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ORIGINS OF SOCKEYE SALMON (*Oncorhynchus nerka*) IN THE COPPER AND BERING RIVER FISHERIES OF 1983 BASED ON SCALE PATTERN ANALYSIS

By:
Samuel Sharr
and
William E. Goshert

September 1985

ALASKA DEPARTMENT OF FISH AND GAME
P.O. Box 3-2000, Juneau, Alaska 99802

Don W. Collinsworth
Commissioner

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Samuel Sharr

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William E. Goshert

Alaska Department of Fish and Game
Division of Commercial Fisheries
Anchorage, Alaska

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ABSTRACT

Sockeye salmon *(Oncorhynchus nerka* Walbaum*)* commercially caught in regulatory fishing Districts 212 and 200 were allocated, using linear discriminant function analysis of scale patterns and age composition data, to two runs, one composed of stocks originating in the Upper Copper River Basin (Upriver) and another of stocks originating in the Copper River Delta and Bering River watersheds (Delta/Bering). Linear discriminant functions were constructed with scale pattern measurements from fish sampled in the escapements of each run. Mean classification accuracies for the linear discriminant models were 77% for fish aged 1.3 and 86% for fish aged 1.2. The linear discriminant models were used to estimate the proportions of Upriver and Delta/Bering fish in temporally stratified samples from the commercial catches in Districts 212 and 200. For District 212, the Upriver contribution to the catches of fish aged 1.3 was 192,121 fish and the Delta/Bering contribution was 200,684 fish. For fish aged 1.2, 37,136 were allocated to the Upriver run and 64,043 to the Delta/Bering run. The estimates of run contribution by the 1.3 and 1.2 age groups were combined with escapement age composition estimates to allocate the remaining age groups in the catch to the Upriver or Delta/Bering runs. The total contribution of the Upriver and Delta/Bering runs to commercial catches were 343,872 and 321,820 fish, respectively. The accuracy of the classification functions for fish aged 1.2 suggests that scale pattern analysis can be used during the 1984 season to allocate fish aged 1.3 which are from the same brood year. Scale measurements in the freshwater growth zone provided the most discriminant power in the linear discriminant models.

KEY WORDS: catch allocation, migratory timing, sockeye salmon, *Oncorhynchus nerka*, scale pattern analysis.

FOREWORD

This report builds upon the 1983 catch and escapement data base for salmon returns to the Copper River and Prince William Sound areas (Sharr et al. 1985). Inshore returns to the Copper River area have been allocated to run of origin since 1982 (Sharr et al. 1984).

INTRODUCTION

The Copper River and Bering River commercial fishing districts are located on the Gulf of Alaska east of Prince William Sound (Figure 1). The Copper River District (212) extends from Cape Martin on the east to Hook Point, Hinchinbrook Island on the west and is divided into three subdistricts (10, 20, and 30). The Bering River District (200) extends from Cape Martin on the west to Cape Suckling on the east and includes Katella Bay (Subdistrict 10), Controller Bay (Subdistrict 20), and the nearshore waters to the east of Kayak Island (Subdistrict 30, Figure 1). Effort and catches are highest in District 212. In 1983, peak effort in District 212 was 486 boats and in District 200, 104 boats. The combined commercial catch of sockeye salmon (*Oncorhynchus nerka* Walbaum) in 1983 to these districts was 812,283 fish.

Sockeye salmon returning to the Copper River District and Bering River Subdistricts 10 and 20 (Bering River Inside) are a mixture of stocks from the Upper Copper River drainage, small watersheds in the Copper River Delta, and from the Bering River. Major stocks from the Upper Copper River can be grouped into two runs: (1) one which is destined for the upper portions of the drainage above Chitina[1] and; (2) one which is destined for the Chitina River drainage and does not contribute to the subsistence fishery extending from Chitina to Slana (Figure 2; Roberson, personal communication). The major stocks from the Delta are from Eyak Lake, McKinley Lake, 27 Mile Slough, Ragged Point Lake, Martin Lake, Little Martin Lake, Tokun Lake, Martin River Slough, and 39 Mile Creek. The major Bering River stocks are from Bering Lake, Kushtaka Lake, and Shepherd Creek. Results of aerial escapement monitoring programs and hydro acoustical enumeration indicate that escapements to the Copper River have been more numerous than to the Delta and to the Bering River.

This report presents the results of an allocation of the 1983 commercial catches of sockeye salmon in Districts 212 and 200 to the Upper Copper River (Upriver run) and to the combined Copper River Delta and Bering River (Delta/Bering run). Because there is evidence that a significant portion of the sockeye salmon returning to Subdistrict 30 (Kayak Island) of District 200 may be stocks which originate outside the Copper and Bering River area (McBride et al. 1984), catches in this subdistrict (146,591 fish) are not included in District 200 catch allocation in this report. Upriver and Delta/Bering contributions to catches from each district are estimated with results of scale pattern analysis of fish aged 1.3[2] and 1.2 and catch and escapement age composition data. The total return to the Copper/Bering River area are estimated from catch allocation and escapement data.

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[1] There are a few minor stocks between Miles Lake and Chitina.

[2] European Formula: Numerals preceding the decimal refer to the number of freshwater annuli, numerals following the decimal are the number of marine annuli. Total age from the brood year is the sum of these two numbers plus one.

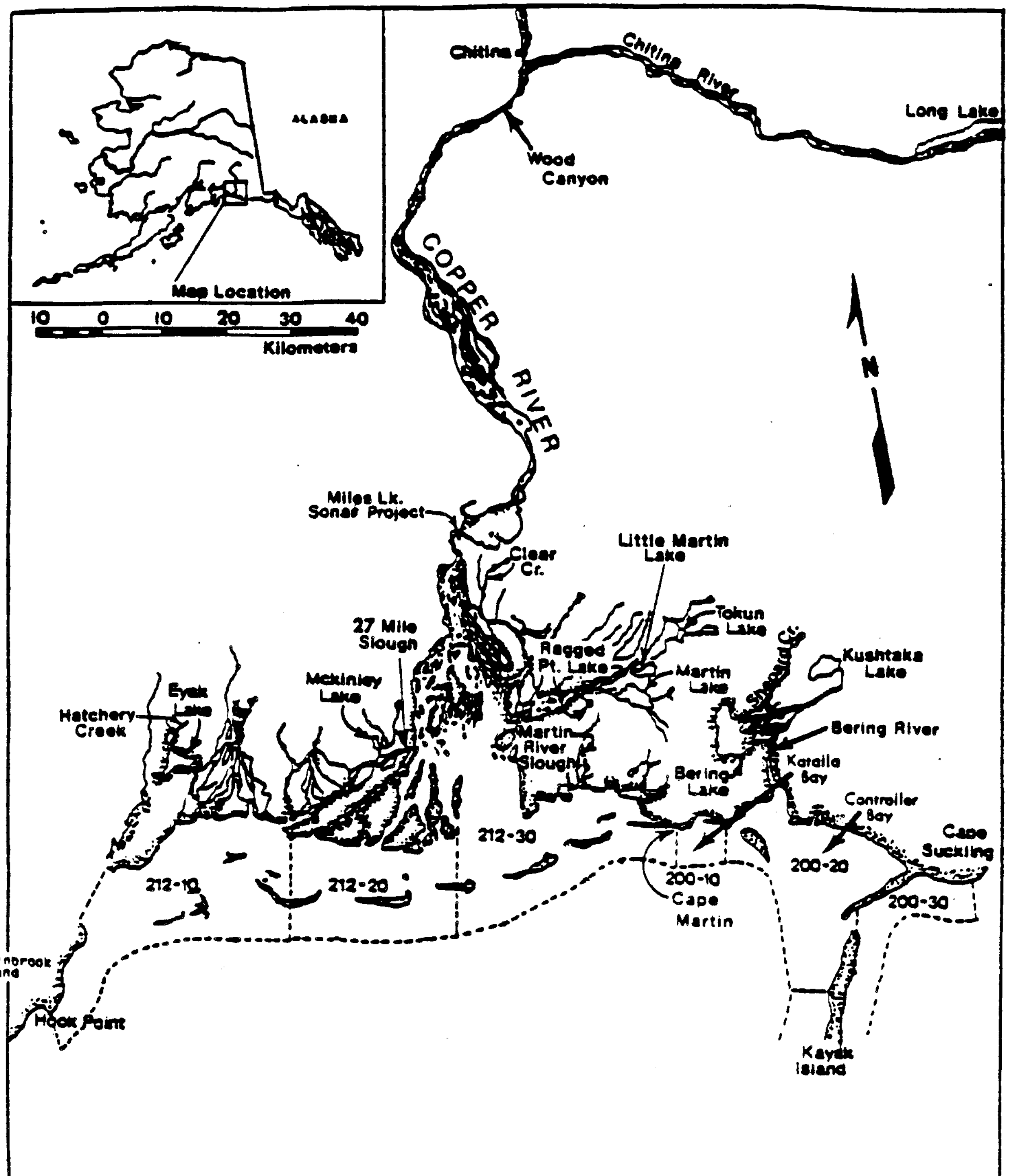

Figure 1. The Copper River and Bering River watersheds with adjoining fishing districts and sampling locations for sockeye salmon.

