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D. ROGERS, B. ROGERS, J. MILLER, D. PETERSON AND G. RUGGERONE

ANNUAL REPORT—1995

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CHIGNIK REGIONAL AQUACULTURE ASSOCIATION
AND NATIONAL MARINE FISHERIES SERVICE

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CONTENTS

	Page
LIST OF FIGURES	iv
LIST OF TABLES.....	v
INTRODUCTION.....	1
BANK EROSION	2
LIMNOLOGY.....	2
METHODS.....	2
RESULTS.....	2
BENTHOS.....	4
METHODS.....	4
RESULTS.....	4
EMERGENT FRY.....	4
TOWNETTING.....	5
BEACH SEINING	5
REFERENCES.....	6

LIST OF FIGURES

Figure	Page
1. Black Lake sampling sites.....	9
2. Chignik Lake sampling sites.....	10
3. Zooplankton densities in Chignik and Black lakes in 1995	11
4. Total zooplankton and chlorophyll a densities for Chignik and Black lakes in 1995	12
5. Average tow net catches in Chignik Lake	13
6. Average townet catches in Black Lake.....	14

LIST OF TABLES

Table	Page
1. Limnological data from Black Lake in 1995	17
2. Limnological data from Chignik Lake in 1995	17
3. Averages of limnological data from Black Lake, 1990, 1992–93, and 1995	18
4. Averages of limnological data from Chignik Lake, 1988–1993, and 1995	19
5. Zooplankton densities in Black Lake in 1995.....	20
6. Zooplankton densities in Black Lake, 1992–93	20
7. Zooplankton densities in Chignik Lake in 1995.....	21
8. Averages of zooplankton densities for Chignik lake, 1968–73 and 1987–93	22
9. Densities of benthic organisms in Black Lake in 1995	23
10. Geometric means of the number of macroorganisms per 225 cm ² in Nushagak district lakes and in Black Lake.....	23
11. Sockeye fry emergence rates during June in Chignik Lake beaches	24
12. Average townet catches for Chignik Lake, 1960–73	25
13. Average townet catches for Black Lake, 1960–73	26
14. Average townet catches for Chignik and Black Lakes, 1980–95.....	27
15. Average beach seine catches for Chignik Lake, 1956–80.....	28
16. Average beach seine catches for Chignik Lakes, 1980–95.....	29

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KEY WORDS

beach seine, benthos, Black Lake, brood table, Chignik Lake, limnology, fry emergence, sockeye salmon, townet

INTRODUCTION

The purpose of this work is to annually measure (1) the relative abundance and size of juvenile sockeye salmon (*Onchorhynchus nerka*); (2) the relative abundance and size of potential competitor and predator species; (3) the biological and physical environment for sockeye in the lakes; and (4) the abundance, size, and age of seaward migrants, which is determined by the Alaska Department of Fish and Game (ADFG). 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.

The choice of measurements depends on the likely impact on sockeye salmon, cost of the measurement, and the availability of past data. An annual smolt program was undertaken by ADFG in 1993 while our main research effort was conducted in the lakes. Our 1995 field work began June 5 and continued to July 20. The crew then worked in Bristol Bay and returned to Chignik on September 3 for 7 days. Dr. Greg Ruggerone supervised the crew for the first 10 days of June and again in September.

The following work was done:

1. Water temperature and lake level recorders were set during September 1994. However, the gauges were lost during the winter and could not be found in the spring.
2. Bank erosion of the south channel of the Alec River was measured in June and September to monitor the changes in the channel.
3. Water transparency (Secchi depth), and phytoplankton (chlorophyll a) and zooplankton densities were measured on 3 dates in June, 2 dates in July and on September 5 to assess the summer standing crop of primary producers and zooplankton (the main source of food for sockeye salmon in Chignik Lake).
4. Bottom samples with an Eckman dredge (225 cm²) were collected from four sites in Black Lake. Counts were analyzed to establish an annual sampling plan for future years to assess the abundance of chironomids (midges)—the primary source of food for sockeye salmon in Black Lake.
5. Emergent fry traps were employed along Hatchery and Delta beaches. The traps were set in early June and checked about every 5 days until July 15, as in past years, to assess the relative abundance and timing of emergent sockeye fry.
6. Beaches were seined weekly at eight established stations. Catches or subsamples were preserved for enumeration and length measurements.
7. Black Lake was townnetted in early June and then in both Black and Chignik Lakes during early September. A new townet was employed that was 1.2 m deep and 2.7 m wide (the same area as our old net of 1.8 m x 1.8 m) to provide for more towing areas in Black Lake. Fishing methods were otherwise the same as past years and the catches were counted and the fish aged and length measured.
8. Brood tables were assembled for both the inshore returns to the Chignik Lakes (catch and escapement) and the estimated returns including sockeye salmon caught in interception

fisheries. The relative productivity of the Chignik stocks was then evaluated and compared with sockeye salmon stocks in the central and western regions (Rogers 1995).

This report presents statistics from limnological and benthic sampling and catch statistics from emergent fry traps, tow netting, and beach seining. Statistics on fish lengths will be summarized in a later report.

BANK EROSION

About 0.3 m (1.3 ft) to 0.6 m (2 ft) on the right bank of the south channel of lower Alek River is lost per year. Between fall 1994 and spring 1995, the loss was greater, ranging from 0.75 (2.5 ft) to 1.89 m (6.2 ft) depending on the location. In addition, ~0.7 m (2.3 ft) of the left bank at the river was lost last year compared with a 4-year average of 0.18 m (0.6 ft) (Ruggerone 1995).

LIMNOLOGY

METHODS

Water temperature, water transparency, phytoplankton, and zooplankton samples were collected four times (three stations, Fig. 1) on Black Lake and six times (two stations, Fig. 2) on Chignik Lake (June 9, June 20, July 11 and September 5; June 8, June 17, June 29, July 7, July 17 and September 5). 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 with a van Dorn bottle at Chignik Lake. Water samples were taken immediately below the surface for Black Lake, which is shallow and well mixed, and at 1, 5, 10 and 20 m below the surface in Chignik Lake using a van Dorn water sampler. The water was filtered through Millipore filters; 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 according to methods described by Vollenweider and Talling (1969). Filters from September 5 were lost. Zooplankton samples were taken with a 153- μ m mesh, .5-m diameter net. In shallow Black Lake, these samples were collected by hauling the net for 20 m horizontally through the water. Samples were collected in Chignik Lake by hauling the net 40 m vertically through the water.

RESULTS

Black Lake is shallow and turbid; Secchi readings are not very deep. Near the middle of the lake (Hydro Point), they averaged 1.7 m during 1995. The Alec Bay site was even less transparent with Secchi depths averaging 1.3 m, and the outlet site averaging 1.4 m (Table 1). Chignik Lake, which is deeper and not as well mixed, had deeper Secchi readings. The Clark Bay site registered 2.6 m

during the summer and the Delta site 1.7 m (Table 2). The Delta site was more turbid because of the influence of the Black River.

