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PRE-SEASON RUN SIZE FORECASTS FOR FRASER RIVER SOCKEYE AND PINK SALMON IN 2009

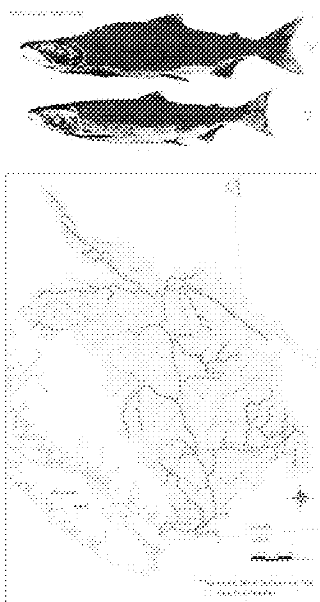

Figure 1. Sockeye adult spawning phase (source: DFO website) and Fraser watershed distribution (DFO GIS Division).

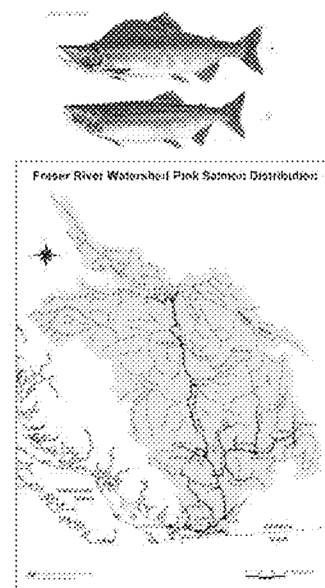

Figure 2. Pink adult spawning phase (source: DFO website) and Fraser watershed distribution (DFO GIS Division).

Context

Pre-season abundance forecasts of returning Fraser River adult sockeye and pink salmon in 2009 were requested by Fisheries and Oceans Canada (DFO) Fisheries Management. Forecasts are used for pre-season planning purposes and for in-season management. They are most useful early in the summer fishing season before reliance on in-season run size estimates. Forecasts are produced by DFO as agreed under the United States (U.S.)-Canada Pacific Salmon Treaty. Detailed methods are documented in Cass et al. (2006) and DFO (2007). Forecasts have been reviewed annually and are publicly available: http://www.meds-sdmm.dfo-mpo.gc.ca/csas/applications/Publications/publicationIndex_e.asp

SUMMARY

- The 2009 forecast of sockeye returns at the 50% probability level for all 19 stocks plus miscellaneous stocks is 10.6 million fish (255,000 Early Stuart, 739,000 Early Summer, and 8.7 million Summer and 907,000 Late).

- This 50% probability level return forecast (10.2 million excluding miscellaneous stocks) is below the long-term average for this cycle of 13 million fish (1980-2005). The Summer Run return forecast (48% Chilko & 41% Quesnel) accounts for 82% of the total forecast. Of the total forecast, Late Run stocks comprise 9%, Early Summer Run stocks 7% and the Early Stuart Run stock comprise 2%.

- The 2009 forecast of pink salmon returns is 17.5 million (50% probability level).
- Forecasts are associated with relatively high uncertainty, consistent with previous Fraser sockeye forecast PSARC reviews (Cass *et al.* 2006) and recent research on coast-wide salmon stocks (Haeseker *et al.* 2007 & 2008).
- For adult sockeye returning in 2009, ocean conditions in their juvenile outmigration period (spring/summer 2007) were good for most physical (sea surface temperatures, upwelling, spring transition) and biological (zooplankton species composition & abundance) indicators. This was an improvement over the transitional year in 2006 and the poor year in 2005 associated with reduced ocean survival and relatively poor returns in 2007 and 2008 for BC salmon stocks. Given the positive ocean productivity signals in 2007 relative to 2006 (transitional between poor and good) & 2005 (poor), emphasis on median probability levels (50%) is recommended for 2009 sockeye return forecasts with the exception of Early Stuart.
- The forecasts for the Early Stuart power model at the 75% probability level for the past five years were closer to true returns compared to forecasts at the 50% probability level.

INTRODUCTION

The Summer Run timing group that includes Quesnel, Late Stuart, Chilko, and Stellako are drivers of the 2009 cycle return abundances accounting for respectively, 54%, 17%, 11%, and 3% of the total sockeye returns on the cycle since 1980. The 2009 cycle is a dominant cycle year for Quesnel and Late Stuart stocks. On the 2009 cycle, average annual returns for all 19 forecasted stocks combined were 13 million (Table 1).

Most Fraser sockeye are comprised of predominantly age-4 fish (Gilbert-Rich aging convention: 4_2), spending their first two winters in freshwater and last two winters in the marine environment prior to returning to the freshwater to spawn. Therefore, most sockeye that return in 2009 are recruited from eggs spawned by adults in 2005 (brood year). In the 2005 brood year, the number of effective female spawners (product of the number of female spawners and the proportion that successfully spawned) for most of the 19 forecasted Fraser sockeye stocks was close to average or above average (time series: 1980-2005) with the exception of Early Stuart, Bowron, Seymour, Late Stuart, Quesnel, & Birkenhead (Table 3). The greatest contributors to the 2005 brood year escapements (82% of the total) were Quesnel (45%), Chilko (16%), Harrison (12%), and Late Stuart (9%). Each of the other 15 forecasted stocks contributed approximately 5% or less to the total. Most sockeye stocks have an age-5 (5_2) component and for most of these stocks the numbers of effective female spawners contributing to age-5 returns in 2009 (2004 brood year) were below average (Table 3).

From the 2005 brood year spawners, juvenile production relative to the 1980-2005 time series varied between stocks. Quesnel fry abundance assessed in 2006 (52 million fish) was below average (58 million), consistent with the lower than average number of effective female spawners in the 2005 brood year. For Cultus sockeye, although the number of effective female spawners was particularly low in the 2005 brood year, hatchery enhancement activities for this stock produced 100,000 smolts in 2007 which is double the time series average of 50,000 (Table 3). Chilko sockeye smolt numbers that outmigrated in 2007 (77 million), produced from

2005 spawners, were the highest number of smolts recorded for this stock (1980-2005 average: 23 million) (Table 3). Chilko smolt body sizes were also relatively large in 2007 (88 mm versus 82 mm average from 1980-2003).

Return forecasts are made for each of 19 individual sockeye stocks that have historical escapement and return data (Table 1). Together the 19 sockeye stocks accounted for 97% of the 2005 brood year escapement to the Fraser River. Forecasts for the remaining miscellaneous stocks (escapement data only available) accounted for 3% of the 2005 brood year escapement.

