ADF&G TECHNICAL DATA REPORT NO. 183
(Limited Distribution)

STATE OF ALASKA
Bill Sheffield, Governor

COPPER RIVER HYDROACOUSTIC SALMON ENUMERATION STUDIES, 1984 AND 1985

By:
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September 1986

ALASKA DEPARTMENT OF FISH AND GAME
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Don W. Collinsworth
Commissioner

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James Brady

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

A continuing upper Copper River salmon escapement enumeration project was conducted at Miles Lake in 1984 and 1985 utilizing side-scanning sonar equipment deployed on the north and south banks of the river. Upriver sockeye *(Oncorhynchus nerka)* escapements were estimated at 536,806 and 436,313 fish for 1984 and 1985, respectively. Unusually low water levels experienced early in the 1984 season were associated with the highest percentage contribution of north bank counts ever observed in the eight-year history of the project. Rising water levels were successfully correlated with the decline in the north banks percent contribution ($r = -.881$). The resulting inverse log relationship was used to estimate missing counts. There were no comparable low water conditions in 1985, and consequently the inverse relationship did not hold. Considerable effort was expended to improve the reliability of the north bank sonar counts, including the implementation of a gill net sampling program and the development of mechanical transducer rotator assembly for substrateless sonar deployments. Test fishing data in 1984 demonstrated presence of coho salmon in the sonar counts starting on 30 July. Daily percent coho salmon in test net catches varied widely but averaged 18% from 30 July through 5 August. Migratory timing statistics, mean date, and variance were calculated for all years of sonar data, 1978-1985. Historical sonar count data and water levels is presented in tabular and standardized graphic formats.

KEY WORDS: Copper River, salmon, escapement enumeration, Miles Lake, side-scan sonar, migratory timing.

FOREWORD

A comprehensive Copper River salmon investigation program began in 1967 with catalog and inventory studies conducted annually by the Division of Commercial Fisheries of the Alaska Department of Fish and Game. Funding was provided by the National Marine Fisheries Service from 1 July 1967 through 30 June 1981 under the authorization of the Anadromous Fish Conservation Act. Subsequent to 1 July 1981, the project has continued under funds provided solely by the State of Alaska.

Early inventory and assessment projects, focusing on Copper River sockeye salmon *(Oncorhynchus nerka)*, included a tagging study using fish wheels in Wood Canyon (1966-1973) and at Miles Lake (1969-1973), a test fishery on the Copper River Delta (1967-1969), as well as other assessment projects including weirs, counting towers, and sonar deployments on upper Copper River tributaries and Eyak River. The tagging study provided valuable information on migration rates as well as annual population estimates but due to funding levels was dropped in 1974 to allow investigations to branch into other areas. In 1978, the first attempt to provide a total enumeration of upper Copper River salmon escapements utilizing sonar technology took place at the outlet of Miles Lake. In the wake of a dramatic decline in sockeye salmon abundance, the timely implementation of this successful project resulted in its immediate incorporation into the management structure for the Copper River commercial fishery. It is now permanently established as an ongoing program integral to the management of the commercial sockeye salmon fishery, which in recent years has grown to a value in excess of six million dollars (Randall et al. 1985a and 1985b).

The Copper River fisheries investigations have been summarized annually in a series of Anadromous Fish Conservation Act completion reports and ADF&G data reports listed in the reference section of this report under the following primary author names: Fridgen, Larson, Roberson, and Merritt. In addition to Copper River salmon stock assessment, the report series covers a broad range of additional topics. Much of this information, such as age structure and aerial survey data are now more comprehensively reported in the ADF&G Technical Data Report series and the Annual Management Report series. This report departs somewhat from the original series, narrowing the scope to focus specifically on the hydroacoustic assessment program located at Miles Lake on the Copper River. Data are presented for the 1984 and 1985 field seasons, along with a historical treatment of data since the project's inception in 1978.

INTRODUCTION

The Copper River and its complex delta (Figure 1) form a large spawning system utilized extensively by sockeye salmon and to a lesser degree by chinook *(Oncorhynchus tshawytscha)* and coho *(O. kisutch)* salmon. Pink *(O. gorbuscha)* and chum salmon *(O. keta)* are also present but at insignificant levels. A commercial drift gill net fishery at the mouth of the Copper River harvests a mixture of these salmon stocks. Current identification work assigns the Copper River commercial sockeye salmon catch into two major stock components; delta stocks, consisting of the coastal systems flowing south of the Chugach Mountains between Eyak Lake and the Bering River, and upriver stocks, consisting of all tributaries flowing into the main stem of the Copper River above Miles Lake (Sharr 1984). The upriver component, generally the stronger of the two, is monitored by the sonar project at Miles Lake. Many of these upriver stocks are subject to further harvest exposure in the subsistence dipnet fishery at Chitna and the subsistence fishwheel fishery on the Copper River upstream of Chitna.

The Copper River is rated as the third largest in Alaska, and drains a significant number of the state's major glaciers flowing out of the Chugach, Alaska, Wrangell, and St. Elias Mountain Ranges. Inherent in dealing with glacial systems are problems in location and enumeration of salmon along their migration route and on the spawning grounds. The primary goal of the Miles Lake sonar enumeration project is to provide timely within-season assessment of upriver sockeye salmon escapements to be applied directly to the day to day management of the commercial and subsistence fisheries. As a secondary objective, post season escapement estimates provide a basis for forecasts of subsequent returns and the establishment of escapement goals.

Real-time escapement assessment became possible in 1978, with the deployment of a single side-scanning sonar salmon counter on the south bank of the Copper River at the outlet of Miles Lake (Million Dollar Bridge site) approximately 53 km upstream from the commercial fishery zone. Comparative catch and catch per unit effort data from the first openings of the commercial fishery that year indicated a poor return. Based on comparisons with population estimates from earlier tagging studies, the daily sonar escapement estimations were also clearly below expectations and consequently contributed to the justification for a total closure of the commercial and subsistence fisheries. In the following years a Copper River management plan was developed with escapement goals based on sonar counts at Miles Lake. Emergency order regulation of the multi-million dollar commercial fishery and highly utilized upriver subsistence dip net and fishwheel fishery, are now routinely based on escapement trends monitored at Miles Lake. Since 1979, two counters have been utilized on opposite banks of the Copper River at the Miles Lake site.

METHODS

Due to the multi-channeled nature of the Copper River delta, the outlet of Miles Lake provides the closest suitable upriver escapement assessment site

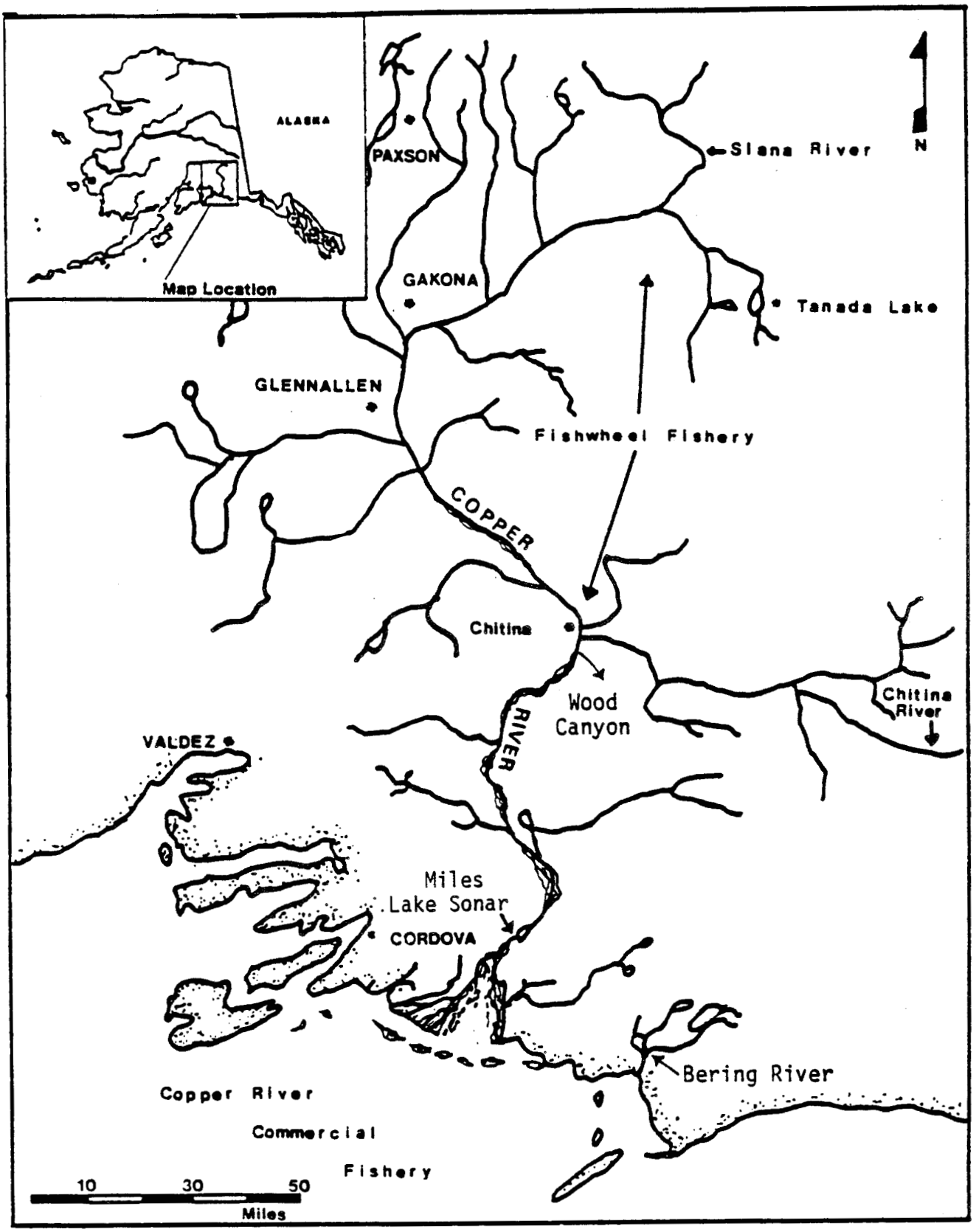


Figure 1. Copper River drainage map showing the commercial and subsistence fishing districts.

upstream of the commercial fishing district. This unique site is created as a result of two major glaciers, the Miles and the Childs, on opposing sides of the valley forcing the river into a single channel (Figure 2). Access to the site is provided by the Copper River highway, however, most years deep snow drifts render the highway impassable well into June and other transportation means are relied upon for the first portion of the season. The sonar units are deployed in the river at the earliest date that breakup conditions will allow.

The basic adult counter consists of four main elements, the electronic counting unit, a transducer, a substrate, and an oscilloscope for calibration. The system is powered by a 12 volt battery recharged daily by a solar panel. The electronic counting units employed by this project are 1978 model Bendix side scanning adult salmon counters. In 1985, a modified 1981 Bendix counter with long range capability was also employed for a portion of the season. The transducer operates at 515 KHz and has an alternating beam width of 2 and 4^{o}. It is mounted in a housing near the river bank and is aimed horizontally across the river perpendicular to the current and slightly off the bottom. Salmon observed migrating upstream in clear swift rivers, salmon tend to follow the path of least resistance by staying in slow water currents located on the bottom near the banks. The aiming of the transducer takes advantage of this behavior by ensonifying the zone most frequently used by migrating salmon.

The sonar units were operated with the transducer beam range set between 13 and 32 meters. The counting range was maintained at the maximum distance that conditions would allow. Bendix salmon counters electronically divide the sonar beam into 12 (1978 models) or 16 (1981 models) segments of equal length referred to as sectors. Sector numbering starts with 1, located immediately in front of the transducer and progresses outward to sector 12 (or 16 as the case may be), located at the extreme end of the counting range. When a fish crosses the sonar beam the resulting count is accumulated in a memory bank for the corresponding sector. At the end of each hour a printout is generated by the unit providing the accumulated fish counts by sector for the previous hour. The counters were calibrated by visual verification on an oscilloscope four times perday to correct for any over counting or under counting tendencies. A detailed description of calibration and other operational procedures for the Miles Lake sonar project is presented in the annual crew leader report, (Chisum and Brady 1985).

Because the geometry of the sonar beam is conical, the transducer must be deployed over either an artificial bottom substrate that provides a straight surface or in areas where the river bottom has a naturally uniform slope and relatively smooth bottom. Both types of deployments are used at Miles Lake. A permanent artificial substrate has been constructed at the south bank site by embedding a railroad rail in concrete forming a uniform surface along the river bottom. The rail serves as a guide on which the transducer housing can be slid up or down in response to water level fluctuations. The permanent substrate has proven to be very sucessful and convenient to work with, however a minimum of 40 inches of water above the lower end of the rail is needed for effective use. When water levels are lower, a portable artificial substrate is employed. This consists of a submerged 8-inch diameter aluminum

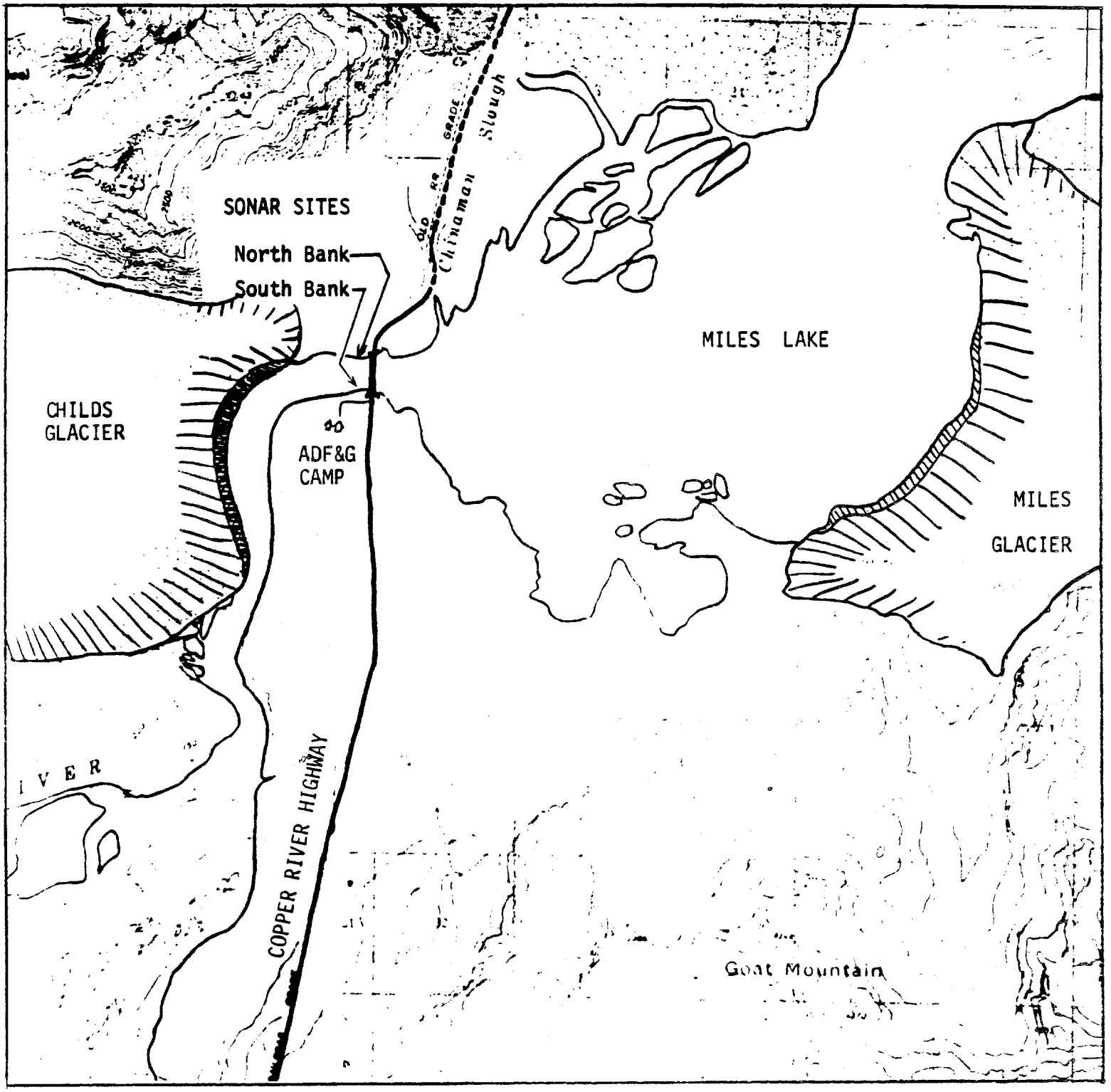


Figure 2. Detail map of the Miles Lake area illustrating the location of the north and south bank sonar sites.

pipe 12 to 18 meters in length and held in place against the current by cables anchored upstream. "Substrateless" deployments were also developed in the past two seasons. The first configuration utilized the Biosonics two axis electric rotators for transducer aiming, and consequently was dependent upon a 120 volt AC power source. To eliminate this dependence, a mechanical rotator assembly was developed and utilized during the 1985 season (Figure 3). This new type of rotator proved to be more convenient to use, and owing to its portability, allowed the investigation of alternate sonar sites on the north bank.

Frequent adjustments of sonar substrates and transducer deployments are required on both banks because of wide fluctuations in river level, wave action caused by strong winds and periods of heavy ice passage.

Test Fishing

A test fishing program was reinitiated in 1984 and 1985. A 50 fathom gill net with 5-3/8 inch mesh was fished (both set and drift) to determine fish presence in areas beyond the sonar beams and to monitor species composition. Three general drift sites were used, north bank, south bank, and mid channel. The north bank drifts started approximately at the bridge, passed over the north bank sonar site, and continued downstream approximately 1000 meters. South bank drifts followed an analogous pattern passing over the south bank sonar site. Mid channel drifts were started above the bridge, passed through the two midstream bridge abutments and extending downstream approximately 1000 meters. Extreme caution was used to insure that drifts did not extend downstream to areas exposed to the ice fall hazards of the Childs Glacier. Portions of the north bank and south bank drift sites may extend beyond the counting range of the sonar beams. Two set net sites were used, a north bank site approximately 100 meters downstream from the sonar site, and a south bank site located approximately 300 meters upstream of the south bank site. Exact locations of all fishing sites were periodically modified in response to water levels which typically show a 13.5 ft rise through the course of each season.

Migratory Timing

Time series sonar data for the history of the project (1978-1985) were compiled for a comparative migratory timing analysis. Daily passage figures were converted to daily proportions to give all years equal weight. Migratory timing descriptive statistics, mean day, median, and variance were calculated for the daily salmon counts at Miles Lake from 1978 to 1985. Mean date and variance are calculated from daily proportions P(t), as follows (Mundy 1979):

$$P(t) = \frac{\text{sonar count on day (t)}}{\text{season cumulative counts}}$$

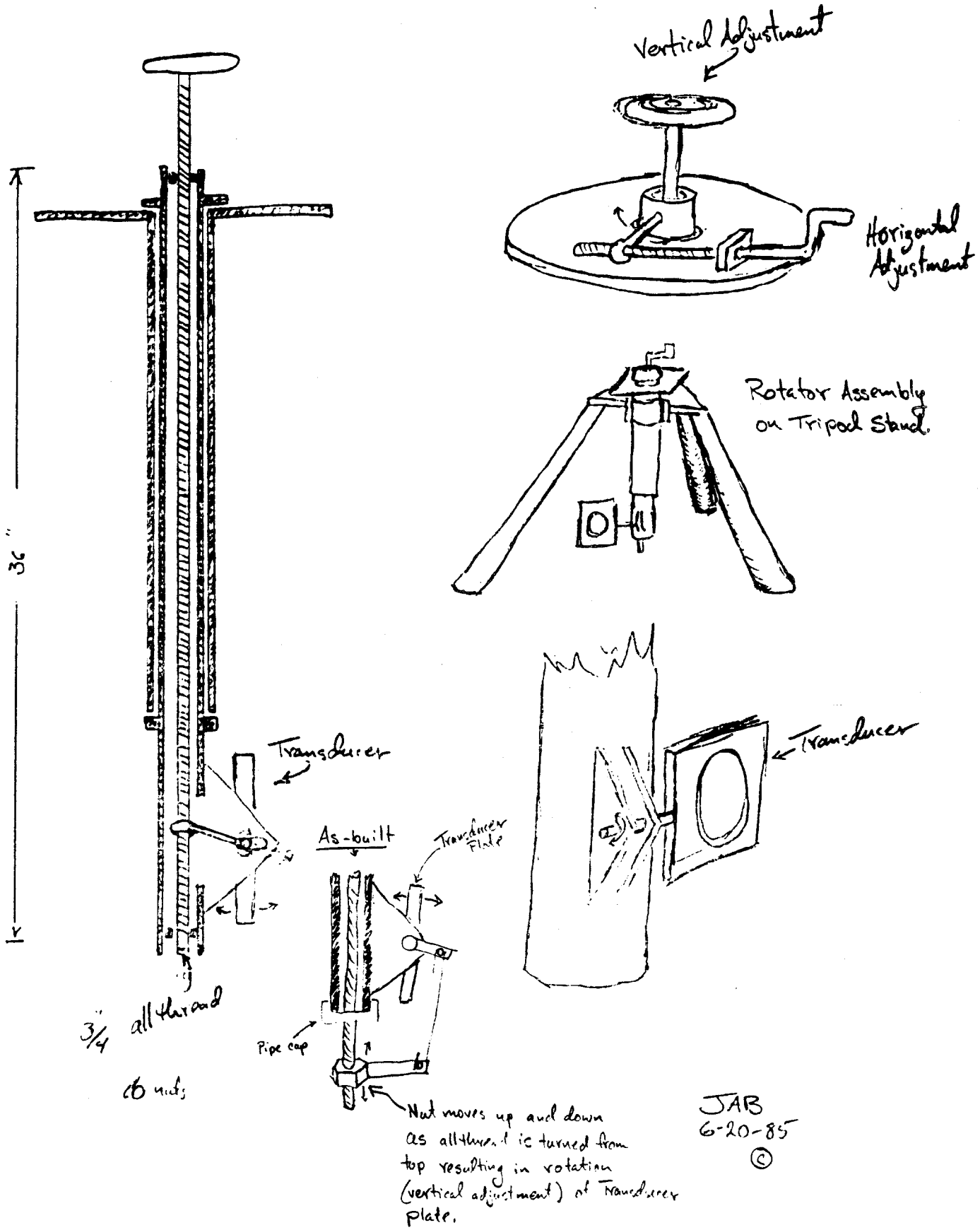


Figure 3. Design sketch of mechanical transducer rotator assembly developed and tested in 1985.

