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Eastern North Slope Dolly Varden Genetic Stock Identification and Stock Assessment.

Annual Report for Study 01-113

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SUMMARY PAGE

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Investigator(s)/Affiliation(s): Tim Viavant/Alaska Department of Fish and Game, Division of Sport Fish.

Management Regions: Region 10 (North Slope).

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TABLE OF CONTENTS

Page

LIST OF TABLES iv

LIST OF FIGURES iv

LIST OF APPENDICES v

INTRODUCTION 1

OBJECTIVES 3

METHODS 4

- Aerial Survey Variability Estimation 4
- Mark/Recapture Abundance Estimation 4
- Radio-telemetry 6
- Spawning and Overwintering Locations and Genetic Stock Identification Baseline Sampling 6

RESULTS 8

- Aerial Survey Variability Estimation 8
- Mark-Recapture Abundance Estimation 8
- Radiotelemetry 12
- Spawning and Overwintering Locations and Genetic Stock Identification Baseline Sampling 12

DISCUSSION 22

- Aerial Survey Variability Estimation 22
- Mark-Recapture Abundance Estimation 23
- Radiotelemetry 25
- Spawning and Overwintering Locations and Genetic Stock Identification Baseline Sampling 25

CONCLUSIONS 26

RECOMMENDATIONS 27

ACKNOWLEDGMENTS 28

TABLE OF CONTENTS (Continued)

Page

LITERATURE CITED 28

Appendix A 30

Appendix B 32

LIST OF TABLES

Table — Page

1. Aerial counts of Dolly Varden Char in a 28-km index reach of the Ivishak River, September 2002 9

2. Marking and recapture history from 2002 Ivishak River Mark-Recapture abundance experiment. 10

LIST OF FIGURES

Figure — Page

1. Map of the eastern North Slope of the Brooks Range and coastal plain showing major drainages containing anadromous Dolly Varden and the boundary of the Arctic National Wildlife Refuge 2

2. Map of the Ivishak River, Alaska, showing the boundaries and subsections of the 28-km index area 5

3 Locations where radio-tagged Dolly Varden were captured and implanted in the Ivishak River, September 2002. 7

4. Length distribution of overwintering anadromous Dolly Varden captured in the Ivishak River, September 2002 11

5. Locations of radio-tagged Dolly Varden in the Ivishak River, Alaska, September 19, 2002. 13

6. Locations of radio-tagged Dolly Varden in the Ivishak River, Alaska, September 22, 2002. 14

7. Locations of radio-tagged Dolly Varden in the Ivishak River, Alaska, September 24, 2002. 15

8. Dolly Varden spawning locations in the Kongakut River, Alaska, August, 2001 16

9. Dolly Varden spawning locations in the Ribdon, Lupine, Saviukviak, Ivishak, Echooka, Shaviovik, and Kavik rivers, Alaska, September 2001 and 2002 17

10. Dolly Varden spawning locations in the Anaktuvuk and Kanayut rivers, Alaska, September 2002. 18

11. Dolly Varden overwintering locations in the Ivishak River, April 2002 19

LIST OF FIGURES (Continued)

Figure Page

12. Dolly Varden overwintering locations in the Ivishak River, April 2003.....21

13. Length distribution of overwintering anadromous Dolly Varden captured in the Ivishak River, September 2000 (n = 1,122), September 2001 (n = 2,955), and September 2002 (n = 2,445).....24

LIST OF APPENDICES

Appendix Page

A. Methodologies for alleviating bias due to size selectivity by means of statistical inference.....31

B. North Slope Dolly Varden spawning locations.....33

INTRODUCTION

This is the second Annual Report of a three-year study of anadromous Dolly Varden on the North Slope of the Brooks Range, and reports results of the second year of the full three-year study. Information regarding the first year of the study is reported in the first Annual Report (Viavant 2002), and information from a feasibility study done prior to the full three-year study is reported in the Final Report of the feasibility study (Viavant 2001).

Anadromous Dolly Varden *Salvelinus malma* are distributed widely in the Beaufort Sea drainages of the North Slope of the Brooks Range between the Colville River and the Canadian border (Figure 1). Fish from these stocks are an important subsistence resource in the communities of Kaktovik, Nuiqsut, and Anaktuvuk Pass (Craig 1987; Pedersen 1990). These same stocks of fish also contribute to sport fisheries along the Dalton Highway and in the Arctic National Wildlife Refuge and Gates of the Arctic National Park.

Much of the habitat that these fish depend on is also located within areas with significant potential for future resource development. Although their distribution is widespread among North Slope drainages, the extent of their distribution within drainages and among drainages has not been completely cataloged. Because of their complex life history, these fish are highly dependant on critical spawning and overwintering habitat that is probably limited (Craig 1989; Krueger et al. 1999), and has also not been completely cataloged.

These fish have complicated migration patterns, and although some research has been done on life history and distribution, very little work has been done on stock assessment. Because resource development on the North Slope is often dependent on the use of large quantities of gravel and water, exploration and development is likely to have significant effects on these subsistence resources. These effects can only be mitigated with sufficient knowledge of the timing and locations of overwintering and spawning habitat needs of these populations.

A more thorough treatment of the rational for conducting this study with supporting citations is included in the first year's Annual Report of the study (Viavant 2002). In addition, the Final Report of this study will include the results of all three years of research, as well as a complete literature review.

This project is intended to investigate the validity of using aerial surveys as a stock assessment tool. The project will estimate the precision of aerial surveys of overwintering aggregations, and determine the relationship between aerial survey abundance estimates and traditional mark-recapture abundance estimates of the same overwintering aggregations.

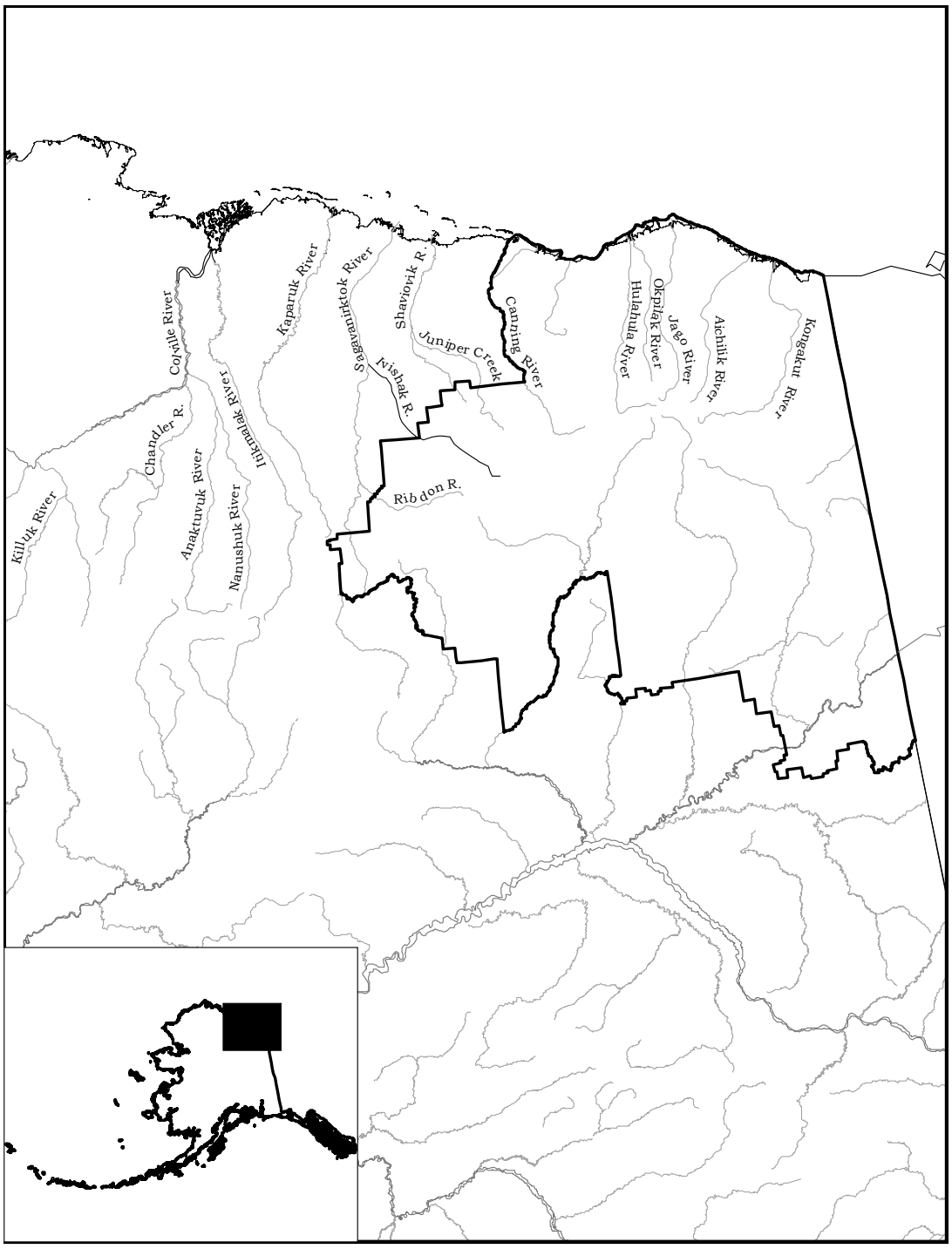

Figure 1. Map of the eastern North Slope of the Brooks Range and coastal plain showing major drainages containing anadromous Dolly Varden and the boundary of the Arctic National Wildlife Refuge.

The project is also intended to collect stock-specific mitochondrial DNA genetic samples from major spawning stocks that contribute to subsistence fisheries. If these spawning stocks show sufficient genetic separation from one another, similar genetic samples taken from subsistence harvests could be used to estimate the stock contribution of different spawning stocks to those harvests. The project will also identify, catalog, and map spawning and overwintering locations.

OBJECTIVES

Multiple Year Project Objective:

1) Characterize the population structure of Dolly Varden using mitochondrial genetic markers and test the performance of the genetic baseline to determine the potential for stock composition estimation of mixed stock subsistence harvests.

Year Two Objectives:

1) Estimate the variability of replicate aerial surveys of the overwintering aggregation (within a fixed 28 km area) on the Ivishak River conducted by the same observers under similar conditions during the same time period.
2) Estimate the abundance and size composition of Dolly Varden in the overwintering aggregation (same geographic area as objective 1) on the Ivishak River such that the abundance estimate is within 20% of the true value 90% of the time.
3) Identify new and verify known overwintering locations on the Ivishak River and collect GIS mapping data for all verified and new locations such that the power to detect up to five overwintering locations comprising 100% of the locations used is at least 95%.
4) Identify new and verify known spawning locations on the Anaktuvuk, Hulahula, and Canning rivers and collect GIS mapping data for all verified and new locations.

