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Characterize and Quantify Residual Steelhead in the Clearwater River, Idaho

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CHARACTERIZE AND QUANTIFY RESIDUAL STEELHEAD IN THE CLEARWATER RIVER, IDAHO

FINAL REPORT 1999-2002

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Executive Summary

During 1999-2002 we determined whether size at release and release site influenced emigration success and survival of hatchery steelhead smolts raised at Dworshak National Fish Hatchery and released into the Clearwater River drainage. We marked 4,500 smolts each year with Passive Integrated Transponder Tags (PIT-tags) which enabled us to track emigration and estimate survival through mainstem Snake and Columbia river dams. Hatchery steelhead raised in System I freshwater were significantly smaller than those raised in warmer System II re-use water (196 mm, 206 mm, 198 mm and 201 mm System I; 215 mm, 213 mm, 206 mm and 209 mm System II). However, there was no significant difference in detection rates to mainstem observation sites between the two groups (65%, 58%, 78% and 55% System I; 69%, 59%, 74% and 53% System II). Survival estimates to Lower Granite Dam were also not significant between the two groups (72%, 81%, 80% and 77% System I; 77%, 79%, 77%, and 72% System II). Smolts less than 180 mm FL were less likely to be detected than larger smolts.

Hatchery steelhead smolts released into Clear Creek, the South Fork Clearwater River and the Clearwater River at Dworshak National Fish Hatchery had significantly different lengths each year, but there was no discernible pattern due to random egg takes and rearing systems. Detection rates to mainstem observation sites for smolts released into Clear Creek were significantly less than the other two groups in all years except 2002 (62%, 57%, 71%, and 57% Clear Creek; 68%, 63%, 73% and 61% South Fork Clearwater River; 70%, 59%, 78% and 55% Clearwater River). However, survival rates to Lower Granite Dam were not significantly different (73%, 65%, 78%, and 77% Clear Creek; 79%, 72%, 79% and 76% South Fork Clearwater River; 81%, 76%, 80% and 83% Clearwater River). Similar to the size at release group, smolts less than 180 mm FL were less likely to get detected than larger smolts.

Smolts from both size at release and release site groups that were mature at tagging rarely migrated downstream. If smolts migrated they did it in the same year they were released, as less than 0.02% were observed migrating the second year.

We sampled the Clearwater River, North Fork Clearwater River, Bedrock Creek, Big Canyon Creek, Cottonwood Creek, Jacks Creek and the Dworshak National Fish Hatchery adult ladder to collect residual hatchery steelhead. We PIT-tagged and released 3,651 hatchery steelhead and collected 645 hatchery steelhead for coded wire tags. Most residual hatchery steelhead were caught within 4 rkm of Dworshak National Fish Hatchery. Hatchery steelhead sampled in the North Fork Clearwater River and the Dworshak Hatchery adult ladder were significantly larger than those sampled in the Clearwater River and lower tributaries in all years except 2001 (205 mm, 205 mm, 223 mm and 238 mm North Fork Clearwater River; 190 mm, 182 mm, 226 mm and 189 mm Clearwater River). Of the hatchery steelhead we PIT-tagged, only 12% were observed at downstream observation sites. Most migrants were tagged in the Clearwater River (91%) and were smaller than hatchery steelhead that were tagged but were not detected. Most migrants were detected in the same year they were tagged, but 14% held over and migrated in the second year after tagging. We documented migration outside of the normal window, as one detection occurred on October 31 at Lower Granite Dam.

We recaptured 130 individual hatchery steelhead that we had tagged during sampling. Over 77% of the recaptures were within one km of where they were tagged, and 67% of the recaptures were tagged in the North Fork Clearwater River and the Dworshak Hatchery adult ladder. We calculated a mean growth rate of 0.27 mm/day for fish we recaptured. For those hatchery steelhead we PIT-tagged, the proportion of males was 13%, the rest we could not ascertain gender. All the males were precocious.

Over 97% of the coded-wire tag recoveries came from hatchery steelhead released at Dworshak National Fish Hatchery. The Contribution group (random egg take and rearing system) comprised 44% of the recoveries, followed by 32% System I and 24% System II. The mean length of the Contribution group was significantly smaller than the other two groups in all years except 2001 (173 mm, 191 mm, 209 mm and 197 mm Contribution; 210 mm, 206 mm, 205 mm and 228 mm System I; 226 mm, 216 mm, 213 mm and 225 mm System II). Males made up 81% of the recoveries, and their maturity ranged from 0% to 100%. The Contribution group had significantly more males than the other two groups in 1999 and 2001.

Stomach content analysis for all hatchery steelhead sampled indicated that most of their diet was aquatic insects in the orders Ephemeroptera, Diptera and Trichoptera. Fish parts were found in less than 2% of all stomachs, indicating predation on other fish was minimal.

Acknowledgements

We thank our colleagues at the Idaho Department of Fish and Game and the U. S. Fish and Wildlife Service Idaho Fishery Resource Office for help in sampling. Particularly we would like to thank Aaron Garcia, Steve Bradbury and Billy Connor. Patricia E. Bigelow initiated this project and was the project lead from 1999-2000. Chris Larson was project lead in 2001 and early 2002. Funding for this project was provided by the Bonneville Power Administration and administered by Allyn Meuleman (1999-2002), Mark Ralston (2002-2004) and Tracy Hauser (2004-2006).

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Project Overview

The intent of the steelhead *Oncoryhnchus mykiss* mitigation program at Dworshak National Fish Hatchery (DNFH) is to annually return 20,000 adult steelhead to the mouth of the Clearwater River in Idaho for tribal and sport harvest while perpetuating and maintaining the unique genetics of the North Fork B-run summer steelhead population (Miller 1987; U.S. Fish and Wildlife Service 2002a). Approximately 2.1 million steelhead smolts are released annually by DNFH into the Clearwater River Basin; 1.2 million steelhead smolts are released directly into the Clearwater River at DNFH and the remaining smolts are released at sites upstream at Clear Creek and the South Fork Clearwater River.

The Clearwater River drainage has two unique runs of summer steelhead, A-run and B-run, as well as Snake River Fall Chinook salmon *O. tshawytscha*, all listed as threatened under the Endangered Species Act. Hatchery-reared fish have been shown to ecologically impact wild fish species through behavioral displacement, (McMichael et al 1999), agnostic interactions (McMichael et al 1992, Pearsons et al 1993), wild fish growth (McMichael et al 1997), and genetic introgression (Busby et al. 1997; Levin and Williams 2002). The summer steelhead program at DNFH has the potential to adversely affect these listed species through these mechanisms, as well as predation, competition, disease transmission, alteration of the gene pool, harvest, and/or facility operation and maintenance (USFWS 2004).

The Clearwater River A-run summer steelhead are native to low elevation tributaries downstream of the Selway and Lochsa rivers, and in the lower South Fork Clearwater River drainage (Nez Perce Tribe and Idaho Department of Fish and Game 1990) (Figure 1). A-run adults typically spend one to two years in the ocean before entering the Columbia River during the summer. They migrate upstream and overwinter in the mainstem Clearwater River and Snake River, spawn from February through early May, and juveniles rear for one or two years before migrating to the ocean (Nez Perce Tribe and Idaho Department of Fish and Game 1990). A-run summer steelhead in the Clearwater River are managed as a wild population since no hatchery supplementation has occurred for this run.

B-run summer steelhead are native to the Lochsa, Selway, and upper South Fork Clearwater rivers, and the North Fork Clearwater River prior to extirpation by the construction of Dworshak Dam (Kiefer et al. 1992) (Figure 1). B-run adults typically spend 1-3 years in the ocean before returning to spawn, with the majority having spent two years before entering the Columbia River in the fall or winter. Spawning typically occurs from mid March through early June, with juveniles rearing one to three years before migrating to the ocean (Byrne 2003). B-run populations with little or no hatchery influence occur in the Lochsa and Selway river drainages. These populations are genetically different than the native North Fork B-run steelhead raised at DNFH (USFWS 2004, Nielsen et al 2004). The South Fork Clearwater drainage and larger tributaries to the Middle Fork Clearwater River have been heavily supplemented with DNFH steelhead.

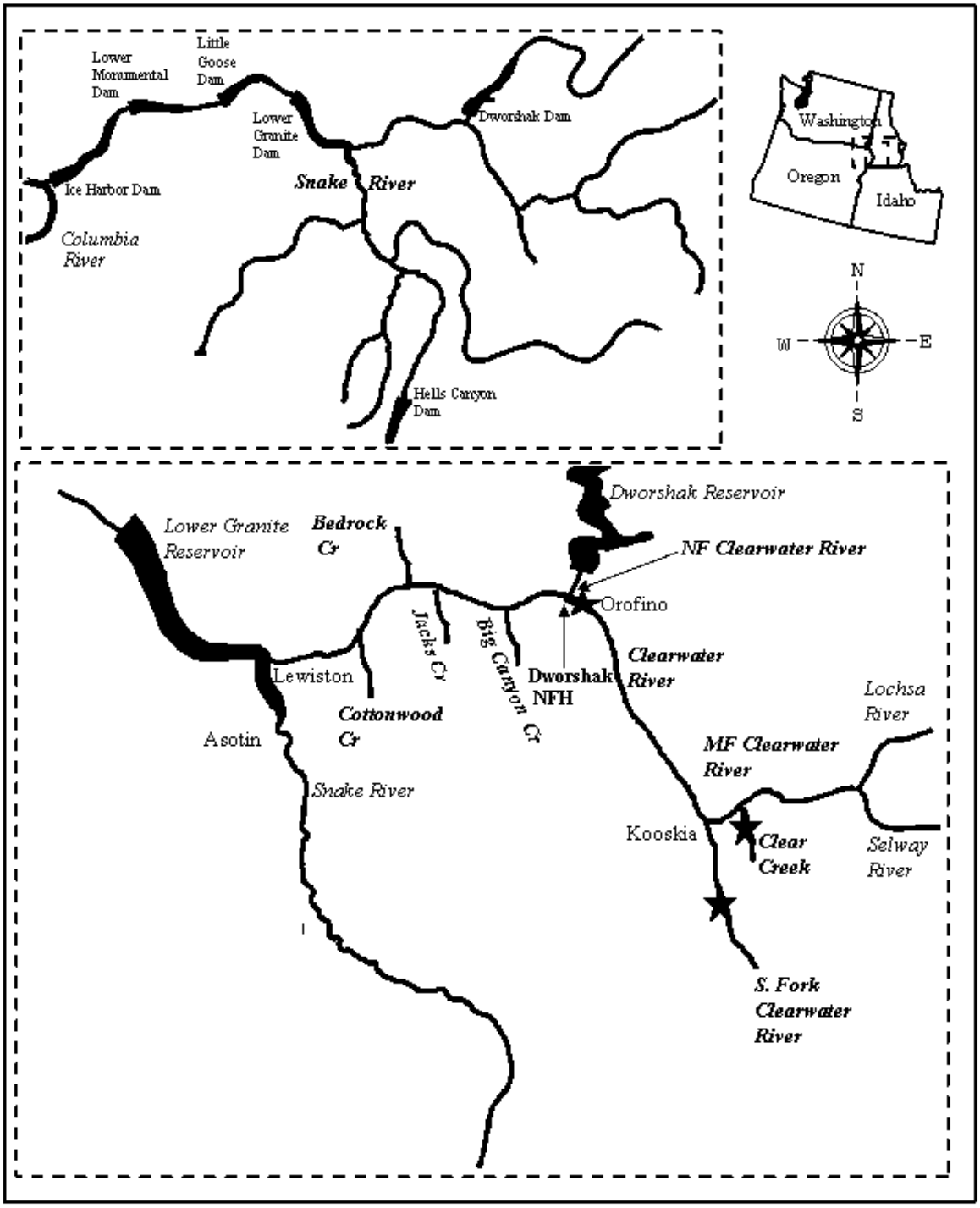

Figure 1. Map of release sites (depicted by stars) and area sampled for hatchery steelhead released from Dworshak National Fish Hatchery, Idaho, 1999-2002. Stars represent smolt release sites.

Previous studies have documented that a large percentage of the steelhead released into the Clearwater River from DNFH never reach Lower Granite Dam located 116 km downstream from DNFH (Bigelow 1995a, Bigelow 1997). These non-migrating B-run steelhead, termed residuals, have been found cohabitating with wild A-run steelhead (Connor 1989, Bigelow 1995b, Bigelow and Bowen 1997) in tributaries downstream of DNFH. This has caused a region wide concern that residuals may be having a negative impact on wild fish in the Clearwater River basin, yet little is known about characteristics of the hatchery steelhead which residualize. Viola and Schuck (1995) found that hatchery steelhead that residualized in the Tucannon River in Washington were predominantly males, over half of the males were precocial, and their length was 230 mm or greater. However, Bigelow (1997) found that steelhead smolts <180 mm FL released from DNFH were much more likely to residualize than smolts 180-200 mm FL or >200 mm FL.

Our project goals were to maximize efficiency of hatchery operations and minimize impacts of residual steelhead on wild fish in the basin. Specific objectives included characterizing successful smolts, unsuccessful smolts (residuals), and comparing the differences. There were three components of this study. The first component evaluated emigration success of steelhead smolts reared from the first three egg takes, raised in either in System I (freshwater, colder water temperature, typical growth) or System II (re-use water, warmer water temperature, faster growth), and released directly into the Clearwater River at DNFH. The second component evaluated emigration success of steelhead smolts reared from random egg takes, raised in Systems I, II or III (same characteristics as System II), and released at DNFH, Clear Creek or the South Fork Clearwater River. The third component collected information from juvenile hatchery steelhead sampled in the mainstem and tributaries downstream of DNFH. This report summarizes the data collected and findings for the years 1999-2002.

CHAPTER ONE

Emigration Success of Dworshak National Fish Hatchery Steelhead Smolts
Evaluated By Size at Release and Release Site

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Introduction

Dworshak National Fish Hatchery (DNFH) steelhead *Oncorhynchus mykiss* are released as smolts with a target size of 200 mm FL at release. Bigelow (1997) found that smaller steelhead (<180 mm FL) were much more likely to residualize and migrated at a different rate than those between 180-200 mm or >200 mm. Steelhead that are not ready to smolt and instead residualize in lower Clearwater River tributaries or the lower Clearwater River present potential for conflict by directly competing with wild or natural salmonids for food, rearing space, and/or preferred habitats.

To achieve the 200 mm target size, several strategies are practiced at DNFH. The adult fish ladder is operated during the fall to ensure inclusion of sufficient early arriving steelhead (~500 adults) into the hatchery gene pool. The trap is then reopened from February through April to capture broodstock from the middle and late portions of the run. Collecting adults from the time they begin to appear at Dworshak until the run is over ensures that genetic differences attributable to run timing are included in the broodstock (U.S. Fish and Wildlife Service 2004).

The first two egg takes for the returning brood year are from adults collected during the fall trapping season, and the third egg take is from ripe, freshly trapped adults in the spring. Approximately 400,000 smolts, or about 20 percent of the smolts released at DNFH, are progeny from these early return adults (U.S. Fish and Wildlife Service 2004). The remaining egg takes are from adults trapped in the spring. Juveniles can be reared with freshwater (System I, colder water temperature, typical growth) or a re-use system (System II and System III, warmer water temperature, faster growth), depending on growth goals and disease issues. Juveniles are reared as one year smolts, primarily due to space constraints at the facility, and released directly into the Clearwater River.

We evaluated the emigration success of steelhead smolts reared from the first three egg takes, raised in either System I or System II, and released directly into the Clearwater River at DNFH. We also evaluated emigration success of steelhead smolts raised from randomly selected egg takes, reared in Systems I, II or III, and released at DNFH, Clear Creek and the South Fork Clearwater River.

Methods

Project area

Steelhead smolts were released at DNFH and two sites upstream (Figure 1). Dworshak National Fish Hatchery is located at the confluence of the North Fork Clearwater River, approximately 65 rkm upstream of the Snake River, and 116 rkm above Lower Granite Dam (Figure 1), the first detection site for the study. Clear Creek is a tributary to the Middle Fork Clearwater, entering approximately 4 rkm above the confluence of the South Fork Clearwater River. Steelhead smolts were released at the Kooskia National Fish Hatchery on Clear Creek 1 rkm above the mouth. On the South Fork Clearwater River, steelhead smolts were released approximately 22 rkm above the mouth.

Size at release

To determine if the size of smolts at release influences emigration success, steelhead from the first three takes of the season were split between System I (typical growth) and System II (faster growth) to represent typical and faster growing steelhead, respectively. Each year, approximately 900 steelhead smolts from each system were sampled at the hatchery about two weeks before release. All steelhead were anesthetized in a 32 mg/L dilution of MS-222, measured to the nearest mm fork length, implanted with PIT-tags (Prentice et al 1990) and a subsample were weighed to the nearest 0.01 g. Gender and precociousness were checked and recorded when obvious. Smolts were released directly into the Clearwater River at DNFH.

Release site

To determine if release site influences emigration success, steelhead from randomly selected egg takes and rearing systems were chosen for each release site. Each year, approximately 900 steelhead smolts for each release site were sampled at the hatchery about two weeks prior to release using the same methods described for the size at release group. Smolts were released directly into the Clearwater River at DNFH, and the sites described for Clear Creek and the South Fork Clearwater River. The upriver site releases were made one to two weeks before the DNFH releases to spread out emigration, arrival at Lower Granite Dam and smolt transport on barges.

Data analysis

A database was created to track all PIT-tagged fish from time of release to adult return. Emigration and growth of PIT-tagged fish was monitored through the Pit Tag Information System (PTAGIS) database maintained by the Pacific States Marine Fisheries Commission, Portland, OR.

Chi-square tests were used to test emigration success of hatchery steelhead based on rearing system, size at release, and release site (Everitt 1977). If a PIT-tagged steelhead was detected at any of the Snake River or Columbia River dams, we called it a successful emigration. We also included estuary detections and tag recoveries from the National Marine Fisheries Service (or NOAA) Avian Predation Project as additional detection sites, as some steelhead passed the mainstem dams without detection but were observed at these locations.

A two-way analysis of variance (year, study group; ANOVA) was conducted (alpha = 0.05) to compare the following study groups: mean fork length, detection rates, percent survival and travel time between System I/System II, mean fork length detected or not detected System I/System II, mean fork length males mature or not mature System I/System II, mean fork length, detection rates, percent survival and travel time between release sites, mean fork lengths detected or not detected release sites, mean fork length males mature or not mature release sites. Only the *P* value for the study group of interest is reported since the main effect of year was not a variable of interest. When the year • study group interaction term was significant ($P \leq 0.05$), an interaction plot of the mean dependent variable against return year was made to determine if the

interaction was orderly or disorderly (Ott 1993). A one-way analysis of variance was then used to test (alpha = 0.05) the main effect of migrant class on a year-by-year basis.

Due to unequal variance, a Kruskal-Wallis ANOVA (Wilkinson 1990) was used to test steelhead lengths, detection rates and travel times to Lower Snake River dams, lengths of detected/non detected smolts, and lengths of mature smolts.

Survival estimates were made for each pond using SURPH (Skalski et al. 1998). Estimates were compared by ANOVA for release site, rearing system, and System I versus System II growth.

All statistical analysis was done using Systat 10.2 (Systat Software, Inc).

Results

Size at release

The mean length of System I smolts was significantly smaller ($P<0.001$) in all years than System II smolts (Table 1). The target mean length of 200 mm was reached in all System II releases and two of four System I releases. Despite the disparity in size, there were no significant differences in detection rates between the two groups in all years (Table 2). Detection rates for both groups were highest in 2001, followed by 1999, 2000 and 2002. Tag recoveries from the Avian Predation Study indicated that in some years as many as six percent of smolts that migrated downstream were never detected at the mainstem observation sites. When these recoveries are included, the percent of smolts observed migrating downstream ranged between 58.7% and 78.1% for all years (Table 2). Two smolts from System II tagged in 2002 did not migrate until the year after release. Their FL at tagging was 115 mm and 150 mm, with travel times to the first observation of 380 days and 361 days, respectively.

Survival estimates to Lower Granite Dam and Lower Monumental Dam were also not significantly different between the two groups for all years (Table 3). System I smolt survival to Lower Granite Dam was slightly higher in all years except 1999. Survival rates to Lower Granite Dam ranged from 72% to 81%. To Lower Monumental Pool, survival rates were between 41% and 70%.

The time it took smolts from the two groups to travel to Lower Granite Dam were significantly different in all years except 1999 (Table 4), with smolts from System I arriving first. The fastest travel times occurred in 2000, and the most protracted travel occurred in 2001.

There was a significant difference ($P<0.001$) between the size of smolts released and those later detected at downstream sites (Figures 2, 3, 4, 5) for both groups of smolts in all years except 2002. The mean length of smolts not detected was smaller than the smolts that were detected (Table 5). Detections of smolts less than 180 mm FL ranged from 35.1% to 51%. Detection rates of smolts between 180-200 mm FL and over 200 mm FL ranged between 55% and 77.3% and 58.8% and 85.5%, respectively (Table 6).

Table 1. Mean, minimum and maximum fork length (mm) with 95% lower and upper confidence limits (CL), of smolts from egg takes 1-3 reared in System I and System II and released into the Clearwater River at Dworshak National Fish Hatchery, 1999-2002.

Year	System	Mean Fork Length	SD	Minimum Fork Length	Maximum Fork Length	P
1999	System I	196	16.2	123	263	<0.001
	System II	215	18.6	132	280	
2000	System I	206	18.5	109	280	<0.001
	System II	213	19.5	139	289	
2001	System I	198	18.3	116	280	<0.001
	System II	206	18.8	105	275	
2002	System I	201	18.4	125	272	<0.001
	System II	209	21.8	115	270	

Table 2. Detection rates (as percentage) at site of first observation and overall detection rates of steelhead from egg takes 1-3, reared in System I and System II and released into the Clearwater River at Dworshak National Fish Hatchery, 1999-2002. Values listed under All Detections include tags not detected in the mainstem but recovered in the avian predation study.

