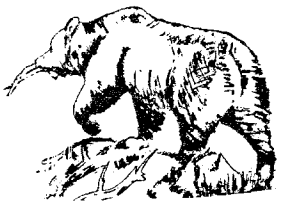
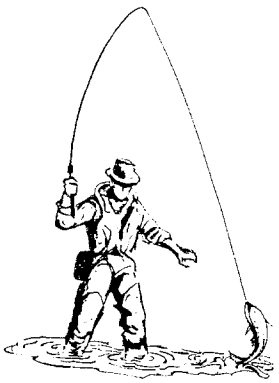
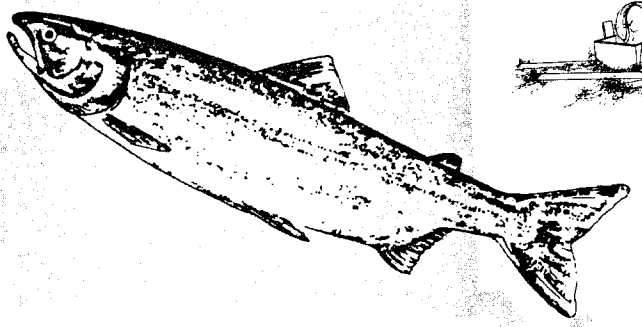
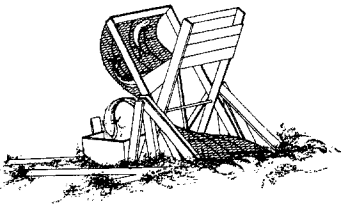
AGE AND LENGTH CHARACTERISTICS OF RAINBOW TROUT FROM DOG SALMON, LITTLE AND UGANIK RIVERS ON THE KODIAK NATIONAL WILDLIFE REFUGE, ALASKA, 1995

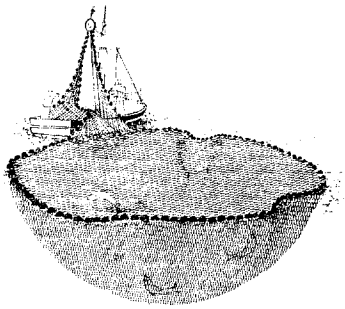
Alaska Fisheries Progress Report Number 96-3











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AGE AND LENGTH CHARACTERISTICS OF RAINBOW TROUT FROM DOG SALMON, LITTLE, AND UGANIK RIVERS ON THE KODIAK NATIONAL WILDLIFE REFUGE, ALASKA, 1995

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Abstract.–Hook-and-line methods were used to collect rainbow trout *Oncorhynchus mykiss* from Dog Salmon, Little and Uganik rivers during June and early-July, 1995. Fork length was recorded and scales were obtained for age determination. Mean lengths of rainbow trout sampled were 375, 189 and 329 mm, respectively. Ages ranged from 2-9 years with modal ages of 6, 3 and 5 years for Dog Salmon, Little, and Uganik rivers, respectively.

Length and age composition, and mean-length-at-age differences between and among rivers were examined. Mean-length-at-age differed among rivers indicating growth differences.

Future monitoring efforts could be improved if combined with habitat and creel information and standardization of methods. This added information will enable managers to determine the effectiveness of regulations on resident rainbow trout populations on the Kodiak National Wildlife Refuge, Alaska.

Introduction

Kodiak Island supports an average of 84,663 (1984-1994) angler days of sport fishing effort in the freshwater environment (Howe et al. 1995). The ten-year trend has shown an increase with a maximum of 99,132 angler days reported in 1994. Although much of this effort targets salmon *O. spp.* and other anadromous fish species, the Kodiak National Wildlife Refuge (Refuge) has documented an increased use of resident fish species (Chatto 1994; U.S. Fish and Wildlife Service 1990). Guided sportfishing use currently accounts for over 1,000 angler days of sportfishing effort on the Refuge (Chatto 1994). The majority of the rainbow trout *Oncorhynchus mykiss* harvest on Kodiak Island is from the road system lakes which are annually stocked for the specific purpose of providing sportfishing opportunity (Howe et al. 1995; Mills 1990-1994). For the more remote river and lake rainbow trout populations, catch and harvest is currently low (harvest 8, and catch 1,683)(Mills 1994). The impact of targeting these fish as a catch and release fishery is unknown. Access to most of these remote fishing locations on the Refuge is by private aircraft, boats or commercial air taxi operators and marine transporters. Recreational use by private parties and commercial sport fish guides has increased on the Refuge since records have been kept (1950's) and is expected to continue to increase in the future (U.S. Fish and Wildlife Service 1990 and 1992). Overall, non-consumptive public use is relatively light, yet high concentrations of bald eagles and brown bears could become an attraction in the future.

Available biological data on resident rainbow trout are limited to historical cataloging and inventory work done primarily on the Kodiak road system lakes by the Alaska Department of Fish and Game (Department) and postal creel surveys conducted by the Department to estimate angler effort, catch and harvest (Mills 1994). The Refuge has monitored guided sportfishing use and catch in Refuge waters though not any biological parameters on wild rainbow trout populations. Lack of biological information on wild resident fish species in Refuge waters, coupled with increasing angler effort in recent years, intensifies the need to learn more about these valuable resources.

Department management goals for this fishery are to maintain historical distribution, age, length and weight frequencies (Schwarz 1992). Although management by the Department is conservative, area managers are concerned that increases in the area sport fishery may adversely affect wild rainbow trout stocks on the island. Possible regulatory actions to conserve stocks include gear restrictions, time and area closures, reductions in bag limits and catch and release regulations. However, complete information regarding the rainbow trout populations and their habitat is not available to support implementation of any stricter management strategy. This lack of information may also prevent attainment of the goals of Section 303 (5)(b) Alaska National Interest Lands Conservation Act (ANILCA), for the Refuge specifically mandates that salmonid populations and their habitats be conserved in their natural diversity.

The Refuge recognized this potential problem and identified the characterization of resident rainbow trout populations as a priority item to meet conservation objectives (U.S. Fish and Wildlife Service 1990). This project provides data to aid managers when making decisions to assure the diversity and health of Refuge rainbow trout stocks. Data collected in 1995 will be used as a baseline and compared with age composition and length-at-age statistics on other Alaskan rainbow trout stocks and future information collected on Refuge populations. These data will be used over time to: 1) evaluate the diversity and health of the Refuge's rainbow trout resources; 2) identify where possible conservation problems may exist; and, 3) decide where management practices for the Refuge may need to be altered.

Project objectives are as follows: 1) characterize rainbow trout populations in terms of length and population age structures; 2) compare these populations to others in Alaska; and, 3) to evaluate management regulations. Objectives accomplished during 1995 were: 1) characterization of lengths and ages of rainbow trout in Uganik, Little and Dog Salmon rivers; and, 2) comparison of relative length and age compositions of rainbow trout from Kodiak Island to other Alaskan populations.

Study Area

The Uganik River is a deep glacially fed river system located approximately 50 km west of Kodiak, Alaska (Figure 1). The drainage which includes Uganik Lake is 257.7 km^2. Average flow ranges from 3-28 m^3 (106-988.8 cfs) with extremes to 277 m^3/s (9,782.1 cfs). Stream banks are mostly grassy and undercut with some gravel bars present. Much of the riparian zone has cottonwood trees. Substrate ranges from pea-sized gravel to boulders. Populations of sockeye *Oncorhynchus nerka*, pink *O. gorbuscha*, chum *O. keta* and coho *O. kisutch* salmon and Dolly Varden *Salvelinus malma* are present in this river (Booth 1995). Most of the river was accessible by wading during the 1995 season.