METHODS

Aerial Survey Variability Estimation

Five replicate aerial surveys of a 28-km index area of the Ivishak River (Figure 2) were conducted from September 19-23. Counts were conducted from a helicopter by two observers, each counting only the fish present on one side of the river. Each observer counted the same side of the river during each survey. In portions of the river where multiple channels existed, the main channel with the majority of the fish present was marked and counted. Although all channels were not counted, during all counts, the same marked river channels were counted during each survey. These replicate counts were conducted after upriver migration was judged to be essentially complete, based on aerial surveys that determined the absence of new fish migrating upstream from below the 28-km index area. The migration was considered complete when less than 10% of the number of fish counted in the assessment area was present in the 10-km reach of river immediately below the index area.

The index area was divided into three subsections, corresponding to the subsections used in the concurrent mark-recapture study, and counts were subtotaled for each subsection. To eliminate conscious or unconscious bias during counts, replicate counts were conducted with the face plates of the counting devices covered, and the totals recorded by the helicopter pilot, so that the observers were not aware of their individual section or daily total counts until after all five replicate counts were complete.

Mark-Recapture Abundance Estimation

A mark-recapture abundance estimate of this same aggregation (the same 28 km index area divided into the same subsections) was conducted using the Bailey modified Petersen two-event estimation procedure (Seber 1982). The estimator was stratified by size and, within the smaller size stratum, by subsection. Adult fish were captured using beach seines, measured, and marked with a small fin-clip and a partial opercular punch. In areas with multiple channels, sampling was conducted in the same marked channels identified and counted during aerial survey counts. Fish were marked during a seven-day period, and were recaptured by a second crew during a seven-day period that began after a two-day mixing period.

In order to evaluate fish movement during the experiment, the 28-km index area was divided into three approximately equal subsections prior to the marking event. Fish were given different fin clips depending on capture section to evaluate movement. Length, date, fin clip, and stream section were recorded for each fish captured. Data from the mark-recapture portion of the study were recorded on optical scan data forms. All Dolly Varden captured were measured for fork length to the nearest 5 mm.

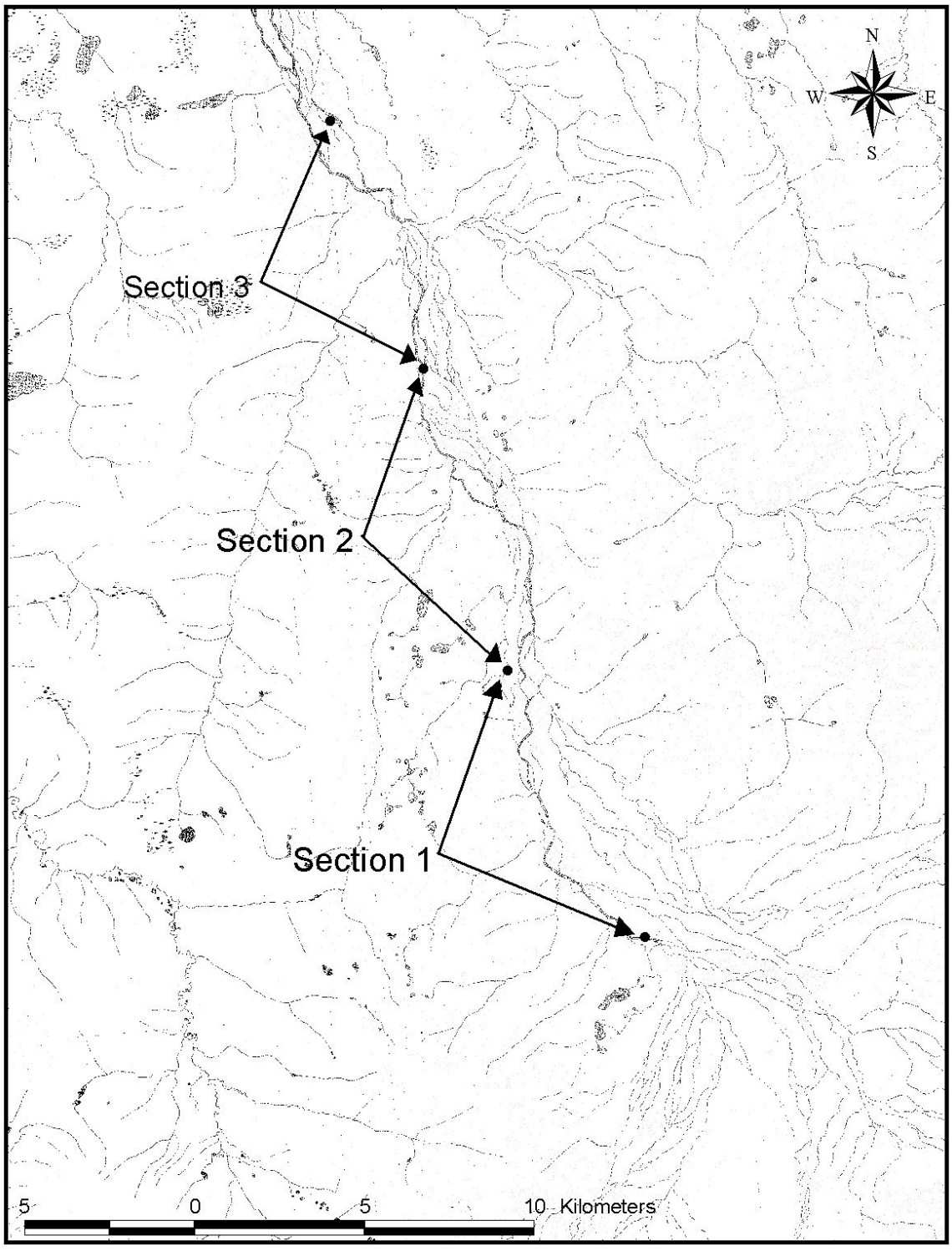

Figure 2. Map of the Ivishak River, Alaska, showing the boundaries and subsections of the 28-km index area.

Radiotelemetry

Forty fish were implanted with radio tags in the Ivishak River on September 14-16, 2001. These fish were located during September, 2001, to evaluate fish movement during the 2001 mark-recapture experiment, and those results are reported in the first Annual Report of this project (Viavant 2002). These fish were also located under the ice April 16, 2002, in order to identify specific overwintering locations.

Forty fish were also implanted with radio tags in the Ivishak River on September 14-16, 2002, to evaluate fish movement during the mark-recapture abundance study, and to identify specific overwintering sites during April 2003. Ten non-spawning fish were implanted at the lower end of each of the three subsections of the index area and 10 non-spawning fish were implanted just below the upstream end of the top subsection (Figure 3). These radio-tagged fish were located from the air on September 19, 22, and 24, 2002, and on April 25, 2003. GPS (latitude/longitude) coordinates were recorded for all fish located.

Spawning and Overwintering Locations and Genetic Stock Identification Baseline Sampling.

Spawning locations were identified in the Ivishak, Anaktuvuk, Kanayut, Ribdon, Lupine, Kavik, and Shaviovik rivers by aerial and ground surveys, and all recorded locations were verified by on-the-ground capture and examination of fish to ensure that fish were in spawning condition. Fish on spawning locations were captured with both hook-and-line and seine. GPS coordinates were recorded for all verified spawning locations. These coordinates were entered into a GIS (geographic information system) database overlaid with USGS 1:63,000 maps. For each location and date, the approximate number of fish observed was recorded.

Wintering locations were identified in the Ivishak River by radio-tracking wintering fish April 16, 2002 that were tagged in September 2001. Fish tagged during September of 2002 were located April 25, 2003. These fish were located by air, and GPS coordinates were recorded for all overwintering locations. These coordinates were entered into a GIS (geographic information system) database.

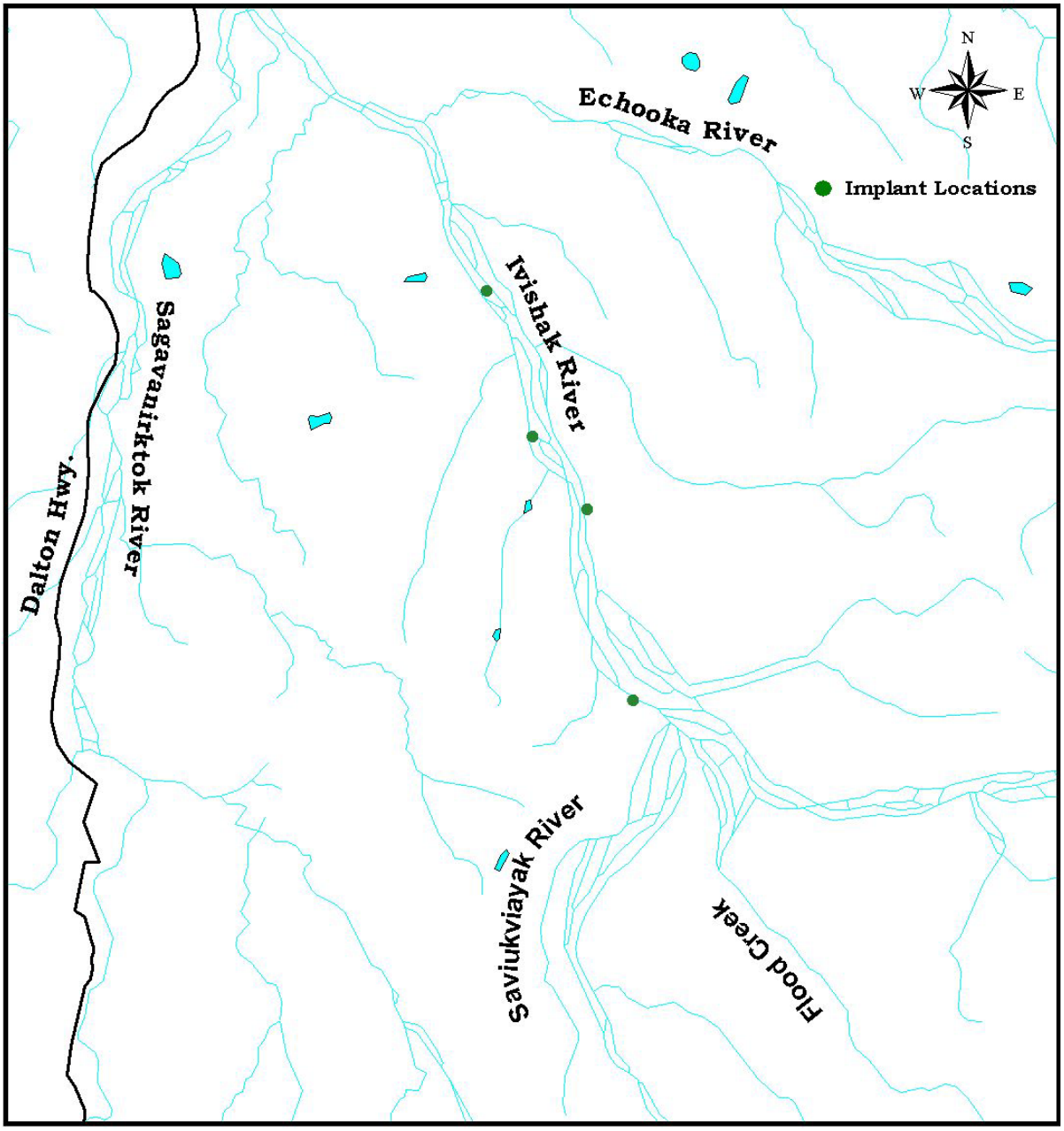

Figure 3. Locations where radio-tagged Dolly Varden were captured and implanted in the Ivishak River, September 2002

