PACIFIC SALMON COMMISSION
JOINT CHINOOK TECHNICAL COMMITTEE REPORT

2021 PSC Chinook Model Calibration

TCCHINOOK (2022)-02

March 31, 2022

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List of Acronyms and Abbreviations

AABM	Aggregate Abundance Based Management
ACL	Annual Catch Limit
ADF&G	Alaska Department of Fish & Game
AEQ	Adult Equivalent
AI	Abundance Index
AIC	Akaike Information Criterion
ARIMA	Auto Regressive Integrated Moving Average
AWG	Analytical Working Group of the Chinook Technical Committee
BC	British Columbia
BSE	Base Calibration File
BY	Brood Year
CAN	Canada
CBC	Central British Columbia
CLB	Calibration
CNR	Chinook Nonretention
CRITFC	Columbia River Inter-Tribal Fish Commission
CTC	Chinook Technical Committee
CWT	Coded-Wire Tag
CY	Calendar Year
CYER	Calendar Year Exploitation Rate
DFO	Department of Fisheries and Oceans Canada
DIT	Double Index Tag
ERA	Exploitation Rate Analysis
EV	Environmental Variable scalar
FCS	Forecast File
FI	Fishery Index
FNC	First Nations Caucus
FP	Fishery Policy
HRI	Harvest Rate Index
IDL	Interdam Loss File
IM	Incidental Mortality
ISBM	Individual Stock-Based Management
MAE	Mean Absolute Error
MAPE	Mean Absolute Percent Error
MASE	Mean Absolute Scaled Error
MAT	Maturity Factor
MATAEQ	Maturation Adult Equivalent
MRE	Mean Relative Error
NA	Not Available
NBC	Northern BC Dixon Entrance to Kitimat including Haida Gwaii
NOAA	National Oceanic and Atmospheric Administration
NWIFC	Northwest Indian Fisheries Commission
ODFW	Oregon Department of Fish & Wildlife
PNV	Proportion Non-Vulnerable
PSC	Pacific Salmon Commission
PST	Pacific Salmon Treaty
QIN	Quinault Indian Nation
RMSE	Root Mean Squared Error
ROM	Ratio of Means
SACE	Stock Aggregate Cohort Evaluation
SEAK	Southeast Alaska Cape Suckling to Dixon Entrance
SPFI	Stratified Proportional Fishery Index
SUS	Southern United States
TAC	Technical Advisory Committee
TBD	To Be Determined
TBR	Transboundary Rivers
UAF	University of Alaska Fairbanks
U.S.	United States
USFWS	US Fish & Wildlife Service
VB	Visual Basic
WA/OR	Ocean areas off Washington and Oregon North of Cape Falcon
WCVI	West Coast Vancouver Island excluding Area 20
WDFW	Washington Department of Fish and Wildlife

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

Figure **Page**

LIST OF APPENDICES

Appendix	Page

EXECUTIVE SUMMARY

The 2019 Pacific Salmon Treaty (PST) Agreement requires the Chinook Technical Committee (CTC) to annually report catch and escapement data and modeling results used to manage Chinook salmon fisheries and stocks harvested within the Treaty area. This report provides an overview of the annual Pacific Salmon Commission (PSC) Chinook Model calibration process and results, including post-season abundance indices (AIs) through 2020 and pre-season AIs through 2021 used for the management of aggregate abundance-based management (AABM) fisheries. Also included is an initial evaluation of AABM fishery performance as it relates to the terms of the 2019 PST Agreement, in addition to evaluations of model performance such as model error, stock composition of AIs, fishery indices, and stock forecasts used as inputs to the PSC Chinook Model. The 2019 PST Agreement applies to all analyses and model calibration results for 2019 through 2028.

Aggregate Abundance-Based Management Abundance Indices and Associated Catches

Paragraphs 6(a) and (b) of the 2019 PST Agreement defines abundance-based annual catch limits (ACLs) for the three AABM fisheries—Southeast Alaska (SEAK), Northern British Columbia (NBC), and West Coast Vancouver Island (WCVI). Each year, the annual model calibration provides the post-season AIs for the previous year and the pre-season AIs for the current year. Pre-season AIs are used to determine the ACLs in the upcoming fishing season for the NBC and WCVI AABM fisheries corresponding to Table 1 of Chapter 3. The pre-season ACL for the SEAK AABM fishery is determined by the SEAK early winter District 113 Troll fishery catch per unit effort (CPUE) metric. Per paragraph 6(a), *"annual catch limits are specified in Table 1 (catch limits specified at levels of the Chinook abundance index)"* based on annual calibrations of the PSC Chinook Model and "*Table 2 (catch limits for the SEAK AABM fishery and the catch per unit effort (CPUE)-based tiers), unless otherwise specified by the Commission."*

Catch overages and underages in AABM fisheries are tracked relative to pre-season AIs (or CPUE metrics) and post-season AIs and their associated ACLs. Any overages relative to the pre-season ACLs must be paid back in the subsequent fishing year, per 2019 PST Agreement subparagraph 6(h)(i). If overages are observed in two successive years relative to post-season ACLs, then the PSC will request that the management entity responsible for the affected AABM fishery take steps to reduce the variance between the pre-season and post-season ACLs per subparagraph 7(b)(i) and the CTC must recommend a plan to the PSC to "*improve the performance of pre-season, in-season, and other management tools so that the deviations between the catches and post-season fishery limits to AABM fisheries are narrowed to a maximum level of 10%*" per subparagraph 7(b)(ii).

Abundance Indices for 2020–2021 for the Southeast Alaska (SEAK), Northern British Columbia (NBC), and West Coast Vancouver Island (WCVI) aggregate abundance-based management (AABM) fisheries. Post-season Indices for each year are from the first post-season calibration following the fishing year. Per paragraph 6(b) of the 2019 PST Agreement, SEAK annual catch limits are set based on a catch per unit effort (CPUE) statistic, which is provided in parentheses following the abundance index (AI).

	SEAK		NBC		WCVI	
Year	Pre-season	Post-season	Pre-season	Post-season	Pre-season	Post-season
2020[1]	1.13 (4.83)	1.11	1.08	1.16	0.75	0.67
2021[2]	1.28 (3.85)		1.27		0.76	

[1] 2020 pre-season AIs are from calibration number (CLB) 2002. During the 2021 calibration process, an error was identified in some of the maturation rates used as inputs to CLB 2002. These errors were corrected in CLB 2003, which yielded 2020 pre-season AIs of 1.02, 1.00, and 0.69 for SEAK, NBC, and WCVI, respectively.

[2] 2020 post-season AIs and 2021 pre-season AIs are from CLB 2104.

The pre-season and post-season Treaty catch limits by fishery for each year and actual Treaty catches (total catch minus any hatchery add-on and exclusion catch) are shown for AABM fisheries for 2020–2021 in the table below.

Pre-season annual catch limits (ACLs) (2020–2021), and post-season ACLs and actual catches (2019) for aggregate abundance-based management (AABM) fisheries. Post-season values for each year are based on abundance indices (AIs) from the first post-season calibration following the fishing year.

Year	SEAK (Troll, Net, Sport)			NBC (Troll, Sport)			WCVI (Troll, Sport)		
	Pre-season ACL	Post-season ACL	Actual Catch	Pre-season ACL	Post-season ACL	Actual Catch	Pre-season ACL	Post-season ACL	Actual Catch
2020[1]	205,165[2]	140,323	204,624	133,000	141,700	36,183	87,000	78,500	43,581
2021[3]	205,165[2]			153,800			88,000		

[1] 2020 pre-season ACLs are based on AIs from CLB 2002.

[2] Per paragraph 6(b) of the 2019 PST Agreement, this number represents the ACL based on a CPUE statistic.

[3] 2020 post-season ACLs and 2021 pre-season ACLs are based on AIs from CLB 2104.

Overages and underages in AABM catches, relative to pre-season and post-season ACLs for a fishing year can occur due to the operation of the in-season management system referred to herein as *management error*, errors in the pre-season calibration process (e.g., forecast error) or CPUE statistic referred to as *model error*, or a combination of the two referred to as *composite error*. The relative influence of each was evaluated by inspecting differences in actual landed catch and the pre- and post-season ACLs, as shown in the table below. In 2020, actual landed catch was less than the pre-season ACL by 541 fish (0%) in SEAK, 96,817 fish (73%) in NBC, and 43,419 fish (50%) in WCVI due to in-season management; thus, no payback was necessary for the 2021 fishing season per the terms of subparagraph 6(h)(i) of the 2019 PST Agreement. The lower catches in British Columbia are partly due to reduced effort due to the

COVID-19 pandemic[1]. In terms of the post-season ACLs for evaluation of the provisions of paragraph 7(b) of the 2019 PST Agreement, 2020 actual catches were more than the post-season ACLs by 64,301 fish in SEAK (46%), and less than post-season ACLs by 105,597 (75%) in NBC and 34,919 (44%) in WCVI. As per paragraph 7(b), no additional actions are warranted as they only occur if there is an overage for two consecutive years.

Summary of aggregate abundance-based management (AABM) fishery performance and deviations between pre- and post-season annual catch limits (ACLs) and actual catches for Southeast Alaska (SEAK), Northern British Columbia (NBC), and West Coast Vancouver Island (WCVI), 2020.

Positive values indicate an overage and negative values indicate an underage. Colored cells indicate AABM fishery performance relative to Treaty obligations; cells shaded green indicate where a fishery met Treaty obligations and red cells indicate where a fishery exceeded Treaty obligations.

	Management Error Actual – Pre ACL		Model Error Pre ACL – Post ACL		Composite Error Actual – Post ACL	
Year	#	%	#	%	#	%
SEAK (Troll, Net, Sport)						
2020	-541	0%	64,842	46%	64,301	46%
NBC (Troll, Sport)						
2020	-96,817	-73%	-8,700	-6%	-105,597	-75%
WCVI (Troll, Sport)						
2020	-43,419	-50%	8,500	11%	-34,919	-44%

[1] Chinook Technical Committee. (January 6, 2022). *COVID-19 Impacts on Chapter 3 of the Pacific Salmon Treaty in 2020 and 2021* [Memorandum]. Pacific Salmon Commission.

1. Introduction

Chapter 3 of the 2019 Pacific Salmon Treaty (PST) Agreement requires the Chinook Technical Committee (CTC) to annually report catch and escapement data and modeling results used to manage Chinook salmon fisheries and stocks harvested within the Treaty area. To fulfill this obligation, the CTC provides a series of annual reports to the Pacific Salmon Commission (PSC). This report provides an overview of the annual PSC Chinook Model calibration process and results, including post-season abundance indices (AIs) through 2020 and pre-season AIs through 2021 used for the management of aggregate abundance-based management (AABM) fisheries. Also included is an evaluation of AABM fishery performance as it relates to the terms of the 2019 PST Agreement, in addition to evaluations of model error, stock composition of AIs, fishery indices, and stock forecasts used as inputs to the PSC Chinook Model. The CTC uses the PSC Chinook Model to generate key outputs of relevance to the PSC's annual fishery management cycle. The model is assessed and adjusted, or calibrated, each year, incorporating pre-season stock-specific abundance forecasts with the latest information on catches, exploitation rates generated through a cohort analysis, terminal runs, and escapements. The Parties rely upon the model to generate annual indices of abundance for AABM fisheries (Figure 1.1).

The pre-season AIs determine the annual catch limits (ACLs) for 2 of the 3 AABM fisheries: Northern British Columbia (NBC) and West Coast Vancouver Island (WCVI). Beginning in 2019, the pre-season ACL for the Southeast Alaska (SEAK) AABM fishery is determined by the SEAK early winter District 113 Troll fishery catch per unit effort (CPUE) metric. These pre-season ACLs drive the in-season management of AABM fisheries and are used to evaluate fishery performance and management error. In addition to generating pre-season AIs, the model provides other information of immediate relevance to PSC management, most notably post-season AIs. The first post-season AI estimates are used to determine the post-season fishery limits from which model error can be evaluated.

This report describes the PSC Chinook Model calibration (CLB) process and results during 2021 (Section 2). The results of the pre-season model calibration for 2021 are based on the CTC's annual exploitation rate analysis (ERA) using coded-wire tag (CWT) data through catch year 2020 (2019 for southern U.S. stocks); coastwide data on catch, spawning escapements, and age structure through 2020; and forecasts of Chinook salmon returns expected in 2021. This report includes: (1) estimated post-season AIs for 1979 through 2020 and the pre-season AIs for 2021 for the AABM fisheries; (2) estimated stock composition for 1979–2020 and a projection for 2021 for the AABM and other fisheries; and (3) estimated fishery indices (harvest rates) for the AABM fisheries. An evaluation of AABM fishery performance relative to the 2019 PST Agreement is provided in Section 3 of this report. Section 4 contains a validation of the PSC Chinook Model and summary of model improvement activities.

Appendix A shows the relationship between the exploitation rate indicator stocks, escapement indicator stocks, model stocks, and PST Attachment I stocks. Appendix B through Appendix G present additional output from the model calibration beyond the summaries presented in the main body of the report. Appendix B and Appendix C show the model estimates of stock composition in AABM, individual stock-based management (ISBM), and other sport and troll fisheries. Appendix D lists the incidental mortality (IM) rates used in the PSC Chinook Model. Appendix E gives the time series of total AIs for the AABM fisheries, and Appendix F provides the AIs for each Model stock within each AABM fishery. Appendix G provides a tabular summary of forecast error for PSC Chinook Model stocks. Calibration methodology is detailed in Appendix H. Issues with and changes to Model calibration, as well as their resolution, are detailed in Appendix I.

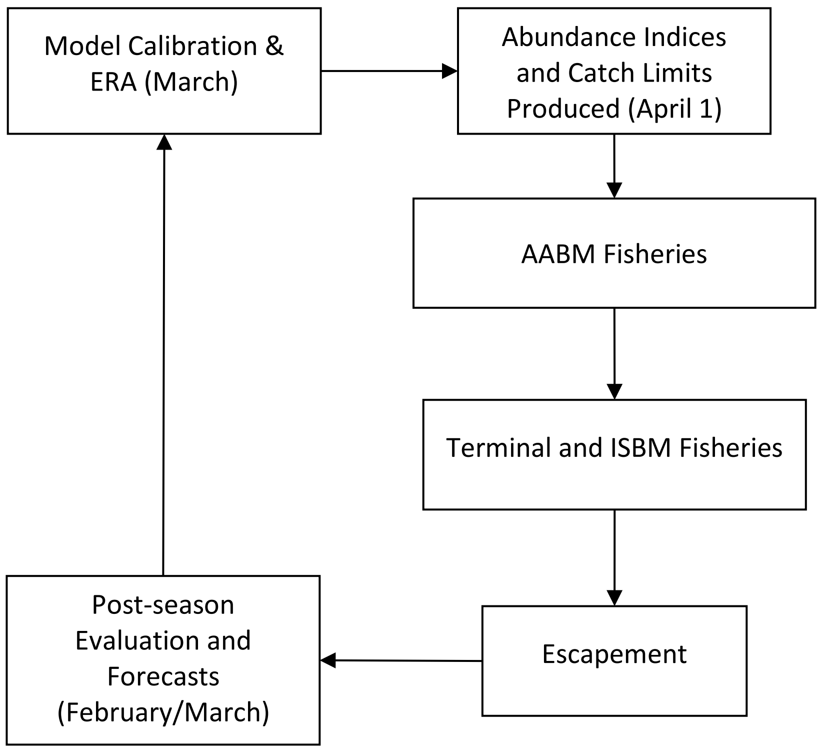

Figure 1.1.—Pacific Salmon Treaty (PST) Chinook management and fishery process.

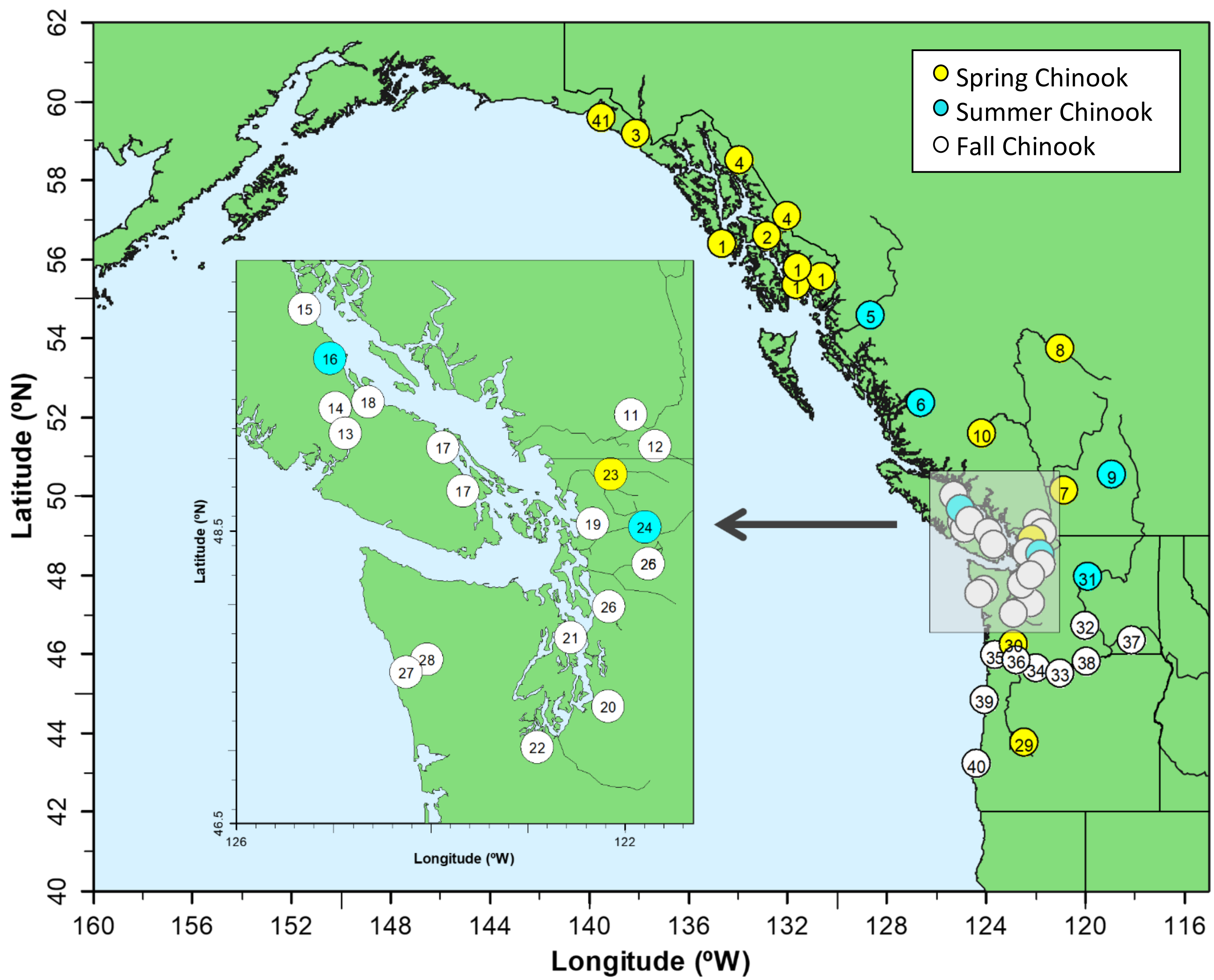

Figure 1.2.—Geographical locations of Phase II PSC Chinook Model stock groups.

Note: See Table 1.1 for the full stock names associated with each abbreviation and map indicator.

Table 1.1.—Stock groups used in the Phase II PSC Chinook Model, associated CWT indicator(s), location, run type, smolt age, and map indicator.

Area	Model Stock	CWT Indicator	Run Type	Smolt Age	Map ID
Southeast Alaska	Southern Southeast Alaska (SSA)	Whitman Lake (AHC), Little Port Walter (ALP), Deer Mountain (ADM), Neets Bay (ANB)	Spring	Age 1	1
	Northern Southeast Alaska (NSA)	Crystal Lake (ACI)	Spring	Age 1	2
Transboundary	Alsek (ALS)	Wild – No indicator	Spring	Age 1	3
	Taku and Stikine (TST)	Wild Taku and Stikine Rivers	Spring	Age 1	4
	Yakutat Forelands (YAK)	Wild – No indicator	Spring	Age 1	41
North/Central British Columbia	Northern B.C. (NBC)	Kitsumkalum (KLM)	Summer	Age 0	5
	Central B.C. (CBC)	Atnarko (ATN)	Summer	Age 1	6
West Coast Vancouver Island	WCVI Hatchery (WVH)	Robertson Creek (RBT)	Fall	Age 0	13
	WCVI Natural (WVN)	Robertson Creek (RBT)	Fall	Age 0	14
Strait of Georgia	Upper Strait of Georgia (UGS)	Quinsam (QUI)	Fall	Age 0	15
	Middle Strait of Georgia (MGS)	Big Qualicum (BQR)	Fall	Age 0	18
	Puntledge Summers (PPS)	Puntledge (PPS)	Summer	Age 0	16
	Lower Strait of Georgia (LGS)	Cowichan (COW); Nanaimo (NAN)[1]	Fall	Age 0	17
Fraser River	Fraser Spring 1.2 (FS2)	Nicola (NIC)	Spring	Age 1	7
	Fraser Spring 1.3 (FS3)	Dome (DOM)[2]	Spring	Age 1	8
	Fraser Ocean-type 0.3 (FSO)	Lower Shuswap (SHU)	Summer	Age 0	9
	Fraser Summer Stream-type 1.3 (FSS)	Chilko (CKO)	Summer	Age 1	10
	Fraser Harrison Fall (FHF)	Harrison (HAR)	Fall	Age 0	11
	Fraser Chilliwack Fall Hatchery (FCF)	Chilliwack (CHI)	Fall	Age 0	12
North Puget Sound	Nooksack Spring (NKS)	Nooksack Spring Fingerling (NSF)	Spring	Age 0	23
	Nooksack Fall (NKF)	Samish Fall Fingerling[3] (SAM)	Summer/Fall	Age 0	19
	Skagit Wild (SKG)	Skagit Summer Fingerling (SSF)	Summer	Age 0	24
	Stillaguamish Wild (STL)	Stillaguamish Fall Fingerling (STL)	Summer/Fall	Age 0	25
	Snohomish Wild (SNO)	Snohomish Wild (SNO)	Summer/Fall	Age 0	26
South Puget Sound	Puget Sound Fingerling (PSF)	S. Puget Sound Fall Fingerling[3] (SPS)	Summer/Fall	Age 0	20
	Puget Sound Natural Fall (PSN)	S. Puget Sound Fall Fingerling[3] (SPS)	Summer/Fall	Age 0	21
	Puget Sound Yearling (PSY)	South Puget Sound Fall Yearling (SPY); University of Washington Accelerated (UWA)[4]	Summer/Fall	Age 1	22
Washington Coast	Washington Coast Natural (WCN)	Hoko Fall Fingerling (HOK)	Fall	Age 0	28
	Washington Coast Hatchery (WCH)	Queets Fall Fingerling (QUE); Tsoo-Yess Fall Fingerling (SOO)	Fall	Age 0	27
Columbia River	Lower Bonneville Hatchery (BON)	Columbia Lower River Hatchery[3] (LRH)	Fall Tule	Age 0	34
	Fall Cowlitz Hatchery (CWF)	Cowlitz Tule (CWF)	Fall Tule	Age 0	35
	Cowlitz Spring Hatchery (CWS)	Cowlitz Spring Hatchery (CWS)	Spring	Age 1	30
	Lewis River Wild (LRW)	Lewis River Wild (LRW)	Fall Bright	Age 0	36
	Spring Creek Hatchery (SPR)	Spring Creek Tule[3] (SPR)	Fall Tule	Age 0	33
	Willamette River Spring (WSH)	Willamette Spring[3] (WSH)	Spring	Age 1	29
	Mid-Columbia River Brights	Mid-Columbia River Brights (MCB)	Fall	Age 0	38
	Columbia River Summer (SUM)	Columbia Summers[5] (WA) (SUM)	Summer	Age 0/1	31
	Upriver Brights (URB)	Columbia Upriver Bright (URB)[1]	Fall Bright	Age 0	32
Snake River	Lyons Ferry (LYF)	Lyons Ferry[3,5] (LYF)	Fall Bright	Age 0	37
North Oregon Coast	North Oregon Coast (NOC)	Salmon (SRH)	Fall	Age 0	39
Mid Oregon Coast	Mid-Oregon Coast (MOC)	Elk River (ELK)	Fall	Age 0	40

[1] Tagged releases for the Nanaimo Fall stock were discontinued after the 2004 brood.
[2] Hatchery production of the Dome Creek stock was discontinued after the 2002 brood.
[3] Double index tags (DIT) associated with this stock.
[4] The last year included in the exploitation rate analysis for University of Washington Accelerated was 1984.
[5] Subyearlings have been CWT-tagged since brood year (BY) 1986, except for BYs 1993–1997.

2. PSC Chinook Model Calibration and Output

The annual calibration of the PSC Chinook Model provides pre-season abundance indices (AIs) and post-season AIs for the previous year for the three aggregate abundance-based management (AABM) fisheries. The AI is the ratio between the expected catch in the year of interest (e.g., 2021) under base period exploitation patterns and the estimated average catch during the 1979–1982 base period. The 2021 pre-season AIs are used to determine the allowable catch limits (ACLs) of Treaty Chinook salmon in the Northern British Columbia (NBC) and West Coast Vancouver Island (WCVI) AABM fisheries for 2021. The pre-season ACL for the Southeast Alaska (SEAK) AABM fishery was determined by the SEAK early winter District 113 Troll fishery catch per unit effort (CPUE) metric. Post-season AIs are used to determine the previous season's ACLs (2020) for all three AABM fisheries and to evaluate PSC Chinook Model error. For additional calibration details, including key input data, procedures, and output data, see Appendix H. For details on improvements to the PSC Chinook Model see Section 4.

2.1 Overview of 2021 Calibration Process

The CTC Analytical Work Group (AWG) met remotely in March 2021 to perform the PSC Chinook Model calibration for use in the upcoming fishing year. Conducting the calibration remotely was challenging and a calibration was not produced during the initial meeting week. As was the case in 2020, compiling maturity rates for the PSC Chinook Model was the primary impediment to completing the final calibration. Several preliminary calibrations were produced after the initial meeting week and the AWG agreed to endorse calibration CLB 2104. In late March, the CTC produced its annual memo to the PSC detailing the 2020 post-season AIs, 2021 pre-season AIs and ACLs for the AABM fisheries based on CLB 2104 and the SEAK early-winter Troll fishery CPUE index (per the 2019 PST Agreement; see details in section 3.1). Model calibrations are named with the last two digits of the year (21) and the iteration of the calibration (04).

The 2020 pre-season ACL for the SEAK fishery, obtained from the early winter Troll CPUE, was determined from Table 2 in Chapter 3 of the 2019 PST Agreement. The 2020 CPUE-derived pre-season ACL indicated that SEAK abundance was in Tier 4 of Table 2. CLB 2104 indicated that the 2020 post-season ACL corresponded to an abundance in Tier 3 of Table 2, resulting in a discrepancy between pre-season and post-season catch limits. While a discrepancy occurred between tiers determined by the early winter CPUE pre-season AI and the Model post-season AI, two other empirical estimators used internally by Alaska Department of Fish and Game (Early/Late Winter and Summer Power Troll Indices) indicated the SEAK ACL in 2020 was in Tier 4. These discrepancies are being investigated following the 2019 PST Agreement.

2.2 AABM Abundance Indices

The AABM fishery management regime relies on data for catches and incidental mortality (IM), fishing effort, fishery impacts (coded-wire tag [CWT] indices), and the AIs generated by the PSC Chinook Model. The PSC Chinook Model uses catch data (i.e., encountered fish that are either kept or released), escapement data, CWT recovery data, and abundance forecasts to predict the AI for the upcoming year and to estimate the time series of AIs since 1979 (including the post-season AIs).

The PST specifies that AABM fisheries are to be managed using pre-season AIs, where a fishery given AI corresponds to a specific ACL for each AABM fishery (Table 1 of Chapter 3 of the 2019 PST Agreement). The 2019 PST Agreement continues the use of pre-season AIs for NBC and WCVI AABM fisheries and establishes a CPUE metric to set ACLs for the SEAK AABM fishery. Pre-season AIs that were used to establish ACLs are listed in Table 2.1 along with the CPUE metric used to set the pre-season SEAK ACLs, beginning in 2019. The 2021 pre-season AI was 1.27 for the NBC AABM fishery and 0.76 for the WCVI AABM fishery; the 2021 CPUE metric was 3.85 for the SEAK AABM fishery.

In October 2019 the PSC adopted the new "Phase II" configuration of the PSC Chinook Model for use beginning with the 2020 annual model calibration. The Phase II configuration of the PSC Chinook Model is based on an updated base period calibration (BPC) that includes improved finer scale stock and fishery stratifications (CTC 2021a; CTC 2021b; CTC *in prep.*). During the 2021 calibration process, an error was identified in some of the maturation rates used as inputs to the CTC approved calibration in 2020 (CLB 2002). These errors were corrected in CLB 2003, which yielded 2020 pre-season AIs of 1.02, 1.00, and 0.69 for SEAK, NBC, and WCVI, respectively.

Post-season AIs are more accurate estimates of the AIs for the AABM fisheries than are the pre-season AIs because they contain empirical return data rather than forecasts. Thus, the Treaty establishes post-season fishery limits (*a posteriori* limits to which the already prosecuted fishery is held accountable rather than the projected *a priori* pre-season limits) based on the first post-season AI that is calculated each year, although other iterations may occur as more information is gathered. Post-season AIs for 1999–2020 are listed Table 2.1.

In response to coastwide conservation concerns, the 2009 PST Agreement called for reduced catches and associated harvest rates in the SEAK and WCVI AABM fisheries. AABM catches prescribed for 2009–2018 included negotiated reductions of 15% in SEAK and 30% in WCVI, but the NBC AABM fishery retained the same ACLs and harvest rates specified in the 1999 PST Agreement (Pacific Salmon Commission 2009). Similarly, in response to coastwide concerns over Chinook productivity and an emerging concern over the viability of the Southern Resident Killer Whale population which have a diet reliant on Chinook salmon, the 2019 PST Agreement called for additional reductions in catches and associated harvest rates in the SEAK and WCVI AABM fisheries. AABM catches prescribed for 2019–2028 include negotiated reductions of up to 7.5% in SEAK (based on CPUE tiers) and 12.5% in WCVI, but the NBC AABM fishery retained the same ACLs and harvest rates specified in the 1999 PST Agreement.

Table 2.1.—Abundance Indices for 1999–2021 for the Southeast Alaska (SEAK), Northern British Columbia (NBC), and West Coast Vancouver Island (WCVI) aggregate abundance-based management (AABM) fisheries. Post-season values for each year are from the first post-season calibration following the fishing year.

	SEAK		NBC		WCVI	
Year	Pre-season	Post-season	Pre-season	Post-season	Pre-season	Post-season
1999	1.15	1.12	1.12	0.97	0.60	0.50
2000	1.14	1.10	1.00	0.95	0.54	0.47
2001	1.14	1.29	1.02	1.22	0.66	0.68
2002	1.74	1.82	1.45	1.63	0.95	0.92
2003	1.79	2.17	1.48	1.90	0.85	1.10
2004	1.88	2.06	1.67	1.83	0.90	0.98
2005	2.05	1.90	1.69	1.65	0.88	0.84
2006	1.69	1.73	1.53	1.50	0.75	0.68
2007	1.60	1.34	1.35	1.10	0.67	0.57
2008	1.07	1.01	0.96	0.93	0.76	0.64
2009	1.33	1.20	1.10	1.07	0.72	0.61
2010	1.35	1.31	1.17	1.23	0.96	0.95
2011	1.69	1.62	1.38	1.41	1.15	0.90
2012	1.52	1.24[1]	1.32	1.15[1]	0.89	0.76[1]
2013	1.20[1]	1.63	1.10[1]	1.51	0.77[1]	1.04
2014[2]	2.57	2.20	1.99	1.80	1.20	1.12
2015[2]	1.45	1.95	1.23	1.69	0.85	1.05
2016	2.06	1.65	1.70	1.39	0.89	0.70
2017	1.27	1.31	1.15	1.14	0.77	0.64
2018	1.07	0.92	1.01	0.89	0.59	0.59
2019[3]	1.07 (3.38)[5]	1.04	0.96	0.94	0.61	0.58
2020[4]	1.13 (4.83)[5]	1.11	1.08	1.16	0.75	0.67
2021	1.28 (3.85)[5]		1.27		0.76	

[1] Due to changes in calibration procedures (reviewed in section Appendix H), 2012 post-season (CLB 1309) and 2013 pre-season (CLB 1308) AIs are based on different calibrations; the procedures and assumptions CLB 1309 mirror those used during the 2012 pre-season calibration.
[2] Due to a disagreement over Model calibration 1503, the Commission agreed to use CLB 1602 to estimate the 2014 and 2015 post-season AIs and 2016 pre-season AI.
[3] Post-season AIs are from CLB 2000–9806 (old model configuration).
[4] Pre-season AIs are from CLB 2002 (Phase II model configuration). During the 2021 Calibration process, an error was identified in some of the maturation rates used as inputs to CLB 2002. These errors were corrected in CLB 2003, which yielded 2020 pre-season AIs of 1.02, 1.00, and 0.69 for SEAK, NBC, and WCVI, respectively.
[5] Per paragraph 6(b) of the 2019 PST Agreement, the number in parentheses represents a CPUE statistic used to determine the ACL.

2.3 STOCK COMPOSITION OF ABUNDANCES AVAILABLE IN AABM FISHERIES, 1979–2020

Most catches in each AABM fishery are comprised of the small subset of geographically similar stocks listed in Appendix A. Figure 2.1–Figure 2.3 show the post-season AIs (resulting from CLB 2104) partitioned into geographic stock groups (Table 2.2) using a combination of CWT and genetic data. In general, post-season AIs had peaks during the late 1980s (1987–1989), in 2003 and 2004, and in 2014 and 2015.

Table 2.2.—Stock groupings comprising AABM fisheries.

SEAK/TBR	Southeast Alaska and Transboundary River stocks (Southern and Northern Southeast Alaska, Alsek, Taku and Stikine, and Yakutat Forelands)
NCBC	North and Central British Columbia stocks
WCVI	West Coast Vancouver Island stocks (hatchery and natural)
SG	Strait of Georgia stocks (Upper, Middle, Lower, and Puntledge Summers)
FR-early	Fraser River Early stocks (Fraser Spring 1.2 and 1.3, Fraser Summer Ocean-type 0.3 and Stream-type 1.3)
FR-late	Fraser River Late stocks (Harrison Fall, Chilliwack Fall Hatchery)
PSD	Puget Sound stocks (Nooksack Fall and Spring, Puget Sound Natural Fall, Puget Sound Fingerlings and Yearlings, Skagit Wild, Stillaguamish Wild, and Snohomish Wild)
WACST	Washington Coast stocks (hatchery and wild)
CR-sp&su	Columbia River Spring and Summer stocks (Willamette, Spring Cowlitz Hatchery, and Columbia Summers)
CR-bright	Columbia River Fall Bright stocks (Upriver, Mid-Columbia, Lewis River Wild, and Lyons Ferry)
CR-tule	Columbia River-Fall Tule stocks (Spring Creek, Lower Bonneville, and Fall Cowlitz Hatchery)
ORCST	North and Mid-Oregon Coast stocks

The major stock groups contributing to the SEAK AIs are Columbia River Brights, WCVI, Oregon Coast, Fraser Early, SEAK/Transboundary Rivers and Washington Coast (Figure 2.1). Since 1999, the average contribution to the SEAK AIs for these stock groups has been 48%, 25%, 16%, 12%, 11% and 11% respectively.

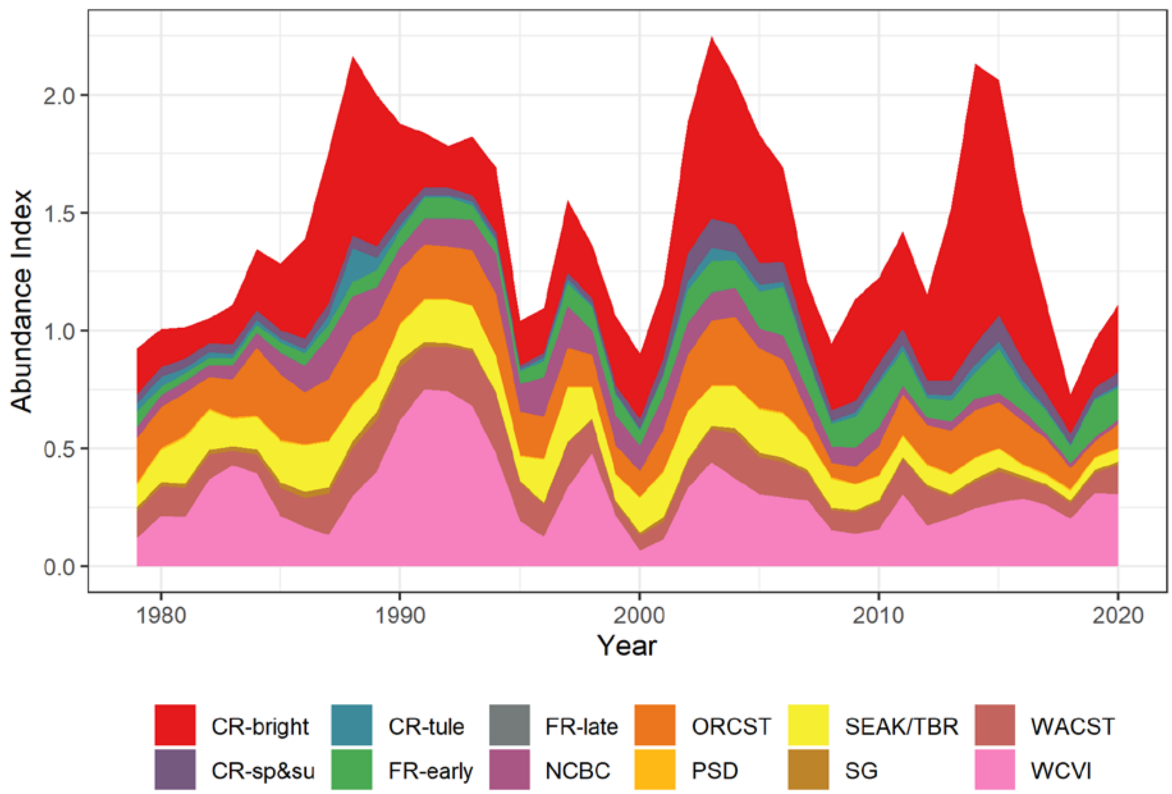

Figure 2.1.—Stock composition of the annual abundance indices for the SEAK Troll fishery from CLB 2104.

