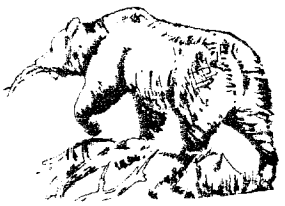
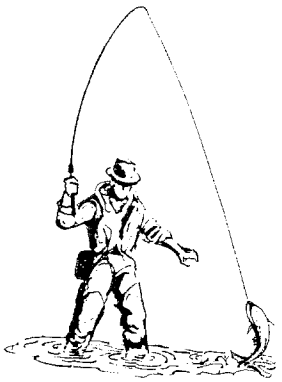
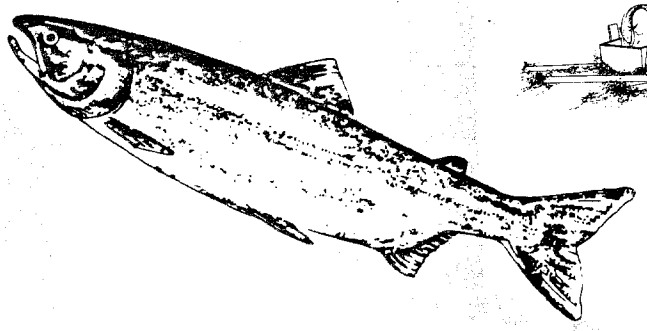
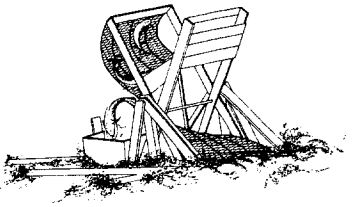
Alaska Fisheries Technical Report Number 35

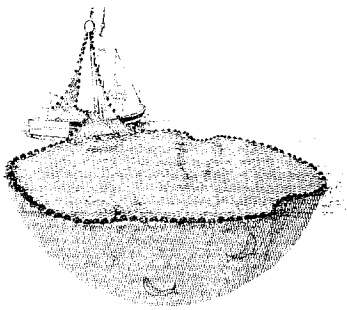
LENGTH FREQUENCY, AGE DISTRIBUTION AND MOVEMENTS OF RAINBOW TROUT IN THE NEGUKTHLIK AND UNGALIKTHLUK RIVERS, TOGIAK NATIONAL WILDLIFE REFUGE, ALASKA, 1989-90











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Length Frequency, Age Distribution and Movements of Rainbow Trout in the Negukthlik and Ungalikthluk Rivers, Togiak National Wildlife Refuge, Alaska, 1989-90.

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Keywords: Rainbow Trout, Negukthlik River,
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ABSTRACT

Rainbow trout are an important sport and subsistence resource throughout Togiak National Wildlife Refuge in Southwest Alaska. The Refuge management objectives are to maintain historical size and age composition of fish populations. In the mid-1980's concern was raised over the status of rainbow trout stocks in the Negukthlik and Ungalikthluk Rivers. Age, weight, and length (AWL) sampling, marking, and telemetry tracking of rainbow trout were conducted by U.S. Fish and Wildlife Service during 1989 and 1990.

We surgically implanted low frequency radio transmitters in rainbow trout in the Negukthlik River during spring (n = 12), and fall (n = 10), 1989. Tracking occurred during 17 air and 28 ground telemetry surveys conducted until 19 August 1990. Fish radio-tagged during the spring exhibited the greatest range of movement (5.2 - 35.4 rkm), averaging 2.0.9 rkm, and moved between the two rivers. Fish radio-tagged during the fall exhibited very little movement (range 0.3 to 15.3 rkm) and remained in the Negukthlik River throughout the winter or until their signal was last received. Observed movements appear to be seasonal, specific to wintering habitat and possibly coincides with the spawning runs of chum and chinook salmon.

Ages, based on scale annuli, of rainbow trout in the study area ranged from 2 to 10 (n = 390). Age 4 fish comprised a substantial component (33.2% and 39.7%) during each year. Age 7 and older fish comprised 11.4% and 12.4% of the 1989 and 1990 samples, respectively.

Fork length ranged between 50 mm and 720 mm. A comparison of relative stock density distributions found a greater proportion of rainbow trout larger than 500 mm were sampled during this study than in either the Kanektok River in 1985-87 (Wagner 1991) or the Goodnews River in 1988-89 (Irving and Faustini 1994).

Mean fork length at age ranged from 177 mm (SE = 7.5) for age 2 fish in 1989 to 662 mm (SE = 11.48) for age 10 fish in 1990. These fish had the largest mean length at age for any population in the western section of the Southwest Alaska sport fish management area (Minard and Dunaway 1991). The mean lengths at age are more comparable to eastern section stocks, than those from other western Alaska stocks, suggesting more favorable environmental or genetic factors.

This study provides a benchmark for rainbow trout populations in the Negukthlik and Ungalikthluk Rivers. With periodic sampling it may be possible to determine if the management objective of historical length and age diversity are being met. Consistency in sampling methods (angling techniques and effort concentration) and scale aging techniques (criteria) are critical to making future comparisons.

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INTRODUCTION

Rainbow trout (*Oncorhynchus mykiss*) are found throughout Togiak National Wildlife Refuge (Refuge) in Southwest Alaska (Fig 1). Populations within the Refuge are near the northern limits of their natural distribution (Morrow 1980 and Alt 1978). Rainbow trout are an important subsistence and sport fish, and an important component of the aquatic ecosystems. One of the primary purposes of the Refuge is to conserve fish and wildlife species in their natural diversity. The Fisheries Management Plan for the Refuge (USFWS 1990) and State Rainbow Trout Management Plan (Minard and Delaney 1989) established a wild stock management policy for rainbow trout stocks within southwest Alaska. The policy emphasizes opportunities to catch fish from a naturally reproducing population while preserving the historic size and age structure for rainbow trout stocks. Sport fisheries targeting resident rainbow trout occur throughout the Refuge. The Refuge Fisheries Management Plan identified rainbow trout as an indicator species to assess the health of river systems and potential impacts of man's activities.

Concern over the status of the rainbow trout population and other salmonids in the Negukthlik and Ungalikthluk Rivers (Rivers) has been expressed by State and Federal biologists, subsistence users, commercial sport fishing guides and anglers. The primary concern is the loss of larger, older fish from the population, and a decline in numbers of breeding age fish. No historical data exist on the population status of rainbow trout in the Negukthlik and Ungalikthluk Rivers (Minard and Dunaway 1991).

Estimates of sport fishing effort and harvest specific to this drainage are lacking. Sport fishing guides began using the Rivers during the late 1970's, but little effort occurred until the mid 1980's (USFWS 1991). Several sport fish guides received a permit to conduct fly-in day use and one base camp existed on the rivers which provided overnight accommodations and motorboat access. Guides reported 500 angler days in 1987 and an average of 300 angler days from 1986 to 1994 (Togiak NWR files). The rivers sustained heavy sport fishing pressure and harvest in 1984 and 1985 when commercial herring fishermen were idle, waiting for commercial openings, and ascended the rivers (Minard 1987). Over limits of sport caught rainbow trout and netting of the fish in the lower river were rumored to have occurred. In 1986 the Alaska Department of Fish and Game (Department) conducted an aerial survey of spawning rainbow trout. Only 30 spawning rainbow trout were observed in the Negukthlik River, a number considered low for the system. The state sport fish biologist closed the river to sport fishing during the spawning season (April and May) in 1986 and 1987, by emergency order. In 1987 the Alaska Board of Fisheries established a spawning season (April 10 to June 7) closure on the river by regulation. Preliminary results of this study were presented to the Alaska Board of Fisheries in the spring of 1990 (Harper 1990). In 1990 the Alaska Board of Fisheries

established regulations, as part of a region wide regulation package, that requires the immediate release of rainbow trout caught in this drainage between 8 June - 31 October. Regulations also require that only single-hook artificial lures be used year-round.

Age, weight and length data from this study have been compiled in the Southwest Alaska rainbow trout historical data reports (Minard and Dunaway 1991, and Riffe 1994), but have not been presented with substantive analysis until now.

The objectives of this report were to:

1. Document the age, weight, and length composition of the rainbow trout population in the Negukthlik and Ungalikthluk Rivers, vulnerable to the sport fishery.

2. Document movements of rainbow trout within the Negukthlik and Ungalikthluk Rivers and determine critical spawning and overwintering habitat areas.

STUDY AREA

The drainage is composed of two main tributaries, the Negukthlik and the Ungalikthluk Rivers (Rivers) located approximately 20 km southeast of the villages of Togiak and Twin Hills between the Togiak and Kulukak Rivers (Fig 2). The Negukthlik River flows south from the tundra headwaters for approximately 11 km into two shallow lakes interconnected by a 0.4 km section of the river. The river then continues south for approximately 21 km joining the Ungalikthluk River approximately 3 km upstream of Togiak Bay. The Ungalikthluk River originates in the mountains between the Togiak River and Kulukak River drainages and flows south for approximately 35.4 km before joining the Negukthlik River.

The two rivers differ in channel type and bottom composition throughout most of their course. The Negukthlik River is primarily contained in one channel. Stream banks are primarily tundra with a narrow band of vegetation consisting of alder (spp?) and small cottonwood (spp?). The upper portion of the river has numerous pools and the river bottom is composed of gravel and some cobble. In the lower 13 km the river is slow and meandering with deep pools and riffles. The stream bottom is composed of gravel and fine sediments. The water and bottom are generally dark in color.

The Ungalikthluk River meanders and braids extensively throughout most of the drainage. The river bottom is composed primarily of fine to medium gravel with occasional areas of cobble. The stream banks are mostly vegetated with alder, willow and cottonwood trees. Water clarity is good downstream to tidal influence. The confluence of the two rivers is within tidal influence.

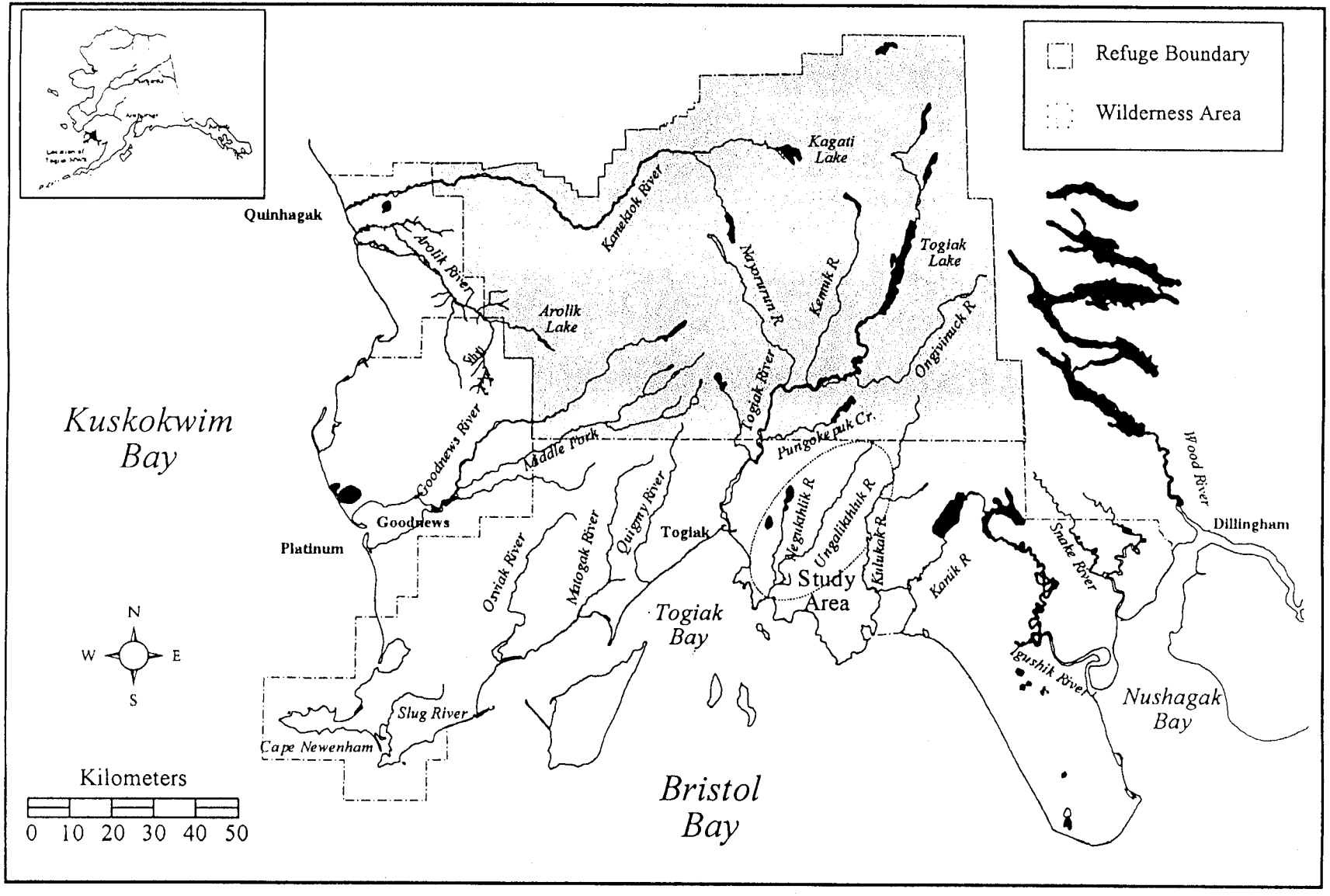


Figure 1. Major drainages and study area, Togiak National Wildlife Refuge, southwest Alaska, 1989 - 1990.

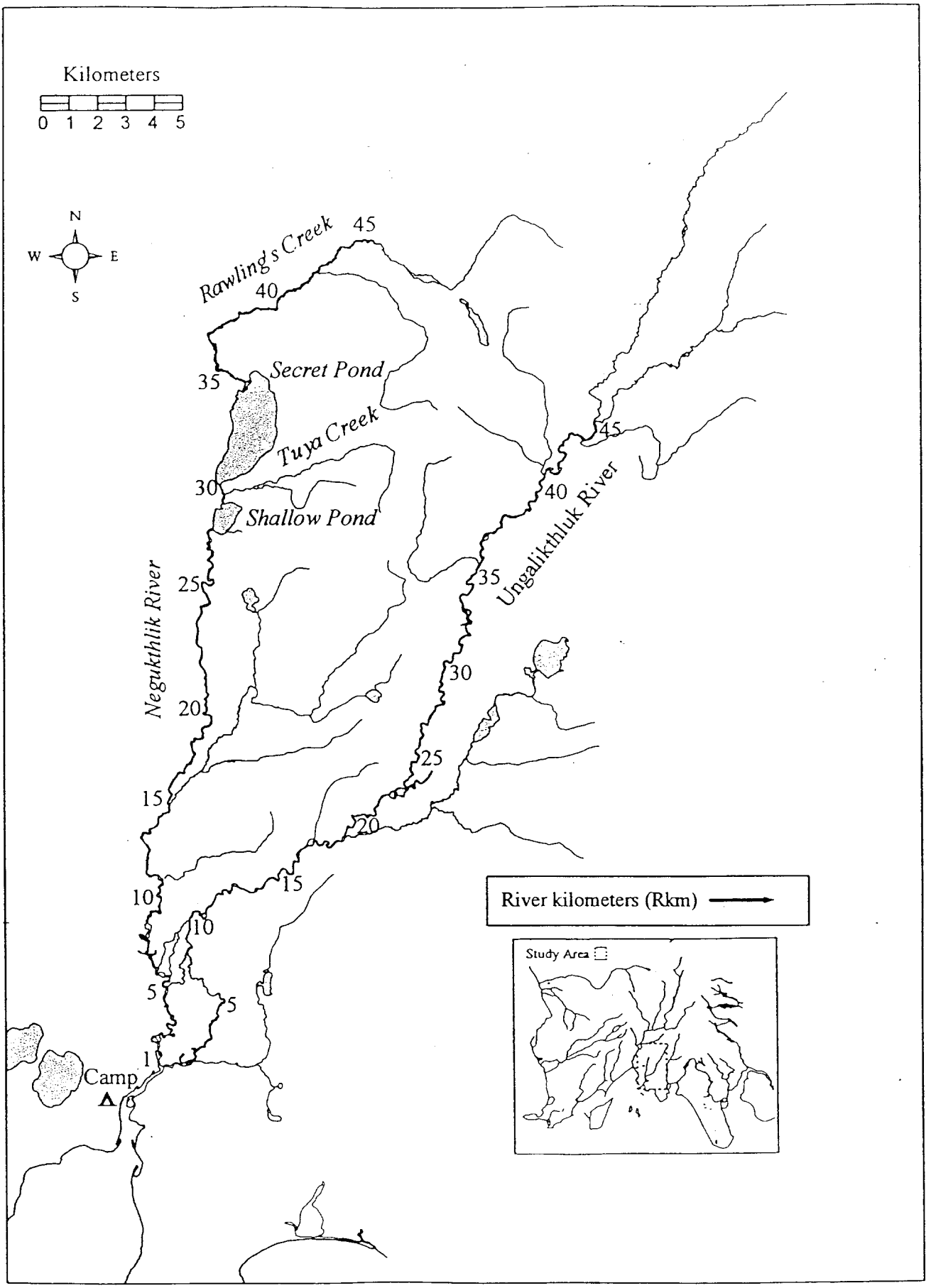


Figure 2. Negukthlik and Ungalikthluk River drainage and study area, Togiak NWR, Alaska, 1989 and 1990.