Stock-specific genetic samples of pre-smolt juveniles were collected during July and August 2002, from the Anaktuvuk and Canning rivers. During September, genetic samples from adult fish in spawning condition were captured from the Ribdon, Lupine, Kavik, and Shaviovik rivers. Attempts to collect stock-specific genetic samples from the Hulahula River during August were unsuccessful due to high water conditions. Fin clips were stored in individual vials containing 90% ethanol. Samples were delivered to the USFWS Fish Genetics Lab at 1011 East Tudor Road, Anchorage for genetic analysis.

DNA was extracted from Dolly Varden from all drainages sampled to date for this project. DNA from these samples specific for eight microsatellite loci (*Sma-3, 5, 9, 10, 17, 21, 22,* and *24*) was amplified via polymerase chain reaction. In conjunction with FIS01-136, additional primers from archived libraries developed through FIS00-011 and FIS00-001 and other *Salvelinus* studies have been screened to increase the number of loci used in the population surveys. The full analysis from these genetic samples will not be completed until after the 2003 sampling season, when all baseline and mixed stock samples are available for analysis.

RESULTS

Aerial Survey Variability Estimation

Five aerial surveys were conducted under good or excellent conditions in the 28-km index area of the Ivishak River in 2002 (Table 1). The mean summed count for both observers over all subsections was 5,408 fish with a standard error of 363, or about 7% of the mean. Counts were highest in section one and lowest in section three. Variability of summed counts (both observers) was different among sections, with the lowest variability in section one. Observer one (left bank) counted less fish than observer two, except in section one during replicates four and five, and observer one counts were more variable than observer two counts.

Mark-Recapture Abundance Estimation

A total of 1,033 Dolly Varden were captured, marked, and measured between September 14 and September 20, 2002. A total of 1,080 fish were captured and examined during the first recapture event, between September 16 and 22, 2002. A second recapture event was conducted on September 23, and an additional 413 fish were captured and examined. During the first and second recapture events, a total of 75 marked fish were recaptured (Table 2).

Table 1. Aerial counts of Dolly Varden Char in a 28-km index reach of the Ivishak River, September 2002.

Replicate Date	Survey Conditions	Section	Observer	Section Count	Section Total	Replicate Total
9/18/2002	Good	1	1	1,530	3,366	5,503
			2	1,836		
		2	1	255	1,390	
			2	1,135		
		3	1	117	747	
			2	630		
9/19/2002	Good	1	1	1,110	2,620	5,302
			2	1,510		
		2	1	222	1,442	
			2	1,220		
		3	1	260	1240	
			2	980		
9/20/2002	Good	1	1	1,761	2,969	4,190
			2	1,208		
		2	1	205	721	
			2	516		
		3	1	164	500	
			2	336		
9/21/2002	Excellent	1	1	3,130	5,060	6,455
			2	1,930		
		2	1	190	980	
			2	790		
		3	1	195	415	
			2	220		
9/22/2002	Excellent	1	1	2,825	4,455	5,588
			2	1,630		
		2	1	260	790	
			2	530		
		3	1	228	343	
			2	115		

Summary Statistics by Section and Observer

	Section 1	Section 2	Section 3	Summed Counts
Mean Count	3,694	983	694	5,408
Standard Error	1,028	150	163	363
Standard Error as Percent of Mean[a]	12.4	15.2	25	6.7

[a] Coefficient of Variation (CV).

Table 2. Marking and recapture history from 2002 Ivishak River mark-recapture abundance experiment.

Section	Number Marked	Number Examined	Number Recaptured from Marking Event			Total
			Section 1	Section 2	Section 3	
			Marking Event			
1	735	0	0	0	0	0
2	250	0	0	0	0	0
3	53	0	0	0	0	0
Total Mark	1,033					
			First Recapture Event			
1	0	742	31	0	0	31
2	0	338	0	26	2	28
3	0	5	0	0	1	1
Total Examined		1,085				
Total Recaptures						60
			Second Recapture Event			
1	0	413	13	2	0	15

Sampling that occurred during the second recapture event only marginally improved the variance of the estimate, and only slightly altered the value of the estimate, and so was not used in the abundance estimate analysis. The lengths from the second recapture event were included in the overall evaluation of sample length frequencies.

Kolmogorov-Smirnoff two-sample tests were performed to evaluate the hypotheses of homogenous size distributions of Dolly Varden marked on the first event (M), caught on the second event (C), and recaptured on the second event (R). When using data pooled from all three sections of the river we rejected the null hypotheses for both M vs. R ($P = 0.0006$) and M vs. C ($P = 0.0000$) tests, indicating that the estimator used would have to be stratified by size at 360 mm fork length. Tests within size strata indicated that the small stratum resulted in a Case I situation and the large stratum resulted in a Case II situation, each not requiring further stratification (Appendix A).

Observations of radio-tagged fish and repeated aerial surveys during the mark-recapture experiment all indicated a significant movement of fish from section 2 to section 1 and from section 3 to section 2 between the two sampling events. This suggested mixing occurred within the study area. However, recaptures of marked fish occurred almost completely within the same section that fish were marked in (Table 2).

When we evaluated the tests for consistency for the Petersen type estimator, we concluded that the Bailey modified Petersen estimator was the appropriate model for the large size stratum. A geographically stratified Bailey modified Petersen estimator was

the appropriate method for the small size stratum. For both size strata we rejected the null hypothesis that mixing patterns between river sections were complete ($P < 0.001$). For the large size stratum, capture probabilities for the first and second events were uniform across sections of the river ($P = 0.99$ and $P = 0.70$). For the small size stratum, however, capture probabilities for the events were not uniform across sections of the river ($P = 0.04$ and $P = 0.001$). Further stratifying the small size stratum by subsection (small fish did not move among subsections) resulted in a small increase in abundance (an increase of 503 fish) with slightly improved precision. Results of the Bailey estimator stratified by size and subsection (within the small size stratum) yielded a point estimate of 21,634 Dolly Varden with a standard error of 3,075.

The mean length of all fish captured was 450 mm fork length. The smallest fish captured was 220 mm fork-length and the largest was 725 mm fork-length. The length distribution of fish captured during 2002 was distinctly bimodal, with a peak around 260 mm and a larger peak around 485 mm (Figure 4).

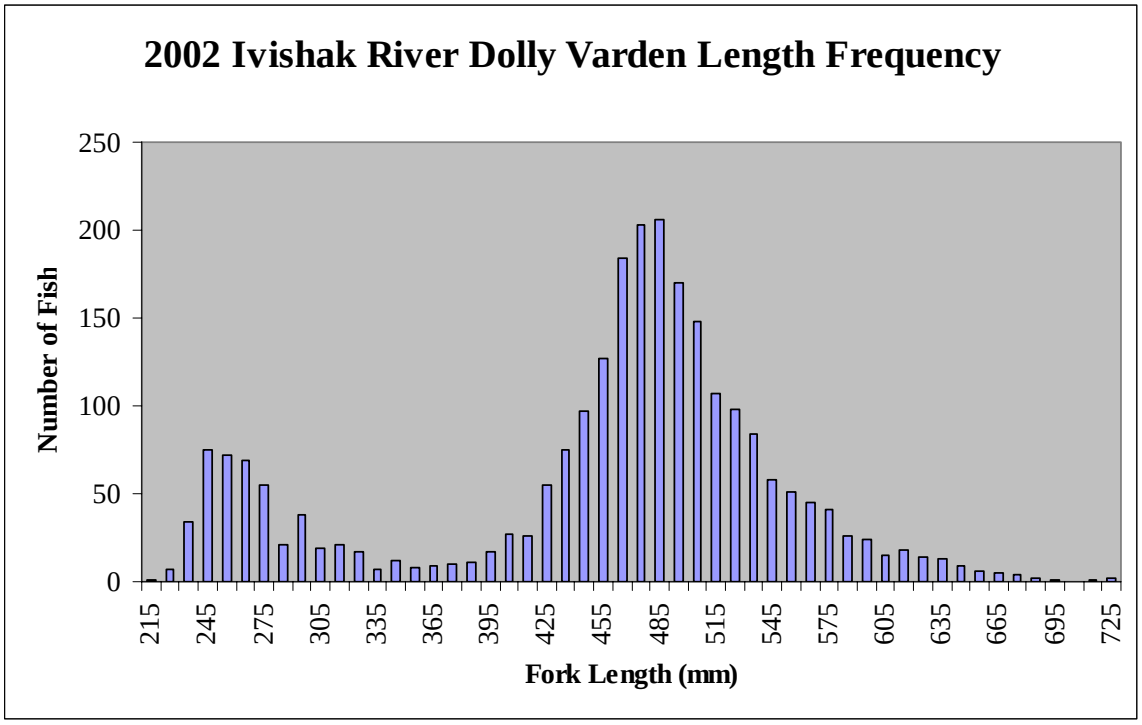

Figure 4. Length distribution of wintering anadromous Dolly Varden captured in the Ivishak River, September 2002.