Surface temperatures were taken from Black Lake whereas a depth profile was taken in Chignik Lake (down to 20 m). An average surface temperature of 11.17°C was recorded on June 9 in Black Lake and an average temperature at 1 m of 7.65°C at Chignik Lake. Black Lake warms rapidly in the spring because of its shallow depth. By mid-July, however, the two lakes were similar, with surface and 1-m temperatures of 12.3°C (Black Lake) and 11.1°C (Chignik Lake).

Chlorophyll *a* at the Hydro and Outlet (Black Lake) sites was high in the spring (4.49 and 5.12 mg/m³), tapering to 1.83 and .91 mg/m³ in July. Alec Bay was the least productive site with 1.39 mg/m³ in early June and 1.72 mg/m³ in the fall (Table 1).

Clark Bay and Delta (Chignik Lake) sites had comparable chlorophyll *a* densities except on July 17 when there was a phytoplankton bloom at the Delta station (Table 2). Average chlorophyll *a* densities started out high on June 8 (4.89 mg/m³) and decreased with time, until July 17, when densities increased (2.91 mg/m³) because of the bloom at the Delta station.

Secchi depths for Black Lake have been shallow for the 4 years included in Table 3 (1990, 92, 93 and 95), averaging 0.7 to 1.75 m below the surface. Chignik Lake ranged from .55 to 2.70 m (Table 4). However, the shallowest measurements were in 1993 when phytoplankton began to bloom early and there were several large storms with their attendant heavy sediment loads.

Total zooplankton densities increased greatly in Chignik Lake at the end of the summer in both the Clark Bay and Delta sites (Fig. 3). Associated with this were rather low fry abundances in tow net sampling. Zooplankton also increased to a lesser extent at Hydro Point in Black Lake. Chignik Lake produced far more zooplankton than Black Lake: the Alec Bay and Outlet sites produced especially low densities of zooplankton.

Because the September 5 chlorophyll *a* samples were lost, we do not know if the high levels of zooplankton in Chignik Lake produced a major cropping effect on the phytoplankton. Such an effect could be expected in September to a lesser extent on the Black Lake phytoplankton (Fig. 4).

Zooplankton abundances in 1995 for Black Lake are given in Table 5. No *Daphnia* were caught in the lake, but *Bosmina*, another cladoceran, were caught in larger numbers during September at Hydro Point than at the Alec Bay and Outlet stations. Average catches of *Bosmina* during 1993 were much higher (80,600/m²) compared with 8,900/m² in 1995. There was an especially large average catch of *Bosmina* on August 14, 1993, of 226,600/m² (Table 6). Other species remained low in abundance.

In Chignik Lake, calanoid copepods, *Daphnia*, and *Bosmina* all “bloomed” towards the end of summer 1995 whereas the density of cyclopoid copepods remained fairly constant throughout the summer (Table 7). Overall means for 1995 compared with those from 1992 and 1993 were very similar except there were more *Daphnia* overall in 1995 (104,000/m² vs. 59,800/m² and 27,000/m², respectively).

In the historic zooplankton catch data for Chignik Lake, cyclopoids usually outnumbered the other types of zooplankters, especially early in the summer (Table 8). During 1992, there were large

numbers of cyclopoids in the spring (488,000/m²), tapering towards the end of the summer (177,000/m²) and a concurrent bloom of calanoids, *Daphnia*, and *Bosmina*. This pattern was not repeated in 1993. In some years such as 1968, 1970, and 1972, zooplankton was not abundant at all. In earlier years, numbers of zooplankters would probably have been reduced because of the larger mesh net (247 μ m vs. 153 μ m) that was used; however, that does not account for differences in the large body of zooplankters.

BENTHOS

METHODS

Benthic sampling was new to the project this year and was done on June 9 and 20 and July 11. Samples were collected from four sites on Black Lake (Fig. 1) with an Eckman dredge that had a 225 cm² opening. Contents were sieved through a bucket with a 30-mesh wire (516- μ m openings) in the bottom. After sieving, each sample was preserved in 10% formalin. Samples were sorted in the lab, and larger samples were divided by one-half or one-quarter for counting. After analysis, the samples were stored for future reference.

RESULTS

The greatest number of oligochaetes and chironomid (midge) larvae were taken at the old FRI site (219 and 24/225 cm² grab). By comparison, the Hydro Point, Alec Bay, and Outlet stations produced very little except the Outlet station did yield ~120 oligochaetes/grab. Surprisingly enough, insect densities were not very high considering the high densities of midges often seen over the lake (Table 9).

Grab samples taken in Bristol Bay in 1965 were compared by lake system with those taken in Black Lake in 1995 (Table 10) for comparable depths. Black Lake and the Igushik Lakes were similar in chironomid densities and were at the low end of the scale. Tikchik Lake (3 m) had a very high chironomid count, but that was for one sample only.

EMERGENT FRY

Numbers of emergent fry have been estimated on two beach spawning areas of Chignik Lake since 1986. There was no field work in 1994, but our sampling resumed in 1995 on the Hatchery and Delta beaches. The averages for stations during 1986-90 were used to estimate emergence rates for South Hatchery South and the North Hatchery locations since 1991 (Table 11). The average emergence rate for 1995 was higher than in the previous 5 years of sampling but still down from the initial 3 years.

TOWNETTING

Townet hauls were made annually in the Chignik Lakes from 1960 to 1973 (Tables 12 and 13). Although tows were sometimes made at various lengths of time, all catches have been standardized to 10 min (Parr 1972). Arithmetic and geometric means have been calculated in the past; however, arithmetic means are presented here. Since 1973, townetting has been sporadic; however, we did tow in both lakes in September 1995 (Table 14). Catches of juvenile sockeye salmon were small in 1995, as has been the case in recent years although large catches of other species were made in 1993 (Figs. 5 and 6).

BEACH SEINING

Beach seining was conducted in Chignik Lake in several years prior to 1973 (Table 15). Catches of juvenile sockeye salmon were usually recorded as larger or smaller than 45 mm. The small fish were likely to be fry (age 0) whereas the larger fish were likely a mixture of small yearlings from Chignik Lake and large fry from Black Lake. Beach seining has been done intermittently since 1980 in Chignik Lake but only in 3 years in Black Lake (Table 16). Coho salmon juveniles are usually more abundant in beach seine catches than in townet catches, which reflects their preference for the nearshore habitat (Ruggerone 1989). Catches of juvenile sockeye salmon were generally low in 1995, whereas beach seine catches of the other common species were somewhat typical of catches made in past years.