METHODS

The rivers were originally sectioned into river miles (rm), from aerial photographs, in 0.05 rm (0.08 rkm) increments. The confluence of the two rivers was labeled as river mile 1.0 (RM 1.0; RKM 1.0). Distances and locations are converted and reported as river kilometers (rkm) and RKM 0.0, respectively.

Access to the river was via a 5.5 m jon boat, with 40-horsepower jet-drive outboard. Conventional sport fishing tackle and methods (spinning and fly) were the primary capture methods used. Fishing commenced from the drifting boat and from shore.

Initial effort was concentrated in the Negukthlik River up to RKM 25.8. Once the range of safe navigation and fish concentration was identified, sampling effort occurred between the confluence and RKM 13.7 of each river. Sampling would generally begin at the location where the previous days' sampling ended and continue downstream. Once the confluence was reached sampling would begin in the upper reaches of the study area accessible to safe boat travel and continue back downstream.

Aquatic habitat, within the study area, were classified into five habitat types based on physical characteristics: riffle, shallow glide, deep glide, pool with riffle, or pool with deep glide. Habitat types were determined every 0.08 rkm. Water temperatures (°C) were recorded during daily sampling using a pocket thermometer.

Age, Weight and Length

Captured rainbow trout were measured using standard age, weight, and length (AWL) sampling techniques as outlined in Clutter and Whitesel (1956). Scales were collected from the left side of the fish in the preferred scale area (Jearld 1983). Fork length was measured to the nearest mm and weight recorded to the nearest 0.25 kg. In addition to length and weight measurements, the tag number, date and time of capture, location (RM), collector and any distinguishing characteristics (recapture, mortality, condition, etc.) were recorded on the scale envelope. Recaptured fish were measured for length and weight. The increase in length (growth) between capture and recapture events is reported. Fish gender was recorded when easily determined. Individual fish maturity was classified using standard Alaska Department of Fish and Game criteria (Alt 1976). The four maturity classifications were: immature, developing, spawning and post-spawning.

Acetate impressions were made of scales using a hydraulic press (Dery 1983 and Riffe 1994a). All scales were aged using a Canon PC 70M microfiche copier with a forty-power (40x) lens. Standard methods (Coggins 1994) were used to determine scale age. Observed "plus" growth beyond the last annuli was interpreted based on date of scale collection. The age of a fish sampled in the spring and having plus growth beyond the last annulus would be the number of visible annulus plus one year. The age of a scale with no

plus growth in the spring or having plus growth later in the summer was interpreted as the number of visible annuli. The scale reader made three independent age determinations for each scale sample and reported the mean modal age for each fish in total years. Samples with no modal age were treated as unreadable.

Data were transferred to Alaska Department of Fish and Game (Department) Standard Age Weight Length mark-sense data form (V1.1) (ADFG 1990) which were optically scanned to create an electronic data set for archiving (Heineman 1989a) (Appendix Table A1). Completed data sets were analyzed using the crosstabulation software program BBX (Heineman 1989b). The BBX program produced unweighted estimates of mean length (and standard errors), weight and age composition following procedures outlined by Sokal and Rohlf (1981) (Riffe 1994b). Age frequency distributions were compared between years using a G-test of independence ($\propto$ =.05). Age groups were combined for comparison if more than 20% of the cells had an expected frequency of less than (<) 5.0. The age at which the population is fully recruited into the sport fishery was considered to be the first year beyond the modal age of the catch curve (Ricker 1975). Length frequency distributions were calculated based on 10 mm size increments. Cumulative length frequency distributions (1.0 mm) were compared ($\propto$ = .05) between years with a Kolmogorov-Smirnov (K-S) two sample test (Sokal and Rohlf 1981).

Relative stock density (RSD) was estimated for rainbow trout based on fork length measurements adapted from Gablehouse (1984) (Wagner 1991, and Irving and Faustini 1994). Length categories were selected to reflect a non-anadromous, riverine resident rainbow trout population strategy for western Alaska. The five relative stock density categories were: Stock <299 mm; Quality 300-399 mm; Preferred 400-499 mm; Memorable 500-599 mm; and Trophy ≥600 mm. A G-test (Sokal and Rohlf 1981) was used to compare ($\propto$ =0.05) RSD distributions between years and with samples from other Western Alaska rainbow trout populations.

Location and Movement

Fish greater than 200 mm fork length were marked with a numbered Floy™ spaghetti tag placed on the left side just posterior to the dorsal fin. Tag number and sampling location, to the nearest 0.08 rkm, were recorded for captured and recaptured fish. Movement between observations was relative to initial location and date. Locations within the Negukthlik River are reported as positive numbers whereas locations in the Ungalikthluk River are reported as negative numbers. Recaptures and their locations which were reported by local area sport fishing guides and their clients are included in movement analysis. Locations and relocations (recaptures) were pooled and sorted according to time of year (season). Sampling effort and tag deployment were concentrated during 3 seasons: spring/post-spawning (May & June); summer (July and August); and fall (September).

During 1989 twenty-two rainbow trout were surgically implanted with low-frequency (40 - 42 MHZ) radio transmitters. Fourteen of the transmitters, Advanced Telemetry Systems (ATS) Model 15, had an expected battery life of 150 days, weighed approximately 30 g, and measured 75 mm long and 17 mm in diameter. Eight transmitters, AVM Model SM-1, had an expected battery life of 270 days, weighed 15 g, and measured 64 mm long and 12 mm in diameter. Both models had an internal loop antennae and were encapsulated in an additional inert coating of beeswax. Transmitters were tested for frequency drift and signal strength immediately prior to and after surgery.

Transmitters were implanted into fish anesthetized with tricaine methane sulfonate (MS-222) using surgical procedures outlined by Burger, et al. (1983) and Summerfelt and Smith (1990). Transmitters were implanted in fish captured during spring and fall and monitored to determine summer migration and location of important winter and spawning habitat.

Radio tracking was conducted from fixed-wing aircraft (USFWS 1981) and boat. An ATS Challenger 2000 programmable scanning receiver was used with a directional loop antenna (range 0.3 to 0.5 km). Tracking surveys were scheduled twice a week during April and May, twice a month from June through August, and once a month during September through April. Ground (boat) surveys were not intended to cover the entire study area, but consisted of monitoring for frequencies while traveling to daily sampling locations. Ground surveys were also used to monitor recently implanted fish to ensure that their transmitters were functioning properly. Aerial tracking consisted of an extensive search of the study area with the aircraft operated between 30 to 300 meters above ground level. Upon receiving a transmission, multi-directional flights were used to pinpoint fish location which were then marked on photocopies of color infrared aerial photographs of the drainage. Capture, recapture and telemetry locations were recorded for each individual fish to the nearest 0.08 rkm.

RESULTS

In 1989 sampling occurred during the spring (13 May - 27 June), summer (3 - 10 August), and fall (2 September to 2 October) (Appendix Table A2). In 1990 sampling occurred during the spring (23 May - 4 June and 15 - 29 June), and summer (19 - 24 August). No effort occurred during fall 1990. A total of 600 rainbow trout were captured and sampled during both years of the study. In 1989, 322 fish were caught, of which 41 were recaptures, 24 were mortalities, 17 sampled and released unmarked, and 240 were marked. In 1990 a total of 278 fish were caught, of which 52 were recaptures, 8 were mortalities, 69 fish sampled and released unmarked, and 149 were marked.

Age, Weight and Length

Ages were determined for 390 readable rainbow trout scales collected in 1989 ($N = 211$) and 1990 (N = 179) (Tables 1 and 2, and Fig 3). Seven age groups were determined from samples collected in 1989 (ages 3-8, and 10). Nine age groups were determined from samples collected in 1990 (ages 2-10). Age 4 was the strongest age class accounting for 33.2% (70) of the sample in 1989 and 39.7% (71) in 1990. Age 7 or greater fish accounted for 11.4% in 1989 and 12.4% in 1990. Rainbow trout were fully recruited into the sport fishery by age 5 (Ricker 1975). Age frequency distributions differed between 1989 and 1990 (G-test; G = 42.66, df = 6, $P < 0.001$).

Fork-length was measured on 285 rainbow trout in 1989 and 273 in 1990 (Fig. 4). Lengths averaged 433 mm (53 - 720 mm, SE = 7.73) in 1989, and 413 mm (150 - 700 mm, SE = 8.03) in 1990. Cumulative length frequency distributions (Fig. 5) differed between 1989 and 1990 (K-S test; D = 0.1507, P = 0.003). Mean lengths of rainbow trout which were unaged due to scale regeneration or a lack of modal age were larger than sample means for both years (Table 1 and 2). Mean length for unaged fish was 480 mm (SE = 19.22) in 1989 and 484 mm (SE = 12.60) in 1990.

Length at age in 1989 (Fig 6 and Table 1) ranged from 269 mm (SE = 7.33) at age 3 to 639 mm (SE = 11.24) at age 10. Length at age in 1990 (Fig 6 and Table 2) ranged from 177 mm (SE =7.5) at age 2 to 662 (SE = 11.48) at age 10.

Weights were taken on 278 rainbow trout sampled in 1989 (Table 1) and 273 in 1990 (Table 2). In 1989 weights ranged from 150 g to 4650 g, and averaged 1303 g (SE = 62.64). In 1990 weights ranged from 50 g to 4625 g, and averaged 1156 g (SE = 61.99).

Sex was determined for 102 rainbow trout in 1989 and 124 in 1990 (Tables 1 and 2). Females constituted 49% (N= 50) and 58.9% (N= 73) of the samples in 1989 and 1990. Females were primarily age 6 in 1989 (N= 10) and age 4 in 1990 (N= 13). Males were primarily age 7 in 1989 (N= 11) and age 6 in 1990 (n = 7). Mean length was larger for males than females for both years. Maturity index for most fish sampled was

undetermined (*N*= 338) or recorded as immature (*N*= 237). Spawning and post-spawning designations were recorded for 23 fish in 1989, and 2 fish in 1990.

Growth, calculated as increase in length over time, was estimated for 57 recaptured fish and averaged 26 mm. Average time between observations was 259.1 days (range 1 - 430 days). For fish recaptured at least one year (365 days) (*N* = 13) from initial capture date growth averaged 39.4 mm per year (range 0.0 to 101.0 mm/yr).

Relative stock density (RSD) category proportions did not differ between years ($G = 3.41$; $df = 4$; $P > 0.05$). Fewer fish in the Memorable and Trophy length categories were taken in 1990 than in 1989 (Figure 7). Trophy length fish (>600 mm) accounted for 13% (37) and 10.6% (29) of the samples collected in 1989 and 1990, respectively. In 1989, 30.2% (86) of the fish were classified in the Quality length category (300 - 399 mm). In 1990, numbers of rainbow trout caught were equally divided between Stock (24.5%) and Quality (25.0%) categories.

RSD distributions of rainbow trout in the Negukthlik and Ungalikthluk Rivers (1989-90) differed than those measured from the Kanektok River in 1985-87 ($G = 32.37$, $P < 0.001$)(Wagner 1991), Goodnews River in 1988-89 ($G = 14.70$, $P = 0.005$) (Irving and Faustini 1994) and the Arolik River in 1991-94 ($G = 45.38$, $P < 0.001$) (Lisac and MacDonald 1995) (Figure 8). The Negukthlik and Ungalikthluk Rivers had a higher proportion of Stock (19.5%), Quality (27.5%), and Trophy (12%) size rainbow trout, and fewer in the preferred (22.5%) size range, than in the other Western Alaska rainbow populations. The proportion of rainbow trout greater than 500 mm (Memorable + Trophy) was greatest for the Arolik (42%), followed by the Negukthlik/Ungalikthluk (31%), Goodnews (26%), and Kanektok (14%) rainbow trout populations.

Habitat type classification were completed for the Negukthllik River from RKM 1.0 to 13.0 (Appendix Table A5). Habitat types were not classified in the Ungalikthluk River. Known seasonal use by rainbow trout was documented by telemetry location, hook and line captures, or visual observations and presented as appendix tables (A5 and A6).

Water temperature measurements were made in the study area during 1989 and 1990 (Appendix Tables A7 and A8). Temperatures varied depending on location of measurement and time of day. Temperatures in the Negukthlik River were generally below 5.5 °C between 10 and 14 May 1989 and stayed above 5.5 °C after 23 May 1989 or 23 May 1990. Ungalikthluk River water temperatures were not taken as consistently, but were lower than Negukthlik River water temperatures and did not exceed 5.5 °C until 17 June in 1989. An earlier recording of 6.2 °C was possibly taken within the tidal area of the Ungalikthluk River and is not considered valid. Until the end of June water temperatures in the Ungalikthluk River did not exceed 10.0 °C.

Table 1. Mean lengths (mm) and weights (g) of rainbow trout by sex and age group from the Negukthlik and Ungalikthluk Rivers, 1989.