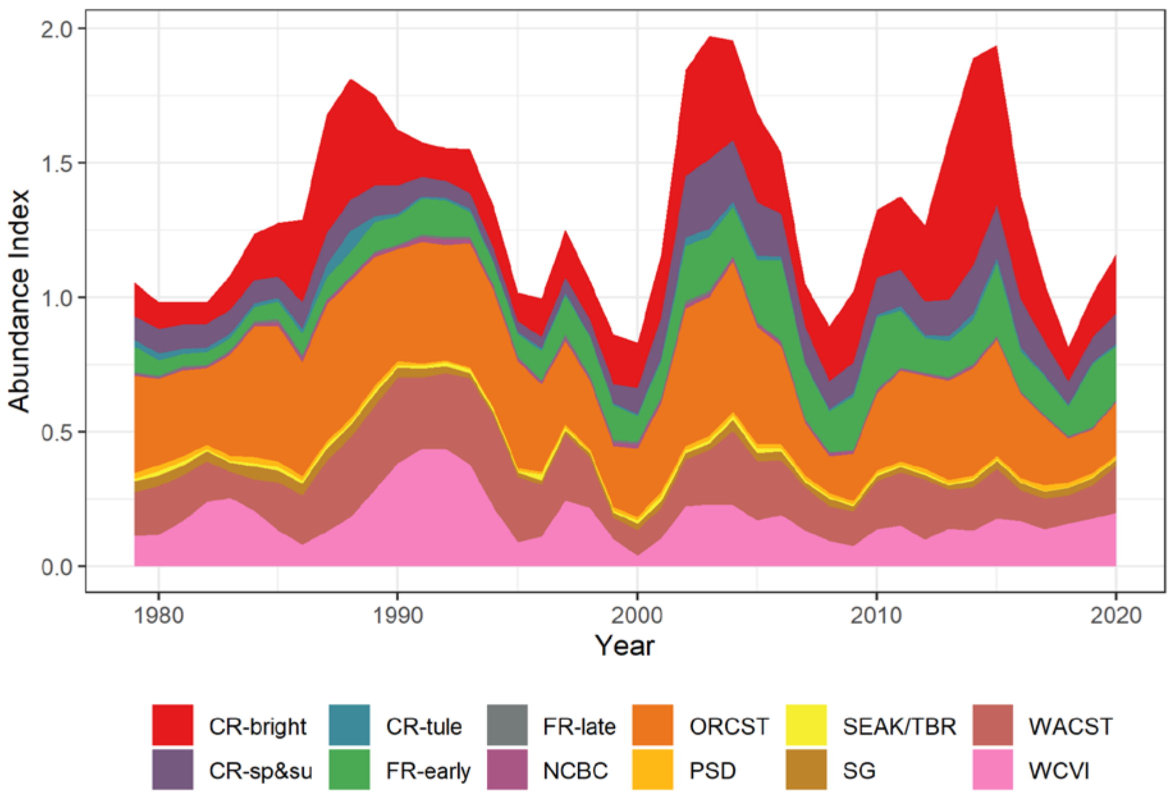

Figure 2.2.—Stock composition of the abundance indices for the Northern B.C. Troll fishery from CLB 2104.

The major stock groups contributing to the NBC AIs are Oregon Coast, Columbia River Brights, Fraser Early, Washington Coast, Columbia Spring/Summer and WCVI (Figure 2.2). Since 1999, the average contribution to the NBC AIs for these stock groups has been 32%, 31%, 18%, 16%, 15% and 15% respectively.

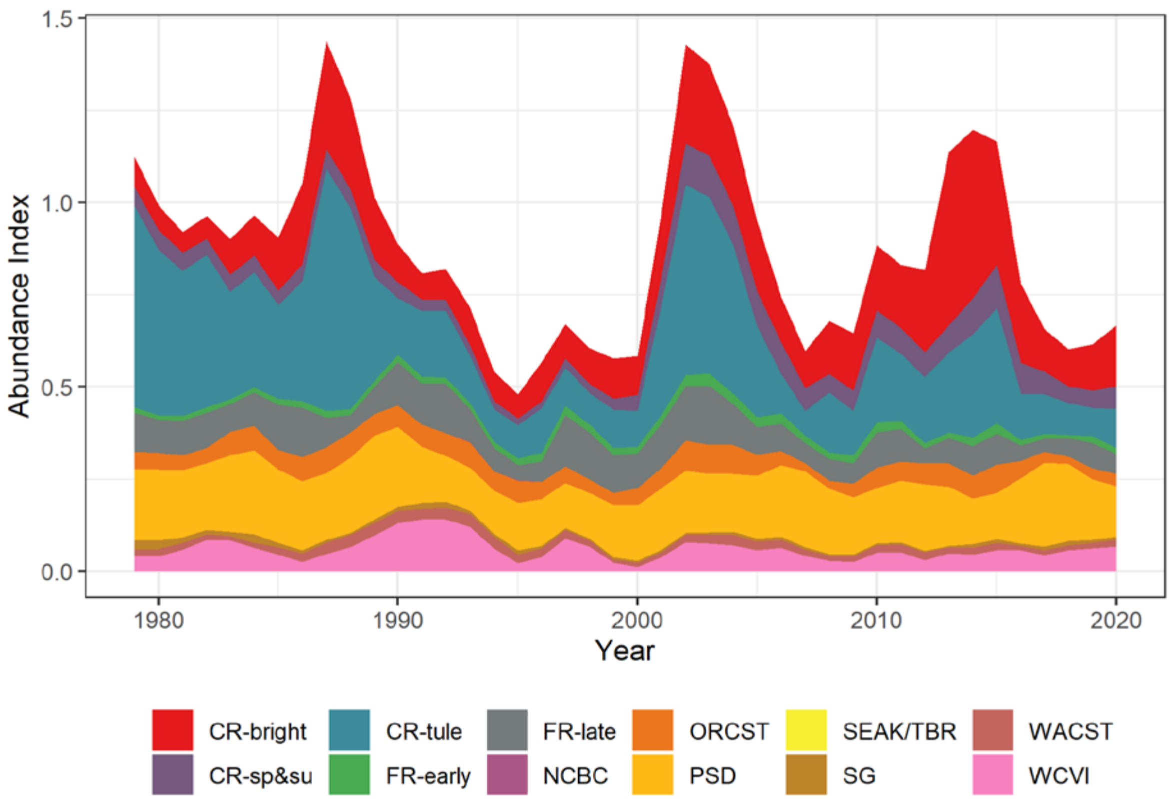

Figure 2.3.—Stock composition of the abundance indices for the WCVI Troll fishery from CLB 2104.

The major stock groups contributing to the WCVI AIs are Columbia River Tules, Columbia River Brights, Puget Sound, Fraser Late and Columbia Spring/Summer (Figure 2.3). Since 1999, the average contribution to the WCVI AIs for these stock groups has been 20%, 20%, 17%, 8% and 7% respectively.

For additional stock composition information, see Appendix B and Appendix F which partitions catches and post-season AIs by the 41 PSC Chinook Model stock stratification. For additional fishery information, see Appendix C for Model-generated stock composition estimates for all fisheries (AABM and ISBM).

3. AABM Fishery Performance

The 2019 PST Agreement defines an AABM fishery as "*an abundance-based regime that constrains catch or total mortality to a numerical limit computed from either a pre-season forecast or an in-season estimate of abundance, from which a harvest rate index can be calculated, expressed as a proportion of the 1979 to 1982 base period*" per paragraph 3(a). The 2019 PST Agreement identified three such fisheries to be managed under an AABM regime: (1) SEAK troll, net, and sport, (2) NBC troll and Haida Gwaii sport, and (3) WCVI troll and outside sport. The CTC is tasked with evaluating AABM fishery performance relative to the obligations set forth in paragraphs 6 and 7 annually (Figure 3.1).

3.1 AABM Management Framework

Paragraph 6(a) of the 2019 PST Agreement specifies that "*the SEAK, NBC, and WCVI AABM fisheries shall be abundance based with the annual catch limits specified in Table 1 (catch limits specified for AABM fisheries at levels of the Chinook abundance index)*" and "*Table 2 (catch limits for the SEAK AABM fishery and the catch per unit effort (CPUE)-based tiers)*". Under previous PST Agreements, annual catch limits (ACLs) were determined from Table 1 in Chapter 3 of the 1999 and 2009 PST Agreements. In the 2009 and 2019 PST Agreements, the relationships between the abundance indices (AIs) and the ACLs changed for SEAK and WCVI from the 1999 PST Agreement; thus, Table 1 has been revised for each successive PST Agreement. The 2019 PST Agreement also contains a new Table 2 which identifies seven catch tiers for the SEAK AABM fishery. The early winter CPUE from the SEAK Troll fishery in District 113 during statistical weeks 41–48 (October–November) determines the pre-season SEAK tier level and the associated ACLs using Table 2. The post-season tier level for SEAK is also determined using Table 2 and the SEAK AI from the post-season calibration of the PSC Chinook Model.

The CTC is tasked with reporting AABM fishery performance for each fishing year relative to pre-season and post-season ACLs. The differences between actual catches and ACLs are the result of two processes: 1) *management error*, defined here as the difference between the actual catch and the pre-season ACL; and 2) *model error* which is the difference between the pre-season ACL and the post-season ACL. The term *management error* is used but that it may be a misnomer in many situations as the deviations of actual catch from the pre-season ACLs may have been the result of deliberate actions. The combination of management error and model error is referred to as *composite error*. Poor performance is generally greatest when management error and model error are in the same direction. Improved performances can also be the result of management errors in the opposite direction of model errors, thereby cancelling out portions of these different deviations. The relative influence of each type of error is evaluated by inspecting differences in actual landed catch and ACLs from both the pre-season calibration or CPUE statistic and the post-season calibration.

Since the 2019 PST Agreement establishes a new method for setting SEAK AABM fishery limits, the Treaty calls for a comparison of the new CPUE-based approach and the existing PSC Chinook Model AI-based approach. Paragraph 7(d) states that the CTC conducts "*up to two reviews of the CPUE-based approach*" with the *"first review occurring as soon as practical after* *the 2022 post-season AI is calculated and the second review as soon as practical after the 2025 post-season AI is calculated."* The 2019 PST Agreement AABM management framework is diagrammed in Figure 3.1.

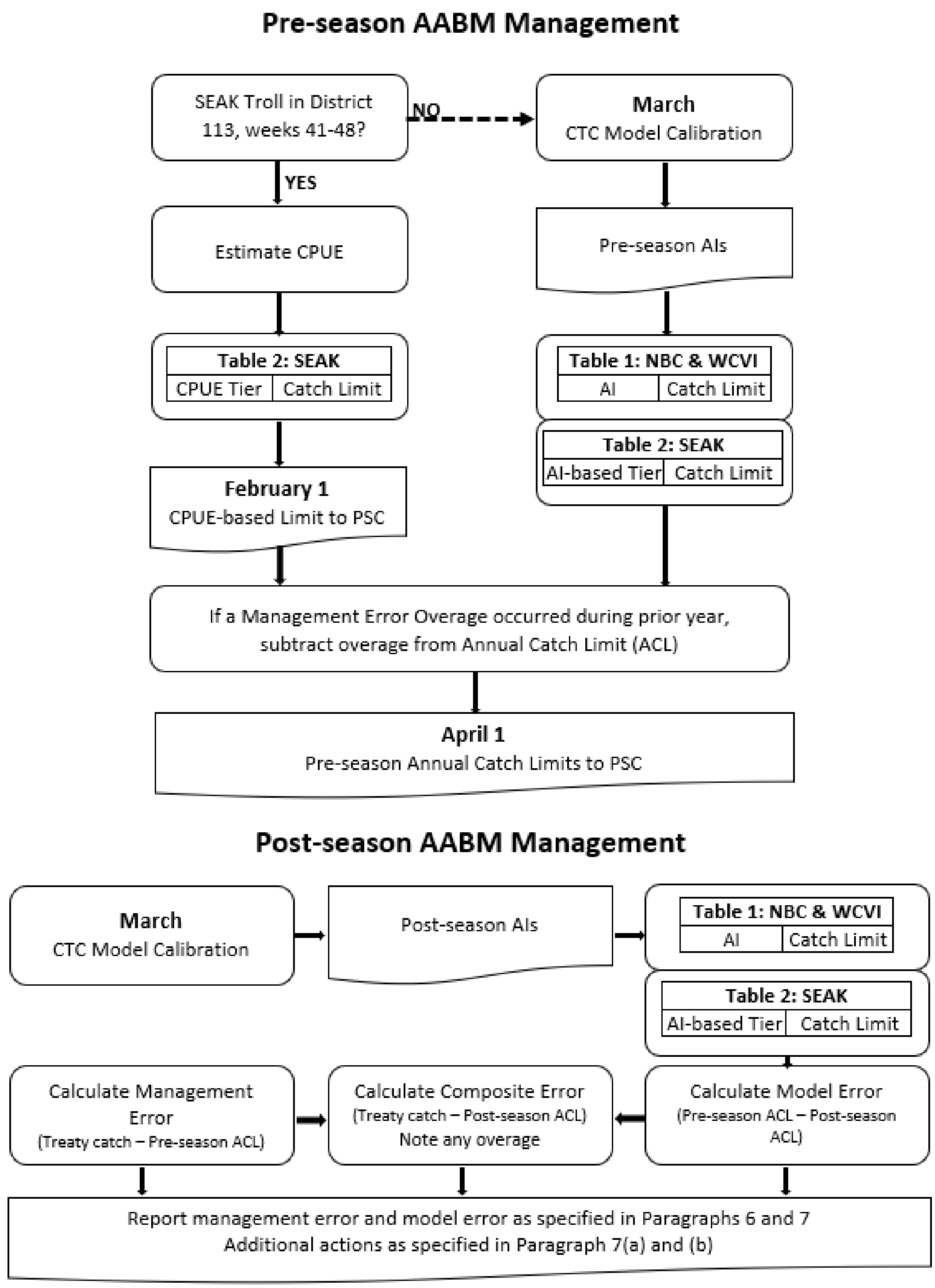

Figure 3.1.—Flow diagrams depicting the sequence of steps for pre-season (top) and post-season (bottom) aggregate abundance-based management (AABM) fisheries management framework under the 2019 PST Agreement.

3.2 Actual catches vs pre-season and post-season annual catch limits

In 2020, the actual catches in SEAK, NBC, and WCVI AABM fisheries were all below pre-season ACLs. Actual landed catch was less than the pre-season ACLs by 541 in SEAK, 96,817 in NBC, and 43,419 in WCVI. In terms of the post-season ACLs for evaluation of the provisions of the PST (paragraph 6(g)), 2020 actual catches were greater than the post-season ACL by 64,301 fish in SEAK, and less than the post-season ACL by 105,597 fish in NBC and 34,919 fish in WCVI. Pre-season ACLs, post-season ACLs, and actual catches are provided in Table 3.1.

Though management, model, and composite error are related concepts, they are considered and evaluated independently per Chapter 3 of the 2019 PST Agreement (Table 3.2). Overall, the performance of AABM fisheries in 2020, as measured by management error (the difference between actual catch and pre-season ACL) was good with catches in all three fisheries below the ACL. Percent differences from the pre-season ACL were 0% in SEAK, -73% in NBC, and -50% in WCVI. The management error in NBC and WCVI was due to travel and other targeted health restrictions related to the COVID-19 pandemic, which resulted in delayed fisheries and a decrease in fishing effort (PSC 2021). Additionally, deliberate management actions by Fisheries and Oceans Canada to conserve Chinook salmon were in place for NBC (PSC 2021, CTC 2021c).

Per paragraph 7(b), relative to post-season ACLs "*overages are of particular concern.*" Both model and composite error are used to monitor overages. Model error (the difference between pre-season ACL and post-season ACL) ranged from -8,700 in WCVI to 64,842 in SEAK. Percent differences from the post-season ACL were 46% in SEAK, -6% in NBC, and 11% in WCVI. Composite error (the difference between actual catch and post-season ACL) ranged from -105,597 in WCVI to 64,301 in SEAK. Percent difference from the post-season ACL were 46% in SEAK, -75% in NBC, and -44% in WCVI. In 2020, only the SEAK fishery experienced a composite error overage; the magnitude of this error is a function of the tiered catch limit management system that the SEAK AABM fishery operates under as defined in paragraph 6 and Table 2. The tiers are binned in 30,000–60,000 fish increments such that a mismatch between the pre-season and post-season ACL will necessarily result in a large model error and composite error. It is currently unknown whether COVID-related impacts on the collection of stock assessment data had an effect on model error.

Table 3.1.—Pre-season annual catch limits (ACLs) for 1999–2021, and post-season ACLs and actual catches for 1999–2020, for aggregate abundance-based management (AABM) fisheries. Post-season values for each year are from the first post-season calibration following the fishing year.

	SEAK (Troll, Net, Sport)			NBC (Troll, Sport)			WCVI (Troll, Sport)		
Year	Pre-season ACL	Post-season ACL	Actual Catch	Pre-season ACL	Post-season ACL	Actual Catch	Pre-season ACL	Post-season ACL	Actual Catch
1999	192,800	184,200	198,842	145,600	126,100	84,324	128,300	107,000	38,540
2000	189,900	178,500	186,493	130,000	123,500	32,048	115,500	86,200	88,617

Year	SEAK (Troll, Net, Sport)			NBC (Troll, Sport)			WCVI (Troll, Sport)		
	Pre-season ACL	Post-season ACL	Actual Catch	Pre-season ACL	Post-season ACL	Actual Catch	Pre-season ACL	Post-season ACL	Actual Catch
2001	189,900	250,300	186,919	132,600	158,900	43,334	141,200	145,500	120,304
2002	356,500	371,900	357,133	192,700	237,800	149,831	203,200	196,800	157,920
2003	366,100	439,600	380,152	197,100	277,200	194,797	181,800	268,900	173,561
2004	383,500	418,300	417,019	243,600	267,000	241,508	192,500	209,600	215,252
2005	416,400	387,400	388,640	246,600	240,700	243,606	188,200	179,700	199,479
2006	346,800	354,500	360,094	223,200	200,000	215,985	160,400	145,500	145,511
2007	329,400	259,200	328,268	178,000	143,000	144,235	143,300	121,900	140,614
2008	170,000	152,900	172,905	124,800	120,900	95,647	162,600	136,900	145,726
2009	218,800	176,000	227,954	143,000	139,100	109,470	107,800	91,300	124,617
2010	221,800	215,800	230,611	152,100	160,400	136,613	143,700	142,300	139,047
2011	294,800	283,300	291,161	182,400	186,800	122,660	196,800	134,800	204,232
2012	266,800	205,100	242,821	173,600	149,500	120,307	133,300	113,800	135,210
2013	176,000	284,900	191,388	143,000	220,300	115,914	115,300	178,000	116,871
2014[1]	439,400	378,600	435,195	290,300	262,600	216,901	205,400	191,700	192,705
2015[1]	237,000	337,500	335,026	160,400	246,600	158,903	127,300	179,700	118,974
2016	355,600	288,200	350,939	248,000	183,900	190,181	133,300	104,800	103,093
2017	209,700	215,800	175,414	149,500	148,200	143,330	115,300	95,800	117,416
2018	144,500	118,700	127,776	131,300	115,700	108,976	88,300	88,300	85,330
2019[3]	140,323[2]	140,323	140,307	124,800	122,200	88,026	79,900	76,000	73,482
2020[4]	205,165[2]	140,323	204,624	133,000	141,700	36,183	87,000	78,500	43,581
2021	205,165[2]			153,800			88,000		

[1] Due to a disagreement over Model calibration 1503, the Commission agreed to use output from CLB 1602 to estimate the catches associated with the 2014 and 2015 post-season AIs and 2016 pre-season AIs.
[2] Per paragraph 6(b) of the 2019 PST Agreement, this number represents an ACL based on a CPUE statistic.
[3] Post-season ACLs are based on AIs from CLB 2000–9806 (old model configuration).
[4] Pre-season ACLs are based on AIs from CLB 2002 (Phase II model configuration).

Table 3.2.—Summary of aggregate abundance-based management (AABM) fishery performance and deviations between pre- and post-season annual catch limits (ACLs) and actual catches for Southeast Alaska (SEAK), Northern British Columbia (NBC), and West Coast Vancouver Island (WCVI), 2019–2020.

Positive values indicate an overage and negative values indicate an underage. Colored cells indicate AABM fishery performance relative to Treaty obligations; cells shaded green indicate where a fishery met Treaty obligations and red cells indicate where a fishery exceeded Treaty obligations.

	Management Error Actual Catch – Pre ACL		Model Error Pre ACL – Post ACL		Composite Error Actual Catch – Post ACL	
Year	#	%	#	%	#	%
SEAK (Troll, Net, Sport)						
2019	-16	0%	0	0%	-16	0%
2020	-541	0%	64,842	46%	64,301	46%
NBC (Troll, Sport)						
2019	-36,774	-29%	2,600	2%	-34,174	-28%
2020	-96,817	-73%	-8,700	-6%	-105,597	-75%
WCVI (Troll, Sport)						
2019	-6,418	-8%	3,900	5%	-2,518	-3%
2020	-43,419	-50%	8,500	11%	-34,919	-44%

3.2.1 Southeast Alaska Aggregate Abundance-Based Management Fishery

Average management error was 1% for SEAK across the 1999–2018 time series and ranged between -16% and 41%[2]. Average management error was 1% in the 1999–2008 time period and 2% across the 2009–2018 time period (Figure 3.2). The difference in the average management error in the 2009 PST Agreement period was driven by the large deviation in 2015 (41%). Model error ranged from -38% to 30% but averaged 3% to 5% for the time periods examined. Deviation of actual catch in SEAK from post-season ACLs was largely driven by model error. SEAK management error was relatively small in all years except 2015 and was in the opposite direction of the model error in 7 of the 10 years between 2009–2018 (Figure 3.2). In 2020, management error was 0% and model error was 46% (Table 3.2).

[2] Historical error data are provided in CTC (2021d).

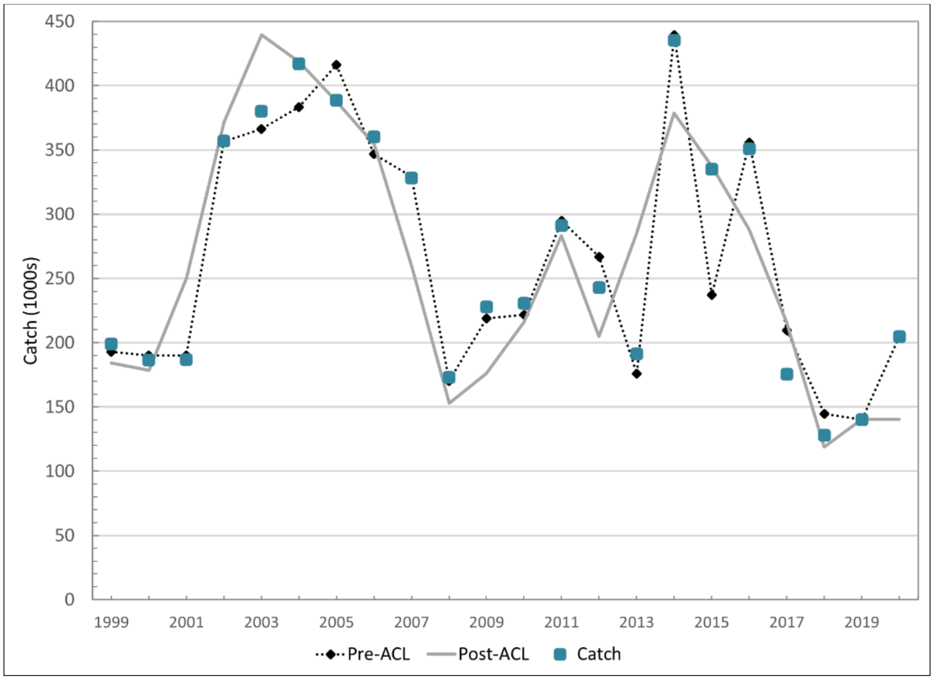

Figure 3.2.—Performance of Southeast Alaska aggregate abundance-based management (AABM) fishery annual catch limits (ACLs) and model metrics, 1999–2020.

3.2.2 Northern British Columbia Aggregate Abundance-Based Management Fishery

NBC actual catch was consistently below the pre-season ACL with an average of -22% from 1999–2018 (range -1% to -75%; Figure 3.3)[2]. The average NBC catch was -26% below the pre-season ACLs from 1999–2008 and -19% from 2009–2018. Management errors in NBC were the result of Canada's domestic efforts to reduce impacts on WCVI-origin Chinook. Management error in the NBC fishery was near zero from 2003 to 2006 and in 2015 and 2017, but catches were significantly below the ACL in all other years except 2016 (Figure 3.3). Management actions in NBC outweighed model errors in most years with a -23% average error between the observed catch and the post-season ACL. In 2020, model error was -6% and conservative management actions combined with impacts from COVID-19 resulted in an actual catch 73% and 75% below the pre- and post-season ACLs, respectively (Table 3.2).

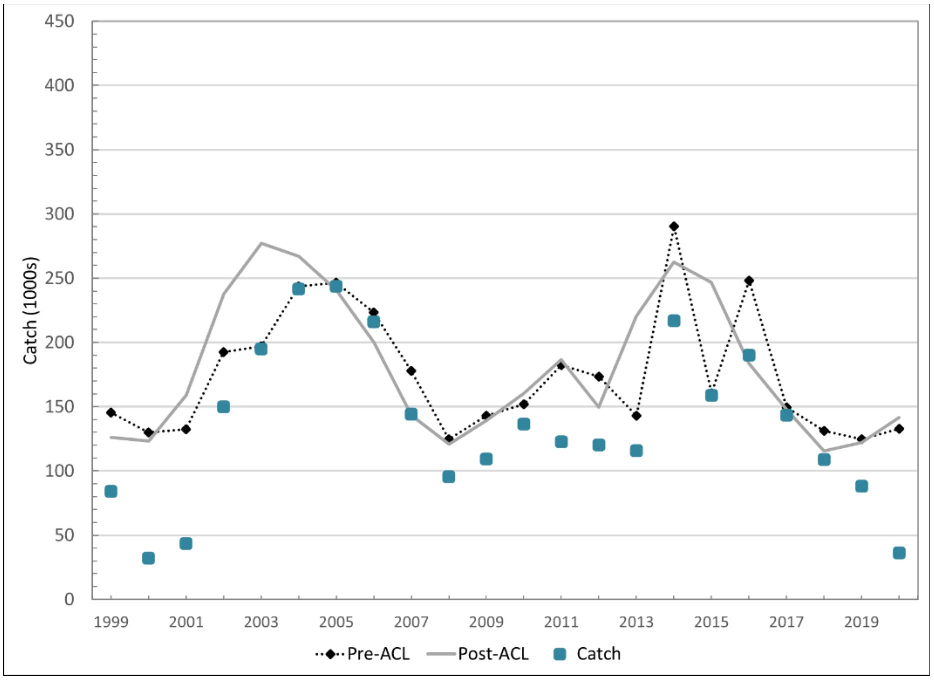

Figure 3.3.—Performance of Northern British Columbia aggregate abundance-based management (AABM) fishery annual catch limits (ACLs) and model metrics, 1999–2020.

3.2.3 West Coast Vancouver Island Aggregate Abundance-Based Management Fishery

Average management error in WCVI was -8% from 1999 to 2018 with more negative values in the beginning of the time series resulting in averages of -14% from 1999–2008 and -2% from 2009–2018 (Figure 3.4)[3]. The deviations of actual catch from the post-season ACL in WCVI ranged from -64% to 52%. Although management error in WCVI played a larger role than model errors in the deviation from the post-season ACL, model errors made up the largest component of the deviations. In 5 of 10 years during the 2009–2018 time series, the WCVI management and model errors occurred in a common direction. In 2010, 2014, 2018, and 2019 both model and management errors were small (Figure 3.4; Table 3.2). In 2020, management error was -50% owing to conservative management actions and impacts of COVID-19; model error was 11%

[3] Historical error data are provided in CTC (2021d).

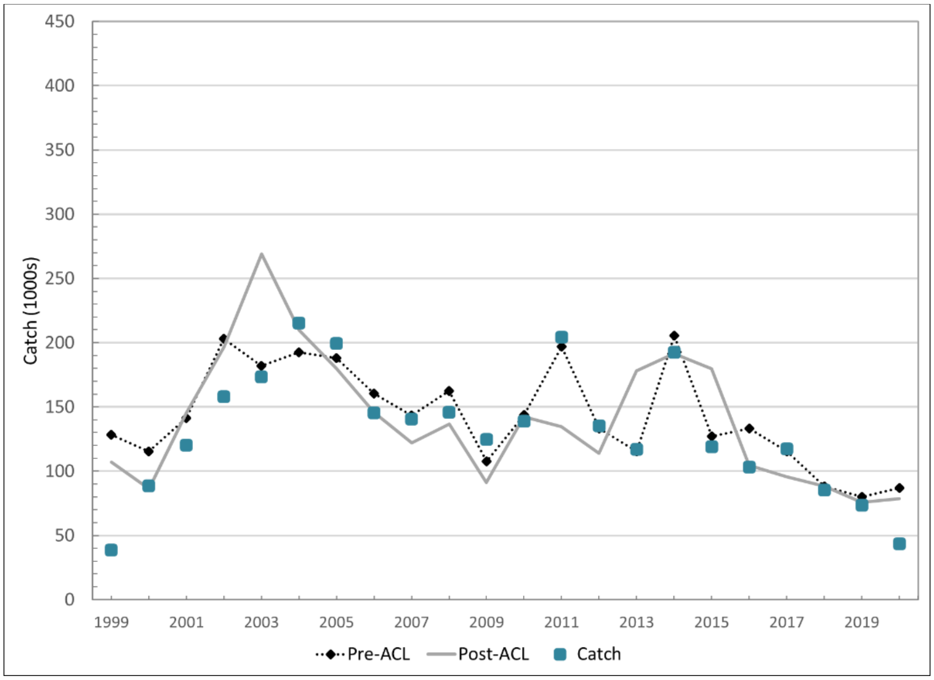

Figure 3.4.—Performance of West Coast Vancouver Island aggregate abundance-based management (AABM) fishery annual catch limits (ACLs) and model metrics, 1999–2020.

3.3 Performance Evaluation

Paragraph 7 of the 2019 PST Agreement defines the accountability provisions for AABM and ISBM fisheries. It describes a set of rules for evaluating fishery performance, stock status, models, management tools, and the effectiveness of the harvest reduction measures taken under the 2019 PST Agreement (Figure 3.1). It also contains conditional tasks in the event of overages. For AABM fisheries, paragraph 7 requires the CTC to conduct specific evaluations of pre-season and post-season deviations, make recommendations for reducing overages meeting specific criteria, and conduct up to two reviews of the CPUE approach to setting pre-season ACLs for the SEAK fishery.

Subparagraph 7(a)(i) requires the CTC to provide the Commission with "*the AABM fisheries pre-season limits, observed catches, and identify the extent of any exceedance (overage) of those limits for the prior fishing season (management error)*." In 2020, none of the three AABM fisheries exceeded pre-season ACLs. Management error data are provided in section 3.2 of this report.

Subparagraph 7(a)(ii) requires the CTC to provide the Commission with "*the AABM fisheries post-season limits for fisheries that occurred two years prior and any exceedance (overage) between the annual pre- and post-season limits from two years prior (model error)*." For 2019 and 2020, the pre-season limit exceeded the post-season limit in four out of six cases, with 2020 having the largest of the exceedances for SEAK (46%) followed by WCVI (11%; Table 3.3). Model error is described in detail in section 4.3 of this report.

Table 3.3.—Model error (calculated as (pre-season ACL – post-season ACL) / post-season ACL) for the past two years for aggregate abundance-based management (AABM) fisheries.

Fishery	2019	2020
SEAK	0%	46%
NBC	2%	-6%
WCVI	5%	11%

Paragraph 7(b) defines "*AABM post-season fishery limits by using the first post-season Commission Chinook model estimate*" and, when compared with actual catches, expresses that overages are of concern. It directs the CTC to provide an analysis of deviations from post-season limits. "*If, in two consecutive years, the NBC or WCVI AABM fishery catches exceed post-season limits by more than 10%, or the SEAK AABM fishery the pre-season tier and catches exceed the post-season tier*," then management agency action is requested by the Commission and the CTC is required to recommend a plan to the Commission to "*improve the performance of pre-season, in-season, and other management tools so that the deviations between catches and post-season fishery limits to AABM fisheries are narrowed to a maximum level of 10%*." For the past two consecutive years (2019 and 2020) only the 2020 SEAK AABM fishery catch exceeded post-season limits by more than 10% (Table 3.4).

Table 3.4.—Composite error (calculated as (actual catch – post-season ACL) / post-season ACL) for the past two years for aggregate abundance-based management (AABM) fisheries.

Fishery	2019	2020
SEAK	0%	46%
NBC	-28%	-75%
WCVI	-3%	-44%

4. PSC Chinook Model Validation and Improvement

The reliability of model outputs, including abundance index (AI) predictions, is dependent on a number of factors including model parameters (e.g., base period exploitation rates); model structure (e.g., spatio-temporal fishery strata); and/or the annual CWT, catch, and run-size inputs (forecast or post-season estimates) used for calibration. In the following sections, reports on annual comparisons of fishery indices (FI) based on model-generated data and CWT estimates, pre-season (forecast) versus post-season run sizes, and differences in AIs between pre- and post-season calibrations are presented. Lastly, a brief review of ongoing model-related improvement activities is presented.

4.1 Evaluation of Fishery Indices

Fishery indices (FI) calculated from model-generated data for all model stocks can be compared to values generated from the estimates of landed catch or total mortality of CWT exploitation rate indicator stocks (Appendix H). Model and CWT-based FIs use the same equation (see Appendix H), however CWT empirical estimates are considered more accurate. The AABM Troll fishery indices derived from CWT recoveries should, in most instances, provide a more accurate estimate of the pattern of exploitation rates compared to fishery indices derived from PSC Chinook Model output. This is due to the fact that CWT-based indices use empirical information from the fisheries each year whereas Model-based indices assume that the yearly pattern of exploitation in a fishery remains static compared to the base period (1979–1982) both temporally and spatially (with the exception of any yearly modifications achieved through stock and age specific exploitation rate scalers) and that most of the change in exploitation can be attributed to stock abundances and the magnitude of the catch.

Fishery indices can be constructed as a ratio of means (ROM) or as a stratified proportional fishery index (SPFI; CTC 2009). Results from the Harvest Rate Index Analysis (CTC 2009) indicated that the SPFI was unbiased and the most accurate estimator for most fishery, time, and area combinations. Therefore, a recommendation was made to use the SPFI estimator as the FI, not only for the SEAK Troll fishery but also for the other two AABM Troll fisheries. Consequently, a SPFI was developed for the WCVI and NBC Troll fisheries. However, the CTC recently determined that the single time strata of data available for the NBC Troll SPFI and a number of missing year-area data values for the WCVI Troll SPFI made implementation of these FIs in the Model problematic. Therefore, in 2019, the CTC decided that ROMs were more appropriate FIs for the WCVI and NBC Troll fisheries. Comparisons among the SPFI, the currently implemented CWT-based ROM FI, and the model data-based FI are provided in this section.

4.1.1 Southeast Alaska Troll Fishery Indices

The SEAK Troll FI based on model data closely follows the trend of the CWT-derived estimate from 1979 through 1989 for both landed catch and total mortality (Figure 4.1 and Figure 4.2). Between 1990 and 2000, the model estimates of both the landed catch and total FIs were less than the CWT-derived estimate for most years. However, since 2001, the model estimates have typically been higher. Since 1990, the model estimates also show less year-to-year variability than the CWT-derived indices. The CWT-derived estimate was at a historic low in 2019 for both total mortality and landed catch. The model-based estimates were also low, though not outside the historic range of estimates. It is also worth noting that since 2012 the model-based estimates have shown increased interannual variability.

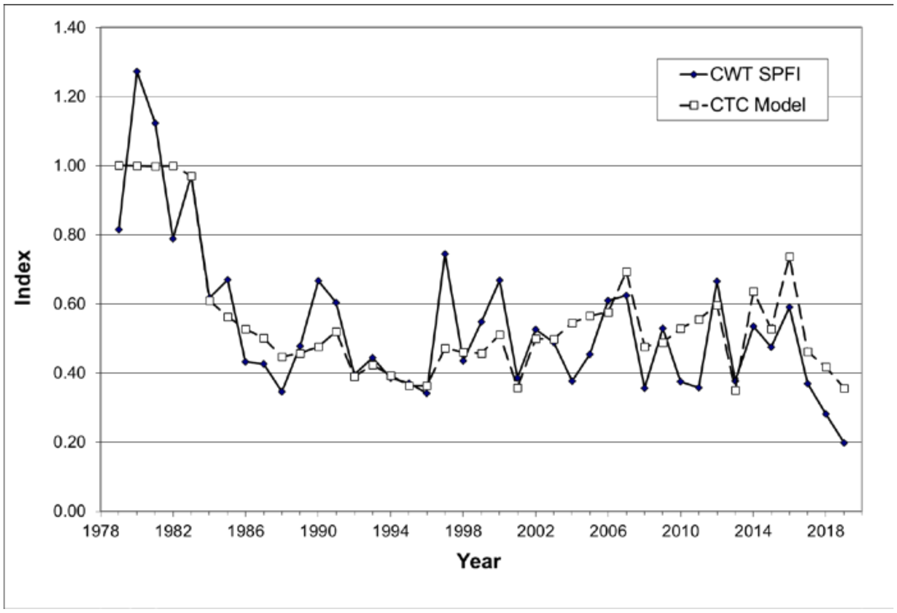

Figure 4.1.—Estimated coded-wire tag (CWT)-based stratified proportional fishery index (SPFI) and model-based fishery indices for landed catch in the Southeast Alaska (SEAK) Troll fishery through 2019.

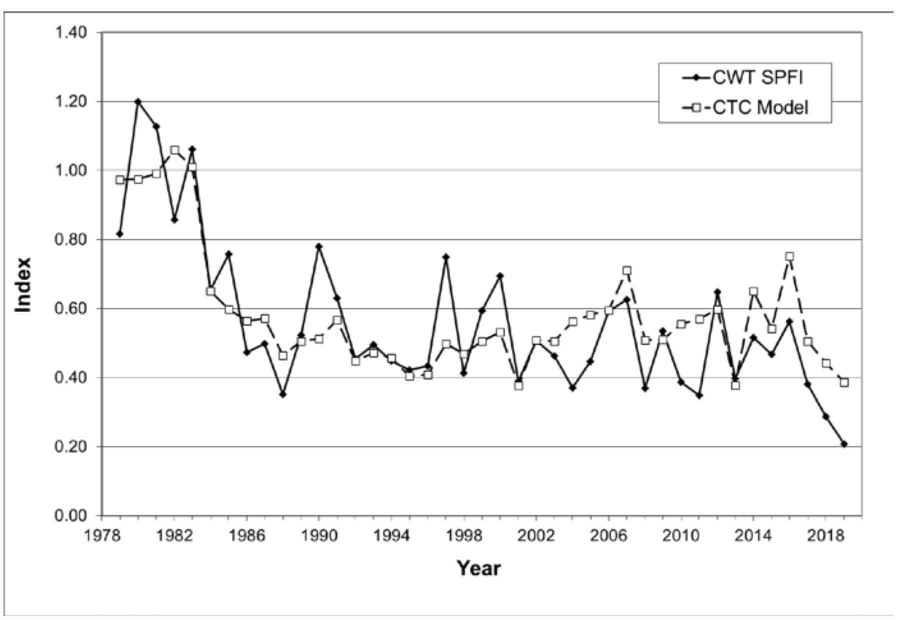

Figure 4.2.—Estimated coded-wire tag (CWT)-based stratified proportional fishery index (SPFI) and model fishery indices for total mortality in the Southeast Alaska (SEAK) Troll fishery through 2019.

