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Abundance Estimates of Spawning Dolly Varden in Tributaries of the Togiak River, Togiak National Wildlife Refuge, Alaska, 2003

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Abstract

Mark-recapture was used to estimate the number of spawning Dolly Varden in three tributaries to the Togiak River in southwest Alaska: Trail Creek, Ongivinuck and Kemuk rivers. Spawning concentrations were spotted from the air during helicopter surveys and fish were captured with gill nets. Capture and recapture events occurred over a 1 or 3-day period for each tributary. Capture sample sizes in Ongivinuck (n = 46) and Kemuk (n = 45) rivers were insufficient for useful estimates of abundance. Sample effort in a 1.5 km stretch of Trail Creek resulted in 137 fish being caught and marked during a two-day capture event. A one-day recapture event resulted in the capture of 74 fish, of which 33 (44.6%) were recaptures. Abundance estimates were stratified by sex and length and combined for an estimated spawning population of 351 (95% CI 255 – 447; SE = 49.02) Dolly Varden greater than 375mm in the Trail Creek study section. The experiment was successful in one of the three spawning tributaries. Future work should emphasize locating several key spawning concentrations in each tributary that can be consistently sampled, and developing a more rigorous study design.

Introduction

Dolly Varden *(Salvelinus malma)* is an important species for subsistence and sport fisheries in southwest Alaska. One of the more heavily utilized subsistence fisheries occurs in the Togiak River in the Togiak National Wildlife Refuge (Refuge). In 1995, the estimated annual subsistence harvest of Dolly Varden from the Togiak River was nearly 11,000 (BBNA and ADFG 1996). Although the sport harvest is less than 200 fish (ADFG 2007), the sport catch averages over 4,000 fish per year (Alaska Department of Fish and Game, unpublished data).

To begin to construct a long term monitoring program for Dolly Varden stocks in the Togiak River, the Refuge began collecting data on the life history characteristics, spawning distribution and genetic stock composition in 1997 (Lisac and Moran 1999; Lisac and Nelle 2000; Reynolds 2000, Lisac and Buchholz 2001; Crane et al. 2003). Developing a long term stock monitoring program for this drainage requires an estimate of Dolly Varden abundance. Complex life history characteristics, mixed stock and mixed maturity migrations, and mixed stock overwintering aggregations, as well as drainage basin complexities, make estimating abundance of Dolly Varden stocks problematic. Radio telemetry and genetic analysis have shown that Togiak drainage Dolly Varden exhibit fidelity to spawning tributaries. Radio-tagged mature Dolly Varden that returned to the Togiak drainage in 1999 were tracked to the same spawning tributaries where they had spent the fall of 1998 (Lisac and Moran 1999; Lisac and Nelle 2000). Dolly Varden spawning in three tributary streams in 2000 exhibited significant genetic differences (Lisac and Buchholz 2001; Crane et al. 2003), indicating spawning site fidelity and

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geographic separation of spawning groups. During spawning, individual stocks segregate from one another in the smaller tributary streams. More importantly, these smaller spawning stocks segregate from the larger component of the run comprised of fish of unknown origin. Based on this previous work, we attempted to estimate the abundance of Dolly Varden spawners in selected areas of key spawning tributaries using mark-recapture techniques. The study objectives were to: determine the feasibility of estimating Dolly Varden spawner abundance in three spawning tributaries of the Togiak River using mark-recapture methods; and describe the length frequency distribution of spawning groups in these tributaries.

Study Area

The Togiak River drainage is located within the 4.7 million acre Togiak National Wildlife Refuge in southwest Alaska (Figure 1), and encompasses 4,572 km^2 (Walsh et al. 2005). The Togiak River flows 93.3 river-kilometers (rkm) from the outlet of Togiak Lake to Togiak Bay and ranges in width from 80 to over 120 m. Togiak Lake is approximately 22.5 km long and is fed by Upper Togiak Lake via Izavieknik River and High Lake via Trail Creek.

