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THE DESIGN AND ANALYSIS OF SALMONID TAGGING STUDIES IN THE COLUMBIA BASIN

Volume XVI: Alternative Designs for Future Adult PIT-tag Detection Studies

Technical Report 2000

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THE DESIGN AND ANALYSIS OF SALMONID TAGGING STUDIES IN THE COLUMBIA BASIN

VOLUME XVI

Alternative Designs for Future Adult PIT-tag Detection Studies

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PREFACE

Project 8910700, Epidemiological Survival Methods, was developed to provide statistical guidance on design and analysis of PIT-tag (Passive Integrated Transponder) survival studies to the Northwest fisheries community. Studies under this project have determined the statistical feasibility of conducting PIT-tag smolt survival studies, assessed analytical capabilities for analyzing the tagging experiments, and made recommendations on study design. As PIT-tag capabilities developed and research interests increased, the project has been instrumental in maintaining the statistical capabilities for designing and analyzing tagging studies to meet these expanded objectives.

In compliance to the Biological Opinion, drafted on July 27, 2000 by National Marine Fisheries Service (NMFS), and similar ones stated in previous NMFS opinions, Bonneville Power Administration (BPA) and U.S. Army Corps of Engineers (COE) are attempting to replace the current network of 400-kHz PIT-tag interrogation systems with a 134.2-kHz ISO-based system, and to install 134.2-kHz ISO-based adult-detection systems at Bonneville Dam and other dams. In the advent of these plans, this report provides general guidelines and a qualitative assessment of adult PIT-tag study capabilities. This overview describes in general terms what can and cannot be estimated under seven different scenarios of adult PIT-tag detection capabilities in the CRB, and it summarizes the assessment in terms of the minimal adult PIT-tag detection configurations required by the ten threatened Columbia River Basin (CRB) chinook and steelhead ESUs.

ABSTRACT

In the advent of the installation of a PIT-tag interrogation system in the Cascades Island fish ladder at Bonneville Dam (BON), and other CRB dams, this overview describes in general terms what can and cannot be estimated under seven different scenarios of adult PIT-tag detection capabilities in the CRB. Moreover, this overview attempted to identify minimal adult PIT-tag detection configurations required by the ten threatened Columbia River Basin (CRB) chinook and steelhead ESUs.

A minimal adult PIT-tag detection configuration will require the installation of adult PIT-tag detection facilities at Bonneville Dam and another dam above BON. Thus, the Snake River spring/ summer and fall chinook salmon, and the Snake River steelhead will require a minimum of three dams with adult PIT-tag detection capabilities to guarantee estimates of "ocean survival" and at least of one independent, in-river returning adult survival (e.g., adult PIT-tag detection facilities at BON and LGR dams and at any other intermediary dam such as IHR). The Upper Columbia River spring chinook salmon and steelhead will also require a minimum of three dams with adult PIT-tag detection capabilities: BON and two other dams on the BON-WEL reach. The current CRB dam system configuration and BPA's and COE's commitment to install adult PIT-tag detectors only in major CRB projects will not allow the estimation of an "ocean survival" and of any in-river adult survival for the Lower Columbia River chinook salmon and steelhead. The Middle Columbia River steelhead ESU will require a minimum of two dams with adult PIT-tag detection capabilities: BON and another upstream dam on the BON-McN reach. Finally, in spite of their importance in terms of releases, PIT-tag survival studies for the Upper Willamette chinook and Upper Willamette steelhead ESUs cannot be perform with the current CRB dam system configuration and PIT-tag detection capabilities.

EXECUTIVE SUMMARY

Objectives

The objectives of this overview were to describe in general terms what can and cannot be estimated under seven different scenarios of adult PIT-tag detection capabilities in the CRB, to identify minimal adult PIT-tag detection configurations required by the ten threatened Columbia River Basin (CRB) chinook and steelhead ESUs.

We assumed that the ability to estimate downstream survival of out-migrating salmonid smolts and/or upstream survival of returning salmonid adults is based on the release-recapture model of Cormack (1964), Jolly (1965) and Seber (1965), hereinafter CJS model, as implemented in *SURPH.1* (Smith et al., 1994). Thus, a minimal adult PIT-tag detection configuration will require the installation of adult PIT-tag detection facilities at Bonneville Dam and another dam above BON (Fig. 1 and 2).

Results

We describe what can and cannot be estimated under seven, increasingly more complex scenarios of adult PIT-tag detection capabilities in the CRB. Starting with the configuration prior to 2000 (Scenario 1, Fig. 6) and that of 2001 (Scenario 2, Fig. 7) adult PIT-tag detection capabilities were added to the most important dams in the CRB (Scenarios 3-7, Fig. 8-12). For each scenario, results were referred to releases of PIT-tagged juvenile salmonids from the three locations previously identified as important (Fig. 4 and 5): 1) Releases of Snake River chinook and steelhead above LGR, 2) Releases of chinook and steelhead in the JDA-McN reach of the Columbia River, and 3) Releases of chinook and steelhead in the Columbia River above Rocky Reach Dam (RRE).

The releases above LGR are expected to include most of the stocks included in the spring/summer and the fall Snake River chinook salmon ESUs, as well as stocks from the Snake River steelhead ESU. Releases to the JDA-McN reach are likely to include part of the stocks from the Middle Columbia River steelhead ESU. Finally, the releases above Rocky Reach Dam may consist of stocks from the Upper Columbia River spring chinook and steelhead ESUs. In spite of their importance (e.g., Fig. 5, 44.6% of all hatchery releases), releases to the Lower Columbia River will not be dealt with here because no adult PIT-tag detection facility is scheduled below BON.

The Snake River spring/ summer and fall chinook salmon, and the Snake River steelhead will require a minimum of three dams with adult PIT-tag detection capabilities to guarantee estimates of "ocean survival" and at least of one independent, in-river returning adult survival (e.g., adult PIT-tag detection facilities at BON and LGR dams and at any other intermediary dam such as IHR, scenario #4, Fig.9). The Upper Columbia River spring chinook salmon and steelhead will also require a minimum of three dams with adult PIT-tag detection capabilities: BON and two other dams on the BON-WEL reach (scenario #5, Fig. 10). The current CRB dam system configuration and BPA's and COE's commitment to install adult PIT-tag detectors only in major CRB projects will not allow the estimation of an "ocean survival" and of any in-river adult survival for the Lower Columbia River chinook salmon and steelhead. The Middle Columbia River steelhead ESU will require a minimum of two dams with adult PIT-tag detection capabilities: BON and another upstream dam on the BON-McN reach. Finally, in spite of their importance in terms of releases, PIT-tag survival studies for the Upper Willamette chinook and Upper Willamette steelhead ESUs cannot be perform with the current CRB dam system configuration and PIT-tag detection capabilities.

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1. INTRODUCTION

Chinook salmon (*Oncorhyncus tshawytscha*) and steelhead (*O. mykiss*) are indigenous to the Columbia River Basin (CRB). Since 1992, ten of their Evolutionary Significant Units (ESU) have been listed as endangered or threatened under the Endangered Species Act (ESA). In 1992, both the spring/summer and fall Snake River chinook salmon were listed as threatened (NMFS, 1992). In 1999, Upper Columbia River spring chinook and Upper Willamette River chinook were listed as threatened, and Lower Columbia River chinook was declared endangered (NMFS, 1999*a*). Steelhead ESUs are endangered in the Upper Columbia River (NMFS, 1997) and threatened in the Lower Columbia, Middle Columbia and Upper Willamette (NMFS, 1998 and 1999*b*). High mortality and delays in seaward migration of juvenile chinook salmon and steelhead caused by CBR dams, as well as changing habitat conditions determined by agricultural and forest harvesting techniques, urbanization and hatchery practices, together with changes in the ESU's genetic variability linked to hatchery side-effects and the impact of excessive harvest contributed to the ESA listing of these ten ESUs.

The Biological Opinion drafted on July 27, 2000 to consider the effects of the existing configuration, continued operation and maintenance of CRB dams on the likelihood of survival and recovery of the ten previously mentioned ESUs describes a series of measures to be undertaken by the Corps of Engineers (COE), Bonneville Power Administration (BPA) and U.S. Bureau of Reclamation (BOR) on a continuous non-discretionary basis. COE, BPA and BOR shall estimate the survival of juvenile and adult salmonids migrating through the CRB using PIT-tags, radio-tags, sonic tags, or other developing technology. Moreover, as adult PIT-tag detection facilities are developed and installed, COE, BPA and BOR will use them to measure adult passage survival on a per-project basis for fish with known origins and passage histories. Finally, BPA and COE shall install necessary adult PIT-tag detectors at appropriate CRB projects prior to the expected return of any adult salmon from the 2001 juvenile out-migration. In compliance to these measures and similar ones stated in previous NMFS opinions, BPA and COE are attempting to replace the current CRB network of 400-kHz PIT-tag interrogation systems with a 134.2-kHz ISO-based system and install 134.2-kHz ISO-based adult-detection systems at Bonneville Dam and other CBR dams.

The purpose of this overview is to provide general guidelines and a qualitative assessment of adult PIT-tag study capabilities. This overview will describe in general terms what can and cannot be estimated under seven different scenarios of adult PIT-tag detection capabilities in the CRB.