The mean day, t, is calculated as

$$t = t*P(t)$$

and the variance, v, and standard deviation, SD, are calculated as

$$v = (t-t) * P(t)$$

$$SD = v$$

North Bank Site Improvement

In the fall of 1984, a D-8 Caterpillar tractor was contracted to reprofile the north bank sonar site. The areas immediately in front of the electronic shed was built up by 3 ft while the offshore area was graded down 3 ft generating a uniform slope of about 7% extending for approximately 235 ft in front of the shed. The previous slope was variable and a poor assessment site at intermediate and high water levels. The reprofile work provided an improved surface for substrateless deployments, however is still far inferior to the south bank permanent substrate with 14% grade.

RESULTS

Sonar Enumeration

The total salmon enumeration estimates for 1984 and 1985 were 536,806 and 436,313 fish, respectively (Tables 1 and 2), exceeding the desired escapement goal of 411,000 in both cases. Sonar operation spanned from 19 May to 6 August in 1984 and from 28 May to 2 August in 1985. The 1985 startup date was the latest in the history of the project. This was a result of the exceptionally late breakup and the difficulty in establishing the camp due to the heavy snow pack (Chisum and Brady 1985). The sonar units, however, were deployed in advance of any significant salmon passage rates.

Daily cumulative counts for 1984 (Figure 4) fell below expectations in late May and early June which led to restrictions of the commercial fishery. A dramatic recovery was observed from 7-14 June, with peak daily passage of 26,619, allowing the commercial fishery to reopen. Daily escapements continued at or above desired levels for the remainder of the season.

Due to the late breakup, migratory timing in the river as delayed and consequently the early 1985 counts were well below expected escapement levels (Figure 5). Commercial fishery catch data, however, indicated a strong return and consequently the fishery was not restricted in the absence of supporting sonar data. Salmon passage rates increased rapidly after 3 June reaching the season peak daily count of 32,953 on 6 June. Between 3 June and 11 June nearly 200,000 fish passed the counting station, bringing the cumulative count well above the desired level for that date. Daily counts declined rapidly in late June and early July causing the cumulative

Table 1. Daily Copper River salmon escapement estimates at Miles Lake sonar project, 1984.

Date	North Bank		South Bank	Daily Total	Cumulative Total	Water Level
5/19	389	*	336	725	725	-8.5
5/20	954	*	970	1,924	2,649	-7.0
5/21	778	*	1,208	1,986	4,635	1.5
5/22	1,807	*	3,317	5,124	9,759	7.0
5/23	1,732	*	3,310	5,042	14,801	8.5
5/24	1,454	*	3,032	4,486	19,287	11.8
5/25	987	*	2,133	3,120	22,407	13.5
5/26	1,381	*	3,264	4,645	27,052	17.5
5/27	1,696	*	4,140	5,836	32,888	19.0
5/28	1,575	*	3,403	4,978	37,866	13.5
5/29	2,348	*	4,778	7,126	44,992	11.0
5/30	1,716	*	3,235	4,951	49,943	8.0
5/31	2,290		1,988	4,278	54,221	7.5
6/01	2,840		5,696	8,536	62,757	5.8
6/02	2,124		6,359	8,483	71,240	4.8
6/03	4,317		5,413	9,730	80,970	7.3
6/04	4,351		8,145	12,496	93,466	13.5
6/05	5,659		11,069	16,728	110,194	18.8
6/06	5,555		12,542	18,097	128,291	30.3
6/07	3,843	*	14,672	18,515	146,806	42.0
6/08	5,444	*	21,175	26,619	173,425	43.0
6/09	4,188	*	16,288	20,476	193,901	43.0
6/10	3,785	*	15,490	19,275	213,176	45.8
6/11	1,979		15,258	17,237	230,413	50.8
6/12	1,480		20,226	21,706	252,119	55.5
6/13	739		11,333	12,072	264,191	62.0
6/14	837	*	5,144	5,981	270,172	67.0
6/15	161		10,130	10,291	280,463	71.0
6/16	1,848	*	12,082	13,930	294,393	70.0
6/17	2,917	*	16,892	19,809	314,202	64.0
6/18	1,797	*	11,053	12,850	327,052	67.0
6/19	430		7,044	7,474	334,526	74.0
6/20	264		8,994	9,258	343,784	80.5
6/21	612		6,547	7,159	350,943	94.0
6/22	395	*	5,127	5,522	356,465	98.0
6/23	318	*	5,595	5,913	362,378	107.0
6/24	185	*	6,556	6,741	369,119	121.5
6/25	62	*	6,441	6,503	375,622	131.0
6/26	94	+	4,291	4,385	380,007	137.0
6/27	103	+	7,121	7,224	387,231	130.5
6/28	172	*	6,556	6,728	393,959	122.0
6/29	188	*	4,265	4,453	398,412	113.0
6/30	397	*	6,052	6,449	404,861	103.0
7/01	474	*	7,752	8,226	413,087	105.0
7/02	452	*	7,102	7,554	420,641	104.0
7/03	511	*	8,070	8,581	429,222	104.0
7/04	363	*	6,152	6,515	435,737	106.0
7/05	423	*	6,239	6,662	442,399	102.0
7/06	261	*	5,188	5,449	447,848	110.0
7/07	64		3,976	4,040	451,888	119.0
7/08	35		3,871	3,906	455,794	128.0
7/09	48		3,162	3,210	459,004	136.0
7/10	22	*	2,905	2,927	461,931	132.0
7/11	66	*	3,542	3,608	465,539	126.0
7/12	125	*	4,155	4,280	469,819	120.0
7/13	176	*	4,406	4,582	474,401	115.0
7/14	1,252		5,321	6,573	480,974	114.0
7/15	734		4,787	5,521	486,495	110.0
7/16	576		6,179	6,755	493,250	106.0
7/17	128		4,827	4,955	498,205	101.0
7/18	141		4,595	4,736	502,941	106.0
7/19	65		3,075	3,140	506,081	107.0
7/20	144		3,245	3,389	509,470	98.0
7/21	57		3,147	3,204	512,674	93.0
7/22	64		3,716	3,780	516,454	92.0
7/23	113		3,092	3,205	519,659	94.0
7/24	50		2,148	2,198	521,857	102.0
7/25	93		1,844	1,937	523,794	110.0
7/26	162		1,525	1,687	525,481	115.0
7/27	83		1,308	1,391	526,872	119.0
7/28	28		976	1,004	527,876	119.0
7/29	21		870	891	528,767	123.0
7/30	33		905	938	529,705	121.0
7/31	102		991	1,093	530,798	123.0
8/01	84		963	1,047	531,845	120.0
8/02	107		981	1,088	532,933	121.0
8/03	83		1,130	1,213	534,146	121.0
8/04	85		1,033	1,118	535,264	124.0
8/05	51		958	1,009	536,273	133.0
8/06	25		508	533	536,806	144.0
8/07				0	536,806	154.0
Total	83,492		453,314	536,806		

* North Bank count estimated from regression equation.
\+ North Bank count estimated from expanded test net C.P.U.E.

Table 2. Copper River daily salmon escapement estimates at Miles Lake sonar project, 1985.

					----- Actual -----			---- Anticipated ----	
Date	North Bank		South Bank		Daily Total	Cumulative Total	Water Level	Daily Count	Cumulative Count
5/17	0		0		0	0		589	589
5/18	0		0		0	0		1,201	1,790
5/19	0		0		0	0		1,407	3,197
5/20	0		0		0	0		1,513	4,710
5/21	0		0		0	0		1,593	6,303
5/22	0		0		0	0		1,604	7,907
5/23	0		0		0	0		2,442	10,349
5/24	0		0		0	0		3,862	14,211
5/25	0		0		0	0		3,950	18,161
5/26	0		0		0	0		4,027	22,188
5/27	0		0		0	0		5,868	28,056
5/28	47	(1)	984		1,031	1,031	50	9,391	37,448
5/29	19	(1)	398		417	1,448	52	5,498	42,946
5/30	27	(1)	572		599	2,047	51	8,107	51,053
5/31	80	(1)	1,678		1,758	3,805	46	10,442	61,495
6/01	82	(2)	3,380		3,462	7,267	40	9,965	71,459
6/02	220	(2)	6,506	(2)	6,726	13,993	35	11,154	82,613
6/03	486	(1)	10,205	(2)	10,691	24,684	34	9,319	91,932
6/04	843	(2)	23,429		24,272	48,956	37	9,723	101,655
6/05	147	(1)	30,360		30,507	79,463	46	11,209	112,864
6/06	1,497	(1)	31,456	(2)	32,953	112,416	56	11,181	124,045
6/07	1,238	(1)	26,018		27,256	139,672	53	11,393	135,437
6/08	1,405	(1)	29,520	(2)	30,925	170,597	43	11,223	146,660
6/09	1,350	(1)	28,352	(3)	29,702	200,299	40	10,707	157,367
6/10	546	(1)	11,464	(2)	12,010	212,309	41	10,212	167,579
6/11	1,571	(2)	10,255		11,826	224,135	39	10,008	177,586
6/12	483		7,748		8,231	232,366	39	9,079	186,665
6/13	398		6,431		6,829	239,195	43	9,366	196,031
6/14	193		6,607		6,800	245,995	44	8,351	204,382
6/15	180		8,645		8,825	254,820	45	8,714	213,096
6/16	1,273		8,074		9,347	264,167	44	8,030	221,126
6/17	1,160		5,110		6,270	270,437	44	8,554	229,680
6/18	348		3,390		3,738	274,175	53	7,742	237,422
6/19	477		2,774		3,251	277,426	58	5,995	243,417
6/20	59		2,364		2,423	279,849	58	5,263	248,680
6/21	41		2,020		2,061	281,910	59	5,495	254,174
6/22	25		2,738		2,763	284,673	52	5,258	259,432
6/23	24		3,345		3,369	288,042	54	5,871	265,304
6/24	114		2,836		2,950	290,992	57	5,606	270,910
6/25	182		1,403		1,585	292,577	68	5,287	276,196
6/26	107		2,274		2,381	294,958	70	4,361	280,557
6/27	94		2,941		3,035	297,993	69	3,855	284,412
6/28	89	(2)	2,175		2,264	300,257	77	3,843	288,255
6/29	67	(2)	2,080		2,147	302,404	86	3,897	292,152
6/30	109		2,030		2,139	304,543	95	3,801	295,953
7/01	37		2,583		2,620	307,163	112	4,219	300,172
7/02	92		2,516		2,608	309,771	130	5,128	305,300
7/03	29		1,790		1,819	311,590	139	5,442	310,742
7/04	55		3,481		3,536	315,126	142	5,994	316,736

-Continued-

Table 2. Copper River daily salmon escapement estimates at Miles Lake sonar project, 1985 (continued).

Date	North Bank		South Bank	Actual Daily Total	Actual Cumulative Total	Water Level	Anticipated Daily Count	Anticipated Cumulative Count
7/05	55		3,199	3,254	318,380	142	4,983	321,719
7/06	79		4,585	4,664	323,044	144	4,356	326,075
7/07	60		3,567	3,627	326,671	151	3,800	329,875
7/08	28		3,865	3,893	330,564	154	3,406	333,280
7/09	74		6,753	6,827	337,391	147	3,351	336,632
7/10	99		10,508	10,607	347,998	139	3,828	340,460
7/11	155		5,302	5,457	353,455	138	3,894	344,354
7/12	201		6,128	6,329	359,784	135	3,705	348,059
7/13	136		5,116	5,252	365,036	142	2,948	351,007
7/14	103		6,010	6,113	371,149	141	3,494	354,501
7/15	83		4,941	5,024	376,173	139	3,811	358,312
7/16	268		5,071	5,339	381,512	135	4,194	362,506
7/17	440	(4)	5,520	5,960	387,472	134	3,645	366,152
7/18	232	(1)	4,878	5,110	392,582	137	4,718	370,869
7/19	154	(2)	4,406	4,560	397,142	137	5,953	376,822
7/20	64		8,112	8,176	405,318	141	5,392	382,214
7/21	46		4,082	4,128	409,446	153	4,582	386,797
7/22	146		3,012	3,158	412,604	152	3,264	390,061
7/23	79		2,791	2,870	415,474	142	2,763	392,823
7/24	113		2,049	2,162	417,636	132	2,560	395,383
7/25	74		2,375	2,449	420,085	127	2,151	397,534
7/26	80		1,894	1,974	422,059	127	1,682	399,216
7/27	37		2,154	2,191	424,250	117	1,465	400,682
7/28	43		2,796	2,839	427,089	117	1,563	402,245
7/29	161		2,652	2,813	429,902	122	1,314	403,559
7/30	110		2,680	2,790	432,692	127	1,236	404,795
7/31	195		1,653	1,848	434,540	133	1,114	405,909
8/01	151		919	1,070	435,610	139	1,125	407,033
8/02	32	(1)	671	703	436,313	156	1,037	408,070
8/03	0		0	0	436,313	210	834	408,904
8/04	0		0	0	436,313	239	881	409,785
8/05	0		0	0	436,313		471	410,256
8/06	0		0	0	436,313		450	410,706
8/07	0		0	0	436,313		208	410,914
8/08	0		0	0	436,313		35	410,949
8/09	0		0	0	436,313		51	411,000
Total	18,692		417,621		436,313			411,000

Footnotes:

(1) Whole day count missing due to heavy ice passage rates, debris problems, malfunctions, or other reasons. Missing day counts on the north bank site are estimated using the average percentage of north bank to south bank, 4.60%.

(2) Some hourly counts missing due to ice passage, debris, water level changes or other reasons. Counts for missing hours estimated by simple interpolation from adjacent time blocks.

(3) Sonar counter at the south bank site changed from the 1978 model, to modified 1981 model with increased transducer sensitivity and long range capability.

(4) North bank counting unit moved downstream for one day to evaluate new sites.

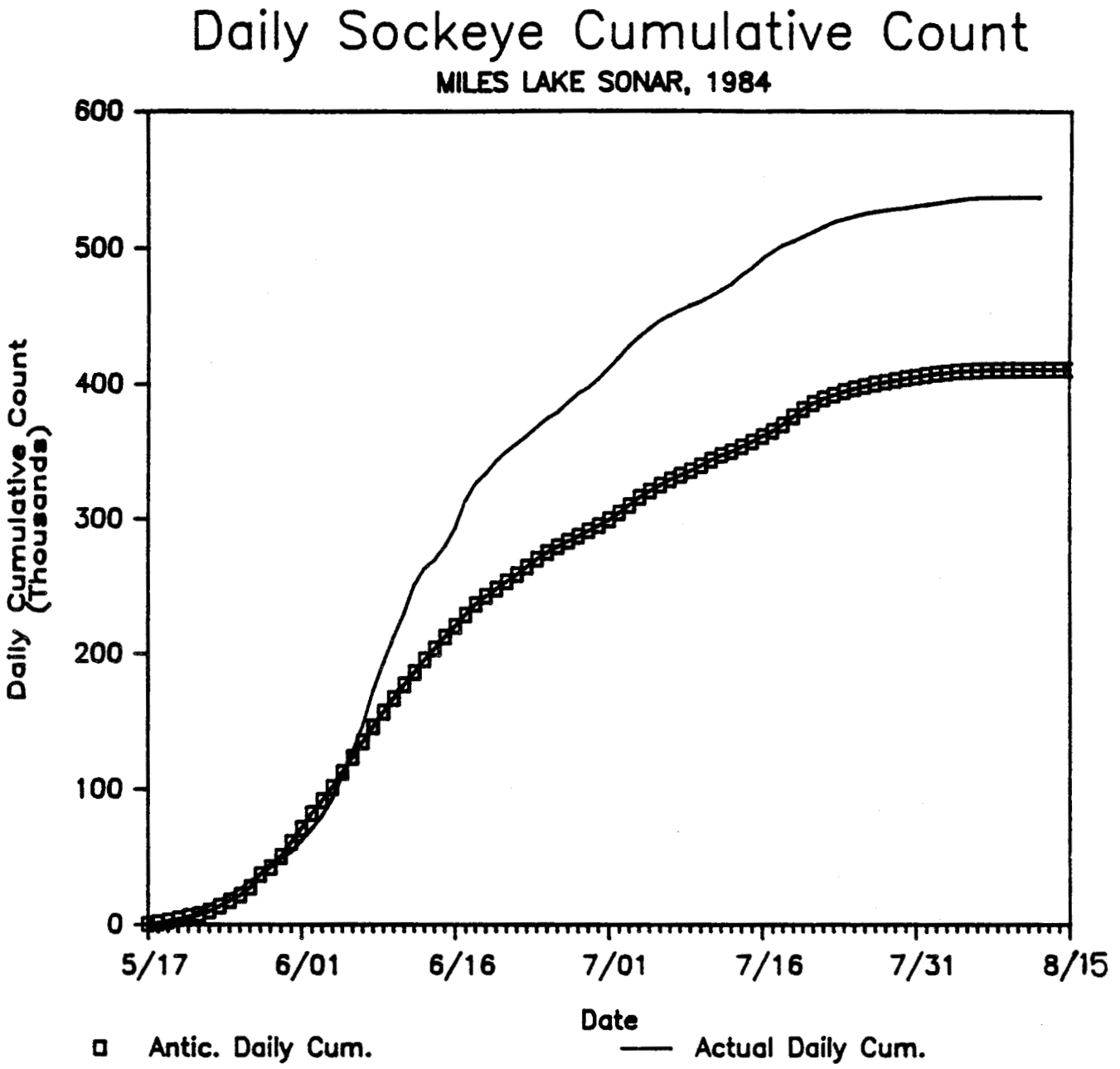


Figure 4. Actual and anticipated daily cumulative Copper River escapement estimates at Miles Lake sonar project, 1984.

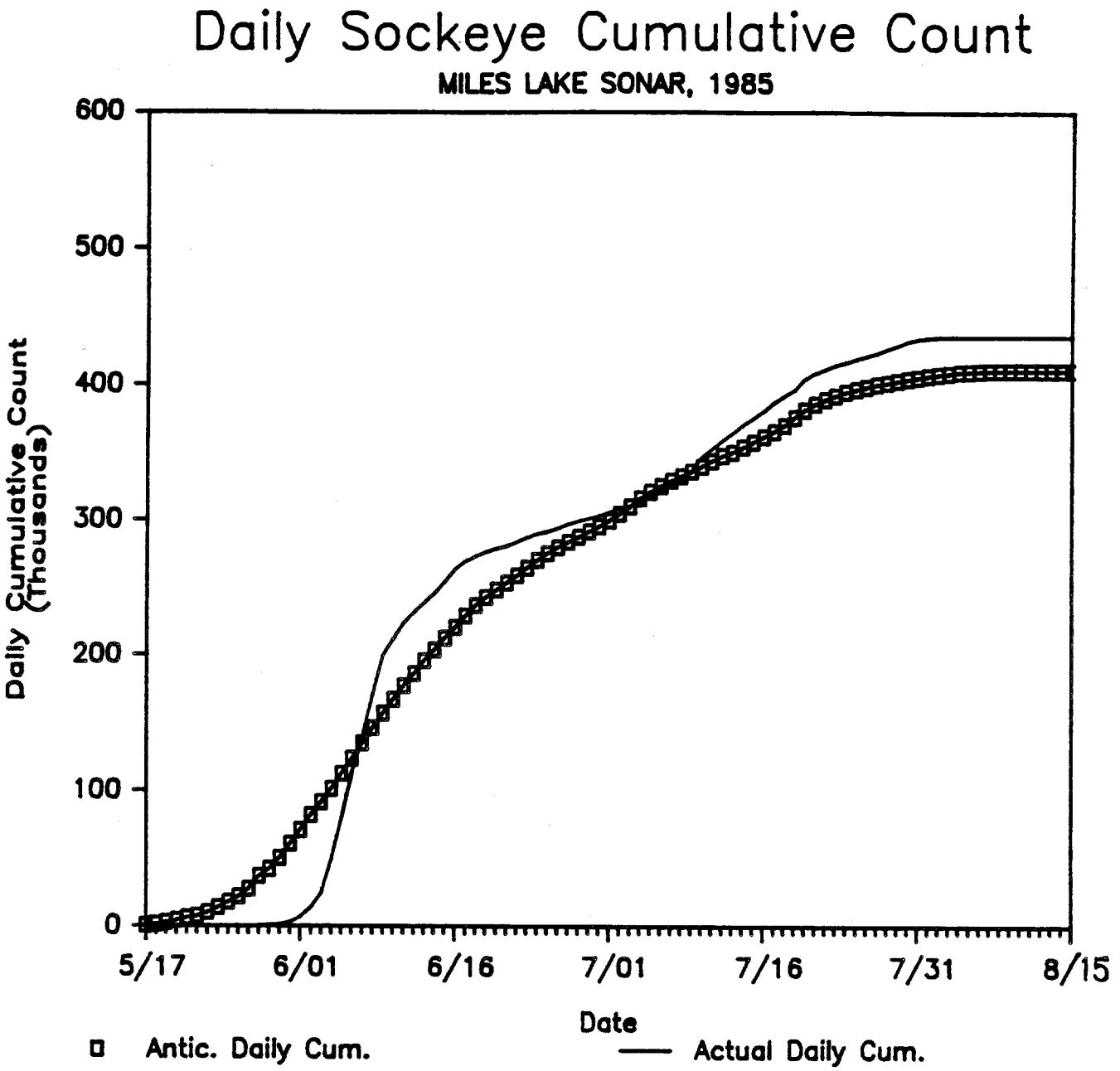


Figure 5. Actual and anticipated daily cumulative Copper River escapement estimates at Miles Lake sonar project, 1985.

count to fall below expectations and generating concerns for escapement quality of middle run sockeye salmon stocks. Consequently, the commercial fishery was restricted and eventually closed from 3 July until 17 July at which time daily counts recovered to desired levels. A more detailed discussion of the Copper River commercial fishery management for 1984 and 1985 is provided by Randall et al. (1985a and 1985b).