Radiotelemetry

Radio-tagged fish were located on September 19, 22, and 24. Most tagged fish had moved upstream from the location they were tagged by September 19 (Figure 5). Although some of the 10 fish tagged near the top of section 1 had moved upstream by September 19, none of these fish moved upstream of the index area boundary. Most radio-tagged fish had continued to move upstream by September 22 and 24 (Figures 6 and 7), but no fish moved out of the index area, either upstream or downstream. The 10 fish tagged near the top of the index area all stayed relatively near the location they were tagged. Several fish that were radio-tagged at the same location moved together, and were located very near each other on subsequent dates.

No fish moved substantially downstream from the tagging location during the entire experiment, and no fish moved from the section tagged in to a section downstream. One fish tagged at each of locations one through three stayed near it's tagging location during the entire experiment, but the exact location of each of these fish changed slightly during each radio tracking event, indicating that these fish were not tagging mortalities. In addition to locating the 40 fish that were radio-tagged earlier in September 2002, six fish that were radio-tagged in September 2001 had returned to the index area, and were located during tracking flights in September 2002. One non-spawning fish that was tagged in the Ivishak in September 2001 was located with a group of spawning fish in the Kavik River in September 2002.

Spawning and Overwintering Locations and Genetic Stock Identification Baseline Sampling

Spawning locations were identified in the Kongakut during 2000 (Figure 8), the Ivishak, Echooka, and Saviukviak rivers during 2001 and 2002 (Figure 9), and the Anaktuvuk, Kanayut, Kavik, Ribdon, Lupine, and Shaviovik rivers during 2002 (Figures 9 and 10). Spawning locations identified in most systems were near the upper reaches of the drainages, where the systems are in the Brooks Range or it's foothills. Many of these spawning areas were associated with spring activity or were in channels along vertical rock walls. The GPS coordinates for all locations and approximate number of fish at each location is listed in Appendix B.

Overwintering locations in the Ivishak River were determined by locating radio-tagged fish (tagged during September, 2001) during April of 2002. Thirty-eight overwintering fish of the forty that were tagged in September of 2001 were located. Fish were dispersed within and both upstream and downstream of the 28 km index area used for the abundance estimate and the aerial surveys (Figure 11). Almost half (18 of 38) fish had moved downstream of where they were last located in September of 2001.

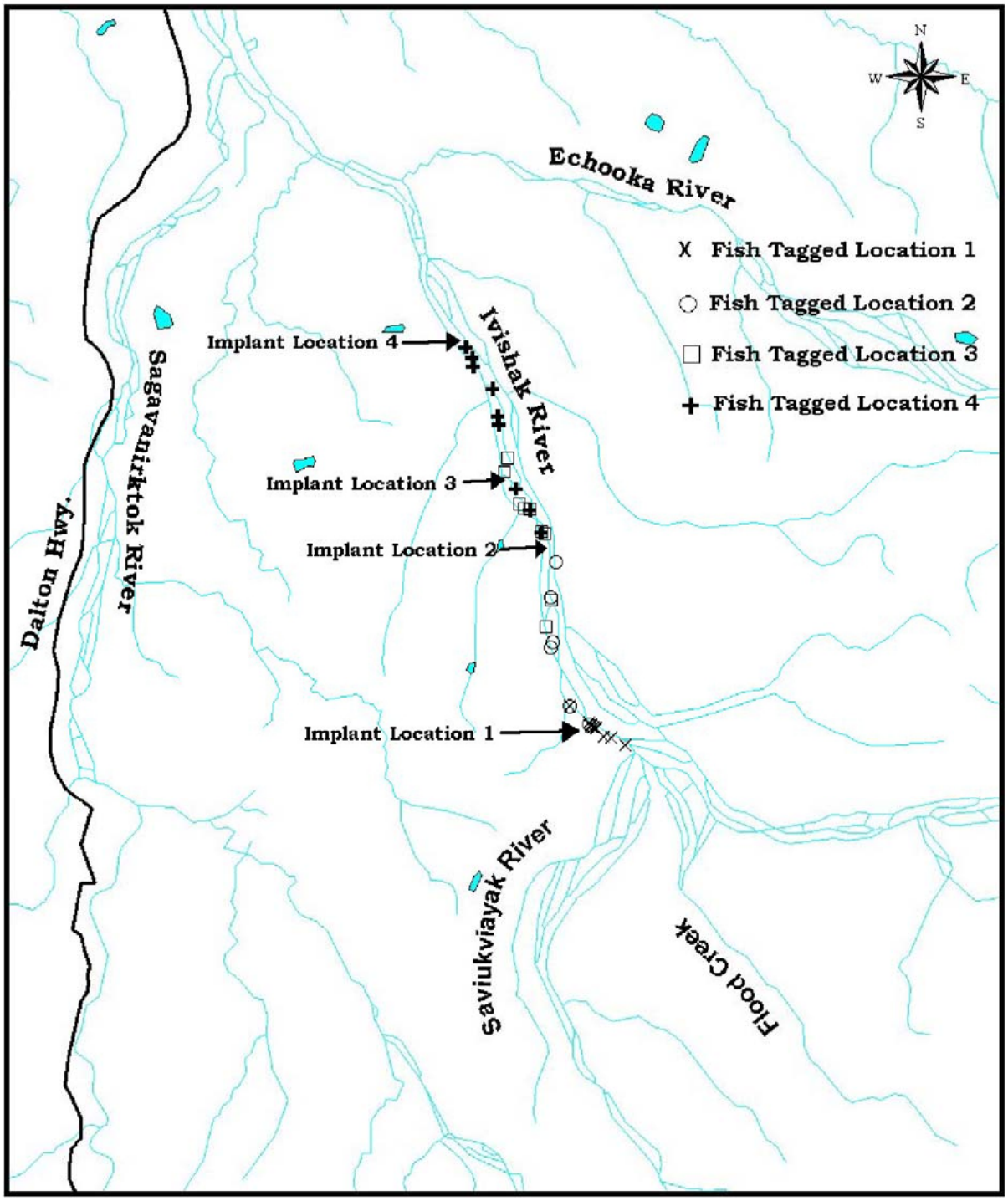

Figure 5. Locations of radio-tagged Dolly Varden in the Ivishak River, Alaska, September 19, 2002.

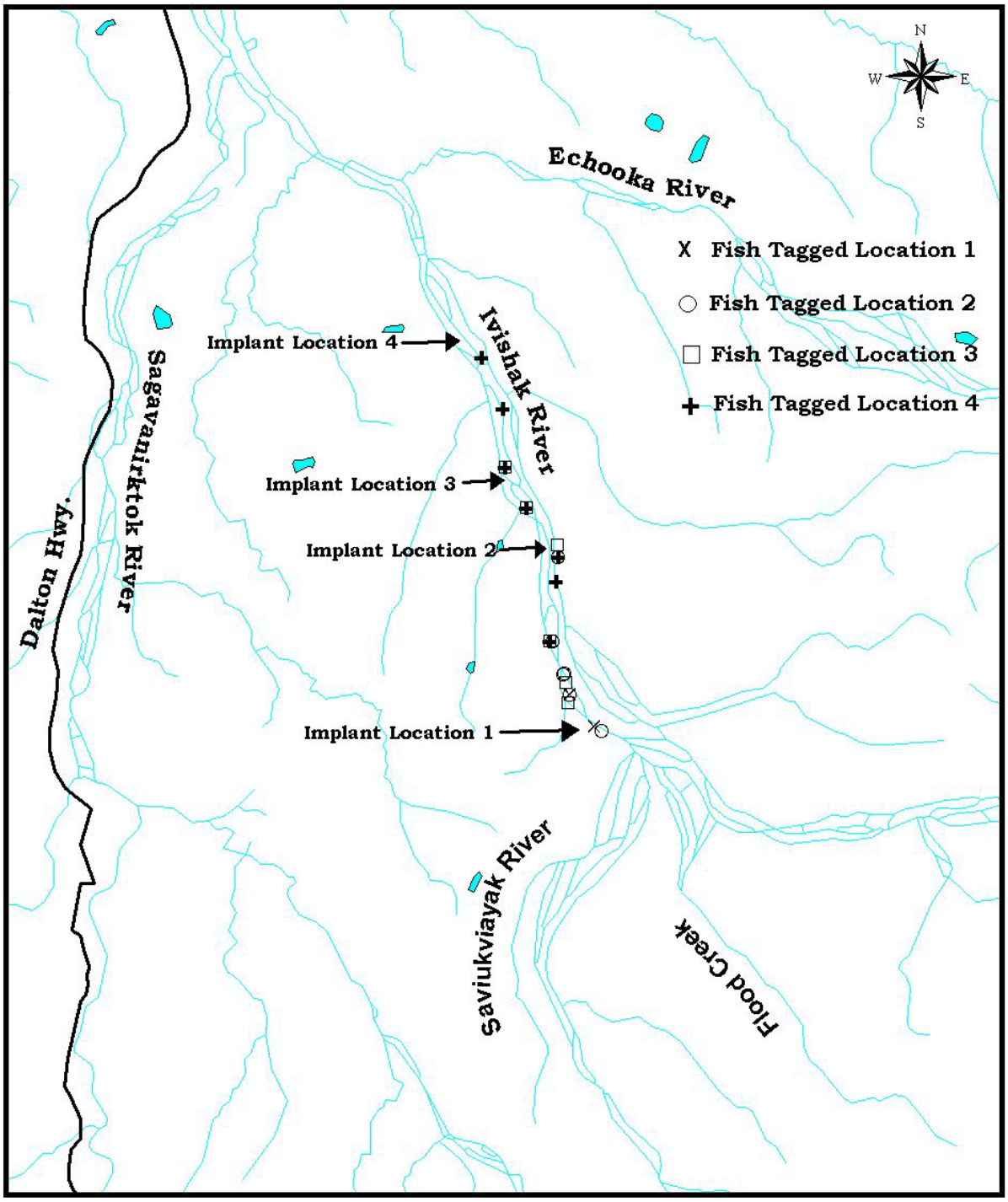

Figure 6. Locations of radio-tagged Dolly Varden in the Ivishak River, Alaska, September 22, 2002.