2. BACKGROUND

2.1 PIT-tag detection systems in the Columbia River Basin

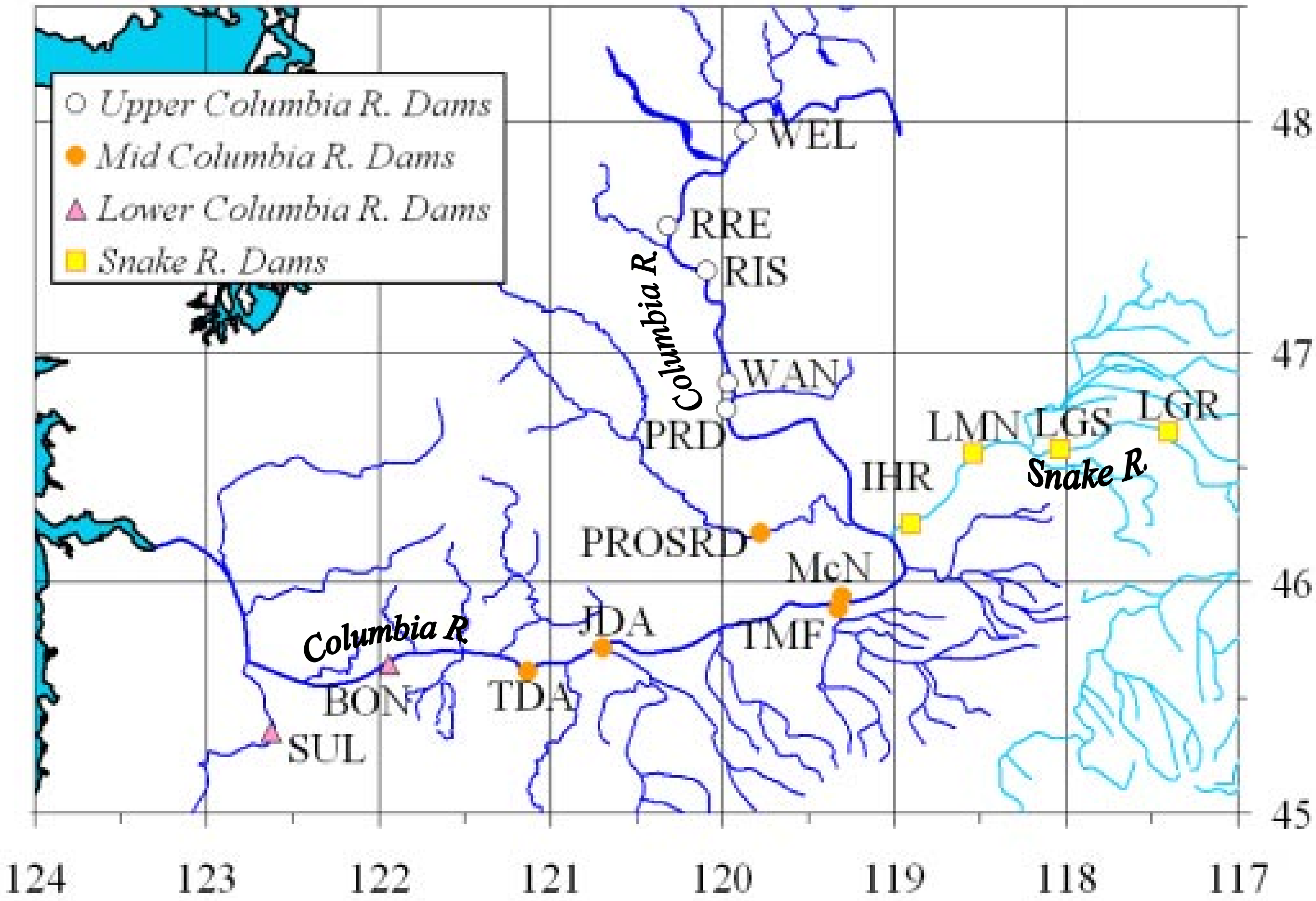
Since 1986, various dams on the Columbia River Basin (CRB) have been supplied with systems for the detection of PIT-tagged out-migrating juveniles and returning adults (Fig.1, Table 1). Until recently, the most common detection system for juveniles consisted of 400-kHz PIT-tag interrogation systems normally associated to the juvenile bypass facility of the dams located on the mainstem of the Columbia and Snake rivers. Until 1999, PIT-tagged adult salmon were only interrogated in 31-cm pipes at the adult monitoring facilities of Lower Granite and Bonneville Dams.

The current network of 400-kHz PIT-tag interrogation systems for juvenile salmon has been replaced with the 134.2-kHz ISO-based system (Table 1). Longer read range is possible with the 134.2-kHz tags than the 400-kHz tags, because they incorporate a different data recovery scheme, new silicon technology, and are governed by less stringent Federal Communication Commission (FCC) emission regulations. These advantages are also expected to enable the detection of returning adult salmon at several locations associated with fish ladders instead of being restricted to small diameter pipes as with the 400-kHz technology. NMFS is developing interrogation systems in a variety of locations in fish ladders. Its initial work has concentrated on the detection in fish ladder orifices, and the installation of a PIT-tag interrogation system that covers orifices in a maximum of four weirs in the Cascades Island fish ladder at Bonneville Dam. Then, based on the flat-plate system developed for Bonneville Dam, pass-by technology will be investigated for detecting fish going through vertical slots and using the over-fall portions of the weirs. If those tasks are completed without technical difficulty by the end of the fiscal year 2000, the plan is to proceed with the installation of PIT-tag interrogation equipment in all ladders of Bonneville Dam in 2001, and to install similar systems at other dams in the CRB in subsequent years.

2.2 Analytical procedure

The ability to estimate downstream survival of out-migrating salmonid smolts and/or upstream survival of returning salmonid adults is based on the release-recapture model of Cormack (1964), Jolly (1965) and Seber (1965), hereinafter CJS model, as implemented in *SURPH.1* (Smith et al., 1994). The method requires uniquely identifiable tag codes and a series of detection sites through which the migrants can pass. The minimum design configuration (Fig. 2) consists of a release location and two

Figure 1: Columbia-Snake River basin showing major dams.

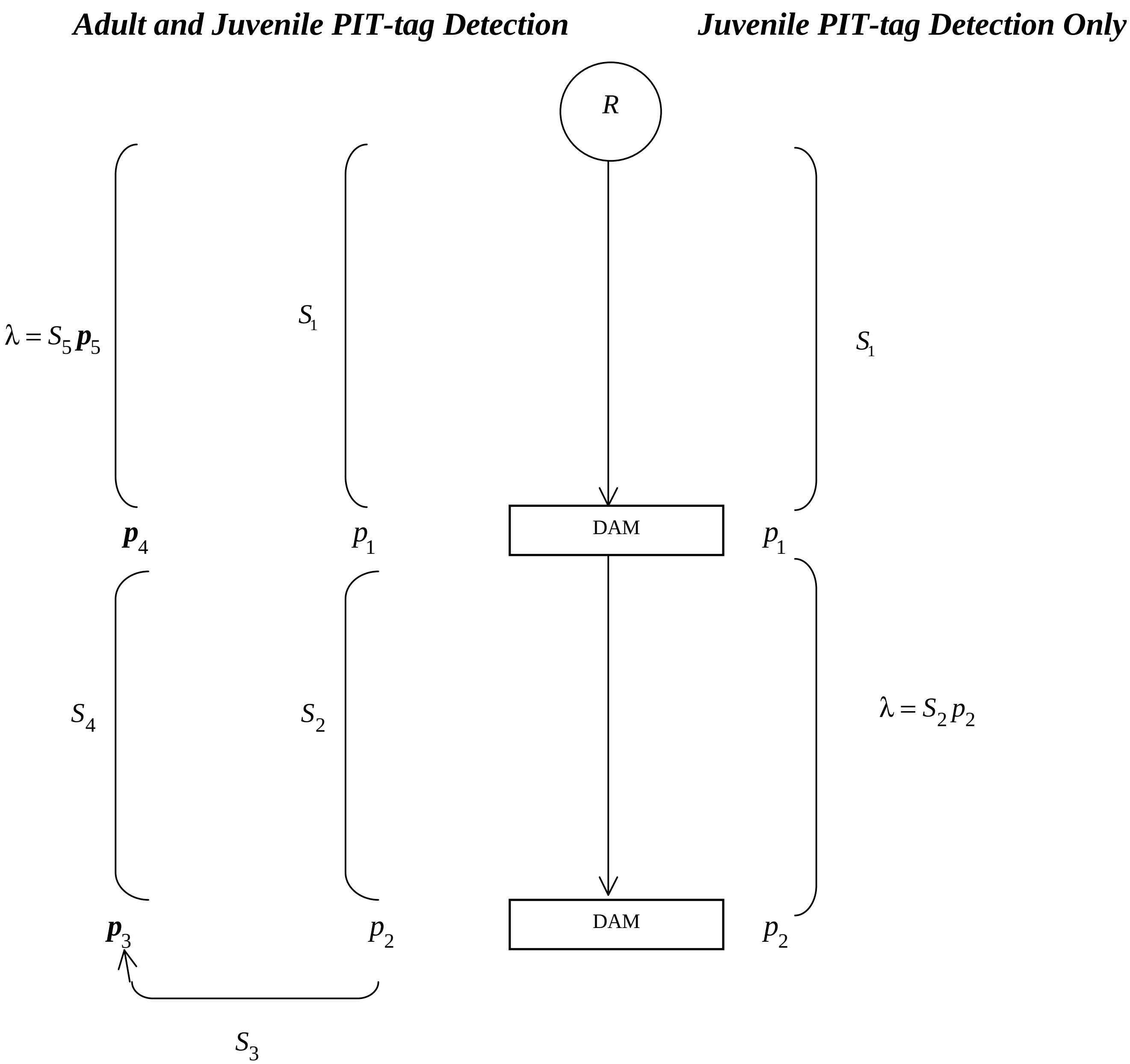


BON = Bonneville Dam	LGS = Little Goose Dam	PROSRD = Prosser Dam	TDA = The Dalles Dam
IHR = Ice Harbor Dam	LMN = Lower Monumental Dam	RIS = Rock Island Dam	TMF = Three Mile Falls Dam
JDA = John Day Dam	McN = McNary Dam	RRE = Rocky Reach Dam	WAN = Wanapum Dam
LGR = Lower Granite Dam	PRD = Priest Rapids Dam	SUL = Sullivan Dam	WEL = Wells Dam

Table 1: PIT-tag detection systems by dam.