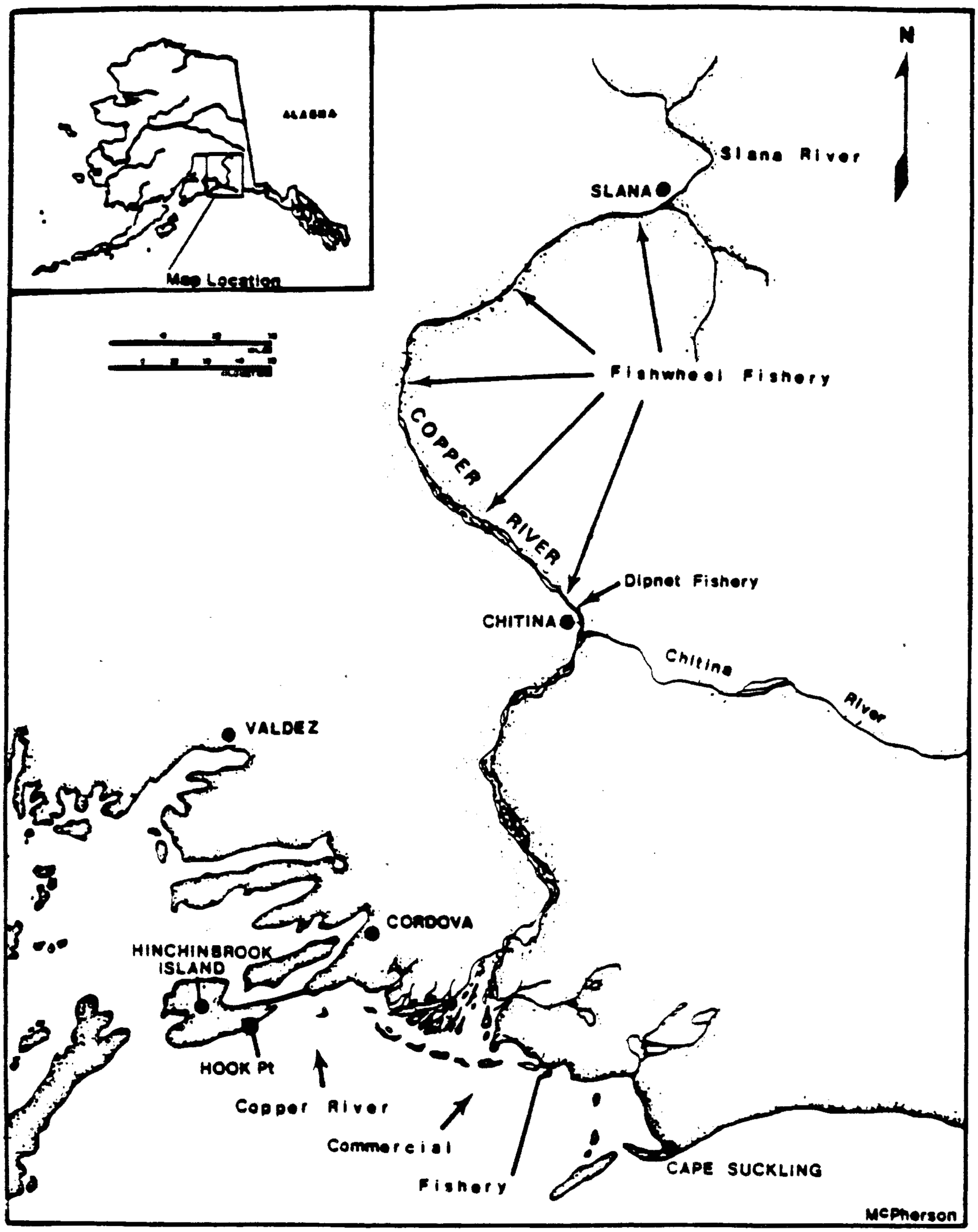

Figure 2. The Upper Copper River drainage showing the locations of the dip net and fishwheel subsistence fisheries.

METHODS

Catch and Escapement Statistics

Commercial catch data used in this report were compiled by the Division of Commercial Fisheries for each management district for each week of the fishing season and are based on tabulations of individual records of sales by fishermen (fish tickets). Samples from a stratified systematic sampling program (Cochran 1977) provided scales and information about the sex and age composition of sockeye salmon in seven segments of the commercial catch in District 212. Because catches in District 200 were much smaller than in District 212 and occurred over a much shorter period of time, they were sampled only once (Sharr et al. 1985). Ages of fish were determined through examination of scales.

Upriver escapement was estimated by subtracting Upper Copper River subsistence catches (Roberson 1984) from the estimates of escapement past the Miles Lake Sonar Project (Merritt and Roberson 1984) as reported by Randall et al. (1984). Estimates of the Delta and Bering River escapements were based on aerial survey data (Fridgen, personal communication) as compiled by Sharr et al. (1985). Subsistence catches at Chitina were assumed to be representative of escapement past the fishery and were, therefore, sampled regularly throughout the season to obtain scales and information about the age and sex composition of the escapement. The escapement to Long Lake (Figure 1) is the principal escapement to the Chitina River drainage and those fish were sampled at a weir at the lake outlet. The major escapements in the Delta/Bering run were sampled at least once during the season. The ages of fish sampled were estimated through examination of scales and the Peterson method of length frequency analysis (Tecsh 1970). The estimate of the escapement by age for the Upriver run is the sum of the estimates for the escapement past the subsistence fishery and the escapement to Long Lake. Similarly, the estimate of the Delta/Bering escapement by age is the sum of the estimates for escapements contributing to that run (Sharr et al. 1985).

Discriminant Analysis

The feasibility of using linear discriminant function analysis of scale patterns to distinguish sockeye salmon returning to the Upper Copper River from those returning to the Delta/Bering watersheds was demonstrated by Sharr (1983) and was first used to estimate the contribution of those two runs to the commercial catches in District 212 in 1982 (Sharr et al. 1984). The technique is used here to estimate the proportions of the two runs in the 1983 commercial catches from Districts 212 and 200.

Linear discriminant, two-way models[1] were calculated with scale pattern data derived from escapement samples from the Upriver and Delta/Bering runs. Scale

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[1] Two-way models are discriminant functions that distinguish the members of two groups, here Upriver and Delta/Bering fish.

samples from the Delta/Bering group were subsampled according to relative run strengths of escapements as estimated by aerial surveys (Appendix Table B1). Scale samples representing the Upriver group were from catches at Chitina subsistence fishery and were subsampled to reflect temporal changes in the magnitude of the Upriver escapement. Scales from Long Lake were also subsampled according to the relative strength of that escapement in the Upriver run. Two age-specific linear discriminant models were constructed, one for fish aged 1.3 and one for fish aged 1.2 These were the two major age groups in both District 212 and District 200 commercial catches and accounted for 61.9% and 16.0%, respectively, of the combined total commercial catch.

The scale patterns for each fish were quantified by counts of circuli and measurements of distances between circuli (Appendix Tables A1 and A2). These data were obtained from three zones relating to the life history of the fish: (1) the first year spent in freshwater, (2) the portion of the second summer in freshwater (plus growth), and (3) the remainder of the second year spent in the marine environment (Figure 3). Scale impressions were projected at 100X using equipment similar to that described by Bilton (1970) and modified by Ryan and Christie (1976). Counts and measurements were recorded from the projected image using a Talos Digitizing Tablet connected to a Vector Graphics microcomputer. All measurements were made along the anterior-posterior axis of the scale.

Scale variables were added to the models using a stepwise procedure with the partial F-statistics as the criterion for variable entry/removal from the model (Enslein et al. 1977). Variables were added until the model accuracy ceased to improve. Accuracy was estimated by a leaving one out procedure (Lachenbruch 1967).

Scales from the catch samples were used to estimate the proportion of each run in each time strata of the catch. The estimated proportions were adjusted for misclassification errors by the procedures of Cook and Lord (1978) and the variance of the adjusted estimates was estimated by the formula of Pella and Robertson (1979).

Catch Allocation

The two-way linear discriminant models for fish aged 1.3 and 1.2 were used to estimate the Upriver and Delta/Bering portions of those age groups in the stratified catch samples from District 212 and the single sample from the Bering River inshore catches. Because there were very few samples of fish aged 1.2 in the first 2 weeks (Weeks 21 and 22) of the fishery in District 212 the point estimate for Week 23 was used to allocate those catches. The estimated contributions of fish aged 1.3 and 1.2 from each run were calculated as a product of the estimate of the proportion, the estimate of the fraction of the catch of the age group in question, and the catch:

