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A BIOLOGICAL ASSESSMENT OF ARCTIC CHARR IN THE NALOAGYOK RIVER, VICTORIA ISLAND, NWT, 1989

by

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Report #89-006

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INTRODUCTION

In 1982, responding to interest expressed by residents of Holman, the Department of Fisheries and Oceans initiated studies to assess the commercial potential of Arctic charr (Salvelinus alpinus L.) stocks in the Prince Albert Sound area of Victoria Island, NWT (Figure 1). During August of 1982 and again the following summer DFO personnel conducted test fisheries near the community in Safety Channel (Kristofferson and McGowan 1982; Kristofferson et al. 1984). Concern had been expressed by DFO that these charr were migrants from the domestically exploited stock at the Kuujjua River, in Minto Inlet, and the studies found this to be the case . They recommended against establishing a commercial fishery in the Safety Channel area and, based on samples obtained from the coincident commercial fishery at the Kagloryuak River, near the head of Prince Albert Sound, suggested that the commercial potential of stocks further afield should be examined.

In 1985, DFO tested the Kuuk ($70^{o}34'N$, $112^{o}38'W$), Naloagyok ($70^{o}13'N$, $112^{o}13'W$), Kagluk ($70^{o}13'N$, $112^{o}58'W$), and Kagloryuak ($70^{o}18'N$, $111^{o}24'W$) rivers which flow into Prince Albert Sound (Kristofferson, pers. comm.). From the data collected neither the durations of migrations nor the relative numbers of charr in the stocks could be determined. The study was repeated in 1986 by North/South consultants Inc. who were contracted by the Fisheries Joint Management Committee (FJMC). It was hampered by unfavorable ice conditions in Prince Albert Sound which prevented testing of the Kagluk and Naloagyok rivers and limited testing at the Kuuk River (Baker 1986).

In 1987 the FJMC contracted Arctic Biological to conduct biological assessments of charr stocks in the Kuuk and Kagluk rivers, coincident with commercial test fisheries (Stewart and Sparling 1987). The Kuuk was found to have a healthy stock of anadromous Arctic charr, with a low rate of exploitation. However, there were too few charr to support a financially viable commercial fishery unless other commercially attractive anadromous stocks are found in the Prince Albert Sound area. Sampling at the Kagluk River suggested that it might support such a stock.

In 1988, the Holman Hunters and Trappers Committee (HTC) contracted P.D. Sparling and Arctic Biological Consultants to evaluate the potential of a fall commercial fishery for

anadromous Arctic charr at the Kagluk River. This involved the enumeration, tagging, and biological sampling of charr at a weir built across the river coincident with a commercial test harvest, and assessments of site suitability for commercial fishing in terms of access, weir location, and run timing.

Assessment of the Kagluk river revealed that the charr stock was too small to support a commercial fishery and that existing exploitation was already significant, it was recommended that any additional exploitation of this stock should be in the form of a sport fishery. The Naloagyok River was also visited to assess potential weir location and accessability.

Again in 1989, the Holman HTC contracted P.D. Sparling to evaluate the potential of a fall commercial fishery for anadromous Arctic charr at the Naloagyok River. The project proceeded in the same fashion as for the Kagluk River in 1988. The Kagloryuak was also visited to determine a suitable location for a weir to be installed in 1990. Results from these investigations are included in this report.

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METHODS

Weir Construction and Evaluation

The field crew arrived by Twin Otter from Holman on August 10. By August 11, the weir was completely finished. The weir was erected approximately 100 m upstream of the mouth and within the tidal zone. At this location the stream was ~~only about~~ 15 m wide and about 50 cm deep at low tide. The weir itself was similar in design and construction to the metal conduit pipe design that was described in Appendix 3 of Kristofferson et al. (1986). The trap was 1.23 m wide, 2.46 m long and 1.54 m high. It had a frame of wooden 2 x 4's with vertically mounted metal conduit pipes on the ends, plastic netting on the sides, and a rear drop gate which had to be installed with the rising tide. The attachment of the wings onto the trap was slightly modified in that the wing panels led right into the trap forming the narrow entrance.

On August 18, part of the field crew went over to the Kagloryuak River to select a suitable location for a weir to be installed in 1990. During this investigation gill nets were set to collect a sample of fish to be sent to Winnipeg for electrophoretic analysis.

On September 7, the weir was dismantled and stored on the west bank of the Naloagyok River.

Biological Evaluation

Arctic charr were counted as they migrated upstream from Prince Albert Sound into the Naloagyok River (Figure 2). The trap was checked at regular intervals to ensure that migrating fish were not unduly stressed, and that the run was not delayed.

During the migration entire trap loads or random selections from larger trap loads were used to give an unbiased account of mean daily lengths. For each charr live sampled, the fork length (+/- 1mm) was measured and tags and scars recorded. The plastic Floy spaghetti tags which were used to mark the fish were numbered sequentially from FC71076 to FC71500. The tags were inserted between the pterigiophores of the dorsal fin on the left side of the fish using a Floy Mark II tagging gun. The fish were not anesthetized and after tagging were released in quite backwater for observation. The needle, gun, and tag were sterilized in a 10% solution of Prepodyne between each fish to prevent the introduction or spread of ~~infectious pancreatic necrosis virus~~. None of these fish were weighed ~~since it~~ stresses them unduly.

To provide the basis for a regression of length against age, a total of 100 fish were sampled for round weight and sometimes dressed weight, sex and maturity, stomach contents, and sagittal otolith bones were removed for later age analysis.

The stage of maturity was determined by gross examination of the gonads following the classification code used by Kristofferson et al. (1982) and aged according to the method of Grainger (1953) by Mr. G. Carder (Fish and Marine Mammal Management Division, DFO Central and Arctic Region, Winnipeg).

An estimate of the instantaneous rate of total mortality (Z) was obtained by fitting a least squares regression to the descending limb of the catch curve which was constructed from the aged samples. Only fully recruited age groups were used. This was accomplished by using the next older age group from the modal age since the modal age will often lie quite close to the first year in which recruitment can be considered effectively complete (Ricker 1975; Kristofferson et al. 1982). Instantaneous natural mortality (M) was assumed to be 0.17 after Moore (1975) and Dempson (1978) and instantaneous rate of fishing mortality (F) was calculated form $Z = F + M$.

Weight at length relationships were calculated using least squares regression analysis on logarithmic transformations of fork lengths and round weights. The relationship is described as follows:

$$\text{Log}_{10} \text{ round weight in g} = b \times \text{Log}_{10} \text{ fork length in mm} + \log a$$

The condition factor (K), a relative measure of the plumpness or robustness of the fish, was determined by the following formula:

$$K = (\text{round weight in g} \times 10^5) \times \text{fork length in mm}^3$$

The length composition of the run over time was described statistically by regression analyses on the individual measurements and t-tests on the population means. The data were tested for sex-related differences using binomial t-tests on the mean length, weight, condition, and age. Statistical differences were considered significant if the probability of error was less than 5% ($P<0.05$).

EXPLORATORY FISHERY

Commercial Fishery

A ~~commercial~~ harvest was conducted during the weir enumeration of the Naloagyok River charr population. A holding pen was constructed to hold fish for the c~~ommercial~~ harvest. Fish were added to the pen until the harvest took place on August 21. The fish were measured for round weight and fork length and shipped to Holman round to be frozen for sale.

A subsample of 30 Arctic charr taken during ~~the commercial~~ this fishery was consigned to the Scientific Authority for genetic and other analyses. The fish were frozen intact in Inuvik, about 12 hours after harvest. These samples were shipped at a later date to DFO Winnipeg for sampling. Biological data from those samples are included in this report.

RESULTS AND DISCUSSION

NALOAGYOK RIVER

1. Site Evaluation

The Naloagyok River drains into a marine bay which has a narrow exit to Prince Albert Sound. Tides from the bay run part way up the river, which is about 200 m long and connects the bay with a small lake. The lower 100 m are fast flowing, about 15 to 20 m wide at low tide, and 0.5 m deep; the upper 100 m are split by a gravel bar into two fast-flowing channels. The river lengthens by nearly 100 m at low tide. Upstream from the lake it diverges into a series of interconnected lakes.

Boat Access

Boat access to the Naloagyok River is poor and should not be relied upon to conduct a commercial fishery. Drifting pack ice, high winds, fog, and snow interact to prevent reliable boat transportation.

Aircraft Access

There is good aircraft access for Twin Otter equipped with tundra tires on the west side of the lake and river, within 200 m of the weir location. The runway is grass, underlain by mud-covered gravel and runs from northeast to southwest. Small float planes including single and twin Otters can land on the bay at the river mouth.

