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Abundance, Length, and Age Composition of Chatanika River Round Whitefish, 1991

by

Renate R. Riffe

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ABSTRACT

Abundance of round whitefish *Prosopium cylindraceum* was estimated in a 124 kilometer section of the Chatanika River between the Elliott Highway Bridge and the Murphy Dome extension road with a Petersen mark-recapture experiment. Abundance was estimated at 7,913 fish (standard error = 1,944) over 239 millimeters of fork length. The dominant year class was age 3, followed by ages 4 and 5. Estimates of overall mortality, fishing mortality, and natural mortality rates were calculated using the abundance estimate, age composition, and the median harvest estimate from creel surveys. A von Bertalanffy growth equation was calculated. Age composition and mean length-at-age was compared to other age and growth studies of round whitefish.

KEY WORDS: round whitefish, *Prosopium cylindraceum*, Chatanika River, abundance estimate, length composition, age composition, mean length, growth.

INTRODUCTION

The Chatanika River has supported the largest recreational fishery for whitefish in the state of Alaska. The harvest of whitefish from this fishery comprised 24% of the Alaskan harvest in 1977, and increased to a high of 77% of the Alaskan harvest in 1987 (Table 1; Mills 1979-1990). The fishery targets humpback whitefish *Coregonus pidschian* and least cisco *C. sardinella*. Round whitefish *Prosopium cylindraceum* are caught incidentally. Between 1972 and 1986, the percentage of the catch represented by round whitefish varied from 1 to 10%, and averaged 6% (Hallberg and Holmes 1987). The number of whitefish harvested from the Chatanika River increased from 1,365 fish in 1977 to a high of 25,704 fish in 1987, just prior to the implementation of the bag limits intended to reduce the harvest (Mills 1979-1990; Timmons 1990). The fishery was closed by Emergency Order part way through the 1990 fishery and again prior to the 1991 fishery due to conservation concerns.

The increase in popularity of the whitefish sport fishery in the Chatanika River, and concerns over levels of sustainable harvest of humpback whitefish and least cisco, has focused attention on these two species. Little has been done to study the dynamics of the round whitefish population in the Chatanika River. The purpose of this study was to investigate the age and growth characteristics of round whitefish in the Chatanika River and to provide an estimate of abundance for the population. Specific objectives were to:

1. estimate abundance;

2. estimate age composition;

3. estimate rates of overall mortality, fishing mortality, and natural mortality; and,

4. estimate mean length-at-age, develop a mean length-at-age relationship, and compare these data to other published studies.

METHODS

The study was divided into a marking event consisting of two marking passes, and a recapture event consisting of one pass. A pass took four to six days to complete, and involved capturing and tagging fish from 15 km upstream of the Elliot Highway Bridge to the Murphy Dome Road extension, a distance of 124 km. This stretch of the river was further subdivided into 12 sublocations, based upon geographical markers and different habitats (Figures 1 and 2). The sublocations were used in testing assumptions and in stratifying the abundance estimate.

The first and second marking passes lasted from 11 July to 16 July 1991, and from 23 August to 26 August 1991, respectively. The recapture event took place from 9 September to 14 September 1991. The first marking pass was characterized by very low water levels, while the second pass took place during high water levels, just after the river was at flood stage.

Table 1. Whitefish harvests from the Chatanika River, Tanana River, and Alaska from 1977 to 1990.[a]

Part 1. Estimated whitefish harvests from the Chatanika River, Tanana River, and state of Alaska, from postal questionnaires, 1977-1990.[a]

Year	Chatanika	Tanana Drainage	Alaska	Chatanika Harvests as Percent of Tanana Drainage	Chatanika Harvests as Percent of Alaska
1977	1,635	3,378	6,748	48	24
1978	6,013	6,573	11,713	91	51
1979	3.021	5,159	9,666	59	31
1980	3,340	5,958	11,464	56	29
1981	3,185	4,873	9,251	65	34
1982	6,640	8,643	15,433	77	43
1983	5,895	8,311	16,872	71	35
1984	9,268	11,658	16,719	79	55
1985	14,350	20,230	30,337	71	47
1986	22,038	26,810	39,718	82	55
1987	25,074	27,159	32,602	92	77
1988	7,983	11,775	20,312	68	39
1989	15,542	16,935	24,337	92	64
1990	5,216	6,891	15,595	76	33

[a] Data source: Mills (1979-91).

Part 2. Estimated whitefish harvests from the Chatanika River, by species from creel surveys, 1986 to 1990.[a]

Year	Humpback Whitefish	Least Cisco	Round Whitefish
1986	2,528	16,575	583
1987	3,072	15,931	187
1988	3,571	4,456	299
1989	3,835	9,784	2,449[b]
1990	957	5,396	148

[a] Data Sources: Clark and Ridder 1987, Baker 1988, Baker 1989, Merritt et al. 1990, Hallberg and Bingham 1991.

[b] Estimate includes round whitefish and unidentified whitefish.