	Age Group									
	UNKNOWN	3	4	5	6	7	8	9	10	TOTAL
UNKNOWN										
n (Known age)		31	66	32	22	3			1	155
Percent		14.7	31.3	15.2	10.4	1.4			0.5	73.5
Std Err		2.44	3.20	2.48	2.11	0.82			0.47	3.05
Mean Ln	348	268	356	422	480	528			610	370
Std Err	27.88	7.59	5.12	8.29	10.76	17.53				7.38
Sample Size	32	31	66	32	22	3			1	187
Mean Wt	925	257	587	966	1464	1907			3050	792
Std Err	147.05	30.56	33.96	62.88	113.21	397.04				44.24
Sample Size	28	30	66	32	22	3			1	182
FEMALES										
n (Known age)			2	5	10	3	2		4	26
Percent			0.9	2.4	4.7	1.4	0.9		1.9	12.3
Std Err			0.67	1.05	1.47	0.82	0.67		0.94	2.27
Mean Ln	547		407	472	540	572	585		646	543
Std Err	16.90		15.50	19.60	17.95	24.85	33.50		11.14	11.29
Sample Size	22		2	5	10	3	2		4	48
Mean Wt	2045		875	1285	2175	2300	2600		3438	2118
Std Err	189.58		75.00	218.27	258.61	312.25	850.00		167.55	134.78
Sample Size	21		2	4	10	3	2		4	46
MALES										
n (Known age)		2	2	6	9	11				30
Percent		0.9	0.9	2.8	4.3	5.2				14.2
Std Err		0.67	0.67	1.15	1.39	1.53				2.41
Mean Ln	616	286	382	461	559	596				561
Std Err	13.18	36.00	12.50	29.44	24.16	18.45				14.63
Sample Size	20	2	2	6	9	11				50
Mean Wt	2940	325	700	1392	2390	2701				2408
Std Err	192.95	125.00	150.00	286.48	350.84	271.08				157.72
Sample Size	20	2	2	6	9	11				50
ALL SAMPLES										
n (Known age)		33	70	43	41	17	2		5	211
Percent		15.6	33.2	20.4	19.4	8.1	0.9		2.4	100.0
Std Err		2.51	3.25	2.78	2.73	1.88	0.67		1.05	
Mean Ln	480	269	359	433	512	580	585		639	433
Std Err	19.22	7.33	4.98	8.09	10.33	14.11	33.50		11.24	7.73
Sample Size	74	33	70	43	41	17	2		5	285
Mean Wt	1850	262	598	1057	1841	2490	2600		3360	1303
Std Err	141.64	29.31	32.77	68.59	130.09	203.22	850.00		151.16	62.64
Sample Size	69	32	70	42	41	17	2		5	278

Table 2. Mean lengths (mm) and weights (g) of rainbow trout by sex and age group from the Negukthlik and Ungalikthluk Rivers, 1990.

	Age Group										
	UNKNOWN	2	3	4	5	6	7	8	9	10	TOTAL
UNKNOWN											
n (Known age)		2	42	55	6	6	1	1	1	1	115
Percent		1.1	23.5	30.7	3.4	3.4	0.6	0.6	0.6	0.6	64.2
Std Err		0.79	3.18	3.46	1.35	1.35	0.56	0.56	0.56	0.56	3.59
Mean Ln	413	177	270	311	398	455	530	532	589	647	338
Std Err	22.15	7.50	6.38	6.31	29.01	9.88					8.56
Sample Size	36	2	42	55	6	6	1	1	1	1	151
Mean Wt	1164	88	272	400	905	1263	1825	1200	2450	2925	642
Std Err	171.75	12.50	18.05	23.08	193.91	109.67					56.83
Sample Size	36	2	42	55	6	6	1	1	1	1	151
FEMALES											
n (Known age)			3	13	9	7			6	2	40
Percent			1.7	7.3	5.0	3.9			3.4	1.1	22.3
Std Err			0.96	1.95	1.64	1.45			1.35	0.79	3.12
Mean Ln	521		345	372	437	512			617	634	486
Std Err	17.02		32.53	9.35	20.25	21.02			16.09	3.00	12.55
Sample Size	32		3	13	9	7			6	2	72
Mean Wt	1939		525	710	1147	1843			3042	3150	1676
Std Err	182.46		137.69	67.55	177.63	188.49			233.24	200.00	121.84
Sample Size	32		3	13	9	7			6	2	72
MALES											
n (Known age)			1	3	3	7		5	2	3	24
Percent			0.6	1.7	1.7	3.9		2.8	1.1	1.7	13.4
Std Err			0.56	0.96	0.96	1.45		1.24	0.79	0.96	2.55
Mean Ln	538		320	386	467	515		556	610	686	531
Std Err	16.63			18.56	1.67	16.30		8.93	22.00	8.33	12.88
Sample Size	26		1	3	3	7		5	2	3	50
Mean Wt	1947		425	750	1317	1675		2366	3100	3650	1959
Std Err	177.78			152.75	44.10	180.85		207.50	600.00	292.97	135.11
Sample Size	26		1	3	3	7		5	2	3	50
ALL SAMPLES											
n (Known age)		2	46	71	18	20	1	6	9	6	179
Percent		1.1	25.7	39.7	10.1	11.2	0.6	3.4	5.0	3.4	100.0
Std Err		0.79	3.28	3.67	2.25	2.36	0.56	1.35	1.64	1.35	
Mean Ln	484	177	276	326	429	496	530	552	612	662	413
Std Err	12.60	7.50	6.75	6.08	14.61	11.14		8.28	11.44	11.48	8.03
Sample Size	94	2	46	71	18	20	1	6	9	6	273
Mean Wt	1645	88	292	471	1095	1610	1825	2172	2989	3362	1156
Std Err	109.17	12.50	20.54	27.26	111.44	107.08		257.82	193.07	193.62	61.99
Sample Size	94	2	46	71	18	20	1	6	9	6	273

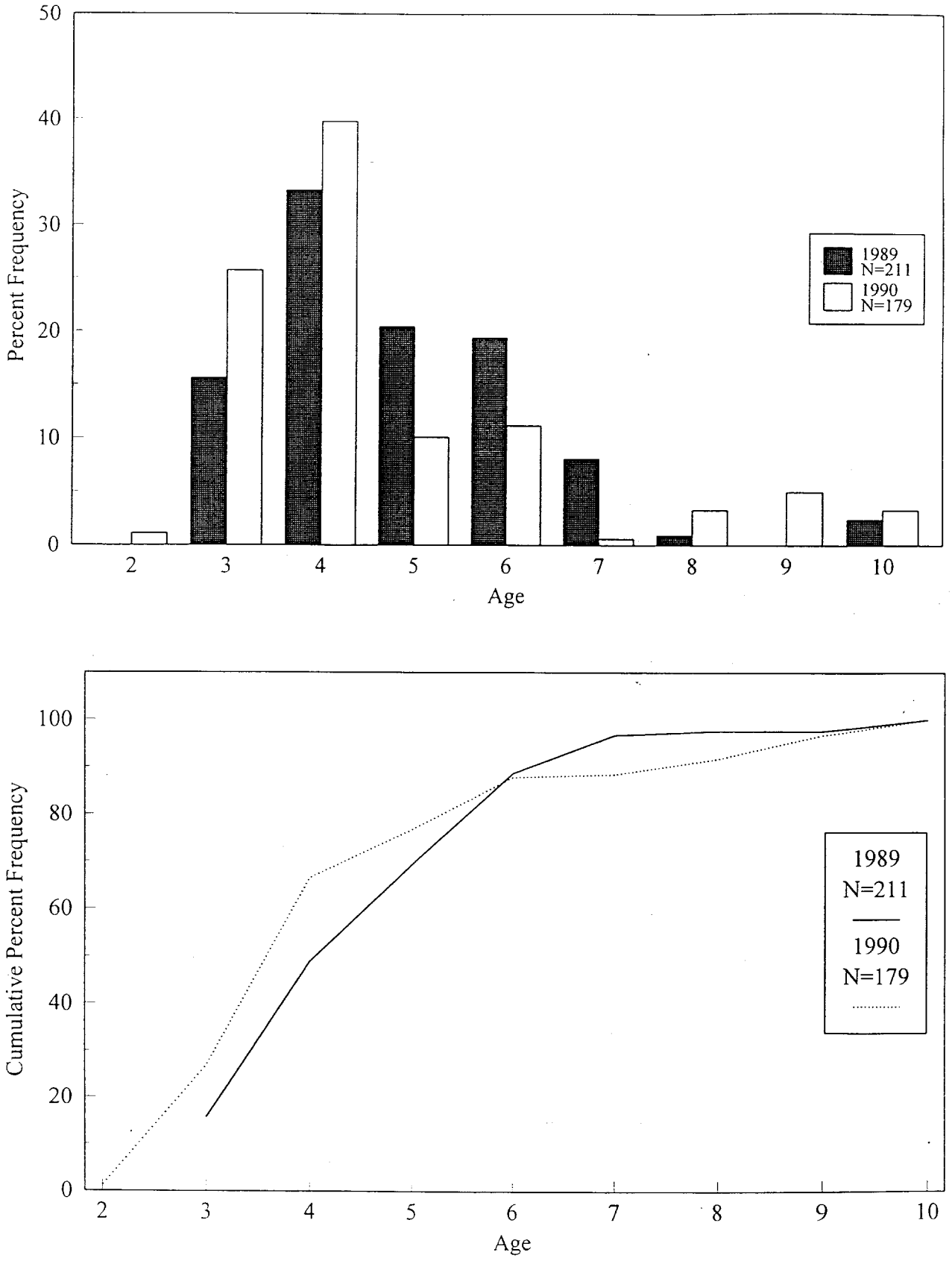
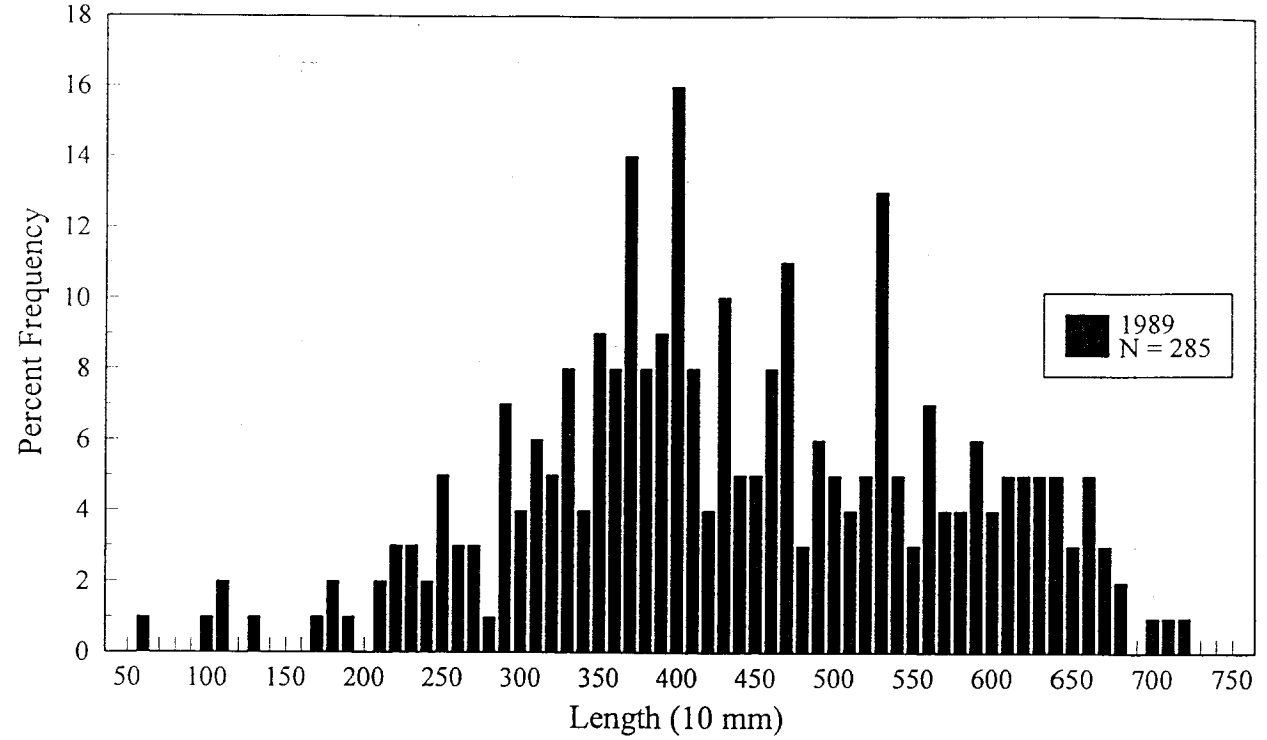


Figure 3. Age frequency and cumulative age frequency of rainbow trout from the Negukthlik and Ungalikthluk Rivers, 1989 and 1990.



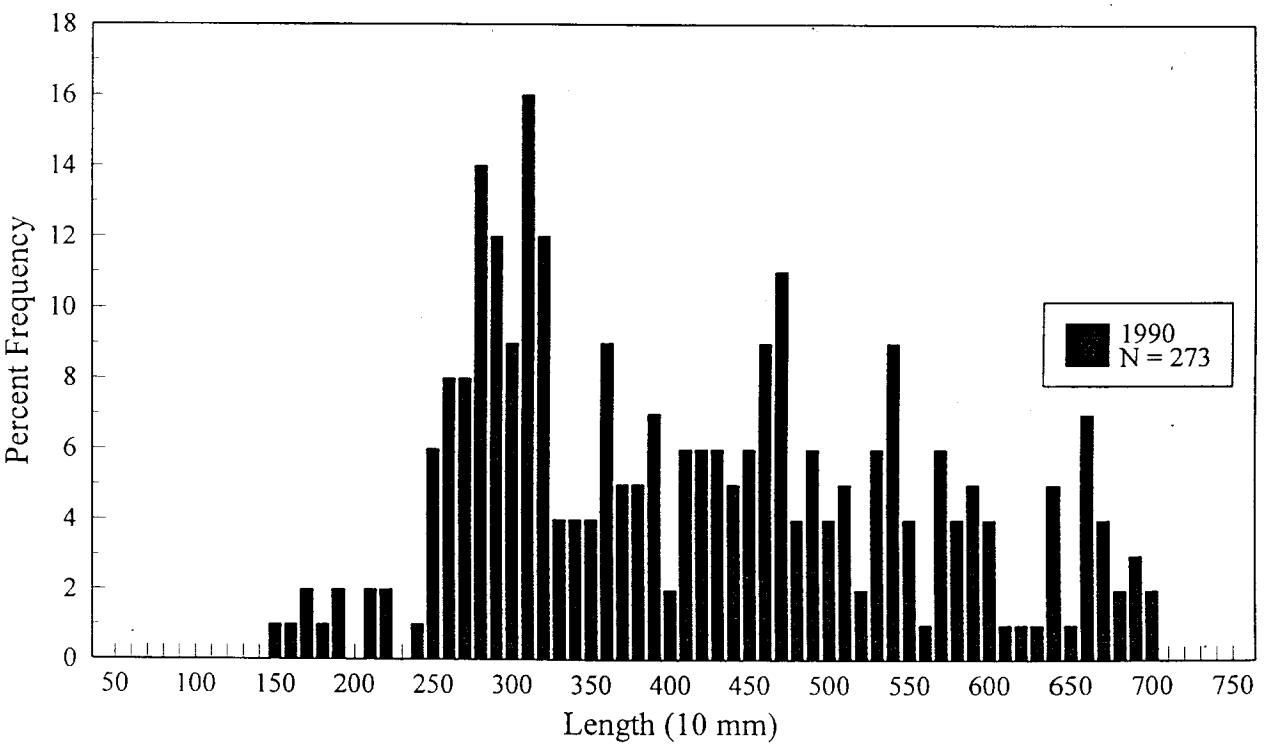


Figure 4. Length frequency distribution (10 mm increments) for rainbow trout in the Negukthlik and Ungalikthluk Rivers, 1989 and 1990.