Camping Sites

There are good tent sites near the recommended weir site. The other suitable site which was utilized during this investigation was situated just beside the remnants of an old outpost camp on the spit of land at the river mouth, one kilometre downstream.

Fishing Methods

The weir worked very well and fish were harvested efficiently and in good condition. Because of the small size of the river, the weir can be easily installed in a period of several hours. Only six panels of the conduit weir are required to block off the entire stream.

2. Biological Evaluation

Run Strength and Timing

Between August 11 and September 7 a total of 22,386 charr were counted moving upstream past the weir. A small number of fish were observed in the river the day the weir was installed so a small portion of the run may have been missed. All of the charr observed were silver-colored fresh from the sea. No current year spawners were seen passing through the weir.

As shown on Figure 3 the Arctic charr run of the Naloagyok River took place between August 11 and September 7 with the peak occurring on August 30.

Charr length did not decrease significantly as the run progressed (Figure 4).

Movements

Tags were placed on a total of 412 Arctic charr from the Naloagyok River as they passed upstream through the trap. Blue plastic Floy spaghetti tags numbered from FC 71076 to FC 71500 were used and data on the tagged fish is presented in Appendix 2. A total of 13 of the tags in the sequence were destroyed. Following tagging most of the fish moved quickly upstream. Some remained for a short duration in the deeper water just upstream of the trap.

The inland extent of the migration is unknown, however, many YOY and older juvenile fish were observed in the stream below lake #2 (Figure 2). Since lake #1 and #2 are both deep enough to provide overwintering habitat, it is suspected that charr spawn along their shores. It is possible that some charr go further upstream to spawn and overwinter, however, there is no information to support this assumption.

Movement of charr between the various Prince Albert Sound rivers appears to be very limited. None of the fish tagged at the Kagluk River in 1988 and at the Kuuk River in 1987 were recaptured in the weir on the Naloagyok River. Similarly, the weir operation on the Kagluk River in 1988 did not recapture any of the tagged Kuuk River fish. We can therefore conclude that natal stream fidelity of Prince Albert Sound charr is high.

Growth

Fork length was measured for 754 charr which passed through the trap (Figure 5). The mean length of these fish was 479 mm. The length frequencies were distributed in a bimodal fashion with a minor mode at 350 to 400 mm and the major mode at 500 to 550 mm. Lengths of the upstream migrating population ranged from 190 mm to 721 mm.

A comparison of growth rates is made between different populations of Arctic charr (Table 3). Age-length relationships for Western Arctic charr illustrated in the form of line graphs are shown in Figure 6. In comparison to the other Prince Albert Sound charr stocks, the Naloagyok River stock has a growth rate exceeding that of the Kuuk River and less than that of the Kagluk River. The major difference with the Naloagyok River charr is the early levelling off of the growth rate at around age 11 and the absence of older charr. Prior to this investigation, it had been noted, based on local information, that the fish in this river system were relatively small. It is now apparent that this is largely due to the absence of older charr and the levelling off of growth rates at a relatively young age.

The weight at length relationship for anadromous charr is best described by the equation:

$$\log_{10}Y = 3.24 \log_{10}X - 5.58$$

where X is fork length in mm and Y is round weight in g ($r^2 = 0.99$, $n = 105$). Based on this relationship, it appears as though these charr are in very good condition. Table 1 shows how the condition of these fish compares to different samples of Prince Albert Sound charr populations. Although the differences observed may be due to stock discreteness, they may simply reflect conditions in given years or seasons.

Sex and Maturity

Sexually mature anadromous charr in Arctic populations seldom spawn every year (Johnson 1980), and there is no adequate classification for multi-year resting fish in the DFO Fish Management maturity code (Appendix 1). Following the code, these charr, which have spawned previously but often do not have resorbing or maturing sex products in their gonads, would be incorrectly classified as "immature".

In an attempt to alleviate this problem charr which were not obviously virgin, with small transparent gonads, were classified as "resting".

The age at first maturity was 10 yr or younger for males and 6 yr or younger for females, and the sex ratio was even (F/M = 0.92; Table 1). Of the 105 migrants sampled, 56.2% were immature, 40% were resting and the remaining 3.8% were unidentified.

Diet

Of the 65 Arctic charr examined for stomach contents, 55 were empty and the remaining 10 fish had small quantities of marine amphipods.

Past and Present Use of the Stock

The Naloagyok River was a traditional domestic fishery for Inuit before they moved to Holman. There are many stone fish caches and tent rings in the area, but it is difficult to access by boat from Holman and has seldom been fished in recent years.

Physical damage in the form of scars or net marks, was observed on 1.5% (n = 11) and 7.1% (n = 54) respectively, on the 761 fish examined. The scars were slash marks more than likely caused by seals. The net marks, new and old, suggest that the stock is being harvested elsewhere, probably in the Safety Channel area nearly 160 km away.

Commercial Fishery

A total of 1178.62 kg (467 Arctic charr) of charr were taken from the Naloagyok River for commercial sale. The entire quota of 2,000 kg was not taken due to the non-availability and cost of aircraft transportation.

Based on a sample of 31 fish, the ratio of round weight to dressed was calculated to be 1.10.

Potential Yield

Of the three Prince Albert Sound anadromous charr stocks which have been assessed in the last three years, the

Naloagyok River stock is the largest. Based on the number of individuals caught during the 1989 season, it is believed that 5% or approximately 1,100 fish from the upstream migrating population could be safely harvested. If commercial fishing was to be carried out every two years (on a rotational basis) then 10 % or approximately 2,200 fish could be safely harvested.

A catch curve constructed from the predicted age-frequency distribution shows complete recruitment to the anadromous population by age 11 y, an abrupt decline in year class strength from age 11 to 15 y and an absence of older charr (Figure 7). The instantaneous total rate of mortality (Z) was calculated to be 0.46.

KAGLORYUAK RIVER

1. Site Evaluation

On August 18, 1989 a sampling crew travelled from the Naloagyok River to the Kagloryuak River to conduct a site evaluation. An 18 foot Lund powered by a 70 hp outboard motor was used to travel between the rivers.

The Kagloryuak River drains into the eastern end of Prince Albert Sound. The river divides into three major tributaries; the main one flows approximately 145 km from its headwaters. This watershed drains several large, deep, freshwater lakes which may be utilized as overwintering habitat.

Weir Location

There is a good weir location approximately 6 km from the mouth of the river just upstream of the first major forks where the two tributaries have the narrowest width of land separating them. The channel at this location is about 35 to 40 m wide and about 0.5 m deep. Most of the charr are believed to migrate up this east flowing major channel. The more southeasterly flowing tributary which has about the same discharge as the main tributary is not believed to be heavily used by Arctic charr.

Boat Access

Boat access to the Kagloryuak River is very poor and should not be relied upon to conduct a commercial fishery. It suffers from the same adverse ice and weather conditions as were described for the Kagluk and Naloagyok Rivers. This location is particularity vulnerable to these conditions as it is located at the very end of Prince Albert Sound where solid ice packs are more likely to occur.

Aircraft Access

The only possible means of accessing this weir site by air is with small float planes. There are two to three stretches of calm water within 1 to 2 km of the weir site suitable for landing. A single Otter or a Beaver on floats would be the most suitable aircraft to set up the camp and to haul out the fish from the test fishery.

Camping Sites

Suitable camping sites are available near the recommended weir site.

SUMMARY AND RECOMMENDATIONS

Between 11 August and 7 September, 1989, 22,386 anadromous Arctic charr were counted migrating upstream in the Naloagyok River. A total of 412 of these charr were tagged. The majority of the fish passed the weir location between August 27 and September 2. Near the latter part of the run, 467 charr (1,178.62 kg) were harvested on a test fishery basis.

Biological sampling of the Naloagyok River stock revealed that these fish are in very good condition but that they were significantly smaller than other Prince Albert Sound charr populations. Mean length is 479 mm with the major mode at 500 to 550 mm. Lengths ranged from 190 to 721 mm. Very few older fish and a high occurrence of net marks on the fish suggests a significant level of exploitation, however, the instantaneous total mortality rate of 0.46 does not support this assumption. The mortality data must be interpreted very cautiously.

It may be feasible to exploit the Naloagyok River charr population since there is very good access to the weir site by Twin Otter or smaller aircraft on wheels or on floats and the number of fish available in this population may be large enough to make such a venture feasible. Since existing exploitation is believed to be close to the 5% level, an additional 5%, approximately 1,100 fish, is considered to be the absolute maximum additional exploitation which the population could sustain on an annual basis. If the commercial fishery was to be carried out every two years, 10% exploitation rate would be acceptable and would represent a harvest of approximately 2,200 charr.

