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Chignik Lakes Research

Investigations of Salmon Populations, Hydrology, and Limnology of the Chignik Lakes, Alaska During 2000

ALASKA SALMON PROGRAM

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KEY WORDS

Alec River, beach seine, Black Lake, Chignik Lagoon, Chignik Lake, escapement goals, fry emergence, hydrology, limnology, *Oncorhynchus nerka*, Ricker recruitment curve, sockeye salmon, townet

CHIGNIK SALMON STUDIES

Investigations of Salmon Populations, Hydrology, and Limnology of the Chignik Lakes, Alaska, During 2000

G.T. RUGGERONE, B. CHASCO, AND R. HILBORN

INTRODUCTION

The purpose of this work is to annually measure the relative abundance and size of juvenile sockeye salmon (*Oncorhynchus nerka*); relative abundance of potential competitor and predator species; and the biological and physical environment for sockeye salmon in the lakes during spring through fall. These data are complementary to sockeye smolt studies conducted by Alaska Department of Fish and Game (ADF&G) and past winter ecology studies by Dr. Greg Ruggerone. A long-term database resulting from these measurements provides a basis from which to evaluate changes in the production of adult sockeye salmon from the Chignik Lakes and perhaps a means of stabilizing or increasing production.

A key concern among Chignik fishermen, residents and biologists has been the substantial change in the water volume of Black Lake since the late 1960s. This change appears to have caused greater premature outmigration of Black Lake sockeye to Chignik Lake (Ruggerone et al. 1993, Ruggerone 1994). Large emigrations of fry appear to have a significant adverse effect on adult returns to Chignik Lake. The exceptionally low water volume and adverse conditions during some winters appears to reduce survival of juvenile sockeye in Black Lake and influence large annual fluctuations in adult returns (Ruggerone 1997).

The objective of the 2000 research and monitoring at Chignik was to continue the basic monitoring of biological and physical characteristics that were monitored in past years and to conduct four additional projects: 1) measure bank erosion of lower Alec River, 2) initiation of a juvenile sockeye sampling protocol in the Chignik lagoon, 3) investigate impacts of commercial seining in the lagoon on emigrating smolts, and 4) comparie zooplankton densities from nets having different mesh sizes. The Alec River hydrology project stems from past measurements documenting the shifting of the Alec River from Alec Bay to the Black Lake outlet (Ruggerone 1997).

In Chignik Lagoon, we collected juvenile salmon from the inner and outer lagoon and examined their weight and stomach contents in order to re-examine use of the lagoon by salmon.

The 2000 fieldwork was completed in two periods: 6 June through 16 July, and 4 September through 8 September. The following work was done:

- Temperature, water transparency (Secchi depth), phytoplankton (chlorophyll a), and zooplankton densities were measured to assess the summer standing crop of primary producers and zooplankton (the main source of food for sockeye salmon in Chignik Lake).
- Data from automatic temperature loggers were downloaded and the temperature loggers were re-deployed to record continuously until collection in spring of 2001 (Chignik air temperatures, Chignik River, and Black Lake).
- Emergent fry traps were deployed along Hatchery Beach and Delta Beach. The traps were set in early-June and checked about every 6 days to assess the relative abundance and timing of emergent sockeye fry.
- Beaches were seined weekly at six established stations on Chignik Lake and two in Chignik Lagoon from June to July, and again during September in Chignik Lagoon, to assess the relative abundance of juvenile sockeye salmon and associated species nearshore.
- Tow netting was conducted in both Black and Chignik lakes during the spring and early September to assess the relative abundance and lengths of juvenile sockeye salmon in the pelagic region.

LIMNOLOGY

Methods

Water temperature, water transparency, phytoplankton, and zooplankton samples were collected six times on both Black Lake (three stations, Fig.1) and Chignik Lake (two stations, Fig. 2). Water clarity was estimated with a Secchi disk. Water temperatures were taken with a pocket thermometer on the lake's surface at Black Lake and from water taken at several depths with a van Dorn bottle at Chignik Lake. Additionally, data from automatic, year-round temperature loggers, deployed in Black Lake, Chignik River and out of the water at the FRI camp to measure air temperature, were collected. After the data from these loggers were downloaded, the loggers were reset to record continuously until retrieval in the summer of 2001. Water samples were taken immediately below the surface for Black Lake, which is shallow and well mixed, and at 0, 1, 5, 10, and 20 m below the surface in Chignik Lake. Chlorophyll *a* analysis was performed on water that was sieved through Millipore filters (0.48µ); the amount filtered depended on how much algae was in the water (i.e., denser samples clogged the filter faster). The filters were then processed with a Spectronic 20 spectrophotometer. Zooplankton samples were taken with a 153µ mesh, 0.5-m diameter net in Chignik Lake by hauling the net 40-m vertically through the water. Additional samples were collected in Chignik Lake using a 223_ net to determine whether abundant filamentous diatoms reduced the efficiency of the standard 153_ mesh net. In Black Lake, zooplankton were collected by hauling the 153_ net horizontally along the lake surface for approximately 20-m.

Results

Black Lake is shallow and turbid. Water temperature responds quickly to air temperature and increases rapidly after ice-out. In 2000, water temperature reached 10°C at one site by the middle of June and then increased to 16∞C by the middle of July (Table 1). A continuous temperature logger recorded water temperatures of >15∞C during some periods in late July and early August of 1999 and <2∞C at times during October and November 1999, and March and May 2000 (Fig. 3). The temperature time series indicates Black Lake was initially froze in late October and was continuously covered in ice from late November through mid-March. Exceptionally cold air temperatures occurred during late December through January. Typically, Black Lake warms more rapidly than Chignik Lake during spring and summer, but temperature also declines more rapidly in the fall (Ruggerone 1997).

Secchi readings (water clarity) in Black Lake are influenced by both phytoplankton and suspended sediments caused by windstorms. Secchi depths in 2000 (1.5 m) were low compared to previous years (1.3-2.2 m) (Tables 1 & 2). Chlorophyll *a* measurements were average during mid-summer, averaging 2.14 mg/m^{-3}. In many years the outlet and Alec Bay, which are both greatly influenced by runoff from Alec River, have had lower concentrations than Hydro Point. Chlorophyll *a* in Black Lake is high compared to that of other sockeye lakes in Alaska (Burgner et al. 1969, Ruggerone 1994).

Chignik Lake is much deeper than Black Lake and the water column is typically well mixed by the strong, consistent winds. Lake level was above average throughout spring and summer due to a high snow-pack. The moderately high water caused the Chignik weir to wash out in early June. Temperatures were average in early June (6.2∞C) and warmed up to about 11∞C by early September (Table 3). Lake temperatures during 2000 were average when compared to previous years. Chignik Lake typically has an exceptionally high concentration of phytoplankton compared to other major sockeye lakes. In 2000, chlorophyll *a* averaged 7.0 mg/m^3, which is considerably higher than observed in past years (Table 3). Phytoplankton concentrations during September were especially high (Table 4). Secchi readings ranged from 0.75-2.70 m (Table 4); these values appear average with previous years.

Zooplankton densities in Black Lake during 2000 were average(Table 5). However, high zooplankton counts occurred among all species in early September. Zooplankton densities in Black Lake were approximately 50% lower compared to those in Chignik Lake after adjusting for tow length (20 v. 40 m) (Table 6). Relatively high densities of *Bosmina* were sampled in Black Lake during early September. It is interesting to note that the zooplankton densities were average even though the tow net catches of sockeye were well above average. We would expect an inverse relationship between zooplankton densities and the number of planktivores.

Zooplankton in Chignik Lake displayed the typical seasonal pattern of relatively high abundance of *Cyclops* spp. during early summer followed by an increase in numbers of cladocerans during late summer and fall. Abundance of zooplankton in 2000 was low (370,000 m^{-2}) compared to the average during the 1990s (448,000 m^{-2}) (Table 7). The exceptionally low abundance of zooplankton may explain the exceptionally high concentrations of chlorophyll; this relationship is particularly pronounced during the fall. Zooplankton abundance in Chignik Lake is high compared to sockeye lakes in central and southeast Alaska (228,000 ± 48,000 m^{-2}) (Kyle 1991) and western Alaska (250,000 m^{-2} for 60 m haul) (D.E. Rogers, unpublished data).

EMERGENT FRY

Since 1986, numbers of emergent fry have been estimated on two beach spawning areas of Chignik Lake using conical shaped traps (Ruggerone 1994). Peak emergence has traditionally occurred in early June, but many fry can emerge in May. The fry emergence index period consistently used in the historical database spans the month of June. No fieldwork was done in 1994, but our sampling resumed in 1995 on the Hatchery and Delta beaches.

