Pacific Salmon Commission
Joint Chinook Technical Committee Report

Pacific Salmon Commission Chinook Model Base Period Re-Calibration Volume II: Stocks Report TCCHINOOK (21)-02 V2

October 29, 2021

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List of Acronyms and Abbreviations

AABM	Aggregate Abundance Based Management
ADF&G	Alaska Department of Fish & Game
AEQ	Adult Equivalents
AUC	Area Under the Curve
AWG	Analytical Working Group of the CTC
BPC	Base Period Calibration
BSE	Base period file
BY	Brood Year
CLB	Calibration File
CRITFC	Columbia River Inter-Tribal Fish Commission
CTC	Chinook Technical Committee
CU	Conservation units
CWT	Coded-Wire Tag
CYER	Calendar Year Exploitation Rate
DFO	Fisheries and Oceans Canada
DSR	Driver Stock Ration
DU	Designatable Units
ER	Exploitation Rate
ERA	Exploitation Rates Analysis
ERIS	Exploitation Rate Indicator Stock
ESA	Endangered Species Act
EV	Environmental Variable
FCS	Forecast File
FN	First Nations Fishery
FNC	First Nations Caucus
FP	Fishery Policy
FRAM	Fishery Regulation Assessment Model
ISBM	Individual Stock-Based Management
MDL	Model File
MR	Mark-Recapture
NA	Not Available
NBC	Northern British Columbia
NOAA	National Oceanic Administration
NWIFC	Northwest Indian Fisheries Commission
NWVI	Northwest Vancouver Island
ODFW	Oregon Department of Fish & Wildlife
OOB	Out-of-Base
PCM	Peak Count Model
PFMA	Pacific Fishery Management Area
PFMC	Pacific Fishery Management Council
PIT	Passive Integrated Transponder Tag
PNV	Proportion Non-Vulnerable
PSC	Pacific Salmon Commission
PST	Pacific Salmon Treaty
PUB	Pool Upriver Brights
QIN	Quinault Nation
SACE	Stock Aggregate Cohort Evaluation
SALT	South Thompson, Lower Adams, Little and Lower Thompson
SEAK	Southeast Alaska
SR	Stock-Recruit
SRW	Snake River Wild
STK	Stock File
SWVI	Southwest Vancouver Island
TAC	Technical Advisory Committee
U.S.	United States
UAF	University of Alaska Fairbanks
USFWS	US Fish & Wildlife Service
WCVI	West Coast Vancouver Island
WDFW	Washington Department of Fish and Wildlife

NOTE: stock acronyms are not presented in this table.

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1 Introduction

Chapter 3 of the Pacific Salmon Treaty (PST) requires the Chinook Technical Committee (CTC) to "*provide annual calibrations of the Commission Chinook model with pre-season and post-season abundance indexes by April 1 of each year*" (Chapter 3, subparagraph 2(b)(viii)). To fulfill this obligation, the CTC maintains a model, the Pacific Salmon Commission's (PSC) Chinook Model, to generate key outputs of relevance to PSC annual fishery management cycle. The model is calibrated each year, incorporating pre-season stock-specific abundance forecasts with the best available catch, exploitation rate, terminal run, and escapement data. The PSC relies upon the model to generate annual estimates of abundance for aggregate abundance-based management (AABM) fisheries.

The PSC Chinook Model was originally constructed in the 1980s. At its inception, computational power was a bottleneck to the complexity, development, and maintenance of the PSC Chinook Model's code, its inputs, and algorithms. These limitations as well as limited ability to verify data in an accepted data exchange format and source allowed for modelling of only a few stocks and fisheries to represent the operation of inter-jurisdictional fisheries.

As computing power increased and stock and fishery assessment programs developed, additional stocks and fisheries were added for greater representation and relevance to Chinook fisheries management under the PST. This increased model stratification and better representation of AABM and individual stock-based management (ISBM) fishery impacts permits finer stock resolution of fishery impacts, and eventually will allow estimation of differential impacts on marked and unmarked stock components as a result of mark-selective fisheries (MSFs).

The PSC Chinook Model is calibrated to base period years (1979–1982) to determine initial exploitation rates (ER) and starting parameters (e.g., cohort size) in which model stocks are constructed and updated to present time. Each year, the PSC Chinook Model is calibrated using updated stock and fishery data and abundance forecasts. During this process, the PSC Chinook Model reconstructs stocks and fisheries and produces projections of Abundance Indices (AIs) relative to the base period for the upcoming season. The previous calibration for the base period was accomplished in 1998 (referred to as 9806) and was used through 2019. A Base Period Calibration (BPC) is a critical component of the Chinook chapter of the PST, as AABM fishery limits in the 1999, 2009, and 2019 PST Agreements are based on the model AIs that scale current conditions to the base period.

Periodic BPCs are necessary to reflect changes in available data to represent stocks and fisheries. This is an intensive process of data collection, analyses and comparisons, and review. In general, previous attempts to reconstruct the base period were hampered by conflicting priorities of the CTC in fulfilling its normal duties and assignments, and the overall complexity and enormity of the task. An attempt at updating the BPC began in 2013 for use in renegotiating the PST. This effort, which received both agency and PSC prioritization and financial support, culminated in 2019 with a successful new BPC. The new PSC Chinook Model (hereinafter referred to as the Phase II Model) was formally adopted by the PSC in October 2019 and is now calibrated annually and documented in CTC Model Calibration report.

The BPC update was accomplished in two phases: Phase I focused on increasing stock stratification and use of updated stock data and Phase II focused on increasing model fishery stratification and use of updated fishery data. The first iteration of the PSC Chinook Model improvement (Phase I) resulted in finer stock resolution by adding stock groups that were not previously represented, splitting some stocks to better represent life histories and ocean distributions, or improving the representation by the coded-wire tag (CWT) hatchery indicator stocks. These changes increased the number of model stocks from 30 to 41. Phase I also updated escapement and terminal run estimates for multiple stocks, reviewed and revised the CWT codes used for modelled stocks, and updated the Ricker parameters for multiple stocks. In the revised stratification of Phase II, several larger fisheries were split in the model, especially terminal area fisheries. These changes increased the number of model fisheries from 25 to 48.

The intent of this report is to document the recent BPC. This report attempts to provide a comprehensive overview of the Phase II BPC and differences between it and the previous Calibration, 9806.

This report is separated into three volumes. Volume One compares fishery-specific base period ERs and observed catches in the previous BPC (9806) to the Phase II BPC (CTC 2021a). Volume Two, this document, contrasts stock-specific base period CWT recoveries, cohort sizes, maturation rates and adult equivalents, and ERs in the previous BPC (9806) to the Phase II BPC. The forthcoming Volume Three contrasts model parameters and programs from the 9806 BPC with those of the Phase II BPC and includes the process that the CTC used to determine if the new BPC was an improvement over the existing BPC. The following naming convention is used for the section headings:

9806 stock name (acronym): Phase II stock name(s) (acronym)

The following statements apply where appropriate:

1. Base CWT recoveries across multiple stocks were summed,
2. ER across multiple fisheries were summed,
3. ER across multiple stocks were averaged, and
4. Escapement and terminal run across multiple model stocks were summed.

2 Overview of Stock Changes

The Phase II PSC Chinook Model contains additional stocks that were not present in the 9806 model (see Table 1). The Phase II model introduces new model stocks: Alsek (ALS), Taku and Stikine (TST), Mid-Oregon Coast (MOC), and Yakutat Forelands (YAK) that added new stocks not previously included in the Chinook Model. Other new model stocks were the result of reconfiguring or splitting existing model stocks, for example, Northern Southeast Alaska (NSA), Southern Southeast Alaska (SSA), Fraser Spring 1.2 (FS2), Fraser Spring 1.3 (FS3), Fraser Summer Ocean-Type (FSO), Fraser Summer Stream-Type (FSS), Fraser Harrison Fall (FHF), and Fraser

Chilliwack Fall Hatchery (FCF). There are also several stocks in the Phase II Model that were the result of both splitting stocks and changing the geographic delineation of the river systems represented in the previous 9806 model.

The PSC Chinook Model uses exploitation rate indicator stocks (ERIS) to estimate Chinook exploitation, maturation, and adult equivalent rates in the Treaty area. Stocks with CWT information are used as ERISs, and those with tags contributing to the base period (1979–1982) are considered “in-base”. Many stocks and tagging programs have contributed information after the 1979–1982 base period and are considered “out-of-base”. Out-of-base (OOB) procedures (described in the forthcoming Volume Three document) are employed to estimate ER that would have been expected to occur during the 1979–1982 base period using fishery indices scaled to the base period generated by the ERA.

Table 1—Stock groups used in the 9806 and the Phase II model calibrations. Phase II stock numbers can be found in Figure 1.

9806 Model Calibration			Phase II Model Calibration			CWT Indicator(s)		Out-of-Base?	
#	Stock Group	Acronym	#	Stock Group	Acronym	9806	Phase II	9806	Phase II
1	Alaska Spring	AKS[1]	1	Southern SE AK	SSA		ADM, AHC, ALP, ANB	Yes	Yes
			2	Northern SE AK	NSA		ACI		Yes
		Not represented	3	Alsek	ALS		-		No
		Not represented	4	Taku and Stikine	TST		TAK, STI		Yes
2	North/Central B.C.	NTH	5	Northern B.C.	NBC		KLM	No	Yes
			6	Central B.C.	CBC		ATN		Yes
3	Fraser Early	FRE	7	Fraser Spring 1.2	FS2		NIC	No	Yes
			8	Fraser Spring 1.3	FS3		DOM		No
			9	Fraser Ocean-type 0.3	FSO		SHU		No
			10	Fraser Summer Stream-type 1.3	FSS		CKO (BP only)		Yes
4	Fraser Late	FRL	11	Fraser Harrison Fall	FHF		HAR	Yes	Yes
			12	Fraser Chilliwack Fall Hatchery	FCF		CHI		Yes
5	WCVI Hatchery	RBH	13	WCVI Hatchery	WVH		RBT	No	No
6	WCVI Natural	RBT	14	WCVI Natural	WVN		RBT	No	No
7	Upper Georgia Strait	GSQ	15	Upper Georgia Strait	UGS		QUI	No	No
			16	Puntledge Summers	PPS		PPS	No	No
8	Georgia Strait Lower Natural	GST	17	Lower Georgia Strait	LGS		COW, NAN	No	Yes
9	Georgia Strait Lower Hatchery	GSH	18	Middle Georgia Strait	MGS		BQR	No	No
10	Nooksack Fall	NKF	19	Nooksack Fall	NKF		SAM	No	No
11	Puget Sound Fingerling	PSF	20	Puget Sound Fingerling	PSF		SPS	No	No

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9806 Model Calibration			Phase II Model Calibration			CWT Indicator(s)		Out-of-Base?	
#	Stock Group	Acronym	#	Stock Group	Acronym	9806	Phase II	9806	Phase II
12	Puget Sound Natural Fall	PSN	21	Puget Sound Natural Fall	PSN	SPS		No	No
13	Puget Sound Yearling	PSY	22	Puget Sound Yearling	PSY	SPY, UWA		No	No
14	Nooksack Spring	NKS	23	Nooksack Spring	NKS	NSF		Yes	Yes
15	Skagit Wild	SKG	24	Skagit Wild	SKG	SSF		No	No
16	Stillaguamish Wild	STL	25	Stillaguamish Wild	STL	STL		Yes	Yes
17	Snohomish Wild	SNO	26	Snohomish Wild	SNO	STL -> SNO		Yes	Yes
18	Washington Coastal Hatchery	WCH	27	Washington Coastal Hatchery	WCH	WCH		Yes	Yes
28	Washington Coastal Natural	WCN	28	Washington Coastal Natural	WCN	WCN		Yes	Yes
24	Willamette River Spring	WSH	29	Willamette River Spring	WSH	WSH		No	No
25	Cowlitz Spring Hatchery	CWS	30	Cowlitz Spring Hatchery	CWS	CWS[2]		No	No
26	Columbia River Summer	SUM	31	Columbia River Summer	SUM	SUM		No	Yes[3]
19	Upriver Brights	URB	32	Upriver Brights	URB	URB		No	No
20	Spring Creek Hatchery	SPR	33	Spring Creek Hatchery	SPR	SPR		No	No
21	Lower Bonneville Hatchery	BON	34	Lower Bonneville Hatchery	BON	BON		No	No
22	Cowlitz Fall Hatchery	CWF	35	Cowlitz Fall Hatchery	CWF	CWF		No	No
23	Lewis River Wild	LRW	36	Lewis River Wild	LRW	LRW		No	No
29	Lyons Ferry	LYF	37	Lyons Ferry	LYF	LYF		Yes	Yes
30	Mid-Columbia River Brights	MCB	38	Mid-Columbia River Brights	MCB	MCB		No	No
27	Oregon Coast	ORC	39	North Oregon Coast	NOC	SRH		No	No
	Not represented		40	Mid-Oregon Coast	MOC	ELK			No
	Not represented		41	Yakutat Forelands	YAK	-			No

[1] Alaska Spring stock in the 9806 Model Calibration was composed of fish from the following hatcheries: Deer Mountain (ADM), Herring Cove (AHC), Little Port Walter (ALP), Neets Bay (ANB), and Crystal Lake (ACI).

[2] CWT indicator is not used in the annual Exploitation Rate Analysis, only for base period recoveries.

[3] 1998–2000 + in-base

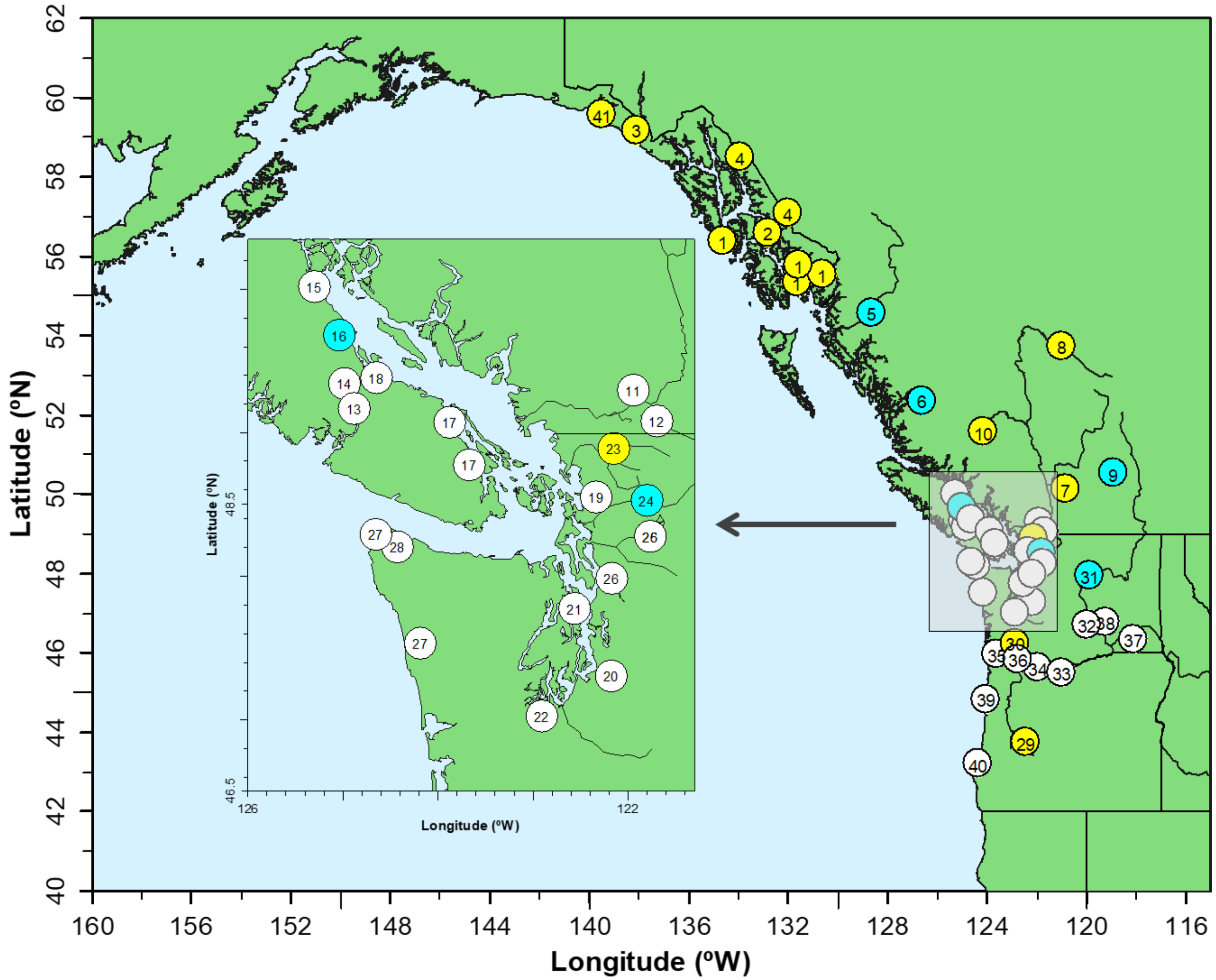

Figure 1—Map of exploitation rate indicator stocks used to represent the Phase II model stock groups.

Numbered circles indicate the Phase II stock group number as found in Table 1. Color of the filled circles indicates adult run timing: yellow = spring, aquamarine = summer, and white = fall. The southern British Columbia and Puget Sound area, where concentration of model stocks is greatest, is shown in expanded view.

3 Changes to Data

In addition to the MDL files, many other parameters in a BPC are specified in the BSE and CLB files. The BSE file specifies the number of age classes, natural mortality rates, proportion of each age class not vulnerable to fishing gear (proportion non-vulnerable [PNV]), stock-fishery variable that indicates whether a particular fishery should be considered terminal for a stock, the age 2 to 1 conversion factor, and stock recruitment (SR) parameters. The CLB file specifies the average base period (1979–1982) and pre-base period (1975–1978) escapement (Table 2).

The BASECALIBRATION program is used to create two computer files critical to a new BPC: an updated BSE file with revised Ricker parameters and age 2 to 1 conversion factors and the STK file. Data contained in the BSE file is the same as before except that it has revised stock recruitment parameters and age 2 to 1 conversion factors. The STK file contains the initial cohort size, maturation rate, adult equivalent (AEQ) factor, and base period ER by model stock and model fishery.

In addition to changes to the base period data, a BPC often involves changes to the annual model calibration input as well. For example, the change in model stock stratification necessitated a change in the reported time series of escapement or terminal runs. Differences between the 9806 and the Phase II model calibrations for all stocks are shown in Figure 2. Some of these changes were a result of the increased model stratification, others were result of updated escapement estimates, and others were a result of changes to model fishery definitions (i.e., the natural or hatchery production considered part of a model stock). Differences between BPCs are documented in the individual stock sections of this report.

CWT data for specific CWT indicator stocks are contained computer files known as C-files. A C-file contains CWT data specific to the tag code: brood year, number of fish tagged, number released, maximum age, the number of fisheries, a list of fisheries, and recoveries by fishery and in escapement. C-files, along with other stock-specific inputs are converted into Model (MDL) files. The structure of MDL files is identical to C-files except that (1) the tag code has been replaced by a stock name, (2) the brood year has been replaced by the word "MODEL", and (3) fisheries may have been aggregated or dropped as specified in the CMB mapping file that maps fisheries in the C-files to fisheries used in the ERA. MDL files contain the model stock-specific estimates of CWT recoveries by model fishery, combined and weighted across brood years and tag codes. MDL files are an important input to the BASECALIBRATION program, which is used to create a new BPC.

Table 2—Pre-base and base escapements for stock groups used in the 9806 and Phase II model calibrations.

The gray shaded cells represent cases where no changes were made between the 9806 and the Phase II model calibrations.

9806					Phase II				
Stock Group	Pre-base Escapement (avg)		Base Escapement (avg)		Stock Group	Pre-base Escapement (avg)		Base Escapement (avg)	
	Number	Years[2]	Number	Years[2]		Number	Years[2]	Number	Years[2]
AKS	12,746	75–78	12,126	79–81	SSA	13,996	75–78	11,546	79–82
					NSA	2,991	75–78	2,578	79–82
Not represented					ALS	9,924	76–78	11,513	79–82
Not represented					TST	48,373	75–78	82,317	79–82
NTH	55,350	75–78	49,254	79–81	NBC	33,179	75–78	32,211	79–82
					CBC	8,785	75–78	6,033	79–82
FRE	50,110	75–78	43,631	79–81	FS2	6,475	75–78	5,622	79–82
					FS3	11,260	75–78	14,105	79–82
					FSO	25,428	75–78	15,762	79–82
					FSS	14,046	75–78	10,228	79–82
FRL	141,000	75–78	120,000	79–81	FHF	141,000	75–78	120,000	79–81
					FCF	100	NA	100	NA
RBH	48,121	75–78	48,121	79–81	WVH	48,121	75–78	48,121	79–81
RBT	68,122	75–78	68,122	79–81	WVN	68,122	75–78	68,122	79–81
GSQ	23,930	75–78	10,809	79–82	UGS	8,702	79–82[1]	4,849	79–82
					PPS	442	75–78	983	79–82
GST	9,310	75–78	11,783	79–82	LGS	9,310	75–78	11,783	79–82
GSH	5,164	76–78	5,164	79–81	MGS	8,057	75–78	3,783	79–82
NKF	11,923	76–78	11,923	79–81	NKF	7,871	76–78	11,975	79–81
PSF	24,769	76–78	24,769	79–82	PSF	19,310	76–78	25,042	79–82
PSN	13,741	76–78	16,966	79–82	PSN	6,793	76–78	10,254	79–82
PSY	9,136	76–78	9,136	79–82	PSY	5,317	76–78	7,202	79–82
NKS	1,703	76–78	1,374	79–81	NKS	1,703	76–78	1,374	79–81
SKG	12,697	76–78	14,207	79–82	SKG	12,138	76–78	12,889	79–82
STL	1,472	76–78	831	79–82	STL	1,616	76–78	817	79–82
SNO	6,178	76–78	5,244	79–82	SNO	6,035	76–78	5,020	79–82
WCH	6,703		6,703		WCH	9,194		9,194	
WCN	13,630		21,180		WCN	11,867		21,243	
WSH	11,400	76–78	8,905	79–82	WSH	64,269	76–78	56,692	79–82
CWS	16,488		16,563	79–81	CWS	16,488		16,563	79–81
SUM	29,695	77–78	22,205	79–82	SUM	16,535	77–78	11,955	79–82
URB	30,980	76–78	27,400	79–81	URB	31,433	76–78	27,400	79–81
SPR	25,600		22,735	79–81	SPR	25,600		22,735	79–81

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9806					Phase II				
Stock Group	Pre-base Escapement (avg)		Base Escapement (avg)		Stock Group	Pre-base Escapement (avg)		Base Escapement (avg)	
	Number	Years	Number	Years		Number	Years	Number	Years
BON	22,643		26,291	79–81	BON	22,643		26,291	79–81
CWF	9,200		17,100	79–81	CWF	9,200		17,100	79–81
LRW	13,500		19,200	79–81	LRW	13,500		19,200	79–81
LYF	1,000	NA	1,000	NA	LYF	1,000	NA	1,000	NA
MCB	4,400	NA	4,400	79–80	MCB	150	NA	4,400	NA
ORC	41,098	75–78	58,619	79–82	NOC	40,517	75–78	67,615	79–82
Not represented					MOC	18,255	75–78	19,542	79–82
Not represented					YAK	17,982	79–82	16,522	76–78

Note: NA = stocks were in limited production prior to the base period.

[1] For UGS pre-base escapement, the years used were updated to 1979–1982 from GSQ.

[2] When years are missing, the CTC could not reconstruct the base period data due to missing or incomplete data or documentation.

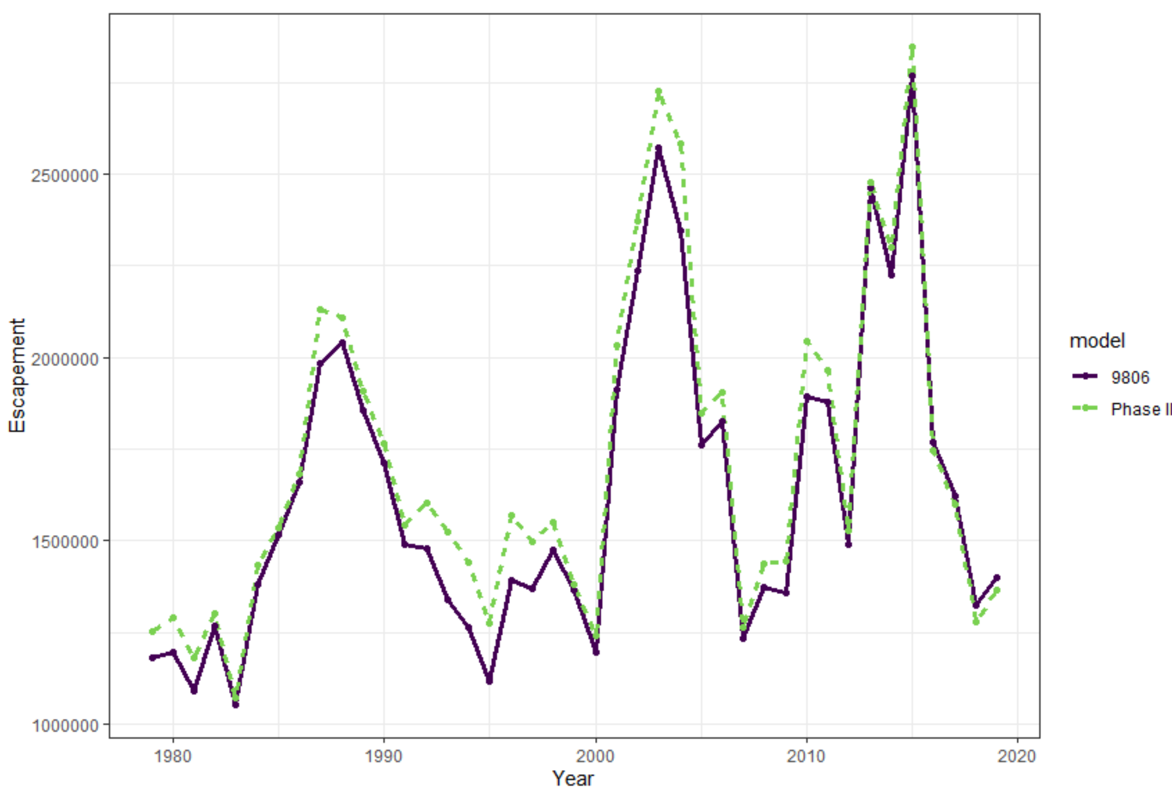

Figure 2—All model stocks escapement and/or terminal run differences between the 9806 and the Phase II model calibrations, including new stocks and updated stock stratification.

Changes in production parameters are contained in Table 3, where gray indicates no change between the 9806 and Phase II model calibrations. These include Ricker α and β SR parameters, optimum number of spawners, and a number indicator determining if the SR parameters are overwritten by model calculated values (where 1 = yes).

The recruits in the SR relationship for hatchery stocks are age-1 fish. For hatchery stocks, the SR relationship is represented as a hockey-stick function truncated at: exp(α) x Optimum Spawners. Stocks with these relationships are indicated as “Method 0” (M0) in Table 3.

For wild stocks, the recruits in the SR relationship are based on expansions of returning adults using assumptions of natural mortality and estimates of maturation rates. For wild stocks, three different kinds of SR relationships can be used depending on the “Compute SR” and the “Truncate” flag as follows:

- Method 1 (M1): Compute SR = 0 and Truncate = 1 (True Ricker),
- Method 2 (M2): Compute SR = 0 and Truncate = 0 (Ricker truncated at recruitment resulting from optimum number of spawners),
- Method 3 (M3): Compute SR = 1 and Truncate = 1 (Ricker truncated at maximum recruitment),
- Method 4 (M4): Compute SR = 1 and Truncate = 0 (Ricker truncated at recruitment resulting from optimum number of spawners).

The PSC Chinook Model recomputes the Ricker β parameter specified in the BSE file using the Hilborn approximation (Hilborn and Walters 1992) if ‘Compute SR = 1”.

Table 3—Stock-recruit parameters found in the 9806 and Phase II model calibrations.

Shaded cells represent where there were no changes from the 9806 calibration.

9806 Model Calibration		Phase II Model Calibration		Ricker α		Ricker β		Optimum Spawners		SR Relationship	
#	Stock Group	#	Stock Group	9806	Phase II	9806	Phase II	9806	Phase II	9806	Phase II
1	Alaska Spring	1	Southern SE AK	1.617	2.426	12,663	13,746	9,110	6,733	M1	M3
		2	Northern SE AK		1.369		14,524		5,870		M3
		3	Alsek	-	1.643	-	11,689	-	4,500		M3
		4	Taku and Stikine	-	1.268	-	131,298	-	53,995		M3
2	North/Central B.C.	5	Northern B.C.	1.400	1.450	254,373	126,420	117,500	50,383	M3	M1
		6	Central B.C.		1.650		19,109		7,348		M1
3	Fraser Early	7	Fraser Spring 1.2	1.400	1.784	218,512	59,035	93,700	22,146		M1
		8	Fraser Spring 1.3		1.789		134,338		50,346	M3	M1
		9	Fraser Ocean-type 0.3		1.941		174,772		63,637		M1
		10	Fraser Summer Stream-type 1.3		1.812		56,881		21,226		M1
4	Fraser Late	11	Fraser Harrison Fall	1.415	1.415	131,683	131,683	75,100	75,100	M1	M1
		12	Fraser Chilliwack Fall Hatchery		3.634		4,072		1,000		M0
5	WCVI Hatchery	13	WCVI Hatchery	5.524	5.000	58,593	61,480	6,472	6,472	M0	M0
6	WCVI Natural	14	WCVI Natural	1.400	1.421	102,830	50,543	42,734	20,244	M3	M3
7	Upper Georgia Strait	15	Upper Georgia Strait	1.463	1.326	58,603	32,396	23,300	13,191	M3	M3
		16	Puntledge Summers	2.136	2.851	64,625	2,663	21,935	800		M0
8	Georgia Strait Lower Natural	17	Lower Georgia Strait	4.616	3.266	30,066	19,310	5,318	9,538	M3	M3
9	Georgia Strait Lower Hatchery	18	Middle Georgia Strait		3.143		16,786		4,700	M0	M0

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9806 Model Calibration		Phase II Model Calibration		Ricker α		Ricker β		Optimum Spawners		SR Relationship	
#	Stock Group	#	Stock Group	9806	Phase II	9806	Phase II	9806	Phase II	9806	Phase II
10	Nooksack Fall	19	Nooksack Fall	4.020	4.020	54,543	54,543	11,923	11,923	M0	M0
11	Puget Sound Fingerling	20	Puget Sound Fingerling	4.020	2.280	113,307	2,764	24,769	24,769	M0	M0
12	Puget Sound Natural Fall	21	Puget Sound Natural Fall	2.184	2.324	34,268	50,296	16,966	16,966	M4	M4
13	Puget Sound Yearling	22	Puget Sound Yearling	4.150	2.367	43,609	27,328	9,136	9,136	M0	M0
14	Nooksack Spring	23	Nooksack Spring	2.015	1.100	11,144	8,905	4,000	4,000	M4	M4
15	Skagit Wild	24	Skagit Wild	1.520	1.520	27,337	27,337	9,778	9,778	M2	M2
16	Stillaguamish Wild	25	Stillaguamish Wild	1.400	1.100	4,561	4,556	2,000	2,000	M4	M4
17	Snohomish Wild	26	Snohomish Wild	2.428	1.100	10,604	12,023	5,250	5,250	M4	M4
18	Washington Coastal Hatchery	27	Washington Coastal Hatchery	3.664	2.395	27,525	20,168	6,703	6,703	M0	M0
28	Washington Coastal Natural	28	Washington Coastal Natural	2.077	2.077	71,808	71,808	21,500	20,026	M1	M1
24	Willamette River Spring	29	Willamette River Spring	1.400	4.338	32,884	68,758	13,500	13,500	M0	M0
25	Cowlitz Spring Hatchery	30	Cowlitz Spring Hatchery	4.051	5.000	5,049	21,235	2,500	2,500	M0	M0
26	Columbia River Summer	31	Columbia River Summer	2.312	2.152	52,436	34,703	17,857	12,143	M1	M2
19	Upriver Brights	32	Upriver Brights	1.894	2.692	173,905	134,600	62,382	40,000	M3	M2
20	Spring Creek Hatchery	33	Spring Creek Hatchery	2.077	4.825	71,808	43,143	21,500	7,000	M0	M0
21	Lower Bonneville Hatchery	34	Lower Bonneville Hatchery	1.400	2.293	8,022	77,175	3,430	26,200	M0	M0
22	Fall Cowlitz Hatchery	35	Fall Cowlitz Hatchery	4.510	3.046	67,824	30,686	12,500	8,800	M0	M0
23	Lewis River Wild	36	Lewis River Wild	2.189	2.189	16,711	16,711	5,700	5,700	M1	M1
29	Lyons Ferry	37	Lyons Ferry	1.400	1.260	8,022	8,329	3,430	3,430	M3	M3
30	Mid-Columbia River Brights	38	Mid-Columbia River Brights	4.510	4.281	67,824	62,397	12,500	12,500	M0	M0
27	Oregon Coast	39	North Oregon Coast	1.894	2.055	173,905	164,348	62,382	57,928	M1	M1
		40	Mid-Oregon Coast	-	2.085	-	47,274	-	16,663		M1
		41	Yakutat Forelands	-	2.163	-	6,881	-	3,376		M3

4 Model Stocks

4.1 Alaska Spring (AKS): Southern Southeast Alaska (SSA) and Northern Southeast Alaska (NSA)

4.1.1 Stock Description

In the 9806 model, the Alaska Spring (AKS) model stock was used to represent wild Chinook production originating from Andrew Creek, King Salmon River, and four rivers in the Behm Canal: Unuk, Chickamin, Blossom, and Keta Rivers. Exploitation rates for the AKS model stock are derived from the AKS hatchery indicator stock, comprised of CWT releases from five Southeast Alaska (SEAK) hatcheries: Little Port Walter, Crystal Lake, Neets Bay, Deer Mountain, and Whitman Lake. Escapement and age structure data are collected annually from each of the six wild stocks.

The new Phase II Chinook model split the Alaska Spring model stock into two model stocks: Northern Southeast Alaska (NSA) and Southern Southeast Alaska (SSA). The NSA model stock is used to represent wild production originating from Northern SEAK, including some production previously represented (Andrew Creek and King Salmon River), but also now includes production from the Chilkat River and an additional 15% from rivers not surveyed annually (Hubartt and Kissner 1987). Exploitation rates for the NSA model stock are derived from the NSA hatchery exploitation rate indicator stock, comprised of CWT releases from the Crystal Lake Hatchery. Escapement and age structure data are collected annually from the 3 surveyed rivers.

The SSA model stock is used to represent wild production originating from Southern SEAK, including some production previously represented (Unuk, Chickamin, Blossom, and Keta Rivers), but also now includes production from the Chilkat River and an additional 30% from rivers not surveyed annually (Hubartt and Kissner 1987). Exploitation rates for the SSA model stock are derived from the SSA hatchery exploitation rate indicator stock, comprised of CWT releases from Little Port Walter, Neets Bay, Deer Mountain, and Whitman Lake. Escapement and age structure data are collected annually from the four surveyed rivers.

4.1.2 Description of Changes

4.1.2.1 MDL File Settings

MDL files contain data related to specific CWT groups used in analysis. Brood year (BY), number of fish tagged, number of fish released, maximum age, and estimated recoveries and escapement are data found in MDL files (Table 4). The reconfigured Alaska SEAK Spring stock (AKS) was split into South SEAK Springs (SSA) and North SEAK Springs (NSA), but with Macaulay Hatchery returns added to the latter, thus also introducing some new fish. The additional fish are reflected in the FCS files for these stock groups (Table 5).

Table 4—Information that was used in the construction of the Southern Southeast Alaska (SSA) and Northern Southeast Alaska (NSA) model (MDL) files.

Information for MDL File Production	Phase II Model Stock	
Model Stock Acronym	SSA	NSA
Brood Years	1978–1981	1979–1982
Out-of-base procedure used?	Yes	Yes
Modification to the WG4 file?	No	No
C-file extension (CWT Indicator ID)	ANB, ADM, AHC, ALP	ACI, AMC
Yearling Stock	Yes	Yes
Weight within BY by production releases	No	No
Exclude Esc for Between BY weighting	No	No
Start age in C-files	2	2
Last age in C-files	6	6
Modifications to escapements in Coshak4	No	No
Terminal fishery CWT moved to escapement	Yes: TAK TERM T, N, S and TUS TERM STRAY N	Yes: TAK TERM T, N, S and TUS TERM STRAY N
Model stock type	Wild, Spring	Wild, Spring
Additional fisheries designated as terminal in the BSE file	None	None
MDL creation date	19 Sept. 2016	19 Sept. 2016

Table 5—FCS file for Alaska Springs (AKS) stock grouping reconfigured into Northern Southeast Alaska (NSA) and Southern Southeast Alaska (SSA) for the Phase II model calibration.

Note: Differences between the Phase II and 9806 model calibration (negative = decreased in Phase II model, in parentheses).

Return Year	age 4	age 5	age 6+
1979	993	1,845	1,401
1980	1,294	2,548	2,013
1981	1,286	2,487	1,895
1982	1,634	3,159	4,380
1983	2,038	3,630	2,665
1984	2,065	5,678	3,326
1985	2,939	5,435	2,190
1986	5,974	8,360	5,693
1987	4,235	7,155	5,253
1988	2,307	4,886	4,400
1989	2,070	4,612	4,267
1990	2,515	3,263	3,414

Return Year	age 4	age 5	age 6+
1991	1,844	5,707	4,150
1992	1,669	3,552	5,794
1993	1,572	4,617	4,716
1994	1,164	4,426	6,595
1995	2,715	1,562	5,590
1996	1,229	7,026	2,517
1997	943	3,406	8,311
1998	1,222	3,151	4,049
1999	2,220	2,374	3,277
2000	2,963	4,497	2,153
2001	2,031	8,172	4,652
2002	2,561	5,467	4,642
2003	2,180	5,859	5,915
2004	4,305	4,019	3,656
2005	3,009	6,075	2,656
2006	2,927	5,842	3,335
2007	1,697	4,472	2,127
2008	2,120	5,178	2,454
2009	3,360	3,860	3,921
2010	2,246	4,459	2,237
2011	2,617	4,696	2,044
2012	954	3,144	789
2013	2,086	2,695	1,847
2014	2,183	3,306	1,372
2015	2,088	4,552	1,258
2016	920	2,455	882
2017	1,427	1,847	588
2018	2,353	2,870	439
2019	3,858	9,807	1,773

4.1.2.2 Base Period Coded-Wire Tags and Recoveries

The 9806 AKS model stock was represented by five hatchery indicator stocks: ACI, ANB, ADM, AHC, and ALP. The Phase II model split the AKS Model stock into a northern (NSA) and southern (SSA) component by associating each hatchery indicator stock to a region. NSA uses tag codes from ACI and SSA uses tag codes from ANB, ADM, AHC, and ALP. Base data for the NSA stock began in 1979, as opposed to 1978 with AKS. New tag codes from Crystal Lake Hatchery were added for the brood years 1981 and 1982 to give NSA a four-year time series. Likewise, brood year 1981 tag codes from Little Port Walter and Neets Bay were added to give SSA a four-year time series of base data as well (Table 6).

Table 6—Coded-wire tag codes used for the Alaska Spring (AKS), Northern Southeast Alaska (NSA), and Southern Southeast Alaska (SSA) model stocks.

Brood Year	Tag Codes		
	9806 (AKS)	**Phase II (NSA)**	**Phase II (SSA)**
1978	031661, 031703, 031704, 031705, 031706, 031707, 031708, 031709, 031710, 031711, 031712, 031713, 031714, 031715, 041932, 041938, 041939, 041940		ALP: 031661, 031661, 031703, 031704, 031705, 031706, 031707, 031708, 031709, 031710, 031711, 031712, 031713, 031714, 031715 ADM: 041932, 041938, 041939, 041940
1979	031716, 031717, 041917, 041943, 041945, 042039, 042040, 042042, 042043, 042045	ACI: 042042, 042043, 042045	ALP: 031716, 031717 ADM: 041917, 041943, 041945, 042039, 042040
1980	031753, 031754, 041944, 042121, 042202, 044005	ACI: 042202	ALP: 031753, 031754 ADM: 041944, 042121 AHC: 044005
1981		ACI: 042229	ALP: 031761, 031762, 031763, 031801, 031802 031803, 031804, 036303, 036304, 036305 ANB: B40907, B40908
1982		ACI: 042354, 042355, 042356	

Note: ACI: Crystal Lake Hatchery; ALP: Little Port Walter Hatchery; ADM: Deer Mountain Hatchery; AHC: Herring Cove/Whitman Lake Hatchery; ANB: Neets Bay.

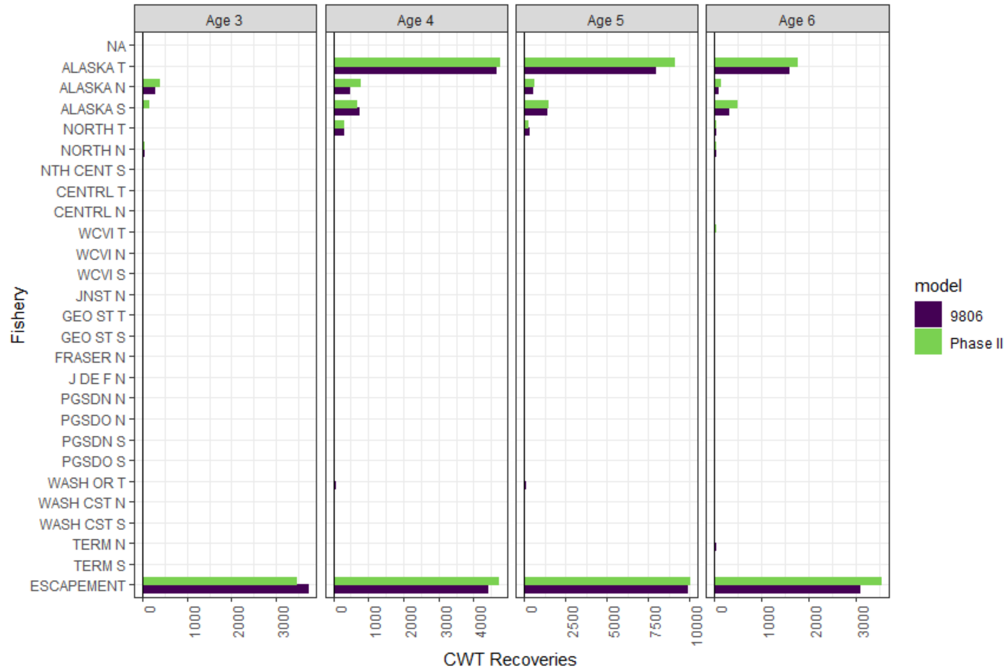

Figure 3—Base period coded-wire tag (CWT) recoveries for Alaska Springs (AKS), Northern Southeast Alaska (NSA), and Southern Southeast Alaska (SSA).

4.1.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

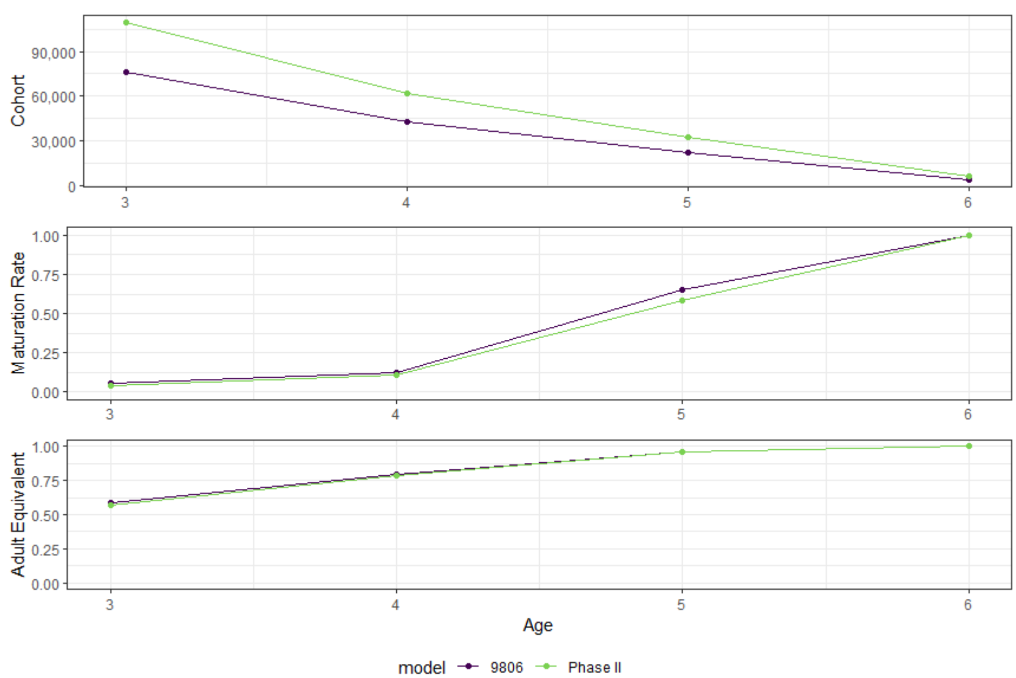

Figure 4—Base period exploitation rates by fishery for Alaska Springs (9806), Northern Southeast Alaska (Phase II), and Southern Southeast Alaska (Phase II).

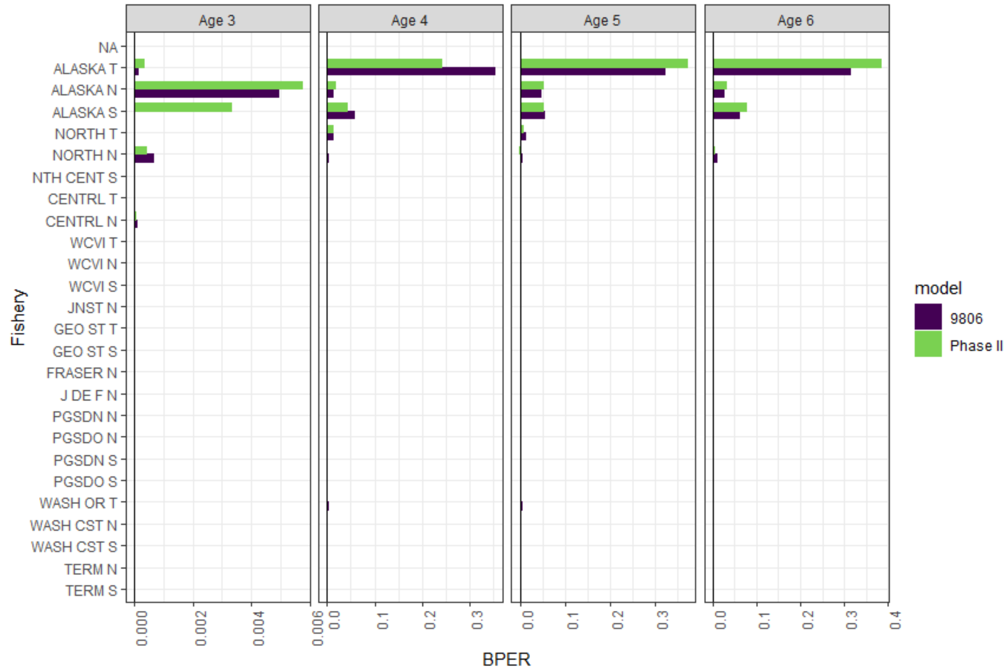

Figure 5—Base period exploitation rates by fishery for Alaska Springs (9806), Northern Southeast Alaska (Phase II), and Southern Southeast Alaska (Phase II).

4.1.2.4 Escapement Time Series

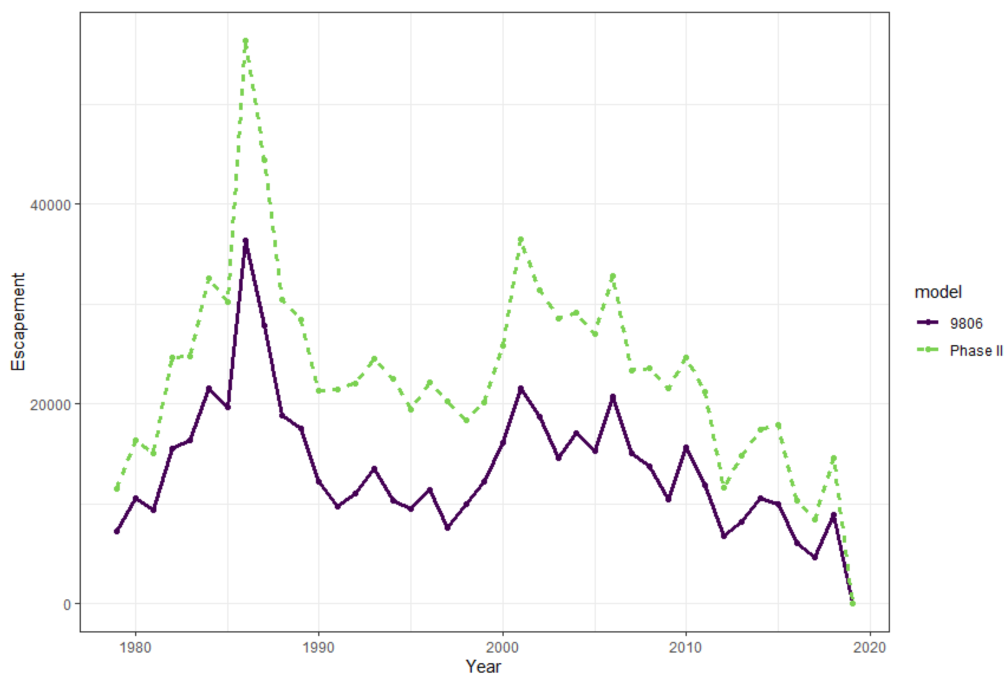

Figure 6—Comparison of escapement Alaska Springs (9806), Northern Southeast Alaska (Phase II), and Southern Southeast Alaska (Phase II).

4.1.2.5 Ricker Parameters

Ricker parameters can be found in the Phase II model stock sections for Southern Southeast Alaska (4.2.2.5) and Northern Southeast Alaska (4.3.2.5).

4.2 Alaska Spring (AKS): Southern Southeast Alaska (SSA)

4.2.1 Stock Description

See section 4.1.1.

4.2.2 Description of Changes

4.2.2.1 MDL File Settings

See section 4.1.2.1 and Table 4 for description of MDL file construction.

4.2.2.2 Base Period Coded-Wire Tags and Recoveries

See section 4.1.2.2 and Table 6 for list of tag codes used for the Southern Southeast Alaska (SSA) stock group.

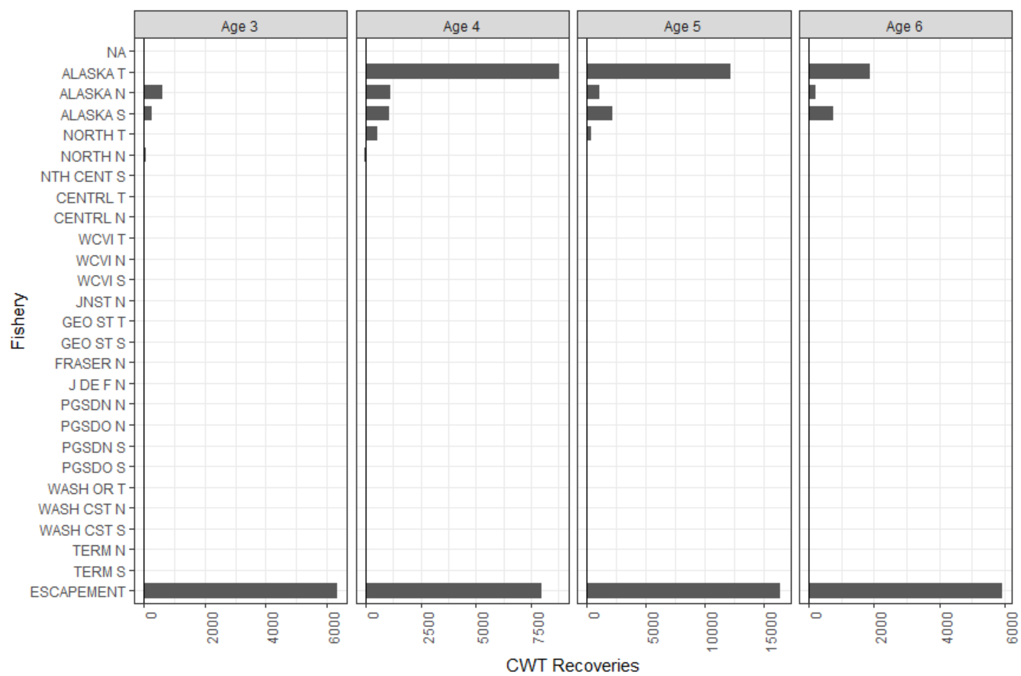

Figure 7—Base period coded-wire tag (CWT) recoveries for Southern Southeast Alaska (SSA) stock group.

4.2.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

See section 4.1.2.3 for details.

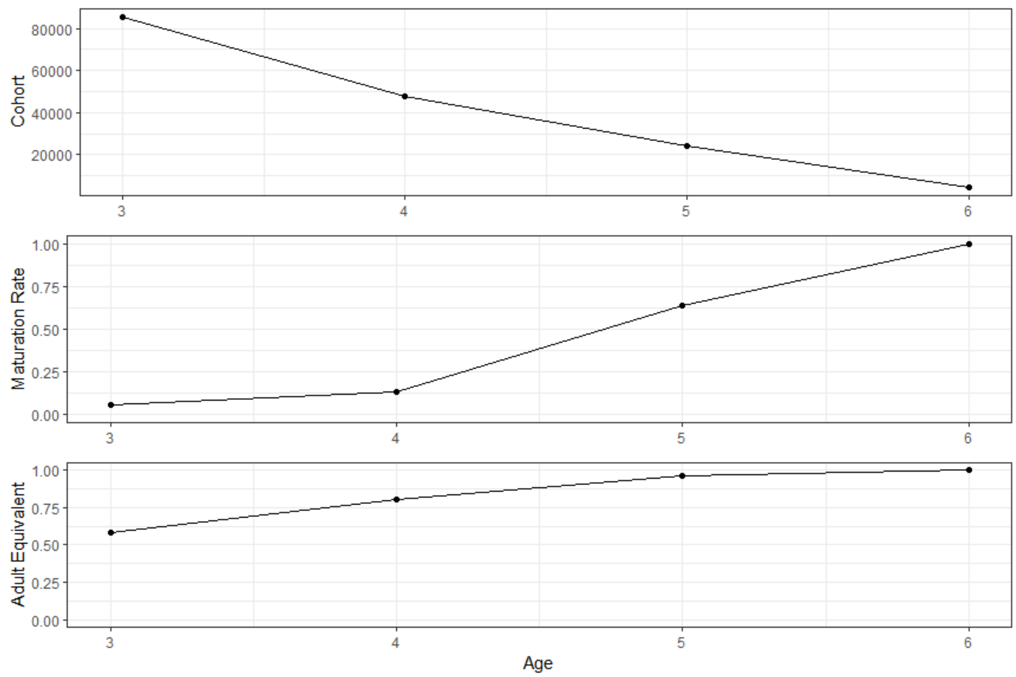

Figure 8—Base period cohort size, maturation schedule, and adult equivalent for the Southern Southeast Alaska (SSA) stock group.

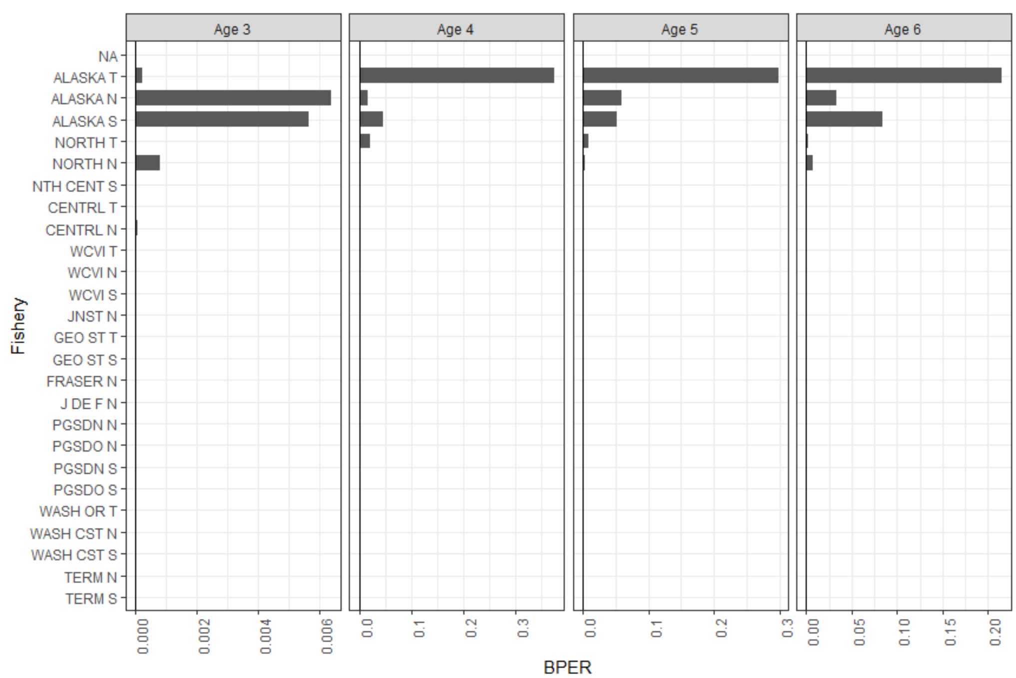

Figure 9—Base period exploitation rate by fishery for the Southern Southeast Alaska (SSA) stock group.

4.2.2.4 Escapement Time Series

See section 4.1.2.4.

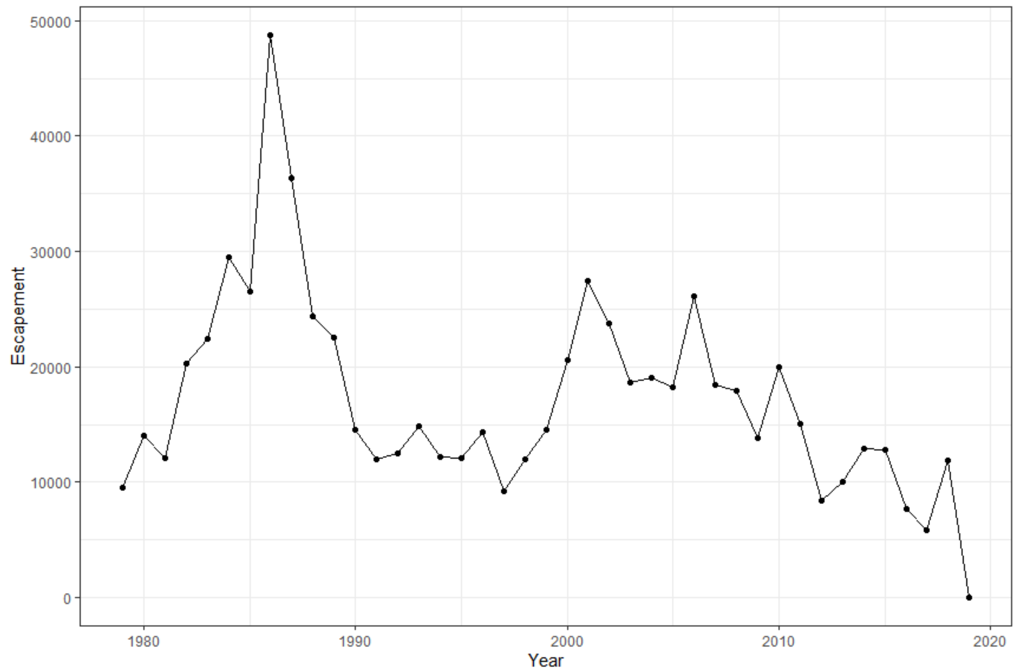

Figure 10—Escapement for the Southern Southeast Alaska (SSA) stock group.

4.2.2.5 Ricker Parameters

Ricker parameters for the Keta and Blossom Rivers are from Fleischman et. al (2011), Chickamin River from McPherson and Carlile (1997), and Unuk River from Hendrich et al. (2008).

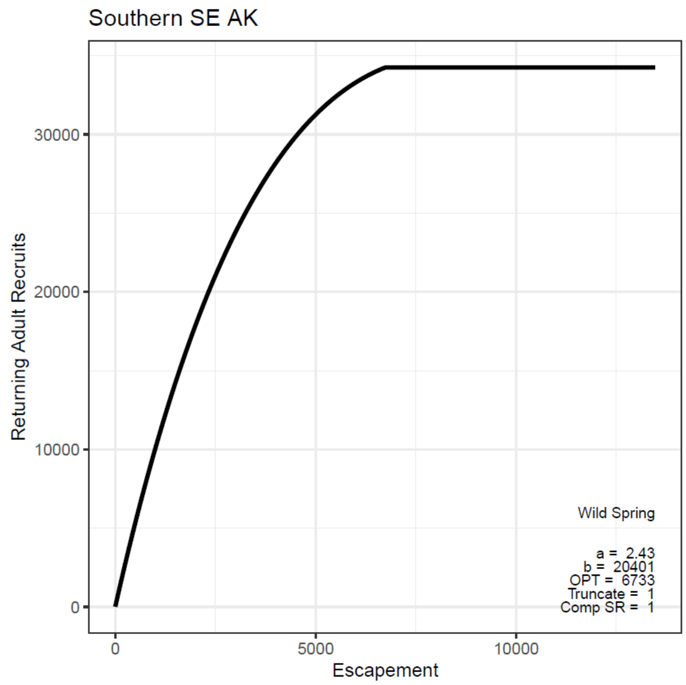

Figure 11—Ricker curve and parameters for the Southern Southeast Alaska (SSA) stock group.

4.3 Alaska South SE (AKS): Northern SE AK (NSA)

4.3.1 Stock Description

See section 4.1.1 for description of stock.

4.3.2 Description of Changes

4.3.2.1 MDL File Settings

See section 4.1.2.1 and Table 4 for description of MDL file construction.

4.3.2.2 Base Period Coded-Wire Tags and Recoveries

See section 4.1.2.2 and Table 6 for list of tag codes used for the Northern Southeast Alaska (NSA) model stock.

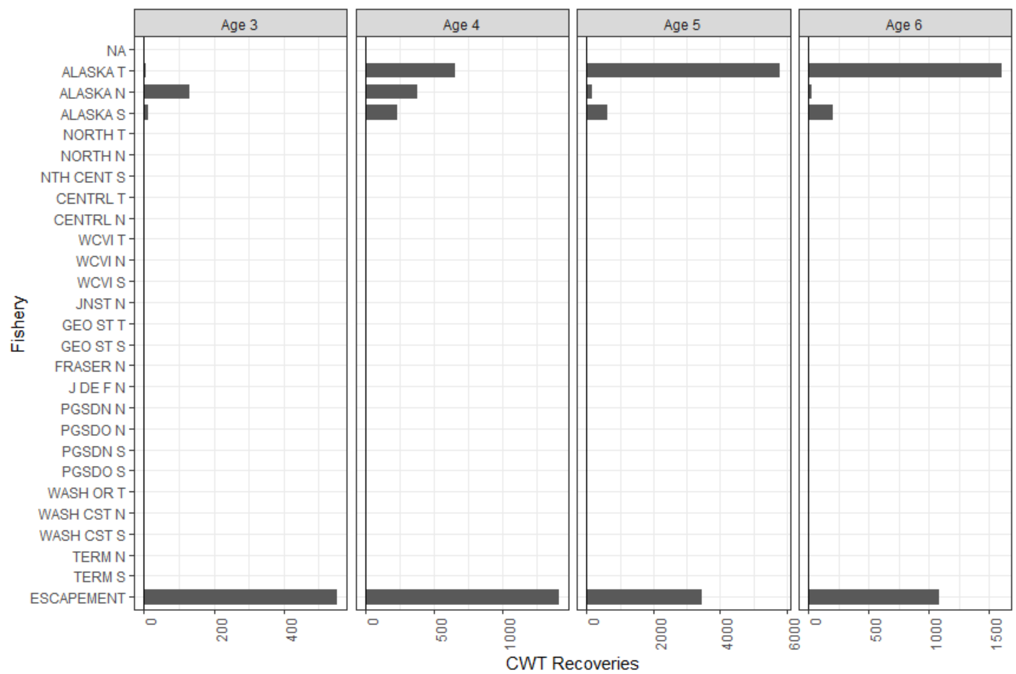

Figure 12—Base period coded-wire tag (CWT) recoveries for Alaska Spring (9806) and Northern Southeast Alaska (Phase II).

4.3.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

See section 4.1.2.3.

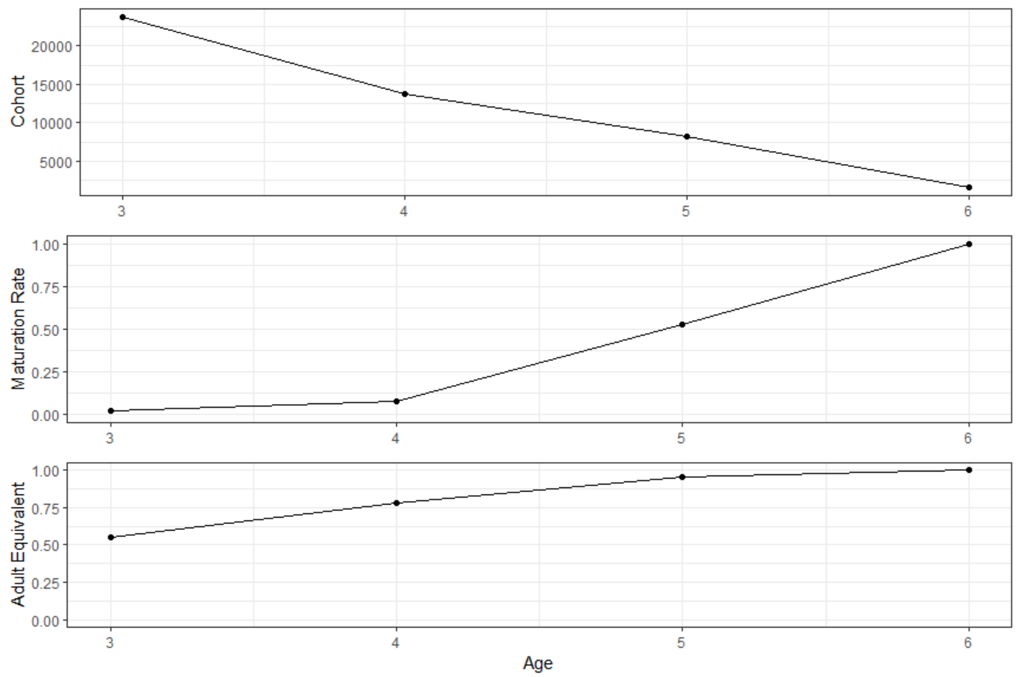

Figure 13—Base period cohort size, maturation schedule, and adult equivalent for Alaska Spring (9806) and Northern Southeast Alaska (Phase II).

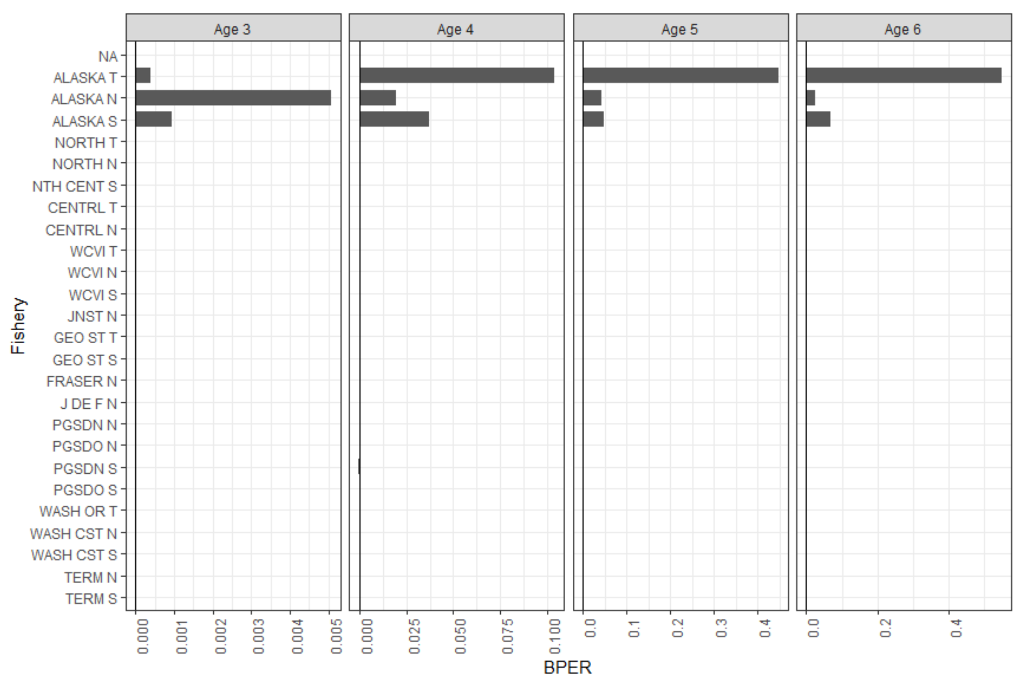

Figure 14—Base period exploitation rate by fishery for Alaska Spring (9806) and Northern Southeast Alaska (Phase II).

4.3.2.4 Escapement/Terminal Run Time Series

See section 4.1.2.4.

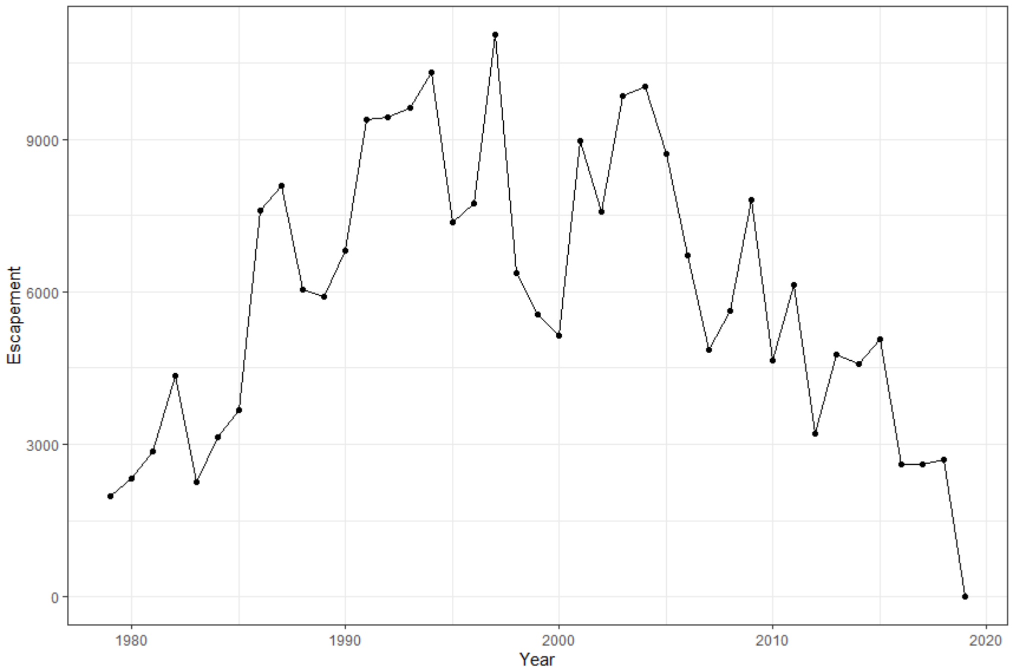

Figure 15—Escapement for Northern Southeast Alaska (Phase II).

4.3.2.5 Ricker Parameters

Ricker parameters for Andrew Creek are from Clark et. al (1998), King Salmon River from McPherson and Clark (2001), and Chilkat River from Ericksen and McPherson (2004).

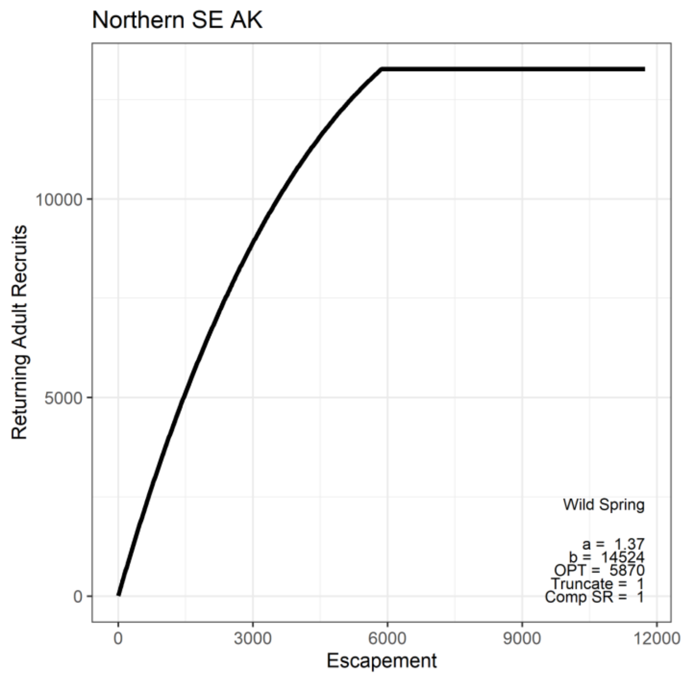

Figure 16—Ricker curve and parameters for Northern Southeast Alaska (NSA) model stock.

4.4 New Model Fishery: Alsek (ALS)

4.4.1 Stock Description

The Alsek River (ALS) model stock represents production of Chinook salmon originating from the Alsek River. The Alsek River is a large glacial system that originates in Southwest Yukon Territory and Northwest British Columbia, Canada, and flows into the Gulf of Alaska about 50 miles east of Yakutat, Alaska. This river supports a run of outside-rearing Chinook salmon. There is no hatchery indicator stock for Alsek Chinook and escapement and age structure data has been cooperatively estimated by Alaska Department of Fish and Game (ADF&G) and Fisheries and Oceans Canada (DFO) since 1976.

4.4.2 Description of Changes

This is a new Model stock. New additions to the FCS file can be found in Table 7.

Table 7—FCS file for Alsek (ALS) introduced into the Phase II Model (returning fish not previously included in the 9806 Model calibration).

Return Year	ALSEK (ALS)		
	age 4	age 5	age 6+
1979	-	8,099	9,255
1980	434	4,345	6,083
1981	739	2,957	4,805
1982	1,202	4,243	3,889
1983	259	7,887	2,198
1984	338	2,976	3,788
1985	604	3,193	2,330
1986	1,720	7,369	1,980
1987	793	6,243	4,105
1988	1,154	2,587	4,936
1989	1,847	3,079	5,192
1990	991	4,578	3,040
1991	306	4,533	6,758
1992	509	1,702	3,369
1993	1,359	6,226	5,612
1994	4,441	5,634	5,744
1995	1,910	18,977	3,821
1996	2,834	6,464	6,496
1997	471	8,539	3,422
1998	1,669	2,940	2,145
1999	3,020	8,389	3,188
2000	763	5,825	1,318
2001	651	4,991	1,042
2002	452	2,945	2,114

Return Year	ALSEK (ALS)		
	age 4	age 5	age 6+
2003	1,261	3,670	894
2004	188	5,272	1,622
2005	224	2,050	2,204
2006	366	1,022	936
2007	209	1,763	849
2008	502	584	766
2009	2,479	3,479	467
2010	780	7,875	1,229
2011	1,239	4,610	1,186
2012	614	2,223	191
2013	287	4,109	697
2014	1,299	1,128	843
2015	678	4,916	103
2016	366	1,555	654
2017	412	1,047	213
2018	809	2,759	673
2019	1,182	4,031	983

4.4.2.1 MDL File Settings

Table 8—Information used in the construction of the Alsek (ALS) MDL file.

Information for MDL File Production	Phase II Model Stock
Model Stock Acronym	ALS
Brood Years	1979–1982
Out-of-base procedure used?	NA
Modification to the WG4 file?	NA
C-file extension (CWT Indicator ID)	NA
Yearling Stock	Yes
Weight within BY by production releases	NA
Exclude Esc for Between BY weighting	NA
Start age in C-files	NA
Last age in C-files	NA
Modifications to escapements in Coshak4	NA
Terminal fishery CWT moved to escapement	NA
Model stock type	Wild, Spring
Additional fisheries designated as terminal in the BSE file	None
MDL creation date	10 Jan. 2018

4.4.2.2 Base Period Coded-Wire Tags and Recoveries

Base period recoveries are calculated through a run reconstruction (Figure 17). Alsek River Chinook are not tagged (Table 9).

Table 9—Coded-wire tag codes used for the Alsek (ALS) model stock.

Brood Year	Tag Codes	
	9806	Phase II
	N/A	
	N/A	
	N/A	
	N/A	

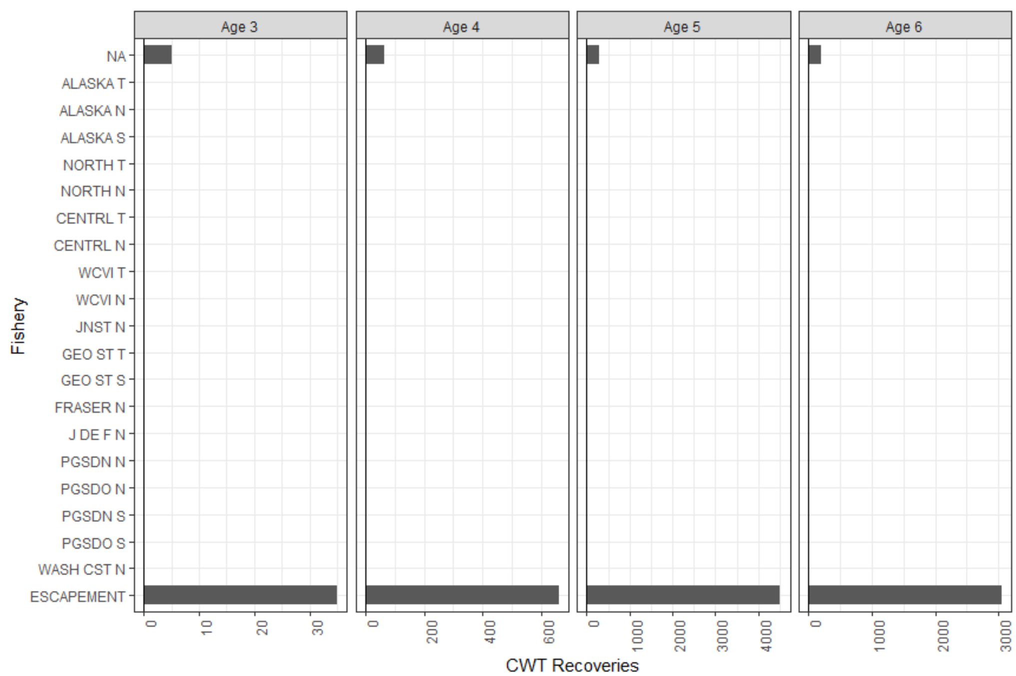

Figure 17—Base period coded-wire tag (CWT) recoveries for Alsek (Phase II only).

4.4.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

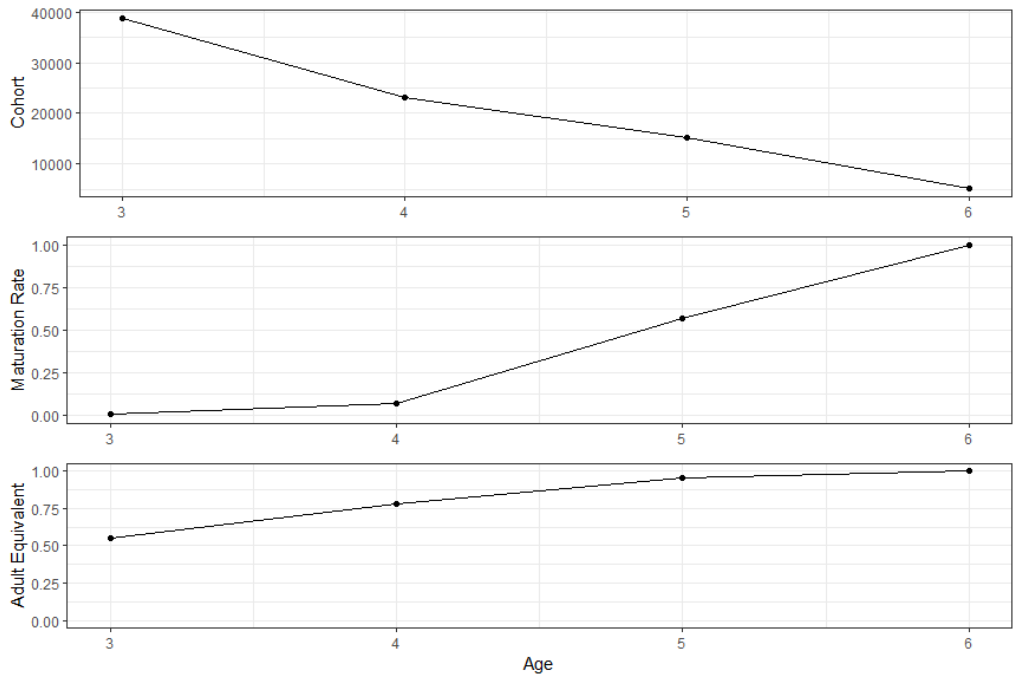

Figure 18—Base period cohort size, maturation schedule, and adult equivalent for Alsek (Phase II only).

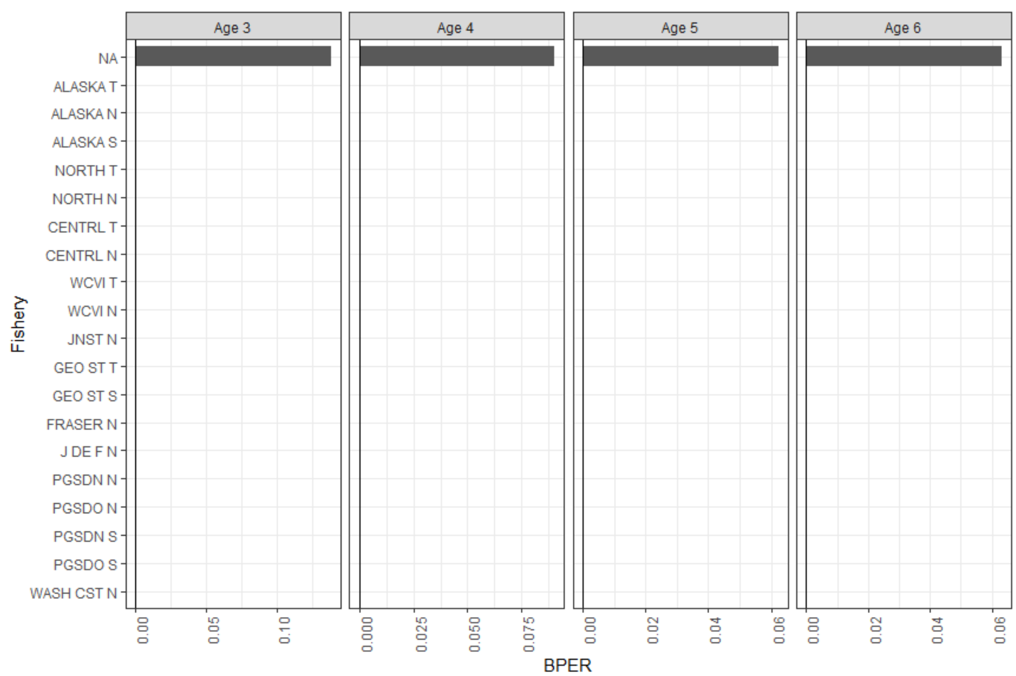

Figure 19—Base period exploitation rate by fishery for Alsek (Phase II only).

4.4.2.4 Escapement/Terminal Run Time Series

Escapement and terminal run to the Alsek River is calculated and reported by the Transboundary Technical Committee (Joint Transboundary Technical Committee 2019).

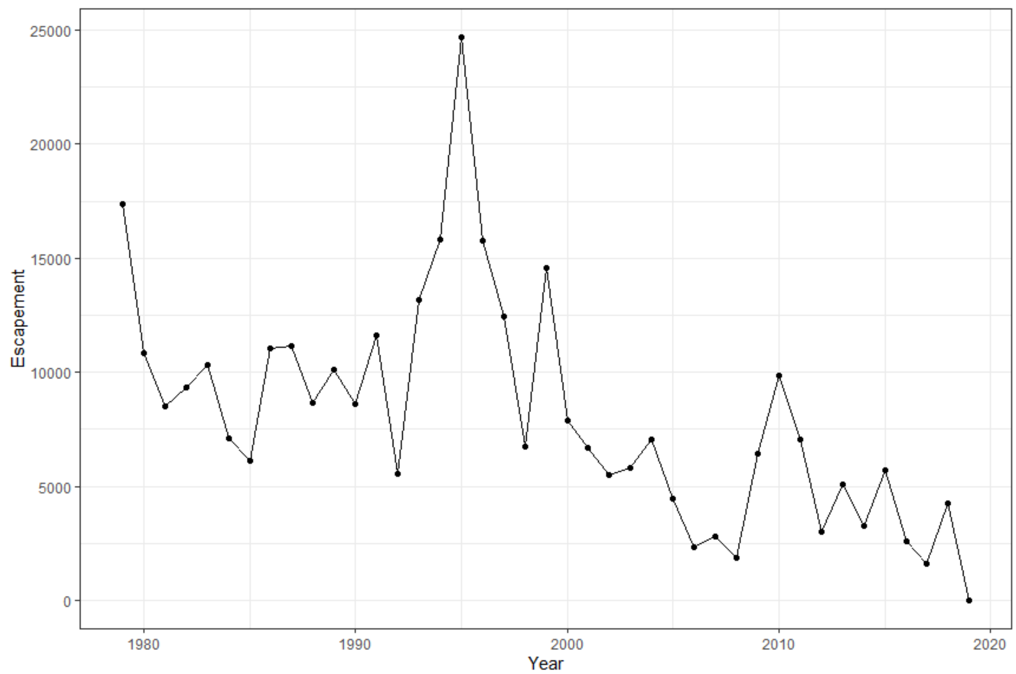

Figure 20—Escapement run size for Alsek (Phase II only).

4.4.2.5 Ricker Parameters

Ricker parameters are from Bernard and Jones (2010).

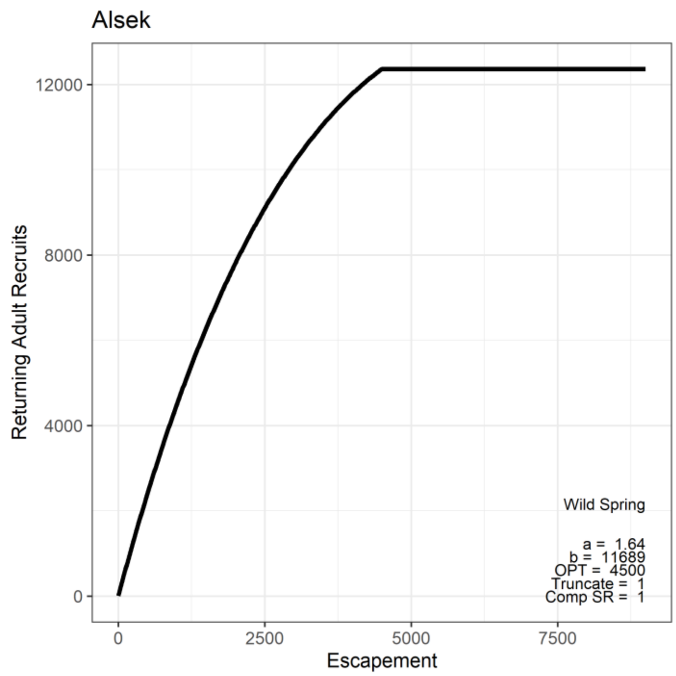

Figure 21—Ricker curve and parameters for Alsek (ALS) model stock.

4.5 New Model Fishery: Taku and Stikine (TST)

4.5.1 Stock Description

The Taku and Stikine Rivers are large glacial systems that originates in British Columbia, flow into marine waters of SEAK, and supports runs of outside-rearing Chinook salmon. There are no hatchery indicator stocks for either river. Exploitation rates for both rivers are estimated directly using the Taku (TAK) and Stikine (STI) wild exploitation rate indicator stocks. Escapement and age structure data has been cooperatively collected by ADF&G and DFO since 1975.

4.5.2 Description of Changes

This a new model stock. New additions to the FCS file can be found in Table 10.

Table 10—FCS file for the Taku and Stikine (TST) stock group introduced into the Phase II Model (returning fish not previously included in the 9806 Model calibration).

Return Year	Transboundary (TST)		
	age 4	age 5	age 6+
1979	30,307	25,527	9,001
1980	20,526	42,615	27,925
1981	16,426	36,823	48,793
1982	7,187	18,475	45,819
1983	7,860	8,383	7,836
1984	11,318	30,098	4,675
1985	13,693	28,959	22,993
1986	8,719	24,202	28,797
1987	8,897	25,226	28,317
1988	18,180	17,720	64,321
1989	11,079	35,384	29,203
1990	9,085	22,590	52,172
1991	23,192	33,048	41,804
1992	19,161	38,817	51,235
1993	11,394	40,195	84,892
1994	5,947	32,628	48,835
1995	34,546	18,696	33,269
1996	9,463	93,477	18,220
1997	3,604	50,553	91,714
1998	10,151	15,029	41,761
1999	14,649	19,755	15,278
2000	22,276	41,109	21,901
2001	5,702	85,200	24,672
2002	11,872	46,056	59,350
2003	25,868	54,661	26,816

Return Year	Transboundary (TST)		
	age 4	age 5	age 6+
2004	37,953	86,694	31,563
2005	8,063	54,507	22,201
2006	4,845	24,524	41,213
2007	8,412	18,554	10,802
2008	12,783	29,309	16,005
2009	12,030	23,191	10,911
2010	10,274	33,545	9,504
2011	16,044	32,564	10,867
2012	5,119	30,004	14,243
2013	17,265	21,776	12,889
2014	16,054	34,678	13,272
2015	12,048	43,606	9,558
2016	9,763	17,032	4,045
2017	4,247	13,294	3,246
2018	10,626	10,404	4,203
2019	12,839	25,060	2,248

4.5.2.1 MDL File Settings

Table 11—Information used in the construction of the Taku and Stikine (TST) MDL file.

Information for MDL File Production	Phase II Model Stock
Model Stock Acronym	TST
Brood Years	1998–2001
Out-of-base procedure used?	Yes
Modification to the WG4 file?	No
C-file extension (CWT Indicator ID)	TAK, STI
Yearling Stock	Yes
Weight within BY by production releases	No
Exclude Esc for Between BY weighting	Yes
Start age in C-files	2
Last age in C-files	6
Modifications to escapements in Coshak4	No
Terminal fishery CWT moved to escapement	No
Model stock type	Wild, Spring
Additional fisheries designated as terminal in the BSE file	None
MDL creation date	21 Sept. 2017

4.5.2.2 Base Period Coded-Wire Tags and Recoveries

The tag codes used to represent TST are from two wild indicator exploitation rate stocks, TAK and STI, using the earliest possible data available for the two (Table 12).

Table 12—Coded-wire tag codes for the Taku and Stikine (TST) model stock. This model stock consists of recoveries from the Taku (TAK) and Stikine (STI) Rivers.

Brood Year	Tag Codes (TAK and STI)	
	9806	**Phase II**
1998	N/A	040353, 040357, 040358
1999	N/A	040354, 040373, 040459
2000	N/A	020604, 040533, 040534, 040541, 040542, 040543, 040549
2001	N/A	040802, 040803, 040828, 040841, 181739, 181740

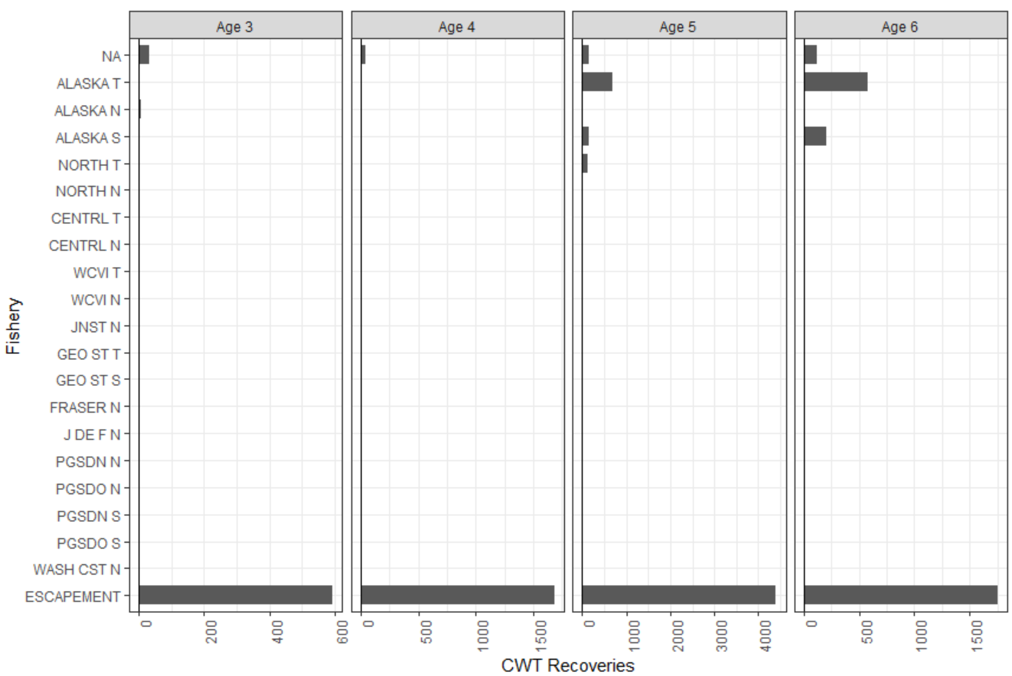

Figure 22—Base period coded-wire tag (CWT) recoveries for Taku and Stikine (Phase II only).

4.5.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

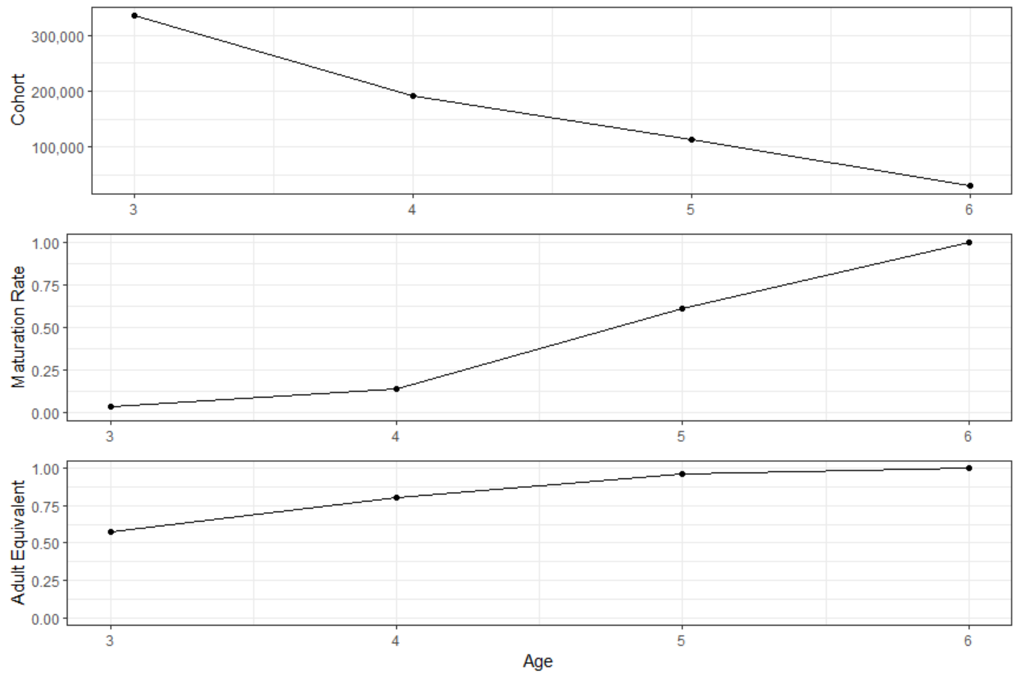

Figure 23—Base period cohort size, maturation schedule, and adult equivalent for Taku and Stikine (Phase II only).

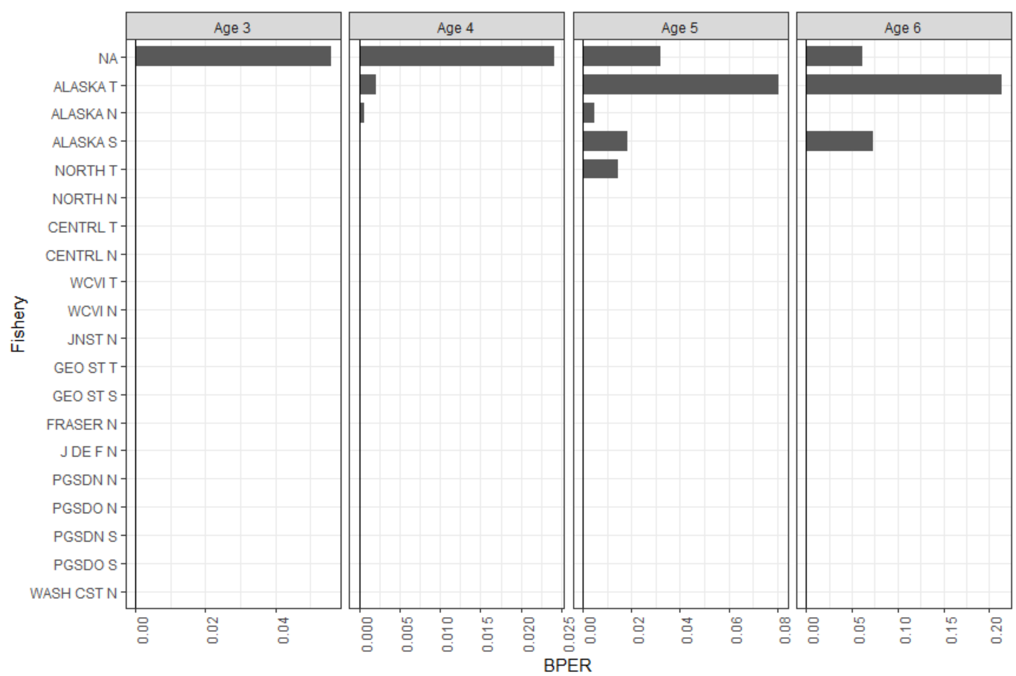

Figure 24—Base period exploitation rate by fishery for Taku and Stikine (Phase II only).

4.5.2.4 Escapement/Terminal Run Time Series

Escapement and terminal runs to the Taku and Stikine rivers are calculated and reported by the Transboundary Technical Committee (Joint Transboundary Technical Committee 2019).

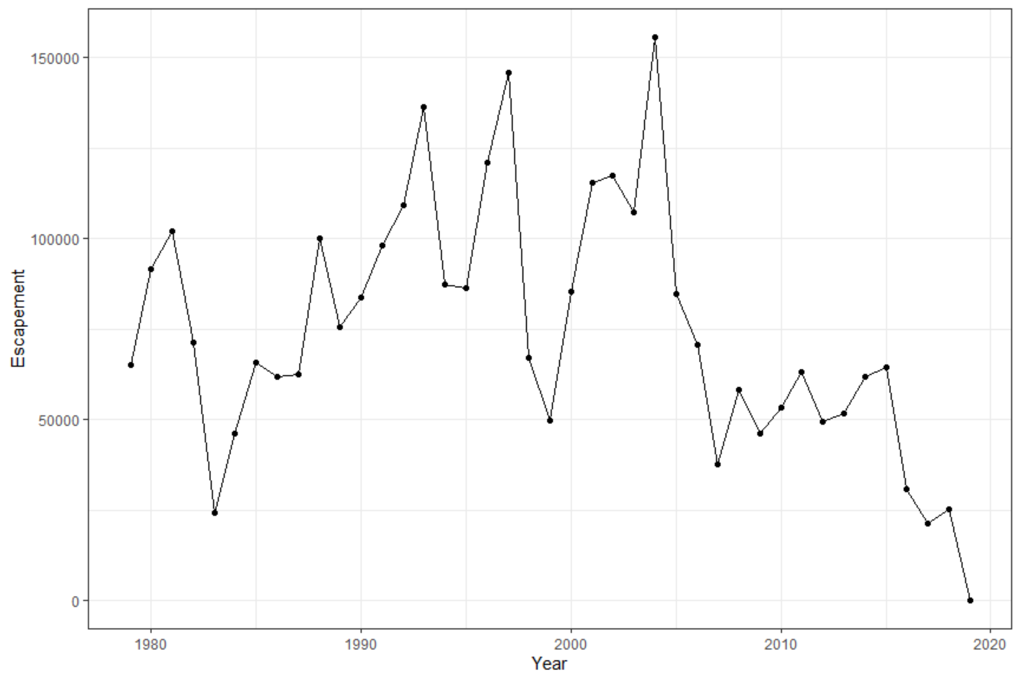

Figure 25—Escapement for Taku and Stikine (TST) model stock (Phase II only).

4.5.2.5 Ricker Parameters

Ricker parameters for the Taku River are from McPherson et al. (2010) and for the Stikine River from Bernard et al. (2000).

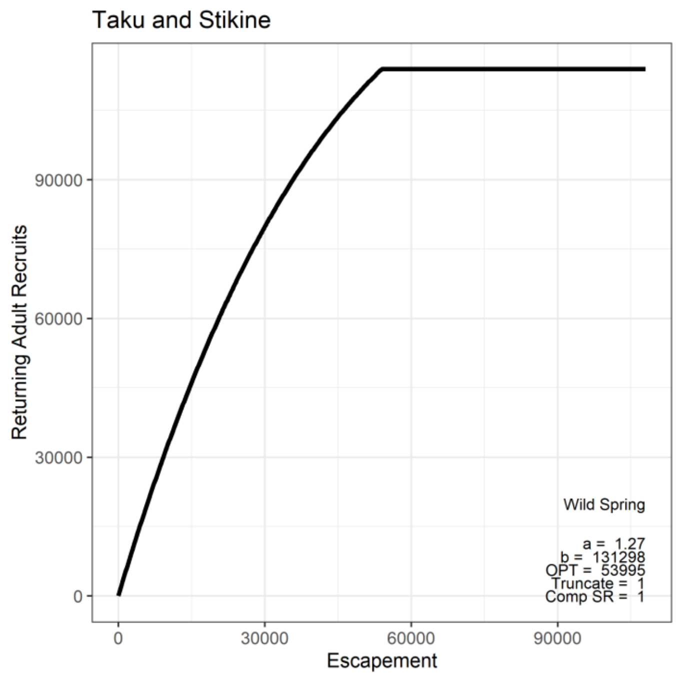

Figure 26—Ricker curve and parameters for Taku and Stikine (TST) model stock.

4.6 New Model Fishery: Yakutat Forelands (YAK)

4.6.1 Stock Description

The Yakutat Forelands (YAK) model stock is used to represent wild production originating from the Yakutat area, except the Alsek River, and includes production from the Situk River and an additional 30% from rivers not surveyed annually (Hubartt and Kissner, 1987). There is no hatchery indicator stock for the Yakutat Forelands model stock, so exploitation rates are derived from a run reconstruction. Escapement and age structure data has been estimated continuously by ADF&G since 1976.

4.6.2 Description of Changes

This is a new Model stock. New additions to the FCS file can be found in Table 10.

Table 13—FCS file for the Yakutat Forelands (YAK) stock introduced into the Phase II Model (returning fish not previously included in the 9806 Model calibration).