$$\hat{C}_{ij} = C\hat{P}_j\hat{S}_{ij}.$$

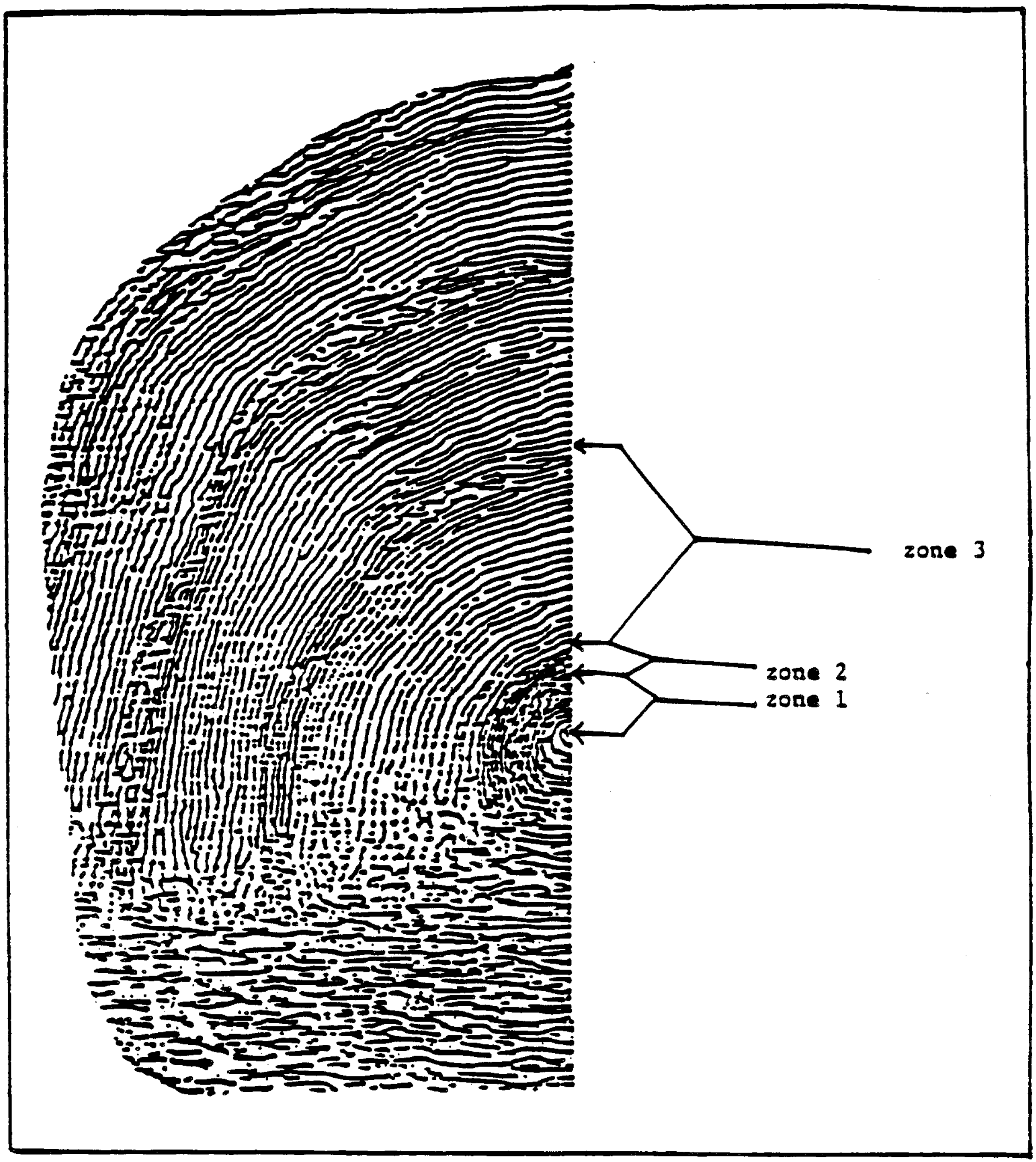

Figure 3. Scale from a sockeye salmon aged 1.3 showing zones measured to generate the variables used to build linear discriminant functions.

where:

$\hat{C}_{ij}$ = Estimated catch of fish aged j returning to run i.

C = District catch of fish during the strata.

$\hat{P}_j$ = Estimated proportion of fish aged j in the catch.

$\hat{S}_{ij}$ = Estimated proportion of run i aged j in the catch.

The variance of the estimated catch of sockeye salmon aged j from run i was calculated as an exact variance of a product according to Goodman (1960):

$$V[\hat{C}_{ij}] = C^2 V[\hat{P}_j \hat{S}_{ij}]$$

$$V[\hat{P}_j \hat{S}_{ij}] = V[\hat{P}_j]\hat{S}^2_{ij} + V[\hat{S}_{ij}]\hat{P}^2_j - V[\hat{S}_{ij}]V[\hat{P}_j]$$

The proportions of the catch contribution by the Upriver and Delta/Bering fish in age groups other than fish aged 1.3 and 1.2 are functions of the sum of the estimates for fish aged 1.3 and 1.2 and the ratio of the sum of fish aged 1.3 and 1.2 to other age groups in the respective escapements:

$$\hat{S}_{ij} = \frac{\bar{\hat{S}}_{i(1.3+1.2)}(\hat{A}_{ij}/\hat{A}_{i(1.3+1.2)})}{\sum_{m=1}^{N} \bar{\hat{S}}_{m(1.3+1.2)}(\hat{A}_{mj}/\hat{A}_{m(1.3+1.2)})}$$

where:

$\hat{S}_{ij}$ = Estimated proportion of run i in the catch of fish aged j.

$\bar{\hat{S}}_{i(1.3+1.2)}$ = Estimated proportion of run i in the catches of fish aged 1.3 and 1.2.

$\hat{A}_{ij}$ = Estimated proportion of fish aged j in the escapement of run i.

$\hat{A}_{i(1.3+1.2)}$ = Estimated proportion of fish aged 1.3 and 1.2 in the escapement of run i.

N = Number of runs.

The contribution of sockeye salmon age j was then calculated as:

$$\hat{C}_{ij} = C\hat{P}_j\hat{S}_{ij}$$

The variance of estimates of the catch of fish other than those aged 1.3 and 1.2 was not calculated.

RESULTS

Catches and Escapements

The 1983 commercial catch of sockeye salmon in District 212 was 633,010 fish (Sharr et al. 1985). Catches peaked during the last week of May (Week 22, Figure 4) and 95% of the catch was landed by the last week of July (Week 31). The commercial catch of sockeye salmon in the inside waters of District 200 was 32,682 fish and over half of the catches occurred during the first week of that fishery (12 June to 15 June) (Sharr et al. 1985). An estimated 708,919 sockeye salmon escaped the commercial fisheries in the two districts in 1983 of which 545,724 were destined for Upriver spawning areas and 163,195 for Bering/Delta spawning areas (Sharr et al. 1985). The Upriver subsistence fishery harvested 110,798 of the fish destined for Upriver spawning areas resulting in a net Upriver escapement of 434,926 sockeye salmon (Sharr et al. 1985).

Fish aged 1.3, 1.2, and 2.3 were the most abundant in District 212 catches, composing 62.0%, 16.0%, and 13.4%, respectively (Appendix Table B2). The proportion of fish aged 1.3 exceeded 50% throughout the season and peaked (69.9%) during the fifth strata (12 June to 25 June). The portion of fish aged 1.2 was insignificant until the first week in June (Week 23) but increased steadily and exceeded 30% by early July. Conversely, the proportion of fish aged 2.3 peaked in the mid-May opening period (Week 21), declined steadily thereafter, and was insignificant by the third week in June (Week 26). Inside catches in District 200 (Subdistricts 10 and 20) were predominantly fish aged 1.3 (59.2%), 1.2 (17.1%), and 0.3 (13.3%) (Appendix Table B3).

Fish aged 1.3 were predominate in the Upriver and Delta/Bering escapements and the portions were similar in both, 54.5% and 52.7%, respectively (Appendix Table B4). The portion of fish aged 1.2 in the Upriver escapement was slightly smaller than in the Bering/Delta escapement (27.0% versus 35.2%). The remainder of the Upriver escapement was predominantly fish aged 2.3 while the remainder of the Bering/Delta escapement was predominantly fish aged 0.3. For a more detailed description of the catch and escapement statistics see Sharr et al. (1985).

Classification Models

Scale characters that corresponded to growth during freshwater life proved the most powerful in distinguishing Upriver from Delta/Bering fish. For fish aged 1.3 (1978 brood year) differences in plus growth were the most powerful: for fish aged 1.2 differences in the distance from the second circulus from the focus to the end of the freshwater annulus were the most powerful. For fish aged 1.3, plus growth was greater in Delta/Bering fish, and for fish aged 1.2, growth in the first year was greater in Upriver fish. The mean classification accuracy of the model for fish aged 1.3 was 77.0% and of the model for fish aged 1.2, was 86.0% (Table 1). The model for fish aged 1.3 classified Delta/

