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Monitoring the Migrations of Wild Snake River Spring/Summer Chinook Salmon Smolts, 2001

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Report of research by

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EXECUTIVE SUMMARY

This report details the 2001 results from an ongoing project to monitor the migration behavior of wild spring/summer chinook salmon smolts in the Snake River Basin. The report also discusses trends in the cumulative data collected for this project from Oregon and Idaho streams since 1989.

The project was initiated after detection data from passive-integrated-transponder tags (PIT tags) had shown distinct differences in migration patterns between wild and hatchery fish for three consecutive years. National Marine Fisheries Service (NMFS) investigators first observed these data in 1989. The data originated from tagging and interrogation operations begun in 1988 to evaluate smolt transportation for the U.S. Army Corps of Engineers.

In 1991, the Bonneville Power Administration began a cooperative effort with NMFS to expand the tagging and interrogation of wild fish. The goals of this expansion were to characterize the outmigration timing of these fish, to determine whether consistent migration patterns would emerge, and to investigate the influence of environmental factors on the timing and distribution of wild fish migrations.

In 1992, the Oregon Department of Fish and Wildlife (ODFW) began an independent program of PIT tagging wild chinook salmon parr in the Grande Ronde and Imnaha River Basins in northeast Oregon. Since then, ODFW has reported all tagging, detection, and timing information on fish from these streams. However, with ODFW concurrence, NMFS will continue to report arrival timing of these fish at Lower Granite Dam.

We continued to tag fish from Idaho after 1992. Principal results from our tagging and interrogation during 2000-2001 are listed below:

1) In August 2000, we PIT tagged and released 3,536 wild chinook salmon parr in 6 Idaho streams.

2) After a 24-hour holding period, average mortality from collection, handling, and tagging of wild fish was 0.6% overall.

3) Using the detection probability expansion method, estimated parr-to-smolt survival to Lower Granite Dam averaged 20.6% (range 13.7-34.8% depending on stream of origin).

4) Length and weights were recorded for 420 recaptured fish from the 6 Idaho streams at Little Goose Dam in 2001. Mean length of these wild fish increased by 43.3 mm, and mean weight increased by 11.4 g over an average of 274 days. Mean condition factor declined from 1.30 at release (parr) to 1.02 at recapture (smolt).

5) Larger fish at release were detected at a significantly higher rate the following spring and summer than their smaller cohorts ($P < 0.001$).

6) Fish that migrated through Lower Granite Dam in April and May were significantly larger at release than fish that migrated after May ($P = 0.0002$).

7) In 2001, peak detections at Lower Granite Dam of all summer-tagged wild fish (from the 6 streams in Idaho and 4 streams in Oregon) occurred during low flows of 57.4 kcfs on 28 April, with a lesser peak on 14 May under moderate flows of 71.6 kcfs, just prior to peak flows for the year. The 50th and 90th percentile passage occurred on 9 and 26 May, respectively.

Since 1998, we have estimated parr-to-smolt survival from streams of origin to Lower Granite Dam. In 2001, we calculated average survival rates retrospectively, using data on wild stocks from Idaho and Oregon collected from 1993 through 1997. These estimates and the estimates calculated from 1998-2001 are shown as follows:

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001
Parr-to-smolt survival (%)	15. 8	18.8	13.5	20.6	20.8	25.7	20.5	17.1	20.6

Over these years, the parr-to-smolt survival estimates for individual populations have been quite variable, ranging from 6.0% for South Fork of the Salmon River in 1996 to 47.6% for Elk Creek in 1998. In addition, migration timing patterns have emerged for some stocks, based on detections at Lower Granite Dam. These patterns range from early to late spring, and shifts in passage distribution for these stocks appear related to annual climatic conditions.

Annual arrival timing of individual stocks at Lower Granite Dam provides the basis to determine similarities or differences in migration patterns between years or between stocks. This report details our findings on the arrival timing distributions for individual stocks in 2001, as well as arrival timing patterns for several stocks over the years.

We have observed a 2- to 3-week shift in timing of combined wild stocks passing Lower Granite Dam between relatively warm and relatively cold years. In the warm years of 1990, 1992, 1994, 1998, and 2001 the median passage date at the dam was between 29 April and 9 May, and the 90th percentile for all wild fish passed by the end of May. In the cold years of 1989, 1991, and 1993, median passage did not occur until mid-May, and the 90th percentile had not passed until mid-June (except during high flows in 1993, when the 90th percentile passed by the end of May). In both 1992 and 2001, we experienced near record low flows in the Snake River. The overall migration timing patterns of wild fish at the dam were both early in these 2 years; however, the timing in 1992 was earlier than 2001 due to the very warm spring in 1992.

In 1995, weather conditions in late winter and early spring were moderate compared to those of the previous 6 years, and we observed intermediate passage timing at the dam relative to previous study years, with the median and 90th percentile passage occurring on 9 May and 5 June, respectively. In 1996 and 1997, too few Idaho fish were detected to make meaningful comparisons of timing with other years.

In 1999, we experienced different climatic conditions than in all previous migration years. In late winter, a near-record snow pack in the Snake River Basin resulted in high flows during the early spring period (late March); however, the ensuing flows were moderated by very dry and cold conditions during mid-to-late spring and early summer. The fluctuating, medium-to-high flows throughout the spring moved wild fish through Lower Granite Dam as observed in warmer years, with the 50th percentile passing by 3 May and the 90th passing by 28 May.

In 2000, we had more typical temperatures and climatic conditions throughout the spring, along with slightly below-normal flows, with the highest flows occurring in April. Consequently, we observed a wild fish migration pattern similar to those seen in warm years, with the 50th and 90th passage percentiles occurring in early and late May, respectively.

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INTRODUCTION

Background

In 1988, the National Marine Fisheries Service (NMFS) began a cooperative study with the U.S. Army Corps of Engineers to mark wild Snake River spring and summer chinook salmon parr with passive integrated transponder (PIT) tags for transportation research. This project continued through mid-1991, with migrating smolts monitored as they passed Lower Granite, Little Goose, and McNary Dams during spring and summer 1989-1991 (Matthews et al. 1990, 1992; Achord et al. 1992, 1996b).

Information from these 3 years of study demonstrated that the migration timing of wild stocks through Lower Granite Dam differs among stream of origin and also differs from the migration timing of hatchery-reared fish. Migrations of wild spring chinook salmon were consistently later and more protracted, and exhibited more variable timing patterns over the 3 years, than those of their hatchery-reared counterparts. In contrast, the migrations of wild summer chinook salmon during these same years were earlier, though also more protracted, than those of their hatchery counterparts.

The present study began in mid-1991, when NMFS and the Bonneville Power Administration (BPA) began a cooperative ongoing project to monitor the migrations of wild chinook salmon smolts (Achord et al. 1994; 1995a,b; 1996a; 1997; 1998; 2000; 2001a,b).

Project Goals

Prior to 1992, decisions on dam operations and use of stored water relied on recoveries of branded hatchery fish, index counts at traps and dams, and flow patterns at the dams. The advent of PIT-tag technology provided the opportunity to precisely track the smolt migrations of many wild stocks as they passed through the hydroelectric complex and other monitoring sites on their way to the ocean. With the availability of the PIT tag, a more complete approach to these decisions was undertaken starting in 1992 with the addition of PIT-tag detections of several wild spring and summer chinook salmon stocks at Lower Granite Dam.

Using data from these detections, we initiated development of a database on wild fish, addressing several goals of the Columbia River Basin Fish and Wildlife Program of the Pacific Northwest Electric Power Planning Council and Conservation Act (PN1980). Section 304(d) of the program states, "The monitoring program will provide information on the migrational characteristics of the various stocks of salmon and steelhead within the Columbia Basin." Further, Section 201(b) urges conservation of genetic diversity, which will be possible only if wild stocks are preserved.

More recently, measures suggested as "Reasonable and Prudent Alternatives" in the 2000 NMFS Biological Opinion (NMFS 2001) identified research needs directly related to our research goals (Section 9.6.2.1, Actions 149, 150, 151, and 152; Section 9.6.5.3.5.1, Actions 188, 190, and 193). These actions identify the importance of monitoring not only the survival, growth, and migratory behavior of wild fish stocks during their juvenile life stage, but also the environmental conditions in their natal and tributary streams.

In 2000-2001, we also continued to collect environmental data for the Baseline Environmental Monitoring Program, which was developed from 1993 to 1997. This project collects data to be used in conjunction with the data on parr and smolt movements to discern patterns or characteristic relationships between these movements and the environmental factors.

The goals of this ongoing study are

1) to characterize the migration timing of different stocks of wild Snake River spring/summer chinook salmon smolts at dams on the Snake and Columbia Rivers,
2) to determine whether consistent migration patterns are apparent, and
3) to determine what environmental factors influence these patterns.

This report provides information on PIT tagging of wild chinook salmon parr in 2000 and the subsequent monitoring of these fish. Fish were monitored as they migrated through juvenile migrant traps in 2000 and 2001 as well as through interrogation systems at Lower Granite, Little Goose, Lower Monumental, McNary, John Day, and Bonneville Dams during 2001.

In addition, data from environmental monitoring in 2000-2001 is reported here. These data consist of conductivity, depth, dissolved oxygen, pH, water temperature, and turbidity measured at five monitoring stations in the Salmon River Basin, Idaho.

METHODS

Fish Collection and Tagging

In 1992, Oregon Department of Fish and Wildlife (ODFW) began PIT tagging wild chinook salmon parr in the Grande Ronde and Imnaha River drainages in northeast Oregon. All tagging, detection, and timing information for fish from these streams in 2000-2001 will be reported by ODFW. However, with ODFW's concurrence, NMFS will continue to report the timing at Lower Granite Dam of summer-tagged fish from these Oregon streams.

Collection and PIT-tagging procedures described by Matthews et al. (1990) and Achord et al. (1994; 1995a,b) were used for our field work in 2000. To further alleviate stress associated with the collection and PIT-tagging operations, we used medical grade oxygen in the carboys during transport of fish to the tagging site. We also supplied oxygen to all containers at the tagging site during tagging operations.

Recaptures at Dams

While collecting and PIT-tagging fish at the dams for various studies, NMFS personnel occasionally encounter wild fish that are already PIT-tagged. In such cases, biological data from these fish are collected, although very few such fish are handled in this manner at the dams. However, in 2001, NMFS began a concerted effort to gather parr-to-smolt growth information on these previously PIT-tagged wild fish from the various streams.

We utilized the PIT-tag separation-by-code system (Downing 2001) at Little Goose Dam to collect this information. A maximum of 100 wild fish from each stream was programmed for separation at this dam for length and weight measurements. All fish that were separated at the dam were handled using water-to-water transfers and other best handling practices. After handling, all tagged fish were returned to the bypass system for release below the dam and all untagged fish were put in the raceways for transport.

In addition to length and weight measurements on these wild smolts at Little Goose Dam, a Fulton-type condition factor (CF) was calculated as

$$CF = \frac{weight(g)}{length(mm)} \times 10^5$$

Condition factors were calculated for these fish both at release and recapture.

Juvenile Migrant Traps

During fall 2000 and spring 2001, juvenile migrant fish traps were operated at Knox Bridge on the South Fork of the Salmon River, on the South Fork of the Salmon River below its confluence with the Secesh River, on Lake Creek, near Chinook Campground on the Secesh River, on Marsh Creek, and near the Sawtooth Hatchery on the upper Salmon River (Fig. 1). Also during spring 2000, juvenile migrant fish traps were operated on the lower Salmon River near Whitebird, Idaho, and on the Snake River at Lewiston, Idaho (Fig. 1). Traps were operated by the Nez Perce Tribe and the Idaho Department of Fish and Game.

Generally, handling procedures for fish at these traps involves anesthetizing the fish and scanning for PIT tags followed by length and weight measurements. Upon recovery, all fish are released back to the streams or rivers.

Interrogation at Dams

During spring and summer 2001, surviving chinook salmon PIT tagged for this study migrated volitionally downstream through hydroelectric dams on the Snake and Columbia Rivers. Of the eight dams the smolts passed, the following six were equipped with smolt collection and/or PIT-tag interrogation systems: Lower Granite, Little Goose, and Lower Monumental Dams on the Snake River (Fig. 1), and McNary, John Day, and Bonneville Dams on the Columbia River.

At these six dams, all smolts guided from turbine intakes into juvenile bypass systems were electronically monitored for PIT tags. The PIT-tag interrogation systems were the same as those described by Prentice et al. (1990). Dates and times to the nearest second were automatically recorded on a computer as PIT-tagged fish passed each detector. Detection data were transferred once daily to the mainframe computer operated by the Pacific States Marine Fisheries Commission in Portland, Oregon.

Migration Timing

During the years of spill from 1993 to 1997, migration timing at each interrogation dam was analyzed based on first-time detection numbers expanded relative to the proportion of daily spill (Achord et al. 1995a,b; 1996b, 1997, 1998). This produced a spill-adjusted or indexed number of PIT-tagged fish passing each dam daily for individual or combined populations. Since 1998, within-season migration timing at Lower Granite Dam has been based on daily detection numbers expanded relative to estimated daily detection probabilities. Detection

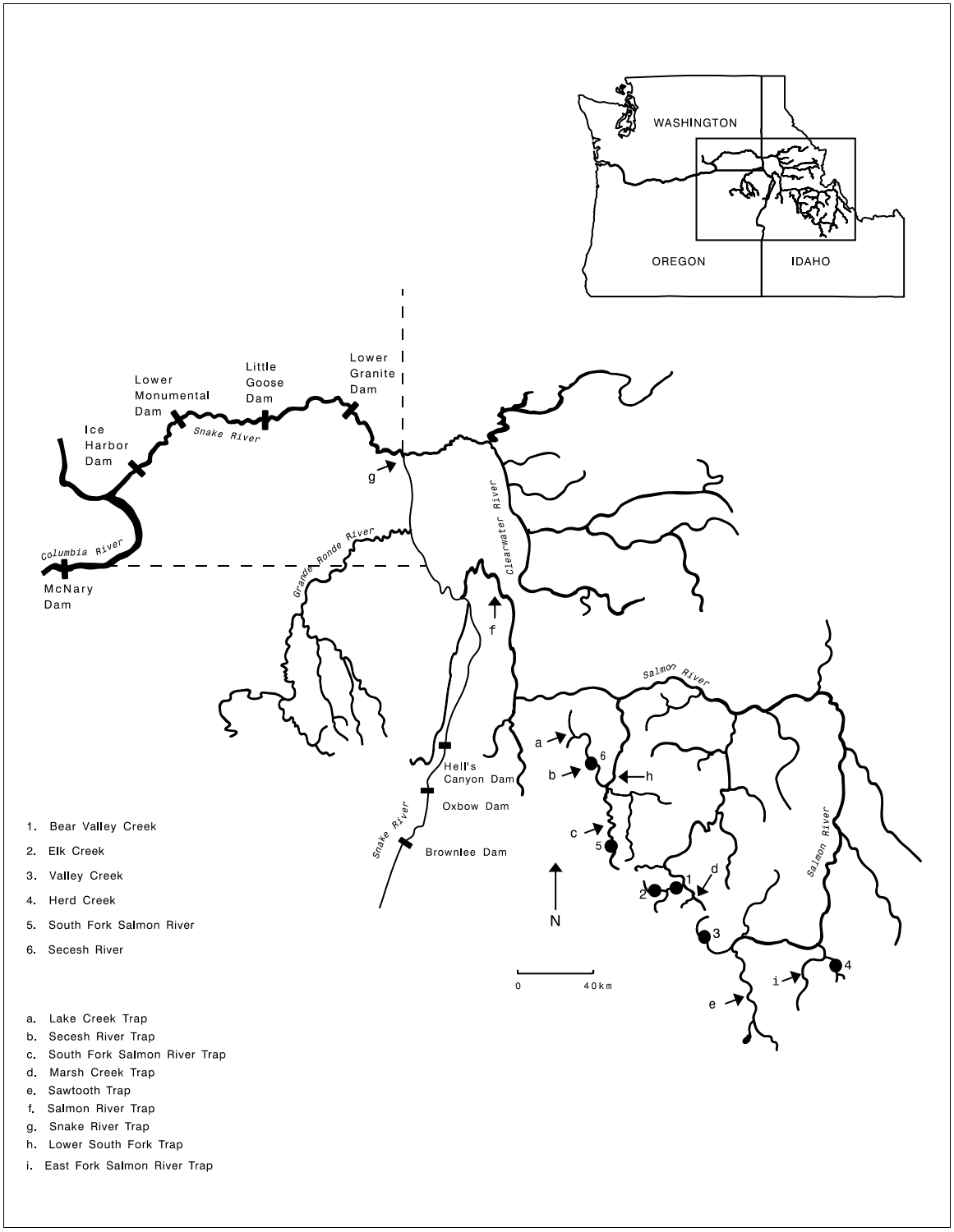

Figure 1. Wild spring/summer chinook salmon parr were PIT tagged during summer 2000 in the six streams identified on the above study area map.

probabilities were calculated using the methods of Sandford and Smith (2002) to provide an estimate of the number of PIT-tagged wild spring/summer chinook salmon smolts that passed the dam each day. At interrogation dams below Lower Granite Dam, migration timing was based simply on first-time detections (without adjustments).

Migration timing at all dams was calculated by totaling the number of detections in 3-day intervals and dividing by total detections during the season (expanded numbers were used only for detections at Lower Granite Dam). This method was applied to detection data for fish from individual and combined streams. Migration timing at Lower Granite Dam was calculated for smolts from individual streams in Idaho and Oregon, while migration timing at all interrogation dams was calculated for smolts from all Idaho streams combined at all interrogation dams except John Day and Bonneville Dams.

There was no straightforward way to compare within-season passage timing dates among stocks from different streams to discern statistically significant differences in arrival timing at Lower Granite Dam. Therefore, we used an approach analogous to analysis of variance with multiple comparisons between the 10th, 50th (median), and 90th percentile passage dates at the dam. Bootstrap methods were used to calculate estimates of the standard error for each statistic (Efron and Tibshirani 1993). A "representative" estimate of variance for each statistic was then calculated as the median of the standard errors for all 10 streams. The Student-Newmann-Keuls (SNK) multiple comparison method ($\alpha = 0.05$) was used to make comparisons between streams for each statistic (Petersen 1985).

We also examined the migration timing at Lower Granite Dam of individual stocks over a period of years to determine similarities or differences between years and between stocks. We chose stocks with 9 or more years of timing data for these analyses. Comparisons of the 10th, 50th, and 90th percentile passage dates were made among 8 streams using a two-factor analysis of variance (ANOVA). Year was considered a random factor and stream a fixed factor. Residuals were visually examined to assess normality. Treatment means were compared using Fisher's least significant difference procedure (Petersen 1985).