The Kagloryuak River has good access by float plane and shows some potential for a commercial fishery. A suitable weir site is also located on the river upstream of the first major forks. If a major biological assessment of this Arctic charr stock is to be carried out, it is recommended that in addition to the installation of the weir on the main tributary at the suggested location, a hoop net operation on the southeasterly flowing tributary should be conducted to determine if a significant number of charr also migrate up this branch.

ACKNOWLEDGEMENTS

We thank John Alikamik and Noah and Earl Ahkiatak for their assistance in the field and their friendship, Gary Carder of DFO Winnipeg for determining the ages of the charr, Dr. Jim Reist and his staff for providing information from the Arctic charr that was collected for electrophoretic analysis, members of the Holman HTC for their assistance with the project, and -------- for editing the manuscript.

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PERSONAL COMMUNICATIONS

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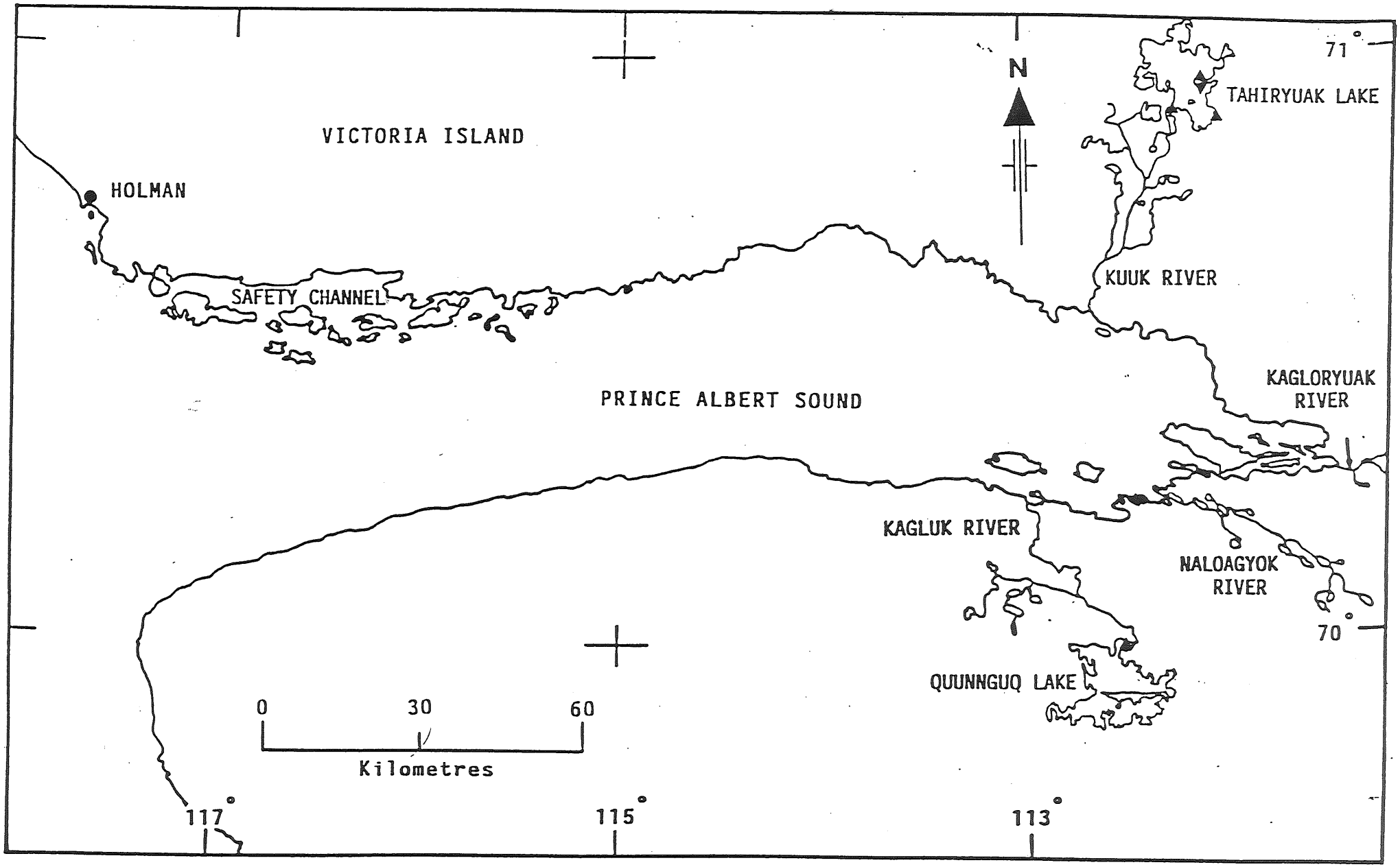


Figure 1. Map of Prince Albert Sound, Victoria Island, N.W.T.

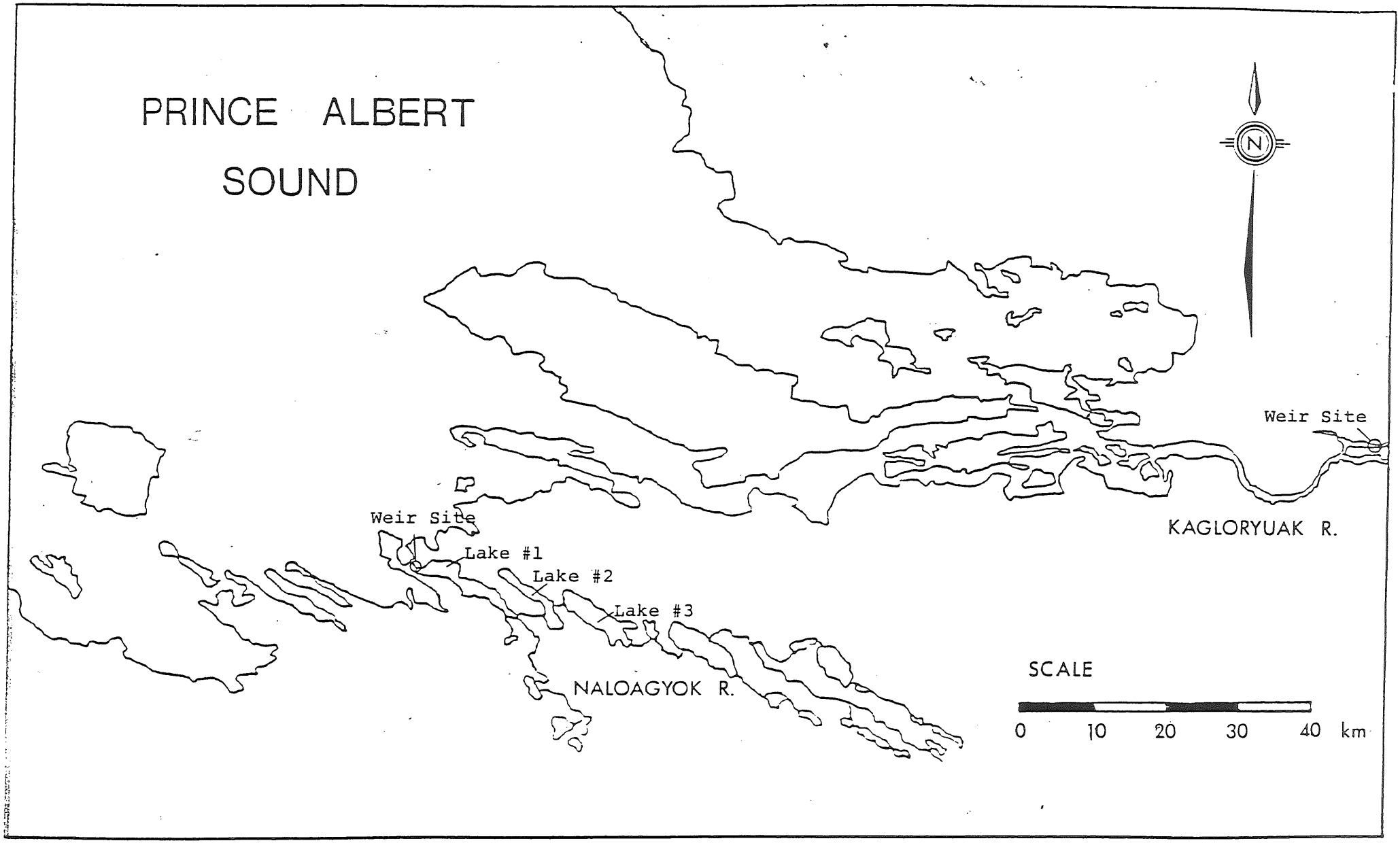


FIGURE 2. Location of weir sites at the Naloagyok and Kagloryuak Rivers, Prince Albert Sound, NWT.