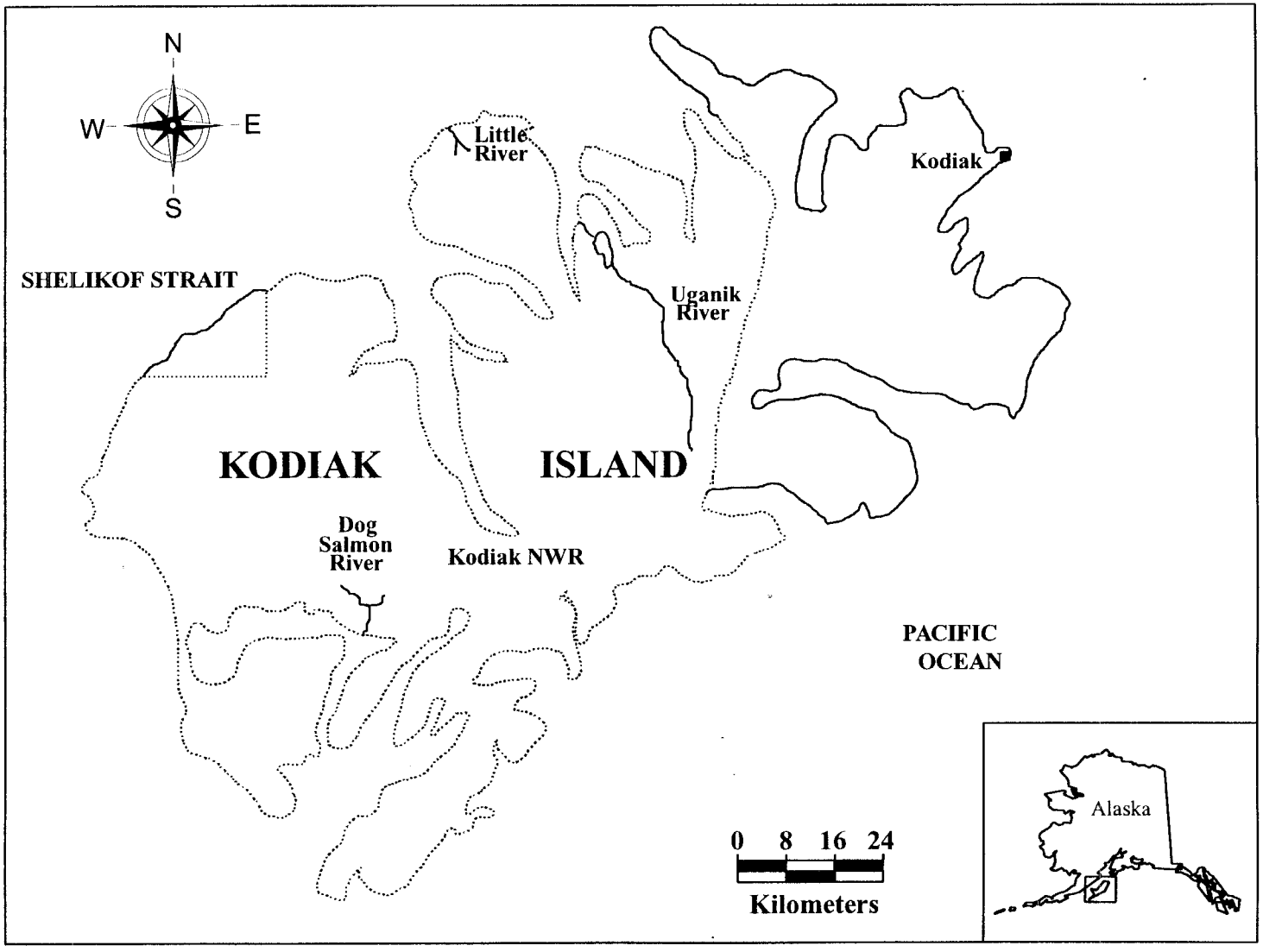

FIGURE 1.–Location of Dog Salmon, Little and Uganik rivers which were sampled for resident rainbow trout during field season 1995 on the Kodiak National Wildlife Refuge, Alaska. Dotted lines indicate the refuge's boundary.

The Little River is a shallower system, draining 106.2 km^2 which includes Little River Lake. Its' average stream width/depth varies from 18.3 m/43.2 cm in the intertidal zone to 12 m/25.4 cm upstream. Stream substrate is medium gravel to large rock, with the best spawning area above the intertidal zone up to the lake. Available spawning habitat is classified moderate to excellent (Department files). High grasses are present on the banks with occasional alder patches. Sockeye salmon, rainbow trout and char spp. are the major recreational species. It is thought that the benthos is less productive than other rivers (T. Chatto, *personal communication*). There are no maintained trails, yet most of the stream is accessible for wading due to moderate velocities and less than a 1° gradient.

The Dog Salmon River watershed (259 km^2) is similar to the Uganik River drainage, although, its lake (Frazer Lake) is classified as more oligotrophic than glacial (U.S. Fish and Wildlife Service 1988). The surface area of Frazer Lake is 260 km^2, and depths range up to 60 m. Stream substrates from the lake outlet to the falls range from small fines to boulders with steep banked riparian habitat consisting of alders and grasses. Below the falls the stream substrates are mainly small to medium gravel with low level grassy banks. The lower third of the river has a much steeper gradient with large boulders interspersed with smaller gravel. Alder and cottonwood line the banks of the lower river. A fish ladder at the falls allows for upstream passage. Five species of Pacific salmon, steelhead/rainbow trout, Dolly Varden, threespine stickleback *Gasterosteus aculeatus,* and coastrange sculpin *Cottus aleuticus* are present.

For all three streams, water quality and structural habitat information are more qualitative than quantitative in nature. Angler use is evident and expected to increase, however these watersheds and their fish and wildlife communities are not, at present, adversely limited by anthropogenic activity.

Methods

Sample Collection

Rainbow trout were sampled from Dog Salmon, Little and Uganik rivers (Figure 1) mostly by hook-and-line. Sampling was not scheduled during most of May due to spawning or mid-August through September as rainbow trout gather in areas of salmon spawning concentrations to feed on eggs. Access and sampling were concentrated in areas used by sportfishing guides and the public. Sampling occurred from 31 May to 10 July, 1995. All of the accessible main stems were fished. In addition, stream inlets and outlets at the lakes and a few first order tributaries draining into the lakes were fished. Baited hoop nets were set overnight 2-3 times in Uganik and Dog Salmon river systems, to supplement hook and line sampling. Hoop net dimensions were 0.66 m x 3.3 m with 2.54 cm mesh (2 ft x 10 ft with 1" mesh). Bait, salmon eggs in perforated containers, was used to increase the effectiveness of the hoop nets.

A minimum of 130 rainbow trout were sampled from each river. Desired sample size was determined by methods in Thompson (1987). All fish captured by hook and line or hoop nets were measured to fork length (FL) to the nearest mm. Five scales were removed from the preferred area from each rainbow trout and placed on a gum card for age determination (Jearld 1983; Ambrose 1983). Fish were then released back into the stream.

Scales were pressed on acetate sheets or mounted between glass slides, magnified under a microfiche reader and aged. Ages were determined according to Summerfelt and Hall (1987).

Data Analysis

Age and length information with associated variances were calculated using normal procedures. Scale ages and associated lengths were used to determine mean length-at-age information. Since effort, capture methodology and time of capture, for the three rivers were deemed similar among the samples, similarity tests were run between rivers and among ages on the age and length data. Mean length-at-age statistical differences were estimated using parametric and non-parametric procedures (Johnson and Bhattacharyya 1987).

The proportion in each age class was estimated as $\hat{p}_i = n_i/n_t$

Where $\hat{p}_i$ = proportion in age class i

n_i= number sampled in age class i

n_t= total number sampled,

The standard error of $\hat{p}_i$ were estimated as $SE_i = [(\hat{p}_i(1-\hat{p}_i))/(n_t-1)]^{1/2}$

To test the hypotheses that age and length composition of rainbow trout do not differ between the three rivers, cumulative age and length distributions between geographic groups were compared. A Kolmogorov-Smirnov (K-S) two sample test was used to compare length distributions between rivers. A Chi-square contingency table analysis was used to compare age distributions (Daniel 1990). Non-parametric box plots were used to determine mean-length-at-age differences within rivers.

Relationships between age and length were examined to obtain an index of growth. Analysis of variance was used to test the hypothesis that the three streams have similar mean lengths-at-age.

Results

The Dog Salmon River was sampled from 14-20 June. Five major areas sampled were from the falls upstream to the lake, falls downstream to the confluence of the East Fork and three tributaries to Frazer Lake (Pinnel Creek, Stumble Creek and Middle Creek). The Uganik River was sampled from 31 May to 8 June. Areas sampled were from the lake downstream to the ocean, upstream of the lake 1.2 km and about 1 km of the East Fork. Little River was sampled in three major areas, two unnamed lake tributaries, the outlet for about 150 meters and downstream from the lake for about 6.4 km. Little River was sampled 8-10 July. Three rainbow trout were caught in the hoop nets set in Uganik River. Their lengths were 317, 333 and 343 mm. These fish were not used in the analysis, due to gear selectivity and variance questions.

Mean lengths ranged from 189-375 mm (Table 1). When comparing, means, medians, minimums and maximums the samples indicate Dog Salmon River rainbow trout (n=137) are slightly larger than Uganik River rainbow trout (n=150) and overall sample means from both of these rivers are larger than the Little River sample mean (n=178).