Forecasts of sockeye returns for the 19 stocks are typically made using a variety of methods that include naïve and biological models. Model selection for each stock depends on data availability and model performance using retrospective analysis (Cass *et al.* 2006). Uncertainty in sockeye forecasts for 2009 is captured using Bayesian statistical inference. Miscellaneous stocks have only escapement data (return data are not available) and these are forecast as a product of their brood year effective female spawners and average recruits per spawners for their respective run timing groups. Sockeye forecasts presented here are based on the same methods and data streams reported in Cass *et al.* (2006) and DFO (2007) except for the addition of recent years data required to generate 2009 forecasts.

Fraser Sockeye Indicator Stock: Chilko

Chilko River sockeye is the only stock for Fraser sockeye with a complete adult and juvenile time series (1949-present) obtained from relatively high accuracy & precision assessments (mark recapture analyses of adults and estimates of outmigrating juveniles at a weir on Chilko River). Chilko is unlikely to provide an indication of freshwater survival for all Fraser sockeye stocks given the broad differences in lake characteristics (e.g. hydrology, limnology, food web) that occur between systems. Chilko, however, may be an indicator of marine survival for Fraser sockeye stocks depending on their similarities in migration timing and ocean distributions.

For Chilko, the highest freshwater survival observed for this stock occurred in the past two brood years (2004 and 2005: 6%) compared to the long term average (brood years 1949-2003: 3%) (Figure 3). Smolt body sizes have also been large in the past two brood years (2004: 100 mm & 2005: 88 mm) relative to the long term average (82 cm). No limnological or food web dynamic surveys have occurred in recent years in Chilko Lake but it is appears there has been a shift in productivity specific to this system (J. Hume, pers. comm.). In contrast, average marine survival has been relatively low in recent years (brood years 2000-2003: ~3%) compared to the long term average (brood years 1949-2003: ~9%) (Figure 3). Ocean conditions were particularly poor in 2005 resulting in low sockeye returns in 2007.

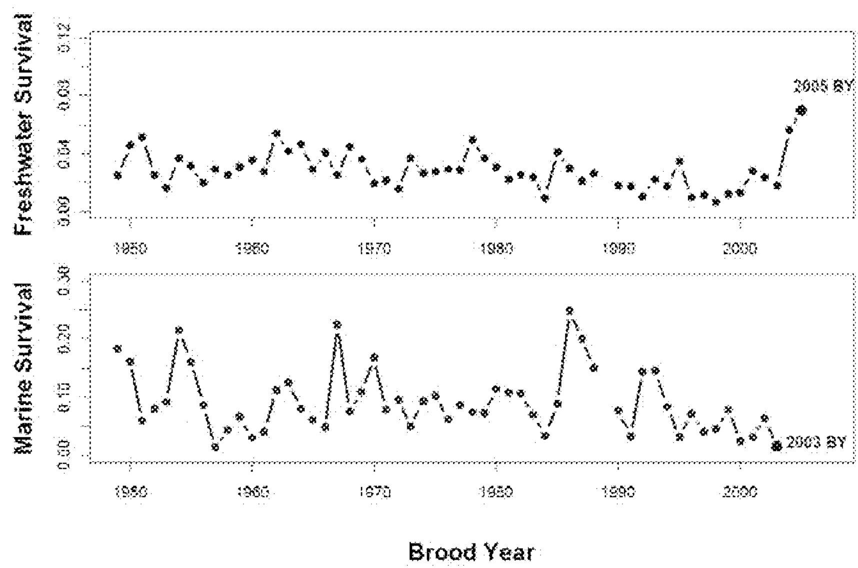

Figure 3. Chilko sockeye freshwater and marine survival.

Methods

Data Sources and Methods:
Data sources and methods have been extensively reviewed by Pacific Scientific Advice Review Committee (PSARC) and are presented in Cass *et al.* (2006) and DFO (2007) available on the Canadian Science Advisory Secretariat (CSAS) website:
http://www.meds-sdmm.dfo-mpo.gc.ca/csas/applications/Publications/publicationIndex_e.asp

Forecast Models

Forecast model descriptions are presented in detail by Cass *et al.* (2006):
http://www.dfo-mpo.gc.ca/csas/Csas/Publications/ResDocs-DocRech/2006/2006_060_e.htm
& DFO (2007): http://www.pac.dfo-mpo.gc.ca/sci/psarc/SSRs/Salmon/sar2007-049_e.pdf.

Bayesian prior probability distributions for the biological model parameters for forecast model are presented Cass *et al.* 2006 (Appendix 3) and DFO (2007).

Retrospective Analysis

Retrospective analyses were conducted based on methodology described in Cass *et al.* (2006). Two performance measures were used to rank each model's performance: mean absolute error (MAE) and root mean square error (RMSE). Smaller differences or errors between the forecasted number of returning salmon and the true return number indicate better model performance. Each model was ranked based on how it performed for each of these two performance measures and the two ranks were then averaged together to produce a final ranking (Table 4).

Forecasts for 2009 were generated for the top three ranking models. If a stock also had juvenile data available, forecasts were generated for top ranking effective female spawner and juvenile biological models. Results for the top ranking models are considered similar unless, the median forecast of one model is more extreme than the 25% or 75% probability level forecast of another model. In cases where results for models were similar, the top ranked model was used to provide the forecast estimates. In cases where results differ between naïve and biological models, biological models get preference. In cases where no additional information exists to evaluate the validity of the different models, divergent estimates were averaged (weighted based on retrospective analysis performance) (Fried & Yuen 1987).

ASSESSMENT

Forecasts based on the best candidate model are provided at various probability levels of achieving specified run sizes by stock and run-timing group (Table 1). The 2009 forecast of sockeye returns at the 50% probability level for all 19 stocks plus miscellaneous stocks is 10.6 million fish (255,000 Early Stuart, 739,000 Early Summer, 8.7 million Summer and 907,000 Late). This 50% probability level return forecast (10.2 million excluding miscellaneous stocks) is below the long-term average for this cycle of 13 million fish (1980-2005). The Summer Run return forecast (48% Chilko & 41% Quesnel) accounts for 82% of the total forecast. Of the total forecast, Late Run stocks comprise 9%, Early Summer Run stocks comprise 7% and the Early Stuart Run stock comprises 2%. The 2009 forecast of pink salmon returns at the 50% probability level is 17.5 million fish.

Table 1. Pre-season sockeye and pink forecasts for 2009 by stock/timing group and probability. Biological model predictor variable indicated (i.e. fry, smolt, or effective female spawners: eff). The Wild Salmon Policy (WSP) conservation units (CU's) that each forecasted stock comprises is numerically referenced below (1 to 32), with corresponding CU name and index listed in Table 2.