Dam Name and Location	Codes	Installation Date	System Type	Detecting:
Bonneville Dam (BON)	B2A	7 May 1998	400-kHz system	Adults
234 River Km	B2J	22 December 1999	134.2-kHz ISO system	Juveniles
		1 April 1996	400-kHz system	
	BVJ	1 May 1992	400-kHz single coil	Juveniles
	BVX	6 May 1996	400-kHz flat plate	Juveniles
John Day Dam (JDA)	JDJ	16 December 1999	134.2-kHz ISO system	Juveniles
247 River Km		1 January 1992	400-kHz system	
McNary Dam (McN)	MCJ	21 January 2000	134.2-kHz ISO system	Juveniles
470 River Km		1 January 1986	400-kHz system	
	MCX	20 February 1998	400-kHz flat plate	
Lower Monumental Dam (LMN)	LMJ	26 January 2000	134.2-kHz ISO system	Juveniles
522.067 River Km		23 April 1993	400-kHz system	
Little Goose Dam (LGS)	GOJ	10 January 2000	134.2-kHz ISO system	Juveniles
522.113 River Km		1 January 1986	400-kHz system	
Lower Granite Dam (LGR)	GRA	1 January 1987	400-kHz system	Adults
522.173 River Km	GRJ	3 January 2000	134.2-kHz ISO system	Juveniles
		25 March 1988	400-kHz system	
	GRX	27 February 1996	400-kHz flat plate	
Wanapum Dam (WAN)	WAJ	28 April 1994	400-kHz system	Juveniles
669 River Km				
Rocky Reach Dam (RRE)	RRJ	25 February 2000	134.2-kHz ISO system	Juveniles
763 River Km		10 April 1996	400-kHz system	
Prosser Dam (PROSRD)	PRJ	10 November 1999	134.2-kHz ISO system	Juveniles
539.076 River Km		25 April 1989	400-kHz system	
Three Mile Falls Dam (TMF)	TMJ	6 March 2000	134.2-kHz ISO system	Juveniles
465.005 River Km		1 January 1999	400-kHz system	
Sullivan Dam (SUL)	SUJ	10 December 1999	134.2-kHz ISO system	Juveniles
163.043 River Km		1 January 1994	400-kHz system	

Figure 2: Minimum design requirements in conducting a PIT-tag release-recapture survival study.



where S = survival probability

p = juvenile detection probability

$\boldsymbol{p}$ = adult detection probability

R = PIT-tagged juvenile release.

downstream detection- sites. With this design, if both detection-sites are provided only with PIT-tag detection facilities for juveniles, survival can only be estimated in the first reach (i.e., S_1). On the other hand, if both detection-sites are capable of detecting juveniles and adults, juvenile survival can be estimated in the first and second reaches (i.e., S_1 and S_2) and adult survival in the second reach (i.e., S_4). An extra survival probability S_3 can also be estimated for the passage from out-migrating smolt to returning adult (i.e., ocean survival). Under both detection configurations, the survival process cannot be separated from the detection probability in the last reach. Only the joint probability of survival and detection can be estimated in the last reach (i.e., $\lambda = S_2 p_2$ and $\lambda = S_5 \boldsymbol{p}_5$), unless PIT-tag detection efficiency at the last detection-site can be ensured to be 100% (see Perez-Comas and Skalski, 2000*a* and 2000*b*). This last-reach limitation has direct implications to the feasibility of conducting adult PIT-tag studies as discussed below.

2.3 Past releases of chinook salmon and steelhead

PIT-tagged chinook and steelhead juveniles have been released into the Columbia and Snake Middle Columbia or their tributaries since 1987 (Fig. 3), although large-size releases did not start until 1993, when the National Marine Fisheries Service (NMFS) started to apply the CJS model to produce reliable reach survival estimates in the Snake River (Iwamoto et al., 1994).

Tables 2-7 compile information gathered by the Columbia Basin PIT Tag Information System (PTAGIS) on the number of PIT-tagged chinook and steelhead juveniles released from 1 January1998 to 1 August 2000. The releases were grouped by species, rearing type, year of release and river reach. Each PIT-tag release group of a given species, rear type and year of release was allocated to the portion of the Columbia or Snake Middle Columbia that receives the waters of the stream or creek where the group was released. Figure 4 summarizes the information from Tables 2-7 in terms of by-reach percentage of all the 1998-2000s releases of PIT-tagged chinook salmon and steelhead. More than half of the 3,522,535 PIT-tagged fish released since 1998 (53.9%) were hatchery and wild chinook salmon and steelhead juveniles released directly into the Snake River above Ice Harbor dam (IHR) or into any of the Snake River tributaries. Most of these Snake River fish, 36.98% of the 3,522,535 PIT-tagged fish released since 1998, were released above Lower Granite Dam (LGR) and consisted of spring/summer and fall chinook salmon, and steelhead (65.8%, 17.3% and 13.7% of the 36.98%, respectively). The remaining releases corresponded to Lower and Middle Columbia chinook and

Figure 3: Annual releases of PIT-tagged chinook and steelhead juveniles into the Columbia-Snake River basin.

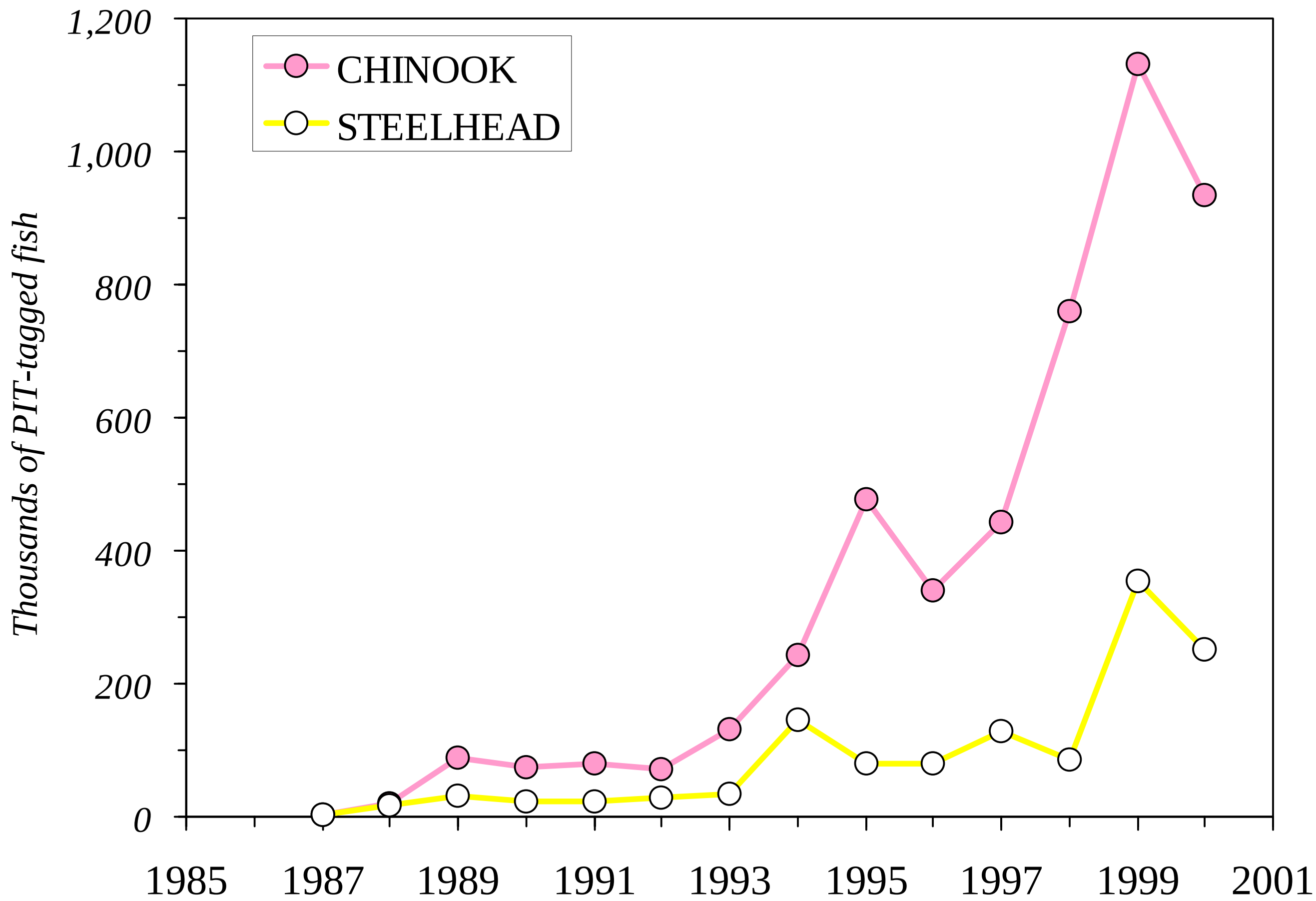


Table 2: Numbers of PIT-tagged hatchery chinook juveniles released at various reaches of the Columbia-Snake Basin in 1998-2000.

Numbers released				**Reach**	**Potential Juvenile or Returning Adult Detection at**
1998	**1999**	**2000**	**Total**		
251	*2,140*	*1,571*	*3,962*	below BON	
7,491	*63,145*	*14,992*	*85,628*	BON-TDA	BON
8,805	*3,012*	*0*	*11,817*	TDA-JDA	TDA, BON
16,870	*13,550*	*17,656*	*48,076*	JDA-MCN	JDA, TDA, BON
0	*10*	*41,227*	*41,237*	MCN-IHR	McN, JDA, TDA, BON
0	*36,537*	*0*	*36,537*	IHR-LMN	IHR, McN, JDA, TDA, BON
6,018	*2,884*	*2,466*	*11,368*	LMN-LGS	LMN, IHR, McN, JDA, TDA, BON
99,451	*107,798*	*139*	*207,388*	LGS-LGR	LGS, LMN, IHR, McN, JDA, TDA, BON
329,879	*342,411*	*250,012*	*922,302*	above LGR	LGR, LGS, LMN, IHR, McN, JDA, TDA, BON
7,560	*95,253*	*65,174*	*167,987*	MCN-PRD	McN, JDA, TDA, BON
0	*0*	*0*	*0*	PRD-WAN	PRD, McN, JDA, TDA, BON
26,261	*3,136*	*25,335*	*54,732*	WAN-RIS	WAN, PRD, McN, JDA, TDA, BON
40,712	*9,788*	*32,573*	*83,073*	RIS-RRE	RIS, WAN, PRD, McN, JDA, TDA, BON
20,846	*5,998*	*5,997*	*32,841*	RRE-WEL	RRE, RIS, WAN, PRD, McN, JDA, TDA, BON
29,701	*7,490*	*8,458*	*45,649*	above WEL	WEL, RRE, RIS, WAN, PRD, McN, JDA, TDA, BON

Table 3: Numbers of PIT-tagged wild chinook juveniles released at various reaches of the Columbia-Snake Basin in 1998-2000.

