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Length Frequency, Age Distribution and Movements of Rainbow Trout in the Arolik River, Togiak National Wildlife Refuge, Alaska, 1991 - 1994

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ABSTRACT

Rainbow trout *Oncorhynchus Mykiss*, are found throughout Togiak National Wildlife Refuge in southwest Alaska and are an important sport and subsistence resource. The Refuge Fisheries Management Plan identified rainbow trout as an indicator species to monitor the success of management actions directed to maintain historical size and age composition of a population. The Arolik River, which lies between the Kanektok and Goodnews Rivers, has received substantially less fishing pressure and biological sampling. This study provides a benchmark of Arolik River rainbow trout population parameters for comparison between years and possibly to other western Alaska rainbow trout

Age, weight, and length (AWL) sampling of rainbow trout was conducted by U.S. Fish and Wildlife Service field crews on the Arolik River from 1991 to 1994 Scale samples, weights, and lengths were collected from 82 rainbow trout in 1991, 227 rainbow trout in 1992, 163 rainbow trout in 1993, and 528 rainbow trout in 1994.

Ages ranged from 3 to 11 (n = 771). Age 6 and 7 fish predominated the samples for all except 1991 (age 4). Fork lengths ranged between 250mm to 700mm Maximum lengths for each year between 1991 and 1994 were 590mm, 680mm, 700mm, and 660mm respectively. Mean fork length at age ranged from 246mm (SE = 4.00) for age 3 fish in 1992 to 590mm (SE = 20.50) for age 11 fish in 1994

The average (1991-94) relative stock density category values of rainbow trout caught in the Arolik River were 0.8% Stock, 17.3% Quality, 41.9% Preferred, 36.7% Memorable, and 3.4% Trophy. A greater proportion of rainbow trout larger than 500mm were sampled from the Arolik River in 1991-1994 than in either the Kanektok River in 1985-87 (Wagner 1991) or the Goodnews River in 1988-89 (Irving and Faustini 1994).

Rainbow trout in the Arolik River were larger in length at age and have a greater maximum age, maximum length and proportion of fish in the larger relative stock density categories than other western populations. Arolik River rainbow trout may be genetically unique, have had more favorable habitat or environmental conditions to contend with prior to this study, or are not effected by stress factors present to a greater degree on the other western rainbow trout populations

The Arolik River provides a unique study area to assess a western Alaska wild rainbow trout population to determine if the management objective of historical length and age diversity is being approached. Recommendations include (1) continued monitoring of this population while human uses are still relatively low, (2) assess using length frequency and relative stock density distributions as a measure of maintaining historical population parameters; (3) standardize sampling and age determination methods, and (4) determine if a reliable estimate of abundance is feasible for this population

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INTRODUCTION

Rainbow trout (*Oncorhynchus mykiss*) are found throughout Togiak National Wildlife Refuge (Refuge) in southwest Alaska. Populations within the Refuge are near the northern limits of their natural distribution (Morrow 1980 and Alt 1977). Rainbow trout are utilized by subsistence fishermen, are a valuable sport fish species, and are an important component of southwest Alaska 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) established a wild stock management policy for resident species, especially rainbow trout. The wild stock management concept 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, but are more intense on the Kuskokwim Bay drainages.

The Arolik, Goodnews and Kanektok Rivers are the major drainages that originate within the Refuge and empty into Kuskokwim Bay (Figure 1). Rainbow trout have been previously sampled in the Kanektok (Wagner 1991 and Alt 1977), Goodnews (Irving and Faustini 1994 and Alt 1977) and Arolik Rivers (Alt 1977). Sampling effort and sample size have been much greater for the Kanektok and Goodnews Rivers than on the Arolik River. Results are being prepared for more recent studies on the Kanektok (Adams In Prep) and Goodnews (Faustini In Prep). Previously Alt (1977) had sampled 24 rainbow trout from the Arolik River. This constitutes the only historical collection of size and age information available from the Arolik River prior to 1991 (Minard and Dunaway 1991).

The Kanektok and Goodnews Rivers annually receive approximately 5000 and 2500 angler days of sport fishing pressure, respectively (Minard 1992). Historical effort estimates are absent or indicate that relatively little use has occurred on the Arolik River. The Statewide sport fisheries participation survey does not provide an estimate for the effort occurring within the Arolik River drainage (Mills 1993 and 1994, and Minard 1992). The Refuge has required sport fish guides operating within the Refuge to submit use reports of their activities since 1983 (Lisac 1989 and USFWS 1991) During the years 1986 to 1991 guides reported an average of 158 client use days on the Arolik River (Togiak NWR Special Use Permit files). Reported use peaked in 1988 at 324 client use days There is no reported use for years other than 1986 through 1991.

Since limited sport fishing effort and biological collection has occurred on the Arolik River rainbow trout population, the Refuge has targeted this system for baseline collection The Arolik River is assumed to have a healthy, relatively low impacted population of rainbow trout

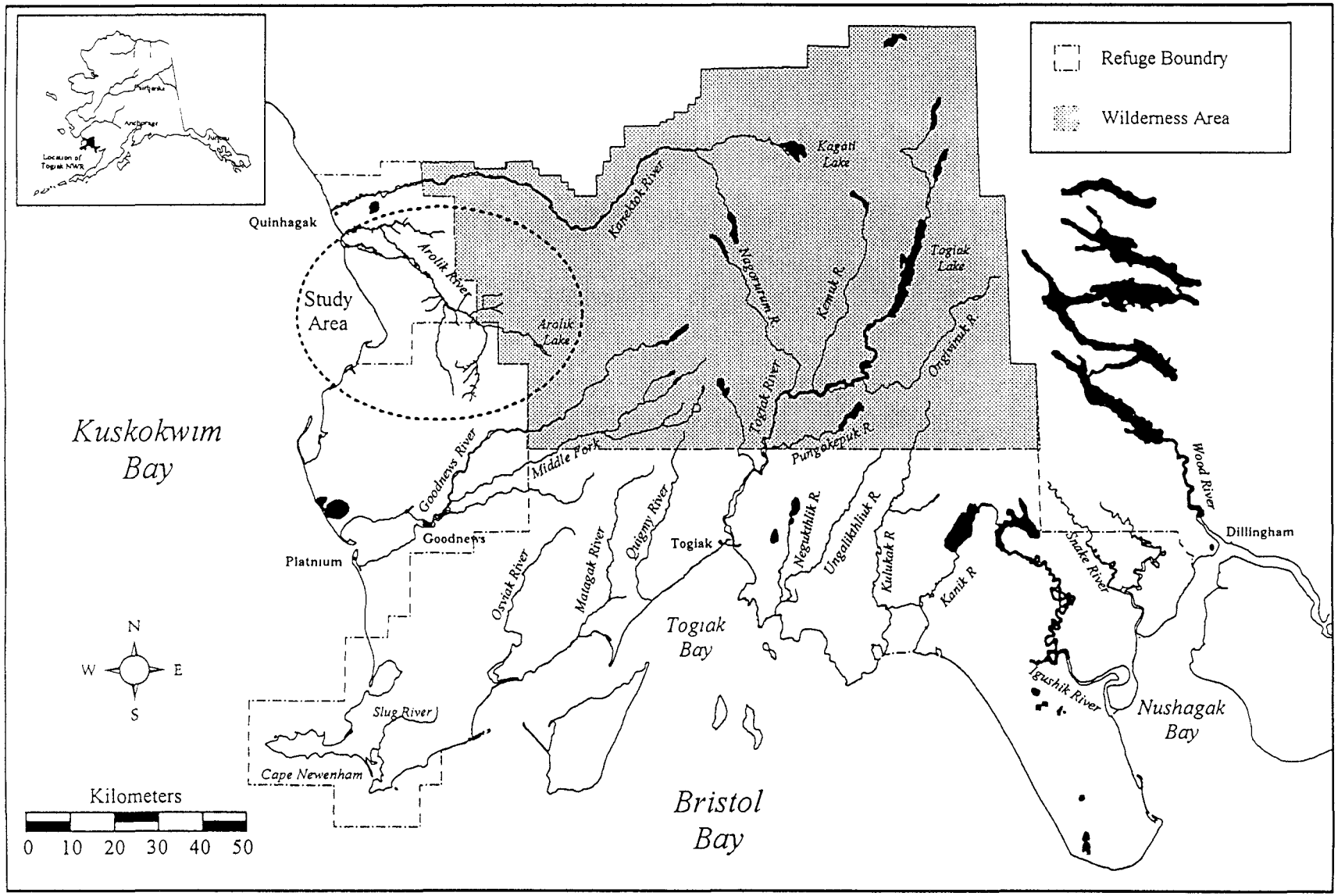

Figure 1. Major river systems and the Arolik River study area within the Togiak National Wildlife Refuge, southwest Alaska.