					Probability of Achieving Specified Run Sizes [a]				
			Mean Run Size [c]						
Sockeye stock/timing group	**CU's (Table 2)**	**Forecast Model [b]**	**all cycles**	**2009 cycle**	**0.1**	**0.25**	**0.5**	**0.75**	**0.9**
Early Stuart [d]	1,2	Pooled	**335,000**	**797,000**	**645,000**	**426,000**	**255,000**	**165,000**	**107,000**
Early Summer			-	-	**2,284,000**	**1,338,000**	**739,000**	**443,000**	**264,000**
(total exlcuding miscellaneous)			***(501,000)***	***(316,000)***	***(1,234,000)***	***(749,000)***	***(443,000)***	***(272,000)***	***(177,000)***
Bowron	3	Ricker (eff)-pi	23,000	13,000	25,000	16,000	10,000	6,000	4,000
Fennell	4	Ricker (eff)	28,000	17,000	101,000	60,000	34,000	21,000	12,000
Gates	5	Ricker (eff)-cyc	65,000	52,000	224,000	127,000	74,000	44,000	30,000
Nadina	6,7	Ricker (eff)-peak	81,000	78,000	181,000	118,000	73,000	43,000	28,000
Pitt	8	Power (eff)	61,000	79,000	270,000	189,000	124,000	86,000	58,000
Raft	4	Power (eff)	32,000	31,000	209,000	131,000	78,000	49,000	32,000
Scotch	9	RS1 (naïve)	64,000	20,000	170,000	77,000	32,000	13,000	6,000
Seymour	9	Ricker (eff)-cyc	147,000	26,000	54,000	31,000	18,000	10,000	7,000
Misc [e]	9	R/S	-	-	22,000	12,000	6,000	4,000	2,000
Misc [f]	4,10	R/S	-	-	47,000	27,000	13,000	8,000	4,000
Misc [g]	11	R/S			25,000	14,000	7,000	4,000	2,000
Misc [h]	12	R/S	-	-	156,000	88,000	44,000	25,000	13,000
Misc [i]	4	R/S			800,000	448,000	226,000	130,000	66,000
Summer			**5,677,000**	**11,111,000**	**31,813,000**	**16,071,000**	**8,677,000**	**4,914,000**	**2,858,000**
Chilko	13,14	Power (smolt)	1,760,000	1,396,000	9,466,000	6,136,000	4,175,000	2,870,000	1,857,000
Late Stuart	15,16	R1C (naïve)	834,000	2,300,000	3,538,000	1,469,000	553,000	208,000	86,000
Quesnel [j]	17,18,19	Pooled	2,556,000	7,082,000	18,037,000	7,936,000	3,575,000	1,575,000	724,000
Stellako	19,20,21	Larkin (eff)	527,000	333,000	772,000	530,000	374,000	261,000	191,000
Late			-	-	**2,875,000**	**1,616,000**	**907,000**	**517,000**	**327,000**
(total exlcuding miscellaneous)			***(3,242,000)***	***(946,000)***	***(2,665,000)***	***(1,482,000)***	***(843,000)***	***(485,000)***	***(310,000)***
Cultus	22	Power (Smolt)-Jack	19,000	3,000	16,000	10,000	5,000	3,000	1,000
Harrison	23	Ricker (eff)-PDO	47,000	NA	373,000	160,000	69,000	46,000	33,000
Late Shuswap	24	Ricker (eff)-cyc	2,204,000	78,000	407,000	171,000	70,000	26,000	10,000
Portage	25	Ricker (eff)	58,000	74,000	259,000	140,000	66,000	31,000	16,000
Weaver	26	Larkin (eff)	432,000	332,000	906,000	546,000	336,000	200,000	126,000
Birkenhead	27	Power (eff)	482,000	459,000	704,000	455,000	297,000	179,000	124,000
Misc. Shuswap [k]	24,28,29	R/S	-	-	91,000	56,000	27,000	17,000	11,000
Misc. non-Shuswap [k]	30,31	R/S	-	-	119,000	78,000	37,000	15,000	6,000
TOTAL			-	-	**37,617,000**	**19,451,000**	**10,578,000**	**6,039,000**	**3,556,000**
(TOTAL excluding miscellaneous)			***(9,755,000)***	***(13,170,000)***	***(36,357,000)***	***(18,728,000)***	***(10,218,000)***	***(5,836,000)***	***(3,452,000)***
Pink Salmon	32		***12,067,000***	-	**32,939,000**	**24,858,000**	**17,535,000**	**12,490,000**	**9,343,000**

a. probability that the actual run size will exceed the specified projection.
b. see Cass et al. (2006) and DFO (2007) for model descriptions.
c. sockeye: 1980-2005 (excluding miscellaneous stocks); pink: 1961-2005.
d. Early Stuart is pooled power and RS2 model (average weighted from retro analysis)
e. unforecasted misc. Early Summer stocks (Early Shuswap stocks: S.Thompson); return timing most similar to Scotch/Seymour).
f. unforecasted misc. Early Summer stocks (N. Thomson tributaries; return timing most similar to Fennell/Bowron/Nadina).
g. Nahatlach River & Lake
h. Chilliwack Lake and Dolly Varden Creek; return timing most similar to Early Stuart.
i. North Thompson River.
j. Quesnel is a pooled Larkin and Power model (average weighted from retro analysis performance during dominant yr)
k. unforecasted miscellaneous Late Run stocks; true lates made up a very small component (~800 at 50% prob. level)

Model definitions: pi (Pine Island SST covariate); cyc (cycle line data only); peak (Fraser R. peak discharge covariate); PDO (Pacific Decadal Oscillation (PDO) covariate); RS1 (product of R/S from last generation & eff fem spawners in brood year); RS2 (product of R/S from last 2 generations and eff fem spawners in brood year); R1C (rec from last generation); R/S (used for stocks with no recruit data: product of R/S for run timing group and eff fem spawners).

Table 2. Conservation units' (CU's) names and index's referenced in Table 1 for each forecasted stock group, including miscellaneous stocks, are listed below (Holtby & Ciruna, 2007).

