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ABUNDANCE AND SIZE COMPOSITION OF CHATANIKA RIVER LEAST CISCO AND HUMP-BACK WHITEFISH WITH ESTIMATES OF EX-PLOITATION BY RECREATIONAL SPEAR FISHERMEN

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ABSTRACT

Mark-recapture experiments, side-scan sonar, and visual counts of passing fish were methods used to estimate abundance of whitefish in the fall spawning migration in the Chatanika River during 1986. Total estimated run strength was 87,912 and 92,038 whitefish from the mark-recapture experiments and from expansions of counts made from towers, respectively. No abundance estimate was obtained using sonar because of difficulties distinguishing upstream versus downstream migrating whitefish. An estimated 83 percent of the run was composed of least cisco with the other 17 percent being humpback whitefish. Estimated rates of exploitation by the recreational spear fishery were 0.218 to 0.227 for least cisco and 0.159 to 0.170 for humpback whitefish. Operations were hindered by a flood on 11 October.

KEY WORDS: humpback whitefish, *Coregonus pidschian* (Gmelin), least cisco, *Coregonus sardinella* Valenciennes, Chatanika River, sonar, population estimate, counting tower, harvest, exploitation.

INTRODUCTION

The Chatanika River supports a large population of humpback whitefish, *Coregonus pidschian* (Gmelin), and least cisco, *Coregonus sardinella* Valenciennes. During late summer and fall, these fish migrate up the Chatanika River from Minto Flats to spawn. Because of its proximity to Fairbanks and the large size of these spawning runs, the Chatanika River fishery accounts for about 70% of the total whitefish harvest in the Tanana River drainage (Mills 1986). Most of the harvest in the Chatanika River occurs during the popular fall spear fishery on spawning whitefish near the Elliott Highway Bridge and along the Steese Highway.

In recent years, human population growth and increasing angler awareness of the unique spear fishery have led to increases in fishing effort and whitefish harvests. Since 1977, harvest of whitefish from the Chatanika River has increased at an average annual rate of 34%, making it the fastest growing recreational fishery in the Tanana River drainage (Table 1).

Mark-recapture experiments to estimate the abundance of spawning whitefish were conducted in 1972 and 1973 in the Chatanika River (Kepler 1973; Kramer 1974), and a visual count of spawning whitefish was performed in 1974 (Kramer 1975). The estimated number of whitefish (humpback and least cisco combined) was 24,000, 19,100, and 29,100 for 1972, 1973, and 1974, respectively. Using these abundance estimates, the 1985 sport harvest of 14,350 fish would have represented an exploitation rate between 49 and 75%. Concern about possible overharvest in this rapidly expanding fishery prompted this study. Our goal is to estimate sustainable yield for the humpback whitefish and least cisco stocks of the Chatanika River. Accurate and timely estimates of population abundance, age composition, growth rates, harvest, exploitation rates, mortality rates, and recruitment rates are needed to estimate sustainable yield for these whitefish species.

In 1986, the specific objectives of this project were:

1. To determine the feasibility of counting post-spawning whitefish in the Chatanika River from atop towers anchored in the river and with side-scan sonar;

2. To estimate species composition of the spawning whitefish in the Chatanika River;

3. To estimate abundance of humpback whitefish and least cisco spawning in the Chatanika River and to estimate exploitation of these stocks by the recreational spear fishery through mark-recapture experiments; and

4. To estimate length, sex, and age composition of the populations of humpback whitefish and least cisco spawning in the Chatanika River.

Table 1. Statistics on harvest, catch per unit of effort, and proportion of least cisco, humpback whitefish, and round whitefish; *Prosopium cylindraceum* (Pallas); from creel census and catch sampling of the Chatanika River fall spear fishery, 1972-1986.

Year	Species Composition (%) Least Cisco	Humpback Whitefish	Round Whitefish	Catch per Hour of Fishing	Harvest[1]
1972	62	28	10	2.32	...
1973	72	18	10	2.24	...
1974	66	24	10	1.82	...
1975	...	...	...	...	...
1976	72	19	9	1.80	...
1977	42	49	9	2.37	1,635
1978	36	58	6	5.70	6,013
1979	83	15	2	2.40	3,021
1980	64	31	5	1.50	3,340
1981	...	...	...	...	3,185
1982	...	...	...	...	6,640
1983	88	8	4	1.94	5,895
1984	83	16	1	2.26	9,268
1985	78	19	3	2.27	14,350
1986	84	13	3	5.78	22,038
Average	69	25	6	2.7	7,359

[1] Total annual harvest from Mills (1986)

MATERIALS AND METHODS

Sonar

The side-scan sonar was located on the Chatanika River approximately 3 km below the Elliott Highway Bridge. The river at the sonar site was 20 m wide and the maximum depth was 1.2 m. The hardware used for the sonar project consisted of the following items:

1. Biosonics model 101 sounder - configured for dual beam use;

2. Biosonics tape interface;

3. Sony video tape recording system;

4. EPC dual channel model 3200 chart recorder; and

5. Dual beam 3.5 x 10 degree and 7 x 21 degree 420 KHZ transducer.

The sonar was housed in a canvas wall tent on the south bank of the river. A generator near the tent supplied power. The transducer was placed under the water on the bank opposite the tent at an oblique angle to the flow of water, and cables to the transducer were laid on the stream bottom. The sonar was operated continuously except when chart paper was changed or when system problems occurred. Sonar data were collected 24 hours per day from 29 September to 11 October. The sonar system was disabled on 11 October due to flooding of the Chatanika River.

Data from the side-scan sonar consisted of both video magnetic tapes of digital information and printed recordings on chart paper. Each datum was a series of "hits" by the sonar on a single target as it passed through the ensonified volume. Because the transducer was pointed downstream at an oblique angle, upstream and downstream targets could be differentiated by the angle of their "shadows" on recording media.

Estimates of fish passage from the sonar (counts of fish from the chart recordings) were calibrated against numbers obtained from the counting tower just upstream of the sonar (see below) and against visual observations of fish in the ensonified volume of the stream. These latter observations were relayed by a two-way, voice-activated radio to an observer in the tent watching the sonar chart recorder. These calibrations allowed us to develop criteria by which targets could be differentiated according to direction of travel (upstream or downstream) and to identity (fish or something else).

Towers

Migrating whitefish were counted from two towers located approximately 100 meters upstream from the sonar site. A section of standard construction scaffolding (two-meters high) was erected in the stream near each bank of the river to serve as a counting platform. A 25 meter long electrical cable with 300 watt flood lamps located at 3 m intervals was suspended across the river approximately 5 m above the water surface to provide illumination for counts conducted during the night. Lights were powered by a portable gasoline generator. A flash panel (approximately 1.3 m wide; made of aluminum roofing material) was anchored to the river bottom beneath the lights to serve as a bright area over which to count migrating whitefish.

From 26 September through 2 October, whitefish were counted from the towers for a 30-minute period every two hours from 2000 until 0600 hours. From 3 October to the end of counting tower operations on 11 October, whitefish were counted for a single 30-minute period every two hours. Counting periods were equally spaced through time. Through 2 October, two people (one located on each tower) counted whitefish; each person counted fish in half the width of the stream. During this time, a test of counts from each tower of all whitefish showed that counts from one observer counting across the entire river were not significantly different from counts by two observers, each counting across half the river (sign test, P = 0.5). Therefore, to conserve manpower, only one person counted whitefish after 2 October. Tower personnel used two tally whackers, one to record upstream and one to record downstream migration. The species of migrants could not be determined from the towers, so counts are numbers of whitefish of all species.