OBJECTIVES

The objectives of this report are to:

1. Establish a baseline of the age, weight, and length composition of the rainbow trout population in the Arolik River vulnerable to the sport fishery.

2. Document locations and movements of rainbow trout within the Arolik River.

In addition to the primary objectives stated above, comparisons are made between this data set and previously published data for more heavily utilized rainbow trout populations of the Kanektok (Wagner 1991) and Goodnews (Irving and Faustini 1994) Rivers.

STUDY AREA

The Arolik River is located within the Togiak National Wildlife Refuge and empties into Kuskokwim Bay approximately 8.0 km (5 miles) south of the village of Quinhagak (Figure 1) It drains a watershed of 1,483 km^2 (573 mi^2) between the Kanektok and Goodnews River drainages There are two forks: the South Fork which is the main stream, and the East Fork which originates at Arolik Lake. The Arolik River from Kuskokwim Bay to Arolik Lake is 70.5 km (44.1 miles). The South Fork is approximately 37 km (23 mi) long from its confluence with the East Fork to the headwaters in Tatlignagpeke Mountain The South Fork was not included in the study area

The study area was divided into four sections as previously defined by Alt (1977) (Figure 2) Section I included the lower 10.9 km (6.8 mi) of the North Mouth. Section II comprised the upper 21 km (13.1 mi) of the North Mouth. Section III, 23 6 kilometers (14.8 mi) long, was bounded by the North Mouth and South Mouth junction and the East Fork-South Fork junction. Section IV, 15.0 km (9.4 mi) long, was comprised of the East Fork of the Arolik River from the East Fork-South Fork confluence upstream to the outlet of Arolik Lake

Alt (1977) previously surveyed the Arolik River and provided channel and flow characteristics by river (study) section. The river has a gravel bottom and moderate velocity (3 - 6 km/hr) throughout most of its course. The river channel is frequently braided with the main stem width varying between 6 and 61m (20-200 ft). Channel water depth is variable averaging approximately 36 cm (14 in). The lower 16 1 km (10 mi) of the North Mouth is under tidal influence with a mud and fine gravel bottom

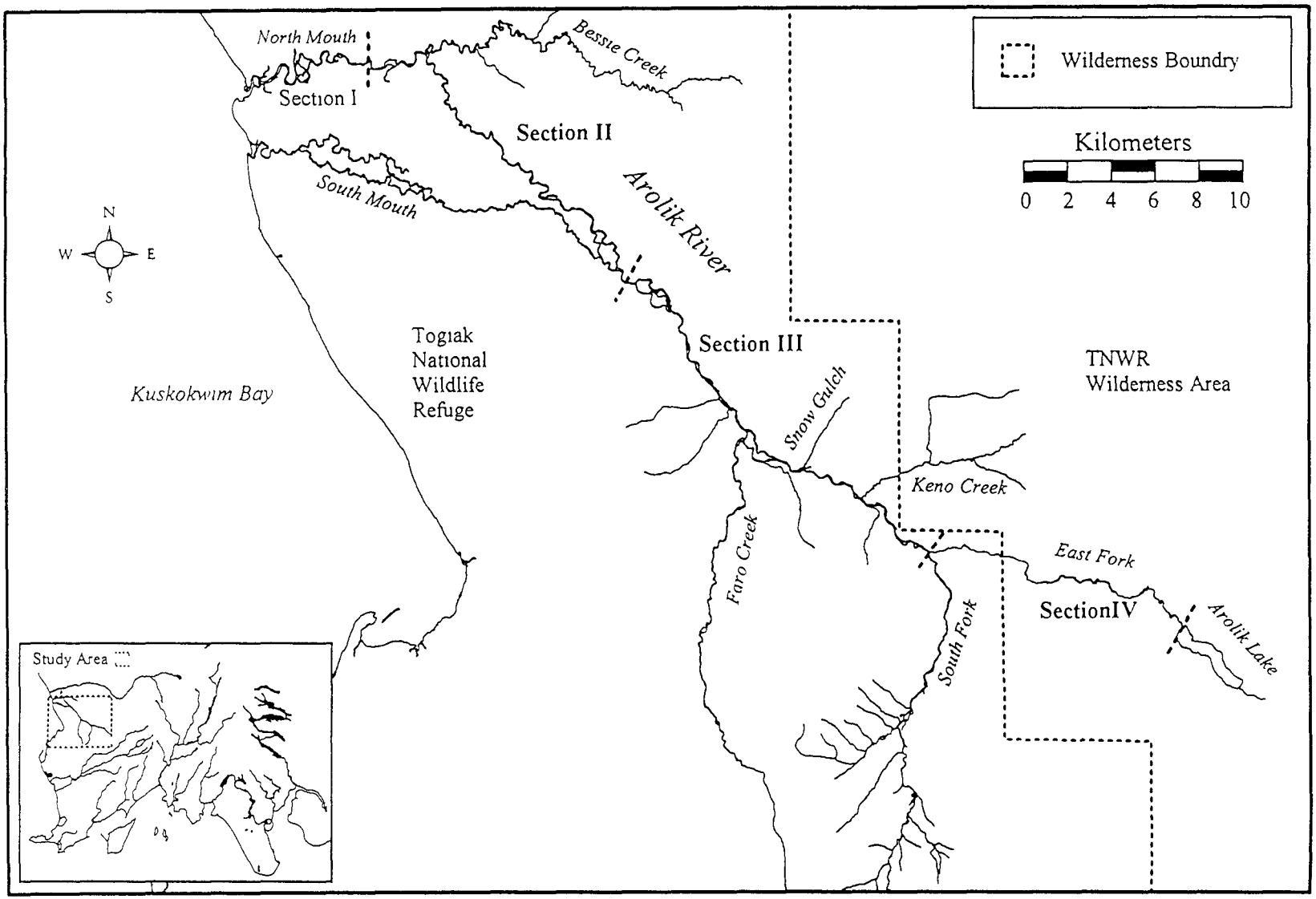

Figure 2. Arolik River and study sections, Togiak National Wildlife Refuge, Alaska, 1991-1994.

METHODS

Access to the river originated at Arolik Lake via float or amphibious aircraft Inflatable river rafts (9 to 13 feet) were used to descend the river course. Conventional sport fishing tackle and methods (spinning and fly) were the only capture methods used. Fishing occurred from the drifting raft and while wading. Effort was summarized by year, trip, study section surveyed by date, number of fish caught and number recaptured per section.

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 0.25kg. In addition to length and weight measurements, the tag number, date and time of capture, location, collector and any distinguishing characteristics (recapture, mortality, condition, etc.) were recorded on the scale envelope. Recaptured fish were measured for length and weight A scale sample was collected from the right side of recaptured fish if a significant time passed since last capture.

Data were transferred to Alaska Department of Fish and Game (ADFG) Standard Age Weight Length mark-sense data form (V1.1) (ADFG 1990) which were optically scanned to create an electronic data set for archiving. Data sets were assigned a file number corresponding to the State fisheries management area, the species sampled, and the year of collection (Heineman 1989a) (Appendix Table A1).

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. Ages were determined using standard interpretation methods (Coggins 1994). 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.

Completed data sets were analyzed using the crosstabulation software program BBX (Heineman 1989b). The BBX program produces unweighted estimates of mean length and percentage by age group and the associated standard error estimates following procedures outlined by Sokal and Rohlf (1981, Boxes 4.2 and 7 1, pages 56 and 139)

(Riffe 1994b). Age frequency distributions were compared between years using a G-test of independence and chi-square statistics ($\propto$ =.05). Age groups were combined for comparison if more than 20% of the cells had an expected frequency of less than (<) 5 0. Length frequency distributions were calculated based on 10mm size increments Cumulative length frequency distributions (1 0mm) were compared between years with a Kolmogorov-Smirnov (K-S) two sample test ($\propto$ = .05) (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 of western Alaska. The five relative stock density categories are: Stock <299mm; Quality 300-399mm, Preferred 400-499mm; Memorable 500-599mm; and Trophy ≥600mm. The average RSD distributions of rainbow trout from Arolik River (1991-1994) were compared by G-test ($\propto$ =0.05) (Sokal and Rohlf 1981) with those derived for the Kanektok (Wagner 1991) and Goodnews (Irving and Faustini 1994) Rivers .

Location and Movement

Fish greater than 250mm were marked with a numbered Floy spaghetti tag (except in 1991) placed posterior to the dorsal fin. The number of fish captured and marked were recorded by study section. Capture locations for each individual fish were determined using the available technology of the time. In 1991 and 1992 aerial photographs and topographic maps were used to determine capture locations by approximate river mile and coordinates of known landmarks. In 1993 and 1994, handheld global positioning units (GPS) were used to determine location coordinates. Movements of recaptured fish were calculated in river kilometer (rkm) and summarized by study sections

A digitized map of the Arolik River was made from United States Geological Survey 1.63,360 quadrangle maps using Atlas GIS Version 3.0 software (Strategic Mapping, Inc). Tag number, and capture or recapture locations for all fish having at least one recapture event were plotted on the digitized file. The distance in river kilometer (rkm) between initial capture and recapture was then generated by tracing the river course with the digital pointer. Upstream movements between observations are reported as positive values while downstream distances are reported as a negative value.