CU Number (Table 1)	CU Name	CU Index
Sockeye		
1	Stuart-EStu	L-06-12
2	Takla/Trembleur-Estu	L06-14
3	Bowron-ES	L-07-01
4	Kamloops-ES	L-10-01
5	Anderson-ES	L-06-01
6	Francois-ES	L-06-04
7	Nadina-ES	L-06-09
8	Pitt-ES	L-03-05
9	Shuswap Complex-ES	L-09-02
10	Taseko-ES	L-06-16
11	Nahatlach-ES	L-05-02
12	Chilliwack-ES	L-03-01
13	Chilko-ES	L-06-02
14	Chilko-S	L-06-03
15	Stuart-S	L-06-13
16	Takla/Trembleur-S	L-06-15
17	McKinley-S	L-06-08
18	Quesnel-S	L-06-10
19	MFR	R05
20	Fraser-S	L-06-07
21	Francois-S	L-06-05
22	Cultus-L	L-03-02
23	LFR	R03
24	Shuswap Complex-L	L-09-03
25	Seton-L	L-06-11
26	Harrison (U/S)-L	L-03-04
27	Lillooet-L	L-04-01
28	Carpenter-L	L-06-17
29	Kamloops-L	L-09-01
30	Harrison (D/S)-L	L-03-03
31	Widgeon	R02
Pink		
32	Fraser River	FR

Table 3. Brood year effective female spawners and/or juvenile outmigration (Early Stuart, Chilko, Quesnel, & Cultus) for Fraser sockeye returning as age-4's (2005 brood year) and age-5's (2004 brood year) in 2009 and the 2009 50% probability forecast (Table 1). Colors indicate escapements and forecasted returns relative to cycle averages: red (R) indicates below average, yellow (Y) indicates average, and green (G) indicates above cycle average. BY: brood year.

Stock Name	2005 BY (age-4)	2004 BY (age-5)	2009 Forecast
Early Stuart	R	R	R
Early Summer			
Bowron	R	R	R
Fennel	Y	R	G
Gates	G	R	G
Nadina	G	Y	Y
Pitt	G	G	G
Raft	G	R	G
Scotch	Y	R	G
Seymour	R	R	R
Summer			
Chilko [a]	G	R	G
Late Stuart	R	Y	R
Quesnel	R	Y	R
Stellako	G	R	G
Late			
Cultus [a]	G	Y	G
Harrison [b]	G	NA	G
Late Shuswap	G	Y	Y
Portage	G	Y	Y
Weaver	G	R	G
Birkenhead	R	R	R

a. Juvenile data for forecasts with juvenile models (Early Stuart, Chilko, Quesnel, and Cultus).
b. Harrison sockeye are 3 & 4 year old sockeye (negligible age-5 component).

Table 4. Top ranked models and associated performance measures (MAE & RMSE) for each of the 19 forecasted stocks; MAE: mean absolute error; RMSE: root mean square error. Highlighted (yellow) models were ruled out (see text under stock's associated run timing group for explanation). Biological model predictor variable indicated (i.e. fry, smolt, or effective female spawners: eff).

RUN TIMING: EARLY STUART

EARLY STUART	MAE	rank	RMSE	rank	MEAN	RANK
Power (eff)	0.144	1	0.189	1	**1.0**	**1**
RS2 (eff)	0.194	3	0.308	2	**3.0**	**3**
Ricker (eff)-ei	0.207	5	0.328	4	**4.0**	**4**

RUN TIMING: EARLY SUMMER

BOWRON	MAE	rank	RMSE	rank	MEAN	RANK
Ricker (eff)-pi	0.018	1	0.026	1	**1.0**	**1**
Power (eff)	0.02	4	0.028	3	**3.5**	**2**
Larkin (eff)	0.021	5	0.027	2	**3.5**	**2**

FENNEL	MAE	rank	RMSE	rank	MEAN	RANK
Ricker (eff)	0.02	1	0.023	1	**1.0**	**1**
TSA (naïve)	0.02	1	0.024	2	**1.5**	**2**
Ricker (eff)-pi	0.02	1	0.026	3	**2.0**	**3**

GATES	MAE	rank	RMSE	rank	MEAN	RANK
Ricker (eff)-cyc	0.003	1	0.003	1	**1.0**	**1**
Larkin (eff)	0.004	2	0.004	2	**2.0**	**2**
Power (eff)	0.043	5	0.058	3	**4.0**	**3**

NADINA	MAE	rank	RMSE	rank	MEAN	RANK
Ricker (eff)-peak	0.06	1	0.115	1	**1.0**	**1**
Ricker (eff)-pi	0.06	1	0.118	4	**2.5**	**2**
Power (eff)	0.06	1	0.118	4	**2.5**	**2**
Power (fry)-pi	0.06	1	0.125	6	**3.5**	**4**

PITT	MAE	rank	RMSE	rank	MEAN	RANK
Power (eff)	0.044	1	0.073	2	**1.5**	**1**
MRS (naïve)	0.048	2	0.068	1	**1.5**	**1**
R2C (naïve)	0.051	5	0.088	4	**4.5**	**3**
Ricker (eff)-disch	0.05	3	0.091	6	**4.5**	**3**

RAFT	MAE	rank	RMSE	rank	MEAN	RANK
Power (eff)	0.013	1	0.016	1	**1.0**	**1**
Ricker (eff)	0.015	2	0.02	2	**2.0**	**2**
R1C (naïve)	0.015	2	0.021	3	**2.5**	**3**

SCOTCH	MAE	rank	RMSE	rank	MEAN	RANK
RS1 (naïve)	0.039	1	0.054	1	**1.0**	**1**
Ricker (eff)-pi	0.04	2	0.058	2	**2.0**	**2**
Ricker (eff)-disch	0.044	3	0.082	3	**3.0**	**3**

SEYMOUR	MAE	rank	RMSE	rank	MEAN	RANK
Ricker (eff)-cyc	0.048	1	0.074	1	**1.0**	**1**
Larkin (eff)	0.067	2	0.087	2	**2.0**	**2**
RAC	0.083	3	0.144	3	**3.0**	**3**

RUN TIMING: SUMMER

CHILKO	MAE	rank	RMSE	rank	MEAN	RANK
Power (smolt)	0.781	1	1.181	2	**1.5**	**1**
Power (smolt)-ei	0.826	2	1.228	3	**2.5**	**2**
Larkin (eff)	0.883	6	1.101	1	**3.5**	**3**

LATE STUART	MAE	rank	RMSE	rank	MEAN	RANK
R1C (naïve)	0.504	1	0.901	1	**1.0**	**1**
Power (eff)	0.565	2	1.032	2	**2.0**	**2**
RAC (naïve)	0.579	4	1.057	3	**3.5**	**3**
R2C (naïve)	0.577	3	1.1	4	**3.5**	**3**

QUESNEL	MAE	rank	RMSE	rank	MEAN	RANK
Power (fry)-pi	1.24	1	1.474	1	**1.0**	**1**
Power (fry)-ei	1.786	2	2.12	2	**2.0**	**2**
RAC (naïve)	1.864	3	2.464	3	**3.0**	**3**
Larkin (eff)	1.894	4	3.444	8	**6.0**	**6**
Power (fry)	1.98	6	2.603	6	**6.0**	**6**