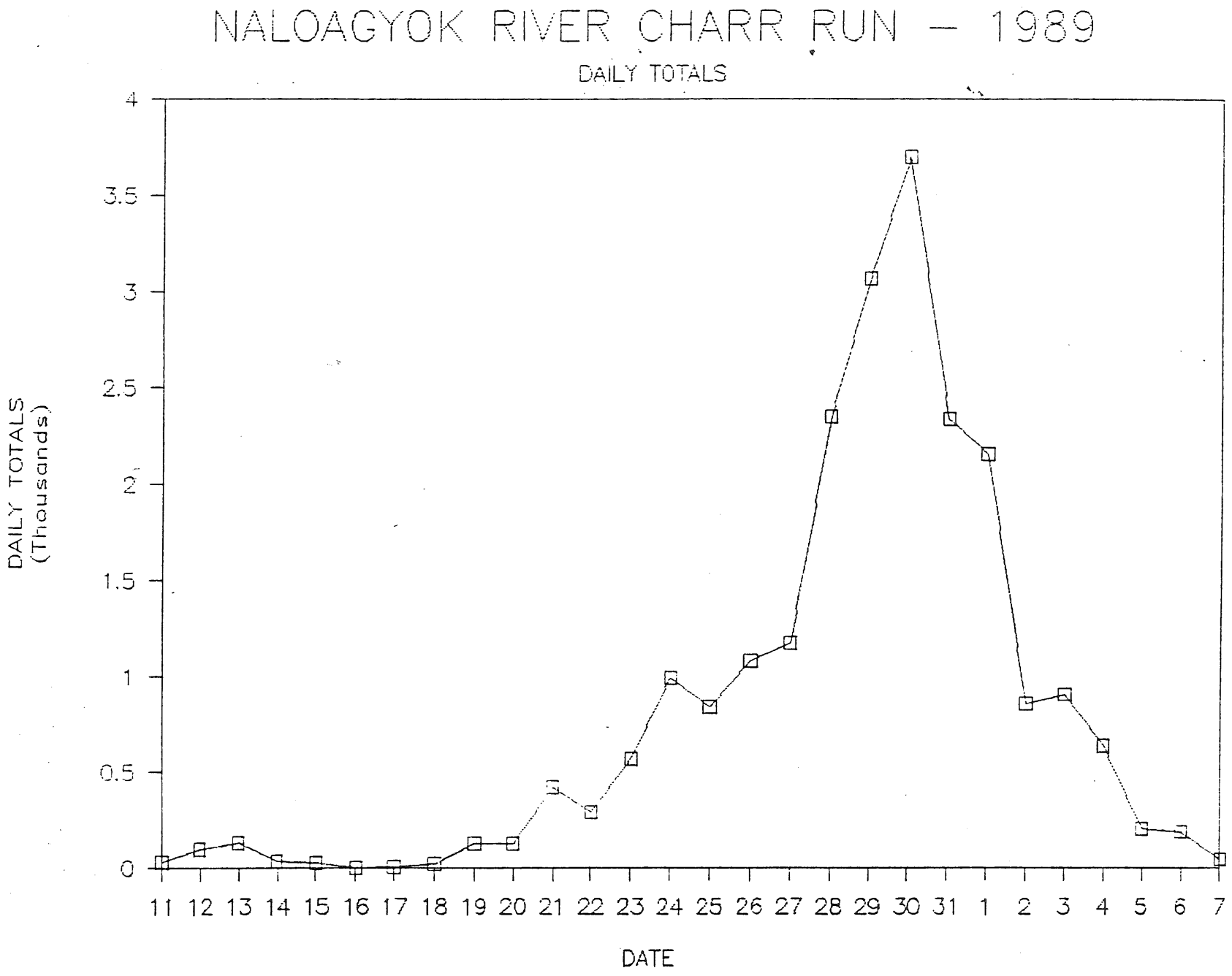


Figure 3. Daily counts of Arctic charr migrating upstream past the Naloagyok River weir between August 11 and September 7.

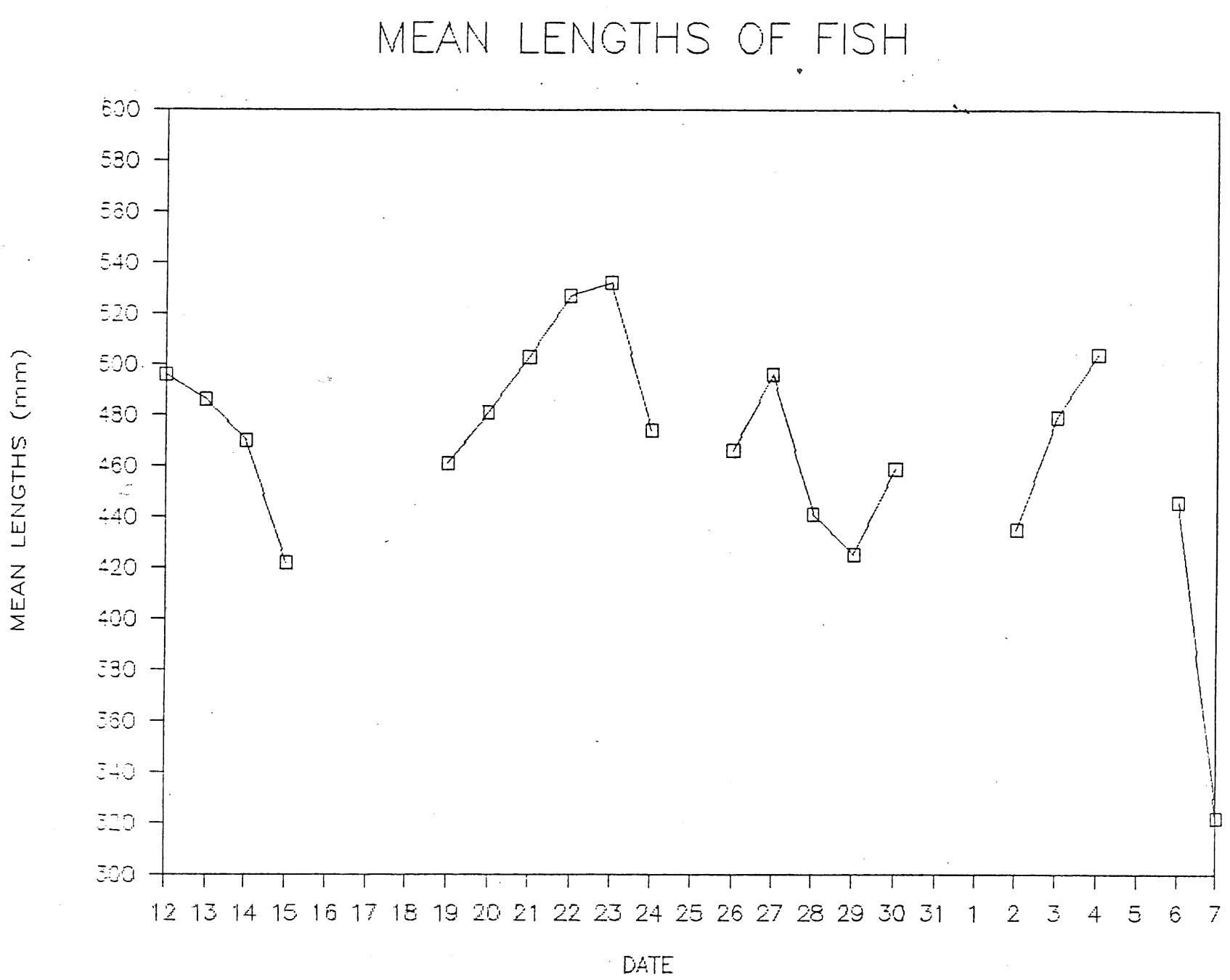
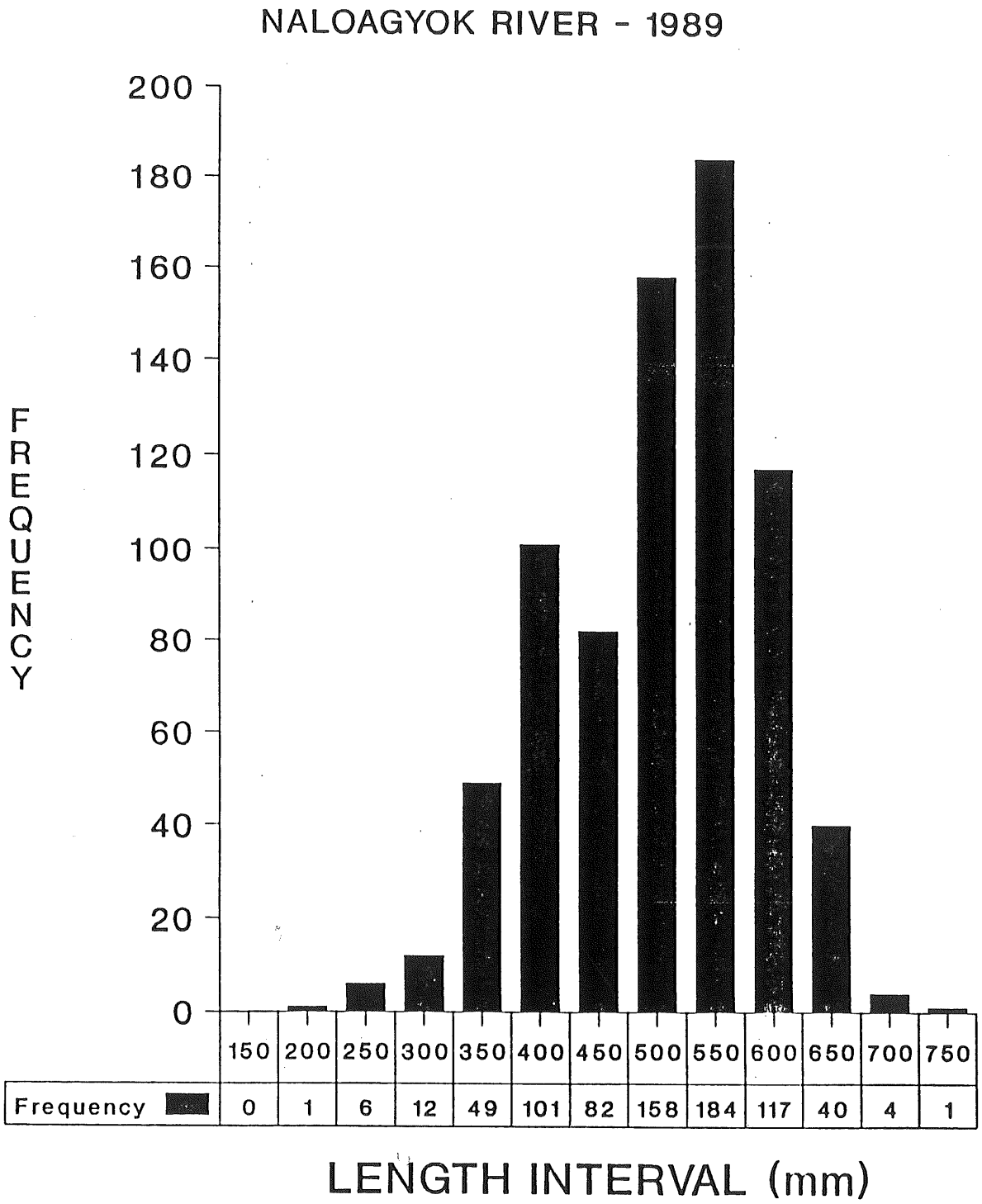