Year	System	Lower Granite Dam	Little Goose Dam	Lower Monumental Dam	Mainstem Sites Combined	All Detections
1999	System I	25.6	25.7	11.3	65.3	66.6
	System II	27.5	28.6	9.5	69.4	71.0
	P	0.437	0.24	0.243	0.063	0.042
2000	System I	44.7	3.8	6.8	58.0	63.1
	System II	46.6	5.3	4.9	59.3	63.7
	P	0.53	0.122	0.097	0.585	0.793
2001	System I	72.6	4.3	0.44	77.5	78.1
	System II	68.3	4.8	0.66	74.1	74.8
	P	0.228	0.659	0.527	0.094	0.092
2002	System I	18.5	16.1	18.3	54.7	58.7
	System II	16.9	14.9	18.5	53.1	59.1
	P	0.401	0.51	0.956	0.48	0.879

Table 3. Mean percent survival to Lower Granite and Lower Monumental dams of smolts from egg takes 1-3 reared in System I and System II and released into the Clearwater River at Dworshak National Fish Hatchery, 1999-2002. Only steelhead that were detected in the same year they were released are represented.

		Lower Granite Dam		Lower Monumental Dam	
Year	System	Survival	P	Survival	P
1999	System I	72	0.36	60	0.32
	System II	77		68	
2000	System I	81	0.71	46	0.87
	System II	79		51	
2001	System I	80	0.09	47	0.13
	System II	77		41	
2002	System I	77	0.13	62	0.06
	System II	72		70	

Table 4. Travel time (days) to Lower Granite Dam of smolts from egg takes 1-3 reared in System I and System II and released into the Clearwater River at Dworshak National Fish Hatchery, 1999-2002. Only steelhead that were detected in the same year they were released are represented.

		Travel Time				
Year	System	Mean	Median	Minimum	Maximum	P
1999	System I	12.9	8.4	1.9	60.1	0.237
	System II	11.7	6.4	1.9	50.1	
2000	System I	4.6	3.5	1.6	27.9	<0.001
	System II	6.0	3.5	1.6	49.0	
2001	System I	9.3	5.8	2.5	92.1	<0.001
	System II	12.4	7.7	2.9	77.7	
2002	System I	7.5	4.6	3.3	44.4	<0.001
	System II	10.6	5.7	2.7	39.0	

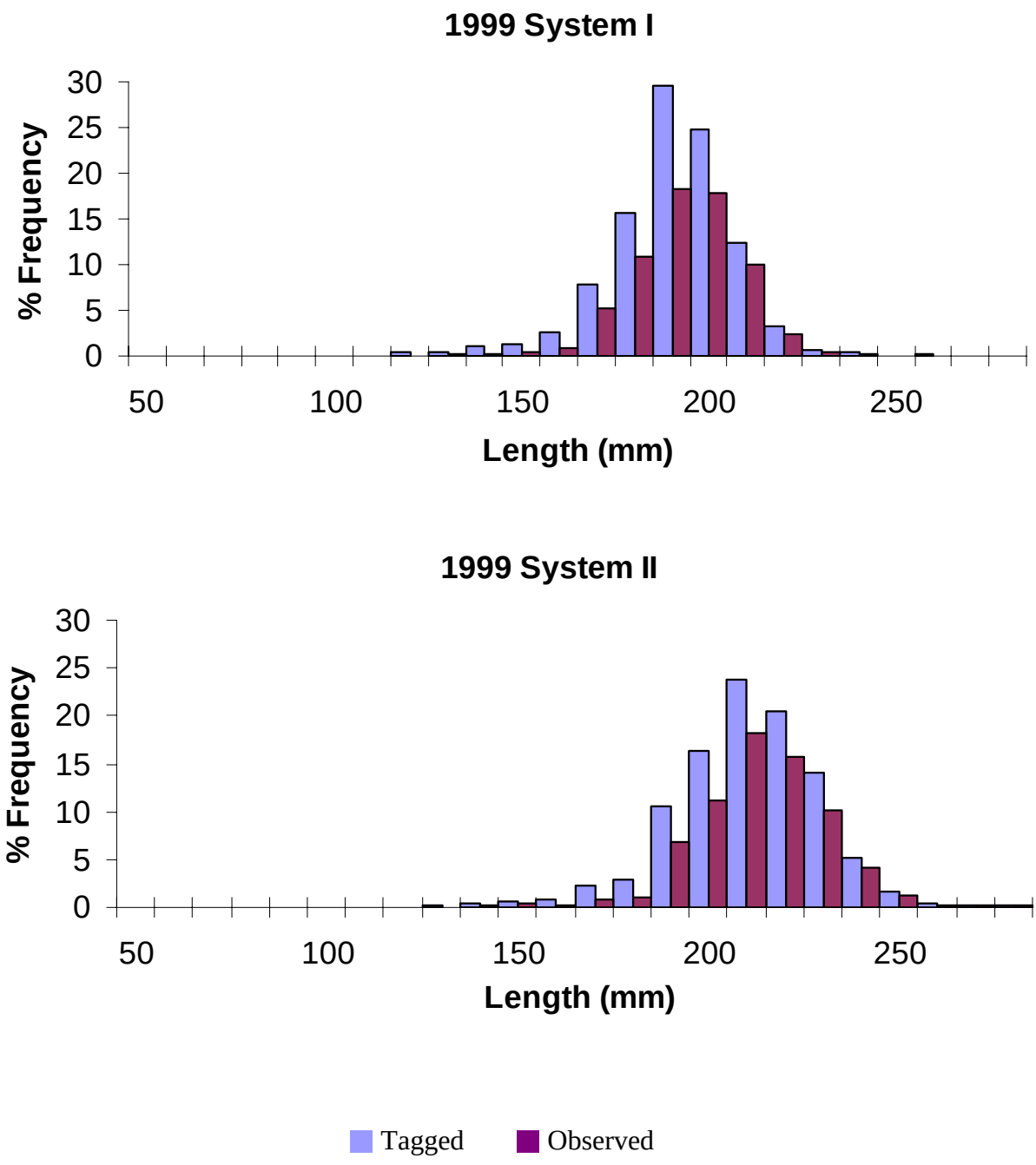


Figure 2. Length frequency of smolts from egg takes 1-3 reared in System I and System II and released into the Clearwater River at Dworshak National Fish Hatchery, 1999.

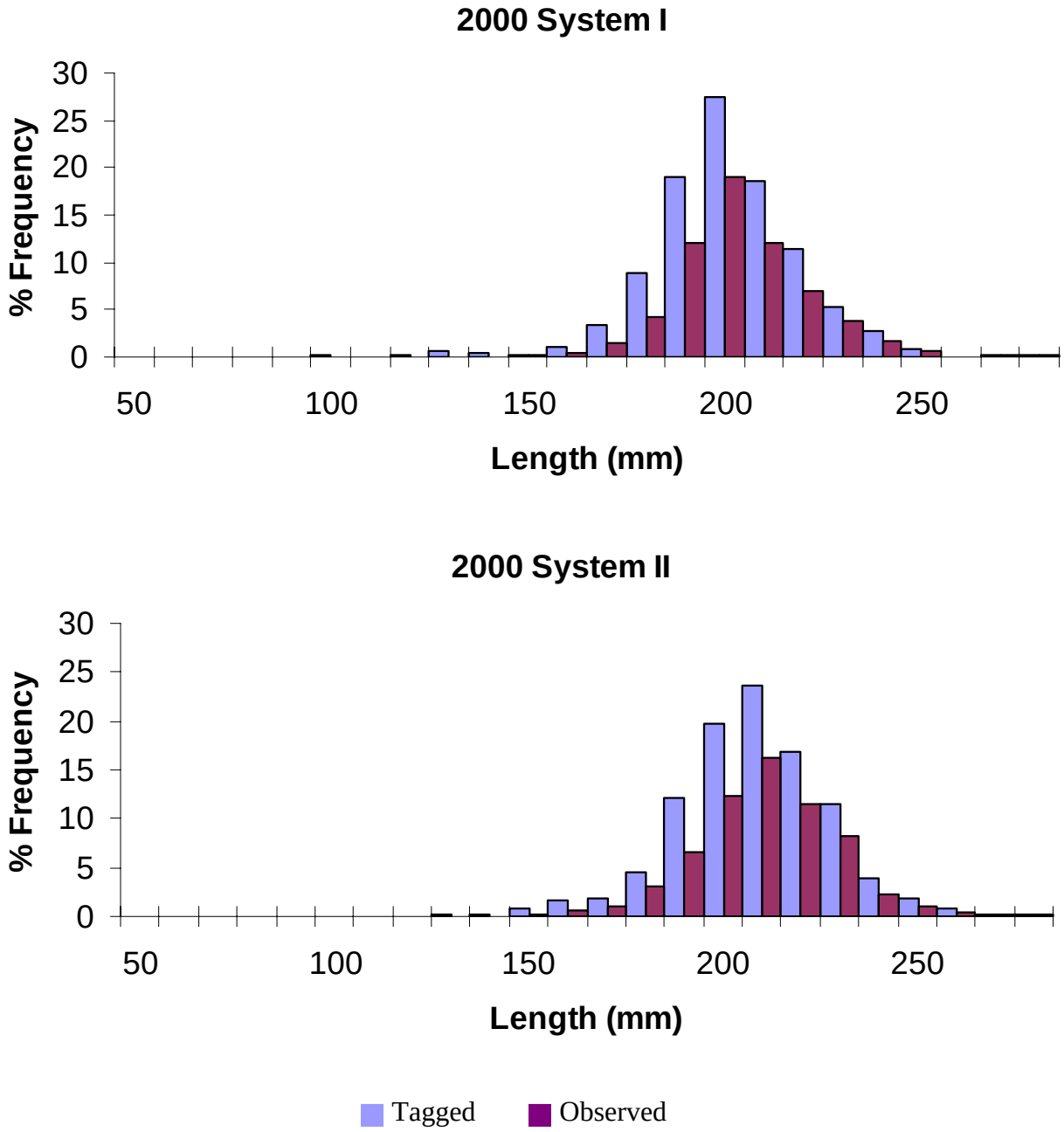


Figure 3. Length frequency of smolts from egg takes 1-3 reared in System I and System II and released into the Clearwater River at Dworshak National Fish Hatchery, 2000.

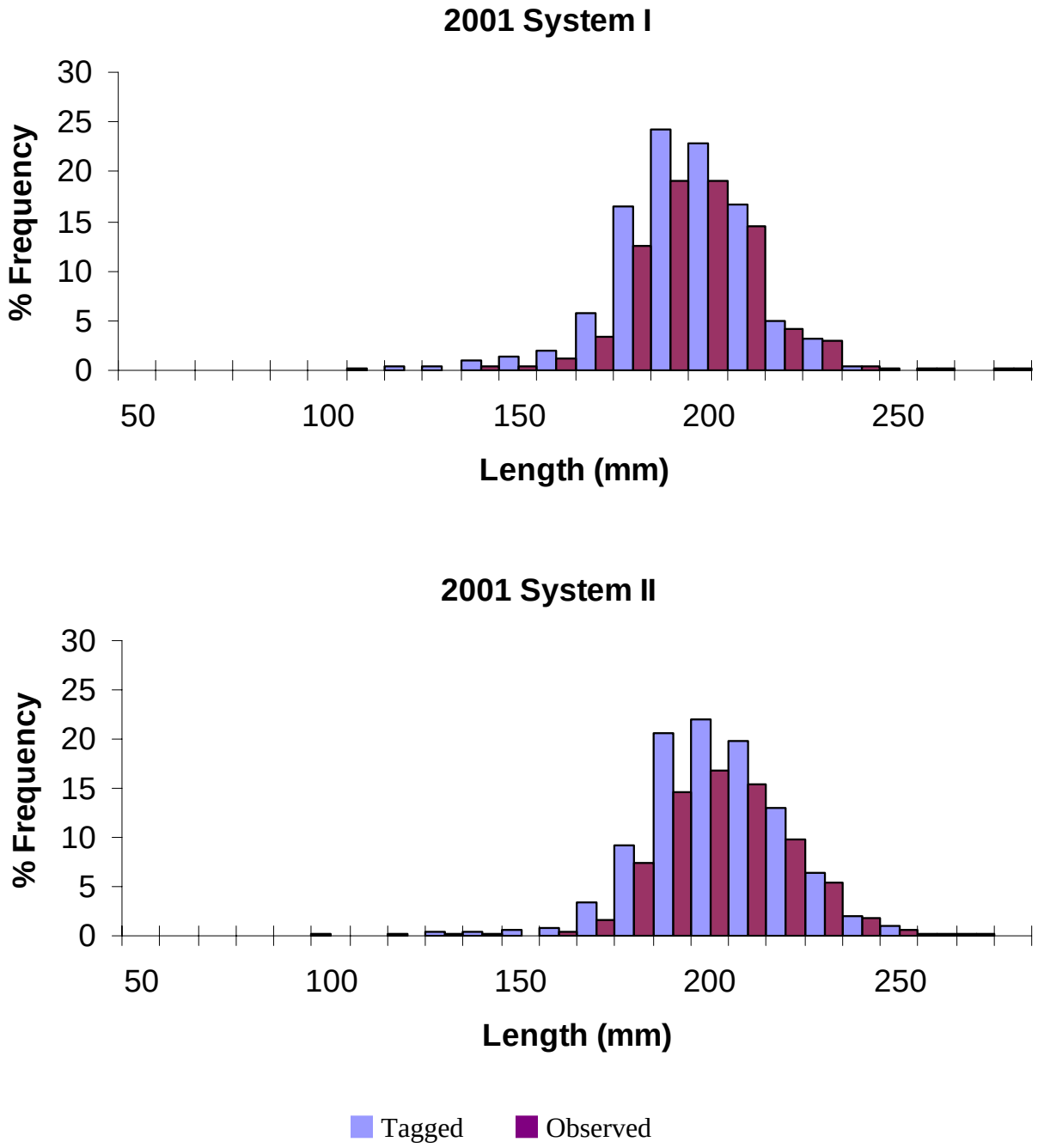


Figure 4. Length frequency of smolts from egg takes 1-3 reared in System I and System II and released into the Clearwater River at Dworshak National Fish Hatchery, 2001.

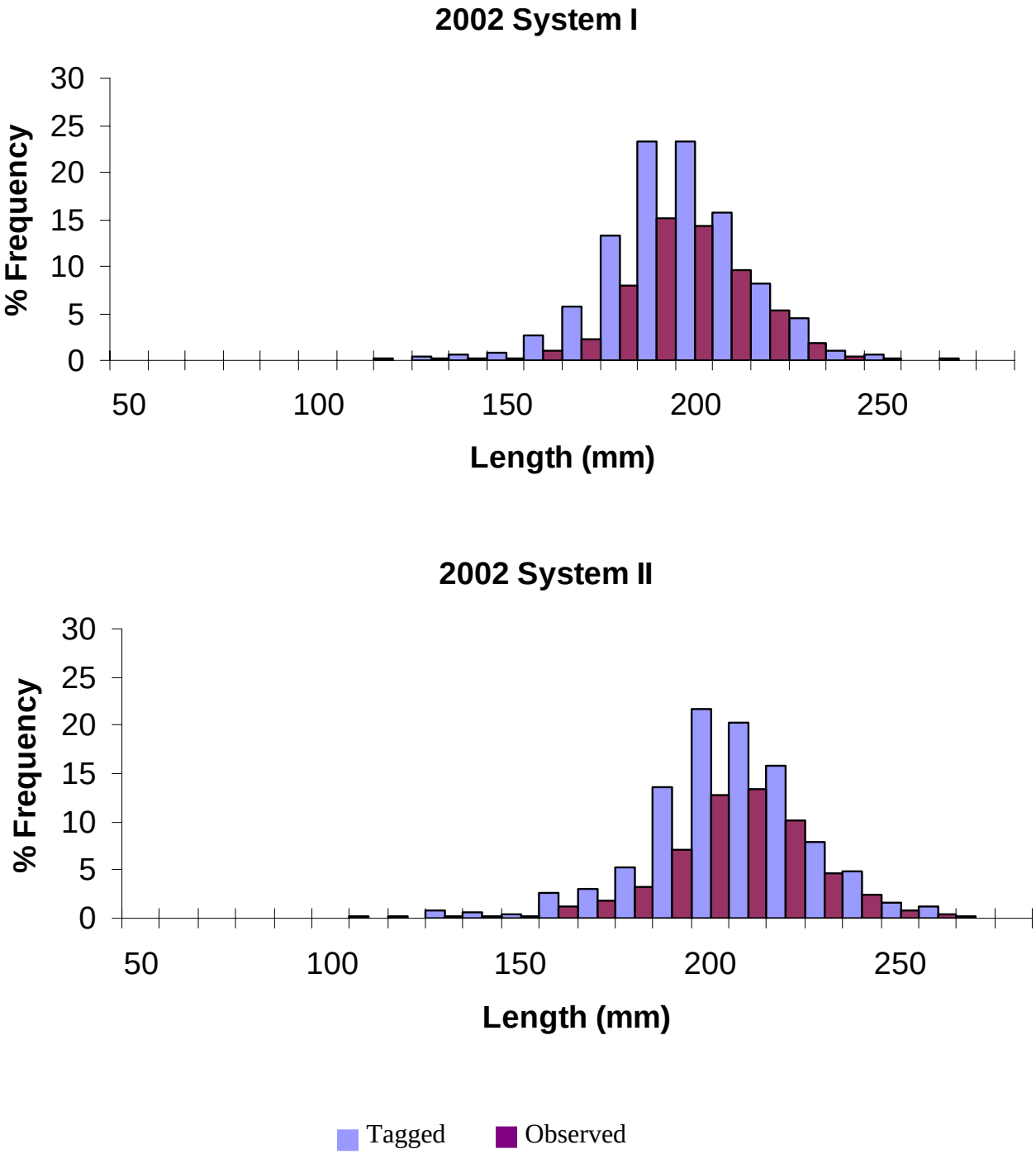


Figure 5. Length frequency of smolts from egg takes 1-3 reared in System I and System II and released into the Clearwater River at Dworshak National Fish Hatchery, 2002.

Table 5. Mean fork length (mm) of smolts tagged, detected and not detected, and mean fork length of mature and immature males, for smolts from egg takes 1-3 reared in System I and System II and released into the Clearwater River at Dworshak National Fish Hatchery, 1999-2002.

		Mean Fork Length (mm)						
Year	System	Tagged	Detected	Not Detected	P	Mature	Not Mature	P
1999	System I	196	198	192	<0.001	195	196	0.704
	System II	215	217	210	<0.001	204	216	<0.001
2000	System I	206	208	203	<0.001	191	206	<0.001
	System II	213	214	210	<0.001	199	213	<0.001
2001	System I	198	201	189	<0.001	193	198	0.064
	System II	206	208	201	<0.001	200	207	0.002
2002	System I	201	201	200	0.236	196	201	0.149
	System II	209	210	208	0.126	207	210	0.614

Table 6. Size groups of steelhead smolts tagged and later detected, from egg takes 1-3 reared in System I and System II and released into the Clearwater River at Dworshak National Fish Hatchery, 1999-2002.

		< 180 mm FL			180-200 mm FL			> 200 mm FL		
		Number		Percent	Number		Percent	Number		Percent
Year	System	Tagged	Detected	Detected	Tagged	Detected	Detected	Tagged	Detected	Detected
1999	System I	121	62	51.0	407	262	64.4	375	277	73.9
	System II	37	13	35.1	122	72	59.0	743	553	74.4
2000	System I	51	19	37.3	250	146	58.4	599	401	66.9
	System II	43	15	34.9	150	87	58.0	708	470	66.4
2001	System I	98	47	48.0	366	283	77.3	435	372	85.5
	System II	52	21	40.4	350	199	56.9	578	451	78.0
2002	System I	92	35	38.0	328	208	63.4	481	283	58.8
	System II	85	32	37.6	169	93	55.0	657	398	60.6

A small percentage of smolts tagged were mature males (Table 7). Few of these smolts were observed at downstream sites, the range in any year was 0%-7.1%. Mature smolts were smaller than smolts that were not mature, with varying levels of significance between their fork lengths (Table SR5).

Table 7. Number of mature smolts released and observed downstream, from egg takes 1-3 reared System I and System II and released into the Clearwater River at Dworshak National Fish Hatchery, 1999-2002.

	System I			System II		
	Number of mature smolts		Percent	Number of mature smolts		Percent
Year	tagged	observed	observed	tagged	observed	observed
1999	65	4	5.8	53	0	0.0
2000	30	2	6.2	49	3	5.8
2001	48	1	2.0	69	5	6.7
2002	31	1	3.2	13	1	7.1

Release site

The mean length of smolts released was just at or below the target length of 200 mm in all years. There was a significant difference in mean length between release sites in all years except 2002 (Table 8). Just as the egg takes and rearing systems were random, the release site that received the larger smolts was also random and thus there was no trend of one release site getting larger smolts.

Detection rates to Lower Granite Dam were significantly different in two of four years (Table 9). This pattern followed through detections at mainstem dams, but when all detections were accounted for the differences were not as significantly different. Similar to the size at release study, tags recovered from the Avian Predation Study accounted for up to five percent of additional observations. Two smolts tagged in 2000 and released into the Clearwater River at DNFH did not migrate until the following year. They were 136 mm and 149 mm FL at tagging, and travel time to first observation was 353 days and 388 days, respectively.

Survival estimates were not significantly different between release sites in any year (Table 10). Survival rates ranged from 65% to 83% to Lower Granite Dam, and between 40% and 73% to Lower Monumental Pool.

Travel time to Lower Granite Dam was significantly different in all years between the three release sites, and in two of four years between Clear Creek and the South Fork Clearwater River (Table 11). The fastest travel time occurred in 2000. The last date of arrival to Lower Granite Dam was not consistent between groups or migration year.