Expansions of half-hour counts of both upstream and downstream migrating fish for times of no counting are based on a stratified, multistage sampling design with systematically drawn samples:

(1) $\hat{A} = 24 N \bar{\bar{x}}$ (2) $\bar{\bar{x}} = \dfrac{\sum_{i=1}^{n} \sum_{j=2}^{m} x_{ij}}{n m}$

where: $\bar{\bar{x}}$ = mean count per 30 minute time period per stratum;

x_{ij} = whitefish counted during the ith period of day j;

$\hat{A}$ = stratum abundance;

24 = number of half hour periods in a 12-hour stratum;

N = the total number of days;

n = the number of days sampled; and,

m = the number of half hours sampled.

The strata were day (0700 to 2059 hours) and night (2100 to 0659 hours) for downstream migrating fish and day (0700 to 2059 hours) and night (2100 to

0659 hours) for upstream migrants. Because the systematic design of this sampling program has proportional allocation of sampling effort, the strata were determined after the completion of the project. The variance for the multistage estimator was taken from Cochran (1977) and Wolter (1984):

$$(3) \quad V[\bar{\bar{x}}] = (1 - n/N) \sum_{i=1}^{n} \frac{(\bar{x}_i - \bar{\bar{x}})^2}{n(n-1)} +$$

$$\frac{(1 - m/24)}{m N} \sum_{i=1}^{n} \sum_{j=2}^{m} \frac{(x_{ij} - x_{i,j-1})^2}{2 n m (m-1)}$$

$$(4) \quad \bar{x}_i = \frac{\sum_{j=1}^{m} x_{ij}}{m}$$

$$(5) \quad V[\hat{A}] = (24 N)^2 V[\bar{\bar{x}}].$$

The differenced variances of the secondary units (half hours) was used because it is a robust estimate of variances for systematically drawn, serially correlated data.

Mark-Recapture Experiments

From 4 August to 25 September, humpback whitefish and least cisco were captured downstream of the Elliott Highway Bridge with a pulsed-DC electrofishing boat. Sixteen km below the bridge was the furthest extent of our sampling. Fish were held in a live box with circulating water and sampled as quickly as possible. All captured fish of each species were measured to the nearest millimeter of fork length (FL), tagged with an individually numbered Floy internal anchor tag, and released.

Creel census and catch sampling of the spear fishery near the Elliott Highway Bridge from mid-September to mid-October provided recapture data for the population estimate. All fish sampled were measured and examined for tags. Scales were taken from all humpback whitefish and the first 600 least cisco for later age determination. Creel census also involved counts and interviews of anglers conducted at random times during weekends and weekdays. Sampling design and methodology of the creel census is outlined in Clark and Ridder (1987). Catch sampling occurred throughout the fishery whenever manpower was available.

Estimated abundance of each whitefish species was obtained using the Chapman modification of the Petersen single-mark estimator (Seber 1973). Bias due to length of whitefish sampled as well as sampling bias related to run timing was evaluated using contingency table analysis. Since most tagging occurred prior to the fishery, the estimated abundance of each species is that at the beginning of the fishery.

Species, Length, Age, and Sex Composition

Species composition of the run was obtained by two methods. First, the mark-recapture experiment provided an estimate of abundance for each species. Second, the numbers of fish tagged and the numbers of fish recaptured in the creel and catch samples were used to apportion both the sum of the tower estimates and the harvest estimate by species with the following formulas:

(6) $$\hat{A}_2 = \frac{\hat{A}}{1 + B}$$

(7) $$\hat{A}_1 = \frac{\hat{A}\ B}{B + 1}$$

(8) $$B = \frac{n_1\ r_2\ m_1}{n_2\ r_1\ m_2}$$

where:

$\hat{A}$ = the estimated abundance of whitefish;

$\hat{A}_i$ = the estimated abundance of species i;

n_i = the number of species i in the creel and catch samples;

r_i = the number of tagged fish of species i in the creel and catch samples; and,

m_i = the number of species i that have been tagged.

Age composition for each species was considered a series of proportions p_i, one for each age group, whose sum is one. The maximum likelihood estimate of a marginal proportion in such a multinomial distribution of ages is:

(9) $$\hat{p}_i = \frac{y_i}{n}$$

where:

y_i = the number of fish of age i in the sample; and,

n = the number of fish in the total sample.

The unbiased variance for each proportion is:

$$(10) \qquad V[\hat{p}_i] = \frac{\hat{p}_i(1 - \hat{p}_i)}{n - 1}$$

Because all means are distributed normally (according to the Central Limit Theorem), simple averages and squared deviations from the mean were used to calculate mean length for each age class and its variance.

Sex of harvested fish was noted by creel clerks when time and light conditions allowed for careful examination. Estimated proportions of males and females and associated standard errors were calculated with equations similar to Equations 9 and 10.

Exploitation Rates

Exploitation rates by species were estimated by dividing harvest (obtained from the creel census study; Clark and Ridder 1987) by abundance estimates from the mark-recapture experiment. The approximate variance of the exploitation rate was calculated according to the delta method (Seber 1973):

$$(11) \qquad \hat{E} = \hat{H}/\hat{A}$$

$$(12) \qquad V[\hat{E}] = \frac{\hat{H}^2}{\hat{A}^2} \left\{ \frac{V[\hat{H}]}{\hat{H}^2} + \frac{V[\hat{A}]}{\hat{A}^2} \right\}$$

where:

$\hat{H}$ = the estimated harvest of a species from the creel census; and,

$\hat{A}$ = the estimated abundance of that species from the mark-recapture experiment.

To estimate the exploitation rate using data from the counting towers, the estimated harvest was added to the estimate of downstream migrating fish because the harvest took place before the downstream migration occurred:

$$(13) \qquad \hat{E} = \hat{H} / \hat{N}$$

$$(14) \quad \hat{N} = \hat{A} + \hat{H}$$

where:

$\hat{N}$ = estimated abundance of whitefish by species prior to the fishery;

$\hat{H}$ = estimated harvest by species; and,

$\hat{A}$ = estimated number of whitefish migrating downstream by species.

No estimate of variance was calculated for Equation 13 because of the unknown variances of estimates of A from Equations 6 and 7.

RESULTS

Sonar

During the first few days of sonar operation, visual counts of upstream and downstream migrating whitefish were compared with recordings on chart paper of target passage. Poor agreement between visual and recorded counts occurred regardless of the criteria used to determine direction of travel and identity of recorded targets.

Due to this technical problem, discovered early in the project, the determination of accurate interpretive criteria was postponed until after the field work had been completed. To date, accurate interpretive criteria have not been defined, and consequently, no analysis of the data from the side-scan sonar is presented in this report. Research to resolve this technical problem is on-going, and if successful, a summary report will be prepared at a later date.

Abundance

Towers:

Most whitefish migrated past the counting towers at night with upstream movement peaking at 2400 hours and downstream movement peaking at 2000 hours (Figure 1). Upstream migration tended to be more dispersed through the night (1800 to 0400 hours), while downstream migration showed a short peak of activity from 2000 to 2200 hours (Figure 1). A relatively constant, slow rate of migration occurred during daylight hours.