Environmental Information

Environmental data were collected from monitoring systems at the following locations: 1) in Marsh Creek, 2) in Valley Creek, 3) near Sawtooth Hatchery in the upper Salmon River, 4) in the South Fork of the Salmon River by Knox Bridge, and 5) near the Chinook Campground in the Secesh River. All monitoring systems except the system at Valley Creek were close to juvenile migrant fish traps.

RESULTS

Fish Collection and Tagging

In 2000, we were authorized by the state of Idaho to collect and PIT tag wild fish from ten Idaho streams. Unfortunately, due to severe forest fires and closures in many areas, we were unable to access Big Creek (lower), Rush Creek, and Chamberlain Creek. We were also denied access to the East Fork of the Salmon River by private land owners.

From 8 to 25 August 2000, we collected 4,044 wild chinook salmon parr in 6 Idaho streams over a distance of about 19 stream kilometers (Table 1; Appendix Table 1). Of these fish, 3,536 were PIT tagged and released back into the streams; the remainder were not tagged because of size, injury, precocious maturation, or because they were collected for genetic studies. Numbers released per stream ranged from 44 in Elk Creek to 1,010 in the South Fork of the Salmon River (Table 1; Appendix Tables 1-2). Fork lengths of tagged and released wild fish ranged from 52 to 113 mm (mean = 71.4 mm) and weights ranged from 2.0 to 19.0 g (mean = 4.9 g)(Appendix Table 1).

Other than chinook salmon parr, sculpin were the most abundant species observed during collection operations (Table 2). However, the records of these observations do not represent total abundances of fish in the areas of collection.

Mortality associated with collection and tagging procedures was low, and 24-hour tag loss was zero (Table 3; Appendix Table 3). Average collection mortality was 0.5%, and average tagging and 24-hour delayed mortality was 0.1%. The average overall observed mortality was 0.6%.

Recaptures at Dams

From 18 April to 18 June 2001, 441 PIT-tagged wild fish from six Idaho streams were recaptured in the separation-by-code system at the Little Goose Dam juvenile fish facility (Table 4a). We gathered parr-to-smolt growth information on 420 of these fish. Mean length increased by 43.3 mm (range 21-77 mm) and mean weight increased by 11.4 g (range 3.7-25.5 g), over an mean recapture interval of 274 days (range 236-313 days). Mean growth between tagging and recapture ranged from 0.14 to 0.18 mm/day in length and from 0.039 to 0.044 g/day in weight. Mean condition factor decreased from 1.30 at release (parr) to 1.02 at recapture (smolt) for these wild fish.

Of the 441 PIT-tagged wild fish from Idaho that were released below Little Goose Dam, 11 of the tags (2.5%) were found on Crescent Island at the Caspian tern nesting area. Twenty-four additional PIT-tagged wild fish were recaptured and handled at the other downstream dams, but only 5 of these were weighed and measured (Table 4b).

Table 1. Summary of collection, PIT-tagging, and release of wild chinook salmon with average fork lengths and weights and approximate distances covered in Idaho streams during August 2000.

Tagging location	Number collected	Number of tagged fish released	Average length of tagged fish (mm)	Average weight of tagged fish (g)	Kilometers covered in streams
Bear Valley Creek	652	581	73.5	4.7	4
Elk Creek	61	44	77.9	5.7	2
Valley Creek	1,046	1,004	72.2	5.2	6
Herd Creek	324	311	82.4	7.9	2
South Fork Salmon River	1,290	1,010	65.3	3.7	2
Secesh River	671	586	72.1	5.1	3
Totals or averages	4,044	3,536	71.4	4.9	19

Table 2. Summary of species other than chinook salmon parr observed during collection operations in Idaho in August 2000. Numbers of steelhead in parentheses were PIT tagged for the Idaho Department of Fish and Game.

Streams	Steelhead	Fry of unknown species	Brook trout	Cutthroat trout	Bull trout	Sculpin	Dace	Sucker	Whitefish	Shiner
Bear Valley Cr.	348 (205)	405	935	1	1	2,232	8	19	61	0
Elk Creek	87(80)	25	439	0	1	342	1	16	31	0
Valley Creek	144 (88)	413	428	0	0	2,207	126	26	161	0
Herd Creek	65(31)	39	0	0	0	116	0	0	14	0
S. Fork Salmon R.	107 (60)	177	20	0	3	290	2	0	73	0
Secesh River	122 (109)	299	29	0	15	468	118	9	324	0
Totals	873	1,358	1,851	1	20	5,655	255	70	664	0

Table 3. Mortality and tag loss for wild chinook salmon parr collected and PIT tagged in Idaho in August 2000.

Tagging location	Mortality (%)				24-hour tag loss (%)
	Collection	Tagging	24-hour	Overall	
Bear Valley Creek	0.9	0.2	0.0	1.1	0.0
Elk Creek	0.0	0.0	0.0	0.0	0.0
Valley Creek	0.1	0.0	0.0	0.1	0.0
Herd Creek	1.8	0.3	0.0	2.2	0.0
South Fork Salmon River	0.2	0.0	0.0	0.2	0.0
Secesh River	0.7	0.2	0.0	0.9	0.0
Totals or averages	0.5	0.1	0.0	0.6	0.0

Table 4a. Recapture information on PIT-tagged wild spring/summer chinook salmon from Idaho that were tagged in summer 2000 and recaptured by the separation-by-code system in the juvenile fish bypass system at Little Goose Dam in 2001.

	No.	Length gain (mm)			Weight gain (g)			Condition factor		Recapture interval	
	Fish	N	range	$\bar{X}$	N	range	$\bar{X}$	release	recapture	range	$\bar{X}$
Bear Valley Cr.	83	74	21-73	43.1	74	5.3-25.5	11.7	1.20	1.01	279-313	286
Elk Cr.	10	10	22-49	38.7	10	6.8-17.3	10.9	1.19	1.03	274-295	280
Valley Cr.	91	87	26-70	44.4	87	5.4-21.4	12.0	1.32	1.03	269-303	283
Herd Cr.	64	64	27-55	40.2	64	5.2-17.8	10.8	1.39	1.01	258-282	268
So. Fork Salmon R.	92	92	27-72	48.3	92	4.2-21.6	11.8	1.34	1.03	249-298	273
Secesh R.	101	93	23-77	45.3	93	3.7-23.0	11.2	1.36	0.99	236-266	252
Totals or averages	441	420	21-77	43.3	420	3.7-25.5	11.4	1.30	1.02	236-313	274

Table 4b. Recapture information on PIT-tagged wild spring/summer chinook salmon from Idaho that were tagged in summer 2000 and recaptured at various sites other than Little Goose Dam in fall 2000 and spring/summer 2001. Spring/summer recaptures have recapture interval days greater than 73.

	No.	Length gain (mm)			Weight gain(g)			Condition factor		Recapture interval	
	Fish	N	range	$\bar{X}$	N	range	$\bar{X}$	release	recapture	range	$\bar{X}$
Traps											
So. Fork Salmon R.	133	133	0-16	3.8	81	-1.2-2.6	0.0	1.32	1.10	2-63	32
So. Fork Salmon R.	8	8	15-32	22.3	8	1.5-5.8	3.7	1.31	1.10	241-256	247
So. Fork Salmon R.	8	8	0-17	5.7	1	1.4	---	0.58	0.99	61-73	65
Secesh River	11	11	0-6	2.5	5	-0.5-0.0	-0.2	1.28	1.11	0-31	8
Salmon River	2	2	25-25	25.0	0	---	---	---	---	216-249	232
Total from traps	162	162			95						
Collector dams											
Ice Harbor Dam	16	1	42.0	---	1	13.5	---	1.24	1.05	296	---
McNary Dam	5	4	40-56	47.0	4	10.4-15.2	13.2	1.24	0.99	251-294	272
Lower Granite Dam	3	0	---	---	0	---	---	---	---	---	---
Total from dams	24										
Streams											
Herd Creek	1	1	47.0	---	1	17.4	---	1.52	1.22	360	---
Valley Creek	2	2	60-62	61.0	2	24.6-35.3	29.9	1.29	1.36	355-357	356
Total from streams	3										
Totals or averages	189	170	---	---	103	---	---	---	---	---	---

Recaptures at Traps

A total of 165 wild fish PIT-tagged in summer 2000 were recaptured above Lower Granite Dam from fall 2000 to summer 2001 (Table 4b). Three of the fish were precocious males recaptured in Valley and Herd Creeks in summer 2001. The remaining 162 fish were recaptured in four juvenile salmonid migrant traps, with 152 recaptured in fall 2000 and 10 recaptured in spring 2001 (Table 4b).

For fish recaptured at traps during fall 2000 and spring 2001, only the South Fork Salmon River trap at Knox Bridge operating in fall 2000 recaptured sufficient numbers of previously summer-tagged fish for meaningful growth rate information (Table 4b). These fish grew an average of 0.12 mm/day in length but gained 0.0 g/day in weight between release in natal rearing areas and recapture at the trap.

Detections at Dams

Based on expanded detections at Lower Granite Dam from 6 April to 7 July 2001 (728 fish), estimated survival from parr to smolt averaged 20.6% (range 13.7-34.8%; Table 5; Appendix Tables 4-9). An additional 98 first-time detections were recorded at Little Goose and Lower Monumental Dams (Table 5; Appendix Tables 4-9) and were used for evaluations of migration timing. By comparing all first-time detections at interrogation dams (706) to the expanded number of detections at Lower Granite Dam (728), we estimated that 3.0% of the wild fish from Idaho passed through the hydropower system undetected.

For parr tagged in Idaho, average fork length at release was 71.4 mm. However, of fish from this group that were detected the following spring at the dams, average fork length at release was 73.2 mm. These length differences were significant ($P = 0.000$). The release-length distribution of detected fish was also significantly different from that of released fish in all length categories except 85-89 and 90-94 mm ($P < 0.031$; Fig. 2).

We also found a significant difference in fork lengths at time of release for fish that migrated through Lower Granite Dam in April and May compared to fish that migrated after May ($P = 0.0002$). Fish migrating through the dam in April and May were on average 4.4 mm larger when released than fish migrating after May. These data suggest that fish size may influence migration timing or overwintering location with respect to detection at the first dam. Timing of smolts from individual streams in Idaho is not presented here for Little Goose, Lower Monumental, McNary, John Day, or Bonneville Dams; see Appendix Tables 4-9 for this information. (Expanded detection numbers in Appendix Tables 4-9 may differ from those in Table 5 due to rounding.)

Migration Timing

Lower Granite Dam

Figure 3 shows the migration timing for fish from the 10 Idaho and Oregon streams. In comparisons among all nine Idaho and Oregon streams (Elk Creek was omitted; Tables 6a-6b), fish from the Secesh River arrived earlier at Lower Granite Dam than fish from all other streams in 2001. Fish from this stream had a significantly earlier timing for 10th percentile passage than fish from all the other streams except the Imnaha River (upper) ($P < 0.05$). The overall 10th percentile passage distributions for fish from all nine streams ranged from 16 April to 10 May (Tables 6a-6b).

Fish from the Secesh River had significantly earlier 50th percentile passage time at the dam than all other Idaho and Oregon streams except the Imnaha River (upper) ($P < 0.05$). The overall 50th percentile passage distributions for fish from all nine streams ranged from 28 April to 19 May (Tables 6a-6b). Secesh River fish also had significantly earlier 90th percentile passage at the dam than fish from Bear Valley Creek, South Fork Salmon River, Valley Creek, and Catherine Creek ($P < 0.05$). Fish from the other four streams had intermediate (non-significant) timing for the 90th percentile passage distributions ($P > 0.05$). The overall 90th percentile passage distributions for fish from all nine streams ranged from 13 May to 17 June (Tables 6a-6b).

The middle 80th percentile passage distributions were of significantly shorter duration (14 days) for fish from Herd Creek than for fish from the Lostine River, Secesh River, Minam River, South Fork Salmon River, and Catherine Creek (27-49 days; $P < 0.05$; Tables 6a-6b). The middle 80th percentile passage distributions for fish from the other 3 streams ranged from 20 to 25 days.

Comparison with Flows

We combined all first-time detections (expanded at Lower Granite Dam) of wild fish from Idaho streams at two interrogation dams and compared the timing at each dam with river flows during the same periods (Fig. 4). Overall, passage occurred between early April and early July at Lower Granite Dam, with the middle 80% passage occurring from late-April to late-May (Table 7). The peak passage dates were 28 April which coincided with low flows (57.4 kcfs), and 14 May (71.6 kcfs) which coincided with increasing flows just prior to peak flows for the year (Appendix Table 10).

Table 5. Summary of first-time detections of PIT-tagged wild spring/summer chinook salmon smolts from Idaho at six dams from April to August, 2001. Expanded detections at Lower Granite Dam provide estimates of parr to smolt survival.

	Detections at dams												
	Lower Granite			Little Goose		Lower Monumental		McNary		John Day		Bonn.	
		Expanded											
	N	N	%	N	%	N	%	N	%	N	%	N	%
Bear Valley Creek	112	134	23.1	12	2.1	3	0.5	0	0.0	0	0.0	0	0.0
Elk Creek	10	12	27.3	3	6.8	0	0.0	0	0.0	0	0.0	0	0.0
Valley Creek	135	161	16.0	18	1.8	1	0.1	0	0.0	0	0.0	0	0.0
Herd Creek	66	79	25.4	20	6.4	0	0.0	0	0.0	0	0.0	0	0.0
South Fork Salmon River	116	138	13.7	18	1.8	1	0.1	0	0.0	0	0.0	0	0.0
Secesh River	169	204	34.8	21	3.6	1	0.2	0	0.0	0	0.0	0	0.0
Totals or averages	608	728	20.6	92	2.6	6	0.2	0	0.0	0	0.0	0	0.0

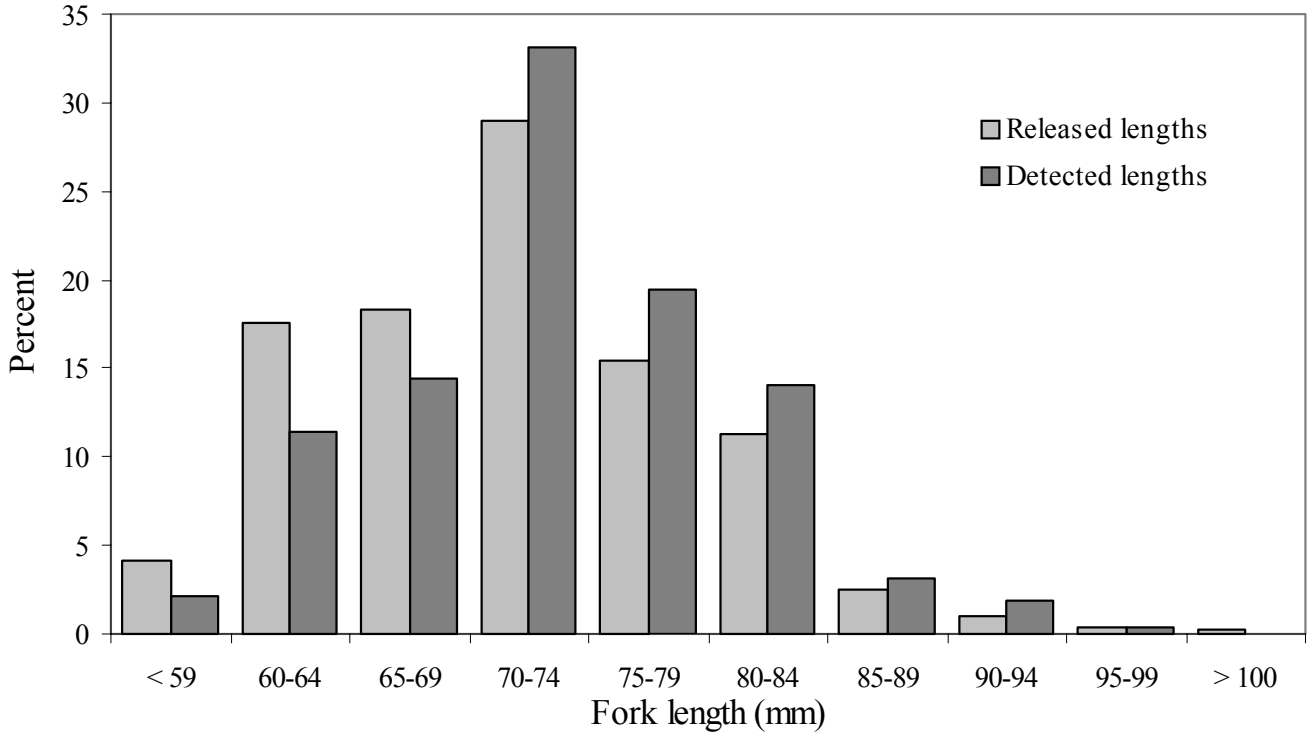

Figure 2. Percent by fork length increments, of PIT-tagged wild spring/summer chinook salmon parr released in Idaho streams in 2000 (n = 3,524) and percent of fish detected for these length increments at dams in spring and summer 2001 (n = 703).