4.1.2 Northern British Columbia Troll Fishery Indices

The model-derived fishery mortality indices for NBC Troll generally follow the same trend as the CWT-derived ROM FIs (Figure 4.3 and Figure 4.4). Differences between the two indices (CWT and model-based FIs) were consistently greater 2003 to 2008 compared to preceding years. The SPFI has followed the same general pattern displayed by the other two FIs (ROM and model-based) but has been lower in magnitude and the year-to-year fluctuations have been smaller in most years throughout the time series. In 2018, the CWT index was much higher than the model-based FI for both landed catch and total mortality. In 2019, the difference between both indices was smaller, though the CWT-based FI was still slightly higher.

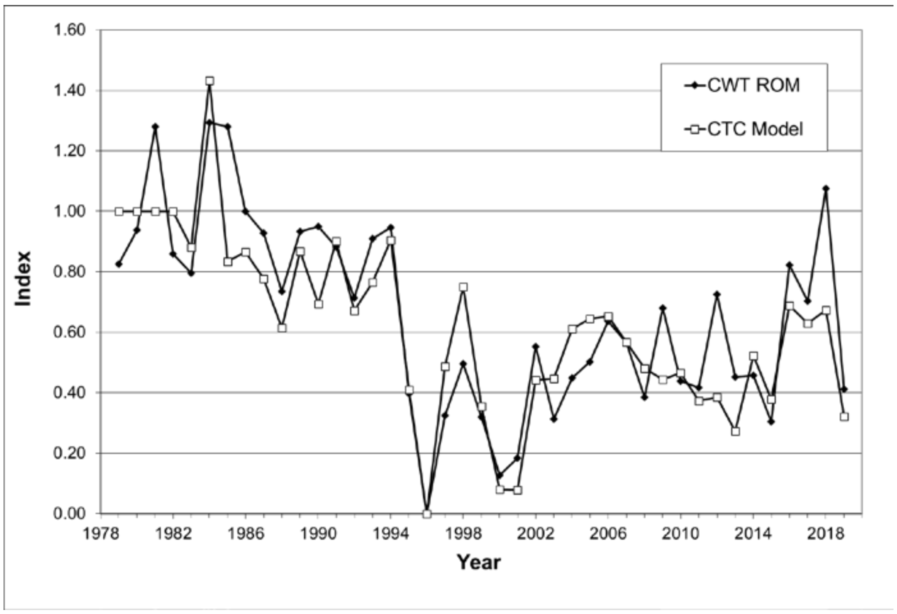

Figure 4.3.—Estimated coded-wire tag (CWT) ratio of means (ROM) and model fishery indices for landed catch in the Northern B.C. (NBC) Troll fishery through 2019.

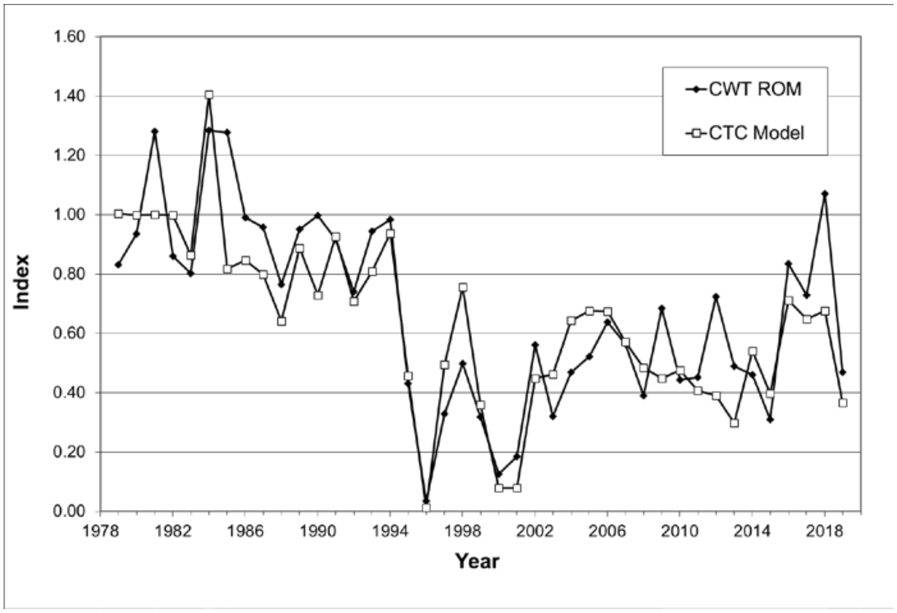

Figure 4.4.—Estimated coded-wire tag (CWT) ratio of means (ROM) and model fishery indices for total mortality in the Northern B.C. (NBC) Troll fishery through 2019.

4.1.3 West Coast Vancouver Island Troll Fishery Indices

For the WCVI Troll fishery, correspondence between the model-derived FI and the CWT-based ROM FI was reasonably close from the start of the time series (1979) to the mid-1990s for both landed catch (Figure 4.5) and mortality (Figure 4.6). Starting around 2000, model data-based and CWT-based ROM FIs diverged noticeably, with the CWT FIs consistently exceeding the model-based FIs. This divergence is attributed to changes in the spatial and temporal conduct of the fishery (e.g., cessation of fishing in the summer period) to reduce impacts on B.C. stocks of conservation concern (e.g., Fraser River early return-timing stocks). Although the SPFI is considered to be a better approach for incorporating temporal and spatial changes in fishery catch patterns, between-year fluctuations have been much greater at times with the SPFI calculated for the WCVI Troll fishery. Since about 2000, after the fishery management changes took place, the SPFI has tended to correspond more closely with the model data-based FI compared to the CWT-based FI (Figure 4.5 and Figure 4.6).

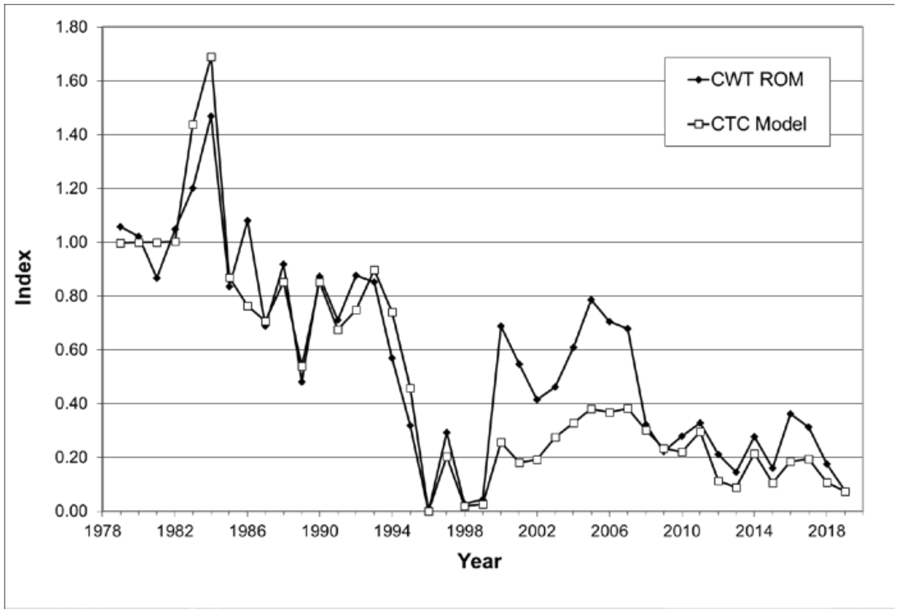

Figure 4.5.—Estimated coded-wire tag (CWT) ratio of means (ROM) and model fishery indices for landed catch in the West Coast Vancouver Island (WCVI) Troll fishery through 2019.

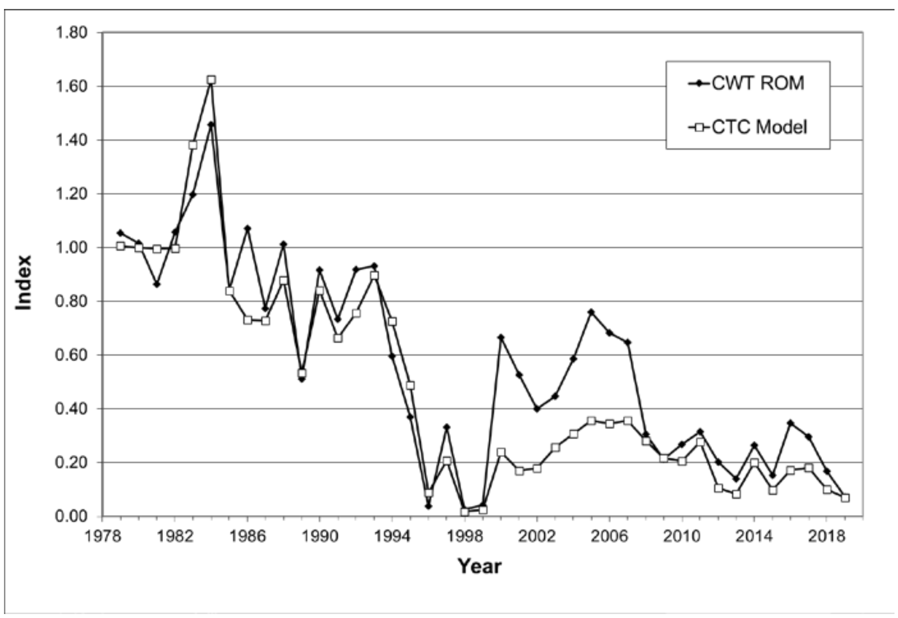

Figure 4.6.—Estimated coded-wire tag (CWT) ratio of means (ROM) and model fishery indices for total mortality in the West Coast Vancouver Island (WCVI) Troll fishery through 2019.

4.1.4 Comparison of Fishery Indices

In Figure 4.1 and Figure 4.2 the Model-based fishery indices generally track the CWT-based SPFI indices. However, there is a period of years from 2004 to 2011 where the Model-based indices are mostly higher than the SPFIs. In Figure 4.3 and Figure 4.4 it can be seen that the Model-based fishery indices generally track the CWT-based ROM indices, although from 2003 to 2008 the Model-based indices are mostly higher than the ROMs. In Figure 4.5 and Figure 4.6 the Model-based fishery indices generally track the CWT-based ROM indices, particularly in 2009 and 2019 where the CWT ROM and PSC Chinook Model were in agreement, with the exception of the years that roughly corresponds to the 1999 PST Agreement. During these years the WCVI CWT ROM indices are consistently higher that the Model indices. This would seem to indicate that the temporal and/or spatial pattern of exploitation in the WCVI Troll fishery had changed compared to the base period which resulted in the discrepancies between the CWT ROM indices and the Model-based indices. This is corroborated by an examination of the temporal distribution of catch in WCVI Troll which shows that the majority of the catch in years prior to 1998 occurred during the July to September time frame, however during 1998 and the years of the 1999 PST Agreement the catch shifted to other months of the year.

4.2 Evaluation of Stock Forecasts Used in the PSC Chinook Model

A major factor influencing the ability of the PSC Chinook Model to predict Chinook salmon abundance in AABM fisheries is the ability of the model to predict the returns of Chinook salmon (in terms of ocean escapement or spawning escapement) in the forecast year. During model calibration, all available agency forecasts for model stocks are input to the model. Thus, for model stocks with external forecasts, the variation between model forecasts and actual returns can be broken into two parts: the ability of the model to match the agency forecasts used as inputs, and the ability of the agency forecasts to accurately predict the actual return of Chinook salmon in the upcoming year.

A summary of model-produced and agency-produced forecasts for 2020–present, including actual returns for 2020, is shown in Appendix G. For information regarding the relationship between the model indicator stocks, exploitation rate indicator stocks, and PST Attachment I stocks, see Appendix A. Note that with the transition to the Phase II PSC Chinook Model base period that occurred in 2020, the stock structure and number of stocks represented in the model have changed. Accordingly, the forecast and post-season return estimates included in Appendix G are now based on the Phase II model stock structure and begin in 2020. For information on forecasts and post-season returns prior to 2020, see Appendix G1 in CTC 2021d.

Overall, since transitioning to the Phase II model in 2020, the model forecasts are similar to the agency forecasts. This result is strongly influenced by the incorporation of the agency forecasts into the model calibration procedure. The mean percent error (MPE) and mean absolute percent error (MAPE) for model forecasts relative to agency forecasts were -1.3% and 12%, respectively, meaning that, on average, they were quite precise, and the model forecasts were close to but slightly lower than the agency forecasts. For 2020 (the only year with both forecasts and actual returns since transitioning to the Phase II model), the agency forecasts were, on average, biased slightly low but fairly precise compared to the actual returns, with MPE of -5.5% and MAPE of 26.6%. Similarly, the MPE and MAPE for model forecasts relative to actual returns were -4.1% and 29%, respectively

In the 2021 calibration of the PSC Chinook Model (CBL 2104) the post-season aggregate abundance for 2020 was greater than the forecast (CBL 2003)[4] for SEAK and NBC, and similar to the forecast for WCVI. For SEAK and NBC the AIs increased from pre-season estimates of 1.02 and 1.00 to post-season estimates of 1.11 and 1.16, respectively. For WCVI, the AI decreased slightly from 0.69 to 0.67. This result can be largely attributed to the fact that for the majority of stocks, particularly some of the larger stocks that are considered to be far north migrators, the agency-provided forecasts used as inputs to the calibration procedure were lower than the actual return (Figure 4.7, Appendix G). It is possible that these greater than expected returns were a function of much lower than average catches along many areas of the coast during 2020 as a result of the COVID-19 pandemic. Agency forecasts were supplied and used in the model calibration for all stocks with the exception of the five SEAK and TBR stocks, which used the forecast generated by the PSC Chinook Model (Figure 4.7).

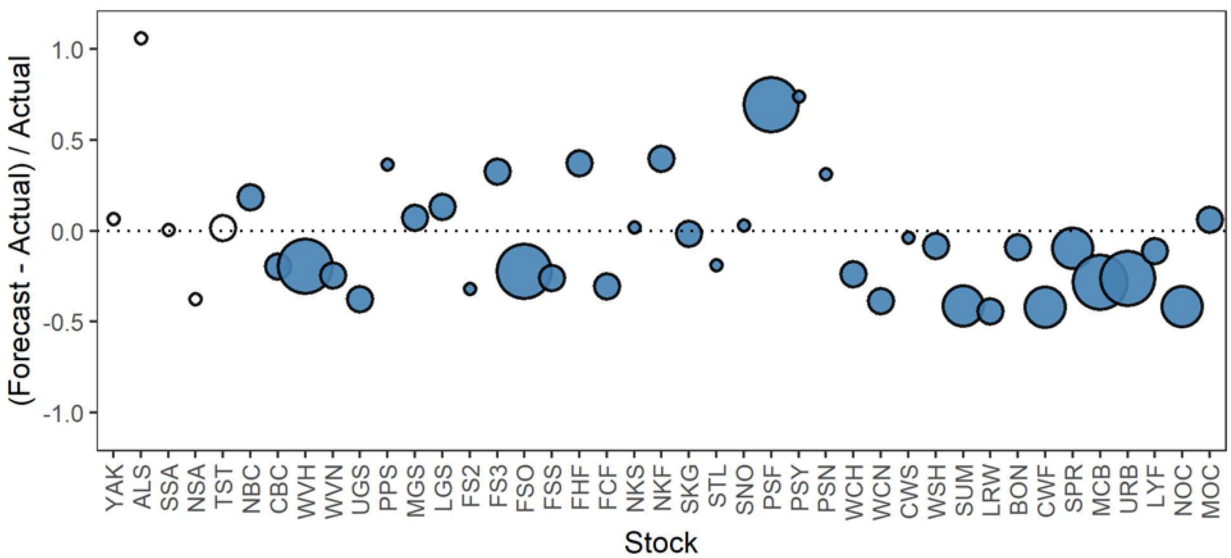

Figure 4.7.—2020 forecast error relative to the actual return for stocks represented in the PSC Chinook Model.

Note: Points lying above the dashed horizontal line returned lower than forecast; points lying below the dashed horizontal line returned greater than forecast. Filled (blue) circles correspond to stocks with agency-supplied forecasts; unfilled (white) circles correspond to stocks with forecasts generated by the PSC Chinook Model. The four symbol sizes correspond to categories of increasing relative stock size (based on average terminal run size: <10,000, 10,000–50,000, 50,000–100,000, and >100,000). Stocks are arranged along the x-axis from north to south and are defined according to the model stock acronyms in Appendix A.

[4] Note that pre-season AIs referenced here are from CLB 2003, which is a corrected version of CLB 2002, the 2020 model calibration that was used for preseason planning.

4.3 Model Error

For the purposes of this section of the report, model error will refer to differences between model-generated pre-season AIs for the AABM fisheries and the first post-season estimate of AIs for the AABM fisheries as generated by the annual calibration in the following year. The yearly percent deviations between pre-season and post-season AIs for the three AABM fisheries are illustrated in Figure 4.8. For each AABM fishery, the deviations between the pre-season and post-season AIs have varied considerably since 1999. The changes in AIs between pre- and post-season calibrations from 2012 to 2016 were among the largest observed (Figure 4.8) and resulted in large discrepancies (greater than 20% difference) between pre-season and post-season ACLs across the three AABM fisheries (Table 3.1). Model errors of this magnitude underscore the importance of routine model validation, as well as occasional targeted investigations and ongoing longer-term efforts to improve the PSC Chinook Model. Large deviations can compromise the utility of pre-season AIs for setting objectives for each of the fisheries, which provisions in the 2019 PST Agreement were intended to address.

AIs are generated without any measures of their uncertainty and although corrective techniques have been explored, none have been applied. The management framework for the three AABM fisheries relate fishery-specific catch and fishery indices to AIs using a proportionality constant that varies annually *in situ* but, as an input to the PSC Chinook Model, is based on a static value. For the previous configuration of the Model (referred to as 9806), the proportionality constant was based on the 1979–1997 average. Beginning in 2020, with the implementation of the Phase II configuration of the Model, the proportionality constant is based on the 1999–2015 average. Uncertainty in the proportionality constant is not explicitly considered within the current AABM fishery regime; it is assumed to be stable in the long term.

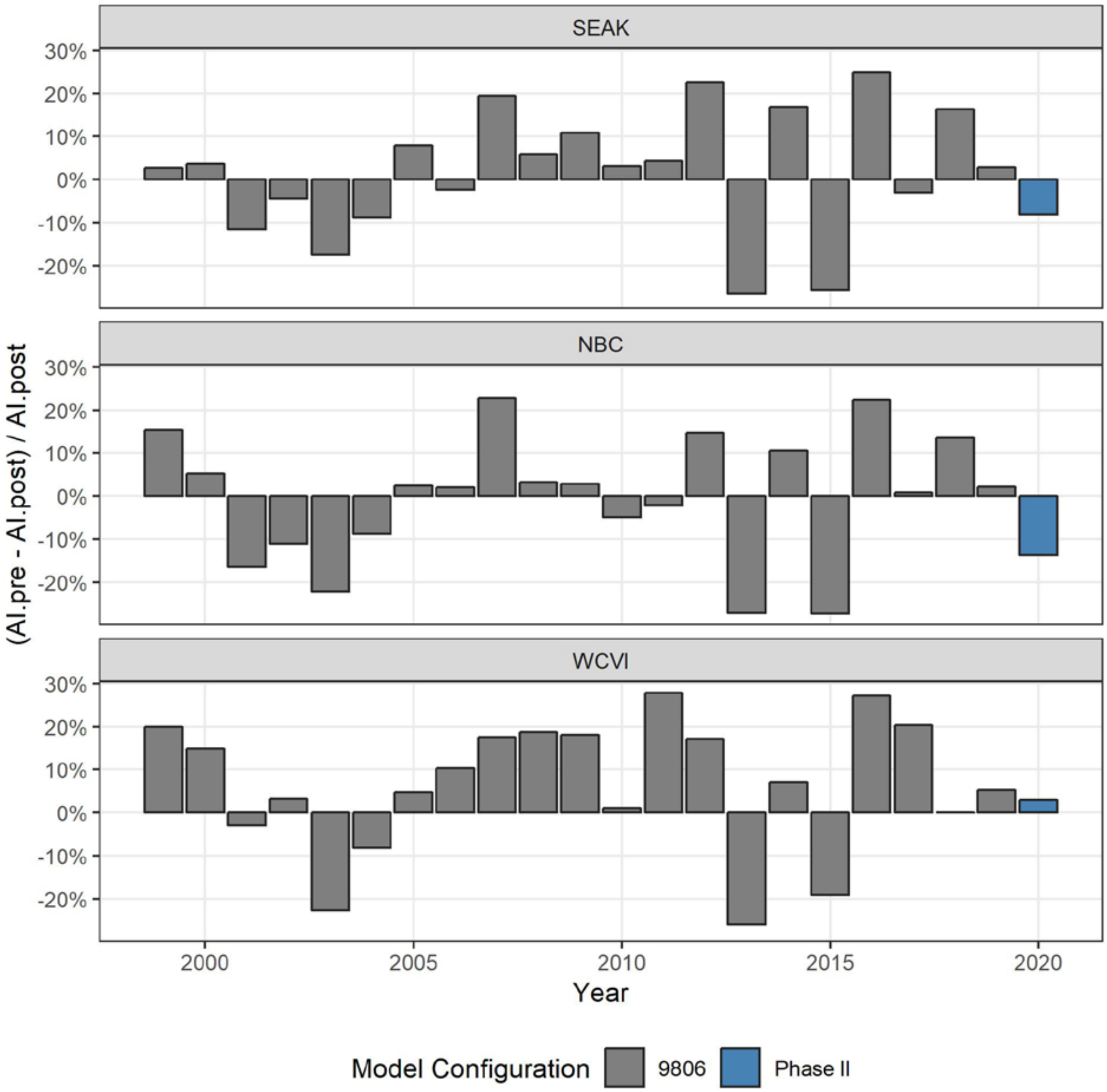

Figure 4.8.—Deviation between pre- and post-season abundance indices (AIs) for the three aggregate abundance-based management (AABM) fisheries, 1999–2020.

Note: there was no CTC consensus on the 2015 and 2016 model calibrations (CLB 1503 and 1601). Outputs from CLB 1503 was used by the Commission to configure AABM fisheries in 2015. Abundances indices for AABM fisheries generated from CLB 1601 were accepted by the Commission. Values for the 2014 and 2015 post-season AIs are from CLB 1601 and values for the 2015 pre-season AI is from CLB 1503.

Note: With the implementation of the Phase II model configuration beginning with the 2020 pre-season, the 2019 post-season AIs are based on CLB 2000-9806, which was conducted using the 9806 model configuration. The 2020 pre-season AIs in this figure are from CLB 2003, which is a corrected version of CLB 2002, the 2020 model calibration that was used for pre-season planning.

Note: Beginning in 2019, the SEAK AABM fishery transitioned to a CPUE index for management in place of the AI.

4.4 Model Improvement Activities

4.4.1 Maturation Rate Workshop

The AWG held a virtual workshop in June 2021 to discuss a variety of topics related to maturity rates and their role in the PSC Chinook Model. This workshop was prompted by the realization that recent and forecasted maturity rates for many key indicator stocks have been increasing and are notably high. An example for the Upriver Bright indicator stock is provided in Figure 4.9. Forecasted maturity rates are very influential to post- and pre-season AIs. It is therefore critical to ensure that the forecasted maturity rates are as accurate as possible and the procedures to produce these rates have a strong technical basis.

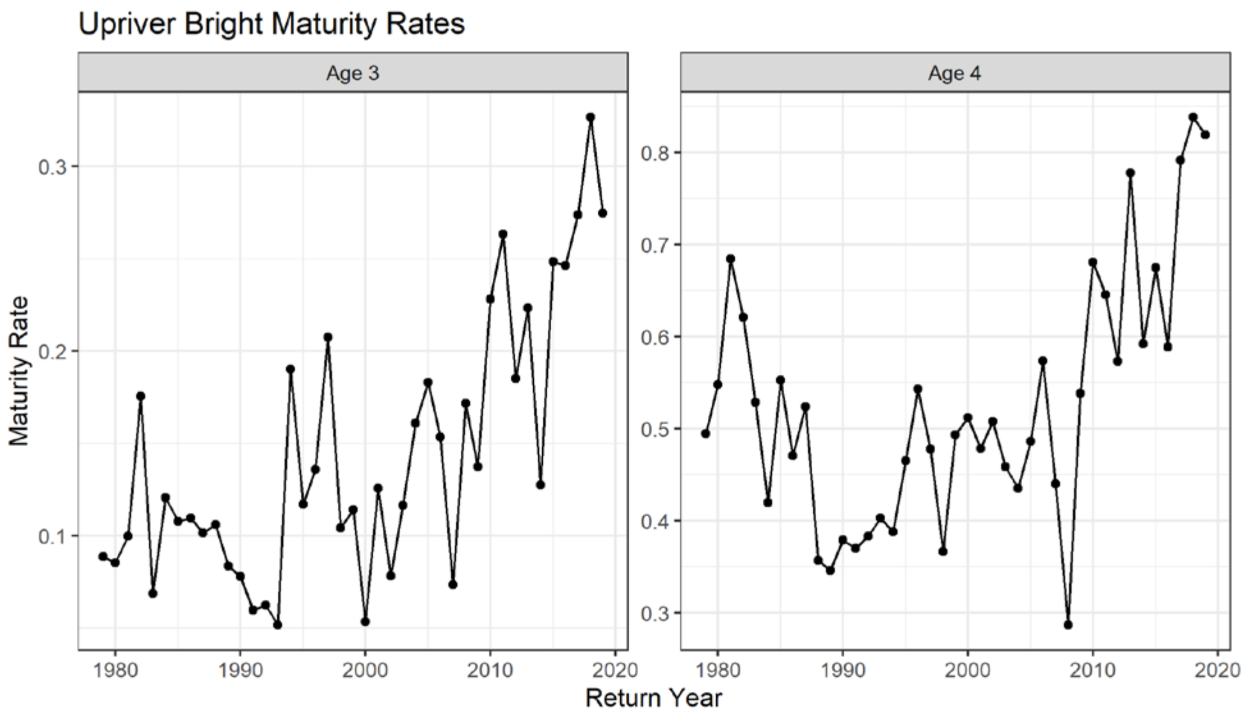

Figure 4.9.—Age 3 and 4 maturity rates for the Upriver Bright indicator stock.

Many different topics were discussed during this one-day workshop. The bullet points below provide an outline of these topics:

- Hierarchy of data and order of operations involved in producing the MATAEQ file. This file consists of maturity rates derived from CWTs, the Stock Aggregate Cohort Evaluation (SACE) procedure, and projections for incomplete broods (i.e., forecasts). The rules determining when each of these different sources of data are used was documented.
- Overview of the SACE procedure. An overview of the SACE methodology and the R program used to produce the SACE derived maturity rates was provided.
- Overview of the MATAEQ program written in Visual Basic (VB). The AWG would like to move this program into R so that it could be integrated with the SACE procedure and

maturity rate forecasting procedure which are both in R. Different subroutines and the flow of the program were demonstrated to facilitate translation of this program into R.

- Overview of the maturation rate forecasting procedure. An explanation of the Exponential Smoothing (ETS) procedure used to produce forecasted maturity rates was provided.
    - The rules to determine the year when the forecasting procedure should start were discussed. A single rule to start ETS projections four years prior to the current calendar year has been used for all stocks.
    - Southern US (SUS) indicator stocks lag 2 years behind in the ERA (e.g., only CWT recoveries up until 2019 are used in the 2021 ERA). The rest of the indicator stocks only lag one year behind.
    - Because of this lag for SUS stocks, in combination with the rules to determine when to start forecasting, it was noted that the maturity rates for the SUS stocks part of the SACE procedure were a mixture of sources derived from the SACE and CWTs. (i.e., the final maturity rate prior to forecasting was derived from CWTs and all other previous rates were derived from SACE). Forecasting will start one year earlier for SUS stocks so that there is not a mixture of CWT and SUS estimates.
- Examination of stock-specific forecasting techniques. The decision to use the ETS (without Box-Cox transformation) procedure was based on an evaluation of many forecasting techniques during Phase II Chinook Model development. The ETS procedure (in combination with a 12-year average environment variable (EV) scalar), resulted in the smallest difference between pre-season and first post-season AIs, forming the recommendation to use this technique (CTC *in prep.*). During this workshop, the CTC examined whether the same forecasting technique (i.e., ETS) would be chosen if instead actual and forecasted errors in maturity rates were minimized for a single stock. URBs and WVH, two large driver stocks, were chosen as examples The procedures tested were the ETS method with and without Box-Cox transformation, naïve-3, naïve-6, naïve-9, and ARIMA with and without Box-Cox transformation. For most ages, this analysis indicated that the ETS procedure was still preferred for WVH, but a naïve 6-year average was preferred for URBs. However, the actual difference between forecasted maturity rates using ETS and naïve 6-year average techniques were negligible. This provided some indication that moving towards stock-specific maturity rate forecasting techniques rates would not drastically improve the Chinook Model.
- Sensitivity analysis to changing the FCS file age-structure. A sensitivity analysis to including returns of 4 ages, as opposed to 3 ages, in the FCS file was presented. The motivation to include to 4 ages in the FCS file was a matter a convenience. It is critical that the SACE procedure use the same return data found in the FCS file (for stocks calibrated to terminal run), but this file currently does not include age 2 (fall stocks) or age 3 (spring stocks) returns. The SACE procedure uses the returns of these youngest

ages. Having all 4 ages in the FCS file would facilitate a straightforward translation between the return tables found in the FCS file and the brood tables needed for the SACE procedure. The sensitivity analysis indicated that including 4 ages in the FCS file altered the AI time series enough to warrant some concern. Since the motivation to switch from 3 to 4 ages was a matter of convenience, but the AI time series was altered, it was concluded that the current 3 age structure should be retained.

Based on the discussions and analyses presented above, several recommendations were identified to form a stronger a technical basis for forecasting maturity rates. For the MATAEQ program, these recommendations included:

- Develop an R version of the MATAEQ program to replace the current program written in VB.
- Change MATAEQ program to reference stock acronyms instead of stock numbers. The stock numbers used by the Chinook Model and MATAEQ program were not consistent.
- Further review utility to calculate AEQs in the MATAEQ program.
- Correct life-history type assumptions for stock TST in the MATAEQ program (i.e., change to yearling stock).
- Remove hard coded details in the MATAEQ program (e.g., start and end years, missing or invalid brood years).

For the Chinook Model, these recommendations included:

- Adjust the PSC Chinook Model code if adding in age 2 or age 3 into the FCS file. This would facilitate easier translation between return tables utilized by the FCS file and brood tables utilized by the SACE R program without altering the time series of AIs.

For the ETS maturity rate forecasting procedure, these recommendations include:

- Change maturity rate forecasting program to specify stock-specific years to start forecasts. SUS stocks should start one year earlier than all other stocks. Data from the HRJ file could be used to determine when forecasting should start.
- In-filling techniques that utilize trends (e.g., regression type models or moving averages) should be incorporated into the revamped/integrated MATAEQ program. The program currently uses naïve averages.
- Forecast logit transformed maturity rates. The current program currently truncates forecasted maturity rates greater than 1. Forecasted the logit-transformed maturity would ensure that these forecasted rates are always less than 1.

4.4.2 ForecastR

ForecastR relies on the open-source statistical software R (R Core Team 2020) to generate age-specific (or total abundance) forecasts of salmon escapement or terminal run using a variety of generic models and enabling users to perform interactive tasks with the help of a Graphical User Interface developed as a Shiny app. These tasks include: (a) the selection of forecasting approaches from a wide set of statistical and/or mechanistic models for forecasting terminal run and escapement ; (b) the selection of several measures of retrospective forecast performance (e.g., MRE, MAE, MAPE, MASE, RMSE); (c) the comparison of forecasting models and model selection and ranking; and, (d) the reporting of forecasting results (point forecasts and interval forecasts) and diagnostics by producing detailed or summary reports.

The original design of ForecastR involved the generation of age-specific or total-abundance forecasts using several forecasting approaches, including: (i) simple and complex sibling regressions with the ability to include environmental/biological covariates; (ii) time series models such as ARIMA, exponential smoothing, and naïve models (based on preceding 1 year, 3 years or 5 years in abundance time series); and (iii) mechanistic models such as average return rate models that depend on auxiliary data such as the number of outmigrant juveniles, the number of hatchery fish released or the number of spawners in previous years. For both age-structured and non-age-structured data, AIC-based model selection takes place within model types (e.g., ARIMA and exponential smoothing) prior to model ranking across model types based on the abovementioned metrics of retrospective evaluation.

After five developmental phases, the latest release has successfully implemented all of the originally envisioned capabilities for this tool. Additional information about the project can be found in the GitHub site: https://github.com/SalmonForecastR. The latest release incorporated improvements and refinements to the Shiny app and incorporated a Kalman-Filter sibling regressions, complex-sibling-regressions allowing the incorporation of environmental or biological variables, and the return-rate mechanistic module. Future improvements include adding additional environmental covariate datasets and the ability to explore the impact on stock forecasts.

Utilizing an html-based Shiny application allows online forecasting exercises without users having ForecastR installed in their computers. The App can be accessed through two different servers: (https://psc1.shinyapps.io/ForecastR/ or https://solv-code.shinyapps.io/forecastr/). ForecastR has been used to produce agency forecasts for Canada and Oregon Model stocks since 2016.

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LIST OF APPENDICES

APPENDIX A: RELATIONSHIP BETWEEN EXPLOITATION RATE INDICATOR STOCKS, ESCAPEMENT INDICATOR STOCKS, AND MODEL STOCKS IN THE PACIFIC SALMON TREATY

LIST OF APPENDIX A TABLES

Appendix A1– Indicator stocks for Transboundary (TBR) Rivers and Southeast Alaska (SEAK).

Region	Run	Attachment I stock	Escapement Indicator (PSC Management Objective)	Exploitation Rate Indicator/Acronym		Model Stock/Acronym	
Transboundary Rivers (TBR)	Spring	Yes	Taku (19,000–36,000)	Taku	TAK	Taku and Stikine	TST
		Yes	Stikine (14,000–28,000)	Stikine	STI		
		Yes	Alsek (3,500–5,300)			Alsek	ALS
Southeast Alaska (SEAK)		Yes	Situk (500–1,000)			Yakutat Forelands	YAK
		Yes	Chilkat (1,750–3,500)	Chilkat Northern Southeast Alaska	CHK, NSA[1]	Northern Southeast Alaska	NSA
		Yes	Unuk (1,800–3,800)	Unuk Southern Southeast Alaska	UNU, SSA[2]	Southern Southeast Alaska	SSA

[1]NSA is an aggregate of Crystal Lake (ACI) and Douglas Island Pink and Chum (DIPAC)/Macaulay (AMC) hatcheries.
[2]SSA is an aggregate of Little Port Walter (ALP), Neets Bay (ANB), Whitman Lake (AHC), and Deer Mountain (ADM) hatcheries.

Appendix A2– Indicator stocks for Northern British Columbia (NBC), Central British Columbia (CBC), and West Coast Vancouver Island (WCVI).

Region	Run	Attachment I stock	Escapement Indicator (PSC Management Objective)	Exploitation Rate Indicator/Acronym		Model Stock /Acronym	
Northern BC (NBC)	Summer	No	Nass	Kitsumkalum (Deep Creek Hatchery)	KLM	Northern BC	NBC
		Yes	Skeena (TBD)				
Central BC (CBC)	Fall	No	Wannock	Atnarko (Snootli Hatchery)	ATN	Central BC	CBC
	Summer		Chuckwalla and Killbella				
		Yes	Atnarko (5,009)				
West Coast Vancouver Island (WCVI)	Fall	Yes	North West Vancouver Island Aggregate (Colonial-Cayeagle, Tashish, Artlish, Kaouk) (TBD)	Robertson Creek Hatchery	RBT (adj)[1]	West Coast Vancouver Island Natural	WVN
		Yes	South West Vancouver Island Aggregate (Bedwell/Ursus, Megin, Moyeha) (TBD)				
		No	West Coast Vancouver Island Aggregate (14 Streams)	Robertson Creek Hatchery	RBT	West Coast Vancouver Island Hatchery	WVH

[1]CWT indicator stocks and fishery adjustments described in CTC (2016), CTC (2019; ISBM Subgroup Technical Note) and CTC 2021e.

Appendix A3– Indicator stocks for Fraser River and Strait of Georgia.

Region	Run	Attachment I stock	Escapement Indicator (PSC Management Objective)	Exploitation Rate Indicator/Acronym		Model Stock /Acronym	
Fraser River	Spring	Yes	Nicola (TBD)	Nicola (Spius Creek Hatchery)	NIC	Fraser Spring 1.2	FS2
				Dome (Penny Creek Hatchery)	DOM	Fraser Spring 1.3	FS3
		Yes	Chilcotin (TBD)	Lower Chilcotin (in development)	LCT		
	Summer	Yes	Lower Shuswap (12,300)	Lower Shuswap (Shuswap Falls Hatchery)	SHU	Fraser Summer Ocean-type 0.3	FSO
				Middle Shuswap (Shuswap Falls Hatchery)	MSH		
		Yes	Chilko (TBD)	Chilko (in development)	CKO	Fraser Summer Stream-type 1.3	FSS
	Fall			Chilliwack Hatchery	CHI	Fraser Chilliwack Fall Hatchery	FCF
		Yes	Harrison (75,100)	Harrison (Chehalis Hatchery)	HAR	Fraser Harrison Fall	FHF
North Strait of Georgia	Fall	No	TBD	Quinsam Hatchery	QUI	Upper Strait of Georgia	UGS
		Yes	East Vancouver Island North (TBD)		QUI (adj)[1]		
		Yes	Phillips	Phillips (Gillard Pass Hatchery)	PHI		
South Strait of Georgia	Fall		Cowichan (6,500)	Big Qualicum Hatchery	BQR	Middle Strait of Georgia	MGS
		Yes		Cowichan Hatchery	COW	Lower Strait of Georgia	LGS
				Nanaimo Hatchery	NAN		
	Summer			Puntledge Hatchery	PPS	Puntledge Hatchery	PPS

[1]CWT indicator stocks and fishery adjustments described in CTC (2016), CTC (2019; ISBM Subgroup Technical Note) and CTC 2021e.

Appendix A4– Indicator stocks for Puget Sound.

Region	Run	Attachment I stock	Escapement Indicator (PSC Management Objective)	Exploitation Rate Indicator/Acronym		Model Stock /Acronym	
Northern Puget Sound	Spring	Yes	Nooksack Spring (TBD)	Nooksack Spring Fingerling (Kendall Creek Hatchery)	NSF	Nooksack Spring	NKS
		Yes	Skagit Spring (690)	Skagit Spring Fingerling (Marblemount Hatchery)	SKF		
	Fall			Samish Fall Fingerling (Samish Hatchery)	SAM	Nooksack Fall	NKF
	Summer/ Fall	Yes	Skagit Summer/Fall (9,202)	Skagit Summer Fingerling (Marblemount Hatchery)	SSF	Skagit Summer/Fall	SKG
	Fall	Yes	Stillaguamish (TBD)	Stillaguamish Fall Fingerling (Whitehorse Hatchery)	STL	Stillaguamish	STL
	Summer	Yes	Snohomish (TBD)	Skykomish Fingerling (Wallace Hatchery)	SKY	Snohomish	SNO
Central Puget Sound	Fall	No	Lake Washington			Puget Sound Natural Fingerling	PSN
		No	Green	Green River Fingerling[1] (Soos Creek Hatchery)	GRN[1]		
Hood Canal				George Adams Hatchery Fall Fingerling	GAD	Puget Sound Hatchery Fingerling	PSF
Southern Puget Sound (SPS)				SPS Fall Fingerling[1]	SPS[1]		
				Nisqually Fall Fingerling (Clear Creek Hatchery)	NIS		
						Puget Sound Hatchery Yearling	PSY
	Spring			White River Hatchery Spring Yearling	WRY		

[1]SPS is aggregate from Soos Creek (Green R), Grovers, and Issaquah hatcheries. The Soos Creek (GRN tag group) are included in the SPS exploitation rate indicator.