Return Year	Yakutat (YAK) age 4	age 5	age 6+
1979	1,348	3,622	3,477
1980	1,023	2,014	2,283
1981	889	1,386	1,799
1982	907	1,779	1,453
1983	746	3,197	852
1984	1,567	2,238	1,451
1985	1,245	2,238	1,153
1986	1,956	4,078	1,116
1987	1,263	3,295	1,784
1988	600	1,602	2,197
1989	1,128	1,598	2,026
1990	851	2,279	1,372
1991	1,169	1,756	2,513
1992	1,048	1,883	1,288
1993	1,125	3,291	2,122
1994	3,961	2,856	2,172
1995	5,558	7,915	1,462
1996	2,649	3,367	2,518
1997	1,830	4,151	1,350
1998	2,200	1,342	820
1999	2,703	3,452	1,160
2000	2,145	2,520	501
2001	496	2,459	392
2002	1,622	1,342	770
2003	3,038	1,675	339

Return Year	Yakutat (YAK)		
	age 4	age 5	age 6+
2004	589	2,719	687
2005	636	1,238	802
2006	969	790	341
2007	897	851	339
2008	864	349	279
2009	2,117	1,374	242
2010	520	2,911	462
2011	652	1,900	573
2012	653	1,080	69
2013	1,208	1,629	254
2014	852	585	330
2015	386	1,853	46
2016	396	687	254
2017	341	1,712	342
2018	483	1,431	404
2019	1,093	1,995	502

4.6.2.1 MDL File Settings

Table 14—Information used in the construction of the Yakutat Forelands (YAK) MDL file.

Information for MDL File Production	Phase II Model Stock
Model Stock Acronym	YAK
Brood Years	79–82
Out-of-base procedure used?	NA
Modification to the WG4 file?	NA
C-file extension (CWT Indicator ID)	NA
Yearling Stock	Yes
Weight within BY by production releases	NA
Exclude Esc for Between BY weighting	NA
Start age in C-files	NA
Last age in C-files	NA
Modifications to escapements in Coshak4	NA
Terminal fishery CWT moved to escapement	NA
Model stock type	Wild, Fall
Additional fisheries designated as terminal in the BSE file	None
MDL creation date	10 Jan. 2018

4.6.2.2 Base Period Coded-Wire Tags and Recoveries

Base period recoveries are calculated through a run reconstruction (Figure 27). Yakutat Forelands is composed of wild stocks from the Situk River and additional rivers that are not surveyed annually, thus there are no coded-wire tag codes associated with this model stock (Table 15).

Table 15—Coded-wire tag codes for Yakutat Forelands (YAK) model stock.

Brood Year	Tag Codes (YAK)	
	9806	Phase II
	N/A	

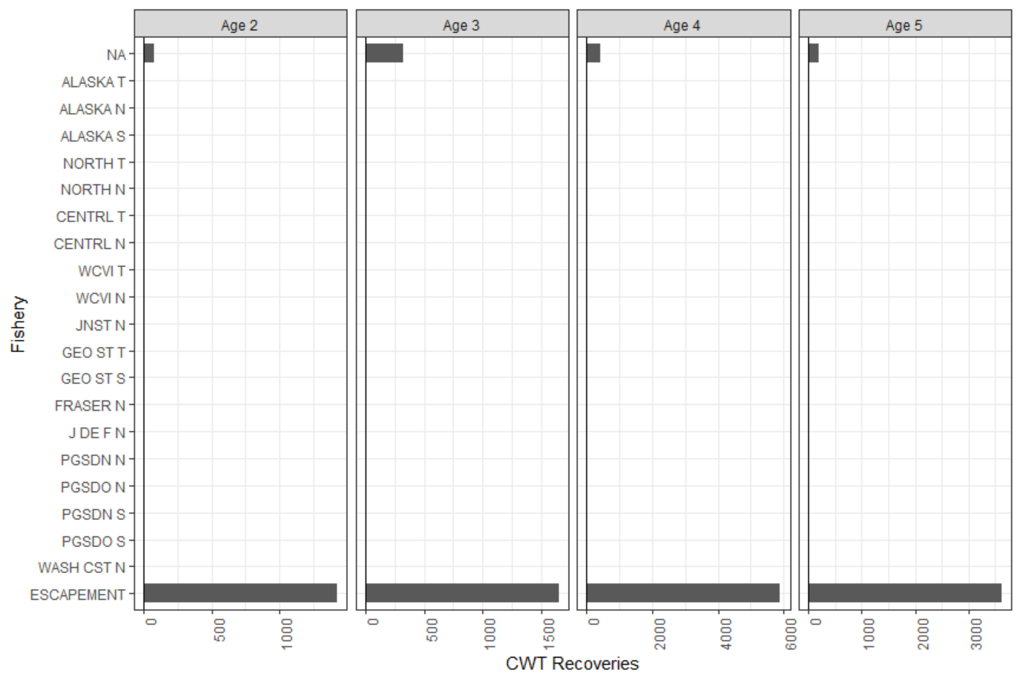

Figure 27—Base period coded-wire tag (CWT) recoveries for Yakutat Forelands (Phase II only).

4.6.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

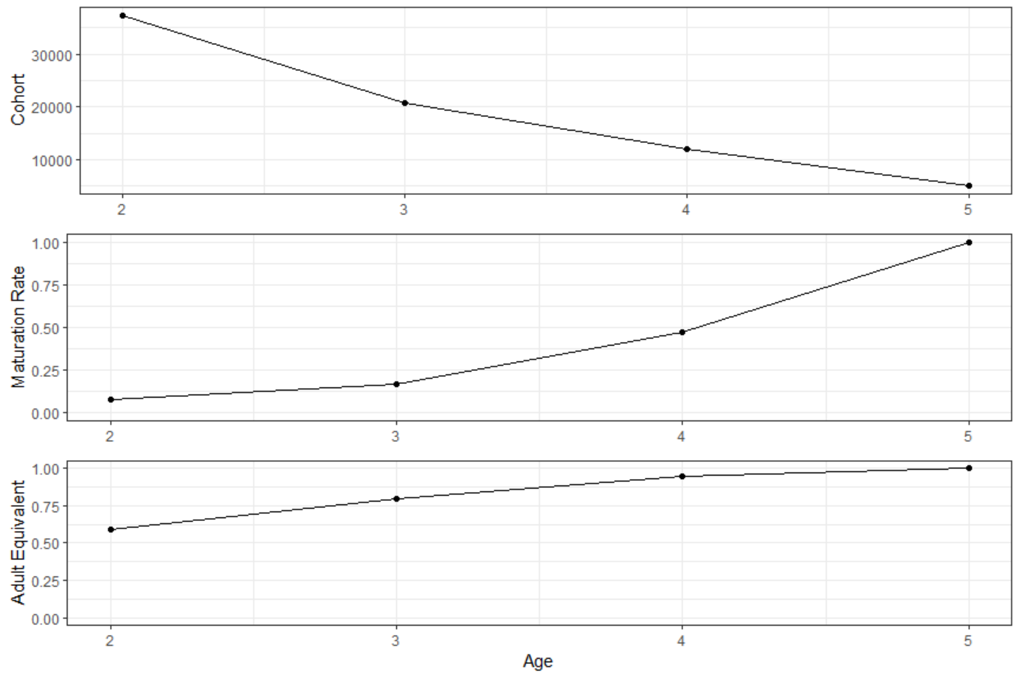

Figure 28—Base period cohort size, maturation schedule, and adult equivalent for Yakutat Forelands (Phase II only).

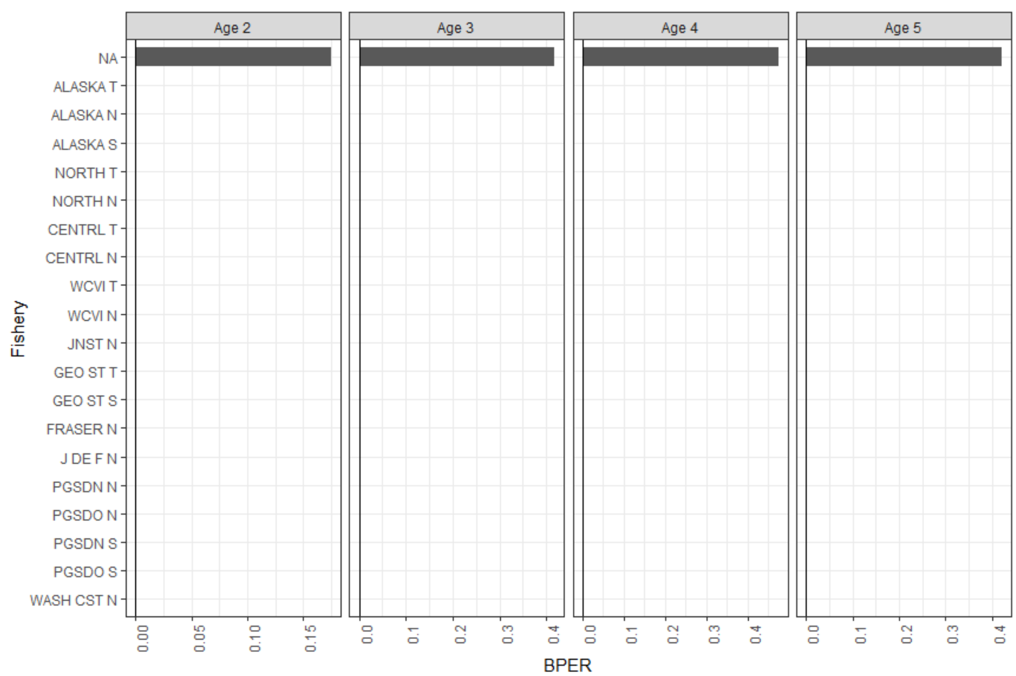

Figure 29—Base period exploitation rate by fishery for Yakutat Forelands (Phase II only).

4.6.2.4 Escapement/Terminal Run Time Series

Escapement and terminal run to the Situk River are tabulated annually by ADF&G through use of a weir and an on-site creel survey (i.e., see Hoffman 2020 for additional details).

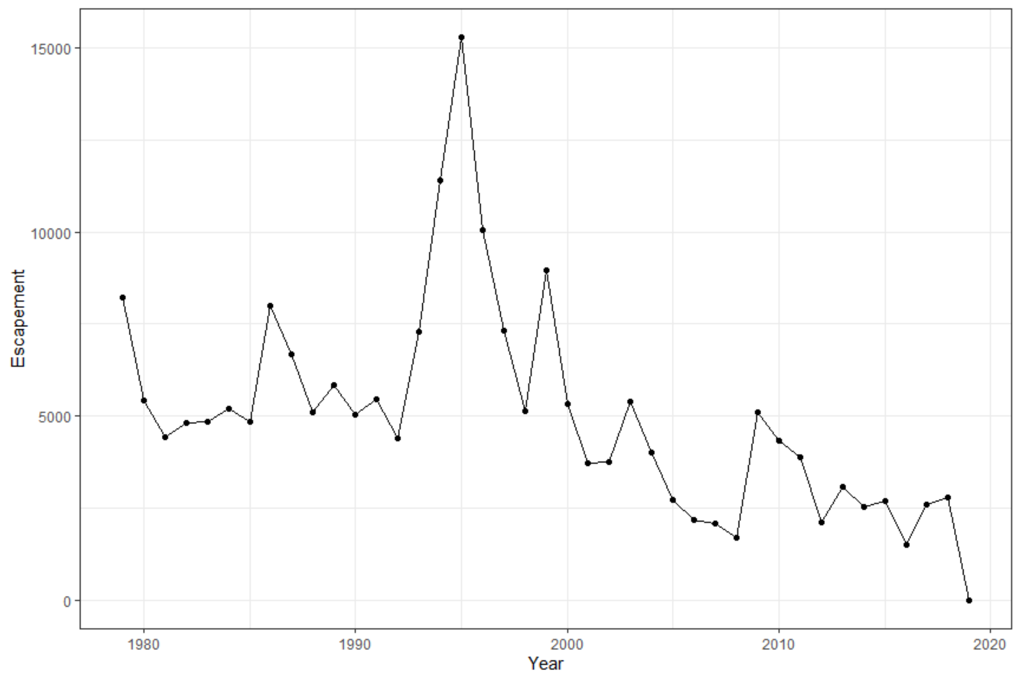

Figure 30—Escapement or terminal run size for Yakutat Forelands (Phase II only).

4.6.2.5 Ricker Parameters

Ricker parameters for the Situk River are from McPherson et al. (2005).

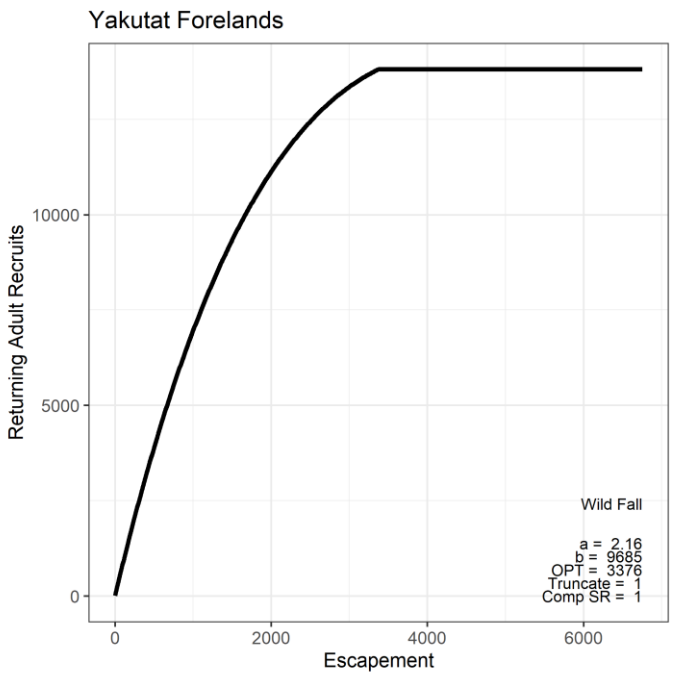

Figure 31—Ricker curve and parameters for Yakutat Forelands (YAK) model stock.

4.7 North/Central British Columbia (NTH): Northern British Columbia (NBC) and Central British Columbia (CBC)

4.7.1 Stock Description

The Northern British Columbia (NBC) and Central B.C. (CBC) stocks in the Phase II model were created by a combination of splitting the North/Central B.C. (NTH) stock present in the 9806 model and changing the makeup of the river systems that are being represented. The escapement time series used for the NTH stock in the 9806 model was intended to represent the entire complex of river systems present in the North and Central B.C. areas. In the Phase II model, the NBC stock was created by splitting out the Nass and Skeena escapements from the rest of the NTH complex. The CBC stock in the Phase II model, representing Central B.C. (Area 8 and Rivers Inlet) was the result of both splitting and removing some of the river systems that were represented in the 9806 model. The main systems in Area 8 are the Atnarko, Bella Coola, and Dean Rivers. The Bella Coola River is not represented in either the Phase II or 9806 models whereas escapement estimation has been discontinued on the Dean River. Therefore, the Dean River which was included in the NTH stock of the 9806 model, is not represented in the CBC stock in the Phase II model. The Atnarko River and the Smith Inlet area in Central B.C. containing the Wannock, Kilbella and Chuckwalla systems are represented in both the 9806 and Phase II models.

4.7.2 Description of Changes

Phase II version of Model calibrates to escapement as opposed to terminal run in 9806. This decision was supported by the robust and reliable mark-recapture programs and analytics in place for both Atnarko and Kitsumkalum. Stock aggregates include Nass and Skeena for NBC and Atnarko, Wannock and Chuckwalla-Kilbella for CBC.

4.7.2.1 MDL File Settings

Table 16—Information used in the construction of the Northern British Columbia (NBC) and Central British Columbia (CBC) MDL files.

Information for MDL File Production	Phase II Model Stock	
Model Stock Acronym	NBC	CBC
Brood Years	1991–1994	1987–1990
Out-of-base procedure used?	Yes	Yes
Modification to the WG4 file?	Yes; used time series for 19 TNBC TERM N. Values from Northern Net FP file prepared manually	Yes; used time series for 21 TCBC TERM N
C-file extension (CWT Indicator ID)	KLM	ATN
Yearling Stock	Yes	No
Weight within BY by production releases	No	No

Exclude Esc for Between BY weighting	No	No
Start age in C-files	2	2
Last age in C-files	6	6
Modifications to escapements in Coshak4	No	No
Terminal fishery CWT moved to escapement	NA	NA
Model stock type	Wild, Spring	Wild, Fall
Additional fisheries designated as terminal in the BSE file	North Net	Central Net
MDL creation date	18 Sept. 2016	18 Sept 2016

4.7.2.2 Base Period Coded-Wire Tags and Recoveries

The out of base (OOB) procedure was used in both NBC and CBC because maturation rates and simple exploitation rates by sector and region produced with this procedure were deemed more representative and reliable than those produced by the in-base approach. 1991–1994 tag code releases were used for NBC's Kitsumkalum (KLM) and 1987–1990 tag code releases were used for CBC's Atnarko (ATN) because these periods are characterized by large CWT recoveries and no gaps in brood year releases.

Table 17—Coded-wire tag codes for North/Central British Columbia (NTH), Northern British Columbia (NBC) and Central British Columbia (CBC) model stocks.

Brood Year	Tag Codes		
	9806 (NTH)	**Phase II (CBC)**	**Phase II (NBC)**
1976	022016, 022017, 022018		
1977	022020, 022021, 022022, 022048		
1978	021614, 021732		
1987		ATN: 025446, 025447, 025448, 025552	
1988		025956, 025957, 025958, 025959, 025960, 025961	
1989		020246, 020247, 020248, 020249, 020250, 020251	
1990		021428, 021429, 021430, 021521, 021522, 021523	
1991			KLM: 021010, 021011, 023116
1992			181046, 181047, 181048, 181049, 181050, 181051, 181052
1993			021104, 181423, 181424

Brood Year	Tag Codes		
	9806 (NTH)	Phase II (CBC)	Phase II (NBC)
1994			180608, 180609, 180640, 180641, 180642, 182155, 182156, 182157

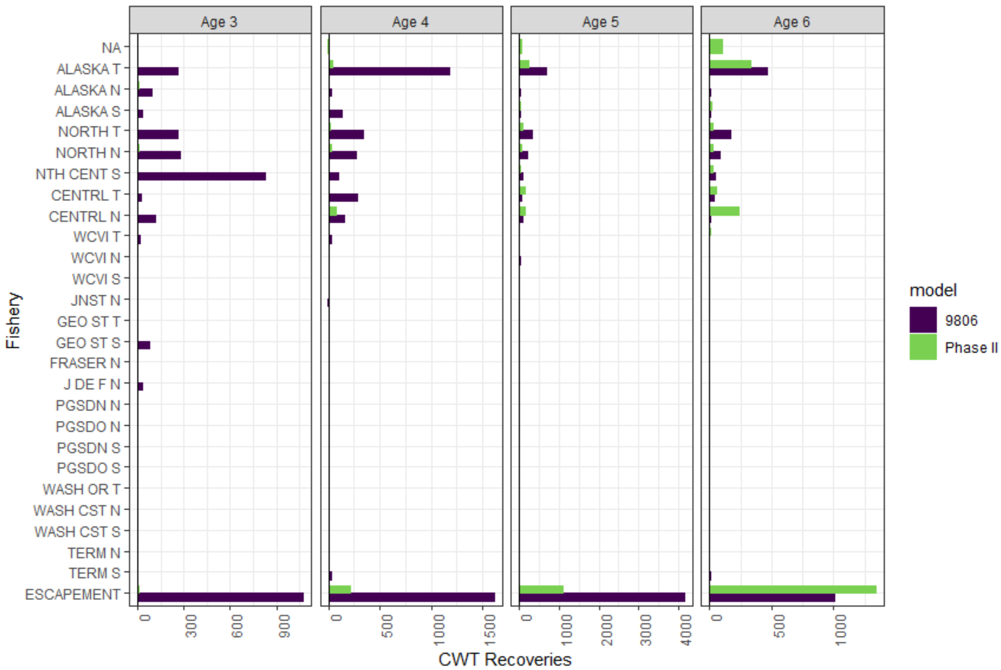

Figure 32—Base period coded-wire tag (CWT) recoveries for North/Central British Columbia (9806), Central British Columbia (Phase II) and Northern British Columbia (Phase II).

4.7.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

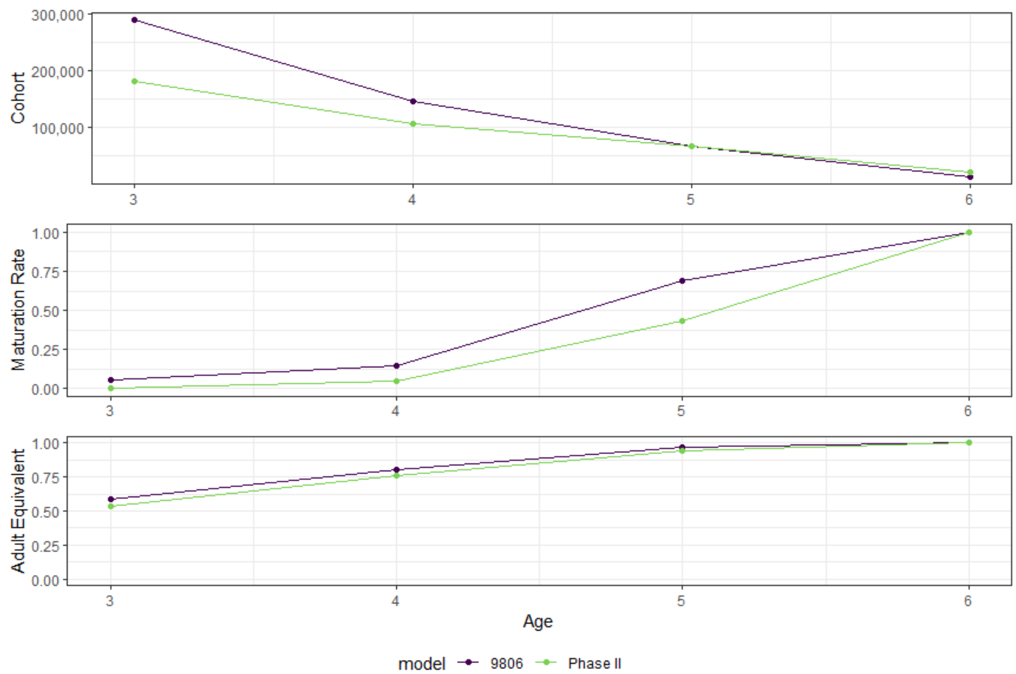

Figure 33—Base period cohort size, maturation schedule, and adult equivalent for North/Central British Columbia (9806), Central British Columbia (Phase II) and Northern British Columbia (Phase II).

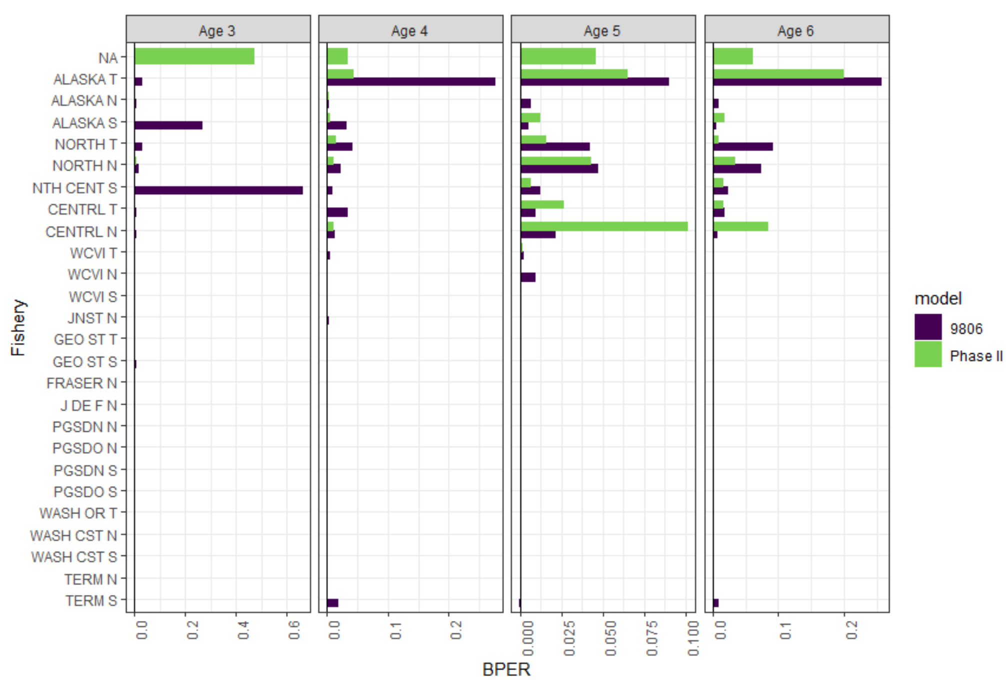

Figure 34—Base period exploitation rate by fishery for North/Central British Columbia (9806), Central British Columbia (Phase II) and Northern British Columbia (Phase II).

4.7.2.4 Escapement/Terminal Run Time Series

Phase II version of Model calibrates to escapement as opposed to terminal run in 9806. This decision was supported by the robust and reliable mark-recapture programs and analytics in place for both Atnarko and Kitsumkalum. Stock aggregates include Nass and Skeena for NBC and Atnarko, Wannock and Chuckwalla-Kilbella for CBC.

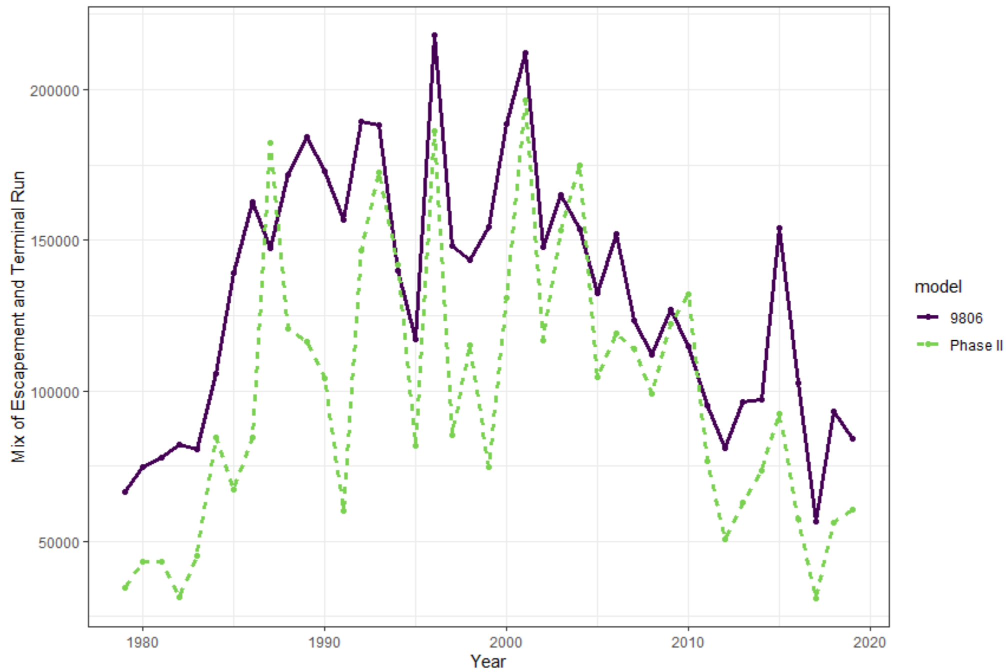

Figure 35—Escapement and terminal run size for North/Central British Columbia (9806), Central British Columbia (Phase II) and Northern British Columbia (Phase II).

4.7.2.5 Ricker Parameters

Ricker parameters can be found in the Phase II model stock sections for Northern B.C. (4.8.2.5) and Central B.C. (4.9.2.5).

4.8 North/Central British Columbia (NTH): Northern British Columbia (NBC)

4.8.1 Stock Description

Northern/Central B.C. stock (NTH) in the 9806 base period calibration was split into Central B.C. (CBC) and Northern B.C. (NBC) model stocks in Phase II to better represent this large region of British Columbia. Kitimat and Atnarko tag code releases were used for NTH in 9806 whereas Atnarko releases (ATN) were used for CBC and Kitsumkalum (KLM) releases for NBC in Phase II.

4.8.2 Description of Changes

Phase II version of Model calibrates to escapement as opposed to terminal run in 9806. This decision was supported by the robust and reliable mark-recapture programs and analytics in place for both Atnarko and Kitsumkalum.

4.8.2.1 MDL File Settings

See section 4.7.2.1.

4.8.2.2 Base Period Coded-Wire Tags and Recoveries

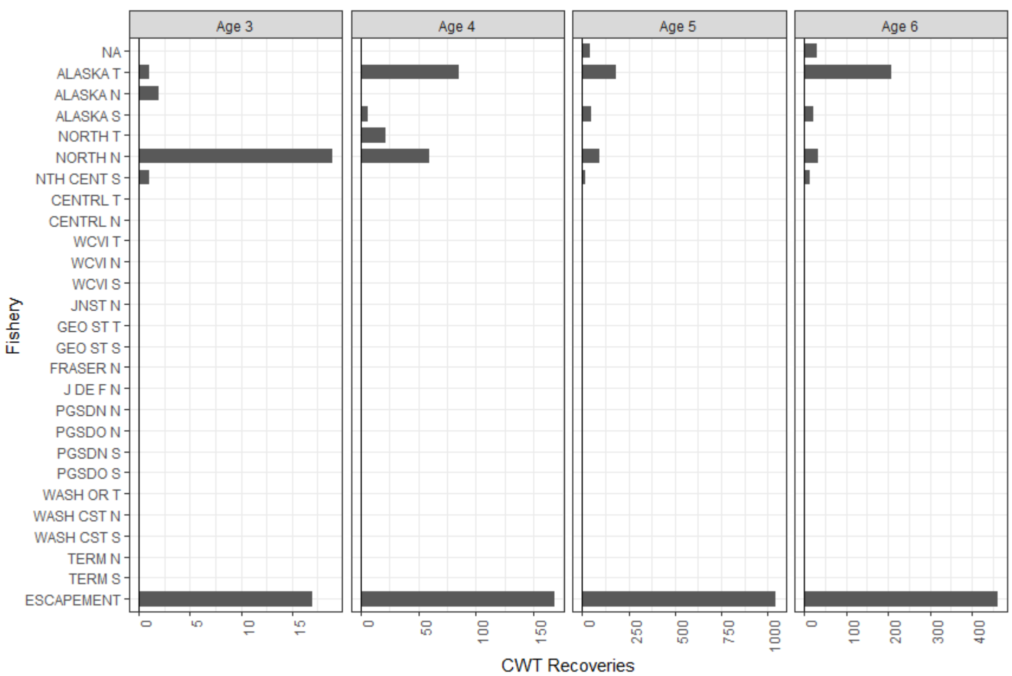

Figure 36—Base period coded-wire tag (CWT) recoveries for Northern British Columbia (Phase II).

4.8.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

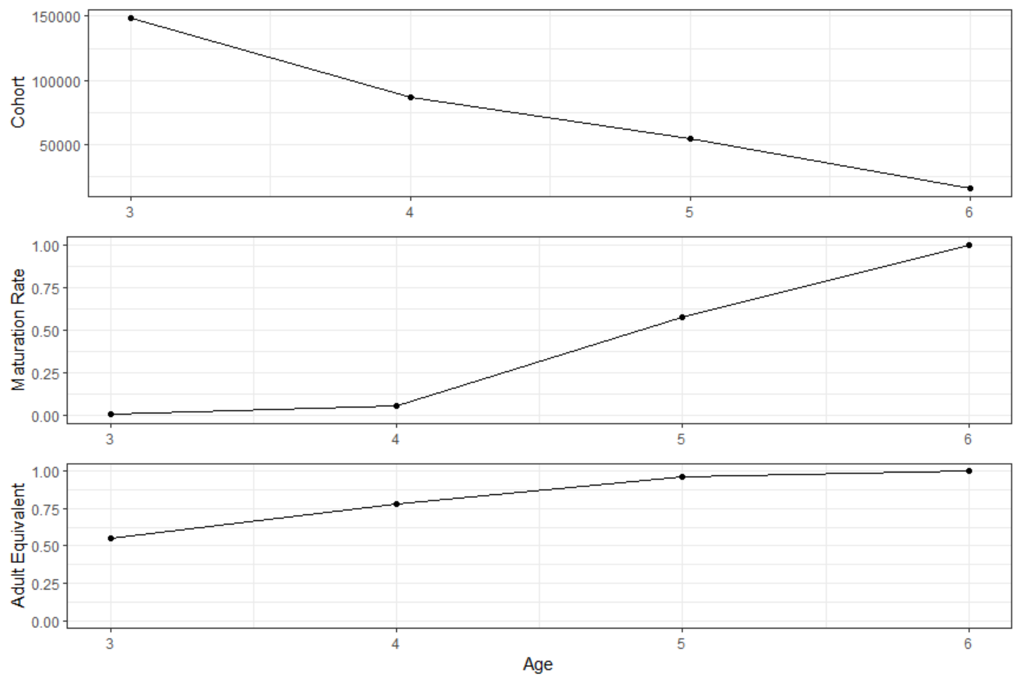

Figure 37—Base period cohort size, maturation schedule, and adult equivalent for Northern British Columbia (Phase II).

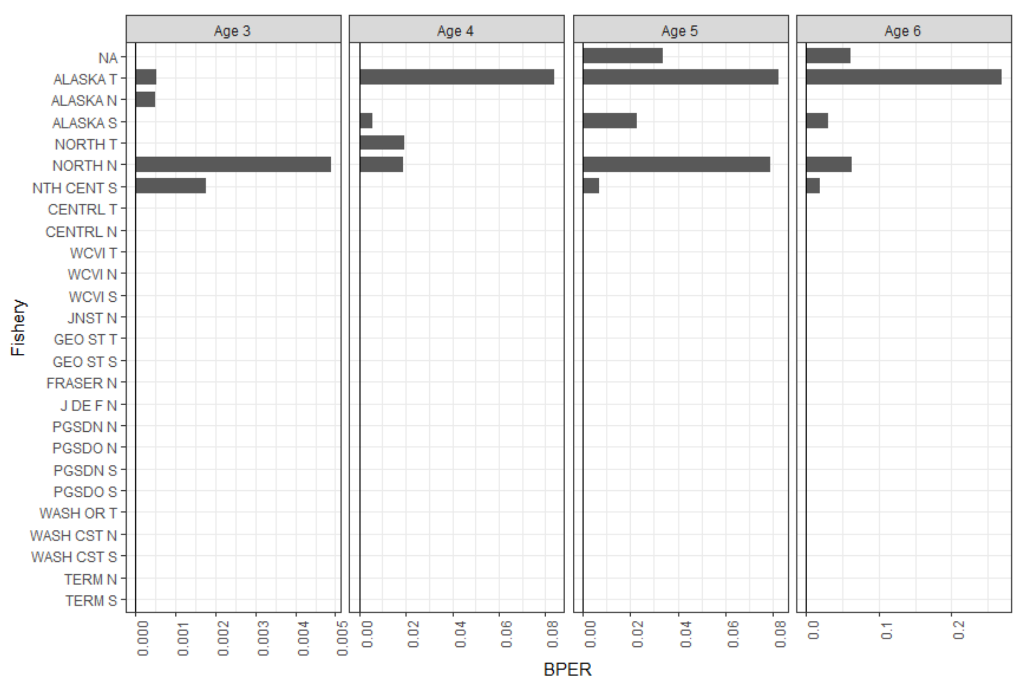

Figure 38—Base period exploitation rate by fishery for Northern British Columbia (Phase II).

4.8.2.4 Escapement/Terminal Run Time Series

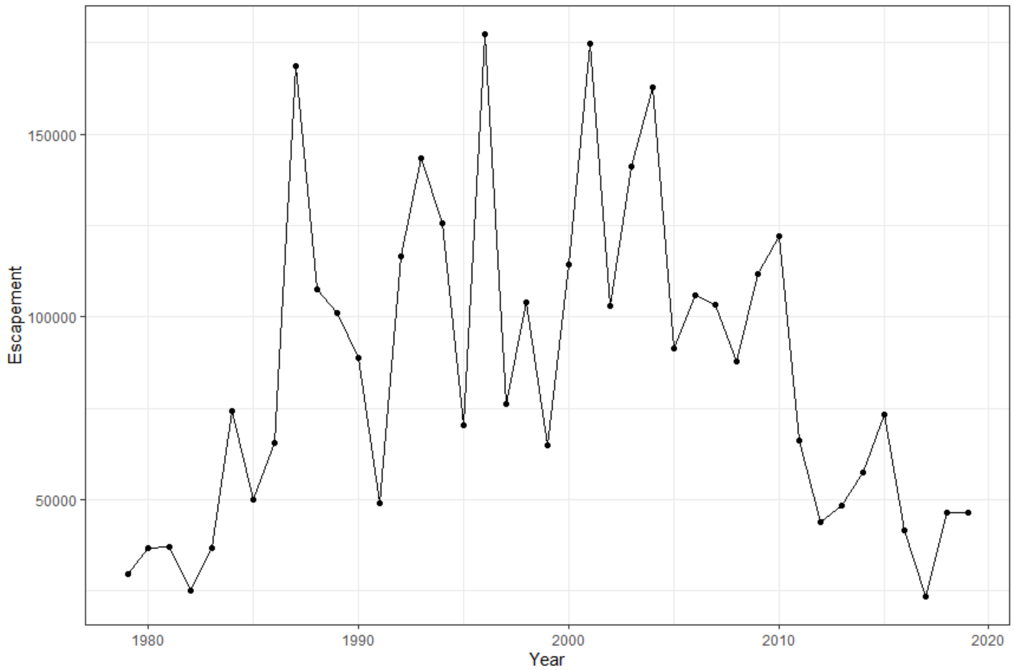

Figure 39—Escapement or terminal run size for Northern British Columbia (Phase II).

4.8.2.5 Ricker Parameters

Stock-recruit parameters for NBC were based on pre-base and base escapement data from Nass and Skeena and escapement-goal data from Nass Chinook.

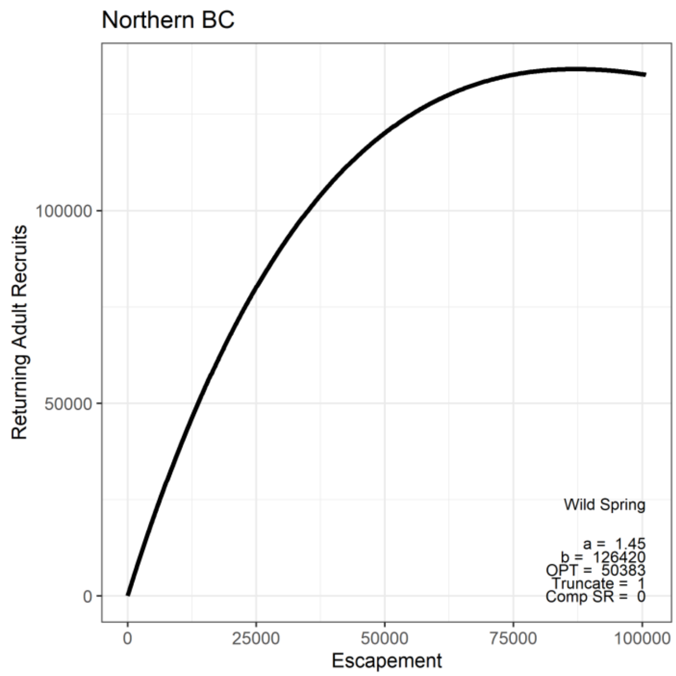

Figure 40—Ricker curve and parameters for Northern British Columbia (NBC) model stock.

4.9 North/Central BC (NTH): Central BC (CBC)

4.9.1 Stock Description

Northern/Central B.C. stock (NTH) in the 9806 base period calibration was split into Central B.C. (CBC) and Northern B.C. (NBC) model stocks in Phase II to better represent this large region of British Columbia. Kitimat and Atnarko tag code releases were used for NTH in 9806 whereas Atnarko releases (ATN) were used for CBC and Kitsumkalum releases (KLM) for NBC in Phase II.

4.9.2 Description of Changes

Phase II version of Model calibrates to escapement as opposed to terminal run in 9806. This decision was supported by the robust and reliable mark-recapture programs and analytics in place for both Atnarko and Kitsumkalum.

4.9.2.1 MDL File Settings

See section 4.7.2.1.

4.9.2.2 Base Period Coded-Wire Tags and Recoveries

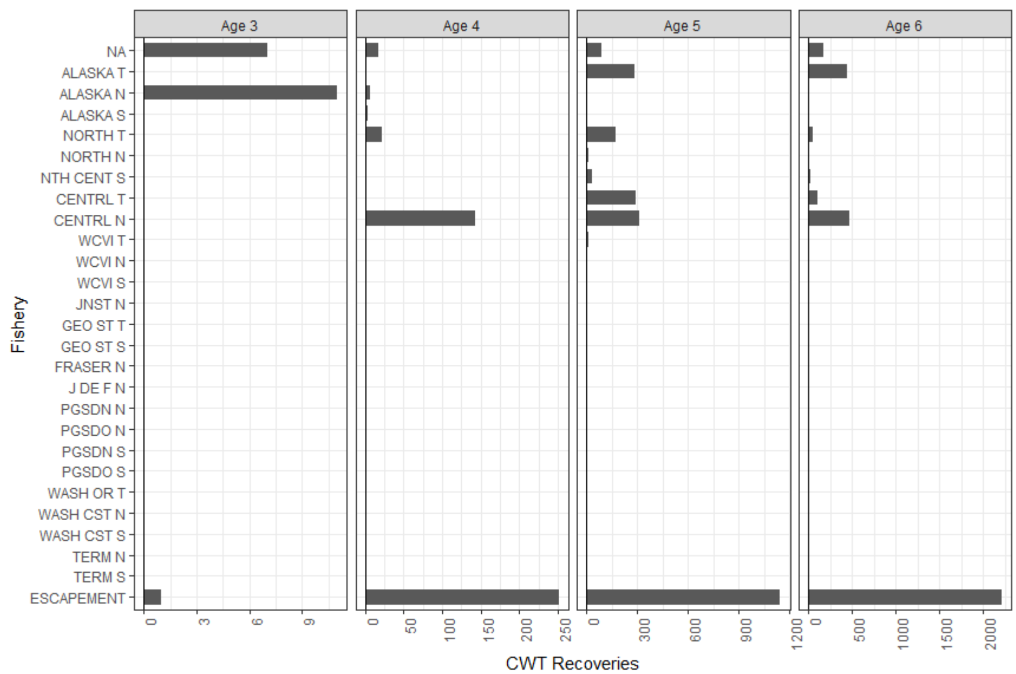

Figure 41—Base period coded-wire tag (CWT) recoveries for Central British Columbia (CBC) model stock. (Phase II).

4.9.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

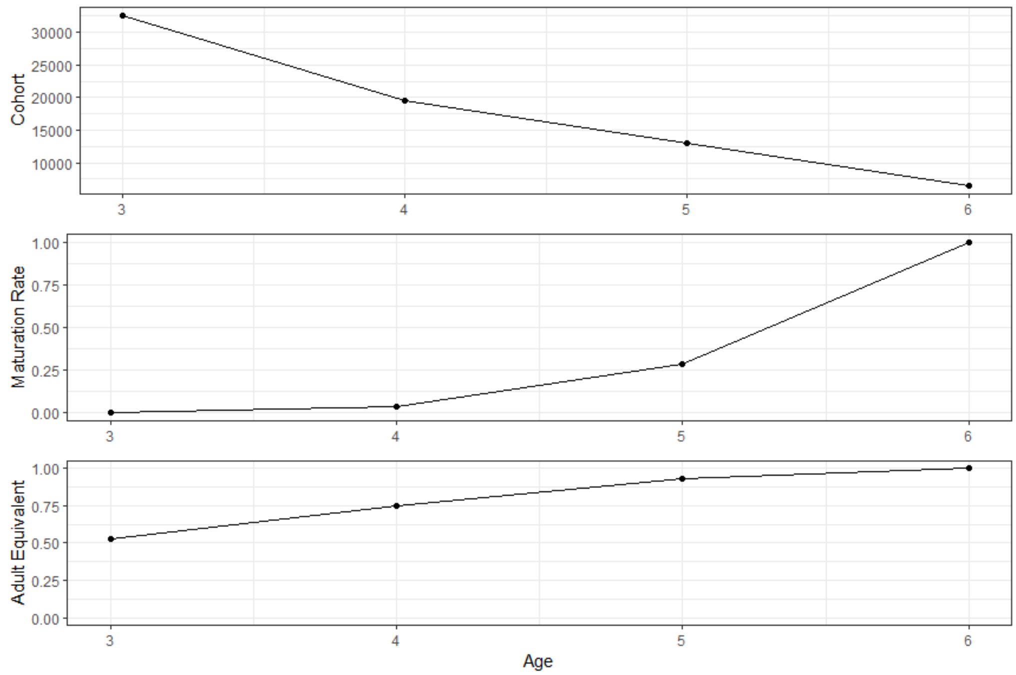

Figure 42—Base period cohort size, maturation schedule, and adult equivalent for Central British Columbia (Phase II).

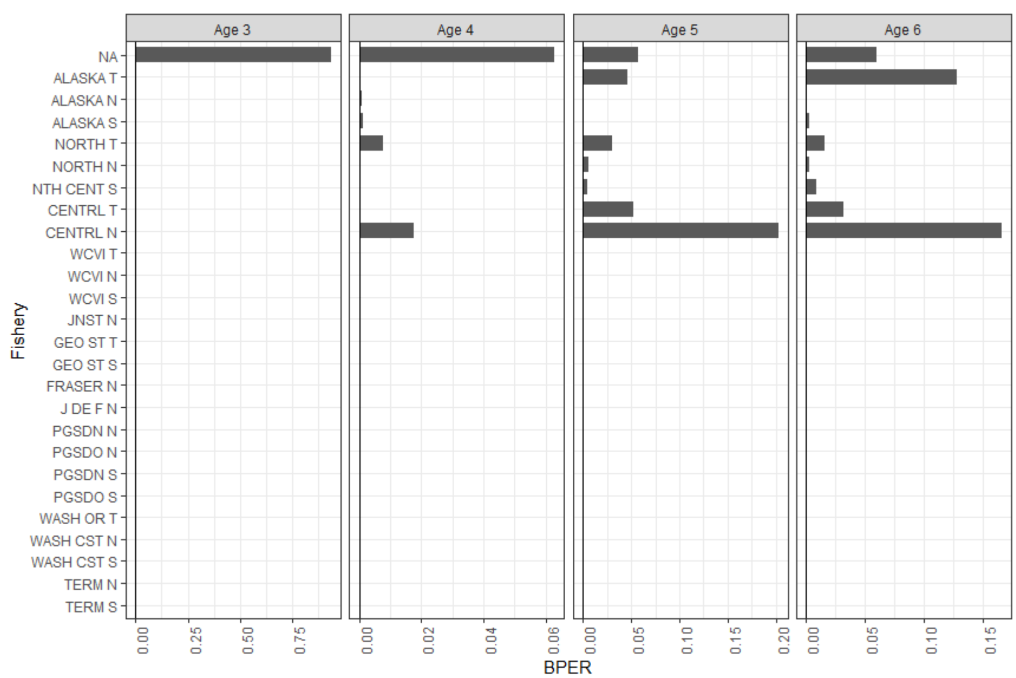

Figure 43—Base period exploitation rate by fishery for Central British Columbia (Phase II).

4.9.2.4 Escapement/Terminal Run Time Series

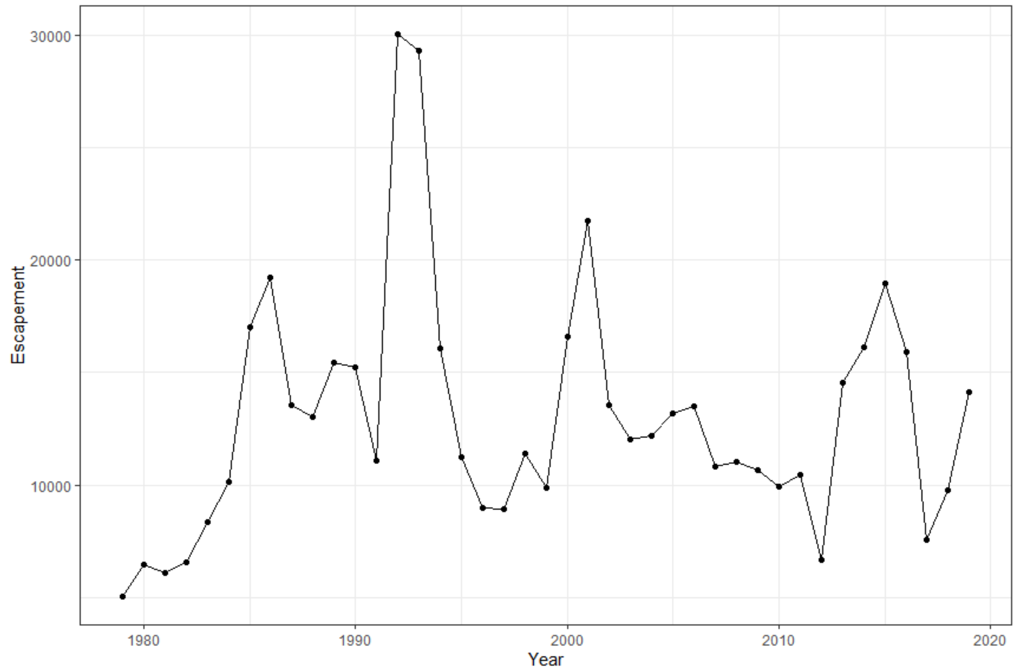

Figure 44—Escapement for Central British Columbia (Phase II).

4.9.2.5 Ricker Parameters

Pre-base and base escapement from Atnarko, Wannock and Chuckwalla-Killbella and escapement-goal data from Atnarko Chinook were used for CBC.

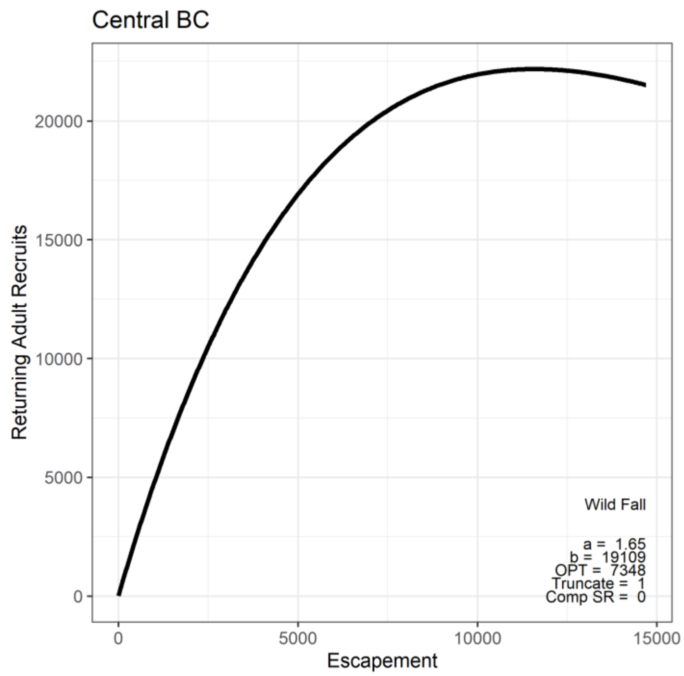

Figure 45—Ricker curve and parameters for Central British Columbia (CBC) model stock.

4.10 Fraser Early (FRE): Fraser Spring 1.2 (FS2), Fraser Spring 1.3 (FS3), Fraser Ocean-type 0.3 (FSO), and Fraser Summer Stream-type 1.3 (FSS)

4.10.1 Stock Description

The Fraser Early stock was the name for one of two model stocks used in the 9806 version of the Chinook Model, and the other is the Fraser Late. There are spring, summer and fall run Chinook in the Fraser (Parken et al. 2008), with adult Chinook returning from February to December. The Fraser Late stock consisted of fall, ocean-type chinook that returned to the Harrison River, largely natural production, and the Chilliwack River, largely hatchery production. Historically, there were not any fall run Chinook in the Chilliwack River until the hatchery program began which used the Harrison stock for brood stock until hatchery returns to the Chilliwack were sufficient to sustain the hatchery program. The Fraser Early stock consisted of all the other stocks in the Fraser River, ranging from rivers located near the Fraser River mouth (i.e., Pitt River) to those located in the Rocky Mountain trench near the Alberta border, and it was a mix of stocks with different life histories, maturation rates, and ocean distributions.

4.10.2 Description of Changes

There is a remarkable amount of biological diversity among Fraser Chinook, with stock differing in the ocean distributions, migration timing, spawn timing, maturation patterns (Candy et al. 2002) and growth rates (Xu et al. 2020). In the past, there was very little data available to represent the different biological and stock population dynamic attributes for these stocks. For CWT data, Chilliwack was the only exploitation rate indicator stock until the Nicola, Lower Shuswap and Harrison stocks were added in the mid-2000s. This new information enabled other techniques, such as the out-of-base procedure to be used to estimate the base period exploitation rates, and these stocks provided maturation rate information. Previously, wild CWT projects on the Lower Shuswap and Chilko Rivers were used to estimate base period exploitation rates, however the terminal First Nations (FN) net fishery was not sampled and when the commercial samples were used to represent the FN fishery impacts, the data were very sparse. One of the largest challenges with representing Fraser stocks is small amount of fishery exploitation information to represent the stocks during the 1979–1982 base period.

In 2002, the CTC began reporting the escapements separate for four of the Fraser Early stocks: Fraser Spring-run Age 1.2 (FS2), Fraser Spring-run Age 1.3 (FS3), Fraser Summer-run Age 1.3 (Fraser Summer Stream-type: FSS), and Fraser Summer-run Age 0.3 (Fraser Summer Ocean-type: FSO; CTC 2002). The stock groups were based on adult migration timing, maturation patterns, and the life history (i.e., stream-type vs ocean-type). The age designation uses the European format, where the first number specifies the number of winters spent in freshwater that are evident on the scale and the second number specifies the number of winters spent in the ocean. Fish mature at multiple ages for these stocks, and the age designation simply identifies the most frequent pattern. For the development of the new model, the Fraser Early stock group was separated into four stocks. This step represents an improvement, however the

FS3 and FSS stocks had little CWT to represent their characteristics. There is a CWT indicator stock at the Chilko River, and another being developed at the Chilcotin River, and these programs will likely provide a better set of information for future Chinook model improvements.

4.10.2.1 MDL File Settings

Table 18—Information used in the construction of the Fraser River spring stocks MDL files.

Information for MDL File Production	Phase II Model Stock			
Model Stock Acronym	FS2	FS3	FSO	FSS
Brood Years	1985, 1987	1986–1988	1978, 1979, 1984–1986	1977, 1978
Out-of-base procedure used?	Yes	Yes	No & Yes	No
Modifications to fisheries in WG4 file	None	TFraser Term Net	TFraser Term Net	NA
C-file extension (CWT Indicator ID)	NIC	DOM	SHU	CKO
Yearling Stock	Yes	Yes	No	Yes
Weight within BY by production releases	No	No	No	No
Exclude Esc for Between BY weighting	No	No	Yes	Yes
Start age in C-files	2	2	2	2
Last age in C-files	6	6	5	6
Modifications to escapements in Coshak4	No	No	No	No
Method used to modify escapement	NA	NA	NA	NA
Terminal fishery CWT moved to escapement	No	No	No	No
Model stock type	Wild, Spring	Wild, Spring	Wild, Fall	Wild, Spring
Additional fisheries designated as terminal	Fraser Net	Fraser Net	Fraser Net	Fraser Net
9806 model stock association	FRE	FRE	FRE	FRE
Other Information				
C-file creation date	26 Jun 2017	25 Apr 2017	13 Dec 2018	25 Apr 2017
Number of C-file and ERA fisheries	188 – 78	188 - 78	194 - 77	188 - 78
MDL creation date	16 May 2017	16 May 2017	16 Jan 2019	16 May 2017

4.10.2.2 Base Period Coded-Wire Tags and Recoveries

The following table summarizes information that was used in the construction of the FS2, FS3, FSO and FSS MDL files for the Phase II Model base period calibration. With the separation of the Fraser Early stock into four stocks, additional CWT data were reviewed and assembled. When the previous version of the model had the last base period calibration (CLB 9806), there were no CWT indicator stocks for any of the stocks in the Fraser Early group. For the base period years, wild CWT programs had occurred at Chilko and at Lower Shuswap, and these tag codes were used to construct the base period exploitation rates for CLB 9806. Several hatchery CWT programs began for Fraser Early stocks during the mid-1980s, however CWT sampling issues in the Fraser First Nation fisheries and the sport fisheries had limited the ability to analyze the CWT through the CTC ERA.

The spawner CWT data that were used in CLB 9806 were reviewed by a) acquiring published and unpublished escapement reports, b) contacting personnel who worked on the escapement estimation programs, and c) searching archives for written and electronic materials. Several reports found were very informative because they described escapement estimation methods and any issues with data collection identified at the time. The most valuable discovery was an unpublished report, available only in hard copy, that does not appear to have been accessible to the staff working on the base period calibrations before Schubert and Milko (1990) describe the methods used to estimate the spawning escapements and recover CWTs for Chilko and Shuswap. Estimated CWT recoveries are provided for Chilko by tag code from 1980–1983 and Lower Shuswap from 1982–1984. After checking the calculations for the estimated CWTs using the spawning escapement and sample data, it was apparent that the recoveries had not been adjusted for 'lost pins.' Adjustments were made for lost pins, so the spawning ground CWTs used below differ from those reported by Schubert and Milko for Chilko in 1982 and 1983 and Lower Shuswap in 1983. One part of the sample data that has not been checked in the Schubert and Milko (1990) report is that the quality of the carcasses used to comprise the number sampled. Raw data sheets were rescued and examined, as well as electronic file media (5 ¼ inch floppy disks) and their data were recovered.

The spawner CWT estimates may be underestimated for several reasons. First, there is a high frequency of no pin recoveries, which may be due to poor tag retention in wild smolts, poor tag detection in the lab (e.g., tags not magnetized or tag detection not sufficiently sensitive), and inclusion of poor quality carcasses that had decayed and lost tags (unconfirmed). These error sources were identified for Chilko recoveries in 1980 and 1981 (Delaney et al. 1982) due to concerns about low tag recoveries. For 1981, there were 2 out of 11 heads with tags where electronic detection failed to detect a tag in the head, but the tags were detected by x-ray. Poor clips of wild fish were also identified as a source for underestimation of spawning ground CWTs. The Schubert and Milko (1990) spawning ground CWT estimates were considered as the best quality ones available, after making adjustments for lost pins to be consistent with standard analytical procedures.

When CLB 9806 was conducted, there was only one ERIS in the Fraser River: Chilliwack River Falls. In the mid-2000s, steps were taken to assemble CWT data for other CWT stocks (Dome, Nicola, Lower Shuswap, Harrison) and the CTC conducted an ERA for some of the Fraser stocks in 2008. Subsequently, efforts continued to reconstruct the historic CWT sample and catch data and address gaps or low sampling rates in fisheries using analytical techniques. Each year the time series was extended further back in time, and data were being checked, revised and improved. Eventually, the Nicola, Dome, Lower Shuswap and Middle Shuswap ERIS CWT stocks were added and are part of the annual CTC model calibration and exploitation rate analysis report.

These CWT data enabled the representation of these four stock groups in the PSC model using either the OOB, base period wild CWT data, or a combination. The following descriptions for each of the stocks illustrate differences in distribution among ocean fisheries, fishery exploitation rates by age, maturation rates, and stock-recruitment information.

Table 19—Coded-wire tag codes for Fraser River Spring model stocks.

Brood Year	Tag Codes				
	9806 (FRE)	**Phase II (FS2)**	**Phase II (FS3)**	**Phase II (FSO)**	**Phase II (FSS)**
1977					CKO: 022119, 022125
1978	CKO: 021602, CKO: 021658, SHU: 021625, SHU: 021638			SHU: 021625, 021638	021602, 021658
1979	SHU: 021601, SHU: 021755			021601, 021755	
1984				023054, 023055, 023421	
1985		NIC: 023535, 023730, 024057		023548, 023549, 023552, 023553	
1986			DOM: 024119, 024120, 25029, 025030, 025031	024316, 024610	
1987		025431, 025432, 025547	025042, 025043, 025207, 025208, 025209		
1988			025246, 025247, 025248, 025249, 025250		

1. Note that escapement categories are not included (1 for C-files and 3 for the ERA)
2. FS3 note: 1 estimated recovery was added in for age-3 escapement in C-file C024119.DOM so that the age-3 maturation rate would be greater than 0. The Chinook Model produces anomalous results unless the STK file has a non-zero value for the MR at the youngest age. WG4 scalars for fishery #43 TFraser Term Net calculated using Fraser Chinook Run Reconstruction Model output (file version 'FraserRiverChinookTerminalRunData_ NT_3Mar17.xlsx').
3. FSO notes: WG4 scalars for fishery #43 TFraser Term Net calculated using Fraser Chinook Run Reconstruction Model output (file version 'FraserRiverChinookTerminalRunData_FPs_79-82base_02May18_ModelV1-22.xlsx'). Two cases of small but negative age-5 catches in the FSO MDL were changed to 1 for use in the base calibration: 1) GEO ST S (-1.288304 and 2) B.C. JF S (-0.772982).

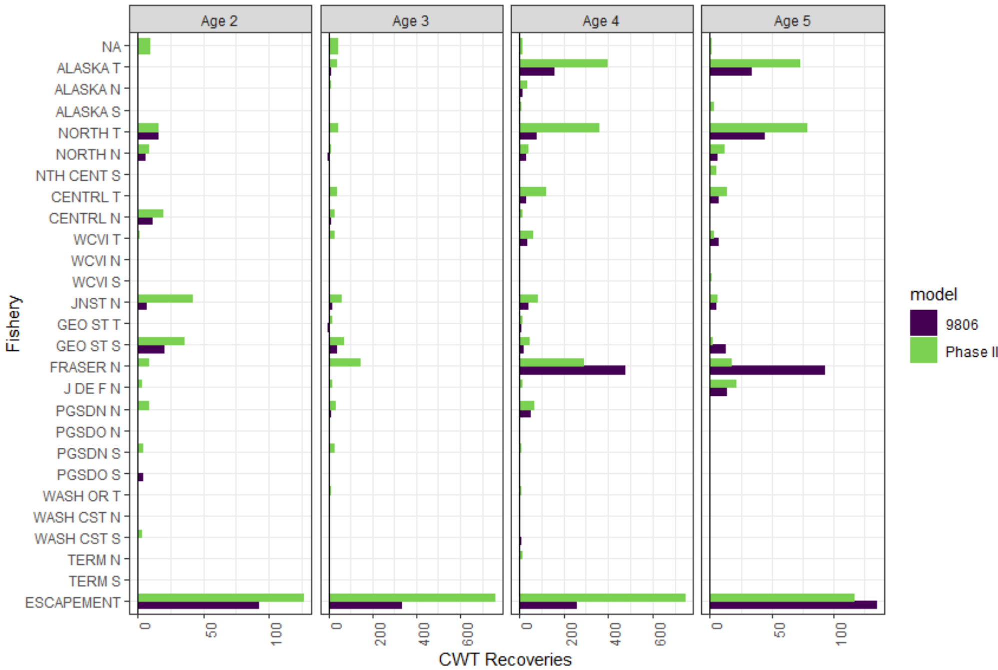

Figure 46—Base period coded-wire tag (CWT) recoveries for Fraser Early (9806), Fraser Spring 1.2 (Phase II), Fraser Spring 1.3 (Phase II), Fraser Ocean-type 0.3 (Phase II), and Fraser Summer Stream-type 1.3 (Phase II).

4.10.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

The figures below represent a comparison of the current model information relative to the new model information for a combination of the four components of the old Fraser Early model stock. The largest changes are in the new terminal fisheries (sport and freshwater net as NA in the figure), the Fraser net fisheries and the WCVI troll fishery. Age-3 Chinook are represented in more fisheries in the new model relative to the current model, which may reflect the way the SHU base period codes were combined with the CKO codes in calibration 9806.

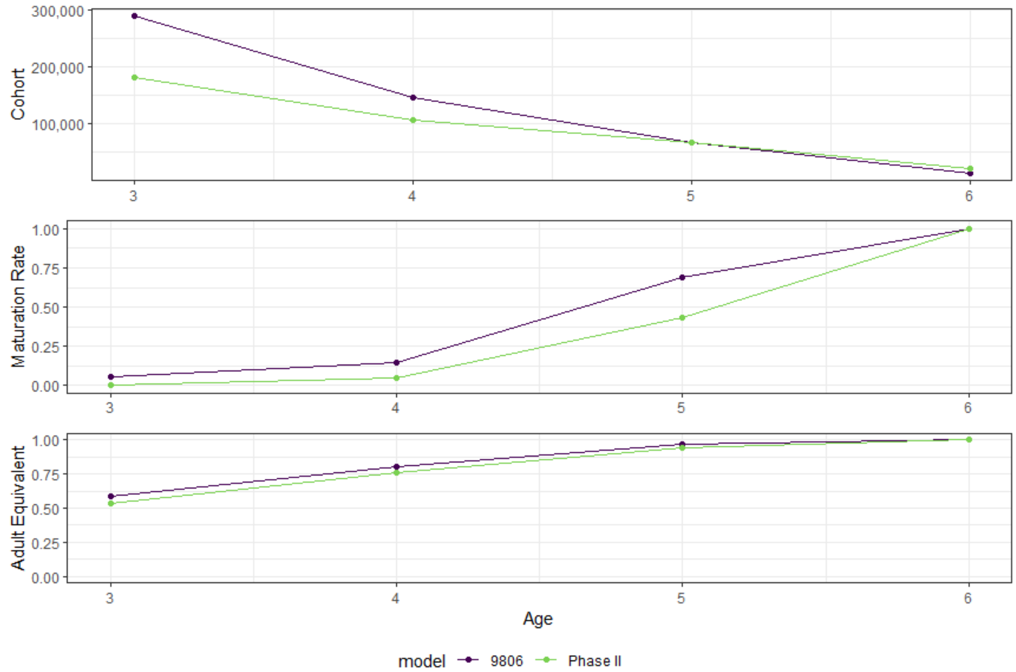

Figure 47—Base period cohort size, maturation schedule, and adult equivalent for Fraser Early (9806), Fraser Spring 1.2 (Phase II), Fraser Spring 1.3 (Phase II), Fraser Ocean-type 0.3 (Phase II), and Fraser Summer Stream-type 1.3 (Phase II).

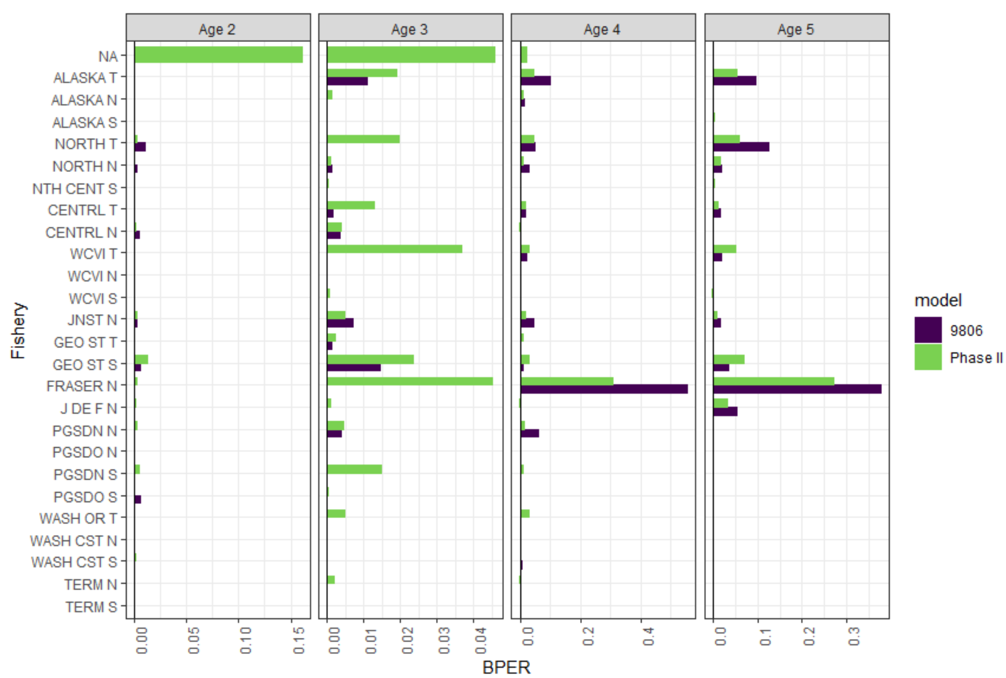

Figure 48—Base period exploitation rate by fishery for Fraser Early (9806), Fraser Spring 1.2 (Phase II), Fraser Spring 1.3 (Phase II), Fraser Ocean-type 0.3 (Phase II), and Fraser Summer Stream-type 1.3 (Phase II).

4.10.2.4 Escapement/Terminal Run Time Series

Several revisions were made to the time series of escapement data for each of the new stock groups, and those changes are described in those sections in more detail. Generally, time series were standardized to estimates of total escapement using new information collected during the Sentinel Stocks Program (PSC 2018), Northern and Southern Enhancement Funded programs, and historic mark-recapture data that were acquired by rescuing data from boxes that had been returned to DFO offices from the Canadian Federal Government Archives. For the latter, data were recovered from paper sheets and entered into electronic records, and then the mark-recapture data were analyzed following the current methods and analytical programs. The standardized time series addressed the negative relative bias that had been found for the aerial survey methodology used for nearly all of the Fraser Early stocks (Bailey et al. 2000; Parken et al. 2003), and escapement estimates increased for these rivers. Other changes involved adding rivers that had escapement data for rivers that had consistent, interannual visual survey counting conditions, and estimates with higher confidence. In comparison, escapement estimates were removed for several rivers because the counting conditions can vary among years, resulting in year-to-year changes in abundance that may resemble the changes in counting conditions more than changes in Chinook abundance. Also, at a minimum all the escapement data have gone through a data quality review back to 1995, which was done to support the Wild Salmon Policy review of the status of Southern B.C. Chinook salmon (Brown et al. 2014), which included Fraser River stocks, and the stocks with calibrated time series were reviewed back to 1979. Since calibration 9806, commercial fishery data were also reviewed and finalized and new methods were applied to address recognized deficiencies in the sales slip data relative to other catch estimation data sources (DFO 2009), which affected terminal run estimates. Lastly, the procedures to estimate the terminal runs were changed between CLB 9806 and the Phase II base period calibration, which relied on a Run Reconstruction model (English et al. 2007) that was created to allocate catches in Fraser River fisheries to individual river-based stocks, and these river-specific stock catches are then aligned with the river-specific escapements and hatchery removals to estimate the terminal runs for the Fraser River CTC stock groups.

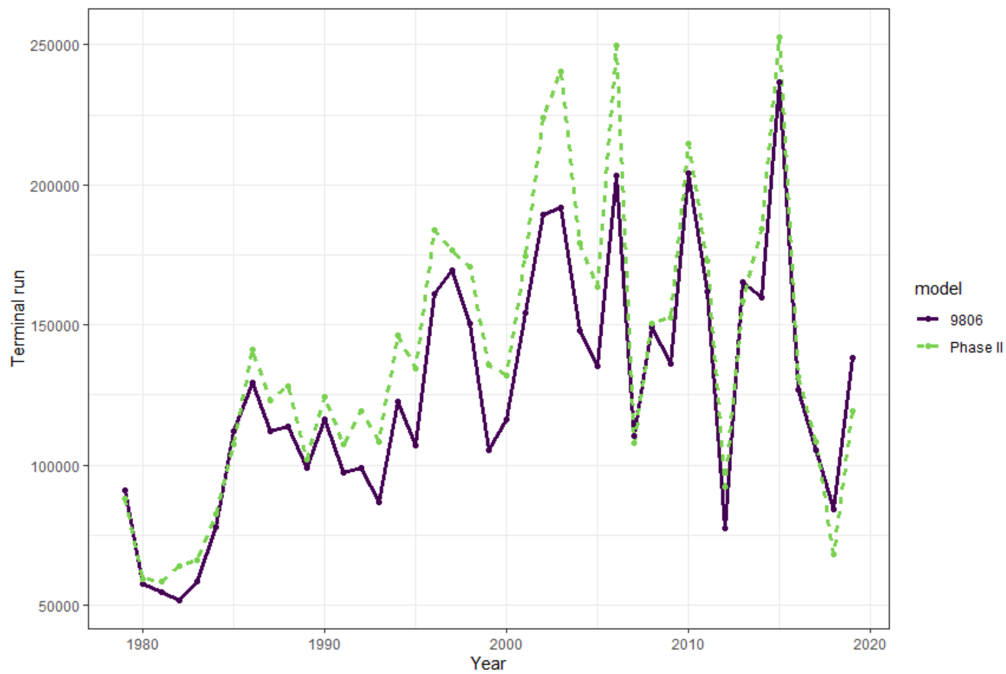

Figure 49—Escapement or terminal run size for Fraser Early (9806), Fraser Spring 1.2 (Phase II), Fraser Spring 1.3 (Phase II), Fraser Ocean-type 0.3 (Phase II), and Fraser Summer Stream-type 1.3 (Phase II).

4.10.2.5 Ricker Parameters

Ricker parameters are described for each Phase II model stock in their individual sections.

4.11 Fraser Early (FRE): Fraser Spring 1.2 (FS2)

4.11.1 Stock Description

The Fraser Spring 1.2 (FS2) stock group consists of seven stocks, representing five tributaries of the lower Thompson River, a tributary in the North Thompson River, and another tributary in the South Thompson (Table 21). The stock has an unusually young maturation schedule ranging from ages 3-5, thus they have relatively small size compared to other Chinook stocks. The youngest age in the C-files is set to age-2 in order to have the program treat all age-5 fish as mature, which is unusual because this is a stream-type stock with juveniles immigrating to sea as age-2 smolts.

Three of the stocks (Louis, Spius and Coldwater) return to the Fraser River with a peak during May and the other four stocks (Bonaparte, Deadman, Nicola and Bessette) have their peak return timing in June or early July. Hatchery production has varied through the time series, but production has been regular for the Nicola, Coldwater and Spius stocks. The Bonaparte stock was enhanced over one generation when the fishway was constructed around a historically impassable falls, which opened a substantial amount of spawning and rearing habitat for Chinook. Hatchery production for the Deadman stock has been intermittent with generally poor success and low survival. Louis and Bessette stocks have not been used as a hatchery brood source.

Table 20—Escapement data used for the Fraser Spring 1.2 stock (FS2) for the base period Model calibration.

Model Stock Name	Fraser Spring 1.2
Model Stock and ID	FS2
Identification Number	7
CWT Indicator Stock	NIC
1975–1978 Pre-Base Average	6,475
1979–1982 Base Period Average	5,622
Year	**Estimate**
1975	9,335
1976	6,254
1977	4,737
1978	5,575
1979	3,373
1980	7,751
1981	3,875
1982	7,487

4.11.2 Description of Changes

For the base period calibration, the Bessette stock was removed from the escapement data set and the Bonaparte stock was added (Table 21). The Bonaparte River historically had a small population of a few hundred Chinook spawners until a fishway around the natural falls and barrier was constructed during the late 1980s. At that time, there was a 4-year period where the Chinook were enhanced using brood stock from the Bonaparte River. The population of spawning Chinook increased into the thousands, and sometimes more than 10,000, after the enhancement activities. Counts were made manually of fish passing the fishway until an electronic resistivity tube detector was installed at the top of the fishway. The data for the Bonaparte stock is very high quality in terms of accuracy and precision. The Deadman stock is enumerated using an electronic resistivity counter in the Deadman River that yields very high-quality escapement estimates. The Bessette stock was removed from the escapement data because the data quality has decreased and there are concerns that the spring-run has declined to very low numbers, less than 25, and that the timing of the spawning ground surveys had shifted from late August to mid-September, when there are small numbers of summer-run middle Shuswap (FSO) fish that enter the system. The Bessette stock represents a very small fraction of the total production for the FS2 stock group. Another change was with the escapement time series for the Nicola stock. Previously, the expanded peak count escapement estimates were used; however, a mark-recapture program was initiated in 1995 (Bailey et al. 2000) and then the expanded peak count estimates were calibrated to the mark-recapture estimates to correct for known biases that exist in the peak count method, which tends to underestimate escapement (Parken et al. 2003). The calibrated peak counts were used for the years 1975-1994, and then the mark-recapture estimates were used subsequently. Overall, these data improvements were made to improve the model's representation of the abundance and production characteristics of the FS2 stock group.

The terminal run was estimated for the FS2 stock group using the stock-specific catch estimates from the Fraser River Run Reconstruction model (English et al. 2007) and the escapement data. Currently, the terminal run, and the escapement are not estimated by age for the FS2 stock group. The Nicola ERIS has age sampling as part of the study design, whereas the other locations have had intermittent age sampling.

The Nicola ERIS was used to represent the CWT statistics, and previously the FS2 stock group was represented by the Lower Shuswap and Chilko CWTs, which have different ocean distributions and maturation patterns.

Table 21—Stocks comprising the Fraser Spring 1.2 FS2 stock group.

Stocks Common to 9806 and Phase II Models	New Stocks Added to Phase II Model	Former Stocks Removed from Phase II Model
Coldwater	Bonaparte	Bessette
Deadman		
Louis		
Nicola		
Spius		

4.11.2.1 MDL File Settings

See section 4.10.2.1 for details.

4.11.2.2 Base period CWT recoveries

Since the 1998 base period calibration, cohort analyses have been conducted for the Nicola to provide the full set of CWT statistics that are used by the CTC. These data enabled the FS2 stock group to be created and to represent the unique maturation characteristics and ocean exploitation patterns. The numbers of CWTs released are generally low by ERIS guidelines and sampling rates tend to be low in the Canadian ISBM ocean sport and terminal net fisheries. The Fraser River First Nation net fishery has had very poor CWT sampling rates, which led to the use of the Fraser River Run Reconstruction model (English et al. 2007) to estimate stock-specific catches in Fraser River fisheries and then these were used with escapement data to generate time series of terminal runs and terminal Fishery Policy (FP) scalers. Wild fry from the Nicola River were coded wire tagged in 1975 and 1979, but the number was very small (<5000) and one of the tag codes was reused by another tagging program. For this reason, the OOB approach was necessary.

Table 22—Summary of coded-wire tag releases in the Nicola River used to represent Nicola Spring (NIC) in the base period model calibration and subsequent recoveries in escapement and Pacific Salmon Treaty fisheries.

				Recoveries in Canada						Recoveries in U.S.				
				AABM		ISBM		Esc		AABM	ISBM		Esc	Grand
Brood	**CWT**	**Tagged**	**Untagged**	**NBC**	**WCVI**	**Marine**	**Fresh**	**Esc**	**Strays**	**SEAK**	**Marine**	**Fresh**	**Strays**	**Total**
1985	023535	19380	7072	0	8	153	24	383	1	0	23	0	0	592
	023730	75240	33970	0	0	68	39	146	0	0	17	0	0	270
	024057	29005	10593	18	7	139	15	508	4	0	31	0	0	722
Total		**123625**	**51635**	**18**	**15**	**360**	**78**	**1037**	**5**	**0**	**71**	**0**	**0**	**1584**
1987	025431	23561	11309	0	21	21	80	307	0	3	14	0	0	446
	025432	26953	13072	3	7	27	75	263	0	0	21	0	0	396
	025547	75624	34210	0	19	28	105	305	12	2	10	0	0	481
Total		**126138**	**58591**	**3**	**47**	**76**	**260**	**875**	**12**	**5**	**45**	**0**	**0**	**1323**

For the OOB cohorts, most CWT data were from ISBM fisheries in Canada (largely in freshwater fisheries), followed by the U.S. ISBM fisheries, and the WCVI AABM fishery. There were very few recoveries in the northern AABM fisheries, although the NBC AABM has regularly had a very small impact when the fishery occurred in June or early July.

The high number of age-3 recoveries for the 1985 cohort is unusual relative to observations for other cohorts, including the 1987 cohort. Of the three tag codes used to represent the 1985 cohort, two of the tag codes were applied to yearlings and one tag code was applied to fish that were released in September as 6.1 g fish, which is less than half the weight of the yearling releases. The September releases were expected to over-winter in the Fraser River watershed and enter the ocean in the following spring, but this was not confirmed. Some further investigation into the recovery patterns of these tag codes could be informative for subsequent base period calibration activities.

Table 23—Summary of estimated coded-wire tags in fisheries and escapements by brood for Nicola Spring (NIC) tag codes selected to represent the Fraser Spring 1.2 (FS2) stock group in the Phase II model calibration.

Brood Year	Recovery Location	Age 2	Age 3	Age 4	Age 5	Age 6	Total
1985	marine	0	84	376	4	0	464
	freshwater	0	18	30	30	0	78
	escapement	1	93	866	77	0	1037
	escapement stray	0	0	4	1	0	5
1987	marine	0	9	153	14	0	176
	freshwater	0	9	233	18	0	260
	escapement	0	3	846	26	0	875
	escapement stray	0	0	12	0	0	12
Grand Total	**All Locations**	**1**	**216**	**2520**	**170**	**0**	**2907**

The NA fishery category represents new fisheries that have been added to the new version of the Chinook model. The recoveries are mainly in the freshwater sport and net fisheries. As mentioned above, CWT sampling has been very poor in the Fraser Freshwater Net fishery, which leads to sparse data. For some years outside of the base period, CWT recoveries were imputed for the Freshwater Net fishery using catch estimates generated by the Fraser River Run Reconstruction model (English et al. 2007) for the Nicola stock.

In general, the tag codes used for the OOB had recoveries in most of the fisheries known to harvest the stock over time (e.g., 1987-2014). Although some of these codes were recovered in the AABM fisheries, the impacts of age-4 in the WCVI AABM troll and NBC AABM sport were not represented in the base period ERs. During the base period, the NBC AABM sport had a very small catch. Further investigation may be helpful to use more recent stock distribution data in the NBC AABM sport fishery to better represent the stocks in the base period. One concern is that if a stock does not have a base period ER, then its annual contribution to all the AABM AIs will be under-represented, but its contribution will be represented on average via the AABM proportionality constant.

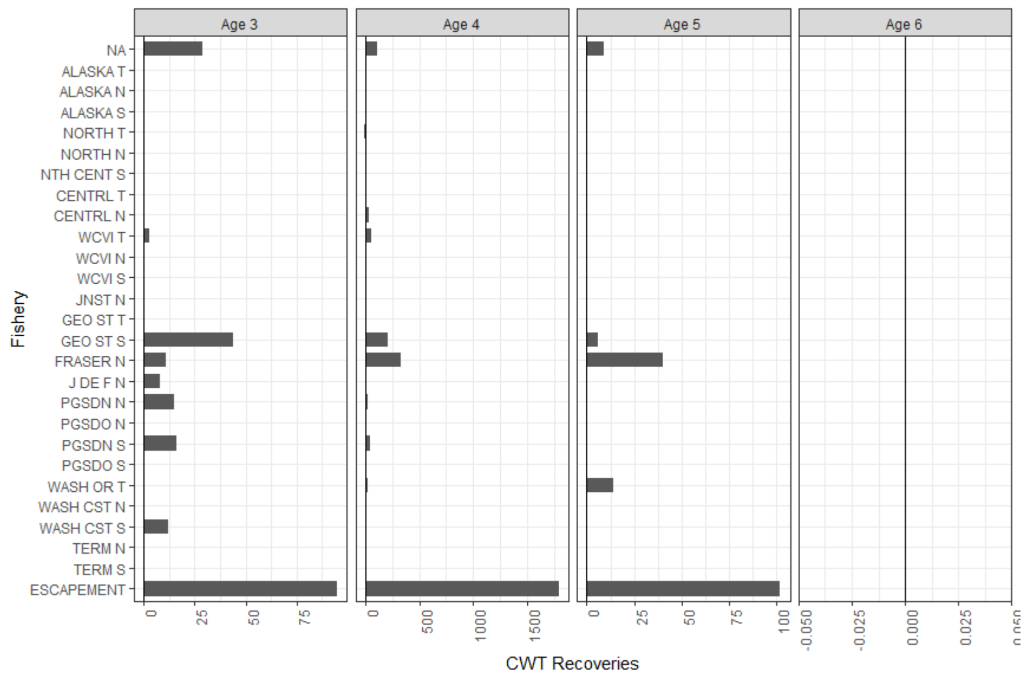

Figure 50—Base period coded-wire tag (CWT) recoveries for the Fraser Spring 1.2 (FS2) stock group

4.11.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

Most of the ER occurs when these fish are migrating back to the Fraser River as mature adults. Thus, fisheries in the Juan de Fuca and Georgia Strait areas have the largest impacts among the ocean fisheries followed by impacts by fisheries in the Fraser River (i.e., Fraser Net, Fraser Freshwater Net, and Fraser Freshwater Sport).

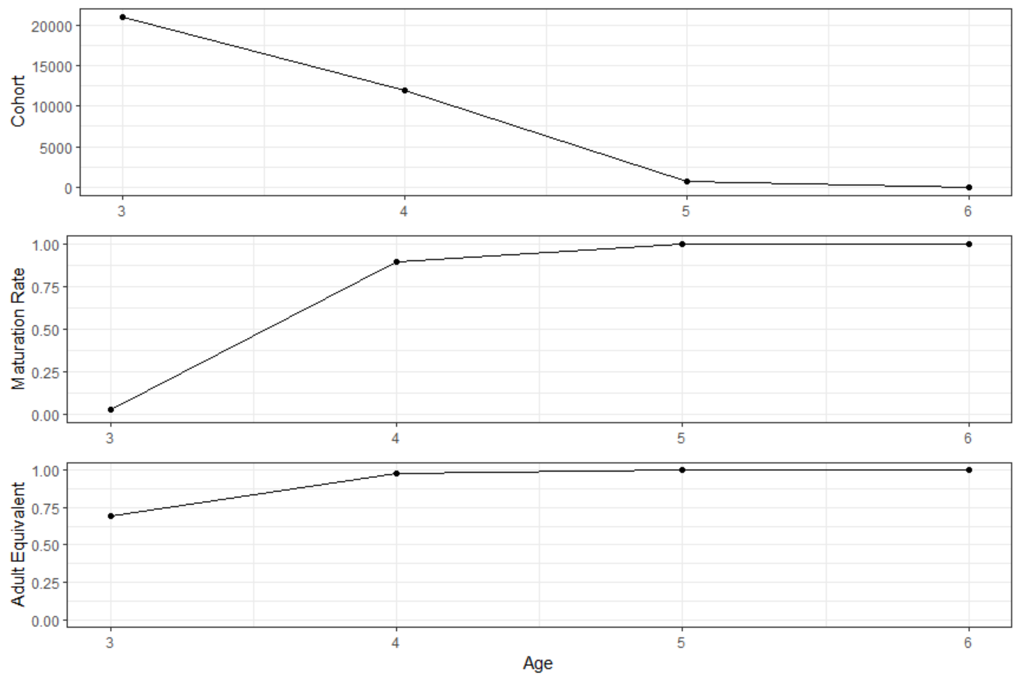

Figure 51—Base period cohort size, maturation schedule, and adult equivalent for the Fraser Spring 1.2 (FS2) stock group.

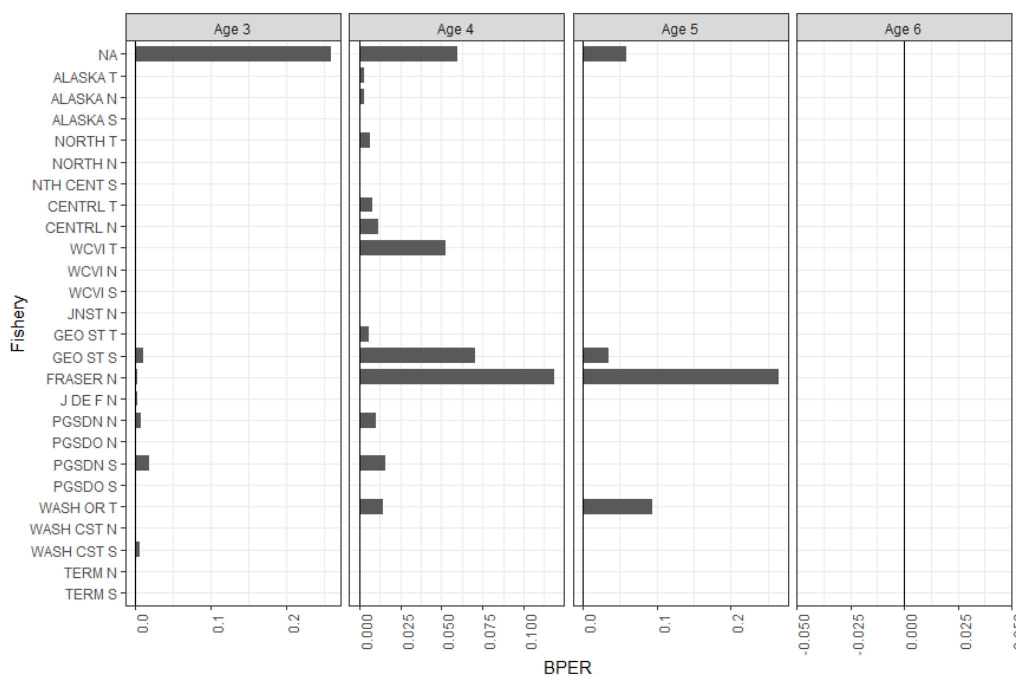

Figure 52—Base period exploitation rate by fishery for the Fraser Spring 1.2 (FS2) stock group.

4.11.2.4 Escapement/Terminal Run Time Series

The Chinook model was set to calibrate to the terminal run for this stock because of concerns about the effect of the uncertainty in the impacts of terminal fisheries on this stock and an absence of a comprehensive biological sampling program (e.g., age, CWT, sex, and length data) on the spawning grounds. A substantial component of the increase in the terminal run for the FS2 stock group during the 1990s is from the production of the Bonaparte stock after the fishway was constructed, and hatchery production was used to help colonize habitats upstream of Bonaparte Falls. The major decrease in abundance during 1998 is thought to have resulted from a large prespawn mortality event during a period of low river levels and high-water temperatures during July and early August that year. The number of fish that died was not estimated and DFO staff were notified by the public about the event after much of the mortality had occurred. The DFO staff confirmed that a substantial prespawn mortality event occurred, but by then a program could not be conducted to estimate the magnitude of the mortality. Future investigations could estimate the survival rate by examining the observed maturation rates for the age-4 cohort in 1998, and then solving for the survival rate that would lead the observed maturation rate for the 1998 brood year to equal the average maturation rate. If a survival rate can be estimated, then there is an option to use an interdam loss approach to enable the missing production to be represented in the Chinook model.

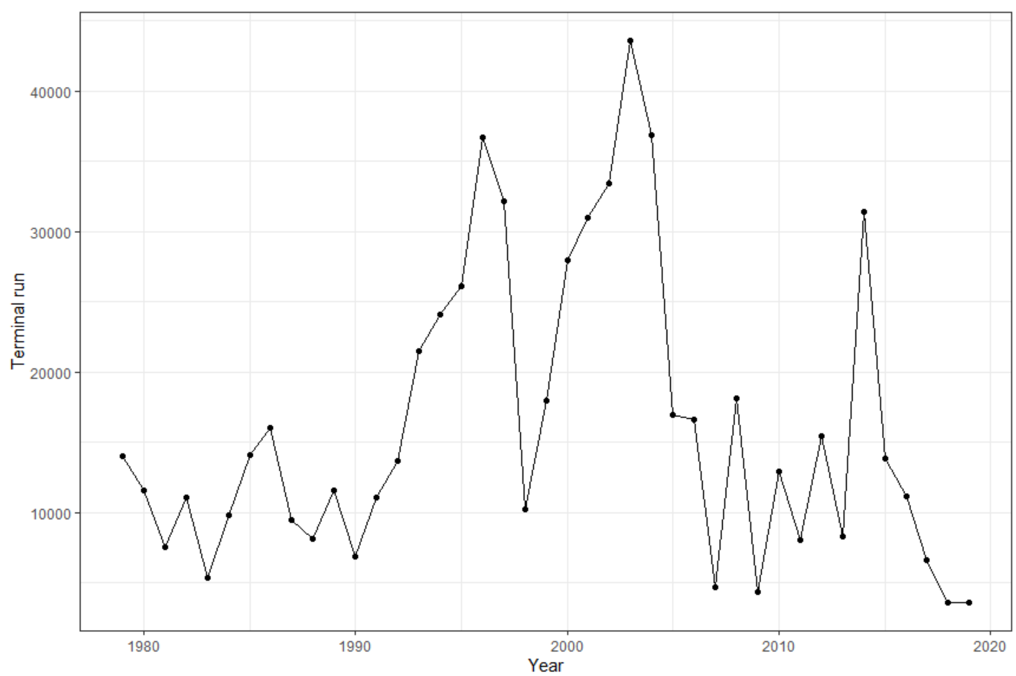

Figure 53—Terminal run size for Fraser Spring 1.2 (FS2) stock group.

4.11.2.5 Ricker Parameters

The Ricker SR parameters were generated using the habitat model (Parken et al. 2006) for each of the six tributaries and associated stocks, with an adjustment for reduced productivity due to lower fecundity rates and smaller body sizes resulting from the younger maturation schedule typical of these stocks. These rivers show independence in their spawn timing, freshwater migration timing, and based on the low level of straying between sites based on CWT studies. The SR data are being analyzed for the Nicola stock, but these data were not available in time for the base period calibration work and preliminary findings indicate that low river flows in August impact juvenile rearing capacity and high-water temperatures in August effect adult spawning success. The river-specific stock estimates of S_{msy} and S_{rep} were added together for an 'all combined' estimate and then the Ricker SR estimates were calculated using the Hilborn (1985) approximation equations.

Table 24—Source of Ricker stock-recruitment parameters used as initial values for the Fraser Spring 1.2 (FS2) stock group in the base period model calibration.

	Stock						
Estimate	**Nicola**	**Bonaparte**	**Spius**	**Coldwater**	**Deadman**	**Louis**	**All Stocks Combined**
S_{msy}*	9,535	5,788	1,953	1,070	2,249	1,551	22,146
S_{rep}*	25,611	15,455	5,148	2,802	5,940	4,079	59,035
S_{msy}/S_{rep}	0.372	0.375	0.379	0.382	0.379	0.380	0.375
log(alpha)*	1.824	1.793	1.723	1.688	1.734	1.711	1.784
Alpha	6.198	6.006	5.603	5.406	5.663	5.534	5.952
U_{msy}	68%	67%	65%	64%	66%	65%	67%
Beta	0.000071	0.000116	0.000335	0.000602	0.000292	0.000419	0.000030
R_{max}	32,012	19,048	6,157	3,302	7,137	4,854	72,471

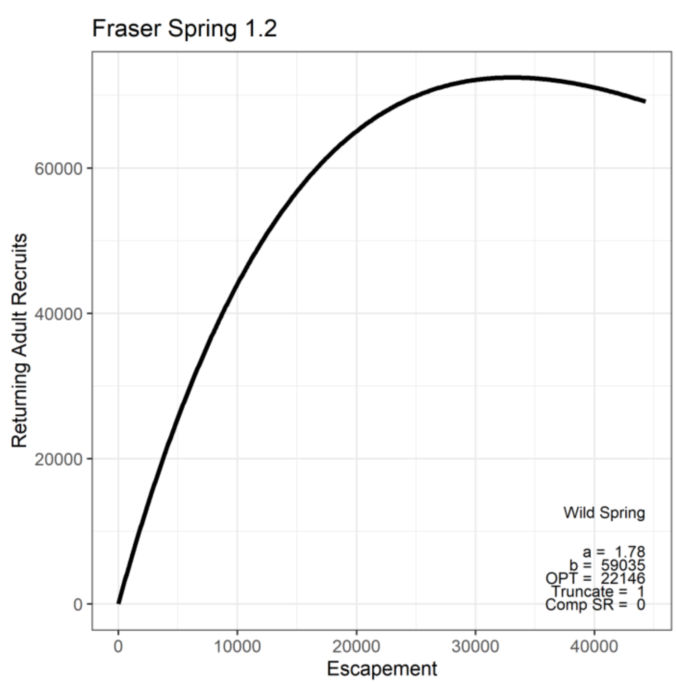

Figure 54—Ricker curve and parameters for Fraser Spring 1.2 (FS2) stock group.

4.11.3 Comparison of Model Performance

Many improvements were made to the model and the calibration inputs during the Phase II model calibration. To examine the effect of these improvements, comparisons were made to independent estimates of cohort sizes by age, brood year ERs, and the model's performance for fitting to the terminal run and escapement.

4.11.3.1 Cohorts

For the FS2 stock group, cohort sizes could not be estimated independently because the terminal run and escapement estimates are not generated by age, because of intermittent age sampling at all locations, except at the Nicola River. Escapements to the Nicola River are estimated by age, but the other spawning locations are not surveyed annually to estimate the age composition. A new comprehensive sampling program would be necessary to collect biological samples (i.e., age, sex, length, CWTs) to estimate the age composition for the FS2 stock group.

4.11.3.2 Exploitation Rates

Based on a comparison of the model and CWT-based ERs (Figure 55, Figure 56), the model tends to produce higher ERs than the CWT estimates (Figure 57). Most of the CWT fishery recovery data are for age-4, and samples are often sparse for age-5 recoveries, which likely contributes to the high variability for that data series. Sampling for CWTs is often very low in the Fraser freshwater net fisheries, which adds to the variability for the age-4 and age-5 data. Overall, the model and CWT-based ERs have a poor correspondence, which suggests that there may be opportunities for further model improvement for the FS2 stock group.

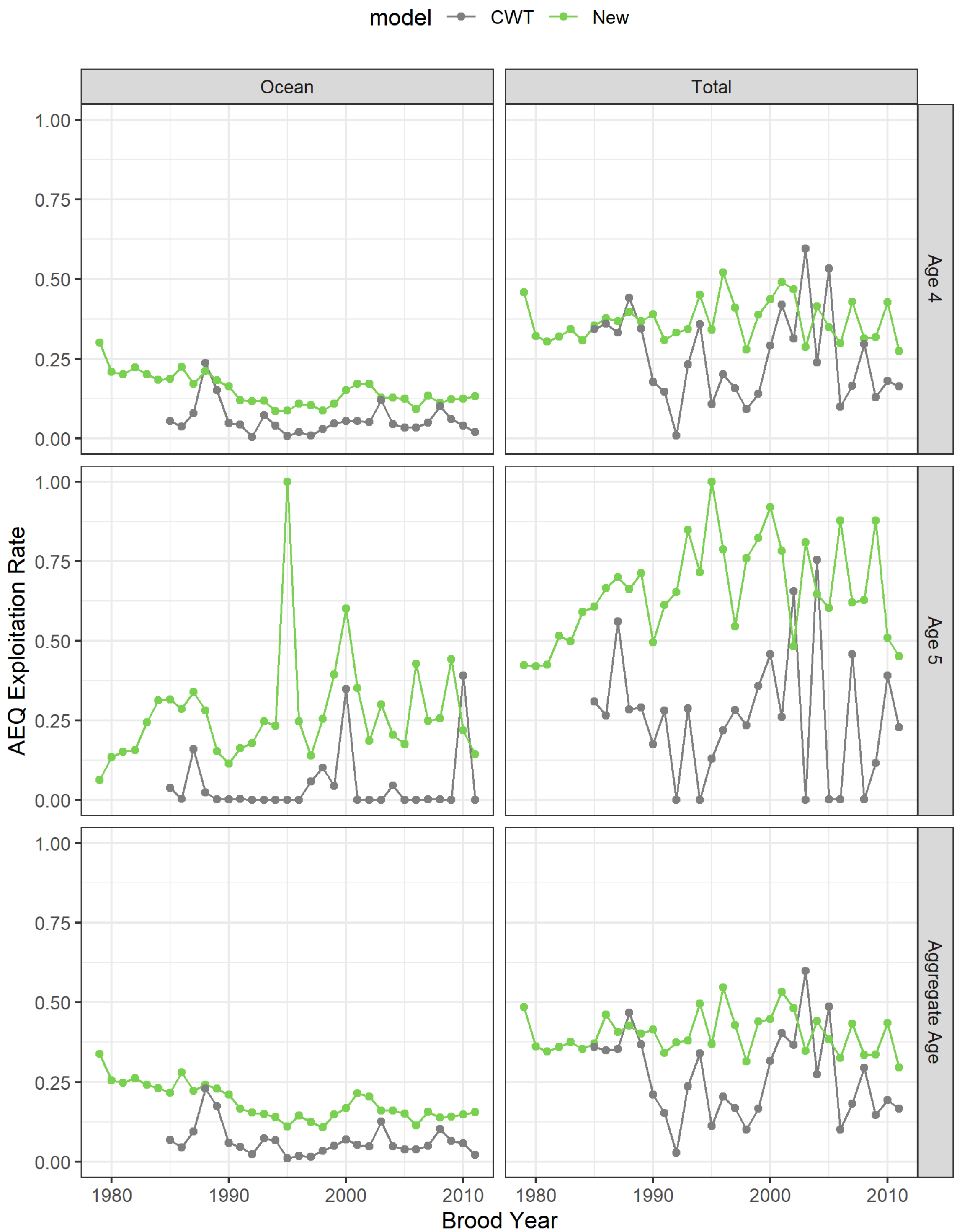

Figure 55—Adult equivalent (AEQ) exploitation rates using the PSC Chinook Model and coded-wire tag recovery estimates for the age-4, age-5, and aggregate age Fraser Spring 1.2 (FS2) stock group for ocean fisheries and total fisheries (including terminal).

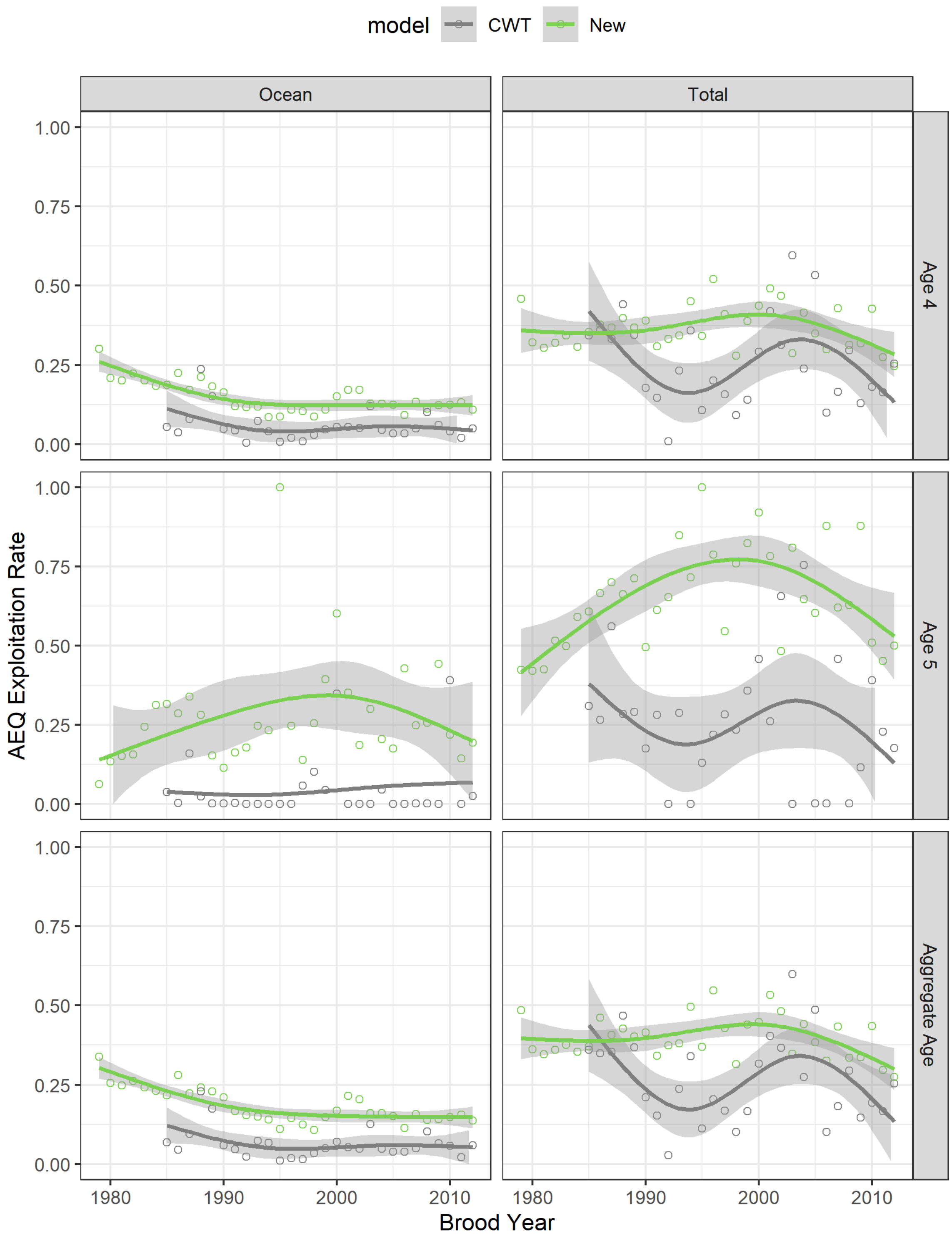

Figure 56—Adult equivalent (AEQ) exploitation rates with a smoothing function using the PSC Chinook Model and coded-wire tag recovery estimates for the age-4, age-5, and aggregate age Fraser Spring 1.2 (FS2) stock group for ocean fisheries and total fisheries (including terminal).