STELLAKO	MAE	rank	RMSE	rank	MEAN	RANK
Ricker (eff)-cyc	0.048	1	0.074	1	**1.0**	**1**
Larkin (eff)	0.23	2	0.282	2	**2.0**	**2**
R2C (naïve)	0.242	3	0.344	3	**3.0**	**3**

RUN TIMING: LATE

CULTUS	MAE	rank	RMSE	rank	MEAN	RANK
Smolt-jack	0.01	2	0.014	1	**1.5**	**1**
RSC (naïve)	0.011	2	0.018	2	**2.0**	**2**
Power (smolt)-peak	0.011	2	0.02	3	**2.5**	**3**
Power (smolt)-ei	0.011	2	0.02	3	**2.5**	**3**
Power (smolt)-pi	0.011	2	0.02	3	**2.5**	**3**
Power (smolt)-PDO	0.011	2	0.02	3	**2.5**	**3**
Power (smolt)	0.011	2	0.02	3	**2.5**	**3**

HARRISON	MAE	rank	RMSE	rank	MEAN	RANK
MRS (naïve)	0.039	2	0.077	1	**1.5**	**1**
R1C (naïve)	0.04	3	0.079	2	**2.5**	**2**
R2C (naïve)	0.04	3	0.084	3	**3.0**	**3**
Ricker (eff)-PDO	0.037	1	0.086	6	**3.5**	**4**
Ricker (eff)-disch	0.04	3	0.086	6	**4.5**	**5**
Power (eff)	0.042	7	0.086	6	**6.5**	**6**

LATE SHUSWAP	MAE	rank	RMSE	rank	MEAN	RANK
Ricker (eff)-cyc	0.817	2	1.351	1	**1.5**	**1**
RAC (naïve)	0.736	1	1.472	3	**2.0**	**2**
Ricker (eff)-peak	0.845	3	1.469	2	**2.5**	**3**
Ricker (eff)	0.891	5	1.543	4	**4.5**	**4**

PORTAGE	MAE	rank	RMSE	rank	MEAN	RANK
Ricker (eff)-cyc	0.034	1	0.038	1	**1.0**	**1**
Ricker (eff)	0.038	2	0.053	2	**2.0**	**2**
Power (eff)	0.038	2	0.054	3	**2.5**	**3**

WEAVER	MAE	rank	RMSE	rank	MEAN	RANK
Larkin (eff)	0.083	1	0.086	1	**1.0**	**1**
Ricker (eff)-cyc	0.127	2	0.178	2	**3.0**	**2**
Power (fry)-PDO	0.18	3	0.239	3	**4.0**	**3**

BIRKENHEAD	MAE	rank	RMSE	rank	MEAN	RANK
Power (eff)	0.278	1	0.4	2	**1.5**	**1**
Ricker (eff)-cyc	0.314	3	0.4	1	**2.0**	**2**
Larkin (eff)	0.303	2	0.414	3	**2.5**	**3**

Early Stuart Sockeye

The 2009 cycle line is the dominant cycle for the Early Stuart Run. Escapement in the 2005 brood year was 51,000 effective females, which is 36% of the cycle average (140,000 from 1980-2005) and the lowest Early Stuart Run escapement on this cycle year in 4 decades (Table

3). Spawning success in the brood year was high; physical conditions (water levels and temperature) on the spawning grounds were conducive to successful spawning.

Fry abundance is estimated in the Early Stuart system, however, due to inconsistencies in data collection further evaluation of this data is required for purposes other than providing an index of fry abundance. Therefore, fry data was not used to generate forecasts for 2009.

Using effective female spawner data, forecasts generated for the top two ranked models diverged (power and RS2: average recruits per spawner for the last two generations on the cycle); the median forecast of the top ranked model was more extreme than the 25% or 75% probability level forecast of the second ranked model. Given forecasts for these two models diverged, they were averaged (weighted by retrospective performance). Note: the third ranked model (Ricker with the Pacific Decadal Oscillation as a covariate) produced a forecast similar to the first ranked model.

The 2009 median (50% probability level) return forecast for Early Stuart Run sockeye is 255,000. Based on the 2009 forecast distribution there is a 25% probability the number of returning sockeye will exceed 426,000 sockeye and a 75% probability that the return will exceed 165,000 sockeye (Table 1). The 2009 forecast (50% probability forecast: 255,000) is below the long term average return for this cycle (1980-2005: 797,000). When comparing the past five year's forecasted returns with actual returns, the power model consistently overestimated returns at the 50% probability level. Forecasted returns for the power model at the 75% probability level were closer to actual returns for Early Stuart.

Early Summer Run Sockeye

The Early Summer Run consists of several small stocks. Eight stocks in this timing group have individual forecasts: Bowron, Fennell, Gates, Nadina, Pitt, Raft, Scotch, and Seymour (Table 1). Escapement in the 2005 brood year was 80,000 effective female spawners for these eight stocks which is above the cycle average of 52,000 (1980-2005). The total effective female spawners for the Early Summer Run including the miscellaneous stocks are 130,000. The North Thompson miscellaneous stock comprises the greatest percentage of this total escapement at 36%, followed by Pitt (25%), Raft (13%), and Nadina (10%).

For all eight stocks except Bowron and Seymour (both ~60% of the brood year effective female spawners), the effective number of female spawners in the brood year is similar (Fennell and Scotch) or greater (Gates, Nadina, Pitt, Raft) than the cycle average (1980-2005) (Table 3). For Nadina, the only Early Summer stock for which consistent juvenile (fry) assessments are conducted, fry numbers in the 2005 brood year (11 million) were above the long-term cycle average of 8 million (1980-2005).

Of the miscellaneous Early Summer Run stocks, Chilliwack Lake-Dolly Varden Creek (Upper Chilliwack River) and the North Thompson River is reported separately in Table 1 due to their high escapements in recent years. Chilliwack Lake-Dolly Varden Creek had a particularly high escapement in 2004 (20,000 effective female spawners) and, subsequent returns in 2008 were estimated at 83,000. The escapement for the 2005 brood year, however, was relatively low at 2,000 effective female spawners. Similarly, the North Thompson River has had high numbers of effective female spawners in recent years with 47,000 sockeye escaping in the 2005 brood year. Since there are no associated recruitment data for these two stocks, they are forecast similarly to all other miscellaneous Early Summer Run stocks through the product of the brood year effective female spawners and the average recruits per spawner for the eight stocks with stock and recruitment data.

Physical conditions (water levels and temperature) on the spawning grounds were conducive to successful spawning. Nonetheless, the egg-to-fry survival rates (assuming average fecundity of 4,000 eggs/spawner) for the 2005 brood year of Nadina (38%) was below average (1973-2006: 47%).