In 2000 sampling did not begin until June 7. A total of 21 traps were deployed from June 7 to July 8. Monthly fry counts per m^2 during June were 19.0 along Hatchery Beach and 4.4 along Delta Beach (Table 8). In 1999 a large number of sockeye entered the system late and spawned late.

The abundance of late spawning fish explains the unusually high rate of emergence observed during July 2000. The late spawning fish and late emergence of fry may produce an above average late run component of the 2006 sockeye run to Chignik Lake.

It is interesting to note that the exceptionally high emergence rate at Hatchery Beach (a major spawning ground) in 1996 corresponds to the exceptionally large smolt emigration in 1998, which will mature primarily in 2001.

Too few data are available for the purpose of comparing emergence rates with adult returns. However, available data suggest adult returns to Chignik Lake may be positively correlated with emergence rates and negatively correlated with large returns to Black Lake (multiple regression, n = 9, overall p = 0.08). These preliminary results are consistent with other data that suggests large emigration of fry from Black Lake to Chignik Lake has an adverse effect of adult returns to Chignik Lake (Ruggerone 1996). The large fry emergence in 1996 and the forecast of a below average Black Lake run in 2001, indicates the Chignik Lake run will be above average in 2001 (see forecast in Appendix I)

TOW NET SAMPLING

Tow-net hauls were made annually in the Chignik Lakes from 1960 to 1973 (Rogers et al. 1996). Although tow lengths sometimes varied, all catches were standardized to 10 min (Parr 1972). Arithmetic and geometric means have been calculated in the past; however, only arithmetic means are presented here. Since 1973, tow netting has been sporadic; however, since the development of relatively stable funding provided by CRAA we have sampled both lakes since 1992, except for 1994[1] (Tables 9 and 10). The catches during September 2000 of juvenile sockeye were very high for Chignik Lake (347 per 10 min tow; 81 ft^2 net) and extremely high for Black Lake (1,591 per 10 min-tow; 36 ft^2 net). The catches during September in Black Lake were the highest in history (Figure 5). It is worth noting, however, that the Black Lake sampling was conducted during the day in 2000, due to weather limitations. Past research demonstrated that daytime sampling produced fewer fish than nighttime.

BEACH SEINING

Chignik Lake

Beach seining was conducted in Chignik Lake several years prior to 1973 and since the mid-1980s (Ruggerone 1989, Rogers et al. 1996). Catches of juvenile sockeye salmon have been recorded as larger or smaller than 45 mm. The small fish were likely to be fry (age 0) whereas the larger fish likely were a mixture of yearlings from Chignik Lake and large fry from Black Lake. Juvenile coho salmon are usually more abundant in beach seine catches than in townet catches, which reflects their preference for the nearshore habitat (Ruggerone 1989).

Catches of small juvenile sockeye salmon (< 45 mm) were similar to recent years, but catches of larger sockeye were considerably smaller (Table 11). However, beach seine sampling may not reflect abundance of Chignik Lake sockeye; especially fry, because fry are readily consumed by juvenile coho that are most abundant nearshore (Ruggerone 1989). Char and 3-spine stickleback catches were about equal to the historical average but were much lower than 1997 and 1998. Coho catches were substantially lower in 2000. An intensive study of coho predation on sockeye salmon during the mid-1980s showed that coho consumed approximately 24 to 78 million sockeye salmon fry depending on year or approximately 59% of the emerging sockeye population (Ruggerone and Rogers 1992).

Chignik Lagoon

Beach seine sampling was conducted in Chignik Lagoon in June and the early part of July, and once during September (Table 12). Two locations were sampled: the sand spit at the outer lagoon, and P. Rock at the upper lagoon. Water content was measured in the sampled sockeye as an index of condition. Low water content at a given size reflects higher condition since fish loose dry weight and absorb water when starving. Sockeye in Black Lake during spring contained relatively high water content compared with Chignik Lake fish of similar weight (Figure 6). Water content of sockeye in the lagoon was similar to that in Chignik Lake fish even though fish in the lagoon were larger. The lowest water content was observed in Black Lake fry during the fall

Stomach contents of sockeye collected in the Lagoon, Chignik Lake, and Black Lake were examined for visual estimates of stomach fullness and the presence of various prey types. Stomach fullness was greatest among sockeye in Black Lake (82.5%), followed by the outer lagoon (73.6%), inner lagoon (56.8%), and Chignik Lake (50%) (Table 13). Amphipods were the dominant prey for fish in the outer lagoon, whereas insects were dominant in fish collected in the upper lagoon. Immature insects (mainly pupae) were consumed by sockeye at both lagoon locations suggesting that sockeye either foraged on drift entering the lagoon or they rapidly moved from freshwater to the outer lagoon. Given the high density of sockeye in Black Lake, the high stomach fullness of Black Lake sockeye indicates food production in the lake was exceptional in 2000.

During one of the commercial fishing periods, we spent

[1]Sampling by ADFG in 1994 using a net towed by a single boat produced only a few sockeye per tow.

eight hours on a seiner at Ollie's Pt. and Diego Channel to determine if smolts were caught in the purse seines and experiencing mortality. Although we did not see any smolts hitting the deck of the vessel, it is unknown whether the fishing pressure increases stress to the smolts. The smolts would often remain in the purse until the last second and then swim through the net as it was brought onboard.

ALEC RIVER HYDROLOGY

Previous research has shown that the south channel of the lower Alec River leading into the lake outlet is becoming larger relative to the north channel leading into the main lake (Ruggerone 1994, 1997). The cause of the shifting Alec River channels appears to be related to the lowering of Black Lake elevation, which was apparently initiated by downstream migration of the West Fork River and subsequent degradation of Black River since the late 1960s[2]. The migration of Alec River channels is important to sockeye salmon because greater discharge to the south channel during early spring will likely carry larger numbers of emerging sockeye fry to the outlet of Black Lake and may encourage more fry to emigrate to Chignik Lake. During low water periods, an exposed sandspit crosses approximately 80% of the lake and separates the main lake from the outlet.

Erosion of the banks along the south channel of Alec River has been monitored since 1991 (Ruggerone and Denman 1991) and in 1993 and 1999 the relationship between total river discharge and the percentage of river water entering the south channel was quantified. During low flows, such as those occurring during fry emergence, approximately 70% of the river flow (and presumably 70% of fry) entered the lake outlet. During exceptionally high flow events, the percentage of total discharge to the outlet declined to approximately 40%. The most recent study indicates flow has continued to shift toward the outlet since 1993 (Ruggerone et al. 2000).

The purpose of the 2000 Alec River investigations was to continue monitoring of the river bank erosion and to determine the extent to which discharge was shifting toward the south channel and the lake outlet (Ruggerone 1994, 1997).

Results

Annual measurements of erosion along the south channel riverbank at nine locations indicated that approximately 0.29—0.45 m of the right bank is lost per year, depending on location (Table 14). This represents an increase in river width of approximately 1.2% per year. Greatest erosion is occurring at the river wye and along the river bend approximately 150 m downstream from the wye. Significant sloughing and sinking of the wye occurred during 1997-1998.

During the fall 1999 field season we observed a broad sand spit extending west from the Alec River delta and across most of Alec Bay toward the old FRI cabin. This spit was visible during fall 1990, but only when the lake level was extremely low and wind was approximately 60 mph from the southeast. During 1999, the spit was visible during calm winds and moderately low water, indicating potentially significant deposition of sediment in this area. Past research indicated significant sediment transport from Alec River (Ruggerone 1994). The spit was observed again in 2000. Observations of this area should continue in the future and profiling of the lake depth contours should be considered. The depth contours of Black Lake were last estimated in 1993 (Ruggerone 1994).

The outlet area of Black lake has become exceptionally shallow. During September 2000, we were unable to sample fish in the lake outlet with the four-foot deep townet, which was specially designed for the outlet in the early 1990s, because water depth was too shallow. Water depth across the lake outlet near the river head was approximately 45 cm (18 inches), which is too shallow to operate propeller skiffs at night (we used two jet boats). As described in previous reports, FRI regularly sampled this area with a six foot deep townet in the 1960s.

GRADUATE STUDIES

Beginning in the summer of 2001, Brandon Chasco will begin a bioenergetics study at Chignik. His project will focus on competition for resources between Chignik Lake and Black Lake juveniles. The project will address specifically how much competition there is between the two stocks in Chignik Lake, and how future changes in the habitat of Black Lake may affect the competition. The use of Chignik Lagoon as a secondary rearing habitat for juvenile salmon will also be evaluated.

