Synthesis of Smolt and Spawner Abundance Information for Coho Salmon from South Coast British Columbia Streams

J. Wade and J.R. Irvine

Fisheries and Oceans Canada
Science Branch, Pacific Region
Pacific Biological Station
3190 Hammond Bay Road
Nanaimo, British Columbia
Canada V9T 6N7

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2018

SYNTHESIS OF SMOLT AND SPAWNER ABUNDANCE INFORMATION FOR COHO SALMON FROM SOUTH COAST BRITISH COLUMBIA STREAMS

by

J. Wade[1] and J.R. Irvine

Fisheries and Oceans Canada
Science Branch, Pacific Region
Pacific Biological Station
3190 Hammond Bay Road
Nanaimo, BC
V9T 6N7

[1] Fundy Aqua Services Inc., 1859 Delanice Way, Nanoose Bay, BC V9P 9B3

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Wade, J. and Irvine, J.R. 2018. Synthesis of smolt and spawner abundance information for Coho Salmon from South Coast British Columbia streams. Can. Manuscr. Rep. Fish. Aquat. Sci. 3161: vi + 39 p.

Data from outmigrating Coho Salmon smolts and spawners returning to streams in southern British Columbia (excluding the Fraser River drainage) are summarized to assist in understanding changing patterns of abundance. We focus on results from monitoring projects of wild Coho Salmon from three Vancouver Island streams (Black Creek, Carnation Creek and Keogh River) but also include data from ~20 other streams. The report includes an extensive bibliography, data summary tables, and a link to the complete database.

RÉSUMÉ

Wade, J. et Irvine, J.R., 2018. Synthèse de l'information sur l'abondance de saumoneaux et de reproducteurs, pour le saumon coho des cours d'eau de la côte sud de la Colombie-Britannique. Rapp. manus. can. des sci. halieut. Sci. 3161: vi + 39 p.

Les données sur les saumoneaux coho qui descendent et les reproducteurs qui remontent dans les cours d'eau dans le sud de la Colombie-Britannique sont résumées pour qu'il soit plus facile de comprendre les changements qui se produisent dans l'abondance. Nous mettons l'accent sur les résultats des projets de surveillance du saumon coho sauvage de trois cours d'eau de l'île de Vancouver (ruisseau Black, ruisseau Carnation et rivière Keogh), mais nous incluons aussi des données d'environ 20 autres cours d'eau. Le rapport comprend une importante bibliographie, des tableaux récapitulatifs de données et un lien vers la base de données complète.

ACKNOWLEDGEMENTS

The authors greatly appreciate the hard work and dedication of the federal (Fisheries and Oceans Canada, DFO) and provincial (British Columbia Ministry of Environment (BC MOE)) employees, First Nations and volunteers who collected these data over so many years. In assembling the information in this report we were assisted by many, some working and others retired (ret) that included Richard Bailey (DFO), Andrew Campbell (DFO), Lyse Godbout (DFO), Caroline Melville (Instream Fisheries Research), Aleta Rushton (DFO), Joe Tadey (DFO), Nicolette Watson (DFO); special thanks go to Steve Baillie (DFO, ret), Tom Johnston (BC MOE, ret), Peter Tschaplinksi (BC MOE), Pieter Van Will (DFO), and Bruce Ward (BC MOE, ret) for access to published and unpublished data and reports. Thanks also to Trevor Davies (BC MOE) for permission to post the Keogh River data at the University of British Columbia (UBC) Strait of Georgia Data Centre and in this report and Lindsay Dealy for drafting Figure 1.

INTRODUCTION

Coho Salmon in southern BC have experienced significant declines over the past two decades. It is generally acknowledged that declining trends are primarily due to reduced survivals in the marine environment (e.g. Irvine et al., 2013; Zimmerman et al., 2016). However, the role that changing sizes of the outmigrating smolts, and their condition have on subsequent marine survival is not known. Also, the effects that widely varying freshwater survivals may have on overall survival patterns are poorly understood.

Young Coho Salmon exiting from and adult Coho Salmon returning to streams in southern BC have been monitored for many years by staff with DFO, BC MOE, and other agencies and groups. However, data collected during these programs are scattered amongst various locations and in several formats. The goal of this project was to assemble relevant data into a common format to permit the types of analyses necessary to better understand reasons for declining Coho Salmon returns. Since study objectives varied among the original studies and information gathered varied accordingly, it was not practicable to summarise all data gathered. We therefore document original sources so that analysts and others interested in the data can track down and verify information as need be. We focused on streams in the South Coast of BC excluding those from the Fraser River watershed (Fig. 1).

In southern BC, most Coho Salmon spawn at age 3 after spending ~1 year in freshwater following emergence and ~1.5 years at sea. Some Coho leave freshwater as fry shortly after emergence but these are rarely seen or counted in wild salmon monitoring programs because their small size means that they are rarely retained at counting facilities. Some Coho Salmon also leave after two years in freshwater and since their sizes typically overlap with one year smolts, ageing is needed to separate the age classes. As well, some male Coho Salmon return to freshwater after spending only ~6 months at sea. Numbers of these precocious males (jacks) are typically

underestimated due to their small size relative to other spawners, and resulting difficulties catching/counting them.

