Fishery Data Series No. 97-36

Stock Assessment of Whitefish in the Chatanika River During 1996 and 1997

by
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November 1997

Alaska Department of Fish and Game

Division of Sport Fish

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
metric ton	mt
milliliter	ml
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
ounce	oz
pound	lb
quart	qt
yard	yd

Spell out acre and ton.

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour (spell out for 24-hour clock)	h
minute	min
second	s

Spell out year, month, and week.

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

All commonly accepted abbreviations.	e.g., Mr., Mrs., a.m., p.m., etc.
All commonly accepted professional titles.	e.g., Dr., Ph.D., R.N., etc.
and	&
at	@
Compass directions:	
east	E
north	N
south	S
west	W
Copyright	©
Corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
et alii (and other people)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.,
id est (that is)	i.e.,
latitude or longitude	lat. or long.
monetary symbols (U.S.)	\$, ¢
months (tables and figures): first three letters	Jan,...,Dec
number (before a number)	# (e.g., #10)
pounds (after a number)	# (e.g., 10#)
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S. state and District of Columbia abbreviations	use two-letter abbreviations (e.g., AK, DC)

Mathematics, statistics, fisheries

alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	F, t, χ^2, etc.
confidence interval	C.I.
correlation coefficient	R (multiple)
correlation coefficient	r (simple)
covariance	cov
degree (angular or temperature)	°
degrees of freedom	df
divided by	÷ or / (in equations)
equals	=
expected value	E
fork length	FL
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
mideye-to-fork	MEF
minute (angular)	'
multiplied by	x
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
standard length	SL
total length	TL
variance	Var

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by

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ABSTRACT

In 1996, 623 humpback whitefish *Coregonus pidschian* ≥ 360 mm FL and 529 least cisco *C. sardinella* ≥ 290 mm FL were sampled from a 30 km section of the Chatanika River during August and September. The August sampling period corresponded to the timing of 1992-1994 assessments, while the September sampling corresponded to the time when the sport spear fishery was open to exploitation (prior to 1994). Ages 4, 5 and 6 predominated in humpback whitefish indicating strong pre-recruit classes; ages 4, 5 and 6 also dominated in least cisco, however the younger age classes (ages 2 and 3), normally vulnerable to sampling gear, were low in abundance. Significantly fewer age 4 humpback whitefish were sampled in September than in August ($\chi 2 = 25.38$, df = 11, P=0.008). There was no significant difference among the August and September age samples for least cisco.

In 1997, we conducted a mark-recapture experiment in a 53 km (33 mi) section of the Chatanika River from August 20-28 to estimate abundance and stock composition of both species. The investigation was timed to correspond to the upstream spawning migration of both species, and to provide in-season estimates of abundance prior to the timing of a recreational spear fishery. An estimated 16,107 (SE = 1,260) humpback whitefish (≥ 360 mm FL) were present in the study area. The assessed stock was characterized by a high proportion of humpback whitefish between 390 and 430 mm FL with ages 5, 6, and 7 predominating. An estimated 22,811 (SE = 4,496) least cisco (≥ 290 mm FL) were present in the study area. The assessed least cisco stock was predominated by age 5 and 6 fish, and primarily comprised of fish greater than 340 mm FL. Poor recruitment within the least cisco stock was indicated by the age composition, and estimated recruitment levels of age 3 fish were the lowest in 11 years of stock assessment.

Key Words: humpback whitefish, *Coregonus pidschian*, least cisco, *Coregonus sardinella*, abundance estimation, age composition, length composition, recruitment, scales.

INTRODUCTION

Each year humpback whitefish *Coregonus pidschian* and least cisco *C. sardinella* migrate from Minto Flats into the Chatanika River to spawn and overwinter (Figure 1). Past investigations have indicated that whitefish migrate to spawning areas in the Chatanika River between June and September (Townsend and Kepler 1974, Fleming *unpublished data*). A significant fall spear fishery for these species developed during the 1980s, primarily between the Elliott Highway Bridge and the Olnes Pond Campground, with a limited harvest taken along the Steese Highway. Estimates of whitefish harvests from the Chatanika River increased from 1,635 in 1977 to a high of 25,074 whitefish in 1987 (Mills 1979-1994). In response to increasing harvests in the whitefish spear fishery, stock assessments were initiated in 1986 for humpback whitefish and least cisco. These studies have since evolved into large area mark-recapture studies.

In 1987 the Board of Fisheries restricted the harvest of whitefish in the Tanana River drainage to a bag limit of 15 fish per day, based on concerns over increasing harvests of whitefish. Further management actions included an emergency closure during 1990, and a complete closure in 1991 as preliminary assessment indicated the need for conservation of the spawning stocks. Research efforts in 1991 confirmed preliminary information: estimated abundance of humpback whitefish over a 125 km section of the river was only 15,313 fish (Timmons 1991). For this reason, the Board of Fisheries in 1992 shortened the season and reduced the geographic area of the fishery so that a low level fishery might continue.

Results from 1992 through 1994 stock assessment investigations indicated that abundance of the whitefish stocks declined despite conservative regulatory action (fishery closures in 1991, 1994-1996), and low levels of exploitation in 1992-1993 (Fleming 1994, 1996). Abundance estimates for the last three years of stock assessment in a 78.2 km section of the Chatanika River were:

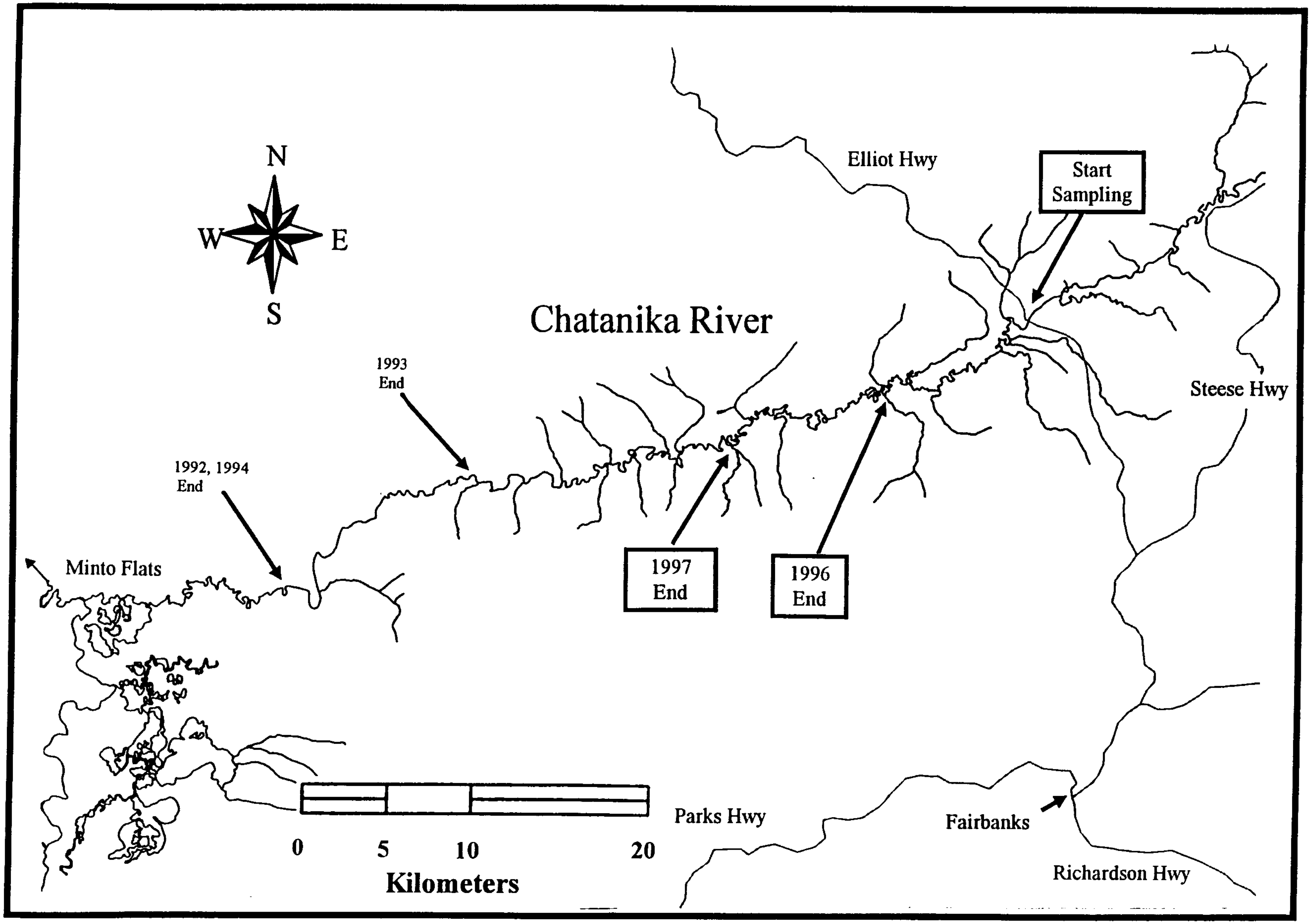

Figure 1.-Map of 1992-1997 study areas encompassing Minto Flats and the Chatanika River.

Assessment Year:	Humpback Whitefish	Least Cisco
1992	19,187 fish (SE = 1,617)	75,035 fish (SE = 8,555)
1993	13,112 fish (SE = 1,096)	46,562 fish (SE = 5,971)
1994	12,700 fish (SE = 1,138)	27,639 fish (SE = 3,211)

Emergency order closures of the spear fishery from 1994-1997 have allowed for the unimpaired spawning of all adult whitefish in the Chatanika River and allowed time for stock rebuilding. No abundance estimation was conducted in 1995 and 1996. The 1997 mark-recapture experiment was undertaken to determine if the abundance of either species had achieved the threshold level as stated in the Fishery Management Plan developed in 1992. The fishery threshold abundance levels stated in the Chatanika River Fishery Management Plan require 10,000 humpback whitefish and 40,000 least cisco to be present before a fishery may be prosecuted.