Forecasts generated for each of these eight stocks produced similar forecast distributions for the top three ranked models; the median forecast of one model was not more extreme than the 25% or 75% probability level forecast of another model. Although an alternative data set (fry data) exists for Gates creek, no comparative fry models were run for this system given the inconsistencies in assessment methods used to produce the fry data estimates. For Nadina, the only other Early Summer Run stock with fry data, the top ranked fry model (ranked 4^{th}) produced similar results to the top three ranked models that rely on effective female spawner data.

The 2009 median (50% probability level) return forecast for Early Summer Run sockeye is 739,000. Based on the 2009 forecast distribution there is a 25% probability the number of returning sockeye will exceed 1,338,000 sockeye and a 75% probability that the return will exceed 443,000 sockeye (Table 1). The 2009 forecast excluding the miscellaneous group (50% probability forecast: 443,000) is above the long term average return for this cycle (1980-2005: 316,000).

Summer Run Sockeye

The Summer Run consists of four stocks: Chilko, Late Stuart, Quesnel and Stellako (Table 1). The 2009 cycle is the dominant cycle for Late Stuart and Quesnel. Escapement in the 2005 brood year was 1.3 million effective female spawners for these four stocks which is below the cycle average of 1.6 million (1980-2005). Quesnel comprised the largest percentage of this total escapement (60%), followed by Chilko (20%), Late Stuart (10%), and Stellako (10%).
The number of effective female spawners in the 2005 brood year for Late Stuart and Quesnel was respectively, 54% and 21% below their cycle average (1980-2005) (Table 3). For Chilko and Stellako, the number of effective female spawners was respectively, 23% and 61% above their cycle average (1980-2005) (Table 3).

Spawning success in the 2005 brood year was high; physical conditions on the spawning grounds were conducive to successful spawning with water levels and temperature within an acceptable range.

Chilko and Quesnel stocks have juvenile data (smolt and fry data respectively); no juvenile assessments have been conducted for Stellako in recent years. Chilko juveniles are enumerated as smolts as they migrate through an enumeration fence. Chilko smolt numbers outmigrating in 2007 (2005 brood year) of 77 million were well above the cycle average of 23 million (1980-2005). Chilko smolt sizes in 2007 (88.4 mm) were also larger than average (82.9 mm $\pm$ 5.69). Quesnel fry are enumerated using hydroaccoustics in Quesnel Lake in the fall prior to their outmigration. Quesnel fry numbers in 2006 (2005 brood year) of 52 million were below the cycle average of 58 million (1980-2005). Quesnel fry sizes in 2007 (2.7 g) were smaller than the cycle average (3.6 g $\pm$ 0.6) and similar in size to the 2001 brood year (2.6 g) when survivals and consequently returns were poorer than average. These sizes, however, are not as small as the 2002 brood year (1.9 g) when returns were well below average.

For Chilko and Late Stuart, forecasts are similar for the top three ranked models; the median forecast of one model was not more extreme than the 25% or 75% probability level forecast of another model. For Chilko, only smolt models were compared given the unprecedented large number of smolts estimated for this stock relative to escapement. For Late Stuart, the top ranked naïve RAC model (average return for the cycle) was ruled out given the brood year escapement for this stock was half the cycle average and, therefore, the RAC forecast would overestimate returns. For Stellako, the model that performed best according to the retrospective analysis (Ricker-cycle) was ruled out given the brood year escapement was above all other escapements of the cycle line data set and when using the Ricker-cycle model produced a lower forecast. The third ranked model for Stellako (R2C) was also ruled out given the lower escapements in the past two cycle years relative to the 2005 brood year.

For Quesnel, top ranked models with environmental variables as covariates were ruled out. These models produced forecasts that increased or decreased conversely to all other stock's biological models with the same environmental covariates. For example, including a sea surface temperature covariate produced lower forecasts for Quesnel, despite the cooler than average water temperatures in 2007 that should have increased marine survival, and therefore, the forecast. The power (fry) and Larkin models ranked 6^{th} after environmental models and were used to generate the top forecasts. Given forecasts for these models diverged (the median forecast of one model was more extreme than the 25% or 75% probability level forecast of the other model), the two forecasts were averaged (weighted by retrospective performance).

The 2009 median (50% probability level) return forecast for Summer Run sockeye is 8,677,000. Based on the 2009 forecast distribution there is a 25% probability the number of returning sockeye will exceed 16,071,000 and a 75% probability that the return will exceed 4,914,000 sockeye (Table 1). The 2009 forecast (50% probability forecast: 8,677,000) is below the long term average return for this cycle (1980-2005: 11,000,000).

Late Run Sockeye

The Late Run consists of six stocks: Cultus, Harrison, Late Shuswap, Portage, Weaver, and Birkenhead (Table 3). The 2005 brood year is on an off cycle for the highly cyclic Late Shuswap stock. Escapement in the 2005 brood year was 280,000 effective female spawners for these stocks which is above the cycle average of 100,000 (1980-2005). In 2005, the total number of effective female Late Run spawners, including the miscellaneous stocks was 290,000. The spawning escapement for Harrison, in particular, has been well above documented escapements in the 2005 (200,000 effective females) and 2006 (90,000 effective females) brood years; Harrison is comprised of age-4 (4_1) fish and age-3 (3_1).

For all stocks except Cultus and Birkenhead, the brood year escapements were above their 1980-2005 cycle average (Table 3); Harrison (85%), Late Shuswap (72%), Portage (41%), and Weaver (20%). Cultus had a particularly low brood year escapement (52 effective spawners: 112 adult spawners x 0.53 spawner success) at 1% of the cycle average (4,500 effective spawners). However, due to hatchery supplementation of fry and smolts into the Cultus system, the number of outmigrating smolts (98,000) was above the cycle average (1980-2005)(Table 3) for this stock (50,000) and a smolt-jack model was used to forecast the number of returning salmon for this stock. Almost all smolts outmigrating in 2007 (2009 returns) were hatchery origin. Of the total outmigrating smolts, 90% were adipose-fin clipped indicating they were hatchery origin and 10% were unclipped (adipose-fin present). The 10% unclipped fish likely has a large component of hatchery-origin fish given unclipped hatchery fry were released into the lake in 2006 (outmigrated as smolts in 2007); currently, it is not possible to determine the proportion of outmigrating smolts that were wild versus hatchery origin.

Weaver was the other stock where a juvenile salmon model was used to forecast returns. Fry numbers (36 million) estimated for Weaver in 2006 (2005 brood year) were above the cycle average of 26 million. Juvenile abundance (hydroacoustic estimates) for Late Shuswap sockeye was not estimated in 2006.