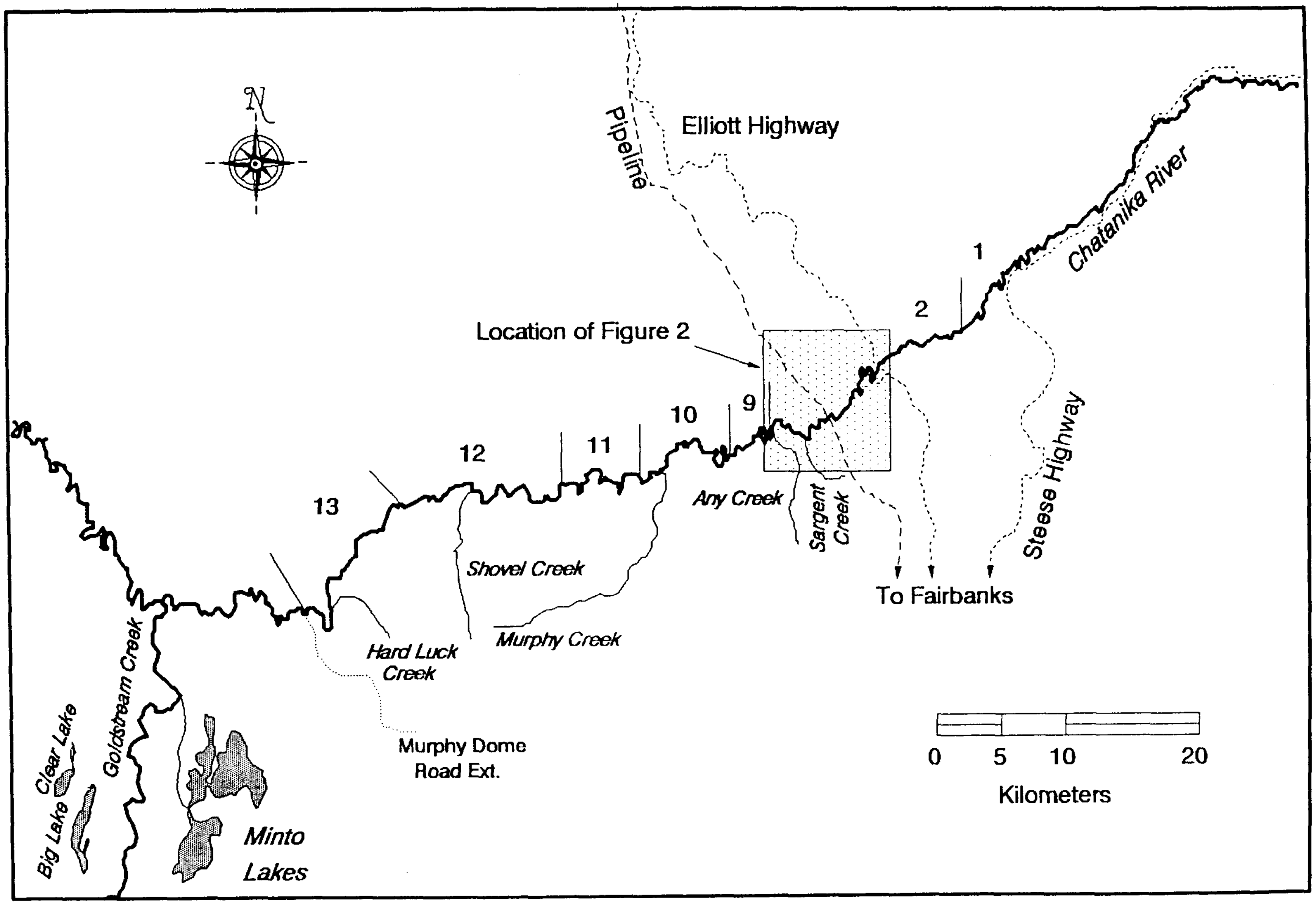


Figure 1. Study sections of the Chatanika River in 1991.

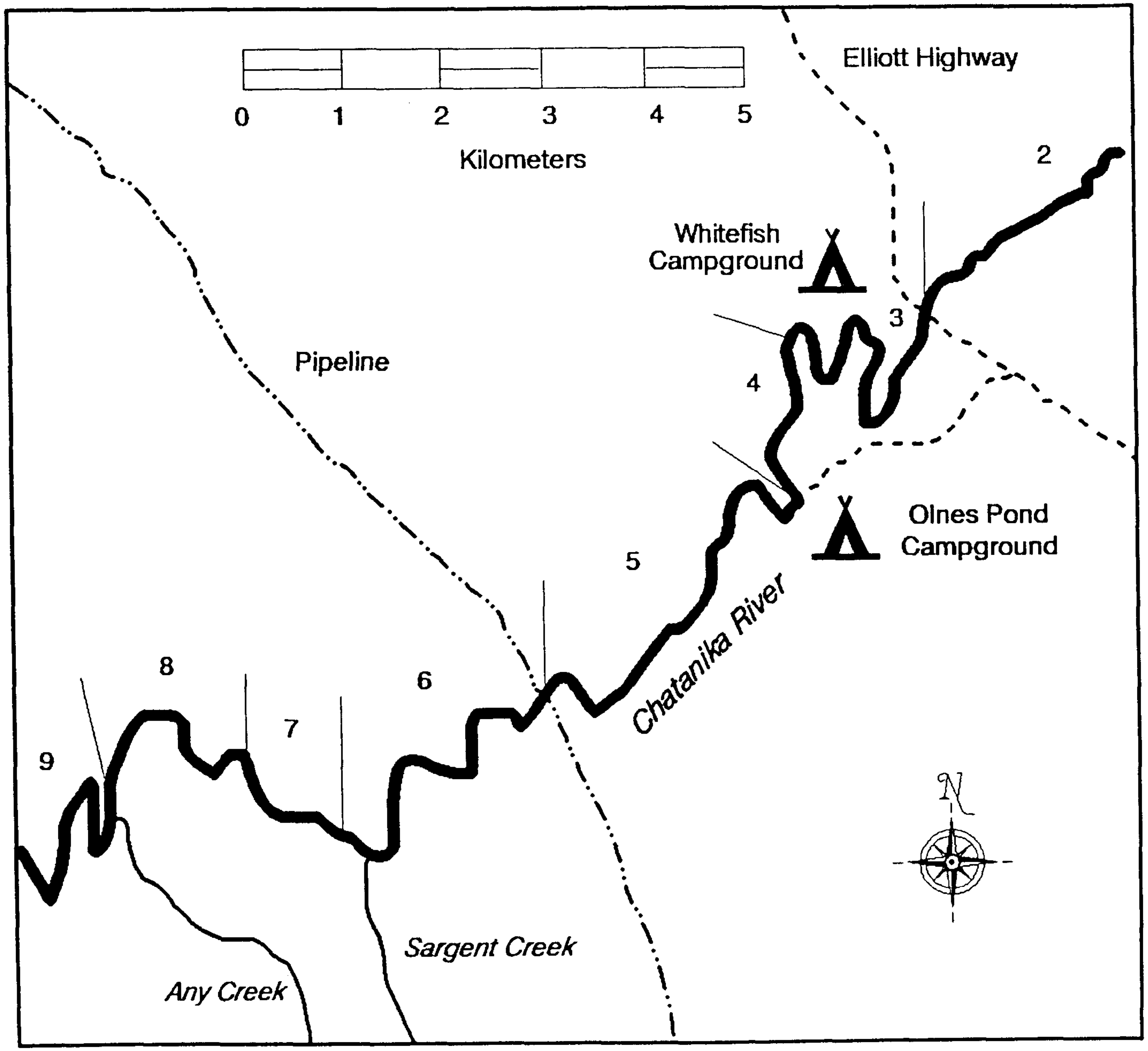


Figure 2. Study sections of the Chatanika River in 1991 between the Elliott Highway and Any Creek.