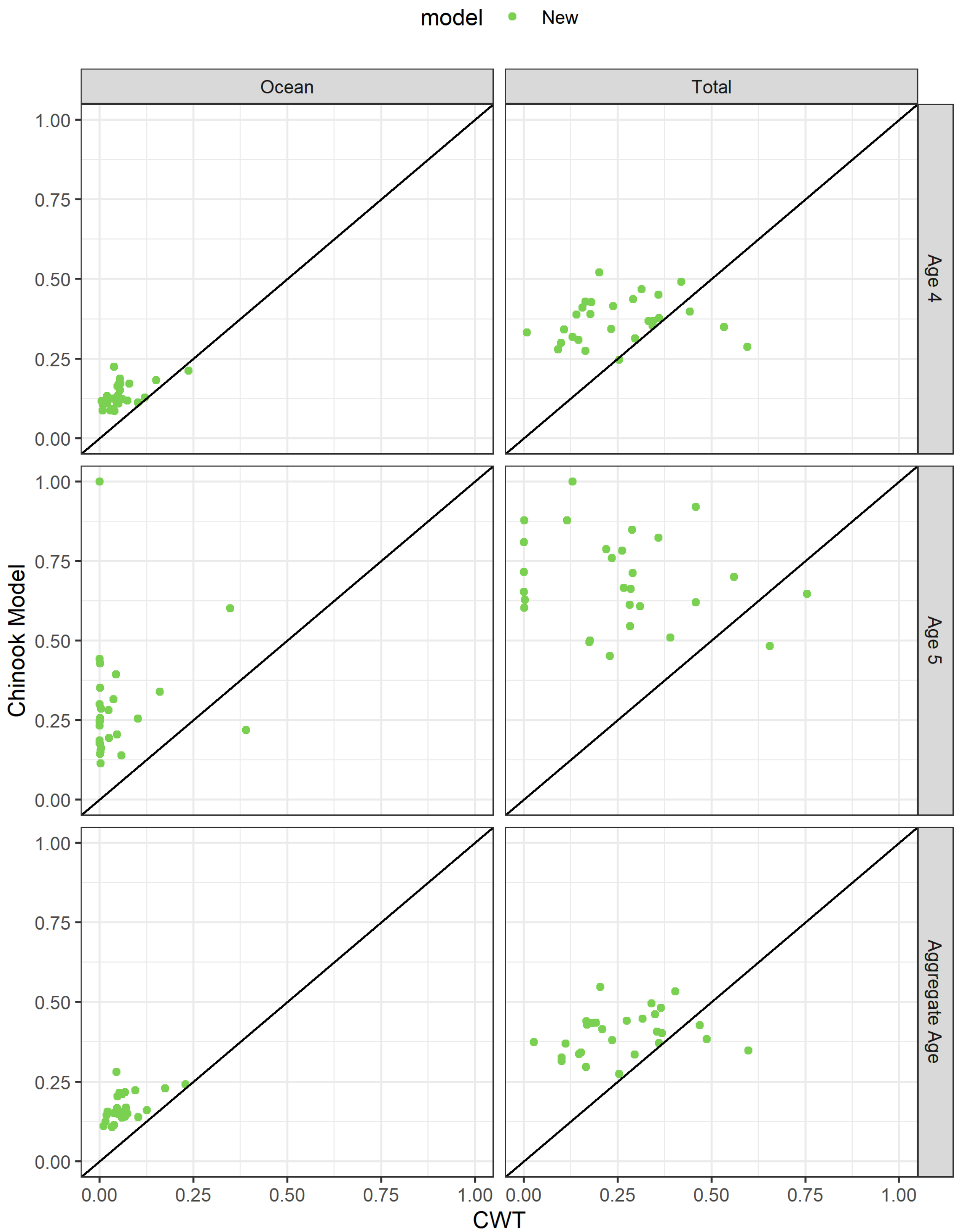

Figure 57—Relationship between exploitation rates from coded-wire tag recovery estimates and from the PSC Chinook Model for the Fraser Spring 1.2 (FS2) stock group.

4.11.3.3 Model Fit to Terminal Run/Escapement

The box plots below (Figure 58) indicate the relative performance of two versions of the new Chinook model (green is intermediate and blue is final) is quite good for the FS2 stock group. The model predictions have a very slight negative bias, but there can be some large over-predictions. Generally, the model predictions were within about 10% of the observed terminal runs.

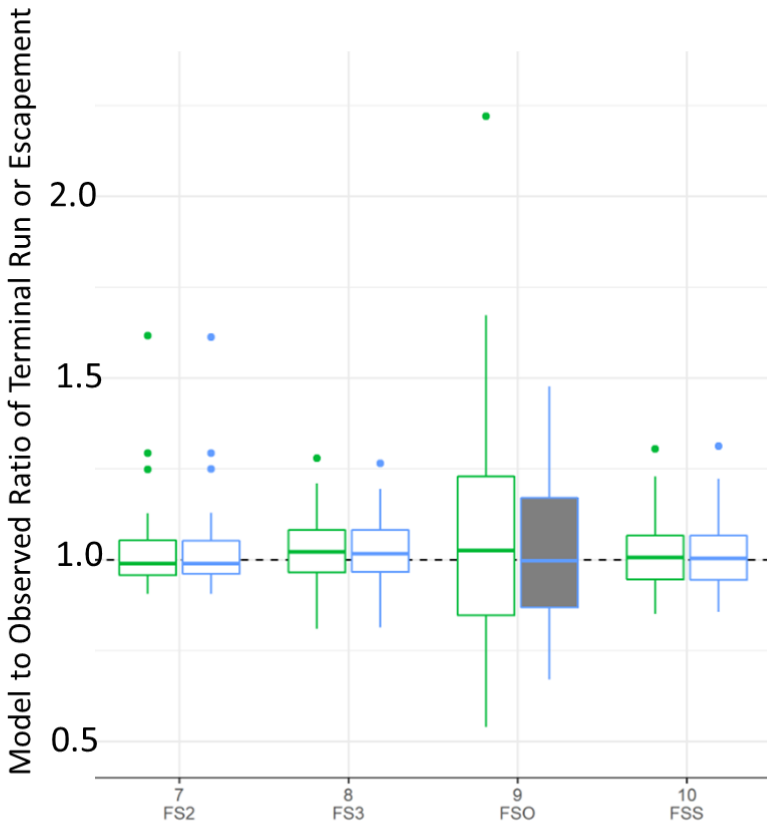

Figure 58—Relative performance of two iterations of the Phase II model calibration for Fraser spring and summer stocks (Fraser Spring 1.2 [FS2], Fraser Spring 1.3 [FS3], Fraser Ocean-type 0.3 [FSO], and Fraser Summer Stream-type [FSS]).

Green boxplots are intermediate iterations of the Phase II model, and blue boxplots are the final iteration of the Phase II model calibration.

4.12 Fraser Early (FRE): Fraser Spring 1.3 (FS3)

4.12.1 Stock Description

The Fraser Spring 1.3 (FS3) stock group consists of fish spawning in about 50 rivers, ranging from those in the lower Fraser (e.g., Pitt and Birkenhead) to those in the North Thompson (e.g., Blue) and to those in the headwaters of the Fraser in the Rocky Mountains. Some of these rivers are grouped into biological population units that are at the level of aggregation that appropriate for the purpose of applying the Parken (2006) habitat model to estimate the stock recruitment parameters. The FS3 stock group consists of several stocks that vary in their ocean distribution patterns, return migration timing, and probably maturation patterns, but there are not sufficient CWT data to represent or even describe these characteristics for all of the stock components. The known CWT maturation rates and distribution patterns are based off CWT information gathered on the Dome indicator stock from the upper Fraser River, near its headwaters. However, tagging numbers were relatively low compared to other ERIS, and this contributed to sparse CWT data and imprecise CWT statistics, which were also affected by low CWT sampling rates in the Fraser Freshwater Net fisheries. Tagging of the Dome indicator stock ended with brood year 2001 when there was a failure with the hatchery water system and the repair costs were too high to keep the hatchery operational. Recently, a new indicator stock program has started on the Chilcotin River, however CWT application has not occurred yet. There were CWTs applied to wild fry from the Chilcotin representing BY 1975 (<1,000) and BY 1976 (~50,000), along with tagging of hatchery smolts during the 1980s and 1990s, and examination of this historical data might improve representation during future model improvement initiatives.

The FS3 stock group contributes to fisheries from age-3 to age-6, with most CWT recoveries at age-5 from hatchery-origin fish (For the OOB cohorts, most CWT data were from ISBM fisheries in Canada (largely in freshwater fisheries), followed by the U.S. ISBM fisheries, and there were few recoveries in any of the AABM fisheries. There are generally very few recoveries in the AABM fisheries, although the WCVI AABM fisheries regularly encountered Dome CWTs in most years during the 1990s and early 2000s and the NBC AABM had some recoveries in the early 2000s. There can be impacts on this stock when the NBC AABM fishery occurs in the spring or early summer. The Dome stock had a pattern of small CWT release groups relative to other ERIS stocks, given survival rates and fishery sampling rates. Some further investigation into the potential use of Chilcotin tag codes could be informative for future base period calibration activities.

Table 28). Scale age data are limited for the FS3 stock group, but there are some fish that have had rare ages indicating that at least some fish in the upper Fraser rear in freshwater for two winters before migrating to the ocean (e.g., age 2.4). Rearing for two years in freshwater is a generally unusual pattern for Chinook salmon, but it is observed more often in areas where the growing season is short and growth rate is slow. The upper Fraser watershed has rivers that drain glacially influenced rivers along the continental divide in the Rocky Mountains, and many of these rivers experience characteristics that are more like a continental climate than to coastal climate. This area experiences the southward flow of extremely cold air from the Artic in the winter that can freeze rivers leading to anchor and frazzle ice and freeze the land to a considerable depth. This delays the timing of the snowmelt and the timing of the ecological response for aquatic and terrestrial organisms during the spring. As a result, some of these Chinook grow very slowly which results in smaller scales having fewer circuli resulting in about 40% of the scales being under-aged by 1 year (Tutty and Yole 1978). This contributes to known challenges with using information from hatchery-reared Chinook and to represent the maturity patterns of natural Chinook too, since the hatchery conditions are stable and very little biological data are collected from wild stocks for comparison. The escapement time series were reviewed for each of the stocks in the FS3stock group and nine stocks were removed and eight were added into the FS3 stock group data. The lower Chilcotin stock had total escapement estimates developed via a PSC Southern Endowment Fund project for 2008, 2009, and 2012 along with paired peak count escapement estimates. These data were used to calibrate the historic time series to estimates of total escapement, which adjusted for a negative bias in the peak count escapement estimates (see description in Parken et al. 2003 regarding the negative bias in the peak count escapement method). Stocks that were removed had estimates that were based on visual surveys that were being affected by highly variable water clarity which affects the detectability of spawners. The current study design does not include estimation of the detection probability in the annual monitoring program (e.g., Pollock et al. 2002), which is one of the reasons why many of the Fraser River escapement estimates are indices of relative abundance, but not measures of total abundance. Variability in the spawner detection probability likely changes among years and rivers with different counting conditions, thus accuracy of the escapement indices varies from year-to-year. Other stocks were removed from the FS3 stock group because escapements were no longer being surveyed. Several rivers were added to the FS3 stock group because they were being surveyed annually and the visual counting conditions were sufficiently consistent among years to generate estimates of relative abundance.

The terminal run was estimated for the FS3 stock group using the stock-specific catch estimates from the Fraser River Run Reconstruction model (English et al. 2007) and the escapement data. Currently, the terminal run, and the escapement are not estimated by age for the FS3 stock group. The Lower Chilcotin ERIS has age sampling as part of the study design; however, other locations have only had intermittent age sampling.

For the FS3 stock group, the CWT statistics were derived from the Dome ERIS, and previously this stock was represented by the Lower Shuswap and Chilko CWTs, which have different ocean distributions, migration timing and maturation patterns.

Table 25—Escapement data used for the Fraser Spring 1.3 (FS3) stock group for the base period model calibration

Model Stock Name	Fraser Spring 1.3
Model Stock	FS3
Identification Number	8
CWT Indicator Stock	DOM
1975–1978 Pre-base Average	11,260
1979–1982 Base Period Average	14,105

Year	Estimate
1975	7,928
1976	9,515
1977	12,511
1978	15,087
1979	14,908
1980	16,072
1981	11,015
1982	14,426

Table 26—Stocks comprising the Fraser Spring 1.3 (FS3) stock group

Stocks Common to 9806 & Phase II Models	New Stocks Added to Phase II Model	Former Stocks Removed from Phase II Model
Ahbau	Blue R	Eagle R
Antler	Chilcotin R (Upper)	Finn Cr
Baezaeko	East Twin Cr	Fontoniko Cr (McGregor)
Birkenhead	Swift R	Herrick Cr
Bowron	West Twin Cr	Ormond Cr
Bridge	Big Silver Cr	Salmon R (PG)
Captain	Kuzkwa R	Salmon R (SA)
Chilako		Spakwaniko Cr (McGregor)
Chilcotin (Lower)		Upper Pitt R
Cottonwood		
Endako		
Fraser @ Tete Jaune		
Goat		
Haggen		
Holmes		
Horsefly		
Horsey		
Indianpoint		
James		
Lightning		
McKale		
Nazko		
Nevin		
Seebach		
Slim		
Swift		
Torpy		
Walker		
Wansa		
West Road (Blackwater)		
Willow		

4.12.1.1 MDL File Settings

See section 4.10.2.1 for details.

4.12.1.2 Base period CWT recoveries

Since the 1998 base period calibration, cohort analyses were conducted for the Dome stock to provide a full set of CWT statistics allowing creation of the FS3 stock group and representation of maturation characteristics and ocean exploitation patterns. The numbers of CWTs released are generally low by ERIS guidelines and sampling rates tend to be low in the Canadian ISBM ocean sport and terminal net fisheries. The Fraser River First Nation net fisheries have low CWT sampling rates, which led to the use of the Fraser River Run Reconstruction model (English et al. 2007) to estimate stock-specific catches in Fraser River fisheries. The stock-specific catches were then these used with escapement data to generate time series of terminal runs and terminal FPs. Tagging of the Dome stock began in 1986, thus the OOB approach was necessary to represent base period ERs.

Table 27—Summary of coded-wire tag releases in Dome Creek used to represent Dome Spring (DOM) in the base period model calibration and subsequent recoveries in escapement and Pacific Salmon Treaty fisheries.

				Recoveries in Canada						Recoveries in U.S.				
				AABM		ISBM		Escapement		AABM	ISBM		Esc	Grand
Brood	**CWT**	**Tagged**	**Untagged**	**NBC**	**WCVI**	**Marine**	**Fresh**	**Esc**	**Strays**	**SEAK**	**Marine**	**Fresh**	**Strays**	**Total**
1986	024119	10645	515	0	0	0	0	7	0	0	0	0	0	7
	024120	10089	512	0	0	0	0	15	0	0	0	0	0	15
	025029	10411	514	0	0	4	0	19	0	0	2	0	0	25
	025030	10489	515	0	0	0	5	10	3	0	0	0	0	18
	025031	10372	513	0	0	0	0	17	0	0	0	0	0	17
Total		**52006**	**2569**	**0**	**0**	**4**	**5**	**68**	**3**	**0**	**2**	**0**	**0**	**82**
1987	025042	10594	456	0	0	0	27	15	4	0	0	0	0	46
	025043	10629	457	0	0	5	16	25	0	0	12	0	0	58
	025207	10644	457	0	0	5	21	11	0	0	4	0	0	41
	025208	10734	457	0	0	5	12	19	0	0	0	0	0	36
	025209	10406	456	0	0	4	7	13	0	0	13	0	0	37
Total		**53007**	**2283**	**0**	**0**	**19**	**83**	**83**	**4**	**0**	**29**	**0**	**0**	**218**
1988	025246	10494	688	0	0	2	27	26	0	0	0	0	0	55
	025247	10318	687	0	0	0	40	20	0	0	2	0	0	62
	025248	10371	687	0	4	4	40	23	0	0	0	0	0	71
	025249	10472	687	0	3	7	26	20	0	0	4	0	0	60
	025250	10151	687	0	0	3	58	27	0	0	2	0	0	90
Total		**51806**	**3436**	**0**	**7**	**16**	**191**	**116**	**0**	**0**	**8**	**0**	**0**	**338**

For the OOB cohorts, most CWT data were from ISBM fisheries in Canada (largely in freshwater fisheries), followed by the U.S. ISBM fisheries, and there were few recoveries in any of the AABM fisheries. There are generally very few recoveries in the AABM fisheries, although the WCVI AABM fisheries regularly encountered Dome CWTs in most years during the 1990s and early 2000s and the NBC AABM had some recoveries in the early 2000s. There can be impacts on this stock when the NBC AABM fishery occurs in the spring or early summer. The Dome stock had a pattern of small CWT release groups relative to other ERIS stocks, given survival rates and fishery sampling rates. Some further investigation into the potential use of Chilcotin tag codes could be informative for future base period calibration activities.

Table 28—Summary of estimated coded-wire tags in fisheries and escapements by brood for Dome Spring (DOM) tag codes selected to represent the Fraser Spring 1.3 (FS3) stock group in the Phase II model calibration.

Brood Year	Recovery Location	Age 2	Age 3	Age 4	Age 5	Age 6	Total
1986	marine	0	0	0	6	0	6
	freshwater	0	0	5	0	0	5
	escapement	0	1	28	39	0	68
	escapement stray	0	0	3	0	0	3
1987	marine	0	0	31	17	0	48
	freshwater	0	0	11	72	0	83
	escapement	0	0	59	23	1	83
	escapement stray	0	0	4	0	0	4
1988	marine	0	0	19	12	0	31
	freshwater	0	0	0	182	9	191
	escapement	0	0	27	86	3	116
	escapement stray	0	0	0	0	0	0
Grand Total	**All Locations**	**0**	**1**	**187**	**437**	**13**	**638**

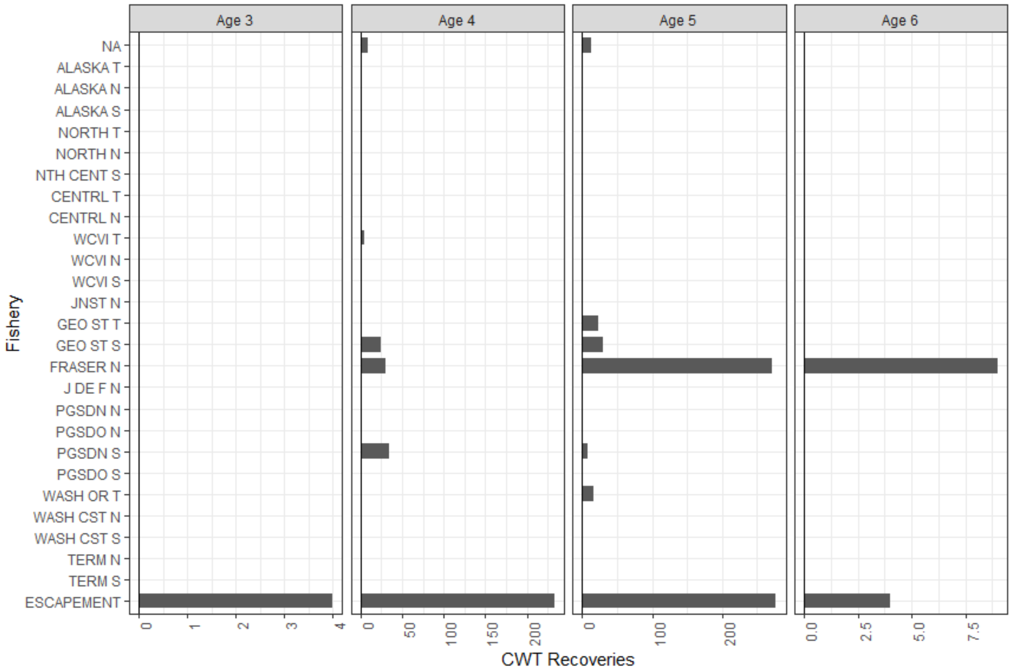

Figure 59—Base period coded-wire tag recoveries for the Fraser Spring 1.3 (FS3) stock group)

4.12.1.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

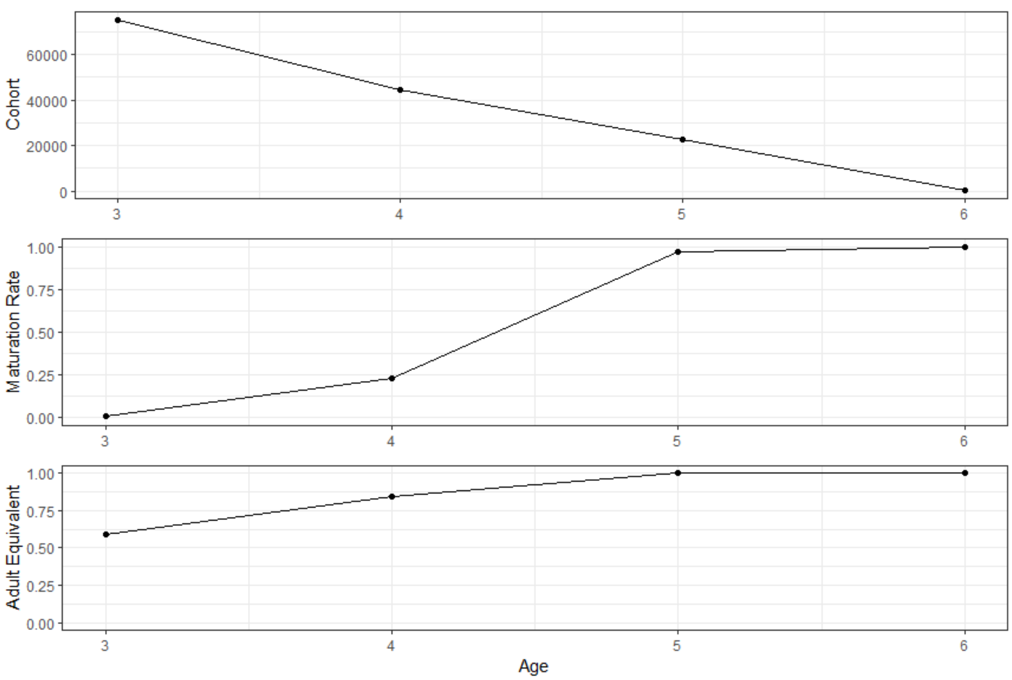

Figure 60—Base period cohort size, maturation schedule, and adult equivalent for the Fraser Spring 1.3 (FS3) stock group.

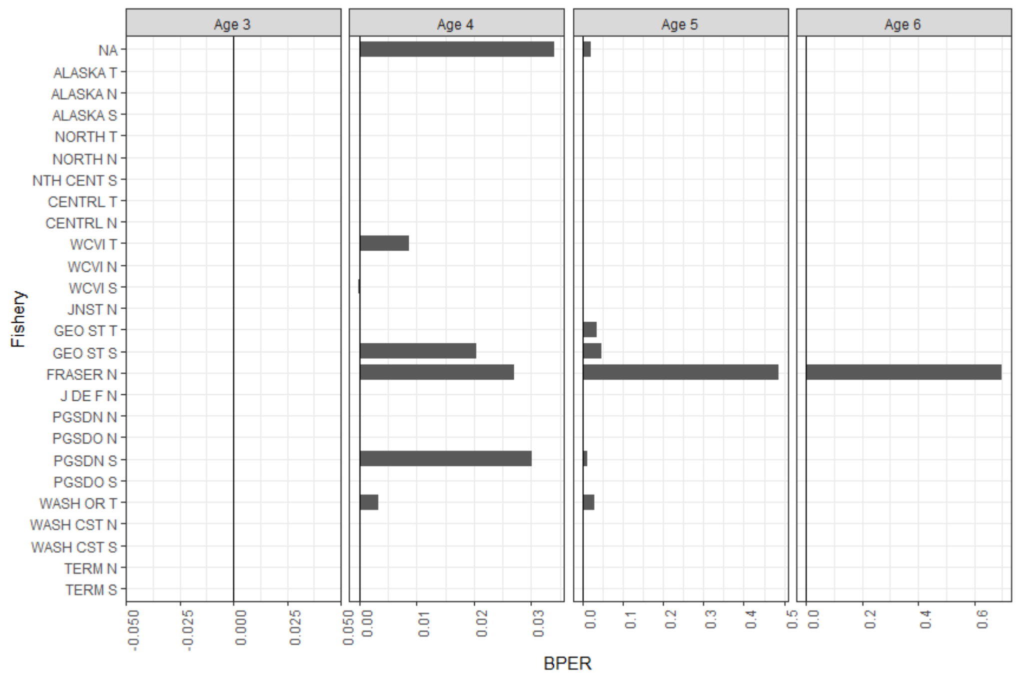

Figure 61—Base period exploitation rate by fishery for the Fraser Spring 1.3 (FS3) stock group.

4.12.1.4 Escapement/Terminal Run Time Series

The Chinook model was set to calibrate to the terminal run for the FS3 stock group because of concerns about the effect of the uncertainty in the impacts of terminal fisheries on this stock and a lack of a comprehensive biological sampling program for spawner escapements. There were mark-recapture studies conducted on the upper Fraser River, near Tete Juane Cache, in 1983, 1984 and 1985, and these data should be examined further for the potential to use this information to calibrate the escapement time series for that location.

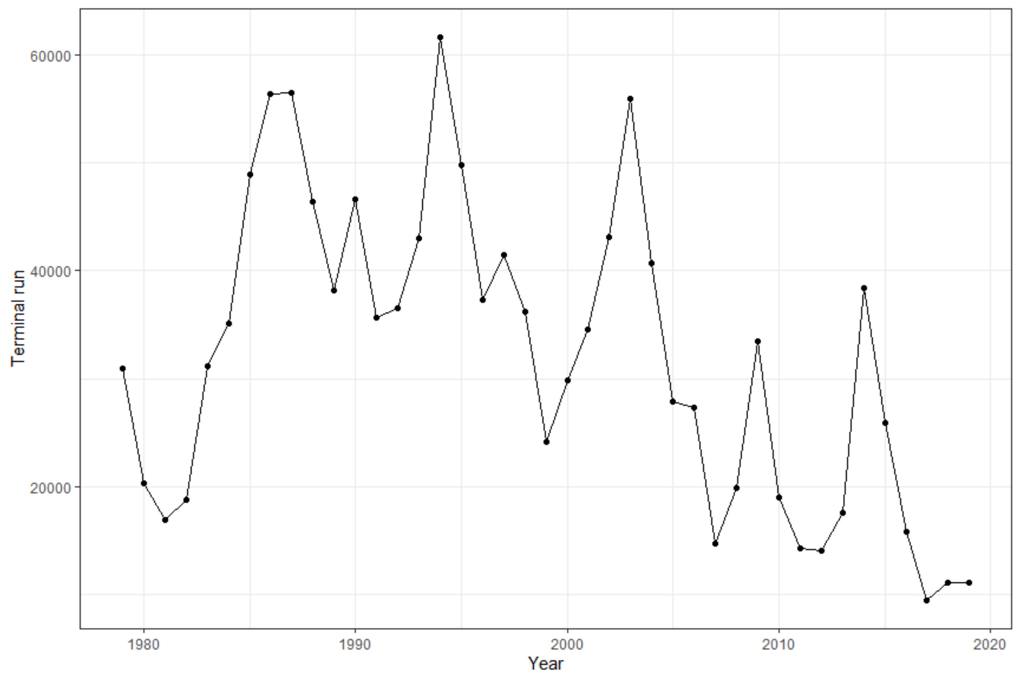

Figure 62—Terminal run size for the Fraser Spring 1.3 (FS3) stock group.

4.12.1.5 Ricker Parameters

The Ricker SR parameters were generated using the habitat model (Parken et al. 2006) for each of the biological stocks, with an adjustment for assumed difference between index escapement estimates and total escapement based on calibration studies at the Lower Chilcotin River. These stock units can be aggregations of the stocks in Table 26, when there are demographic connections between the fish spawning in different locations, such as when there are fish spawning in tributaries and the main river in a watershed. The stock unit estimates of S_{msy} and S_{rep} were added together for an 'all combined' estimate and then the Ricker SR estimates were calculated using the Hilborn (1985) approximation equations. The SR data have not been collected to directly measure the recruitment dynamics for the FS3 stock group. More comprehensive spawner escapement estimation programs that involve the collection of age data and development of unbiased, estimates of total escapement and estimates of ER by age could help to improve the representation of the FS3 stock group. There is more recent SR parameter information from the habitat model and the calibration studies that can be used at the next iteration of the base period calibration.

Table 29—Source of Ricker stock-recruitment parameters used as initial values in the base period Model calibration.

	River System							
Estimate	**Birkenhead**	**Upper Fraser Spring Timing**	**Westroad, Baker, Naver, Narcosli, Cottonwood**	**Chilcotin (upper & lower)**	**Horsefly**	**Chilako**	**Bridge**	**Endako**
S_{msy}*	1,609	30,193	11,972	4,373	1,666	4,245	1,332	2,116
S_{rep}*	4,232	80,694	32,243	11640	4,384	11,294	3,496	5,584
S_{msy}/S_{rep}	0.380	0.374	0.371	0.376	0.380	0.376	0.381	0.379
log(alpha)*	1.711	1.798	1.838	1.776	1.714	1.773	1.700	1.729
alpha	5.537	6.035	6.287	5.906	5.551	5.891	5.473	5.637
U_{msy}	0.65	0.67	0.68	0.67	0.65	0.67	0.65	0.66
Beta	0.000404407	0.00002228	0.00005702	0.000152568	0.000391	0.000157	0.000486	0.00031
R_{max}	5,037	99,666	40,563	14,240	5,223	13,801	4,141	6,696

Table 30—Source of Ricker stock-recruitment parameters used as initial values in the base period model calibration for all rivers in the Fraser Spring 1.3 model stock.

	All Rivers Combined	
Estimate	**Raw**	**Adjusted**
S_{msy}*	61,422	50,346
S_{rep}*	163,892	134,338
S_{msy}/S_{rep}	0.375	0.375
log(alpha)*	1.789	1.789
Alpha*	5.983	5.983
U_{msy}	0.67	0.67
Beta	1.09156E-05	1.33171E-05
R_{max}	201,652	165,289

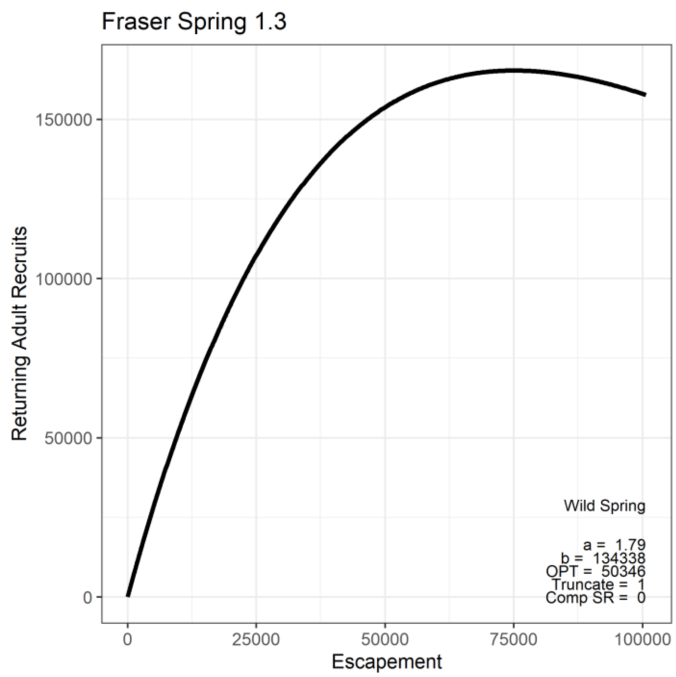

Figure 63—Ricker curve and parameters for Fraser Spring 1.3 (FS3) model stock.

4.12.2 Comparison of Model Performance

Many improvements were made to the model and the calibration inputs during the Phase II model calibration. To examine the effect of these improvements, comparisons were made to independent estimates of cohort sizes by age, brood year ERs, and the model's performance for fitting to the terminal run/escapement.

4.12.2.1 Cohorts

For the FS3 stock group, cohort sizes could not be estimated independently because the terminal run and escapement estimates are not generated by age, because of intermittent age sampling at all locations, except recently at the Chilcotin River. Escapements to the Chilcotin River are estimated by age, but the other spawning locations are not surveyed annually to estimate the age composition. A new sampling program would be necessary to collect biological samples (i.e., age, sex, length, stray CWTs) to estimate the age composition of the stock group.

4.12.2.2 Exploitation Rates

Based on a comparison of the model and CWT-based ERs, the model tends to produce higher ERs for ocean fisheries than the CWT estimates, but it has the opposite pattern when the freshwater fisheries are included. A comparison of the different patterns for the freshwater fisheries for FS2 and FS3 suggests that the model may be overestimating the freshwater fishery impacts on FS2 and underestimating the impacts on FS3. This may suggest that there are errors in the FP scalars for the terminal fisheries which are derived from the Fraser Run Reconstruction model (English et al. 2007). The Run Reconstruction model does not account for any difference in the size and age composition of stocks, and it may be helpful to further examine that model's representation of the Fraser stocks, and identify if any improvements are needed. For example, freshwater sport fisheries have had size slot limits that were intended to produce differential impacts on some stocks, and these management regulations are not represented in the Run Reconstruction model. It may be helpful to further examine the Run Reconstruction model performance and the FP time series when more CWT data are available from the Chilcotin ERIS.

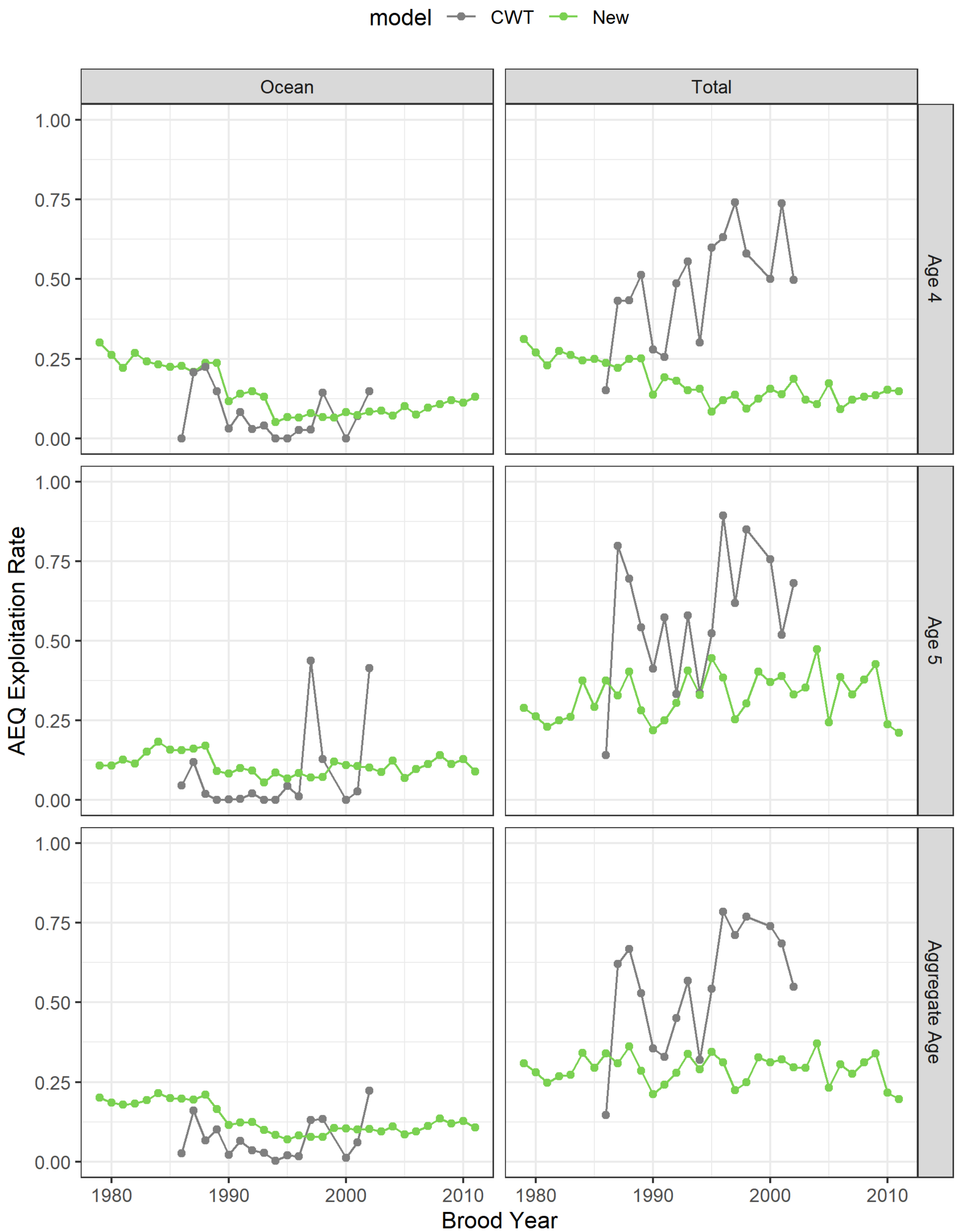

Figure 64—Adult equivalent (AEQ) exploitation rates using the PSC Chinook Model and coded wire tag recovery estimates for the age-4, age-5, and aggregate age Fraser Spring 1.3 (FS3) stock group for ocean fisheries and total fisheries (including terminal).

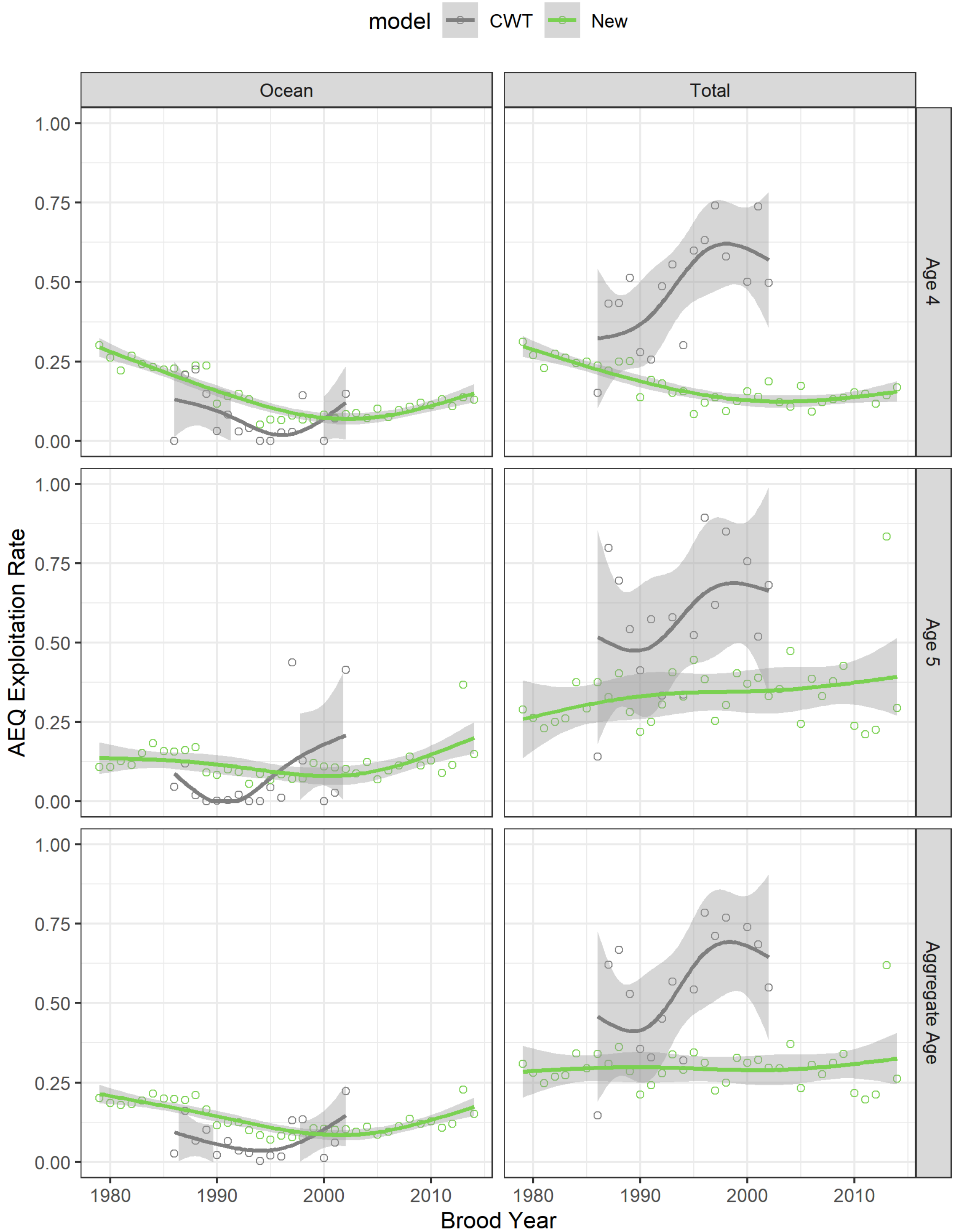

Figure 65—Adult equivalent (AEQ) exploitation rates with a smoothing function using the PSC Chinook Model and coded wire tag recovery estimates for the age-4, age-5, and aggregate age Fraser Spring 1.3 (FS3) stock group for ocean fisheries and total fisheries (including terminal).

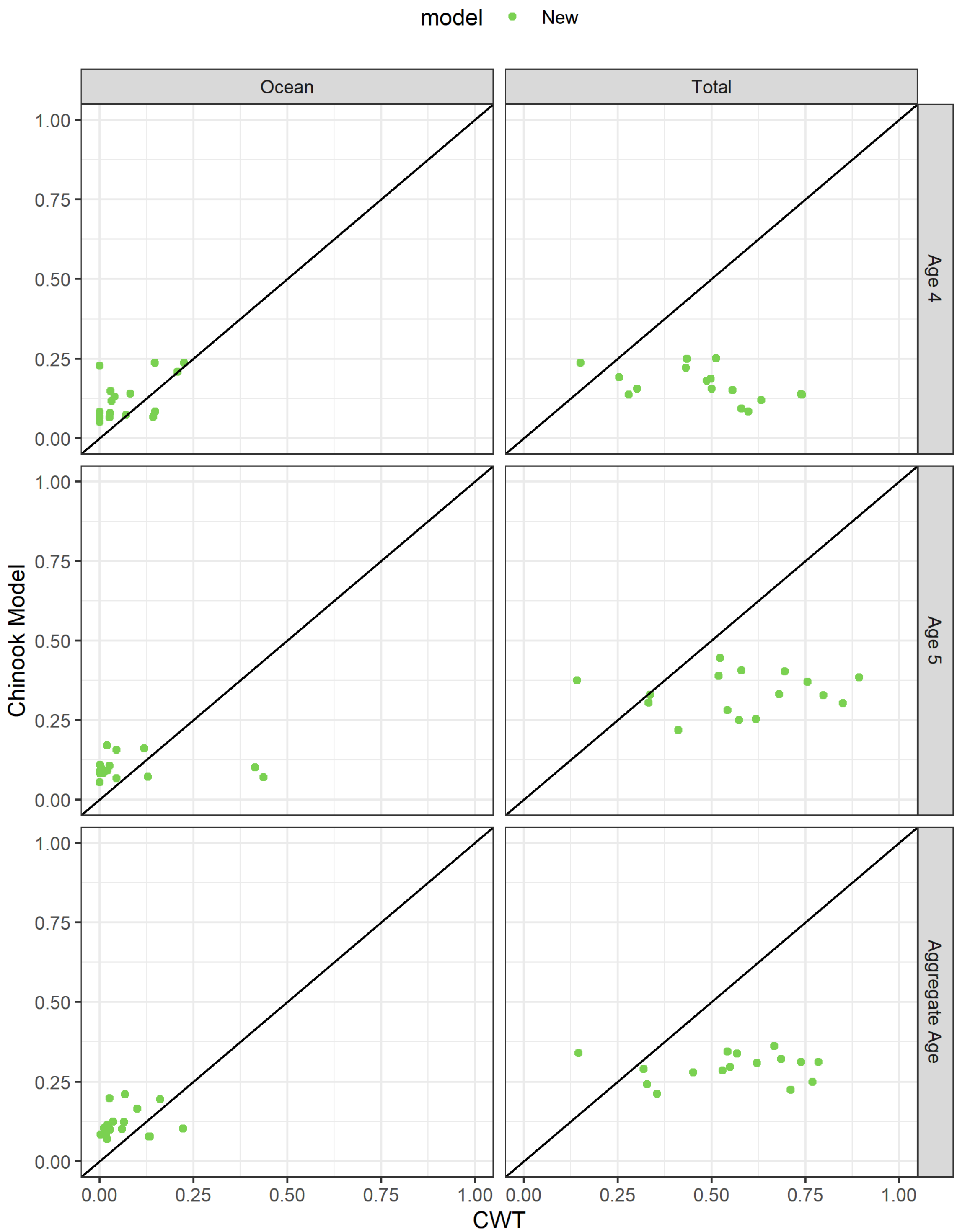

Figure 66—Relationship between exploitation rates from coded wire tag recovery estimates and from the PSC Chinook Model for the Fraser Spring 1.3 (FS3) stock group.

4.12.2.3 Model Fit to Terminal Run/Escapement

Figure 58 indicates the relative performance of two versions of the new Chinook model (green is intermediate and blue is final) is quite good for the FS3 stock group. The model predictions have a very slight positive bias.

4.13 Fraser Early (FRE): Fraser Ocean-type 0.3 (FSO)

4.13.1 Stock Description

The stock group spawns in six rivers in the Thompson River area and one river in the lower Fraser River area, and it can have high abundance and contributions to fisheries ranging from Southeast Alaska to the Fraser River. The stock has an ocean-type life history and matures from ages 2 to 5, and these summer-run populations return to the Fraser River mouth from late June through mid-September (Parken et al. 2008). Hatchery production has varied through the time series, but production has been most consistent at the Middle and Lower Shuswap rivers, with intermittent hatchery production at Maria Slough (Lower Fraser). There is a long time series of CWT data from the Lower Shuswap River, beginning with wild fish tagged from BY 1978. The Lower Thompson River population has relatively poor quality escapement data based on redd counts, which are excluded from the escapement time series due to many years without estimates and concerns about the reliability of the redd-based estimates. During the mid-2000s, a new escapement method (Driver Stock Ratio; DSR) was developed and applied to estimate the total escapement of the stock group (PSC 2018). Since then the method has been applied annually, with refinements to the study design to improve accuracy and estimation of the uncertainty, and a new, calibrated time series may be available for future base period calibrations. The Chinook Model performance may be improved when the calibrated time series can be used because this stock has larger abundance relative to many others in the Chinook Model.

4.13.2 Description of Changes

The escapement time series were reviewed for each of the six rivers. Since the last base period calibration (9806), historic data were rescued from government archives and spawner escapements were estimated using mark recapture methods from 1982-1985 for the Lower Shuswap River. Also, the historic escapement time series were calibrated using paired mark recapture and peak count salmon escapement estimates for the Middle and Lower Shuswap rivers (PSC 2018). There were no changes to the rivers included in the escapement series.

The terminal run was estimated for this stock using the stock-specific catch estimates from the Fraser River Run Reconstruction model (English et al. 2007) and the escapement data. The escapements have been estimated by age for the stock group recently due to application of the DSR method, which has enabled model calibration to the escapements by age for the years that have escapement estimates by age, which are reported in the FCS file.

The CWT statistics are from the Lower Shuswap exploitation rate indicator stock. Previously, this stock group was represented by the Lower Shuswap and Chilko CWTs. The Chilko has a different ocean distribution and maturation pattern since it is a stream type life history. Since the calibration 9806, CWT data were also analyzed for the Middle Shuswap stock to implement the DSR escapement method. Although two ERIS stocks are monitored, the Lower Shuswap stock has higher quality data and a longer time series, thus it is considered more representative of the total stock group. Note that CWT data have been assembled for nearly all of the lower Shuswap cohorts, however some cohorts did not have escapement CWT sampling, but it may be possible to impute the escapement CWTs for the incomplete cohorts using assumptions about the maturation rates and the fishery CWT recovery data. This is something to consider for future work.

Table 31—Escapement data used for the Fraser Summer Ocean-type 0.3 (FSO) stock group for the base period Model calibration.

Model Stock Name	**Fraser Summer Ocean-type 0.3**
Model Stock	FSO
Identification Number	9
CWT Indicator Stock	SHU
1975–1978 Pre-base Average	25,428
1979–1982 Base Period Average	15,762
Year	**Estimate**
1975	43,188
1976	5,958
1977	27,962
1978	24,605
1979	26,517
1980	10,649
1981	17,589
1982	8,294

Table 32—River systems comprising the Fraser Summer Ocean-type 0.3 (FSO) stock group.

Stocks Common to Phase II & 9806 Model	**New Stocks Added to Phase II Model**	**Former Stocks Removed from Phase II Model**
Adams R (Lower)	None	None
Little R		
Maria Slough		
Shuswap R (Lower)		
Shuswap R (Middle)		
South Thompson R		

4.13.2.1 MDL File Settings

See section 4.10.2.1 for details.

4.13.2.2 Base period CWT recoveries

Since the 1998 base period calibration, CWT data were improved for terminal fisheries and escapements. For terminal fisheries, the catches in the mainstem Fraser freshwater net fisheries were not sampled historically, but because catches were substantial, they were combined with the catches in the freshwater commercial net fisheries, and then the CWT recoveries were estimated to represent the impacts of the combined fisheries. This indirect method can be refined in the future to enable the freshwater net imputed CWTs to be identified specifically for that fishery. Also, for calibration 9806 the Freshwater Sport fisheries had CWT recoveries estimated indirectly using the average submission rates for the Southern B.C. ocean fisheries, however the actual creel survey catch estimates for the Freshwater Sport fisheries were assembled and used to directly calculate the CWT sampling rates and estimate CWT recoveries. Although this is an improvement over previous data, there are more opportunities to refine the information to better represent terminal fisheries. For the escapement CWTs, the rescued historical data were used to generate mark-recapture escapement estimates using the current methods and tools, and then the CWT recoveries were estimated using these new CWT sample rates.

For the base period, the largest number of tag recoveries were often in the SEAK and NBC AABM troll fisheries, and there were recoveries in numerous ISBM fisheries, but relatively few in the WCVI AABM troll fishery.

Table 33—Summary of Lower Shuswap River Summer (SHU) CWT releases used for base period calibration and recoveries in escapement and PST fisheries.

				Recoveries in Canada						Recoveries in U.S.				
				AABM		ISBM		Escapement		AABM	ISBM		Esc	Grand
Brood	**CWT**	**Tagged**	**Untagged**	**NBC**	**WCVI**	**Marine**	**Fresh**	**Esc**	**Strays**	**SEAK**	**Marine**	**Fresh**	**Strays**	**Total**
1978	021625	122797	1125	74	24	96	5	161	0	104	37	6	0	507
	021638	18705	118	12	0	22	0	23	0	15	6	0	0	78
Total		**141502**	**1243**	**86**	**24**	**118**	**5**	**184**	**0**	**119**	**43**	**6**	**0**	**585**
1979	021601	45440	1200	22	0	63	0	44	0	38	6	0	0	173
	021755	12402	283	7	0	15	0	2	0	9	0	0	0	33
Total		**57842**	**1483**	**29**	**0**	**78**	**0**	**46**	**0**	**47**	**6**	**0**	**0**	**206**
1984	023054	51470	15541	88	37	227	76	815	0	90	19	0	0	1352
	023055	48721	3148	115	42	148	22	747	6	52	28	3	0	1163
	023421	16725	4131	18	8	38	3	185	0	12	0	0	0	264
Total		**116916**	**22820**	**221**	**87**	**413**	**101**	**1747**	**6**	**154**	**47**	**3**	**0**	**2779**
1985	023548	20568	5157	25	2	49	0	176	0	15	7	0	0	274
	023549	20829	4843	8	9	59	14	233	0	7	2	0	0	332
	023552	20735	6389	33	6	57	0	221	2	55	11	3	0	388
	023553	20764	6397	21	6	52	3	207	6	18	9	8	0	330
Total		**82896**	**22786**	**87**	**23**	**217**	**17**	**837**	**8**	**95**	**29**	**11**	**0**	**1324**
1986	024316	51771	500229	122	14	68	56	256	2	123	5	0	0	646
	024610	49392	512508	151	75	73	82	325	6	226	5	0	0	943
Total		**101163**	**1012737**	**273**	**89**	**141**	**138**	**581**	**8**	**349**	**10**	**0**	**0**	**1589**

Table 34—Summary of estimated CWTs in fisheries and escapements by brood for SHU tag codes selected to represent the Fraser Summer Ocean-type 0.3 stock in the Phase II Model base period calibration.

Brood Year	Recovery Location	Age 2	Age 3	Age 4	Age 5	Age 6	Total
1978	marine	37	27	287	39	--	390
	freshwater	0	2	9	0	--	11
	escapement	30	82	55	17	--	184
	escapement stray	0	0	0	0	--	0
1979	marine	10	13	95	42	--	160
	freshwater	0	0	0	0	--	0
	escapement	6	3	13	24	--	46
	escapement stray	0	0	0	0	--	0
1984	marine	96	213	570	43	--	922
	freshwater	0	48	48	8	--	104
	escapement	104	293	1170	180	--	1747
	escapement stray	0	1	5	0	--	6
1985	marine	17	71	321	42	--	451
	freshwater	0	4	21	3	--	28
	escapement	4	84	727	22	--	837
	escapement stray	1	0	0	7	--	8
1986	marine	5	81	658	118	--	862
	freshwater	0	5	107	26	--	138
	escapement	75	185	291	30	--	581
	escapement stray	0	0	7	1	--	8
Grand Total	**All Locations**	**385**	**1112**	**4384**	**602**	--	**6483**

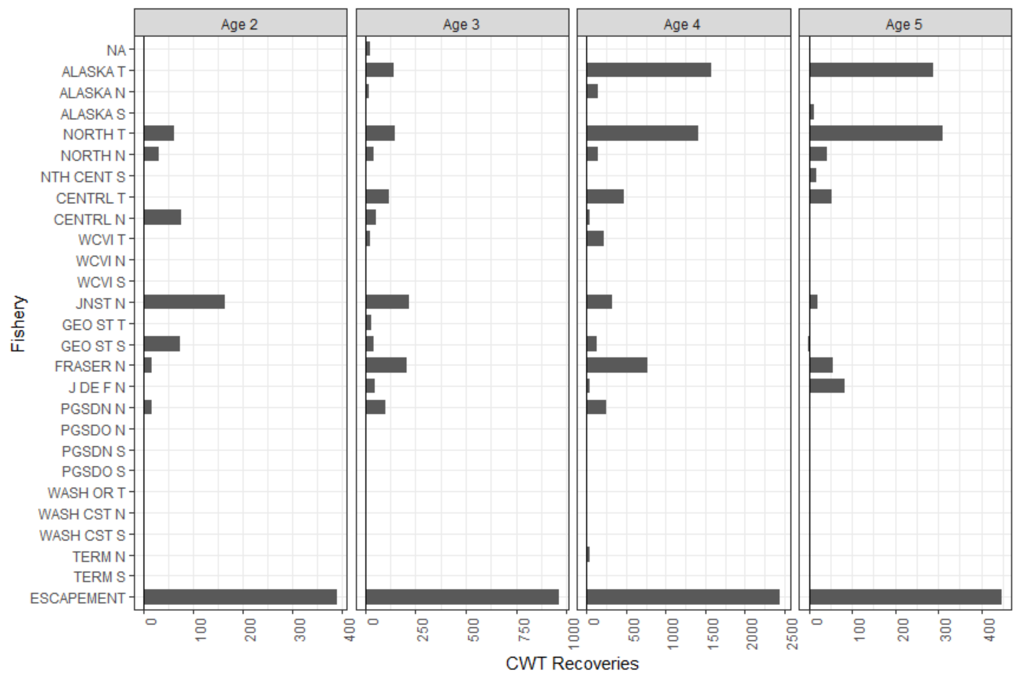

Figure 67—Base period coded-wire tag (CWT) recoveries for Fraser Ocean-type 0.3.

4.13.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

In general, the SHU tag codes had recoveries in most of the fisheries that have been observed to harvest the stock based on data patterns for many cohorts (e.g., 1988–2018). For the stock maturation pattern, differences in the maturation schedule have been identified between the Lower Shuswap ERIS and the rivers in the South Thompson Conservation Unit (SALT: South Thompson, Lower Adams, Little and Lower Thompson; PSC 2018). The Sentinel Stocks Program identified that the SALT appears to have a higher component of the cohort maturing at age-5 than other rivers in the stock group, which is indicated by the lower stock aggregate cohort evaluation (SACE) maturation rates for ages 3 and 4 relative to that the SHU ERIS CWT-based maturation rate (Figure 68). Note that many cohorts did not have escapement age sampling to directly calculate the SACE maturation rates, thus they were estimated using a non-linear model which leads to the pattern in Figure 68. Currently, at Maria Slough there are plans to estimate spawning escapement using mark-recapture methods and to apply and recover CWTs in order to examine the representativeness of the SHU ERIS.

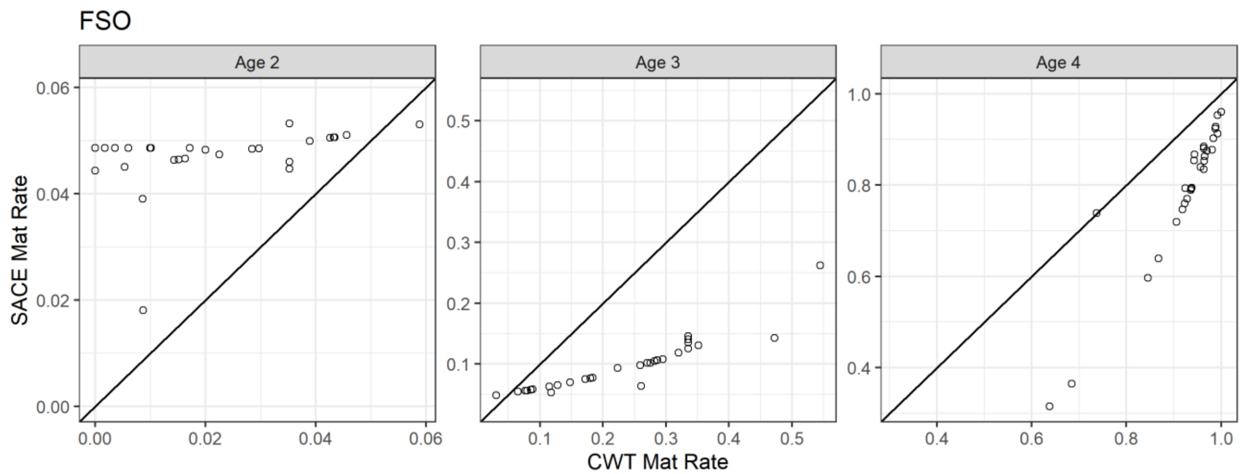

Figure 68—Maturation rate comparison between the Lower Shuswap exploitation rate indicator stock (x-axis) and the stock aggregate cohort evaluation (SACE) of rivers in the South Thompson Conservation Unit (y-axis).

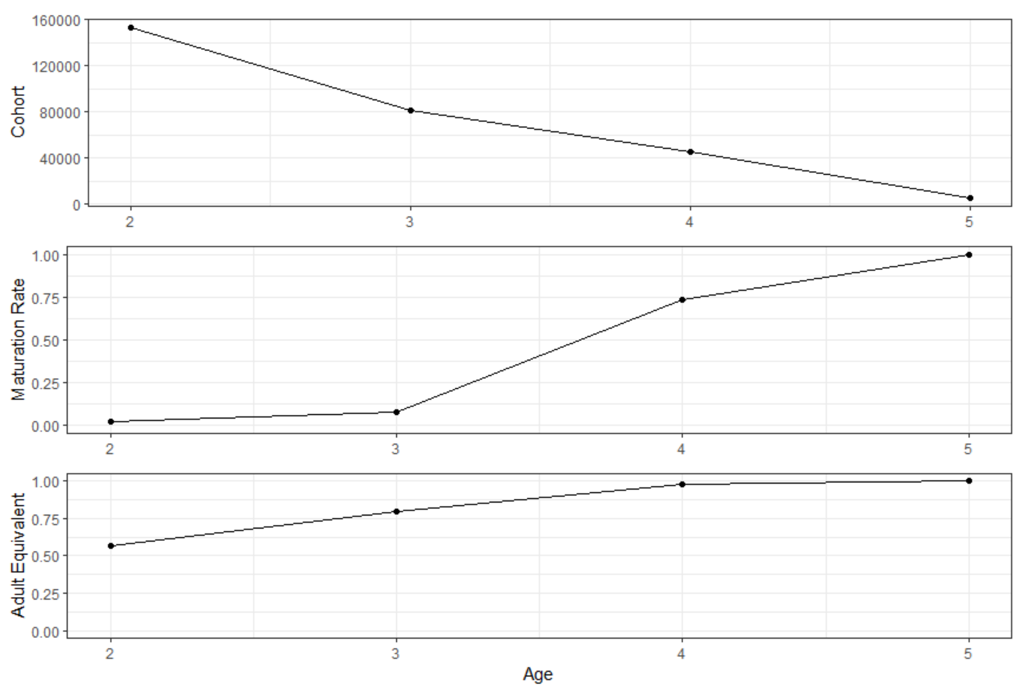

Figure 69—Base period cohort size, maturation schedule, and adult equivalent for Fraser Ocean-type 0.3.

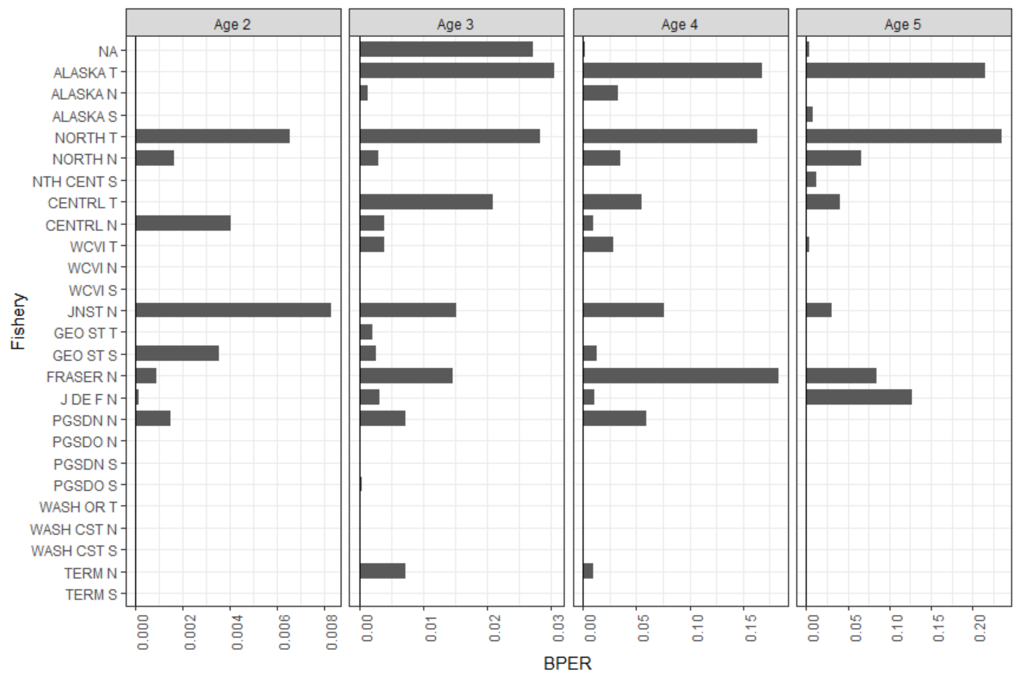

Figure 70—Base period exploitation rate by fishery for Fraser Ocean-type 0.3.

4.13.2.4 Escapement/Terminal Run Time Series

The Chinook model was set to calibrate to the escapement for this stock because these data are of relatively higher quality, since two of the rivers have escapements that have been calibrated to mark-recapture estimates and age samples are available for some of the years. Also, there are programs underway to estimate the total escapement by age for the stock group, and to conduct a mark-recapture program at Maria Slough and calibrate the historic escapement time series.

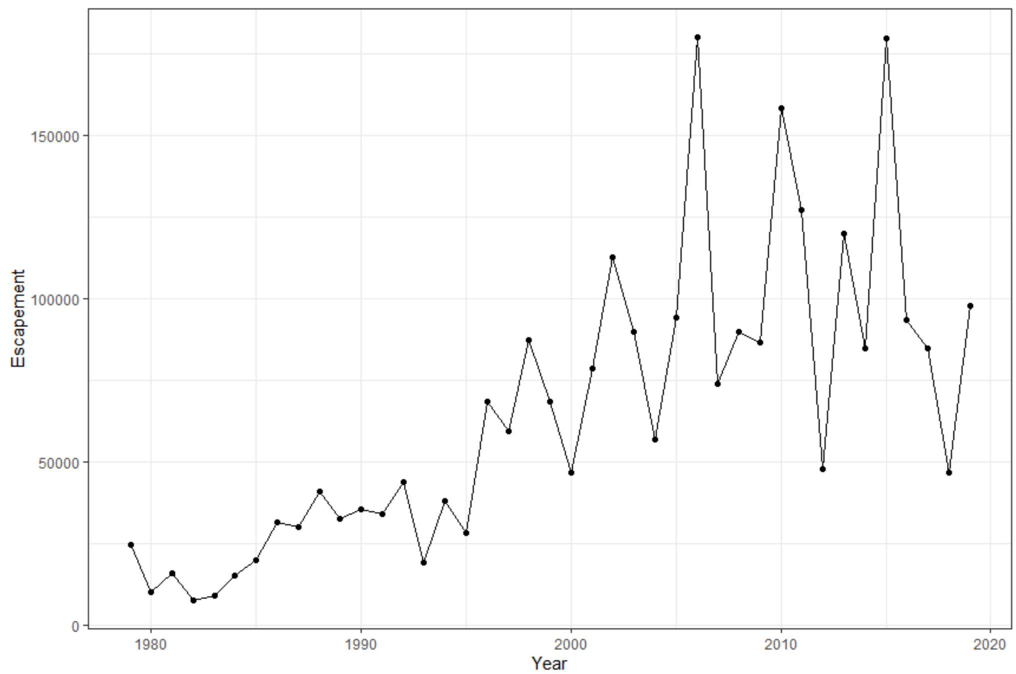

Figure 71—Escapement for Fraser Ocean-type 0.3.

4.13.2.5 Ricker Parameters

The Ricker stock recruitment parameters were generated using the habitat model (Parken et al. 2006) for each of the stock units. The river-specific stock estimates of S_{msy} and S_{rep} were added together for an 'all combined' estimate and then the Ricker stock-recruitment estimates were calculated using the Hilborn (1985) approximation equations. Stock-recruitment data have not been collected to directly measure the recruitment dynamics for this stock group, but there may be sufficient data for stock-recruitment analysis of the Lower Shuswap River population in the future. More comprehensive spawner escapement estimation programs that involve the collection of age data and development of unbiased, estimates of total escapement and estimates of exploitation rate by age could help to improve the representation of this stock.

Table 35—Source of the Ricker stock-recruitment parameters used as initial values for FSO in the base period Model calibration.

	River System				
Estimate	Maria	Middle Shuswap	Lower Shuswap	South Thompson, Little River, Lower Adams	**All Rivers Combined**
Smsy*	235	3,485	12,339	47,813	63,637
Srep*	770	12,339	34,726	127,707	174,772
Smsy/Srep	0.305	0.282	0.355	0.374	0.364

	River System				
Estimate	Maria	Middle Shuswap	Lower Shuswap	South Thompson, Little River, Lower Adams	**All Rivers Combined**
log(alpha)*	2.783	3.108	2.067	1.794	1.941
alpha	16.166	22.377	7.899	6.016	6.967
Umsy	0.85	0.88	0.73	0.67	0.71
Beta	0.003614197	0.000251887	5.95171E-05	1.40505E-05	1.11072E-05
Rmax	1,646	32,681	48,827	157,503	230,762

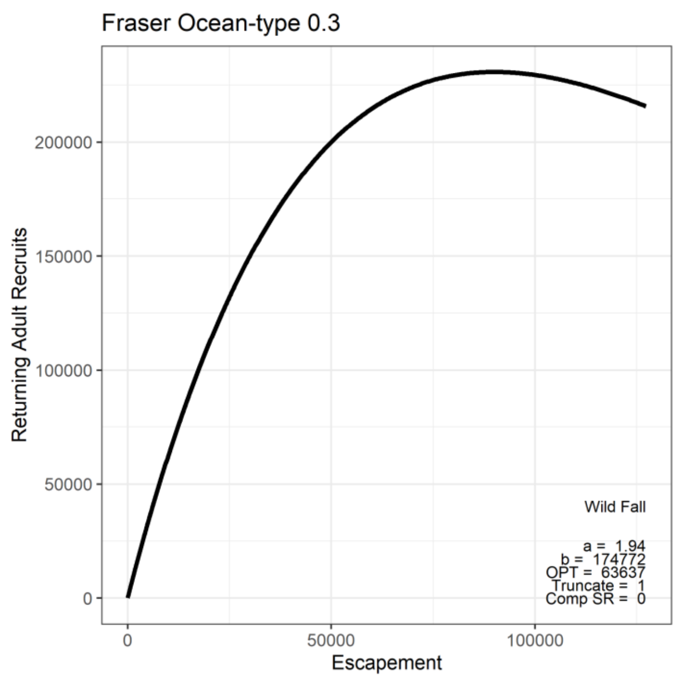

Figure 72—Ricker curve and parameters for Fraser Ocean-type 0.3 (FSO)model stock.

4.13.3 Comparison of Model Performance

Many improvements were made to the model and the calibration inputs during the course of phase II of the base period calibration. To examine the effect of these improvements, comparisons were made to independent estimates of cohort sizes by age, brood year exploitation rates, and the model's performance for fitting to the terminal run/escapement.

4.13.3.1 Cohorts

For the FSO stock group, cohort sizes were estimated independently for a small number of cohorts that had sufficient escapement age sampling. These SACE maturation rates, labeled CWT-FCS on Figure 73 and Figure 74, corresponded considerably well to those that were estimated by the new model. Ages 3 and 4 were centered around the 1:1 reference line, whereas for age 2 the new model cohort sizes were generally higher than those estimated from the SACE method, and for age-5 the new model cohort sizes were somewhat lower than those from the SACE method (Figure 73). Overall, the new model appeared to estimate the temporal pattern of the cohort sizes fairly well relative to those developed using escapement and CWT data (Figure 74).

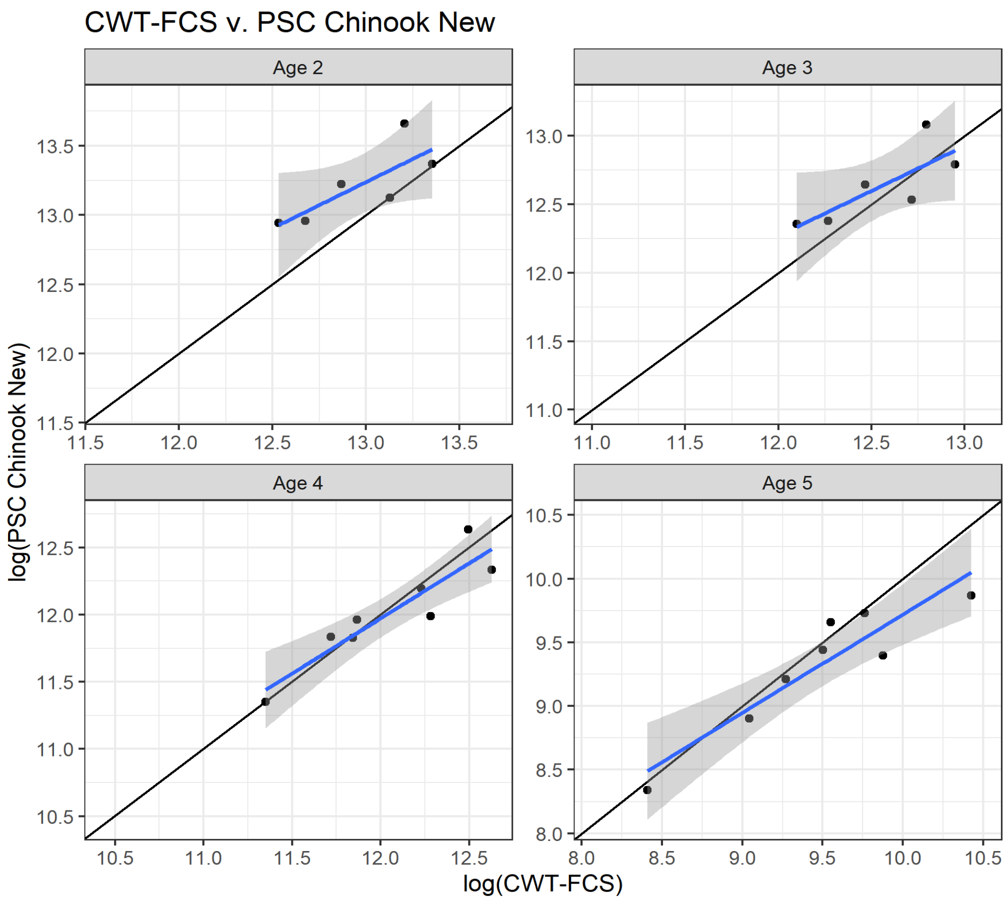

Figure 73—Comparison of cohort sizes estimated using the CWT FCS files and the Phase II PSC Chinook Model for Fraser Ocean-type 0.3.

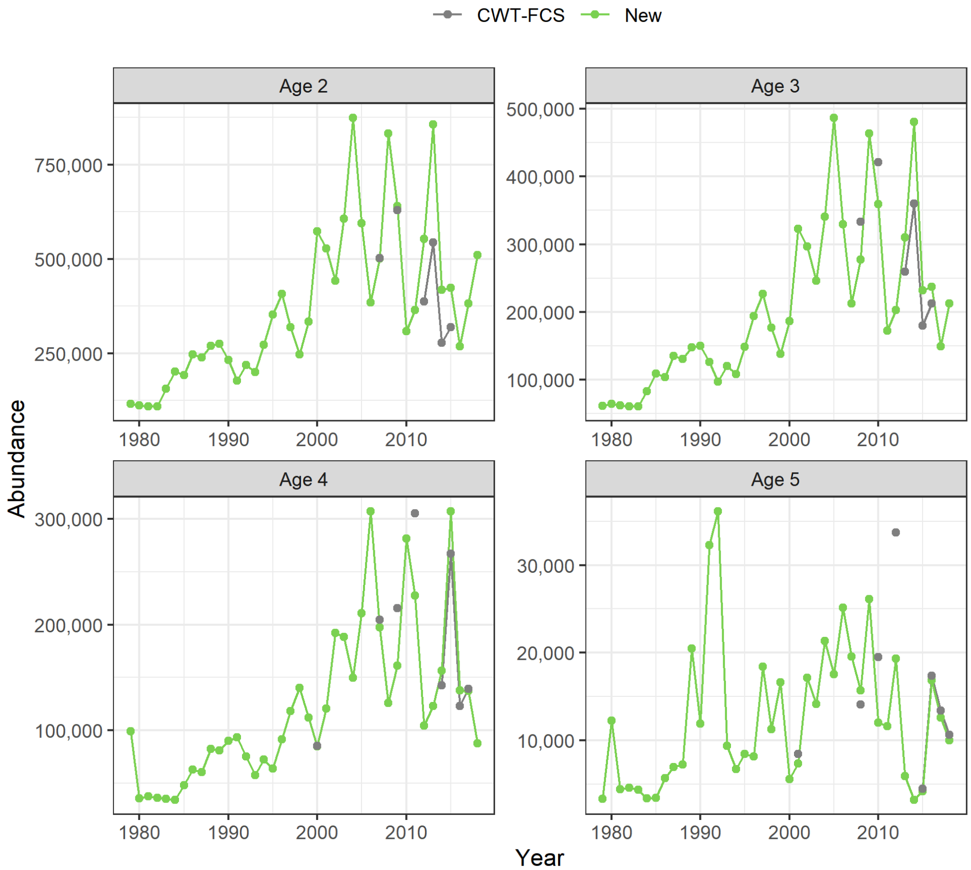

Figure 74—Time series comparisons of cohort size abundance estimated using the CWT FCS files and the Phase II PSC Chinook Model for Fraser Ocean-type 0.3.

4.13.3.2 Exploitation Rates

Based on a comparison of the model and CWT-based exploitation rates, the new model represents the ocean fisheries very well relative to the exploitation rates measured from the SHU ERIS CWT data. In comparison, the new model underestimates the terminal fishery exploitation rates compared the ERIS data. As aforementioned for the Fraser spring stocks, this may indicate errors in the FP scalars for the terminal fisheries which are derived from the Fraser Run Reconstruction model (English et al. 2007). The new model appears to do fairly well representing the temporal pattern exploitation rates for age-3, and very well representing the rates for ages 4 and 5 when compared to the ERIS data. Given the large abundance of this stock and its contributions to many PSC fisheries, the new model appears to be considerably improved in terms of its representation of this component of the Chinook resource.

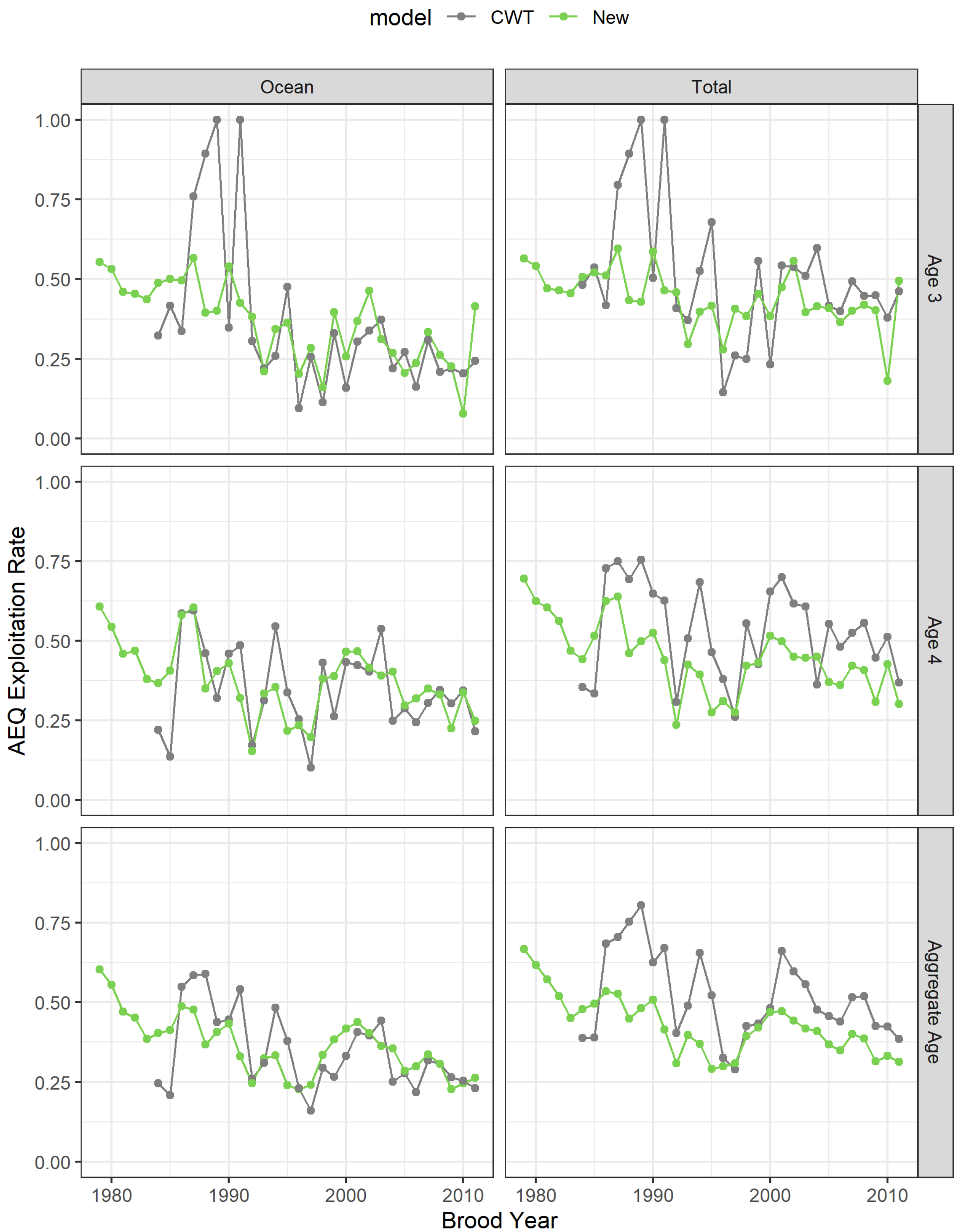

Figure 75—Adult equivalent (AEQ) exploitation rates using the PSC Chinook Model and coded-wire tag recovery estimates for the age-4, age-5, and aggregate age Fraser Ocean-type 0.3 (FSO) stock group for ocean fisheries and total fisheries (including terminal).

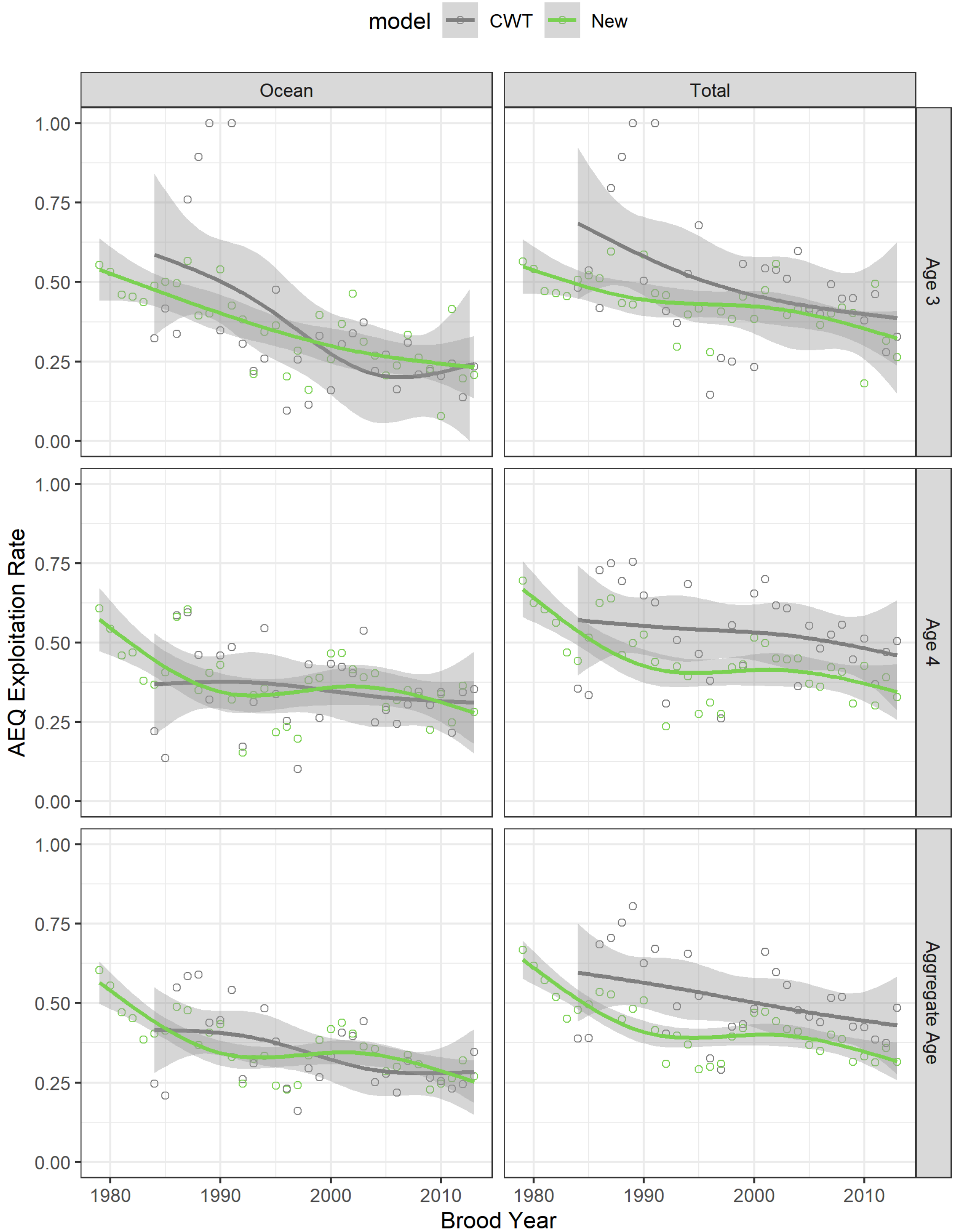

Figure 76—Adult equivalent (AEQ) exploitation rates with a smoothing function using the PSC Chinook Model and coded-wire tag recovery estimates for the age-4, age-5, and aggregate age Fraser Ocean-type 0.3 (FSO) stock group for ocean fisheries and total fisheries (including terminal).

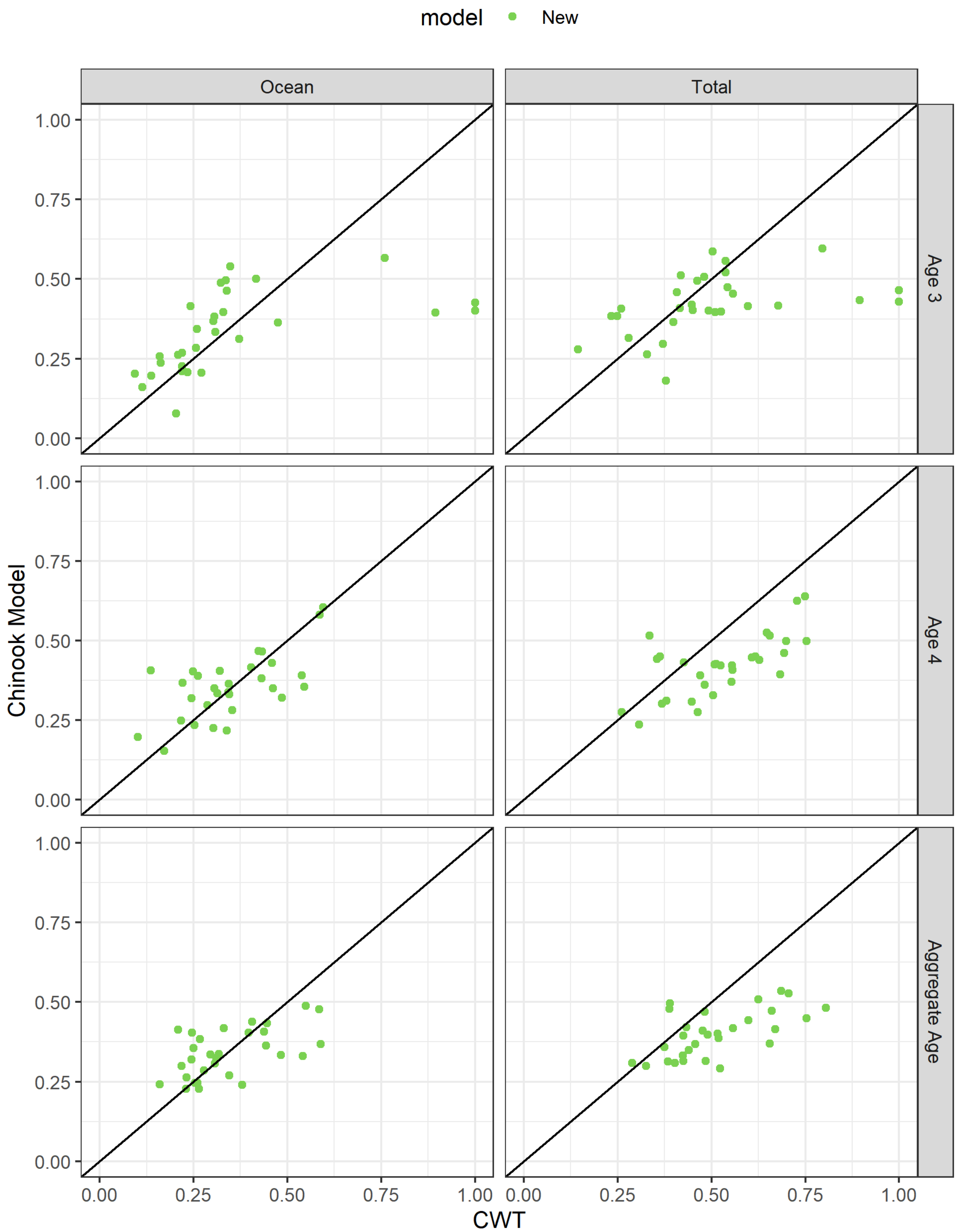

Figure 77—Relationship between exploitation rates from coded-wire tag recovery estimates and from the PSC Chinook Model for the Fraser Ocean-type 0.3 (FSO) stock group.

4.13.3.3 Model Fit to Terminal Run/Escapement

Figure 58 indicates the relative performance of two versions of the new Chinook model (green is intermediate and blue is final) for the FSO stock group. The blue shaded box plot represents the version of the new Chinook model where the SACE method was applied, which enabled the model to perform better for estimating the spawning escapement, as indicated by the smaller box plot distribution and the median value is closer to 1.

4.14 Fraser Early (FRE): Fraser Summer Stream-type 1.3 (FSS)

4.14.1 Stock Description

This stock group spawns in several larger rivers, including several that are downstream of large lakes in the Middle Fraser, Lower Fraser, and North Thompson areas. Nearly all of these stocks are summer-run, with peak migrations occurring during June through August, with the Quesnel stock having some migration in September and Portage, a fall-run stock, having a peak migration into the Fraser River during September (Parken et al. 2008). The Nechako River population is downstream of a large dam that has diverted a substantial amount of the river discharge out of the Fraser River watershed and through a tunnel to the Kemano River on the B.C. North Coast. The production dynamics of the regulated Nechako River have often differed considerably from those in unregulated rivers in the middle and upper Fraser Rivers (Bradford 1994).

Many of the populations in the FSS stock group have had some hatchery enhancement and CWT application, but escapement estimation and CWT sampling were insufficient to develop an ERIS stock. Recently, the Chilko River is being developed as an ERIS and this stock also had a wild fish CWT program to represent the base period exploitation and maturation rate characteristics for the FSS stock. There were CWTs applied to wild Chilko fry for BY 1977 (150,000) and BY 1978 (200,000), along with tagging hatchery smolts during the 1980s and 1990s. The stock group contributes to fisheries from age-3 to age-6, with most CWT recoveries at age-5 from hatchery-origin fish. Scale age data are limited from this stock group.

Table 36—Escapement data used for the Fraser Summer Stream-type 1.3 stock (FSS) for the base period Model calibration

Model Stock Name	Fraser Summer Stream-type 1.3
Model Stock	FSS
Identification Number	10
CWT Indicator Stock	CKO
1975–1978 Pre-base Average	14,046
1979–1982 Base Period Average	10,228
Year	**Estimate**
1975	15,285
1976	10,974
1977	14,515
1978	15,410
1979	8,125
1980	10,975
1981	9,868
1982	11,943

4.14.2 Description of Changes

The escapement time series were reviewed for each of the rivers in the FSS stock group, and three new locations were added, and four rivers were removed from the stock group for various reasons (Table 37). The North Thompson River is glacially turbid, and Chinook spawners cannot be counted using visual surveys, except at locations where clear river tributaries improve water clarity (e.g., Finn Creek confluence). The Stuart River frequently has very poor visibility due to wave erosion of the shoreline near the outlet of Stuart Lake, which causes the entire river to become turbid. These conditions vary among years depending on the weather, and the relative changes in estimated spawners is likely more affected by changes in weather and the water clarity than changes in the Chinook abundance. The Stellako Chinook numbers have declined to less than 10 per year based on anecdotal reports, and the stream is not surveyed annually. The Seton River flows from the Seton Dam for a few kilometers to the Fraser, but the river is not surveyed annually for Chinook spawners. Small numbers of Chinook spawn in the Seton and the Cayoosh Creek tributary, however there is very little spawning habitat remaining in the system due to high water scour events and the construction of the dam at the outlet of Seton Lake, which was likely the main spawning area prior to dam construction. The time series of escapement estimates for the Chilko River have been calibrated to estimates of total escapement, estimated from the mark recapture program which began in 2010 (PSC 2018).

The terminal run was estimated for this stock using the stock-specific catch estimates from the Fraser River Run Reconstruction model (English et al. 2007) and the escapement data. The escapements are not estimated by age for this stock, with the exception of escapements at Chilko River.

Previously this stock group was represented in the Chinook Model by the Lower Shuswap and Chilko CWTs, and the new model only uses wild Chinook CWT data from the Chilko River. The Lower Shuswap has a different ocean distribution and maturation pattern, since it is an ocean type life history.

Table 37—River systems comprising the Fraser Summer Stream-type 1.3 stock

Stocks Common to Phase II & 9806 Model	New Stocks Added to Phase II Model	Former Stocks Removed from Phase II Model
Barriere R	Big Silver Cr	North Thompson
Cariboo R (Lower)	Elkin Cr	Seton R
Chilko R	Kuzkwa R	Stellako R
Clearwater R		Stuart R
Mahood R		
Nechako R		
Portage R		
Quesnel R		
Raft R		

4.14.2.1 MDL File Settings

See section 4.10.2.1 for details.

4.14.2.2 Base period CWT recoveries

Since the 1998 base period calibration, cohort analyses were conducted for Chilko River (CKO) to provide the full set of CWT statistics that are used by the CTC for the base period calibration. The historic escapement estimates and CWT samples were reviewed and the escapement CWT estimates were revised to address the treatment of no pins in the CWT estimation (Bernard and Clark 1996), and to address low CWT sample rates. This information enabled the FSS stock group to be created and to represent its maturation characteristics and ocean exploitation patterns. The numbers of wild CWTs released for BY 1977 and 1978 are generally high for a wild ERIS, but survival rates were low and CWT sampling rates were low in the spawning grounds. There were also concerns about the CWT detection (see aforementioned use of x-ray technology) and identification of adipose clipped fish in the escapements (reference photos were taken in the field).

For the base period, the largest number of tag recoveries occurred in the Canadian marine and freshwater ISBM fisheries, with fewer recoveries in the SEAK, NBC and WCVI AABM fisheries and the U.S. ISBM fisheries (Table 38).

Table 38—Summary of Chilko River Summer (CKO) CWT releases used for base period calibration and recoveries in escapement and PST fisheries.

				Recoveries in Canada						**Recoveries in U.S.**				
				AABM		**ISBM**		**Escapement**		**AABM**	**ISBM**		**Esc**	**Grand**
Brood	**CWT**	**Tagged**	**Untagged**	**NBC**	**WCVI**	**Marine**	**Fresh**	**Esc**	**Strays**	**SEAK**	**Marine**	**Fresh**	**Strays**	**Total**
1977	022119	73246	808	10	7	19	45	37	0	0	6	0	0	124
	022125	75913	503	0	15	4	1	39	0	0	0	0	0	59
Total		**149159**	**1311**	**10**	**22**	**23**	**46**	**76**	**0**	**0**	**6**	**0**	**0**	**183**
1978	021602	45932	2316	0	4	12	0	27	0	3	0	0	0	46
	021658	149523	2492	0	11	39	30	97	0	5	10	0	0	192
Total		**195455**	**4808**	**0**	**15**	**51**	**30**	**124**	**0**	**8**	**10**	**0**	**0**	**238**

The base period CWT recoveries for CKO occurred from ages 2 through 7, with most recoveries at age-5 (Table 39). The age-7 CWT data were combined with age-6 and the age-2 CWT data were combined with age-3 for the ERA. The age-2 recoveries were in the sport fisheries in the Strait of Juan de Fuca and Puget Sound, and the South-Central Troll fishery (B.C. Central Coast), and the age-7 recovery was in the Strait of Georgia sport fishery.

Table 39—Summary of estimated CWTs in fisheries and escapements by brood for CKO tag codes selected to represent the Fraser Summer Stream-type 1.3 stock in the Phase II Model base period calibration.

Brood Year	Recovery Location	Age 2	Age 3	Age 4	Age 5	Age 6	Total
1977	marine	13	2	16	27	3	61
	freshwater	0	1	2	41	2	46
	escapement	0	8	24	38	6	76
	escapement stray	0	0	0	0	0	0
1978	marine	8	24	25	15	12	84
	freshwater	0	8	5	14	3	30
	escapement	0	6	3	110	5	124
	escapement stray	0	0	0	0	0	0
Grand Total	**All Locations**	**21**	**49**	**75**	**245**	**31**	**421**

4.14.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

In general, the CKO ERIS tag codes had recoveries in most of the fisheries where the FSS stocks are harvested, but there were few age-4 and age-5 CWTs recovered in the SEAK and NBC troll fisheries (Figure 79). When new ERA information is available for the Chilko ERIS it would be worthwhile to review those patterns with those for these base period CWTs, and to examine the results from the OOB procedure to see if fishery representation can be improved.

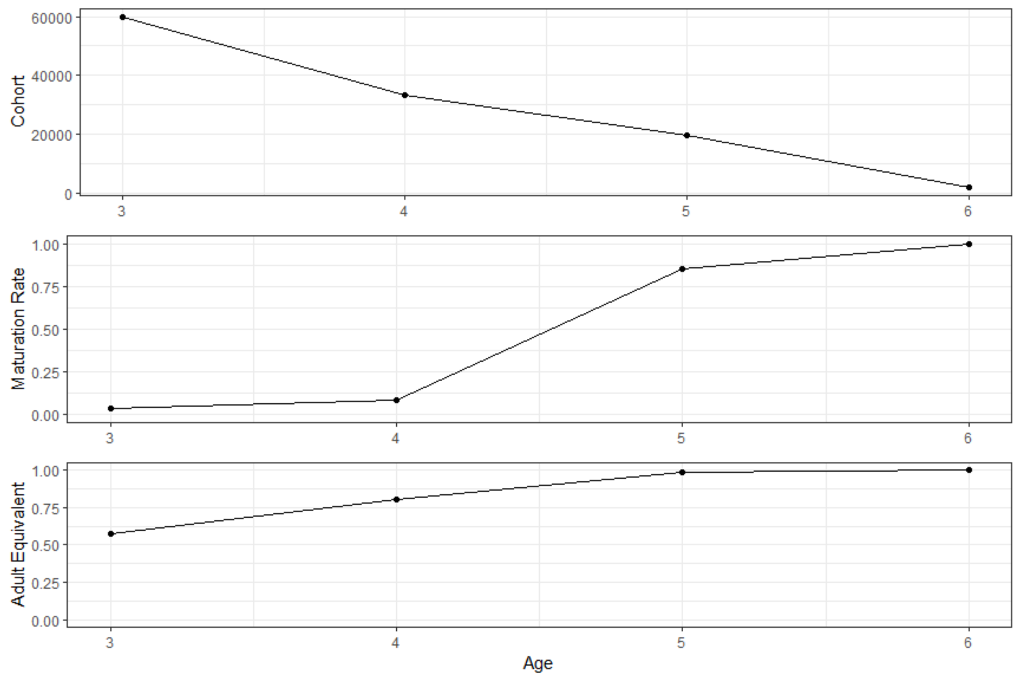

Figure 78—Base period cohort size, maturation schedule, and adult equivalent for Fraser Summer Stream-type 1.3.

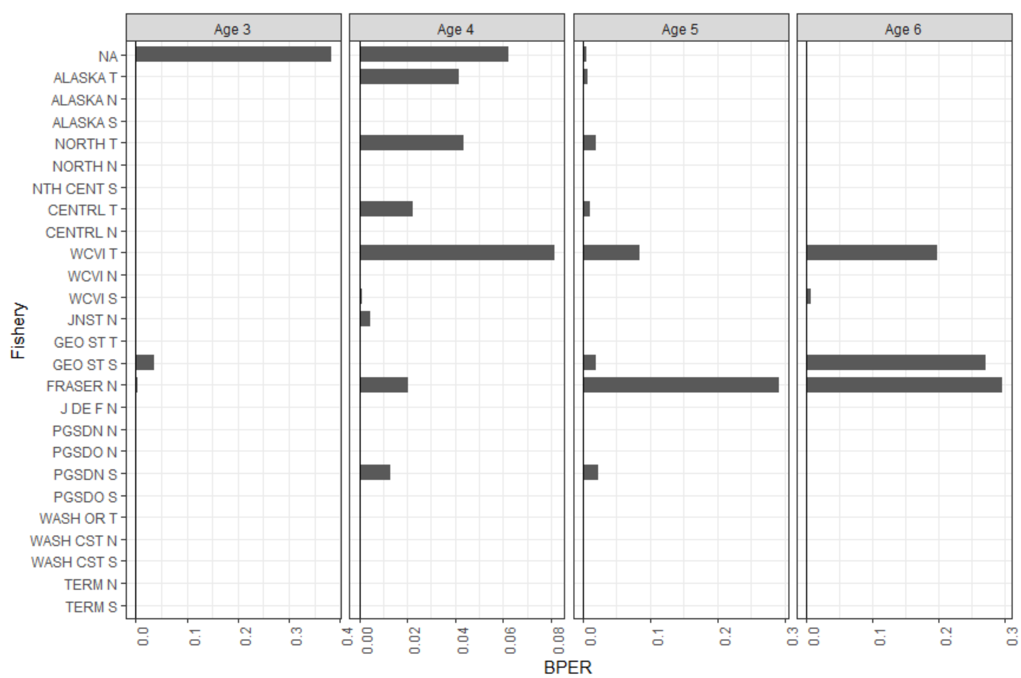

Figure 79—Base period exploitation rate by fishery for Fraser Summer Stream-type 1.3.

4.14.2.4 Escapement/Terminal Run Time Series

The Fraser River First Nation net fisheries have had low CWT sampling rates, which led to the use of the Fraser River Run Reconstruction model (English et al. 2007) to estimate stock specific catches in Fraser River fisheries and then these were used with escapement data to generate time series of terminal runs and terminal FPs. The Chinook Model was set to calibrate to the terminal run for the FSS stock because of concerns about the effect of the uncertainty in the escapement estimates and terminal fisheries data.

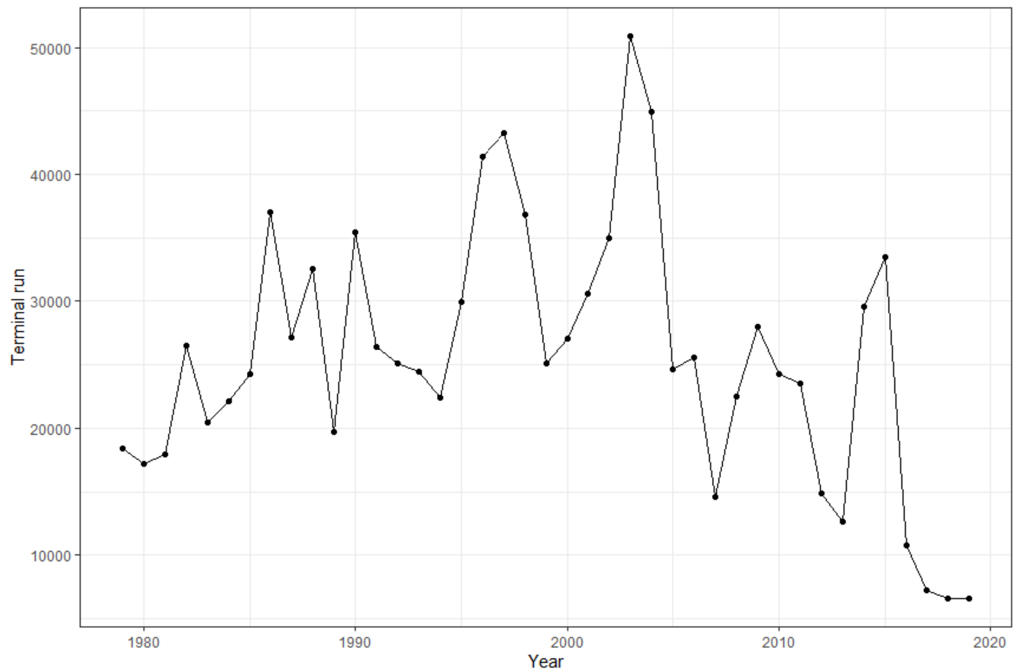

Figure 80—Terminal run size for Fraser Summer Stream-type 1.3.