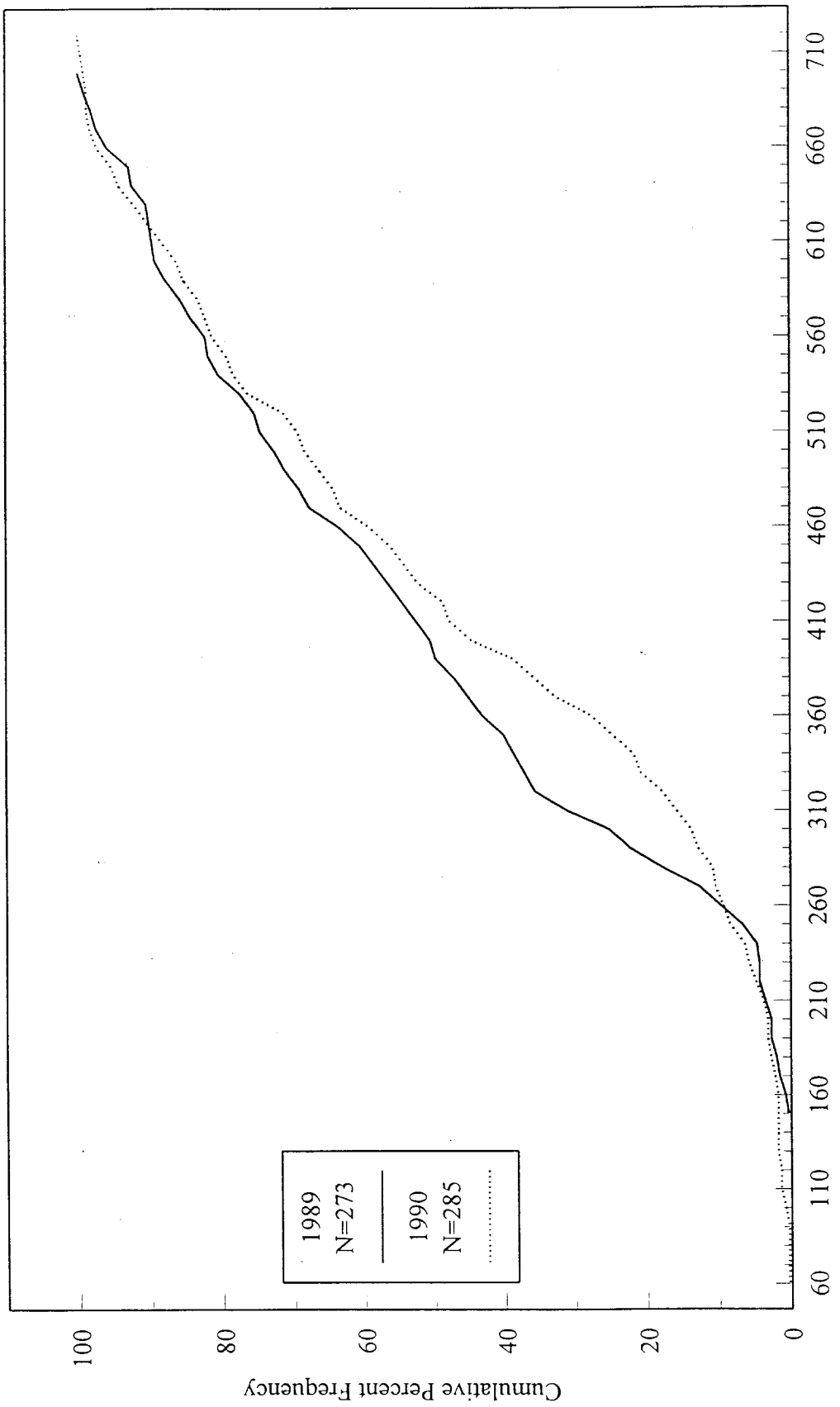


Figure 5. Cumulative fork length frequency of rainbow trout from the Negukthlik and Ungalikthluk Rivers, 1989 and 1990.

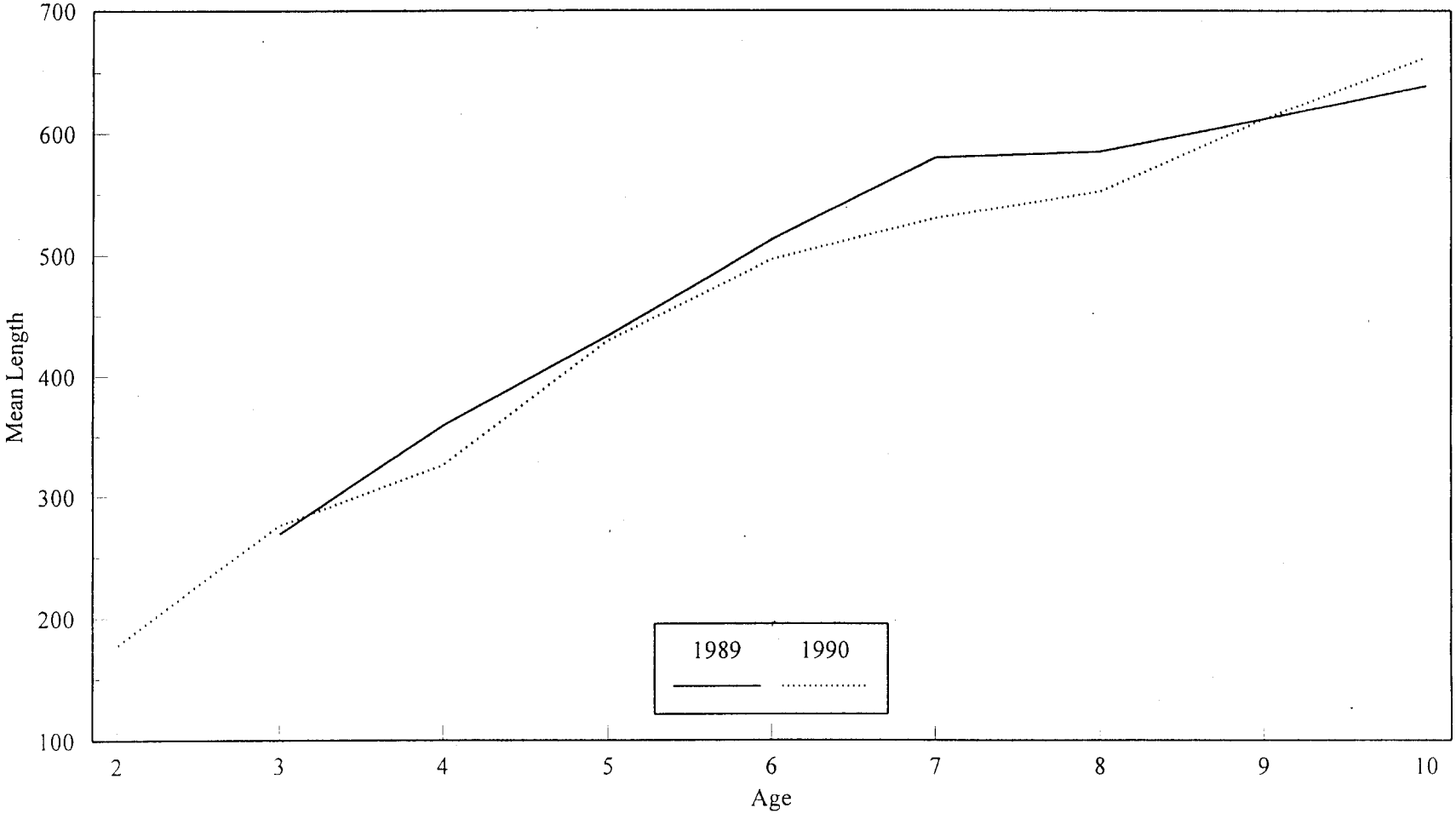
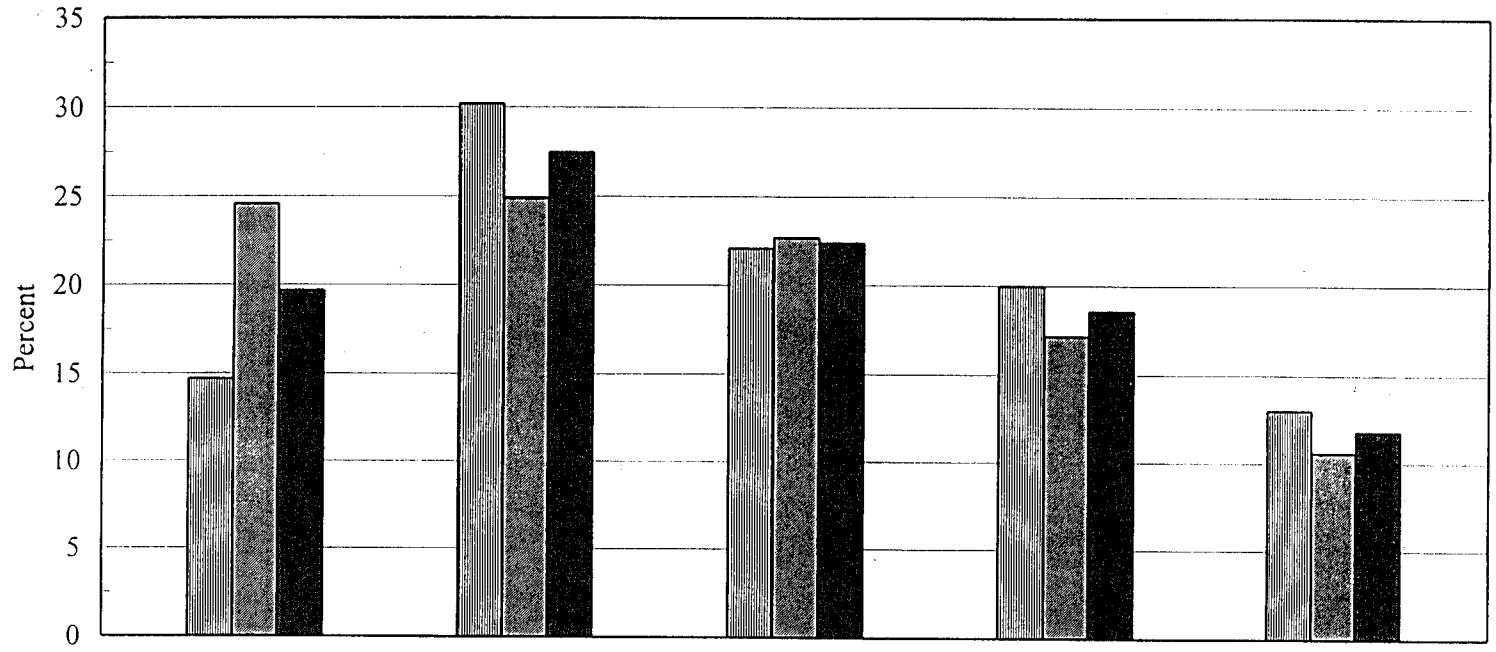
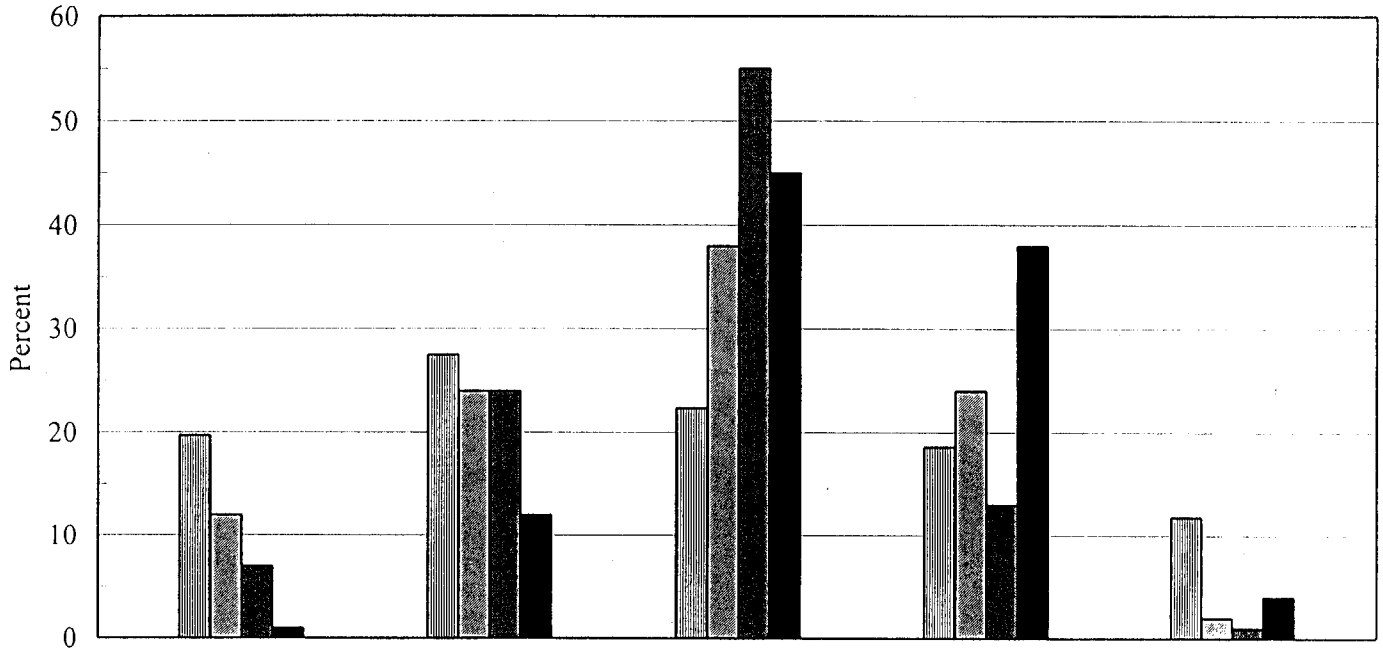


Figure 6. Mean length at age for rainbow trout from the Negukthlik and Ungalikthluk Rivers, Togiak National Wildlife Refuge, 1989 and 1990.



Relative Stock Density	Stock <299mm	Quality 300-399mm	Preferred 400-499mm	Memorable 500-599mm	Trophy >=600mm
1989 (N=285)	14.7	30.2	22.1	20.0	13.0
1990 (N=273)	24.6	24.9	22.7	17.2	10.6
Combined	19.7	27.5	22.4	18.6	11.8

Figure 7. Relative stock density (%) of rainbow trout from the Negukthlik and Ungalikthluk Rivers (1989 - 1990).



Relative Stock Density	Stock <299mm	Quality 300-399mm	Preferred 400-499mm	Memorable 500-599mm	Trophy >=600mm
Negukthlik/Ungaliktluk (N=558)	19.7	27.5	22.4	18.6	11.8
Goodnews 1988 - 89 (N=364)	12.0	24.0	38.0	24.0	2.0
Kanektok 1985 - 87 (N=865)	7.0	24.0	55.0	13.0	1.0
Arolik 1991-94 (N=999)	1.0	12.0	45.0	38.0	4.0

Figure 8. Relative stock density (%) of rainbow trout from the Negukthlik and Ungalikthluk Rivers (1989 - 1990), Goodnews River (1988 - 1989), Kanektok River (1985 - 1987), and Arolik River (1991 - 1994).

Location and Movement

Radio transmitters were implanted in 24 rainbow trout during May (6), June (8) and September (10) in 1989 (Figure 9 and Appendix Table A3). Two transmitters were recovered from fish that died shortly after release. All of the remaining 22 fish tagged provided useable data for variable lengths of time. Implanted fish averaged 584.7 mm in length (475 - 677 mm) and 2562.5 g (1250 - 3650 g). Ten implanted rainbow trout were males, 9 were females, and 3 unknown.

Most transmitters (21) were implanted in fish captured at the confluence of the two rivers up to RKM 12.1 of the Negukthlik River. The remaining implant occurred at RKM 32.2 (Secret Pond inlet) of the Negukthlik River. One fish (#1259) was originally caught on 9 August 1989 at RKM -9.0 (Ungalikthluk River), but wasn't radio-tagged until it was recaptured in the Negukthlik River (RKM 11.4) on 26 September 1989.