Numbers released				Reach	Potential Juvenile or Returning Adult Detection at
1998	**1999**	**2000**	**Total**		
0	*3,002*	*0*	*3,002*	below BON	
0	*66,742*	*0*	*66,742*	BON-TDA	BON
0	*318*	*0*	*318*	TDA-JDA	TDA, BON
0	*1,066*	*2,197*	*3,263*	JDA-MCN	JDA, TDA, BON
0	*0*	*0*	*0*	MCN-IHR	McN, JDA, TDA, BON
0	*0*	*0*	*0*	IHR-LMN	IHR, McN, JDA, TDA, BON
499	*374*	*555*	*1,428*	LMN-LGS	LMN, IHR, McN, JDA, TDA, BON
16,857	*20,928*	*58,776*	*96,561*	LGS-LGR	LGS, LMN, IHR, McN, JDA, TDA, BON
38,885	*87,570*	*74,170*	*200,625*	above LGR	LGR, LGS, LMN, IHR, McN, JDA, TDA, BON
8,878	*13,589*	*9,950*	*32,417*	MCN-PRD	McN, JDA, TDA, BON
0	*0*	*0*	*0*	PRD-WAN	PRD, McN, JDA, TDA, BON
27	*0*	*10,967*	*10,994*	WAN-RIS	WAN, PRD, McN, JDA, TDA, BON
3	*0*	*64*	*67*	RIS-RRE	RIS, WAN, PRD, McN, JDA, TDA, BON
0	*0*	*0*	*0*	RRE-WEL	RRE, RIS, WAN, PRD, McN, JDA, TDA, BON
1	*0*	*0*	*1*	above WEL	WEL, RRE, RIS, WAN, PRD, McN, JDA, TDA, BON

Table 4: Numbers of PIT-tagged wild and hatchery chinook juveniles released at various reaches of the Columbia-Snake Basin in 1998-2000. Numbers include releases of PIT-tagged chinook juveniles with unrecorded rearing type.

Numbers released				Reach	Potential Juvenile or Returning Adult Detection at
1998	**1999**	**2000**	**Total**		
4,069	*5,859*	*6,807*	*16,735*	below BON	
84,168	*297,294*	*266,681*	*648,143*	BON-TDA	BON
8,805	*3,330*	*0*	*12,135*	TDA-JDA	TDA, BON
34,815	*83,311*	*69,662*	*187,788*	JDA-MCN	JDA, TDA, BON
0	*30*	*41,227*	*41,257*	MCN-IHR	McN, JDA, TDA, BON
0	*36,537*	*0*	*36,537*	IHR-LMN	IHR, McN, JDA, TDA, BON
6,517	*3,258*	*3,021*	*12,796*	LMN-LGS	LMN, IHR, McN, JDA, TDA, BON
116,308	*128,727*	*58,915*	*303,950*	LGS-LGR	LGS, LMN, IHR, McN, JDA, TDA, BON
368,804	*430,428*	*324,587*	*1,123,819*	above LGR	LGR, LGS, LMN, IHR, McN, JDA, TDA, BON
16,486	*108,842*	*75,124*	*200,452*	MCN-PRD	McN, JDA, TDA, BON
0	*0*	*0*	*0*	PRD-WAN	PRD, McN, JDA, TDA, BON
31,149	*8,858*	*40,811*	*80,818*	WAN-RIS	WAN, PRD, McN, JDA, TDA, BON
42,549	*10,710*	*34,123*	*87,382*	RIS-RRE	RIS, WAN, PRD, McN, JDA, TDA, BON
20,846	*5,998*	*5,997*	*32,841*	RRE-WEL	RRE, RIS, WAN, PRD, McN, JDA, TDA, BON
29,702	*7,490*	*8,458*	*45,650*	above WEL	WEL, RRE, RIS, WAN, PRD, McN, JDA, TDA, BON

Table 5: Numbers of PIT-tagged hatchery steelhead juveniles released at various reaches of the Columbia-Snake Basin in 1998-2000.

Numbers released				Reach	Potential Juvenile or Returning Adult Detection at
1998	**1999**	**2000**	**Total**		
120	*1,525*	*1,797*	*3,442*	below BON	
0	*0*	*0*	*0*	BON-TDA	BON
0	*0*	*788*	*788*	TDA-JDA	TDA, BON
3,178	*4,251*	*7,608*	*15,037*	JDA-MCN	JDA, TDA, BON
0	*61*	*0*	*61*	MCN-IHR	McN, JDA, TDA, BON
0	*1*	*401*	*402*	IHR-LMN	IHR, McN, JDA, TDA, BON
1,066	*1,151*	*1,592*	*3,809*	LMN-LGS	LMN, IHR, McN, JDA, TDA, BON
23,326	*100,750*	*21,040*	*145,116*	LGS-LGR	LGS, LMN, IHR, McN, JDA, TDA, BON
32,699	*39,340*	*38,489*	*110,528*	above LGR	LGR, LGS, LMN, IHR, McN, JDA, TDA, BON
347	*353*	*349*	*1,049*	MCN-PRD	McN, JDA, TDA, BON
0	*0*	*0*	*0*	PRD-WAN	PRD, McN, JDA, TDA, BON
2,795	*47,778*	*2,676*	*53,249*	WAN-RIS	WAN, PRD, McN, JDA, TDA, BON
1,448	*46,041*	*1,192*	*48,681*	RIS-RRE	RIS, WAN, PRD, McN, JDA, TDA, BON
0	*30,599*	*35,495*	*66,094*	RRE-WEL	RRE, RIS, WAN, PRD, McN, JDA, TDA, BON
0	*40,105*	*29,795*	*69,900*	above WEL	WEL, RRE, RIS, WAN, PRD, McN, JDA, TDA, BON

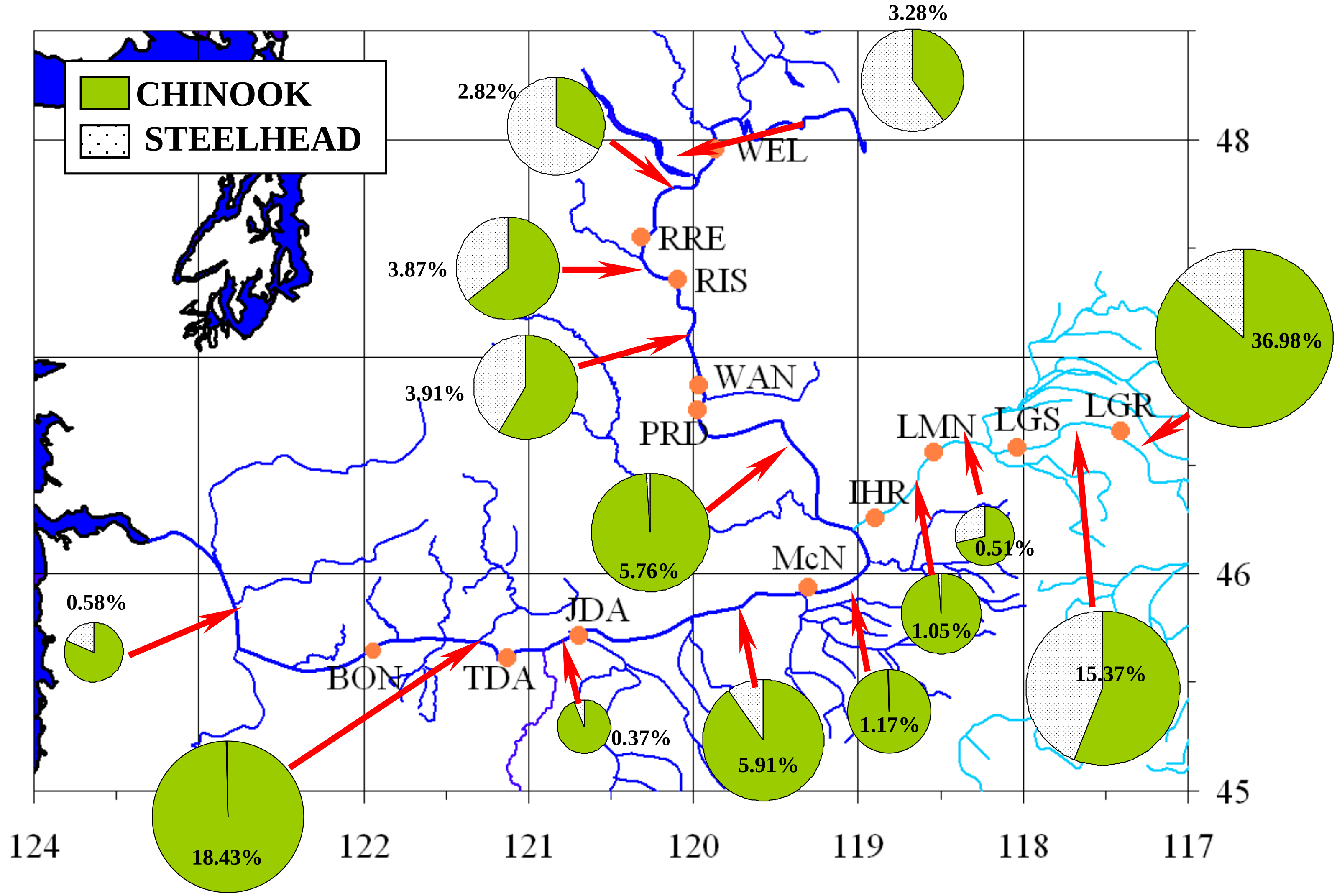
Table 6: Numbers of PIT-tagged wild steelhead juveniles released at various reaches of the Columbia-Snake Basin in 1998-2000.