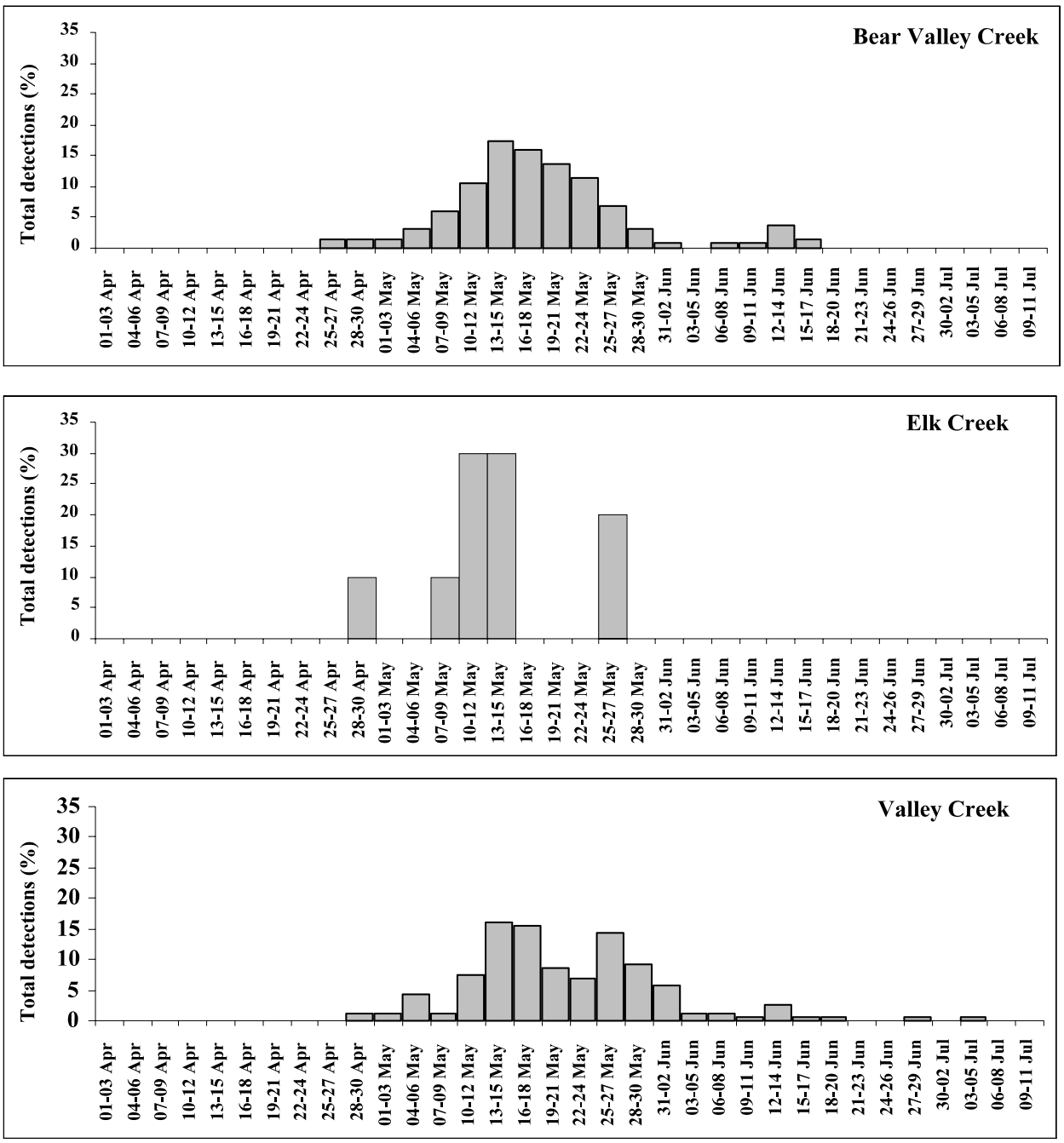

Figure 3. The migration timing (expanded by estimated detection probabilities) at Lower Granite Dam in 2001 of wild spring/summer chinook salmon smolts from individual streams in Idaho and Oregon PIT tagged during summer 2000.

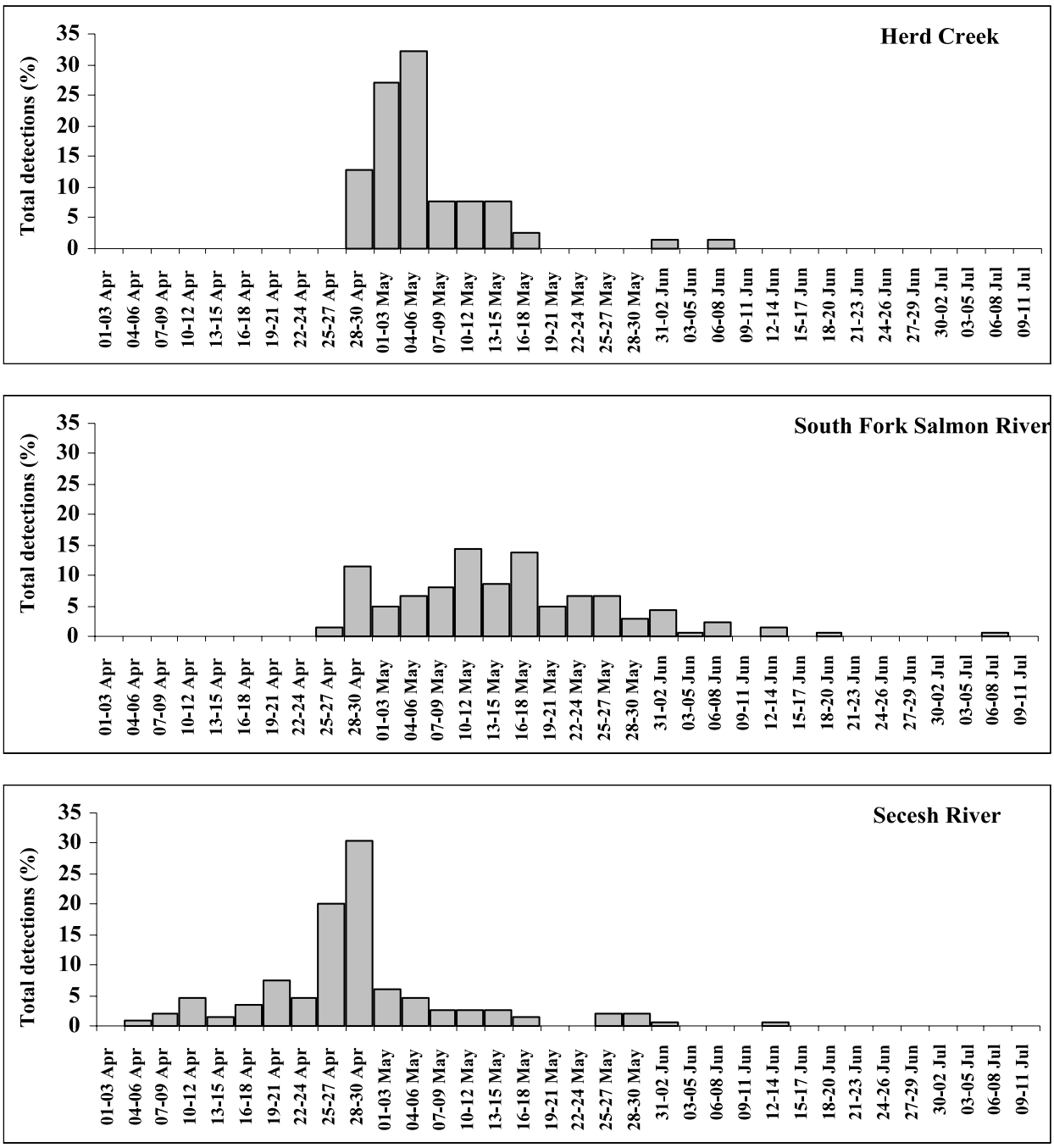

Figure 3. Continued.

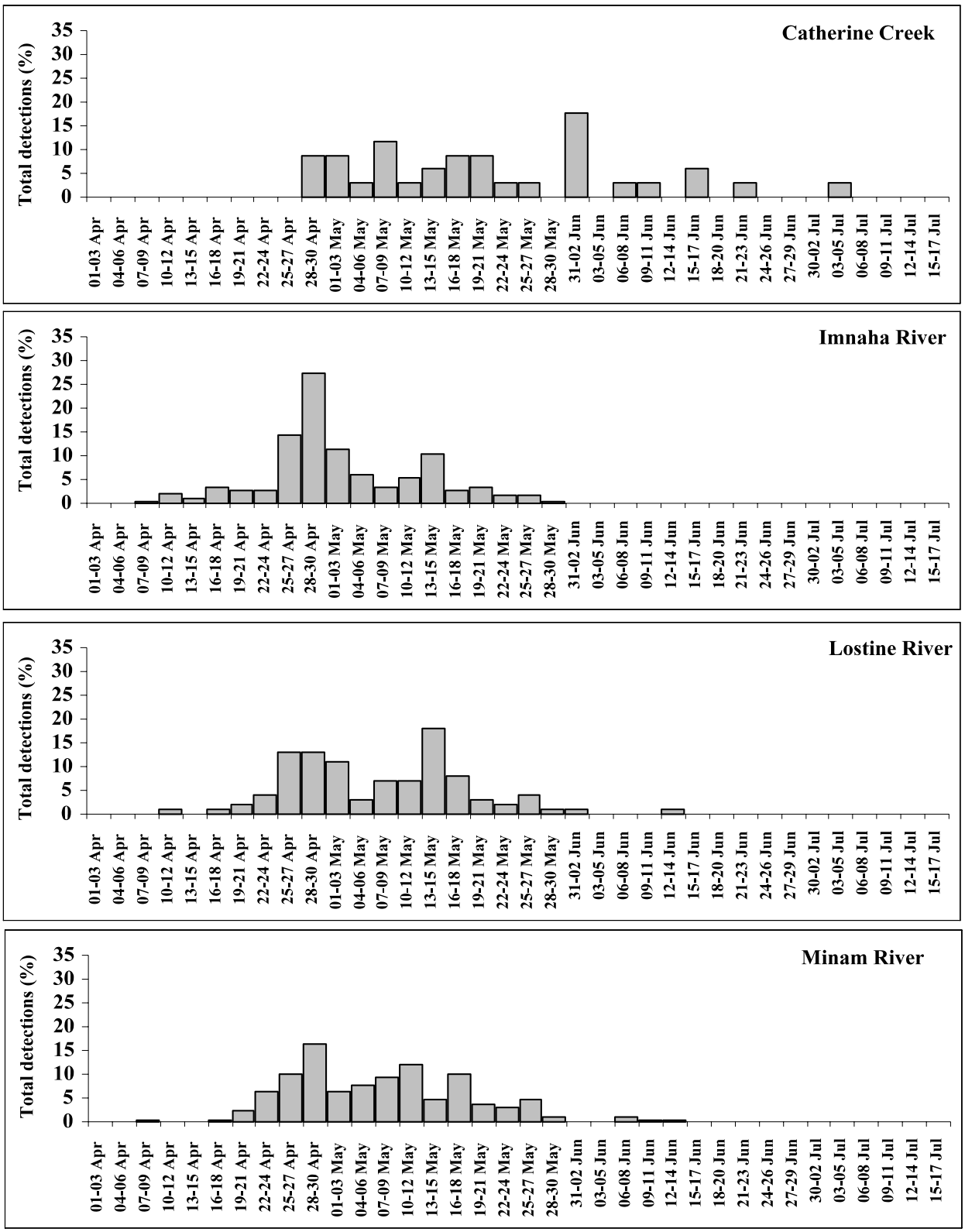

Figure 3. Continued.

Table 6a. Accumulated and 2001 passage dates at Lower Granite Dam for PIT-tagged wild spring/summer chinook salmon smolts from streams in Idaho.

	Percentile passage dates at Lower Granite Dam			
Year	10th	50th	90th	Range
Bear Valley Creek				
1990	19 April	05 May	31 May	11 April-18 July
1991	03 May	20 May	12 June	18 April-23 June
1992	15 April	02 May	24 May	07 April-28 June
1993	29 April	16 May	22 June	22 April-27 July
1994	22 April	06 May	29 May	16 April-15 July
1995	28 April	18 May	12 June	13 April-20 July
1996[a]	---	---	---	---
1997[a]	---	---	---	---
1998	25 April	06 May	23 May	31 March-25 June
1999	23 April	03 May	07 June	20 April-21 June
2000	18 April	07 May	02 June	14 June-02 July
2001	**08 May**	**16 May**	**28 May**	**26 April-17 June**
Elk Creek				
1990[b]	---	---	---	---
1991	03 May	20 May	16 June	25 April-24 June
1992	11 April	30 April	28 May	05 April-17 July
1993	02 May	16 May	11 June	21 April-26 June
1994	23 April	04 May	21 May	18 April-09 July
1995	18 April	11 May	05 June	10 April-09 July
1996[a]	---	---	---	---
1997[a]	---	---	---	---
1998	07 April	02 May	15 May	04 April-21 June
1999	21 April	03 May	27 May	01 April-08 July
2000	15 April	28 April	19 May	13 April-28 May
2001	**30 April**	**11 May**	**27 May**	**30 April-27 May**
Sulphur Creek				
1990	18 April	30 April	31 May	11 April-27 June
1991[a]	---	---	---	---
1992	16 April	03 May	23 May	10 April-01 June
1993	28 April	16 May	12 June	24 April-28 June
1994[a]	---	---	---	---
1995	02 May	23 May	09 June	11 April-09 July
1996[a]	---	---	---	---
1997[a]	---	---	---	---
1998[a]	---	---	---	---
1999	24 April	19 May	27 May	22 April-29 May
2000	15 April	07 May	24 May	12 April-30 May
2001[a]	---	---	---	---

Table 6a. Continued.

Year	Percentile passage dates at Lower Granite Dam			
	10th	50th	90th	Range
Cape Horn Creek				
1990[a]	---	---	---	---
1991	24 April	16 May	28 May	19 April-06 June
1992	12 April	28 April	30 May	10 April-01 June
1993	08 May	19 May	26 June	05 May-01 July
1994[a]	---	---	---	---
1995	29 April	14 May	19 June	14 April-28 July
1996[a]	---	---	---	---
1997[a]	---	---	---	---
1998[a]	---	---	---	---
1999	29 April	22 May	29 May	25 April-12 June
2000	01 May	24 May	01 June	20 April-09 July
2001[a]	---	---	---	---
Camas Creek				
1993	03 May	16 May	27 May	24 April-24 June
1994	30 April	15 May	26 May	24 April-11 July
1995	27 April	12 May	05 June	17 April-11 June
1996[a]	---	---	---	---
1997[a]	---	---	---	---
1998[a]	---	---	---	---
1999[a]	---	---	---	---
2000	26 April	25 May	02 June	13 April-24 June
2001[a]	---	---	---	---
Marsh Creek				
1990	17 April	29 April	31 May	09 April-01 July
1991	26 April	20 May	09 June	17 April-18 June
1992	17 April	07 May	02 June	10 April-13 July
1993	29 April	15 May	27 May	24 April-10 August
1994	23 April	04 May	18 May	16 April-08 August
1995	17 April	09 May	24 May	11 April-08 July
1996[a]	---	---	---	---
1997[a]	---	---	---	---
1998[a]	---	---	---	---
1999	21 April	01 May	25 May	11 April-13 June
2000	21 April	28 April	27 May	14 April-16 June
2001[a]	---	---	---	---
Valley Creek				
1989	24 April	14 May	12 June	09 April-17 June
1990	16 April	08 May	05 June	12 April-29 June
1991	11 May	20 May	20 June	21 April-13 July
1992	15 April	30 April	27 May	13 April-04 June

Table 6a. Continued.

Year	Percentile passage dates at Lower Granite Dam			
	10th	50th	90th	Range
Valley Creek (Continued)				
1993	30 April	16 May	02 June	24 April-06 June
1994	24 April	04 May	03 June	22 April-09 June
1995	04 May	02 June	08 July	22 April-18 July
1996[a]	---	---	---	---
1997[a]	---	---	---	---
1998[a]	---	---	---	---
1999	24 April	13 May	12 June	19 April-01 July
2000	20 April	12 May	29 May	13 April-14 July
2001	**10 May**	**19 May**	**01 June**	**28 April-03 July**
Loon Creek				
1993	05 May	12 May	17 May	03 May-5 June
1994	29 April	10 May	24 May	22 April-07 June
1995	23 April	11 May	28 May	13 April-07 June
1996[a]	---	---	---	---
1997[a]	---	---	---	---
1998[a]	---	---	---	---
1999	30 April	18 May	27 May	22 April-16 June
2000	22 April	08 May	24 May	14 April-01 June
2001[a]	---	---	---	---
East Fork Salmon River				
1989	22 April	03 May	18 May	07 April-08 June
1990[a]	---	---	---	---
1991	22 April	09 May	26 May	16 April-20 June
1992	13 April	21 April	16 May	10 April-03 June
1993	25 April	06 May	18 May	22 April-01 June
1994	22 April	28 April	17 May	20 April-25 May
1995	14 April	28 April	10 May	11 April-27 May
1996[a]	---	---	---	---
1997[a]	---	---	---	---
1998[a]	---	---	---	---
1999[a]	---	---	---	---
2000	21 April	07 May	25 May	15 April-27 May
2001[a]	---	---	---	---
Herd Creek				
1992	14 April	20 April	10 May	13 April-18 May
1993	26 April	30 April	18 May	26 April-31 May
1994[b]	---	---	---	---
1995	18 April	03 May	14 May	11 April-28 May
1996[a]	---	---	---	---

Table 6a. Continued.

Year	Percentile passage dates at Lower Granite Dam			
	10th	50th	90th	Range
Herd Creek (Continued)				
1997[a]	---	---	---	---
1998[a]	---	---	---	---
1999	20 April	29 April	10 May	30 March-20 May
2000	16 April	25 April	18 May	14 April-19 May
2001	**30 April**	**04 May**	**14 May**	**28 April-07 June**
South Fork Salmon River				
1989	25 April	13 May	14 June	16 April-20 June
1990[a]	---	---	---	---
1991	20 April	16 May	10 June	17 April-13 July
1992	14 April	29 April	27 May	07 April-27 July
1993	29 April	16 May	02 June	26 April-28 June
1994	27 April	15 May	28 June	22 April-09 July
1995	20 April	10 May	10 June	13 April-13 July
1996	19 April	15 May	09 June	19 April-03 July
1997	13 April	28 April	12 June	07 April-15 June
1998	25 April	12 May	15 June	02 April-07 August
1999	31 March	04 May	01 June	27 March-11 June
2000	20 April	18 May	31 May	12 April-20 July
2001	**29 April**	**14 May**	**01 June**	**26 April-07 July**
Big Creek (upper)				
1990	27 April	30 May	22 June	17 April-18 July
1991	18 May	10 June	26 June	26 April-01 July
1992	22 April	08 May	03 June	15 April-26 June
1993	08 May	18 May	26 May	26 April-15 June
1994	03 May	19 May	19 July	25 April-30 August
1995	05 May	23 May	09 June	02 May-26 June
1996[a]	---	---	---	---
1997[a]	---	---	---	---
1998[a]	---	---	---	---
1999	28 April	14 May	03 June	25 April-19 June
2000	30 April	27 May	14 June	15 April-29 June
2001[a]	---	---	---	

Table 6a. Continued.

	Percentile passage dates at Lower Granite Dam			
Year	10th	50th	90th	Range
Big Creek (lower)/Rush Creek				
1993	24 April	29 April	13 May	21 April-16 May
1994	23 April	29 April	11 May	21 April-15 June
1995	19 April	01 May	14 May	11 April-05 June
1996[a]	---	---	---	---
1997[a]	---	---	---	---
1998[a]	---	---	---	---
1999	19 April	28 April	23 May	04 April-30 May
2000	19 April	30 April	13 May	16 April-26 May
2001[a]	---	---	---	---
West Fork Chamberlain Creek				
1992[c]	15 April	26 April	03 June	12 April-24 June
1993	28 April	15 May	23 June	23 April-22 July
1994[c]	24 April	01 May	05 July	24 April-04 September
1995[c]	16 April	09 May	20 June	12 April-22 September
1996[a]	---	---	---	---
1997[a]	---	---	---	---
1998[a]	---	---	---	---
1999[a]	---	---	---	---
2000[a]	---	---	---	---
2001[a]	---	---	---	---
Secesh River				
1989	20 April	27 April	09 June	09 April-19 July
1990	14 April	22 April	07 June	10 April-13 July
1991	20 April	27 April	14 June	13 April-20 July
1992	13 April	29 April	04 June	05 April-03 July
1993	26 April	16 May	16 June	22 April-15 July
1994	22 April	26 April	11 July	21 April-07 August
1995	14 April	01 May	24 May	10 April-10 July
1996	14 April	25 April	29 May	12 April-15 July
1997	10 April	18 April	04 May	04 April-11 July
1998	08 April	24 April	28 May	03 April-06 July
1999	03 April	23 April	25 May	29 March-21 June
2000	13 April	23 April	04 June	12 April-11 July
2001	**16 April**	**28 April**	**13 May**	**06 April-13 June**

Table 6a. Continued.