Five major named tributaries enter Togiak River downstream of Togiak Lake: Gechiak and Pungokepuk Creeks, and Kashaiak, Kemuk, and Ongivinuck rivers. Several smaller, un-named tributaries also enter the river. Headwater lakes are associated with all major tributaries, except for two. Additional descriptions and previous survey information on the tributaries and lakes of the Togiak valley are provided by USFWS (1990), Lisac and MacDonald (1996), and MacDonald (1997).

Methods

Spawning areas in each tributary where sampling occurred were identified from previous radio telemetry surveys (Lisac and Nelle 2000), genetic tissue collection surveys (Lisac and Buchholz 2001), or by visual observations made during surveys from helicopter. Concentrations of Dolly Varden were located via low-level survey using a Robinson R-44 helicopter. The downstream and upstream boundaries of a survey area were determined in the field based on changes in fish abundance or natural physical stream characteristics. Capture efforts began at the upstream boundary of the survey section and continued downstream. Monofilament gill nets (25m x 2m) with mesh size ranging from 25 mm to 75 mm were drifted through the entire area identified using multiple sets. These nets were effective in previous efforts to capture Dolly Varden; these fish are capable of avoiding more visible gill nets and seines (Kristofferson et al. 1991; Lisac and Buchholz 2001). Net sets (drifts) were of short duration to minimize the time fish spent entangled in a net.

Upon capture, the fish were removed from the gill net as quickly as possible and placed in a portable holding pen. Fish from multiple sets were transported in-river in the portable net pen until the density of fish in the pen necessitated processing. All captured fish were measured for fork length, sex and maturity index, given a unique mark (dorsal tag) and a secondary mark (partial fin clip). Maturity index values were: immature, prespawning, ripe, spawned-out or unknown.

