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Stock Assessment of Humpback Whitefish and Least Cisco in the Chatanika River During 1992

by

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Alaska Department of Fish and Game

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STOCK ASSESSMENT OF HUMPBACK WHITEFISH AND LEAST CISCO IN THE CHATANIKA RIVER DURING 1992[1]

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ABSTRACT

Stock assessment of humpback whitefish *Coregonus pidschian* and least cisco *Coregonus sardinella* occurred in a 105 kilometer area of the Chatanika River, near Fairbanks, Alaska during August 1992. Mark-recapture experiments were conducted simultaneously for both species as two electrofishing crews systematically sampled the river during two complete passes, with two pulsed DC electrofishing boats. 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 onset of a recreational spear fishery. An estimated 20,180 (SE = 1,663) humpback whitefish (≥360 millimeters fork length) were present in the study area. The stock was characterized by a high proportion of large humpback whitefish (≥420 millimeters fork length) with ages 7, 8, and 9 predominating. The continued absence of young humpback whitefish indicates potential recruitment failures to the spawning stock over the next few years. An estimated 86,989 (SE = 9,097) least cisco (≥290 millimeters fork length) were present in the study area. The stock was distributed almost evenly between all lengths, which ranged from 290 to 427 millimeters fork length, with ages 3, 4, and 6 most abundant. Almost 36% of the assessed stock was age three and although they are not fully recruited, indicates potentially strong recruitment in 1993.

KEY WORDS: humpback whitefish, *Coregonus pidschian*, least cisco, *Coregonus sardinella*, abundance estimation, age composition, length composition, spawning stock.

INTRODUCTION

Each year during summer and early fall, humpback whitefish *Coregonus pidschian* and least cisco *Coregonus sardinella* make large-scale movements into the Chatanika River to spawn (Figure 1). The Chatanika River is fed by runoff in the White Mountains northeast of Fairbanks, Alaska. It flows to the southwest, draining through the Minto Flats area, and into the Tolovana River which flows into the Tanana River. A significant recreational fall spear fishery for whitefish developed during the 1980's, primarily between the Elliott Highway Bridge and the Olnes Pond Campground, with a limited harvest taken along the Steese Highway. Estimates of whitefish harvests on the Chatanika River increased from 1,635 in 1977 to a high of 25,074 whitefish in 1987 (Mills 1979-1988).

In response to the rapid growth of the whitefish spear fishery and increasing harvests, stock assessments were initiated in 1986. Several methods of estimating abundance of whitefish, including sidescan sonar, counting towers, and mark-recapture experiments, were evaluated in 1986 and 1987 (Hallberg and Holmes 1987, Hallberg 1988). Based on those evaluations, mark-recapture experiments were chosen to estimate abundance. Electrofishing boats were used to capture whitefish for marking; creel surveys conducted during the spear fishery were used as the recapture event in 1988 and 1989 (Hallberg 1989, Timmons 1990). These early experiments were conducted in close proximity to the fishery, within a few kilometers of the Elliott Highway Bridge, which later proved problematic. In 1988, least cisco tagged in the vicinity of the Alyeska Pipeline crossing never entered the fishery, precluding an estimate of abundance for least cisco. In 1989, large numbers of least cisco and humpback whitefish were found well downstream of the previously studied areas. In the 1990 and 1991 assessments, investigations focused on assessing the geographic extent of the exploited population. Humpback whitefish and least cisco were found to be migrating upstream as early as July. Additionally, the previous assumption that the Alyeska Pipeline delimited the downstream extent of the exploitable portion of whitefish stocks was violated when fish tagged in the Goldstream Creek area of Minto Flats were later recovered far upstream in the Chatanika River (Timmons 1991).

Prompted by concern over increasing sport harvests of whitefish, in 1987 the Board of Fisheries restricted harvest of whitefish in the Tanana River drainage to a bag limit of 15 fish per day. Although estimated harvest of whitefish initially dropped during the 1988 season (Mills 1989), estimated harvest nearly doubled in 1989 while estimated fishing effort (days fished) for the Chatanika River changed little (Mills 1990). Further management actions have led to emergency closures during the 1990 season, and a complete closure in 1991 when a preliminary assessment indicated the need for conservation of the spawning stocks. Research efforts in 1991 confirmed preliminary estimates: abundance of humpback whitefish over a 110 km section of the river was estimated at only 15,313 fish, and these were mostly older fish (Timmons 1991). Board of Fisheries action in 1992 included additional regulations which shortened the season to one month and reduced the geographic area of the fishery. With the new regulations, a low level fishery might be allowed to continue.