REFERENCES

- Parr, W. H. Jr. 1972. Interactions between sockeye salmon and lake resident fish in the Chignik Lakes, Alaska. M.S. Thesis. Univ. Washington. Seattle. 103 p.
- Rogers, D.E. 1975. Alaska salmon studies. The study of red salmon in the Nushagak District. Periodic Report No.3 to NOAA. Univ. Washington, Fish. Res. Inst.. Seattle. 21 p.
- Rogers, D.E. 1995. Recent variation in the catches of Chignik sockeye salmon. Univ. Washington, Fisheries Research Institute, FRI-UW-9509. 14 p.
- Ruggerone, G.T. 1989. Coho salmon predation on juvenile sockeye salmon in the Chignik Lakes, Alaska. Ph.D. Dissertation. Univ. Washington, Seattle. 151 p.
- Ruggerone, G.T., C. Harvey, J. Bumgarner and D.E. Rogers. 1992. Investigations of salmon populations, hydrology and limnology of the Chignik Lakes, Alaska. Univ. Washington, Fish. Res. Inst., FRI-UW-9211.
- Ruggerone, G.T., C. Harvey, J. Bumgarner and D.E. Rogers. 1993. Chignik salmon studies. Investigations of salmon populations, hydrology and limnology of the Chignik Lakes, Alaska, during 1992. Univ. Washington, Fish. Res. Inst., FRI-UW-9302. Seattle. 70 p.
- Ruggerone, G.T. 1994. Investigations of salmon populations, hydrology and limnology of the Chignik Lakes, Alaska, during 1993. Prepared for the Chignik Regional Aquaculture Association by Natural Resources Consultants, Seattle. 129 p.
- Ruggerone, G.T. 1995. Winter investigations of salmon in the Chignik Lakes, Alaska, 1995. Prepared for the Chignik Regional Aquaculture Association by Natural Resources Consultants, Seattle.
- Vollenweider, R.A. and J.F Talling. 1969. Photosynthetic pigments. Pages 21-25 *in* R.A. Vollenweider (ed.), A Manual on Methods for Measuring Primary Production in Aquatic Environments. Intern. Biol. Program. Handbook No. 12. F.A. Davis Co., Philadelphia, PA.

FIGURES

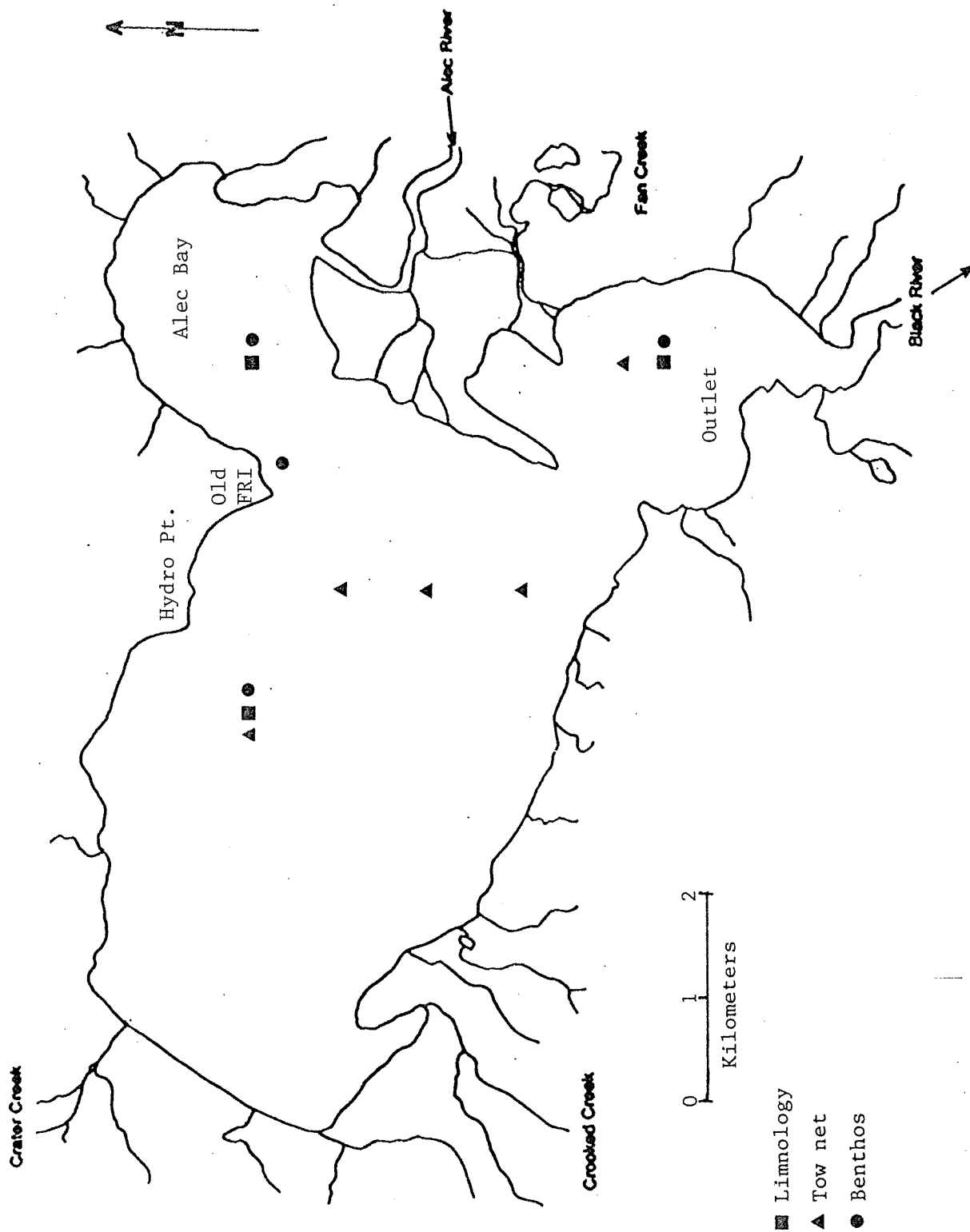


Figure 1. Black Lake sampling sites.