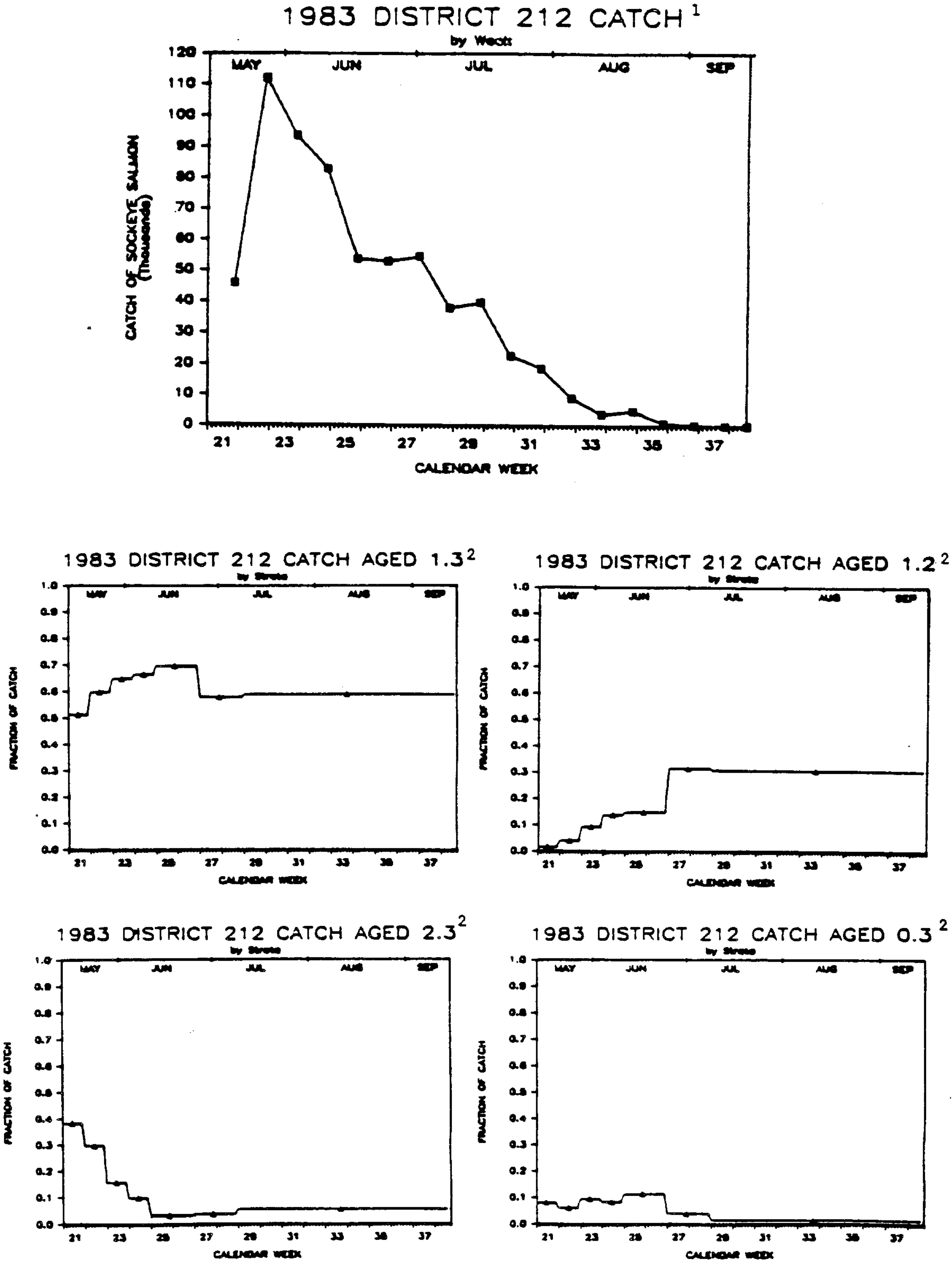

Figure 4. Numbers of sockeye salmon and proportions of fish aged 1.3, 1.2, 2.3, and 0.3 in weekly catches in District 212.

[1] Data are from Sharr et al. (1985).

[2] These data are from Appendix Table B2.

Table 1. Classification accuracies of linear discriminant models for fish aged 1.3 and 1.2, 1983.

Fish Aged 1.3

Actual Run	Sample Size	Number of Fish Classified to Run		Percent Correct
		Upriver	Delta/Bering	
Upriver	100	74	26	74.0
Delta/Bering	100	20	80	80.0
		Mean Classification Accuracy		77.0

Fish Aged 1.2

Actual Run	Sample Size	Number of Fish Classified to Run		Percent Correct
		Upriver	Delta/Bering	
Upriver	100	79	21	79.0
Delta/Bering	100	7	93	93.0
		Mean Classification Accuracy		86.0

Bering fish with better accuracy than Upriver fish (80% versus 74%) as did the model for fish aged 1.2 (93% versus 79%).

Catch Allocations

The estimates of the proportion of Upriver fish aged 1.3 in the District 212 catches were similar (Table 2, Figure 5) among all strata and exceeded 50% only in late May and early June (Weeks 22 and 23). Total catches of Upriver fish aged 1.3 peaked during the last week of May or Week 22 (Table 3, Figure 6). Total catches of Delta/Bering fish aged 1.3 peaked in early June (Week 24) and were greater than catches of Upriver fish for the remainder of the season. The season total catches of Upriver and Delta/Bering fish aged 1.3 were similar (192,121 versus 200,684).

The estimated proportions of Upriver fish aged 1.2 in District 212 catches of sockeye salmon were similar among all strata (Table 2, Figure 4) and the proportion exceeded 50% only during Weeks 21 through 23 (15 May - 4 June). The estimated proportions of Delta/Bering fish aged 1.2 were also not demonstrably different among strata but they exceeded 50% in all but Weeks 21 through 23 and, peaked in mid-June (Weeks 25-26). Estimated catches of Upriver and Delta/Bering fish aged 1.2 both peaked in mid-June (Weeks 28) and total catches of Delta/Bering fish aged 1.2 exceeded those of Upriver fish from 5 June to the end of the season (Table 4, Figure 6).

For District 200 catches of sockeye salmon aged 1.3, the estimated number of Upriver fish was greater than the estimated number of Delta/Bering fish (11,823 fish versus 7,527 fish), while the estimated numbers of Upriver and Delta/Bering fish aged 1.2 were approximately equal (2,684 fish versus 2,896 fish) (Table 4).

For the entire 1983 season the combined catches of all fish in District 212 and 200 (Subdistricts 10 and 20) were composed of approximately equal portions of Upriver (51.7%) and Delta/Bering (48.3%) fish (Table 5). The portion of Upriver fish aged 1.3 were nearly equal to the portion of Delta/Bering fish aged 1.3 (49.5% versus 50.5%), but smaller for fish aged 1.2 (37.3% versus 62.7%). The Upriver portion of fish aged 2.3 was much larger than the Delta/Bering portion aged 2.3 (86.5% versus 13.5%), slightly larger for fish aged "Other" (53.2% versus 46.8%), but smaller for fish aged 0.3 (37.8% versus 62.2%) (Table 5).

The estimated combined total return of sockeye salmon to Districts 212 and 200 (Subdistricts 10 and 20) in 1983 was 1,363,361 fish (Table 6). Escapement comprised 48.8% of the total return, commercial catch comprised 43.0%, and subsistence catches on the Upper Copper River comprised 8.1%. Though the estimated commercial catch of Upriver fish (343,871) was approximately equal to the catch of Delta/Bering fish (321,821), an additional 110,798 Upriver fish were captured in the Upriver subsistence fishery, and the estimated Upriver escapement (434,926 fish) was much larger than the estimated Delta/Bering escapement (151,945).

DISCUSSION

In 1983, Upriver and Delta/Bering fish comprised approximately equal portions of the commercial catch and there was no evidence of temporal variation in

Table 2. Run composition estimates and 90% confidence intervals from scale pattern analysis of sockeye salmon aged 1.3 and 1.2 in District 212 and Subdistricts 10 and 20 of District 200, 1983.

District 212			Aged 1.3			Aged 1.2		
Week(s)	Catch Dates	Run	Sample Size	Estimated Proportion	90% Confidence Interval [1]	Sample Size	Estimated Proportion	90% Confidence Interval
21	5/15 - 5/21	Upriver	100	0.463	± 0.176	59	0.508[2]	± 0.160
		Delta/Bering		0.537			0.492	
22	5/22 - 5/28	Upriver	100	0.667	± 0.180	59	0.508[2]	± 0.160
		Delta/Bering		0.333			0.492	
23	5/29 - 6/04	Upriver	100	0.519	± 0.177	59	0.508	± 0.160
		Delta/Bering		0.481			0.492	
24	6/05 - 6/11	Upriver	100	0.463	± 0.176	58	0.430	± 0.154
		Delta/Bering		0.537			0.570	
25-26	6/12 - 6/25	Upriver	100	0.389	± 0.175	96	0.250	± 0.112
		Delta/Bering		0.611			0.750	
27-28	6/26 - 7/09	Upriver	100	0.500	± 0.176	100	0.403	± 0.121
		Delta/Bering		0.500			0.597	
29-39	7/10 - 9/24	Upriver	100	0.407	± 0.175	100	0.306	± 0.139
		Delta/Bering		0.593			0.694	
District 200 (Subdistricts 10 and 20)			Aged 1.3			Aged 1.2		
Week(s)	Catch Dates	Run	Sample Size	Estimated Proportion	90% Confidence Interval [1]	Sample Size	Estimated Proportion	90% Confidence Interval
25-39	6/12 - 9/24	Upriver	100	0.611	± 0.179	72	0.481	± 0.143
		Delta/Bering		0.389			0.519	

[1] In a two-way model the confidence intervals are the same for both groups.

[2] Because there were very few samples of fish aged 1.2 available for Weeks 21 and 22 the estimate for Week 23 was applied to these weeks.