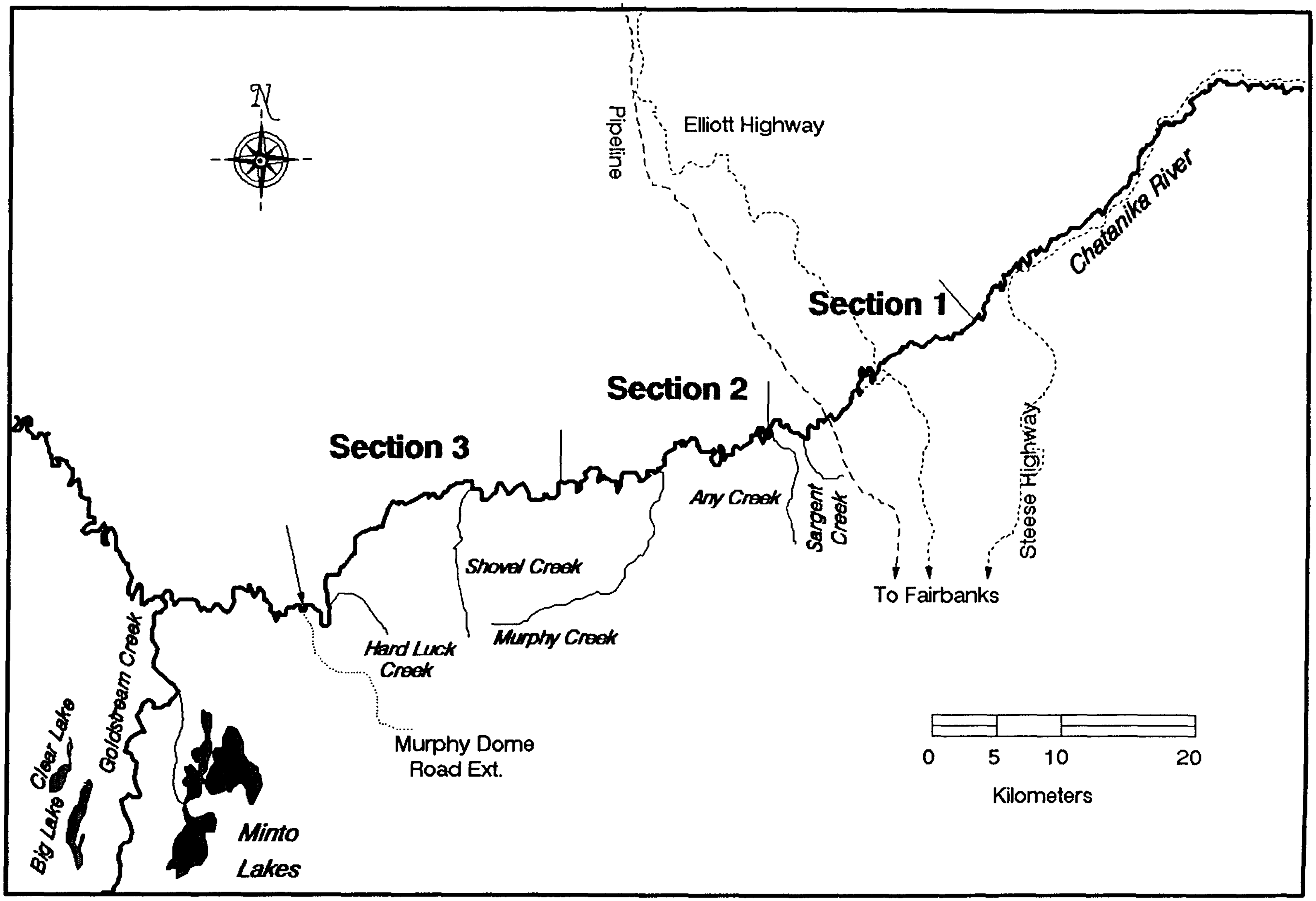

Figure 1. Map of the 1992 study area encompassing 105 km divided among three adjacent sections of the Chatanika River.

Information gathered in the past several years has increased the breadth of knowledge on sampling these mobile populations, and indicated constraints for stock assessment. Information about contribution of fish marked and released in lower portions of the Chatanika River and Goldstream Creek, and their eventual migration to the area of the spear fishery attests the need of assessing as much of the exploitable stock as feasible. Because of a conservation concern associated with a shift towards older fish in the humpback whitefish population and uncertainties about observed patterns of recruitment, it has been necessary to use in-season management. Because managers need assessment information prior to the spearing season, the timing of stock assessment is constrained to late August.

OBJECTIVES

Specific objectives for the 1992 studies on humpback whitefish and least cisco in the Chatanika River were to estimate:

1. abundance of humpback whitefish greater than 359 mm FL and least cisco greater than 289 mm in a 125 km area of the Chatanika River, beginning 16 km above the Elliott Highway Bridge downstream to the Murphy Dome Road Extension; and,

2. age and length compositions of humpback whitefish and least cisco inhabiting the 125 km area of the Chatanika River.

METHODS

Study Area and Sampling Design

Past stock assessments for both species of whitefish occurred over limited areas of the Chatanika River accessed by the Elliott Highway, but recent assessments have extended sampling significantly downstream. The assessments prior to 1990 were within an area 16 km above and below the Elliott Highway crossing. This section of the Chatanika River is characterized by moderate gradient, with short meandering stretches interspersed with gravel riffles. This area has been thought to provide spawning habitat for the whitefish as well as being the area affected by the recreational spear fishery. In 1991, the study area was extended downstream an additional 83 km after detecting exploitation of whitefish tagged well below the spearfishing area (Timmons 1991). This addition to the study area includes 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 cutbanks. This middle portion extends downstream 51 km, beginning with continuous meanders and oxbows which changes to long straight reaches. Then the river changes to a higher gradient, and continues 28 km to the end of the study area as a series of wide shallow runs and riffles, with coarse cobble and bedrock substrate.

Field Sampling

To minimize potential bias in the abundance estimate, the hiatus between events was shortened and the study area was enlarged. The mark-recapture experiment on the Chatanika River in 1992 began on 17 August, and was completed on 28 August. There were two distinct sampling events. Sampling was performed by three crews, each with three persons. Two of the crews used pulsed DC electrofishing boats to capture fish, while the other crew sampled fish in a separate boat. Each sampling event lasted five days and consisted of a single downstream pass by the three crews working together. The upstream limit of the 1992 study section was approximately 5 km upstream of the Elliot Highway bridge, and the lower limit was downstream 100 km at the terminus of the Murphy Dome Road Extension (Figure 1).

To limit holding time and stress of captured fish and to ensure an even distribution of marked fish in the study area, sampling was conducted as a series of 48 discrete "runs". A run consisted of 20 min of electrofishing in a downstream direction. In the upper and lowermost portions of the river, where the stream channel width was confined, electrofishing boats were often fished in a staggered formation. In the middle portion, where the river was more typically wide and slow, boats were fished side-by-side along each bank. Variable voltage pulsator (VVP) settings were 60 Hz pulse DC ranging from 190 to 250 volts and 2 to 7 A. Water conditions remained low and clear through both sampling events, with temperatures remaining at 9.5 °C and conductivity at 130 μS. Fish were dipped and put into large aerated live wells to await sampling. At the completion of each run, labelled flagging was staked and left for later reference. At each flagged end-point, a global positioning system (GPS) unit determined near-exact location for later referencing of release-recapture information. All captured fish in the first sampling event were measured to the nearest 1 mm FL, fin clipped (upper caudal clip), and tagged with an individually numbered blue Floy FD-67 internal anchor tag at the base of the dorsal fin. During the second (recapture) sampling event, all fish were examined for marks, measured, and fin clipped (lower caudal clip). Additionally, scales were collected systematically from approximately one out of every three least cisco and one out of every two humpback whitefish, gently cleaned, and mounted directly onto gum cards for later pressing and ageing. Fish with tag losses were given new tags, and previous fin clips were noted. Data collection procedures from previously marked humpback whitefish and least cisco were similar, but previous fin clips, tag losses, tag numbers, and colors were also recorded. Scales were also collected from all humpback whitefish and least cisco tagged in previous years for relative age validation. All data was recorded on Alaska Department of Fish and Game Tagging Length Form, Version 1.0. Gum cards were later used to make triacetate impressions using a scale press (30 sec at 137,895 kPa, at a temperature of 97°C). Ages were obtained by counting annuli on scales viewed with a microfiche viewer at 25X enlargement.

<u>Abundance Estimation</u>

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 fish have the same probability of capture during the first event or in the second event or marked and unmarked fish mix randomly between the first and second events;

3) marking of fish does not affect their probability of capture in the second event, and;

4) fish do not lose their mark between 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 feasible. It was improbable that substantial migration, mortality, or recruitment occurred during the seven 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. Size selectivity was tested with two Kolmogorov-Smirnov two-sample 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 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 in three 35 km sections of the study area. The results of this test determined whether the mark-recapture data should be stratified by section. The last testable assumption was met by double marking each fish, with a tag and a fin-clip specific to the 1992 mark-recapture experiment.

Examination of the assumptions demonstrated that size selective sampling was detected for humpback whitefish, requiring the data to be stratified into size classes. To delimit the stratified size classes, an iterative series of chi-square tests was performed to find maximal differences in capture probability. The length at which the chi-square statistic was maximal demarcated the size strata. Because the assumption of equal capture probability by section was not violated, the modified Petersen estimator of Bailey (1951, 1952) was selected. Use of Bailey's modification was sought 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 (Seber 1982). Stratified and unstratified point estimates of abundance were estimated as:

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

where:
- M = the number of fish marked and released during the marking event sample;
- 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 humpback whitefish or least cisco.