4.14.2.5 Ricker Parameters

The Ricker stock recruitment parameters were generated using the habitat model (Parken et al. 2006) for each of the stock units. The river-specific stock estimates of S_{msy} and S_{rep} were added together for an 'all combined' estimate and then the Ricker stock-recruitment estimates were calculated using the Hilborn (1985) approximation equations (Table 40). Stock-recruitment data have not been collected to directly measure the recruitment dynamics for this stock group.

Table 40—Source of the Ricker stock-recruitment parameters used as initial values for FSS in the base period Model calibration.

	River System					All Rivers Combined	
Estimate	**Chilko**	**Quesnel & Lower Cariboo**	**Nechako, Kuzkwa, Pinchi**	**Clearwater, Mahood, Lemeiux, Raft, Barrier**	**Portage**	**Raw**	**Adjusted**
Smsy*	4,536	7,042	5,980	4,601	1,589	23,748	21,226
Srep*	12,078	18,847	16,181	12,353	4,180	63,639	56,881
Smsy/Srep	0.376	0.374	0.370	0.372	0.380	0.373	0.373
log(alpha)*	1.778	1.805	1.864	1.822	1.712	1.812	1.812
Alpha	5.916	6.081	6.447	6.184	5.541	6.122	6.122
Umsy	0.67	0.67	0.69	0.68	0.65	0.68	0.68
Beta	1.47187E-04	9.57785E-05	1.15172E-04	1.47494E-04	4.09626E-04	2.84726E-05	3.18552E-05
Rmax	14,787	23,356	20,592	15,425	4,977	79,105	70,706

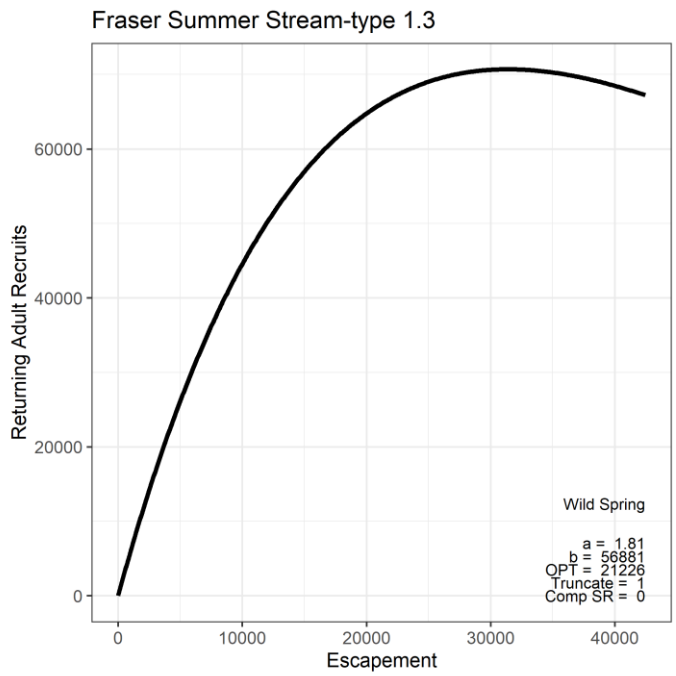

Figure 81—Ricker curve and parameters for Fraser Summer Stream-type 1.3 (FSS) model stock.

4.14.3 Comparison of Model Performance

Many improvements were made to the model and the calibration inputs during the course of phase II of the base period calibration. However, the performance of these improvements could not be compared to empirical estimates because there is not an ERIS for FSS and the escapements and terminal runs are not estimated by age.

4.14.3.1 Cohorts

For the FSS stock group, cohort sizes could not be estimated independently because the terminal run and escapement estimates are not generated by age, because of intermittent age sampling at all locations, except recently at the Chilko River. Escapements to the Chilko River are estimated by age, but the other spawning locations are not surveyed annually to estimate the age composition. A new sampling program would be necessary to collect biological samples (i.e., age, sex, length, stray CWTs) to estimate the age composition of the stock group.

4.14.3.2 Exploitation Rates

The ER for FSS could not be compared to CWT-based estimates because there is not an ERIS. Efforts are underway to develop Chilko as an ERIS, however CWT release numbers have been very low (~60,000–90,000) and it is likely that CWT recoveries will be insufficient until more CWTs are released or survival increase substantially. The exploitation rate figures are included below, which describe the temporal pattern estimated by the new model. The model ER estimates have a pattern of increasing total exploitation since the lower levels estimated during the early 1990s.

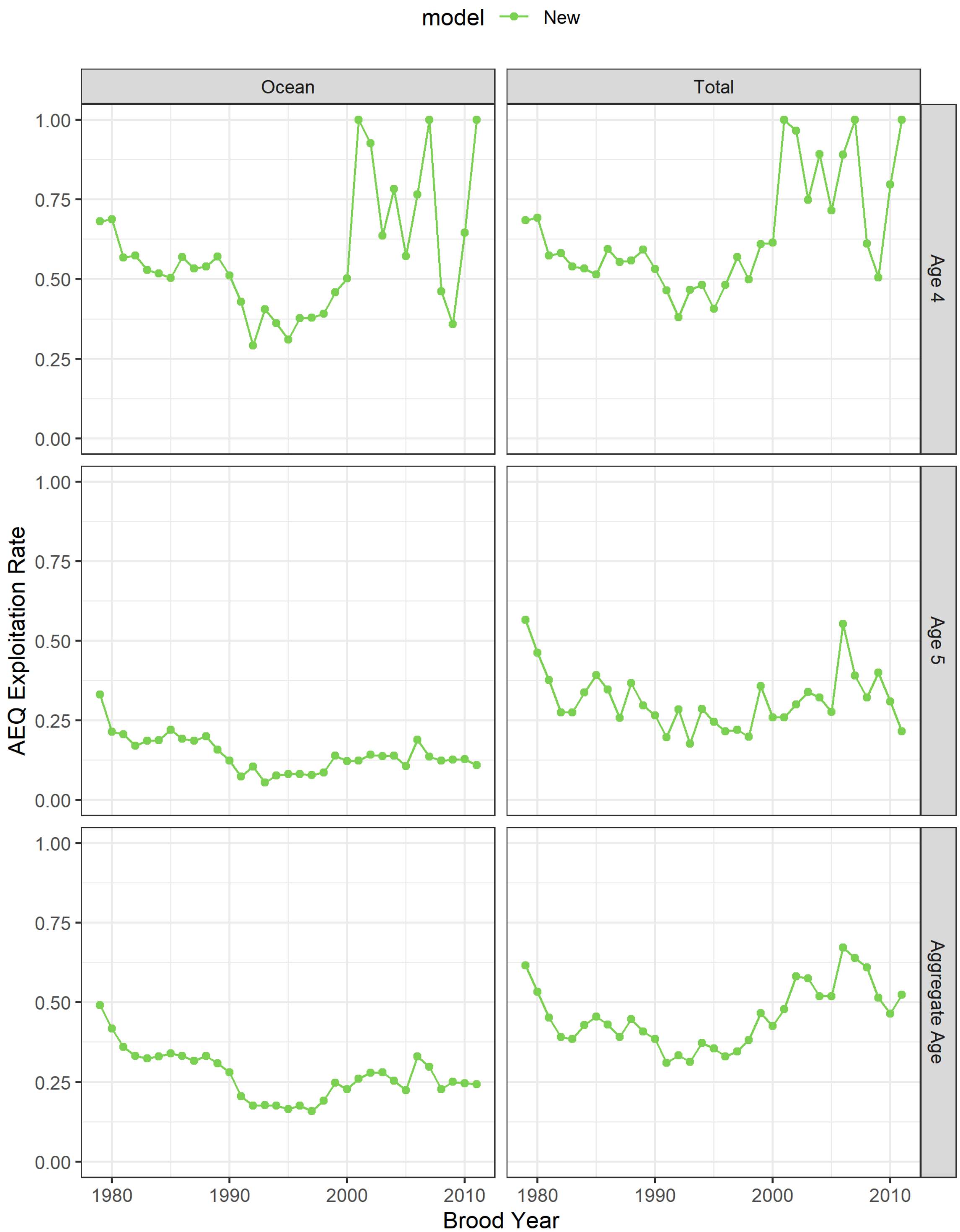

Figure 82—Adult equivalent (AEQ) exploitation rates using the PSC Chinook Model and coded wire tag recovery estimates for the age-4, age-5, and aggregate age Fraser Summer Stream-type 1.3 (FSS) stock group for ocean fisheries and total fisheries (including terminal).

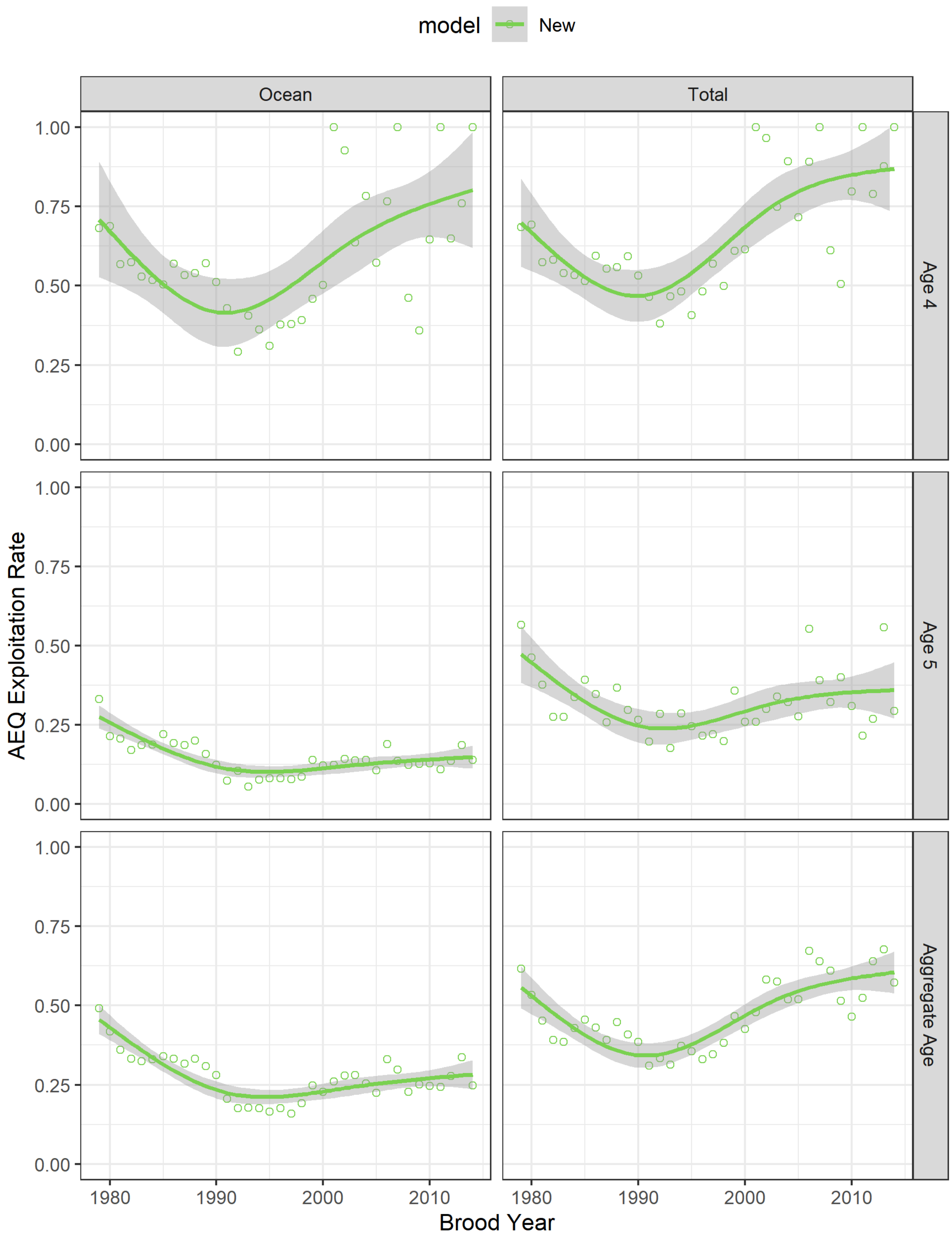

Figure 83—Adult equivalent (AEQ) exploitation rates with a smoothing function using the PSC Chinook Model and coded-wire tag recovery estimates for the age-4, age-5, and aggregate age Fraser Summer Stream-type 1.3 (FSS) stock group for ocean fisheries and total fisheries (including terminal).

4.15 Fraser Late (FRL): Fraser Harrison Fall (FHF) and Fraser Chilliwack Fall Hatchery (FCF)

4.15.1 Stock Description

The current version of the chinook model uses two stocks to represent Fraser River Chinook production: Fraser Early and Fraser Late. Fraser Late Chinook are fall-run, ocean-type chinook that return to the Fraser River from late August through November, with a peak migration during late September and early October (Parken et al. 2008). The only natural population of Fraser Late Chinook is in the Harrison River, which is the largest single river population in Canada. Chinook from the Harrison River have been transplanted to several other locations in the lower Fraser area and Strait Georgia, including hatchery programs at the Chilliwack, Stave, Alouette, and Coquitlam rivers (Fraser River tributaries) and the Lang Creek, Capilano River and ocean net pens in Vancouver Harbour and Burrard Inlet (B.C. Mainland Inlets). The Chilliwack River is the most abundant of these hatchery production programs. It should be noted that the stock production of the Capilano hatchery has changed among different stock origins over the years depending upon the hatchery objectives (e.g., summer vs fall returning Chinook stocks).

4.15.2 Description of Changes

In the current version of the model, the Harrison and Chilliwack are a combined stock. However, there are differences in key population attributes between them, and accordingly these two stocks are represented separately in the new model. Separation of the stocks enables better representation of the stock production dynamics, maturation patterns, any differences in fishery distribution, terminal fisheries, as well as escapements, terminal runs, and stock abundance forecasts for the model calibration.

4.15.2.1 MDL File Settings

Table 41—Information that was used in the construction of the FHF and FCF MDL files for the Phase II Model base period calibration.

Information for MDL File Production	Phase II Model Stock	
Model Stock Acronym	FHF	FCF
Brood Years	1985–1987	1981–1983
Out-of-base procedure used?	Yes	Yes
C-file extension (CWT Indicator ID)	HAR	CHI
Modifications to fisheries in WG4 file	Fraser Net[2]	TFraser Term Net[3]
Yearling Stock	No	No
Weight within BY by production releases	No	Yes
Exclude Esc for Between BY weighting	Yes	Yes
Start age in C-files	2	2
Last age in C-files	5	5
Modifications to escapements in Coshak4	No	No
Method used to modify escapement	NA	NA

Terminal fishery CWT moved to escapement	No	No
Model stock type	Wild, Fall	Hatchery, Fall
Additional fisheries designated as terminal	Fraser Net	Fraser Net
9806 Model stock association	FRL	FRL
Other Information		
C-file creation date	25 Apr 2017	25 Apr 2017
Number of C-file and ERA fisheries[1]	188 - 78	188 - 78
MDL creation date	22 Oct 2017	16 May 2017

1. Note that escapement categories are not included (1 for C-files and 3 for the ERA)
2. FHF note: WG4 scalars for fishery #42 Fraser Net calculated using Fraser Chinook Run Reconstruction Model output (file version 'FraserRiverChinookTerminalRunData_ NT_3Mar17.xlsx'). Scalar values of 1 were used in the WG4 file for fisheries #43 (TFraser Term Net) and #73 (TFraser FS).
3. FCF note: WG4 scalars for fishery #43 TFraser Term Net calculated using Fraser Chinook Run Reconstruction Model output (file version 'FraserRiverChinookTerminalRunData_ NT_3Mar17.xlsx'). Scalar values for fishery #42 (Fraser Net) were left unmodified from the initial calculated values. Scalar values of 1 were used in the WG4 file for fishery #73 (TFraser FS).

4.15.2.2 Base Period Coded-Wire Tags and Recoveries

Table 42—Coded-wire tag codes for Fraser Late (9806), Fraser Harrison Fall (FHF, Phase II), and Fraser Chilliwack Fall Hatchery (FCF, Phase II) model stocks.

Brood Year	Tag Codes		
	9806 (FRL)	**Phase II (FHF)**	**Phase II (FCF)**
1981	CHI: 022163, HAR: 022205		CHI: 022163
1982			022422
1983			022658, 022659, 022660
1985		HAR: 023754, 023755, 023756, 023757, 023758, 023759, 024051, 024052	
1986		024402, 024403, 024404, 024405, 024406, 024407, 024408, 024409	
1987		024738, 024739, 024740, 024741	

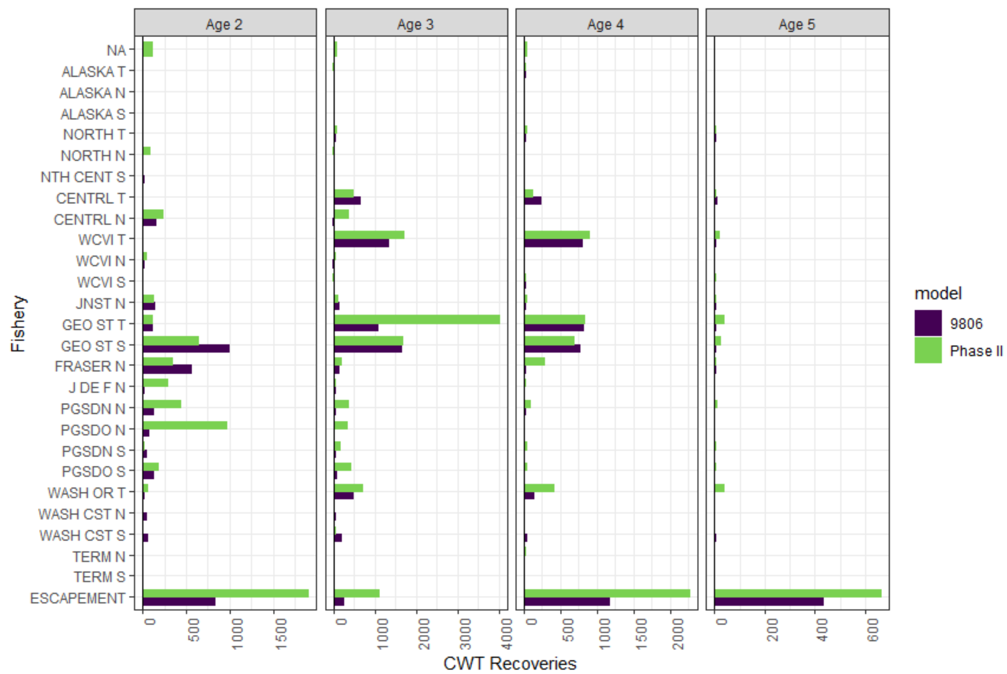

Figure 84—Base period coded-wire tag (CWT) recoveries for Fraser River Late (9806), Fraser Harrison Fall (Phase II), and Fraser Chilliwack Fall Hatchery (Phase II).

4.15.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

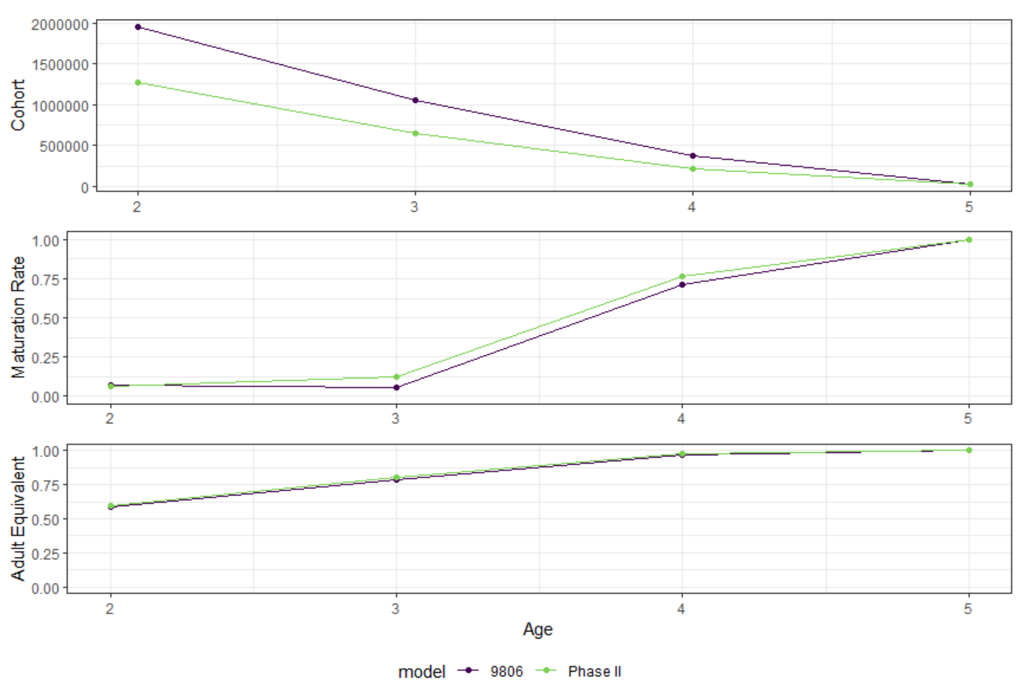

Figure 85—Base period cohort size, maturation schedule, and adult equivalent for Fraser River Late (9806), Fraser Harrison Fall (Phase II), and Fraser Chilliwack Fall Hatchery (Phase II).

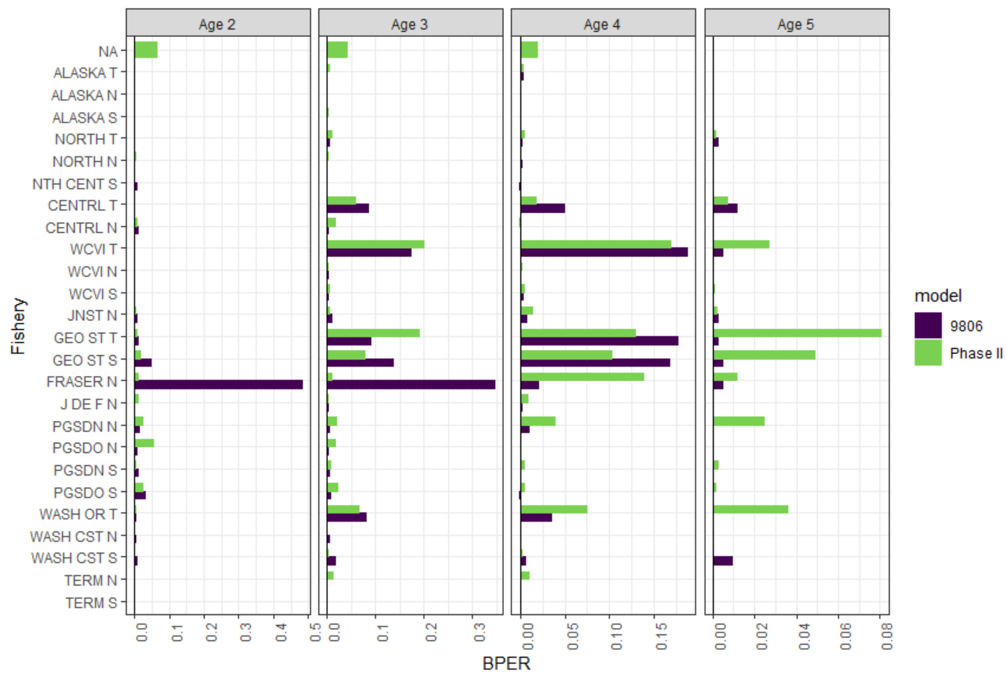

Figure 86—Base period exploitation rate by fishery for Fraser River Late (9806), Fraser Harrison Fall (Phase II), and Fraser Chilliwack Fall Hatchery (Phase II).

4.15.2.4 Escapement/Terminal Run Time Series

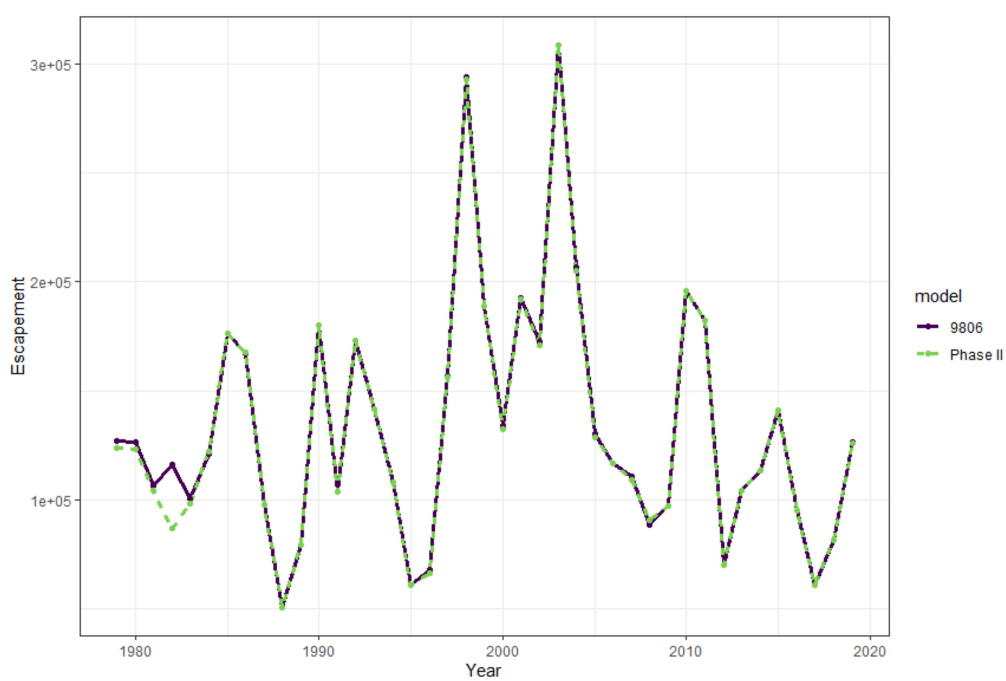

Figure 87—Escapement for Fraser River Late (9806), Fraser Harrison Fall (Phase II), and Fraser Chilliwack Fall Hatchery (Phase II).

4.15.2.5 Ricker Parameters

Ricker parameters for Phase II model stocks can be found in sections 4.16.2.5 (FHF) and 4.17.2.5 (FCF).

4.16 Fraser Late (FRL): Fraser Harrison Fall (FHF)

4.16.1 Stock Description

The Harrison River flows for about 16 km from Harrison Lake to the Fraser River. This fall-run, ocean-type stock spawns from late October through early December, and fry emigrate from the river shortly after emergence in March to May (Starr and Schubert 1990), and then they rear along the lower Fraser River and off channel habitats as they make their way down to the Fraser River estuary (Levy and Northcote 1982). Fry arrive in the estuary from March to June and appear to rear there until they grow large enough to move to deeper waters or redistribute to other nearby estuaries in the Salish Sea. The stock has a local distribution and appears to rear mainly in the Salish Sea, Coastal Washington and WCVI, however some CWT fish are regularly recovered in all ocean fisheries ranging from California to Alaska.

The stock matures from ages 2 to 5, with most fish maturing at age-4. The Harrison has had direct enhancement from the Chehalis River hatchery, a tributary to the Harrison, regularly since 1981 and as early as 1971. Enhancement levels have been high at times, but they have been reduced to levels that are only the ERIS CWT production target.

Escapements have been estimated with mark-recapture methods since 1984, with sampling for age, sex, length and CWTs, however the abundance of small males (jacks) did not begin until 1996. The escapement of age 2 CWTs for the HAR ERIS were estimated for years prior to 1996 using average maturation rates and backwards cohort reconstruction techniques.

4.16.2 Description of Changes

Escapement data used for the Fraser Harrison Fall stock for the base period Model calibration are from the mark-recapture program and age sampling. The study design stratifies the population into females, small males, and larger males, with further stratification to use the CWT ages for the adipose fin clipped components and scale ages for the unmarked components. Sampling rates differ among the strata.

The average base period and pre-base escapement estimates used for the base period calibration of the current Model were also used for the Phase II Model base calibration. The derivation of these values is unknown but given the high level of uncertainty of the available data, the use of approximate values is the preferred approach. Efforts to calibrate the historic visual counts with the mark-recapture estimates was abandoned after it was determined that the visual counts were unreliable measurements of spawner abundance, since they were determined to be based more on subjective evaluation rather than objective data (Starr and Schubert 1990). There is a long time series of Chinook fry abundance data that have been collected by the fry trapping program at Mission, B.C. since 1964. It may be helpful to examine these data further to see if they can be used to corroborate the estimates used for the Chinook model or to produce an alternate set of escapement data prior to 1984 that could be considered by future base period calibration work.

The FHF terminal run was estimated using the stock-specific catch estimates from the Fraser River Run Reconstruction model (English et al. 2007) and the escapement data. The escapements are estimated by age for this stock and reported by age in the FCS file.

Previously this stock group was represented in the Chinook model by the Harrison and Chilliwack CWTs, and the new model only uses Harrison CWT data. The Chilliwack has some differences in maturation patterns and there is a large sport fishery in the Chilliwack River that can have a high harvest rate, whereas the sport fishery is much smaller in the Harrison, and most years have had Chinook non-retention regulations.

Table 43—Escapement data used for the Fraser Harrison Fall stock (FHF) for the base period Model calibration

Model Stock Name	**Fraser Harrison Fall**
Model Stock	FHF
Identification Number	11
CWT Indicator Stock	HAR
1975–1978 Pre-base Average	141,000
1979–1982 Base Period Average	120,000
Year	**Estimate[1]**
1975	15,000
1976	7,500
1977	25,000
1978	15,000
1979	78,000
1980	52,000
1981	104,000
1982	114,400

[1] The 1975–1982 estimates of escapement are based on expanded counts from overflights which varied annually in number. Due to their high uncertainty, they were not used in the derivation of the pre-base and base escapement averages for use in the base period calibration.

Table 44—River systems comprising the Fraser Harrison Fall stock

Stocks Common to Phase II & 9806 Model	**New Stocks Added to Phase II Model**	**Former Stocks Removed from Phase II Model**
Harrison R	None	Chilliwack R (added as a separate stock)

4.16.2.1 MDL File Settings

See section 4.15.2.1 for details.

4.16.2.2 Base period CWT recoveries

The HAR ERIS CWT data from brood years 1985, 1986 and 1987 were used along the OOB to estimate the base period exploitation rates, maturation rates and other characteristics. Most of the CWT recoveries were in the Canadian ISBM fisheries, followed by the WCVI AABM fishery and the U.S. ISBM fisheries. Most recoveries were at age-4 and age-3 recoveries were only slightly less (Table 45).

Table 45—Summary of Harrison River Fall (HAR) CWT releases used for base period calibration and recoveries in escapement and PST fisheries.

				Recoveries in Canada						Recoveries in U.S.				
				AABM		ISBM		Escapement		AABM	ISBM		Esc	Grand
Brood	**CWT**	**Tagged**	**Untagged**	**NBC**	**WCVI**	**Marine**	**Fresh**	**Esc**	**Strays**	**SEAK**	**Marine**	**Fresh**	**Strays**	**Total**
1985	023754	25480	788	0	0	24	0	42	0	0	22	0	0	88
	023755	23501	664	0	10	40	0	23	0	0	22	0	0	95
	023756	27717	86326	0	10	42	0	78	0	0	6	4	0	140
	023757	25248	78370	0	6	49	5	42	0	0	14	0	0	116
	023758	25498	388	0	29	77	0	39	0	7	13	0	0	165
	023759	24707	699	0	32	63	0	131	0	0	3	0	0	229
	024051	25228	255	0	11	11	0	0	0	2	14	0	0	38
	024052	24456	756	0	21	29	0	38	0	0	4	0	0	92
Total		**201835**	**168246**	**0**	**119**	**335**	**5**	**393**	**0**	**9**	**98**	**4**	**0**	**963**
1986	024402	24862	909	0	108	125	0	200	0	0	52	0	0	485
	024403	26333	244	0	121	121	3	81	0	0	85	0	0	411
	024404	26339	25458	0	120	196	0	302	0	0	150	0	0	768
	024405	25686	25090	4	165	217	10	201	0	0	102	0	0	699
	024406	25535	80759	8	88	118	0	630	0	2	88	0	0	934
	024407	25288	79979	3	89	131	0	124	0	0	96	0	0	443
	024408	25468	64881	0	176	169	5	56	0	0	72	0	0	478
	024409	24498	62026	10	164	190	7	174	0	0	103	8	0	656
Total		**204009**	**339346**	**25**	**1031**	**1267**	**25**	**1768**	**0**	**2**	**748**	**8**	**0**	**4874**
1987	024738	26947	47653	0	36	87	5	42	0	3	83	0	0	256
	024739	26782	47675	0	74	39	12	139	0	5	73	0	0	342
	024740	27006	47191	4	53	70	0	51	0	0	48	0	0	226
	024741	25277	952553	0	20	32	0	27	0	0	44	0	0	123
Total		**106012**	**1095072**	**4**	**183**	**228**	**17**	**259**	**0**	**8**	**248**	**0**	**0**	**947**

Table 46—Summary of estimated CWTs in fisheries and escapements by brood for HAR tag codes selected to represent the Fraser Harrison Fall stock in the Phase II Model base period calibration.

Brood Year	Recovery Location	Age 2	Age 3	Age 4	Age 5	Age 6	Total
1985	Marine	68	320	173	0	--	561
	Freshwater	5	0	4	0	--	9
	Escapement	65	45	185	98	--	393
	escapement stray	0	0	0	0	--	0
1986	Marine	438	1539	1048	48	--	3073
	Freshwater	5	4	20	4	--	33
	Escapement	337	295	1031	105	--	1768
	escapement stray	0	0	0	0	--	0
1987	Marine	85	350	207	29	--	671
	Freshwater	0	12	5	0	--	17
	Escapement	68	58	133	0	--	259
	escapement stray	0	0	0	0	--	0
Grand Total	**All Locations**	**1071**	**2623**	**2806**	**284**	**--**	**6784**

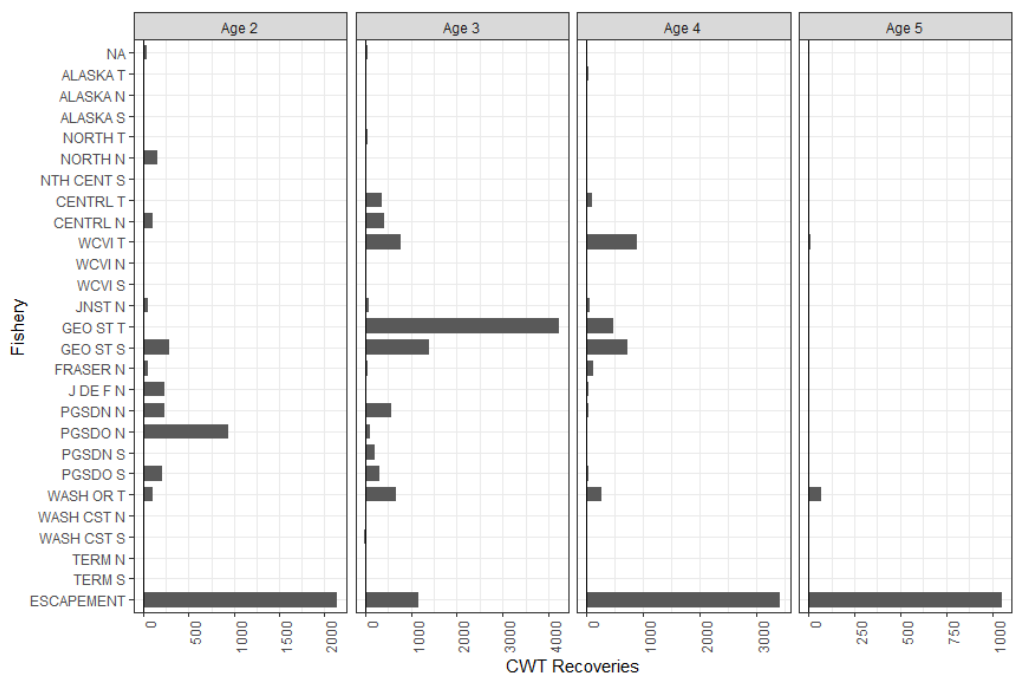

Figure 88—Base period coded-wire tag (CWT) recoveries for Fraser Harrison Fall (FHF).

4.16.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

Maturation rates for the ERIS CWT group were generally higher than for the entire stock for age 2, slightly lower for age-3 and about the same for age-4 (Figure 89).

Base period exploitation rates were highest in the Strait of Georgia troll fishery for age-3, the WCVI troll fishery for age-4, and the Washington/Oregon troll fishery for age-5 for FHF (Figure 90). In general, the HAR tag codes had recoveries in most of the base period fisheries that have been observed to harvest the stock based on data patterns for many cohorts (e.g., 1985–2018).

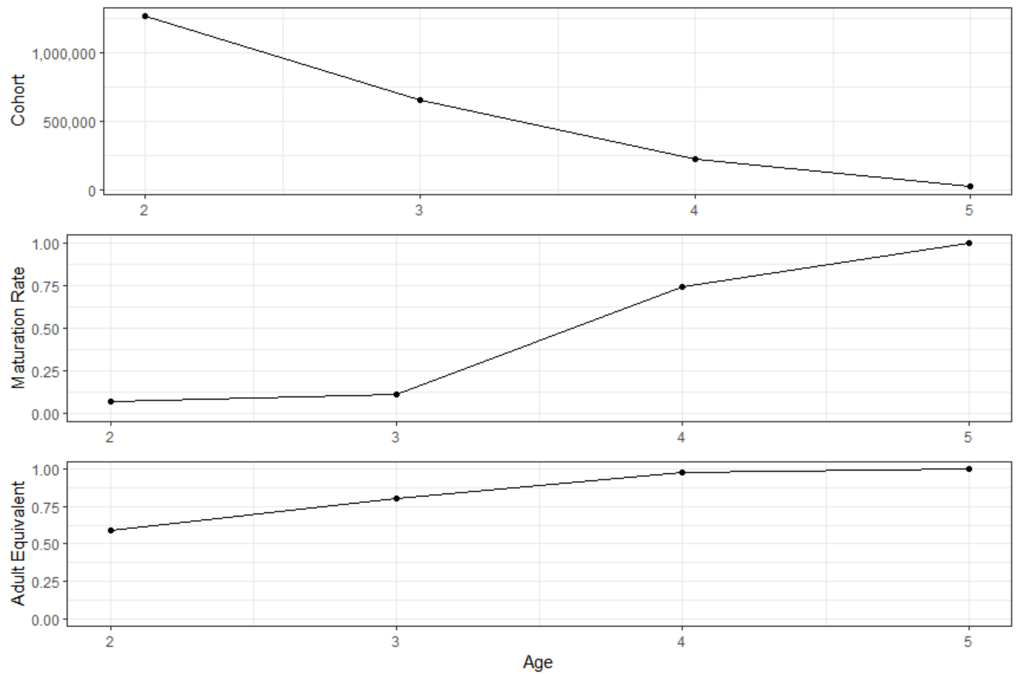

Figure 89—Base period cohort size, maturation schedule, and adult equivalent for Fraser Harrison Fall.

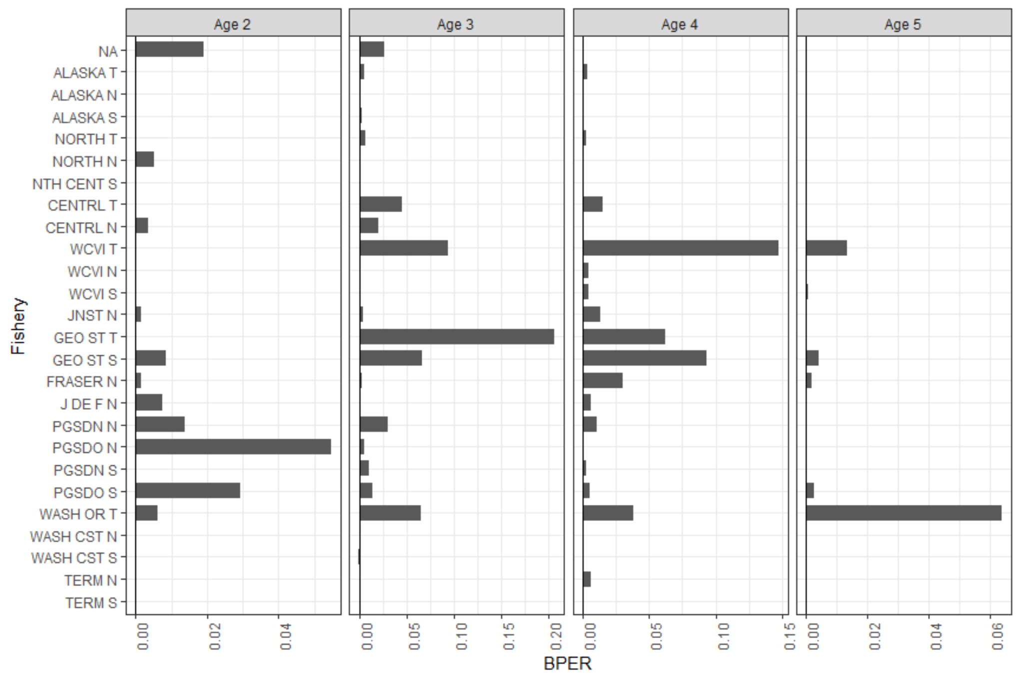

Figure 90—Base period exploitation rate by fishery for Fraser Harrison Fall.

4.16.2.4 Escapement/Terminal Run Time Series

The Fraser River First Nation net fisheries have had low CWT sampling rates, which led to the use of the Fraser River Run Reconstruction model (English et al. 2007) to estimate stock specific catches in Fraser River fisheries and then these were used with escapement data to generate time series of terminal runs and terminal FPs. The Chinook model was set to calibrate to the escapement because the escapements at age data are high quality and there is more uncertainty about the terminal fishery impacts.

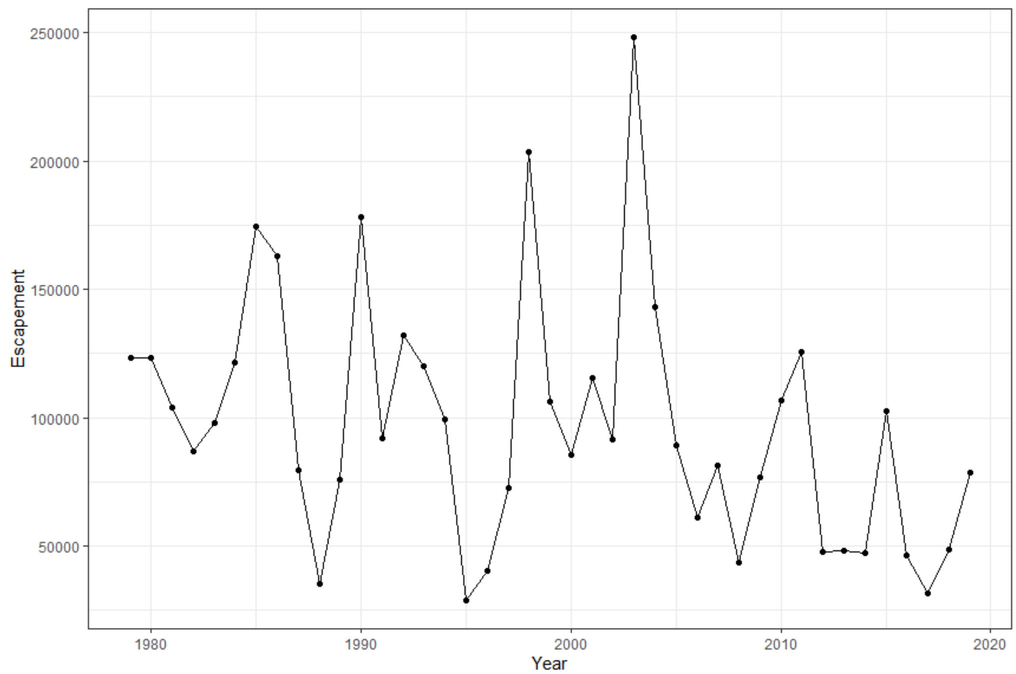

Figure 91—Escapement for Fraser Harrison Fall.

4.16.2.5 Ricker Parameters

The stock-recruitment parameters are from Brown et al. (2001) and they are based on a stock-recruitment analysis with an age 2 CWT cohort survival covariate.

Table 47—Source of the Ricker stock-recruitment parameters used as initial values for FHF in the base period Model calibration.

	River System
Estimate	**Harrison**
Smsy*	75,100
Srep*	131,683
Smsy/Srep	0.570
log(alpha)*	1.415
alpha	4.116
Umsy	0.57
Beta	1.07455E-05
Rmax	140,931

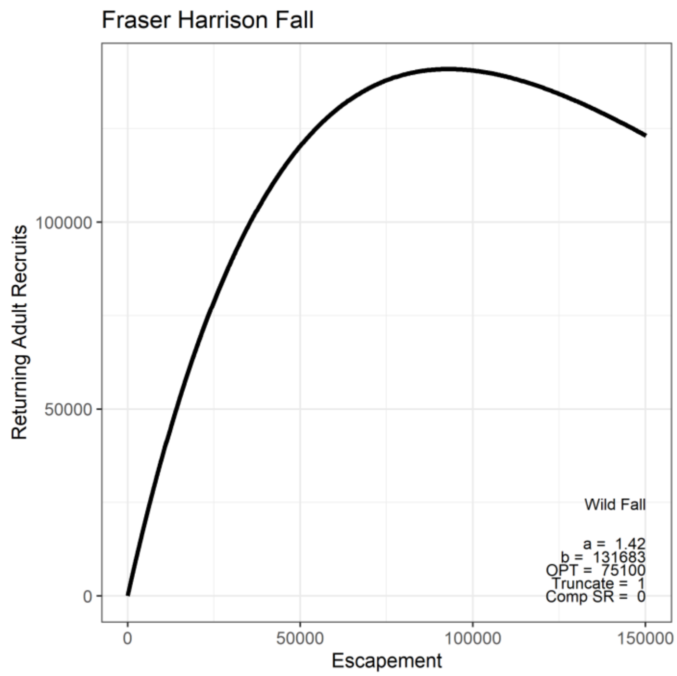

Figure 92—Ricker curve and parameters for Fraser Harrison Fall (FHF) model stock.

4.16.3 Comparison of Model Performance

Many improvements were made to the model and the calibration inputs during the course of phase II of the base period calibration. To examine the effect of these improvements, comparisons were made to independent estimates of cohort sizes by age, brood year exploitation rates, and the model's performance for fitting to the terminal run/escapement.

4.16.3.1 Cohorts

For the FHF stock group, cohort sizes were estimated independently when there were sufficient escapement age data. These SACE maturation rates, labeled CWT-FCS on the following figures, corresponded exceptionally well to those that were estimated by the new model. Ages 3 and 4 were centered around the 1:1 reference line, whereas for age 2 the new model cohort sizes were generally higher than those estimated from the SACE method. For age-5 the new model cohort sizes were higher than those from the SACE method and they had a small amount of positive bias. The largest difference was for brood year 1982 cohort sizes for ages 2 to 4, but the age-5 cohort sizes were fairly similar. Overall the new model appeared to estimate the temporal pattern of the cohort sizes very well relative to those developed using escapement and CWT data.

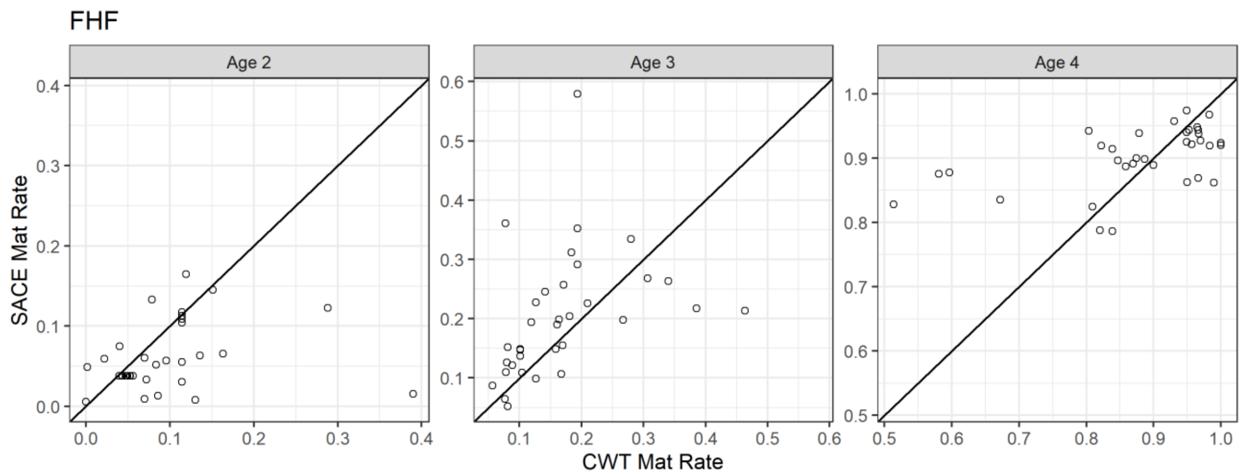

Figure 93—Maturation rate comparison between the Harrison exploitation rate indicator stock (x-axis) and the stock aggregate cohort evaluation (SACE; y-axis).

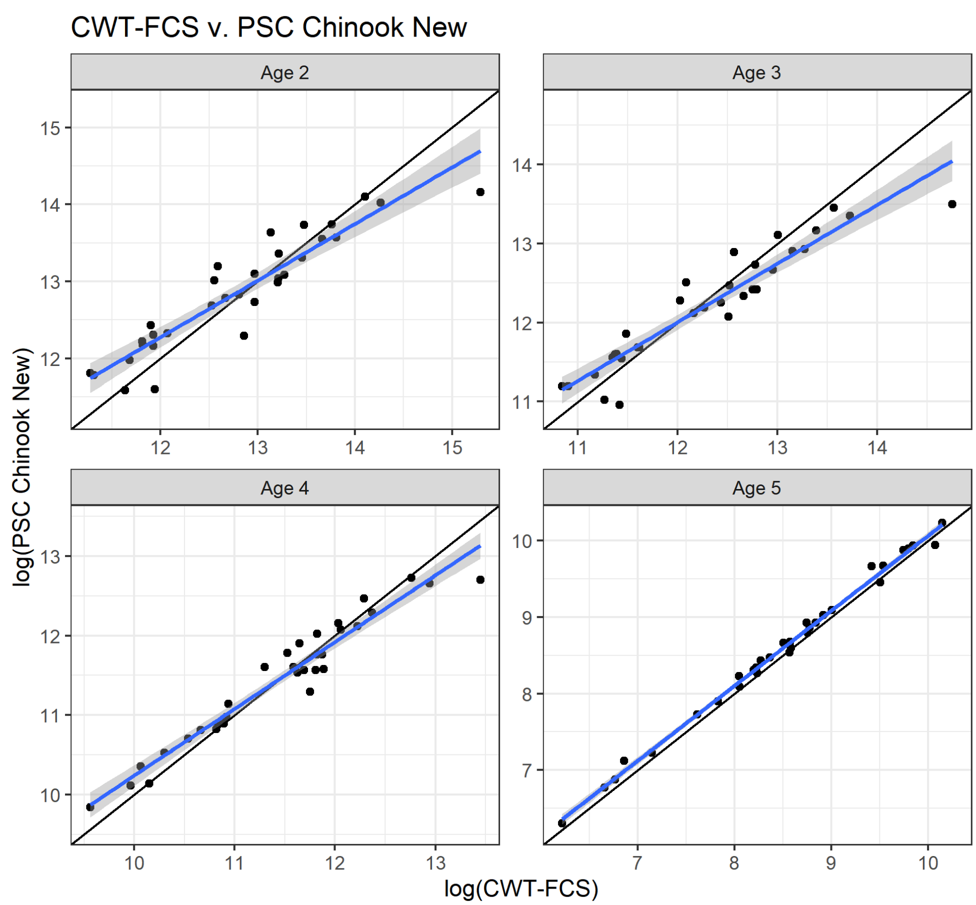

Figure 94—Comparison of cohort sizes estimated using the CWT FCS files and the Phase II PSC Chinook Model for Fraser Harrison Fall.

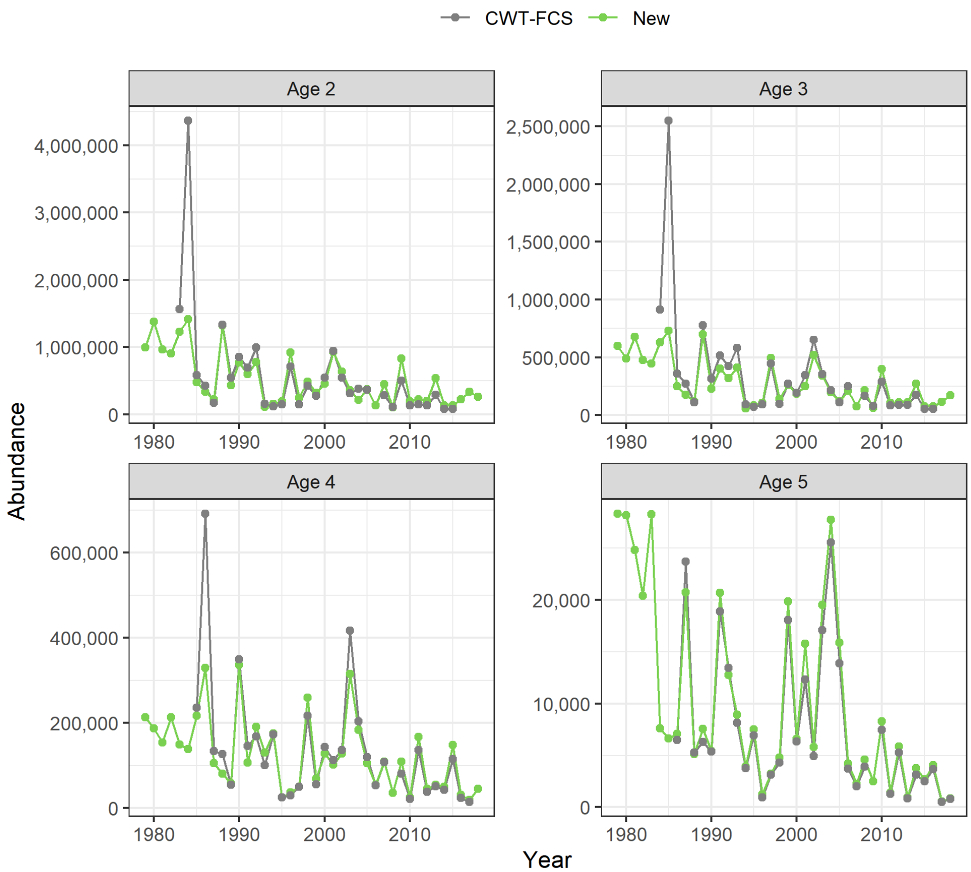

Figure 95—Time series comparisons of cohort size abundance estimated using the CWT FCS files and the Phase II PSC Chinook Model for Fraser Harrison Fall.

4.16.3.2 Exploitation Rates

Based on a comparison of the model and CWT-based exploitation rates, the new model represents the temporal pattern of the exploitation rates relatively well for age-3 but not for age-4. The new model tends to underestimate the exploitation for ages 3, 4 and the total aggregate relative to the CWT-based exploitation rates measured from the Harrison ERIS CWT data. This pattern of underestimation of the exploitation rate by the new model appears to happen in the ocean and freshwater fisheries. Given the large abundance of FHF and its contributions to fisheries in Southern B.C. and Washington, the new model appears to be considerably improved in terms of its representation of this component of the Chinook resource.

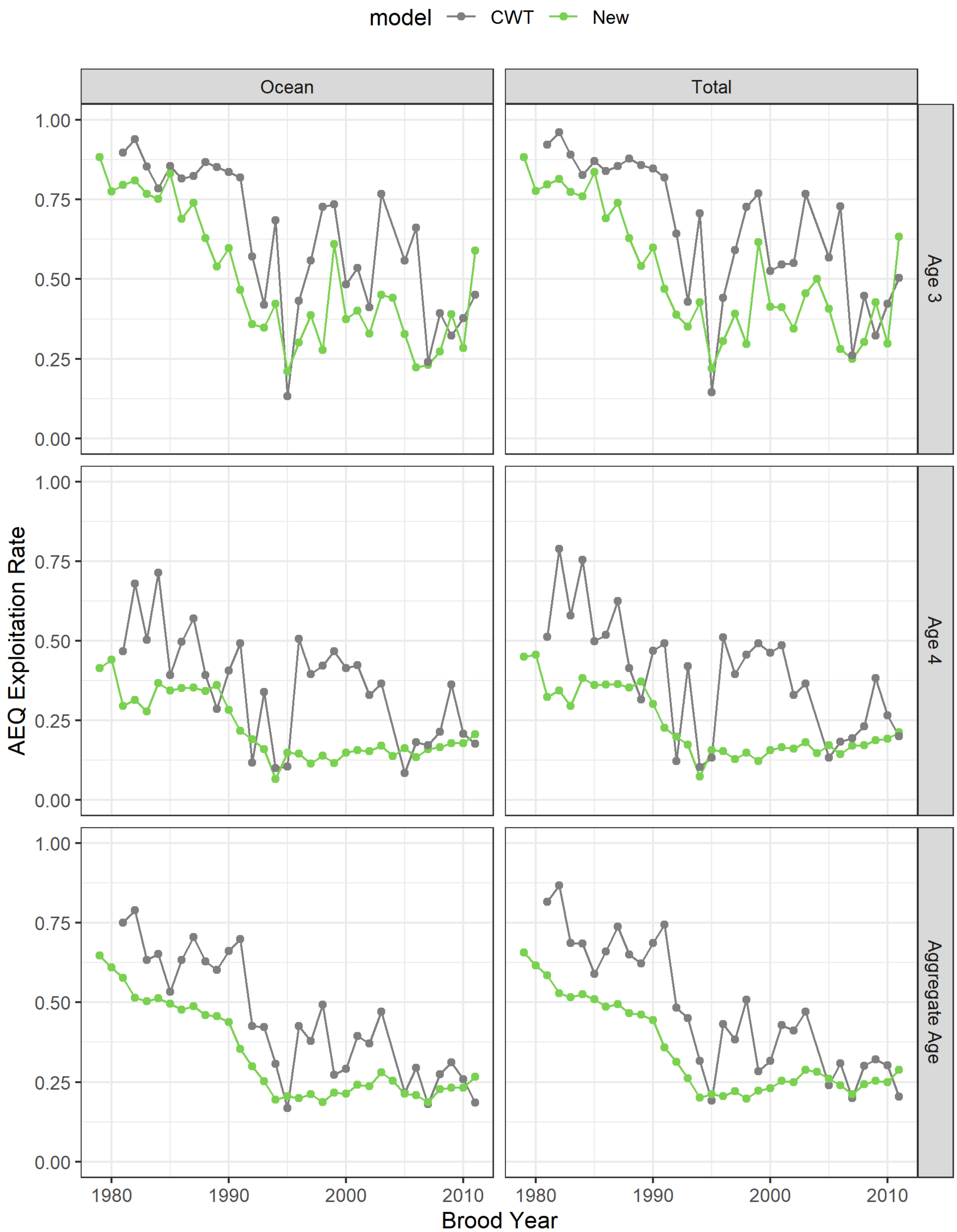

Figure 96—Adult equivalent (AEQ) exploitation rates using the PSC Chinook Model and coded-wire tag recovery estimates for the age-4, age-5, and aggregate age Fraser Harrison Fall (FHF) stock group for ocean fisheries and total fisheries (including terminal).

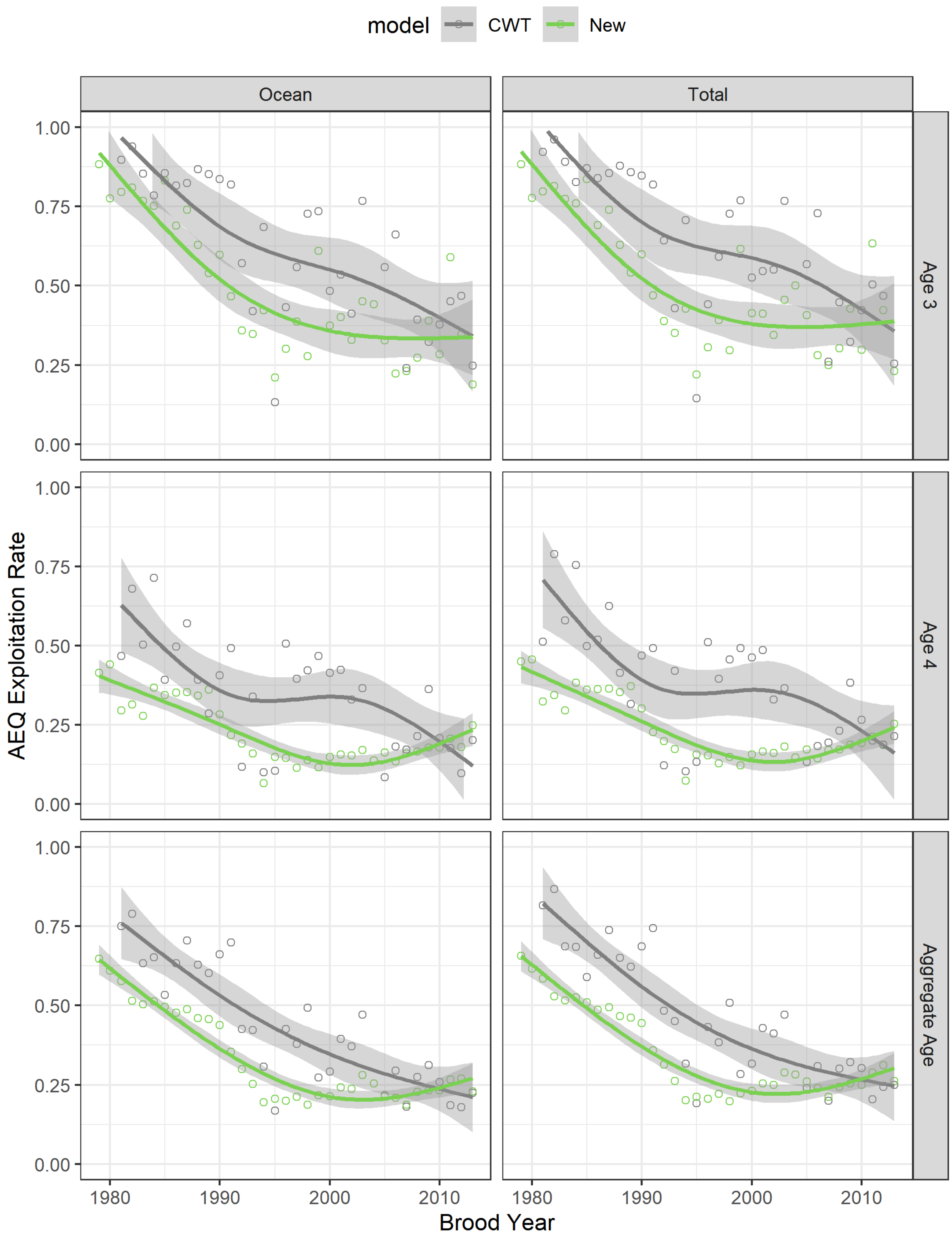

Figure 97—Adult equivalent (AEQ) exploitation rates with a smoothing function using the PSC Chinook Model and coded-wire tag recovery estimates for the age-4, age-5, and aggregate age Fraser Harrison Fall (FHF) stock group for ocean fisheries and total fisheries (including terminal).

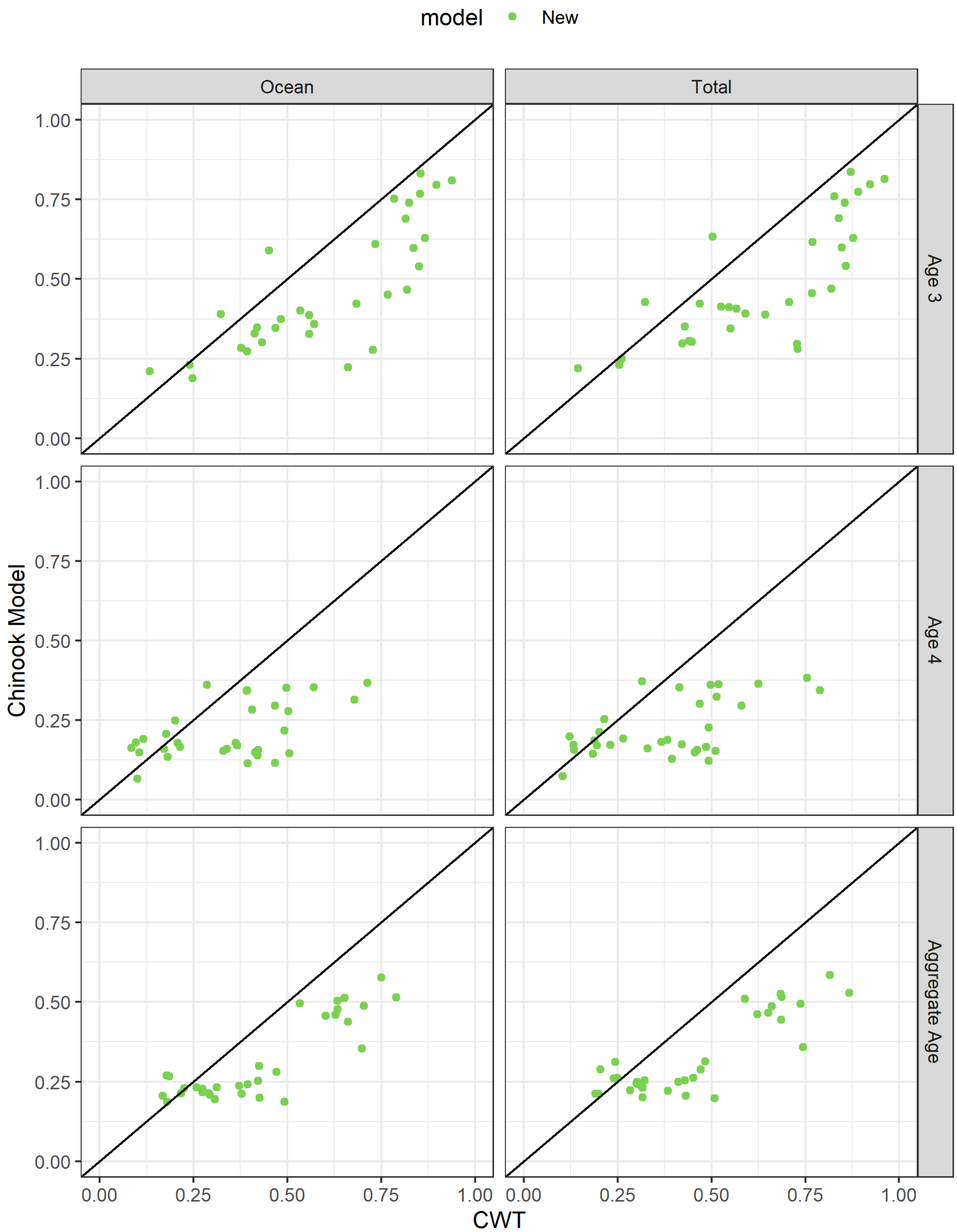

Figure 98—Relationship between exploitation rates from coded-wire tag recovery estimates and from the PSC Chinook Model for the Fraser Harrison Fall (FHF) stock group.

4.16.3.3 Model Fit to Terminal Run/Escapement

The box plots below (Figure 99) indicate the relative performance of two versions of the new Chinook model (green is intermediate and blue is final) for the FHF stock group. The blue shaded box plot represents the version of the new Chinook model where the SACE method was applied, which enabled the model to perform substantially better for estimating the spawning escapement, as indicated by the smaller box plot distribution and the median value is closer to 1. The SACE method appears to have eliminated an over-forecasting pattern that was present during a previous iteration of the new model.

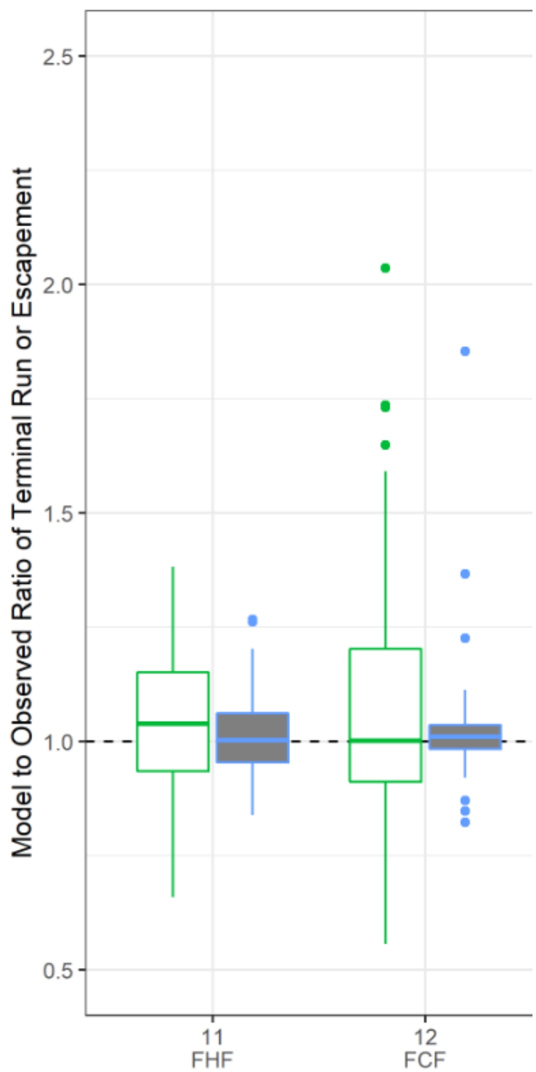

Figure 99—Relative performance of two iterations of the Phase II model calibration for Fraser Fall stocks (Fraser Harrison Fall [FHF] and Fraser Chilliwack Fall [FCF]).

4.17 Fraser Late (FRL): Fraser Chilliwack Fall Hatchery (FCF)

4.17.1 Stock Description

The Chilliwack Fall Hatchery stock originated from brood stock collected from the Harrison River in 1981. Prior to the transplant, there were no fall chinook in the Chilliwack River, and the habitat appears to be unsuitable for natural production of the stock because very little natural production has been detected among otolith samples collected from Chinook spawning in the river. Each year the hatchery produces about one to two million smolts, which survive exceptionally well relative to other hatchery programs.

4.17.2 Description of Changes

The average base period and pre-base escapement estimates used for the base period calibration of the current Model were also used for the Phase II Model base calibration. Since there was no hatchery production during the base period, the pre-base and base period average escapements were set at 100 spawners to facilitate the model calibration. Essentially, this hatchery stock did not exist in the base period, however some very small values were used to facilitate model calibration.

The terminal run was estimated using the stock-specific catch estimates from the Fraser River Run Reconstruction model (English et al. 2007) and the escapement data. The escapements are estimated by age for this stock and reported by age in the FCS file.

Previously this stock group was represented in the Chinook model by the Harrison and Chilliwack CWTs, and the new model only uses Chilliwack CWT data. The Harrison has some differences in maturation patterns and there is a large sport fishery in the Chilliwack River than can have a high harvest rate, whereas the sport fishery is much smaller in the Harrison, and most years have had chinook non-retention regulations.

Table 48—Escapement data used for the Fraser Chilliwack Fall stock (FCF) for the base period Model calibration.

Model Stock Name	**Fraser Chilliwack Fall Hatchery**
Model Stock	FCF
Identification Number	12
CWT Indicator Stock	CHI
1975–1978 Pre-base Average	100
1979–1982 Base Period Average	100
Year	**Estimate**
1975	0
1976	0
1977	0
1978	0
1979	0

Year	Estimate
1980	0
1981	0
1982	0

Table 49—River systems comprising the Fraser Chilliwack Fall stock

Stocks Common to Phase II & 9806 Model	New Stocks Added to Phase II Model	Former Stocks Removed from Phase II Model
Chilliwack R	None	Harrison R (added as a separate stock)

4.17.2.1 MDL File Settings

See section 4.15.2.1 for details.

4.17.2.2 Base period CWT recoveries

The CHI ERSI CWT data from brood years 1981, 1982 and 1983 were used along the OOB to estimate the base period exploitation rates, maturation rates and other characteristics. Most of the CWT recoveries were in the Canadian ISBM fisheries, followed by the WCVI AABM fishery and the U.S. ISBM fisheries (Table 50).

Although FCF was transplanted directly from the FHF natural stock, there are considerable differences in the maturation patterns between these stocks, which must be related to the environment at the Chilliwack hatchery compared to conditions at the Chehalis hatchery, where the Harrison ERIS is produced. Most recoveries of FCF were at age-3 and there were about half this amount at age-4, which is a considerably different pattern than that for FHF which had slightly more recoveries at age-4 than age-3. Also, FCF had about 10% more recoveries at age 2 than age-4, whereas FHF had three times as many recoveries at age-4 than age 2.

Table 50—Summary of Chilliwack River Fall (CHI) CWT releases used for base period calibration and recoveries in escapement and PST fisheries.

				Recoveries in Canada						Recoveries in U.S.				
				AABM		ISBM		Escapement		AABM	ISBM		Esc	Grand
Brood	**CWT**	**Tagged**	**Untagged**	**NBC**	**WCVI**	**Marine**	**Fresh**	**Esc**	**Strays**	**SEAK**	**Marine**	**Fresh**	**Strays**	**Total**
1981	022163	74018	282370	33	1870	3841	126	2608	139	10	597	11	0	9235
1982	022422	73504	1047225	6	269	531	27	211	23	2	193	3	0	1265
1983	022658	26088	323785	0	181	287	19	377	1	0	112	8	0	985
	022659	24015	297764	5	142	333	0	169	10	0	69	2	0	730
	022660	26829	329433	10	135	283	14	262	16	0	57	3	0	780
Total		**76932**	**950982**	**15**	**458**	**903**	**33**	**808**	**27**	**0**	**238**	**13**	**0**	**2495**

Table 51—Summary of estimated CWTs in fisheries and escapements by brood for CHI tag codes selected to represent the Fraser Chilliwack Fall stock in the Phase II Model base period calibration.

Brood Year	Recovery Location	Age 2	Age 3	Age 4	Age 5	Age 6	Total
1981	marine	1366	3739	1174	72	--	6351
	freshwater	74	45	18	0	--	137
	escapement	1405	900	239	64	--	2608
	escapement stray	0	15	112	12	--	139
1982	marine	155	548	275	23	--	1001
	freshwater	16	3	11	0	--	30
	escapement	41	13	129	28	--	211
	escapement stray	0	0	12	11	--	23
1983	marine	184	1020	387	23	--	1614
	freshwater	8	12	26	0	--	46
	escapement	41	183	490	94	--	808
	escapement stray	0	0	21	6	--	27
Grand Total	**All Locations**	**3290**	**6478**	**2894**	**333**	--	**12995**

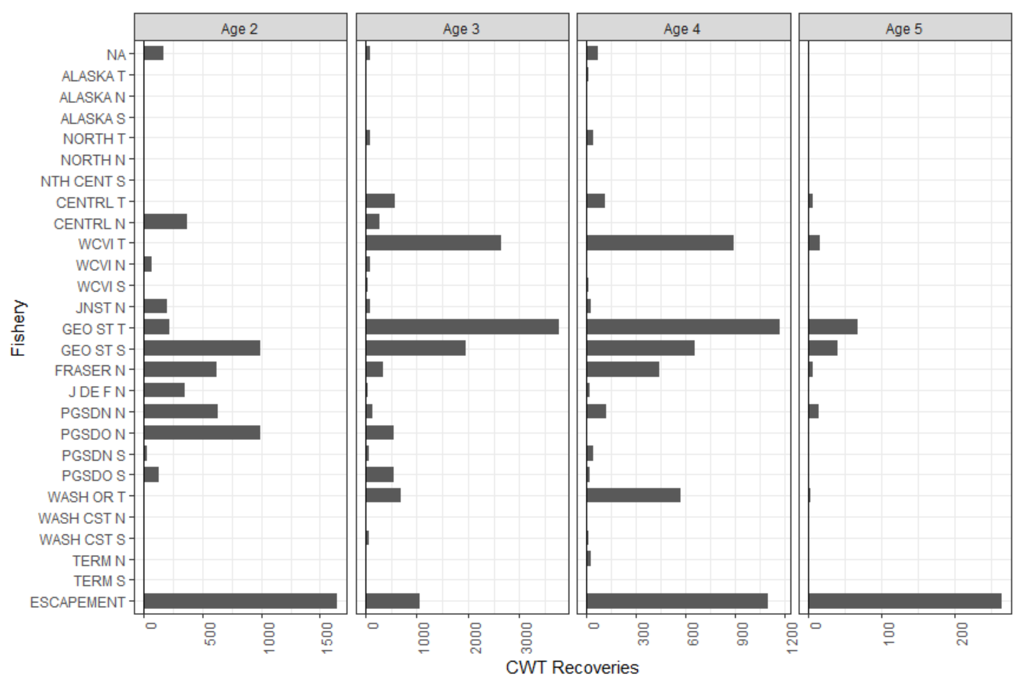

Figure 100—Base period coded-wire tag (CWT) recoveries for Fraser Chilliwack Fall Hatchery.

4.17.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

Maturation rates for the ERIS CWT and the SACE methods were very similar for ages 2, 3 and 4, and further corroborate other information that has found that there is very little natural production of fall Chinook in the Chilliwack River and that nearly all of the fish were produced by the hatchery (Figure 101).

Base period exploitation rates were highest in the WCVI troll fishery for age-3, and the Strait of Georgia troll fishery for ages 4 and 5 (Figure 102). In general, the CHI tag codes had recoveries in most of the base period fisheries that have been observed to harvest the FCF stock based on data patterns for many cohorts (e.g., 1985–2018).

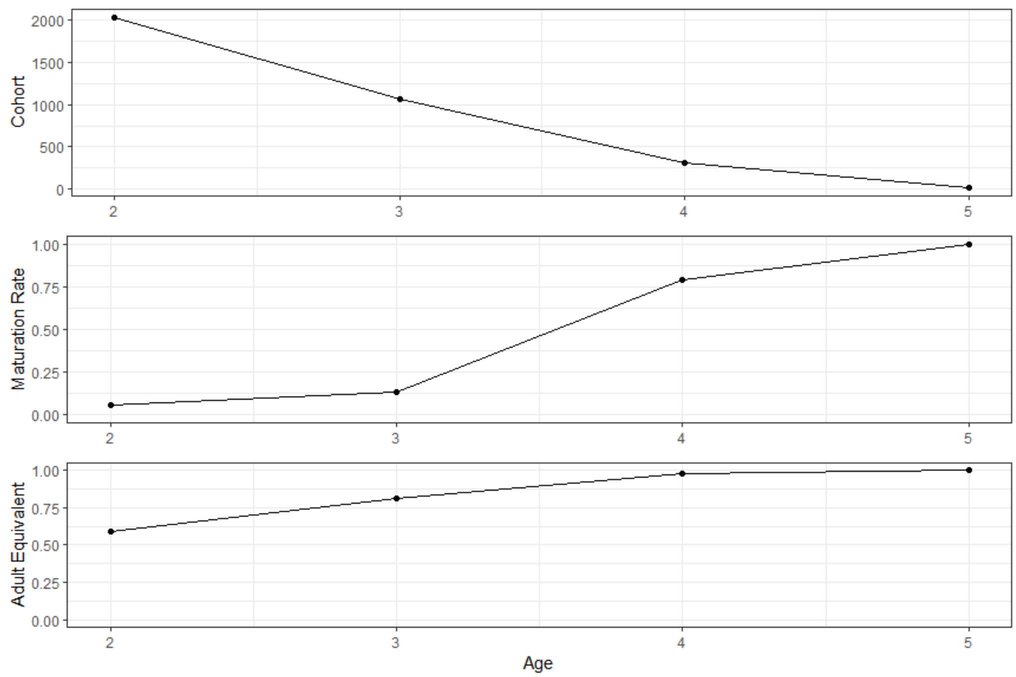

Figure 101—Base period cohort size, maturation schedule, and adult equivalent for Fraser Chilliwack Fall Hatchery.

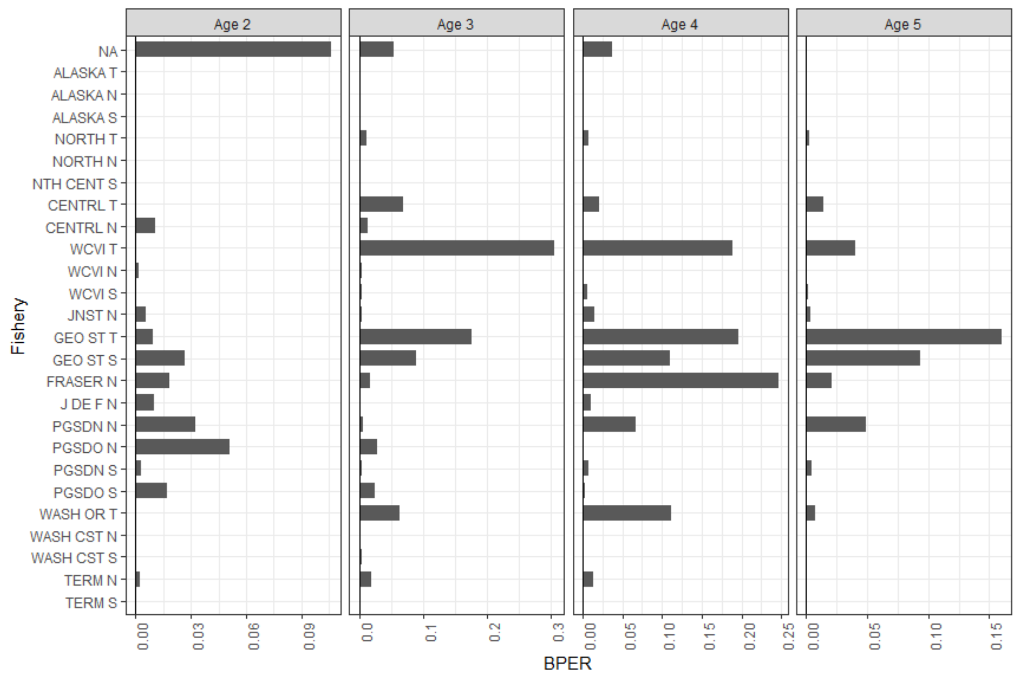

Figure 102—Base period exploitation rate by fishery for Fraser Chilliwack Fall Hatchery.

4.17.2.4 Escapement/Terminal Run Time Series

The Fraser River First Nation net fishery has had low CWT sampling rates, which led to the use of the Fraser River Run Reconstruction model (English et al. 2007) to estimate stock specific catches in Fraser River fisheries and then these were used with escapement data to generate time series of terminal runs and terminal FPs. The Chinook model was set to calibrate to the escapement for FCF because there is more uncertainty about the terminal fishery impacts in comparison to the quality of the escapement estimates. The quality of the escapement data has not been examined, and there are likely opportunities to review and improve the quality of those data. Since FCF can have a large escapement, improvements to the quality of the escapement data could also contribute improvements to the Chinook model performance.

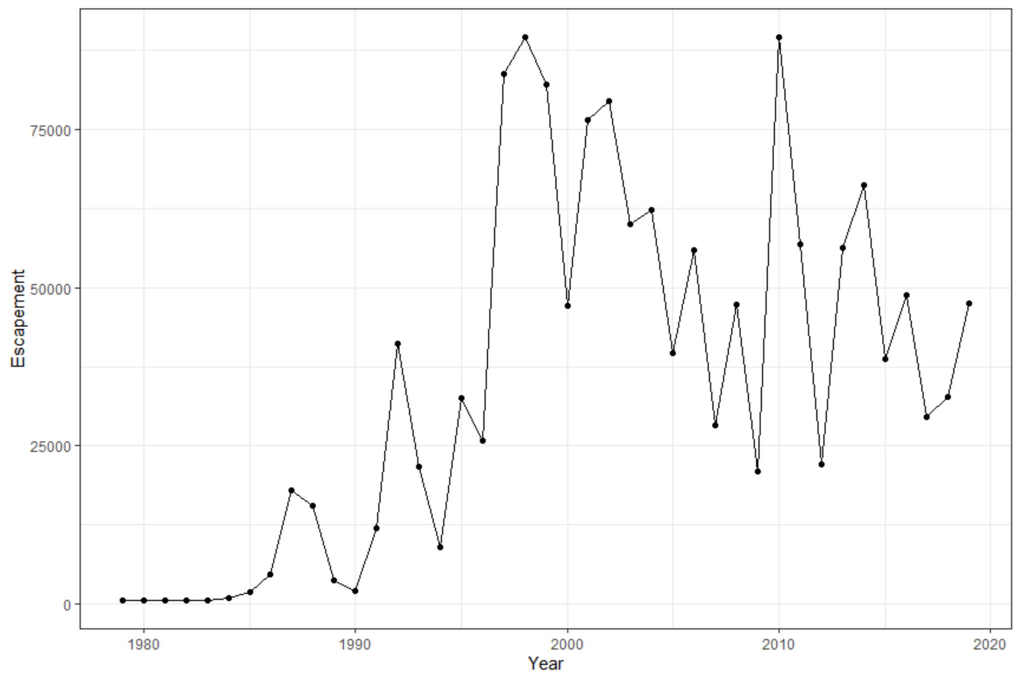

Figure 103—Escapement for Fraser Chilliwack Fall Hatchery.

4.17.2.5 Ricker Parameters

The FCF is a hatchery stock and the productive capacity is limited by the hatchery rearing capacity and allocations of capacity among stocks and species.

Table 52—Source of the Ricker stock-recruitment parameters used as initial values for FCF in the base period Model calibration.

	River System
Estimate	**Chilliwack**
Smsy*	1,000
Srep*	4,072
Smsy/Srep	0.246
log(alpha)*	3.635
Alpha	37.886
Umsy	0.89
Beta	0.00089258
Rmax	15,615

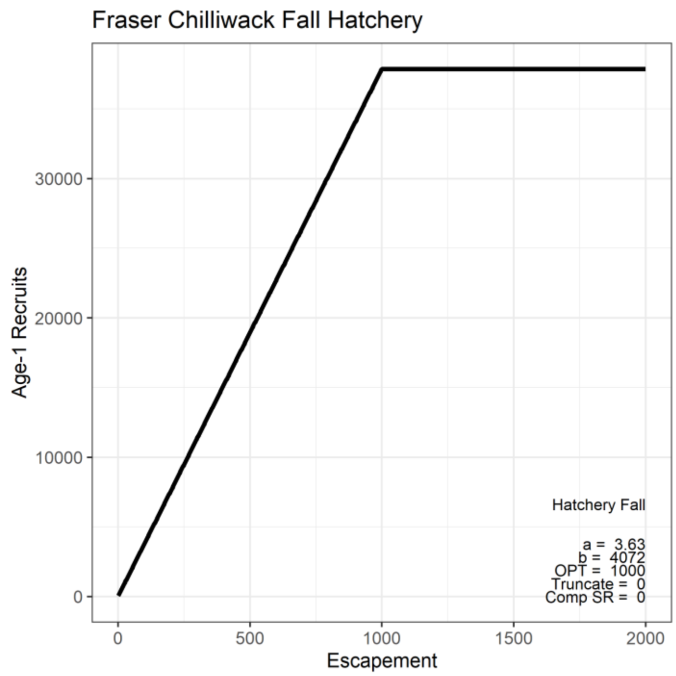

Figure 104—Ricker curve and parameters for Fraser Chilliwack Fall Hatchery (FCF) model stock.

4.17.3 Comparison of Model Performance

Many improvements were made to the model and the calibration inputs during the course of phase II of the base period calibration. To examine the effect of these improvements, comparisons were made to independent estimates of cohort sizes by age, brood year exploitation rates, and the model's performance for fitting to the terminal run/escapement.

4.17.3.1 Cohorts

For the FCF stock group, cohort sizes were estimated independently for cohorts that had sufficient escapement age sampling. These SACE maturation rates, labeled CWT-FCS on the following figures, corresponded exceptionally well to those that were estimated by the new model for all ages. However. the new Chinook model overestimates the cohort sizes for ages 2, 3 and 4 relative to the CWT-FCS (SACE) method, since most observation were above the 1:1 reference line. Overall the new model appeared to estimate the temporal pattern of the cohort sizes very well relative to those developed using escapement and CWT data.

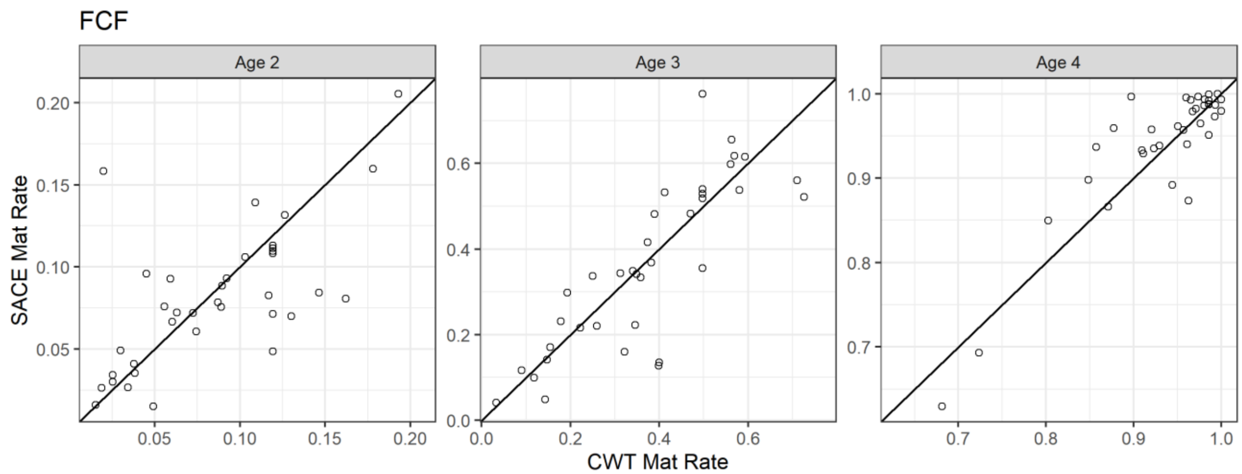

Figure 105—Maturation rate comparison between the Chilliwack exploitation rate indicator stock (x-axis) and the stock aggregate cohort evaluation (SACE; y-axis).

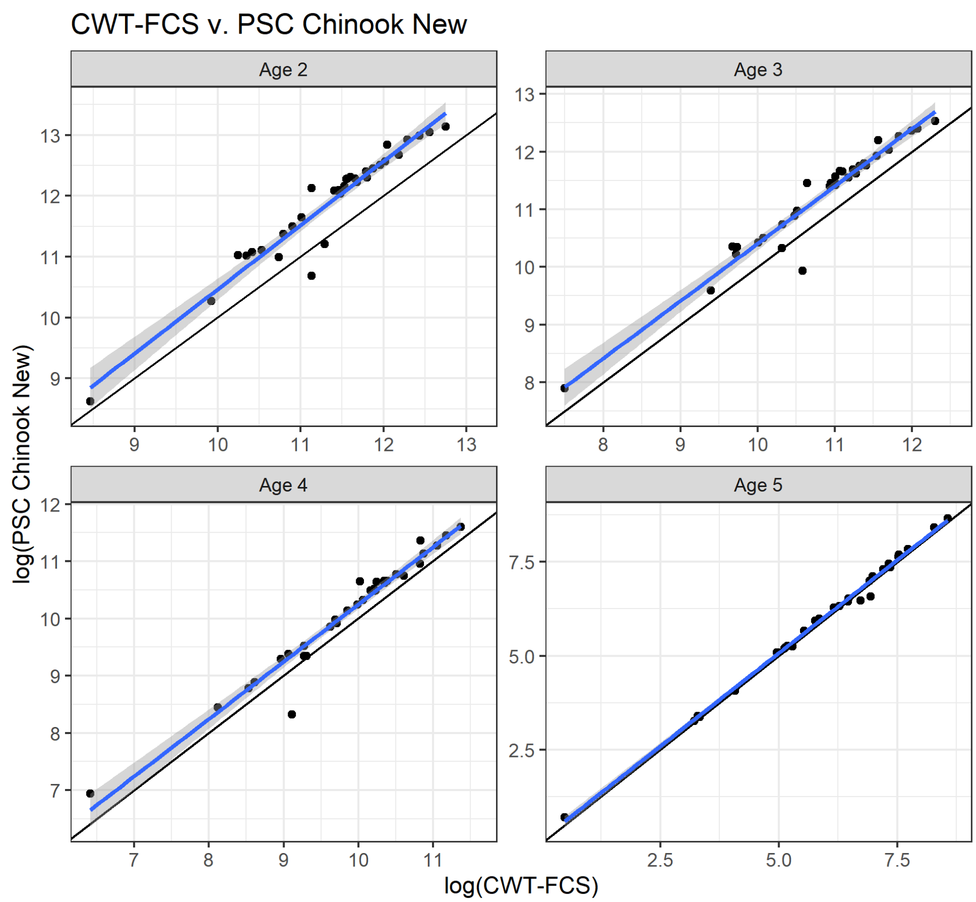

Figure 106—Comparison of cohort sizes estimated using the CWT FCS files and the Phase II PSC Chinook Model for Fraser Chilliwack Fall.

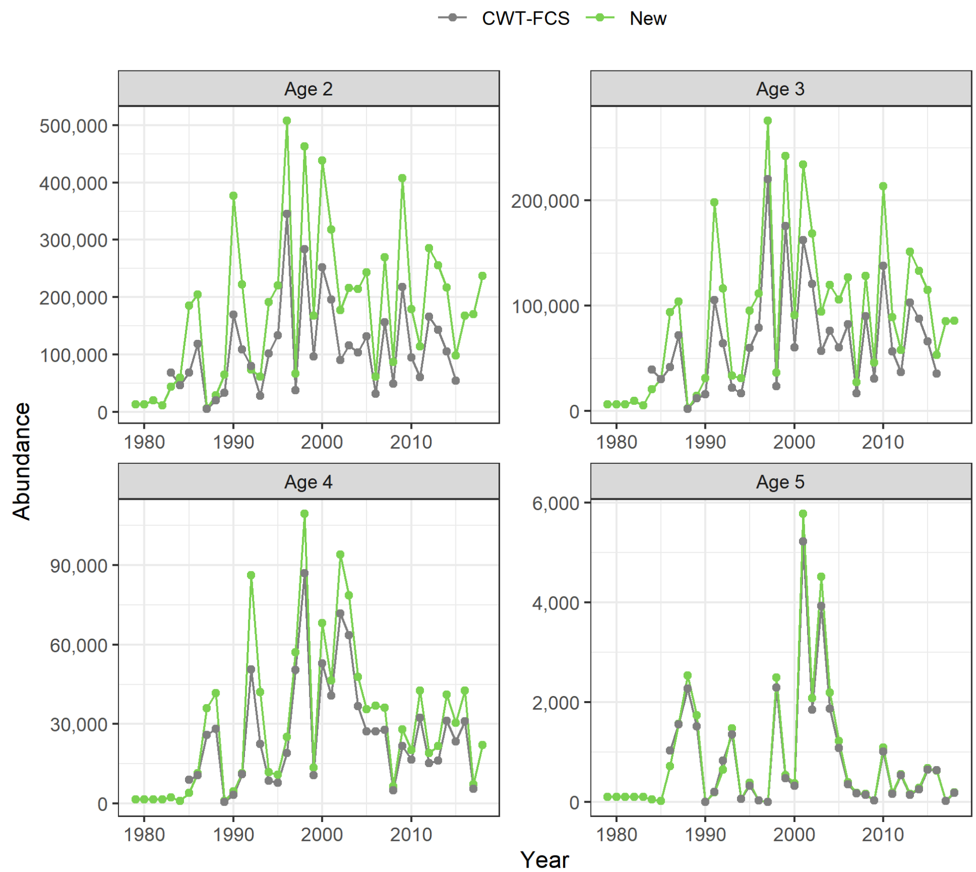

Figure 107—Time series comparisons of cohort size abundance estimated using the CWT FCS files and the Phase II PSC Chinook Model for Fraser Chilliwack Fall.

4.17.3.2 Exploitation Rates

Based on a comparison of the model and CWT-based exploitation rates, the new model represented the temporal pattern of the exploitation rates very well for FCF, with no biases apparent. This pattern is evident for ocean and freshwater fisheries. Given the large abundance of this stock and its contributions to fisheries in Southern B.C. and Washington, the new model appears to be considerably improved in terms of its representation of this component of the Chinook resource.

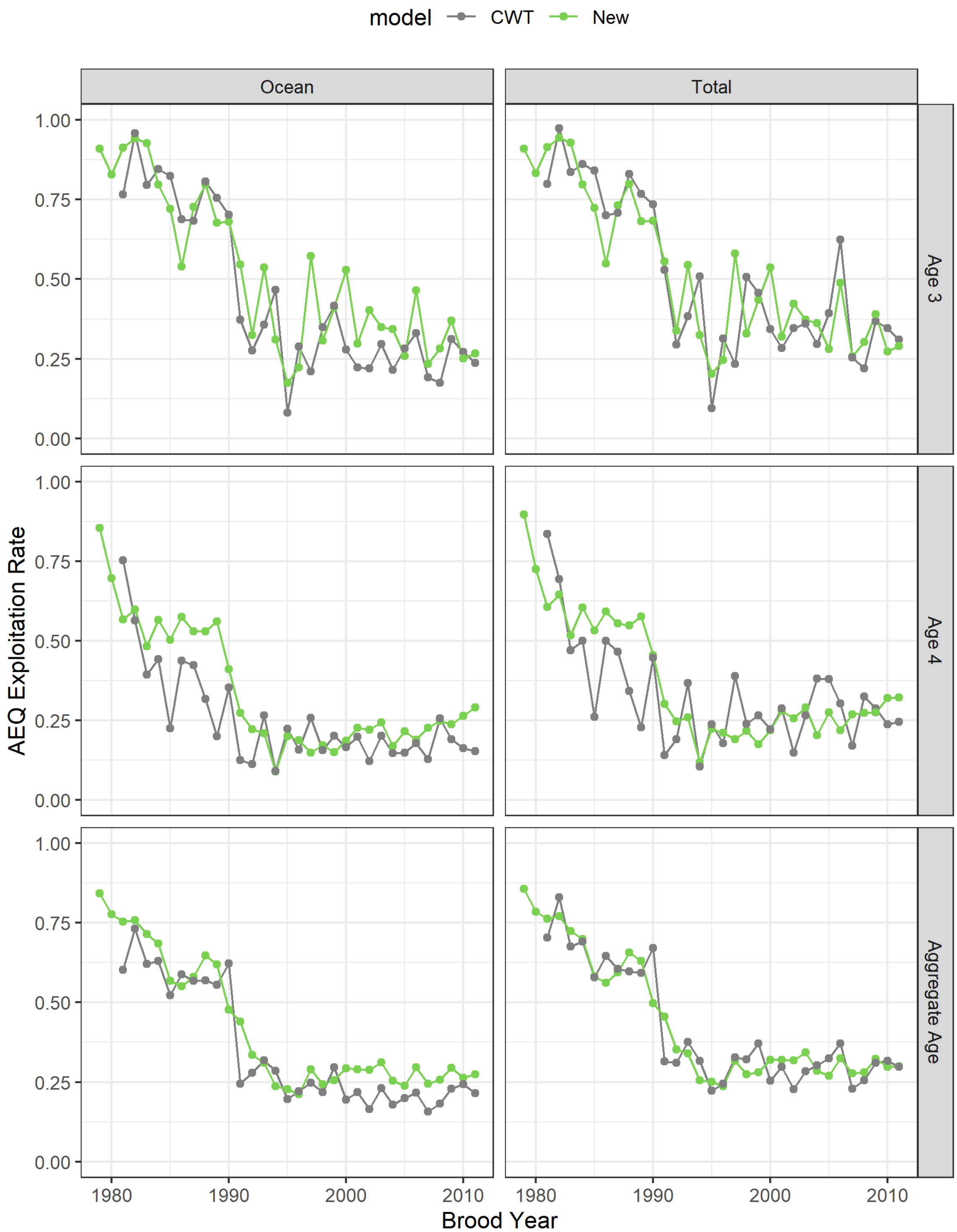

Figure 108—Adult equivalent (AEQ) exploitation rates using the PSC Chinook Model and coded-wire tag recovery estimates for the age-4, age-5, and aggregate age Fraser Chilliwack Fall (FCF) stock group for ocean fisheries and total fisheries (including terminal).

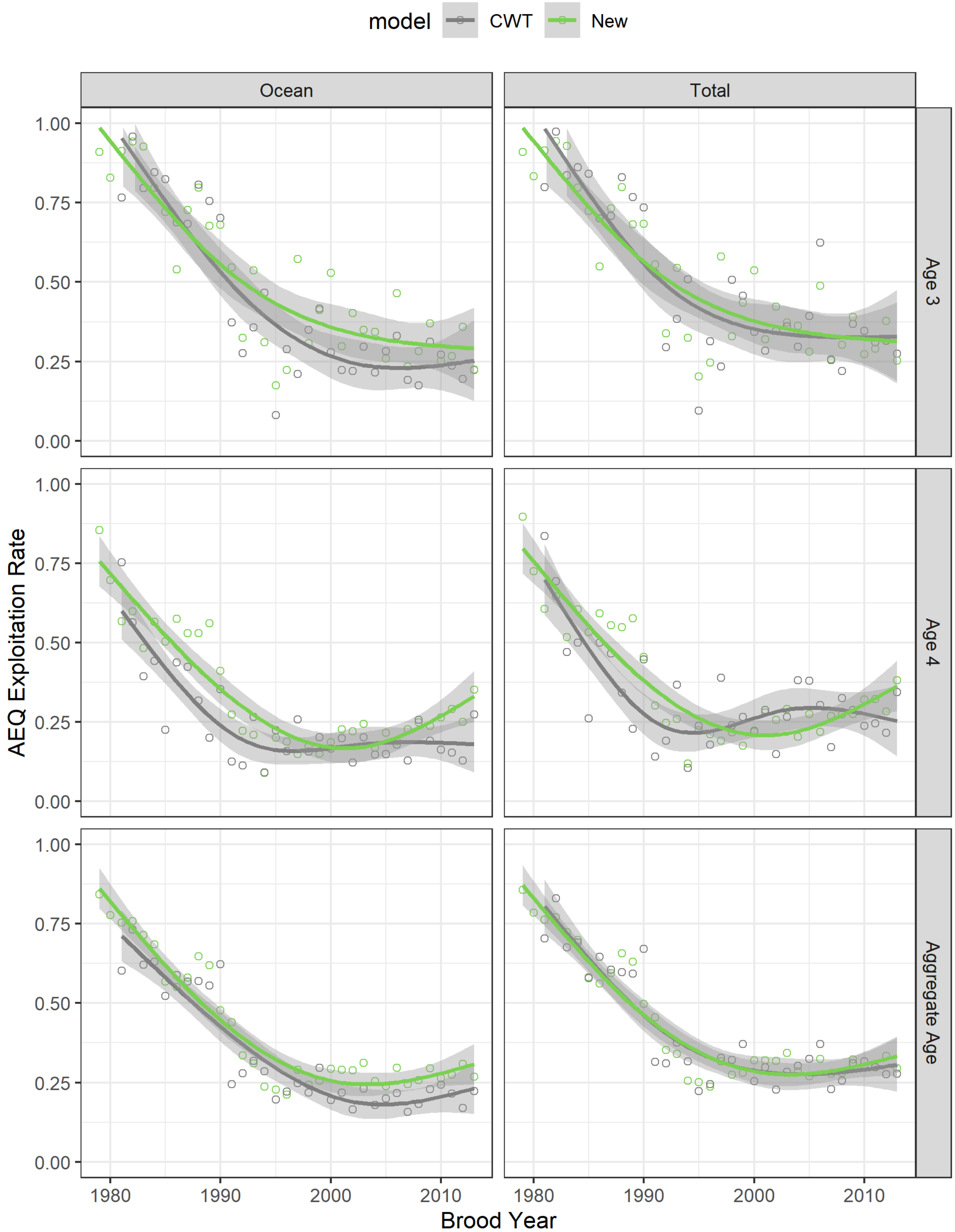

Figure 109—Adult equivalent (AEQ) exploitation rates with a smoothing function using the PSC Chinook Model and coded-wire tag recovery estimates for the age-4, age-5, and aggregate age Fraser Chilliwack Fall (FCF) stock group for ocean fisheries and total fisheries (including terminal).