RESULTS

Over the course of the four years of sampling effort 1000 rainbow trout were captured,

772 were marked (tagged) and 87 fish were recaptured (Table 1). The greatest majority of fish were captured (528) and recaptured (70) during 1994 when the most sampling effort occurred. Effort occurred during the months of June, July or August for each year. The exact timing and number of trips per year varied between years. More effort occurred in study sections III and II than in the other two sections. Sections III and II (44.6km) included 63% of the total study area length, and accounted for 90.4% (904) of the rainbow trout captured and 94.2% (82) of the recaptured fish.

Age, Weight and Length

1991

A crew of three caught 82 rainbow trout during a 5-day float between 1-5 August (Table 1). Effort was similar between all four sections of the study area. Most rainbow trout were caught in sections II (35) and III (35). The fewest fish were caught in section I (4). No fish were tagged during the 1991 survey.

Four age groups were determined (ages 4, 5, 7 and 8) from 52 readable scale samples (Table 2 and Figure 3). Thirty scales were regenerated or unreadable Most fish sampled were four years old (25 fish, 48 1%). Five (15.4%) and seven (26.9%) year old fish also accounted for a large portion of the sample. No age 6 fish were collected.

Rainbow trout weights (n = 80) ranged from 300g to 2200g, and averaged 1012g (SE = 60.86) (Table 2). One to seven fish were in each of the 50g weight classes from 300g to 2200g. Two fish sampled were not weighed

Fork lengths (n = 82) ranged from 300mm to 590mm and averaged 436mm (SE = 8.79) (Figures 4 and 5) Length at age (Figure 6 and Table 2) ranged from 365mm (SE = 4.06) at age 4 to 540mm (SE = 19.48) at age 8.

The relative stock density category values of rainbow trout caught in 1991 were 41% Quality, 26% Preferred, and 33% Memorable (Figure 7). No fish were found in the Stock or Trophy categories

1992

Two sampling efforts (11 days) resulted in the capture of 227 rainbow trout (Table 1) The first trip (25-30 June) began at Arolik Lake and included the entire study area. The second trip (11-14 July) began above the North and South Mouth divergence in the lower end of section III. Less effort was spent in sections III and IV than in the other two

Table 1 Number of rainbow trout caught, marked and recaptured by survey trip per year, Arolik River, 1991 to 1994

1991

	TRIP DATES	RIVER SECTION	# FISH CAUGHT	# FISH MARKED	NUMBER OF RECAPTURES 1992	1993	1994	TOTAL
	1 - 5 AUG	I - IV	82	0	NA	NA	NA	NA

1992

	TRIP DATES	RIVER SECTION	# FISH CAUGHT	# FISH MARKED	NUMBER OF RECAPTURES 1992	1993	1994	TOTAL
TRIP #1	25 JUN - 1 JUL	I - IV	117	108	0	NA	NA	0
TRIP #2	11 - 14 JUL	I - II	110	108	0	NA	NA	0
TOTAL	YEAR	I - IV	227	216	0	NA	NA	0

1993

	TRIP DATES	RIVER SECTION	# FISH CAUGHT	# FISH MARKED	NUMBER OF RECAPTURES 1992	1993	1994	TOTAL
TRIP #1	19 - 24 JUN	I - III	159	128	18	0	NA	18
TRIP #2	19 JUL	I	4	0	0	0	NA	0
TOTAL	YEAR	I - III	163	128	18	0	NA	18

1994

	TRIP DATES	RIVER SECTION	# FISH CAUGHT	# FISH MARKED	NUMBER OF RECAPTURES 1992	1993	1994	TOTAL
TRIP #1	16 - 20 JUN	I - IV	228	175	12	15	0	27
TRIP #2	7 - 13 JUL	I - IV	237	204	10	7	13	30
TRIP #3	22 - 24 AUG	II - III	63	49	1	1	10	12
TOTAL	YEAR	I - IV	528	428	23	23	23	69

TOTAL ALL YEARS

RIVER SECTION	# FISH CAUGHT	# FISH MARKED	NUMBER OF RECAPTURES 1992	1993	1994	TOTAL
IV	39	28	1	0	1	2
III	339	258	11	10	11	32
II	565	441	26	13	11	50
I	57	45	3	0	0	3
I - IV	1000	772	41	23	23	87

Table 2 Mean lengths (mm) and weights (g) of rainbow trout by age group by year from the Arolik River, 1991 - 1994

	Age Group										
	UNKNOW	3	4	5	6	7	8	9	10	11	TOTAL
1991											
n (Known Age)			25	8		14	5				52
Percent			48 1	15 4		26 9	9 6				100 0
Std Err			7 00	5 05		6 21	4 13				0 0
Mean Length	454		365	417		498	540				436
Std Err	15 97		4 06	14 01		8 57	19 48				8 79
Sample Size	30		25	8		14	5				82
Mean Weight	1160		546	757		1418	1700				1012
Std Err	107 18		22 90	115 7		89 20	167 3				60 86
Sample Size	29		25	7		14	5				80
1992											
n (Known Age)		2	22	33	52	27	31	11	2		180
Percent		1 1	12 2	18 3	28 9	15 0	17 2	6 1	1 1		100 0
Std Err		0 78	2 45	2 89	3 39	2 67	2 82	1 79	0 78		0 00
Mean Length	486	246	361	408	443	494	532	574	587		463
Std Err	9 99	4 00	9 70	5 92	4 85	7 66	7 31	19 42	9 00		5 03
Sample Size	47	2	22	33	52	27	31	11	2		227
Mean Weight	1475	300	678	923	1179	1528	1797	2261	2350		1332
Std Err	89 47	-	43 91	47 10	45 56	77 26	76 18	173 9	-		39 07
Sample Size	45	2	22	33	51	26	30	11	2		222
1993											
n (Known Age)		1	12	26	49	25	13	5	1		132
Percent		0 8	9 1	19 7	37 1	18 9	9 8	3 8	0 8		100 0
Std Err		0 76	2 51	3 47	4 22	3 42	2 60	1 67	0 76		
Mean Length	514	291	380	435	481	517	551	560	575		485
Std Err	12 26	-	18 32	4 59	4 92	8 02	12 49	37 77	-		5 25
Sample Size	31	1	12	26	49	25	13	5	1		163
Mean Weight	1793	350	792	1066	1459	1744	2108	2304	2150		1527
Std Err	89 53	-	117 2	48 22	43 82	96 23	157 2	487 9	-		45 65
Sample Size	30	1	12	26	48	24	13	5	1		160
1994											
n (Known Age)			24	33	88	132	81	31	16	2	407
Percent			5 9	8 1	21 6	32 4	19 9	7 6	3 9	0 5	100 0
Std Err			1 17	1 35	2 04	2 32	1 98	1 32	0 96	0 35	
Mean Length	501		361	383	427	483	518	542	547	590	477
Std Err	5 09		6 56	10 00	4 65	3 60	4 12	9 40	10 05	20 50	2 93
Sample Size	121		24	33	88	131	81	31	16	2	527
Mean Weight	1529		701	773	1042	1404	1712	1934	2028	2475	1403
Std Err	38 96		64 21	50 54	41 25	32 35	51 95	96 38	99 03	225 0	23 29
Sample Size	121		24	33	86	130	80	31	16	2	523
Grand Mean 1991-1994											
Percent		1 0	18 8	15 4	29 2	23 3	14 1	5 8	1 9	0 5	100 0
Std Err *		0 15	9 84	2 59	4 48	3 92	2 61	1 11	0 99	-	-
Mean Length	489	269	367	411	450	498	535	559	570	590	465
Std Err *	12 92	22 50	4 52	10 82	16 01	7 08	6 94	9 26	11 85	-	10 76
Mean Weight	1489	325	679	880	1227	1524	1829	2166	2176	2475	1319
Std Err *	129 89	25 00	50 78	72 47	122 71	78 56	95 39	116 83	93 86	-	109 82