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

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

Age and Length Compositions

Apportionment of the estimated abundance among age or length classes depends upon the extent of sampling biases. The outcome of tests for size selectivity and chi-square tests to detect geographic differences in capture probabilities, determined the necessary adjustments. Because length selectivity was detected for humpback whitefish, the sampled age and length compositions could be adjusted by length-specific capture probabilities. The appropriate sample or samples (from the first event, second, or both events) was used to estimate the age and length compositions. When no adjustments for length selectivity or geographic differences in capture probability were required, the proportion of fish at age *k* (or length class *k*) was estimated using the appropriate sample (Appendix A1: from the first event, second, or both events) by:

$$\hat{p}_k = \frac{y_k}{n} \qquad (3)$$

where: $\hat{p}_k$ = the proportion of fish that are age *k*;
y_k = the number of fish sampled that are age *k*; and,
n = the total number of fish sampled.

The unbiased variance of this proportion was estimated as:

$$\hat{V}[p_k] = \frac{\hat{p}_k\ (1 - \hat{p}_k)}{n - 1} \qquad (4)$$

RESULTS

Field Sampling

A total of 3,225 humpback whitefish (≥ 360 mm FL) and 5,547 least cisco (≥ 290 mm FL) were captured over a 12-day period in the latter half of August. Water conditions were low and clear, while stream temperatures remained stable at 9.5 °C. Low water conditions and stream channel alterations in the uppermost section precluded sampling as far upstream as was done in the 1991 assessment. During the field investigation, 1,411 humpback whitefish (≥ 360 mm FL) were marked and released alive over the 105 km of river in the first sampling event. In the second sampling event, 1,944 were examined for marks, yielding 135 recaptures (Figure 2). From both sampling events, 21 fish and 147 fish retained tags from 1990, and 1991, respectively. Concurrently, 2,312 least cisco ($\geq$ 290 mm FL) were marked and released alive in the first sampling event, and in the second sampling event 3,310 were examined for marks, yielding 87 recaptures (Figure 3).

From both sampling events, 27 fish and 65 fish retained tags from 1990, and 1991, respectively. The tag shedding rate from the marking to the recapture event was 1.5%, based on two of 135 humpback whitefish that were recaptured without tags, and 0% for least cisco based on zero of 87 recaptures. The incidence of tag shedding from past years to present was 42%, based on 123 tags shed among 291 humpback whitefish examined bearing tags and or fin clips from 1990 and 1991 assessments. The incidence of shedding rate for least cisco was 14.8%, based on 16 tags shed among 108 fish examined bearing tags and or fin clips from 1990 and 1991 assessments. The overall acute mortality rate from the experiment was eight out of 3,225 individual humpback whitefish handled, or 0.25%. The overall acute mortality rate was 0.45% for least cisco, based on 25 mortalities from 5,547 fish handled.

Abundance Estimation

Capture probabilities by sections for both humpback whitefish and least cisco were examined in three equivalently sized portions of the study area (each ~35 km) corresponding to the upper, middle, and lower sampled sections (Tables 1 and 2). Capture probabilities were estimated to be similar among sampled areas for humpback whitefish (χ^2 = 0.20, df = 2, P = 0.91) and least cisco (χ^2 = 1.37, df = 2, P = 0.51).

A Kolmogorov-Smirnov comparison of cumulative distribution functions (CDF's) from the humpback whitefish mark-recapture experiment showed that length selectivity occurred in both sampling events (Figure 4A -mark vs recaptures: D = 0.12, P = 0.04; and, Figure 4B - mark vs catch: D = 0.05, P = 0.04). As a result, abundance was estimated using both stratified and unstratified approaches to examine the effect of length selectivity (Case IVb; Appendix A1). Length strata selected for abundance estimation were: 360 to 426 mm FL (small), and, 427 mm FL and larger (large). The estimated abundance of small humpback whitefish was 8,994 fish (SE = 1,477; Table 3). The estimate for large humpback whitefish was 11,795 fish (SE = 1,111). The sum of stratified estimates for abundance was 20,789 fish (SE = 1,848, CV = 8.9%) greater than 359 mm FL in the Chatanika River at the time of the first sampling event. The unstratified estimate of abundance was 20,180 fish (SE = 1,663, CV = 8.2%). The similarity of the two point estimates supported the conclusion to use the unstratified abundance estimate and perform no further adjustments to the age and length compositions.

A Kolmogorov-Smirnov comparison of cumulative distribution functions (CDF's) from the least cisco mark-recapture experiment showed that length selectivitywas not present in the mark-recapture sampling events (mark vs recaptures: D = 0.06, P = 0.92; and, mark vs catch: D = 0.03, P = 0.12). The estimated abundance of least cisco greater than 289 mm FL was 86,989 fish (SE = 1,856, CV = 14%).

