Puget Sound Chinook Harvest Management Performance Assessment 2003 – 2010

Puget Sound Indian Tribes
And
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Executive Summary

This report assesses Puget Sound Chinook harvest management performance for management years 2003-04 through 2010-11. Comparison of pre-season and post-season (validation) FRAM estimates of total and southern U.S. exploitation rates can determine if the ceiling rates stipulated by the Harvest Plan have been exceeded, and whether there is consistent positive or negative deviation for a given management unit. For this recent time period, post-season deviations from pre-season rates vary widely for a given management unit, but they are not consistently negative or positive. Generally, validation runs indicate that SUS or total exploitation rate ceilings have not been exceeded, but such incidents are examined below.

Deviations from projected commercial and recreational catch are also summarized to detect consistent differences that might be addressed by adjusting pre-season planning. Generally deviations for a given marine region or river are not consistently negative or positive. Forecast accuracy is also examined, based on uniformly obtained values of terminal abundance for each management unit. Forecast error also varies widely for each unit, but we did not detect consistent errors.

The current status of each Chinook population is assessed from the time series of estimates of natural escapement, to provide a context for assessing management error. We used adjusted estimates for many populations, and limited assessment of NOR escapement in particular to years when these estimates have been based on consistent methods and adequate carcass sampling. However, for many populations NOR abundance is uncertain.

Management response to critical status (i.e. implantation of the CER ceiling when projected escapement is lower than the Low Abundance Threshold) was appropriate in most cases. The Nooksack early and Mid Hood Canal management units were in critical status for 2003 – 2010. The Stillaguamish was managed under the critical ER ceiling in 2006 – 2008 and 2010, due to projected higher ERs associated with northern fisheries, or due to forecasted critical abundance for the fall stock. Pre-season models did not anticipate escapement below the LAT for the summer stock that was observed in 2007, 2009, and 2010. The Snohomish was managed under the critical ER ceiling in 2004 – 2009 due to higher ERs associated with northern fisheries. Observed escapement to the Skykomish was less than the LAT in 2007 and 2009. Pre-season models did not project the observed escapements to the Green River in 2009 and 2010 that were lower than the LAT. Projected escapement to the Dungeness was projected to be less than the LAT in 2003 and 2004, but actual escapement was higher than the LAT. Pre-season models did not anticipate that escapement would be less than the LAT in 2007 – 2010.

Fisheries that contributed to exceeding ER ceilings are described with reference to deviations from pre-season, fishery-specific harvest rates.

	Validation ER (ER ceiling)
Skagit Summer Fall	2007 55%; 2009 - 65% (50% Total)
Stillaguamish	2007 22% (15% SUS)
Snohomish	2003 - 25% (24% Total); 2007 - 21% (15% SUS); 2009 - 17% (15% SUS)
White	2004 - 32%; 2006 - 34% (20% Total)
Puyallup	2003 - 2010 - 51% - 71% (50% Total)
Nisqually	2010 - 67% (65% Total)
Skokomish	2010 - 56% (50% Total)
Dungeness	2004 - 7% (5% SUS)

Deviations from pre-season projected total and SUS exploitation rates (ER) are quantified for each management unit. Mean deviations in total ER range from -6% to +9%, equivalent to a range of 8% to 28% when expressed as a proportion of the projected ER. Mean deviations in SUS ER range from -5% to + 7%, equivalent to a range of 14% to 74% when expressed as a proportion of the projected SUS ER.

Mean deviations in observed, landed, commercial catch from pre-season modeled values ranged from -17% to +48% among regions of Puget Sound.

	Min	Max	Mean
SJDF Net &Troll	-62%	394%	14%
7/7A Net	-98%	59%	-13%
7B/C/D	-55%	91%	-5%
8 & Skagit R	-54%	90%	8%
8A & 8D	-48%	69%	5%
Mid Sound	-65%	72%	-17%
South Sound	-5%	124%	33%
Hood Canal	-36%	193%	48%
Total	-19%	29%	3%

Landed, marine, recreational catch for all Puget Sound areas combined was lower than projected for all years except 2007. Average deviations for individual marine areas ranged from -62% to +69%.

	Average	Min	Max
Area 5/6	1%	-55%	91%
Area 7	-6%	-50%	39%
Area 8-1 & 8-2	-30%	-87%	8%
Area 8D	-62%	-91%	1%
Area 9	-43%	-85%	7%
Area 10	-39%	-80%	86%
Area 10A	-46%	-91%	-9%
Area 10E	14%	-58%	125%
Area 11	-9%	-47%	43%
Area 12	69%	18%	119%
Area 13	-21%	-71%	35%
Total	-22%	-46%	20%

We assessed deviations in freshwater, recreational fishing mortality from pre-season projections for the Skagit, Skykomish, Puyallup-Carbon, Nisqually, and Skokomish rivers. Mean deviations in mortality of marked and unmarked Chinook ranged from -25% to +80%.

We quantified trends in natural escapement for each population with two statistical methods: regression of log-transformed estimates against time, and the method of Geiger and Zhang (2002). Regression detected significant negative trends for the Suiattle, Lower Sauk, Lower Skagit, Skykomish, Cedar, Puyallup (South Prairie Creek), and Elwha populations, and significant positive trends for the North/Middle Fork Nooksack, Cascade, Stillaguamish summer, Snoqualmie, White, Nisqually, and Dungeness. The Geiger and Zhang method detected 'biologically significant' 15- and/or 21-year negative trends for the South Fork Nooksack, Stillaguamish fall, Green, and mid-Hood Canal populations, and significant positive trends for the North/Middle Forks Nooksack, Upper Skagit, Snoqualmie, Cedar, White, Nisqually, and Dungeness.

Qualitative inspection of natural escapement indicates more recent declining escapement for the Suiattle, all three Skagit summer-fall, Stillaguamish summer and fall (NORs), Skykomish, Snoqualmie, and Skokomish (NORs) populations.

We compared pre-season projections to observed terminal area abundance to quantify forecast error for each management unit, and found that errors ranged broadly for all management units:

	Minimum	Maximum
Nooksack Early	-1.411	0.437
Skagit summer fall natural	-0.974	0.193
Skagit spring natural	-1.370	0.486
Stillaguamish natural	-1.146	0.448
Snohomish natural	-2.158	0.418
Wallace Hatchery	-0.749	1.181
Lake Washington aggregate	-1.913	0.607
Green aggregate	-0.936	0.174
White aggregate	-1.856	-0.132
Puyallup aggregate	-0.807	0.416
Nisqually aggregate	-0.448	0.391
Skokomish natural	-1.659	0.484
Mid HC natural	-2.689	0.805
Geo Adams Hatchery	0.006	0.578
Hoodsport Hatchery	-1.704	0.414
Dungeness aggregate	-3.303	0.515
Elwha aggregate	-1.120	0.367
Hoko aggregate	-2.499	0.604

This report assesses management performance in the context of population abundance status, to inform the changes in management. However, decisions with regard to changes in management objectives or revision of management tools deferred to the fisheries managers.

1 EXPLOITATION RATES

This chapter compares projected exploitation rates (ER) estimated by the final pre-season FRAM runs to observed exploitation rates estimated by FRAM validation runs, and to the ER ceilings implemented for each management unit, for management years 2003-04 through 2010-11. Assessment of management performance in achieving the Harvest Plan objectives also looks for consistent patterns in the annual deviations of exploitation rates from pre-season projections, which may warrant changes in pre-season management strategy or changes in the model, to improve the accuracy of projections.

1.1 Changes in Exploitation Rate Objectives

Three versions of the Harvest Plan were implemented during the eight management years under review, but there were few changes in ER ceilings:

- Critical ER ceilings were implemented for all management units in the 2004 Plan.
- The Skagit spring ER ceiling was lowered from 42% in the 2003 Plan to 38% in the 2004 and 2010 Plans
- The Skagit Summer Fall ER ceiling was lowered from 52% in the 2003 Plan to 50% in the 2004 and 2010 Plans
- The Snohomish ER ceiling was lowered from 24% to 21% in the 2004 Plan
- The Lake Washington (Cedar) ER ceiling was revised from 15% PT SUS to 20% SUS in the 2010 Plan
- A stepped ER ceiling was implemented for Nisqually in the 2010 Plan
- A 50% ER ceiling was implemented for the Skokomish in the 2010 Plan

Table 1-1 Abundance-based management objectives implemented under the 2003, 2004, and 2010 Harvest Management Plans

	2003 Plan		2004 Plan		2010 Plan	
	ER Ceiling	Critical ER	Total ER	Critical ER	Total ER	Critical ER
Nooksack		5 - 9% SUS		7%/9% SUS		7%/9% SUS
Skagit Spring	42%	21 - 27%	38%	18% SUS	38%	18% SUS
Skagit Summer Fall	52%	25 - 33%	50%	15% / 17%	50%	15% / 17%
Stillaguamish	25%	12 - 16%	25%	15% SUS	25%	15% SUS
Snohomish	24%	18 - 26%	21%	15% SUS	21%	15% SUS
Cedar	15% PT SUS	9 - 15% PT SUS	15% PT SUS	12% PT SUS	20% SUS	10% PT SUS
Green	15% PT SUS	7 - 15% PT SUS	15% PT SUS	12% PT SUS	15% PT SUS	12% PT SUS
White	20%	12 - 14%	20%	15% SUS	20%	15% SUS
Puyallup	50%	36 - 46%	50%	12% PT SUS	50%	12% PT SUS
Nisqually					65%-56%- 47%	
Skokomish	15% PT SUS	11 - 15% PT SUS	15% PT SUS	12% PT SUS	50%	12% PT SUS
Mid-Hood Canal	15% PT SUS	11 - 15% PT SUS	15% PT SUS	12% PT SUS	15% PT SUS	12% PT SUS
Dungeness	10% SUS	5 - 10% SUS	10% SUS	6% SUS	10% SUS	6% SUS
Elwha	10% SUS	5 - 10% SUS	10% SUS	6% SUS	10% SUS	6% SUS
Western Strait-Hoko	10% SUS	5 - 10% SUS	10% SUS	6% SUS	10% SUS	6% SUS

Critical ER ceilings were implemented when escapement projected by the Terminal Area Management Modules (TAMM) was less than the low abundance threshold (LAT), or when northern fisheries caused the total exploitation rate (ER) ceiling to be exceeded, even with minimal SUS fisheries. For MUs comprising more than one population, projected escapement below the LAT for any population was sufficient to trigger the critical ER ceiling.

For most of the management units, pre-season harvest planning refers to ERs associated with the unmarked component for comparison to the implemented ER ceiling. For the Nooksack, Skagit summer-fall, Dungeness, and Elwha units, planning refers to the ER associated with the aggregate of marked and unmarked components.

When the 2004 Plan was implemented (management years 2004 – 2009) the effective critical ER ceilings were in a few cases adjusted downward according to rates output from the 'base year regulation' model run. Base year fishery scalars (representing the Minimum Fisheries Regime) and forecasted abundance scalars for the current year were input to these models. These adjustments were made for the Nooksack early (2006 and 2008), Stillaguamish (2006), and Mid Hood Canal (2006 and 2007) MUs.

1.2 Preseason Management Response to Critical Status

The Harvest Plans set Low Abundance Thresholds to trigger implementation of critical ER ceilings during pre-season planning. The section below describes occurrences of (1) the critical response not being implemented, because forecasting and pre-season planning did not anticipate escapements lower than the LATs; and (2) implementation of the critical response when observed escapement exceeded the LAT.

Nooksack Early: Projected escapement was below the LAT (2000) in all years; Forecasted abundance has not been close to 1000 NORs for either population;

Skagit Spring: Projected MU escapement exceeded the LAT in all years. Suiattle spring abundance, parsed from the projected MU total, was not projected to fall below the LAT (170) in 2007, but the observed escapement was 108. In 2010 Suiattle abundance was projected lower than the LAT, triggering the critical ER ceiling. Observed escapement in 2010 exceeded the LAT.

Skagit Summer-Fall: Projected management unit escapement exceeded the UMT in 2004 – 2006, and 2008 – 2009. Projected management unit total escapement did not fall close to the LAT (4800). The Skagit S-F critical ER ceiling was implemented once in 2007 because the projected total ER (52%) exceeded the ER ceiling (50%) due to northern fishery mortality. Observed escapement to the Lower Sauk was below the LAT (400) in 2007, and 2009-2011. Observed Lower Skagit abundance was lower than the LAT (900) in 2011.

Stillaguamish: The critical ER ceiling was implemented during pre-season planning for the Stillaguamish unit, in 2008, 2010, and 2011 because projected abundance was below the LAT, and in 2006 and 2007 because the total ER ceiling (25%) was exceeded due to mortality in northern fisheries. The management unit LAT was increased to 700 in the 2010 Plan, by setting the South Fork LAT to 200; in previous plans the MU LAT was 650, but an LAT was not specified for the South Fork. Projection of South Fork escapement lower than the LAT triggered the critical response in 2010 and 2011. Observed South Fork escapement was below 200 in all years except 2006 and 2008.

Forecasting and pre-season harvest planning did not anticipate critical North Fork status in 2007, 2009, and 2010, when observed NOR escapements were less than the LAT (500). North Fork abundance was much lower than forecasted in 2007.

Snohomish: The Snohomish critical ER ceiling was implemented in 2004 – 2009, and 2011 because the projected total ER exceeded the ER ceiling due to northern fishery mortality. Projected MU escapements were never close to the LAT 2,800. Observed NOR escapement to the Skykomish was lower than the LAT (1745 NORs) in 2007, 2009, and 2011. Observed Snoqualmie escapement was less than the LAT (521 NORs) in 2011.

Lake Washington (Cedar): Projected and observed escapement to the Cedar River exceeded the LAT (200) all years; the last year observed escapement was below 200 was in 2000.

Green: Projected escapements exceeded 5800 in all years (the intent of pre-season planning and in-season management has been to achieve that goal). Observed escapement was less than 5800 in 2005, and 2007, and in 2009-2011 was less than the LAT (1800). The directed terminal fishery did not occur in 2010 due to the low test fishery catch. In 2011 the second night of treaty fishing was canceled even know the criteria was met from the first commercial opening. This was in reaction to the low catch that occurred in Elliott bay. Higher than expected terminal Chinook catch occurred in 2011, incidental to the coho fishery.

White: Projected and observed escapement exceeded the LAT (500) all years.

Puyallup: Projected and observed escapement exceeded the LAT (MU total 500) in all years. Post-season harvest management assessment refers to escapement in the South Prairie Creek index, i.e. assumes that 500 or more spawners indicates adequate seeding of all habitat in the basin. Observed total escapements have exceeded 1000 all years, even when South Prairie Creek escapement was less than 500 (i.e., in 2005, 2010, and 2011.

Nisqually: In 2003 - 2010, harvest of Nisqually Chinook was managed to achieve natural escapement of 1100 (Plan UMT); the goal was raised to 1200 when the Nisqually Chinook Recovery Plan was updated. Harvest Plans have not specified an LAT for Nisqually. Projected escapements were always above 1100. Observed escapement was less than 1100 in 2003 and 2009.

Skokomish: Projected escapements exceeded 1200 in all years. Observed escapement exceeded 800 all years except 2007; it was less than 1200 in 2008 and 2009. The hatchery component of the LAT (500) has been exceeded in all recent years.

Mid Hood Canal: Projected escapement was less than the LAT (400) all years 2004-2011. Observed escapement was also less than 400 all years back to 2001, and prior to 1997. Observed escapement was less than projected except in 2008 and 2011.

Dungeness: Projected escapement was lower than the LAT (500) in 2003 and 2004, and close in 2010 (535), but observed escapements exceeded 500 in those years. Pre-season planning did not anticipate that escapement would be lower than the LAT in 2007 – 2010. For a period prior to 2000, before the hatchery program began, escapements were less 200.

Table 1-2 Forecasted and observed escapement relative to LATs.

Yellow highlight indicates years where critical abundance was forecasted; red highlight indicates years where it was not forecasted;

	Nooksack		Suiattle		Lower Sauk		Lower Skagit		Stillaguamish			Snohomish		Mid Hood Canal		Dungeness	
	LAT = 2000		LAT = 170		LAT = 400		LAT = 900		LAT 500+200			Skykomish LAT = 1745		LAT = 400		LAT = 500	
	Project	Observ	Project	Observ	Project	Observ	Project	Observ	Project	NF Obsv	SF Obsv	Snoh Projected	Sky Observed	Project	Observ	Project	Observ
2003	399	279							2322	661	106	5073		531	194	352	640
2004	570	343							1891	1123	169	9341		298	129	461	1014
2005	822	229							1572	576	89	10487		185	45	675	1077
2006	682	337							872	756	219	6523	4815	104	30	844	1543
2007	565	363	503	108	465	383			782	214	40	9552	1510	114	73	1101	403
2008	375	390							355	872	278	4401	4780	57	273	1033	229
2009	315	314			1025	250			875	497	43	6665	1146	114	130	786	220
2010	439	228			537	356			685	479	21	7835	1836	138	82	535	457
2011	289		159	215	537	210	1759	820	665	538	104	6484	880	142	289	844	665

1.3 Exceeded ER Ceilings

This section summarizes the incidents of validation ERs exceeding the implemented ER ceilings for management years 2003 – 2010. Where they are identifiable, contributing factors are described in the MU analyses below.

Table 1-3 Incidence of exceeded ER ceilings.

	Validation ER (ER ceiling)
Skagit Summer Fall	2007 55%; 2009 - 66% (50% Total)
Stillaguamish	2007 21% (15% SUS)
Snohomish	2003 - 25% (24% Total); 2007 - 20% (15% SUS); 2009 - 17% (15% SUS)
White	2004 - 32%; 2006 - 34% (20% Total)
Puyallup	2003 - 2010 - 51% - 71% (50% Total)
Nisqually	2010 - 66% (65% Total)
Skokomish	2010 - 56% (50% Total)
Dungeness	2004 - 7% (5% SUS)

In the summary tables for each management unit, the fishery specific ER deviations (validation – pre-season) are tabulated, with positive deviations shaded red.

Skagit Summer Fall

The total ER exceeded the ER ceiling in 2007 and 2009. The 2007 validation total ER (55%) was higher than the pre-season projection (52%), due to the deviation in northern fisheries ER (+3%). The northern fisheries ER was substantially higher in 2007 than previous years (e.g. validation ER was 43% for 2007, and 21% for 2006).

Table 1-4 2007 and 2009 Pre-season and validation ERs for Skagit summer-fall Chinook.

	2007		2009	
	Pre-season	Validation	Pre-season	Validation
SUS	14%	13%	25%	32%
Total	52%	55%	49%	66%

In 2009, the higher total ER (66%) was primarily due to the +12% deviation in northern fisheries. The SUS ER was also higher than projected (+7%), due to the +7% deviation in the terminal net fishery.

Table 1-5 Fishery specific ER deviations (validation vs. pre-season) for Skagit summer-fall Chinook, 2007 and 2009.

	2007	2009
Alaska	0.023	0.015
Canada	0.011	0.100
South Of Falcon Ocean	0.000	0.000
NOF Ocean Troll:	-0.001	-0.001
	-0.001	-0.003
NOF Ocean & B10 Spt	-0.001	0.000
Pgt Snd Trty Troll	0.000	0.004
Pgt Snd 6 Sport		0.000
Pgt Snd 5 Sport	-0.001	0.000
Pgt Snd 7 Sport	0.004	-0.004
Pgt Snd 8-13 Sport	0.001	0.001
Preterm. Pgt Snd or Out-of-Region net:	-0.004	-0.005
	-0.006	-0.003
Terminal Pgt Snd or Local Terminal Net:	0.000	0.001
	0.000	-0.003
Freshwater Sport:	0.003	-0.008
Freshwater Net:	-0.002	0.085

Note: in this and all following ER tables in this section, red highlit cells indicate where pre-season ER projections were exceeded.

Stillaguamish

The SUS ER exceeded the critical ER ceiling (15%) in 2007, which was in effect because northern fisheries caused the ER ceiling (25%) to be exceeded.

Table 1-6 2007 pre-season and validation SUS ERs for Stillaguamish Chinook.

	Pre-season	Validation
North	17%	15%
SUS	15%	21%
Total	32%	36%

The validation model estimated the northern fishery ER (15%) to be lower than the SUS ER (21%). The +6% SUS deviation was primarily attributable to higher than expected mortality in the Area 8 – 13 recreational fisheries. Landed catch in Area 10 and 11 sport fisheries was higher than projected (see Chapter 3).

Table 1-7 Deviations (pre-season vs. validation) in fishery-specific ERs for Stillaguamish Chinook in 2007.

Alaska	0.005
Canada	-0.032
S. Of Falcon Ocean	0.000
NOF Ocean Troll: NT	0.001
Tr	0.002
Ocean & Buoy10 Spt	0.000
Pgt Snd Trty Troll	0.001
Pgt Snd 5,6 Sport	0.004
Pgt Snd 7 Sport	0.010
Pgt Snd 8-13 Sport	0.075
Out-of-Region net NT	-0.002
Tr	-0.007
Local Terminal Net NT	0.000
Tr	-0.001
Freshwater Sport \5	-0.005
Freshwater Net \5	-0.018

Snohomish

The total ER exceeded the ER ceiling (24%) by 1% in 2003, and the SUS ER exceeded the CERC (15%) in 2007 and 2009 (when northern fisheries caused the ER ceiling to be exceeded).

Table 1-8 Pre-season and validation ERs for Snohomish Chinook in 2003, 2007 and 2009.

	2003		2007		2009	
	Pre-season	Valid	Pre-season	Valid	Pre-season	Valid
North	6%	11%	22%	14%	12%	14%
SUS	15%	14%	13%	20%	14%	17%
Total	20%	25%	35%	34%	26%	31%

In 2003, the ER ceiling was exceeded due to 5% higher than projected mortality in northern fisheries.

In 2007, the northern fishery validation ER (14%) was lower than the pre-season projection (23%). The critical ER ceiling (15%) was exceeded due to the SUS ER (20%) being higher than projected (13%). This deviation was primarily due to higher than expected impacts in Area 8 – 13, and freshwater sport fisheries.

In 2009, higher than projected northern and SUS ERs caused the ER ceiling to be exceeded. Mortality in Puget Sound marine and the freshwater recreational fisheries account for the difference in the SUS ER.

Table 1-9 Deviations (pre-season vs. validation) in fishery specific ER for Snohomish Chinook: 2003, 2007, and 2009.

	2003	2007	2009
Alaska	0.000	0.005	0.002
Canada	0.048	-0.090	0.018
S. Of Falcon Ocean	0.000	0.000	0.000
NOF Ocean Troll:	-0.005	0.001	-0.002
	-0.007	0.009	-0.020
Ocean & B10 Spt	0.000	0.000	0.000
Pgt Snd Trty Troll	0.003	-0.003	0.017
Pgt Snd 6 Sport			0.004
Pgt Snd 5,6 Sport	0.002	0.001	0.004
Pgt Snd 7 Sport	0.000	0.014	0.005
Pgt Snd 8-13 Sport	0.019	0.031	0.011
Preterm. Pgt Snd or Out-of-Region net:	-0.001	-0.004	-0.002
	-0.008	-0.009	-0.002
Terminal Pgt Snd or Local Terminal Net:	-0.001	0.000	0.000
	-0.008	-0.005	-0.011
Freshwater Sport:	0.014	0.039	0.030
Freshwater Net:	0.000	0.000	-0.004

White

The ER ceiling for White spring Chinook was exceeded in 2004 and 2006; deviations for 2004 and 2006 were +13% and +14%, respectively. Fishing mortality occurs primarily in SUS fisheries.

Table 1-10 Pre-season and validation ERs for White spring Chinook in 2006 and 2006.

	2004		2006	
	Preseason	Validation	Preseason	Validation
SUS	18%	29%	18%	33%
Total	19%	32%	20%	34%

In 2004 the deviation from pre-season projections was primarily due to higher mortality in Area 8-13 recreational fisheries, but higher mortality also occurred in British Columbia, and Treaty Ocean and Strait of Juan de Fuca troll fisheries.

In 2006 the deviation was primarily due to higher than projected mortality (+06%) in the Area 8 – 13 sport fisheries.

Table 1-11 Deviations (pre-season vs. validation) in fishery specific ER for White spring Chinook, 2004 and 2006.

	2004	2006
Alaska	0.000	0.000
Canada	0.021	-0.005
S. Of Falcon Ocean	0.000	0.000
NOF Ocean Troll:	-0.001	-0.001
	0.003	0.002
Ntrty NOF & Buoy10 Spt	0.000	0.000
Pgt Snd Trty Troll	0.000	0.000
Pgt Snd 5,6 Sport	0.005	0.005
Pgt Snd 7 Sport	0.000	0.004
Pgt Snd 8-13 Sport	0.133	0.190
Preterm. Pgt Snd or	-0.006	-0.001
Out-of-Region net:	-0.008	0.001
Terminal Pgt Snd or	0.000	0.000
Local Terminal Net:	0.000	0.000
Freshwater Sport:	0.000	0.000
Freshwater Net:	-0.040	-0.051

Puyallup

The total ER for Puyallup (fall) Chinook exceeded the ER ceiling (50%) all years from 2003 - 2008, by margins ranging from 1% to 21%.

Table 1-12 Preseason and validation estimates of total ER for Puyallup Chinook, 2003 - 2008.

	Pre-season	Validation	Difference
2003	50%	61%	11%
2004	50%	71%	21%
2005	49%	71%	22%
2006	50%	52%	2. %
2007	49%	54%	5%
2008	49%	51%	2%
2009	50%	56%	6%
2010	50%	56%	6%

Causes of the ER ceiling being exceeded varied among years. In 2003, 2005, 2007, and 2009 there was higher than expected mortality in B.C. fisheries. In 2004, 2005, and 2009 mortality was higher in the Strait of Juan de Fuca troll fishery. There was higher than expected mortality in the freshwater sport fishery in 2003, 2004, and 2005, and mortality was higher than expected in the terminal river net fishery in 2004 - 2010.

Table 1-13 Deviations (pre-season vs. validation) in fishery specific ERs for Puyallup Chinook.

	2003	2004	2005	2006	2007	2008	2009	2010
Alaska	-0.002	-0.001	0.001	0.001	0.003	0.001	0.002	0.001
Canada	0.049	-0.046	0.127	-0.024	0.029	-0.044	0.076	-0.036
S. Of Falcon Ocean	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NOF Ocean Troll:	-0.002	-0.002	-0.002	-0.004	0.000	-0.004	-0.005	-0.003
	-0.006	0.003	0.005	-0.001	-0.004	-0.007	-0.021	-0.008
NOF B10 Sport	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.001
Pgt Snd Trty Troll	0.002	0.053	0.019	0.001	-0.004	-0.003	0.017	0.006
Pgt Snd 6 Sport	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.001
Pgt Snd 5,6 Sport	-0.002	-0.003	-0.001	0.001	0.000	0.000	0.003	0.001
Pgt Snd 7 Sport	-0.001	-0.006	0.001	0.003	0.002	0.000	0.000	-0.001
Pgt Snd 8-13 Sport	-0.010	-0.026	0.009	0.008	0.019	-0.007	-0.003	0.001
Out-of-Region net:	-0.001	-0.001	0.000	0.000	-0.001	-0.001	-0.002	-0.001
	0.000	0.000	0.001	0.002	-0.001	0.003	-0.005	0.000
Local Terminal Net	0.001	0.000	-0.001	0.000	-0.001	-0.001	-0.002	-0.001
	-0.002	-0.005	-0.004	0.000	-0.006	0.002	-0.002	0.000
Freshwater Sport	0.107	0.020	0.025	-0.003	-0.015	0.003	-0.009	-0.015
Freshwater Net	-0.015	0.221	0.036	0.038	0.029	0.080	0.013	0.123

Nisqually

The total ER for Nisqually exceeded its ER ceiling (65%) in 2010 by a small margin (2%). Mortality in the terminal net fishery exceeded the pre-season projection by 14%, but mortality in B.C., Puget Sound Area 8 – 13 recreational, and to a lesser extent other SUS fisheries, was collectively lower than expected.

Table 1-14 Deviations (pre-season vs. validation) in fishery specific ERs for Nisqually Chinook in 2010.

Alaska	0.007
Canada	-0.066
South of Falcon Ocean	0.000
NOF Ocean Troll:	0.004
	-0.005
NOF& Buoy10 Spt	-0.001
Puget Sound Trty Troll	-0.000
Puget Sound 6 Sport	0.001
Puget Sound 5 Sport	0.005
Puget Sound 7 Sport	-0.001
Puget Sound 8-13 Sport	-0.030
Out-of-Region net:	-0.001
	0.002
Local Terminal Net	-0.003
	-0.018
Freshwater Sport	-0.008
Freshwater Net	0.135

Skokomish

In 2010, the total ER for Skokomish exceeded its ER ceiling (50%) by 6%, largely due to overages in the terminal and in-river net fisheries. Lower than projected impacts in B.C. and other SUS fisheries partially offset the terminal impacts.

Table 1-15 Deviations in fishery-specific ERs for Nisqually Chinook in 2010

Alaska	0.000
Canada	-0.052
S. Of Falcon Ocean	0.000
NOF Ocean Troll:	-0.005
	-0.007
Ocean & Buoy10 Spt	0.003
Pgt Snd Trty Troll	0.012
	0.001
Pgt Snd 5,6 Sport	0.002
Pgt Snd 7 Sport	0.002
Pgt Snd 8-13 Sport	-0.008
Pre-terminal net:	-0.003
	-0.007
Local Terminal Net	0.000
	0.028
Freshwater Sport \5	0.004
Freshwater Net \5	0.084

Dungeness

In 2004 the SUS ER was 7%, exceeding the CER ceiling for Dungeness (5%), which was implemented due to forecasted critical status. The overage in the SUS ER was due to higher than expected mortality in the (winter) Strait of Juan de Fuca troll fishery. These overages were partially offset by lower than expected mortality in other SUS fisheries. Mortality in the Southeast Alaska troll fishery was substantially higher than projected in 2004.

Table 1-16 Deviations in fishery-specific ERs for Dungeness Chinook in 2004.

Alaska	0.132
Canada	-0.049
S. Of Falcon Ocean	0.000
NOF Ocean Troll:	-0.001
	-0.002
Ocean & Buoy10 Spt	0.000
Pgt Snd Trty Troll	0.046
Pgt Snd 5,6 Sport	-0.005
Pgt Snd 7 Sport	-0.002
Pgt Snd 8-13 Sport	-0.009
Out-of-Region net:	0.000
	0.001
Local Terminal Net	0.000
	0.000
Freshwater Sport	0.000
Freshwater Net	-0.001

1.4 Comparison of Pre-season and Validation ERs

The following sections compare pre-season projected ERs with values from FRAM validation runs. These comparisons are inconsistent because the FRAM and TAMM spreadsheets were revised each year for pre-season use, whereas all validation runs use the most recent TAMM spreadsheets (i.e. same as the 2011 pre-season version). Deviations between pre-season projections and validation estimates are summarized in the table below, expressed as the difference in rates and the proportionate deviation from the pre-season projections.

Table 1-17 Mean deviation in FRAM validation estimates of exploitation rates from pre-season projections, 2003 – 2010.