Kolmogorov-Smirnov test results supported the preceding trends for cumulative length frequency distributions. Dog Salmon and Uganik River had similar length distributions and Little River length distributions were significantly different from the other two (K-S test, $P < 0.05$; Table 2, Figures 2 and 3).

TABLE 1.–Statistical description of rainbow trout lengths sampled by hook-and-line from Dog Salmon, Little and Uganik rivers, Kodiak National Wildlife Refuge, Alaska, 1995. Statistics recorded include: Minimum, Maximum, Mean, SD and Median.

Statistic	Dog Salmon River	Little River	Uganik River
Mean	375.0	188.9	329.0
SD	49.31	58.62	61.33
Minimum	209	104	166
Maximum	544	342	464
Median	380.0	173.5	329.5
N	137	178	150

TABLE 2.–Kolmogorov-Smirnov two sample test results comparing cumulative lengths of rainbow trout sampled by hook-and-line from Dog Salmon, Little and Uganik rivers, Kodiak National Wildlife Refuge, Alaska, 1995. Maximum differences for pairs of groups and two-sided probability matrixes are presented for 10 mm length increments of rainbow trout sampled from three rivers.

River	Dog Salmon River	Little River
Maximum differences for (increments of 10 mm) pairs of groups/(p-value)		
Dog Salmon River	-	
Little River	0.609/(<0.001)	-
Uganik River	0.174/(0.440)	0.500/(0.005)

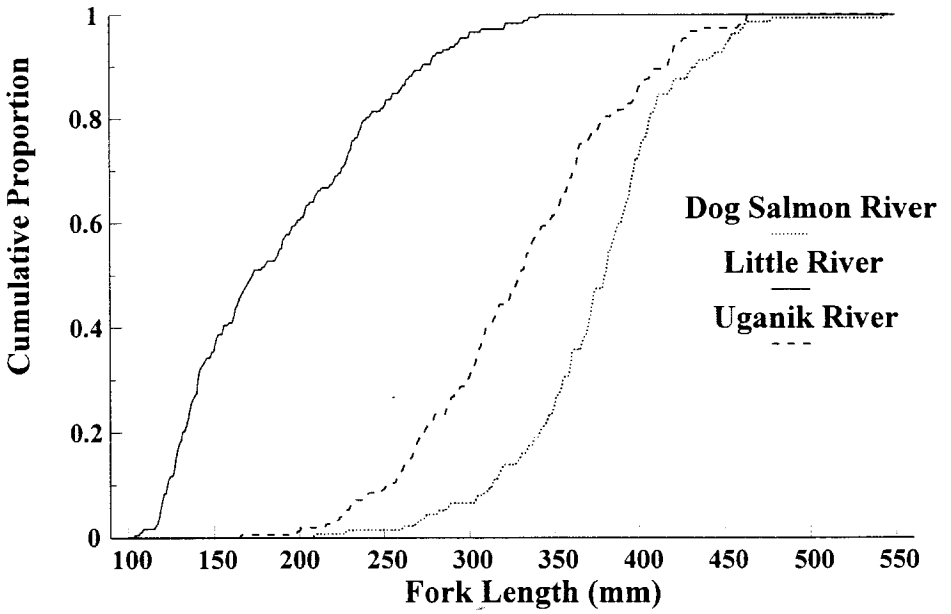

FIGURE 2.–Cumulative length frequency distribution of rainbow trout sampled by hook-and-line from Dog Salmon, Little and Uganik rivers, Kodiak National Wildlife Refuge, Alaska, 1995.

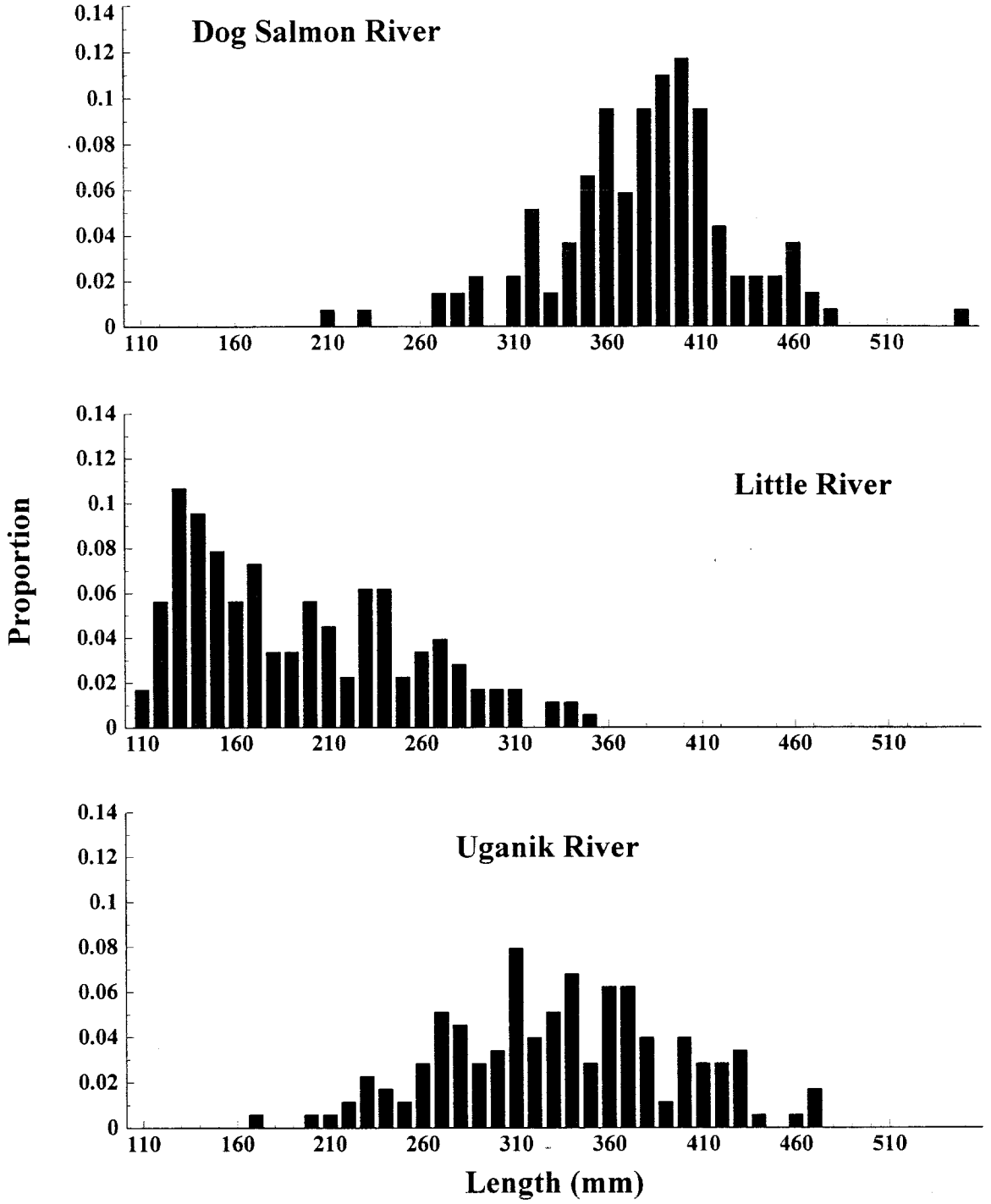

FIGURE 3.–Length frequency distribution of rainbow trout, sampled by hook-and-line from Dog Salmon, Little and Uganik rivers, Kodiak National Wildlife Refuge, Alaska, 1995.

Age trends follow similar trends as the length data. Uganik River rainbow trout and Dog Salmon River rainbow trout appear to be similar to each other (Table 3, Figures 4 and 5). When comparing sample means, medians, minimums and maximums; Dog Salmon River rainbow trout are slightly older than Uganik River rainbow trout and both samples from these rivers are older than the Little River sample (Table 3).

Chi-square results indicated age compositions differed for all three rivers. Ages 2 and 9 were not represented in all three rivers, more than 20% of the expected cells were zero, therefore Chi-square tests were re-run on only age 3-8. Results supported the hypothesis that age compositions of rainbow trout were different (6x3 Contingency Table Analysis, df = 10, $X^2 = 183.2$, $p < 0.001$) for the rivers. Table 4 lists rainbow trout age proportions for each river.