Creel survey estimates of Chatanika River whitefish harvest beginning in 1986 were as follows: (Clark and Ridder 1987; Baker 1988, 1989; Merritt et al. 1990; and, Hallberg and Bingham 1991, 1992, 1993, 1994, 1995):

Year	Humpback Whitefish Harvest	SE	Least Cisco Harvest	SE
1986	2,528	914	16,575	2,513
1987	4,577	926	23,735	5,121
1988	3,571	293	4,456	314
1989	3,835	491	9,784	1,443
1990	957	34	5,396	175
1991[a]	0	---	0	---
1992	392	9	1,898	49
1993	87	18	609	62
1994[a]	0	---	0	---
1995[a]	0	---	0	---
1996[a]	0	---	0	---
1997[a]	0	---	0	---

[a] The spear fishery was closed by emergency order in these years.

Continued declines in whitefish abundance may have resulted in part from past harvest levels of the parental spawning stock, but it is unlikely that the most recent harvests have contributed to the continued declines. Additionally, it is unlikely that recent subsistence fisheries have contributed to the decline in whitefish abundance. The estimated subsistence harvest in Minto Flats for 1994 was 415 humpback whitefish and 115 least cisco (J. E. Hallberg, Alaska Department of Fish and Game, Fairbanks, personal communication). These recent subsistence harvests were less than reported by Andrews in 1988 (6,477 coregonids, all species). It is likely that recent subsistence harvests of whitefish in Minto Flats in 1995-1997 were of similar magnitude as those in 1994.

It is more likely that in recent years, declining recruitment and abundance levels are related to natural mortality. The Chatanika River drainage and Minto Flats complex contains several predatory fish stocks and is subjected to changing water conditions which may directly or indirectly affect the natural mortality of all species. One of the more abundant predator species is the northern pike. Northern pike abundance may have increased recently in response to combinations of regulatory measures and favorable water conditions for reproduction and rearing. Although it is well known that northern pike feed on least cisco and humpback whitefish, no studies have been directed at the detection and quantification of predation on whitefish species in the Chatanika River.

In 1995, the stocks of humpback whitefish and least cisco were not assessed to allow for stock rebuilding. In 1996, age and size sampling of whitefish in the upper Chatanika River was conducted to detect stock rebuilding through recruitment of smaller and younger fish. In 1997, we conducted a complete stock assessment, which included estimating abundance of least cisco and humpback whitefish. This report serves to report on objectives associated with field studies conducted in 1996 and 1997.

OBJECTIVES

The research objectives for 1996 were to estimate:

1. age composition of least cisco and humpback whitefish in a 30 km section of the Chatanika River during August and September, such that all proportions are within 10 percentage points of the true proportion 95% of the time; and,
2. length composition of least cisco and humpback whitefish in a 30 km section of the Chatanika River during August and September, such that all proportions are within 10 percentage points of the true proportion 95% of the time.

The research objectives for 1997 were to estimate:

1. abundance of humpback whitefish greater than 359 millimeters Fork Length (mm FL) and least cisco greater than 289 mm FL in a 78 km section of the Chatanika River in early September, beginning at the Elliott Highway Bridge and continuing downstream to an area 24 km above the Murphy Dome Road Extension, such that each estimate is within 25% of the true abundance 95% of the time; and,
2. age and length compositions of humpback whitefish and least cisco in the same 78 km section of the Chatanika River in early September, such that all proportions are within 5 percentage points of the true proportion 95% of the time.

METHODS

STOCK ASSESSMENT STUDY AREA

Past whitefish stock assessments occurred over limited areas of the Chatanika River accessed by the Elliott Highway, but recent assessments (Figure 1) have extended sampling significantly downstream. The assessments prior to 1990 were within an area 15 km above and below the Elliott Highway bridge. This section of the Chatanika River is characterized by moderate gradient, with short meandering stretches interspersed with gravel riffles, is thought to provide spawning habitat for the whitefish, and is affected by the recreational spear fishery. In 1991, the study area was extended downstream an additional 83.7 km after exploitation of whitefish tagged well below the spear fishing area was detected (Timmons 1991). The extension of the study area has included several different types of river habitat. Immediately downstream, moderate gradient habitat (described above) continues for 5 km before changing to a low gradient section of slow flows, with silt and sand bottom and high cut banks. This middle low gradient stream type extends downstream 51.4 km, beginning with continuous meanders and oxbows and changing to long straight reaches. In both 1996 and 1997, field investigations were confined to the moderate and low gradient portions of the Chatanika River. Then, the river changes to a higher gradient, and continues 28.2 km to the end of the study area as a series of wide shallow runs and riffles, with coarse cobble and bedrock substrate.

STUDY DESIGN AND FIELD SAMPLING

1996

Age and size sampling occurred in two sampling periods. A single crew of three persons used a pulsed DC electrofishing boat to capture fish within a 30 km stretch of the Chatanika River. Sampling in each period was conducted between the Elliot Highway bridge and Any Creek. The first sampling period was August 21- 22, which corresponded to the timing of recent stock assessments (Timmons 1991, Fleming 1993, 1994, 1996). Late immigration of least cisco into the area of the fishery is known to occur after the time of August assessments and prior to the September 30 end of the fishery (Fleming 1996). While late immigrating fish may be relatively few in number, it has not been known if their age composition differs from those present in August. The second sampling period was September 17-18, which corresponded to the mid-point of the spearing season and the time when late immigrants would be present. Age samples (scales) and lengths were taken in the two sampling periods for comparison. A comparison was conducted to determine if the age composition of the population assessed in August was similar to the age composition of the population which is vulnerable to exploitation during September. Sample sizes were set low in each sampling period to minimize handling and disturbances to the whitefish stocks.

To limit holding time and stress of captured fish, the electrofishing crew fished in a downstream direction for a maximum of 20 min. Twenty-minutes of electrofishing constituted each recorded sampling run. Variable voltage pulsator (VVP) settings were 60 Hz pulsed DC ranging from 205 to 220 volts and 1 to 4 A. The river water's measured conductivity was 150 μ S. During sampling events, all fish were examined for tags, measured, and fin clipped with a partial upper caudal clip in August, and partial lower caudal in September. Three scales were systematically collected from each fish, gently cleaned, and mounted directly onto gum cards for later pressing and aging. Scales were taken from an area above the lateral line and below the dorsal fin on the left side of each sampled fish (Van Oosten 1923). Three scales per fish were collected and mounted to offset high scale regeneration rates and to maintain higher precision levels in composition estimates. As a result, the scales from 10 fish were mounted on each gum card. Gum cards were later used to make triacetate impressions using a scale press (30 s at 137,895 kPa, at a temperature of 97°C). Ages were determined by counts of annuli from impressions of scales magnified to 40X with the aid of a microfiche reader. Criteria for determining the presence of an annulus were: 1) complete circuli cutting over incomplete circuli; 2) clear areas or irregularities in circuli along the anterior and posterior fields; and, 3) regions of closely spaced circuli followed by a region of widely spaced circuli (Van Oosten 1923).

1997

The mark-recapture experiment began on August 20, and was completed on August 28, with near identical timing to 1992 -1994 assessments. Sampling was performed by two crews, each with three persons. One of the crews used pulsed DC electrofishing boats to capture fish and conduct mark-recapture sampling of captured fish. The second crew sampled the captured fish in a separate boat. There were two distinct sampling events. The first sampling event lasted three days and consisted of a single downstream pass by the two crews working together. The second sampling event began after a five-day hiatus and lasted four days. The upstream limit of the 1997 study section was the Elliott Highway bridge. The 1997 lower sampling boundary was 53.1 km downstream from the bridge. Sampling could not be conducted over the planned 78 km section because of record low-water conditions.

To limit holding time and stress of captured fish, and to ensure an even distribution of marked fish in the study area, electrofishing was conducted in a series of 20 discrete sampling "runs". A run consisted of 20 min of electrofishing in the downstream direction. Variable voltage pulsator (VVP) settings were 60 Hz pulse DC ranging from 140 to 200 volts and 2 to 7 A. The river's measured conductivity was 175 μ S. Stunned fish were dipped and placed into large aerated live wells to await sampling. At the completion of each run, labeled flagging was staked or tied to trees for later relocation during the second sampling event. All captured fish in the first sampling event were measured to the nearest millimeter FL, and given a partial fin clip. Fish from different sections of the study area were given different partial fin clips. Fish in the upper 17 km were given adipose fin clips. Fish were given upper caudal clips in the middle section of the study area, and lower caudal clips in the lowermost section. During the second sampling event, all fish were examined for marks, measured, and fin clipped (left pelvic clip). A single scale was systematically collected from each fish during the second sampling event, gently cleaned, and mounted directly onto gum cards for later pressing and aging. In 1997, a single scale was sampled from each fish to increase efficiency, and as a way to reduce over-sampling for age composition given high catches in the mark recapture projects. An assumption of this approach was that the presence of regenerated (and unreadable) scales would not lead to biases in age composition because fish of all sizes and ages share the same rate of scale regeneration. To validate this assumption, the lengths of fish that were aged were compared by KS test to the lengths of fish whose scales were regenerated, and could not be aged. This test was conducted in 1997, but not in 1996 because in 1996 three scales were collected from each fish.

Data collection procedures from previously marked humpback whitefish and least cisco were similar, but tag numbers, and tag colors were also recorded. All data was recorded on Alaska Department of Fish and Game Tagging Length Form, Version 1.0.

ABUNDANCE ESTIMATION

A closed-model mark-recapture experiment was used to estimate the abundance of whitefish in 1997, similar to the approach used in 1992 -1994. The use of a closed-model abundance estimator using mark-recapture experiments assumes the following (Seber 1982):

1. the population in the study area must be closed, i.e. the effects of migration, mortality, and recruitment are negligible;
2. all whitefish have the same probability of capture during the first sample or in the second sample or marked and unmarked whitefish mix completely between the first and second samples;
3. marking of whitefish does not affect their probability of capture in the second sample; and,
4. whitefish do not lose their mark between sampling events.