	Total ER		SUS ER	
	Mean	Proportionate	Mean	Proportionate
Nooksack	0.4%	17%	-2.1%	42%
Skagit spring	-6.3%	22%	-5.2%	30%
Skagit S-F	2.0%	15%	0.3%	19%
Stillaguamish	-4.9%	20%	-3.1%	34%
Snohomish	-1.9%	16%	-0.3%	25%
Lk Washington	1.4%	18%	-0.2%	23%
Green	-1.2%	11%	-2.9%	22%
White	2.5%	25%	2.2%	28%
Puyallup	9.5%	19%	7.8%	28%
Nisqually	6.0%	10%	2.5%	16%
Skokomish	4.3%	8%	4.6%	20%
Mid-Hood Canal	-1.9%	14%	-1.7%	14%
Dungeness	5.9%	28%	1.7%	67%
Elwha	5.2%	28%	1.3%	54%
Hoko	4.6%	22%	2.0%	74%

1.5 Comparison of FRAM and CWT exploitation rates for Puget Sound Chinook

State, Federal and tribal FRAM experts compared estimates of exploitation rates based on coded-wire tag (CWT) recoveries with FRAM validation runs, for several Puget Sound populations. Below we summarize one part of this analysis, which compared calendar year ERs for landed catch of marked fish in 2003 – 2008. A new set of FRAM validation runs were developed for this time period in 2012. In part, this work was motivated by concern that FRAM, because it utilizes base-period CWT data from 1979 – 1982, does not accurately estimate ERs for modern fisheries regimes. Other CWT analyses have detected significant changes in ERs associated with recently implemented fishery regimes in British Columbia (CTC 2006). A draft of this part of the analysis is included as an appendix; following are its primary conclusions.

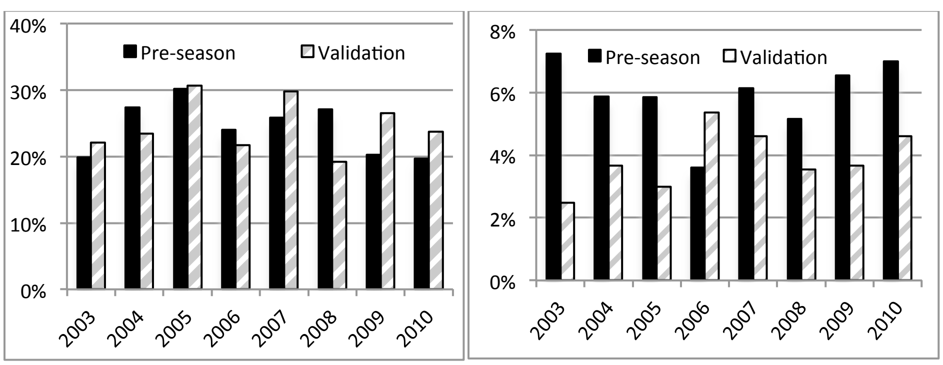
Comparison outcomes fell into four general categories of agreement: For some stocks the pairs of estimates were similar and strongly correlated, exemplified by the Green, Samish, and Skagit spring fingerling total ERs. Second were those cases for which FRAM and CWT estimates were similar on average but uncorrelated. This pattern was often observed among stocks for which ERs varied little during the 2003-2010 fishing period, and is exemplified in the SUS ER comparisons for Skykomish, Nooksack Early, and Stillaguamish. The third pattern involved systematic differences in estimates (i.e., FRAM>CWT or FRAM<CWT) but with a strong statistical association. This pattern was evident for total ERs for the Nisqually, Skagit summer/fall fingerlings, and Skagit spring yearling stocks. Last, there were cases for which FRAM and CWT estimates differed consistently and were unrelated. We noted this pattern of deviation for total ERs for the Skokomish, Puyallup, Nooksack early stocks, and to a lesser extent for the Skykomish and Stillaguamish stocks, for nearly all stocks for ERs associated with fisheries in British Columbia and Alaska, and for SUS ERs for the Skokomish and Puyallup stocks.

1.6 Nooksack Early

Due to critical status, the 7% CER ceiling (9% once in five years) has been in effect every year since 2004. In 2004 the ceiling was adjusted by the base regulation model run to 6.7%; in 2006 it was adjusted to 4%.

FRAM validation estimates of total ER range from 19% to 31%. Differences from the pre-season estimates range from -8% to + 6%; the mean difference, as a proportion of the pre-season estimates, was 17%. SUS ERs from the validation runs ranged from 2% to 5%. Validation estimates are a mean 2% lower than preseason estimates, or expressed as a proportion of the pre-season, a mean of 42% different.

Figure 1-1 Total and SUS exploitation rates for Nooksack early Chinook.

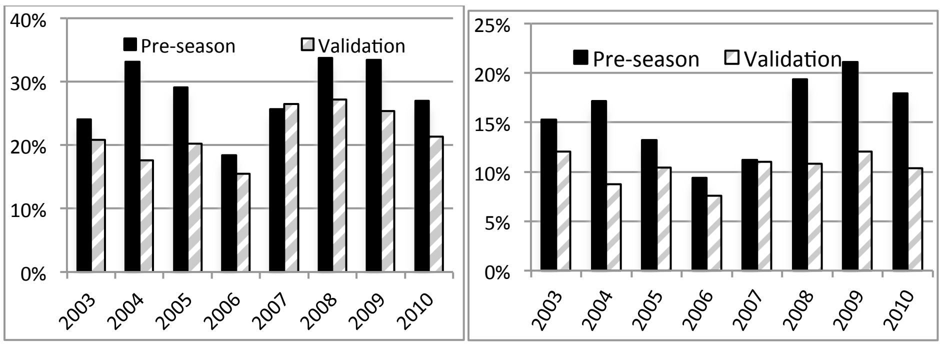


1.7 Skagit Spring

The ER ceiling was 42% for 2000 – 2004, and 38% for 2005 - 2010. The CER ceiling has never been implemented due to forecast critical abundance for any of the three populations, or due to elevated northern fishery mortality. Validation estimates of total ER ranged from 15% to 27%, and were lower than pre-season projections all years since except 2007. The mean deviation from pre-season is – 6%; expressed as a proportion of the pre-season projections the mean deviation was 22%.

Validation estimates of the SUS ER ranged from 8% to 12%, and were lower than pre-season projections. Their mean deviation from the preseason projections was -5%; expressed as a proportion of the pre-season projection the mean deviation was 30%.

Figure 1-2 Total and SUS exploitation rates for Skagit spring Chinook.



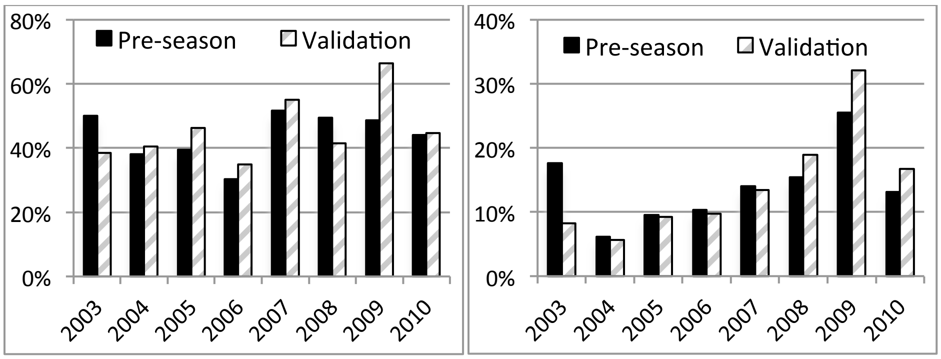
Terminal ERs have increased since 2008 with the implementation of fisheries directed at hatchery spring Chinook. Validation estimates of the terminal ER ranged from 1% to 7%. These are lower than pre-season projections for most years by a mean of -2%.

1.8 Skagit Summer/Fall

The Skagit summer-fall ER ceiling (52% in the 2003 Harvest Plan, and 50% in the 2004 and 2010 Plans) was the effective management objective for all years. In 2007, a pink year, the pre-season projection of total ER was 51%, so the CERC of 18% was also referenced during pre-season planning. As previously discussed (Section 1.4), validation estimates of total ER exceeded the ER ceiling in 2007 and 2009. In other years they ranged from 35% to 46%. Validation estimates of total ER were more frequently been higher than the pre-season projections, with mean deviation of +2%. As the proportion of the pre-season projection, the mean deviation was 15%.

Validation estimates of the SUS ER ranged from 6% to 19%, except 2009 when it was 31%, due to higher terminal impacts. The mean deviation was zero, or expressed as a proportion of pre-seasons values, 17%. Terminal ER projections ranged from 1% to 16%, except for the 2009 rate of 28%, which was associated with directed terminal fisheries. Their deviation from pre-season projections ranged from -7% to +6%, mean of +1% (mean proportionate difference 35%).

Figure 1-3 Total and SUS exploitation rates for Skagit summer-fall Chinook.



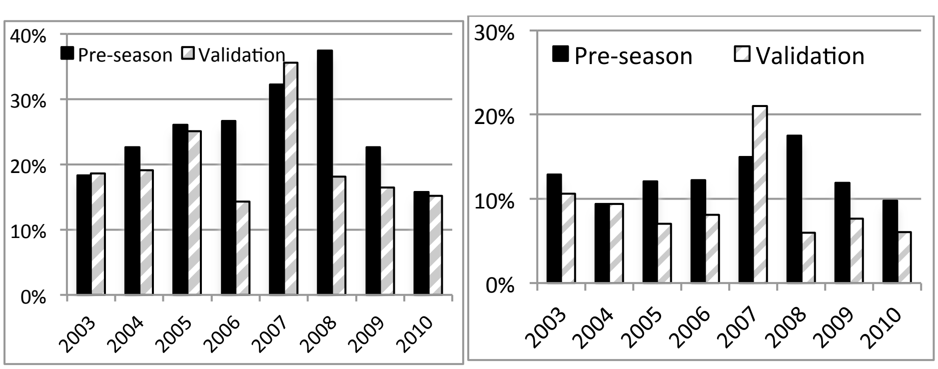
The validation estimate of SUS ER was 31% in 2009, higher than the projected rate (26%), thereby influencing escapement, but the effect of northern fisheries was potentially greater (35% and 11% higher than projected).

1.9 Stillaguamish

The Stillaguamish management unit was managed under an ER ceiling of 25% in 2003 – 2005, and 2009. The ER and CERC ceilings are specific to natural origin Chinook. In 2006 and 2007 the CER ceiling of 15% SUS was implemented because the total ER ceiling was exceeded due to northern fishery mortality. In 2008 and 2010 the CER ceiling was implemented due to forecasted critical status for the South Fork – Mainstem population. In 2006 the ceiling was adjusted according to the base regulation model run, to 13% SUS. The 2010 Harvest Plan implemented a higher LAT for the Stillaguamish management unit, to better protect the critically depressed South Fork population. Terminal harvest has comprised only limited tribal C&S fisheries.

Validation estimates of the total ER ranged from 14% to 36%, with estimates for most years lower than pre-season projections. The mean deviation was -5%, which, expressed, as a proportion of the pre-season projection was 20%.

Figure 1-4 Total and SUS exploitation rates for Stillaguamish Chinook.



As discussed in Chapter 1.4, validation estimates of the SUS ER exceeded the implemented ceiling in 2007. They ranged from 6% to 21%. Except for 2007, they were less than preseason estimates. The mean deviation was -3%; the mean proportionate difference was 34%.

1.10 Snohomish

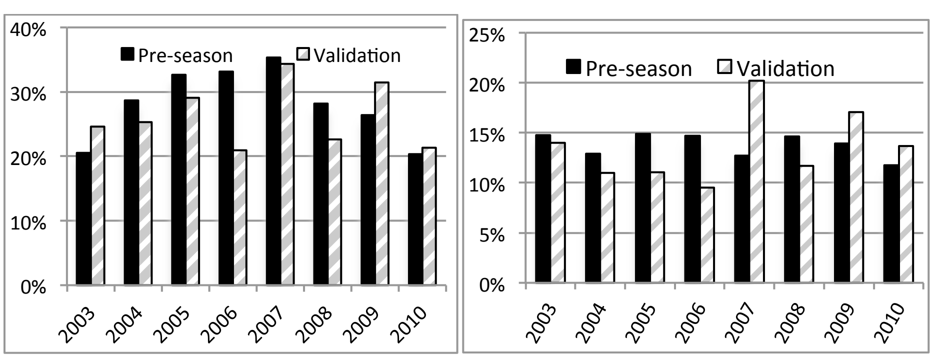
Snohomish Chinook were managed under the ER ceiling of 24% in 2003 and 21% in 2010. In the intervening years the CERC (15% SUS) was implemented because northern fishery impacts caused the total ER to exceed the ceiling. The base regulation model run did not adjust the CERC in any year (these model outputs all exceeded 15%).

Snohomish harvest objectives are based largely on quantification of Skykomish productivity. Fishing mortality has been estimated from surrogate Puget Sound fall CWT indicator stocks, although tag groups released from Wallace River Hatchery provide direct estimates since brood year 20??). There are no CWT data to inform direct estimates of fishing mortality for the Snoqualmie stock. The Plans assumed that harvest objectives designed to protect the Skykomish population would also protect the Snoqualmie population.

Validation estimates of total ER range from 21% to 34%, exceeding the operative ER ceiling in 2003. Deviations from the pre-season projections range from -12% to +5% mean of -2%; expressed as a proportion of the projected value, is 16%. Validation estimates of the ER associated with northern fisheries ranged from 8% to 18% averaged 13%. Northern ERs were projected accurately, with deviation from the pre-season estimates averaging 2%.

Validation estimates of the SUS ER ranged from 10% to 20%, exceeding the operative SUS ceiling in 2007 and 2009. The deviations from the pre-season estimate range from -5% to + 7%; the median deviation was zero percent (mean proportionate was 25%.

Figure 1-5 Total and SUS exploitation rates for Snohomish Chinook.



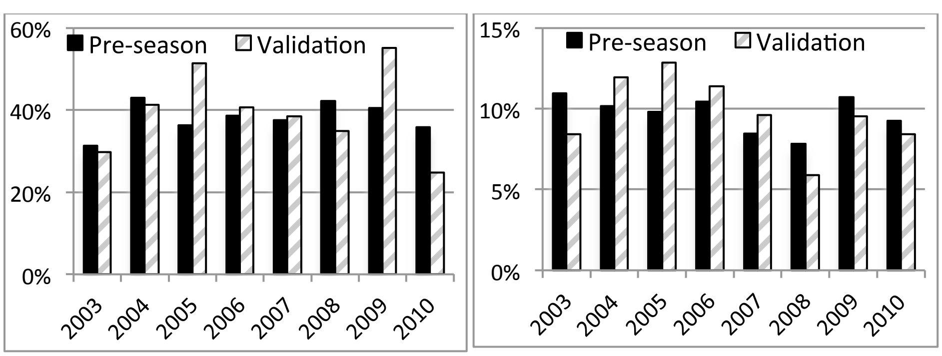
1.11 Lake Washington

Harvest management objectives have responded primarily to the status of the Cedar River population with a ceiling ER of 15% applied to pre-terminal SUS fisheries under normal status, and 12% under critical status. The 2010 Harvest Plan set the CERC at 10% applied to all SUS fisheries. Although some hatchery-origin Chinook (primarily from Issaquah, University of Washington, Grover's Creek, and Tulalip hatcheries) stray into the Cedar production is principally of natural origin. The Sammamish returns comprise, primarily, Issaquah Hatchery origin adults. There is assumed to be very low natural production in the Sammamish system, due to severe habitat constraints. It is uncertain whether the Sammamish ever supported an independent population. The potential for the system to do so in future appear less likely. These realities underlie the emphasis on conserving and rebuilding the Cedar population.

The management focus on pre-terminal fisheries has been appropriate because directed terminal fisheries on Cedar Chinook have been closed due to conservation issues since 1994. Sammamish hatchery and natural abundance is accounted, but the TAMM projects harvest impacts and escapement for the Cedar. Incidental terminal harvest impacts occur in coho fisheries. Fisheries directed at Issaquah Hatchery Chinook occur in Lake Sammamish.

Validation estimates of the total ER for Cedar range from 25% to 55%. Deviations from the pre-season projections range from -11% to +15%; the mean deviation was +1% (mean proportionate difference was 18%). Validation estimates of the SUS ER range from 10% to 26%. Deviations from the pre-season projection range from -7% to +7%, with a mean of zero. Expressed as a proportion of the preseason projection the mean deviation was 23%. Validation estimates of the pre-terminal SUS ERs have ranged from 6% to 13%, i.e. less than the CERC even though the management unit was not managed as critical.

Figure 1-6 Total and pre-terminal SUS exploitation rates for Cedar River Chinook.



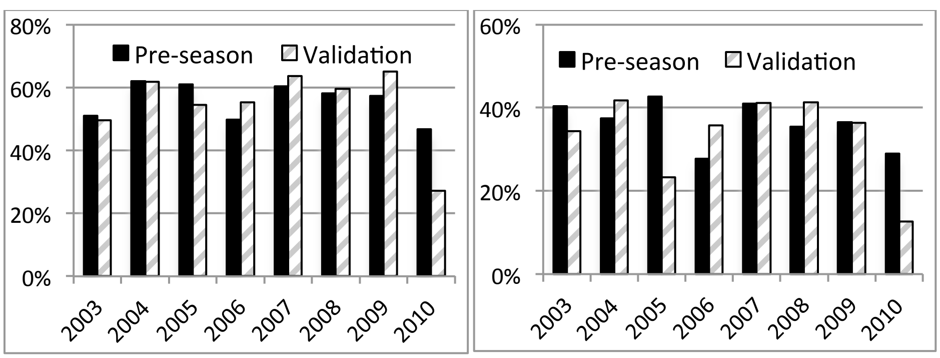
The Lake Washington management unit has not been managed under critical status; Cedar escapement was last below the LAT in 2000. Sammamish escapement, which includes primarily hatchery-origin, natural spawners in Bear Creek and lower Issaquah Creek, has averaged over 1,200 since 2003, although the number of natural origin spawners is very low.

1.12 Green

Harvest of Green River Chinook has been managed under a 15% ER ceiling on pre-terminal SUS fisheries, with terminal fisheries managed to achieve the escapement goal of 5,800. The CERC of 12% for pre-terminal SUS fisheries would be implemented if escapement was forecast to fall below 1,800, but this scenario had not occurred through 2010. Chinook-directed terminal fishing is contingent on catch in the Area 10A test fishery. Terminal fisheries did not occur in 2010 because the 10A test fishery catch was lower than the number needed to trigger a commercial opening.

Validation estimates of the total ER ranged from 50% to 65% in 2003 to 2009; the estimate for 2010 was substantially lower (27%). Deviation from pre-season projections ranged from –7% to +8% for 2003 – 09, but was -20% for 2010. Validation estimates of SUS ER ranged from 23% to 42% for 2003 – 2009; the 2010 estimate was 13%. The larger negative deviation from the pre-season estimate in 2010 was due to closure of the terminal fishery during the Chinook management period. Validation estimates of pre-terminal SUS ERs have been relatively stable, ranging from 6% to 13% (i.e., in most years less than the CERC). Validation estimates of the terminal ER ranged from 10% to 35% in years when directed fishing occurred, but was 4% in 2010.

Figure 1-7 Total and SUS exploitation rates for Green River Chinook.

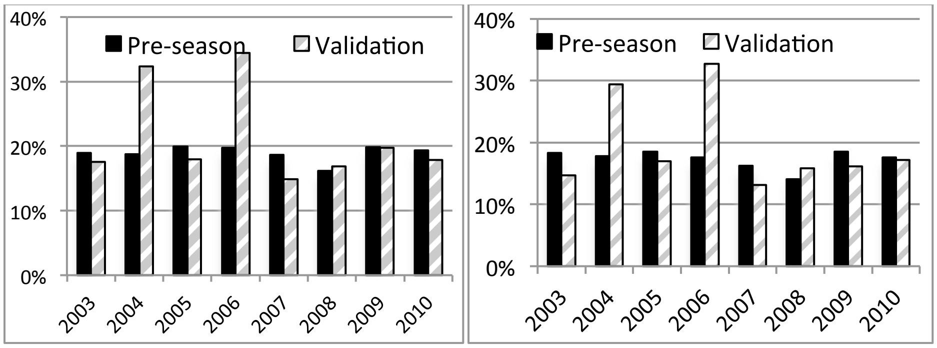


The recent decline in the abundance of Green River Chinook, evidenced by markedly lower returns of hatchery and natural-origin fish seen in 2009 – 2011, requires assessment of fishery and hatchery strategies to rebuild abundance.

1.13 White Spring

Fisheries have been managed to not exceed a total ER of 20%. Validation estimates of total ER ranged from 15% to 34%, exceeding the ER ceiling in 2004 and 2006. Validation estimates of SUS ER ranged from 13% to 33%. The ER ceiling was exceeded in 2004 and 2006 was due to higher-than-anticipated mortality in pre-terminal SUS fisheries. Deviations from the pre-season projected SUS ER ranged from -3% to + 15%, mean of +2% (mean proportionate deviation 28%). Validation estimates of terminal ER ranged from 5% to 8% in 2003 – 2007, and 11% to 14% in 2008 – 2010, but terminal ERs have been lower than projected in most years.

Figure 1-8 Total and SUS exploitation rates for White River spring Chinook.

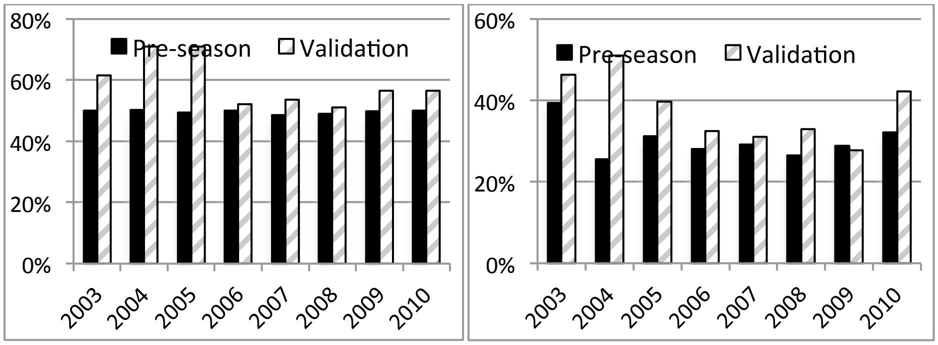


White abundance is forecasted as the aggregate of returning NORs, White River Hatchery HORs, and acclimation pond HORs to the Buckley and White River hatchery traps. The TAMM reports the ER and escapement for this 'unmarked' aggregate for pre-season management reference. White River hatchery releases are 100% coded-wire tagged, but not adipose-clipped; subyearlings outplanted to the acclimation ponds in the upper basin are marked with a ventral-clip. Except for natural-origin fish retained for use as hatchery broodstock (these are genetically tested to verify spring identity), fish lacking CWTs, and acclimation pond returns are transported above Mud Mountain Dam to enable natural spawning in the upper watershed. Because of logistical issues with the antiquated Buckley Trap, in recent years most Chinook transported above Mud Mountain Dam have not been sampled. Consequently, the hatchery and natural spring and fall components are not quantified. If forecasted escapement were to fall below 200 the CER ceiling of 15% SUS would be implemented; this has not occurred since inception of the Puget Sound harvest plans in 2001.

1.14 Puyallup

Harvest has been managed under a total ER ceiling of 50%. As discussed in Section 1.4, validation estimates of total ER have ranged from 51% to 71%, exceeding the ER ceiling every year. The largest deviations occurred in 2004 and 2005. Deviations from the pre-season projected total ER ranged from +2% to +21%, mean of 9%. Validation estimates of SUS ER ranged from 28% to 51%. Deviations from pre-season SUS estimates were positive in most years, ranged from -1% to +10%, except in 2004 when the deviation was +25%. Validation estimates of terminal ER ranged from 18% to 39%; deviations from pre-season projections averaged 8%.

Figure 1-9 Total and SUS exploitation rates for Puyallup fall Chinook.



Typically, fisheries during the Chinook management period operated for a one, partial day, so net fishery mortality occurred primarily during the first week of coho management. Projection of terminal net impacts has been refined in the TAMM, but fishing effort and catchability are highly variable and hard to predict. Mark selective recreational fisheries operated in all years since 2003. Puyallup abundance forecasts, beginning in 2009, include fall Chinook spawning in the lower White River tributaries.

The 50% exploitation rate ceiling has been implemented since the 2001 Harvest Plan. It is not based on quantified natural productivity, but rather was agreed as an interim guideline that would provide 'adequate seeding of available spawning and rearing habitat' (WDFW and Puyallup Tribe 2000). Spawning in the mainstem and Carbon River is estimated by an historical relationship with surveyable clear tributaries, but is highly uncertain, so 'adequate seeding' is ascertained primarily from escapement to the South Prairie / Wilkeson basin, which may comprise half or more of total escapement. Historically, escapements above 500 to South Prairie Creek have equated to total escapements ranging from 1,000 to 3,000. On this basis forecasted escapements lower than 500 implement the CERC. South Prairie surveys have been influenced by increasing, concurrent pink salmon spawning in odd years, so are also uncertain. However, in three recent years South Prairie escapements less than 500 have coincided with estimates of total escapement of 1,500 or more. Managers will re-assess the efficacy of the ER ceiling in achieving stable natural escapement.

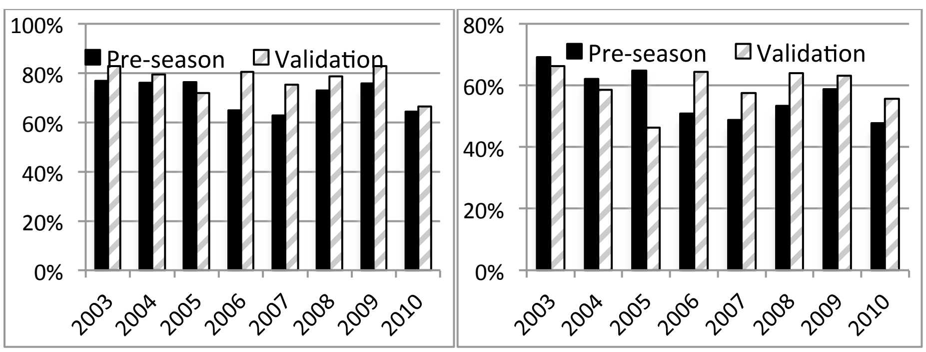
[Habitat conditions that constrain Chinook productivity are worsening, despite restoration efforts. The upper watershed, above the Electron diversion, remains largely inaccessible. Intensive timber harvest continues in the upper watershed. The lower river has been intensively developed to provide housing and the channel, naturally sinuous, is constrained by flood control levees. The lower river estuary and Commence Bay are industrialized, polluted, and provide only marginal rearing habitats.

1.15 Nisqually

Harvest objectives have evolved since the 2001 Harvest Plan was implemented. The 2004 Plan established an objective of 1200 natural spawners, with reference to habitat model derivation of MSY escapement. The 2010 Plan initiated a descending sequence of total ER ceilings: 65% for 2010 and 2011; 56% for 2012 and 2013; and 47% for 2014. The intended reductions in ER have, to date, largely been achieved by further constraint of the terminal fishery. The Nisqually tribe has tested selective gear as a tool to further reduce the impact on natural-origin returns. The strategy to rebuild a naturally produced population, while maintaining a segregated hatchery program to support harvest, is being advanced because significant progress has been achieved in restoring freshwater and estuarine habitat in the Nisqually system.

Validation estimates of total ER for years prior to 2010 ranged from 72% to 83%; the estimate for 2010 was 66% (slightly exceeding the ER ceiling of 65%). The deviations from pre-season projections were positive all years except 2005, ranged from -4% to + 16%, with a mean of +6% (mean proportionate deviation 10%). FRAM output indicates that harvest mortality occurs predominantly (average 77%) in SUS fisheries, and that terminal harvest impacts comprise the majority (average 68%) of SUS impact. Validation estimates of SUS ER ranged from 46% to 66%; terminal ER estimates ranged from 26% to 51%. Deviations from pre-season projections of SUS ER range from -18% to + 11%, mean of +2%, and for terminal ER range from -15% to + 12%, mean of +4%. Expressed as a proportion of the pre-season projections, deviations for SUS and terminal ERs were 16% and 28%, respectively.

Figure 1-10 Total and SUS exploitation rates for Nisqually Chinook.



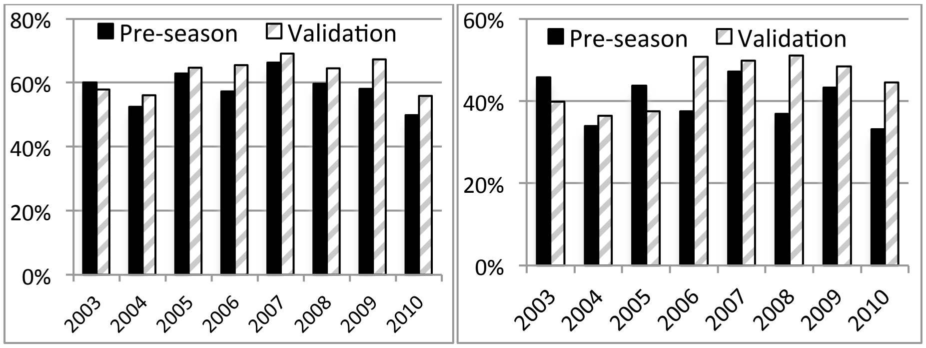
1.16 Skokomish

The 2004 Harvest Plan established 'normal' and critical management regimes keyed to Upper Management (1650) and Low Abundance (800) thresholds. Under normal escapement projections pre-terminal SUS ERs were not to exceed 15%; under critical status they would not exceed 12%. Skokomish escapement has fallen to the critical threshold once, in 2007, but the pre-season projection was above the LAT. The abundance of the FRAM unmarked stock is derived from a forecast reconstructed from aggregate natural escapement, comprising natural- and hatchery-origin returns. Escapement estimated by the TAMM spreadsheets is of the same character. The 2010 Harvest Plan established a new total ER ceiling of 50% (previous Plans established ceiling ERs only for pre-terminal SUS fisheries. The critical response to projected escapement less than the LAT (800) has not changed.

Validation estimates of total ER ranged from 56% to 69%. The 2010 estimate (56%) exceeded the Plan ceiling (50%). Deviations from pre-season projections of total ER have been relatively small, ranging -2% to + 9%, mean of +4% (mean proportionate deviation 9%). Validation estimates of pre-terminal SUS ER varied little, ranging from 9% to 13%. Terminal harvest comprised, on average, 74% of the SUS ER.

Validation estimates of the terminal ER ranged from 23% to 40%; deviations from pre-season projections ranged from -5% to +12%, average of +4% (mean proportionate deviation 22%).

Figure 1-11 Total and SUS exploitation rates for Skokomish fall Chinook.