TABLE 3 .–Summary of age information on rainbow trout sampled by hook-and-line from Dog Salmon, Little and Uganik rivers, Kodiak National Wildlife Refuge, Alaska, 1995. Statistics recorded include: Minimum, Maximum, Mean and Median.

Statistic	Dog Salmon River	Little River	Uganik River
N	137	178	150
Minimum	3	2	3
Maximum	9	8	8
Mean	6.2	4.2	5.4
Median	6	4	5

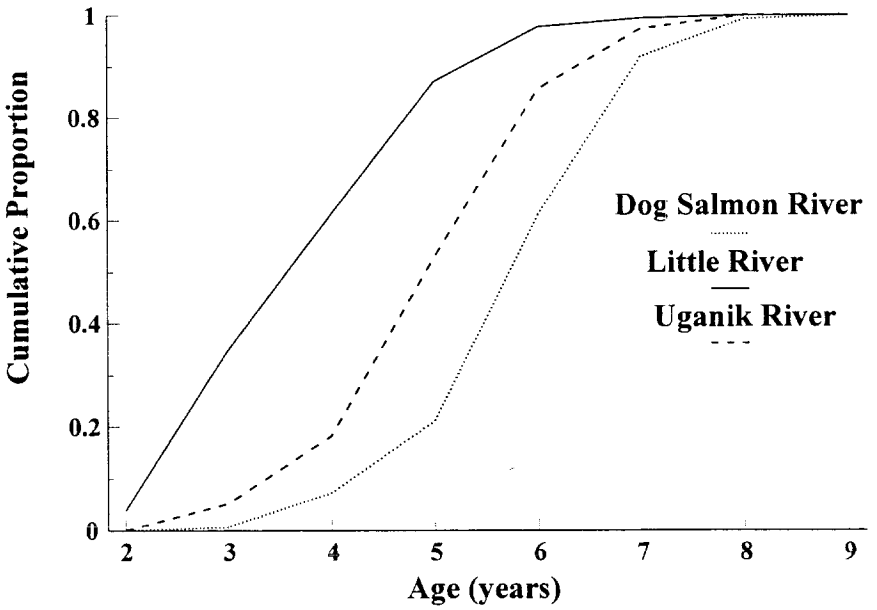

FIGURE 4.–Cumulative age frequency distribution of rainbow trout, sampled by hook-and-line from Dog Salmon, Little and Uganik rivers, Kodiak National Wildlife Refuge, Alaska, 1995.

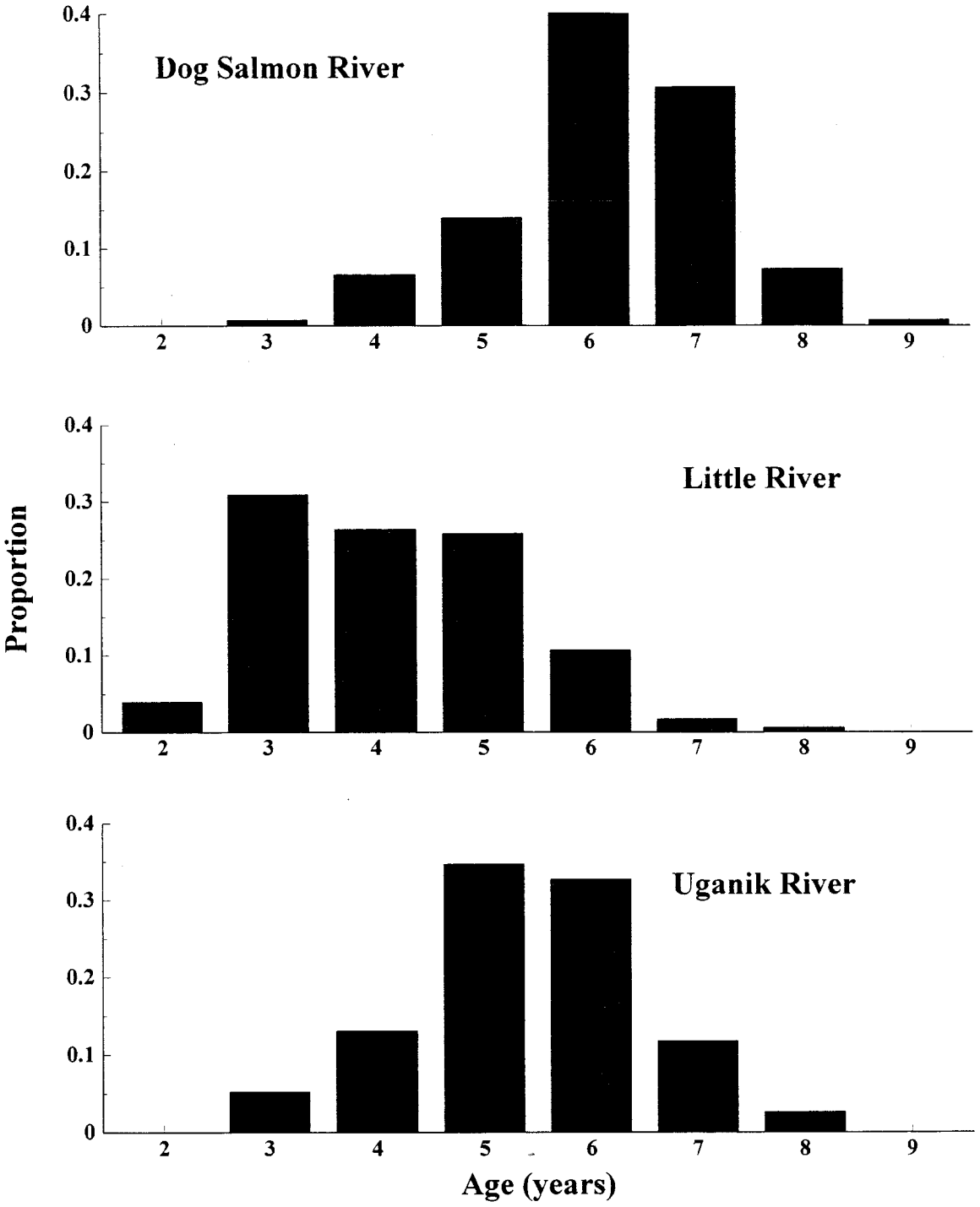

FIGURE 5.–Age frequency distribution of rainbow trout, sampled by hook-and-line from Dog Salmon, Little and Uganik rivers, Kodiak National Wildlife Refuge, Alaska, 1995.

TABLE 4.-Age composition and mean length-at-age data for rainbow trout, sampled by hook-and-line from Dog Salmon, Little and Uganik rivers, Kodiak National Wildlife Refuge, Alaska, 1995.

River	n	Age	Mean length	SD	Age proportion	SE
Dog Salmon River	0	2	-	-	.000	-
	1	3	209.0	-	.007	0.0073
	9	4	279.1	25.03	.066	0.0212
	19	5	339.5	29.79	.139	0.0296
	55	6	373.2	26.58	.401	0.0420
	42	7	396.4	27.66	.307	0.0395
	10	8	499.0	19.00	.073	0.0223
	1	9	544.0	-	.007	0.0073
Little River	7	2	116.6	11.154	.039	0.0146
	55	3	133.6	11.183	.309	0.0347
	47	4	178.1	28.175	.264	0.0331
	46	5	232.7	34.714	.258	0.0329
	19	6	267.2	32.488	.107	0.0232
	3	7	327.7	17.616	.017	0.0097
	1	8	322.0	-	.006	0.0056
	0	9	-	-	.000	-
Uganik River	0	2	-	-	.000	-
	8	3	219.1	30.178	.053	0.0184
	20	4	256.5	24.025	.133	0.0278
	51	5	309.2	28.526	.340	0.0388
	49	6	361.3	32.757	.327	0.0384
	18	7	405.9	32.327	.120	0.0266
	4	8	444.3	23.099	.027	0.0132
	0	9	-	-	.000	-

Comparing relationships of mean length-at-ages versus lengths clarifies an over all river difference (Figure 6) rather than just a difference in mean lengths. Little River rainbow have a lower length to age relationship. This suggests slower growth for Little River rainbow trout. ANOVA results for the model where length is predicted using river name and age as the independent variables indicate a significant river and age interaction effect ($P \leq 0.026$). Most of the variation in length is explained by this model ($r^2=0.92$)(Table 5).