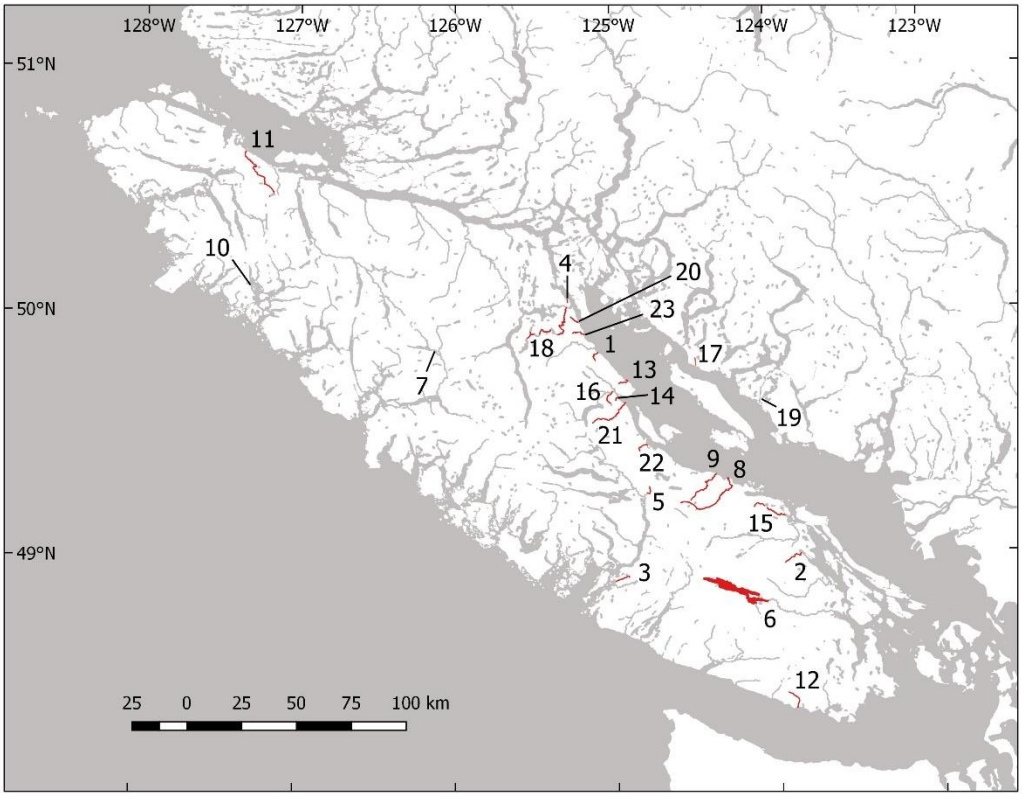

Figure 1.Location of Coho Salmon streams referenced in this report. Stream numbers (names) are: 1 (Black Creek), 2 (Bush Creek), 3 (Carnation Creek), 4 (Casey Creek), 5 (Cherry Creek), 6 (Cowichan Lake), 7 (Dunlop Creek), 8 (Englishman River), 9 (French Creek), 10 (Jansen Lake Creek), 11 (Keogh River), 12 (Kirby Creek), 13 (Little River), 14 (Millard Creek), 15 (Millstone River), 16 (Morrison Creek), 17 (Myrtle Creek), 18 (Quinsam River), 19 (Sakinaw Creek), 20 (Simms Creek), 21 (Trent River), 22 (Waterloo Creek) and 23 (Woods Creek).

This report briefly describes Coho Salmon streams included in the study, documents the publications and data reports with the original data, and provides summary tables of data pertaining to smolts and returning adults. Detailed data sets (Excel) are posted at the UBC Strait of Georgia Data Centre (http://sogdatacentre.ca/about/data-contents/data-submission-form/).

METHODS

Data were from multiple sources due to the large number of individuals and agencies involved in Coho Salmon monitoring programs over the years, and the lack of a central database. We initially compiled as many reports, published and unpublished, with detailed data as we could (see Bibliography). We contacted individual data holders, both current and retired, and asked them to provide us with data sets and reports (see Acknowledgements). In many cases it was possible to extract data from reports to develop our time series. When discrepancies between published and unpublished data were found, we use the published data except when there was evidence of appropriate post publication data-processing (e.g. corrections). Data tables indicate sources and data-users are encouraged to go to original sources for more details, including descriptions of approaches used in the field to gather data. As described earlier, data on outmigrating fry were rarely gathered, many projects were unable to differentiate between one and two year smolts, and estimates of jack coho, when available, were usually biased low.

We focused on results from monitoring projects of wild Coho Salmon in Black Creek, Carnation Creek, and Keogh River (Fig. 1), three Vancouver Island indicator streams with lengthy time series of relatively reliable smolt and adult abundance data. Datasets from other systems with shorter time series are also summarized. We do not provide catch data that can be obtained for coded-wire tag release groups from other sources (e.g. Zimmerman et al., 2015; DFO Mark Recovery Program Database).

Table 1. Description of column headings for data tables.

Column Heading	Description
OEY	Ocean Entry Year, calendar year that smolts entered the ocean
Smolt	Number of smolts counted or estimated at the fence
FL	Average fork length (mm)
Age 1	Number of smolts calculated to be age 1
Age 2	Number of smolts calculated to be age 2
Age 3	Number of smolts calculated to be age 3
Prop. Age 1	Based on calculated ages, the proportion of the total number of smolts counted at the fence that are age 1
Prop. Age 2	Based on calculated ages, the proportion of the total number of smolts counted at the fence that are age 2
Prop. Age 3	Based on calculated ages, the proportion of the total number of smolts counted at the fence that are age 3
N	Sample size
CWT	Number of coded wire tagged fish released
Year	Calendar Year
Jack	Number of precocious male spawners
M	Number of adult (non-jack) males that escaped fisheries and returned to spawn
F	Number of adult females that escaped fisheries and returned to spawn
Adult	Total number of adult males and females (jacks not included)
ER	Fishery exploitation rate (i.e. catch/(catch + escapement))
Catch	Number caught in fisheries
Weight	Average weight (g)

Start	Date when fence monitoring began
Stop	Date when fence monitoring stopped
Mort.	Number of mortalities
Q	End dates for 1st, 2nd, and 3rd quartiles of smolt outmigration
MR	Mark recapture estimate of spawner numbers

COHO SALMON DATA

BLACK CREEK

Black Creek, DFO's primary Coho Salmon indicator population for east coast Vancouver Island, is a small stream near Courtenay (Fig. 1). The first adult counting fence constructed near the mouth of this 26 km creek in 1968 was rebuilt in 1972 but only partial counts were obtained in these early years. In 1978 and 1979, a temporary smolt enumeration fence was also operated, coded-wire tags were inserted in downstream migrating smolts and the first estimates of fishery exploitation and marine survival resulted from increased effort monitoring spawner escapements during 1978-1980 (Clark and Irvine, 1989).

Beginning in 1984, Coho Salmon returning to Black Creek were monitored until 1988 using a combination of fence counts and mark recapture estimates while outmigrating smolts were enumerated and CWTs implanted from 1985 to 1987 (Labelle 1990, 1991). These studies continue with some differences as reported in a series of DFO published and unpublished Manuscript Reports listed in the Bibliography. The Black Creek Coho Salmon monitoring program continues under the direction of DFO who are working with the A-Tiegay Fisheries Society that is comprised of five member First Nations; We Wai Kai, Wei Wai Kum, K'omoks, Tlowitsis and Kwiakah.