Sampling was designed to lessen risks associated with closure (assumption 1) by shortening the duration of the mark-recapture experiment considerably and sampling as much of the river as practically feasible. It was improbable that substantial migration, mortality, or recruitment occurred during the five day hiatus, given the large size of the sampling area. This assumption could be partially examined through comparison of the marked-to-unmarked ratios in the lowermost section (subject to immigration from fish downstream). Assumptions 2 and 3 were examined for size and geographic differences in capture probability. The effects of size selectivity was examined with two Kolmogorov-Smirnov two-sample tests (KS tests). The first test examined the cumulative length frequency distributions of marked fish with those recaptured. The second test compared cumulative length frequency distributions of all fish from the first (mark event) and second (recapture event) samples. The results of these tests suggested methods to alleviate size bias (Appendix A1). Spatial differences in capture probability were evaluated through comparisons of area specific recapture-to-catch ratios. The last testable assumption was met by marking each fish with a fin-clip specific to the 1997 mark-recapture experiment.

The two KS tests indicated that size selectivity was not present in either sampling events for least cisco. Results of the KS tests with humpback whitefish indicated the second sampling event was marginally size selective, which led to examination of a stratified abundance estimate. This was accomplished by partitioning the data into size strata. To maximize the difference in capture probability between size strata, a series of chi-squared tests determined the included size classes for stratification. The length at stratification that produced the largest chi-squared test statistic was used to delimit the size strata.

When meaningful geographic differences among capture probabilities were not detected within the sampled areas, no further stratification is required. Because the assumption of equal capture probability among sections was not rejected, the modified Petersen estimator of Bailey (1951, 1952) was selected. Bailey's modification was used because of the systematic sampling approach and the level of mixing (localized, not complete; Seber 1982) of marked and unmarked fish over the length of the sampling area . Stratified by length group and unstratified point estimates of abundance were calculated as:

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

where: M = the number of fish marked and released during the marking event ;
C = the number of fish examined for marks during the recapture event;

R = the number of fish recaptured during the second sampling event (recapture); and,

$\hat{N}$ = estimated abundance of fish.

Variance of the abundance estimate was estimated by (Bailey 1951, 1952):

$$V\left[\hat{N}\right]=\frac{\hat{N}M(C-R)}{\left[(R+1)(R+2)\right]}. \tag{2}$$

Population estimates were then generated for each size class and these independent estimates summed to estimate the overall population. Summed-stratified and unstratified estimates of abundance and variance were compared on the basis of similarity of abundance and variance, and the appropriate estimator was then selected to represent the assessed stock.

AGE AND SIZE COMPOSITION

Apportionment of the estimated abundance among age or size groupings depends on the extent of sampling biases, if known. The outcome of tests for size selectivity, and chi-square tests to detect geographic differences in capture probabilities, determined the necessary adjustments for the 1997 mark-recapture assessment. When no adjustments to composition estimates were required for length selectivity or geographic differences in capture probability, the proportion of fish at age *k* (or length class *k*) in 1996 and 1997 was estimated by:

$$\hat{p}_k=\frac{y_k}{n} \tag{3}$$

where: $\hat{p}_k$ = the proportion of fish that are age or length class *k*;

y_k = the number of fish sampled that are age or length class *k*; and,

n = the total number of fish sampled.

The unbiased variance of this proportion was estimated as:

$$\hat{V}[p_k]=\left[\frac{\hat{p}_k(1-\hat{p}_k)}{(n-1)}\right]. \tag{4}$$

Stock assessment categories for the 1996 and 1997 studies used the same approach, where substitutions for class were: age classes and 10 mm FL incremental size classes. Incremental 10 mm FL size classes had mid-points ranging from 295 to 395 mm FL for least cisco and 365 to 560 mm FL for humpback whitefish.

RESULTS

FIELD SAMPLING

1996

A total of 623 humpback whitefish (≥ 360 mm FL) and 529 least cisco (≥ 290 mm FL) was captured and sampled. On August 21-22, the crew captured and sampled 334 humpback whitefish and 252 least cisco. On September 17-18, the crew captured and sampled 289 humpback whitefish and 277 least cisco. During both sampling events, water conditions were moderately low and clear. Water temperatures in August ranged between 8.5^{O}C and 11^{O}C. During September, water temperatures ranged between 4.3^{O}C and 5.2^{O}C. The overall acute mortality rate from sampling was one out of 637 individual humpback whitefish handled, or 0.15 %. The overall acute mortality rate was 0.18 % for least cisco, based on one mortality.

1997

A total of 2,938 humpback whitefish ($\geq$ 360 mm FL) and 1,465 least cisco ($\geq$ 290 mm FL) were captured over a 10-day period in the latter half of August. Throughout most of the mark-recapture experiment water conditions were exceptionally low and clear, which presented difficulties for navigation and electrofishing. The start of sampling coincided with marginally higher water levels (0.2 m higher) following a brief storm. Water temperatures ranged between 8.0 ^{O}C and 11.5 ^{O}C. During the field investigation, 1,614 humpback whitefish ($\geq$ 360 mm FL) were marked and released alive over a 53 km study area in the first sampling event. In the second sampling event, 1,469 were examined for marks, yielding 145 recaptures. Concurrently, 662 least cisco ($\geq$ 290 mm FL) were marked and released alive in the first sampling event, and in the second sampling event 826 fish were examined for marks, yielding 23 recaptures. The overall acute mortality rate from the experiment was 11 out of 2,942 individual humpback whitefish handled, or 0.3%. The overall acute mortality rate was 0.3% for least cisco, based on five mortalities from 1,503 fish.

ABUNDANCE ESTIMATION IN 1997

No significant differences were detected in humpback whitefish capture probabilities (recapture-to-catch ratios) when examined by geographic area (χ 2 = 2.76, df = 1, P = 0.096). The lower sampling section (sampling runs 14-20) was not included in the examination because only one marked fish was recaptured in this section. Capture probabilities for the upper (sampling runs 1-7) and middle (sampling runs 8-13) sections were 0.12 and 0.09, respectively. Because of similar capture probabilities, the humpback whitefish abundance could be estimated using an unstratified approach with respect to geographic area.

Kolmogorov-Smirnov (KS) tests of cumulative length frequencies from the humpback whitefish mark-recapture experiment inferred that size selectivity was present during the second sampling event, but its presence was unknown for the marking event (Figure 2A- mark vs recaptures: D = 0.14, P = 0.007; and, Figure 2B - mark vs catch: D = 0.10, P < 0.001). As a result of assumption testing, the abundance of humpback whitefish ≥ 360 mm FL was estimated with both

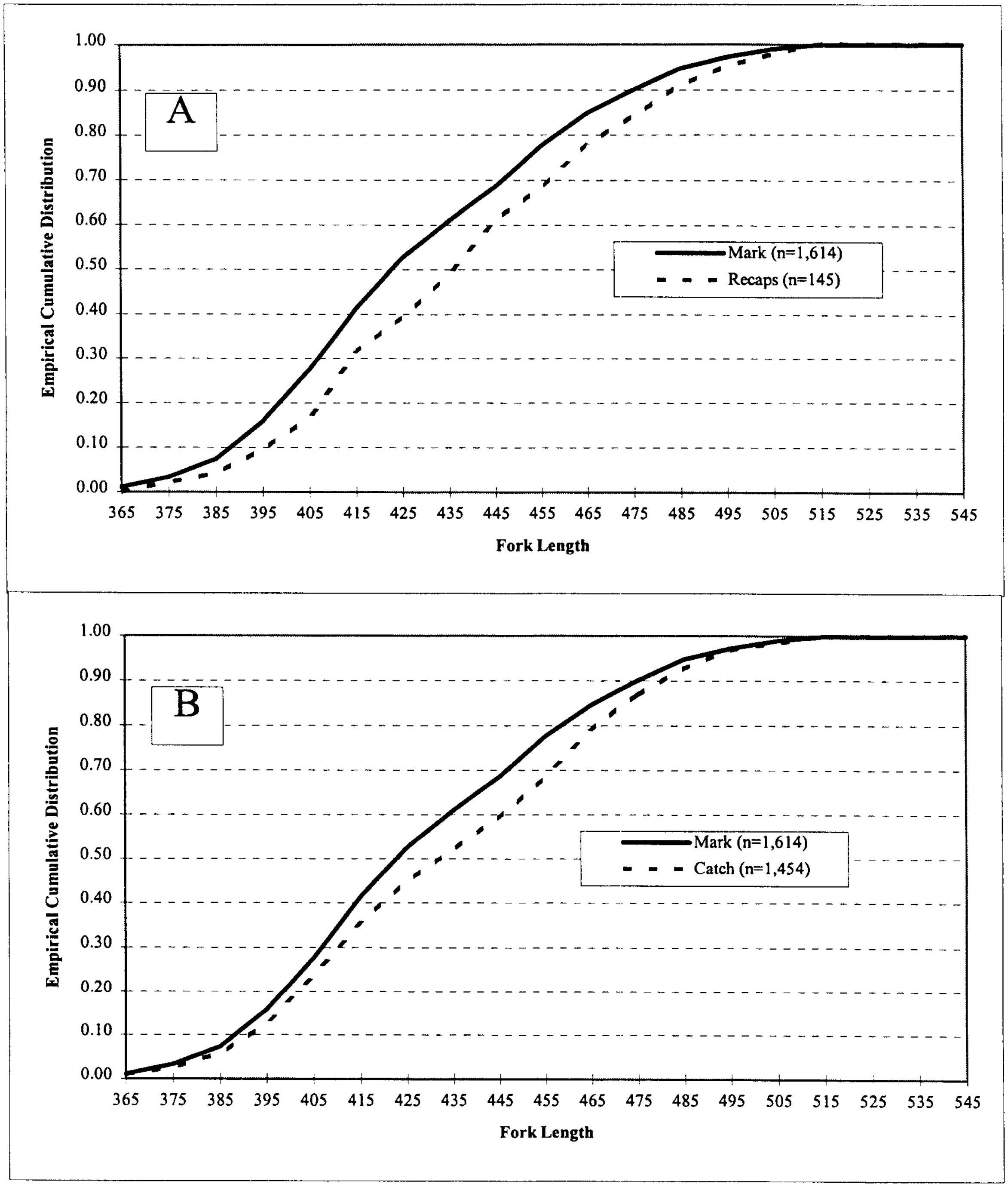

Figure 2.-Empirical cumulative distribution of lengths of humpback whitefish marked versus lengths of humpback whitefish recaptured (A); and, versus lengths of humpback whitefish examined for marks (B) in the Chatanika River, August 20-28, 1997.

unstratified and stratified approaches (Appendix A1; Case IV). The selected size strata were: 360 to 429 mm FL, and 430 mm Fl and larger. This was based on maximal differences in recapture-to-catch ratios among possible strata ($\chi2_{430mm}$ = 11.4, df = 1, P = 0.0007). Stratified and unstratified estimates of abundance using Bailey's modification to the Petersen estimator (Bailey 1951, 1952) were:

Strata- {size grouping}	Mark M	Catch C	Recap R	Capture Probability	Abundance N-hat	Standard Error
360 to 429 mm FL	850	652	57	0.08	9,570	1,189
≥ 430 mm FL	764	804	88	0.11	6,910	687
Total	1,614	1,456	145	----	16,480	1,373
Unstratified	1,614	1,456	145	0.10	16,107	1,260

Since the stratified and unstratified estimates were similar, the unstratified estimator was selected (Appendix A1; Case IV). The estimated abundance of humpback whitefish (≥ 360 mm FL) in the 53 km study area was 16,107 fish (SE = 1,260, CV = 7.8%).