Table 8. Mean, minimum and maximum fork length (mm) with 95% lower and upper confidence limits (CL), of smolts from random egg takes and released into Clear Creek, South Fork Clearwater River and the Clearwater River at Dworshak National Fish Hatchery, 1999-2002.

Year	Release Site	Mean Length	SD	Minimum Length	Maximum Length	P
1999	Clear Creek	186	16.5	103	222	<0.001
	South Fork Clearwater River	186	19.2	108	244	
	Clearwater River	194	17.7	127	253	
2000	Clear Creek	191	21.2	99	235	<0.001
	South Fork Clearwater River	197	22.9	100	247	
	Clearwater River	192	27.6	94	254	
2001	Clear Creek	193	19.1	110	277	<0.001
	South Fork Clearwater River	188	18.1	106	247	
	Clearwater River	194	19.1	114	243	
2002	Clear Creek	199	19.4	120	262	0.27
	South Fork Clearwater River	200	19.3	126	269	
	Clearwater River	200	39.7	116	223	

Table 9. Detection rates (as percentage) at site of first observation and overall detection rates of steelhead from random egg takes and released into Clear Creek, South Fork Clearwater River and the Clearwater River at Dworshak National Fish Hatchery, 1999-2002. Values listed under All Detections include tags not detected in the mainstem but were recovered in the avian predation study.

Year	Release Site	Lower Granite Dam	Little Goose Dam	Lower Monumental Dam	Mainstem Sites Combined	All Detections
1999	Clear Creek	23.5	28.0	9.9	62.2	66.4
	South Fork Clearwater River	27.3	27.9	12.0	67.5	72.3
	Clearwater River	22.9	35.2	8.3	70.4	71.6
	P	0.139	0.004	0.049	0.001	0.012
2000	Clear Creek	32.1	10.8	9.6	56.7	56.9
	South Fork Clearwater River	31.6	16.0	10.3	63.2	63.4
	Clearwater River	46.4	5.8	5.2	58.6	62.1
	P	<0.001	<0.001	<0.001	0.014	0.011
2001	Clear Creek	70.7	4.7	0.44	71.2	76.0
	South Fork Clearwater River	73.7	3.4	0.67	73.2	78.1
	Clearwater River	71.6	4.6	1.4	77.7	78.1
	P	0.743	0.413	0.054	0.006	0.457
2002	Clear Creek	20.1	12.8	17.0	57.3	57.3
	South Fork Clearwater River	18.1	15.0	21.0	61.0	61.0
	Clearwater River	12.3	16.5	23.2	54.8	59.7
	P	<0.001	0.088	0.008	0.026	0.276

Table 10. Mean percent survival to Lower Granite and Lower Monumental dams of smolts raised from random egg takes and rearing systems, and released into Clear Creek, South Fork Clearwater River and the Clearwater River at Dworshak National Fish Hatchery, 1999-2002. Only steelhead that were detected in the same year they were released are represented.

		Lower Granite Dam		Lower Monumental Dam	
Year	Release Site	% Survival	P	% Survival	P
1999	Clear Creek	73	0.36	61	0.22
	South Fork Clearwater River	79		72	
	Clearwater River at DNFH	81		66	
2000	Clear Creek	65	0.66	52	0.64
	South Fork Clearwater River	72		58	
	Clearwater River at DNFH	76		45	
2001	Clear Creek	78	0.89	40	0.30
	South Fork Clearwater River	79		46	
	Clearwater River at DNFH	80		48	
2002	Clear Creek	77	0.62	78	0.59
	South Fork Clearwater River	76		73	
	Clearwater River at DNFH	83		73	

Table 11. Travel time (days) to Lower Granite Dam of smolts from random egg and rearing systems, and released into Clear Creek, South Fork Clearwater River and the Clearwater River at Dworshak National Fish Hatchery, 1999-2002. Only steelhead that were detected in the same year they were released are represented.

		Travel Time (Days)				
Year	Release Site	Mean	Median	Minimum	Maximum	P
1999	Clear Creek	11.1	7.8	2.8	36.9	0.12
	South Fork Clearwater River	12.4	8.3	2.9	36.8	
	Clearwater River at Dworshak	9.3	4.8	1.5	37.7	0.001
2000	Clear Creek	11.0	5.5	2.9	70.6	0.003
	South Fork Clearwater River	8.7	5.5	2.8	50.9	
	Clearwater River at Dworshak	6.5	3.6	1.6	66.6	<0.001
2001	Clear Creek	13.8	12.6	5.7	40.7	<0.001
	South Fork Clearwater River	15.3	12.4	5.6	75.7	
	Clearwater River at Dworshak	11.3	7.4	2.8	88.1	<0.001
2002	Clear Creek	15.2	11.8	2.4	43.5	0.128
	South Fork Clearwater River	17.3	13.4	3.6	43.5	
	Clearwater River at Dworshak	12.2	8.5	2.4	41.3	<0.001

There was a significant difference between the size of smolts released and those later detected at downstream sites (Figures 6, 7, 8, 9) for all release groups and years except the 2002 Clearwater River release. The mean length of smolts not detected was smaller than the smolts that were detected (Table 12). Detections of smolts less than 180 mm FL ranged from 31.0% to 65.3%. Detection rates of smolts between 180-200 mm FL and over 200 mm FL ranged between 58.6% and 80.5%, and 59.6% and 86.5%, respectively (Table 13).

Very few smolts tagged were mature males (Table 14), and of those smolts that were mature, downstream observations were sparse. Observations at downstream sites ranged from 0%-13.3%.

Discussion

The rearing system used to raise early egg takes has a significant influence on the size of smolts. Those smolts raised in warmer, reuse water were more likely to reach the target length of 200 mm than those raised in colder, fresh water. Regardless of rearing system, smolts from the later egg takes were less likely to reach the target length. As evidenced by the significant differences in the length of smolts tagged versus those detected downstream, fish less than 180 mm were less likely to migrate than those over 200 mm. However, it appeared that smaller smolts from later egg takes were more likely to migrate than those from the early egg takes. The reason for this cannot be determined from this study, but growth rates toward the end of rearing or other factors may have influenced smoltification. Smolts that were mature at release rarely migrated downstream, and in some years they were significantly smaller than the smolts that were not mature.

This study had different results than those found in the Tucannon River (Viola and Schuck 1995), where smolts between 230-250 mm residualized in greater numbers than smaller steelhead, and tended to be transitional in maturity. In the Clearwater River, smolts less than 200 mm tended to residualize, and few of these smolts were mature, at least when they were tagged. Since this study ended, the rearing systems at DNFH have been reconfigured so that all Systems can be either run with freshwater or reuse water. This will help the hatchery manipulate growth rates and condition factors that will positively influence smolting characteristics while minimizing maturation rates.

Few of the smolts released were observed migrating the year after release. Of those that migrated, they were in the small length groups. We cannot ascertain that some smolts released in 1999 did not hold over to migrate the following year. The detection equipment at the dams was changed over to detect a new tag frequency, and since the new frequency tags were not available in 1999, we were not able to track this release group through time.

Factors such as river flow, the amount of spill, smolt development and fish guidance efficiency influence whether a smolt will be detected at mainstem dams. For smolts that did migrate, there was no difference in detection rates between smolts raised in System I or System II. The release site, however, influenced detection rates, with smolts released into Clear Creek being less likely to be detected. However, survival rates between System I and System II, and between release sites, were not significantly different, indicating that detection rates alone cannot be used to

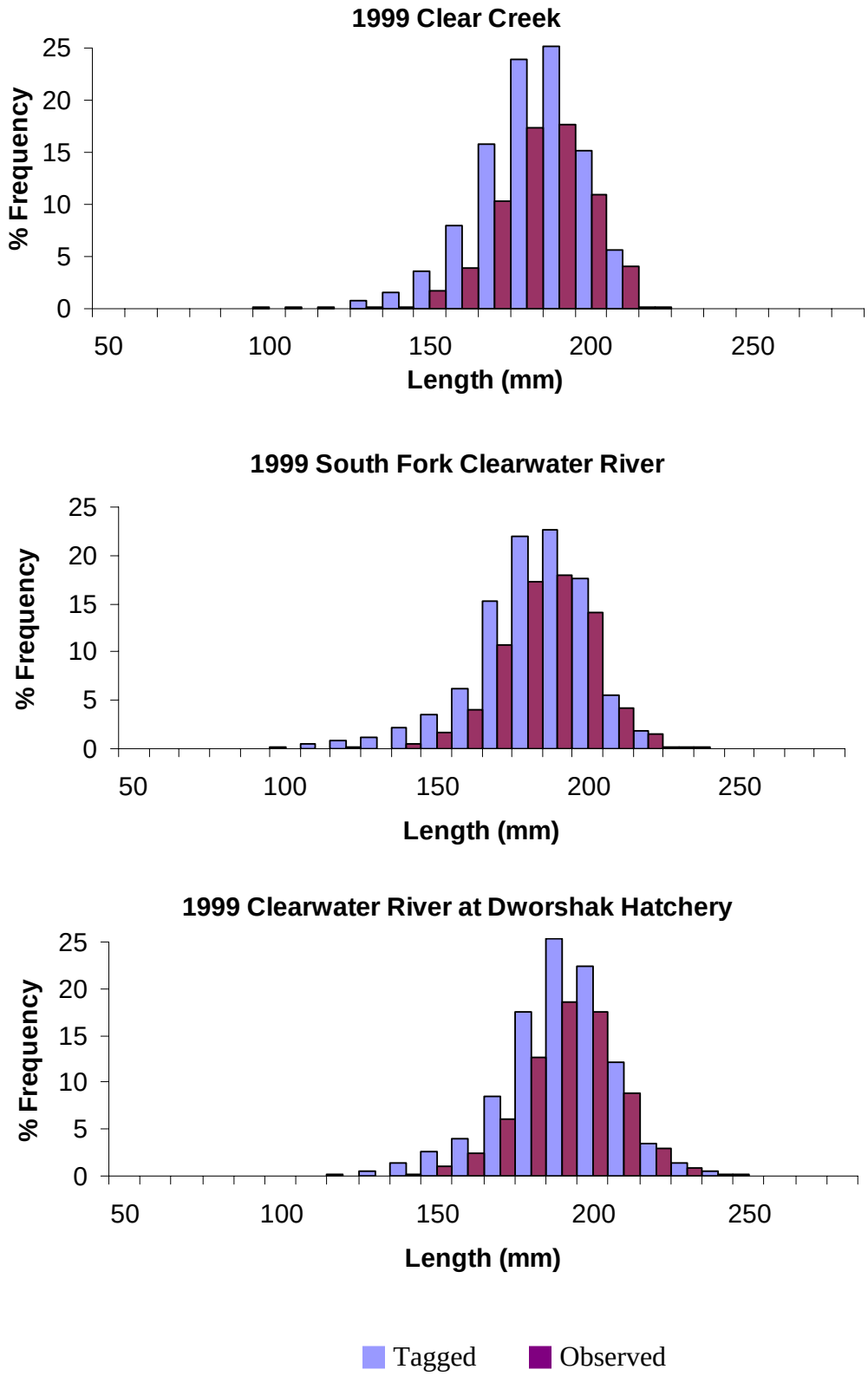


Figure 6. Length frequency of smolts from random egg takes reared in Systems I-III and released into Clear Creek, South Fork Clearwater River and the Clearwater River at Dworshak National Fish Hatchery, 1999.

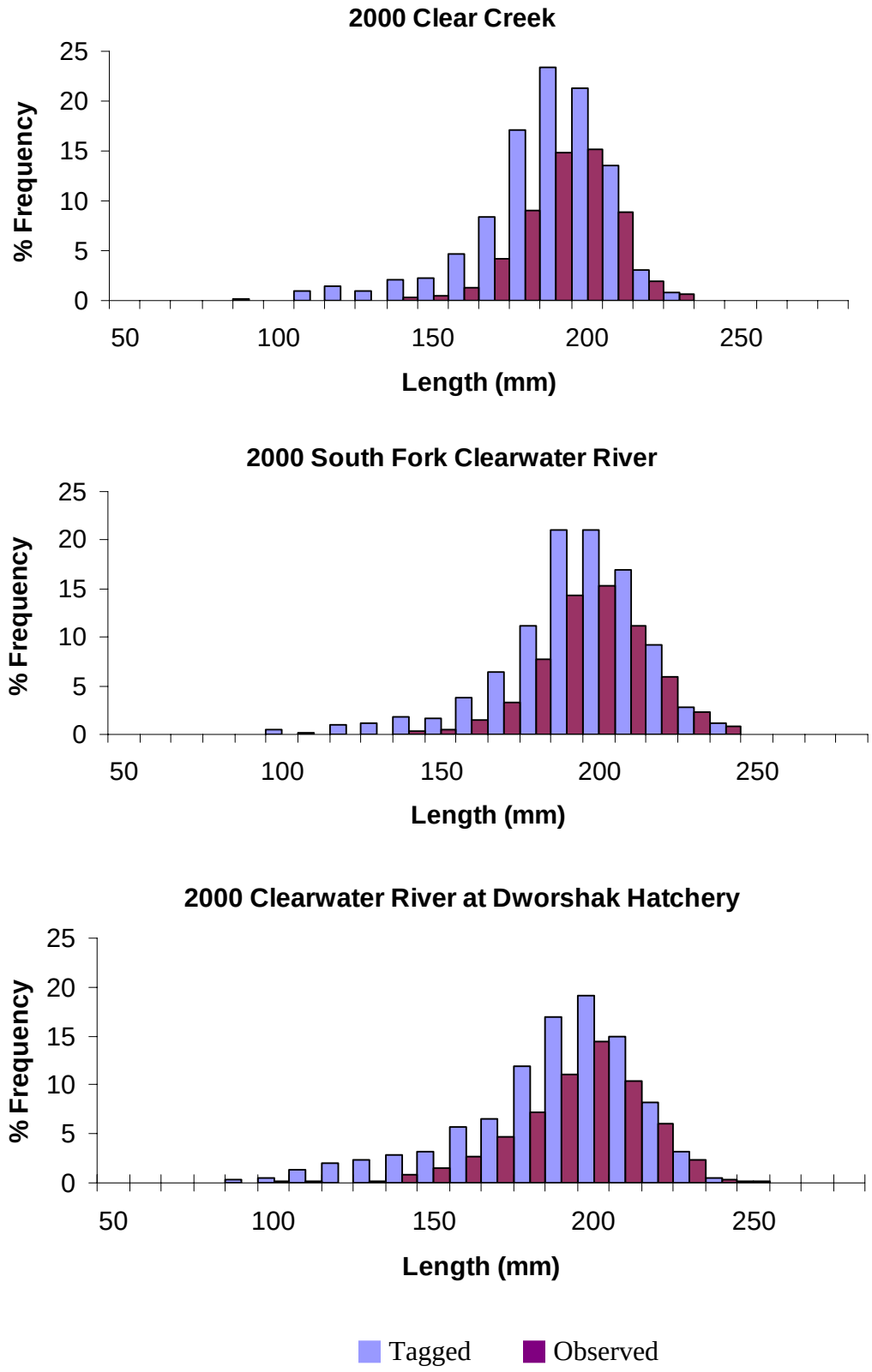
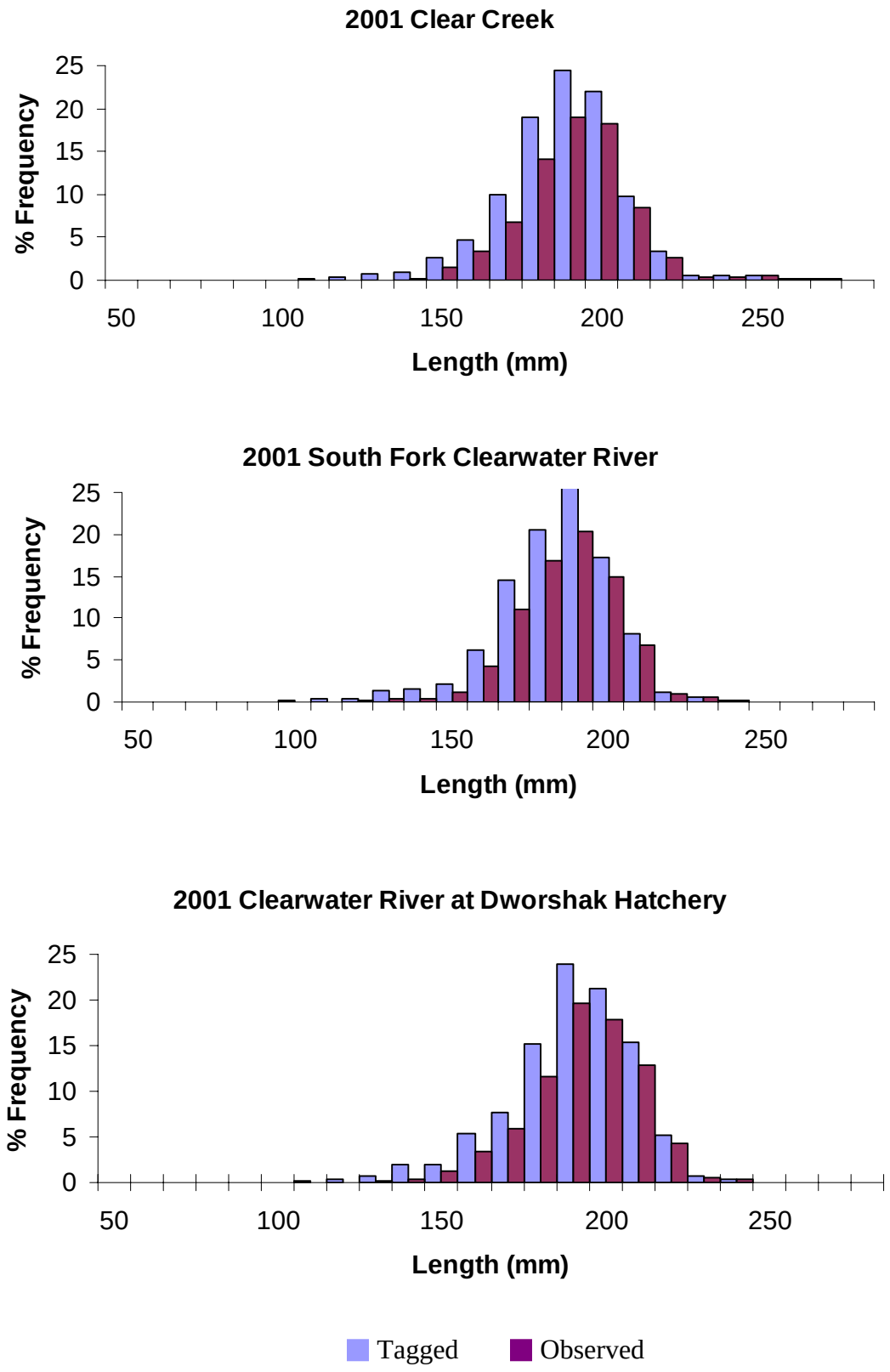


Figure 7. Length frequency of smolts from random egg takes reared in Systems I-III and released into Clear Creek, South Fork Clearwater River and the Clearwater River at Dworshak National Fish Hatchery, 2000.



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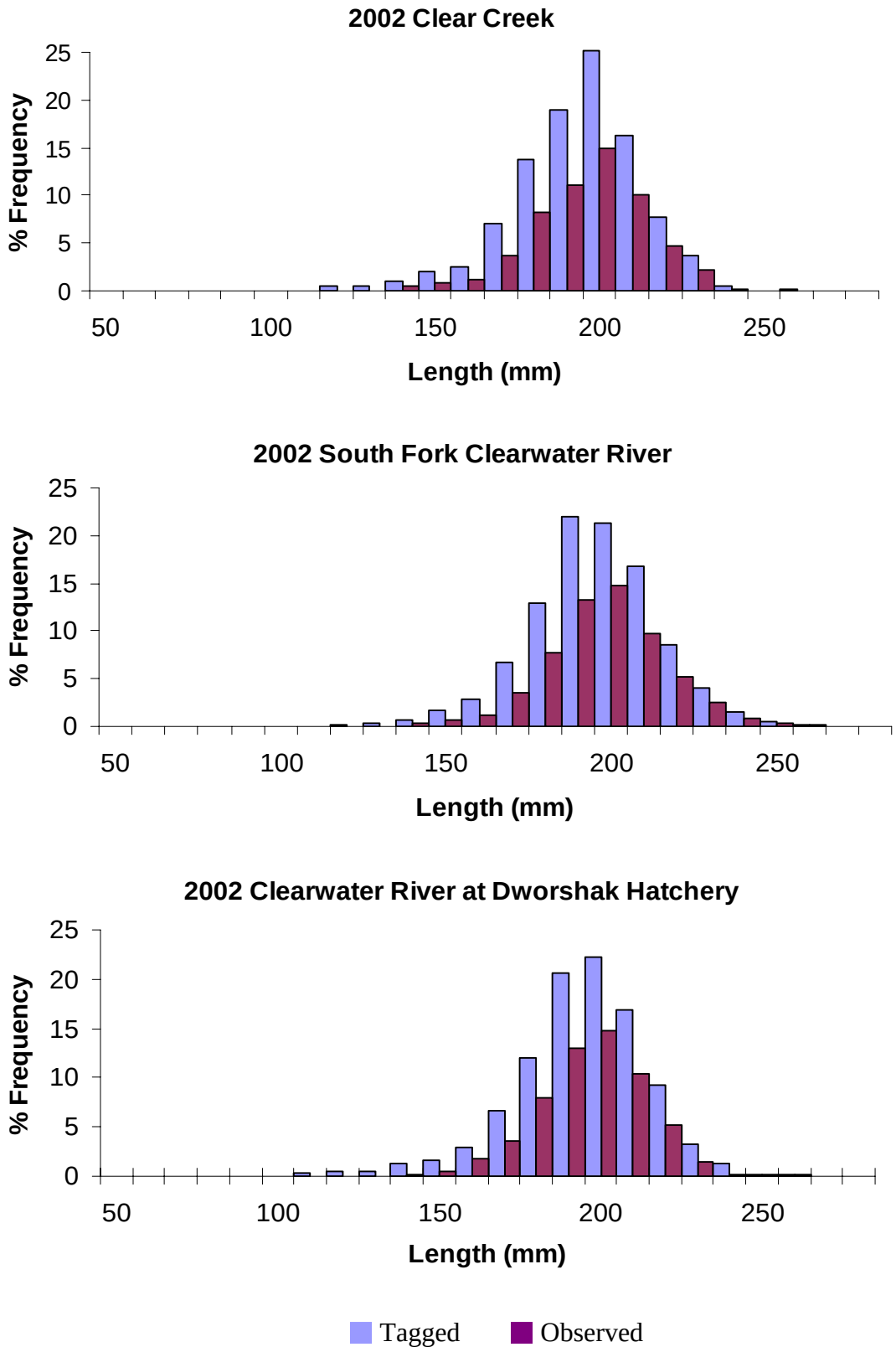

Figure 9. Length frequency of smolts from random egg takes reared in Systems I-III and released into Clear Creek, South Fork Clearwater River and the Clearwater River at Dworshak National Fish Hatchery, 2002.