Spawning success in the 2005 brood year was high; physical conditions on the spawning grounds were conducive to successful spawning with water levels and temperature within an acceptable range.

To forecast Harrison 2009 returns, an estimate of age-3 and age-4 returns for the 2005 brood year was generated to produce a stock-recruit data point in the recent year's high escapement range; without this no data existed to inform the model at the recent year's high escapements. Age-3 returns in 2008 (2005 brood year) were estimated as a product of in-season return estimated in 2008 (~46,000) and the proportion age-3's in these returns (~9%). Age-4 returns in 2009 (2005 brood year) were estimated based on the proportion of total recruits age-4's comprise using the age-3 returns in 2008 estimate. Using this extra data point in the Harrison stock-recruit time series, forecasts were generated for the top ranked models for this stock.
The Harrison forecast has greater uncertainty compared to all other forecasts. In-season Harrison run size estimate for 2008 used to estimate the 2005 brood year returns are preliminary and the 2005 (age-4's returning in 2009) and 2006 (age-3's returning in 2009) brood year escapements were estimated with lower accuracy/precision visual survey methods, despite recent large escapements.

Forecasts generated for the top three ranked models for all six Late Run stocks produced similar forecast distributions (see METHODS). For Cultus, naïve and adult models were excluded from comparisons given the hatchery supplementation of this stock which resulted in above average smolt outmigration despite low numbers of adult spawners in recent years. For Harrison, given the well above average brood year escapements in 2005 and 2006, naïve models were ruled out and only biological models were used. For Weaver, the top model using fry data (ranked 4^{th}) produced similar results compared to the top three ranked models based on effective female spawner numbers. For Late Shuswap, the naïve model RAC (average return across the cycles) was ruled out given the 2005 brood year escapement was approximately four times the cycle average escapement making it likely for the RAC model to underestimate returns.

The 2009 median (50% probability level) return forecast for Late Run sockeye is 907,000. Based on the 2009 forecast distribution there is a 25% probability the number of returning sockeye will exceed 1,616,000 sockeye and a 75% probability that the return will exceed 517,000 sockeye (Table 1). The 2009 forecast excluding the miscellaneous groups (50% probability forecast: 843,000) is below the long term average return for this cycle (1980 to 2005: 1,036,000).

Pink Salmon

Fraser pink salmon are age-2 fish (2_1), spending their first winter in freshwater and their last winter in the marine environment, prior to returning to the freshwater to spawn; Fraser pink salmon immediately migrate to the ocean after their emergence from the spawning gravel. In the Fraser River, pink salmon are an odd year run with negligible numbers migrating to the system in even years. Therefore, pink salmon that return in 2009 are recruited from eggs spawned by adults in 2007 (brood year). The total number of outmigrating fry in 2008 (2007 brood year) was 500 million, which is greater than the long term average of 400 million (1961-2007). Forecasts generated for the top ranked models produced similar forecast distributions; the median forecast of one model was not more extreme than the 25% or 75% probability level forecast of another model.

The 2009 median (50% probability level) return forecast for Fraser River pink salmon is 17.5 million. Based on the 2009 forecast distribution there is there is a 25% probability the number of returning pink salmon will exceed 24.9 million and a 75% probability that the return will exceed 12.5 million (Table 1). The 2009 forecast is above the long term average return for Fraser River pink salmon (1961-2005: 12 million).

CONCLUSIONS

Forecasts are associated with relatively high uncertainty, consistent with previous Fraser sockeye forecast PSARC reviews (Cass *et al.* 2006) and recent research on coast-wide salmon stocks (Haeseker *et al.* 2007 & 2008). In attempts to improve forecast performance, individual ocean indicators of salmon survival (e.g. sea-surface temperature, Fraser discharge, etc.) have been used as covariates in forecast models and compared retrospectively. However, environmental variables explored to date have not explained a significant component of salmon survival or recruitment variability (Myers 1998; Mueter *et al.* 2005; Cass *et. al* 2006) and individual indicators alone have also not been able to explain the extremely poor ocean survival conditions encountered by sockeye salmon that migrated to the ocean in 2005 and returned in poor numbers (well below forecast) in 2007. In a recent study that explored systemic temporal shifts in productivity (annual Ricker-*a* parameter estimates) between salmon species and stocks, no consistent productivity trends were identified specifically for Fraser sockeye stocks (Dorner *et al.* 2008). These results suggest that the survival responses of Fraser sockeye to environmental and other factors are complex and, at present, not well understood (Dorner *et al.* 2008).

Wild Salmon Policy Conservation Units

To protect biological diversity of wild salmon stocks, the first strategy described by the *Wild Salmon Policy* (DFO 2005) includes the identification and inventory of the units of diversity to conserve. The methodology for the identification of Pacific wild salmon conservation units (CU's) and the CU's are reported in Holtby & Ciruna (2007). For future conservation and management of salmon resources, the CU's that each forecasted stock comprises is numerically referenced from 1 to 32 in Table 1, with the corresponding CU name and index listed in Table 2.

Ocean Conditions

To provide some indication of survival conditions for Fraser River sockeye salmon, a compilation of ocean survival indicators for salmon are presented (Table 5) to qualitatively compare relative ocean survival conditions from 1998 to 2007. Annual ocean indicators are linked to the period sockeye salmon first migrate to the ocean (e.g. 2007 for most sockeye returning in 2009), when salmon are at their smallest size in their ocean phase and, therefore, most vulnerable to size-dependent mortality.

The methodology for ranking individual indicators is based on W.T. Peterson's (U.S. Northwest Fisheries Sciences Centre, National Ocean and Atmospheric Agency) approach: http://www.nwfsc.noaa.gov/research/divisions/fed/oeip/g-forecast.cfm. Currently, the suite of ocean indicators explored only partially track Chilko marine survival (marine survival indicator system for Fraser sockeye stocks) (Table 5). This suggests that more ocean indicators need to be explored and/or developed to improve forecasting methodology. The suite of indicators currently used (Table 5) does provide a strong indication of the very poor ocean survival conditions experienced by Fraser sockeye in 2005 (poor returns in 2007). Therefore, it may provide an indication of below average returns. **For sockeye returning in 2009, ocean conditions in their juvenile outmigration period (spring/summer 2007) were good for most physical and biological indicators (Table 5). Although emphasis on median probability levels (50%) is recommended for 2009 sockeye return forecasts, further work is required for ocean indicators of sockeye survival. The indicators of ocean condition are as follows:**

1. Pacific Decadal Oscillation (PDO): a broad index of sea surface temperature in the North Pacific (Mantua *et al.* 1997); http://jisao.washington.edu/pdo/PDO.latest

2. Aleutian Low Pressure Index (ALPI): an index of the relative intensity of the Aleutian Low pressure system of the North Pacific in the winter period (Beamish *et al.* 1997); http://www.pac.dfo-mpo.gc.ca/sci/sa-mfpd/downloads/indices/alpi.txt

3. Sea-Surface-Temperature (SST) Entrance Island: average SST data (April to June) in the SOG where juvenile Fraser sockeye first enter the marine environment. http://www.pac.dfo-mpo.gc.ca/sci/OSAP/data/SearchTools/Searchlighthouse_e.htm

4. Sea-Surface-Temperature (SST) Pine Island: average SST data (April to July) on the northern tip of Vancouver Island (see previous weblink).