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[2]Significant changes in the Black River channel continue to occur between Chiatuak Creek and the area immediately below the old West Fork channel. At the FRI camp across from Chiaktuak Creek approximately 50 feet or more of the bank has been lost, including two cabins since 1984. During the past 6-7 years, the large sandbars in this area have been invaded by dense perennial vegetation. It appears that the channel is continuing to degrade since the sandbars appear to be covered less frequently by river flows. The implication of channel degradation is that it will likely lead to additional lowering of Black Lake water elevation.

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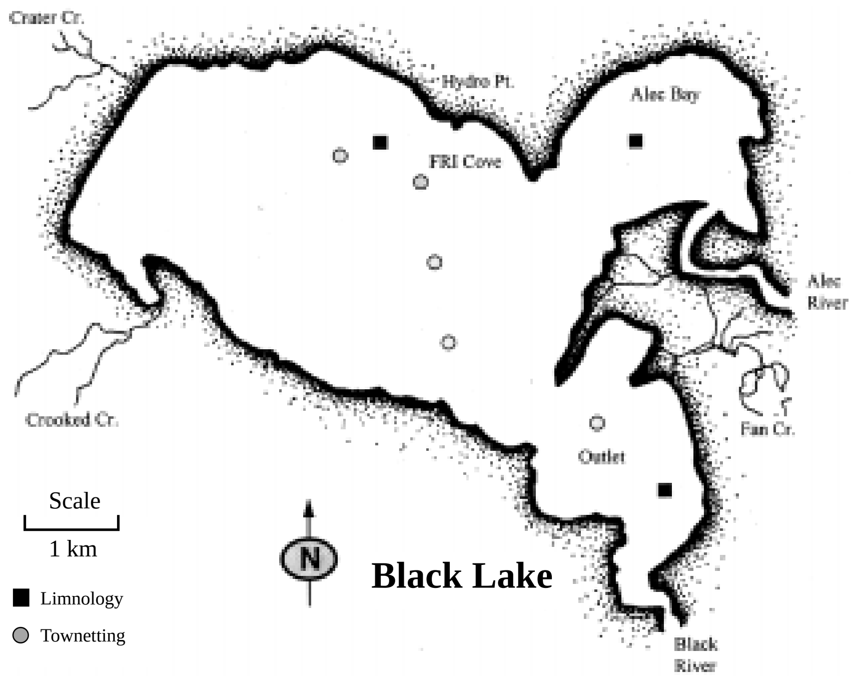

FIGURE 1. Black Lake sampling sites.

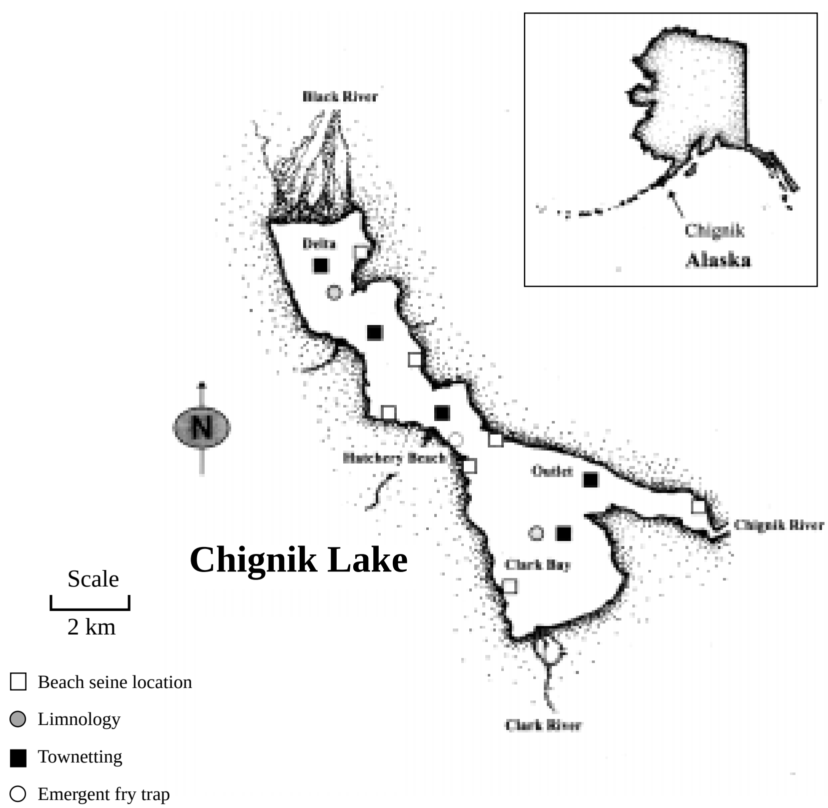

FIGURE 2. Chignik Lake sampling sites.

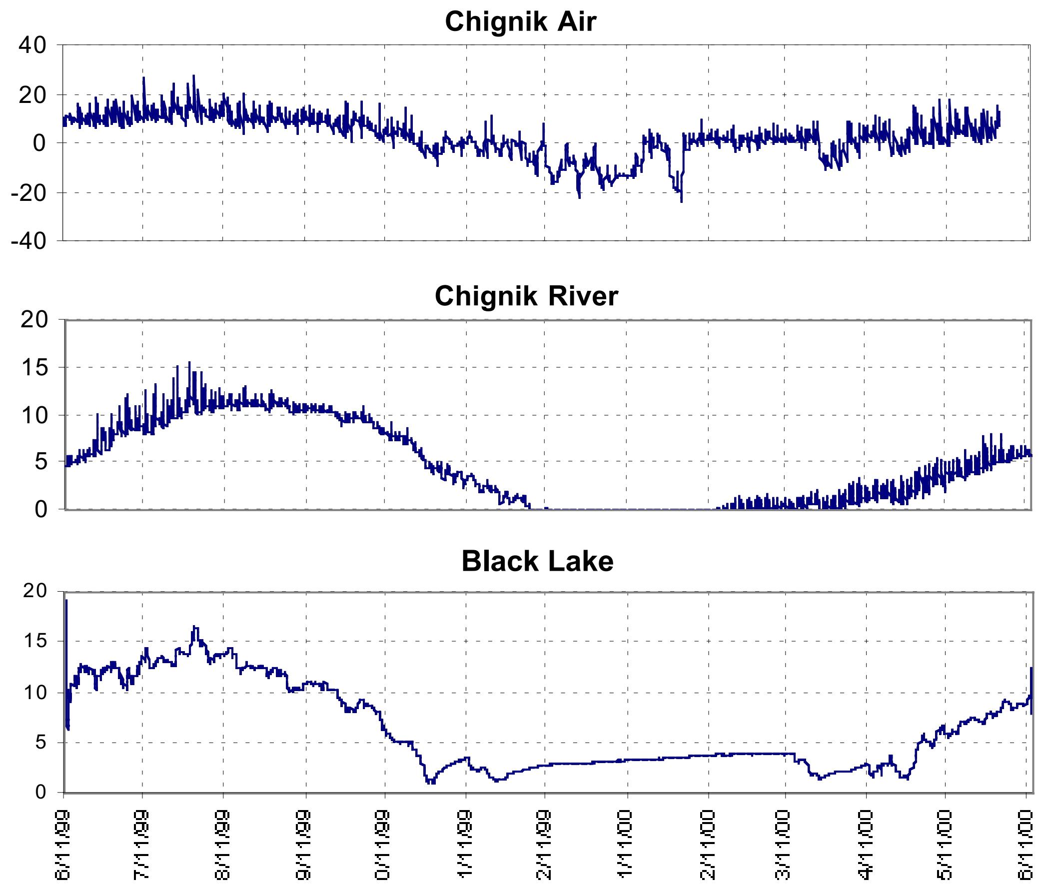

FIGURE 3. Daily temperatures (°C) measured year-round with automatic temperature loggers from Black Lake (water), Chignik River (water), and from our camp (air), 1999–2000.