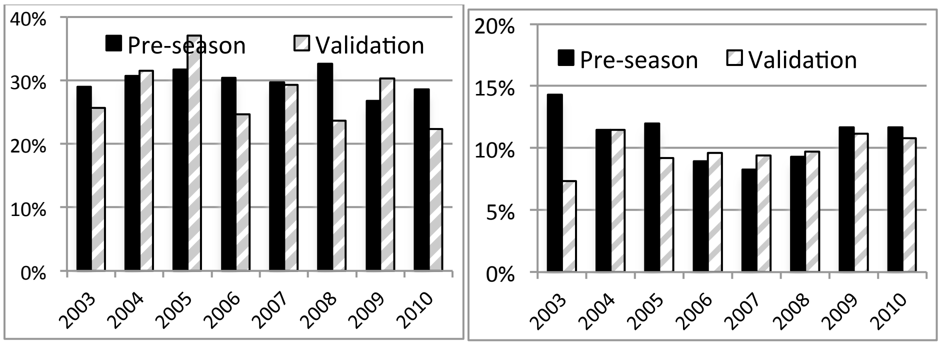
The primary intent of harvest management for the Skokomish has been achieved, i.e., to maintain stable natural escapement, recognizing this requires a majority contribution of hatchery-origin Chinook. A broad range of habitat restoration measures are being implemented, for the North Fork under a Settlement Agreement with the City of Tacoma regarding its license to operate the Cushman Hydroelectric project, and address of channel structure and stability in the South Fork. Concurrently the managers are implementing re-introduction of spring Chinook into the North Fork. Dependent on success for this program, when habitat function has been restored in the South Fork and mainstem, further measures to recover a fall Chinook population may be considered.

1.17 Mid-Hood Canal

The Mid-Hood Canal population comprises Chinook originating in the Hamma Hamma, Duckabush, and Dosewallips rivers. Harvest has, since 2004, been managed under the CERC - a pre-terminal SUS ER ceiling of 12% - because escapement has been projected to fall below the Low Abundance Threshold (400). Observed escapements have confirmed the population's critical status.

Validation estimates of the total ER have ranged from 22% to 31%. These deviated little from the pre-season estimates (mean deviation 2%). Validation estimates of the pre-terminal SUS ER ranged from 7% to 11%. Their deviations from pre-season projections ranged from -7% to +1%, mean of -1%.

Figure 1-12 Total and pre-terminal SUS exploitation rates for Mid-Hood Canal Chinook.



On average, approximate one third of harvest mortality occurs in pre-terminal SUS fisheries. Under the current model assumptions, impacts in the terminal area are near zero (validation estimates ranged from 0.1% to 0.3%, arguably lower than the detectable threshold of the model).

Two issues arise in considering these estimates of ER. FRAM depends on base period recoveries of George Adams Hatchery tag groups to estimate harvest impacts. Although some releases from the Hamma Hamma hatchery have been tagged, there are insufficient recoveries to quantify harvest rates and distribution, or determine if there are substantial differences in harvest distribution. The very low abundance of the population limits the accuracy of model projections. Managers, however, have used model output to shape fisheries to effect small reductions in harvest mortality.

The TRT was uncertain regarding designating an historical, independent Chinook population in the Mid-Hood Canal rivers, and raised the possibility that Chinook production in these rivers was always dependent on larger, native source populations in the Skokomish River. The NMFS has expressed concern that recent abundance is primarily due to escapement to the Hamma Hamma River. It is not evident that Chinook production is independently sustainable in the Hamma; recent returns suggest that production in the other two rivers is not independently sustainable. The Hamma Hamma Hatchery program operating may be responsible for higher returns, but there are too few carcass samples collected to estimate the hatchery origin component of spawners in most years. From 2010 to 2012 59% of carcasses were recovered and sampled; 58% were of hatchery origin. Managers assume that harvest measures can have only a limited effect to increase escapement, and no measureable effect on improving distribution to the Duckabush and Dosewallips rivers.

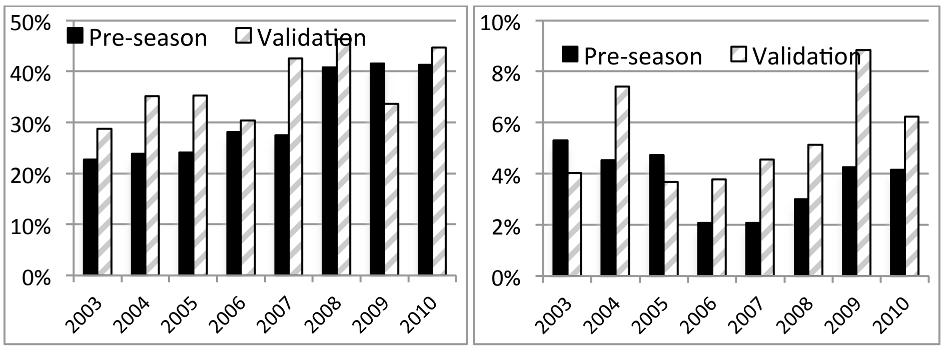
1.18 Dungeness

For most years considered in this review harvest has been managed under a 10% ceiling ER for SUS fisheries. Projected escapement was less than the LAT (500) in 2003 and 2004. The base regulation model run for 2004 planning did not adjust the effective CERC of 5%. The 'normal' abundance objectives reflect that harvest was conservative prior to implementation of the 2001 harvest plan, because of the managers' long-standing concern about the population's critically depressed abundance.

Validation estimates of total ER ranged from 29% to 46%. Deviations from pre-season projected rates were mostly positive, ranged from -8% to + 11%, with a mean of +6%. Validation estimates of the SUS

ER varied slightly over the range of 4% to 9%. Deviations from the pre-season projections ranged from -1% to +5%, with a mean of +2%. The 2004 estimate (7%) exceeded the CERC. Terminal-area harvest impacts have been very small all years; validation estimates were zero most years.

Figure 1-13 Total and SUS exploitation rates for Dungeness Chinook.



Highly conservative harvest objectives are certainly justified for the Dungeness population, but the relatively low impact of SUS fisheries (mean of 6%) limits their effect on escapement. The FRAM utilizes recoveries of Elwha CWTs in the base period to simulate impacts on Dungeness. Recoveries of tag groups released from the Dungeness hatchery programs are insufficient to validate FRAM estimates. However, all Dungeness production is currently tagged, so we expect, in the future, there will be sufficient recoveries to estimate harvest mortality directly.

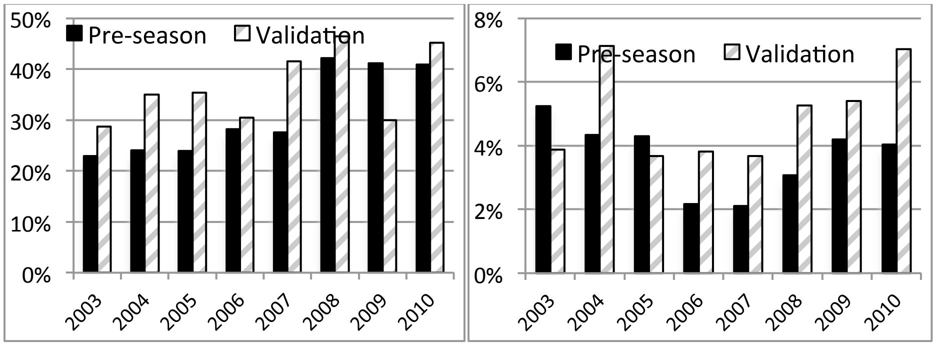
The increase in returns to the Dungeness from 2001 to 2006, decline in 2007 – 09, and rebound in 2010-11 are largely attributed to the effect of the captive brood program, its interruption, and subsequent start of the conventional supplementation program. It is apparent the hatchery program is necessary to reduce extinction risk.

1.19 Elwha

Harvest management objectives for the Elwha have been the same as for the Dungeness population: a 10% ceiling on SUS ERs, reduced to 5% if abundance is forecasted to fall below the LAT of 500.

Validation estimates of total ER ranged from 29% to 46%. Deviations from pre-season projections ranged from -11% to +14%, with a mean of +5% (mean proportionate deviation was 28%). Validation estimates of SUS ERs ranged from 4% to 7%. Deviations from pre-season projections ranged from -1% to +3%, with a mean of +1%. Except for a very few Chinook harvested for tribal ceremonial purposes, terminal harvest has not occurred.

Figure 1-14 Total and SUS exploitation rates for Elwha Chinook.



Historical CWT groups released from the Elwha Channel (hatchery) provide the basis for FRAM's estimation of harvest impacts. Tagging stopped after 1997 when the PSC Chinook Technical Committee stopped using the tag recoveries as an indicator. Tagging has recently begun again.

Harvest constraint has supported maintenance of stable escapement to the Elwha, while recovery was constrained by restriction to the lower five miles of the river, below Elwha Dam. Habitat in the lower reach was degraded, with very limited potential natural production. Under these constraints returns have presumably been predominantly fish of hatchery origin. Hatchery releases have not been ad clipped, and the number of natural-origin adults has not been estimated, until analysis of otoliths began in 2009 (?).

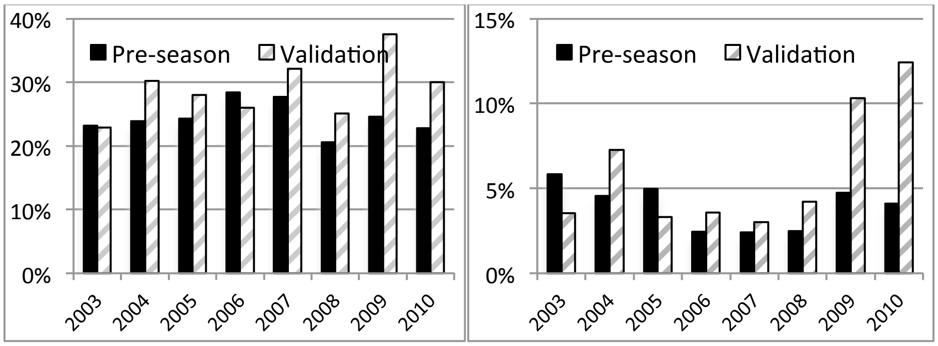
Removal of the two dams began in September 2011, and is expected to be completed in 2013. An intensive monitoring program will be implemented, contingent on funding support, to describe re-colonization of the watershed above the former dam sites, and to quantify natural smolt production and adult recruitment. The hatchery program will continue to operate at least until there is strong evidence of robust natural production. Eventually harvest management objectives will reflect quantified productivity and habitat capacity.

1.20 Western Strait of Juan de Fuca

The Hoko River Chinook stock is part of the Washington Coastal ESU, but harvest has been managed under the Puget Sound harvest plan since 2001. Management objectives are similar to the Dungeness and Elwha, with an SUS ER ceiling in effect under normal abundance, and a CERC of 5% implemented if forecasted abundance fell below the LAT (200). Forecasts have exceeded the LAT since the 2001 harvest plan was implemented; observed escapement was below 500 in 2009.

Validation estimates of total ER ranged from 23% to 37%. Deviations from pre-season projections ranged from -2% to + 13%, mean of +5% (mean proportionate deviation 22%). Validation estimates of the SUS ER ranged from 3% to 12%. Deviations from pre-season projections ranged from -2% to +3% for 2003 – 2008, and were 6% and 8% for 2009 and 2010, respectively.

Figure 1-15 Total and SUS exploitation rates for Hoko River Chinook.



Conservative harvest has enabled maintenance of more consistent escapement to the Hoko, but degraded habitat, and in some years unfavorable high flows, still limit natural production. Hatchery returns comprised the majority of natural spawners in most years since the program's inception, but the program has not met its original objective of rebuilding natural production to a level that will support terminal harvest.

Table 1-18 Pre-season projected and validation exploitation rates for Puget Sound Chinook.

Nooksack Early

	Total ER				SUS ER		
	Pre-season	Validation	Difference		Pre-season	Validation	Difference
2003	19.8%	22.1%	2.3%		7.2%	2.5%	-4.8%
2004	27.4%	23.4%	-3.9%		5.9%	3.7%	-2.2%
2005	30.3%	30.7%	0.4%		5.8%	3.0%	-2.9%
2006	24.1%	21.8%	-2.3%		3.6%	5.3%	1.7%
2007	25.9%	29.9%	4.0%		6.1%	4.6%	-1.5%
2008	27.1%	19.2%	-7.9%		5.1%	3.5%	-1.6%
2009	20.3%	26.5%	6.3%		6.6%	3.7%	-2.9%
2010	19.7%	23.8%	4.1%		7.0%	4.6%	-2.4%

Skagit Spring

	Total ER				SUS ER				Terminal		
	Pre-season	Validation	Difference		Pre-season	Validation	Difference		Pre-season	Validation	Difference
2003	24.1%	20.8%	-3.2%		15.3%	12.1%	-3.2%		1.3%	0.7%	-0.5%
2004	33.2%	17.6%	-15.5%		17.2%	8.7%	-8.4%		0.9%	1.4%	0.5%
2005	29.1%	20.2%	-8.9%		13.2%	10.5%	-2.8%		1.5%	1.4%	-0.1%
2006	18.4%	15.5%	-2.9%		9.4%	7.6%	-1.8%		2.6%	2.0%	-0.6%
2007	25.7%	26.5%	0.8%		11.2%	11.0%	-0.2%		1.9%	2.5%	0.6%
2008	33.7%	27.2%	-6.5%		19.3%	10.8%	-8.5%		11.0%	4.3%	-6.7%
2009	33.5%	25.4%	-8.1%		21.1%	12.1%	-9.0%		11.0%	7.9%	-3.1%
2010	27.0%	21.3%	-5.7%		17.9%	10.3%	-7.6%		11.0%	4.4%	-6.6%

Skagit Summer – Fall

	Total ER				SUS ER				Terminal		
	Pre-season	Validation	Difference		Pre-season	Validation	Difference		Pre-season	Validation	Difference
2003	50.0%	38.5%	-11.5%		17.6%	8.2%	-9.4%		8.3%	1.5%	-6.8%
2004	38.0%	40.5%	2.5%		6.1%	5.6%	-0.5%		1.2%	1.2%	0.0%
2005	39.6%	46.2%	6.6%		9.6%	9.3%	-0.3%		4.0%	6.7%	2.7%
2006	30.3%	34.9%	4.5%		10.3%	9.8%	-0.6%		6.2%	5.4%	-0.8%
2007	51.6%	55.0%	3.4%		14.0%	13.4%	-0.5%		7.4%	7.4%	0.1%
2008	49.5%	41.5%	-8.0%		15.4%	18.9%	3.5%		11.3%	16.2%	4.9%
2009	48.6%	66.4%	17.8%		25.5%	32.0%	6.5%		20.6%	28.1%	7.5%
2010	43.9%	44.6%	0.7%		13.1%	16.7%	3.6%		8.1%	12.9%	4.8%

Stillaguamish

	Total ER				SUS ER		
	Pre-season	Validation	Difference		Pre-season	Validation	Difference
2003	18.3%	18.6%	0.3%		12.9%	10.6%	-2.2%
2004	22.6%	19.2%	-3.4%		9.4%	9.4%	0.0%
2005	26.1%	25.1%	-1.0%		12.1%	7.1%	-5.0%
2006	26.7%	14.3%	-12.4%		12.2%	8.1%	-4.1%
2007	32.2%	35.6%	3.3%		15.0%	21.0%	6.1%
2008	37.5%	18.2%	-19.3%		17.5%	6.0%	-11.5%
2009	22.7%	16.5%	-6.2%		11.9%	7.7%	-4.3%
2010	15.8%	15.2%	-0.6%		9.8%	6.1%	-3.7%

Snohomish

	Total ER				SUS ER		
	Pre-season	Validation	Difference		Pre-season	Validation	Difference
2003	20.5%	24.6%	4.1%		14.8%	14.0%	-0.8%
2004	28.7%	25.3%	-3.4%		12.9%	11.0%	-1.9%
2005	32.7%	29.1%	-3.6%		14.9%	11.0%	-3.9%
2006	33.1%	20.9%	-12.2%		14.7%	9.5%	-5.1%
2007	35.3%	34.3%	-1.0%		12.7%	20.2%	7.5%
2008	28.1%	22.6%	-5.5%		14.6%	11.7%	-3.0%
2009	26.4%	31.5%	5.1%		14.0%	17.1%	3.1%
2010	20.3%	21.3%	1.0%		11.8%	13.7%	1.9%

Lake Washington (Cedar)

	Total ER				SUS ER				Pre-Terminal SUS ER		
	Pre-season	Validation	Difference		Pre-season	Validation	Difference		Pre-season	Validation	Difference
2003	31.3%	29.8%	-1.5%		20.6%	14.6%	-6.0%		11.0%	8.4%	-2.5%
2004	42.9%	41.3%	-1.6%		18.3%	21.3%	3.1%		10.1%	11.9%	1.8%
2005	36.3%	51.4%	15.0%		18.1%	20.2%	2.2%		9.8%	12.9%	3.0%
2006	38.6%	40.7%	2.1%		16.7%	21.1%	4.4%		10.4%	11.4%	1.0%
2007	37.5%	38.5%	1.0%		18.1%	16.0%	-2.1%		8.5%	9.6%	1.1%
2008	42.2%	34.9%	-7.3%		19.6%	16.7%	-2.9%		7.8%	5.9%	-1.9%
2009	40.5%	55.1%	14.5%		19.6%	26.3%	6.7%		10.7%	9.5%	-1.2%
2010	35.8%	24.8%	-11.1%		17.5%	10.4%	-7.1%		9.2%	8.4%	-0.8%

Green

	Total ER				SUS ER				Terminal ER		
	Pre-season	Validation	Difference		Pre-season	Validation	Difference		Pre-season	Validation	Difference
2003	51.0%	49.6%	-1.5%		40.4%	34.4%	-6.0%		29.4%	26.0%	-3.5%
2004	62.0%	61.8%	-0.3%		37.4%	41.8%	4.4%		27.3%	29.9%	2.6%
2005	60.9%	54.4%	-6.5%		42.7%	23.3%	-19.4%		32.8%	10.4%	-22.4%
2006	49.7%	55.3%	5.6%		27.8%	35.7%	7.9%		17.4%	24.3%	6.9%
2007	60.3%	63.7%	3.4%		40.9%	41.2%	0.3%		32.5%	31.6%	-0.9%
2008	58.1%	59.5%	1.4%		35.5%	41.3%	5.8%		27.7%	35.5%	7.8%
2009	57.4%	65.0%	7.7%		36.5%	36.3%	-0.2%		25.8%	26.8%	1.0%
2010	46.7%	27.1%	-19.6%		28.9%	12.7%	-16.2%		20.0%	4.3%	-15.7%

White

	Total ER				SUS ER				Terminal ER		
	Pre-season	Validation	Difference		Pre-season	Validation	Difference		Pre-season	Validation	Difference
2003	18.9%	17.5%	-1.4%		18.3%	14.7%	-3.6%		8.6%	7.1%	-1.5%
2004	18.7%	32.4%	13.6%		17.8%	29.3%	11.5%		8.6%	4.6%	-4.0%
2005	19.9%	17.9%	-2.0%		18.6%	17.0%	-1.6%		8.5%	7.8%	-0.7%
2006	19.7%	34.4%	14.7%		17.6%	32.7%	15.2%		11.7%	6.6%	-5.1%
2007	18.6%	14.9%	-3.8%		16.3%	13.2%	-3.1%		12.0%	7.6%	-4.3%
2008	16.2%	16.8%	0.7%		14.1%	15.8%	1.7%		12.2%	13.1%	0.9%
2009	19.8%	19.7%	-0.1%		18.5%	16.1%	-2.4%		13.8%	11.3%	-2.4%
2010	19.3%	17.9%	-1.4%		17.5%	17.2%	-0.3%		13.9%	14.0%	0.2%

Puyallup

	Total ER				SUS ER				Terminal ER		
	Pre-season	Validation	Difference		Pre-season	Validation	Difference		Pre-season	Validation	Difference
2003	50.0%	61.4%	11.5%		39.3%	46.3%	6.9%		28.4%	37.9%	9.5%
2004	50.2%	70.9%	20.7%		25.6%	51.0%	25.4%		15.4%	39.1%	23.6%
2005	49.4%	70.9%	21.4%		31.2%	39.7%	8.5%		21.4%	26.9%	5.5%
2006	50.0%	52.1%	2.1%		28.1%	32.5%	4.4%		17.7%	21.1%	3.5%
2007	48.6%	53.5%	5.0%		29.2%	31.1%	1.9%		20.7%	21.5%	0.7%
2008	49.0%	51.1%	2.0%		26.4%	32.9%	6.4%		18.6%	27.0%	8.4%
2009	49.8%	56.5%	6.7%		28.9%	27.7%	-1.2%		18.1%	18.2%	0.0%
2010	50.0%	56.5%	6.6%		32.0%	42.1%	10.1%		23.0%	33.7%	10.7%

Nisqually

	Total ER				SUS ER				Terminal ER		
	Pre-season	Validation	Difference		Pre-season	Validation	Difference		Pre-season	Validation	Difference
2003	76.7%	82.8%	6.1%		69.1%	66.1%	-3.0%		40.6%	46.0%	5.3%
2004	76.0%	79.5%	3.5%		62.0%	58.4%	-3.6%		40.4%	30.5%	-9.9%
2005	76.3%	71.9%	-4.4%		64.8%	46.3%	-18.4%		41.1%	25.7%	-15.4%
2006	64.7%	80.4%	15.6%		50.8%	64.2%	13.4%		29.9%	40.1%	10.1%
2007	62.8%	75.3%	12.5%		48.6%	57.5%	8.8%		33.5%	43.4%	9.9%
2008	72.8%	78.6%	5.8%		53.2%	63.8%	10.6%		39.1%	51.3%	12.2%
2009	75.8%	82.8%	7.0%		58.8%	63.0%	4.2%		39.3%	45.7%	6.5%
2010	64.4%	66.4%	2.0%		47.7%	55.6%	8.0%		30.6%	41.2%	10.7%

Skokomish

	Total ER				Pre-Terminal SUS ER				Terminal ER		
	Pre. - Seas	Validat	Difference		Pre-seas	Validation	Difference		Pre-seas	Validation	Difference
2003	60.0%	57.8%	-2.2%		14.5%	8.5%	-6.0%		31.3%	31.3%	0.1%
2004	52.5%	56.0%	3.5%		11.7%	13.4%	1.7%		22.2%	23.1%	0.9%
2005	62.9%	64.7%	1.8%		12.1%	10.9%	-1.2%		31.6%	26.5%	-5.1%
2006	57.3%	65.4%	8.1%		9.0%	11.3%	2.3%		28.5%	39.3%	10.9%
2007	66.3%	69.1%	2.8%		8.4%	11.8%	3.4%		38.7%	38.1%	-0.6%
2008	59.7%	64.4%	4.8%		9.3%	11.2%	1.9%		27.7%	39.9%	12.2%
2009	58.1%	67.3%	9.2%		11.9%	12.1%	0.3%		31.5%	36.2%	4.7%
2010	49.8%	55.9%	6.1%		11.9%	11.5%	-0.4%		21.3%	33.0%	11.7%

Mid-Hood Canal

	Total ER				SUS ER				Pre-Terminal SUS ER		
	Pre-season	Validation	Difference		Pre-season	Validation	Difference		Pre-season	Validation	Difference
2003	29.1%	25.7%	-3.3%		14.7%	7.5%	-7.2%		14.3%	7.4%	-6.9%
2004	30.7%	31.5%	0.8%		12.0%	11.5%	-0.5%		11.5%	11.5%	0.0%
2005	31.8%	37.0%	5.3%		12.4%	9.2%	-3.2%		12.0%	9.2%	-2.8%
2006	30.5%	24.6%	-5.8%		10.4%	9.6%	-0.7%		8.9%	9.6%	0.6%
2007	29.7%	29.3%	-0.4%		10.3%	9.5%	-0.8%		8.3%	9.4%	1.1%
2008	32.7%	23.6%	-9.1%		9.4%	10.0%	0.6%		9.3%	9.7%	0.4%
2009	26.8%	30.4%	3.6%		12.0%	11.2%	-0.8%		11.7%	11.2%	-0.5%
2010	28.7%	22.4%	-6.3%		12.0%	10.9%	-1.2%		11.7%	10.8%	-0.9%

Dungeness

	Total ER				SUS ER		
	Pre-season	Validation	Difference		Pre-season	Validation	Difference
2003	22.7%	28.8%	6.1%		5.3%	4.0%	-1.3%
2004	23.8%	35.1%	11.3%		4.5%	7.4%	2.9%
2005	24.1%	35.3%	11.2%		4.7%	3.7%	-1.1%
2006	28.1%	30.4%	2.3%		2.1%	3.8%	1.7%
2007	27.5%	42.5%	15.0%		2.1%	4.6%	2.5%
2008	40.8%	46.3%	5.4%		3.0%	5.1%	2.1%
2009	41.6%	33.7%	-7.9%		4.3%	8.8%	4.6%
2010	41.3%	44.7%	3.3%		4.2%	6.2%	2.1%

Elwha

	Total ER				SUS ER		
	Pre-season	Validation	Difference		Pre-season	Validation	Difference
2003	22.9%	28.7%	5.8%		5.2%	3.9%	-1.4%
2004	24.0%	35.0%	10.9%		4.3%	7.1%	2.8%
2005	24.0%	35.4%	11.4%		4.3%	3.7%	-0.6%
2006	28.2%	30.5%	2.3%		2.2%	3.8%	1.6%
2007	27.5%	41.5%	13.9%		2.1%	3.7%	1.6%
2008	42.2%	46.5%	4.3%		3.1%	5.3%	2.2%
2009	41.2%	30.0%	-11.2%		4.2%	5.4%	1.2%
2010	40.9%	45.1%	4.3%		4.0%	7.0%	3.0%

Hoko

	Total ER				SUS ER		
	Pre-season	Validation	Difference		Pre-season	Validation	Difference
2003	23.2%	22.9%	-0.3%		5.8%	3.5%	-2.3%
2004	23.9%	30.2%	6.3%		4.6%	7.3%	2.7%
2005	24.3%	28.0%	3.8%		5.0%	3.3%	-1.7%
2006	28.4%	26.0%	-2.3%		2.4%	3.6%	1.1%
2007	27.7%	32.1%	4.4%		2.4%	3.0%	0.6%
2008	20.6%	25.1%	4.5%		2.5%	4.2%	1.7%
2009	24.6%	37.5%	12.9%		4.8%	10.3%	5.5%
2010	22.8%	30.0%	7.3%		4.1%	12.4%	8.3%

2 Comparison of Projected and Observed Catch

The accuracy of pre-season projections of landed catch is a source of management error. This section compares pre-season projections with observed landed catch for commercial net and recreational fisheries in Puget Sound, to assess the magnitude and consistency of deviations.

2.1 Commercial Net and Troll

The tables below compile data from annual Chinook management reports for management years 2003-04 through 2010-11. Pre-season projections for commercial catch area were taken from TAMM tables. Observed commercial catch was either queried from the jointly-maintained catch database, or provided by local management staff. Observed catch data used for this assessment are from annual post-season reports; they have not been adjusted to reflect subsequent revision or reconciliation.

Commercial net catch includes marine and freshwater catch and tribal ceremonial and subsistence fisheries. Troll catch in the Strait of Juan de Fuca (Areas 4B, 5, and 6C) excludes catch during the summer period in Area 4B when it is managed under PFMC regulations or quotas.

Annual deviation of aggregate total commercial catch ranged from -19% to +29%, with a mean of +3%. Regional mean deviations ranged from -17% to +48%, and were highest for South Sound and Hood Canal.

Table 2-1Deviation of regional (a) and aggregate Puget Sound (b) commercial catch from pre-season projections.

(a)	Min	Max	Mean
SJDF Net &Troll	-62%	394%	14%
7/7A Net	-98%	59%	-13%
7B/C/D	-55%	91%	-5%
8 & Skagit R	-54%	90%	8%
8A & 8D	-48%	69%	5%
Mid Sound	-65%	72%	-17%
South Sound	-5%	124%	33%
Hood Canal	-36%	193%	48%
Total	-19%	29%	3%

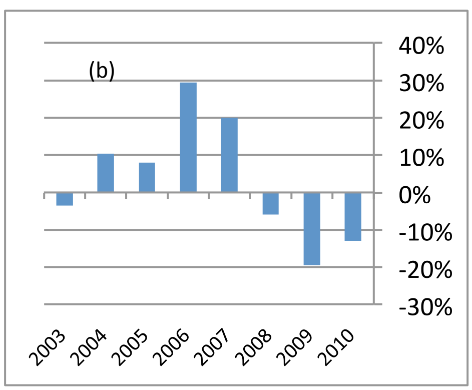


Figure 2-1 Regional deviations of observed commercial Chinook catch from pre-season projections.

Table 2-2 Deviation from pre-season projected commercial Chinook catch, 2003-2010.

	2003-04			2004-05			2005-06			2006-07		
	Pre-season	Observed	Deviation	Pre-season	Observed	Deviation	Pre-season	Observed	Deviation	Pre-season	Observed	Deviation
SJDF Net &Troll	2,360	2,467	5%	4,190	20,713	394%	10,099	4,556	-55%	9,950	3,735	-62%
7/7A Net	5,071	4,827	-5%	3,746	5,959	59%	4,275	4,880	14%	4,136	5,233	27%
7B/C/D	41,377	18,877	-54%	23,751	10,616	-55%	18,504	11,477	-38%	13,125	25,049	91%
8 & Skagit R	663	305	-54%	366	567	55%	1401	2660	90%	2065	1706	-17%
8A & 8D	7,352	9,237	26%	4974	6253	26%	7469	8007	7%	9,583	5,526	-42%
Mid Sound	24,692	20,990	-15%	14,814	13,501	-9%	15,489	8,552	-45%	11,207	10,989	-2%
South Sound	9703	10648	10%	18636	18771	1%	15588	22463	44%	17111	32380	89%
Hood Canal	16,332	36,512	124%	13,542	16,326	21%	8,708	25,485	193%	21,715	30,402	40%
Total	107,550	103,863	-3%	84,019	92,706	10%	81,533	88,080	8%	88,892	115,020	29%
	2007-08			2008-09			2009-10			2010-11		
	Pre-season	Observed	Deviation	Pre-season	Observed	Deviation	Pre-season	Observed	Deviation	Pre-season	Observed	Deviation
SJDF Net &Troll	9,774	5,736	-41%	8,824	6,375	-28%	9,200	4,816	-48%	10,944	5,568	-49%
7/7A Net	6,766	2,621	-61%	6,026	97	-98%	5,026	1,017	-80%	4,807	6,840	42%
7B/C/D	17,726	18,339	3%	13,474	18,221	35%	14,520	11,446	-21%	19,434	19,285	-1%
8 & Skagit R	1436	1848	29%	5100	3621	-29%	6760	6287	-7%	2013	1961	-3%
8A & 8D	7,645	6,201	-19%	2,198	3,713	69%	3,081	1,604	-48%	2,301	2,832	23%
Mid Sound	14,597	25,036	72%	25,294	18,558	-27%	19,244	9,827	-49%	19,668	6,927	-65%
South Sound	23108	51690	124%	36455	39513	8%	30733	29094	-5%	29702	28257	-5%
Hood Canal	25,454	16,410	-36%	15,506	16,125	4%	17,227	21,124	23%	18,905	22,112	17%
Total	106,506	127,881	20%	112,877	106,223	-6%	105,791	85,215	-19%	107,774	93,782	-13%

2.2 Marine recreational fisheries

Pre-season projections of marine sport catch were obtained from final model runs (i.e. TAMX tabulation of landed mortality). Observed landed catch data conform with data input to FRAM validation runs. Deviations are calculated as a proportion of the pre-season projected values.