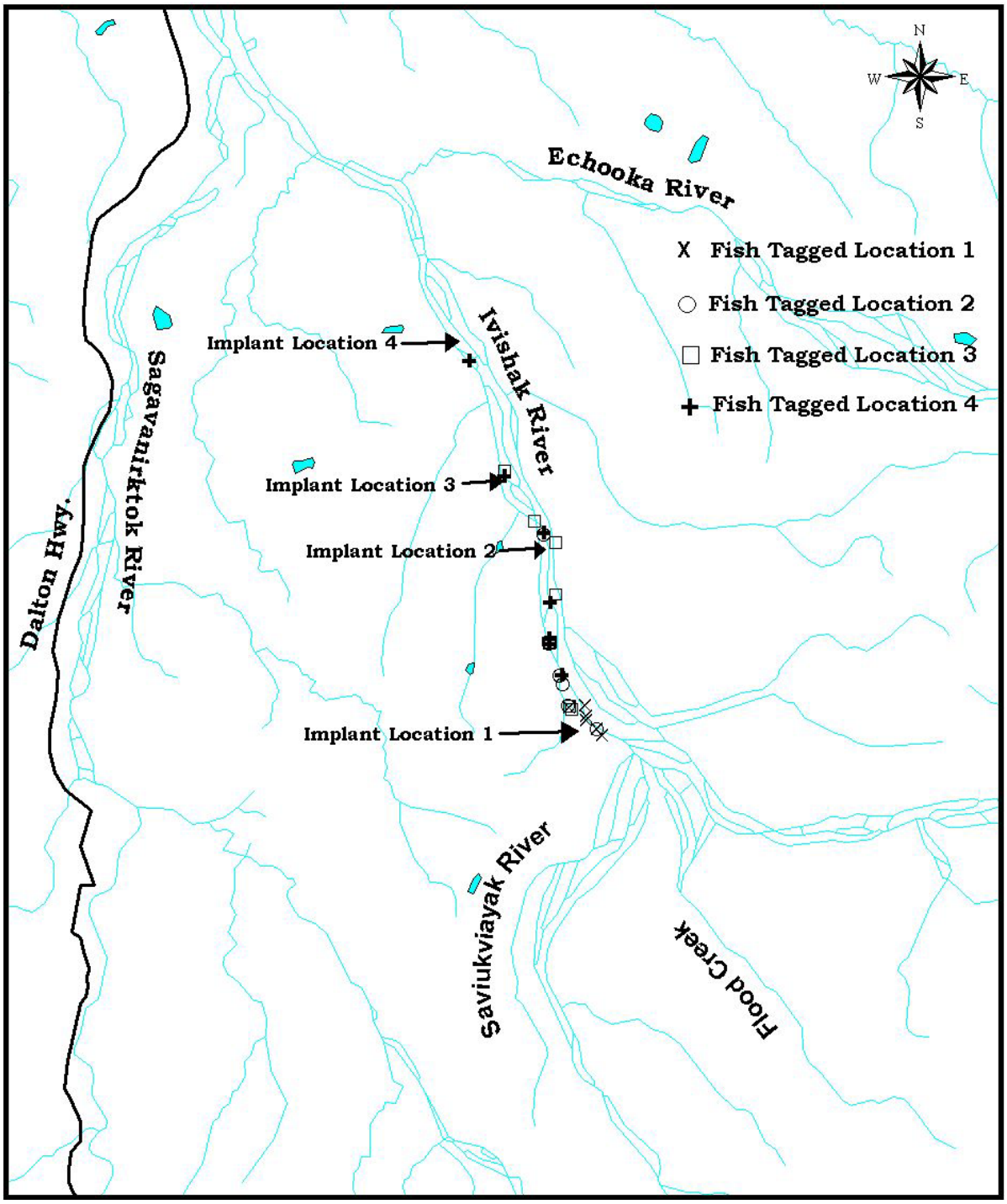

Figure 7. Locations of radio-tagged Dolly Varden in the Ivishak River, Alaska, September 24, 2002.

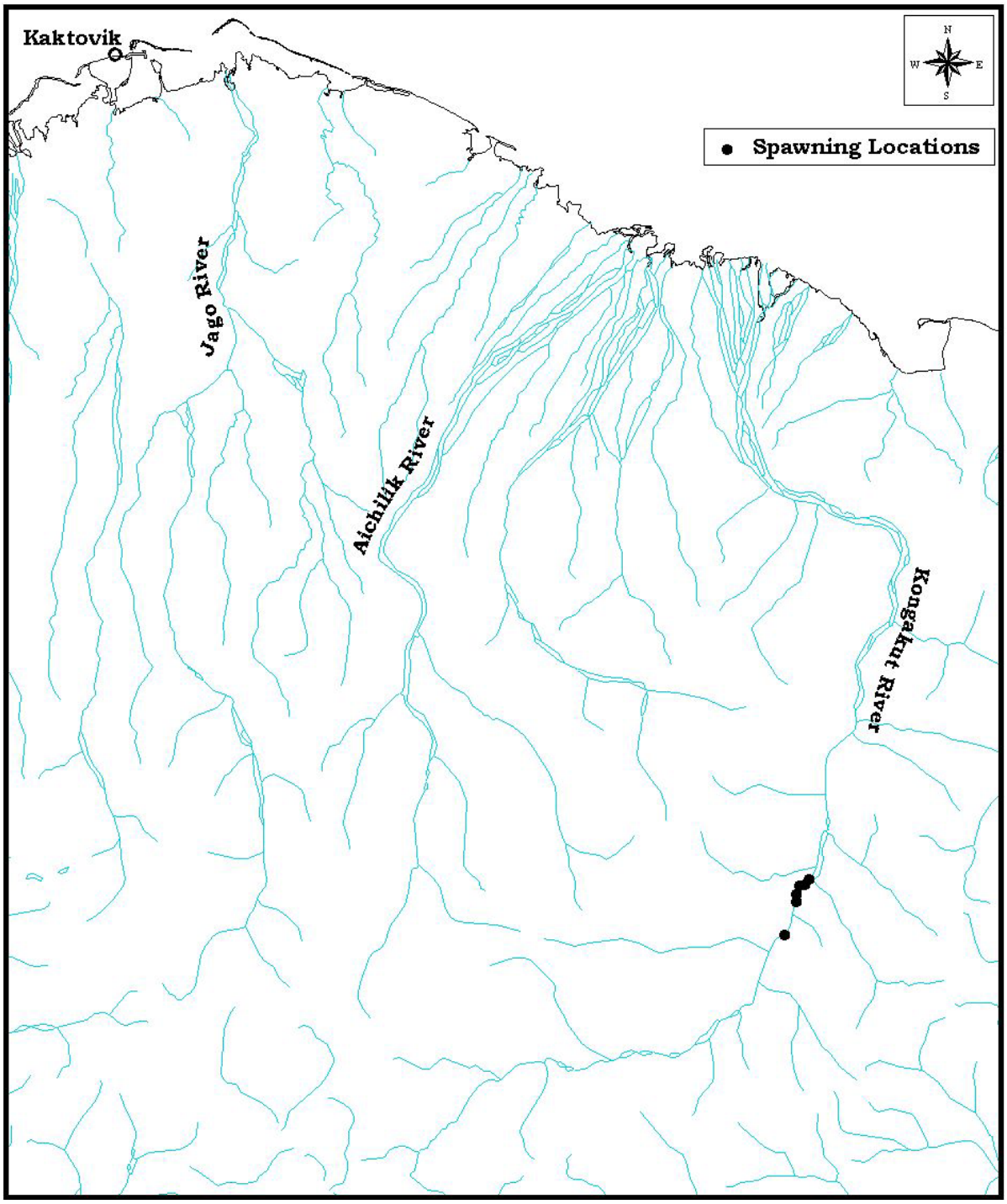

Figure 8. Dolly Varden spawning locations in the Kongakut River, Alaska, August 2001.

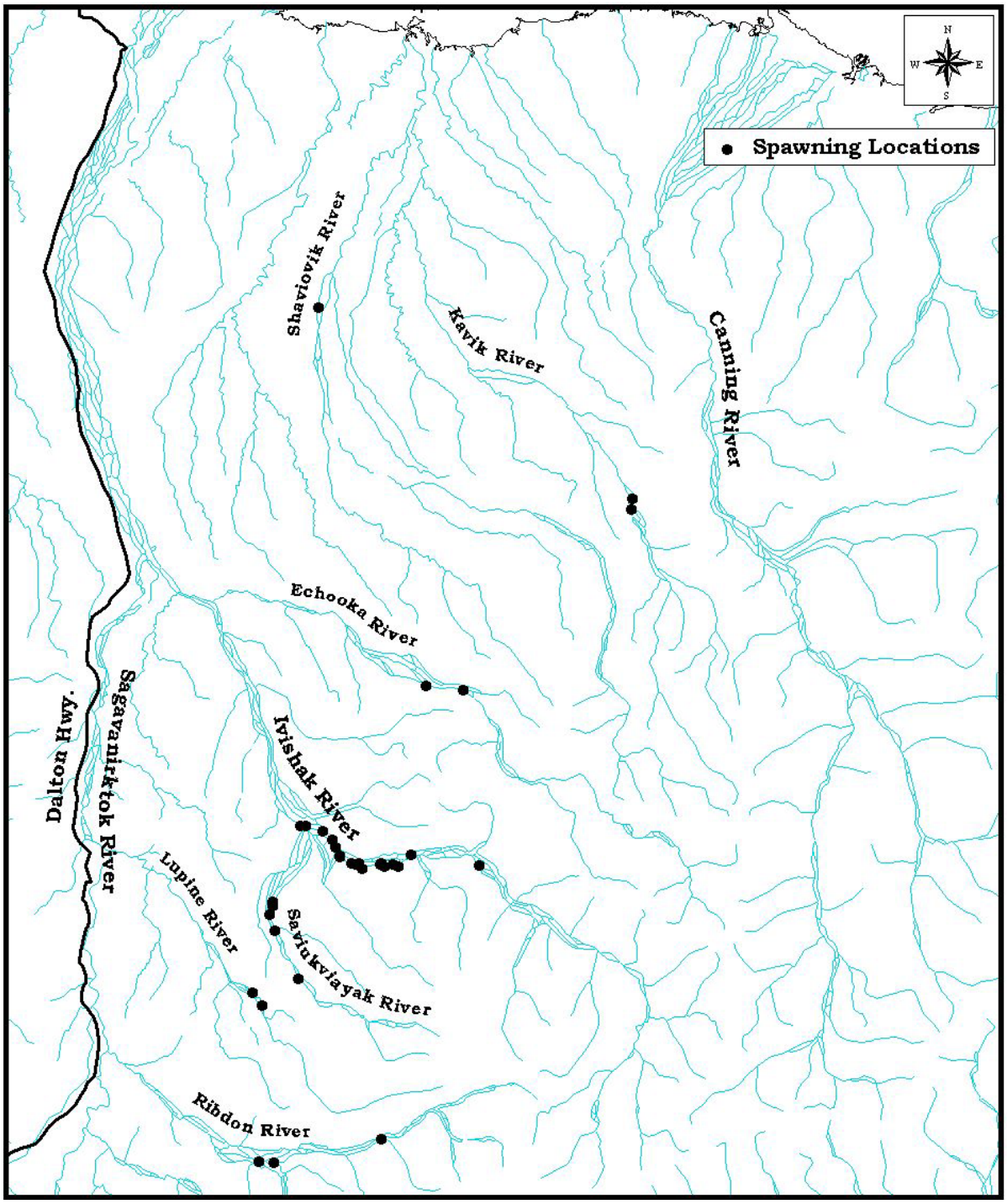

Figure 9. Dolly Varden spawning locations in the Ribdon, Lupine, Saviukviak, Ivishak, Echooka, Shaviovik, and Kavik rivers, September 2001 and 2002.