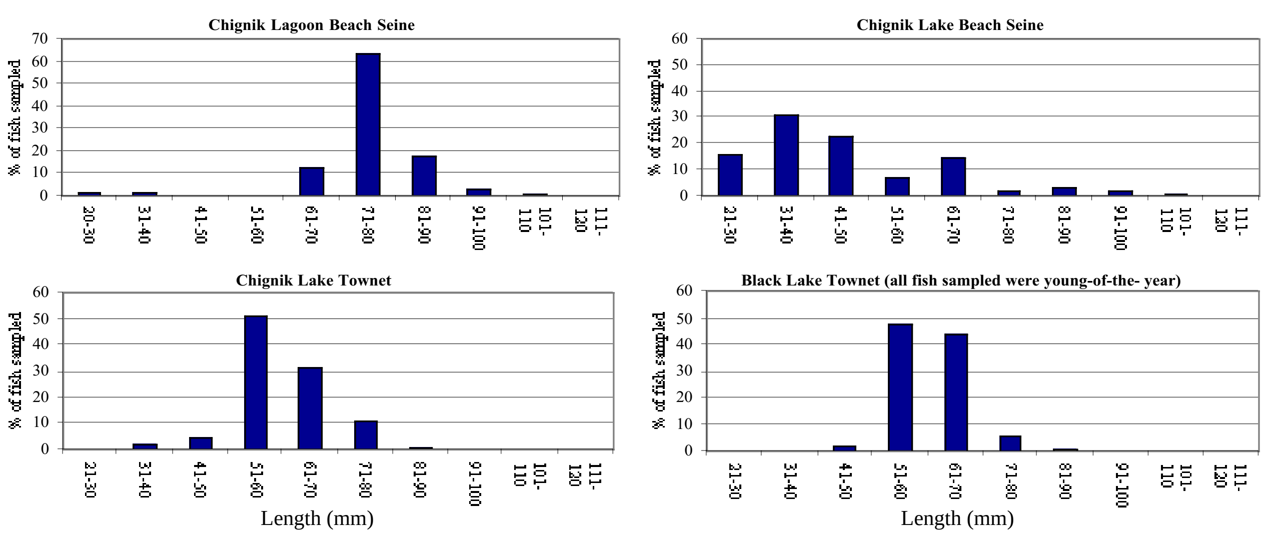

FIGURE 4. Length frequency distributions of juvenile sockeye sampled from beach seining (Chignik Lagoon and Chignik Lake) and tow netting (Chignik and Black Lakes) during the 2000 season.

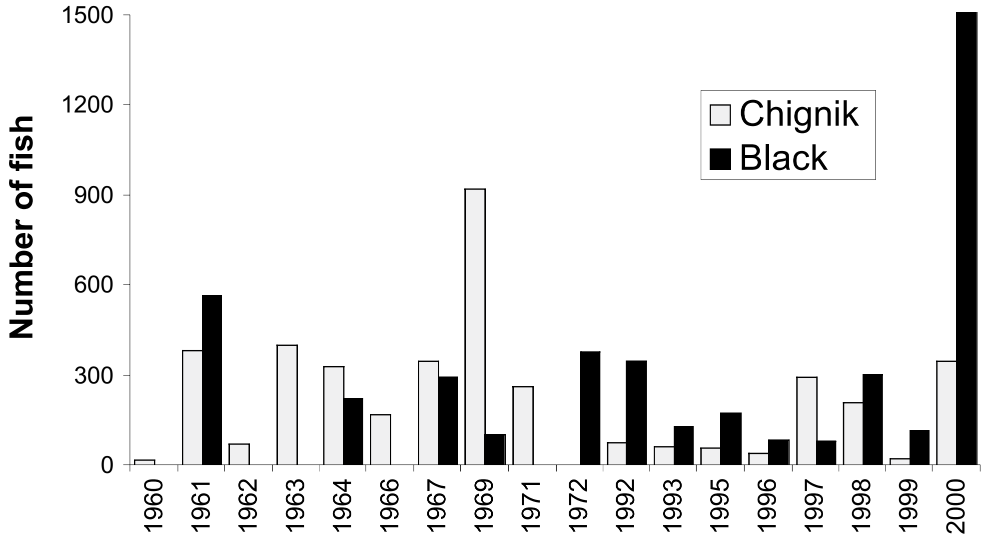

FIGURE 5. Historical tow net catches for Chignik and Black Lakes, during September.

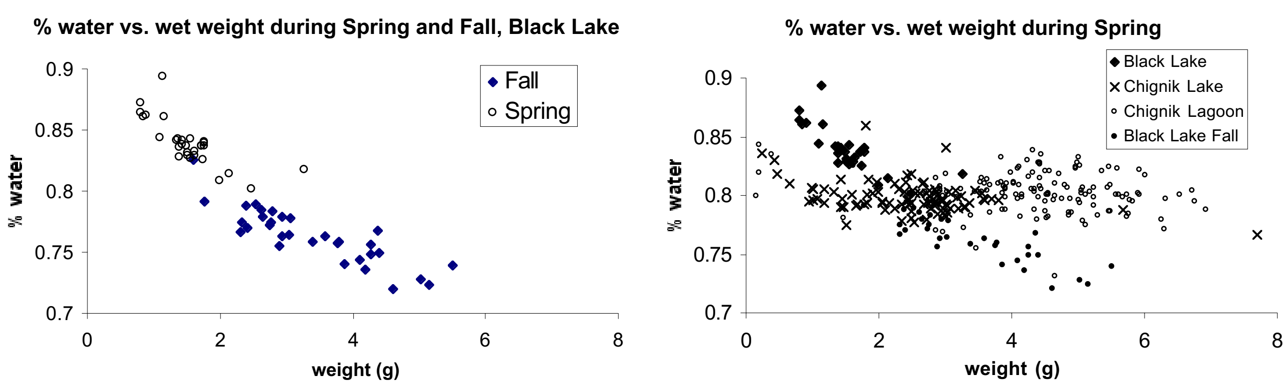

FIGURE 6. Percent water vs. wet weight of juvenile sockeye sampled from beach seining (Chignik Lagoon) and tow netting (Chignik and Black Lake) during the 2000 season.

TABLE 1. Limnological data from Black Lake, 2000.

Date	Location	Secchi depth (m)	Surface Temp. (C)	Chlorophyll *a* (mg/m^3)
10-Jun-00	Alec	1.00	10.00	1.96
	Hyrdo	1.40	10.00	3.37
	Outlet	1.50	9.00	0.74
19-Jun-00	Alec	1.25	10.00	4.12
	Hyrdo	1.75	10.00	3.42
	Outlet	0.75	7.00	1.20
27-Jun-00	Alec	2.00	n/a	1.59
	Hyrdo	2.00	n/a	1.68
	Outlet	2.00	n/a	3.54
06-Jul-00	Alec	1.50	12.00	1.99
	Hyrdo	1.75	12.00	2.47
	Outlet	1.75	12.00	0.84
13-Jul-00	Alec	2.25	16.00	n/a
	Hyrdo	2.50	15.00	2.99
	Outlet	1.25	15.00	2.25
07-Sep-00	Alec	0.60	9.50	n/a
	Hyrdo	0.60	9.00	0.01
	Outlet	0.75	10.00	n/a
	2000 means	1.5	11.1	2.14

TABLE 2. Historical averages of limnological data from Black Lake, 1990–2000.

Date			Secchi depth	Surface water	Chloro-phyll a
Mo	Day	Year	(m)	temp. (C)	mg/m^3
6	27	90	1.8	13.0	2.65
6	20	92	n/a	n/a	3.24
7	8	92	n/a	n/a	2.28
9	3	92	n/a	n/a	4.59
5	18	93	1.6	8.8	1.26
6	16	93	1.7	9.7	0.98
7	16	93	1.8	15.5	0.60
8	15	93	0.9	12.7	4.33
9	9	93	0.7	12.5	3.32
6	9	95	1.4	11.2	3.67
6	20	95	1.4	10.7	1.34
7	11	95	1.5	12.3	1.15
7	23	96	1.8	13.8	2.26
6	2	97	2.2	12.5	1.75
6	20	98	1.2	9.7	n/a
7	3	98	1.0	12.3	4.02
7	16	98	1.3	13.2	1.99
9	3	98	0.5	10.3	n/a
6	12	99	0.5	7.8	2.13
6	21	99	1.3	11.3	2.65
6	26	99	1.3	10.4	3.01
7	5	99	1.2	11.0	4.75
9	7	99	1.5	9.8	4.29
6	10	00	1.3	10.0	9.50
6	19	00	1.3	9.0	7.03
6	27	00	2.0	n/a	6.00
7	6	00	1.7	12.0	5.47
7	13	00	2.0	15.3	3.27
9	7	00	0.7	9.5	10.94

TABLE 3. Historical averages of limnological data from Chignik Lake, 1988–2000.