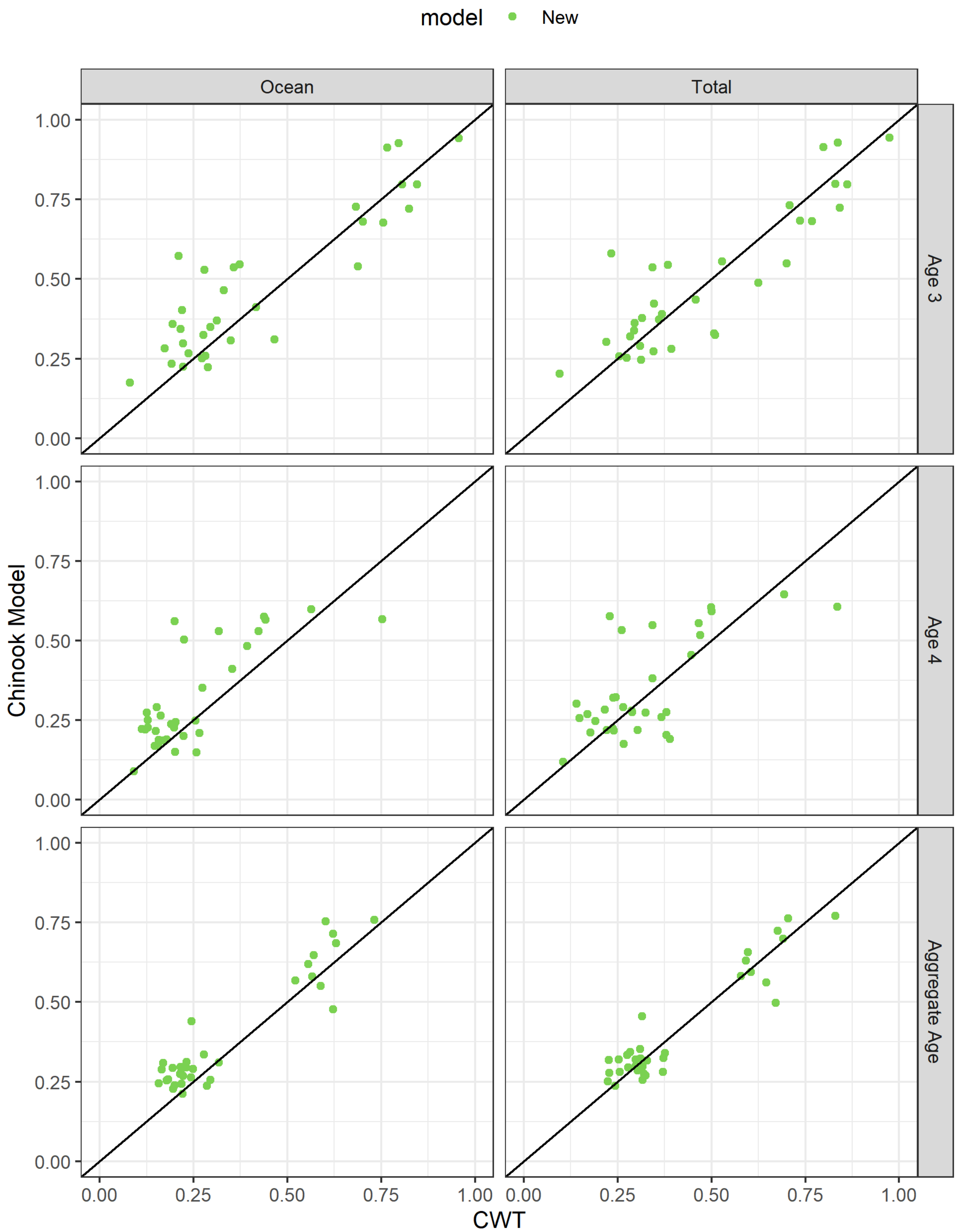

Figure 110—Relationship between exploitation rates from coded-wire tag recovery estimates and from the PSC Chinook Model for the Fraser Chilliwack Fall (FCF) stock group.

4.17.3.3 Model Fit to Terminal Run/Escapement

Figure 99 indicates the relative performance of two versions of the new Chinook Model (green is intermediate and blue is final) for the FCF stock group. The blue shaded box plot represents the version of the new Chinook model where the SACE method was applied, which enabled the model to perform tremendously better for estimating the spawning escapement, as indicated by the much smaller box plot distribution, with the median value close to 1. The SACE method appears to have made an impressive improvement to the performance of the new model.

4.18 West Coast Vancouver Island Hatchery (WVH): West Coast Vancouver Island Hatchery (WVH)

4.18.1 Stock Description

WCVI Chinook are dominated by ocean-type, fall run stocks. WCVI Chinook enter the ocean as fry and spend their early marine period in local Sounds. The young fish then gradually migrate along the coastline through B.C. and Southern Alaska to rear for 2-5 years in the Alaska Gyre. Returning adult WCVI Chinook reverse their migratory pathway and are vulnerable to SE Alaskan and then central/northern B.C. fisheries en route. Their migration makes landfall on Northern Vancouver Island in early July and are nearshore oriented as the migrate south down the WCVI. Returning fish are susceptible to near-shore WCVI fisheries during this time. Terminal returns begin in mid-July in Northwest Vancouver Island (NWVI) and through August in Southwest Vancouver Island (SWVI). Spawning begins in mid-September and finishes around late October. There are also differences in run timing between North and South Vancouver Island stocks (NWVI and SWVI, respectively). NWVI stocks return approximately 3 weeks earlier than SWVI stocks, and may also have higher marine survival. Historically, WCVI Chinook were larger in size and were more abundant, but there have been declining trends in both run sizes and size-at-age. Clayoquot Sound (Area 24), in particular, has been depressed for many years. Exploitation rates and maturation rates are estimated from CWT'd Chinook salmon from the Somass River system. Robertson Creek (RBT) is used as a CWT indicator stock for both hatchery and wild-origin WCVI Chinook, and a significant number of WCVI hatchery-origin Chinook fish are captured during the ocean harvest from the Gulf of Alaska to the Strait of Juan de Fuca. Due to high harvest rates on hatchery-origin fish returning to the Alberni canal, a terminal adjustment is implemented when estimating the CYER (Calendar Year Exploitation Rates). Using this adjustment, the exploitation rates may be applied to other WCVI terminal areas (e.g., Clayoquot Sound). Between 1999–2011, the Canadian exploitation rates were approximately 10–15% (Brown et al. 2020), and over all fisheries, averaged 36% for Clayoquot Sound from 2015–2019 (CTC 2021b).

Unfortunately, over a 16-year period that was investigated, escapement estimates based on CWT recoveries consistently underestimated RBH and RBT returns by 10–60% (average of 32%) when compared to estimates from a Run Reconstruction based on marked otolith samples. The percent difference increased at higher run sizes. Although this discrepancy is not likely to influence exploitation rates, it may bias survival rate, escapement, catch, and effort estimates, and investigation should be continued. Several factors likely contribute to the discrepancy between the two estimation methods, including: sampling bias, sampling design, tagging rates, tag shedding, and differential homing abilities between tagged and un-tagged fish.

RBT and RBH escapements are counted via a fishway; the return is typically made up of a high percentage of hatchery fish. Hatchery fish occasionally stray from their natal watersheds. Straying rates among Conuma, Nitinat, and Robertson Creek Hatchery fish range from approximately 1–4%.

4.18.2 Description of Changes

Burman River Chinook are genetically screened for brood stock collection and are marked via adipose fin clips as of 2019. A mass marking trial for Conuma hatchery Chinook was initiated in the spring of 2020. Marking was interrupted due to COVID-19, but 100% mark rates are the target for the next two releases. Sarita River Hatchery fish (Pacific Fishery Management Area [PFMA] 23) have been mass marked since 2019, but this project was also interrupted by COVID-19 in 2020.

For SWVI (Chinook [CK] Conservation Unit [CU] CK-31), Nahmint, Sarita, Tranquil and Bedwell Rivers are used by the CTC as escapement indicator stocks, and Bedwell has a 100% mark rate for enhancement (Brown et al. 2020). One CU was formed by combining Port San Juan (CK-30) and SWVI (CK-31), which corrected spawning time information (Brown et al. 2020).

4.18.2.1 MDL File Settings

Table 53—Information used in the construction of the West Coast Vancouver Island Hatchery (WVH) MDL file.

Information for MDL File Production	Phase II Model Stock
Model Stock Acronym	WVH
Brood Years	1974–1977
Out-of-base procedure used?	No
Modifications to fisheries in WG4 file	NA
C-file extension (CWT Indicator ID)	RBT
Yearling Stock	No
Weight within BY by production releases	Yes
Exclude Esc for Between BY weighting	Yes
Start age in C-files	2
Last age in C-files	5
Modifications to escapements in Coshak4	Yes
Terminal fishery CWT moved to escapement	No
Model stock type	Hatchery, Fall
Additional fisheries designated as terminal in the BSE file	WCVI Net
MDL creation date	12 Sept. 2018

4.18.2.2 Base Period Coded-Wire Tags and Recoveries

Table 54—Coded-wire tag codes for West Coast Vancouver Island Hatchery (WVH) model stock.

Brood Year	Tag Codes	
	9806	Phase II
1974	RBT: 020606, 020906, 021206	RBT: 020906, 020906
1975	020408, 020409	020408, 020409
1976	021629, 021630, 021631	021630, 021631
1977	022217, 022218	022217, 022218

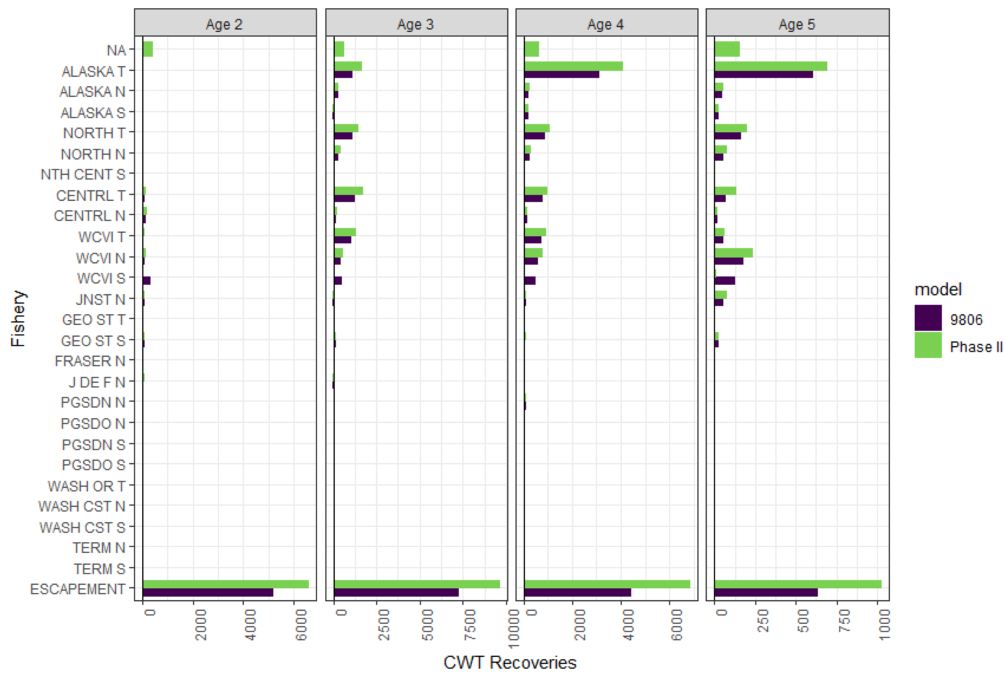

Figure 111—Base period coded-wire tag (CWT) recoveries for West Coast Vancouver Island Hatchery (9806, Phase II).

4.18.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

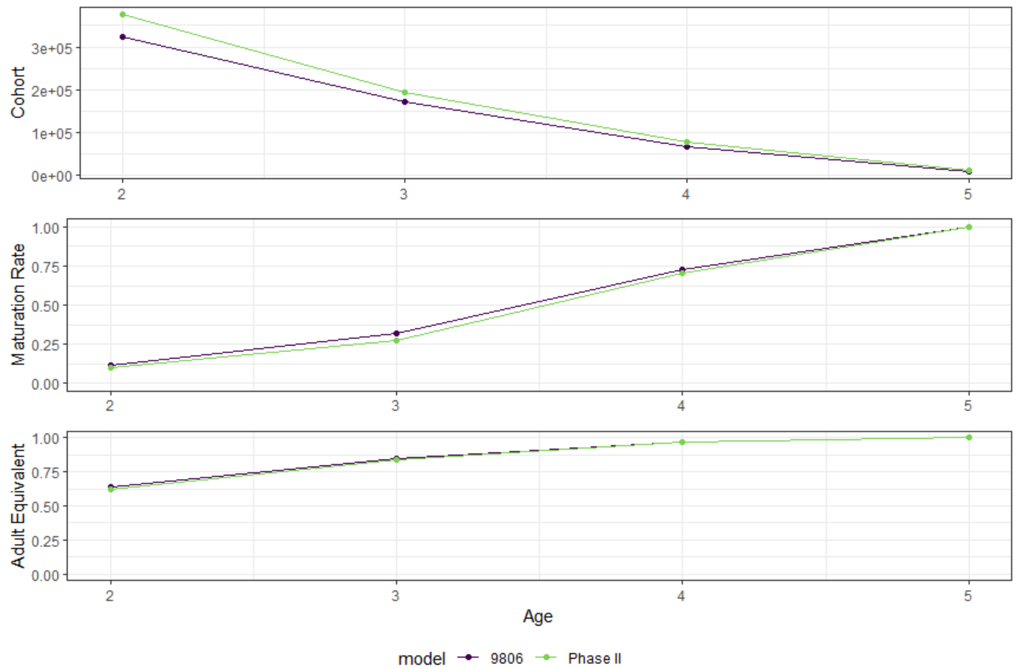

Figure 112—Base period cohort size, maturation schedule, and adult equivalent for West Coast Vancouver Island Hatchery (9806, Phase II).

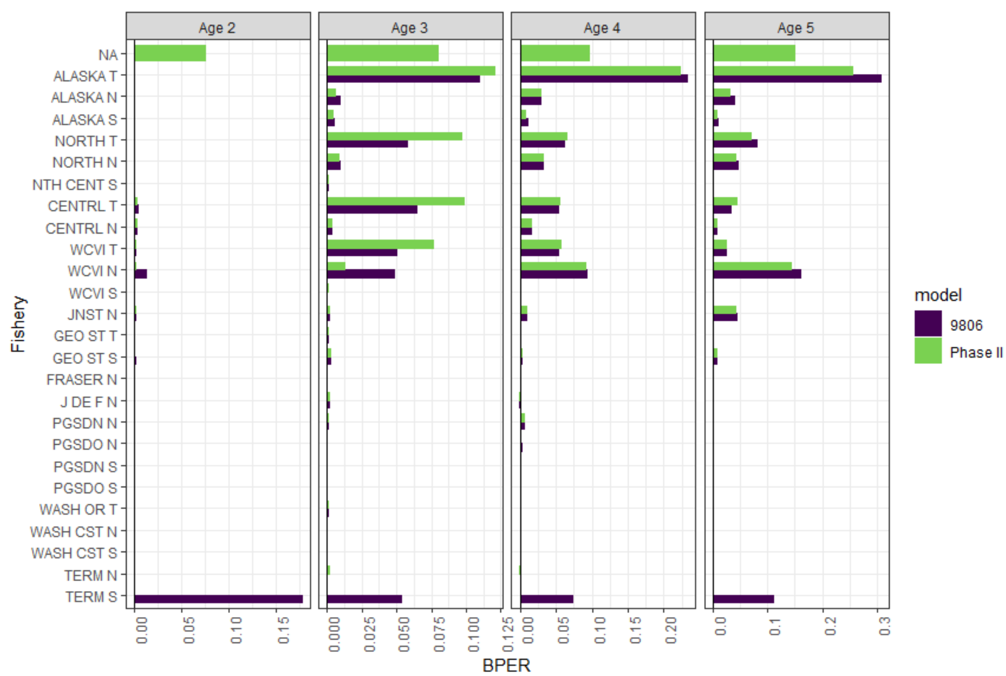

Figure 113—Base period exploitation rate by fishery for West Coast Vancouver Island Hatchery (9806, Phase II).

4.18.2.4 Escapement/Terminal Run Time Series

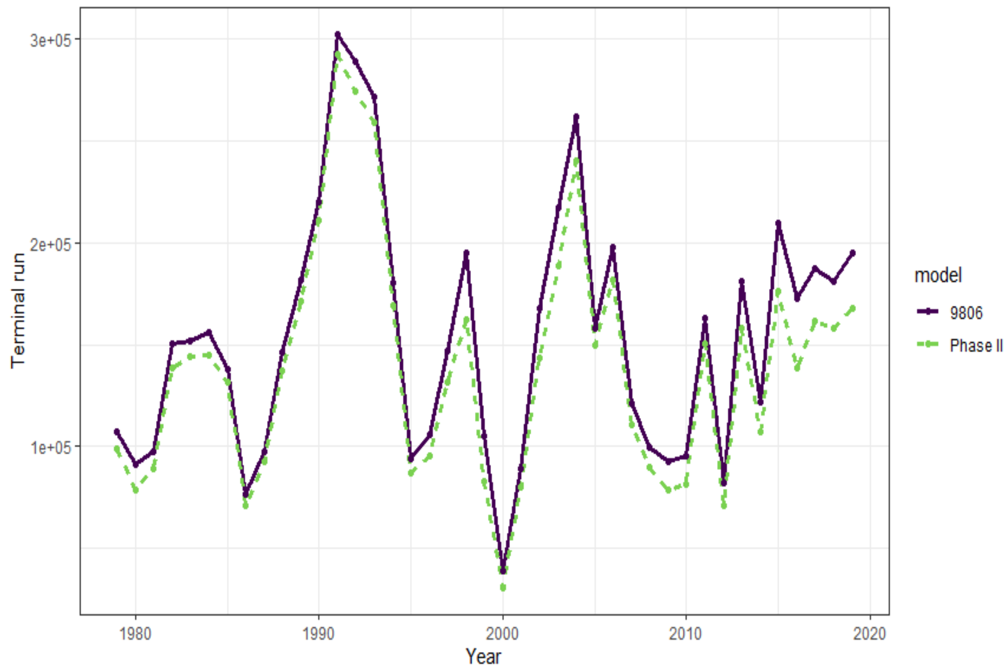

Figure 114—The combined West Coast Vancouver Island hatchery and natural terminal run time series from the 9806 model calibration and the terminal run time series from Phase II. Note that for the 9806 calibration, the West Coast Vancouver Island model stocks' terminal run time series were not stratified by hatchery and natural; however, in Phase II model stratified estimates were used.

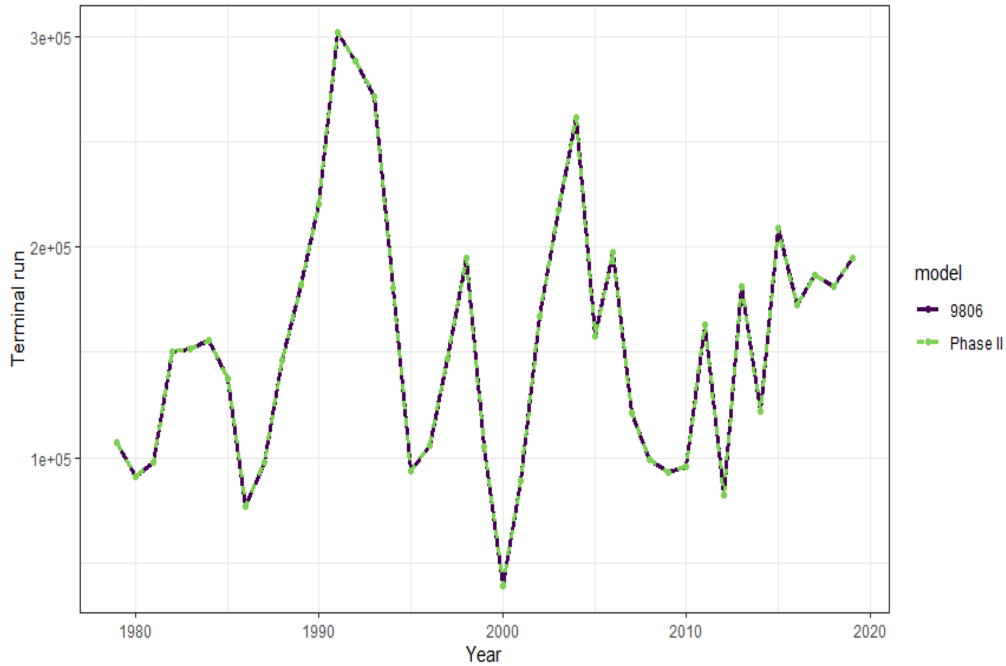

Figure 115—Combined West Coast Vancouver Island hatchery and natural terminal run time series from both the 9806 calibration and Phase II models.

4.18.2.5 Ricker Parameters

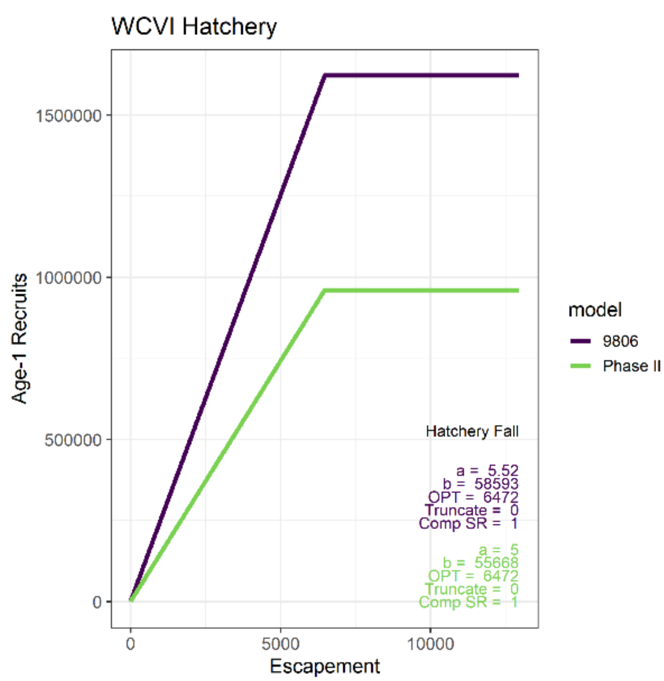

Figure 116—Ricker curve and parameters for West Coast Vancouver Island Hatchery (WVH) model stock.

4.19 West Coast Vancouver Island Natural (WVN): West Coast Vancouver Island Natural (WVN)

4.19.1 Stock Description

Estimates of the terminal return of tagged chinook salmon from Robertson Creek in combination with sampling data from ocean fisheries subsequently results in estimates of exploitation rates and ocean cohort sizes for the entire WCVI complex of natural and hatchery origin chinook salmon. Crucial to the accuracy of the estimates is the condition that harvest rates and maturation rates of tagged Robertson Creek Hatchery (RBH) fish provide applicable proxy data for the entire WCVI complex of natural and hatchery origin Chinook salmon. While the RBH data may provide reasonable approximations for open ocean fisheries, the various stocks of WCVI origin chinook undoubtedly are susceptible to very different harvest patterns in near shore fisheries that take place along the WCVI. In 2015, the WCVI Chinook Run Reconstruction Project was initiated which provides improved accuracy and precision of abundance estimates along with improved spatial, temporal resolution of biological catch and escapement data to improve the assessment and forecast of WCVI hatchery and wild chinook abundance used in the fishery management in the PST AABM fisheries and in the terminal ISBM areas of the WCVI. This project supports the application of the ‘distant fishery index’ methodology (also called ‘driver stock method’). Distant fishery catch ratios such as ‘total WCVI abundance/ Robertson Creek Hatchery abundance’ can be combined with known terminal abundance of Robertson Creek Hatchery stock to estimate total terminal abundance of WCVI chinook. There is significant potential for such ‘distant fishery indices’ to improve assessment and management of such complex stock aggregates such as WCVI chinook.

RBT fish pass through a fishway in the Stamp River, where they are enumerated to estimate escapement. Snorkel surveys are conducted in various other streams (funding-dependent) between early-September and late-October to gather visual counts of spawner abundances. Area under the curve (AUC) calculations are then applied to the visual counts to estimate total adult spawner escapements in PFMAs 20–27. AUC estimates perform relatively well in WCVI streams compared to other streams in B.C. thanks to the relatively short survey sections and high visibility in clear waters. Gold River is not assessed by snorkel surveys because the rapids are too dangerous to swim. Mark-recapture studies are also conducted (infrequently due to high cost) in systems with significant flooding and challenging swim conditions.

The natural WCVI escapement index is based on six rivers that were combined to form the WCVI aggregate (CTC 2004): Kaouk, Artlish, Burman, Tahsis, Tahsish, and Marble. Burman, Tahsis, Leiner, Artlish, Tahsish, and Kaouk River are all escapement indicator stocks for CK-21. Marble River is used as an escapement indicator stock for CK-33, but it is not known how well it represents all of NWVI. S_{msy} was predicted for this WCVI aggregate based on watershed productivity. Parken et al. (2006) predicted S_{msy} values within the range of AUC escapement estimates for Marble, Tahsis, Kaouk, Burman, Tahsish, and the WCVI aggregate index. However, recent escapement estimates in the Artlish exceeded the predicted S_{msy} (Parken et al. 2006). Limit references points are currently being developed for WCVI Chinook focusing on natural indicators and considering Wild Salmon Policy objectives to main and restore Conservation Units within major stock groupings.

4.19.2 Description of Changes

Discussions and planning are underway to implement mass-marking of RBH Chinook and a corresponding mark-selective recreational fishery in PFMA 23. Under this scenario, RBH CWT recoveries will no longer be useful for estimating exploitation rates on RBT Chinook because RBH Chinook will be subjected to increased harvest.

4.19.2.1 MDL File Settings

Table 55—Information used in the construction of the West Coast Vancouver Island Natural (WVN) MDL file.

Information for MDL File Production	Phase II Model Stock
Model Stock Acronym	WVN
Brood Years	1979–1978; 1984–1985
Out-of-base procedure used?	Yes
Modifications to fisheries in WG4 file	No
C-file extension (CWT Indicator ID)	RBT
Yearling Stock	No
Weight within BY production releases	No
Exclude Esc for Between BY weighting	No
Start age in C-files	2
Last age in C-files	5
Modifications to escapements in Coshak4	No
Terminal fishery CWT moved to escapement	Yes; TWCVI TERM S, N
Model stock type	Wild, Fall
Additional fisheries designated as terminal in the BSE file	WCVI Net
MDL creation date	22 Oct. 2015

4.19.2.2 Base Period Coded-Wire Tags and Recoveries

Table 56—Coded-wire tag codes for West Coast Vancouver Island Natural (WVN) model stock.

Brood Year	Tag Codes	
	9806	Phase II
1974	RBT: 020606, 020906, 021206	RBT: 020906, 020906
1975	020408, 020409	020408, 020409
1976	021629, 021630, 021631	021630, 021631
1977	022217, 022218	022217, 022218

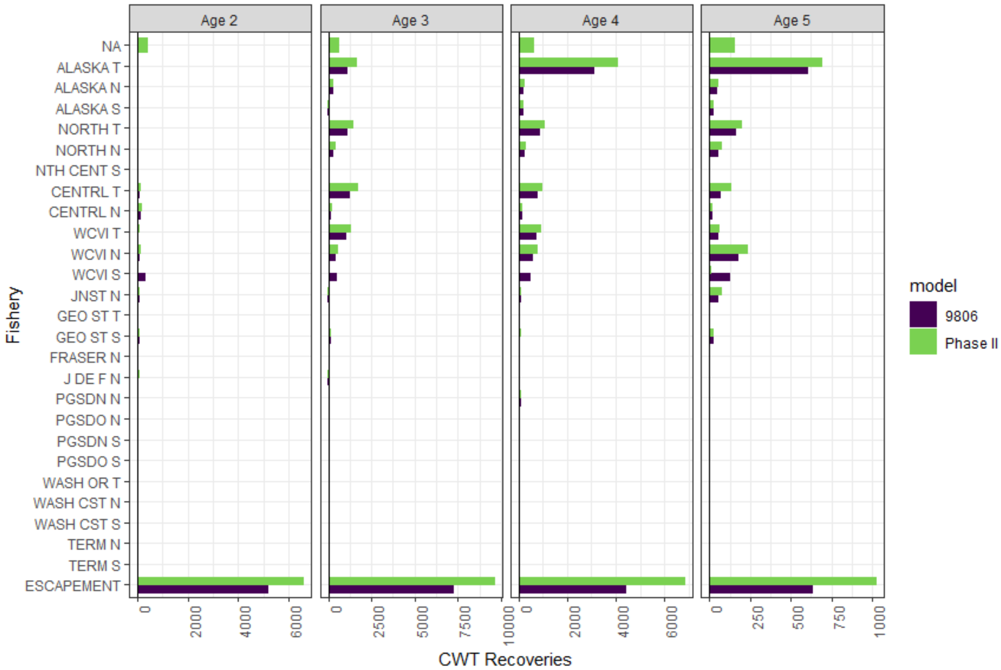

Figure 117—Base period coded-wire tag (CWT) recoveries for West Coast Vancouver Island Natural (9806, Phase II).

4.19.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

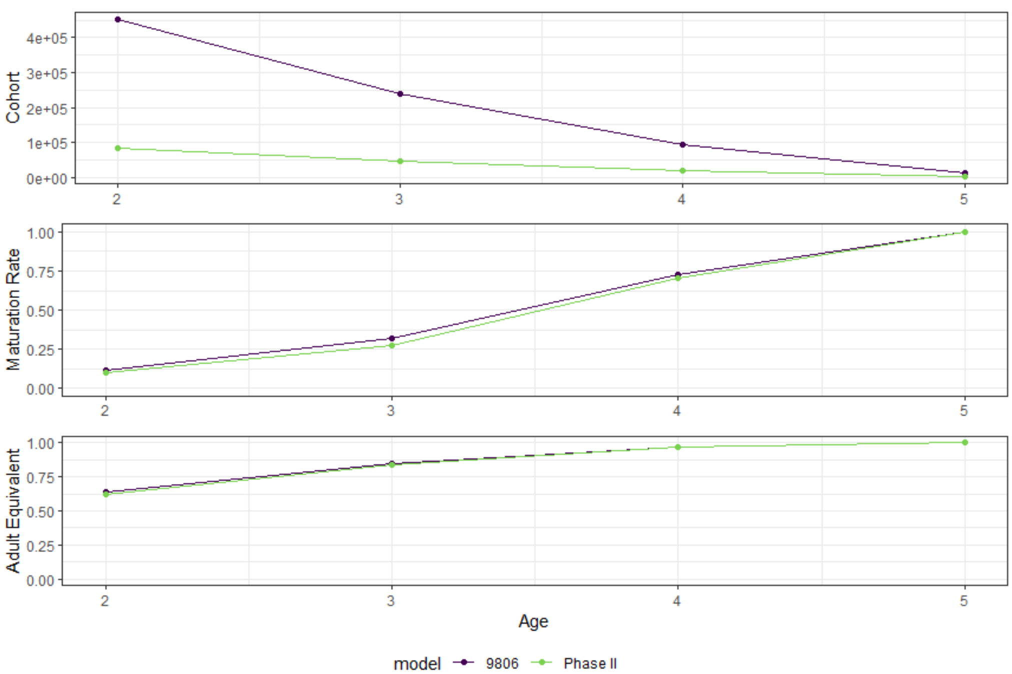

Figure 118—Base period cohort size, maturation schedule, and adult equivalent for West Coast Vancouver Island Natural (9806, Phase II).

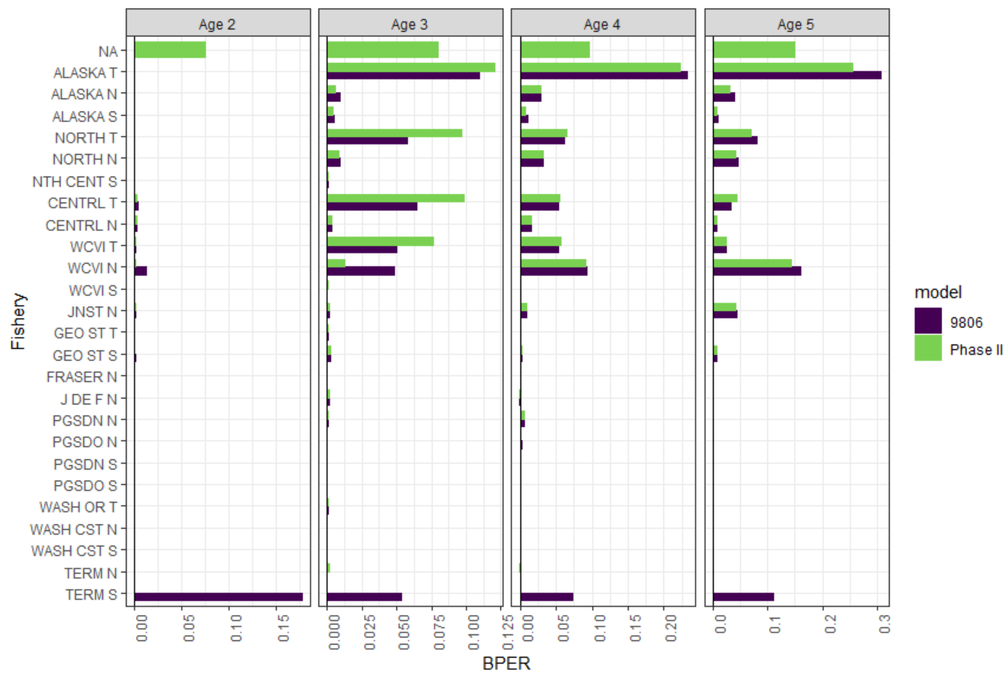

Figure 119—Base period exploitation rate by fishery for West Coast Vancouver Island Natural (9806, Phase II).

4.19.2.4 Escapement/Terminal Run Time Series

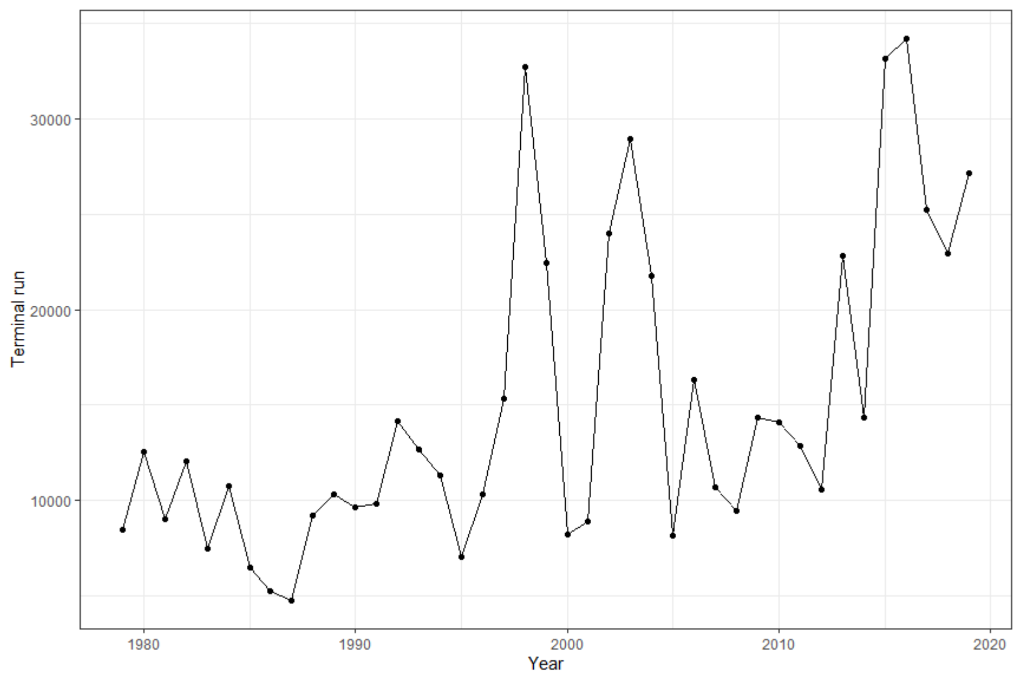

Figure 120—Terminal run size for West Coast Vancouver Island Natural (9806, Phase II).

4.19.2.5 Escapement/terminal run time for RBH/RBT series combined

Note that in CLB1804, the WCVI model stocks' terminal run time series were not stratified by hatchery and natural; however, in Phase II model stratified estimates were used (Figure 121).

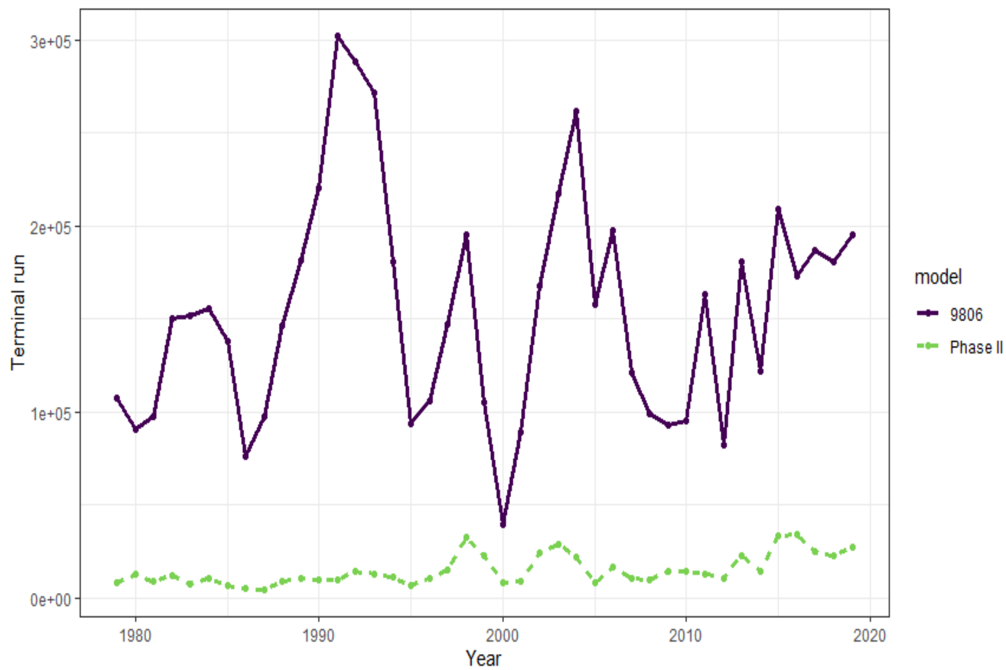

Figure 121—Comparison of the West Coast Vancouver Island hatchery and natural terminal run time series from CLB1804 against the terminal run time series of naturals from phase II. A comparison of the aggregate time series of both model stocks in both models can be found in section 4.18.

4.19.2.6 Ricker Parameters

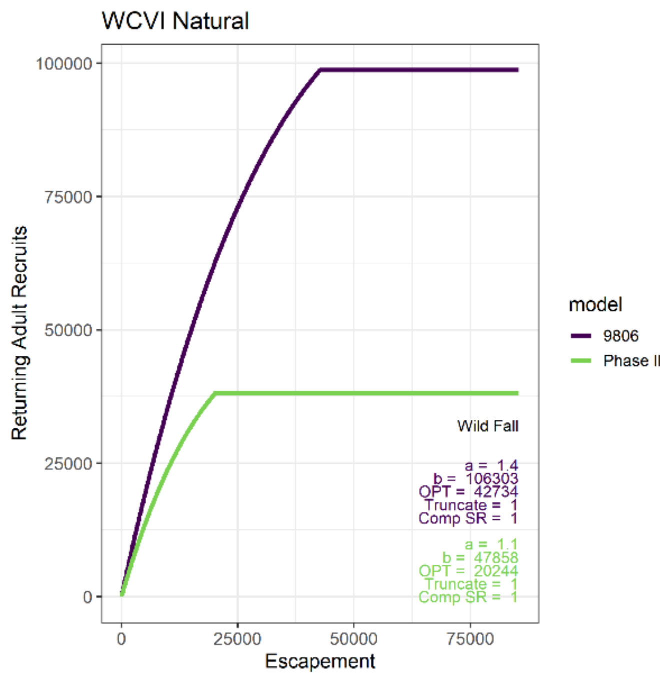

Figure 122—Ricker curve and parameters for West Coast Vancouver Island Natural (WVN) model stock.

4.20 Upper Georgia Strait (GSQ): Upper Strait of Georgia (UGS) and Puntledge Summers (PPS)

4.20.1 Stock Description

Puntledge summer Chinook are part of the East Vancouver Island ocean type summer designatable unit (DU) 20. They are subject to significant hatchery enhancement efforts including genetic selection of brood to maintain separation from the fall run. The natural spawning population occupies the upper reaches of the watershed with a significant amount of habitat at the outlet of Comox Lake. Run timing is May through August with June/July representing the peak of migration. Brood stock are collected via a fence in the lower river and is typically finished by August 1 in order to avoid selecting early fall runs. Abundance is generally around 1000 adults resulting in persistent terminal marine fishery closures. A recovery potential assessment is currently under development in conjunction with the Nanaimo summer population.

Quinsam River Chinook are part of DU 23 in the East Vancouver Island ocean type fall group. They differ from other Georgia Strait fall stocks in their marine distribution which tends to be more northerly. The Quinsam River Hatchery has been enhancing Chinook in both the Quinsam and Campbell rivers since 1974. The proportion of hatchery fish in brood stock has averaged 85% since 2000 suggesting the population is significantly enhanced. A target of 1.9M smolts are released annually while 475K are coded-wire tagged as a PST indicator. Four-year-old females comprise the majority of returns while 5-year-olds can be 25% of the population in some years. Three-year-old males are common while jacks typically represent <10% of the total.

The Upper Georgia Strait (GSQ) stock in the 9806 model was split to form the Puntledge Summers (PPS) stock and the Upper Georgia Strait (UGS) stock in the Phase II model. However, escapement estimation on the Klinaklini river was discontinued in 2003 which has been removed from the UGS stock in the Phase II model. Historically, Klinaklini produced a large portion of the escapement in Upper Strait of Georgia. This has greatly reduced the size of the UGS stock in the Phase II model compared to the GSQ stock in the 9806 model.

4.20.2 Description of Changes

Assessment methodology for Puntledge summers has changed very little over time. A fence in the lower river is operated year-round and diverts fish into the facility where brood is collected. Surplus fish are enumerated using a camera system and allowed to pass upstream though a fishway. The fence can be overtopped by high flows resulting in natural upstream passage in some years. Recent coded-wire tag releases have been in the order of 50–150K over the last decade while total hatchery production has varied between 100–750K.

Since 1984, an intensive mark-recapture program has been conducted to estimate and assess the escapement of natural spawners to the Quinsam River (below the counting fence) and to the Campbell River. Quinsam River escapement estimates are also inclusive of hatchery removals, upstream transfers and fence enumeration. Returns to the Quinsam River are enumerated through a permanent fence although some fish swim in directly to the hatchery. A mark recapture program is used to estimate the number of natural spawners below the fence in the Quinsam River as well as in the Campbell River.

4.20.2.1 MDL File Settings

Table 57—Information used in the construction of the Upper Strait of Georgia (UGS) and Puntledge Summers (PPS) MDL files.

Information for MDL File Production	**Phase II Model Stock**	
Model Stock Acronym	UGS	PPS
Brood Years	1976–1978	1977–1979
Out-of-base procedure used?	No	No
Modifications to fisheries in WG4 file	NA	NA
C-file extension (CWT Indicator ID)	QUI	PPS
Yearling Stock	No	No
Weight within BY by production releases	No	Yes
Exclude Esc for Between BY weighting	Yes	No
Start age in C-files	2	2
Last age in C-files	6	5
Modifications to escapements in Coshak4	Yes	No
Terminal fishery CWT moved to escapement	No	No
Model stock type	Wild, Fall	Hatchery, Fall
Additional fisheries designated as terminal in the BSE file	None	None
MDL creation date	18 Sept. 2016	18 Sept. 2016

4.20.2.2 Base Period Coded-Wire Tags and Recoveries

Table 58—Coded-wire tag codes for Upper Strait of Georgia (UGS) and Puntledge Summers (PPS) model stocks.

Brood Year	**Tag Codes**		
	9806 (GSQ)	**Phase II (UGS)**	**Phase II (PPS)**
		QUI	**PPS**
1976	QUI: 021916	QUI: 021916	
1977	021738, 021737, 021736	021738, 021737, 021736	PPS: 021634
1978	021759	021759	021731
1979			021854

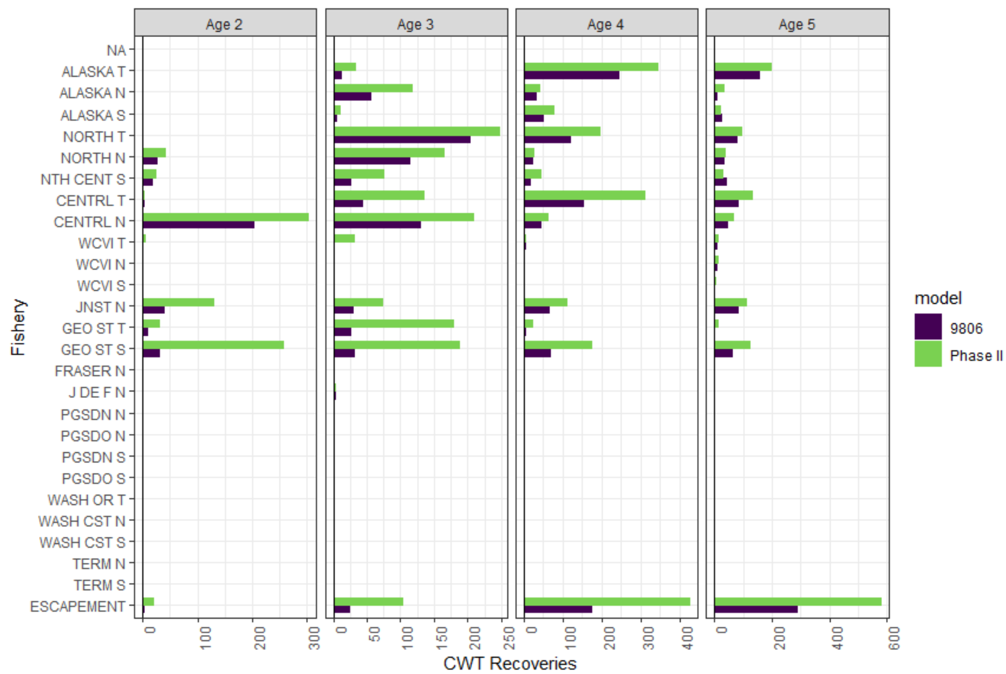

Figure 123—Base period coded-wire tag (CWT) recoveries for Upper Georgia Strait (9806), Upper Strait of Georgia (Phase II), and Puntledge Summers (Phase II).

4.20.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

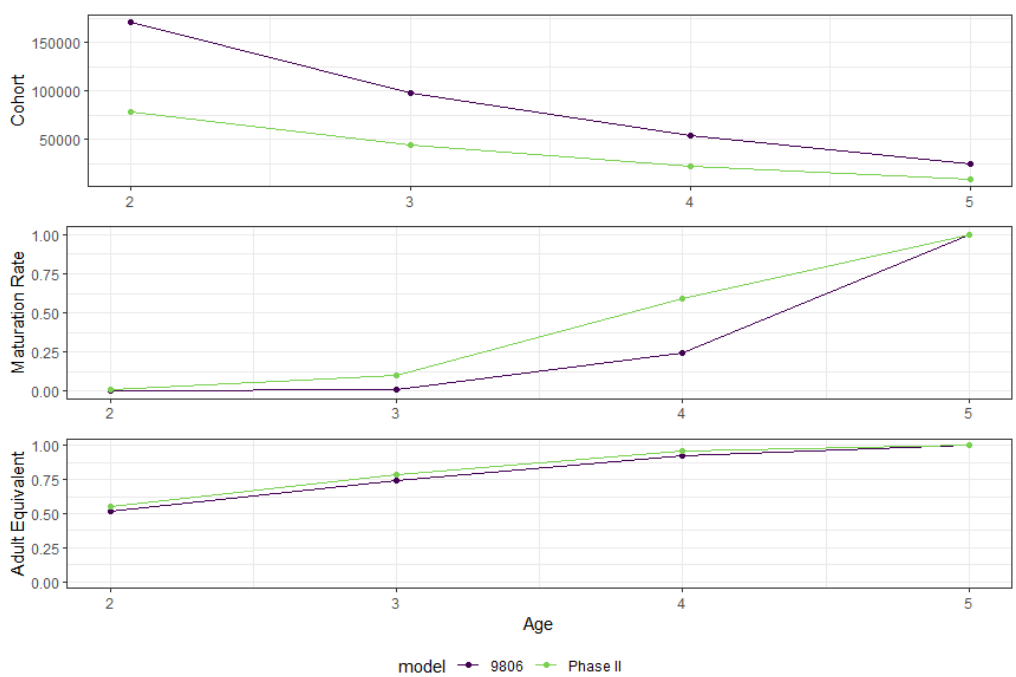

Figure 124—Base period cohort size, maturation schedule, and adult equivalent for Upper Georgia Strait (9806), Upper Strait of Georgia (Phase II), and Puntledge Summers (Phase II).

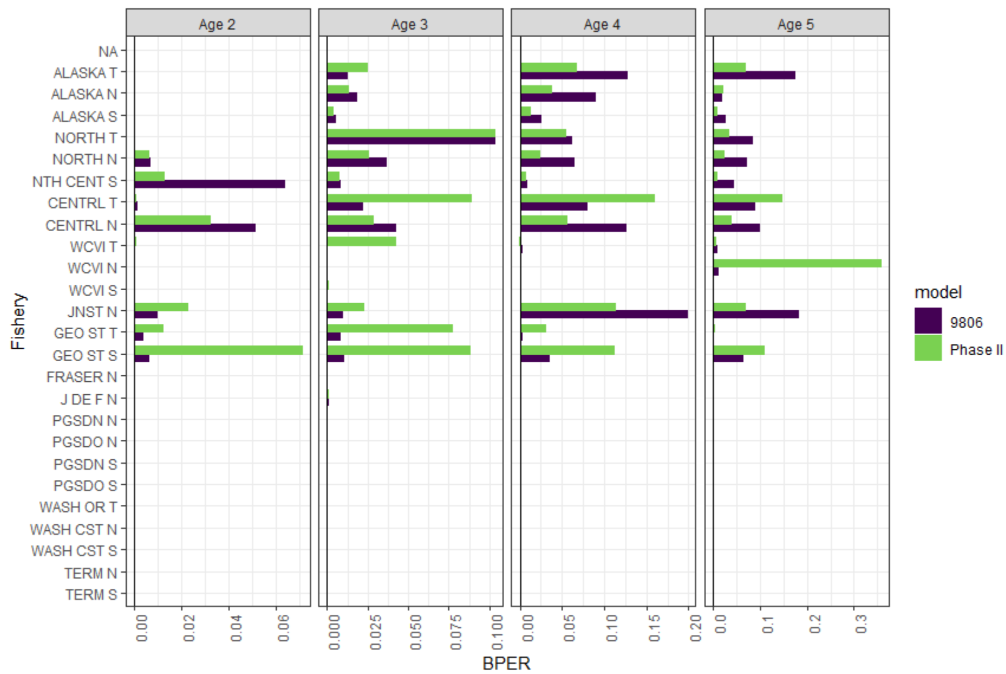

Figure 125—Base period exploitation rate by fishery for Upper Georgia Strait (9806), Upper Strait of Georgia (Phase II), and Puntledge Summers (Phase II).

4.20.2.4 Escapement/Terminal Run Time Series

In addition to the split of GSQ into natural (UGS) and hatchery (PPS), differences in time series of natural Chinook salmon between the two versions of the Model are due to the fact that several river systems were removed in the New version do to the known poor quality or inconsistency of their escapement estimates. Excluding Puntledge Summer, the GSQ aggregate in the Current version included the following rivers: Quinsam, Campbell, Salmon, Nimpkish, Phillips, Kingcome, Wakeman, Klinaklini, Ahnuhati, Kakweiken, Orford, Southgate, Homathko, and Apple. The UGS aggregate in the New version does not include Klinaklini, Ahnuhati, Kakweiken, Orford, Southgate, Homathko, and Apple.

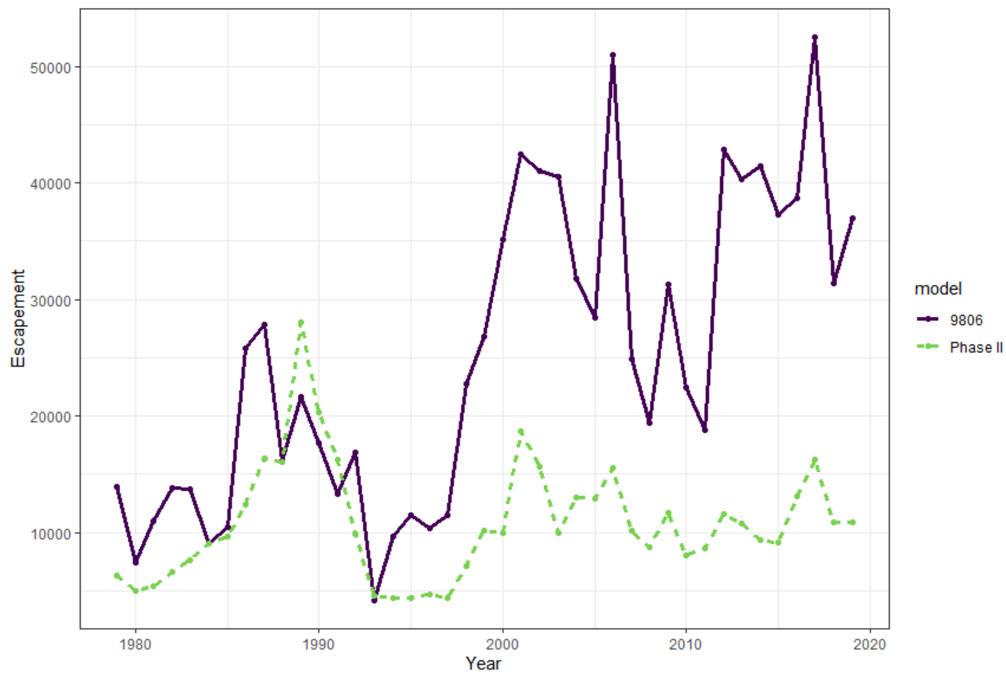

Figure 126—Escapement or terminal run size for Upper Georgia Strait (9806), Upper Strait of Georgia (Phase II), and Puntledge Summers (Phase II).

4.20.2.5 Ricker Parameters

For Ricker parameters, see sections 4.21.2.5 (UGS) and 4.22.2.5 (PPS).

4.21 Upper Georgia Strait (GSQ): Upper Strait of Georgia (UGS)

4.21.1 Stock Description

See section 4.20.1 for details.

4.21.2 Description of Changes

See section 4.20.2 for details.

4.21.2.1 MDL File Settings

See section 4.20.2.1 for details.

4.21.2.2 Base period CWT recoveries

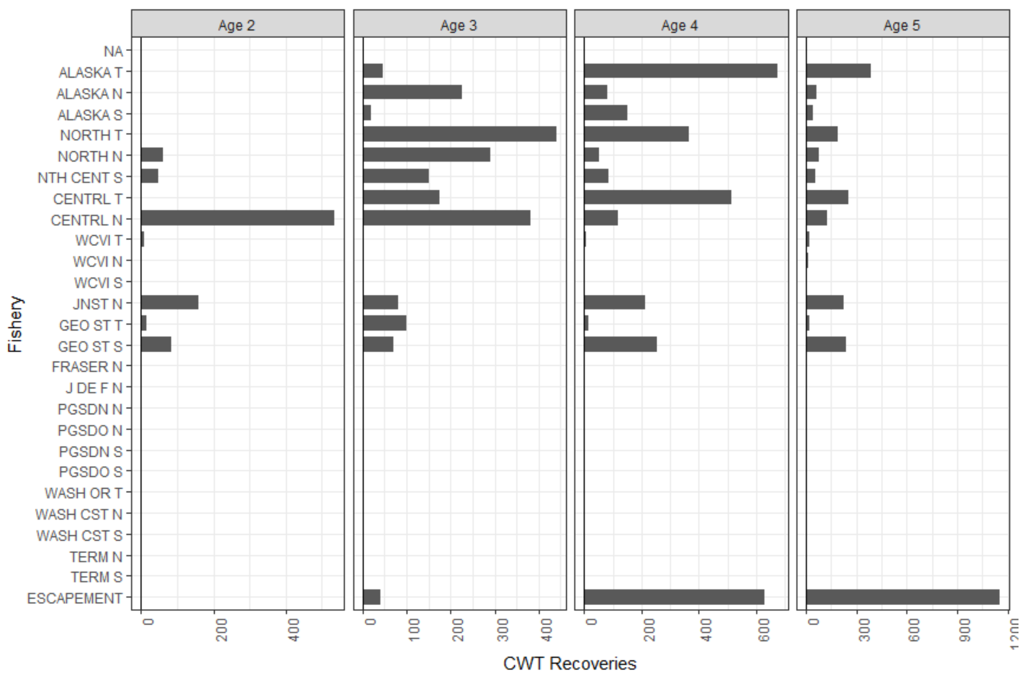

Figure 127—Base period coded-wire tag (CWT) recoveries for Upper Strait of Georgia.

4.21.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

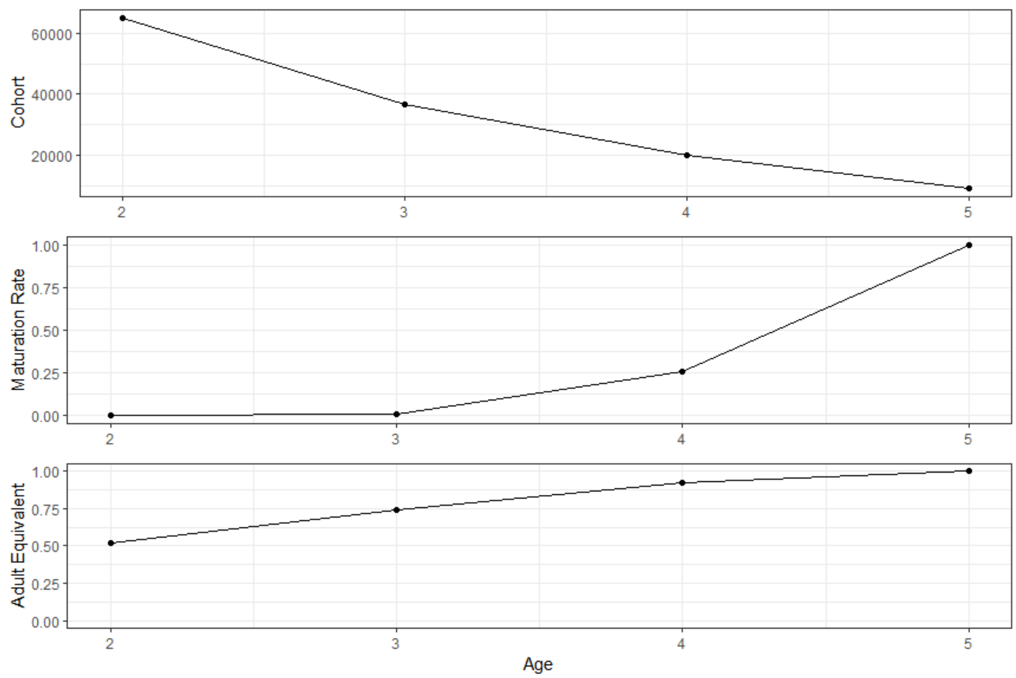

Figure 128—Base period cohort size, maturation schedule, and adult equivalent for Upper Strait of Georgia.

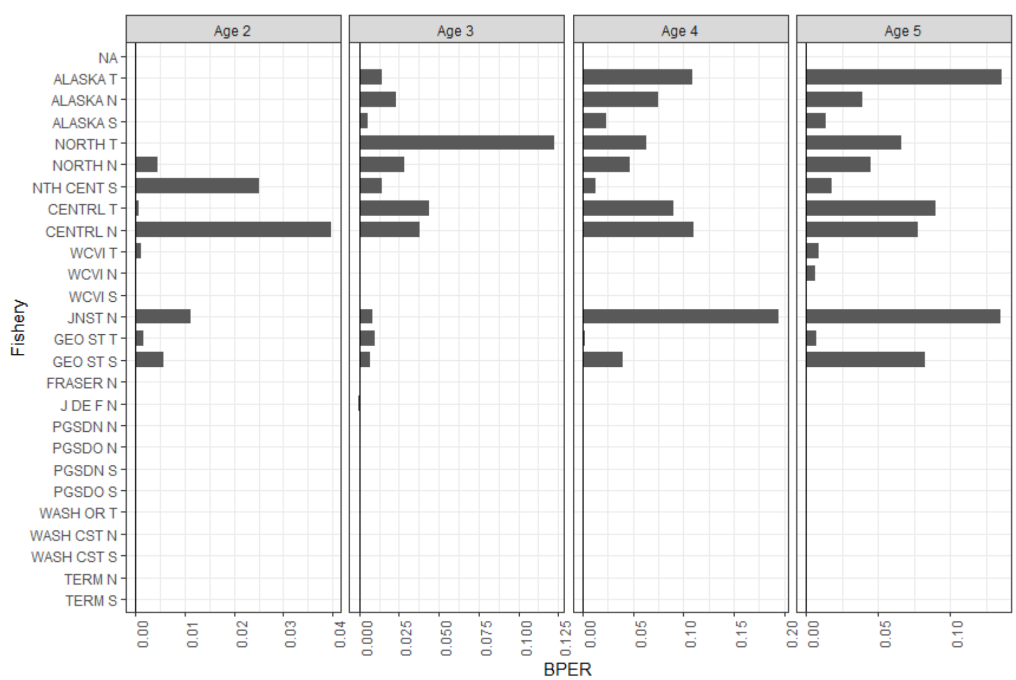

Figure 129—Base period exploitation rate by fishery for Upper Strait of Georgia.

4.21.2.4 Escapement/Terminal Run Time Series

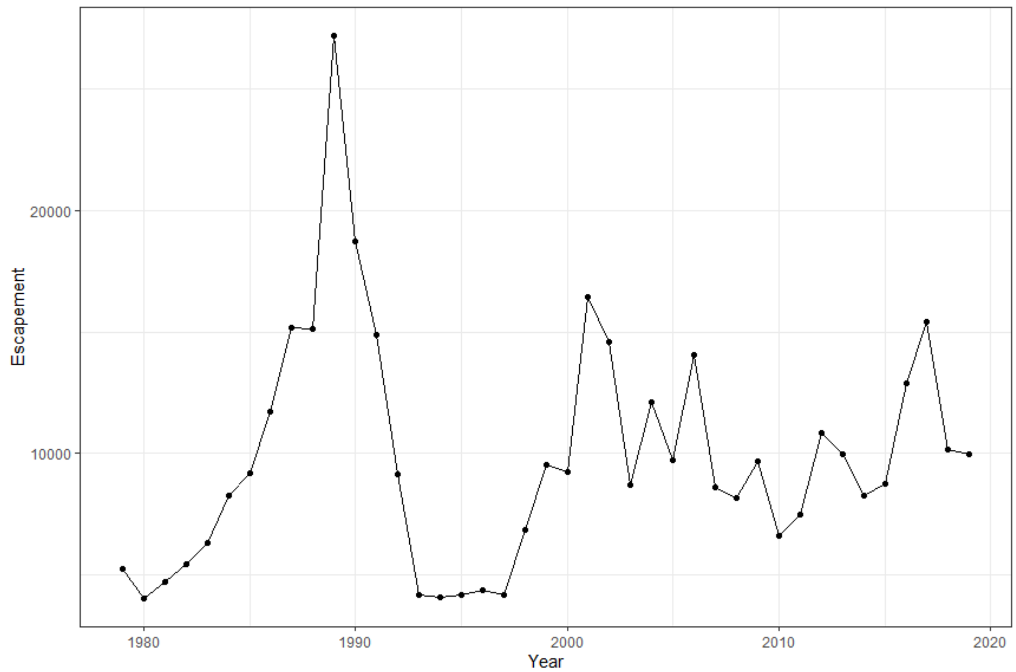

Figure 130—Escapement for Upper Strait of Georgia.

4.21.2.5 Ricker Parameters

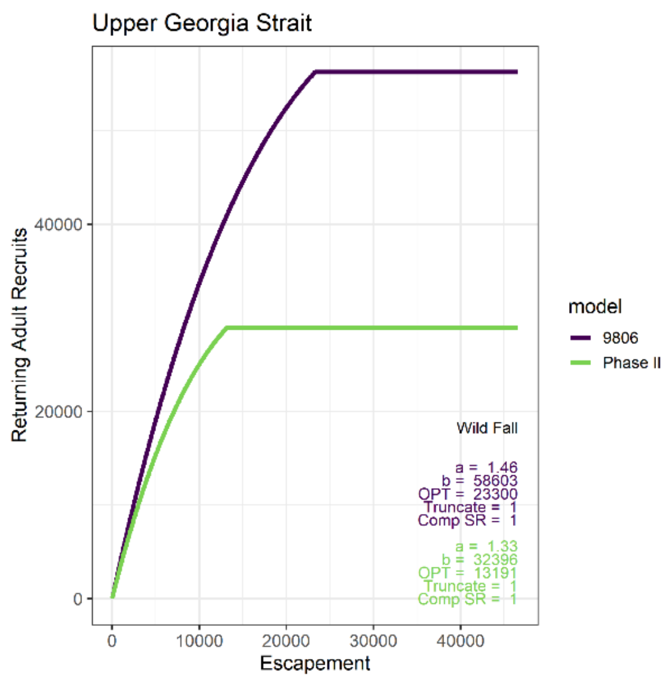

Figure 131—Ricker curve and parameters for Upper Strait of Georgia (UGS) model stock.

4.22 Upper Georgia Strait (GSQ): Puntledge Summers (PPS)

4.22.1 Stock Description

See section 4.20.1 for more details.

4.22.2 Description of Changes

See section 4.20.2 for more details.

4.22.2.1 MDL File Settings

See section 4.20.2.1 for more details.

4.22.2.2 Base period CWT recoveries

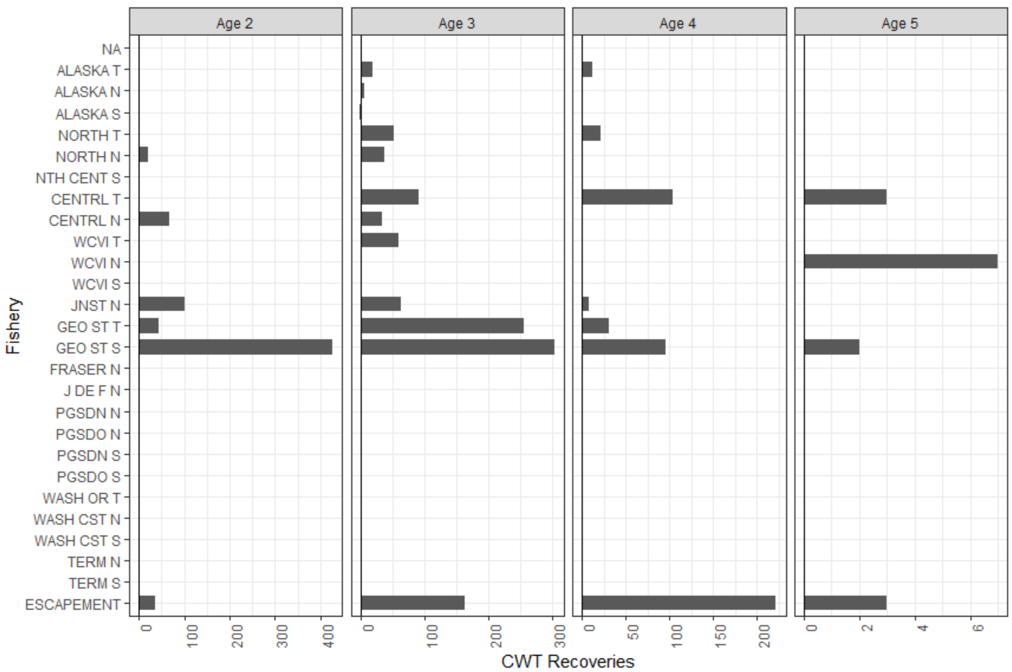

Figure 132—Base period coded-wire tag (CWT) recoveries for Puntledge Summers.

4.22.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

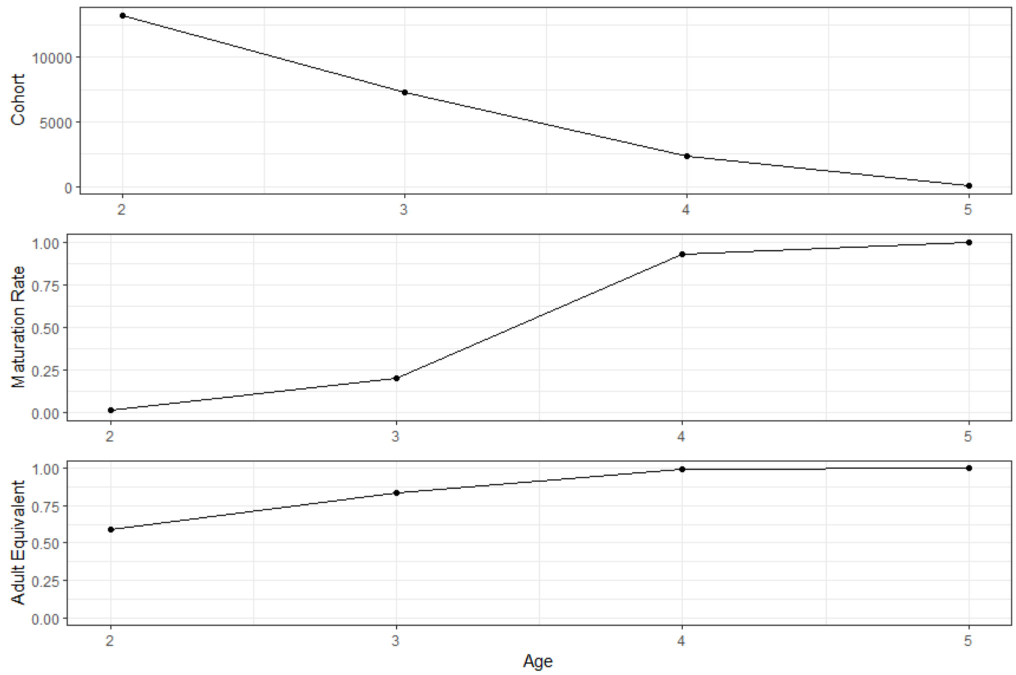

Figure 133—Base period cohort size, maturation schedule, and adult equivalent for Puntledge Summers.

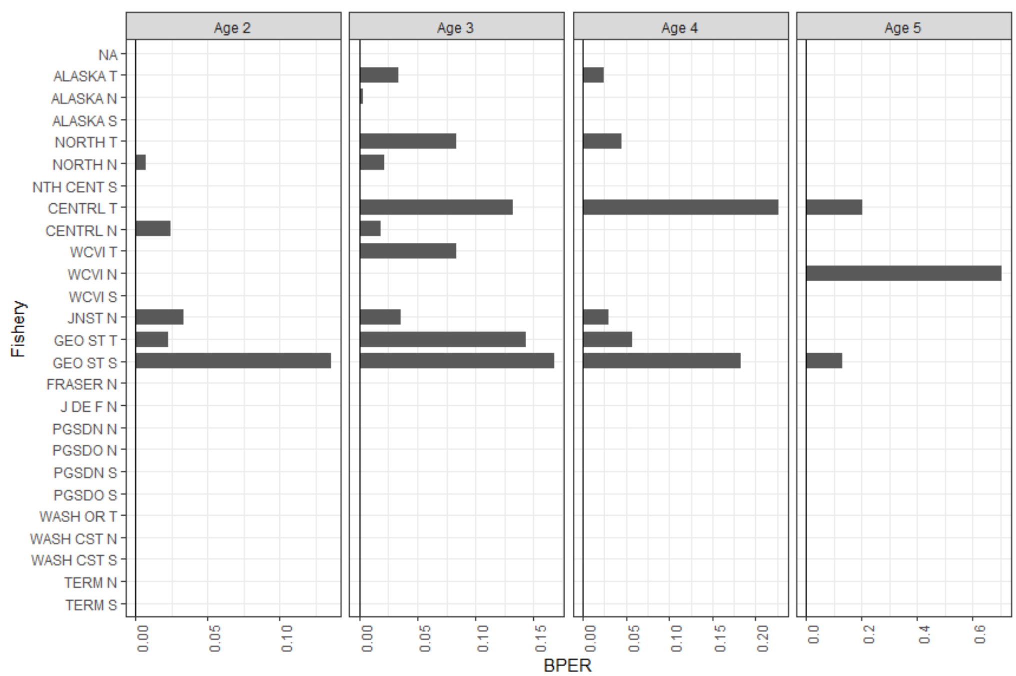

Figure 134—Base period exploitation rate by fishery for Puntledge Summers.

4.22.2.4 Escapement/Terminal Run Time Series

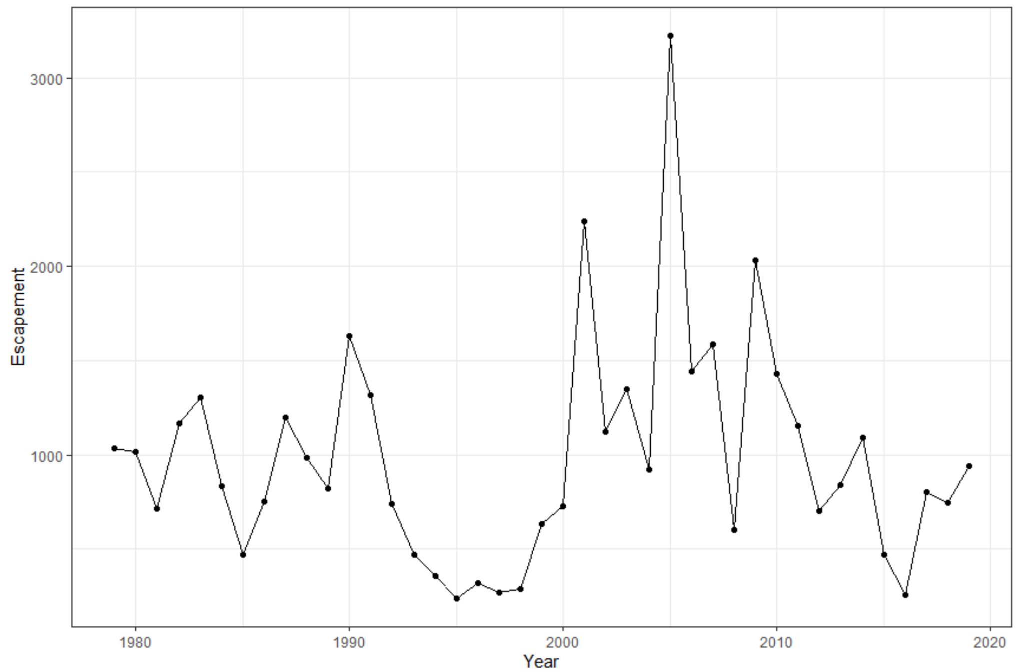

Figure 135—Escapement for Puntledge Summers.

4.22.2.5 Ricker Parameters

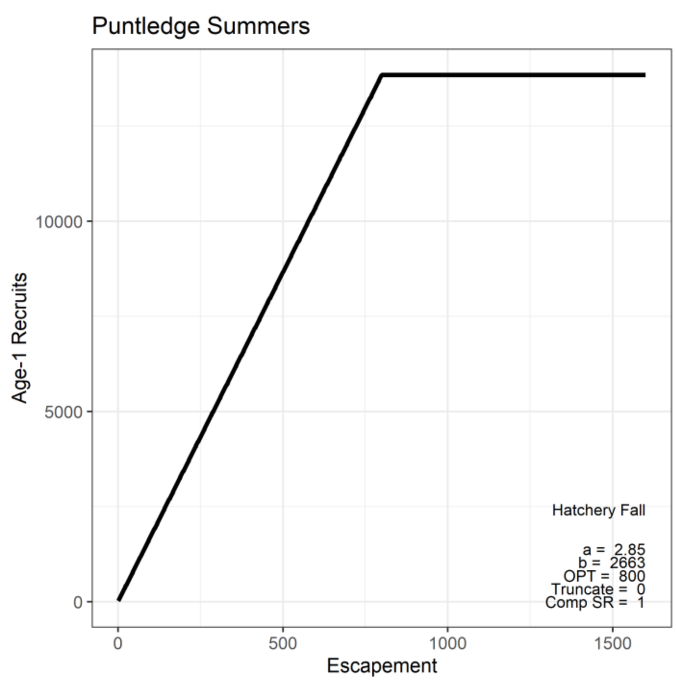

Figure 136—Ricker curve and parameters for Puntledge Summers (PPS) model stock.

4.23 Georgia Strait Lower Natural (GST): Lower Strait of Georgia (LGS)

4.23.1 Stock Description

Nanaimo Chinook are part of the East Vancouver Island ocean type fall DU 21 along with Cowichan River. The stock is enhanced by the Nanaimo River hatchery resulting in a contribution of >50% to the natural spawning population. The ecotype is confined to the section of river below White Rapids Falls while a summer run persists in the upper watershed. Run timing is typical of other systems with the peak if the run occurring in late September/early October.

Cowichan River Chinook have a similar migration time as comparable fall run stocks but tend to spawn later with peak activity in the first week of November. They utilize the entire length of the mainstem with significant spawning activity consistently observed in the 5 km section below the lake. The age structure of the population tends to be younger than other stocks with a strong component of age 2 jacks and very few 5 year olds. Production from the Cowichan River hatchery was reduced from a peak of 3M smolts to 650K over the last 20 years. As a result, the current population is composed primarily of naturally produced Chinook while hatchery fish represent approximately 15% of recent returns. The stock has exhibited a strong recovery following a low point in 2009 and the adult escapement target of 6500 has been exceeded in 5 consecutive years.

4.23.2 Description of Changes

Enumeration of Nanaimo River Chinook has been conducted using several different methods including a counting fence which was last operated in 2006. Currently abundance is estimated through an AUC expansion of regular snorkel surveys throughout the run. Coded-wire tags are not currently part of the assessment program and were last deployed in the 2004 brood year as a surrogate for Cowichan.

A counting fence has been operated in the lower Cowichan River since 1988 although the site was relocated downstream in 2006. The proportion of the run enumerated through the fence varies annually with flow as early removal is often necessary. Final expansions for incomplete years have been conducted using varying methods including run timing curves. A PIT tag based method has been piloted since 2017 while several improvements to fish passage through the fence have also been made. Dead pitch has also been conducted annually as part of the indicator program. Between 85% and 95% of the hatchery production has been coded-wire tagged and adipose clipped since 2013 in part to assist with ongoing marine survival studies.

4.23.2.1 MDL File Settings

Table 59—Information used in the construction of the Lower Strait of Georgia (LGS) MDL file.

Information for MDL File Production	Phase II Model Stock
Model Stock Acronym	LGS
Brood Years	1989
Out-of-base procedure used?	Yes
Modifications to fisheries in WG4 file	16 GEO ST T
C-file extension (CWT Indicator ID)	LGS
Yearling Stock	No
Weight within BY by production releases	No
Exclude Esc for Between BY weighting	No
Start age in C-files	2
Last age in C-files	5
Modifications to escapements in Coshak4	No
Terminal fishery CWT moved to escapement	No
Model stock type	Wild, Fall
Additional fisheries designated as terminal in the BSE file	None
MDL creation date	18 Sept. 2016

4.23.2.2 Base Period Coded-Wire Tags and Recoveries

Table 60—Coded-wire tag codes for Lower Strait of Georgia (LGS) model stock.

Brood Year	Tag Codes	
	9806 (GST)	Phase II (LGS)
1977	CAP[1]: 021639, 021642 BQR: 021726, 021727	
1978	CAP[1]: 021728, 021729, 021730 BQR: 021612, 021613, 021656	
1989		COW: 020938, 020939, 020624, 026103, 020352, 020522, 020622, 020623 NAN: 026304, 026305, 026303, 026308

[1]CAP tag code is from the discontinued Capilano Hatchery stock.

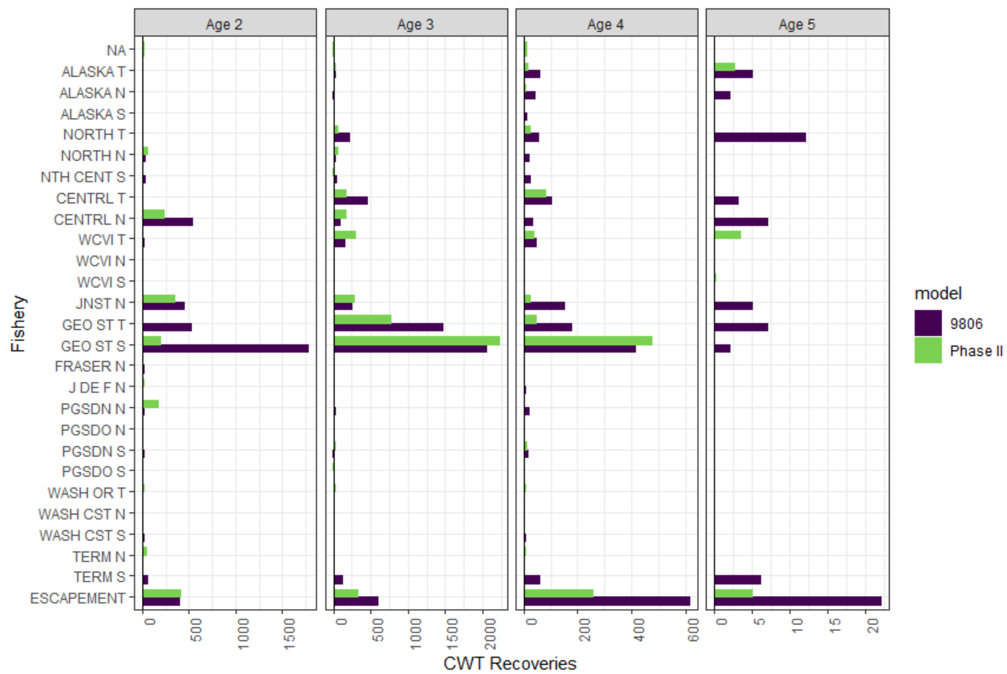

Figure 137—Base period coded-wire tag (CWT) recoveries for Georgia Strait Lower Natural (9086) and Lower Strait of Georgia (Phase II).

4.23.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

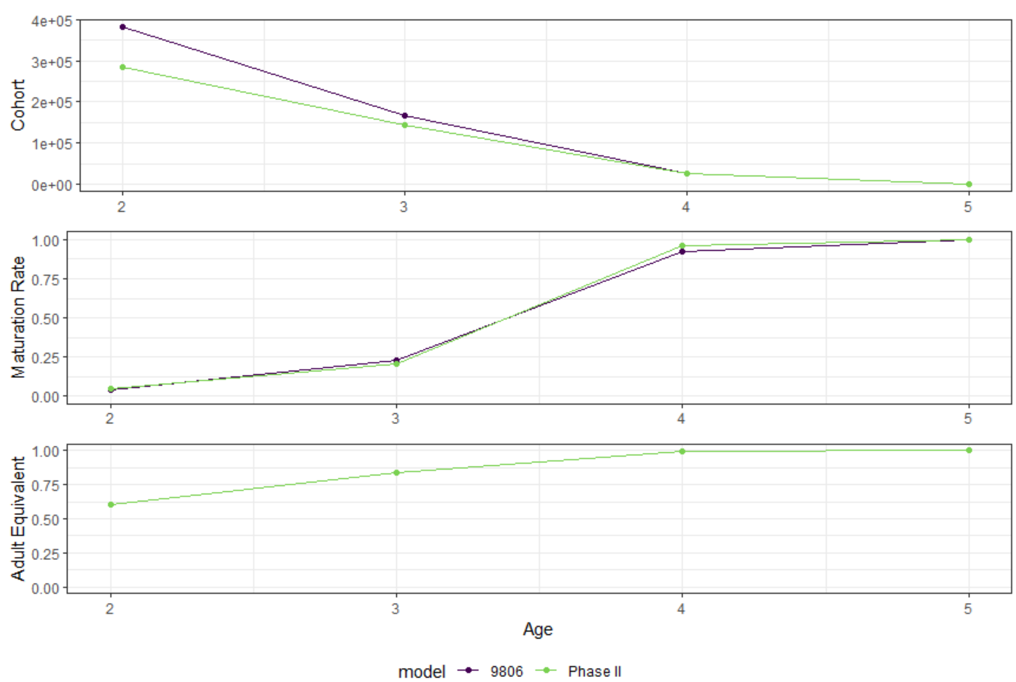

Figure 138—Base period cohort size, maturation schedule, and adult equivalent for Georgia Strait Lower Natural (9086) and Lower Strait of Georgia (Phase II).

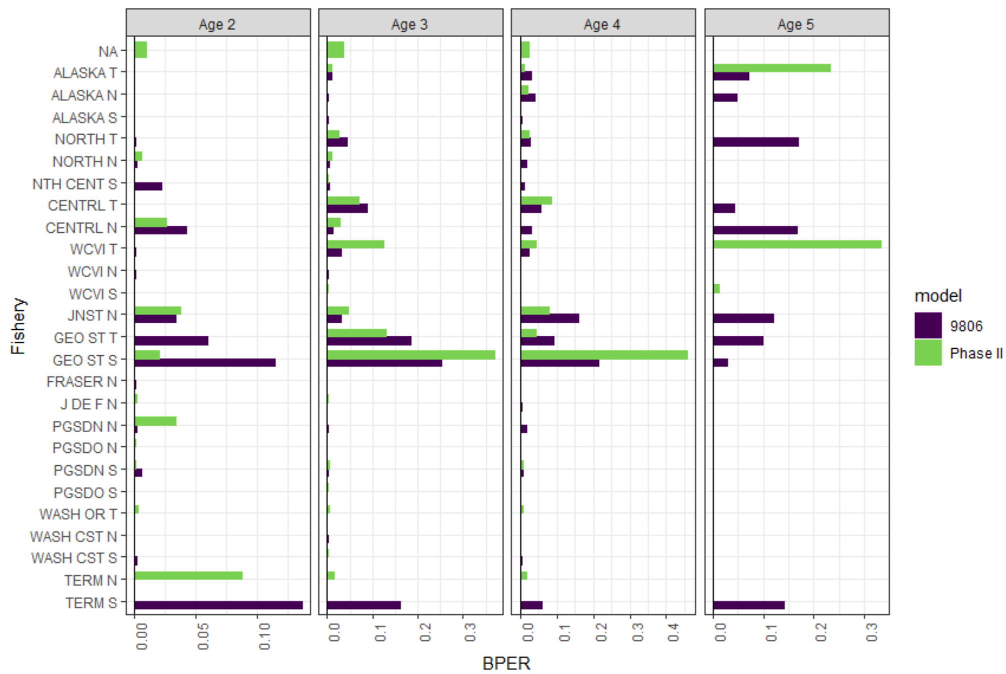

Figure 139—Base period exploitation rate by fishery for Georgia Strait Lower Natural (9086) and Lower Strait of Georgia (Phase II).

4.23.2.4 Escapement/Terminal Run Time Series

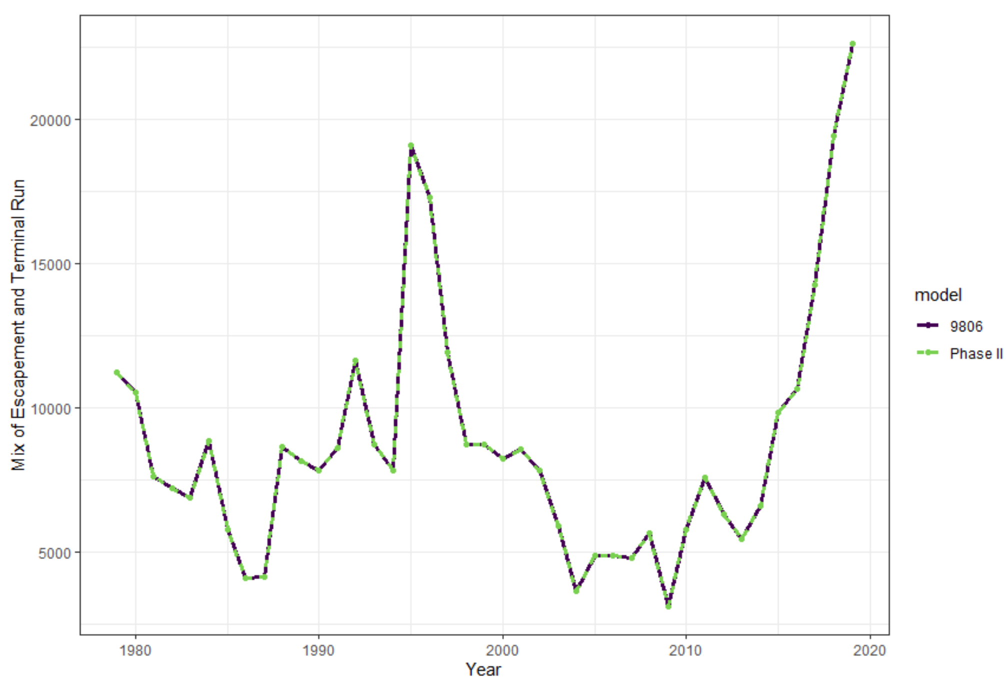

Figure 140—Escapement or terminal run size for Georgia Strait Lower Natural (9086) and Lower Strait of Georgia (Phase II).

4.23.2.5 Ricker Parameters

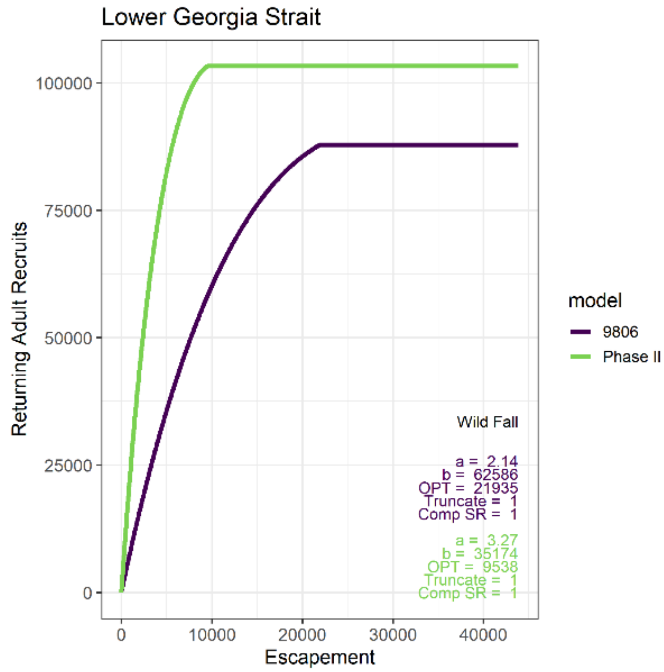

Figure 141—Ricker curve and parameters for Lower Strait of Georgia (LGS) model stock.

4.24 Georgia Strait Lower Hatchery (GSH): Middle Strait of Georgia (MGS)

4.24.1 Stock Description

Big Qualicum River Chinook are part of DU 21 along with Cowichan River and Nanaimo River stocks. Run and spawning timing is consistent with other ocean type fall stocks on east coast of Vancouver Island. The majority of fish are produced by the Big Qualicum hatchery and are a PST indicator for exploitation and marine survival since 1967. Marine distribution is similar to Puntledge and Cowichan stocks.

4.24.2 Description of Changes

Assessment methodology has changed very little at the site over the duration of the program. A fence is operated in the lower river annually and most fish are diverted into the facility. Those not used for broodstock are passed upstream through a fishway or allowed through the fence when open. The annual smolt production target is 3.5M of which 200K are coded-wire tagged.

4.24.2.1 MDL File Settings

Table 61—Information used in the construction of the Middle Strait of Georgia (MGS) MDL file.

Information for MDL File Production	Phase II Model Stock
Model Stock Acronym	MGS
Brood Years	1976–1978
Out-of-base procedure used?	No
Modifications to fisheries in WG4 file	NA
C-file extension (CWT Indicator ID)	BQR
Yearling Stock	No
Weight within BY by production releases	Yes
Exclude Esc for Between BY weighting	Yes
Start age in C-files	2
Last age in C-files	5
Modifications to escapements in Coshak4	No
Terminal fishery CWT moved to escapement	No
Model stock type	Hatchery, Fall
Additional fisheries designated as terminal in the BSE file	None
MDL creation date	18 Sept. 2016

4.24.2.2 Base Period Coded-Wire Tags and Recoveries

Table 62—Coded-wire tag codes for Middle Strait of Georgia (MGS) model stock.

Brood Year	Tag Codes	
	9806 (GSH)	**Phase II (MGS)**
1976		BQR: 021716
1977	CAP: 021639, 021642 BQR: 021726, 021727	021726, 021727
1978	CAP: 021728, 021729, 021730 BQR: 021612, 021613, 021656	021612, 021613, 021656

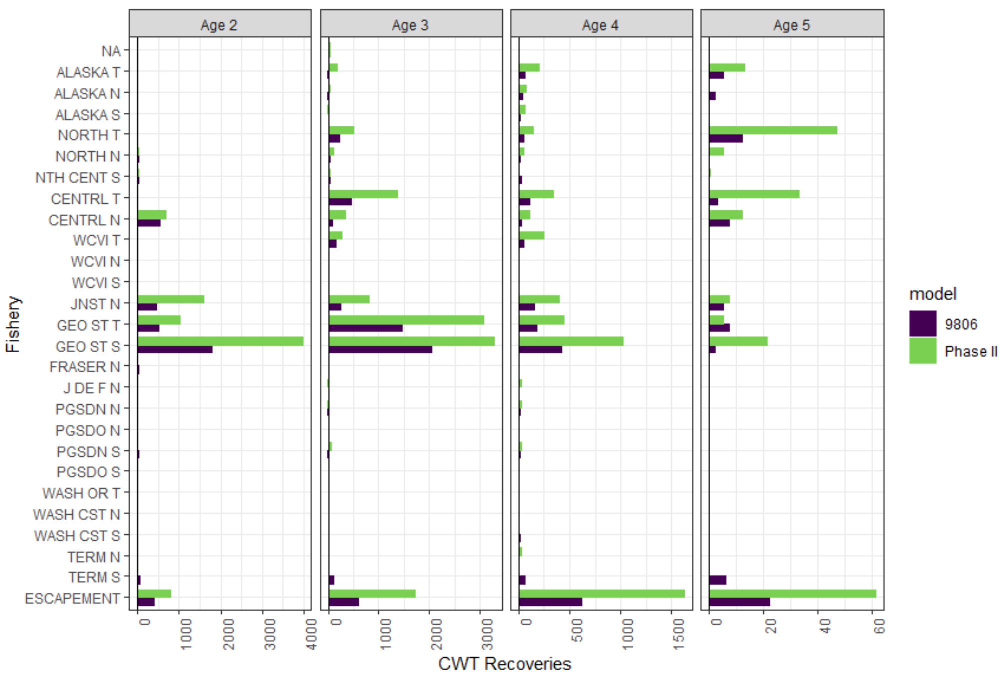

Figure 142—Base period coded-wire tag (CWT) recoveries for Georgia Strait Lower Hatchery (9086) and Middle Strait of Georgia (Phase II).

4.24.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

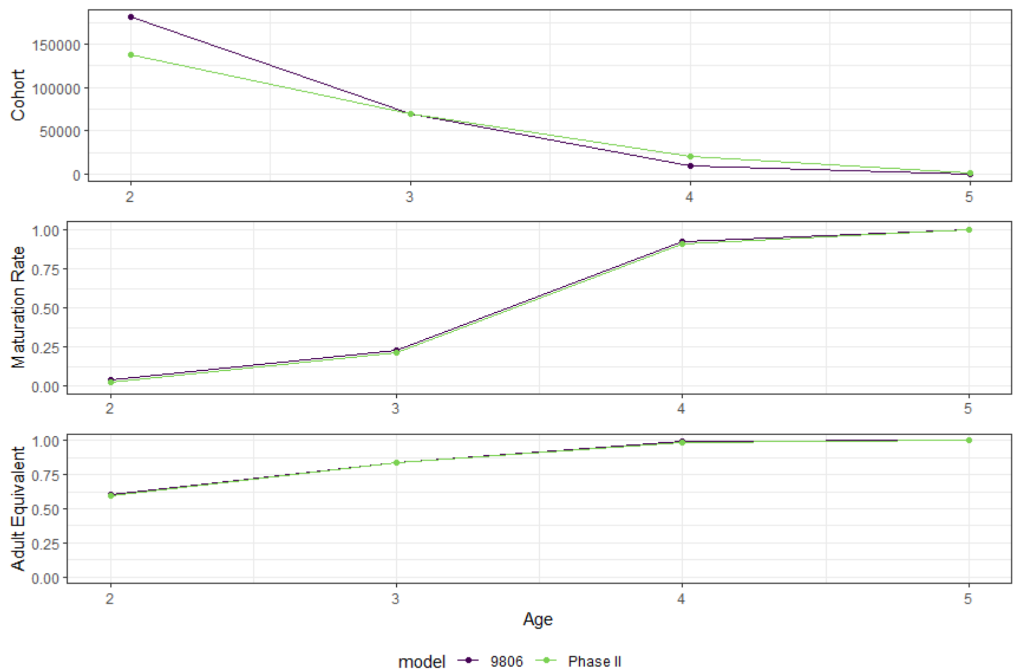

Figure 143—Base period cohort size, maturation schedule, and adult equivalent for Georgia Strait Lower Hatchery (9086) and Middle Strait of Georgia (Phase II).

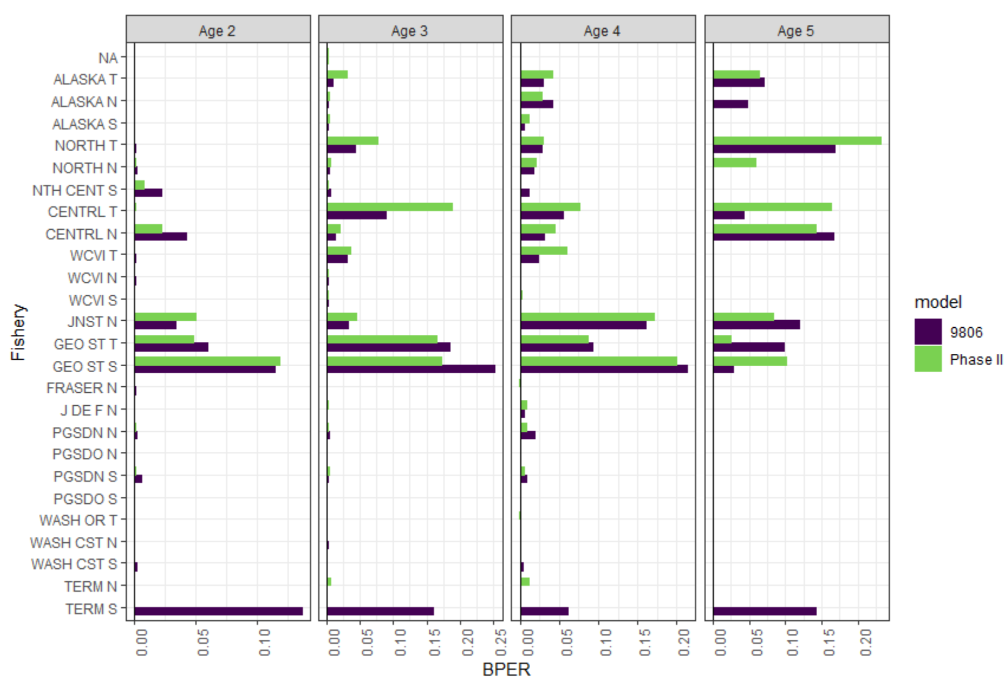

Figure 144—Base period exploitation rate by fishery for Georgia Strait Lower Hatchery (9086) and Middle Strait of Georgia (Phase II).

4.24.2.4 Escapement/Terminal Run Time Series

Differences in the time series of escapement between GSH in the Current version of the Model and MGS in the New version is due to the fact that several systems were dropped from the aggregate. GSH included the following systems: Puntledge River Fall, Big Qualicum River, Little Qualicum River Fall, Capilano Hatchery, Lang Creek, Squamish River, Oyster River, Englishman River, and Chemainus River. For the New version of the Model, Squamish River, Oyster River, Englishman River, and Chemainus River were dropped from the aggregate do to known poor quality or inconsistency of escapement estimates.

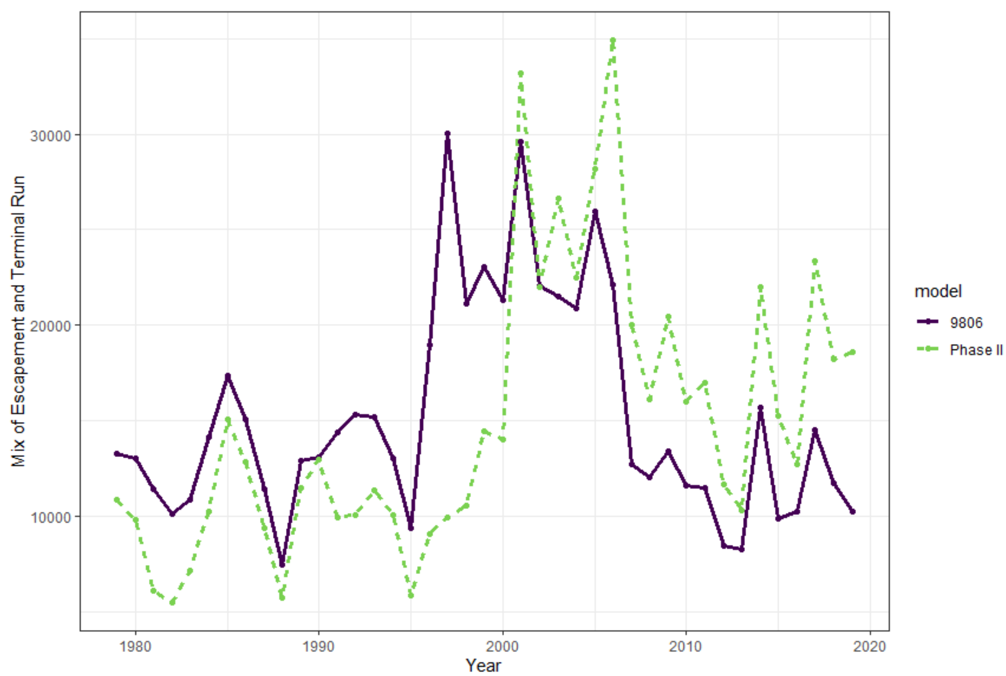

Figure 145—Escapement or terminal run size for Georgia Strait Lower Hatchery (9086) and Middle Strait of Georgia (Phase II).

4.24.2.5 Ricker Parameters

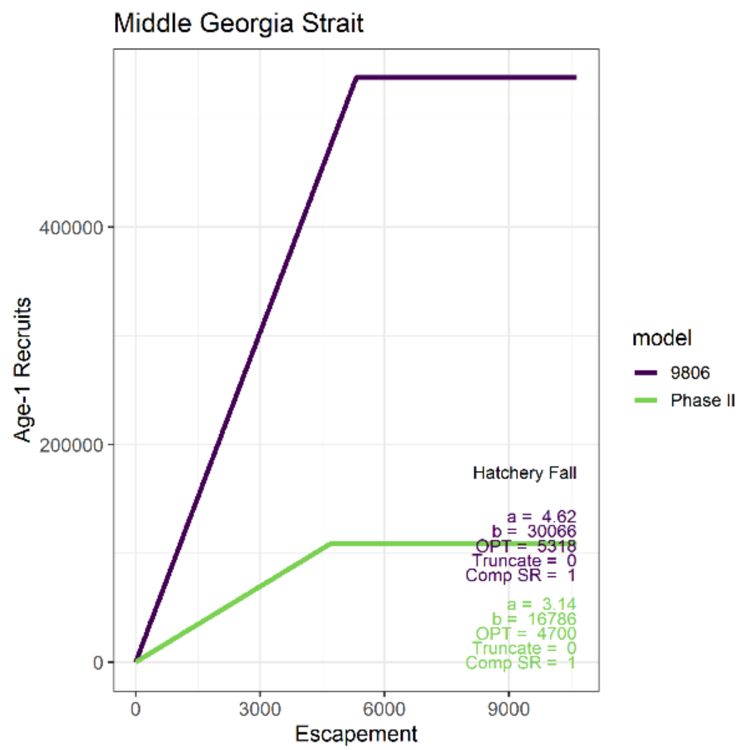

Figure 146—Ricker curve and parameters for Middle Strait of Georgia (MGS) model stock.