5. Coastal Upwelling Index (CUI): an index of the coastal water volume that upwells (Bakun 1973); can provide an indication of coastal ocean productivity. http://www.pfeg.noaa.gov/products/PFEL/modeled/indices/upwelling/NA/upwell_menu_NA.html

6. Physical Spring Transition: the period in the coastal ocean when the winter downwelling period transitions to a summer upwelling period. Generally the earlier this transition the more productive the coastal ocean (See previous (CUI) weblink).

7. Southern Copepods (SVI: Southern Vancouver Island & NVI: Northern Vancouver Island): typically occur in more southern latitudes (e.g. coastal California); their increased abundance in coastal BC waters provides an indication of warmer ocean conditions; southern copepods are smaller and have a lower energetic content compared to boreal shelf copepods (data obtained from D.L. Mackas, Institute of Ocean Sciences, Canadian Department of Fisheries and Oceans; see Irvine & Crawford 2008).

8. Boreal Shelf Copepods (SVI: Southern Vancouver Island & NVI: Northern Vancouver Island): typically occur in BC coastal waters; their abundance in coastal BC waters provides an indication of average to cooler ocean conditions; boreal shelf copepods are larger and have a higher energetic content (see previous reference).

Table 5. Indicators of ocean conditions (1998-2007) (methodology & approach from W.T. Peterson, U.S. NFSC, NOAA). For 2009 returns: most sockeye (age-4's) spawned in 2005 and migrated to the ocean in 2007. All data used is referenced above. For each indicator, annual estimates were ranked across all years from 1 to 10 from best to worst salmon ocean survival conditions. Green (G): ranks 1 to 4; yellow (Y): ranks 5 to 7; red (R): ranks 7 to 10.

(BROOD YEAR) **OCEAN ENTRY YEAR** (RETURN YEAR)	(1996) **1998** (2000)	(1997) **1999** (2001)	(1998) **2000** (2002)	(1999) **2001** (2003)	(2000) **2002** (2004)	(2001) **2003** (2005)	(2002) **2004** (2006)	(2003) **2005** (2007)	(2004) **2006** (2008)	(2005) **2007** (2009)
Chilko Marine Survival	G	Y	G	G	R	Y	G	R	NA	NA
Ocean Indices										
1 PDO (Jan-March average)	R	G	G	R	G	R	R	R	Y	Y
2 ALPI	R	G	Y	R	R	R	R	Y	G	G
Physical Conditions										
3 SST (Entrance Island)	R	G	G	G	G	R	R	R	Y	Y
4 SST (Pine Island)	R	G	G	G	Y	R	R	R	Y	G
5 Upwelling index (48ºN)	G	G	R	Y	G	R	Y	R	Y	G
6 Spring transition timing (48ºN)	G	G	Y	Y	G	Y	Y	R	Y	Y
Biological Conditions										
7 Southern Copepods (SVI)	R	G	Y	G	G	R	Y	R	R	G
8 Boreal Shelf Copepods (SVI)	R	G	G	Y	G	Y	R	R	R	G
9 Southern Copepods (NVI)	R	G	G	G	Y	R	Y	R	R	G
10 Boreal Shelf Copepods (NVI)	Y	G	G	R	G	R	R	R	Y	G

SOURCES OF INFORMATION

Bakun, A. 1973. Coastal upwelling indices, west coast of North America, 1946–71. U.S. Department of Commerce, NOAA Technical Report NMFS–SSRF–671.

Beamish, R.J., Neville, C.E., & Cass, A.J. 1997. Production of Fraser River sockeye salmon (*Oncorhynchus nerka*) in relation to decadal-scale changes in the climate and the ocean. Can. J. Fish. Aquat. Sci. 54: 543-554.

Cass, A.J., Folkes, M., Parken, C.K., & Wood, C.C. 2006. Pre-season run size f orecasts for Fraser River sockeye for 2006. PSARC Working Paper S2006/060.

DFO. 2005. Canada's policy for conservation of wild Pacific salmon. Fisheries & Oceans Canada, 401 Burrard St., Vancouver, BC, V6C 3S4. p. 49+v.

DFO. 2007. Pre-season run size forecasts for Fraser River sockeye and pink salmon in 2008. DFO Can. Sci. Advis. Rep. 2007/049.

DFO. 2008. State of the Pacific Ocean 2007. DFO Can. Sci. Advis. Rep. 2008/028

Dorner, B., Peterman, R.M., & Haeseker, S.L. 2008. Historical trends in productivity of 120 Pacific pink, chum and sockeye salmon stocks reconstructed by using a Kalman filter. Can. J. Fish. Aquat. Sci. 65: 1842-1866.

Haeseker, S.L., Dorner, B., Peterman, R.M., & Zhenming, S. 2007. An improved sibling model for forecasting chum salmon and sockeye salmon abundance. N. Am. J. Fish. Manag. 27: 634-642.

Haeseker, S.L., Peterman, R.M., & Zhenming, S. 2008. Retrospective evaluation of preseason forecasting models for sockeye and chum salmon. N. Am. J. Fish. Manag. 28: 12-29.

Irvine, J. & Crawford, W. (editors). 2008. State of physical, biological, and selected fishery resources of Pacific Canadian marine ecosystems. CSAS Res. Doc. 2008/013. 109 pp.

Mantua, N.J., Hare, S.R., Zhang, Y., Wallace, J.M., & and Francis, R.C. 1997. A Pacific decadal climate oscillation with impacts on salmon. Bull. Am. Meterol. Soc. 78: 1069-1079.

Mueter, F.J., Pyper, B.J., & Peterman, R.M. 2005. Relationship between coastal ocean conditions and survival rates of Northeast Pacific Salmon at multiple lags. Trans. Am. Fish. Soc. 134: 105-119.

Myers, R.A. 1998. When do environment-recruitment correlations work? Rev. Fish. Bio. Fish. 8: 285-305.

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