Total marine sport catch in Puget Sound for management years 2003-04 through 2010-11 was lower than projected (mean -22%) in all years except 2007. Average deviations for individual areas ranged from -62% (Area 8D Special Area Fishery) to + 69% (Area 12). Annual deviations generally exceeded 20% for most areas, and ranged from -91% to +125%. But annual deviations were consistently negative for Areas 8 (8-1 and 8-2 combined). 9, 10, and 11, and consistently positive for Area 12.

Table 2-3 Deviation of marine recreational Chinook catch from pre-season projections.

	Average	Min	Max
Area 5/6	1%	-55%	91%
Area 7	-6%	-50%	39%
Area 8-1 & 8-2	-30%	-87%	8%
Area 8D	-62%	-91%	1%
Area 9	-43%	-85%	7%
Area 10	-39%	-80%	86%
Area 10A	-46%	-91%	-9%
Area 10E	14%	-58%	125%
Area 11	-9%	-47%	43%
Area 12	69%	18%	119%
Area 13	-21%	-71%	35%
Total	-22%	-46%	20%

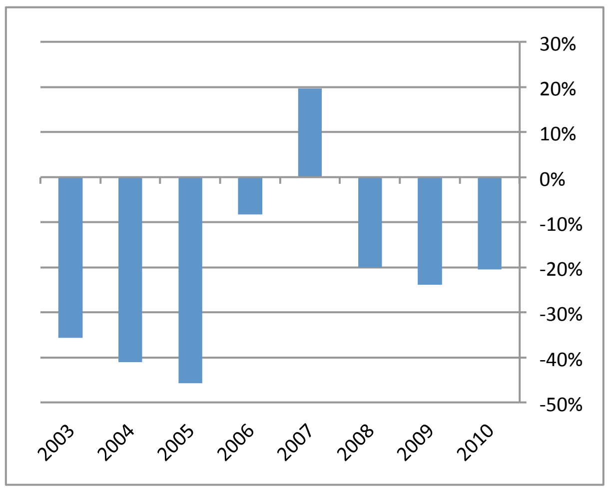


Table 2-4 Deviation from pre-season projections of marine recreational Chinook catch, 2003-04 to 2010-11.

	2003-04			2004-05			2005-06			2006-07		
	Pre-season	Observed	Deviation	Pre-season	Observed	Deviation	Pre-season	Observed	Deviation	Pre-season	Observed	Deviation
Area 5 & 6	6464	4799	-0.26	6792	4395	-0.35	6065	2887	-0.52	4653	5688	0.22
Area 7	4313	3032	-0.30	3856	1947	-0.50	3842	2703	-0.30	3543	4200	0.19
Area 8-1	1478	431	-0.34	1689	726	-0.43		530	-0.46		559	-0.51
Area 8-2 & 8D	3867	3079		1886	1303		3385	1309		4655	1710	
Area 9	5179	1400	-0.73	5754	1617	-0.72	3660	1502	-0.59	3343	3212	-0.04
Area 10		4660	-0.03		12252	0.57		2906	-0.26		4432	0.04
Area 11	14522	9355		12939	8059		14352	7763		13315	9358	
Area 12	1045	1356	0.30	1037	2916	1.81	1172	2590	1.21	575	2177	2.79
Area 13	3766	1502	-0.60	4099	1154	-0.72	3554	1911	-0.46	2821	2311	-0.18
Total	40634	29614	-0.27	38052	34369	-0.10	36030	24101	-0.33	32905	33647	0.02

	2007-08			2008-09			2009-10			2010-11		
	Pre-season	Observed	Deviation	Pre-season	Observed	Deviation	Pre-season	Observed	Deviation	Pre-season	Observed	Deviation
Area 5 & 6	5090	6068	0.19	4730	4721	0.00	5158	10910	1.12	5582	8608	0.54
Area 7	2536	6737	1.66	2536	3359	0.32	4353	4061	-0.07	46106	3568	-0.92
Area 8-1		692	-0.35		414	-0.57		323	-0.46		78	-0.85
Area 8-2 & 8D	3249	1414		2482	643		2572	1074		2191	252	
Area 9	7171	7697	0.07	6308	5417	-0.14	11396	5106	-0.55	7072	5430	-0.23
Area 10	6787	8599	0.25	8924	3662	-0.32	8358	3655	-0.36	6778	3372	-0.47
Area 11	9544	11825		8084	7922		3204	3778		7306	4112	
Area 12	1657	2766	0.67	891	1470	0.65	612	879	0.44	701	699	0.00
Area 13	2593	3088	0.19	1086	2964	1.73	1183	1282	0.08	1067	673	-0.37
Total	38627	48886	0.27	35041	30572	-0.13	36836	31068	-0.16	76803	26792	-0.65

Figure 2-2 Regional deviations in marine sport catch from pre-season projections.

2.3 Freshwater Recreational Fisheries

Following is a comparison of observed (estimated) and projected freshwater recreational fishing mortality in five Puget Sound rivers where Chinook-directed fisheries have occurred. In most recent years regulations for these rivers have required release of un-marked Chinook, but the Puyallup-Carbon fishery was not selective in 2003, Nisqually was not selective in 2003 – 2005, and Skokomish was not selective in 2003 – 2009. Mortality estimates are based on various combinations of CRC data and creel data where available. Mortality estimates for mark-selective fisheries included estimates of landed catch (legal marked and illegal unmarked), and release mortality for marked and unmarked fish released. For some fisheries, multiple methods can and have been used for estimating mortality in the past. The estimates presented here match the values used in the 2012 FRAM validation runs. Pre-season projections of mortality were developed from previous years' creel or Catch Record Card estimates. In general, deviation in the mortality of un-marked Chinook exceeded that for marked Chinook.

In general observed mortality more often exceeded the pre-season estimate for these fisheries, but in some instances (e.g. Skykomish in 2005, 2006 and 2010, Skagit in 2009, and Puyallup in 2010) mortality was much lower than projected (those negative deviations were greater than positive deviations, and great enough to offset much of the positive deviation in other years). Annual deviations in observed total mortality (marked + unmarked) for the spring Chinook fishery in the Skagit River ranged from -82% to +129%, weighted mean of -5%. Deviations for the Skykomish River fishery ranged from -80% to +125%, weighted mean of -7%. Deviations for the Puyallup-Carbon fishery ranged from -76% to +137%, weighted mean of -21%. Deviations for the Nisqually fishery ranged from -35% to +197%, with a mean of +13%. Deviations for the Skokomish fishery ranged were consistently positive, with a weighted mean of +52%.

Figure 2-3 Annual deviations in total mortality for freshwater recreational fisheries in the Skagit, Skykomish, Puyallup, Nisqually, and Skokomish rivers.

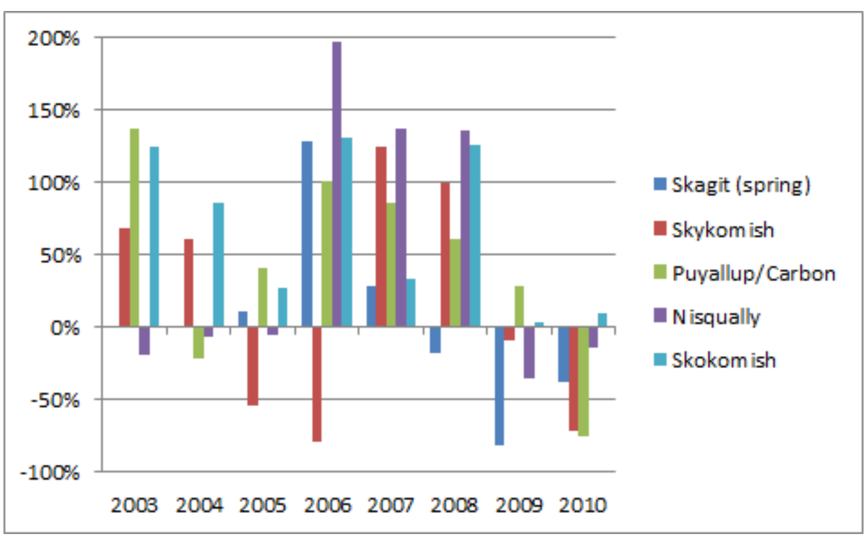


Figure 2-4 Deviations in freshwater recreational fishing mortality for five Puget Sound Rivers.

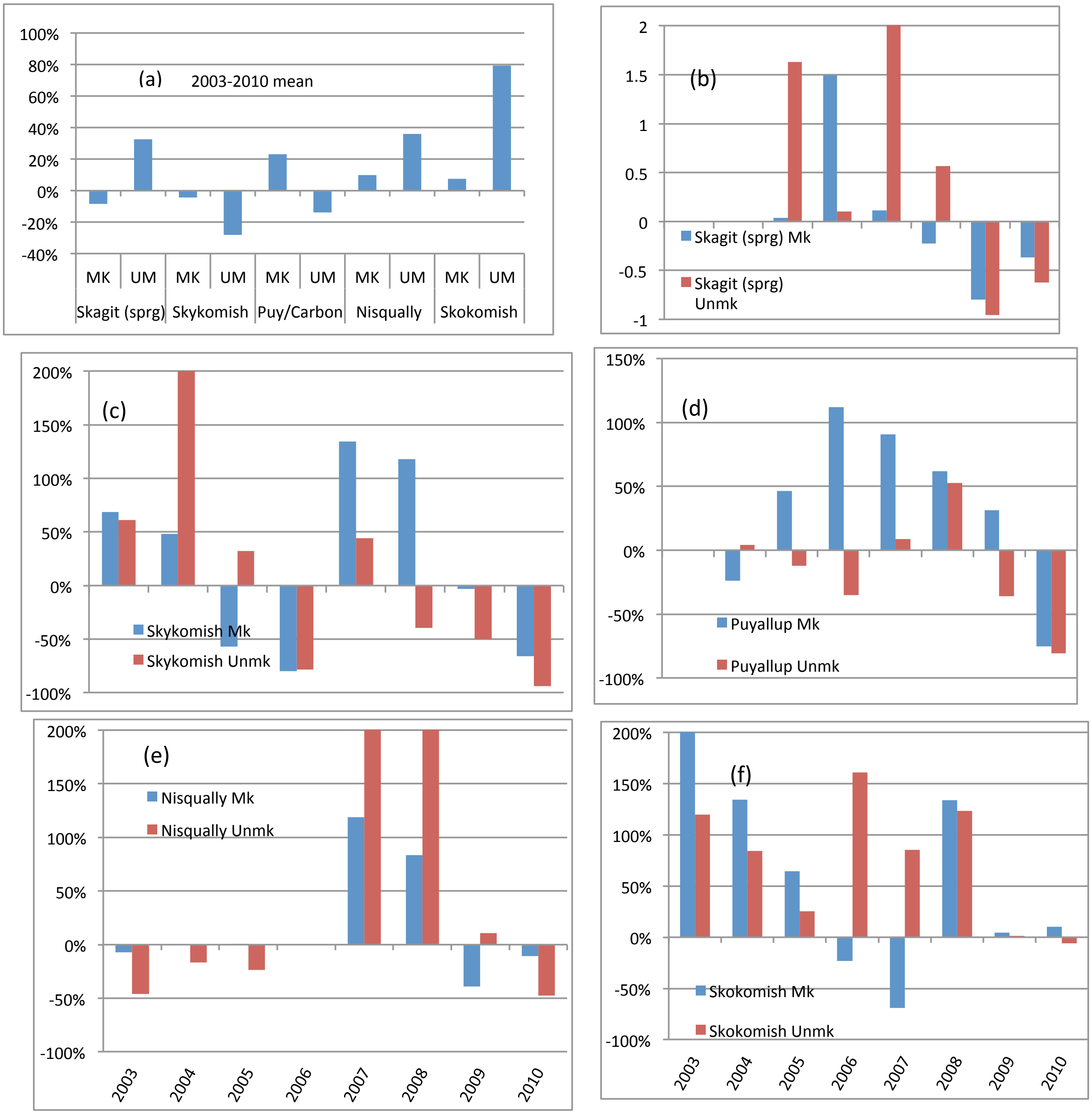


Table 2-5 Projected and observed Chinook mortality in five freshwater recreational fisheries in Puget Sound.

		2003			2004			2005			2006		
		Pre-season	Observed	Deviation	Pre-season	Observed	Deviation	Pre-season	Observed	Deviation	Pre-season	Observed	Deviation
Skagit (spr)	Marked							277	288	4%	184	459	150%
	Unmarked	N/A	N/A	N/A	N/A	N/A	N/A	13	34	163%	32	35	10%
	Total							290	322	11%	216	495	129%
Skykomish	Marked	241	407	69%	351	521	48%	732	314	-57%	305	61	-80%
	Unmarked	25	40	61%	11	63	494%	20	27	32%	42	9	-79%
	Total	266	447	68%	362	584	62%	752	341	-55%	347	70	-80%
Puyallup	Marked	735	1,922		1,309	996	-24%	1,171	1,714	46%	892	1,889	112%
	Unmarked	167	215		132	138	4%	118	104	-12%	74	48	-35%
	Total	902	2,137	137%	1,441	1,134	-21%	1,289	1,818	41%	966	1,937	101%
Nisqually	Marked	606	563	-7%	654	648	-1%	800	806	1%	724	1,705	
	Unmarked	264	142	-46%	374	312	-17%	266	203	-24%	20	504	
	Total	870	705	-19%	1,028	960	-7%	1,066	1,009	-5%	744	2,209	197%
Skokomish	Marked	88	321	265%	58	136	134%	157	258	64%	519	399	-23%
	Unmarked	2,559	5,628	120%	1,403	2,583	84%	3,661	4,584	25%	2,648	6,907	161%
	Total	2,647	5,949	125%	1,461	2,719	86%	3,818	4,842	27%	3,167	7,306	131%
		2007			2008			2009			2010		
		Pre-season	Observed	Deviation	Pre-season	Observed	Deviation	Pre-season	Observed	Deviation	Pre-season	Observed	Deviation
Skagit (spr)	Marked	372	415	12%	457	353	-23%	310	63	-80%	382	241	-37%
	Unmarked	22	89	305%	33	52	57%	46	2	-96%	20	8	-62%
	Total	394	504	28%	490	405	-17%	356	65	-82%	402	249	-38%
Skykomish	Marked	215	504	134%	211	460	118%	173	168	-3%	495	168	-66%
	Unmarked	25	36	44%	28	17	-39%	26	13	-50%	118	7	-94%
	Total	240	540	125%	239	477	100%	199	181	-9%	613	175	-71%
Puyallup	Marked	1,456	2,777	91%	1,588	2,571	62%	2,155	2,831	31%	2,257	555	-75%
	Unmarked	89	97	9%	75	114	52%	107	69	-36%	82	16	-81%
	Total	1,545	2,874	86%	1,663	2,686	61%	2,262	2,900	28%	2,339	571	-76%
Nisqually	Marked	841	1,839	119%	1,046	1,920	84%	2,046	1,252	-39%	2,172	1,937	-11%
	Unmarked	20	201	905%	56	676	1107%	147	163	11%	195	102	-48%
	Total	861	2,040	137%	1,102	2,596	136%	2,193	1,415	-35%	2,367	2,039	-14%
Skokomish	Marked	1,726	534	-69%	812	1,898	134%	2,929	3,054	4%	5,757	6,343	10%
	Unmarked	3,456	6,400	85%	2,688	6,001	123%	2,935	2,969	1%	409	384	-6%
	Total	5,182	6,934	34%	3,500	7,899	126%	5,864	6,023	3%	6,166	6,727	9%

3 Escapement Trends

This chapter examines recent abundance trends for Puget Sound Chinook populations from analysis of time series of estimates of natural escapement through 2011, and where data are sufficient, for the natural-origin component of natural escapement.

For most populations we utilized a time series generated from a consistent survey method, which covered a consistent set of index reaches. However, for virtually all populations, there are frequent, minor changes in survey design (length of surveyed reaches), or survey coverage (frequency), or estimation method. We do not describe these method variations in this report, but they are included in annual management reports. With the exception of the White River where traps enable monitoring of upstream migrants, escapement surveys count redds or adults. Although field data may include a qualitative estimate of visibility, count accuracy and survey frequency is affected to a greater or lesser extent by flow and turbidity. Estimates are subject to further, unquantified uncertainty from the universal assumptions made regarding sex ratio (e.g. 2.5 adults per redd) and, for many populations, redd life. Redd superimposition by concurrently spawning pink or chum salmon also confounds redd counts in some systems. Time series have not been thoroughly annotated to identify minor or major annual deviations in methods.

We used two methods to assess abundance trends: a regression of the log-transformed estimates against time, and the method proposed by Geiger and Zhang (2002). The regression slope provides a conventional parametric estimator of trend, with significance determined by a 95% confidence interval about the slope parameter. Missing data points are included in the regression by adding one to all estimates. The disadvantage of this method is that annual variation in escapement creates relative wide confidence intervals; so significant positive or negative trends cannot be identified.

The Geiger method calculates a slope from the median value of three 5-year or 7-year intervals. The starting value (i.e., for the year preceding the first estimate) is back-cast using the slope, and the 'biological significance' of the slope determined by whether the slope exceeds five percent of the starting value. This non-parametric approach is robust to large interannual variability, and captures the complex life cycle of Chinook wherein a given brood recruits to maturity over five years.

Summary of statistical trend analysis

Regression trends are positive for seven populations: North – Middle Fork Nooksack, Cascade (Skagit spring), North Fork Stillaguamish, Snoqualmie, White, Nisqually, and Dungeness. Geiger trends are positive for eight populations: North – Middle Fork Nooksack (15 year), Upper Skagit (21 year), Snoqualmie (21 year), Cedar (15 year), White (15 year), Nisqually (both), and Dungeness (both).

Regression trends are negative for five populations: Suiattle, Lower Sauk, Lower Skagit, Puyallup (South Prairie Creek index), and Elwha. Geiger trends negative for five populations: South Fork Nooksack (15 year), South Fork Stillaguamish (15 year), Green (15 year), and Mid-Hood Canal (15 year).

Statistical trend analyses inform harvest management, to the extent they can detect changes in abundance that may be are obscured by escapement estimation error and high annual variability. However, managers will also reference short term changes in abundance obtained from qualitative examination of the time series. In tables summarizing the trends from regression and Geiger and Zhang analyses, significantly positive and negative trends are shaded green and red, respectively.

Table 3-1 Trends in spawning escapement for Puget Sound Chinook populations, estimated by regression analysis.

Mgmt Unit / population	Time series	X_1	95% C.I.	
Nooksack				
North/Middle Fork	1993 - 2011	0.121	0.049	0.192
NORs	1997 - 2011	0.076	0.004	0.149
South Fork	1999 - 2010	-0.083	-0.207	0.040
Skagit spring	1975 - 2011	-0.002	-0.015	0.012
Upper Sauk		0.009	-0.011	0.028
Cascade		0.015	0.002	0.028
Suiattle		-0.021	-0.034	-0.008
Skagit S/F	1973 - 2011	-0.006	-0.019	0.007
Upper Skagit		0.001	-0.014	0.016
Lower Sauk		-0.037	-0.056	-0.018
Lower Skagit		-0.024	-0.040	-0.007
Stillaguamish	1988 - 2011	0.014	-0.003	0.032
North Fork		0.021	0.004	0.038
NORs		0.006	-0.019	0.030
South Fork		-0.039	-0.078	0.000
Snohomish	1965 - 2011			
Skykomish		-0.008	-0.017	0.000
Snoqualmie		0.023	0.012	0.034
Lk Washington				
Cedar	1964 - 2011	-0.012	-0.024	0.000
Sammamish				
Green	1968 - 2011	-0.006	-0.021	0.008
White	1964 - 2011	0.049	0.020	0.078
Puyallup	1992 - 2011	-0.020	-0.044	0.004
South Prairie Cr		-0.041	-0.076	-0.007
Nisqually	1980 - 2011	0.053	0.021	0.085
Skokomish	1988 - 2011	0.003	-0.024	0.031
Mid Hood Canal	1990 - 2011	0.029	-0.068	0.126
Dungeness	1986 - 2011	0.070	0.026	0.114
Natural spawners		1.015	0.946	1.084
NORs		0.646	0.109	1.183
Elwha	1986 - 2011	-0.027	-0.050	-0.004
Hoko	1986 - 2011	-0.003	-0.027	0.022

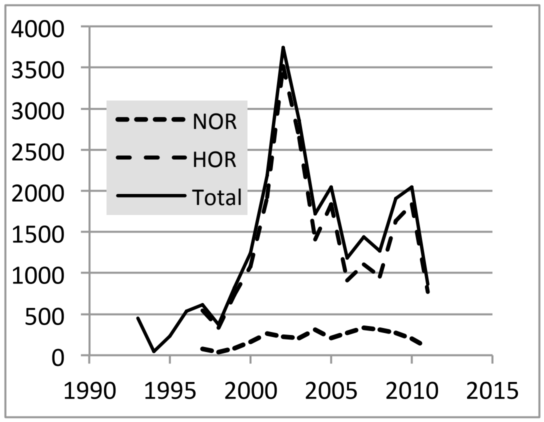
Table 3-2 Trends (Geiger & Zhang 2002) in natural escapement for Puget Sound Chinook populations.

MU	Population	15-year series			21 - year series	
		Slope	Slope/y_0		Slope	Slope/y_0
Nooksack	North / Mid Fk	61.50	0.065			
	NF/MF NORs	18.40	0.405			
	So Fork NOR	-10.75	0.081			
Skagit spring	Suiattle	-21.30	0.042		-6.50	0.016
	Upper Sauk	6.20	0.019		3.14	0.010
	Cascade	-2.40	0.007			
Skagit S/F	Lower Sauk	-10.40	0.016		6.29	0.018
	Upper Skagit	246.00	0.035		275.71	0.058
	Lower Skagit	-132.40	0.040		35.50	0.027
Stillaguamish	Stilly Total					
	North Fork	-33.40	0.035		5.54	0.010
	North Fork NORs	-15.20	0.013		19.30	0.026
	So Fork - MS	-21.00	0.065		-4.61	0.021
Snohomish	Skykomish	-190.36	0.036		32.57	0.012
	Snoqualmie	-55.70	0.023		43.29	0.050
Lake Washington	Sammamish	4.85	0.005			
	Cedar River	86.36	0.385		13.98	0.025
Green		-438.13	0.053		-244.92	0.032
White		111.80	0.105		137.57	3.862
Puyallup		-35.20	0.017		-65.86	0.024
	South Prairie Cr	-31.80	0.029			
Nisqually		98.80	0.101		95.86	0.270
Skokomish		-4.30	0.003		17.79	0.017
	NORs	8.37	0.023		-0.28	0.001
Mid Hood Canal		-25.00	16.067		-1.25	0.007
Hamma Hamma		-21.65	14.859		2.71	0.046
Duckabush						
Dosewallips		-3.45	18.386		-3.86	0.044
Dungeness		90.40	0.458		34.07	0.415
NOR natural spawners		8.30	0.114		2.14	0.018
Elwha		-96.80	0.036		21.50	0.013
Hoko		-37.80	0.034		-23.29	0.021

3.1 North / Middle Fork Nooksack Early

Figure 3-1 Chinook escapement to the North and Middle Forks of the Nooksack River.

	NOR	HOR	Total
1993			449
1994			45
1995			230
1996			535
1997	74	543	617
1998	37	333	370
1999	85	738	823
2000	160	1082	1242
2001	264	1921	2185
2002	224	3517	3741
2003	210	2647	2857
2004	314	1405	1719
2005	210	1837	2047
2006	275	909	1184
2007	334	1104	1438
2008	307	959	1266
2009	269	1634	1903
2010	204	1840	2044
2011	96	769	865



Natural spawners in the North and Middle Forks, which comprise, primarily, hatchery-origin Chinook, rose and subsequently fell in response to changes in production at the Kendall Creek Hatchery. The number of natural-origin spawners has been fluctuating between 200 and 300 since 2000, but has declined since 2007. The estimates in Figure 3-1 do not include North-Middle Fork Chinook spawning in the South Fork. Natural production is unresponsive to supplementation, due primarily to habitat conditions. FRAM validation estimates of total ER have not increased, but analysis of Kendall Creek hatchery CWT recoveries suggest that fisheries mortality increased in 2004 – 2008 (CTC 2012).

Regression and Geiger analyses found a biologically significant positive trend in total natural and NOR spawners since the early 1990s, but managers remain concerned about low NOR levels, particularly in light on the recent decline. The relatively short time series limits the precision of regression trends.

Data gaps & problems: Glacial turbidity in the North and Middle Forks in most years forces reliance on an expansion of survey data which focuses on carcass enumeration, with an historical ratio of carcass counts and redds from previous years when survey conditions were favorable. The estimation method has changed, with different accounting of spawners in Kendall Creek and Kendal Slough, where carcasses were enumerated but not expanded in 2010 and 2011. Identification of hatchery-origin spawners relies on carcass sampling to detect presence of a CWT and/or an adipose clip, and on otolith analysis. Kendall Hatchery and North Fork NOR adults spawning in the South Fork are not included in the estimates shown above. The extent to which South Fork early Chinook, or local and non-local fall Chinook, are spawning in the North Fork has not been estimated. The number of South Fork early Chinook is likely small, if the estimates of native South Fork abundance are correct.

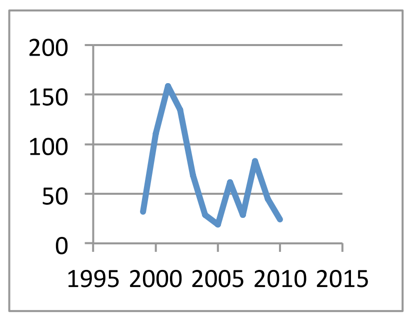
Table 3-3 Trend in escapement for Nooksack early Chinook.

	Regression			Geiger 15 y	
	X_1	95% C.I.		Slope	Slope/y_0
North–Middle Fk	0.1207	0.0494	0.1919	61.50	0.065
NORs	0.0762	0.0038	0.14868	18.4	0.404692
South Fork NOR	-0.0834	-0.2069	0.0401	-10.75	0.081

3.2 South Fork Nooksack Early

Figure 3-2 Chinook escapement to the South Fork Nooksack River.

	South Fk Native	North Fk NOR	Fall NOR	Kendall Cr Hatchery	Other Hatchery	Total Natural
1993						235
1994						118
1995						290
1996						203
1997						180
1998						157
1999	32	0	127	90	39	288
2000	111	42	132	74	15	373
2001	159	51	65	138	8	420
2002	135	55	98	289	47	625
2003	69	0	150	210	162	591
2004	29	29	88	14	12	172
2005	19	56	56	32	70	233
2006	62	104	192	84	90	532
2007	29	44	128	112	35	348
2008	83	106	126	109	23	447
2009	45	58	187	128	38	456
2010	24	49	123	299	58	552
2011						470



Spawners in the South Fork comprise a variable mix of native South Fork NORs, North Fork NORs, fall NORs, Kendall Hatchery returns, and strays from the Samish and Lummi Bay hatcheries. Estimates in Figure 3-2 are based on redds or adults observed until September 30. Native South Fork Chinook population spawners comprise a declining proportion of all natural spawners, ranging from 4% to 38% (median 12%) of natural spawners since 1999, based on genetic assignment, due to the increasing aggregate number of other spawners. The Geiger regression slope for native South Fork spawners is negative and biologically significant, but the short time series preclude a precise statistical assessment

Data gaps and problems: High flow and turbidity influence spawning surveys in many years, and upper basin spawning habitat is surveyed infrequently, so the conventional escapement estimates contain inconsistent and uncertain bias. Potential sources of bias in escapement estimates include: 1) not expanding for redds that are missed due to sub-optimal viewing conditions; 2) surveying at lower frequencies than specified in the methodology; 3) potential biases in carcass sampling that result in inaccurate proportions of the various NOR groups; and 4) possibly not surveying all spawning areas. Most of these would bias population escapement estimates below true population sizes.

Continued genetic assignment is desirable to monitor native South Fork abundance, but funding to support this costly analysis is uncertain. It is expected that native population abundance will increase markedly as supplementation program adults are recruited. Genetic monitoring is further justified to estimate the productivity of these HORs over subsequent generations. Carcass sampling has revealed uncertainty in coded wire tag detection in unclipped adults from the double-index groups, necessitating that otoliths be read to determine their origin. New-design wands now in use are detecting CWTs more reliably.

3.3 Skagit Spring

Aggregate escapement for the three spring populations exceeded the MU Low Abundance Threshold except in 1994 and 1999; the Upper Management Threshold was attained twice since 1975, in 1985 and 1988. The spring management unit has not been in critical status (i.e. forecast abundance below the LAT) since inception of the Puget Sound Harvest Plan.

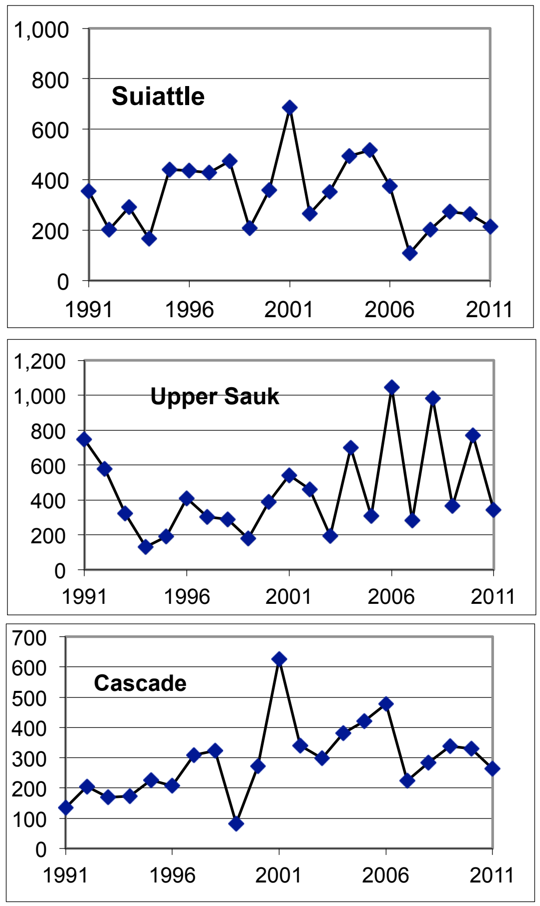
The spring population escapement data comprise native, natural-origin adults. Survey frequency and flow conditions have enabled a relatively consistent census of all spawning habitat. Surveys since 2009 have quantified natural spawning by Marblemount hatchery-origin adults, but these surveys corroborate the assumption that spawning is spatially distinct from native spring Chinook spawning areas. The extent of interaction (i.e. straying) between the native populations is unknown. The Suiattle and Cascade populations are more genetically similar but all three populations are genetically distinct.

The regression trend for the Suiattle population is negative. The 2011 estimates included a rarely surveyable reach (RM 9.6 – 24.5) in the mainstem, so is inconsistent with previous estimates in the series. The Geiger slopes are non-significant. Escapement has exceeded the Plan's Low Abundance Threshold (170) except in 1994 and 2007.

The decline in Suiattle escapement since 2006 is apparent for other Skagit spring and summer-fall populations. Declining production in the Suiattle is associated with high flows that particularly affect redds in the lower reaches, but the influence of lower marine survival is apparent on all the Skagit populations.

Figure 3-3 Natural escapement for Skagit spring Chinook populations.