The fish were captured using pulsed direct current from a generator and variable voltage pulsator mounted on a boat. The applied voltages and currents varied from 260 to 300 volts, and 2 to 5 amps, depending upon conductivity, water level, and degree of visibility. The signal had a pulse rate of 60 cycles per second, with a 50% pulse width. The fish were netted and placed into a tub with circulating water. In addition to round whitefish, the fish captured for marking included humpback whitefish, least cisco, Arctic grayling *Thymallus arcticus*, sheefish *Stenodus leucichthys*, northern pike *Esox lucius*, and burbot *Lota lota*.

After a number of fish had been captured, they were transferred to a second boat where the data were collected. A length measurement to the nearest millimeter was taken from the tip of the snout to the fork of the tail (FL). Three scales per fish were taken from above the lateral line and below the dorsal fin. The scales were mounted directly on gum cards. An individually numbered Floy tag was inserted at the base of the dorsal fin and the number on the tag was recorded. Round whitefish received an adipose clip as a secondary mark. The fin clip was used to recognize fish which had been caught and tagged previously, but had lost the Floy tag. Floy tag numbers from earlier marks and tag losses were also recorded. The fish were then released. During the recapture event, sex was recorded whenever sex products could be extruded, but virtually all of the fish which were sexed were males.

Abundance Estimate

Certain assumptions must be fulfilled in order to achieve unbiased estimates of abundance from two-event mark-recapture experiments (Seber 1982):

1. The population is closed during the estimation study;

2. Marking does not affect the catchability of the fish;

3. Fish do not lose their marks between sampling events;

4. The marked fish become completely mixed with the unmarked fish between sampling events: <u>or</u>, every fish has the same probability of being caught and released during the marking event(s): <u>or</u>, every fish has the same probability of being caught in the recapture event; and,

5. All marked fish are recorded during the recapture event.

Migration as a factor affecting population closure (Assumption 1) was studied by reviewing sublocations where individual fish were marked and recaptured. Growth (recruitment) was examined (Assumption 1) by checking for a change in length of recaptured fish between the events via a paired t-test. Since several of the assumptions could not be tested, procedures were used to minimize their violation. Fish were handled as swiftly and carefully as possible to reduce mortalities, and the marks used were assumed to have little effect on fish behavior and mortality (Assumption 2). Secondary marks were employed to adjust for tag losses (Assumptions 3 and 5).

A series of tests was performed to verify Assumption 4. A chi-square test was used to determine whether (complete) mixing occurred between marked and unmarked fish. Two Kolmogorov-Smirnov (K-S) tests and a chi-square test were used to ascertain whether fish of all sizes had the same probability of being caught. One K-S test was used to examine lengths of fish during the marking passes versus recaptured fish. The second K-S test was used to examine lengths of fish caught in the marking event versus fish caught in the recapture event. A chi-square test was used to investigate probabilities of capture in different sublocations of the study.

As a result of the K-S and chi-square tests, abundance was estimated with Bailey's modification of the Petersen estimate (Bailey 1951, 1952). Bailey's version of the Petersen estimate and associated variance, intended to be used when Assumption 4 is fulfilled, is:

$$\hat{N} = \frac{M(C+1)}{(R+1)}; \text{ and,} \tag{1}$$

$$V[\hat{N}] = \frac{\hat{N}^2(C-R)}{(C+1)(R+2)}; \tag{2}$$

where:

C = total number of fish captured during the recapture event;

M = number of fish marked;

R = number of marked fish captured during the recapture event;

$\hat{N}$ = estimate of abundance of round whitefish in the Chatanika River in 1991; and,

$V[\hat{N}]$ = variance of the abundance estimate.

Virtually all methods of fish capture are selective with respect to size. Therefore any abundance estimate is valid only for that portion of the population within the range of the fish sampled. Since electrofishing is more effective on larger fish, the sample was truncated to include only fish large enough to be fully vulnerable to the method of capture, and, the population estimate was applied to round whitefish above a minimum size.

Age and Length Compositions

To estimate age compositions, the fish were assigned to an age class based upon the age derived from a scale sample. Age compositions were a series of proportions, one for each age class, which sum to 1. Age compositions and respective variances were estimated as follows:

$$\hat{p}_i = \frac{y_i}{n}; \text{ and,} \quad (3)$$

$$V[\hat{p}_i] = \frac{\hat{p}_i(1-\hat{p}_i)}{n - 1}; \quad (4)$$

where:

$\hat{p}_i$ = the estimated proportion of fish of age i in the population;

y_i = the number of fish of age class i in the sample;

n = the number of fish in the sample; and,

$V[\hat{p}_i]$ = the variance of the estimated proportion of fish of age i in the population.

Length compositions were calculated as proportions with the same equations, with length class substituted for age. Mean length-at-age was calculated as the arithmetic mean of the lengths of all fish of age i in the sample. Associated standard errors were calculated using standard normal procedures. All fish in the study with an assigned age were used in calculating mean length at age.

The estimated abundance of round whitefish by age or length was calculated as:

$$\hat{N}_i = p_i N \quad (5)$$

The variance for $\hat{N}_i$ is a sum of the exact variance of a product (Goodman 1960):

$$V[\hat{N}_i] = V[\hat{p}_i]N^2 + V[\hat{N}]\hat{p}_i^2 - V[\hat{p}_i]V[\hat{N}] \quad (6)$$

Mortality Rates

Estimates of the overall mortality rate, fishing mortality rate, and natural mortality rate were calculated from a non-linear least squares regression analysis, using estimated abundance, age composition, and estimated annual harvest of round whitefish in the Chatanika River. The assumptions of the analysis are: the recruitment of round whitefish is stable; the overall mortality rate is constant; and, the estimated annual harvest is too small to influence natural mortality. Mean annual harvest was calculated using harvest estimates from creel surveys between 1986 and 1990. The equations used in the analysis are as follows:

$$Z = F+M; \tag{7}$$

$$B_t = B_0(1 - e^{-Z*t}); \tag{8}$$

where:

Z = the overall instantaneous mortality rate;

F = the instantaneous fishing mortality rate;

M = the instantaneous natural mortality rate;

B_t = number surviving at time t; and,

B_0 = initial cohort size.