Sector Distribution

Salmon counts were consistently highest in the nearshore sectors of the sonar beam in both 1984 and 1985 (Figures 6 and 7). This concentration of counts in the slower nearshore waters is especially pronounced on the south bank and is consistent with distribution in prior years (Merritt et al. 1983 and 1984).

North Bank Site Investigations

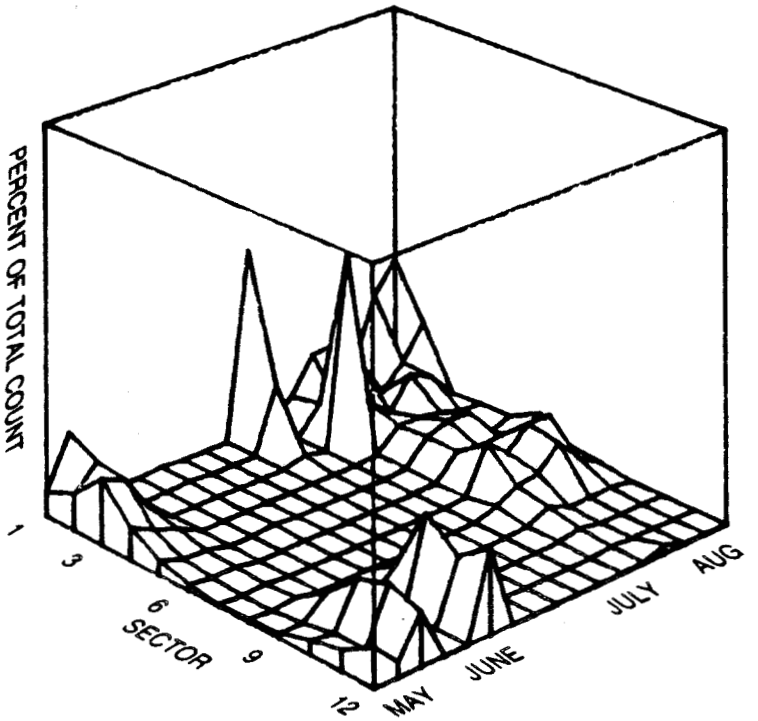
As previously observed, the majority of the documented escapement occurred at the south bank site, 84% in 1984 and 96% in 1985. North bank counts have been plagued with difficult counting conditions and unreliable counts ever since the first counting unit was installed in 1979. A significant effort was made in 1984 and 1985 to investigate the sources of counting problems and improve the accuracy of north bank daily passage estimates. The north bank counting unit was operated more days in 1984 and 1985 than in any previous year, 41 and 54 days, respectively.

The relative proportion of north bank to south bank counts have changed from year to year as have the methods of estimating counts for days when the north bank unit was not operational. In 1984 the north bank unit was initially deployed on 31 May. This was the earliest date a unit had ever been deployed at this site. At this time the water level of the Copper River was 18 inches, unseasonably low (Appendix A). Interestingly, the north bank counts during the first five days of operation averaged 58% of the south bank counts for the same period. This was surprising in light of previous estimates of north bank counts averaging around 10% (Merritt et al. 1983 and 1984). As water levels rose, the north bank percentage of south bank counts dropped dramatically. A linear regression was performed on this inverse relationship (Table 3). An inverse log function (Figure 8) was shown to give the best fit ($r = -.881$). This relationship was used to estimate missing north bank counts in determination of the final escapement estimate. The same correlation analysis was performed on the 1985 data, however, the relationship in this case was insignificant. Consequently missing north bank counts were estimated as the mean percentage of south bank counts (4.6%) for the 1985 data.

Test Fishing

The test fishing program initiated in 1984 operated on an as time permits basis between 5 June and 5 August. Early efforts were directed towards identifying offshore passage rates beyond the sonsified zone and the north bank. A nine-minute drift on 5 June in the mid-channel site yielded 7 sockeye salmon and 1 king salmon, thus confirming the presence of fish

North Bank



South Bank

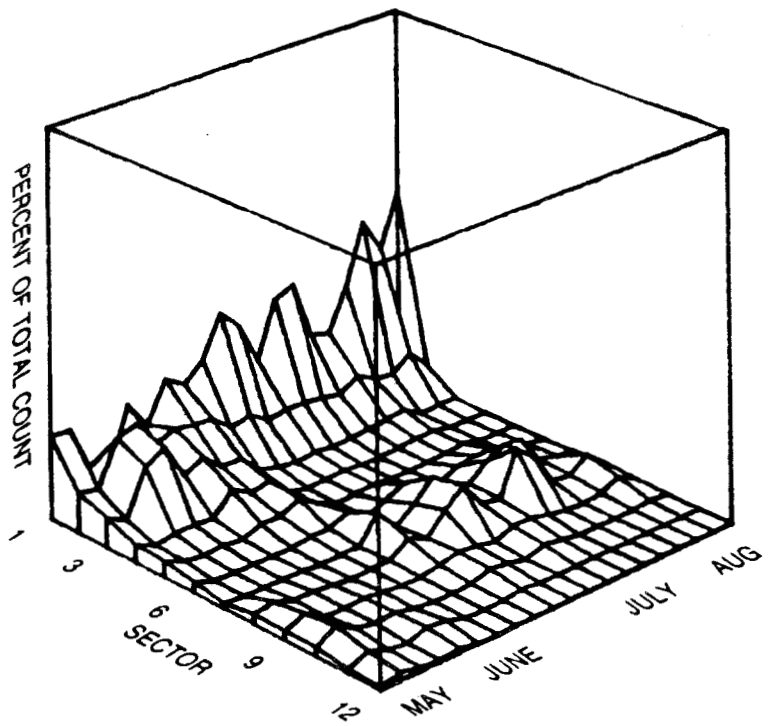
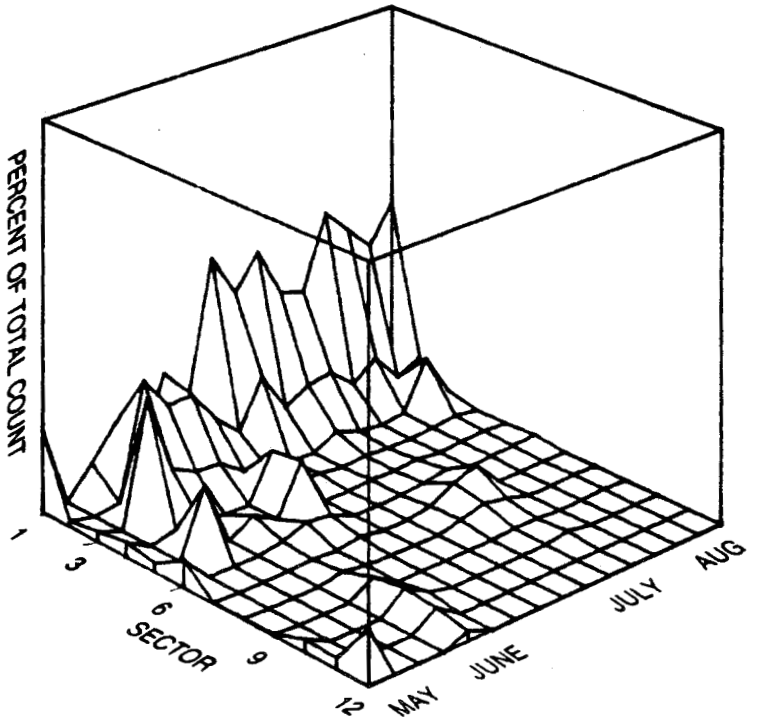


Figure 6. Mean sector count percentages for south and north bank counting units through time, Miles Lake sonar project, 1984.

North Bank



South Bank

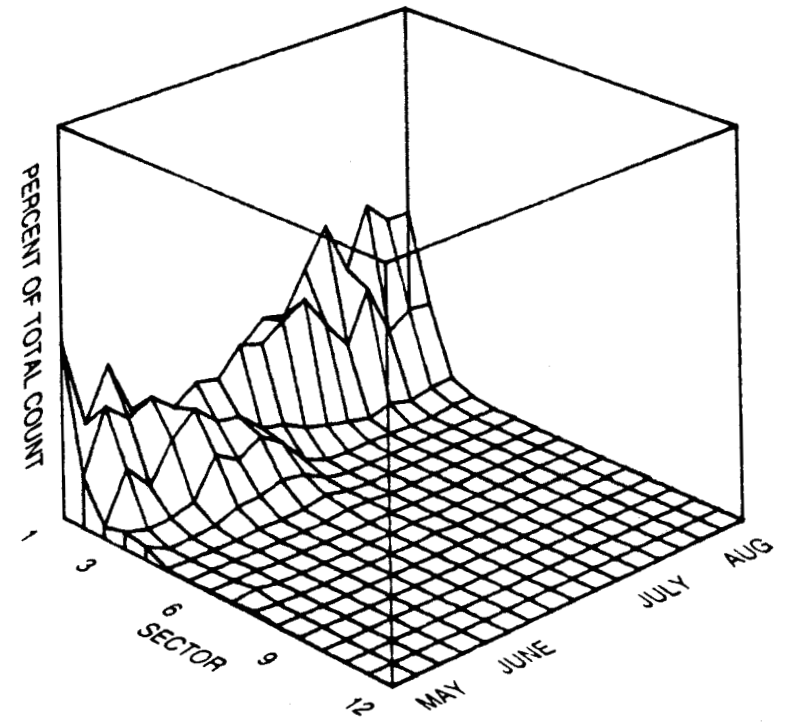


Figure 7. Mean sector count percentages for south and north bank counting units through time, Miles Lake sonar project, 1985.

Table 3. Correlation between North Bank vs South Bank sonar counts and water level, Miles Lake sonar project, 1984.

ROW □	Date	North Bank Count	South Bank Count	N.B. % of South Bank	Water Level (plus 10in.)
1	601	2,840	5,696	49.8	16
2	602	2,124	6,359	33.4	15
3	603	4,317	5,413	79.8	17
4	604	4,351	8,145	53.4	24
5	605	5,659	11,069	51.1	34
6	606	5,555	12,542	44.3	40
7	611	1,979	15,258	13.0	63
8	612	1,480	20,226	7.3	66
9	613	739	11,333	6.5	72
10	620	263	8,994	2.9	90
11	621	612	6,547	9.4	104
12	707	64	3,976	1.6	129
13	708	35	3,871	0.9	138
14	715	734	4,787	15.3	120
15	716	576	5,625	10.2	117
16	717	128	4,827	2.7	111
17	718	141	4,595	3.1	116
18	719	65	3,075	2.1	117
19	720	144	3,245	4.4	108
20	721	57	3,147	1.8	103
21	722	64	3,716	1.7	102
22	723	113	3,092	3.6	104
23	724	50	2,148	2.3	112
24	725	93	1,844	5.0	110
25	726	162	1,525	10.6	124
26	722	83	1,308	6.4	129
27	728	28	976	2.9	129
28	729	21	870	2.4	133
29	730	33	905	3.6	131
30	731	102	991	10.3	133
31	801	84	963	8.7	130
32	802	107	981	10.9	131
33	803	83	1,130	7.4	131
34	805	51	958	5.3	143

-Continued-

Table 3. Correlation between North Bank vs South Bank sonar counts and water level, Miles Lake sonar project, 1984 (continued).

X	A+(B*X)	A*EXP(B*X)	A+B*LOG(X)	A*X^B	Y
16	46.8572	41.2442	56.0151	64.8484	49.8
15	47.2571	42.1478	57.648	70.7277	33.4
17	46.4572	40.36	54.4813	59.7716	79.8
24	43.6576	34.679	45.7566	37.5933	53.4
34	39.6582	27.922	36.9442	23.5343	51.1
40	37.2585	24.5174	32.8324	18.9143	44.3
63	28.0598	14.8936	21.3394	10.2685	13
66	26.86	13.956	20.1624	9.64587	7.3
72	24.4603	12.2543	17.961	8.58079	6.5
90	17.2613	8.2961	12.3153	6.35642	2.9
104	11.6621	6.12499	8.65728	5.23333	9.4
129	1.66349	3.56291	3.20698	3.91718	1.6
138	-1.936	2.93155	1.50066	3.57757	.9
120	5.26299	4.33026	5.03674	4.31726	15.3
117	6.46282	4.62114	5.67729	4.46677	10.2
111	8.86248	5.26286	7.00922	4.79443	2.7
116	6.86276	4.72239	5.89446	4.51862	3.1
117	6.46282	4.62114	5.67729	4.46677	2.1
108	10.0623	5.61639	7.70243	4.97437	4.4
103	12.062	6.25918	8.90174	5.30177	1.8
102	12.462	6.39631	9.14858	5.37178	1.7
104	11.6621	6.12499	8.65728	5.23333	3.6
112	8.46254	5.15003	6.78231	4.73696	2.3
110	9.26243	5.37816	7.23818	4.85313	5
124	3.66321	3.97068	4.20714	4.13104	10.6
129	1.66349	3.56291	3.20698	3.91718	6.4
129	1.66349	3.56291	3.20698	3.91718	2.9
133	.0637169	3.26706	2.43437	3.75958	2.4
131	.863602	3.41178	2.81773	3.83697	3.6
133	.0637169	3.26706	2.43437	3.75958	10.3
130	1.26355	3.48653	3.0116	3.87671	8.7
131	.863602	3.41178	2.81773	3.83697	10.9
131	.863602	3.41178	2.81773	3.83697	7.4
143	-3.93572	2.63049	.600189	3.41038	5.3
A REG COEFF	53.2563	58.3385	126.163	2698.2	
B REG COEFF	-.399944	-.021672	-25.3007	-1.3447	
A STD ERROR	5.0262 1	.360698	10.7374	.860001	
B STD ERROR	.047495	.0034084	2.3946	.191793	
STD ERR EST	10.859	.779275	9.19149	.736182	
COEFF DET	.689047	.55819	.777213	.605702	
COVARIANCE	-633.529	-34.3293	-11.296	-.600367	
CORR COEFF	-.830088	-.747121	-.881597	-.778269	
DURBN-WATSN	1.12387	1.15973	1.51703	1.22079	

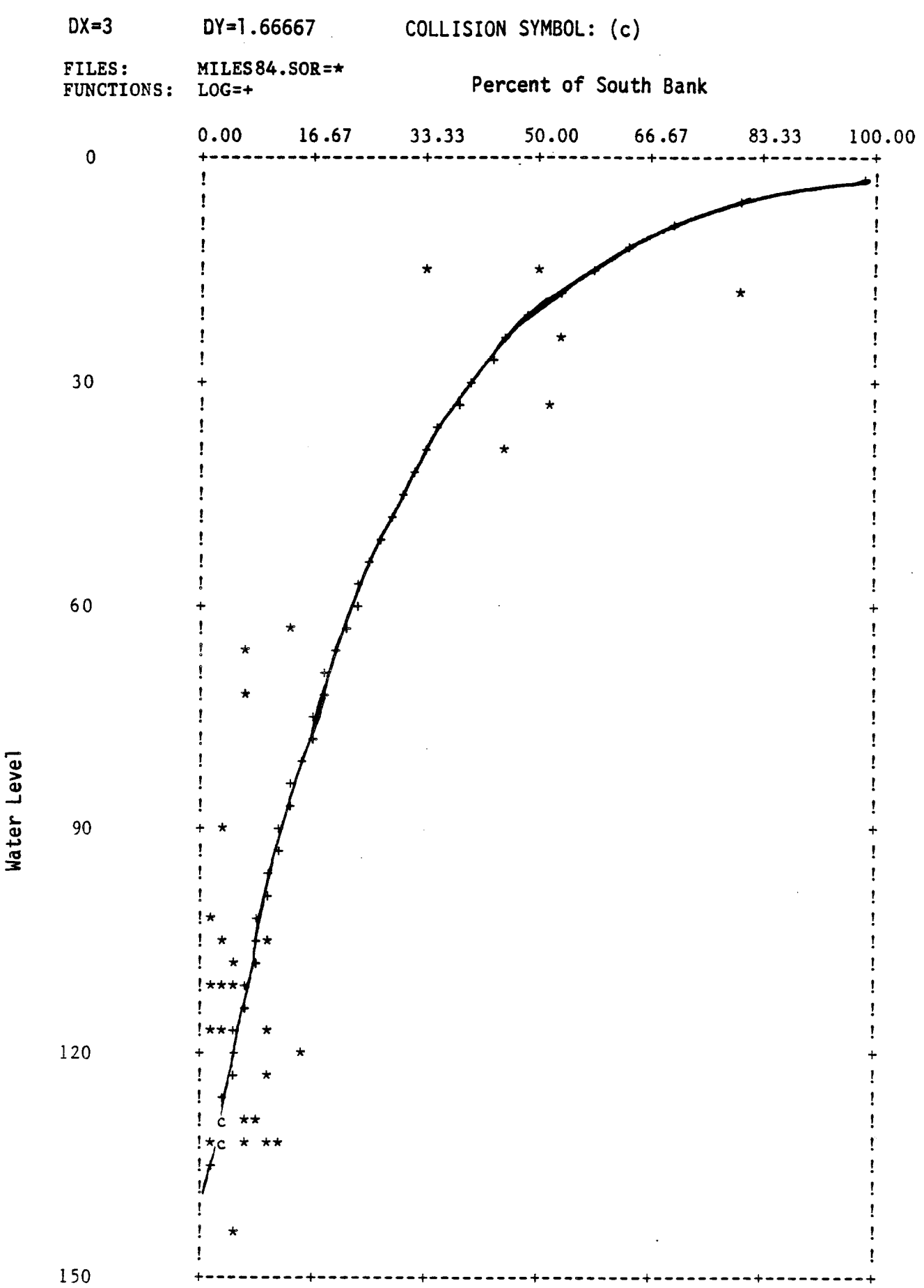


Figure 8. Linear regression of north bank counts as a percentage of the south bank counts vs water level, 1984.

outside the counting range (Table 4). This was during the period of peak passage while water levels were still relatively low. Subsequent drifts at this site failed to produce additional fish. In late July test fishing efforts were focused on identifying the shift in species composition from sockeye salmon to coho salmon. The first coho salmon was captured on 30 July. Daily percentage of coho salmon in the test net catches varied widely but the average for the remainder of the season was 18%. Applying this percentage to the post 30 July sonar count of 7,101 fish, yields an estimated 1,271 coho salmon passing during the enumeration period.

In 1985 the test fishing effort was reduced to allow time for major camp renovations. Test fishing spanned 15 June to 28 July and focused primarily on improving understanding of fish migration routes in the vicinity of the north bank site. The results of this effort were inconclusive, but are presented in more detail in the crew leader's report (Chisum and Brady 1985). A summary of the 1985 test fishing results are presented in Table 5.

Migratory Timing

As background and general reference for migratory timing analysis, comparative historical sonar daa are presented in Appendices B and C. Daily sonar counts and daily cumulative percentages for all years since 1978 are given in Appendix B. Comparative daily counts are plotted for each year compared to desired timing curve in Appendix C.

The mean date of salmon migration, measured at the sonar counters, ranges from 16 June (1982) to 23 June (1980) (Table 6). The median dates range from 9 June (1981) to 19 June (1980). In every year the mean date occurs later than the median owing to the nature of the timing curve which is skewed toward the early portion of the run (Figure 9). The variance, or standard deviation (positive square route of the variance) describe the relative breadth or compactness of a given season's run timing. With the exception of two years, 1978 and 1981, this measurement of dispersion is surprisingly consistent, probably owing in large part to the long duration of the run which tends to average out overall run performance. In 1978, the migratory timing stands out as being somewhat more compressed in part due to the shorter period of monitoring and the normal shape of the timing curve. The 1981 timing data, on the other hand, is quite dispersed due to the occurrence of a series of exceptionally high counts in late July.

The mean migratory timing curve (Figure 3) is derived froom annual daily proportions. Mean daily proportions are scaled to the escapement goal, 411,000 fish, yielding desired daily escapement figures. This type of plot is used within-season to provide fishery managers a basis for evaluating real-time escapement performance.

DISCUSSION

Species Apportionment

Sonar counts from Miles Lake are treated as strictly sockeye salmon counts even through other species, primarily chinook and coho salmon, make up a

Table 4. Copper River gill net test fishing catches at Miles Lake sonar project, 1984.