Table 12. Mean fork length (mm) of smolts tagged, detected and not detected for smolts from random egg takes released into Clear Creek, South Fork Clearwater River and the Clearwater River at Dworshak National Fish Hatchery, 1999-2002.

		Mean Fork Length (mm)						
Year	Release Site	Tagged	Detected	Not Detected	P	Mature	Not Mature	P
1999	Clear Creek	186	188	181	<0.001	177	188	0.027
	South Fork Clearwater River	186	189	177	<0.001	177	186	0.128
	Clearwater River	194	196	189	<0.001	184	194	0.043
2000	Clear Creek	191	197	183	<0.001	178	191	0.008
	South Fork Clearwater River	197	201	189	<0.001	178	198	<0.001
	Clearwater River	192	199	180	<0.001	185	192	0.44
2001	Clear Creek	193	195	186	<0.001	188	193	0.329
	South Fork Clearwater River	188	191	180	<0.001	180	189	0.012
	Clearwater River	194	197	185	<0.001	191	194	0.55
2002	Clear Creek	199	200	196	0.005	202	198	0.467
	South Fork Clearwater River	200	202	198	0.01	209	200	0.117
	Clearwater River	200	200	201	0.85	ND	200	ND

Table 13. Size groups of steelhead smolts tagged and later detected, from random egg takes and released into Clear Creek, South Fork Clearwater River and the Clearwater River at Dworshak National Fish Hatchery, 1999-2002.

		< 180 mm FL			180-200 mm FL			> 200 mm FL		
		Number		Percent	Number		Percent	Number		Percent
Year	Release site	Tagged	Detected	Detected	Tagged	Detected	Detected	Tagged	Detected	Detected
1999	Clear Creek	270	146	54.1	441	315	71.4	188	135	71.8
	South Fork Clearwater River	268	153	57.1	402	316	78.6	228	167	73.2
	Clearwater River	155	88	56.8	388	282	72.7	360	276	76.7
2000	Clear Creek	187	58	31.0	364	214	58.8	348	240	69.0
	South Fork Clearwater River	149	51	34.2	289	197	68.2	461	321	69.6
	Clearwater River	206	91	44.2	262	165	63.0	418	305	73.0
2001	Clear Creek	175	106	60.6	390	296	75.9	332	278	83.7
	South Fork Clearwater River	239	156	65.3	415	334	80.5	245	212	86.5
	Clearwater River	164	98	59.8	352	281	79.8	384	322	83.9
2002	Clear Creek	123	55	44.7	295	173	58.6	482	287	59.6
	South Fork Clearwater River	110	50	45.5	315	189	60.0	475	302	63.5
	Clearwater River	126	54	42.9	297	191	64.3	486	293	60.3

Table 14. Number of mature smolts released and observed downstream, from random egg takes and released into Clear Creek, South Fork Clearwater River and the Clearwater River at Dworshak National Fish Hatchery, 1999-2002.

	Clear Creek			South Fork Clearwater River			Clearwater River		
	Number of mature smolts			Number of mature smolts			Number of mature smolts		
Year	tagged	observed	Percent observed	tagged	observed	Percent observed	tagged	observed	Percent observed
1999	16	0	0.0	10	1	10.0	13	0	0.0
2000	18	0	0.0	38	1	2.6	10	0	0.0
2001	15	0	0.0	25	0	0.0	15	2	13.3
2002	17	0	0.0	13	0	0.0	0	0	0.0

evaluate migration success. Survival rates, which take capture probabilities into account, are a better indicator of downstream migration. In this study, survival to Lower Granite Dam met or exceeded 65% for all System groups and release site groups, indicating most smolts migrated downstream.

Interesting to note is the number of smolts that escaped detection through the mainstem observation points, but their tags were recovered through the Avian Predation Study on nesting colony islands. As many as six percent of smolt detections were observed from that study. While it is likely not a significant source if detections, it does document for this study that the smolts did migrate downstream out of the study area.

The discharge in the Clearwater appeared to influence how many days it took smolts From System I and System II to migrate to Lower Granite Dam (Figures 10, 11, 12, 13). Discharge above 1000 m^3/s in 2000 resulted in the fastest travel time and 75% of the smolts reaching Lower Granite Dam in less than a week after release. Despite variable discharge in other years, 75% of the smolts migrated to Lower Granite Dam by late May, and all smolts were detected by the beginning of July in all but 2001.

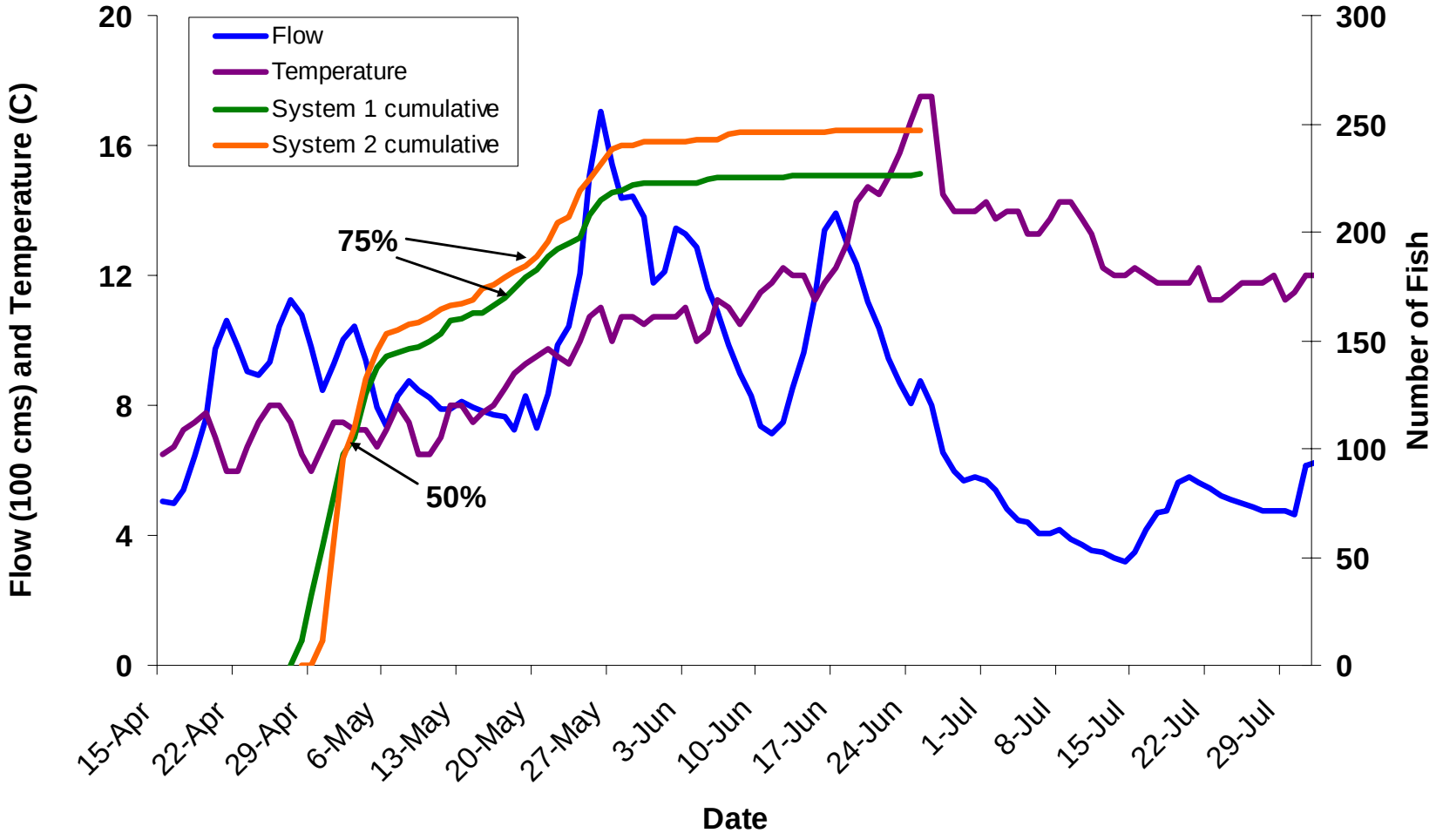

Figure 10. Discharge and water temperature for the Clearwater River at Peck, Idaho April 15 through July 31, 1999, and cumulative frequencies of PIT tag detections at Lower Granite Dam of steelhead from egg takes 1-3 reared in freshwater (System I) and reuse water (System II) and released into the Clearwater River at Dworshak National Fish Hatchery April 26, 1999.

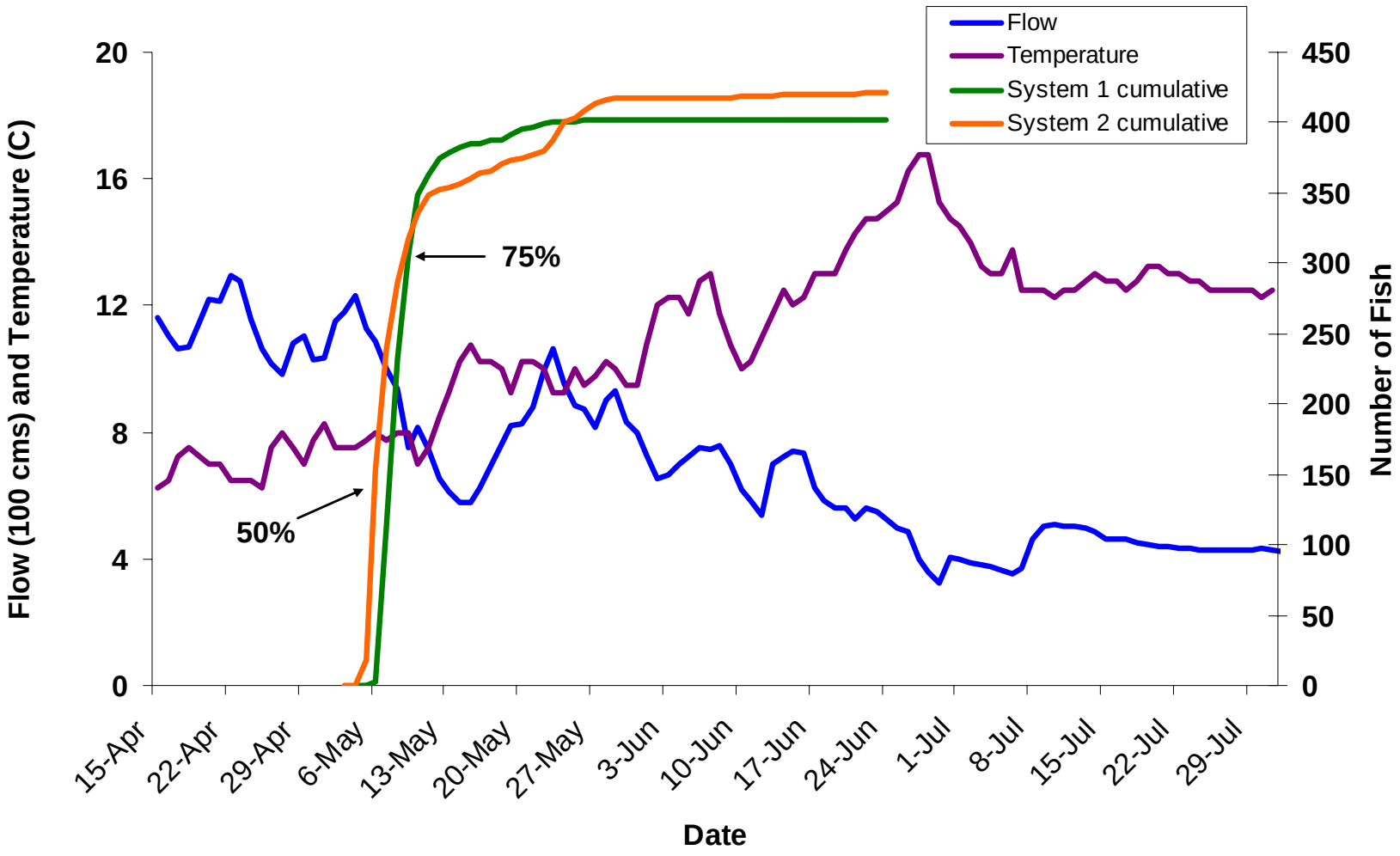

Figure 11. Discharge and water temperature for the Clearwater River at Peck, Idaho April 15 through July 31, 2000, and cumulative frequencies of PIT tag detections at Lower Granite Dam of steelhead from egg takes 1-3 reared in freshwater (System I) and reuse water (System II) and released into the Clearwater River at Dworshak National Fish Hatchery May 4, 2000.

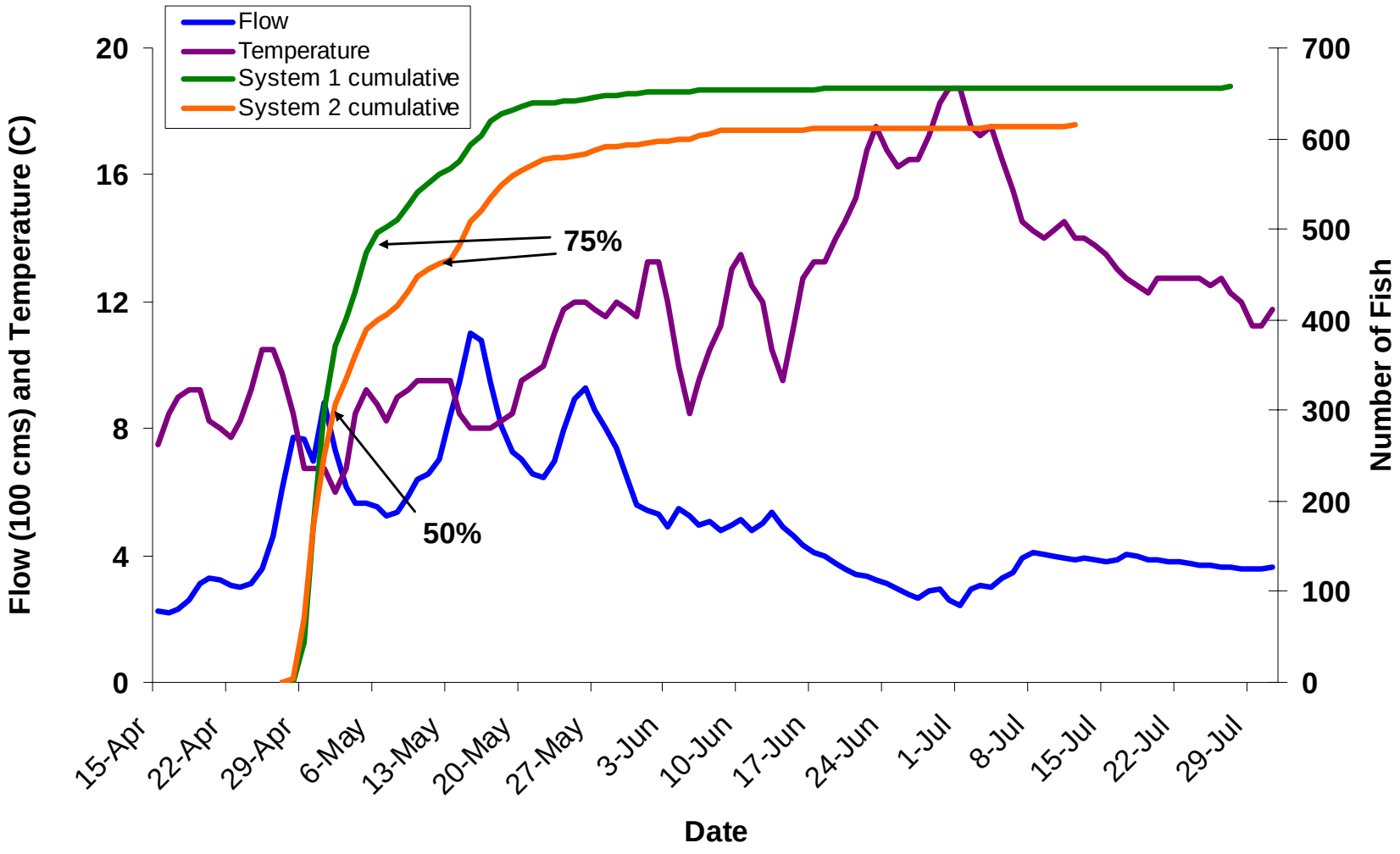

Figure 12. Discharge and water temperature for the Clearwater River at Peck, Idaho April 15 through July 31, 2001, and cumulative frequencies of PIT tag detections at Lower Granite Dam of steelhead from egg takes 1-3 reared in freshwater (System I) and reuse water (System II) and released into the Clearwater River at Dworshak National Fish Hatchery April 23, 2001.

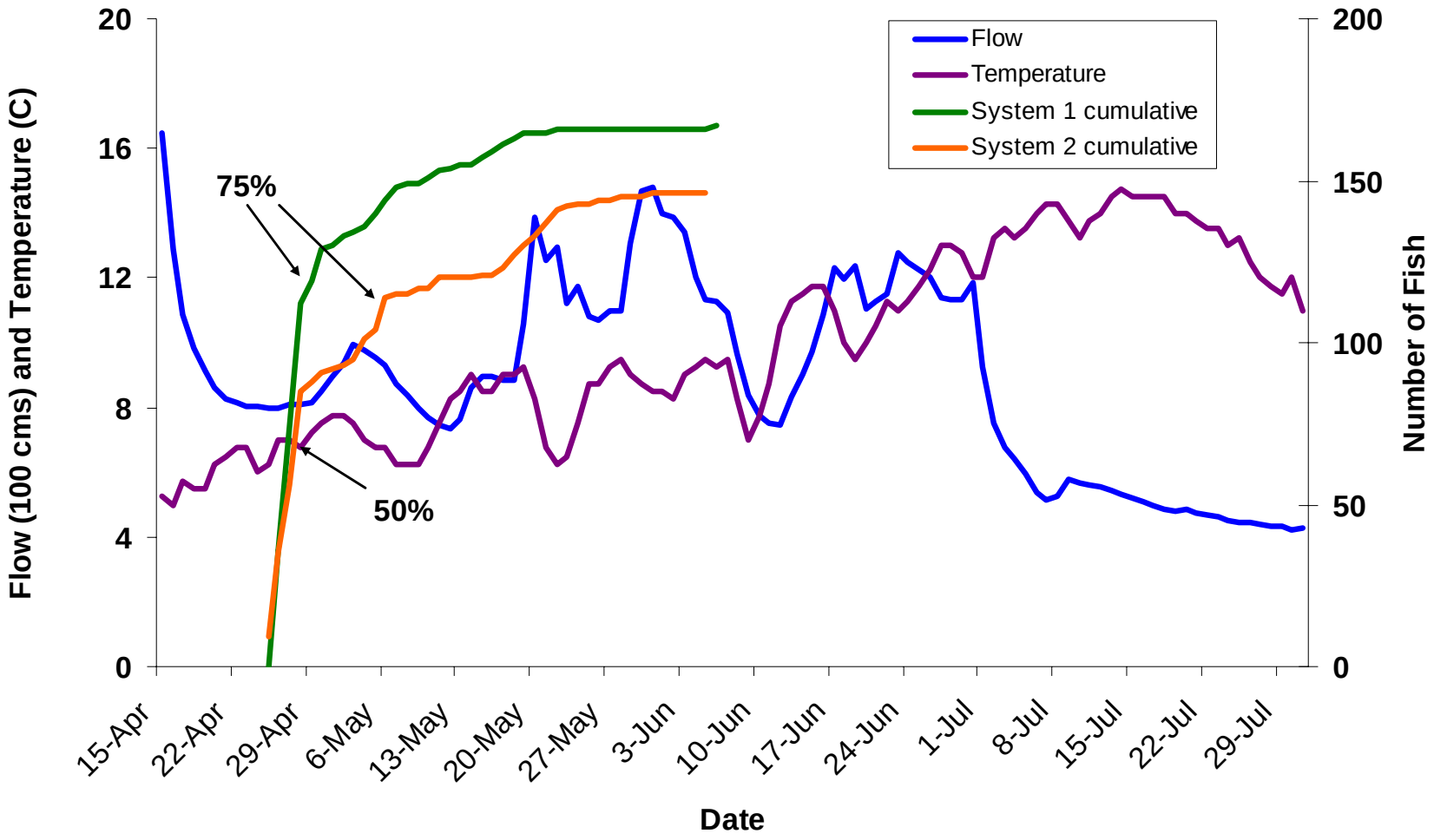

Figure 13. Discharge and water temperature for the Clearwater River at Peck, Idaho April 15 through July 31, 2002, and cumulative frequencies of PIT tag detections at Lower Granite Dam of steelhead from egg takes 1-3 reared in freshwater (System I) and reuse water (System II) and released into the Clearwater River at Dworshak National Fish Hatchery April 22, 2002.