	Suiattle	Upper Sauk	Cascade	Total
1991	354	747	135	1442
1992	201	580	205	986
1993	291	323	168	782
1994	167	130	173	470
1995	440	190	225	855
1996	435	408	208	1,051
1997	428	305	308	1,041
1998	473	290	323	1,086
1999	208	180	83	471
2000	360	388	273	1,021
2001	688	543	625	1,856
2002	265	460	340	1,065
2003	353	193	298	844
2004	495	700	380	1,575
2005	518	308	420	1,246
2006	375	1,043	478	1,896
2007	108	282	223	613
2008	203	983	284	1,470
2009	273	367	338	978
2010	263	768	330	1,361
2011	215	345	265	825



Regression and Geiger trends for the Upper Sauk population are not significant. Escapement has exhibited greater interannual variation since 2002. The Low Abundance Threshold has been exceeded in all recent years.

Escapement to the Cascade shows a significant positive regression trend since 1975. The 15-year Geiger slope is positive, but non-significant. Estimates for 1975 – 1991 were based on less frequent, spot surveys of miscellaneous Cascade tributaries. Starting with 1992, escapement surveys intensified and the estimation method changed to use expanded redd counts.

Table 3-4 Escapement trends for Skagit Chinook populations.

	Regression			Geiger 15 y		Geiger 21 y	
	X_1	95% C.I.		Slope	Slope/y_0	Slope	Slope/y_0
Skagit spring	-0.002	-0.015	0.012				
Suiattle	-0.021	-0.034	-0.008	-10.40	0.016	-6.50	0.016
Upper Sauk	0.009	-0.011	0.028	246.00	0.035	3.14	0.010
Cascade	0.015	0.002	0.028	-132.40	0.040		
Skagit S/F	-0.006	-0.019	0.007				
Low Sauk	-0.037	-0.056	-0.018	-33.40	0.035	6.29	0.018
Upper Skagit	0.001	-0.014	0.016	-15.20	0.013	275.71	0.058
Lower Skagit	-0.024	-0.040	-0.007	-21.00	0.065	35.50	0.027

3.4 Skagit Summer-Fall

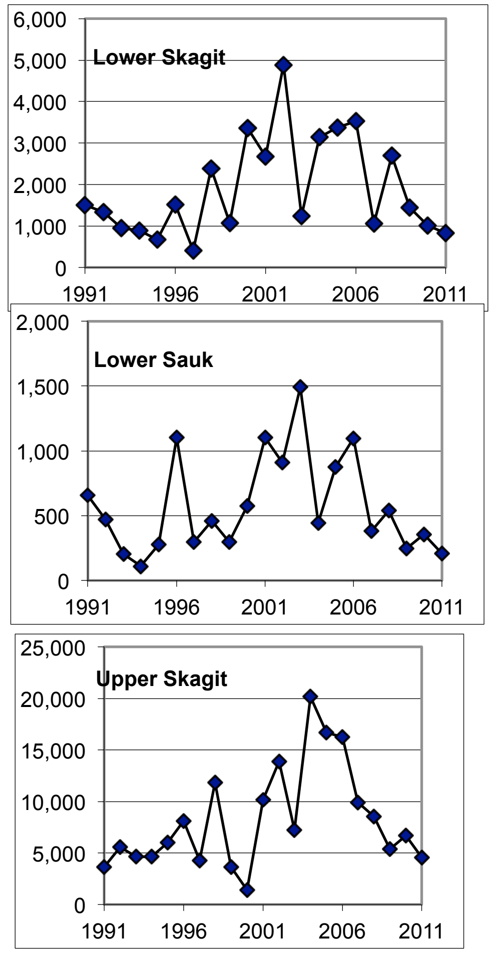
Since 1973, aggregate escapement for summer-fall populations exceeded the current Upper Management Threshold from 2004 -2006, due to relatively high abundance of the Upper Skagit population. Aggregate escapement exhibits a non-significant negative trend since 1975. Aggregate escapement has never fallen to the MU Low Abundance threshold.

Escapement to the Lower Sauk exhibits a significant negative regression trend since 1975. The Geiger trends are non-significant. The influence of hatchery returns on natural escapement prior to 1996 has not been quantified. Despite ambiguous statistical trends there is heightened concern over the declining escapement evident for all three summer-fall populations over the last six to eight years. Observed escapement was below the LAT (400) several years since 1991, including in 2009 – 2011. Changes in spawning and rearing habitat in the Lower Sauk have contributed to the recent decline, but this effect cannot be distinguished from that of lower marine survival.

The regression trends for the Upper Skagit population since 1973 is non-significant. The positive 21-year Geiger trend is significant. Escapement has never been lower than the LAT (2,200), except in 2000. The decline in escapement since 2004 requires the managers' attention, particularly considering the historical status of the Upper Skagit as the most abundant among Puget Sound populations. The population rebounded from similarly low abundance twenty years ago. The relatively small hatchery program is operated for research purposes, to monitor harvest rates and catch distribution. It utilizes natural-origin broodstock, ranging from 60 – 100 since 1994.

Figure 3-4 Natural escapement for Skagit summer-fall Chinook populations.

	Lower Skagit	Lower Sauk	Upper Skagit
1991	1,510	658	3,656
1992	1,331	469	5,548
1993	942	205	4,654
1994	884	112	4,654
1995	666	278	6,027
1996	1,521	1,103	8,082
1997	409	295	4,247
1998	2,388	460	11,852
1999	1,076	295	3,659
2000	3,351	576	1,398
2001	2,683	1,103	10,159
2002	4,884	910	13,878
2003	1,236	1,493	7,212
2004	3,146	443	20,141
2005	3,372	875	16,698
2006	3,522	1,095	16,244
2007	1,064	383	9,921
2008	2,689	538	8,514
2009	1,439	250	5,364
2010	1,017	356	6,707
2011	820	210	4,541



Regression and 15-year Geiger trends for the Lower Skagit population are negative and significant. Increasing abundance from 1997 to 2002, and subsequent decline is generally similar to other Skagit populations. Observed escapement was lower than the LAT (900) in 1994, 1995, 1997, and 2011. The 2011 forecast did not predict critical abundance. Declining escapement since 2008 warrants management attention. Lower mainstem production is more susceptible to high incubation period flows, which explain in part the generally lower abundance of this population, but lower marine survival has also exerted strong effect. The Lower Skagit (fall) hatchery program, which operated for harvest monitoring purposes, has been discontinued.

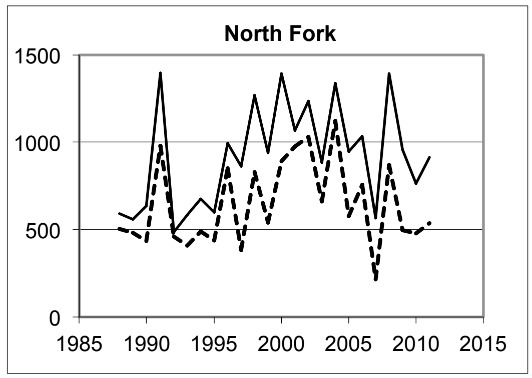
3.5 Stillaguamish

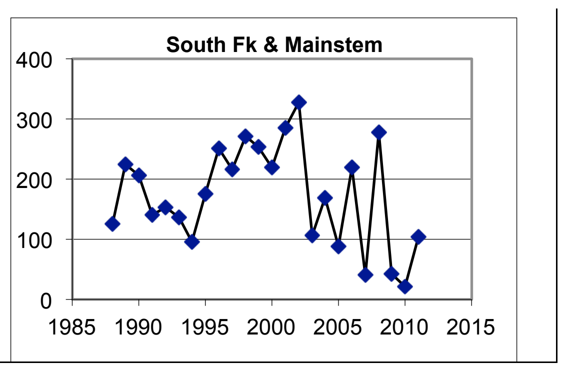
Harvest planning has been attentive to the critical status of the South Fork Stillaguamish population, which has implemented the Critical Exploitation Rate ceiling in 2008 and 2010. A Low Abundance Threshold of 200 was implemented for the South Fork population in the 2010 Plan, thereby raising the LAT that triggers the CER ceiling.

North Fork (summer) escapement estimates shown below are developed from redd surveys in the North Fork and several tributaries (Grant, Deer, Brooks, Boulder, French, Segelson, and Ashton creeks). South Fork / mainstem (fall) escapements are developed from redd surveys in the South Fork, mainstem, and Pilchuck, Jim, Siberia and Canyon creeks. Tributary surveys vary annually, with broader coverage in recent years. Prior to 2009, aerial (helicopter) surveys of the North Fork were conducted to count redds, and escapement estimates developed by the AUC method. Since 2009 foot surveys have generated a redd census. High flow and turbidity influenced survey accuracy in some years (e.g. 2007 and 2010 redd-based estimates were significantly lower than GMR estimates). Nonetheless, the time series analyzed below, starting in 1988, are believed to accurate represent the trend in escapement.

Figure 3-5. Natural escapement for Stillaguamish Chinook.

	North Fork	NOR	South Fork & Mainstem
1988	591	506	126
1989	560	483	224
1990	636	434	206
1991	1396	978	140
1992	486	460	153
1993	583	408	136
1994	677	491	96
1995	599	437	176
1996	993	852	251
1997	862	383	216
1998	1269	831	271
1999	941	542	253
2000	1393	892	219
2001	1066	977	285
2002	1236	1030	328
2003	884	661	106
2004	1340	1123	169
2005	947	576	89
2006	1035	756	219
2007	567	214	40
2008	1393	872	278
2009	958	497	43
2010	763	479	21
2011	914	538	104





Observed escapement to the South Fork / mainstem has been close to or lower than 200. The regression and 15-year Geiger trends are negative and significant. Since 2002 there has been relatively higher interannual variation in escapement.

Interpretation of South Fork status from escapement is tempered by probable bias in estimates due to high flow and turbidity that affect stream survey accuracy. In many recent years natural escapement is not accurately estimated or indexed. Regardless, the status of the population is regarded as critical, and a captive-brood hatchery supplementation program has been initiated to rebuild abundance.

Re-analysis of genetic baseline samples suggests a greater degree of spatial overlap among summer and fall spawners (i.e., North Fork origin adults are spawning in the South Fork and mainstem, and vice versa).

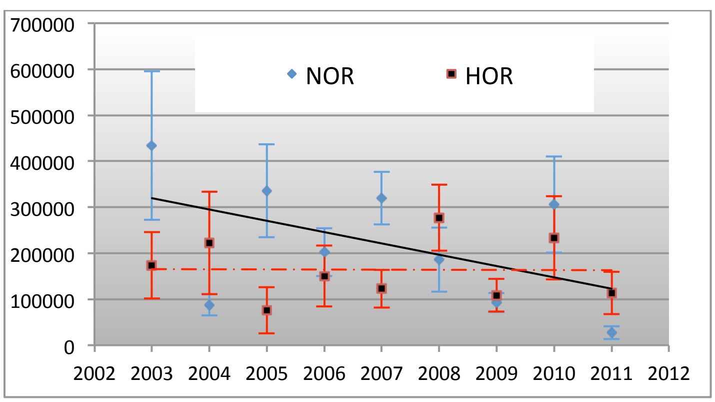
Table 3-5 Escapement trends for Stillaguamish Chinook

	Regression			Geiger 15 y		Geiger 21 y	
	X_1	95% C.I.		Slope	Slope/y_0	Slope	Slope/y_0
Stillaguamish	0.0144	-0.0028	0.0317				
North Fork	0.0212	0.0043	0.0381	-33.40	0.035	5.54	0.010
NORs	0.0056	-0.0192	0.0304	-15.20	0.013	19.30	0.026
South Fork	-0.0391	-0.0780	-0.0002	-21.00	0.065	-4.61	0.021

The regression trend for North Fork natural spawners since 1988 is positive. North Fork NOR escapement has declined in recent years. For managers, the inability of the North Fork hatchery supplementation program to rebuild natural abundance is of great concern, and caused by poor and likely deteriorating freshwater and estuarine habitat conditions.

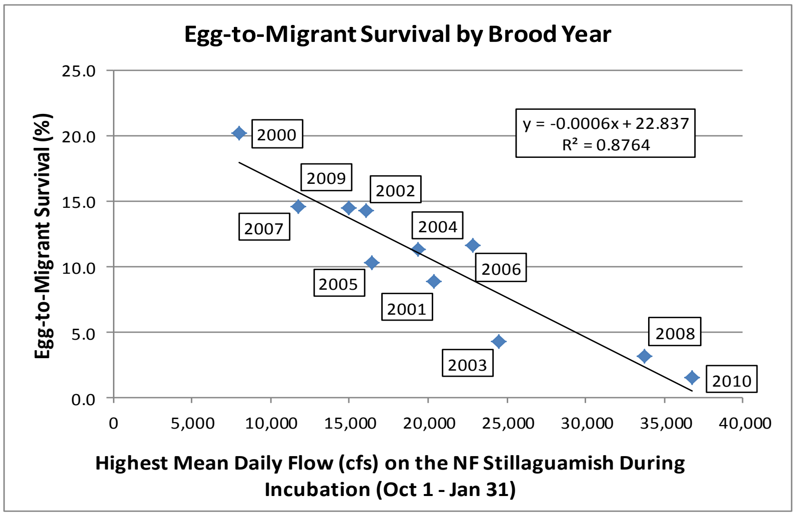
The decline in NOR escapement to the Stillaguamish is, in part, attributable to declining freshwater (i.e. egg to smolt) survival. Natural smolt production, measured by the smolt trap, exhibits a declining trend since 2003.

Figure 3-6 Natural and hatchery Chinook smolt outmigration in the Stillaguamish River.



Egg-to-smolt survival is closely correlated with peak flow in the North Fork, a similar relationship to what has been observed in other Puget Sound rivers.

Figure 3-7 The correlation between egg to migrant smolt survival and peak (October - January) flow in the North Fork Stillaguamish River.



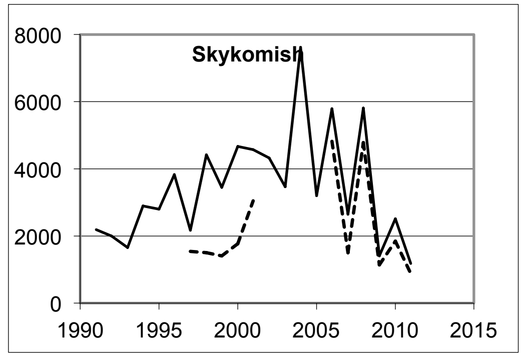
3.6 Snohomish

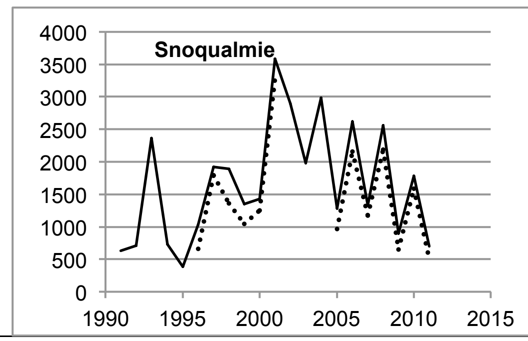
The escapement time series for Snohomish Chinook extends back to 1965 for both populations, but we have not closely examined survey coverage and frequency for years prior to 1990. Survey coverage and the estimation method have been relatively consistent since 1990. The Snohomish Recovery Workplan (Snohomish River Basin Salmonid Recovery Tech Committee 1999) advocated use of historical estimates for 1965 – 1976 as benchmarks for monitoring the two populations.

The number of natural spawners for the Skykomish and Snoqualmie populations has declined since the relatively high numbers observed in 2004 and 2001, respectively. The Skykomish population comprises an average of 65% of total escapement to the Snohomish system.

Figure 3-8 Escapement of Snohomish Chinook populations.

	Skykomish	NOR	Snoqualmie	NOR
1991	2192		628	
1992	2002		706	
1993	1653		2366	
1994	2898		728	
1995	2791		385	
1996	3819		1032	660
1997	2161	1540	1917	1796
1998	4415	1495	1891	1361
1999	3446	1401	1345	1040
2000	4668	1775	1427	1248
2001	4577	3054	3589	3284
2002	4327		2896	
2003	3472		1975	
2004	7614		2988	
2005	3201		1279	968
2006	5797	4815	2615	2161
2007	2648	1510	1334	1174
2008	5813	4780	2560	2190
2009	1414	1146	895	649
2010	2511	1836	1788	1585
2011	1180	880	700	506





The regression and 21-year Geiger trends for Snoqualmie are positive and significant. Trends in the NOR component of spawners for both populations is confounded by the missing data points for 2002 – 2004. Escapement has declined for both populations in recent years.

Table 3-6 Escapement trends for Snohomish Chinook populations.

	Regression			Geiger 15 y		Geiger 21 y	
	X_1	95% C.I.		Slope	Slope/y_0	Slope	Slope/y_0
Skykomish	-0.0082	-0.0167	0.0003	-190.36	0.036	32.57	0.012
Snoqualmie	0.0231	0.0122	0.0340	-55.70	0.023	43.29	0.050

The hatchery- and natural-origin components of natural spawners have been monitored for both populations by stratified sampling of carcasses from all major spawning areas. There are gaps in these data in 2003 - 2005. For 1992 – 2011 the median NOR proportions of Skykomish and Snoqualmie escapement were 77% and 67%, respectively. Wallace River hatchery returns, and strays from other basins, explain the lower NOR component of the Skykomish. Wallace Hatchery returns spawn primarily in the Wallace River and the mainstem below its confluence.

Naturally-produced Chinook make up a sizeable fraction of the spawning abundance, averaging 77.4% for the basin in recent years (2005-2011), which is up from an average of 61.0% from 1997 to 2001 and the 12-year average of 70.0% (M. Crewson, Tulalip Tribes and P. Verhey WDFW unpublished data). The average hatchery-origin fraction of the Skykomish Chinook population in five recent years (2006-2011; 24.8%) has dropped to about half of what it was 15 years ago, when the five-year (1997-2001) average was 49.9%. The hatchery-origin fraction of the Snoqualmie Chinook population has remained similar but slightly higher in recent years (18.4% from 2005-2011) than the 1997-2001 average of 15.6% (Table 2.2.2.6) (Tulalip HGMP draft Dec 2012). Reasons for the lower proportion of hatchery-origin spawners in the Skykomish River in recent years are not entirely understood, but lower straying rates associated with the switch to native summer Chinook broodstock at Wallace River hatchery, starting in 1997, are likely a contributing factor. The contribution of Tulalip Hatchery strays has also declined substantially since the switch to native summer broodstock. Perhaps the most significant factor is the lower (marine) survival of hatchery releases.

Table 3-7 The natural-origin fraction of Chinook spawning in the Skykomish and Snoqualmie rivers.

	Skykomish	Snoqualmie
1997	70.9%	93.7%
1998	33.9%	71.9%
1999	40.7%	77.4%
2000	38.0%	87.5%
2001	66.8%	91.5%
Average	50.0%	84.4%
2005	96.6%	75.7%
2006	83.2%	82.6%
2007	57.0%	88.0%
2008	82.2%	85.5%
2009	81.0%	72.5%
2010	73.1%	88.7%
Average	75.3%	83.5%

Harvest strategy for the Snohomish management unit is based largely on the more detailed knowledge of the productivity of the Skykomish population. The 2010 Plan, and previous versions, assumes that management objectives (i.e., the ER ceiling and Critical Exploitation Rate Ceiling) demonstrated to reduce harvest risk to the Skykomish will also protect the Snoqualmie population. The Plan and the Snohomish Recovery Workplan suggest that monitoring escapement for the two populations might indicate differential effect of harvest. A comparison of 1965-76 and 1992 – 2011 means shows the Skykomish proportion of total (MU) escapement, all natural and just NOR spawners, has declined. The two populations show a similar abundance trend – generally increasing during the 1990s and declining since 2000, but with the Skykomish decline proportionately greater. We cannot, however, attribute this to differential harvest because we don't know if the harvest distribution or harvest rate of Snoqualmie Chinook is different. Many other factors could have influenced the disparate population abundance.

3.7 Cedar River

The time series of escapement estimates for the Cedar River extends back to 1964, based on live counts in the mainstem index reach below Landsburg Dam. Starting in 1999, surveys in this reach also counted redds. Expansion of redd counts produced estimates that differ from the AUC method. Redd count expansion is thought to be more accurate than the AUC method. After ten years of conducting both methods (1999-2008) managers determined that AUC estimates prior to 1999 could be converted to redd-based equivalents based on linear regression. The escapement goal for the Cedar was also adjusted by this method from 1,200 to 1,680.

Since 2003 Chinook have passed above Landsburg Dam through a new fishway. Chinook redds counted upstream of the dam are added to the lower mainstem redd estimate.

The Geiger slope over the last 15 years is positive and significant; the 21-year slope is not significant.

Estimates of the hatchery-origin component of Cedar escapement are available since 2006, based on carcass sampling in the reach below Landsburg Dam, and visual identification of Chinook passing through the dam fishway. The HOR proportion has varied from 10% to 21%. These ad-clipped or tagged adults originated primarily at four hatcheries: Issaquah Creek, the University of Washington, Grovers Creek and Bernie Gobin. Under the current agreement with Seattle, hatchery- and natural-origin Chinook are passed above Landsburg Dam.

Table 3-8 Sampling data used to determine the origin of Cedar River Chinook spawners.

Year	Location	Tot sampled	# Clipped	# Unclipped	% Un-clipped	% Clipped
2003	Above Dam	79	55	24	30%	70%
	Below Dam	288	64	224	78%	22%
	Tribs below Dam	41	28	13	32%	68%
2004	Above Dam	51	34	17	33%	67%
	Below Dam	373	112	261	70%	30%
	Tribs below Dam	26	25	1	4%	96%
2005	Above Dam	69	29	40	58%	42%
	Below Dam	259	76	183	71%	29%
	Tribs below Dam	20	12	8	40%	60%
2006	Above Dam	182	82	100	55%	45%
	Below Dam	472	94	378	80%	20%
	Tribs below Dam	4	4	0	0%	100%
2007	Above Dam	397	93	298	75%	23%
	Below Dam	607	64	543	89%	11%
	Tribs below Dam	58	28	30	52%	48%
2008	Above Dam	147	25	122	83%	17%
	Below Dam	304	30	268	88%	10%
	Tribs below Dam	0	0	0		
2009	Above Dam	138	41	97	70%	30%
	Below Dam	170	31	139	82%	18%
	Tribs below Dam	0	0	0		
2010	Above Dam	169	51	118	70%	30%
	Below Dam	131	19	112	85%	15%
	Tribs below Dam	1	1	0	0%	100%
2011	Above Dam	211	77	134	64%	36%
	Below Dam	163	28	135	83%	17%
	Tribs below Dam	5	3	2	40%	60%

The regression trend from the 1964-2011 series is non-significant. The Geiger slope for the last 15 years is positive and biologically significant; the 21-year slope, also positive, is not biologically significant.

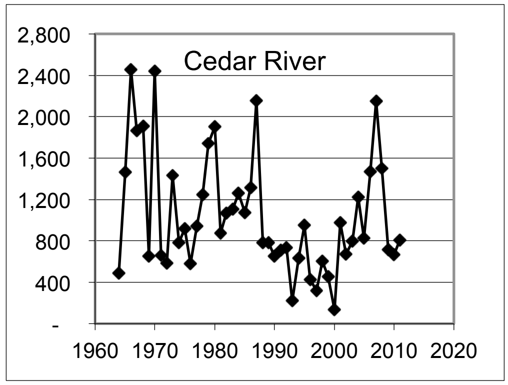
Table 3-9 Escapement trends for Cedar River Chinook.

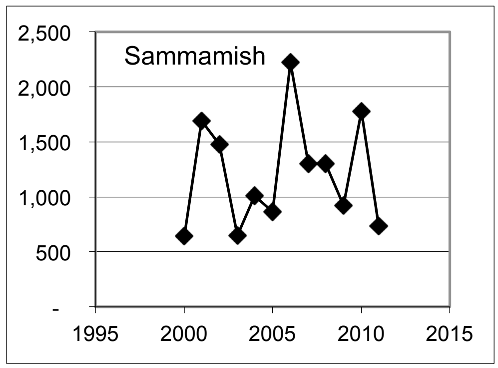
	Regression			Geiger 15 y		Geiger 21 y	
	X_1	95% C.I.		Slope	Slope/y_0	Slope	Slope/y_0
Cedar	-0.012	-0.0241	0.0001	86.363	0.3852	13.98	0.016

Estimates of the hatchery-origin component of Cedar escapement are available since 2006, based on carcass sampling in the reach below Landsburg Dam and monitoring at the Landsburg fishway. The HOR proportion has varied from 10% to 21%. The majority of these ad-clipped or tagged adults originated at Issaquah Creek Hatchery. Under the current agreement with Seattle, hatchery and natural origin Chinook are passed above Landsburg Dam.

Figure 3-9 Chinook escapement to the Cedar River and Sammamish basin.

	Cedar	NORs	Sammamish	NORs
1992	734			
1993	218			
1994	632			
1995	953			
1996	424			
1997	318			
1998	604			
1999	455			
2000	133		642	
2001	975		1,690	
2002	673		1,478	
2003	798		650	
2004	1,225		1,012	
2005	828		866	
2006	1,468	1,164	2,223	620
2007	2,148	1,893	1,300	168
2008	1,498	1,346	1,301	155
2009	713	577	924	47
2010	665	546	1,781	83
2011	805	646	733	33



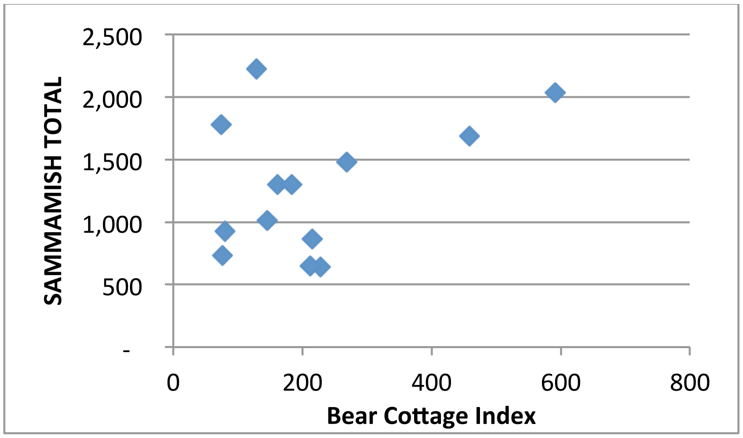


3.8 Sammamish

Escapement estimates to the Sammamish basin include spawners in Bear Creek and the mainstem and East Fork of Issaquah Creek below the hatchery weir. The time series extends back to 2000. Formerly escapement was monitored in the Bear Creek and Cottage Lake Creek index reaches, where estimates are available back to 1983. Bear Creek reaches outside of the index have also been surveyed since 1998. Adults are also passed above the Issaquah weir, but these fish are not included in the Sammamish estimate because this component is entirely discretionary. The Sammamish escapement trend is uncertain with such a short time series, but apparently stable. The geometric mean of estimates since 2000 is 1,126.

Since the 2010 harvest plan was implemented managers have referred to the aggregate of escapement to Bear Creek and Issaquah Creek to inform harvest strategy. Formerly, the relatively low number of spawners in Bear Creek was interpreted as evidence of critical status. But there is no correlation between the Bear / Cottage estimates and total escapement (Figure x), so the reach does not function as an index. Adult entry into Bear Creek may be more related to water temperature or flow. The proportion of natural-origin adults, estimated since 2006, has ranged up to 28%, but has been 5% the last three years, so it is apparent that natural productivity potential is very low in the Sammamish basin.

Figure 10. Scatter plot of Sammamish population and Bear Creek index escapement.



3.9 Green

Green River escapement estimates are available for years back to 1965, based on redd surveys in the mainstem from RM 24 to 61 and Newaukum Creek from RM 0 to 4.5. Natural spawners in Soos Creek are not included. The regression and both Geiger slopes are negative, but only the 15-year Geiger parameter is significant. Of immediate concern are the lower escapement estimates in 2009 – 2011. High discharge during flood events in 2005, 2006, and 2008, in part related to curtailed storage capacity at Howard Hanson Dam, appear to explain much of the downturn in natural recruitment. Juvenile outmigrant estimates for those years show very low egg to outmigrant survival. But the concurrent decrease in hatchery survival suggests late-phase freshwater and/or marine survival has suddenly fallen. Natural spawners are predominantly of hatchery origin, due to the large-scale hatchery production of subyearlings at Soos Creek and yearlings at Icy Creek, but their productivity is low primarily due to highly degraded spawning and rearing habitat. The hatchery component of natural spawners has ranged from 33% to 75% since 2003. These estimates are based on mass-marked hatchery fish. Estimates for previous years are unreliable because they were based on CWT expansion.

In 2009 - 2011 there were relatively few hatchery-origin adults spawning in the mainstem, compared to the number entering the hatchery rack. Though carcass sampling has been thorough in recent years, there is concern that the number of NORs is so low relative to hatchery fish that, even with mass marking, the unclipped or mis-clipped hatchery fish could account for a substantial proportion of the apparent number of NORs.

Figure 3-11 Natural Chinook escapement to the Green River.

	Total	NOR
1992	5,166	
1993	2,444	
1994	3,880	
1995	7,921	
1996	5,952	
1997	7,101	
1998	5,963	
1999	7,135	
2000	4,473	
2001	6,473	
2002	7,564	
2003	5,864	2,613
2004	7,947	2,922
2005	2,523	1,167
2006	5,790	2,663
2007	4,301	1,904
2008	5,971	3,974
2009	688	169
2010	2,092	925
2011	993	397

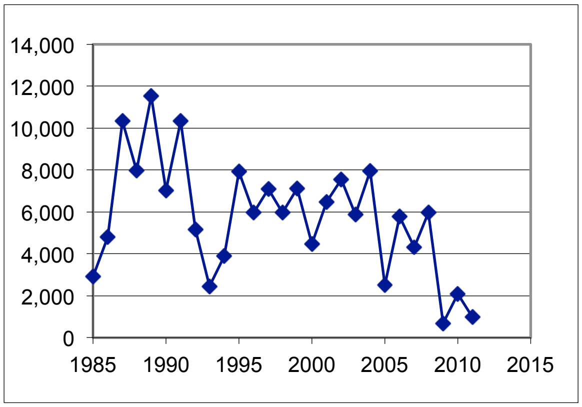


Table 3-10 Escapement trends for Green River Chinook.

	Regression			Geiger 15 y		Geiger 21 y	
	X_1	95% C.I.		Slope	Slope/y_0	Slope	Slope/y_0
Green	-0.0064	-0.0207	0.0079	-438.13	0.053	-244.92	0.032

Analysis continues to reconcile escapement estimates calculated by the conventional method with those estimates calculated through tagging or genetic mark/recapture estimates. The conventional method involves either a redd census or an index redd expansion, so is subject to assumptions regarding the sex ratio and, for index redd expansion, assumptions regarding the representative nature of the index reaches. Adult Chinook were captured below the spawning area for three years, 2000-2002, marked, and recaptured on the spawning grounds and in the hatchery. In 2010, adult Chinook were sampled for genetic material, followed by juvenile genetic sampling in 2011. Both of these mark/recapture studies estimated two to three times more Chinook than redd based estimates. The 2010 genetic M/R estimate also exceeded the redd census-based estimate. The results of these studies have not been used by the co-managers due to a number of technical problems with the studies, and because the escapement goal is expressed in conventional redd method units.