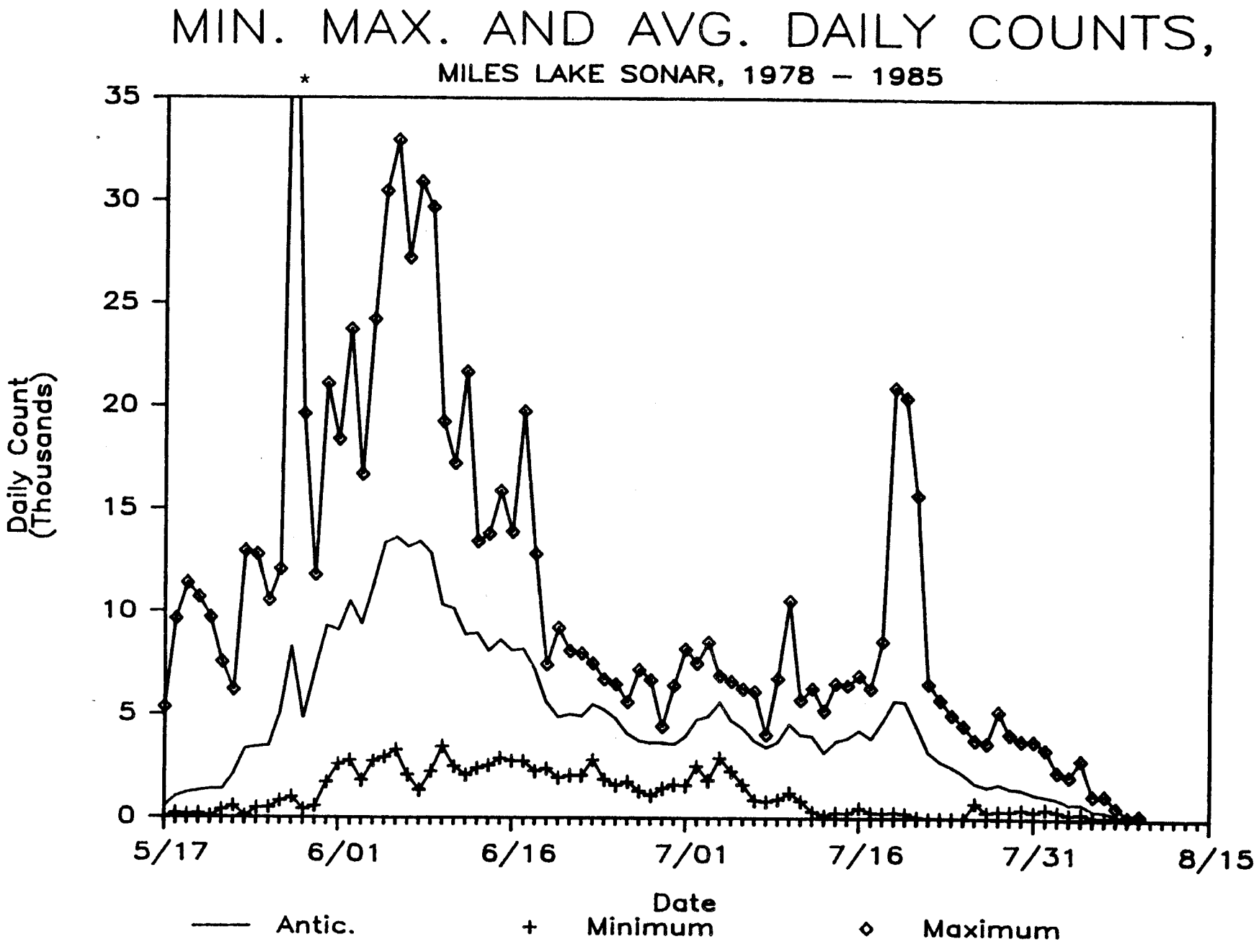
Date	Number of sets	Fishing Time (Min.)	Total Daily Catch				Site	Set/Drift
			King	Sockeye	Coho	Pink		
6/05	1	12	1	7			Mid	Drift
6/17	1	9					Mid	Drift
6/24	1	10					Mid	Drift
6/26	1	6					Mid	Drift
6/27	1	5					Mid	Drift
Mid Channel Sub.	42		1	7	0	0		
6/05	2	17		9			N.B.	Drift
6/08	2	19					N.B.	Drift
6/17	2	16					N.B.	Drift
6/23	1	15					N.B.	Drift
6/24	3	30					N.B.	Drift
6/26	6	123		8			N.B.	Drift
6/27	3	96		7			N.B.	Drift
6/28	2	38		14			N.B.	Drift
6/29	2	60		7			N.B.	Set
6/30	1	55		11			N.B.	Set
7/02	1	55		10			N.B.	Set
7/03	1	55		7			N.B.	Set
7/04	3	140		5			N.B.	Set
7/05	3	112		13			N.B.	Set
7/06	3	148		24			N.B.	Set
7/14	3	82		18			N.B.	Set
7/15	3	67		2			N.B.	Set
7/16	3	95		9			N.B.	Set
7/17	3	99		2			N.B.	Set
7/18	2	69		2			N.B.	Set
7/19	2	71		3			N.B.	Set
7/21	2	75		10			N.B.	Set
7/22	2	78		1			N.B.	Set
7/24	2	75		2			N.B.	Set
7/25	1	27					N.B.	Set
7/26	2	62					N.B.	Set
7/27	2	89		2			N.B.	Set
7/30	2	117		4			N.B.	Set
North Bank Sub.	1985		0	170	0	0		
6/05	1	8	5	3			S.B.	Drift
6/27	1	10					S.B.	Drift
6/28	1	5					S.B.	Drift
7/25	1	17		14			S.B.	Set
7/26	1	13		9			S.B.	Set
7/27	1	30		8			S.B.	Set
7/30	1	25		10	2		S.B.	Set
7/31	2	30		3	4		S.B.	Set
8/01	3	72		26	4	1	S.B.	Set
8/02	3	92		20	2		S.B.	Set
8/03	2	48		4	2		S.B.	Set
8/05	2	53		15	3		S.B.	Set
South Bank Sub.	403		5	112	17	1		
Grand Total	2430		6	289	17	1		

Table 5. Copper River gill net test fishing catches at Miles Lake sonar project, 1985.

Date	Number of sets	Fishing Time (Min.)	Total Daily Catch				Site	Set/Drift
			King	Sockeye	Coho	Pink		
7/02	2	8					Mid	Drift
Mid Channel Sub.		8	0	0	0	0		
6/15	5	33		12			N.B.	Mixed
6/19	3	38		4			N.B.	Mixed
6/22	5	57		11			N.B.	Mixed
6/24	1	60		3			N.B.	Set
6/26	2	30					N.B.	Set
6/27	1	40		2			N.B.	Set
7/02	2	10					N.B.	Drift
7/05	4	40					N.B.	Drift
7/09	1	45					N.B.	Set
7/12	1	8		23			N.B.	Set
7/15	1	5		16			N.B.	Set
7/22	4	30		8			N.B.	Mixed
North Bank Sub.		396	0	79	0	0		
7/09	1	5		13			S.B.	Set
7/25	2	15		12			S.B.	Set
7/28	2	20	1	25		1	S.B.	Set
South Bank Sub.		40	1	50	0	1		
Grand Total		444	1	129	0	1		

Table 6. Comparative annual Copper River escapement estimates and migratory timing data at Miles Lake sonar project, 1978 to 1985.

Year	Sonar Count	Mean Day Number	Mean Date	Median Date	Variance	S.D.
1978	107,011	32.5	6/18	6/16	163.1	12.8
1979	237,173	34.6	6/20	6/14	378.9	19.5
1980	276,538	38.4	6/23	6/19	316.9	17.8
1981	535,263	33.1	6/18	6/09	529.1	23.0
1982	467,306	31.3	6/16	6/11	326.1	18.1
1983	545,724	34.3	6/19	6/13	372.8	19.3
1984	536,806	34.5	6/20	6/15	281.2	16.8
1985	436,313	35.3	6/20	6/10	312.2	17.7



* Max daily count on May 28, 1982 recorded at 47,303.

Figure 9. Historic maximum, minimum, and average daily escapement estimates at Miles Lake sonar project, 1978 to 1985.

portion of the annual count. The project is timed to correspond with the peak of the sockeye salmon migration. Chinook salmon escape into the Copper River during the early portion of the run but only make up a small relative proportion, 4.1% and 4.4% for 1984 and 1985, respectively of the commercial catch during the period of sonar enumeration (Tables 7 and 8). The contribution of chinook salmon to the overall sonar index may be somewhat different as a significant proportion of the commercial catches are composed of delta stocks which do not significantly produce chinook or contribute to the Miles Lake sonar count, and chinook salmon may be subjected to a variable exploitation rate in the commercial fishery. Chinook salmon comprised 2.7% and 3.2% of the 1984 and 1985 upriver subsistence catches (Randall et al. 1985), (Robertson 1985). The 1981 and later model Bendix counter have a large fish discrimination feature. This feature has proven successful in species discrimination of non-salmonids (Menin, personal communication), but may require a broader spread in mean body weight than is typically seen in chinook and sockeye salmon.

Coho salmon timing is relatively late and consequently only contributes to the tail end of the sonar enumeration period. Coho salmon catches in the commercial fishery lagged in time to correspond to the period of sonar operation, comprised 1.1% and 0.8% of the catch in 1984 and 1985, respectively. This percentage would indicate a higher coho salmon distribution to the 1984 sonar index (5,904) than indicated by test fishing (1,217).

Current species data indicates that chinook and coho salmon together conservatively make up less than 6% of the total sonar count. Species identification could be improved by a stepped-up gill netting program utilizing different mesh sizes and adjusting catches for mesh size selectivity. Consequent to this would be a relatively high sampling mortality which may overshadow the potential benefits in light of the recent decline in chinook salmon stocks. As an alternative, beach seines will be evaluated for species sampling during the 1986 season. Species apportionment is not critical to current sockeye salmon management strategies. The greatest benefit of such a program would be in estimating chinook escapements, the timing of which falls within the period of sonar operation. Benefits to coho salmon management are limited to assessment of early run timing, because the vast majority of the coho salmon escapement past Miles Lake occurs after the sonar units are normally pulled.

Fish Distribution

Understanding the distribution of upstream migrating salmon across the river at the sonar site is critical to evaluating the effectiveness of the sonar estimates. Plots of sector counts at the south bank through time (Figures 6 and 7) support the concept that nearshore areas are greatly preferred. This may be to minimize energy costs, as demonstrated in a radiotelemetry study of Atlantic salmon (Smith et al. 1982). The sector distribution across the north bank site however, is not as clearly defined. The north bank site lies in slower waters off the main flow of the river and does not experience the gradient in current velocity across the counting range that is seen on the south bank. During the early portion of the 1984 season, when a relatively high percentage of the daily counts were recorded on the north bank, water levels were exceptionally low. Under these conditions the north bank site is closer to the swift current and lies on a steeper slope. It was during this

Table 7. Commercial salmon catch by period and species, Copper River district, 1984.

Dates	Fishing Time (Hrs.)	Effort	Catch by Species					
			King	Sockeye	Coho	Pink	Chum	Total
5/14-5/15	36	430	8,896	33,591	0	0	9	42,496
5/21-5/22	36	410	11,264	175,360	0	1	6	186,631
5/27-5/28	36	463	7,352	136,757	4	0	370	144,483
6/05-6/06	24	464	4,505	62,241	9	0	77	66,832
6/09-6/11	48	451	3,491	95,261	106	1	441	99,300
6/14-6/16	48	399	1,888	92,642	26	2	591	95,149
6/18-6/20	48	230	752	47,576	41	89	413	48,871
6/21-6/23	36	240	338	49,029	83	1,086	820	51,356
6/25-6/27	48	154	176	33,315	50	91	372	34,004
6/28-6/30	36	172	92	23,661	153	641	1,619	26,166
7/02-7/04	48	152	81	35,691	314	1,329	616	38,031
7/05-7/07	36	149	28	21,765	239	1,849	162	24,043
7/09-7/11	48	127	20	25,049	354	1,967	231	27,621
7/12-7/14	36	121	16	19,082	182	1,405	75	20,760
7/16-7/18	48	87	9	16,879	257	2,654	277	20,076
7/19-7/21	36	93	6	8,842	727	5,496	341	15,412
7/23-7/25	48	51	5	8,238	947	4,406	290	13,886
7/26-7/28	36	52	6	4,233	2,320	2,195	32	8,786
7/30-8/01	48	61	5	3,692	4,709	3,466	94	11,966
8/02-8/04	36	70	1	2,331	5,077	2,410	43	9,862
8/06-8/09	84	140	13	4,034	29,138	2,664	45	35,894
8/13-8/16	84	238	9	373	57,618	391	6	58,397
8/20-8/23	84	289	1	51	77,878	43	5	77,978
8/27-8/30	84	311	1	4	73,741	8	0	73,754
9/03-9/06	84	285	0	78	81,198	0	0	81,276
9/10-9/13	84	286	0	0	30,109	0	0	30,109
9/17-9/20	84	182	0	1	10,811	0	0	10,812
9/24-9/27	83	99	0	0	6,341	0	0	6,341
Totals			38,955	899,776	382,432	32,194	6,935	1,360,292

Table 8. Commercial salmon catch by period and species, Copper River district, 1985.

Date	Per	Boats	# Kings	Pounds	# Reds	Pounds	# Cohos	Pounds	# Pinks	Pounds	# Chums	Pounds
5/13-14	1	446	3,577	103,607	46,386	277,276	0	0	0	0	10	90
5/16-17	2	456	3,210	91,124	87,608	513,613	3	18	0	0	42	276
5/20-21	3	476	3,836	107,882	98,329	575,557	4	23	0	0	214	1,745
5/23-24	4	475	6,476	175,545	87,189	514,603	1	7	1	5	194	1,597
5/27-28	5	475	7,089	191,162	152,676	903,294	0	0	1	5	2,157	15,900
5/30-31	6	254	3,612	100,775	86,181	501,577	0	0	0	0	0	0
6/03-04	7	417	4,270	122,406	57,422	337,281	1	6	1	4	195	1,285
6/06-07	8	489	3,372	92,658	50,970	302,059	11	90	3	13	681	4,948
6/10-11	9	435	2,539	70,771	47,059	281,324	8	56	4	16	436	3,181
6/13-15	10	392	2,199	61,665	48,613	287,535	20	136	20	75	504	3,687
6/17-19	11	273	859	25,608	30,330	177,767	1	6	6	22	85	638
6/20-22	12	263	682	19,456	39,726	236,835	257	1,791	76	281	609	4,463
6/24-26	13	172	411	12,163	31,075	185,911	103	727	56	224	197	1,493
7/01-03	15	188	148	3,877	37,627	227,028	1,315	9,568	1,324	7,560	402	3,001
7/17-19	16	80	5	153	7,620	46,218	458	2,987	737	2,926	43	338
7/22-24	17	84	10	269	5,843	34,654	2,035	13,367	2,497	10,333	27	234
7/29-31	18	94	13	369	6,232	37,255	3,931	26,771	6,271	25,624	30	222
8/01-03	19	77	3	45	2,434	14,482	3,132	21,373	1,674	6,714	29	249
8/05-08	20	162	5	162	4,897	28,478	14,961	110,220	4,213	16,728	38	295
8/12-15	21	252	7	139	2,013	12,152	65,072	559,000	1,264	4,882	41	353
8/19-22	22	333	5	127	632	3,958	100,787	985,822	297	867	24	194
8/26-29	23	334	1	45	171	1,133	158,771	1,648,167	16	58	8	58
9/02-05	24	317	0	0	26	169	129,585	1,397,886	0	0	0	0
9/09-12	25	263	0	0	11	64	69,455	772,061	0	0	0	0
9/16-19	26	190	0	0	2	10	30,617	338,572	0	0	0	0
9/23-26	27	91	0	0	0	0	7,438	84,091	0	0	0	0
9/30-03	28	1	0	0	0	0	24	242	0	0	0	0
SEASON TOTALS			42,333	1,180,008	931,132	5,500,433	587,990	5,972,987	19,061	76,337	5,966	44,247
AV. WEIGHTS				27.87		5.90		10.15		4.00		7.41

Number of Rows: 24,904

period of low water that gill net catches were recorded in the middle areas of the river. It is possible that during these low water periods fish utilize a number of migration areas across the river. The river bottom between the north and south bank sites is not uniform but has two mid-channel humps one of which breaks the surface at the zero water level reference. These humps may provide areas of slower water currents used by upstream migrating salmon. At higher levels and consequently higher flow velocities, these areas may no longer offer desirable migration corridors. Higher water levels increase the calving activity of the Childs Glacier, downstream of the north bank site. This may contribute to the selective use of the south bank at the sonar site.

Program Direction

The Miles Lake sonar project continues to provide invaluable information to biologists in the management of the Copper River commercial and subsistence fisheries. With the establishment of escapement goals, a real-time monitoring system and an aggressive management program, the achievement of the escapement goal is now regularly realized (Figure 10). Consequently the commercial fishery is now enjoying an apparent recovery from the disastrous returns of the lat 1970's.

When applied in a day to day management program, the precision of hydroacoustic escapement monitoring is constantly under examination. Consequently, a great deala of effort is expended to maintain the accuracy of escapement estimates, within the limitations of the tools that are employed, to insure that in-season data will provide a solidly defensible basis for regulatory action in the commercial fishery.

Lingering questions remain unanswered such as the effectiveness of the north bank site, offshore migration rates and species apportionment while new parameters such as water level and test fishing results contribute to the overall understanding and interpretation of results.

ACKNOWLEDGMENTS

The author wishes to acknowledge Mr. Albert Menin of Allied Bendix Aerospace, for his continued efforts to advance sonar counting technology and specific assistance to the Miles Lake program. Evelyn B. Chisum, the 1985 crew leader, provided considerable in-season support in on-site operations as well as post season assistance in compilation of sonar data and report graphics. Michael Jackson, of the Commercial Fisheries staff in Cordova, provided logistical support to the project as well as significant contributions in the design and construction of the mechanical transducer rotator. Sam Sharr and Rich Randall provided technical review of this report. The sonar crew members of the past two seasons deserve special recognition for their dedication to the project; Bob Sanderlin, Russell Scribner, Charlie Trowbridge, Nathan Callis, Frank Bird, Dale Russell, Bob Ritchie, John Murk, Bill Busher, Randy Phipps, and Mark Willette.

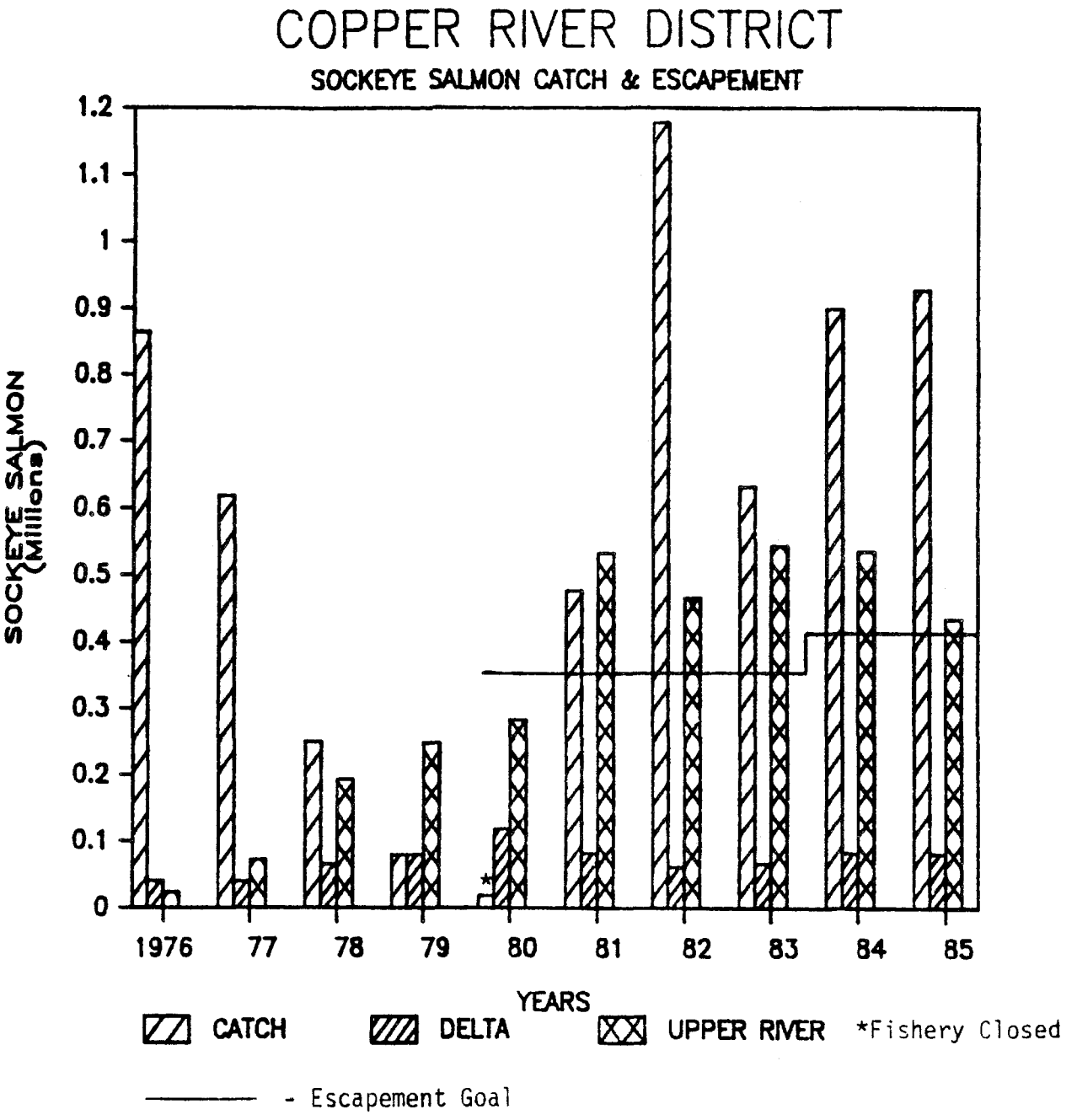


Figure 10. Sockeye salmon catch and escapement, Copper River district, 1976-1985.

