DRAFT

STATUS OF THE RAT RIVER CHARR POPULATION

1989

DRAFT REPORT

by

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SUMMARY

In response to concerns about the status of the Rat River arctic charr population, DFO with support from FJMC conducted a study in 1989 to obtain 1) estimates of the total abundance of the anadromous population (size of the upstream run) and 2) biological data to determine the population's current status.

Two different mark-recapture estimation techniques were used: a Schaefer estimate for the upstream run, and a Petersen estimate on the spawning grounds. Charr migrating upstream were live-captured in hoop nets, tagged and measured. The domestic harvest of native fishermen provided tag recaptures for the Schaefer estimate and fish for biological (dead) sampling. Charr on the spawning grounds were censused using a backpack electrofisher and a seine, and released after finclipping. Tag recaptures here were used for the Petersen estimate.

Between 2 August and 12 September, 1112 charr were caught in the hoop nets and live-sampled. Of these, 972 were tagged, and 133 tags were recaptured during the period of study. The run peaked about 5 September, but the latter portion was not well assessed because of flood problems. Charr were still being caught by the local fishermen when they pulled their last nets on 22 September.

During the Petersen census at the "fish holes" between 4 - 6 October, 690 charr were caught, including 50 tag recaptures.

The population estimates are in close agreement with one another, indicating that some confidence in the results is justified. The Schaefer estimate for the truncated run (2 August - 7 September) was 8 928. The "adjusted" estimate of the population which migrated past Destruction City, based on extrapolation to the end of the run, was about 10 000. The Petersen technique yielded an estimate of 11 191 with 95% confidence limits at 8532 and 15 020. Separate estimates of spawners and "silvers" gave a total population estimate of 2184 + 8736 = 10 920.

While the population size estimates are a little larger than was expected, analysis of the population structure, based on biological data, indicates heavy fishing pressure. Biological sample data, from 504 charr obtained mainly from the domestic gillnet catch, identified mean and modal length in the range 400-450 mm, corresponding to mean and modal age of about 7 years. Data from 1112 charr live-captured in the (non-selective) hoop nets, disclosed an overwhelming relative abundance (>50% of total catch) of charr in the range 300-350 mm, corresponding to the 4 year age class.

Approximately 25% of the population spawn in a given year. After reaching maturity at age 6 or 7, these charr spawn only every second or third year. Mortality rate is very high for age 7 and older fish, and individuals older than 8 years are not abundant.

STATUS OF THE RAT RIVER ARCTIC CHARR POPULATION - 1989

INTRODUCTION

The Rat River flows out of the Richardson Mountains into the southwest corner of the MacKenzie River Delta, Northwest Territories (Fig. 1). It is one of two major drainage systems in the MacKenzie Delta that support populations of anadromous arctic charr (Salvelinus alpinus). Charr from these populations descend the rivers in the spring and spend the summer feeding in nearshore areas along the Beaufort Sea coast, west of the Delta. They return upstream in August and September to spawning and overwintering grounds in the mountain tributaries.

Arctic charr have been traditionally harvested in the western Delta area by native residents of Aklavik and Fort McPherson. Annual fishing starts with the early movements of charr past Shingle Point on the Yukon north coast (Fig. 1). The precise distributions and degree of segregation of different stocks in this area are not known, but it is assumed that some of the fish taken here are from the Rat River stock. Aklavik residents also harvest from the Rat River stock as the fish migrate past the townsite and into the mouth of the Husky Channel. Fishermen from Fort McPherson take charr at Big Eddy, at the mouth of the Rat River, and at "Destruction City". In the past, large numbers of charr have also been taken from the "fish holes" or overwintering areas on Fish Creek.

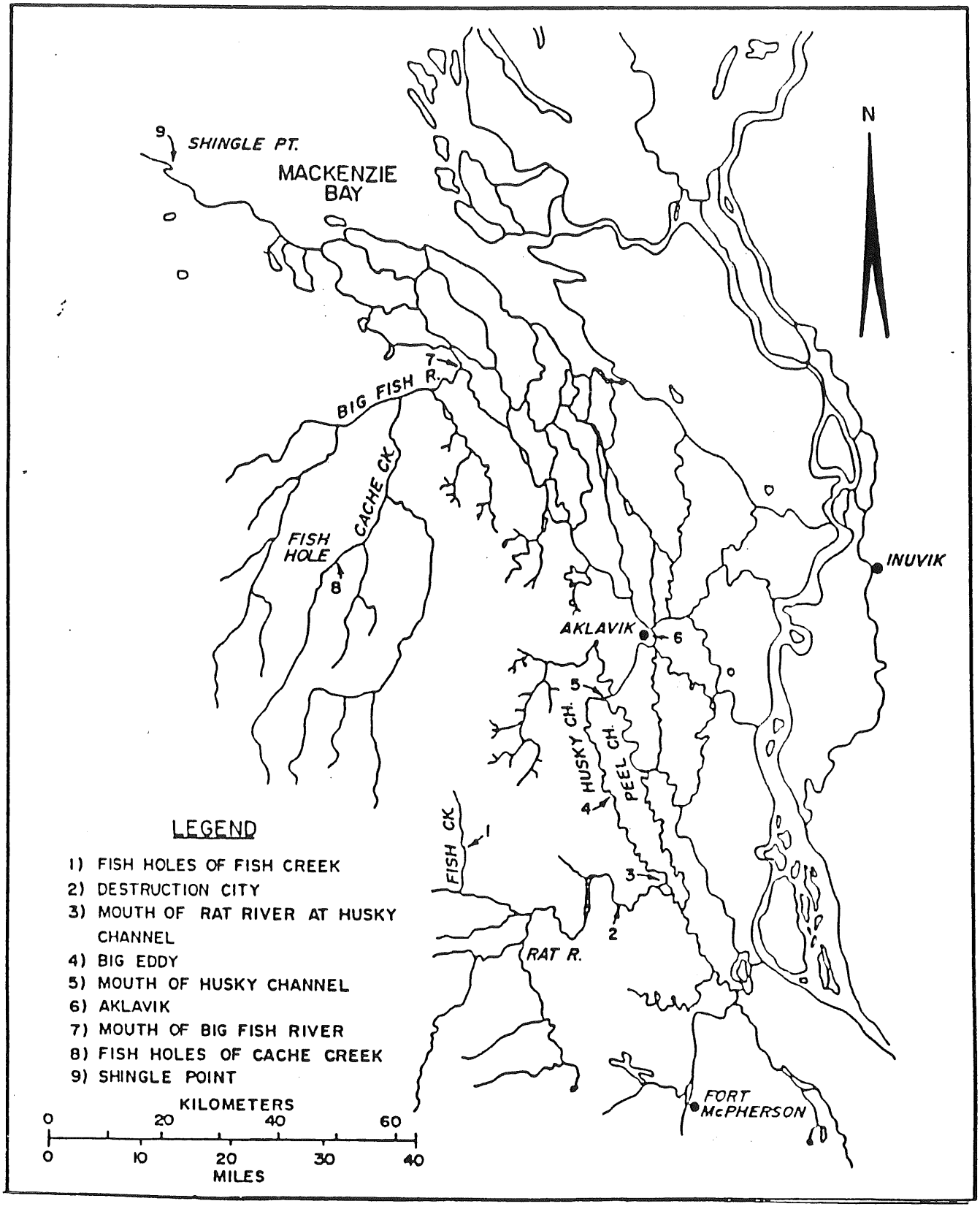

Figure 1. Map of the Mackenzie Delta showing the Rat River and Fish Creek. (from Gillman and Sparling 1985).

A survey of Delta fisheries in 1972 estimated a harvest of 6500 charr from the Rat River population (Jessop et al. 1973). A large portion of this catch likely came from the spawning and overwintering grounds, since anecdotal accounts from area fishermen refer to harvests of 1000 fish in a day from the "fish holes" in the early 1970's. Harvest estimates from 1973 and 1975 were 2600 and 2100 charr, respectively (Low, 1973, unpublished data). It is not known whether fish were harvested at the fish holes in these years.

In the late 1970's and early 1980's, area fishermen complained that the charr fishing was poor. In response to this concern, attempts were made by the Department of Fisheries and Oceans (DFO) in 1983 and 1985 to obtain population counts of the stock and assess its ability to sustain contemporary harvest levels (Gillman and Sparling 1985). These attempts were only partially successful due to flash flooding of the river before the count was completed.

Annual harvest estimates from 1983 to 1985 dropped from 500 to 400 to 200 charr (Clarke et. al., 1989). These numbers are not standardized to reflect possible differences in fishing effort, but apparently the catch per unit effort, as well as total harvest and overall size of the fish, had decreased. A focussed harvest study in 1986 estimated a total of 1000 charr were taken from the Rat River population. Biological data obtained from the 1986 harvest samples indicated heavy overexploitation of the stock (Clarke, et al. 1989).

A concurrent assessment of the Big Fish River, the only other major drainage system in the MacKenzie Delta inhabited by arctic charr, showed that the stock there was severely depleted from over-exploitation (Clarke et al. 1989). The Fisheries Joint Management Committee (FJMC), in conjunction with DFO, decided to close the Big Fish River charr fishery in 1987. It was recognized that this closure could result in an increase of fishing pressure by Aklavik residents on the Rat River stock.

In 1987, the Arctic Fisheries Scientific Advisory Committee (AFSAC) of DFO recommended that another attempt be made to estimate the abundance of the Rat River charr stock and determine its status, in order to plan a recovery strategy. DFO, with cooperation from the Fort McPherson Hunters and Trappers Associations (HTAs) and the Fisheries Joint Management Committee (FJMC), proposed another assessment project for 1989. The primary objectives of this study were (1) to estimate the total abundance of anadromous charr in the Rat River by applying two different mark-recapture estimation techniques during the upstream migration and on the spawning grounds, (2) to determine the biological characteristics (size and age composition, mortality rates, etc.) of the population to evaluate its current status.

STUDY AREA

The Rat River flows eastward approximately 93 km from its source in the Richardson Mountains to its outlet at the Husky Channel on the southwest side of the MacKenzie Delta (67°46'N, 135°06'W), draining an area approximately 1680 km^2. The river can be divided into three distinct segments, determined by topography, as described by Gillman and Sparling (1985): (1) In the mountainous upper region, the water is clear and swift-flowing over gravel and rough cobble substrates. The headwater tributaries course in single or braided channels through rugged, boulder-strewn valleys between rocky mountain peaks. Only one tributary, Fish Creek, is known to be used by arctic charr for spawning and overwintering; its shallow, gravelly riffles provide good spawning substrate, and the deeper "holes" are spring-fed, thus inhibiting complete freeze-up and providing winter refugia. (2) The middle segment of the river passes through a "foothills" region characterized by rolling upland tundra cut by the wide river valley. In this region the mainstem varies from a single channel confined within steep banks to a complex, braided network flowing over a wide gravel floodplain. (3) The lowland segment of the river meanders in a single, low-gradient channel through the spruce muskeg typical of the MacKenzie Delta. Here, the banks and substrate are mud, silt and sand, and the water is turbid, clearing only when the mountains are frozen and the water level drops (September).

The location of the camp and gillnet sites for this study was at "Destruction City" (Fig. 2), a traditional charr fishing site about 1 km below the first set of rapids marking the boundary between the lowland and foothills. The "tagging site" was located approximately 2 km downstream from Destruction City, about 1 km below any of the gillnets of the domestic fishermen.

Typical of relatively short mountainous rivers, flow rates and water levels are highly variable, responding quickly to increases in runoff within the drainage basin. Flash flood events occurred four times, with increasing amplitude, during the course of the project (Fig. 3). Current velocities measured during normal flow conditions ranged from approximately 0.4 ms^{-1} at the tagging site and camp to 0.8 ms^{-1} just below the rapids. Depth profiles for the channel at the camp, below the rapids, and at the tagging site are given in Appendix 1.

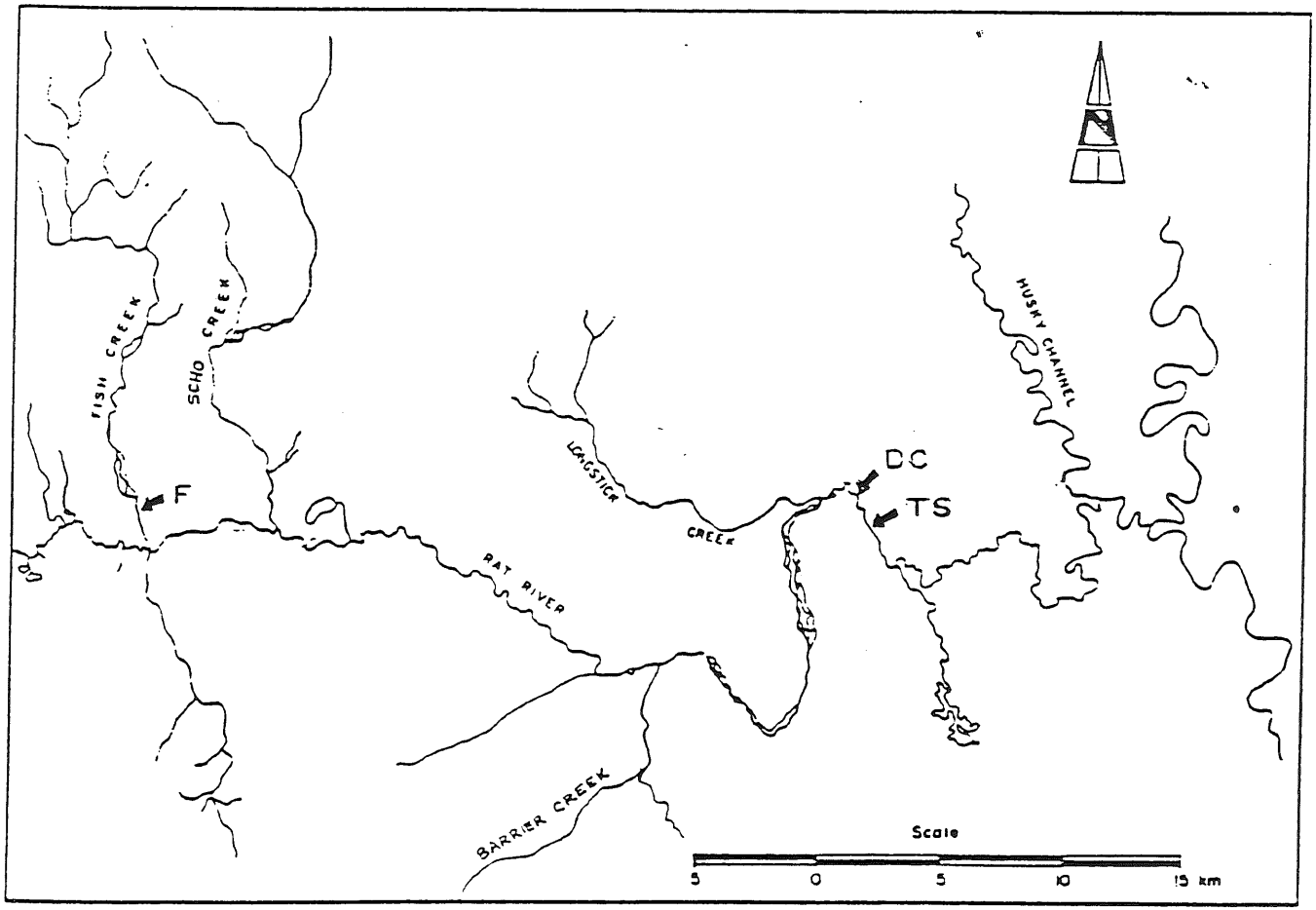

FIGURE 2. The Rat River and its main tributaries, showing location of Destruction City (DC), the tagging site (TS) and the fish holes on Fish Creek (F).