CHAPTER TWO

Characteristics of Residualized Dworshak National Fish Hatchery Steelhead Smolts in the Clearwater River, Idaho

By

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Introduction

Dworshak National Fish Hatchery (DNFH) releases 2.1 million steelhead *Oncorhynchus mykiss* smolts annually into the Clearwater River Basin. In most years, 1.2 million steelhead smolts are released directly into the Clearwater River at DNFH, with the remaining smolts released at sites upstream, primarily at Clear Creek and the South Fork Clearwater River. Of the steelhead smolts released annually, 140,000 receive a coded-wire tag and a left ventral fin clip. These marked groups provide the opportunity to evaluate various aspects of the production program such as rearing systems, release sites, size at release, and return timing of adults (USFWS 2004).

Previous studies have documented that a large percentage of the steelhead released into the Clearwater River from DNFH never reach Lower Granite Dam 116 rkm downstream from DNFH (Bigelow 1995a, Bigelow 1997). These non-migrating B-run steelhead, termed residuals, have been found cohabitating with wild A-run steelhead (Connor 1989, Bigelow 1995b, Bigelow and Bowen 1997) in tributaries downstream of DNFH. This has caused a region wide concern that residuals may be having a negative impact on wild fish in the Clearwater River basin through competition, genetic introgression, predation or behavioral interaction, yet little is known about characteristics of the hatchery steelhead which residualize.

From 1999-2002, information on gender, maturity and piscivory of hatchery steelhead was collected by electrofishing the mainstem Clearwater River below DNFH, the North Fork Clearwater River, the tributaries downstream of DNFH and sampling the adult collection facility at DNFH. By injecting hatchery steelhead with Passive Integrated Transponder (PIT) tags (Prentice et al. 1990) and utilizing mark/recapture techniques, we documented movement and estimated growth of residuals in the Clearwater River Basin below DNFH. Steelhead with coded-wire tags (approximately 10% of all hatchery-released steelhead) were collected for their tags to provide information on rearing site, systems, techniques, gender and sexual maturity. Stomach samples were also collected to check for piscivory among hatchery steelhead.

Methods

Project Area

Our project area consisted of the Clearwater River Basin from just upstream of DNFH, downstream to the river's confluence with the Snake River in Lewiston, Idaho, a distance of 66 rkm (Figure 14, Table 15). We also sampled the North Fork Clearwater River downstream of Dworshak Dam to its confluence with the mainstem (about 3 rkm) and Big Canyon, Jacks, Bedrock, and Cottonwood creeks which are downstream of the North Fork Clearwater River. The adult trap at DNFH located at rkm 0.05 on the North Fork Clearwater River was included as a separate sample site.

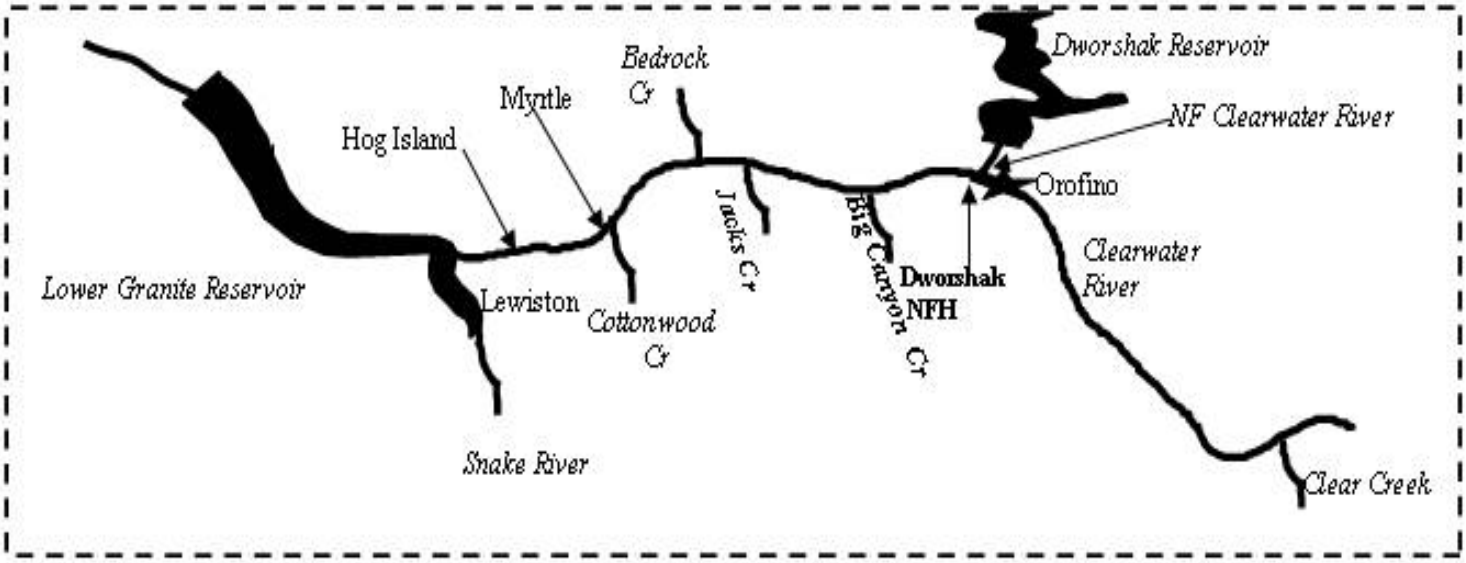


Figure 14. Clearwater River drainage sampled for hatchery steelhead released from Dworshak National Fish Hatchery, Idaho, 1999-2002.

Table 15. Sections sampled for residual hatchery steelhead smolts released from Dworshak National Fish Hatchery, 1999-2002.

Sample Section	River Kilometer Upper boundary	Lower boundary
Orofino to Big Canyon Creek	66	57
Big Canyon Creek to Bedrock Creek	57	42
Bedrock Creek to Myrtle	42	29
Myrtle to Hog Island	29	15
Hog Island to Snake River	15	1
North Fork Clearwater River	3	0
Dworshak Hatchery Adult Ladder	0.05	na
Bedrock Creek	1	0
Big Canyon Creek	1	0
Cottonwood Creek	1	0
Jacks Creek	1	0

Fish capture and tagging

Hatchery steelhead on the Clearwater River and the North Fork Clearwater River were collected using an 11 horsepower Honda generator (model GX340) and a Smith-Root 16 amp electrofisher (model 5.0-GPP) mounted on an 18 foot aluminum jet boat (Figure 15). Hook and line sampling using barbless flies and lures was conducted on occasion. Sample locations were selected weekly using a stratified random sampling scheme. Prior to electrofishing, we recorded water temperature and conductivity which were used to determine electroshocker settings, and followed National Oceanic Atmospheric Administration Fisheries (NOAA Fisheries) electrofishing protocols for water temperature, voltage and frequency (National Marine Fisheries Service 1998). Effort, defined as seconds the electrofishing unit was "on" was recorded for each sampling session in 1999 and most of 2000. Late in 2000 the counter malfunctioned and was not repaired. All wild fish caught were enumerated and released.

Figure 15. Electrofishing boat and set-up used to sample the Clearwater River for hatchery steelhead, 1999-2002.

Tributaries were sampled a using a Smith-Root model 15-B electrofisher and Honda model EX-350 generator mounted to a portable backpack. Prior to electrofishing, we recorded water temperature and conductivity which we used to determine electroshocker settings. We followed NOAA Fisheries electrofishing protocols for water temperature, voltage and frequency

(National Marine Fisheries Service 1998). Effort, defined as seconds the electrofishing unit was "on", was recorded for each sampling session. All wild fish were enumerated and released.

Occasionally residualized steelhead will return to DNFH via the hatchery fish ladder. When adult steelhead and spring Chinook were handled for enumeration or spawning, all smaller steelhead in the holding ponds were sampled for this project.

Captured hatchery steelhead were anesthetized in a 32 mg/L dilution of MS-222. Steelhead determined to have coded-wire tags based on fin clips were measured to the nearest millimeter (mm) fork length, and sacrificed to determine hatchery rearing system, sex, maturity, and stomach contents. All steelhead captured without a coded-wire tag were measured to the nearest mm fork length, scanned for PIT-tags and implanted with PIT-tags (Prentice et al 1990) if none were present. Gender and precociousness were checked and recorded when obvious.

Diet analysis

To determine extent of piscivory, fish stomach contents were evacuated using stomach lavage (Figure 16). Pressure was used to pump water into the stomachs to induce regurgitation. Regurgitated contents were collected in a 300 Φm mesh strainer, preserved with 70% alcohol, and stored in whirl packs until analysis could be completed. In 2001 and 2002, only stomachs that contained fish parts were saved in whirl packs.

Stomach contents for each steelhead were analyzed primarily to determine if piscivory was occurring. However, all contents were enumerated. For each stomach, contents were placed into six categories: aquatic insects, terrestrial insects, crustaceans, fishes, molluscs, and miscellaneous food items. Insects were categorized to order. Prey items such as other fishes were categorized to the lowest easily-identifiable taxa. Prey categories were blotted dry and weighed to the nearest mg. The number and weight of each category in each stomach was recorded. When possible, parts of insects were placed into their proper order and weighed with that group. Unidentifiable insect parts were placed and weighed in an insect parts category.

Data analysis

A database was created to track all PIT-tagged fish from time of release to adult return. Emigration and growth of PIT-tagged fish was monitored through the Pit Tag Information System (PTAGIS) database maintained by the Pacific States Marine Fisheries Commission, Portland, OR. Descriptive characteristics of residuals include length frequency, sex, maturity, and piscivory.

A two-way analysis of variance (year, study group; ANOVA) was conducted (alpha = 0.05) to compare mean fork length for the following study groups: Clearwater River and tributaries/North Fork Clearwater River and DNFH catch, migrants/nonmigrants, first year/second year migrants, mature/immature tagged steelhead, coded wire tagged release groups, and mature/immature coded wire tagged steelhead. Only the *P* value for the study group of interest is reported since the main effect of year was not a variable of interest. When the year • study group interaction term was significant ($P \leq 0.05$), an interaction plot of the mean dependent variable against return year was made to determine if the interaction was orderly or

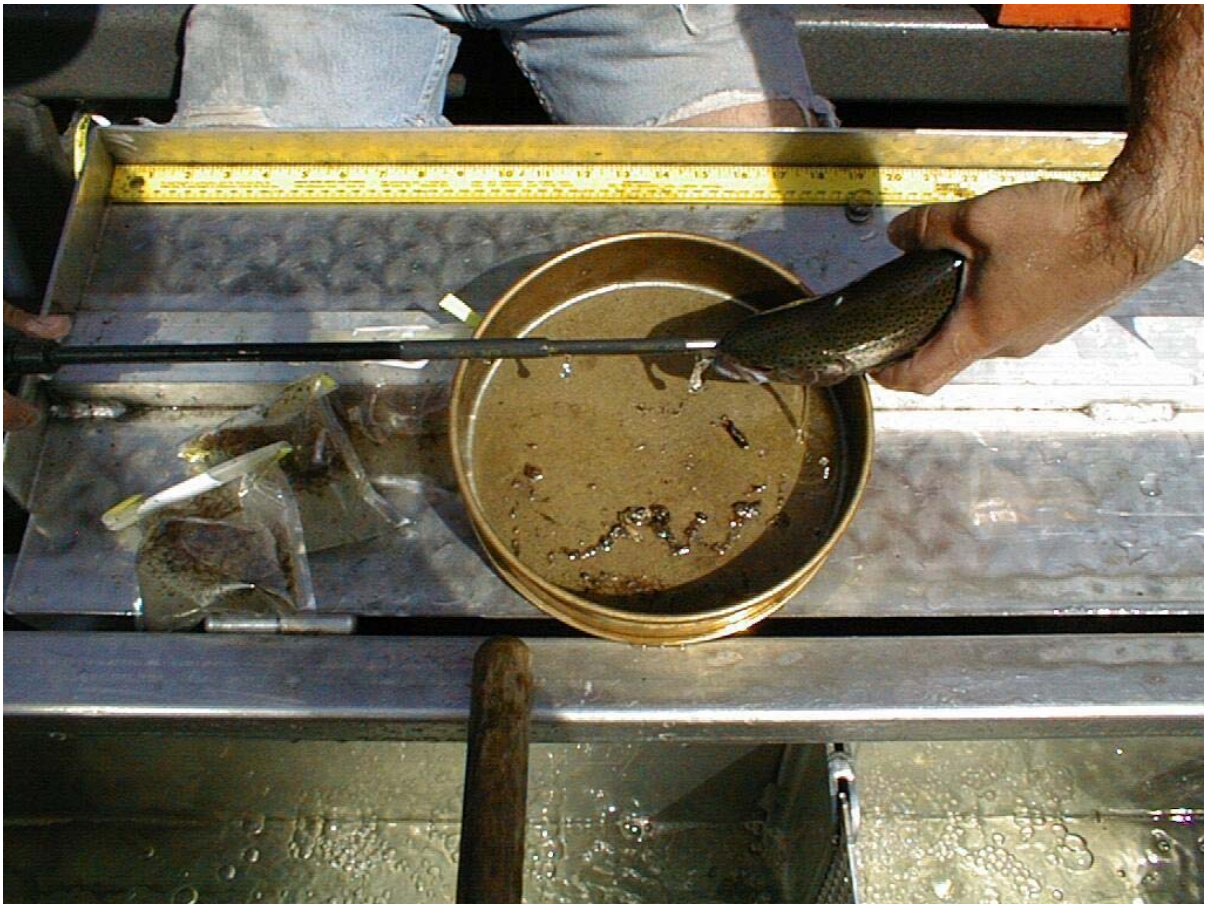


Figure 16. Stomach lavage technique used to sample stomach contents from hatchery steelhead, 1999-2002.

disorderly (Ott 1993). A one-way analysis of variance was then used to test (alpha = 0.05) the main effect of migrant class on a year-by-year basis.

A chi-square test was used to test (alpha = 0.05) for significant differences in gender for the coded wire release groups.

All statistical analysis was done using Systat 10.2 (Systat Software, Inc).

Results

Fish capture and tagging

We sampled the Clearwater River and tributaries 262 days over the course of this study (Table 16). Water flows in both the mainstem and the tributaries at times limited our ability to sample effectively. In addition, water temperatures in the lower tributaries were too warm for safe handling of fish after the third week in June, usually earlier. The project was not fully geared up to sample until mid 1999, so some sampling time was lost early in the season. In 2002, a change in project personnel and high flows limited sampling effort to late in the season.

We caught 4,567 hatchery steelhead from 1999-2002. Of those fish sampled, we PIT-tagged 3,651, collected 645 for coded-wire tags, recaptured 130 PIT-tagged steelhead, and 134 died during sampling (Table 17). The majority of hatchery steelhead were caught in the North Fork Clearwater River, followed by the DNFH adult ladder and the Clearwater River between Orofino and Big Canyon Creek.

Table 16. Number of days each section was sampled for hatchery steelhead smolts, Clearwater River and tributaries, 1999-2002.

Capture Section	1999	2000	2001	2002	Total
Orofino to Big Canyon Creek	15	12	4	4	35
Big Canyon Creek to Bedrock Creek	8	9	12	4	33
Bedrock Creek to Myrtle	6	6	9	1	22
Myrtle to Hog Island	2	7	7	2	18
Hog Island to Snake River	2	2	0	1	5
North Fork Clearwater River	8	13	12	6	39
Dworshak Hatchery Adult Ladder	7	17	28	15	67
Bedrock Creek	3	4	3	1	11
Big Canyon Creek	2	5	2	1	10
Cottonwood Creek	2	4	3	1	10
Jacks Creek	3	5	3	1	12
Total	58	84	83	37	262

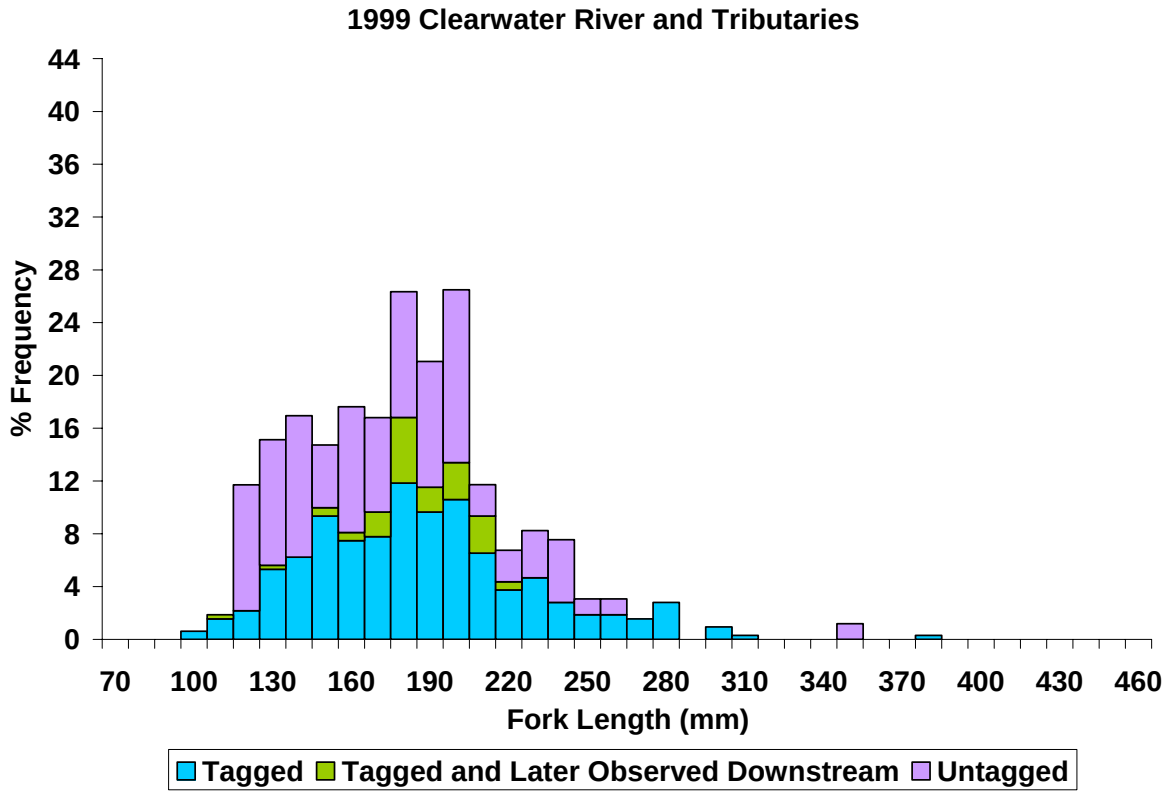
The length of hatchery steelhead caught ranged between 76-455 mm (Figures 17, 18, 19, 20). For all hatchery steelhead captured, those in the Clearwater River and smaller tributaries was significantly smaller ($P < 0.001$) than those captured in the North Fork Clearwater River and DNFH adult ladder in all years except 2001. This trend was also observed for hatchery steelhead that we PIT-tagged (Table 18).

Only 437, or 12%, of the 3,651 hatchery steelhead PIT-tagged in the study area were detected at downstream observation sites. We consider this a minimum percentage as the changes in the PIT-tag system at the dams in 2000 would not have detected steelhead tagged in 1999. Percent detections by year were 15%, 9%, 15% and 16% for 1999, 2000, 2001 and 2002, respectively. The majority of steelhead that migrated were tagged in the mainstem Clearwater River and smaller tributaries (398, or 91%). Migrants were significantly smaller than nonmigrants in 2001 and 2002 (Table 19), larger in 2000 and smaller but not significantly so in 1999.

Fourteen percent of the steelhead detected were observed the second year after they were tagged. The average length of second year migrants at tagging (2000=209, 2001=237, 2002=234) was larger than same year migrants (2000=201, 2001=207, 2002=195), but the difference was only highly significant in 2001 ($P<0.001$) and slightly significant in 2002 ($P=0.041$).

Table 17. Hatchery steelhead sampled in the Clearwater River drainage, 1999-2002.