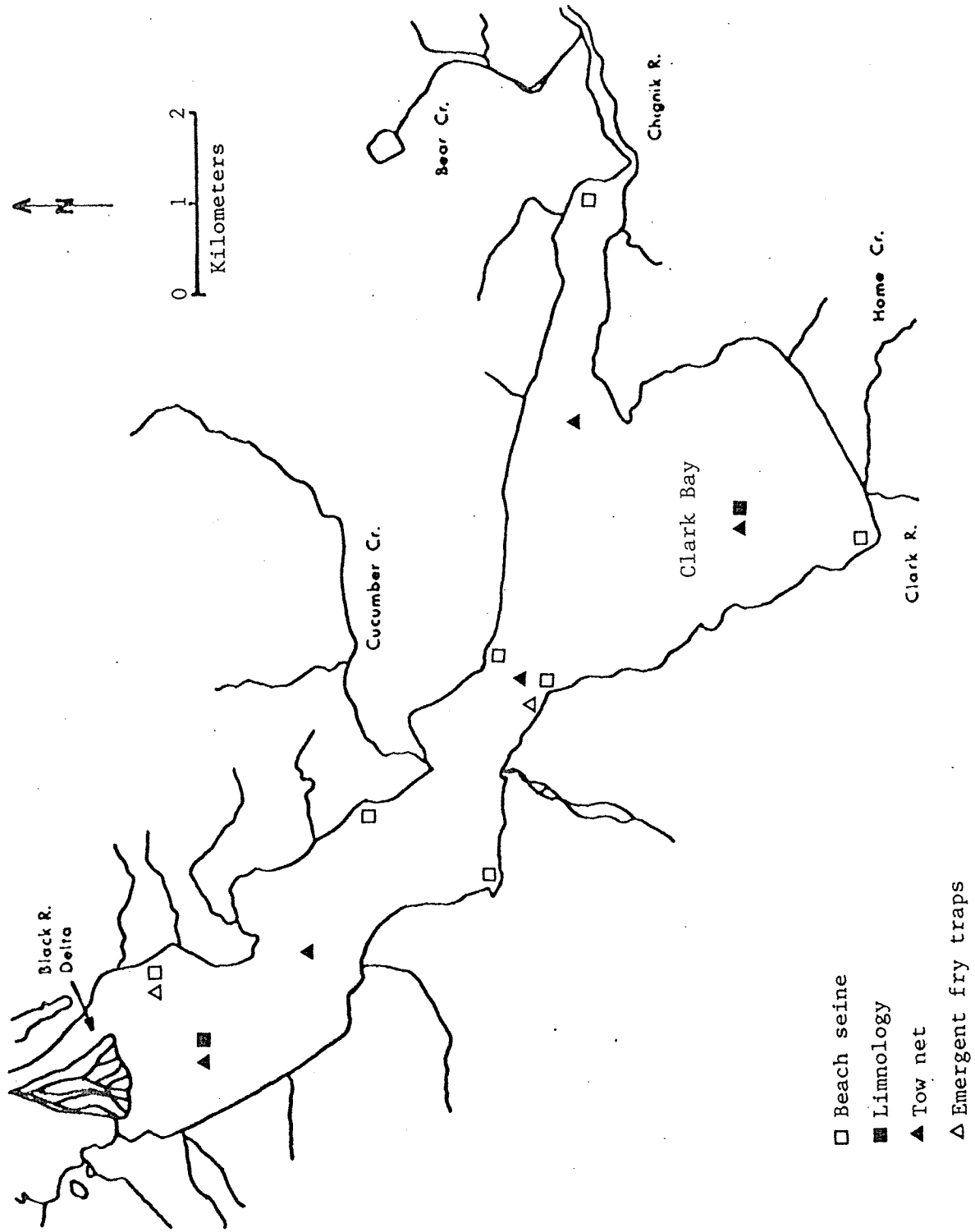


Figure 2. Chignik Lake sampling sites.

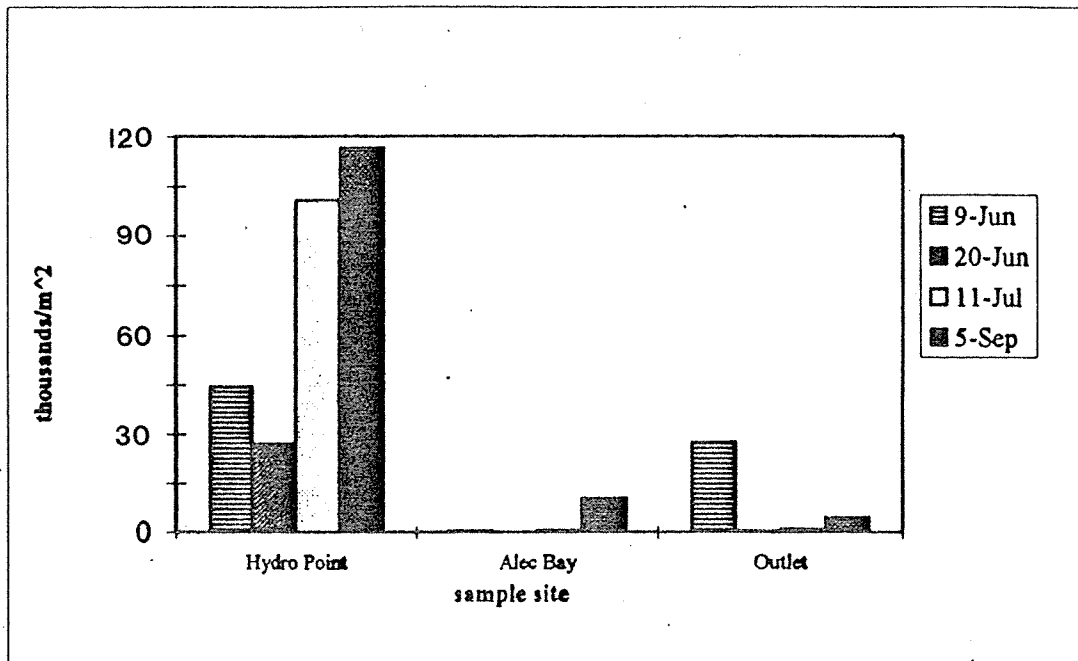
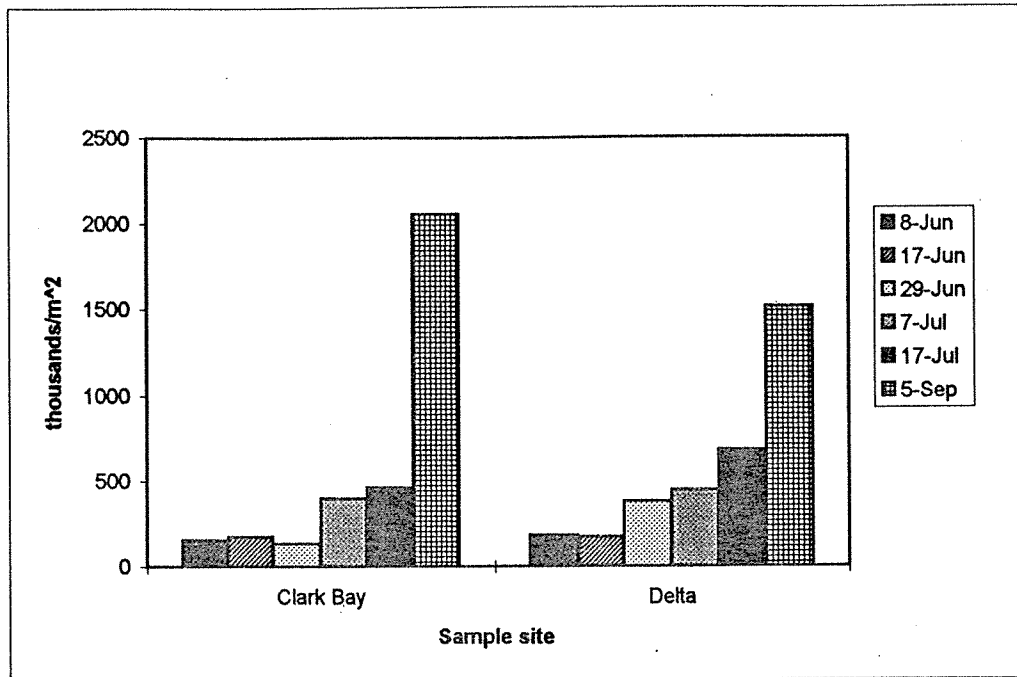


Figure 3. Zooplankton densities in Chignik (top) and Black (bottom) lakes in 1995.