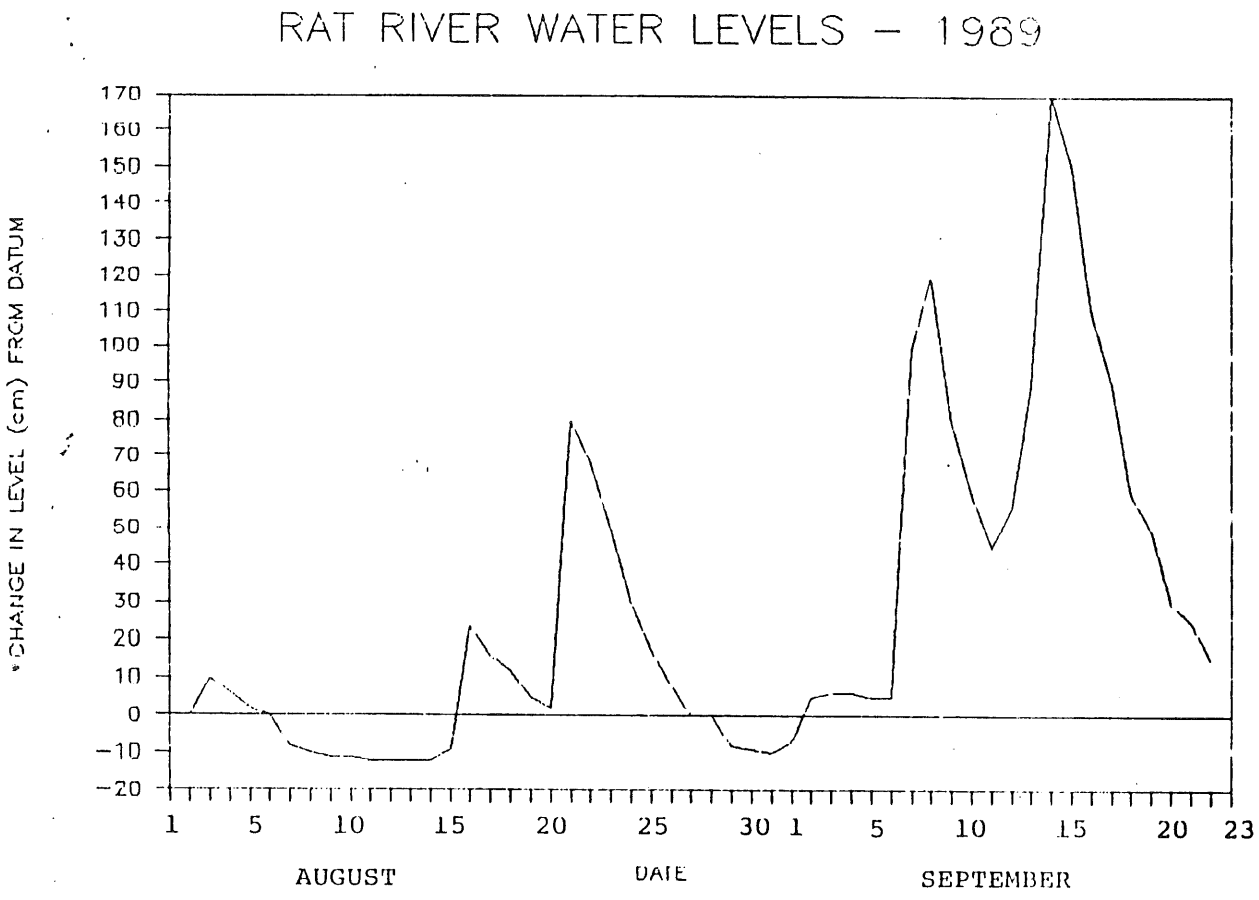

FIGURE 3. Changes in water levels at Destruction City over the study period.

METHODS

POPULATION ESTIMATES

Past attempts to obtain total population counts using a standard full-span weir have proven unsuccessful on the Rat River. An alternative to a direct count of the total population is an estimate, based on marking a portion of the population and extrapolating from the subsequent recapture of marked individuals. Two different mark-recapture estimation techniques were used in this study: the Schaefer method for stratified populations and the adjusted Petersen method for a single census (Ricker 1975). The Schaefer method was applied to fish captured at Destruction City during the upstream migration; the Petersen estimate was used subsequently at the fish holes on Fish Creek.

Schaefer estimate

The Schaefer method is designed specifically for populations that are stratified with respect to time. A migrating population of arctic charr in a river is a perfect example of such a stratified population. Since individuals do not all begin the migration simultaneously, the population can, in effect, be considered as a series of partially discrete units, each passing a certain point along the migration route at a different time. The Schaefer method takes advantage of this by assessing the numbers of marked and recaptured fish in separate time periods.

Capture

Hoop nets were used to capture fish for marking. They are a prefered gear for this use primarily because they are non-selective. Furthermore, after the initial installation, they are relatively easy to operate and can be removed relatively quickly in case of sudden flooding. Two basic types were used: a "3-1/2 -foot" (3.5' diameter), with round hoops and a double funnel; and two "4-foot" (4' diagonal) square hoop nets, with only a single funnel. Both types had 1" (2.5 cm) mesh and wings approximately 15-20 m long. The "3.5" was prefered on the basis of catch size, depth of water required, sturdiness of construction and ease of handling.

The capture location ("tagging site") was a relatively even-bottomed, shallow, straight reach about 2 km below Destruction City. Two net sites were established on opposite sides of the river, slightly staggered, which effectively spanned the whole width of the river (Fig. 4). Another site was set up about 400m below this, in a shallower location that would permit the net to be worked during periods of higher water levels. Under normal conditions, water depth at the lower net was about 0.9 m and about 1.1 - 1.5 m at the upper two nets.

Table 1 indicates the number, type and location of hoop nets set each day during the charr run. (The first nets were set on 23 July, but did not start catching charr until 2 August.) The hoop nets could not be fished during the two high water periods between 21-24 August and 7-11 September, nor after 12 September

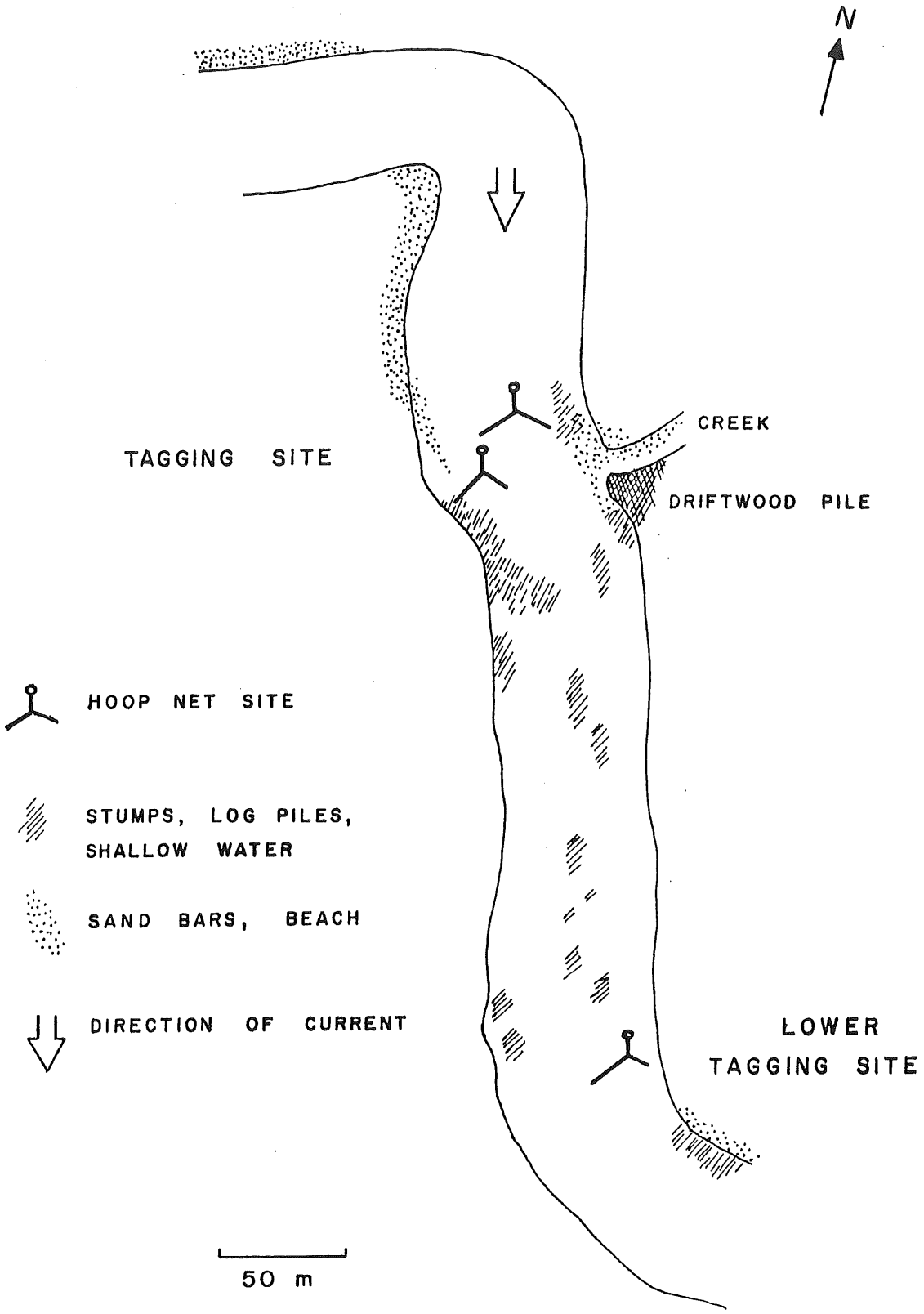

FIGURE 4. Location of hoop nets at the tagging site.

TABLE 1. Dates and locations fished with each hoop net. Location codes: TS = tagging site; LTS = lower tagging site; ADC = above Destruction City; OUT = removed from water. A fractional number preceding location code indicates approximate portion of that day fished at that location. Arrows indicate net was moved.

DATE	3.5'	4'A	4'B	DATE	3.5'	4'A	4'B
AUG 2	TS	-	-	AUG 25	LTS	-	-
3	TS	.5TS	-	26	LTS	.7TS	-
4	TS	TS	-	27	LTS	TS	.3TS
5	TS	TS	-	28	LTS	TS	TS
6	TS	TS	.3ADC	29	LTS	TS	TS
7	TS	TS	ADC	30	LTS	TS	TS
8	TS	TS	ADC	31	LTS	TS	.7TS>.3ADC
9	TS	TS	ADC				
10	TS	TS	ADC	SEPT 1	LTS	TS	ADC
11	TS	TS	ADC	2	LTS	.7TS>OUT	ADC
12	TS	TS	ADC	3	LTS	-	ADC
13	TS	TS	ADC	4	LTS	-	ADC
14	TS	TS	ADC	5	LTS	-	ADC
15	TS	TS	ADC	6	LTS	-	ADC
16	TS	TS	.7ADC>OUT	7	.7LTS>OUT	.3TS>OUT	.7ADC>OUT
17	.7TS	TS	-	8	-	-	-
18	.3LTS	TS	-	9	-	-	-
19	LTS	TS	-	10	-	-	-
20	LTS	TS	-	11	.5LTS	-	-
21	.7LTS>OUT	.3TS>OUT	-	12	.7LTS>OUT	-	-
22	-	-	-		** END OF FISHING **		
23	-	-	-				
24	-	-	-				

when the water level suddenly rose again. Freeze-up began before the level dropped sufficiently to permit resumption of netting.

Tagging

Arctic charr were marked with orange plastic Floy ("spaghetti") tags numbered in the FJMC 70 000 - 71 000 series. Tags were inserted with a Dennison tagging gun between the basal pterygiophores below the posterior half of the dorsal fin. Tags and tagging gun/needle were sterilized in a strong (approx. 20%) Dettol solution between tagging each fish, to prevent the spread of infectious pancreatic necrosis virus. Initially, tagged fish were measured for fork length and weighed, but weighing was discontinued after about 350 samples because it was too time-consuming and caused greater stress for the unanaesthetized animals. Tagged fish which did not immediately dart away when returned to the water were held until completely recovered.

Only 87% of the charr captured in the hoop nets were tagged. Some individuals less than 300 mm were released untagged, since they were unlikely to be recaptured in the gillnets. Tagging was limited to 50-60 fish per day from 3 September until the nets were pulled on 7 September. Untagged fish were measured for fork length and released.

Recapture

The recovery of marked fish was accomplished with the gillnet catch of the two local fishermen at Destruction City. These men fished continuously from 8 August to 22 September with 3.5" and 4.5" gillnets. The number of nets fishing on a given

day varied from 2 or 3 at the beginning and end of the season, to 11 at about the peak of the run.

At the beginning of the season and during the peak period, one of the 4' hoop nets was set just below the rapids above Destruction City, to provide additional recaptures. This proved to be of little value, since the net caught very few charr. Sufficient recaptures were obtained, however, from the domestic harvest.

Although the gillnets are size selective, the accuracy of the Schaefer method is not compromised as long as either the capture or the recapture gear is non-selective. An additional criterion that must be met is that the tagged fish be randomly distributed within the group or stratum from which they are recaptured. The tagging site was at least 1 km downstream from the first recapture net, and almost 2 km from the majority of the nets. This was presumed to be far enough away to allow for random remixing of the tagged fish with the rest of the concurrent migrants.

Calculation

To calculate the Schaefer estimate, both the marking and recovery of fish must be divided into appropriate time intervals. In this case, the data divide out more naturally into 6-day periods rather than an arbitrary 7-day week. The mark and recapture information for each time period is then set up in a table of double entry and estimates calculated for each cell,

based on the example published by Schaefer (1951) and presented by Ricker (1975). The total population is calculated from the equation:

$$N = \left(R_{ij} \quad \frac{M_i}{R_i} \quad \frac{C_j}{R_j}\right)$$

where: N = total population

R_{ij} = number of fish marked in the ith marking period which are recovered in the jth recovery period

M_i = number of fish marked in the ith marking period

R_i = total recaptures of fish marked in the ith period of marking

R_j = total recaptures of marked fish during the jth recovery period

C_j = number of fish caught and examined in the jth period of recovery

Petersen estimate

The Petersen method for a single census is a straightforward extrapolation of the proportion of recaptured marked fish in a single census sample from a population with known number of randomly-distributed marks. The modified formula that gives the best unbiased estimate is described by Ricker (1975):

$$N = \frac{(M+1)(C+1)}{(R+1)}$$

where: N = total population

M = number of marked fish in the population

C = number of fish caught in the census sample

R = number of recaptured marks in the census sample

Ricker (1975) provides a table of information for determining the 95% confidence intervals for Petersen estimates. This table was used to calculate upper and lower limits for each estimate, based on the 95% confidence limits for R.

Two separate Petersen population estimates were originally proposed, both to be based on census samples taken at the fish holes in October, when it was confirmed by aerial survey that all migrating charr had reached that destination. For one Petersen estimate, the tags served as marks. The second estimate was to be based on fin clips administered during the first census. This required that two separate censuses be completed at the fish holes: the first to mark (clip the adipose fin) all untagged charr and to recapture tagged charr; the second to recapture the newly marked (finclipped) fish and augment the tag recoveries.

Censuses

The first complete census was carried out over 3 days between 4-6 October, and thoroughly covered approximately 7 km of Fish Creek upstream from its mouth. The lower section, consisting of shallow, boulder-strewn, braided channels, was sampled with a backpack electrofisher; the deeper pools in the upper portion were seined with a 45 m, 6 cm mesh, modified

herring net (monofilament). All untagged charr were finclipped. Recaptured tag number codes were recorded, as was the number of recaptured fin clips. All charr were recorded as male or female spawners or "silvers" (sea-run, not current year spawners). The sex of silvers could not be easily identified.

An attempt at the second census was postponed because of weather until 20 October, and then aborted after only an hour's sampling, again due to bad weather. A final trip to Fish Creek took place on 25 October, but by this date, the extent of ice overhang along the edges of the stream made it practically impossible to fish. Only 6 fish were caught. The second Petersen estimate, using the finclipped fish, was therefore not feasible. The finclips were useful, nonetheless, for determining an accurate count of untagged fish caught during tag recoveries for the first Petersen estimate.

Spawners and Non-spawners

Separate Petersen estimates were calculated for spawning and non-spawning charr in Fish Creek, using the same tag recapture information as the total population estimate. There was no difficulty distinguishing spawners and "silvers" captured in the fish holes, so the number in the sample (C) and number recaptured (R) were known for each group. When the fish were tagged during their upstream run, however, current year spawners had not yet developed the secondary (external) sexual characteristics, so they could not be differentiated from the non-spawners. Thus, the number of spawners tagged could not be separated from the

total tagged. To determine this, an estimate was made based on information obtained from the biological sampling.