3.10 White River Spring

Escapement estimates are available back to 1941, when the Buckley trap was installed at RM 24.3. Mud Mountain Dam was completed in 1946 at RM 29. Since then, Chinook have been captured at the trap and hauled above the dam to spawn naturally in the upper watershed. Natural-origin Chinook, and returns of hatchery-reared subyearlings reared in acclimation ponds in the upper watershed, comprise most of the sampled fish hauled above the dam. In some years other White River Hatchery-origin adults (returns from on-station releases) are also transported upstream. Transported fish comprise a varying mix of natural- and hatchery-origin jacks and adults captured at the Buckley Trap on the left bank, and the White River Hatchery trap on the right bank. In recent years, especially when there were large pink salmon returns, a significant portion of the Chinook captured in the Buckley trap were not sampled. These comprise an unknown and in some years large proportion of fall Chinook By convention the escapement estimates used for management comprise only adults, though in some years many jacks return and are transported.

Spring and fall Chinook also spawn in the lower White River and Boise Creek (and other tributaries). The lower mainstem is intermittently surveyable, but regular surveys of Boise Creek began in 1994. These lower river survey data are not included in the spring estimates used for management.

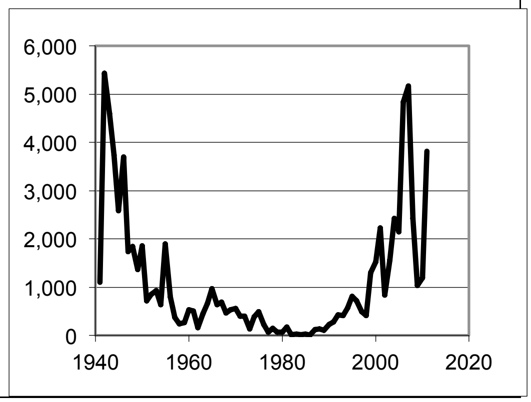
White River Hatchery on-site releases are 100% coded-wire tagged, but they are not adipose clipped. Prior to brood year 1997 White River releases were coded-wire tagged and ad-clipped. The acclimation ponds in the upper watershed have been stocked with sub-yearlings from the White River Hatchery and Hupp Springs Hatchery. Acclimation pond releases are alternately left- or right-ventral clipped in odd and even brood years. Unclipped and untagged Chinook are assumed to be of natural-origin; aside from those utilized for broodstock at the hatchery, they are all hauled upstream. Marks on acclimation pond fish varied since the first releases in 1993. Except for some body-tagged CWTs in brood year 2004, all acclimation pond releases since brood year 1999 have been ventral clipped.

Accounting Chinook escapement is confounded by several factors. Fish hauled above the dam comprise spring and fall Chinook. It is uncertain whether a native fall run was ever present in the upper White, or the run started from fall hatchery production in the Puyallup system. Two genetic studies have concluded that run timing of the two stocks overlaps substantially, nullifying any simple assumption of a date cut-off to account spring Chinook. However it is likely that the majority of hauled fish in some years are falls. The Army Corps of Engineers, with assistance from the Puyallup Tribe, is responsible for operating the Buckley trap and transporting fish above the dam. Trap capacity is overwhelmed by high pink and coho salmon returns. To minimize trap mortality to all species, sampling to count and distinguish adult and jack Chinook, and hatchery- and natural-origin Chinook, is not done. So the ACOE haul records are inaccurate for years since 2003.

Harvest management objectives are specific to White River production; spring and fall timed fish of natural origin are aggregated in forecasts and harvest impact modeling. Harvest of White River-origin spring Chinook produced and released at Hupp Springs (in addition to those fish used to stock the acclimation ponds) is modeled as part of pre-terminal White River impacts.

Figure 3-12 Natural Chinook escapement to the White River (fish transported above Mud Mountain Dam, plus natural-origin broodstock used at White River Hatchery.

	Adults	NORs
1992	423	406
1993	414	401
1994	567	385
1995	813	605
1996	715	619
1997	494	402
1998	405	242
1999	1,302	453
2000	1,519	1470
2001	2,224	2022
2002	838	642
2003	1,560	1185
2004	2,423	1277
2005	2,141	1321
2006	4,829	1443
2007	5,160	2891
2008	2,420	1369
2009	1,027	593
2010	1,187	550
2011	3,820	2675



Harvest management strategy is based on aggregate escapement above Mud Mountain Dam, so the trend in transported Chinook is relevant. The regression and both Geiger trends are positive and significant. The extent to which these trends accurately depict spring abundance is uncertain, due to the uncertainties in trap data, described above.

Table 3-11 Escapement trend for White River Chinook.

	Regression			Geiger 15 y		Geiger 21 y	
	X_1	95% C.I.		Slope	Slope/y_0	Slope	Slope/y_0
White	0.0494	0.0204	0.0784	111.80	0.11	137.57	3.86

3.11 Puyallup

Escapement estimates since 1992 have been based on consistent survey coverage and calculation methods.   Estimates for 1965 – 1976 (WDF 1977) were based on tagging studies, whereas recent estimates are based on redd or live counts in South Prairie Creek and other clear tributaries. The mainstem Puyallup and Carbon are infrequently surveyable due to glacial turbidity. Their contribution to escapement is estimated from a ratio in one historical year when surveys were possible, and therefore highly uncertain. Concurrent spawning by pink salmon has affected surveys and estimates of Chinook escapement to South Prairie Creek – the primary surveyable tributary that provides the index basis for management. Calculation of escapement to various tributaries has varied from year to year, based on survey conditions.

With inconsistency in estimates of total escapement, the South Prairie – Wilkeson sub-basin is the most reliable index of escapement. The regression slope for the South Prairie escapement series since 1994 is negative and significant.

Figure 3-13 Natural Chinook escapement to the Puyallup River.

	Total	South Prairie
1992	3034	
1993	1999	
1994	2526	798
1995	2701	1408
1996	2444	1268
1997	1554	667
1998	3071	1028
1999	1988	1430
2000	1193	695
2001	1915	1154
2002	1807	840
2003	1547	740
2004	1843	573
2005	1064	389
2006	2232	978
2007	2932	1194
2008	2725	925
2009	1526	710
2010	1563	382
2011	1486	439

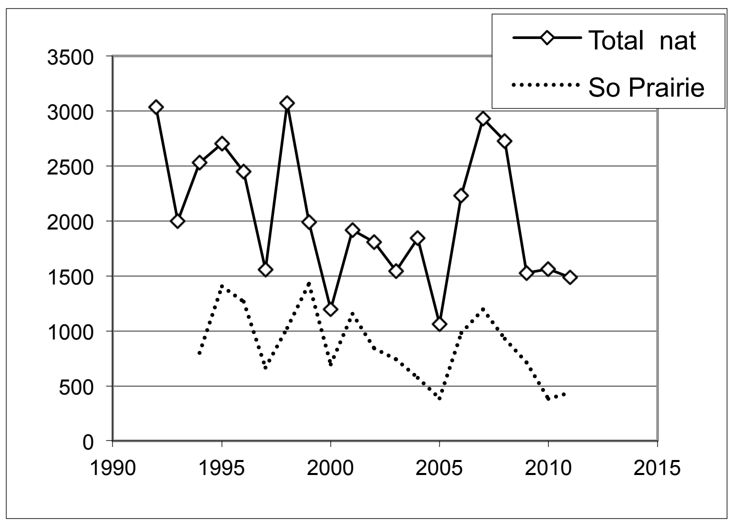


Table 3-12 Trends for Chinook escapement to the Puyallup River (South Prairie Creek index).

	Regression			Geiger 15 y		Geiger 21 y	
	X_1	95% C.I.		Slope	Slope/y_0	Slope	Slope/y_0
Puyallup South Prairie	-0.0413	-0.0759	-0.0067	-35.20	0.017	-65.86	0.024

With continuing uncertainty in estimates of total escapement, and inability to set an escapement goal or thresholds of total escapement, harvest strategy responds to forecasts in relation to the Low Abundance Threshold of 500 in the South Prairie index. Puyallup has not been in critical status since inception of the Puget Sound Chinook Harvest Plan in 2001. Although observed South Prairie abundance has been lower than 500 in three recent years, total escapement has not fallen below 1,000 in these years. Geometric mean abundance over 2002 - 2011 for total and South Prairie escapement were 1794 and 668, respectively.

3.12 Nisqually

Natural escapement is estimated from iterated surveys to count redds in the Nisqually mainstem index (RM 21.8 to 26.2) and in the Mashel river (to RM 3.2) to count live and dead Chinook. The estimation method expands the total of (peak mainstem redds * 2.5) + (peak Mashel live/dead) by 6.81. The expansion factor was derived from surveys prior to the large increase in hatchery production. Mainstem surveys are influenced by flow and turbidity. A time series of estimates by this method are available since 1977. Estimates for 1965 – 1976 (WDF 1977) were derived by a different expansion of peak counts in Coulter, Rocky, and Burley creeks, so these estimates were not included in trend analysis. Estimates for years since 2004 were based on more frequent surveys.

The regression and both Geiger slopes are significantly positive. The apparent increase in escapement may be, in part, attributed to increased survey frequency since 2004. Increases in hatchery production evident in return year 1993 and again in 1999 also resulted in increased natural spawner abundance. The extent of spawning in the mainstem below the index reach has not been estimated, but has probably increased with higher hatchery returns.

Estimates of the proportion of natural-origin fish spawning in the mainstem and Mashel are available since 2004, but their accuracy is uncertain. The NOR proportion ranged from 21% to 51% in this period (median 22%), so managers assume that first generation hatchery returns have comprised the majority of natural spawners. These estimates are uncertain, in part because the marking rate of hatchery fish has changed and is in some years uncertain, and because very few carcasses on the spawning grounds can be sampled. The majority of the carcass samples are collected in the lower Mashel River, which is well upstream of the hatchery release sites, so the proportion of hatchery-origin adults in the Mashel is probably substantially lower than in the lower mainstem.

A full-span weir began operating at RM 21 on the Nisqually mainstem in 2012, and is expected to enable reliable escapement estimates for the upper river. The weir will also enable management of spawner composition.

Figure 3-14 Natural Chinook escapement to the Nisqually River.

	Total	NORs
1992	106	
1993	1655	
1994	1730	
1995	817	
1996	606	
1997	340	
1998	834	
1999	1399	
2000	1253	
2001	1079	
2002	1542	
2003	627	
2004	2788	434
2005	2159	477
2006	2179	544
2007	1744	765
2008	3398	1371
2009	872	82
2010	2067	481
2011	2264	344

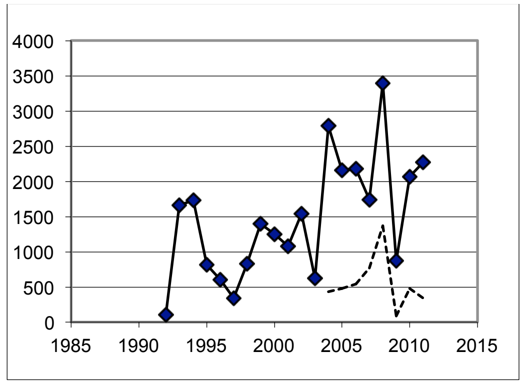


Table 3-13 Trends in Chinook escapement to the Nisqually River.

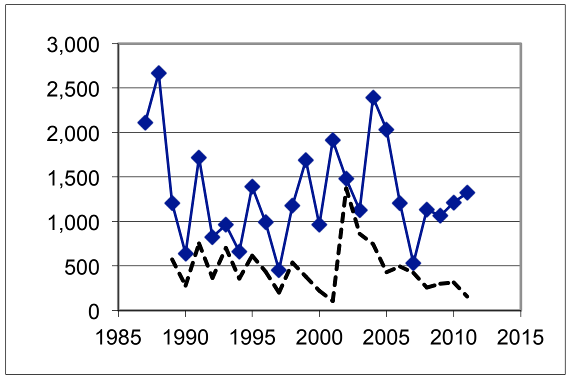
	Regression			Geiger 15 y		Geiger 21 y	
	X_1	95% C.I.		Slope	Slope/y_0	Slope	Slope/y_0
Nisqually	0.0530	0.0212	0.0848	98.80	0.10	95.86	0.27

3.13 Skokomish

Estimates of natural escapement for 1988 – 2011 are derived from surveys of the mainstem (RM 2.2 to 9.0), North Fork (RM 0.0 to 15.6), South Fork (up to RM 2.2), and Vance and Hunter creeks. Survey design has been relatively consistent since 1988, with some deviation in survey frequency in each area. Since 2008 additional area in the South Fork up to RM 5.5 have been surveyed and included in the estimate. There has been increased frequency of surveys of some reaches since 2008.

Figure 3-15 Natural Chinook escapement to the Skokomish River.

	Total natural	NOR
1987	2,112	
1988	2,666	
1989	1,204	577
1990	642	282
1991	1,719	755
1992	825	362
1993	960	707
1994	657	360
1995	1,398	614
1996	995	437
1997	452	198
1998	1,177	539
1999	1,692	382
2000	962	220
2001	1,913	105
2002	1,479	1370
2003	1,126	860
2004	2,398	748
2005	2,032	433
2006	1,209	492
2007	531	419
2008	1,134	257
2009	1,066	304
2010	1,214	312
2011	1,321	157



Regression and Geiger trends for Skokomish natural escapement and NOR escapement are non-significant. Qualitatively, a decline in NOR escapement is apparent since 2002.

Table 3-14 Trends in Chinook escapement to the Skokomish River.

	Regression			Geiger 15 y		Geiger 21 y	
	X_1	95% C.I.		Slope	Slope/y_0	Slope	Slope/y_0
Skokomish	0.0034	-0.0244	0.0313	-4.30	0.003	17.79	-0.017
NORs	-0.0346	-0.0736	0.0043	8.37	-0.023	-0.285	0.001

Current habitat conditions cannot support an independently sustainable population. Hatchery returns, however, provide a stabilizing influence on natural escapement.

The NOR component of natural spawners is estimated from carcass sampling for mark status and presence of CWTs. Hatchery marking rates were less than 100% until brood year 2006, so until 2011 the NOR proportion was derived by adjusting the unmarked carcass proportion by the marking rate for each of the three contributing hatchery broods. Carcass sampling rates are very low for several years. These factors increase uncertainty in those estimates.

Since 2005 the majority (mean 65%) of redds have been counted in the mainstem reach, with a mean of 28% in the North Fork and 7% in the Lower South Fork. The South Fork has been inaccessible for much of the migration and spawning season in several recent years, when surface flow is near zero due to aggradation. Surveys of Hunter Creek, which has very limited suitable spawning habitat, have observed 7% to 20% of total redds.

Table 3-15 Distribution of Chinook spawning in the Skokomish River.

	Total	Mainstem	%	North Fork	%	South Fork	%
2005	2032	1445	71%	529	26%	58	3%
2006	1209	934	77%	275	23%	0	0%
2007	429	303	71%	123	29%	3	1%
2008	1134	671	59%	295	26%	168	15%
2009	1067	666	62%	368	34%	33	3%
2010	1214	701	58%	325	27%	188	15%
2011	1321	758	57%	405	31%	158	12%

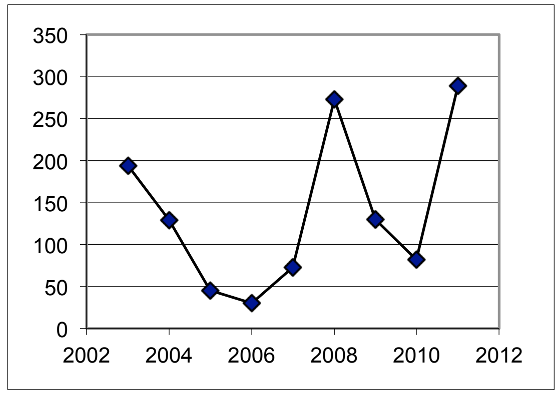
In 2008 (372 adults + 26 jacks) and 2009 (400) surplus adults and jacks being held at George Adams hatchery were transported into the upper South Fork (released at confluence with Brown's Creek. This program was terminated when the revised Chinook Recovery Plan (2010) was completed.

3.14 Mid Hood Canal

The lower reaches of the Hamma Hamma and Duckabush Rivers, and a more extensive area of the Dosewallips (RM 0 – 2.3, 3.6 – 6.7, and 7 – 11), are surveyed to count live fish and redds. Higher reaches of the Hamma and Duckabush have been surveyed in some years since 1998, but few redds have been observed. Pink and summer chum spawning in the lower reaches of these rivers concurrently with Chinook make it difficult to distinguish Chinook redds.

Figure 3-16 Natural Chinook escapement to Mid-Hood Canal rivers.

	Hamma Hamma	Duckabush	Dosewallips	Total
1990	35	10	1	46
1991	30	14	42	86
1992	52	3	41	96
1993	28	17	67	112
1994	78	9	297	384
1995	25	2	76	103
1996	11	13	0	24
1997				
1998	172	57	58	287
1999	557	151	54	762
2000	381	28	29	438
2001	248	29	45	322
2002	32	20	43	95
2003	95	12	87	194
2004	49	0	80	129
2005	33	2	10	45
2006	16	1	13	30
2007	60	4	9	73
2008	255	0	18	273
2009	98	9	23	130
2010	67	0	15	82
2011	273	5	11	289



The time series of escapement estimates since 1990 were consistently derived. The 15-year Geiger slope negative and significant.

Table 3-16 Trends in Chinook escapement for the Mid-Hood Canal population.

	Regression			Geiger 15 y		Geiger 21 y	
	X_1	95% C.I.		Slope	Slope/y_0	Slope	Slope/y_0
Mid Hood Canal	0.0294	-0.0677	0.1265	-25.00	16.07	-1.25	0.01

Escapement to the Hamma Hamma River comprises the majority of Mid-Hood Canal population abundance (median since 2005 82%). A hatchery supplementation program utilizing locally-collected and George Adams Hatchery broodstock began operating in 1995. Hamma escapement increased in 1998 – 2001, 2008, and 2011, but the difficulty in sampling carcasses has caused uncertainty in estimates of the local hatchery component of spawners, and the contribution of Chinook originating in southern Hood Canal.

Low aggregate population abundance, and more particularly, low escapement to the Dosewallips and Duckabush, elevates conservation concern. Harvest has been consistently managed for critical status, but low natural productivity in these rivers is preventing recovery. There is substantial uncertainty about the potential for the Mid Canal watersheds to support an independent population, or whether viability has always, and will continue to depend on Chinook originating in southern Hood Canal. There are similarly low numbers of Chinook observed in the Dewatto River, Liliwaup Creek, Tahuya River, and the Union River.

3.15 Dungeness

The mainstem Dungeness (up to RM 18.8) and the lower Greywolf River (up to RM 5.0) are surveyed to estimate natural escapement. Population escapement tabulated below include adult collected for broodstock. A time series of consistently derived estimates extends back to 1986.

The regression and Geiger slopes for total escapement and NOR spawners since 1986 are significantly positive.

The increase in total escapement observed from 2000 – 2006 is an effect of the hatchery supplementation program; the subsequent decline and increase in the last two years is attributed to the interruption after brood year 2002, and subsequent re-starting of that program. NOR returns remain at critically low levels, indicating that hatchery supplementation is essential to maintain the population. It is evident that natural productivity is very low due to impaired freshwater habitat function.

Figure 3-17 Natural Chinook escapement to the Dungeness River.

	Total	Nat Origin
1992	153	153
1993	43	43
1994	65	65
1995	163	163
1996	183	183
1997	50	50
1998	110	110
1999	75	75
2000	218	218
2001	453	17
2002	633	115
2003	640	123
2004	1014	193
2005	1077	304
2006	1543	293
2007	403	146
2008	229	86
2009	220	99
2010	457	101
2011	665	104

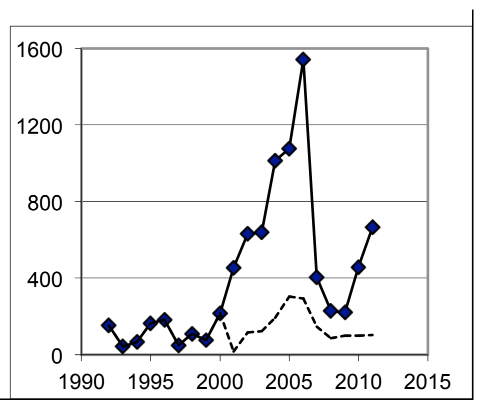


Table 3-17 Trends in Chinook escapement to the Dungeness River.

	Regression			Geiger 15 y		Geiger 21 y	
	X_1	95% C.I.		Slope	Slope/y_0	Slope	Slope/y_0
Total	0.0704	0.0264	0.1144	90.40	0.46	34.07	0.41
NORs	0.6458	0.1091	1.1825	8.30	0.11	2.14	0.02

Harvest strategy is informed by the forecasted aggregate abundance (i.e. NOR and HOR returns), which has not fallen to the LAT in recent years. But the relatively low SUS ER ceiling (10%) is deemed sufficiently conservative under these circumstances.

3.16 Elwha River

Escapement to the Elwha River has been monitored by surveying the lower river up to RM 4.8, and by returns to the Elwha Rearing Channel. In recent years redds have also been counted in the Hunt's Road side channel. A consistently derived time series is available since 1986. The regression trend in this series is significantly negative.

The majority of the return has been utilized for hatchery broodstock (median 63% since 1999). The hatchery program is essential to maintain the population until access to the upper river is restored and channel conditions and water quality stabilize after removal of the dams, which began in September 2011, and is expected to be complete by the fall of 2013.

Figure 3-18 Natural Chinook escapement to the Elwha River.

	Total	Nat spawners
1986	2,269	
1987	3,631	
1988	7,395	
1989	4,927	
1990	2,956	
1991	3,361	
1992	1,222	
1993	1,562	
1994	1,216	
1995	1,150	
1996	1,608	
1997	2,517	
1998	2,358	
1999	1,625	903
2000	1,913	715
2001	2,246	655
2002	2,408	863
2003	2,305	1,045
2004	3,439	2,075
2005	2,238	835
2006	1,933	693
2007	1,146	380
2008	1,153	470
2009	2,192	651
2010	1,278	564
2011	1,863	843

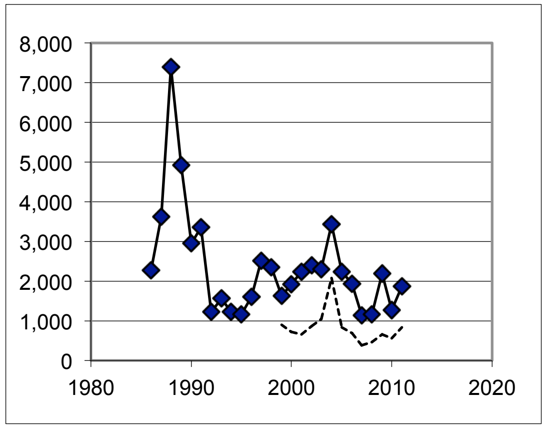


Table 3-18 Trends in Chinook escapement to the Elwha River.

	Regression			Geiger 15 y		Geiger 21 y	
	X_1	95% C.I.		Slope	Slope/y_0	Slope	Slope/y_0
Elwha	-0.0268	-0.0500	-0.0037	-96.80	0.04	21.50	0.01

In 2009 – 2011 the proportion of hatchery-origin fish in the return was estimated at 92%, by reading otoliths, and sampling adults for presence of a coded wire tag. Groups of Elwha Channel releases were formerly coded-wire tagged as a PSC Indicator Stock, but estimates of the composition of 1986 – 1997 returns are not available. Coded wire tagging began again with brood year 2007 (?).

3.17 Hoko River

The Hoko Chinook return comprises natural spawners and adults utilized as broodstock for the hatchery program, which has been (median) 16% of the total return. The hatchery program has been operating since 1986(?), with intent to rebuild the run and create terminal harvest opportunity. CWT groups released from the Hoko Hatchery enable monitoring of catch distribution and harvest rates. The Hoko mainstem between RM 2.8 and 21.7, and reaches in the Little Hoko River, and Browne's, Herman, North Fork Herman, Ellis, Bear, and Cub creeks are surveyed to count redds.

The trends in total escapement since 1988 are not significant.

Figure 3-19 Natural Chinook escapement to the Hoko River.

	Total	Natural
1988	776	731
1989	842	736
1990	493	190
1991	1006	145
1992	740	441
1993	894	699
1994	428	256
1995	905	271
1996	1265	435
1997	894	365
1998	1722	705
1999	1688	734
2000	731	294
2001	946	496
2002	680	192
2003	1098	402
2004	1086	266
2005	284	72
2006	895	172
2007	568	251
2008	483	106
2009	385	
2010	793	322
2011	1504	1081

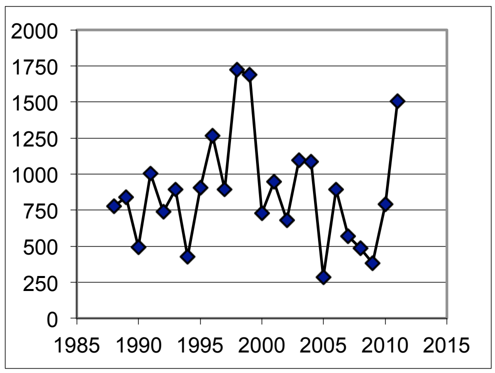


Table 3-19 Trends in Chinook escapement to the Hoko River.

	Regression			Geiger 15 y		Geiger 21 y	
	X_1	95% C.I.		Slope	Slope/y_0	Slope	Slope/y_0
Hoko	-0.0026	-0.0267	0.0216	-37.80	0.034	-23.29	0.021

3.18 Estimating escapement with genetic mark-recapture techniques

There are multiple approaches to making inferences about spawning escapement from genetic analysis of progeny (aka GMR methods). An indirect result can be obtained from sampling progeny as outmigrating smolts or returning spawners aged to brood-year. A direct estimate is possible from assigning next-generation recaptures (either juvenile or aged returning adults) back to tissue samples collected from their parent spawners.

In the case of indirect inference, population genetics techniques allow for estimation of the number of spawners that produced the sample (N_b, number of breeders). It is important to note the number of breeders may differ from total escapement. Extrapolating from the sample to make the best estimate of the number of spawners producing the brood year depends on considerations that went into collecting that sample. When the sample is from migrating juveniles, smolt trap efficiency may give a simple expansion factor. N_b estimates from returning adults that have been aged are best obtained from multi-year samples encompassing the age distribution of the brood year in question.

Direct inference requires tissue samples from spawners in the brood year of interest. The next generation, whether sampled as outmigrating smolts or as returning adults aged to that brood year, can then be assigned back to their candidate parents. The next generation assignments will be apportioned among those with both parents known, one parent known, and no parents known. In the case of next-generation samples consisting of returning adults, multi-year samples reflecting the age distribution of the brood year are expected. In these analyses, the genotype of each adult is treated as a mark, and the genotype from members of the next generation with one or two known parents are treated as recaptures of that mark. Population-level estimates are then derived using mark-recapture methodology.

GMR methods have produced estimates of escapement for South Fork Nooksack, Stillaguamish (Small et al 2012), and Green (Seamons et al 2012) Chinook populations. Additional years of data are being processed, and/or will continue to be collected for these populations, and for the Snohomish, White, and Nisqually populations. The following table compares conventional with GMR estimates (*cite authors)*.

There are sources of potential bias in GMR estimates, in some cases unique to each river. The techniques are best suited to rivers supporting a single Chinook population. In large river systems logistics may prevent obtaining samples that represent the entirety of spawning habitat (e.g. smolt traps located upstream of spawning areas). The precision of estimates can be limited by carcass sample size and tissue quality. Application to populations producing a substantial proportion of yearling smolts is more complex. Hatchery releases of un-marked smolts must be distinguished from natural-origin smolts. The cost of genotyping samples has and will continue to decline, but currently limits application to a few rivers.

GMR estimates of escapement to the Green River in 2010 Green range ~3800 – 4500, substantially higher than the conventional redd-count estimate of 2092. An estimate for 2011 escapement is being developed, and funding will be sought to extend the study additional years.

GMR methods provided estimates of the total number of Chinook spawning in the Stillaguamish river (i.e. it included the summer and fall populations). For 2007 the range of four GMR estimates (1291 - 2560) was higher than the conventional estimate of 773 (Small et al says 616). The 2008 range of four GMR estimates (~1711 - 2098) was close to the conventional estimate of 1671. The 2009 range of four GMR estimates (901 - 1239) was close to the conventional estimate of 1001, and the 2010 range of four GMR estimates (range 837 – 1508) was higher than the conventional estimate of 783.

The South Fork Nooksack study estimated the number of parents and effective breeders ($N_{b)}$ that produced the juveniles that were collected for captive rearing. Genotyping of brood year 2006 (n=457) and 2007 (n = 780) samples estimated that the collected juveniles were members of 132 and 182 families, respectively. The number of effective breeders was 39 and 71, respectively. The conventional estimates of the number of native South Fork spawners were 29 for 2007 and 83 for 2008; these estimates were based on redd counts expansion to estimate total natural escapement, and, after separating hatchery-origin fish from scale or otoliths analysis, genotyping spawner tissue samples from natural-origin adults, to differentiate native SF from North Fork early and fall-run fish. (Small, M.P, A. A. Spidle, C. Scofield, J. Griffith, D. Rawding, T. Seamons, and E. Martinez. 2012. 2011 Progress Report: Chinook salmon abundance in the Stillaguamish River using GMR analyses. Report on PSC Sentinel Stocks Program Project SSP-2011-13). Neither the GMR number of families or N_b is directly comparable to the conventional estimate. Given that the captive brood sampling collected only a small proportion of the total SF native juveniles produced, the GMR estimates suggest that actual total escapement was considerably higher than conventional estimates.

4 Forecast accuracy

The accuracy of forecasting abundance is one of two primary influences on management error (the other being the accuracy of projecting harvest). These two inputs drive the FRAM and TAMM algorithms. This section examines forecast accuracy for each Puget Sound Chinook management unit, for management years 2003 – 2010.

For the purposes of this analysis, forecasted terminal abundance values (i.e., the sum of terminal fishing mortality and escapement) were obtained from the final pre-season model runs. Observed terminal abundance was obtained from post-season TAMM input tables. Forecast error is the difference between forecast and observed abundance, expressed as a proportion of the observed value.

Differences in TAMM table calculations among the eight pre-season runs, related to successive 'patching' to improve their performance, and the latest version used for all validation runs may confound this analysis, but to the extent possible it utilizes consistently calculated values of forecasted and observed abundance.

For most stocks, forecast terminal abundance values were extracted from the final pre-season TAMM workbooks, Tables 2A, 2B, or 2C. For the Skagit spring and summer-fall, Stillaguamish, Snohomish, Tulalip Hatchery, and White stocks, these values represent the natural component of production (i.e., they exclude hatchery returns). For the Lake Washington, Green, Puyallup, Nisqually, Dungeness, and Elwha stocks, these values are aggregate natural-hatchery production. Forecasted terminal abundance for the Skokomish 'natural', George Adams Hatchery, and Hoodsport Hatchery stocks were obtained from Table 13E in TAMM. Forecasted escapement of the Nooksack early natural stock, rather than terminal abundance, was obtained from the 'ER Escapement Overview' Table in the TAMM. Observed terminal abundance for all stocks, conforming to either natural or aggregate returns, were extracted from 'input' tables in the TAMM workbooks.