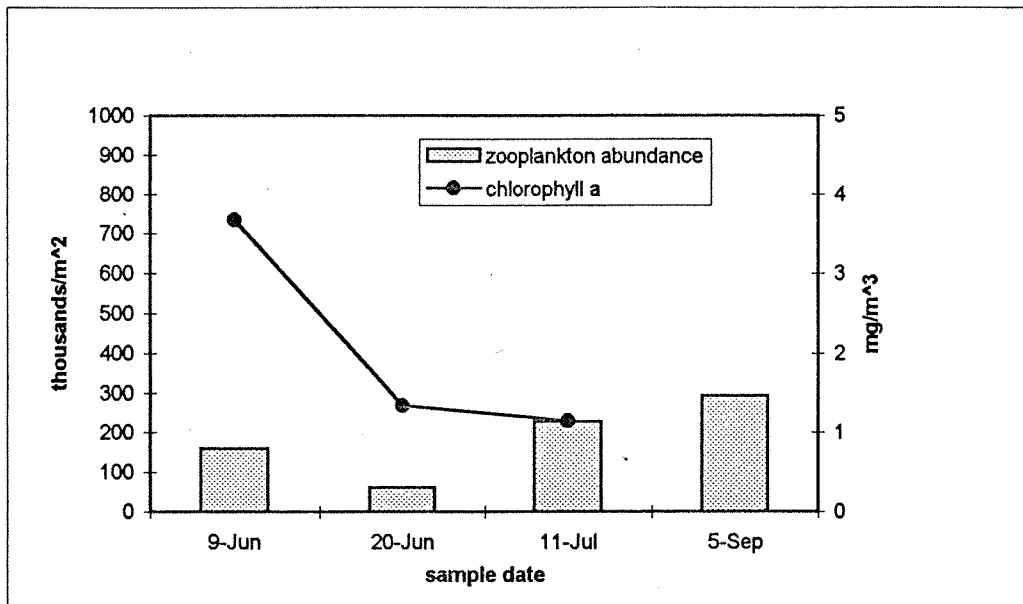
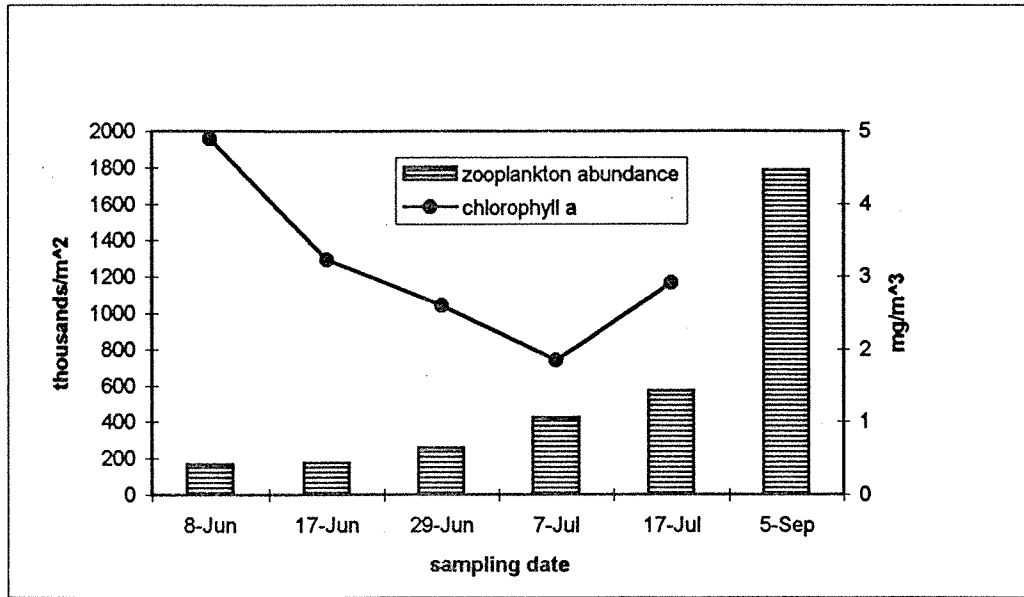


Figure 4. Total zooplankton and chlorophyll a densities for Chignik (top) and Black (bottom) lakes in 1995.