It was known previously that mature charr (current year spawners) generally return earlier, at the beginning of the upstream run, than do immature and resting individuals. From a sample of 505 fish caught at Destruction City, the percentage of mature fish in each day's sample dropped sharply during the last week of August (Fig. 5). Therefore, all the fish tagged prior to 26 August (200) were assumed to be spawners, and all fish tagged on or after that date were assumed to be "silvers". Of course, some overlap occurred, but likely balanced out. The number of marked spawners and silvers available for recapture (M) was obtained by subtracting from each group the appropriate number of tagged fish that had been removed by the domestic harvest.

BIOLOGICAL EVALUATION

In addition to the live-captured charr measured for fork lengths, biological ("dead") samples were taken from the domestic harvest at Destruction City. The Kay family who traditionally fishes here was extremely cooperative in providing fish for sampling. It is thanks to them that a very large, chronologically continuous sample was obtained from 8 August to 18 September.

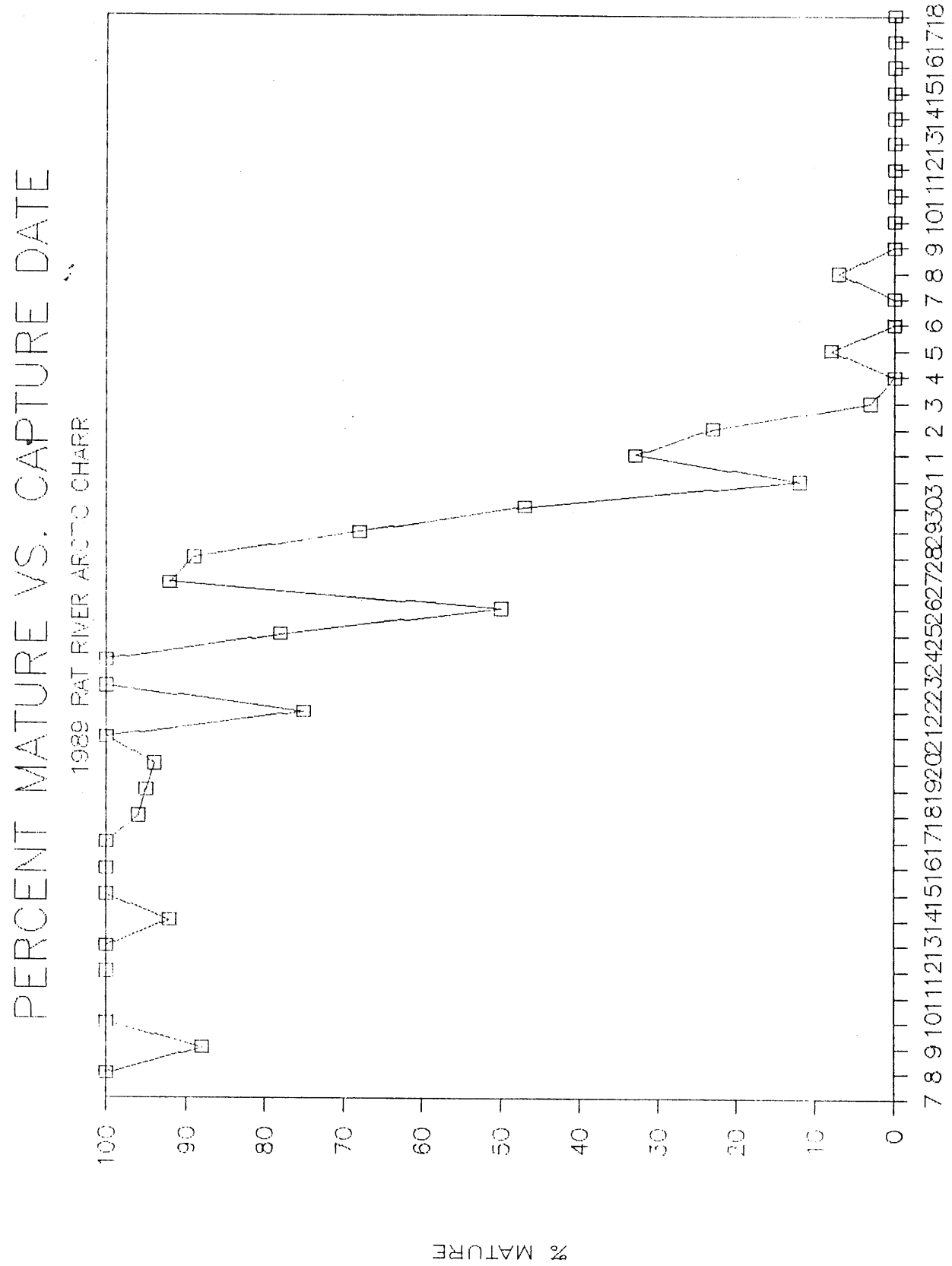

FIGURE 5. Sexually mature charr (current year spawners) as a percentage of daily total sample. N=505.

A few dead samples were also obtained from the hoop net catches, for the smaller size classes that were not vulnerable to the gillnets. Data gathered from the dead samples consisted of fork length ($^{+}$5mm), round weight ($^{+}$50g), sex and stage of maturity (determined by gross examination of the gonads). Sagittal otoliths were collected for subsequent aging by DFO personnel in Winnipeg.

Two separate length frequency distibutions were computed: from the live-sampled hoop net catch (non-selective) and from the harvest (dead) samples. Standard biological data were calculated by DFO-Winnipeg from the total dead sample, including mean lengths and weights, condition factor (K), length-weight relationship, length-at-age relationship, etc. Mortality rates were calculated from "smoothed" age-frequency distributions (catch curves). Smoothing was accomplished by averaging the logarithm of frequency for a given age class with the preceding and succeeding age class frequencies.

RESULTS AND DISCUSSION

POPULATION ESTIMATES

Schaefer estimate

Between 2 August and 12 September, 1112 arctic charr were caught in the hoop nets and live-sampled. Data for these fish are listed in Appendix 2. Of these, 972 charr were tagged. A total of 1020 charr were captured by the native fishermen at Destruction City, of which 987 were caught during the period used for the Schaefer estimate. From this harvest, 133 tags were recovered.

The daily mark and recapture data used for the Schaefer estimate are recorded in Table 2. These data were divided into 6-day time periods and the appropriate totals for each time period were compiled into Schaefer's double entry table, Table 3. Table 4 gives the computed estimates for each cell of the double entry table, estimates of the number of charr passing Destruction City during each time period, and the estimate for the total population. The final figure of 8928 represents the Schaefer estimate of the number of charr passing Destruction City from the beginning of the run on 2 August until 12 September.

Due to the high water after 7 September, mark-recapture sampling of the run was incomplete. Obviously the run was still in progress, but it is an open question as to how many more fish passed by after tagging was discontinued. According to the

TABLE 2. Daily mark (M), capture (C) and recapture (R) of arctic charr. M = number of charr marked (tagged) each day; C = number of charr caught each day in gillnets at recapture site (Destruction City); R = number of tagged charr recaptured each day in gillnet catch. Data are divided into 6-day time periods used in the Schaefer estimate: i = tagging period; j = recapture period (time lag of one period = 6 days). The last four days were not included in calculations for the Schaeffer estimate.

TIME PERIOD	DATE	M	C	R
i1j-	AUG 2	1	-	-
"	3	1	-	-
"	4	1	-	-
"	5	3	-	-
"	6	8	-	-
"	7	9	-	-
i2j1	AUG 8	1	1	1
"	9	6	6	2
"	10	2	1	-
"	11	5	2	-
"	12	9	6	1
"	13	14	7	2
i3j2	AUG 14	25	11	3
"	15	37	32	12
"	16	16	8	3
"	17	12	14	3
"	18	12	23	8
"	19	18	15	6
i4j3	AUG 20	7	12	3
"	21	6	15	2
"	22	-	10	-
"	23	-	2	-
"	24	-	2	1
"	25	7	-	-

..Table 2 continued

TABLE 2: continued

TIME PERIOD	DATE	M	C	R
i5j4	AUG 26	4	2	1
"	27	24	11	2
"	28	27	16	8
"	29	53	22	10
"	30	79	15	9
"	31	64	13	5
i6j5	SEPT 1	74	19	3
"	2	121	17	3
"	3	46	33	9
"	4	60	45	8
"	5	66	54	10
"	6	65	70	6
i7j6	SEPT 7	53	64	3
"	8	-	65	3
"	9	-	59	1
"	10	-	51	1
"	11	9	68	-
"	12	27	69	1
i-j7	SEPT 13	-	50	2
"	14	-	28	-
"	15	-	12	1
"	16	-	6	-
"	17	-	24	-
"	18	-	7	-
----	SEPT 19	-	10	-
	20	-	9	-
	21	-	9	-
	22	-	5	-

TABLE 3. Recaptures of tagged arctic charr from the gillnet catches at Destruction City, arranged according to period of tagging (i) and period of recovery (j). R_i = tagged fish recovered from tagging period i; M_i = total fish tagged in tagging period i; R_j = tagged fish recovered in recovery period j; C_j = total fish recovered in recovery period j. Each cell entry corresponds to R_{ij} = number of fish recovered in recovery period j that were tagged in tagging period i. The numbers for M_i, R_j, and C_j correspond to the totals for M, R, and C in Table 2 for the designated time periods. To obtain the numbers for each cell entry (R_{ij}), each tagged fish had to be cross-referenced with the tagging and recapture data in Appendix 2 to determine the correct tagging and recovery period to which it belonged.

PERIOD OF	PERIOD OF TAGGING (i)									$\frac{C_j}{R_j}$
RECOVERY (j)	1	2	3	4	5	6	7	R_j	C_j	
1	2	4						6	23	3.83
2		3	32					35	103	2.94
3			4	2				6	41	6.83
4				1	34			35	79	2.26
5					3	36		39	238	6.10
6						2	7	9	376	41.78
7						1	2	3	127	42.33
								=	=	
R_i	2	7	36	3	37	39	9	= 133	987	
M_i	23	37	120	20	251	432	89	= 972		
M_i/R_i	11.50	5.28	3.33	6.67	6.78	11.08	9.89			

TABLE 4. Computed estimates of arctic charr passing Destruction City, using Schaefer's method. (See equation in Methods, p. 15.) Total of all cell entries yields total population estimate.

PERIOD OF RECOVERY (j)	PERIOD OF TAGGING (i)								TOTAL
	1	2	3	4	5	6	7		
1	88	81							169
2		47	313						360
3			91	91					182
4				15	521				536
5					124	2433			2557
6						926	2892		3818
7						469	837		1306
								=	
TOTAL	88	128	404	106	645	3828	3729	=	8928

catch per unit effort (CPUE) data for the hoop nets, shown in Figure 6, it appears the peak of the run occurred on 5 September. Similar approximate catch per unit effort data for the gillnets (Fig. 7) shows a more protracted peak, lagging a day or more behind, and charr were still being caught until the last nets were pulled on 22 September. Reports from local fishermen indicate that some charr are caught right up until freeze-up.

To obtain a more complete estimate of the total population, including those fish moving upstream after 7 September, it is only possible or to extrapolate from the CPUE curves in Figures 6 and 7.

Extrapolation is complicated because the duration of the peak and the characteristics of the tail end of the run are not known. Additionally, the effect of high water on the fishing efficiency of the gillnets is not known, although it is well-accepted by the native fishermen that decreased catches are correlated with high water. A further caution against extrapolating from the gillnet CPUE data is that these data are only approximate, since the number of nets was not monitored closely, and nets were occasionally set or removed without being reported.

In spite of these cautions, however, for purposes of gaining an estimate of the likely number of charr in the latter portion of the run, the hoop net CPUE curve was extrapolated based on the CPUE curve for the gill nets. Thus it was assumed that the hoop

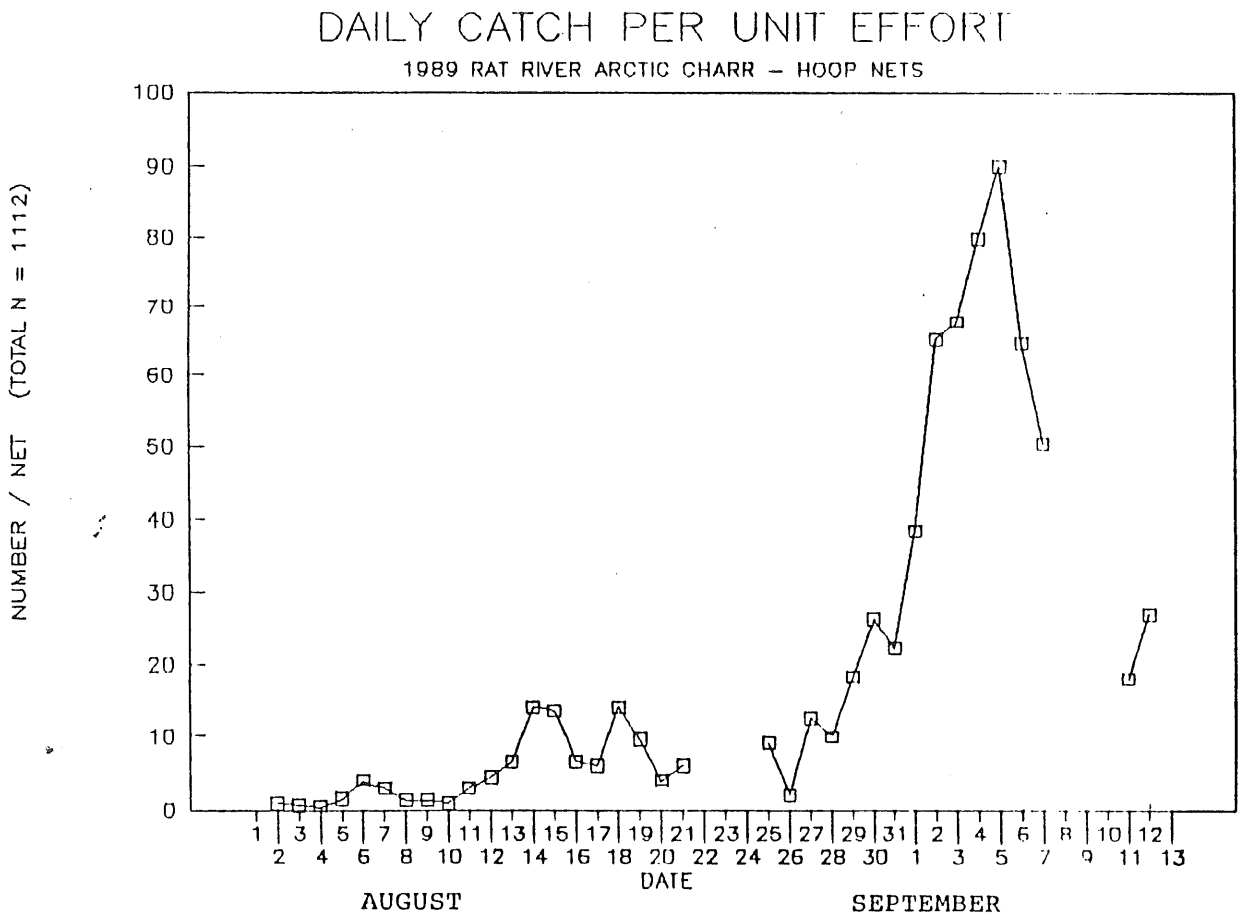

FIGURE 6. Daily CPUE curve for hoop nets at tagging site. Breaks indicate periods when nets were removed because of high water.

