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Status of Rainbow Trout in Tributaries of the Upper King Salmon River, Becharof National Wildlife Refuge, Alaska, 1990-92

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Status of Rainbow Trout in Tributaries of the Upper King Salmon River, Becharof National Wildlife Refuge, Alaska, 1990-92

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Abstract.–The King Salmon River is a glacially turbid stream with several clear water tributaries that support rainbow trout *Oncorhynchus mykiss*. During the late 1980's, sport fishing effort appeared to increase on Gertrude Creek, one of the more easily accessible tributaries in the drainage. To monitor stock status of rainbow trout, Gertrude Creek and four other tributaries of the upper river were sampled using hook and line during May-September 1990-1991 and May-June 1992. One thousand two-hundred rainbow trout ≥ 200 mm were captured with fork lengths ranging from 200-652 mm and ages from scales ranging from 3-11 years. To estimate abundance, fish > 300 mm were marked with anchor tags, but a valid estimate could not be generated due to the low number of fish recaptured in each tributary.

To determine seasonal movements, rainbow trout were implanted with radio transmitters and relocated from aircraft during October 1991-October 1992. Most fish overwintered in four areas in the river, and entered only one tributary to spawn. Information from radio tagged and anchor tagged fish during summer and fall indicated that two geographic groups existed within the study area: one group predominately used the upper three tributaries while the second group used the two lower tributaries. Although most fish remained within one tributary during summer-fall, several fish moved among tributaries between and within the sampling years.

Rainbow trout in the King Salmon River were characterized by a sex composition, maturity, and spawning frequency typical of rainbow trout in southwest Alaska. Based on movements, maturity, size and age of fish captured during spring, Whale Mountain Creek appeared to be the primary spawning stream.

A creel survey conducted at Gertrude Creek in summer 1991 indicated that the fishery was small, it was strictly a catch and release sport fishery, and anglers targeted rainbow trout. Likewise, the winter subsistence fishery in the lower river was small, but targeted all species and was harvest oriented.

Three hundred ninety-seven Arctic grayling and 178 Dolly Varden were incidentally captured in Gertrude Creek during 1990-92. Fork lengths and ages ranged from 230-460 mm and 3-9 years for Arctic grayling. Fork lengths for Dolly Varden ranged from 220-627 mm; ages were not estimated. Dates of first capture suggested that Dolly Varden were anadromous.

The study indicated that the rainbow trout population in the upper King Salmon River was stable over the sampling years. With the limited amount of fishing effort and small harvest, there were no immediate threats to the population. To maintain the health of the population, conservative management is imperative and requires that the population and fishing pressure be monitored periodically. Arctic grayling and Dolly Varden populations should also be monitored as part of the rainbow trout studies.

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INTRODUCTION

Rainbow trout *Oncorhynchus mykiss* populations in southwest Alaska are world famous and support many sport and subsistence fisheries (Alaska Department of Fish and Game 1990). During the early to late 1980's, sport fishing effort on the Becharof National Wildlife Refuge (Refuge) increased considerably (U. S. Fish and Wildlife Service 1994). One of the streams reflecting this increase was Gertrude Creek, a tributary of the upper King Salmon River. The proximity of the stream to the community of King Salmon and the availability of rainbow trout partly accounts for its popularity. Due to the increase in fishing pressure, and little information available about the population, the King Salmon Fishery Resource Office (Office) initiated a rainbow trout population assessment on Gertrude Creek in 1990. This assessment was designed as the beginning of a long term project to monitor the population.

Previous information concerning rainbow trout in Gertrude Creek comes from surveys conducted by the U.S. Fish and Wildlife Service and the Alaska Department of Fish and Game (Department) once a season during 1970 (U.S. Fish and Wildlife Service, unpublished report, 1970), 1977, and 1983 (R. Russell, unpublished report, 1977a and 1983). Additionally, the Office conducted three sampling trips in 1988 and two trips in 1989 (B. Mahoney, unpublished report, 1988 and 1989). These trips were associated with other sampling projects, collected minimal data, and did not provide enough information to characterize the rainbow trout population.

As part of the initial assessment of Gertrude Creek in 1990, other tributaries in the upper King Salmon River within the Refuge were surveyed for the existence of rainbow trout. Rainbow trout were captured in these streams, and the project was expanded in 1991 to include these tributaries as well as Contact Creek within Katmai National Park and Preserve (Park).

Primary objectives were to: (1) describe the length and age compositions of rainbow trout in the study area; (2) estimate the abundance of rainbow trout ≥ 300 mm in the study area; (3) monitor the seasonal distribution of rainbow trout in the King Salmon River drainage; (4) describe the sex composition, spawning frequency, and maturity of rainbow trout from Gertrude Creek; (5) assess the value of using ages from otoliths to adjust the scale age distribution of rainbow trout from Gertrude Creek; and (6) estimate the seasonal catch and harvest of rainbow trout from Gertrude Creek. Secondary objectives were to describe the length and age compositions of incidentally captured Arctic grayling *Thymallus arcticus* and Dolly Varden *Salvelinus malma* in the study area.

STUDY AREA

The King Salmon River is located in the northern portion of the Alaska Peninsula (Figure 1). The headwater of the river consists of two glacial streams (Angle and Takayofo creeks) that form the King Salmon River about 10 km above the boundary of the Refuge and the Park. These streams begin in the Kejulik Mountains of the Aleutian Range and

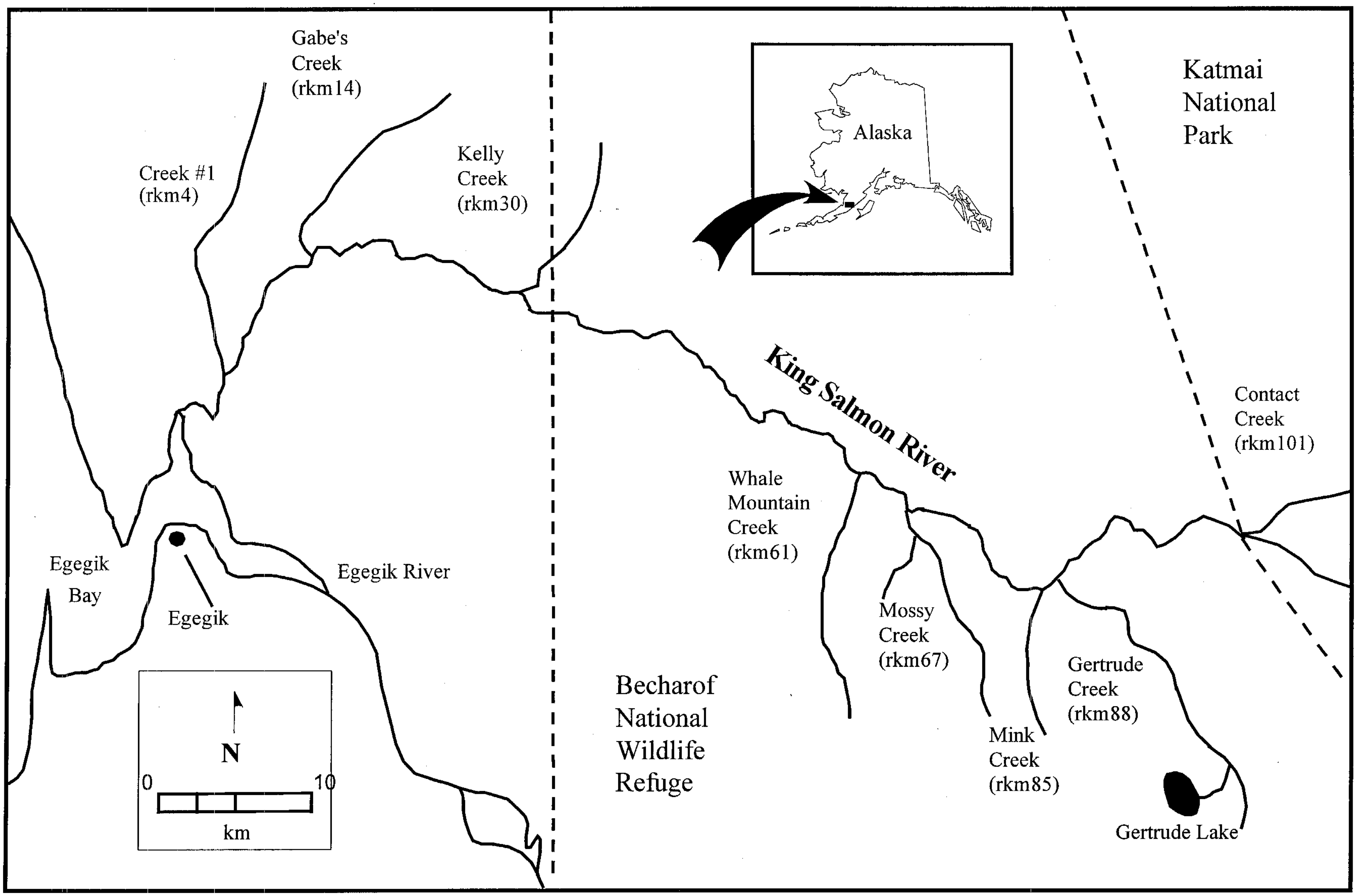

Figure 1. King Salmon River drainage. Rkm refers to river km of the mouth of the tributary.

flow 120 km to the Egegik River near the village of Egegik. The river remains one channel until it passes through some small rapids just above Gertrude Creek. From this point the King Salmon River is a typical glacial stream with highly turbid water and many braids. Several clear water tributaries enter the river throughout its course. The lower 3 km of the river are tidally influenced.

The climate of the area is moderate, polar maritime, characterized by high winds, mild temperatures, protracted cloud cover, and frequent precipitation (U.S. Fish and Wildlife Service 1985). Vegetation in the drainage is predominately lowland tundra with scattered areas of willow (*Salix* spp.).

Other fish species in the King Salmon River drainage include Arctic grayling, Dolly Varden, chinook *O. tshawytscha*, coho *O. kisutch*, sockeye *O. nerka*, chum *O. keta*, and pink *O. gorbuscha* salmon, round whitefish *Prosopium cylindraceum*, northern pike *Esox lucius*, and slimy sculpin *Cottus cognatus*.

The study area in 1990 included only the portion of Gertrude Creek from east of Gertrude Lake to the stream's mouth (15 km). The study area in 1991 and 1992 included the lower 10 km of Contact Creek, the lower 5 km of Gertrude and Whale Mountain creeks, and the lower 3 km of Mink and Mossy creeks. These streams are small and shallow with clear but tannin-stained water and range from 3-30 m in width. They consist of series of pools-runs-riffles with predominant substrates of sand and gravel. Gertrude Creek is the largest of the tributaries; Mink Creek the smallest. The portion of the study area within Contact Creek had the highest gradient; Mossy Creek the lowest.

METHODS

Length and Scale Age

Sampling during 1990 focused on Gertrude Creek. Access to the area was by float airplane landing on Gertrude Lake. A small raft and other equipment were carried to the stream on foot. Six raft trips ranging from 8-10 days each were conducted about every two weeks from 25 May to 19 September on the lower 15 km of the stream. One raft trip was extended to sample Mink, Mossy, and Whale Mountain creeks to assess the feasibility of expanding the project to include these tributaries in 1991. Sampling in 1991 and 1992 focused on Contact, Gertrude, Mink, Mossy, and Whale Mountain creeks with periodic sampling of the main river. Access to the area was by wheeled airplane landing at an airstrip near Contact Creek. A raft and other equipment were carried to the stream on foot. The lower 10 km of Contact Creek were sampled before entering the King Salmon River and floating to the mouths of the remaining tributaries. From the mouths of the tributaries, the study area on each stream was sampled on foot. Six raft trips ranging from 11-13 days each were conducted about every three weeks beginning on 12 May and ending on 18 September 1991. A single trip of nine days was conducted from 27 May to

4 June in 1992 on the same areas of all tributaries. Each tributary was sampled for 2-3 days on each trip. At the completion of each sampling trip, the crew floated down the King Salmon River to a gravel bar for pickup. In 1990 and 1991, crews consisted of two people. In 1992 the only trip consisted of four people and two rafts. All fish were captured by hook and line using artificial lures.

Fork length (mm) was recorded for all captured rainbow trout. Kolmogorov-Smirnov paired tests compared cumulative length frequency distributions for rainbow trout captured in Gertrude Creek in 1990 and 1991; in all tributaries in 1991; and in all tributaries during the spawning season (12 May- 4 June) in all years. Due to gear selectivity against small fish, length distributions were truncated to include only fish ≥ 200 mm.

Scales from rainbow trout ≥ 200 mm were collected from the preferred scale area (Jearld 1983) and aged according to Koo (1962). In 1990 scales were collected from all rainbow trout captured in Gertrude Creek. In 1991 scales were systematically collected from 75% of the rainbow trout captured. In 1992 scales were collected from all rainbow trout captured. Scales were not collected from recaptured rainbow trout. Ages were interpreted by two readers and disagreements resolved by conference. Regenerated scales were discarded. X^2 tests of independence were used to compare age frequency distributions for the same groups of rainbow trout as those used in testing length distributions. Depending on the tributary and year, to ensure that the number of cells with expected frequencies > 5 was > 80% (Santner and Duffy 1989), combinations of ages 3, 9, 10 and 11 were excluded from the X^2 analyses. Data for comparisons of length and age were standardized by date and sampling area within each stream. Mean length at age was calculated within each tributary within each year. Sample sizes with less than 30 fish were not used in any of the analyses. All the statistical tests used in this report were conducted with $\alpha = 0.05$ using the computer program, SYSTAT for Windows 1992.

Abundance Estimate

During 1990 rainbow trout ≥ 300 mm that were captured in Gertrude Creek were marked with numbered anchor tags (Floy Tag and Manufacturing, Seattle WA). The adipose fin was clipped as a secondary mark to assess tag loss. It was assumed that rainbow trout in Gertrude Creek were a closed population, but the capture of marked fish in other tributaries during 1990 invalidated this assumption. Therefore, the other tributaries within the study area were included in sampling during 1991 and 1992.

The same marking protocol was adopted for rainbow trout captured in the five tributaries in 1991. Fish that were captured in the clear water plume where a tributary entered the river were considered to have been captured in the tributary. An abundance estimate was attempted using the Schnabel multiple event closed population model (Krebs 1989). Only data from 1991 was used. The model operates on the following assumptions: (1) the population is closed with no recruitment, mortality, immigration or emigration; (2) all fish have equal capture probability in the first capture event or in later capture events, or marked fish mix completely with unmarked fish prior to later capture events; (3) marking does not affect capture probability in later capture events; (4) marks are not lost between capture events; and (5) all recaptured fish are correctly identified and recorded (Krebs 1989).

The abundance estimate was calculated as follows:

$$\hat{N} = \frac{\Sigma(C_t M_t)}{\Sigma(R_t)}$$

The variance of the Schnabel estimator is calculated on the reciprocal of N:

$$Var\left(\frac{1}{\hat{N}}\right) = \frac{\Sigma R_t}{(\Sigma C_t M_t)^2}$$

where:

C_t = the total number of rainbow trout ≥ 300 mm captured in sample event t;

M_t = the number of marked rainbow trout ≥ 300 mm at large just before sample event t;

R_t = the number of marked rainbow trout ≥ 300 mm captured in sample event t.

Although fishing mortality may have occurred, harvest was low (see Effort, Catch, and Harvest section), and any hooking and handling mortality from sport fishers was assumed to affect marked and unmarked fish equally. The sampling crew handled and tagged captured fish with care to minimize stress and to preclude violation of the assumption that marking affected the probability of capture in future events. Natural mortality was assumed to act equally on marked and unmarked fish. All captured fish were examined for marks, and data were recorded accurately. Any emigration from study area was assumed to affect marked and unmarked fish equally. To test for immigration, a X^2 test of independence was used to compare the ratio of marked to unmarked fish among sampling events. To test for equal probability of capture among the tributaries and to determine if marked fish mixed equally among the tributaries two X^2 tests of independence were conducted.

To test for equal probability of capture by length, two two-sample Kolmogorov-Smirnov tests were conducted. The first test compared the cumulative length frequency distribution of all rainbow trout ≥ 300 mm captured during the first event with fish ≥ 300 mm recaptured later. The second test compared the cumulative length frequency distributions of all rainbow trout ≥ 300 mm captured during the first event with all rainbow trout ≥ 300 mm captured later.

Small unnamed tributaries within the study area were not sampled. Other small unnamed tributaries above the mouth of Contact Creek were periodically sampled for marked rainbow trout. Due to the location of the landing area for pickup after completion of sampling, no tributaries downstream of the mouth of Whale Mountain Creek were sampled.