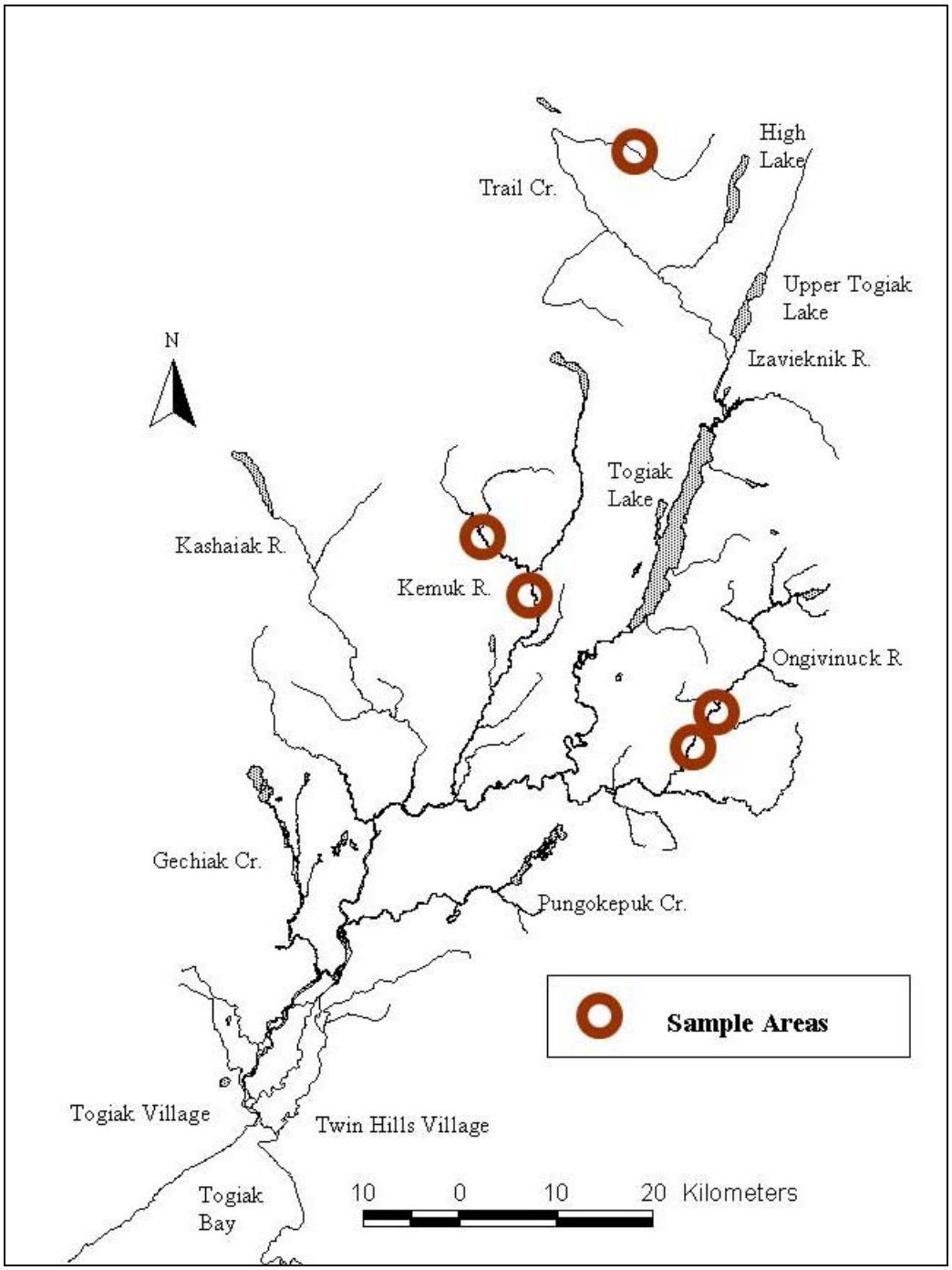

FIGURE 1. –Togiak River drainage and tributary sample locations, 2003.

A two-event mark-recapture sampling design was employed in three Togiak River tributaries between 25 and 28 September, 2003. Fish were captured over a one or two day marking event and recaptured during a one day recapture event. Mark and recapture events were separated by no more than a one-day hiatus. To account for size selection of the sample gear, the sampled population is defined as those fish having a length equal to or greater than the smallest fish encountered in the recapture event (Bernard and Hansen 1992). All marked fish from the first event or unmarked fish caught in the second event that are smaller than the smallest recaptured fish are excluded from the experiment. Fish that were captured, but did not have their length recorded were also excluded.

Abundance was estimated for a defined geographical area over a short period of time. Because the populations of Dolly Varden were believed to be relatively small and recruitment was assumed to be negligible, the Chapman modification of the Lincoln-Peterson estimator for closed populations was employed (Chapman 1951). This estimator is appropriate for small populations because it reduces statistical bias of the abundance estimate, which can be large when sample sizes are small (Bernard and Hansen 1992). A good discussion of the statistical properties and assumptions of the Chapman estimator is provided by Seber (1982). The primary assumptions are that: marks are not lost or missed; capture and marking fish does not affect fish behavior or mortality; the population is closed both geographically and demographically; and every fish has an equal probability of capture during at least one of the two capture events.

Fish were double marked during the initial capture event and all fish were thoroughly inspected for marks during the second event to identify marked fish and ensure that marks were not missed. The secondary mark of a partial fin clip was permanent throughout the duration of this study. Capture and handling techniques impart some level of stress on fish (Schreck and Moyle 1990). To minimize capture mortalities or the effects of handling on fish behavior, fish were handled with caution and released as quickly as possible.

Movement in and out of the sampling area was expected to be minimal because sampling took place in late September, targeting Dolly Varden in prespawning aggregates (Lisac and Nelle 2000, Lisac and Buchholz 2001). This aggregating behavior, in addition to the short duration of the experiments, was believed to minimize violations of demographic and geographic closure.