	Percentile passage dates at Lower Granite Dam			
Year	10th	50th	90th	Range
Lake Creek				
1989	23 April	02 May	16 June	12 April -01 July
1990[a]	---	---	---	---
1991[a]	---	---	---	---
1992[a]	---	---	---	---
1993	23 April	09 May	22 June	22 April - 25 June
1994	21 April	28 April	19 May	20 April - 24 June
1995	17 April	10 May	10 June	14 April - 20 July
1996	15 April	21 April	19 May	15 April -02 June
1997	11 April	25 April	02 July	07 April - 22 September
1998	04 April	25 April	26 May	02 April - 16 July
1999	20 April	26 April	27 May	08 April - 20 June
2000	13 April	04 May	04 June	13 April - 18 July
2001[a]	---	---	---	---

[a] No parr were tagged the summer prior to this migration year.
[b] Insufficient numbers detected to estimate timing.
[c] Includes fish from Chamberlain Creek.

Table 6b. Accumulated and 2001 passage dates at Lower Granite Dam for PIT-tagged wild spring/summer chinook salmon smolts from streams in Oregon.

	Percentile passage dates at Lower Granite Dam			
Year	10th	50th	90th	Range
Catherine Creek				
1991	01 May	14 May	08 June	17 April-23 June
1992	16 April	01 May	21 May	09 April-29 June
1993	06 May	18 May	05 June	29 April-26 June
1994	25 April	11 May	20 May	13 April-26 July
1995	01 May	19 May	09 June	26 April-02 July
1996[a]	19 April	13 May	29 May	14 April-14 June
1997	08 May	14 May	01 June	24 April-10 June
1998	28 April	21 May	28 May	24 April-04 June
1999	26 April	25 May	15 June	26 April-26 June
2000	30 April	08 May	23 May	12 April-06 June
2001	**29 April**	**17 May**	**17 June**	**28 April-03 July**
Grande Ronde River (upper)				
1989	12 May	06 June	19 June	27 April-22 July
1990[b]	---	---	---	---
1991[b]	---	---	---	---
1992[b]	---	---	---	---
1993	05 May	16 May	25 May	23 April-20 June
1994	28 April	23 May	07 July	23 April-29 August
1995	27 April	29 May	12 June	12 April-01 July
1996[c]	26 April	17 May	29 May	19 April-06 June
1997[b]	---	---	---	---
1998[b]	---	---	---	---
1999[b]	---	---	---	---
2000[b]	---	---	---	---
2001[b]	---	---	---	---
Imnaha River (lower)				
1989	11 April	30 April	11 May	04 April-05 June
1990	10 April	18 April	09 May	05 April-27 May
1991	20 April	01 May	13 May	14 April-15 May
1992	10 April	21 April	03 May	06 April-21 May
1993[b]	---	---	---	---
1994[b]	---	---	---	---
1995[b]	---	---	---	---
1996[b]	---	---	---	---
1997[b]	---	---	---	---
1998[b]	---	---	---	---
1999[b]	---	---	---	---
2000[b]	---	---	---	---
2001[b]	---	---	---	---

Table 6b. Continued.

Year	Percentile passage dates at Lower Granite Dam			
	10th	50th	90th	Range
Imnaha River (upper)				
1993	24 April	14 May	28 May	15 April-23 June
1994	24 April	08 May	09 June	20 April-11 August
1995	13 April	02 May	03 June	10 April-07 July
1996	16 April	26 April	18 May	14 April-12 June
1997	11 April	19 April	11 May	03 April-02 June
1998	11 April	28 April	13 May	03 April-24 May
1999	22 April	08 May	26 May	17 April-03 June
2000	14 April	02 May	24 May	12 April-16 June
2001	**21 April**	**30 April**	**16 May**	**08 April-28 May**
Lostine River				
1990[d]	---	---	---	---
1991	29 April	14 May	26 May	20 April-09 July
1992	16 April	30 April	11 May	12 April-02 June
1993	23 April	03 May	17 May	17 April-01 June
1994	22 April	30 April	16 May	19 April-07 June
1995	12 April	02 May	17 May	08 April-09 June
1996	23 April	15 May	07 June	17 April-19 June
1997	17 April	28 April	16 May	09 April-21 May
1998[b]	---	---	---	---
1999	30 March	09 May	27 May	29 March-29 May
2000	13 April	08 May	25 May	13 April-3 June
2001	**25 April**	**09 May**	**22 May**	**10 April-12 June**
Minam River				
1999	08 April	28 April	25 May	31 March-02 June
2000	15 April	03 May	22 May	10 April-29 May
2001	**25 April**	**07 May**	**23 May**	**08 April-12 June**

[a] Includes fish tagged from summer 1995 through spring 1996.
[b] No parr were tagged the summer prior to this migration year.
[c] All fish tagged at traps in fall or spring for this migration year.
[d] Insufficient numbers detected to estimate timing.

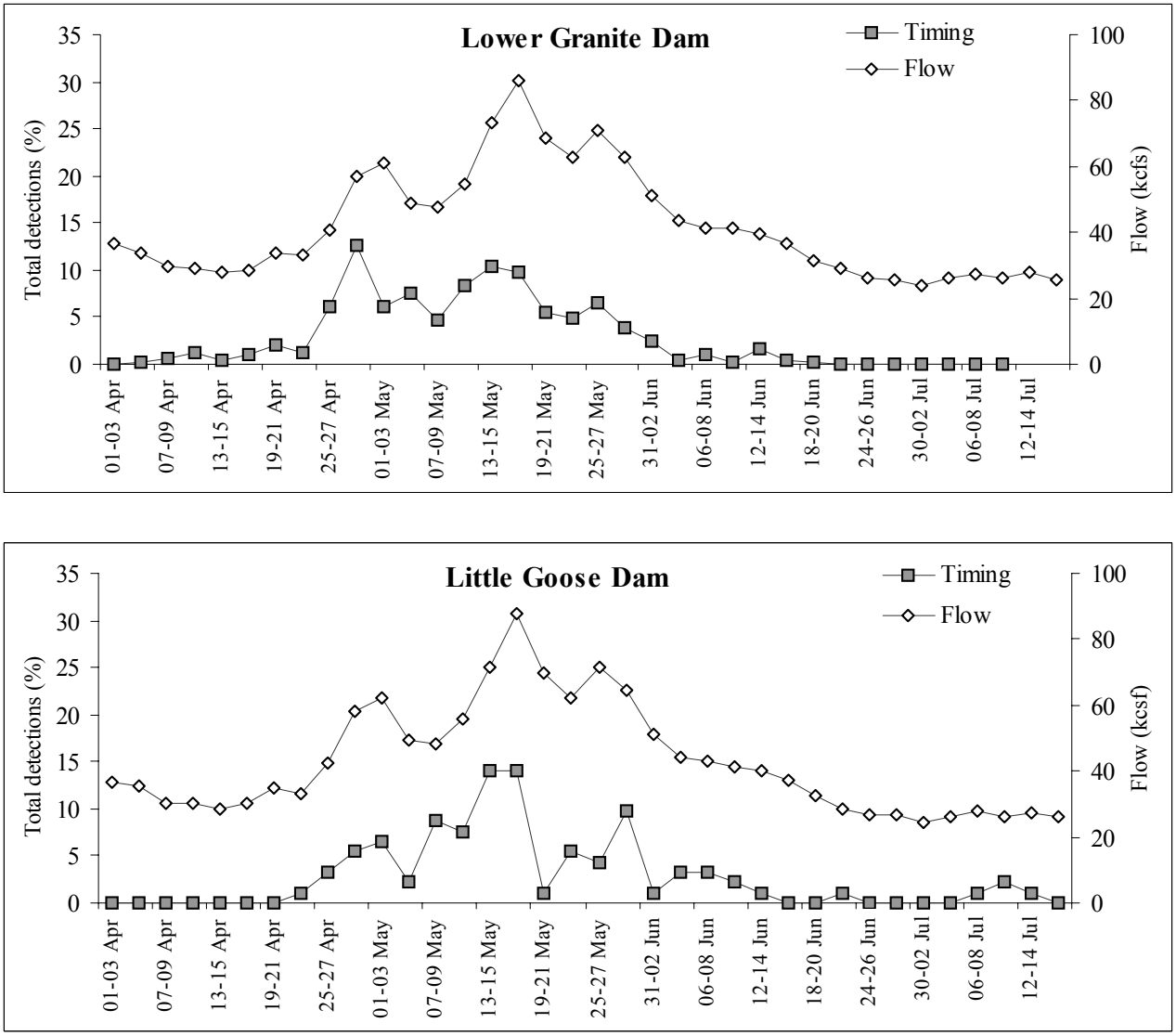

Figure 4. The overall migration timing of PIT-tagged wild spring/summer chinook salmon smolts at Lower Granite and Little Goose Dams in 2001, with associated river flows at these dams. Data represent detections from 6 Idaho streams combined by 3-day intervals and average flow at the dams over the same time periods. Detections were expanded by estimated daily detection probabilities at Lower Granite Dam only.

Table 7. Passage dates based on first-time detections at Lower Granite (expanded), Little Goose, Lower Monumental, McNary, John Day, and Bonneville Dams for combined populations of PIT-tagged wild spring/summer chinook salmon smolts from six streams in Idaho in 2001.

	Percentile passage dates at dams			
Site	10th	50th	90th	Range
Lower Granite Dam	26 April	12 May	28 May	06 April -07 July
Little Goose Dam	01 May	16 May	06 June	23 April - 12 July
Lower Monumental Dam[a]	---	---	---	---
McNary Dam[b]	---	---	---	---
John Day Dam[b]	---	---	---	---
Bonneville Dam[b]	---	---	---	---

[a] Insufficient numbers detected to estimate timing.
[b] No first-time detections of fish at this dam.

The middle 80% passage of wild fish at Little Goose Dam occurred between early May and early June (Table 7). Peak passage for fish at Little Goose Dam coincided with medium river flows in mid-May which happened to be the peak flows (79.9-92.4 kcfs) for the year at this dam (Fig. 4 and Appendix Table 11). No first-time detections of wild fish from Idaho occurred at dams downstream of Lower Monumental Dam and too few (6) were detected at Lower Monumental Dam to make meaningful comparisons (Appendix Table 12).

Environmental Information

In 2000-2001, we collected hourly measurements of temperature, dissolved oxygen, specific conductance, turbidity, depth, and pH from five environmental monitoring stations in the Salmon River Basin. We recorded these data, as well as data from previous years, in the Baseline Environmental Monitoring Program database (Perkins 1998).

Environmental data collected during 2000-2001 can be used to compare various water quality parameters to chinook salmon fry, parr, and smolt movements through adjacent traps (Fig. 1) in 2000-2001. Appendix Tables 13-17 provide a summary of information collected from the five environmental monitoring sites (Marsh Creek, Valley Creek, Sawtooth Hatchery, Knox Bridge, and Secesh River) from August 2000 to July 2001. Appendix Table 18 provides a summary of flow information at five USGS sites in the Salmon River drainage from August 2000 to July 2001. Appendix Figures 1 and 2 show trap operation periods and daily fish passage information for brood year 1999. Appendix figures 3-8 show fish movement at the traps plotted against environmental data collected near the traps.

DISCUSSION

Mortality rates associated with collection and tagging in 2000 were comparable to those in earlier years (Achord et al. 1992; 1994; 1995a,b; 1996a,b; 1997; 1998; 2000, 2001a,b). Based on measurements taken at Little Goose Dam after an average recapture interval of 274 days, the average length increase was 43.3 mm and the average weight gain was 11.4 g for wild fish from Idaho streams. Thus, the mean growth rate during the parr-to-smolt stage was 0.16 mm/day and 0.042 g/day. This growth rate was comparable to those observed in 1990 and 1991 at Lower Granite Dam during testing of a PIT-tag diversion apparatus (Achord et al. 1996b). During these studies we observed mean growth rates of 0.15 mm/day and 0.034 g/day in 1990 and 0.14 mm/day and 0.038 g/day in 1991 for wild fish from many of the same streams.

Of the 133 wild fish tagged and released in summer 2000 at the South Fork of the Salmon River and recaptured in fall at the Knox Bridge trap, an estimated 32 (24.1%) arrived at Lower Granite Dam in spring 2001. This estimated survival rate was 75.9% higher than the estimated survival to the dam for all fish tagged and released in summer 2000 in the South Fork Salmon River (13.7%). This estimated survival rate was similar to the detection rates observed in 1998, 1999, and 2000 for fish trapped at Knox Bridge in the fall, when detections were 83.2, 107.3, and 80.7% higher, respectively, for these fish than for all South Fork of the Salmon River fish. From 1995 to 1997, too few summer-tagged fish (15-38) were detected at the trap to provide meaningful comparisons.

Further comparisons between detection rates at Lower Granite Dam for fish seen at traps vs. all fish tagged in summer from a given stream were not made due to the low numbers monitored at other traps. However, the higher detection rates at the dams for PIT-tagged fish previously detected at traps in the fall may provide important insights for the study of wild fish migration characteristics. For example, they may indicate a higher survival rate for known fall migrants and/or may indicate significant mortality in the stream from summer to fall.

The average number of days between tagging and recapture for fish marked and released in fall at the Knox Bridge was 19, 22, and 32 for 1998, 1999, and 2000, respectively. Respective average increases in length during 1998, 1999, and 2000 were 2.9, 2.0, and 3.8 mm. Thus, average growth rates for fish from South Fork Salmon River over these three years exhibited high variability, ranging from 0.09 to 0.15 mm/day.

In 1998, we began annual estimates of parr-to-smolt survival for wild stocks from the location where they were tagged to Lower Granite Dam. In 2000, we used PIT-tag data collected since 1993 from fish that were returned to the river below the dams to estimate parr-to-smolt survival rates for these fish from 1993 through 1997. Results of these parr-to-smolt survival estimates for wild stocks from Idaho and Oregon were as follows:

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001
Parr-to-smolt survival (%)	15.8	18.8	13.5	20.6	20.8	25.7	20.5	17.1	20.6

Parr-to-smolt survival estimates for individual populations have been quite variable over these years, ranging from 6.0% for South Fork of the Salmon River fish in 1996 to 47.6% for Elk Creek fish in 1998. Length-distribution curves for data collected over the last 13 years have generally shown that wild fish released and subsequently detected at dams are slightly larger at release than fish released but not detected. The reason for this difference in detection rates is unknown, but based on these distributions, we speculated that higher survival may have been related to larger fish size.

However, Zabel and Achord (in prep) compared parr-to-smolt survival over a 5-year period with length, weight, and condition index for these stocks and found that mean population length and weight were not related to survival, although year and site effects were detected. Consistent patterns across years of selection for length and weight were found, but condition factor was selectively neutral. These results implied that although the relative size of an individual within a population was important, but the average size of the population was not, at least in terms of performance during the juvenile life stage.

Another consistent trend that has emerged over the years is the difference in arrival timing at Lower Granite Dam with respect to size at release. In 2001, we again observed that wild fish detected at the dam in April and May had been significantly larger at release than fish migrating after May. This suggests that size is an important factor related to either the initiation of smoltification or to other life-history dynamics that affect the migration timing of wild fish.

Relationships with Flow

In 2001, peak detections of wild fish at Lower Granite Dam from 10 Idaho and Oregon streams coincided with low flows of 57.4 kcfs on 28 April. Detections peaked again on 14 May under moderate flows of 71.6 kcfs, just prior to peak flows for the year at this dam (Fig. 5). As observed at Lower Granite Dam from 1989 through 2000, peak detections of wild spring/summer chinook salmon smolts from Idaho and Oregon were highly variable and generally independent of river flows before about 9 May.

However, in every year except 2000, peak detections of wild fish from 9 to 31 May coincided with periods of peak flow. Raymond (1979) showed that peaks in migration for the composite population of spring and summer chinook salmon smolts (mostly wild) passing Ice Harbor Dam from 1964 to 1969 preceded periods of maximum river discharge in most years. During these years, fish passage peaked between 26 April and 13 May. With respect to river flows, our observations matched those of Raymond for wild fish migrating before mid-May.

Climatic Influence

Annual overall climatic variation is emerging as an important factor controlling the overall migrational timing and passage dynamics of wild spring/summer chinook salmon smolts at Lower Granite Dam. In the warm years of 1990, 1992, 1994, 1998, and 2001, the median passage date at the dam was between 29 April and 9 May, and the 90th percentile of all wild fish passed by the end of May.

In the cold years of 1989, 1991, and 1993, median passage did not occur until mid-May, and the 90th percentile had not passed until mid-June (except during high flows in 1993, when the 90th percentile passed by the end of May).

Within these eight years, we saw a consistent 2- to 3-week shift in timing of wild fish at the dam between relatively warm and relatively cold years. In 1995, intermediate weather conditions prevailed in late winter and early spring (compared to the previous six years), and we observed intermediate passage times of 9 May and 5 June for the 50th and 90th percentile passage dates, respectively, for these combined wild populations.