No significant differences were detected in capture probabilities (recapture-to-catch ratios) for least cisco when examined by geographic area ($\chi2$ = 0.07, df = 1, P = 0.79). The lower sampling section (sampling runs 14-20) was not included in the examination because no marked fish were recaptured in this section. Capture probabilities for the upstream (sampling runs 1-7) and middle (sampling runs 8-13) sections were 0.03 and 0.03, respectively. As a result, the least cisco abundance could be estimated using an unstratified approach with respect to geographic area.

A KS comparison of cumulative length frequencies from the least cisco mark-recapture experiment failed to detect length selectivity in either sampling event (Figure 3A- mark vs recaptures: D = 0.11, P = 0.95; and, Figure 3B -mark vs catch: D = 0.03, P = 0.79). As a result, least cisco abundance could be estimated using an unstratified approach with respect to size selectivity (Case I; Appendix A1). The unstratified abundance was estimated using Bailey's modification to the Petersen estimator (Bailey 1951, 1952). The 1997 estimated abundance of least cisco (≥ 290 mm FL) was 22,811 fish (SE = 4,496, CV = 19.7%).

AGE AND SIZE COMPOSITION IN 1996

Humpback Whitefish

Scale samples were collected from 339 humpback whitefish during August, of which 316 were aged after an incidence of 7% regenerated or illegible scales. During September sampling, scale samples were collected from 299 humpback whitefish, of which 257 were aged after an incidence of 14% regenerated or illegible scales. Ages observed for humpback whitefish in the Chatanika River ranged from 3 to 14 years for fish ranging between 360 and 515 mm FL, with age 5 as the median age. The predominant age class present was age 5 in August (38%; Table 1) and September (35%; Table 2) samples followed by age 4 fish in August (21%) and age 6 fish in September (17%). Comparisons of August and September samples indicated a statistically significant difference between samples (chi-square Goodness of Fit test on ages 3-14: $\chi2$ =

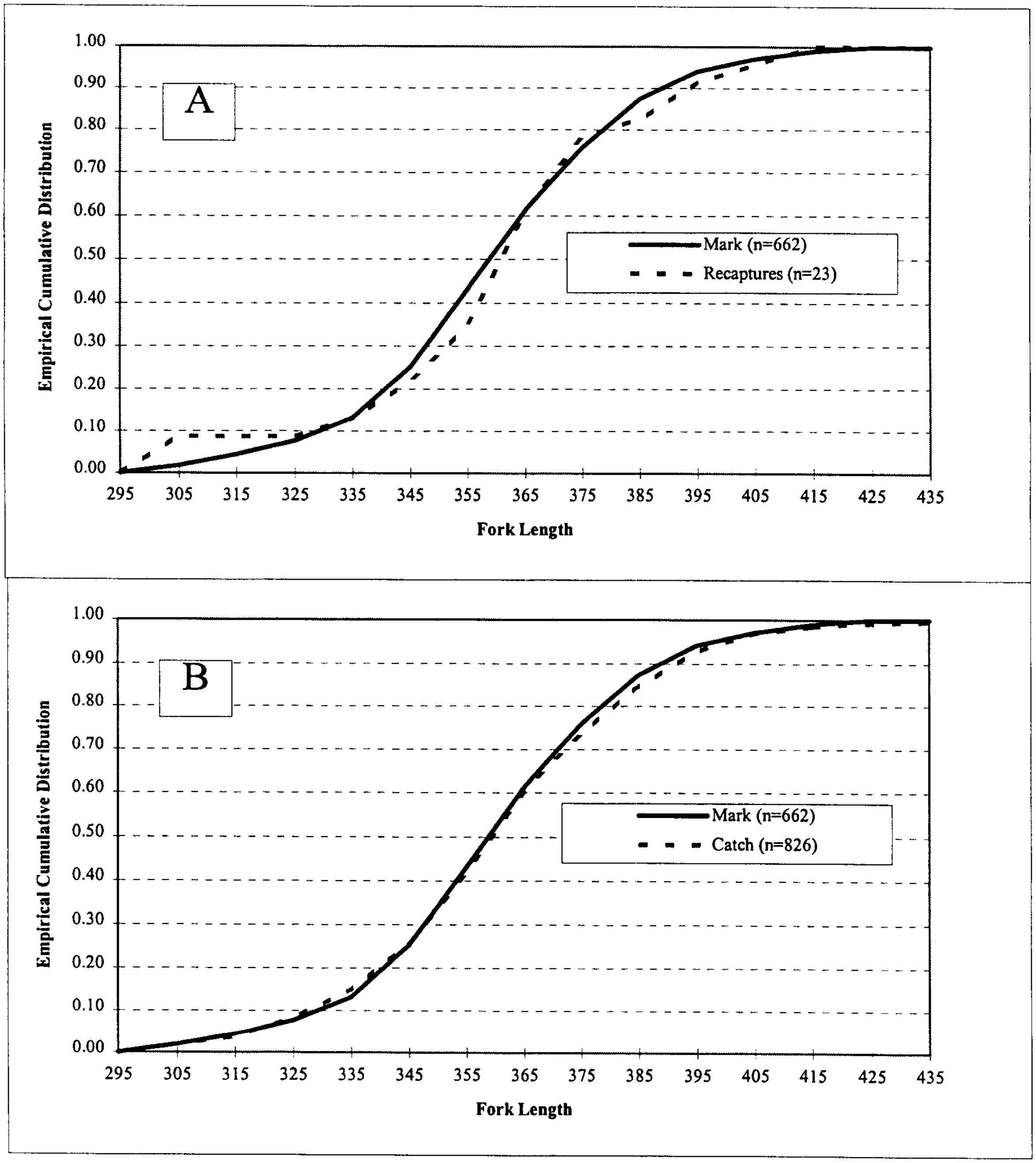

Figure 3.-Empirical cumulative distribution of lengths of least cisco marked versus lengths of least cisco recaptured (A); and, versus lengths of least cisco examined for marks (B) in the Chatanika River, August 20-28, 1997.

Table 1.-Estimates of the sampled contributions by each age class and 10 mm FL incremental size classes for humpback whitefish (≥ 360 mm FL) captured from the Chatanika River, August 21 through 22, 1996.

Age	Count	$\hat{p}$[a]	SE[b]	Length	Count	$\hat{p}$[a]	SE[b]
3	3	0.01	< 0.01	335	0	0.00	0.00
				345	0	0.00	0.00
4	66	0.21	0.02	355	0	0.00	0.00
				365	15	0.04	0.01
5	119	0.38	0.03	375	32	0.09	0.02
				385	48	0.14	0.02
6	52	0.17	0.02	395	50	0.15	0.02
				405	53	0.16	0.02
7	22	0.07	0.01	415	35	0.10	0.02
				425	17	0.05	0.01
8	20	0.06	0.01	435	18	0.05	0.01
				445	22	0.06	0.01
9	11	0.03	0.01	455	9	0.03	0.01
				465	10	0.03	0.01
10	11	0.03	0.01	475	14	0.04	0.01
				485	6	0.02	0.01
11	7	0.02	0.01	495	3	0.01	< 0.01
				505	1	< 0.01	< 0.01
12	1	< 0.01	< 0.01	515	1	< 0.01	< 0.01
				525	0	0.00	0.00
13	2	0.01	< 0.01	535	0	0.00	0.00
				545	0	0.00	0.00
14	2	0.00	< 0.01	555	0	0.00	0.00
				565	0	0.00	0.00
15	0	0.00	0.00	575	0	0.00	0.00
				585	0	0.00	0.00
16	0	0.00	0.00	595	0	0.00	0.00
				605	0	0.00	0.00
> 16	0	0.00	0.00				
Totals	316	1	---	Total	339	1.00	----

[a] $\hat{p}$ = proportion of humpback whitefish in the assessed stock at the time of sampling.

[b] SE = standard error of the proportional contribution.

Table 2.- Estimates of the sampled contributions by each age class and 10 mm FL incremental size classes for humpback whitefish (≥360 mm FL) captured from the Chatanika River, September 17 through 18, 1996.

Age	Count	$\hat{p}$[a]	SE[b]		Length	Count	$\hat{p}$[a]	SE[b]
3	1	<0.01	< 0.01		335	0	0.00	0.00
					345	0	0.00	0.00
4	26	0.10	0.02		355	0	0.00	0.00
					365	8	0.03	< 0.01
5	91	0.35	0.03		375	17	0.06	0.01
					385	36	0.12	0.02
6	43	0.17	0.02		395	38	0.13	0.02
					405	39	0.13	0.02
7	25	0.09	0.02		415	29	0.10	0.02
					425	23	0.08	0.01
8	27	0.10	0.02		435	26	0.09	0.02
					445	24	0.08	0.02
9	17	0.06	0.02		455	22	0.07	0.01
					465	21	0.07	0.01
10	15	0.06	0.01		475	3	0.01	0.01
					485	6	0.02	0.01
11	6	0.02	0.01		495	4	0.01	0.01
					505	1	< 0.01	< 0.01
12	5	0.02	0.01		515	0	0.00	0.00
					525	0	0.00	0.00
13	1	< 0.01	< 0.01		535	0	0.00	0.00
					545	0	0.00	0.00
14	0	0.00	0.00		555	0	0.00	0.00
					565	0	0.00	0.00
15	0	0.00	0.00		575	0	0.00	0.00
					585	0	0.00	0.00
16	0	0.00	0.00		595	0	0.00	0.00
					605	0	0.00	0.00
> 16	0	0.00	0.00					
Totals	257	1	---		Total	298	1.00	----

[a] $\hat{p}$ = proportion of humpback whitefish in the assessed stock at the time of sampling.