Date			Secchi depth	Averages over 1-20 m	
Mo	Day	Year	(m)	Temp. (C)	Chlorophyll a (mg/m^3)
6	16	88	n/a	n/a	4.13
7	14	88	n/a	n/a	2.92
6	24	89	2.4	9.2	3.38
6	24	90	1.8	8.6	2.40
6	21	91	n/a	8.3	2.55
6	23	92	1.8	9.6	3.27
7	11	92	2.6	9.9	2.68
9	3	92	n/a	10.8	5.42
5	10	93	2.2	4.3	7.96
6	17	93	1.4	9.1	0.88
7	26	93	0.6	12.4	0.81
8	18	93	0.8	11.7	1.49
9	10	93	0.8	11.6	1.71
6	8	95	1.7	7.5	4.89
6	17	95	1.6	9.0	3.23
6	29	95	2.5	9.1	2.61
7	7	95	2.4	10.1	1.85
7	17	95	2.7	11.1	2.91
6	17	96	2.0	9.0	3.22
7	4	96	2.7	n/a	1.50
7	12	96	2.6	9.6	2.03
7	30	96	2.8	12.3	1.94
8	8	96	4.2	11.2	1.92
5	26	97	3.2	7.0	2.93
6	11	97	2.3	9.2	3.64
8	15	97	1.6	13.1	1.73
8	28	97	2.1	12.3	2.10
6	22	98	1.6	8.2	n/a
7	4	98	2.4	10.1	2.80
7	14	98	2.5	11.0	2.00
9	5	98	1.9	11.2	n/a
6	8	99	3.0	4.7	3.23
6	16	99	2.0	7.2	4.16
6	24	99	1.8	7.1	3.37
7	6	99	n/a	n/a	n/a
9	6	99	0.6	10.2	2.91
6	9	00	2.2	6.2	9.50
6	18	00	1.3	7.0	7.00
6	26	00	1.6	8.0	6.00
7	5	00	1.5	9.1	5.50
7	11	00	2.0	10.5	3.30
9	5	00	1.0	11.0	10.90

TABLE 4. Limnological data from Chignik Lake, 2000.

	Clark				Delta			
Date	Secchi (m)	Depth (m)	Temp (C)	Chl a	Secchi (m)	Depth	Temp (C)	Chl a
6/9	2.70	0	6.0		1.60	0	7.0	
		1	6.0	7.64		1	7.0	9.55
		5	6.0	10.79		5	6.0	11.37
		10	6.0	9.63		10	6.0	11.34
		20	6.0	7.17		20	6.0	8.50
6/18	1.75	0	7.0		0.75	0	8.0	
		1	7.0	7.90		1	7.0	3.90
		5	7.0	8.59		5	7.0	5.91
		10	7.0	8.86		10		5.83
		20	6.0	8.31		20		6.95
6/26	1.75	0	8.0		1.50	0	8.0	
		1	8.0	5.23		1	9.0	3.62
		5	7.0	10.01		5	9.0	3.74
		10	7.0	4.96		10	8.0	5.65
		20	8.0	7.31		20	8.0	7.52
7/5	1.75	0	9.0		1.25	0	9.0	
		1	9.0	8.36		1	10.0	2.75
		5	9.0	8.66		5	9.0	2.70
		10	8.0	9.30		10	10.0	2.50
		20	8.0	6.07		20	10.0	3.43
7/11	2.50	0	11.0		1.50	0	13.0	
		1	12.0	2.10		1	12.0	2.23
		5	10.0	3.31		5	10.0	2.84
		10	9.0	2.24		10	9.0	2.71
		20	9.0	3.83		20	10.0	6.87
9/5	1.25	0	11.0		0.75	0	11.0	
		1	11.0	10.23		1	11.0	10.49
		5	11.0	11.08		5	11.0	12.16
		10	11.0	11.38		10	11.0	11.77
		20	11.0			20	11.0	9.46
2000 mea	1.25		8.4	7.5	0.75		9.0	6.4

TABLE 5. Historical zooplankton densities (1000 m²) in Black Lake, 1992-2000.

Year	Month	Day	# Sites	Category							
				Calanoids	*Cyclops*	*Daphnia*	*Bosmina*	*Chydoris*	Nauplii	*Asplanchia*	Total
1992	6	20		6	37	0	5	0	13	3	64
1993	5	17		1	1	0	3	0	0	0	5
1993	6	15		13	1	0	21	0	0	0	35
1993	7	15		1	1	0	3	0	0	0	5
1993	8	14		9	19	0	227	0	0	0	255
1993	9	8		6	6	0	149	0	0	0	161
1995	6	9		1	14	0	1	1	5	1	23
1995	6	20		0	5	0	2	0	1	0	8
1995	7	11		2	12	0	8	2	2	9	35
1995	9	5		3	6	0	24	6	3	3	45
1998	6	20	2	2	8	0	1	0	3	1	15
1998	7	3	2	6	22	0	9	1	5	3	46
1998	7	16	2	5	5	0	14	0	6	1	31
1998	9	3	2	4	16	0	53	4	4	6	87
1999	6	12	3	13	5	0	6	0	7	0	30
1999	6	21	3	5	6	0	8	1	8	0	28
1999	6	26	3	17	13	0	39	1	14	0	84
1999	7	5	3	38	29	0	55	3	22	1	146
1999	9	7	3	1	6	0	83	1	2	0	93
2000	6	10	3	2	9	0	14	2	9	0	35
2000	6	18	3	6	10	0	19	4	16	0	54
2000	6	26	3	0	0	0	7	0	0	0	7
2000	7	05	3	9	9	0	25	4	4	0	51
2000	7	11	3	5	5	0	24	1	3	0	38
2000	9	05	3	14	40	0	294	48	2	0	399

TABLE 6. Zooplankton densities in Chignik and Black Lakes (1,000 m^2), 2000.

		Date		Category							
Lake	Location	Mo	Day	Asplanchna	Bosmina	Calanoids	Chydoris	Cyclops	Daphnia	Nauplii	Total
Black Lake	Alec	6	10	0	2	1	0	2	0	7	12
		6	19	0	28	8	5	14	0	16	71
		6	27	0	3	0	0	1	0	1	5
		7	06	0	4	4	0	3	0	2	13
		7	13	0	25	8	0	5	0	4	42
		9	7	0	148	1	8	15	0	0	172
Black Lake	Hyrdo	6	10	0	37	6	4	23	0	12	82
		6	19	0	16	6	3	10	0	21	56
		6	27	0	16	0	0	0	0	0	16
		7	06	0	68	22	11	25	0	9	135
		7	13	0	26	8	0	4	0	4	42
		9	7	0	550	18	103	81	1	5	758
Black Lake	Outlet	6	10	0	2	1	1	1	0	7	12
		6	19	0	12	3	4	7	0	10	36
		6	27	0	2	0	0	0	0	0	2
		7	06	0	4	0	0	0	0	0	4
		7	13	0	20	1	1	6	0	1	29
		9	7	0	185	23	35	23	0	1	267
Chignik Lake	Clark	6	9	0	4	7	0	26	1	8	46
		6	18	1	1	2	0	26	0	1	31
	***	6	18	1	2	7	0	47	1	0	58
		6	26	0	5	7	1	22	1	4	40
		7	05	1	7	7	1	36	0	1	53
		7	11	3	11	15	1	15	0	2	47
		9	05	16	48	31	1	17	4	11	128
Chignik Lake	Delta	6	9	0	1	3	0	31	0	5	40
		6	18	0	8	8	0	16	1	15	48
	***	6	18	0	8	4	0	9	1	1	23
		6	26	1	6	4	1	245	0	7	264
		7	05	0	8	10	1	8	0	6	33
		7	11	1	8	13	2	34	1	0	59
		9	05	6	29	38	4	15	5	6	103

Chignik Lake: From 40-m vertical hauls with a .5-m net of 153-µm mesh. Two hauls per date and station.
Black Lake: From 20-m horizontal hauls with a .5-m net of 153-µm mesh. Two hauls per date and station.
*** Two additional hauls were made with 223-micron mesh.

TABLE 7. Historical zooplankton densities in Chignik Lake (1,000 m²), 1968–2000.