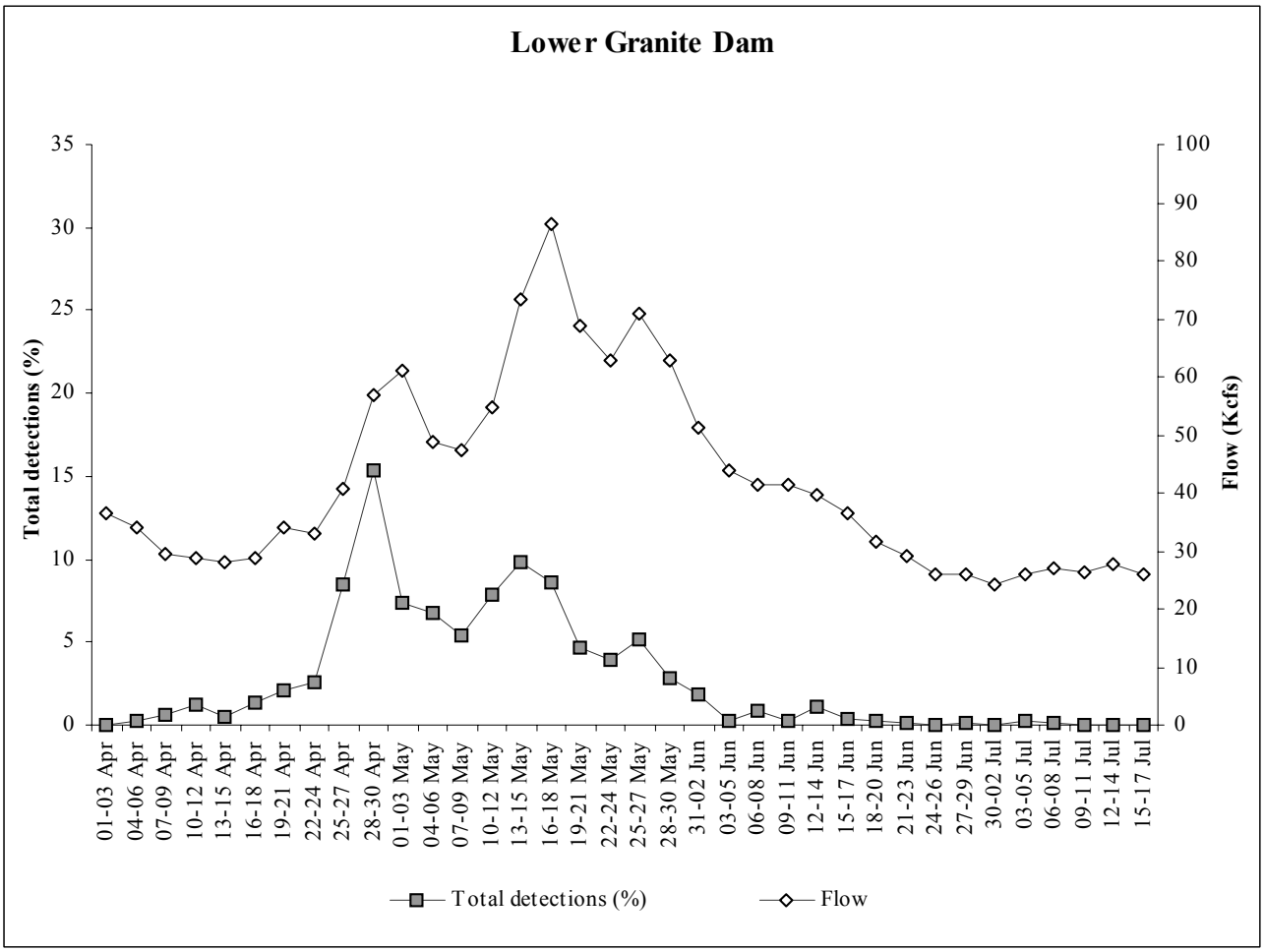

Figure 5. Overall migration timing of PIT-tagged wild spring/summer chinook salmon smolts with associated rivers flows at Lower Granite Dam, 2001. Daily detections from 6 Idaho and 4 Oregon streams were pooled in 3-day intervals and expanded based on daily detection probability (Sandford and Smith 2002). River flows at the dam were averaged daily over the same periods.

In 1999, we experienced different climatic conditions than in all previous migration years. In late winter, a near-record snow pack in the Snake River Basin resulted in high flows early in the migration period (during late March); however, the ensuing flows were moderated by very dry and cold conditions during the remaining spring and early summer. Fluctuating medium-to-high flows throughout the spring moved the wild fish through Lower Granite Dam as observed in warmer years, with the 50th percentile passing by 3 May and the 90th by 28 May (Achord et al. 2001a). Flows during 2000 were slightly below normal, with highest flows occurring in April, along with more seasonal temperatures and climatic conditions throughout the spring. Consequently, we observed a wild fish migration pattern similar to a warm year, with the 50the percentile passing by 6 May and the 90th by 29 May.

The migration timing of individual wild stocks has been highly variable and usually protracted at Lower Granite Dam. However, migration-timing patterns emerging for some stocks range from early to late spring. Shifts in timing of passage distribution for these stocks have been less than 1 to 5 weeks over all years, and these shifts appear directly related to annual climatic conditions.

Cumulative Data: 1989-2001

An important objective of this study is to examine the migration timing at Lower Granite Dam of individual stocks over a period of years to determine similarities or differences between years and between stocks. We now have at least nine years of migration-timing data for fish from eight of the study streams, and this allowed us to construct 95% confidence intervals for the 10th, 50th, and 90th percentile passage dates at Lower Granite Dam for fish from these streams (Table 8).

Results showed that Secesh River fish had a significantly earlier timing for the 10th percentile passage than fish from Elk Creek, Bear Valley Creek, Valley Creek, or Catherine Creek ($P < 0.05$). The 10th percentile passage of fish from Secesh River was also earlier than those of fish from the Lostine, South Fork of the Salmon, or Imnaha Rivers, though the differences were not significant ($P > 0.05$). Secesh River fish also had significantly earlier arrival timing at the dam for the 50th percentile passage than fish from the other seven streams ($P < 0.05$). However, for the 90th percentile passage, the Lostine and Imnaha River fish had significantly earlier timing at the dam than fish from the other six streams ($P < 0.05$).

We also examined the length of time that encompassed the middle 80th percentile passage as a measure of protracted or compressed timing characteristics for stocks from individual streams and from wild fish from all streams combined. The middle 80th percentile passage at Lower Granite Dam averaged 42 days (range 34 to 50 days) for fish from these

Table 8. The 95% confidence interval passage dates at Lower Granite Dam for wild fish from five streams in Idaho and three streams in Oregon that have nine or more years of migration timing data from1989 to 2001.

	Passage periods at Lower Granite Dam				
Stream	95% CI	10th	50th	90th	Data years
Secesh River	lower	11 April	22 April	23 May	13
	upper	18 April	30 April	12 June	
	mean	15 April	26 April	02 June	
South Fork Salmon River	lower	14 April	06 May	03 June	12
	upper	25 April	15 May	14 June	
	mean	20 April	10 May	08 June	
Catherine Creek	lower	23 April	10 May	26 May	11
	upper	02 May	19 May	08 June	
	mean	27 April	14 May	01 June	
Imnaha River (upper)	lower	13 April	26 April	15 May	9
	upper	21 April	07 May	30 May	
	mean	17 April	01 May	23 May	
Bear Valley Creek	lower	19 April	05 May	27 May	10
	upper	30 April	14 May	10 June	
	mean	25 April	10 May	03 June	
Elk Creek	lower	13 April	01 May	21 May	9
	upper	28 April	13 May	07 June	
	mean	21 April	07 May	30 May	
Valley Creek	lower	20 April	07 May	30 May	10
	upper	03 May	20 May	17 June	
	mean	26 April	13 May	08 June	
Lostine River	lower	11 April	01 May	15 May	10
	upper	24 April	10 May	27 May	
	mean	17 April	05 May	21 May	

eight streams over the years. The Lostine River fish had a significantly shorter passage duration (middle 80th) at the dam (34 days) than fish from Bear Valley Creek, Elk Creek, Valley Creek, Secesh River, and South Fork Salmon River (39-50 days; $P < 0.05$). The Lostine River fish also had shorter passage duration at the dam than fish from Catherine Creek and Imnaha River but the differences were not significant (36-37 days; $P > 0.05$).

In examining wild chinook salmon smolt passage timing at the dams over the last 13 years, it has become clear that several factors influence passage timing. Complex yearly interrelationships between flow and annual climatic conditions are primary factors contributing to passage timing. However, water temperature, turbidity, physiological development, variability in stock behavior, fish size, and other yet unknown factors may all contribute substantially to wild smolt passage timing at dams.

As additional environmental monitors and traps are installed in study streams, we can more accurately monitor fry, parr, and smolt movements out of rearing areas and examine the relationships between these movements and environmental conditions within the streams. Mapped over time, this information, along with weather and climate data, will provide tools for the accurate prediction of movement in different wild stocks. Such tools are vital to recovery planning for Pacific salmon species listed as threatened or endangered under the Endangered Species Act.

Action 152 of the "Reasonable and Prudent Alternatives" in the 2000 NMFS Biological Opinion encourages cooperation between government agencies by sharing water quality and biological monitoring information, project reports, and data from existing programs and from subbasin or watershed assessment products (NMFS 2001). During 2001, we encouraged a cooperative spirit in all future data exchanges with agencies and tribes during ongoing studies in spawning and rearing areas. Such cooperation will serve to facilitate planning for recovery of the wild fish stocks.

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APPENDIX

Appendix Table 1. Summary of tagging dates, number collected, tagged, released, and minimum, maximum, and average lengths and weights of wild chinook salmon parr, PIT tagged in six Idaho streams in 2000.

Stream	Tagging dates	Number collected	Number tagged	Number released	Length		Weight	
					Range	Mean	Range	Mean
Bear Valley Creek	08-10 Aug	652	582	581	57-113	73.5	2.1-19.0	4.7
Elk Creek	11 Aug	61	44	44	64-106	77.9	3.2-13.9	5.7
Valley Creek	14-16 Aug	1,046	1,004	1,004	54-104	72.2	2.2-15.0	5.2
Herd Creek	17 Aug	324	312	311	68-103	82.4	3.6-17.9	7.9
South Fork Salmon River	21-22 Aug	1,290	1,010	1,010	52-95	65.3	2.0-10.9	3.7
Secesh River	24-25 Aug	671	587	586	58-95	72.1	2.4-12.7	5.1
Totals or averages	---	4,044	3,539	3,536	52-113	71.4	2.0-19.0	4.9

Appendix Table 2. Summary of tagging dates and start times and release dates and times with temperature, method of capture, and distance between the release point and mouth of the stream. Numbers released (in 2000), and numbers (unadjusted) of first-time detections at 6 downstream dams during 2001 are shown for each group.

Stream	Tag group	Tagging		Release		Temperature (°C)		Capture method	Release site (RKm)	Number released	Detections	
		Date	Time	Date	time	Tagging	Release				N	(%)
Bear Valley Creek	SA00221.BV1	08 Aug	06:59	09 Aug	07:00	11.0	12.5	Shock	12	112	25	22.3
	SA00221.BV2	08 Aug	10:31	09 Aug	07:00	13.0	12.5	Shock	12	99	18	18.2
	SA00222.BV1	09 Aug	08:01	09 Aug	12:00	12.5	15.0	Shock	14	189	43	22.7
	SA00223.BV1	10 Aug	06:23	11 Aug	07:00	12.0	12.0	Shock	15	181	41	22.6
Elk Creek	SA00224.EC1	11 Aug	06:28	11 Aug	11:15	12.0	14.5	Shock	1	44	13	29.5
Valley Creek	SA00227.VC1	14 Aug	06:31	15 Aug	07:15	07.0	07.5	Shock	4	102	14	13.7
	SA00227.VC2	14 Aug	07:31	14 Aug	12:00	07.0	12.0	Shock	4	371	49	13.2
	SA00228.VC1	15 Aug	07:19	15 Aug	11:30	07.0	10.0	Shock	18	116	12	10.3
	SA00229.VC1	16 Aug	06:45	16 Aug	12:00	08.0	14.0	Shock	9	415	79	19.0
Herd Creek	SA00230.HC1	17 Aug	07:12	18 Aug	09:30	07.0	10.0	Shock	1	101	29	28.7
	SA00230.HC2	17 Aug	08:07	17 Aug	10:50	08.0	09.0	Shock	2	210	57	27.1
South Fork Salmon River	SA00234.SF1	21 Aug	07:01	22 Aug	07:10	08.0	10.0	Shock	117	123	14	11.4
	SA00234.SF2	21 Aug	08:14	21 Aug	12:45	08.0	10.0	Shock	118	549	78	14.2
	SA00235.SF1	22 Aug	08:10	22 Aug	11:45	06.0	08.0	Shock	121	338	43	12.7
Secesh River	SA00237.SE1	24 Aug	07:40	25 Aug	07:00	12.0	09.0	Shock	25	111	41	36.9
	SA00237.SE2	24 Aug	11:33	25 Aug	09:00	12.0	09.0	Shock	25	44	15	34.1
	SA00238.SE1	25 Aug	06:04	25 Aug	11:00	09.0	10.0	Shock	26	73	20	27.4
	SA00238.SE3	25 Aug	07:08	25 Aug	12:30	09.0	12.5	Shock	26	358	115	32.1

Appendix Table 3. A summary of observed total mortality for PIT tagged wild chinook salmon parr collected from six Idaho streams during August 2000. Number rejected includes fish too small to tag, precocious males, injured fish, fish collected for genetic evaluation, previously tagged fish, and in some cases extra collected fish. The proportion of precocious males rejected for tagging are shown in parentheses.

Stream	Number collected	Number tagged	Number rejected	Percent rejected (%)	Observed total mortality			
					Collection	Tagging	Total	%
Bear Valley Creek	652	582	70(62)	10.7	6	1	7	1.1
Elk Creek	61	44	17(17)	27.9	0	0	0	0.0
Valley Creek	1,046	1,004	42(29)	4.0	1	0	1	0.1
Herd Creek	324	312	12(4)	3.7	6	1	7	2.2
South Fork Salmon R.	1,290	1,010	280(9)	21.7	3	0	3	0.2
Secesh River	671	587	84(8)	12.5	5	1	6	0.9
Totals or averages	4,044	3,539	505	12.5	21	3	24	0.6

Appendix Table 4. Detections during spring 2001 at three Snake River dams and three Columbia River dams from 581 wild chinook salmon tagged and released as parr at Bear Valley Creek (631-635 km above Lower Granite Dam) during 8-10 August 2000.

	Lower Granite		First Detections				
Detection date	First detection	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
26 Apr	1	1					
27 Apr	1	1					
29 Apr	1	1					
30 Apr	1	1		1			
02 May	2	2					
04 May	1	1					
05 May	1	1					
06 May	2	2					
08 May	3	4					
09 May	3	4					
10 May	3	4					
11 May	4	5					
12 May	4	5	1				
13 May	5	6	1				
14 May	8	10					
15 May	6	7	1				
16 May	9	11	2				
17 May	5	6	1	1			
18 May	3	4	1				
19 May	7	8					
20 May	5	6					
21 May	3	4	1				
22May	7	8					
23 May	6	7					
25 May	1	1		1			
26 May	5	6					
27 May	2	2					
28 May		3	1				
29 May	1	1	1				
01 Jun	1	1					
06 Jun	1	1					
07 Jun			1				
09 Jun	1	1					
13 Jun	4	5					
16 Jun	1	1					
17 Jun	1	1					
21 Jun			1				
06 Jul							
09 Jul							
10 Jul							
Totals	112	132	12	3	0	0	0

Appendix Table 5. PIT-tag detections during spring 2001 at three Snake River dams and three Columbia River dams from 44 wild chinook salmon tagged and released as parr at Elk Creek (634-635 km above Lower Granite Dam) on 11 August 2000.

	Lower Granite		First Detections				
Detection date	First detection	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
30 Apr	1	1					
09 May	1	1					
11 May	1	1					
12 May	2	2	1				
13 May	1	1					
14 May	2	2					
15 May			1				
16 May			1				
27 May	2	2					
Totals	10	10	3	0	0	0	0

Appendix Table 6. Detections during spring 2001 at three Snake River dams and three Columbia River dams from 1,004 wild chinook salmon PIT-tagged and released as parr at Valley Creek (743-757 km above Lower Granite Dam) from 14-16 August 2000.

	Lower Granite		First Detections				
Detection date	First detection	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
28 Apr	1	1					
30 Apr	1	1					
01 May	1	1					
02 May	1	1					
04 May	4	5					
05 May	2	2					
08 May	1	1					
09 May	1	1					
10 May	3	4	1				
11 May	2	2					
12 May	5	6					
13 May	3	4					
14 May	10	12					
15 May	8	10	3				
16 May	15	18	1				
17 May	1	1					
18 May	5	6	1				
19 May	4	5					
20 May	4	5					
21 May	3	4					
22 May	5	6					
23 May	3	4					
24 May	1	1					
25 May	4	5					
26 May	11	13					
27 May	4	5	2				
28 May	8	9	1				
29 May	3	4	2				
30 May	2	2	2				

Appendix Table 6. Continued.

Detection date	Lower Granite		First Detections				
	First detection	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
31 May	4	5					
01 Jun	3	4	1				
04 Jun			1				
05 Jun	2	2					
06 Jun			1				
07 Jun	1	1					
08 Jun	1	1					
10 Jun	1	1					
13 Jun	3	4					
16 Jun	1	1					
18 Jun	1	1					
29 Jun	1	1					
03 Jul	1	1					
06 Jul				1			
09 Jul			1				
10 Jul			1				
Totals	135	161	18	1	0	0	0

Appendix Table 7. Detections during spring 2001 at three Snake River dams and three Columbia River dams from 311 wild chinook salmon PIT-tagged and released as parr at Herd Creek (699-701 km upstream from Lower Granite Dam) on 17 August 2000.

	Lower Granite		First Detections				
Detection date	First detection	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
28 Apr	2	2					
29 Apr	2	2					
30 Apr	5	6					
01 May	4	5					
02 May	4	5					
03 May	9	11	1				
04 May	10	12					
05 May	6	7	1				
06 May	5	6					
07 May			3				
08 May	1	1	4				
09 May	4	5	1				
10 May	4	5	1				
12 May	1	1	3				
13 May	1	1					
14 May	4	5	1				
15 May			2				
16 May			1				
17 May	2	2	1				
22 May			1				
31 May	1	1					
07 Jun	1	1					
Totals	66	78	20	0	0	0	0

Appendix Table 8. Detections during spring 2001 at three Snake River dams and three Columbia River dams from 1,010 wild chinook salmon PIT-tagged as parr and released at the South Fork Salmon River (467 - 472 km above Lower Granite Dam) 21-22 August 2000.

	Lower Granite		First Detections				
Detection date	First detection	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
26 Apr	2	2	1				
28 Apr	3	4					
29 Apr	7	8					
30 Apr	3	4					
01 May	1	1					
02 May	4	5	1				
03 May	1	1					
04 May	1	1					
05 May	3	4					
06 May	3	4					
08 May	4	5					
09 May	5	6					
10 May	3	4					
11 May	3	4					
12 May	10	12					
13 May	2	2	1				
14 May	5	6					
15 May	3	4					
16 May	2	2					
17 May	8	10	1				
18 May	6	7	2				
19 May	3	4					
20 May	1	1					
21 May	2	2					
22 May	3	4	1				
23 May	1	1	2				
24 May	3	4					
25 May	1	1					
26 May	3	4	1				
27 May	3	4					

Appendix Table 8. Continued.

	Lower Granite		First Detections				
Detection date	First detection	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
28 May	1	1	1				
29 May	2	2	1				
30 May	1	1					
01 Jun	4	5		1			
02 Jun	1	1					
04 Jun	1	1	1				
06 Jun			1				
07 Jun	2	2					
08 Jun	1	1					
10 Jun			1				
11 Jun			1				
14 Jun	2	2	1				
18 Jun	1	1					
07 Jul	1	1					
12 Jul			1				
Totals	116	139	18	1	0	0	0

Appendix Table 9. Detections during spring 2001 at three Snake River dams and three Columbia River dams from 586 wild chinook salmon PIT-tagged and released as parr at the Secesh River (429-431 km above Lower Granite Dam) during 24-25 August 2000.