Homogeneity of capture probability cannot be directly tested with a two-event mark-recapture design, although certain violations of homogeneity and capture effects can be detected. Due to size-selectivity of gillnets (Millar and Fryer 1999; Bromaghin 2005), capture probability may be expected to vary with fish length, and the genders may respond differentially to capture and handling. Logistic regression (Hosmer and Lemeshow 2000) was used to model the probability of recapture as a function of gender, length, and the interaction of gender and length. Estimated parameters of the model were judged biologically meaningful if their statistical significance was less than $\alpha = 0.025$. Parameters of the logistic regression models were estimated using SAS Stat, version 8 (SAS 1999). Paired Kolmogorov-Smirnov (KS) tests (Conover 1999) were also employed to detect the presence of size-selectivity in the two capture occasions. The first KS test (KS #1) assessed the equality of the length distributions of (1) all fish marked during the first capture event and (2) all marked fish recaptured during the second capture event. The second KS test (KS #2) assessed the equality of the length distributions of (1) all fish captured during the first capture event and (2) all fish captured during the second capture event. The results of the paired KS tests were jointly interpreted to infer the presence of size-selectivity during the experiment (Bernard and Hansen 1992; Hetrick and Bromaghin 2006). Exact KS tests were conducted using StatXact 7 (Cytel 2005). The test results were used to guide decisions regarding the need to stratify abundance estimation by gender or length.

Results

Field operations were conducted during five days from 25 to 29 September, 2003. Two areas with small concentrations of fish were located in each of the Ongivinuck and Kemuk Rivers. Ten gill net drifts resulted in the capture of 46 Dolly Varden in the two sections of the Ongivinuck River on 27 September (Table 1 and 2; Figure 2). The maturity of the 44 unique fish

was designated as ripe (12), prespawning (30) and unknown (2). Seven gill net drifts resulted in 45 Dolly Varden being captured in two sections of the Kemuk River on 29 September(Table 1 and 2; Figure 2). The maturity of the 38 unique fish was designated as ripe (22), prespawning (10) and spawned-out (6). Because only small concentrations of spawning fish were observed and capture success was low, no effort was made to recapture fish in these tributaries.

TABLE 1. –Number of Dolly Varden by tributary, capture event, and gender, Togiak River 2003.

Tributary	Event	Caught	Marked	Recaptured	Males	Females
Trail Creek	Mark	137	137		63	74
	Recapture	74		33	48	26
	Total	211		33	111	100
Ongivinuck River	Mark	46	44	2	12	32
Kemuk River	Mark	45	38	7	24	14

A larger concentration of Dolly Varden was located in an approximately 1.5 km section of Trail Creek. Sixty gill net drifts resulted in 211 Dolly Varden being captured in Trail Creek (Table 1). Efforts occurred on 25, 26 and 28 September. Of the 211 fish caught, 137 were initially marked and released in the 2-day marking event. Of the 74 fish caught during the recapture event, 33 (44.6%) were recaptures from the first event and 41 fish were captured for the first time. There were 175 individual fish measured for length, comprised of 85 males and 90 females (Figure 2). The maturity of these fish was designated as ripe (50), prespawning (20), or spawned-out (105). Mean fork lengths of fish caught in Trail Creek were similar between the marking event and the recapture event (Table 2). Because 376 mm was the minimum length of recaptured fish, the abundance estimate used only those fish marked, caught and recaptured during all events that were greater than 375 mm. This resulted in 133 fish initially caught, measured and marked, and 71 fish recaptured. The number of usable recaptures was reduced to 32 because one fish had no length measurement recorded.

TABLE 2. –Mean fork lengths (mm) for Dolly Varden by tributary of capture, capture event and sex, Togiak River 2003.