[b] SE = standard error of the proportional contribution.

25.38, df = 11, P = 0.008). Construction of 95% confidence intervals for proportions at age in August and September samples indicated significant differences among samples of age 4 fish (Figure 4). The median size humpback whitefish was 403 mm FL during August and 413 mm FL in September, with a mode in relative abundance between 400 and 409 mm FL in both samples (Tables 1 and 2). Kolmogorov-Smirnov tests of cumulative length frequencies from August and September samples inferred a change in the size composition toward larger fish in September (D = 0.15, P = 0.0009).

Least Cisco
Scale samples were collected from 277 least cisco during August, of which 260 were aged after an incidence of 6% regenerated or illegible scales. During September sampling, scale samples were collected from 275 least cisco, of which 259 were aged after an incidence of 6 % regenerated or illegible scales. Ages observed for least cisco in the Chatanika River ranged from 2 to 8 years and lengths ranged between 290 and 420 mm FL. The predominant and median age class present among sampled least cisco (≥ 290 mm FL) was age 4 in August (47% of the stock: Table 3) and September (48%; Table 4), followed by age 5 (August: 31%, September 24%). Comparisons of August and September age samples indicated that the null hypothesis of similarity should not be rejected (chi-square Goodness of Fit test on ages 2-8: $\chi 2 = 8.37$, df = 6, P = 0.21). The median size least cisco was 346 mm FL during August and 348 mm FL in September, with corresponding modes of abundance occurring between 350 to 399 mm FL and 340 to 349 mm FL, respectively. Kolmogorov-Smirnov tests of cumulative length frequencies from August and September samples inferred that the size composition did not change (D = 0.06, P = 0.72). As a result of the two comparisons (age and size); August and September samples were pooled for 1996 least cisco composition estimates (Table 5).

AGE AND SIZE COMPOSITION IN 1997

Humpback Whitefish
Scale samples were collected from a total of 1,439 humpback whitefish, of which 926 were aged after an incidence of 35% regenerated or illegible scales. Length comparisons of humpback whitefish that were aged to fish with regenerated scales indicated statistically significant differences existed (KS two sample test: D = 0.13, P < 0.001). This examination indicated a higher tendency for regenerated scales to be collected from larger fish, and as a result, a slight bias in age composition toward younger ages. Ages ranged from 3 to 16 years and ages ranged between 295 and 544 mm FL, with age 7 as the median age. The predominant age class of sampled humpback whitefish ≥ 360 mm FL was age 6 (23% of the stock; Table 6) followed by age 5 (17%). The median-size humpback whitefish was 438 mm FL, with a mode in relative abundance between 410 and 419 mm FL (Figure 5).

Least Cisco
Scale samples were collected from a total of 829 least cisco, of which 606 were aged after an incidence of 27% regenerated or illegible scales. Length comparisons of least cisco that were aged to fish with regenerated scales indicated no statistically significant differences existed (KS two sample test: D = 0.08, P = 0.20). This examination validated the assumption that for least cisco the incidence of collecting a regenerated scale would be similar for all sizes of sampled fish. Ages observed for least cisco in the Chatanika River ranged from 2 to 12 years and lengths ranged between 290 and 450 mm FL, with age 6 as the median age. The predominant age class

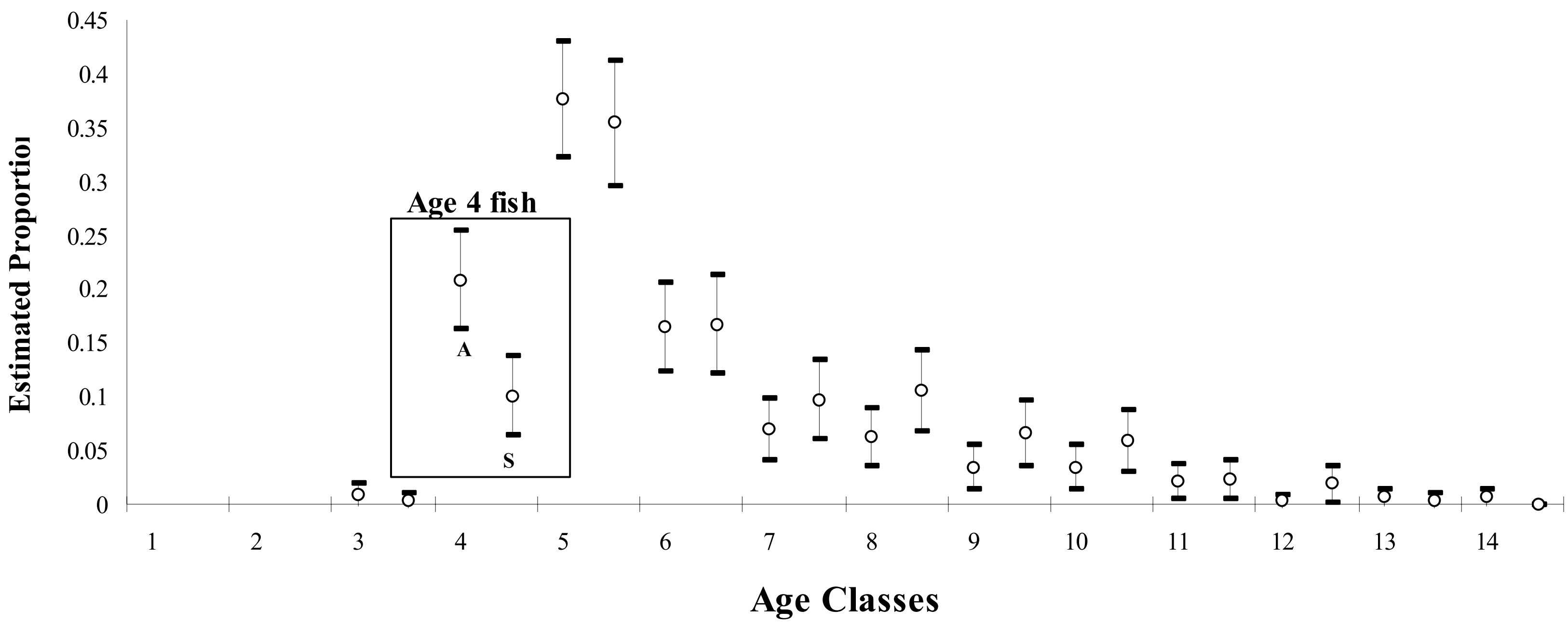

Figure 4.-Estimated proportions and 95% confidence intervals of humpback whitefish by age (≥ 360 mm FL) in the Chatanika River, during August 21-22, and September 17-18, 1996. Confidence intervals for age-4 fish are labeled A and S, which denote August (left) and September (right) samples.

Table 3.- Estimates of the sampled contributions by each age class and 10 mm FL incremental size classes for least cisco (≥290 mm FL) captured from the Chatanika River, August 21 through 22, 1996.

Age	Count	$\hat{p}$[a]	SE[b]		Length	Count	$\hat{p}$[a]	SE[b]
1	0	0.00	0.00		295	0	0.00	0.00
					305	6	0.02	0.01
2	3	0.01	0.01		315	20	0.07	0.02
					325	26	0.09	0.02
3	36	0.14	0.02		335	48	0.17	0.02
					345	48	0.17	0.02
4	122	0.47	0.03		355	50	0.18	0.02
					365	39	0.14	0.02
5	81	0.31	0.03		375	24	0.09	0.02
					385	9	0.03	0.01
6	12	0.05	0.01		395	3	0.01	0.01
					405	2	0.01	< 0.01
7	5	0.02	0.01		415	0	0.00	0.00
					425	1	< 0.01	< 0.01
8	1	< 0.01	< 0.01		435	0	0.00	0.00
					445	0	0.00	0.00
9	0	0.00	0.00		455	0	0.00	0.00
					465	0	0.00	0.00
10	0	0.00	0.00		475	0	0.00	0.00
					485	0	0.00	0.00
11	0	0.00	0.00		495	0	0.00	0.00
					505	0	0.00	0.00
12	0	0.00	0.00		515	0	0.00	0.00
					525	0	0.00	0.00
Totals	260	1	---		Total	276	1.00	----

[a] $\hat{p}$ = proportion of least cisco in the assessed stock at the time of sampling.

[b] SE = standard error of the proportional contribution.

Table 4.- Estimates of the sampled contributions by each age class and 10 mm FL incremental size classes for least cisco (≥290 mm FL) captured from the Chatanika River, September 17 through 18, 1996.

Age	Count	$\hat{p}$[a]	SE[b]	Length	Count	$\hat{p}$[a]	SE[b]
1	0	0.00	0.00	295	1	< 0.01	< 0.01
				305	9	0.03	0.01
2	7	0.03	0.01	315	14	0.05	0.01
				325	28	0.10	0.02
3	52	0.20	0.02	335	42	0.15	0.02
				345	52	0.19	0.02
4	124	0.48	0.03	355	49	0.18	0.02
				365	36	0.13	0.02
5	63	0.24	0.03	375	25	0.09	0.02
				385	10	0.04	0.01
6	10	0.04	0.01	395	5	0.02	0.01
				405	4	0.01	0.01
7	3	0.01	0.01	415	0	0.00	0.00
				425	0	0.00	0.00
8	0	0.00	0.00	435	0	0.00	0.00
				445	0	0.00	0.00
9	0	0.00	0.00	455	0	0.00	0.00
				465	0	0.00	0.00
10	0	0.00	0.00	475	0	0.00	0.00
				485	0	0.00	0.00
11	0	0.00	0.00	495	0	0.00	0.00
				505	0	0.00	0.00
12	0	0.00	0.00	515	0	0.00	0.00
				525	0	0.00	0.00
Totals	259	1	---	Total	298	1.00	----

[a] $\hat{p}$ = proportion of least cisco in the assessed stock at the time of sampling.