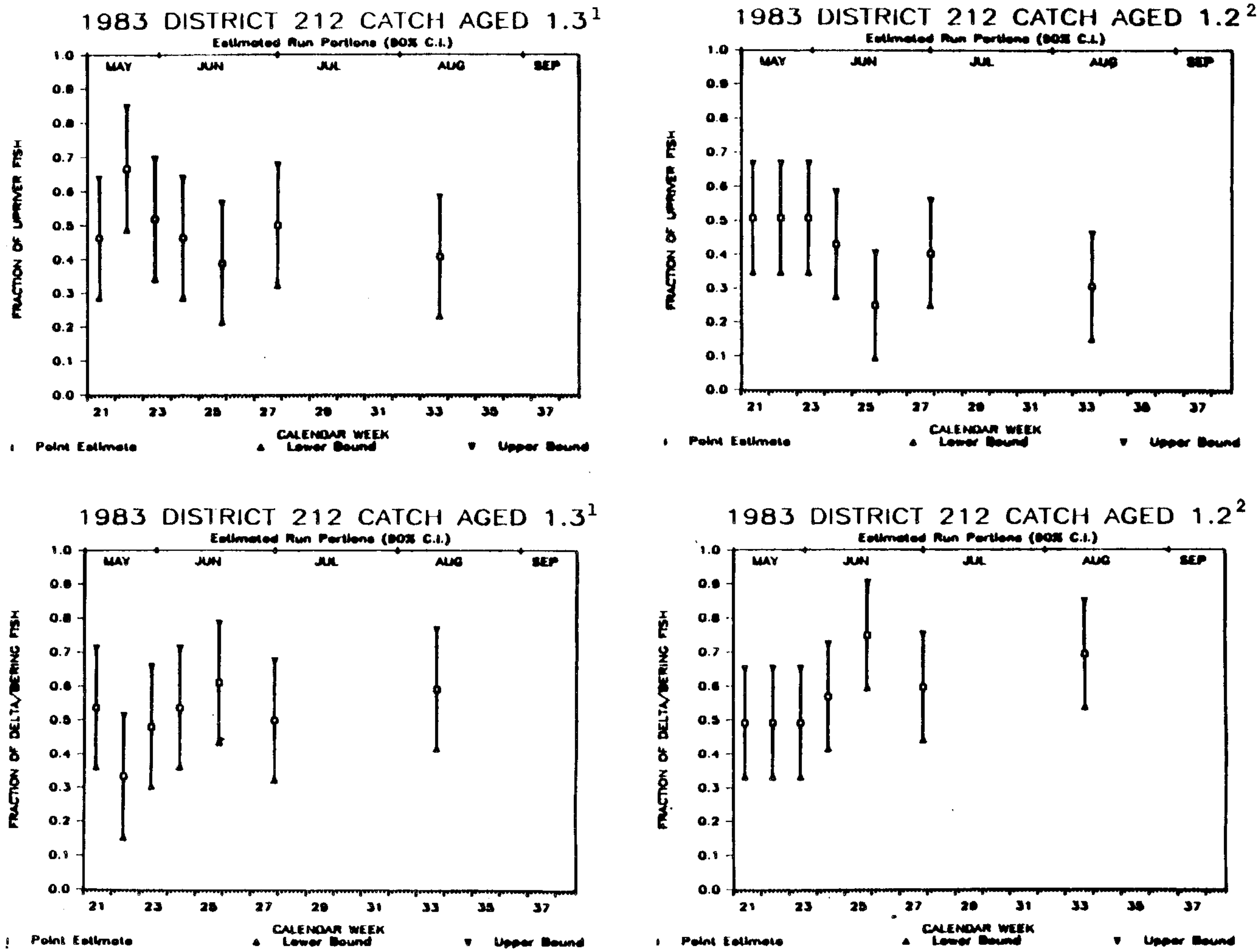

Figure 5. Estimated proportions and 90% confidence intervals of Upriver and Delta/Bering River fish aged 1.3 and 1.2 in District 212 catches, 1983.

[1] The brackets around the point estimates correspond to the 90% confidence intervals.

[2] Because there were no estimates for Weeks 21 and 22, the estimate for Week 23 was sampled to these strata.

Table 3. Estimated numbers of Upriver and Delta/Bering sockeye salmon aged 1.3 caught in District 212 and Subdistricts 10 and 20 of District 200, 1983.

District 212 Week(s)	Catch Dates	Run	Estimated Proportion	Standard Error of Estimate	Estimated Catch	Standard Error of Estimate
21	5/15 - 5/21	Upriver	0.463	0.10717	10,912	2,546
		Delta/Bering	0.537	0.10717	12,657	2,553
		Total	1.000		23,569	
22	5/22 - 5/28	Upriver	0.667	0.10951	44,712	7,421
		Delta/Bering	0.333	0.10951	22,322	7,359
		Total	1.000		67,034	
23	5/29 - 6/04	Upriver	0.519	0.10773	31,370	6,558
		Delta/Bering	0.481	0.10773	29,073	6,551
		Total	1.000		60,443	
24	6/05 - 6/11	Upriver	0.463	0.10717	25,484	5,932
		Delta/Bering	0.537	0.10717	29,557	5,944
		Total	1.000		55,041	
25-26	6/12 - 6/25	Upriver	0.389	0.10650	28,900	7,944
		Delta/Bering	0.611	0.10650	45,394	7,993
		Total	1.000		74,294	
27-28	6/26 - 7/09	Upriver	0.500	0.10754	26,807	5,836
		Delta/Bering	0.500	0.10754	26,807	5,836
		Total	1.000		53,614	
29-39	7/10 - 9/24	Upriver	0.407	0.10666	23,936	6,329
		Delta/Bering	0.593	0.10666	34,874	6,396
		Total	1.000		58,810	
Total (21-39)	5/15 - 9/24	Upriver	0.489	0.28435	192,121	16,642
		Delta/Bering	0.511	0.28435	200,684	16,667
		Total	1.000		392,805	

-Continued-

Table 3. Estimated numbers of Upriver and Delta/Bering sockeye salmon aged 1.3 caught in District 212 and Subdistricts 10 and 20 of District 200, 1983 (continued).

District 200 (Subdistricts 10 and 20)						
Week(s)	Catch Dates	Run	Estimated Proportion	Standard Error of Estimate	Estimated Catch	Standard Error of Estimate
25-39	6/12 - 9/24	Upriver	0.611	0.10880	11,823	2,154
		Delta/Bering	0.389	0.10880	7,527	2,124
		Total	1.000		19,350	
Total[1] (25-39)	6/12 - 9/24	Upriver	0.611	0.10880	11,823	2,154
		Delta/Bering	0.389	0.10880	7,527	2,124
		Total	1.000		19,350	

Districts 212 and 200 Combined						
Week(s)	Catch Dates		Estimated Proportion	Standard Error of Estimate	Estimated Catch	Standard Error of Estimate
Total (21-39)	5/15 - 9/24	Upriver	0.495	0.30445	203,944	16,781
		Delta/Bering	0.505	0.30445	208,211	16,802
		Total	1.000		412,155	

[1] One stratum was representative of the total catch in District 200.

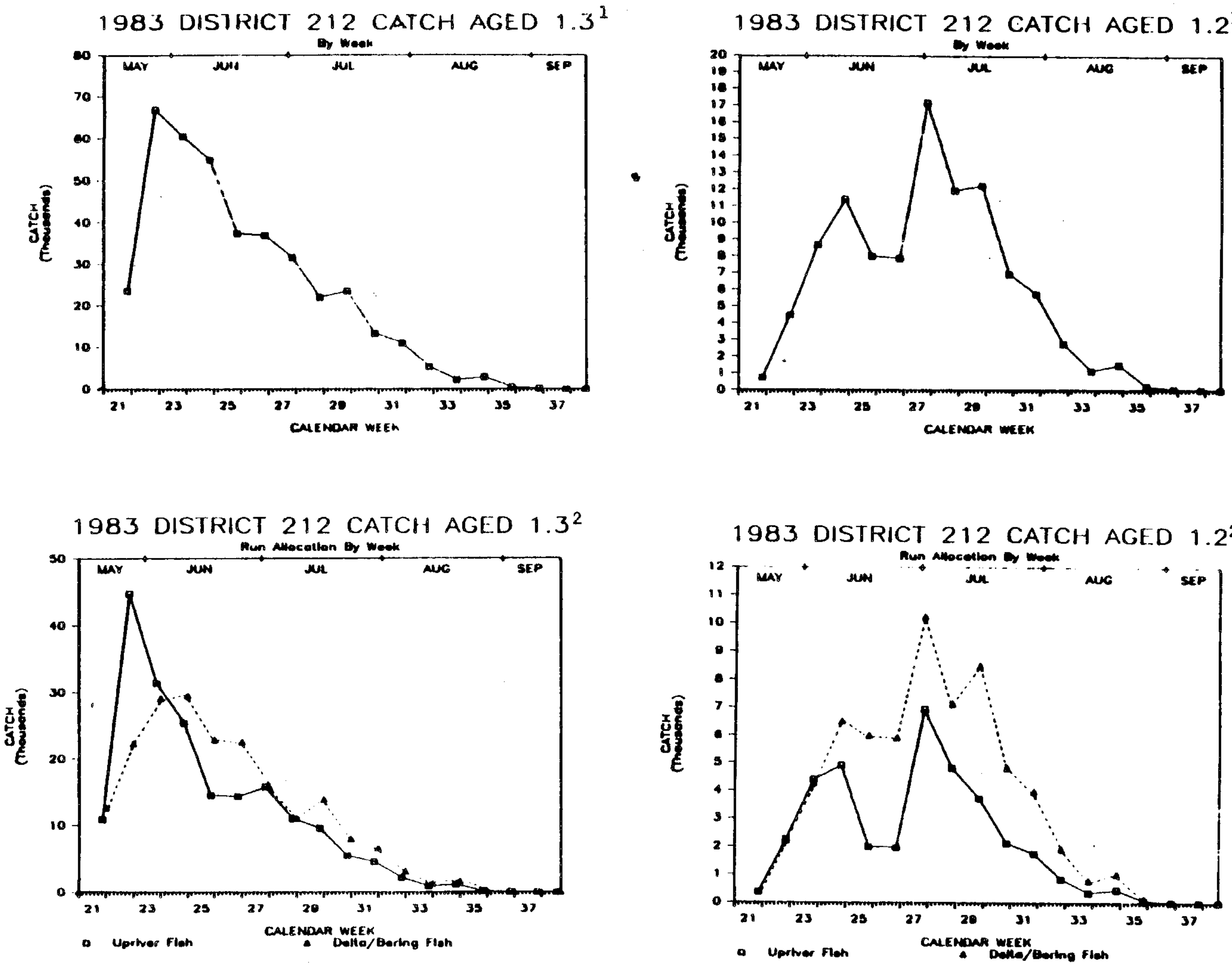

Figure 6. Numbers of Upriver and Delta/Bering fish aged 1.3 and 1.2 in District 212 catches, 1983.

[1] Weekly estimates are interpreted from the strata estimates in Appendix Table B2.