* Standard error of the grand mean

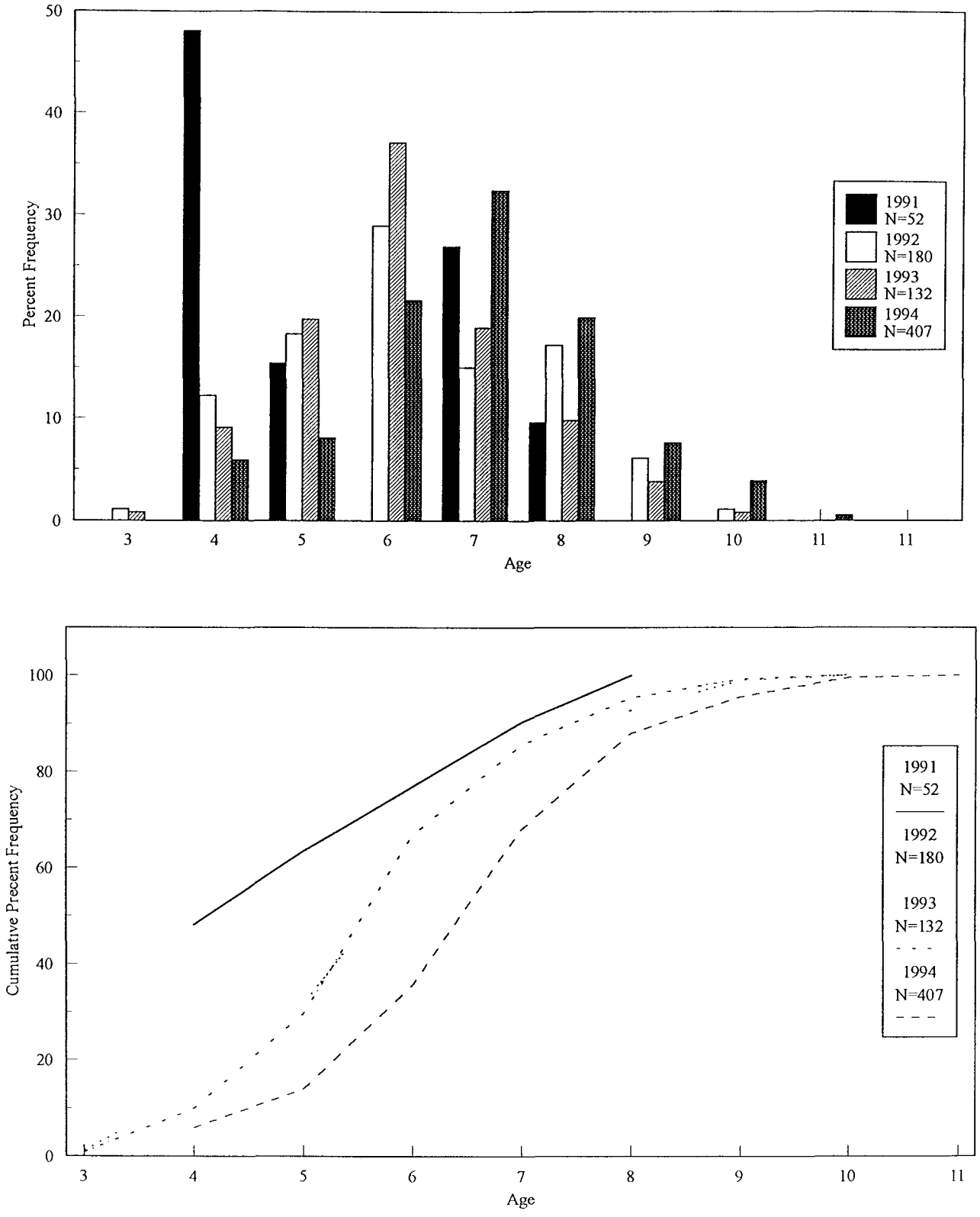

Figure 3 Age frequency and cumulative age frequency of rainbow trout from the Arolik River, Togiak National Wildlife Refuge, 1991 - 1994

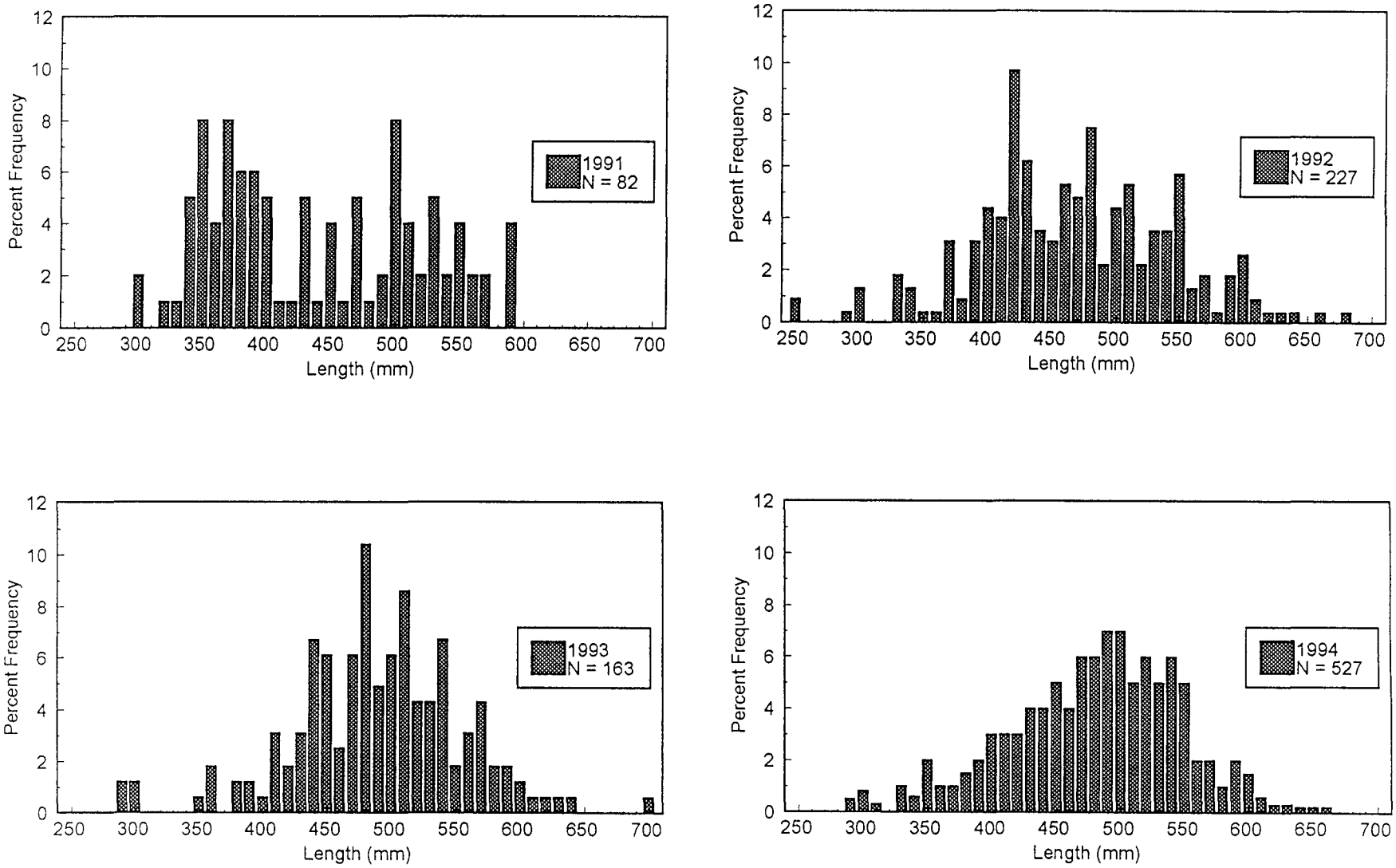

Figure 4 Fork length frequency distribution (10mm increments) for rainbow trout in the Arolik River, Togiak National Wildlife Refuge, 1991 - 1994