4.25 Nooksack Fall (NKF): Nooksack Fall (NKF)

4.25.1 Stock Description

Nooksack Falls represent fall fingerling production from the Nooksack system and summer/fall fingerling production Samish system in North Puget Sound.

4.25.2 Description of Changes

Changes to the base period include updated tag codes. No changes to stock composition were made.

4.25.2.1 MDL File Settings

Table 63—Information used in the construction of the Nooksack Fall (NKF) MDL file.

Information for MDL File Production	Phase II Model Stock
Model Stock Acronym	NKF
Brood Years	1977, 1979
Out-of-base procedure used?	No
Modifications to fisheries in WG4 file	NA
C-file extension (CWT Indicator ID)	NKF
Yearling Stock	No
Weight within BY by production releases	Yes
Exclude Esc for Between BY weighting	No
Start age in C-files	2
Last age in C-files	5
Modifications to escapements in Coshak4	Yes
Terminal fishery CWT moved to escapement	No
Model stock type	Hatchery, Fall
Additional fisheries designated as terminal in the BSE file	Puget Sound Other Net; Puget Sound North Net
MDL creation date	18 Sept. 2016

4.25.2.2 Base Period Coded-Wire Tags and Recoveries

CWT groups are from Skookum Creek Hatchery, Lummi Sea Ponds and Samish Hatchery, with tag codes from the base period, including releases for the 1977 and 1978 brood (Table 64). These are the same tag codes that have been used in past base period calibrations (CTC 1991).

Table 64—Coded-wire tag codes for Nooksack Fall (NKF) model stock.

Brood Year	Tag Codes	
	9806	Phase II
1977	050324, 050325	NKF: 050324, 050325
1979	632042, 632101, 632102, 050726, 050727	NKF: 050726, 050727 SAM: 632042, 632102, 632101

A comparison of the estimated tags by fishery between calibration 9812 and the BPC in 2009 shows two differences of significance, for Georgia Strait sport (GEOSTS) and Escapement. The first is due to changes in data since 1998 and the second is due to a difference in the method used to estimate escapement for tag codes with no escapement recoveries.

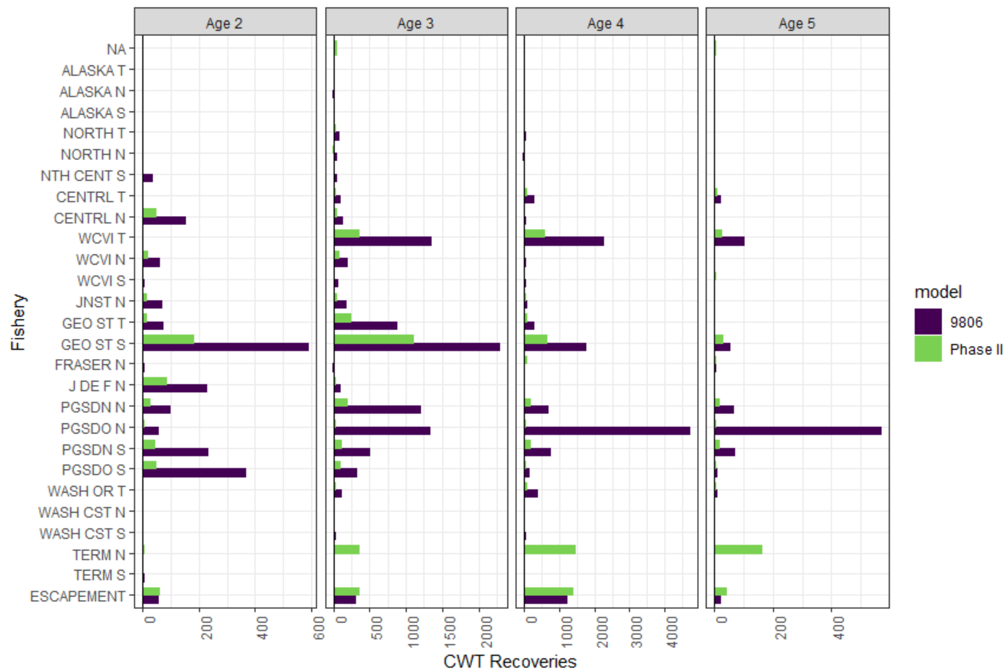

Figure 147—Base period coded-wire tag (CWT) recoveries for Nooksack Fall.

4.25.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

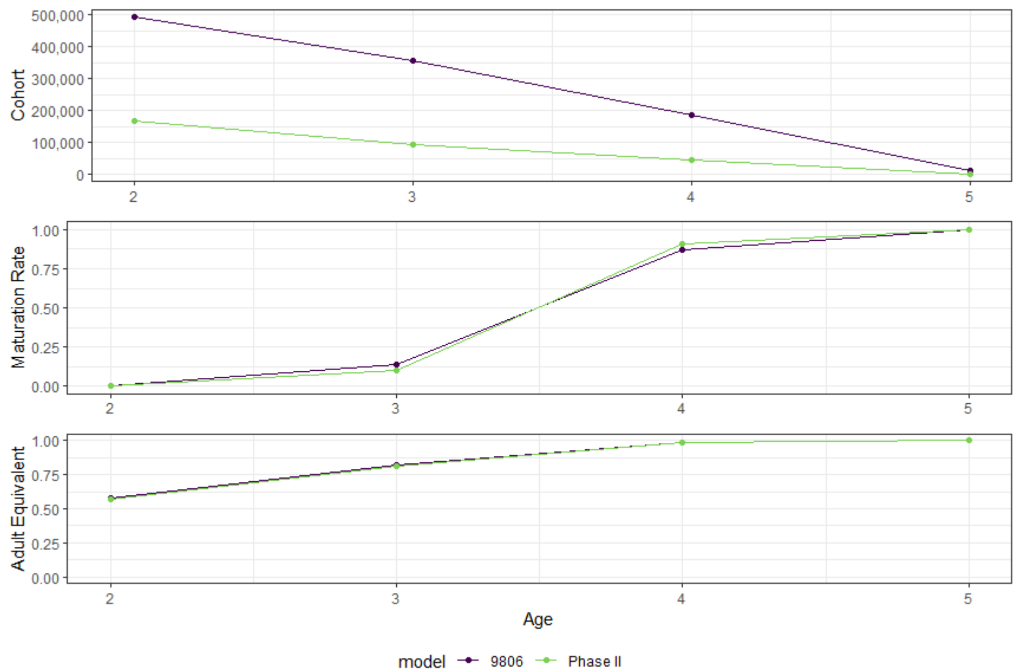

Figure 148—Base period cohort size, maturation schedule, and adult equivalent for Nooksack Fall.

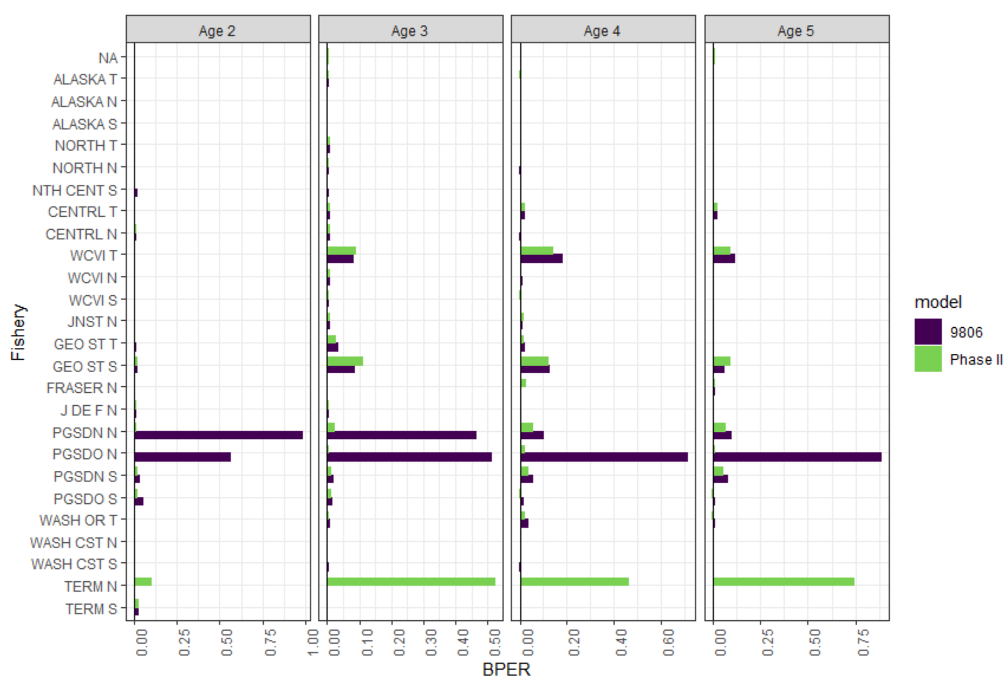

Figure 149—Base period exploitation rate by fishery for Nooksack Fall.

4.25.2.4 Escapement/Terminal Run Time Series

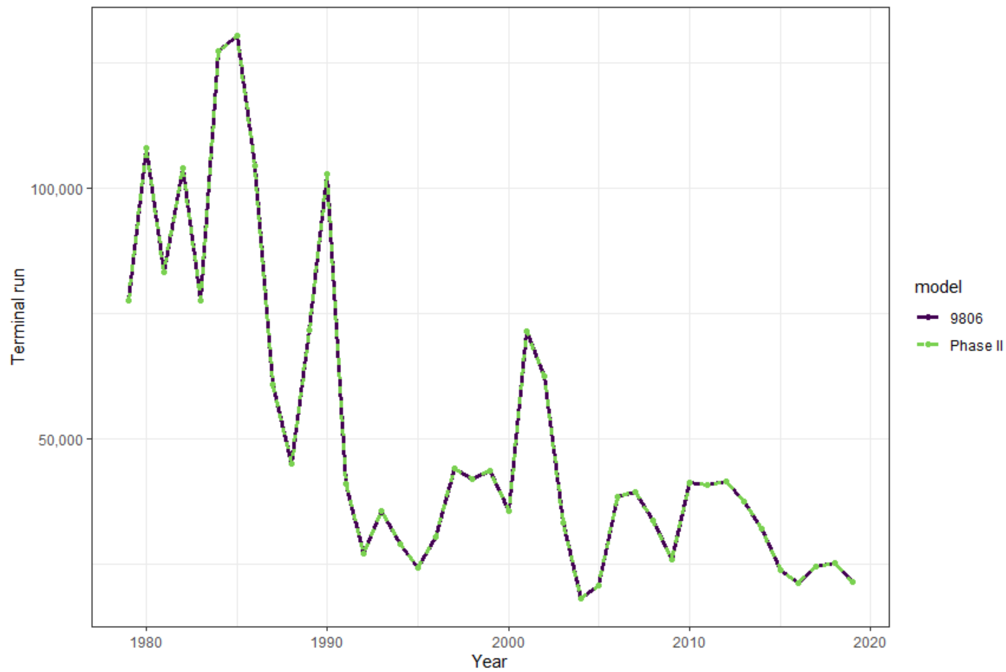

Figure 150—Terminal run size for Nooksack Fall.

4.25.2.5 Ricker Parameters

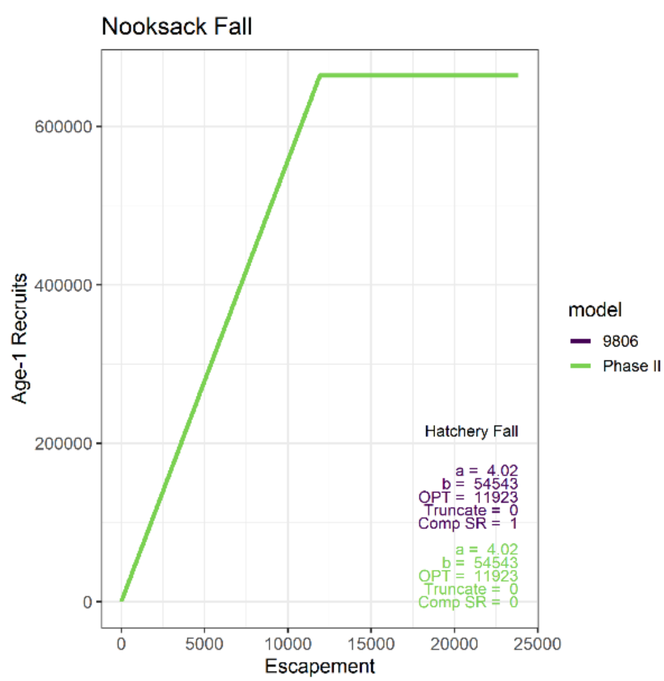

Figure 151—Ricker curve and parameters for Nooksack Fall (NKF) model stock.

4.26 Puget Sound Fingerling (PSF): Puget Sound Fingerling (PSF)

4.26.1 Stock Description

The Puget Sound Fingerling is an aggregate stock of fall fingerling hatchery production from South Puget Sound and Hood Canal.

4.26.2 Description of Changes

Changes to the base period include updated tag codes. No changes to stock composition were made.

4.26.2.1 MDL File Settings

Table 65—Information used in the construction of the Puget Sound Fingerling (PSF) MDL file.

Information for MDL File Production	Phase II Model Stock
Model Stock Acronym	PSF
Brood Years	1978–1979
Out-of-base procedure used?	No
Modifications to fisheries in WG4 file	NA
C-file extension (CWT Indicator ID)	PSF
Yearling Stock	No
Weight within BY by production releases	No
Exclude Esc for Between BY weighting	Yes
Start age in C-files	2
Last age in C-files	5
Modifications to escapements in Coshak4	Yes
Terminal fishery CWT moved to escapement	No
Model stock type	Hatchery, Fall
Additional fisheries designated as terminal in the BSE file	Puget Sound Other Net; Puget Sound North Net
MDL creation date	18 Sept. 2016

4.26.2.2 Base Period Coded-Wire Tags and Recoveries

Table 66—Coded-wire tag codes for Puget Sound Fingerling (PSF) model stock.

Brood Year	Tag Codes	
	9806	Phase II
1978	631814, 631842, 631907, 631935, 631936, 631940, 631945	ISS: 631940 GAD: 631752, 631915 SPS: 631814, 631842, 631907 GRN: 631936, 631945, 631935
1979	050722, 631903, 631943, 631944, 632020, 632063, 632103, 632104	NIS: 050722 GAD: 632109, 632041 SPS: 631814, 631842, 631907 GRN: 631944

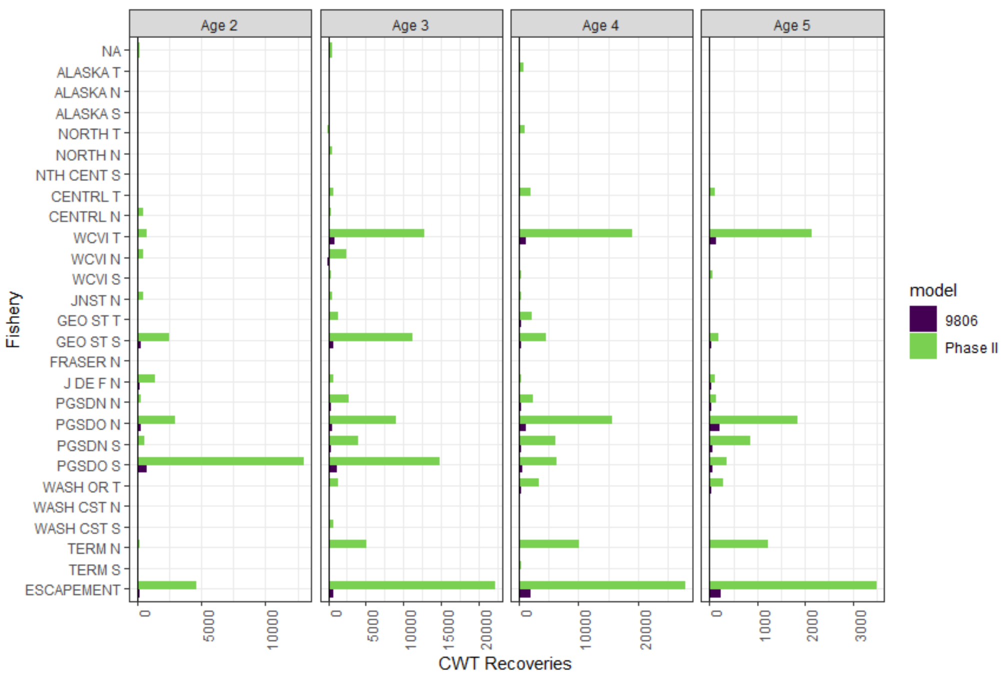

Figure 152—Base period coded-wire tag (CWT) recoveries for Puget Sound Fingerling.

4.26.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

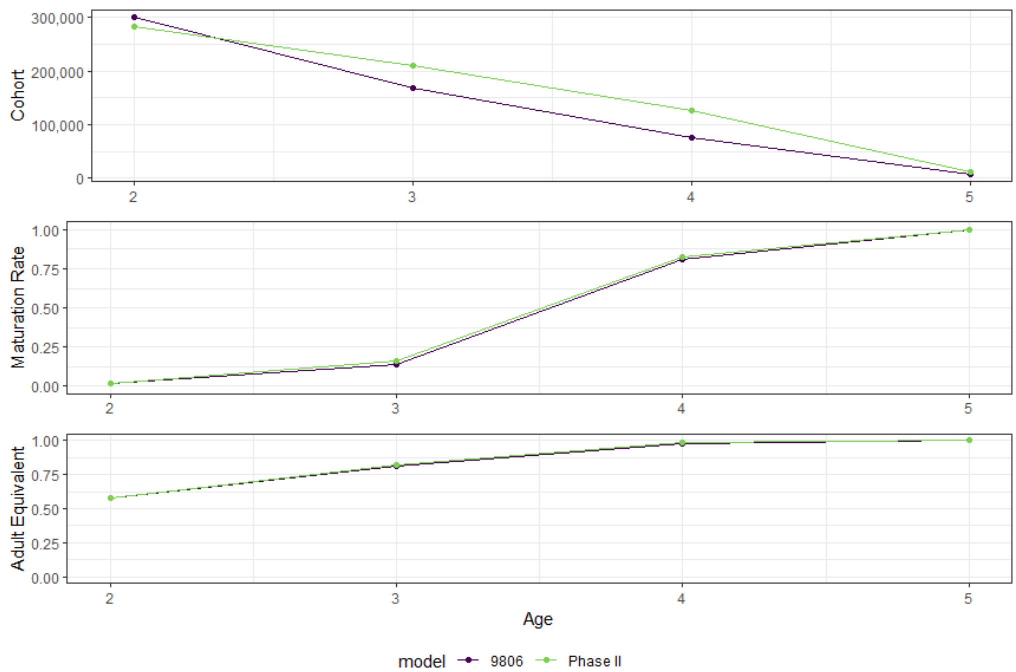

Figure 153—Base period cohort size, maturation schedule, and adult equivalent for Puget Sound Fingerling.

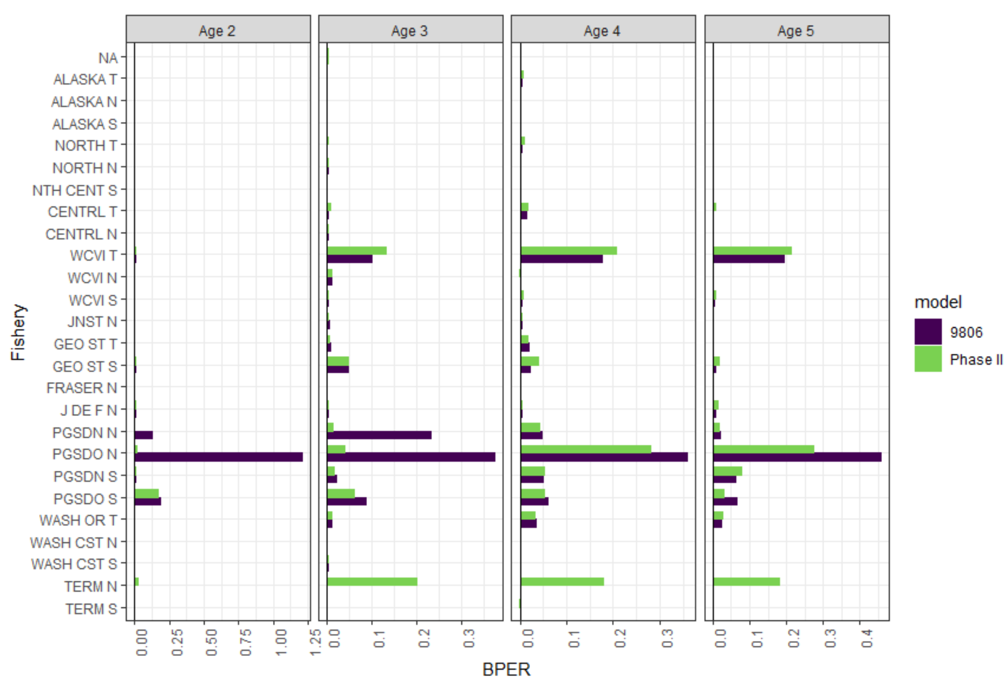

Figure 154—Base period exploitation rate by fishery for Puget Sound Fingerling.

4.26.2.4 Escapement/Terminal Run Time Series

Note that in the 9806 model calibration, the PSF/PSY model stocks' terminal run time series were not stratified by fingerling and yearling; however, in Phase II model stratified estimates were used (Figure 155).

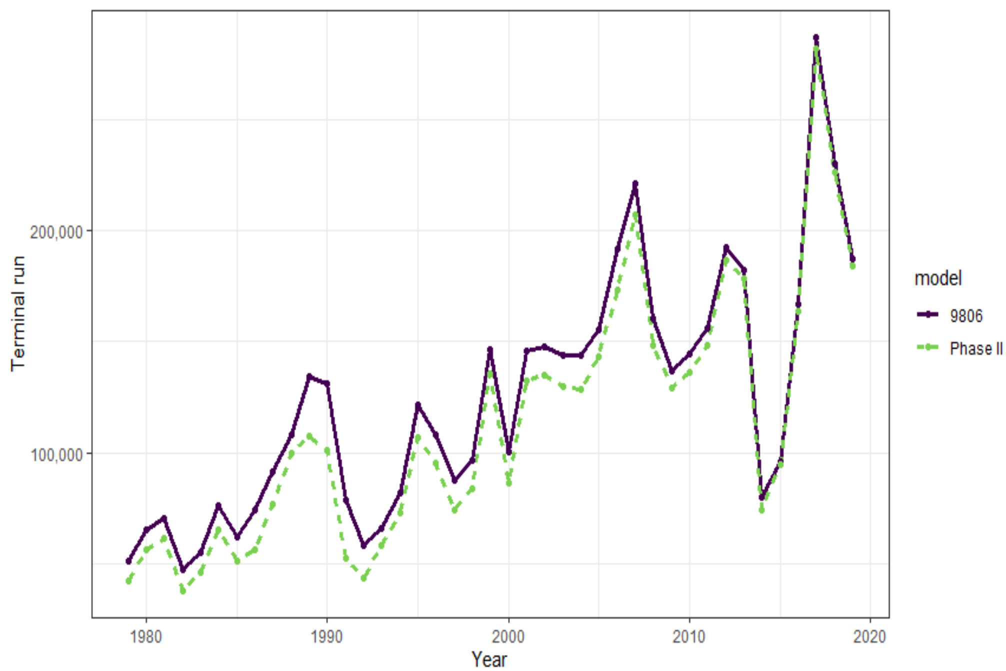

Figure 155—Comparison between the combined fingerling and yearling terminal run time series from 9806 against the terminal run time series of fingerlings from Phase II.

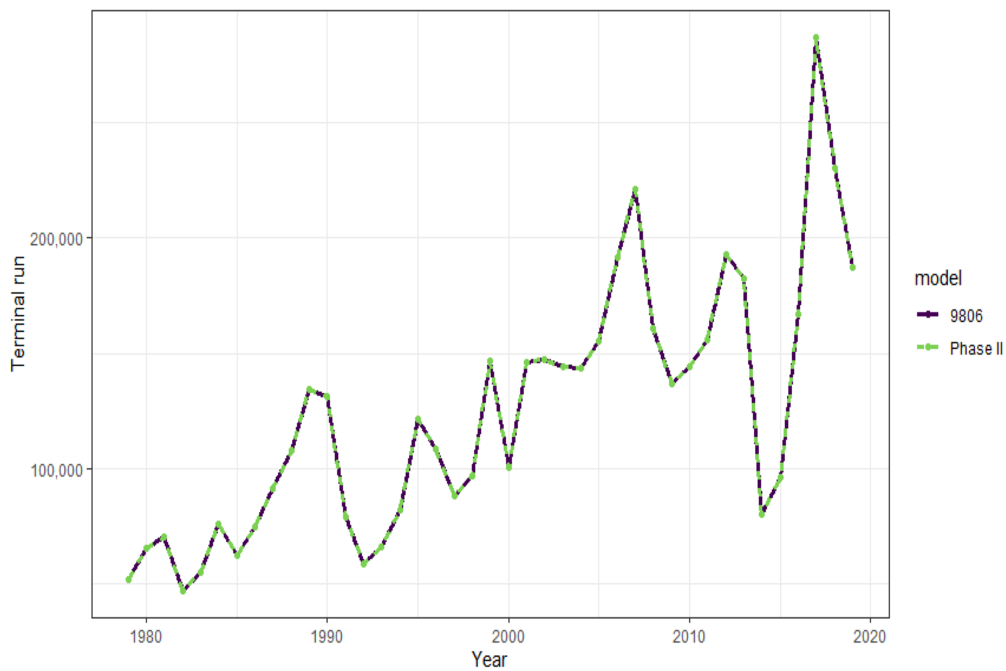

Figure 156—Combined Puget Sound fingerling and Puget Sound yearling terminal run time series from both 9806 and Phase II models.

4.26.2.5 Ricker Parameters

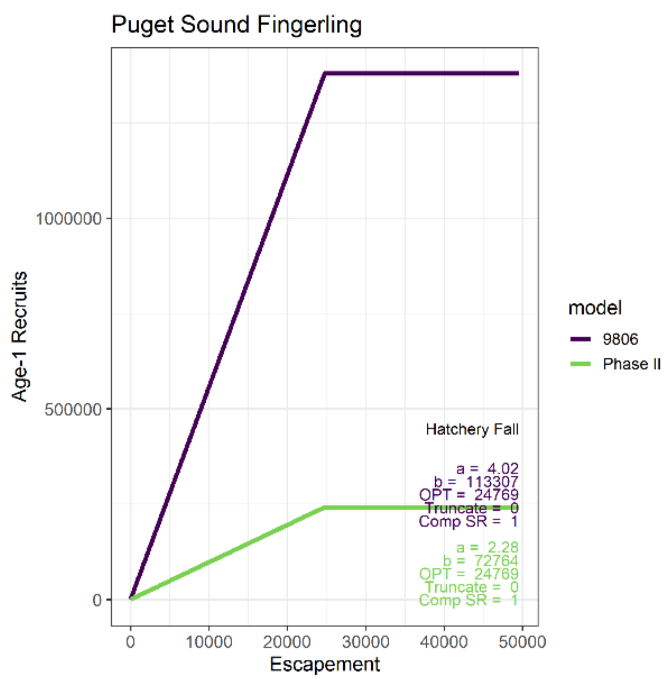

Figure 157—Ricker curve and parameters for Puget Sound Fingerling (PSF) model stock.

4.27 Puget Sound Natural Fall (PSN): Puget Sound Natural Fall (PSN)

4.27.1 Stock Description

The Puget Sound natural stock includes natural stocks returning to South Puget Sound and Hood Canal.

4.27.2 Description of Changes

Changes to the base period include updated tag codes. No changes to stock composition were made.

4.27.2.1 MDL File Settings

Table 67—Information used in the construction of the Puget Sound Natural Fall (PSN) MDL file.

Information for MDL File Production	Phase II Model Stock
Model Stock Acronym	PSN
Brood Years	1978–1979
Out-of-base procedure used?	No
Modifications to fisheries in WG4 file	NA
C-file extension (CWT Indicator ID)	SPS
Yearling Stock	No
Weight within BY by production releases	No
Exclude Esc for Between BY weighting	Yes
Start age in C-files	2
Last age in C-files	5
Modifications to escapements in Coshak4	Yes
Terminal fishery CWT moved to escapement	No
Model stock type	Wild, Fall
Additional fisheries designated as terminal in the BSE file	Puget Sound Other Net; Puget Sound North Net
MDL creation date	18 Sept. 2016

4.27.2.2 Base Period Coded-Wire Tags and Recoveries

Table 68—Coded-wire tag codes for Puget Sound Natural Fall (PSN) model stock.

Brood Year	Tag Codes	
	9806	Phase II
1978	631814, 631842, 631907, 631935, 631936, 631940, 631945	ISS: 631940 GAD: 631752, 631915 SPS: 631814, 631842, 631907 GRN: 631936, 631945, 631935
1979	050722, 631903, 631943, 631944, 632020, 632063, 632103, 632104	NIS: 050722 GAD: 632109, 632041 SPS: 631814, 631842, 631907 GRN: 631944

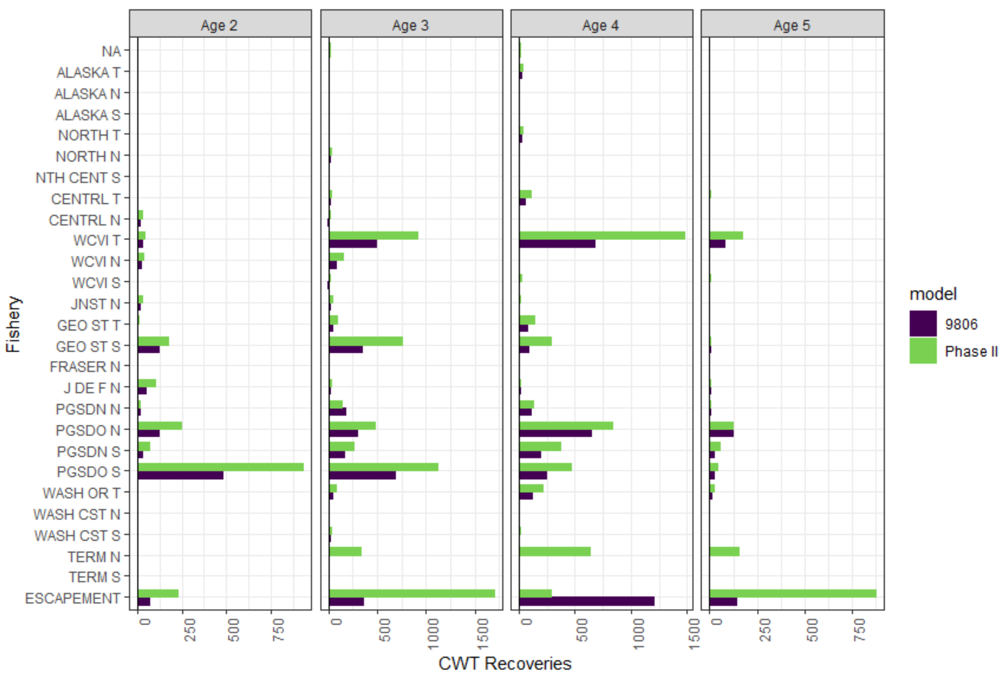

Figure 158—Base period coded-wire tag (CWT) recoveries for Puget Sound Natural Fall.

4.27.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

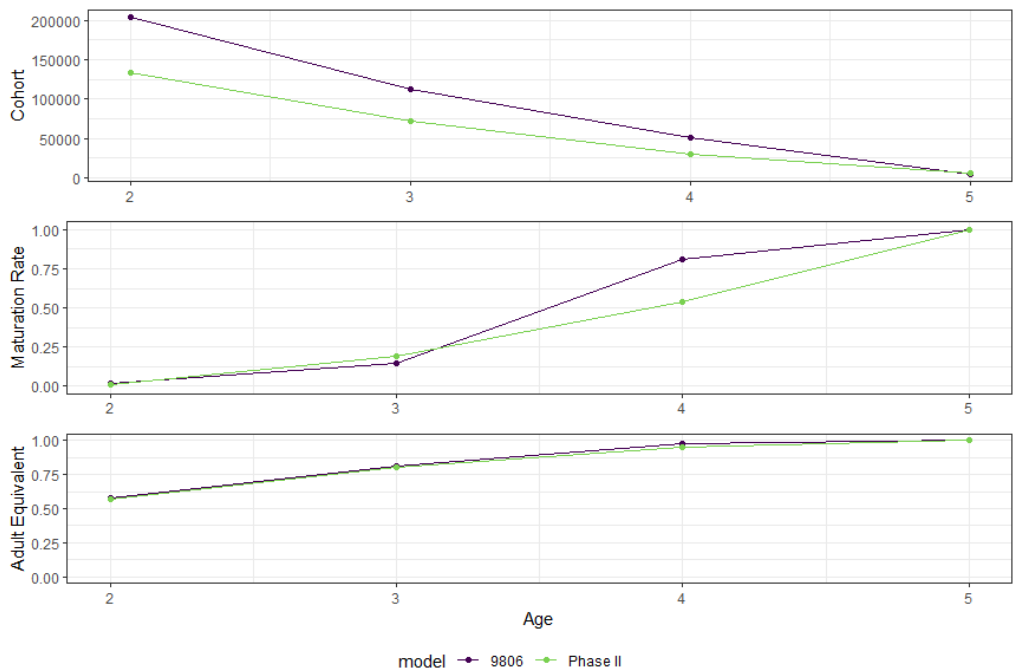

Figure 159—Base period cohort size, maturation schedule, and adult equivalent for Puget Sound Natural Fall.

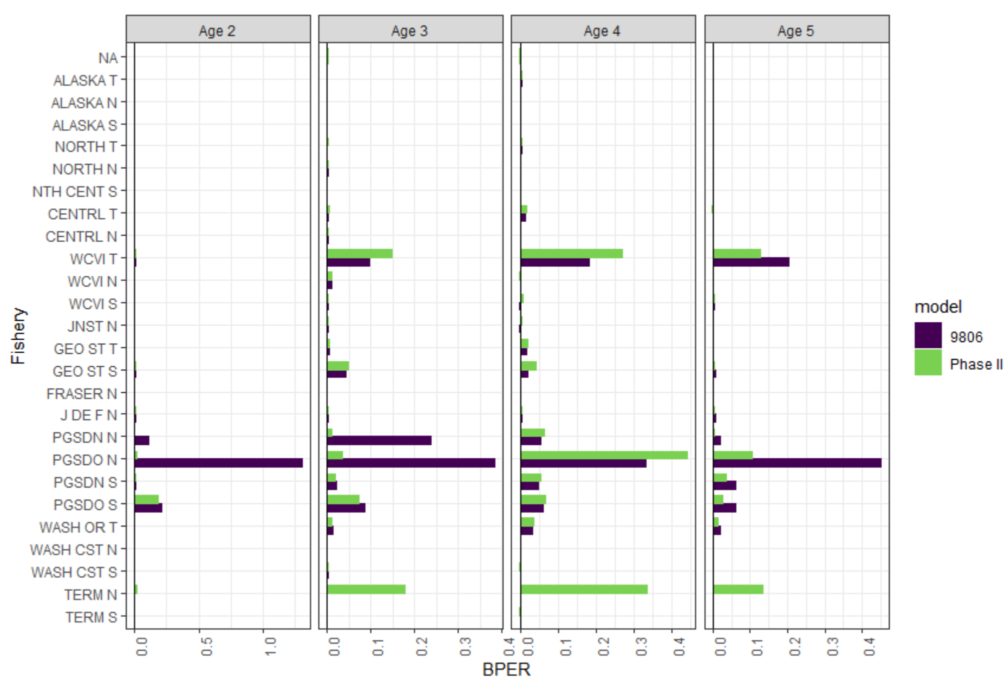

Figure 160—Base period exploitation rate by fishery for Puget Sound Natural Fall.

4.27.2.4 Escapement/Terminal Run Time Series

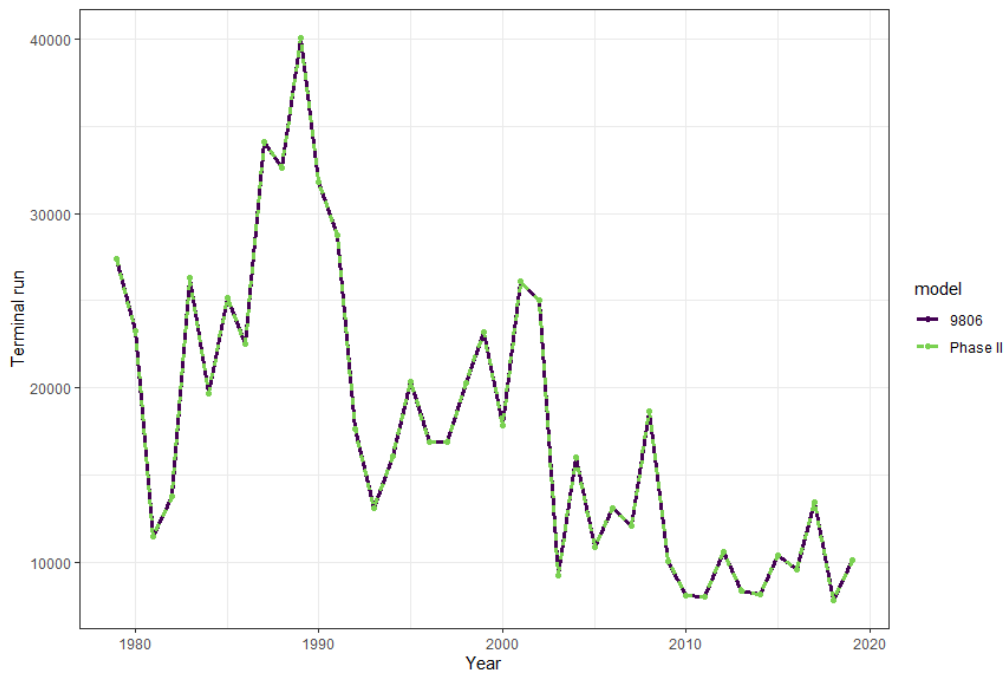

Figure 161—Terminal run size for Puget Sound Natural Fall.

4.27.2.5 Ricker Parameters

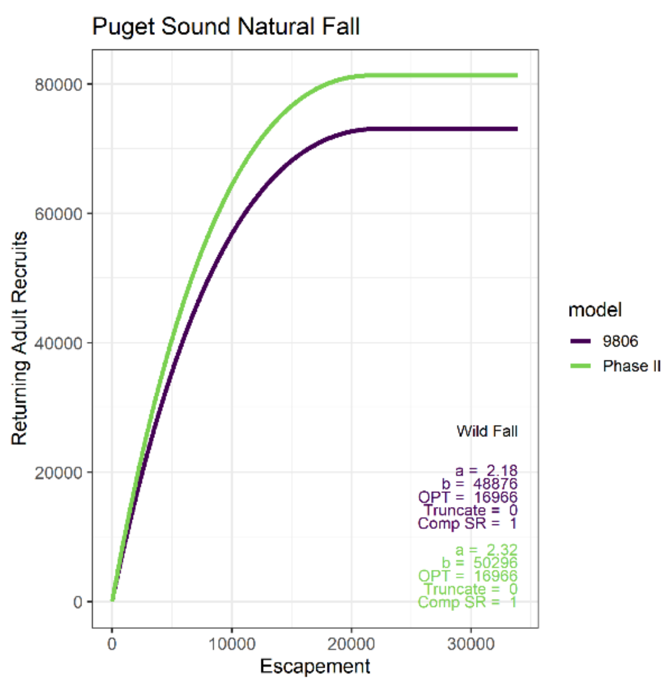

Figure 162—Ricker curve and parameters for Puget Sound Natural Fall (PSN) model stock.

4.28 Puget Sound Yearling (PSY): Puget Sound Yearling (PSY)

4.28.1 Stock Description

The Puget Sound yearling stock consists of hatchery production of yearlings from hatcheries in South Puget Sound (including accelerated production from the University of Washington), Hood Canal, Skagit, and the North Puget Sound region.

4.28.2 Description of Changes

Changes to the base period include updated tag codes. No changes to stock composition were made. However, a split of Puget Sound Yearlings (PSY) into a separate Model stock from Puget Sound Fingerlings (PSF) was made as the two had been combined for calibration of the 9806 Model calibration; these estimates changed only in 2018 and 2019 (Table 69).

Table 69—FCS file for Puget Sound Yearling (PSY) and Puget Sound Fingerling (PSF) reconfigured for the Phase II Model.

Note: differences between the Phase II and 9806 Model calibrations (negative=decreased in Phase II model, in parentheses). 2019 forecasts become observed in 2020.

9806 Model	**Puget Sound Fingerlings (PSF)/Yearlings (PSY) combined**
Phase II Model	**split: PSF and PSY separated**
Return Year	**all ages**
2017	-
2018	(17,951)
2019	18,552

4.28.2.1 MDL File Settings

Table 70—Information used in the construction of the Puget Sound Yearling (PSY) MDL file.

Information for MDL File Production	**Model Stock**
Model Stock Acronym	PSY
Brood Years	1976–1979
Out-of-base procedure used?	No
C-file extension (CWT Indicator ID)	PSY
Yearling Stock	Yes
Weight within BY by production releases	No
Exclude Esc for Between BY weighting	Yes
Start age in C-files	2
Last age in C-files	5

Information for MDL File Production	Model Stock
Modifications to escapements in Coshak4	Yes
Terminal fishery CWT moved to escapement	No
Model stock type	
Additional fisheries designated as terminal in the BSE file	PGSDN N; PGSDO N
MDL creation date	Sept. 2016

4.28.2.2 Base Period Coded-Wire Tags and Recoveries

Table 71—Coded-wire tag codes for Puget Sound Yearling (PSY) model stock.

Brood Year	Tag Codes	
	9806	Phase II
1976		WAL: 631701
1977	111601, 111602, 111603	UWA: 111602, 111601
1978	111604, 111605, 111606, 111617, 111618, 111624, 631853, 631905, 632004, 632023	UWA: 111603, 111605, 111604, 111606, 111618, 111624 SPY: 631637, 631840, 631853, 631852, 631905, 632004, 632023
1979	111627, 111628, 111629, 111630, 111631, 111632, 632015, 632019, 632027, 632055	UWA: 111627, 111629, 111628, 111630, 111631, 111632 SPY: 632015, 632027, 632019, 632055, 631701 HOOD: 632057

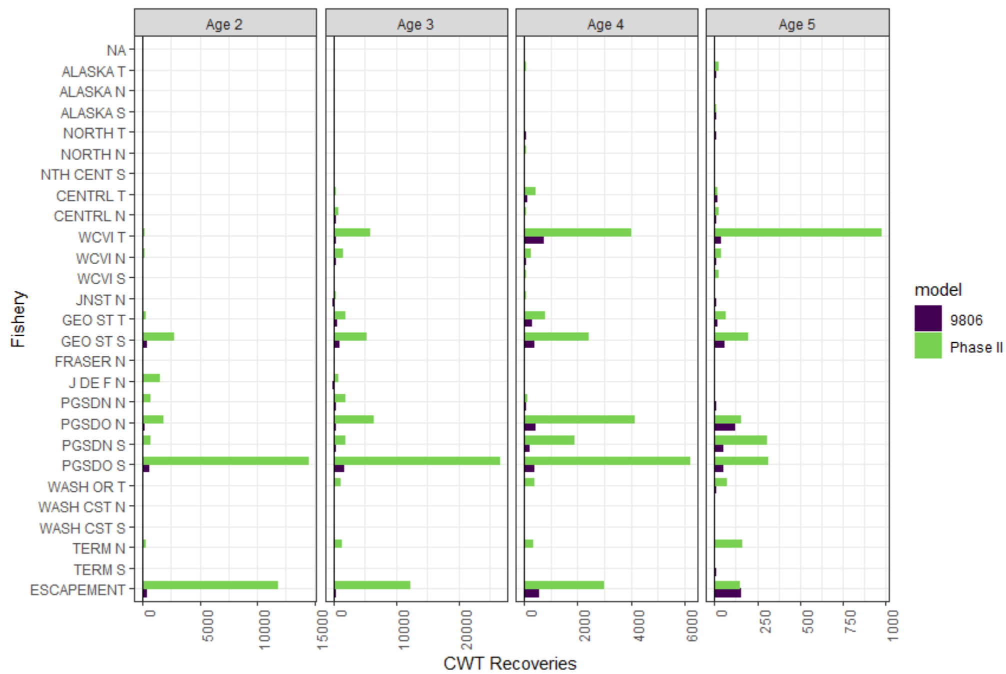

Figure 163—Base period coded-wire tag (CWT) recoveries for Puget Sound Yearling.

4.28.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

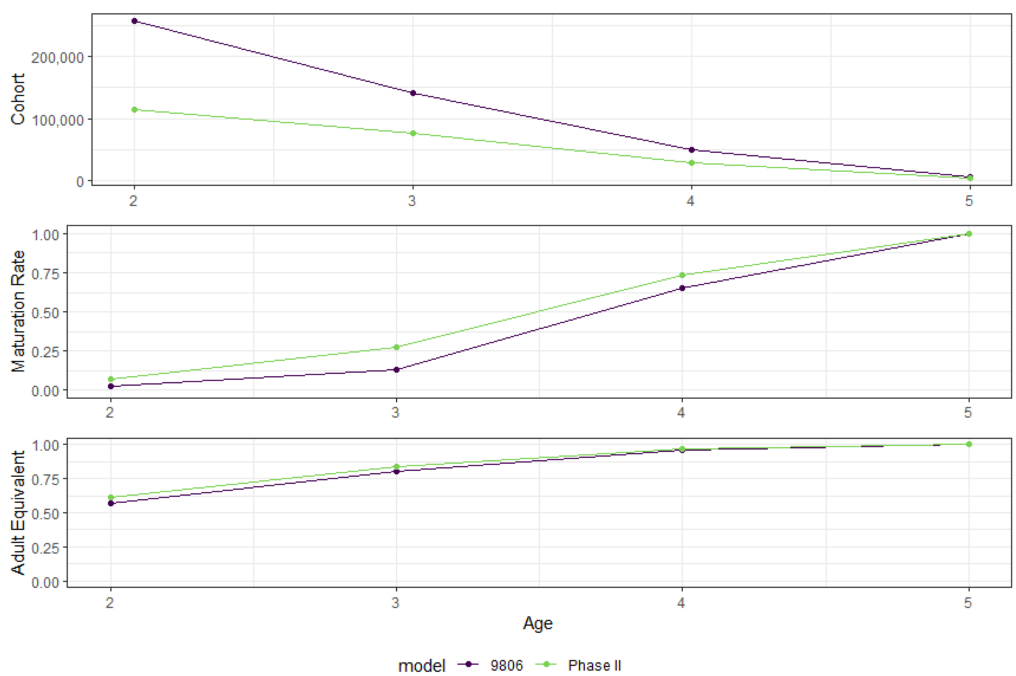

Figure 164—Base period cohort size, maturation schedule, and adult equivalent for Puget Sound Yearling.

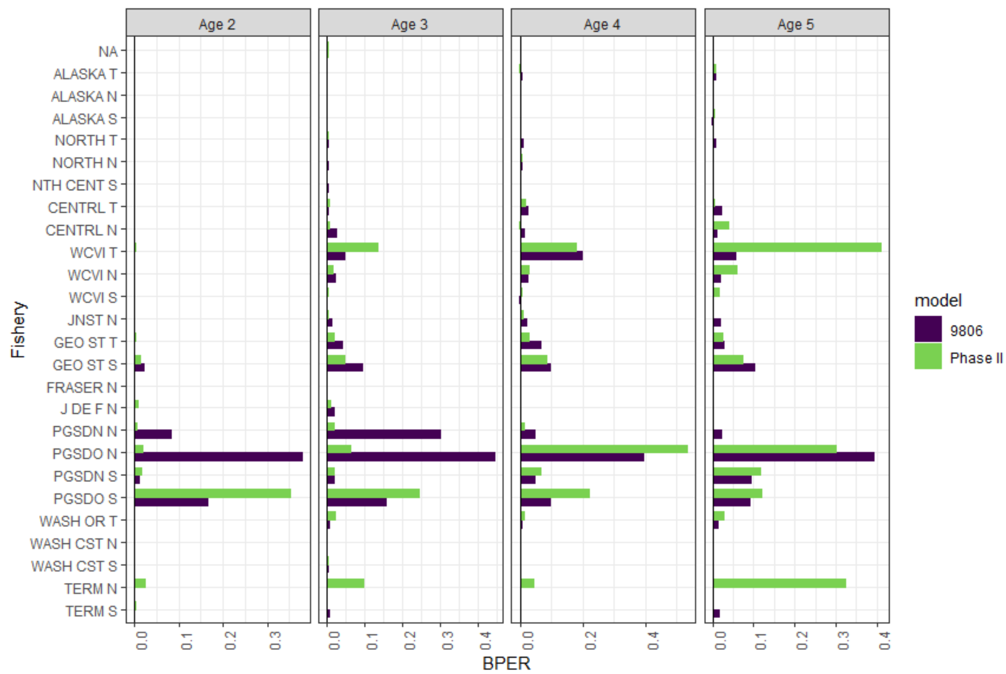

Figure 165—Base period exploitation rate by fishery for Puget Sound Yearling.

4.28.2.4 Escapement/Terminal Run Time Series

Note that in CLB1804, the PSF/PSY model stocks' terminal run time series were not stratified by fingerling and yearling; however, in Phase II model stratified estimates were used (Figure 166). A comparison of the aggregate time series from of both model stocks in both models can be found in the Puget Sound Fingerling section (section 4.26).

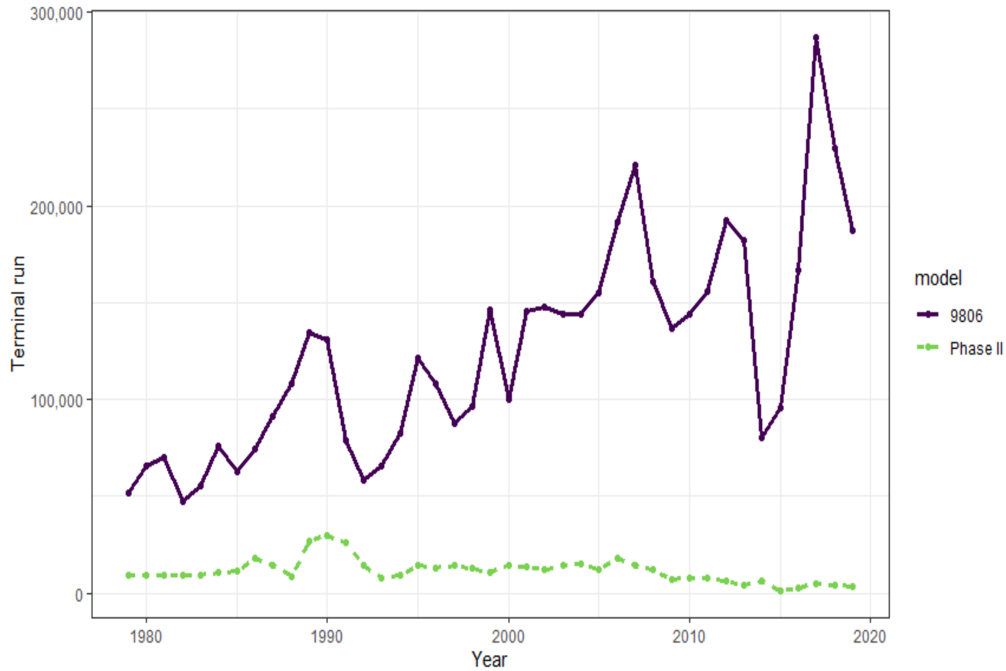

Figure 166—Comparison of the combined fingerling and yearling terminal run time series from 9806 calibration against the terminal run time series of yearlings from Phase II.

4.28.2.5 Ricker Parameters

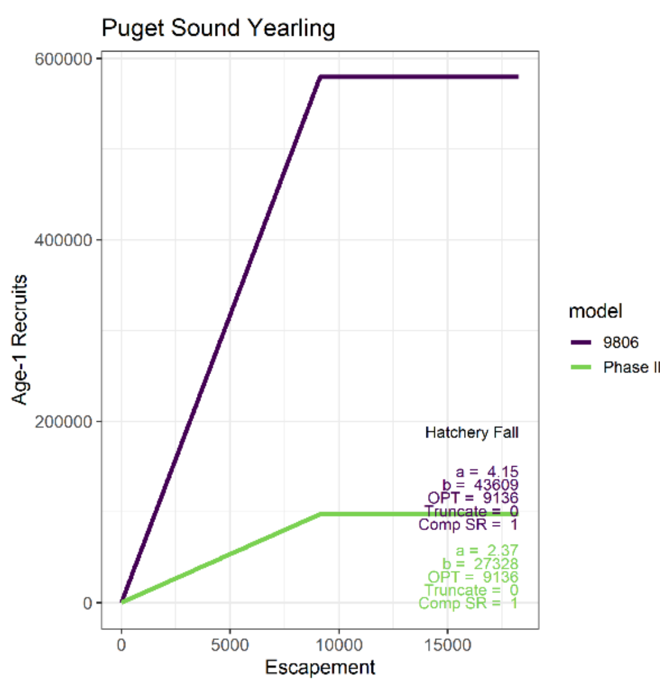

Figure 167—Ricker curve and parameters for Puget Sound Yearling (PSY) model stock.

4.29 Nooksack Spring (NKS): Nooksack Spring (NKS)

4.29.1 Stock Description

Nooksack spring fingerlings represent the spring production from the Nooksack River system.

4.29.2 Description of Changes

Changes to the base period include updated tag codes. No changes to stock composition were made.

4.29.2.1 MDL File Settings

Table 72—Information used in the construction of the Nooksack Spring (NKS) MDL file.

Information for MDL File Production	Phase II Model Stock
Model Stock Acronym	NKS
Brood Years	1984, 1989
Out-of-base procedure used?	Yes
Modifications to fisheries in WG4 file	No
C-file extension (CWT Indicator ID)	NSF
Yearling Stock	No
Weight within BY by production releases	No
Exclude Esc for Between BY weighting	No
Start age in C-files	2
Last age in C-files	5
Modifications to escapements in Coshak4	Yes
Terminal fishery CWT moved to escapement	No
Model stock type	Wild, Spring
Additional fisheries designated as terminal in the BSE file	Puget Sound Other Net; Puget Sound North Net
MDL creation date	18 Sept. 2016

4.29.2.2 Base Period Coded-Wire Tags and Recoveries

The tag codes used to represent this stock were from brood years 1984 (tag code 632846) and 1989 (tag codes 051952 and 630225). The tag code 051418 was used for the BPC in 1987 and 1990, but that tag code has very low escapement. In 2004 and 2006 tag codes from brood 1994 were used, but the WCVI troll fishery dropped to historical lows in 1996–1999 and the distribution of catch was significantly different from the base period. For these reasons the 1984 and 1989 tag codes were chosen for this BPC (Table 73).

Table 73—Coded-wire tag codes for Nooksack Spring (NKS) model stock.

Brood Year	Tag Codes	
	9806	Phase II
1984		632846
1987	051418	
1989		630225, 051952

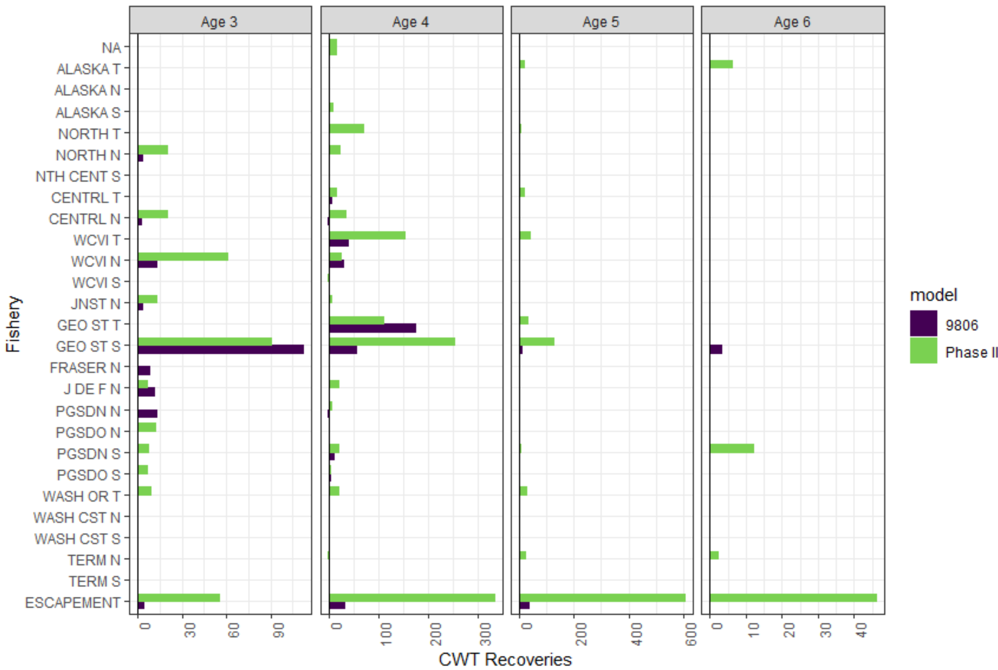

Figure 168—Base period coded-wire tag (CWT) recoveries for Nooksack Spring.

4.29.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

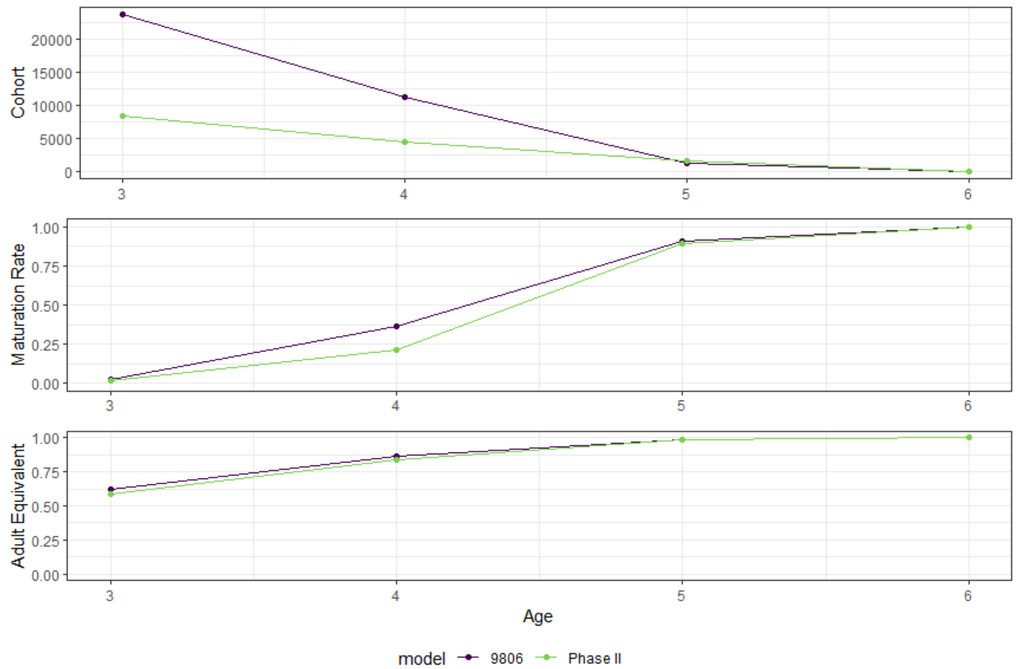

Figure 169—Base period cohort size, maturation schedule, and adult equivalent for Nooksack Spring.

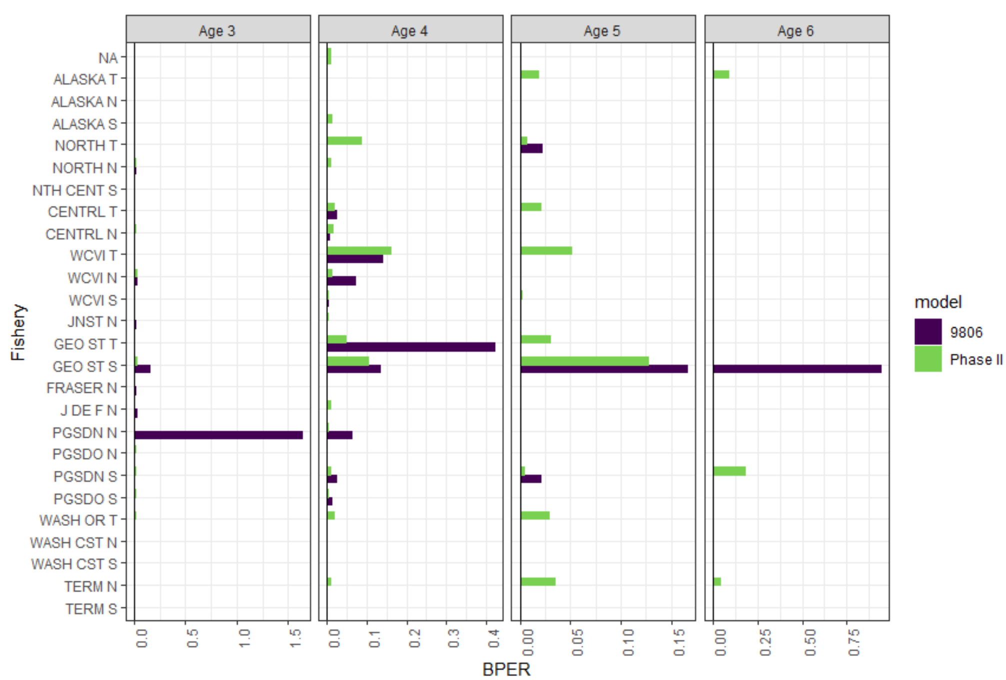

Figure 170—Base period exploitation rate by fishery for Nooksack Spring.

4.29.2.4 Escapement/Terminal Run Time Series

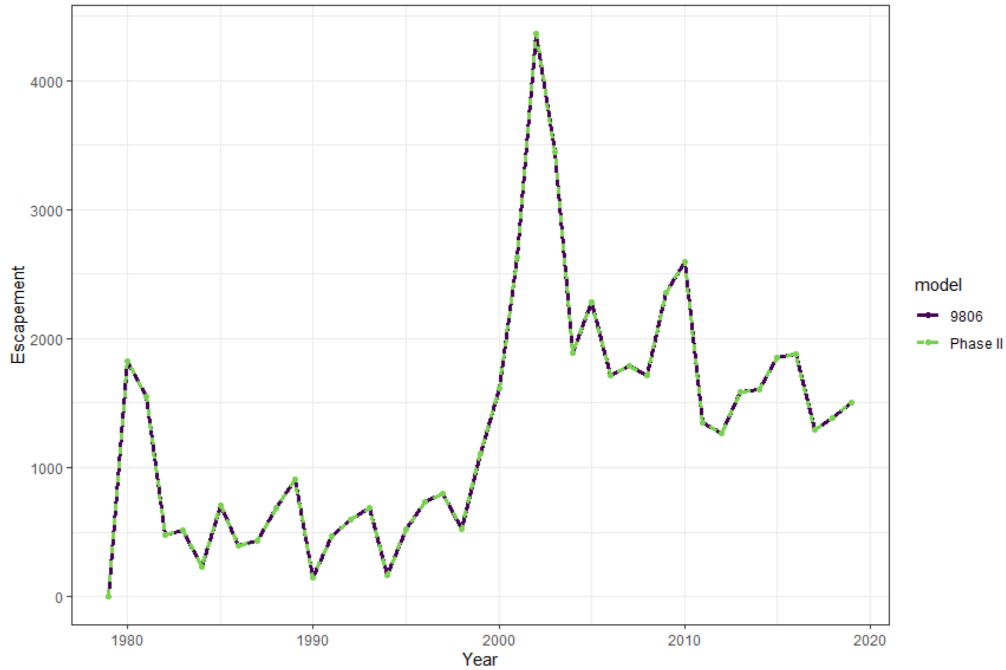

Figure 171—Escapement for Nooksack Spring.

4.29.2.5 Ricker Parameters

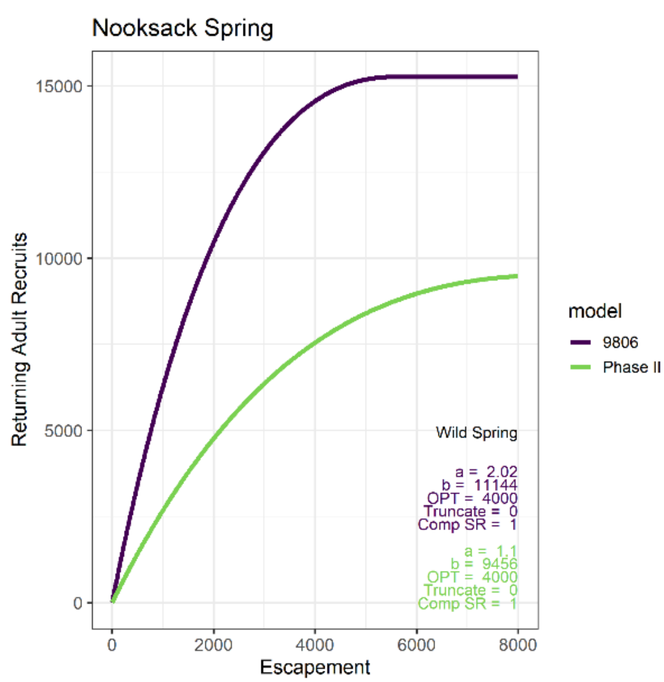

Figure 172—Ricker curve and parameters for Nooksack Spring (NKS) model stock.

4.30 Skagit Wild (SKG): Skagit Wild (SKG)

4.30.1 Stock Description

Skagit Wild represents summer/fall natural production from the Skagit River system.

4.30.2 Description of Changes

Changes to the base period include updated tag codes. No changes to stock composition were made.

4.30.2.1 MDL File Settings

Table 74—Information used in the construction of the Skagit Wild (SKG) MDL file.

Information for MDL File Production	Phase II Model Stock
Model Stock Acronym	SKG
Brood Years	1976–1977
Out-of-base procedure used?	No
Modifications to fisheries in WG4 file	NA
C-file extension (CWT Indicator ID)	SSF
Yearling Stock	No
Weight within BY by production releases	No
Exclude Esc for Between BY weighting	No
Start age in C-files	2
Last age in C-files	5
Modifications to escapements in Coshak4	Yes
Terminal fishery CWT moved to escapement	No
Model stock type	Wild, Fall
Additional fisheries designated as terminal in the BSE file	Puget Sound Other Net; Puget Sound North Net
MDL creation date	17 Sept. 2016

4.30.2.2 Base Period Coded-Wire Tags and Recoveries

Table 75—Coded-wire tag codes for Skagit Wild (SKG) model stock.

Brood Year	Tag Codes (SSF)	
	9806	Phase II
1976	631624, 631625, 631626, 631627, 631628, 631629, 631606	631624, 631625, 631626, 631627, 631628, 631629, 631606
1977	631630, 631631, 631632, 631633, 631635, 631636	631630, 631631, 631632, 631633, 631635, 631636

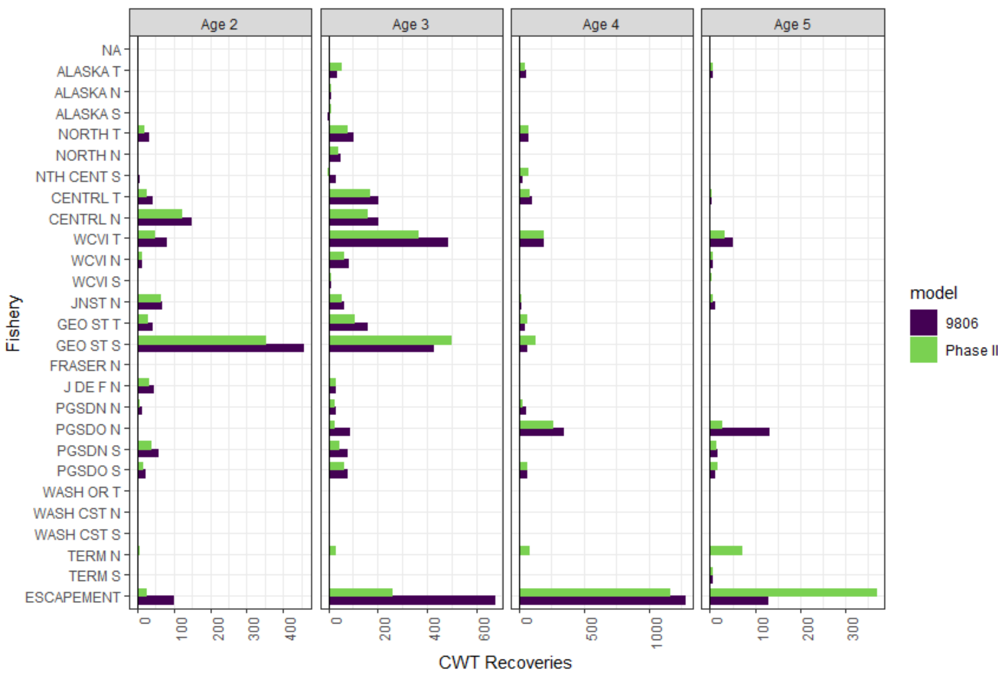

Figure 173—Base period coded-wire tag (CWT) recoveries for Skagit Wild.

4.30.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

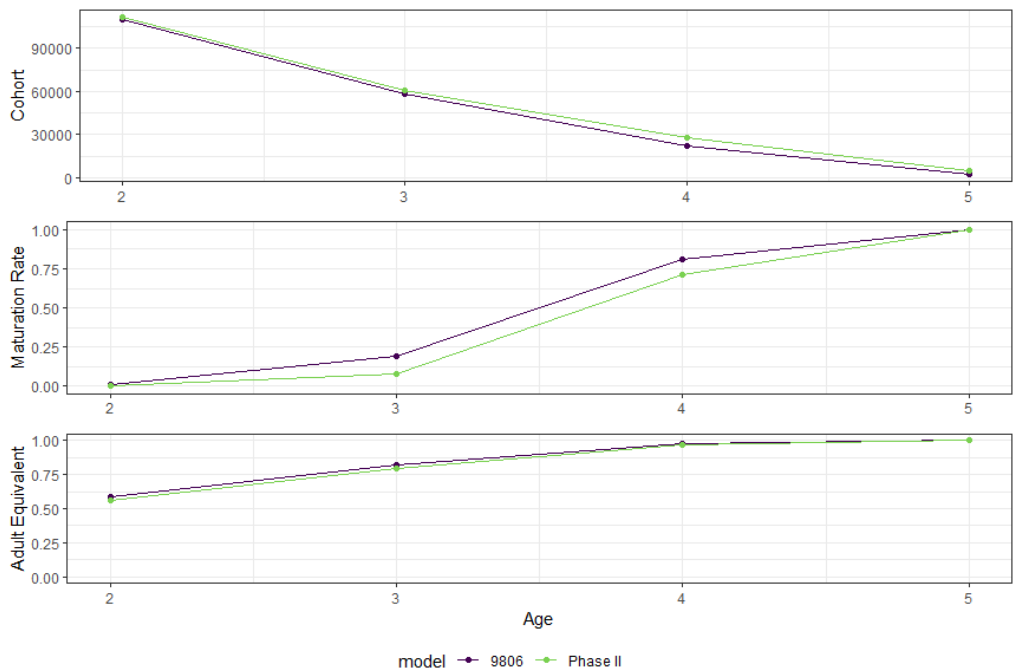

Figure 174—Base period cohort size, maturation schedule, and adult equivalent for Skagit Wild.

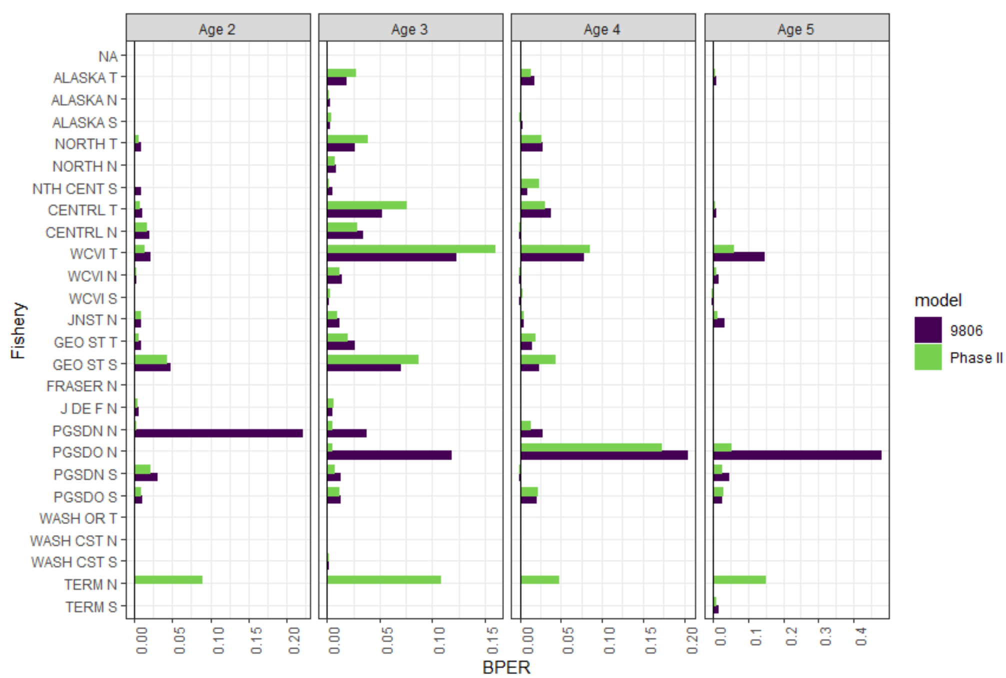

Figure 175—Base period exploitation rate by fishery for Skagit Wild.

4.30.2.4 Escapement/Terminal Run Time Series

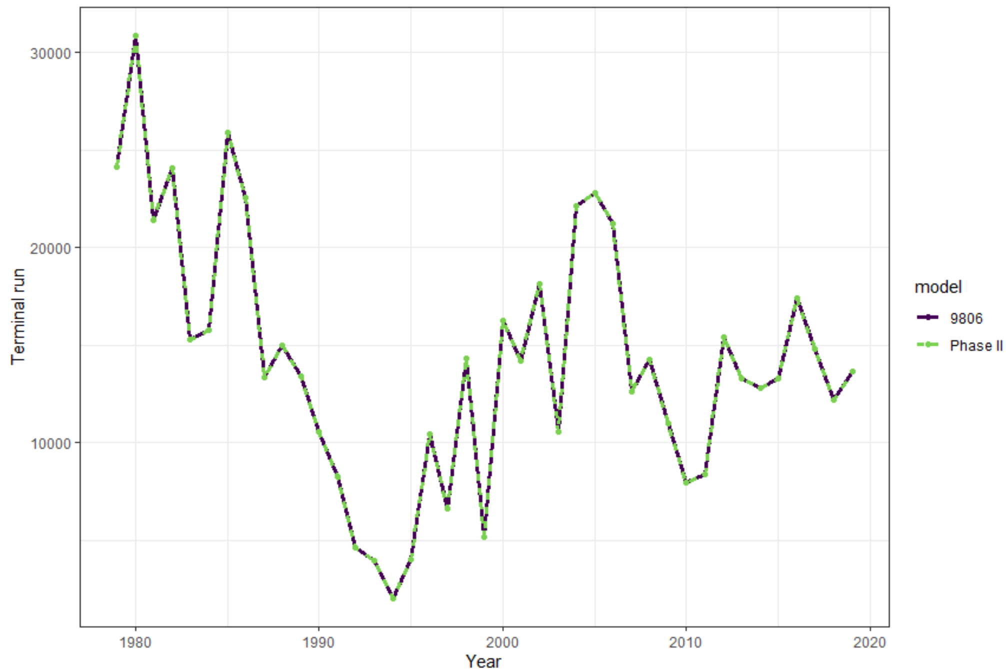

Figure 176—Terminal run size for Skagit Wild.

4.30.2.5 Ricker Parameters

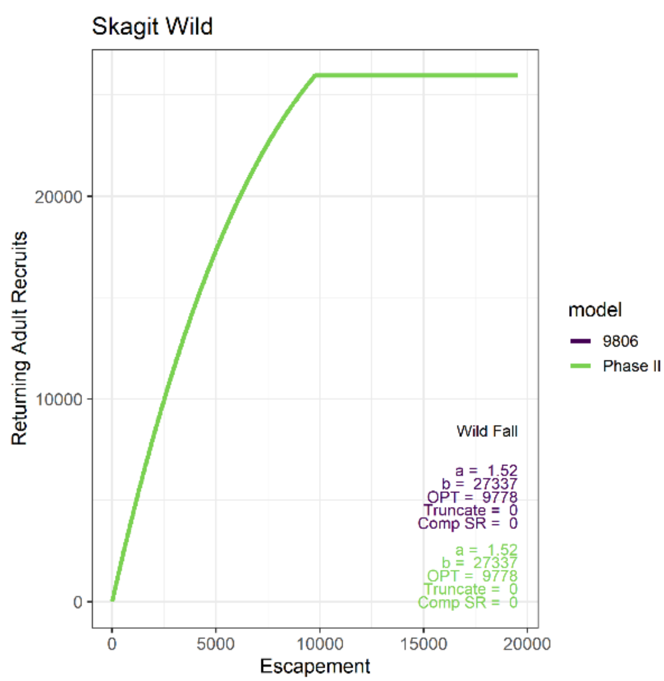

Figure 177—Ricker curve and parameters for Skagit Wild (SKG) model stock.

4.31 Stillaguamish Wild (STL): Stillaguamish Wild (STL)

4.31.1 Stock Description

Stillaguamish Wild represents Fall Chinook production from the Stillaguamish River.

4.31.2 Description of Changes

Changes to the base period include updated tag codes. No changes to stock composition were made.

4.31.2.1 MDL File Settings

Table 76—Information used in the construction of the Stillaguamish Wild (STL) MDL file.

Information for MDL File Production	Phase II Model Stock
Model Stock Acronym	STL
Brood Years	1987–1990
Out-of-base procedure used?	Yes
Modifications to fisheries in WG4 file	No
C-file extension (CWT Indicator ID)	STL
Yearling Stock	No
Weight within BY by production releases	No
Exclude Esc for Between BY weighting	Yes
Start age in C-files	2
Last age in C-files	5
Modifications to escapements in Coshak4	Yes
Terminal fishery CWT moved to escapement	No
Model stock type	Wild, Fall
Additional fisheries designated as terminal in the BSE file	Puget Sound Other Net; Puget Sound North Net
MDL creation date	18 Sept. 2016

4.31.2.2 Base Period Coded-Wire Tags and Recoveries

The Stillaguamish stock is managed on a natural basis. The tag groups used for this stock originate from the Stillaguamish hatchery program. Brood stock is taken in the river and juveniles reared in the hatchery, but no adults return to the hatchery. For the calibration in 1991 tag codes from broods 1980–1982 were used, but in later years, including 2006, tag codes from 1987–1990 have been used. This has been done as no escapement recoveries are available prior to brood 1986, and for 1987–1990 escapement recoveries are available and total returns are highest. These tag groups are part of the current tag codes used in the ERA for the Stillaguamish. As these tag groups were released in years after the base period of 1979–1982, it was necessary to adjust the recoveries prior to aggregating the tag groups for the subsequent calibration.

Table 77—Coded-wire tag codes for Stillaguamish Wild (STL) model stock.

Brood Year	Tag Codes (STL)	
	9806	Phase II
1980	050843	
1981	051063	
1982	051427	
1983		
1986		
1987		212555
1988		213147
1989		211826
1990		212026
1991		
1992		

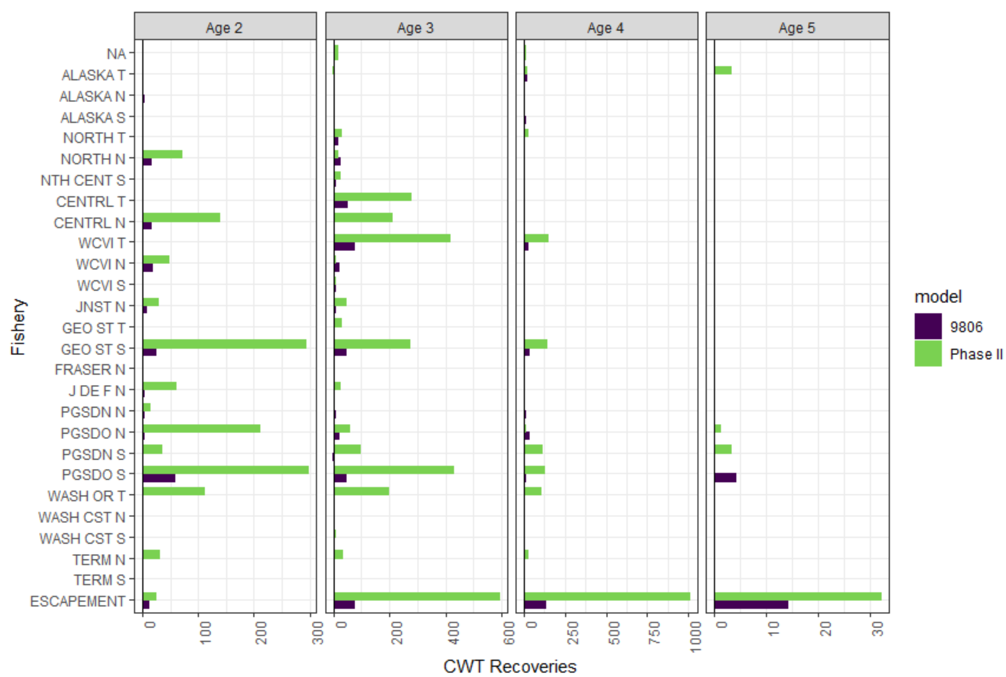

Figure 178—Base period coded-wire tag (CWT) recoveries for Stillaguamish Wild.

4.31.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

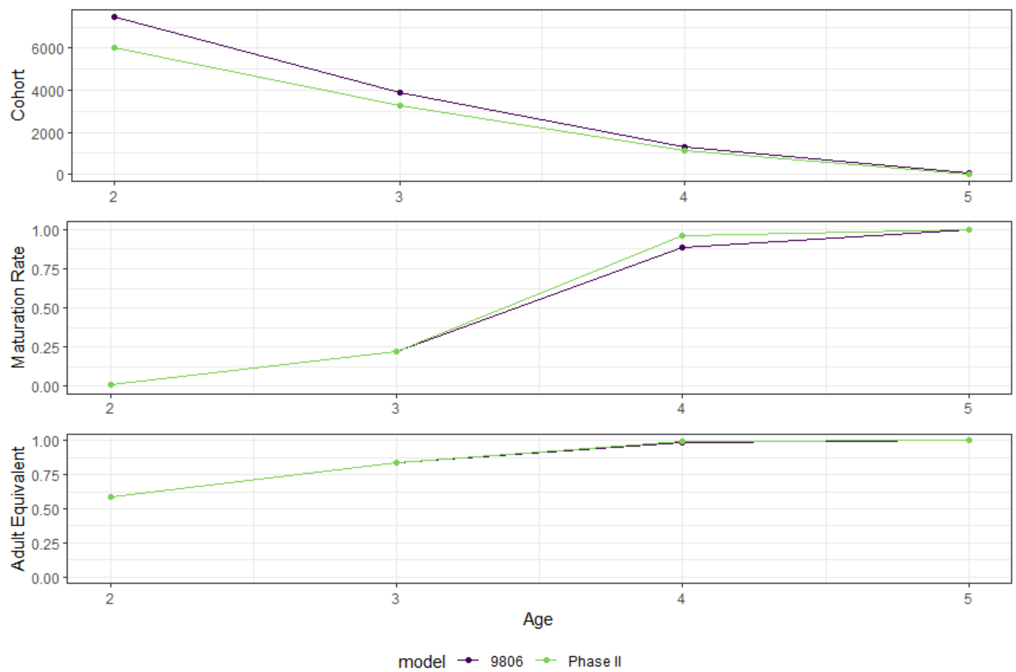

Figure 179—Base period cohort size, maturation schedule, and adult equivalent for Stillaguamish Wild.

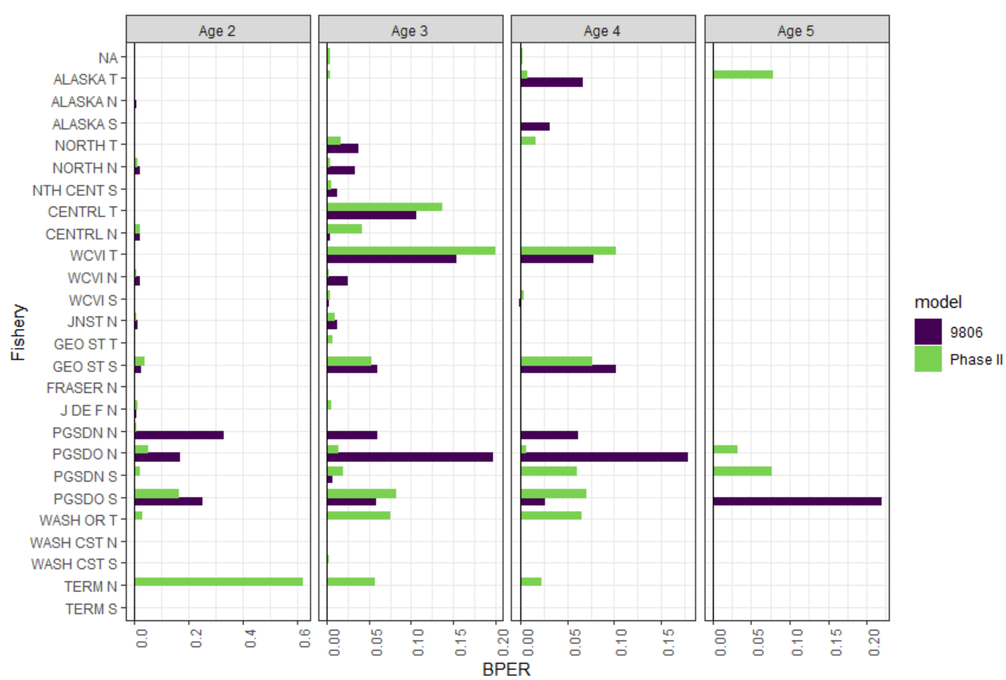

Figure 180—Base period exploitation rate by fishery for Stillaguamish Wild.

4.31.2.4 Escapement/Terminal Run Time Series

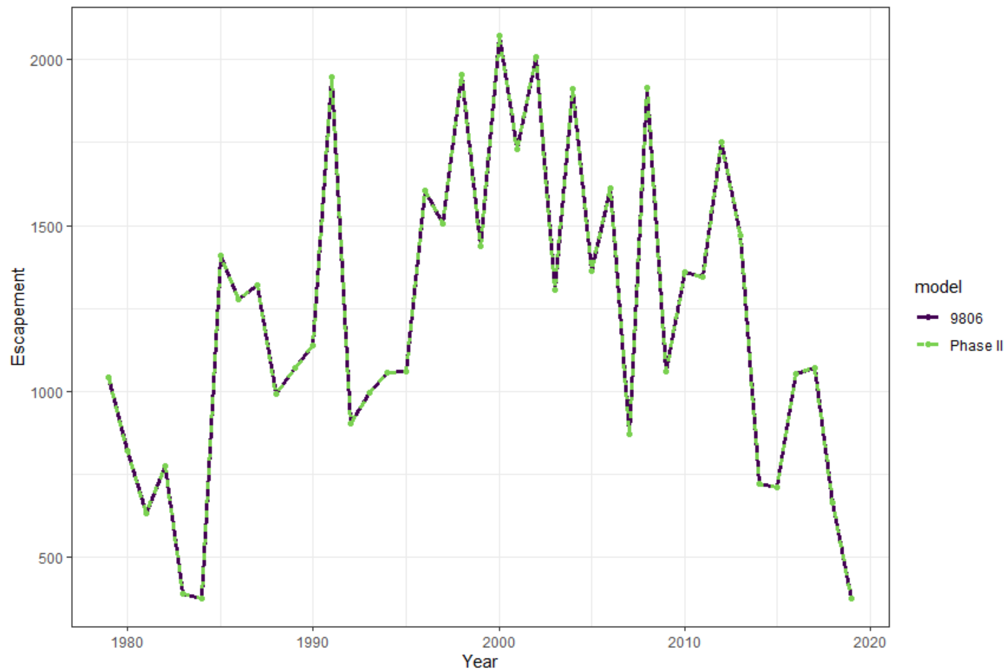

Figure 181—Escapement or terminal run size for Stillaguamish Wild.

4.31.2.5 Ricker Parameters

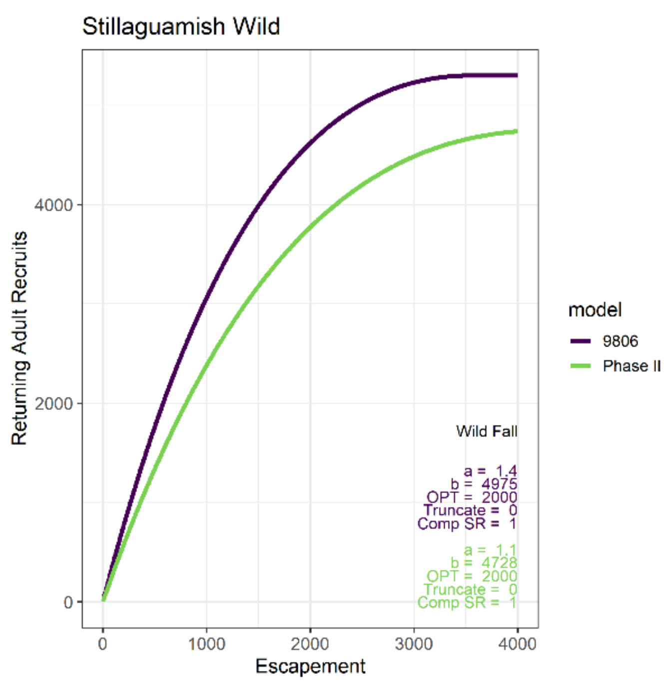

Figure 182—Ricker curve and parameters for Stillaguamish Wild (STL) model stock.

4.32 Snohomish Wild (SNO): Snohomish Wild (SNO)

4.32.1 Stock Description

Snohomish Wild represents the natural production of Fall Fingerlings in the Snohomish system.

4.32.2 Description of Changes

Changes to the base period include updated tag codes. No changes to stock composition were made.

4.32.2.1 MDL File Settings

Table 78—Information used in the construction of the Snohomish Wild (SNO) MDL file.

Information for MDL File Production	Phase II Model Stock
Model Stock Acronym	SNO
Brood Years	1987–1990
Out-of-base procedure used?	Yes
Modifications to fisheries in WG4 file	No
C-file extension (CWT Indicator ID)	STL
Yearling Stock	No
Weight within BY by production releases	No
Exclude Esc for Between BY weighting	Yes
Start age in C-files	2
Last age in C-files	5
Modifications to escapements in Coshak4	Yes
Terminal fishery CWT moved to escapement	No
Model stock type	Wild, Fall
Additional fisheries designated as terminal in the BSE file	Puget Sound Other Net; Puget Sound North Net
MDL creation date	18 Sept. 2016

4.32.2.2 Base Period Coded-Wire Tags and Recoveries

There are no tag codes available for this natural stock and the Stillaguamish tag codes were used for this stock. Escapement derived from tag recoveries were used in this analysis, similar to the method used in 2006. This escapement is significantly higher than that estimated using the Run Reconstruction catch/escapement (C/E) ratio for the Snohomish. Between brood year weights were applied to the Puget Sound net tag recoveries prior to escapement estimation using the C/E ratios.

Table 79—Coded-wire tag codes for Snohomish Wild (SNO) model stock.

Brood Year	Tag Codes (STL)	
	9806	Phase II
1980	050843	
1981	051063	
1982	051427	
1983		
1986		
1987		212555
1988		213147
1989		211826
1990		212026
1991		
1992		

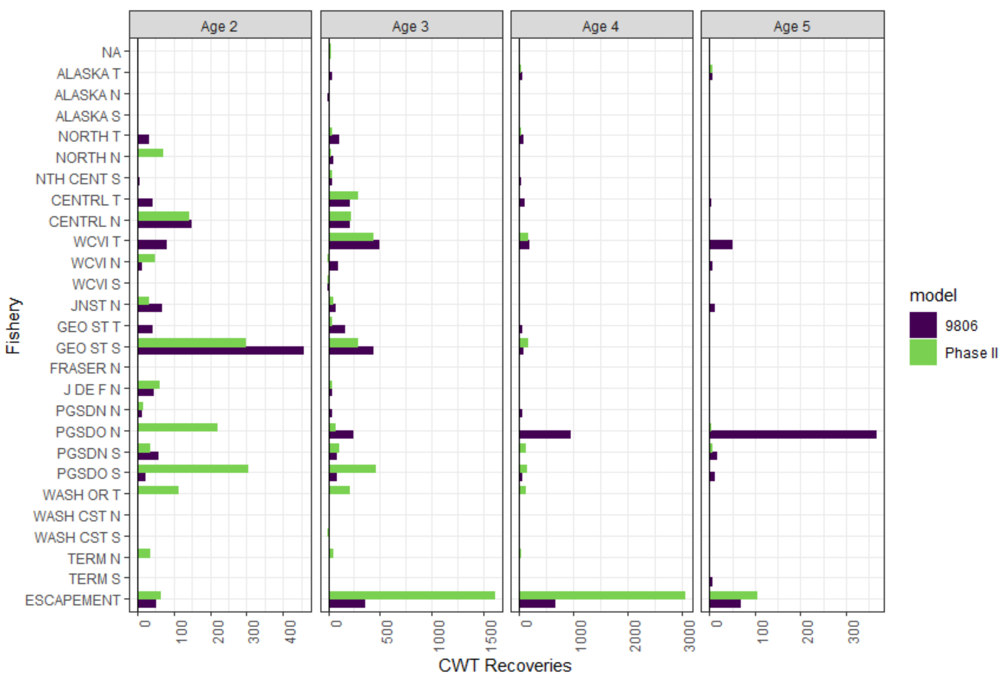

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Figure 183—Base period coded-wire tag (CWT) recoveries for Snohomish Wild.

4.32.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

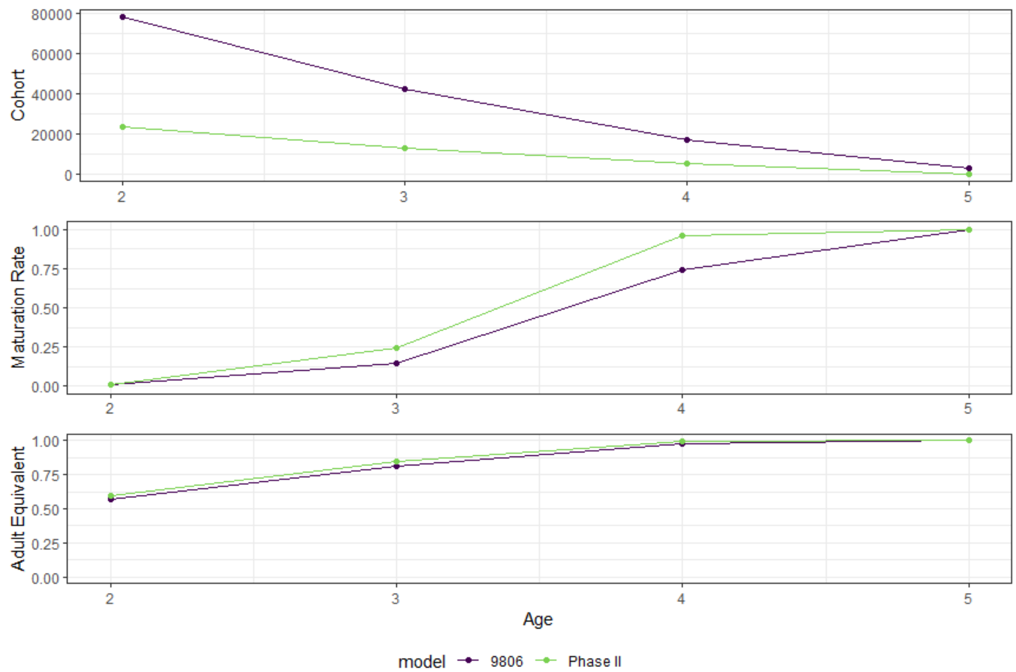

Figure 184—Base period cohort size, maturation schedule, and adult equivalent for Snohomish Wild.

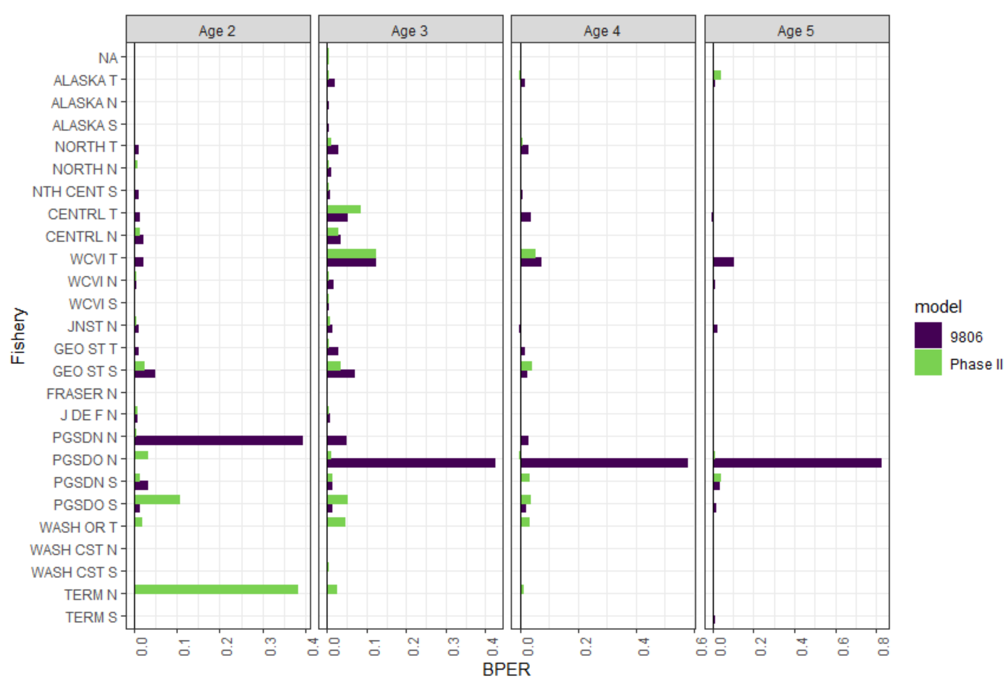

Figure 185—Base period exploitation rate by fishery for Snohomish Wild.

4.32.2.4 Escapement/Terminal Run Time Series

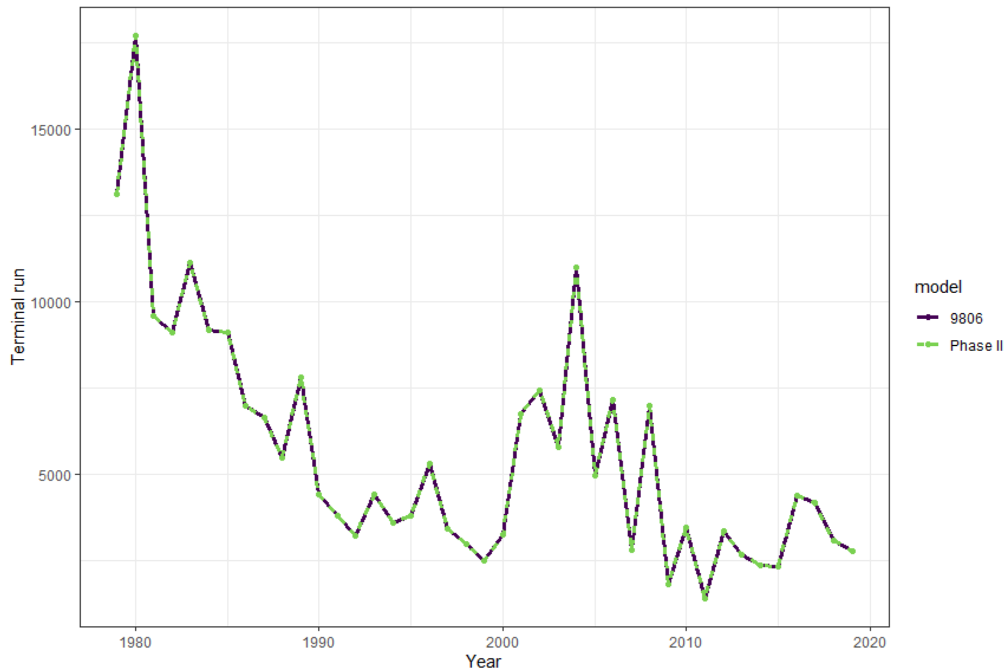

Figure 186—Escapement or terminal run size for Snohomish Wild.

4.32.2.5 Ricker Parameters

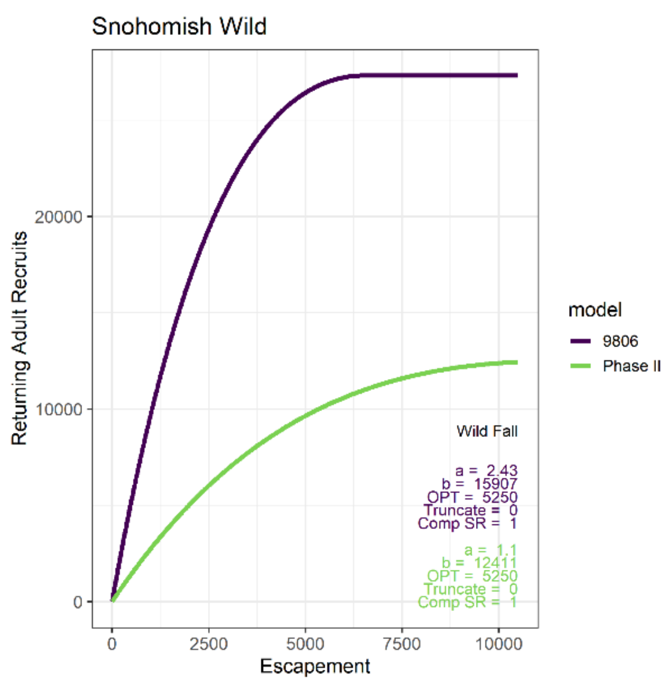

Figure 187—Ricker curve and parameters Snohomish Wild (SNO) model stock.

4.33 Washington Coastal Hatchery (WCH): Washington Coastal Hatchery (WCH)

4.33.1 Stock Description

Washington Coastal Hatchery is an aggregate stock of hatchery production of fall Chinook from the Washington coast for the area from Willapa Bay to the Quillayute River system.

4.33.2 Description of Changes

Changes to the base period include updated tag codes. No changes to stock composition were made. However, beginning in 1992 there were consistent and relatively large changes in returns. The Phase II Model's newly implemented Stock Aggregate Cohort Evaluation (SACE)/maturation rate adjustment procedure. Accounting for returns switched from all ages to age-specific estimates (Table 80). Compiling this escapement data required extensive and repeated contacts among several CTC-AWG members and various state and tribal agency staff on the Washington coast, as well as repeated updates/revisions of the data from the several coastal areas.

Table 80—FCS file for Washington Coast Hatchery (WCH) re-estimated for the Phase II Model.

Note: differences between the Phase II and 9806 Model calibrations (negative = decreased in Phase II model, in parentheses). 2019 forecasts become observed in 2020.