Figure 4. Mean fork lengths of Arctic charr migrating upsteam past the Naloagyok River weir between August 11 and September, 1989. Gaps in the line graph represent missing values.

Figure 5. Length-frequency distribution for Arctic charr migrating upstream past the Naloagyok River weir between August 11 and September 7, 1989.



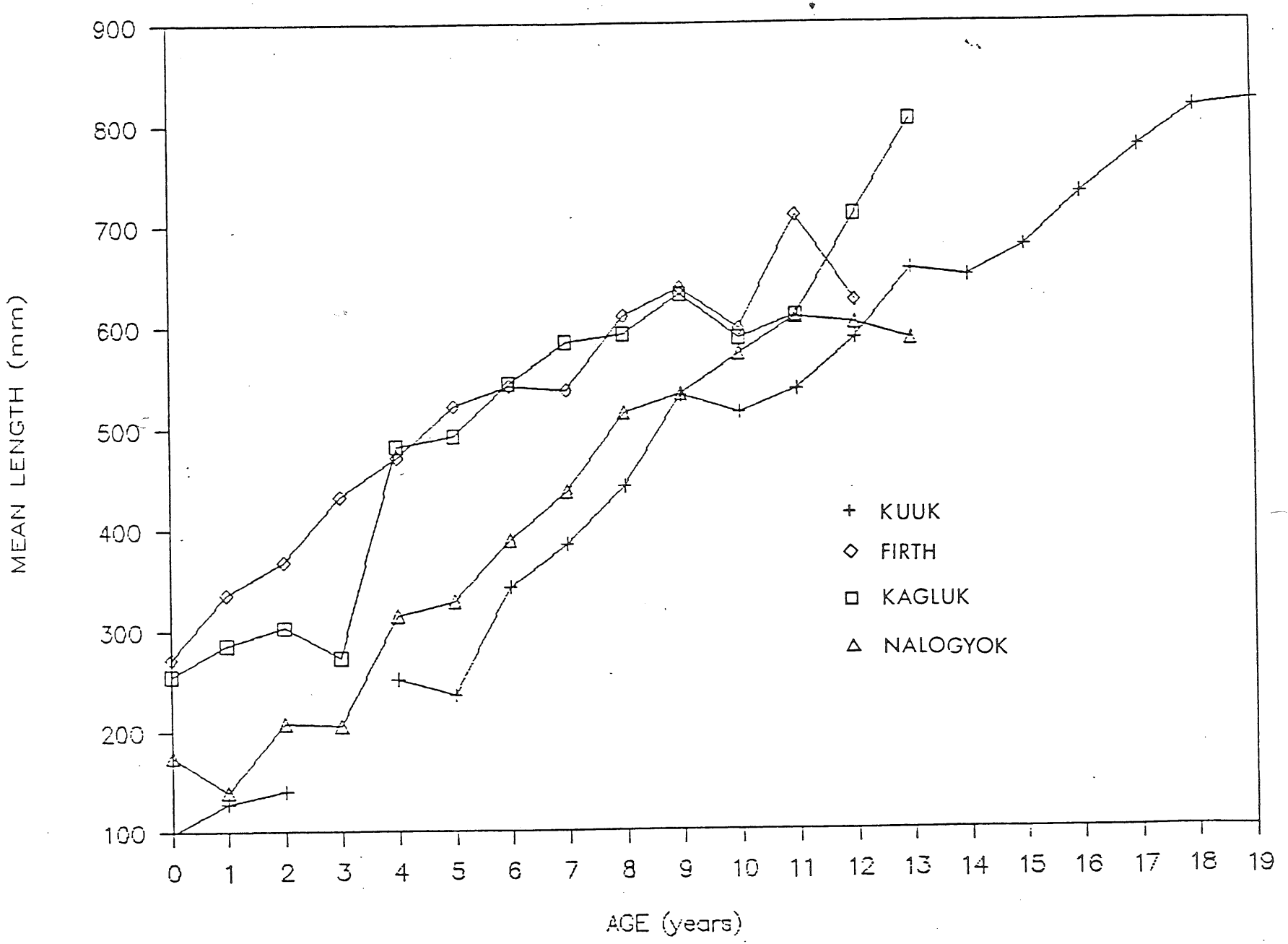


Figure 6. Age-length relationships for Arctic charr from the Kuuk (1987), Kagluk (1988) Firth (1980) and Naloagyok (1989) rivers.