	Lower Granite		First Detections				
Detection date	First detection	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
06 Apr	2	2					
07 Apr	2	2					
08 Apr	1	1					
09 Apr	1	1					
10 Apr	2	3					
11 Apr	1	1					
12 Apr	4	5					
13 Apr	1	1					
14 Apr	2	2					
16 Apr	2	2					
18 Apr	4	5					
19 Apr	8	10					
20 Apr	3	4					
21 Apr	1	1					
22 Apr	2	2					
23 Apr	2	2	1				
24 Apr	4	5					
25 Apr	6	7					
26 Apr	17	20	1				
27 Apr	11	13	1				
28 Apr	29	35	2				
29 Apr	16	19	1				
30 Apr	5	6	2				

Appendix Table 9. Continued.

	Lower Granite		First Detections				
Detection date	First detection	Expanded	Little Goose	Lower Monumental	McNary	John Day	Bonneville
01 May	3	4	3				
02 May	5	6	1				
03 May	2	2					
04 May	3	4	1				
05 May	3	4					
06 May	1	1					
08 May	1	1					
09 May	3	4					
10 May	2	2		1			
11 May	2	2					
12 May	1	1					
13 May	3	4					
14 May	1	1					
15 May			3				
16 May	1	1					
17 May	1	1					
18 May	1	1	1				
24 May			1				
26 May	2	2					
27 May	2	2	1				
28 May	2	2					
29 May	1	1					
30 May	1	1					
01 Jun	1	1					
03 Jun			1				
13 Jun	1	1					
06 Jul			1				
Totals	169	198	21	1	0	0	0

Appendix Table 10. Daily and expanded detections of PIT-tagged wild spring/summer chinook salmon smolts from Idaho at Lower Granite Dam during 2001, with associated river flows (kcfs), spill (kcfs), and water temperatures.

Date	Mean flow (kcfs)	Mean spill (kcfs)	Scroll-case water temperature (°C)	Numbers detected	Expanded numbers detected
04 Apr	37.0	0.0	7.7	0	0
05 Apr	32.2	0.0	7.9	0	0
06 Apr	32.4	0.0	7.8	2	2
07 Apr	31.1	0.0	7.7	2	2
08 Apr	29.3	0.0	7.6	1	1
09 Apr	28.3	0.0	7.9	1	1
10 Apr	29.7	0.0	8.1	2	3
11 Apr	29.0	0.0	8.3	1	1
12 Apr	27.9	0.0	8.2	4	5
13 Apr	29.1	0.0	8.2	1	1
14 Apr	28.9	0.0	8.4	2	2
15 Apr	26.3	0.0	9.0	0	0
16 Apr	25.7	0.0	9.0	2	2
17 Apr	29.8	0.0	8.8	0	0
18 Apr	30.4	0.0	8.8	4	5
19 Apr	31.9	0.0	9.3	8	10
20 Apr	33.5	0.0	9.8	3	4
21 Apr	36.7	0.0	10.2	1	1
22 Apr	33.2	0.0	10.4	2	2
23 Apr	33.4	0.0	10.8	2	2
24 Apr	32.6	0.0	11.3	4	5
25 Apr	34.5	0.0	11.9	6	7
26 Apr	40.6	0.0	11.9	20	23
27 Apr	47.4	0.0	12.4	12	14
28 Apr	57.4	0.0	11.9	35	42
29 Apr	59.0	0.0	12.3	26	30
30 Apr	54.6	0.0	12.1	16	19

Appendix Table 10. Continued.

Date	Mean flow (kcfs)	Mean spill (kcfs)	Scroll-case water temperature (°C)	Numbers detected	Expanded numbers detected
01 May	68.1	0.0	11.4	9	11
02 May	62.0	0.0	10.2	16	19
03 May	53.0	0.0	10.2	12	14
04 May	49.5	0.0	10.4	19	23
05 May	49.9	0.0	9.5	15	18
06 May	46.5	0.0	9.6	11	13
07 May	45.5	0.0	10.8	0	0
08 May	47.6	0.0	11.2	10	12
09 May	49.4	0.0	11.4	17	21
10 May	52.1	0.0	11.7	15	19
11 May	55.3	0.0	12.4	12	14
12 May	57.1	0.0	12.7	23	27
13 May	62.7	0.0	12.5	15	18
14 May	71.6	0.0	12.6	30	36
15 May	85.8	0.0	12.6	17	21
16 May	88.0	0.0	12.1	27	32
17 May	89.2	0.0	11.2	17	20
18 May	81.3	0.0	10.8	15	18
19 May	74.4	0.0	10.8	14	17
20 May	69.7	0.0	10.9	10	12
21 May	61.7	0.0	12.1	8	10
22 May	60.8	0.0	12.6	15	18
23 May	61.5	0.0	13.4	10	12
24 May	65.7	0.0	13.7	4	5
25 May	70.0	0.0	14.6	6	7
26 May	74.6	0.0	15.1	21	25
27 May	68.2	0.0	15.4	13	15
28 May	63.4	0.0	15.2	14	15
29 May	66.4	0.0	15.1	7	8
30 May	58.8	0.0	15.0	4	4
31 May	53.8	0.0	15.6	5	6

Appendix Table 10. Continued.

Date	Mean flow (kcfs)	Mean spill (kcfs)	Scroll-case water temperature (°C)	Numbers detected	Expanded numbers detected
01 Jun	53.3	0.0	15.5	9	11
02 Jun	46.2	0.0	14.8	1	1
03 Jun	43.6	0.0	14.6	0	0
04 Jun	43.8	0.0	14.7	1	1
05 Jun	43.9	0.0	14.8	2	2
06 Jun	40.9	0.0	15.0	1	1
07 Jun	42.4	0.0	15.5	4	4
08 Jun	40.6	0.0	15.2	2	2
09 Jun	44.9	0.0	14.1	1	1
10 Jun	40.6	0.0	14.1	1	1
11 Jun	38.5	0.0	14.5	0	0
12 Jun	38.7	0.0	14.3	0	0
13 Jun	41.0	0.0	15.0	8	10
14 Jun	38.8	0.0	15.2	2	2
15 Jun	37.8	0.0	15.2	0	0
16 Jun	38.6	0.0	15.2	2	2
17 Jun	33.4	0.0	14.7	1	1
18 Jun	32.7	0.0	15.0	2	2
19 Jun	31.9	0.0	16.3	0	0
20 Jun	30.0	0.0	17.0	0	0
21 Jun	31.4	0.0	17.8	0	0
22 Jun	28.4	0.0	17.1	0	0
23 Jun	27.8	0.0	17.1	0	0
24 Jun	27.5	0.0	17.5	0	0
25 Jun	25.8	0.0	18.0	0	0
26 Jun	24.5	0.0	19.0	0	0
27 Jun	25.2	0.0	19.2	0	0
28 Jun	25.3	0.0	19.3	0	0
29 Jun	26.8	0.0	19.2	1	1
30 Jun	25.0	0.0	19.1	0	0

Appendix Table 10. Continued.

Date	Mean flow (kcfs)	Mean spill (kcfs)	Scroll-case water temperature (°C)	Numbers detected	Expanded numbers detected
01 Jul	23.8	0.0	19.1	0	0
02 Jul	23.4	0.0	20.6	0	0
03 Jul	26.5	0.0	22.0	1	1
04 Jul	24.7	0.0	22.1	0	0
05 Jul	26.9	0.0	21.5	0	0
06 Jul	27.7	0.0	21.6	0	0
07 Jul	26.9	0.0	22.4	1	1
08 Jul	26.7	0.0	22.5	0	0
09 Jul	26.1	0.0	22.4	0	0
10 Jul	25.9	0.0	23.6	0	0
11 Jul	26.7	0.0	24.3	0	0
12 Jul	26.9	0.0	24.0	0	0
13 Jul	26.3	0.0	24.8	0	0
14 Jul	30.2	0.0	22.8	0	0

Appendix Table 11. Daily first-time detections of PIT-tagged wild spring/summer chinook salmon smolts from Idaho at Little Goose Dam during 2001, with associated river flows (kcfs), spill (kcfs), and water temperatures.

Date	Mean flow (kcfs)	Mean spill (kcfs)	Scroll-case water temperature (°C)	Numbers detected
23 Apr	34.6	0.0	9.3	1
26 Apr	45.1	0.0	11.9	2
27 Apr	46.7	0.0	11.7	1
28 Apr	58.1	0.0	10.8	2
29 Apr	60.6	0.0	11.3	1
30 Apr	55.8	0.0	11.4	2
01 May	67.9	0.0	11.2	3
02 May	62.0	0.0	11.5	2
03 May	57.0	0.0	12.4	1
04 May	50.5	0.0	11.9	1
05 May	51.7	0.0	11.5	1
07 May	43.5	0.0	11.6	3
08 May	50.3	0.0	11.7	4
09 May	50.4	0.0	10.3	1
10 May	54.6	0.0	10.7	2
12 May	55.8	0.0	14.2	5
13 May	62.7	0.0	10.2	2
14 May	72.1	0.0	12.2	1
15 May	79.9	0.0	12.5	10
16 May	92.4	0.0	12.6	5
17 May	88.5	0.0	12.7	3
18 May	82.4	0.0	12.6	5
21 May	63.2	0.0	12.5	1
22 May	60.2	0.0	13.5	2
23 May	62.6	0.0	13.1	2
24 May	64.3	0.0	12.4	1
26 May	74.9	0.0	14.6	1
27 May	67.6	0.0	14.8	3
28 May	68.4	0.0	14.0	3
29 May	64.2	0.0	14.8	4

Appendix Table 11. Continued.

Date	Mean flow (kcfs)	Mean spill (kcfs)	Scroll-case water temperature (°C)	Numbers detected
30 May	60.5	0.0	15.2	2
01 Jun	50.8	0.0	16.1	1
03 Jun	44.3	0.0	15.4	1
04 Jun	43.7	0.0	15.3	2
06 Jun	41.5	0.0	14.8	2
07 Jun	42.4	0.0	16.0	1
10 Jun	38.2	0.0	15.5	1
11 Jun	39.2	0.0	15.4	1
14 Jun	38.8	0.0	14.5	1
21 Jun	28.4	0.0	17.4	1
06 Jul	29.7	0.0	20.4	1
09 Jul	26.0	0.0	21.8	1
10 Jul	25.6	0.0	24.1	1
12 Jul	28.5	0.0	23.3	1

Appendix Table 12. Daily first-time detections of PIT-tagged wild spring/summer chinook salmon smolts from Idaho at Lower Monumental Dam during 2001, with associated river flows (kcfs), spill (kcfs), and water temperatures.

Date	Mean flow (kcfs)	Mean spill (kcfs)	Scroll-case water temperature (°C)	Numbers detected
30 Apr	59.2	0.0	11.1	1
10 May	56.1	0.0	12.1	1
17 May	94.1	0.0	12.8	1
25 May	74.3	0.0	13.3	1
01 Jun	53.5	0.0	15.6	1
06 Jul	28.9	0.0	19.2	1

Appendix Table 13. Monthly environmental data collected from Valley Creek (609.4 km upstream from the mouth of the Salmon River) from August 2000 through July 2001.

	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
						Temperature (°C)						
Min	8.0	2.7	0.9	0.1	0.0	0.1	0.0	0.2	0.1	1.5	5.6	9.8
Max	15.7	15.7	13.1	4.8	0.8	0.9	1.4	9.5	15.2	15.7	15.7	15.6
Mean	12.4	10.3	6.1	0.8	0.4	0.4	0.6	2.9	5.6	9.6	11.4	13.5
						Dissolved Oxygen (ppm)						
Min	7.4	9.0	10.4	12.6	12.5	12.4	12.9	9.2	8.1	7.7	6.9	5.5
Max	11.4	14.1	14.2	14.2	13.9	14.2	14.2	14.2	11.5	11.4	11.0	9.5
Mean	9.1	11.0	12.7	13.3	13.1	13.2	13.5	12.7	10.0	9.3	8.8	7.9
						Specific Conductance (µS/cm)						
Min	66.0	64.0	64.0	67.0	78.0	80.0	82.0	70.0	56.0	46.0	56.0	73.0
Max	86.0	78.0	81.0	95.0	87.0	91.0	97.0	97.0	90.0	70.0	77.0	96.0
Mean	72.8	72.2	69.8	82.5	81.7	84.6	88.1	87.2	77.7	58.6	67.2	84.7
						Turbidity (ntu)						
Min	0.4	0.4	0.4	0.1	0.1	0.3	0.3	0.3	0.6	1.2	0.9	0.6
Max	2.3	44.2	31.5	11.9	2.6	5.6	14.6	20.2	33.1	45.8	38.8	45.5
Mean	0.9	1.6	1.5	0.9	0.8	0.9	2.3	3.4	3.4	5.1	2.2	1.9
						Depth (feet)						
Min	0.9	0.7	0.7	0.7	0.9	0.8	0.6	0.8	0.8	1.5	1.3	1.0
Max	1.4	1.4	1.5	1.6	1.9	1.8	1.5	1.7	1.8	2.7	1.9	1.6
Mean	1.1	1.2	1.2	1.2	1.4	1.3	1.1	1.2	1.3	2.0	1.6	1.3
						pH						
Min	7.4	7.5	7.5	7.6	7.4	7.4	7.5	7.2	7.6	7.4	7.6	6.9
Max	8.5	9.0	8.8	8.4	8.0	7.9	8.2	8.5	8.4	8.9	8.8	8.4
Mean	7.9	8.0	7.9	7.8	7.6	7.6	7.7	7.7	8.0	7.9	8.0	7.7

Appendix Table 14. Monthly environmental data collected from Secesh River (27 km upstream from its confluence with the South Fork Salmon River) from August 2000 through July 2001.

	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
						Temperature (°C)						
Min	7.6	1.2	0.0	---	---	---	---	---	---	---	---	---
Max	15.7	15.6	9.7	---	---	---	---	---	---	---	---	---
Mean	12.6	8.6	3.9	---	---	---	---	---	---	---	---	---
						Dissolved Oxygen (ppm)						
Min	7.1	8.9	10.6	---	---	---	---	---	---	---	---	---
Max	11.8	14.1	14.2	---	---	---	---	---	---	---	---	---
Mean	9.2	11.0	12.8	---	---	---	---	---	---	---	---	---
						Specific Conductance (µS/cm)						
Min	33.0	38.0	35.0	---	---	---	---	---	---	---	---	---
Max	46.0	69.0	51.0	---	---	---	---	---	---	---	---	---
Mean	40.8	43.1	40.2	---	---	---	---	---	---	---	---	---
						Turbidity (ntu)						
Min	0.0	0.0	0.0	---	---	---	---	---	---	---	---	---
Max	8.4	40.6	18.0	---	---	---	---	---	---	---	---	---
Mean	0.6	2.5	1.6	---	---	---	---	---	---	---	---	---
						Depth (feet)						
Min	0.5	1.3	1.2	---	---	---	---	---	---	---	---	---
Max	1.9	2.6	2.4	---	---	---	---	---	---	---	---	---
Mean	1.6	1.8	1.9	---	---	---	---	---	---	---	---	---
						pH						
Min	6.5	6.5	6.4	---	---	---	---	---	---	---	---	---
Max	9.0	8.9	7.7	---	---	---	---	---	---	---	---	---
Mean	7.7	7.4	6.7	---	---	---	---	---	---	---	---	---

Appendix Table 15. Monthly environmental data collected from South Fork Salmon River (112 km from its confluence with the Salmon River) from August 2000 through July 2001.

	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
						Temperature (°C)						
Min	8.7	2.6	0.4	0.0	0.0	0.0	0.0	0.0	---	---	---	---
Max	15.7	15.4	11.7	3.3	1.1	1.2	2.6	5.4	---	---	---	---
Mean	12.8	9.4	4.9	0.3	0.1	0.2	0.5	1.7	---	---	---	---
						Dissolved Oxygen (ppm)						
Min	6.9	7.1	7.8	9.6	13.3	13.6	13.8	12.6	---	---	---	---
Max	9.4	10.5	10.9	14.0	14.2	14.2	14.2	14.2	---	---	---	---
Mean	7.9	8.4	9.4	13.0	13.7	14.1	14.1	13.9	---	---	---	---
						Specific Conductance (µS/cm)						
Min	46.0	44.0	44.0	45.0	45.0	47.0	55.0	43.0	---	---	---	---
Max	57.0	59.0	58.0	70.0	63.0	66.0	64.0	66.0	---	---	---	---
Mean	52.2	54.1	53.0	57.3	58.0	57.5	59.1	54.6	---	---	---	---
						Turbidity (ntu)						
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	---	---	---	---
Max	1.0	9.4	13.0	4.0	1.0	1.2	2.6	8.4	---	---	---	---
Mean	0.1	0.3	0.4	0.2	0.1	0.2	0.2	0.7	---	---	---	---
						Depth (feet)						
Min	0.2	0.0	0.0	0.4	0.6	0.4	0.3	0.5	---	---	---	---
Max	0.9	0.8	0.8	2.0	3.2	3.3	2.1	1.7	---	---	---	---
Mean	0.5	0.4	0.4	1.2	1.6	1.6	0.9	0.9	---	---	---	---
						pH						
Min	7.5	7.5	7.3	7.4	7.7	7.6	7.6	7.5	---	---	---	---
Max	8.8	8.7	8.3	8.0	8.0	8.1	8.1	8.0	---	---	---	---
Mean	7.9	7.8	7.6	7.7	7.8	7.8	7.8	7.7	---	---	---	---

Appendix Table 16. Monthly environmental data collected from Marsh Creek (179.5 km from its confluence with the Middle Fork Salmon River) from August 2000 through July 2001.

