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Jay S. Hammond, Governor

Annual Performance Report for

A STUDY OF A TYPICAL SPRING-FED STREAM OF INTERIOR ALASKA

by

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RESEARCH REPORT

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ABSTRACT

The Delta Clearwater River was sampled with an electrofishing boat in the seventh year of a project to monitor existing stocks of Arctic grayling, Thymallus arcticus (Pallas), and round whitefish Prosopium cylindraceum (Pallas). Comparisons are made of relative abundance with like sampling in previous years. Water conditions in the lower river were seen to affect relative capture rates of grayling upriver.

Age class compositions of grayling from index sampling are compared with those from previous years. Three year-classes, 1974-1976, have dominated the last 4 years of sampling.

Similar sampling was conducted on the Richardson Clearwater River. Age, length, and capture rate are discussed and compared with like sampling in previous years and with the Delta Clearwater sample. Year-class strengths were the same in both systems.

Clear Creek, a small spring-fed stream, was sampled for the third year in July. Age compositions are compared with 2 previous years of sampling and with sampling in the Delta and Richardson Clearwater Rivers.

Monitoring of the spring migration of immature grayling and round whitefish into the Delta Clearwater River at Mile One Slough was conducted for the sixth year. Composition changes in the catches of both species first noted in 1979 continued in 1981. A correlation was found in recruitment between age compositions found in spring monitoring and in index sampling.

A creel census conducted on the Delta Clearwater River from May 16 to August 31, 1981, estimated a harvest of 4,073 grayling and 7,543 angler hours of effort, both of which represented the third year of a decline from

highs in 1978. Catch rate was inversely proportional to harvests and reached 0.79 grayling per hour in 1981, the highest rate recorded since 1953.

A voluntary creel census for residents of the Richardson Clearwater River was conducted for the second year. Thirty-five percent of the resident households responded at the end of the season. They expended 282 angler hours to harvest 531 grayling, a catch rate of 1.91 grayling per hour. The estimated harvest was 1,522 grayling for all resident households.

A creel census was conducted at Shaw Creek, a major spawning stream for the Richardson Clearwater River, from April 5 to April 22, 1981. An estimated 4,343 grayling were harvested at a catch rate of 2.14 grayling per hour. Tag recaptures generated by the fishery are compared to like data from the Richardson Clearwater River and Caribou Creek.

Stock enhancement through the stocking of pond-reared fingerling grayling into the Delta Clearwater River system was assessed. Scale analysis of Age III-VI grayling sampled during index and creel monitoring showed a 24 percent contribution to the total combined catch. The contribution of the enhancement program to the total angler harvest of the past 5 years was estimated at 14.2 percent and represents a return to date of 12.2 percent of those originally stocked.

Tag returns from 651 Age I grayling stocked in 1979 are discussed and comparisons are made with previous tagging studies. Second year returns were below the average found with "wild" grayling.

A description and analysis of an experimental two-way weir for use on Caribou Creek, a Shaw Creek tributary, are presented.

Length frequencies, age compositions, and sex ratios of 2,123 grayling sampled in the post-spawning migration out of Caribou Creek are presented, along with catch statistics on eight other species. Length range comparisons with 1980 data show an increase in Age I and a decrease in Age VI and older grayling captured. Total grayling tagged in Caribou Creek was 1,323. Subsequent recoveries were compared with 1980 data and were found similar, with the majority occurring in the Richardson Clearwater River.

Age compositions and tagging summaries are presented from spring and fall sampling of the Volkmar River. As in 1980, all tag recaptures were obtained from the Delta Clearwater River.

Discriminant analysis of scale variables from Age III Arctic grayling produced 3-way test classification accuracies in separating stocks of 74.4% for the Goodpaster River, 73.1% for the Volkmar River and 55.3% for Caribou Creek. Overall accuracy was 68.2%. Two-way test classification accuracies were 90.7% for the Goodpaster and 80.6% for the Volkmar and the overall accuracy was 84.5%.

Escapement counts of coho salmon, Oncorhynchus kisutch (Walbaum), into the Delta Clearwater River were made in October and were estimated at 8,563. Escapement counts from 7 previous years are presented.

KEY WORDS

Interior Alaska, spring and bog-fed streams, Arctic grayling, tagging, spawning migrations, stocking, creel census, index monitoring, stock separation, weir.

BACKGROUND

Studies of typical interior Alaska spring-fed streams were initiated in 1952 by the U.S. Fish and Wildlife Service as part of the Arctic grayling life history study in the Tanana River drainage. From 1952 to 1958 investigations were conducted on age and growth, food and spawning habits, migrations of graying and angler success. The study emphasized creel censusing and migration habits. The latter established several general trends of grayling migratory behavior. Results of these studies were presented as Quarterly Progress Reports of Federal Aid in Fish Restoration, F-1-R-1 to F-1-R-8.

From 1959 to 1966 studies of spring-fed streams centered on the Delta Clearwater River and were divided into the determination of stocks, migrations (interstream and intrastream) and angler success. They included the nearby drainages (Fig. 1) of the Richardson Clearwater River, Shaw Creek, and Goodpaster River, but with emphasis on the latter. The studies narrowed the generalities of graying migratory behavior found in the earlier studies. They documented the homing instincts of graying in their use of the spring-fed streams as summer feeding areas and the role of the Goodpaster River as a source of recruitment. The results of these studies are published in the annual Department of Fish and Game Federal Aid in Fish Restoration Reports, Volumes 2 through 7.

A 1973 study brought to date information on the status of fish species present in the Delta and Richardson Clearwater Rivers. Pearse (1974) provided life history information regarding length frequencies and distribution, length-weight relationships, condition factors, age and sex composition and maturity for Arctic grayling and round whitefish. Estimates of abundance and standing crop for both species were also made.

Annual work since 1975 has centered on the Delta Clearwater River, with the monitoring of its graying and round whitefish populations and the assessment of an experimental program for enhancing the grayling population by transplanting pond-reared fingerlings. Comparative population monitoring has been conducted on the Richardson Clearwater River since 1977. Investigations of local spawning streams and the post-spawning migration of their graying populations were begun in 1979 to determine the relative importance of each to the recruitment to the above spring-fed stream populations.

Additional information on the Delta Clearwater River is contained in baseline studies conducted between 1978 and 1980 in response to large-scale agricultural development in the area. Individual reports on water quality and benthic investigations, chlorinated organics, and geohydrology of the area are on file with the Alaska Department of Natural Resources, North Central District, Division of Forest, Land and Water Management and with ADF&G, Sport Fish Division, Delta Jct. Field Office.

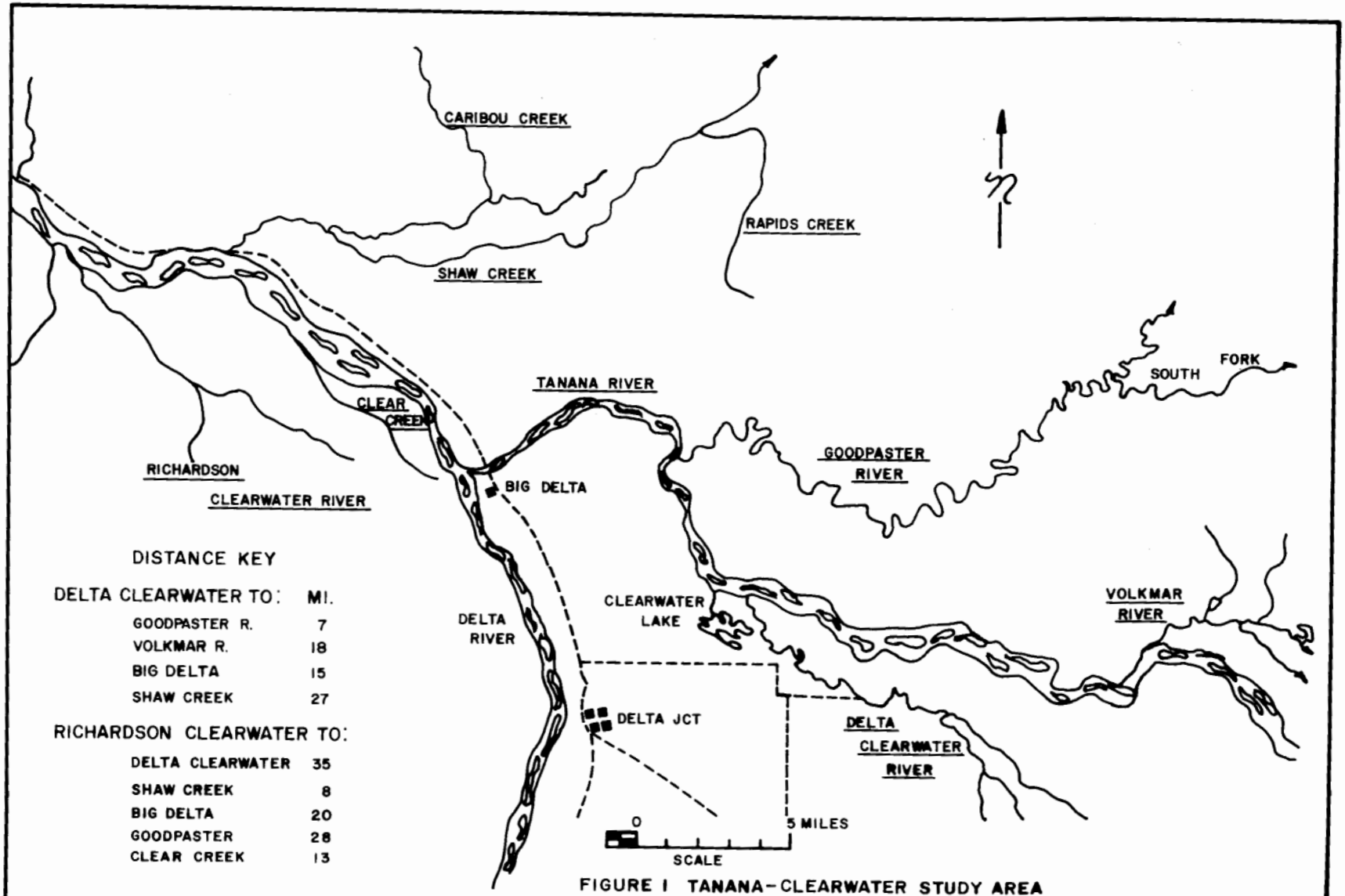


FIGURE 1 TANANA-CLEARWATER STUDY AREA

The Delta Clearwater River is located approximately 8 mi northeast of Delta Junction. The main channel of the river is approximately 20 mi in length and the north fork is about 6 mi in length. The river drains an area of approximately 350 sq mi, drawing heavily on groundwater as its source. Fairly constant water flows and water temperatures characterize this and other interior Alaskan spring-fed systems. The river provides a very popular sport fishery for Arctic grayling and a growing fishery for the fall run of coho salmon. Public access is available at the State of Alaska Clearwater Campground at Mile 8 of the river and includes a boat launching ramp. Downstream access is also provided via Clearwater Lake, where the U.S. Army has a launching facility. The two access points provide a popular float trip for canoists and kayakers. Common and scientific names and abbreviations of fish referred to in the report are listed in Table 1.

TECHNIQUES

All lengths of fish species mentioned in this report were measured to fork length. All grayling tagging utilized Floy FD 68 anchor tags.

Fish population sampling to obtain estimates of relative abundance in the Delta Clearwater River was done by utilizing an alternating current boat-mounted shocker described by Van Hulle (1968). Grayling and whitefish were captured during a single downstream run. At the end of each 1-mile section, lengths and scale samples were taken and all grayling and whitefish were counted. Grayling were released within the section in which they were captured. Identical techniques were used in the Richardson Clearwater River sampling, with the exception that sections were delineated by a 20-minute shocking run rather than by distance. Sampling at Mile One Slough utilized a New Hampshire style fyke net with a 50 ft lead attached to one end to block the slough. All fish species captured were measured and a random sample of grayling were scale sampled. All grayling $\geq$ 200 mm were tagged. Water temperatures were recorded to the nearest 1/2 degree Celsius as close to mid-day as possible. Delta Clearwater River temperatures were recorded above Mile One Slough.