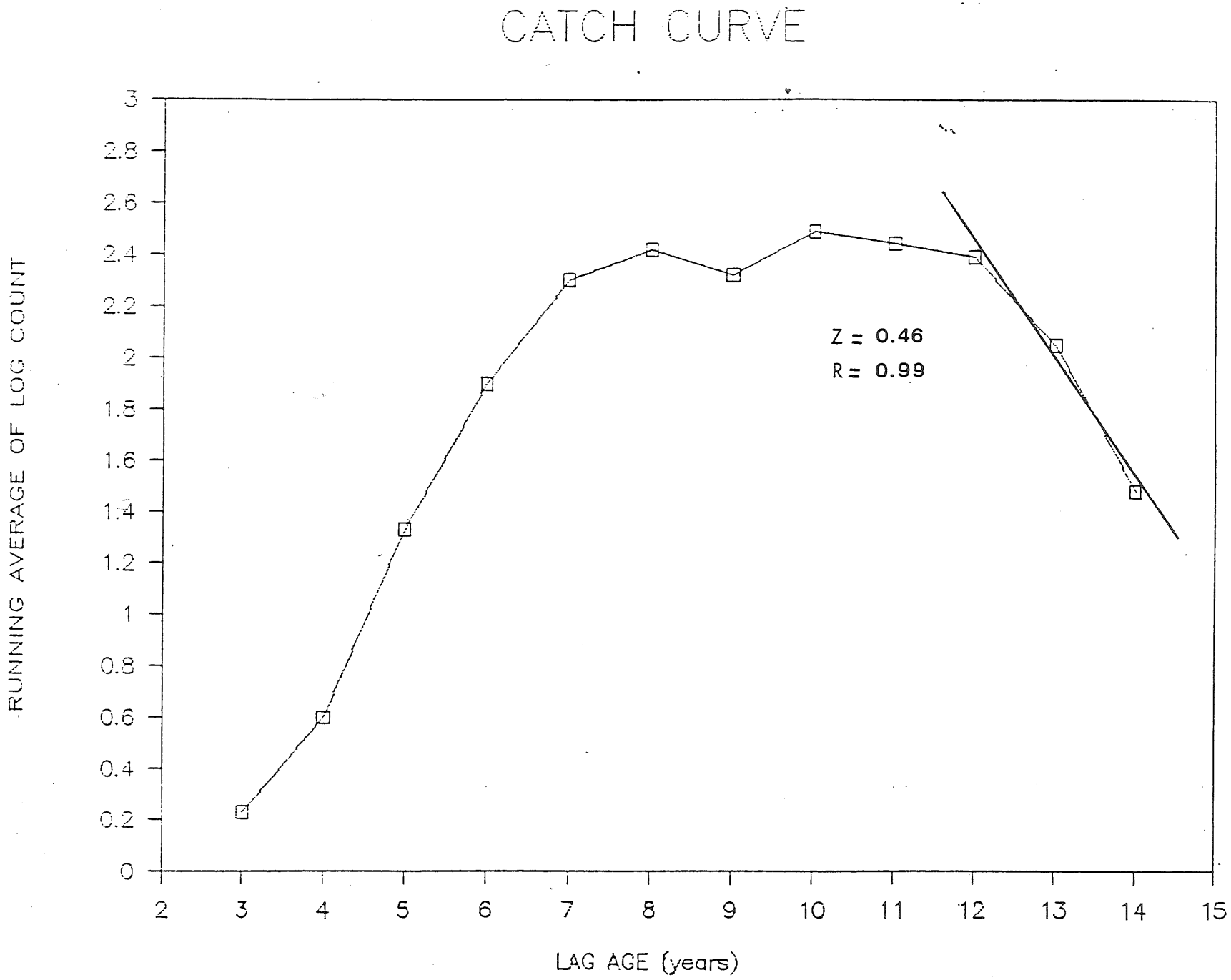


Figure 7. Catch curve for anadromous Arctic charr from the Naloagyok River using the regression of length on age. A least square linear regression over the range of 12 to 14 years was used to determine the instantaneous total mortality rate (Z).

Table 1 . Biological data by age group for Arctic charr caught by a weir from Naloagyok River (Prince Albert Sound)(Holman area), 12 August - 4 September 1989.

AGE (YR)	MALES N	MALES LENGTH(MM) MEAN	MALES LENGTH(MM) SD	MALES WEIGHT(G) MEAN	MALES WEIGHT(G) SD	MALES K	MALES % MAT	FEMALES N	FEMALES LENGTH(MM) MEAN	FEMALES LENGTH(MM) SD	FEMALES WEIGHT(G) MEAN	FEMALES WEIGHT(G) SD	FEMALES K	FEMALES % MAT	COMBINED N	COMBINED LENGTH(MM) MEAN	COMBINED LENGTH(MM) SD	COMBINED WEIGHT(G) MEAN	COMBINED WEIGHT(G) SD	COMBINED K	COMBINED % MAT
2	1	175	-	51	-	0.95	0	-	-	-	-	-	-	-	1	175	-	51	-	0.95	0
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	139	-	22	-	0.82	-
4	2	208	38	93	48	0.99	0	-	-	-	-	-	-	-	2	208	38	93	48	0.99	0
5	-	-	-	-	-	-	-	2	233	6	128	14	1.02	0	3	205	48	94	59	0.94	0
6	3	306	69	330	277	0.98	0	6	319	77	387	265	1.02	17	9	315	70	368	252	1.01	11
7	4	345	84	501	317	1.06	0	7	319	58	359	193	1.01	0	11	328	65	411	240	1.03	0
8	4	408	43	730	250	1.04	0	5	383	76	669	365	1.08	20	10	388	60	667	300	1.06	11
9	6	418	72	846	327	1.11	0	7	451	58	1041	411	1.07	57	13	436	65	951	373	1.09	31
10	3	464	86	1132	548	1.05	67	5	544	66	1848	730	1.11	60	8	514	80	1580	727	1.09	63
11	10	528	84	1864	806	1.16	50	7	540	47	1957	735	1.20	43	17	533	70	1903	755	1.18	47
12	7	582	45	2356	504	1.18	86	4	556	64	2143	887	1.20	75	11	573	51	2278	633	1.19	82
13	7	608	66	2689	1019	1.14	71	-	-	-	-	-	-	-	7	608	66	2689	1019	1.14	71
14	4	612	37	2544	415	1.11	100	2	581	14	2438	194	1.24	100	6	602	34	2508	337	1.15	100
15	-	-	-	-	-	-	-	2	586	76	1893	222	0.97	50	2	586	76	1893	222	0.97	50
TOTAL	51							47							101						
MEAN		480	135	1544	1058	1.10			441	123	1189	890	1.09			454	136	1338	1000	1.09	
MEAN AGE		10.1							9.2							9.5					

Table 2 . Biological data by length interval for Arctic charr caught by a weir from Naloagyok River (Prince Albert Sound) (Holman area), 12 August - 4 September 1989.

LENGTH INTERVAL (MM)	MALES N	MALES LENGTH(MM) MEAN	MALES WEIGHT(G) MEAN	MALES WEIGHT(G) SD	MALES K	MALES % MAT	FEMALES N	FEMALES LENGTH(MM) MEAN	FEMALES WEIGHT(G) MEAN	FEMALES WEIGHT(G) SD	FEMALES K	FEMALES % MAT	COMBINED N	COMBINED LENGTH(MM) MEAN	COMBINED WEIGHT(G) MEAN	COMBINED WEIGHT(G) SD	COMBINED K	COMBINED % MAT
100	-	-	-	-	-	-	-	-	-	-	-	-	1	139	22	-	0.82	0
150	2	178	55	6	0.97	0	-	-	-	-	-	-	3	169	46	17	0.92	0
200	2	236	130	4	0.99	0	4	230	121	17	0.99	0	6	232	124	14	0.99	0
250	3	273	212	72	1.02	0	4	274	208	36	1.01	0	7	273	210	49	1.01	0
300	4	339	378	42	0.97	0	6	329	372	90	1.03	0	11	333	376	68	1.01	0
350	2	375	575	106	1.08	50	2	381	550	36	1.00	0	4	378	562	66	1.04	25
400	8	421	817	111	1.09	0	6	421	798	97	1.07	50	14	421	809	101	1.08	21
450	4	477	1092	118	1.01	0	6	477	1253	204	1.15	17	10	477	1188	186	1.09	10
500	7	523	1669	240	1.16	43	11	518	1578	128	1.14	64	18	520	1613	179	1.15	56
550	10	576	2241	198	1.17	80	5	576	2249	281	1.18	80	15	576	2244	218	1.17	80
600	7	621	2836	319	1.18	100	6	634	2833	572	1.11	100	13	627	2835	433	1.15	100
650	2	660	3188	88	1.11	100	-	-	-	-	-	-	2	660	3188	88	1.11	100
700	1	706	4300	-	1.22	100	-	-	-	-	-	-	1	706	4300	-	1.22	100
TOTAL	52						50						105					
MEAN		477	1523	1059	1.10			450	1251	903	1.09			457	1354	998	1.09	

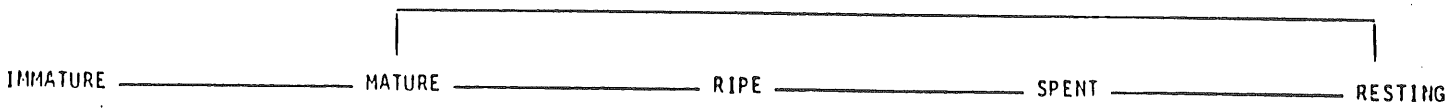
Table 3. Mean length (mm) at age (y) for various stocks of Arctic charr in the Northwest Territories.