Ongivinuck River	All	Males	Females
Mean FL	480.2	547.3	455.0
SD	73.41	88.90	47.68
n	44	12	32
min	380	403	380
max	675	675	555

Kemuk River	All	Males	Females
Mean FL	499.6	490.5	515.1
SD	69.49	70.42	67.53
n	38	24	14
min	366	370	366
max	658	615	658

Trail Creek	All	Males	Females
Mean FL	472.3	489.0	456.6
SD	62.57	69.89	50.28
n	175	85	90
min	296	296	358
max	640	640	550

Trail Creek	Mark Event	Recap Event	Recaptured Fish
Mean FL	477.0	478.2	505.4
SD	58.95	67.44	49.76
n	136	71	32
min	358	296	376
max	611	640	581

The logistic regression model of the probability of recapture as a function of gender and length contained a significant gender effect ($X^2 = 13.86$; df = 1; p = 0.0002); terms for length (p = 0.0404) and the interaction of gender and length (p = 0.7542) were not statistically significant. The estimated recapture probability was 0.1081 for females and 0.3968 for males.

Because the recapture probability differed by gender, the paired KS tests were conducted separately for each gender. None of the KS tests were statistically significant (Figure 3). The KS test results and lack of significant length terms in the logistic regression models suggest that capture probabilities were independent of size during both capture events.

Because of the significant gender effect in the logistic regression model, abundance estimation was stratified by gender (Table 3). The total abundance of fish greater than 375 mm within the Trail Creek study area, estimated as the sum of the gender-specific estimates, was 351 (95% CI = {255 -- 447}; SE = 49.02).

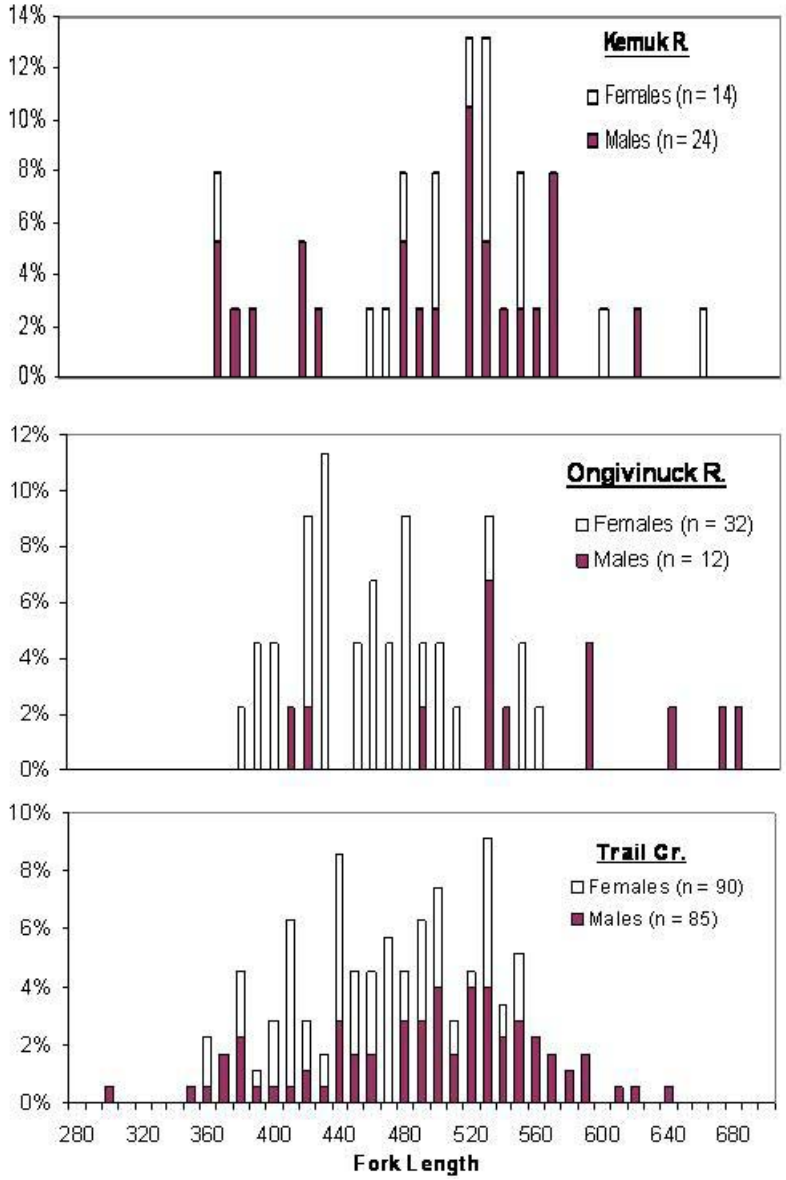

FIGURE 2. –Fork length (mm) frequency distributions for Dolly Varden from three tributary sample locations, Togiak River 2003.