Sampling at Caribou Creek used an experimental two-way weir (Fig. 2). Seine hauls were made to drive holding fish into the weir during the last 3 days. All information gathered on grayling was entered on Biological Data Processing forms and stored on Alaska Dept. of Fish and Game, Sport Fish Division B.D.P. data storage system at Boeing Computer Services, Tape #530264.

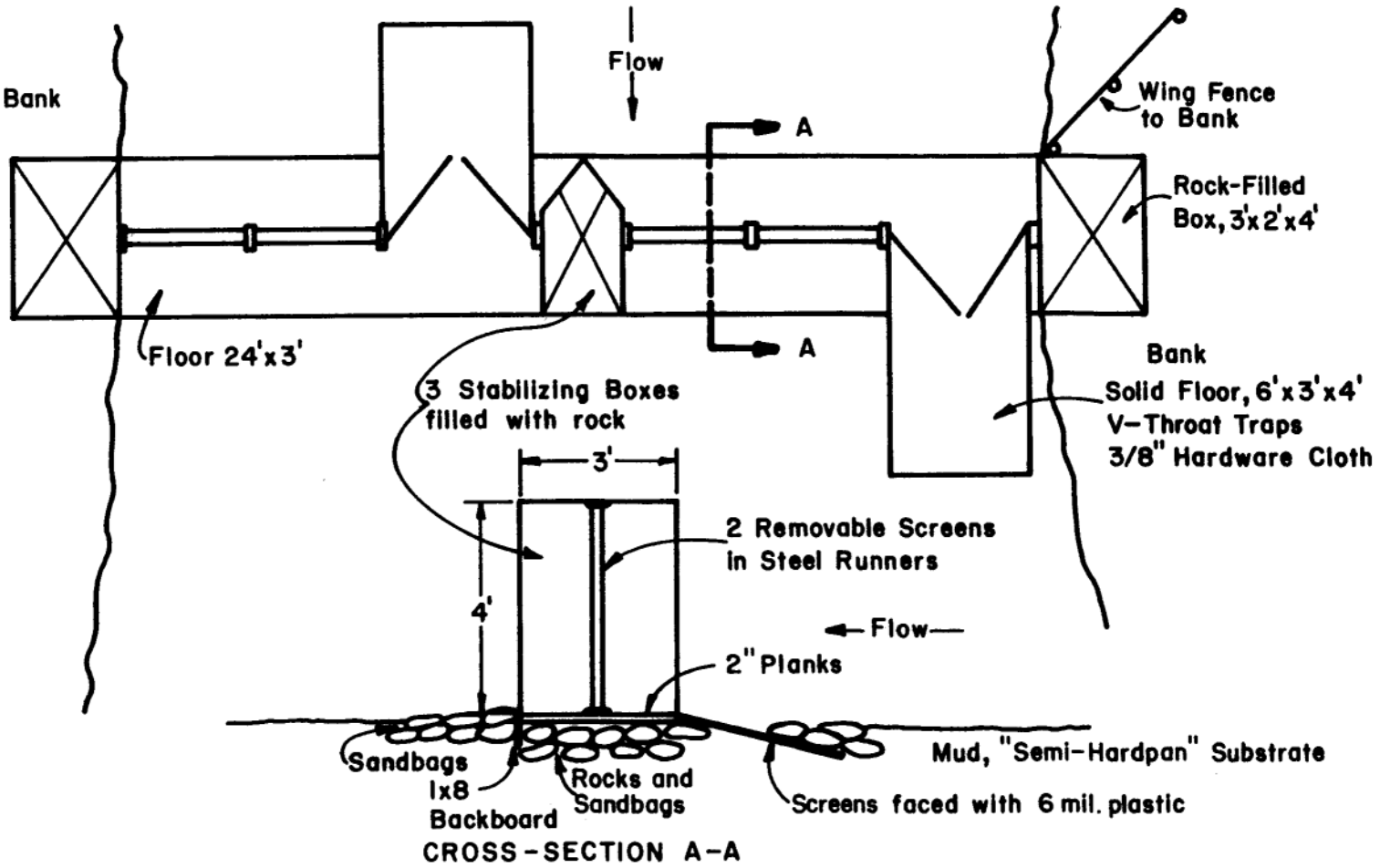
Sampling in the Volkmar River used hook and line (fly fishing gear), an Alaskan style fyke net and a 6 ft x 100 ft bag seine of 3/8 in sq mesh. All grayling $\geq$ 200 mm were tagged and had scale samples taken.

All grayling scales used for age determination and scale variable analysis (circuli numbers and annuli distances) were taken from the fifth row above the lateral line and in line with the insertion of the dorsal fin. They were cleaned and those from fish <200 mm were mounted between glass slides and read using a Bausch and Lomb micro-projector at 46x magnification. For fish $\geq$ 200 mm, the cleaned scales were impressed on 20 mil acetate using a Carver press at 20,000 psi and heated to 200°F. They were aged along their dorsal radius using a 3 M model 114 microfiche reader.

Table 1. List of common, scientific names, and abbreviations of species mentioned in this report.

Common Name	Scientific Name and Author	Abb
Arctic grayling	Thymallus arcticus (Pallas)	
Burbot	Lota lota (Linnaeus)	
Chum salmon	Oncorhynchus keta (Walbaum)	
Coho salmon	Oncorhynchus kisutch (Walbaum)	
Humpback whitefish	Coregonus pidschian (Gmelin)	
Lake chub	Couesius plumbeus (Agassiz)	
Least cisco	Coregonus sardinella (Valenciennes)	
Longnose sucker	Catostomus catostomus Forster	
Northern pike	Esox lucius Linnaeus	
Round whitefish	Prosopium cylindraceum (Pallas)	
Slimy sculpin	Cottus cognatus Richardson	
Sockeye salmon	Oncorhynchus nerka (Walbaum)	

FIGURE 2
CARIBOU CREEK WEIR



CROSS-SECTION A-A

Determinations of stream and pond-reared grayling were made from cou circuli to and including the first annulus along the anterior dorsal f All circuli counts of 11 or greater were considered to be pond-reared f as described by Peckham and Ridder (1979). Scale impressions selected analysis of variables were projected at 100X magnification using equip described by Cross et al. (1981) and all circuli and annuli bisect line originating in the center of the focus and extending on a radius anterior to the dorso-ventral axis were encoded with a digitizer at Alaska Department of Fish and Game Stock Separation Laboratory. Cir that bisected the line but were less than 10 mm in magnified length excluded.

RECOMMENDATIONS

1. Index sampling of Arctic grayling and round whitefish in the Delta and Richardson Clearwater Rivers should be continued.

2. Monitoring of sport fish harvest in the Delta Clearwater River should continue.

3. The experimental program of pond-rearing and transplanting of Arctic grayling to the Delta River should be continued, but utilizing grayling pond-reared for 2 summers rather than 1 summer.

4. Assessment of the contribution of the enhancement program to year-classes and angler harvest should continue.

5. Monitoring of early spring fish movement in the Delta Clearwater should continue.

6. Investigations should be continued on the post-spawning migration of grayling from the Shaw Creek drainage, with emphasis on its Caribou Creek tributary.

7. A study on the dynamics and life history of the grayling population in Caribou Creek should be initiated.

8. Investigations on the post-spawning migration of grayling from the lower Goodpaster River to spring-fed systems should be initiated.

OBJECTIVES

1. To continue annual monitoring of existing stocks of Arctic grayling and whitefish in the Delta Clearwater River to determine changes in population structure, and to monitor existing stocks of Arctic grayling and whitefish in the Richardson Clearwater River to determine changes in population structure and similarity with trends in the Delta Clearwater River.

2. To assess transplanting of pond-reared grayling into the Delta Clearwater River to determine contribution to year-class strength and angler harvest.

3. To investigate the post-spawning migration of grayling from spawning streams to local spring-fed systems to determine mechanism and levels of recruitment.

4. To evaluate the use of scale analysis in separation of spring-fed systems' grayling stocks.

FINDINGS

Monitoring of Arctic grayling and round whitefish stocks

Spring monitoring:

Since 1976 spring monitoring of Arctic grayling and round whitefish has taken place at Mile One Slough, a side channel of the Tanana River that enters the Delta Clearwater at Mile One. The slough is strongly influenced by springs during the months the Tanana is low and non-glacial. A fyke trap is fished totally blocking the slough at its mouth. A percentage of fish entering the Delta Clearwater from the Tanana in April move into the slough prior to further movement, possibly due to its temperature typically being several degrees warmer than the Delta Clearwater.

The date of trap placement in 1981, April 15 (2 days after the initial sighting of round whitefish in the river), was similar to previous years. (An exception was in 1979, when the trap was positioned prior to fish observations.) At this time, the temperatures of the slough and river were 3.3°C and 2.2°C respectively. In 1981, the trap was fished until May 1, a total of 16 days.

As in previous years (Ridder, 1981), the number of fish captured in the slough and observed in the river increased after the river temperature reached 5°C on April 20 and peaked within 4 to 7 days. The fluctuations in numbers captured during the trapping follow those of the temperature recordings. Table 2 lists the temperatures of Mile One Slough and the Delta Clearwater River, along with the catch of three species of fish during spring monitoring.

The catch during the 16 days of monitoring in 1981 totaled 4,252 fish of nine species. The catch of Arctic grayling was 1,250 and represented a catch per unit effort (CPUE; number of fish per trap day) of 78, a large increase over the CPUE of 26 recorded in 1980. The catch and CPUE of round whitefish in 1981, 111 and seven respectively, continued the decline from the high catch of 996 and CPUE of 83 found in 1978. A summary of all species captured at Mile One Slough and the CPUE for grayling and whitefish from 1976 to 1981 is shown in Table 3.

Table 2. Temperature and catch recordings during spring monitoring at Mile One Slough of the Delta Clearwater River, 1981.

Date	Temperature (°C)		Catch		
	Slough	River	GR	RWF	SS
4/15	3.3°	2.2°	Trap Set		
4/17	4.1°	2.8°	2	2	10
4/20	7.0°	5.0°	98	7	56
4/21	5.1°	3.5°	39	8	67
4/24	7.0°	5.2°	403	29	680
4/27	6.0°	4.2°	471	25	1274
4/29	6.0°	4.1°	92	7	564
5/1	6.5°	5.0°	145	33	157

Table 3. Summary of fish captured by fyke trap and crab for grayling and round whitefish at Mile One Slough, Delta Clearwater River, 1976-1981.

	1976	1977	1978	1979	1980	1981
GR: FL < 200	242	757	763	1,016	480	1,179
FL ≥ 200	159	436	869	140	65	71
Total	401	1,193	1,632	1,156	545	1,250
RWF: FL < 200	8	52	43	279	161	63
FL ≥ 200	380	486	953	322	89	48
Total	388	538	996	601	250	111
SS	318	681	692	1,744	612	2,808
HWF	6	3	60	74	68	11
LCI	442	6	5	12	30	26
BB	15	11	8	22	13	35
NP	0	0	1	1	1	2
SSC	6	8	2	5	1	8
LNS	0	2	0	3	15	1
Total	1,576	2,442	3,396	3,618	1,535	4,252
# Trap Days	8	8	12	12	21	16
CPUE* GR	50	148	136	96	26	78
RWF	49	67	83	50	12	7

* Catch per day.

[illegible] Delta Clearwater River, 1976-1981.

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LNS	0	2	0	3	15	1
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# Trap Days	8	8	12	12	21	16
CPUE* GR	50	148	136	96	26	78
RWF	49	67	83	50	12	7

* Catch per day.

The composition, length range, and mean length of all species captured Mile One Slough in 1981 is shown in Table 4. As in 1980, the majority the fish were juveniles and their length ranges and means are similar both years.

As pointed out in 1980 (Ridder, 1981), the length composition of grayling and round whitefish caught at Mile One Slough had chan dramatically from the percentages found during the first 3 years monitoring. It was postulated that the formation of a silt island in Delta Clearwater River adjacent to the mouth of Mile One Slough during monitoring in 1979 and 1980 may have accounted for the change in len compositions. In 1981, the island was nonexistent, yet the compositio for grayling and whitefish were similar to those found in 1979 and 198 Grayling greater than 200 mm (Age Class III and older) comprised from 40 53% of the total catch of the species during the years 1976-1978. In 19 and 1980, their composition fell to 12% and in 1981, to 6%. Rou whitefish of the same size range averaged between 90-98% of their tot catch during these same years and 45% for 1979 and 1980 and 38% in 1981.

