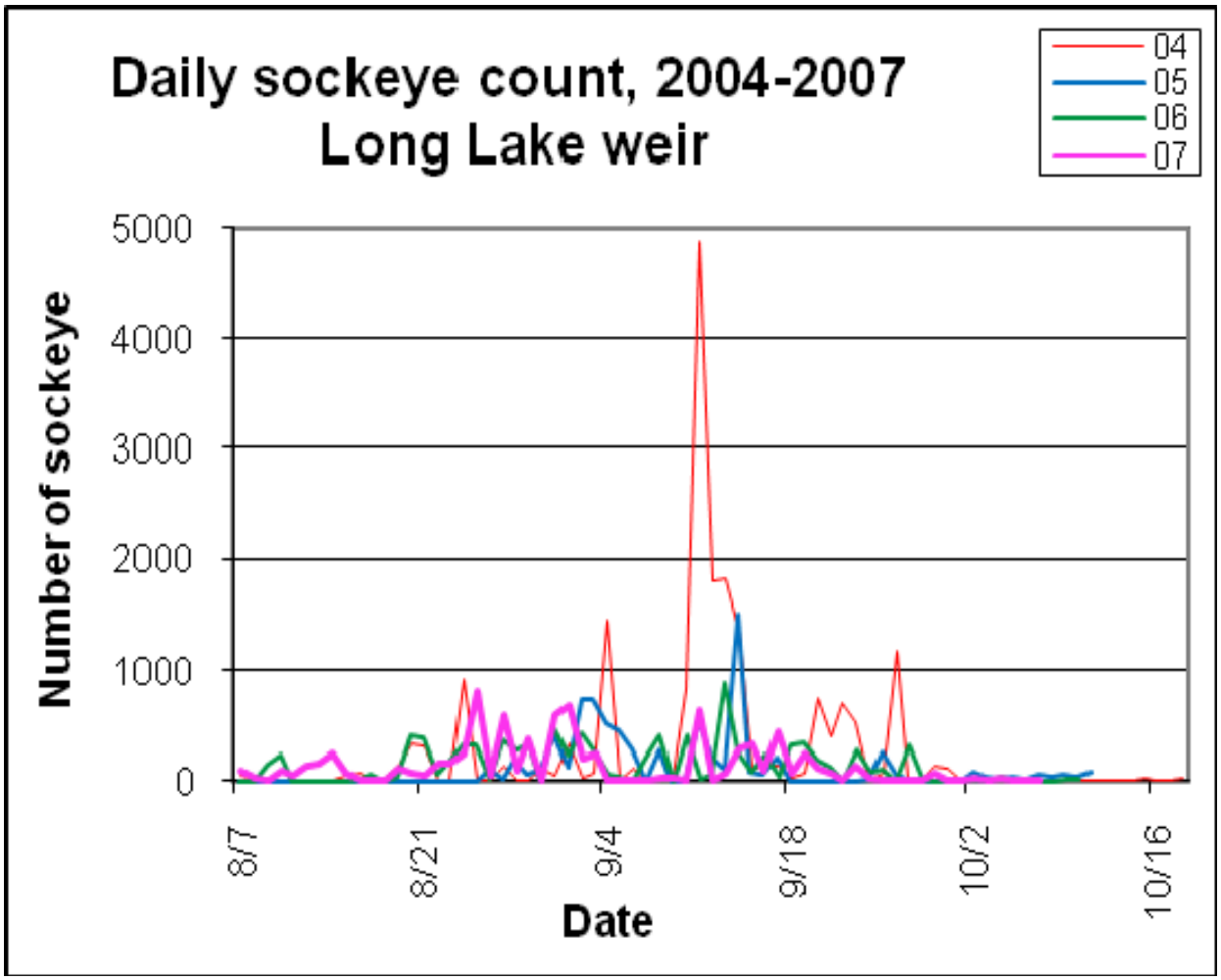

Figure 9. Comparison of 2004-2007sockeye salmon counts, Long Lake weir.

Daily water temperature data ranged from a high of 65° F on August 16 to a low of 28° F on October 22 (Figure 10).