[b] SE = standard error of the proportional contribution.

Table 5.- Pooled estimates of the sampled contributions by each age class and 10 mm FL incremental size classes for least cisco (≥290 mm FL) captured from the Chatanika River, 1996[a].

Age	Count	$\hat{p}$[b]	SE[c]		Length	Count	$\hat{p}$[b]	SE[c]
1	0	0.00	0.00		295	1	< 0.01	< 0.01
					305	15	0.03	0.01
2	10	0.02	0.01		315	34	0.06	0.01
					325	54	0.10	0.01
3	88	0.17	0.01		335	90	0.16	0.02
					345	100	0.18	0.02
4	246	0.47	0.02		355	99	0.18	0.02
					365	75	0.14	0.01
5	144	0.28	0.02		375	49	0.09	0.01
					385	19	0.03	0.01
6	22	0.04	0.01		395	8	0.01	< 0.01
					405	6	0.01	< 0.01
7	8	0.01	< 0.01		415	0	0.00	0.00
					425	1	< 0.01	< 0.01
8	1	< 0.01	< 0.01		435	0	0.00	0.00
					445	0	0.00	0.00
9	0	0.00	0.00		455	0	0.00	0.00
					465	0	0.00	0.00
10	0	0.00	0.00		475	0	0.00	0.00
					485	0	0.00	0.00
11	0	0.00	0.00		495	0	0.00	0.00
					505	0	0.00	0.00
12	0	0.00	0.00		515	0	0.00	0.00
					525	0	0.00	0.00
Totals	519	1	---		Total	551	1.00	----

[a] Age and size samples were collected on August 21 and 22, and later on September 17 and 18, 1996.

[b] $\hat{p}$ = proportion of least cisco in the assessed stock at the time of sampling.

[c] SE = standard error of the proportional contribution.

Table 6.- Estimates of the sampled contributions by each age class and 10 mm FL incremental size groupings for humpback whitefish (≥360 mm FL) captured from the Chatanika River, August 20 through 28, 1997[a].

Age	Count	$\hat{p}$[b]	SE[c]		Length	Count	$\hat{p}$[b]	SE[c]
3	3	<0.01	< 0.01		335	0	0.00	0.00
					345	0	0.00	0.00
4	44	0.05	0.01		355	0	0.00	< 0.01
					365	14	0.01	< 0.01
5	158	0.17	0.01		375	22	0.02	< 0.01
					385	49	0.03	0.01
6	212	0.23	0.01		395	97	0.07	0.01
					405	164	0.11	0.01
7	117	0.13	0.01		415	171	0.12	0.01
					425	135	0.09	0.01
8	69	0.07	0.01		435	108	0.07	0.01
					445	106	0.07	0.01
9	73	0.08	0.01		455	130	0.09	0.01
					465	157	0.11	0.01
10	84	0.09	0.01		475	111	0.08	0.01
					485	84	0.06	0.01
11	62	0.07	0.01		495	61	0.04	< 0.01
					505	23	0.02	< 0.01
12	59	0.06	0.01		515	20	0.01	< 0.01
					525	1	< 0.01	< 0.01
13	20	0.02	< 0.01		535	0	0.00	0.00
					545	1	< 0.01	< 0.01
14	17	0.02	< 0.01		555	0	0.00	0.00
					565	0	0.00	0.00
15	6	0.01	< 0.01		575	0	0.00	0.00
					585	0	0.00	0.00
16	2	< 0.01	< 0.01		595	0	0.00	0.00
					605	0	0.00	0.00
> 16	0	0.00	0.00					
Totals	926	1	---		Total	1,454	1.00	----

[a] Stock assessment was conducted between August 20 and 28, but age sampling occurred only during the second event, August 25 through 28.

[b] $\hat{p}$ = unadjusted proportion of humpback whitefish in the assessed stock at the time of the second sampling event, August 25 to 28, 1994.

[c] SE = standard error of the proportional contribution.

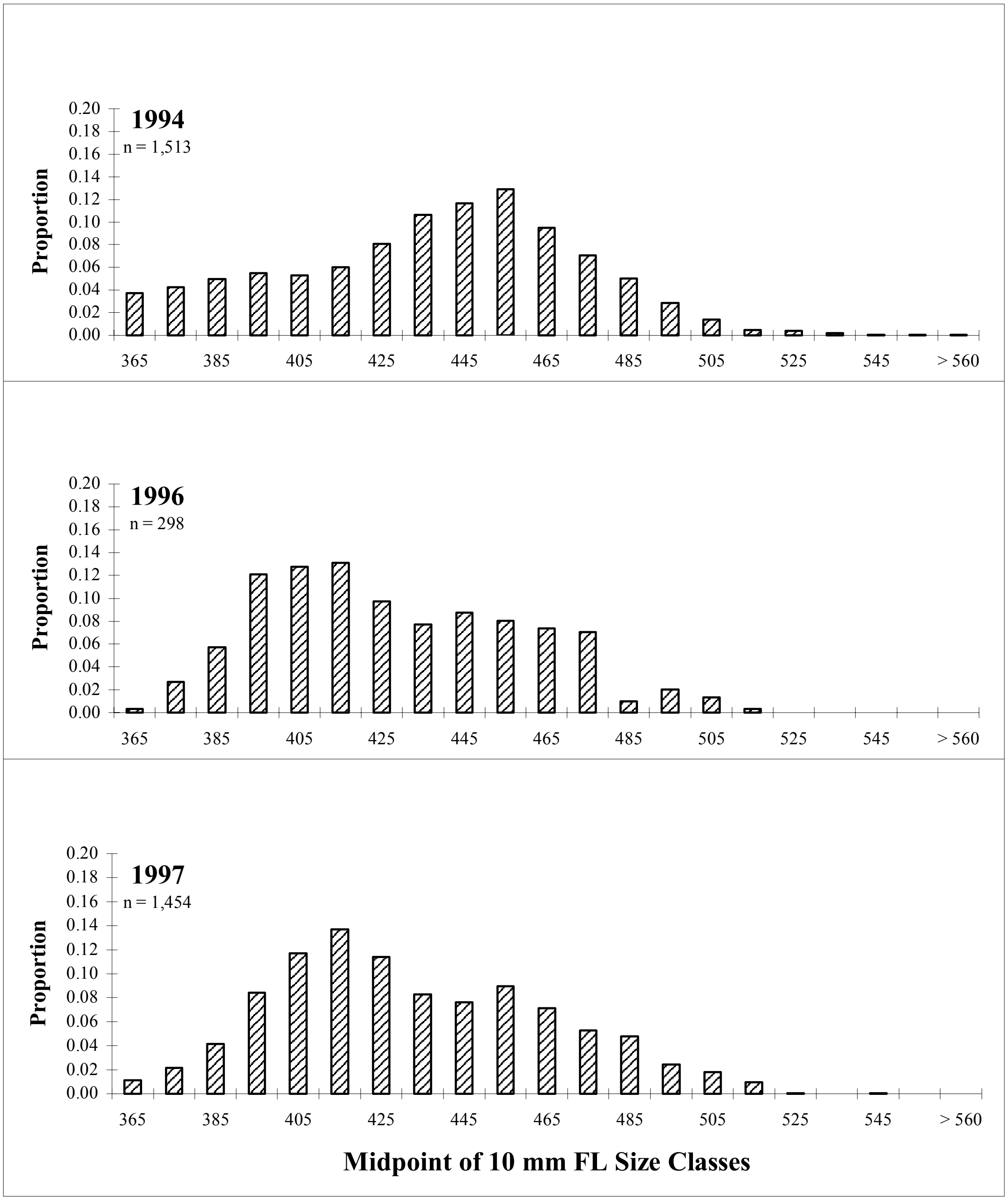

Figure 5.-Estimated proportions of humpback whitefish by length (≥360 mm FL) in the Chatanika River, 1994, 1996, and 1997.

present among sampled least cisco (≥ 290 mm FL) was age 6 (38% of the stock; Table 7) followed by age 5 (25%). The median size least cisco was 353 mm FL, with the mode of abundance occurring between 350 to 359 mm FL (Figure 6).

DISCUSSION

In the past seven years (1991-1997) management actions have significantly reduced harvests of Chatanika River whitefish (total harvest: 2,507 least cisco and 479 humpback whitefish) to conserve stocks and allow undisturbed spawning. After the results of the 1994 stock assessment were discussed, assessment was suspended in 1995, and only limited sampling was undertaken in 1996. Findings from the current analysis of composition (1996 and 1997) and abundance (1997) have indicated the humpback whitefish population is recovering, while the least cisco population is not.

Sampling in 1996 detected increasing numbers of small humpback whitefish recruiting to the population. Moreover, the 1997 assessment reconfirmed their presence and abundance within the spawning stock. On the other hand, findings from 1996 and 1997 have indicated no improvements in least cisco abundance and recruitment. The composition of the least cisco stock has shifted toward older and larger fish, with correspondingly fewer fish less than age 3. When compared to recent assessments, the 1997 estimated number of recruits to the sampling gear and area for humpback whitefish was increasing, while that for least cisco was decreasing:

	Estimated Number of Recruits to Sampling Gear and Sampling Area[a]	
Year	Humpback whitefish (age 7)	Least cisco (age 3)
1991	3,859	32,408
1992	3,521	26,944
1993	1,965	14,135
1994	901	8,630
1997	2,035	1,129

[a] The estimates for 1991, 1992, and 1994 are based on a 102 km study area, the 1993 estimate is from a 78.2 km section, and the 1997 estimate is from a 53 km section.