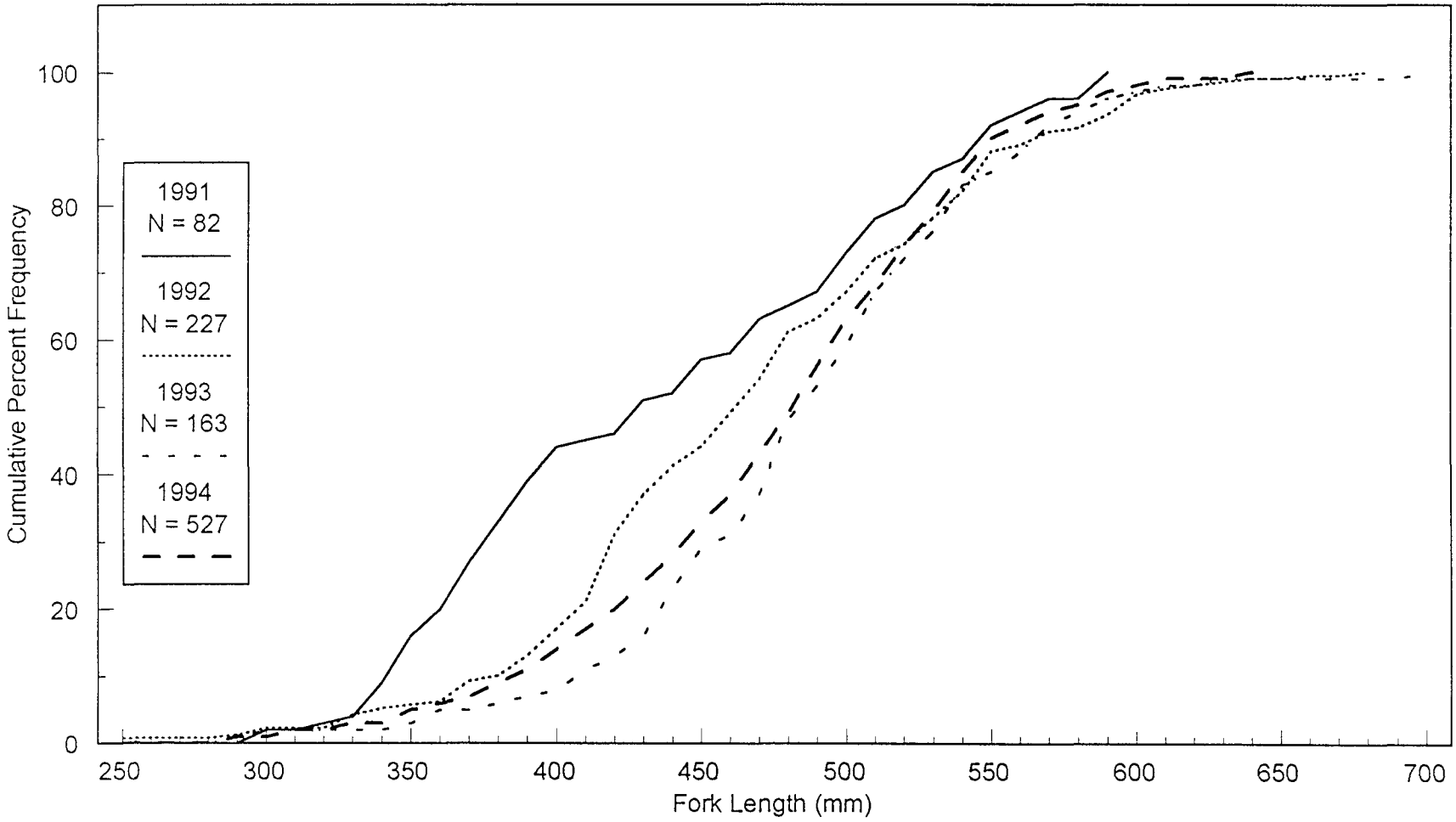

Figure 5 Cumulative fork length frequency of rainbow trout from the Arolik River, Togiak National Wildlife Refuge, 1991 - 1994

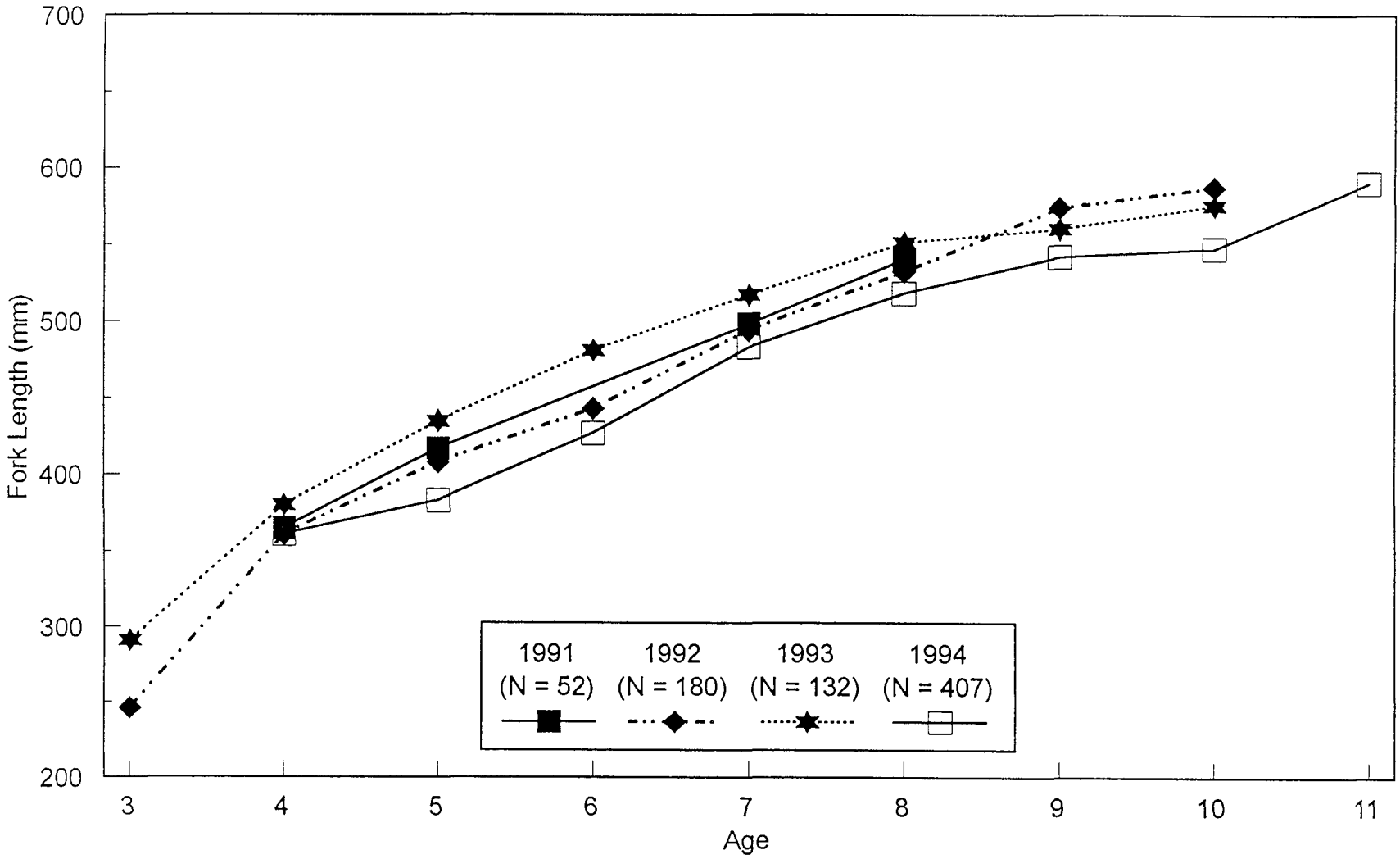

Figure 6 Mean length at age for rainbow trout from the Arolik River, Togiak National Wildlife Refuge, 1991- 1994.

(lower river) study sections during 1992. Most (148) rainbow trout were caught in section II The fewest fish (3) were caught in section IV. A similar number of fish were caught on each trip although section II accounted for 79% of the fish caught during July and 52% of fish caught in June. A total of 216 rainbow trout were floy tagged during 1992 (Table 2) No marked fish were recaptured during 1992

Eight age groups (ages 3 through 10) were represented in the 180 readable scale samples (Table 2 and Figure 3) Forty-seven (21%) samples contained regenerated or unreadable scales. Age 6 fish were the most abundant (52 fish, 28.9%) age group, with ages 4, 5, 7 and 8 accounting for another 62.7% of the sample.

Rainbow trout weights (n = 222) ranged from 300g to 3525g and averaged 1332 (SE = 39.07) (Table 2). Eight fish sampled were not weighed.

Fork lengths (n = 227) for rainbow trout ranged from 250mm to 680mm and averaged 463mm (SE = 5.03) (Figures 4 and 5). Length at age (Table 2 and Figure 6) ranged from 246mm (SE = 4.00) at age 3 to 587mm (SE = 9.00) at age 10. Length at age for age 6 fish averaged 443mm (SE = 4.85). The relative stock density category values of rainbow trout caught in 1992 were 1.3% Stock, 12.3% Quality, 50.7% Preferred, 30.0% Memorable, and 5.7% Trophy (Figure 7).

1993

One sampling trip of the entire study area was conducted from 19 - 23 June (5 days) and a one day trip to the lower river (section I) occurred on 19 July This resulted in the capture of 163 rainbow trout (Table 1). Very little sampling effort and zero catch occurred in section IV. Effort was equally distributed between the other three sections Approximately 56% (91) of the total fish were caught in study section II. A total of 128 rainbow trout were floy tagged during 1993. All recaptures (17) during 1993 were of fish originally tagged in 1992.

Eight age groups (ages 3 - 10) were represented in the 132 readable rainbow trout scale samples (Table 2 and Figure 3). Thirty-one (19%) of the samples contained regenerated or unreadable scales. Age six fish accounted for the greatest proportion (37.1%, 49 fish) of the sample Five (19.7%) and seven (18 9%) year old fish also accounted for a large portion of the sample.