Appendix A5– Indicator stocks for the Washington Coast.

Region	Run	Attachment I stock	Escapement Indicator (PSC Management Objective)	Exploitation Rate Indicator/Acronym		Model Stock /Acronym	
Juan de Fuca	Fall			Elwha Fall Fingerling (Lower Elwha Hatchery)	ELW		
Washington Coast (WAC)		Yes	Hoko (TBD)	Hoko Fall Fingerling (Hoko Falls Hatchery)	HOK		
		Yes	Queets Fall (2,500)	Queets Fall Fingerling (Salmon River brood stock)	QUE QUE (adj)	WA Coastal Wild	WCN
		Yes	Grays Harbor Fall (13,326)				
		Yes	Quillayute Fall (3,000)				
		Yes	Hoh Fall (1,200)				
						WA Coastal Hatchery	WCH
				Tsoo-Yess Fall Fingerling (Makah National Fish Hatchery)	SOO		
	Spring	No	Grays Harbor Spring[1]				
	Spring/ Summer	No	Queets Spring/Summer (700)[1]				
	Summer	No	Quillayute Summer[1]				
	Spring/ Summer	No	Hoh Spring/Summer (900)[1]				

[1] Escapement indicator stock is not included in the Washington Coastal model stocks.

Appendix A6– Indicator stocks for Columbia River and Oregon Coast.

Region	Run	Attachment I stock	Escapement Indicator (PSC Management Objective)	Exploitation Rate Indicator/Acronym		Model Stock /Acronym	
Columbia River	Spring					Cowlitz Spring Hatchery	CWS
				Willamette Spring (Hatchery Complex)	WSH	Willamette River Hatchery	WSH
	Summer	Yes	Mid-Columbia Summers (12,143)	Columbia Summers (Wells Hatchery)	SUM	Columbia River Summers	SUM
	Fall			Columbia Upriver Brights (Priest Rapids Hatchery)	URB	Mid-Columbia Brights	MCB
		Yes	Upriver Brights (40,000)			Columbia Upriver Brights	URB
				Hanford Wild	HAN		
				Lyons Ferry Fingerling	LYF	Lyons Ferry Hatchery	LYF
				Lyons Ferry Year	LYY		
		Yes	Lewis (5,700)	Lewis River Wild	LRW	Lewis River	LRW
		Yes	Coweeman (TBD)	Cowlitz Hatchery Fall Tule	CWF	Cowlitz Hatchery	CWF
				Spring Creek National Fish Hatchery	SPR	Spring Creek	SPR
				Lower River Hatchery (Big Creek Hatchery)	LRH	Bonneville Hatchery	BON
North Oregon Coast (NOC)	Fall	Yes	Nehalem (6,989)	Salmon River Hatchery (adj)	SRH (adj)	North Oregon Coast	NOC
		Yes	Siletz (2,944)				
		Yes	Siuslaw (12,925)				
Mid-Oregon Coast (MOC)		Yes	Coquille (TBD)	Elk River Hatchery (adj)	ELK (adj)	Mid-Oregon Coast	MOC
		Yes	South Umpqua (TBD)				

APPENDIX B: MODEL STOCK COMPOSITION ESTIMATES FOR THE AABM AND ISBM FISHERIES IN 2020 AND THE 1985–2019 AVERAGE

This appendix summarizes PSC Chinook Model stock composition estimates for the three AABM fisheries (Appendix B1, Appendix B2 and Appendix B3) and all ISBM fisheries by country (Appendix B4 and Appendix B5). Estimates are based on Model fishery catch, Model stock contribution, and Model stock escapement, each expressed as a percentage. Three metrics of stock composition are presented. Stock composition (% of Fishery Catch) is the Model stock contribution divided by the sum catch in a Model fishery aggregate. Distribution of fishing mortalities (% of Stock Catch) is the Model stock contribution divided by a Model stock's contribution summed across Model fisheries. Distribution of fishing mortalities and escapement (% of Stock Total Return) is the Model stock contribution divided by a Model stock's contribution summed across Model fisheries plus escapement.

Estimated stock compositions may not reflect the true stock composition for several reasons:

1. The yearly catch estimates by stock are influenced by the base period stock composition in a fishery and may not reflect the current stock composition in a fishery.
2. The distribution of Model stocks may have changed over time.
3. The 41 Model stocks do not represent all production available to a fishery.

For example, in the SEAK fishery a substantial component (over 20%) of the catch is comprised of Alaska hatchery fish, most of which do not count as Treaty catch and therefore not included in Appendix B1. Also, in the sport fishery portion of the present NBC AABM fishery, the base period data used is from fisheries which were located near shore and do not represent the current stock composition of the sport fishery which is located offshore.

Hence, these tables do not necessarily portray the true stock composition of the fisheries in Appendices B1 to B5. Genetic stock composition estimates are available for most of these fisheries in select years, which provide more accurate accounting of contributions by stocks or stock groups.

LIST OF APPENDIX B TABLES

Appendix B1–Southeast Alaska aggregate abundance-based management (AABM) troll, net, sport stock composition.

FISHERY:	**SE ALASKA AABM TROLL NET AND SPORT**				
	2020	**Average (1985–2019)**			
Model Stock	**% of Fishery Catch**	**% of Fishery Catch**	**% of Stock Catch**	**% of Stock Total Return**	**Associated Escapement Indicator Stocks[1]**
Upriver Brights	15.05%	18.82%	21.54%	11.86%	Upriver Brights
WCVI Hatchery	20.89%	15.58%	28.58%	13.40%	NA
North Oregon Coast	7.83%	9.52%	21.57%	11.91%	Nehalem
					Siletz
					Siuslaw
Northern BC	2.11%	7.59%	66.90%	13.34%	Skeena
Fraser Summer Ocean-type 0.3	12.41%	7.14%	31.10%	12.12%	Lower Shuswap
WA Coastal Wild	6.73%	5.78%	33.35%	15.73%	Grays Harbor Fall
					Queets Fall
					Quillayute Fall
					Hoh Fall
Mid Columbia River Brights	7.92%	5.32%	19.27%	11.02%	Not Represented
Taku and Stikine	1.99%	4.45%	52.84%	10.02%	Taku
					Stikine
Southern SE AK	1.99%	3.96%	96.64%	32.22%	Unuk
WA Coastal Hatchery	5.10%	3.68%	32.35%	13.81%	NA
Columbia River Summer	4.38%	3.16%	17.83%	9.71%	Mid-Columbia Summers
Northern SE AK	1.66%	2.68%	99.62%	45.49%	Chilkat
Yakutat Forelands	0.00%	2.27%	0.00%	35.59%	Situk
WCVI Natural	4.22%	2.18%	30.58%	16.26%	NWVI Natural Aggregate
					SWVI Natural Aggregate
Mid-Oregon Coast	1.45%	2.04%	10.56%	5.55%	South Umpqua
					Coquille
Upper Georgia Strait	1.50%	1.17%	40.24%	13.52%	East Vancouver Island North
					Phillips
Willamette River Spring	0.87%	0.95%	6.25%	2.67%	NA
Fall Cowlitz Hatchery	0.72%	0.85%	3.04%	1.61%	NA
Central BC	0.44%	0.62%	28.83%	6.89%	Atnarko

Lewis River Wild	1.14%	0.58%	16.09%	5.64%	Lewis
Middle Georgia Strait	0.53%	0.39%	9.60%	3.05%	NA
Harrison Fall	0.16%	0.33%	1.79%	0.53%	Harrison
Puget Sound Fingerling	0.25%	0.19%	0.37%	0.21%	NA
Fraser Summer Stream-type 1.3	0.12%	0.16%	2.22%	0.94%	Chilko
Skagit Wild	0.13%	0.11%	3.72%	1.27%	Skagit Summer/Fall
Spring Cowlitz Hatchery	0.03%	0.08%	1.50%	0.81%	NA
Alsek	0.06%	0.08%	45.34%	2.78%	Alsek
Lower Georgia Strait	0.06%	0.08%	2.68%	1.05%	Cowichan
Lyons Ferry	0.13%	0.07%	1.85%	1.17%	Not Represented
Nooksack Fall	0.03%	0.06%	0.30%	0.19%	Not Represented
Puget Sound Natural Fall	0.02%	0.02%	0.33%	0.18%	NA
Chilliwack Fall Hatchery	0.03%	0.02%	0.19%	0.07%	NA
Nooksack Spring	0.02%	0.02%	4.81%	1.65%	Nooksack Spring
Puget Sound Yearlings	0.01%	0.01%	0.25%	0.16%	NA
Fraser Spring 1.2	0.01%	0.01%	0.42%	0.14%	Nicola
Puntledge Summers	0.01%	0.01%	5.76%	1.70%	NA
Snohomish Wild	0.00%	0.01%	1.00%	0.23%	Snohomish
Stillaguamish Wild	0.00%	0.00%	1.00%	0.39%	Stillaguamish
Fraser Spring 1.3	0.00%	0.00%	0.00%	0.00%	Chilcotin
Lower Bonneville Hatchery	0.00%	0.00%	0.00%	0.00%	NA
Spring Creek Hatchery	0.00%	0.00%	0.00%	0.00%	NA

[1] NA = a hatchery stock; Not represented = a wild stock without an escapement indicator.

Appendix B2–Northern British Columbia aggregate abundance-based management (AABM) troll and sport stock composition.

FISHERY:	NORTH BC AABM TROLL AND SPORT				
	2020	Average (1985–2019)			
Model Stock	% of Fishery Catch	% of Fishery Catch	% of Stock Catch	% of Stock Total Return	Associated Escapement Indicator Stocks[1]
North Oregon Coast	22.03%	21.23%	32.04%	18.21%	Nehalem Siletz Siuslaw
Upriver Brights	18.05%	16.46%	12.60%	7.10%	Upriver Brights
Fraser Summer Ocean-type 0.3	13.12%	12.31%	34.72%	14.44%	Lower Shuswap
WCVI Hatchery	5.42%	10.14%	10.94%	5.48%	NA
WA Coastal Wild	7.76%	7.76%	28.70%	14.18%	Grays Harbor Fall Queets Fall Quillayute Fall Hoh Fall
Mid-Oregon Coast	5.91%	6.74%	22.40%	11.92%	South Umpqua Coquille
Columbia River Summer	7.67%	6.11%	22.99%	12.92%	Mid-Columbia Summers
WA Coastal Hatchery	5.85%	4.99%	28.98%	12.90%	NA
Mid Columbia River Brights	5.00%	3.56%	9.12%	5.42%	Not Represented
Willamette River Spring	1.80%	2.15%	9.30%	4.12%	NA
WCVI Natural	1.00%	1.33%	11.14%	6.34%	NWVI Natural Aggregate SWVI Natural Aggregate
Upper Georgia Strait	0.91%	0.96%	20.69%	7.48%	East Vancouver Island North Phillips
Fall Cowlitz Hatchery	0.70%	0.87%	2.10%	1.14%	NA
Middle Georgia Strait	0.75%	0.62%	9.78%	3.25%	NA
Fraser Summer Stream-type 1.3	0.29%	0.48%	4.47%	1.90%	Chilko
Northern BC	0.13%	0.48%	2.94%	0.61%	Skeena
Puget Sound Fingerling	0.55%	0.47%	0.64%	0.37%	NA
Taku and Stikine	0.22%	0.46%	3.70%	0.66%	Taku Stikine
Lewis River Wild	0.81%	0.36%	6.06%	2.29%	Lewis

Central BC	0.25%	0.32%	9.72%	2.40%	Atnarko
Lyons Ferry	0.54%	0.32%	6.26%	4.04%	Not Represented
Spring Cowlitz Hatchery	0.11%	0.30%	3.62%	1.99%	NA
Skagit Wild	0.28%	0.28%	6.16%	2.16%	Skagit Summer/Fall
Harrison Fall	0.09%	0.26%	0.82%	0.26%	Harrison
Chilliwack Fall Hatchery	0.24%	0.23%	1.12%	0.45%	NA
Lower Georgia Strait	0.21%	0.19%	2.47%	1.14%	Cowichan
Southern SE AK	0.10%	0.19%	3.05%	1.01%	Unuk
Nooksack Fall	0.04%	0.09%	0.27%	0.18%	Not Represented
Puget Sound Natural Fall	0.03%	0.05%	0.42%	0.23%	NA
Lower Bonneville Hatchery	0.01%	0.05%	0.21%	0.10%	NA
Puntledge Summers	0.02%	0.05%	10.91%	3.48%	NA
Nooksack Spring	0.03%	0.04%	6.86%	2.51%	Nooksack Spring
Spring Creek Hatchery	0.02%	0.04%	0.07%	0.05%	NA
Fraser Spring 1.2	0.02%	0.03%	0.51%	0.17%	Nicola
Snohomish Wild	0.02%	0.03%	1.99%	0.48%	Snohomish
Stillaguamish Wild	0.01%	0.02%	2.13%	0.88%	Stillaguamish
Northern SE AK	0.01%	0.02%	0.17%	0.08%	Chilkat
Puget Sound Yearlings	0.01%	0.01%	0.04%	0.03%	NA
Alsek	0.00%	0.00%	0.00%	0.00%	Alsek
Fraser Spring 1.3	0.00%	0.00%	0.00%	0.00%	Chilcotin
Yakutat Forelands	0.00%	0.00%	0.00%	0.00%	Situk

[1] NA = a hatchery stock; Not represented = a wild stock without an escapement indicator.

Appendix B3–West Coast Vancouver Island aggregate abundance-based management (AABM) troll and sport stock composition.

FISHERY:	**WCVI AABM TROLL AND SPORT**				
	2020	**Average (1985–2019)**			
Model Stock	**% of Fishery Catch**	**% of Fishery Catch**	**% of Stock Catch**	**% of Stock Total Return**	**Associated Escapement Indicator Stocks[1]**
Puget Sound Fingerling	13.49%	13.18%	18.13%	10.93%	NA
Upriver Brights	21.74%	13.17%	10.27%	5.94%	Upriver Brights
Spring Creek Hatchery	7.93%	10.56%	20.48%	15.76%	NA
Fall Cowlitz Hatchery	6.88%	8.34%	21.79%	12.26%	NA
Lower Bonneville Hatchery	3.27%	6.47%	32.71%	18.40%	NA
Harrison Fall	2.31%	5.82%	18.73%	6.18%	Harrison
WCVI Hatchery	5.77%	5.27%	5.71%	3.05%	NA
Chilliwack Fall Hatchery	5.29%	5.22%	25.02%	10.71%	NA
Mid Columbia River Brights	5.89%	4.27%	11.11%	6.85%	Not Represented
North Oregon Coast	6.30%	3.99%	6.25%	3.59%	Nehalem
Columbia River Summer	5.05%	3.76%	16.86%	9.75%	Siletz
					Siuslaw
					Mid-Columbia Summers
Nooksack Fall	1.00%	2.98%	10.58%	7.08%	Not Represented
Puget Sound Natural Fall	1.04%	2.45%	22.11%	13.04%	NA
Mid-Oregon Coast	1.90%	1.81%	6.71%	3.72%	South Umpqua
					Coquille
WA Coastal Wild	1.33%	1.55%	5.98%	2.97%	Grays Harbor Fall
					Queets Fall
					Quillayute Fall
					Hoh Fall
Puget Sound Yearlings	0.32%	1.39%	14.09%	9.34%	NA
Fraser Summer Stream-type 1.3	0.72%	1.36%	13.03%	5.63%	Chilko
Lyons Ferry	1.61%	1.09%	20.40%	13.86%	Not Represented
WA Coastal Hatchery	1.03%	1.03%	6.20%	2.81%	NA
Skagit Wild	0.76%	0.92%	21.53%	7.89%	Skagit Summer/Fall
Lewis River Wild	1.80%	0.81%	15.12%	5.91%	Lewis
Willamette River Spring	0.76%	0.81%	3.68%	1.66%	NA

Spring Cowlitz Hatchery	0.33%	0.77%	9.59%	5.63%	NA
Fraser Summer Ocean-type 0.3	0.90%	0.70%	2.27%	0.99%	Lower Shuswap
Lower Georgia Strait	0.64%	0.63%	9.72%	4.44%	Cowichan
WCVI Natural	0.99%	0.54%	5.64%	3.36%	NWVI Natural Aggregate
					SWVI Natural Aggregate
Middle Georgia Strait	0.50%	0.36%	5.74%	1.99%	NA
Snohomish Wild	0.11%	0.19%	18.49%	4.64%	Snohomish
Fraser Spring 1.2	0.11%	0.18%	4.14%	1.44%	Nicola
Stillaguamish Wild	0.08%	0.13%	18.20%	7.81%	Stillaguamish
Nooksack Spring	0.06%	0.09%	16.24%	5.96%	Nooksack Spring
Fraser Spring 1.3	0.04%	0.06%	0.99%	0.26%	Chilcotin
Puntledge Summers	0.02%	0.03%	7.33%	2.29%	NA
Upper Georgia Strait	0.02%	0.02%	0.56%	0.21%	East Vancouver Island North
					Phillips
Central BC	0.01%	0.01%	0.37%	0.09%	Atnarko
Northern SE AK	0.00%	0.00%	0.06%	0.02%	Chilkat
Yakutat Forelands	0.00%	0.00%	0.00%	0.00%	Situk
Taku and Stikine	0.00%	0.00%	0.00%	0.00%	Taku
					Stikine
Alsek	0.00%	0.00%	0.00%	0.00%	Alsek
Northern BC	0.00%	0.00%	0.00%	0.00%	Skeena
Southern SE AK	0.00%	0.00%	0.00%	0.00%	Unuk

[1] NA = a hatchery stock; Not represented = a wild stock without an escapement indicator.

Appendix B4–Canada individual stock-based management (ISBM) troll, net, and sport stock composition.

FISHERY:	**CANADA ISBM TROLL NET AND SPORT**				
	2020	**Average (1985–2019)**			
Model Stock	**% of Fishery Catch**	**% of Fishery Catch**	**% of Stock Catch**	**% of Stock Total Return**	**Associated Escapement Indicator Stocks[1]**
WCVI Hatchery	44.85%	28.39%	54.37%	26.06%	NA
Harrison Fall	2.71%	7.84%	39.90%	13.92%	Harrison
Puget Sound Fingerling	6.81%	6.10%	13.18%	7.80%	NA
Fraser Summer Stream-type 1.3	3.63%	5.75%	76.04%	33.94%	Chilko
Fraser Summer Ocean-type 0.3	8.05%	5.70%	28.07%	11.32%	Lower Shuswap
Nooksack Fall	2.31%	5.32%	29.20%	19.58%	Not Represented
Lower Georgia Strait	4.43%	4.39%	75.42%	40.83%	Cowichan
Chilliwack Fall Hatchery	4.69%	4.21%	36.14%	17.28%	NA
WCVI Natural	6.86%	3.90%	52.29%	28.59%	NWVI Natural Aggregate
					SWVI Natural Aggregate
Fraser Spring 1.3	0.65%	3.81%	84.06%	23.35%	Chilcotin
Northern BC	0.55%	3.62%	30.16%	6.10%	Skeena
Middle Georgia Strait	4.43%	3.26%	72.49%	30.09%	NA
Fraser Spring 1.2	0.48%	3.15%	87.13%	31.85%	Nicola
Upriver Brights	1.22%	2.50%	3.57%	2.15%	Upriver Brights
Fall Cowlitz Hatchery	0.92%	1.56%	5.96%	3.29%	NA
Columbia River Summer	1.62%	1.52%	11.83%	6.53%	Mid-Columbia Summers
Central BC	1.27%	1.25%	61.00%	14.65%	Atnarko
Upper Georgia Strait	0.66%	1.16%	38.51%	15.29%	East Vancouver Island North
					Phillips
Skagit Wild	0.90%	1.03%	37.61%	13.99%	Skagit Summer/Fall
Puget Sound Natural Fall	0.45%	0.99%	14.64%	8.34%	NA
Puget Sound Yearlings	0.26%	0.87%	14.46%	9.66%	NA
Spring Creek Hatchery	0.60%	0.80%	2.71%	2.06%	NA
Mid Columbia River Brights	0.39%	0.67%	4.06%	2.75%	Not Represented
Lower Bonneville Hatchery	0.27%	0.49%	3.87%	2.03%	NA
North Oregon Coast	0.03%	0.33%	0.91%	0.51%	Nehalem
					Siletz

					Siuslaw
Snohomish Wild	0.13%	0.23%	35.54%	8.81%	Snohomish
Nooksack Spring	0.15%	0.20%	57.56%	21.05%	Nooksack Spring
Puntledge Summers	0.13%	0.19%	76.00%	30.34%	NA
Lewis River Wild	0.27%	0.17%	4.39%	1.73%	Lewis
Stillaguamish Wild	0.10%	0.16%	35.69%	15.15%	Stillaguamish
WA Coastal Wild	0.05%	0.14%	0.87%	0.44%	Grays Harbor Fall
					Queets Fall
					Quillayute Fall
					Hoh Fall
Spring Cowlitz Hatchery	0.04%	0.11%	2.10%	1.15%	NA
WA Coastal Hatchery	0.04%	0.09%	0.91%	0.44%	NA
Lyons Ferry	0.05%	0.05%	2.70%	1.98%	Not Represented
Willamette River Spring	0.00%	0.03%	0.22%	0.12%	NA
Mid-Oregon Coast	0.00%	0.01%	0.06%	0.03%	South Umpqua
					Coquille
Southern SE AK	0.00%	0.01%	0.31%	0.10%	Unuk
Northern SE AK	0.00%	0.00%	0.05%	0.02%	Chilkat
Taku and Stikine	0.00%	0.00%	0.00%	0.00%	Taku
					Stikine
Alsek	0.00%	0.00%	0.00%	0.00%	Alsek
Yakutat Forelands	0.00%	0.00%	0.00%	0.00%	Situk

[1] NA = a hatchery stock; Not represented = a wild stock without an escapement indicator.

Appendix B5–United States individual stock-based management (ISBM) troll, net, and sport stock composition.

FISHERY:	US ISBM TROLL NET AND SPORT				
	2020	Average (1985–2019)			
Model Stock	% of Fishery Catch	% of Fishery Catch	% of Stock Catch	% of Stock Total Return	Associated Escapement Indicator Stocks[1]
Upriver Brights	25.74%	17.58%	52.02%	28.87%	Upriver Brights
Puget Sound Fingerling	20.05%	13.18%	67.68%	38.94%	NA
Spring Creek Hatchery	9.04%	10.61%	76.73%	58.45%	NA
Fall Cowlitz Hatchery	3.42%	7.04%	67.11%	37.09%	NA
North Oregon Coast	4.57%	6.77%	39.23%	21.43%	Nehalem Siletz Siuslaw
Mid Columbia River Brights	12.51%	5.93%	56.43%	33.10%	Not Represented
Willamette River Spring	2.91%	5.28%	80.54%	37.00%	NA
Mid-Oregon Coast	2.63%	4.73%	60.26%	32.08%	South Umpqua Coquille
Nooksack Fall	2.06%	4.60%	59.65%	38.85%	Not Represented
Lower Bonneville Hatchery	2.46%	3.47%	63.21%	33.77%	NA
Harrison Fall	0.87%	3.27%	38.76%	12.85%	Harrison
Columbia River Summer	2.88%	2.38%	30.49%	17.00%	Mid-Columbia Summers
WA Coastal Wild	1.94%	2.23%	31.10%	14.72%	Grays Harbor Fall Queets Fall Quillayute Fall Hoh Fall
Puget Sound Yearlings	0.64%	2.03%	71.16%	45.81%	NA
Puget Sound Natural Fall	1.07%	1.95%	62.49%	34.97%	NA
Chilliwack Fall Hatchery	1.48%	1.94%	37.52%	15.75%	NA
Spring Cowlitz Hatchery	0.22%	1.83%	83.19%	47.11%	NA
WA Coastal Hatchery	1.06%	1.63%	31.56%	13.82%	NA
Lewis River Wild	2.09%	0.96%	58.33%	23.39%	Lewis
Lyons Ferry	0.81%	0.88%	68.79%	45.65%	Not Represented
Skagit Wild	0.41%	0.35%	30.97%	10.87%	Skagit Summer/Fall
Fraser Summer Ocean-type 0.3	0.37%	0.31%	3.84%	1.54%	Lower Shuswap
Fraser Spring 1.3	0.15%	0.27%	14.96%	3.91%	Chilcotin

Lower Georgia Strait	0.19%	0.20%	9.71%	4.48%	Cowichan
Snohomish Wild	0.07%	0.12%	42.98%	10.57%	Snohomish
Fraser Summer Stream-type 1.3	0.09%	0.11%	4.23%	1.78%	Chilko
WCVI Hatchery	0.08%	0.09%	0.40%	0.19%	NA
Stillaguamish Wild	0.05%	0.08%	42.98%	18.06%	Stillaguamish
Fraser Spring 1.2	0.04%	0.08%	7.81%	2.59%	Nicola
Middle Georgia Strait	0.07%	0.04%	2.38%	0.82%	NA
Nooksack Spring	0.02%	0.02%	14.54%	5.22%	Nooksack Spring
WCVI Natural	0.01%	0.01%	0.35%	0.19%	NWVI Natural Aggregate
					SWVI Natural Aggregate
Northern SE AK	0.00%	0.00%	0.09%	0.04%	Chilkat
Central BC	0.00%	0.00%	0.09%	0.02%	Atnarko
Puntledge Summers	0.00%	0.00%	0.00%	0.00%	NA
Northern BC	0.00%	0.00%	0.00%	0.00%	Skeena
Taku and Stikine	0.00%	0.00%	0.00%	0.00%	Taku
Yakutat Forelands	0.00%	0.00%	0.00%	0.00%	Stikine
					Situk
Alsek	0.00%	0.00%	0.00%	0.00%	Alsek
Upper Georgia Strait	0.00%	0.00%	0.00%	0.00%	East Vancouver Island North
					Phillips
Southern SE AK	0.00%	0.00%	0.00%	0.00%	Unuk

[1] NA = a hatchery stock; Not represented = a wild stock without an escapement indicator.

APPENDIX C: FIGURES OF PSC CHINOOK MODEL-GENERATED STOCK COMPOSITION OF ACTUAL LANDED CATCH FOR ALL (AABM AND ISBM) MODEL FISHERIES, 1979–2020

Stock composition in the AABM and ISBM fisheries are estimated using the PSC Chinook Model. Assumptions of the estimation procedure are described in Appendix B. The relative contribution of a model stock to a model fishery is computed as:

$$P_{F,S,Y} = \frac{Q_{F,S,Y}}{\sum_S Q_{F,S,Y}}$$

where $Q_{F,S,Y}$ is model landed catch by fishery F, stock S, and year Y. Landed catch stock composition is computed:

$$C_{F,S,Y} = C_{F,Y} * P_{F,S,Y}$$

where $C_{F,Y}$ is the landed catch by fishery F and year Y. Since the PSC Chinook Model does not include the Alaska Hatchery Addon, the landed catch stock composition is adjusted to include this harvest:

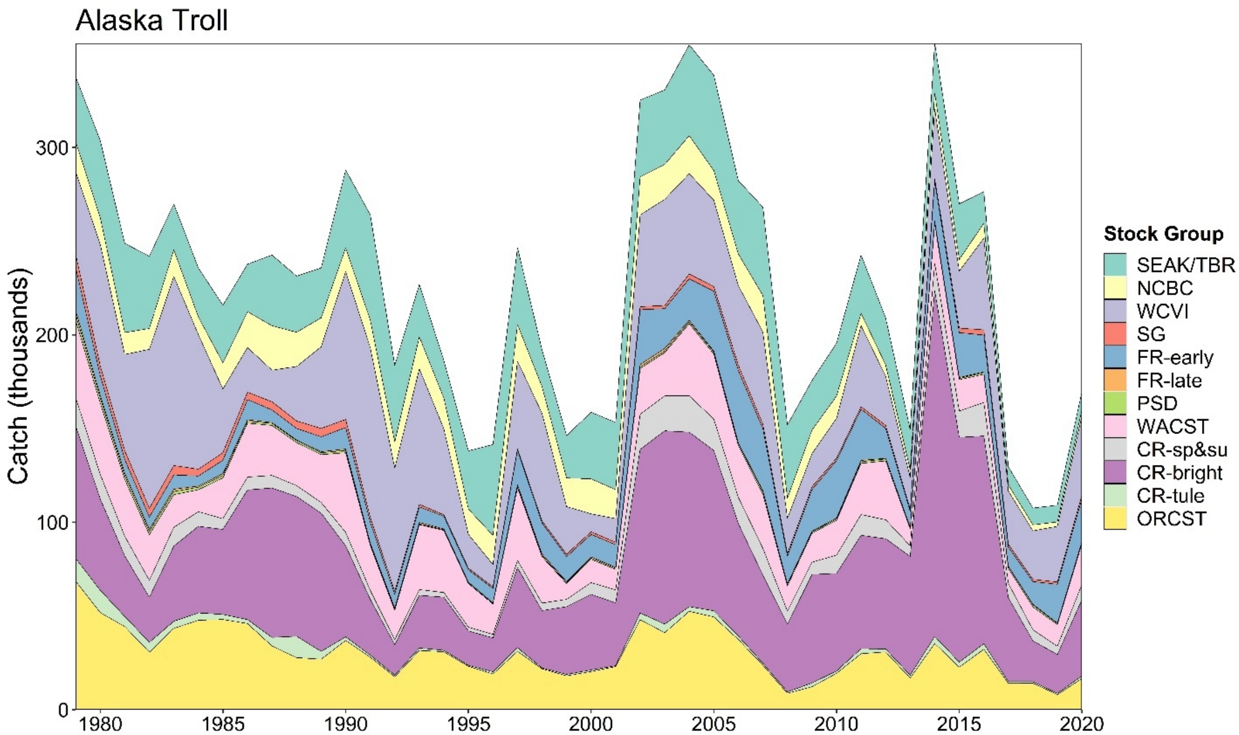
$$C_{F,S=AK,Y} = C_{F,S=AK,Y} + A_{F,S=AK,Y}$$

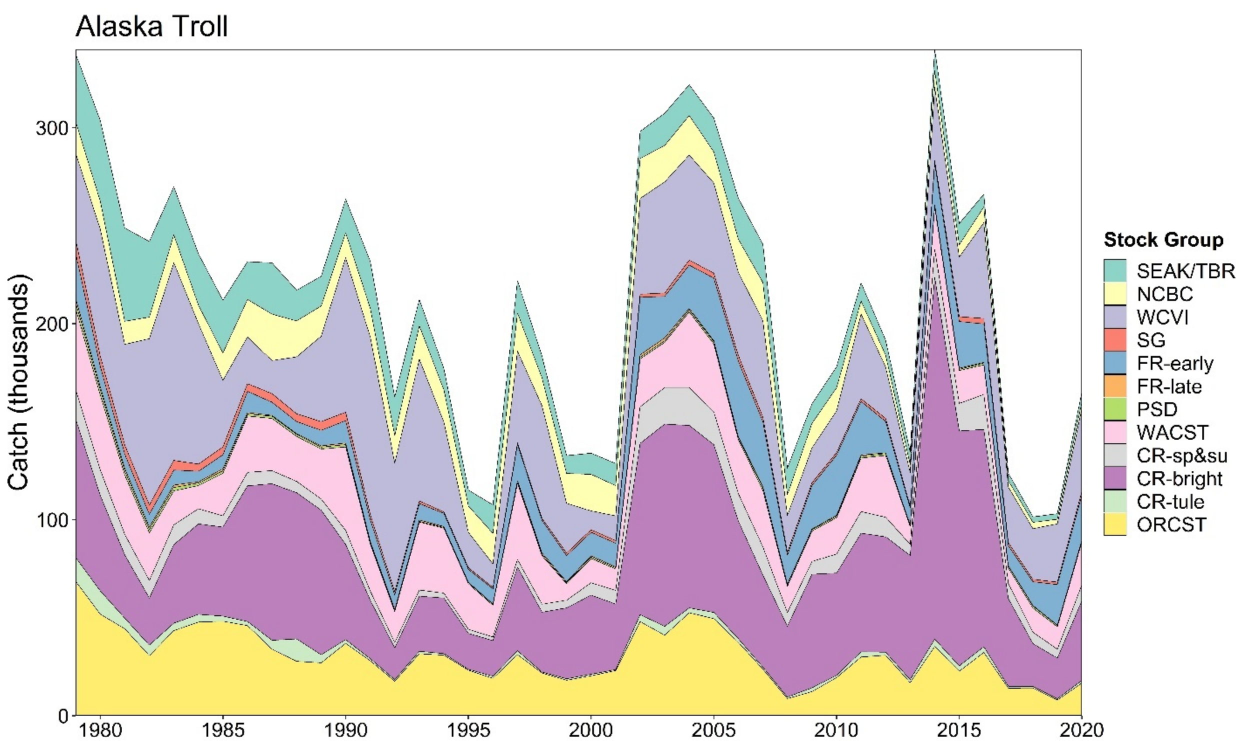
where $A_{F,S=AK,Y}$ is the Alaska Hatchery Addon by fishery F and year Y for the SEAK and TBR stock groups. Results with and without the Alaska Hatchery Addon are reported. Stock group definitions in each figure correspond to the following model stock aggregations:

SEAK/TBR	Southeast Alaska and Transboundary River stocks (Southern and Northern SE AK, Alsek, Taku and Stikine, and Yakutat Forelands)
NCBC	North and Central British Columbia stocks
WCVI	West Coast Vancouver Island stocks (hatchery and natural)
SG	Strait of Georgia stocks (Upper, Middle, Lower, and Puntledge Summers)
FR-early	Fraser River Early stocks (Fraser Spring 1.2 and 1.3, Fraser Summer Ocean-type 0.3 and Stream-type 1.3)
FR-late	Fraser River Late stocks (Harrison Fall, Chilliwack Fall Hatchery)
PSD	Puget Sound stocks (Nooksack Fall and Spring, Puget Sound Natural Fall, Puget Sound Fingerlings and Yearlings, Skagit Wild, Stillaguamish Wild, and Snohomish Wild)
WACST	Washington Coast stocks (hatchery and wild)
CR-sp&su	Columbia River Spring and Summer stocks (Willamette, Spring Cowlitz Hatchery, and Columbia Summers)
CR-bright	Columbia River Fall Bright stocks (Upriver, Mid-Columbia, Lewis River Wild, and Lyons Ferry)
CR-tule	Columbia River-Fall Tule stocks (Spring Creek, Lower Bonneville, and Fall Cowlitz Hatchery)
ORCST	North and Mid-Oregon Coast stocks

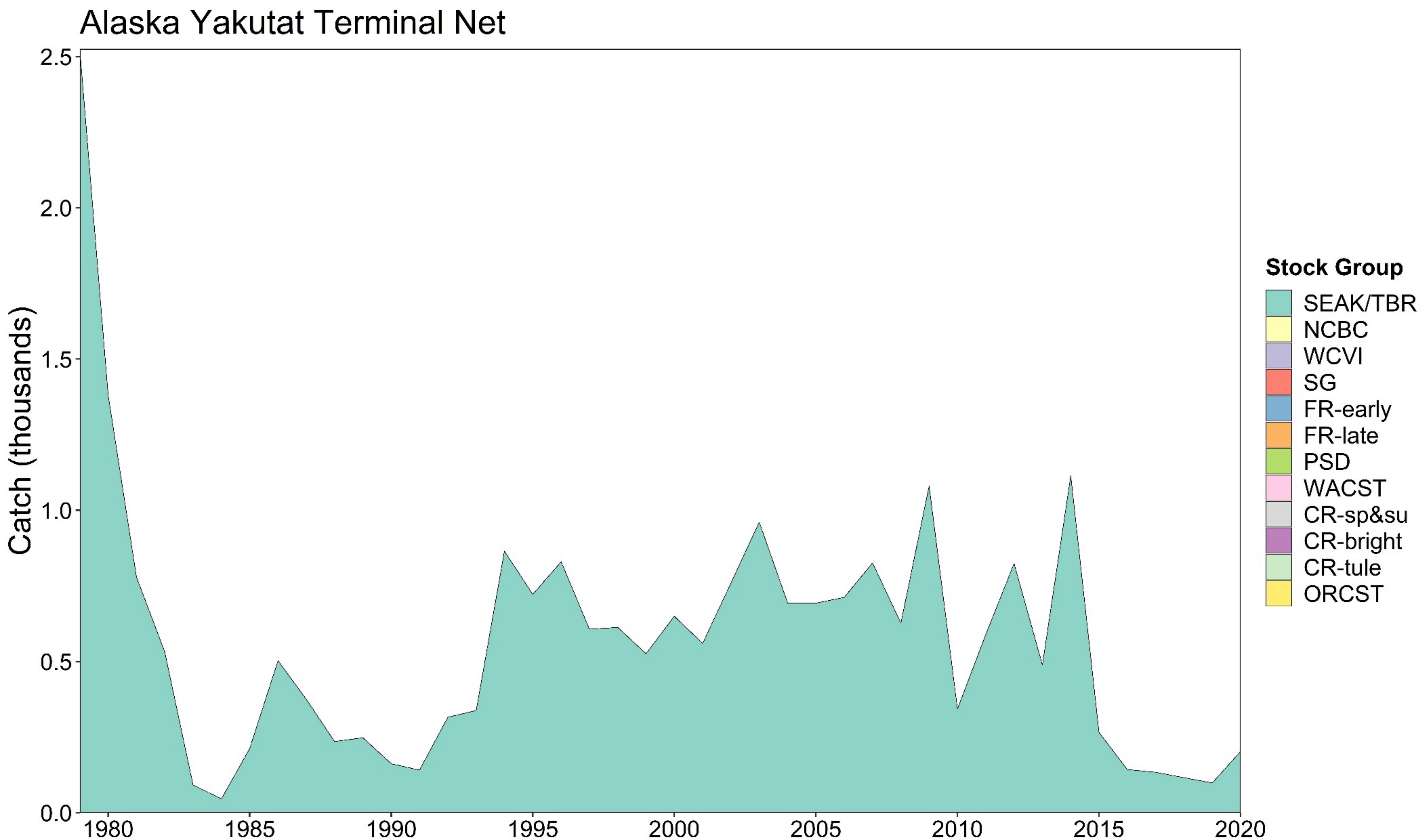
LIST OF APPENDIX C FIGURES

Appendix C1— PSC Chinook Model estimates of landed catch stock composition for Alaska Troll with (upper) and without (lower) Alaska hatchery add-on and terminal exclusion, 1979–2020.