In 1981, the composition of grayling in the combined catch of grayling a round whitefish was 92%. During the 5 previous years of monitoring, 19 through 1980, the grayling composition was quite similar and ranged fr 62% in 1978 to 69% in 1980. From observations of large numbers of rou whitefish in the river below Mile One Slough during spring monitoring a from the species composition in the July indexing sample (described late in this report), this composition change is thought to be dependent more o behavioral factors than on numbers of whitefish migrating into the system.

The age frequencies of grayling captured at Mile One Slough in 1981 show marked change in the compositions of Age Classes I and II from the previou 2 years of monitoring and indicate a poor initial recruitment to the syste of the 1980 year class. In 1979, Age Class I was found to comprise 50% o the grayling caught, while Age Class II comprised 33%. Both age classe represented not only recruitment of "wild" grayling but also included grayling from the last two fingerling plants of the enhancement program. In 1980, Age Classes I and II represented 37% and 34%, respectively, of the sample of 156 grayling, with Age Class I representing only "wild" fish. In 1981, Age Class I represented only 7% of a sample of 120 and Age Class II, 76%. The age frequency and length of the 1981 sample is shown in Table 5, and a comparison of age frequencies for the 3 years, 1979 to 1981, is shown in Table 6.

To validate the representativeness of the age composition sample in Table 6 and to put into perspective the low recruitment of the 1980 year-class in 1981, frequencies of length ranges that approximate specific age classes of grayling in the spring of the year were computed for each of 4 years of spring monitoring in which all captured grayling were measured. These frequencies are shown in Table 7 and are felt to be accurate for Age Classes I and II, but progressively less so for successive age classes due to length range overlap. For 1981 monitoring, the length derived age frequencies are very similar to those frequencies found from scale analysis. The dissimilarities seen in a comparison of Tables 6 and 7 for 1979 and Age Classes I and II and, to a lesser extent for the 1980 data, are derived from the contributions to these age classes of the pond-reared

Table 4. Composition and length ranges of fish species captured at Mile One Slough, April 17-May 1, 1981.

Species	Number	Percent	Length (mm) Range	Mean
GR	1,250	29	77-267*	148
RWF	111	3	70-391	187
HWF	11	(<1)	221-398	296
LCI	26	1	133-308	229
SS	2,808	66	69-103**	79
BB	35	1	163-340	224
NP	2	(<1)	246-272	259
LNS	1	(<1)		110
SSC	8	(<1)	62-103	83
	4,252			

* n=120

** n=20

Table 5. Age frequency and length of Arctic grayling captured at Mile One Slough, Delta Clearwater River, April, 1981.

Age Class	Number	%	Length (mm) Range	Mean
I	8	7	77-106	92
II	92	76	114-173	141
III	17	14	166-220	194
IV	2	2	230-267	249
V	1	1	228	228
	120		77-267	148

Table 6. Age frequency of Arctic grayling captured at Mile One Slough, April, 1979 through 1981.

Age Class	Per Cent 1979*	1980*	1981
I	50	37	7
II	33	34	76
III	10	19	14
IV	5	8	2
V	2	2	1
VI	<1		
Sample Size	1156	156	120

* Weighted age frequencies, see Ridder, 1980, 1981.

Table 7. Length frequencies related to Age Classes of Arctic grayling captured in Mile One Slough, Delta Clearwater River, 1978 to 1981.

Length Range (mm)	Related Age Class	Percent			
		1978	1979	1980	1981
70-109	I	11	36	35	9
110-169	II	23	41	41	77
170-229	III	36	16	18	12
230-269	IV	21	5	5	2
270-309	V	8	2	1	(<1)
≥310	VI	1	(<1)		
Sample Size N		1,632	1,156	545	1,250

grayling from the enhancement program. These fish, when planted into the river as Age 0 fingerlings, averaged 10-20 mm greater in length than their "wild" cohorts. The Age Class I compositions in Table 7 would exclude them in the 1979 and 1978 data (the 1977 and 1978 year-classes represented the last fingerling plants of the program) and would accurately describe the recruitment of "wild", stream-reared fish to Age Class I, as found in spring monitoring.

As seen in Table 7, the low recruitment of Age Class I found in 1981 is not an unprecedented occurrence. There was a similar low recruitment to this age class by the 1977 year-class in 1978. As will be described later, index sampling in 1981 gave a composition of 14% for Age Class IV, the 1977 year-class (Table 9). At face value, this composition is not remarkably lower than the average composition of this age class found during 6 previous years of indexing, 17%. Yet if the enhancement program's contribution of 32% to this year class in 1981 (Table 23) is considered, a similar poor recruitment of this year-class to Age Classes IV would be indicated. Here there appears a correlation between year-class recruitment, as defined by spring monitoring, and recruitment, as defined by index sampling. Expansion of the data base through future monitoring should clarify and define this correlation.

Delta Clearwater River

Index sampling:

Index sampling for Arctic grayling and round whitefish was conducted in the Delta Clearwater River from Mile 17 to the mouth of the Delta Clearwater River on July 7 and 8, 1981 and utilized the same electrofishing gear and three crew members as during the years 1977 through 1980. Weather conditions were not optimum, as rain, at times heavy, occurred during both sampling days. The total catch of grayling (85) was 45% below the record catch in 1980 (182). The difference in catch between the 2 years is the largest recorded to date. The capture rates for each of the three sections of river sampled (described by Ridder, 1980) are presented in Table 8, along with comparative data from 7 previous years of indexing.

The changes in capture rate that effected the low index rate in 1981 occurred in both the upper and lower sections of the river. The upper section, Mile 14 to 17, has given the widest range in capture rates during the 8 years of indexing; from a low of nine grayling in 1978 to a high of 98 in 1980. Yet this section offers the best physical conditions for electrofishing and the rates are considered a reliable index of numbers of fish present. Here, weather conditions would have the least effect. The 1981 capture of 40 grayling compares to the mean rate of 54 for the 7 years between 1973 and 1980 (Table 8).

The lower section, Mile 0 to 7, has produced a constant decline in grayling captures over the last 2 years, from a high of 59 in 1979 to 18 in 1981. This section is populated by immature grayling, Ages 0-IV (Pearse, 1974; Ridder, 1980). The increase in captures found from 1977 to 1979, 27 to 59, was felt attributable to the grayling enhancement program begun in 1975. The program's pond-reared fish, Ages I-IV, contributed 52% to the capture rate of this section in 1979 (Ridder, 1980). In 1981, they represented 16% of the catch.

ble 8. Capture rates per section for Arctic grayling and round whitefish during index sampling, Delta Clearwater River, 1973-1981.

cies	Date	Mile Sections 0-7	8-13	14-17	Total Captured	Percent Composition
GR	6/27/73	9	20	66	95	15.7
	7/02/75	13	8	43	64	14.0
	6/30/76	17	27	41	85	17.3
	7/06/77	27	25	49	101	22.2
	7/10/78	50	28	9	87	16.7
	7/17/79	59	24	74	157	23.3
	7/15/80	39	45	98	182	38.5
	7/07/81	18	27	40	85	19.5
RWF	6/27/73	189	159	163	511	84.3
	7/02/75	37	117	239	393	86.0
	6/30/76	116	163	128	407	82.7
	7/06/77	96	107	151	354	77.8
	7/10/78	142	237	54	433	83.3
	7/17/79	150	174	194	518	76.7
	7/15/80	82	118	91	291	61.5
	7/07/81	47	168	135	350	80.5

Although the lack of enhancement fish doubtlessly affected the lower river's capture rate, the weather conditions and especially the unseasonably low water levels in the lower 3 miles of the river are felt to have had a larger effect. As the glacial Tanana River (See Fig. 1) reaches its summer flows, it acts as a dam to the Delta Clearwater River and causes the lower 3 miles to rise 2-3 feet above spring levels. The Tanana River also affects Mile One Slough, turning it glacial, which in turn silts up the lower mile of the Delta Clearwater. The net effect is a decrease in suitable habitat for grayling, which forces the fish present into other areas, presumably further up the Delta Clearwater River and into Clearwater Lake outlet. Without this seasonal decrease in habitat, grayling during the 1981 index sampling were dispersed throughout the lower river where greater width and depth preclude effective electrofishing. On July 30, 1981, well after conditions returned to normal in the lower river, an electrofishing run was conducted from Mile 8 to Mile 3. Twenty-two grayling (mean length, 260 mm) and 47 round whitefish were captured during this second "indexing" of the 5-mile section as opposed to the eight grayling (mean length, 257 mm) and 52 whitefish captured during the first run on July 8. The increase is not considered due to in-migration from other systems. Tag recaptures appear to verify that water conditions or levels in the lower Delta Clearwater River affect fish presence in the upper river. Recaptures of grayling tagged in Mile One Slough in April have been routinely made in the upper river during the season, as well as in Clearwater Lake outlet (see Table 31). Of 15 recaptures of 1979-tagged grayling made the same year, seven or 47% were made upriver in May and June. (Ridder, unpublished data). Also in 1980, when seven 1980 tags were returned, five or 71% came from upriver in May and June (Ridder, unpublished data). In 1981, of the nine tag returns from the spring's tagging effort, only one came in during May and June and that from Clearwater Lake Outlet. Five, 56% of the 1981 tags, were recovered between July 12 and July 26 upriver. During a creel census run on July 12, Mile One Slough was first noticed to be high and running silt. During indexing in July 8, 1981, it was low and only slightly turbid. Normally, silt and high water in Mile One Slough occur around the first of May (Peckham and Ridder, 1979; Ridder, 1980).

The total capture of round whitefish during the 1981 index sampling was 350, 80.5% of the combined catch of both grayling and whitefish. The mean composition of whitefish in the catch is 78.9% for the 7 years, 1973 and 1975 through 1980.

The age frequency and length of 80 Arctic grayling captured during the 1981 index run are presented in Table 9 and a comparison of age composition from 7 years of indexing, 1975-1981, is shown in Table 10. Compositions of older age classes continued to increase in 1981 over the lows found in 1978. Three year-classes, 1974, 1975 and 1976 have shown exceptionally strong recruitment to the system in the 4 years since 1978. In 1978 and representing Age Classes II-IV, they comprised 60% of the seven age classes in the sample. In 1979 they comprised 57% of the sample consisting of nine age-classes and in 1980, 78% of eight classes. In 1981, with the 1976 year-class predominant, the three year-classes accounted for 60% of the entire sample. Either through coincidence or by effectuation, these year classes correspond with the largest grayling plants of the enhancement

Table 9. Age frequency and length of Arctic grayling captured in the Delta Clearwater River, July 7, 8, 1981.

Age Class	Number	Percent	Length (mm) Range	mean
I	0	...	...	...
II	4	5	153-190	175
III	9	11	190-253	219
IV	11	14	242-288	267
V	19	24	260-335	289
VI	14	17	311-369	329
VII	15	19	307-378	347
VIII	5	6	346-382	365
IV	3	4	355-415	384
	80		153-415	299

Table 10. Percent age composition of Arctic grayling electrofished in the Delta Clearwater River, 1975-1981.

Age Class	1975	1976	1977	1978	1979	1980	1981
I	0	0	0	2	2	0	0
II	0	1	6	16	9	6	5
III	0	6	15	20	15	10	11
IV	11	13	20	24	10	26	14
V	33	28	13	18	32	27	24
VI	33	42	27	6	12	25	17
VII	14	9	16	14	11	3	19
VIII	5	1	1	0	8	1	6
IX	4	0	1	0	1	2	4
X	0	0	1	0	0	0	0
	n=63	n=76	n=98	n=80	n=152	n=166	n=80
mean length (mm)	...	...	277	252	285	294	299

program. In 1974, 300,000 fry were planted in the system. In 1975, 100,000 fry and 9,100 fingerlings were stocked and, in 1976, 12,467 fingerlings. While the contribution of the fingerling plants can be found (described later in this report), these strong year-classes offer the only evidence of the possible success of the fry plants. The 1974 year-class, and the largest fry plant was predominant in two index samples, 1978 and 1979, and nearly in a third in 1980. Similarly, but adding skepticism to the fry plants' influence, these year-classes were showing strong recruitment to index samples in the Richardson Clearwater River, 35 miles downstream of the Delta Clearwater River.