Forecast error is not assessed for Kendall Creek Hatchery early, Wallace River Hatchery, Lake Washington, Green, and Puyallup or Nisqually hatchery abundance. TAMM tables that may eventually provide a uniform means for estimating errors for these stock components have not been vetted or updated for all pre-season runs.

These comparisons of forecasted to observed terminal abundance provides a relatively standardized metric of forecast error. Even over this relatively short range of years forecast methodology varies among MUs – and has been characterized as 'terminal area abundance', '4B runsize', and some as 'ocean' runsize. But ocean runsize forecasts are also derived by 'escapement without fishing' calculations. All these methods, and associated units, are essentially the expected return of mature Chinook. Age specific abundance scalars are developed for input to the FRAM, but the methods for doing so have evolved substantially since 2003. The 'input' values driving the validation TAMM computations are based upon regional or Puget Sound run reconstruction estimates of terminal abundance (terminal area fishing mortality plus escapement).

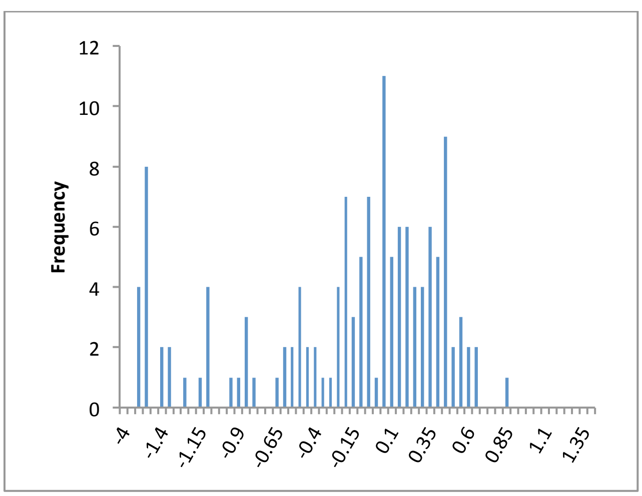
Differences in methods aside, there are insufficient years (8) in this dataset to compare forecast accuracy among MUs, so beyond a subjective assessment of the range of forecast error for each MU, the principal result of this analysis is an overall relationship between forecasted and observed values

Table 4-1 Ranges of forecasting errors for Puget Sound Chinook.

	Minimum	Maximum
Nooksack Early	-1.411	0.437
Skagit SF natural	-0.974	0.193
Skagit spr natural	-1.370	0.486
Stillaguamish natural	-1.146	0.448
Snohomish natural	-2.158	0.418
Wallace Hatchery	-0.749	1.181
Lake Washington aggregate	-1.913	0.607
Green aggregate	-0.936	0.174
White aggregate	-1.856	-0.132
Puyallup aggregate	-0.807	0.416
Nisqually aggregate	-0.448	0.391
Skokomish natural	-1.659	0.484
Mid HC natural	-2.689	0.805
Geo Adams Hatchery	0.006	0.578
Hoodsport Hatchery	-1.704	0.414
Dungeness aggregate	-3.303	0.515
Elwha aggregate	-1.120	0.367
Hoko aggregate	-2.499	0.604

Summary statistics on the combined set of forecasting errors shows that 50 percent of the values (i.e., the boundaries of second and third quartiles) fall within the range of -0.061 to +0.247

Figure 4-1 The distribution of forecast error for Puget Sound Chinook.



The slope parameter of linear regression of observed on forecasted abundance is 0.987 (95% confidence interval 0.894 – 1.081) indicates a general conformance of the data pairs, despite the wide range in errors observed for individual management units. The prevalence of negative errors (70) slightly exceeds positive errors (60).

Figure 4-2 Scatter plot of observed vs. forecasted terminal abundance of Puget Sound Chinook.

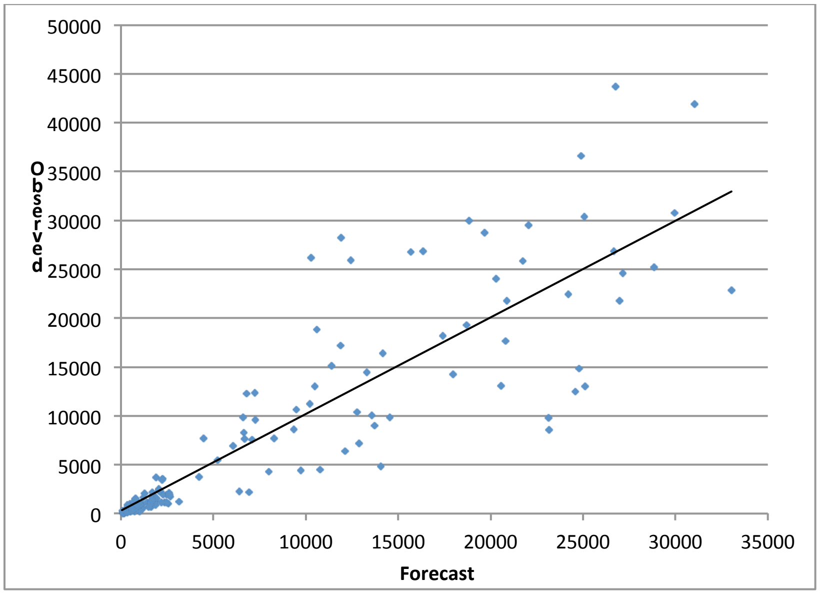


Table 4-2 Forecasting errors for Puget Sound Chinook management units and components, 2003 - 2010.

	Nooksack Early natural			Skagit S/F natural			Skagit Spring natural		
Year	Pre-Season	Post-season	Error	Pre-Season	Post-season	Error	Pre-Season	Post-season	Error
2003	399	429	0.070	13,563	10,057	-0.349	1,156	933	-0.240
2004	570	460	-0.239	20,304	24,008	0.154	1,200	1,693	0.291
2005	822	341	-1.411	24,209	23,352	-0.037	1,872	1,342	-0.395
2006	682	633	-0.077	24,203	22,450	-0.078	1,715	1,936	0.114
2007	565	535	-0.055	10,501	13,014	0.193	1,617	682	-1.370
2008	375	622	0.397	24,783	14,808	-0.674	1,687	1,582	-0.066
2009	315	559	0.437	24,575	12,449	-0.974	1,403	1,140	-0.231
2010	439	399	-0.099	14,558	9,859	-0.477	760	1,479	0.486

	Stillaguamish natural			Snohomish natural			Tulalip Hatchery		
2003	2,372	1,122	-1.114	5,230	5,477	0.045	6,541	9,051	0.277
2004	1,932	1,539	-0.255	9,491	10,612	0.106	4,743	6,045	0.215
2005	1,682	1,176	-0.431	10,776	4,484	-1.403	6,391	7,644	0.164
2006	959	1,102	0.130	6,638	8,316	0.202	9,038	5,245	-0.723
2007	1,023	624	-0.639	9,716	4,424	-1.196	7,055	6,145	-0.148
2008	574	1,040	0.448	4,464	7,673	0.418	2,722	3,480	0.218
2009	1,478	689	-1.146	6,909	2,188	-2.158	2,306	1,978	-0.166
2010	1,192	560	-1.130	8,007	4,273	-0.874	2,349	3,779	0.379

Year	Lake Washington aggregate Pre-Season	Post-season	Error	Green aggregate Pre-Season	Post-season	Error	White aggregate Pre-Season	Post-season	Error
2003	6,050	6,918	0.125	14,175	16,416	0.136	1,666	1,324	-0.258
2004	6,803	12,269	0.445	20,897	21,799	0.041	1,886	890	-1.119
2005	10,201	11,252	0.093	25,113	12,974	-0.936	2,564	1,014	-1.528
2006	11,394	15,101	0.245	28,839	25,179	-0.145	2,667	1,753	-0.521
2007	10,270	26,153	0.607	25,078	30,360	0.174	4,229	3,735	-0.132
2008	23,149	9,818	-1.358	27,154	24,603	-0.104	6,400	2,241	-1.856
2009	14,048	4,823	-1.913	20,819	17,633	-0.181	1,629	1,074	-0.517
2010	12,123	6,389	-0.897	17,989	14,265	-0.261	1,703	1,409	-0.209

Year	Puyallup aggregate Pre-Season	Post-season	Error	Nisqually aggregate Pre-Season	Post-season	Error
2003	8,285	7,686	-0.078	16,360	26,859	0.391
2004	6,693	7,635	0.123	21,749	25,871	0.159
2005	7,110	7,552	0.059	18,853	29,975	0.371
2006	7,289	9,596	0.240	24,892	36,587	0.320
2007	7,224	12,374	0.416	31,029	41,900	0.259
2008	6,613	9,863	0.329	33,032	22,808	-0.448
2009	9,339	8,630	-0.082	26,978	21,784	-0.238
2010	12,898	7,138	-0.807	26,781	43,674	0.387

Year	Skokomish natural			Mid Hood Canal natural			George Adams Hatchery			Hoodsport Hatchery		
	Pre-Season	Post-season	Error	Pre-Season	Post-season	Error	Pre-Season	Post-season	Error	Pre-Season	Post-season	Error
2003	2,447	1,928	-0.269	498	194	-1.566	11,864	17,175	0.309	18,702	19,300	0.031
2004	1,898	3,677	0.484	293	129	-1.272	10,581	18,824	0.438	20,576	13,074	-0.574
2005	2,245	3,579	0.373	166	45	-2.689	11,924	28,226	0.578	15,679	26,774	0.414
2006	2,057	2,537	0.189	99	30	-2.292	12,447	25,932	0.520	17,424	18,163	0.041
2007	3,144	1,182	-1.659	108	73	-0.476	22,060	29,543	0.253	23,161	8,566	-1.704
2008	2,042	2,448	0.166	53	273	0.805	19,663	28,752	0.316	13,702	9,010	-0.521
2009	2,139	2,228	0.040	113	228	0.503	26,657	26,830	0.006	13,301	14,415	0.077
2010	2,281	1,954	-0.167	136	84	-0.613	29,962	30,792	0.027	12,768	10,385	-0.229

Year	Dungeness aggregate			Elwha aggregate			Hoko aggregate		
	Pre-Season	Post-season	Error	Pre-Season	Post-season	Error	Pre-Season	Post-season	Error
2003	350	640	0.453	2,050	2,305	0.111	1,000	866	-0.155
2004	486	1,003	0.515	2,200	3,439	0.360	866	762	-0.137
2005	685	1,079	0.365	2,603	2,128	-0.223	516	202	-1.551
2006	806	1,543	0.478	2,616	1,922	-0.361	343	867	0.604
2007	1,095	404	-1.710	2,444	1,153	-1.120	359	464	0.226
2008	1,007	234	-3.303	2,178	1,157	-0.882	489	431	-0.134
2009	727	231	-2.147	1,708	2,181	0.217	359	102	-2.499
2010	556	457	-0.217	1,298	2,049	0.367	612	323	-0.896

5 Habitat Protection and Restoration

Conservation and recovery of Puget Sound Chinook salmon requires, in addition to proper constraint of harvest, integrated protection and restoration of freshwater and marine habitat. Chinook salmon populations require abundant, productive, diverse, and widely distributed habitats.

Degraded freshwater and marine habitat, declines in ocean survival rates, species and genetic interactions and excessive harvest rates have contributed to the decline in Puget Sound Chinook abundance (PSSSRG 1993; PSSSRG 1997, Spence et. al 1996; WDFW 1997 (WSP); NMFS 2006). Of these factors, habitat condition currently exerts the largest influence on natural Chinook production, so addressing habitat limiting factors is of paramount importance in an integrated management plan to restore their productive potential.

In all Puget Sound watersheds, habitat conditions preclude Chinook recovery (e.g., see NMFS Evaluation and Determination regarding Chinook Harvest Management Plan (May 27, 2011)). However, while harvest management is expected to contribute to salmon recovery, most actions affecting habitat only need to maintain the status quo or meet a 'no net loss' standard. It is clear that all regulatory authorities need to require improvement in habitat conditions to preserve the potential for salmon recovery.

Protecting existing salmon habitat from further decline is the key to recovering salmon populations. According to the 2007 Puget Sound Chinook Salmon Recovery Plan adopted by NOAA Fisheries and developed by the state and tribal salmon co-managers, and numerous watershed entities:

Protecting existing habitat and restoring the ecological processes that create and maintain it are *the most important actions needed in the short term* to increase the likelihood of achieving plan outcomes. Protection must occur in both urban and rural areas if we are to ensure the long-term persistence of salmon in Puget Sound.

In the final supplement to the recovery plan in 2006, NMFS concurred that immediate habitat protection is imperative, stating, "protecting functioning habitat is one of the top priorities and first steps for achieving a viable ESU (evolutionarily significant unit)."

Despite broad concurrence regarding the pressing the need for habitat protection and recovery, salmon habitat within the Puget Sound region continues to decline (NMFS 2010, NWIFC 2012). A recent geographic information system (GIS) analysis of Puget Sound examined key indicators of habitat quality and quantity across more than 20 watersheds in western Washington using the SSHIAP database. The conclusions of this report, with specific examples from the GIS analysis, are cited below:

- Estuary Degradation Outpaces Restoration

Estuaries in western Washington are losing functional habitat because of population increases in lower portions of watersheds. For example, in the Suquamish Tribe's area of concern there has been a 39% loss of vegetated estuarine wetland area and a 23% loss of natural shoreline habitats, particularly small "pocket" estuaries. Moreover, there are now 18 miles of bulkheads, fill and docks armoring the shoreline and degrading nearshore salmon habitat. In the Stillaguamish watershed, the sustained loss of approximately 75% of salt marsh habitat is being investigated as a major factor limiting the size of Chinook populations.

- Freshwater Shoreline Armoring Continues Unabated

Shoreline armoring contributes to river channel degradation by impeding natural bank erosion and river meandering, and disconnecting terrestrial and aquatic ecosystems, directly impacting salmon habitat. Juvenile Chinook utilization (i.e. density) of riprap armored river banks is five times lower compared to natural banks (SRSC; WDFW, 2005; Beamer and Henderson, 1998). The Skagit River Chinook Recovery Plan recommends that no new construction of riprap occur without mitigation, however, since 1998, at least 1 mile has been added to the existing 14 miles of riprap shoreline along the middle Skagit River.

- Increasing impervious surface area affects hydrology and water quality

The common rate of increase in impervious surfaces for Puget Sound watersheds has exceeded 200% since the 1970s. These increases in impervious surfaces impact salmon habitat by removing essential vegetation and biota, increasing runoff, conveying pollutants, and altering hydrology. Without appropriate planning, placement, and mitigation, these actions will continue to imperil salmon.

Impervious surface is well documented as a coarse measure of human impact on watershed scale hydrology and biology (Alberti et al 2007; Booth et al 2002; Booth and Jackson, 1997). Sensitive habitat elements may be loss when 10% of the watershed is covered by impervious surfaces. One aspect of these habitat alterations is the resultant increase in the severity and frequency of peak flow. Research has demonstrated the negative relationship that exists between peak winter flows and Chinook egg-to-smolt survival rates in several watersheds (Seiler et. al. 1998, Beamer and Pess 1999).

- Forest Cover Disappearing

Timber harvest has removed vast amounts of forest cover throughout all of the watersheds. The rapid removal of forest in the watersheds can have dynamic affects on the stability of watersheds and the overall quality of salmon habitat. Large clearcuts, inadequate stream buffers and poorly maintained forest roads have all led to degraded salmon habitat. Forest cover continues to decline and some lowland watershed areas are severely damaged. The salmon recovery plan for the Stillaguamish watershed recommends that 80% of forest cover be mature forest in 14 forest-dominated sub-basins (SIRC 2005). However, of the 14 sub-basins only two are more than 80% mature forest.

- Streams Lack Large Woody Debris

Large woody debris plays an important role in channel stability, habitat diversity and overall habitat quantity and quality. Unfortunately, the potential to restore large woody debris to improve salmon habitat is often restricted by land management approaches and policies. For example only 1% of the Nooksack watershed is meeting the recovery thresholds for abundance of instream wood. Similarly, estimates of large woody debris in the Green and Cedar rivers are 89% to 95% below the levels necessary for "properly functioning conditions" for salmon habitat.

- Riparian Forests Are Not Recovering

Riparian forests are an essential component of healthy fish habitat, providing shade, temperature regulation, stream bank stability and food supply. However, riparian buffers along most fish-bearing streams lack necessary vegetation because of poor protection and proper management. For example, in the Stillaguamish, only 23% of the 1,777 acres of riparian area within the floodplain currently have any forest cover. In the Snohomish River basin, the Salmon Conservation Plan recommends that 150-foot buffers on both sides of fish-bearing streams be at least 65% forested. In 2006 those buffers were just 41% forested, with no gain since 1992 and little increase since that time.

- High Road Density Increases Sediment Input and Affects Migration

The number of roads crossing streams can greatly affect the health of salmon habitat in lowland watersheds. Projected population growth and associated land conversions will continue to push the need for more roads and stream crossings throughout the lower portions of the watersheds. In the upper Nooksack there are more than 1,376 miles of forest roads. Road densities exceed 2 miles of road length per 1 square mile of watershed area in more than 65% of the upper Nooksack's watershed. In the Sauk River watershed there are 518 miles of roads on National Forest land. As of 2011 only 28% (147 miles) of these roads have received necessary drainage upgrades.

- Agricultural Lands Remain Degraded

Two key factors that limit Chinook recovery are human modification of floodplains and the associated loss of freshwater wetlands. Agricultural practices have played a significant role in contributing to these limiting factors, by removing trees, diking, and draining. These actions have resulted in a loss of stream channels, wetlands, stream buffers, increased sediment, and pollution in the form of runoff from agricultural activities. In 1880 the Nooksack basin contained 4,754 acres of wetland to 741 acres of stream channel. By 1938, nearly 4,500 acres (95%) of off-channel wetland area had been cleared, drained and converted to agriculture. As of 1998, the lower mainstem retained less than 10% of its historical wetlands. As of 2006, riparian areas of the Skagit River delta region are 83% impaired. Of that amount only 12% are developed; the remaining 71% of impaired lands support crops and pasture.

- Rapidly Increasing Permit-Exempt Wells Reduce Streamflow

The state of Washington provides a water right permit exemption to property owners not served by a community water system that allows users to pump up to 5,000 gallons of groundwater per day. When more water is extracted from an aquifer than is being recharged, aquifer volume is reduced and the natural outflow from the aquifer decreases. This reduces the amount of fresh water available to lakes, wetlands, streams and the Puget Sound nearshore, which can harm salmon at all stages of their life cycle. Since 1980, there has been an 81% increase in the number of new wells being drilled per 100 new Puget Sound residents moving into the area. The number of exempt wells in the Skagit and Samish watersheds since 1980 has increased by 611% from an estimated 1,080 exempt wells to approximately 7,232.

- Degraded Nearshore Habitat Reduce Production of Forage Fish

Nearshore areas provide critical rearing and forage fish for salmon. In the Port Gamble Tribe's focus area, according to studies since the 1970s, herring stocks have decreased from a status of healthy to depressed. In Port Gamble Bay and Quilcene Bay, which contain two of the largest herring stocks in Puget Sound, approximately 51% of spawning areas inventoried by Port Gamble Tribe have been either modified or armored.

Renewed commitment and increased support is required for habitat protection and restoration efforts and the hatchery production necessary to mitigate for reduced natural production, both in the short-term and long-term. Harvest management strategy in each watershed will reflect the extent to which habitat limiting factors are being alleviated.

Appendix – Comparison of FRAM and CWT exploitation rates of landed catch for Puget Sound Chinook

To: Kyle Adicks, Marianna Alexandersdottir, Will Beattie, Susan Bishop, Galen Johnson,
Jim Packer, Laurie Peterson, Andy Rankis, Casey Ruff
From: Pete McHugh , Larrie LaVoy, Angelika Hagen-Breaux
Cc: Craig Bowhay, Pat Pattillo
Date: 29 May 2013
Subject: Comparison of FRAM and coded-wire tag exploitation rates of landed catch for Puget Sound Chinook
Attachments: FRAMvCWT_markedlandedsummary052813.xlsx

In support of the 2013 performance review of the Puget Sound Chinook Harvest Management Plan (PS HMP), we compared estimates of fishery impacts generated through FRAM validation runs to independently estimated values derived from coded-wire tag (CWT) release/recovery data for eleven stocks for 2003-2010 fishing years (Table 1). Here we provide an overview of the comparison approach, summarize our main findings, and briefly discuss the implications of observed differences for ongoing applications of both data types (i.e., FRAM and CWT) to fishery planning and evaluation. We consider this work to be in a draft state and welcome suggestions or requests for further comparisons. Additionally, future comparisons will likely be necessary as we explore the potential for developing an updated FRAM base period.

Our comparisons suggest the following, relative to the rates calculated for landed catch ERs from CWTs:

- FRAM had both higher and lower total ERs across the stocks represented in the analysis,
- FRAM had consistently lower total ERs for Nooksack Early, Skagit spring yearling, Stillaguamish and Snohomish (Skykomish) summer-fall fingerling stocks.
- FRAM had consistently lower ERs in northern fisheries for Nooksack early and Stillaguamish and Snohomish summer-fall fingerling stocks,
- FRAM had consistently higher ERs in southern U.S. (SUS) fisheries for Hood Canal (George Adams), Nisqually, and Puyallup stocks,
- FRAM and CWT impact rates were highly correlated in a number of cases: total ER for Skagit spring, Skagit summer-fall fingerling, Nisqually, and Samish stocks, and SUS ER for Green, Skagit spring, Skagit summer-fall and Nisqually stocks. Where differences were noted, these correlations may allow for an equivalency adjustment mechanism.

Comparison Approach

We compared FRAM validation run results (January 2013 release) to CWT impact estimates generated using the cohort reconstruction methods and tools of the PSC Chinook Technical Committee (Coshak 12.3, Distribution Tables 1.4, CAS database [Feb 2013 version]). FRAM validation runs provide estimates of exploitation rates (ER) for Puget Sound Chinook stocks in a particular fishing year given a set of stock-specific base period ERs (CWT based, 1979-84 fishing years) and incidental mortality rates, combined with yearly estimates of catches across retention fisheries, encounters in non-retention fisheries, and terminal run sizes. Thus, if fish are distributed in space and time in a manner similar to FRAM's base period, validation runs should yield impact estimates comparable to those derived from recent CWT data, assuming that CWTs are sampled representatively across fisheries (or at least in a manner similar to the FRAM base period years).

FRAM vs. CWT comparisons are complicated by the different approaches used by each tool to estimate incidental mortality, especially for mark-selective fisheries (MSFs). Whereas the FRAM/TAMM stocks of primary interest to the PS HMP are unmarked natural fish, CWT stocks are adipose clipped and are therefore impacted differently in MSFs, which have proliferated in Puget Sound during the 2003-2010 assessment period. Although FRAM addresses MSF impacts appropriately, CWT cohort reconstruction methods at present do not. In addition to the MSF issue, the CTC's CWT cohort reconstruction approach estimates sublegal and non-landed mortalities differently than FRAM. In combination, these issues make it difficult to assess whether differences noted in CWT vs. FRAM comparisons are due to algorithmic or distributional (i.e., between the FRAM base and today) differences, or a combination thereof. We avoided this issue by limiting our comparisons to impact estimates common to both data sets, namely ERs computed in terms of *landed mortality of marked fish*. While we acknowledge that the primary utility of FRAM to the PS HMP is in the estimation of total mortality on unmarked fish, focusing on landed marked impacts allows us to directly assess FRAM's static base period assumption in the absence of confounding input- or algorithm-based differences. However, a comparison between FRAM and CWTs for unmarked AEQ total mortality will be presented in figures and in a worksheet in a subsequent supplemental memo.

Data Preparation and Comparison Methods

In order to make CWT and FRAM impact estimates directly comparable, several data manipulations were made. First, we had to disaggregate the CTC South Puget Sound (SPS) fall fingerling CWT indicator stock, which includes CWTs for Soos Creek, Grovers, and Issaquah hatcheries, into a Green River-only stock for direct comparison to the TAMM equivalent. Second, we created a new CWT indicator stock for the Puyallup River based on the recent record of fingerling releases from Vought's Creek Hatchery. Third, we modified calculations for both the Skagit spring and Snohomish summer/fall TAMM stocks so that ER calculations were done in terms of marked fish (both) and fingerlings only (Snohomish). Finally, we created a new set of validation run TAMMs within which fishery impacts were computed from landed catch only (i.e., exported from FRAM in from TAMX), rather than adult-equivalent (AEQ) landed + incidental (i.e., total) mortality. Beyond these minor modifications, initial comparisons revealed a deficiency in freshwater sport CWT recoveries for multiple rivers and years, which required us to impute recoveries in several instances. In particular, very few CWTs were recovered in the Nisqually, Puyallup, Skokomish, Samish, and Snohomish (Skykomish) sport fisheries, despite the presence of sizeable hatchery-directed catches in some years. For each stock and year we estimated the number of CWTs that should have been recovered in freshwater sport fisheries based on Catch Record Card catches and tagged escapement to total escapement ratios in hatchery returns. Expansions were discounted by hatchery mark rates when sport fisheries were MSFs, and based upon jack catches and escapements for tag codes representing age 2 fish[1]. These recoveries were then imported into an unofficial version of the CTC's CAS and then processed through the same data processing and estimation flow as the other stocks. Although it was not immediately evident here, there may be other fisheries for which tags were under-sampled, requiring future analysis/imputing.

Following the data modifications outlined above, we summarized both FRAM validation run and CWT datasets and compared landed marked ERs between them in terms of total ER, a coarsely resolved ER

[1] **CWT estimates of ER are computed inclusive of terminal catch and escapement of age 2 fish, whereas FRAM** validation run ERs are not (age 2s are accounted for in preterminal catch only). ERs computed from age 3-5 and age 2-5 CWTs are expected to be comparable unless age 2 fish make up a substantial proportion of total CWTs (all catch + escapement) and have a considerably different impact pattern.

distribution (i.e., in northern [Alaska + Canada] and SUS categories), and in terms of the preterminal SUS ER. We approached the comparison with one-to-one correspondence as our null expectation, and graphically examined the patterns for the summary statistics total ER, SUS ER, and northern ER. In addition to evaluating similarity in values, we assessed whether or not FRAM and CWT values were correlated in some fashion. Although we provide statistical (i.e., paired *t*-test with H_0: diff = 0) and graphical (i.e., fitted relationships +/- 95% CIs vs. 1:1 line) comparisons, we note that our statistical power is generally low given the short duration of the comparison time series (8 fishing years max, 4 years in some cases). Given this, we relaxed our tolerance for type I errors by using an $\alpha = 0.10$.

Results and Discussion

Overall, our comparisons revealed striking similarity in FRAM and CWT estimates of fishery impacts for several stocks and ER categories. Comparison outcomes fell into four general categories of agreement (or lack thereof). First was the best case outcome—stocks for which impacts estimated via the two methods were similar and strongly correlated—a pattern exemplified by the Green, Samish, and Skagit spring fingerling total ERs (Figure 1). Second were those cases for which FRAM and CWT estimates were similar on average but were uncorrelated (Table 2). This pattern was often observed for stocks and ER categories that varied little during the 2003-2010 fishing period, and is exemplified in the SUS ER comparisons for Skykomish, Nooksack Early, and Stillaguamish (Figure 3). The third pattern involved systematic differences in estimates (i.e., FRAM>CWT or FRAM<CWT) but with a strong statistical association. This pattern was evident for Nisqually, Skagit summer/fall fingerlings, and Skagit spring yearling total ERs. Lastly–perhaps the worst case scenario—were cases for which FRAM and CWT estimates differed consistently and were unrelated. We noted this pattern of deviation for Skokomish, Puyallup, Nooksack Early (and to a lesser extent Skykomish and Stillaguamish) for total ER (Figure 1), nearly all stocks for Northern ER (Figure 2), and Skokomish and Puyallup for SUS ER (Figure 3).

In addition to comparing FRAM and CWT for individual stocks with years as replicates, we compared estimates within years while viewing stocks as replicates (Figures 4-6). This comparison illustrates that while FRAM deviated from CWT for particular stocks in some cases, it accurately captured the total (Figure 4) and SUS (Figure 6) impact estimate for the 'average' PS Chinook stock. As was the case for stock-by-stock comparison outcome, however, there was little evidence of an association between datasets for Northern ER. Additionally, there was pronounced stock clustering for Northern ER deviation in year-by-year comparisons: impacts for north Puget Sound and early timed stocks were consistently under predicted by FRAM, whereas the reverse (FRAM > CWT) occurred for Hood Canal and south Puget Sound stocks (Figure 5).

In summary, FRAM and recent CWT provided similar estimates of both overall and (coarsely resolved) category-specific fishery impacts for a handful of stocks, and comparable estimates of SUS impacts for most stocks during the 2003-2010 assessment period. However, FRAM provided a poor depiction of northern fishery impacts for nearly all stocks, and performed poorly (e.g., ER differences in excess of 0.20) in total for Nooksack Early, Skokomish, Nisqually, and Puyallup stocks. From an ESA standpoint, the FRAM vs. CWT differences are conservative (i.e., FRAM > CWT) for the Hood Canal and south Puget Sound stocks with significant deviation, but the reverse appears to be true (i.e., FRAM < CWT) for north Sound stocks lacking FRAM-CWT correspondence. The development of a contemporary FRAM base period data set from recent year CWT recovery analysis should help to alleviate some or all of the bias (high or low) between FRAM and CWT exploitation rates, and provide a more reliable estimate of impacts from current fishing season structure and time-area stock distribution.

Table 1. Stocks for which CWT vs. FRAM/TAMM comparisons were made.

FRAM Stock	TAMM Stock	CWT Indicator Stock & Abbreviation	Fishing years compared	Notes
Stillaguamish summer/fall fingerling	Stillaguamish summer/fall fingerling	Wild broodstock (STL)	2006-10	
Skagit summer/fall fingerling	Skagit summer/fall fingerling	Wild broodstock (SSF)	2003-10	
Snohomish summer/fall fingerling	Snohomish summer/fall fingerling	Wallace River Hatchery (SKY)	2004-10	TAMM output modified to include fingerling only (i.e., to match CWT production type).
Skagit spring yearling	Skagit spring yearling	yearlings from Marblemount Hatchery (SKS)	2003-10	Yearling program discontinued
Skagit spring yearling	Skagit spring yearling	fingerlings from Marblemount Hatchery (SKF)	2003-10	Comparison made to yearling FRAM stock given its use to represent combined fing/yrl production
Nooksack-Samish summer/fall	Nooksack-Samish summer/fall fingerling	Samish River Hatchery (SAM)	2003-10	
Mid S. Puget Sound fall fingerling	Puyallup fall fingerling	Voights Creek Hatchery (PUY)	2006-10	
NF & SF Nooksack early fingerling/yearling	Nooksack spring fingerling/yearling	Kendall Creek Hatchery (NSF)	2003-10	
Deep S. Puget Sound fall fingerling	Nisqually fall fingerling	Clear Creek Hatchery (NIS)	2003-10	
Mid S. Puget Sound fall fingerling	Green fall fingerling	Soos Creek Hatchery (GRN)	2003-10	Subset of CTC SPS Indicator stock tags
Hood Canal fall fingerling	Skokomish fall fingerling	George Adams Hatchery (GAD)	2003-10	

Table 2. Mean FRAM and CWT estimates of fishing year ERs for Puget Sound Chinook, fishing years 2003-2010. (Continued on next page). *P*-values are from a paired two-sided *t*-test with a hypothesized mean difference of 0. Shaded values are ones where $P < 0.10$ for *t*-tests and where positive correlations exceeded the ρ significance threshold for the sample size in question ($n = 8$). Continued on next page.