Year	Month	Day	# Sites	Depth (m)	Categories							Total
					Calanoids	*Cyclops*	*Daphnia*	*Bosmina*	*Chydoris*	Nauplii	*Asplanchia*	
1968	6	25	5	30	12	25	1	2	3	0	0	43
1968	7	20	5	30	15	11	3	11	8	0	0	48
1968	8	4	5	30	41	32	13	51	7	0	0	144
1968	8	29	5	30	98	24	110	67	5	0	0	304
1969	6	29	5	44	5	364	4	7	2	0	0	382
1969	7	27	5	47	13	329	11	22	2	0	0	377
1969	8	15	5	42	26	161	34	45	3	0	0	269
1969	8	30	5	44	33	28	42	51	2	0	0	156
1970	6	28	4	30	24	83	5	3	1	0	0	116
1970	7	27	4	30	39	37	10	20	2	0	0	108
1970	8	29	4	30	99	32	31	59	7	0	0	228
1971	7	3		45	0	126	4	2	0	0	0	132
1971	7	28		45	3	263	18	10	0	0	0	294
1971	8	29		42	1	132	27	70	0	0	0	230
1972	7	14		15	12	19	1	5	7	0	0	44
1972	8	6		15	3	82	3	5	4	0	0	97
1972	8	31		15	0	17	3	7	0	0	0	27
1973	7	21		45	11	659	40	35	14	0	55	814
1987	6	5	5	40	10	56	2	3	0	0	4	75
1988	6	16	5	40	15	277	3	11	2	0	2	310
1988	7	14	5	40	7	35	3	39	2	0	3	89
1989	6	22	5	40	19	212	3	16	14	2	4	270
1990	6	11	1	40	6	650	1	1	0	0	8	666
1990	6	24	2	40	14	189	10	9	0	0	56	278
1991	6	27	5	40	21	41	1	19	0	0	31	113
1992	5	19	5	40	1	488	29	1	0	11	7	537
1992	6	6	3	40	2	292	12	1	0	6	19	332
1992	6	23	5	40	17	251	18	4	0	11	66	367
1992	7	11	5	40	22	199	34	16	0	9	231	511
1992	8	31	5	40	285	177	206	338	0	133	37	1176
1993	5	9	2	40	74	144	2	4	0	0	0	224
1993	6	19	2	40	48	77	0	22	0	0	0	147
1993	7	26	2	40	380	239	16	423	0	0	0	1058
1993	8	16	2	40	82	67	35	120	0	0	0	304
1993	9	9	2	40	17	26	82	109	0	0	0	234
1995	6	8	2	40	9	115	7	7	2	24	6	170
1995	6	17	2	40	5	124	6	7	3	20	10	175
1995	6	29	2	40	7	155	16	20	4	16	38	256
1995	7	7	2	40	15	205	25	56	7	44	68	420
1995	7	16	2	40	39	258	32	107	3	52	78	569
1995	9	5	2	40	356	224	537	498	18	108	43	1784
1996	6	17	2	40	33	69	4	19	11	20	59	215
1996	7	4	2	40	51	131	4	27	24	78	116	431
1996	7	12	2	40	286	258	10	97	34	215	152	1052
1996	7	29	2	40	108	96	10	62	34	13	176	499
1996	8	8	2	40	182	117	36	159	17	62	159	732

TABLE 7—cont.

Year	Month	Day	# Sites	Depth (m)	Categories							Total
					Calanoids	*Cyclops*	*Daphnia*	*Bosmina*	*Chydoris*	Nauplii	*Asplanchia*	
1997	5	26	2	40	2	187	2	6	2	30	1	230
1997	6	11	2	40	8	189	6	3	6	14	0	224
1997	8	15	2	40	145	42	234	195	1	83	40	739
1997	8	28	2	40	68	51	108	164	1	30	22	444
1998	6	23	2	40	16	128	4	8	108	21	1	286
1998	7	4	2	40	24	93	7	18	222	20	1	385
1998	7	14	2	40	41	65	8	12	212	19	1	358
1998	9	5	2	40	154	98	73	181	7	88	5	606
1999	6	8	2	40	10	135	7	6	0	19	3	180
1999	6	16	2	40	17	147	8	6	1	21	1	200
1999	6	24	2	40	55	95	25	20	0	29	2	226
1999	7	6	2	40	45	77	13	10	2	33	5	185
1999	9	6	2	40	97	37	20	30	3	26	1	214
2000	6	9	2	40	23	143	3	11	1	33	1	215
2000	6	18	2	40	27	123	4	22	1	20	2	199
2000	6	26	2	40	28	668	3	26	3	26	3	757
2000	7	05	2	40	42	109	2	37	5	17	2	214
2000	7	11	2	40	71	122	2	47	8	5	9	264
2000	9	05	2	40	170	79	22	193	13	41	54	572

TABLE 8. Sockeye fry emergence rates during June, 2000 (fry per m^2 per 30 days) on Chignik Lake beaches.

Year	South Hatchery north	Delta	Average
1986	26.3	12.8	19.6
87	40.3	25.1	32.7
88	43.5	40.4	42.0
89	2.9	15.8	9.4
90	6.2	12.3	9.3
91	13.4	2.7	8.1
92	5.0	6.3	5.7
93	2.6	2.1	2.4
94			n/a
95	7.5	20.3	13.9
96	70.4	2.9	36.7
97	31.4	19.4	25.4
98	5.1	6.4	5.8
99	5.2	7.4	6.3
00	19.0	4.4	11.7
1986-2000 Averages	21.2	13.9	17.6

Calculations based on Ruggerone et al. 1993,1994.
1998, 1999, and 2000 numbers could be underestimates as samplir occurred at later dates.

TABLE 9. Historical average tow net catches for Chignik Lake (10 min. tows), 1960-2000.

Date		No. of tows	Species						
			Sockeye salmon		Juvenile	Juvenile	Pond	Stickleback	
Mo	Year		Fry	Yearling	coho	chinook	smelt	3-spine	9-spine
6	60	15	6	33	0	0	0	0	1
7	60	42	5	25	0	0	0	1	3
8	60	9	74	83	0	0	0	1	9
9	60	1	6	12	0	0	0	0	0
7	61	14	1	136	0	0	0	1	12
8	61	65	308	286	0	0	0	13	50
9	61	1	278	103	0	0	1	6	10
7	62	17	46	648	1	0	0	2	12
8	62	80	55	238	0	0	0	32	14
9	62	11	14	58	0	0	3	121	6
6	63	4	66	76	2	1	1	2	11
7	63	22	28	147	1	0	1	5	26
8	63	44	56	87	0	0	4	26	15
9	63	13	230	171	0	0	16	39	16
7	64	13	5	28	0	0	0	2	7
8	64	38	61	83	0	0	1	10	15
9	64	15	251	79	0	0	0	30	15
7	65	14	65	152	1	2	0	1	15
8	65	27	91	410	0	0	4	3	24
7	66	6	60	319	1	1	1	1	3
8	66	16	419	144	0	0	0	1	3
9	66	15	137	34	0	0	0	4	5
6	67	11	145	74	0	1	0	0	4
7	67	18	1338	177	0	0	3	1	76
9	67	18	295	53	0	0	1	45	9
6	68	2	86	100	2	2	53	0	5
7	68	18	138	163	1	0	1	1	3
8	68	26	36	64	0	0	3	18	5
6	69	10	48	0	4	0	0	2	2
8	69	20	124	26	0	0	1	4	6
9	69	14	910	13	0	0	9	20	7
6	70	10	67	440	10	0	2	3	1
7	70	10	59	120	0	0	1	3	18
8	70	15	14	52	0	0	0	21	2
7	71	20	183	63	1	0	0	4	7
9	71	15	247	18	0	0	4	28	4
7	72	10	25	27	3	0	0	1	2
8	72	30	131	41	0	0	0	9	15
7	73	10	78	76	0	0	0	1	5
8	73	20	156	168	0	0	1	2	11
7	80	20	52	50	0	0	20	2	8
7	82	5	8	1	2	0	0	1	1
6	83	5	33	87	0	0	0	0	1
7	83	10	173	101	0	0	1	0	1
9	92	9	65	9	0	0	5	2	3
8	93	7	61	23	0	0	39	47	11
9	93	8	44	18	0	0	108	19	16
9	95	5	38	17	0	0	17	8	3
9	96	6	16	24	0	0	4	58	4
9	97	5	95	200	0	0	58	59	24
9	98	5	53	156	0	0	6	1618	12
9	99	5	13	9	0	0	90	27	5
6	00	3		* 116	0	0	0	134	26
7	00	3		* 38	1	0	0	54	3
9	00	5		* 347	0	0	198	14	2

* These numbers combine both the fry and yearlings.

TABLE 10. Historical average tow net catches for Black Lake (10 min. tows), 1960-2000.