WA Coastal Fall Hatchery (WCH)	
Return Year	**All Ages**
1992	(1,089)
1993	(8,377)
1994	(2,152)
1995	(78)
1996	(4,610)
1997	427
1998	(1,040)
1999	(183)
2000	(3,274)
2001	(3,368)
2002	(2,473)
2003	(3,088)
2004	(1,933)
2005	(2,201)
2006	(3,377)
2007	(1,687)
2008	(1,883)

WA Coastal Fall Hatchery (WCH)	
Return Year	All Ages
2009	(2,370)
2010	(4,427)
2011	(3,787)
2012	(1,071)
2013	1,696
2014	(3,200)
2015	6,470
2016	(899)
2017	3,630

4.33.2.1 MDL File Settings

Table 81—Information used in the construction of the Washington Coastal Hatchery (WCH) MDL file.

Information for MDL File Production	Phase II Model Stock
Model Stock Acronym	WCH
Brood Years	1985–1987, 1989–1990
Out-of-base procedure used?	Yes
Modifications to fisheries in WG4 file	22 TWCVI N
C-file extension (CWT Indicator ID)	QUE
Yearling Stock	No
Weight within BY by production releases	No
Exclude Esc for Between BY weighting	No
Start age in C-files	2
Last age in C-files	6
Modifications to escapements in Coshak4	No
Terminal fishery CWT moved to escapement	No
Model stock type	Hatchery, Fall
Additional fisheries designated as terminal in the BSE file	None
MDL creation date	18 Sept. 2016

4.33.2.2 Base Period Coded-Wire Tags and Recoveries

Tag codes used for this stock were from Queets River program for brood years 1985–1990. In calibrations before 2004 tag codes from 1977 and 1978 from the Quinault system were used, but escapement recoveries were underestimated due to water flow issues. In order to improve escapement estimates the Queets River tag codes were used in 2006 and 2009.

Table 82—Coded-wire tag codes for Washington Coastal Hatchery (WCH) model stock.

Brood Year	Tag Codes (WCH)	
	9806	Phase II
1977	050337	
1978	050338, 050518, 050519	
1985		211908
1986		212101
1987		212835
1989		211835
1990		212010

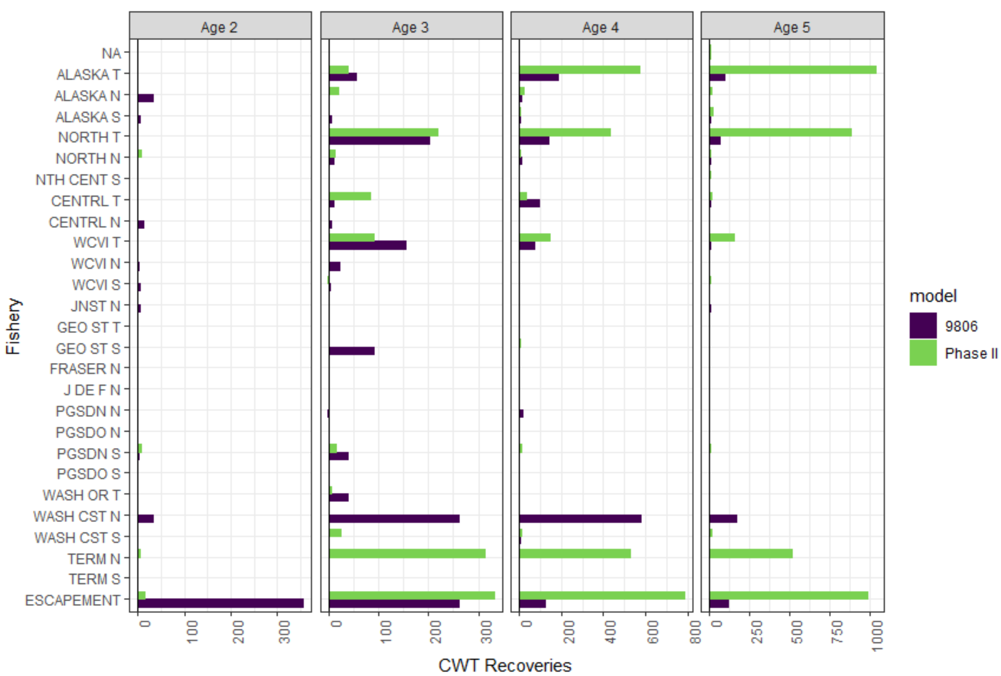

Figure 188—Base period coded-wire tag (CWT) recoveries for Washington Coastal Hatchery.

4.33.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

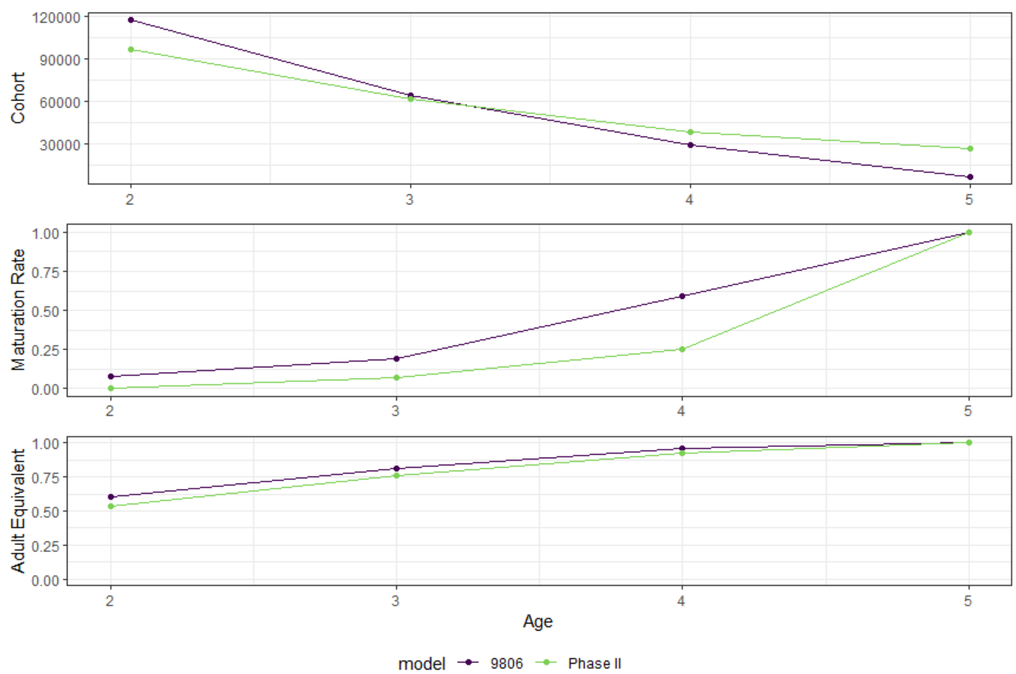

Figure 189—Base period cohort size, maturation schedule, and adult equivalent for Washington Coastal Hatchery.

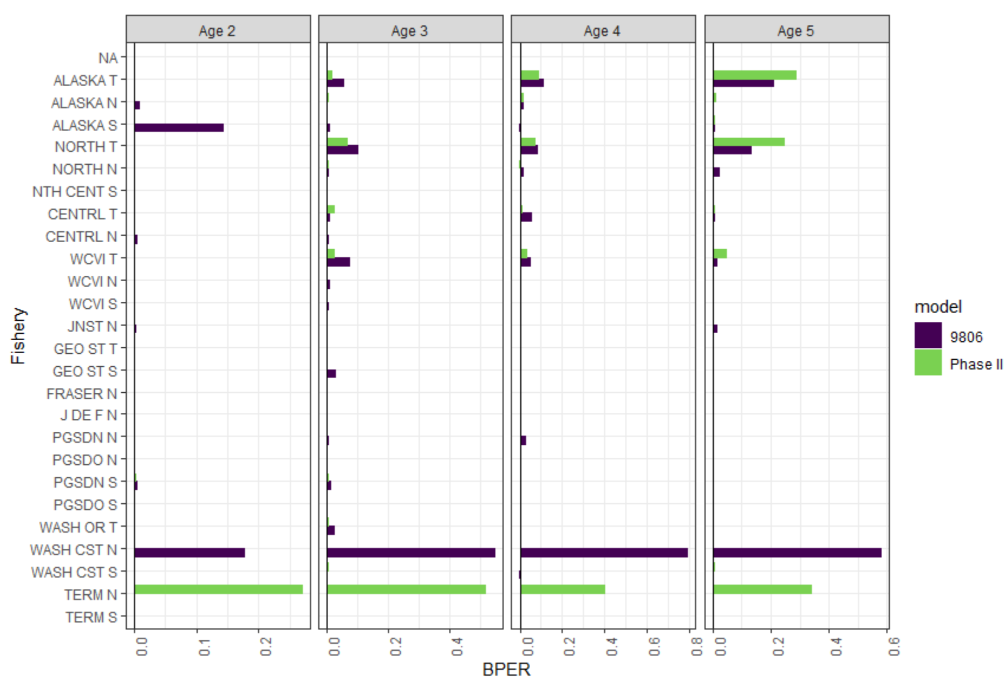

Figure 190—Base period exploitation rate by fishery for Washington Coastal Hatchery.

4.33.2.4 Escapement/Terminal Run Time Series

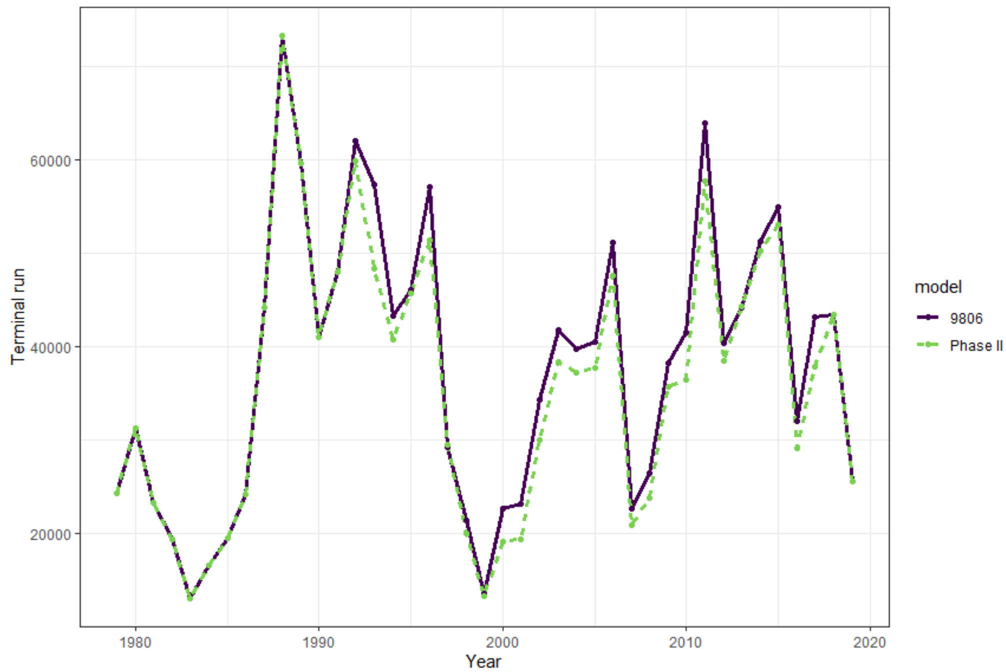

Figure 191—Terminal run size for Washington Coastal Hatchery.

4.33.2.5 Ricker Parameters

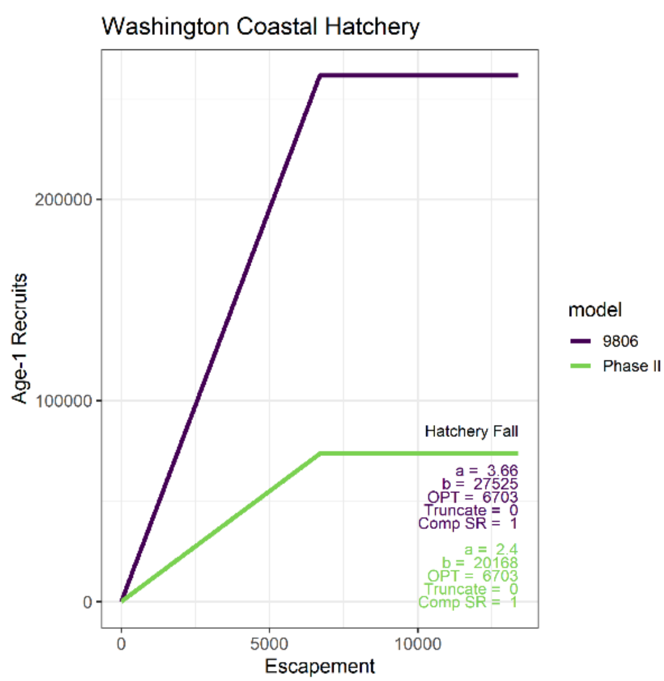

Figure 192—Ricker curve and parameters for Washington Coastal Hatchery (WCH) model stock.

4.34 Washington Coastal Natural (WCN): Washington Coastal Natural (WCN)

4.34.1 Stock Description

Washington Coastal Natural is an aggregate stock of natural production of fall Chinook from Willapa Bay, Grays Harbor, Queets, Quinault, Quillayute, Hoh and Tsoo-Yess systems.

4.34.2 Description of Changes

Changes to the base period include updated tag codes. No changes to stock composition were made. However, beginning in 1992 there were consistent and relatively large changes in returns. The Phase II Model's newly implemented Stock Aggregate Cohort Evaluation (SACE)/maturation rate adjustment procedure. Accounting for returns switched from all ages to age-specific estimates (Table 83). Compiling this escapement data required extensive and repeated contacts among several CTC-AWG members and various state and tribal agency staff on the Washington coast, as well as repeated updates/revisions of the data from the several coastal areas.

Table 83—FCS file for Washington Coast Natural (WCN) re-estimated for the Phase II Model.

Note: differences between the Phase II and 9806 Model calibrations (negative = decreased in Phase II model, in parentheses). 2019 forecasts become observed in 2020.

WA Coastal Fall Natural (WCN)	
Return Year	All Ages
1992	10,311
1993	12,839
1994	7,371
1995	2,038
1996	22,681
1997	13,773
1998	24,591
1999	2,554
2000	6,446
2001	7,156
2002	6,510
2003	10,107
2004	12,144
2005	10,700
2006	8,367
2007	4,473
2008	5,805

WA Coastal Fall Natural (WCN)	
Return Year	All Ages
2009	7,904
2010	11,388
2011	8,686
2012	6,250
2013	2,719
2014	12,511
2015	2,715
2016	4,504
2017	341

4.34.2.1 MDL File Settings

Table 84—Information used in the construction of the Washington Coastal Natural (WCN) MDL file.

Information for MDL File Production	Phase II Model Stock
Model Stock Acronym	WCN
Brood Years	1985–1987, 1989–1990
Out-of-base procedure used?	Yes
Modifications to fisheries in WG4 file	22 TWCVI N
C-file extension (CWT Indicator ID)	QUE
Yearling Stock	No
Weight within BY by production releases	No
Exclude Esc for Between BY weighting	No
Start age in C-files	2
Last age in C-files	6
Modifications to escapements in Coshak4	No
Terminal fishery CWT moved to escapement	No
Model stock type	Wild, Fall
Additional fisheries designated as terminal in the BSE file	None
MDL creation date	18 Sept. 2016

4.34.2.2 Base Period Coded-Wire Tags and Recoveries

Tag codes used for this stock were from Queets River program for brood years 1985–1990. In calibrations before 2004 tag codes from 1977 and 1978 from the Quinault system were used, but escapement recoveries were underestimated due to water flow issues. In order to improve escapement estimates the Queets River tag codes were used in 2006 and 2009.

Table 85—Coded-wire tag codes for Washington Coastal Natural (WCN) model stock.

Brood Year	Tag Codes (QUE)	
	9806 (QUE, QIN)	Phase II (QUE)
1977	050337	
1978	050338, 050518, 050519	
1985		211908
1986		212101
1987		212835
1989		211835
1990		212010

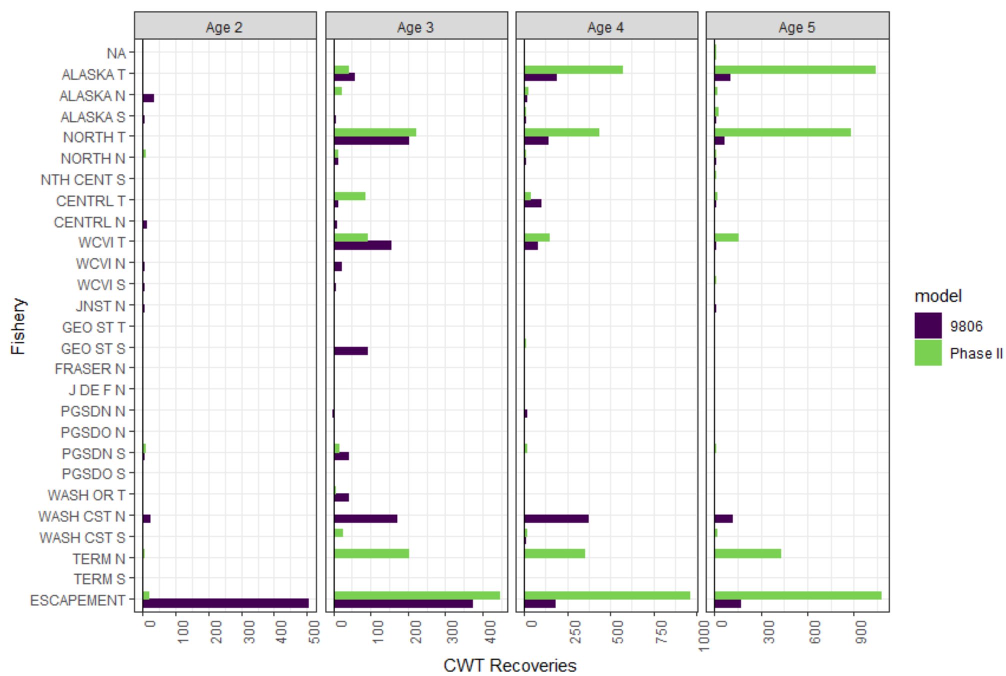

Figure 193—Base period coded-wire tag (CWT) recoveries for Washington Coastal Wild.

4.34.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

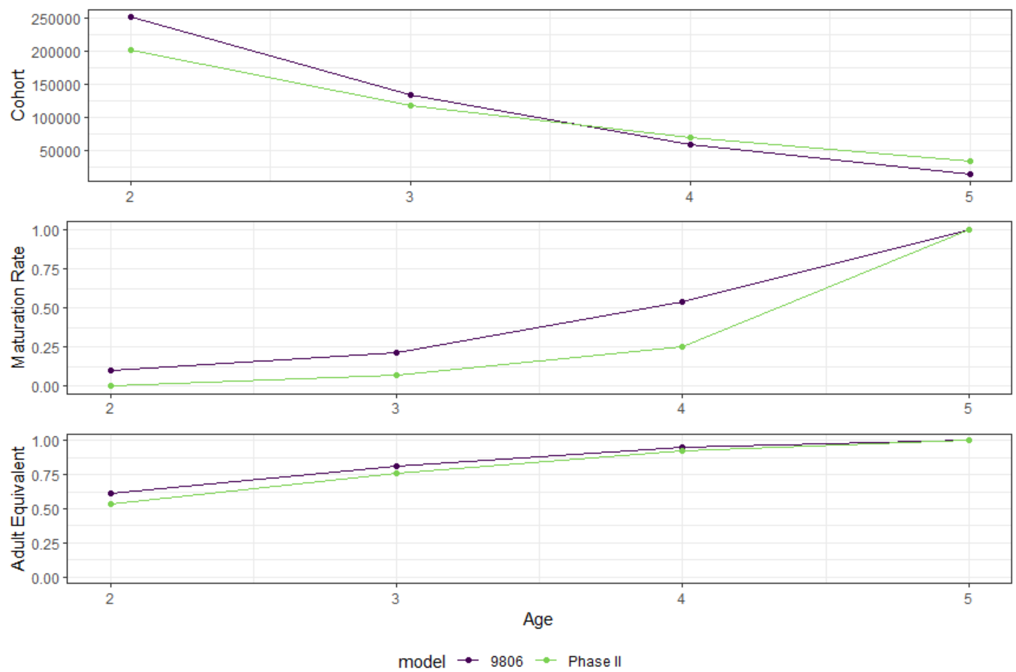

Figure 194—Base period cohort size, maturation schedule, and adult equivalent for Washington Coastal Wild.

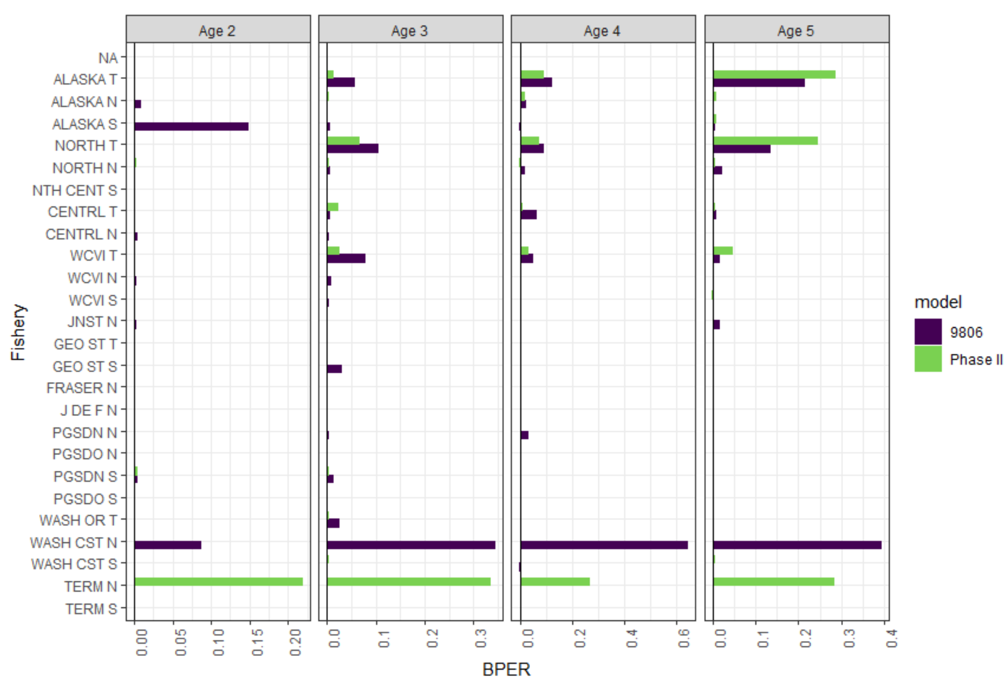

Figure 195—Base period exploitation rate by fishery for Washington Coastal Wild.

4.34.2.4 Escapement/Terminal Run Time Series

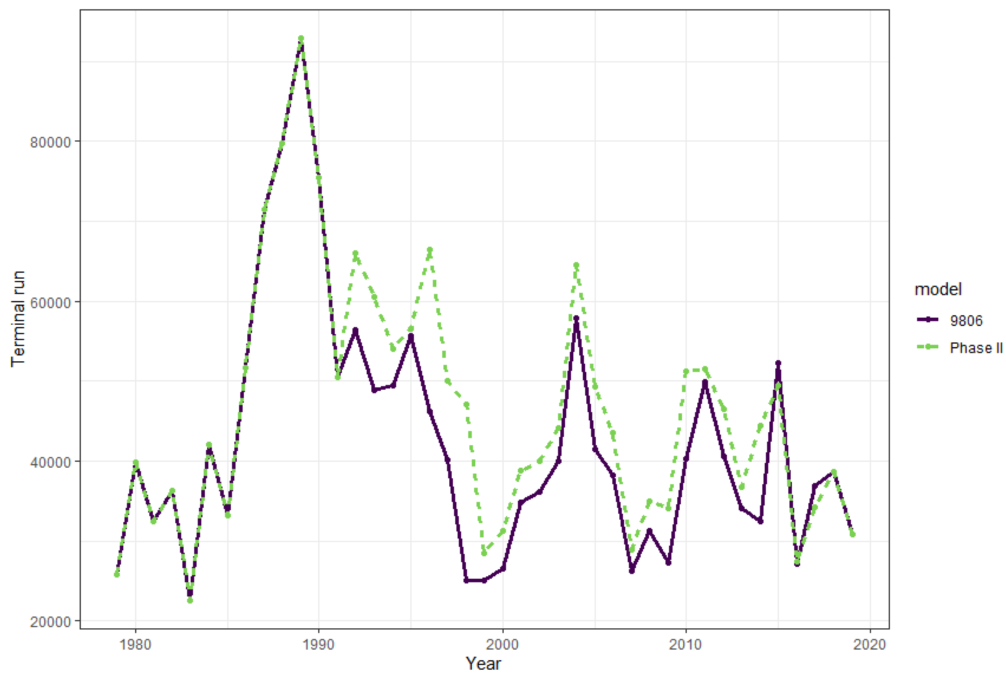

Figure 196—Terminal run size for Washington Coastal Wild.

4.34.2.5 Ricker Parameters

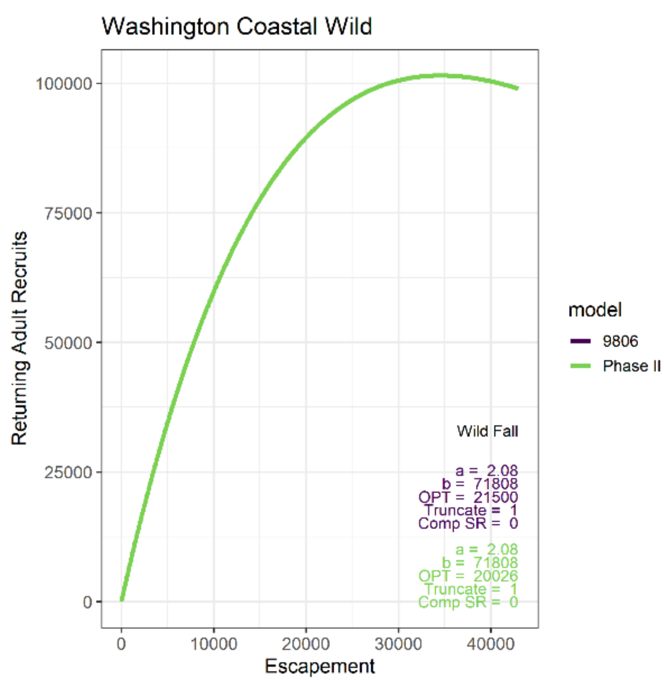

Figure 197—Ricker curve and parameters for Washington Coastal Natural (WCN) model stock.

4.35 Willamette River Spring (WSH): Willamette River Spring (WSH)

4.35.1 Stock Description

Willamette River Spring is a hatchery predominated basin which is represented by one of the highest number of coded-wire tag releases throughout the coastwide CWT system, including those releases back through the base period. Consequently, the in-base procedure was utilized in generating those MDLs representing the WSH model stock.

4.35.2 Description of Changes

Previous WSH MDL construction was based upon tagged releases which had little or no fishery recruitments. A thorough review of each tag release during the base period was engaged and only those CWT release groups which were recruited to both fisheries and escapement were included in the reconstruction of this round of MDL construction. CWT from the base period and onwards into the future are anticipated, with little or no interruptions of hatchery production anticipated nor observed through time. There are observations of brood year releases which did not contribute towards either fisheries or escapement recruitment, and these have been specifically removed from those analyses/data used to represent this group in maturation/AEQ calculation.

4.35.2.1 MDL File Settings

Table 86—Information used in the construction of the Willamette River Spring (WSH) MDL file.

Information for MDL File Production	Phase II Model Stock
Model Stock Acronym	WSH
Brood Years	1975–1978
Out-of-base procedure used?	No
C-file extension (CWT Indicator ID)	WSH
Modifications to fisheries in WG4 file	NA
Yearling Stock	Yes
Weight within BY by production releases	No
Exclude Esc for Between BY weighting	Yes
Start age in C-files	3
Last age in C-files	6
Modifications to escapements in Coshak4	No
Method used to modify escapement	NA
Terminal fishery CWT moved to escapement	No
Model stock type	Hatchery, Spring
Additional fisheries designated as terminal	None
9806 Model stock association	WSH
Other Information	
C-file creation date	19 Sept. 2015
Number of C-file and ERA fisheries	188 - 78

Information for MDL File Production	Phase II Model Stock
MDL creation date	18 Sept. 2016

4.35.2.2 Base Period Coded-Wire Tags and Recoveries

Table 87—Coded-wire tag codes for Willamette River Spring (WSH) model stock.

Brood Year	Tag Codes (WSH)	
	9806	Phase II
1975	090509	090509, 090503, 090507
1976	091701, 091703, 091621, 091622, 091623, 091624, 091625, 091626	091703, 091628, 091629, 091627, 091626, 091622, 091621
1977	071741, 071742	071928, 071926, 071927, 071921, 071920, 071919, 071743, 071737, 071732, 071731, 071730
1978	072042, 072053	072051, 072044, 072050, 072022, 072021, 071946, 071945, 071925

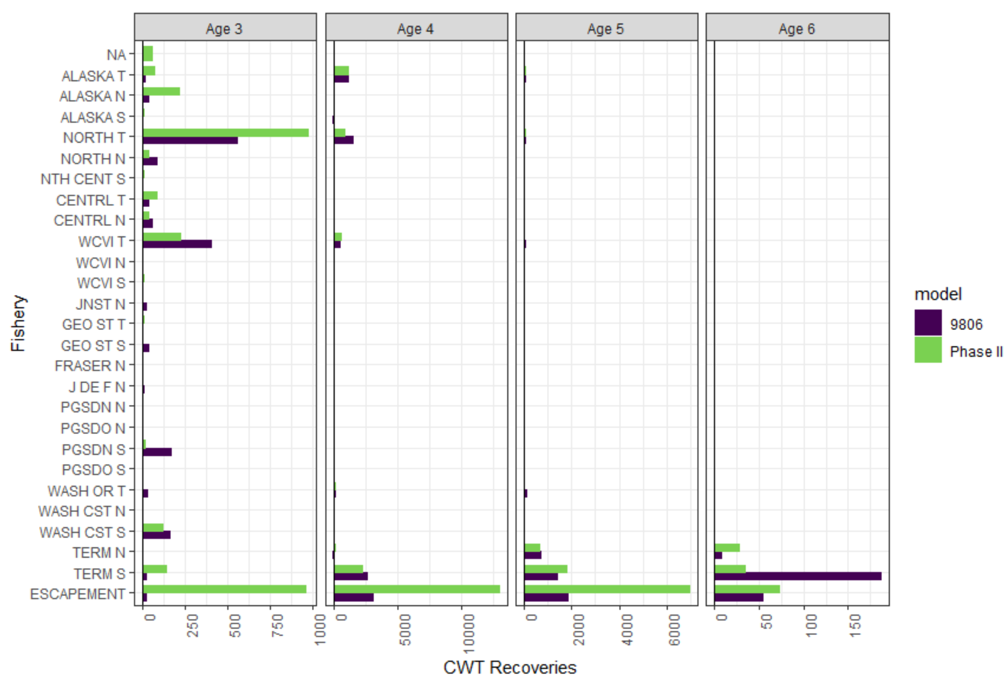

Figure 198—Base period coded-wire tag (CWT) recoveries for Willamette River Spring.

4.35.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

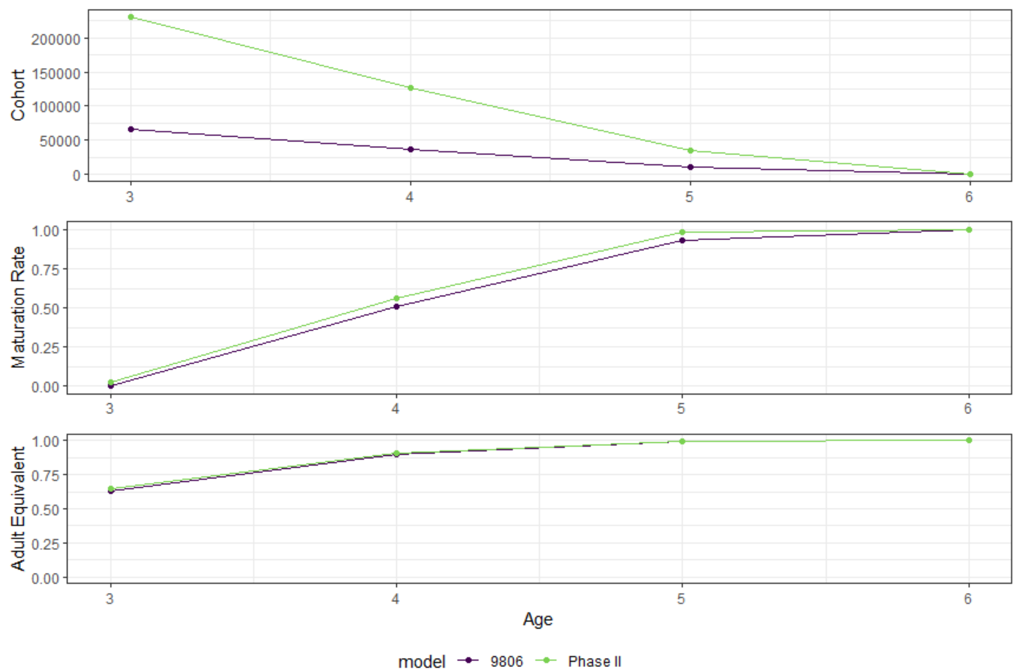

Figure 199—Base period cohort size, maturation schedule, and adult equivalent for Willamette River Spring.

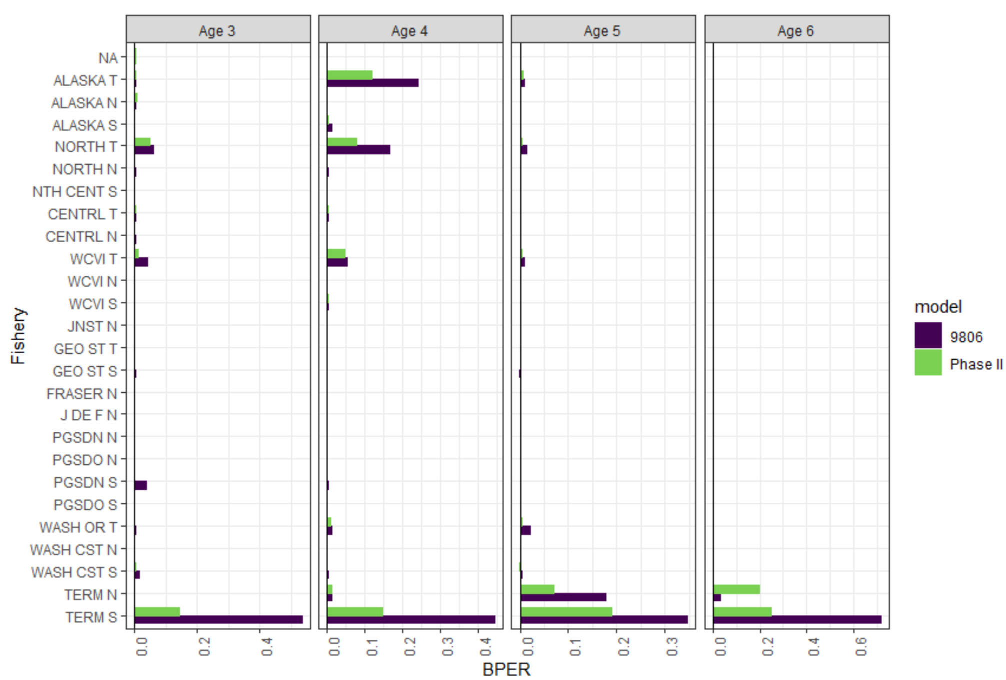

Figure 200—Base period exploitation rate by fishery for Willamette River Spring.

4.35.2.4 Escapement/Terminal Run Time Series

In the former model, the escapement time series recorded in the FCS file had originally included the escapement of Sandy River Spring Chinook. Base and pre-base estimates of productivity were taken from only a subset of hatcheries within the Willamette system. The new model's FCS does not include that escapement which is headed into the Sandy River, but only Willamette drainage escapement which is accounted for through the U.S. v Oregon Columbia River management framework through its Technical Advisory Committee (TAC). Those escapement numbers are reconstructed to the mouth of the Columbia River, and the forecast produced annually is taken from the same "currency". Both base and pre-base escapement estimates of productivity used for model input had included 3 year old fish, with estimates of terminal escapement. Ongoing analysis and re-reporting will be required to maintain consistency between those pre-base/base escapements, observations of escapement and forecasting in the .fcs file. In the new model input, only 4, 5, 6 year old fish are being reported, whereas in the previous model input, ages 3+4, 5 and 6 year old fish were being reported.

There had been an enormous disjoint between those productivity factors accounted for this stock and the observations of escapement. The result was annual environmental variable (EVs) (a model residual, referred to as Environmental Variables) commonly well above 30 to 40. Subsequent to the newer model input parameters (different base and pre-base escapements, different Ricker values, updated escapement time series), EV values are much more in-line with observations seen in other stocks (<10).

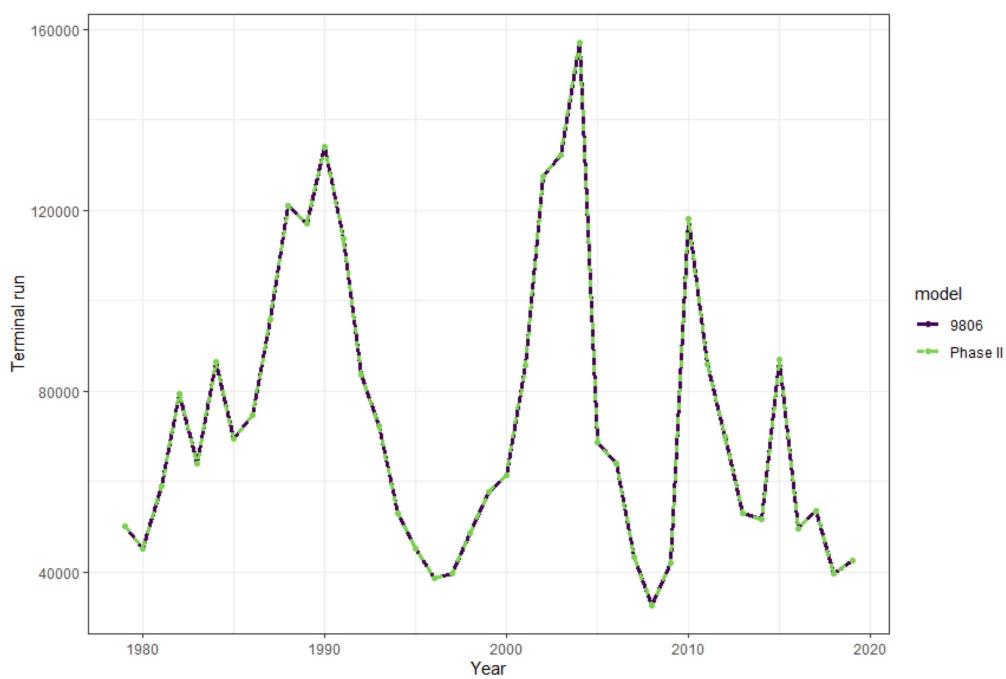

Figure 201—Terminal run size for Willamette River Spring.

4.35.2.5 Ricker Parameters

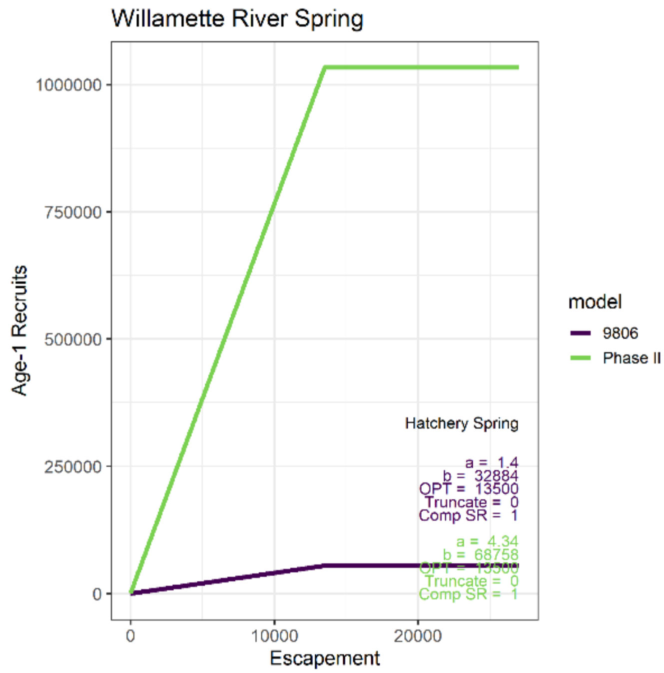

Figure 202—Ricker curve and parameters for Willamette River Spring (WSH) model stock.

4.36 Cowlitz Spring Hatchery (CWS): Cowlitz Spring Hatchery (CWS)

4.36.1 Stock Description

Hatchery spring Chinook returning to the Washington tributaries of the lower Columbia River are destined for the Cowlitz, Kalama, and Lewis rivers. Wild components of these groups are listed under the Endangered Species Act (ESA) and are genetically similar. Washington lower river spring Chinook migrate earlier than Upriver Columbia River stocks (e.g., Snake River spring Chinook) with the majority of the run passing through the lower Columbia River from mid-March to mid-May. This stock group has a southernly ocean distribution which contributes to both WCVI Troll and Pacific Fishery Management Council (PFMC) fisheries recruitments. There is a long time series of spring Chinook CWT releases from Cowlitz Hatchery, but currently there is not an indicator stock for this stock group.

4.36.2 Description of Changes

Tag codes originating from Cowlitz Salmon Hatchery from brood year 1977 were used to estimate base period parameters. There were no changes from the current to the new base period.

4.36.2.1 MDL File Settings

Table 88—Information used in the construction of the Cowlitz Spring Hatchery (CWS) MDL file.

Information for MDL File Production	Phase II Model Stock
Brood Years	1977
Out-of-base procedure used?	No
C-file extension (CWT Indicator ID)	CWS
Modifications to fisheries in WG4 file	NA
Yearling Stock	Yes
Weight within BY by production releases	No
Exclude Esc for Between BY weighting	No
Start age in C-files	3
Last age in C-files	6
Modifications to escapements in Coshak4	No
Terminal fishery CWT moved to escapement	No
Model stock type	Hatchery, Spring
Additional fisheries designated as terminal	None
9806 Model stock association	CWS
Other Information	
C-file creation date	-
Number of C-file and ERA fisheries	188 - 78
MDL creation date	-

4.36.2.2 Base Period Coded-Wire Tags and Recoveries

Table 89—Coded-wire tag codes for Cowlitz Spring Hatchery (CWS)model stock.

Brood Year	Tag Codes (CWS)	
	9806	Phase II
1977	631817, 631818	631817, 631818

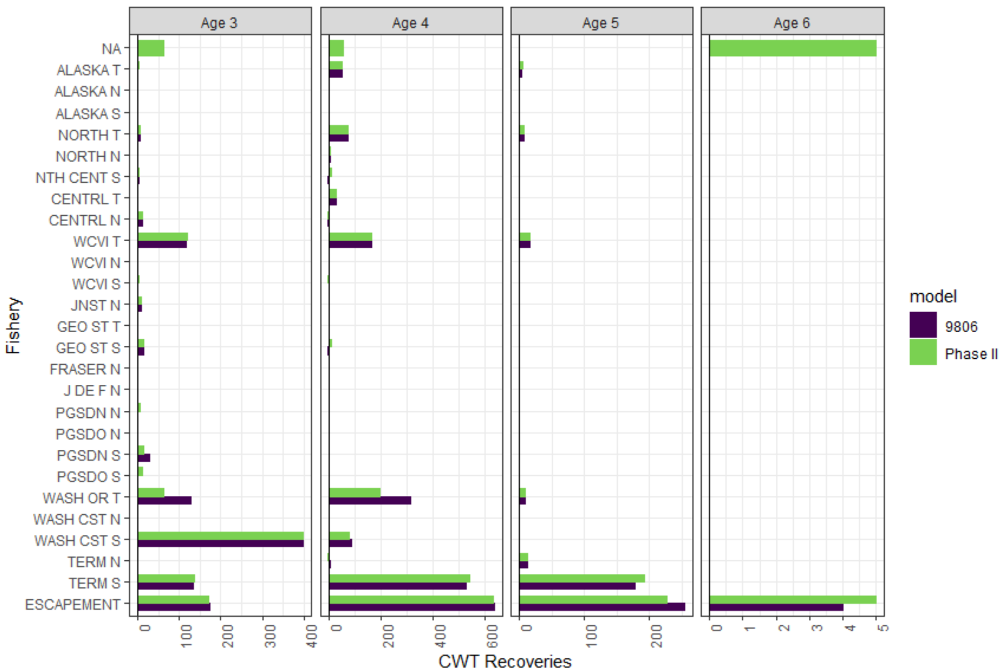

Figure 203—Base period coded-wire tag (CWT) recoveries for Cowlitz Spring Hatchery.

4.36.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

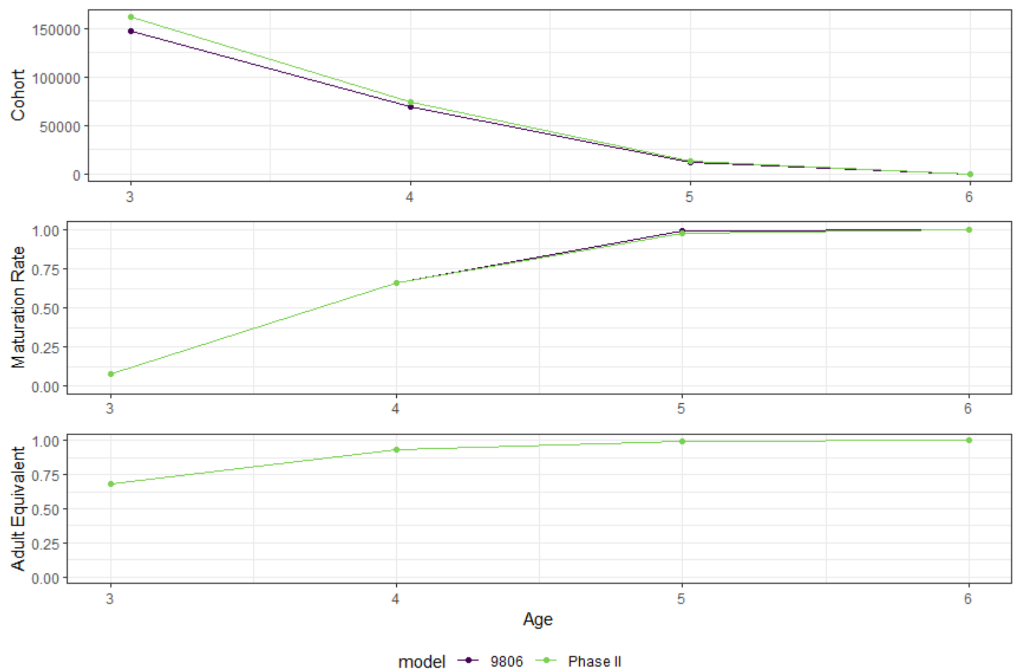

Figure 204—Base period cohort size, maturation schedule, and adult equivalent for Cowlitz Spring Hatchery.

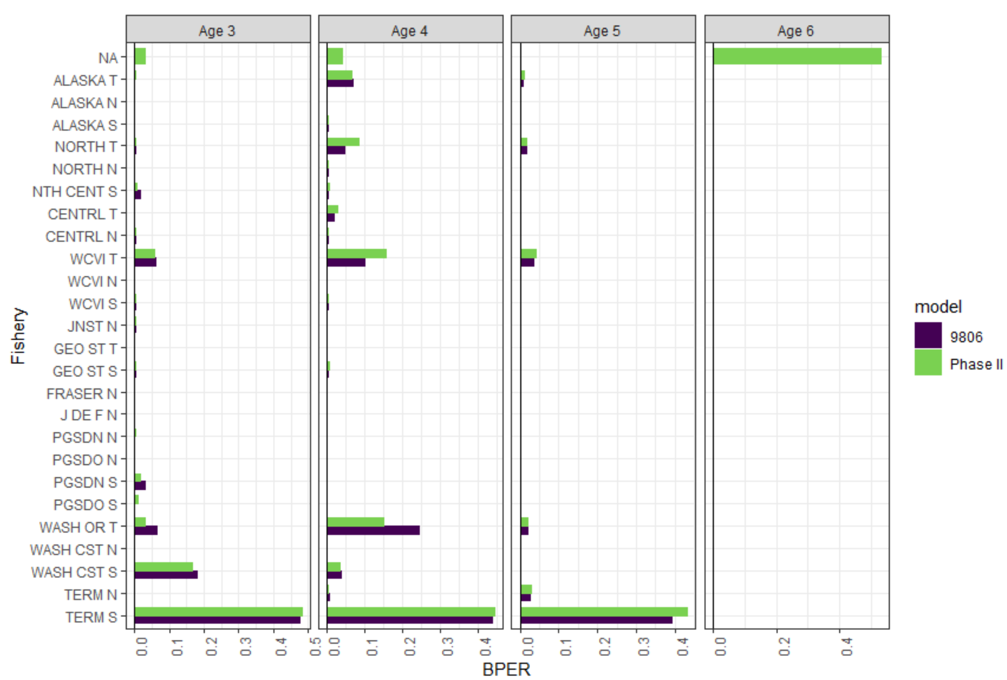

Figure 205—Base period exploitation rate by fishery for Cowlitz Spring Hatchery.

4.36.2.4 Escapement/Terminal Run Time Series

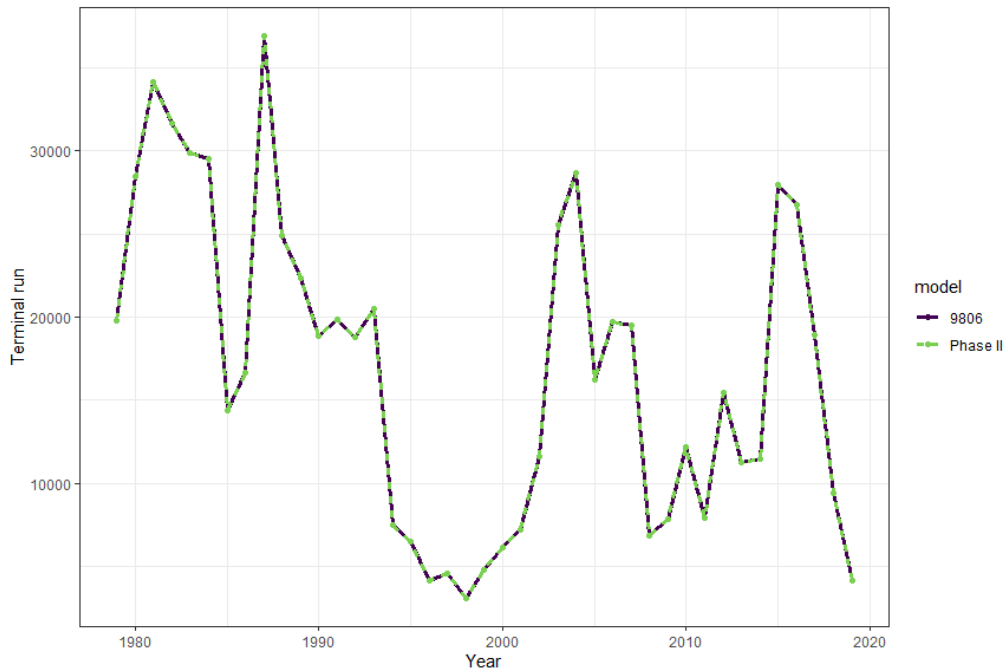

Figure 206—Terminal run size for Cowlitz Spring Hatchery.

4.36.2.5 Ricker Parameters

The base period calibration program was used to estimate new Ricker parameters resulting in different estimates of productivity and density dependence (Figure 207).

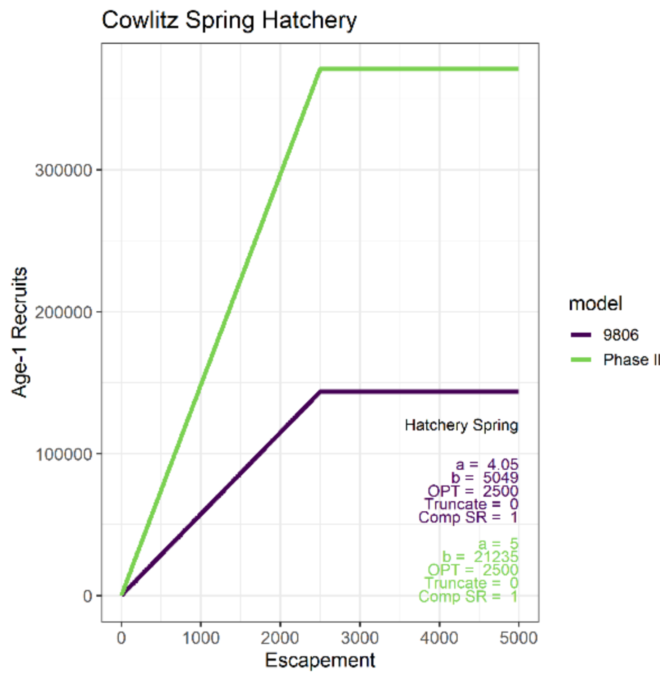

Figure 207—Ricker curve and parameters for Cowlitz Spring Hatchery (CWS) model stock.

4.37 Columbia River Summer (SUM): Columbia River Summer (SUM)

4.37.1 Stock Description

Upper Columbia River summer Chinook are destined for production areas and hatcheries upstream of Priest Rapids Dam. Historically, these fish occupied a broad range in the Upper Columbia, Wenatchee, Okanogan, and Similkameen rivers. The construction of the Grand Coulee Dam in 1939 without fish passage facilities eliminated access to 1,140 lineal miles of spawning habitat in the upper Columbia River. The building of Chief Joseph Dam further reduced access to mainstem spawning habitat. Since completion of the Columbia River hydropower system, summer Chinook redds are found in the Columbia, Wenatchee, Okanogan, Methow, Similkameen, Chelan, and Entiat rivers. The upper Columbia summer Chinook run size was at low levels throughout the 1980s and 1990s, with average returns of 19,243 and 15,090 fish, respectively. The average run size during the 2000s was 59,805 adults, which was approximately three times greater than the average run size of the 1980s and four times greater than the average run size of the 1990s. Supplementation programs and improved natural habitat have played a significant role in the increased abundance trends observed since 1999. Since 2002, the majority of the hatchery production has been CWT'ed and mass-marked with an adipose fin-clip. Natural-spawning populations also contribute significantly to the run and the stock is managed as a composite population.

The Columbia River summer Chinook run consists only of the upper Columbia component (Snake River summer Chinook are included in the upriver spring run). The Columbia River return is calculated as the sum of the Bonneville Dam count and the number of Chinook mortalities resulting from lower river fisheries during June 16 through July 31. The Upper Columbia summer population is currently considered healthy.

4.37.2 Description of Changes

While both sub-yearling and yearling hatchery releases have occurred annually, the 9806 model did not include yearling tag codes when determining base period parameters. Naturally spawning summer Chinook above Priest Rapids Dam are considered "ocean-type" fish that migrate as sub-yearlings. However, hatchery production of this stock is skewed toward yearling released fish due their higher juvenile survival rates and better adult returns. For this reason, a mix of sub-yearling and yearling tag codes from Wells Hatchery were used to determine base period parameters for this stock.

4.37.2.1 MDL File Settings

Table 90—Information used in the construction of the Columbia River Summer (SUM) MDL file.

Information for MDL File Production	Phase II Model Stock
Brood Years	1976, 1977, 1984–1986
Out-of-base procedure used?	Yes
C-file extension (CWT Indicator ID)	SUM
Modifications to fisheries in WG4 file	NA
Yearling Stock	No
Weight within BY by production releases	No
Exclude Esc for Between BY weighting	No
Start age in C-files	2
Last age in C-files	5
Modifications to escapements in Coshak4	No
Terminal fishery CWT moved to escapement	No
Model stock type	Wild, Fall
Additional fisheries designated as terminal	none
9806 Model stock association	SUM
Other Information	
C-file creation date	-
Number of C-file and ERA fisheries	188 - 78
MDL creation date	-

4.37.2.2 Base Period Coded-Wire Tags and Recoveries

A memo dated November 8, 2018 was sent from Tommy Garrison to the CTC-Analytical Working Group (AWG) documenting the selection of tag codes to use in the base period calibration program. Generally, five criteria were used to determine the set of tag codes: (1) out of base brood years as close to the base period as possible and before there were large changes to AABM troll fishery structures (i.e. brood years with recoveries prior to 1996), (2) out of base tag codes from multiple brood years to capture "average" fishery patterns, (3) tag codes with recoveries in all major fisheries where you would expect to observe recoveries, (4) tag codes with adequate escapement recoveries and in all age classes and (5) combinations of tag codes that yielded approximately equal fishery recoveries of sub-yearling and yearling tag groups.

Note that because a mix of sub-yearling and yearling tag codes were used, the brood year specified in the C-files for yearling tag codes was incremented one year. This was done so that the scalars in the WG4 file were assigned to the right brood. As an example, a sub-yearling release in brood year x would result in recoveries of CWTs in calendar years x+2, x+3, x+4 and x+5. The recoveries in these calendar years would contribute to the brood year x specific scalars in the WG4 file. A yearling released from brood year x-1 would have recoveries in calendar years x+2, x+3, x+4 and x+5. Thus, the appropriate WG4 scalar for a yearling from brood year x-

1 would be the scalar that utilizes recoveries from years x+2, x+3, x+4 and x+5 (i.e. the brood year x scalar).

Table 91—Coded-wire tag codes for Columbia River Summer (SUM) model stock.

Brood Year	Tag Codes (SUM)	
	9806	Phase II
1975	130910	
1976	631607, 631642	631607 (sub-yearling), 631642 (sub-yearling)
1977	631762	631762 (sub-yearling), 631749 (sub-yearling)
1984		633224 (yearling)
1985		B10310 (yearling)
1986		634402 (yearling)

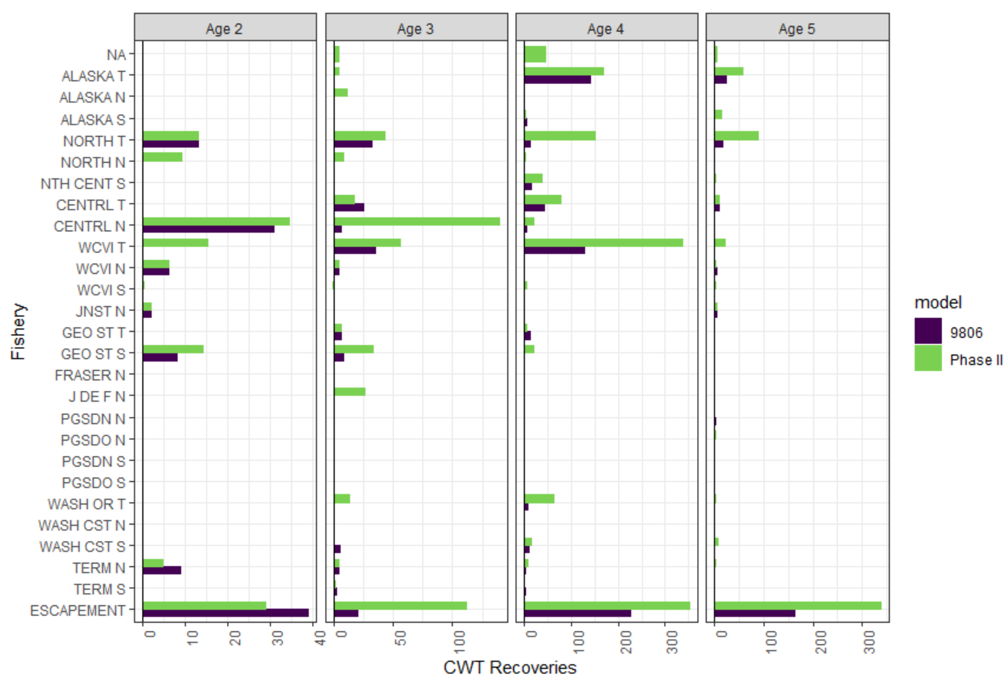

Figure 208—Base period coded-wire tag (CWT) recoveries for Columbia River Summer.

4.37.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

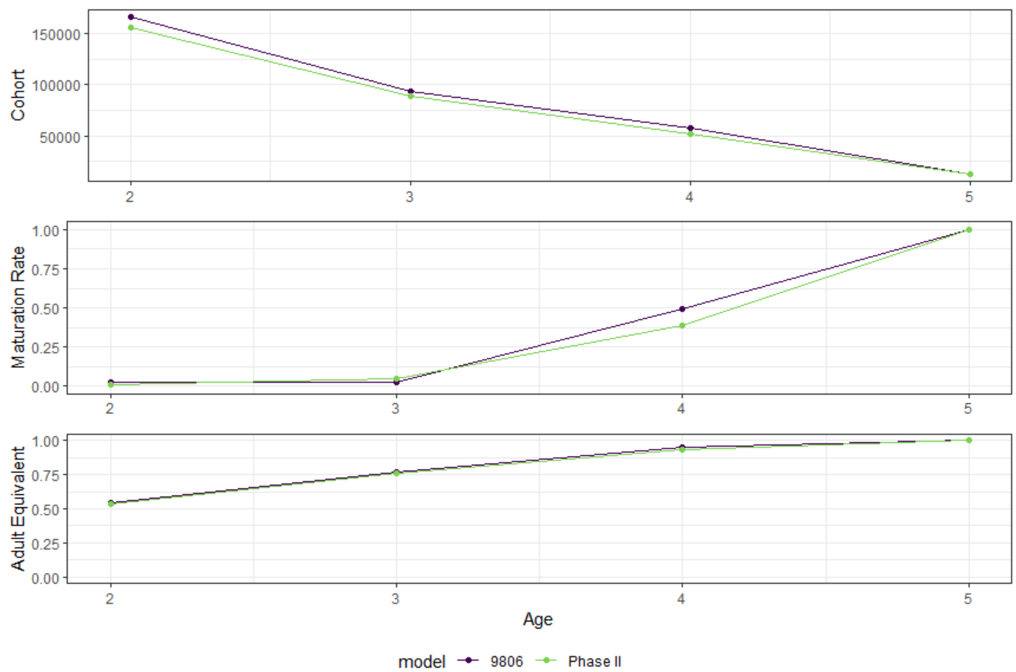

Figure 209—Base period cohort size, maturation schedule, and adult equivalent for Columbia River Summer.

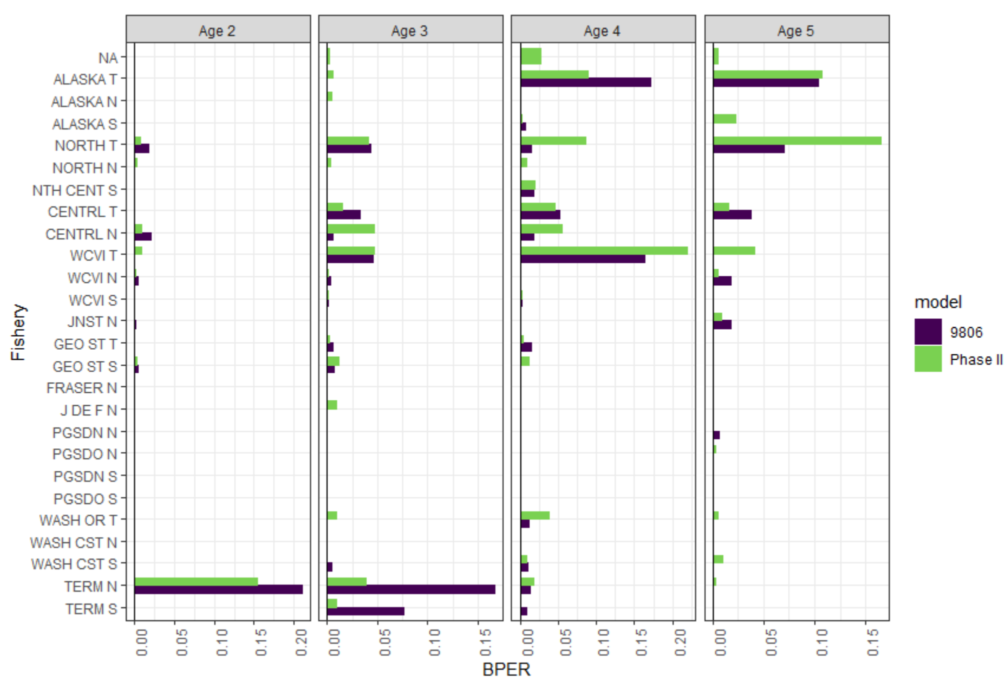

Figure 210—Base period exploitation rate by fishery for Columbia River Summer.

4.37.2.4 Escapement/Terminal Run Time Series

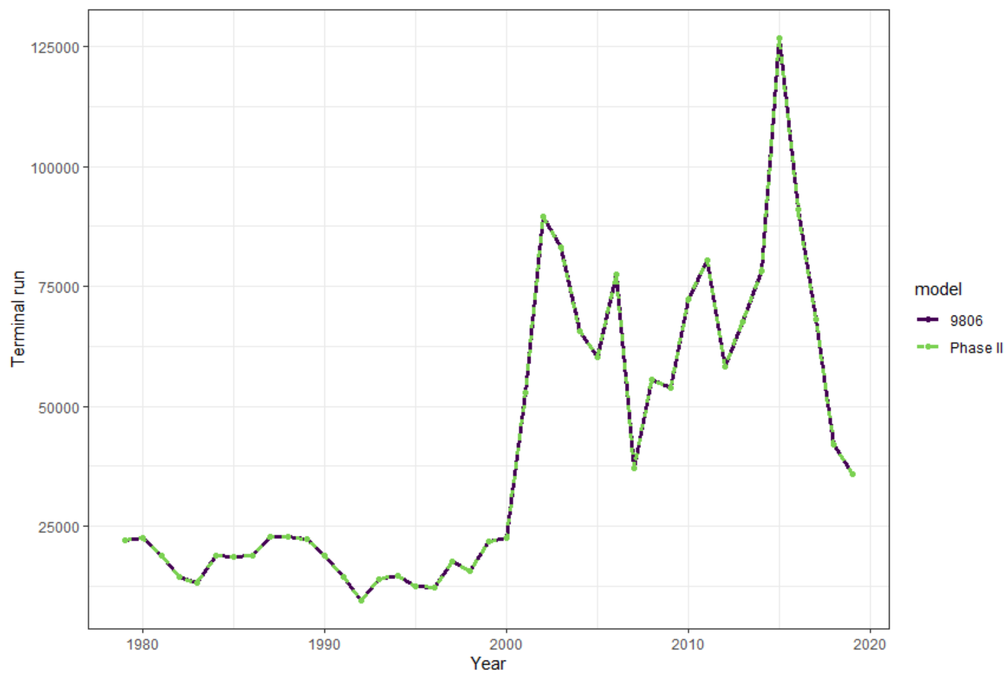

Figure 211—Terminal run size for Columbia River Summer.

4.37.2.5 Ricker Parameters

Ricker parameters were updated from external estimates (CTC 1999). The truncate flag in the BSE file was specified to cap recruitment at the level corresponding to the optimum number of spawners (Figure 212).

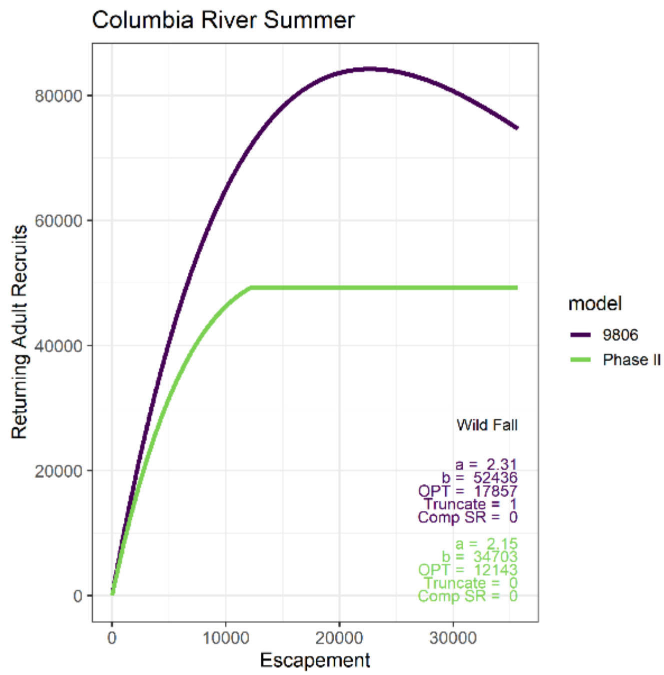

Figure 212—Ricker curve and parameters for Columbia River Summer (SUM) model stock.

4.38 Upriver Brights (URB): Upriver Brights (URB)

4.38.1 Stock Description

Upriver Brights return to the Columbia River from late July through October with abundance peaking in the lower river from mid-August to mid-September, and passage at Bonneville Dam peaking in early to mid-September. Most URBs are destined for the Hanford Reach area of the Columbia River, Priest Rapids Hatchery, areas upstream of Priest Rapids Dam, and the Snake River. Smaller components are destined for the Deschutes and Yakima rivers. Snake River natural-origin (SRW) fall Chinook are a sub-component of this stock. Upriver Brights are far north migrating and often make up a large percentage of the catch in AABM fisheries. Priest Rapids Hatchery is used as the indicator stock for URBs, but a wild tagging program also exists in the Hanford Reach.

4.38.2 Description of Changes

Tag codes from brood years 1975 to 1977 were used to estimate base period parameters. The three tag codes from the 1975 brood year were not used previously.

4.38.2.1 MDL File Settings

Table 92—Information used in the construction of the Upriver Brights (URB) MDL file.

Information for MDL File Production	Phase II Model Stock
Model Stock Acronym	URB
Brood Years	1975–1977
Out-of-base procedure used?	No
C-file extension (CWT Indicator ID)	URB
Modifications to fisheries in WG4 file	NA
Yearling Stock	No
Weight within BY by production releases	No
Exclude Esc for Between BY weighting	No
Start age in C-files	2
Last age in C-files	5
Modifications to escapements in Coshak4	No
Terminal fishery CWT moved to escapement	No
Model stock type	Wild, Fall
Additional fisheries designated as terminal	None
9806 Model stock association	URB
Other Information	
C-file creation date	-
Number of C-file and ERA fisheries	188 - 78
MDL creation date	-

4.38.2.2 Base Period Coded-Wire Tags and Recoveries

Table 93—Coded-wire tag codes for Upriver Brights (URB) model stock.

Brood Year	Tag Codes (URB)	
	9806	Phase II
1975		130713, 131101, 131202
1976	631662	631662
1977	631741, 631745	631741, 631745

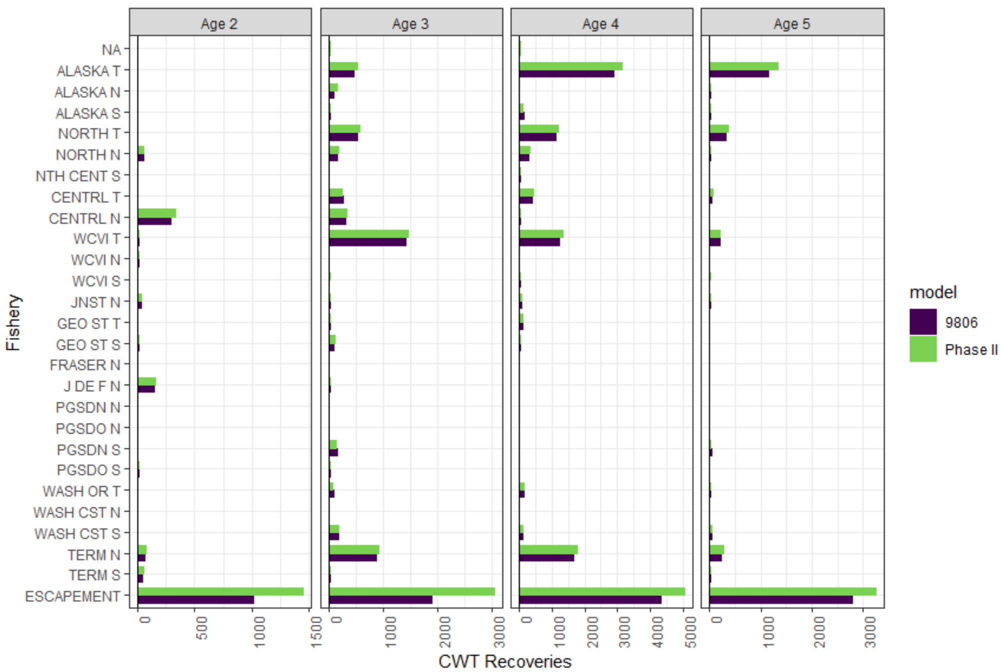

Figure 213—Base period coded-wire tag (CWT) recoveries for Upriver Brights.

4.38.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

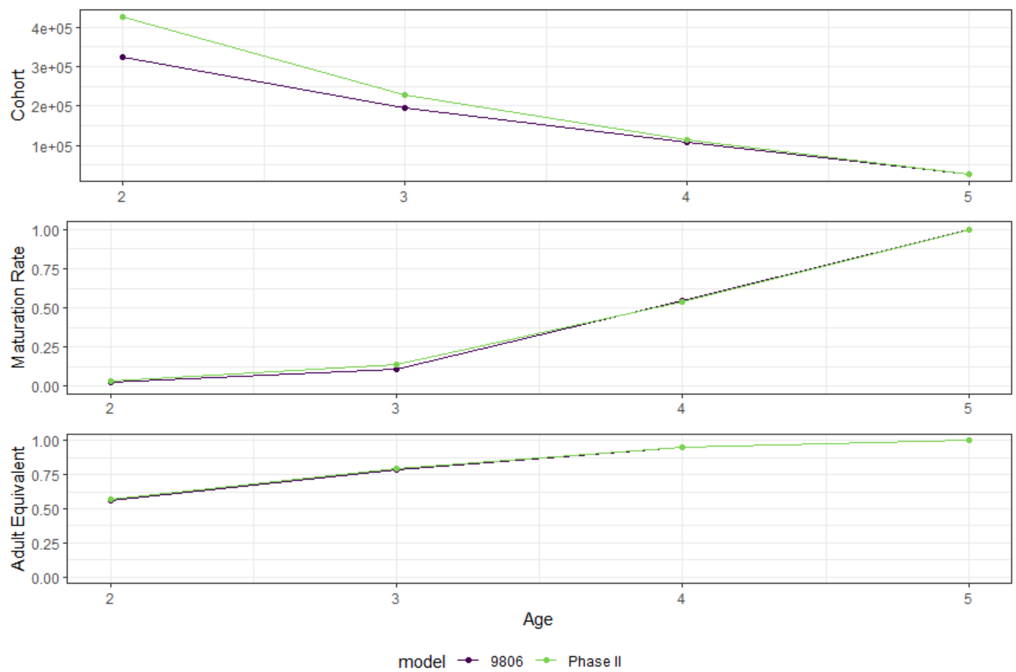

Figure 214—Base period cohort size, maturation schedule, and adult equivalent for Upriver Brights.

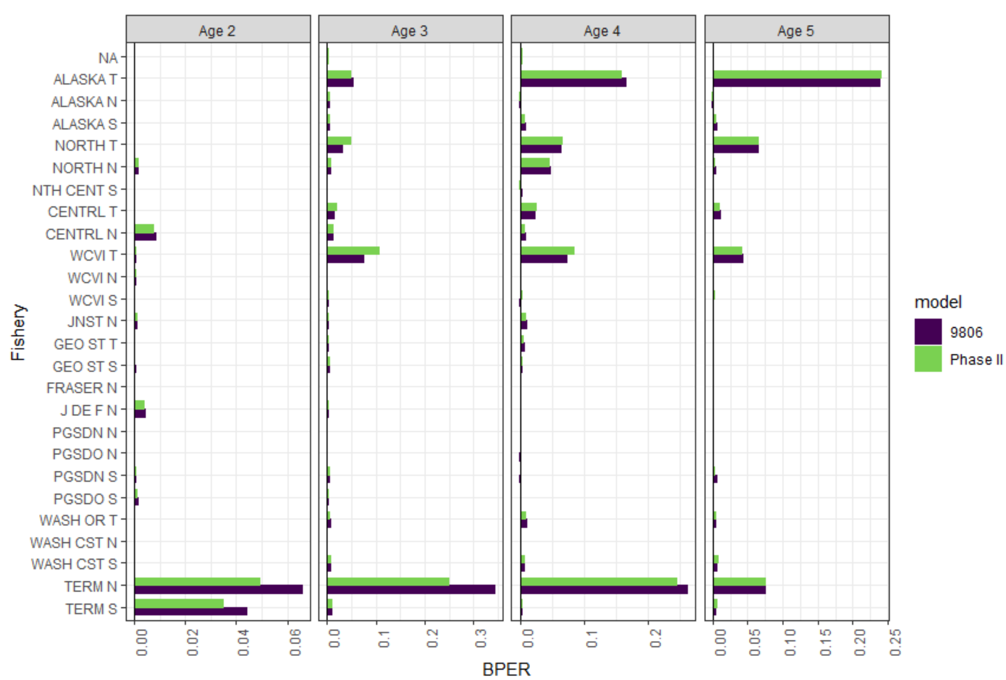

Figure 215—Base period exploitation rate by fishery for Upriver Brights.

4.38.2.4 Escapement/Terminal Run Time Series

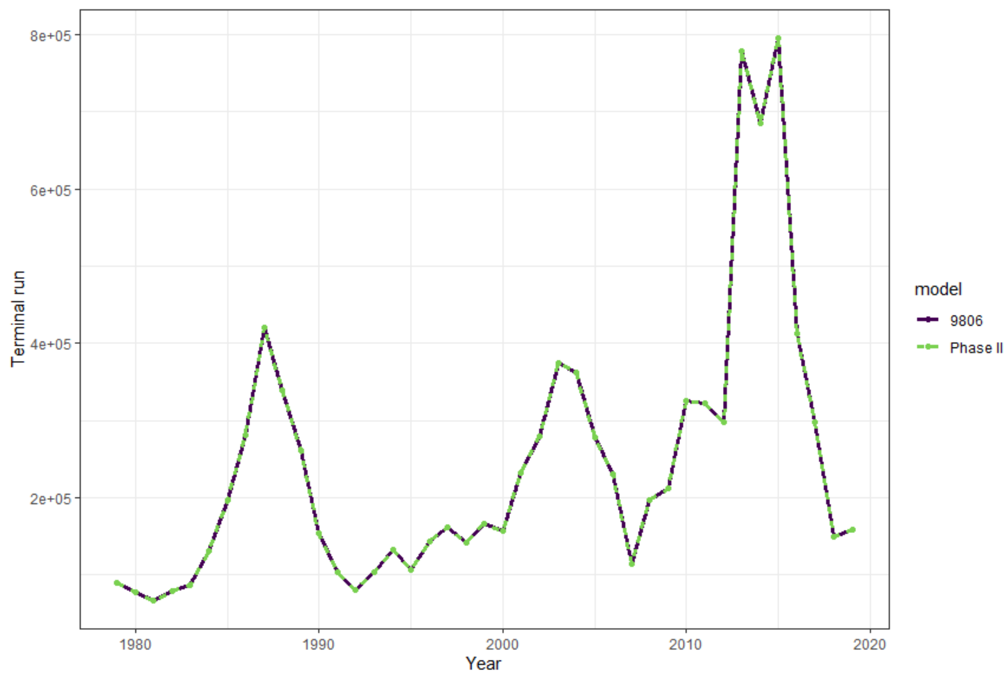

Figure 216—Terminal run size for Upriver Brights.

4.38.2.5 Ricker Parameters

Ricker parameters were updated from external estimates (Langness and Reidinger, 2003). The truncate flag in the BSE file was specified to cap recruitment at the level corresponding to the optimum number of spawners (Figure 217).

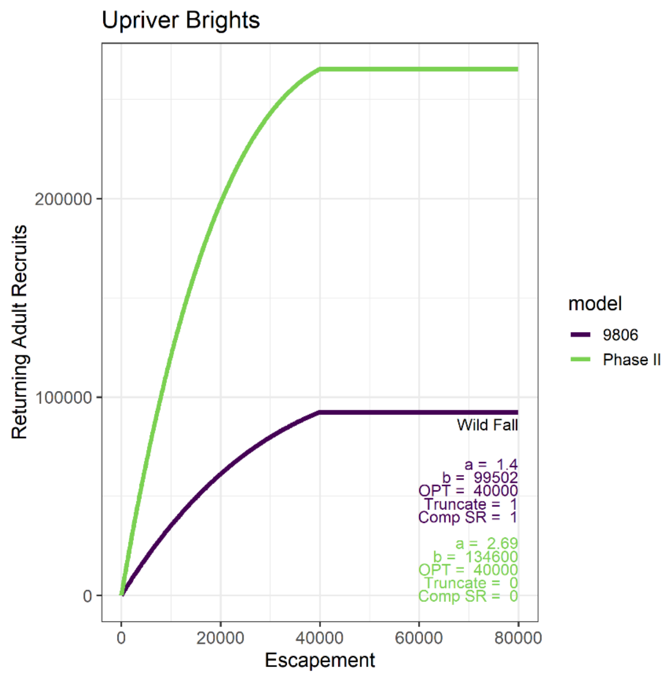

Figure 217—Ricker curve and parameters for Upriver Brights (URB) model stock.

4.39 Spring Creek Hatchery (SPR): Spring Creek Hatchery (SPR)

4.39.1 Stock Description

The Spring Creek Hatchery stock (also known as Bonneville Pool Hatchery in Columbia River Management forums) is a fall hatchery tule stock located a few miles upstream of Bonneville Dam. The stock is produced primarily at the Spring Creek Hatchery in Bonneville Pool, although very small natural production of tules also occurs in the Wind, White Salmon, Hood, and Klickitat rivers. Hatchery production of Spring Creek Chinook has been reduced in recent years and offset by increased tule releases in Oregon facilities downstream of Bonneville Dam. Spring Creek passage at Bonneville Dam occurs over a shorter timeframe than for Upriver Bright Chinook. The stock has a southernly ocean distribution and often makes up a large percentage of the catch the WCVI AABM fishery.

4.39.2 Description of Changes

Tag codes in brood years 1976 to 1979 were used to estimate base period parameters. One tag code from the 1977 brood (055501) and one from the 1979 brood (050642) were used to estimate current, but not new, base period parameters.

4.39.2.1 MDL File Settings

Table 94—Information used in the construction of the Spring Creek Hatchery (SPR) MDL file.

Information for MDL File Production	Phase II Model Stock
Model Stock Acronym	URB
Brood Years	1976–1979
Out-of-base procedure used?	No
C-file extension (CWT Indicator ID)	SPR
Modifications to fisheries in WG4 file	NA
Yearling Stock	No
Weight within BY by production releases	No
Exclude Esc for Between BY weighting	No
Start age in C-files	2
Last age in C-files	5
Modifications to escapements in Coshak4	No
Terminal fishery CWT moved to escapement	No
Model stock type	Hatchery, Fall
Additional fisheries designated as terminal	None
9806 Model stock association	URB
Other Information	
C-file creation date	-
Number of C-file and ERA fisheries	188 - 78
MDL creation date	-

4.39.2.2 Base Period Coded-Wire Tags and Recoveries

Table 95—Coded-wire tag codes for Spring Creek Hatchery (SPR) model stock.

Brood Year	Tag Codes (SPR)	
	9806	**Phase II**
1976	054101, 054201, 054401, 054501, 054601	054101, 054201, 054401, 054501, 054601
1977	055501, 055601, 055701, 056001, 056201	055601, 055701, 056001, 056201
1978	050433, 050434, 050444, 050446	050433, 050434, 050444, 050446
1979	050639, 050640, 050641, 050642	050639, 050640, 050641

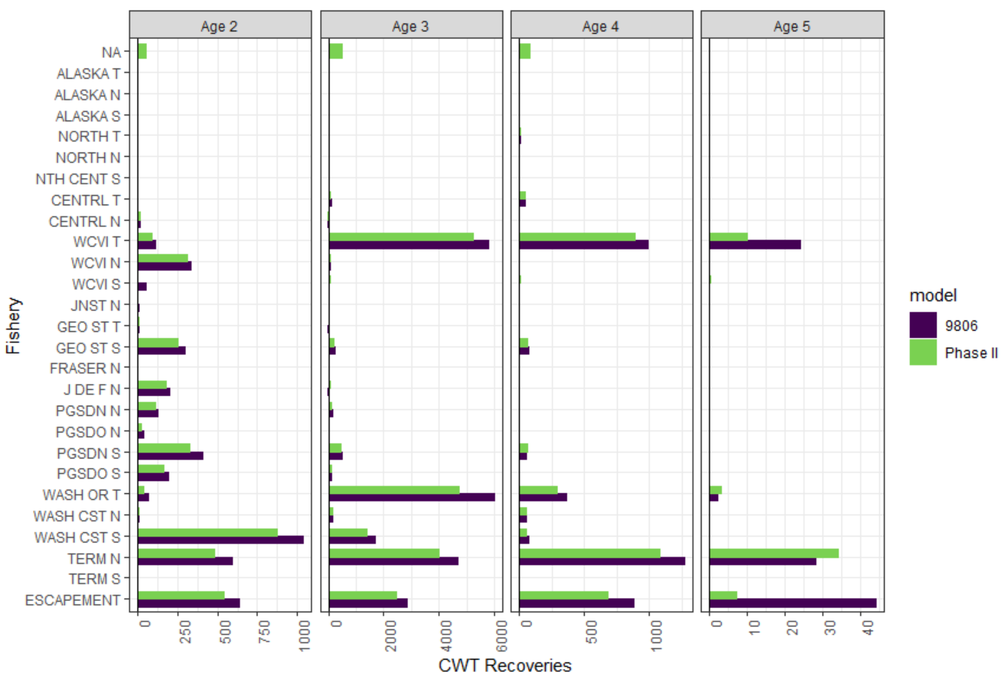

Figure 218—Base period coded-wire tag (CWT) recoveries for Spring Creek Hatchery.

4.39.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

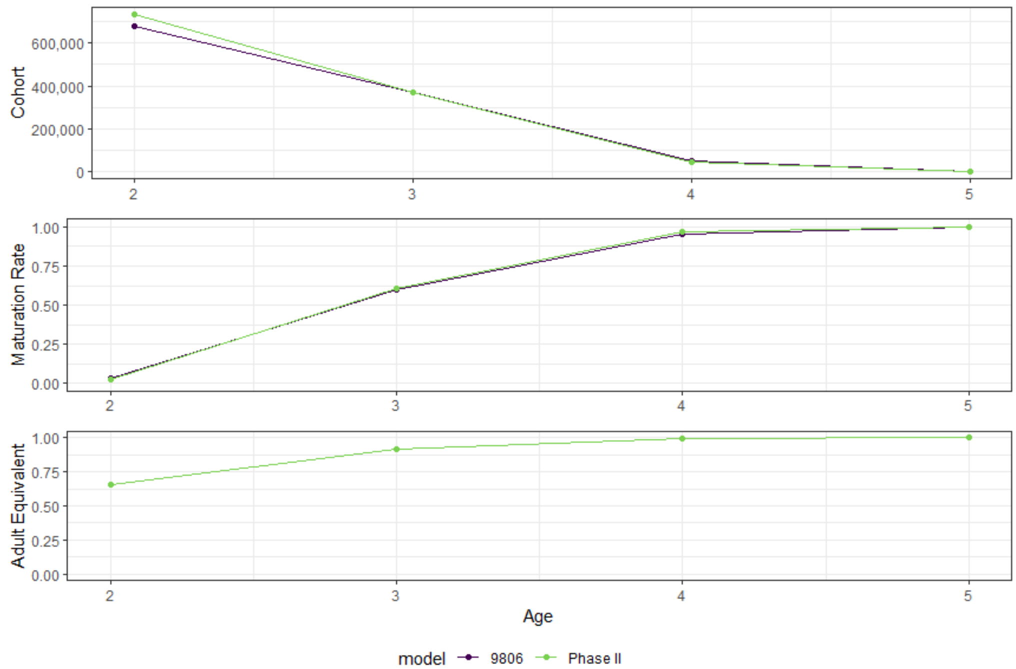

Figure 219—Base period cohort size, maturation schedule, and adult equivalent for Spring Creek Hatchery.

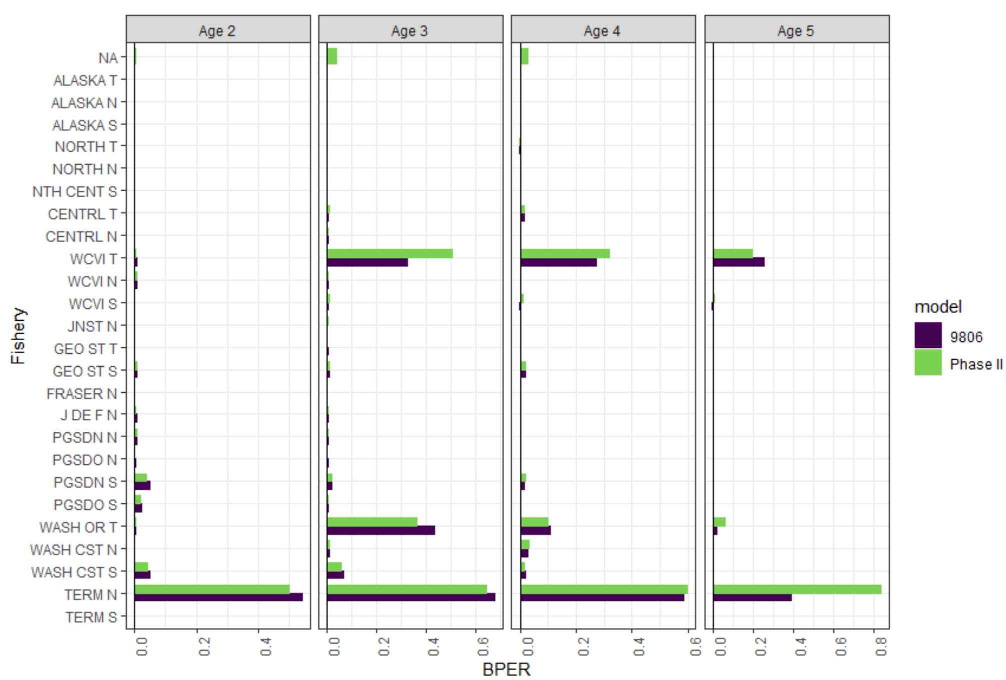

Figure 220—Base period exploitation rate by fishery for Spring Creek Hatchery.

4.39.2.4 Escapement/Terminal Run Time Series

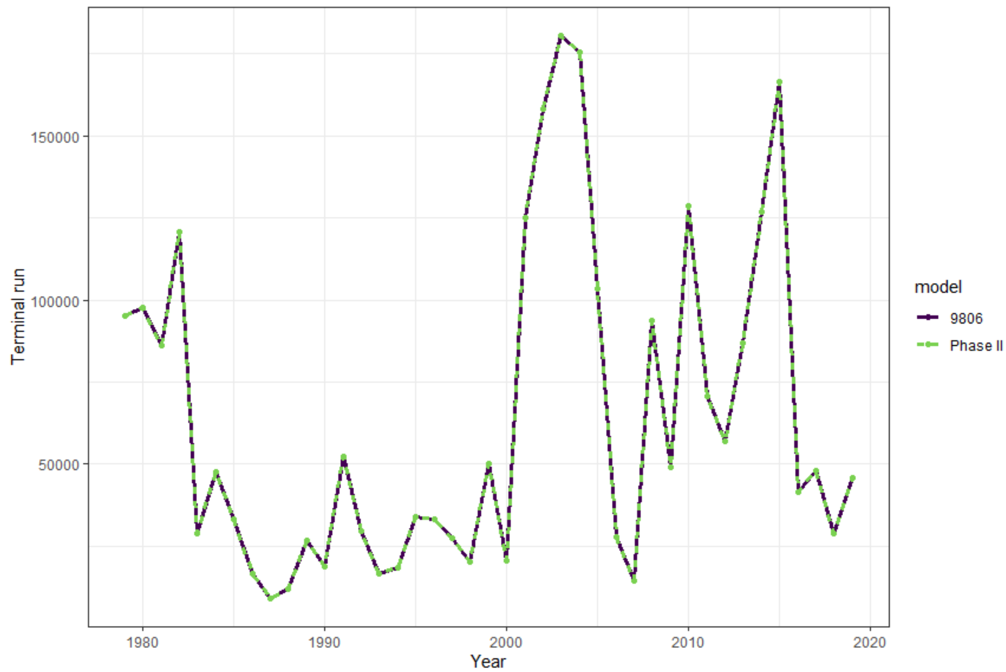

Figure 221—Terminal run size for Spring Creek Hatchery.

4.39.2.5 Ricker Parameters

The base period calibration program was used to estimate new Ricker parameters resulting in different estimates of productivity and density dependence (Figure 222).

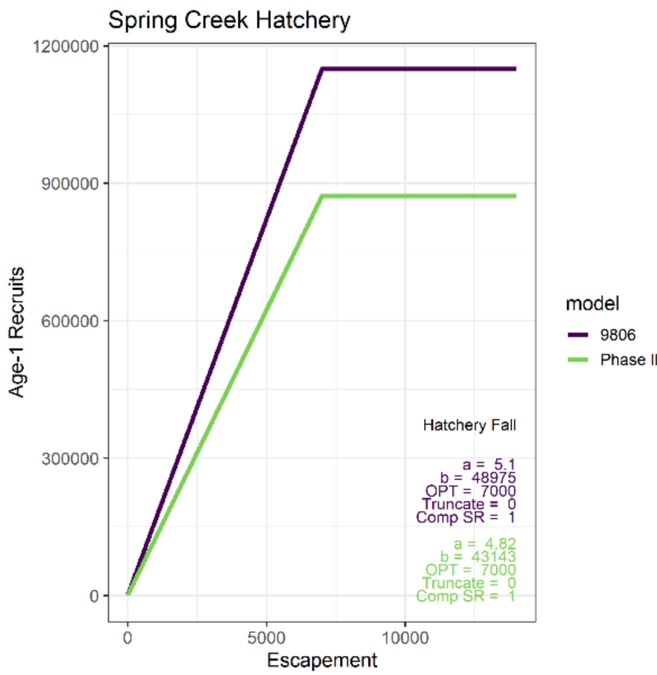

Figure 222—Ricker curve and parameters for Spring Creek Hatchery (SPR) model stock.

4.40 Lower Bonneville Hatchery (BON): Lower Bonneville Hatchery (BON)

4.40.1 Stock Description

Lower Bonneville Hatchery is a fall tule stock originating below Bonneville Dam and in Oregon. These fish are generally more mature (distinguished by their darker color) when entering the main stem and are quick to reach the tributaries to spawn. Columbia River management forums do not distinguish between Oregon and Washington tule production below Bonneville Dam and collectively refer to the stock as the Lower River Hatchery. Production of this stock occurs at Lower Bonneville Hatchery, Big Creek Hatchery and North Fork Klaskanine Hatchery. There are very small amounts of natural production in some tributaries below Bonneville Dam. Coded-wire tags from Big Creek Hatchery are used as the indicator for this stock group. The Lower Bonneville Hatchery stock group generally has a southernly ocean distribution, contributing primarily to catches in WCVI fisheries.

4.40.2 Description of Changes

Tag codes from brood years 1978 to 1979 were used to estimate base period parameters. Tag codes 071841 from the 1978 brood and 071841 from the 1979 brood were not used previously.

4.40.2.1 MDL File Settings

Table 96—Information used in the construction of the Lower Bonneville Hatchery (BON) MDL file.

Information for MDL File Production	**Phase II Model Stock**
Model Stock Acronym	BON
Brood Years	1978–1979
Out-of-base procedure used?	No
C-file extension (CWT Indicator ID)	LRH
Modifications to fisheries in WG4 file	NA
Yearling Stock	No
Weight within BY by production releases	No
Exclude Esc for Between BY weighting	No
Start age in C-files	2
Last age in C-files	5
Modifications to escapements in Coshak4	No
Terminal fishery CWT moved to escapement	No
Model stock type	Hatchery, Fall
Additional fisheries designated as terminal	None
9806 Model stock association	BON
Other Information	
C-file creation date	-
Number of C-file and ERA fisheries	188 - 78
MDL creation date	-

4.40.2.2 Base Period Coded-Wire Tags and Recoveries

Table 97—Coded-wire tag codes for Lower Bonneville Hatchery (BON) model stock.

Brood Year	**Tag Codes (LRH)**	
	Current	**New**
1978	071842	071841, 071842
1979	072157, 072163	072157, 072163, 072055

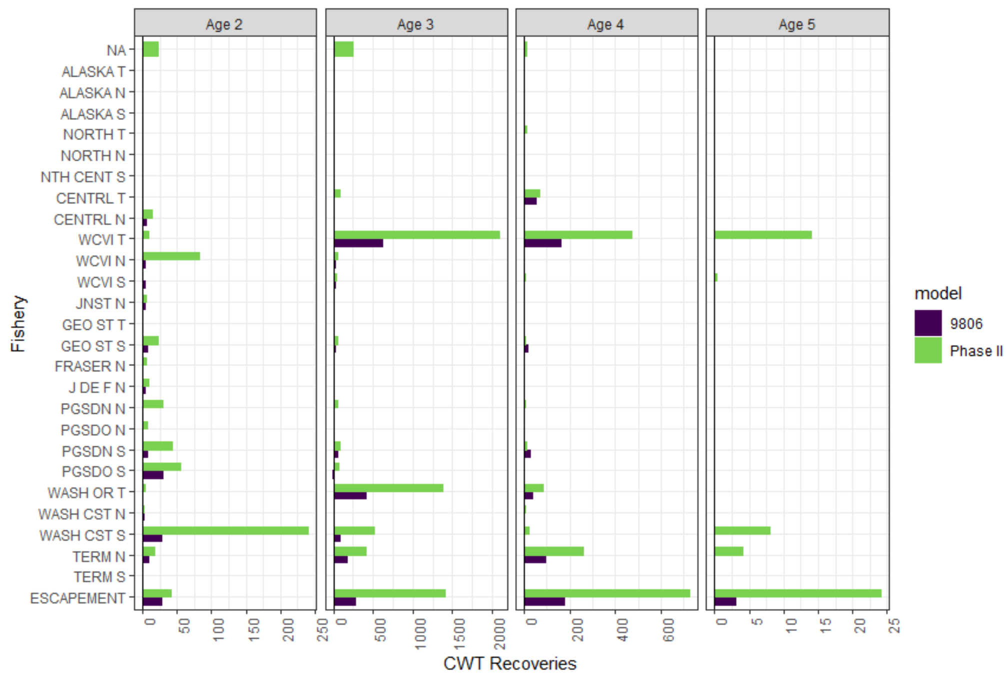

Figure 223—Base period coded-wire tag (CWT) recoveries for Lower Bonneville Hatchery.

4.40.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

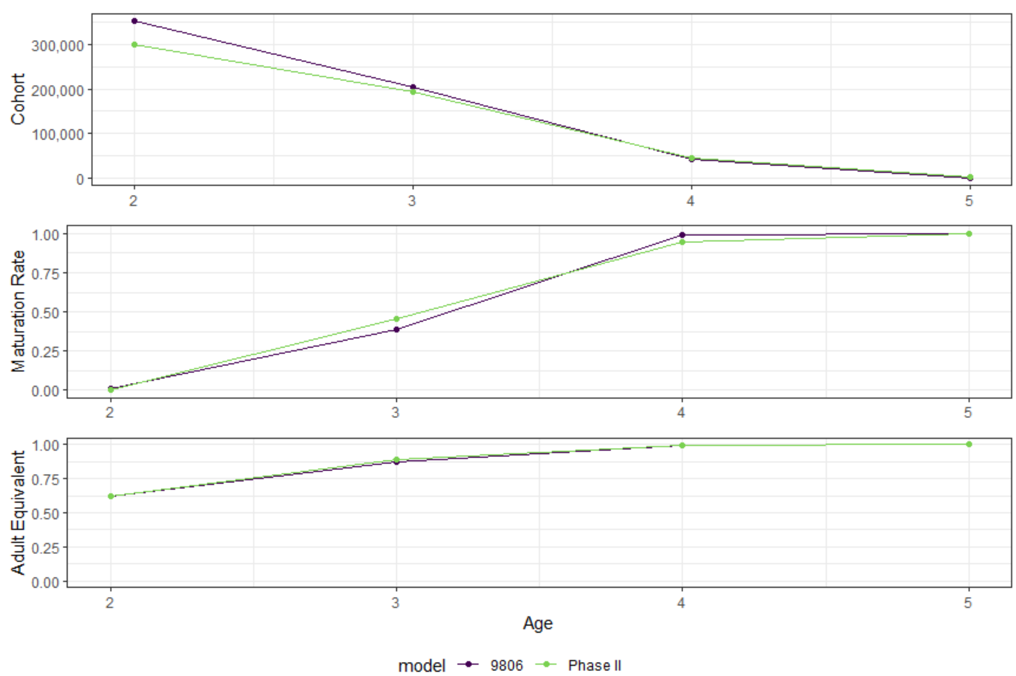

Figure 224—Base period cohort size, maturation schedule, and adult equivalent for Lower Bonneville Hatchery.

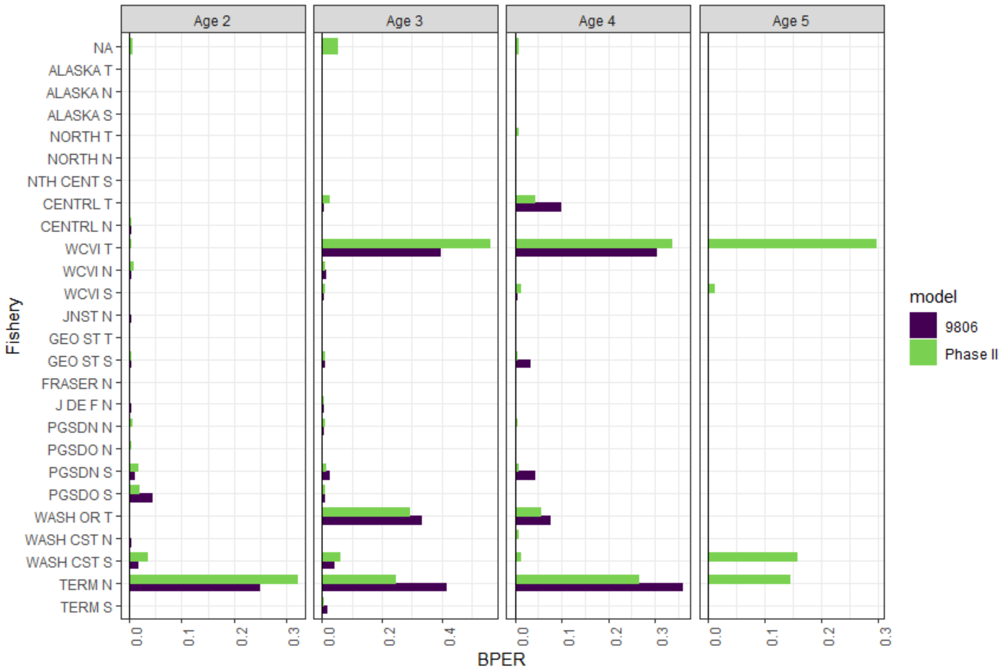

Figure 225—Base period exploitation rate by fishery for Lower Bonneville Hatchery.

4.40.2.4 Escapement/Terminal Run Time Series

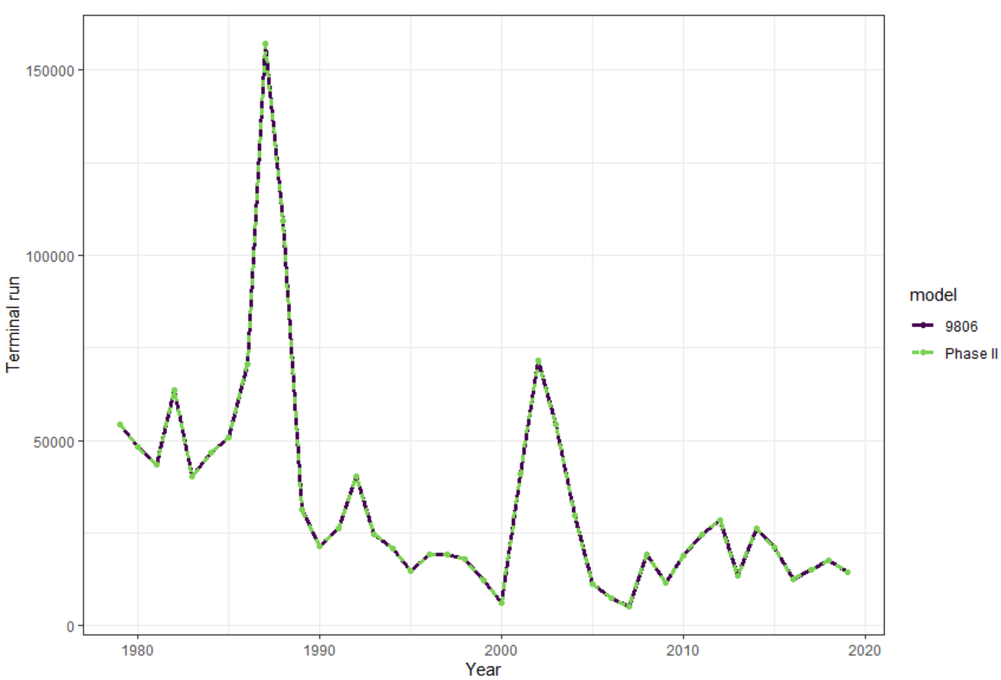

Figure 226—Escapement or terminal run size for Lower Bonneville Hatchery.