Numbers released				Reach	Potential Juvenile or Returning Adult Detection at
1998	**1999**	**2000**	**Total**		
0	*0*	*0*	*0*	below BON	
0	*285*	*776*	*1,061*	BON-TDA	BON
0	*0*	*0*	*0*	TDA-JDA	TDA, BON
0	*3,855*	*1,556*	*5,411*	JDA-MCN	JDA, TDA, BON
0	*0*	*0*	*0*	MCN-IHR	McN, JDA, TDA, BON
0	*0*	*0*	*0*	IHR-LMN	IHR, McN, JDA, TDA, BON
481	*364*	*553*	*1,398*	LMN-LGS	LMN, IHR, McN, JDA, TDA, BON
6,850	*14,375*	*71,020*	*92,245*	LGS-LGR	LGS, LMN, IHR, McN, JDA, TDA, BON
11,755	*20,785*	*35,551*	*68,091*	above LGR	LGR, LGS, LMN, IHR, McN, JDA, TDA, BON
0	*1,371*	*0*	*1,371*	MCN-PRD	McN, JDA, TDA, BON
0	*0*	*0*	*0*	PRD-WAN	PRD, McN, JDA, TDA, BON
1,201	*1,199*	*1,154*	*3,554*	WAN-RIS	WAN, PRD, McN, JDA, TDA, BON
100	*48*	*3*	*151*	RIS-RRE	RIS, WAN, PRD, McN, JDA, TDA, BON
0	*0*	*0*	*0*	RRE-WEL	RRE, RIS, WAN, PRD, McN, JDA, TDA, BON
0	*0*	*0*	*0*	above WEL	WEL, RRE, RIS, WAN, PRD, McN, JDA, TDA, BON

Table 7: Numbers of PIT-tagged wild and hatchery steelhead juveniles released at various reaches of the Columbia-Snake Basin in 1998-2000. Numbers include releases of PIT-tagged steelhead juveniles with unrecorded rearing type.

Numbers released				Reach	Potential Juvenile or Returning Adult Detection at
1998	**1999**	**2000**	**Total**		
120	*1,892*	*1,833*	*3,845*	below BON	
0	*285*	*776*	*1,061*	BON-TDA	BON
0	*0*	*788*	*788*	TDA-JDA	TDA, BON
3,178	*8,108*	*9,164*	*20,450*	JDA-MCN	JDA, TDA, BON
0	*62*	*0*	*62*	MCN-IHR	McN, JDA, TDA, BON
0	*1*	*401*	*402*	IHR-LMN	IHR, McN, JDA, TDA, BON
1,547	*1,515*	*2,145*	*5,207*	LMN-LGS	LMN, IHR, McN, JDA, TDA, BON
30,176	*115,135*	*92,060*	*237,371*	LGS-LGR	LGS, LMN, IHR, McN, JDA, TDA, BON
44,528	*60,126*	*74,040*	*178,694*	above LGR	LGR, LGS, LMN, IHR, McN, JDA, TDA, BON
347	*1,724*	*349*	*2,420*	MCN-PRD	McN, JDA, TDA, BON
0	*0*	*0*	*0*	PRD-WAN	PRD, McN, JDA, TDA, BON
3,996	*48,977*	*3,831*	*56,804*	WAN-RIS	WAN, PRD, McN, JDA, TDA, BON
1,548	*46,089*	*1,195*	*48,832*	RIS-RRE	RIS, WAN, PRD, McN, JDA, TDA, BON
0	*30,901*	*35,495*	*66,396*	RRE-WEL	RRE, RIS, WAN, PRD, McN, JDA, TDA, BON
0	*40,105*	*29,795*	*69,900*	above WEL	WEL, RRE, RIS, WAN, PRD, McN, JDA, TDA, BON

Figure 4: By-reach percent distribution of 1998-2000 releases of PIT-tagged chinook salmon and steelhead. Reported percentages indicate percent of all releases into the CRB system. Pie charts indicate the proportions of chinook salmon and steelhead released at the specific site.



steelhead (932,264 fish or 26.5% of all PIT-tagged releases since 1998), and Upper Columbia chinook and steelhead (691,495 fish or 19.6% of all PIT-tagged releases). The Lower and Middle Columbia releases consisted mostly of fall (60.3%) and spring chinook (29.9%), while the 691,495 tagged fish released in the Upper Columbia and tributaries above McNary Dam (McN) were identified as 41.1% spring/summer chinook, 18.3% fall chinook and 35.3% steelhead.

Whether Tables 2-7 and Figure 4 describe the geographical distribution of most recent PIT-tag releases, they do not confer an idea of the potentiality of each geographical area for future PIT-tag releases. Figure 5, that summarizes all hatchery releases by river reach during 1998 and 1999, was designed with the purpose of inferring the regional potentiality for future PIT-tag releases. Figure 5 condenses the information gathered by the Regional Mark Information System (RMIS) on all tagged and untagged chinook and steelhead juveniles released in the CRB. The main difference between the patterns displayed in Figures 4 and 5 is the importance of releases below Bonneville Dam (BON); 70,099,629 hatchery chinook and steelhead juveniles (44.6% of 157,248,889 fish released in 1998-99) were released directly in this Lower Columbia reach or its many tributaries. For example, 10,114,279 hatchery juveniles (95.4% spring chinook and 4.1% steelhead) were released from different sites on the Willamette River and its tributaries. On the other hand, with 40,590,364 fish (46.6% of 157,248,889 released fish), the importance of Snake River chinook and steelhead releases still remains. Like PIT-tag releases, most of these Snake River hatchery fish were released above LGR (24.67%, Fig. 5). The releases of Upper Columbia hatchery fish (12.3% of all chinook and steelhead released in 1998-99) consisted of 53.7% spring/summer chinook, 35.1% fall chinook and 11.1% steelhead.

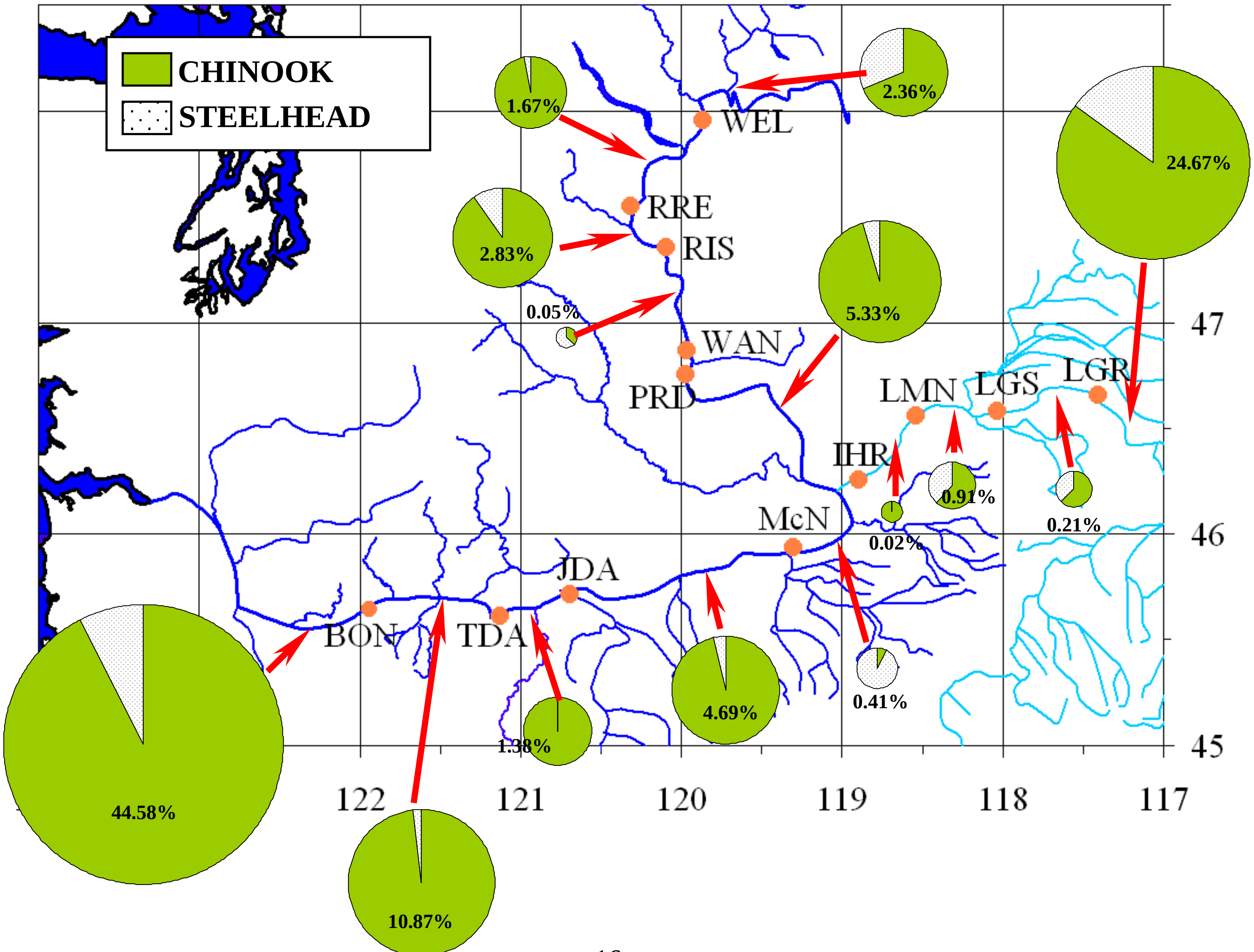
3. ALTERNATIVE ADULT DETECTION SCENARIOS

In following paragraphs, we describe what can and cannot be estimated under seven, increasingly more complex scenarios of adult PIT-tag detection capabilities in the CRB. In each case, we will refer to releases of PIT-tagged juvenile salmonids from the three locations previously identified as important (Fig. 4 and 5). These are:

1) Releases of Snake River chinook and steelhead above LGR.
2) Releases of chinook and steelhead in the JDA-McN reach of the Columbia River.
3) Releases of chinook and steelhead in the Columbia River above Rocky Reach Dam (RRE).

The releases above LGR are expected to include most of the stocks included in the spring/summer and the fall Snake River chinook salmon ESUs, as well as stocks from the Snake River steelhead ESU.