Date		No. of	Species						
			Sockeye salmon		Juvenile	Juvenile	Pond	Stickleback	
Mo	Year	tows	Fry	Yearling	coho	chinook	smelt	3-spine	9-spine
6	60	12	5	1	0	0	9	18	2
7	60	8	11	0	0	0	0	19	2
7	61	10	2096	0	1	0	11	872	94
8	61	9	1057	0	0	0	113	3439	227
9	61	10	567	0	0	0	43	206	14
7	62	10	570	0	4	0	0	2387	136
8	62	65	279	0	0	0	45	697	52
6	63	4	369	0	1	0	198	188	5
7	63	14	182	3	1	0	90	61	27
8	63	22	304	3	2	0	229	267	55
7	64	28	313	3	1	0	12	121	16
8	64	8	385	5	1	0	65	824	27
9	64	13	221	4	1	0	258	588	64
7	65	10	1426	6	2	0	31	75	21
8	65	21	1001	2	0	0	36	396	36
8	66	22	585	2	1	0	56	64	13
6	67	21	1798	12	1	0	38	13	37
7	67	13	968	8	1	0	473	146	80
8	67	3	338	1	1	0	213	1139	373
9	67	5	294	1	0	0	117	250	109
7	68	15	614	1	2	0	51	100	24
8	68	13	60	1	1	0	170	394	91
9	68	7	102	1	0	0	62	197	74
6	69	1	772	0	6	0	172	2	2
7	69	6	1265	2	5	0	138	35	26
8	69	21	615	0	1	0	59	193	29
6	70	8	126	3	2	0	0	4	3
7	70	8	573	1	1	0	8	36	22
8	70	20	332	1	1	0	19	139	60
7	71	14	637	1	1	0	11	26	17
8	71	13	141	0	1	0	200	32	35
7	72	8	144	7	1	0	8	11	10
8	72	8	406	0	1	0	6	80	21
9	72	12	379	0	0	0	127	10	8
9	73	8	291	0	4	0	905	486	54
11	73	8	20	0	0	0	61	42	31
9	92	7	347	0	1	0	110	70	78
6	93	2	3260	0	0	0	148	10	30
7	93	1	478	0	0	0	13	0	0
8	93	9	143	0	11	0	729	910	1148
9	93	4	126	0	23	0	1914	565	269
6	95	6	28	4	0	0	19	4	2
9	95	5	176	1	0	0	49	15	12
9	96	3	82		(All other fishes released)				
9	97	3	80	0	3	0	173	217	64
9	98	5	303	0	15	0	92	219	128
9	99	4	114	0	23	0	208	95	126
6	00	3	73	0	0	0	0	0	0
7	00	4	30	0	0	0	1	0	0
9	00	4	1591	0	0	0	438	51	153

TABLE 11. Historical average beach seine catches for Chignik Lake, 1956-2000.

Date		No. of	Species								
			Sockeye salmon		Juvenile	Juvenile		Stickleback			Pygmy
Mo	Year	sets	< 45mm	> 45mm	coho	chinook	Char	3-spine	9-spine	Sculpin	whitefish
5	56	5	0	94							
7	56	4	53	65							
8	56	10	28	57							
5	57	3	0	167							
6	57	4	6	109							
7	57	6	11	92							
8	57	6	1	98							
5	59	4	5	81							
6	59	1	0	98							
6	61	1	4	309	120	0	0	248	0	0	90
7	61	2	1	149	20	0	0	70	0	0	52
8	61	4	17	283	19	0	3	441	140	1	54
9	61	3	16	216	0	0	0	86	7	3	35
6	62	2	0	0	0	0	22	291	5	0	29
7	62	5	0	0	4	0	39	114	4	1	83
8	62	3	7	208	26	0	3	30	2	59	4
9	62	2	1	527	19	0	3	20	0	4	1
6	63	4	27	81	35	0	2	18	6	1	2
7	63	4	3	81	3	0	2	1	2	1	0
8	63	4	8	114	0	0	0	124	0	0	0
9	63	3	8	291	0	0	0	61	0	0	0
6	64	9		49	2	0	2	22	3	5	32
7	64	10		83	7	0	15	69	5	13	2
8	64	9		264	26	24	26	667	72	2	95
6	65	4	138	162	3	2	2	27	2	4	7
7	65	10	74	27	29	6	14	12	1	4	9
8	65	2	51	227	16	5	3	546	50	4	28
6	67	4	13	155	97	97	66	23	8	8	3
6	68	4	24	3	2	0	0	42	1	6	27
6	69	4	22	4	11	22	23	7	23	20	3
6	70	4	23	41	1	0	0	3	0	1	32
7	70	5	0	0	8	0	25	45	17	22	22
8	70	7	0	0	25	0	64	55	0	3	10
6	71	10	408	36	7	0	3	112	27	6	3
7	71	5	1	6	8	0	2	53	4	15	4
6	72	6	87	380	3	0	1	9	6	13	4
7	72	6	19	3	58	0	36	92	25	29	18
6	80	5	47	0	2	0	7	16	1	28	0
7	80	12	52	9	3	1	2	22	1	16	1
5	85	10	113	189	103	2	6	3317	53	12	2
6	85	18	15	71	112	3	36	1031	136	18	28
7	85	17	9	217	30	4	104	399	28	11	6
8	85	6	20	183	9						
9	85	6	0	2	7	0	18	943	18	25	6
5	86	33	33	85	48	8	10	499	33	22	7
6	86	49	49	3	31	8	17	111	15	14	7
7	86	46	46	4	12	2	12	162	9	13	5
8	86	12	2	15	6	2	24	154	5	14	11

TABLE 11—cont.

Date Mo	Date Year	No. of sets	Sockeye salmon < 45mm	Sockeye salmon > 45mm	Juvenile coho	Juvenile chinook	Char	Stickleback 3-spine	Stickleback 9-spine	Sculpin	Pygmy whitefish
5	87	12	1048	714	136	7	25	639	54	13	19
6	87	54	6	230	113	9	65	260	6	13	15
7	87	58	16	51	17	0	8	44	5	14	3
6	92	15	10	15	13	0	7	123	22	13	2
7	92	6	9	2	20	2	23	192	16	7	7
5	93	6	1	173	57	0	13	224	7	9	41
6	93	6	1	20	6	0	15	24	0	8	13
6	95	21	27	9	11	1	13	244	26	18	8
7	95	21	16	13	13	1	10	49	6	17	6
6	96	7	12	121	39	1	15	117	3	22	<1
7	96	21	9	47	30	0	24	215	9	7	19
8	96	7	3	16	41	0	22	82	7	1	9
5	97	6	77	324	15	7	19	1367	24	61	0
6	97	6	5	125	7	0	6	14	3	6	2
6	98	11	140	436	104	43	58	4488	214	74	16
7	98	9	31	359	307	11	374	4106	219	79	17
6	99	18	36	28	55	9	77	527	16	8	2
6	00	12	33	17	13	0	17	317	7	10	9
7	00	6	32	6	4	0	1	110	3	1	1

TABLE. 12 Beach seine catches for Chignik Lagoon, 2000.

Location	Date	Species sockeye	Species 3 spine	Species 9-spine	Species char	Species coho
P. Rock (Upper Lagoon)	15-Jun	55	20	0	1	2
	24-Jun	400	50	0	20	60
	30-Jun	100	220	0	156	506
	10-Jul	300	60	0	25	20
Spit (Lower Lagoon)	15-Jun	65	15	0	200	1
	24-Jun	89	0	0	106	0
	1-Jul	116	6	0	10	0

TABLE 13. Stomach contents of juvenile sockeye, between June 14 and July 11, 2000.

Lake	Location	Length Ave	Length StDev	Stomach fullness Ave	Stomach fullness StDev	% volume Zooplankton Ave	Zooplankton StDev	Amphipods Ave	Amphipods StDev	Insects Ave	Insects StDev	Other Ave	Other StDev
Chignik Lagoon	P. Rock	80.1	11.9	56.8	25.7	9.5	8.5	7.7	13.8	30.9	34.5	51.9	30.6
	Spit	82.6	6.9	76.3	30.5	30.0	28.5	44.7	35.1	1.1	2.7	17.6	21.8
Chignik Lake	Clark Bay	70.0	3.3	51.8	38.4	59.3	34.1	0.0	0.0	1.0	3.1	33.0	31.0
	Delta	67.6	8.2	56.4	28.6	40.0	32.4	0.0	0.0	30.8	37.4	29.2	23.8
	Roos	71.8	5.3	41.8	25.5	35.0	20.7	0.0	0.0	20.8	16.9	44.2	20.8
Black Lake	Hydro	59.9	6.0	82.5	21.6	38.8	43.0	0.0	0.0	48.5	41.6	12.8	4.4

TABLE 14. Estimates of bank erosion along the upper reach of the south channel of Alec River, 1990-2000.