4.40.2.5 Ricker Parameters

The base period calibration program was used to estimate new Ricker parameters resulting in different estimates of productivity and density dependence (Figure 227).

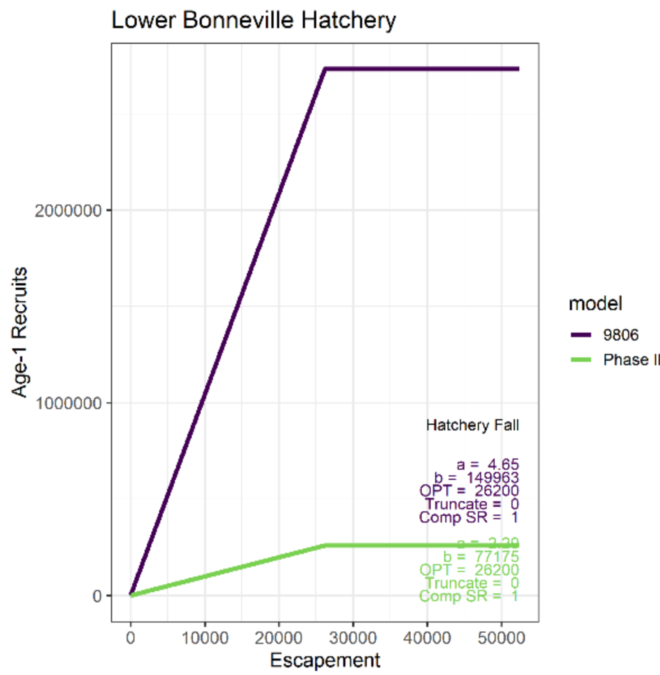

Figure 227—Ricker curve and parameters for Lower Bonneville Hatchery (BON) model stock.

4.41 Cowlitz Fall Hatchery (CWF): Cowlitz Fall Hatchery (CWF)

4.41.1 Stock Description

Cowlitz Fall Hatchery is a fall tule stock originating below Bonneville Dam and in Washington. These fish are generally more mature (distinguished by their darker color) when entering the mainstem and are quick to reach the tributaries to spawn. Columbia River management forums do not distinguish between Oregon and Washington tule production below Bonneville Dam and collectively refer to the stock as the Lower River Hatchery. Production of this stock occurs at Cowlitz Salmon Hatchery, Kalama Falls Hatchery, North Toutle Hatchery and Lewis River Salmon Hatchery. There are very small amounts of natural production in some tributaries below Bonneville Dam. Coded-wire tags from Cowlitz Salmon Hatchery are used as the indicator for this stock group. The Cowlitz Fall Hatchery stock group generally has a slightly more northernly ocean distribution in comparison to the Lower Bonneville Hatchery stock group.

4.41.2 Description of Changes

Tag codes from brood year 1977 to 1979 were used to estimate base period parameters. There were no changes from the current to the new base period.

4.41.2.1 MDL File Settings

Table 98—Information used in the construction of the Cowlitz Fall Hatchery (CWF) MDL file.

Information for MDL File Production	Phase II Model Stock
Model Stock Acronym	CWF
Brood Years	1977–1979
Out-of-base procedure used?	No
C-file extension (CWT Indicator ID)	CWF
Modifications to fisheries in WG4 file	NA
Yearling Stock	No
Weight within BY by production releases	No
Exclude Esc for Between BY weighting	No
Start age in C-files	2
Last age in C-files	5
Modifications to escapements in Coshak4	No
Terminal fishery CWT moved to escapement	No
Model stock type	Hatchery, Fall
Additional fisheries designated as terminal	None
9806 Model stock association	CWF
Other Information	
C-file creation date	-
Number of C-file and ERA fisheries	188 - 78
MDL creation date	-

4.41.2.2 Base Period Coded-Wire Tags and Recoveries

Table 99—Coded-wire tag codes for Cowlitz Fall Hatchery (CWF)model stock.

Brood Year	Tag Codes (CWF)	
	9806	Phase II
1977	631802	631802
1978	631942	631942
1979	632154	632154

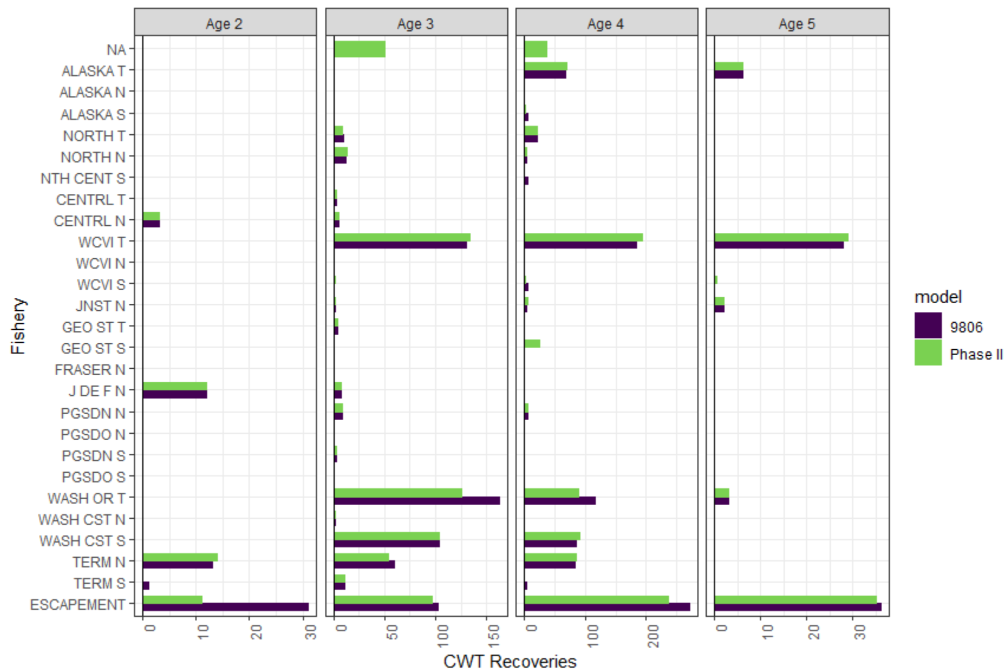

Figure 228—Base period coded-wire tag (CWT) recoveries for Fall Cowlitz Hatchery.

4.41.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

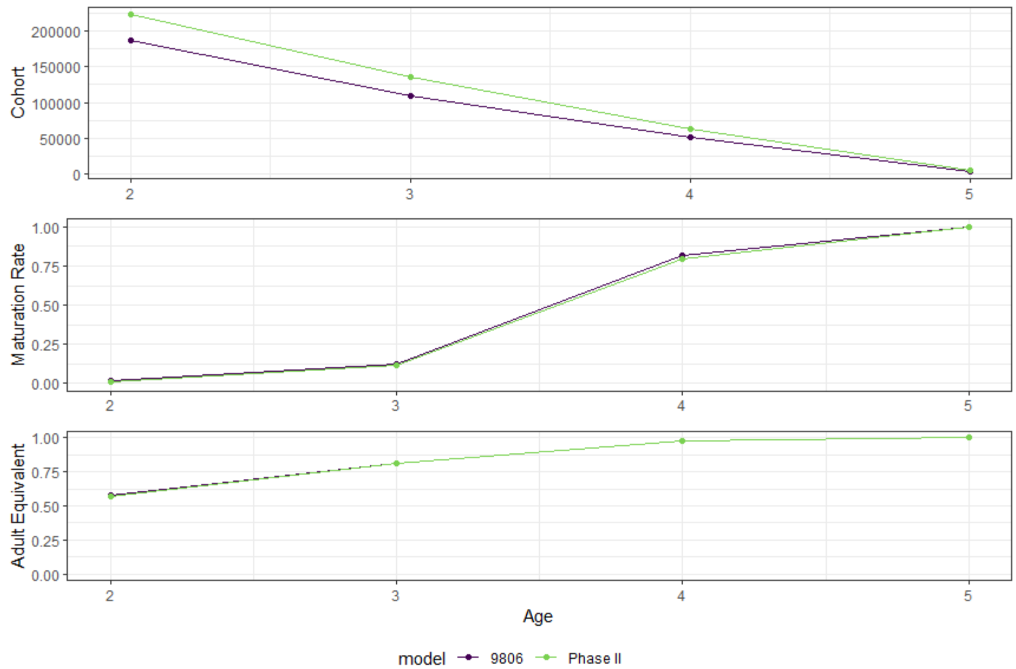

Figure 229—Base period cohort size, maturation schedule, and adult equivalent for Fall Cowlitz Hatchery.

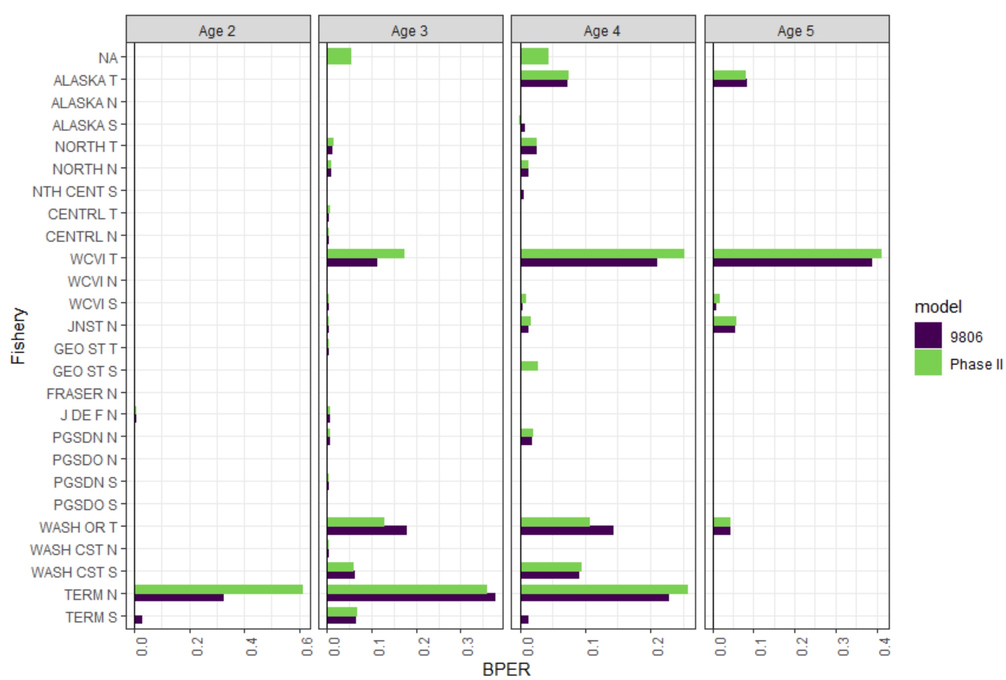

Figure 230—Base period exploitation rate by fishery for Fall Cowlitz Hatchery.

4.41.2.4 Escapement/Terminal Run Time Series

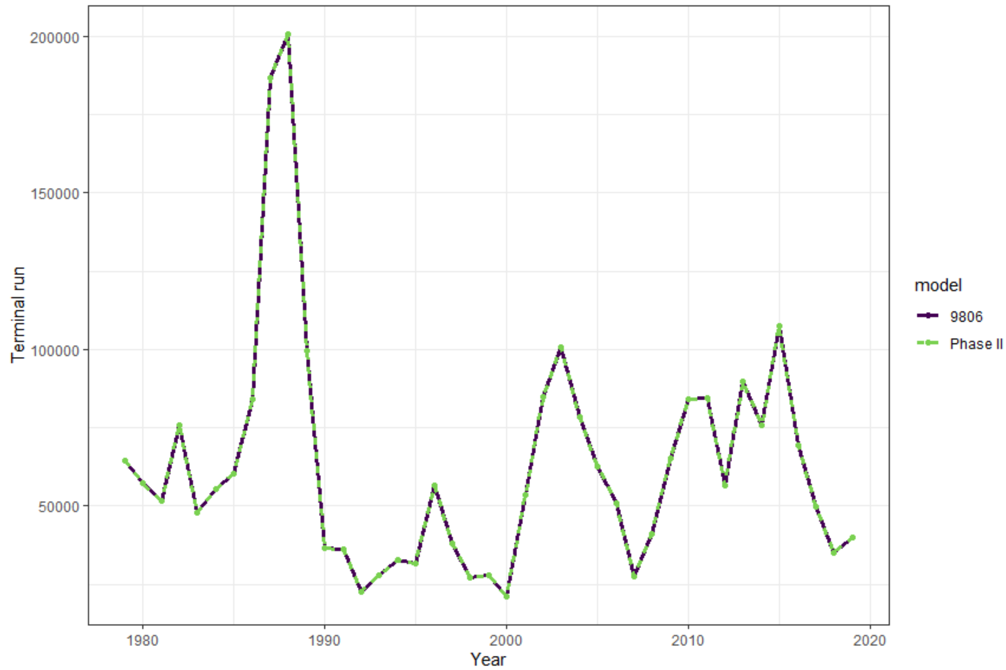

Figure 231—Escapement or terminal run size for Fall Cowlitz Hatchery.

4.41.2.5 Ricker Parameters

The base period calibration program was used to estimate new Ricker parameters resulting in different estimates of productivity and density dependence (Figure 232).

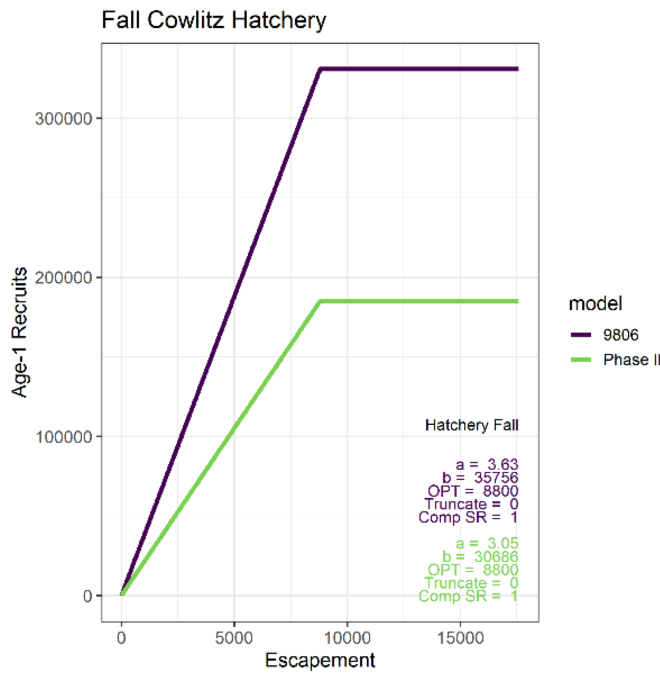

Figure 232—Ricker curve and parameters for Cowlitz Fall Hatchery (CWF) model stock.

4.42 Lewis River Wild (LRW): Lewis River Wild (LRW)

4.42.1 Stock Description

The Lewis River Wild stock is naturally-produced fall bright stock, primarily in the Lewis River system with smaller components also present in the Cowlitz and Sandy rivers. Adults generally begin freshwater migration in early August with peak spawning in mid-November. In 1931, construction of Merwin Dam blocked migrating adults from at least one-half of their historic spawning habitat. The main spawning area is now the 6.4 km below Merwin Dam and above Lewis River Hatchery. Coded-wire tags from this stock group originate from a wild tagging program. The stock is far north migrating and is caught in all three AABM fisheries.

4.42.2 Description of Changes

Tag codes from brood years 1977 to 1978 were used to estimate base period parameters. Tag codes 631902 from the 1978 brood was not used previously. Tag codes 631611, 631813 and 631920 are from Lewis River Salmon Hatchery and the other tag codes are from a wild tagging program on the Lewis River.

4.42.2.1 MDL File Settings

Table 100—Information used in the construction of the Lewis River Wild (LRW) MDL file.

Information for MDL File Production	Phase II Model Stock
Model Stock Acronym	LRW
Brood Years	1977–1978
Out-of-base procedure used?	No
C-file extension (CWT Indicator ID)	LRW
Modifications to fisheries in WG4 file	NA
Yearling Stock	No
Weight within BY by production releases	No
Exclude Esc for Between BY weighting	No
Start age in C-files	2
Last age in C-files	5
Modifications to escapements in Coshak4	No
Terminal fishery CWT moved to escapement	No
Model stock type	Hatchery, Fall
Additional fisheries designated as terminal	None
9806 Model stock association	LRW
Other Information	
C-file creation date	-
Number of C-file and ERA fisheries	188 - 78
MDL creation date	-

4.42.2.2 Base Period Coded-Wire Tags and Recoveries

Table 101—Coded-wire tag codes for Lewis River Wild (LRW) model stock.

Brood Year	Tag Codes (LRW)	
	9806	**Phase II**
1977	631611, 631618, 631619	631611, 631618, 631619
1978	631813, 631920, 631858, 631902, 631859, 632002	631813, 631920, 631858, 631902, 631859, 632002

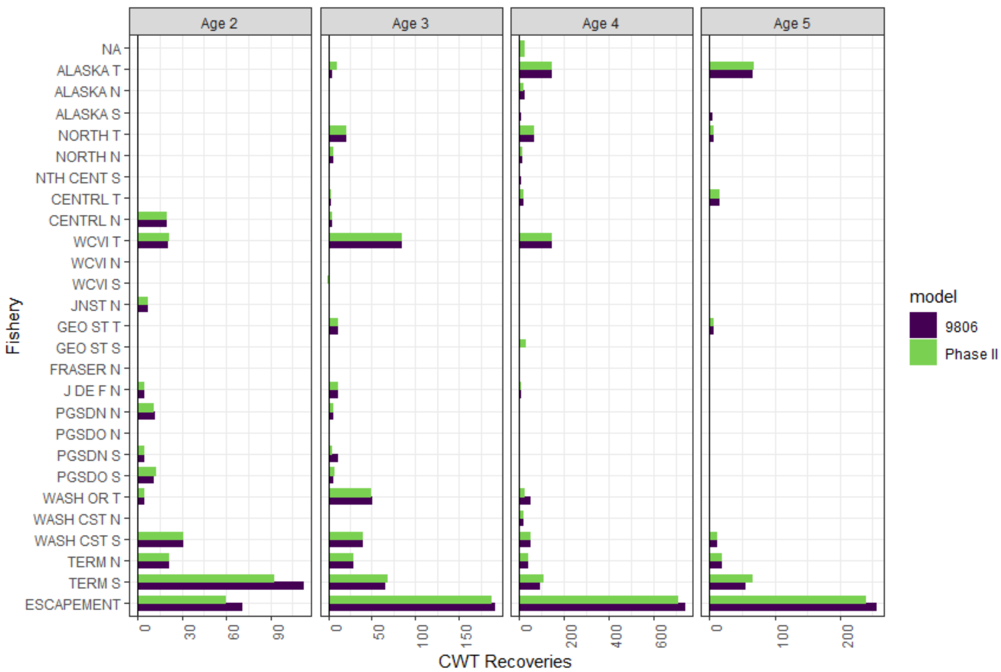

Figure 233—Base period coded-wire tag (CWT) recoveries for Lewis River Wild.

4.42.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

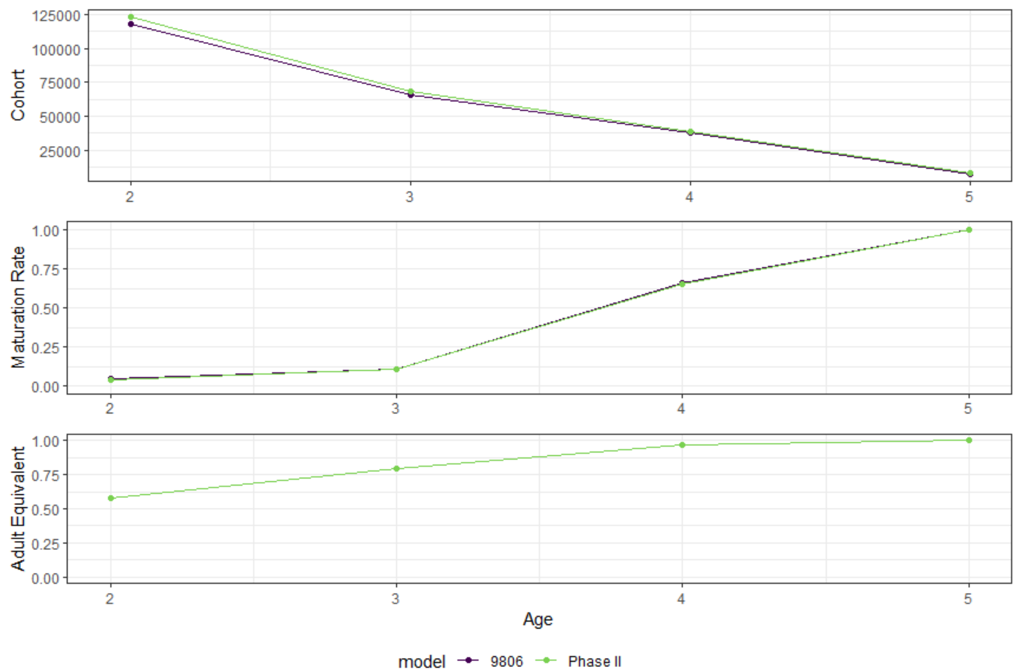

Figure 234—Base period cohort size, maturation schedule, and adult equivalent for Lewis River Wild.

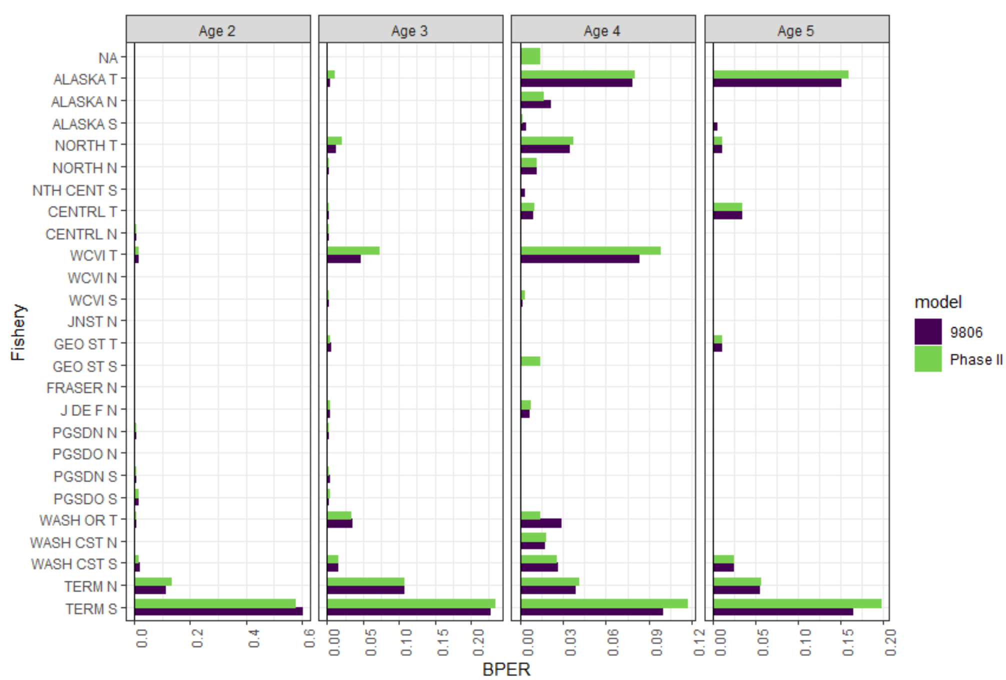

Figure 235—Base period exploitation rate by fishery for Lewis River Wild.

4.42.2.4 Escapement/Terminal Run Time Series

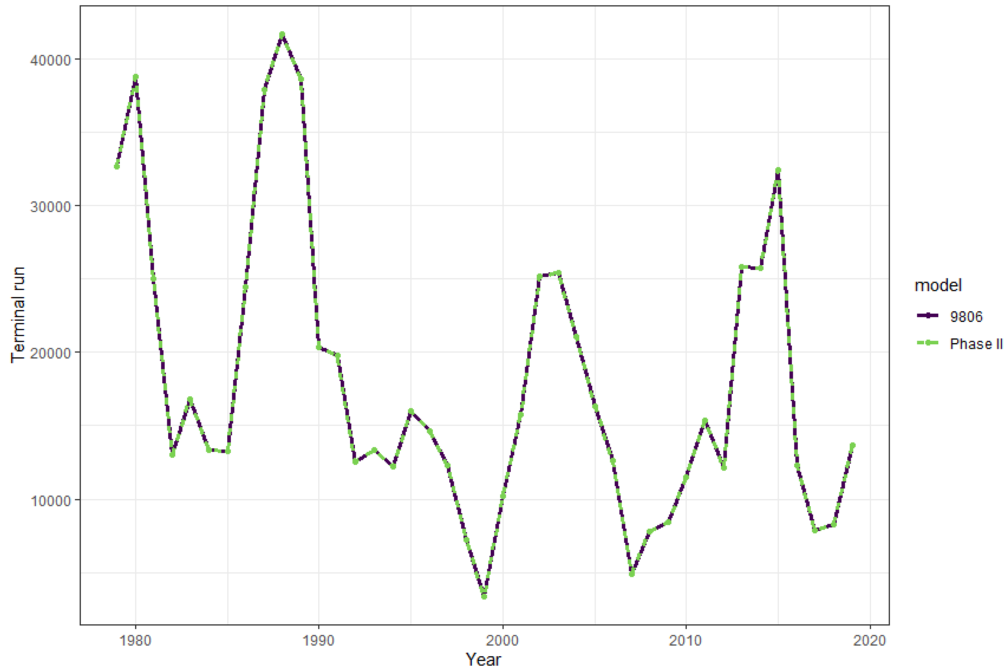

Figure 236—Escapement or terminal run size for Lewis River Wild.

4.42.2.5 Ricker Parameters

Estimates of Ricker parameters can be found in TCCHINOOK (99)-3. The current and new Ricker parameters are identical (Figure 237).

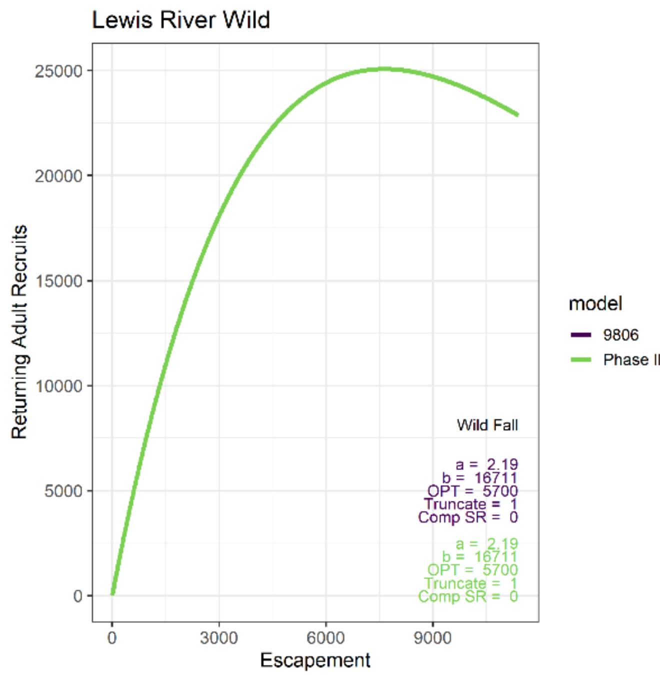

Figure 237—Ricker curve and parameters for Lewis River Wild (LRW) model stock.

4.43 Lyons Ferry (LYF): Lyons Ferry (LYF)

4.43.1 Stock Description

Hatchery and wild Snake River fall Chinook are a component of the Upriver Bright stock complex. However, naturally spawning Snake River Fall Chinook are included in the Chinook Model for ESA purposes. Sub-yearling (Lyons Ferry Fingerling [LYF]) and yearling (Lyons Ferry Yearling [LYY]) CWTs from Lyon's Ferry Hatchery are used for indicator stock purposes. These fish are intercepted in fisheries as far north as Southeast Alaska but tend to have more southernly distribution in comparison to Upriver Brights.

4.43.2 Description of Changes

The current model did not include yearling tag codes when determining base period parameters. These tag codes were included for consistency with the Fishery Regulation Assessment Model (FRAM) base period. Estimates for Lyons Ferry Falls (LYF) were increased; the new Model reconfigures enumeration at the Columbia River mouth, where LYF was previous enumerated at Lower Granite Dam on the Snake River (Table 102).

Table 102—FCS file for Lyons Ferry (LYF) re-estimated for the Phase II Model.

Note: differences between the Phase II and 9806 Model calibrations (negative = decreased in Phase II model, in parentheses). 2019 forecasts become observed in 2020.

Return Year	All Ages Forecast Differences
1979	3,143
1980	1,631
1981	1,902
1982	2,569
1983	878
1984	603
1985	1,793
1986	2,387
1987	1,530
1988	3,190
1989	1,699
1990	433
1991	1,528
1992	740
1993	732
1994	552
1995	946
1996	1,117
1997	1,042
1998	424

Return Year	All Ages Forecast Differences
1999	1,514
2000	1,464
2001	8,970
2002	1,543
2003	4,229
2004	5,174
2005	6,792
2006	10,614
2007	7,949
2008	6,707
2009	14,210
2010	3,318
2011	9,331
2012	6,480
2013	14,247
2014	6,582
2015	8,637
2016	5,375
2017	4,754
2018	4,509
2019	9,796

4.43.2.1 MDL File Settings

Table 103—Information used in the construction of the Lyons Ferry (LYF) MDL file.

Information for MDL File Production	**Phase II Model Stock**
Model Stock Acronym	LYF
Brood Years	1984–1986
Out-of-base procedure used?	Yes
C-file extension (CWT Indicator ID)	LYF, LYY
Modifications to fisheries in WG4 file	NA
Yearling Stock	No
Weight within BY by production releases	No
Exclude Esc for Between BY weighting	No
Start age in C-files	2
Last age in C-files	5
Modifications to escapements in Coshak4	No
Terminal fishery CWT moved to escapement	No
Model stock type	Hatchery, Fall
Additional fisheries designated as terminal	None
9806 Model stock association	LYF
Other Information	
C-file creation date	-
Number of C-file and ERA fisheries	188 - 78
MDL creation date	-

4.43.2.2 Base Period Coded-Wire Tags and Recoveries

Note that because a mix of sub-yearling and yearling tag codes were used, the brood year specified in the C-files for yearling tag codes was incremented one year. This was done so that the scalars in the WG4 file were assigned to the right brood. As an example, a sub-yearling release in brood year x would result in recoveries of CWTs in calendar years x+2, x+3, x+4 and x+5. The recoveries in these calendar years would contribute to the brood year x specific scalars in the WG4 file. A yearling released from brood year x-1 would have recoveries in calendar years x+2, x+3, x+4 and x+5. Thus, the appropriate WG4 scalar for a yearling from brood year x-1 would be the scalar that utilizes recoveries from years x+2, x+3, x+4 and x+5 (i.e., the brood year x scalar).

Table 104—Coded-wire tag codes for Lyons Ferry (LYF) model stock.

Brood Year	Tag Codes	
	9806 (LYF)	**Phase II (LYF, LYY)**
1984	633226, 633227, 633228	LYF: 633226, 633227, 633228 LYY:632841
1985	633638, 633639, 633640, 633641, 633642, 633633, 633634, 633635, 633636, 633637, 634159	
1986	634259, 634261, 634262, 634401	LYF: 634259, 634261 LYY: 634407, 634408, 634411, 634413

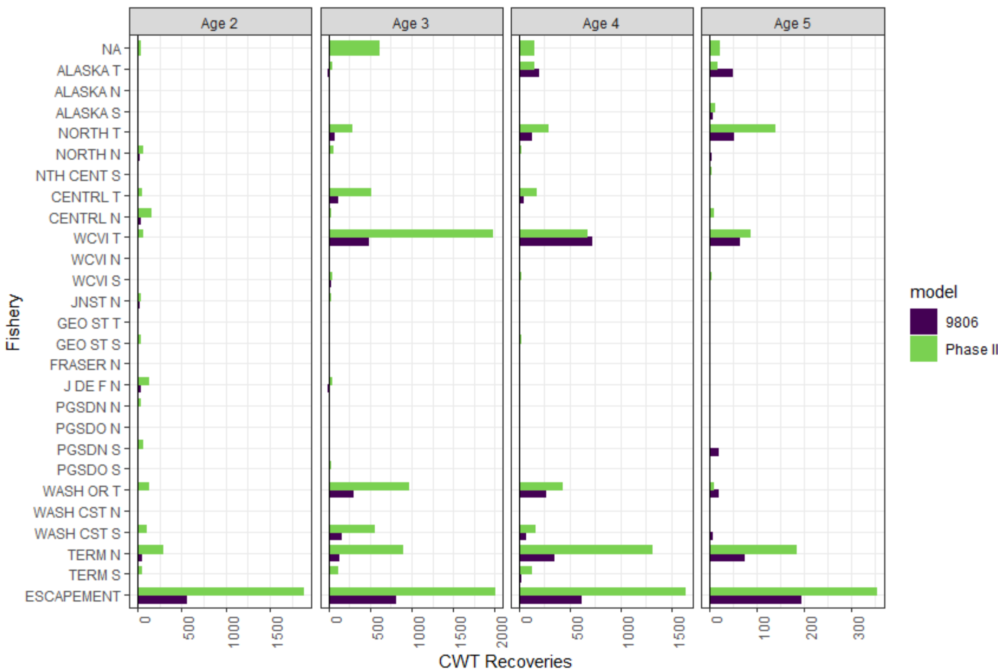

Figure 238—Base period coded-wire tag (CWT) recoveries for Lyons Ferry.

4.43.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

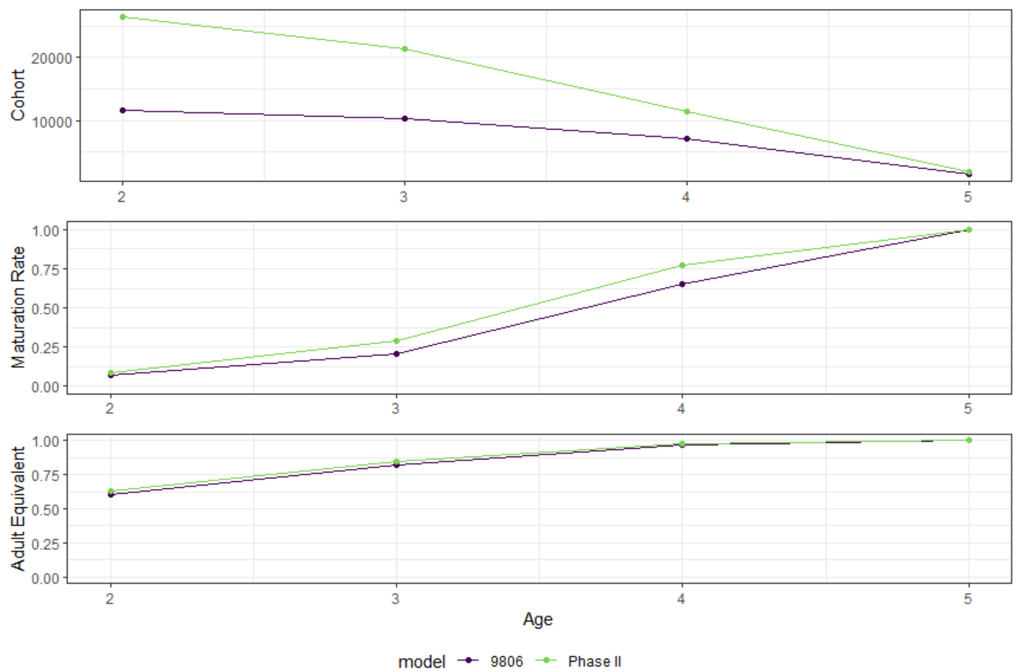

Figure 239—Base period cohort size, maturation schedule, and adult equivalent for Lyons Ferry.

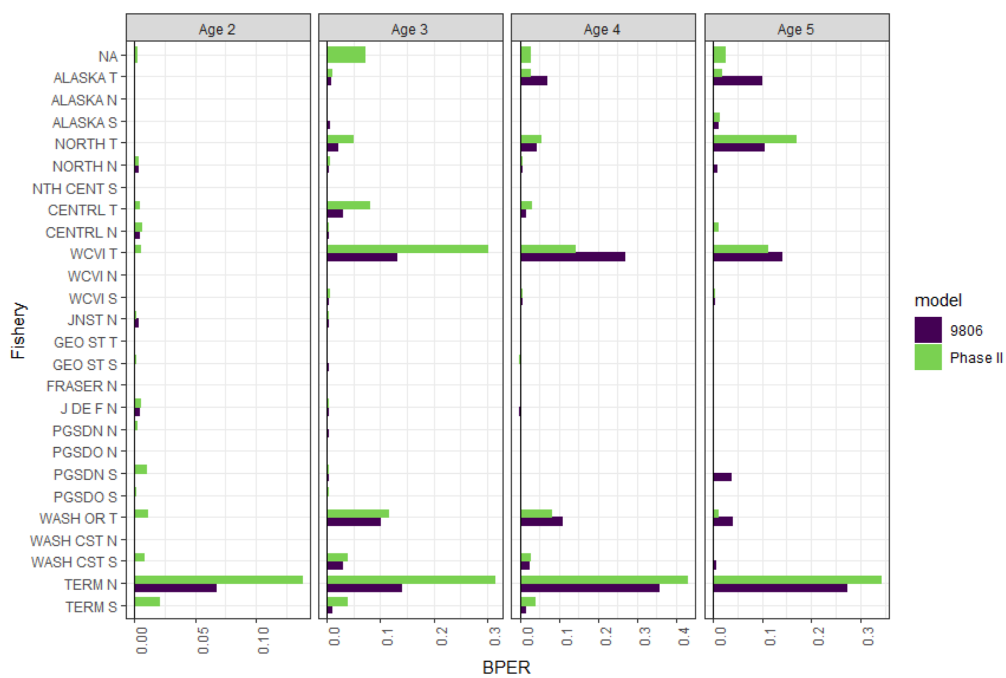

Figure 240—Base period exploitation rate by fishery for Lyons Ferry.

4.43.2.4 Escapement/Terminal Run Time Series

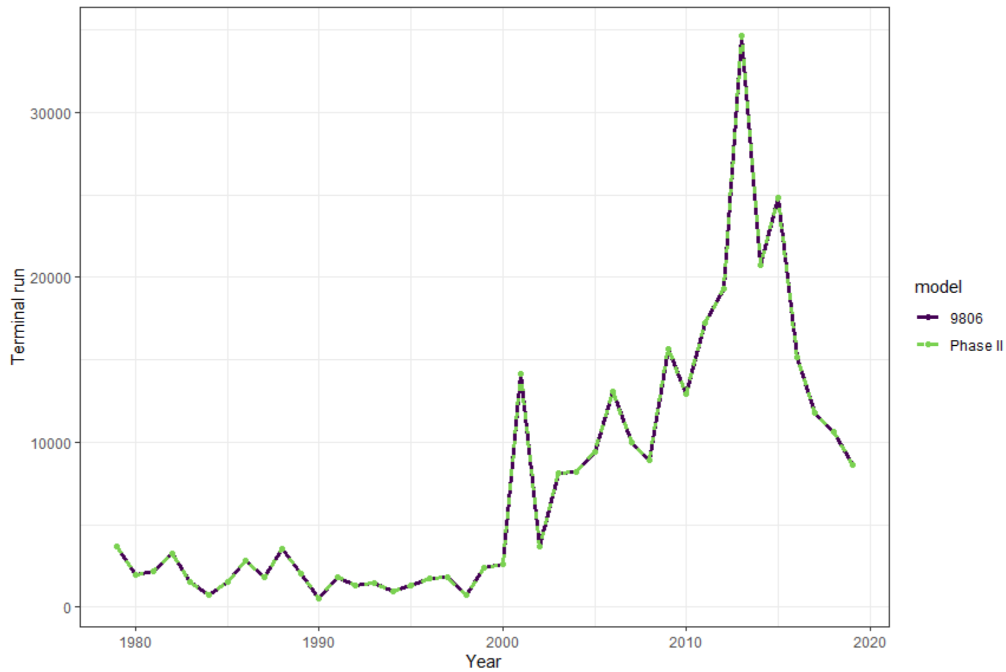

Figure 241—Escapement or terminal run size for Lyons Ferry.

4.43.2.5 Ricker Parameters

The base period calibration program was used to estimate new Ricker parameters resulting in different estimates of productivity and density dependence (Figure 242).

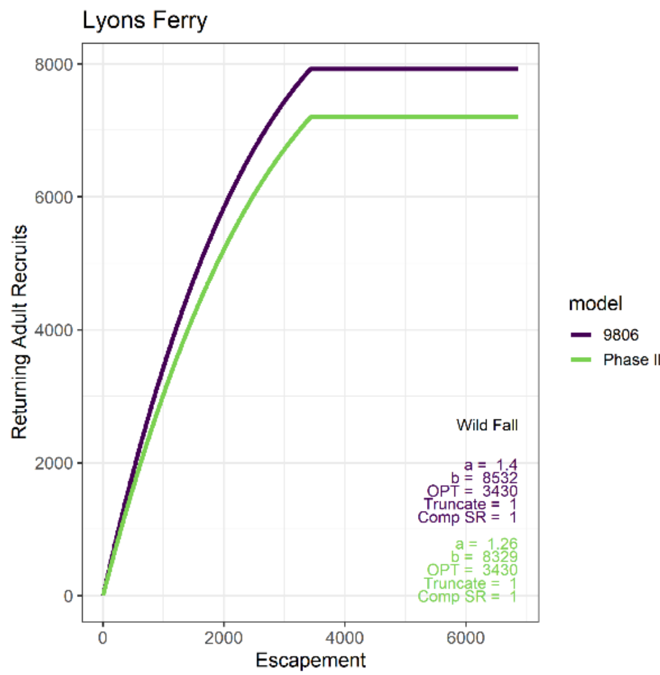

Figure 242—Ricker curve and parameters for Lyons Ferry (LYF) model stock.

4.44 Mid-Columbia River Brights (MCB): Mid-Columbia River Brights (MCB)

4.44.1 Stock Description

Mid-Columbia Brights are a fall stock primarily of hatchery origin. Columbia River Management forums divide this stock into two separate management components: Pool Upriver Brights (PUB) and Lower Upriver Brights (LRB). PUBs are a bright stock reared at Little White Salmon, Umatilla, and Klickitat hatcheries, and released in areas between Bonneville and McNary dams. Natural production of fish derived from the PUB stock is believed to also occur in the main stem Columbia River below John Day Dam, and in the Wind, White Salmon, Klickitat, and Umatilla rivers. The LRBs are a natural stock that spawn in the main stem Columbia River approximately three miles downstream from Bonneville Dam. The LRB stock is closely related to URBs. Because there were no releases of CWTs in the base period, URB tag codes (Priest Rapids Hatchery) are used as the indicator for this stock group. The stock is far north migrating and is caught in all three AABM fisheries.

4.44.2 Description of Changes

Mid-Columbia River Brights use Upriver Bright (Priest Rapids Hatchery) tag codes to represent this stock group. See description of Upriver Bright changes in previous section.

4.44.2.1 MDL File Settings

Table 105—Information used in the construction of the Mid-Columbia River Brights (MCB) MDL file.

Information for MDL File Production	Phase II Model Stock
Model Stock Acronym	MCB
Brood Years	1975–1977
Out-of-base procedure used?	No
C-file extension (CWT Indicator ID)	URB
Modifications to fisheries in WG4 file	NA
Yearling Stock	No
Weight within BY by production releases	No
Exclude Esc for Between BY weighting	No
Start age in C-files	2
Last age in C-files	5
Modifications to escapements in Coshak4	No
Terminal fishery CWT moved to escapement	No
Model stock type	Wild, Fall
Additional fisheries designated as terminal	None
9806 Model stock association	MCB
Other Information	
C-file creation date	-
Number of C-file and ERA fisheries	188 - 78
MDL creation date	-

4.44.2.2 Base Period Coded-Wire Tags and Recoveries

Table 106—Coded-wire tag codes for Mid-Columbia River Brights (MCB) model stock.

Brood Year	Tag Codes (URB)	
	9806	Phase II
1975		130713, 131101, 131202
1976	631662	631662
1977	631741, 631745	631741, 631745

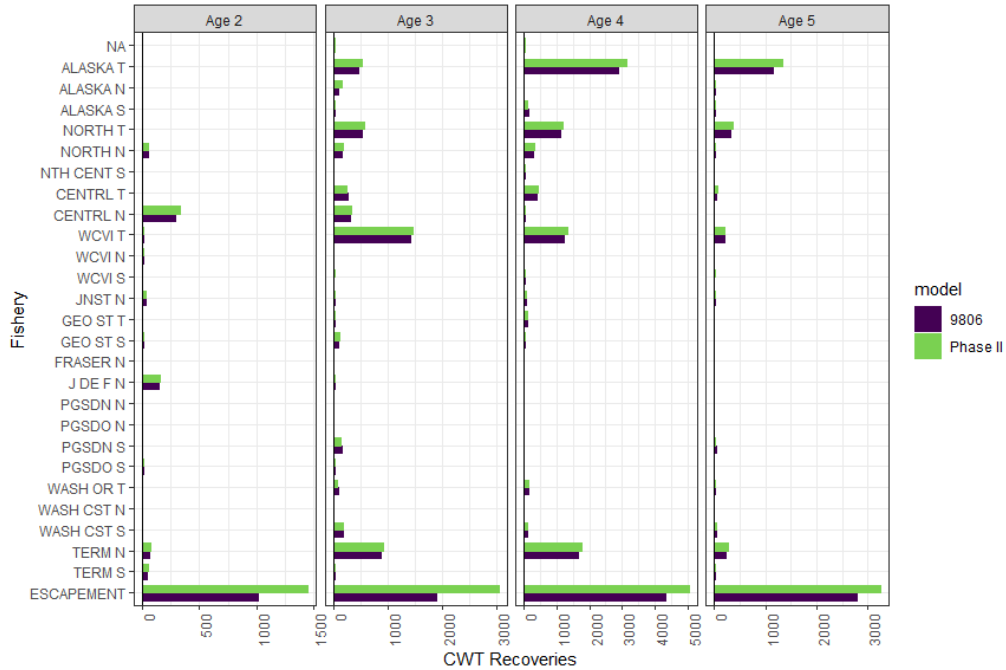

Figure 243—Base period coded-wire tag (CWT) recoveries for Mid-Columbia River Brights.

4.44.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

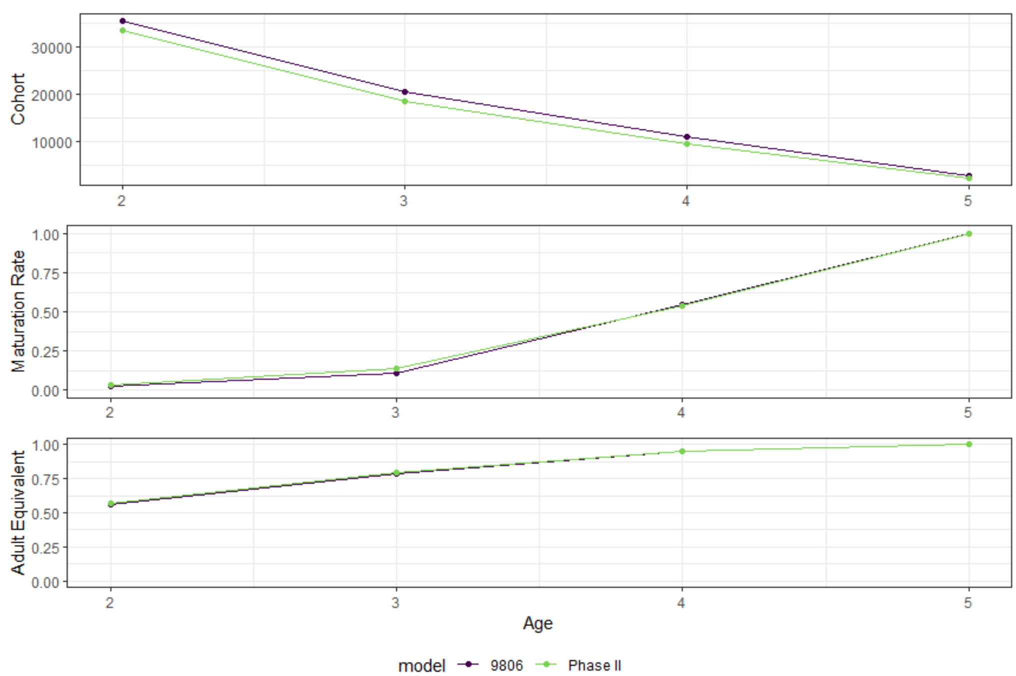

Figure 244—Base period cohort size, maturation schedule, and adult equivalent for Mid-Columbia River Brights.

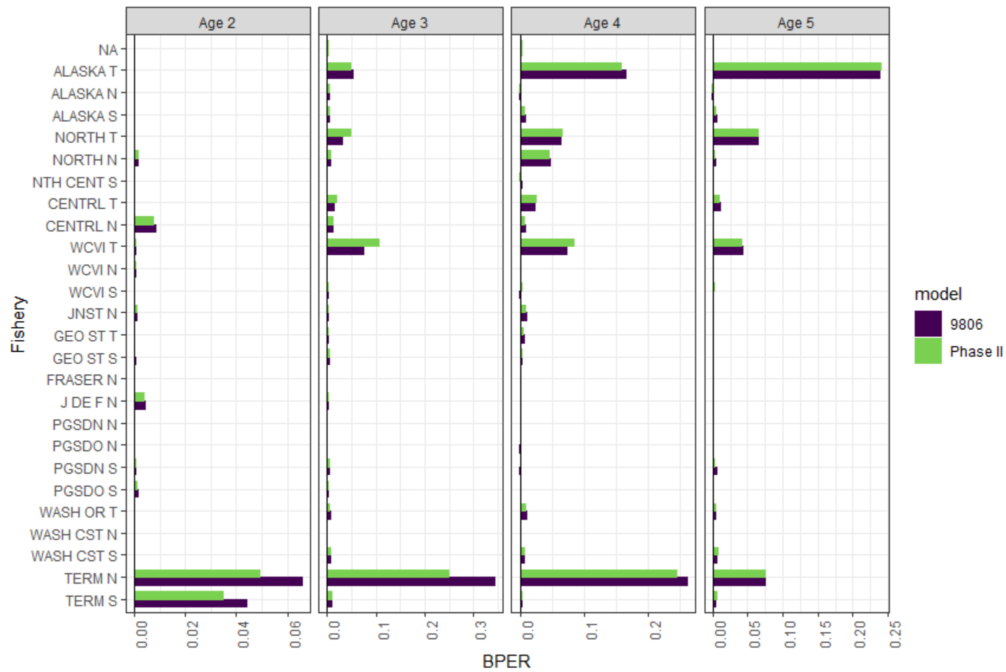

Figure 245—Base period exploitation rate by fishery for Mid-Columbia River Brights.

4.44.2.4 Escapement/Terminal Run Time Series

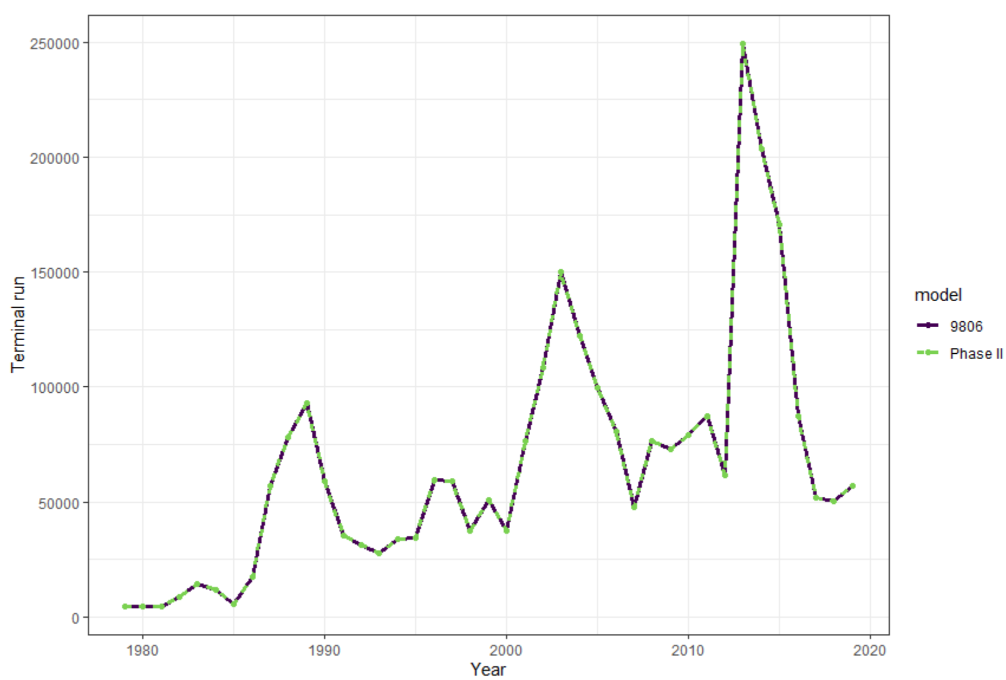

Figure 246—Escapement or terminal run size for Mid-Columbia River Brights.

4.44.2.5 Ricker Parameters

The base period calibration program was used to estimate new Ricker parameters resulting in different estimates of productivity and density dependence (Figure 247).

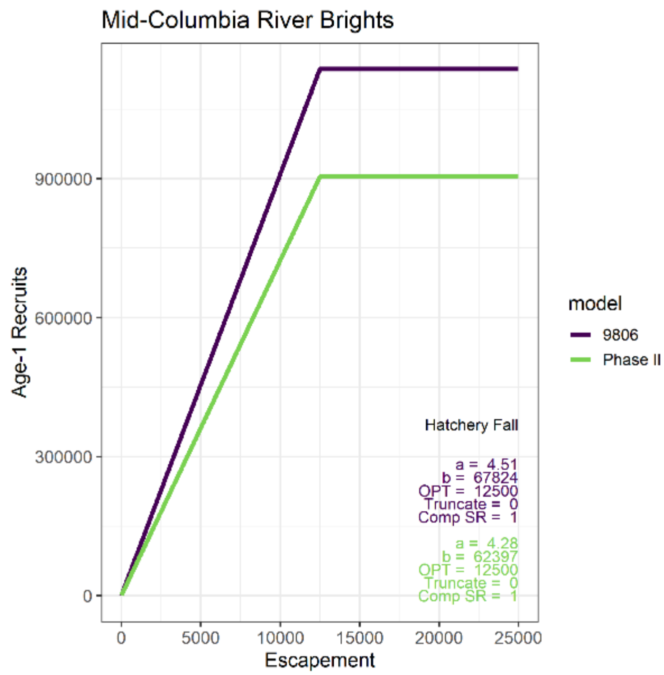

Figure 247—Ricker curve and parameters for Mid-Columbia River Brights (MCB) model stock.

4.45 Oregon Coast (ORC): North Oregon Coast (NOC)

4.45.1 Stock Description

The North Oregon Coast (NOC) model stock consists of all fall Chinook from the Nehalem basin to the Siuslaw basin, inclusively (plus the relatively small but unique Nehalem River summer run component). All are sub-yearling migrants, and all are natural production except for Salmon River Hatchery sub-yearling releases, usually a minor component of total NOC adult spawner return (1-14%, average=4%). The NOC model stock is far-north migrating with relatively high exploitation in AABM fisheries of SEAK and NBC.

4.45.2 Description of Changes

See section 4.45.2.4 Escapement/Terminal Run Time Series below.

4.45.2.1 MDL File Settings

Table 107—Information used in the construction of the North Oregon Coast (NOC) MDL file.

Information for MDL File Production	Phase II Model Stock
Brood Years	1976, 1978–1980, 1982
Out-of-base procedure used?	No
C-file extension (CWT Indicator ID)	SRH
Modifications to fisheries in WG4 file	NA
Yearling Stock	No
Weight within BY by production releases	No
Exclude Esc for Between BY weighting	No
Start age in C-files	2
Last age in C-files	5+
Modifications to escapements in Coshak4	No
Terminal fishery CWT moved to escapement	No
Model stock type	Wild, Fall
Additional fisheries designated as terminal	None
9806 Model stock association	NOC

4.45.2.2 Base Period Coded-Wire Tags and Recoveries

Base period CWT codes used for the new model were the same as those used in the current model with the exception that the single CWT code release group for brood year (BY) 1977 was dropped owing to poor survival/recoveries for that brood. Estimated terminal recoveries for these tag codes were unchanged between the current and new model.

Table 108—Coded-wire tag codes for North Oregon Coast (NOC) model stock.

Brood Year	Tag Codes (SRH)	
	9806	Phase II
1976	091637, 091638	091637, 091638
1977	071643	
1978	071849, 071850	071849, 071850
1979	072239, 072240	072239, 072240
1980	072504, 072505	072504, 072505
1981	(No CWT releases)	(No CWT releases)
1982	072647	072647

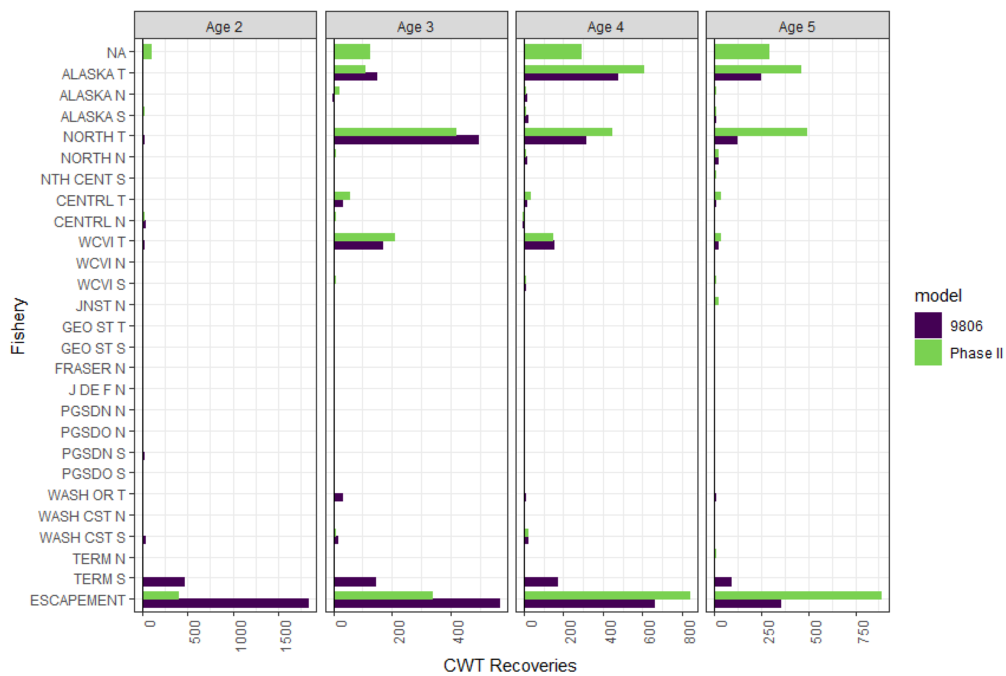

Figure 248—Base period coded-wire tag (CWT) recoveries for Oregon Coast (9806) and North Oregon Coast (Phase II).

4.45.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

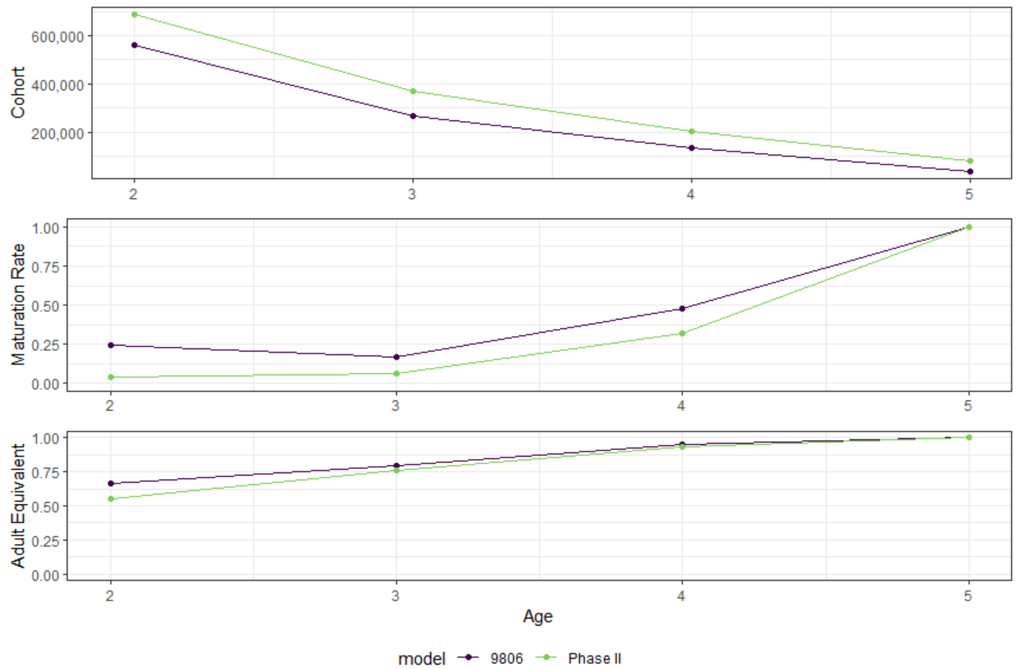

Figure 249—Base period cohort size, maturation schedule, and adult equivalent for Oregon Coast (9806) and North Oregon Coast (Phase II).

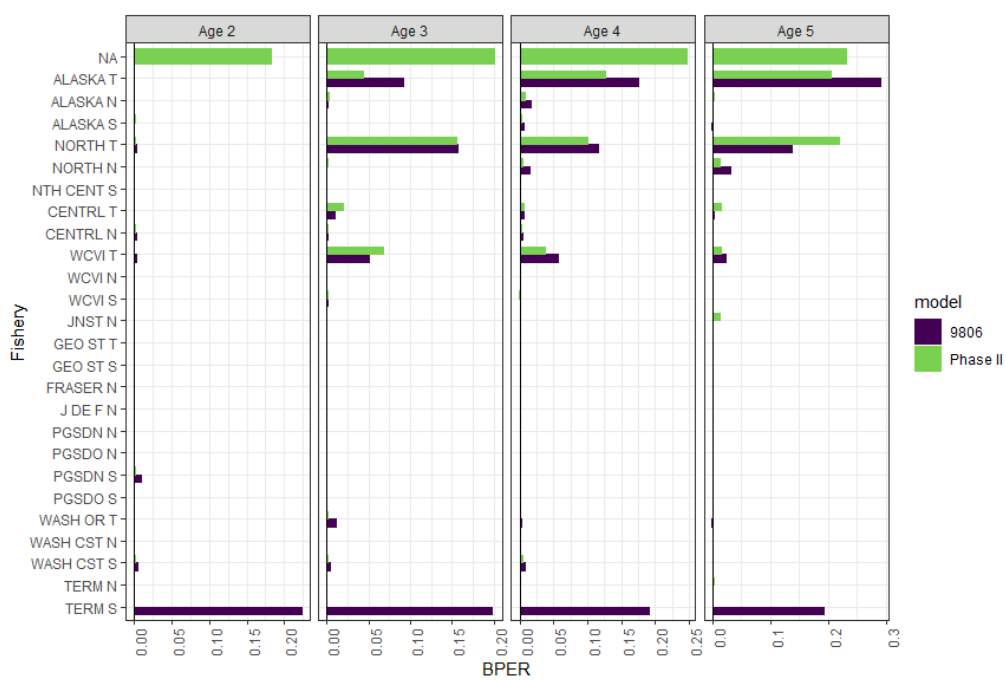

Figure 250—Base period exploitation rate by fishery for Oregon Coast (9806) and North Oregon Coast (Phase II).

4.45.2.4 Escapement/Terminal Run Time Series

Estimated spawner escapement for NOC in the new model is somewhat lower in almost all years than for the current model (Table 109). For the current model, annually estimated natural spawner escapement of all the major rivers was summed, then an additional 17.8% was added to account for unsurveyed areas and Salmon River production (hatchery and wild). These escapements were estimated annually for each river using a habitat expansion (spawning habitat river miles) and spawner survey peak counts (live + dead). For the new model, natural spawner escapement in the Nehalem, Nestucca, Siletz, and Siuslaw basins are instead based on calibration of peak counts or sum-of-carcasses to estimated abundance in multiple Mark-Recapture (MR) experiments. For Tillamook Bay, Alsea, and Yaquina basins (no MR experiments), annual escapement is estimated by the Peak Count Model (PCM): this model relates escapement estimates in the rivers with MR experiments to relationships between survey peak counts and hydro-geomorphic variables of the surveyed reaches; these relationship distributions, averaged across MR rivers, are then employed to estimate escapement in each non-MR river based on quantification of the hydro-geomorphic variables across all reaches accessible to Chinook in each non-MR river. Finally, annual escapement in the Salmon River is the sum of estimated returns to the hatchery and natural fish spawner escapement estimates based on MR experiments and survey peak counts.

Table 109—FCS file for North Oregon Coast (NOC) re-estimated for the Phase II Model.

Note: differences between the Phase II and 9806 Model calibrations (negative = decreased in Phase II model, in parentheses). 2019 forecasts become observed in 2020.

Return Year	age 3	age 4	age 5+
1979	1,678	(3,021)	5,857
1980	5,150	(5,783)	(2,454)
1981	1,847	(1,633)	(945)
1982	9,678	(10,340)	(908)
1983	(1,108)	(2,242)	(3,265)
1984	(1,428)	(10,809)	(7,249)
1985	(1,051)	(303)	(5,222)
1986	(3,843)	(2,570)	(9,500)
1987	(5,590)	(9,153)	(1,921)
1988	(5,371)	(24,078)	(24,252)
1989	(7,803)	(8,048)	(10,599)
1990	(2,610)	(10,031)	(9,394)
1991	(3,070)	(7,318)	(5,402)
1992	(2,463)	(13,960)	(9,891)
1993	(2,100)	(3,256)	(9,110)
1994	(338)	(11,565)	2,845

Return Year	age 3	age 4	age 5+
1995	(8,423)	(2,805)	(7,574)
1996	(4,369)	(19,277)	(2,198)
1997	(2,382)	(4,398)	(8,911)
1998	(3,737)	(10,575)	(11,849)
1999	(1,280)	(18,013)	(4,366)
2000	(6,370)	(6,553)	(4,442)
2001	(16,057)	(29,436)	(4,558)
2002	(23,451)	(15,496)	(3,603)
2003	(5,989)	(46,318)	(12,766)
2004	(5,784)	(13,910)	(25,121)
2005	(3,982)	(11,900)	(11,834)
2006	(880)	(13,186)	(7,541)
2007	(2,756)	(6,126)	(7,061)
2008	(2,117)	(4,830)	(9,265)
2009	(10,688)	(11,526)	(4,760)
2010	(4,526)	(16,267)	(276)
2011	(5,116)	(18,025)	(9,345)
2012	(3,798)	(9,590)	(7,939)
2013	(5,845)	(15,901)	(6,723)
2014	(4,842)	(19,252)	(10,751)
2015	15,076	(22,845)	(31,918)
2016	(2,121)	(22,075)	(5,456)
2017	(873)	(7,813)	(12,001)
2018	(4,496)	(13,678)	(13,208)
2019	10,558	(1,640)	(14,047)

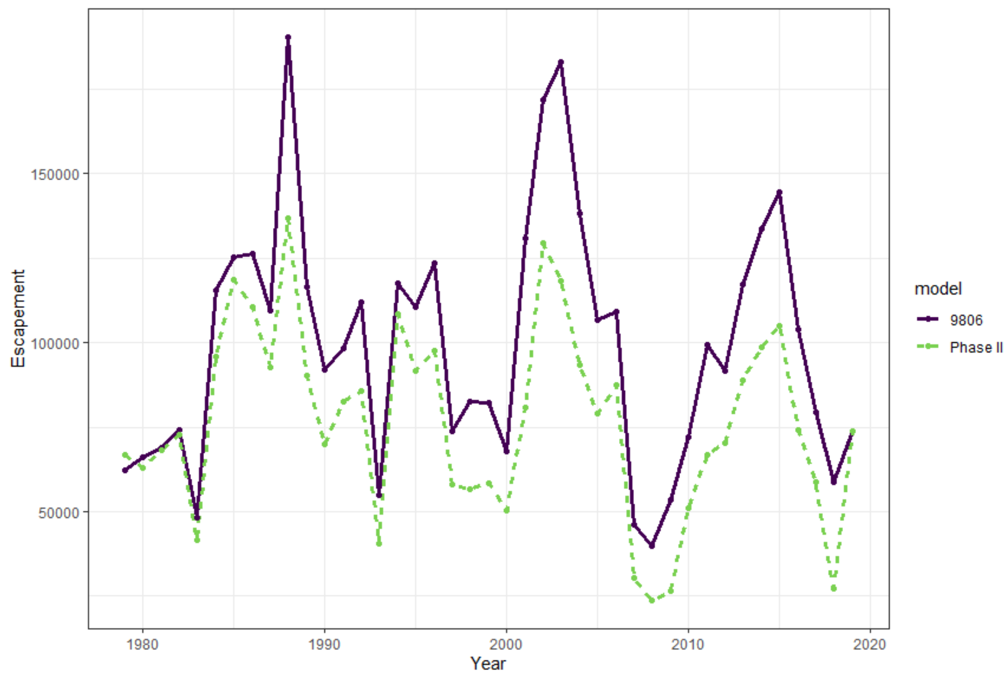

Figure 251—Escapement for Oregon Coast (9806) and North Oregon Coast (Phase II).

4.45.2.5 Ricker Parameters

Ricker parameters for the NOC are externally supplied from ODFW external analyses; standard Ricker functions (not truncated) are employed. Ricker functions for the current and new model are quite similar; new model capacity and optimum spawners are slightly lower, productivity slightly higher (Figure 252).

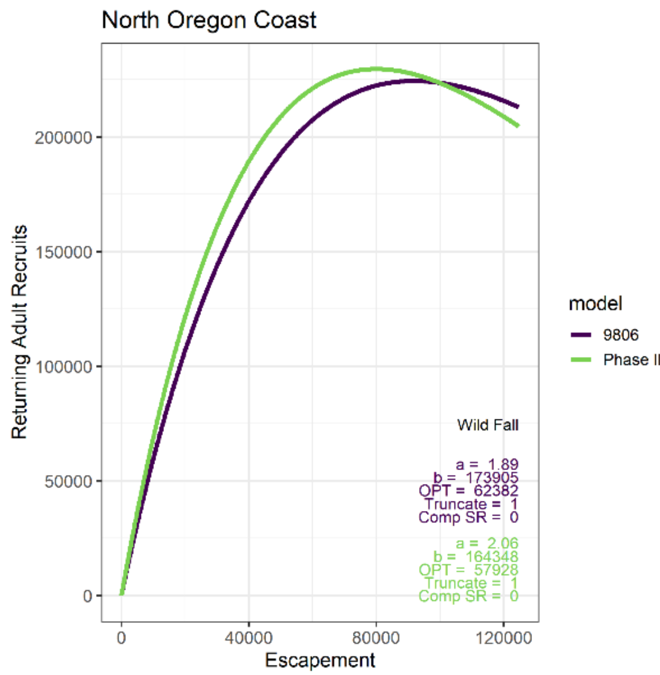

Figure 252—Ricker curve and parameters for North Oregon Coast (NOC) model stock.

4.46 New Model Fishery: Mid Oregon Coast (MOC)

4.46.1 Stock Description

The Mid Oregon Coast aggregate is a newer construct with the updated model which is intended to provide representation for those North migrating stocks from the mid-Oregon coast originating from basins between the Elk River to the South up through the Umpqua River at the Northern extent of this aggregate. Coded-wire tag groups released from the Elk River Hatchery have been part of the Elk River Hatchery's production since it was constructed in the middle 1970's. Those basins which contribute to the aggregate's overall production include the Elk, Sixes, Coquille, Coos Bay complex, and Umpqua drainages. Coded-wire tag recoveries from the Elk River releases indicate a more southerly pattern of exploitation than those from the neighboring NOC aggregate, with SEAK troll, NBC troll, WCVI troll and both North and South of Falcon Troll contributing towards the major fisheries which exploit these stocks. Those stocks originating from the MOC tend to return to spawn later in the season than the NOC, on average, and tend towards an earlier age at maturation than those stocks in the NOC as well.

There is a long-standing terminal area fishery off of the mouth of the Elk River which is referred to as the "Elk River bubble" which is aimed at those returning hatchery fish to the Elk and is managed differently than the neighboring PFMC management areas for Chinook. In this regard, those recoveries into the bubble fishery are different for the CWT group which originates from Elk hatchery compared to those basins in the MOC which are further North.

4.46.2 Description of Changes

The addition of the MOC to the Chinook model suite of stocks and stock aggregates allows for representation of stocks which were not previously accounted for in the current modeling framework, and also represents those stocks originating furthest South out of all of those managed within the PSC framework. See Table 110 for new FCS file values.

Table 110—FCS file for Mid Oregon Coast (MOC) introduced into the Phase II Model (returning fish not previously included in the 9806 Model calibration).

Return Year	Mid Oregon Coast (MOC)		
	age 3	age 4	age 5+
1979	3,331	11,957	5,862
1980	3,709	9,394	7,226
1981	3,896	8,082	4,289
1982	4,687	12,610	5,157
1983	4,597	10,605	4,175
1984	4,015	14,154	6,098
1985	2,073	12,757	3,655
1986	8,743	4,472	6,319
1987	5,429	25,193	2,216
1988	7,279	15,068	14,114
1989	5,999	17,886	10,370

Return Year	Mid Oregon Coast (MOC)		
	age 3	age 4	age 5+
1990	4,886	9,651	11,028
1991	5,125	20,251	7,333
1992	10,486	22,587	15,571
1993	5,075	13,573	11,199
1994	3,917	23,848	12,432
1995	21,244	19,074	18,547
1996	9,578	38,041	5,817
1997	8,421	11,853	17,818
1998	7,466	13,914	8,974
1999	3,034	18,161	10,695
2000	7,455	8,902	10,206
2001	13,728	27,236	4,249
2002	23,056	28,523	10,561
2003	14,009	48,442	11,698
2004	9,336	33,145	23,012
2005	2,206	9,661	7,380
2006	2,424	8,705	9,112
2007	2,120	7,867	4,741
2008	4,076	14,789	4,200
2009	14,168	15,703	8,148
2010	27,122	37,588	8,569
2011	8,147	33,972	9,086
2012	9,880	16,041	11,499
2013	12,948	20,736	6,365
2014	9,281	32,736	5,582
2015	38,615	48,421	23,286
2016	4,740	22,113	6,600
2017	8,398	13,523	5,592
2018	6,621	8,745	2,156
2019	7,456	8,442	1,269

4.46.2.1 MDL File Settings

Table 111—Information used in the construction of the Mid-Oregon Coast (MOC) MDL file.

Information for MDL File Production	Phase II Model Stock
Model Stock Acronym	ELK
Brood Years	1997–1999
Out-of-base procedure used?	Yes
C-file extension (CWT Indicator ID)	ELK
Modifications to fisheries in WG4 file	No

Information for MDL File Production	Phase II Model Stock
Yearling Stock	No
Weight within BY by production releases	Yes
Exclude Esc for Between BY weighting	No
Start age in C-files	2
Last age in C-files	5
Modifications to escapements in Coshak4	no
Method used to modify escapement	NA
Terminal fishery CWT moved to escapement	Yes; 0.75
Model stock type	Hatchery, Fall
Additional fisheries designated as terminal	TCOL R N and TCOL R S (default choices maintained within GUI)
9806 Model stock association	MOC
Other Information	
C-file creation date	21 Sept. 2015
Number of C-file and ERA fisheries	188-78
MDL creation date	9 May 2019

4.46.2.2 Base Period Coded-Wire Tags and Recoveries

Table 112—Coded-wire tag codes for Mid-Oregon Coast (MOC) model stock.

Brood Year	Tag Codes (ELK)	
	9806	Phase II
1977	071646	
1978	072008	
1979	072242, 072244, 072243, 072245	
1980	072535, 072536, 072537, 072538	
1997	N/A	091857, 092449
1998	N/A	092810
1999	N/A	093052

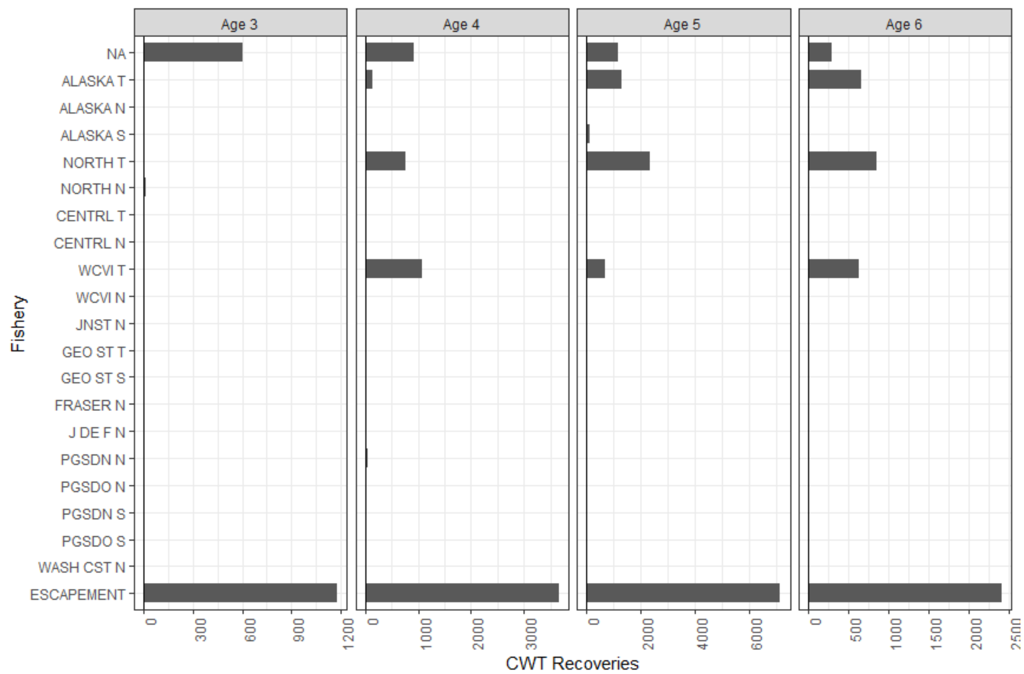

Figure 253—Base period coded-wire tag (CWT) recoveries for Mid-Oregon Coast (Phase II only).

4.46.2.3 Base Period Cohort, Maturation, Adult Equivalent, and Exploitation Rate

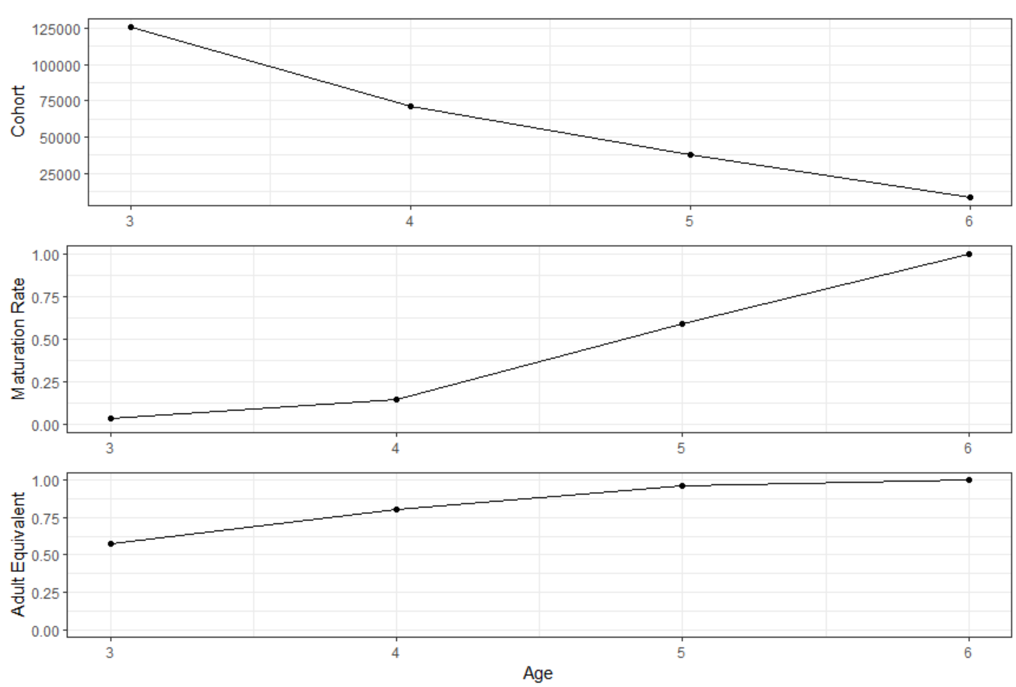

Figure 254—Base period cohort size, maturation schedule, and adult equivalent for Mid-Oregon Coast (Phase II only).

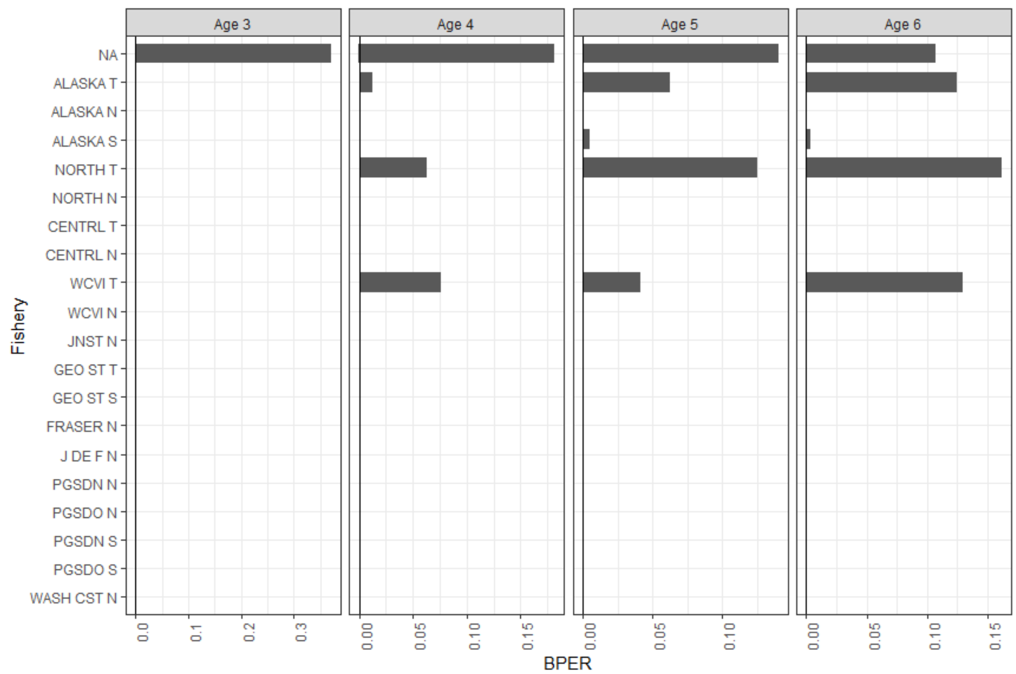

Figure 255—Base period exploitation rate by fishery for Mid-Oregon Coast (Phase II only).

4.46.2.4 Escapement/Terminal Run Time Series

During the CTC's review of the phase II Base period recalibration, it was observed that the modeled catch for the newly modeled fishery "Terminal South of Falcon Freshwater Sport" was biased high and inaccurate in its depiction of the terminal harvest which occurs on both the NOC and MOC aggregates' production. Discussions within the AWG and AWG plus workgroups between September 2018 and May 2019 had yielded several questions and concerns in how to rectify the disparity seen between those modeled depictions of catch and independent observations of terminal harvest and recovery in both NOC and MOC aggregates.

One approach has been developed and deployed to account for terminal harvest model disparities which has been referred to as the "Larrie method" in honor of one of the AWG members who had developed this methodology in order to tune the model FPs to account for differences between modeled and observed terminal catch. After much discussion and debate, the AWG decided that this method (the Larrie method) should only be applied to stocks/terminal fisheries in which the model calibrates to the terminal run, not escapement estimates. Both the NOC and MOC are modeled to the escapement observed in each aggregate, not the terminal run, and terminal harvest estimates are not available within a usable PST management time framework. The Larrie method had also been applied to the Terminal South of Falcon Freshwater Sport during preliminary investigations, and resulted in estimates of catch close to if not spot-on to observed estimates of catch, but concerns as to the appropriateness of this approach had lead the group to charge others with an investigation of an alternative approach to reduce the bias seen between modeled and observed catch for this fishery.

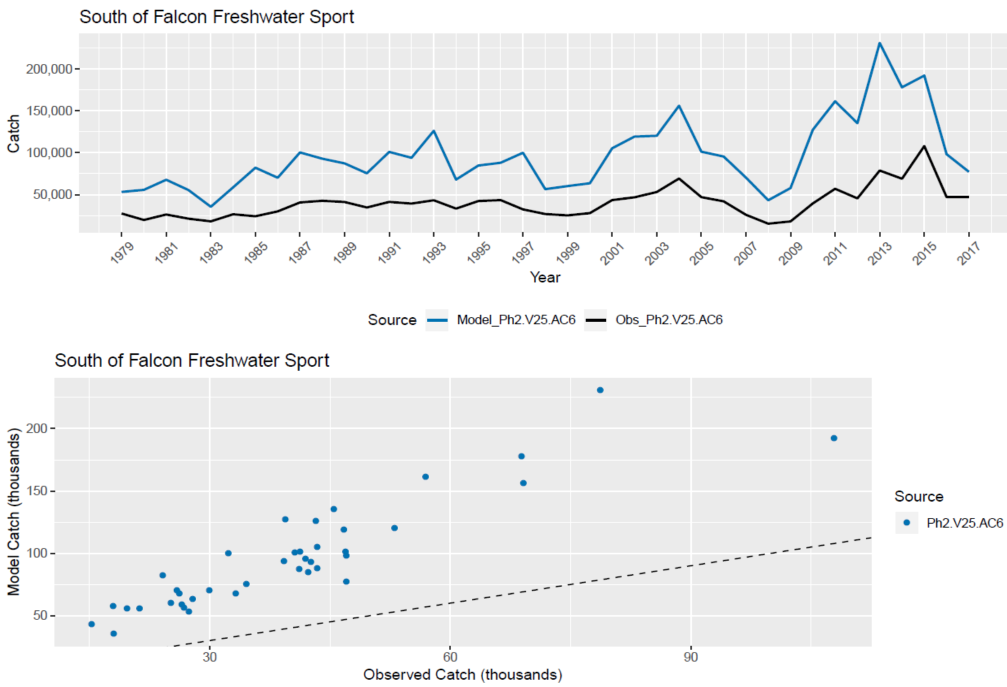

Figure 256—Results of the Larrie method applied to the South of Falcon Freshwater Sport fisheries. The dashed line in the bottom figure represents the 1:1 line of observed and modeled catches.

4.46.2.4.1 Approach

During discussion it had been noted that the terminal harvest rates which are applied by the model to both the NOC and the MOC are known not to be representative of those naturally produced aggregated stocks. The terminal fisheries which operate on both the Salmon River and the Elk River are much more intensively exploitive, by design, than those which are encountered by other basins of natural production in both the NOC and MOC aggregates. The Salmon River Hatchery (SRH) CWT releases and recoveries are used to generate the NOC MDL file, and Elk River Hatchery (ELK) CWT releases and recoveries are used to generate the MOC MDL file. Both NOC and MOC MDLs contribute to modeled expectations of terminal recruitment to the Terminal South of Falcon Freshwater Sport through the generation of several stock parameters that are produced from the MDL file and carry into the STK file for each stock aggregate.

In order to accurately depict the behavior of these terminal fisheries on an aggregated level, an assessment of the harvest rates encountered by each aggregate. In a previous iteration, the use of those terminal harvest rates encountered by the escapement indicator stocks of each aggregate was used to generate updated terminal harvest recoveries. The difference in this updated-updated approach is to utilize those terminal harvest rates encountered by the entire aggregates production, not just those values which were available for the escapement indicator stocks. The resultant outcome is negligible for the MOC stock, but much greater for the NOC stock. Nonetheless, both NOC and MOC stocks were updated with the same method in order to maintain consistency

Table 113—Terminal harvest rate indicators for North Oregon Coast (NOC; top) and Mid-Oregon Coast (MOC; bottom). Average base period harvest rates are highlighted.

Terminal harvest rate NOC indicators					
Year	**Nehalem**	**Siletz**	**Siuslaw**	**EIS average**	**Base period EIS average**
1979	0.0475	0.087	0.180	0.1050	0.1086
1980	0.1060	0.100	0.096	0.1006	
1981	0.0441	0.151	0.141	0.1122	
1982	0.0976	0.102	0.151	0.1167	

Terminal harvest rate MOC indicators				
Year	**Umpqua**	**Coquille**	**EIS average**	**Base period EIS average**
1979	0.202563	0.159312	0.180937	0.164026
1980	0.221352	0.123233	0.172292	
1981	0.185506	0.132355	0.15893	
1982	0.21002	0.077873	0.143946	

Those base period EIS average rates (highlighted values) were used to generate estimates of terminal harvest recoveries that were needed to produce the overall base period terminal harvest rate (at age) by MOC or NOC MDL. Harvest was allocated to the MDL entries in proportion to those CWT recoveries at age in order to produce an overall harvest which was identical to that base period EIS average rate in those tables above. While harvest rates at age may vary slightly, the overall harvest rate matches for each aggregate for the base period.

Escapement recoveries were held constant as each MDL which was modified, and terminal sport recoveries were adjusted to maintain the age composition and modified to overall harvest determined to be needed to generate the aggregate’s base period terminal harvest rate.

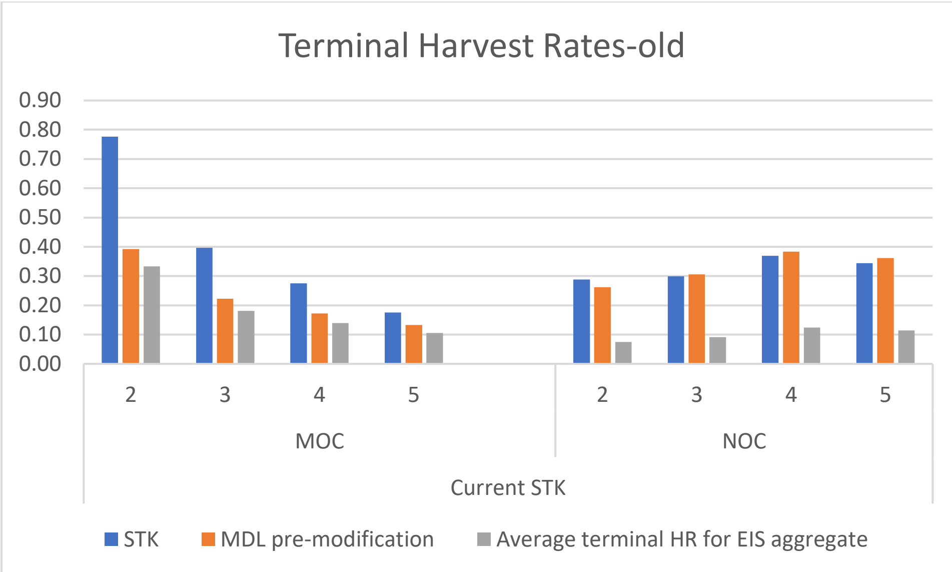

Figure 257—Terminal harvest rates by age for rivers in both North Oregon Coast (NOC) and Mid-Oregon Coast (MOC) areas using the 9806 model calibration.

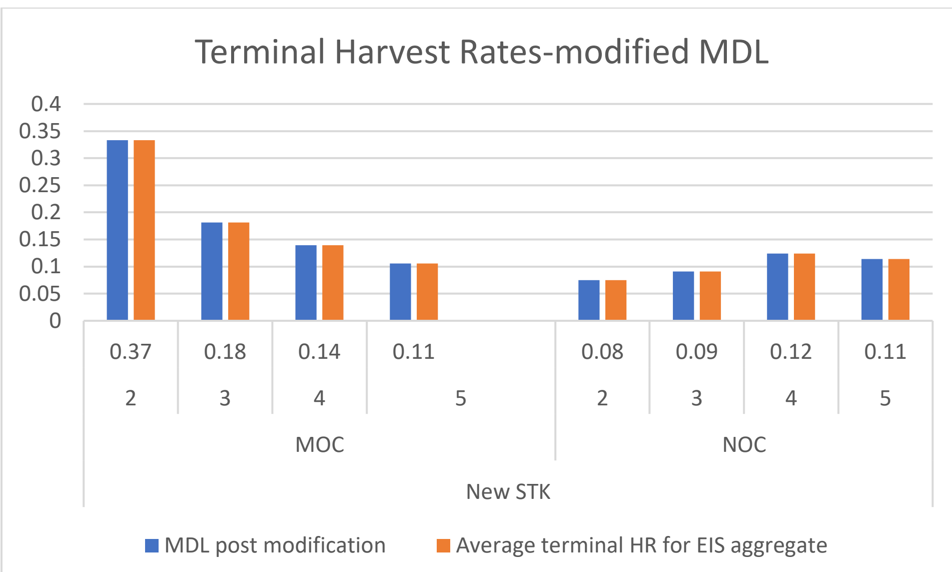

Figure 258—Terminal harvest rates by age for rivers in both North Oregon Coast (NOC) and Mid-Oregon Coast (MOC) areas using the Phase II model.

In addition to those external modifications made on the MDL files themselves for NOC and MOC, a newer version of the MOC MDL was constructed using OOB procedures after selection of a different series of Coded-wire tag codes as well. In previous editions, tag codes representing brood years 1977, 78, 79 and 80 were selected to construct the MDL for the Elk/MOC aggregate. In review it was observed that the earlier brood years in this series had very poor survival, and consequently low numbers of tag recruitment across fisheries.

Additionally, all of these brood year releases suffer from a lack of consistent, appropriately sized tagged release groups. Release sizes approaching the recommended 200,000 in the Elk River do not begin until the 1990 brood year. A review of the tag code by BY recoveries across fisheries showed that a stable regime of recoveries is observed beginning in the 1997 BY, and is stable through BY 1999. Subsequently, tag codes from these broods were chosen to represent the MOC in the construction of the updated MDL file. Earlier brood years' releases were also reviewed and considered for MDL construction, but all suffered from either poor release sizes, survival, or inconsistent recovery within the suite of C-file fisheries which were examined.

The resultant MDL which was constructed from these new tag codes does supply a more representative dispersal of recoveries amongst fisheries and escapement than the previously constructed MDL.

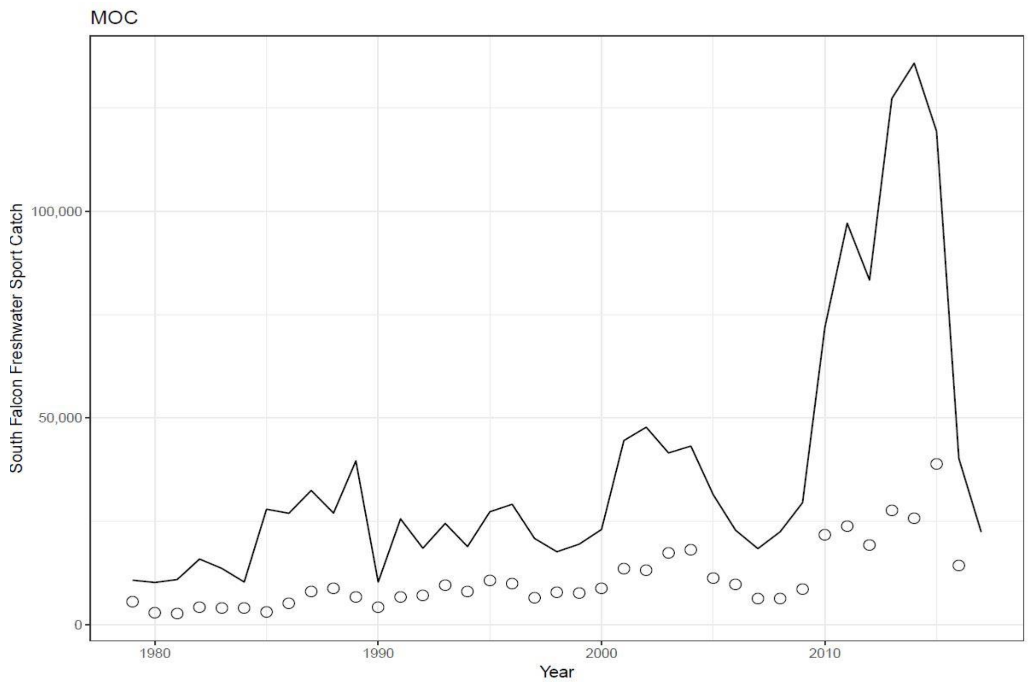

Figure 259—Old MOC MDL, without newer codes and terminal fisheries adjustments, and the resultant observed (circles) and modeled catch (solid line).

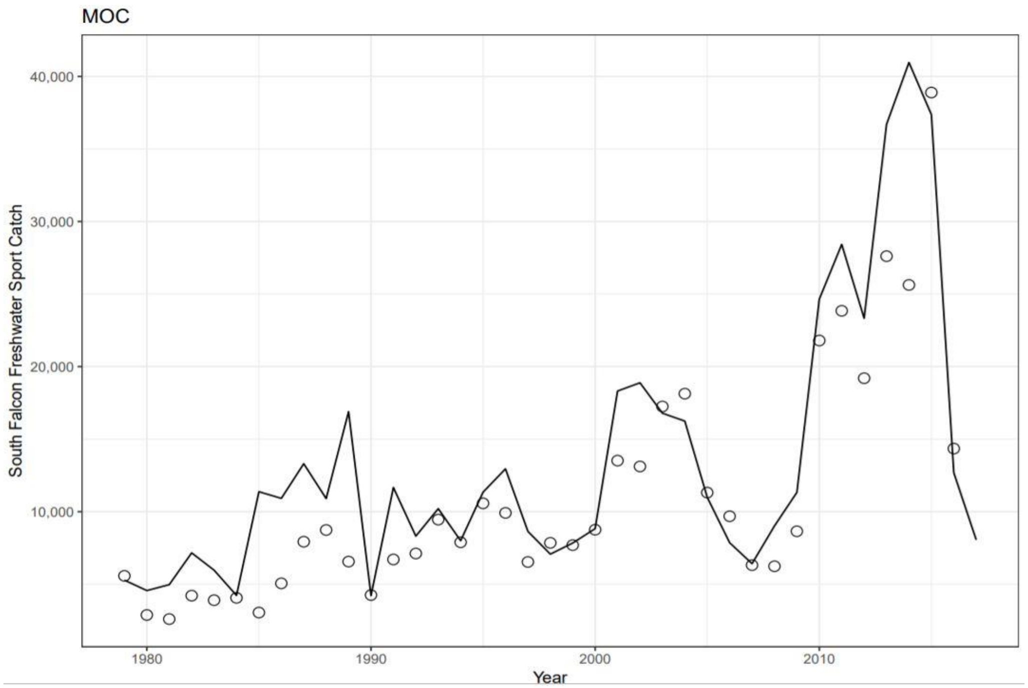

Figure 260—New MOC MDL, with newer codes and terminal fisheries adjustments, and the resultant observed (circles) and modeled catch (solid line).

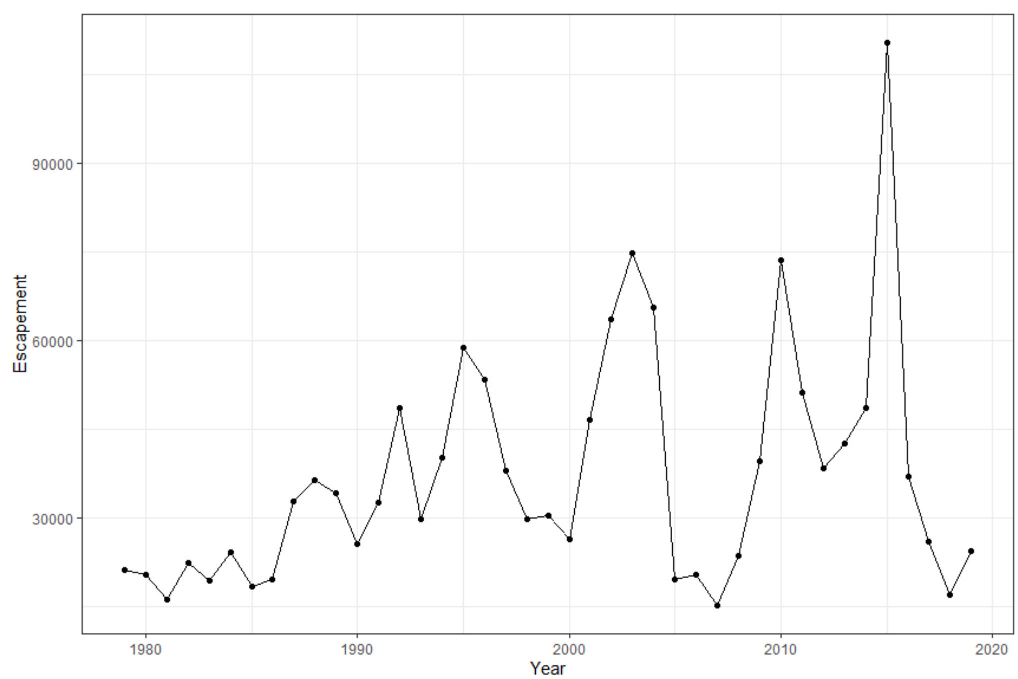

Figure 261—Escapement or terminal run size for Mid-Oregon Coast (Phase II only).

4.46.2.5 Ricker Parameters

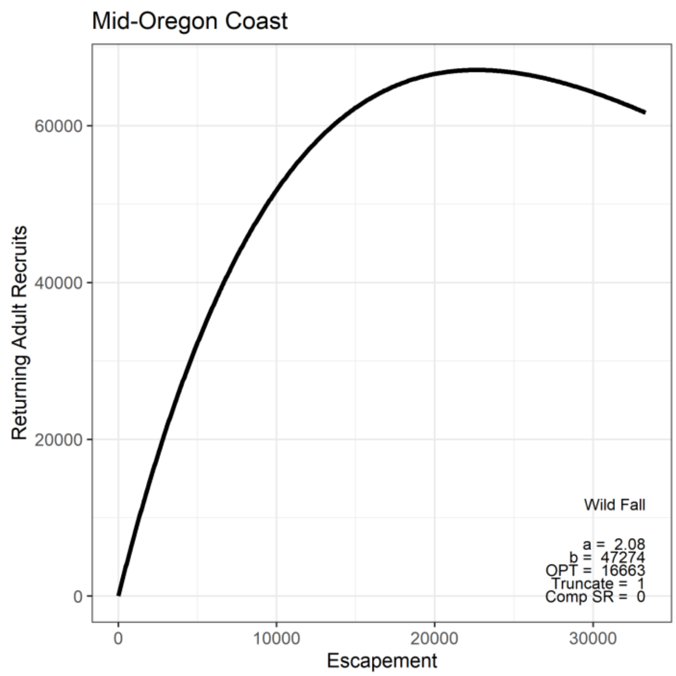

Figure 262—Ricker curve and parameters for Mid-Oregon Coast (MOC) model stock.

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