Biological Data

In 2007, 7,846 sockeye salmon were enumerated through the Long Lake weir (Figure 11 and Appendix A). The first sockeye salmon passed through the weir on August 15 when 94 were counted. The largest daily passage of sockeye salmon occurred on September 2 when 874 sockeye salmon migrated through the weir. The median run day occurred on September 8 when 4,068 sockeye salmon had been counted through the weir. A total of 982 sockeye salmon were sampled for sex, length, and age; otoliths were taken from an additional 125 sockeye salmon carcasses. Of these, 964 were usable, 12.5% of the total escapement (Table 2). Between September 21 and October 16, 175 coho salmon were also enumerated.

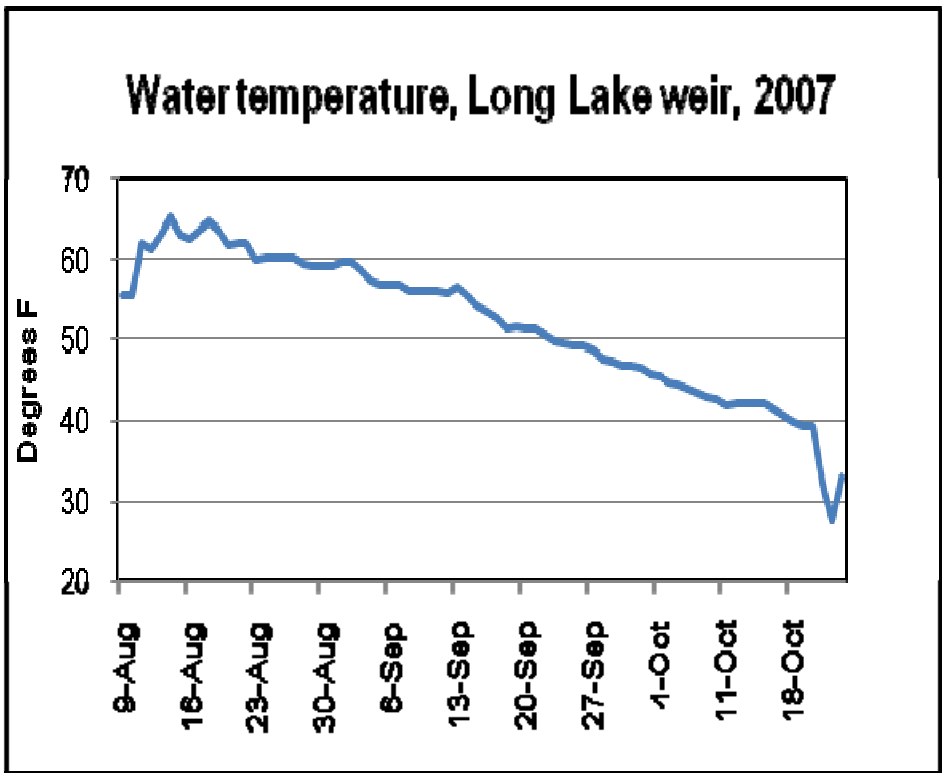

Figure 10. Daily water temperatures, Long Lake weir, 2007.