The stock assessment in 1997 encompassed a smaller-than-anticipated study area, reduced from 102 km in 1994 to 53 km in 1997. Record dry conditions led to exceptionally low water levels in Fairbanks area rivers, and created some problems for navigation and electrofishing. Although we originally planned an assessment in September, we decided to initiate sampling when water conditions permitted. After a brief storm and increase in water levels, mark-recapture sampling began on August 20. In order to successfully electrofish and navigate the Chatanika River at the record low water levels, camping, food, water, and fuel supplies were cached along the river immediately before sampling. While sampling, whitefish were often seen swimming downstream through the shallows ahead of the electrofishing boat. When a shallow riffle was

Table 7.-Estimates of the sampled contributions by each age class and 10 mm FL incremental size classes for least cisco (≥ 290 mm FL) captured from the Chatanika River, August 20 through 28, 1997.[a]

Age	Count	$\hat{p}$[b]	SE[c]		Length[d]	Count	$\hat{p}$[e]	SE[c]
1	0	0.00	0.00		295	25	0.02	< 0.01
					305	33	0.02	< 0.01
2	1	<0.01	<0.01		315	60	0.04	< 0.01
					325	89	0.06	0.01
3	30	0.05	0.01		335	165	0.11	0.01
					345	252	0.17	0.01
4	53	0.09	0.01		355	265	0.18	0.01
					365	202	0.14	0.01
5	152	0.25	0.02		375	169	0.11	0.01
					385	110	0.07	0.01
6	232	0.38	0.02		395	52	0.03	< 0.01
					405	25	0.02	< 0.01
7	53	0.09	0.01		415	12	0.01	< 0.01
					425	3	< 0.01	< 0.01
8	48	0.07	0.01		435	3	< 0.01	< 0.01
					445	0	0.00	0.00
9	29	0.05	0.01		455	0	0.00	0.00
					465	0	0.00	0.00
10	6	0.01	< 0.01		475	0	0.00	0.00
					485	0	0.00	0.00
11	1	< 0.01	< 0.01		495	0	0.00	0.00
					505	0	0.00	0.00
12	1	< 0.01	< 0.01		515	0	0.00	0.00
					525	0	0.00	0.00
Totals	606	1	---		Total	1,465	1.00	----

[a] Stock assessment was conducted between August 20 and 28, but age sampling occurred only during the second event, August 25 through 28.

[b] $\hat{p}$ = unadjusted proportion of least cisco in the assessed stock at the time of the second sampling event, August 25 to 28, 1997.

[c] SE = standard error of the proportional contribution.

[d] Size composition estimates were based on the pooled sample from the first and second sampling events in August 1997. Lengths of recaptured fish in the second sample were excluded to avoid redundancy and resulting bias.

[e] $\hat{p}$ = unadjusted proportion of least cisco in pooled sample from the first and second sampling events in August 1997.

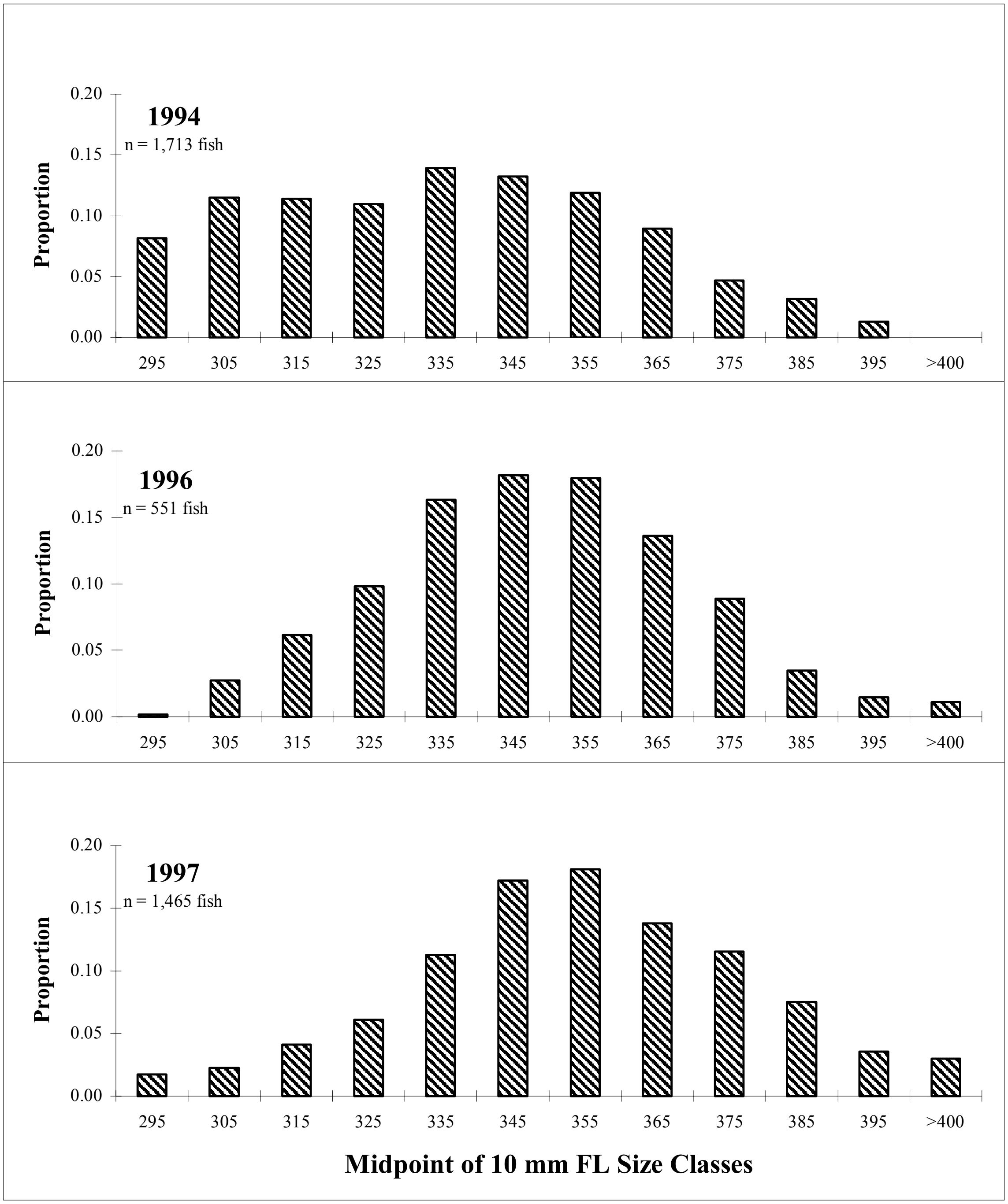

Figure 6.- Estimated proportions of least cisco by length (≥290 mm FL) in the Chatanika River, 1994, 1996, and 1997.

reached, the whitefish would stop and be stunned. Oftentimes the boat became grounded in riffles before all stunned fish could be dipped, whereby crew members pursued stunned fish on foot, or dipped them after the boat was mobile again. Sampling was discontinued 53 km downstream of the Elliot Highway when navigation worsened.

The resulting 1997 estimated abundances of whitefish were 16,107 humpback whitefish ≥ 360 mm FL, and 22,811 least cisco ≥ 290 mm FL within 53 km of the Chatanika River during the last week in August. However, the 1997 estimates of abundance were minimum estimates, because of the likelihood that additional humpback whitefish and least cisco were downstream of the 1997 study area. In 1992, substantial August catches of both species occurred downstream of areas sampled in 1997 (Fleming 1993). Additionally, late immigrating least cisco were documented in a 1994 migration experiment (Fleming 1996). Moreover, the true extent of population increase or decline remains unknown because of time and area factors which may have biased 1997 estimates low. However, the extent of this bias relative to other August estimates may be examined using information collected during 1992 and 1994. In these years mark-recapture assessments encompassed the maximum sized study areas (102 km), which included the 49 km section not sampled in 1997. In 1992 and 1994 approximately 31 and 30% of the assessed humpback whitefish, respectively, were estimated to be resident in the lower 49 km section. In 1992 and 1994, approximately 36% and 11% of the least cisco, respectively, were estimated to be resident in the same section (*Unpublished data*). Using the range of these proportions, it is possible that an additional 6,000 to 7,000 humpback whitefish and 2,700 to 13,000 least cisco may have been present in the 49 km area not sampled during August.

In August and September 1996, humpback whitefish age compositions were found to be significantly different, particularly age 4 fish (August 21%; September 10%). The discrepancy may have been due to a combination of smaller sample sizes and, a smaller study area than in previous years. As spawning begins in late-September, it is likely that upstream movements during the sampling hiatus by larger spawning and prespawning fish to sampled spawning areas could dilute the composition of age 4 fish.

The composition of the 1997 humpback whitefish population has indicated significant recruitment of age 7 fish. The prerecruit year classes (age classes not fully vulnerable to sampling gear; ages 1-6) presently comprise 45% of the abundance, and will likely contribute substantially to the population in the next few years (Figure 7). Prerecruit year class strengths have ranged between 21% and 27 % since 1991, and was as high as 87% in 1987 (Hallberg 1988). It should be cautioned that bias exists in the 1997 age composition, based on patterns of scale regeneration from humpback whitefish in 1997. It is likely that the statistically significant bias was only detected in 1997 due to influences from greater numbers of smaller and younger humpback whitefish sampled, which may have fewer regenerated scales. In future sampling of humpback whitefish, additional scales will be taken, as was the procedure in prior assessments, to avoid further bias in age composition estimates.