Upstream migration was strongest in late September (when counting operations began) and waned during the course of the project (Figure 2). Downstream migration peaked on 28 September and 8 October. The peak on 28 September is thought to be the result of boat traffic herding large numbers of fish downstream during the counting period. Numbers of downstream

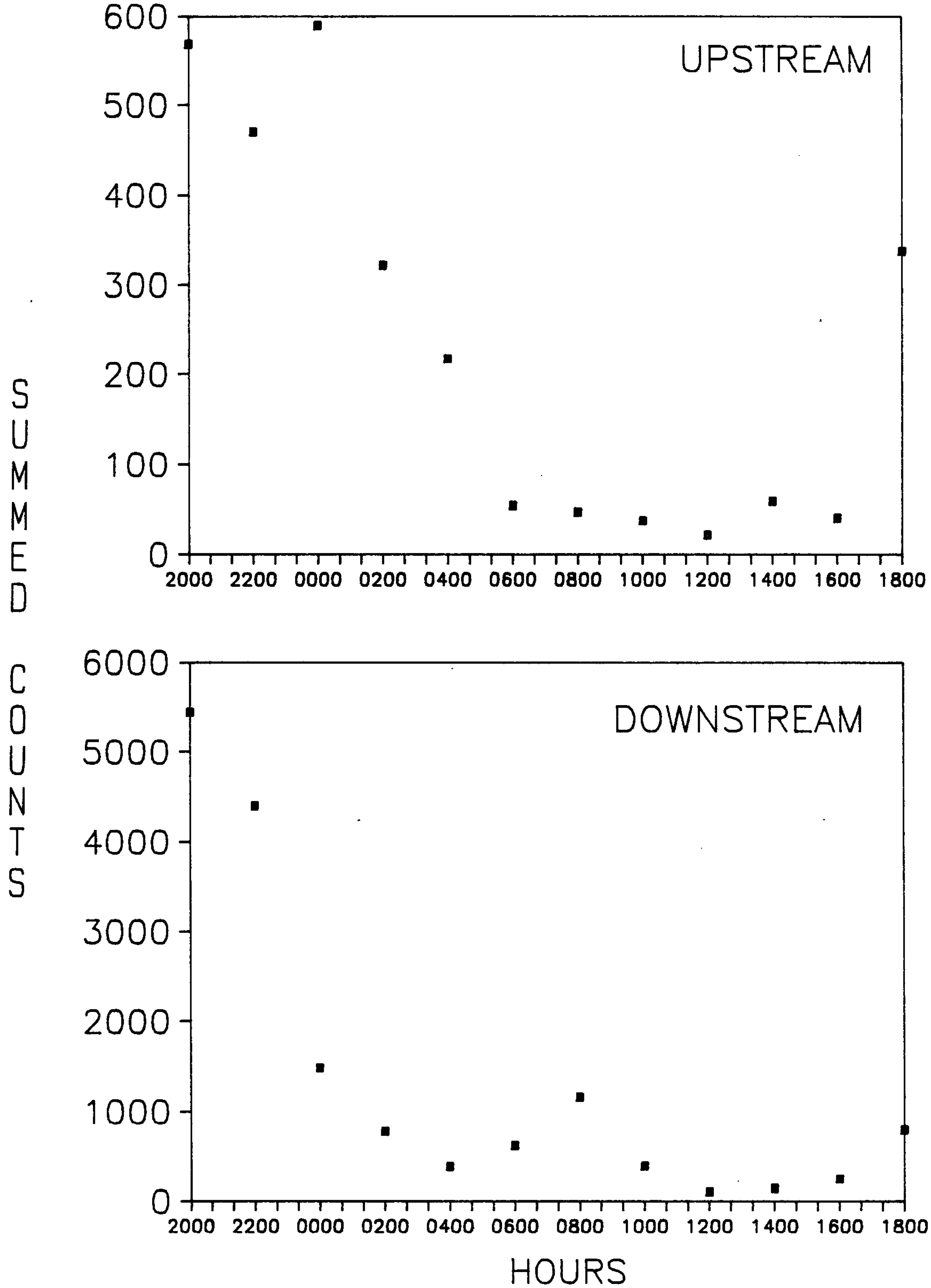

Figure 1. Counts of whitefish at the tower site on the Chatanika River in 1986 summed over days for each hour of the day.

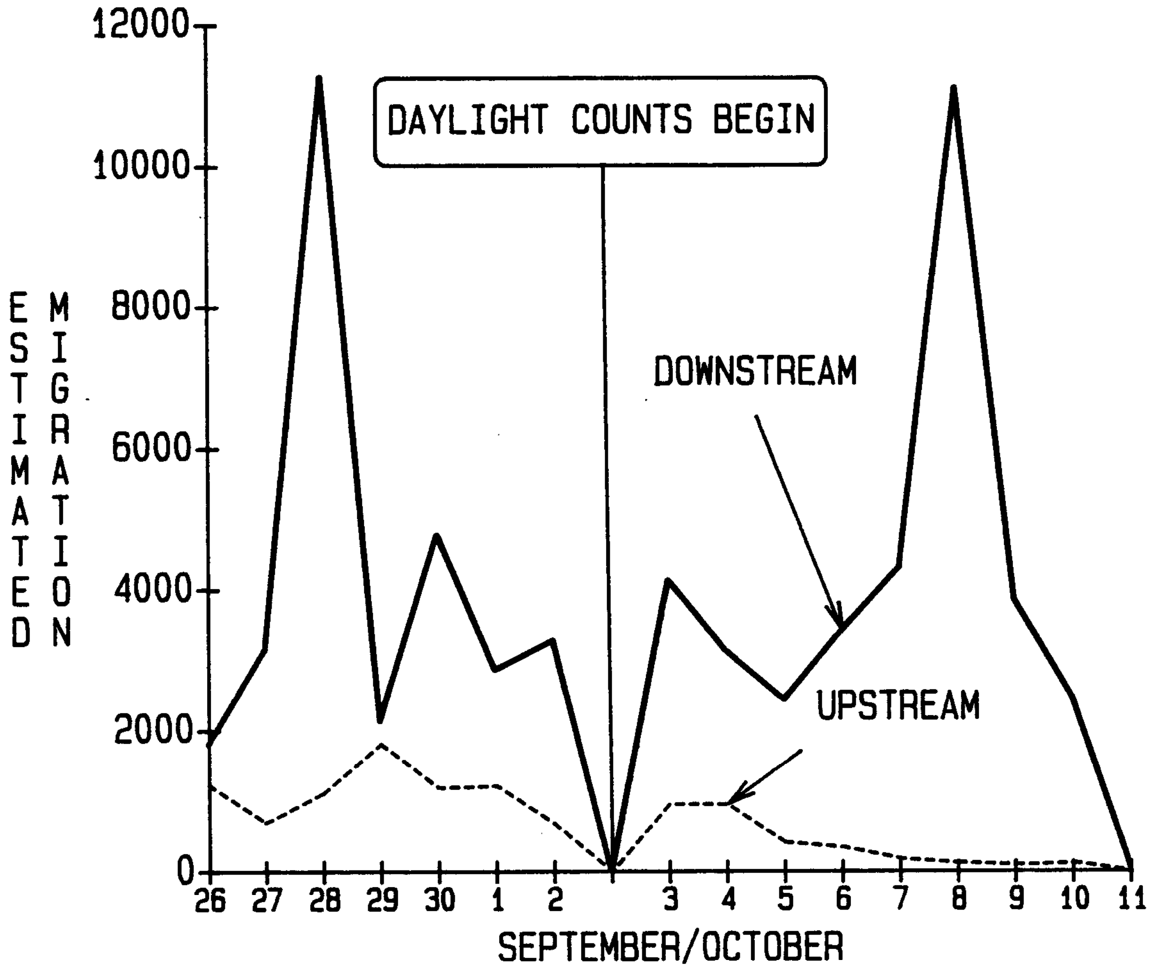

Figure 2. Daily estimates of upstream and downstream migrating whitefish at the tower site on the Chatanika River, 1986.