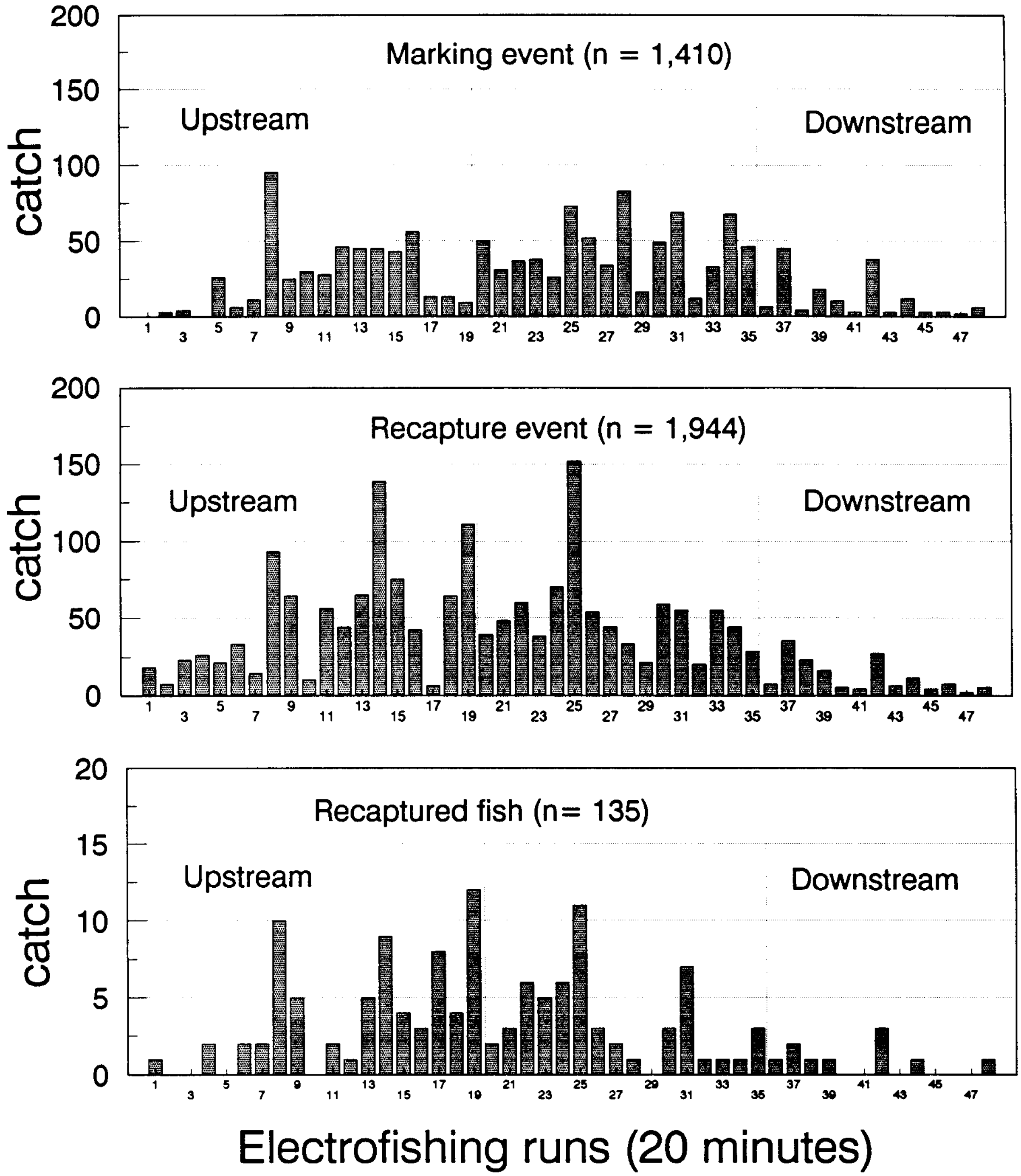

Figure 2. Systematic marking and recapture event samples of humpback whitefish (≥360 mm FL) and distribution of recaptures over 48 sequential electrofishing runs in a 105 km study area of the Chatanika River, 17 - 28 August 1992.

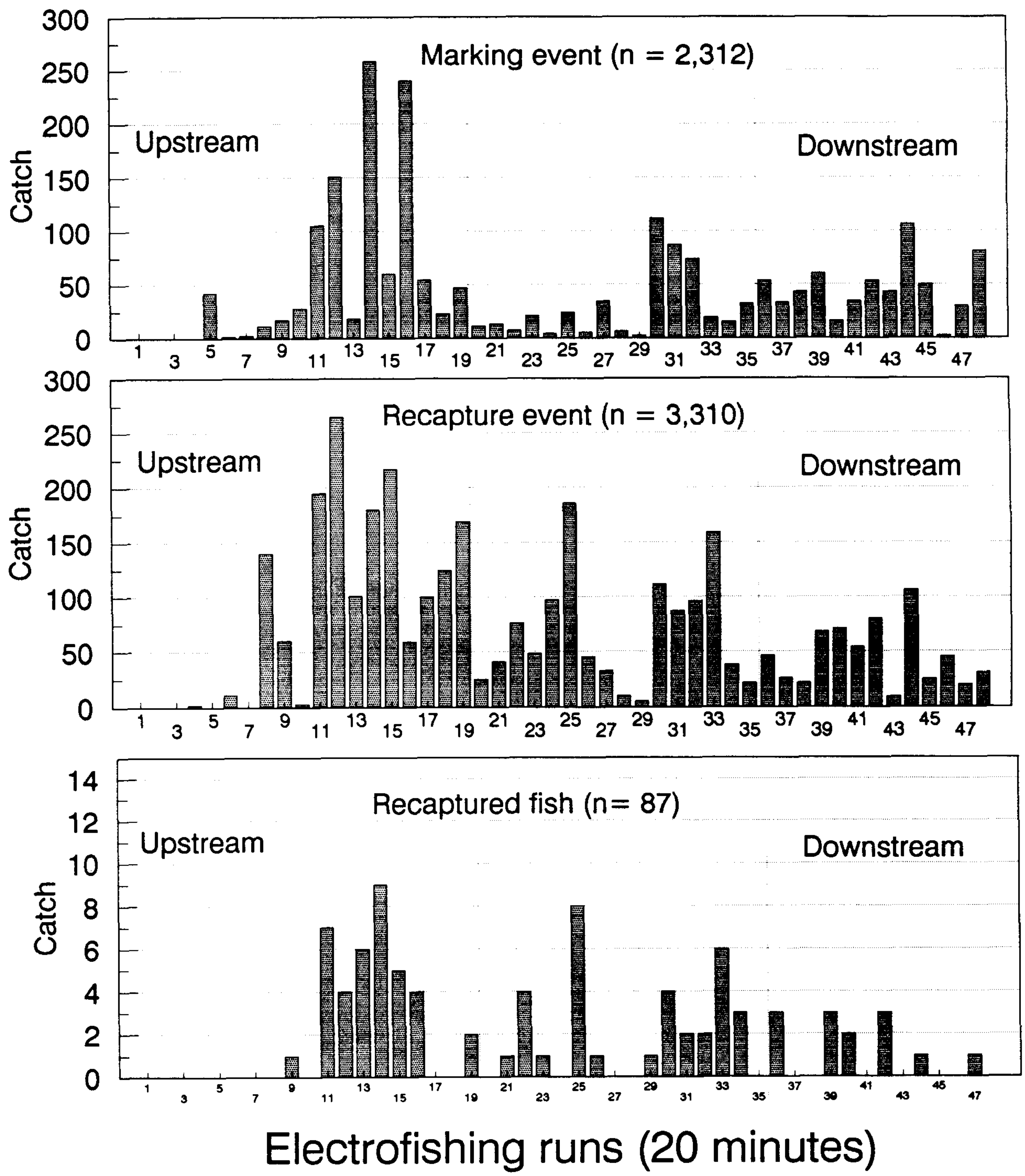

Figure 3. Systematic marking and recapture event samples of least cisco (≥290 mm FL) and distribution of recaptures over 48 sequential electrofishing runs in a 105 km study area of the Chatanika River, 17 - 28 August 1992.

Table 1. Numbers of marked and recaptured humpback whitefish ($\geq$ 360 mm FL) by section, Chatanika River, 17 - 28 August 1992.

	Marking Event		Section Recaptured[a]			Recovered	
	Number marked	Section	1	2	3	Yes	No
	498	1	37	0	0	37	461
	717	2	33	50	1	84	633
	196	3	0	5	9	14	182
Total	1,411	Recaptured (R)	70	55	10	$\sum$ = 135	1,276
		Unmarked (U)	902	765	142	$\sum$ = 1,809	
		Catch (C)	972	820	152	$\sum$ = 1,944	
		R/C Ratio[b]	0.07	0.07	0.06		

[a] The Chatanika River was delineated into three sections that were approximately 35 km in length (see Figure 1).

[b] Capture probabilities were tested for statistical similarity using chi-square tests on numbers of recaptured (R) and examined (C) humpback whitefish. Failure to reject the null hypothesis of similarity between adjacent sections (χ^2 = 0.20, 2 df, P = 0.91) suggests that no section-specific differences in capture probability existed within the experiment.

Table 2. Numbers of marked and recaptured least cisco (≥290 mm FL) by section, Chatanika River, 17 - 28 August 1992

	Marking Event		Section Recaptured[a]				Recovered	
	Number marked	Section	1	2	3		Yes	No
	1,217	1	36	0	0		36	1,181
	466	2	5	17	0		22	444
	629	3	0	16	13		29	600
Total	2,312	Recaptured (R)	41	33	13	∑ =	87	2,225
		Unmarked (U)	1,586	1,047	590	∑ =	3,223	
		Catch (C)	1,627	1,080	603	∑ =	3,310	
		R/C Ratio[b]	0.02	0.03	0.02			

[a] The Chatanika River was delineated into three sections that were approximately 35 km in length (see Figure 1).