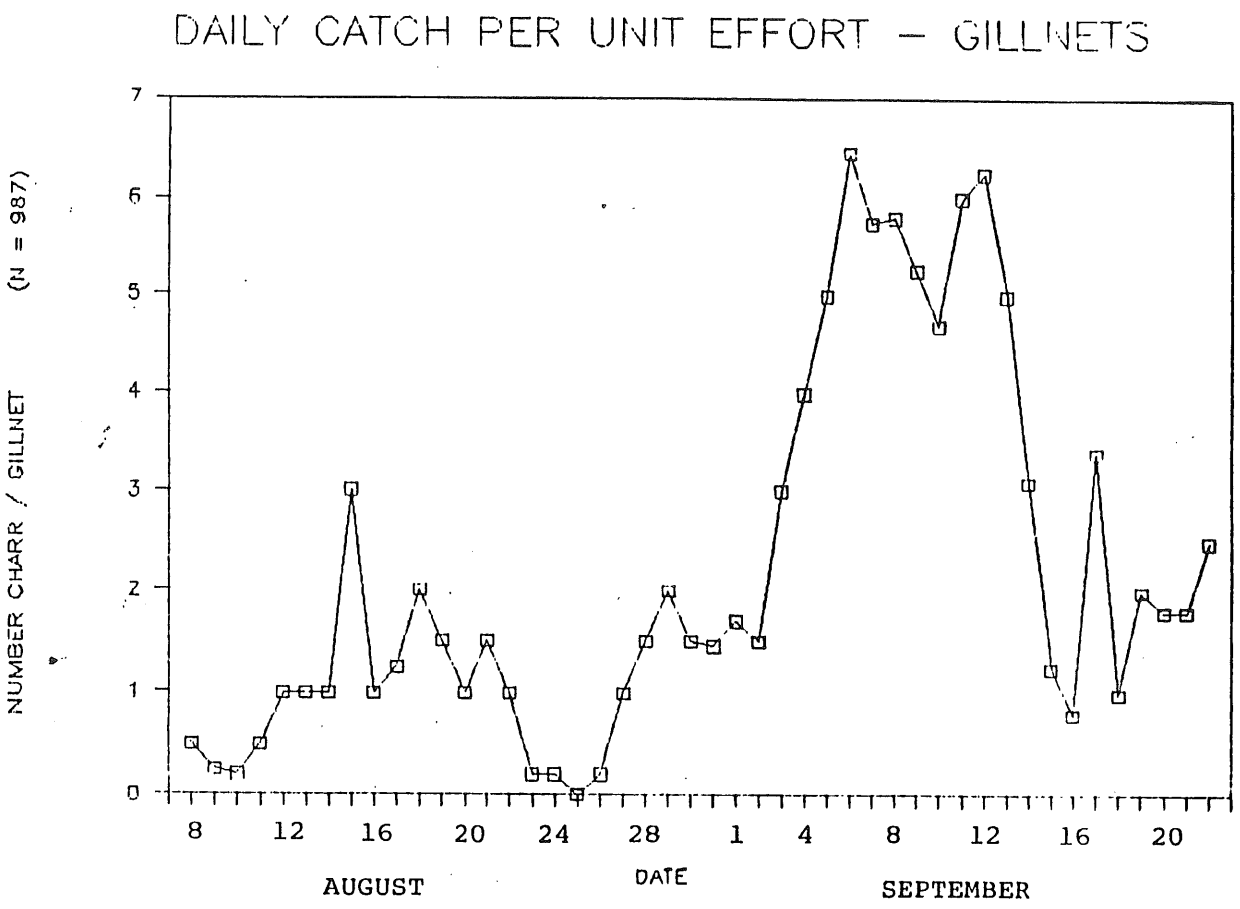

FIGURE 7. Daily CPUE for gillnets at Destruction City (recapture site).

net catch would have shown a "trailing off" period similar to the beginning of the run. This extrapolation of the curve for the period after 12 September was used simply to identify comparable periods within the Schaefer estimate table. Therefore, it is surmised that the peak run was followed by about two weeks comparable to two periods prior to the run (i5j4 and i3j2). (The period i4j3 was not used because this was also an abnormal period of high water.) Using the approximate estimates in Table 4 for each of these time periods, a rough estimate of the number of additional charr, therefore, is:

$$(i5j4) + (i3j2)$$
$$= (650) + (400)$$
$$= 1050$$

If this is added to the estimate obtained by Schaefer's method, the resulting population estimate for Rat River charr is about 10 000.

Petersen estimate

During the census at Fish Creek (4-6 October), 690 charr were captured (C). Because all untagged charr were finclipped, all fish that were captured more than once during the census could be recognized and excluded from this total. Exactly 50 tagged charr were recaptured (R). The total number of tagged fish available for recapture, assuming no mortality other than the domestic harvest, was 972 - 147 = 825 (M). (The number of tags removed by the harvest includes those recovered in

locations other than Destruction City.)

Therefore, the Petersen estimate is:

$$N = \frac{(M+1)(C+1)}{(R+1)} = \frac{(826)(691)}{(51)} = 11\ 191$$

The lower and upper 95% confidence limits are 8532 and 15 020.

These results substantiate the findings of the previous method. The Schaefer estimate for the portion of the run prior to the flooding lies within the 95% confidence interval for the Petersen estimate. The "adjusted" Schaefer estimate, although crude, is close to the Petersen estimate.

It was apparent from sampling for this census that spawners and non-spawners are spatially segregated in Fish Creek. In the lower reaches, the catch comprised exclusively "silvers". All of the current year spawners and only a few silvers were captured in the upper, deeper pools. Only four "residual" charr were found.

Separate Petersen estimates were calculated for spawners and silvers. Of the 690 charr captured in the census, 187 were spawners. It was estimated (see Methods, p.15) that approximately 200 current year spawners had been tagged during the upstream run. Tag numbers recorded from the domestic harvest indicated that 50 of these tagged spawners had been removed, leaving only 150 tagged spawners available for recapture. Twelve of these were caught during the census. The number of tagged silvers remaining after the domestic harvest was approximately 675. Thus the Petersen estimates for each group yielded:

Spawners: $N = \frac{(M+1)(C+1)}{(R+1)} = \frac{(151)(188)}{(13)} = 2184$

(95% confidence interval: 1290 - 3940)

Silvers: $N = \frac{(M+1)(C+1)}{(R+1)} = \frac{(676)(504)}{(39)} = 8736$

(95% confidence interval: 6400 - 12 260)

If these are totalled, the population estimate obtained is 10 920. This close concordance with the other population estimates lends confidence to the separate estimates for spawners and silvers and increases confidence in the overall population estimates.

Based on the above calculations, the approximate ratio of spawners to non-spawners in Fish Creek is 25%.

BIOLOGICAL EVALUATION

Raw data, including fork length, weight, sex and maturity, for 506 "dead-sampled" charr are compiled in Appendix 3. Standard biological summary data computed by DFO-Winnipeg from the dead samples are presented in Tables 5 and 6. Data by age interval (Table 5) are based on the whole sample (N=401); length-related data (Table 6) are from a subsample (N=504).

The length frequency distribution from these data is presented in Figure 8. Length range is from 231 mm to 601 mm. Modal length is in the interval 400-450 mm, with mean at 414 mm.

Table 5 . Biological data by age group for Arctic charr (all gears combined) from the Rat River (MacKenzie delta area), 8 August to 18 September 1989.

AGE (YR)	MALES							FEMALES							COMBINED						
	LENGTH(MM)			WEIGHT(G)			%	LENGTH(MM)			WEIGHT(G)			%	LENGTH(MM)			WEIGHT(G)			%
	N	MEAN	SD	MEAN	SD	K	MAT	N	MEAN	SD	MEAN	SD	K	MAT	N	MEAN	SD	MEAN	SD	K	MAT
3	2	283	74	325	247	1.27	50	1	290	-	250	-	1.03	0	3	285	52	300	180	1.19	33
4	7	332	15	450	96	1.21	0	3	323	29	430	137	1.24	0	10	329	19	444	102	1.22	0
5	15	343	30	507	111	1.24	13	29	343	41	499	191	1.18	3	44	343	37	502	167	1.20	7
6	28	359	42	583	201	1.24	18	52	372	45	616	201	1.18	29	81	367	44	603	199	1.20	25
7	23	397	70	792	451	1.19	30	101	418	46	854	252	1.15	57	125	414	52	840	298	1.16	52
8	12	464	56	1105	398	1.07	67	65	455	36	1041	246	1.10	89	77	457	39	1051	273	1.09	86
9	4	445	27	853	133	0.96	50	34	482	36	1226	308	1.08	85	38	478	37	1186	316	1.06	82
10	1	498	-	1650	-	1.34	100	16	493	29	1291	252	1.07	94	17	493	28	1312	259	1.09	94
11	1	572	-	2250	-	1.20	100	3	521	14	1460	95	1.03	100	4	534	28	1658	403	1.07	100
12	1	601	-	1650	-	0.76	100	1	505	-	1325	-	1.03	100	2	553	68	1488	230	0.89	100
TOTAL	94							305							401						
MEAN		386	72	725	411	1.19			422	62	885	344	1.13			413	66	846	367	1.15	
MEAN AGE		6.4							7.2							7.0					

Table 6 . Biological data by length interval for Arctic charr (all gears combined) from the Rat River (MacKenzie delta area), 8 August to 18 September 1989.

LENGTH INTERVAL (MM)	MALES						FEMALES						COMBINED					
	LENGTH(MM)		WEIGHT(G)			%	LENGTH(MM)		WEIGHT(G)			%	LENGTH(MM)		WEIGHT(G)			%
	N	MEAN	MEAN	SD	K	MAT	N	MEAN	MEAN	SD	K	MAT	N	MEAN	MEAN	SD	K	MAT
200	1	231	150	-	1.22	100	-	-	-	-	-	-	1	231	150	-	1.22	100
250	4	283	213	23	0.94	25	9	282	209	52	0.92	0	13	283	210	44	0.93	8
300	41	335	492	108	1.30	7	58	336	495	80	1.30	7	101	335	494	91	1.30	7
350	29	364	595	72	1.23	7	59	375	627	68	1.19	31	88	371	616	71	1.20	23
400	19	420	778	159	1.04	63	113	426	861	151	1.11	64	132	425	849	154	1.10	64
450	13	468	1115	218	1.09	62	110	474	1127	136	1.06	95	123	473	1125	146	1.06	92
500	7	526	1596	231	1.10	71	36	515	1484	205	1.08	94	43	517	1502	210	1.08	91
550	2	566	2070	255	1.14	100	-	-	-	-	-	-	2	566	2070	255	1.14	100
600	1	601	1650	-	0.76	100	-	-	-	-	-	-	1	601	1650	-	0.76	100
TOTAL	117						385						504					
MEAN		386	724	393	1.18			423	889	334	1.13			414	849	356	1.14	

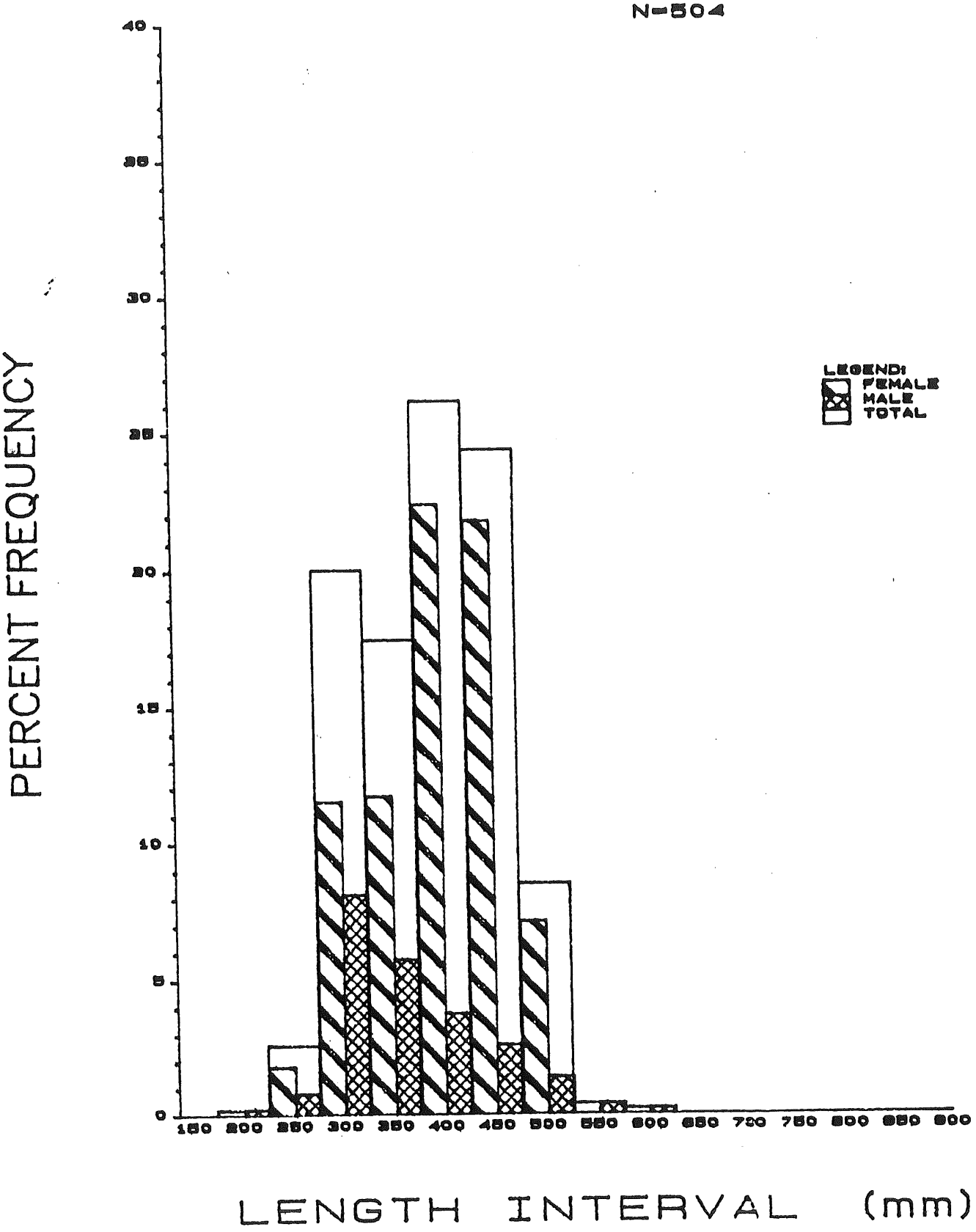

FIGURE 8. Length frequency distribution for dead sampled fish.

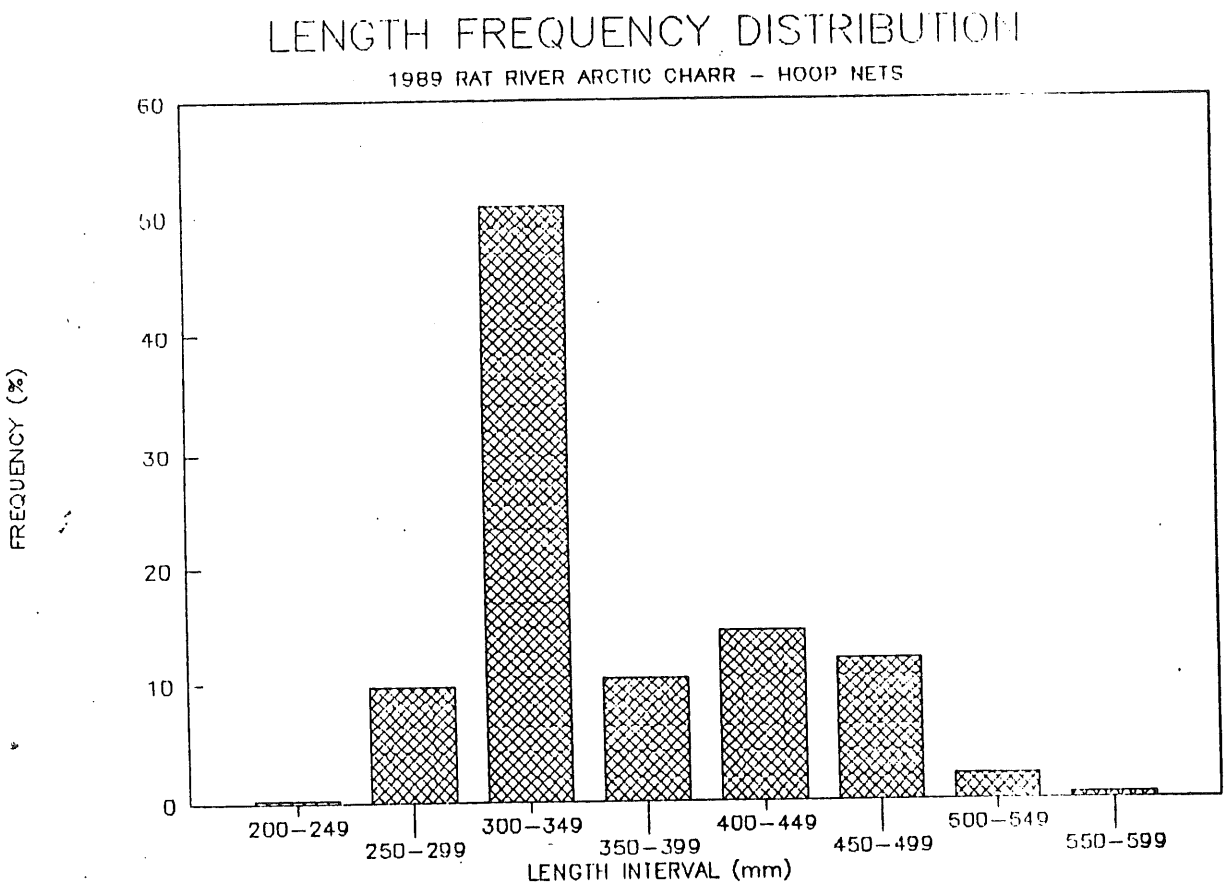

FIGURE 9. Length-frequency distribution for live-sampled arctic charr in Rat River. N=1112

Length frequency distribution was also examined for the 1112 live-sampled charr from the non-selective hoop net catch. This distribution, shown in Figure 9, is strikingly dissimilar from the previous one, most noticeably in the very large proportion of fish (>50%) in the 300-350 mm interval. If this category were decreased to about a third, the overall distribution would resemble the slightly bimodal pattern from the dead sample.