		FRAM		CWT		FRAM - CWT		Pearson
FRAM/TAMM Stock	**Metric**	**Mean**	**SD**	**Mean**	**SD**	**Diff.**	**P-value**	**Correl. Coeff.**
Stillaguamish FF	Total	0.213	0.094	0.331	0.084	-0.117	0.113	0.789
	AK	0.006	0.001	0.015	0.005	-0.008	0.202	-0.861
	BC	0.103	0.034	0.197	0.075	-0.094	0.154	0.593
	SUS	0.104	0.065	0.119	0.040	-0.015	0.799	0.102
	FW spt	0.000	0.001	0.000	0.000	0.000	NA	NA
	(PT SUS)	0.102	0.065	0.097	0.030	0.005	0.978	0.320
Skagit SF	Total	0.490	0.103	0.345	0.137	0.145	0.191	0.687
	AK	0.028	0.009	0.063	0.016	-0.035	0.066	0.108
	BC	0.325	0.058	0.174	0.042	0.151	0.048	0.168
	SUS	0.137	0.087	0.108	0.125	0.028	0.410	0.959
	FW spt	0.005	0.006	0.001	0.001	0.004	0.346	0.580
	(PT SUS)	0.044	0.014	0.019	0.011	0.025	0.099	0.327
Skykomish FF	Total	0.272	0.059	0.345	0.076	-0.073	0.441	0.257
	AK	0.006	0.001	0.005	0.002	0.001	0.570	0.340
	BC	0.086	0.031	0.195	0.097	-0.109	0.132	0.831
	SUS	0.181	0.049	0.146	0.044	0.035	0.599	0.269
	FW spt	0.089	0.027	0.064	0.029	0.025	0.598	0.169
	(PT SUS)	0.084	0.031	0.082	0.024	0.002	0.928	0.328
Skagit Spr Yrl/Fing	Total	0.353	0.106	0.497	0.118	-0.145	0.068	0.819
	AK	0.006	0.002	0.005	0.004	0.001	0.342	0.446
	BC	0.107	0.034	0.191	0.095	-0.084	0.544	-0.620
	SUS	0.239	0.087	0.303	0.179	-0.064	0.657	0.903
	FW spt	0.093	0.083	0.160	0.131	-0.067	0.460	0.775
	(PT SUS)	0.099	0.028	0.083	0.038	0.016	0.619	0.481
Skagit Spr Yrl/Fing	Total	0.353	0.106	0.395	0.090	-0.043	0.486	0.836
	AK	0.006	0.002	0.009	0.010	-0.003	0.946	0.029
	BC	0.107	0.034	0.182	0.060	-0.074	0.369	-0.300
	SUS	0.239	0.087	0.205	0.140	0.034	0.649	0.768
	FW spt	0.093	0.083	0.101	0.080	-0.007	0.897	0.760
	(PT SUS)	0.099	0.028	0.039	0.025	0.060	0.158	0.069
Samish FF	Total	0.787	0.068	0.765	0.076	0.022	0.702	0.682
	AK	0.002	0.001	0.004	0.003	-0.001	0.752	0.099
	BC	0.251	0.036	0.167	0.041	0.084	0.117	0.318
	SUS	0.533	0.060	0.594	0.059	-0.061	0.291	0.602
	FW spt	0.102	0.037	0.176	0.058	-0.074	0.146	0.555
	(PT SUS)	0.106	0.023	0.412	0.063	-0.306	0.001[/1]	0.159

FRAM/TAMM Stock	Metric	FRAM Mean	FRAM SD	CWT Mean	CWT SD	FRAM - CWT Diff.	FRAM - CWT P-value	Pearson Correl. Coeff.
Puyallup FF	Total	0.860	0.071	0.609	0.069	0.251	0.234	0.487
	AK	0.004	0.001	0.002	0.001	0.001	0.338	0.469
	BC	0.220	0.056	0.148	0.038	0.072	0.474	-0.766
	SUS	0.637	0.053	0.459	0.079	0.177	0.066	0.521
	FW spt	0.285	0.104	0.198	0.138	0.087	0.512	0.448
	(PT SUS)	0.126	0.027	0.160	0.027	-0.034	0.602	-0.354
Nooksack Spr	Total	0.278	0.043	0.474	0.100	-0.196	0.118	-0.037
	AK	0.029	0.004	0.030	0.015	-0.001	0.974	0.427
	BC	0.206	0.041	0.391	0.094	-0.185	0.120	-0.055
	SUS	0.043	0.010	0.053	0.023	-0.010	0.672	0.429
	FW spt	0.000	0.000	0.001	0.002	-0.001	NA	NA
	(PT SUS)	0.019	0.004	0.040	0.019	-0.021	0.360	-0.515
Nisqually	Total	0.835	0.074	0.610	0.108	0.225	0.014	0.744
	AK	0.011	0.003	0.001	0.000	0.011	0.002	-0.208
	BC	0.170	0.044	0.089	0.023	0.081	0.124	0.045
	SUS	0.653	0.093	0.521	0.101	0.132	0.040	0.855
	FW spt	0.068	0.045	0.058	0.029	0.010	0.930	-0.003
	(PT SUS)	0.215	0.029	0.122	0.034	0.093	0.044	0.419
Green River	Total	0.564	0.105	0.525	0.120	0.039	0.649	0.736
	AK	0.004	0.001	0.006	0.005	-0.002	0.461	-0.479
	BC	0.220	0.056	0.156	0.018	0.064	0.285	0.135
	SUS	0.341	0.082	0.368	0.121	-0.027	0.684	0.941
	FW spt	0.003	0.003	0.002	0.003	0.001	0.569	0.777
	(PT SUS)	0.126	0.027	0.181	0.057	-0.055	0.499	-0.610
George Adams	Total	0.764	0.121	0.537	0.059	0.227	0.093	0.328
	AK	0.000	0.000	0.005	0.002	-0.005	NA	NA
	BC	0.186	0.047	0.159	0.046	0.027	0.425	0.792
	SUS	0.578	0.137	0.374	0.068	0.203	0.115	0.563
	FW spt	0.095	0.079	0.147	0.047	-0.053	0.430	0.481
	(PT SUS)	0.146	0.039	0.165	0.016	-0.019	0.650	0.023

[/1] This difference is due to the preterminal definition of the 7BCD net fishery in the CTC ER analysis system, rather than an actual difference in impact.

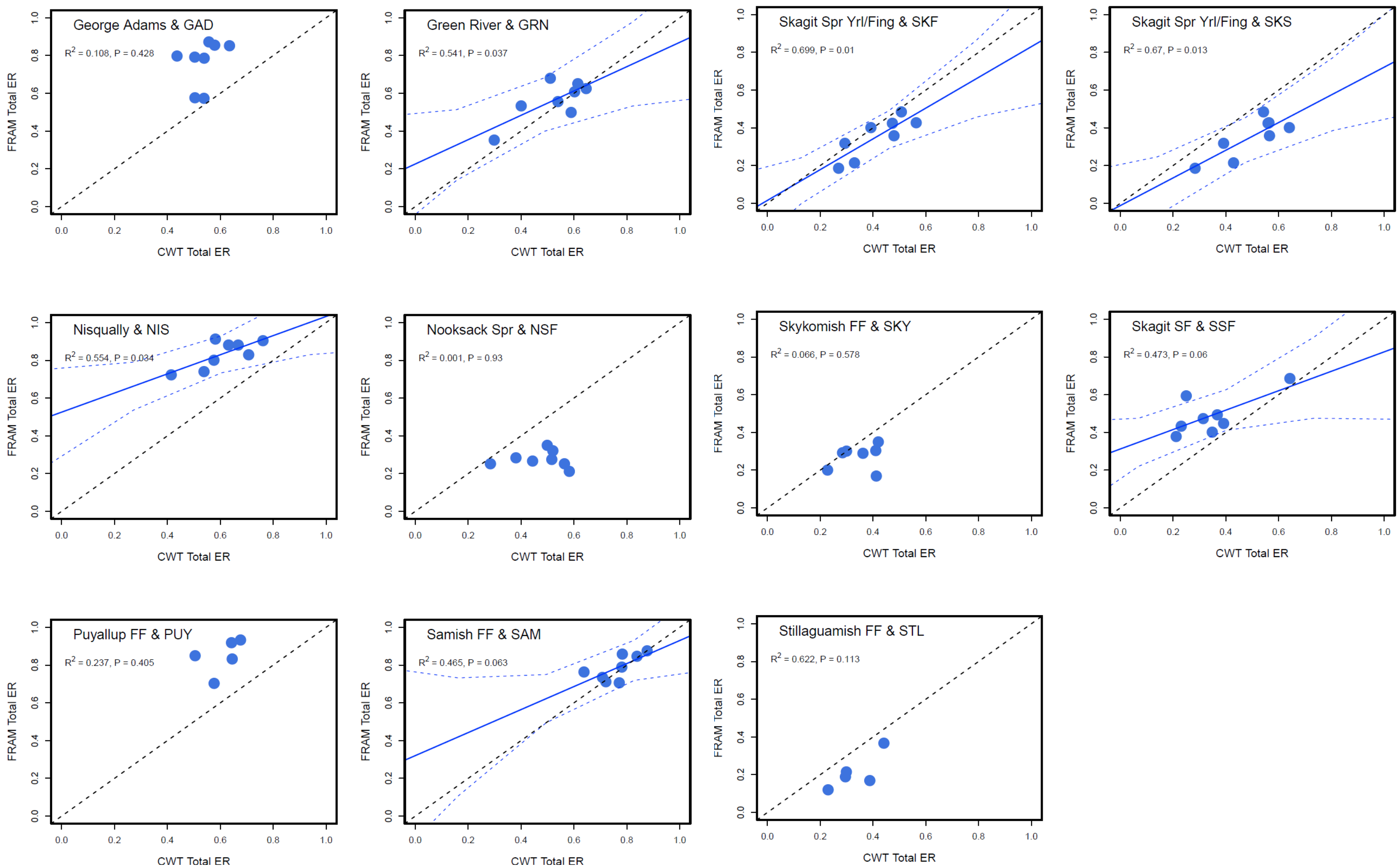


Figure 1. Comparison of total ER estimates from FRAM validation runs (y-axis) and coded wire tag data sets (x-axis) for Puget Sound indicator stocks. The dashed diagonal line represents the line of equality (1:1) whereas solid lines and dashed curves represent fitted regressions and 95% confidence bands where relationships were detected ($\alpha = 0.10$).

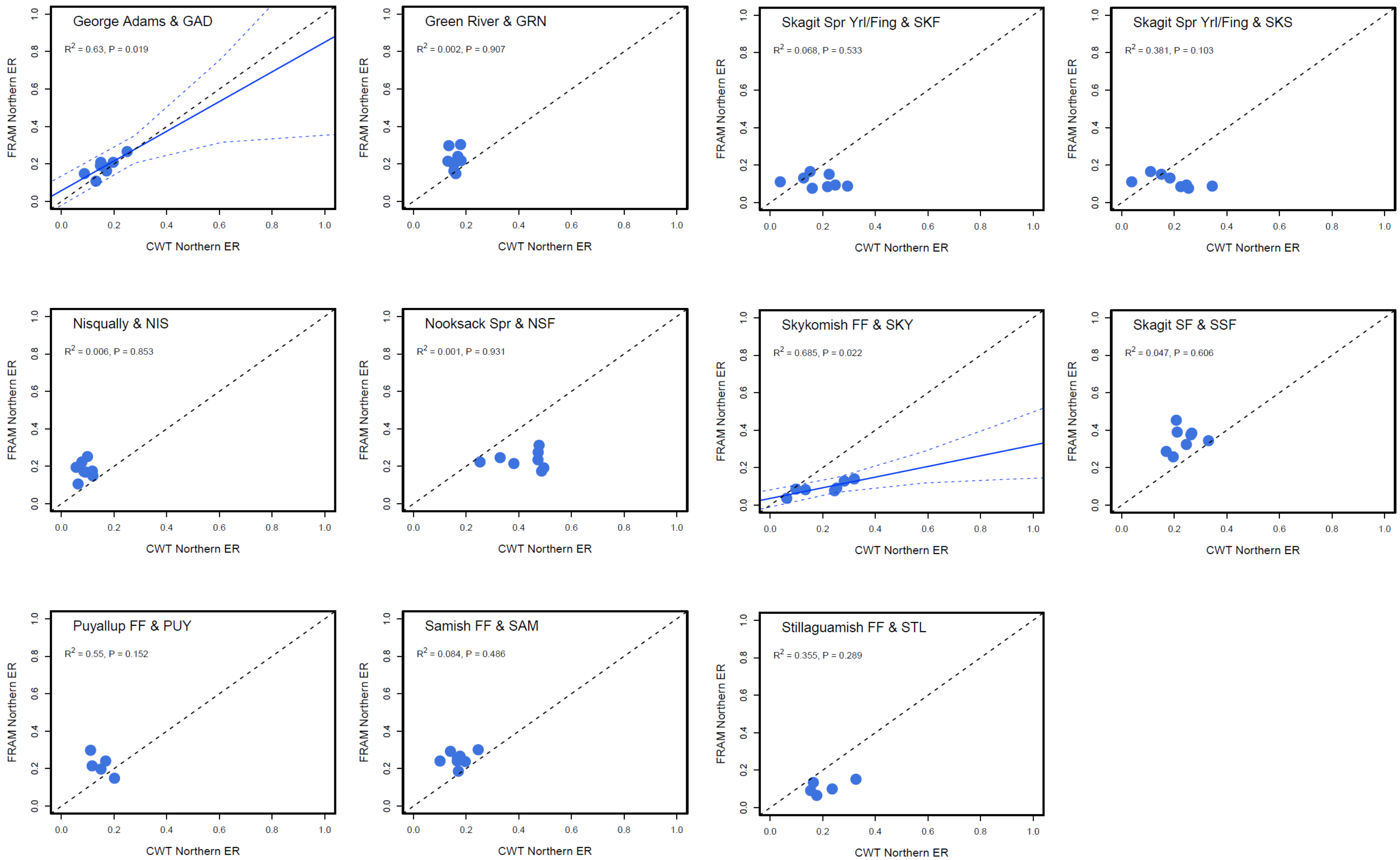


Figure 2. Comparison of northern (Alaska + Canada) ER estimates from FRAM validation runs (y-axis) and coded wire tag data sets (x-axis) for Puget Sound indicator stocks. The dashed diagonal line represents the line of equality (1:1) whereas solid lines and dashed curves represent fitted regressions and 95% confidence bands where relationships were detected ($\alpha = 0.10$).

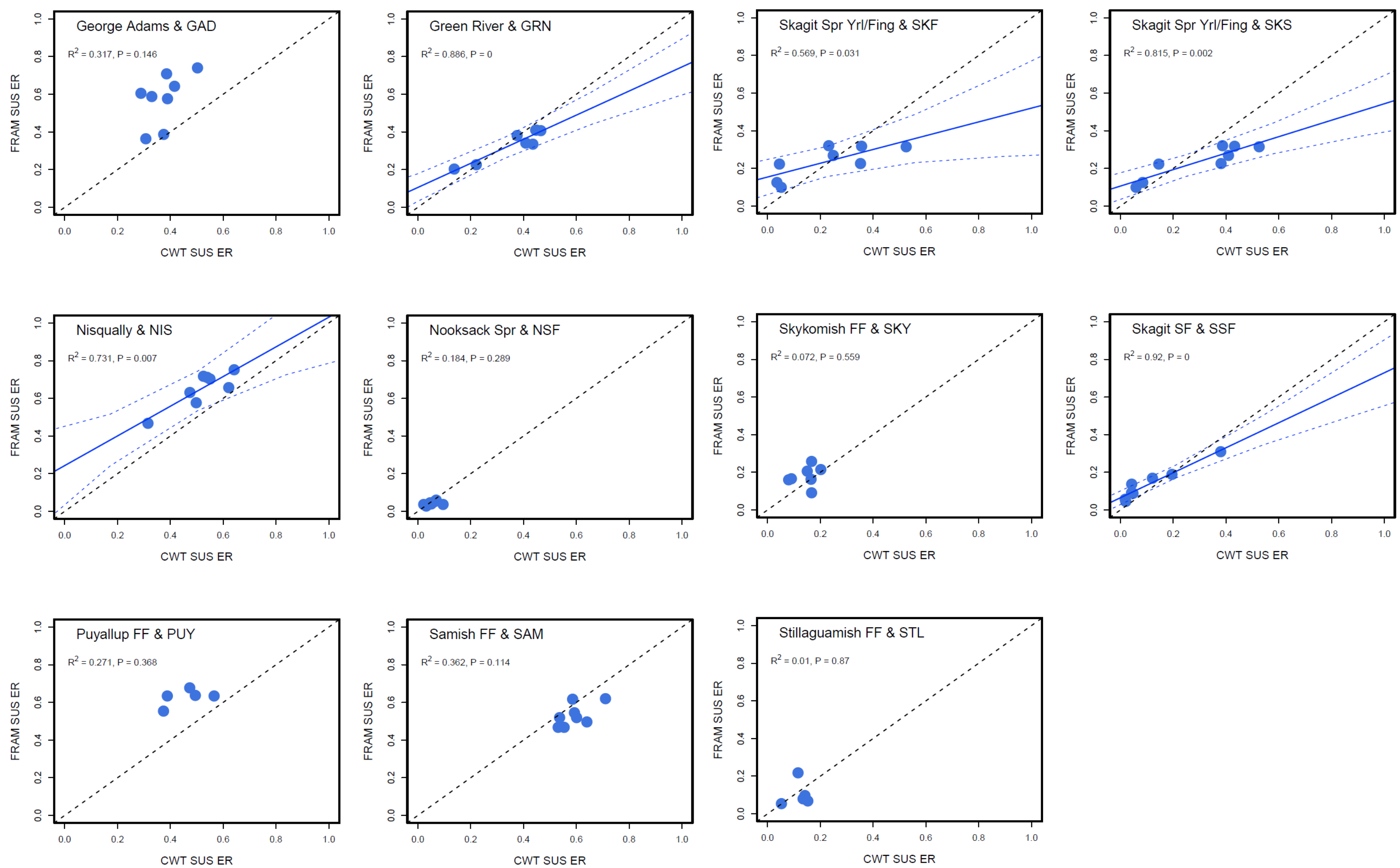


Figure 3. Comparison of southern US (preterminal and terminal) ER estimates from FRAM validation runs (y-axis) and coded wire tag data sets (x-axis) for Puget Sound indicator stocks. The dashed diagonal line represents the line of equality (1:1) whereas solid lines and dashed curves represent fitted regressions and 95% confidence bands where relationships were detected ($\alpha = 0.10$).

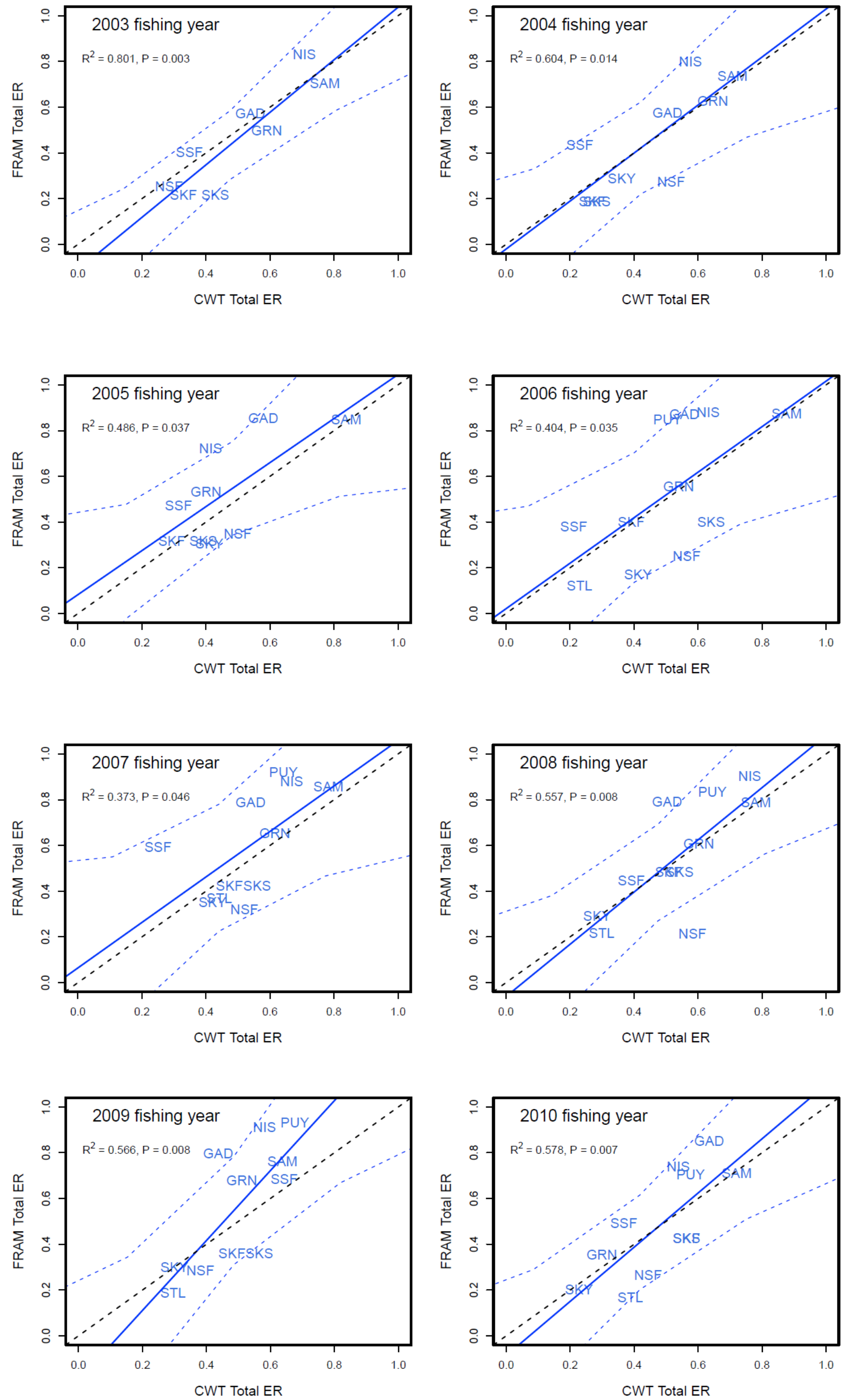


Figure 4. Comparison of total ER estimates from FRAM validation runs (y-axis) and coded wire tag data sets (x-axis) for Puget Sound indicator stocks for 2003-2010 fishing years. Stocks corresponding to three letter codes are listed in Table 1. The dashed diagonal line represents the line of equality (1:1) whereas solid lines and dashed curves represent fitted regressions and 95% confidence bands where relationships were detected ($\alpha = 0.10$).

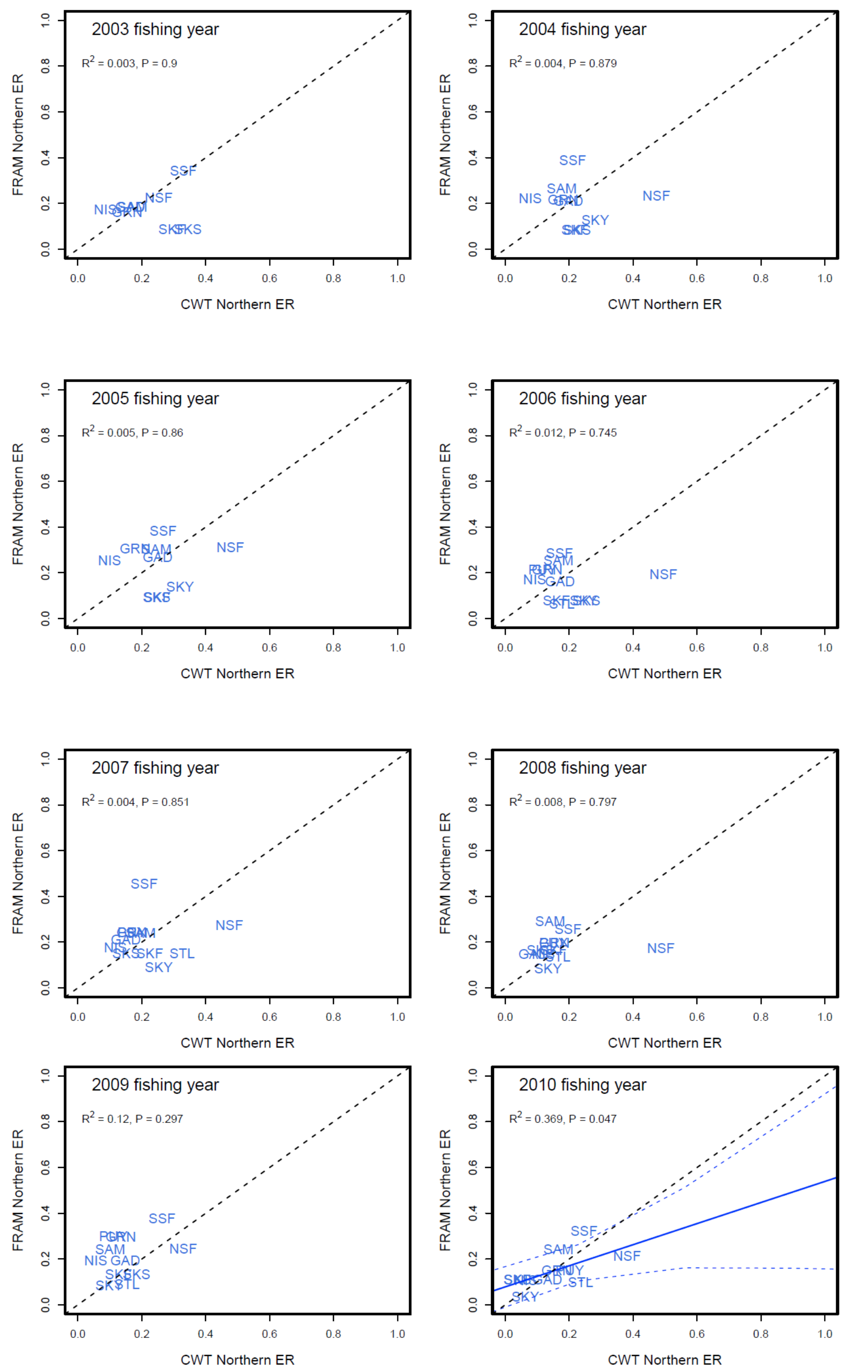


Figure 5. Comparison of northern (Alaska + Canada) ER estimates from FRAM validation runs (y-axis) and coded wire tag data sets (x-axis) for Puget Sound indicator stocks for 2003-2010 fishing years. Stocks corresponding to three letter codes are listed in Table 1. The dashed diagonal line represents the line of equality (1:1) whereas solid lines and dashed curves represent fitted regressions and 95% confidence bands where relationships were detected (α = 0.10).

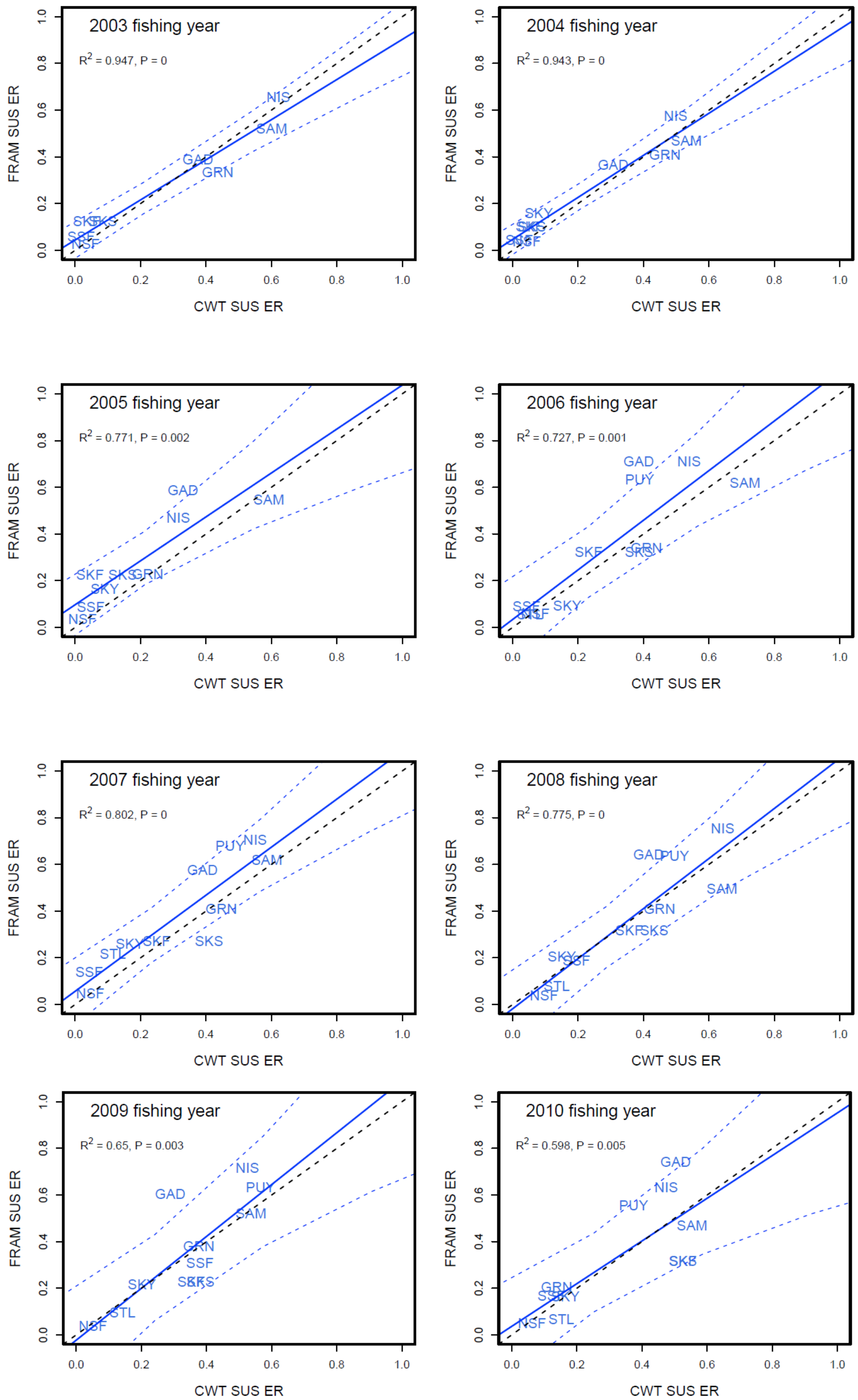


Figure 6. Comparison of southern US (preterminal and terminal) ER estimates from FRAM validation runs (y-axis) and coded wire tag data sets (x-axis) for Puget Sound indicator stocks for 2003-2010 fishing years. Stocks corresponding to three letter codes are listed in Table 1. The dashed diagonal line represents the line of equality (1:1) whereas solid lines and dashed curves represent fitted regressions and 95% confidence bands where relationships were detected ($\alpha = 0.10$).