Stake	Location	Minimum distance from stake to river bank (m)										Present	Total	Change/
		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	condition	change (m)	year (m)
Wye Pt														
1	Wye Pt.			4.00	3.40	3.40	2.96	2.80	1.20	1.20		sunken	-2.80	-0.47
2				4.40	3.10	3.00	2.60	2.53	1.70	1.60	1.17	at river	-2.80	-0.47
3	(near S. channel)			3.25	3.00	3.00	2.20	1.78	0.80	0.80	n/a		-2.45	-0.41
					-0.72	-0.03	-0.55	-0.22	-1.14	-0.03	-0.33		-3.02	-0.45
Straight channel														
1	(rebar)	3.3	3.10	2.85	*2.53*	2.20	1.10	1.08	0.60	0.60	0.76	overhang	-2.70	-0.34
2	Discharge area		2.37	2.30	1.95	1.30	0.90	0.90	0.90	0.13	0.25	active	-2.24	-0.32
				-0.16	-0.34	-0.49	-0.75	-0.01	-0.24	-0.39	0.28		-2.10	-0.33
River bend														
1	upriver		8.30	7.65	7.60	5.40	5.32	5.32	5.35	5.35	5.35		-2.95	-0.42
2			10.30	9.95	*9.08*	8.20	7.80	7.80	7.10	6.65	6.65		-3.65	-0.52
3			10.30	9.75	9.70	9.70	9.50	9.45	8.90	8.60	8.60	overhang	-1.70	-0.24
4			15.10	13.95	13.70	13.40	13.40	12.15	12.15	12.15	12.15	steep slough	-2.95	-0.42
5			12.50	12.50	11.55	11.40	11.00	10.70	10.50	10.15	10.15	straight down	-2.35	-0.34
6			9.20	8.75	8.70	7.60	7.35	7.40	6.75	6.75	5.49	tree fell in	-2.45	-0.35
7	down river		6.70	6.60	*6.43*	6.25	5.90	5.80	6.10	3.50	5.79	beaver tunnel	-3.20	-0.46
				-0.46	-0.34	-0.69	-0.24	-0.24	-0.25	-0.53	2.32		-0.43	-0.39
Left bank Pt.														
1	Lt. bank Pt.	2.5	2.50	2.20	1.90	1.80	*1.70*	*1.40*	1.15	1.10	1.09		-1.41	-0.16
			0.00	*-0.30*	*-0.30*	*-0.10*	*-0.10*	*-0.30*	*-0.25*	*-0.05*	*-0.01*			

Appendix: Chignik Sockeye Salmon Forecast, 2001

Greg Ruggerone
March 8, 2001

Recap of 2000 Sockeye Run

The 2000 sockeye run of approximately 3.1 million sockeye salmon to the Chignik Lakes (including interception harvests and adjustments for weir out) was above the average of 2.78 million sockeye during 1978 to 1999. The above average run in 2000 followed the exceptional 1999 run (4.46 million or fourth largest run since 1922), and the relatively weak runs in 1997 and 1998 (1.6 to 1.9 million).

The 2000 run was characterized by a strong early sockeye run to Black Lake (approx. 2.1 million) and a slightly below average late run to Chignik Lake (approx. 0.96 million). The Black Lake run equaled the lower end of my forecast (2.1 to 2.7 million), and the Chignik Lake run was slightly smaller than my forecast (1.2 to 1.5 million; Table A-1). However, while describing the year 2000 forecast, I noted that the size of age-1.2 sockeye in 1999 was exceptional, indicating the possibility of early maturation of these fish and an overestimate of the year 2000 run size.

The large Black Lake run and small Chignik Lake run continues the inverse run size pattern that has been observed since 1970s. This relationship appears to be the result of juvenile Black Lake sockeye prematurely emigrating to Chignik Lake and adversely affecting Chignik Lake fish (Ruggerone 1999).

Approximately 91% of the 2000 sockeye run migrated to sea as smolts in 1997, the year of the El Nino event. Apparently, the warm summer waters in 1997 and factors leading to widespread mortality of seabirds did not have a significant effect on sockeye survival. The exceptional large size of Chignik sockeye (8.1 lbs per fish) was related, in part, to the very high percentage of sockeye spending three years in the ocean (91% compared to the mean of ~80-85%). However, the large size probably reflects rapid growth at sea as indicated by the exceptional size of siblings (age 1.2 sockeye) returning to Black Lake in 1999.

Documentation of conditions leading to the large return in 2000 is important:

- Parent spawning escapement to Black Lake (366,000 fish) and Chignik Lake (197,000 fish) were below average.
- Chignik and Black Lake smolts were abundant in 1997; age-1 (Black Lake) smolts were slightly below average in size, whereas age-2 (Chignik Lake) smolts were very large.
- Black Lake contained moderate oxygen and lake levels during winter 1997
- Fry emergence in Chignik Lake was moderate in 1995.

Sockeye Forecast for 2001

Black Lake Run:	0.8 to 1.0 million
Chignik Lake Run:	1.4 to 1.9 million
Total Run:	2.2 to 2.9 million

(values include Cape Igvak and southeastern mainland interceptions)

The Black Lake forecast was developed primarily from the below average return of age 1.2 sockeye in 2000, along with parent year escapement (slightly above average: 465,000 fish). I also considered 1998 winter conditions in Black Lake (moderate), age composition of sockeye sampled in Chignik Lake during winter and spring 1998 (mostly age 2.x sockeye), size of age-1 juveniles in the lakes during winter 1998 (average), and length of age-1.2 sockeye returning to Black lake in 2000 (average).

In addition to the traditional forecast model that incorporates siblings returning in 2000 and parent year spawning escapement, I developed a new model for 2001. This new multiple regression model incorporated the aforementioned variables along with mean precipitation in King Salmon/Dillingham during the winter when juveniles reared in Black Lake (y-3) and year. These variables were statistically significant ($n = 21$, $r^2 = 0.92$, partial $P < 0.02$, overall $P < 0.001$) and serial autocorrelation was low (-0.10). This model produced a Black Lake forecast of 600,000 fish, which was less than the traditional model.

This new model incorporates two variables that appear to have significance for Black Lake. The effect of the variable forecast year was negative, indicating that fewer sockeye have returned to Black Lake in recent years, other factors being equal. This effect is consistent with changes in Black Lake habitat that have been documented over the past 30 years (i.e., significant loss of water volume and changing course of lower Alec River; Ruggerone 1994, 1999). The winter rain variable is positively correlated with adult run size, indicating that years with greater winter rain while juveniles rear in Black and Chignik lakes leads to greater survival. Greater rainfall would lead to greater water volume and oxygen content in Black Lake during winter, which have been positively correlated with past run sizes to Black Lake. Although the statistical model provides interesting information about changes in Black Lake, I am somewhat hesitant to rely on a complex model for forecasting salmon run size.

The Chignik Lake run is somewhat more difficult to forecast because we do not have a relatively precise statistical model for this run. However, the Chignik Lake run also varies less from year to year compared with the Black Lake run. I developed the Chignik Lake forecast from the number of jacks in 1999 (moderate number), the projected run to Black lake in 2001 (below average), but I also considered the above average parent escapement (374,000 fish), age composition of juveniles during winter and spring 1998 (mostly age-2 or Chignik Lake fish), smolt abundance in 1998 (largest on record), size of age-2 smolts (very small due to high abundance), and fry emergence in Chignik Lake (second highest on record). The 2001 Chignik Lake forecast is above average.

ADFG forecasted a below average total run of 1.91 million sockeye salmon in 2001 (1.0 million to Black Lake, 0.91 million to Chignik Lake, including interception harvests). The Black Lake forecast is similar to my forecast; whereas the Chignik Lake forecast is lower.

APPENDIX TABLE A-1. Recent Chignik sockeye forecast history (values are millions of fish and they include interception harvests).

	Preseason Forecast		
	Ruggerone	ADFG	Actual
		1996	
Black Lake	1.7	1.4	2.1
Chignik Lake	1.1	1.6	1.1
		1997	
Black Lake	1.0	1.0	0.66
Chignik Lake	1.2	1.6	0.92
		1998	
Black Lake	1.1	0.9	0.72
Chignik Lake	1.3	1.1	1.24
		1999	
Black Lake	Greater than Chignik Lk[a]	1.0	2.49
Chignik Lake	Lower than Black Lk	1.3	1.97
		2000	
Black Lake	2.1 to 2.7	3.90	2.0 to 2.2[b]
Chignik Lake	1.2 to 1.5	1.09	0.93 to 1.0
		2001	
Black Lake	0.8 to 1.0	1.00	?
Chignik Lake	1.4 to 1.9	0.91	?

a: Ruggerone was not asked to make a forecast in 1999, but he provided trend information

b: lower value based on ADFG sonar counts, upper value includes potential under-counting of escapement; upper Chignik run includes fish after weir removed on Sept. 4