[2] Weekly estimates are interpreted from the stratified age composition estimates (Appendix Table B1) and run composition estimates (Tables 3 and 4). The estimates for fish aged 1.2 in weeks 22 and 23 are extrapolated from the run composition estimates for Week 23.

Table 4. Estimated numbers of Upriver and Delta/Bering sockeye salmon aged 1.2 caught in District 212 and Subdistricts 10 and 20 of District 200, 1983.

District 212 Week(s)	Catch Dates	Run	Estimated Proportion	Standard Error of Estimate	Estimated Catch	Standard Error of Estimate
21	5/15 - 5/21	Upriver	0.508[1]	0.09773	371	113
		Delta/Bering	0.492	0.09773	359	111
		Total	1.000		730	
22	5/22 - 5/28	Upriver	0.508[1]	0.09773	2,319	556
		Delta/Bering	0.492	0.09773	2,245	550
		Total	1.000		4,564	
23	5/29 - 6/04	Upriver	0.508	0.09773	4,411	968
		Delta/Bering	0.492	0.09773	4,272	961
		Total	1.000		8,683	
24	6/05 - 6/11	Upriver	0.430	0.09397	4,903	1,152
		Delta/Bering	0.570	0.09397	6,499	1,213
		Total	1.000		11,402	
25-26	6/12 - 6/25	Upriver	0.250	0.09397	3,974	1,532
		Delta/Bering	0.750	0.09397	11,923	1,847
		Total	1.000		15,897	
27-28	6/26 - 7/09	Upriver	0.403	0.09397	11,752	2,824
		Delta/Bering	0.597	0.09397	17,409	2,926
		Total	1.000		29,161	
29-39	7/10 - 9/24	Upriver	0.306	0.09397	9,407	2,948
		Delta/Bering	0.694	0.09397	21,335	3,204
		Total	1.000		30,742	
Total (21-39)	5/15 - 9/24	Upriver	0.367	0.21183	37,136	4,647
		Delta/Bering	0.633	0.21183	64,043	4,995
		Total	1.000		101,179	

-Continued-

Table 4. Estimated numbers of Upriver and Delta/Bering sockeye salmon aged 1.2 caught in District 212 and Subdistrict 10 and 20 of District 200, 1983 (continued).

District 200 (Subdisticts 10 and 20)[2] Week(s)	Catch Dates	Run	Estimated Proportion	Standard Error of Estimate	Estimated Catch	Standard Error of Estimate
25-39	6/12 - 9/24	Upriver	0.481	0.08713	2,684	558
		Delta/Bering	0.519	0.08713	2,896	569
		Total	1.000		5,580	
Total (25-39)	6/12 - 9/24	Upriver	0.481	0.08713	2,684	558
		Delta/Bering	0.519	0.08713	2,896	569
		Total	1.000		5,580	

Districts 212 and 200 Combined Week(s)	Catch Dates		Estimated Proportion	Standard Error of Estimate	Estimated Catch	Standard Error of Estimate
Total (21-39)	5/15 - 9/24	Upriver	0.373	0.22905	39,820	4,681
		Delta/Bering	0.627	0.22905	66,939	5,027
		Total	1.000		106,759	

[1] Because there were very few samples of fish aged 1.2 for Weeks 21 and 22 the estimated proportions from Week 23 were applied to these weeks.

[2] One stratum was representative of the total catch in District 200.

Table 5. Age-specific run contributions of sockeye salmon to catches in District 212 and 200 (Subdistricts 10 and 20) based upon expanded estimates from scale pattern analysis of fish aged 1.3 and fish aged 1.2, 1983.

	1.3		1.2		2.3		0.3		Other[1]		Total	
Run	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number
Upriver	49.5	203,944	37.3	39,820	86.5	75,824	37.8	17,595	53.2	6,688	51.7	343,872
Delta/Bering	50.5	208,211	62.7	66,939	13.5	11,834	62.2	28,953	46.8	5,884	48.3	321,820
Total	100.0	412,155	100.0	106,759	100.0	87,658	100.0	46,548	100.0	12,572	100.0	665,692

[1] Includes fish aged 1.4, 0.4, 2.2, 2.1, 0.2, and 1.1.

Table 6. Total return of sockeye salmon by run and age group to Districts 212 and 200 (Subdistricts 10 and 20) combined, 1983.

Run	1.3		1.2		2.3		0.3		Other		Total	
	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number
Upriver												
Commercial Catch [1]	15.0	203,944	2.9	39,820	5.6	75,824	1.3	17,595	0.5	6,688	25.3	343,871
Subsistence Catch [2]	4.7	63,488	1.7	23,349	1.0	14,148	0.4	5,796	0.3	4,017	8.1	110,798
Escapement [3]	17.3	236,533	9.1	123,660	2.7	37,031	1.3	17,392	1.5	20,310	31.9	434,926
Total	37.0	503,965	13.7	186,829	9.3	127,003	3.0	40,783	2.3	31,015	65.3	889,595
Delta/Bering												
Commercial Catch [1]	15.3	208,211	4.9	66,939	0.9	11,834	2.1	28,953	0.4	5,884	23.6	321,821
Escapement [4]	5.9	80,154	3.9	53,410	0.2	2,118	0.7	10,028	0.5	6,235	11.1	151,945
Total	21.2	288,365	8.8	120,349	1.1	13,952	2.8	38,981	0.9	12,119	34.7	473,766
Total												
Commercial Catch	30.2	412,155	7.8	106,759	6.4	87,658	3.4	46,548	0.9	12,572	48.8	665,692
Subsistence Catch	4.7	63,488	1.7	23,349	1.0	14,148	0.4	5,796	0.3	4,017	8.1	110,798
Escapement	23.2	316,687	13.0	177,070	2.9	39,149	2.0	27,420	1.9	26,545	43.0	586,871
Total	58.1	792,330	22.5	307,178	10.3	140,955	5.9	79,764	3.2	43,134	100.0	1,363,361

1 Combined catches in District 212 and subdistricts 10 and 20 in District 200.

2 These catches were reported by date and the age composition is a weighted sum of the age composition estimates for catches from the early, middle, and late segments of the fishery (Sharr et al. 1985).

3 This is the estimated escapement by age for all salmon which migrated past the Miles Lake Sonar Project (Roberson 1984) minus the estimated subsistence catches of sockeye salmon as compiled by Roberson and reported by Sharr et al. (1985). It should be noted that the total escapement of sockeye salmon (545,724) as reported by Randall et al. (1984), and Sharr et al. (1985) is really an estimate for all species of which 2% to 3% may be chinook salmon (Roberson, personal communication 1984).

4 This is the sum of escapements by age for Eyak Lake, McKinley Lake, 27-Mile Slough, Martin River Slough, 39-Mile Creek, Ragged Point Lake, Martin Lake, Little Martin Lake, Tokun Lake, Bering Lake, Shepherd Creek, and Kushtaka Lake (Sharr et al. 1985).

the stock composition of the catches of fish aged 1.3 or 1.2. However, in 1982 temporal trends in stock composition were evident as the Upriver portion of the catch of fish aged 1.3 peaked (81%) during the second week of June then declined steadily to zero by the fourth week of July (Sharr 1983). Confidence intervals around 1983 stock estimates were larger than in 1982 and the sampling strata were broader late in the season which may prevent temporal changes from being discerned.

Although there was no evidence of temporal variation in the stock composition of the catches of fish aged 1.3 or 1.2, stock-specific temporal trends were evident when all age classes were considered in aggregate (Figure 7). The predominance of Upriver fish during the early portion of the season was a result of the large numbers of fish aged 2.3 in the early season catches, most of which were allocated to the Upriver run (86.5%). As the season progressed, the proportion of age 2.3 fish declined which resulted in a corresponding decline of the overall contribution of Upriver fish. Caution should be taken when interpreting these results as it is not possible to calculate variances around these estimates of stock composition.

Fish originating from some of the large Upriver occuluded rearing areas such as Klutina Lake may account for a significant portion of strong early season Upriver returns in some years. The contribution of these stocks to the fishery is currently unknown as are their relative escapements. The migratory timing of stocks from Klutina Lake are certainly consistent with the early segment of the Upriver run (Merritt and Roberson 1983) and in 1983 a large portion of the Klutina Lake escapement consisted of fish aged 2.3 (Sharr unpublished data) as were early season commercial catches of Upriver fish. It is not clear if returns to the Upriver occluded areas are typically predominated by fish aged 2.3 but if there were large returns of fish aged 1.3 to these systems in some years it could explain the large portion of Upriver fish aged 1.3 in the commercial catches in years such as 1982. Sharr et al. (1984) noted that in both 1981 and 1982 there were two modes in the frequency distribution of the measurements across the freshwater annulus of Upriver fish and suggested that the first mode, corresponding to less growth might result from fish which reared in occluded areas where growth rates are typically slower than in non-occluded areas (Cross et al. 1983; McPherson et al. 1983). If the mean of this first mode can be shown to be similar to the mean distance across the freshwater annulus of fish sampled on the spawning grounds of Upriver occluded systems, then the size of the first mode relative to the size of the second could be used as a relative measure of the escapement to Upriver occluded versus escapement to non-occluded systems. Relative escapement estimates coupled to lagged escapement estimates from the Miles Lake Sonar Project could be used to estimate total escapement to Upriver occluded systems.