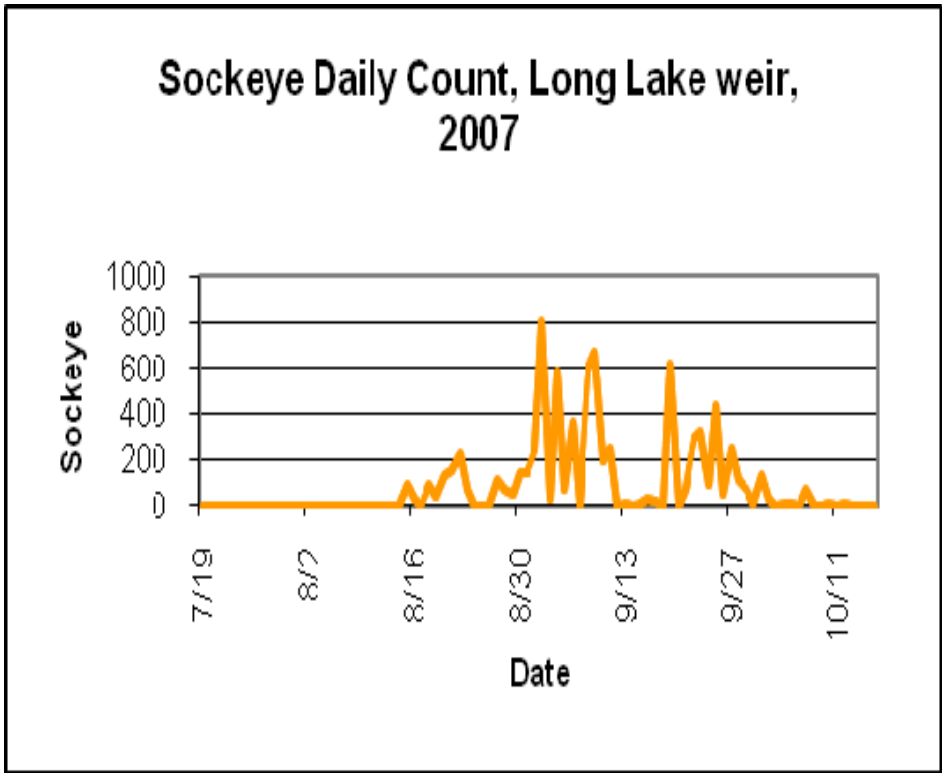

Figure 11. Daily sockeye salmon count, Long Lake weir, 2007.

Sockeye returns to Long Lake during the 34 year period of weir operations have been highly variable, ranging from a high of 50,000 in 2002 to a low of 4,443 in 1997 (Table 1, Figure 12). The number of sockeye salmon counted through the weir in 2007 was approximately 48% of the 34 year average of 16,497 sockeye salmon and represented about 0.8% of the total inriver run estimated by the Miles Lake sonar project. During 1978-2007, Long Lake escapements counts represented an average of 3.8% of the total inriver run, but ranged from 0.4% to 19.4% of the total inriver run. Long Lake escapements show no significant ($p > 0.05$) abundance trend during this time period, while Miles Lake estimates show a significant ($p < 0.05$) trend ($R = 0.786$) of increasing abundance. A significant ($p < 0.05$) negative correlation ($R = -0.403$) was found between Long Lake escapements and Miles Lake estimates for these years (Figure 13).