Growth Equation

A von Bertalanffy growth curve was developed through a non-linear weighted least squares regression analysis, using mean lengths-at-age. The mean-lengths-at age were calculated using data from fish of all sizes captured during the study. The Marquardt compromise (Marquardt 1963) was used to fit the three von Bertalanffy parameters. The von Bertalanffy growth equation is:

$$l_t = L_\infty(1 - e^{(-K(t-t_0))}); \tag{9}$$

where:

l_t = length of fish at age t;

L_∞ = maximum size an average fish would attain if left to grow indefinitely;

K = the Brody growth coefficient, a dimensionless variate that regulates incremental growth; and,

t_0 = the hypothetical age at which a fish would have a length of zero.

RESULTS

Round whitefish were found in all areas sampled during the July, August, and September sampling events. In July, 219 fish were tagged and released, and 165 fish were tagged and released in August, for a total of 384 fish. Two fish tagged in July were recaptured in August. In September, 684 fish were examined for tags. A total of 14 recaptures and no tag losses were observed (Table 2).

Abundance Estimate

Migration was discounted as a factor affecting population closure because recaptured fish exhibited no directed movement (Table 2). Nine of 14 recaptures were caught in the same sublocation where they were marked, while three were recaptured in downstream sublocations, and two were caught upstream. Growth did not affect population closure, as the 14 recaptured fish did not grow significantly during the hiatus between the mark and the recapture events ($t = 1.31$, $P = 0.217$).

The fish which were marked and later recaptured ranged in length from 244 mm to 340 mm (FL) (Table 2). The size range of fish caught in either the mark or the recapture event was from 150 mm to 470 mm. The proportion of fish larger than 340 mm was about 5%, while those fish smaller than 244 mm constituted about 35% of the fish sampled. Since no tags were recovered from smaller fish, the population estimate pertains only to the larger fish. The minimum size for fish included in the population estimate was 240 mm.

Statistically significant differences between length distributions of fish marked and released in July and August and lengths of fish captured in September were found (Figure 3). Fish marked during July or August and recaptured in September did not have significant differences in length ($DN = 0.2$, $P = 0.999$). Fish caught in September were different in size than fish caught in July or August ($DN = 0.241$, $P < 0.001$). Thus, size selectivity was present in the marking event, but not in the recapture event. As a result, abundance of round whitefish was estimated with an unstratified data.

Due to the low number of recaptures, the sublocations were collapsed into two groups; sublocations 2 to 5; and, 6 to 13. Results of the chi-square test for mixing of marked with unmarked fish between sublocations was marginal (Table 3; $\chi^2 = 3.76$, $P = 0.052$). The capture rate in sublocations 2 to 5 was not significantly different from that in sublocations 6 to 13 (Table 3; $\chi^2 = 2.49$, $P = 0.115$). Hence, Bailey's modification of the Petersen population estimate was selected as the proper estimator. The estimate using Bailey's variation was 7,913 for fish over 239 mm, with a standard error of 1,944.

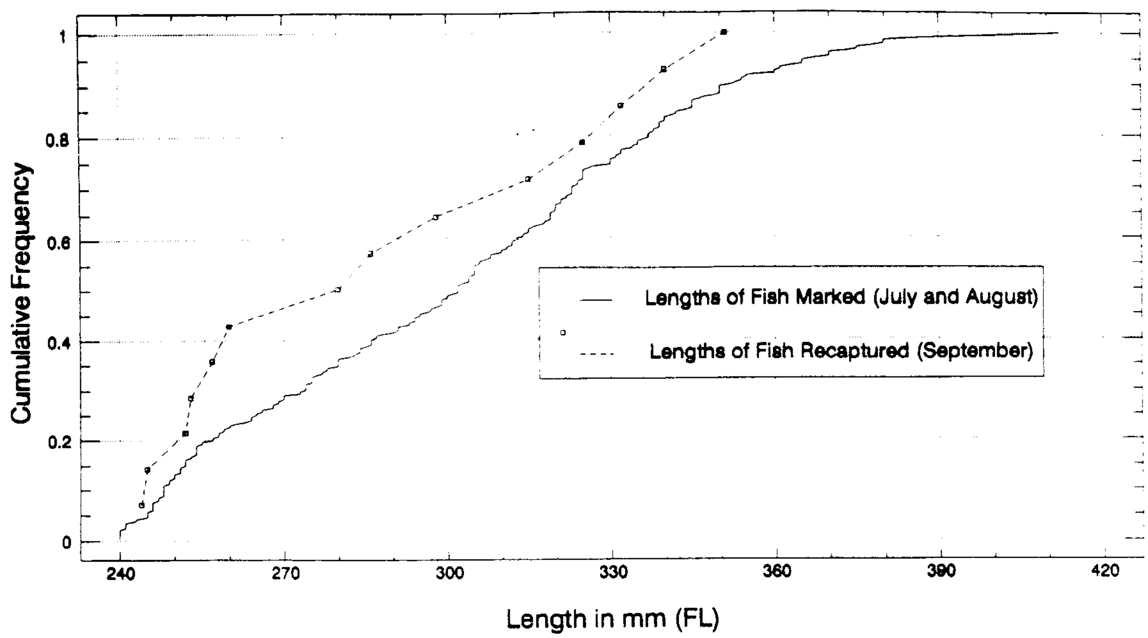
Age and Length Compositions

In view of the apparent size selectivity of the marking event versus the recapture event, only the age and size data collected in September was used to calculate age and length compositions. Proportions of age classes with respect to sex were not included because of lack of data concerning sex of most study fish.

Round whitefish collected from the Chatanika River in September ranged in size from 142 mm to 470 mm (FL). Since electrofishing is a size selective method of capture, smaller fish were not proportionately represented. Size at full recruitment into the method of fishing was approximately 240 mm (FL). The

Table 2. Length, marking dates, and marking and recovery sublocations of round whitefish recaptured in the Chatanika River, September 1991.