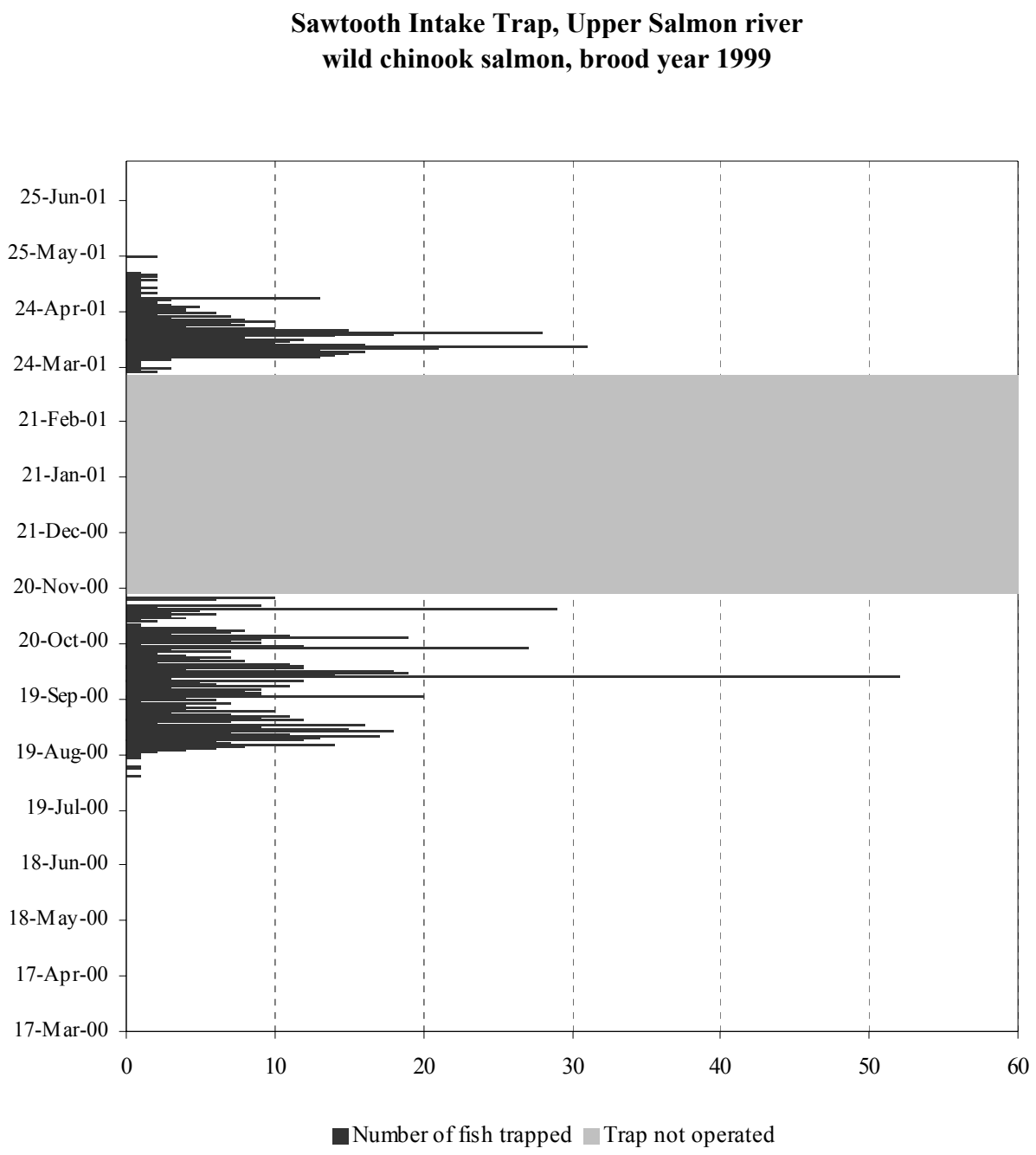
	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
						Temperature (°C)						
Min	5.5	1.5	0.4	-0.1	0.0	0.0	-0.1	-0.1	0.1	0.6	3.3	6.7
Max	15.7	15.3	11.2	5.8	2.2	3.6	4.8	9.4	12.4	15.6	15.7	15.7
Mean	10.7	8.6	5.1	0.7	0.1	0.3	0.8	3.1	3.9	7.7	9.9	11.7
						Dissolved Oxygen (ppm)						
Min	7.4	8.2	9.0	---	0.9	---	0.9	9.6	10.0	9.6	8.6	8.6
Max	10.3	11.7	12.5	---	7.8	---	12.9	13.6	14.1	13.7	14.0	12.1
Mean	8.8	9.7	10.7	---	3.1	---	8.4	12.0	12.1	11.7	11.3	10.3
						Specific Conductance (µS/cm)						
Min	61.0	63.0	59.0	47.0	68.0	68.0	66.0	60.0	34.0	33.0	50.0	61.0
Max	69.0	69.0	69.0	84.0	80.0	122.0	128.0	131.0	72.0	59.0	67.0	70.0
Mean	65.5	66.4	65.0	73.4	71.5	72.6	71.8	70.9	60.9	49.8	58.6	66.7
						Turbidity (ntu)						
Min	0.0	0.0	0.1	0.0	0.3	0.0	0.0	0.0	0.2	0.8	0.6	1.8
Max	14.5	3.6	2.5	12.2	32.6	30.9	38.3	10.7	47.5	46.1	49.9	49.7
Mean	0.3	0.4	0.7	1.2	1.5	2.8	1.2	0.7	3.2	4.4	12.9	19.2
						Depth (feet)						
Min	0.7	0.4	0.4	0.7	0.9	0.8	0.5	0.7	0.2	1.4	1.2	1.0
Max	1.2	1.1	1.1	2.0	2.7	2.4	2.0	1.6	2.1	2.6	1.9	1.7
Mean	1.0	0.9	0.9	1.2	1.7	1.5	1.1	1.1	1.0	1.9	1.5	1.3
						pH						
Min	7.5	7.7	7.7	7.1	7.3	7.3	7.4	7.2	6.9	6.9	7.3	7.3
Max	9.0	9.4	9.5	9.2	7.7	7.8	7.9	8.0	8.7	8.7	8.6	8.4
Mean	8.1	8.2	8.2	7.5	7.5	7.5	7.6	7.6	7.6	7.5	7.7	7.7

Appendix Table 17. Monthly environmental data collected from the Salmon River near Sawtooth Hatchery (Salmon River kilometer 627.9) from August 2000 through July 2001.

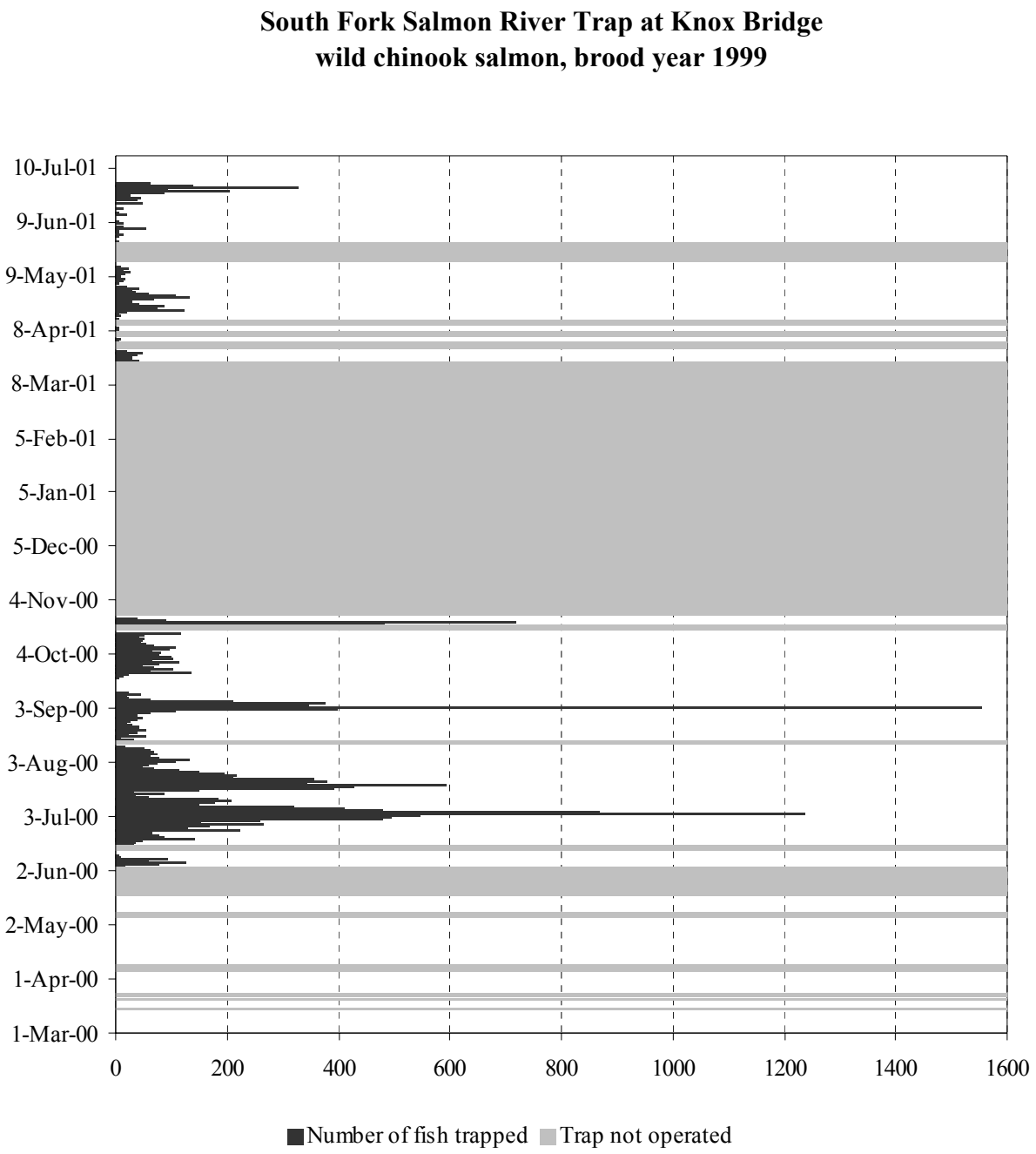
	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
						Temperature (°C)						
Min	8.1	4.7	2.3	0.1	0.1	0.0	0.0	0.1	0.1	2.3	6.5	9.3
Max	15.7	15.7	12.7	5.9	3.2	4.4	5.3	10.3	13.5	15.7	15.7	15.7
Mean	12.2	10.5	6.8	1.7	0.6	0.8	1.6	4.6	6.5	10.2	11.5	12.7
						Dissolved Oxygen (ppm)						
Min	7.3	7.8	8.8	9.8	9.6	10.5	9.9	8.6	5.4	8.4	7.9	3.4
Max	11.4	13.3	13.3	12.7	14.1	14.1	14.2	14.2	11.9	12.0	12.4	14.0
Mean	8.8	9.7	10.5	11.0	11.5	11.8	11.9	11.2	9.6	9.9	10.0	9.1
						Specific Conductance (µS/cm)						
Min	137.0	137.0	126.0	5.0	116.0	123.0	135.0	7.0	84.0	74.0	95.0	144.0
Max	147.0	149.0	146.0	177.0	175.0	173.0	177.0	171.0	159.0	100.0	146.0	178.0
Mean	142.0	143.7	137.6	162.0	153.1	156.6	160.3	158.2	132.4	90.3	123.3	161.2
						Turbidity (ntu)						
Min	0.2	0.3	0.7	0.0	0.0	0.0	0.0	0.4	0.2	---	---	---
Max	18.1	47.3	50.0	32.0	9.0	49.1	42.7	49.7	13.4	---	---	---
Mean	0.6	3.9	13.4	0.3	0.8	0.7	4.0	19.6	1.5	---	---	---
						Depth						
Min	0.9	0.8	0.9	1.5	2.2	1.9	1.8	0.9	0.7	0.8	1.0	0.9
Max	2.9	1.6	2.2	2.4	3.0	2.6	2.3	1.9	1.6	1.5	1.8	2.2
Mean	1.5	1.2	1.4	2.0	2.6	2.2	2.0	1.4	1.2	1.2	1.4	1.5
						pH						
Min	7.8	7.8	7.8	7.6	7.4	7.3	7.5	7.6	7.2	7.5	7.7	7.7
Max	9.0	9.1	9.0	8.6	8.9	8.7	8.8	9.1	8.4	8.4	8.7	8.9
Mean	8.2	8.2	8.2	8.0	8.0	8.0	8.1	8.2	8.0	7.9	8.0	8.1

Appendix Table 18. Monthly flow information from August 2000 through July 2001 in cubic feet per second (cfs) for various sites in the Salmon River drainage in Idaho. These data were provided by the U. S. Geological Survey and is cited as provisional data subject to revision.

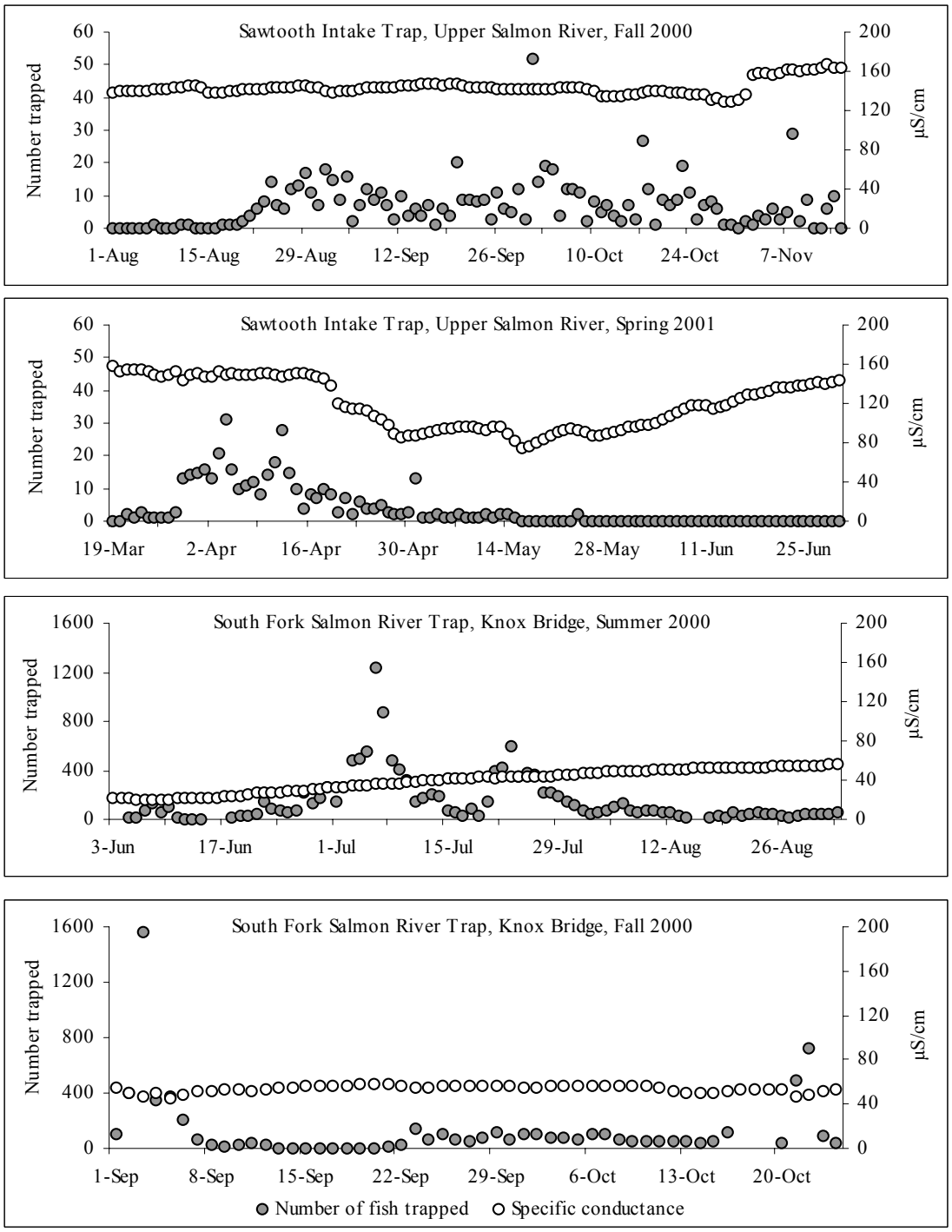
	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Station number 13295000--Valley Creek at Stanley, ID												
Mean	65	75	88	74	97	81	66	86	113	271	157	73
Min	55	66	72	55	83	70	50	54	73	149	105	47
Max	85	93	112	101	111	88	87	154	231	582	240	98
Station number 13302500--Salmon River at Salmon, ID												
Mean	697	833	1,232	1,224	1,105	994	1,015	1,095	1,144	2,069	1,434	808
Min	634	674	1,000	1,000	950	750	800	906	990	1,200	999	550
Max	804	957	1,460	1,420	1,240	1,100	1,100	1,310	1,670	3,200	2,110	977
Station number 13310700--South Fork Salmon River near Krassel Ranger Station, ID												
Mean	134	134	150	132	------	------	105	159	263	872	347	149
Min	111	113	115	110	------	------	85	105	154	474	202	103
Max	169	200	207	156	------	------	110	269	705	1,739	557	192
Station number 13314300--South Fork Salmon River at mouth near Mackay Bar, ID												
Mean	490	486	586	461	414	378	372	523	917	3,581	1,747	682
Min	390	397	421	348	287	181	243	289	530	1,820	1,020	458
Max	647	789	841	592	493	567	441	870	2,600	6,480	2,640	956
Station number 13317000--Salmon River at White Bird, ID												
Mean	3,567	3,720	4,909	4,260	3,690	3,403	3,452	4,607	6,691	20,223	11,705	4,837
Min	3,130	3,250	3,930	3,650	3,180	2,849	3,020	3,150	4,440	12,500	7,260	3,430
Max	4,260	4,780	6,030	5,180	4,110	3,820	3,760	6,850	16,400	31,200	16,900	6,800



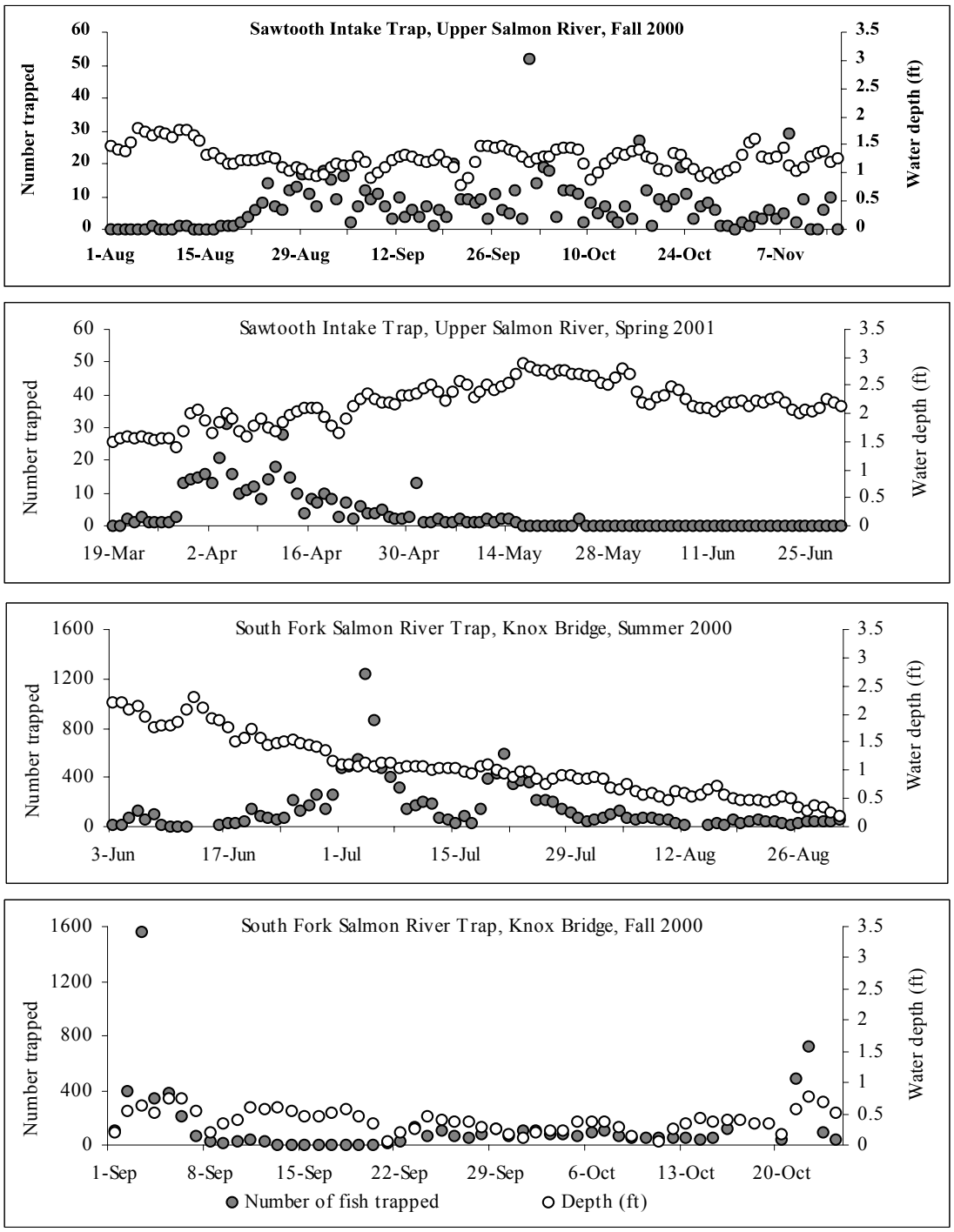
Appendix Figure 1. Daily passage totals at Sawtooth Intake Trap on the upper Salmon River for wild chinook salmon fry, parr, and smolts from brood year 1999. Catch data and periods of trap operation provided by the Idaho Department of Fish and Game.