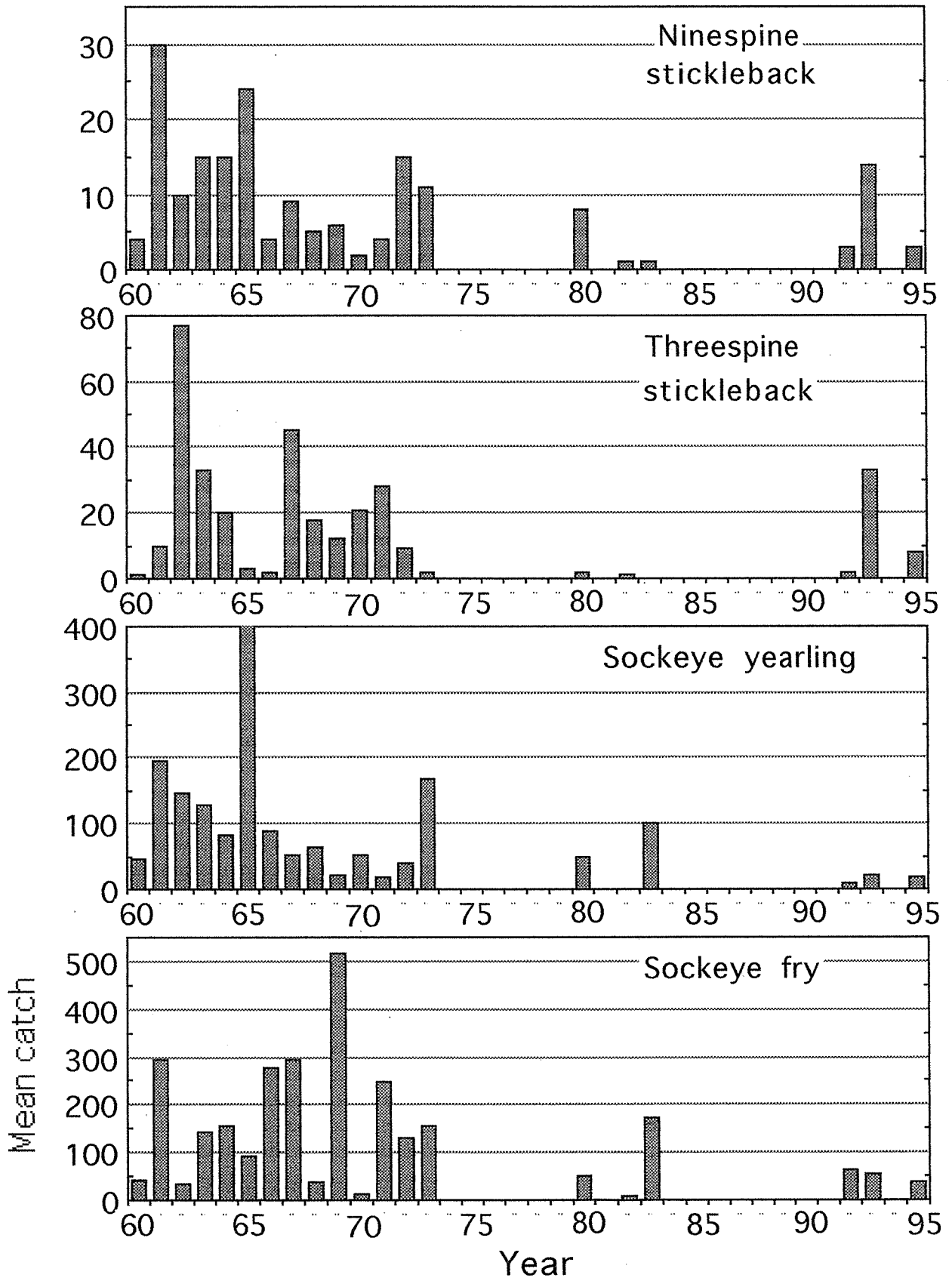


Figure 5. Average tow net catches in Chignik Lake.

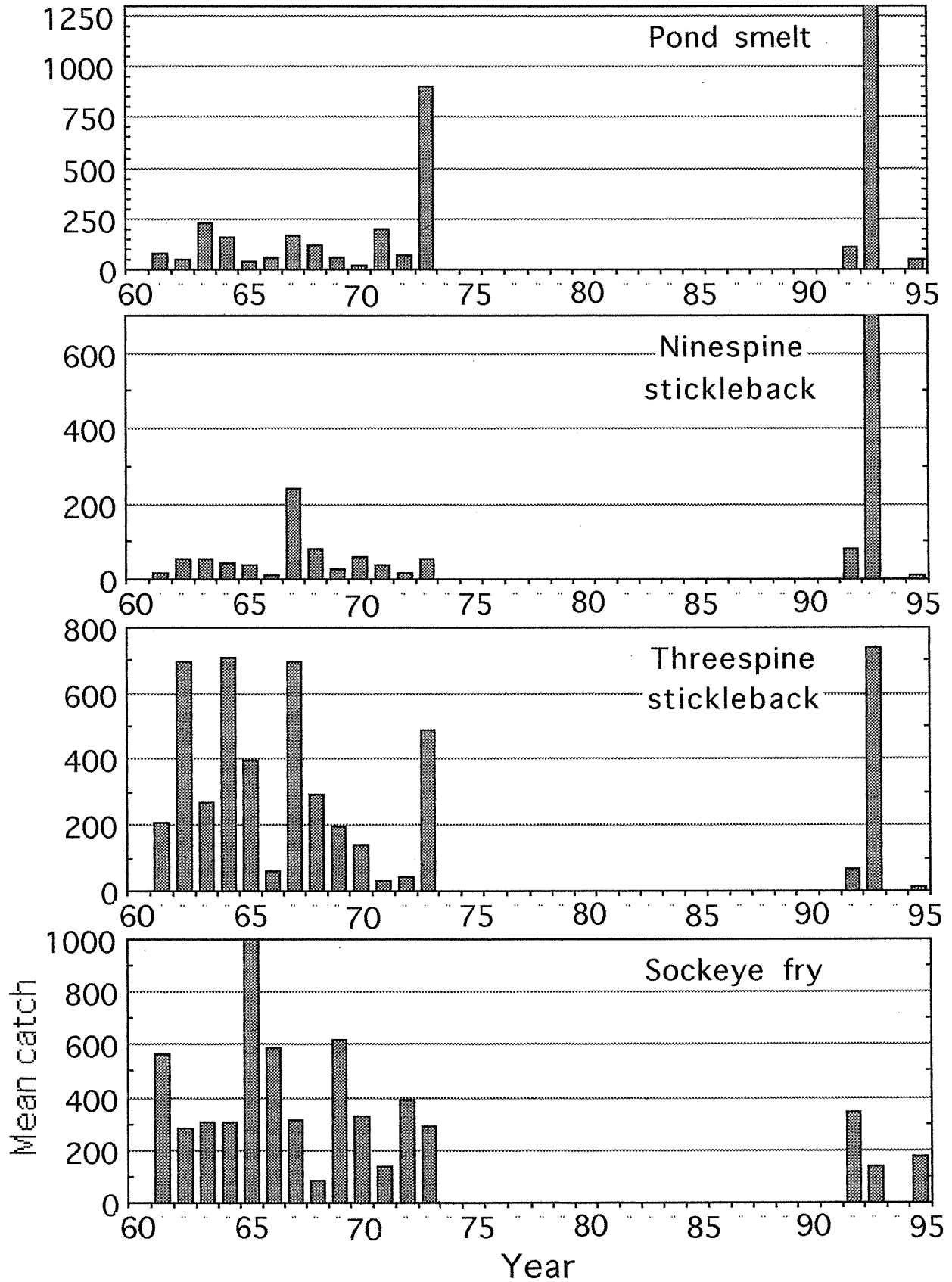


Figure 6. Average townet catches in Black Lake.

TABLES

Table 1. Limnological data from Black Lake in 1995.

Date	Location	Secchi depth (m)	Surface temp. (°C)	Chlorophyll a mg/m ³
9-Jun	Hydro Pt.	1.8	12.0	4.49
	Alec Bay	1.2	10.5	1.39
	Outlet	1.2	11.0	5.12
20-Jun	Hydro Pt.	1.7	12.0	1.67
	Alec Bay	1.1	10.5	0.58
	Outlet	1.5	9.5	1.77
11-Jul	Hydro Pt.	1.7	13.5	1.83
	Alec Bay	1.5	11.5	0.72
	Outlet	1.4	12.0	0.91
9-Jun	Average	1.4	11.2	3.67
30-Jun	Average	1.4	10.7	1.34
11-Jul	Average	1.5	12.3	1.15
1995 means		1.4	11.4	2.05

Table 2. Limnological data from Chignik Lake in 1995.