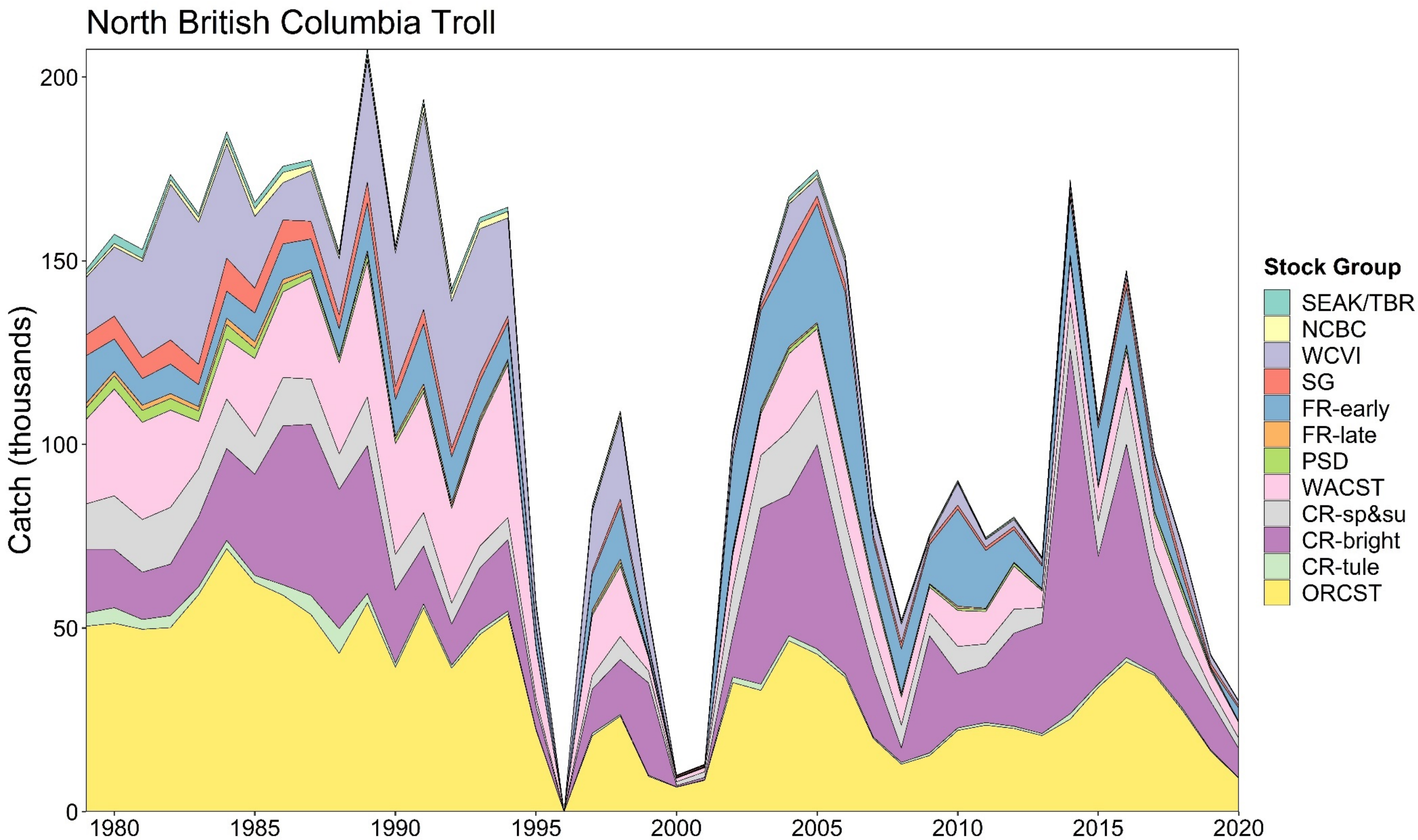




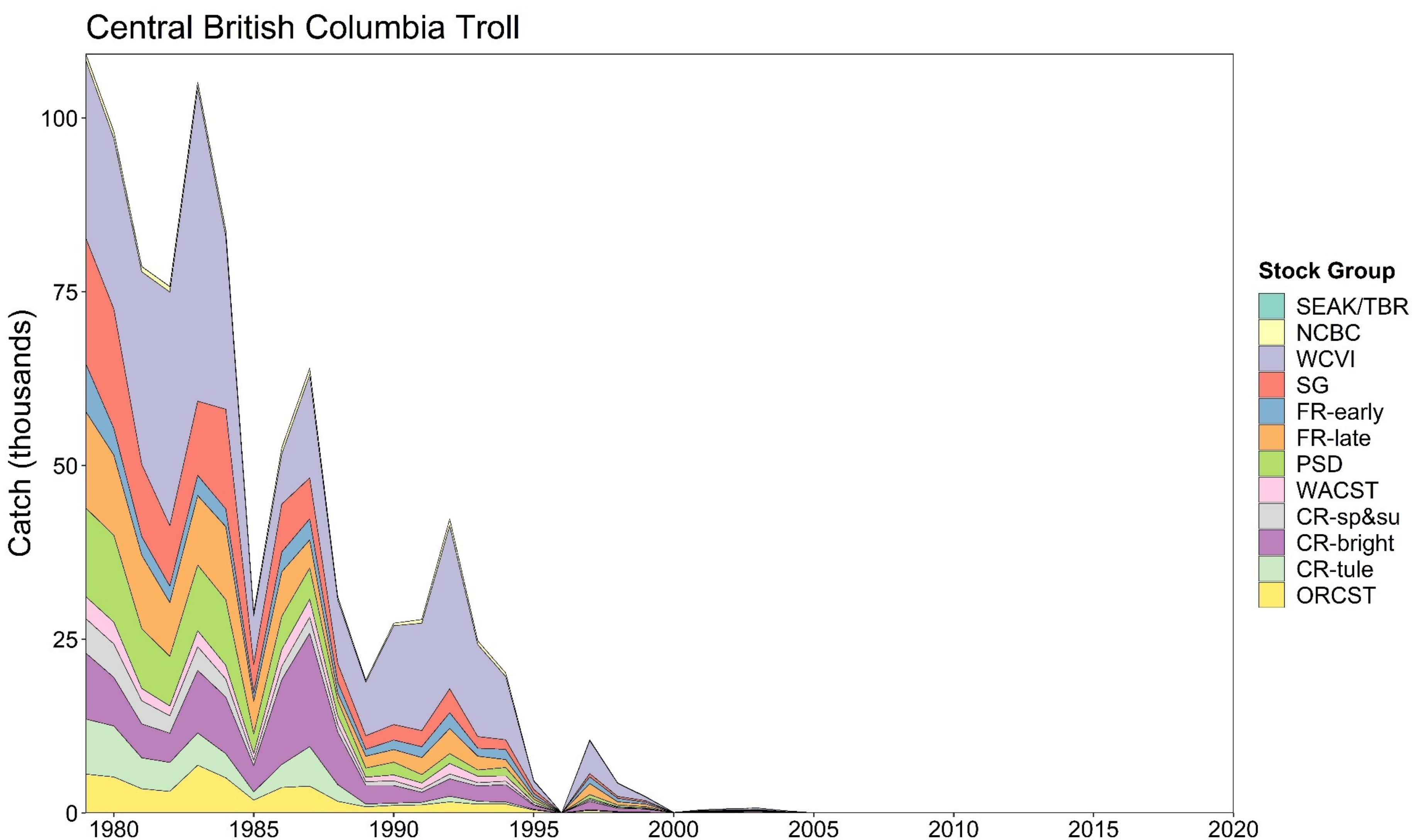
Appendix C2— PSC Chinook Model estimates of landed catch stock composition for Alaska Yakutat Terminal Net, 1979–2020.



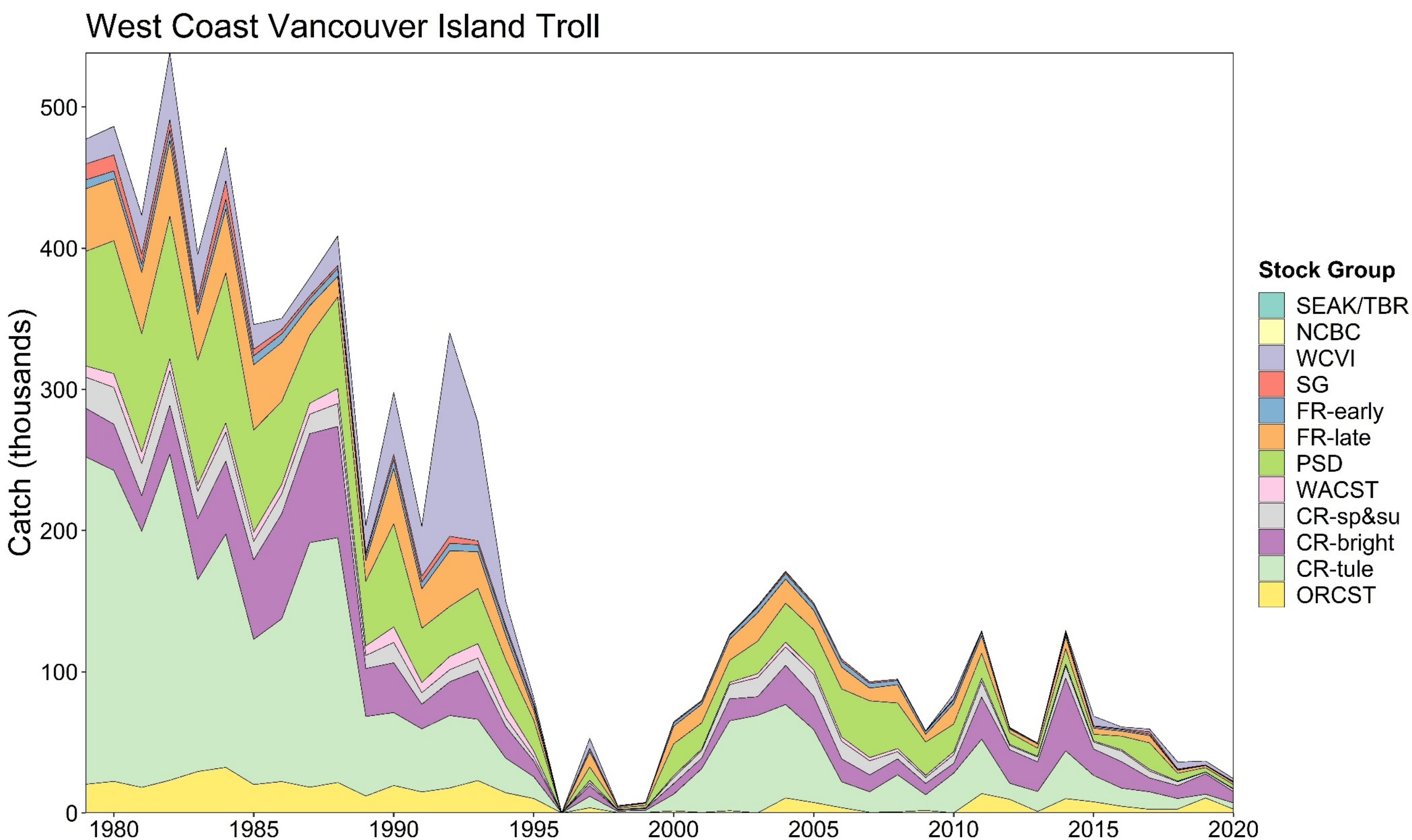
Appendix C3— PSC Chinook Model estimates of landed catch stock composition for North British Columbia Troll, 1979–2020.



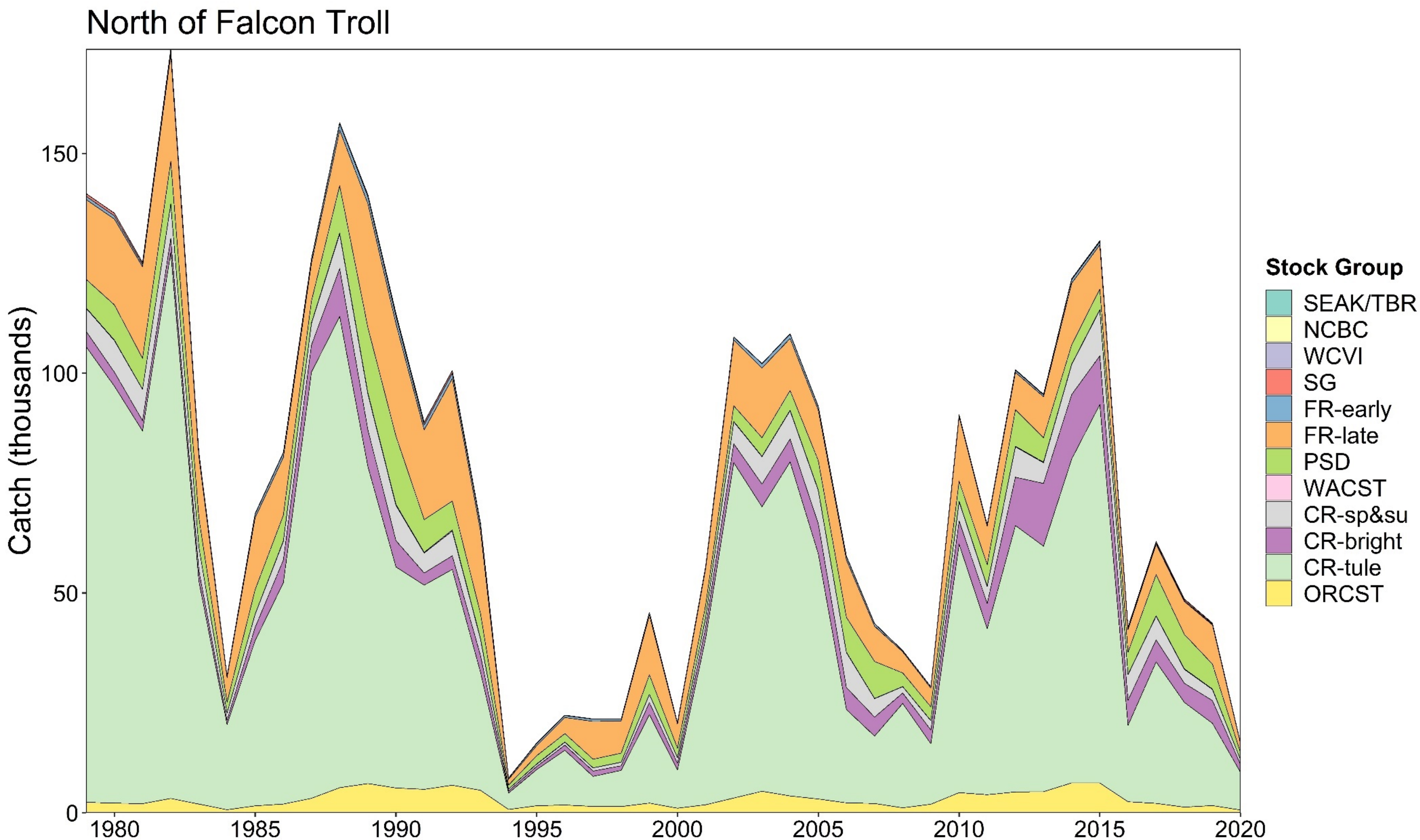
Appendix C4— PSC Chinook Model estimates of landed catch stock composition for Central British Columbia Troll, 1979–2020.



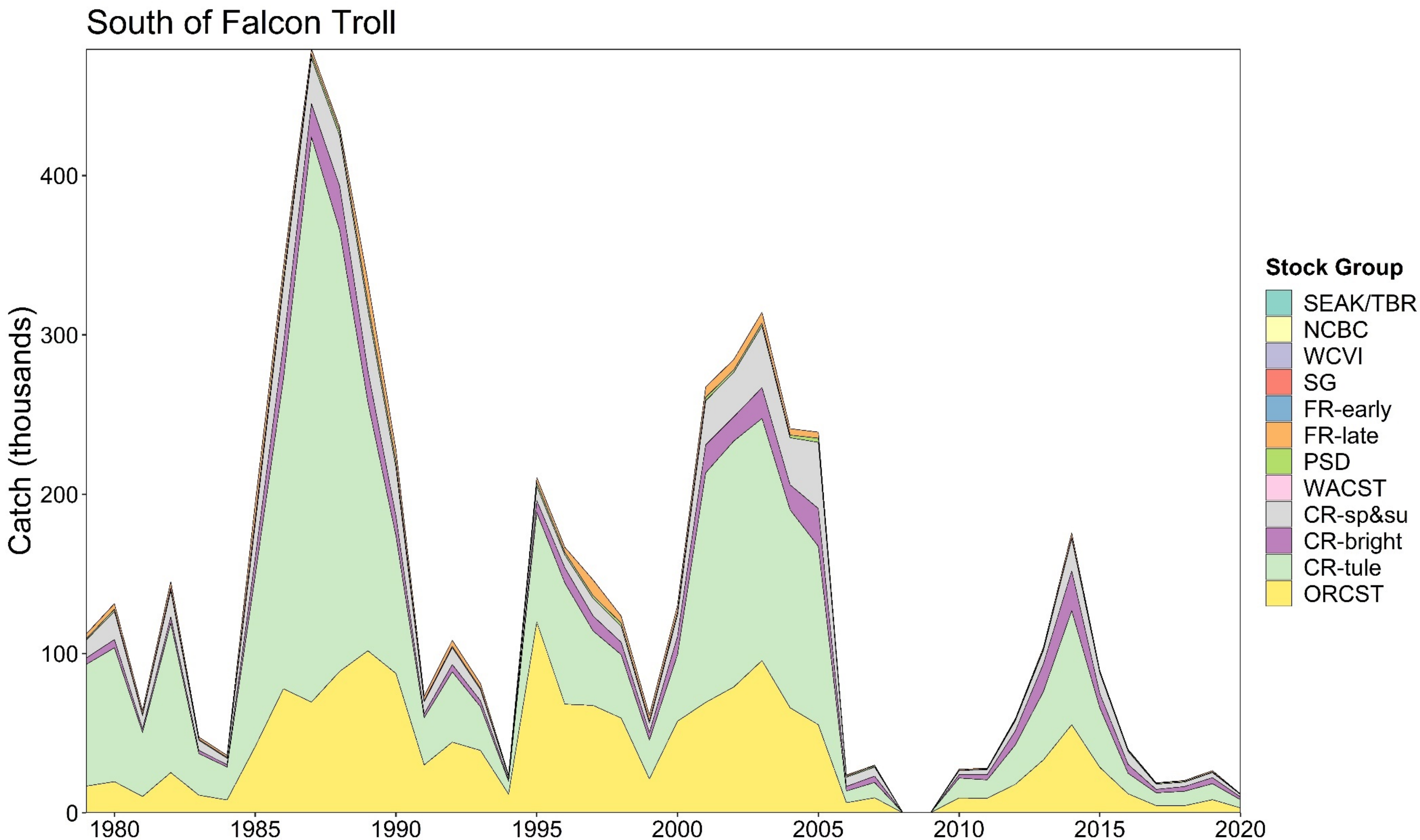
Appendix C5— PSC Chinook Model estimates of landed catch stock composition for West Coast Vancouver Island Troll, 1979–2020.



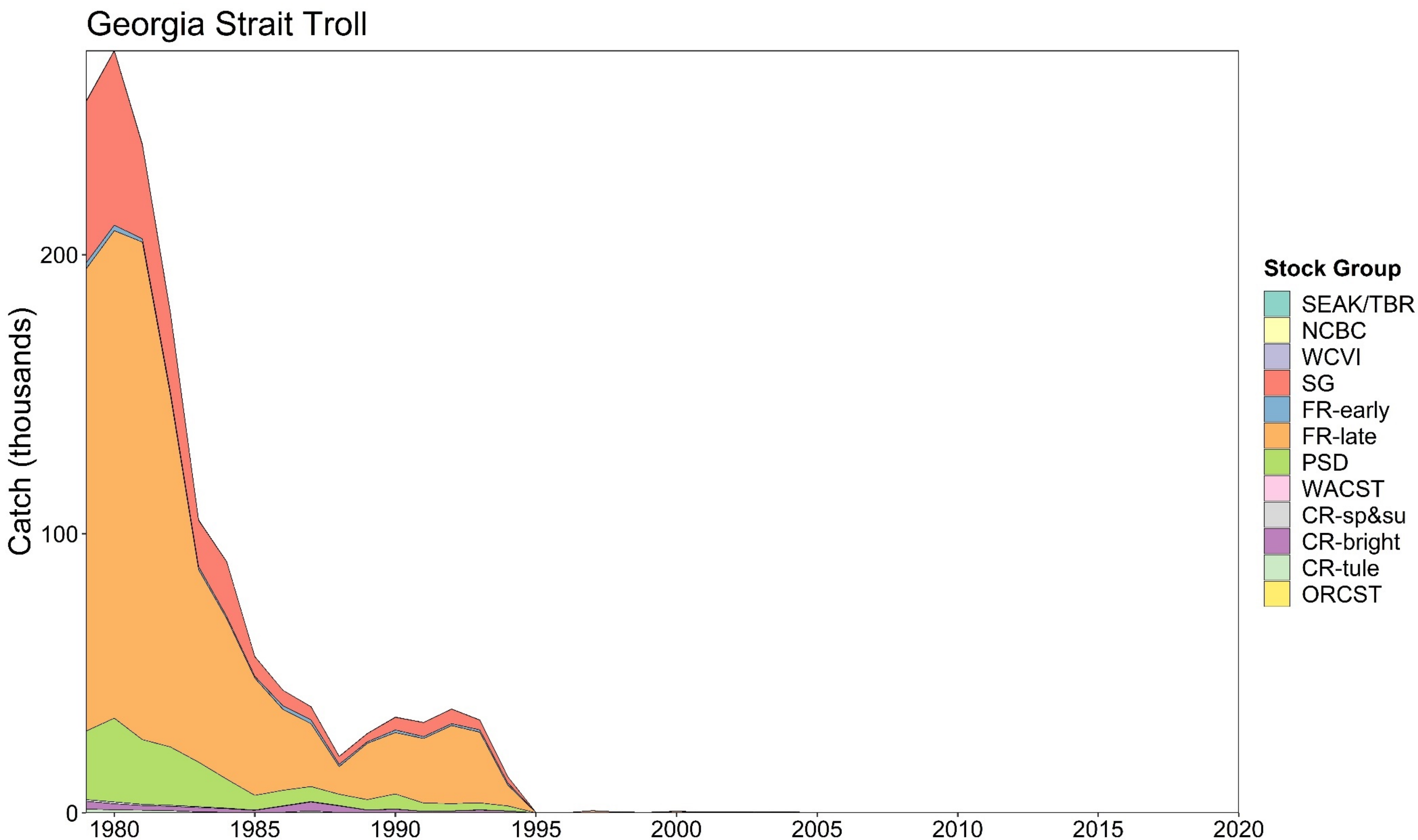
Appendix C6— PSC Chinook Model estimates of landed catch stock composition for North of Falcon Troll, 1979–2020.



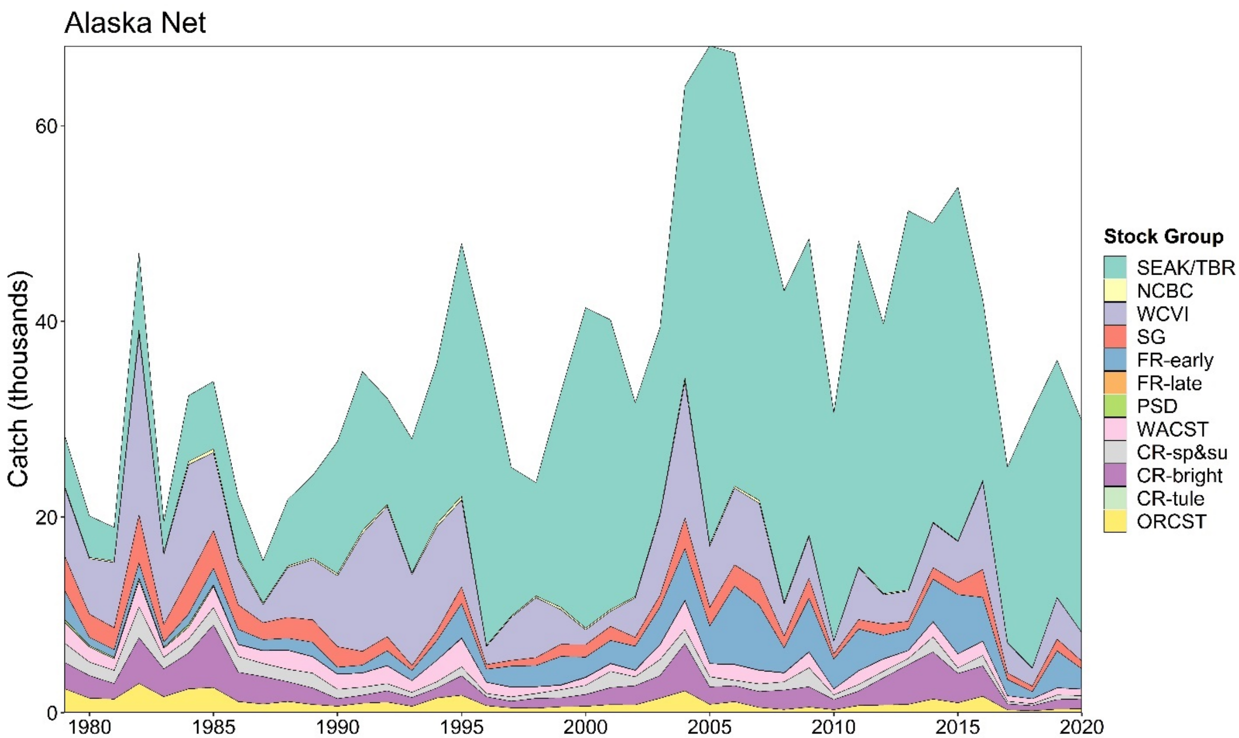
Appendix C7— PSC Chinook Model estimates of landed catch stock composition for South of Falcon Troll, 1979–2020.

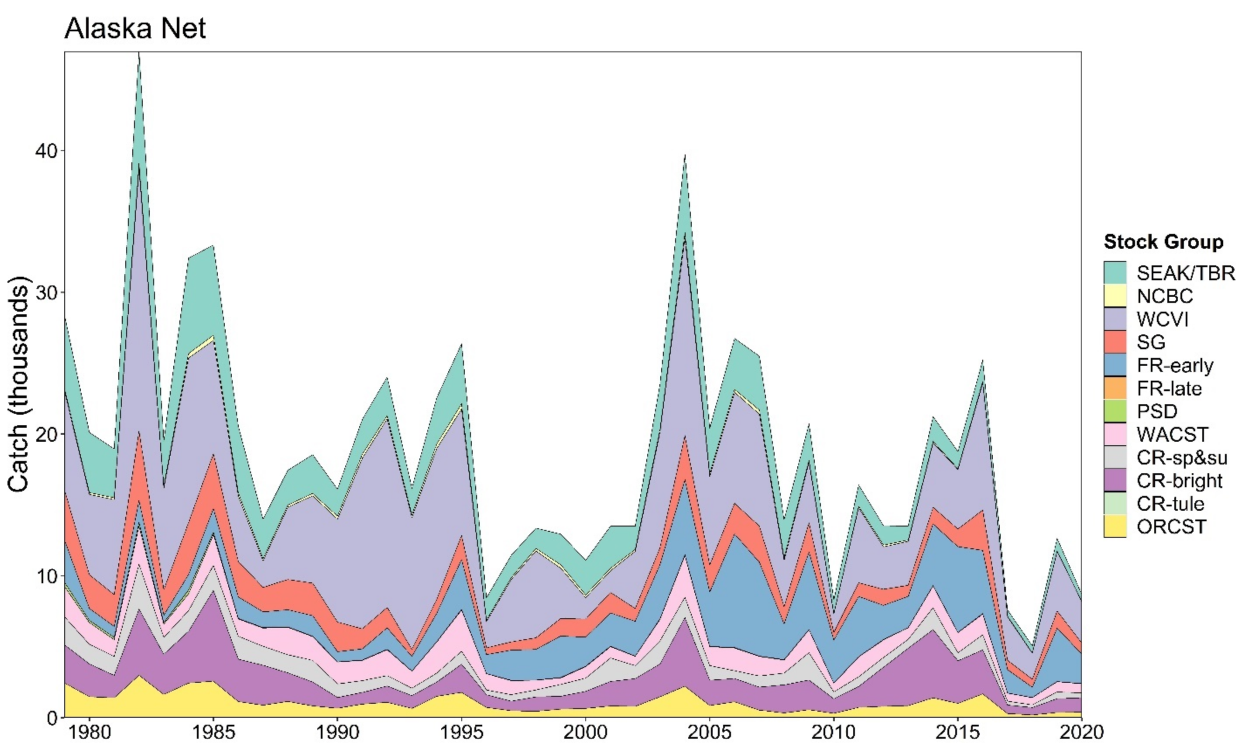


Appendix C8— PSC Chinook Model estimates of landed catch stock composition for Strait of Georgia Troll, 1979–2020.

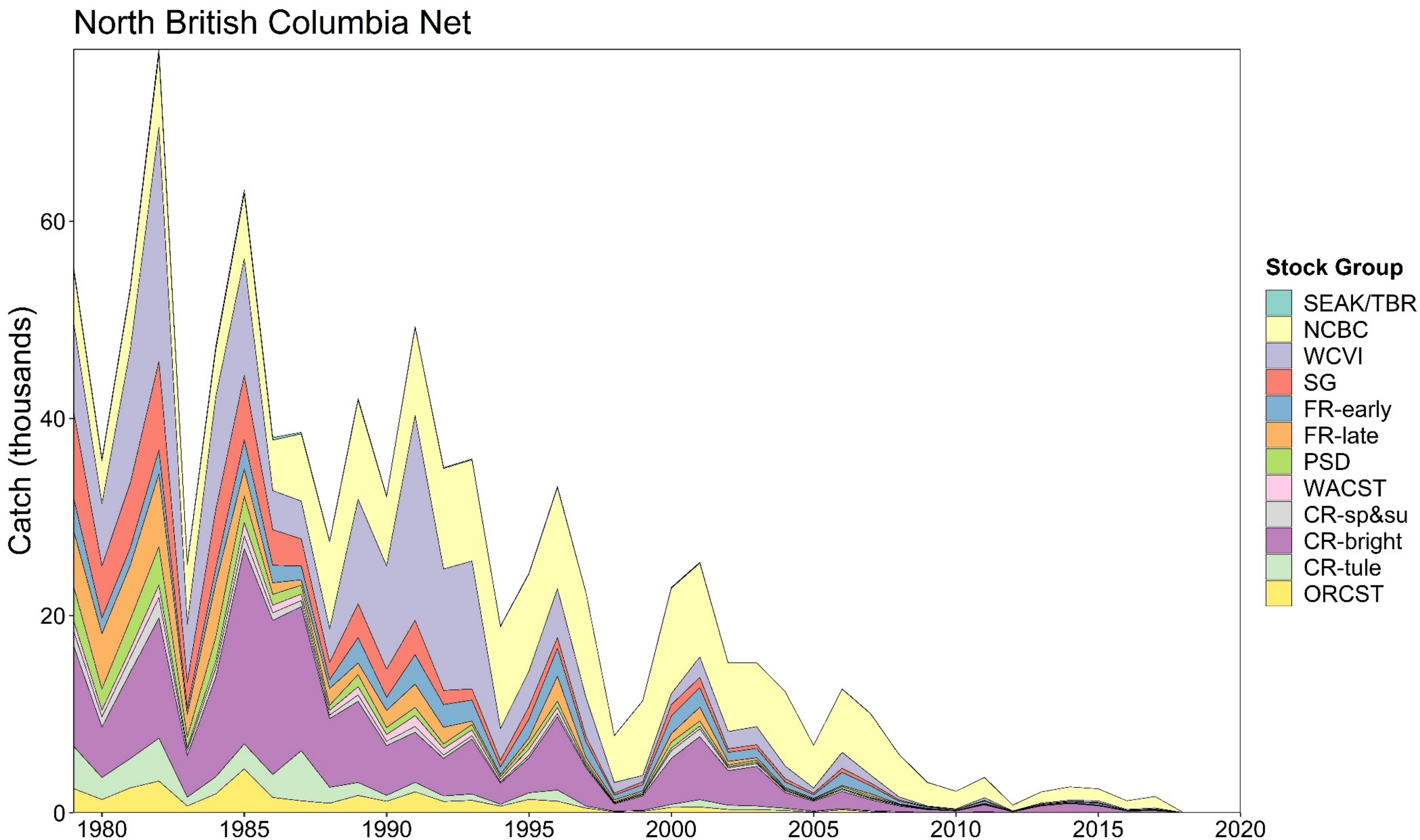


Appendix C9— PSC Chinook Model estimates of landed catch stock composition for Alaska net with (upper) and without (lower) hatchery add-on and terminal exclusion, 1979–2020.

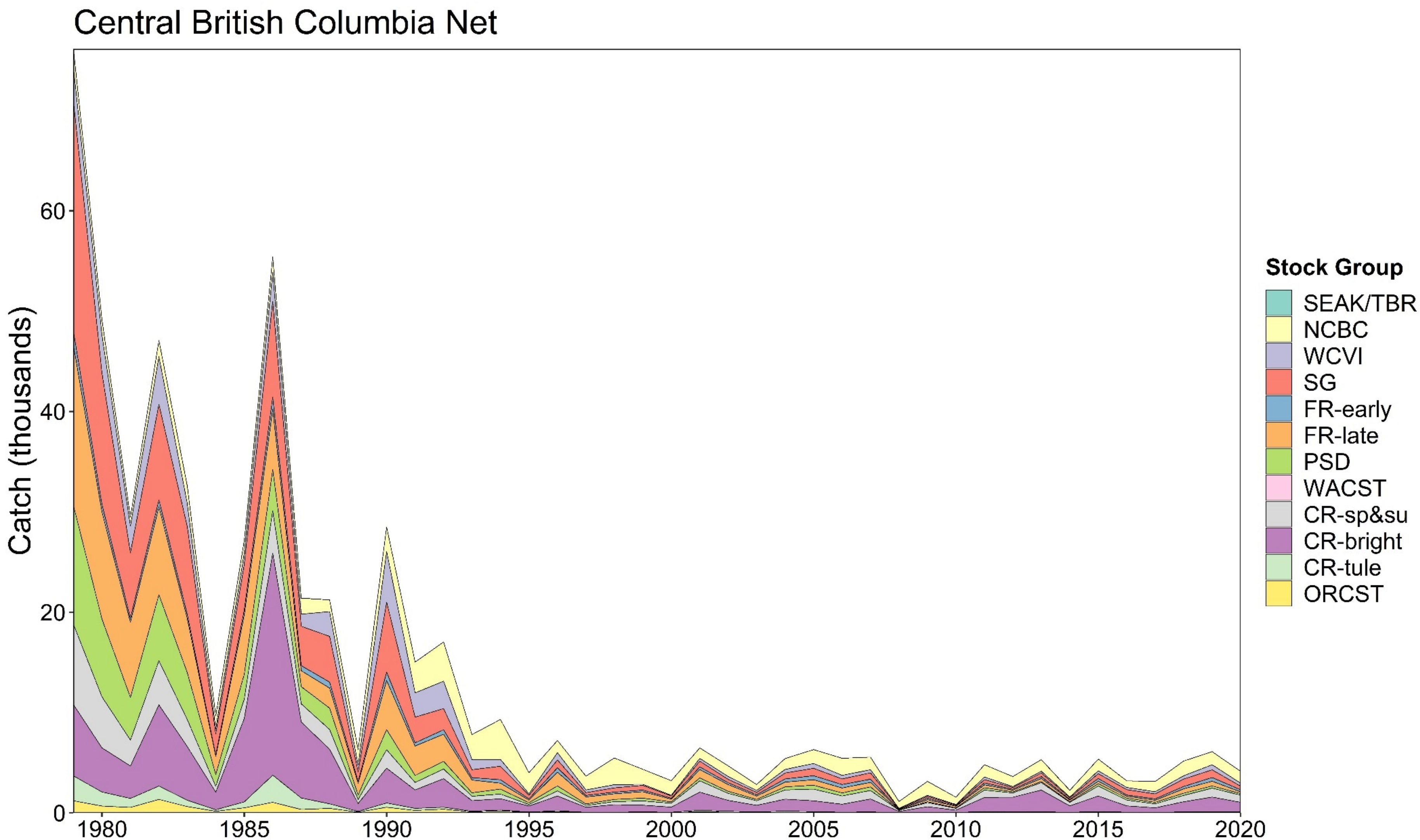




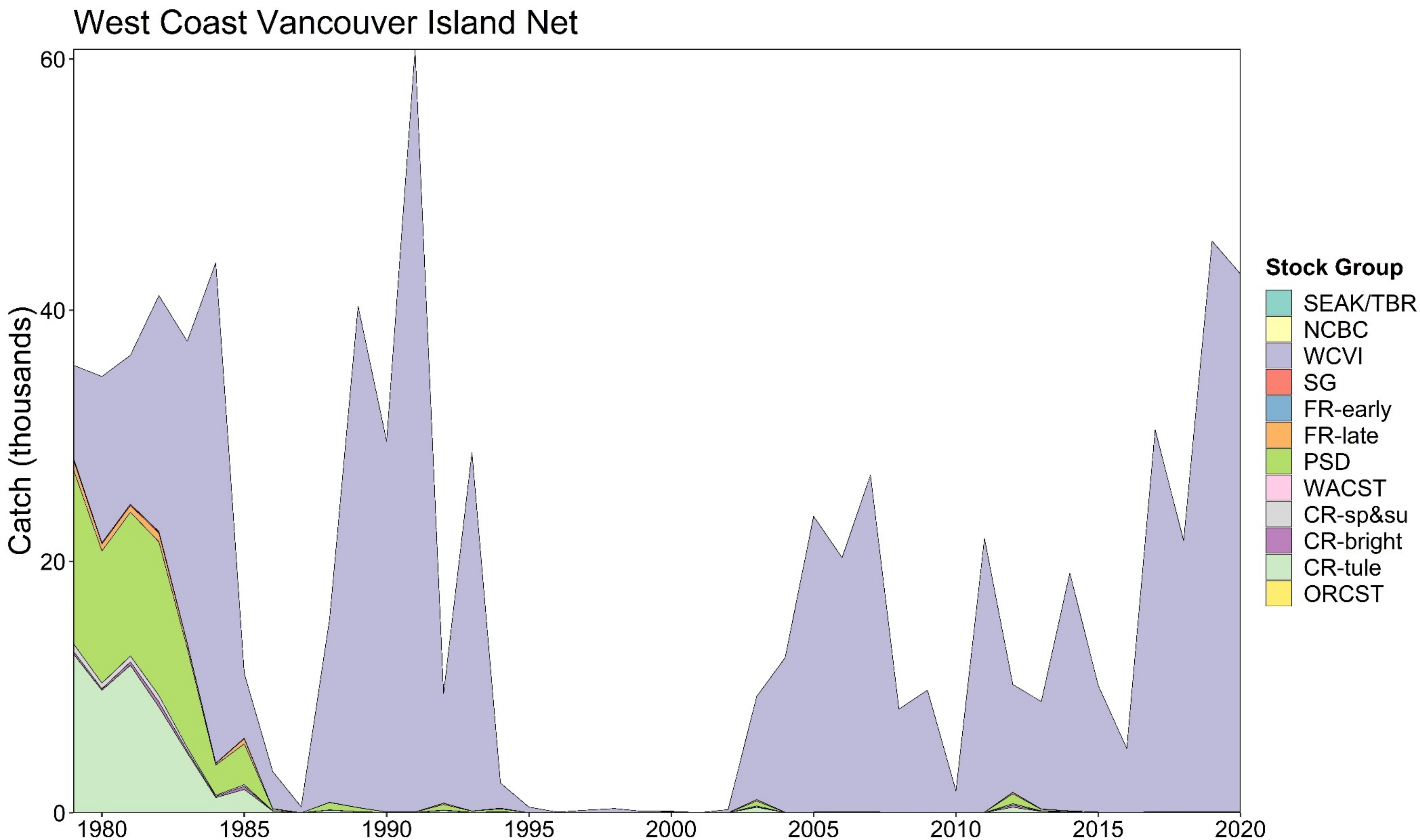
Appendix C10— PSC Chinook Model estimates of landed catch stock composition for North British Columbia Net, 1979–2020.