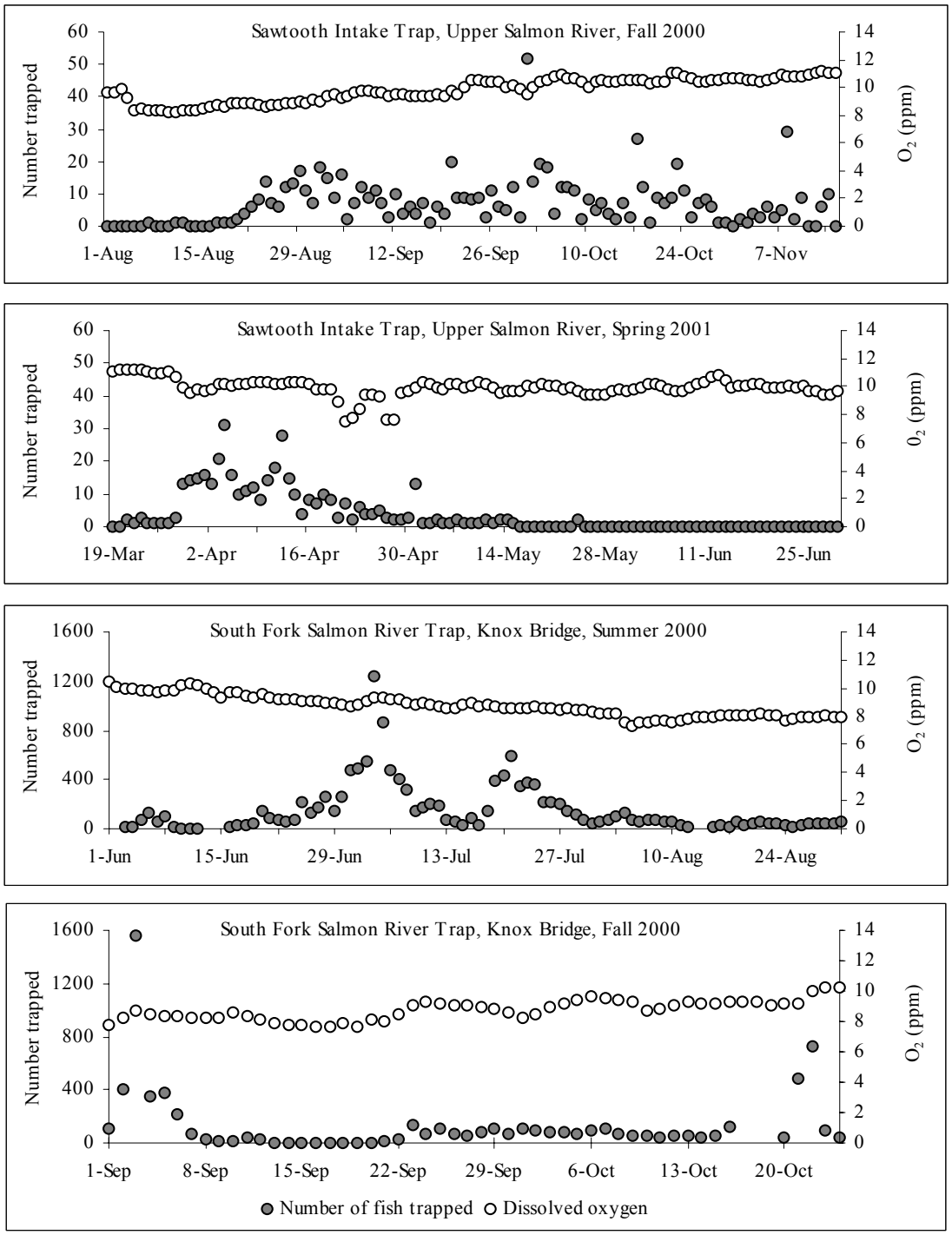
Appendix Figure 2. Daily passage totals at the South Fork of the Salmon River Trap at Knox Bridge for wild chinook salmon fry, parr, and smolts from brood year 1999. Catch data and periods of trap operation provided by the Idaho Department of Fish and Game.



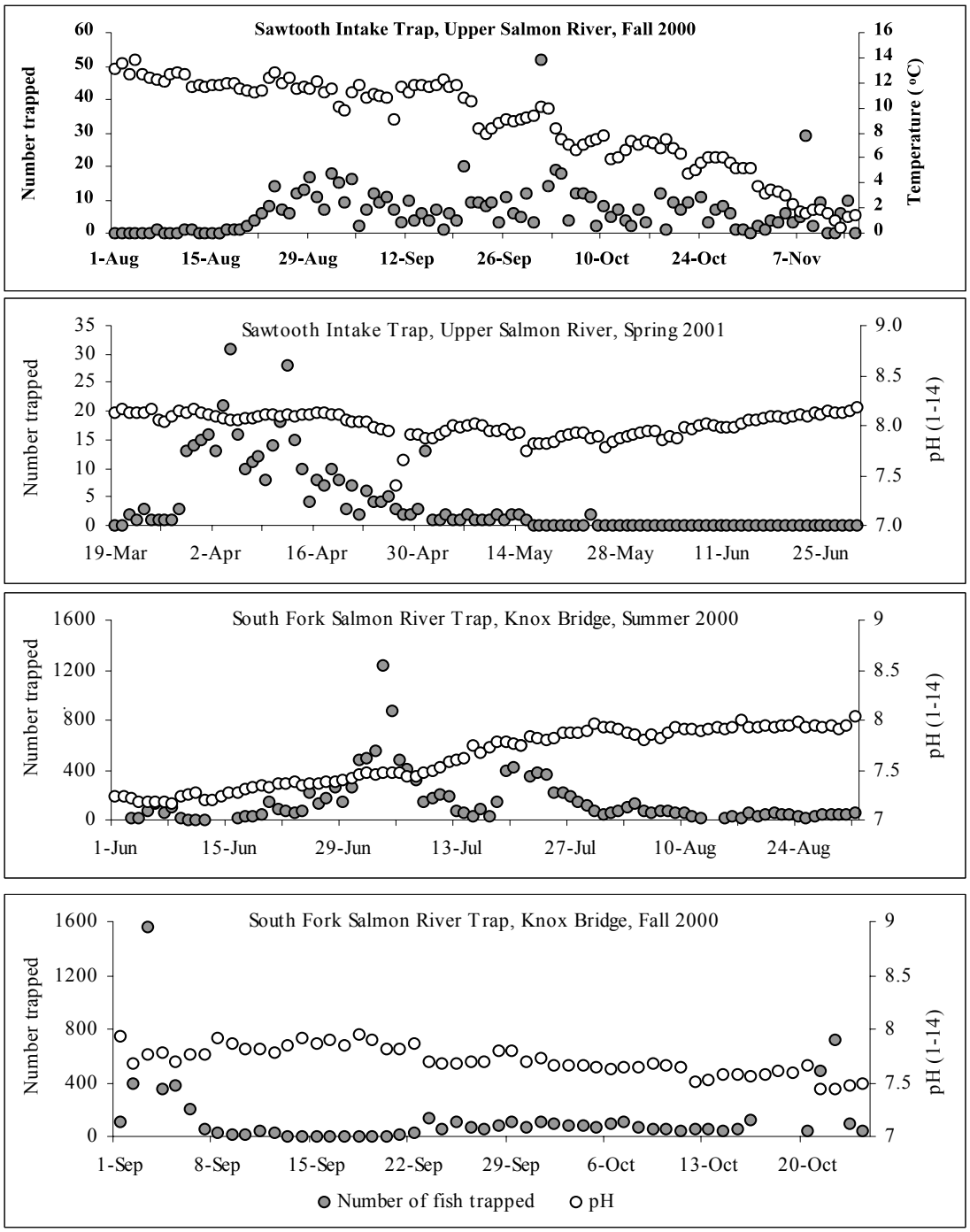
Appendix Figure 3. Daily average conductivity in microSiemens per centimeter (mS/cm) at two migrant fish traps plotted against daily passage counts of brood year 1999 wild chinook salmon. Environmental monitoring data were collected near the traps.



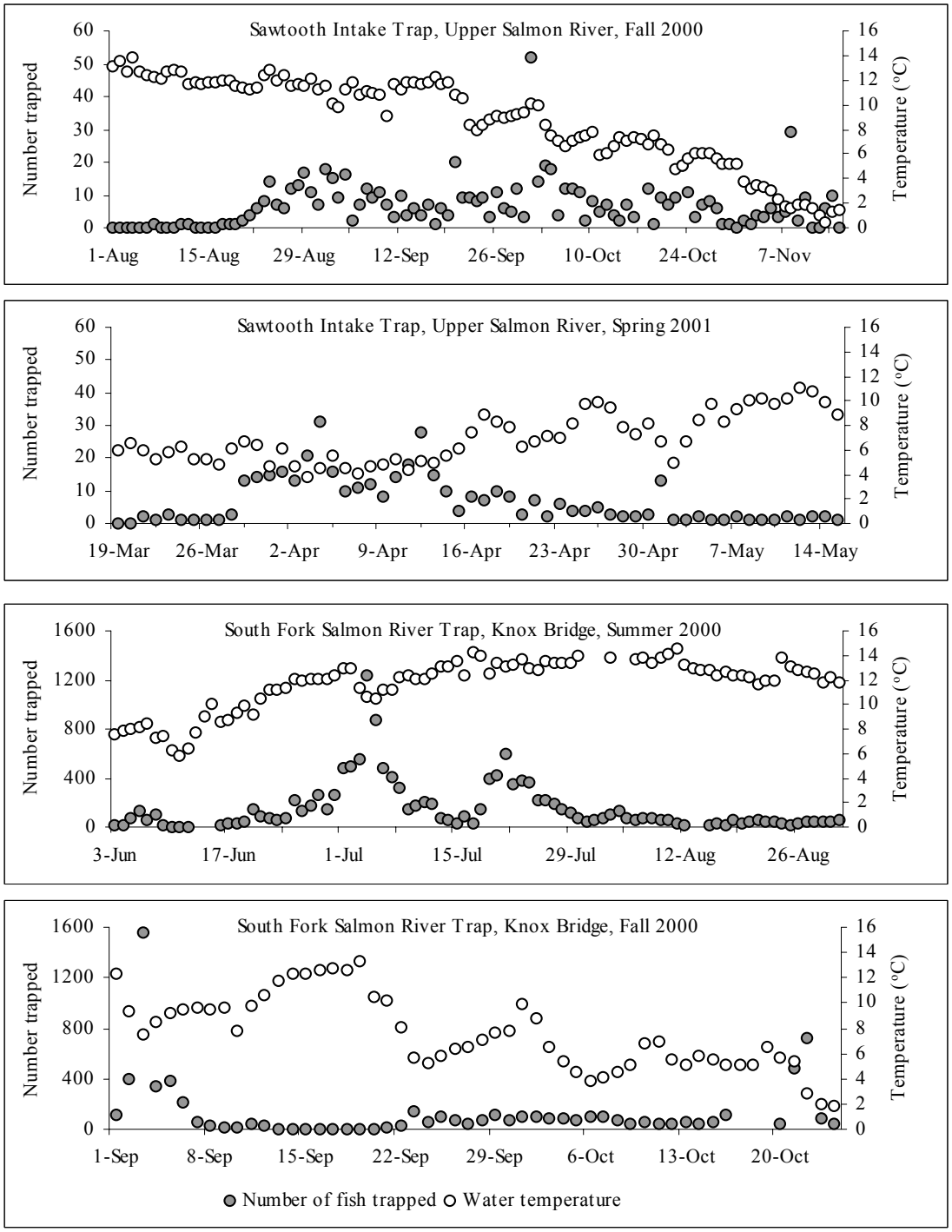
Appendix Figure 4. Daily average depth at two migrant fish traps plotted against daily passage counts of brood year 1999 wild chinook salmon. Environmental monitoring data were collected near the traps.



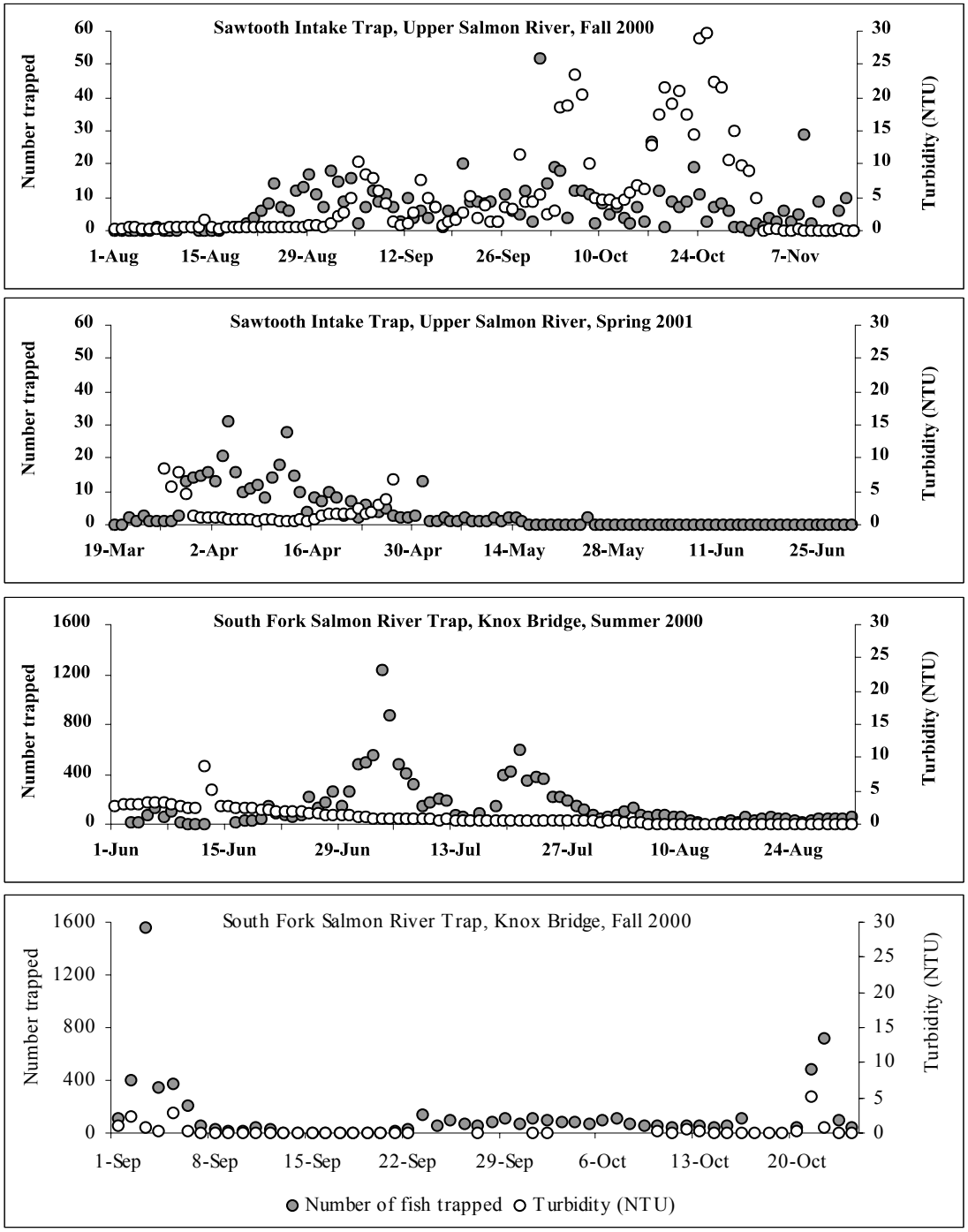
Appendix Figure 5. Daily average levels of dissolved oxygen at two migrant fish traps plotted against daily passage counts of brood year 1999 wild chinook salmon. Environmental monitoring data were collected near the traps.



Appendix Figure 6. Daily average pH at two migrant fish traps plotted against daily passage counts of brood year 1999 wild chinook salmon. Environmental monitoring data were collected near the traps.



Appendix Figure 7. Daily average water temperature at two migrant fish traps plotted against daily passage counts of brood year 1999 wild chinook salmon. Environmental monitoring data were collected near the traps.



Appendix Figure 8. Daily average turbidity in NTUs (nephelometric turbidity units) at two migrant fish traps plotted against daily passage counts of brood year 1999 wild chinook salmon. Environmental monitoring data were collected near the traps.