The large discrepancy between the two distributions likely results from the size selectivity of the gillnets used to obtain most of the dead sample. These nets do not readily capture the smaller fish. The hoop nets, however, are not selective with respect to size and therefore catch a more representative sample of the whole population. This is an illustrative example of how biological evaluations gleaned from harvest data may be biased and may give an incomplete representation of the status of a population. In this case, the relatively large proportion of 4-5 year olds would have gone completely unnoticed, if only the dead sample data were available.

The age frequency distribution (Fig. 8B) from a subsample of the dead sample indicates a modal age of 7 years. The computed mean is 6.8 yr, with a range from 3 to 12. The appearance of 3 year olds in the sample is somewhat surprising, since it is generally maintained that charr from this region do not begin anadromous migrations until 4 years of age (ref).

Again, it should be noted that these data were obtained from the selective harvest, which does not include many of the

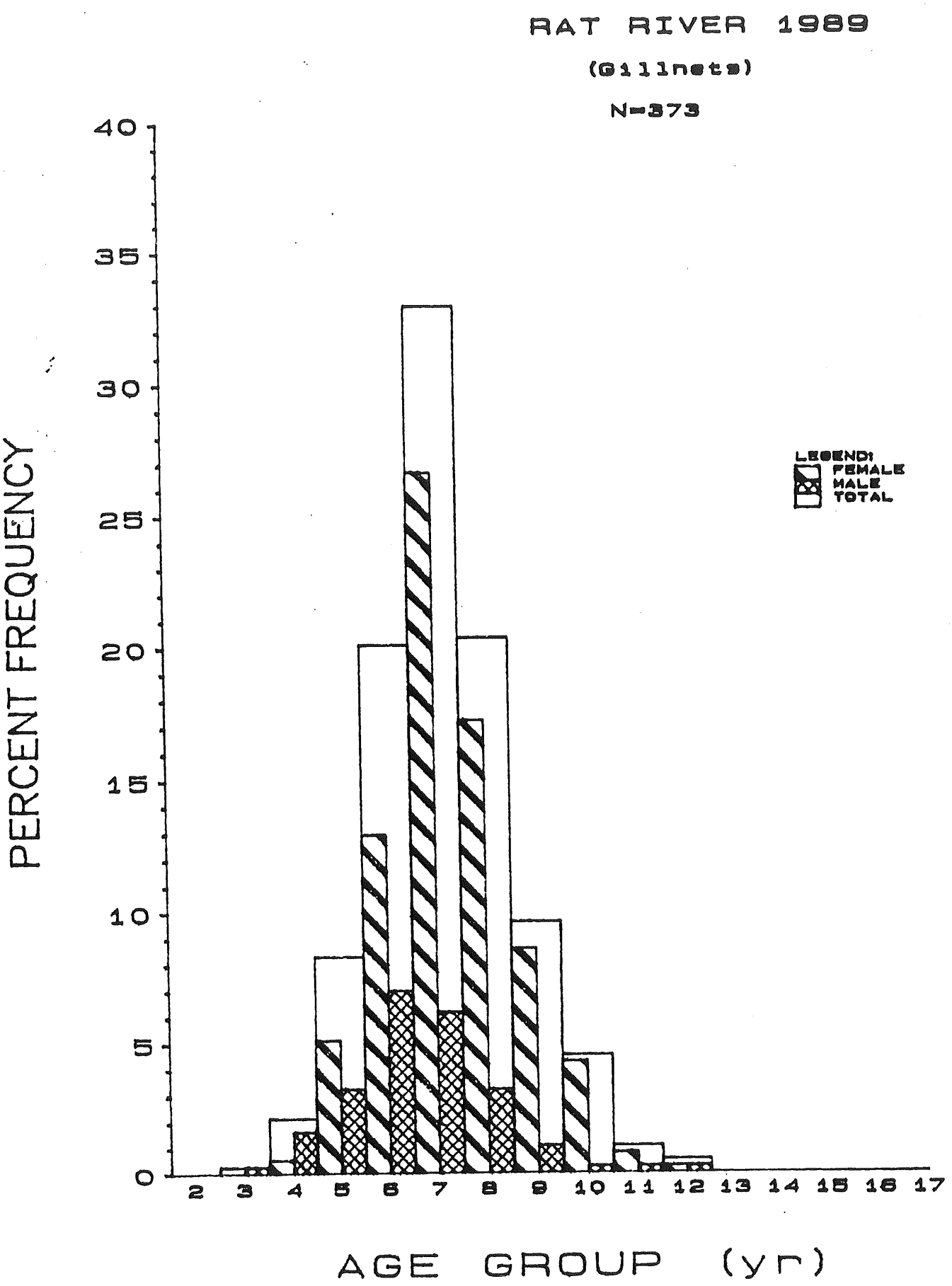

FIGURE 10. Age distribution of charr taken from the domestic fishery.

smaller, younger individuals. Furthermore, the subsample used for aging was not selected completely randomly and, therefore, it is not necessarily representative of the whole sample. The slightly bimodal length frequency distribution of the dead sample is not reflected in the age distribution.

A plot of the length-at-age relationship, as shown in Figure 11, is useful for identifying age characteristics of the population from length frequency data. Based on this plot and the length frequency histogram for the live-sampled hoop net catch (Fig. 9), the very large modal length group can be identified as the 4 year age class. The mean length (362 mm) for this sample corresponds to 5 years of age.

Sexual maturity appears to be first reached at about age 6 (Table 5, ignoring the abberant 3 year old). Data representing the percent mature versus length category (Table 6) indicate that over 50% of charr in the length category 400-450 mm are mature (current year spawners). This category corresponds to 6-7 year old fish. All older age classes had much higher proportions of current year spawners.

Observations of gonads during sampling indicated that some fish may "rest" for more than one year between spawning. Three distinct stages of egg development in females were noted relating, presumably, to current year spawners, next year's spawners, and fish that would not spawn until at least the year after next. Some fish in the latter category were large, older individuals, so it does not seem likely that they were immature.

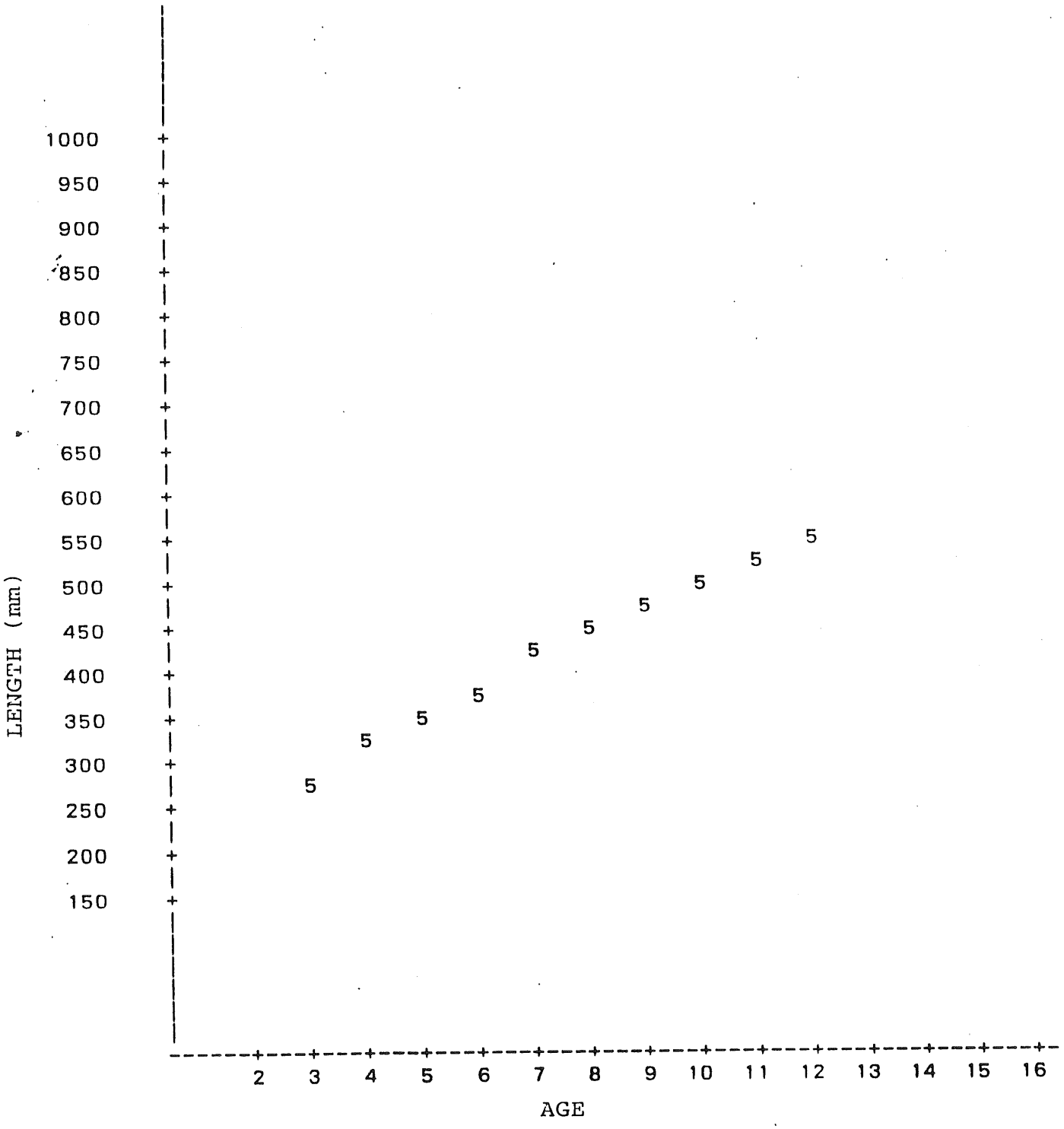

Figure 11. Mean fork length (mm) at age relationship for Rat River charr (N = 401).

The ratio of females to males in the dead sample is 3.3 : 1. Of the mature spawners only (N=244), the ratio is 6.2 : 1. Female to male ratio at the fish holes in Fish Creek in October was 3.5 : 1. This information might indicate that males may tend not to migrate during the year of spawning. It appears, however, that females do.

Condition factor (K) is generally high, especially for the younger age classes (Table 6). This corresponds with the general observation in the field, that all fish appeared in very good condition, with remarkable amounts of fat. Mean condition factor is 1.14 (N=504).

Mortality estimates from the smoothed catch curve (Fig 11) are quite high: instantaneous mortality (Z) for age classes 7-12 (N=115) is 0.78. Annual mortality rate is 53%.

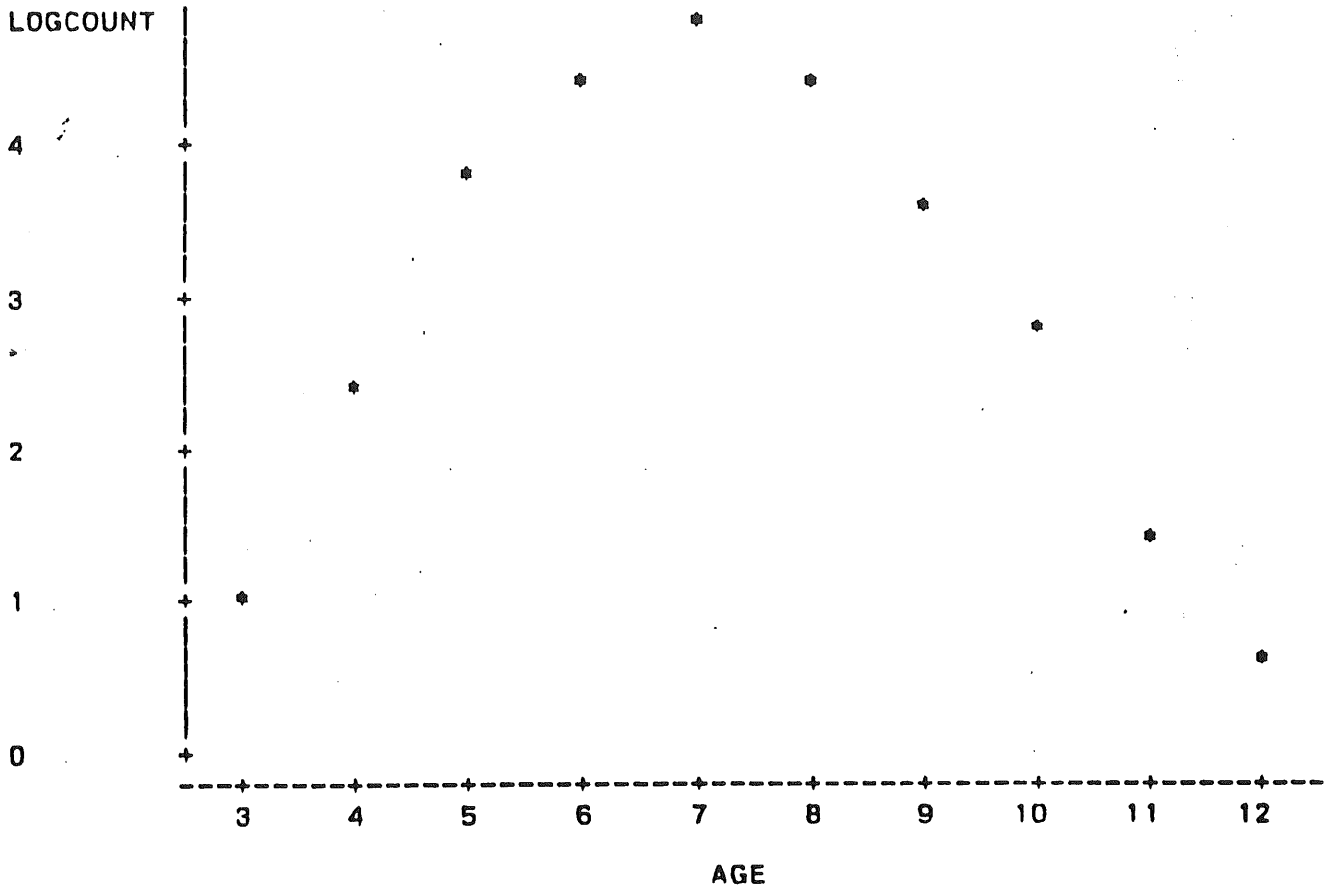

FIGURE 12. Smoothed catch curve for Rat River arctic charr. The logarithm of each age class frequency is averaged with that of the preceding and succeeding age class and plotted against (age - 1).

CONCLUSIONS AND RECOMMENDATIONS

POPULATION STATUS

The results of this study are indicative of a population that is heavily fished. The size of the population may be a little larger than was expected, but the composition, or population structure, reflects the harvest pressure.

Individual fish are in good condition, and there does not appear to be problems with reproduction. The length frequency data from the live-captured sample show an abundant 4 year age class, indicating good potential recruitment. However, older larger fish are much less abundant. Even in the dead sample, which "missed" the majority of the age 4 class, the relative abundance of fish older than 8 years is low. This frequency distribution pattern (many small fish, few large fish) is reminiscent of the "fishing up" pattern associated with overexploited populations that are selectively harvested for the larger individuals, as with gillnet fisheries. As larger individuals get rarer, fishing pressure is concentrated on progressively smaller individuals.