Movement

Radio Telemetry.- During 16-27 August and 8-17 September 1991, 39 radio transmitters from AVM (AVM Instrument Company, Limited, Livermore, CA) were surgically implanted into rainbow trout from the five main tributaries within the study area. Transmitters operated in the 40 MHZ range, and individual frequencies were generally separated by 10 KHz. Transmitters were 60 mm long, 14 mm in diameter, and weighed 11 g. Following the criteria of Winter (1983) where transmitter weight should not exceed 2 percent of fish weight, the smallest fish to be implanted was 550 g. However, to minimize the burden, the minimum weight of each fish actually implanted was 600 g. Fish were captured by hook and line and anesthetized to stage 4 (Summerfelt and Smith 1990) with MS-222. Surgical procedures followed Summerfelt and Smith (1990). The gills of each fish were continually bathed with stream water during surgery. After surgery each fish was held upright in gently flowing water to facilitate recovery. Fish were released near the capture site in a protected area of the stream when they were fully recovered.

Implanted fish were monitored with an ATS (Advanced Telemetry Systems, Ipsilanti, MN) scanner/receiver from fixed wing aircraft flying at 140 km/h and 300 m above the ground. On each flight the five tributaries and the main stem river from the confluence of Angle and Takayofo creeks to the Refuge boundary below Whale Mountain Creek were searched a minimum of three times. The lower 10 km of Angle and Takayofo creeks and the area of the river downstream of the Refuge boundary were searched once toward the end of each flight. Aerial relocation was conducted monthly from October 1991 to October 1992 except during May 1992 when relocation was conducted twice to identify spawning aggregations.

The location of each implanted fish was recorded as the location directly beneath the aircraft when the volume of the signal from that transmitter was loudest. Accuracy of the relocation was estimated to be within 1 km of the actual location of the transmitter.

Anchor tags.- Fish marked and recaptured during 1990-92 were also monitored for movement. For fish recaptured more than once in the same tributary within a season, only the initial recapture was used to identify movement. A two-sample Kolmogorov-Smirnov test of length frequencies was used to describe any differences in movement between fish captured and recaptured in the same tributary versus fish captured and recaptured in different tributaries. For multiple recaptures, length and location of the most recent capture were used as the basis for comparison with the length and location at recapture.

Sex Composition, Maturity, and Spawning Frequency

Sexes of rainbow trout were determined by inspection of the fresh gonads from fish sacrificed for otolith collection during 1990 at Gertrude Creek. Modifying the criteria of Martin and Olver (1980) for lake trout *S. namaycush*, fish whose sex could be determined were considered to be mature. Fish whose sex could not be determined were classified as juveniles. Females with residual eggs or egg diameters from 4-7 mm were considered to be spawners. Males with a testis width > 10 mm and any fish that released gametes during handling were also considered to be spawners. The sex ratio was determined only from sacrificed fish. Spawning frequency for females was determined by presence/absence of retained eggs and diameter of developing eggs.

Scale and Otolith Age Comparison

Scale ages are known to underage fish (Lentsch and Griffith 1987). In 1988 a preliminary study was conducted to assess the feasibility of compensating for under aging by using ages estimated from sagittal otoliths to adjust scale ages of rainbow trout from Gertrude Creek. The stream was accessed opportunistically by helicopter during 29 April - 4 September. In 1990 a sub sample of rainbow trout captured for the current study was also sacrificed for collection of otoliths. In both years a collection of 10 pairs of otoliths per 25 mm length group was attempted. Otoliths were stored dry in coin envelopes, cleared with clove oil, and read according to Barber and McFarlane (1987). Otoliths were read whole under a microscope by two readers with disagreements resolved by conference. Scales were collected and read as described previously. The scale age frequency distribution was modified from the otolith age frequency distribution to produce an adjusted scale age frequency distribution using the proportional contribution equation from Wagner (1991):

$$E_j = \sum_{i,j=1} S_i A_{ij} \div T_i$$

where:

E_j = the estimated number of adjusted scale aged j fish
S_i = the total number of scale aged i fish in the scale aged sample
A_{ij} = the number of otolith age j fish in the scale age i category of the otolith and scale aged sample
T_i = the total number of scale age i fish in the otolith and scale aged sample

Scale, otolith, and adjusted scale age frequency distributions were compared with X^2 tests of independence. To ensure that the number of cells with expected frequencies > 5 was > 80% (Santner and Duffy 1989), ages 9 and 10 were excluded from the X^2 analyses for scale age distributions and ages 10, 11, and 12 were excluded from analysis of the otolith age distributions.

Effort, Catch and Harvest Estimates

During May-August 1991 a creel survey was conducted on the lower 5 km of Gertrude Creek. This area is known by fishing guides to be the most productive section of the stream for anglers fishing for rainbow trout. This perception was also supported with data from this study during 1990. The crew was stationed at an airstrip that is the main access point to the creek, and all anglers were interviewed only after completed trips. The study area for the creel was surveyed daily to count anglers. Anglers were requested to provide: 1) the species of fish targeted; 2) the number of hours fished per angler per day; 3) the number of fish captured by species; 4) the number of fish harvested by species; and 5) if they considered themselves to sport or subsistence fishermen.

Data collected was designed to estimate catch and harvest of each species based on the formulae of Scheaffer et al. (1986) as follows:

The average weekly catch per angler determined by:

$$\overline{Y}_j = \frac{\sum_{i=1}^{n_j} Y_{ij}}{n_j}$$

where:

Y_{ij} = Catch for the i^{th} angler from complete-trip interviews during the j^{th} week.
n_j = # anglers from completed trip interviews for the j^{th} week.

The total estimated catch for a week determined by:

$$C_j = N_j \overline{Y}_j$$

where:

N_j = the sum of the daily angler counts for the j^{th} week.

The variance of the catch from complete-trip interviews for a week calculated as:

$$s_j^2 = \frac{\sum_{i=1}^{n_j} (Y_{ij} - \overline{Y}_j)^2}{n_j - 1}$$

The variance of the estimated catch for a week calculated as:

$$VAR_j = N_j^2 \left(\frac{s_j^2}{n_j}\right)\left(\frac{N_j - n_j}{N_j}\right)$$

The 95% confidence interval of the estimated catch for a week calculated as:

$$CI_j = 2\sqrt{VAR_j}$$

The estimated total catch for the season calculated as:

$$C_s = \sum_j C_j$$

The variance of the season's estimated catch calculated as:

$$VAR_s = \sum_j VAR_{jc}$$

The 95% confidence interval of the season's estimated catch calculated as:

$$CI_s = 2\sqrt{VAR_s}$$

Fork length and sex were recorded and scale samples were collected from harvested fish. Captured and released fish were not sampled.

Arctic grayling and Dolly Varden

Fork length was recorded from all Arctic grayling and Dolly Varden incidentally captured during all years of the study. In 1990 scales were collected from every second Arctic grayling captured in all tributaries. In 1991 scales were collected in the same manner in all tributaries except Contact Creek where scales were collected from all fish. Scales were collected from all Arctic grayling from all tributaries in 1992. Scales were aged with the same methods used for rainbow trout. No aging structures were collected from Dolly Varden. No statistical analyses were conducted with these data. Tributaries with sample sizes < 30 in any year were not included.

RESULTS

Length and Scale Age

Sample sizes of rainbow trout ≥ 200 mm ranged from zero in Contact Creek in 1992 to 298 in Whale Mountain Creek in 1991 (Table 1). Six of the 10 Kolmogorov-Smirnov tests from 1990 and 1991 resulted in significant differences in length frequency distributions between tributaries (Table 2 and Figures 2-3). Four of 10 X^2 tests from 1990 and 1991 resulted in significant differences in age frequency distributions between tributaries (Table 2 and Figure 4). Rainbow trout were captured only in the lower 5 km of Contact Creek. Fish captured in the main stem river within the clear water plume of a tributary were assigned to that tributary. No fish were captured in the turbid water of the main stem river. Contact Creek was not sampled in 1990.

Mean length at age ranged from 240 mm at age 3 in Mink Creek during 1991 to 638 mm at age 10 in Gertrude Creek in 1990 (Table 3). About one quarter of the scale samples were unreadable.

Results from Kolmogorov-Smirnov paired tests of length frequency distributions during spring 1990-92 indicated that significantly larger ($P < 0.01$) rainbow trout were captured in all years from Whale Mountain Creek than in all tributaries except Mink Creek in 1992 ($P > 0.25$) (Table 4 and Figures 5 and 6). X^2 tests of independence for age frequency distributions also indicated that significantly older ($P < 0.001$) rainbow trout were captured in Whale Mountain Creek than in all tributaries except Gertrude Creek in 1990 ($P > 0.08$) (Table 4 and Figure 7). However, the age distributions from 1991 and 1992 within Whale Mountain Creek were also significantly different ($P = 0.03$).

Abundance Estimate

The significant difference between the numbers of marked to unmarked fish ($X^2 = 11.42$; df = 4; $P = 0.02$) indicated that immigration had occurred after the third event (Table 5). The data were truncated and further testing only included data collected during the first three sampling events. Because no marked rainbow trout < 355 mm were recaptured, the data were again truncated to reflect this minimum size. Although three fish were missing tags, the fresh secondary mark indicated that these fish had been tagged during the previous event in 1991. No rainbow trout were captured in tributaries above the mouth of Contact Creek.

Since the data from event 3 contained more recaptures and exhibited a higher marked to unmarked ratio than event 2, only data from event 3 were used to check for equal probability of capture and equal mixing. The significant differences from X^2 tests indicated that the probability of capture was not equal ($X^2 = 11.46$; df = 4; $P = 0.02$) (Table 6), and that marked fish did not mix equally among the tributaries ($X^2 = 67.69$; df = 16; $P < 0.001$) (Table 7). Also, the small number of recaptures in both X^2 tests violated

Table 1. Sample sizes of rainbow trout ≥ 200 mm captured by hook and line from the tributaries of the upper King Salmon River, 1990-1992.

Tributary	Year		
	1990	1991	1992
Contact Creek	-	26	0
Gertrude Creek	189	259	17
Mink Creek	27	86	30
Mossy Creek	10	110	37
Whale Mountain Creek	16	298	121
Total	242	779	205

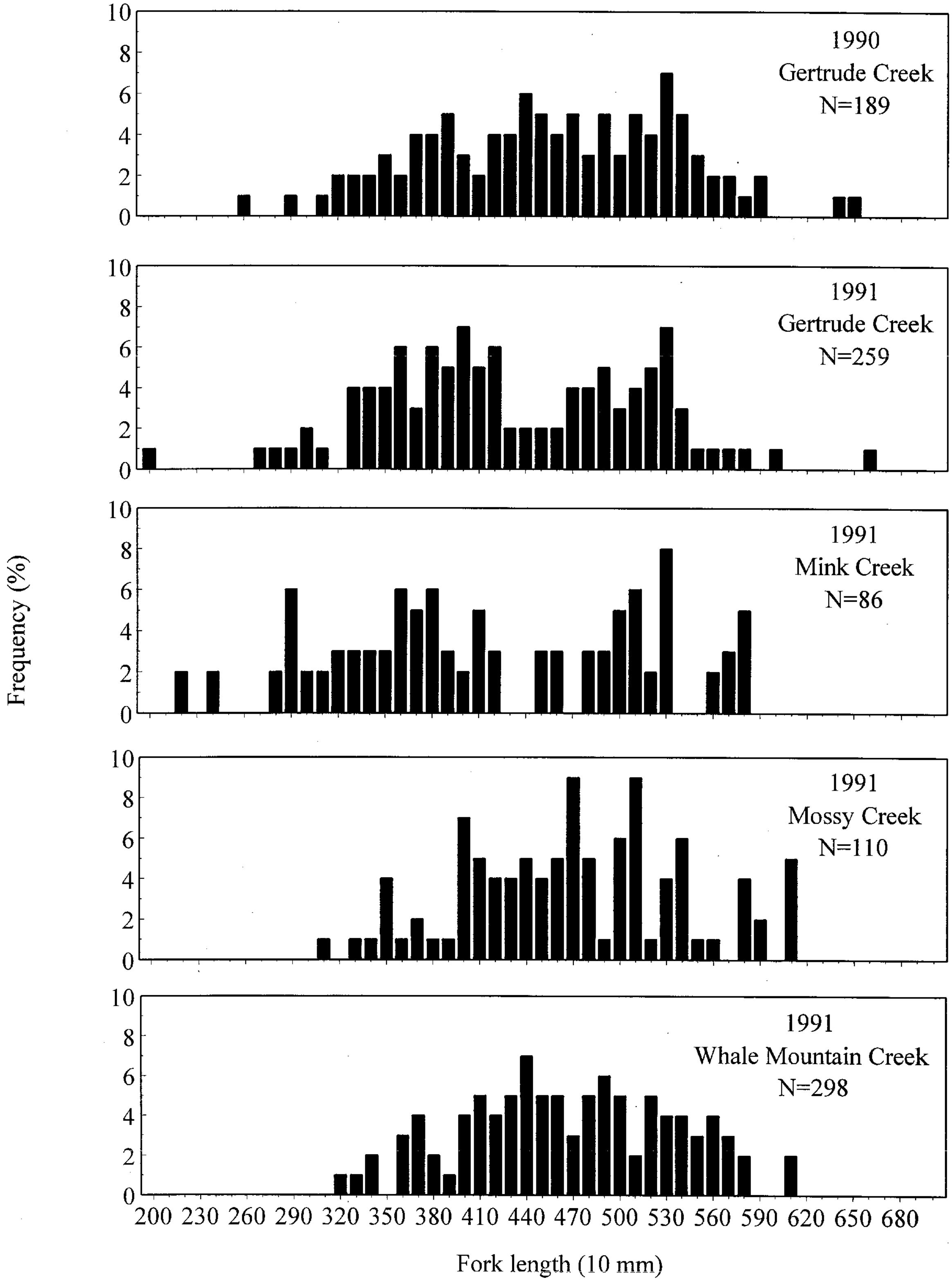

Figure 2. Fork length frequency distributions for rainbow trout captured by hook and line from Gertrude Creek, 1990 and 1991 and from Mink, Mossy, and Whale Mountain creeks, 1991.

Table 2. Probability values for paired Kolmogorov-Smirnov tests of length distributions (top) and paired X^2 tests of age distributions (bottom) from rainbow trout captured by hook and line from tributaries of the upper King Salmon River, 1990 and 1991.

Tributary	Gertrude Creek 1990	Gertrude Creek 1991	Mink Creek 1991	Mossy Creek 1991	Whale Mountain Creek 1991
Gertrude Creek 1990	1.00 1.00	- -	- -	- -	- -
Gertrude Creek 1991	< 0.001[a] <0.01[a]	1.00 1.00	- -	- -	- -
Mink Creek 1991	<0.01[a] 0.27	0.27 0.91	1.00 1.00	- -	- -
Mossy Creek 1991	0.37 0.67	<0.01[a] <0.01[a]	<0.01[a] 0.13	1.00 1.00	- -
Whale Mountain Creek 1991	0.44 0.09	< 0.001[a] < 0.001[a]	< 0.001[a] <0.01[a]	0.77 1.00	1.00 1.00

[a] Denotes significant differences at $\alpha = 0.05$

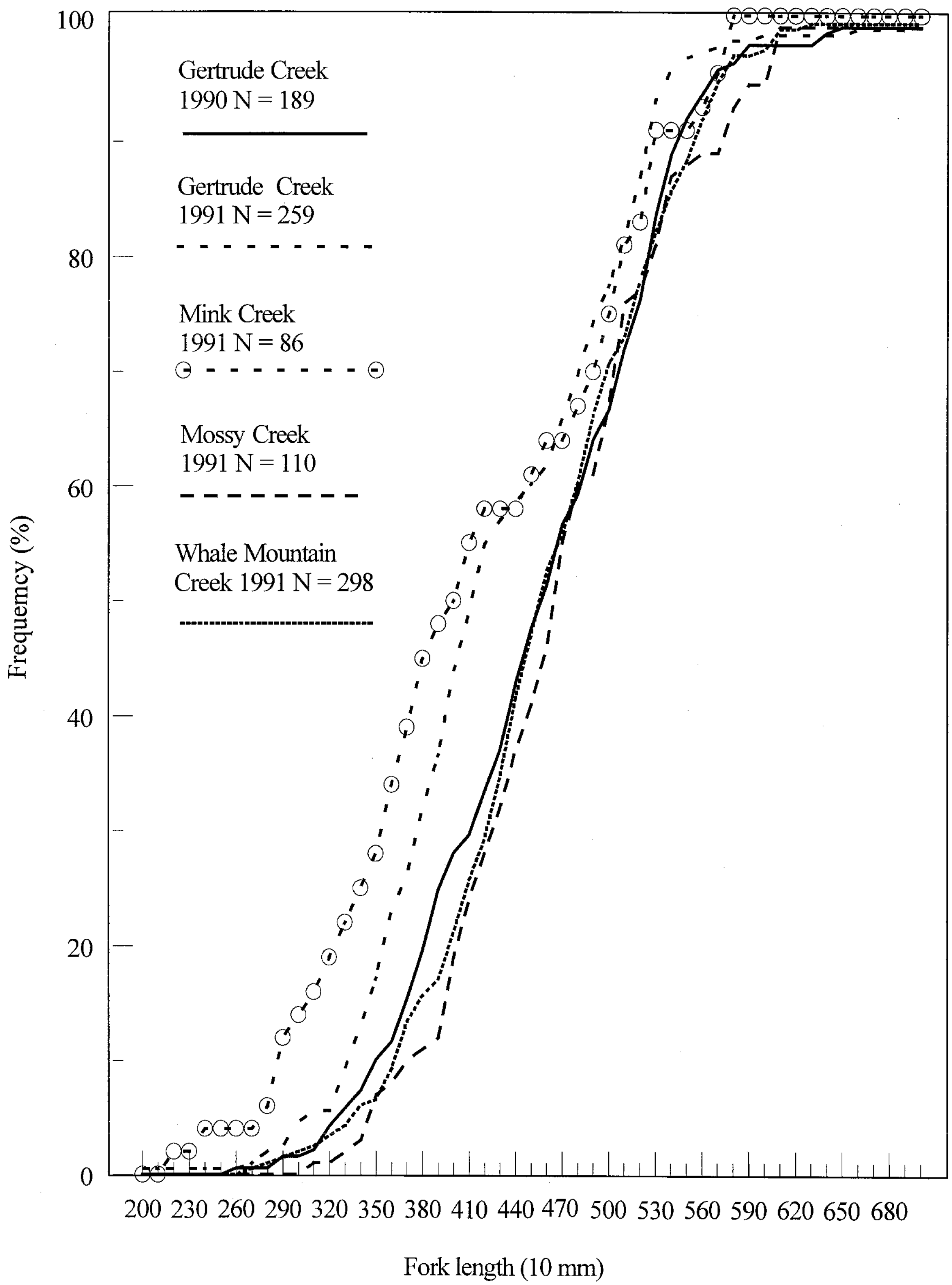

Figure 3. Cumulative fork length frequency distributions for rainbow trout captured by hook and line from Gertrude Creek, 1990 and 1991 and from Mink, Mossy, and Whale Mountain creeks, 1991.