Rainbow trout weights (n = 160) ranged from 250g to 4220g and averaged 1527g (SE = 89.53) in 1993 (Table 2). Three fish sampled were not weighed

Fork lengths (n = 163) ranged from 290mm to 700mm and averaged 485mm (SE = 12.26) (Figures 4 and 5). Length at age (Figure 6 and Table 2) ranged from 291mm (n =1) at age 3 to 575mm (n = 1) at age 10 Length at age for age 6 fish averaged 481mm

(SE = 4.92). The relative stock density category values of rainbow trout caught in 1993 were 1.2% Stock, 6.2% Quality, 45.4% Preferred, 42.9% Memorable, and 4.3% Trophy (Figure 7).

1994

During 1994 three sampling trips were conducted between 16 - 20 June, 7 - 13 July, and 22 - 27 August resulting in the capture of 528 rainbow trout (Table 1). Most (291) rainbow trout were caught in section II. The fewest fish (16) were caught in section I. A total of 428 rainbow trout were marked during 1994, 70 of which were recaptured. Recaptured fish were originally tagged during 1992, 1993 and 1994.

Eight age groups (ages 4 - 11) were determined from 407 readable rainbow trout scale samples collected (Table 2 and Figure 3). One hundred twenty-one (23%) of the samples contained regenerated or unreadable scales. Most all fish sampled were seven year old rainbow trout (132 fish; 32.4%). Six and eight year old fish also accounted for a large portion of the sample with 88 fish (21.6%) and 81 (19.9%), respectively.

Rainbow trout weights (n = 523) ranged from 250g to 3700g and averaged 1403g (SE = 38.96) (Table 2). Five fish sampled were not weighed.

Fork lengths were recorded from 527 rainbow trout. Lengths ranged from 290mm to 660mm and averaged 477mm (SE = 2.93) (Figures 4 and 5). Length at age (Figure 6 and Table 2) ranged from 361mm (SE = 6.56) at age 4 to 590mm (SE = 6.56) at age 11. Length at age for age 7 fish averaged 483mm (SE = 3.60). The relative stock density category values of rainbow trout caught in 1994 were 0.6% Stock, 9.8% Quality, 45.4% Preferred, 40.8% Memorable, and 3.4% Trophy (Figure 7).

Age frequency distributions between 1992 and 1993 (Figure 3) did not differ ($G = 7.13$; $df = 5$; $P > 0.05$). Differences ($P < 0.05$) were observed for all other pairwise comparisons (G ranged from 42.42 to 85.57). The greatest difference ($P < 0.001$) was observed between 1991 and 1994. Age 6 fish comprised a substantial component of the 1992 (28 9%) and 1993 (37.1%) samples whereas age 7 fish comprised 32.4% of the 1994 sample. In 1991 a majority (48.1%) of fish sampled were age 4 and there were no age 6 fish.

Cumulative length frequency distributions did not differ between 1993 and 1994 (K-S test, $P = 0.14$; $D = 0.08$) (Figure 5). All other pairwise comparisons differed ($P < 0$ 001) The greatest difference ($P = 0$ 0002; $D = 0.279$) was found between the 1991 and 1992 samples

Relative stock density (RSD) distributions based on fork length were similar between 1992, 1993 and 1994 (Figure 7) The 1991 sample contained a higher percentage (41%)

of fish in the Quality (300-399mm) category. The average (1991-94) relative stock density category values of rainbow trout caught in the Arolik River were 0 8% Stock, 17.3% Quality, 41.9% Preferred, 36.7% Memorable, and 3.4% Trophy (Figure 7) This average RSD for the Arolik River rainbow trout population was different, by G-test (X^2 = 9.488; df = 4), than that reported for the Kanektok (G = 24.87; P< 0.001), and Goodnews Rivers (G = 19.51; P<0.05) rainbow trout populations (Figure 8). A greater proportion of rainbow trout larger than 500mm (Memorable + Trophy) were sampled from the Arolik River (1991-94) than in either the Kanektok River (1985-87), or the Goodnews River (1988-89).

Mean length per age from 1991 through 1994 varied between all years by as little as 19mm for age 4, to 54mm for age 6 (Figure 6). For age classes 5 through 10, mean length differed by more than 30mm. The annual mean length of unaged fish was greater than the annual total mean length for each sample year (Table 2).

Location and Movement

During 1992 - 1994, 772 rainbow trout were marked and released (Table 1). No fish were marked in 1991. Total tags at large at the end of each year were: 1991 (0), 1992 (216), 1993 (343) and 1994 (761).

Most rainbow trout caught (56.5%), marked (57.1%) and recaptured (62.1%) were within study section II. Section III accounted for 33.9% of fish caught, 33.4% of total fish marked, and 32.2% of recaptured fish. Section I accounted for less than 6% and section IV for less than 4%, of fish caught, marked and recaptured.

Eighty-seven (87) fish were recaptured during 1993 to 1994 (Table 1). Five (5) rainbow trout were recaptured twice, accounting for 10 recapture observations. Two (2) other fish were recaptured, but no tag number was read because the tag was lost at the net or only a visible tag scar was present. These two recaptures are not included in movement analysis.

All of the 18 fish recaptured in 1993 were originally marked in 1992, accounting for 8.3% of available tags. In 1994, 69 fish were recaptured. An equal number (23) of fish were recaptured from each tagging year. Recaptured fish accounted for 10 6% available 1992 marked fish and 18.0% of the 1993 available marked fish.

About 85% (74 fish) of the recaptured rainbow trout were found in the study section of original capture (Table 3) Of the 13 remaining recaptures, 3 fish moved into the survey section immediately upstream and 10 moved one section downstream. Sixteen (94%) of the 18 fish recaptured in 1993 were found in the same study section of original capture in 1992. Fifty-eight (84%) of the recaptures observed in 1994 were found in the study

section of original capture; 18 (78.3%) of fish marked in 1992 and 1993; and 22 (96%) of fish marked in 1994.

Distance travelled (rkm) between original capture and first recapture averaged 3.8rkm (n = 82). Sixty-two fish (76%) travelled less than 5rkm; 14 fish (17%) travelled 5-10rkm; 3 fish (4%) travelled 10-15 kilometers; 1 fish (1%) travelled 15-20 kilometers; and 2 fish (3%) travelled more than 20 kilometers (Table 4)

Thirty-eight (38) rainbow trout travelled downstream, 35 rainbow trout travelled upstream, and 9 rainbow trout (11%) did not travel any measurable distance (< 0 1rkm). Downstream movements ranged from 0.1rkm to 26.3rkm and averaged 4.5rkm Upstream movements ranged from 0.1rkm to 20.1rkm and averaged 4.1rkm. Recaptured fish that moved from initial capture study section (n = 13) moved an average distance of 10.4rkm.