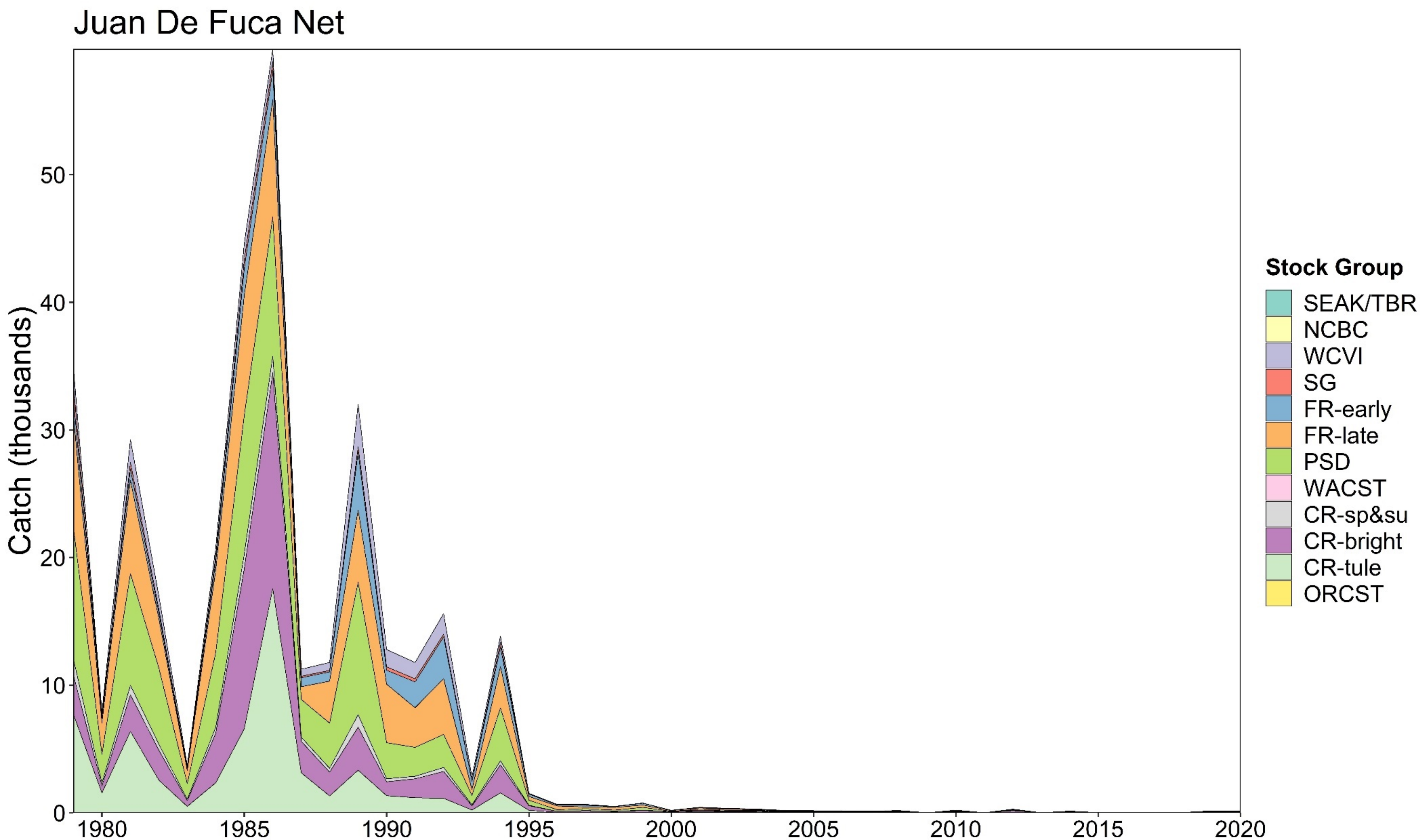
Appendix C11— PSC Chinook Model estimates of landed catch stock composition for Central British Columbia Net, 1979–2020.



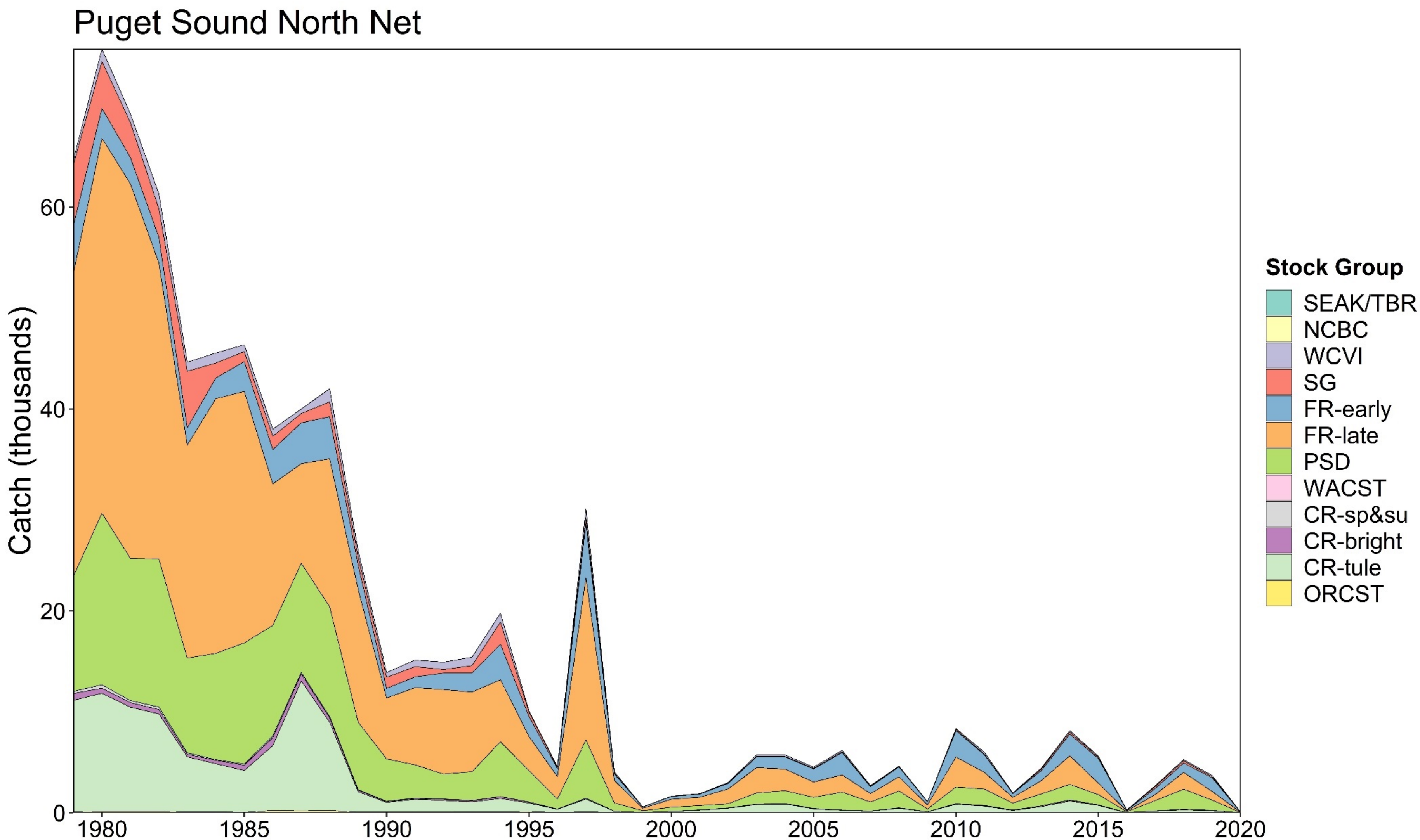
Appendix C12— PSC Chinook Model estimates of landed catch stock composition for West Coast Vancouver Island Net, 1979–2020.



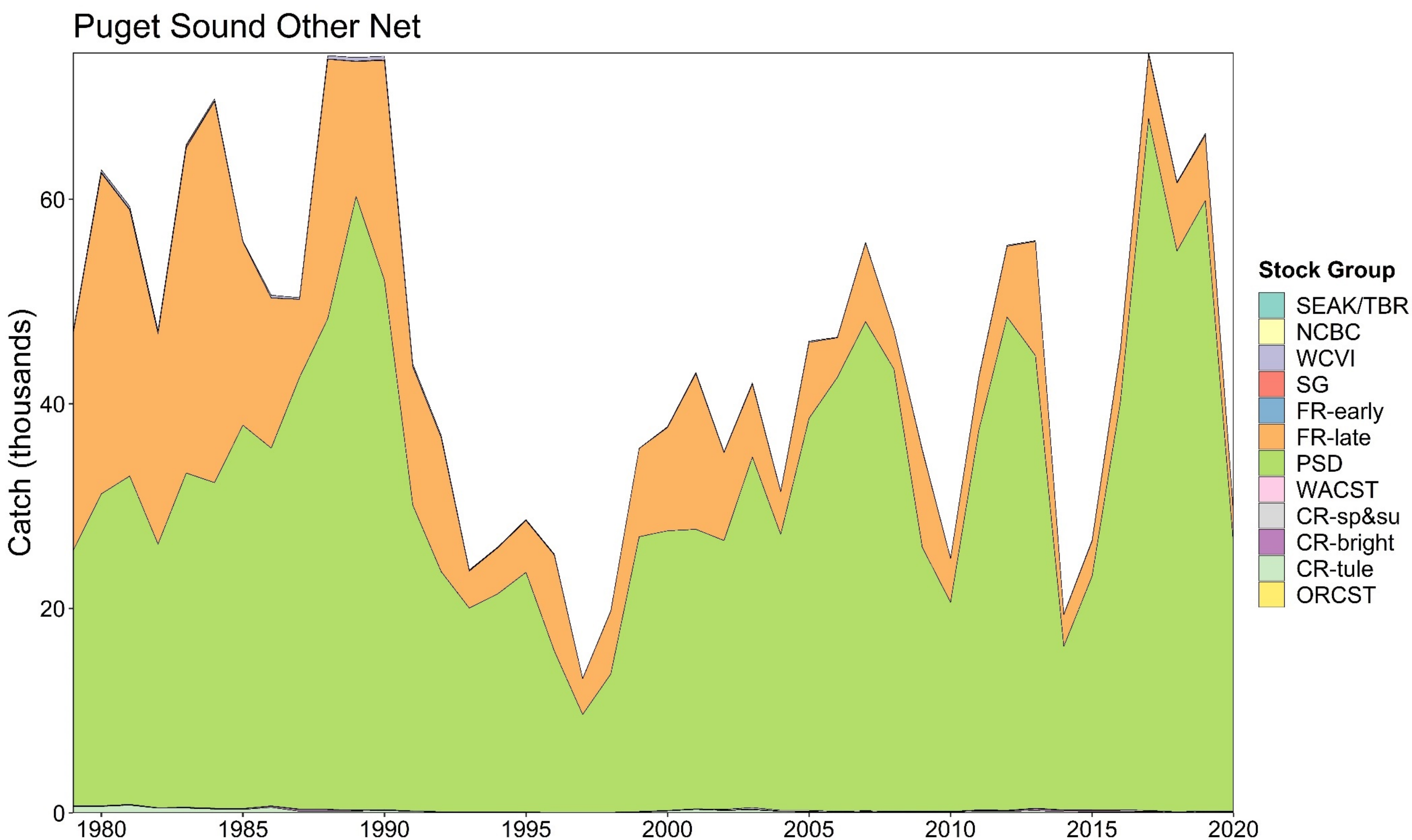
Appendix C13— PSC Chinook Model estimates of landed catch stock composition for Juan De Fuca Net, 1979–2020.



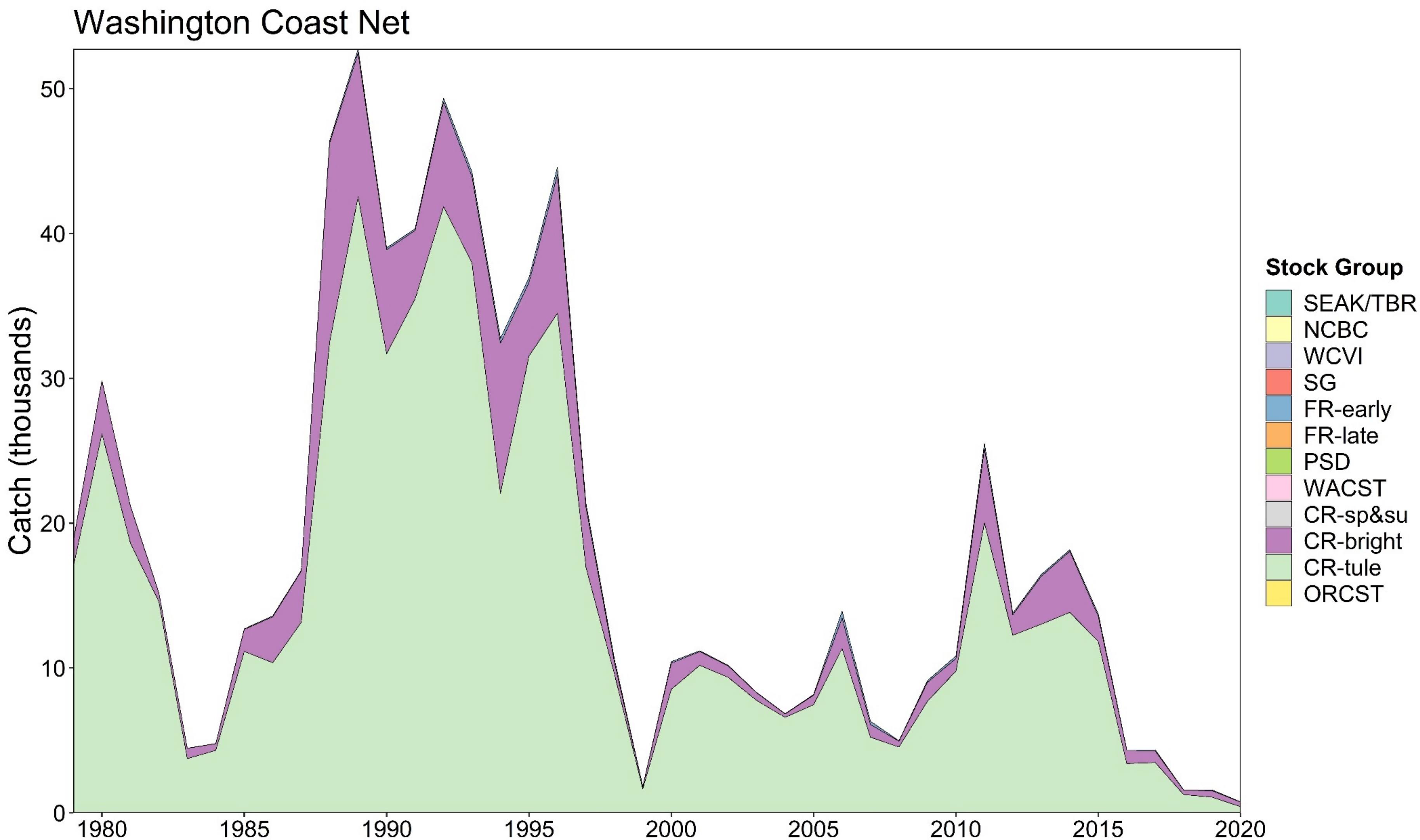
Appendix C14— PSC Chinook Model estimates of landed catch stock composition for Puget Sound North Net, 1979–2020.



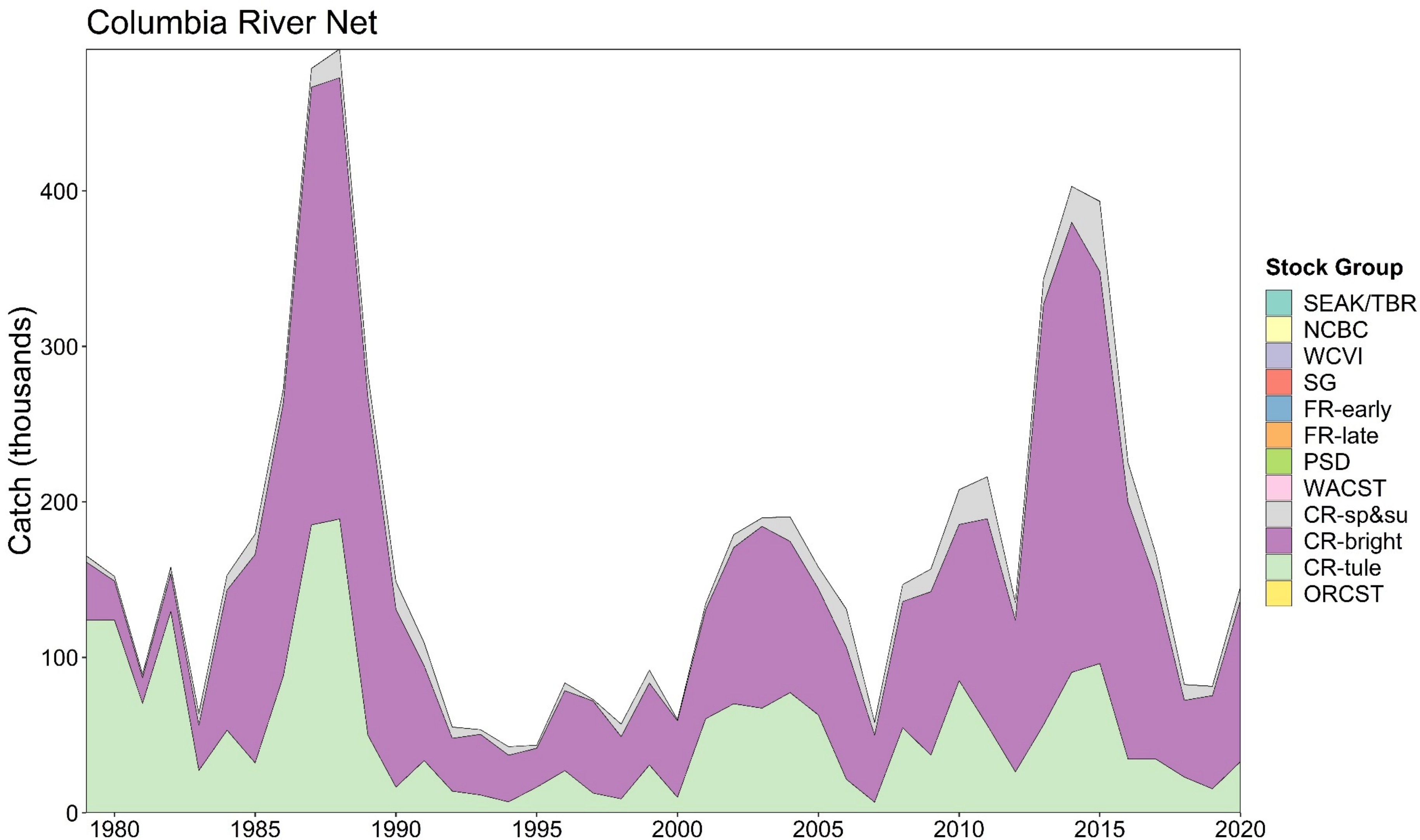
Appendix C15— PSC Chinook Model estimates of landed catch stock composition for Puget Sound Other Net, 1979–2020.



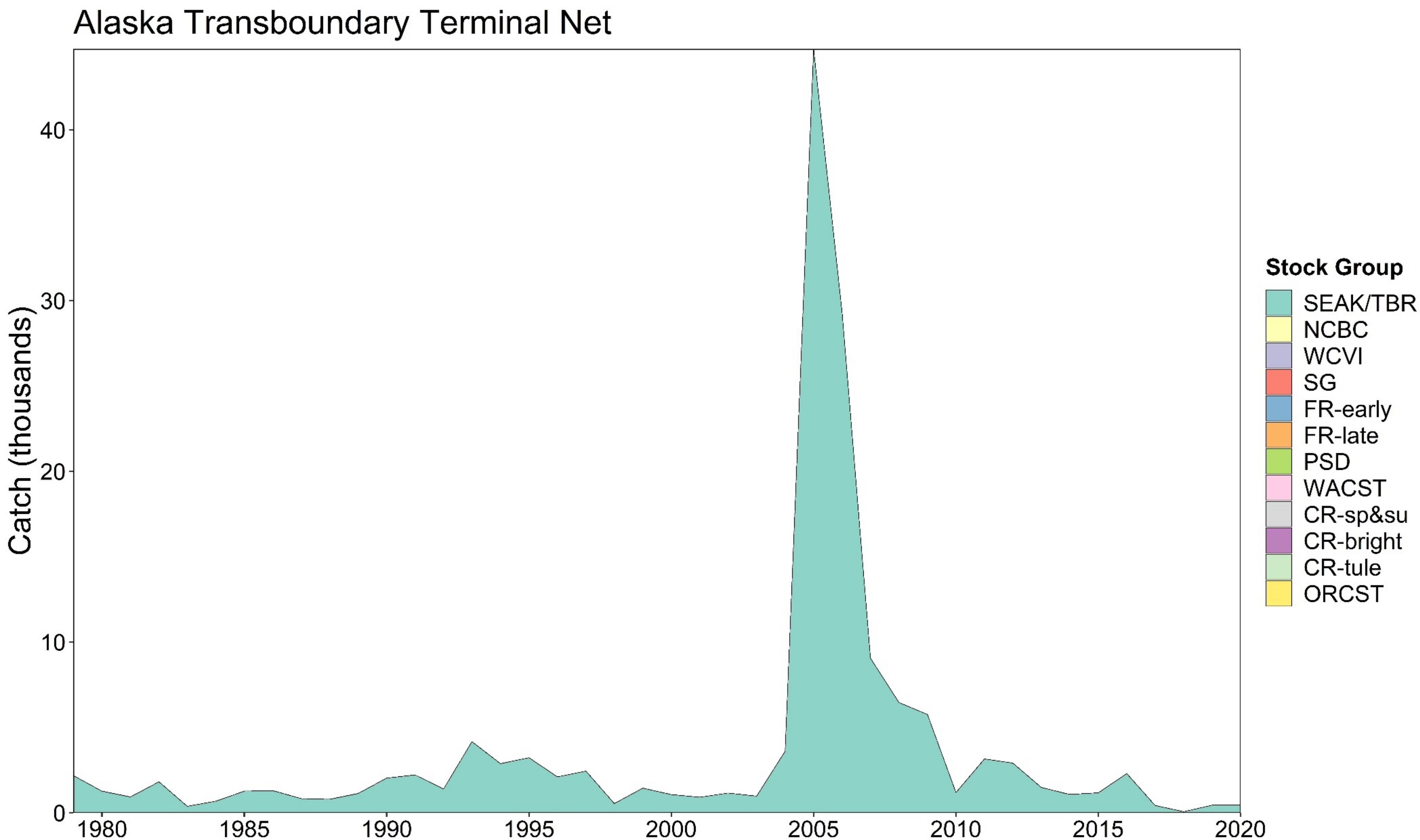
Appendix C16— PSC Chinook Model estimates of landed catch stock composition for Washington Coast Net, 1979–2020.



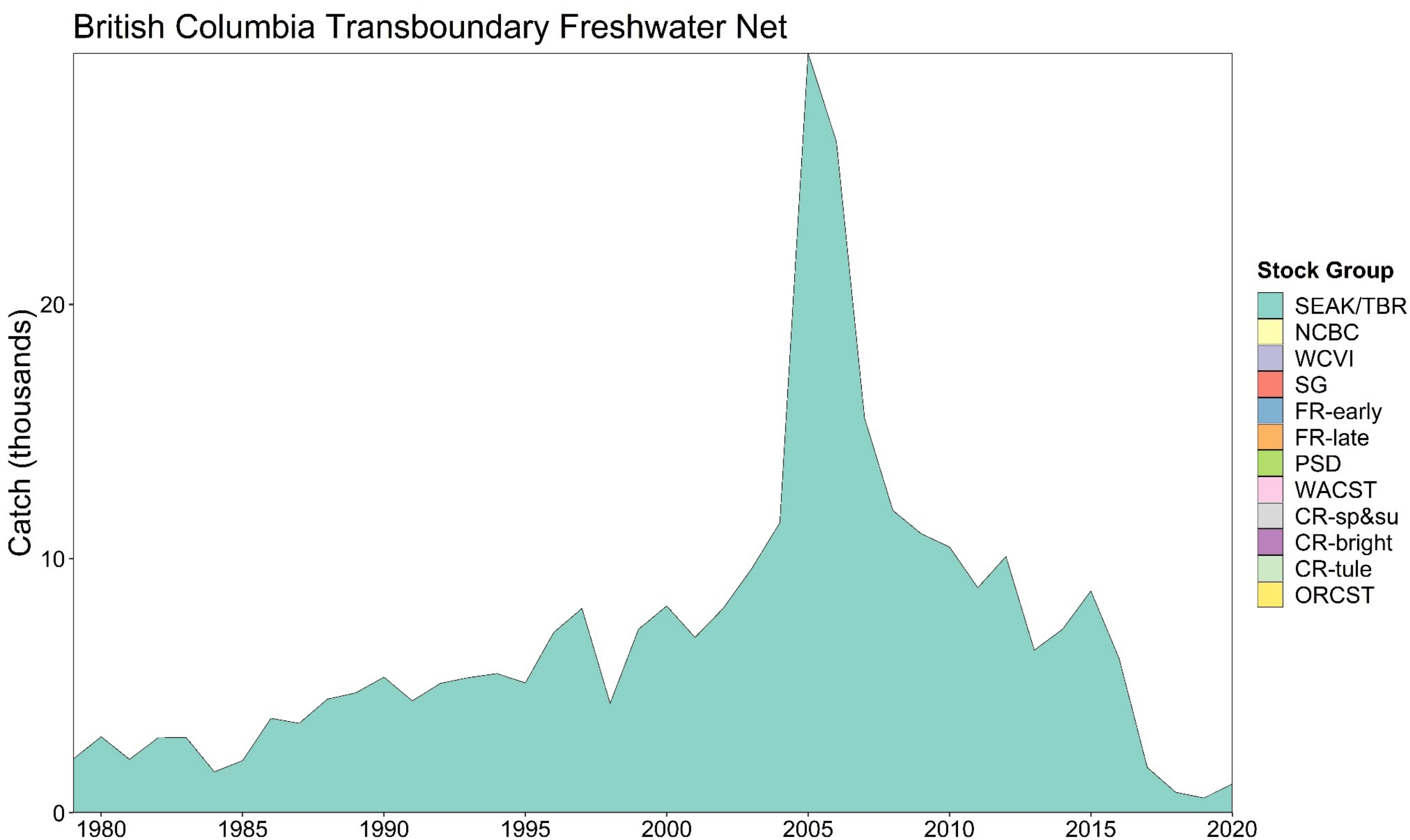
Appendix C17— PSC Chinook Model estimates of landed catch stock composition for Columbia River Net, 1979–2020.



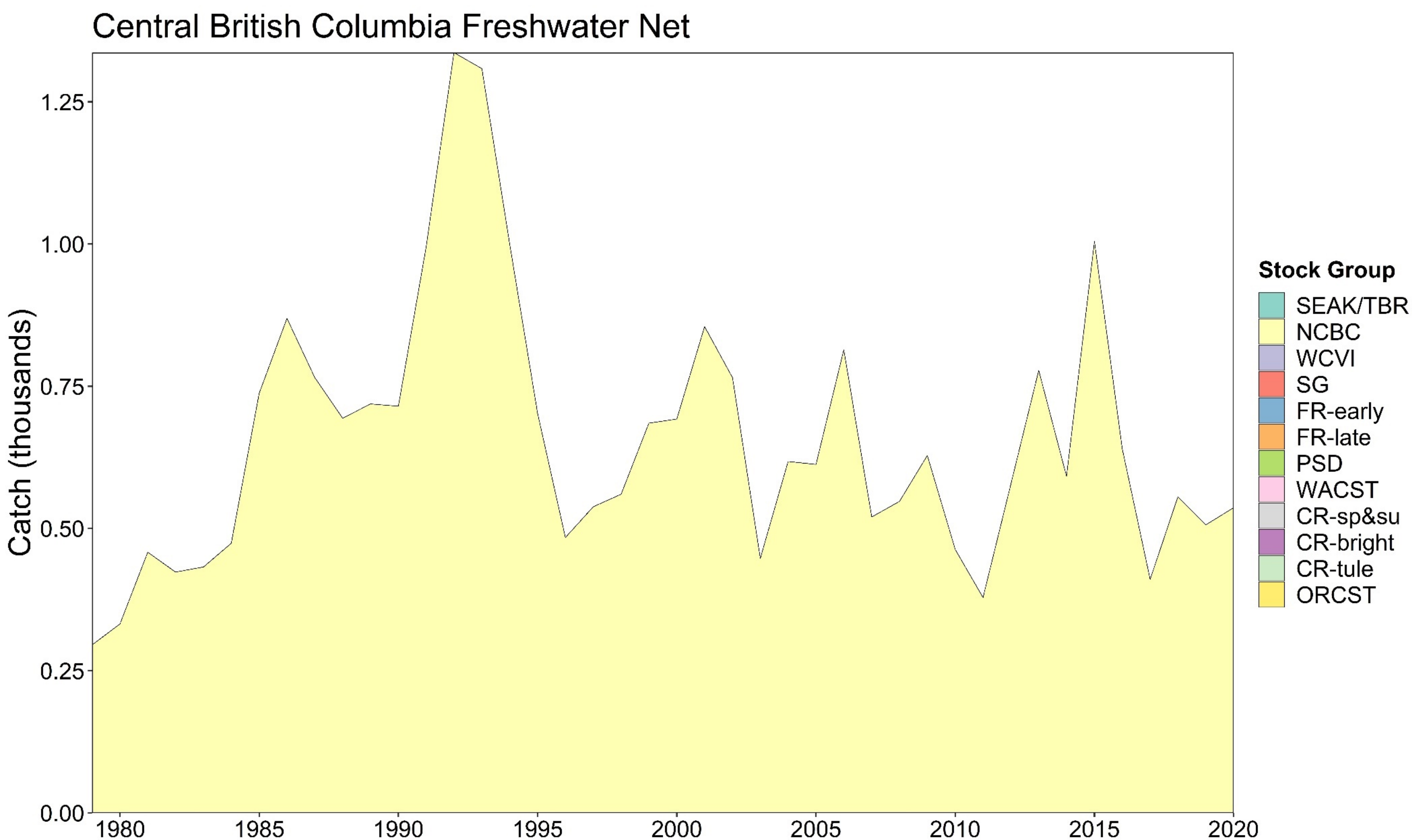
Appendix C18— PSC Chinook Model estimates of landed catch stock composition for Alaska Transboundary River Terminal Net, 1979–2020.



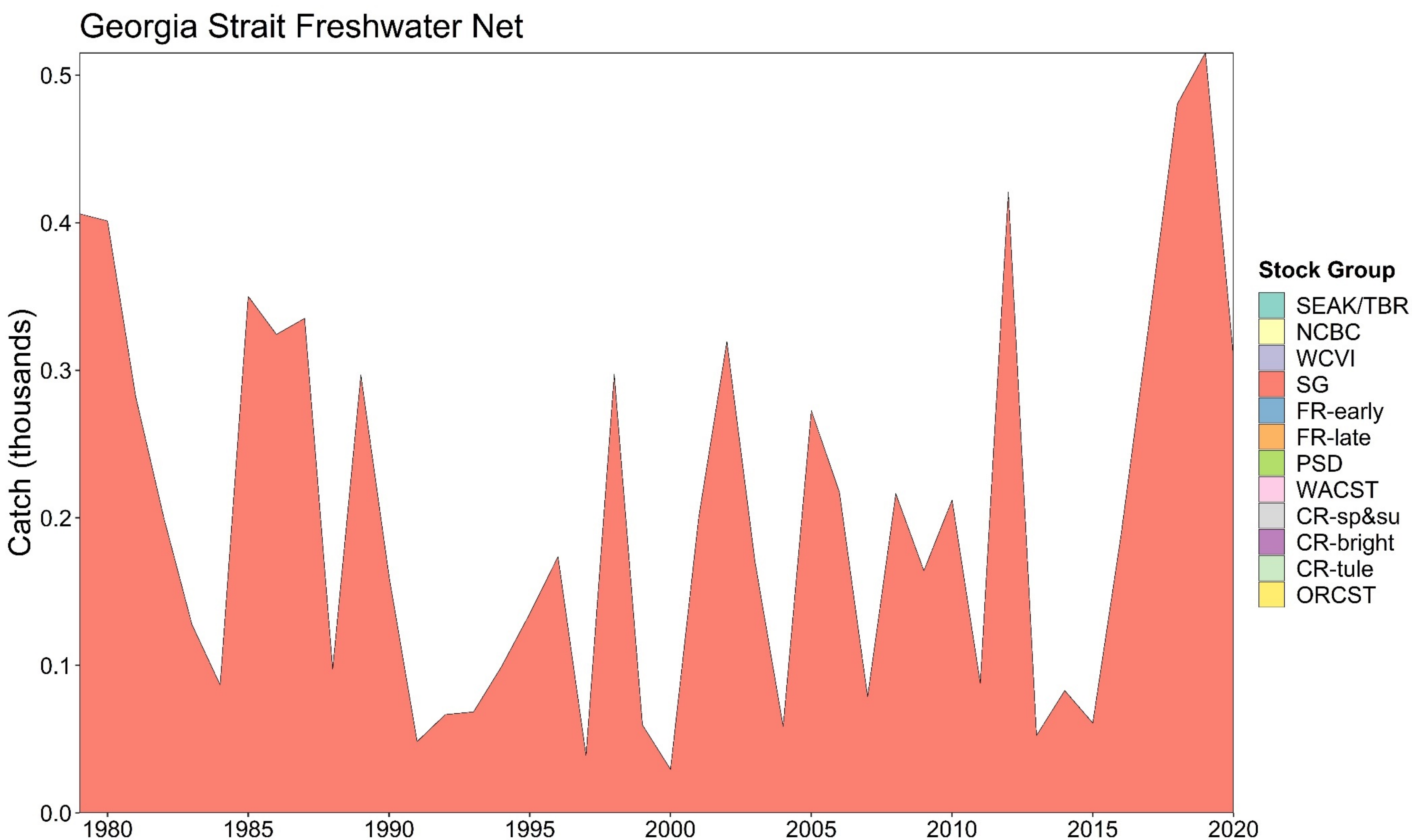
Appendix C19— PSC Chinook Model estimates of landed catch stock composition for Canada Transboundary River Freshwater Net, 1979–2020.



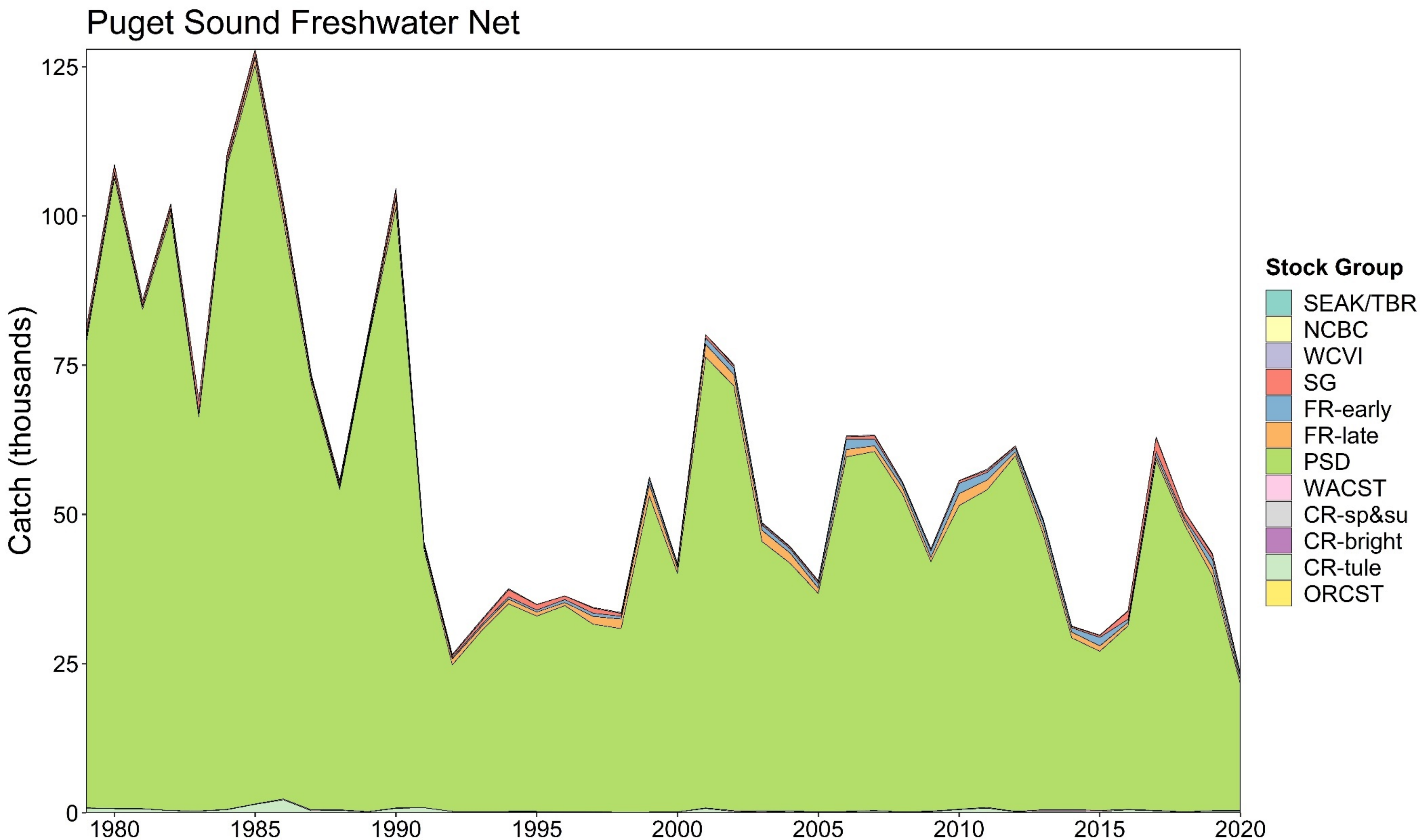
Appendix C20— PSC Chinook Model estimates of landed catch stock composition for Central British Columbia Freshwater Net, 1979–2020.