migrants were generally three to four times that of upstream migrants, and this relationship became stronger with the passage of time. Fish were counted from the towers until 11 October at which time a flood and subsequent freezeup of the river prevented continued counting. However, it is assumed that the decline in counts at the end of the season coupled with a concurrent decline in the catch per unit of effort (CPUE) and harvest of least cisco from the recreational spear fishery after 29 September (Figure 3) indicated that the majority of the downstream migration of least cisco had passed the towers. On the other hand, CPUE and harvest of humpback whitefish was peaking immediately prior to the flood (Figure 3) indicating that a significant portion of the downstream migration of humpback whitefish was still upstream of the counting towers when operations ceased.

An estimated 13,300 and 72,978 whitefish passed upstream and downstream, respectively, of the counting tower from September 26 through October 11 (Table 2). In both cases, migrants at night (2100 to 0659 hours) were over twice as abundant as during the day. Coefficients of variation (CV) were similar for estimates of migrants passing during the day and during the night, 17.1% and 18.2%, respectively. Relative variability of the estimates was greatest for those fish migrating upstream during the day (CV = 32.4%) and lowest for migration upstream during the night (CV = 10.3%).

The combined harvest of humpback whitefish and least cisco in the recreational spear fishery near the Elliott Highway Bridge between 1 September and 11 October was an estimated 19,105 fish (Clark and Ridder 1987). This harvest estimate plus estimates from the counting towers put the pre-fishery abundance of whitefish at 92,083 (catch + downstream migration) (Table 2).

Mark-Recapture Experiments:

One thousand three hundred five least cisco and almost 1,198 humpback whitefish were tagged between 4 August and 25 September (Figure 4). Most of the humpback whitefish were tagged in August and early September when they dominated the samples. Least cisco dominated the samples on the last two days of sampling, 24 and 25 September. During the creel census and catch sampling, 1,904 least cisco and 237 humpback whitefish were sampled (Table 3). Of these, 33 least cisco and 18 humpback whitefish were recaptured. With these statistics, the estimates from the mark-recapture experiments are 73,006 (SE = 12,069; CV = 16.5%) for least cisco and 14,906 (SE = 3,172; CV = 21.3%) for humpback whitefish.

Ancillary analysis indicates that the estimate for least ciscos meets the conditions for accurate use of the modified Petersen estimator while the estimate for humpback whitefish does not. The length composition of fish tagged by species was not significantly different from that of fish recaptured by species ($\chi^2 \leq 2.78$, df = 2, P > 0.25 for both humpback whitefish and least cisco), indicating that all sizes of whitefish had equal opportunities of being speared in the fishery. For least cisco, there was no significant difference in the proportion of recaptured to unmarked fish obtained through the course of the fishery (week 1 through

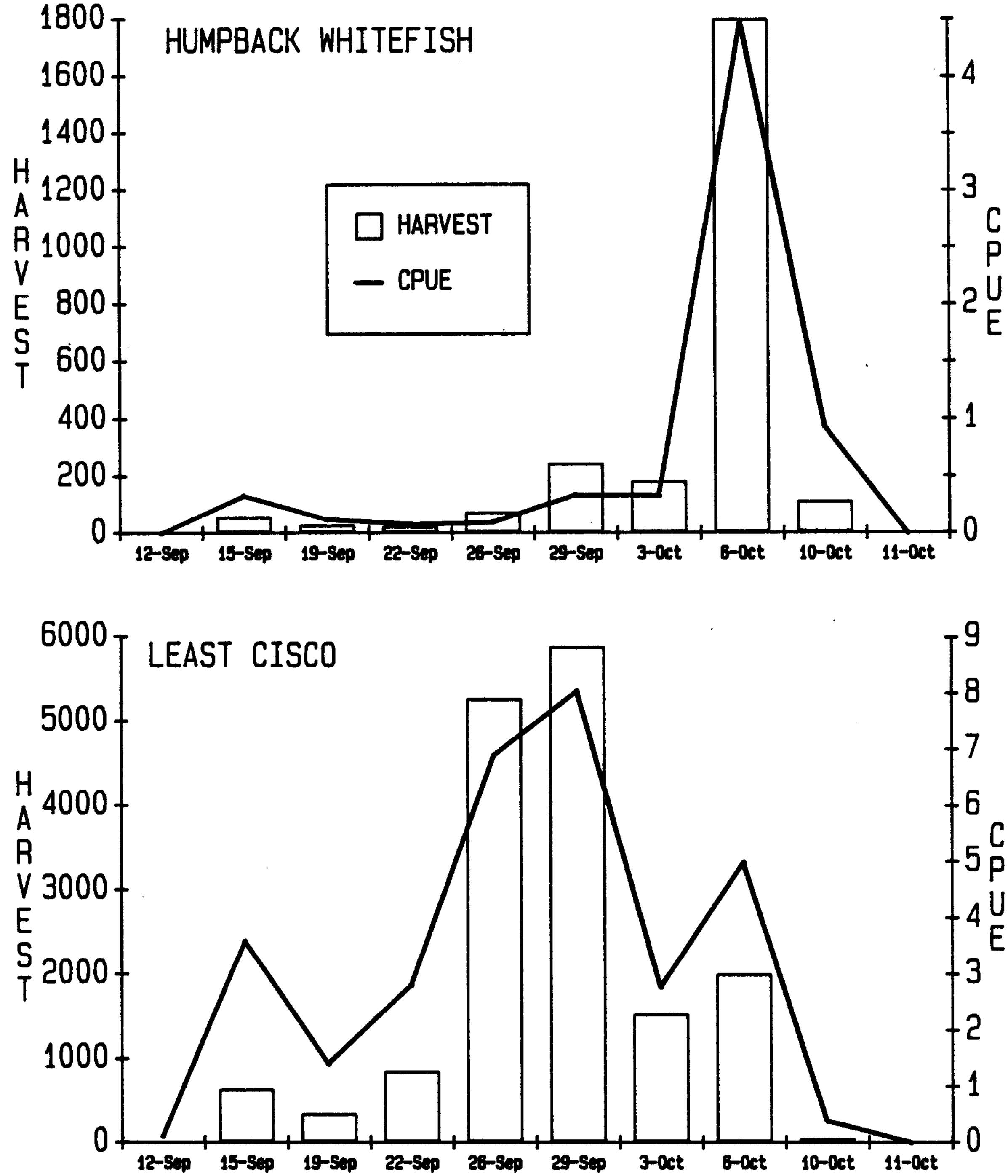

Figure 3. Estimated harvest and CPUE (whitefish speared per hour of fishing) of least cisco and humpback whitefish from the Chatanika River spear fishery, 1986.