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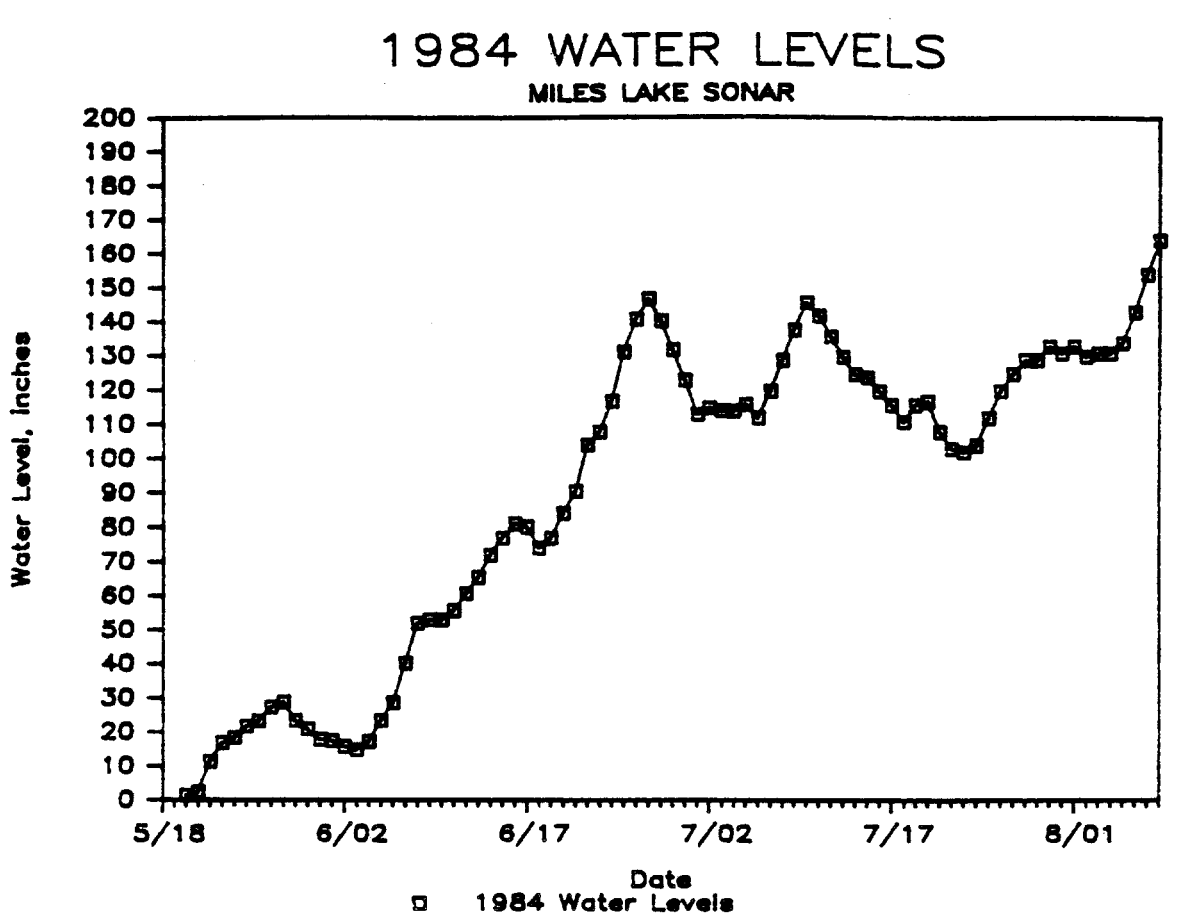
APPENDICES

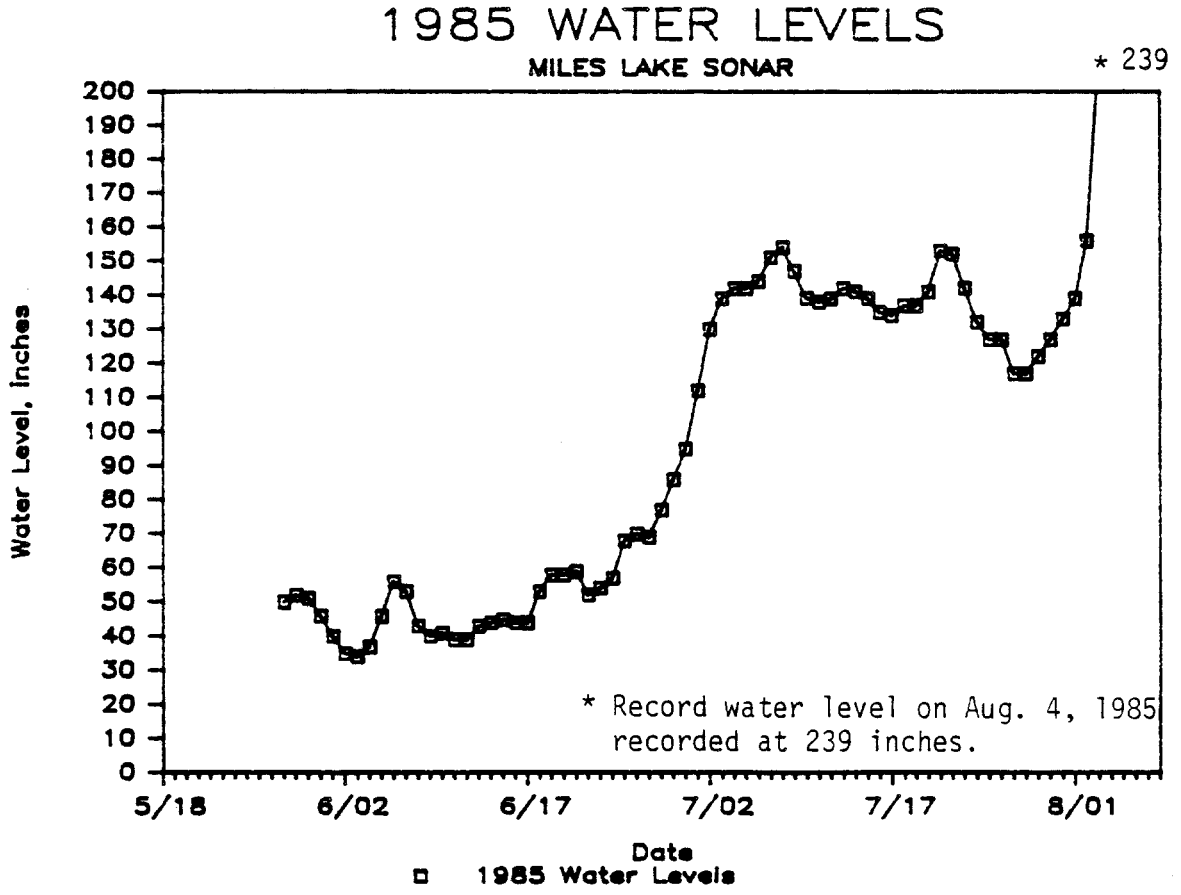
Appendix A1. Copper River daily water level measurements taken at the south bank sonar site, Miles Lake sonar project, 1982-1985.

Date	1985	1984	1983	1982
5/18				
5/19				
5/20		1.50		
5/21		2.50		
5/22		11.50		
5/23		17.00		
5/24		18.50	14.75	
5/25		21.80	14.75	
5/26		23.50	13.50	
5/27		27.50	14.00	
5/28	50.00	29.00	14.75	
5/29	52.00	23.50	14.25	
5/30	51.00	21.00	16.75	24.00
5/31	46.00	18.00	22.25	
6/01	40.00	17.50	36.50	
6/02	35.00	15.80	64.00	40.00
6/03	34.00	14.80	78.00	51.00
6/04	37.00	17.30	75.75	62.50
6/05	46.00	23.50	75.75	67.00
6/06	56.00	28.80	73.75	71.50
6/07	53.00	40.30	71.25	66.75
6/08	43.00	52.00	71.25	66.13
6/09	40.00	53.00	72.25	
6/10	41.00	53.00	72.00	97.75
6/11	39.00	55.80	71.00	
6/12	39.00	60.80	71.75	
6/13	43.00	65.50	70.75	
6/14	44.00	72.00	65.11	
6/15	45.00	77.00	66.75	88.75
6/16	44.00	81.00	62.50	
6/17	44.00	80.00	68.50	80.50
6/18	53.00	74.00	73.50	75.50
6/19	58.00	77.00	77.00	
6/20	58.00	84.00	90.50	84.50
6/21	59.00	90.50	101.00	97.75
6/22	52.00	104.00	111.50	99.50
6/23	54.00	108.00	115.75	
6/24	57.00	117.00	118.00	92.00
6/25	68.00	131.50	125.00	
6/26	70.00	141.00	134.50	102.50
6/27	69.00	147.00	134.75	
6/28	77.00	140.50	134.50	133.00
6/29	86.00	132.00	141.00	
6/30	95.00	123.00	139.00	153.00
7/01	112.00	113.00	134.50	149.50
7/02	130.00	115.00	127.00	
7/03	139.00	114.00	130.50	140.00
7/04	142.00	114.00	137.75	124.50
7/05	142.00	116.00	141.00	
7/06	144.00	112.00	144.00	

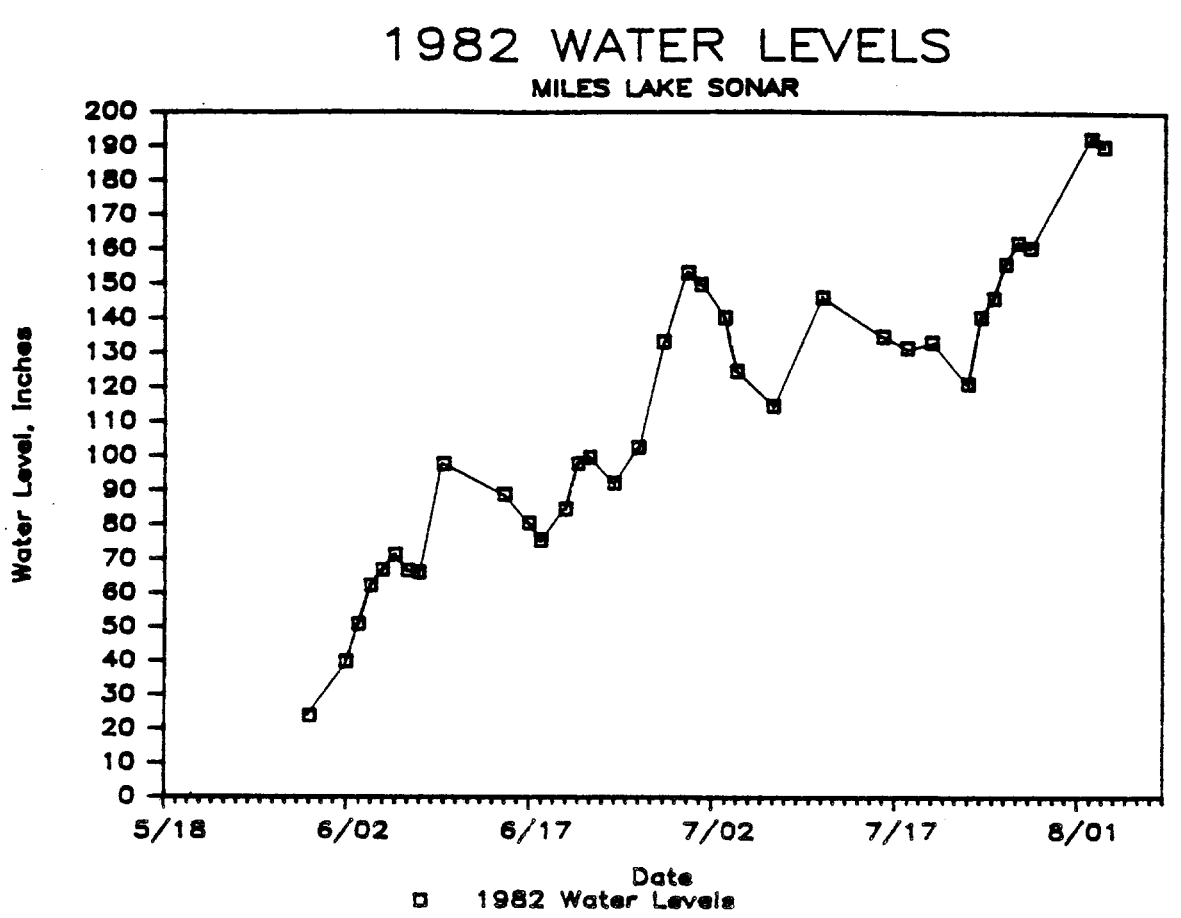
Appendix A1. Copper River daily water level measurements taken at the south bank sonar site, Miles Lake sonar project, 1982-1985 (continued).

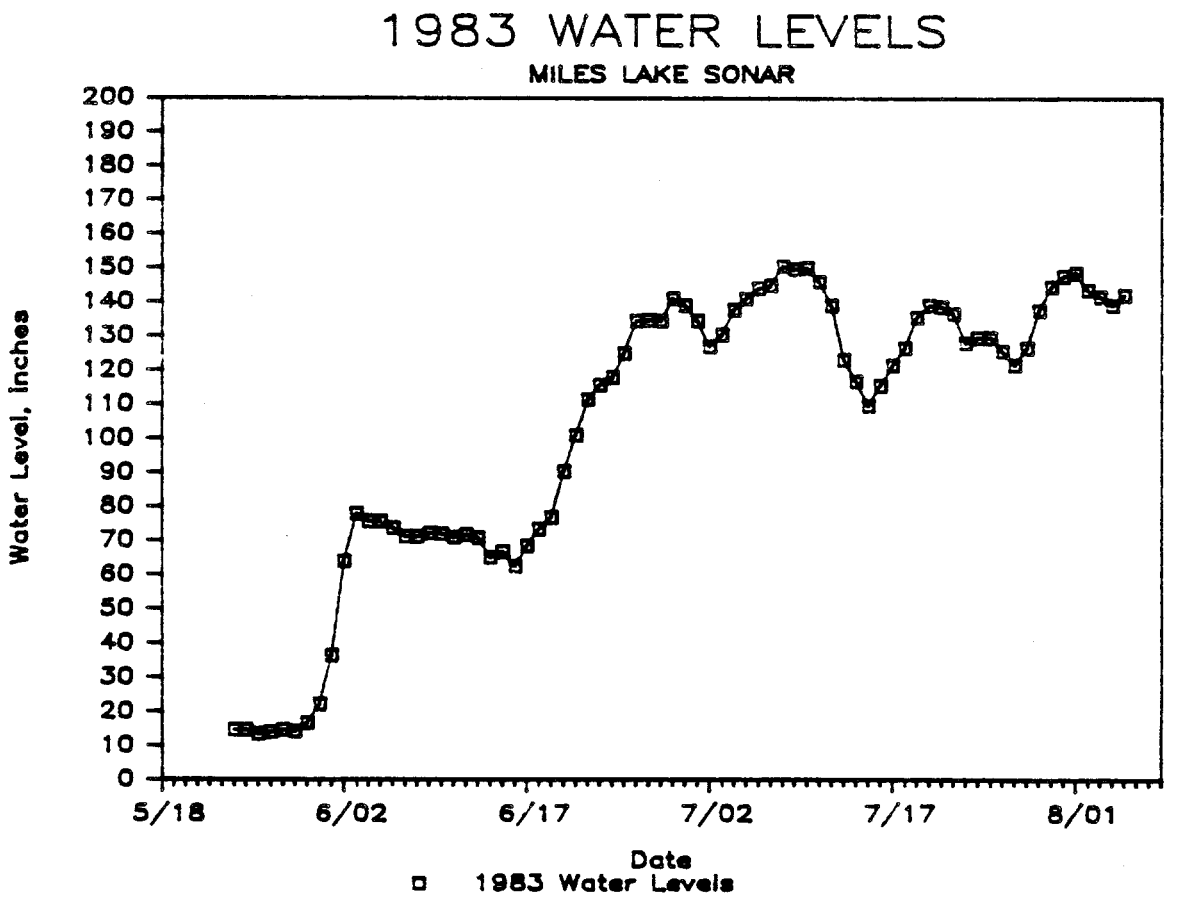
Date	1985	1984	1983	1982
7/07	151.00	120.00	145.00	114.50
7/08	154.00	129.00	150.50	
7/09	147.00	138.00	149.50	
7/10	139.00	146.00	150.00	
7/11	138.00	142.00	146.00	146.00
7/12	139.00	136.00	139.00	
7/13	142.00	130.00	123.00	
7/14	141.00	125.00	116.75	
7/15	139.00	124.00	109.50	
7/16	135.00	120.00	115.50	134.75
7/17	134.00	116.00	121.50	
7/18	137.00	111.00	126.50	131.50
7/19	137.00	116.00	135.50	
7/20	141.00	117.00	139.00	133.00
7/21	153.00	108.00	138.50	
7/22	152.00	103.00	136.50	
7/23	142.00	102.00	128.00	121.00
7/24	132.00	104.00	129.50	140.50
7/25	127.00	112.00	129.50	146.00
7/26	127.00	120.00	125.50	156.00
7/27	117.00	125.00	121.50	162.00
7/28	117.00	129.00	126.50	160.50
7/29	122.00	129.00	137.50	
7/30	127.00	133.00	144.50	
7/31	133.00	131.00	147.50	
8/01	139.00	133.00	148.50	
8/02	156.00	130.00	143.50	192.50
8/03	210.00	131.00	141.50	190.00
8/04	239.00	131.00	139.00	
8/05		134.00	142.00	
8/06		143.00		
8/07		154.00		
8/08		164.00		





Appendix A2. Annual plots of daily Copper River water level measurements, Miles Lake sonar project, 1981-1985.





Appendix A2. Annual plots of daily Copper River water level measurements, Miles Lake sonar project, 1981-1985 (continued).

Appendix B1. Copper River daily salmon escapement estimates at the Miles Lake sonar project, 1978-1985.

Date	1978	1979	1980	1981	1982	1983	1984	1985	Average Daily Count	S.D.	C.V.
5/17				5,372					2,686	2,686	100.00
5/18		381	218	9,665					3,421	4,415	129.06
5/19		487	167	11,409			725		3,197	4,745	148.43
5/20		847	221	10,733			1,924		3,431	4,259	124.14
5/21		1,199	88	9,729			1,986		3,251	3,801	116.93
5/22		1,916	391	7,558			5,124		3,747	2,785	74.33
5/23		2,901	594	6,214		3,310	5,042		3,612	1,925	53.28
5/24		3,402	494	12,985	90	8,620	4,486		5,013	4,548	90.72
5/25		2,397	713	12,816	493	11,587	3,120		5,188	5,054	97.43
5/26	502	4,927	1,057	6,383	1,023	10,575	4,645		4,159	3,376	81.17
5/27	837	6,821	2,115	2,842	12,091	8,661	5,836		5,600	3,693	65.95
5/28	1,047	2,768	1,693	2,560	47,303	8,456	4,978	1,031	8,730	14,763	169.11
5/29	661	3,905	1,080	2,160	19,671	6,380	7,126	417	5,175	5,978	115.51
5/30	3,241	7,482	1,903	11,822	8,781	8,296	4,951	599	5,884	3,600	61.17
5/31	2,549	8,655	3,620	21,126	11,389	17,123	4,278	1,758	8,812	6,744	76.53
6/01	2,616	4,078	5,257	18,415	15,385	18,428	8,536	3,462	9,522	6,384	67.04
6/02	2,811	3,465	7,061	23,771	17,213	14,414	8,483	6,726	10,493	6,849	65.27
6/03	1,837	3,536	7,437	16,716	13,383	13,137	9,730	10,691	9,558	4,748	49.68
6/04	3,256	2,778	8,996	9,755	12,355	15,357	12,496	24,272	11,158	6,443	57.75
6/05	2,970	4,352	9,746	10,478	14,806	19,110	16,728	30,507	13,587	8,296	61.06
6/06	3,318	6,453	5,407	11,975	15,585	14,069	18,097	32,953	13,482	8,841	65.58
6/07	3,808	7,031	2,093	13,585	12,506	19,309	18,515	27,256	13,013	8,009	61.54
6/08	3,275	11,078	1,349	14,412	8,430	16,094	26,619	30,925	14,023	9,778	69.73
6/09	2,252	7,385	3,543	15,694	7,017	11,415	20,476	29,702	12,261	8,704	71.00
6/10	3,475	5,205	7,301	12,856	7,599	8,009	19,275	12,010	9,466	4,724	49.90
6/11	2,490	4,426	12,032	7,877	7,879	9,563	17,237	11,826	9,166	4,344	47.39
6/12	2,082	2,227	11,584	4,844	8,587	13,292	21,706	8,231	9,069	6,106	67.33
6/13	2,419	3,903	7,600	3,556	9,932	13,444	12,072	6,829	7,469	3,823	51.18
6/14	2,835	2,563	5,661	5,228	12,551	13,831	5,981	6,800	6,931	3,881	55.99
6/15	2,913	3,351	7,308	7,071	12,677	15,915	10,291	8,825	8,544	4,137	48.42
6/16	2,782	3,473	5,655	6,885	13,595	7,938	13,930	9,347	7,951	3,517	44.26
6/17	2,779	4,640	7,189	6,467	12,030	5,671	19,309	6,270	8,107	5,069	62.53
6/18	2,261	3,911	6,741	4,565	6,544	5,689	12,850	3,738	5,787	3,021	52.20
6/19	3,035	3,413	2,391	2,985	4,369	6,461	7,474	3,251	4,172	1,713	41.06
6/20	3,035	1,954	3,597	2,891	3,352	7,382	9,258	2,423	4,237	2,451	57.85
6/21	2,515	2,223	4,142	3,446	3,346	8,124	7,159	2,061	4,127	2,143	51.92
6/22	2,068	2,585	3,954	3,397	4,467	8,005	5,522	2,763	4,170	1,789	42.91
6/23	2,841	2,865	3,896	4,363	7,031	7,528	5,913	3,369	4,726	1,741	36.84
6/24	2,616	1,877	5,217	4,651	6,329	6,009	6,741	2,950	4,549	1,732	38.07
6/25	2,130	3,013	5,104	3,398	4,903	5,226	6,303	1,585	3,383	1,599	40.16
6/26	1,771	1,973	3,595	2,412	4,416	5,638	4,385	2,381	3,321	1,309	39.41
6/27	2,178	1,315	3,421	2,507	2,732	4,738	7,224	3,035	3,394	1,719	50.64
6/28	1,103	1,697	4,324	2,949	2,174	4,771	6,728	2,264	3,251	1,761	54.16
6/29	1,604	1,450	3,845	3,421	2,130	4,304	4,453	2,147	2,919	1,145	39.22
6/30	1,632	1,899	3,465	2,378	2,313	6,146	6,449	2,139	3,303	1,801	54.54
7/01	1,587	2,651	3,559	2,723	2,190	6,106	8,226	2,620	3,708	2,129	57.42
7/02	2,533	2,524	3,365	2,606	4,420	6,113	7,554	2,608	3,965	1,799	45.36
7/03	2,527	2,859	4,104	2,548	5,751	6,826	8,581	1,819	4,277	2,176	50.89
7/04	2,980	3,806	2,934	4,094	5,245	6,943	6,515	3,536	4,507	1,454	32.27
7/05	2,269	3,008	2,879	4,256	4,995	5,347	6,662	3,254	4,084	1,401	34.30
7/06	1,623	1,996	3,025	3,476	6,300	3,973	5,449	4,664	3,813	1,518	39.82

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Appendix B1. Copper River daily salmon escapement estimates at the Miles Lake sonar project, 1978-1985 (continued).