[b] Capture probabilities were tested for statistical similarity using chi-square tests on numbers of recaptured (R) and examined (C) least cisco. Failure to reject the null hypothesis of similarity between adjacent sections (χ^2 = 1.37, 2 df, P = 0.51) suggests that no section-specific differences in capture probability existed within the experiment.

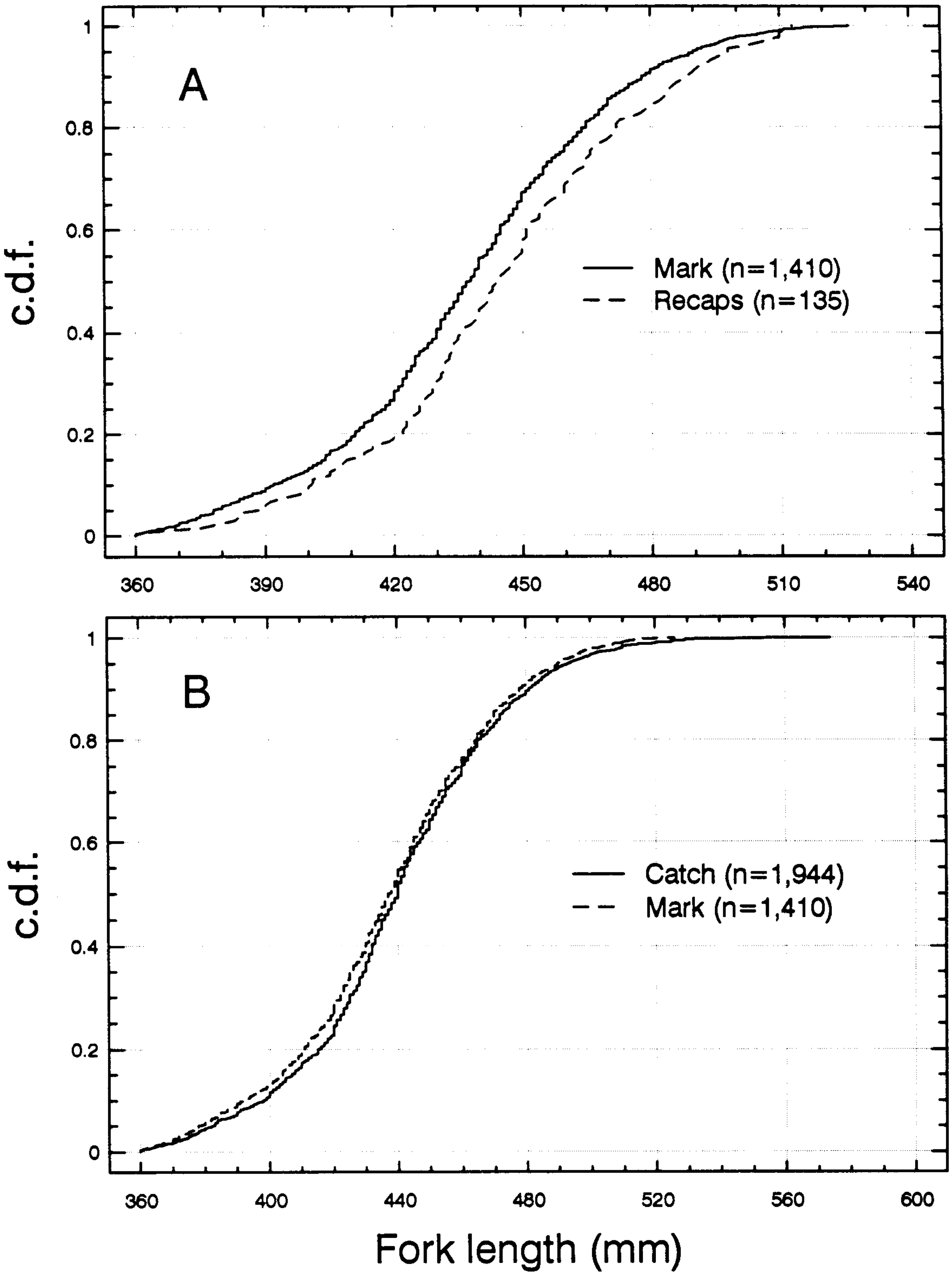

Figure 4. Cumulative distribution functions of lengths of humpback whitefish marked versus lengths of humpback whitefish recaptured (A) and versus lengths of humpback whitefish examined for marks (B) in the Chatanika River, 17 - 28 August, 1992.

Table 3. Size-stratified and unstratified abundance estimates of humpback whitefish ($\geq$ 360 mm FL) in the Chatanika River, at the time of the first sampling event, 17 - 21 August 1992.

Length category	Mark M	Catch C	Recap R	ρ[a]	N[b]	SE[N][c]
360 to 426 mm	503	607	33	0.05	8,994	1,477
$\geq$ 426 mm	908	1,337	102	0.07	11,795	1,111
Total	1,411	1,944	135	---	20,789	1,848
Unstratified	1,411	1,944	135	0.07	20,180	1,663

[a] ρ is the point estimated probability of capture.

[b] N is the point estimated abundance in a stratified length category or unstratified population.

[c] SE[N] is the standard error of N.

Age and Length Compositions

Scale samples were collected from 995 humpback whitefish, of which 642 were aged, with an incidence of 35% regenerated or illegible scales. Ages observed for humpback whitefish in the Chatanika River ranged from 2 to 15 years for fish between 360 and 874 mm FL, with 8 years as the median age. The predominant age class present among humpback whitefish sampled in the Chatanika River was age 8 (22.9% of the stock; Table 4, Figure 5) followed by age 7 (18.4% of the stock). Most humpback whitefish were greater than 420 mm FL, with a peak in abundance between 430 and 439 mm FL (Figure 6).

Scale samples were collected from 1,158 least cisco, of which 880 were aged, with an incidence of 24% regenerated or illegible scales. Ages observed for least cisco in the Chatanika River ranged from 2 to 9 years for fish between 290 and 427 mm FL, with 4 years as the median age. The predominant age class present among least cisco sampled in the Chatanika River was age 3 (35.9% of the stock; Table 4, Figure 7) followed by age 4 (22.2% of the stock). Maximum abundance of least cisco occurred at 320 to 329 mm FL (Figure 8).

DISCUSSION

Field Sampling

Changes made to the sampling design and its implementation in 1992 appeared to work well within the constraints of in-season assessment and management. The addition of a second electrofishing boat and crew led to total catches that were 50% higher for least ciscos, and 67% higher for humpback whitefish. The improved capture efficiency led to a higher marked proportion and ultimately higher precision in the abundance estimates for both species. Catches of both species, by electrofishing run (Figures 2 and 3), were lowest in both the upstream and downstream electrofishing runs relative to the midstream runs. Catches made in 1991, at similar times and locations were also low (Timmons 1991). Together, catch information from both years indicate the geographic extent of sampling was sufficient, covering the bulk of the migrating whitefish. By shortening the duration of the experiment, fish had less time to immigrate or emigrate from the study area.