The abundant age 4 class provides good potential for strengthening the stock, if they are successfully recruited into the reproductive population. However, age at first maturity is 6 or 7 years, and mature individuals spawn only every second or third year. The very high mortality rate after 7 years of age

means that the majority of these fish may be able to spawn only once, if at all, before they are killed. In order to allow these fish more opportunity to reproduce, only the older (larger) fish should be harvested. Using 4.5" mesh gillnets would help by allowing more of the 6 - 7 year old fish to escape and have a chance to spawn.

Another strategy to help prevent the depression of this stock is to forgo all fishing at the "fish holes". This is where the charr are most vulnerable. The large harvest from the fish holes in the early 1970's may have been the main factor contributing to the decline of the stock. Similar indications relate to the Big Fish River charr stock, which was fished heavily on the spawning grounds.

ACKNOWLEDGEMENTS

Our appreciation is extended to the FJMC for their financial support of this project. We would like to thank Richard Martin, Selwyn Kaye and Joe Vittrekwa for their assistance in the field. A special thanks is extended to the Kaye family who made a significant contribution to the program and provided very welcomed company at the field camp. Finally, we would like to thank the community of Ft. McPherson for supporting our project and participating in the planning and management discussions.

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APPENDIX 1. Rat River depth profiles and current velocity at three sites in the study area (Fig. A1). Depth (z) measured at approximately 2 m intervals across transect distance (d).

A) BELOW RAPIDS - (FIG. A1-A) - measured on 25 August 1989

TRANSECT 1:

-depth (z) measured at distance (d) from E (cut bank) to W (slowing) across gravel bar:

d (m)	z (m)	substrate	d (m)	z (m)	substrate
0	0	silty,stumps	22	1.0	rocky
1	0.8	"	24	1.0	"
2	0.9	"	26	1.1	silty
3	1.0	rocky,silty	28	1.0	"
4	0.8	"	30	1.1	"
6	0.8	rocky	32	1.0	"
8	0.8	"	34	1.0	"
10	0.8	"	36	1.0	"
12	0.7	"	38	1.0	"
14	0.7	"	40	1.0	"
16	0.7	"	42	1.0	"
18	0.8	"	44	0.9	"
20	0.9	"	45	0	"

-current velocity (v) measured at distance (d) E to W:

d (m)	v (m/s)
15	0.87
22	0.83
30	0.74
38	0.64

A) BELOW RAPIDS - (FIG. A1-A) - measured on 25 August 1989

TRANSECT 2:

-depth measured from E bank to W sand bar:

d (m)	z (m)	substrate	d (m)	z (m)	substrate
0	0	silty sand	22	1.5	silty sand
2	0.3	"	24	1.5	"
4	1.1	"	26	1.4	"
6	1.6	"	28	1.3	"
8	2.0	"	30	1.2	"
10	1.9	"	32	1.0	"
12	1.8	"	34	0.8	"
14	1.7	"	36	0.6	"
16	1.7	"	38	0.3	"
18	1.6	"	40	0	"
20	1.6	"			

-current velocity measured E to W:

d (m)	v (m/s)
15	0.57
25	0.60

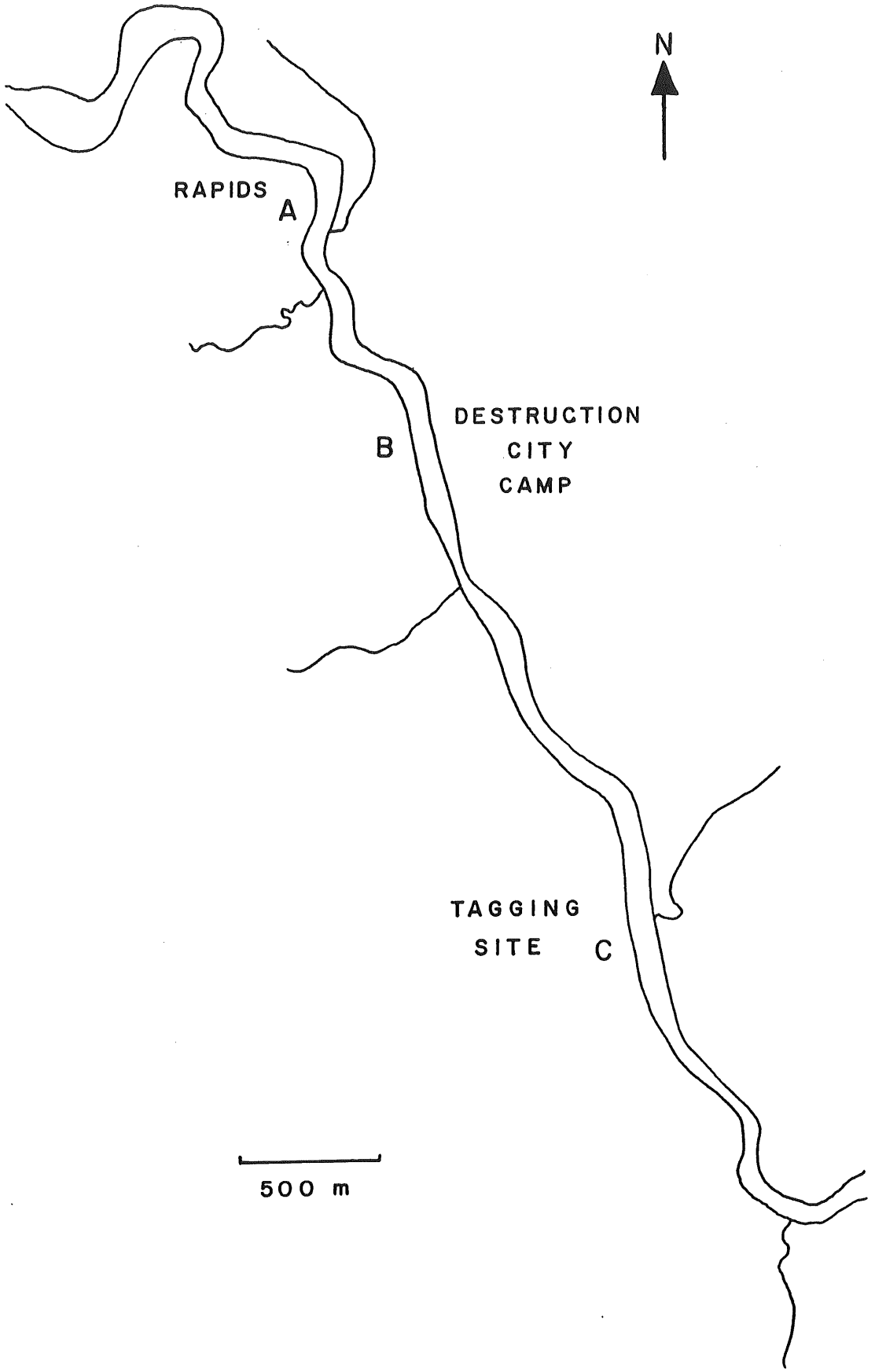

FIGURE A1. Depth profile sites: rapids (A), Destruction city (B), and tagging site (C).

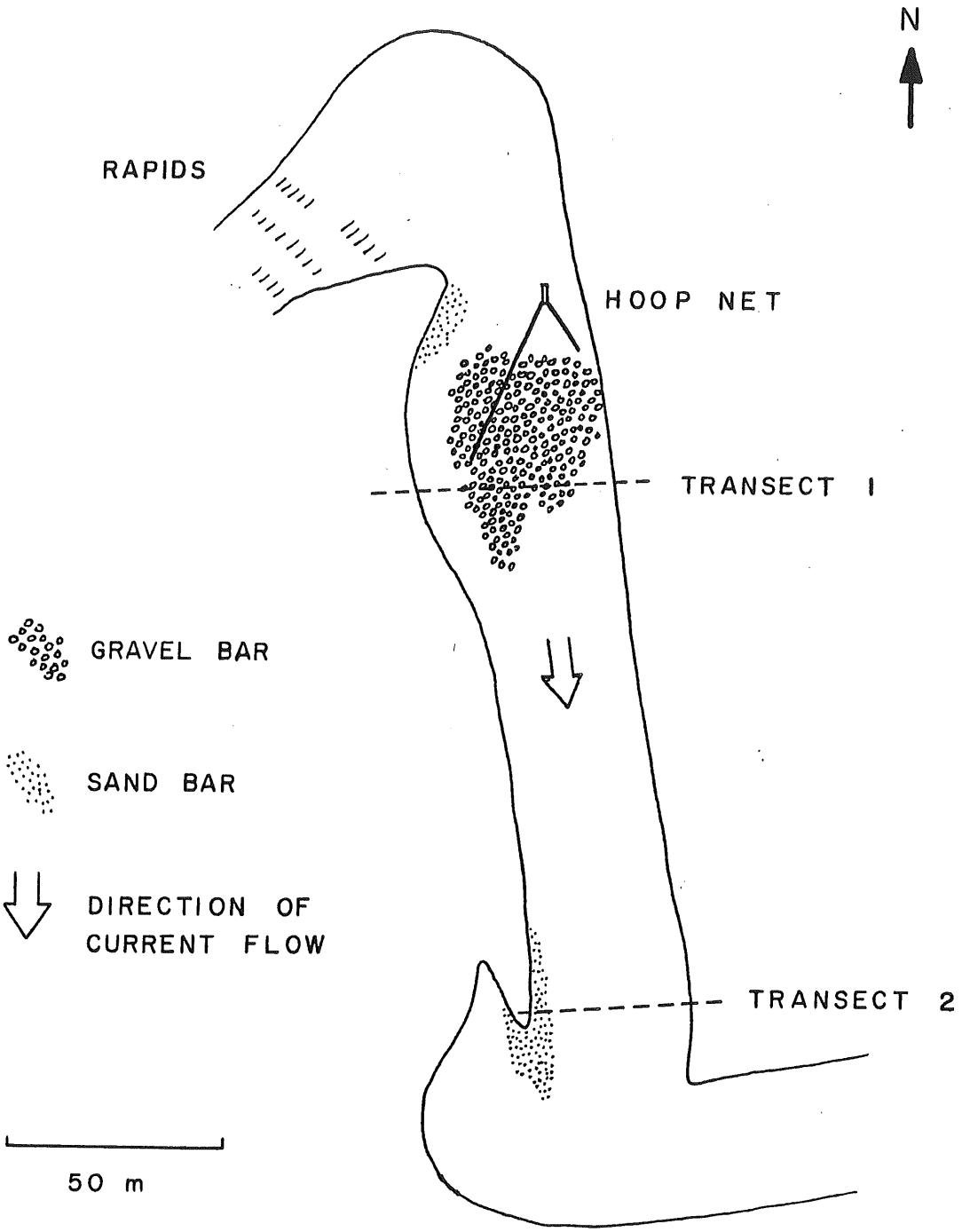

FIGURE A1-A. Depth profile transects below rapids.

B) AT DESTRUCTION CITY - (FIG. A1-B) - measured on 19 Sept 89

TRANSECT 1:

-depth measured from sloping N bank (camp side) to cut S bank

d (m)	z (m)	substrate	d (m)	z (m)	substrate
0.5	0.2	silty sand	24	3.4	silty san
1	0.4	"	26	3.7	"
2	0.5	"	28	3.8	"
4	0.8	"	30	4.0	"
6	1.2	"	32	4.2	"
8	1.5	"	34	4.1	"
10	1.7	"	36	3.7	"
12	2.0	"	38	3.5	"
14	2.2	"	40	2.7	"
16	2.4	"	42	1.8	"
18	2.5	"	43	1.0	"
20	2.9	"	44	0.5	"
22	3.3	"			

-current velocity measured N to S:

d (m)	v (m/s)
25	0.45
35	0.38

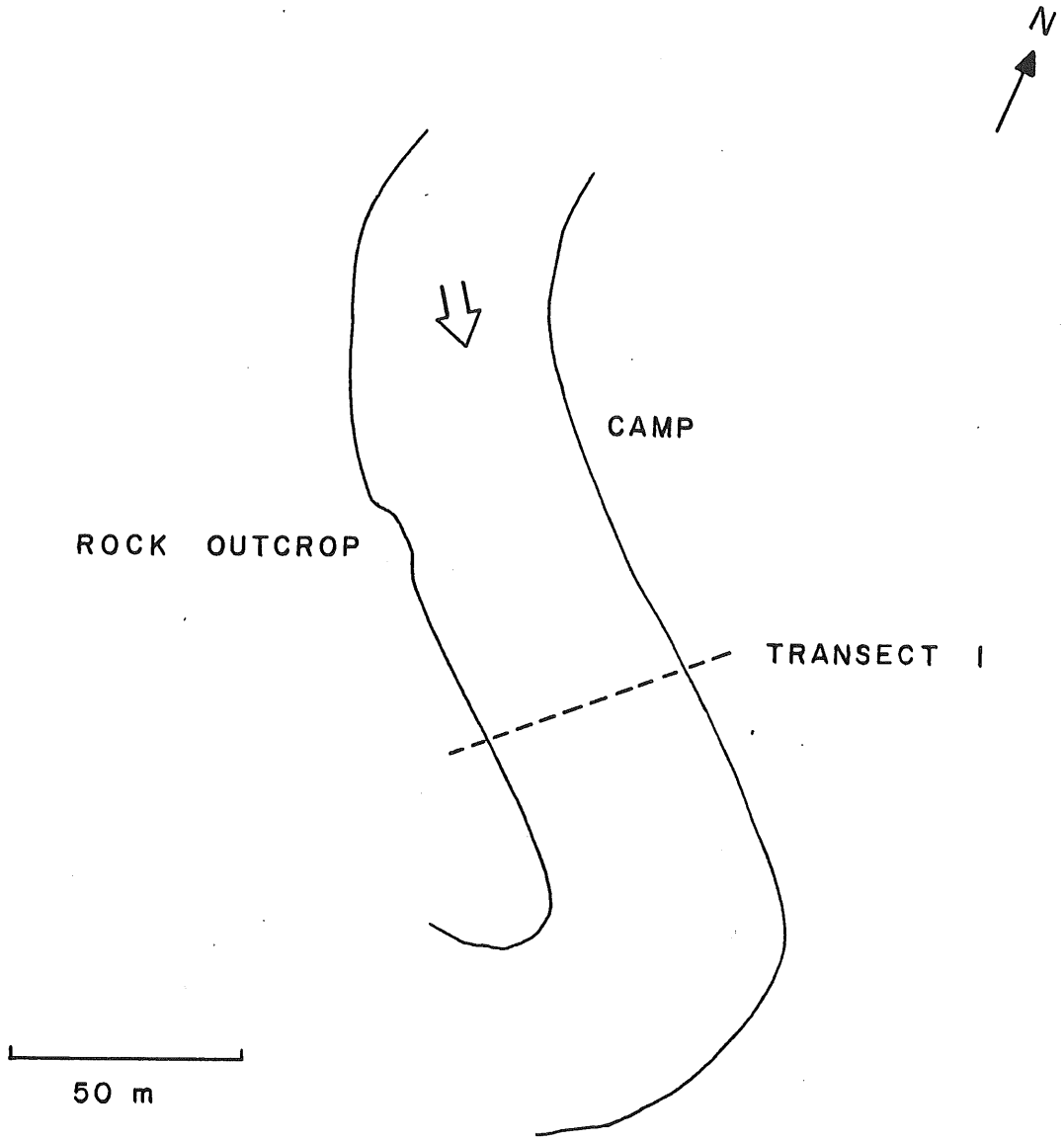

FIGURE A1-B. Depth profile transect at Destruction City.