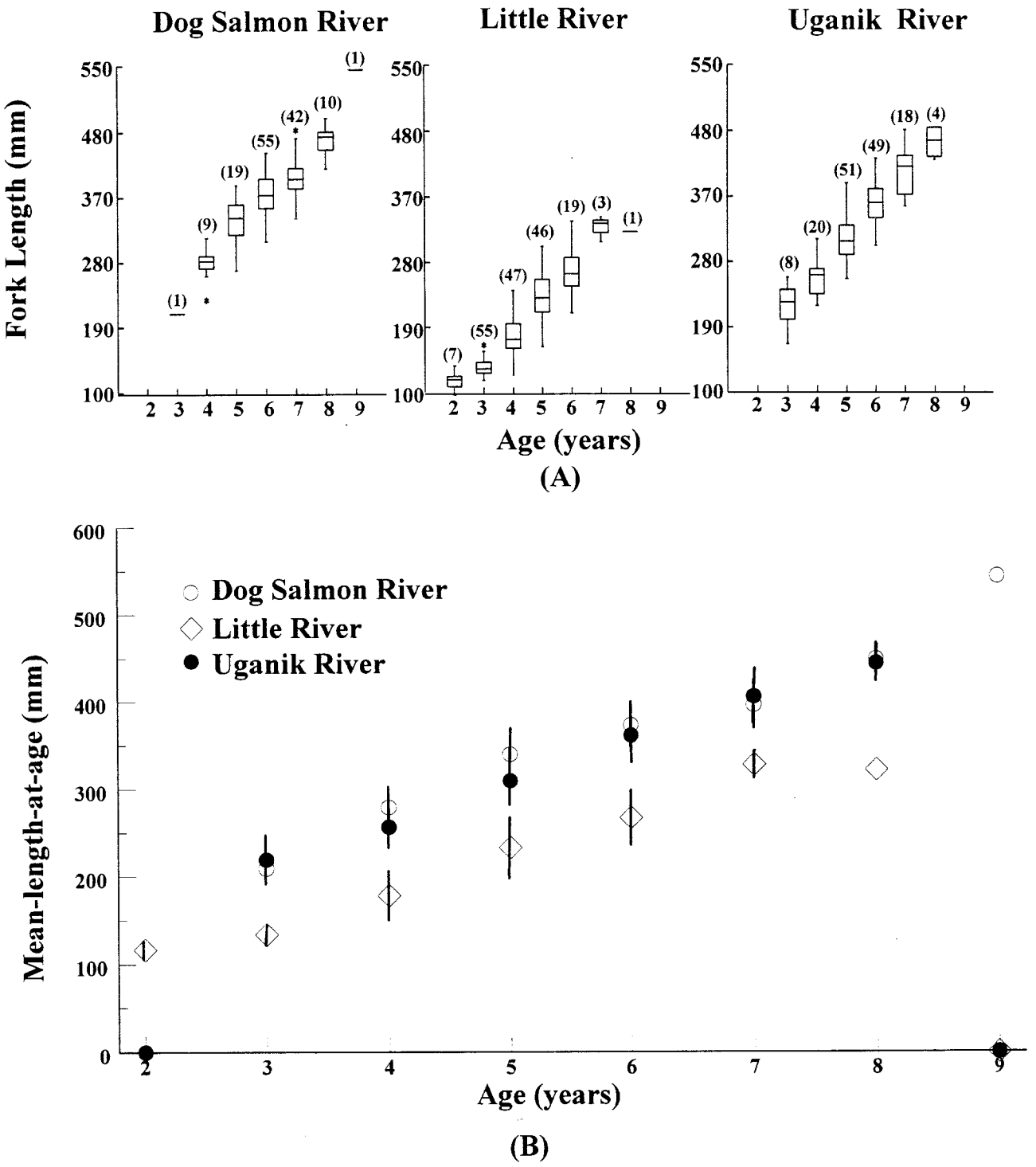

FIGURE 6.–Age and length relationships for rainbow trout, sampled by hook-and-line on Kodiak National Wildlife Refuge, Alaska, 1995. (A) Boxplots for length versus age data. Sample sizes are indicated in parenthesis. (B) Mean length-at-age data.

TABLE 5.–ANOVA results for rainbow trout sampled by hook-and-line from Dog Salmon, Little and Uganik rivers, Kodiak National Wildlife Refuge, Alaska, 1995.

Source	DF	Mean-Square	F-Ratio	P
Age	5	120832.0	156.6	< 0.001
River	2	83568.3	108.3	< 0.001
Age*River	10	1591.6	2.1	0.026
Error	439	771.8		

Conclusions

Summary

Generalizations have been made with the condition of accepting the assumption that the rainbow trout collected by hook and line represent the actual populations. Supportive arguments for hook and line sampling include: 1) what is sampled is available to an angler as the 'catchable' population; 2) a large enough sample size and wide enough size range is more than likely representative of the present populations; and, 3) when one compares percent compositions of age and lengths directly, it is still possible to compare length-at-age and their ratios as an index of growth.

Study results indicate Little River rainbow trout are significantly smaller at a given age than Uganik River and Dog Salmon River populations. The rainbow trout populations for the latter two rivers are more similar in age and length composition. The Fishery Management Plan for the Refuge designates habitat and water quality as one of the highest priorities and are not considered to be limiting. Size and growth differences probably occur because of the productivity in the rivers. Baseline data on water quality, productivity in combination with the information from angler monitoring would help support or contradict this assessment.

The age composition difference of more 2-4 year old fish in Little River may be attributed to not being able to differentiate resident rainbow trout from juvenile (pre-smolt) steelhead. This report assumes all collected fish were resident rainbow trout. Separating juvenile rainbow trout and steelhead is not possible and timing is crucial for determining if a fish is smolting to leave for the ocean. It is not known whether there are growth differences between resident rainbow and steelhead fish before they migrate from the Little River. Again comparisons of structural habitat and water quality, and/or productivity within and among sampled sites would aid in determining causes of Little River rainbow trout differences.

Length differences between samples are possibly due to the available food resources (number/timing of different salmon runs), habitat or possibly genetic growth differences between steelhead and resident rainbow trout, but not angling pressure. Prior to changes in management practices a different study design is necessary which would include relative angling pressure and diet availability.

A cursory comparison between mean-lengths at ages of rainbow trout populations from other systems in the south-central and southwestern regions of Alaska was explored. Data suggests that Uganik and Dog Salmon River rainbow trout are similar and Little River rainbow trout are smaller than other southcentral and southwestern populations (Irving and Faustini 1993; Riffe 1994; Lisac and MacDonald 1995; Department data files, McCarron 1996 *personal communication*). Comparison data were chosen for their similarity in sampling effort (hook-and-line method and seasonality). Additional assumptions were that water quality and structural habitat are not limited. This comparison between other studies should be cautioned due to the possibility of different variances for different sized fish due to their catchability and hook-and-line effort differences. Hook and line may not effectively sample the smaller sizes of fish and therefore different variances per age group make comparisons less clear. Variances of length-at-age were not compared. Appendix 4 lists dates and sources used.

Recommendations

Projects that would support goals and objectives for rainbow trout management on the Refuge are:

1) Evaluate the length and age structure of other rainbow trout populations which occur on the Refuge. Other watersheds which support rainbow trout on the refuge are Spiridon River, Upper Station Creek and Akalura Creek. Standardization of hook-and-line methods should be consistent in terms of; period of season, habitat type and time fished for stretch of stream, and possibly tackle type.

2) An investigation which examines water quality, structural habitat, productivity, fish species interactions combined with angler survey information would be needed to determine factors limiting the growth of Little River rainbow trout. A back calculation of growth from returning steelhead scales may aid in determining if growth differences exist between resident and anadromous populations while they are in the stream.

3) Continue angler surveys and monitoring of length and age structure to aid Refuge managers in detecting changes, due to angling pressure, in a timely manner and permit them to make informed management decisions regarding the resident rainbow trout populations on the Refuge.

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References

Adams, F.J. 1995. Status of rainbow trout in the Kanektok River, Togiak National Wildlife Refuge, Alaska, 1993. U.S. Fish and Wildlife Service, Alaska Fisheries Technical Report Number 77, King Salmon, Alaska.

Ambrose, J. 1983. Age determination. Pages 301-324 *in* L.A. Nielson and D.L. Johnson, editors. Fisheries Techniques. American Fisheries Society, Bethesda, Maryland.

Booth, J.A. 1995. Escapement timing and abundance of adult salmonids in the Uganik River, Kodiak National Wildlife Refuge, Alaska, 1990, 1991 and 1992. U.S. Fish and Wildlife Service, Alaska Fisheries Technical Report Number 32, Kenai, Alaska.