Date	1978	1979	1980	1981	1982	1983	1984	1985	Average Daily Count	S.D.	C.V.
7/07	1,152	892	3,291	3,863	6,171	4,209	4,040	3,627	3,406	1,595	46.85
7/08	831	2,091	2,995	3,774	3,990	4,080	3,906	3,893	3,195	1,095	34.27
7/09	947	3,190	2,817	3,449	2,210	3,353	3,210	6,827	3,250	1,558	47.94
7/10	1,252	4,209	3,642	2,942	2,070	3,644	2,927	10,607	3,912	2,679	68.50
7/11	841	3,684	5,763	2,271	1,980	4,454	3,608	5,457	3,507	1,612	45.97
7/12	341	3,262	4,788	3,468	3,420	4,541	4,280	6,329	3,804	1,607	42.25
7/13	167	3,144	1,725	2,265	4,032	4,543	4,582	5,252	3,214	1,615	50.25
7/14	290	4,124	1,679	2,596	4,339	5,819	6,573	6,113	3,342	2,110	53.53
7/15	275	3,535	1,743	3,691	4,714	6,496	5,521	5,824	3,875	1,912	49.35
7/16	538	5,175	2,515	2,580	3,561	6,970	6,755	5,339	4,179	2,113	50.57
7/17	304	3,555	3,419	780	2,925	6,327	4,955	5,960	3,528	2,065	58.52
7/18	284	3,760	5,878	8,633	3,413	4,326	4,736	5,110	4,518	2,206	48.84
7/19	321	3,344	5,613	20,975	4,296	3,703	3,140	4,560	5,744	5,933	103.29
7/20	238	2,716	5,060	20,511	3,920	3,988	3,389	8,176	6,000	5,867	97.79
7/21	81	2,583	3,826	15,741	4,049	4,463	3,204	4,128	4,759	4,352	91.44
7/22	18	2,012	3,173	6,566	3,871	4,881	3,780	3,158	3,432	1,804	52.57
7/23	15	1,915	2,143	5,787	3,099	3,603	3,285	2,870	2,830	1,533	54.16
7/24	40	2,182	1,353	5,063	3,061	3,303	2,198	2,162	2,435	1,437	57.60
7/25	13	1,112	1,623	3,391	3,374	4,535	1,937	2,449	2,304	1,351	58.61
7/26		771	1,256	2,493	2,596	3,839	1,687	1,974	2,088	933	44.67
7/27		318	1,198	2,451	2,247	3,687	1,391	2,191	1,926	997	51.74
7/28		387	698	2,785	2,375	5,234	1,004	2,839	2,189	1,557	71.11
7/29		365	400	3,686	1,426	4,138	891	2,813	1,960	1,457	74.33
7/30		491	470	3,814	963	3,512	938	2,790	1,854	1,356	73.14
7/31		703	353	3,802	1,176	1,835	1,093	1,848	1,544	1,052	68.09
8/01		758	825	3,396	511	1,912	1,047	1,070	1,360	926	68.09
8/02		379	1,034	2,304	942	2,211	1,088	703	1,237	682	55.15
8/03		227	764	1,913	494	2,088	1,213		1,117	694	62.17
8/04		286	708	1,297	581	2,897	1,118		1,148	851	74.10
8/05		173	758	1,181	122		1,009		649	431	66.45
8/06		103	877	1,170			533		671	398	59.31
8/07		76	615						346	270	78.00
8/08			166						166	0	0.00
8/09			239						239	0	0.00
8/10									ERR	ERR	ERR
8/11									ERR	ERR	ERR
8/12									ERR	ERR	ERR
8/13									ERR	ERR	ERR
8/14									ERR	ERR	ERR
8/15									ERR	ERR	ERR
Total	107,011	237,173	276,538	535,263	467,306	545,724	536,806	436,313			
Avg.	1,726	2,892	3,292	6,528	6,315	7,375	6,710	6,512		Over All	5,194
S.D.	1,137	2,073	2,658	5,355	6,646	4,413	5,592	7,664			5,285
C.V.	65.9	71.7	80.7	82.0	105.2	59.8	83.3	117.7			101.8

Appendix B2. Copper River cumulative daily salmon escapement estimates at the Miles Lake sonar project, 1978-1985.

Date	Accumulative Count 1978	1979	1980	1981	1982	1983	1984	1985	Average Daily Count	S.D.	C.V.
5/17	0	0	0	5,372	0	0	0	0	672	1,777	264.58
5/18	0	381	218	15,037	0	0	0	0	1,955	4,947	253.08
5/19	0	868	385	26,446	0	0	725	0	3,553	8,659	243.71
5/20	0	1,715	606	37,179	0	0	2,649	0	5,269	12,096	229.59
5/21	0	2,914	694	46,988	0	0	4,635	0	6,894	15,209	220.62
5/22	0	4,830	1,085	54,466	0	0	9,759	0	8,768	17,576	200.47
5/23	0	7,731	1,679	60,680	0	3,310	14,801	0	11,025	19,372	175.71
5/24	0	11,133	2,173	73,665	90	11,930	19,287	0	14,785	23,240	157.19
5/25	0	13,530	2,886	86,481	583	23,517	22,407	0	18,676	27,239	145.85
5/26	502	18,457	3,943	92,864	1,606	34,092	27,052	0	22,315	29,354	131.55
5/27	1,339	25,278	6,058	95,706	13,697	42,753	32,888	0	27,215	29,599	108.76
5/28	2,386	28,046	7,751	98,266	61,000	51,209	37,866	1,031	35,944	31,525	87.71
5/29	3,047	31,951	8,831	100,426	80,671	57,589	44,992	1,448	41,119	34,492	83.88
5/30	6,288	39,433	10,734	112,248	89,452	65,885	49,943	2,047	47,004	37,874	80.58
5/31	8,837	48,088	14,354	133,374	100,841	83,000	54,221	3,805	55,816	43,982	78.80
6/01	11,453	52,166	19,611	151,789	116,226	101,436	62,757	7,267	65,338	49,892	76.36
6/02	14,264	55,631	26,672	175,560	133,439	115,850	71,240	13,993	75,831	56,265	74.20
6/03	16,101	59,167	34,109	192,276	146,822	128,987	80,970	24,684	85,390	60,127	70.42
6/04	19,357	61,945	43,105	202,031	159,177	144,344	93,466	48,956	96,548	60,848	63.02
6/05	22,327	66,297	52,851	212,509	173,983	163,454	110,194	79,463	110,135	62,504	56.75
6/06	25,645	72,750	58,258	224,484	189,568	177,523	128,291	112,416	123,617	65,225	52.76
6/07	29,453	79,781	60,351	238,069	202,074	196,832	146,806	139,672	136,630	69,684	51.00
6/08	32,728	90,859	61,700	252,481	210,504	212,926	173,425	170,597	150,653	74,280	49.31
6/09	34,980	98,844	65,243	268,175	217,521	224,341	193,901	200,299	162,913	79,219	48.63
6/10	38,455	104,049	72,544	281,031	225,120	232,350	213,176	212,309	172,379	82,169	47.67
6/11	40,945	108,475	84,576	288,908	232,999	241,913	230,413	224,135	181,546	84,062	46.30
6/12	43,827	110,702	96,160	293,752	241,586	255,205	252,119	232,366	190,615	86,619	45.44
6/13	45,446	114,605	103,760	297,308	251,518	268,649	264,191	239,195	198,084	88,674	44.77
6/14	48,281	117,168	109,421	302,536	264,069	282,480	270,172	245,995	205,015	91,066	44.42
6/15	51,194	120,519	116,729	309,607	276,746	298,395	280,463	254,820	213,559	94,200	44.11
6/16	53,976	123,992	122,384	316,492	290,341	306,333	294,393	264,167	221,510	97,140	43.85
6/17	56,755	128,632	129,573	322,959	302,371	312,804	314,202	270,437	229,617	99,814	43.47
6/18	59,016	132,543	136,314	327,524	308,915	317,693	327,052	274,175	235,404	101,289	43.03
6/19	62,051	135,956	138,705	330,509	313,284	324,154	334,526	277,426	239,576	102,305	42.70
6/20	65,086	137,910	142,302	333,400	316,636	331,536	343,784	279,849	243,813	103,550	42.47
6/21	67,601	140,133	146,444	336,846	319,982	339,660	350,943	281,910	247,940	104,712	42.23
6/22	69,669	142,718	150,398	340,843	324,449	347,665	356,465	284,673	252,110	105,939	42.02
6/23	72,510	145,583	154,294	345,206	331,480	355,193	362,378	288,042	256,836	107,259	41.76
6/24	75,126	147,460	159,511	349,857	337,809	361,202	369,119	290,992	261,385	108,492	41.51
6/25	77,256	150,473	164,615	353,255	342,712	366,428	375,622	292,577	265,367	109,290	41.18
6/26	79,827	152,446	168,210	355,667	347,128	372,866	380,007	294,958	268,689	110,151	41.00
6/27	81,205	153,761	171,631	358,174	349,860	376,804	387,231	297,993	272,082	111,177	40.86
6/28	82,308	155,458	175,955	361,123	352,034	381,575	393,959	300,257	275,334	112,210	40.75
6/29	83,912	156,908	179,800	364,544	354,164	385,879	398,412	302,404	278,253	112,916	40.58
6/30	85,544	158,807	183,265	366,922	356,477	392,025	404,861	304,543	281,556	114,010	40.49
7/01	87,131	161,458	186,824	369,645	358,667	398,131	413,087	307,163	285,263	115,293	40.42
7/02	89,664	163,982	190,189	372,251	363,087	404,244	420,641	309,771	289,229	116,506	40.28
7/03	92,191	166,841	194,293	374,799	368,838	410,270	429,222	311,590	293,506	117,834	40.15
7/04	95,171	170,647	197,227	378,893	374,083	417,213	435,737	315,126	298,012	119,018	39.94
7/05	97,440	173,655	200,106	383,149	379,078	422,560	442,399	318,380	302,096	120,281	39.82
7/06	99,063	175,651	203,131	386,625	385,378	426,533	447,848	323,044	305,309	121,520	39.72

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Appendix B2. Copper River cumulative daily salmon escapement estimates at the Miles Lake sonar project, 1978-1985 (continued).

Date	Accumulative Count 1978	1979	1980	1981	1982	1983	1984	1985	Average Daily Count	S.D.	C.V.
7/07	100,215	176,543	206,422	390,488	391,549	430,742	451,888	326,671	309,315	122,812	39.70
7/08	101,046	178,634	209,417	394,262	395,539	434,822	455,794	330,564	312,510	123,825	39.62
7/09	101,993	181,824	212,234	397,711	397,749	438,175	459,004	337,391	315,760	124,380	39.39
7/10	103,245	186,033	215,876	400,653	399,819	441,819	461,931	347,998	319,672	124,707	39.01
7/11	104,006	189,717	221,639	402,924	401,799	446,273	465,539	353,455	323,179	125,000	38.68
7/12	104,427	192,979	226,427	406,392	405,219	450,814	469,819	359,784	326,983	125,916	38.51
7/13	104,594	196,123	228,152	408,657	409,251	455,357	474,401	365,036	330,196	127,164	38.51
7/14	104,884	200,247	229,831	411,253	413,590	461,176	480,974	371,149	334,138	128,789	38.54
7/15	105,159	203,782	231,574	414,944	418,304	467,672	486,495	376,173	338,013	130,503	38.61
7/16	105,697	208,957	234,089	417,524	421,865	474,642	493,250	381,512	342,192	131,955	38.56
7/17	106,001	212,512	237,508	418,304	424,790	480,969	498,205	387,472	345,720	133,101	38.50
7/18	106,285	216,272	243,386	426,937	428,203	485,295	502,941	392,582	350,238	134,253	38.33
7/19	106,606	219,616	248,999	447,912	432,499	488,998	506,081	397,142	355,982	136,222	38.27
7/20	106,844	222,332	254,059	468,423	436,419	492,986	509,470	405,318	361,981	138,703	38.32
7/21	106,925	224,915	257,885	484,164	440,468	497,449	512,674	409,446	366,741	140,933	38.43
7/22	106,943	226,927	261,058	490,730	444,339	502,330	516,454	412,684	370,173	142,484	38.49
7/23	106,958	228,842	263,201	496,517	447,438	505,933	519,659	415,474	373,003	143,787	38.55
7/24	106,998	231,024	264,554	501,580	450,499	509,836	521,857	417,636	375,498	144,930	38.60
7/25	107,011	232,136	266,177	504,971	453,873	514,371	523,794	420,085	377,802	146,081	38.67
7/26	107,011	232,907	267,433	507,464	456,469	518,210	525,481	422,059	379,629	147,037	38.73
7/27	107,011	233,225	268,631	509,915	458,716	521,897	526,872	424,250	381,315	147,984	38.81
7/28	107,011	233,612	269,329	512,700	461,091	527,131	527,876	427,089	383,230	149,179	38.93
7/29	107,011	233,977	269,729	516,386	462,517	531,269	528,767	429,902	384,945	150,301	39.04
7/30	107,011	234,468	270,199	520,200	463,480	534,781	529,705	432,692	386,567	151,321	39.14
7/31	107,011	235,171	270,552	524,002	464,656	536,616	530,798	434,540	387,918	152,119	39.21
8/01	107,011	235,929	271,377	527,398	465,167	538,528	531,845	435,610	389,108	152,756	39.26
8/02	107,011	236,308	272,411	529,702	466,109	540,739	532,933	436,313	390,191	153,353	39.30
8/03	107,011	236,535	273,175	531,615	466,603	542,827	534,146	436,313	391,028	153,898	39.36
8/04	107,011	236,821	273,883	532,912	467,184	545,724	535,264	436,313	391,889	154,466	39.42
8/05	107,011	236,994	274,641	534,093	467,306	545,724	536,273	436,313	392,294	154,632	39.42
8/06	107,011	237,097	275,518	535,263	467,306	545,724	536,806	436,313	392,630	154,733	39.41
8/07	107,011	237,173	276,133	535,263	467,306	545,724	536,806	436,313	392,716	154,665	39.38
8/08	107,011	237,173	276,299	535,263	467,306	545,724	536,806	436,313	392,737	154,649	39.38
8/09	107,011	237,173	276,538	535,263	467,306	545,724	536,806	436,313	392,767	154,627	39.37
8/10	107,011	237,173	276,538	535,263	467,306	545,724	536,806	436,313	392,767	154,627	39.37
8/11	107,011	237,173	276,538	535,263	467,306	545,724	536,806	436,313	392,767	154,627	39.37
8/12	107,011	237,173	276,538	535,263	467,306	545,724	536,806	436,313	392,767	154,627	39.37
8/13	107,011	237,173	276,538	535,263	467,306	545,724	536,806	436,313	392,767	154,627	39.37
8/14	107,011	237,173	276,538	535,263	467,306	545,724	536,806	436,313	392,767	154,627	39.37
8/15	107,011	237,173	276,538	535,263	467,306	545,724	536,806	436,313	392,767	154,627	39.37
Total											
Avg.	70,010	149,553	162,849	346,612	311,556	346,016	344,977	271,714	Over All		250,411
S.D.	40,885	79,078	100,102	157,243	157,123	183,648	191,421	157,646			174,819
C.V.	58.4	52.9	61.5	45.4	50.4	53.1	55.5	58.0			69.8

Appendix B3. Copper River daily percent salmon escapement estimates at the Miles Lake sonar project, 1978-1985.

Date	Daily percents 1978	1979	1980	1981	1982	1983	1984	1985	Average Daily Percent	S.D.	C.V.
5/17	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.00	0.1	0.3	264.6
5/18	0.0	0.2	0.1	1.8	0.0	0.0	0.0	0.00	0.3	0.6	230.2
5/19	0.0	0.2	0.1	2.1	0.0	0.0	0.0	0.00	0.3	0.7	232.1
5/20	0.0	0.4	0.1	2.0	0.0	0.0	0.1	0.00	0.3	0.6	200.6
5/21	0.0	0.5	.0	1.8	0.0	0.0	0.4	0.00	0.3	0.6	173.4
5/22	0.0	0.8	0.1	1.4	0.0	0.0	0.4	0.00	0.3	0.5	141.6
5/23	0.0	1.2	0.2	1.2	0.0	0.6	1.0	0.00	0.5	0.5	96.3
5/24	0.0	1.4	0.2	2.4	.0	1.6	0.9	0.00	0.8	0.9	104.9
5/25	0.0	1.0	0.3	2.4	0.1	2.1	0.8	0.00	0.8	0.9	106.2
5/26	0.5	2.1	0.4	1.2	0.2	1.9	0.6	0.00	0.9	0.7	86.1
5/27	0.8	2.9	0.8	0.5	2.6	1.6	0.9	0.00	1.2	1.0	76.1
5/28	1.0	1.2	0.6	0.5	10.1	1.5	1.1	0.24	2.0	3.1	152.0
5/29	0.6	1.6	0.4	0.4	4.2	1.2	0.9	0.10	1.2	1.2	104.3
5/30	3.0	3.2	0.7	2.2	1.9	1.5	1.3	0.14	1.7	1.0	56.6
5/31	2.4	3.6	1.3	3.9	2.4	3.1	0.9	0.40	2.3	1.2	53.3
6/01	2.4	1.7	1.9	3.4	3.3	3.4	0.8	0.79	2.2	1.0	46.3
6/02	2.6	1.5	2.6	4.4	3.7	2.6	1.6	1.54	2.6	1.0	38.9
6/03	1.7	1.5	2.7	3.1	2.9	2.4	1.6	2.45	2.3	0.6	25.3
6/04	3.0	1.2	3.3	1.8	2.6	2.8	1.8	5.56	2.8	1.2	45.2
6/05	2.8	1.8	3.5	2.0	3.2	3.5	2.3	6.99	3.3	1.5	47.1
6/06	3.1	2.7	2.0	2.2	3.3	2.6	3.1	7.55	3.3	1.7	49.8
6/07	3.6	3.0	0.8	2.5	2.7	3.5	3.4	6.25	3.2	1.4	44.5
6/08	3.1	4.7	0.5	2.7	1.8	2.9	3.4	7.09	3.3	1.8	56.0
6/09	2.1	3.4	1.3	2.3	1.5	2.1	5.0	6.81	3.1	1.8	56.7
6/10	3.2	2.2	2.6	2.4	1.6	1.5	3.8	2.75	2.5	0.7	29.1
6/11	2.3	1.9	4.4	1.5	1.7	1.8	3.6	2.71	2.5	1.0	38.9
6/12	1.9	0.9	4.2	0.9	1.8	2.4	3.2	1.89	2.2	1.0	47.8
6/13	2.3	1.6	2.7	0.7	2.1	2.5	4.0	1.57	2.2	0.9	42.2
6/14	2.6	1.1	2.0	1.0	2.7	2.5	2.2	1.56	2.0	0.6	32.7
6/15	2.7	1.4	2.6	1.3	2.7	2.9	1.1	2.02	2.1	0.7	32.6
6/16	2.6	1.5	2.0	1.3	2.9	1.5	1.9	2.14	2.0	0.5	27.1
6/17	2.6	2.0	2.6	1.2	2.6	1.0	2.6	1.44	2.0	0.6	31.9
6/18	2.1	1.6	2.4	0.9	1.4	1.0	3.7	0.86	1.8	0.9	51.8
6/19	2.8	1.4	0.9	0.6	0.9	1.2	2.4	0.75	1.4	0.8	56.2
6/20	2.8	0.8	1.3	0.5	0.7	1.4	1.4	0.56	1.2	0.7	59.2
6/21	2.4	0.9	1.5	0.6	0.7	1.5	1.7	0.47	1.2	0.6	49.0
6/22	1.9	1.1	1.4	0.7	1.0	1.5	1.3	0.63	1.2	0.4	33.3
6/23	2.7	1.2	1.4	0.8	1.5	1.4	1.0	0.77	1.3	0.6	41.3
6/24	2.4	0.8	1.9	0.9	1.4	1.1	1.1	0.68	1.3	0.6	44.3
6/25	2.0	1.3	1.8	0.6	1.0	1.0	1.3	0.36	1.2	0.5	44.2
6/26	1.7	0.8	1.3	0.5	0.9	1.0	1.2	0.55	1.0	0.4	37.3
6/27	2.0	0.6	1.2	0.5	0.6	0.9	0.8	0.70	0.9	0.5	53.1
6/28	1.0	0.7	1.6	0.6	0.5	0.9	1.3	0.52	0.9	0.4	42.8
6/29	1.5	0.6	1.4	0.6	0.5	0.8	1.3	0.49	0.9	0.4	44.4
6/30	1.5	0.8	1.3	0.4	0.5	1.1	0.8	0.49	0.9	0.4	42.9
7/01	1.5	1.1	1.3	0.5	0.5	1.1	1.2	0.60	1.0	0.4	37.4
7/02	2.4	1.1	1.2	0.5	0.9	1.1	1.5	0.60	1.2	0.6	47.2
7/03	2.4	1.2	1.5	0.5	1.2	1.1	1.4	0.42	1.2	0.6	47.3
7/04	2.8	1.6	1.1	0.8	1.1	1.3	1.6	0.81	1.4	0.6	44.1
7/05	2.1	1.3	1.0	0.8	1.1	1.0	1.2	0.75	1.2	0.4	34.9
7/06	1.5	0.8	1.1	0.6	1.3	0.7	1.2	1.07	1.1	0.3	26.9

-Continued-

Appendix B3. Copper River daily percent salmon escapement estimates at the Miles Lake sonar project, 1978-1985 (continued).