C) AT TAGGING SITE - (FIG. A1-C)

TRANSECT 1: measured on 7 Sept 89, beginning of a flood

-depth measured from sloping N bank to steep S bank

d (m)	z (m)	substrate
1	0.1	silty sand
2	0.3	"
3	0.4	"
5	0.6	"
7	0.9	"
9	1.2	"
11	1.4	"
13	1.6	"
15	1.8	"
17	1.8	"
19	1.8	"
21	1.8	"
23	1.9	"
25	2.0	"
27	2.0	"
29	2.0	silty sand
31	1.9	"
33	1.8	"
35	1.6	"
37	1.6	"
39	1.6	"
41	1.5	"
43	1.3	"
45	1.2	"
46	1.1	"
47	0.8	"
48	0.5	"
49	0.3	"
50	0	"

-current velocity measured approximately mid-channel just above net sets, 250 m downstream from transect 1

date	v (m/s)
08 AUG 89	0.33
16 AUG 89	0.60

C) AT TAGGING SITE - (FIG. A1-C)

TRANSECT 2: measured on 11 Sept 89, flood abating

-depth measured from W to E bank

d (m)	z (m)	substrate
0.5	0.3	silty sand
1	0.8	"
2	1.0	"
4	1.0	"
6	1.0	"
8	1.1	"
10	1.2	"
12	1.3	"
14	1.4	"
16	1.6	"
18	1.6	"
20	1.6	"
22	1.6	"
24	1.4	"
26	1.3	"
28	1.3	"
30	1.3	"
32	1.3	"
34	1.1	"
36	1.0	"
38	1.1	"
40	1.2	"
42	1.1	"
44	1.0	"
46	1.1	"
48	1.1	"
50	1.0	"
51	0.7	"
52	0.7	"
53	0.5	"
54	0.2	"

-current velocity measured approximately mid-channel

v (m/s)
0.66

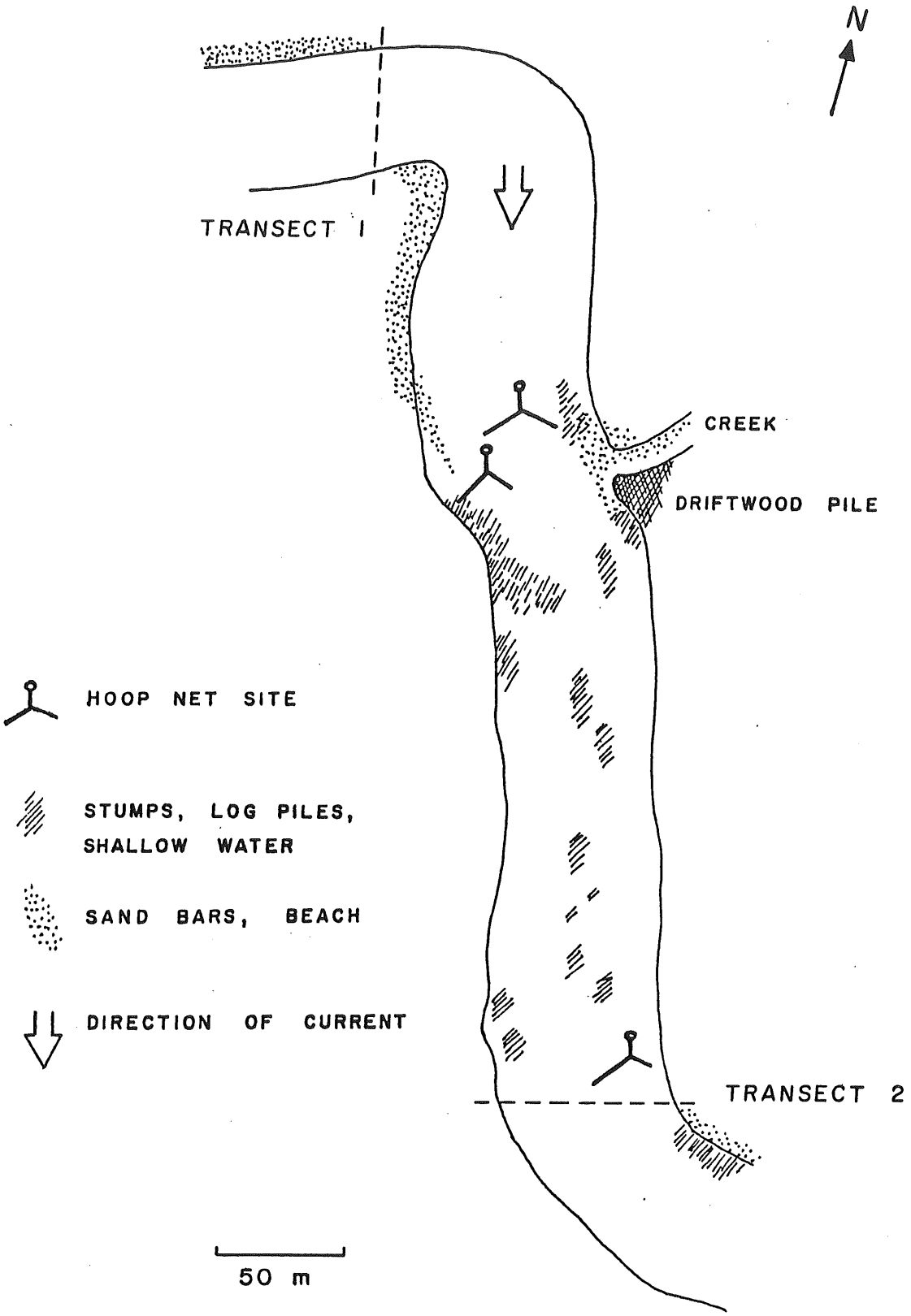

FIGURE A1-C. Depth profile transects at tagging site

APPENDIX 2. Sample data for 1112 charr captured in hoop nets, listed by tag number. Untagged fish that were dead-sampled are listed by a sample code; untagged fish that were live-sampled and released have no code and are ordered by date only.

TAG #/ CODE	DATE TAGGED	FORK LN (mm)	RND WT (g)	RECAP DATE
70001	890802	573	2350	
70002	890803	490	1250	
70003	890804	499	1450	
70004	890805	439	940	
70005	890805	393	600	
70006	890805	475	950	
70007	890806	418	750	
70008	890806	445	900	
70009	890806	472	1220	
70010	890806	399	730	
70011	890806	490	1220	890808
70012	890806	493	1260	
70013	890806	490	1090	
70014	890806	428	900	
70016	890807	490	1160	
70017	890807	494	1050	
70018	890807	497	1050	
70019	890807	480	1240	
70020	890807	445	1000	
70021	890807	438	900	
70022	890807	470	1050	
70023	890807	395	650	890809
70024	890808	379	1050	
70025	890808	487	1025	
70026	890808	535	1400	890809
70027	890809	460	1100	
70028	890809	590	2250	
70029	890809	525	1450	
70030	890809	487	850	
70031	890810	490	1290	
70032	890810	441	900	
70033	890811	470	1140	
70034	890811	491	1160	
70035	890811	470	1100	
70036	890811	450	940	
70037	890811	470	950	
70038	890812	402	670	
70039	890912	340		
70040	890812	453	900	
70041	890812	460	1170	890812
70042	890812	455	960	
70043	890812	446	950	
70044	890812	352	500	
70045	890812	444	1050	
70046	890812	429	950	890813
70047	890812	423	850	
70048	890813	455	900	
70049	890813	437	1000	
70050	890813	464	1130	890813
70051	890813	478	1100	
70052	890813	493	1200	890815
70053	890813	450	1050	890815
70054	890813	438	860	890814
70055	890813	439	850	
70056	890813	270	190	
70057	890813	402	650	
70058	890813	439	800	
70059	890813	295	200	
70060	890813	364	500	
70061	890813	500	1300	
70062	890814	384	384	890824
70063	890814	447	1050	
70064	890814	465	1000	
70065	890814	446	900	
70066	890814	448	1050	
70067	890814	378	600	
70068	890814	398	600	890814
70069	890814	370	600	
70070	890814	502	1400	
70071	890814	447	850	
70072	890814	443	900	890814
70073	890814	478	1100	890815
70074	890814	455	110	890815
70075	890814	440	1050	890815
70076	890814	457	1130	890815
70077	890814	497	1390	
70078	890814	555	1850	890815
70079	890814	442	950	890815
70080	890814	532	1400	
70081	890814	471	1120	
70082	890814	440	960	890815
70083	890814	473	1100	
70084	890814	410	700	
70085	890814	366	460	
70086	890814	405	800	
70087	890814	450	960	890815
70088	890814	495	1150	
70089	890814	440	850	890815
70090	890814	395	720	
70091	890814	385	600	
70092	890814	415	780	
70093	890814	410	790	
70095	890815	403	750	
70096	890815	414	700	
70097	890815	497	1300	890816
70098	890815	521	1700	890818
70099	890815	552	1460	890815
70100	890815	367	510	
70101	890815	483	1200	
70102	890815	463	910	
70103	890815	464	1100	
70104	890815	445	1000	
70105	890815	442	950	
70106	890815	420	750	
70107	890815	452	850	
70108	890815	454	1100	
70109	890815	483	1160	
70110	890815	437	825	
70111	890815	442	760	
70113	890815	431	960	
70114	890815	383	540	
70115	890815	480		
70116	890815	455	1130	
70117	890815	376	500	
70118	890815	530	1500	
70119	890815	450	1000	890816
70120	890815	379	600	
70121	890815	369	600	
70122	890815	464	1100	
70123	890815	475	1050	890817

APPENDIX 2. Cont'd

TAG #/ CODE	DATE TAGGED	FORK LN (mm)	RND WT (g)	RECAP DATE
70126	890816	470	950	
70127	890816	446	850	
70128	890816	410	740	
70129	890816	498	1300	
70130	890816	440	960	890819
70131	890816	457	1050	
70132	890816	445	1000	890818
70133	890816	420	760	
70134	890816	437	910	
70135	890816	504	1400	
70137	890816	460	1020	
70138	890816	469	1100	890818
70139	890816	382	600	
70139	890912	290		
70140	890816	463	950	
70141	890816	466	950	
70142	890816	426	700	890816
70143	890817	457	950	
70144	890817	376	550	
70145	890817	438	650	
70146	890817	430	950	
70147	890817	450	950	
70148	890817	508	1330	
70150	890817	440	850	890817
70151	890817	551	1650	
70152	890817	507	1150	
70153	890817	464	1200	890818
70154	890817	489	1460	
70155	890817	473	1050	890818
70156	890818	490	1250	
70157	890818	472	1150	
70158	890818	433	760	
70159	890818	474	1050	890818
70160	890818	405	700	890819
70161	890818	496	1320	890818
70162	890818	487	1300	890818
70163	890818	401	700	
70164	890818	464	1250	
70165	890818	413	720	
70166	890818	403	810	890819
70167	890912	325		
70168	890818	366	500	
70169	890819	443	960	890819
70170	890819	444	1100	
70171	890819	440	950	890819
70172	890819	420	800	890819
70173	890819	460	1000	890820
70174	890819	454	960	
70175	890819	380	600	
70176	890912	305		
70178	890912	435		
70180	890819	468	900	890821
70181	890819	465	950	
70182	890819	503	1200	
70183	890819	440	750	890821
70184	890819	460	1000	890820
70187	890820	460	1100	
70188	890820	467	1150	890820
70189	890820	475	1200	
70190	890820	506	1300	
70191	890820	495	1300	
70192	890820	388	700	
70193	890821	389	650	890824
70194	890821	374	550	
70195	890821	447	1010	
70196	890821	490	1300	
70197	890821	465	1200	
70198	890821	460	700	
70199	890825	477	1200	
70200	890825	435	1100	
70201	890825	469	1150	
70202	890825	394	650	890826
70203	890825	440	900	
70204	890825	445	1000	
70205	890825	440	850	
70206	890826	434	900	890829
70207	890826	495	1450	
70208	890826	515	1600	
70209	890826	435	950	
70210	890827	528	1525	890828
70211	890827	500	1450	
70212	890827	445	825	
70213	890827	476	1175	890827
70214	890827	437	900	
70215	890827	385	550	
70216	890827	485	1350	
70217	890827	485	1250	
70218	890827	501	1350	
70219	890827	475	1150	
70220	890827	475	1050	
70221	890827	437	950	890828
70222	890827	466	1100	
70223	890827	470	1050	
70224	890827	395	750	
70225	890827	475	1300	
70227	890827	416	750	
70228	890827	475	1100	
70229	890827	391	650	890827
70230	890827	490	1300	
70231	890827	460	1000	
70232	890827	483	1250	
70233	890827	513	1450	890828
70234	890827	442	1000	
70235	890828	460	1200	890829
70236	890828	495	1350	
70237	890828	490	1150	890828
70238	890828	400	650	890828
70239	890828	338	550	
70240	890828	418	925	890828
70241	890828	470		890828
70242	890828	405	600	890828
70243	890828	346	400	

APPENDIX 2. Cont'd

TAG #/ CODE	DATE TAGGED	FORK LN (mm)	RND WT (g)	RECAP DATE
70246	890828	315	400	890829
70248	890828	474	1100	890829
70249	890828	394	650	890829
70250	890828	320	350	
70251	890828	435	900	890829
70252	890828	470	1050	890000
70253	890828	392	550	
70254	890828	460	1200	
70255	890828	457	1250	
70256	890828	305	500	
70257	890828	305	400	
70258	890828	340	600	890830
70259	890828	305	450	
70260	890828	330	600	
70261	890828	440	750	
70262	890829	329	450	
70263	890829	291	250	
70264	890829	427	750	890829
70265	890829	435	1050	890829
70266	890829	310	350	
70267	890829	308	300	
70268	890829	296	250	
70269	890829	319	300	890829
70270	890829	319	350	
70271	890829	316	450	890830
70272	890829	422	800	
70273	890829	359	450	
70274	890829	385	600	890829
70275	890829	420	750	
70276	890829	540	1950	
70277	890829	300	250	890830
70278	890829	397	600	
70279	890829	425	750	
70280	890829	347	450	
70281	890829	385	550	
70282	890829	334	550	
70283	890829	295	260	
70284	890829	455	950	
70285	890829	275	250	
70286	890829	305	350	
70287	890829	281	250	
70288	890829	478	1150	890830
70289	890829	446	900	
70290	890829	310	400	
70291	890829	334	450	
70292	890829	309	450	
70293	890829	331	500	
70294	890829	319	400	
70296	890829	305	250	
70297	890829	395	700	
70298	890829	280	250	
70299	890829	345	550	890830
70300	890829	407	850	890830
70302	890829	320	450	
70303	890829	441	1000	
70304	890829	430	1050	
70305	890829	335	500	
70306	890829	370	450	
70307	890829	300	250	
70308	890829	492	1250	890830
70309	890829	310	400	
70310	890829	326	350	890830
70311	890829	461	1050	
70312	890829	388	600	
70313	890829	328	400	890830
70314	890829	319	450	
70315	890829	325	400	
70316	890829	290	250	
70317	890830	320	400	
70318	890830	315	400	
70319	890830	350	400	
70320	890830	320	300	
70321	890830	330	450	
70322	890830	325	400	
70323	890830	320	400	
70324	890830	320	400	
70325	890830	295	300	
70326	890830	297	250	
70327	890830	315	450	
70328	890830	295	250	
70329	890830	290	250	
70330	890830	323	410	890830
70331	890830	330	450	
70332	890830	458	1050	
70333	890830	327	430	
70334	890830	300	350	
70335	890830	328	450	
70336	890830	330	500	
70337	890830	318	400	
70338	890830	304	250	
70339	890830	330	450	
70340	890830	305	400	890900
70341	890830	418	800	
70342	890830	320	350	
70343	890830	335	400	
70344	890830	335	450	
70345	890830	445	1050	890901
70346	890830	333	550	
70347	890830	329	400	
70348	890830	340	500	
70349	890906	385		
70350	890830	505	1450	
70351	890830	485	1200	
70352	890906	335		
70353	890830	315	400	
70354	890906	320		
70355	890830	324	400	
70356	890830	325	350	
70357	890906	310		
70358	890830	287	350	
70359	890830	410	750	890830
70360	890830	300	350	
70361	890830	285	250	
70362	890830	295	250	
70363	890830	285	250	
70364	890830	276	200	
70365	890830	305	400	
70366	890830	468	1150	890830