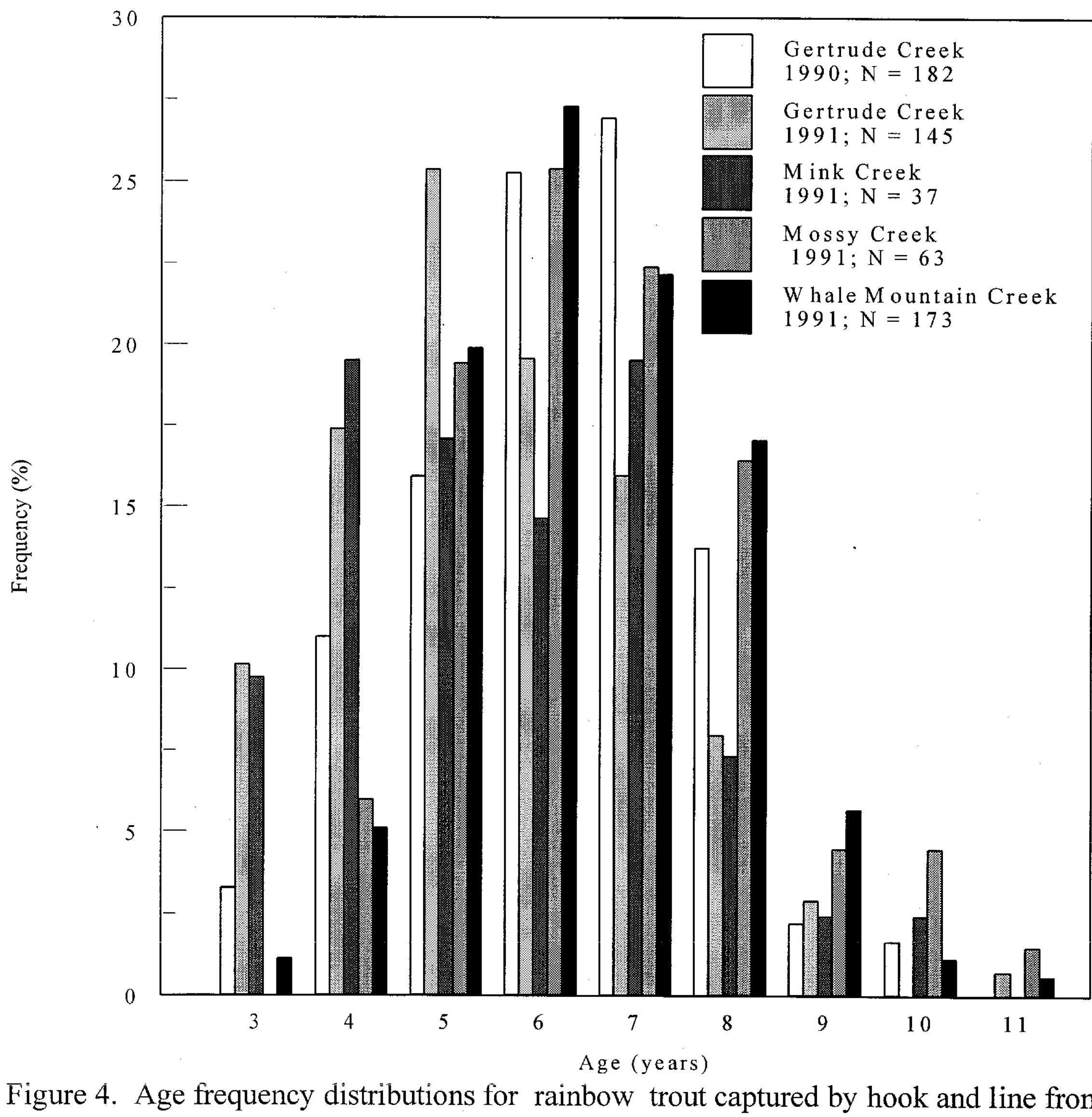

Figure 4. Age frequency distributions for rainbow trout captured by hook and line from Gertrude Creek, 1990 and 1991 and from Mink, Mossy, and Whale Mountain creeks, 1991.

Table 3. Mean fork lengths (FL; mm) at age, standard deviations (SD), and sample sizes (N) for rainbow trout captured by hook and line from Gertrude Creek, 1990-91 and Mink, Mossy and Whale Mountain creeks, 1991-92.

	Age								
	3	4	5	6	7	8	9	10	11
1990									
Gertrude Creek									
FL (SD)	350 (54.6)	344 (26.4)	415 (61.0)	451 (58.0)	482 (48.0)	516 (36.6)	543 (22.8)	638 (4.0)	-
N	6	20	46	46	49	25	4	3	0
1991									
Gertrude Creek									
FL (SD)	294 (39.3)	351 (31.2)	405 (57.9)	450 (56.3)	489 (57.2)	505 (40.7)	510 (59.8)	-	512 (-)
N	21	23	35	28	22	11	4	0	1
Mink Creek									
FL (SD)	240 (33.0)	323 (38.6)	388 (62.6)	420 (55.8)	478 (68.8)	490 (20.0)	441 (-)	560 (-)	-
N	3	10	7	5	8	2	1	1	0
Mossy Creek									
FL (SD)	-	332 (44.1)	375 (26.3)	456 (31.9)	450 (33.9)	537 (35.3)	524 (27.1)	571 (34.7)	577 (-)
N	0	4	12	16	14	10	3	3	1
Whale Mountain Creek									
FL (SD)	270 (14.2)	341 (64.7)	394 (48.8)	443 (50.5)	483 (59.7)	513 (44.2)	529 (52.9)	525 (25.5)	555 (-)
N	4	12	32	43	34	35	10	2	1
1992									
Mossy Creek									
FL (SD)	257 (12.0)	363 (44.7)	408 (42.2)	423 (33.2)	485 (58.0)	486 (-)	497 (-)	-	-
N	2	4	12	12	5	1	1	0	0
Whale Mountain Creek									
FL (SD)	-	374 (49.3)	443 (54.0)	484 (42.9)	512 (56.4)	516 (55.7)	527 (45.9)	-	-
N	0	7	21	31	35	14	4	0	0

Table 4. Probability values for paired Kolmogorov-Smirnov tests of length distributions (top) and paired X^2 tests of age distributions (bottom) from rainbow trout captured by hook and line from tributaries of the upper King Salmon River during spawning seasons 1990-92.

Tributary	Gertrude Creek 1990	Gertrude Creek 1991	Mink Creek 1992	Mossy Creek 1992	Whale Mountain Creek 1991	Whale Mountain Creek 1992
Gertrude Creek 1990	1.00 1.00	- -	- -	- -	- -	- -
Gertrude Creek 1991	0.26 0.55	1.00 1.00	- -	- -	- -	- -
Mink Creek 1992	0.06 [b]	0.02[a] [b]	1.00 1.00	- -	- -	- -
Mossy Creek 1992	0.39 0.44	0.39 0.15	0.01[a] [b]	1.00 1.00	- -	- -
Whale Mountain Creek 1991	0.01[a] 0.08	< 0.001[a] < 0.001[a]	0.42 [b]	< 0.001[a] < 0.001[a]	1.00 1.00	- -
Whale Mountain Creek 1992	0.01[a] 0.71	< 0.001[a] < 0.001[a]	0.25 [b]	< 0.001[a] < 0.001[a]	0.89 0.03[a]	1.00 1.00

[a] Denotes significant differences at $\alpha = 0.05$

[b] Insufficient sample size

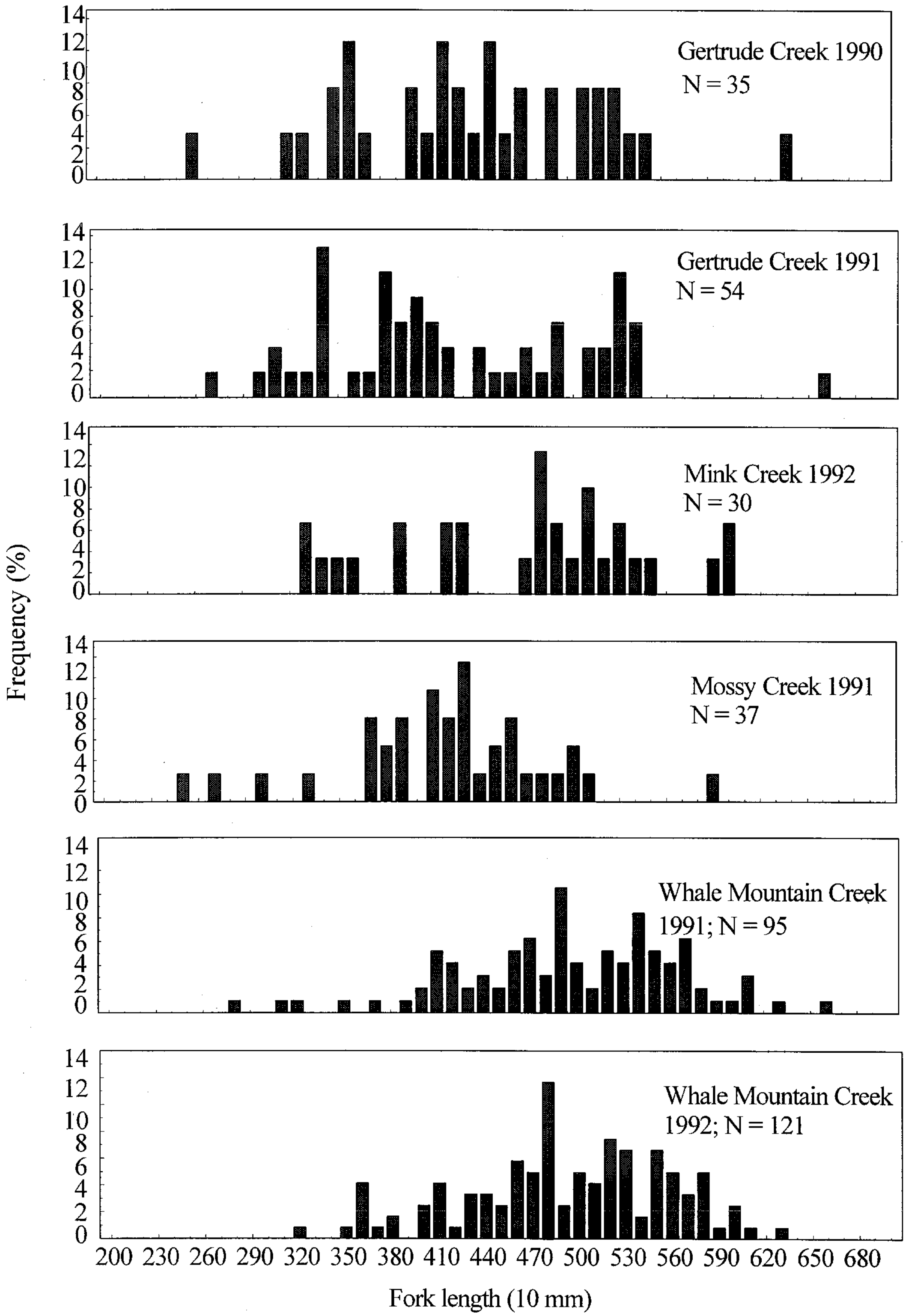

Figure 5. Fork length frequency distributions for rainbow trout captured by hook and line from Gertrude, Mink, Mossy, and Whale Mountain creeks during spawning seasons, 1990-1992.

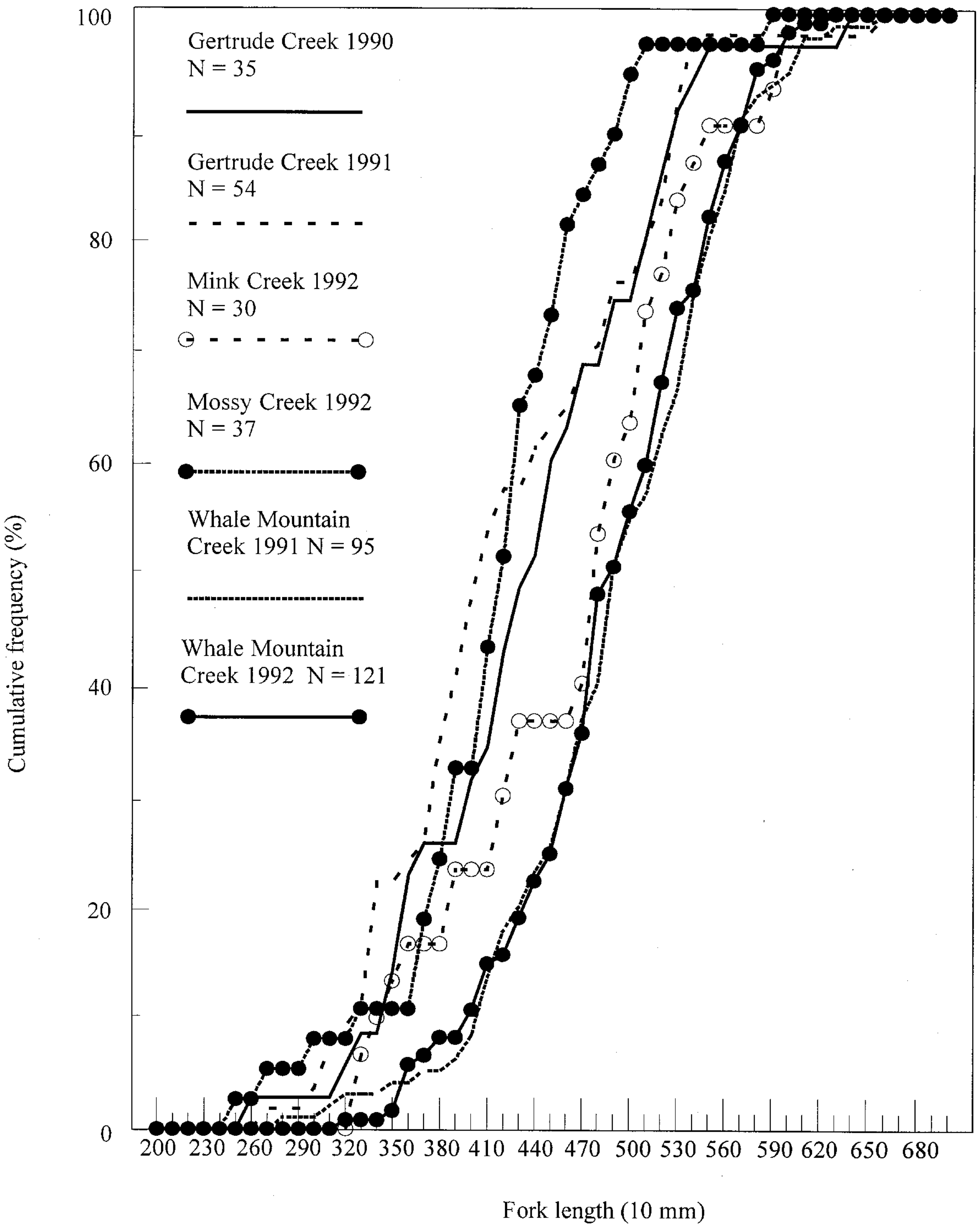

Figure 6. Cumulative fork length frequency distributions for rainbow trout captured by hook and line from Gertrude, Mink, Mossy, and Whale Mountain creeks during spawning seasons, 1990-92.