Additional research at Black Creek has included an evaluation of alternate sampling designs applied to visual survey data for adult and jack Coho Salmon escapements (English et al.,1992; Irvine et al., 1992), an extensive radio tracking study to identify major spawning areas in 1999 (Baillie et al., 2015), analyses of Coho Salmon stock recruitment relationships (Routledge and Irvine, 1999) and an evaluation of the relationship between smolt sampling effort and the accuracy and precision of total smolt estimates (Irvine et al., 2003).

Pertinent Coho Salmon data are summarised in Tables 2 and 3.

Table 2. Black Creek Coho Salmon smolt data (OEY 1978-2016). Data sources: see Appendix 1; Abbreviations: see Table 1.

OEY	Smolt	Age 1	Age 2	Age 3	CWT
1978	48,145				29,884
1979	45,813				39,293
1980					
1981					
1982					
1983					
1984					
1985	50,208				24,134
1986	38,212				31,648
1987	60,909				35,640
1988	75,401				74,909
1989	29,862	25,480	4,346	36	29,181
1990	118,897	106,334	12,563	0	118,410
1991	53,876	50,707	3,169	0	52,431
1992	50,271	45,895	4,250	126	49,874
1993	65,171	60,757	4,414	0	54,898
1994	78,282	75,998	2,284	0	76,004
1995	18,295	14,828	3,413	54	18,154
1996	14,178	14,044	134	0	13,709
1997	76,592	75,955	637	0	69,973
1998	24,738	21,327	3,411	0	24,583
1999	26,370	26,207	163	0	26,247
2000	154,326	154,164	162	0	151,129
2001	42,772	38,998	3,756	18	42,420
2002	89,400	87,806	1,562	32	88,384
2003	82,320	78,495	3,554	271	43,316
2004	41,790	38,584	3,206	0	14,375
2005	49,133	44,968	4,037	128	8,319
2006	126,171	122,007	4,164	0	36,221
2007	35,238	28,606	6,632	0	12,250
2008	34,700	30,274	4,426	0	10,269
2009	68,517	65,518	2,999	0	19,016
2010	22,754	19,097	3,657	0	6,852
2011	28,080	26,180	1,878	22	9,611
2012	32,274	30,231	2,043	0	
2013	57,177				11,327
2014	57,377				13,986
2015	19,364				4,413
2016	25,436				8,382

Table 3. Black Creek Coho Salmon adult data (1979-2015). Data sources: see Appendix 1; Abbreviations: see Table 1.

Year	Jack	M	F	Adult
1979				822
1980				1,927
1981				750
1982				2,500
1983				3,000
1984	350	3,175	2,995	6,170
1985	349	3,176	2,816	5,992
1986	483	2,385	2,433	4,818
1987	1,071	422	363	785
1988	396	1,848	1,274	3,122
1989	692	1,607	1,665	3,272
1990	1,328	524	713	1,237
1991	2,373	1,719	1,849	3,568
1992	2,348	904	816	1,720
1993	1,502	570	389	959
1994	1,500	484	416	900
1995	1,150	850	910	1,760
1996	678	158	126	284
1997	2,200	605	595	1,200
1998	1,128	3,669	3,947	7,616
1999	575	189	322	511
2000	1,950	451	663	1,114
2001	2,700	6,086	6,014	12,100
2002	95	1,876	2,446	4,322
2003	370	1,239	1,543	2,782
2004	461	1,901	2,164	4,065
2005	278	1,008	1,240	2,248
2006	519	233	332	565
2007		2,552	2,901	5,453
2008		518	602	1,120
2009		1,420	2,116	3,536
2010		1,818	2,232	4,050
2011		760	1,051	1,811
2012		2,494	2,667	5,161
2013		5,185	5,730	10,915
2014		2,702	2,742	5,444
2015		1,393	1,230	2,623

CARNATION CREEK

Coho Salmon studies at Carnation Creek, a small stream on the south side of Barkley Sound (Fig. 1), were recently reviewed by Tschaplinski and Pike (2017). Carnation Creek has the longest continual time series of Coho Salmon smolt and adult abundance in BC, beginning in 1970. Initiated by DFO with forest industry, provincial and other federal government partners, the project is now managed by the Province of BC. This basin scale, multidisciplinary study of the effects of forestry practices on watershed processes and key species including Coho Salmon encompasses five years of pre-logging, six years during logging and 34 years post-logging (Tschaplinski and Pike, 2017).

Results from this project are instructive for those monitoring trends in salmon populations. Logging resulted in increased stream temperatures that benefited freshwater growth and survival of young Coho Salmon including smolt production for 3 decades (Tschaplinski and Pike, 2017). These apparent benefits were however diminished and then lost due to delayed effects of bank erosion and stream channel instability including loss of large woody debris. Overwinter fry survival is now only 15% of what it was pre-logging, and smolt numbers are down. The time series also documents declines in smolt survivals similar to those found in other systems.

Carnation Creek has been the site of much scientific research and contributed significantly to our understanding of Coho Salmon biology and especially effects of forest harvesting (see Bibliography and research described in Tschaplinski and Pike, 2017).

Pertinent Coho Salmon data are summarised in Tables 4 and 5.

Table 4. Carnation Creek Coho Salmon smolt data (OEY 1971-2015). Data sources: see Appendix 1; Abbreviations: see Table 1.

OEY	Smolt	FL	Age 1	Age 2	Prop. Age 1	Prop. Age 2	CWT
1971	2,477	89.3					
1972	1,920	90.8	1,345	574	0.70	0.30	
1973	1,891	88.3	1,115	776	0.59	0.41	
1974	2,658	88.8	1,214	1,444	0.46	0.54	
1975	2,121	83.7	1,247	874	0.59	0.41	
1976	3,062	79.8	1,994	1,068	0.65	0.35	
1977	2,560	85.5	1,625	935	0.63	0.37	
1978	4,646	86.6	3,868	778	0.83	0.17	
1979	3,530	83.6	2,862	668	0.81	0.19	
1980	4,567	89.6	3,576	991	0.78	0.22	
1981	4,164	84.5	3,768	396	0.90	0.10	
1982	3,470	89.0	2,848	622	0.82	0.18	
1983	3,745	87.5	3,440	305	0.92	0.08	
1984	3,113	84.7	2,994	119	0.96	0.04	