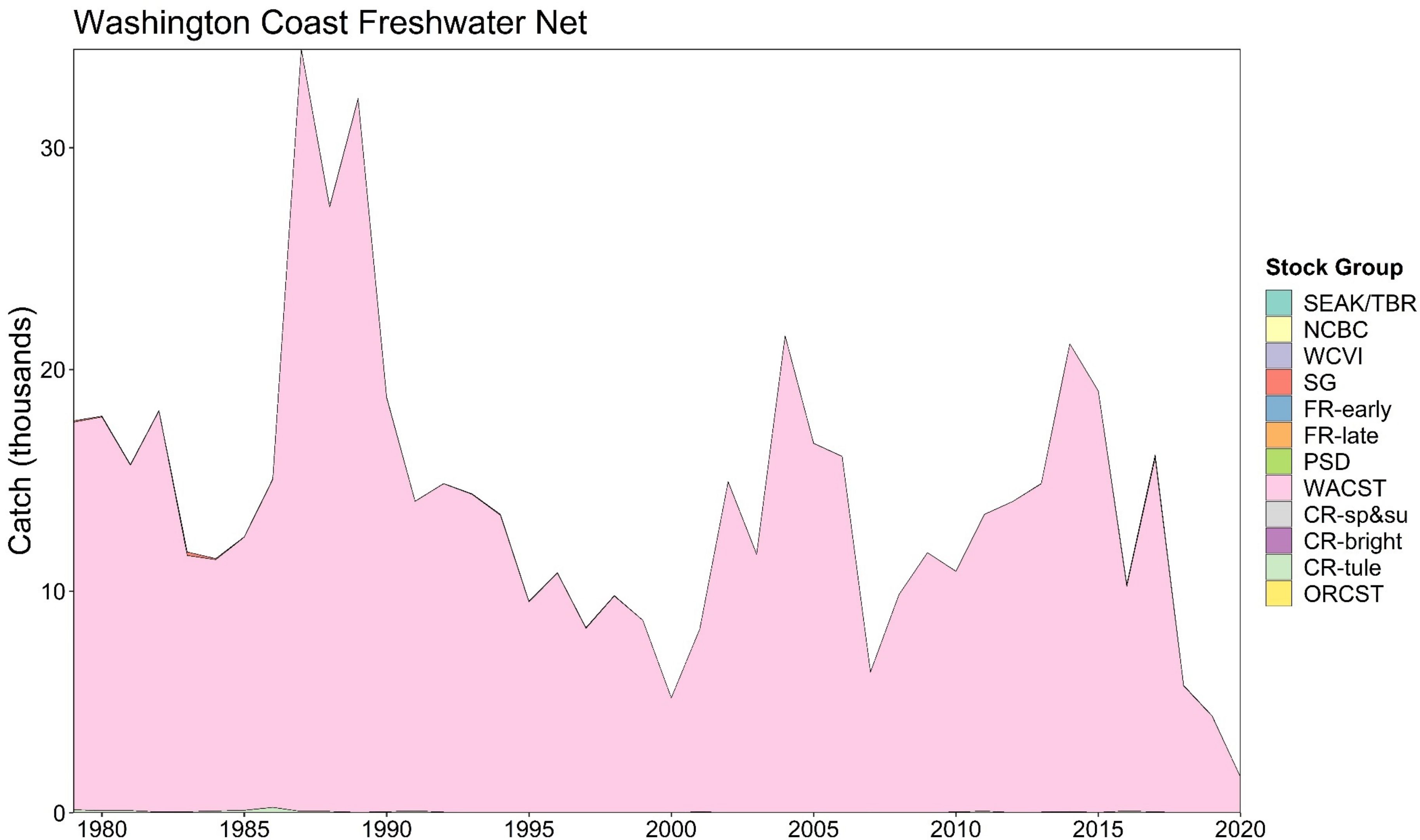
Appendix C21— PSC Chinook Model estimates of landed catch stock composition for Strait of Georgia Freshwater Net, 1979–2020.



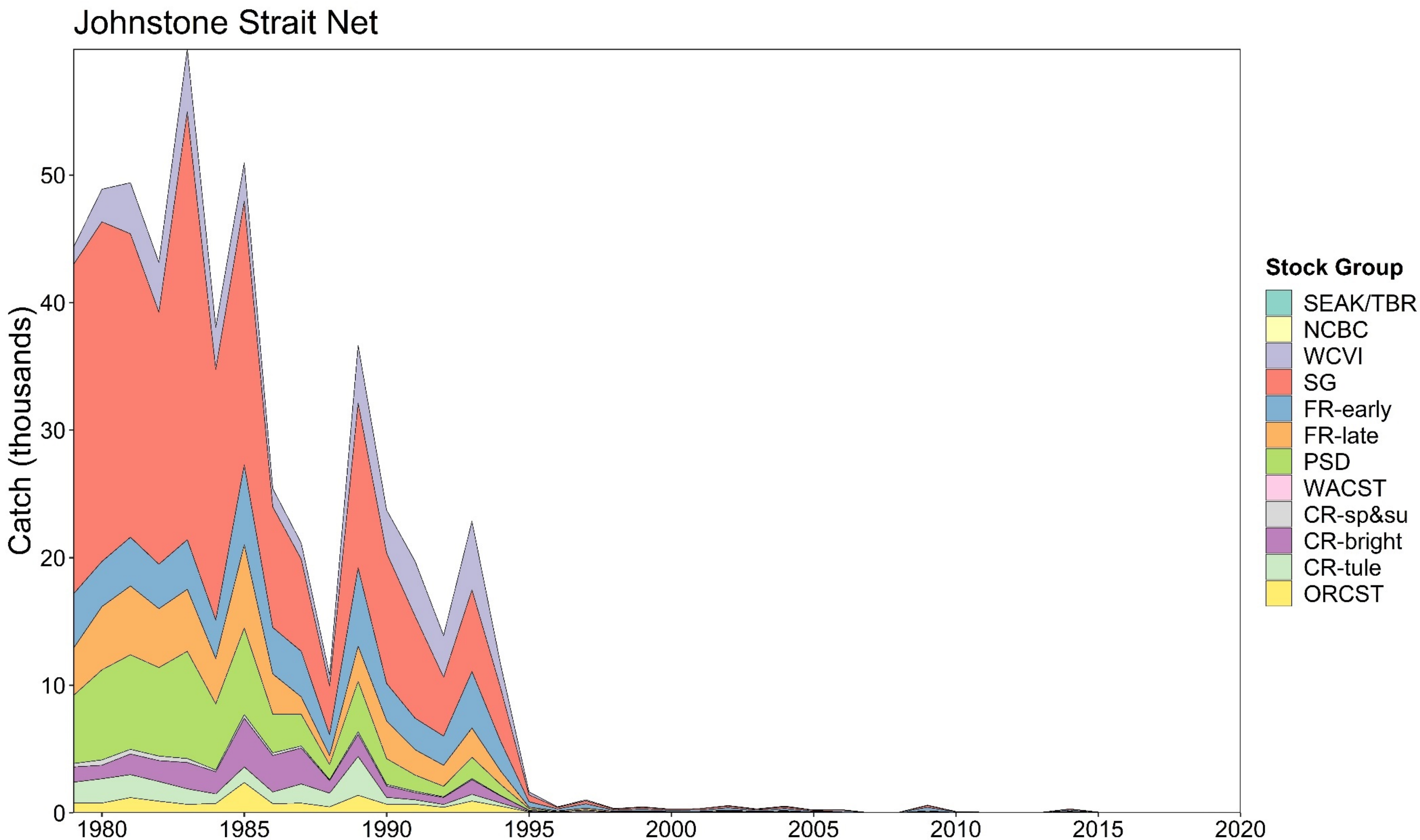
Appendix C22— PSC Chinook Model estimates of landed catch stock composition for Puget Sound Freshwater Net, 1979–2020.



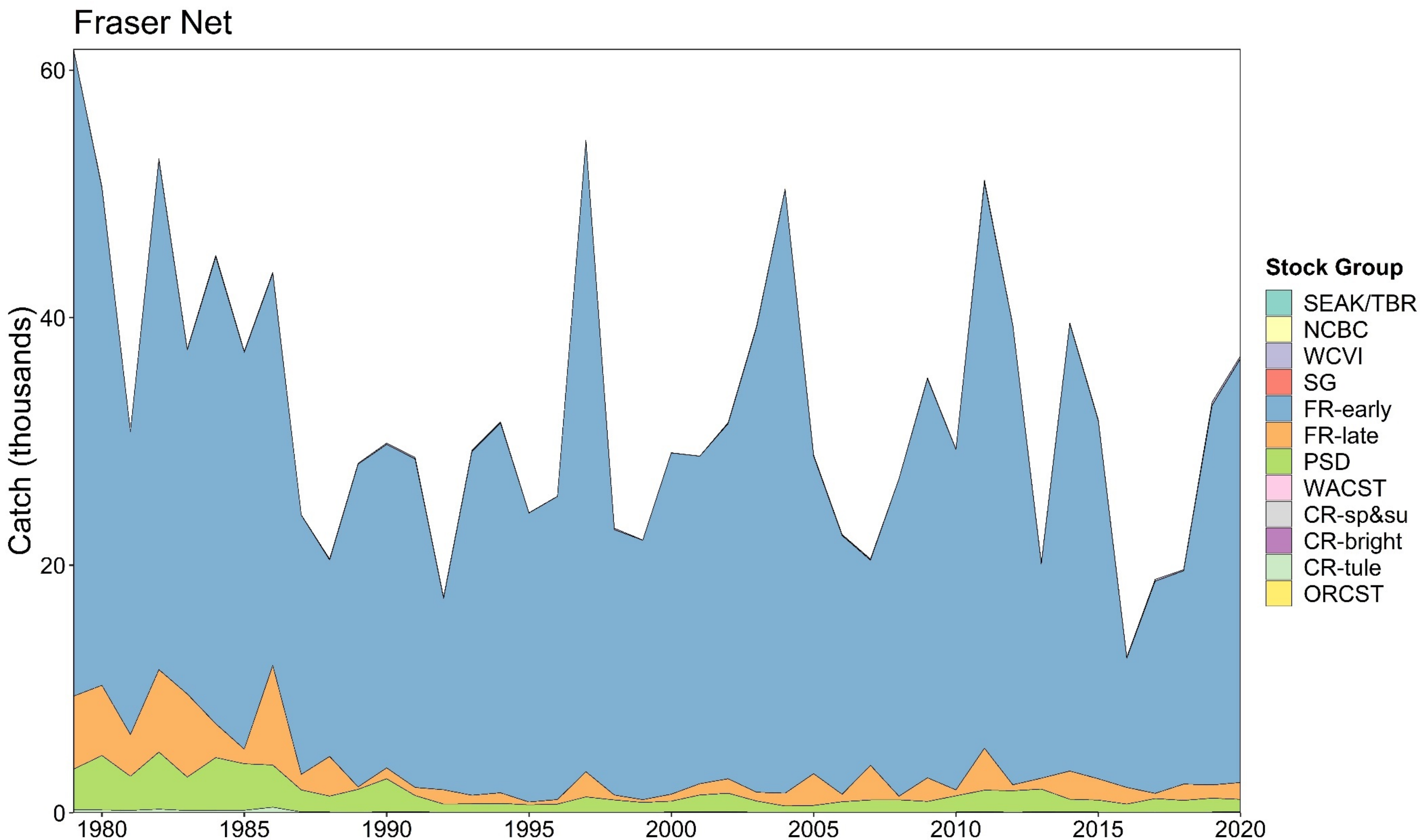
Appendix C23— PSC Chinook Model estimates of landed catch stock composition for Washington Coast Freshwater Net, 1979–2020.



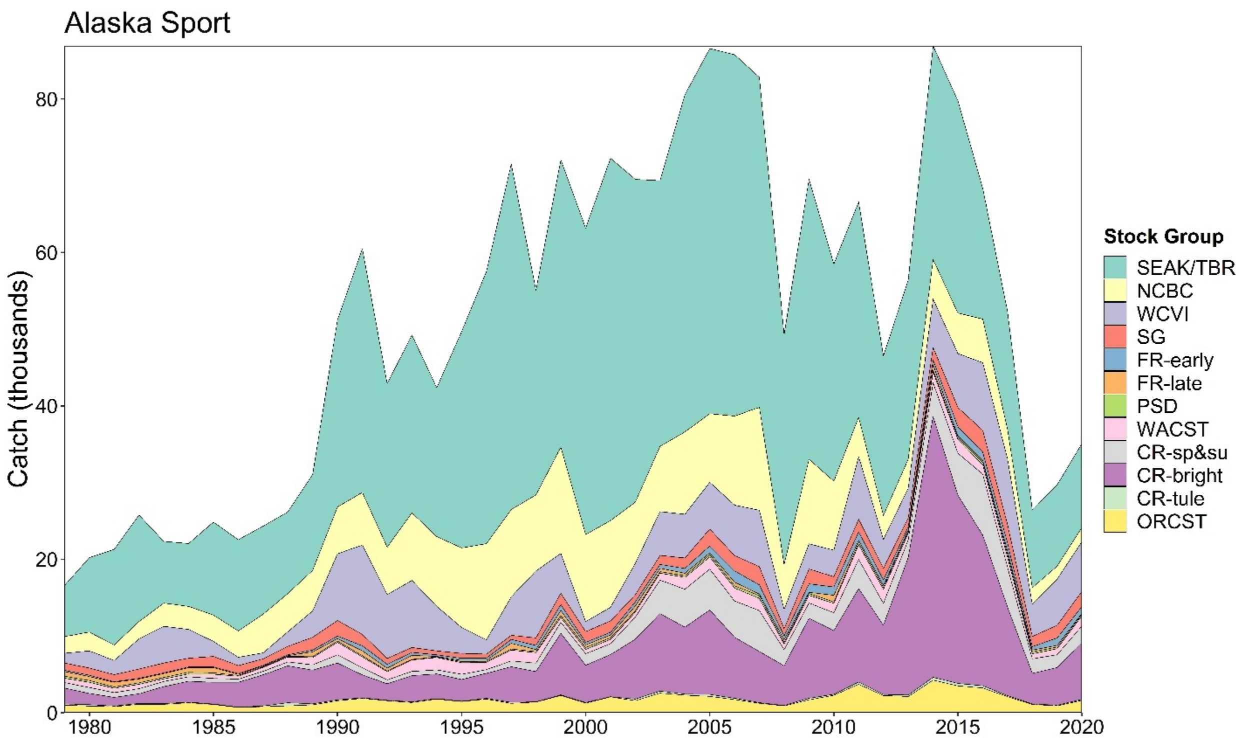
Appendix C24— PSC Chinook Model estimates of landed catch stock composition for Johnstone Strait Net, 1979–2020.

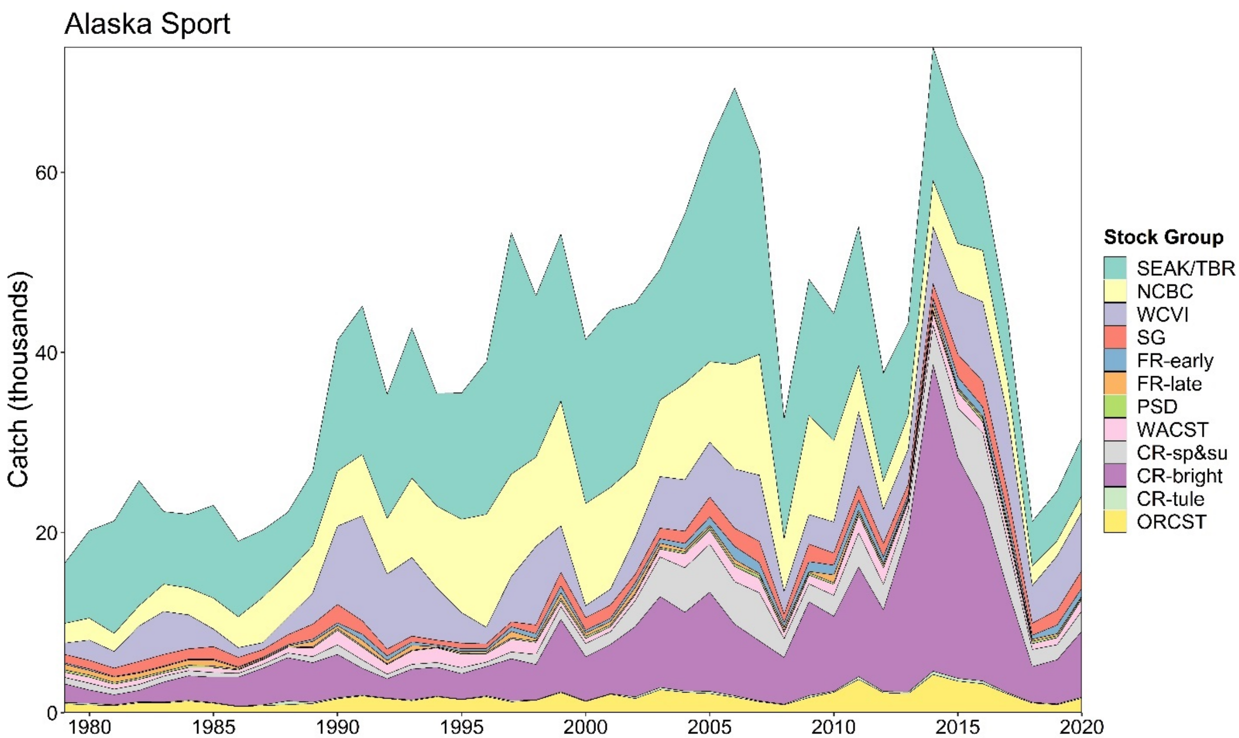


Appendix C25— PSC Chinook Model estimates of landed catch stock composition for Fraser Net, 1979–2020.

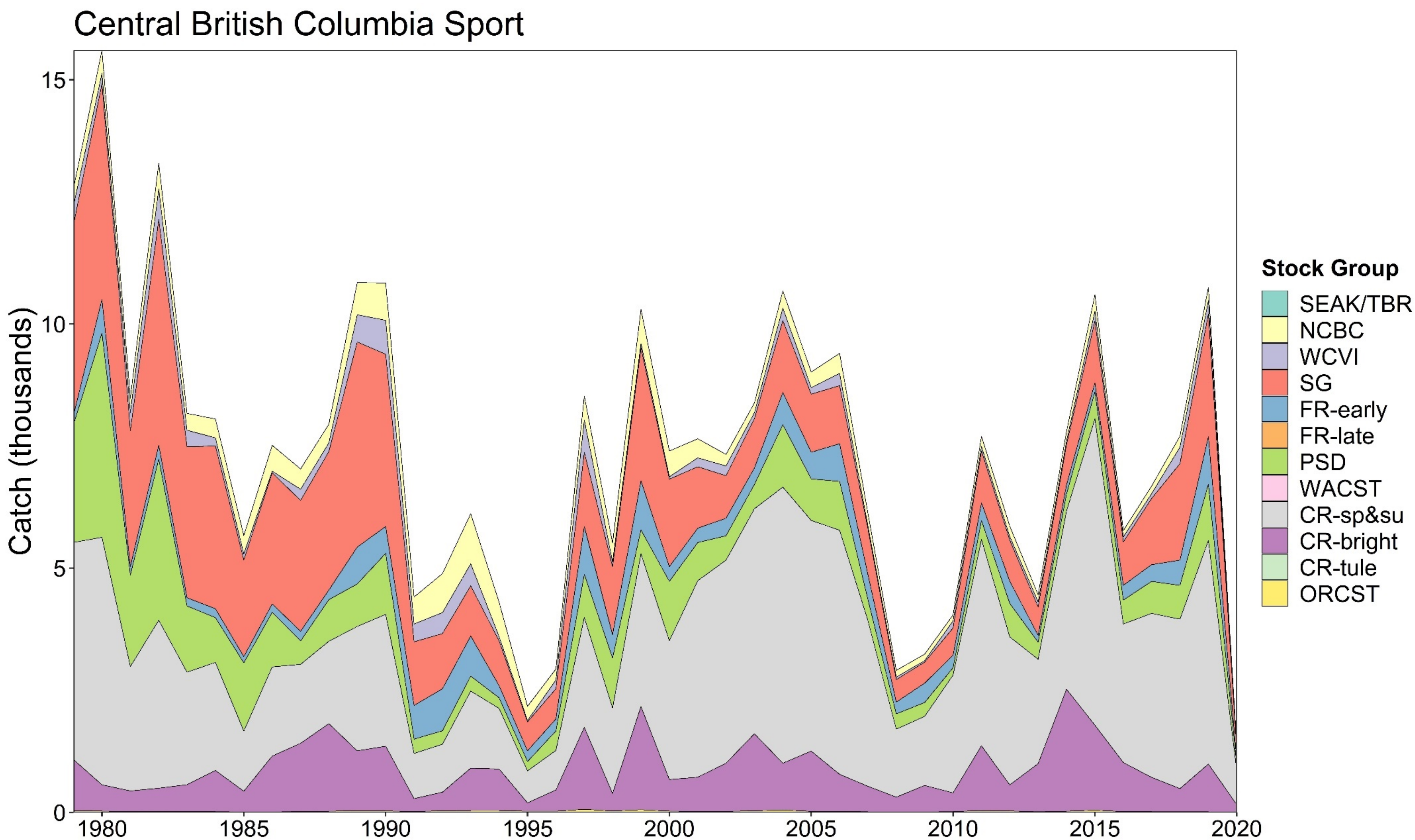


Appendix C26— PSC Chinook Model estimates of landed catch stock composition for Alaska sport with (upper) and without (lower) Alaska hatchery add-on and terminal exclusion, 1979–2020.

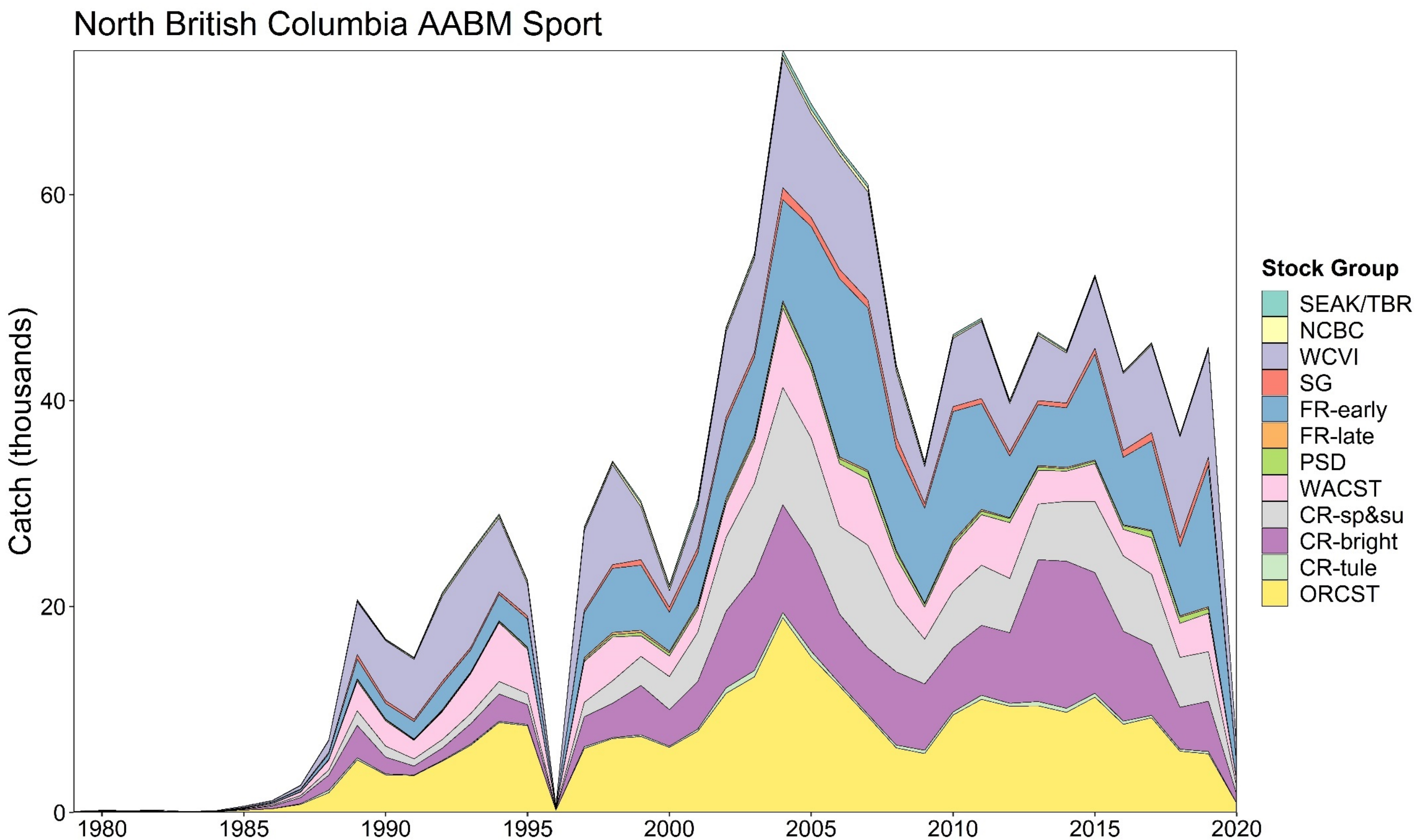




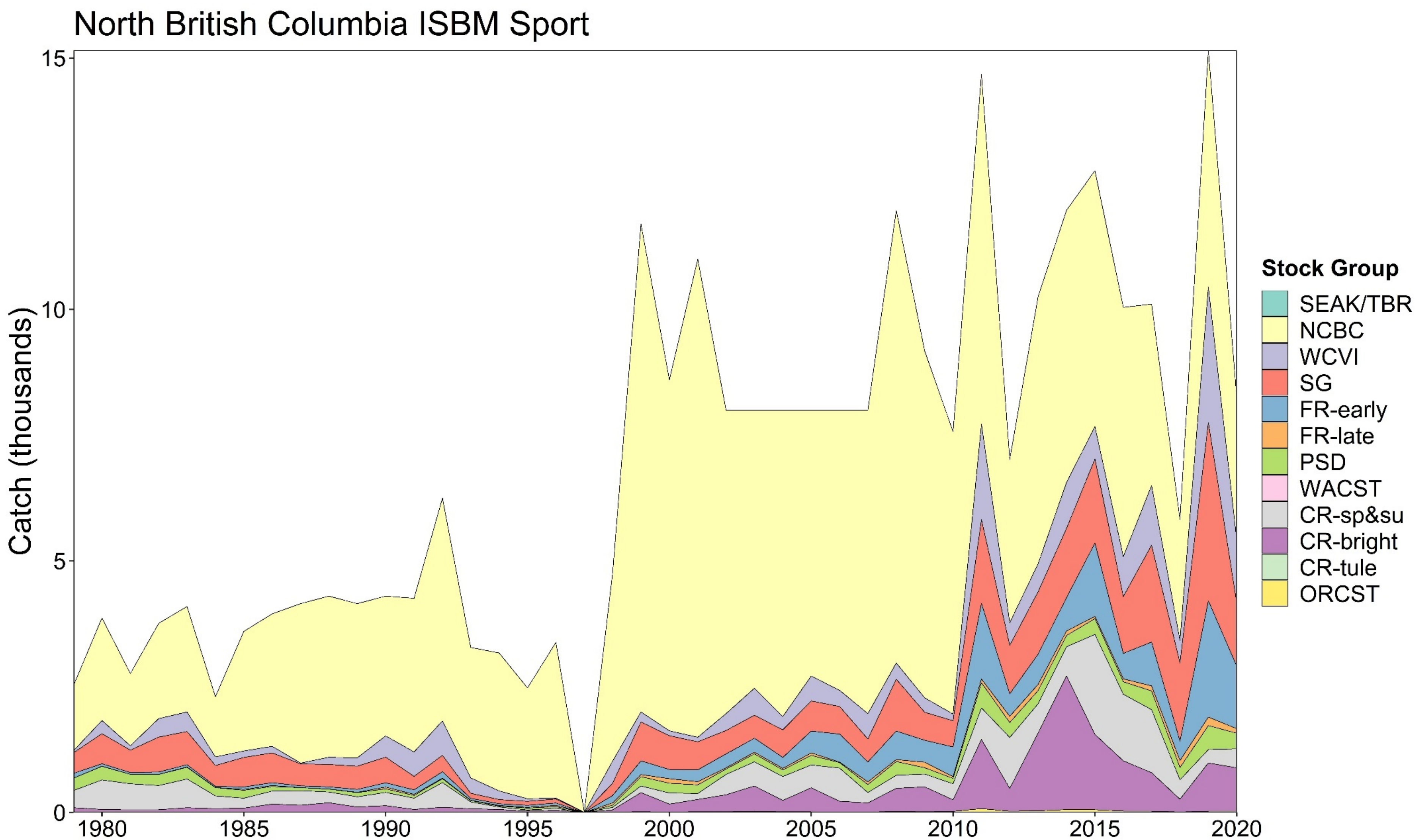
Appendix C27— PSC Chinook Model estimates of landed catch stock composition for Central British Columbia Sport 1979–2020.



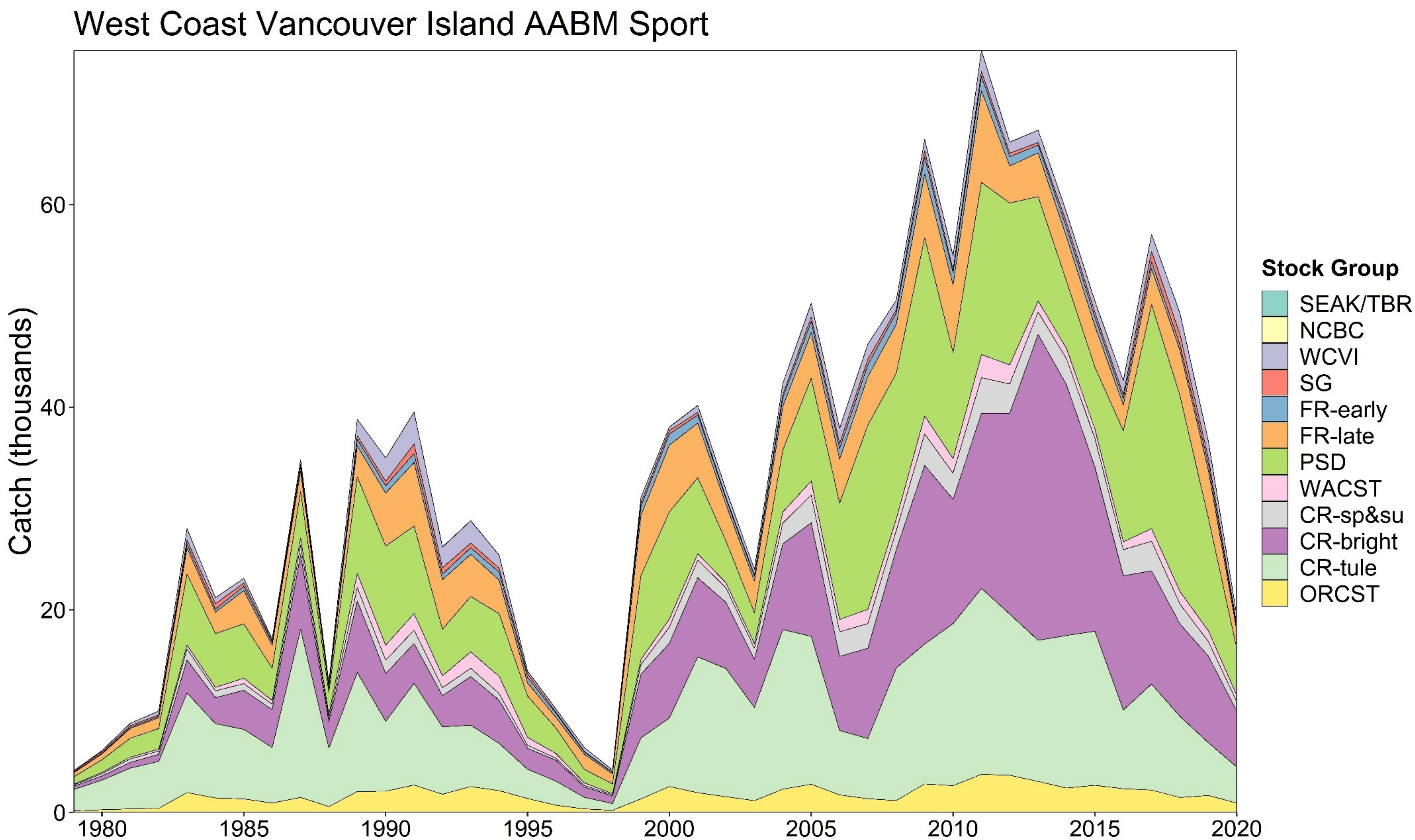
Appendix C28— PSC Chinook Model estimates of landed catch stock composition for North British Columbia AABM Sport, 1979–2020.



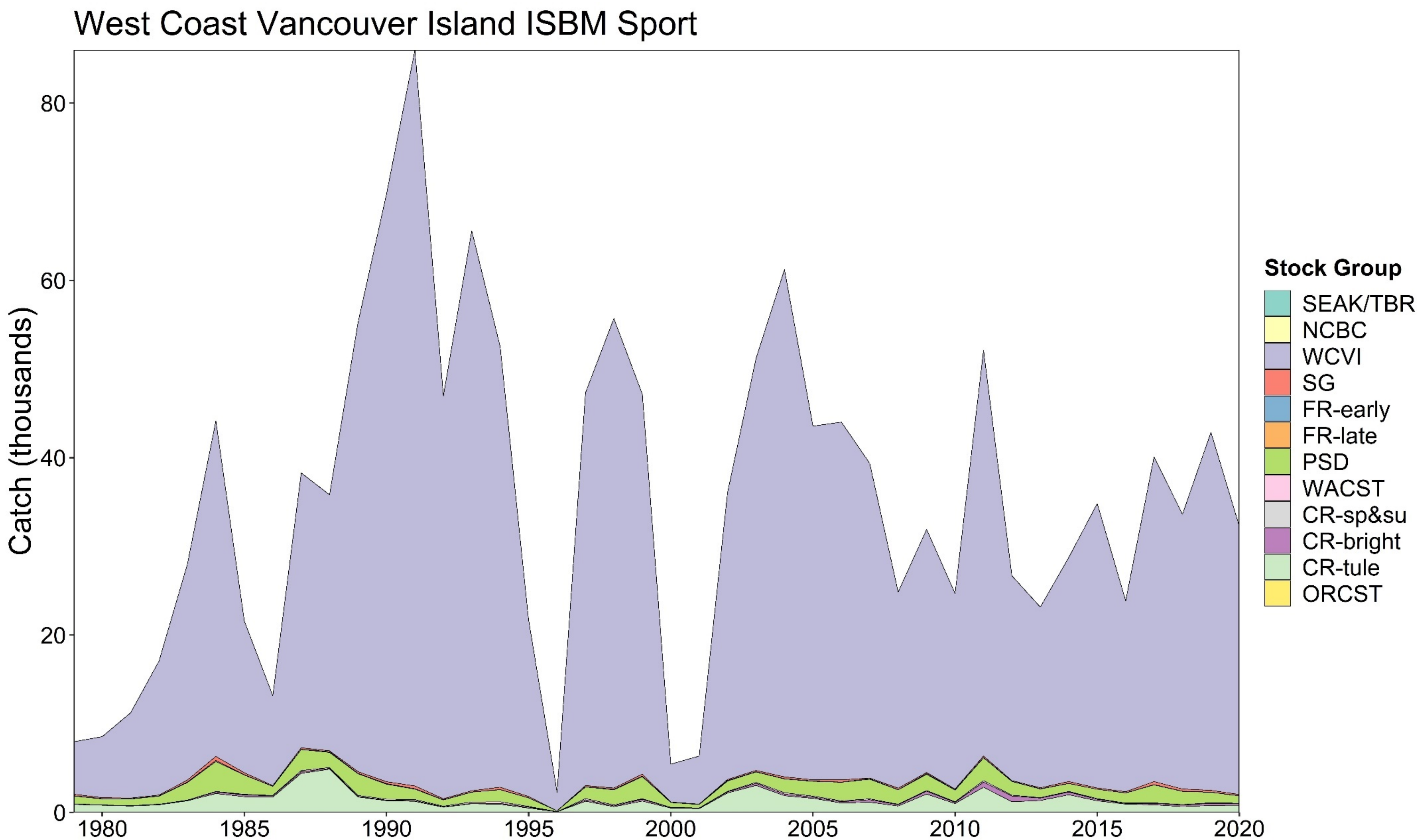
Appendix C29— PSC Chinook Model estimates of landed catch stock composition for North British Columbia ISBM Sport 1979–2020.



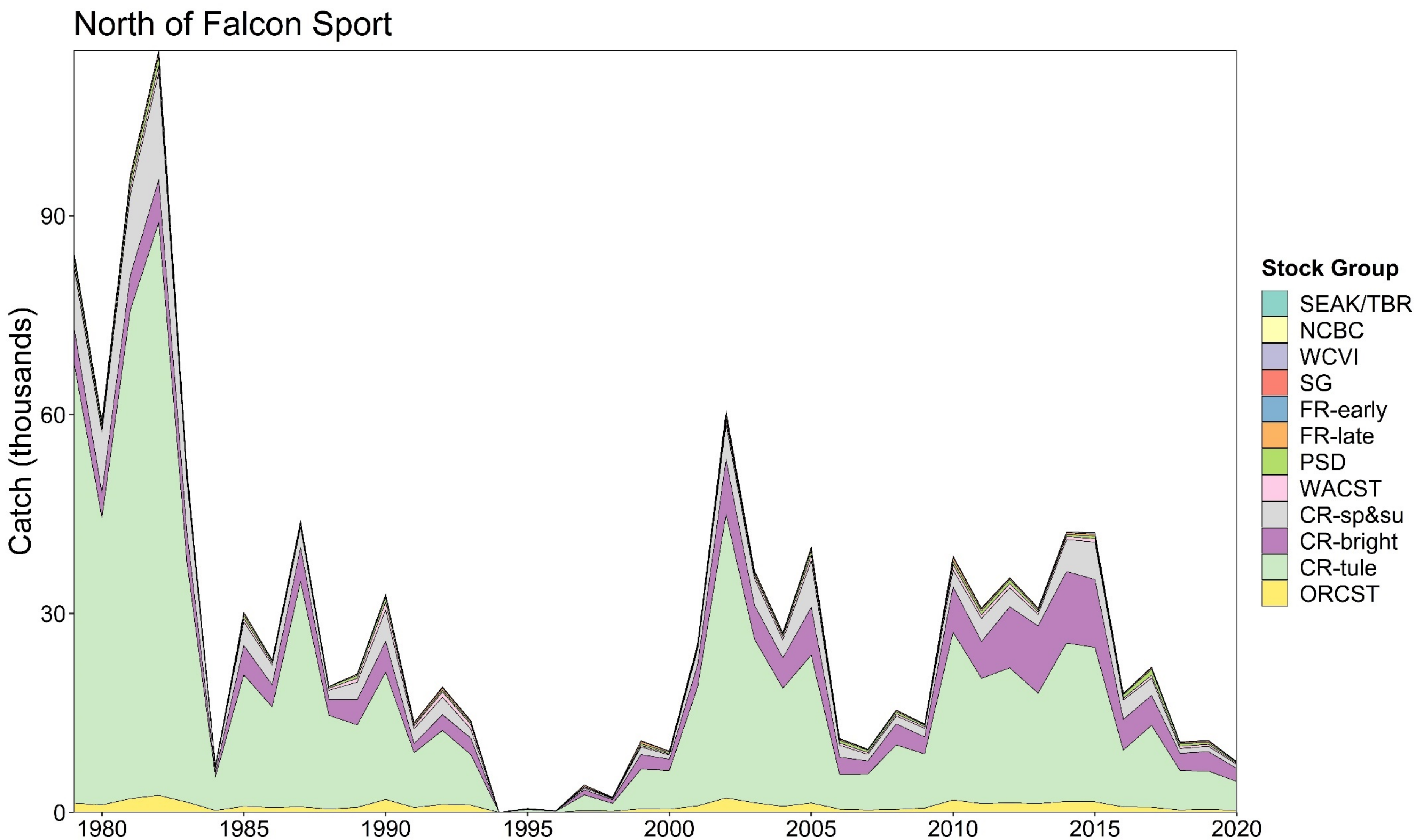
Appendix C30— PSC Chinook Model estimates of landed catch stock composition for West Coast Vancouver Island AABM Sport, 1979–2020.