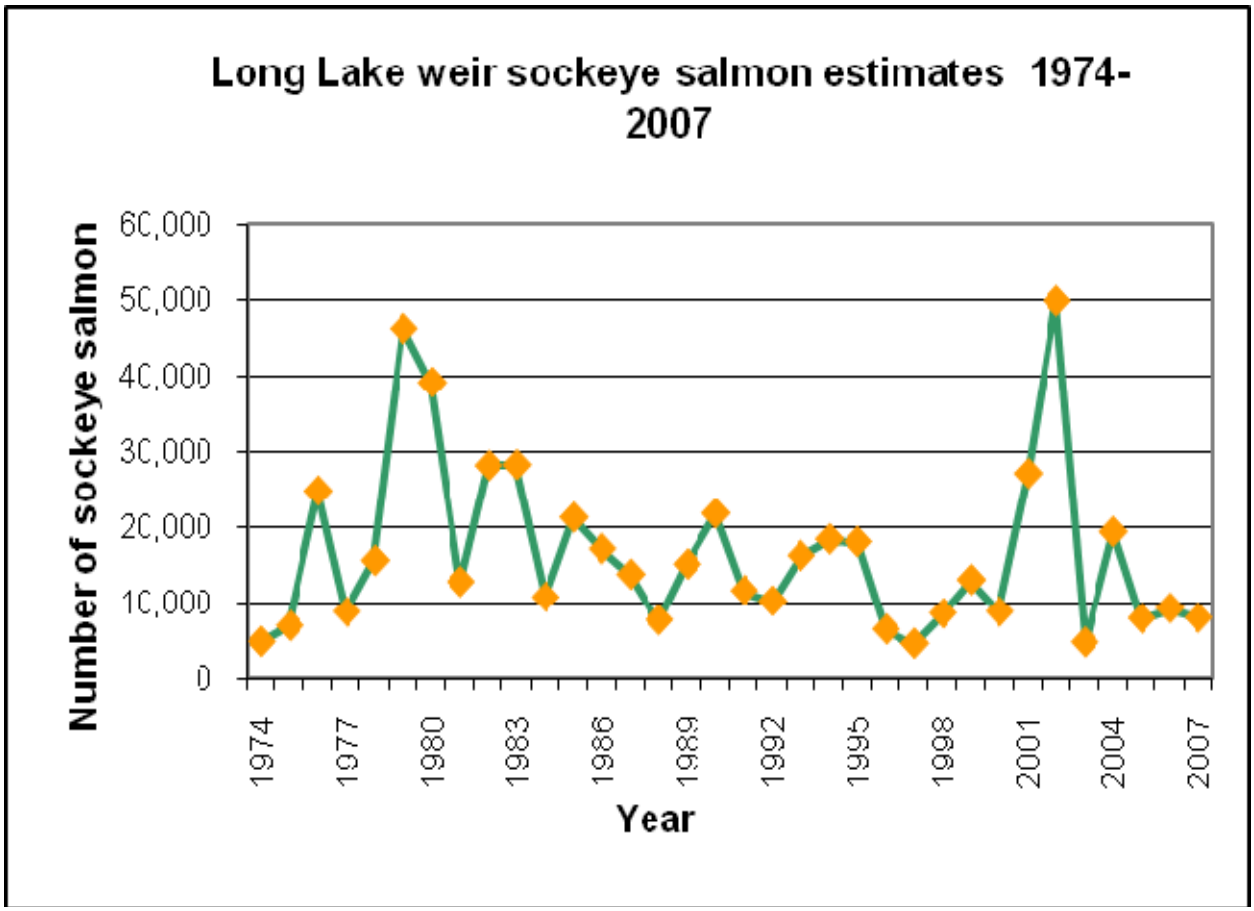

Figure 12. Long Lake weir sockeye estimates, 1974-2007.

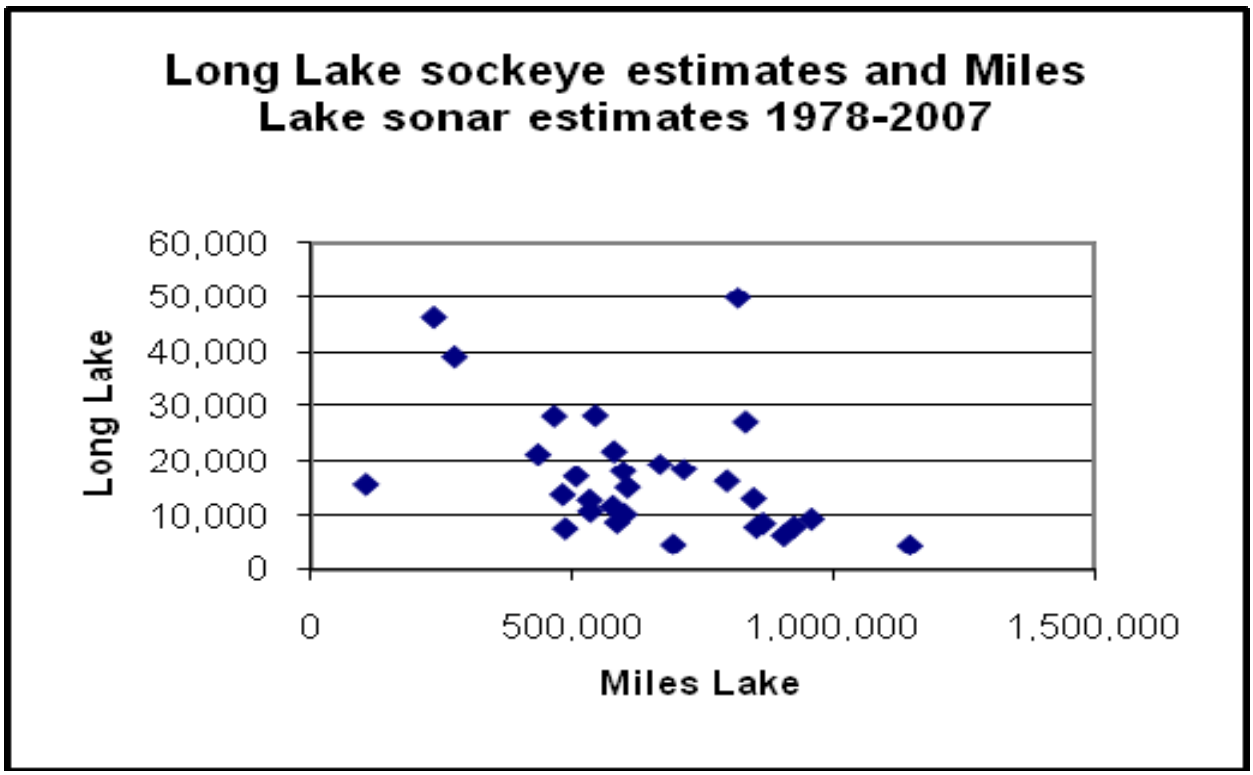

Figure 12. Relationship between Long Lake sockeye salmon weir and Miles Lake sonar counts (1978-2007).