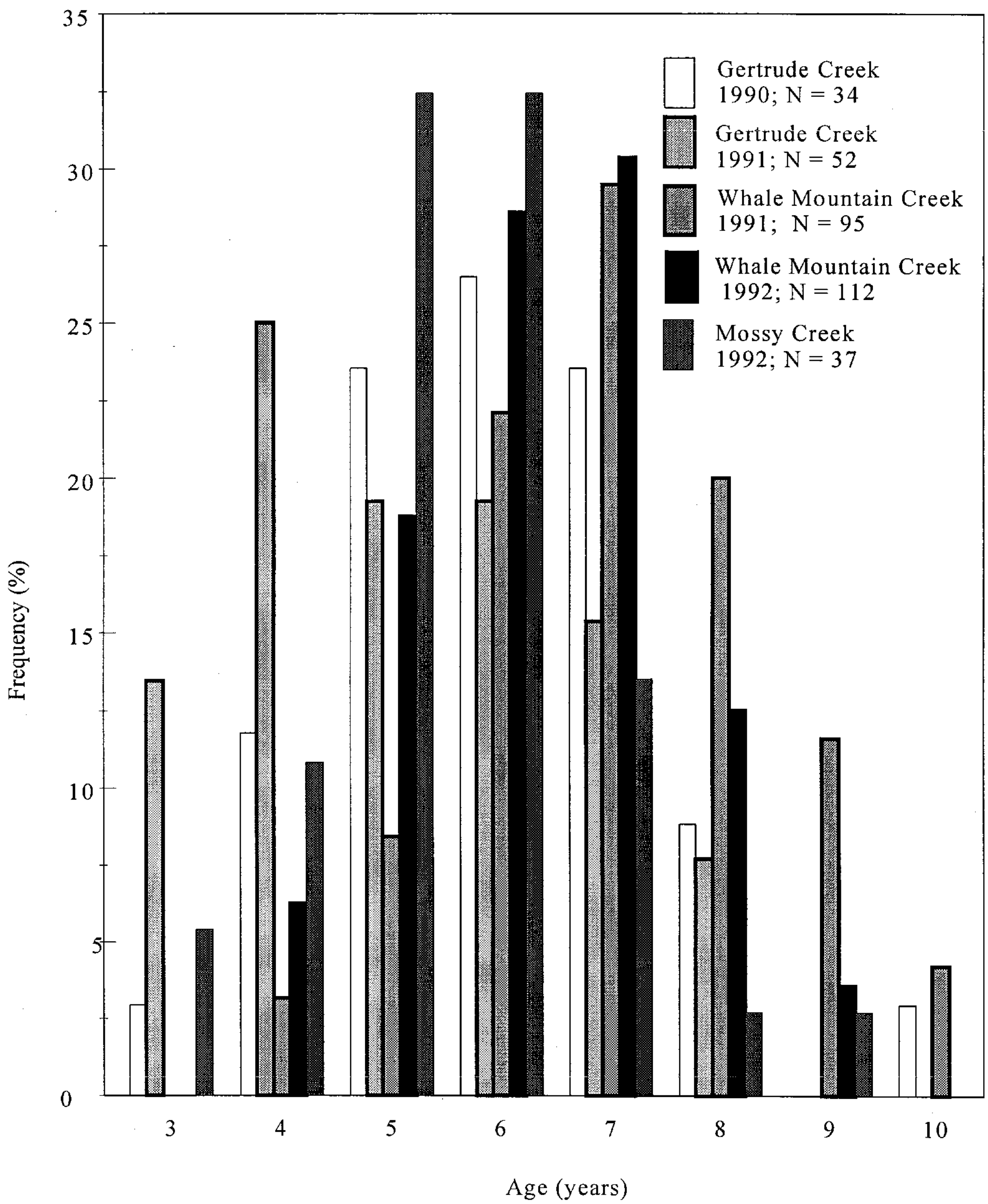

Figure 7. Age frequency distributions of rainbow trout captured by hook and line from Gertrude, Mink, Mossy, and Whale Mountain creeks during spawning seasons, 1990-92.

Table 5. Numbers of unmarked and marked and marked to unmarked ratios of rainbow trout ≥ 355 captured by hook and line from the five main tributaries of the upper King Salmon River during each sampling event, 1991.

	Sampling event and date						
	1	2	3	4	5	6	Total
	12-24 May	15-26 Jun	5-17 Jul	27 Jul-8 Aug	17-29 Aug	8-18 Sep	
Unmarked	141	119	70	69	54	63	516
Marked	-	19	28	13	14	24	98
Ratio	-	0.16	0.40	0.19	0.26	0.38	0.19

X^2=11.42; df=4; P=0.02

Table 6. Numbers of marked and unmarked, and marked to unmarked ratios of rainbow trout ≥ 355 mm captured by hook and line from the five main tributaries of the study area during sampling event 3, 1991.

	Tributary					
Recapture location	Contact Creek	Gertrude Creek	Mink Creek	Mossy Creek	Whale Mountain Creek	Total
Marked	1	4	7	8	8	28
Unmarked	3	21	5	9	32	70
Ratio	0.33	0.19	1.40	0.89	0.25	0.40

X^2=11.46; df=4; P=0.02 (expected frequencies in >20% of cells is < 5; Santner and Duffy 1989)

Table 7. Numbers of rainbow trout ≥ 355 mm recaptured by hook and line in each tributary during sampling event 3, 1991, and the tributary where the fish was previously captured.

	Tributary of recapture					
Tributary of previous capture	Contact Creek	Gertrude Creek	Mink Creek	Mossy Creek	Whale Mountain Creek	Total
Contact Creek	1	0	0	0	0	1
Gertrude Creek	0	4	2	1	0	7
Mink Creek	0	0	2	0	0	2
Mossy Creek	0	0	2	6	0	8
Whale Mountain Creek	0	0	1	1	8	10
Total	1	4	7	8	8	28

X^2=67.69; df=16; P<0.001 (expected frequencies in >20% of cells is < 5; Santner and Duffy 1989) the requirement that expected frequencies in > 20% of the cells be > 5 (Santner and Duffy 1989). The significant differences and the few recaptures canceled the need to test for equal probability of capture by length, and an abundance estimate was not generated.

Movement

Radio telemetry.- A total of 39 transmitters was implanted in rainbow trout from Contact (N = 7), Gertrude (N = 9), Mink (N = 7), Mossy (N = 8), and Whale Mountain (N = 8) creeks. Fork lengths and weights of the fish that received transmitters ranged from 355 mm and 600 g to 574 mm and 2,300 g. Of the 39 transmitters implanted, information from 16 was not appropriate for analysis: 12 transmitters (31%) were never relocated and were assumed to have failed; two (5%) fish apparently died soon after implantation; and two (5%) fish were relocated only during the first flight. Therefore, movements of 23 (59%) implanted fish were analyzed: four from Contact Creek; three from Gertrude Creek; five from Mink Creek; seven from Mossy Creek; and four from Whale Mountain Creek (Appendix A). Fourteen flights were conducted with a maximum of 20 and a minimum of three fish per flight relocated. The number of fish relocated during fall 1991 and winter 1991-92 ranged from 17-22. During spring and summer 1992, signals from 14 transmitters were received. By October 1992 only three transmitters were operating, and the project was terminated.

The number of relocations for an individual fish throughout the study ranged from 1-12. During the first flight in October 1991, 53% of the relocated fish were detected at their release sites. Of the remaining fish, equal numbers moved upstream or downstream from their release sites. Other than the two fish that died, there appeared to be no additional effects from surgery. The first relocation of an implanted fish in an overwintering area occurred during the 9 November 1991 flight, and by January 1992 all the relocated fish had moved into the river (Figure 8). From 10 January-2 March 1992 six locations in the river were identified as overwintering areas. Twenty of 22 (91%) relocated fish were regularly observed in four areas with 14 (64%) of these fish relocated in the two areas near Mossy and Whale Mountain creeks.

There were three general patterns of movement to overwintering areas based on the tributary where fish were implanted with radio transmitters: (1) three of four fish from Contact Creek overwintered upstream of the mouth of Gertrude Creek and included the only fish that overwintered above the study area; the fourth fish overwintered near Mink Creek; (2) four of the seven fish from Gertrude and Mink creeks overwintered in the Mossy-Whale Mountain creeks area, two fish overwintered in the Gertrude-Mink creeks area, and one fish overwintered at a location below the study area; and (3) ten of the 11 fish from Mossy and Whale Mountain creeks overwintered in the Mossy-Whale Mountain creeks area with the remaining fish above Gertrude Creek.

During spring (20 April-26 May 1992) 14 implanted fish were relocated. On 20 April 1992 only four implanted fish were located, and all were residing in the river. By 11 May, four of 10 (40%) relocated fish had moved into tributaries, and by 26 May, 11 of 12

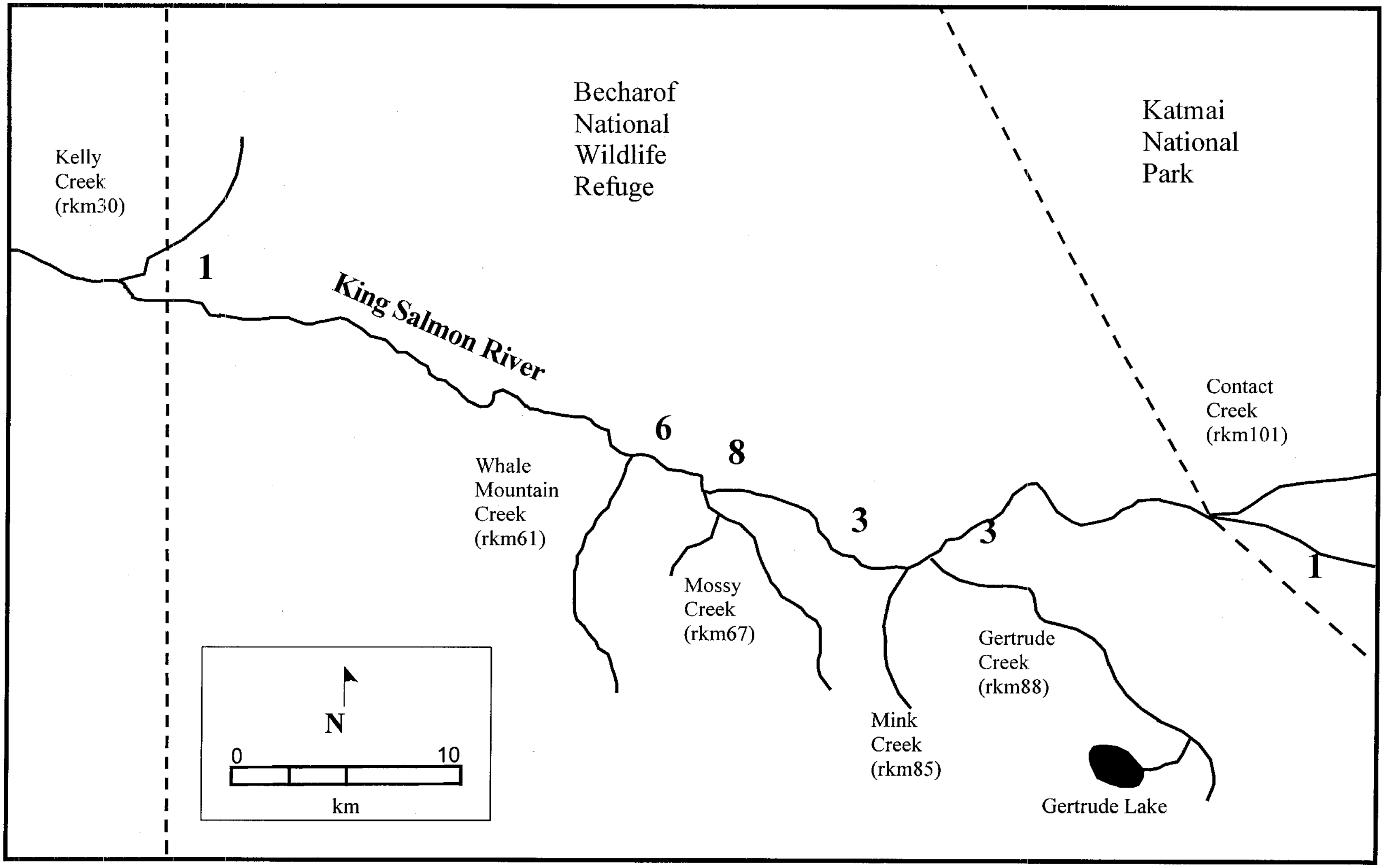

Figure 8. Overwintering (November 1991 - March 1992) locations for rainbow trout from tributaries of the King Salmon River that were implanted with radio transmitters during fall 1991. Numerals refer to the number of fish that regularly used each location, and rkm refers to the river km at the mouth of the tributary.

(92%) relocated fish were in tributaries. The general pattern of movement during this season was into Mossy and Whale Mountain creeks regardless of the tributary where the radio transmitter had been implanted. Eleven of 14 fish (79%) were relocated in these two tributaries with six of these fish relocated in Whale Mountain Creek. Seven of these 11 had been implanted in these two streams. Three fish that were implanted in Mink Creek and one from Gertrude Creek were also relocated in Whale Mountain Creek. The remaining three of 14 fish were relocated in the river.

During summer (19 June-22 September 1992) fish that were implanted with radio tags in the upper tributaries moved considerably more than fish with radio tags implanted in the lower tributaries. Of eight fish from the three upper tributaries, five (63%) were relocated in a different tributary than their original implantation site. Two fish from Mink Creek were relocated in the river and one fish from Contact Creek was relocated in the same stream. Of six fish from the lower two tributaries, (67%) four were relocated in the same stream as their original implantation site. One fish from Whale Mountain Creek was relocated in Mossy Creek and a fish from Mossy Creek was relocated in the river. By 20 October 1992 only three fish, all from Gertrude Creek, were relocated. Two were relocated in the river upstream of Gertrude Creek and the third was relocated in Gertrude Creek.

Anchor tags.- During the summers of 1990-91 and spring 1992, 230 individual rainbow trout accounted for 271 recaptures (Appendix B). One hundred ninety-three individuals were recaptured once; 33 were recaptured twice; and four were recaptured three times. Sixty-seven of the recaptures (25%) indicated movement between tributaries. Sixty-six of these movements between tributaries involved the four tributaries other than Contact Creek.

Movement between tributaries occurred most often between Gertrude and Mink creeks (23 times; 35%), followed by Mossy and Whale Mountain creeks (13 times; 20%), Mink and Whale Mountain creeks (12 times; 18%), and Gertrude and Whale Mountain creeks (10 times; 15%). These exchanges involved nearly equal numbers of fish moving either direction between the two tributaries. Of the potential combinations of movements between tributaries, all were satisfied with at least one example except no fish tagged in Contact Creek was recaptured in any other stream. The only movement involving Contact Creek consisted of one fish marked in Gertrude Creek and recaptured in Contact Creek.

In 1991, one fish was recaptured in three different tributaries, and 11 fish were recaptured in two different tributaries with seven of these movements involving Gertrude and Mink creeks. The minimum time between captures was four days and occurred between Gertrude and Mossy creeks. One hundred two (38%) of the total recaptures occurred among the years with several fish at liberty for more than 700 days. During all years, the months with the most recaptures involving movement between tributaries were in May and June. There was a significant difference ($D = 0.50$; $n_1 = 176$; $n_2 = 95$; $P < 0.001$) between length distributions of fish captured and recaptured in the same or a different tributary with smaller fish tending to be recaptured in the same tributary (Figure 9). Fish that were recaptured in the same stream as their previous capture showed little within stream movement.

Sex Composition, Maturity, and Spawning Frequency

The female (N = 41) to male (N = 35) ratio for rainbow trout sacrificed during 1990 at Gertrude Creek was 1.2:1. Smallest size at maturity for females was 318 mm at age 4; for males, 319 mm also at age 4. Smallest size at spawning for females was 471 mm at age 7, based on five females that contained residual eggs. No females released eggs during handling. Smallest size at spawning for males was 464 mm at age 5 and was determined from one of two fish that released milt during handling. No males showed a testis width > 10 mm. Eleven fish were classified as juveniles. The largest of these was 376 mm at age 4.