Consistency of estimated marked-to-unmarked ratios among the upper, middle, and lower sections of the study area, for both species, demonstrated that significant immigration from areas downstream of the study area had not occurred after the seven day hiatus. Low water and channel alterations prevented sampling the uppermost 5 km sampled in 1991 (more than 5 km upstream of the Elliot Highway bridge). If we had sampled this area, fish emigrating from downstream areas, or other concentrations may have been detected. In 1991, few fish were captured or recaptured in the portion above the Alyeska Pipeline (areas 1-5 in 1991; Timmons 1991), when the overall duration of the experiment was as much as 66 days, and the hiatus was a minimum of 17 days(August and September sampling only). Since few fish in 1991 moved into the uppermost areas after a minimum of 17 days, it is unlikely with similar catch patterns and a seven-day hiatus, that a significant portion of marked and unmarked fish moved upstream, leaving the study area, during August 1992. The present timing of the assessment program may be optimal for future use, but geographic closure should be investigated by sampling the uppermost areas.

Table 4. Estimates of the sampled contributions by each age class for humpback whitefish (≥360 mm FL) and least cisco (≥290 mm FL) captured in the Chatanika River, 24 - 28 August 1992[a].

	Humpback Whitefish			Least Cisco		
Age Class	p[b]	n[c]	SE[d]	p[b]	n[c]	SE[d]
1	0.00	0	---	0.00	0	---
2	<0.01	2	<0.01	0.10	87	0.01
3	<0.01	7	<0.01	0.36	316	0.02
4	0.06	41	0.01	0.22	195	0.01
5	0.06	36	0.01	0.10	93	0.01
6	0.07	48	0.01	0.13	113	0.01
7	0.18	118	0.01	0.06	58	<0.01
8	0.23	147	0.02	0.02	16	<0.01
9	0.18	113	0.01	<0.01	2	<0.01
10	0.11	71	0.01	0.00	0	---
11	0.05	32	0.01	0.00	0	---
12	0.02	17	<0.01	0.00	0	---
13	<0.01	6	<0.01	0.00	0	---
14	<0.01	3	<0.01	0.00	0	---
15	<0.01	2	<0.01	0.00	0	---
Totals	1.0	642	--- -	1.0	880	---

[a] Stock assessment was conducted between 17 and 28 August, but age sampling occurred during the second event, 24 through 28 August.
[b] p = unadjusted proportion of humpback whitefish or least cisco in the population at the time of the second sampling event, 24 to 28 August, 1992.
[c] N= number of individuals sampled in each age class.
[d] SE = standard error of the proportional contribution.

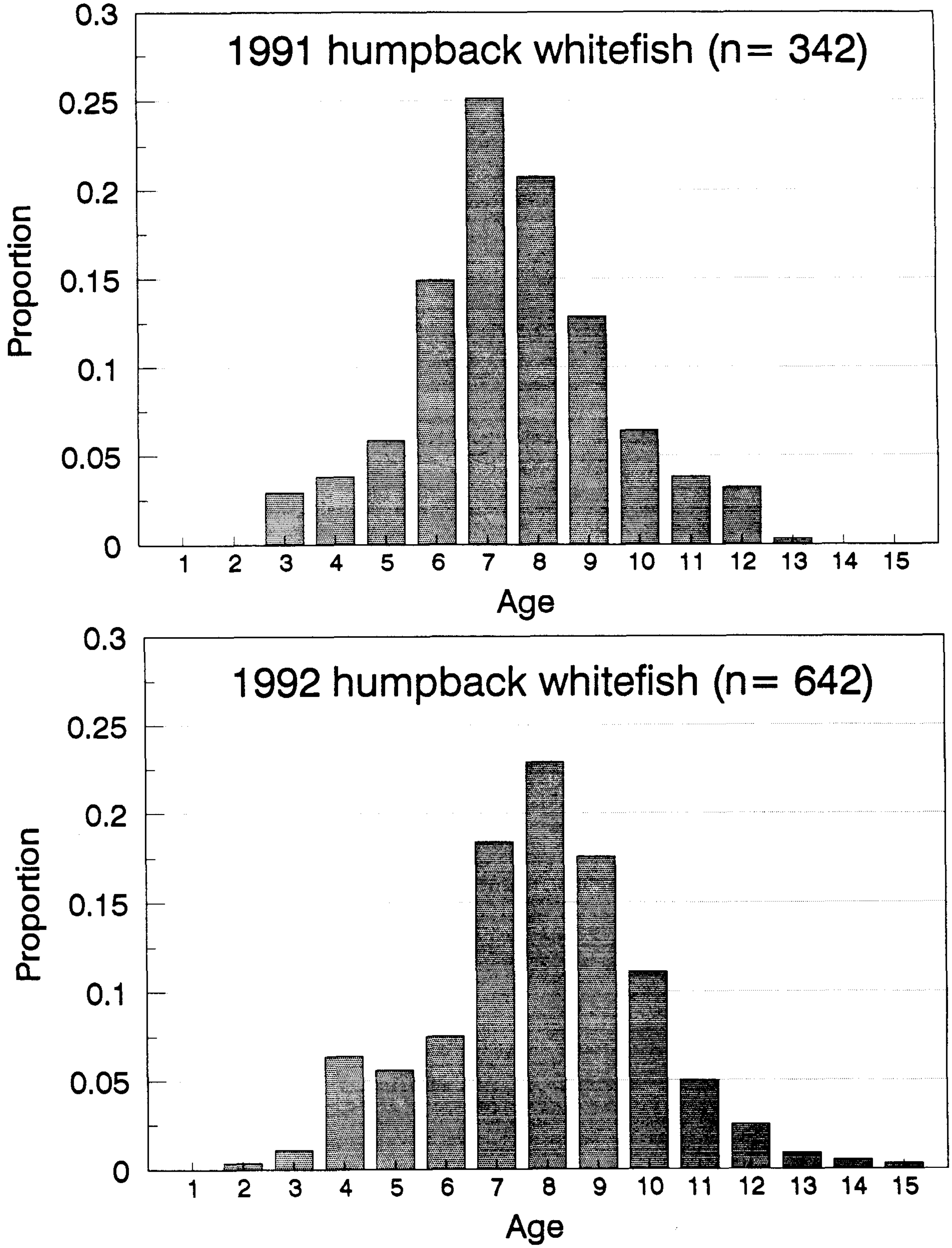

Figure 5. Estimated proportion of humpback whitefish (≥360 mm FL) by age in the Chatanika River during the second sampling event, 24 - 28 August 1992.