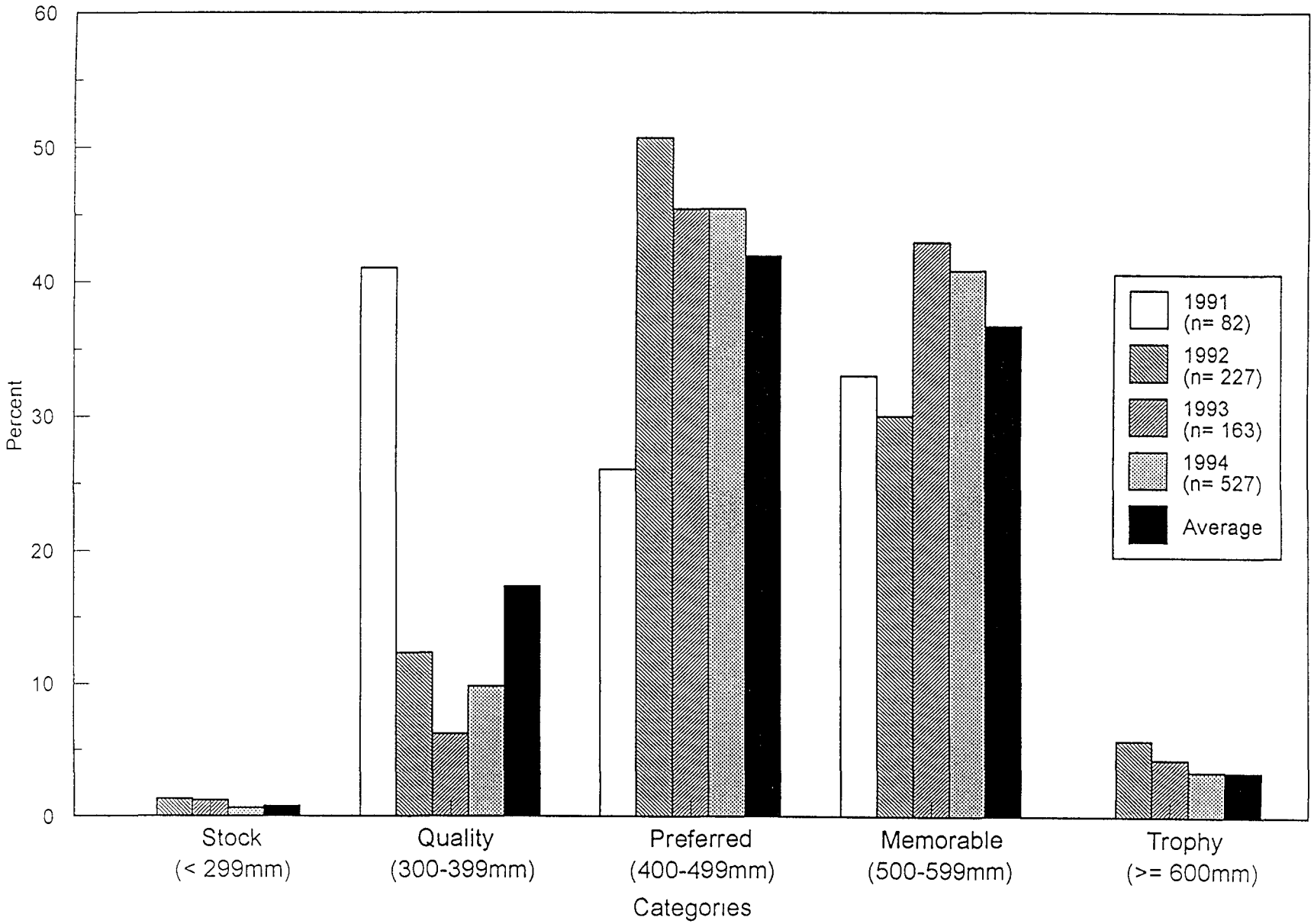

Figure 7 Relative stock density of rainbow trout from the Arolik River, 1991 - 1994

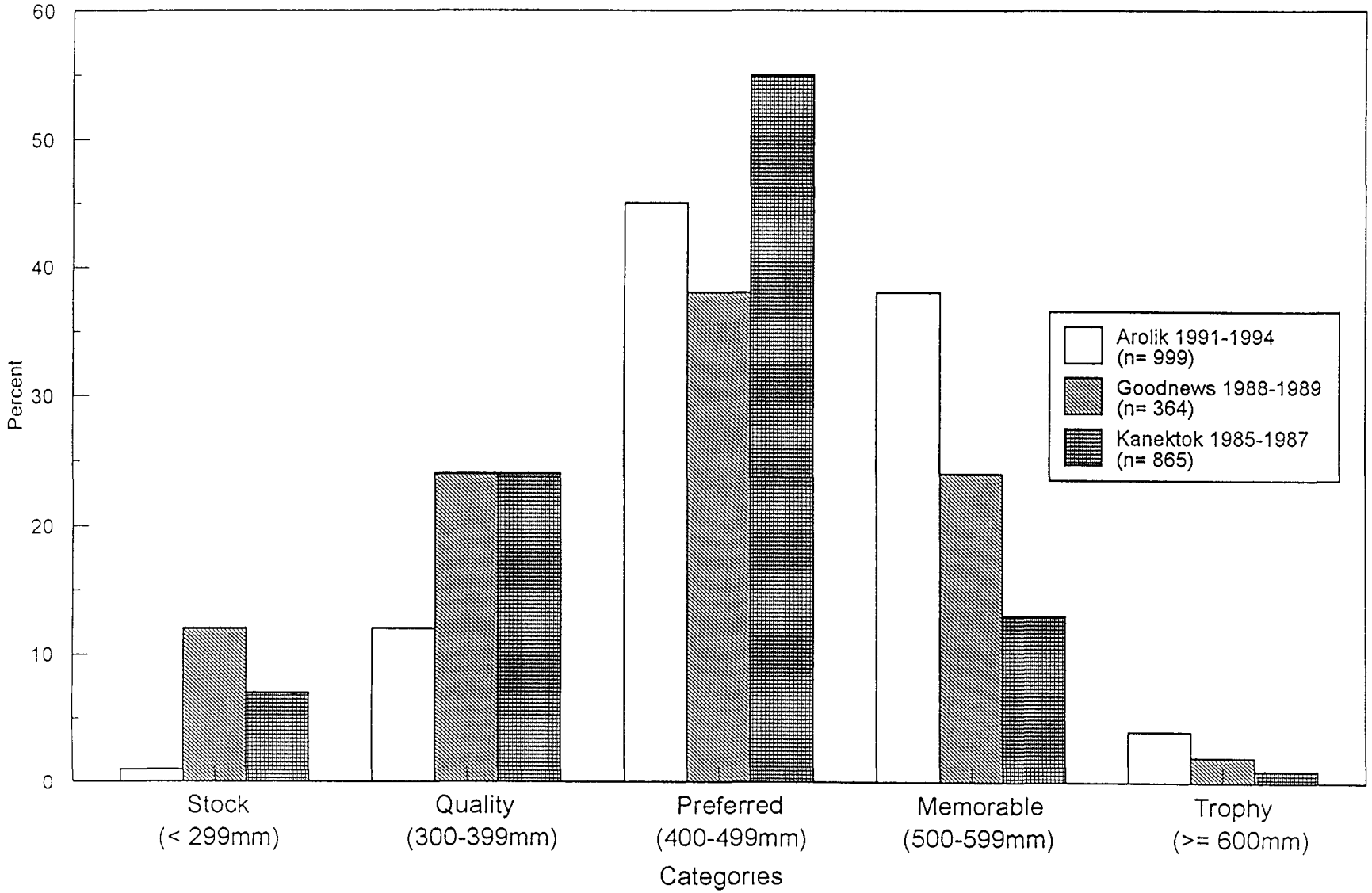

Figure 8 Relative stock density of rainbow trout from the Arolik River (1991 - 1994), Goodnews River (1988-1989), and Kanektok River (1985-1987)

Table 3 Movement of rainbow trout between study section of original capture and recapture events, in the Arolik River, 1992 - 1994 (N=87 recaptures)

			RECAPTURE EVENTS											
	CAPTURE SECTION (TAGGED)	N =	SECTION IN 1993				SECTION IN 1994				TOTAL BY SECTION			
			I	II	III	IV	I	II	III	IV	I	II	III	IV
CAPTURE EVENTS	1992													
	IV	1	-	-	1	-	-	-	-	-	-	-	1	-
	III	14	-	-	1	-	-	3	9	1	-	3	10	1
	II	23	-	13	-	-	1	9	-	-	1	22	-	-
	I	3	2	1	-	-	-	-	-	-	2	1	-	-
	1993													
	IV	0	-	-	-	-	-	-	-	-	-	-	-	-
	III	13	-	-	-	-	-	4	9	-	-	4	9	-
	II	10	-	-	-	-	-	9	1	-	-	9	1	-
	I	0	-	-	-	-	-	-	-	-	-	-	-	-
	1994													
	IV	1	-	-	-	-	-	-	-	1	-	-	-	1
	III	12	-	-	-	-	-	1	11	-	-	1	11	-
	II	10	-	-	-	-	-	10	-	-	-	10	-	-
	I	0	-	-	-	-	-	-	-	-	-	-	-	-
	TOTAL BY YEAR		I	II	III	IV	I	II	III	IV	I	II	III	IV
	IV	2			1					1			1	1
	III	39			1			8	29	1		8	30	1
	II	43		13			1	28	1		1	41	1	
	I	3	2	1							2	1		
		87	2	14	2	0	1	36	30	2	3	50	32	2

Table 4 Number of recaptured rainbow trout and observed movement between initial capture and first recapture, by study section, Arolik River, 1992 - 1994

Initial Capture River Section	Total Recaptures	Movement (rkm)			
		0 - 1 km	1 - 5 km	5 - 10 km	> 10 km
I	3	1	1	1	0
II	41	14	20	5	2
III	36	8	17	8	3
IV	2	1	0	0	1
TOTAL	82	24	38	14	6

DISCUSSION

Age, Weight and Length

Differences in age distribution were observed for all pairwise comparisons except between 1992 and 1993, even after combining age groups with low (<5.0) expected frequencies. Differences between years are dictated by the difference in prominent age group (age 6 vs age 7). Age 6 fish comprise a substantial component of 1992 and 1993, whereas age 7 fish and age 4 fish were most prominent in 1994 and 1991, respectively In 1991 there were also no age 6 fish. These differences are possibly the result of sampling biases due to surveyors' experience, time of year of sampling, sampling effort intensity, sample size, and variability in scale aging. Fish that were identified as age 4 in 1991 do however, show up as a significant component in successive years.