Date	Clark Bay				Delta			
	Secchi depth (m)	Depth (m)	Water temp. (°C)	Chlorophyll a mg/m ³	Secchi depth (m)	Depth (m)	Water temp. (°C)	Chlorophyll a mg/m ³
8-Jun	2.2	1	6.8	5.50	1.2	1	8.5	4.46
		5	6.8	5.64		5	8.5	4.56
		10	6.5	5.85		10	8.5	3.92
		20	6.5	4.54		20	8.0	4.64
17-Jun	1.5	1	10.0	3.10	1.8	1	9.0	3.48
		5	10.0	3.15		5	9.0	2.76
		10	9.0	3.26		10	8.5	n/a
		20	9.0	3.45		20	8.5	3.39
29-Jun	3.0	1	9.0	2.85	2.0	1	9.5	2.33
		5	8.5	3.16		5	9.5	2.39
		10	8.5	3.13		10	9.5	2.30
		20	8.5	2.61		20	9.5	2.09
7-Jul	3.2	1	10.5	1.71	1.5	1	11.0	1.58
		5	10.0	1.86		5	10.5	2.25
		10	10.0	1.82		10	10.0	1.86
		20	9.5	1.83		20	9.5	1.88
17-Jul	3.2	1	12.5	1.27	2.2	1	11.5	4.84
		5	11.0	4.22		5	11.5	5.40
		10	10.5	1.49		10	11.0	4.49
		20	10.0	0.59		20	10.5	0.99

Table 3. Averages of limnological data from Black Lake, 1990, 1992–93, and 1995.

Date			Secchi depth (m)	Water temp. (°C)	Chloro- phyll a mg/m ³
Mo	Day	Year			
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

Source: Ruggerone et al. (1993) and Ruggerone (1994).

Sampling site in 1990 was north end of lake; 1992 was north end plus Alec Bay and outlet; 1993 and 1995 were Hydro Pt., Alec Ba and outlet.

Table 4. Averages of limnological data from Chignik Lake, 1988–1993, and 1995.

Date			Secchi depth (m)	Averages over 1-20 m	
Mo	Day	Year		Temperature (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

Sources prior to 1995: Ruggerone et al. (1992, 1993), and Ruggerone (1994).

Table 5. Zooplankton densities (1,000 m⁻²) in Black Lake in 1995.

Location	Date		Category							Total
	Mo	Day	Calanoids	Cyclops	Daphnia	Bosmina	Chydoris	Nauplii	Asplanchna	
Alec Bay	6	9	0.0	0.2	0.0	0.2	0.0	0.0	0.0	0.4
	6	20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	7	11	0.2	0.2	0.0	0.2	0.0	0.0	0.2	0.8
	9	5	1.2	0.8	0.0	4.2	0.7	1.8	1.4	10.1
Hydro Point	6	9	1.6	24.2	0.0	2.6	3.1	11.6	0.9	44.0
	6	20	1.5	16.2	0.0	6.9	0.0	2.1	0.2	26.9
	7	11	4.2	35.1	0.0	23.7	7.2	5.1	25.4	100.7
	9	5	6.4	16.2	0.0	63.6	15.4	5.8	8.6	116.0
Outlet	6	9	0.9	18.8	0.0	1.5	1.2	3.0	2.1	27.5
	6	20	0.0	0.2	0.0	0.3	0.0	0.0	0.0	0.5
	7	11	0.0	0.2	0.0	0.2	0.0	0.0	0.6	1.0
	9	5	0.0	0.6	0.0	3.3	0.3	0.0	0.3	4.5
Combined average	6	9	0.9	14.4	0.0	1.4	1.4	4.8	1.0	23.9
	6	20	0.4	5.4	0.0	2.4	0.0	0.8	0.0	9.0
	7	11	1.5	11.8	0.0	8.0	2.4	1.6	8.7	34.0
	9	5	2.6	5.8	0.0	23.7	5.6	2.6	3.4	43.7
1995 averages			1.4	9.4	0.0	8.9	2.4	2.5	3.3	27.7

Averages of two 20-m horizontal hauls with a .5-m net of 153 μ m mesh and based on a bottom depth of 3 m.

Table 6. Zooplankton densities (1,000 m⁻²) in Black Lake, 1992–93.

Mo	Date		Category							Total
	Day	Year	Calanoids	Cyclops	Daphnia	Bosmina	Chydoris	Nauplii	Asplanchna	
6	20	92	5.6	37.4	0.0	5.2	0.3	13.4	3.2	65.1
5	17	93	0.9	0.9	0.0	3.2	0.0	0.0	0.0	5.0
6	15	93	13.4	0.8	0.0	20.8	0.0	0.0	0.0	35.0
7	15	93	0.8	0.8	0.0	3.4	0.0	0.0	0.0	5.0
8	14	93	8.7	18.9	0.0	226.6	0.0	0.0	0.0	254.2
9	8	93	5.8	5.8	0.0	148.9	0.0	0.0	0.0	160.5
1993 averages			5.9	5.4	0.0	80.6	0.0	0.0	0.0	91.9

From 20-m horizontal hauls, three hauls per date and a bottom depth of 3 m.

Table 7. Zooplankton densities (1,000 m⁻²) in Chignik Lake in 1995.

Location	Date		Category							Total
	Mo	Day	Calanoids	Cyclops	Daphnia	Bosmina	Chydoris	Nauplii	Asplanchna	
Clark Bay	6	8	8	115	9	4	2	10	8	156
	6	17	7	114	9	11	2	21	13	177
	6	29	3	91	8	7	3	4	18	134
	7	7	7	195	21	43	6	40	85	397
	7	16	28	180	18	57	5	32	140	460
	9	5	401	246	567	653	14	139	37	2057
Delta	6	8	9	115	5	9	2	38	5	183
	6	17	3	134	3	3	4	20	8	175
	6	29	11	219	25	33	4	28	58	378
	7	7	23	216	30	70	8	47	52	446
	7	16	51	336	46	157	1	72	15	678
	9	5	311	202	507	343	23	76	50	1512
Combined average	6	8	9	115	7	7	2	24	6	170
	6	17	5	124	6	7	3	20	10	175
	6	29	7	155	16	20	4	16	38	256
	7	7	15	205	25	56	7	44	68	420
	7	16	39	258	32	107	3	52	78	569
	9	5	356	224	537	498	18	108	43	1784
1995 means			72	180	104	116	6	44	41	562

From 40-m vertical hauls with a .5-m net of 153- μ m mesh, two hauls per date and station.

Table 8. Averages of zooplankton densities (1,000 m⁻²) for Chignik lake, 1968–73 and 1987–93.