Richardson Clearwater River

The Richardson Clearwater River was sampled with an electrofishing boat on July 9, 1981 under favorable conditions. Crew members and gear were identical to previous sampling years except 1973. A total of 167 Arctic grayling and 44 round whitefish were captured in 1981, which is nearly identical to the 170 grayling and 33 whitefish sampled in 1980. In the upper section of the river (Mile 7 to 8.3) 109 grayling were caught, while in 1980, 97 grayling were captured. The capture of 58 grayling in the lower section, Mile 7 to the mouth, is lower than the 73 grayling sampled in 1980 and the 63 grayling in 1979. Round whitefish captures were slightly above the 33 sampled in 1980 but far less than the 105 caught in 1979. A summary of 6 years of capture rates for both species in the Richardson Clearwater is presented in Table 11.

The changes in the capture rates of Arctic grayling in the lower 7 miles of the Richardson Clearwater River over the past 3 years parallel those found during the same years in indexing the Delta Clearwater River, though they are not as extreme. Overall, the morphology of the Richardson is more favorable to electrofishing sampling than the Delta. This fact could easily diminish the variability in yearly capture rates due to environmental conditions given all other variables constant. The low water conditions found during the Delta's indexing were also present during the Richardson's indexing. The slough that the latter river flows into was unseasonally low and clear, allowing suitable habitat for grayling. The last run of the indexing was extended along a quarter mile section of the slough and 22 grayling were captured (they were not included in the 1981 index rate). This would help explain the decreased capture rate found in the lower river this year.

The age frequency and length of 158 grayling sampled during the 1981 Richardson Clearwater River's index sampling are presented in Table 12 and a comparison of age frequencies from 6 years of like sampling is shown in Table 13. In 1981, the grayling ranged from 190 to 405 mm, with a mean length of 307 mm. This mean represents a continued increase from the mean length recorded in 1978, 252 mm.

As was found in the Delta Clearwater River, three year-classes, 1974-1976, have comprised the majority of those sampled during the past 4 years. These year-classes made up 66% of the sample in 1978, 76% in 1979, 81% in 1980, and 86% in 1981. This gradual increase is a more logical, even progression than that found in the Delta Clearwater River.

Table 11. Captures of Arctic grayling and round whitefish electrofished in the Richardson Clearwater River, 1973 to 1981.

Date	No. grayling	No. Round whitefish	River Miles Sa
8/01/73	75	...	4
8/30/77	104	123	7
8/31/78	117	53	7
7/17/79	63	105	7
7/17/80	170 (73)*	33 (33)	8.3 (7)
7/09/81	167 (58)*	44 (44)	8.3 (7)

* Numbers in parentheses indicate captures in lower 7 mi.

Table 12. Age frequency and length of Arctic grayling captured in the Richardson Clearwater River, July 9, 1981.

Age Class	Number	Percent	Length (mm) Range	Mean
III	2	1	190-288	239
IV	13	8	236-299	265
V	59	37	241-354	281
VI	43	27	280-362	315
VII	34	22	278-377	341
VIII	4	3	335-405	375
IX	2	1	354-402	378
X	1	1		398
	158		190-405	307

Table 13. Percent age composition of Arctic grayling electrofished in the Richardson Clearwater River 1977 through 1981.

Age Class	Aug. 1973*	Aug. 1977	Aug. 1978	July 1979	July 1980	July 1981
I	4	0	1	0	0	0
II	0	2	3	2	3	0
III	17	15	17	11	2	1
IV	29	10	46	26	16	8
V	35	21	15	39	32	37
VI	11	33	11	11	33	27
VII	3	15	7	6	11	22
VIII	0	4	0	5	3	3
IX	0	0	0	0	0	1
X	1	0	0	0	0	1
	n=75	n=100	n=74	n=62	n=152	n=158
Mean length (mm)	...	291	252	280	301	307

* In 1977-1979 the lower 7 mi were sampled and in 1980-1981 the lower 8.3 mi.

It follows the fact that grayling position themselves further up river as they age, locations where electrofishing is more efficient in sampling them (Pearse, 1974; Tack, 1980; Ridder, 1980, 1981).

While in 1981 the 1976 year-class was predominant in the sample as in the Delta's sample, the 1974 year-class was predominant in the 3 previous years, 1978-1980. In 1981, it gave the highest composition of Age Class VII found in any previous samples of the Richardson. As in the Delta Clearwater, this year-class precipitated the decline in mean length found in 1978, and then the gradual increase of the mean length during succeeding years, and the trend toward greater numbers of older fish in the two systems.

Clear Creek

Clear Creek, a small spring-fed system lying on the south side of the Tanana River, was sampled for the third consecutive year with hook and line and seine on July 17, 1981. It flows from its source near Big Delta (9 mi northwest of Delta Junction) 7 miles into a side slough of the Tanana River approximately 4 miles above Shaw Creek (Fig. 1). Unlike the larger spring-fed systems, fish species present in Clear Creek appear to be restricted to grayling for the majority of the season. Both round whitefish and grayling were observed in August 1979 (Ridder, 1980) in the creek's lower half mile, but July sampling in 1980 and 1981 observed only grayling between the mouth and Mile 4 of the creek. Juvenile coho salmon, abundant in the larger systems, have not been observed in Clear Creek.

The age frequency and length of 43 of the 46 Arctic grayling captured in Clear Creek in 1981 are presented in Table 14 and a comparison of age frequencies for the three years 1979-1981 is shown in Table 15. As in the larger spring-fed systems, the 1976 year-class, Age Class V in 1981, was predominant in 1981 with 51% of the sample. Unlike the larger systems, this year-class was also predominant in the creek as Age Class IV in 1980 and as Age Class III in 1979. This strength in successive age-classes has increased the mean length of the creek's sample from 250 mm in 1979 to 270 mm in 1981. The strong recruitment of the 1974 and 1975 year-classes noted in the larger systems over the past 3 years (Table 10 and 13) is not reflected in Clear Creek's sampling and may be due to the overriding strength of the 1976 year-class. Clear Creek's small size and physical similarities to the larger spring-fed systems make it an ideal candidate for the complete manipulation and sampling of fish populations necessary to accurately define the recruitment strategy grayling and other species use in such systems. The question is whether fish, specifically grayling, utilize it in the same manner and degree as they do the larger systems. A comparison of mean age frequencies for the years 1979-1981 among the three spring systems in this report is shown in Table 16. Clear Creek's age frequencies are derived from hook and line sampling and are biased toward younger grayling of Age Class V and less. The larger system's age frequencies, derived from electrofishing sampling, are predominantly of fish Age Class V and greater. The biases of the electrofishing gear lie towards the larger fish in these systems. The gear's sampling efficiencies

Table 14. Age frequency and length of Arctic grayling captured by seine, hook and line in Clear Creek, July 17, 1981.

Age Class	Number	Percent	Length (mm) Range	Mean
I	1	2	105	105
II	1	2	189	189
III	5	11	187-292	226
IV	10	23	235-305	262
V	22	51	252-324	283
VI	2	5	318-329	324
VII	2	5	332-339	336
	43		105-339	270

Table 15. Percent age composition of Arctic grayling captured in Clear Creek, 1979-1981.

Age Class	8/29/79	7/7/80	7/17/81
I	0	0	2
II	5	4	2
III	43	17	11
IV	26	58	23
V	23	19	51
VI	3	2	5
VII	0	0	5
	n=39	n=52	n=43
Mean Length (mm)	250	256	270

Table 16. Mean age frequencies of Arctic grayling for 3 years, 1979-1981 from three spring-fed systems of Interior Alaska.

Age Class	Delta Clearwater River		Richardson Clearwater River	Clear Creek
	Index %	Creel %	Index %	Index (H & L*) %
I	0.7	0	0	0.7
II	6.6	2.7	1.6	3.7
III	12.0	16.7	4.7	23.7
IV	16.7	29.3	16.7	35.7
V	27.7	33.3	36.0	31.0
VI	18.0	11.7	23.7	3.3
VII	11.0	5.0	13.0	1.7
VIII	5.0	1.0	3.7	...
IX	2.3	0.3	0.3	...
X	...	...	0.3	...
n =	398	525	372	134

* H & L = hook and line.

are greatest in the upper sections of these rivers, where the larger grayling are concentrated, and can easily account for the age frequency compositions and discrepancies shown in Table 16. The creel sample from the Delta Clearwater River, also hook and line sampling and biased in it's own right (Ridder, 1980, 1981), is seen to fall between the large and small systems' frequencies. Given the above sampling biases, plus the weighted influence of the 1976 year-class in all of Clear Creek's samples, the age structure of Clear Creek's population may be more indicative of a spring-fed system's grayling population than previously thought (Ridder, 1981).

Angler Harvest

Delta Clearwater River:

Creel census was conducted on the Delta Clearwater River from May 16 to August 31, 1981 using a stratified random sampling schedule and technique nearly identical to the 1980 censusing. A total of 163 anglers was contacted, of which 56 represented completed trips. Boat anglers represented 62% of the completed trips, which is similar to percentages found in previous years: 61% in 1980, 58% in 1979, and 59% in 1978. They had a catch rate of 0.70 grayling per hour, representing grayling kept, the same as in 1980. In 1979 and 1978, boat anglers experienced a catch rate of 0.68 and 0.51 grayling per hour respectively. Shore anglers comprised the remainder of the completed trips (38%) and had a catch rate of grayling creeled of 0.85 grayling per hour. This rate compares to the 0.59 grayling per hour recorded in 1980 and the 0.30 and 0.34 rates found in 1979 and 1978, respectively. The combined catch rate of 0.79 for completed trips represents the third consecutive increase since the 0.54 rate for completed trips in 1978. A 0.70 rate for combined trips was found in 1980. A summary of the creel census by month is shown in Table 17 which includes both completed and incomplete trips.

The catch rate for completed trips in 1981 is the highest recorded in 13 years of censusing the Delta Clearwater River. The rate represents only those grayling kept. Including released fish, the rate in 1981 increases to 1.0 grayling per hour. As will be discussed later in this report, the grayling enhancement program's four year-classes contributed 23% to anglers creels in 1981. Subtracting this percentage from the year's censused catch would give a catch rate of 0.58 grayling per hour, which compares to the mean catch rate of 0.55 for 4 years from 1973 to 1978 and to the rate of 0.47 for the years 1953 to 1978. A comparison of 13 years of censused catch data from 1953 to 1981 is shown in Table 18.
The estimates of 3,143 man-days (7,543 angler hours) and 4,073 grayling harvested in 1981 represent the third consecutive year of a decline from the 1978 estimates of 6,206 man-days and 7,638 grayling harvested. The 61% decrease in censusing effort from the fairly intensive censusing in 1978 and 1979 (23% of the 108 day season was sampled in 1981), in addition to a change in sampling technique (directed towards angler contacts rather than split between contacts and pressure counts as in the former years), would seem to prejudice the estimate's validity. The same situation held in 1980 (Ridder, 1981), yet results of the 1980 statewide harvest survey (Mills, 1981) closely agree with the 1980 estimates as previous surveys had with the harvest and pressure estimates of the years 1977-1979. Also, the

Table 17. Creel census summary, boat and shore anglers combined, Delta Clearwater River, May 9 through Sept. 1, 1981.

Month	Anglers Contacted	Angler Hours	Grayling Caught	Fish Per Angler	Hours Per Angler	Fish Per Angler Hour
May	40	82.25	41	1.0	2.1	0.48
June	14	15.25	16	1.1	1.1	1.00
July	70	136.0	119	1.7	1.9	0.89
August	39	61.5	41	1.1	1.6	0.69
Totals	163(56)	295(136)	217(104)	1.3(1.9)	1.8(2.4)	0.72(0.7

* Numbers in parentheses are for completed trips only.

Table 18. Comparison of censused grayling catch from the Delta Clearwater River, 1953-1981.