Females comprised about 51% of the returning adults sampled in 2007, and age-1.3 sockeye salmon comprised 77.9% (Table 2).

Table 2. Numbers by sex and age class of sockeye salmon sampled at the Long Lake weir, August 15 - October 19, 2007.

Sex		Age Class					Total Fish Counted	Number of fish sampled
		0.2	1.2	1.3	2.2	2.3		
F	Percent	0.0	3.1	40.7	1.1	6.2	4,013	493
	Number	0	244	3,190	90	488		
M	Percent	0.2	5.0	37.2	1.6	4.9	3,833	471
	Number	16	391	2,922	122	383		
Total	Percent	0.2	8.1	77.9	2.7	11.1	7,846	964
	Number	16	635	6,112	212	871		
	SE	12	69	105	41	79		

The average MEF length of age-1.3 males was 576 mm, while the average MEF length of age-1.3 females was 556 mm (Table 3).

Table 3. Average length (mid-eye to tail fork) by sex and age of sockeye salmon sampled at the Long Lake weir, August 18 - October 19, 2007.

		Age Class				
Sex		0.2	1.2	1.3	2.2	2.3
F	Average Length (mm)	0	492	556	501	553
	SE	0.0	6.6	1.1	3.7	2.7
	Sample Size	0	29	376	11	60
M	Average Length (mm)	493	522	576	529	572
	SE	32.5	3.1	1.0	2.0	2.4
	Sample Size	2	47	345	15	47
Total	Average Length (mm)	493	510	566	517	561
	SE	32.5	3.5	0.8	3.3	2.1
	Sample Size	2	76	721	26	107

Run Timing

Run timing in 2007 was similar to that observed for the last four years, which have all been about one week later than the 1974-2007 average (Table 4, Figure 14). The first sockeye salmon were passed through the weir on August 15 when 94 fish were counted. The median point of the run occurred on September 8 when the cumulative total reached 3,923 sockeye salmon. The last sockeye salmon were counted through the weir on October 15.

Table 4. Annual date of arrival of the first sockeye salmon and the median point of the sockeye salmon migration past Long Lake weir**.**

	First fish	Median date	Median Number
2004	August 8	September 12	9,608
2005	August 11	September 12	3,885
2006	August 7	September 4	4,620
2007	August 15	September 8	3,923