Age (y)	Kagluk River 1988(a)	Kagluk River 1987(b)	Kagluk River 1985(c)	Kuuk River (b)	Nauyuk Lake (d)	Sylvia Grinnel River(e)	Diana River (f)	Jayco River (g)	Hayes River (h)	Firth River (i)	Naloagyok River 1985(c)	Naloagyok River 1989(j)
0												
1				98		14						
2				128		25						175
3				140	225	50	248			272		139
4					239	80	280			336		208
5	255			252	234	116	322			368		205
6	286			236	278	154	352			432		315
7	303			342	416	196	437			471	345	328
8	273			384	510	240	516			522	370	388
9	482			441	601	285	573			541	390	436
10	492		478	532	605	335	597		593	537	444	514
11	544	518	538	514	653	382	604		611	610	565	533
12	584	557	619	537	676	427	696	587	624	637	620	573
13	592	580	653	587	694	468	721	636	649	597	620	608
14	631	651	656	655	725	503		703	676	709	620	602
15	588	625	643	648	721	353		647	721	624	650	586
16	610	683	737	677	742	563		688	699		630	
17	710		770	729	736	586		709	723			
18	804			776	724	604		716	723			
19		745		814		623		698	690			
20				821		639		697				
21		843				653		758	830			
22						664		728				
23						675		748				
24						685		696				
25								778				
26								714				
27												
N	69	26	44	109	264	680	130	130	166	281	30	101

b = Stewart and Sparling (1987), c = Baker (1986), d = Johnson (1980), e = Grainger (1953), f = McGowan (1987), g = Kristofferson and Carder (1980), h = Stewart and Bernier unpublished data, i = McCart (1980), j = Lemieux (1989)

Appendix 1. A flow chart and code for the determination of the maturity stages of Arctic charr.

MATURITY FLOW CHART



FISH MATURITY CODE

Maturity State	Female		Male	
Immature (virgin)	1	- ovaries granular in texture - hard and triangular in shape - up to full length of body cavity - membrane full - eggs distinguishable	6	- testes long and thin - tubular and scalloped shape - up to full body length - putty-like firmness
Mature	2	- current year spawner - ovary fills body cavity - eggs near full size but not loose - not expelled by pressure	7	- current year spawner - testes large and lobate - white to purplish color - centers may be fluid - milt not expelled by pressure
Ripe	3	- ovaries greatly extended and fill body cavity - eggs full size and transparent - expelled by slight pressure	8	- testes full size - white and lobate - milt expelled by slight pressure
Spent	4	- spawning complete - ovaries ruptured and flaccid - developing oocytes visible - some retained eggs in body cavity	9	- spawning complete - testes flaccid with some milt - blood vessels obvious - testes violet-pink in color
Resting	5	- ovary 40-50% of body cavity - membrane thin, loose, and semi-transparent - healed from spawning - developing oocytes apparent with few atretic eggs - some eggs may be retained in body cavity	10	- testes tubular, less lobate - healed from spawning - no fluid in center - usually full length - mottled and purplish in color
Unknown (virgin)	0	- cannot be sexed - gonads long or short and thin - transparent or translucent		
Unknown (non-virgin)	11	- resting fish - has spawned but gonads regenerated - sexing not possible		

Appendix 2. Length data for anadromous Arctic charr that were tagged during August and September 1989, as they migrated up the Naloagyok River, Victoria Island, NWT. The tags used were blue Floy spaghetti tags numbered sequentially from FC71076 to FC71500.

TAG #	DATE	FORK LENGTH	COMMENTS
71076	13/08/89	466	
71077	13/08/89	526	
71078	13/08/89	447	
71079	13/08/89	destroyed	
71080	13/08/89	466	
71081	13/08/89	destroyed	
71082	13/08/89	491	
71083	13/08/89	406	
71084	13/08/89	438	
71085	13/08/89	444	
71086	13/08/89	destroyed	
71087	13/08/89	417	
71088	13/08/89	489	
71089	13/08/89	493	
71090	13/08/89	508	seal scar (healed)
71091	13/08/89	448	
71092	13/08/89	481	
71093	13/08/89	386	
71094	13/08/89	351	
71095	13/08/89	344	
71096	13/08/89	446	
71097	13/08/89	destroyed	
71098	13/08/89	destroyed	
71099	13/08/89	577	
71100	13/08/89	541	
71101	15/08/89	459	net marks
71102	15/08/89	469	net marks
71103	15/08/89	390	
71104	15/08/89	387	
71105	15/08/89	555	
71106	15/08/89	462	net marks
71107	15/08/89	455	
71108	15/08/89	destroyed	
71109	15/08/89	397	
71110	15/08/89	destroyed	
71111	15/08/89	429	
71112	15/08/89	445	
71113	15/08/89	469	
71114	15/08/89	454	
71115	15/08/89	445	
71116	15/08/89	476	
71117	15/08/89	390	net marks
71118	15/08/89	490	
71119	15/08/89	373	

TAG #	DATE	FORK LENGTH	COMMENTS
71120	15/08/89	366	
71121	21/08/89	destroyed	
71122	21/08/89	472	
71123	21/08/89	535	
71124	21/08/89	510	
71125	21/08/89	531	
71126	21/08/89	541	
71127	21/08/89	532	
71128	21/08/89	566	
71129	21/08/89	523	
71130	21/08/89	517	
71131	21/08/89	475	
71132	21/08/89	591	
71133	21/08/89	463	net marks
71134	21/08/89	557	
71135	21/08/89	505	seal scars
71136	21/08/89	destroyed	
71137	21/08/89	485	
71138	21/08/89	482	net marks
71139	21/08/89	521	
71140	21/08/89	495	
71141	21/08/89	474	
71142	21/08/89	565	
71143	21/08/89	400	
71144	21/08/89	444	
71145	21/08/89	510	
71146	21/08/89	355	
71147	21/08/89	546	
71148	21/08/89	521	
71149	21/08/89	631	
71150	21/08/89	572	
71151	24/08/89	527	
71152	24/08/89	537	
71153	24/08/89	475	
71154	24/08/89	576	
71155	24/08/89	566	
71156	24/08/89	548	
71157	24/08/89	546	
71158	24/08/89	541	
71159	24/08/89	438	
71160	24/08/89	499	
71161	24/08/89	482	
71162	24/08/89	402	
71163	24/08/89	515	
71164	24/08/89	407	
71165	24/08/89	destroyed	
71166	24/08/89	502	
71167	24/08/89	467	
71168	24/08/89	507	

TAG #	DATE	FORK LENGTH	COMMENTS
71169	24/08/89	522	
71170	24/08/89	422	
71171	24/08/89	407	
71172	24/08/89	469	
71173	24/08/89	452	
71174	24/08/89	422	
71175	24/08/89	502	
71176	25/08/89	510	net marks
71177	25/08/89	410	net marks
71178	25/08/89	530	net marks
71179	25/08/89	520	
71180	25/08/89	destroyed	
71181	25/08/89	531	
71182	25/08/89	470	
71183	25/08/89	destroyed	
71184	25/08/89	390	
71185	25/08/89	495	
71186	25/08/89	400	
71187	25/08/89	505	
71188	25/08/89	490	
71189	25/08/89	345	
71190	25/08/89	510	
71191	25/08/89	520	
71192	25/08/89	400	
71193	25/08/89	390	
71194	25/08/89	525	
71195	25/08/89	460	
71196	25/08/89	435	
71197	25/08/89	530	
71198	25/08/89	495	
71199	25/08/89	435	
71200	25/08/89	545	
71201	25/08/89	515	
71202	25/08/89	520	
71203	25/08/89	430	
71204	25/08/89	365	
71205	25/08/89	475	
71206	25/08/89	505	
71207	25/08/89	485	
71208	25/08/89	405	
71209	25/08/89	525	
71210	25/08/89	495	
71211	25/08/89	540	
71212	25/08/89	510	
71213	25/08/89	490	
71214	25/08/89	455	
71215	25/08/89	335	
71216	25/08/89	540	
71217	25/08/89	465	