Year	Anglers Contacted	Angler Hours	Catch	GR/Hour
1953	300	1,057	307	0.29
1954	48	113	52	0.46
1955*	52	172	126	0.73
1956*	172	680	211	0.31
1957*	102	514	211	0.41
1958*	115	835	259	0.31
1973	315	664	436	0.65
1976	58	124	52	0.42
1977	307	596	333	0.56
1978	453 (274)**	1,049 (723)	592 (385)	0.56 (0.54)
1979	390 (191)	840 (469)	504 (286)	0.59 (0.60)
1980	189 (59)	301 (136)	222 (92)	0.75 (0.70)
1981	163 (56)	295 (136)	217 (104)	0.72 (0.79)

* 12-inch size limit in effect from 1955-1958.
** Numbers in parentheses are for completed trips only.

increase in catch rates over the last 3 years (Table 18) can be, in the simplest sense, the result of these years' decreasing pressures and harvests. In addition, other factors, such as unseasonally poor weather and the similarity of the censused catches of 1981 and 1980 (Table 18), are felt to override the presumed statistical deficiencies in the 1981 estimates and substantiate the trend of lowered harvest and pressure in 1981. A comparison of man-days and grayling harvest for the Delta Clearwater River for 1977-1981, derived from creel census programs and from results of the statewide harvest surveys, is shown in Table 19.

The enhancement program which has stocked grayling into the river from 1974 to 1979, obscures any effects angling pressure has had on the "wild" grayling population. Listed here are harvests and catch rates from 1977 through 1981 adjusted to eliminate the benefits of the enhancement program (discussed later in this report):

Date	Harvest	Catch Rate (GR/Hr)
1977	6,205	0.54
1978	7,218	0.51
1979	5,492	0.46
1980	4,314	0.51
1981	3,328	0.58

Instead of the steady increase in catch rates from 0.56 in 1977 to 0.79 in 1981 (Table 18) corresponding to harvests that climb and then fall (Table 19), we see the adjusted catch rates fall and rise inversely behind the harvests in an apparent cause and effect relationship. The age frequencies and lengths of 153 grayling harvested by anglers in 1981 are presented in Table 20. Age Class V, the 1976 year class, was predominant among the eight year-classes present with 31%, followed closely by Age Class IV with 28%. The 1976 year-class was also predominant in the 1980 creel sample with 41%. In comparison, the Delta Clearwater River's 1981 index sample also had the 1976 year-class predominant (24%) but was followed by Age Class VII, the 1974 year-class, with 19%.

The young age classes, I-IV, of immature grayling made up a larger percentage of the sample for the second consecutive year (49% in 1981, 59% in 1980) than for the three previous years, 1977-1979 in which each showed 38%. Index sampling gave percentages of these same age classes of 29% in 1981, 42% in 1980, and 36% in 1979. The older age classes, VI-IX, showed a slight increase in their combined percentages in 1981, 20%, over the 17% found in both 1980 and 1979. The mean frequency for these age classes in the index sample is 38.3% for the same 3 years. A comparison of mean age frequencies for the years 1979-1981 between the index and creel samples is shown in Table 16 and comparison of age frequencies from 5 years of creel samples is shown in Table 21.

A comparison of 7 years of creel samples is shown in length frequencies in Table 22. The predominant length ranges of 265-314 mm found in 1981 is unchanged from the previous 6 years. The large increase in the 215-264 mm range first noted in 1979 continued in 1981. This range averaged 16% for the years 1973-1978 and 36% for the last 3 years, 1979-1981. The enhancement program, discussed later in this report, is felt to be partly

Table 19. Comparison of statewide postal harvest survey * and Delta Clearwater River creel census estimate 1977-1981.

Year	Harvest Survey		Creel Census	
	Man-days	Harvest	Man-days	Harvest
1977	6,881	6,118	5,923	6,397
1978	7,210	7,657	6,206	7,638
1979	8,398	6,492	5,379	6,968
1980	4,240	5,680	3,586	5,878
1981	NA	NA	3,143	4,073

* From Mills, 1979, 1980, 1981a and 1981b.

Table 20. Age frequency and length of sport harvested Arctic grayl
Delta Clearwater River, May 15 - Sept. 1, 1981.

Age Class	Number	Percent	Length (mm) Range	Mean
II	2	1	188-218	203
III	31	20	202-277	234
IV	43	28	226-309	268
V	48	31	246-355	285
VI	18	12	285-414	341
VII	9	6	304-392	352
VIII	1	1	398	398
IX	1	1	420	420
	153		188-420	281

Table 21. Percent age composition and mean length of Arctic grayling caught by anglers, Delta Clearwater River, 1977-1981.

Age Class	Percent					Mean Frequency
	1977	1978*	1979	1980	1981	
I	0	0	0	0	0	0
II	3	2	2	5	1	2.6
III	11	8	17	13	20	13.8
IV	24	28	19	41	28	28.0
V	33	19	45	24	31	30.4
VI	19	14	11	12	12	13.6
VII	9	22	6	3	6	9.2
VIII	1	7	(<1)	2	1	2.2
IX	0	0	0	0	1	0.2
n =	139	97	225	147	153	761
Mean Length (mm)	284	299	273	277	281	283

* Possibly biased towards larger fish (Peckham and Ridder, 1979).

Table 22. Percent length frequency of sport harvested Arctic grayling, Delta Clearwater River, 1973-1981.

Length Class (mm)	1973	1976	1977	1978	1979	1980	1981	Mean
115-164	0	0	0	0	0	0	0	0
165-214	3	0	10	3	3	3	2	3.4
215-264	19	9	19	18	36	34	37	24.5
265-314	39	52	46	37	46	47	40	43.8
315-364	24	36	21	29	14	14	14	21.7
365-414	13	3	4	11	1	2	6	5.7
415-464	2	0	0	3	0	0	1	0.9
Mean Length (mm)	304	305	284	299	273	277	281	289
Mean Length (in)	11.9	12	11.2	11.7	10.7	10.9	11.1	11.4
Number in sample	120	33	142	202	227	147	164	

responsible; in 1978 it contributed 6% to anglers' creels, in 1979 and 1981 its contribution was 23% and in 1980, 31%. The larger length ranges, 315-464 mm, which first showed a large decline in 1979 when they represented 15% of the sample showed a small increase in 1981 to 21%. The mean frequency for this range was 36.5 for the years 1973-1978.

Richardson Clearwater River

A voluntary creel census program was conducted on the Richardson Clearwater River for the second consecutive year in 1981, not only for catch statistics but mainly as an aid in monitoring recaptures of grayling tagged in the Shaw Creek drainage. As in 1980, a letter explaining the program and 1980 results, a tally sheet, and a stamped return envelope were distributed to 17 summer residences by May 31, 1981. Six returns were received by late December, representing a 35.3% response. In 1980, a 44.4% total response was realized but in terms of usable catch information, response was only 33.3%.

The six respondents represented 50 angling trips, 8.33 trips per household, and 122 man-days of effort that translated into 282 angler hours. In 1980, there were 7.83 trips per household. Total grayling caught were 873, of which 531 were kept. The catch rate of 1.91 grayling per hour (3.13 grayling per hour including released fish) compares to the 1.47 rate for creeled fish found in 1980. Expanding these data in a simple ratio to include non-respondents would give a minimum estimate of 1,522 grayling harvested and 346 man-days of effort. The estimate in 1980 gave a harvest of 995 grayling with 334 man-days of effort.

A total of 47 tags was returned by the respondents, or 8.9% of fish reported harvested. In 1980, tags represented 6.7% of the reported harvest.

Shaw Creek

A creel census was conducted on Shaw Creek from April 5 to April 22, 1981. This bog-fed creek is an apparently major spawning area for grayling utilizing the Richardson Clearwater River. Caribou Creek, the largest tributary to Shaw Creek, is also the focus of post-spawning migrations investigations mentioned later, in this report and censusing provides accurate monitoring of grayling tagged there in 1980.

This early fishery focused on predominantly prespawning grayling that concentrate at the mouth of the creek prior its breakup. This was a traditional spring activity primarily for residents of the Delta Jct. area until highway construction in 1976 rerouted the mouth of the creek. With the traditional holding areas destroyed, the fishery was disrupted until 1981 when the late breakup of Shaw Creek and changing river channels again allowed grayling to concentrate in numbers off the mouth of Shaw Creek and, after 5 years, the fishery unexpectedly resumed. Census data from the spring fishery in 1974 and 1975 are reported on by Peckham (1976). Estimated harvests for both years were less than 1,300 grayling.

Censusing in 1981 was conducted randomly as time from other on-going projects (spring-monitoring) permitted. A day was divided into 12 hourly

periods and pressure counts were taken at the start of each period, with angler interviews and catch sampling taken between counts. Seventeen days of the 19 day fishery were sampled, in which 29% of the total periods were censused. A total of 204 anglers was interviewed. They spent 355 hours to catch 948 grayling of which 600 were harvested. Eighty-three anglers contacted had completed their trips. They spent 174 hours (2.1 hours per angler) to catch 523 grayling of which 374 (4.5 fish per angler) were kept, for a harvest rate of 2.14 grayling per hour. Total catch rate was 3.0 grayling per hour.

An estimate of pressure was made by averaging the number of anglers found per period (8.9), then multiplying by total periods (228) and amounted to 2,029 angler hours or 966 man-days of effort. Multiplying the effort by the catch statistics from completed trips gives a total catch of 6,087 grayling of which 4,343 were harvested.

Censusing yielded a catch sample of 271 grayling. Their lengths ranged from 184 to 379 mm with a mean of 292 mm. Forty-one percent of the sample had lengths greater than 300 mm (11.8 inches), which relates to Age Classes VI and older. Eighty-six percent were over 260 mm (10.2") in length, which includes most of Age Class V and thus represents predominantly mature fish. Two hundred and nineteen grayling (81% of the sample) were sexed either by autopsies, ripeness or secondary characteristics. The male to female ratio was 0.9 to 1.0.

Tag returns generated by the fishery totaled 100, of which 83 were from 1980 tagging in Caribou Creek (See Table 30). Twenty-eight of the total recaptures were received during creel censusing or 4.7% of the censused catch of 600 grayling. Of these, 24 tags, 4%, were from grayling tagged in Caribou Creek in 1980. Also one recapture was of a fish tagged as a 3-year-old in Delta Clearwater River in April, 1978. One recaptured grayling was tagged in the Tanana River 12 mi above Shaw Creek in April, 1980, also a 3-year-old.

During the censusing of the spring fishery at Shaw Creek, some grayling that were being caught were freely running eggs and milt. During this time, grayling were congregated not only below but to a distance of 1/2 mi above the mouth. Since Shaw Creek did not begin flowing till May 1, some of these grayling may have spawned in the Tanana River and never ascended the creek. Catches of 1980 tagged grayling were reported in the Richardson Clearwater River on May 16.

Grayling Stock Enhancement

Assessment:

The grayling enhancement program was begun in 1974 and has provided 400,000 fry, 34,438 fingerlings (Age 0), and 1,022 catchable (Age I) for stocking into the Delta Clearwater River system. Stocking techniques, locations, numbers and evaluations can be found in Pearse (1976), Peckham (1978), Peckham and Ridder (1979) and Ridder (1980; 1981). Due to the unavailability of fry or fingerlings, no plants have been made since 1979. Barring unforseen mortalities, the program should resume in 1982 with the stocking of Age I catchables.

To assess the contribution of the enhancement program to the 1981 population of Arctic grayling in the Delta Clearwater River, 233 scale samples were collected from index sampling in July, and from angler creels throughout the season. The assessment is limited to the plants of pond-reared fingerlings which represent four year-classes, 1975 through 1978 (Age Classes III through VI in 1981). These plants are easily defined by their circuli counts to and including the first annulus, which are typically greater than those of stream-reared fish (Pearse, 1976; Peckham, 1977). The contribution of the fry plants of 1974 (300,000) and 1975 (100,000) is not as easily defined since the circuli distinction is lacking. A summary of the numbers and percentages of pond-reared grayling from the enhancement program derived from the two samples is presented in Table 23.

In 1981, for the second year, all four year-classes of enhancement grayling (Age Classes III-VI) were available to the sport fishery of the Delta Clearwater River. In 1981, grayling of Age Classes III through VI made up 91% of the eight age classes found in the creel sample and 66% of the eight classes found in the index sample. Pond reared grayling of the program made up 23% of the total creel sample and 26% of the total index sample or 24% of the total combined samples. This is a decrease from the percentages of the total combined catch found in 1980 of 30% and can possibly be attributed to the increased recruitment of "wild" fish into the grayling population at Age Classes III and IV. (Pearse, 1976; Ridder, 1980). In 1979, pond-reared fish made up 23% of the combined creel and index samples.