The five females that contained residual eggs were sacrificed in late May and July and also contained small (1 mm), developing eggs in the ovaries. These fish apparently had spawned earlier in the year, but would not spawn during the upcoming year. Two females that were sacrificed in September 1990 did not contain residual eggs, but did contain large (4 mm) eggs. Because no retained eggs were observed, these fish apparently spawned had not during the previous spring, but would spawn during the upcoming spring. It appears the most often that female rainbow trout could spawn in Gertrude Creek would be every other year. Spawning frequency for males could not be determined.

Scale and Otolith Age Comparison

Scale and otolith ages were compared only for the samples collected from Gertrude Creek during 1988 and 1990. In 1988 ages from 61 scale samples were determined; 176 ages in 1990. Ages from 78 otoliths were determined in 1988; 55 in 1990. Scale age frequency distributions from Gertrude Creek for 1988 and 1990 were not significantly different (X^2 = 10.5; df = 5; P = 0.06). Otolith age frequency distributions from each year were not significantly different (X^2 = 6.9; df = 5; P = 0.23) so the samples of each aging structure between the years were combined for further analysis.

Two hundred thirty-seven ages were determined from scales and 133 ages were determined from otoliths. Fork lengths ranged from 254-588 mm. Scale ages ranged from 3 to 10 years; otolith ages from 4 to 12 years (Figure 10). For the 103 fish with both scales and otoliths collected, scale ages underestimated otolith ages by 1 to 5 years (Figure 11). Scale and otolith ages were the same for 22 (20%) of the fish. Scale ages were older for four (4%) of the fish. Scale and otolith age frequency distributions were significantly different (X^2 = 36.2; df = 7; P < 0.001). Scale and adjusted scale age distributions were significantly different (X^2 = 56.1; df = 7; P < 0.001). The otolith age frequency distribution was not significantly different from the adjusted scale age distribution (X^2 = 4.7; df = 9; P = 0.86). Sample sizes of the scale and adjusted scale age

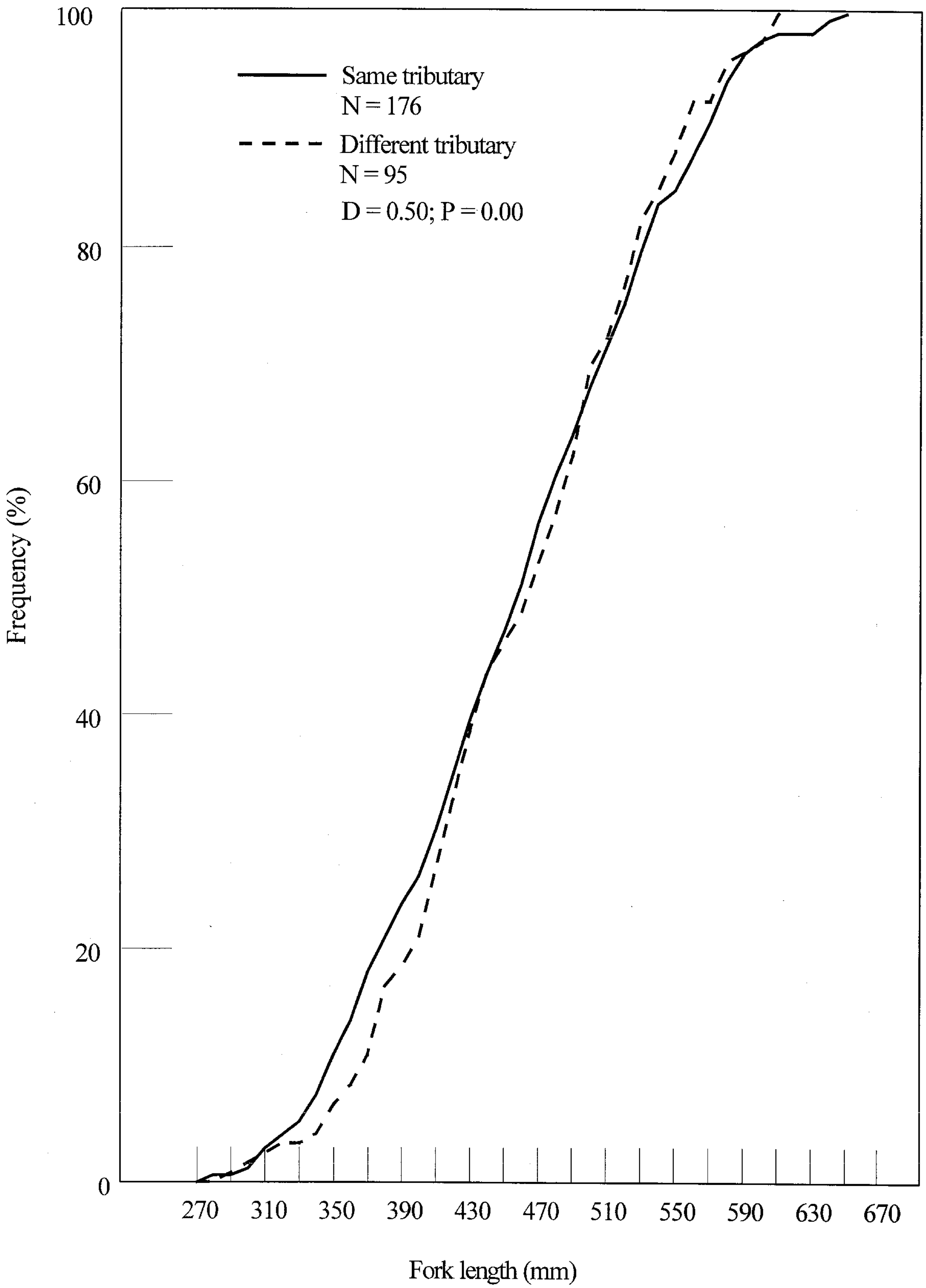

Figure 9. Cumulative length frequency distributions of rainbow trout recaptured in the same or a different tributary as the previous capture, 1990-92.

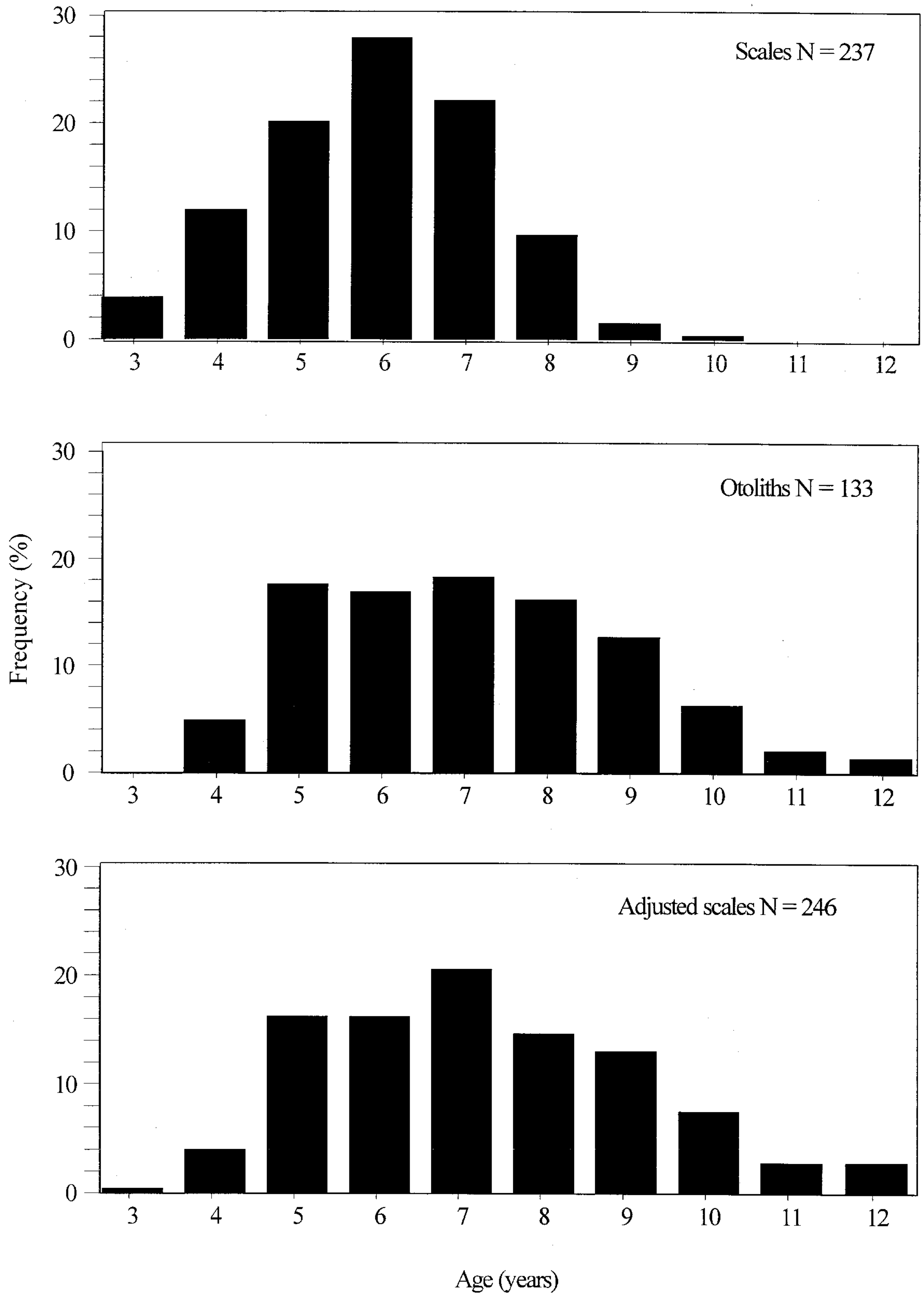

Figure 10. Scale, otolith, and adjusted scale age frequency distributions from rainbow trout captured by hook and line from Gertrude Creek, 1988 and 1990.

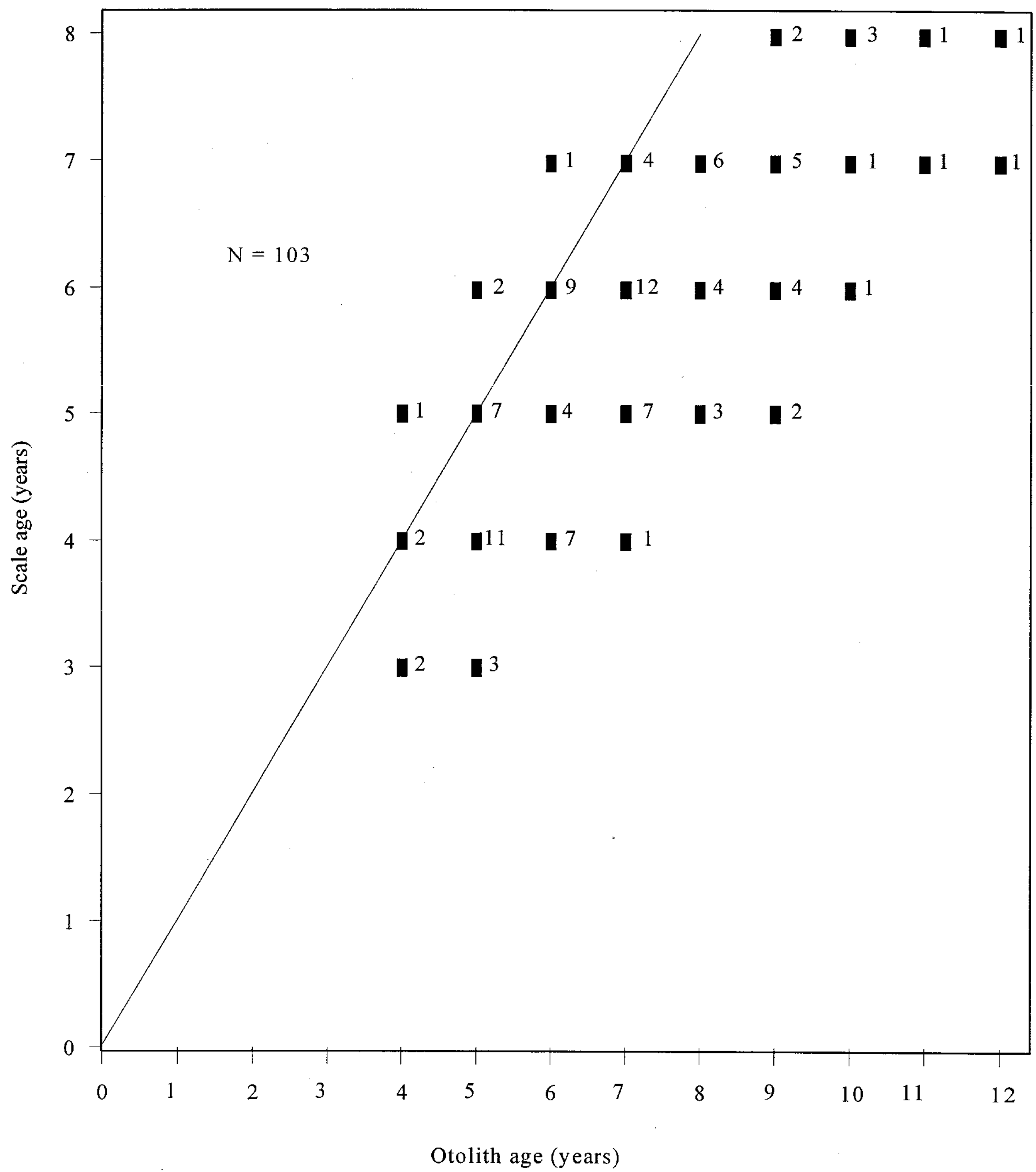

Figure 11. Relation between ages estimated from scales and otoliths collected from the same rainbow trout from Gertrude Creek, 1988 and 1990. Numerals refer to sample sizes.

distributions were different because there were no corresponding otoliths for scale ages 9 and 10.

Effort, Catch, and Harvest Estimates

Because the creel camp was located at the primary access point to the lower area of Gertrude Creek, all anglers that fished this area were interviewed at the end of their fishing day. All anglers that were counted were interviewed, and no anglers departed from the lower area without completing an interview. Therefore, the results from the survey were actually a census, and required no expansion of the data. All anglers considered themselves to be sport fishermen.

From 25 May-15 August 1991, 14 parties consisting of 46 anglers accounted for 82 angler days and 284 hr of effort (Table 8). There were eight guided parties and six unguided parties. Most parties fished only one day. Although the fishery targeted rainbow trout, nearly five times as many Arctic grayling and more than twice as many Dolly Varden were captured. The fishery practiced catch and release for all species with only four fish of three species harvested. No biological sampling was conducted.

Arctic grayling and Dolly Varden

Substantial numbers of Arctic grayling and Dolly Varden were captured only in Gertrude and Contact creeks. Two hundred seventy-seven, 87, and 33 Arctic grayling were captured from Gertrude Creek in 1990, 1991, and 1992, respectively. One hundred-three Arctic grayling were captured from Contact Creek in 1991. Fork lengths ranged from 230-460 mm in Gertrude Creek and from 229 to 430 mm in Contact Creek (Figure 12). Ages of Arctic grayling from Gertrude Creek ranged from 3-9 years (Figure 13) with mean length at age ranging from 247 mm at age 3 to 415 mm at age 8 (Table 9). Ages of Arctic grayling from Contact Creek ranged from 4-8 years with mean length at age ranging from 328 mm at age 4 to 393 mm at age 8. There were few regenerated scales. Arctic grayling were captured throughout the sampling seasons.

One hundred twenty-two Dolly Varden were captured from Gertrude Creek in 1990 and 56 Dolly Varden were captured in 1991. Forty-seven Dolly Varden were captured from Contact Creek in 1991. Fork lengths ranged from 220 to 627 mm in Gertrude Creek and from 265 to 622 mm in Contact Creek (Figure 14). The earliest date of capture for Dolly Varden in any sampling season was 3 July.

Table 8. Summer creel survey[a] results from Gertrude Creek, 1991.

Date	Number of anglers	Angler hours	Catch by species[b]						
			RBT	GRL	DV	CS	KS	SS	RWF
25 May	2	10		3					
14 Jun	2	8	1	16					
20 Jun	3	21	7	30					
24 Jun	2	3	2		10				
27-28 Jun	10	41	19	78	1	3			
30 Jun-2 Jul	3	47	11	136	3	35			4
4-5 Jul	4	20	12	53	11	9			
7-8 Jul	4	9	2	9	5	3			
19 Jul	2	8	1	7	7	2	1		
21 Jul	2	6			3	1	2		
31 Jul	3	23	3	40	2	2	1		
7-8 Aug	3	26	9	30	70				
11-12 Aug	3	30	14	24	68	14	2	1	
13-15 Aug	3	32	8	12	38	2		1	
Totals	46	284	89	439	218	71	6	2	4

[a] Table represents catch data only. 1 RBT, 2 DV, and 1 KS were harvested.
[b] RBT = rainbow trout, GRL = Arctic grayling, DV = Dolly Varden, CS = chum salmon, KS = chinook salmon, SS = coho salmon, RWF = round whitefish.