Figure 5: By-reach percent distribution of all 1998-99 hatchery releases of chinook salmon and steelhead. Reported percentages indicate percent of all releases into the CRB system. Pie charts indicate the proportions of chinook salmon and steelhead released at the specific site.



Releases to the JDA-McN reach are likely to include part of the stocks from the Middle Columbia River steelhead ESU. Finally, the releases above Rocky Reach Dam may consist of stocks from the Upper Columbia River spring chinook and steelhead ESUs. In spite of their importance (e.g., Fig. 5, 44.6% of all hatchery releases), releases to the Lower Columbia River will not be dealt with here because no adult PIT-tag detection facility is scheduled below BON. Only Upper Willamette chinook and steelhead releases (6.43% of all hatchery releases in 1998-99) will be discussed under scenario # 7.

3.1 Scenario # 1

The simplest of scenarios would be to have a single detection facility at Lower Granite Dam (LGR) for adult returns (Fig. 6). With this design configuration, six juvenile survival probabilities for Snake River juvenile salmonids that are released above LGR can be estimated: S_{R-LGR}, $S_{LGR-LGS}$, $S_{LGS-LMN}$, $S_{LMN-McN}$, $S_{McN-JDA}$ and $S_{JDA-BON}$. Survival probabilities for the returning adults of the release cannot be estimated. Instead, only the joint probability of surviving from Bonneville-to-Lower Granite and the probability of being detected as an adult at LGR (i.e., $\lambda = S_{BON-LGR} \cdot \boldsymbol{p}_{GRA}$) can be estimated. This joint probability parameter (λ) would have little interpretive value unless the detection probability at LGR was 100% for adult returns (i.e., $\boldsymbol{p}_{GRA}$ = 1). A perfect adult detection facility at LGR would be needed for adult returns in order to estimate a mixture of ocean survival and in-river adult survival (i.e., $S_{BON-LGR}$) for any Snake River juvenile release.

For Upper Columbia River chinook and steelhead juveniles, released above Rapid Reach Dam (RRE), only three juvenile survival probabilities can be estimated: S_{R-RRE}, $S_{RRE-McN}$ and $S_{McN-JDA}$. For these releases, a joint probability of surviving from John Day-to-Bonneville and the probability of being detected as an out-migrating juvenile at BON (i.e., $\lambda = S_{JDA-BON} \cdot p_{BON}$) can also be estimated. Unfortunately, this parameter has little interpretative value.

Under this scenario, PIT-tagged chinook and steelhead juveniles released in the JDA-McN reach will fare the worst. For them, only one juvenile survival probability S_{R-JDA}, in addition to the terminal joint probability λ ($\lambda = S_{JDA-BON} \cdot p_{BON}$), will be estimable.

3.2 Scenario # 2

In this scenario, adult PIT-tag facilities would exist at both Bonneville and Lower Granite dams (Fig. 7). With seven estimable survival probabilities, releases of Snake River juvenile salmonids

Figure 6: Columbia-Snake River basin showing dams with 134.2-kHz ISO-based PIT-tag interrogation systems for the detection of juvenile and adult salmonids under scenario 1. The circles and squares indicate type of detection capability of a dam.

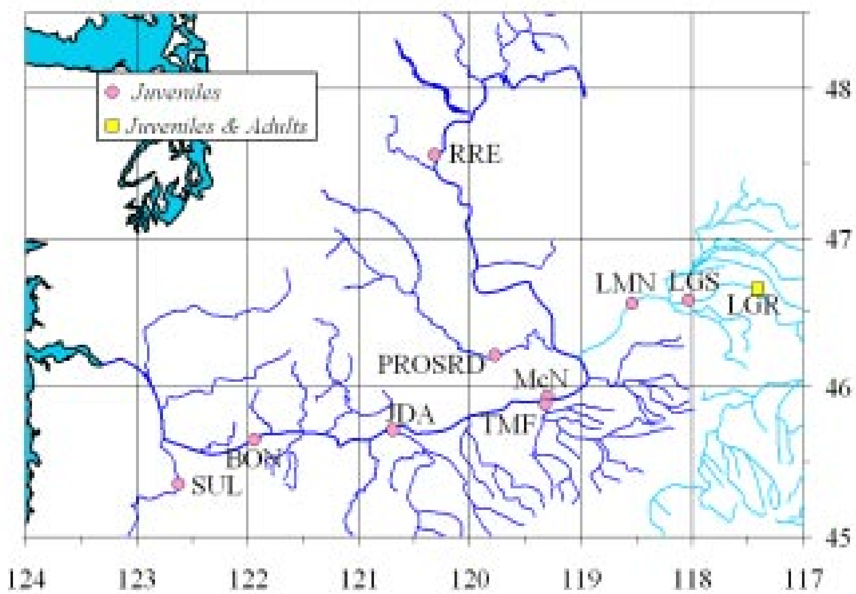
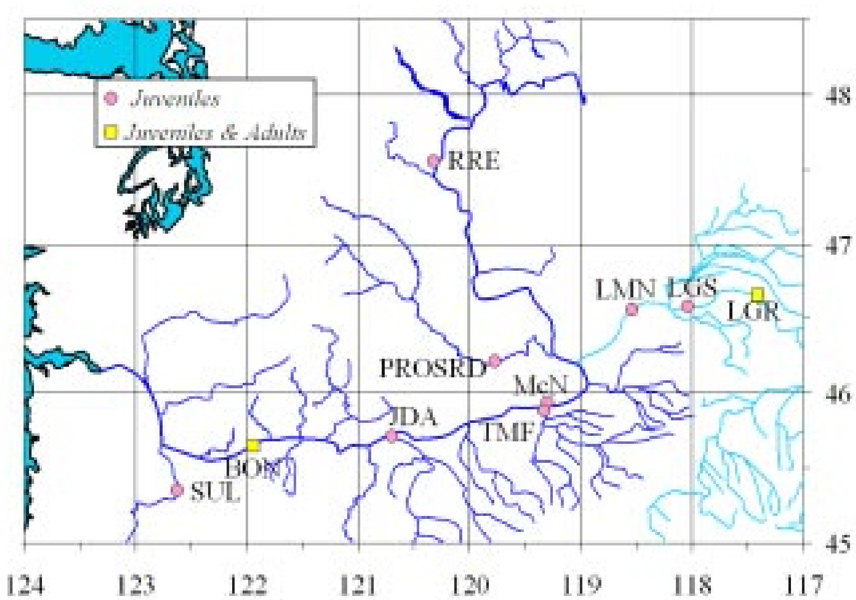


Figure 7: Columbia-Snake River basin showing dams with 134.2-kHz ISO-based PIT-tag interrogation systems for the detection of juvenile and adult salmonids under scenario 2. The circles and squares indicate type of detection capability of a dam.



above LGR fare better than any other potential release. Now, not only the six juvenile survivals for the river reaches between the release point and Bonneville Dam are estimable, but also the Bonneville-to-Bonneville survival ($S_{BON-BON}$) can be estimated. The precision of this "ocean survival" will, however, depend on the adult detection rates at Bonneville and Lower Granite dams (i.e., $\boldsymbol{p}_{BON}$, $\boldsymbol{p}_{GRA}$). Perez-Comas and Skalski (2000*a*) discuss the anticipated precision of ocean survival estimates as a function of detection capabilities. Under this scenario, in-river survival of adults $S_{BON-LGR}$ cannot be estimated directly (i.e., only $\lambda = S_{BON-LGR} \cdot \boldsymbol{p}_{GRA}$ can be estimated), unless the adult PIT-tag facility at Lower Granite has a perfect detection rate such that $\boldsymbol{p}_{GRA}$ = 1, leading to $\lambda = S_{BON-LGR} \cdot \boldsymbol{p}_{GRA} = S_{BON-LGR}$. Perez-Comas and Skalski (2000*b*) consider the expected precision of estimates of the in-river survival of returning adult PIT-tagged chinook salmon between BON and LGR dams as a function of various levels of adult detection efficiency at Bonneville Dam.

Under this scenario, Upper Columbia River juvenile salmonids released above Rocky Reach Dam also do better than under scenario #1. Four juvenile survivals will be estimated: S_{R-RRE}, $S_{RRE-McN}$, $S_{McN-JDA}$ and $S_{JDA-BON}$. However, the "ocean survival" $S_{BON-BON}$ cannot be estimated (i.e., $\lambda = S_{BON-BON} \cdot \boldsymbol{p}_{BON}$) unless the adult PIT-tag facility at Bonneville Dam has a perfect detection rate such that $\boldsymbol{p}_{BON}$ = 1, leading to $\hat{\lambda} = \hat{S}_{BON-BON}$. Under no circumstances, in-river survivals of returning adults will be estimable for these Upper Columbia River juvenile releases.

PIT-tagged chinook and steelhead juveniles released in the JDA-McN reach will face a similar situation, no independent "ocean survival" estimate (i.e., $\lambda = S_{BON-BON} \cdot \boldsymbol{p}_{BON}$) and no in-river survival estimate for returning adults. The only disadvantage is that two juvenile survival estimates will be possible: $\hat{S}_{R-JDA}$ and $\hat{S}_{JDA-BON}$.

3.3 Scenario # 3

In this scenario, an additional adult detection facility is added at Priest Rapids Dam (PRD) along with capabilities at Bonneville and Lower Granite dams (Fig. 8). Under this scenario, the situation for releases of Snake River juvenile salmonids above LGR and PIT-tagged chinook and steelhead juveniles released in the JDA-McN reach is not altered from scenario # 2. Only the Upper Columbia River juvenile salmonids released above RRE fare better than under the previous scenario.

Figure 8: Columbia-Snake River basin showing dams with 134.2-kHz ISO-based PIT-tag interrogation systems for the detection of juvenile and adult salmonids under scenario 3. The circles and squares indicate type of detection capability of a dam.