APPENDIX 2. Cont'd

TAG #/ CODE	DATE TAGGED	FORK LN (mm)	RND WT (g)	RECAP DATE
70368	890830	290	270	
70369	890830	400	750	
70370	890830	325	550	
70371	890830	329	410	
70372	890830	299	400	
70373	890830	305	350	
70374	890830	298	350	
70375	890830	285	300	
70376	890830	338		
70377	890830	308		
70379	890830	317		
70380	890830	307		
70381	890830	300		
70382	890830	310		
70383	890830	333		
70384	890830	317		
70385	890830	393		
70386	890830	327		
70387	890830	320		
70388	890830	473		
70389	890830	315		
70390	890830	329		
70391	890830	309		
70392	890830	279		
70393	890830	308		
70395	890830	273		
70396	890830	310		
70397	890830	319		
70398	890830	320		
70399	890830	310		890831
70400	890830	310		
70401	890831	390		
70402	890831	415		890831
70403	890831	303		
70404	890831	368		
70405	890831	326		
70406	890831	291		
70407	890831	413		
70408	890831	311		
70409	890831	345		
70410	890831	330		
70411	890831	314		
70412	890831	290		
70413	890831	306		
70414	890831	295		
70415	890831	278		
70416	890831	340		
70417	890831	298		
70418	890831	325		
70419	890831	340		
70420	890831	305		
70421	890831	320		
70422	890831	325		
70423	890831	335		
70424	890831	320		
70425	890831	290		
70426	890831	329		890901
70427	890831	330		
70428	890831	322		
70429	890831	335		
70431	890831	465		
70434	890831	335		
70435	890831	340		
70436	890831	380		890831
70437	890831	310		
70438	890831	335		890831
70439	890831	335		
70440	890831	345		
70441	890831	310		890831
70442	890831	300		
70443	890831	290		
70444	890831	297		
70445	890831	315		
70446	890831	515		
70447	890831	315		
70448	890831	317		
70449	890831	321		
70450	890831	283		
70451	890831	278		
70452	890831	340		
70453	890831	315		
70454	890831	301		
70456	890831	378		
70457	890831	305		
70458	890831	423		890901
70459	890831	320		
70460	890831	330		
70461	890831	347		
70464	890831	335		
70466	890831	296		
70467	890831	325		
70468	890831	327		
70469	890831	325		
70470	890901	330		
70472	890901	400		
70473	890901	348		
70474	890901	333		
70475	890901	370		
70476	890819	379	550	
70477	890819	293	250	
70478	890819	436	850	
70479	890819	401	750	
70480	890819	421	750	
70481	890901	315		
70482	890901	330		
70483	890901	311		
70484	890901	302		
70485	890901	314		
70486	890901	332		
70487	890901	310		
70488	890901	325		
70489	890901	310		
70490	890901	285		
70491	890901	485		890902
70492	890901	345		890902
70493	890901	318		
70494	890901	322		
70495	890901	302		
70496	890901	335		890912
70498	890901	335		
70499	890901	316		
70500	890901	319		

APPENDIX 2. Cont'd

TAG #/ CODE	DATE TAGGED	FORK LN (mm)	RND WT (g)	RECAP DATE
70505	890901	332		
70506	890901	325		
70507	890901	301		
70508	890901	325		
70509	890901	302		
70510	890901	400		
70511	890901	316		
70512	890901	302		
70513	890901	351		
70514	890901	348		890903
70515	890901	321		890904
70516	890901	388		
70517	890901	310		
70518	890901	346		
70519	890901	327		
70520	890901	326		
70521	890901	323		
70522	890901	313		
70524	890901	312		
70525	890901	302		
70526	890901	310		
70527	890901	303		
70528	890901	332		
70529	890901	337		
70530	890901	322		
70532	890901	330		
70533	890901	345		
70534	890901	332		
70535	890901	432		890902
70536	890901	333		
70537	890901	297		
70538	890901	310		
70539	890901	323		
70540	890901	319		
70541	890901	298		
70542	890901	318		
70543	890901	315		
70544	890901	305		
70547	890901	267		
70548	890901	411		
70549	890901	330		
70550	890901	325		
70551	890901	312		
70552	890901	285		
70553	890901	317		
70554	890901	314		890900
70555	890901	302		
70556	890902	315		
70557	890902	347		
70558	890902	310		
70559	890902	335		
70560	890902	355		
70561	890902	310		
70562	890902	350		
70563	890902	320		
70564	890902	295		
70567	890902	350		890915
70568	890902	310		
70569	890902	320		
70570	890902	320		
70571	890902	360		
70572	890902	350		890903
70573	890902	325		
70574	890902	325		
70575	890902	310		
70576	890902	315		
70577	890902	330		
70578	890902	405		
70579	890902	440		
70580	890902	323		
70581	890902	415		890903
70582	890902	320		
70583	890902	415		
70584	890902	350		
70585	890902	325		
70586	890902	335		
70587	890902	320		
70588	890902	308		
70589	890902	345		
70590	890902	330		
70591	890902	320		
70592	890902	300		
70593	890902	317		
70594	890902	305		
70595	890902	317		
70596	890902	317		
70597	890902	320		
70598	890902	330		
70599	890902	333		
70600	890902	328		
70601	890902	340		
70602	890902	305		
70603	890902	320		
70604	890902	300		
70605	890902	300		
70606	890902	335		
70607	890902	315		
70608	890902	320		
70609	890902	332		
70611	890902	318		
70612	890902	334		890904
70613	890902	359		890903
70614	890902	345		
70615	890902	349		
70616	890902	401		
70617	890902	338		
70618	890906	350		
70619	890902	324		
70620	890902	482		
70621	890902	349		
70622	890902	291		
70623	890902	324		

APPENDIX 2. Cont'd

TAG #/ CODE	DATE TAGGED	FORK LN (mm)	RND WT (g)	RECAP DATE
70626	890902	298		
70627	890902	490		890903
70628	890902	330		
70629	890902	402		
70630	890902	320		
70631	890902	293		
70632	890902	320		
70633	890902	317		
70634	890902	334		
70635	890902	305		
70636	890902	475		
70637	890902	330		
70638	890902	305		
70639	890902	280		
70640	890902	301		
70641	890902	287		
70642	890902	434		
70643	890902	330		
70644	890902	325		
70645	890902	341		
70646	890902	305		
70647	890902	302		
70648	890902	325		890904
70649	890902	314		
70650	890902	315		
70651	890902	398		
70652	890902	360		
70653	890902	341		
70654	890902	320		
70655	890902	430		
70656	890902	282		
70657	890902	311		
70658	890902	308		
70659	890902	345		
70660	890902	357		
70661	890902	335		
70662	890902	387		
70663	890902	291		
70664	890902	333		890902
70665	890902	431		
70666	890902	295		
70667	890902	323		
70668	890902	394		890904
70669	890902	301		890904
70670	890902	320		
70671	890902	318		
70672	890902	326		
70673	890902	306		
70674	890902	335		890903
70676	890902	295		
70677	890902	280		890900
70678	890902	273		
70679	890902	309		
70680	890903	520		890903
70681	890903	320		
70682	890903	340		
70683	890903	295		
70684	890903	345		
70685	890903	345		
70686	890903	450		890904
70687	890903	390		
70690	890903	330		
70691	890903	345		
70692	890903	325		
70693	890903	330		
70694	890903	520		890903
70695	890903	360		
70696	890903	295		
70697	890903	390		
70698	890903	410		
70699	890903	430		
70700	890903	330		
70701	890903	310		
70702	890903	330		
70703	890903	323		
70704	890903	323		
70705	890903	305		
70706	890903	335		
70707	890903	354		
70708	890903	354		
70709	890903	320		
70710	890903	300		
70711	890903	315		
70712	890903	425		
70713	890903	330		
70714	890903	300		
70715	890903	310		
70716	890903	375		890903
70717	890903	420		
70718	890903	315		
70719	890903	305		
70720	890903	330		
70721	890903	317		
70722	890903	323		
70723	890903	315		
70724	890903	312		
70725	890903	300		
70726	890904	320		
70727	890904	412		890905
70728	890904	407		
70729	890904	461		890904
70730	890904	343		
70731	890904	325		
70732	890904	320		
70733	890904	407		
70734	890904	325		
70735	890904	309		
70736	890904	358		
70737	890904	321		
70738	890904	320		
70739	890904	315		
70740	890904	318		
70741	890904	320		
70742	890904	320		
70743	890904	335		
70744	890904	308		
70745	890904	315		
70746	890904	519		890905
70747	890904	319		
70748	890904	421		
70749	890904	337		
70750	890904	373		890904

APPENDIX 2. Cont'd

TAG #/ CODE	DATE TAGGED	FORK LN (mm)	RND WT (g)	RECAP DATE
70753	890904	460		
70754	890904	311		
70755	890904	337		890905
70756	890904	308		
70757	890904	407		
70758	890904	360		
70759	890904	319		
70760	890904	335		
70761	890904	311		
70762	890904	339		
70763	890904	325		
70764	890904	318		
70765	890904	318		
70766	890904	350		890905
70767	890904	335		890905
70768	890904	404		
70769	890904	340		
70770	890904	320		
70771	890904	485		
70772	890904	340		
70773	890904	325		
70774	890904	330		
70775	890904	350		
70776	890904	425		
70777	890904	350		890905
70778	890904	300		
70779	890904	315		
70780	890904	365		
70781	890904	330		
70782	890904	325		
70783	890904	315		
70784	890904	300		
70785	890904	305		
70785	890905	330		
70786	890905	345		890905
70787	890905	330		
70788	890905	335		
70789	890905	335		
70790	890905	340		890906
70791	890905	345		
70792	890905	325		
70793	890905	330		
70794	890905	300		
70795	890905	336		
70796	890905	375		890906
70797	890905	405		
70798	890905	325		
70799	890905	320		
70800	890905	330		
70801	890905	325		
70802	890905	325		
70803	890905	315		
70804	890905	314		
70805	890905	315		
70806	890905	320		
70807	890905	295		
70808	890905	320		
70809	890905	290		
70810	890905	300		
70811	890905	370		
70812	890905	335		
70813	890905	330		
70814	890905	340		
70815	890905	310		
70816	890905	340		
70821	890905	310		
70822	890905	347		
70823	890905	370		
70824	890905	332		890905
70825	890905	320		
70826	890905	324		
70827	890905	310		
70828	890905	285		
70829	890905	330		
70830	890905	278		
70831	890905	300		
70832	890905	424		890906
70833	890905	328		
70834	890905	330		
70835	890905	320		
70836	890905	335		
70837	890905	430		
70838	890905	345		
70839	890905	360		890906
70840	890905	320		
70841	890905	330		
70842	890905	300		
70843	890905	355		890905
70844	890905	350		
70845	890905	330		
70846	890905	350		
70847	890905	330		
70848	890905	320		
70849	890905	313		
70850	890905	320		
70851	890906	340		
70853	890906	327		
70855	890906	452		
70856	890906	320		
70857	890906	320		
70858	890906	317		
70859	890906	347		
70860	890906	354		890907
70861	890906	295		
70863	890906	315		
70864	890906	308		
70865	890906	310		
70866	890906	320		
70867	890906	328		
70868	890906	330		
70869	890906	310		
70870	890906	342		
70871	890906	307		
70872	890906	301		
70873	890906	290		
70874	890906	335		
70875	890906	331		890906
70876	890906	318		
70877	890906	480		
70878	890906	318		
70879	890906	340		
70880	890906	342		

APPENDIX 2. Cont'd

TAG #/ CODE	DATE TAGGED	FORK LN (mm)	RND WT (g)	RECAP DATE
70883	890906	322		
70884	890906	325		890906
70885	890906	325		
70886	890906	327		
70887	890906	367		
70888	890906	358		
70889	890906	350		
70890	890906	319		
70891	890906	304		
70892	890906	314		
70893	890906	317		
70894	890906	309		
70895	890906	305		
70896	890906	415		
70898	890906	470		
70899	890906	345		
70900	890906	340		
70901	890906	305		
70902	890906	305		
70903	890906	320		
70904	890906	320		
70905	890906	325		
70906	890906	405		890907
70907	890906	335		
70908	890906	285		
70909	890906	330		
70910	890906	305		
70911	890906	315		
70912	890906	307		
70913	890906	323		
70914	890907	334		890908
70915	890907	309		
70916	890906	295		
70917	890907	350		
70918	890907	433		
70919	890907	415		
70920	890907	420		
70921	890907	357		
70922	890907	340		
70923	890907	325		
70924	890907	315		
70925	890907	329		
70926	890907	310		
70927	890907	295		
70928	890907	315		
70929	890907	360		890909
70930	890907	470		
70931	890907	355		890908
70932	890907	330		
70933	890907	340		
70934	890907	410		890911
70935	890907	325		
70936	890907	300		
70937	890907	350		
70938	890907	335		
70939	890907	340		890907
70940	890907	345		
70941	890907	330		
70942	890907	310		
70943	890907	315		
70944	890907	406		
70945	890907	430		
70946	890907	475		890908
70947	890907	517		
70948	890907	395		
70949	890907	436		
70950	890907	495		
70951	890907	355		
70952	890907	328		
70953	890907	345		
70954	890907	317		890912
70955	890907	443		
70956	890907	346		
70957	890907	395		
70958	890907	410		
70959	890907	340		
70960	890907	333		
70961	890907	330		
70962	890907	312		890910
70963	890907	320		
70964	890907	323		
70965	890907	443		
70966	890907	327		
70967	890907	300		
70968	890911	405		
70969	890911	445	1000	890912
70970	890911	335		
70971	890911	413		
70972	890911	298		
70973	890911	365		
70974	890911	330		
70975	890911	345		
70976	890911	345		
70977	890912	320		
70978	890912	345		
70979	890912	310		
70980	890912	442		
70981	890912	340		
70982	890912	311		
70983	890912	405		
70984	890912	332		
70985	890912	328		
70986	890912	430		
70987	890912	435		
70988	890912	350		
70989	890912	415		
70990	890912	340		890913
70991	890912	410		890913
70992	890912	345		
70993	890912	352		
70995	890912	450		
70997	890912	350		
70998	890912	330		
70999	890912	335		
71000	890912	405		
AC001	890808	448		
AC022	890814	480		
AC048	890815	477		
AC073	890818	290		
AC078	890818	445		
AC094	890819	284		
AC100	890820	300		
AC138	890825	318		
AC146	890825	290		
AC149	890827	323		
AC159	890828	290		
AC160	890828	231		
AC167	890828	417		

APPENDIX 2. Cont'd

TAG #/ CODE	DATE TAGGED	FORK LN (mm)	RND WT (g)	RECAP DATE
AC172	890829	387		
AC173	890829	317		
AC177	890830	268		
AC190	890831	377		
AC191	890831	345		
AC196	890831	285		
AC197	890901	337		
AC198	890901	280		
AC211	890902	268		
AC212	890902	284		
AC213	890902	290		
AC228	890902	317		
AC229	890903	296		
AC254	890904	422		
AC269	890904	265		
0	890901	283		
0	890901	310		
0	890902	295		
0	890902	315		
0	890902	314		
0	890902	332		
0	890902	329		
0	890902	308		
0	890902	276		
0	890902	371		
0	890902	300		
0	890902	335		
0	890902	340		
0	890902	323		
0	890902	295		
0	890902	320		
0	890902	275		
0	890902	322		
0	890902	277		
0	890902	320		
0	890903	304		
0	890903	305		
0	890903	319		
0	890903	302		
0	890903	290		
0	890903	313		
0	890903	286		
0	890903	304		
0	890903	351		
0	890903	325		
0	890903	401		
0	890903	308		
0	890903	341		
0	890903	320		
0	890903	351		
0	890903	338		
0	890903	350		
0	890903	326		
0	890903	282		
0	890903	277		
0	890903	307		
0	890903	291		
0	890903	280		
0	890903	308		
0	890903	283		
0	890903	322		
0	890903	291		
0	890903	323		
0	890903	305		
0	890903	353		
0	890903	323		
0	890904	322		
0	890904	315		
0	890904	295		
0	890904	292		
0	890904	293		
0	890904	320		
0	890904	290		
0	890904	291		
0	890904	300		
0	890904	290		
0	890904	310		
0	890904	285		
0	890904	300		
0	890904	315		
0	890904	291		
0	890904	485		
0	890904	295		
0	890904	285		
0	890904	299		
0	890904	312		
0	890904	295		
0	890905	320		
0	890905	320		
0	890905	320		
0	890905	317		
0	890905	405		
0	890905	310		
0	890905	335		
0	890905	360		
0	890905	310		
0	890905	335		
0	890905	330		
0	890905	340		
0	890905	210		
0	890905	380		
0	890905	300		
0	890905	350		
0	890905	370		
0	890905	315		
0	890905	330		
0	890905	305		
0	890905	290		
0	890905	310		
0	890905	330		
0	890905	292		
0	890905	402		
0	890905	340		
0	890905	338		
0	890905	330		
0	890905	350		
0	890905	404		
0	890905	415		
0	890906	355		
0	890906	440		
0	890907	350		
0	890907	315		
0	890907	308		
0	890907	235		
0	890907	340		
0	890907	430		
0	890907	300		
0	890907	335		