Table 9. Mean fork lengths (FL; mm) at age, standard deviations (SD), and sample sizes (N) for Arctic grayling captured by hook and line from Gertrude Creek, 1990-92 and Contact Creek, 1991.

	Gertrude Creek									Contact Creek		
	1990			1991			1992			1991		
Age	FL	SD	N	FL	SD	N	FL	SD	N	FL	SD	N
3	247	0	1	-	-	0	-	-	0			
4	303	28.8	19	300	21.1	6	328	42.5	2	281	30.2	17
5	343	35	48	327	37.3	15	342	45.6	15	328	30.9	45
6	375	37.3	38	349	29.4	16	388	32.1	12	359	27.1	25
7	402	26.7	22	378	21.1	6	399	38.3	3	384	26.6	7
8	415	17.9	5	384	0	1	-	-	0	393	24.8	3
9	400	0	1	-	-	0	-	-	0			

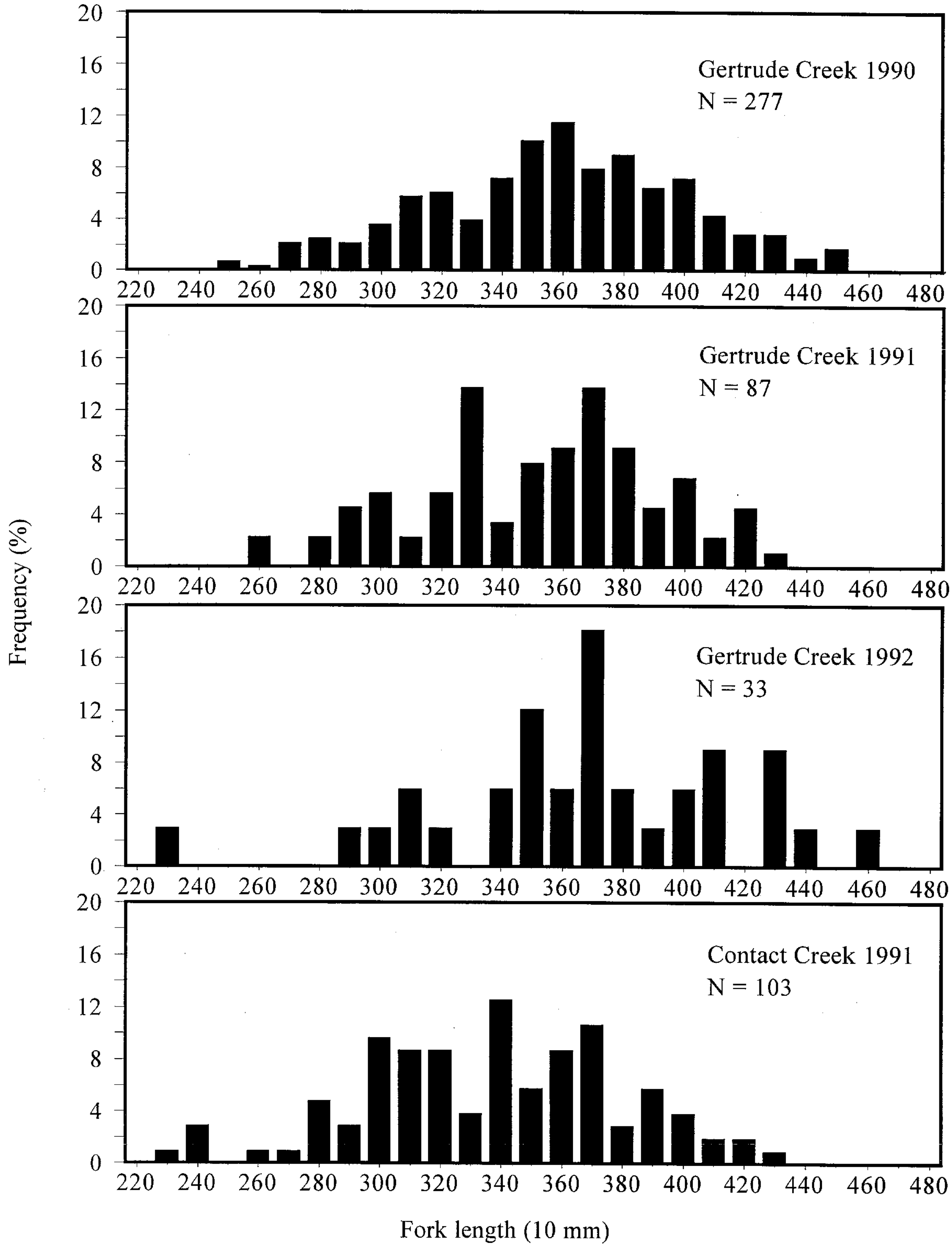

Figure 12. Fork length frequency distributions for Arctic grayling captured by hook and line from Gertrude Creek, 1990-92 and Contact Creek, 1991.

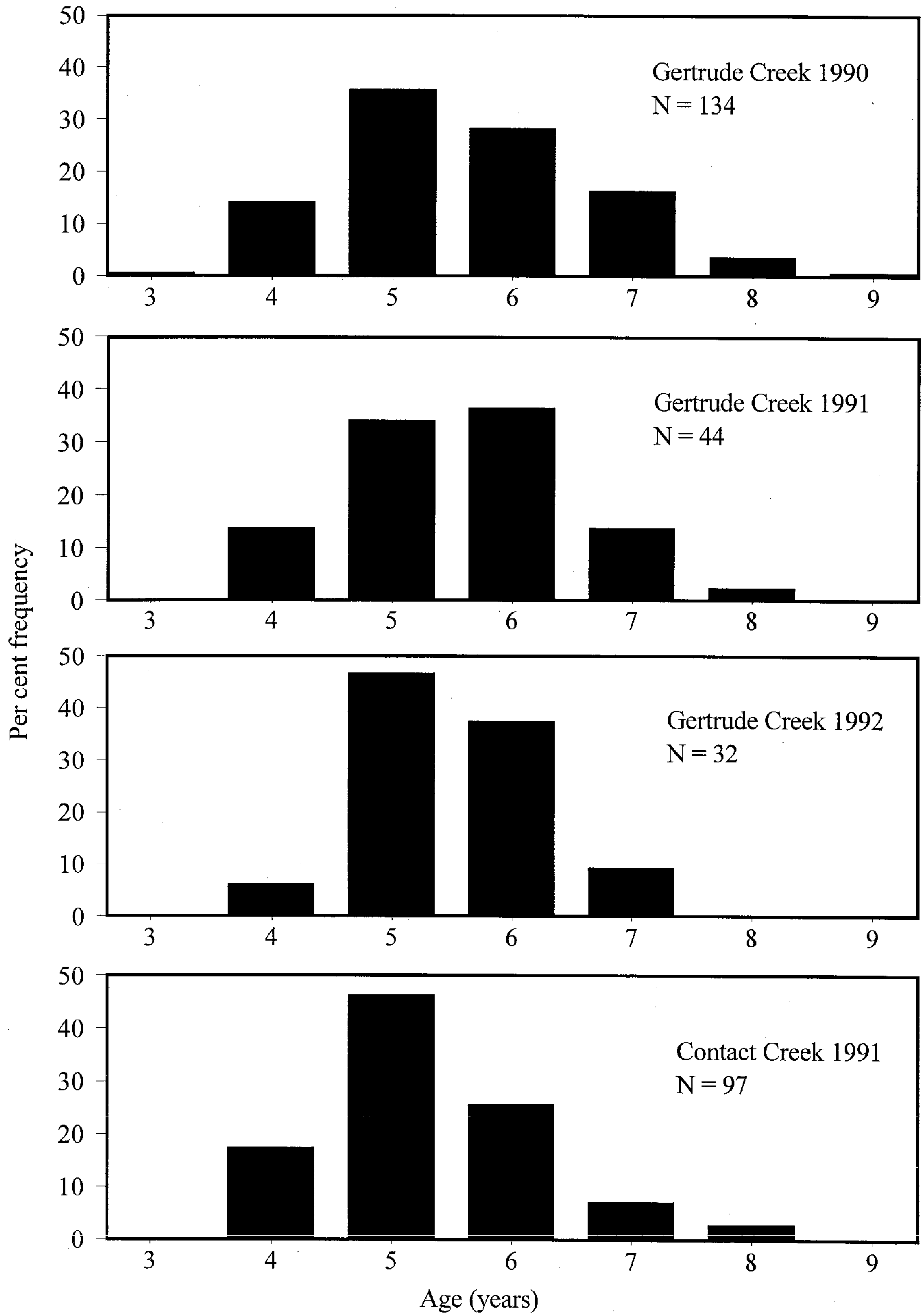

Figure 13. Age frequency distributions for Arctic grayling captured by hook and line from Gertrude Creek, 1990-92 and Contact Creek, 1991.

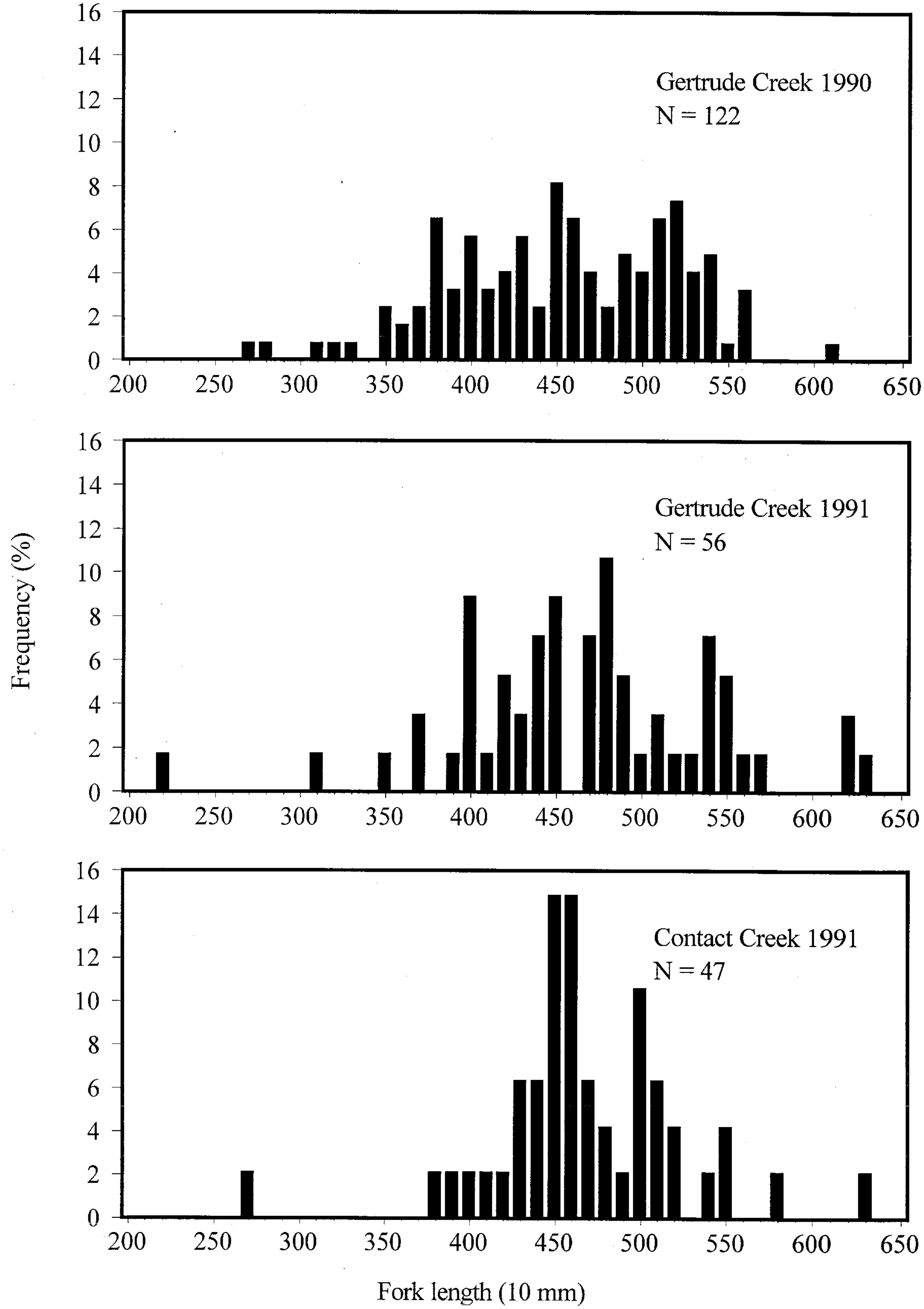

Figure 14. Fork length frequency distributions for Dolly Varden captured by hook and line from Gertrude Creek, 1990-91 and Contact Creek, 1991.

DISCUSSION

The Refuge Comprehensive Conservation Plan (U.S. Fish and Wildlife Service 1985) and Fishery Management Plan (U.S. Fish and Wildlife Service 1994) require that fish and wildlife populations on the Refuge be conserved in their natural diversity, including natural size and age diversity. The Department's Southwest Alaska Rainbow Trout Management Plan (Alaska Department of Fish and Game 1990) requires rainbow trout populations to be managed to maintain historic size and age structures. These two plans guide a management approach that provides for optimal fishing opportunity while conserving the historic size and age compositions of the population. This study established a benchmark for the King Salmon River population and provided the information needed to make this management approach effective.

Prior to the initiation of this study, it was expected that rainbow trout in the upper King Salmon River would exhibit characteristics similar to other small populations of rainbow trout in southwest Alaska. While this was generally true for biological characteristics such as length, age, and maturity, the complex movement of these fish during summer was unexpected. Also, the behaviors of two distinct geographic groups within the study area provided additional insight into the life history of the population.

Length, Age, and Maturity Characteristics

Length and scale ages.- Length, age and mean lengths at age of rainbow trout in the upper King Salmon River were similar to rainbow trout populations from other streams in southwest Alaska. The smallest fish in the Kanektok (Adams 1996) and Goodnews (Faustini 1996) rivers during 1993 ranged from 226-255 mm at ages 2 and 3 while the largest fish in these streams ranged from 581-625 mm and ages 9-10. Mean length at age for fish from the Kanektok River ranged from 284 mm at age 3 to 521 mm at age 9 (Adams 1996). Mean length at age of fish from the Goodnews River ranged from 226 mm at age 2 to 559 mm at age 9 (Faustini 1996).

Historical information concerning rainbow trout in the King Salmon River consisted of periodic sampling in Gertrude Creek from 1970 to 1989. Sampling in 1970, 1977, and 1983 occurred during 3-4 days annually and resulted in sample sizes from 14-35 rainbow trout (U.S. Fish and Wildlife Service, unpublished report, 1970; R. Russell, unpublished reports, 1977a and 1983; D. Mumma, unpublished report, 1983). Fork lengths ranged from 272-577 mm with scale ages from 4-10 years. Sampling during 1988 and 1989 was conducted several times throughout the summer and resulted in sample sizes of 85 and 35 rainbow trout, respectively (B. Mahoney, unpublished reports, 1988 and 1989). Fork lengths and scale ages ranged from 310-588 mm and 3-8 years in 1988; from 286-577 mm and 3-7 years in 1989. Paired Kolmogorov-Smirnov tests indicated length distributions from 1988 and 1989 were not different ($P = 0.58$) from each other, nor were they different from the length distribution from 1990 ($P > 0.40$). However, both distributions were significantly different from the 1991 distribution ($P < 0.001$). The sample size for ages from 1989 was small, but X^2 tests of independence indicated that the age distribution from

1989 was significantly different ($P = 0.03$) from the age distribution from 1990, but not different from the age distribution from 1991 ($P = 0.14$).

The presence of older fish in the samples from 1970-83 in Gertrude Creek, and the lack of older fish during 1988 and 1989 indicated that the perception of over fishing during the late 1980's may have been accurate. However, the samples in 1990 and 1991 contained older fish suggesting that the lack of these fish in 1988-89 may have been due to aging error, small sample size, selective sampling, or natural variability. The differences in length distributions may also have been due to selective sampling, or natural variability.