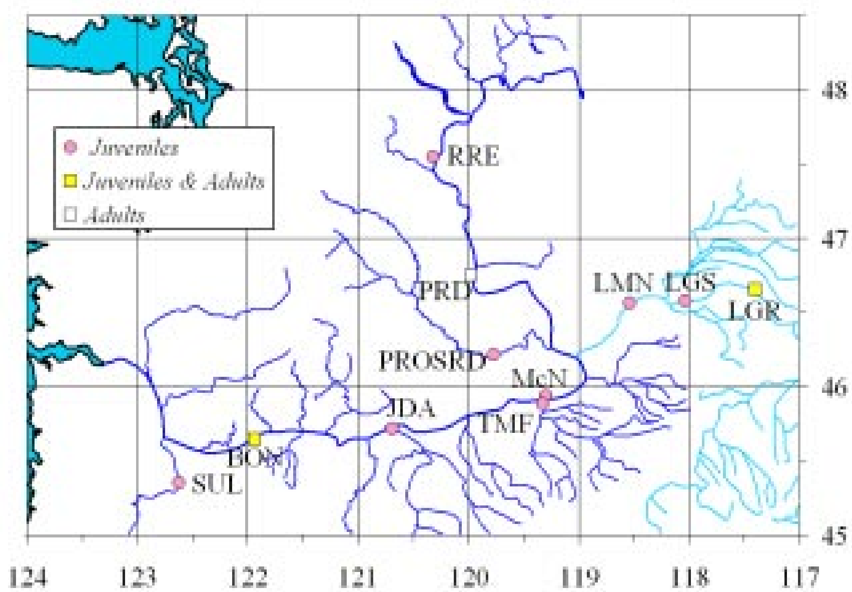
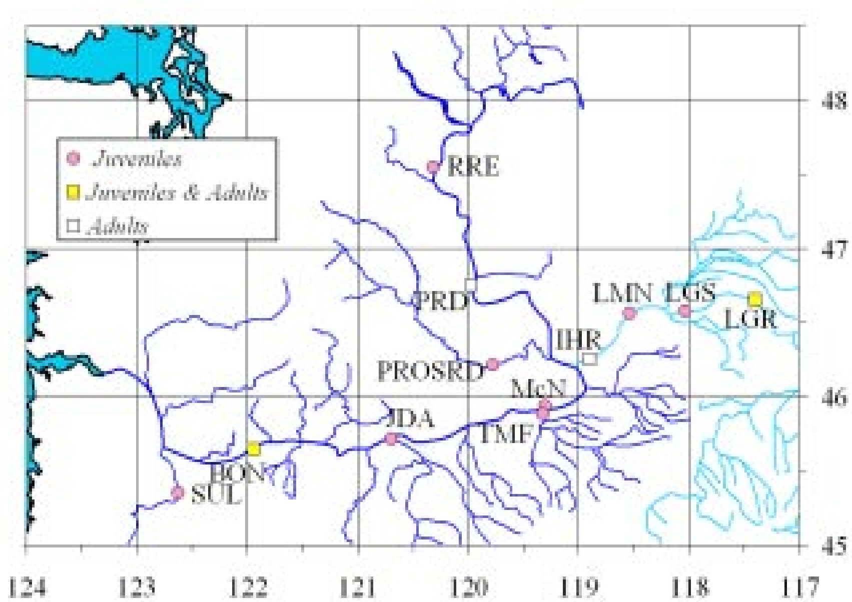


Figure 9: Columbia-Snake River basin showing dams with 134.2-kHz ISO-based PIT-tag interrogation systems for the detection of juvenile and adult salmonids under scenario 4. The circles and squares indicate type of detection capability of a dam.



For these releases four juvenile survivals will be estimable: S_{R-RRE}, $S_{RRE-McN}$, $S_{McN-JDA}$ and $S_{JDA-BON}$. In addition, the "ocean survival" $S_{BON-BON}$ will also be estimable, with its precision depending upon the adult detection rates at Bonneville and Priest Rapids dams (i.e., $\boldsymbol{p}_{BON}$, $\boldsymbol{p}_{GRA}$). In-river survival of returning adults $S_{BON-PRD}$ cannot be estimated (i.e., only $\lambda = S_{BON-PRD} \cdot \boldsymbol{p}_{PRD}$ can be estimated) unless the adult PIT-tag facility at Priest Rapids has a perfect detection rate such that $\boldsymbol{p}_{PRD}$ = 1, leading to $\hat{\lambda} = \hat{S}_{BON-PRD}$.

3.4 Scenario # 4

In this configuration there are four adult detection facilities located at BON, LGR, PRD and Ice Harbor (IHR) dams (Fig. 9). Under this scenario, the situation for the Upper and Middle Columbia River chinook and steelhead juvenile releases do not change, only the Snake River juvenile releases are benefited by enabling the estimation of in-river adult survivals in the BON-IHR reach. Thus, a Snake River juvenile salmonid release will have six juvenile survival estimates (e.g., $\hat{S}_{R-LGR}$, $\hat{S}_{LGR-LGS}$, $\hat{S}_{LGS-LMN}$, $\hat{S}_{LMN-McN}$, $\hat{S}_{McN-JDA}$ and $\hat{S}_{JDA-BON}$), one "ocean survival" estimate ($\hat{S}_{BON-BON}$), one in-river adult survival estimate ($\hat{S}_{BON-IHR}$) and a terminal joint probability estimate $\hat{\lambda}$. In this case, $\lambda = S_{IHR-LGR} \cdot \boldsymbol{p}_{GRA}$. As with previous examples, the in-river adult survival estimate for the Snake River reach IHR-LGR will be estimable only if Lower Granite has a perfect adult detection rate such that $\boldsymbol{p}_{GRA}$ = 1.

3.5 Scenario # 5

In scenario #5, an additional adult detection facility is added at John Day Dam (JDA). Thus, there are a total of five adult detection facilities (Fig. 10), two at Columbia River dams below the confluence with the Snake River (BON and JDA), one on a Columbia River dam above the confluence with the Snake River (PRD), and two at Snake River dams (IHR and LGR). Under this scenario, both the Snake River and Upper Columbia River salmonid releases will incorporate an extra survival estimate for returning adults migrating upstream in the BON-JDA reach, and an independent "ocean survival" estimate will be possible for Middle Columbia River juvenile salmonids released into the JDA-McN reach. Summarizing, Snake River juvenile salmonid released above LGR will have six juvenile survival estimates (e.g., $\hat{S}_{R-LGR}$, $\hat{S}_{LGR-LGS}$, $\hat{S}_{LGS-LMN}$, $\hat{S}_{LMN-McN}$, $\hat{S}_{McN-JDA}$ and

Figure 10: Columbia-Snake River basin showing dams with 134.2-kHz ISO-based PIT-tag interrogation systems for the detection of juvenile and adult salmonids under scenario 5. The circles and squares indicate type of detection capability of a dam.

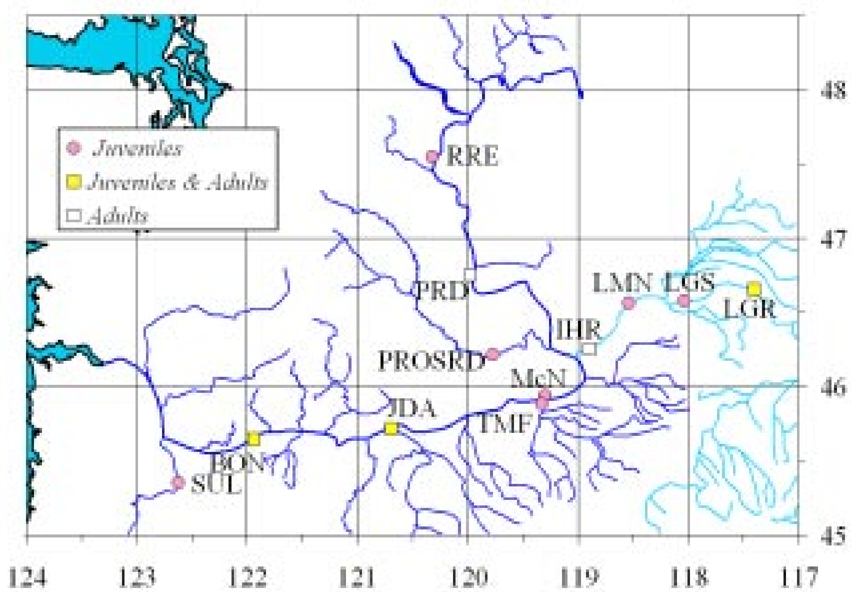
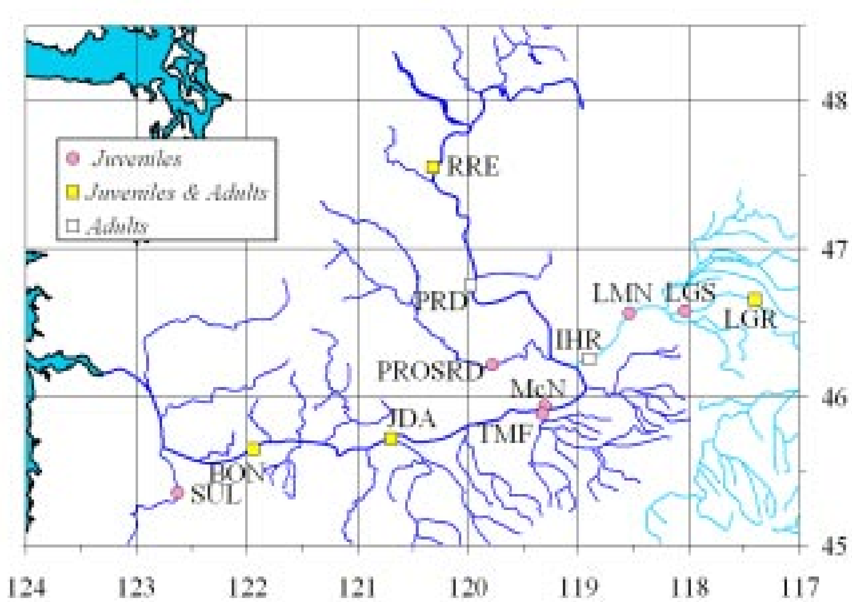


Figure 11: Columbia-Snake River basin showing dams with 134.2-kHz ISO-based PIT-tag interrogation systems for the detection of juvenile and adult salmonids under scenario 6. The circles and squares indicate type of detection capability of a dam.