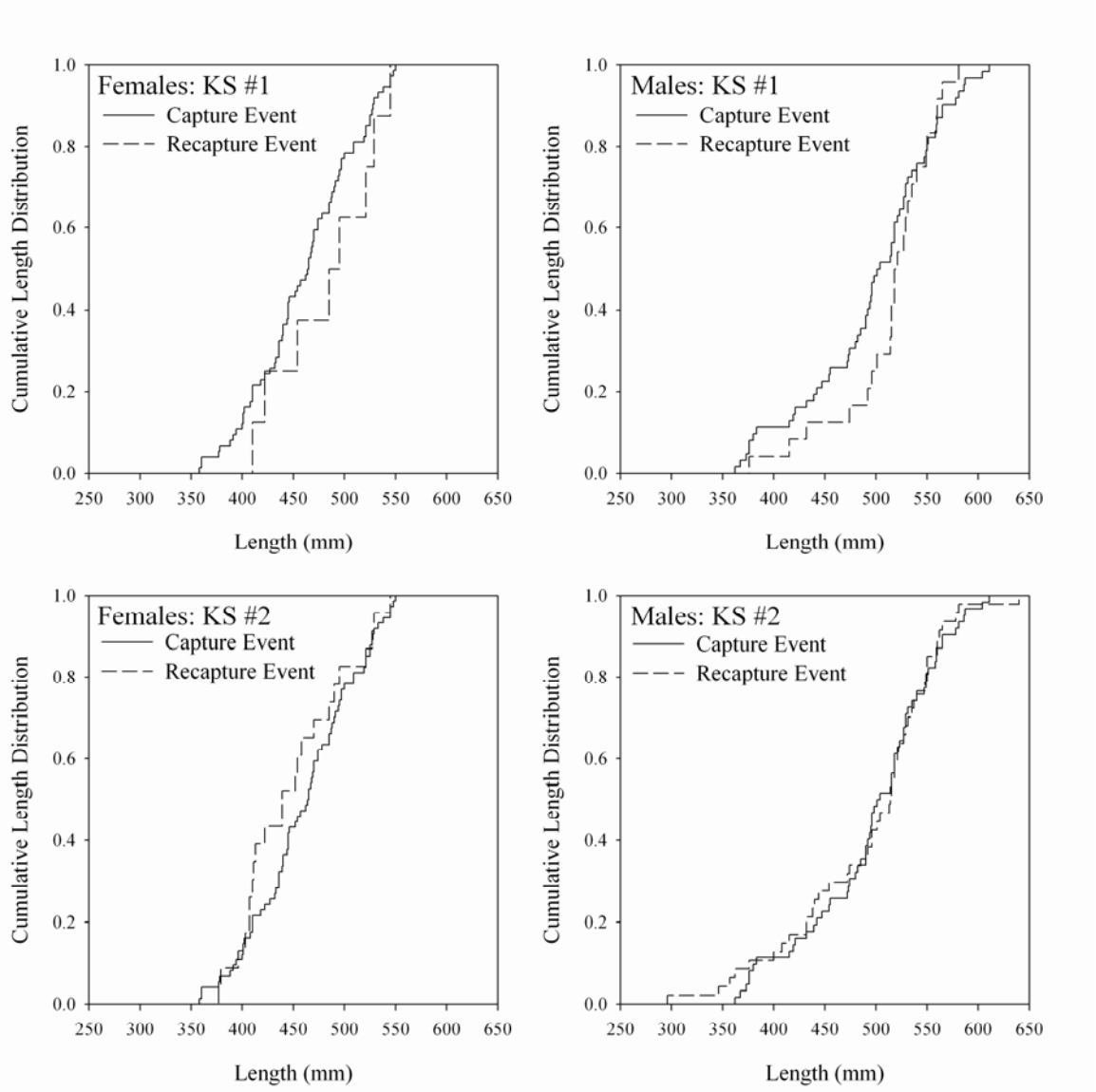

FIGURE 3. – Cumulative fork-length (mm) frequency distributions for Dolly Varden, Trail Creek, 2003. One test (KS #1) compares the length distribution of all fish marked during first event with that of all marked fish recaptured during second event. The second test (KS #2) compares the length distributions of all fish captured in first event with that of all fish captured in the second event. The p-values of the tests were 0.5925 for Females KS #1, 0.4340 for Females KS #2, 0.2180 for Males KS #1, and 0.9924 for Males KS #2.

TABLE 3.—Estimated abundance of fish greater than 375mm, stratified by gender, Trail Creek 2003.

	Males	Females	Total
Marked & released	62	71	133
Caught event 2	47	24	71
Recaptured event 2	24	8	32
N	126	225	351
Var	162.6	2240.0	2402.6
SE	12.75	47.33	49.02
95% CI lower limit	101	132	255
95% CI upper limit	151	318	447

Discussion

This pilot study to estimate the abundance of Dolly Varden spawner abundance proved only partially successful. Locating large enough concentrations of mature fish was easily accomplished in the smallest of the three tributaries. Trail Creek is narrow (< 20 m) and water conditions were low and clear during this study period. This allowed fish to be easily sighted and captured. Capture methods were ineffective in the other tributaries, though the exact reason is unknown: limited visibility, more widespread spawning locations and timing, lower numbers of spawning Dolly Varden, or a combination of these or other factors. Increasing survey intensity (more frequency and extensive drainage coverage) may prove successful at locating additional spawning concentrations in the other drainage tributaries. In the larger tributaries, using larger nets in conjunction with downstream block or trap nets would likely increase capture success.

Survey timing might have also contributed to the poor capture results in the larger tributaries. Active spawning was observed in the Trail Creek study section and most fish were spawned-out (60%) or ripe (28.6%). Fish captured in the Ongivinuck River were primarily (71.4%) in prespawning condition or ripe (28.6%). Fish captured in the