Table 24 presents a summary of the contributions of four year-classes of pond-reared grayling to successive age classes captured in the Delta Clearwater River since 1976 and of the numbers of each year-class stocked. It also supports the theory of additional recruitment to the system by older age classes. The average composition of the pond-reared fish in the first three age classes is greater than that of the older age classes, 48% versus 27%, respectively.

A summary of the estimated harvest of pond-reared grayling for the year 1977 to 1981 is shown in Table 25. The estimates are based on the creel census programs and age compositions found in Tables 19 and 20. The compositions used for the contribution of pond-reared grayling to each age class were adjusted downward by 5% from the values found in the reports cited in Table 25 to account for the overlap of circuli counts from stream-reared grayling noted by Peckham and Ridder (1979). An initial review of circuli counts from 180 grayling sampled in the Delta Clearwater River from 1976 to 1979 which did not belong to the four year classes represented by pond-reared grayling showed that 5% had circuli counts to the first annulus of 11 or more which is the criterion used to determine whether grayling were pond-reared. Since numbers of circuli are an envirnomentally-affected variable, this adjustment is considered tentative pending further investigations.

The estimated harvest of the four year-classes, 1975-1978, totaled 12,190 grayling for the 5 years from 1977 to 1981. This "sub" harvest comprised 39.4% of the total estimated 5 year harvest of 30,954 grayling. Pond-reared grayling of the four year-classes totaled 4,387 or 36.0% of the "sub" harvest and 14% of the total harvest.

Table 23. Mean length in mm and percent composition of Arctic grayling with circuli counts to and including first annulus of 11 or greater and 10 or less, Delta clearwater River, 1981.

Year Class	Age	No. Circuli	Sample: Index n	Index %	Index Mean Length	Creel n	Creel %	Creel Mean Length	Totals n	Totals %
1978	Age III	≤10	7	78	210	19	61	228	26	65
		≥11	2	22	248	12	39	245	14	35
		Total	9		219	31		234	40	
1977	Age IV	≤10	3	27	249	34	79	266	37	68
		≥11	8	73	274	9	21	276	17	32
		Total	11		267	43		268	54	
1976	Age V	≤10	13	68	284	37	77	281	50	75
		≥11	6	32	301	11	23	296	17	25
		Total	19		289	48		285	67	
1975	Age VI	≤10	9	64	328	15	83	332	24	75
		≥11	5	36	331	3	17	385	8	25
		Total	14		329	18		341	32	
	Ages I-IX	≥11	21	26%		35	23%		56	24%
		Total*	80			153			233	

* All totals and corresponding percentages include other age classes.

captured in Delta Clearwater River, 1976-1981.

Year Class	Number Stocked	Age I		Age II		Age III		Age IV		Age V		Age VI	
		N*	%	N	%	N	%	N	%	N	%	N	%
1975	9,100	10	60	70	31	42	52	116	29	80	21	32	25
1976	12,467**	46	76	59	46	170	41	112	39	67	25		
1977	6,684	307	53	397	28	65	60	54	32				
1978	7,209***	581	41	70	56	40	35		—		—		—
Average %			58		40		47		33		23		25

* Total sample size of each age class.
** 371 stocked at Age I in Sept. 1977.
*** 651 stocked at Age I in Sept. 1979.

Table 25. Summary of estimated harvest of pond and stream reared Arctic grayling of four year-classes, 1975-1978, Delta Clearwater River, 1977-1981.*

Year	Estimated Total Harvest	Year Class	Age Class	Creel Composition %	Estimated Age class Harvest	Composition of Pond-reared Grayling/% **	Estimated Harvest Pond-reared n	(%Total harvest)	Stream-reared
1977	6,397	1975	II	3	192	95			10
							182	(2.8)	
1978	7,638	1976	II	2	153	95	145		8
		1975	III	8	611	45	275		336
							420	(5.5)	
1979	6,968	1977	II	2	139	95	132		7
		1976	III	17	1185	71	841		344
		1975	IV	19	1324	38	503		821
							1,476	(21.2)	
1980	5,878	1978	II	5	294	38	112		182
		1977	III	13	764	58	443		321
		1976	IV	41	2410	36	868		1542
		1975	V	24	1411	10	141		1270
							1,564	(26.6)	
1981	4,073	1978	III	20	815	34	277		538
		1977	IV	28	1140	16	182		958
		1976	V	31	1263	18	227		1036
		1975	VI	12	489	12	59		430
							745	(18.3)	
	30,954 (100%)				12,190 (39.4%)		4,387	(14.2%)	7,803 (25.2%)
					100%		36.0%		64.0%

* Adjusted from Peckham, 1978; Peckham and Ridder, 1979; Ridder, 1980, 1981, see text.

** Compositions from creel samples only.

This harvest of pond-reared grayling represents a return of 12.2% of the 35,954 Age 0 grayling stocked to date in the Delta Clearwater River system. In 1979, 651 Age I grayling pond-reared for 2 summers in Big Lake were stocked in the Delta Clearwater River at Mile 8. They averaged 247 mm F.L. and all were tagged. In 1980, 26 Big Lake tags caught in the River were returned by anglers or 4% of those stocked the previous fall (Table 31). This rate compares to the average recapture of 3.6% from 4 years of recapture data (1978-1981) of grayling caught in the Delta Clearwater River which were tagged the previous spring at Mile One Slough (see Table 31). Past tagging studies (Schallock and Roguski, 1967) have shown the strong tendency of grayling to return yearly to the Delta Clearwater River from overwintering and spawning areas. Although the Delta Clearwater River rates were from fish that experienced an average of 5 more months of mortality factors than the Big Lake fish, the rates are comparable and indicate that the same homing tendency, or imprinting, occurred in the Big Lake transplants in 1980. Straying probably accounted for the absence of a higher recapture rate, assuring similar mortality rates for both pond and stream-reared fish.

A definite lower second year return of Big Lake fish was noted in 1981. Only four recaptures were recorded for Big Lake grayling in 1981. All were caught in the Delta Clearwater River, and returned by anglers. The fish averaged 307 mm and represented a 0.6% return of those stocked in 1979. In comparison, 3 years of recapture rates (1979-1981) of Delta Clearwater River grayling tagged 2 years previously at Mile One Slough gave an average rate of 2.1% (See Table 31). The average size of the grayling caught would indicate a mature stream-reared fish, thus a number of these Age III pond-reared fish may have sought suitable spawning streams and then elected to remain rather than migrate to the Delta Clearwater River. Of course, neither mortality factors nor additional straying can be ruled out as causative factors.

Post-Spawning Migration Investigations

Past studies of spring-fed streams, predominantly the Delta Clearwater River, dating back to 1952 have shown that little or no grayling spawning or overwintering occur in these systems. Mark-and-recapture experiments conducted within the systems have documented the consistent homing of adult grayling to the Delta and Richardson Clearwater Rivers and suggest similar homing to spawning streams. They also suggest that the utilization of these streams as summer feeding areas is a result of a seemingly complex pattern of migrations of juvenile and adult grayling between a number of streams and river systems. The individual importance of these systems to the spawning and recruitment levels of the grayling populations of the spring-fed streams and how this recruitment occurs is not well understood and yet is essential to their management. Toward this end, investigations of likely spawning streams were initiated in 1979 (Ridder 1980) and continued during this reporting period, centering on Caribou Creek and the Volkmar River (See Fig. 1 for locations in relation to spring-fed streams).

Tagging:

Caribou Creek, approximately 16 mi long, is the largest of nine named tributaries of Shaw Creek and located 6 mi upstream of its mouth. At the

trapping site, the creek is approximately 20 feet wide with an average depth of 18 inches and has a bottom consisting of 1 to 6 inches of mud and debris overlying a dense silt and clay base. The creek has an average flow of 17 cfs but is subject to rapid fluctuations. From May 21 to June 19, 1981 water levels ranged from 18 to 57 inches and flows from 17 to 42 cfs. Water levels rose 24 inches during 16 hours on June 6. During trapping in May and June of 1980, flows remained relatively stable, approximately 17 to 24 cfs.

Capture methods in 1981 utilized an experimental weir (See Fig. 2) instead of the fyke trap used in 1980. The weir consists of a 2 inch thick plank floor that extends 3 feet into each bank. Three wooden boxes filled with rock weight the floor at the ends and middle and provide structural support for the traps and screen assemblies. The upstream and downstream traps are of a simple V-throated design with plywood floor and screened with 3/8 inch hardware cloth. Double screen panels, each removable for cleaning, were used between traps and boxes. An inclined apron (framed screens covered with plastic sheeting) that extends 4 feet upstream of the floor and a sunken backboard protected the floor from being undermined. Structurally, the weir functioned perfectly with no undermining in water levels from 18 to 48 inches. With only daily checks, however, the downstream trap proved too small, especially in lower water levels, to handle the large numbers of fish caught. The overcrowding caused excessive mortality among fish less than 200 mm--18% in grayling <200 mm, 1.4% with grayling $\geq$ 200 mm.

Due to construction delays and high water, the weir was not functional until June 6, 1981. It was in continuous operation until June 19 when other projects and time constraints warranted its dismantling. During its 13 days of operation, 4,730 fish of nine species were captured, including 1,802 upstream migrants and 2,928 downstream migrants. Of these 2,122 were grayling comprising 367 upstream and 1,755 downstream migrants. A total of 1,323 grayling was tagged. In 1980 during 21 days of out-migrant trapping, 1,547 grayling were captured (1,291 were tagged) with 96% being captured in the last 11 days, June 2 to June 12. In both years when trapping terminated, there remained large numbers of grayling above the traps with an estimated 1,000 + in 1981. A summary of 1981 daily fish captures by species and by direction is presented in Table 26 along with daily recordings of water temperatures and levels.

Water temperature appears to be correlated with numbers of grayling out-migrating from the creek. On June 11, 1981, when the temperature of Caribou Creek first reached 11^{o}C, there was a marked change in grayling captured in both traps. Up-migrant catches dropped while down-migrant captures increased, both significantly. Captures of other species were not affected. A similar temperature and out-migrant catch correlation was seen in Caribou Creek in 1980.

In 1981 the total grayling catch in the upstream trap was 367. Lengths ranged from 73 to 317 mm with a mean of 175 mm. One hundred forty-seven grayling were greater than 200 mm and of these, 143 were tagged.

The upstream grayling catch was predominantly of immature fish. The age composition derived from a sample of 70 grayling is shown in Table 27 and showed Age Class III predominant at 50% of the sample. Only 27 grayling

Table 26. **Summary of fish species captured at Caribou Creek weir, upstream (US) and downstream (DS) traps, June 7 - June 19, 1981.**

Date	Water Temp. (°C)	Water Level (in.*)	GR		LNS		HWF		RWF		LC		LCI		Other	
			US	DS	US	DS	US	DS	US	DS	US	DS	US	DS	US	DS
6/7	8.0°	48	49	14	83	12	12	8	9	2	9		2			
6/8	8.5°	46	64	24	293	0	14	7	25	4	16	7				
6/9	9.0°	33	80	41	161	11	36	10	19	5	31		1			
6/10	10.0°	27	84	36	99	9	13	8	19	2	25	6	3	1		
6/11	11.0°	24	9	161	103	24	26	7	13	35	25	17	2			
6/12	12.5°	21	8	119	101	27	16	1	8	4	20	10	2			
6/13	13.5°	19	13	117	32	20	15	17	6	15	17	19	3	1	2 NP	
															1 SS	9 SS
															4 SSC	22 SSC**
6/14	13.5°	17	14	130	23	10	5	15	7	13	15	13	1	1		
6/15	14.5°	17	12	74	15	58	9	4	10	9	4	2	2	1		
6/16	15.5°	16	5	100	6	84	7	10	3	7	4	17	2			
6/17	15.0°	17	10	159	18	174	3	15	4	21	6	20	2	1		
(Seine)				(174)		(17)		(5)		(8)		(3)				
6/18	15.0°		19	90	16	38	4	1	1	1	1	8	1	1		
(Seine)				(143)				(2)		(12)						
6/19	14.0°			73												
(Seine)		US DS		(300)		(211)		(6)		(31)		(34)				
		1802 2928	367	1755	950	695	160	116	124	169	173	156	21	6	7	31
		4730	2122		1645		276		293		329		27		38	

* Measured from weir floor.