Tagging Date	Tag Number	Length	Tagging Sublocation	Recovery Sublocation
7/11	83014	286	2	2
7/11	83016	280	2	8
7/12	83354	332	7	2
7/13	83277	325	9	4
7/13	83326	351	9	9
7/16	409	298	12	12
7/16	600	253	12	9
8/23	1125	245	8	8
8/24	1601	340	10	10
8/25	3722	244	12	12
8/25	4495	252	12	12
8/26	5014	257	2	3
8/26	5145	315	6	6
8/26	4703	260	13	13



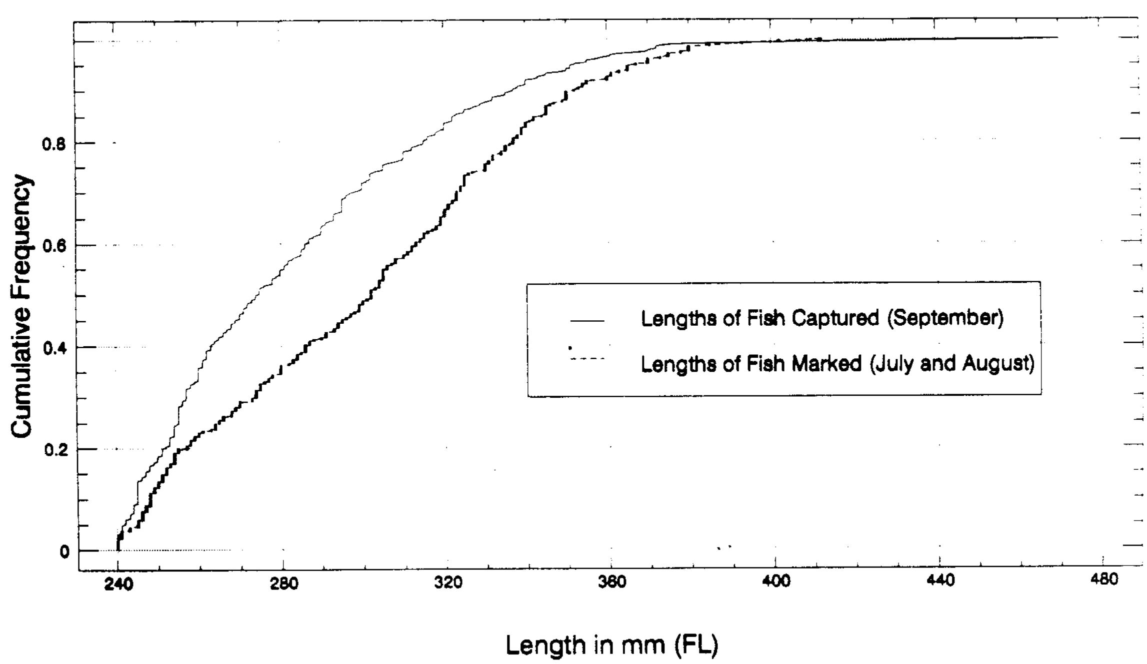


Figure 3. Cumulative distribution functions of lengths of round whitefish marked versus: (A) lengths of round whitefish recaptured; and, (B) lengths of round whitefish examined for marks.

Table 3. Numbers of 240 mm FL and larger round whitefish sampled by area during the mark-recapture experiment.

Part I. Number of round whitefish marked and released during event 1.[a]

Area Released	Recapture Locations: Areas 1-5	Recapture Locations: Areas 6-13	Total Recaptured	Number Not Recaptured	Total Released
1-5	3	1	4	83	87
6-13	2	8	10	264	274
Totals	5	9	14	347	361

[a] $\chi^2 = 3.76$, df = 1, $\rho = 0.052$, three cells have expected values less than five, one cell has an expected value less than two.

Part II. Number of round whitefish examined for marks during event 2.[a]

Category	Area of Capture: Areas 1-5	Area of Capture: Areas 6-13	Totals
Number of Fish With Marks	5	9	14
Number of Unmarked Fish	241	182	423
Totals	246	191	437
Proportion With Marks	0.020	0.047	0.032

[a] $\chi^2 = 2.489$, df = 1, $\rho = 0.115$.

youngest age class to be fully recruited was age 5. The age and size compositions are based upon fish $\geq$ 240 mm FL (Tables 4 and 5). The most numerous length class, 240 to 259 mm in fork length, comprised 32.95% of the fish 240 mm or larger. The second most numerous length class, 260 to 279 mm, comprised 20.59%.

The September sample of round whitefish $\geq$ 240 mm ranged in age from 2 to 11. Age 3 fish were the most numerous age class, and comprised 33% of the sample, with a mean fork length of 256 mm. Age 4 fish included 23% of the sample, and had a mean length of 268 mm. Age 5 fish comprised 24% of the sample, and had a mean length of 286 mm. Older age classes formed consistently smaller proportions of the population sampled. The two oldest fish in the sample were 10 and 11 years old, and were 410 and 470 mm long, respectively.

Mortality Rates

The large number of age classes and gradual reduction in proportion of older age classes suggests that the Chatanika River round whitefish population is stable and is not greatly affected by fishing mortality (Figures 4 and 5). An average fishing mortality of 243 fish was estimated as the median mortality from creel surveys between 1986 and 1990 (Table 1, part 2). A non-linear regression used age class composition multiplied by estimated total abundance for its data points (Table 5, Figure 6). Since the younger age classes were not fully recruited into the sampling method, only age classes 5 and older were used in the regression. The overall instantaneous mortality rate was estimated at 0.643 (Table 6), which results in a 47% annual mortality rate. Approximately 47% of 7,913 fish, or an estimated 3,753 fish over 240 mm die annually. Since approximately 243 fish are harvested annually, 6% of the total die due to fishing mortality, assuming that all harvested fish are over 240 mm, fork length. The estimated fishing mortality rate was 0.031. The estimated natural mortality rate was 0.612.

Mean Length-at-Age for Both Events

Since recaptured fish did not exhibit significant growth during the study, and the growth equation was not tied to the abundance estimate, all aged fish from both events were used in developing a growth equation for the round whitefish population. Age 1 fish ranged in size from 142 mm to 198 mm, and had a mean length of 220 mm (Table 7). Age 3 fish had a mean length of 239 mm, with a standard error of 1.4, and ranged in size from 187 to 302 mm.

Growth Equation

A von Bertalanffy growth curve was generated using age and length data from both events. A minimum sample size of five was required for inclusion of a given mean length-at-age into the growth equation. The maximum size an average round whitefish would attain in the Chatanika River (L_∞) was calculated at 457 mm (Table 8). The estimated age of the fish at hypothetical length zero (t_0) was -2.313.

Table 4. Length composition of round whitefish 240 mm FL and larger caught in the Chatanika River during September 1991.

Length	Number Sampled	Proportion	SE Proportion	Population Estimate	SE Population Estimate
240-259	144	0.330	0.023	2,607	532
260-279	90	0.206	0.019	1,630	565
280-299	73	0.167	0.018	1,332	570
300-319	52	0.119	0.016	942	584
320-339	38	0.087	0.014	688	593
340-359	25	0.057	0.011	453	609
360-379	11	0.025	0.008	199	627
380-480	4	0.009	0.005	72	694
Totals	437	1.000		7,913	

Table 5. Age composition of round whitefish 240 mm FL and larger caught in the Chatanika River during September 1991.