Tracking of radio tagged fish occurred between 19 May 1989, to 19 August 1990. During this time there were 17 aerial tracking flights, 28 ground tracking surveys, and 8 hook and line recaptures. The number of locations per fish averaged 9.6 (range 4 - 23). Duration from initial implant to latest known location averaged 199.5 days (range 70 - 430 days).

Rainbow trout implanted during May and June ($N = 12$) exhibited an average range of movement of 20.9 rkm (range 5.2 - 35.4 rkm) (Figure 9). All but two of these fish traveled to the Ungalikthluk River, between RKM -10.8 and -17.7, during July and August. Of the two fish which remained in the Negukthlik River, one (#525) traveled upstream above RKM 20.1 and never returned downstream, while the other (#530) remained near the location of initial implant (RKM 10.8) until September, when it moved downstream. Nine of the ten fish which traveled to the Ungalikthluk River returned to the Negukthlik River by fall of 1989.

Rainbow trout implanted during September 1989 ($N = 10$) moved an average of 4.8 rkm (range 0.3 to 15.3 rkm). Nine of these fish were initially captured between RKM 7.1 and 12.1. The last fish was implanted at RKM 32.2 of the Negukthlik River. All of these fish remained in the Negukthlik River throughout the winter until the last tracking flight (May 1990). One fish (#1292) from this group however, was recaptured by hook and line in the Ungalikthluk River (RKM -6.4) on 27 June 1990. This fish was located 188 days after its last known radio location on 21 December 1989.

Locations and movements were determined for 93 recaptured Floy™ tagged fish (Appendix Table A4). There were 13 fish recaptured twice and two fish recaptured 3 times for a total of 120 recapture locations. Fish were recaptured between 2 and 420 days after initial marking. Average distance between capture and recapture was 3.1 rkm (SD = 4.73; range 0.0 to 22.7 rkm). Twenty-three (20%) of recaptured fish moved between the two rivers or confluence.

Most fish were originally marked during the spring and recaptured during either the spring (N = 47) or summer (N = 38) (Table 3). The average distance moved was highest for fish originally marked in the summer and recaptured in the fall (5.6 rkm; SD = 6.98).

Most recaptured fish (57.5%) moved less than 1.0 rkm between capture and recapture events (Table 4). The mean fork length at capture for this group was 451.2 mm (SD = 82.83). Sixteen fish (13.3%) moved a distance greater than 10.0 rkm. These fish had the greatest average fork length at 541.8 mm (SD = 102.15).

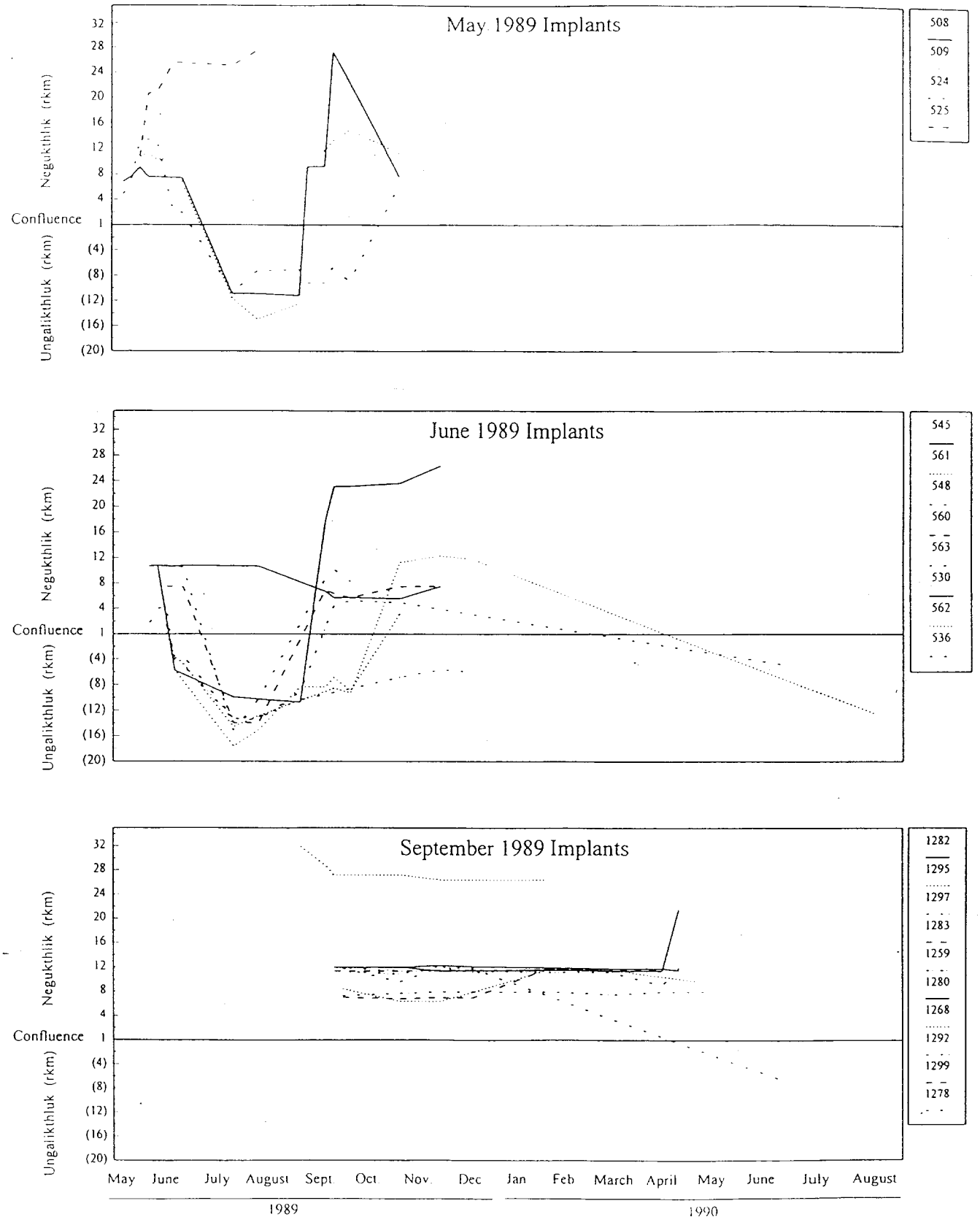


Figure 9. Movements of radio tagged rainbow trout by aerial and ground tracking or recaptured by hook and line, Negukthlik and Ungalikthluk Rivers, 1989 - 1990.

Table 3. Seasonal movement observed* between initial capture and recapture events for marked (Floy tagged) rainbow trout in the Negukthlik and Ungalikthluk Rivers, 1989 - 1990.

Season**			Movement (river kilometers)			Recapture Location		
Initial Capture	Recapture	N	Mean	S.D.	Range	Negukthlik	Ungalikthluk	Confluence
Spring	Spring	47	2.11	2.91	0.0 - 11.19	40	6	1
Spring	Summer	38	4.62	6.07	0.0 - 22.69	26	11	1
Spring	Fall	9	2.82	1.08	0.0 - 17.22	9	0	
Summer	Spring	14	2.37	3.12	0.0 - 12.15	13	1	
Summer	Summer	5	0.80	0.43	0.48 - 1.61	3	2	
Summer	Fall	4	5.60	6.98	0.16 - 17.22	4	0	
Fall	Spring	3	5.28	6.97	0.08 - 15.13	2	1	
Total		120	3.09	4.73	0.0 - 22.69	97	21	2

* Includes all USFWS and Guide Reported recaptures

** Spring: 13 May to 27 June, 1989: 23 May to 29 June, 1990.
** Summer: 3 Aug to 10 Aug, 1989: 19 Aug to 24 Aug, 1990.
** Fall: 2 Sept to 2 Oct, 1989.

Table 4. Distance moved and mean length of recaptured Floy tagged rainbow trout in the Negukthlik and Ungalikthluk Rivers, 1989 and 1990.

Distance moved (km)	N	%	Mean length (mm)	Range (mm)	S.D.
0 - 1.0	69	57.5	451.2	275 - 644	82.83
1.1 - 5.0	30	25.0	460.3	273 - 654	100.53
5.1 - 10.0	5	4.2	505.0	380 - 658	99.48
> 10.0	16	13.3	541.8	301 - 660	102.15
	120	100.0	469.2	273 - 660	95.39

DISCUSSION

Age, Weight and Length

Negukthlik and Ungalikthluk River rainbow trout ages (2 - 10) were similar to previously reported ages for western Alaska rainbow trout stocks (Minard and Dunaway 1991). The western section includes the Kuskokwim Bay (Kanektok, Arolik and Goodnews) and Togiak Bay Rivers. Ages based on scale annuli ranged between 3 to13 for the 1,794 rainbow trout reported by Minard and Dunaway (1991). More recent (1993-94) data for the Kanektok (Adams 1996) and Goodnews (Faustini 1996) Rivers revealed rainbow trout ages ranging between 2 - 10, and 2 - 9 years.

Applying rainbow trout ages based on scale annuli to assess management actions and making age comparisons between years or between rivers may be suspect. Differences in age frequency distributions between years could be due to sampling or aging biases, occurrence of unreadable or regenerated scales, or to an actual differences in age composition between years. Methods or criteria used in determining scale ages for rainbow trout can influence age ranges and distributions. Scales from riverine rainbow trout populations are difficult to read and are subject to error (Lentsch and Griffith 1987). The greater annual mean length for fish which were unaged due to unreadable or regenerated scales is further evidence that rainbow trout are difficult to age especially in the later years of life. Additionally within-reader and between-reader age estimation variability can effect the outcomes of population age composition analysis (Coggins 1994). In this study within-reader variability was minimized by using the same trained scale reader for both datasets and applying standard criteria outlined by Coggins (1994). Ages for other western rivers' rainbow trout were determined by different readers and may not be comparable.

Differences in annual sampling methods, intensity and timing possibly contributed to differences in age distribution between years. In 1989 the crew looked primarily for spawning age and larger fish for transmitter implant, hence they spent most of their time working in areas of previous success. In 1990, minimum size was not a factor. Also, a new crew was used. Similar factors could be responsible for differences observed in mean length and cumulative length frequency between years.

Unlike ages, the maximum length (720 mm) was greater than those reported for the Kanektok (Wagner 1991; 640 mm) and the Goodnews River (Irving and Faustini 1994; 686 mm). However, maximum length was less than those reported for eastern Bristol Bay rainbow trout populations (Minard and Dunaway 1991) which are primarily lacustrine.

Difference observed between RSD category distribution of Negukthlik and Ungalikthluk rainbow trout and other western Alaska Rivers may be due to environmental factors (habitat and climate), or population life history strategies or the level of external influences

each river receives. The Negukthlik and Ungalikthluk Rivers are further south than the other three rivers and in an area that may provide more favorable environmental conditions and allow individual fish to attain a greater length.

The mean lengths at age for rainbow trout in the study area were larger than those reported for other populations in the western section of the southwest Alaska during 1954 - 1989, and similar to those reported in the eastern section (Minard and Dunaway 1991). Minard and Dunaway (1991) reported that mean lengths per year class for rainbow trout from the western section (N = 1,794 fish) for ages 3 to 9 ranged from 225 mm to 540 mm, respectively. They reported that mean length at age was greatest in the eastern section (N = 17,460 fish), for ages 3 to 10, ranging from 260 mm to 690 mm. Rainbow trout in the Negukthlik and Ungalikthluk Rivers had a mean length at age greater than the eastern populations at ages 3, 4 and 5 and lower for ages 8, 9 and 10. Based on the range of mean length at age it appears as though rainbow trout in the Negukthlik and Ungalikthluk Rivers exhibit a greater growth rate than other western populations and grow similar to eastern stocks until approximately age 7. These apparent growth rate differences could be attributed to different life histories (lacustrine vs riverine) and environmental conditions facing these different stocks or be due to the same factors affecting scale age determination.

Location and Movements

Telemetry and floy tag movement data both indicate that rainbow trout in this study are not discrete populations and move throughout the entire Negukthlik River upstream to the Shallow Pond outlet and at least the lower 17.7 rkm of the Ungalikthluk River. However, the results may be biased because all transmitters were implanted in fish captured in the Negukthlik River or confluence of the two rivers.

Observed movements, or lack of movement, were related to the time of year (season) in which initial and subsequent relocations occurred. Results from radio and visual tag relocations suggest that most rainbow trout in this study area winter and probably spawn in the Negukthlik River. Fish then move downstream and ascend the Ungalikthluk River between mid-June through late July. This upstream migration would coincide with the spawning migration of chum (O. keta) and chinook (O. tshawytscha) salmon documented in this area (ADFG 1996). Beginning in mid or late August through early September, rainbow trout moved back downstream and return to the Negukthlik River near the site where they were initially captured. Fish in the Negukthlik River by September of 1989 remained in a limited area of the river. During the winter months (November to March) 17 of 20 active transmitters were found between RKM 3.2 and 12.4 Negukthlik River. There were variations observed in a minority of this sample which may be indicative of the limited range of locations where fish were captured and implanted with radio transmitters. It is conceivable that separated populations of rainbow trout may exist in the upper portions of each river. One fish originally radio-tagged at RKM 32.2 Negukthlik was

never located below RKM 26.6, the outlet of Shallow Pond. Effort to deploy transmitters above RKM 13.7 in either river was limited. If there is a resident population in the Ungalikthluk River they were not captured.

Limitations of the telemetry data were primarily due to shorter than expected transmitter life and fewer surveys than initially scheduled. Transmitters with an expected life of 270 days which were implanted in September only lasted an average of 176 days (range 84 to 227 days). Transmitter failure is assumed for four fish which were recaptured by hook and line from 71 to 241 days after they were last located via telemetry. Transmitter life variability may also be due to cold water temperatures affecting battery life; fish being removed by predator or man; or fish may have spent time in the estuary (tidal) waters or under stream banks where transmission range is reduced.

I believe that the limited movement observed between location of implant and last known location by rainbow trout radio-tagged in September is real and not the result of fish mortality. Most fish exhibited enough movement to discount mortality. Two fish in this implant group remained relatively stationary during winter surveys, but moved some distance by their last relocation. One fish moved 9.6 rkm upstream and the other was recaptured by hook and line the following summer in the Ungalikthluk River. Another fish form this group was recaptured by hook and line, 71 days after it's last relocation. It had moved 2.4 rkm downstream.

Spawning by radio-tagged fish was not observed, but is presumed to occur between mid-April to June (Morrow 1980). Telemetry observations during March, April and May indicate that radio tagged rainbow trout in this study area likely spawn in the Negukthlik River between RKM 4.0 and 26.6. No radio tagged fish were located in the Ungalikthluk River during the spawning season.

The two rivers differ in the type of water and habitat they offer. The shallow, weed-choked ponds at the headwaters of the Negukthlik River may have a warming influence on the river temperatures. Burger and Gwartney (1986) suggested that a lakes warming influence on a river may result in attaining optimal spawning temperatures earlier in the spring. Temperature requirements of rainbow trout in this area are not known. Morrow (1980) reported that rainbow trout spawn at temperatures of 10 - 13 °C and that northern populations are known to spawn at temperatures as low as 5.5 °C. Although water temperatures were not measured consistently during this study, those taken indicate that the Negukthlik River was above 5.5 °C for more than twenty days before temperatures rose to that level in the Ungalikthluk River.

RECOMMENDATIONS

This study provides the first substantial sample and description of the rainbow trout

population in the Negukthlik and Ungalikthluk Rivers. Future study should seek to determine if the management objective to maintain historical length and age diversity is being achieved. Consistency in sampling methods (angling techniques and effort concentration) and scale aging techniques (criteria) are critical to establish and maintain between years and between rivers in southwest Alaska.