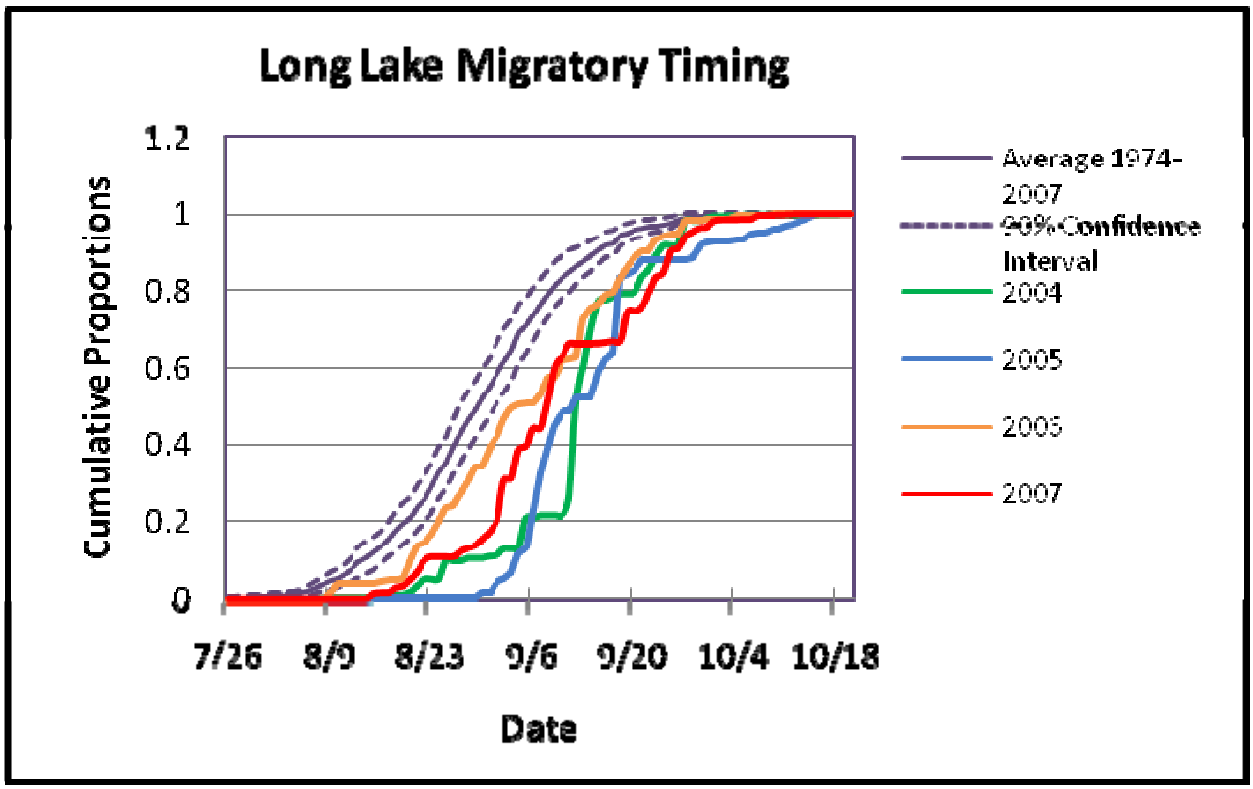

Figure 13. Average migratory run timing, Long Lake weir, 1974-2007 and 2004-2007

DISCUSSION

Weir Operation

There were no major changes in weir operations in 2007. The basic construction of the weir has changed very little since it was built in 1974 because the rigid picket design works well in this location. The pickets are removed from the weir and stored at the end of each field season and then replaced each summer, while the weir's framework can remain in place in the creek throughout the winter (Fig. 15).

The 2004 sampling box design continued to work well This sampling box replaced a smaller one that was built in 2003 (that can be seen in Figure 2), which was the first year sampling was done at the weir and the first year that WRST was involved in the project. The redesigned box is larger than the 2003 box, and was built adjacent to the northwestern bank of Salmon Creek. Erecting the electric fence earlier to deter bears seems to have provided a safer work place at the weir site. The 2007 sampling crew, which was composed of two individuals living in the Collins' household and one other local resident, functioned very well. No major changes are planned for 2008.

Figure 14. Long Lake weir, April, 2006.

Biological Data

Otolith collecting was started in 2007 to supplement the age data collected from scale samples. Scales taken from the sockeye salmon that return to Long Lake are often hard to d because they are worn at the edges and have started to be resorbed. Otoliths may provide a more accurate way to age the salmon. However, it is more difficult to sample sockeye salmon in the lake than at the weir, and it would be very difficult to obtain a representative sample of 10% of the population,. In 2008 we will do a combination of scale samples and otolith collection again.

Sockeye salmon returns to Long Lake have been highly variable, from a high of 50,000 in 2002 to a low of 4,443 in 1997 (Table 1). While the total run of sockeye salmon to the Copper River estimated at the Miles Lake sonar site has shown an increasing trend in abundance, a similar trend has not been seen for the Long Lake component of the run. In fact, there is a negative correlation between Miles Lake sonar and Long Lake weir counts. We are unable to determine whether this is due to unequal fishing exploitation rates or other causes. However, it does indicate the importance of monitoring individual spawning populations along with the total run to this drainage, since increasing total runs do not indicate that all segments of the spawning

population are experiencing similar trends. It is vitally important to conserve all segments of the population to ensure the continued health and sustainability of the total run.

RECOMMENDATIONS

Continue monitoring the sockeye salmon escapement into Long Lake so that an appropriate natural and healthy escapement range can be determined.

1. Continue sampling sockeye salmon for age, length, and sex information so to monitor the health of the spawning population.
2. Continue collecting otolith as a means to determine accurate age information for the sockeye salmon spawning population.

ACKNOWLEDGMENTS

The Collins family and the Prince William Sound Science Center provided the majority of the labor for operating the weir. Robin Lohse with some help from Aaron Lang was instrumental in assuring that age, sex, and length sampling was conducted properly. Steve Moffit and crew at the ADF&G, Commercial Fisheries Division in Cordova, Alaska proposed the sampling regime for the weir, read scale samples, and provided the age, sex, and length information used in Tables 2 and 3. The U.S. Fish and Wildlife Service, Office of Subsistence Management, provided $19,252 in funding support for 2007 through the Fisheries Resource Monitoring Program, under contract number FIS07-505. Stephen Fried, FWS, OSM, provided statistical support.