The estimate of the ratio of catch to escapement is much higher for the Delta/Bering run than for the Upriver run based on the estimated run composition of the catches and the estimates of escapement for the two runs. Sharr (1983) showed a similarly higher catch to escapement ratio for Delta/Bering versus Upriver fish in 1982 and proposed two alternative hypotheses to explain this difference: (1) differences in the catch to escapement ratios for the two runs result from imprecise escapement estimates for delta stocks; or (2) the

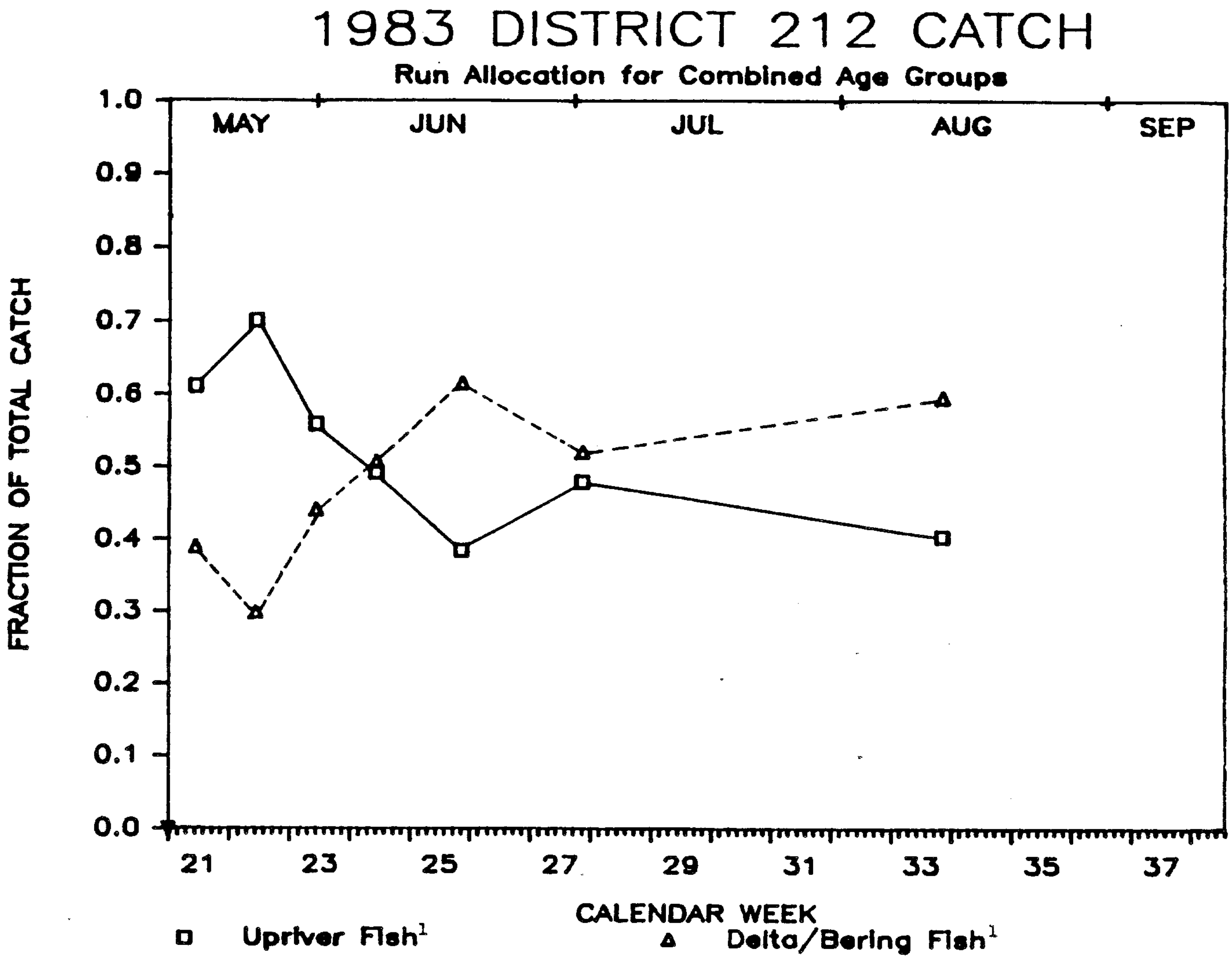

Figure 7. Proportions of Upriver and Delta/Bering fish of all age groups in District 212 catches, 1983.

[1] Symbols are plotted at midpoint of each sampling stratum.

higher catch to escapement ratio for the Delta/Bering run result from a higher rate of exploitation of that run in the fishery. Acceptance/rejection of these alternatives will be based on development of an independent estimate of the magnitude of Bering/Delta escapements. Additional years of catch stock composition data should provide the necessary information to estimate the magnitude of Bering/Delta escapements.

Based on the two-way model for fish aged 1.2 (1979 brood year), scale pattern analysis should separate Upriver from Delta/Bering fish aged 1.3 in 1984 with greater accuracy than it did fish aged 1.3 in 1983 (1978 brood year). Sharr (1983) showed that accuracies between models for fish aged 1.2 and 1.3 from the 1976 brood year were similar and went on to predict similar accuracies between the model for fish aged 1.2 in 1982 (1978 brood year) and fish from the same brood year (aged 1.3) in 1983. In fact, the models for fish aged 1.2 and 1.3 from the 1978 brood year have very similar accuracies (79.5% versus 77.0%). Sharr (1983) also suggested that when the accuracy of the model for fish aged 1.2 is high, it could be used inseason to allocate catches of fish aged 1.3 in the following year. This is a particularly valuable tool in the Copper River fishery where it is impossible to obtain timely inseason standards for fish aged 1.3. The relatively high accuracy of the model for fish aged 1.2 in 1983 indicates that inseason allocations of fish aged 1.3 in 1984 should be attempted.

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APPENDIX A

Scale characters examined for linear discriminant analysis.

Appendix Table A1. Scale pattern variables considered for possible inclusion in linear discriminant function analysis classification models for sockeye salmon aged 1.3 and 1.2[1].

Variable No.	Description
	First Freshwater (FW) Annular Zone
1	Number of circuli in the zone
2	Distance across the zone
3	Distance: scale focus (CO) to the second circulus in zone (C2)
4	Distance: CO to C4
5	Distance: CO to C6
6	Distance: CO to C8
7	Distance: C2 to C4
8	Distance: C2 to C6
19	Distance: C2 to C8
10	Distance: C4 to C6
11	Distance: C4 to C8
12	Distance: fourth from the last circulus of zone to end of zone
13	Distance: second from the last circulus of zone to end of zone
14	Distance: C2 to end of zone
15	Distance: C4 to end of zone
16	Relative Distance: (Variable #3)/(Variable #2)
17	Relative Distance: (Variable #4)/(Variable #2)
18	Relative Distance: (Variable #5)/(Variable #2)
19	Relative Distance: (Variable #6)/(Variable #2)
20	Relative Distance: (Variable #7)/(Variable #2)
21	Relative Distance: (Variable #8)/(Variable #2)
22	Relative Distance: (Variable #9)/(Variable #2)
23	Relative Distance: (Variable #10)/(Variable #2)
24	Relative Distance: (Variable #11)/(Variable #2)
25	Relative Distance: (Variable #12)/(Variable #2)
26	Relative Distance: (Variable #13)/(Variable #2)
27	Average distance between circuli: (Variable #1/Variable #2)
28	Number of circuli in the first 3/4 of the zone
29	Maximum distance between two adjacent circuli in the zone
30	Relative distance: (Variable #29)/(Variable #2)
	Freshwater Plus Growth (PG)
61	Number of circuli in the zone
62	Distance across the zone
	Combined Freshwater Zones
65	Total number of circuli in the combined zones
66	Total distance across the combined zones
67	Relative Distance: (Variable #2/(Variable #66)

-Continued-

Appendix Table A1. Scale pattern variables considered for possible inclusion in linear discriminant function analysis classification models for sockeye salmon aged 1.3 and 1.2[1] (continued).

Variable No.	Description
	First Marine Annular Zone
70	Number of circuli in the zone
71	Distance across the zone
72	Distance: end of FW (EFW) to the third circulus in zone (C3)
73	Distance: EFW to C6
74	Distance: EFW to C9
75	Distance: EFW to C12
76	Distance: EFW to C15
77	Distance: C3 to C6
78	Distance: C3 to C9
79	Distance: C3 to C12
80	Distance: C3 to C15
81	Distance: C6 to C9
82	Distance: C6 to C12
83	Distance: C6 to C15
84	Distance: C9 to C15
85	Distance: sixth from the last circulus of zone to end of zone
86	Distance: third from the last circulus of zone to end of zone
87	Distance: C3 to end of zone
88	Distance: C9 to end of zone
89	Distance: C15 to end of zone
90	Relative Distance: (Variable #72)/(Variable #71)
91	Relative Distance: (Variable #73)/(Variable #71)
92	Relative Distance: (Variable #74)/(Variable #71)
93	Relative Distance: (Variable #75)/(Variable #71)
94	Relative Distance: (Variable #76)/(Variable #71)
95	Relative Distance: (Variable #77)/(Variable #71)
96	Relative Distance: (Variable #78)/(Variable #71)
97	Relative Distance: (Variable #79)/(Variable #71)
98	Relative Distance: (Variable #80)/(Variable #71)
99	Relative Distance: (Variable #81)/(Variable #71)
100	Relative Distance: (Variable #82)/(Variable #71)
101	Relative Distance: (Variable #83)/(Variable #71)
102	Relative Distance: (Variable #84)/(Variable #71)
103	Relative Distance: (Variable #85)/(Variable #71)
104	Relative Distance: (Variable #86)/(Variable #71)
105	Average distance between circuli: (Variable #71/Variable #70)
106	Number of circuli in the first 1/2 of the zone
107	Maximum distance between two adjacent circuli in the zone
108	Relative distance: (Variable #107)/(Variable #71)

[1] Zones were measured along the anterior-posterior axis of the scale. Within each zone, the total number of circuli were counted and the distances between pairs of adjacent circuli were measured. Distances were recorded in hundredths of inches.