Management of rainbow trout populations based on maintaining historical age and length composition may not be realistic because of the difficulty of accurately aging rainbow trout and the subjectivity of current sampling methods. An alternative management strategy would be to maintain the historical length composition which may automatically maintain the historical age composition. (Irving and Faustini 1994). Slow growth of western Alaska rainbow trout, especially beyond age 5, may not allow for separation of older age classes and loss of older fish could occur without a noticeable change in length frequency. Likewise the use of relative stock density to assess changes in a population likely lumps several age classes, especially older age classes in the Memorable and Trophy categories. The assignment of minimum lengths for each relative stock density category, and the number of categories needed for Alaskan rainbow trout stock management should reflect the varying life strategies of these stocks. Continued analysis is needed to refine the relative stock density categories to more accurately reflect western Alaska riverine resident rainbow trout population growth, recruitment and mortality characteristics.

Angling has been an accepted method of capture for rainbow trout throughout southwest Alaska (Minard and Dunaway 1991). Basing all calculations on a single sampling method (hook and line) needs to be assessed. Variability in angler experience and gear selection, weather and water conditions, and previously caught fish's shyness of gear are all likely to significantly influence sample size and hence, reliable monitoring of population structure. Hook and line sampling methods need to be standardized between years and between river systems, and validated using an objective sampling method (e.g., electro-fishing, direct observation, traps or weirs).

Future sampling efforts should include more intense effort in the upper reaches of both rivers and within the lower Ungalikthluk River. Sampling during July, October and April may include rainbow trout not accessible during the times of this study, and thus may provide a more complete picture of age and length distributions, and provide better data on seasonal movement.

Future telemetry studies in this drainage should seek to disperse radio tags throughout each river, as well as throughout all seasons. With advanced telemetry technologies transmitters are now available which would allow monitoring movement patterns throughout an annual cycle.

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REFERENCES

Adams, F.J. 1996. Status of rainbow trout in the Kanektok River, Togiak National Wildlife Refuge, Alaska, 1993-94. USFWS, Alaska Fisheries Technical Report Number 39, King Salmon, Alaska

ADFG (Alaska Department of Fish and Game). 1990. Instructions for using sport fish creel survey and biological mark-sense forms, 1990. Division of Sport Fish, Research and Technical Services. Anchorage.

ADFG (Alaska Department of Fish and Game). 1996. Annual management report, Bristol Bay Area, 1995. Div. Of Commercial Fisheries Management and Development. Regional Information Report No. 2A96-06.

Alt, K. T. 1977. Inventory and cataloging of sport fish and sport fish waters of western Alaska. Federal Aid in Fish Restoration. Alaska Department of Fish and Game, Division of Sport Fish. Volume 18. Project No. F-9-9.

Burger, C. V., M. Scott, M. Small, and W. Potterville. 1983. Overwintering and spawning areas of steelhead trout (Salmo gairdneri) in tributaries of the Upper Copper River, Alaska. U.S. Fish and Wildlife Service, National Fishery Research Center, Anchorage, Alaska. Final Report to Bureau of Land Management.

Burger, Carl V. and Louis A. Gwartney. 1986. A radio tagging study of Naknek drainage rainbow trout. U.S. National Park Service, Alaska Regional Office, Anchorage.

Clutter, R. I. and L. E. Whitesel. 1956. Collection and interpretation of sockeye salmon scales. International Pacific Salmon Fishery Commission, Bulletin 9. 159pp.

Coggins, L.G. 1994. Precision of ages estimated from scales for rainbow trout in Bristol Bay, Alaska. Alaska Department of Fish and Game, Fisheries Data Series No. 94-26.

Dery, L.M. 1983. Use of laminated plastic to impress fish scales. Progressive Fish Culture, 45(2), April 1983. Pages 87-88.

Faustini, M.A. 1996. Status of rainbow trout in the Goodnews River, Togiak National Wildlife Refuge, Alaska, 1993-1994. USFWS, Alaska Fisheries Technical Report Number 36, King Salmon, Alaska.

Gablehouse, D.W. 1984. A length categorization system to assess fish stocks. North American Journal of Fisheries Management 4:273-285.

Harper, K.H 1990. Single hook artificial lure and catch and release proposals for the Western portion of Bristol Bay, Togiak National Wildlife Refuge. A report to the Alaska Board of Fisheries. USFWS, Togiak NWR, Dillingham, Alaska.

Heineman, G. M. 1989a. Instructions for using sport fish mark sense diskettes 1989. Alaska Department of Fish and Game, Division of Sport Fish, Research and Technical Services. Anchorage.

_____. 1989b. BBX computer program for analysis of biological samples. Revised 3/13/89. Alaska Department of Fish and Game, Division of Sport Fish, Research and Technical Services. Anchorage.

_____. 1989c. BBX crosstabulation system for Bristol Bay historic rainbow trout data. Alaska Department of Fish and Game, Division of Sport Fish, Research and Technical Services. Anchorage.

Irving, D.B. and M.A. Faustini 1994. Status of rainbow trout in the Goodnews River, Togiak National Wildlife Refuge, Alaska, 1988-1989. U.S. Fish and Wildlife Service, Alaska Fisheries Technical Report No. 24, King Salmon, Alaska.

Lisac, M. J. 1989. Estimated public use within Togiak National Wildlife Refuge, 1984 - 1988. USFWS, Togiak NWR Draft Public Use Management Plan (1990), Appendix B.

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

Lux, F.E. undated . Age Determination of Fishes (Revised). U.S. Department of Commerce. NOAA, National Marine Fisheries Service. Fishery Leaflet 637. Revision of Lux, Fred E. Age Determination of Fishes, USFWS, Fishery Leaflet No. 488.

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

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

Minard, R.E. 1987. Sport Fishing Emergency Order, Issued April 13, 1987. Closing the Ungalikthluk and Negukthlik River drainages to sport fishing from April 20, to

June 7, 1987. E.O. No. 2-RT-509-8. Alaska Department of Fish and Game, Dillingham, Alaska.

Minard R.E. and K. Delaney 1989. Rainbow trout management plan: Southwest Alaska. in F. Richardson and R. H Hamre editors. Wild Trout IV.

Minard R.E. and D.O. Dunaway 1991. Compilation of age, weight and length statistics for rainbow trout samples collected in southwest Alaska, 1954 through 1989. Alaska Department of Fish and Game, Division of Sport Fish. Fishery Data Series No. 91-62.

Minard R.E. 1992. Summary of effort and harvest statistics for the major sport fisheries in Southwestern Alaska. Alaska Department of Fish and Game, Division of Sport Fish. Unpublished inter-departmental report providing a summary of the Statewide sport fisheries harvest reports from 1978 through 1991.

Morrow, J. E. 1980. The freshwater fishes of Alaska. Alaska Northwest Publishing Company, Anchorage, Alaska.

Mosher, K.H. 1969. Identification of Pacific salmon and steelhead trout by scale characteristics. USDOI, U.S. Fish and Wildlife Service, Bureau of Commercial Fisheries, XF WC-A 317 1-17 (1969).

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bulletin of the Fisheries Research Board of Canada 191:382.

Riffe, R. 1994a. Pressing Scales. An internal memo describing the performance and procedures of using the hydraulic press for creating acetate scale impressions. Alaska Department of Fish and Game, Dillingham, Alaska. Dated January 14, 1994.

Riffe, R. 1994b. Compilation of age, weight, and length statistics for rainbow trout samples collected in southwest Alaska, 1990 - 1993. Alaska Department of Fish and Game, Division of Sport Fish. Fishery Data Series No. 94-17.

Russell, R. 1977. Rainbow trout studies, Lower Talarik Creek-Kvichak. Alaska Department of Fish and Game. D-J Project F-9-9, Study G-11. Completion Report. 48pp.

Summerfelt, R.C. and L. S. Smith. 1990. Anesthesia, surgery, and related techniques. Pages 213-272 in C.B. Schereck and P.B. Moyle, editors. Methods for fish biology. American Fisheries Society, Bethesda, MD.

USFWS 1981. Procedures for the use of aircraft in wildlife biotelemetry studies. U.S.

Department of the Interior, Fish and Wildlife Service, Washington, D.C.. Resource Publication 140.

USFWS 1990a. Fishery Management Plan, Togiak National Wildlife Refuge. U.S. Department of the Interior, Fish and Wildlife Service, Alaska.

USFWS 1991. Public Use Management Plan and Environmental Assessment, Togiak National Wildlife Refuge. U.S. Department of the Interior, Fish and Wildlife Service, Alaska.

Wagner, T.A. 1991. Southwestern Alaska rainbow trout Investigations, Kanektok River, Togiak National Wildlife Refuge, Alaska. 1985-1987 Final Report. U.S. Fish and Wildlife Service Technical Report No. 13.

APPENDICES

Appendix Table A1. Sample size and data file name for Negukthlik and Ungalikthluk River rainbow trout samples collected and analyzed by USFWS, 1989-1990.

Year	Number of Fish Sampled	Aged	RTS File Number
1989	322	211	T1520BA9.DTA
1990	278	179	T1520BA1.DTA

Appendix Table A2. Rainbow trout sampling effort, Negukthlik and Ungalikthluk Rivers, 1989 and 1990.

		Sample Period	Survey Site (km)	Number of fish Caught	Tagged	Recaptured	Mortalities	Marked at large
1989	1.	5/9 - 6/17	2.41 - 9.33 Ung.	0				46
		5/10	2.41 - 9.25 Neg.	0				46
		5/13 - 6/17	13.6 - 1.0 Neg.	64	46	7	4	46
		6/17 - 6/27	1.0 - 13.68 Neg.	87	76	6	2	122
		6/26	5.79 Ung.	2	2	0	0	124
	2.	8/3 - 8/7	13.68 - 3.86 Neg.	103	69	16	11	193
		8/8 - 8/10	15.37 - 7.4 Ung.	29	22	5	2	215
	3.	9/2 - 10/2	32.19 - 5.47 Neg.	37	25	7	5	240
		9/11	11.26 Ung	0				240
1990	1.	5/23 - 6/16	13.68 - 1.93 Neg.	105	69	24	3	69
		5/29	13.84 - 15.29 Ung.	0				69
		6/17 - 6/23	11.43 - 1.61 Neg.	68	32	8	1	101
		6/24 - 6/26	11.56 - 6.44 Neg.	31	14	4	1	115
		6/27 - 6/29	12.55 - 1.69 Ung.	24	16	8	1	131
	2.	8/19 - 8/21	13.68 - 8.37 Ung.	23	14	7	1	145
		8/23 - 8/24	13.68 - 9.98 Neg.	27	4	1	1	149

Appendix Table A3. Locations (river km) of rainbow trout implanted with radio transmitters in the Negukthlik and Ungalikthluk Rivers, 1989 and 1990.

	Floy Tag	508	509	524	525	536	548	545	530	560	561	563	562	1268	1282	1283	1259	1280	1278	1295	1292	1297	1299
	Transmitter Make	ATS	ATS	ATS	ATS	ATS	ATS	ATS	ATS	ATS	ATS	ATS	ATS	ATS	ATS	AVM	AVM	AVM	AVM	AVM	AVM	AVM	ATS
	Date Implanted	05/18/89	05/18/89	05/31/89	05/31/89	06/03/89	06/04/89	06/04/89	06/04/89	06/14/89	06/15/89	06/15/89	06/15/89	09/02/89	09/26/89	09/26/89	09/26/89	09/26/89	09/26/89	09/26/89	09/28/89	09/28/89	09/29/89	09/29/89
Relocation Date	Implant Location	5.8	5.8	10.8	10.8	10.8	1.6	10.8	10.8	7.6	1.6	1.6	1.6	32.2	12.1	11.4	11.4	12.1	12.1	8.5	11.9	7.4	7.1
	Survey Type																						
05/19/89	Ground Survey		4.02																				
05/20/89	Hook & Line	6.84																					
05/20/89	Ground Survey	6.84	4.75																				
05/21/89	Ground Survey	7.24	6.68																				
05/22/89	Ground Survey	7.24	7.08																				
05/23/89	Ground Survey	6.92	7.08																				
05/24/89	Ground Survey	6.92																					
05/25/89	Ground Survey	7.64																					
05/26/89	Ground Survey	7.72																					
05/28/89	Ground Survey																						
05/29/89	Ground Survey																						
05/30/89	Ground Survey																						
05/31/89	Air Survey	8.85	13.27																				
05/31/89	Ground Survey	9.17																					
06/01/89	Ground Survey			10.94	10.78																		
06/03/89	Ground Survey		13.76	10.78	10.78																		
06/04/89	Ground Survey			10.78	10.78																		
06/04/89	Hook & Line					10.78																	
06/07/89	Air Survey	7.64	13.60	11.42	20.92	10.78	4.02	10.94	10.94														
06/13/89	Ground Survey			10.46		10.94	3.86		10.78														
06/14/89	Ground Survey	7.56					4.51																
06/15/89	Ground Survey	7.56					4.34			7.56													
06/16/89	Ground Survey	7.56		10.54			4.34		10.78	7.56	0.80												
06/17/89	Ground Survey	7.56								7.56													
06/19/89	Ground Survey						3.22				3.22												
06/21/89	Ground Survey																						
06/21/89	Air Survey	7.56	2.01	10.54	25.74	10.78	-4.18	-5.79	10.78	7.56	-5.79	-3.62	-3.62										
06/23/89	Ground Survey												-3.62										
06/24/89	Ground Survey	7.56	2.01	6.60		10.62			10.94	7.56													
06/26/89	Ground Survey						-3.54						-4.67										
07/24/89	Air Survey	-10.94	-10.78	-11.75	25.26	-15.29	-13.35	-9.98		-14.00	-17.70	-13.35	-14.64										
08/09/89	Hook & Line							-9.33															
08/09/89	Air Survey	-10.94	-7.32	-14.00	27.67	-10.30	-13.52	-10.30	10.78	-14.00	-15.12	-13.03	-12.87										
08/10/89	Hook & Line			-15.04																			
09/02/89	Air Survey	-11.26	-7.08	-12.55			-9.17	-10.78			-8.37	-10.46											
09/21/89	Air Survey	9.25	-9.25	11.75		8.85		18.02	6.76	7.08	-8.37			28.96									
09/27/89	Air Survey	27.35	-6.76	13.27		10.30	4.51	23.33	5.79	6.44	-6.84		-8.61	27.35									
09/29/89	Ground Survey																			7.40			
10/02/89	Air Survey		-9.01	14.96		8.37	5.31	23.33	5.79	5.79	-9.01		-9.33										7.08
11/06/89	Air Survey	7.56	6.44	11.26			4.99	23.81	5.63	7.56	3.22	-6.84	11.42	27.35	12.07	11.42	10.94	12.07	11.42	6.44	9.65	7.72	6.84
11/28/89	Air Survey							26.55	7.56	7.64		-5.63	12.47	26.55	11.42	11.58	12.23	12.39	11.42	6.44	12.07	8.05	7.08
12/21/89	Air Survey											-6.03	11.91	26.55	11.58	11.58	11.26	12.23	11.42		11.91	8.05	7.08
02/01/90	Air Survey													26.55	11.58	11.75	11.83	12.07	11.26	11.58		8.05	11.83
03/14/90	Air Survey														11.50	11.58		11.91	11.26	11.58		7.64	11.91
04/13/90	Air Survey														11.50	11.58		11.91	9.17			8.05	
04/27/90	Air Survey														21.72			11.58	12.07			8.05	
05/14/90	Air Survey																					8.05	
05/24/90	Hook & Line																			9.17			
05/27/90	Ground Survey																						
05/28/90	Ground Survey																						
06/27/90	Hook & Line																				-6.44		
06/28/90	Hook & Line						-4.99																
08/19/90	Hook & Line												-12.55										
9.6	Number of Locations	23	17	16	7	10	15	11	11	12	10	7	11	6	7	6	4	7	7	6	4	8	6
199.5	Number of Days	172	172	159	70	121	389	177	177	167	144	189	430	152	213	199	128	213	213	238	272	227	166
166.1	Transmission Days	172	172	159	70	121	155	177	177	167	144	189	189	152	213	199	128	213	213	167	84	227	166

Appendix Table A4. Locations and distances traveled (river kilometer) by recaptured rainbow trout in the Negukthlik and Ungalikthluk Rivers, 1989 - 1990.