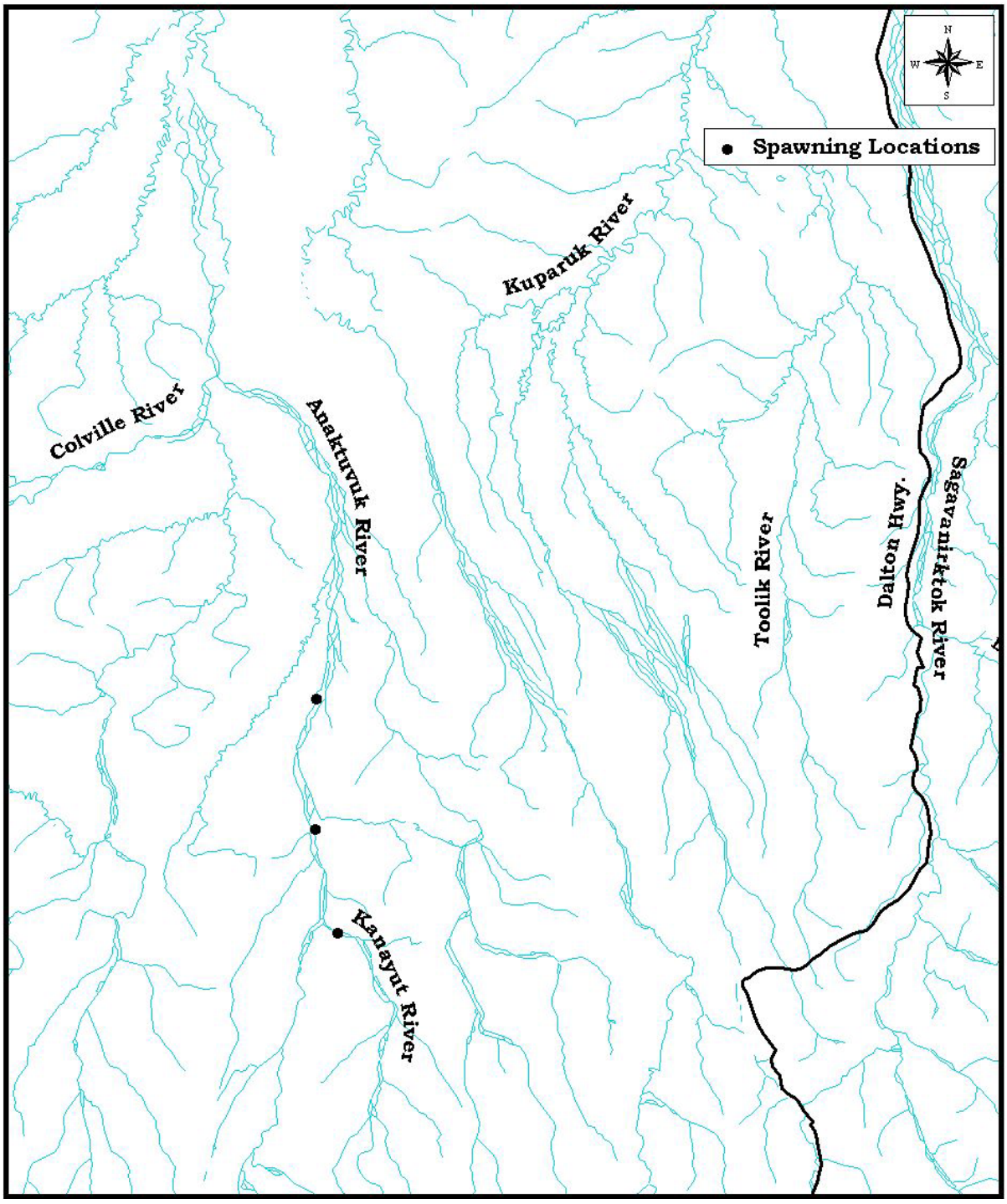

Figure 10. Dolly Varden spawning locations in the Anaktuvuk and Kanayut rivers, September 2002.

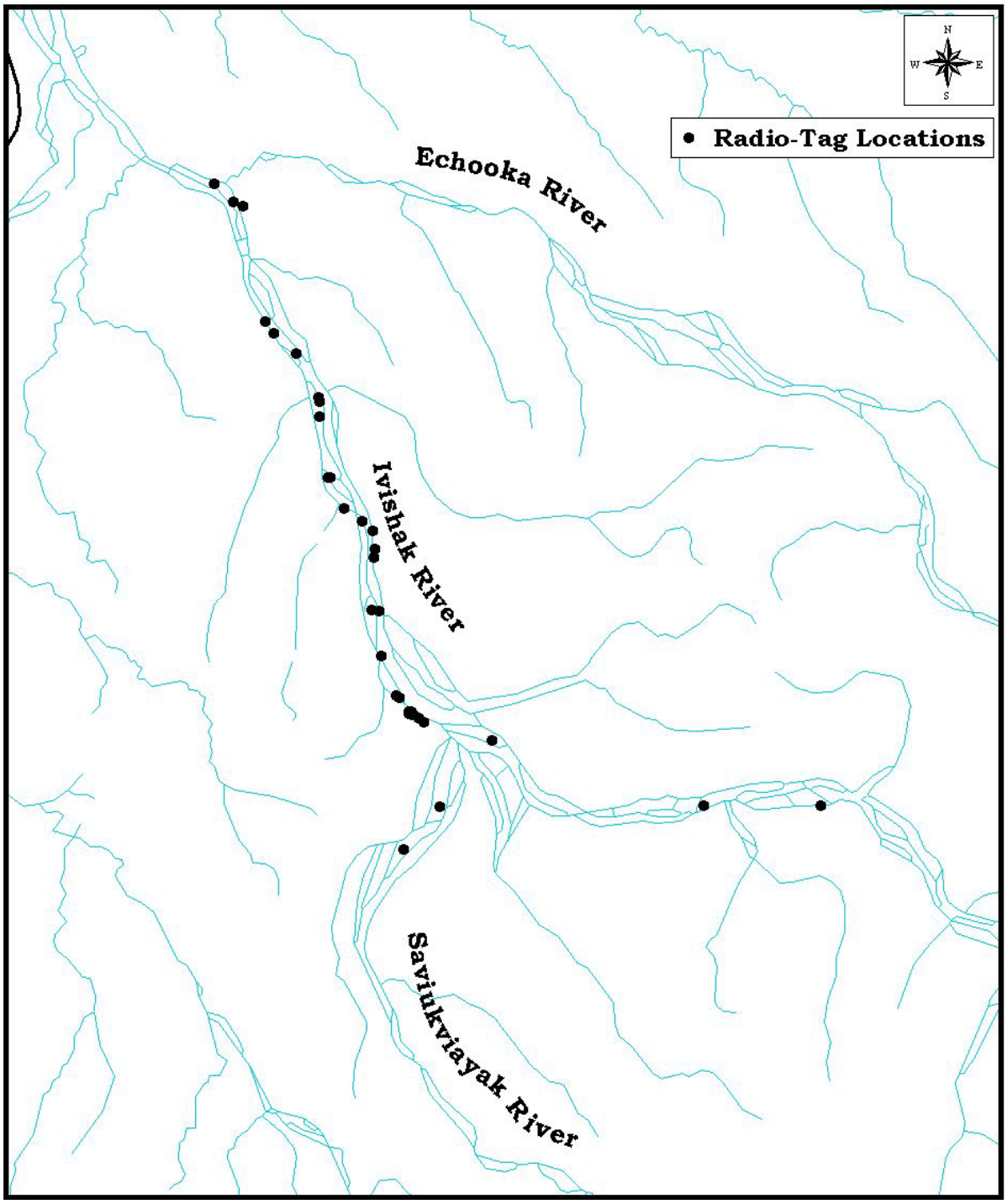

Figure 11. Dolly Varden wintering locations in the Ivishak River, April 2002.

During April 2003 all 40 fish tagged in September of 2002 were located, as well as the six fish tagged in 2001 that had returned to the index area in the fall of 2002. During April, 2003, overwintering fish were also dispersed within and below the 28-km index area used for the abundance estimate and the aerial surveys, but no fish were located upstream of the upstream boundary of the index area (Figure 12).

Baseline genetic samples of pre-smolt juveniles (200 fish from each drainage) were successfully collected during 2002 from the Anaktuvuk River and the Main and Marsh Forks of the Canning River. Baseline genetic samples of spawning adults (100 spawning adults) were successfully collected during 2002 from the Kavik River. In addition, during September 2002, partial samples of spawning adults were collected from or added to the collections from the Lupine, Ribdon, Anaktuvuk, Saviukviak, and Shaviovik rivers.