Table 2. Estimated harvest[1] of whitefish from the Chatanika River spear fishery, and the estimated numbers of upstream and downstream migrating whitefish expanded from information obtained from counting towers 26 September through 11 October.

Stratum	Average Count Per Period	Estimated Number of Migrants	Standard Error of Estimate	Coefficient of Variation of Estimate
UPSTREAM:				
Night (2100-0659)	22	9,152	940	10.3%
Day (0700-2059)	10	4,148	1,344	32.4%
Total	16	13,300	1,640	12.3%
DOWNSTREAM:				
Night (2100-0659)	129	52,816	9,612	18.2%
Day (0700-2059)	49	20,162	3,443	17.1%
Total	89	72,978	10,210	14.0%
HARVEST:				
Humpback		2,528	914	36.2%
Cisco		16,577	2,513	15.2%
Total		19,105	2,674	14.0%
Run Total (Downstream + Harvest)		92,083	10,554	11.5%

[1] Data taken from Clark and Ridder (1987); harvest relates to the period 1 September through 11 October near the Elliott Highway Bridge only.

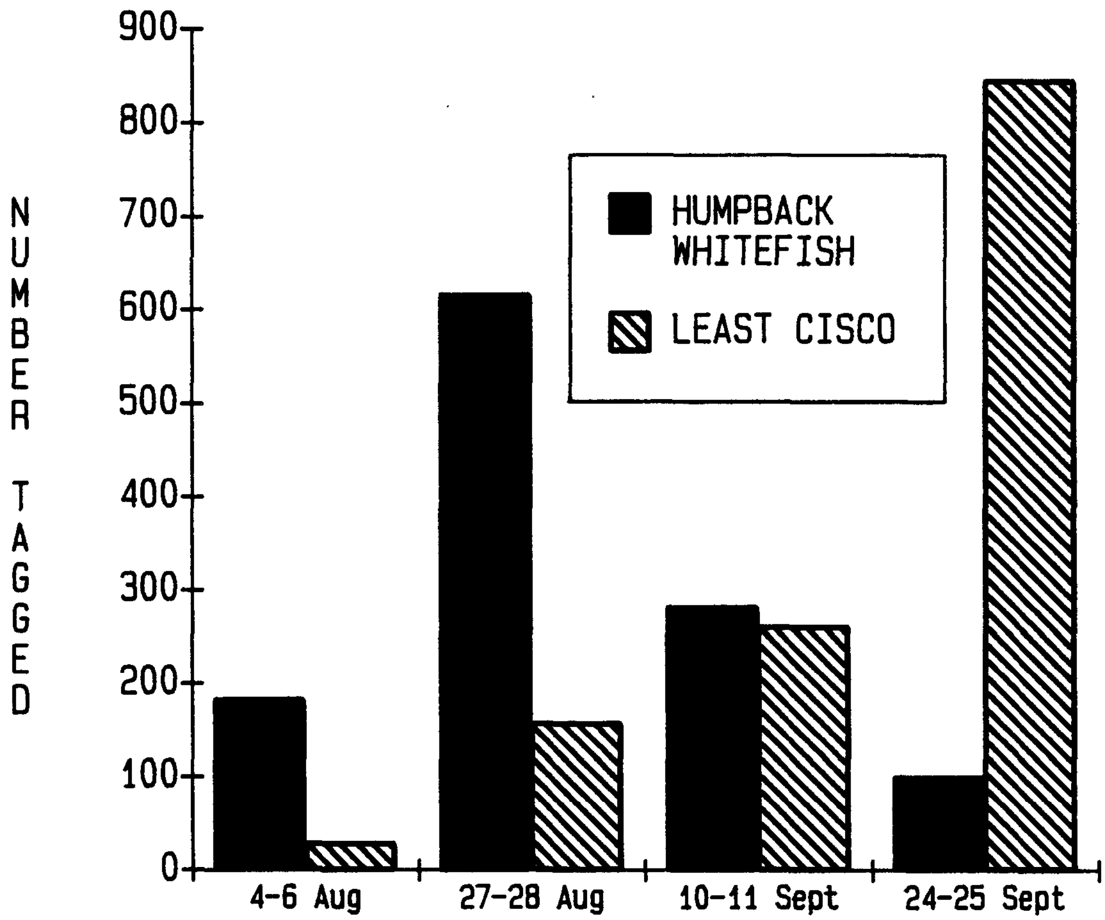

Figure 4. Numbers of humpback whitefish and least cisco tagged by date in the Chatanika River below the Elliot Highway Bridge in 1986.

Table 3. Numbers of whitefish sampled and recaptured in the creel census and catch sampling in the spear fishery near the Elliot Highway Bridge across the Chatanika River in 1986.

	Least Cisco				Humpback Whitefish			
Date	Number Examined	Tags Recovered	Cumulative Examined	Cumulative Recovered	Number Examined	Tags Recovered	Cumulative Examined	Cumulative Recovered
14-Sept	1	0	1	0	1	0	1	0
16-Sept	21	0	22	0	1	0	2	0
18-Sept	64	0	86	0	5	0	7	0
19-Sept	37	0	123	0	5	0	12	0
21-Sept	8	0	131	0	1	0	13	0
23-Sept	61	1	192	1	0	0	13	0
24-Sept	74	5	266	6	3	0	16	0
26-Sept	173	2	439	8	2	0	18	0
27-Sept	194	3	633	11	1	0	19	0
28-Sept	234	2	867	13	0	0	19	0
29-Sept	184	5	1,051	18	10	0	29	0
01-Oct	69	0	1,120	18	12	1	41	1
02-Oct	87	1	1,207	19	5	1	46	2
03-Oct	159	0	1,366	19	14	0	60	2
04-Oct	136	6	1,502	25	20	3	80	5
05-Oct	178	4	1,680	29	21	1	101	6
06-Oct	39	0	1,719	29	19	0	120	6
07-Oct	136	1	1,855	30	35	2	155	8
08-Oct	21	3	1,876	33	26	5	181	13
10-Oct	28	0	1,904	33	56	5	237	18

week 4) (χ^2 = 2.65, df = 3, P > 0.40), indicating that either all least cisco had equal probability of being recaptured regardless of when they had been tagged or that all least cisco had an equal probability of being tagged. However, almost all humpback whitefish were recaptured just before the flood caused the end of sampling on 11 October (Table 3). Because of the small number of humpback whitefish recaptured, we could not stratify the estimate to remove bias caused by unequal rates of recapture of fish through time.

Species, Length, Age, and Sex Composition

Species Composition:

Of the 92,003 whitefish (Table 2) estimated to have been in the spawning run (the expanded number of whitefish migrating downstream past the tower plus the estimated catch from the fishery), 76,202 (83%) were least cisco and 15,881 (17%) were humpback whitefish according to calculations with Equations 6 through 8. Estimates of abundance by species from the mark-recapture experiment are 73,006 and 14,906 humpback whitefish. Thirteen percent of the fish sampled in the creel census and catch sampling were humpback whitefish and 84% were least cisco. This proportion of humpback whitefish is the second lowest documented level in the history of the fishery (Table 1).