Comparison of scale and otolith age distributions.- Comparisons of ages of scales and otoliths collected from the same rainbow trout from Gertrude Creek in 1990 indicated that scale ages consistently underestimate otolith ages. This was similar to results from the Kanektok River and the Goodnews River where scale ages underestimated otolith ages by 1-4 (Wagner 1991) and 1-3 years (Irving and Faustini 1994), respectively. This supports the conclusions of Lentsch and Griffith (1987) who noted that scale ages of rainbow trout are not as accurate as otolith ages because: 1) scale annuli are indistinct; 2) resorption of the scale edge during spawning erases annuli; and 3) annuli may not be formed during the first winter.

The underestimation of age by scales led to adoption of the proportional contribution method. Although this technique compensated for underestimation of age from scales, the near equality of the otolith and adjusted scale age distributions from the Gertrude Creek data indicated that there was no advantage in adjusting the scale age distribution. The number of otoliths needed to provide confidence in the adjusted scale age data would be enough to estimate the age distribution of the population using otolith ages alone. However, the loss of sacrificed fish may have negative effects on the population.

To determine what affects the collection of otoliths in 1990 may have had on the population in 1991, a simulation was conducted whereby the length distribution from 1991 was combined with the length distribution of the sacrificed fish from 1990. Also, a year was added to the scale age of each sacrificed fish in 1990, and this distribution was combined with the scale age distribution of 1991. These two combined distributions were compared to the respective length or age distribution from 1990 using a Kolmogorov-Smirnov paired test and a X^2 test of independence. For the X^2 test, scale ages 9-11 were deleted to ensure that the number of cells with expected frequencies > 5 was > 80% (Santner and Duffy 1989). The Kolmogorov-Smirnov test indicated that the length distributions remained significantly different ($D = 0.44$; $n_1 = 189$; $n_2 = 314$; $P < 0.001$) with the new distribution being nearly identical to the 1991 distribution (Figure 15). The X^2 test also indicated that the scale age distributions remained significantly different ($X^2 = 33.86$; df = 5; $P < 0.001$) (Figure 16). Results of these tests suggested that the loss of fish sacrificed for otolith collection in 1990 did not affect the 1991 distributions, and that the differences between length and age distributions in Gertrude

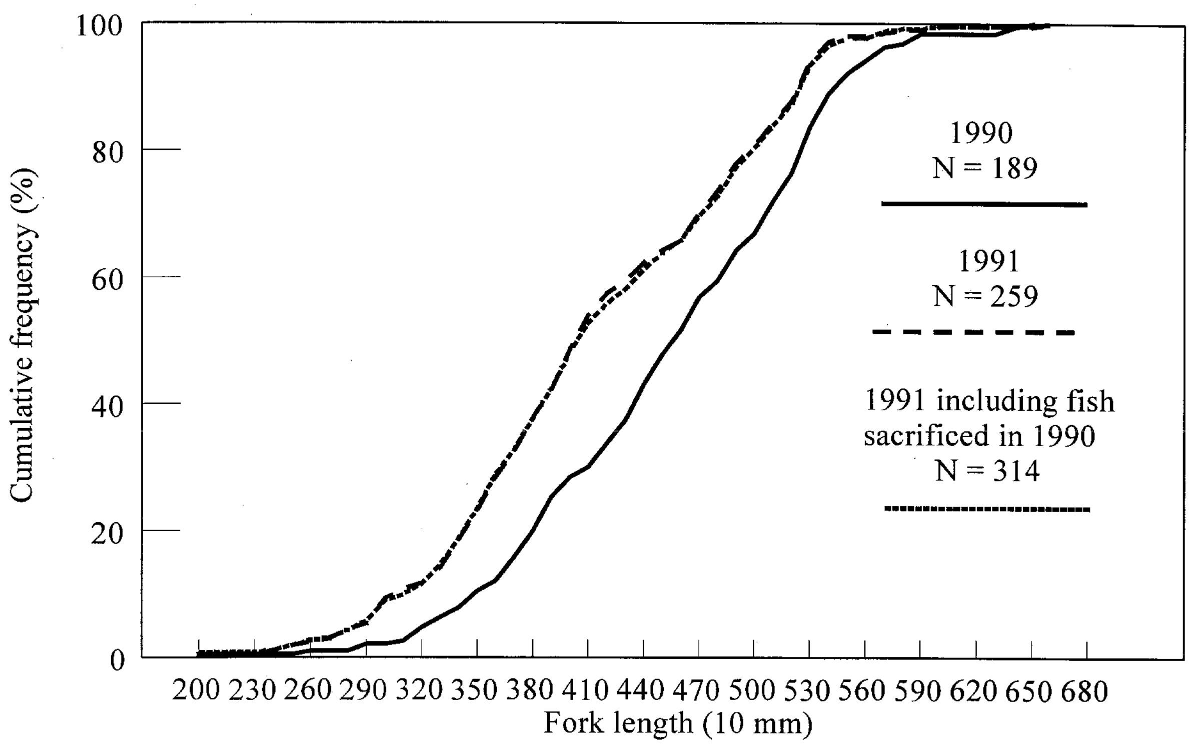

Figure 15. Cumulative fork length frequency distributions for rainbow trout captured by hook and line from Gertrude Creek during 1990 and 1991, and 1991 with sacrificed fish from 1990 included.

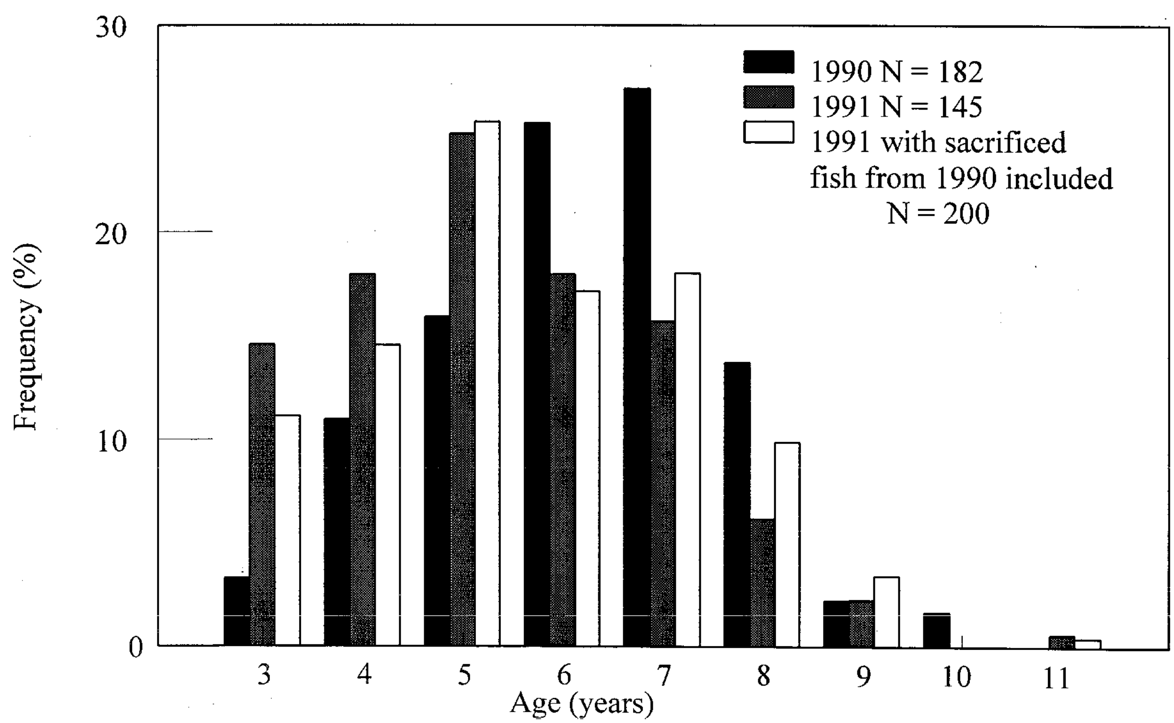

Figure 16. Age frequency distributions for rainbow trout captured by hook and line from Gertrude Creek during 1990 and 1991, and 1991 with sacrificed fish from 1990 included.

Creek were due to natural variation between the years. However, these otoliths were not collected randomly, and it was not possible to assess the effect that potential growth by the sacrificed fish may have had on the length distribution in 1991.

Because the loss of sacrificed fish in 1990 appeared not to affect the population in 1991, it may be attractive in the future to establish age distributions of rainbow trout based on otoliths. However, sacrificing a large number of rainbow trout would be socially unacceptable. Collecting otoliths from fish harvested by subsistence or sport fisheries may be possible, but any collection must be random, or at least representative of the population. Since sport fishing for rainbow trout is mostly catch and release, and subsistence fisheries for rainbow trout are generally small, obtaining large enough sample sizes would be difficult.

Maturity characteristics.- The only information for comparison of maturity characteristics of rainbow trout in southwest Alaska comes from a study conducted during 1971-75 at Talarik Creek, a tributary of Lake Iliamna. The sex ratio and spawning frequency of the Talarik Creek population were similar to those from Gertrude Creek with a female to male ratio of 1.9:1, and both sexes also did not spawn every year (Russell 1977b). Fish from Talarik Creek were considerably smaller and younger at spawning with females first spawning at 325-349 mm and age 4 while first spawning for males occurred at 200-224 mm and age 3. Fish from Talarik Creek are relatively fast growing (Russell 1977b) and apparently have the environmental conditions and genetic capability to spawn at smaller sizes and younger ages than fish from Gertrude Creek. However, the maturity characteristics of rainbow trout from Gertrude Creek may not be representative of the spawning population in the upper King Salmon River because Gertrude Creek was not considered to be a major spawning stream, sample sizes of sacrificed fish were small, and fish were not sacrificed randomly.

Movement

Morrow (1980) reports that resident rainbow trout do not move a great deal. This perception was supported by results from the Kanektok (Adams 1996) and Goodnews (Faustini 1996) rivers where most radio tagged fish moved little and appeared to spawn, summer, and overwinter near their implant location. However, while most fish from the upper King Salmon River did not move extensive distances, these fish left their implant site, traveled freely between tributaries, and moved to several overwintering areas within the main stem river. Unlike the King Salmon River, the Kanektok and Goodnews rivers are both year round clear water systems with few tributaries that contain rainbow trout. The differences in water clarity and the availability of tributaries may have accounted for the distinct behaviors.

Because rainbow trout are generally associated with clear water systems (Smith 1991), it was assumed that the turbidity of the King Salmon River during summer would impede the movement of fish between the tributaries. If movement was to occur, it was assumed it would occur during late fall after glacial freeze-up and late winter before glacial melt.

However, the movement of fish between the tributaries during summer indicated that these fish did enter the river when it was turbid. Also, the relocation of several implanted fish in the river during summer indicated that there may be a portion of the population that resides there during this season. Nonetheless, rainbow trout are sight feeders (Fausch 1991), and seeing prey in turbid water would be difficult. Therefore, the main use of the river during summer is probably as a corridor for fish to move between tributaries as they exploit seasonally available food sources such as the eggs and flesh of returning Pacific salmon.

In contrast to using the river as a corridor in summer, the main use of the river during winter was as a refugium for overwintering. Soon before freeze-up implanted fish began moving into overwintering areas, and most fish remained within a five kilometer area throughout the season. While the four main overwintering areas apparently provided appropriate conditions to survive the winter, the habitats for the two upper sites were distinct from the other two. From observation on the ground, the overwintering areas near Gertrude and Mink creeks are located in an area where the river cuts through bedrock and has created deep pools and eddies. The other two overwintering areas are located near the marsh drained by Mossy Creek. While these areas near Mossy and Whale Mountain creeks appeared to be shallow, springs may make these areas suitable for overwintering.

In addition to the overwintering areas identified by radio telemetry, recaptures of anchor tagged rainbow trout during the winter ice fishery indicated that fish from the study area also overwinter in the river near the village of Egegik. Of three tagged fish harvested during winters 1991-92 and 1992-93, two of these fish were originally tagged in Whale Mountain Creek during 1991 and 1992. The remaining fish was tagged in Mink Creek in 1991 and captured in the ice fishery during winter 1991-92.

Information gathered during 1991 and 1992 suggested that Whale Mountain Creek is the main spawning stream in the study area. During spring of both years the length frequencies of fish from this stream were significantly different from the distributions from the other tributaries ($P < 0.02$), and more fish > 550 mm and older than 6 years were captured in Whale Mountain Creek. Also, relocations of radio tagged fish indicated that the larger rainbow trout moved to Whale Mountain Creek prior to the 1992 spawning season, and a higher percent of fish captured in Whale Mountain Creek released gametes during handling. Although the differences in lengths, the presence of older and larger fish, the movement of fish into the stream, and the capture of more ripe fish, did not conclusively prove that Whale Mountain Creek was the main spawning stream in the study area, these factors dictate that this tributary deserves special management attention.

Based on where a fish was implanted in late summer-early fall 1991, rainbow trout in the upper King Salmon River belonged to two groups. Fish implanted in Contact, Gertrude, and Mink creeks comprised the upper group and moved considerably throughout the study area. These fish overwintered at all sites in the river, spawned in Whale Mountain Creek, and spent summer and fall in one of these same three tributaries. The lower group included fish implanted in Mossy and Whale Mountain creeks. These fish moved little, overwintered in the river near these two streams, and spent spring, summer, and fall in one of these two tributaries. The relatively long distance between Mink and Mossy creeks (18 rkm) and the relatively close distances between Gertrude and Mink creeks (3 rkm) and Mossy and Whale Mountain creeks (6 rkm) influenced the behavior patterns of these fish. However, some of the movements were based on one relocation and may not truly characterize the behavior of the population.

Abundance

Results indicated that more rainbow trout resided in Gertrude and Whale Mountain creeks than the other tributaries, and that Contact Creek appeared to be a minor contributor to the population during the sampling periods. Sampling in 1992 was designed to assess the spawning population and resulted in almost twice as many rainbow trout captured in Whale Mountain Creek as in any of the other tributaries. The differences in sample sizes between years and tributaries were directly attributable to the amount of effort expended. Sampling in 1990 focused almost exclusively on Gertrude Creek with other tributaries being surveyed only for the existence of rainbow trout. Sampling in 1991 was focused on equal effort among the streams and was reflective of the relative abundance of rainbow trout in the tributaries during summer.

The large size of the King Salmon River drainage, its numerous tributaries, and the movements of the fish made efficient sampling for absolute abundance difficult. Too few rainbow trout were recaptured in each tributary during 1991, and an abundance estimate could not be generated. However, the recapture of marked fish provided insight into the behavior of these fish. The decrease in the marked to unmarked ratio after 17 July coincided with the arrival of spawning chinook and chum salmon in the tributaries of the study area. The salmon acted as an attractant to unmarked rainbow trout from other tributaries, from the main stem river, from outside the study area, or from other areas within a tributary and diluted the ratio of marked fish within the study area. The attraction of the salmon may also have caused marked fish to emigrate to other areas of the drainage.

For planning a mark-recapture experiment in the future, data from this study generated a preliminary estimate of about 1,000 rainbow trout ≥ 355 mm. With a population of this size, a simple Petersen estimate would require at least 350 fish to be handled; 300 during the marking event and 50 during the recapture event (Krebs 1989). While sample sizes in the current study approached these levels, the small crew size, extended sampling periods, and the inter-tributary movement of the fish resulted in small numbers of recaptured fish in each tributary. Future sampling must expend more effort in each tributary over a shorter period of time, and the study area should be expanded to include other areas where rainbow trout may exist.

Effort, Catch, and Harvest Estimates

Effort from sport anglers on Gertrude Creek in 1991 was extremely low due in part to the difficulty in accessing the stream. The main access point was a gravel bar where wheeled fixed wing aircraft could land. Locating the camp on this gravel bar allowed the crew to contact all anglers that arrived by this method. The other methods of accessing the area involved extensive hiking, or floating the King Salmon River to the mouth of Gertrude Creek. Because there was no evidence of anglers arriving by these methods, it is reasonable to assume that the data from 1991 were truly a census, and that no anglers were overlooked.

Because the Gertrude Creek fishery is small, it has not been mentioned in the Alaska Department of Fish and Game Statewide Harvest Survey (Mills 1983-94; Howe et al. 1995 and 1996). However, by reviewing the data from the Becharof Lake-Egegik River system in these reports, it may be possible to develop an index of the sport catch and harvest of rainbow trout in Gertrude Creek. Rainbow trout exist only in the King Salmon River portion of the Becharof Lake-Egegik River system, and Gertrude Creek supports the major sport fishery for rainbow trout in the drainage. Most of the sport catch and harvest of rainbow trout in the Becharof Lake-Egegik River system can probably be attributed to Gertrude Creek.

This approach compared the 1991 data from the Statewide Harvest Survey (Mills 1992) with the results from the 1991 creel census and indicated that the reported catch from both methods was similar, but harvest was very different. Mills (1992) reported that 96 rainbow trout were captured in the Becharof Lake-Egegik River system in 1991, and this figure is very similar to the number (89) reported in the creel census. Mills (1992) also reported 32 rainbow trout were harvested, but the creel census documented a harvest of one fish. While the Statewide Harvest Survey is valuable for characterizing large fisheries, it may not be appropriate for small fisheries without further ground truthing. The Statewide Harvest Survey may also have included subsistence caught fish or fish that were mistakenly identified as rainbow trout.