Kemuk River were primarily ripe (57.9%) or prespawning (26.3%), with 15.8% of the fish spawned out. It appears from the lower proportion of spawned out fish that the peak of spawning occurs later in the Kemuk and Ongivinuck tributary groups. It is possible that not all the mature fish had yet reached these spawning areas. Previous telemetry studies (Lisac and Nelle 2000) indicated that prespawning fish entered the tributaries during August. Spawning was inferred to generally occur from mid-September to mid-October based on the furthest upstream movement of individual fish and the lack of movement during that time. No on-grounds observations of spawning were made during that study and the frequency of tracking flights did not allow for a more detailed analysis of individual tributary groups spawn timing. Radio-tagged fish descended the tributaries during late October and November and it was assumed spawning was over at that time.

The analysis revealed a potential negative response by females to the capture and handling associated with this study. The estimated recapture probability for males was over 350% that of females. The total sample size between the two capture events declined by 48%, while the number of females in the two samples declined by 69%. Whether this observed response is due to emigration, a behavioral (trap-shy) response, or mortality is not known. Future studies of this type may address this question by increasing the number of capture events and extending sampling efforts outside the study area.

The abundance estimate of 351 mature Dolly Varden in the Trail Creek study area appears reasonable, but a large standard error (SE =49.02) is associated with this estimate. This large error is primarily due to the small number of recaptured females when abundance estimation is stratified by gender. Locating additional spawning groups in this tributary, and more detailed genetic analysis, may give more insight into how this one spawning area can contribute to the management goal of developing methods to monitor the long term health of Dolly Varden populations in the Togiak Refuge.

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