Length and Age Composition:

The mean length of humpback whitefish obtained from samples obtained through electrofishing, creel census, and catch sampling was 395 mm (range 300-525). The modal length group of 390 to 399 mm (Figure 5) corresponded to approximately the average length of a five-year-old fish (Table 4). Humpback whitefish ranged in age from 3 to 10 years with age 5 being the dominant age class (Table 4). Average length of least cisco in samples from electrofishing, creel census, and catch sampling was 313 mm (range 232-396). The modal length group of 300 to 309 mm (Figure 5) corresponded to the length of a three-year-old fish (Table 4). Least cisco ranged in age from 2 to 7 with age 4 being the dominant age class. Since all fish were sampled from the spawning run, these length and age compositions can be assumed to represent that of mature fish.

Growth of individual whitefish prior to maturity is rapid but slows after maturity. Age 4 humpback whitefish averaged 370 mm in length, while 10 year old fish were only 68 mm longer on average (Table 4). Age 3 least cisco averaged 305 mm in length, while 7 year old fish were only 56 mm longer on average.

Male whitefish tended to be smaller than female whitefish (Figure 6). Male humpback whitefish averaged 391 mm FL (SE = 18) while females averaged 400 mm (SE = 14). Male least cisco averaged 307 mm (SE = 1) and females averaged 322 (SE = 1). For both species, the age distributions by sex are not significantly different ($\chi^2 \leq 4.67$, df = 3, $P \geq 0.20$; see Table 5).

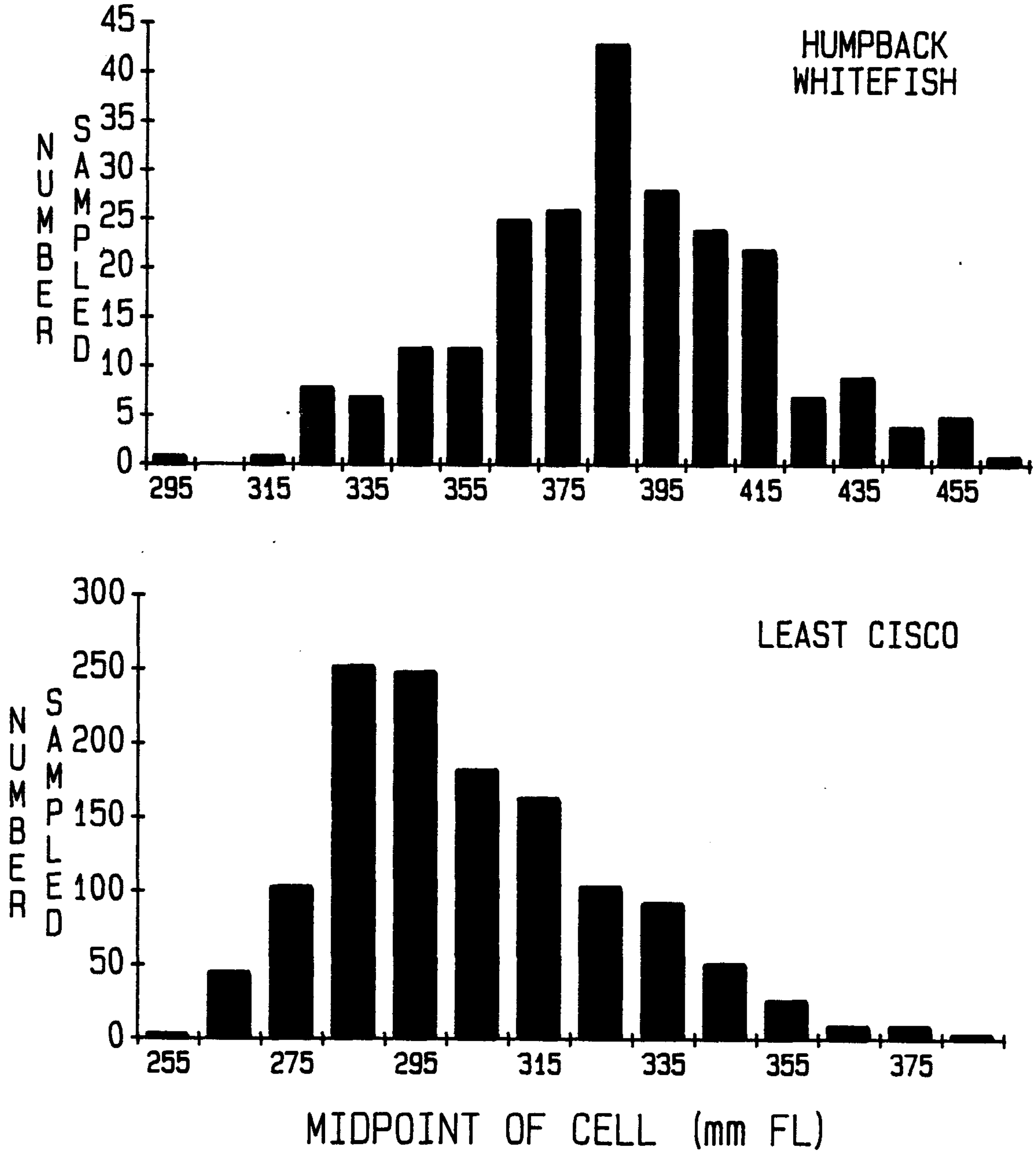

Figure 5. Length frequency distributions for least cisco and humpback whitefish sampled from the Chatanika River spear fishery, 1986.

Table 4. Estimated age composition and mean fork length (mm) at age for least cisco and humpback whitefish harvested in the Chatanika River/Elliott Highway spear fishery, 14 September to 14 October, 1986.

	Age Composition			Fork Length(mm)		
Age	n[1]	p[2]	±CI[3]	Mean	SE[4]	±CI[5]
<u>Least Cisco</u>:						
2	2	0.00	0.00	288	13	159
3	195	0.31	0.04	305	1	2
4	314	0.50	0.04	312	1	2
5	93	0.15	0.03	329	3	5
6	17	0.03	0.01	348	4	9
7	8	0.01	0.01	361	7	17
Total	629	1.00		313	1	2
<u>Humpback whitefish</u>:						
3	1	0.00	0.01	354	13	159
4	50	0.22	0.05	370	1	2
5	102	0.44	0.06	391	1	2
6	33	0.14	0.05	402	3	5
7	19	0.08	0.04	414	4	9
8	19	0.08	0.04	432	7	17
9	6	0.03	0.02	428	17	44
10	2	0.01	0.01	438	2	19
Total	232	1.00		395	2	4

[1] n = sample size
[2] p = proportion of sample
[3] 95% confidence interval based on normal theory approximation of binomial distribution
[4] SE = standard error of run length at age
[5] 95% confidence interval based on t-distribution with n-1 degrees of freedom