A cursory survey of winter subsistence anglers from the village of Egegik indicated that most effort occurred in the lower river near the mouths of Creek #1 and Gabe's Creek (Figure 1). Unlike summer fishing at Gertrude Creek, the ice fishery concentrated on the harvest of fish. During winter 1991-92, 12 anglers reported the capture and harvest of 22 rainbow trout and eight Arctic grayling. During winter 1992-93, 13 anglers reported the capture and harvest of 26 rainbow trout, 22 Arctic grayling, one Dolly Varden, and one round whitefish. While these data were not complete, they provided an index to the winter harvest and underscored the importance of these fish to the local community.

The rainbow trout population in the upper King Salmon River received fishing pressure from sport and subsistence users. The sport fishery at Gertrude Creek harvested few fish, and hooking and handling mortality probably did not affect the population. Assuming a hooking and handling mortality of 3-12% (Taylor and White 1992), only 3-11 additional rainbow trout from Gertrude Creek would have died during 1991. With the small number of anglers currently fishing the stream and the capability of rainbow trout to move among the tributaries, the summer fishery should have little effect on the population. Conversely, the ice fishery in the river was a harvest fishery with local residents releasing very few fish. While both of these fisheries have the potential to affect the rainbow trout population, the focus on harvest and the easy access to the lower river make the winter fishery of greater concern to managers. However, this subsistence fishery has historically occurred (Shirley Kelly, U.S. Fish and Wildlife Service, personal communication) with no apparent effects on the population. The additive impacts of both fisheries may be the greatest concern.

Arctic grayling and Dolly Varden

Lengths and ages of Arctic grayling and Dolly Varden captured during the study were typical for these species in Alaska (Morrow 1980). The differences in sample sizes for each species within a tributary by year was due to the amount of effort expended. As with rainbow trout, sampling in 1990 focused on Gertrude Creek, and the sample sizes of Arctic grayling and Dolly Varden reflect this directed effort. Also, sampling in 1991 was conducted over five months while sampling in 1992 was limited to a two-week period.

Dolly Varden in Alaska exhibit several life history strategies including resident and anadromous forms (Armstrong and Morrow 1980). The date of first capture for these fish in this study was consistent with the arrival of spawning Pacific salmon and also coincided with arrival times at spawning streams of adult anadromous Dolly Varden in other areas of Alaska (Krueger 1981). These two comparisons suggest that this population may be anadromous. However, these fish may also overwinter and feed during spring in Becharof Lake or other areas of the Egegik River drainage before emigrating to the King Salmon River in summer.

Recommendations

While the rainbow trout population in the upper King Salmon River appeared to be stable with no immediate threats, conservative management is imperative. Future management must be based on the specifics of this population, especially related to its complex movement patterns. To maintain the stability, anticipate any threats, and develop population specific management, the following actions are recommended: 1) expand the study area to include the river and tributaries upstream and downstream of the current study area; 2) sample the expanded study area every five years for length, age, and abundance; 3) evaluate the summer and winter fisheries every five years; and 4) monitor Arctic grayling and Dolly Varden populations, including anchor tagging to determine summer movements, as part of the rainbow trout studies.

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APPENDIX

Appendix A. Aerial relocations (river km and tributary) of radio tagged rainbow trout from the upper King Salmon River, 1991-92 (all radio tags were implanted during 16-27 August or 8-17 September 1991; km 0 = river mouth; Whale Mt. = Whale Mountain Creek). Locations are listed chronologically for seasons with more than one relocation.

		Relocation season and site				
Frequency	Implant location	Fall[a]	Winter[b]	Spring[c]	Summer[d]	Fall[e]
40.031	Contact	Gertrude	93-106	-	-	
40.721	Contact	Contact	Contact, 96-99	99	Contact	
40.791	Contact	-	93, Gertrude, 96	-	Gertrude	
40.810	Contact	-	72-80	75-80	Mink, 80	
40.061	Gertrude	Mossy	Mossy, 65	Whale Mt.	Mossy, Gertrude	Gertrude
40.081	Gertrude	Gertrude	Gertrude, 38-48	-	Mossy	96
40.132	Gertrude	-	96-99	-	-	93
40.501	Mink	Whale Mt.	59-64	59, Whale Mt.	-	
40.531	Mink	Mink	-	80, Whale Mt.	Gertrude	
40.602	Mink	Mossy	69-72	72, Whale Mt.	75	
40.649	Mink	Mink	63-72	-	-	
40.841	Mink	Mink	Gertrude, 80-93	93	99	
40.511	Mossy	Mossy	Mossy, 65-69	Mossy	-	
40.631	Mossy	Mossy	64-69	69, Mossy	65, Mossy	

Appendix A. Continued.

		Relocation season and site				
Frequency	Implant location	Fall[a]	Winter[b]	Spring[c]	Summer[d]	Fall[e]
40.641	Mossy	Mossy	Mossy, 64-65	-	-	
40.741	Mossy	-	59-69	-	-	
40.761	Mossy	-	64-69	-	-	
40.801	Mossy	-	69-99	-	-	
40.831	Mossy	Mossy	Mossy, 69	Mossy	75	
40.071	Whale Mt.	Whale Mt.	Whale Mt., 64	Whale Mt.	Whale Mt.	
40.446	Whale Mt.	Whale Mt.	Mossy, 69-72	69, Mossy	Whale Mt.	
40.591	Whale Mt.	Whale Mt.	65-69	Whale Mt.	Whale Mt., 65	-
40.622	Whale Mt.	Whale Mt.	Mossy, 69-72	Mossy	Mossy	-

[a] Fall = 1 October 1991.
[b] Winter = 9 November 1991 to 2 March 1992.
[c] Spring = 20 April to 26 May 1992.
[d] Summer = 19 June to 22 September 1992.
[e] Fall = 20 October 1992.

Appendix B. Year and stream location of anchor tagged rainbow trout ≥ 200 mm recaptured in tributaries of the upper King Salmon River, 1990-92 (includes fish not used in abundance estimate; Whale Mt. = Whale Mountain Creek).

Tag number	Capture location	Recapture year and location 1990	1991	1992
Tagged in 1990				
13	Gertrude	Gertrude		
18	Gertrude	Gertrude		
27	Gertrude	Gertrude		
65	Gertrude	Gertrude		
122	Gertrude	Gertrude		
174	Gertrude	Gertrude		
208	Gertrude	Gertrude		
213	Gertrude	Gertrude		
216	Gertrude	Gertrude		
298	Gertrude	Gertrude		
215	Gertrude	Gertrude	Contact	
46	Gertrude	Gertrude	Gertrude	
207	Gertrude	Gertrude	Gertrude	
299	Gertrude	Gertrude	Gertrude	
1,216	Gertrude	Gertrude	Gertrude	
136	Gertrude	Gertrude	Gertrude	Gertrude
11	Gertrude		Contact	
8	Gertrude		Gertrude	
31	Gertrude		Gertrude	
41	Gertrude		Gertrude	
48	Gertrude		Gertrude	
54	Gertrude		Gertrude	
56	Gertrude		Gertrude	
61	Gertrude		Gertrude	
66	Gertrude		Gertrude	
125	Gertrude		Gertrude	
132	Gertrude		Gertrude	
141	Gertrude		Gertrude	
156	Gertrude		Gertrude	
160	Gertrude		Gertrude	
161	Gertrude		Gertrude	
172	Gertrude		Gertrude	

Appendix B. Continued.

Tag number	Capture location	Recapture year and location		
		1990	1991	1992
203	Gertrude		Gertrude	
212	Gertrude		Gertrude	
142	Gertrude		Gertrude	Gertrude
210	Gertrude		Gertrude	Whale Mt.
17	Gertrude		Gertrude	
53	Gertrude		Gertrude	
159	Gertrude		Mink	
214	Gertrude		Whale Mt.	
248	Gertrude		Whale Mt.	
4	Gertrude			Gertrude
152	Gertrude			Whale Mt.
21	Mink	Gertrude		
225	Mink	Gertrude		
177	Mink	Gertrude	Mink	
22	Mink		Gertrude	
78	Mink		Gertrude	
179	Mink		Gertrude	
49	Mink		Gertrude & Mink	
20	Mink		Mink	
50	Mink		Mink	
70	Mink		Whale Mt., Mink, & Gertrude	
19	Mink			Whale Mt.
436	Mossy		Mossy	
191	Mossy			Whale Mt.
74	Whale Mt.	Mink	Whale Mt.	
114	Whale Mt.		Whale Mt.	
116	Whale Mt.		Whale Mt.	
199	Whale Mt.		Whale Mt.	
Tagged in 1991				
1,122	Contact		Contact	
150	Gertrude		Gertrude	
313	Gertrude		Gertrude	
509	Gertrude		Gertrude	
523	Gertrude		Gertrude	
679	Gertrude		Gertrude	

Appendix B. Continued.

Tag number	Capture location	Recapture year and location		
		1990	1991	1992
747	Gertrude		Gertrude	
1,131	Gertrude		Gertrude	
1,203	Gertrude		Gertrude	
1,205	Gertrude		Gertrude	
1,206	Gertrude		Gertrude	
1,207	Gertrude		Gertrude	
1,231	Gertrude		Gertrude	
1,253	Gertrude		Gertrude	
1,255	Gertrude		Gertrude	
1,282	Gertrude		Gertrude	
1,301	Gertrude		Gertrude	
1,303	Gertrude		Gertrude	
1,334	Gertrude		Gertrude	
1,337	Gertrude		Gertrude	
1,339	Gertrude		Gertrude	
1,344	Gertrude		Gertrude	
1,378	Gertrude		Gertrude	
507	Gertrude		Gertrude & Mink	
1,283	Gertrude		Gertrude & Mink	
1,139	Gertrude		Mink	
1,261	Gertrude		Mink & Gertrude	
520	Gertrude		Gertrude	Mink
1,220	Gertrude		Gertrude	Mink
1,387	Gertrude		Gertrude	Mink
1,204	Gertrude		Gertrude	Gertrude
728	Gertrude			Gertrude
1,235	Gertrude			Mink
1,046	Gertrude			Mossy
334	Gertrude			Whale Mt.
1,291	Gertrude			Whale Mt.
1,210	Gertrude		Gertrude	
1,222	Gertrude		Gertrude	
1,236	Gertrude		Gertrude	
1,226	Gertrude		Gertrude & Mink	
1,238	Gertrude		Gertrude	

Appendix B. Continued.

Tag number	Capture location	Recapture year and location 1990	1991	1992
1,250	Gertrude		Mink	
690	Gertrude		Mossy	
693	Gertrude		Mossy	
251	Gertrude		Whale Mt.	
302	Gertrude		Whale Mt.	
84	Gertrude		Gertrude	Mink
1,237	Gertrude		Gertrude	Gertrude
1,016	Gertrude		Mossy	Whale Mt.
504	Mink		Gertrude	
336	Mink		Mink	
566	Mink		Mink	
567	Mink		Mink	
1,061	Mink		Mink	
1,166	Mink		Mink	
1,309	Mink		Mink	
1,333	Mink		Mink	
1,374	Mink		Mink	
1,398	Mink		Mink	
568	Mink		Mink & Gertrude	
1,304	Mink		Mink	Gertrude
731	Mink		Mink	Mink
1,271	Mink		Mink	Whale Mt.
1,034	Mink		Whale Mt.	Whale Mt.
337	Mink			Mink
726	Mink			Mink
1,394	Mink			Mossy
87	Mossy		Gertrude	
697	Mossy		Gertrude	
344	Mossy		Mossy	
347	Mossy		Mossy	
349	Mossy		Mossy	
350	Mossy		Mossy	
694	Mossy		Mossy	
931	Mossy		Mossy	
933	Mossy		Mossy	

Appendix B. Continued.

Tag number	Capture location	Recapture year and location		
		1990	1991	1992
1,015	Mossy		Mossy	
1,022	Mossy		Mossy	
1,025	Mossy		Mossy	
429	Mossy		Whale Mt.	
427	Mossy		Mink	Mossy
346	Mossy		Mossy & Whale Mt.	Whale Mt.
934	Mossy		Whale Mt.	Mossy
345	Mossy			Mossy
428	Mossy			Mossy
989	Mossy			Mossy
1,000	Mossy			Mossy
695	Mossy			Whale Mt.
988	Mossy			Whale Mt.
259	Whale Mt.		Gertrude	
973	Whale Mt.		Gertrude	
304	Whale Mt.		Gertrude & Mossy	
447	Whale Mt.		Gertrude & Mossy	
608	Whale Mt.		Mink	
968	Whale Mt.		Mink	
1,039	Whale Mt.		Mink	
269	Whale Mt.		Mink & Whale Mt.	
252	Whale Mt.		Mossy	
619	Whale Mt.		Mossy	
1,038	Whale Mt.		Mossy	
92	Whale Mt.		Whale Mt.	
94	Whale Mt.		Whale Mt.	
95	Whale Mt.		Whale Mt.	
98	Whale Mt.		Whale Mt.	
100	Whale Mt.		Whale Mt.	
230	Whale Mt.		Whale Mt.	
236	Whale Mt.		Whale Mt.	
239	Whale Mt.		Whale Mt.	
241	Whale Mt.		Whale Mt.	
242	Whale Mt.		Whale Mt.	
254	Whale Mt.		Whale Mt.	

Appendix B. Continued.

Tag number	Capture location	Recapture year and location: 1990	1991	1992
258	Whale Mt.		Whale Mt.	
262	Whale Mt.		Whale Mt.	
263	Whale Mt.		Whale Mt.	
268	Whale Mt.		Whale Mt.	
445	Whale Mt.		Whale Mt.	
449	Whale Mt.		Whale Mt.	
615	Whale Mt.		Whale Mt.	
618	Whale Mt.		Whale Mt.	
620	Whale Mt.		Whale Mt.	
935	Whale Mt.		Whale Mt.	
951	Whale Mt.		Whale Mt.	
954	Whale Mt.		Whale Mt.	
965	Whale Mt.		Whale Mt.	
975	Whale Mt.		Whale Mt.	
1,009	Whale Mt.		Whale Mt.	
1,026	Whale Mt.		Whale Mt.	
1,033	Whale Mt.		Whale Mt.	
1,052	Whale Mt.		Whale Mt.	
1,055	Whale Mt.		Whale Mt.	
1,056	Whale Mt.		Whale Mt.	
1,085	Whale Mt.		Whale Mt.	
1,106	Whale Mt.		Whale Mt.	
1,108	Whale Mt.		Whale Mt.	
1,109	Whale Mt.		Whale Mt.	
1,110	Whale Mt.		Whale Mt.	
1,111	Whale Mt.		Whale Mt.	
1,115	Whale Mt.		Whale Mt.	
1,120	Whale Mt.		Whale Mt.	
1,121	Whale Mt.		Whale Mt.	
1,175	Whale Mt.		Whale Mt.	
1,189	Whale Mt.		Whale Mt.	
1,190	Whale Mt.		Whale Mt.	
228	Whale Mt.		Whale Mt.	Whale Mt.
617	Whale Mt.		Whale Mt.	Whale Mt.
883	Whale Mt.		Whale Mt.	Whale Mt.

Appendix B. Continued.

Tag number	Capture location	Recapture year and location		
		1990	1991	1992
974	Whale Mt.		Whale Mt.	Whale Mt.
1,040	Whale Mt.		Whale Mt.	Whale Mt.
1,042	Whale Mt.		Whale Mt.	Whale Mt.
1,011	Whale Mt.			Mossy
1,035	Whale Mt.			Mossy
1,044	Whale Mt.			Mossy
99	Whale Mt.			Whale Mt.
235	Whale Mt.			Whale Mt.
238	Whale Mt.			Whale Mt.
247	Whale Mt.			Whale Mt.
256	Whale Mt.			Whale Mt.
267	Whale Mt.			Whale Mt.
446	Whale Mt.			Whale Mt.
622	Whale Mt.			Whale Mt.
1,004	Whale Mt.			Whale Mt.
1,031	Whale Mt.			Whale Mt.
1,076	Whale Mt.			Whale Mt.
1,116	Whale Mt.			Whale Mt.
1,160	Whale Mt.			Whale Mt.
1,372	Whale Mt.			Whale Mt.
Tagged in 1992				
1,713	Mink			Mink
1,732	Mink			Mink
1,357	Mossy			Mossy
1,411	Whale Mt.			Whale Mt.
1,443	Whale Mt.			Whale Mt.
1,456	Whale Mt.			Whale Mt.
1,755	Whale Mt.			Whale Mt.