Differences in the cumulative length frequency between most years could also be due to some of the same sampling biases identified above. A small sample size (n = 82) most likely contributes to the difference between 1991 and all other years. This is not the case in 1992 where sample size appears to be adequate (n = 227) yet no pairwise comparison shows this distribution to be similar with any other year There is a greater proportion of fish between 420 - 480mm in 1992 than in either 1993 or 1994 which may be the result of a greater sampling effort in study sections I and II.

The range of scale ages (3 to 11) found in this study is similar to results reported by Alt (1977) for a small sample of Arolik River rainbow trout. He sampled 24 rainbow trout from the Arolik River, using hook and line methods, which represented ages 5 - 10 with age 7 fish comprising 42% (n=10). Age 11, the oldest fish captured in the Arolik River between 1991 to 1994, is the greatest maximum scale age reported for Kuskokwim Bay western Alaska rainbow trout stocks (Irving and Faustini 1994; Wagner 1991). More recent (1993-94) rainbow trout collections by the Service (Adams, In prep; and Faustini, In prep) found rainbow trout scale ages ranging between 2 - 10, and 2 - 9 for the Kanektok and Goodnews Rivers, respectively.

The use of rainbow trout scale ages to assess management actions and compare population parameters between years or between rivers can be problematic. Scales from riverine rainbow trout populations are difficult to read and subject to error because: (1) slow growth produces compressed circuli with indistinct annuli; (2) scale margins are resorbed (or abraded) during spawning; (3) annuli often do not form during the first winter (Lentsch and Griffith 1987) and (4) plus growth after the last annulus can be interpreted differently. A combination of these factors can result in a difference in age determination of 1 - 3 years for an individual fish. Scales have been used to age rainbow trout because they are easy to collect without significantly harming the fish, relatively

inexpensive to process, and there is a historical database. Within-reader and between reader age estimation variability can effect the outcome of population age composition analysis (Coggins 1994) Standardizing criteria for determining ages from scales of rainbow trout in southwestern Alaska is a necessity to allow for meaningful comparisons within or between fish populations. In this study, within reader variability was minimized by using a scale reader trained in standard age interpretation criteria. Ages from the Arolik, Kanektok and Goodnews Rivers' rainbow trout were determined by different readers and may not be comparable. Future work should strive to reduce bias by continuing to apply standard ageing criteria for riverine rainbow trout.

Using standard age interpretation criteria will reduce, but not eliminate all factors contributing to scale age variability. In this study annual mean length of unaged fish was greater than annual total mean length for all years. Mean length at age also varied between years by as much as 54mm (age 6) and average greater than 30mm for age classes 5 through 10. These observations further support the notion that rainbow trout are difficult to age, especially in the later years of life.

Arolik River rainbow trout have a greater maximum length and a greater proportion of larger fish than the other Kuskokwim Bay drainage populations studied to date. Maximum length (700mm) for Arolik River rainbow trout is greater than that reported for the Kanektok (Wagner 1991; 640mm) and the Goodnews River (Irving and Faustini 1994; 686mm). Averaging the RSD distribution for all four years of this study provides a conservative estimate of the larger size categories. Differences observed in the relative stock density distribution are due to the greater proportion of rainbow trout larger than 500mm (Memorable + Trophy) in the Arolik River (1991-94) than in either the Kanektok (1985-87), or the Goodnews (1988-89) Rivers.

The mean lengths at age for rainbow trout in the Arolik River (1991 - 1994) were larger than those previously reported for populations in the western section of the southwest Alaska, but similar to eastern rainbow trout populations until age 8 when growth was observed to slow considerably. Minard and Dunaway (1991) reported that mean lengths at age for rainbow trout from the western section for ages 3 to 9 ranged from approximately 225mm to 540mm, respectively. The minimum estimate of mean length at age for Arolik River rainbow trout is greater than or equal to these earlier estimates. By age 5 rainbow trout have a greater length-at-age in the eastern sections of the southwest Alaska management area than in the western sections (Minard and Dunaway 1991). Those found at the northwestern limits of their natural distribution exhibited the smallest size at age. This was attributed to different life histories (lacustrine vs riverine) and environmental conditions facing these different stocks Eastern rainbow trout generally face more favorable environmental conditions. Rainbow trout in the Arolik River were larger in length at age and have a greater maximum age, maximum length and proportion of fish in the larger relative stock density categories than other western populations. Arolik River rainbow trout may be genetically unique, have had more favorable habitat or

environmental conditions to contend with prior to this study, or are not effected by stress factors present to a greater degree on the other western rainbow trout populations.

Location and Movements

In general stream dwelling rainbow trout tend to be non-migratory (Morrow 1980). Based on locations of recaptured rainbow trout in the Arolik River these fish exhibited no significant movement pattern and have a relatively small home range during the sampling season. Direction and distances traveled were nearly equal between upstream and downstream migrating fish and most rainbow trout (76%) traveled less than 5.0rkm. This is similar to movements observed for Kanektok River rainbow trout which were recaptured within 1.6km of their original tagging location (Wagner 1991). Although no general pattern was observed there were several fish (19) which moved more than 5rkm, and 13 which moved between study sections. These results suggest geographic closure and that a reliable estimate of abundance may be feasible.

RECOMMENDATIONS

This study provides the first substantial sample and description of the rainbow trout population in the Arolik River. Based on results of this data analysis the Arolik River provides a unique and manageable study area to assess a western Alaska wild rainbow trout population and provide a benchmark to determine if the management objective of historical length and age diversity is being approached. Continued evaluation of these data and future sampling efforts should include a long term monitoring program to replicate length, weight, and age sampling at a frequency similar to studies occurring on other western Alaska populations. Consistency in sampling methods (angling techniques and effort concentration) and scale age interpretation criteria are critical to establish and maintain between years and between rivers in southwest Alaska. Annual sampling should occur while angling and subsistence effort is still relatively low compared to other fisheries. This may provide an opportunity to monitor changes in population characteristics, or lack of changes, in response to changes in sport fishing effort.

The validation of scale ages was beyond the scope of this study. Further analysis of recaptured fish ages was not included in this report, but may provide some insight into the consistency of scale age determination for western Alaska rainbow trout Future efforts should include collection and comparison of multiple aging structures (otoliths, scales and fin rays) to assess the potential of using other non-lethal sampling methods that may provide more reliable estimates of age. To assist in determining when the first annulus is laid down, juvenile rainbow trout (age 0 and 1) should also be sampled in the future.

Because of the difficulty of accurately aging rainbow trout and the subjectivity of current sampling methods the management strategy to maintain historical age and length composition may not be realistic. An alternative management strategy would be to strive to maintain the historical length composition or relative stock density distributions, 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. Continued analysis may help to further refine the relative stock density categories to more accurately reflect western Alaska riverine resident rainbow trout population growth, recruitment and mortality characteristics. The assignment of minimum lengths for each relative stock density category, and the determination of the number of categories to be used for Alaskan rainbow trout stocks should reflect varying life strategies of these stocks.

Although 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. Results of this study indicate that comparing length frequencies per year (K-S test) may point to inconsistencies in angling as a sampling method. 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 to allow assessment of resource health and whether management objectives are being met. Analysis of age and length frequencies within river (study) section may also provide a better look into the statistical use of hook and line sampling methods for estimating length and age composition.

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REFERENCES

Adams, F.J. In prep. Status of rainbow trout in the Kanektok River, Togiak National Wildlife Refuge, Alaska, 1993. USFWS, 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.

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

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. In prep. Status of rainbow trout in the Goodnews River, Togiak National Wildlife Refuge, Alaska, 1993-1994.

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

Heineman, G. M. 1989a. Instructions for using sport fish mark sense diskettes 1989. ADFG, Div. of Sport Fish, Research and Technical Services. Anchorage.

_____. 1989b. BBX crosstabulation system for Bristol Bay historic rainbow trout data Alaska Department of Fish and Game, Division of Sport Fish, RTS 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.

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

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

Lentsch, L. D. and J. S. Griffith 1987. Lack of first-year annuli on scales: Frequency of occurrence and predictability in trout of the western United States. In R. C Summerfelt and G. E. Hall, editors. The Age and Growth of Fish. Iowa State University Press. Ames, Iowa.

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

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

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. ADFG, 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. ADFG, 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.

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.

_____. 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

Sokal, R.R. and F.J. Rohlf. 1981. Biometry, the principles of statistics in biological research Second Edition. W. H. Freeman and Company, New York, NY.

USFWS 1990. Fishery Management Plan, 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. USFWS, Technical Report No. 13.

APPENDICES

Appendix Table A1. Sample size and data file name by year for Arolik River rainbow trout samples collected and analyzed by USFWS, 1991 - 1994

Year	Number of Fish Sampled	Number of Fish Aged	RTS File Number
1991	82	60	V0880BA1.DTA
1992	227	189	V0880BB2.DTA
1993	163	132	V0880BA3.DTA
1994	528	407	V0880BC4.DTA
	1000	788	