1985	1,978	93.3	1,788	190	0.90	0.10	
1986	2,933	86.1	2,745	88	0.97	0.03	
1987	2,648	93.5	2,408	240	0.91	0.09	
1988	2,712	83.6	2,684	28	0.99	0.01	
1989	3,862	91.7	3,582	280	0.93	0.07	283
1990	3,222	84.9	3,132	90	0.97	0.03	346
1991	3,103	86.6	2,903	200	0.94	0.06	
1992	5,253	84.8	4,746	507	0.90	0.10	
1993	3,989	85.5	3,592	397	0.90	0.10	
1994	4,759	84.9	4,592	167	0.96	0.04	
1995	3,480	92.5	3,358	122	0.96	0.04	
1996	892	108.1	478	414	0.54	0.46	
1997	4,942	85.6	4,902	40	0.99	0.01	
1998	4,865	87.5	4,104	761	0.84	0.16	
1999	2,842	88.3	2,689	153	0.95	0.05	
2000	4,828	79.7	4,635	193	0.96	0.04	
2001	2,205	86.0	1,705	547	0.76	0.24	2,027
2002	4,740	88.8	4,433	309	0.93	0.07	4,660
2003	4,539	90.8	3,573	966	0.79	0.21	4,352
2004	4,433	87.6	4,045	388	0.91	0.09	4,306
2005	2,974	95.6	2,455	375	0.87	0.13	2,807
2006	2,248	91.3	1,796	452	0.80	0.20	2,210
2007	1,100	86.6	1,070	42	0.96	0.04	
2008	682	105.4	470	214	0.69	0.31	675
2009	3,205	no data	3,055	185	0.94	0.06	2,565
2010	2,617	no data	1,982	646	0.75	0.25	2,273
2011	2,757	87.6	2,020	737	0.73	0.27	2,295
2012	2,861	85.2	2,380	481	0.83	0.17	
2013	819		737	82	0.90	0.10	
2014	1,386						
2015	1,203						

Table 5. Carnation Creek adult Coho Salmon escapement data (1970-2015). Data sources: see Appendix 1; Abbreviations: see Table 1.

Year	Jack		Male		Female		Adult
	(N)	FL	(N)	FL	(N)	FL	
1970	62	35.0					
1971	76	33.0	108	55.7	81	61.0	189
1972	43	33.8	87	65.2	75	68.6	162
1973	75	35.6	85	62.8	71	66.8	164

1974	54	33.4	88	58.1	70	66.9	159
1975	35	30.1	89	65.4	69	65.9	158
1976	53	34.7	68	56.1	55	63.5	123
1977	233	33.5	76	57.3	51	65.2	127
1978	114	33.2	46	60.7	56	65.3	102
1979	101	34.8	136	58.2	176	64.0	312
1980	61	32.7	110	57.0	65	66.8	175
1981	61	34.7	76	56.2	43	64.4	119
1982	83	34.7	103	55.6	71	64.4	174
1983	25	30.4	52	54.7	51	61.2	103
1984	59	34.4	27	54.1	22	63.9	49
1985	27	33.6	43	56.2	26	64.3	69
1986	58	34.6	64	55.2	55	63.5	119
1987	98	32.2	38	58.9	26	63.8	64
1988	152	33.9	34	59.7	23	68.5	57
1989	121	34.0	89	55.4	60	62.6	149
1990	51		89	57.4	97	65.5	186
1991	43		135		76		211
1992	6		54		53		107
1993	104		66		29		95
1994	90		8		1		9
1995	87		97		78		175
1996	126		30		44		74
1997	82		17		33		50
1998	77		159		172		331
1999	88		29		25		54
2000	118		81		62		143
2001	218		161		128		289
2002	141		177		180		357
2003	143		239		229		468
2004	26		82		78		160
2005	60		65		73		138
2006	75		3		4		7
2007	116		75		62		137
2008	70		83		80		163
2009	103		92		149		241
2010	74		39		70		109
2011	88		66		122		188
2012	89		32		56		88
2013	62		102		94		196
2014	208		63		94		157
2015			21		39		60

KEOGH RIVER

The Keogh, a medium size river on northern Vancouver Island (Fig. 1) has been a major research and monitoring site for the Province of BC since the 1970's. Outmigrating smolts are enumerated each spring at a smolt fence and trap near the river mouth. Since the timing of Coho Salmon and Steelhead Trout smolts is similar, accurate counts for each species are usually obtained. Mark recapture and electronic counters have been used to estimate steelhead spawner numbers but since Coho Salmon return much later in the year than steelhead, accurate estimates of Coho (and Pink) salmon spawners were not usually possible until recent years with the installation of electronic counters. The province has been primarily responsible for the Keogh program although DFO has collaborated on research and assisted with funding throughout. Instream Fisheries Research (IFR), primarily funded by the Habitat Conservation Trust Program currently operates the Keogh project; the Moore Lab at SFU is collaborating with IFR on analysis of the valuable data assembled.

The Fisheries Research Section of the BC Fish and Wildlife Branch first operated traps in the Keogh River watershed in 1975 to evaluate in-stream enhancement techniques for anadromous gamefish, with a primary focus on steelhead trout and to a lesser extent for cutthroat trout, Dolly Varden and Coho Salmon (de Hrussoczy-Wirth, 1979; Mottram, 1977). The federal government's involvement began in 1977 with a coded wire tag study of Coho Salmon smolts at five different fence/ trap locations on the Keogh system (de Hrussoczy-Wirth, 1979).

Over the years, the Keogh River system has been the site of many different studies, McCubbing (2002) reported that at the time more than 100 scientific and technical papers had been published on the Keogh River and its salmonid populations. Apart from the continued monitoring of fences for Steelhead Trout and other anadromous salmonids, the Keogh River was selected as a part of the Forest Renewal BC for training and education of forest workers in habitat assessment and restoration techniques (Ward and McCubbing, 1998). The Waukwaas and Keogh watersheds were part of a long term paired watershed study for the Watershed Restoration Program, assessing the in-river restoration techniques on salmonid production and growth (McCubbing and Ward 1997, 1998, 2000abc, 2001, 2002). In 1997 the Keogh River was chosen as the development site for electronic enumeration of migrating adult salmonids in BC coastal streams (Ward and McCubbing, 1998; McCubbing et al., 1999). It is also the experimental river for hatchery conservation research and the living gene bank project (Ward, 2000). Further details regarding these programs are summarized in McCubbing (2002).