	Total Steelhead Sampled	Collected for coded-wire tags				PIT-tagged and released				PIT-tag recaptures				Unintentional mortality			
Section	All years	1999	2000	2001	2002	1999	2000	2001	2002	1999	2000	2001	2002	1999	2000	2001	2002
Orofino to Big Canyon Creek	860	43	58	11	9	207	411	44	35	4	4	0	0	6	22	2	3
Big Canyon Creek to Bedrock Creek	509	6	13	29	13	54	110	206	59	2	0	4	3	4	2	2	1
Bedrock Creek to Myrtle	357	9	13	29	1	23	85	179	4	0	2	4	0	0	5	4	0
Myrtle to Hog Island	332	2	9	39	2	1	35	239	1	0	1	2	0	0	0	2	0
Hog Island to Snake River	12	0	0	0	1	3	8	0	0	0	0	0	0	0	0	0	0
North Fork Clearwater River	1,303	12	117	40	22	54	538	374	88	1	29	7	1	0	17	1	0
Dworshak Hatchery Adult Ladder	970	10	69	44	13	44	294	287	83	3	29	26	5	10	25	22	6
Big Canyon Creek	29	2	3	0	0	1	15	5	0	0	2	0	0	0	0	0	0
Jacks Creek	85	3	6	2	0	20	25	26	0	0	3	0	0	0	0	0	0
Bedrock Creek	30	1	3	3	0	0	6	17	0	0	0	0	0	0	0	0	0
Cottonwood Creek	81	0	4	4	0	10	25	35	0	0	2	1	0	0	0	0	0
Totals	4,567	88	295	201	61	417	1,552	1,412	270	10	72	44	9	20	71	33	10



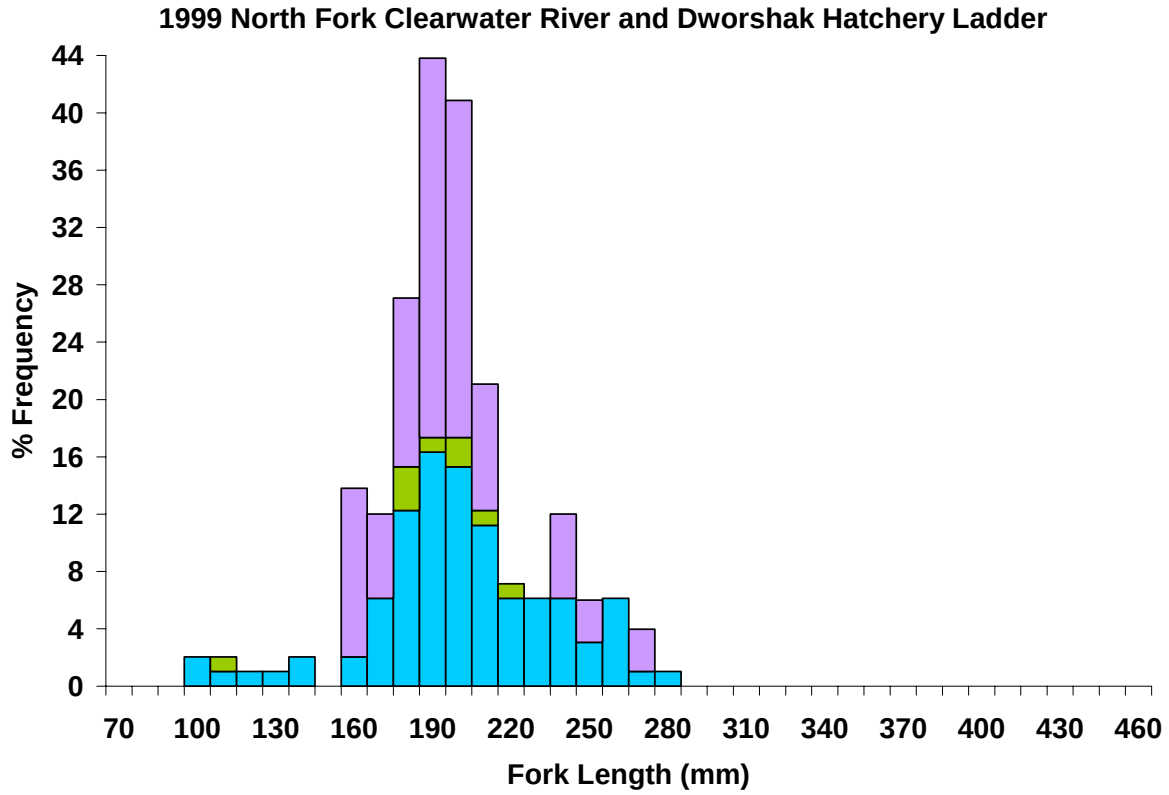


Figure 17. Length frequency of hatchery steelhead smolts tagged, untagged, and later observed downstream, Clearwater River and tributaries, 1999.

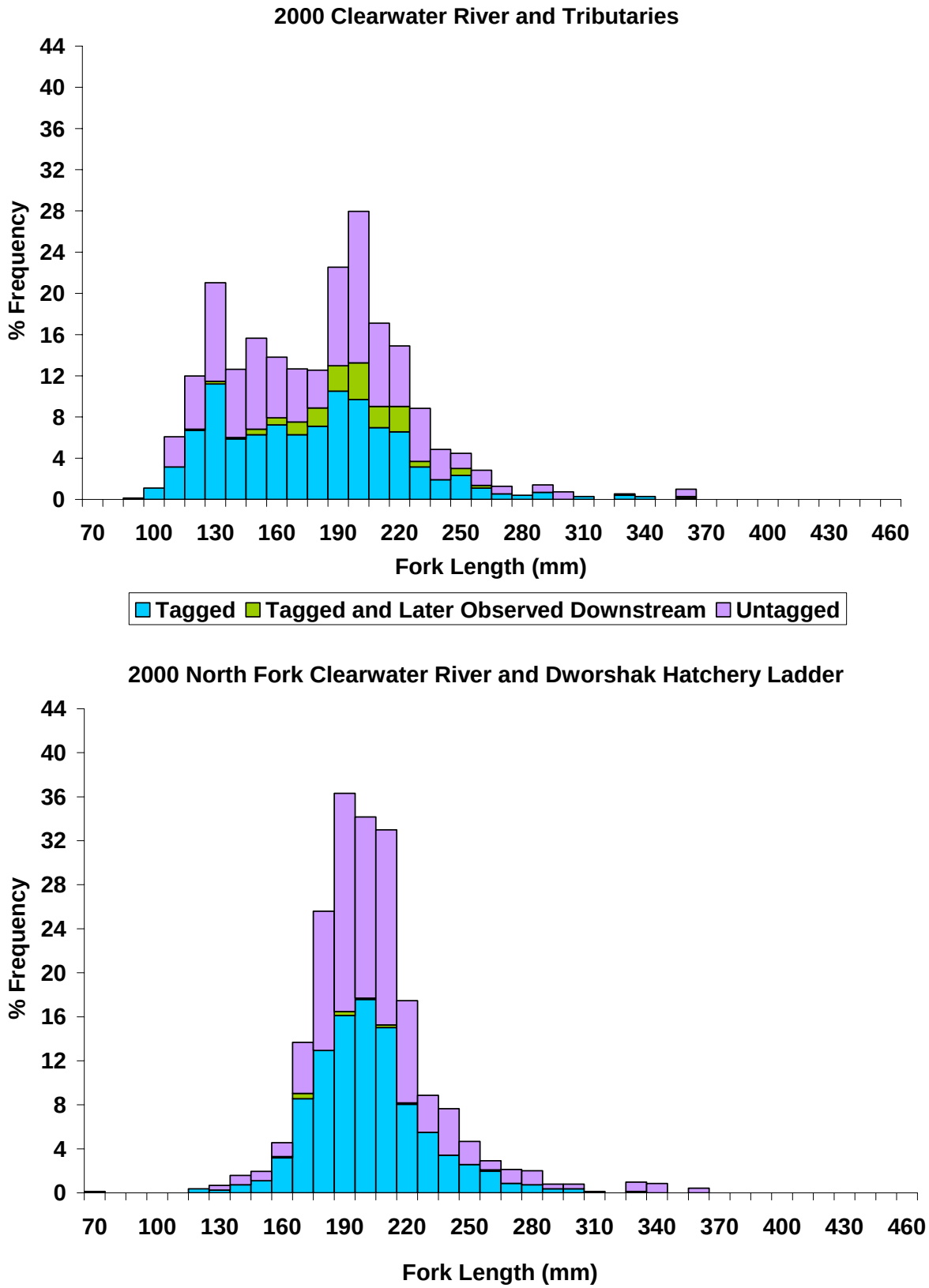
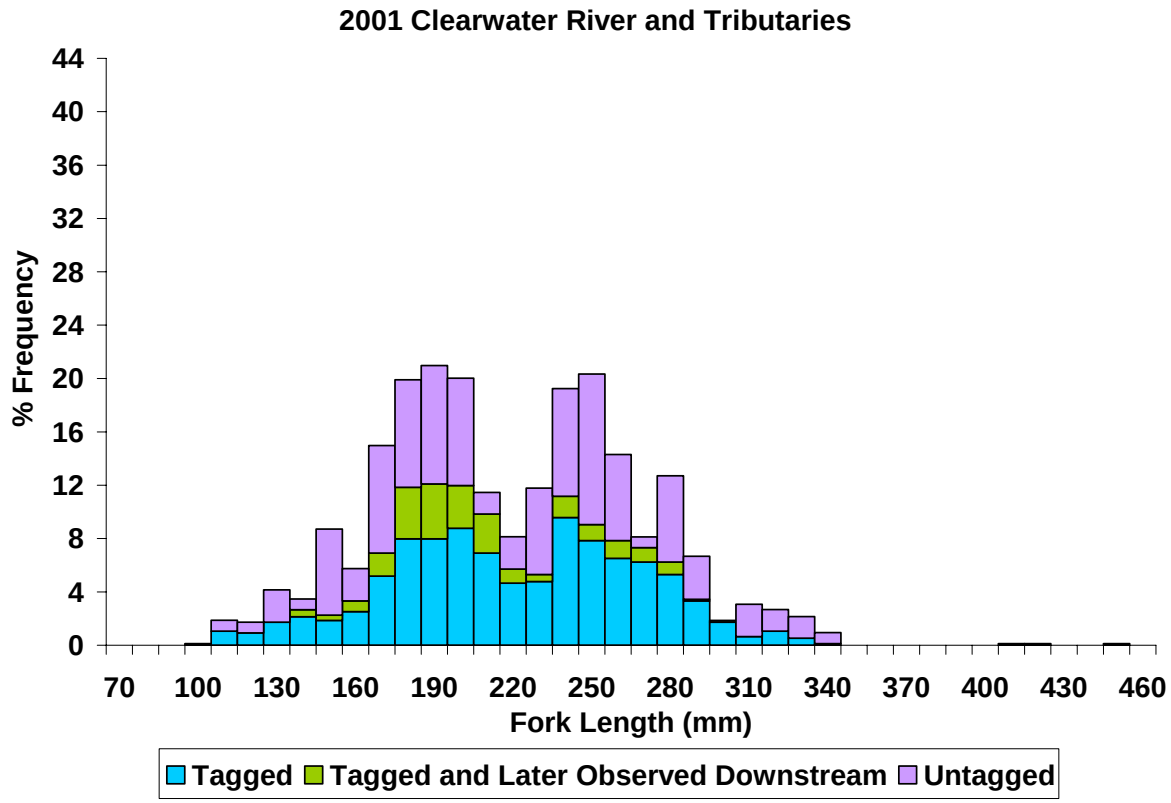


Figure 18. Length frequency of hatchery steelhead smolts tagged, untagged, and later observed downstream, Clearwater River and tributaries, 2000.



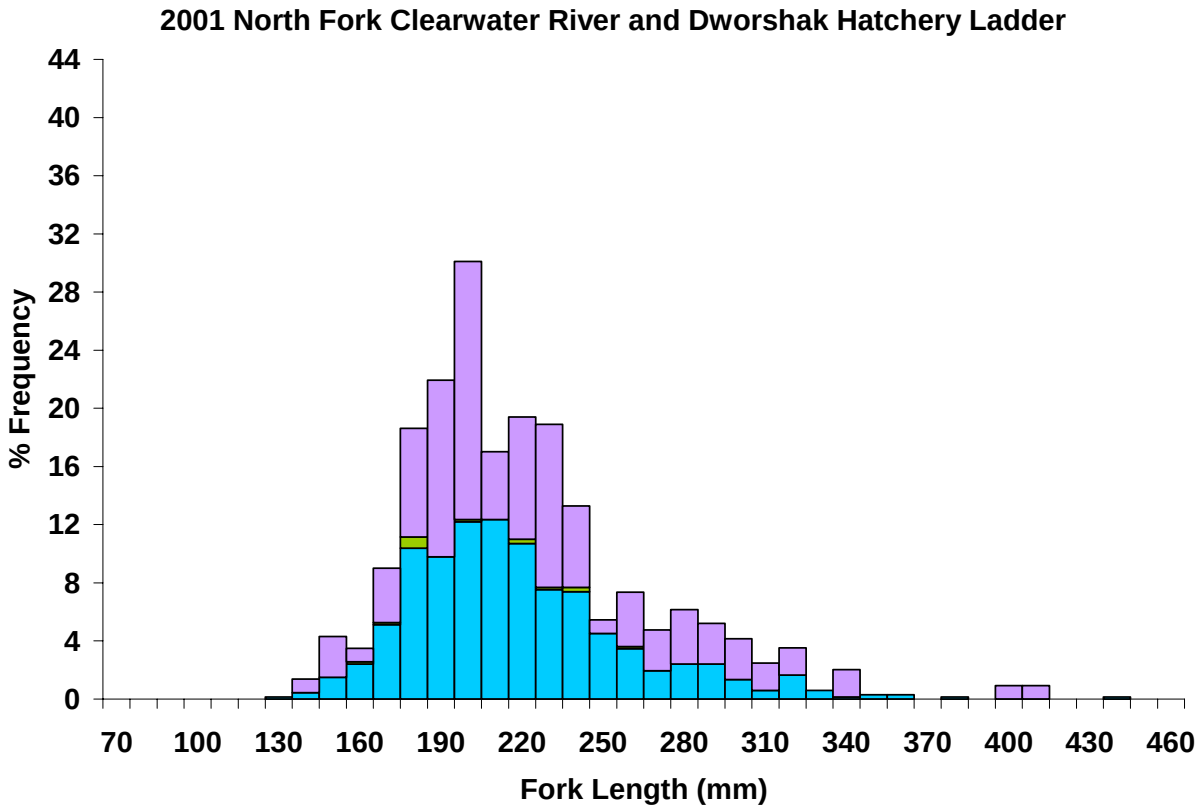


Figure 19. Length frequency of hatchery steelhead smolts tagged, untagged, and later observed downstream, Clearwater River and tributaries, 2001.

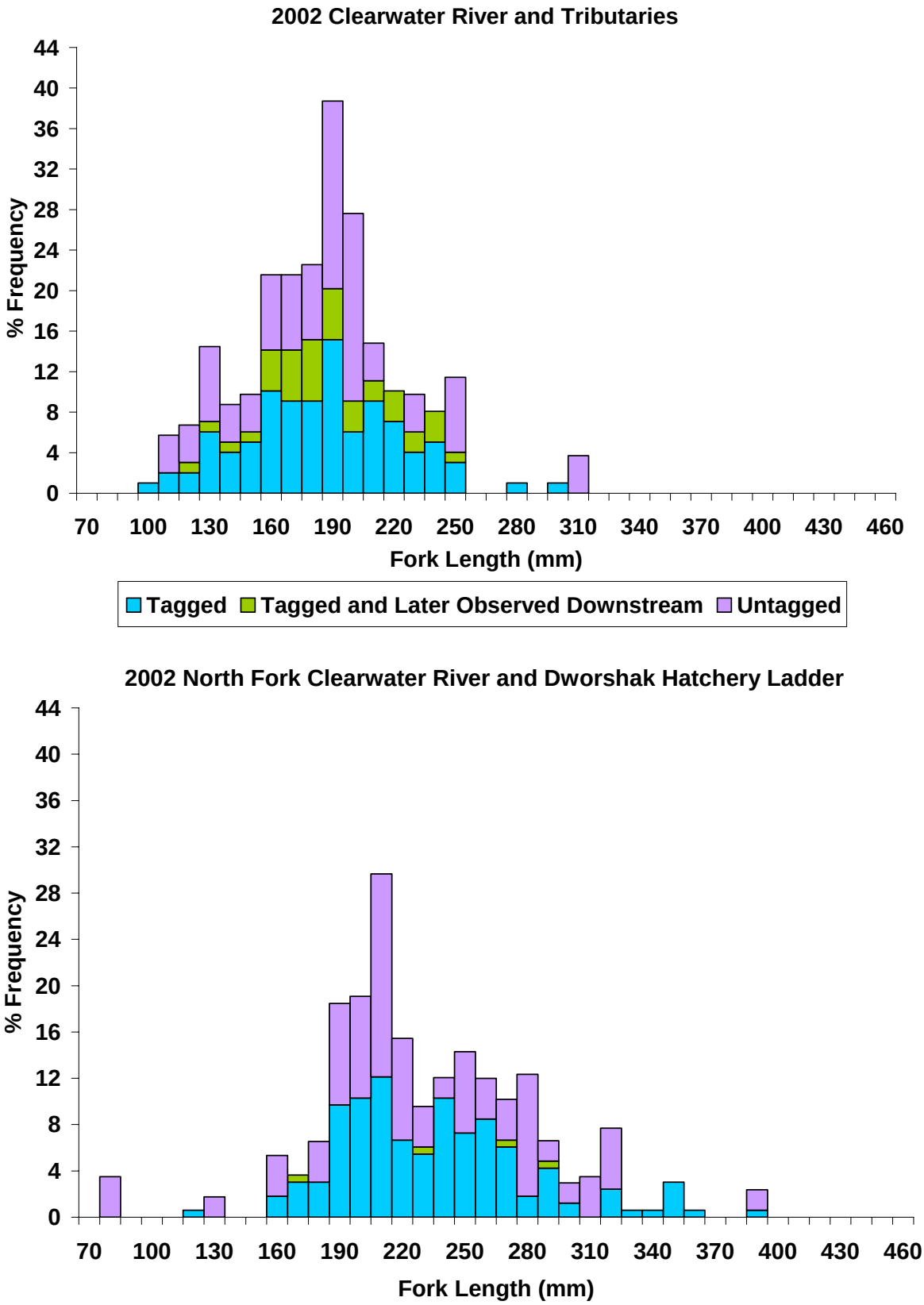


Figure 20. Length frequency of hatchery steelhead smolts tagged, untagged, and later observed downstream, Clearwater River and tributaries, 2002.

Table 18. Mean fork length (mm) and length range of hatchery steelhead tagged in the Clearwater River and tributaries, 1999-2002. Lower Clearwater tributary catch is combined with the mainstem Clearwater River catch, and the Dworshak Hatchery Adult Ladder catch is combined with the North Fork Clearwater River.

Tagging Year and Tag Group	Number tagged	Mean Capture length	SD	Length Range	P
1999					
Clearwater River	319	190	42.5	106-380	0.002
North Fork Clearwater River	98	205	35.3	100-285	
2000					
Clearwater River	731	182	43.5	98-360	<0.001
North Fork Clearwater River	819	205	27.7	76-330	
2001					
Clearwater River	750	226	18.2	101-452	0.131
North Fork Clearwater River	663	223	40.1	136-455	
2002					
Clearwater River	99	189	38.0	109-305	<0.001
North Fork Clearwater River	166	238	44.6	125-381	

Table 19. Mean fork length (mm) and length range of migrating and non-migrating hatchery steelhead tagged in the Clearwater River and tributaries, 1999-2002. Second year migrants included.

Tagging Year and Migrant Group	Number tagged	Mean Capture length	SD	Length Range	P
1999					
Migrants	63	189	22.6	113-229	0.308
Nonmigrants	354	195	43.8	100-380	
2000					
Migrants	137	202	31.7	129-360	0.011
Nonmigrants	1413	193	38.4	76-345	
2001					
Migrants	206	212	34.6	141-305	<0.001
Nonmigrants	1207	227	45.8	101-455	
2002					
Migrants	42	198	36.6	129-292	0.002
Nonmigrants	223	224	49.2	109-381	

Most PIT-tagged hatchery steelhead that migrated the same year they were PIT-tagged were observed at downstream dams within three weeks of tagging. The average travel time ranged from 9-19 days for same year migrants and 255-284 days for second year migrants (Table 20). For all migrants combined, the fastest travel time was 2 days and the longest was 412 days. Regardless of what year they migrated, 85% or more of the hatchery steelhead were observed at downstream sites by July 1 in all years (Table 20).

Table 20. Travel time (days) for same year and second year migrants of hatchery steelhead tagged in the Clearwater River and tributaries, 1999-2002.

Tagging Year and Migrant Group	Number Migrants	Mean Travel Time	SD	Range Travel Time	Observation Date Range	Percent by July 1
1999						
Same Year	62	16	11.4	3-44	4/27/1999 to 6/30/1999	100
Second Year	0					
2000						
Same Year	107	12	9.7	2-67	4/29/2000 to 8/5/2000	98
Second Year	25	284	55.1	160-412	3/27/2001 to 8/14/2001	96
2001						
Same Year	168	19	18.7	4-110	4/24/2001 to 10/31/2001	85
Second Year	33	274	31	183-341	3/29/2002 to 6/19/2002	100
2002						
Same Year	36	9	5.2	4-30	5/19/2002 to 6/15/2002	100
Second Year	6	255	47.6	208-327	4/3/2003 to 5/31/2003	100

We recaptured 135 PIT-tag hatchery steelhead, of which 130 were unique recaptures and 5 were multiple recaptures. Most of the recaptures were from fish tagged during sampling (117), followed by 12 Dworshak Hatchery releases and one recapture from out of the drainage. Over 67% of the recaptured hatchery steelhead were caught in the North Fork Clearwater River and the Dworshak Hatchery Adult ladder.

Most recaptured hatchery steelhead did not exhibit any movement between tagging and recapture. Over 77% of the recaptures were caught within one kilometer of where they were tagged (Figure 21). The farthest distance traveled was 102 km downstream by a hatchery steelhead released into the South Fork Clearwater River and recaptured in the section between Big Canyon Creek and Bedrock Creek. Upstream movement also occurred, with one hatchery steelhead traveling 15 km from the section between Big Canyon Creek and Bedrock Creek to the section between Orofino and Big Canyon Creek. Not surprisingly, most movement by hatchery steelhead occurred within the same section that they were PIT-tagged (Figure 22). The three steelhead recaptured more than once were tagged and recaptured in the North Fork Clearwater River.