Chatto, T. 1996. (personal communication). Kodiak National Wildlife Refuge, Kodiak, Alaska

_____. 1994. Guided sportfishing use and catch on the Kodiak National Wildlife Refuge for 1993. U.S. Fish and Wildlife Service, Kodiak, Alaska.

Daniel, W. W. 1990. Applied nonparametric statistics-Second edition. PWS-Kent Publishing Co., Boston, Massachusetts.

Howe, A.L., G. Fidler, and M.J. Mills. 1995. Harvest, catch, and participation in Alaska sport fisheries during 1994. Alaska Department of Fish and Game, Fishery Data Series No. 95-24, Anchorage, Alaska.

Irving, D.B. and M.A. Faustini. 1993. Southwestern Alaska rainbow trout investigations, Good News River, Togiak National Wildlife Refuge, 1988-1989. U.S. Fish and Wildlife Service, Alaska Fisheries Technical Report Number 24, King Salmon, Alaska.

Jearld, A. 1983. Age determination. Pages 301-324 *in* L.A. Nielson and D.L. Johnson, editors. Fisheries Techniques. American Fisheries Society, Bethesda, Maryland.

Johnson, R. and G. Bhattacharyya. 1987. Statistics: principals and methods-revised printing. John Wiley & Sons, New York.

Lafferty, R. 1989. Population dynamics of rainbow trout, Kenai River, Alaska. Masters Thesis, University of Alaska, Fairbanks, Alaska.

Lisac, M.J. and R. MacDonald. 1995. Length frequency, age distribution and movements of rainbow trout in the Arolik River, Togiak National Wildlife Refuge, Alaska, 1991-1994. Alaska Fisheries Technical Report No. 34.

McCarron, S. *(personal communication)*. Unpublished data files on mean-length-at-age data on Kenai River rainbow trout, Alaska Department of Fish and Game, Sport Fish Division, Anchorage, Alaska.

Mills, M.J. 1990. Harvest and participation in Alaska sport fisheries during 1989. Alaska Department of Fish and Game, Fishery Data Series No. 90-44, Anchorage, Alaska.

_____. 1991. Harvest and participation in Alaska sport fisheries during 1990. Alaska Department of Fish and Game, Fisheries Data Series No. 91-58, Anchorage, Alaska.

_____. 1992. Harvest, catch, and participation in Alaska sport fisheries during 1991. Alaska Department of Fish and Game, Fishery Data Series No. 92-40, Anchorage, Alaska.

_____. 1993. Harvest, catch, and participation in Alaska sport fisheries during 1992. Alaska Department of Fish and Game, Fishery Data Series No. 93-42, Anchorage, Alaska.

_____. 1994. Harvest, catch, and participation in Alaska sport fisheries during 1993. Alaska Department of Fish and Game, Fishery Data Series No. 94-28, Anchorage, Alaska.

Minard, R. E. and J. J. Hasbrouck. 1994. Stock assessment of Arctic char in the Agulowak and Agulukpak Rivers of the Wood River Lake system, 1993. Fishery Data Series No. 94-92, Alaska Department of Fish and Game, Division of Sport Fish, Anchorage, Alaska

Riffe, R. 1994. Compilation of age, weight , and length statistics for rainbow trout samples collected in Southwest Alaska, 1990-1993. Alaska Department of Fish and Game, Sport Fish Division Fisheries Data Series Number 94-17 Anchorage, Alaska.

Rutz, D.S. 1993. Age and size statistics for rainbow trout collected in the Susitna River drainage during 1992. Alaska Department of Fish and Game, Sport Fish Division Fisheries Data Series Number 93-55, Anchorage, Alaska.

Schwarz, L. 1992. Area management report for the recreational fisheries of the Kodiak and Alaska Peninsula/Aleutian Islands regulatory areas. Alaska Department of Fish and Game, Division of Sport Fish, Kodiak, Alaska.

Summerfelt, R.C. and G.E. Hall. 1987. Age and growth of fish. Iowa State University Press. 544 pp.

Thompson, S.K. 1987. Sample size for estimating multinomial proportions. The American Statistician. Vol. 14 No.1:42-46.

U.S. Fish and Wildlife Service. 1992. Kodiak National Wildlife Refuge public use management plan and environmental assessment for public use regulations, final report. U.S. Department of Interior, Fish and Wildlife Service, Kodiak, Alaska.

_____. 1990. Fishery Management Plan, Kodiak National Wildlife Refuge. Kodiak, Alaska.

_____. 1988. Environmental assessment: permits for the controlled addition of nitrogen and phosphorous into Frazer Lake. Kodiak, Alaska.

APPENDIX 1.–Data from Dog Salmon River rainbow trout sampled during 14-20 June, 1995. Information included is length (fork length), age (by scale) and dates sampled.

River Name	Date Sampled	Length (mm)	Age (yr)
Dog Salmon River	14 June 95	347	6
Dog Salmon River	14 June 95	420	7
Dog Salmon River	14 June 95	359	6
Dog Salmon River	14 June 95	452	8
Dog Salmon River	14 June 95	451	7
Dog Salmon River	14 June 95	429	7
Dog Salmon River	14 June 95	393	6
Dog Salmon River	14 June 95	390	7
Dog Salmon River	14 June 95	382	7
Dog Salmon River	14 June 95	387	5
Dog Salmon River	14 June 95	386	6
Dog Salmon River	14 June 95	390	7
Dog Salmon River	14 June 95	379	6
Dog Salmon River	15 June 95	407	7
Dog Salmon River	15 June 95	388	7
Dog Salmon River	15 June 95	429	7
Dog Salmon River	15 June 95	462	7
Dog Salmon River	15 June 95	395	7
Dog Salmon River	15 June 95	397	7
Dog Salmon River	15 June 95	381	7
Dog Salmon River	15 June 95	373	7
Dog Salmon River	15 June 95	335	6
Dog Salmon River	15 June 95	367	6
Dog Salmon River	15 June 95	318	6
Dog Salmon River	15 June 95	345	7
Dog Salmon River	15 June 95	355	6
Dog Salmon River	16 June 95	396	6
Dog Salmon River	16 June 95	379	6
Dog Salmon River	16 June 95	381	5
Dog Salmon River	16 June 95	384	7
Dog Salmon River	16 June 95	392	7
Dog Salmon River	16 June 95	394	6
Dog Salmon River	16 June 95	372	6
Dog Salmon River	16 June 95	395	7
Dog Salmon River	16 June 95	406	6
Dog Salmon River	16 June 95	398	6
Dog Salmon River	16 June 95	401	7

APPENDIX 1.-(Continued).

River Name	Date Sampled	Length (mm)	Age (yr)
Dog Salmon River	16 June 95	404	7
Dog Salmon River	16 June 95	406	7
Dog Salmon River	16 June 95	411	7
Dog Salmon River	16 June 95	431	6
Dog Salmon River	16 June 95	435	8
Dog Salmon River	16 June 95	450	8
Dog Salmon River	16 June 95	368	7
Dog Salmon River	16 June 95	372	5
Dog Salmon River	16 June 95	341	7
Dog Salmon River	16 June 95	366	6
Dog Salmon River	16 June 95	309	6
Dog Salmon River	16 June 95	331	5
Dog Salmon River	16 June 95	319	6
Dog Salmon River	16 June 95	282	4
Dog Salmon River	16 June 95	305	5
Dog Salmon River	16 June 95	338	6
Dog Salmon River	16 June 95	272	4
Dog Salmon River	16 June 95	228	4
Dog Salmon River	16 June 95	366	6
Dog Salmon River	16 June 95	334	6
Dog Salmon River	16 June 95	356	6
Dog Salmon River	16 June 95	351	6
Dog Salmon River	16 June 95	360	5
Dog Salmon River	16 June 95	342	5
Dog Salmon River	16 June 95	350	6
Dog Salmon River	16 June 95	360	7
Dog Salmon River	16 June 95	346	6
Dog Salmon River	16 June 95	343	7
Dog Salmon River	17 June 95	407	7
Dog Salmon River	17 June 95	411	6
Dog Salmon River	17 June 95	398	6
Dog Salmon River	17 June 95	454	8
Dog Salmon River	17 June 95	455	8
Dog Salmon River	17 June 95	401	7
Dog Salmon River	17 June 95	371	6
Dog Salmon River	17 June 95	397	6
Dog Salmon River	17 June 95	380	6
Dog Salmon River	17 June 95	338	6

APPENDIX 1.–(Continued).