Although research has focused on Steelhead Trout (Bailey et al., 2018), research on Coho Salmon has included evaluations of the effects of instream enhancement structures and nutrient additions (Ward and Slaney, 1979, 1981), Ward et al. (2003), downstream smolt migration patterns (Irvine and Ward, 1989), and overwintering habitats (Swales et al., 1998).

Pertinent Coho Salmon data are summarised in Tables 6-8.

Table 6. Keogh River Coho Salmon smolt data (OEY 1976-2016). Data sources: see Appendix 1; Abbreviations: see Table 1.

OEY	FL	FL (N)	Weight	Weight (N)	Start	Stop	Smolt	CWT
1976	95.1	843	9.7	843	30 April	12 June		
1977							63,000	
1978	111.0	81			22 March	24 June	52,000	
1979	111.1	471			11 March	25 July	65,900	
1980	97.5	2,245	10.0	56	1 April	12 June	62,962	
1981	108.1	2,702	14.6	71	12 March	15 July	105,256	
1982	96.1	1,415	11.6	116	16 March	28 June	55,250	
1983	106.2	1,402	14.4	93	14 April	19 July	56,453	
1984	101.8	1,333	10.4	115	11 April	15 June	74,409	
1985	100.6	2,346	10.7	548	15 April	12 June	73,572	
1986	99.1	3,113	11.5	1,656	5 April	9 July	85,381	
1987	111.1	505	14.5	432	4 April	28 June	81,898	
1988	105.1	1,211	12.5	1,211	26 April	20 June	71,505	
1989	103.5	1,569	13.0	462	10 March	26 June	71,620	
1990	101.7	1,298	10.9	1,223	5 April	12 June	57,238	
1991	116.0	1,121	17.4	330	5 April	15 June	41,551	
1992	99.4	1,687	10.3	413	6 April	17 June	70,537	
1993	105.5	1,354	14.4	355	20 April	14 June	73,909	
1994	103.8	1,462	12.2	365	11 April	15 June	40,993	
1995	107.6	1,437	13.6	278	31 March	15 June	30,000	
1996	110.8	1,469	14.8	111	19 April	15 June	57,544	
1997	103.1	1,339	11.7	245	12April	15 June	64,557	
1998	105.2	1,252	13.0	150	19 April	15 June	21,694	
1999	109.0	1,443					52,000	31,953
2000	97.3	1,501	10.2	175	7 April	18 June	74,400	29,644
2001	98.0	1,705					59,993	23,274
2002	98.0	1,786					60,213	25,556
2003	101.0	1,603					93,630	29,978
2004	104.0	1,410					22,482	8,133
2005	104.0	1,061	12.0	174	16 April	15 June	58,900	19,467
2006	99.9	1,443			10 April	14 June	51,300	23,202
2007	99.2	1,313	11.2	150	11 April	9 June	56,187	25,471
2008	99.7	1,443	11.9	224	9 April	16 June	72,208	32,442
2009	102.0	1,562	12.2	251	14 April	10 June	78,151	39,013
2010	105.5	2,011	12.7	288	15 April	5 June	62,300	26,041

2011	96.0	2,051					89,778	53,124
2012	97.0	2,655					108,063	50,714
2013	99.0	2,432					111,042	48,284
2014	109.0	1,710					66,785	42,826
2015							111,718	51,552
2016							92,073	

Table 7. Keogh River Coho Salmon smolt age data (OEY 2006-2016). Data sources: see Appendix 1; Abbreviations: see Table 1.

OEY	Age 0		Age 1		Age 2		Age 3	
	(N)	FL	(N)	FL	(N)	FL	(N)	FL
2006			98	107.2	12	118.0		
2007			66	111.1	10	120.2		
2008			40	109.7	9	127.5		
2009	8	109.6	89	118.1	41	137.7		
2010			122	115.0	47	143.0		
2011	4	116.3	143	114.4	36	131.1		
2012			190	104.6	44	120.8		
2013	3	123.7	130	110.1	57	133.1		
2014			93	112.5	26	125.7	1	134
2015			109	111.0	43	120.7		
2016	1	89.0	473	117.1	131	149.5	1	131

Table 8. Keogh River adult Coho Salmon escapement data (1998-2016). Data sources: see Appendix 1; Abbreviations: see Table 1.

Year	Adult	Male		Female	
		(N)	FL	(N)	FL
1998	8,501				
1999	2,887				
2000	1,206				
2001	2,175				
2002	3,307				
2003	1,162				
2004	1,156	36	634.9	46	661.5
2005	3,347	13	662.7	14	690.1
2006	1,840	11	736.4	8	712.5
2007	2,780	34	596.0	24	595.2
2008	926	10	666.0	2	700.0
2009	3,390				
2010	2,106				

2011	2,129	28	638.0	12	650.8
2012	4,832	89	658.2	104	662.6
2013	5,594	85	637.5	93	626.5
2014	12,187	69	671.2	66	667.2
2015	697	14	593.9	32	653.0
2016	1,848	26	565.0	36	578.2

NON-INDICATOR STREAMS

Coho Salmon data from non-indicator streams came from several sources including Abbott (unpub), Steve Baillie (DFO South Coast, Nanaimo, pers. comm.), Andrew Campbell (DFO South Coast, Nanaimo, pers. comm.) and various publications as listed in Appendix 1.

Pertinent Coho Salmon data have been summarized in Tables 9-30. Only streams with five or more years of data are included.

Table 9. Bush Creek Coho Salmon smolt data (OEY 2000-2009). Data sources: see Appendix 1; Abbreviations: see Table 1.

OEY	Migration Quartile			FL	Smolt	Comment
	Q1	Q2	Q3			
2000	1 May	11 May	19 May	94.5	1,593	
2001						
2002						
2003						
2004						
2005	6 May	11 May	15 May	93.7	4,521	Fence started on 4 May. Estimated 1,087 smolts were missed, plus 3,434 counted.
2006	12 May	16 May	22 May		4,839	Started counting on 6 May, estimated 823 smolts prior to fence, plus 4,016 enumerated.
2007	13 May	16 May	20 May		326	
2008	18 May	22 May	27 May		1,015	
2009					1,021	

Table 10. Casey Creek Coho Salmon smolt data (OEY 2002-2008). Data sources: see Appendix 1; Abbreviations: see Table 1.