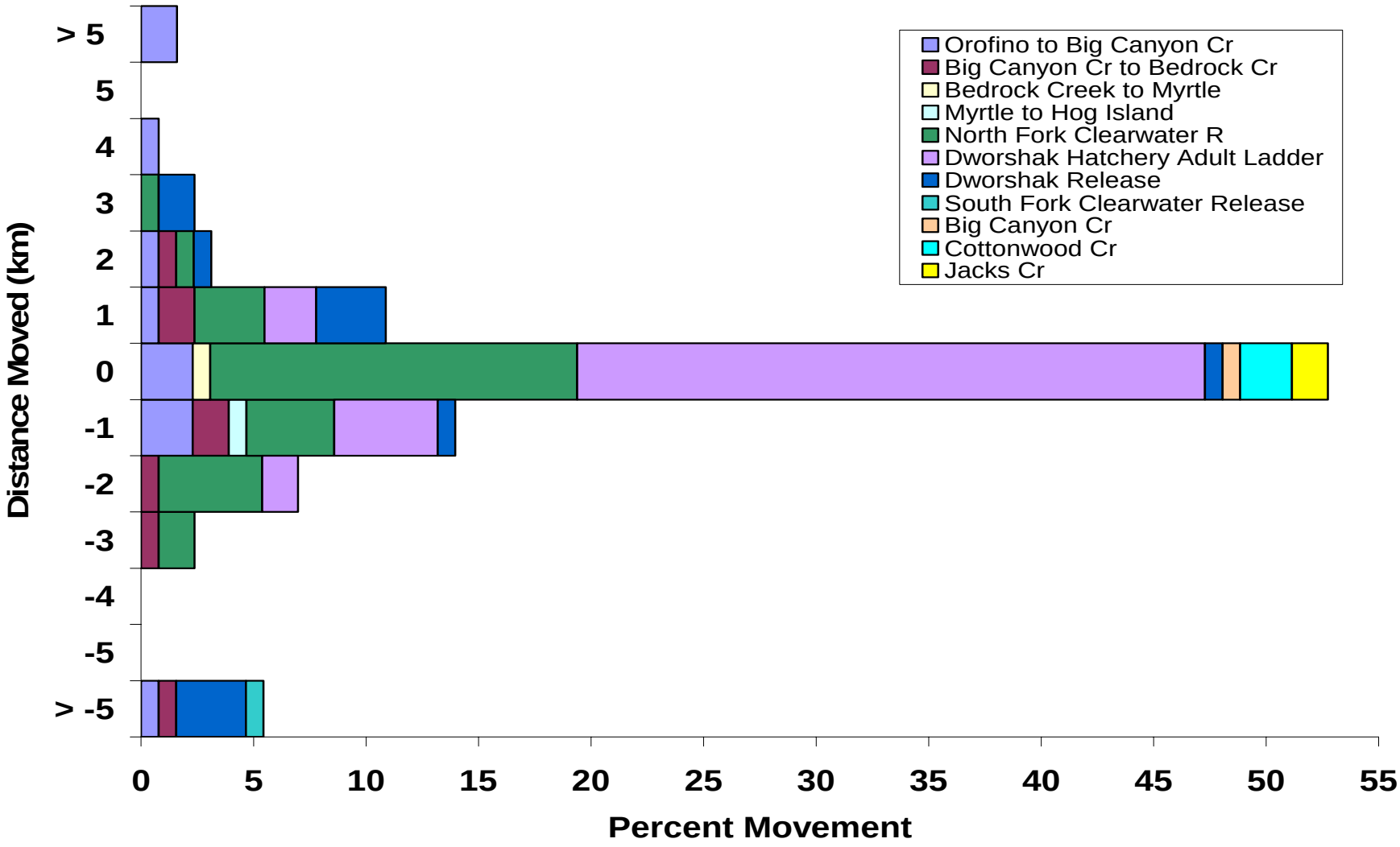


Figure 21. Distance traveled by hatchery steelhead from initial PIT-tagging to recapture, by river section the PIT-tagging or release occurred, Clearwater River and tributaries, 1999-2002. Negative number denotes downstream movement, positive number denotes upstream movement.

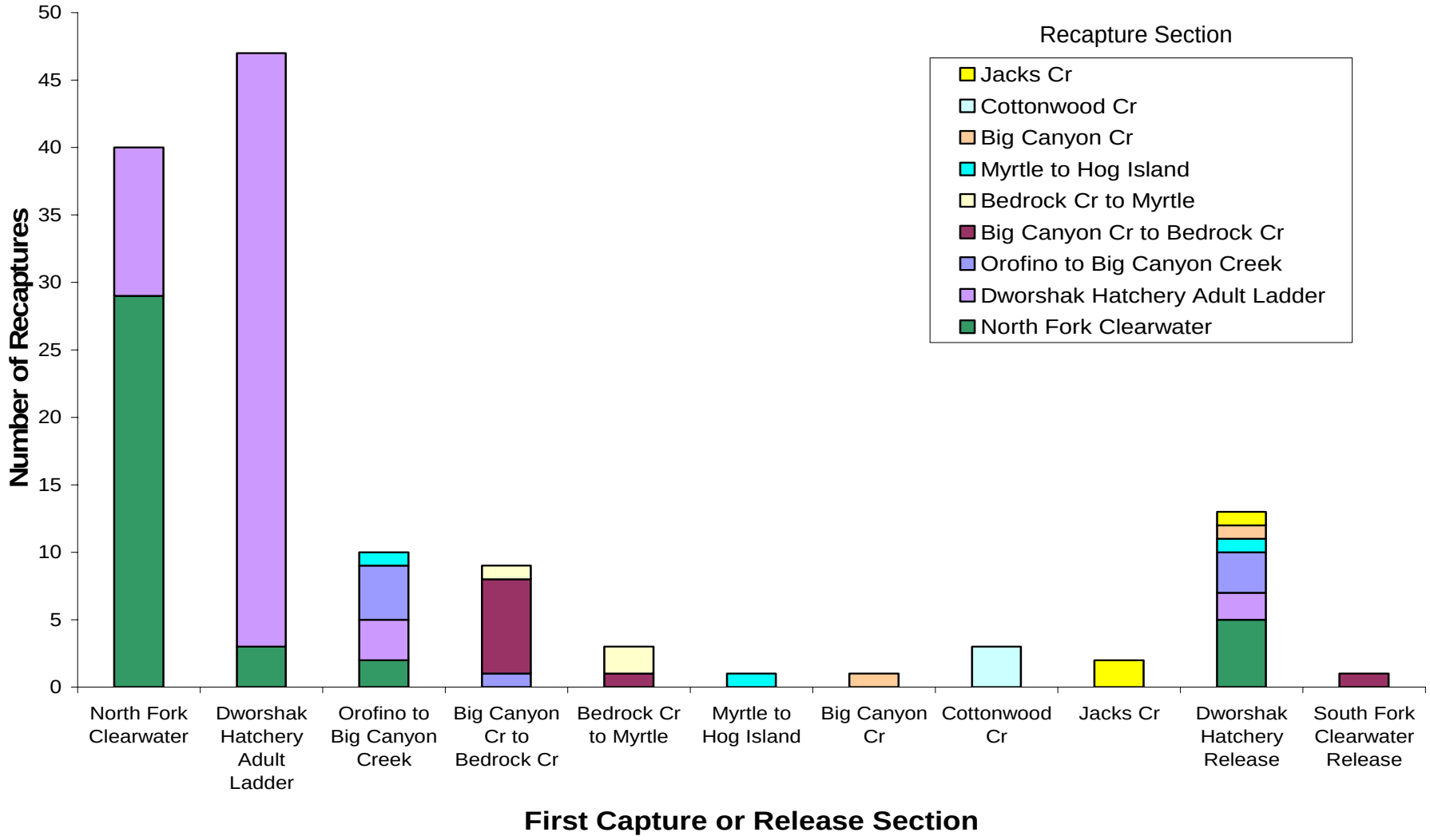


Figure 22. Number of hatchery steelhead PIT-tagged and later recaptured, by release and recapture section, Clearwater River and tributaries, 1999-2002.

The time between tagging and first recapture averaged 38 days (SD 48.17), the range 1-319 days for all years combined. The three hatchery steelhead recaptured more than once were caught within one month of the first recapture event.

Despite our documentation of little movement, five steelhead that we recaptured were eventually observed at downstream observation sites. Two of these steelhead overwintered and were observed the following spring. One steelhead, tagged and recaptured in August in the section between Bedrock Creek and Myrtle, was observed at Lower Granite Dam on October 31 of the same year, suggesting that some fall and winter movement out of the Clearwater River does occur.

Growth rate of recaptured hatchery steelhead was calculated by dividing the change in length by the number of days between initial tagging and recapture. We removed anomalous data (such as negative values from recording mistakes) before calculating values. The average growth rate was 0.27 mm/day (range 0-1.8, SD 0.28), based on an average number of days between tagging and recapture of 42 days (range 1-319 days, SD 51.2).

Most of the PIT-tagged hatchery steelhead fell into the "unknown" category for gender. The number of known males sampled ranged from 3.4% in 2002 to 17.5% in 2000. For all years combined, the average percentage of males sampled was 13%. All males captured were precocious.

Coded-Wire Tags

Most of the coded-wire tag tags were recovered from steelhead captured in the North Fork Clearwater River, the DNFH adult ladder and the Clearwater River between Orofino and Big Canyon Creek (Figure 23). The majority of recoveries came from steelhead released at DNFH, with other Clearwater drainage releases making up less than 3% for all years. Interestingly in 2001, 30% of the coded-wire recoveries came from steelhead released into the Salmon River and the Snake River drainages from other hatcheries.

Three study groups were represented in the DNFH coded-wire tag recoveries – Contribution, Early Return Progeny raised in System I, and Early Return Progeny raised in System II (see chapter 1 for descriptions). We recovered 216 tags from the Contribution group, 154 from Early Return System I and 117 from Early Return System II. The fork length of steelhead captured varied by study group and year recovered (Figure 24), with some steelhead attaining a large size in the same year they were released (Table 21). Twenty-four steelhead captured were holdovers from previous year releases. The average length of the Contribution group at capture was significantly smaller ($P<0.001$) than the Early Return groups in all years except 2001 (Table 22). The only significant difference in length ($P<0.001$) between the two Early Return groups occurred in 2000.

There were significantly ($P<0.001$) more males (371) than females (89) recovered for all groups and years combined, and for all studies combined each year. The Contribution group had significantly more males than either Early return groups in 1999 and 2001. The percentage

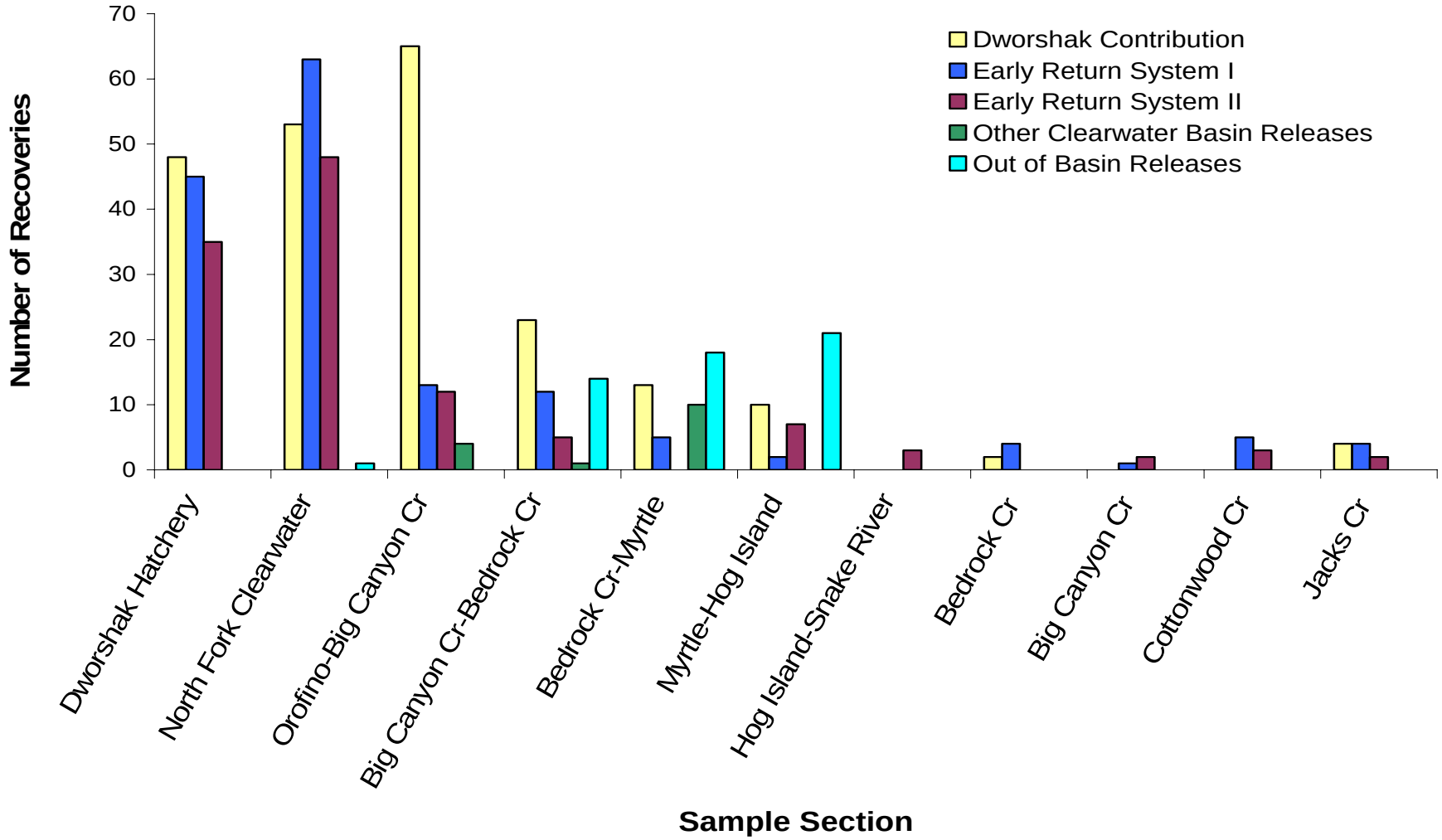


Figure 23. Coded-wire tag recoveries by sample section and release group, all years combined, Clearwater River and tributaries, 1999-2002.

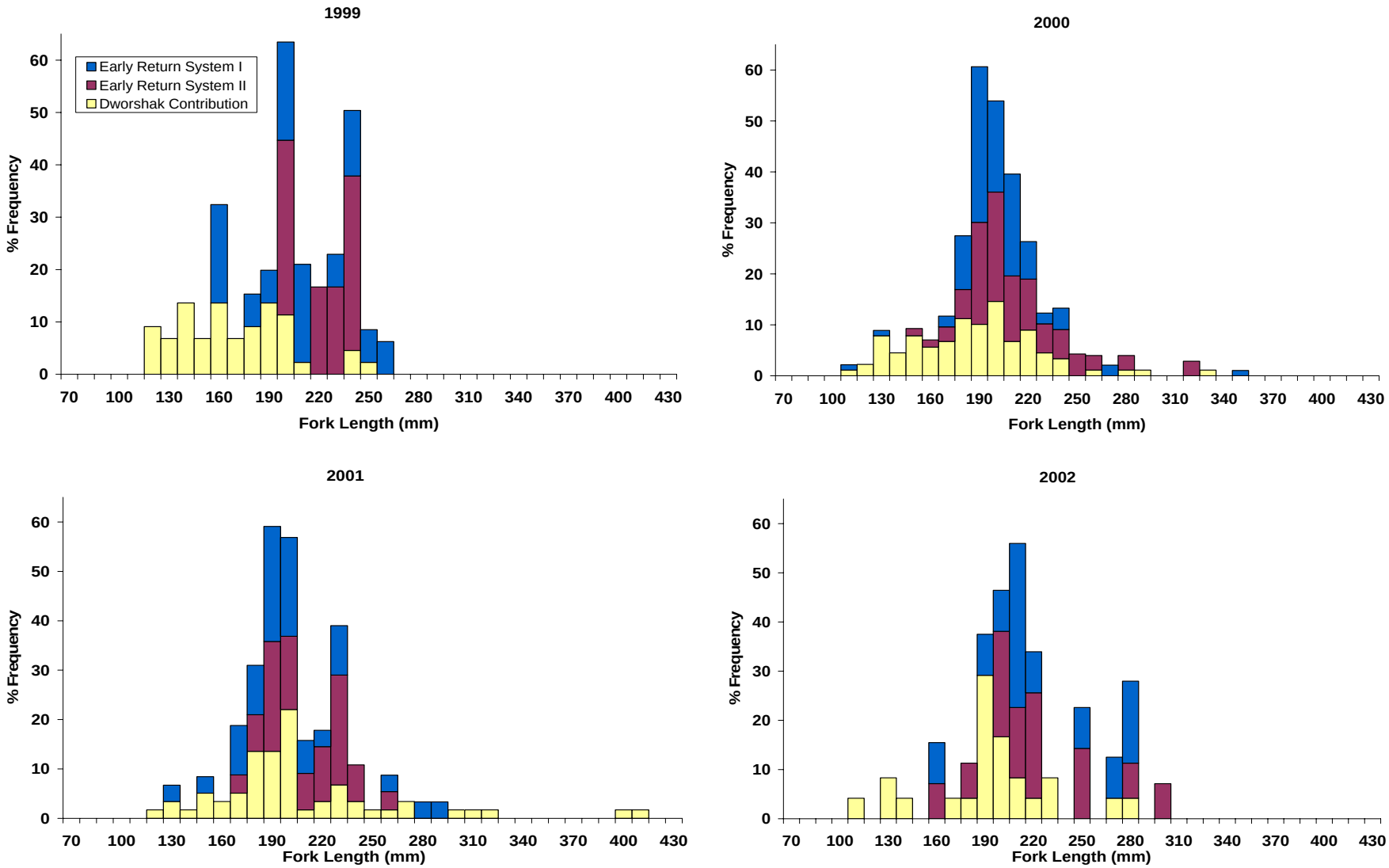


Figure 24. Length frequency of hatchery steelhead recovered with coded-wire tags, by release group, Clearwater River and tributaries, 1999-2002.

Table 21. Length, gender and maturity of coded-wire tagged hatchery steelhead recovered in Clearwater River and tributaries, 1999-2002. No females recovered were mature.

Recovery year		Contribution				Early Return System I				Early Return System II			
		Release Year				Release Year				Release Year			
		1999	2000	2001	2002	1999	2000	2001	2002	1999	2000	2001	2002
	Release length	182	202	197	205	200	200	195	211	215	212	207	207
1999	Recoveries	43				16				6			
	Mean Length	170				210				226			
	Length Range	122-248				161-261				201-248			
	% Males	48				56				83			
	% Mature	15				44				40			
2000	Recoveries	0	89			1	94			0	70		
	Mean Length		191			274	205				216		
	Length Range		111-330				113-351				159-328		
	% Males		72			100	77				76		
	% Mature		38			0	56				53		
2001	Recoveries	1	9	50		1	4	26		0	4	23	
	Mean Length	410	268	195		133	254	200			226	211	
	Length Range		205-320	118-405			210-254	156-264			200-260	171-248	
	% Males	100	89	84		100	100	77			100	96	
	% Mature	100	88	57		0	75	60			75	68	
2002	Recoveries	0	0	2	22	0	0	1	11	0	0	0	14
	Mean Length			219	195			217	229				225
	Length Range			210-228	116-286				163-282				165-302
	% Males			100	77			100	91				100
	% Mature			0	29			100	60				21

Table 22. Mean, minimum and maximum fork length (mm) of coded-wire tagged hatchery steelhead released at Dworshak National Fish Hatchery and captured in the Clearwater River and tributaries, 1999-2002.

Recovery Year and Study Group	Number collected	Capture length	SD	Minimum length	Maximum length	P
1999						
Contribution	44	173	32.5	122	250	<0.000
Early Return Progeny System I	16	210	31.0	161	261	
Early Return Progeny System II	6	226	19.3	201	248	
2000						
Contribution	89	191	39.0	111	330	<0.000
Early Return Progeny System I	95	206	26.3	113	351	
Early Return Progeny System II	70	216	31.7	159	328	
2001						
Contribution	60	209	55.4	118	410	0.778
Early Return Progeny System I	30	205	33.2	133	295	
Early Return Progeny System II	27	213	22.5	171	260	
2002						
Contribution	24	197	39.9	116	286	0.036
Early Return Progeny System I	12	228	36.4	163	282	
Early Return Progeny System II	14	225	37.5	165	302	

of males captured ranged from 48% to 100%; their maturity ranged from 0% to 100% (Table 21). There were no significant difference in mean length between mature males and immature males regardless of study or year, although the range in lengths varied (Table 23).

Less than one percent of coded-wire tags from hatchery steelhead released from DNFH were recovered during sampling (Table 24). Since there is no way to track coded-wire tags through the mainstem migration system, we do not know whether the number caught is an artifact of the number of coded-wire tagged hatchery steelhead in the river or our sampling efficiency.

Diet Analysis

Stomach contents were collected and analyzed for all fish sampled in 1999 and 2000. Aquatic insects in the orders Ephemeroptera, Diptera, and Trichoptera were found in over half of the fish sampled in both years (Table 25). Between these orders, Trichoptera had the highest total weight. Hymenoptera was almost the only terrestrial insect found in the diet of sampled fish, appearing in almost half of the fish sampled (Table 25). While other insect orders were present, they were a minor part of the diet. The percent of fish sampled containing fish or fish parts in their stomachs was less than 2 % in each year, indicating predation on listed fish species or other fish was minimal.

Table 23. Lengths of mature and immature CWT hatchery steelhead collected in the Clearwater River and tributaries, 1999-2002.

	Mature Males				Immature Males			
Recovery Year and Study Group	Number collected	Capture length	SD	Length Range	Number collected	Capture length	SD	Length Range
1999								
Contribution	4	192	41.4	158-250	40	172	31.5	122-248
Early Return Progeny System I	4	204	11.0	191-218	12	212	35.5	161-261
Early Return Progeny System II	2	235	10.6	227-242	3	229	21.9	205-248
2000								
Contribution	24	192	18.6	137-220	65	191	44.5	111-330
Early Return Progeny System I	40	204	17.6	171-203	55	207	31.3	113-351
Early Return Progeny System II	28	204	14.3	176-240	25	218	31.7	159-289
2001								
Contribution	32	227	64.7	128-410	28	189	33.5	118-254
Early Return Progeny System I	15	216	36.3	156-295	15	194	26.6	133-264
Early Return Progeny System II	19	221	20.9	182-260	7	196	16.1	171-220
2002								
Contribution	5	233	46.0	190-286	19	188	33.5	116-235
Early Return Progeny System I	7	246	34.5	196-282	5	203	22.5	163-216
Early Return Progeny System II	3	251	51.0	200-302	11	218	32.4	165-286

Table 24. Coded-wire tags recovered by sample year and study, Clearwater River and selected tributaries, 1999-2002.