** n = 22, 6/15-6/18

Table 27. Age frequency and length of Arctic grayling captured in A, upstream trap, and B, downstream trap, Caribou Creek weir, June 7-19, 1981.

	Age Class	Number	Percent	Length (mm) Range	Length (mm) Mean
A.					
	I	9	13	80-105	91
	II	10	14	134-216	150
	III	35	50	175-240	203
	IV	8	11	217-258	231
	V	8	11	216-297	257
		70	99	80-297	191
B.					
	I	4	4	81-89	84
	II	0	0		
	III	2	2	172-216	194
	IV	9	9	233-263	251
	V	43	44	244-314	279
	VI	31	31	271-333	303
	VII	8	8	329-338	333
	VIII	2	2	312-344	328
		99	100	81-344	280

were considered mature and were sexed either by secondary sexual characteristics (swollen or normal vent in combination with dorsal fin size) or reproductive products. Thirteen females had lengths ranging from 237 to 317 mm with a mean of 268 mm. Fourteen males ranged from 255-297 mm with a mean of 274 mm. The 340 remaining fish had lengths ranging from 73-273 mm, with a mean of 169 mm.

Total grayling catch in the downstream trap was 1,755. Their lengths ranged from 70 to 400 mm with a mean of 223 mm. Of these, 1,254 were greater than 200 mm, had a mean length of 267 mm, and 1,180 of them were tagged. No ripe individuals were noted and autopsies on 25 grayling revealed 22 had spawned and three were immature. Eight hundred forty-seven grayling were sexed by secondary characteristics. Of these 425 were females from 191 to 373 mm in length with a mean of 276 mm and 422 were males from 214 to 400 mm with a mean of 291 mm. The male to female sex ratio was 0.99 to 1.0. The observed sex ratio found from sampling 291 grayling harvested in April 1981 at the mouth of Shaw Creek was 0.90 males to 1.0 female. In 1980 at Caribou Creek, the male to female ratio was 1.33 to 1.0. However it was based only on fish greater than 300 mm and, considering the above length data, was probably biased towards males.

The age composition of out-migrant grayling in 1981 based on scale samples from 99 fish is shown in Table 27. Age Class V, the 1976 year- class, was predominant with 44% followed by Age Class VI, the 1975 year class, with 31%. In 1980, the 1974 year-class, Age Class VI, was predominant, followed again by the 1975 year-class at Age Class V. The mean length of this sample was 280 mm, while in 1980 the aged sample had a mean of 305 mm.

In 1980, the lack of Age Class III in the out-migrant sample was noted and compared to a similar poor composition of this age class in the index sampling of the Richardson Clearwater River, from where the majority of tag returns of Caribou grayling came. A comparison of all age compositions in both samples showed them to be closely similar, including mean length. In 1981, such a comparison again shows similarities in all age compositions except Age Class VII, the 1974 year-class, which represented 8% of the Caribou sample (18% in 1980) and 22% of the Richardson sample (11% in 1980). This dissimilarity was also noted in mean lengths, 280 mm in Caribou versus 307 mm in the Richardson Clearwater.

In comparing the length ranges and related age classes of the total catch of out-migrating grayling in Caribou Creek in 1980 and 1981 as shown in Table 28, a marked difference can be seen in the percentages of the youngest and oldest grayling captured. Grayling less than 110 mm length, all Age Class I, comprised 2.1% of the catch in 1980 and a much larger percentage, 24.6%, in 1981. Conversely, grayling larger than 310 mm, predominantly Age Class VI and older, made up the dominant part of the catch in 1980 with 32.5%, while in 1981 they comprised only 7.7% of the post-spawning out-migration. Likewise, grayling in the 110-169 mm range, Age Class II, represented 11.5% of the 1980 catch and only 1.8% of the 1981 catch. Grayling between the lengths 170 and 309 mm, which comprises all of Age Classes III and IV and most of Age Class V, represented 65.9% of the downstream catch in 1981 and 53.9% in 1980.

Table 28. Length frequency and related age classes of Arctic grayling captured in Caribou Creek, 1980, 1981.

Length Range (mm)	Related Age Class	6/2-6/12/80* downstream migrants n	%	6/7-6/19/81** downstream migrants n	%	upstream migrants n	%
0.70-109	I	31	2.1	430	24.6	84	22.8
110-169	II	170	11.5	32	1.8	61	16.6
170-229	III	77	5.1	131	7.4	156	42.6
230-269	IV-V	309	20.9	532	30.4	49	13.4
270-309	V-VI	413	27.9	493	28.1	16	4.3
310-409	≥ VI	482	32.5	137	7.7	1	0.3
		1482		1755		367	
Length Range				70-400mm		73-317mm	
Mean				223mm		175mm	

* Fyke Trap
** 2-way weir

At first consideration, the decrease of larger adult grayling in 1981 could easily be attributable to the large harvest of pre-spawners in the spring at Shaw Creek's mouth, where 41% of the estimated 4,343 grayling harvested were greater than 300 mm in length. There are complications to this conclusion. These include: the late installation of the weir; the possibility that the larger grayling, unlike in 1980 could have out-migrated prior to the temperature-related peaks noted in both years; and the high water levels effect on behavior. Especially contradictory are the strong compositions of older grayling found during July indexing of the Richardson Clearwater River. If this river is as strongly associated with Caribou Creek as was reported in 1980 (Ridder, 1981) and to Shaw Creek in general as is seen this year (following section), any decline in large numbers of grayling would logically have had an opposite effect from that found in the index sampling.

During the 13 days of trapping 72 tag recoveries were recorded. Fifty-five of these recaptures were from tagging conducted in 1980 and 1979 and all were caught in the downstream trap: 46 represented the 1980 Caribou tagging; 2 tags were from fall sampling in Caribou Creek in 1979 (see Peckham, 1980), and 7 tags were from 1980 (5) and 1979 (2) efforts in Shaw Creek. Thirteen recaptures were made of grayling tagged on their in-migration to Caribou Creek in 1981. The interval between their captures and recaptures ranged from 1 to 12 days and averaged 5.8 days. This interval is considerably below the average found in 1980 of 18 days and might be due to their mean length, 244 mm, which suggests predominantly immature fish. Four recaptures were made of fish seined into the downstream trap, tagged, and recaptured the same day in the upstream trap.

One interesting statistic compiled during weir operations was prompted by the large amount of catch-and-release fishing during the spring fishery at the mouth of Shaw Creek. The presence or absence of mouth damage presumed to be caused by hooking was tabulated on all grayling over 200 mm in length. The predominant damage observed was to the maxillary, which was either torn and dangling, missing, or deformed (an old' injury). To a lesser degree, torn or punctured skin of the dentary and premaxillaries was found. Of the 1,393 fish examined, 163, or 11.7% exhibited such damage. An increase in occurrences was found in each 50 mm grouping from 200 to 400 mm. Of fish 200-249 mm, 6.1% of 396 examined had mouth damage; from 250-299 mm, 12.2% of 788; from 300-349 mm, 19.9% of 186, and from 350 mm to 400 mm, 28.6% of 21. Similar observations were noted in 1981 during index sampling on the Richardson and Delta Clearwater Rivers and during spring monitoring at Mile One Slough; percentages found in each sample were, respectively, 19%, 34%, and 5.1%.

The Volkmar River, located 18 mi above the Delta Clearwater River and 45 mi above Shaw Creek (see Fig. 1), was implicated as a possible major spawning stream for the Delta Clearwater River's grayling population on the basis of 1980 tag returns (Ridder, 1981). Two trips were made to the river in 1981 to expand the tag base, one between May 19 and 22, and the other between September 14 and 16.

Only 55 grayling were tagged during the spring trip, and water temperatures, which ranged from 4 to 5^{o}C, indicated that the post-spawning migration had yet to begin. Sampling, utilizing hook-and- line, seine, and

fyke trap, captured only 65 grayling with lengths ranging from 148 to 418 mm and a mean of 268 mm. Two of these fish were ripe females. The predominant age class in a sample of 63 was Age Class III, with a composition of 21%. A summary of age frequencies and mean lengths for this spring sampling is shown in Table 29 along with like data for the fall sampling.

Fall sampling with hook and line captured 70 grayling whose lengths ranged from 194 to 370 mm and averaged 282 mm. All captures were made in one small pool located above a beaver dam, while sampling a 2-mile section below the dam proved fruitless. Fifty-five of the grayling were greater than 200 mm and were tagged. One recapture was made of a fish tagged during the May trip; it had grown 15 mm. The predominant age class in a sample of 44 was Age Class III (Table 29).

An overnight, 18 hour, fyke trap set on September 14-15 captured 1,312 fish of eight species. Grayling captured totaled 684 and were predominantly less than 110 mm (n=421). Three recaptures were made of grayling tagged the day before 2 mi upstream. Ninety-four grayling were tagged, bringing the total number tagged in the Volkmar River in 1981 to 204.

Tag Recoveries:

Recaptures in 1981 of grayling tagged in the Volkmar River in 1980 (n=112) and 1981 (n=204) totaled four fish; one by our crew in the Volkmar River (see above) and three by anglers in the Delta Clearwater River. All nine recaptures in 1980 were made in the Delta Clearwater River. Of the three 1981 recaptures, two were from the 1980 tagging and both were Age Class VII in 1981. The remaining Delta Clearwater recapture was from the 1981 spring tagging effort (n=55) and was Age Class X. No returns from the fall tagging were expected.

Although returns were small, all were mature fish that probably had spawned in the Volkmar River before migrating to the Delta Clearwater River, a distance of 18 mi. Considering that the spring 1981 tagging was prior to the major post-spawning migration and predominantly involved immature fish, their 1.8% recapture rate (percent of total tagged) is not surprising. In 1980, the 8% recapture rate, which was considered significant, was from grayling tagged during the post-spawning migration (Ridder, 1981). These grayling (1980 recaptures) had a mean length of 312 mm and six of the nine were considered mature fish.

Grayling tagged in the Shaw Creek drainage since 1979 totaled 2,878, with 245 recaptured in 1981. Unlike 1980 returns, the majority of returns, 160 tags, came from the drainage itself and of these, 97 recaptures were generated by the unexpected 19 day fishery at Shaw Creek mouth, 55 tags were recaptured at the Caribou Creek weir and eight were returned by anglers during the season. The remaining 84 recaptures came from the same locations and in similar percentages as those found in 1980 (Ridder, 1981). Seventy-seven of these tags, 91.6%, were recovered in downstream locations (84% {71} in 1980). Seventy tags were recovered in the Richardson Clearwater River (65 in 1980), 4 from the Fivemile Clearwater River (2 in 1980) and 3 from the Salcha River (4 in 1980). Upstream recoveries totaled seven tags, 8.4% (7% in 1980), with four tags recovered from the Tanana

Table 29. Age frequency and mean length (mm) of Arctic grayling captured by hook-and-line in the Volkmar River. May 19-22 and Sept. 14, 1981.

Age Class	May n=63		September n=44		Both n=107
	Percent	Mean Length	Percent	Mean Length	Percent
II	13	162	14	209	13
III	21	207	38	257	28
IV	17	243	25	302	21
V	19	294	7	330	14
VI	13	326	14	351	13
VII	9	356	2	363	6
VIII	6	390			4
IX					
X	2	395		282	1
		268			

River's spring fishery at Big Delta (one in 1980), two from Clear Creek (three in 1980), and one tag from the Delta Clearwater River (n=3 in 1980). A summary of 1981 recaptures along with the year, location and number tagged is shown in Table 30.

Although the 1981 recaptures of Shaw Creek grayling show the same out-migration destinations and percentages as recaptures made in 1980, a comparison of recaptures of grayling tagged in its Caribou Creek tributary shows that fewer of them were recovered in the Richardson Clearwater in 1981 than in 1980.

In 1980, 4.8% (n=62) of the 1,283 grayling tagged in the creek were subsequently recaptured in the Richardson (Ridder, 1981), while 2.7% of the 1981 tags (Table 30) were recaptured there. Since recapture effort in the Richardson was the same for both years, the recaptures and their rates are considered comparable.