River Name	Date Sampled	Length (mm)	Age (yr)
Dog Salmon River	17 June 95	379	6
Dog Salmon River	17 June 95	360	5
Dog Salmon River	17 June 95	371	6
Dog Salmon River	17 June 95	374	6
Dog Salmon River	18 June 95	391	7
Dog Salmon River	18 June 95	382	6
Dog Salmon River	18 June 95	382	7
Dog Salmon River	18 June 95	386	7
Dog Salmon River	18 June 95	478	8
Dog Salmon River	18 June 95	398	7
Dog Salmon River	18 June 95	420	7
Dog Salmon River	18 June 95	463	8
Dog Salmon River	18 June 95	359	6
Dog Salmon River	18 June 95	373	6
Dog Salmon River	18 June 95	370	7
Dog Salmon River	18 June 95	355	6
Dog Salmon River	18 June 95	353	6
Dog Salmon River	18 June 95	312	5
Dog Salmon River	18 June 95	209	3
Dog Salmon River	18 June 95	275	4
Dog Salmon River	18 June 95	287	4
Dog Salmon River	18 June 95	261	4
Dog Salmon River	18 June 95	314	4
Dog Salmon River	18 June 95	314	5
Dog Salmon River	18 June 95	317	5
Dog Salmon River	18 June 95	330	5
Dog Salmon River	18 June 95	320	5
Dog Salmon River	19 June 95	402	6
Dog Salmon River	19 June 95	418	6
Dog Salmon River	19 June 95	409	8
Dog Salmon River	19 June 95	410	7
Dog Salmon River	19 June 95	442	7
Dog Salmon River	19 June 95	421	7
Dog Salmon River	19 June 95	544	9
Dog Salmon River	19 June 95	445	7
Dog Salmon River	19 June 95	460	8
Dog Salmon River	19 June 95	402	6
Dog Salmon River	19 June 95	351	6

APPENDIX 1.-(Continued).

River Name	Date Sampled	Length (mm)	Age (yr)
Dog Salmon River	19 June 95	400	6
Dog Salmon River	19 June 95	361	6
Dog Salmon River	19 June 95	396	6
Dog Salmon River	19 June 95	269	5
Dog Salmon River	19 June 95	349	5
Dog Salmon River	19 June 95	360	7
Dog Salmon River	19 June 95	372	6
Dog Salmon River	19 June 95	384	6
Dog Salmon River	19 June 95	385	6
Dog Salmon River	19 June 95	395	6
Dog Salmon River	20 June 95	370	6
Dog Salmon River	20 June 95	405	7
Dog Salmon River	20 June 95	405	6
Dog Salmon River	20 June 95	392	7
Dog Salmon River	20 June 95	382	6
Dog Salmon River	20 June 95	304	4
Dog Salmon River	20 June 95	370	5
Dog Salmon River	20 June 95	354	5
Dog Salmon River	20 June 95	350	5
Dog Salmon River	20 June 95	374	7
Dog Salmon River	20 June 95	328	5
Dog Salmon River	20 June 95	289	4
Dog Salmon River	20 June 95	411	6

APPENDIX 2.–Data from Little River rainbow trout sampled during 9 & 10 July, 1995. Information included is length (fork length), age (by scale) and dates sampled.

River Name	Date Sampled	Length (mm)	Age (yr)
Little River	8 July 95	301	5
Little River	8 July 95	238	5
Little River	8 July 95	333	7
Little River	8 July 95	322	6
Little River	8 July 95	293	5
Little River	8 July 95	286	5
Little River	8 July 95	279	5
Little River	8 July 95	264	5
Little River	8 July 95	241	4
Little River	8 July 95	256	5
Little River	8 July 95	228	4
Little River	8 July 95	205	4
Little River	8 July 95	124	2
Little River	8 July 95	119	2
Little River	8 July 95	123	3
Little River	8 July 95	149	3
Little River	8 July 95	128	3
Little River	8 July 95	130	3
Little River	8 July 95	144	3
Little River	9 July 95	141	3
Little River	9 July 95	138	3
Little River	9 July 95	140	4
Little River	9 July 95	149	3
Little River	9 July 95	141	3
Little River	9 July 95	141	3
Little River	9 July 95	134	3
Little River	9 July 95	136	2
Little River	9 July 95	342	7
Little River	9 July 95	132	3
Little River	9 July 95	129	3
Little River	9 July 95	128	3
Little River	9 July 95	127	3
Little River	9 July 95	119	3
Little River	9 July 95	117	2
Little River	9 July 95	116	3
Little River	9 July 95	107	2
Little River	9 July 95	152	4
Little River	9 July 95	151	3

APPENDIX 2 .-(Continued).

River Name	Date Sampled	Length (mm)	Age (yr)
Little River	9 July 95	146	3
Little River	9 July 95	156	3
Little River	9 July 95	162	4
Little River	9 July 95	269	5
Little River	9 July 95	236	4
Little River	9 July 95	164	4
Little River	9 July 95	239	5
Little River	9 July 95	252	5
Little River	9 July 95	256	5
Little River	9 July 95	264	6
Little River	9 July 95	266	6
Little River	9 July 95	274	6
Little River	9 July 95	232	5
Little River	9 July 95	279	5
Little River	9 July 95	280	5
Little River	9 July 95	290	6
Little River	9 July 95	296	6
Little River	9 July 95	301	6
Little River	9 July 95	308	7
Little River	9 July 95	336	6
Little River	9 July 95	232	6
Little River	9 July 95	238	4
Little River	9 July 95	230	5
Little River	9 July 95	197	4
Little River	9 July 95	165	3
Little River	9 July 95	172	4
Little River	9 July 95	174	4
Little River	9 July 95	229	4
Little River	9 July 95	182	4
Little River	9 July 95	196	4
Little River	9 July 95	181	4
Little River	9 July 95	199	4
Little River	9 July 95	202	5
Little River	9 July 95	226	5
Little River	9 July 95	210	4
Little River	9 July 95	226	5
Little River	9 July 95	224	5
Little River	9 July 95	214	5
Little River	9 July 95	211	5

APPENDIX 2 .-(Continued).

River Name	Date Sampled	Length (mm)	Age (yr)
Little River	10 July 95	262	6
Little River	10 July 95	252	5
Little River	10 July 95	260	6
Little River	10 July 95	261	6
Little River	10 July 95	322	8
Little River	10 July 95	268	6
Little River	10 July 95	273	5
Little River	10 July 95	282	6
Little River	10 July 95	295	5
Little River	10 July 95	249	5
Little River	10 July 95	251	6
Little River	10 July 95	244	5
Little River	10 July 95	109	2
Little River	10 July 95	137	3
Little River	10 July 95	141	3
Little River	10 July 95	139	3
Little River	10 July 95	137	3
Little River	10 July 95	137	3
Little River	10 July 95	142	3
Little River	10 July 95	136	3
Little River	10 July 95	136	3
Little River	10 July 95	141	4
Little River	10 July 95	142	3
Little River	10 July 95	134	3
Little River	10 July 95	152	4
Little River	10 July 95	156	3
Little River	10 July 95	153	3
Little River	10 July 95	151	4
Little River	10 July 95	151	4
Little River	10 July 95	142	4
Little River	10 July 95	145	4
Little River	10 July 95	143	3
Little River	10 July 95	135	4
Little River	10 July 95	132	3
Little River	10 July 95	132	3
Little River	10 July 95	159	4
Little River	10 July 95	120	3
Little River	10 July 95	121	3
Little River	10 July 95	120	3

APPENDIX 2 .-(Continued).

River Name	Date Sampled	Length (mm)	Age (yr)
Little River	10 July 95	119	3
Little River	10 July 95	120	3
Little River	10 July 95	123	3
Little River	10 July 95	118	3
Little River	10 July 95	118	3
Little River	10 July 95	121	3
Little River	10 July 95	123	4
Little River	10 July 95	131	3
Little River	10 July 95	129	3
Little River	10 July 95	130	3
Little River	10 July 95	129	3
Little River	10 July 95	128	3
Little River	10 July 95	128	3
Little River	10 July 95	124	3
Little River	10 July 95	127	3
Little River	10 July 95	125	3
Little River	10 July 95	156	4
Little River	10 July 95	162	4
Little River	10 July 95	243	6
Little River	10 July 95	207	5
Little River	10 July 95	212	5
Little River	10 July 95	210	6
Little River	10 July 95	204	5
Little River	10 July 95	205	5
Little River	10 July 95	221	5
Little River	10 July 95	204	4
Little River	10 July 95	200	5
Little River	10 July 95	219	5
Little River	10 July 95	222	5
Little River	10 July 95	193	4
Little River	10 July 95	234	5
Little River	10 July 95	237	5
Little River	10 July 95	236	6
Little River	10 July 95	231	5
Little River	10 July 95	232	5
Little River	10 July 95	222	6
Little River	10 July 95	230	5
Little River	10 July 95	229	5
Little River	10 July 95	196	4

APPENDIX 2 .-(Continued).