$\hat{S}_{JDA-BON}$), one "ocean survival" estimate ($\hat{S}_{BON-BON}$), two in-river adult survival estimate ($\hat{S}_{BON-JDA}$ and $\hat{S}_{JDA-IHR}$) and a terminal joint probability estimate $\hat{\lambda}$, where $\lambda = S_{IHR-LGR} \cdot \boldsymbol{p}_{GRA}$. Upper Columbia River chinook and steelhead juveniles released above RRE will have four juvenile survival estimates (e.g., $\hat{S}_{R-RRE}$, $\hat{S}_{RRE-McN}$, $\hat{S}_{McN-JDA}$ and $\hat{S}_{JDA-BON}$), the "ocean survival" estimate, only one in-river adult survival estimate ($\hat{S}_{BON-JDA}$) and the estimate of the terminal joint probability $\lambda = S_{JDA-PRD} \cdot \boldsymbol{p}_{PRD}$. Finally, Middle Columbia River juvenile salmonids released into the JDA-McN reach will have only two juvenile survival estimates (e.g., $\hat{S}_{R-JDA}$ and $\hat{S}_{JDA-BON}$), the "ocean survival" estimate $\hat{S}_{BON-BON}$, and the estimate of the terminal joint probability $\lambda = S_{BON-JDA} \cdot \boldsymbol{p}_{JDA}$.

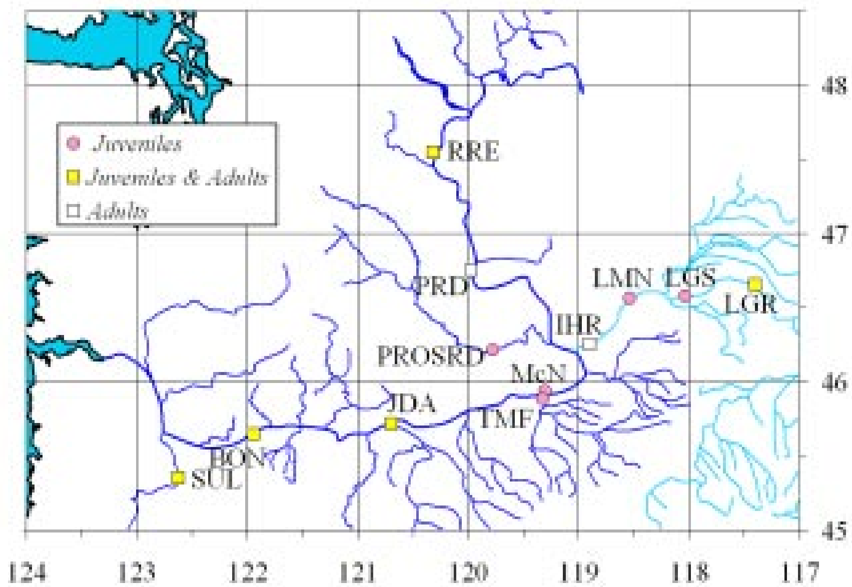
3.6 Scenario # 6

Scenario #6 adds an extra adult detection facility at Rocky Reach Dam (RRE) to the previous five adult detection facilities (Fig. 11). This new addition will change the situation of estimable survival probabilities only for releases of chinook and steelhead juveniles above Rocky Reach Dam. Now there will be two independent in-river survival estimates for the returning adults: $\hat{S}_{BON-JDA}$ and $\hat{S}_{JDA-PRD}$.

3.7 Scenario # 7

Scenario #7 adds an extra adult detection facility at Sullivan Dam (SUL) to the previous six adult detection facilities (Fig. 12). This new addition will not alter the number of estimable survival probabilities for any of the three groups of PIT-tagged fish that has being discussed so far. That is, under this scenario the number of estimable survival probabilities for releases of Snake River chinook and steelhead above LGR, as well as those of chinook and steelhead in the JDA-McN reach and above Rocky Reach Dam will remain the same as under scenario # 6. However, releases of Upper Willamette chinook and steelhead (e.g., 6.43% of all hatchery releases in 1998-99) will now be amenable to survival studies based on PIT-tags. Under scenario # 7, any release of PIT-tagged chinook or steelhead juveniles in the Willamette River and its tributaries upstream from Willamette Falls (i.e., above Sullivan Dam) would produce one juvenile survival estimate $\hat{S}_{R-SUL}$ and the estimate of the terminal joint probability $\lambda = S_{SUL-SUL} \cdot \boldsymbol{p}_{SUL}$. As with cases discussed under previous scenarios, the only way

Figure 12: Columbia-Snake River basin showing dams with 134.2-kHz ISO-based PIT-tag interrogation systems for the detection of juvenile and adult salmonids under scenario 7. The circles and squares indicate type of detection capability of a dam.



to obtain an estimate of “ocean survival” (i.e., $\hat{S}_{SUL-SUL}$) for Upper Willamette releases would be to guarantee that the adult detection facility at Sullivan Dam has a perfect adult detection rate such that $\boldsymbol{p}_{SUL}$ = 1. Only in this case an estimate of “ocean survival” would be possible because $\hat{\lambda} = \hat{S}_{SUL-SUL}$.

4. CONCLUDING REMARKS

Given the need for further PIT-tag survival studies for salmonids migrating through the CRB (Biological Opinion, July 27, 2000), and BPA's and COE's commitment to install adult PIT-tag detectors at CRB projects, minimal adult PIT-tag detection configurations could be determined for each of the ten CRB threatened chinook and steelhead ESUs. These minimal configurations should provide estimates of survival for out-migrating juveniles, ocean survival and at least one in-river survival for returning adults of ESUs releases with known origin. In general, these minimal configurations will require the installation of adult PIT-tag detection facilities at Bonneville Dam and two other dams above Bonneville Dam. However, only two dams with adult PIT-tag detection capabilities will be required if a 100% detection efficiency can be guarantee for the most upstream dam of the pair (Perez-Comas and Skalski, 2000*b*). The minimal adult PIT-tag detection configurations for the ten threatened CRB chinook and steelhead ESUs are listed below.

1) Snake River spring/summer and fall chinook salmon, and Snake River steelhead

A minimum of three dams with adult PIT-tag detection capabilities are required to guarantee estimates of "ocean survival" and at least of one independent, in-river returning adult survival for Snake River spring/summer and fall chinook salmon, and Snake River steelhead. For example, for releases above LGR, the installation of adult PIT-tag detection facilities at BON and LGR dams and at any other intermediary dam such as IHR (scenario # 4, Fig. 9) will provide an in-river survival estimate for returning adults (i.e., $\hat{S}_{BON-IHR}$).

2) Upper Columbia River spring chinook salmon and steelhead

Upper Columbia River spring chinook salmon and Upper Columbia River steelhead will also require a minimum of three dams with adult PIT-tag detection capabilities: Bonneville Dam and two other dams on the BON-WEL reach. Scenario #5 (Fig. 10) with adult PIT-tag detection facilities at BON, JDA and PRD will provide an in-river adult survival estimate (i.e., $\hat{S}_{BON-JDA}$) only for releases from Columbia River tributaries above RRE (e.g., Okanagan River, Methow

River, Entiat River, etc). Releases of spring chinook salmon or steelhead from tributaries below RRE (e.g., Yakima River,) will require the installation of an adult PIT-tag detection facility at McNary Dam instead of at Priest Rapids Dam.

3) ***Lower Columbia River chinook salmon and steelhead***

The current CRB dam system configuration (Fig. 1) and BPA's and COE's commitment to install adult PIT-tag detectors only in major CRB projects will not allow the estimation of an "ocean survival" and of any in-river adult survival. Since Lower Columbia River chinook salmon and Lower Columbia River steelhead ESUs are distributed in Columbia River tributaries between the Cowlitz and Wind Rivers in Washington and between the Willamette and Hood Rivers in Oregon, the only possible location for an adult PIT-tag facility is Bonneville Dam. Such facility will not permit the estimation of any in-river adult survival. Moreover, the estimation of an "ocean survival" ($S_{BON-BON}$) will be possible only if a 100% detection efficiency (i.e., $\boldsymbol{p}_{BON} = 1$) can be guarantee at the Bonneville facility.

4) ***Middle Columbia River steelhead***

Middle Columbia River steelhead ESU, distributed in all Columbia River tributaries between the confluence of the Klickitat and Columbia Rivers and that of the Yakima and Columbia Rivers, will require a minimum of two dams with adult PIT-tag detection capabilities: Bonneville Dam and another upstream dam on the BON-McN reach. Configurations such as those in scenarios #5 and 6 (Fig. 10 and 11), with adult PIT-tag detection facilities at BON and JDA, will permit one adult survival estimate ($\hat{S}_{BON-JDA}$) for all releases of juvenile steelhead from John Day, Umatilla, Yakima and Walla Walla Rivers and from Willow Creek. For releases from the Klickitat and Deschutes Rivers, however, no adult survival estimate will be possible. Releases from these two rivers will produce only one juvenile survival estimate and an "ocean survival" estimate whenever 100 % detection efficiency at the Bonneville facility can be guarantee.

5) ***Upper Willamette River chinook salmon and steelhead***

In spite of their importance in terms of releases (e.g., 6.43% of all hatchery releases in 1998-99, Fig. 5), PIT-tag survival studies for the Upper Willamette chinook and Upper Willamette steelhead ESUs cannot be perform with the current CRB dam system configuration (Fig. 1) and PIT-tag detection capabilities (Table 1). Only the installation of a 100% efficient 134.2-kHz ISO-based adult PIT-tag detection system at the fish ladder of Sullivan Dam might allow the estimation of juvenile survival from the release site to Sullivan Dam and of the ocean survival for Upper

Willamette chinook and steelhead releases. In order to obtain reliable survival estimates, not only should the adult detection facility be fully efficient, but also the configuration of the juvenile PIT-tag detection facility should be altered to guarantee better detection efficiency. Currently the detection efficiency of the juvenile PIT-tag detection system at Sullivan Dam is rather poor. For example in a recent analysis of fish guidance efficiency trials at the T.W. Sullivan Plant, average detection efficiencies of 84%, 74% and 73% were observed for PIT-tagged spring chinook, fall chinook and steelhead juveniles released directly in the forebay of the dam.

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