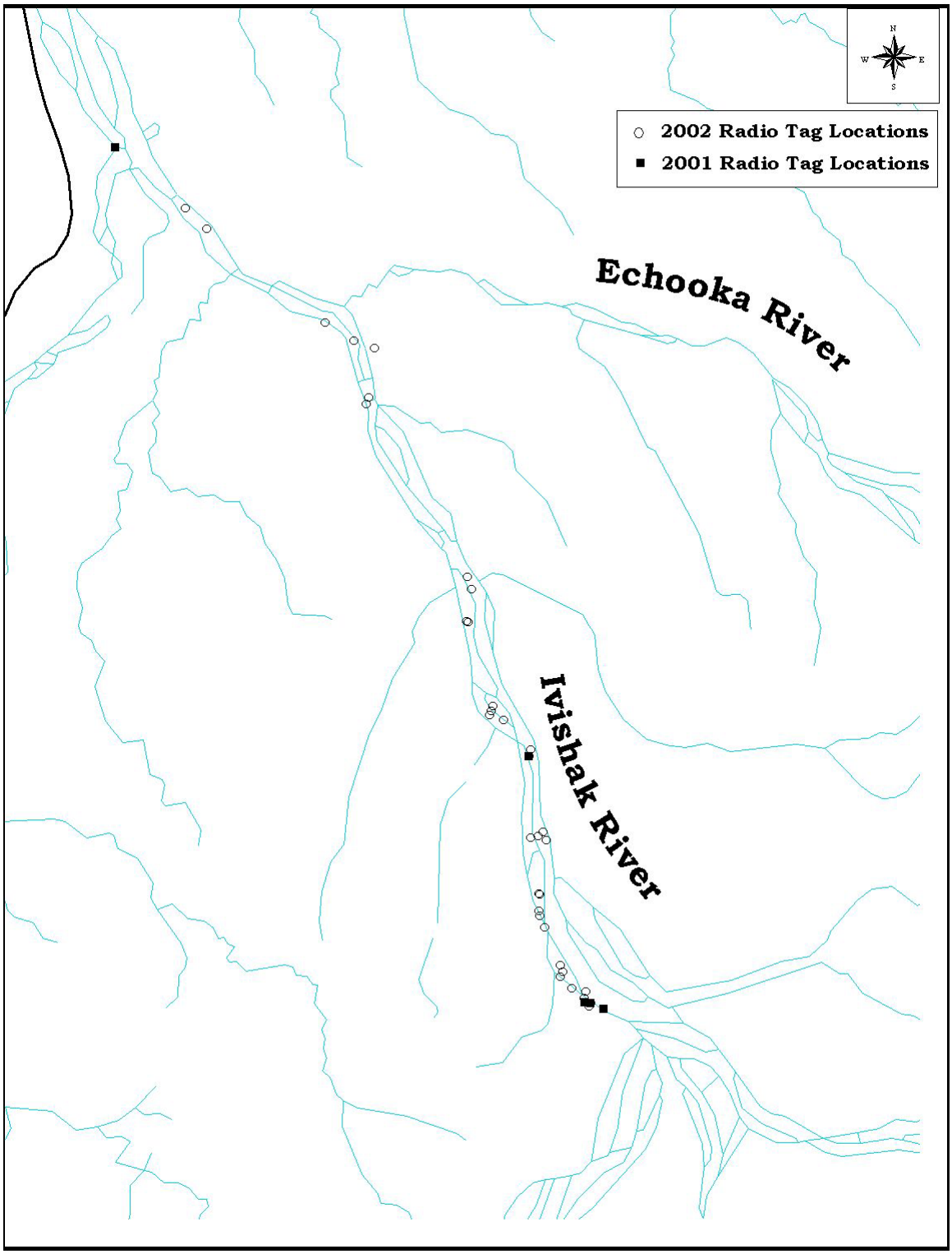

Figure 12. Dolly Varden wintering locations in the Ivishak River, April 2003.

DISCUSSION

Aerial Survey Variability Estimation

The average summed index area count of all sections for both observers from the five replicate aerial surveys was 5,408 fish with a standard error of 363. The 2002 counts showed higher variability than the 2001 counts, but were still relatively precise; with the coefficient of variation (CV) of the summed mean counts for 2002 of 6.7%. This compares with a CV of 2.8% for the counts from 2001.

The higher variability of the 2002 summed index area counts could be related to the smaller number of fish present, although in general, studies have indicated that aerial survey variability increases with the density of fish being counted (Bevan 1961; Eicher 1953; Jones 1995). Counting conditions during both years were similar, and the same observers and the same pilot conducted the counts. Aerial counts from 2002 also showed a similar pattern to the counts from 2001, in that during both years, the counts tended to increase in the upriver sections, and decrease in the downriver sections over the five days that replicate counts were made.

The average summed aerial count was just under half (45.5%) of the same average summed aerial count from 2001. The 2002 count of 5,408 represents 25% of the abundance as estimated by the mark-recapture experiment. This compares with the 2001 average aerial count representing 22% of the mark-recapture abundance estimate from 2001. Taking into account the variability in both methods (Delta method with alpha = 90%; Seber 1982), the aerial surveys counted between 19 and 31 percent of the abundance as estimated by the mark-recapture experiment.

This compares to the 2001 aerial counts (including the variability in both methods) that counted between 17 and 27 percent of the 2001 mark-recapture estimate. Although the variability of the aerial counts in 2002 was approximately double from 2001, the variability between replicates was still relatively small. More importantly, the proportion of the population counted (as measured by mark-recapture) was very similar between the two paired estimates, indicating that the method is not only internally precise, but also may be a consistent index of abundance.

Mark/Recapture Abundance Estimation

The abundance estimate for 2002 was just under 44% of estimate for 2001. This relationship is very similar to the two aerial survey estimates, but the variability surrounding the mark-recapture estimates is substantially higher than for the aerial survey estimates. The mark-recapture abundance estimate from 2001 had slightly better precision than the 2002 estimate ($RP_{0.90}$ of 0.22 for 2001 vs. $RP_{0.90}$ of 0.25 for 2002). Precision of both estimates was slightly lower than the criteria stated in the objective.

The average length of the sample was 450 mm, which was within 5 mm of the average sample length from both 2001 and 2000. The sample length distribution of all fish caught with seines was different from that of the fish captured in 2000 and 2001 (Figure 13). Because the same gear was fished in the same manner and locations in both years, these differences are not likely a result of variable gear selectivity's. Fish captured during 2002 showed a distinctly bi-modal distribution, with one peak around 250 mm. This indicates significant recruitment of small fish to the sampling gear. These fish probably represent a strong year class of returning first year out-migrants. The length distributions from 2001 and 2002 also show a shift in the main peak from around 425 mm to 485 mm, which is likely a shift due to growth in that age class.

The sample length distribution of the fish caught in 2002 was more similar to that reported by Yoshihara (1972, 1973) than the sample length distribution from 2000 or 2001. Samples collected by Yoshihara also were bimodal, with a small peak at 325 mm. The length distribution of the 2002 sample may have been affected not only by recruitment of first-year migrants to the sampling gear, but also by the percentage of mature fish spawning in 2002. Despite the overwintering abundance being roughly half from 2001, there were substantially more spawners present in the upper Ivishak during 2002 than in 2001.

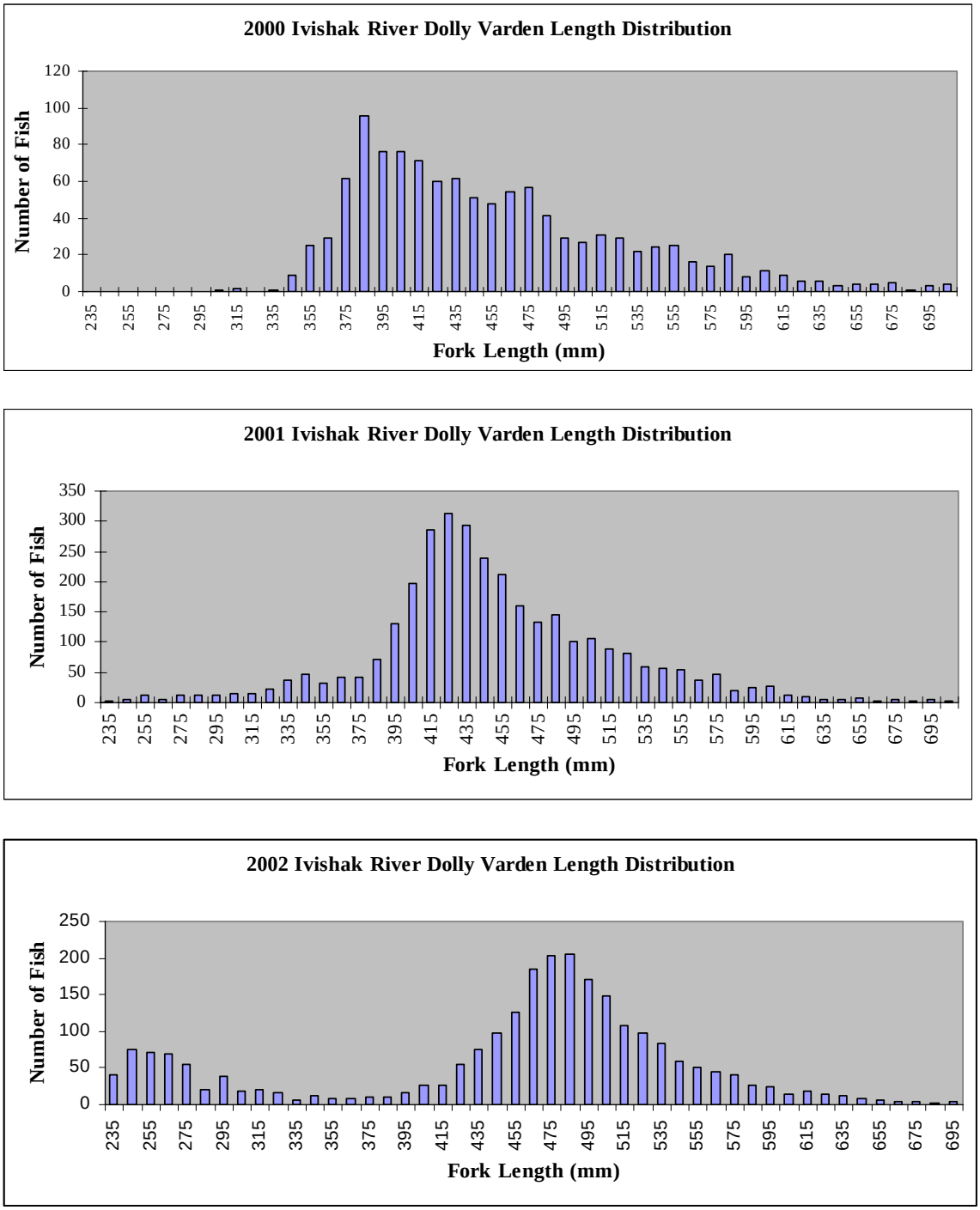

Figure 13. Length distribution of wintering anadromous Dolly Varden captured in the Ivishak River, September 2000 (n = 1,122), September 2001 (n = 2,955), and September 2002 (n = 2,445).