OEY	Migration Quartile			FL	Smolt
	Q1	Q2	Q3		
2002					285
2003					
2004					
2005	3 May	3 May	6 May	110.0	92
2006					552
2007	7 May	19 May	24 May	102.9	21
2008	8 May	12 May	14 May	123.5	301

Table 11. Cherry Creek Coho Salmon smolt data (OEY 1992-2013). Data sources: see Appendix 1; Abbreviations: see Table 1.

OEY	Migration Quartile			FL	Smolt
	Q1	Q2	Q3		
1992	17 April	26 April	27 April	125.8	4,466
1993	30 April	9 May	16 May	102.8	1,403
1994	20 April	28 April	9 May	100.3	5,683
1995	10 May	14 May	22 May	97.6	2,087
1996	9 May	12 May	14 May		422
1997	12 May	17 May	24 May		3,182
1998	1 May	2 May	7 May		8,742
1999	13 May	18 May	24 May	97.6	6,958
2000	9 May	14 May	19 May		16,438
2001	9 May	14 May	24 May		9,078
2002	10 May	19 May	29 May		13,853
2003	7 May	19 May	26 May		5,345
2004	29 April	2 May	6 May		3,476
2005	1 May	4 May	10 May		6,499
2006	6 May	14 May	20 May		8,750
2007	4 May	15 May	25 May		4,708
2008	14 May	16 May	21 May		2,017
2009	4 May	11 May	18 May		10,306
2010	29 April	8 May	16 May		15,943
2011	4 May	9 May	16 May		11,662
2012	3 May	8 May	14 May		11,676
2013	27 April	5 May	12 May		15,147

Table 12. Cowichan Lake watershed Coho Salmon smolt data (1997-2007). Incomplete counts. Data sources: see Appendix 1; Abbreviations: see Table 1.

OEY	Smolt
1997	97,711
1998	
1999	88,500
2000	255,000
2001	233,000
2002	236,000
2003	111,000
2004	
2005	126,000
2006	90,000
2007	14,500

Table 13. Dunlop Creek Coho Salmon smolt data (OEY 2002-2012). Data sources: see Appendix 1; Abbreviations: see Table 1.

OEY	Migration Quartile			FL	Weight	Smolt
	Q1	Q2	Q3			
2002						682
2003				99.8		742
2004	22 April	1 May	8 May			1,011
2005				93.7	10.2	657
2006						
2007						52
2008						
2009						
2010						
2011						
2012						249

Table 14. Englishman River Coho Salmon smolt data (OEY 1998-2010). Data sources: see Appendix 1; Abbreviations: see Table 1.

OEY	Smolt
1998	33,531
1999	50,622
2000	
2001	31,005
2002	38,996
2003	39,100

2004	38,000
2005	42,701
2006	
2007	
2008	
2009	85,467
2010	42,038

Table 15. French Creek Coho Salmon smolt data (OEY 1986-1990). Data sources: see Appendix I; Abbreviations: see Table 1.

OEY	Start	Stop	Smolt	CWT	Date of Peak Daily Catch	FL			Weight			Age (N)	Calculated Age		
						N	Mean	SD	N	Mean	SD		1	2	3
1986	18 April	12 June	29,155	23,838	27 May										
1987	11 April	5 June	33,917	24,354	15 May										
1988	13 April	13 June	27,568	26,512	22 May										
1989	17 April	20 June	12,337	12,173	16 May	517	111	4.5	517	14.4	1.7	986	937	49	
1990	15 April	18 June	41,335	40,763	18 May	331	109.3	14	295	17.6	5.5	929	891	36	2

Table 16. French Creek Coho Salmon adult data (OEY 1985-1990). Data sources: see Appendix 1; Abbreviations: see Table 1.

Year	Adult	MR
1985	661	
1986	625	
1987	86	107
1988	962	993
1989	369	527
1990	114	228

Table 17. Jansen Lake Creek Coho Salmon smolt data (OEY 2001-2005). Data sources: see Appendix 1; Abbreviations: see Table 1.

OEY	Migration Quartile			FL	Smolt	Comment
	Q1	Q2	Q3			
2001	24 April	26 April	5 May	107.5	2,279	
2002	12 April	18 April	1 May	92.2	1,635	includes estimated 400 smolts during flood event
2003	23 April	24 April	2 May	91.3	93	
2004	23 April	4 May	7 May		242	
2005	16 May	19 May	21 May	99.7	2,451	

Table 18. Kirby Creek Coho Salmon smolt data (OEY 1998-2002). Data sources: see Appendix 1; Abbreviations: see Table 1.

OEY	Smolt (Age 1)	Smolt (Age 2.0)	Smolt (Total)
1998			6,004
1999	1,852	6	1,858
2000			2,151
2001	2,815	139	2,954
2002	1,925	104	2,029

Table 19. Little River Coho Salmon smolt data (OEY 2001-2012). Data sources: see Appendix 1; Abbreviations: see Table 1.

OEY	Migration Quartile			FL	Weight	Smolt	Comment
	Q1	Q2	Q3				
2001						6,973	
2002						16,959	
2003	5 May	11 May	20 May	107.8	13.5	18,986	Does not include an estimated 15,000 hatchery release.
2004	5 May	9 May	14 May			15,379	Does not include 3,772 that were stranded in ponds or 13,600 hatchery release.
2005	3 May	10 May	19 May	97.8	10.4	13,407	May be changed. This number is based on a total count of 19,656 'wild' + 225 clipped Coho Salmon, multiplied by the observed clip rate (32.6% over four days) to get wild and clipped Coho Salmon smolts
2006	10 May	15 May	19 May	112.6	13.6	6,350	
2007	8 May	14 May	19 May	110.7	12.8	5,796	
2008	5 May	14 May	18 May	118.0	15.1	8,828	
2009	6 May	13 May	19 May	112.4	13.8	19,214	
2010	15 May	18 May	25 May	115.7	14.4	6,888	
2011	16 May	21 May	24 May	145.1	15.01	600	
2012	7 May	12 May	16 May	99.0	10.9	18,083	

Table 20. Millard Creek Coho Salmon smolt data (OEY 1999-2015). Data sources: see Appendix 1; Abbreviations: see Table 1.