Date	Daily percents 1978	1979	1980	1981	1982	1983	1984	1985	Average Daily Percent	S.D.	C.V.
7/07	1.1	0.4	1.2	0.7	1.3	0.8	1.0	0.83	0.9	0.3	30.8
7/08	0.8	0.9	1.1	0.7	0.9	0.7	0.8	0.89	0.8	0.1	13.5
7/09	0.9	1.3	1.0	0.6	0.5	0.6	0.7	1.56	0.9	0.4	39.1
7/10	1.2	1.8	1.3	0.5	0.4	0.7	0.6	2.43	1.1	0.7	58.7
7/11	0.8	1.6	2.1	0.4	0.4	0.8	0.5	1.25	1.0	0.6	56.6
7/12	0.3	1.4	1.7	0.6	0.7	0.8	0.7	1.45	1.0	0.5	47.1
7/13	0.2	1.3	0.6	0.4	0.9	0.8	0.8	1.20	0.8	0.4	46.1
7/14	0.3	1.7	0.6	0.5	0.9	1.1	0.9	1.40	0.9	0.5	49.2
7/15	0.3	1.5	0.6	0.7	1.0	1.2	1.2	1.15	1.0	0.4	39.2
7/16	0.5	2.2	0.9	0.5	0.8	1.3	1.0	1.22	1.0	0.5	48.8
7/17	0.3	1.5	1.2	0.1	0.6	1.2	1.3	1.37	0.9	0.5	51.3
7/18	0.3	1.6	2.1	1.6	0.7	0.8	0.9	1.17	1.2	0.6	48.5
7/19	0.3	1.4	2.0	3.9	0.9	0.7	0.9	1.05	1.4	1.1	76.3
7/20	0.2	1.1	1.8	3.8	0.8	0.7	0.6	1.87	1.4	1.1	77.6
7/21	0.1	1.1	1.4	2.9	0.9	0.8	0.6	0.95	1.1	0.8	71.5
7/22	.0	0.8	1.1	1.2	0.8	0.9	0.6	0.72	0.8	0.3	44.4
7/23	.0	0.8	0.8	1.1	0.7	0.7	0.7	0.66	0.7	0.3	41.9
7/24	.0	0.9	0.5	0.9	0.7	0.7	0.6	0.50	0.6	0.3	44.3
7/25	.0	0.5	0.6	0.6	0.7	0.8	0.4	0.56	0.5	0.2	43.8
7/26	0.0	0.3	0.5	0.5	0.6	0.7	0.4	0.45	0.4	0.2	46.1
7/27	0.0	0.1	0.4	0.5	0.5	0.7	0.3	0.50	0.4	0.2	54.2
7/28	0.0	0.2	0.3	0.5	0.5	1.0	0.3	0.65	0.4	0.3	69.2
7/29	0.0	0.2	0.1	0.7	0.3	0.8	0.2	0.64	0.4	0.3	76.0
7/30	0.0	0.2	0.2	0.7	0.2	0.6	0.2	0.64	0.3	0.3	75.1
7/31	0.0	0.3	0.1	0.7	0.3	0.3	0.2	0.42	0.3	0.2	69.2
8/01	0.0	0.3	0.3	0.6	0.1	0.4	0.2	0.25	0.3	0.2	65.0
8/02	0.0	0.2	0.4	0.4	0.2	0.4	0.2	0.16	0.2	0.1	57.8
8/03	0.0	0.1	0.3	0.4	0.1	0.4	0.2	0.00	0.2	0.1	79.6
8/04	0.0	0.1	0.3	0.2	0.1	0.5	0.2	0.00	0.2	0.2	85.5
8/05	0.0	0.1	0.3	0.2	.0	0.0	0.2	0.00	0.1	0.1	107.4
8/06	0.0	.0	0.3	0.2	0.0	0.0	0.2	0.00	0.1	0.1	123.4
8/07	0.0	.0	0.2	0.0	0.0	0.0	0.1	0.00	.0	0.1	169.1
8/08	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.00	.0	.0	264.6
8/09	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.00	.0	.0	264.6
8/10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.0	ERR
8/11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.0	ERR
8/12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.0	ERR
8/13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.0	ERR
8/14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.0	ERR
8/15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.0	0.0	ERR
Total	100.0	100	100	100.0	100	100	100	100	100.0		
Avg.	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	Over All		1.1
S.D.	1.2	0.9	1.0	1.0	1.4	0.9	1.1	1.6			1.2
C.V.	105.1	82.5	88.9	92.6	126.2	81.9	96.3	149.7			105.2

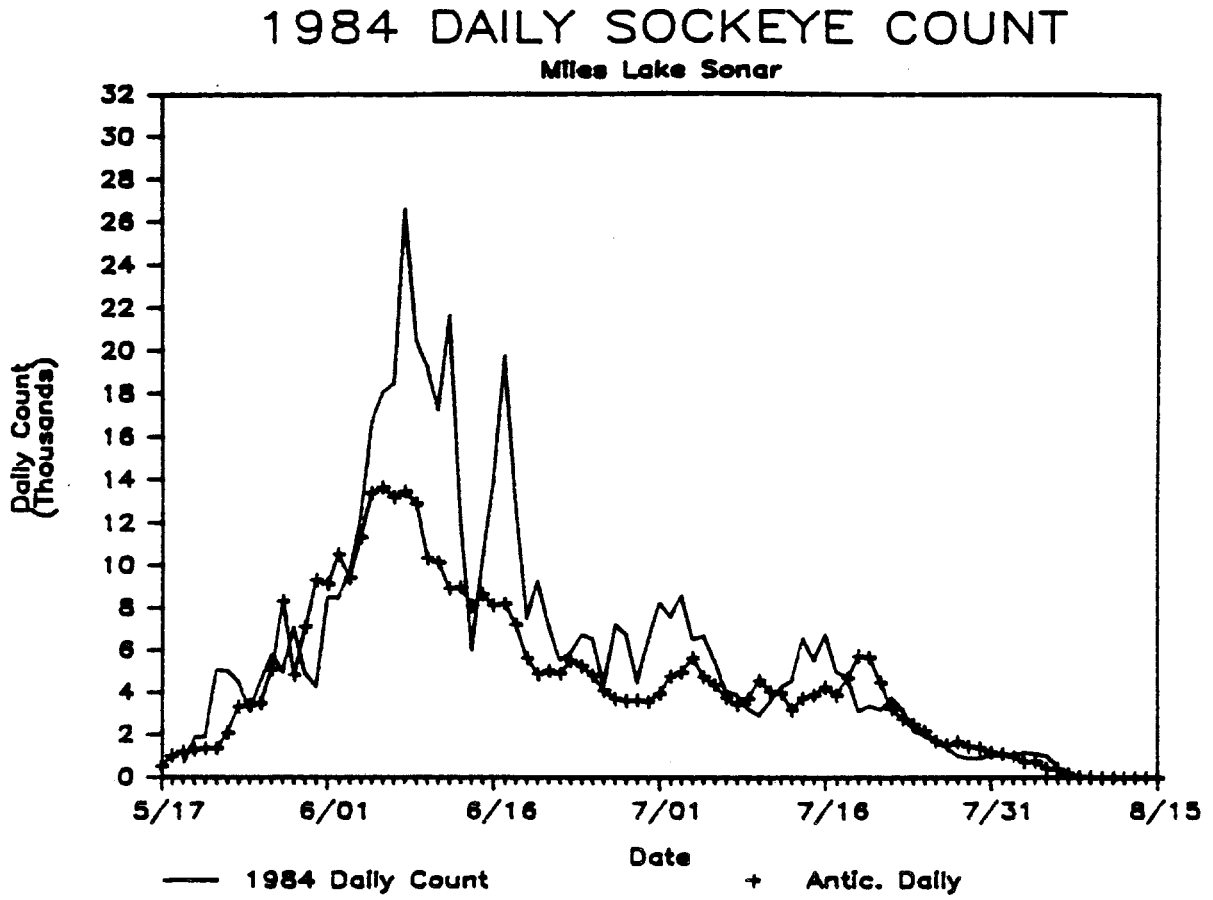
Appendix B4. Copper River cumulative daily percent salmon escapement estimates at the Miles Lake sonar project, 1978-1985.

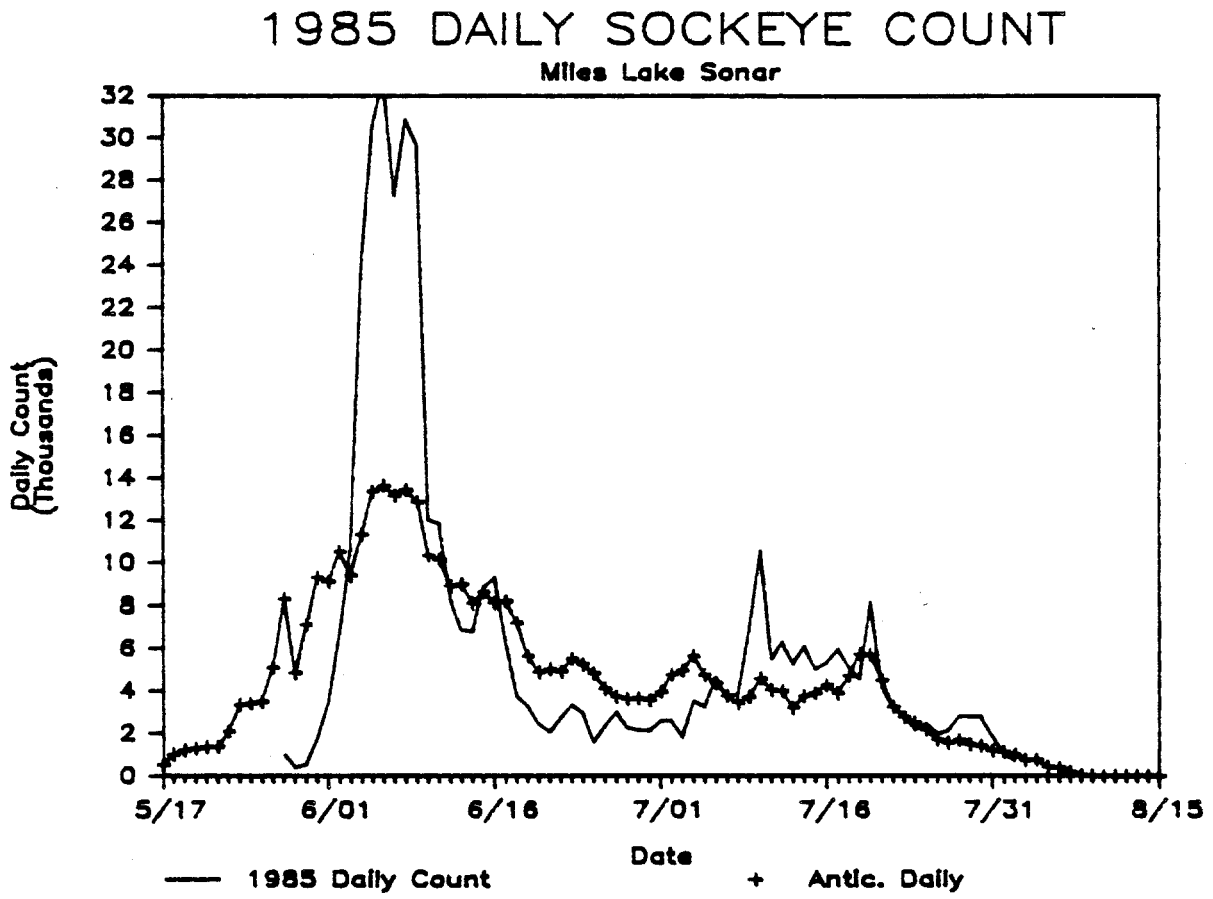
Date	Accumulative Percent 1978	1979	1980	1981	1982	1983	1984	1985	Average Daily Percent	S.D.	C.V.
5/17	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.1	0.3	264.6
5/18	0.0	0.2	0.1	2.8	0.0	0.0	0.0	0.0	0.4	0.9	241.2
5/19	0.0	0.4	0.1	4.9	0.0	0.0	0.0	0.0	0.7	1.6	237.2
5/20	0.0	0.7	0.2	6.9	0.0	0.0	0.1	0.0	1.0	2.3	225.1
5/21	0.0	1.2	0.3	8.8	0.0	0.0	0.5	0.0	1.3	2.8	211.1
5/22	0.0	2.0	0.4	10.2	0.0	0.0	0.9	0.0	1.7	3.3	194.7
5/23	0.0	3.3	0.6	11.3	0.0	0.6	1.8	0.0	2.2	3.6	163.9
5/24	0.0	4.7	0.8	13.8	.0	2.2	2.8	0.0	3.0	4.3	143.7
5/25	0.0	5.7	1.0	16.2	0.1	4.3	3.6	0.0	3.9	5.1	131.4
5/26	0.5	7.8	1.4	17.3	0.3	6.2	4.2	0.0	4.7	5.5	116.4
5/27	1.3	10.7	2.2	17.9	2.9	7.8	5.0	0.0	6.0	5.6	93.5
5/28	2.2	11.8	2.8	18.4	13.1	9.4	6.1	0.2	8.0	5.8	73.1
5/29	2.8	13.5	3.2	18.8	17.3	10.6	7.1	0.3	9.2	6.5	70.6
5/30	5.9	16.6	3.9	21.0	19.1	12.1	8.4	0.5	10.9	7.0	64.2
5/31	8.3	20.3	5.2	24.9	21.6	15.2	9.3	0.9	13.2	8.0	60.9
6/01	10.7	22.0	7.1	28.4	24.9	18.6	10.1	1.7	15.4	8.8	57.0
6/02	13.3	23.5	9.6	32.8	28.6	21.2	11.7	3.2	18.0	9.5	52.8
6/03	15.0	24.9	12.3	35.9	31.4	23.6	13.3	5.7	20.3	9.7	47.9
6/04	18.1	26.1	15.6	37.7	34.1	26.5	15.1	11.2	23.0	9.0	38.9
6/05	20.9	28.0	19.1	39.7	37.2	30.0	17.4	18.2	26.3	8.2	31.3
6/06	24.0	30.7	21.1	41.9	40.6	32.5	20.5	25.8	29.6	7.8	26.2
6/07	27.5	33.6	21.8	44.5	43.2	36.1	23.9	32.0	32.8	7.8	23.7
6/08	30.6	38.3	22.3	47.2	45.0	39.0	27.3	39.1	36.1	8.1	22.4
6/09	32.7	41.7	23.6	50.1	46.5	41.1	32.3	45.9	39.2	8.4	21.3
6/10	35.9	43.9	26.2	52.5	48.2	42.6	36.1	48.7	41.8	8.0	19.2
6/11	38.3	45.7	30.6	54.0	49.9	44.3	39.7	51.4	44.2	7.3	16.4
6/12	40.2	46.7	34.8	54.9	51.7	46.8	42.9	53.3	46.4	6.4	13.9
6/13	42.5	48.3	37.5	55.5	53.8	49.2	47.0	54.8	48.6	5.9	12.1
6/14	45.1	49.4	39.6	56.5	56.5	51.8	49.2	56.4	50.6	5.7	11.3
6/15	47.8	50.8	42.2	57.8	59.2	54.7	50.3	58.4	52.7	5.6	10.6
6/16	50.4	52.3	44.3	59.1	62.1	56.1	52.2	60.5	54.6	5.6	10.2
6/17	53.0	54.2	46.9	60.3	64.7	57.2	54.8	62.0	56.6	5.3	9.4
6/18	55.1	55.9	49.3	61.2	66.1	58.2	58.5	62.8	58.4	4.8	8.3
6/19	58.0	57.3	50.2	61.7	67.0	59.4	60.9	63.6	59.8	4.7	7.8
6/20	60.8	58.1	51.5	62.3	67.8	60.8	62.3	64.1	61.0	4.4	7.3
6/21	63.2	59.1	53.0	62.9	68.5	62.2	64.0	64.6	62.2	4.3	6.9
6/22	65.1	60.2	54.4	63.7	69.4	63.7	65.4	65.2	63.4	4.2	6.6
6/23	67.8	61.4	55.8	64.5	70.9	65.1	66.4	66.0	64.7	4.2	6.5
6/24	70.2	62.2	57.7	65.4	72.3	66.2	67.5	66.7	66.0	4.2	6.4
6/25	72.2	63.4	59.5	66.0	73.3	67.1	68.8	67.1	67.2	4.2	6.2
6/26	73.8	64.3	60.8	66.4	74.3	68.2	70.0	67.6	68.2	4.3	6.2
6/27	75.9	64.8	62.1	66.9	74.9	69.0	70.8	68.3	69.1	4.4	6.4
6/28	76.9	65.5	63.6	67.5	75.3	69.9	72.1	68.8	70.0	4.3	6.2
6/29	78.4	66.2	65.0	68.1	75.8	70.7	73.4	69.3	70.9	4.4	6.2
6/30	79.9	67.0	66.3	68.5	76.3	71.8	74.2	69.8	71.7	4.5	6.2
7/01	81.4	68.1	67.6	69.1	76.8	73.0	75.4	70.4	72.7	4.6	6.3
7/02	83.8	69.1	68.8	69.5	77.7	74.1	77.0	71.0	73.9	5.0	6.7
7/03	86.2	70.3	70.3	70.0	78.9	75.2	78.4	71.4	75.1	5.4	7.2
7/04	88.9	72.0	71.3	70.8	80.1	76.5	80.0	72.2	76.5	5.9	7.7
7/05	91.1	73.2	72.4	71.6	81.1	77.4	81.2	73.0	77.6	6.2	8.0
7/06	92.6	74.1	73.5	72.2	82.5	78.2	82.4	74.0	78.7	6.5	8.2

-Continued-

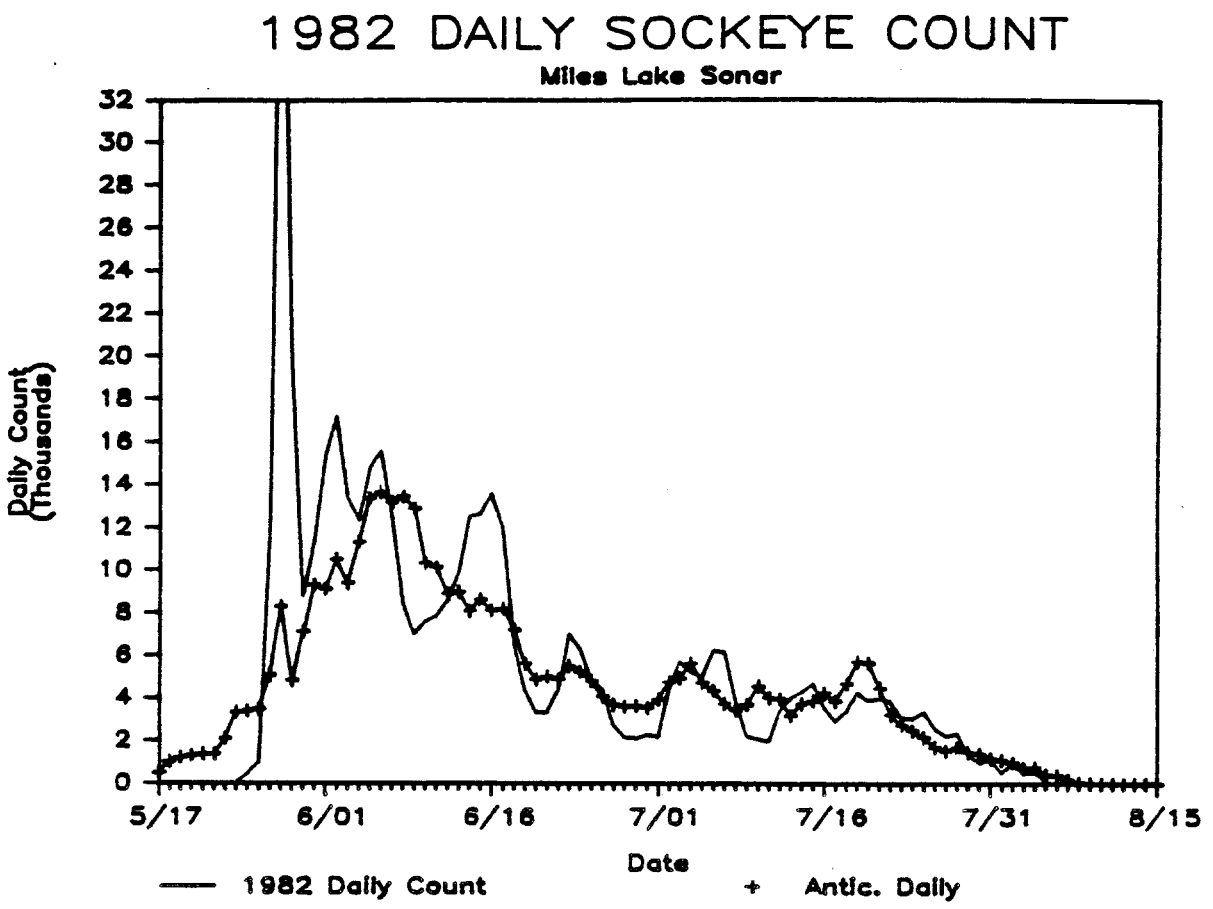
Appendix B4. Copper River cumulative daily percent salmon escapement estimates at Miles Lake sonar project, 1978-1985 (continued).