Recaptures of 1980 Caribou tags when viewed as percentages of the 1981 samples drawn from pre-spawning, post-spawning, and summer feeding area grayling populations were remarkably similar. These tags represented 4.0% of the censused catch of 600 made during the April fishing at the mouth of Shaw Creek, 3.3% of the 1,395 grayling (200 mm) caught in June at the Caribou Creek weir, and 3.9% of the combined index and creel sample (n=698) from the Richardson Clearwater River. These similarities indicate the same population was present in each locale if it is assumed that no differential mortality occurred between the marked and unmarked segments. Considering the distinct homing ability of grayling (Tack and cited references, 1980), a larger percentage would have been expected in the catch at Caribou Creek in 1981.

The above findings and those regarding age composition differences mentioned earlier in this report show incongruities regarding expectations in the relationship between Shaw Creek, Caribou Creek, and the Richardson Clearwater River's grayling populations. Although more years of data are needed to clarify this relationship, one possible explanation may be the extreme differences in Shaw Creek water conditions between the two years and its effect on fish behavior. In 1980, Shaw Creek had a gradual break-up and low water conditions, while in 1981 break-up was delayed and water levels were high.

Scale Analysis

A technique based on scale pattern analysis has been successfully applied by the Division of Commercial Fisheries, Alaska Dept. of Fish and Game, (CF, ADF&G) in the separation of Alaskan salmon stocks in mixed-stock fisheries and is described fully by Krasnowski and Bethe (1978). Simply stated, the statistical technique uses discriminant analysis and is based on the concept that two (or more) stocks may differ slightly in the mean and distribution of values for circuli counts and radii, the two measurable characteristics of scale growth chosen as variables. Since no single characteristic will allow identification with a particular stock due to value range overlap, the discriminant analysis uses a multivariate approach which combines variables to yield discriminant functions which serve to

Table 30. Summary of 1981 tag recoveries of grayling tagged in the Shaw Creek drainage, 1979-1981.

Water	Year Tagged	Number Tagged	Number Recoveries	Recovery Areas: Delta Clearwater N	%	Richardson Clearwater N	%	Clear Creek N	%	5 Mile Clearwater N	%	Shaw Creek N	%	Caribou Creek N	%	Salcha River N	%	Tanana River N	%
Shaw Creek:																			
Caribou	1980	1,283	167	1		29		1		1		86		46		1		1	
	1981	1,323	49	0		36		1		3		5		0		2		1	
Rapids	1979	22	1	0		0		0		0		1		0		0		0	
Main Stem (0-7 mi)	1979	156	13	0		2		0		0		7		4		0		0	
	1980	94	15	0		3		0		0		6		5		0		2	
Totals		2,878	245	1	(<1)	70**	29	2**	1	4	2	105*	43	55**	22	3	1	4	2

* n=97 Caught at mouth of Shaw Creek, April 1981.

** ADF&G recaptures; n=2, Clear Creek
n=17, Richardson
n=55, Caribou Cr. weir

identify stock membership. The analysis first requires measurements of variables of known stocks which provide the data for formulating the discriminant function. The variables measured from the mixed stock are then compared and classified by discriminant analysis into the various known stocks.

An evaluation of the technique in determining the stock origins of the Delta Clearwater River grayling populations was begun in 1980 (Ridder, 1981). Scale variables (number of circuli and distances between annuli for each year of growth) from Age V grayling collected in three known spawning streams of the area, the Goodpaster and Volkmar Rivers, and Caribou Creek, a tributary of Shaw Creek (Fig. 1), were analyzed and significant differences were found for some variables (means) among the three streams. Of the five pairs of variables analyzed, these differences were found only among those from the first 3 years of growth. Yet, abnormal distributions of each variable from all three streams suggested deficiencies in either aging equipment, age determinations, and/or sample sizes (Total n=83) and questioned the formation of an effective discriminating function (T. Robertson, CF, ADF&G, pers. comm., 1981).

In 1981, in an effort to correct the abnormal distributions, scale samples were collected in the same streams from Age III grayling, where age determinations are more exact, and sample sizes were almost doubled (total n=157). In addition, the more refined aging equipment of the Stock Separation Laboratory, ADF&G, was used exclusively in generating the measurements of the scale variables. The variables measured were the same as in 1980 and they generated values that were found to be normally distributed and whose statistics were applicable to further analysis (B. Van Allen, and N. Newcombe, ADF&G pers. comm., 1982). A summary of sample sizes, mean and standard deviation for each variable measured in 1981 is shown in Table 31.

The variables derived from the 1981 sampling were subjected to discriminant analysis (see Nie et al., 1975) which selected, in a step-wise manner, the combination of variables that added the most to the separation of the three streams. From these selected variables, classification functions, i.e., the discriminant functions, were derived whose adequacy was determined by classifying the original sample variables to see how many of them were correctly classified. The results of these test classification matrices generated by discriminant analysis for all three streams and for two streams, the Goodpaster and Volkmar Rivers, are shown in Table 32.

The overall classification accuracy of the three-way test was 68.2%. The Goodpaster River, the largest of the three spawning streams and a rapid run-off river, showed the best classification accuracy with 74.4%. It was followed by the Volkmar River, a bog-fed stream, with 73.1%. Caribou Creek, also a bog-fed stream and the smallest in size of the three, gave the poorest accuracy with 55.3%. In comparison, overall classification accuracies found in Age V sockeye from Upper Cook Inlet and derived from 4-way, 3-way, and 2-way models ranged from 67.9% to 81.7% with individual accuracies from 45% to 93% (Cross et al., 1981). Krasnowski and Bethe (1978) found overall classification accuracies for Kodiak Island sockeye salmon stocks of 60-70%, for Bristol Bay sockeyes of 60-80% and for Norton Sound chum salmon of 63-70%.

Table 31. Sample size, mean ($\bar{x}$), and standard deviation (s) for each variable measured from Age III Arctic grayling from the Goodpaster and Volkmar Rivers, and Caribou Creek, 1981.

Number of Circuli		NC1*		NC2**		NC3	
Location	Sample Size	x	S	x	s	x	s
Goodpaster	43	7.53	.96	10.58	2.08	8.91	1.25
Volkmar	67	9.52	1.54	11.10	2.05	9.89	2.06
Caribou	47	7.85	1.14	9.89	2.15	9.55	2.06

Incremental Distance		ID1*		ID2**		ID3**	
Location	Sample Size	x	s	x	s	x	s
Goodpaster	43	191.49	21.76	182.65	35.54	174.65	26.15
Volkmar	67	226.00	31.71	211.18	45.43	217.97	48.73
Caribou	47	210.06	22.26	190.17	43.53	203.68	48.39

* Discriminating variables chosen for 3-way test classifications, Table 32 A.
** Discriminating variables chosen for 2-way test classifications, Table 32 B.

Table 32. Test classification matrices from discriminant analyses of Age III Arctic grayling from A; Goodpaster and Volkmar Rivers, and Caribou Creek, and B; Goodpaster and Volkmar Rivers, 1981.

A.

Actual Group of Origin	Sample Size	Classified Group of Origion		
		Goodpaster	Volkmar	Caribou
Goodpaster	43 (.274)	.744	.070	.186
Volkmar	67 (.427)	.104	.731	.165
Caribou	47 (.299)	.255	.192	.553
Total	157 (1.000)	.325	.389	.286

Overall correctly classified = .682

B.

Actual Group of Origin	Sample Size	Classified Group of Origion	
		Goodpaster	Volkmar
Goodpaster	43 (.391)	.907	.093
Volkmar	67 (.609)	.194	.806
Total	110 (1.000)	.473	.527

Overall corectly classified = .845

Note: Underlined proportions represent proportion correctly classified, all other proportions are misclassified.

The overall classification accuracy increased to 84.5% when only the Goodpaster and Volkmar River were used in the discriminant analysis (Table 32). Individual acccuracies were 90.7% for the Goodpaster and 80.6% for the Volkmar. The Caribou Creek sample (n=47), when included in the two-way classification model, was classified as 68.1% Goodpaster River grayling and as 32.9% Volkmar River fish.

These classification accuracies can be refined and possibly improved if the sample sizes from the streams were larger by formulating a discriminating function for half the sample. The other half, the test sample, would then be classified by the function and classification accuracies computed. The two samples are then interchanged and a second classification model is made and tested. The accuracies of the two classifications are averaged to determine the final classification accuracies and misclassification rates for each stream. This method was used in obtaining the accuracies found with the Upper Cook Inlet sockeye stocks.

The classification accuracies indicate that this technique of stock separation is applicable to delineating the grayling stocks comprising the population in the Delta Clearwater River. Considering the tag return data from one spawning stream, Caribou Creek, and specifically those returns from the Salcha River located 40 mi downstream, the three streams used in the above analysis, and all located within 30 mi of the Delta Clearwater, may not comprise all the streams that provide recruitment to the Delta Clearwater's population. The river-lake systems of Healy Lake, 30 mi upstream of the Delta Clearwater and George Lake, 40 mi upstream, may also contribute. However, the streams used, specifically the Goodpaster and Volkmar Rivers, are considered the principal sources (Schallock and Roguski, 1967; Ridder, 1981). With the future acquisition of a suitable sample of the 1978 year-class of grayling from the Delta Clearwater River, application of the discriminant functions developed in 1981 will do much to define the relationships of these streams to the Delta Clearwater River.

Delta Clearwater Tagging:

A summary of tag recaptures by anglers of Arctic grayling tagged at Mile One Slough, Delta Clearwater River for the years 1977 to 1981 is shown in Table 33. It is included here primarily as a reference for citations made elsewhere in this report regarding the correlation of successive yearly recapture rates (percent of total tagged) between each of the 5 tagging years. Of the 15 rates derived from the 5 years of tagging, only 2 fall out of the pattern shown. The first year recapture rate of 4.5% shown for the 1977 tagging is much below the average 10.2% found during for the following 4 years and is probably the result of the lack of an active creel census program in 1977 whereas, in all other years, such a program was in place. The second year rate of 0.0% found for the 1980 tagging is probably due to the small number of fish tagged.

Escapement Counts:

Escapement counts of coho salmon in the Delta Clearwater River were made on October 21, 1981 and are presented along with counts made since 1973 in Table 34. The estimated escapement in the river in 1981 was 8,563 and is based on a count of 4,453 salmon in Miles 9-17.5 of the river. Between

Table 33. Summary of Tag recaptures by anglers of Arctic grayling tagged in Delta Clearwater River*, 1977-1981.

Recapture Location	Tagged in 1977, n=582					1978, n=884				1979, n=146			1980, n=63		1981, n=68	Big Lake** n=652		n=2395	
	77	78	79	80	81	78	79	80	81	79	80	81	80	81	1981	1980	1981	Totals	%
Delta Clearwater R.	26	26	10	4	1	89	35	23	6	14	8	3	6	0	8	26	4	289	88.4
% of Total Tagged	(4.5)	(4.5)	(1.7)	(.7)	(.2)	(10.1)	(4.0)	(2.6)	(.7)	(9.6)	(5.5)	(2.1)	(9.5)	(0)	(11.8)	(4.0)	(.6)	(12.1)	
Clearwater Lk Outlet	6	4				13	1			1			1		1	1		28	8.6
Richardson Clearwater						1												1	.3
Tanana River		1					3											4	1.2
Shaw Creek	1						1		1									3	,9
Volkmar River		1																1	.3
Dry Creek	1																	1	.3
Totals	34	32	10	4	1	103	40	23	7	15	8	3	7	0	9	27	4	327	100

* All tagging conducted in April at Mile One Slough, Mile 1, Delta Clearwater River.
** Stocked in Delta Clearwater River 9/79

)le 34. Coho salmon escapement counts * for the Delta Clearwater River and Clearwater Lake Outlet, 1973-1981.

Date	Delta Clearwater River	Clearwater Lake Outlet
t. 17 & 24, 1973	3,322	551
74	ND	ND
t. 22 & 24, 1975	5,100	1,500
t. 21 & 22, 1976	1,920	460
t. 24 & 25, 1977	4,793	730
t. 25 & 26, 1978	4,798	570
t. 22 & 23, 1979	8,970	1,015
t. 27 & 28, 1980	3,946	1,545
t. 21, 1981	8,563**	ND

Counts made from elevated platform mounted on riverboat.
Estimate based on count of 4,453 in miles 9-17.5. Section averaged 52% during 1975-1980 counts.

1975 and 1980 this river section averaged 52% of the total river escapement (ADF&G field office files). In 1980, the escapement in the river totaled 3,946 coho.

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