OEY	Migration Quartile			FL	Smolt	Comment
	Q1	Q2	Q3			
1999	13 May	20 May	23 May	97.9	5,098	
2000	6 May	13 May	20 May		15,808	
2001	9 May	15 May	18 May	108.0	10,081	
2002	no data				2,988	
2003	5 May	16 May	22 May	110.7	5,214	Does not include 1,063 hatchery smolts
2004	4 May	9 May	15 May		4,760	
2005	16 May	16 May	18 May		645	
2006	15 May	21 May	24 May	98.6	2,402	Does not include 55 clipped Coho Salmon. Fence operated from 21 April - 16 June.
2007	7 May	11 May	16 May	65.6	336	
2008	12 May	17 May	27 May	111.9	2,274	
2009	9 May	17 May	21 May	108.7	840	
2010	3 May	16 May	23 May	108.8	1,756	
2011						
2012	8 May	12 May	22 May		825	
2013	10 May	14 May	23 May		751	
2014						
2015	9 May	19 May	3 June		238	

Table 21. Millstone River Coho Salmon wild smolt data (OEY 1999-2009). Data sources: see Appendix 1; Abbreviations: see Table 1.

OEY	Migration Quartile			FL	Weight	Smolt	Comment
	Q1	Q2	Q3				
1999						1,600	
2000	8 May	12 May	17 May	115.7	14.6	5,949	
2001							no fence
2002	20 May	22 May	29 May	112.3	14.1	1,403	
2003							no fence
2004	8 May	14 May	19 May	120.0	17.8	7,580	
2005	9 May	15 May	18 May	121.0	17.6	6,956	
2006	9 May	16 May	22 May	117.4	16.3	15,007	
2007							no fence
2008							no fence
2009	18 May	21 May	26 May	112.6	13.4	17,181	

Table 22. Morrison Creek Coho Salmon smolt data (OEY 2002-2009). Data sources: see Appendix 1; Abbreviations: see Table 1.

OEY	Migration Quartile			FL	Smolt
	Q1	Q2	Q3		
2002	13 May	18 May	24 May	94.9	14,585
2003	8 May	16 May	24 May	97.6	9,996
2004	1 May	11 May	16 May	96.5	4,734
2005	4 May	7 May	11 May	99.2	6,698
2006	7 May	13 May	18 May		3,789
2007	9 May	15 May	18 May	102.3	5,174
2008	14 May	17 May	20 May	99.4	6,018
2009	15 May	19 May	23 May	102.0	11,264

Table 23. Myrtle Creek Coho Salmon smolt data (OEY 2000-2012). Data sources: see Appendix 1; Abbreviations: see Table 1.

OEY	Migration Quartile			FL	Weight	Smolt				CWT
	Q1	Q2	Q3			Age 1	Age 2	Age 3	Total	
2000	16 May	20 May	27 May	106.1	11.1	2,089	15	4	2,108	
2001	22 May	27 May	31 May	103.9	10.9	1,836	0	0	1,836	1,629
2002	22 May	25 May	28 May	110.0	12.3	3,562			3,562	3,304
2003	12 May	18 May	26 May			1,694	28	0	1,723	1,687
2004	11 May	17 May	25 May	107.6					2,767	
2005	16 May	20 May	26 May	108.1					2,046	2,002
2006									1,767	
2007	16 May	22 May	27 May						544	
2008	9 May	17 May	24 May						340	
2009	16 May	23 May	30 May						630	
2010	19 May	20 May	26 May	114.7					613	
2011	19 May	24 May	28 May	105.0					708	
2012	18 May	26 May	2 June						1,665	

Table 24. Quinsam River Coho Salmon smolt data (OEY 1997-2002). Data sources: see Appendix 1; Abbreviations: see Table 1.

OEY	Smolt
1997	61,296
1998	45,502
1999	62,722
2000	48,109
2001	46,193
2002	54,189
1997	156,116
1998	59,626
1999	67,783
2000	125,118
2001	82,388
2002	32,874

Table 25. Sakinaw Creek Coho Salmon smolt data (OEY 2003-2017). Data sources: see Appendix 1; Abbreviations: see Table 1.

OEY	Migration Quartile			FL	Smolts Captured				Mort.	Smolts Released			
	Q1	Q2	Q3		Age 1	Age 2	Age 3	Total		Age 1	Age 2	Age 3	Total
2003	5 May	15 May	19 May	134.0	11,571	17,245	1,776	30,592	5,578	9,461	14,100	1,452	25,013
2004	5 May	9 May	24 May	142.0				13,934	3				13,931
2005	28 April	4 May	8 May					16,264					
2006	30 April	6 May	12 May					21,465					
2007	7 May	9 May	11 May				0	15,986					
2008	5 May	7 May	12 May					9,197					
2009	3 May	10 May	15 May					32,648					
2010	1 May	6 May	10 May	127.0									
2011	6 May	9 May	14 May	134.4				19,830					
2012	6 May	9 May	13 May					33,864					
2013								26,860					
2014	30 April	5 May	10 May					21,149					
2015	28 April	4 May	14 May					4,094					
2016	27 April	30 April	5 May					12,473					
2017	25 April	1 May	11 May					2,966					

Table 26. Simms Creek Coho Salmon smolt data (OEY 1998-2008). Data sources: see Appendix 1; Abbreviations: see Table 1.

OEY	Migration Quartile			FL	Smolt
	Q1	Q2	Q3		
1998					902
1999					2,059
2000					4,738
2001					3,463
2002					2,854
2003	7 May	15 May	21 May	105.8	10,803
2004					2,583
2005	3 May	7 May	11 May	117.5	5,781
2006					8,692
2007	11 May	20 May	28 May	114.6	901
2008	11 May	20 May	21 May	130.5	2,384

Table 27. Trent River Coho Salmon smolt data (OEY 1985-1990). Fork length and weight data derived from random sample. Data sources: see Appendix 1; Abbreviations: see Table 1.

OEY	Start	Stop	Smolt	CWT	Date of peak daily catch	FL			Weight		Age (N)	Calculated age	
						N	Mean	SD	N	Mean		1	2
1985	1 May	14 June	12,952	8,975	25 May								
1986	25 April	18 June	11,388	10,531	20 May								
1987	25 April	8 June	17,635	15,691	10 May								
1988	16 April	6 June	18,704	18,410	28 May								
1989	23 April	21 June	12,703	12,321		712	101.3	3.8	623	9.5	429	417	12
1990	23 April	18 June	10,826	10,439	23 May	488	113.7	11.3	486	15.8	255	254	1

Table 28. Trent River Coho Salmon adult data (1985-1990). Data sources: see Appendix 1; Abbreviations: see Table 1.