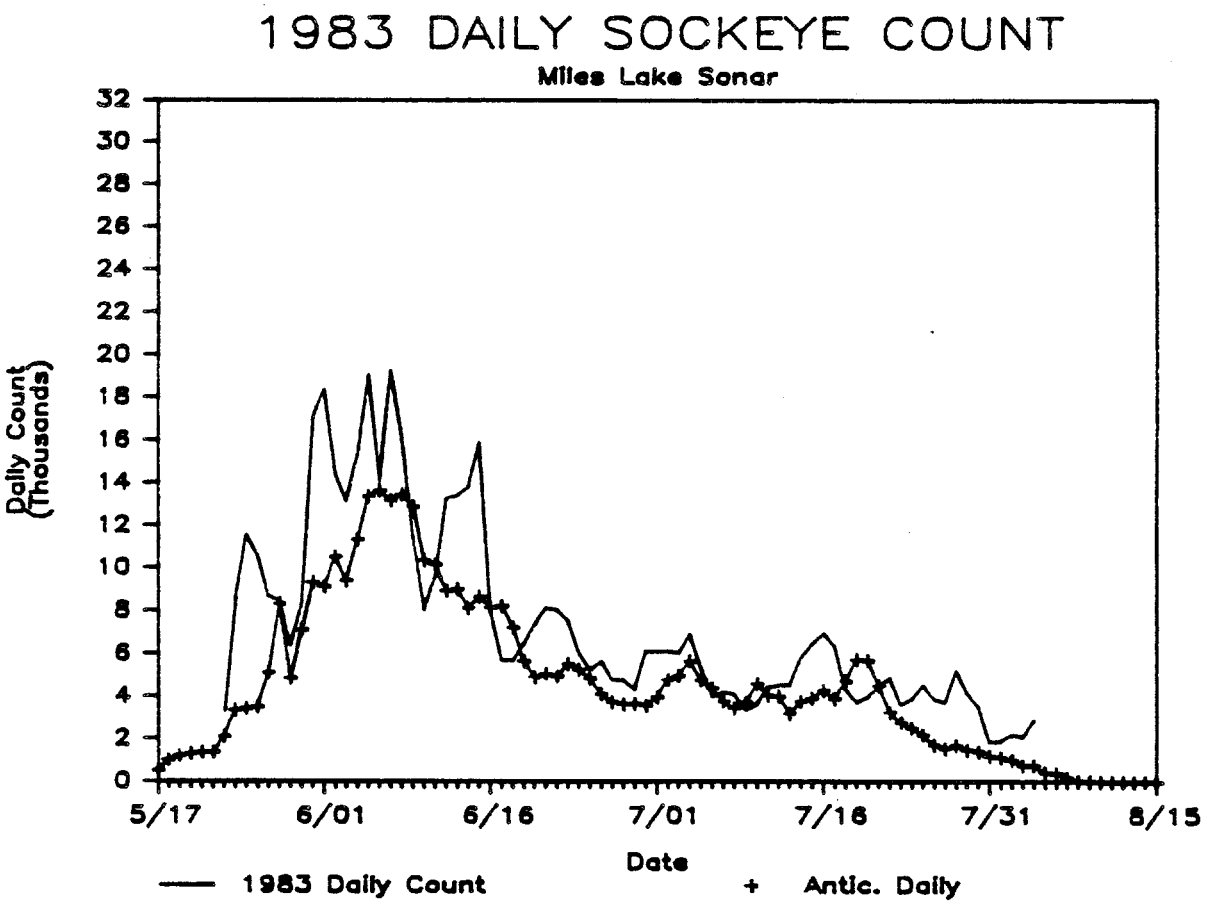
Date	Accumulative Percent 1978	1979	1980	1981	1982	1983	1984	1985	Average Daily Percent	S.D.	C.V.
7/07	93.6	74.4	74.6	73.0	83.8	78.9	83.4	74.9	79.6	6.6	8.3
7/08	94.4	75.3	75.7	73.7	84.6	79.7	84.2	75.8	80.4	6.6	8.2
7/09	95.3	76.7	76.7	74.3	85.1	80.3	84.9	77.3	81.3	6.4	7.9
7/10	96.5	78.4	78.1	74.9	85.6	81.0	85.5	79.8	82.5	6.3	7.7
7/11	97.3	80.0	80.1	75.3	86.0	81.8	86.1	81.0	83.4	6.1	7.4
7/12	97.6	81.4	81.9	75.9	86.7	82.6	86.7	82.5	84.4	5.9	7.0
7/13	97.7	82.7	82.5	76.3	87.6	83.4	87.5	83.7	85.2	5.8	6.8
7/14	98.0	84.4	83.1	76.8	88.5	84.5	88.4	85.1	86.1	5.6	6.5
7/15	98.3	85.9	83.7	77.5	89.5	85.7	89.6	86.2	87.1	5.5	6.3
7/16	98.8	88.1	84.6	78.0	90.3	87.0	90.6	87.4	88.1	5.5	6.2
7/17	99.1	89.6	85.9	78.1	90.9	88.1	91.9	88.8	89.1	5.5	6.2
7/18	99.3	91.2	88.0	79.8	91.6	88.9	92.8	90.0	90.2	5.1	5.7
7/19	99.6	92.6	90.0	83.7	92.6	89.6	93.7	91.0	91.6	4.2	4.6
7/20	99.8	93.7	91.9	87.5	93.4	90.3	94.3	92.9	93.0	3.3	3.6
7/21	99.9	94.8	93.3	90.5	94.3	91.2	94.9	93.8	94.1	2.7	2.9
7/22	99.9	95.7	94.4	91.7	95.1	92.0	95.5	94.6	94.9	2.4	2.5
7/23	100.0	96.5	95.2	92.8	95.7	92.7	96.2	95.2	95.5	2.1	2.2
7/24	100.0	97.4	95.7	93.7	96.4	93.4	96.8	95.7	96.1	2.0	2.0
7/25	100.0	97.9	96.3	94.3	97.1	94.3	97.2	96.3	96.7	1.8	1.8
7/26	100.0	98.2	96.7	94.8	97.7	95.0	97.6	96.7	97.1	1.6	1.6
7/27	100.0	98.3	97.1	95.3	98.2	95.6	97.9	97.2	97.5	1.4	1.5
7/28	100.0	98.5	97.4	95.8	98.7	96.6	98.1	97.9	97.9	1.2	1.2
7/29	100.0	98.7	97.5	96.5	99.0	97.4	98.3	98.5	98.2	1.0	1.0
7/30	100.0	98.9	97.7	97.2	99.2	98.0	98.5	99.2	98.6	0.9	0.9
7/31	100.0	99.2	97.8	97.9	99.4	98.3	98.7	99.6	98.9	0.8	0.8
8/01	100.0	99.5	98.1	98.5	99.5	98.7	98.9	99.8	99.1	0.6	0.6
8/02	100.0	99.6	98.5	99.0	99.7	99.1	99.1	100.0	99.4	0.5	0.5
8/03	100.0	99.7	98.8	99.3	99.8	99.5	99.3	100.0	99.6	0.4	0.4
8/04	100.0	99.9	99.0	99.6	100.0	100.0	99.5	100.0	99.7	0.3	0.3
8/05	100.0	99.9	99.3	99.8	100.0	100.0	99.7	100.0	99.8	0.2	0.2
8/06	100.0	100.0	99.6	100.0	100.0	100.0	99.9	100.0	99.9	0.1	0.1
8/07	100.0	100.0	99.9	100.0	100.0	100.0	100.0	100.0	100.0	.0	.0
8/08	100.0	100.0	99.9	100.0	100.0	100.0	100.0	100.0	100.0	.0	.0
8/09	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	ERR	ERR
8/10	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	ERR	ERR
8/11	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	ERR	ERR
8/12	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	ERR	ERR
8/13	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	ERR	ERR
8/14	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	ERR	ERR
8/15	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	ERR	ERR
Total											
Avg.	65.4	63.1	58.9	64.8	66.7	63.4	63.2	62.3	Over All		63.5
S.D.	38.2	33.3	36.2	29.4	33.6	33.7	36.1	36.1			34.7
C.V.	58.4	52.9	61.5	45.4	50.4	53.1	57.1	58.0			54.7



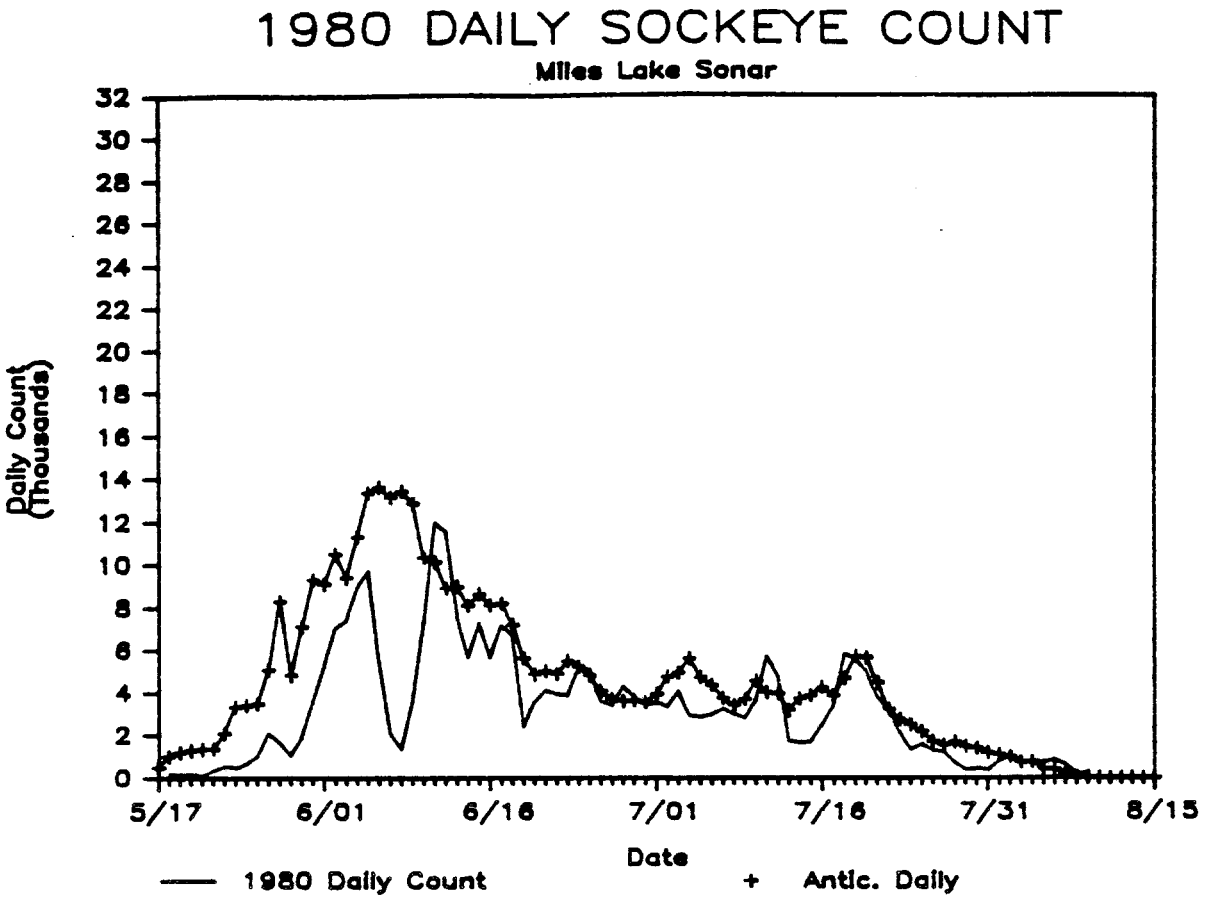


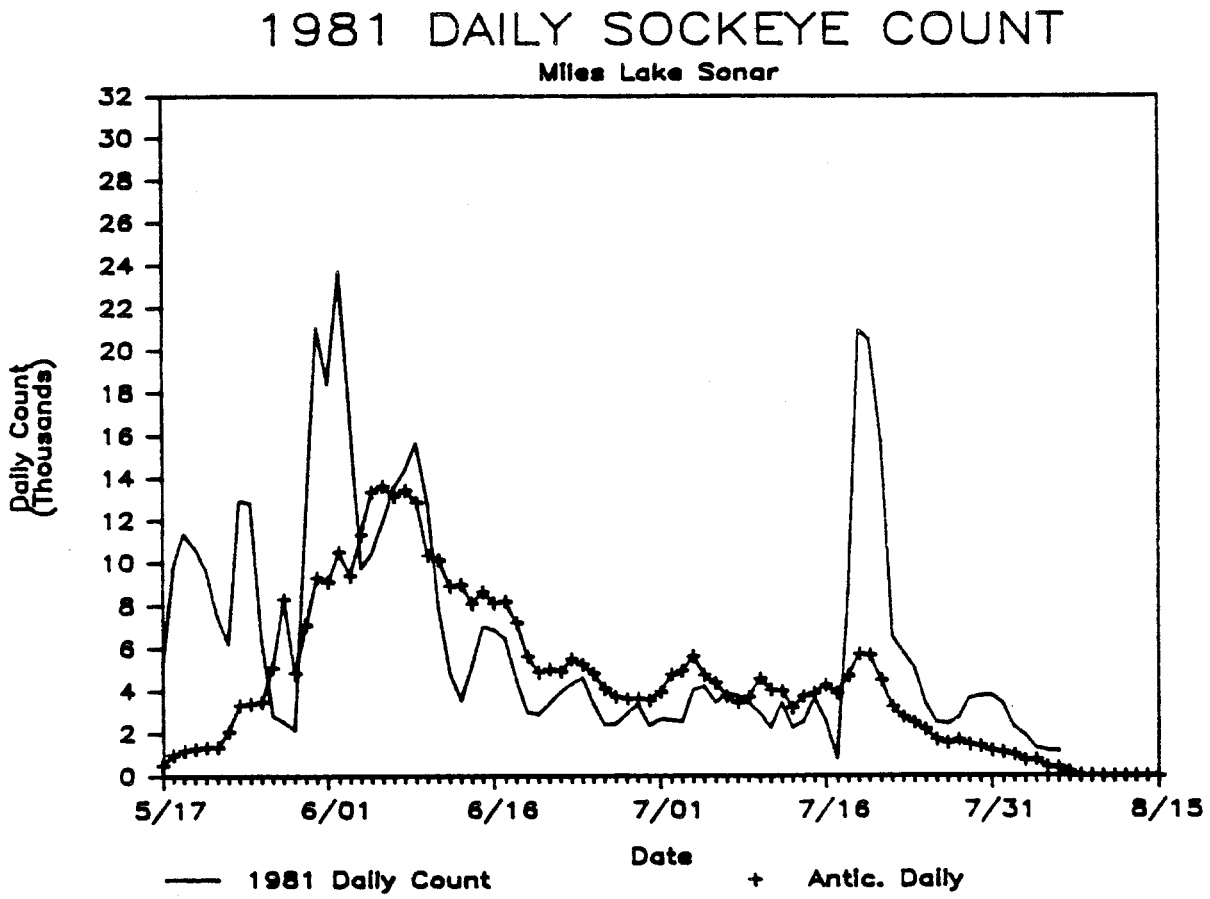
Appendix C1. Comparative annual plots of daily sonar counts as compared to the desired daily timing curve projected to achieve the escapement goal of 411,000 fish.



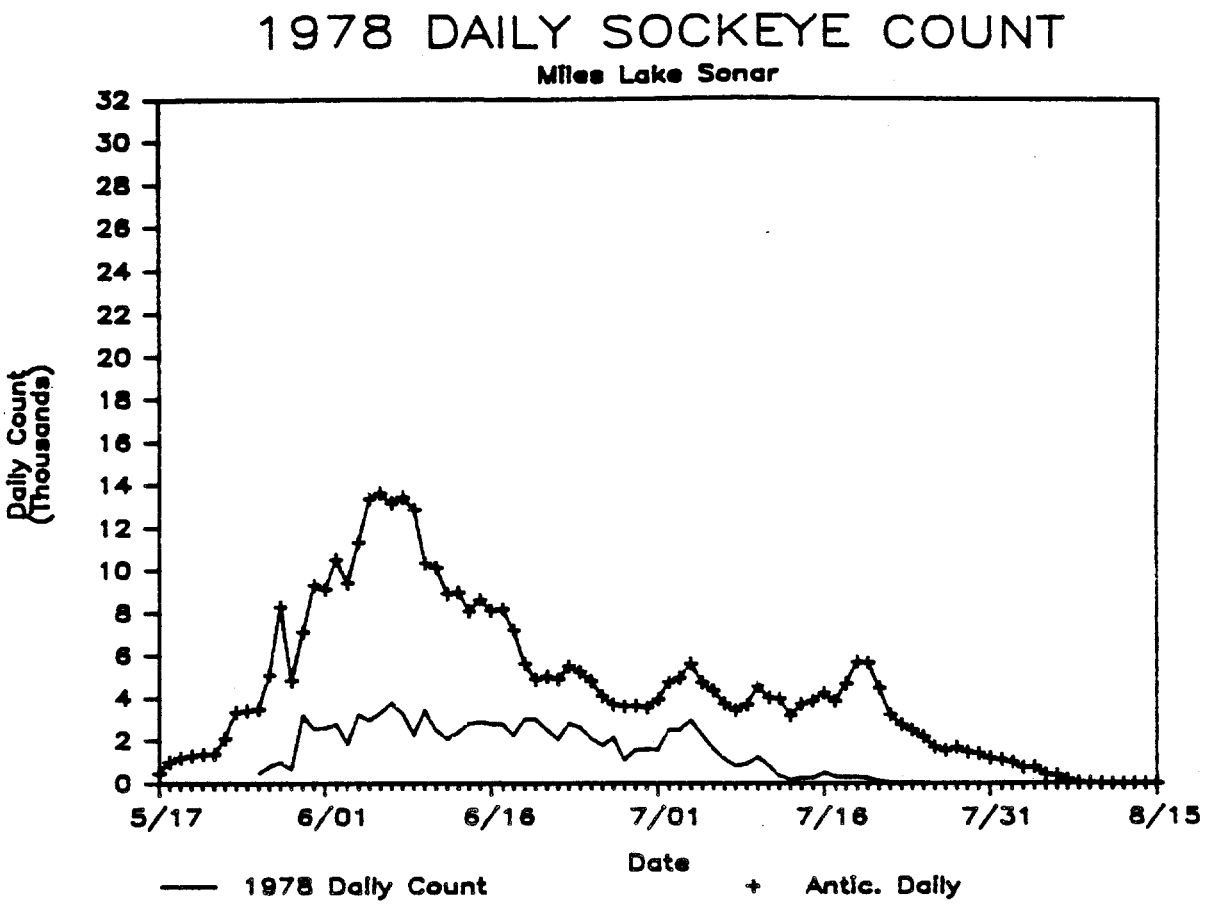


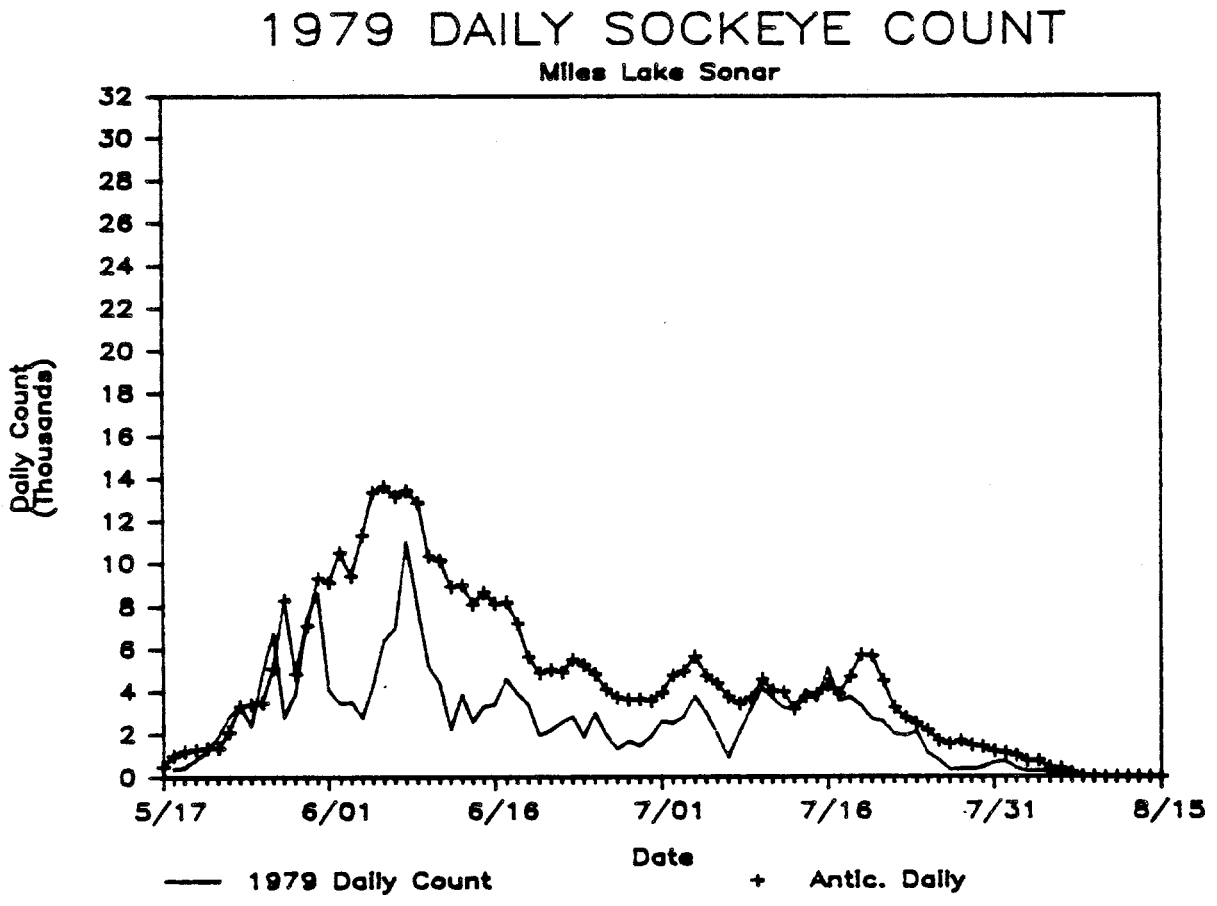
Appendix C1. Comparative annual plots of daily sonar counts as compared to the desired daily timing curve projected to achieve the escapement goal of 411,000 fish (continued).





Appendix C1. Comparative annual plots of daily sonar counts as compared to the desired daily timing curve projected to achieve the escapement goal of 411,000 fish (continued).





Appendix C1. Comparative annual plots of daily sonar counts as compared to the desired daily timing curve projected to achieve the escapement goal of 411,000 fish (continued).

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