Age	Sample Size	Proportion	SE Proportion	Population Estimate	SE Population Estimate
2	2	0.007	0.005	57	41
3	70	0.251	0.026	1,985	527
4	63	0.226	0.025	1,787	479
5	67	0.240	0.026	1,900	506
6	39	0.140	0.021	1,106	315
7	24	0.086	0.017	680	211
8	8	0.029	0.010	227	95
9	4	0.014	0.007	113	61
10	1	0.004	-	29	-
11	1	0.004	-	29	-
Totals	279	1.0000		7,913	

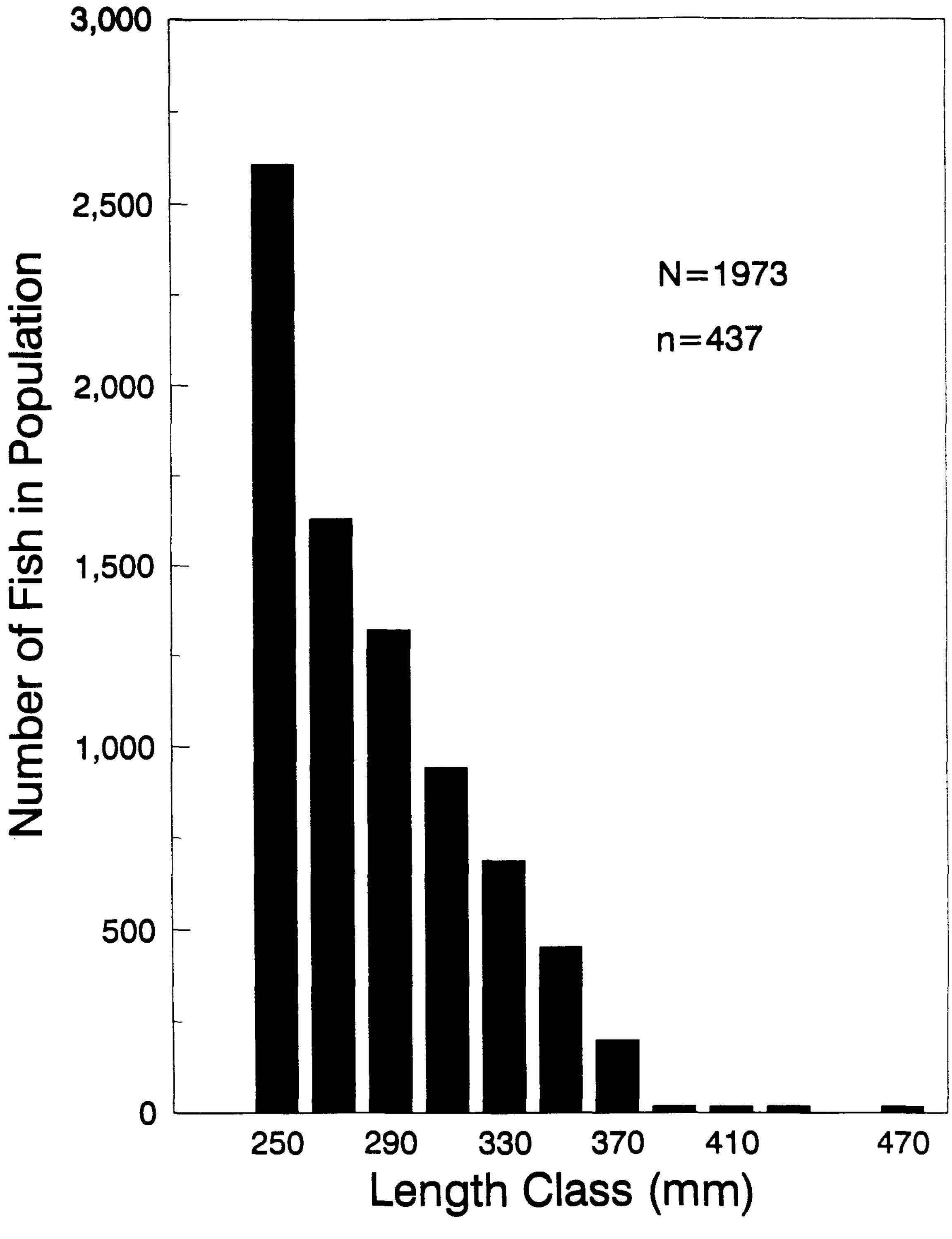


Figure 4. Estimated abundance by fork length of round whitefish ≥ 240 mm (FL) from the Chatanika River in 1991.