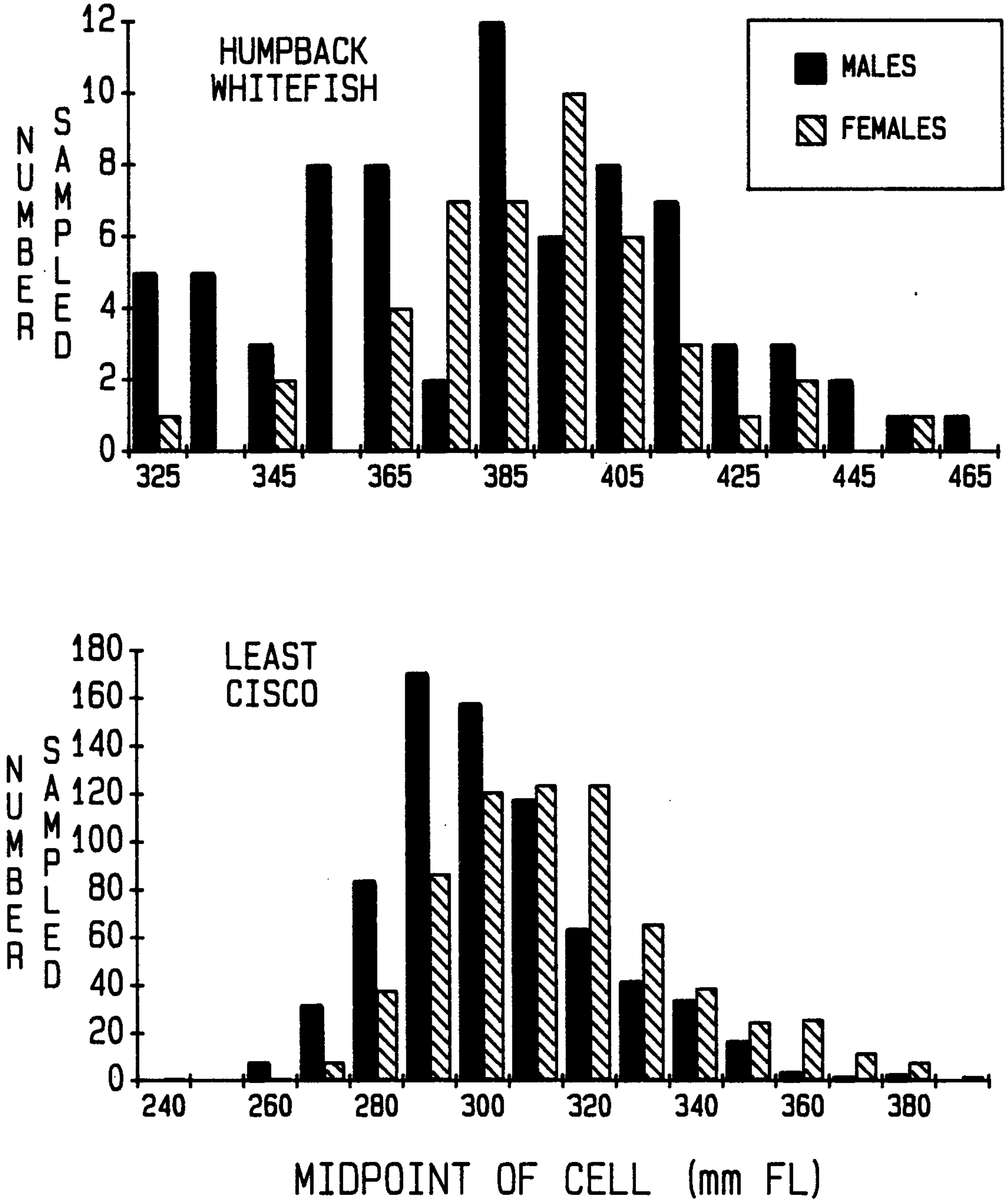

Figure 6. Length frequency by sex for least cisco and humpback whitefish sampled in the Chatanika River spear fishery, 1986.

Table 5. Estimated sex composition by age of least cisco and humpback whitefish in the harvest from the Chatanika River/Elliott Highway spear fishery, 14 September to 14 October, 1986.

	Males			Females		
Age	n[1]	p[2]	SE[3]	n[1]	p[2]	SE[3]
Least Cisco:						
2	1	0.002	0.002	1	0.006	0.006
3	122	0.334	0.025	42	0.256	0.034
4	175	0.479	0.027	92	0.561	0.039
5	55	0.151	0.019	21	0.128	0.026
6	9	0.025	0.008	4	0.024	0.012
7	3	0.008	0.002	4	0.024	0.012
Total	365	1.00		164	1.00	
Humpback Whitefish:						
4	15	0.201	0.047	7	0.167	0.058
5	26	0.356	0.056	22	0.524	0.780
6	12	0.164	0.044	7	0.167	0.058
7	11	0.151	0.042	2	0.048	0.033
8	7	0.096	0.035	3	0.071	0.040
9	2	0.027	0.019	0		
10	0			1	0.023	0.023
Total	73	1.00		42	1.00	

[1] n = sample size
[2] p = proportion of sample
[3] SE = standard error of the proportion

Therefore, the larger size of females in the length frequency distribution is due to faster growth among females and not due to an older age composition (Figure 7).

Sex Composition:

Of the 1,243 least cisco that were dissected, 739 ($p = 0.595$, SE = 0.014) were males and 504 ($p = 0.404$, SE = 0.014) were females. The preponderance of males was even greater for humpback whitefish where, a sample of 119 dissected fish contained 75 males ($p = 0.63$, SE = 0.044) and 44 females ($p = 0.37$, SE = 0.044).

Exploitation Rates

Using estimates from the mark-recapture experiment and from the creel census, the estimated rate of exploitation was 0.227 (SE ≈ 0.051) for least cisco and 0.170 (SE ≈ 0.035) for humpback whitefish. From information gathered at the counting towers, the estimated exploitation rates were 0.218 and 0.159 for least cisco and humpback whitefish, respectively. Analysis of the rates of recapture in the creel census and catch sampling showed that least cisco suffered a greater exploitation rate than did humpback whitefish ($\chi^2 = 3.17$, df = 1, $P < 0.10$).

In contrast, information voluntarily supplied by all spearfishermen and by fishermen spearing upstream of the Elliot Highway Bridge shows a higher rate of exploitation for humpback whitefish than 17%. Casual conversations with fishermen after they had speared whitefish along the Steese Highway in which they were certain of the size and species composition of their catch revealed that out of 117 fish 68.4% had been humpback whitefish. Also, contingency table analysis of the rates of recapture of tagged whitefish based on voluntary returns of tags indicates that the exploitation rates for the two species were similar ($\chi^2 = 0.22$, df = 1, $P > 0.50$). Thirty-two tags were taken off humpback whitefish and 39 off of least cisco and voluntarily returned through the mails.