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Appendix A. Daily and cumulative sockeye and coho salmon counts, and number of sockeye salmon sampled for age, sex, and length information, Long Lake weir, 2007.

	Sockeye Salmon			Coho Salmon	
Date	Daily Count	Cumulative Count	Number Sampled	Daily Count	Cumulative Count
19 July	0	0		0	0
20 July	0	0		0	0
21 July	0	0		0	0
22 July	0	0		0	0
23 July	0	0		0	0
24 July	0	0		0	0
25 July	0	0		0	0
26 July	0	0		0	0
27 July	0	0		0	0
28 July	0	0		0	0
29 July	0	0		0	0
30 July	0	0		0	0
31 July	0	0		0	0
1 Aug	0	0		0	0
2 Aug	0	0		0	0
3 Aug	0	0		0	0
4 Aug	0	0		0	0
5 Aug	0	0		0	0
6 Aug	0	0		0	0
7 Aug	0	0		0	0
8 Aug	0	0		0	0
9 Aug	0	0		0	0
10 Aug	0	0		0	0
11 Aug	0	0		0	0
12 Aug	0	0		0	0
13 Aug	0	0		0	0
14 Aug	0	0		0	0
15 Aug	94	94	0	0	0
16 Aug	26	120	0	0	0
17 Aug	2	122	0	0	0
18 Aug	91	213	40	0	0
19 Aug	43	256	0	0	0
20 Aug	133	389	39	0	0
21 Aug	155	544	63	0	0
22 Aug	231	775	0	0	0
23 Aug	67	842	65	0	0
24 Aug	0	842	0	0	0
25 Aug	0	842	0	0	0

-continued-

Appendix A. Continued.

	Sockeye Salmon			Coho Salmon	
Date	Daily Count	Cumulative Count	Number Sampled	Daily Count	Cumulative Count
26 Aug	0	842	0	0	0
27 Aug	114	956	0	0	0
28 Aug	72	1028	0	0	0
29 Aug	52	1080	38	0	0
30 Aug	143	1223	35	0	0
31 Aug	141	1364	73	0	0
1 Sept	243	1607	0	0	0
2 Sept	802	2409	76	0	0
3 Sept	34	2443	0	0	0
4 Sept	588	3031	22	0	0
5 Sept	77	3108	71	0	0
6 Sept	364	3472	100	0	0
7 Sept	2	3474	0	0	0
8 Sept	594	4068	100	0	0
9 Sept	673	4741	0	0	0
10 Sept	193	4934	100	0	0
11 Sept	247	5181	0	0	0
12 Sept	0	5181	0	0	0
13 Sept	6	5187	0	0	0
14 Sept	0	5187	0	0	0
15 Sept	7	5194	0	0	0
16 Sept	26	5220	25	0	0
17 Sept	23	5243	0	0	0
18 Sept	0	5243	0	0	0
19 Sept	618	5861	0	0	0
20 Sept	3	5864	0	0	0
21 Sept	71	5935	35	2	2
22 Sept	291	6226	100	11	13
23 Sept	321	6547	0	15	28
24 Sept	96	6643	0	24	52
25 Sept	431	7074	0	21	73
26 Sept	56	7130	0	5	78
27 Sept	246	7376	0	24	102
28 Sept	111	7487	0	21	123
29 Sept	72	7559	0	10	133
30 Sept	8	7567	0	2	135
1 Oct	129	7696	0	17	152
2 Oct	28	7724	0	8	160
3 Oct	0	7724	0	2	162

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Appendix A. Continued.

	Sockeye Salmon			Coho Salmon	
Date	Daily Count	Cumulative Count	Number Sampled	Daily Count	Cumulative Count
4 Oct	6	7730	0	2	164
5 Oct	10	7740	0	3	167
6 Oct	0	7740	0	1	168
7 Oct	74	7814	0	4	172
8 Oct	0	7814	0	0	172
9 Oct	0	7814	0	0	172
10 Oct	15	7829	0	2	174
11 Oct	2	7831	0	0	174
12 Oct	11	7842	0	1	175
13 Oct	0	7842	0	0	175
14 Oct	0	7842	0	0	175
15 Oct	4	7846	0	0	175
16 Oct	0	7846	0	0	175

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