	Initial Capture			First Recapture			Second Recapture			Movement		
	Location			Location			Location					
Tag #	(rkm)	River	Date	(rkm)	River	Date	(rkm)	River	Date	L1 - Lo (rkm)	L2 - Lo (rkm)	L1 - L2 (rkm)
508	5.79	NEG	5 18 89	6.84	NEG	5 20 89				1.05		
520	5.79	NEG	5 25 89	6.76	NEG	5 27 90				0.97		
512	7.08	NEG	5 23 89	7.48	NEG	6 14 89	7.08	NEG	6 3 90	0.40	0.00	0.40
519	10.78	NEG	5 25 89	10.78	NEG	6 16 89	10.78	NEG	8 4 89	0.00	0.00	0.00
521	7.73	NEG	5 26 89	1.61	CONF	6 18 89				6.12		
518	10.78	NEG	5 25 89	11.02	NEG	6 27 89				0.24		
501	5.63	NEG	5 13 89	5.79	NEG	8 6 89				0.16		
524	10.78	NEG	5 31 89	15.05	UNG	8 10 89				22.61		
548	1.61	CONF	6 4 89	4.99	UNG	6 28 90				3.38		
634	1.61	CONF	6 23 89	2.58	NEG	6 15 90				0.97		
645	1.61	CONF	6 21 89	9.33	UNG	8 9 89				7.73		
562	1.61	CONF	6 15 89	12.55	UNG	8 19 90				10.94		
583	3.30	NEG	6 19 89	3.70	UNG	6 29 90				3.78		
585	3.30	NEG	6 19 89	2.58	NEG	6 15 90				0.72		
584	3.30	NEG	6 19 89	13.36	UNG	8 8 89	12.88	UNG	8 19 90	13.44	12.96	0.48
592	3.38	NEG	6 20 89	3.30	NEG	6 21 89				0.08		
598	3.38	NEG	6 21 89	13.68	UNG	8 19 90				13.84		
587	3.38	NEG	6 19 89	10.38	UNG	8 20 90				10.54		
650	3.46	NEG	6 21 89	7.00	NEG	8 5 89				3.54		
646	3.70	NEG	6 21 89	8.69	UNG	8 9 89				9.17		
636	5.63	NEG	6 22 89	5.55	NEG	5 27 90	2.58	NEG	6 15 90	0.08	3.06	2.98
637	5.63	NEG	6 22 89	6.92	NEG	8 5 89				1.29		
535	5.79	NEG	6 20 89	6.58	NEG	6 20 90				0.79		
573	6.92	NEG	6 17 89	6.92	NEG	8 6 89				0.00		
675	8.61	NEG	6 27 89	8.61	NEG	6 18 90				0.00		
575	8.61	NEG	6 17 89	5.79	UNG	6 27 90	5.63	UNG	6 28 90	11.19	11.02	0.16
677	8.61	NEG	6 27 89	8.61	NEG	8 5 89				0.00		
676	8.61	NEG	6 27 89	8.53	NEG	8 5 89				0.08		
674	8.85	NEG	6 27 89	26.07	NEG	10 2 89				17.22		
671	9.01	NEG	6 27 89	9.17	NEG	8 4 89				0.16		
666	9.17	NEG	6 27 89	9.50	NEG	8 4 89				0.32		
664	9.25	NEG	6 27 89	9.17	NEG	8 4 89				0.08		
658	9.50	NEG	6 27 89	9.33	NEG	8 4 89				0.16		
657	9.66	NEG	6 27 89	10.14	NEG	6 1 90	9.01	NEG	6 18 90	0.48	0.64	1.13
532	10.78	NEG	6 1 89	10.78	NEG	6 16 89	10.78	NEG	8 4 89	0.00	0.00	0.00
609	10.78	NEG	6 25 89	11.02	NEG	6 27 89				0.24		
533	10.78	NEG	6 1 89	10.78	NEG	6 27 89				0.00		
536	10.78	NEG	6 3 89	10.78	NEG	6 4 89				0.00		
608	10.78	NEG	6 25 89	10.78	NEG	6 27 89	10.86	NEG	8 4 89	0.00	0.08	0.08
539	10.78	NEG	6 4 89	5.79	NEG	6 14 89	6.36	NEG	5 27 90	4.99	4.43	0.56
530	10.78	NEG	6 1 89	10.78	NEG	6 4 89				0.00		
545	10.78	NEG	6 4 89	9.33	UNG	8 9 89				16.90		
607	10.78	NEG	6 25 89	6.92	NEG	8 6 89				3.86		
652	10.78	NEG	6 27 89	10.30	NEG	9 25 89				0.48		
612	11.27	NEG	6 25 89	10.46	NEG	9 25 89				0.80		
620	12.55	NEG	6 25 89	12.71	NEG	5 30 90				0.16		
619	12.55	NEG	6 25 89	2.58	NEG	6 15 90				9.98		
623	12.71	NEG	6 24 89	4.99	NEG	6 23 90				7.73		
622	12.71	NEG	6 25 89	13.44	NEG	9 12 89				0.72		
624	13.04	NEG	6 24 89	10.30	NEG	9 28 89				2.74		
629	13.52	NEG	6 24 89	13.68	NEG	8 3 89				0.16		
632	13.52	NEG	6 24 89	13.60	NEG	8 3 89				0.08		
625	13.68	NEG	6 24 89	10.78	NEG	5 30 90				2.90		
1236	6.36	NEG	8 6 89	6.60	NEG	6 19 90				0.24		
1218	7.73	NEG	8 5 89	12.55	NEG	9 26 89	10.94	NEG	5 31 90	4.83	3.22	1.61
1217	7.97	NEG	8 5 89	6.76	NEG	6 26 90				1.21		
1206	8.85	NEG	8 5 89	8.85	NEG	6 2 90				0.00		
1260	9.01	UNG	8 9 89	4.67	UNG	6 28 90				4.35		
1261	9.01	UNG	8 9 89	9.95	UNG	8 20 90				0.93		
1259	9.01	UNG	8 9 89	11.43	NEG	9 26 89				17.22		
800	9.33	NEG	8 4 89	5.47	NEG	5 27 90				3.86		
1256	9.33	UNG	8 9 89	10.94	UNG	8 20 90				1.61		
799	9.50	NEG	8 4 89	9.98	NEG	5 24 90				0.48		
798	9.50	NEG	8 4 89	5.79	NEG	6 3 90				3.70		
795	10.14	NEG	8 4 89	9.17	NEG	5 24 90				0.97		
789	10.78	NEG	8 4 89	10.78	NEG	6 24 90				0.00		
787	10.86	NEG	8 4 89	10.86	NEG	5 23 90				0.00		
781	12.23	NEG	8 3 89	11.91	NEG	5 31 90				0.32		
696	13.52	NEG	8 3 89	10.94	NEG	5 31 90				2.58		
1295	8.53	NEG	9 28 89	9.17	NEG	5 24 90				0.64		
1292	11.91	NEG	9 28 89	6.44	UNG	6 27 90				15.13		
1269	13.52	NEG	9 12 89	13.60	NEG	5 30 90				0.08		
1376	2.74	NEG	6 23 90	4.51	UNG	6 28 90				4.02		
1358	6.04	UNG	6 27 90	5.31	UNG	6 28 90				0.72		
1366	7.56	NEG	6 25 90	7.56	NEG	6 26 90				0.00		
1419	6.92	NEG	5 26 90	5.15	NEG	6 4 90				1.77		
1420	6.92	NEG	5 26 90	2.74	NEG	6 23 90				4.18		
1414	7.56	NEG	5 26 90	6.92	NEG	6 19 90				0.64		
1404	10.30	NEG	5 23 90	9.50	UNG	8 21 90				16.58		
1439	10.78	NEG	5 30 90	10.78	NEG	5 31 90				0.00		
1432	10.78	NEG	5 28 90	10.94	NEG	6 24 90				0.16		
1435	10.78	NEG	5 30 90	10.46	NEG	8 24 90				0.32		
1442	12.88	NEG	5 30 90	9.98	NEG	6 17 90				2.90		
502	5.63	NEG	5 13 89	9.66	NEG	8 14 89				4.02		
508	5.79	NEG	5 18 89	8.05	UNG	8 15 89				10.62		
528	10.78	NEG	6 1 89	10.78	NEG	9 10 89				0.00		
530	10.78	NEG	6 1 89	0.00	NEG	8 14 89				0.00		
546	1.61	CONF	6 4 89	2.25	NEG	6 20 90				0.64		
572	7.56	NEG	6 16 89	6.44	NEG	8 14 89				1.13		
581	9.33	NEG	6 19 89	9.33	NEG	9 13 89				0.00		
598	3.38	NEG	6 21 89	2.01	NEG	6 21 90				1.37		
633	13.68	NEG	6 24 89	10.30	NEG	8 10 89	10.78	NEG	9 10 89	3.38	2.90	0.48
635	7.56	NEG	6 22 89	9.66	NEG	8 9 89				2.09		
653	10.06	NEG	6 27 89	9.33	NEG	6 18 90				0.72		
655	9.66	NEG	6 27 89	9.01	NEG	6 18 90				0.64		
656	9.66	NEG	6 27 89	10.78	NEG	8 13 89				1.13		
660	9.50	NEG	6 27 89	9.66	NEG	8 9 89				0.16		
662	9.33	NEG	6 27 89	8.85	NEG	9 4 89				0.48		
669	9.25	NEG	6 27 89	9.66	NEG	8 14 89				0.40		
677	8.61	NEG	6 27 89	0.00	NEG	8 13 89				0.56		
776	8.61	NEG	6 27 89	1.61	CONF	7 2 89				7.00		
789	10.78	NEG	8 4 89	10.30	NEG	8 10 89				0.48		
799	9.50	NEG	8 4 89	9.98	NEG	8 16 89	9.66	NEG	9 12 89	0.48	0.16	0.32
800	9.33	NEG	8 4 89	8.85	NEG	8 14 89	9.17	NEG	9 12 89	0.48	0.16	0.32
1246	13.12	UNG	8 8 89	2.25	NEG	6 20 90				12.15		
1421	6.76	NEG	5 27 90	5.15	NEG	6 22 90				1.61		
1426	6.44	NEG	5 27 90	2.01	NEG	6 21 90				4.43		
107										3.15	2.97	0.66

Appendix Table A5. Habitat type and known seasonal use by rainbow trout, by river kilometer, in the Negukthlik River, 1989 and 1990.

River Kilometer	1*	2*	3*	4*	5*	Known Spring Use (April 16 to June 15) >450 mm	Known Spring Use (April 16 to June 15) <450 mm	Known Summer Use (June 16 to September)	Known Winter Use (October to April 15)
1.00						X	X	X	
1.69		X							
1.77		X							
1.85		X							
1.93		X						X	
2.01		X						X	
2.09		X							
2.17		X							
2.25		X							
2.33		X							
2.41		X						X	
2.49		X							
2.58		X				X		X	
2.66		X							
2.74		X						X	
2.82	X								
2.90		X							
2.98		X							
3.06		X							
3.14			X						
3.22					X			X	X
3.30					X			X	
3.38					X			X	
3.46		X						X	
3.54					X				
3.62		X							
3.70					X		X		
3.78		X							
3.86					X	X	X	X	
3.94		X							
4.02					X	X			
4.10		X							
4.18					X				
4.26					X			X	
4.35					X	X		X	
4.43		X						X	
4.51					X	X	X	X	
4.59					X				
4.67					X				
4.75		X				X			
4.83		X							
4.91		X							
4.99					X	X	X	X	X
5.07					X			X	
5.15			X			X	X	X	
5.23		X							
5.31		X							X
5.39		X						X	
5.47		X				X	X	X	
5.55		X				X			
5.63					X	X	X	X	X
5.71		X						X	
5.79				X		X	X	X	X
5.87		X						X	
5.95		X					X	X	
6.04		X						X	
6.12			X						
6.20		X						X	
6.28		X							
6.36		X				X		X	
6.44		X				X		X	X
6.52		X						X	
6.60			X					X	
6.68	X					X		X	
6.76		X				X	X	X	
6.84		X				X		X	X
6.92					X	X	X	X	
7.00		X							
7.08		X				X	X	X	X
7.16		X						X	
7.24		X				X		X	
7.32		X							
7.40		X					X	X	
7.48		X						X	
7.56	X					X	X	X	X
7.64					X	X	X	X	X
7.73					X	X	X	X	X
7.81		X							
7.89		X							
7.97			X					X	
8.05				X		X	X	X	X
8.13				X					
8.21				X				X	

River Kilometer	1*	2*	3*	4*	5*	Known Spring Use (April 16 to June 15) >450 mm	Known Spring Use (April 16 to June 15) <450 mm	Known Summer Use (June 16 to September)	Known Winter Use (October to April 15)
8.29		X							
8.37	X							X	X
8.45		X						X	
8.53	X							X	
8.61					X			X	
8.69		X				X		X	
8.77		X						X	
8.85		X				X		X	
8.93		X							
9.01		X						X	
9.09		X							
9.17		X				X		X	X
9.25	X							X	
9.33		X						X	
9.41		X							
9.50	X						X	X	
9.58	X								
9.66				X				X	X
9.74	X								
9.82		X						X	
9.90		X							
9.98	X					X		X	
10.06	X							X	
10.14	X					X	X	X	
10.22		X						X	
10.30		X				X	X	X	
10.38	X							X	
10.46	X					X	X	X	
10.54		X						X	
10.62		X						X	
10.70		X							
10.78	X					X	X	X	
10.86		X				X		X	
10.94		X				X	X	X	X
11.02	X							X	
11.10				X				X	
11.19		X						X	
11.27		X						X	X
11.35		X							
11.43	X					X		X	X
11.51	X							X	X
11.59	X					X		X	X
11.67	X								
11.75	X						X	X	X
11.83	X						X		X
11.91	X					X	X	X	X
11.99	X								
12.07	X					X		X	X
12.15	X								
12.23	X							X	X
12.31		X							
12.39		X						X	X
12.47	X								X
12.55	X							X	
12.63	X							X	
12.71	X					X	X	X	
12.79		X							
12.88					X	X	X	X	
12.96	X								
13.04	X							X	
13.12	X							X	
13.20	X								
13.28	X					X	X	X	
13.36	X								
13.44	X						X	X	
13.52	X						X	X	
13.60	X					X	X	X	
13.68				X			X	X	
13.76						X			
14.97									X
18.03								X	
20.92						X			
21.73						X			
23.34								X	X
23.82									X
25.27								X	
25.75								X	
26.07								X	
26.56								X	X
27.36								X	X
27.68								X	
28.97								X	
32.19								X	

* 1 = Riffle 2 = Shallow Glide 3 = Deep Glide 4 = Pool with Riffle 5 = Pool with Deep Glide

Appendix Table A6. Known seasonal use by rainbow trout, by river kilometer, in the Ungalikthluk River, 1989 and 1990.