River Name	Date Sampled	Length (mm)	Age (yr)
Little River	10 July 95	192	4
Little River	10 July 95	163	4
Little River	10 July 95	167	4
Little River	10 July 95	169	4
Little River	10 July 95	168	4
Little River	10 July 95	165	4
Little River	10 July 95	166	5
Little River	10 July 95	171	5
Little River	10 July 95	163	5
Little River	10 July 95	163	4
Little River	10 July 95	170	4
Little River	10 July 95	173	4
Little River	10 July 95	188	5
Little River	10 July 95	189	4
Little River	10 July 95	191	4
Little River	10 July 95	191	4
Little River	10 July 95	189	4
Little River	10 July 95	104	2
Little River	10 July 95	191	5
Little River	10 July 95	187	4
Little River	10 July 95	179	4
Little River	10 July 95	174	5
Little River	11 July 95	135	3

APPENDIX 3 .-Data from Uganik River rainbow trout sampled during 14-20 June, 1995. Information included is length (fork length), age (by scale) and dates sampled.

River Name	Date Sampled	Length (mm)	Age (yr)
Uganik River	31 May 95	354	5
Uganik River	1 June 95	333	5
Uganik River	1 June 95	343	5
Uganik River	3 June 95	372	7
Uganik River	3 June 95	376	6
Uganik River	3 June 95	358	6
Uganik River	3 June 95	356	7
Uganik River	3 June 95	356	6
Uganik River	3 June 95	346	6
Uganik River	3 June 95	342	6
Uganik River	3 June 95	317	6
Uganik River	4 June 95	364	6
Uganik River	4 June 95	378	6
Uganik River	4 June 95	365	6
Uganik River	4 June 95	364	7
Uganik River	4 June 95	362	7
Uganik River	4 June 95	361	6
Uganik River	4 June 95	318	5
Uganik River	4 June 95	326	6
Uganik River	4 June 95	259	5
Uganik River	4 June 95	309	5
Uganik River	4 June 95	340	6
Uganik River	4 June 95	358	6
Uganik River	4 June 95	348	6
Uganik River	4 June 95	352	6
Uganik River	5 June 95	312	5
Uganik River	5 June 95	308	5
Uganik River	5 June 95	300	5
Uganik River	5 June 95	307	6
Uganik River	5 June 95	331	5
Uganik River	5 June 95	328	5
Uganik River	5 June 95	422	6
Uganik River	5 June 95	364	6
Uganik River	5 June 95	368	6
Uganik River	5 June 95	399	6
Uganik River	5 June 95	400	6
Uganik River	5 June 95	418	7
Uganik River	5 June 95	429	7

APPENDIX 3.–(Continued).

River Name	Date Sampled	Length (mm)	Age (yr)
Uganik River	5 June 95	302	6
Uganik River	5 June 95	270	5
Uganik River	5 June 95	299	5
Uganik River	5 June 95	251	3
Uganik River	5 June 95	295	5
Uganik River	5 June 95	219	4
Uganik River	5 June 95	228	4
Uganik River	5 June 95	231	3
Uganik River	5 June 95	231	3
Uganik River	5 June 95	240	4
Uganik River	5 June 95	241	4
Uganik River	5 June 95	258	3
Uganik River	5 June 95	258	4
Uganik River	5 June 95	216	3
Uganik River	5 June 95	292	5
Uganik River	5 June 95	274	5
Uganik River	5 June 95	269	4
Uganik River	5 June 95	268	5
Uganik River	5 June 95	262	4
Uganik River	6 June 95	398	7
Uganik River	6 June 95	365	6
Uganik River	6 June 95	371	6
Uganik River	6 June 95	384	6
Uganik River	6 June 95	388	5
Uganik River	6 June 95	394	6
Uganik River	6 June 95	397	7
Uganik River	6 June 95	461	7
Uganik River	6 June 95	404	6
Uganik River	6 June 95	408	6
Uganik River	6 June 95	415	7
Uganik River	6 June 95	418	7
Uganik River	6 June 95	421	6
Uganik River	6 June 95	421	7
Uganik River	6 June 95	429	8
Uganik River	6 June 95	459	7
Uganik River	6 June 95	361	6
Uganik River	6 June 95	363	7
Uganik River	6 June 95	349	6

APPENDIX 3.–(Continued).

River Name	Date Sampled	Length (mm)	Age (yr)
Uganik River	6 June 95	359	6
Uganik River	6 June 95	354	6
Uganik River	6 June 95	300	5
Uganik River	6 June 95	351	5
Uganik River	6 June 95	166	3
Uganik River	6 June 95	230	4
Uganik River	6 June 95	261	4
Uganik River	6 June 95	264	5
Uganik River	6 June 95	267	4
Uganik River	6 June 95	288	5
Uganik River	6 June 95	287	5
Uganik River	6 June 95	301	5
*Uganik River	6 June 95	305	6
Uganik River	6 June 95	329	5
Uganik River	6 June 95	306	5
Uganik River	6 June 95	334	5
Uganik River	6 June 95	325	5
Uganik River	6 June 95	311	4
Uganik River	6 June 95	308	5
Uganik River	6 June 95	337	5
Uganik River	7 June 95	334	5
Uganik River	7 June 95	353	5
Uganik River	7 June 95	338	6
Uganik River	7 June 95	324	5
Uganik River	7 June 95	333	5
Uganik River	7 June 95	330	5
Uganik River	7 June 95	329	5
Uganik River	7 June 95	376	6
Uganik River	7 June 95	364	5
Uganik River	7 June 95	464	8
Uganik River	7 June 95	380	6
Uganik River	7 June 95	420	8
Uganik River	7 June 95	316	6
Uganik River	7 June 95	464	8
Uganik River	7 June 95	426	7
Uganik River	7 June 95	420	6
Uganik River	7 June 95	394	6
Uganik River	7 June 95	407	7
Uganik River	7 June 95	407	6

APPENDIX 3.–(Continued).

River Name	Date Sampled	Length (mm)	Age (yr)
Uganik River	7 June 95	403	7
Uganik River	7 June 95	318	5
Uganik River	7 June 95	304	5
Uganik River	7 June 95	310	6
Uganik River	7 June 95	310	5
Uganik River	7 June 95	268	4
Uganik River	7 June 95	256	5
Uganik River	7 June 95	224	4
Uganik River	7 June 95	226	4
Uganik River	7 June 95	274	5
Uganik River	7 June 95	201	3
Uganik River	7 June 95	199	3
Uganik River	7 June 95	271	4
Uganik River	7 June 95	249	4
Uganik River	7 June 95	275	5
Uganik River	7 June 95	305	5
Uganik River	7 June 95	276	4
Uganik River	7 June 95	306	5
Uganik River	7 June 95	302	6
Uganik River	7 June 95	292	5
Uganik River	7 June 95	290	5
Uganik River	7 June 95	280	5
Uganik River	7 June 95	280	5
Uganik River	8 June 95	324	6
Uganik River	8 June 95	400	6
Uganik River	8 June 95	377	6
Uganik River	8 June 95	339	5
Uganik River	8 June 95	325	6
Uganik River	8 June 95	263	4
Uganik River	8 June 95	315	5
Uganik River	8 June 95	289	5
Uganik River	8 June 95	287	4
Uganik River	8 June 95	279	4
Uganik River	8 June 95	437	7
Uganik River	6 July 95	359	6
Uganik River	6 July 95	336	6
Uganik River	7 July 95	336	5
Uganik River	7 July 95	334	6

APPENDIX 4.–List of comparison studies mean length-at-age comparison data.

River name	Year of Study	Author(s)
Upper Kenai R.	1995	McCarron, S. (unpubl)
Mink Cr	1990	Riffe, R. (1994)
Naknek	1991	Riffe, R. (1994)
Agulowak	1992	Minard, R.E and J.J. Hasbrouk (1994)
Kanektok	1993	Adams, F.J. (1996)
Good News	1989	Irving, D. and M. Faustini (1993)
Arolik	1991-94	Lisac, M.J. and R. MacDonald (1995)
Lwr. Talachulitina	1992	Riffe, R. (1994)
Susitna	1991	Rutz, D.S. (1993)