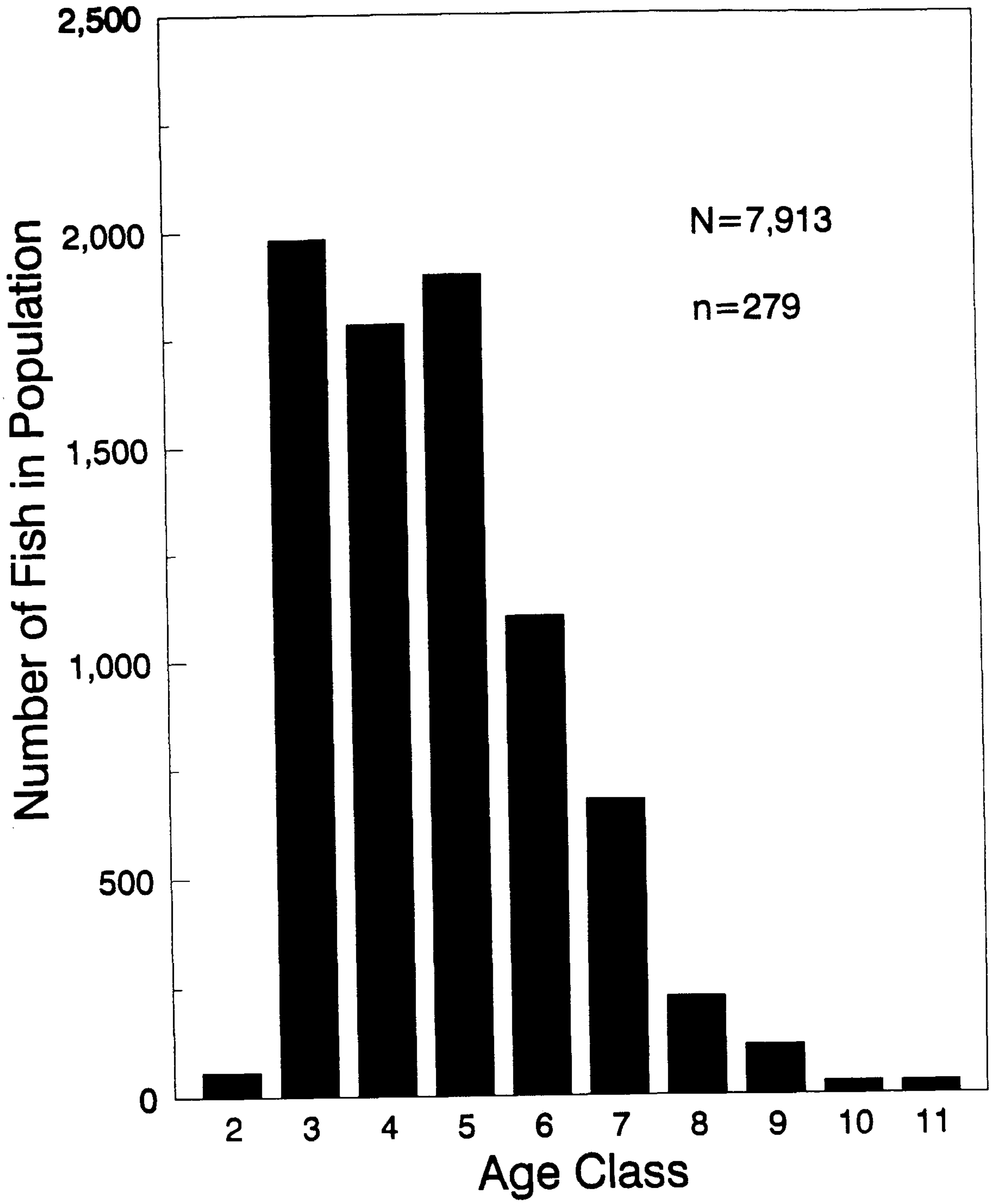


Figure 5. Estimated abundance by age of round whitefish ≥ 240 mm (FL) from the Chatanika River in 1991.

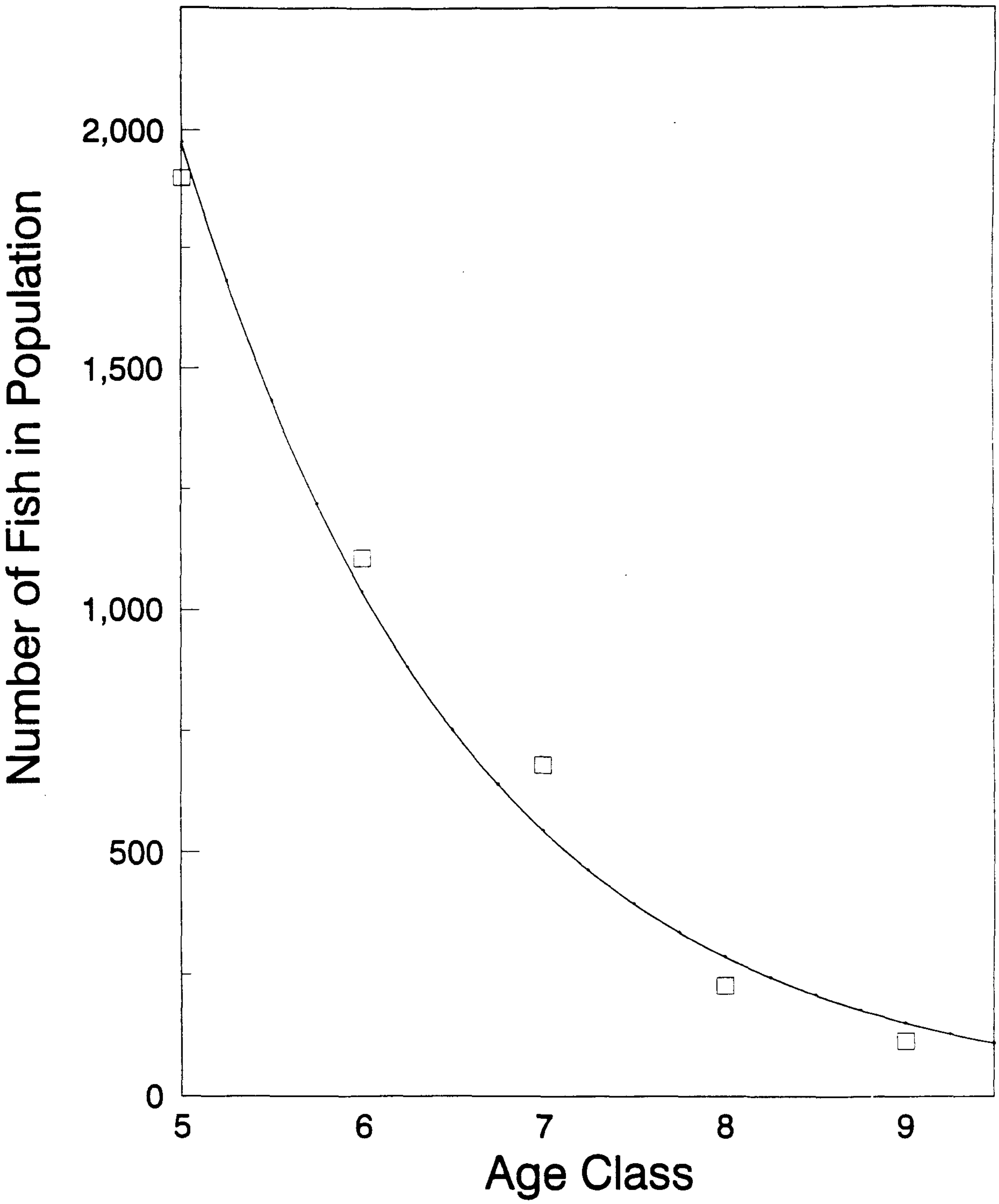


Figure 6. Population survival curve derived from estimated population abundance by age of round whitefish from the Chatanika River in 1991.

Table 6. Parameter estimates and standard errors of the model of the survival curve for round whitefish from the Chatanika River, 1991.

Parameter	Estimate	Standard Error
B_0	49,238	17,756
Z	0.643	0.062
Corr(B_0,Z)	0.984	-
F	0.031	-
M	0.612	-

Table 7. Length-at-age of round whitefish sampled from the Chatanika River in 1991.