The 1996 and 1997 least cisco composition estimates have indicated a continued shortage of younger age classes. In 1996, age 3 fish comprised 17% of the pooled sample (Table 5) and one year later comprised only 5% of the assessed stock. The 1997 estimate represents the lowest

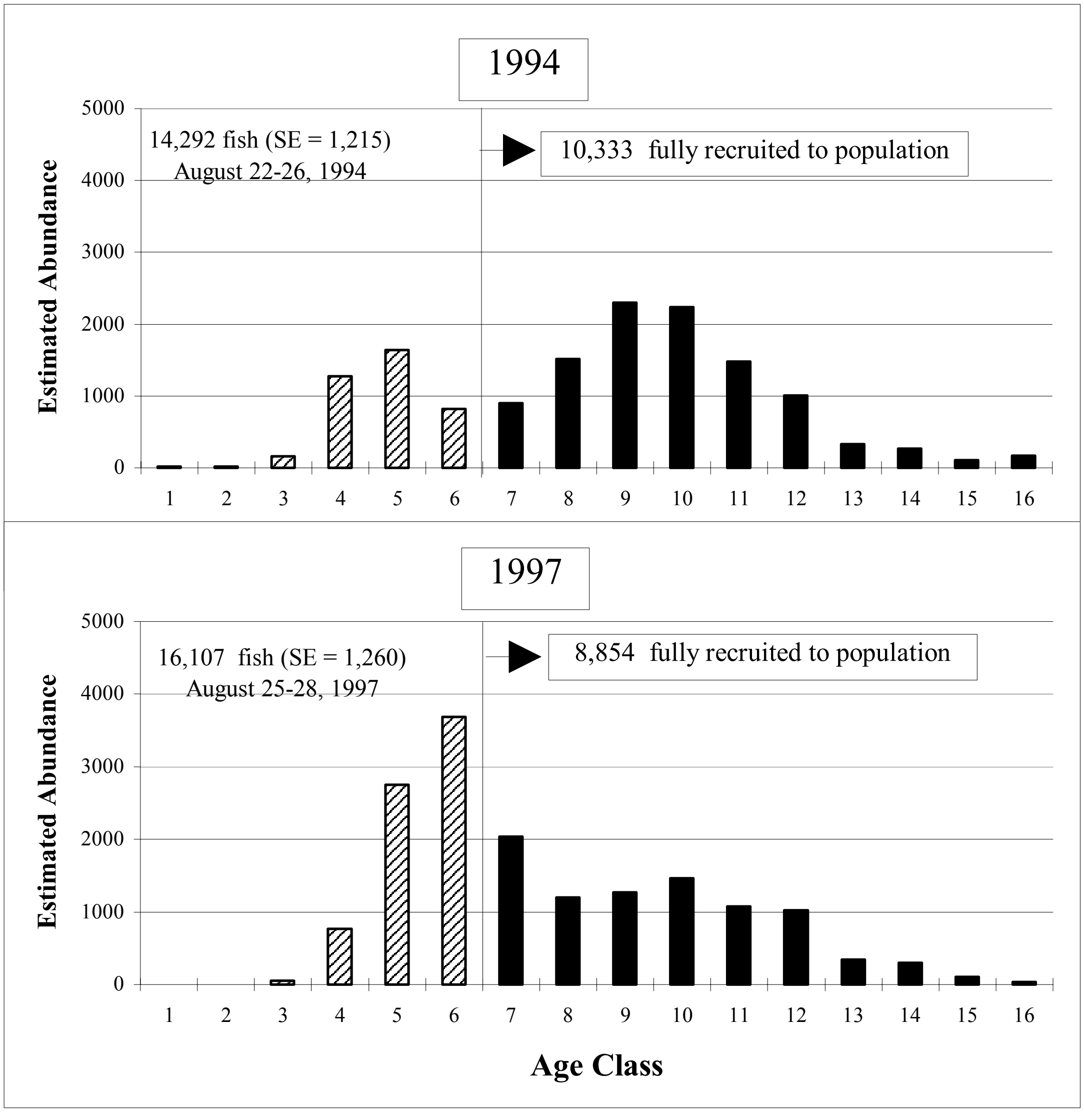

Figure 7.- Estimated abundance by age class for humpback whitefish ($\geq$360 mm FL) in a 102 km section of the Chatanika River during August 1994 and a 53 km section in August 1997.

sampled proportion of age 3 least cisco in 11 years of stock assessment. Prior to 1996, the average age 3 year class strength has been 22% (9 year average 1986-1994: Hallberg and Holmes 1987, Hallberg 1988, Hallberg 1989, Timmons 1990, Timmons 1991, Fleming 1993, Fleming 1994, Fleming 1996). Health of the least cisco population can also be judged by the distribution of recent abundances among age classes. When the 1994 and 1997 abundances were apportioned among year classes it became apparent that the recruitment levels of age 3 fish were low in 1995 and 1996 (seen as age 4 and age 5 fish; Figure 8). Although strict conservation measures have been taken, with near zero harvest for 7 years, the pressure of natural mortality appears to have remained high.

Based on the 1996 and 1997 assessment findings, it is likely that fisheries will not be prosecuted upon these stocks in the near future unless least cisco stocks recover substantially.

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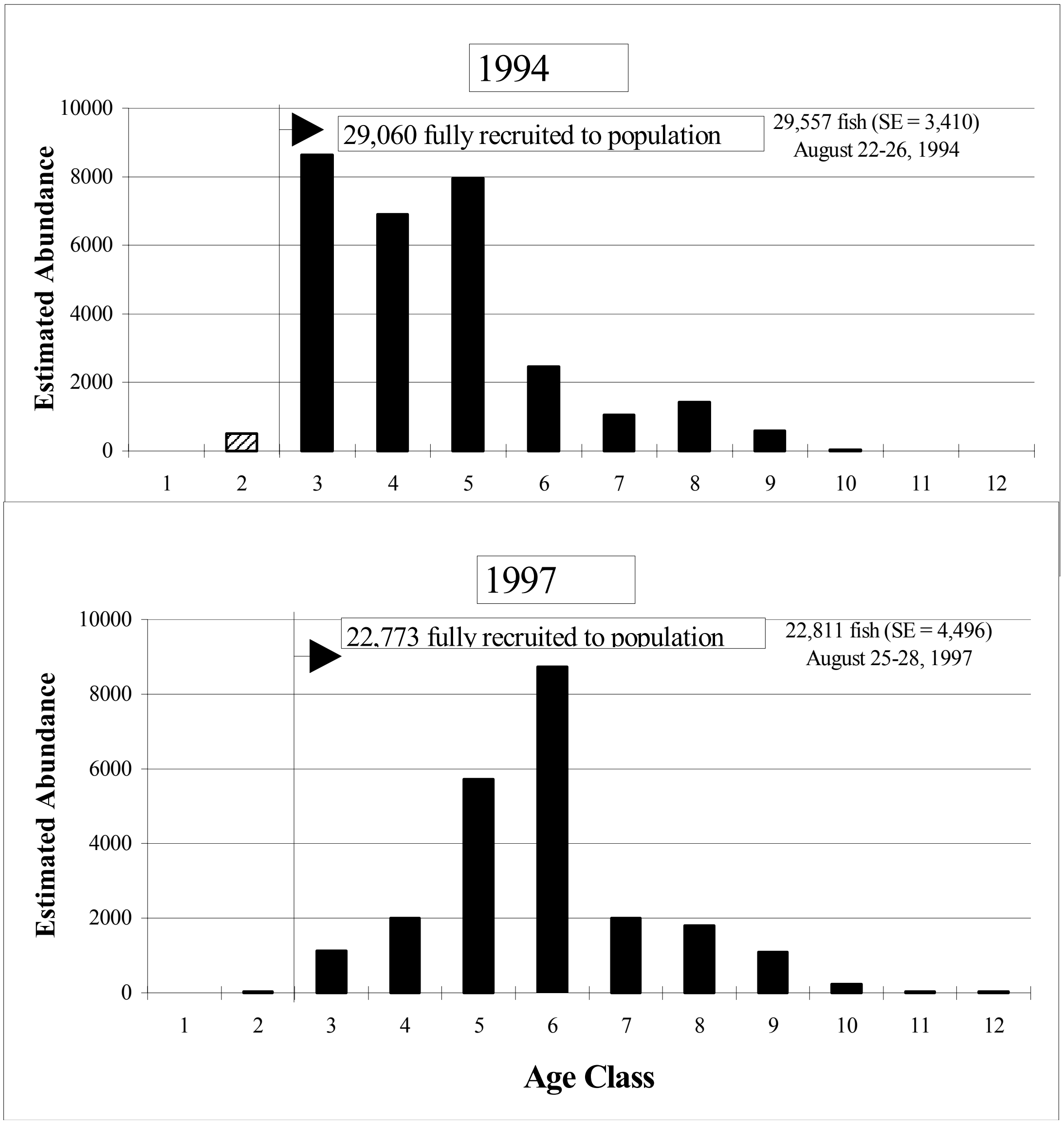

Figure 8.- Estimated abundance by age class for least cisco (≥290 mm FL) in a 102 km section of the Chatanika River during August 1994 and a 53 km section in August 1997.

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Appendix A

Appendix A1.-Methodologies for alleviating bias due to gear selectivity by means of statistical inference.

Result of first K-S test[a]	Result of second K-S test[b]
Case I[c]	
Fail to reject H_0	Fail to reject H_0
Inferred cause: There is no size-selectivity during either sampling event.	
Case II[d]	
Fail to reject H_0	Reject H_0
Inferred cause: There is no size-selectivity during the second sampling event, but there is during the first sampling event	
Case III[e]	
Reject H_0	Fail to reject H_0
Inferred cause: There is size-selectivity during both sampling events.	
Case IV[f]	
Reject H_0	Reject H_0
Inferred cause: There is size-selectivity during the second sampling event; the status of size-selectivity during the first event is unknown.	

a The first K-S (Kolmogorov-Smirnov) test is on the lengths of fish marked during the first event versus the lengths of fish recaptured during the second event. H_0 for this test is: The distribution of lengths of fish sampled during the first event is the same as the distribution of lengths of fish recaptured during the second event.

b The second K-S test is on the lengths of fish marked during the first event versus the lengths of fish captured during the second event. H_0 for this test is: The distribution of lengths of fish sampled during the first event is the same as the distribution of lengths of fish sampled during the second event.

c Case I: Calculate one unstratified abundance estimate, and pool lengths and ages from both sampling event for size and age composition estimates.

d Case II: Calculate one unstratified abundance estimate, and only use lengths and ages from the second sampling event to estimate size and age composition.

e Case III: Completely stratify both sampling events and estimate abundance for each stratum. Add abundance estimates across strata. Pool lengths and ages from both sampling events and adjust composition estimates for differential capture probabilities.

f Case IV: Completely stratify both sampling events and estimate abundance for each stratum. Add abundance estimates across strata. Also calculate a single abundance estimate without stratification.

If stratified and unstratified estimates are dissimilar, discard unstratified estimate and use lengths and ages from second event and adjust these estimates for differential capture probabilities.

If stratified and unstratified estimates are similar, discard estimate with largest variance. Use lengths and ages from first sampling event to directly estimate size and age compositions.