Date			No. of sites	Haul depth (m)	Category							Total
Mo	Day	Year			Calanoids	Cyclops	Daphnia	Bosmina	Chydoris	Nauplii	Asplanchna	
6	25	68	5	30	12	25	1	2	3	0	0	43
7	20	68	5	30	15	11	3	11	8	0	0	48
8	4	68	5	30	41	32	13	51	7	0	0	144
8	29	68	5	30	98	24	110	67	5	0	0	304
6	29	69	5	44	5	364	4	7	2	0	0	382
7	27	69	5	47	13	329	11	22	2	0	0	377
8	15	69	5	42	26	161	34	45	3	0	0	269
8	30	69	5	44	33	28	42	51	2	0	0	156
6	28	70	4	30	24	83	5	3	1	0	0	116
7	27	70	4	30	39	37	10	20	2	0	0	108
8	29	70	4	30	99	32	31	59	7	0	0	228
7	3	71	n/a	45	0	126	4	2	0	0	0	132
7	28	71	n/a	45	3	263	18	10	0	0	0	294
8	29	71	n/a	42	1	132	27	70	0	0	0	230
7	14	72	n/a	15	12	19	1	5	7	0	0	44
8	6	72	n/a	15	3	82	3	5	4	0	0	97
8	31	72	n/a	15	0	17	3	7	0	0	0	27
7	21	73	n/a	45	11	659	40	35	14	0	55	814
6	5	87	5	40	10	56	2	3	0	0	4	75
6	16	88	5	40	15	277	3	11	2	0	2	310
7	14	88	5	40	7	35	3	39	2	0	3	89
6	22	89	5	40	19	212	3	16	14	2	4	270
6	11	90	1	40	6	650	1	1	0	0	8	666
6	24	90	2	40	14	189	10	9	0	0	56	278
6	27	91	5	40	21	41	1	19	0	0	31	113
5	19	92	5	40	1	488	29	1	0	11	7	537
6	6	92	3	40	2	292	12	1	0	6	19	332
6	23	92	5	40	17	251	18	4	0	11	66	367
7	11	92	5	40	22	199	34	16	0	9	231	511
8	31	92	5	40	285	177	206	338	0	133	37	1176
5	9	93	2	40	74	144	2	4	0	0	0	224
6	19	93	2	40	48	77	0	22	0	0	0	147
7	26	93	2	40	380	239	16	423	0	0	0	1058
8	16	93	2	40	82	67	35	120	0	0	0	304
9	9	93	2	40	17	26	82	109	0	0	0	234

Mesh size from 1968-1991 was 247 μm and since 1992 it has been 153 μm .

Table 9. Densities of benthic organisms (no./225 cm²) in Black Lake in 1995.

Location	Date		Bottom depth (m)	Number of organisms per 225 cm ²							Total
	Mo	Day		Oligochaetes	Chironomids	Gastropods	Pelycepods	Ostracods	Amphipods	Leaches	
Hydro Pt.	6	9	2.7	0	2	0	6	12	0	0	20
	6	20	2.8	8	15	0	1	3	0	0	27
	7	11	2.6	12	32	4	52	0	0	0	100
	6	9	3.7	5	5	1	1	1	0	0	13
	6	20	3.7	7	22	1	6	0	0	0	36
	7	11	3.8	4	0	0	2	0	0	0	6
	6	9	3.7	5	5	1	1	1	0	0	13
Alec Bay	6	9	1.9	20	1	7	8	0	3	0	39
	6	20	2.0	85	7	9	5	3	0	0	109
	7	11	2.0	34	2	21	8	0	0	0	65
	6	9	3.5	37	6	1	2	5	0	0	51
Old FRI	6	9	2.5	356	28	4	12	0	0	8	408
	6	20	2.7	108	32	0	24	8	0	0	172
	7	11	2.8	272	16	0	12	0	0	4	
Outlet	6	9	1.9	190	5	0	21	11	0	0	227
	6	20	1.5	145	2	2	9	10	0	0	168
	7	11	1.4	63	3	1	2	7	0	4	80
Geometric means				30.2	6.1	1.2	5.6	1.7	0.0	0.3	
Arithmetic means				70.6	8.5	2.5	7.0	3.1	0.1	0.5	

Table 10. Geometric means of the number of macroorganisms per 225 cm² in Nushagak district lakes (1965) and in Black Lake (1995).

Lake system	Bottom depth (m)	Number of grabs	Oligochaetes	Chironomids	Gastropods	Pelycepods	Total
Wood River	5	29	10.0	20.0	1.6	1.9	33.5
Snake River	3	2	54.7	52.5	49.8	10.7	167.7
	5	6	12.8	16.6	0.6	1.6	31.6
Igushik	6	5	1.4	5.6	0.2	0.4	7.6
Tikchik	3	1	21.5	248.6	31.8	12.0	313.9
	5	27	10.2	13.8	7.0	5.2	36.2
Black Lake	1 to 3	12	46.7	6.5	1.8	8.4	63.4
	3 to 5	4	8.5	4.3	0.9	2.2	15.9

Source: Rogers (1975)

Table 11. Sockeye fry emergence rates during June in Chignik Lake beaches.

Year	South hatchery south	South hatchery north	North hatchery	Delta	Average	Area weighted averages
1986	6.3	26.3	17.5	12.8	15.7	18.0
87	9.5	40.3	28.3	25.1	25.8	29.2
88	18.4	43.5	32.7	40.4	33.8	36.4
89	6.6	2.9	8.4	15.8	8.4	7.8
90	2.8	6.2	8.0	12.3	7.3	7.5
91	3.0	13.4	6.5	2.7	6.4	7.7
92	2.2	5.0	4.8	6.3	4.6	4.8
93	0.9	2.6	2.0	2.1	1.9	2.1
94					n/a	n/a
95	5.5	7.5	12.0	20.3	11.3	11.3
86-90	8.7	23.8	19.0	21.3		
Averages						

Numbers are geometric means of fry per m² for 30 days.

Area weights: So. Hatchery So., .149; So. Hatchery No., .372; No. Hatchery, .248; and Delta, .231.

Italics = estimates of missing data.

Source: Ruggerone (1994) and Ruggerone et al. (1993).

Table 12. Average townet catches for Chignik Lake, 1960–73.

Date		No. of tows	Species						
			Sockeye salmon		Juvenile coho	Juvenile king	Pond smelt	Stickleback	
mo.	year	fry	yearling	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

Table 13. Average townet catches for Black Lake, 1960–73.

Date		No. of tows	Species						
			Sockeye salmon		Juvenile	Juvenile	Pond	Stickleback	
mo.	year		Fry	Yearling	coho	king	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

Table 14. Average townet catches for Chignik and Black Lakes, 1980–95.

Date		No. of tows	Species						
mo.	year		Sockeye salmon		Juvenile coho	Juvenile king	Pond smelt	Stickleback	
			Fry	Yearling				3-spine	9-spine
Chignik Lake									
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
Black Lake									
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
7	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

1992 values are geometric means

Table 15. Average beach seine catches for Chignik Lake, 1956–72.

Date		No. of sets	Species								
			Sockeye salmon		Juvenile coho	Juvenile king	Char	Stickleback		Sculpin	Pygmy whitefish
Mo	Year	<45 mm	>45 mm	3-spine				9-spine			
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	45
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

Table 16. Average beach seine catches for Chignik Lakes, 1980–95.

Date		No. of sets	Sockeye salmon		Juvenile coho	Juvenile king	Species					
Mo	Year		<45 mm	>45 mm			Char	Stickleback		Sculpin	Pygmy whitefish	
						3-spine		9-spine				
Chignik Lake												
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	
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	
Black Lake												
5	85	2	374	0	2	0	1	8	12	2	0	
6	85	11	47	1	2	0	3	363	75	2	0	
7	85	22	1	99	4	0	1	62	14	1	0	
6	86	20	55	2	3	0	0				0	
7	86	10	6	63	6	0	0				0	
6	87	10	420	5	3	0	0	2	1	2	0	
7	87	7	20	122	9	0	5	2	0	0	0	