TAG #	DATE	FORK LENGTH	COMMENTS
71218	25/08/89	520	
71219	25/08/89	550	
71220	25/08/89	500	
71221	25/08/89	destroyed	
71222	25/08/89	480	
71223	25/08/89	335	
71224	25/08/89	545	
71225	25/08/89	600	
71226	25/08/89	585	
71227	25/08/89	486	
71228	25/08/89	544	net marks
71229	25/08/89	485	
71230	25/08/89	495	
71231	25/08/89	530	
71232	25/08/89	525	
71233	25/08/89	614	
71234	25/08/89	525	
71235	25/08/89	596	
71236	25/08/89	553	
71237	25/08/89	445	
71238	25/08/89	558	
71239	25/08/89	605	
71240	25/08/89	537	
71241	26/08/89	596	
71242	26/08/89	504	
71243	26/08/89	518	
71244	26/08/89	493	
71245	26/08/89	617	
71246	26/08/89	600	
71247	26/08/89	563	
71248	26/08/89	535	
71249	26/08/89	470	
71250	26/08/89	646	
71251	26/08/89	670	
71252	26/08/89	482	
71253	26/08/89	544	net marks
71254	26/08/89	658	
71255	26/08/89	579	
71256	26/08/89	612	
71257	26/08/89	550	
71258	26/08/89	590	
71259	26/08/89	598	
71260	26/08/89	599	
71261	26/08/89	665	
71262	26/08/89	603	
71263	26/08/89	489	
71264	26/08/89	509	
71265	26/08/89	493	
71266	26/08/89	520	

TAG #	DATE	FORK LENGTH	COMMENTS
71267	26/08/89	528	
71268	26/08/89	682	damaged dorsal fin
71269	26/08/89	535	
71270	26/08/89	611	
71271	26/08/89	558	
71272	26/08/89	452	
71273	26/08/89	555	
71274	26/08/89	520	
71275	26/08/89	492	
71276	26/08/89	550	
71277	26/08/89	675	
71278	26/08/89	575	
71279	26/08/89	555	
71280	26/08/89	547	
71281	26/08/89	519	net marks
71282	26/08/89	540	
71283	26/08/89	533	
71284	26/08/89	505	
71285	26/08/89	455	
71286	26/08/89	549	
71287	26/08/89	470	
71288	26/08/89	519	
71289	26/08/89	462	
71290	26/08/89	492	net marks
71291	26/08/89	430	
71292	26/08/89	destroyed	
71293	26/08/89	521	
71294	26/08/89	387	
71295	26/08/89	377	
71296	26/08/89	547	
71297	27/08/89	589	
71298	27/08/89	545	
71299	27/08/89	400	
71300	27/08/89	521	net marks
71301	27/08/89	422	
71302	27/08/89	562	
71303	27/08/89	422	
71304	27/08/89	461	
71305	27/08/89	620	
71306	27/08/89	477	net marks
71307	27/08/89	380	
71308	27/08/89	393	
71309	27/08/89	315	
71310	27/08/89	496	
71311	27/08/89	520	
71312	27/08/89	431	
71313	27/08/89	405	
71314	27/08/89	destroyed	
71315	27/08/89	520	

TAG #	DATE	FORK LENGTH	COMMENTS
71316	27/08/89	410	
71317	27/08/89	540	
71318	27/08/89	490	
71319	27/08/89	439	
71320	27/08/89	480	
71321	27/08/89	560	
71322	27/08/89	480	seal scar
71323	27/08/89	560	
71324	27/08/89	560	
71325	27/08/89	539	
71326	27/08/89	435	
71327	27/08/89	destroyed	
71328	27/08/89	380	
71329	27/08/89	590	
71330	27/08/89	430	
71331	27/08/89	565	
71332	27/08/89	470	
71333	27/08/89	535	net mark
71334	27/08/89	410	
71335	27/08/89	590	
71336	27/08/89	390	
71337	27/08/89	525	net mark
71338	27/08/89	345	
71339	27/08/89	485	
71340	27/08/89	600	
71341	27/08/89	530	net mark
71342	27/08/89	525	
71343	27/08/89	370	net mark
71344	27/08/89	660	
71345	27/08/89	540	
71346	27/08/89	515	
71347	27/08/89	360	
71348	27/08/89	520	
71349	27/08/89	500	
71350	27/08/89	530	
71351	28/08/89	545	
71352	28/08/89	462	
71353	28/08/89	495	
71354	28/08/89	505	
71355	28/08/89	525	
71356	28/08/89	365	
71357	28/08/89	402	
71358	28/08/89	530	
71359	28/08/89	450	
71360	28/08/89	505	
71361	28/08/89	560	
71362	28/08/89	370	
71363	28/08/89	340	
71364	28/08/89	500	

TAG #	DATE	FORK LENGTH	COMMENTS
71365	28/08/89	535	
71366	28/08/89	580	
71367	28/08/89	480	
71368	28/08/89	430	
71369	28/08/89	490	
71370	28/08/89	430	
71371	28/08/89	430	
71372	28/08/89	520	
71373	28/08/89	370	
71374	28/08/89	380	
71375	28/08/89	395	
71376	28/08/89	destroyed	
71377	28/08/89	522	
71378	28/08/89	602	
71379	28/08/89	598	
71380	28/08/89	522	
71381	28/08/89	533	
71382	28/08/89	445	
71383	28/08/89	387	
71384	28/08/89	485	
71385	28/08/89	498	
71386	28/08/89	500	
71387	28/08/89	487	
71388	28/08/89	458	
71389	28/08/89	563	
71390	28/08/89	555	
71391	28/08/89	559	
71392	28/08/89	462	
71393	28/08/89	556	
71394	28/08/89	554	
71395	28/08/89	destroyed	
71396	29/08/89	550	
71397	29/08/89	555	
71398	29/08/89	755	
71399	29/08/89	470	
71400	29/08/89	485	
71401	29/08/89	530	
71402	29/08/89	385	net mark
71403	29/08/89	470	
71404	29/08/89	520	
71405	29/08/89	530	
71406	29/08/89	470	
71407	29/08/89	431	
71408	29/08/89	409	net mark
71409	29/08/89	487	
71410	29/08/89	452	seal scar
71411	29/08/89	488	
71412	29/08/89	485	
71413	29/08/89	521	

TAG #	DATE	FORK LENGTH	COMMENTS
71414	29/08/89	528	
71415	29/08/89	530	
71416	29/08/89	525	seal scar
71417	29/08/89	520	seal scar
71418	29/08/89	472	
71419	29/08/89	520	
71420	29/08/89	541	
71421	29/08/89	525	net mark
71422	29/08/89	565	
71423	29/08/89	510	
71424	29/08/89	535	
71425	29/08/89	560	
71426	29/08/89	470	
71427	29/08/89	515	
71428	29/08/89	596	
71429	29/08/89	485	
71430	29/08/89	542	
71431	29/08/89	529	
71432	29/08/89	685	
71433	29/08/89	701	net mark
71434	29/08/89	512	net mark
71435	29/08/89	575	
71436	29/08/89	540	net mark
71437	29/08/89	615	
71438	29/08/89	495	
71439	29/08/89	625	
71440	29/08/89	525	
71441	29/08/89	650	net mark
71442	29/08/89	479	
71443	29/08/89	572	net mark
71444	29/08/89	525	
71445	29/08/89	512	net mark
71446	29/08/89	547	
71447	29/08/89	562	net mark
71448	29/08/89	555	
71449	29/08/89	609	
71450	29/08/89	575	seal scar
71451	30/08/89	516	
71452	30/08/89	543	
71453	30/08/89	483	
71454	30/08/89	573	
71455	30/08/89	489	net mark
71456	30/08/89	341	
71457	30/08/89	336	
71458	30/08/89	536	net mark
71459	30/08/89	708	
71460	30/08/89	520	
71461	30/08/89	373	
71462	30/08/89	531	

TAG #	DATE	FORK LENGTH	COMMENTS
71463	30/08/89	561	
71464	30/08/89	421	
71465	30/08/89	576	
71466	30/08/89	583	
71467	30/08/89	585	net mark
71468	30/08/89	525	
71469	30/08/89	558	
71470	30/08/89	456	
71471	30/08/89	371	
71472	30/08/89	561	net mark
71473	30/08/89	371	
71474	30/08/89	602	
71475	30/08/89	531	net mark
71476	01/09/89	549	
71477	01/09/89	542	
71478	01/09/89	575	
71479	01/09/89	535	
71480	01/09/89	476	
71481	01/09/89	515	
71482	01/09/89	482	
71483	01/09/89	535	
71484	01/09/89	522	
71485	01/09/89	528	
71486	01/09/89	525	
71487	01/09/89	512	
71488	01/09/89	582	
71489	01/09/89	511	
71490	01/09/89	450	
71491	01/09/89	505	
71492	01/09/89	452	
71493	01/09/89	514	net mark
71494	01/09/89	532	
71495	01/09/89	520	net mark
71496	01/09/89	560	
71497	01/09/89	521	
71498	01/09/89	409	
71499	01/09/89	604	
71500	01/09/89	511	