Year	Adult (N)	MR
1985	459	
1986	926	
1987	295	
1988	484	
1989	162	1,334
1990	262	718

Table 29. Waterloo Creek Coho Salmon smolt data (OEY 2002-2010). Data sources: see Appendix 1; Abbreviations: see Table 1.

OEY	Migration Quartile			FL	Weight	Smolt
	Q1	Q2	Q3			
2002	17 May	23 May	27 May	89.6		2,435
2003	5 May	15 May	22 May	86.0	6.9	1,402
2004	7 May	12 May	16 May	90.7	8.3	
2005	5 May	10 May	15 May	97.1	9.6	2,329
2006	17 May	19 May	23 May	93.0	8.5	2,042
2007	11 May	18 May	23 May	97.5	10.7	922
2008	6 May	13 May	17 May	82.1	6.6	163
2009	17 May	21 May	26 May	86.7	7.5	2,457
2010	12 May	18 May	26 May	88.4	7.9	607

Table 30. Woods Creek Coho Salmon smolt data (OEY 1998-2008). Data sources: see Appendix 1; Abbreviations: see Table 1.

OEY	Migration Quartile			FL	Weight	Smolt
	Q1	Q2	Q3			
1998						3,713
1999						936
2000						1,988
2001						1,897
2002						4,603
2003	1 May	11 May	18 May	107.3		1,307
2004						232
2005	1 May	2 May	7 May	122.0	18.5	196
2006						148
2007	9 May	11 May	16 May	118.1	16.6	
2008	11 May	14 May	15 May	141.3	18.4	

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APPENDIX 1: DATA SOURCES FOR SMOLT AND SPAWNER ESCAPEMENT TABLES.

System	Year(s)	Life Stage	Sources	Tables
Black Creek	1978-1979	Smolt	Clark and Irvine, 1989	2,3
	1984-1988	Smolt	Labelle (1990,1991)	
	1989-2016	Smolt	Pieter Van Will, Aleta Rushton and Steve Baillie (DFO); Bocking et al. (1991, 1992); Nass et al. (1993b); Campbell et al. (2012, 2013, 2014); Meldrum et al. (2017); Nelson et al. (1994a, 1994b, 1995, 1996); Taylor et al. (2006); Taylor et al. (unpub. a-h); Van Will (2010a, b, 2011)	
	1978-2014	Adult	Various including: Pieter Van Will and Steve Baillie (DFO); Clark and Irvine, 1989; Labelle, 1990; Baillie et al., 2004; Taylor et al., 2006; Taylor et al., unpub a-h; Van Will et al. (2010, 2011); Campbell et al. (2012, 2013, 2014); Irvine et al., 1992; Bocking et al (1991); Fielden et al. 1989; Nass et al. (1993a); Meldrum et al. (2017); Nelson et al. (1994a, 1994b, 1995, 1996); Taylor et al. (2006); Taylor et al. (unpub. a-h); Van Will (2010a, b, 2011)	
Carnation Creek	1971-2015	Smolt	Peter Tschaplinksi (BC MOE); Zimmerman et al., 2015; Tschaplinksi and Pike, 2017	4
	1970-2015	Adult	Peter Tschaplinksi (BC MOE); Tschaplinksi and Pike, 2017; Tschaplinski personal communication	5
	1970-1988	Adult	Andersen and Scrivener,1992; Tschaplinksi and Pike, 2017	5
Keogh River	1976-2010	Smolt	Bruce Ward (BC MOE)	6
	1999-2015	Smolt	Pieter Van Will and Aleta Rushton (DFO)	6,7
	1977-2013	Smolt	Clarke and McCubbing, 2014	6
	1997-2015	Adult	Steve Baillie (DFO);	8
	2003-2016	Adult	Pieter Van Will and Aleta Rushton (DFO)	8
Bush Creek	2000-2008	Smolt	Steve Baillie (DFO)	9
	2009	Smolt	Abbott unpublished	9
Casey Creek	2002-2008	Smolt	Steve Baillie (DFO)	10
Cherry Creek	1992-2013	Smolt	Steve Baillie (DFO)	11
Cowichan Lake and Cowichan River above Skutz Falls	1997-2007	Smolt	Steve Baillie (DFO)	12
Dunlop Creek	2002-2007	Smolt	Steve Baillie (DFO)	13
	2012	Smolt	Abbott unpublished	13
Englishman River	1998-2010	Smolt	Steve Baillie (DFO)	14

French Creek	1986-1987	Smolt	Labelle, 1990	15
	1988	Smolt	Fielden et al., 1989	15
	1989	Smolt	Bocking et al., 1991	15
	1990	Smolt	Nass et al., 1993b	15
	1985-1988	Adult	Labelle, 1990	16
	1987-1989	Adult	Irvine et al., 1992	16
	1989	Adult	Bocking et al., 1992	16
	1990	Adult	Nass et al., 1993a	16
Jansen Lake	2001-2005	Smolt	Steve Baillie (DFO)	17
Kirby Creek	1998-2002	Smolt	Steve Baillie (DFO)	18
Little River	2001-2012	Smolt	Steve Baillie (DFO)	19
Millard Creek	1999-2015	Smolt	Steve Baillie (DFO)	20
Millstone River	1999-2009	Smolt	Steve Baillie (DFO)	21
Morrison Creek	2002-2009	Smolt	Steve Baillie (DFO)	22
Myrtle Creek	2000-2012	Smolt	Steve Baillie (DFO)	23
Quinsam River	1997-2002	Smolt	Steve Baillie (DFO)	24
Sakinaw River	2003-2012	Smolt	Steve Baillie (DFO)	25
	2013-2017	Smolt	Andrew Campbell (DFO)	25
Simms Creek	1998-2008	Smolt	Steve Baillie (DFO)	26
Trent River	1985-1987	Smolt	Labelle, 1990	27
	1988	Smolt	Fielden et al.,1989	27
	1989	Smolt	Bocking et al., 1991	27
	1990	Smolt	Nass et al., 1993b	27
	1985-1988	Adult	Labelle et al., 1990	28
	1989	Adult	Bocking et al., 1992	28
	1990	Adult	Nass et al., 1993a	28
Waterloo Creek	2002-2010	Smolt	Steve Baillie (DFO)	29
Woods Creek	1998-2008	Smolt	Steve Baillie (DFO)	30