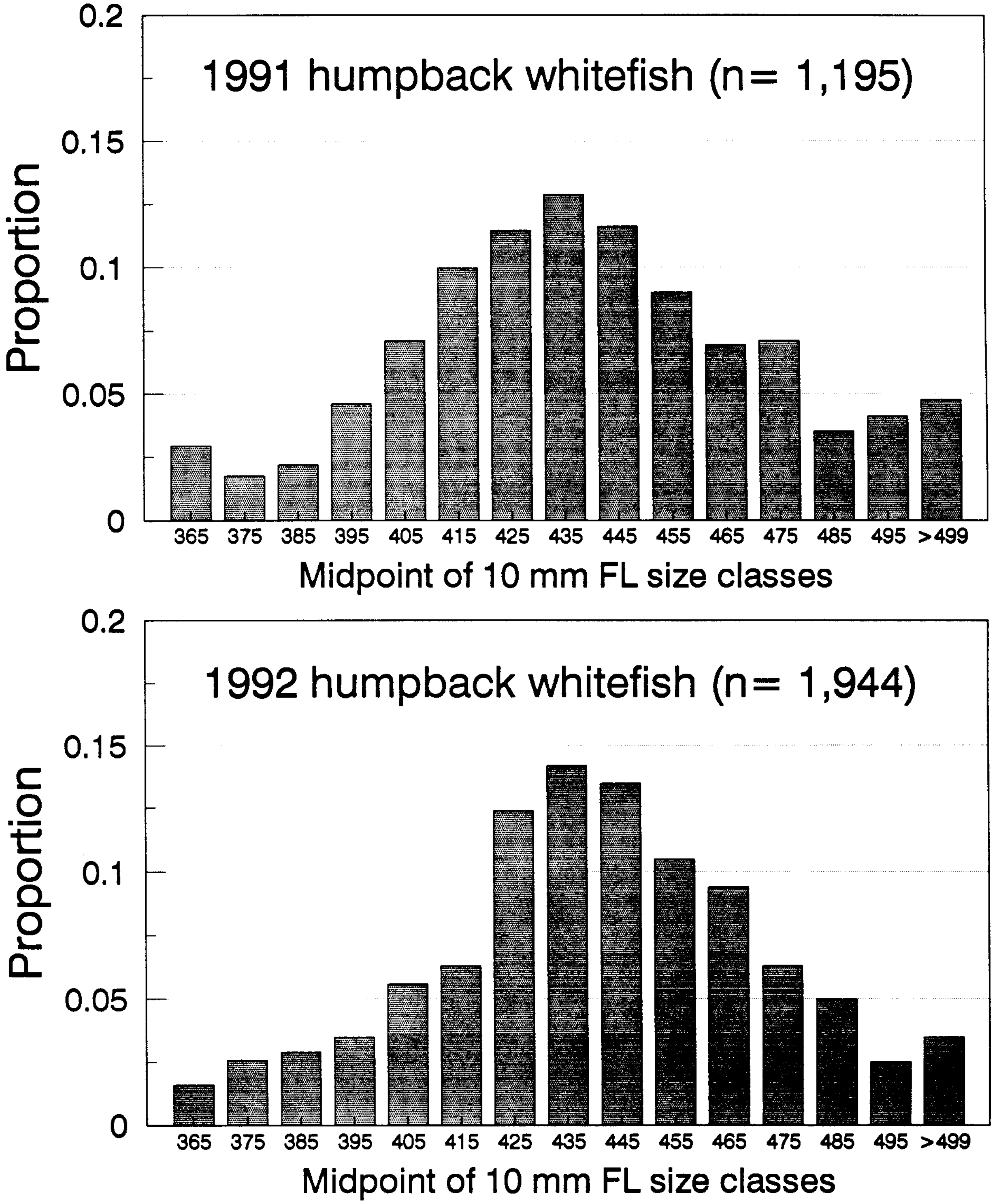

Figure 6. Estimated proportion of humpback whitefish (≥360 mm FL) by length in the Chatanika River during the second sampling event, 24 - 28 August 1992.

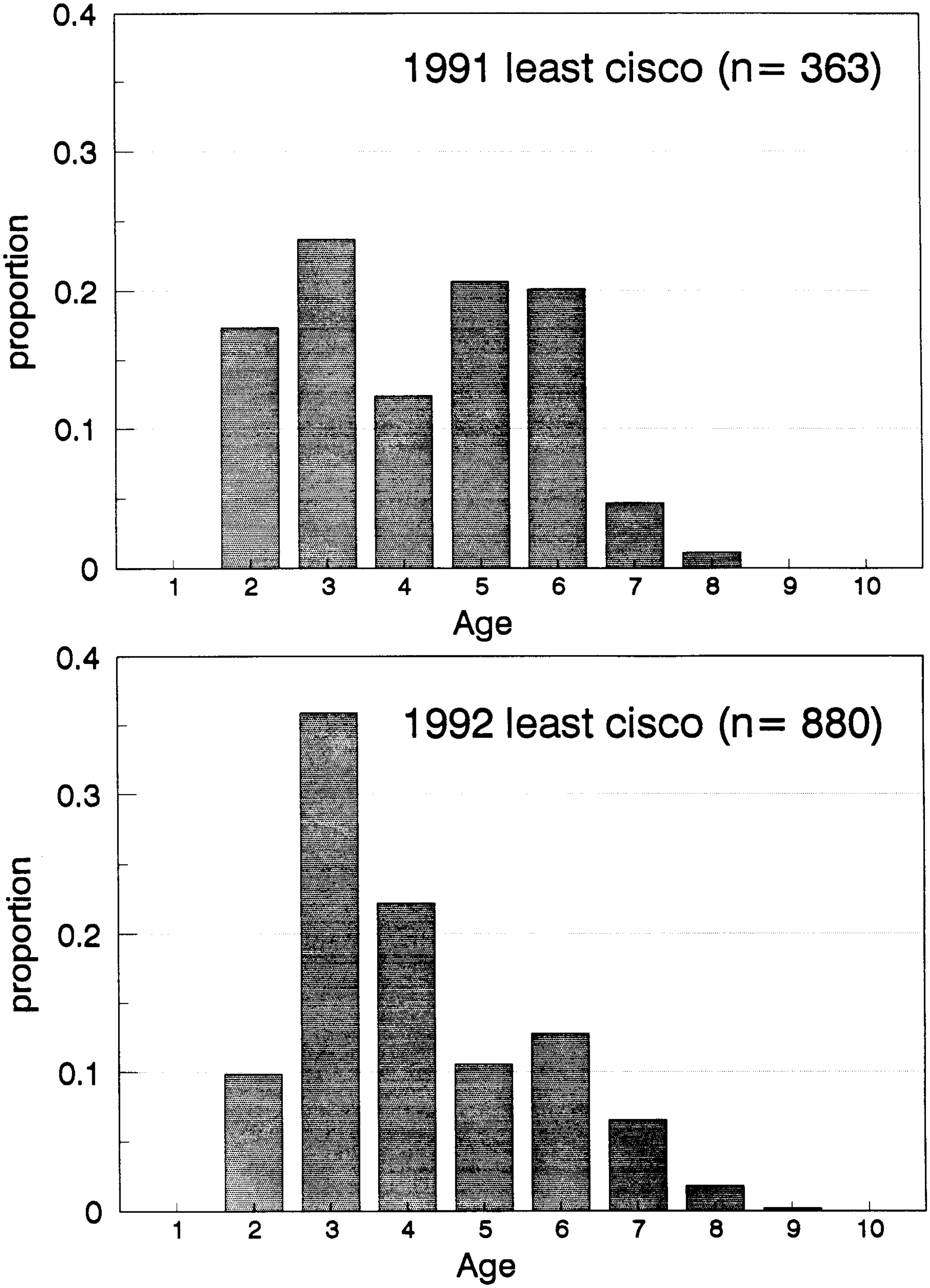

Figure 7. Estimated proportion of least cisco (≥290 mm FL) by age in the Chatanika River during the second sampling event, 24 - 28 August 1992.