Appendix Table A2. Means and standard errors of scale variables used to construct two-way linear discriminant functions for fish aged 1.3 and 1.2, 1983.

Fish Aged 1.3		Upriver		Delta/Bering	
Variable No.[1]	F-Value[2]	Mean	Standard Error	Mean	Standard Error
62	42.12	28.64	1.66	44.72	1.84
71	11.35	397.95	4.28	418.85	4.49
14	32.40	102.09	3.16	80.44	2.12

Fish Aged 1.2		Upriver		Delta/Bering	
Variable No.	F-Value	Mean	Standard Error	Mean	Standard Error
14	170.57	113.42	3.30	64.13	1.83
86	9.79	36.68	0.53	34.22	0.58

[1] Variable numbers are defined in Appendix B1.

[2] Values of F represent the relative degree of differences of the variables between discriminant groups.

APPENDIX B

Age, sex, and abundance estimates of sockeye salmon catches and escapements.

Appendix Table B1. Estimated escapements by age used to subsample scales of known origin from the Upriver and Delta/Bering runs to construct two-way discriminant functions for fish aged 1.3 and 1.2, 1983.

			Aged 1.3			Aged 1.2		
Grouping	Escapement Samples	Statistical Code	Number	% Group Total	Number Standards	Number	% Group Total	Number Standards
Upriver	Chitina 06/01 - 06/03[1]	212-20-000-100	97,255	32.4	32	23,047	15.7	16
	Chitina 06/08 - 06/10[1]	212-20-000-100	105,372	35.1	35	37,884	25.8	26
	Chitina 06/15 - 06/17[1]	212-20-000-100	50,428	16.8	17	44,564	30.3	30
	Chitina 06/20 - 06/24[2]	212-20-000-100	36,015	12.0	12	29,241	19.9	20
	Long Lake[3]	212-20-000-101	10,951	3.7	4	12,273	8.3	8
	Upriver Total		300,021	100.0	100	147,010	100.0	100
Delta/Bering[4]	Eyak Lake - West Beaches	212-10-000-211	6,333	7.9	8	1,833	3.4	3
	Eyak Lake - Hatchery Creek	212-10-000-215	420	0.5	1	1,699	3.2	3
	McKinley Lake	212-20-000-230	12,399	15.5	15	6,338	11.9	12
	27 - Mile Slough	212-20-000-295	3,741	4.7	5	3,459	6.5	6
	Martin River Slough	212-30-000-381	4,024	5.0	5	3,074	5.7	6
	39 - Mile Creek	212-30-000-391	4,196	5.2	5	7,684	14.4	14
	Ragged Point Lake	212-30-000-310	2,789	3.5	3	3,902	7.3	7
	Martin Lake - West Beaches	212-30-000-321	5,296	6.6	7	10,368	19.4	19
	Martin Lake - South Feeders	212-30-000-322	5,832	7.3	7	1,496	2.8	3
	Little Martin Lake	212-30-000-340	567	0.7	1	3,898	7.3	7
	Tokun Lake	212-30-000-350	6,438	8.0	8	1,171	2.2	2
	Bering Lake	200-20-000-410	20,845	26.0	26	6,451	12.1	12
	Kushtaka Lake	200-20-000-420	477	0.6	1	541	1.0	1
	Shepherd Creek	200-20-000-430	6,797	8.5	8	1,496	2.8	3
	Delta/Bering Total		80,115	100.0	100	53,410	100.0	100

1 This is an estimate of escapement past the Mile Lake Sonar Project which was based on age composition data from Chitina subsistence fishery data and sonar counts from Miles Lake lagged to account for travel time from the sonar site to the fishery.

2 Because Long Lake fish are probably not intercepted by the subsistence fishery (Roberson, personal communication)and their migratory timing is consistent with this segment of the escapement (Merritt and Roberson 1983), the estimate was subtracted from the sonar counts for this portion of the run.

3 Based on counts and samples from fish passed through the weir at the outlet of Long Lake.

4 Escapement estimates as reported by Sharr et al. (1985).

Appendix Table B2. Age and sex composition of the commercial catches of sockeye salmon in District 212 by sampling strata, 1983[1].

					Brood Year and Age Group										
					1977		1978			1979			1980		
Week(s)	Catch Dates	**Sample Dates**	Sample Size		1.4	2.3	0.4	1.3	2.2	0.3	1.2	2.1	0.2	1.1	**Total**
21	5/15 - 5/21	5/16 - 5/17	1.068	%	0.1	38.2	0.0	51.3	0.8	8.0	1.6	0.0	0.0	0.0	100.0
				Number	43	17.516	0	23.569	343	3,649	730	0	0	0	45,850
				Std. Error	43	682	0	702	121	380	177	0	0	0	
22	5/22 - 5/28	5/23 - 5/24	1,105	%	0.0	29.6	0.0	59.8	0.7	5.9	4.0	0.0	0.0	0.0	100.0
				Number	0	33,162	0	67,034	811	6,490	4,564	0	0	0	112,861
				Std. Error	0	1,539	0	1.653	286	788	666	0	0	0	
23	5/29 - 6/04	5/30 - 5/31	838	%	0.1	15.5	0.0	64.8	0.6	9.3	9.3	0.0	0.4	0.0	100.0
				Number	111	14,471	0	60,443	556	8,683	8,683	0	446	0	93,393
				Std. Error	111	1,167	0	1,541	248	936	936	0	221	0	
24	6/05 - 6/11	6/06 - 6/08	799	%	0.0	9.6	0.0	66.4	1.7	8.1	13.8	0.0	0.4	0.0	100.0
				Number	0	7,981	0	55,041	1,348	6,737	11,402	0	311	0	82,820
				Std. Error	0	865	0	1,383	371	801	1,010	0	179	0	
25-26	6/12 - 6/25	6/20 - 6/21	678	%	0.6	3.1	0.0	69.6	0.6	11.2	14.9	0.0	0.0	0.0	100.0
				Number	630	3,305	0	74,294	630	11,962	15,897	0	0	0	106,718
				Std. Error	314	710	0	1,885	317	1,293	1,459	0	0	0	
27-28	6/26 - 7/09	7/04 - 7/06	609	%	0.5	3.6	0.0	57.9	2.8	3.7	31.5	0.0	0.0	0.0	100.0
				Number	455	3,341	0	53,614	2,582	3,342	29,161	0	0	0	92,495
				Std. Error	262	699	0	1,850	617	699	1,742	0	0	0	
29-39	7/10 - 9/24	7/07 - 7/20	522	%	0.2	5.4	0.0	59.0	3.0	1.4	30.8	0.2	0.0	0.0	100.0
				Number	191	5,346	0	58,810	3,056	1,337	30,742	191	0	0	99.673
				Std. Error	191	983	0	2,146	752	502	2,015	191	0	0	
Total (21-39)	5/15 - 9/24	5/15 - 7/20	5.620	%	0.2	13.4	0.0	62.0	1.5	6.7	16.0	0.0	0.1	0.0	100.0
				Number	1,430	85,122	0	392,805	9,326	42,200	101,179	191	757	0	633.010
				Std. Error	467	2.627	0	4.369	1.159	2,167	3,405	191	284	0	

[1] From Sharr et al. (1985).

Appendix Table B3. Age and sex composition of the commercial catches of sockeye salmon in District 200 (Subdistricts 10 and 20) by sampling strata, 1983[1].

					Brood Year and Age Group										
					1977		1978			1979			1980		
Week(s)	Catch Dates	Sample Dates	Sample Size		1.4	2.3	0.4	1.3	2.2	0.3	1.2	2.1	0.2	1.1	Total
25-39	6/12 - 9/24	6/12 - 6/15	451	%	0.2	7.8	0.0	59.2	1.1	13.3	17.1	0.0	1.1	0.2	100.0
				Number	72	2.536	0	19,350	362	4,348	5,580	0	362	72	32,682
				Std. Error	69	410	0	756	161	524	579	0	161	69	
Total (25-39)	6/12 - 9/24	6/12 - 6/15	451	%	0.2	7.8	0.0	59.2	1.1	13.3	17.1	0.0	1.1	0.2	100.0
				Number	72	2,536	0	19,350	362	4,348	5,580	0	362	72	32.682
				Std. Error	69	410	0	756	161	524	579	0	161	69	

[1] From Sharr et al. (1985).

Appendix Table B4. Estimated age composition of the Upriver and Delta/Bering escapements of sockeye salmon, 1983.

Run Escapement	Statistic	1.4	2.3	3.2	0.4	1.3	2.2	0.3	1.2	2.1	0.2	1.1	Total
Upriver[1]	%	0.3	9.4	.0	0.0	54.5	4.2	4.2	27.0	.0	0.2	0.1	100.0
	Number	1,490	37,031	47	0	236,533	17,332	17,392	123,660	47	1,119	275	434,926
Delta/Bering[2]	%	.0	1.4	0.0	.0	52.7	0.8	6.6	35.2	.0	1.7	1.6	100.0
	Number	55	2,118	0	31	80,154	1,268	10,028	53,410	17	2,531	2,343	151,945

1 This is the escapement estimate for fish past the Miles Lake Sonar Project minus the Upriver subsistence and personal use catches (Sharr et al. 1985).

2 As compiled by Sharr et al. (1985).