Age	Sample Size	Mean	Standard Error	Range
1	19	162	3	142-198
2	68	198	3	156-251
3	236	239	1	187-302
4	138	251	2	211-332
5	108	286	2	220-340
6	78	313	3	260-370
7	60	320	3	282-380
8	29	341	5	274-375
9	13	361	6	325-412
10	9	370	10	322-410
11	1	470	-	-
Total	697			

Table 8. Parameter estimates and standard errors of the von Bertalanffy growth model for round whitefish from the Chatanika River, 1991.

Parameter	Estimate	Standard Error
L_∞	457	41
K	0.134	0.030
t_0	-2.313	0.509
Corr(L_∞,K)	-0.984	-
Corr(L_∞,t_0)	-0.884	-
Corr(K,t_0)	0.986	-

DISCUSSION

Abundance Estimate

The abundance estimate for round whitefish over 240 mm (FL) of 7,913 fish is a reasonable estimate, given the size of the study area and available habitat. The major weakness in the estimate is the relatively low number of recaptures (14 fish).

The low number of recaptures and lack of recapture of smaller fish is partly due to the different species involved in the overall study. Round whitefish was a secondary species in the overall Chatanika River study. Given the limited available resources, effort was concentrated in habitats which would yield best results for all species, namely deeper areas in the river. Shallow habitats favored by smaller and younger round whitefish were not intensively sampled. Extremely low water levels during the July marking pass and flood stage water levels during the August marking pass complicated matters by forcing fish out of their normal habitats and territories. The extreme water levels may be the reason for size selectivity in the marking event.

Other possible reasons for low numbers of recaptures include potential tag loss and increased mortality of tagged fish. Tag loss was a serious problem with other species in the study, but no evidence of this was found with round whitefish. Mortality of tagged fish after release may have affected recapture rates of round whitefish. Electrofishing has been suggested as a factor in marking mortality. Anecdotal evidence about mountain whitefish *Prosopium williamsoni* indicates that they are very susceptible to electrofishing (Bernard pers. comm.[1]), but no published studies exist on electrofishing mortality rates for round whitefish. No instance of direct electrofishing mortality was observed for round whitefish during the Chatanika River study.

The population estimate was extended to include fish which were larger than the size range of recaptured fish. The proportion of marked fish between 244 and 351 mm during the recapture event was about 3.5%. Multiplying the number of fish in the recapture event larger than 351 mm by 3.5% results in 0.8, or 0.8 marked fish larger than 350 mm should have been recovered during the recapture event.

The population estimate should be viewed as a reasonable estimate of abundance of round whitefish in the Chatanika River. Because the study was not specifically targeted at round whitefish, additional sampling biases may exist in the data set. The direction and degree of these biases is unknown. If marking mortality is affecting the number of recaptures, the estimate is larger than the actual population size. Under the current sampling regime, the most accurate population estimate would be obtained if both the mark and the recapture events took place under very low water conditions; the number and size range of fish that could be sampled would be at a maximum.

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[1] Bernard, Dave. 1991. Personal Communication. ADF&G, 333 Raspberry Rd., Anchorage, Alaska 99518.

Age and Length Compositions

The age composition of round whitefish indicates relatively constant mortality and recruitment rates. The number of fish in the older age classes declines gradually (Table 5, Figure 6). Old fish, while not numerous, are represented in the population. This gradual reduction is also reflected in the length frequencies (Table 4, Figure 5). Studies of (unexploited) round whitefish populations in northern Quebec also exhibit gradual reduction in frequencies of older fish (Mackay and Power 1967, Jessop and Power 1973, Morin et al. 1982). The primary age classes in those studies ranged from age 4 to age 6, and fish aged 8 or older comprised a greater proportion of the population than is the case in the Chatanika River. By contrast, in studies of round whitefish in Lake Michigan, where commercial exploitation was ongoing, the oldest fish sampled were age 7, or 4 years younger than in the Chatanika River study. Moreover, age classes 3 and 4 comprised between 77% and 86% of the round whitefish sampled in the Lake Michigan studies (Mraz 1964, Armstrong et al. 1977), versus 53% in the Chatanika River study (Table 7).

Mortality Rates

The round whitefish population appears to fulfill the assumptions inherent for estimation of mortality rates. The assumption that all harvested fish are over 239 mm (FL) is probable, as round fish harvested in the sport spear fishery are usually mistaken for least cisco or humpback whitefish. In addition, the total number harvested is very small, thus having little effect on the overall mortality rate. Fish of age classes 2, 3, and 4 were not included because the younger age classes were not fully recruited into the fishing method. Regression is sensitive to values at the end points, and the inclusion of underrepresented age classes would underestimate the mortality rates.

Mean Length-at-Age

Comparison of mean lengths at age was somewhat complicated by the fact that studies in the Great Lakes used total length as the length measure, while the northern Quebec and the Chatanika River studies used fork length. A conversion between total length and fork length referenced in Carlander (1969) was used to convert fork lengths into total lengths (Neth 1955). Round whitefish in Lake Michigan were larger at a given age than in the Chatanika River (Mraz 1964, Armstrong et al. 1977). Fish in the Lake Superior study had equivalent mean lengths at age from age class 4 onward. The mean length-at-age for Chatanika round whitefish was consistently larger than for fish of the same ages studied in northern Quebec (Mackay and Power 1967, Jessop and Power 1973). Fish in northern Quebec with comparable mean lengths were generally 3 years older than Chatanika River fish.

The age composition and mean length-at-age for Chatanika River whitefish most resembles the Lake Superior study (Bailey 1963), where environmental conditions were more severe than in Lake Michigan, but the rate of commercial exploitation was not as relentless. In light of their consistently smaller mean length-at-age, round whitefish in northern Quebec likely inhabit a more rigorous environment than round whitefish in the Chatanika River.

Growth Equation

The von Bertalanffy equation produced an asymptotic fork length (L_∞) which was very close to the length of the largest fish caught during the study (Tables 7 and 8). The theoretical time when length equals zero (t_0) was negative. The small number of age 1 and age 2 fish caught during the study was the primary reason for a negative t_0. Since parameter estimates are highly correlated, inclusion of new data can radically change all parameter estimates. In comparison to the Chatanika River study, fish from the LaGrande River on James Bay in northern Quebec had an L_∞ of 370 mm (Morin et al. 1982). The LaGrande River study had a higher growth coefficient ($K=0.211$) and a positive t_0 ($t_0=0.005$).

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