Radiotelemetry

The movements of the 40 fish radio-tagged within the assessment area showed that movement of fish during the experiment was almost exclusively upstream. None of the radio-tagged fish moved upstream of the upper boundary of the index area, including those 10 fish that were tagged near the upstream boundary. This pattern of movement was similar to 2001, and indicates that overwintering, non-spawning fish tend to move upstream during September, but concentrate within section one of the index area by late September. The movement indicated by radio telemetry during the mark-recapture experiment, combined with aerial surveys of the area below and above the index area indicated there was no substantial movement of fish into or out of the index area during the mark-recapture experiment.

Spawning and Overwintering Locations and Genetic Stock Identification Baseline Sampling

Spawning locations of Dolly Varden in the Ivishak, Echooka, and Kavik rivers appear to be widely dispersed, and primarily in the upper reaches of the drainages, within the Brooks Range. Spawning abundance of fall spawners in the Saviukviak, Ribdon and Lupine Rivers during 2002 was substantially lower than in the Ivishak, Echooka, or Kavik (Appendix B), and spawning locations in these drainages are also in the uppermost reaches of the drainages

In most drainages, most spawning groups consisted of less than 100 fish, however, during 2002 there were a number of very large groups (>200) spawners in the upper Ivishak. All spawning fish that were handled during 2002 had already spawned by September 20, which was markedly different from 2001, when no fish that were observed in spawning condition in these drainages after September 20. The timing of spawning, and the number of fish spawning, appears to be quite variable from year to year.

The distribution of spawners in the Anaktuvuk River during 2002 was significantly different than in the drainages to the east of the Dalton Highway. Spawners were only located in three areas, and those locations were near the area where large numbers of overwintering fish were located. These areas were not in the upper reaches of the drainage, but almost at the end of the foothills, near the beginning of the coastal plain.

Overwintering locations in the Ivishak River were widely dispersed, both within and below the index area. During both 2002 and 2003, approximately 25% of radio-tagged fish moved downstream of the locations they occupied in late September of the previous year, sometime between then and early April. In the fall of 2001, six fish were radio-tagged above the index area, three at a spawning area in the upper Ivishak, and three at a

spawning area in the Saviukviak. During the spring of 2002, two of these fish in each drainage had remained above the main overwintering area (the index area), near the locations where they were implanted (Figure 11).

No fish radio-tagged during September of 2002 had moved upstream of the upper boundary of the index area by April of 2003, and no fish radio-tagged during September of 2001 that were tagged within the index area had moved upstream of the index area. During both years, fish were dispersed well downstream of the index area, including below the Echooka River, and, in 2003, one fish had moved all the way downstream into the Sagavanirktok River (Figure 12).

The radio tags used were not equipped with mortality sensors, however, all fish located during the fall of each year had moved upstream between being located, indicating that no fish had died just after being implanted. No fish tagged in the fall of 2001 and located during the spring of 2002 were located during the fall of 2002, except for six, all of which moved upstream between September 19 and 24, 2002. Thus it is assumed that no fish located during April of each year were mortalities, since it is unlikely that the tags from a mortality would have washed downstream completely out of the drainage.

As of spring of 2003, complete genetic samples from spawning Dolly Varden have been collected from the Ivishak, Echooka, Anaktuvuk, Kavik, Main Fork Canning, and Marsh Fork of the Canning rivers. Incomplete baseline genetic samples have been collected from the Kongakut, Saviukviak, Shaviovik, Ribdon, and Lupine Rivers.

The majority of these samples have been analyzed for the development of marker regions that might distinguish stocks from drainages or groups of drainages. If sufficient genetic differences exist among spawning stocks, as previous research indicates (Everett et al. 1997, Krueger at al. 1999), this baseline will be compared to mixed-stock samples from subsistence fisheries if available, and from wintering populations, to attempt to estimate stock composition of these harvests or populations.

CONCLUSIONS

1. Replicate aerial counts of overwintering Dolly Varden within a 28-km section of the Ivishak River have relatively low variability, and these aerial counts appear to represent approximately 22% to 24% of the abundance in the same 28-km section as measured by mark-recapture methods.

2. The overwintering aggregation of Dolly Varden in the Ivishak River in the fall of 2002 was 21,634 (SE = 3,075).

3 Non-spawning anadromous Dolly Varden overwinter in the Ivishak River throughout an area of approximately 50 km of stream, from the confluence of the Sagavanirktok upstream to approximately the confluence of the Saviukviak River. In addition, fish spawning in the Ivishak and Saviukviak rivers may overwinter even higher in the drainages closer to the areas where they spawn. Overwintering habitat utilization is probably variable over time, due to shifting channel morphology and groundwater movement changes.

RECOMMENDATIONS

1. Aerial surveys of overwintering aggregations of Dolly Varden in North Slope drainages can be used as an indicator of overwintering abundance, but these surveys should be combined with surveys of spawning areas in the same drainage, since the number of spawners among the total overwintering population seems highly variable from year to year.

2. The specific locations of critical spawning and overwintering habitat used by anadromous Dolly Varden in Beaufort Sea drainages may change significantly between years within a relatively large area of a drainage. Protection of such habitat should not be based on locations determined during only one or a few years.

3. Stock-specific genetic samples should be collected from the remaining major Dolly Varden spawning stocks for which collections do not yet exist or are not yet complete (Nanushak, Kuparak, Aichilik, Hulahula, Lupine, Ribdon, Saviukviayak, upper Sagavanirktok, and Shaviovik rivers). Mitochondrial DNA from all baseline samples should be analyzed to establish a library of marker regions that could be compared with genetic samples from subsistence Dolly Varden fisheries on the North Slope to estimate the stock composition of those harvests.

4. Subsistence harvests of Dolly Varden in the communities of Kaktovik and Nuiqsut should be estimated for a minimum of two consecutive years, and genetic samples should be collected from those harvests to attempt to estimate the stock composition of those harvests (see recommendation 3).

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APPENDIX A

Appendix A. Methodologies for alleviating bias due to size selectivity by means of statistical inference.

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

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

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

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

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

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

[f] Case IV: Completely stratify both sampling events and estimate abundance for each stratum. Add abundance estimates across strata. Estimate length and age distributions from second event and adjust these estimates for differential capture probabilities.

APPENDIX B

Appendix B.–North Slope Dolly Varden spawning locations.

River	Date	Latitude (Degrees)	Latitude (Minutes)	Latitude (decimal minutes)	Longitude (Degrees)	Longitude (Minutes)	Longitude (decimal minutes)	Approximate Number of Fish
Kongakut	8/17/00	142	3	09	69	2	43	60
	8/17/00	141	59	54	69	4	45	75
	8/17/00	141	59	39	69	5	16	50
	8/17/00	141	58	46	69	5	44	90
	8/17/00	141	57	53	69	5	47	100
	8/17/00	141	56	55	69	6	06	40
Ivishak	9/24/00	147	43	04	69	2	04	120
	9/24/00	147	42	18	69	1	51	160
	9/24/00	147	35	57	69	2	32	85
	9/20/02	147	53	52	69	04	40	20
	9/20/02	147	52	88	69	03	82	40
	9/20/02	147	52	283	69	03	01	10
	9/20/02	147	55	61	69	05	97	10
	9/20/02	147	58	73	69	05	79	60
	9/20/02	147	59	22	69	05	76	110
	9/20/02	148	00	49	69	05	83	300
	9/20/02	147	52	10	69	02	98	15
	9/20/02	147	49	76	69	02	36	25
	9/20/02	147	48	64	69	02	25	135
	9/20/02	147	47	48	69	01	84	20
	9/20/02	147	43	17	69	02	04	125
	9/20/02	147	42	69	69	01	91	200
	9/20/02	147	48	12	69	02	231	30
	9/20/02	147	47	96	69	02	25	20
	9/20/02	147	40	320	69	01	91	50
	9/20/02	147	39	22	69	01	73	15
	9/20/02	147	20	96	69	01	13	35
Shaviovik	9/21/02	147	45	21	69	48	75	150
Echooka	9/19/01	147	59	80	69	24	42	40
	9/19/01	147	54	90	69	23	40	30
	9/19/01	147	50	96	69	23	16	40
	9/19/01	147	28	79	69	16	46	45
	9/19/01	147	30	16	69	16	98	50
	9/19/01	147	27	12	69	16	17	45
	9/19/01	147	24	85	69	16	09	50
	9/19/01	147	23	46	69	16	13	35
	9/20/01	147	22	83	69	16	07	150
	9/20/01	147	25	79	69	15	95	35

-continued-

Appendix B.–Page 2 of 2.

River	Date	Latitude (Degrees)	Latitude (Minutes)	Latitude (decimal minutes)	Longitude (Degrees)	Longitude (Minutes)	Longitude (decimal minutes)	Approximate Number of Fish
Echooka	9/20/01	147	19	89	69	15	65	50
	9/20/01	147	19	22	69	15	62	45
	9/20/01	147	12	72	69	11	62	40
Saviukviak	9/16/01	148	01	07	69	03	19	35
	9/16/01	148	02	62	69	02	55	40
	9/16/01	148	07	90	68	57	22	35
	9/16/01	148	04	09	68	53	18	25
	9/19/02	148	08	36	68	59	77	40
	9/19/02	148	08	27	68	57	34	30
	9/19/02	148	09	25	68	58	69	15
	9/19/02	148	08	24	68	59	78	20
	9/19/02	148	08	27	68	59	36	20
Ribdon	9/17/2002	147	48	73	68	39	34	50
	9/17/2002	147	48	69	69	02	23	25
	9/17/2002	148	16	42	68	38	38	25
	9/17/2002	148	13	10	68	38	17	15
Lupine	9/18/2002	148	14	54	68	52	41	20
	9/18/2002	148	12	83	68	51	29	25
	9/18/2002	148	14	54	68	52	41	35
Kavik	9/19/2003	69	30	9	146	37	41	15
	9/19/2003	69	28	47	146	36	36	10
	9/19/2003	69	28	22	146	36	9	20
	9/19/2003	69	27	97	146	35	88	15
	9/19/2003	69	27	81	146	35	90	25
	9/19/2003	69	25	73	146	34	45	35
	9/19/2003	69	30	10	146	37	29	15
	9/19/2003	69	30	19	146	37	12	80
	9/19/2003	69	29	32	146	37	46	30
	9/19/2003	69	31	87	146	38	1	30
	9/19/2003	69	31	87	146	39	21	20
	9/19/2003	69	32	34	146	39	33	25
	9/19/2003	69	32	28	146	39	55	65
	9/19/2003	69	33	29	146	39	75	50
Anaktuvuk		69	03	17	151	07	02	35
		68	52	32	151	08	52	20