Abundance Estimation

The sampling design used in 1992 was sufficient to estimate the abundance of humpback whitefish and least cisco in the Chatanika River study area during August. Although fish were migrating upstream, combinations of intense, short duration sampling over much of the available habitat satisfied the assumptions necessary for use of the Petersen estimator of abundance. Approximately 20,180 humpback whitefish and 86,989 least cisco were estimated to be in the 105 km sampled area of the Chatanika River, in the latter half of August 1992. Although size selectivity for humpback whitefish was found by statistical comparison, no meaningful differences could be inferred given similarities of the stratified and unstratified estimates. Size selectivity may have been detected by the statistical power of the Kolmogorov-Smirnov two-sample test given the large sample sizes associated with this study (Zar 1984).

The increased sampling intensity yielded estimates with improved precision, but these estimates are not biologically consistent with the 1991 estimates. In 1991, classification of tag losses was identified as a likely source of bias, which was resolved with the use of differing fin clips in 1992. Because of classification uncertainties in 1991, no biological inferences were drawn from a comparison of the 1991 and 1992 estimates. If tag shedding rates estimated from the present study and future investigations could be assumed to be representative, then the 1991 estimate could be reevaluated.

Age and Length Compositions

Age and length composition estimates from 1992 continue to indicate the lack of younger and smaller humpback whitefish, as reported by Timmons (1991). Investigations in 1986-1988 (Hallberg and Holmes 1987, Hallberg 1988, 1989) sampled proportionally more humpback whitefish belonging to younger and smaller age and size classes. Based on these samples, the assessed stock was dominated by fish younger than 6 years old and smaller than 400 mm FL. This is considerably different than samples collected in 1992, where humpback whitefish age 8 and lengths above 420 mm FL were clearly dominant.

Isolating the causal mechanism of the observed change in composition towards older fish may be an impossible task using harvest estimates for pooled species of whitefish. If changes in recruitment levels, using 7 years as the estimated age of full recruitment, could be correlated to harvest of parental stocks by species, impacts to recruitment by combinations of fishery and environmental forces may be separable. At present, and in the near future, observable strengths of age 7 cohorts in 1992 and upcoming 1993 and 1994 assessments will show the product of high harvest years 1985, 1986, and 1987 and unknown levels of variation in natural mortality. In order to use this information, a necessary assumption is that all other losses affect all cohorts equitably.

Age and length compositions of least cisco in the Chatanika River appear more balanced between young and old, and small and large fish, than seen in earlier assessments (Figures 7 and 8). In 1992, a strong age 3 cohort has doubled its representation in the sample relative to its strength at age 2 in 1991. Full recruitment, or maximal representation by least cisco cohorts is currently thought to occur at age 4. If so, then in 1993 this cohort may be stronger yet.

The monitoring of fully recruited progeny from past high harvest (and natal) years (1985, 1986, and 1987) is presently possible using the 4 year cohort strengths. This assumes that all other losses affect all cohorts equitably. Proportional strengths of these cohorts were 43% -1985 cohort in 1989 (Timmons 1990), 29% -1986 cohort in 1990 (Timmons 1991), and 12.4% -1987 cohort in 1991 (Timmons 1991). Harvest of both species of whitefish in the corresponding natal years were: 14,350 fish (1985; Mills 1986), 22,038 fish (1986; Mills 1987), and 25,074 fish (1987; Mills 1988). The declining relative strengths of these three cohorts as they entered the stock at age 4, may indicate some spawner-dependent response to the cumulative removal of spawners during 1985, 1986, and 1987. With the lowering of harvest pressure through restrictions to bag limits, duration of the fishery, and its location, it is thought that both species can provide recreational harvests.

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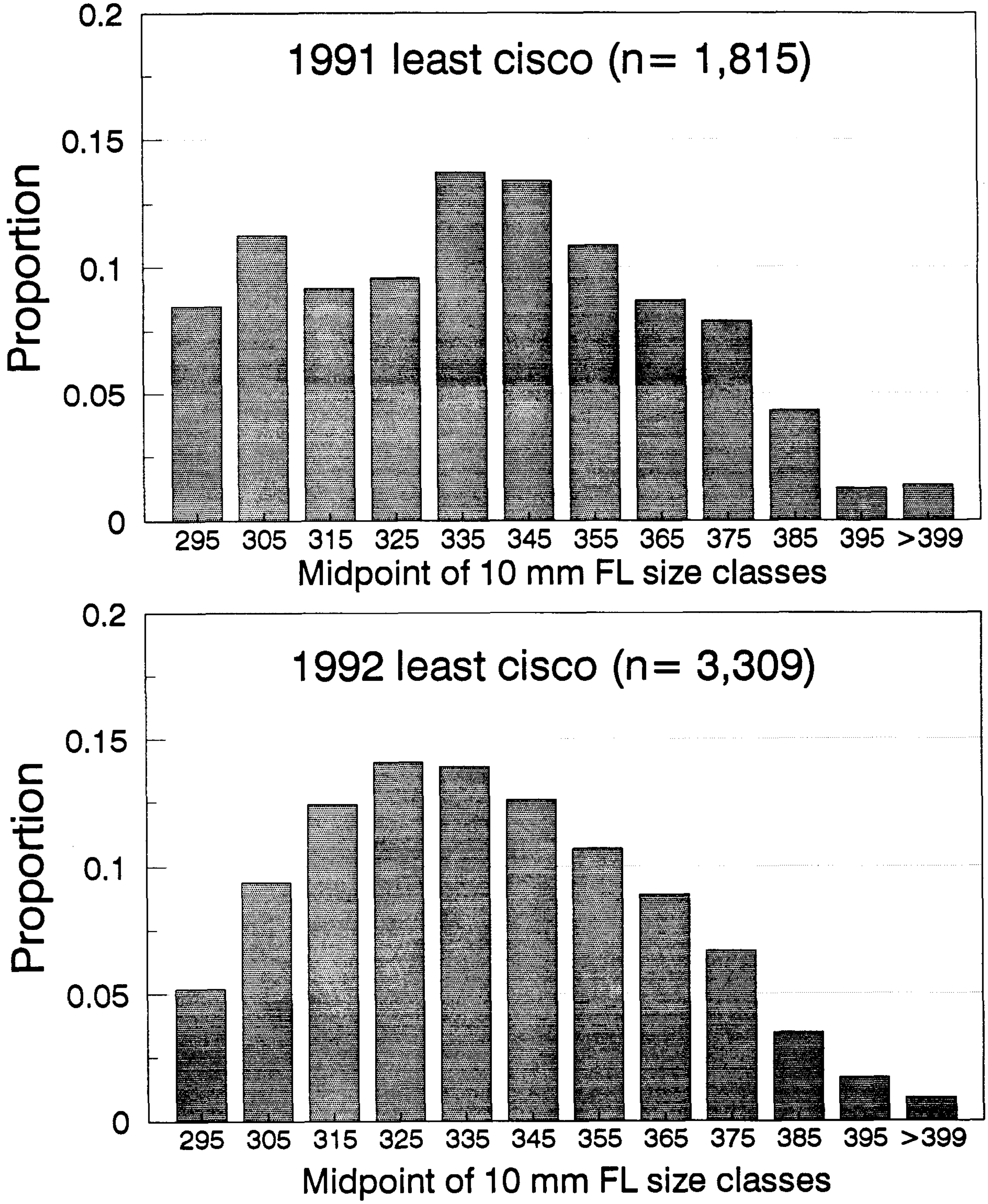

Figure 8. Estimated proportion of least cisco (≥290 mm FL) by length in the Chatanika River during the second sampling event, 24 - 28 August 1992.

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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.