River Kilometer	Known Spring Use (April 16-June 15)	Known Summer Use (June 16-Sept)	Known Winter Use (Oct-April 15)
1.00			
1.69		X	
1.77			
1.85			
1.93		X	
2.01			
2.09			
2.17			
2.25			
2.33			
2.41			
2.49			
2.58			
2.66			
2.74			
2.82			
2.90			
2.98			
3.06			
3.14			
3.22		X	
3.30			
3.38			
3.46			
3.54		X	
3.62		X	
3.70		X	
3.78			
3.86		X	
3.94			
4.02			
4.10			
4.18		X	
4.26			
4.35			
4.43			
4.51		X	
4.59			
4.67		X	
4.75			
4.83		X	
4.91			
4.99		X	
5.07			
5.15			
5.23			
5.31		X	
5.39			
5.47			
5.55			
5.63		X	X
5.71			
5.79		X	
5.87			
5.95			
6.04		X	X
6.12		X	
6.20			
6.28		X	
6.36			
6.44		X	
6.52			
6.60			
6.68			
6.76		X	
6.84		X	X
6.92			
7.00			
7.08		X	
7.16			
7.24			
7.32		X	
7.40		X	
7.48			
7.56			
7.64			
7.73			
7.81			
7.89			
7.97			

River Kilometer	Known Spring Use (April 16-June 15)	Known Summer Use (June 16-Sept)	Known Winter Use (Oct-April 15)
8.05		X	
8.13			
8.21			
8.29			
8.37		X	
8.45			
8.53			
8.61		X	
8.69		X	
8.77		X	
8.85		X	
8.93			
9.01		X	X
9.09			
9.17		X	
9.25		X	
9.33		X	X
9.41			
9.50		X	
9.58			
9.66		X	
9.74			
9.82		X	
9.90		X	
9.98		X	
10.06			
10.14		X	
10.22			
10.30		X	
10.38		X	
10.46		X	
10.54			
10.62			
10.70			
10.78		X	
10.86		X	
10.94		X	
11.02			
11.10			
11.19			
11.27		X	
11.35			
11.43			
11.51		X	
11.59			
11.67			
11.75		X	
11.83			
11.91			
11.99		X	
12.07			
12.15		X	
12.23		X	
12.31			
12.39		X	
12.47			
12.55		X	
12.63			
12.71			
12.79		X	
12.88		X	
12.96			
13.04		X	
13.12		X	
13.20			
13.28			
13.36		X	
13.44			
13.52		X	
13.60		X	
13.68		X	
14.00		X	
14.65		X	
14.73		X	
15.05		X	
15.13		X	
15.29		X	
15.37		X	
17.70		X	

Appendix Table A7. Recorded temperatures by time and location on the Negukthlik and Ungalikthluk Rivers, and Confluence, 1989.

Negukthlik River

Date	Location	Time	Temp (C)
05/10/89	1.50	11:00	2.6
05/13/89	2.50	13:20	4.0
05/13/89	3.50	15:25	4.0
05/13/89	3.50	19:45	4.6
05/14/89	3.50	17:15	5.0
05/15/89	3.80	12:20	2.5
05/15/89	4.60	13:05	3.5
05/15/89	5.80	14:15	5.5
05/15/89	7.00	19:15	5.9
05/16/89	3.50	17:30	5.3
05/18/89	3.60	15:20	4.2
05/18/89	3.60	16:45	4.4
05/18/89	3.60	18:40	5.4
05/18/89	3.60	20:40	5.2
05/18/89	3.60	22:17	5.0
05/19/89	3.60	13:25	5.0
05/19/89	16.50	15:30	4.7
05/19/89	16.80	17:10	5.7
05/20/89	4.25	20:05	4.9
05/21/89	4.15	12:45	4.2
05/21/89	3.60	13:30	4.5
05/21/89	3.60	16:10	5.3
05/22/89	4.30	21:22	4.2
05/23/89	4.40	14:30	5.8
05/23/89	4.40	15:45	6.6
05/23/89	4.30	16:10	7.0
05/23/89	3.80	17:35	8.2
05/24/89	4.40	11:45	5.1
05/24/89	4.30	12:50	5.8
05/25/89	4.40	10:35	5.6
05/25/89	4.75	12:35	6.0
05/25/89	6.30	12:55	6.7
05/25/89	6.70	15:45	8.7
05/26/89	4.80	13:05	5.5
05/26/89	6.70	14:20	5.7
05/26/89	5.50	15:30	5.9
05/28/89	6.35	15:35	5.5
05/31/89	8.40	13:40	6.5
05/31/89	6.70	15:50	7.5
06/01/89	6.70	15:30	8.5
06/01/89	3.65	16:10	8.5
06/03/89	6.70	11:35	5.5
06/03/89	6.70	13:45	6.0
06/03/89	8.30	14:30	6.5
06/03/89	4.40	16:00	6.5
06/04/89	4.40	10:40	5.5
06/04/89	6.70	11:30	6.5
06/04/89	6.70	13:40	7.5
06/04/89	6.50	14:05	8.0
06/13/89	8.50	19:50	12.0
06/13/89	8.20	21:45	12.0
06/14/89	2.80	14:50	12.0
06/14/89	3.50	15:45	12.0
06/14/89	4.70	19:00	13.5
06/15/89	4.70	20:56	9.0
06/16/89	4.70	15:20	10.5
06/17/89	4.25	12:20	10.5
06/18/89	4.25	11:00	9.0
06/18/89	4.25	16:45	13.0
06/19/89	2.00	10:45	10.5
06/20/89	2.00	16:30	12.0
06/21/89	2.00	15:30	10.5
06/21/89	2.15	17:15	10.5
06/21/89	2.30	19:00	10.5
06/22/89	2.00	12:00	8.5
06/22/89	2.00	13:15	8.5
06/22/89	3.15	14:10	9.0
06/22/89	3.65	17:00	9.0
06/22/89	4.70	18:00	9.0
06/24/89	8.50	17:30	12.8
06/25/89	7.90	13:30	13.3
06/25/89	7.60	17:00	13.9
06/27/89	6.85	12:05	14.7
06/27/89	5.60	18:00	17.2
06/27/89	3.40	21:30	18.3
08/03/89	8.50	12:25	13.9
08/03/89	7.80	16:00	15.0
08/03/89	6.95	19:00	16.1
08/04/89	6.85	11:00	14.4
08/04/89	6.30	15:30	16.7
08/05/89	5.60	12:30	15.0
08/05/89	5.00	17:30	18.9
08/05/89	4.60	19:30	18.9
08/06/89	4.30	12:15	14.4
08/06/89	4.00	17:10	18.3
08/07/89	3.60	12:00	13.9
08/07/89	2.10	16:30	14.4
09/12/89	6.70	12:00	11.1
09/12/89	8.50	12:35	11.1
09/12/89	6.70	15:20	12.2
09/12/89	7.60	15:20	12.2
09/13/89	6.70	11:20	10.6
09/13/89	5.60	13:30	10.6
09/26/89	7.50	16:56	9.4
09/27/89	5.30	14:08	6.7
09/27/89	7.20	20:40	9.0
09/28/89	3.55	13:00	7.2
09/28/89	3.55	15:05	7.8
09/29/89	3.60	11:25	7.8

Ungalikthluk River

Date	Location	Time	Temp (C)
05/10/89	1.50	19:25	6.2
05/11/89	2.00	12:20	2.5
05/16/89	1.50	14:00	3.9
05/16/89	1.74	15:08	3.9
05/18/89	1.50	13:50	3.5
06/17/89	3.40	17:05	10.0
06/26/89	3.60	13:30	10.0
08/08/89	9.15	11:45	10.0
08/08/89	7.20	20:30	10.6
08/09/89	6.15	12:45	10.0
08/10/89	9.75	12:45	9.4
09/11/89	7.00	13:40	8.9
09/11/89	6.30	15:15	9.4

Confluence

Date	Location	Time	Temp (C)
05/12/89	0.00	18:30	4.8
05/16/89	1.00	13:28	4.0
05/23/89	0.00	10:00	3.0
05/24/89	0.00	11:05	4.4
06/14/89	0.50	09:30	10.0
06/14/89	1.00	11:55	12.0
06/15/89	1.00	13:00	8.5
06/15/89	1.00	16:00	9.0
06/16/89	1.00	13:40	9.0
06/17/89	1.00	10:15	9.0
06/17/89	1.00	17:30	13.5
06/24/89	1.00	12:50	9.0

Appendix Table A8. Recorded temperatures by time and location on the Negukthlik and Ungalikthluk Rivers, and Confluence, 1990.

Negukthlik River

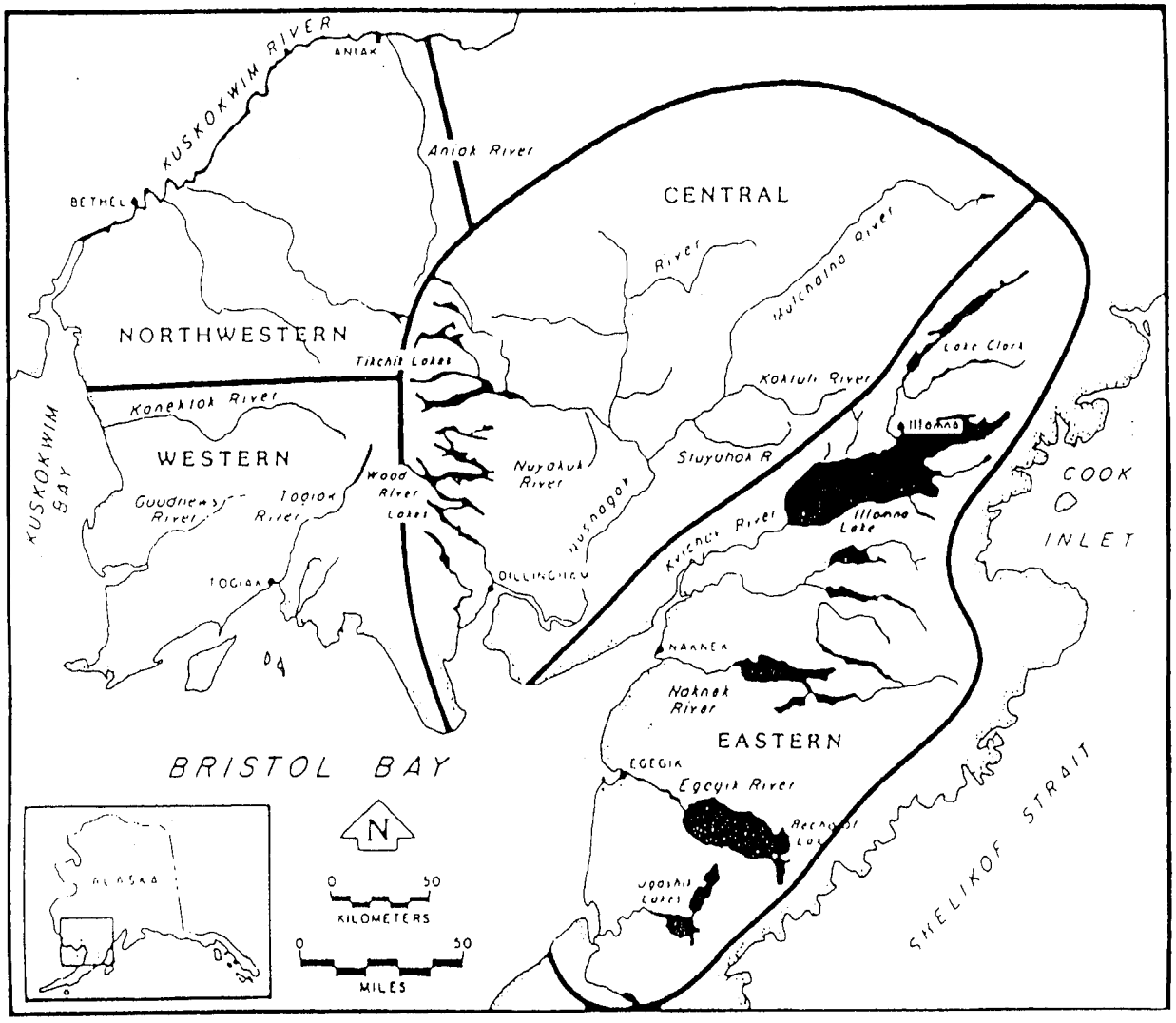
Date	Location	Time	Temp (C)
05/23/90	7.50	13:00	5.6
05/23/90	6.80	15:00	5.6
05/23/90	6.70	19:33	6.7
05/24/90	6.20	17:30	7.0
05/26/90	5.70	12:52	8.4
05/26/90	5.50	14:20	8.9
05/26/90	4.90	15:50	10.0
05/27/90	4.00	13:50	8.4
05/27/90	3.95	16:30	10.3
05/27/90	3.10	21:36	10.6
05/28/90	3.00	13:15	10.9
05/28/90	2.20	17:14	11.4
05/28/90	6.70	19:47	12.0
05/30/90	6.70	14:30	10.0
05/31/90	7.50	14:00	12.2
05/31/90	6.70	20:10	13.4
06/01/90	6.70	14:47	15.6
06/01/90	6.50	16:45	16.7
06/01/90	6.30	20:04	16.1
06/01/90	6.00	21:25	15.9
06/02/90	6.00	14:15	12.2
06/02/90	5.10	17:10	12.8
06/03/90	4.40	14:05	12.8
06/03/90	3.40	19:50	13.4
06/04/90	3.20	14:30	14.5
06/04/90	3.10	17:30	16.7
06/04/90	2.20	20:10	17.2
06/15/90	2.20	12:30	10.6
06/15/90	2.20	13:50	11.1
06/15/90	1.60	17:20	11.1
06/16/90	1.20	14:07	10.0
06/17/90	6.70	12:03	9.0
06/17/90	6.20	19:50	13.4
06/18/90	6.20	12:15	11.1
06/18/90	5.60	17:00	12.2
06/18/90	5.35	18:55	12.8
06/19/90	5.00	13:45	11.1
06/20/90	4.09	13:00	13.4
06/21/90	3.40	12:03	11.1
06/22/90	3.20	14:50	11.1
06/23/90	3.20	12:21	12.2
06/23/90	1.40	16:16	16.7
06/24/90	7.10	12:30	14.5
06/24/90	6.70	16:30	16.7
06/25/90	5.80	12:19	12.2
06/26/90	4.80	17:13	13.4
06/27/90	8.75	15:56	10.6
06/28/90	4.00	14:58	12.2
06/29/90	3.00	16:45	15.6
08/23/90	8.50	17:05	14.5
08/24/90	7.18	13:03	12.8
08/24/90	6.50	18:01	12.8

Ungalikthluk River

Date	Location	Time	Temp (C)
08/19/90	8.50	11:30	9.5
08/19/90	8.25	15:10	11.1
08/19/90	7.80	17:20	12.2
08/19/90	7.60	19:26	12.8
08/20/90	6.80	13:05	10.0
08/20/90	6.79	17:00	11.1
08/21/90	5.90	13:00	10.6
08/21/90	5.45	17:39	12.2
08/21/90	5.45	20:35	12.8
08/23/90	4.00	11:05	10.0
08/23/90	4.00	14:26	11.1

Confluence

Date	Location	Time	Temp (C)
08/26/90	0.00	12:20	13.4



Appendix B. Southwestern Alaska sport fish management area, showing the eastern, central, western, and northwestern sections (Minard and Dunaway, 1991).