	Dworshak Hatchery						Clear Creek	South Fork Clearwater River
	Early Return Progeny		Contribution			All releases		
	System I	System II	System I	System II	System III	Total	All Systems	All Systems
1999								
Number Recovered	18	6	18	19	7	68	5	3
Number Released	21,652	21,239	19,652	34,306	33,924	130,773	20,041	54,674
Percent Recovered	0.08	0.03	0.09	0.06	0.02	0.05	0.02	<0.01
2000								
Number Recovered	98	74	25	37	36	270	0	
Number Released	21,966	21,799	22,046	43,613	41,042	150,466	21,213	0
Percent Recovered	0.45	0.34	0.11	0.08	0.09	0.18	0.00	
2001								
Number Recovered	27	23	21	17	14	102	0	
Number Released	21,835	21,922	21,293	41,897	42,974	149,921	21,115	0
Percent Recovered	0.12	0.11	0.10	0.04	0.03	0.07	0.00	
2002								
Number Recovered	11	14	2	10	10	47	1	
Number Released	22,502	23,799	21,352	42,213	44,884	154,750	21,856	0
Percent Recovered	0.05	0.06	<0.01	0.02	0.02	0.03	<0.01	

Table 25. Food item, total number and total weight of stomach contents of hatchery juvenile steelhead sampled in the Clearwater River Basin from Dworshak National Fish Hatchery and downstream, 1999 and 2000. Some samples were collected in tributaries.

	Total Number		Total Weight (g)		Number of fish with this item		Percent of fish with this item	
Food Item	1999	2000	1999	2000	1999	2000	1999	2000
Aquatic insects								
Ephemeroptera	1,305	568	4.21	2.66	167	124	58.8	55.4
Diptera	3,555	2,959	7.30	1.60	176	174	62.0	77.7
Plecoptera	159	148	0.98	2.54	38	37	13.4	16.5
Odonata	13	1	3.48	0.05	8	1	2.8	0.4
Trichoptera	3,841	2,295	23.27	25.45	219	140	77.1	62.5
Coleoptera	123	240	2.07	2.20	42	51	14.8	22.8
Lepidoptera	21	18	0.54	1.05	13	10	4.6	4.5
Hemiptera	821	240	5.36	0.87	114	50	40.1	22.3
Terrestrial insects								
Megaloptera	4	0	0.50	0	4	0	1.4	0
Orthoptera	3	0	0.33	0	3	0	1.1	0
Hymenoptera	1,801	1,368	15.23	13.16	138	93	48.6	41.5
Crustaceans								
Isopoda	1	14	0.03	0.40	1	6	0.4	2.7
Amphipoda	4	0	0.19	0	3	0	1.1	0
Corophium	2	0	0.01	0	2	0	0.7	0
Cladocera	X	83	3.69	12.66	17	4	6.0	1.8
Decapoda	8	1	0.31	0.01	8	1	2.8	0.4
Mollusca	46	54	1.97	3.24	14	13	4.9	5.8
Pisces								
Nonsalmonid	1	0	0.12	0	1	0	0.4	0
Larval fishes	5	16	0.04	0.06	1	1	0.4	0.4
Catastomidae	2	0	0.01	0	2	0	0.7	0
Cottidae	3	1	0.69	0.02	3	1	1.1	0.4
Fish eggs	X	33	0.03	0.64	2	3	0.7	1.3
Unidentified flesh	X	X	0.24	0.94	3	1	1.1	0.4
Empty stomach					48	20		

Discussion

Based on the four years we sampled, most of the hatchery steelhead released from DNFH and that later residualize stay within four kilometers of the hatchery. Over 68% of the hatchery steelhead we sampled were in the North Fork Clearwater River, DNFH adult ladder and the Clearwater River between Orofino and Big Canyon Creek. Within the Orofino-Big Canyon Creek section, almost 65% of the hatchery steelhead captured were within one kilometer of the mouth of the North Fork Clearwater River. The catch per unit effort (CPUE) for the two years it was collected supports our observations. The North Fork Clearwater River had the highest mean CPUE (0.0433 steelhead/second) followed by the Clearwater River between Orofino and Big Canyon Creek (0.0128 steelhead/second). The CPUE for all other sections sampled was 0.007 or less.

The interaction plot of mean fork length of migrants, nonmigrants (not observed downstream), and residuals sampled (all combined, North Fork and Clearwater) (Figure 25) is disorderly. However, several significant differences occurred among the groups. Migrants were larger than nonmigrants in all years except 2002. Residual hatchery steelhead caught in the North Fork Clearwater and DNFH adult ladder were larger than those caught in the other sections in all years except 2001. The North Fork Clearwater River residuals were the same size of migrants in 1999 and 2000, and were larger in 2001 and 2002. They were also larger than nonmigrants in all years. Clearwater River residuals were significantly smaller than both migrants and nonmigrants in all years except 2001. When all the residuals were combined into one group, the differences were not as clear. If the nonmigrants did residualize in the Clearwater drainage in the vicinity of DNFH, with a growth rate of 0.27mm/day they would be approximately the same size as those we sampled in the North Fork Clearwater River, and much larger than the hatchery steelhead we sampled in the Clearwater River.

We do have evidence that some hatchery steelhead hold over one year before migrating, though was less than 2% of what we PIT-tagged. Oddly, these steelhead tended to be larger at tagging than their counterparts that migrated in the same year they were tagged. We do have some indication that hatchery steelhead migrate downstream outside of the normal migration window, with detections as late as the end of October. It may be possible that the smaller steelhead we sampled in the Clearwater River may achieve enough growth to start migration downstream when the detection systems are not operating, but since we have no data to support this we can only speculate. More likely is that the smaller fish in the Clearwater River move into the North Fork when flows drop and temperatures moderate.

The residual hatchery steelhead remaining near DNFH may be attracted to the lower water temperature in the North Fork Clearwater River, a result of releases from Dworshak Dam. Starting around the second week of June, water temperature in the North Fork Clearwater is at least 5ºC colder than the Clearwater River below the North Fork confluence, and 10ºC or greater than the Clearwater River above the confluence (Figure 26). This trend continues until the beginning of October, when water releases from Dworshak Dam end and air temperatures drop, facilitating water cooling in the Clearwater River above the North Fork. Since we did not electrofish either the North Fork Clearwater River or Clearwater River after August, we do not

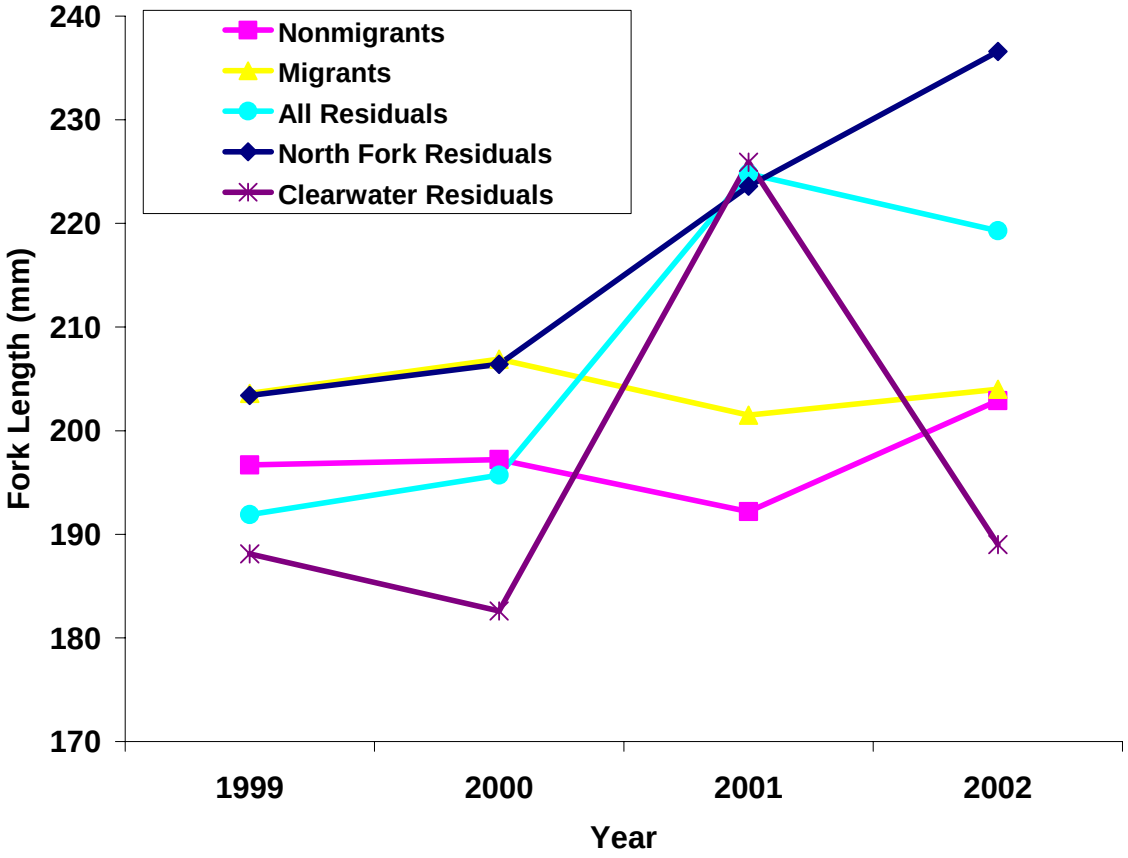


Figure 25. Interaction plot of mean fork length between migrants, nonmigrants and residuals, Clearwater River 1999-2002.

know if hatchery steelhead would have showed a different distribution than what we saw during the summer.

For those steelhead not ready to migrate, the North Fork Clearwater River serves as a thermal refuge, which may then influence whether or not smoltification will ever occur. Not only are the North Fork Clearwater residuals larger than those sampled downstream, few tagged fish from the North Fork Clearwater and DNFH adult ladder emigrated, and most recaptured steelhead sampled in the North Fork Clearwater River and DNFH were originally tagged there, all indicating that these steelhead would likely not go elsewhere. In addition, 36% of the hatchery steelhead caught in the North Fork Clearwater and DNFH adult ladder were males, of which 86% were mature. Residual steelhead in the Tucannon River (Viola and Schuck 1995) had a sex ratio of 4:1 (male:female), and 55% of the males were precocious. The sex ratio in this study was closer to 3:1, but the ratio was mostly based on hatchery steelhead we sacrificed to collect coded-wire tags. Had we been able to determine gender of hatchery steelhead we PIT-tagged, we may have found ratios similar to those found in the Tucannon. The percent maturity in this study was probably higher than what we would expect, since most of the sampling in the DNFH adult ladder occurred in the fall, when precociousness seemed most prevalent.

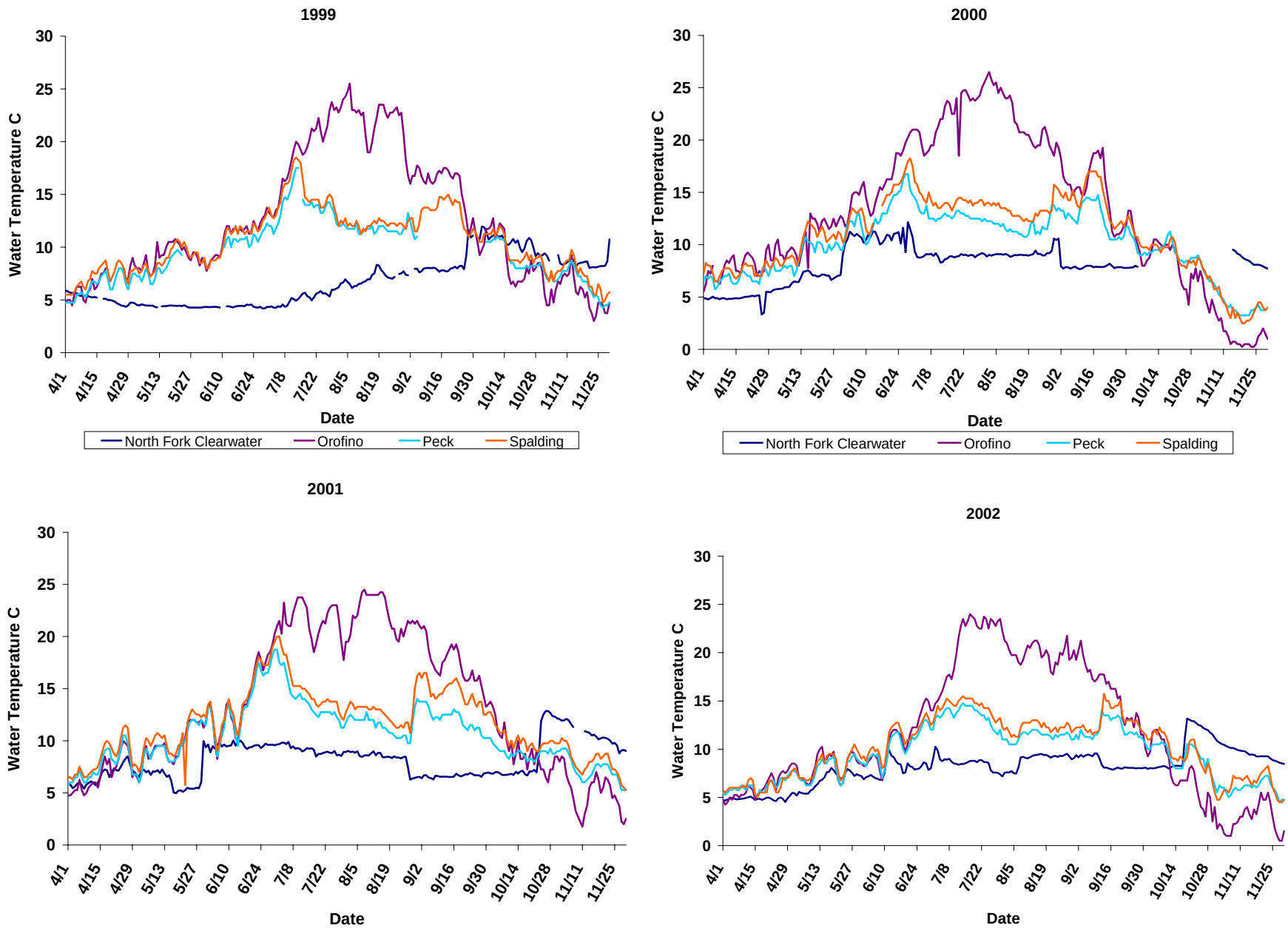


Figure 26. Water temperatures on the Clearwater River at Orofino, Peck, Spalding and on the North Fork Clearwater River, 1999-2002.

The farther downstream from DNFH we sampled, the less likely we were to catch hatchery steelhead. We were limited in our ability to sample effectively in some flows in the lower Clearwater River. In low flows, we were not able to get the boat close enough to shore habitat. In high flows, even though we could get close to the shore, water velocities were often too fast to sample effectively. We were also limited to daytime sampling due to safety concerns. However, most hatchery steelhead we did sample in the lower Clearwater River sections were caught during May through the first week of July. This trend was observed by the Idaho Department of Fish and Game when they sampled the Clearwater River from 1995-1999 looking for signs of gas bubble trauma (Cochnauer 1995, Cochnauer 1996, Cochnauer and Davis 1998, Schriever et al 1999). Hatchery steelhead captured were likely active migrants since there were few recaptures in these sections and migrants tagged there were generally detected by July 1. Even though we were unable to sample the lower tributaries after the third week of June, warm water temperatures in the tributaries after that time probably forced hatchery steelhead into the cooler Clearwater River. Over half of the hatchery steelhead tagged in the tributaries were later observed downstream.

We originally proposed to conduct a population estimate using mark-recapture techniques. Since we only recaptured 130 individual steelhead out of 3,651 tagged, this task was not possible without a large source of error and violation of assumptions. We can, however, make a rough estimate of residual steelhead using average survival rate to Lower Granite Dam of PIT-tagged steelhead released at DNFH. Assuming an average 78% survival of PIT-tagged hatchery steelhead released from DNFH to Lower Granite Dam (Chapter 1 this report), almost 265,000 hatchery steelhead released annually at DNFH are unaccounted for. If those steelhead remain in the Clearwater River and distribute themselves similar to what we found sampling, over 172,000 would remain within one km of DNFH, the remaining 92,700 would be found downstream. When comparing length of hatchery steelhead caught sampling to length frequency of PIT-tagged hatchery steelhead released from DNFH but not detected, the two groups are similar in 1999 and 2000 (Figure 27). However, in 2001 and 2002, the distribution of sampled hatchery steelhead shifted to larger length groups, indicating that in some years, some of the hatchery steelhead that never migrate live two years or longer after release, growing and maturing in the area of Dworshak National Fish Hatchery.

Stomach contents analysis indicated that residual hatchery steelhead eat mostly aquatic and terrestrial insects, and since few fish parts were found, are likely not having a negative impact on listed fish species.

It appears that most residual hatchery steelhead remain in the general vicinity of DNFH, grow to a larger size in the colder water of the North Fork, mature, and based on the length frequencies observed, die out after they reach around 350 mm in length. These residual hatchery steelhead do provide a minor local sport fishery in the North Fork Clearwater River during the summer months. While hatchery steelhead released from DNFH may have a negative impact on wild steelhead in the Clearwater Basin, our data showing temporal and spatial distribution, movement and diet suggest that the interaction between the two groups is minimal.

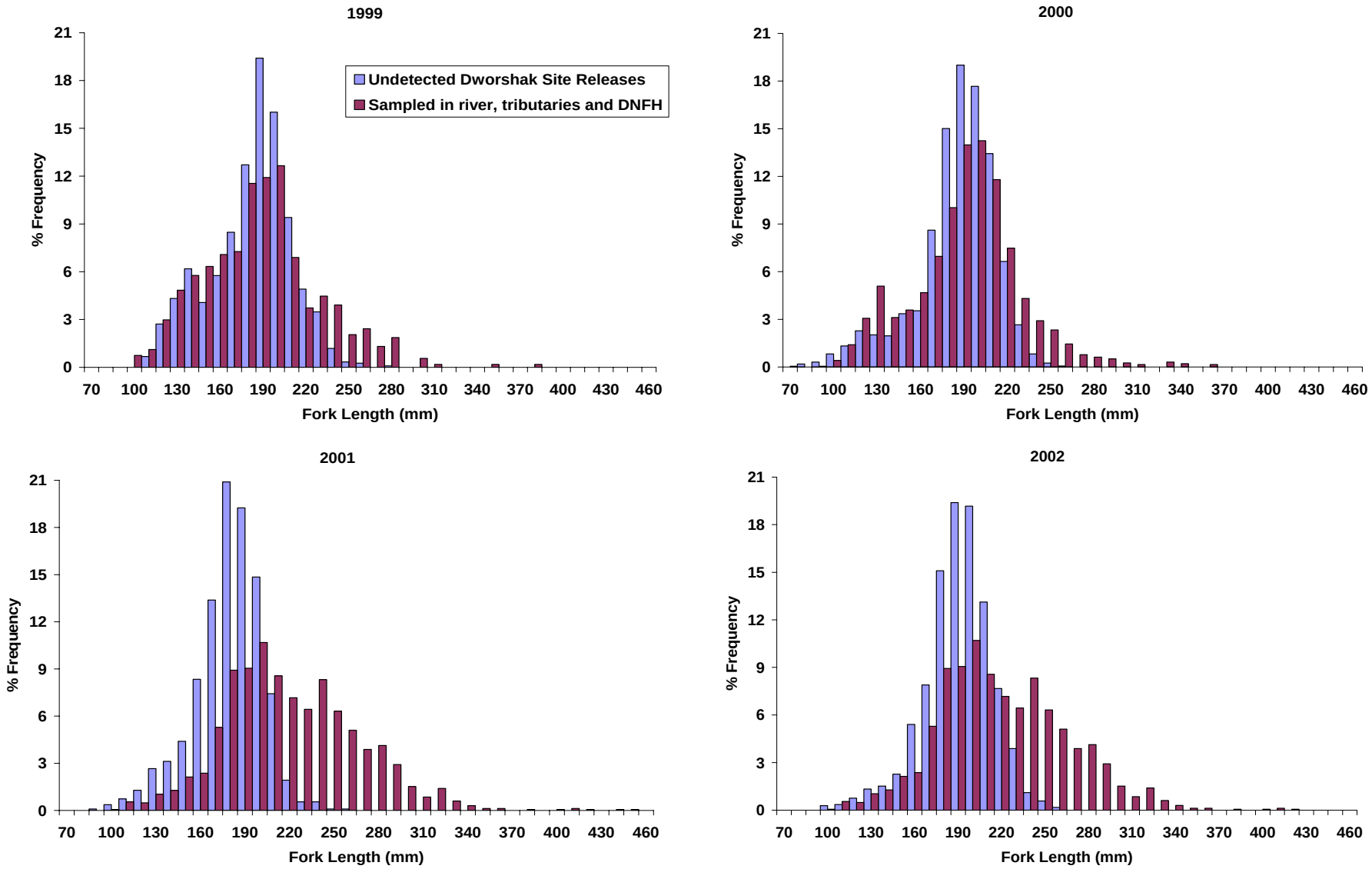


Figure 27. Length frequency of hatchery steelhead released from Dworshak National Fish Hatchery that were PIT-tagged but not detected, and hatchery steelhead sampled in the Clearwater River and tributaries, 1999-2002.

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