DISCUSSION

The major problem with using side-scan sonar in stock assessment of migrating whitefish in the Chatanika River is the inability to define interpretive criteria for recorded information, and hence, to distinguish upstream from downstream migrating fish. Observations of whitefish at the counting towers revealed that, unlike salmon, these fish often dart ahead, fall back, and change direction while migrating. This behavior would make the development of interpretive criteria very difficult. However, there are other disadvantages with sonar unrelated to the accuracy of the gear, including cost of equipment, ease of operation, and need for specially

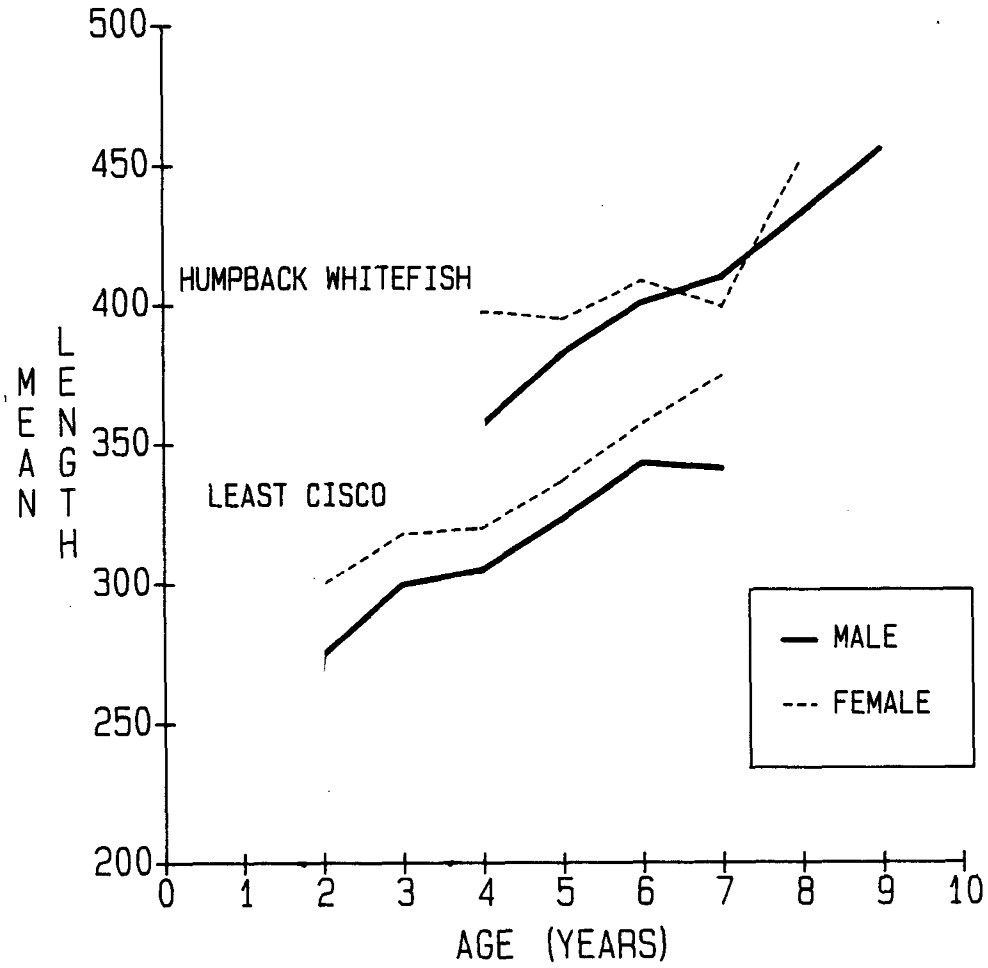

Figure 7. Mean length (FL) at age by sex for least cisco and humpback whitefish sampled in the Chatanika River spear fishery, 1986.

trained personnel. The most attractive attribute of sonar is that it is unaffected by turbid waters. Yet, mark-recapture experiments have the same attractive attribute. From consideration of these factors, we conclude that side-scan sonar at its present state of development is an unacceptable alternative for the stock assessment of whitefish in the Chatanika River.

The estimated numbers of spawning whitefish from data collected at the counting tower and from the mark-recapture experiment are within 5% of each other. Although the similarity of these two estimates is gratifying, the accuracy of both estimates is doubtful. Counting towers were placed into operation 26 September and pulled on October 11. Since large numbers of migrants passed downstream of the towers on these dates, similar numbers probably passed by before and after the period of data collection as well. Also, the counting towers were not manned during daylight hours for the first seven days of sampling. Although the number of daytime migrants for this period were estimated through extrapolation, there is no evidence to support that migration during the day before 2 October was similar to that after 2 October. To improve the accuracy of abundance estimates of migrating whitefish obtained with counting towers in the future, counting should begin at least by 15 September and should continue until counts decline to near zero or until flooding or freezeup intercedes.

The flood and what is now an apparent segregation of the species on the spawning grounds produced an underestimate of abundance for humpback whitefish. Voluntarily supplied information from fishermen spearing outside and inside the boundaries of the traditional fishing grounds, and the late appearance of humpback whitefish in the creel without a complementary increase in the number of upstream migrants past the counting tower, indicate that a significant number of humpback whitefish migrated upstream of the Elliott Highway Bridge to spawn and were therefore not covered by our creel census and catch sampling. The remedies that would cure the estimates of abundance from the mark-recapture experiments are the same as those outlined above to insure the accuracy of abundance estimates from counting towers. In addition, the creel census and catch sampling should be expanded to include the fishermen along the Steese Highway.

The flood and the limited boundaries of our creel census and catch sampling also affected the accuracy of the estimated exploitation rates of humpback whitefish. Since exploitation rates were calculated by dividing harvest by abundance, an underestimate of harvest will tend to underestimate the rate of exploitation. But since both harvest and abundance of humpback whitefish were probably underestimated, the bias in the calculated exploitation rate is unknown. However, the value of this exploitation rate can be inferred to be the same as for least ciscos from the analysis of the voluntary return of tags.

Even though the abundance estimate obtained through this project (approximately 90,000 fish; humpback whitefish and least cisco combined) is biased low, this estimate is still three to four times the abundance estimates obtained in the early 1970's (Kepler 1973; Kramer 1974, 1975). The earlier projects were conducted from mid-August to early September, times of the year before most of the fish had reached the spawning areas in

1986. Also, estimates of abundance of spawning whitefish from Kepler (1973) and Kramer (1974) were based on sampling in two small sections of the river; expansions of information from these two sections were made without full knowledge of the extent of the spawning area and without a concomitant calculation of variance for the ultimate estimate. The estimate from Kramer (1974) was conducted during daylight hours in mid-August over a large section of the river, but was made without the benefit of flash panels on the stream bottom to highlight the silhouette of passing fish. In our study, flash panels were essential to the clear, visual recognition of fish passing the counting towers.

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LITERATURE CITED

Clark, R.A., and W.P. Ridder. 1987. Tanana drainage creel census and harvest surveys, 1986. Alaska Department of Fish and Game, Fisheries Data Series. In press.

Cochran, W.G. 1977. Sampling techniques, 3rd ed. John Wiley & Sons, Inc. New York. 428 p.

Kepler, P. 1973. Population studies of northern pike and whitefish in Minto Flats complex with emphasis on the Chatanika River. Alaska Department of Fish and Game, Federal Aid in Fish Restoration, Annual Report of Progress, 1972-1973, Project F-9-5.

Kramer, M.J. 1974. Inventory and cataloging of interior Alaska waters, Fairbanks District. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1973-1974, Project F-9-6.

______. 1975. Inventory and cataloging of interior Alaska waters, Fairbanks District. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1974-1975, Project F-9-7.

Mills, M.J. 1986. Statewide harvest survey; 1985 data. Alaska Department of Fish and Game. Federal Aid in Fish Restoration and Anadromous Fish Studies, Annual Performance Report, 1985-1986, Project F-10-2, (27): RT-2. 90pp.

Seber, G.A.F. 1973. The estimation of animal abundance and related parameters. Charles Griffin & Company, Ltd. London. 506 p.

Wolter, K.M. 1984. An investigation of some estimators of variance for systematic sampling. J. American Statistical Association 79(288):781-790.