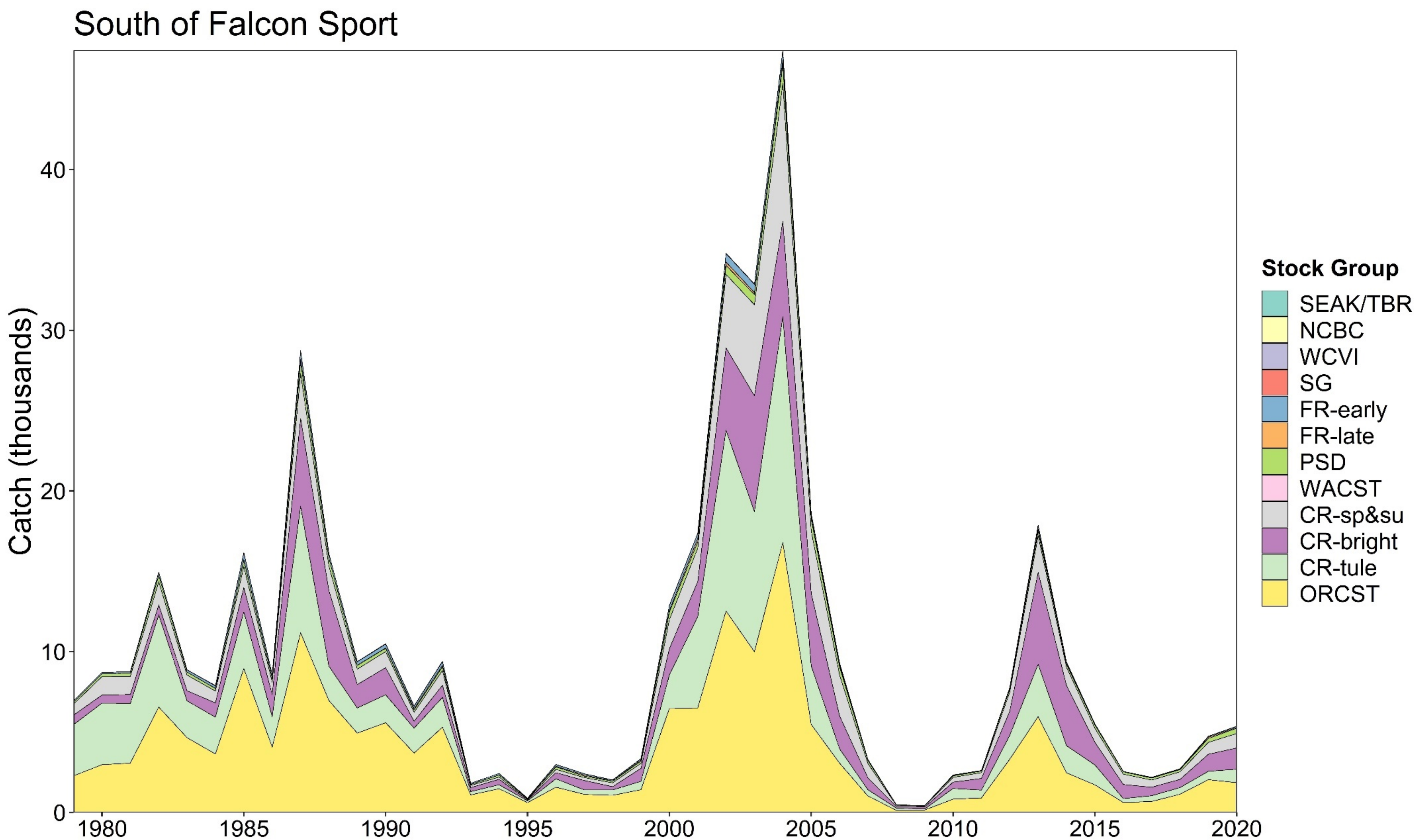
Appendix C31— PSC Chinook Model estimates of landed catch stock composition for West Coast Vancouver Island ISBM Sport, 1979–2020.



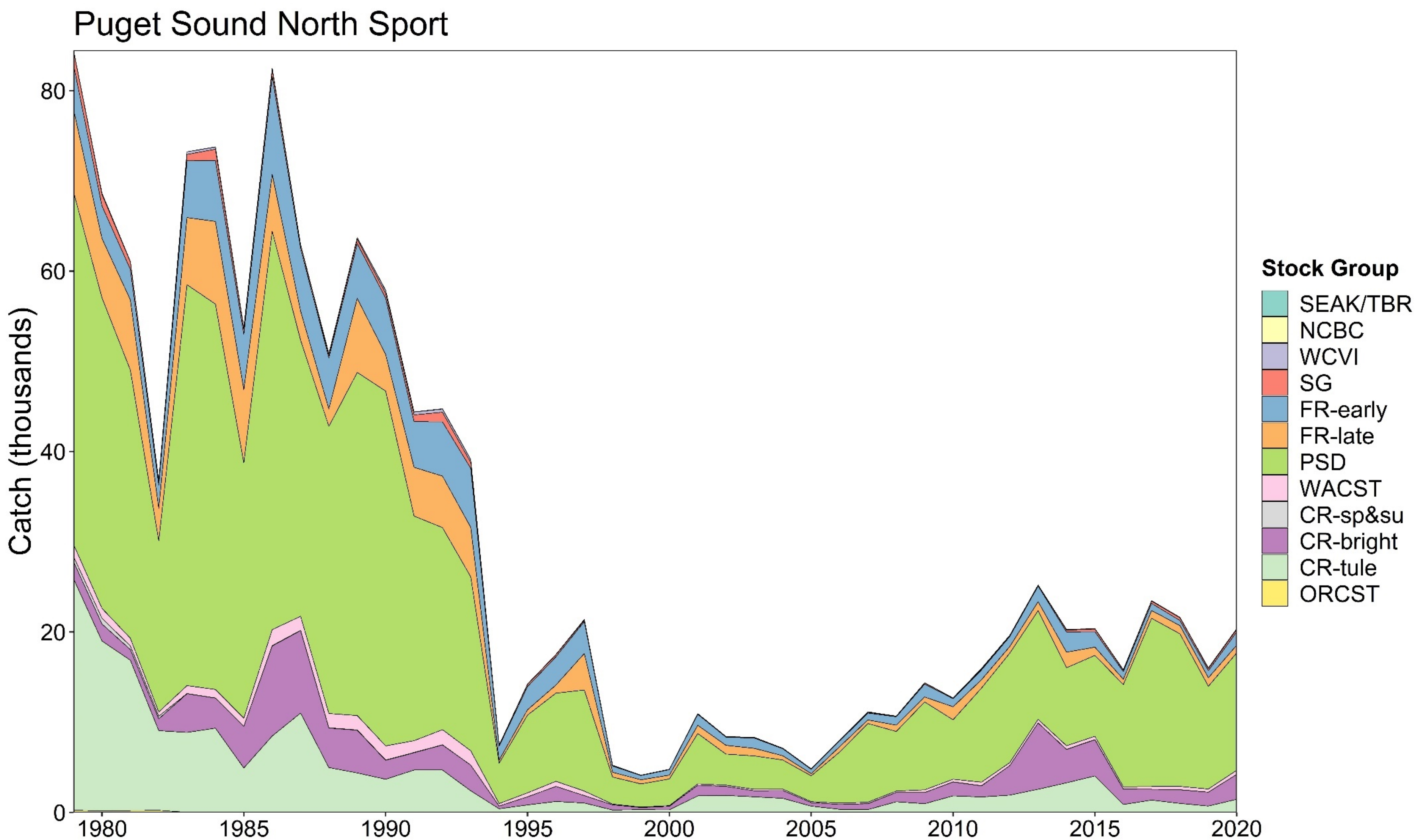
Appendix C32— PSC Chinook Model estimates of landed catch stock composition for North of Falcon Sport, 1979–2020.



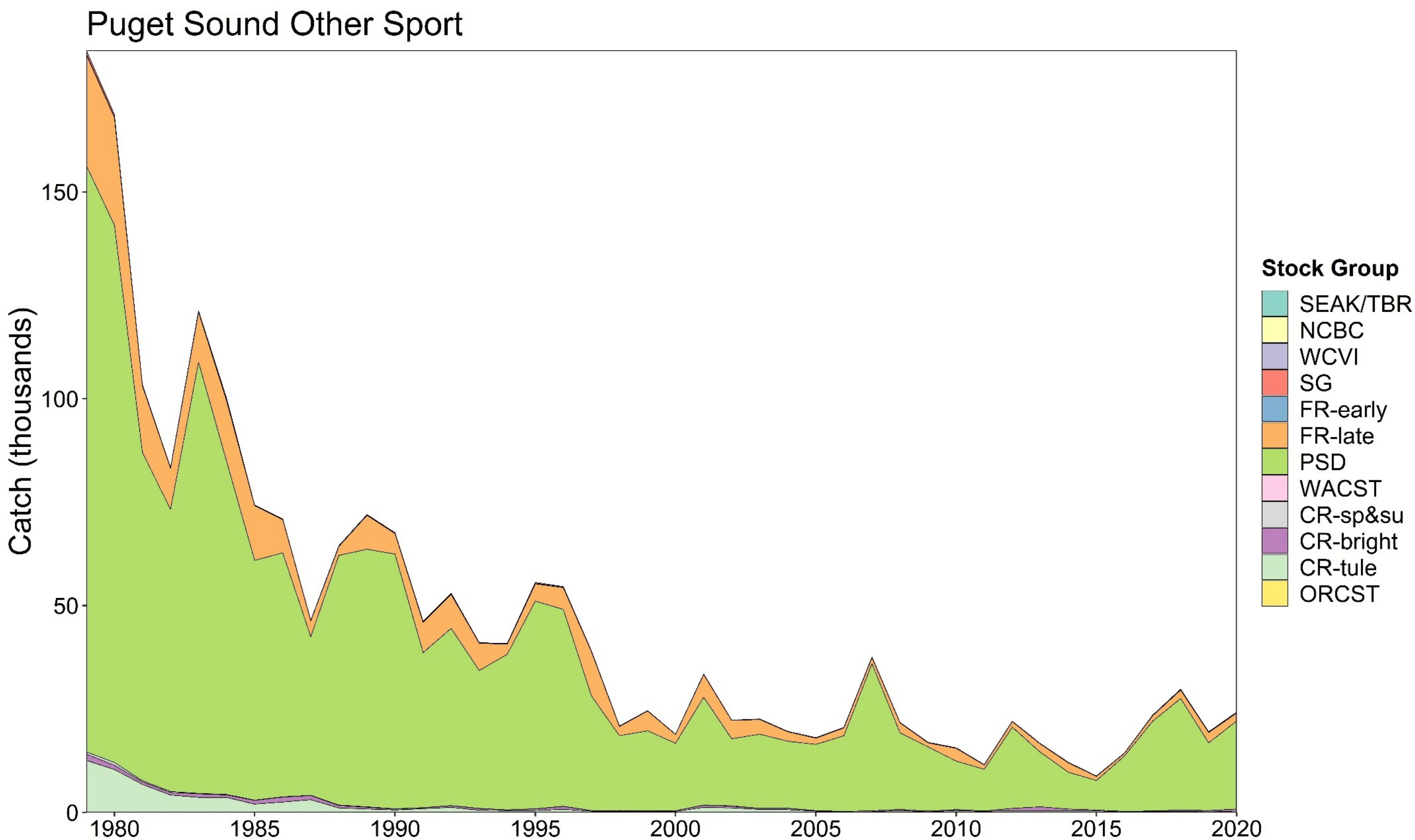
Appendix C33— PSC Chinook Model estimates of landed catch stock composition for South of Falcon Sport, 1979–2020.



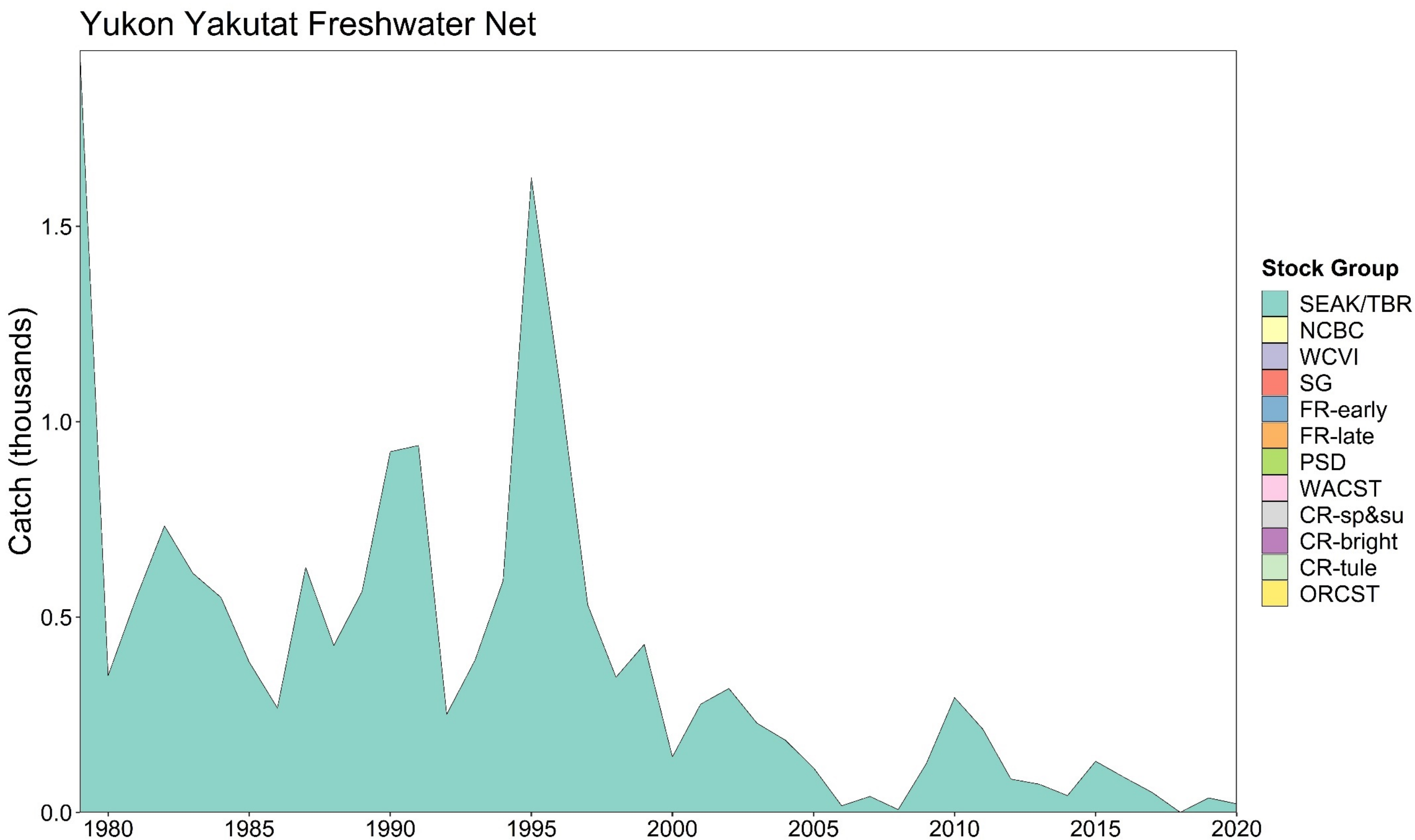
Appendix C34— PSC Chinook Model estimates of landed catch stock composition for Puget Sound North Sport, 1979–2020.



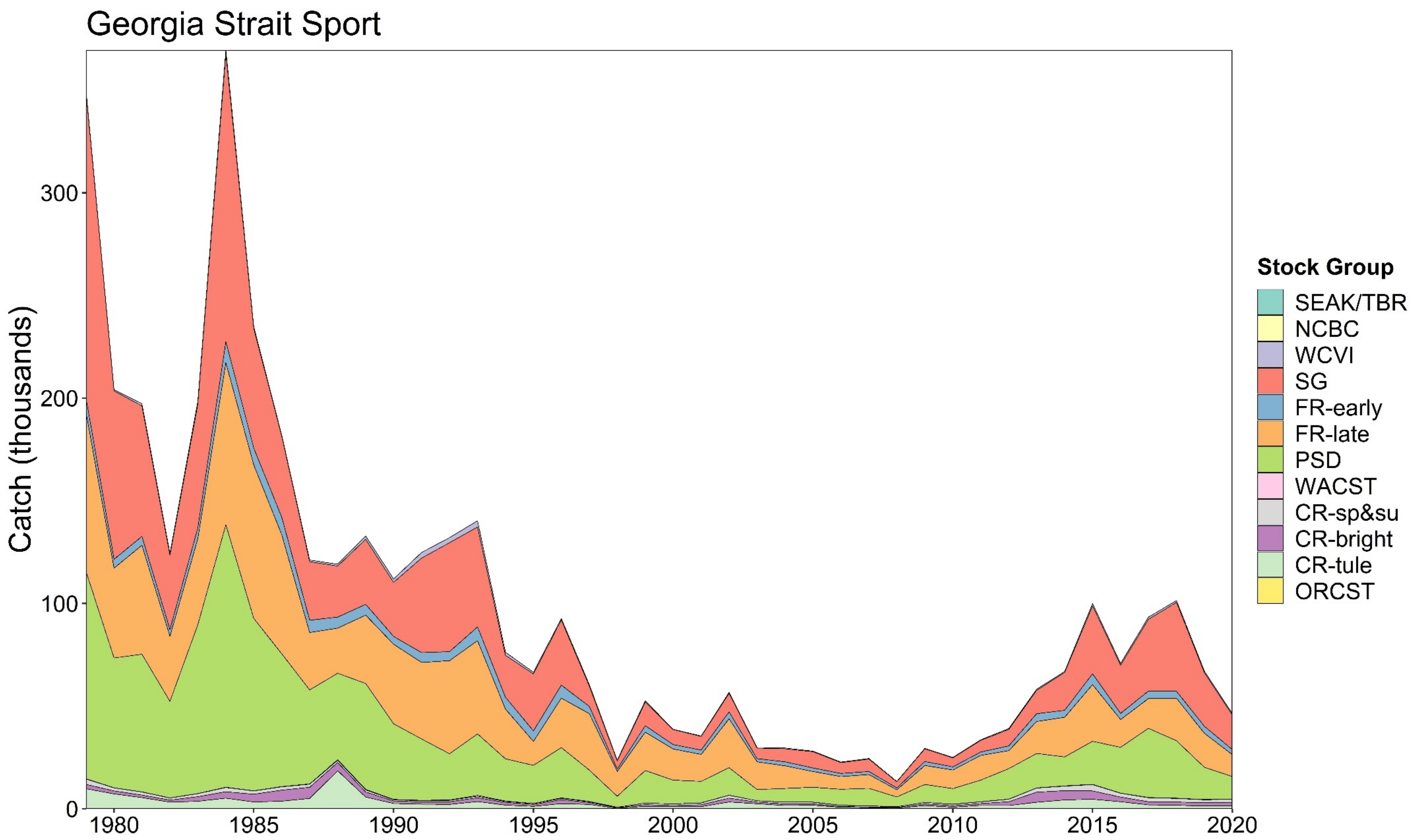
Appendix C35— PSC Chinook Model estimates of landed catch stock composition for Puget Sound Other Sport, 1979–2020.



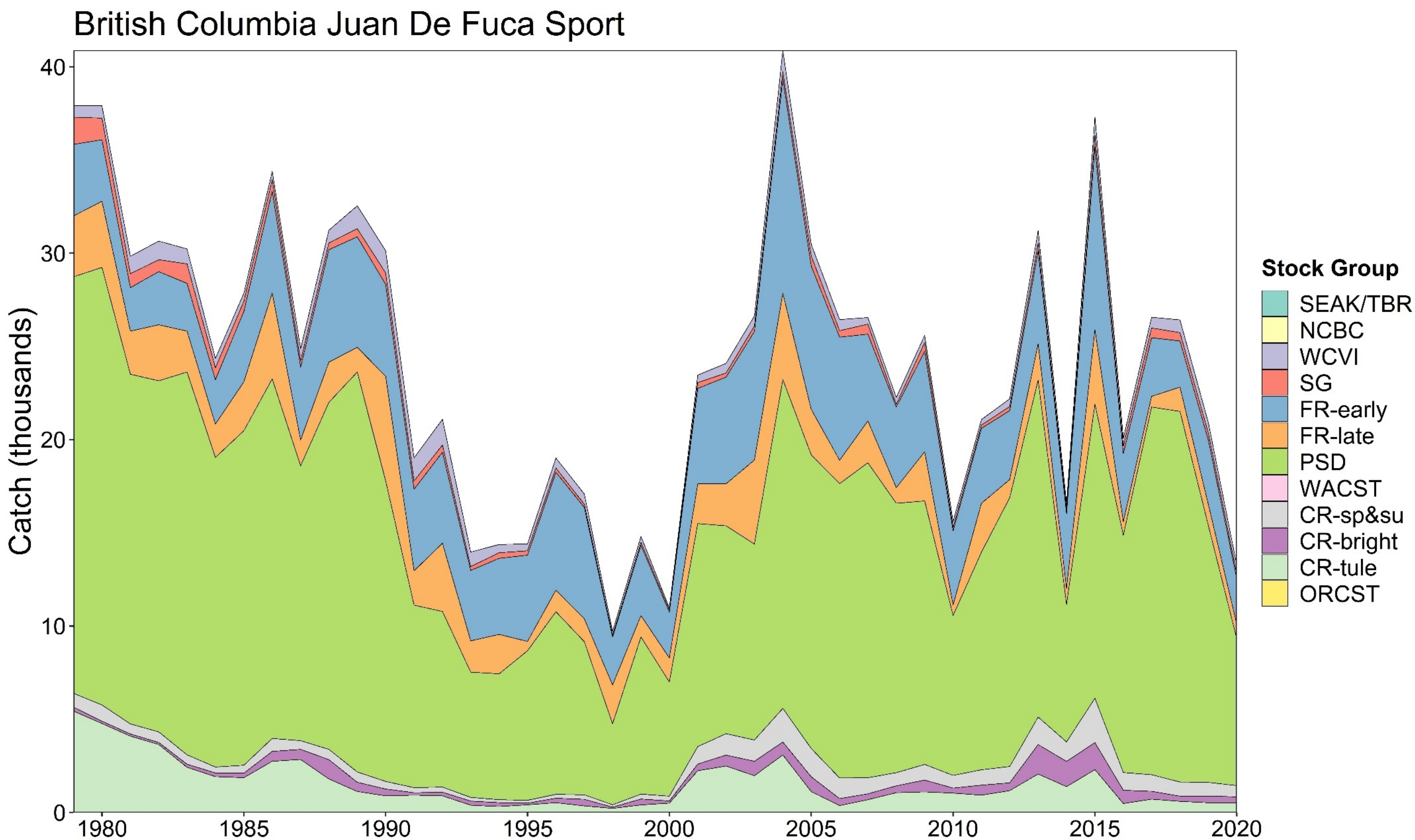
Appendix C36— PSC Chinook Model estimates of landed catch stock composition for Terminal Yukon Alsek Freshwater Net, 1979–2020.



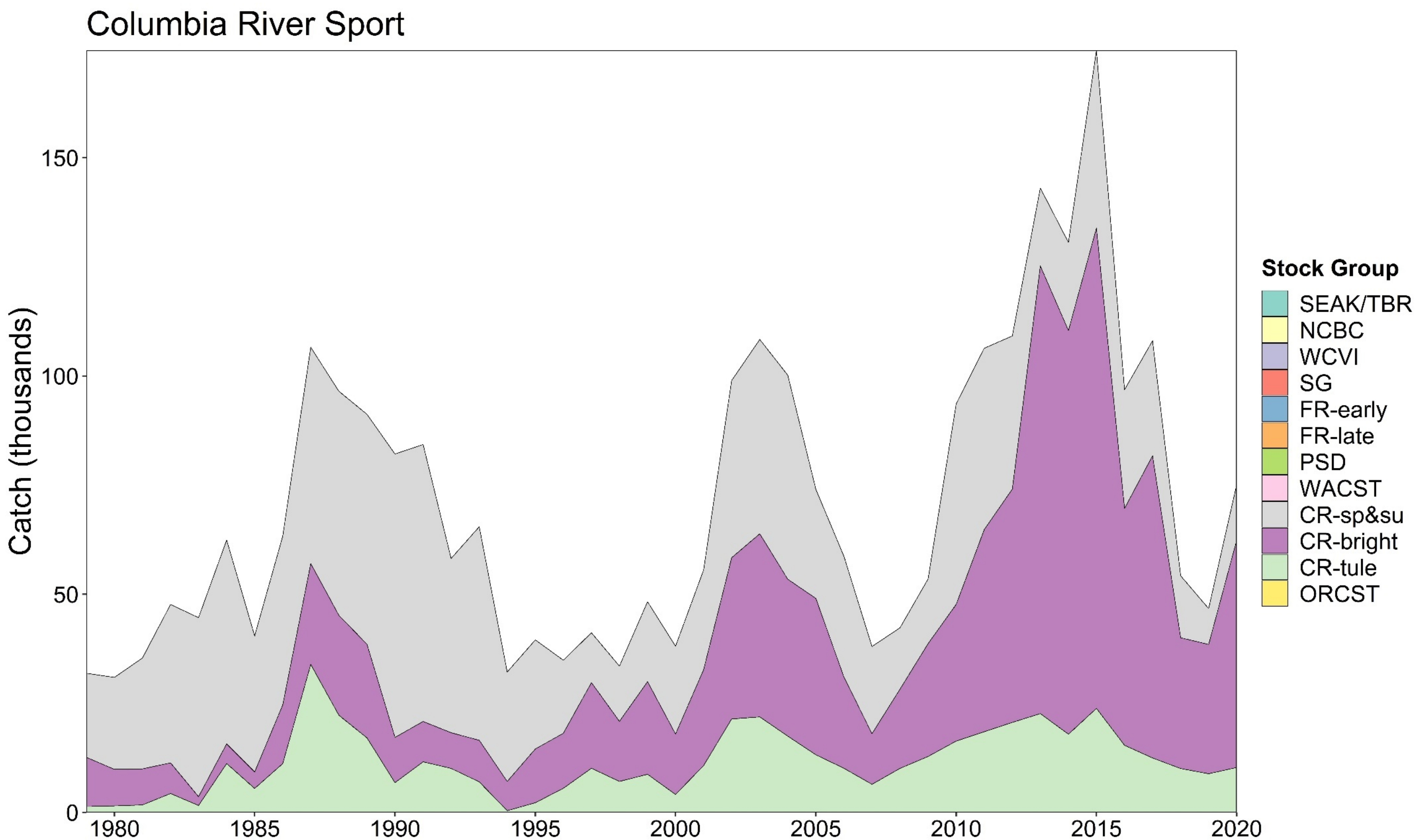
Appendix C37— PSC Chinook Model estimates of landed catch stock composition for Strait of Georgia Sport, 1979–2020.



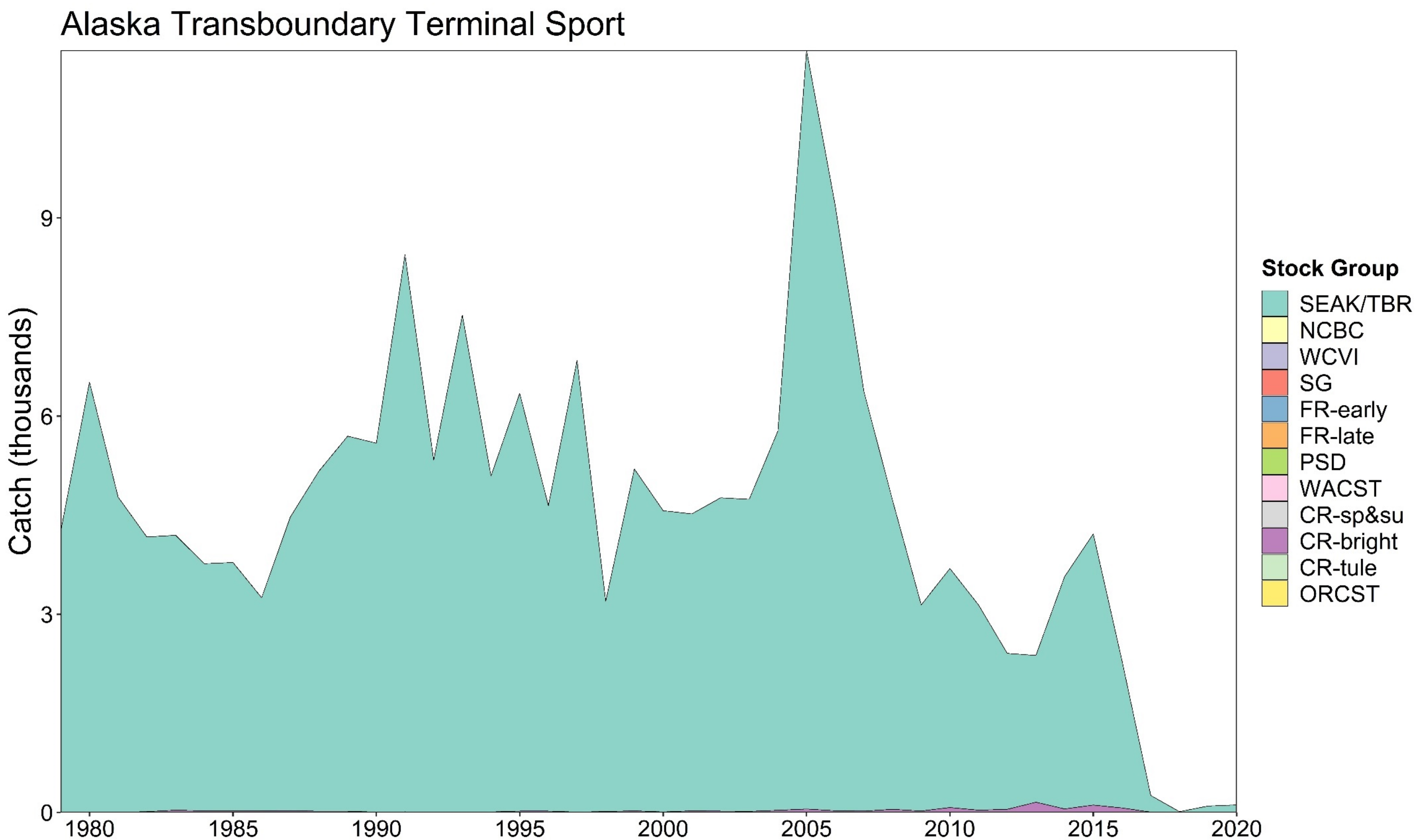
Appendix C38— PSC Chinook Model estimates of landed catch stock composition for British Columbia Juan De Fuca Sport, 1979–2020.



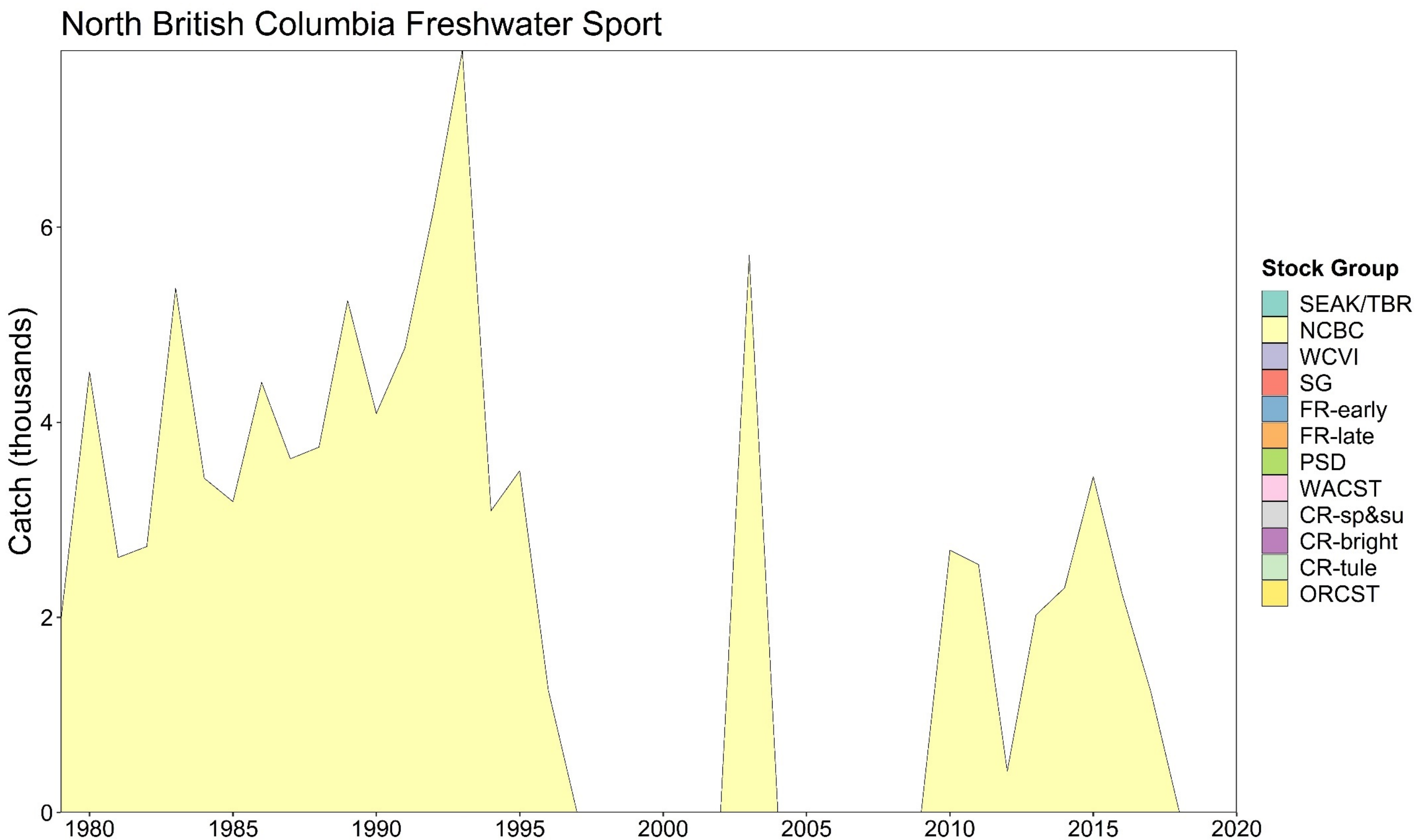
Appendix C39— PSC Chinook Model estimates of landed catch stock composition for Columbia River Sport, 1979–2020.



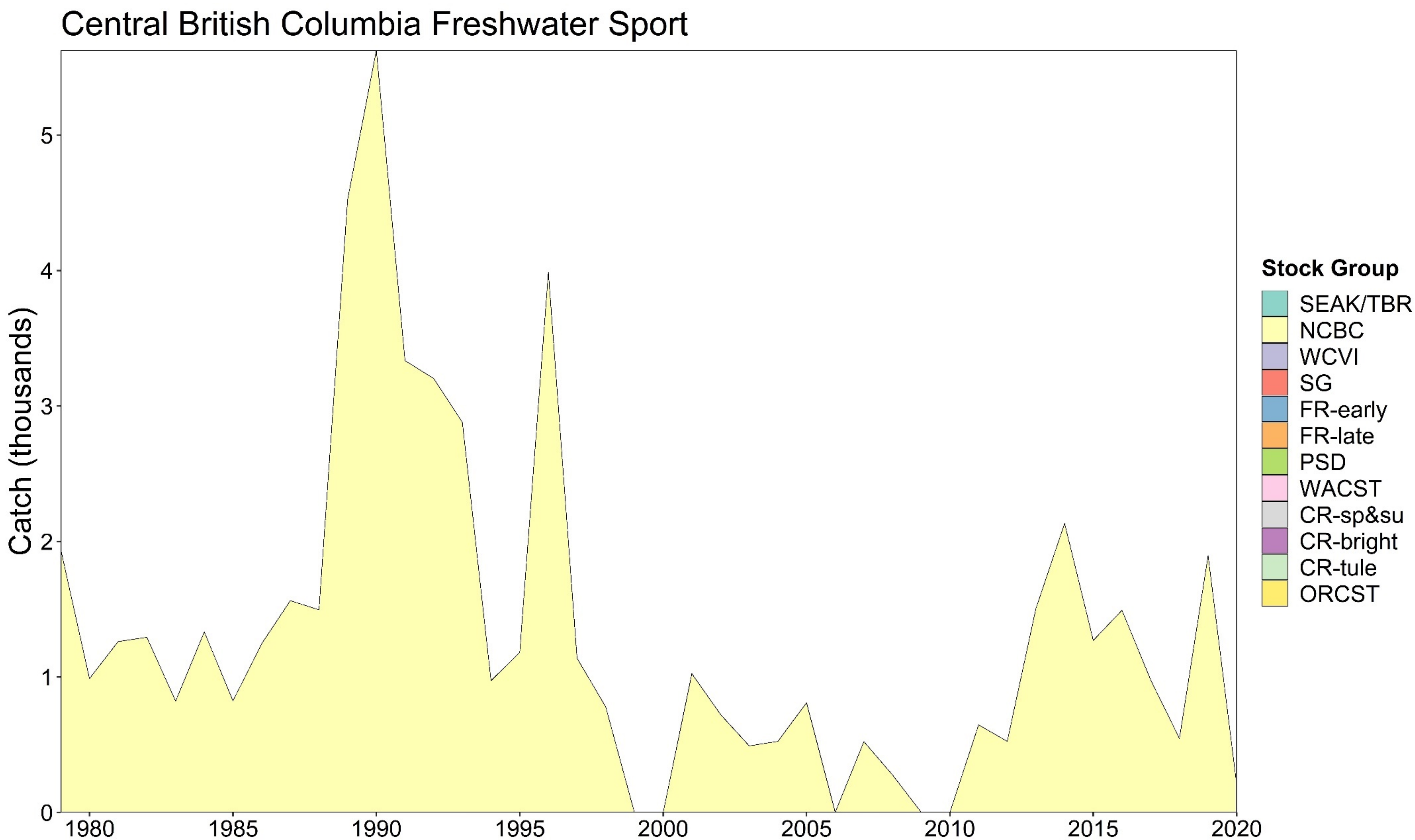
Appendix C40— PSC Chinook Model estimates of landed catch stock composition for Alaska Transboundary River Terminal Sport, 1979–2020.



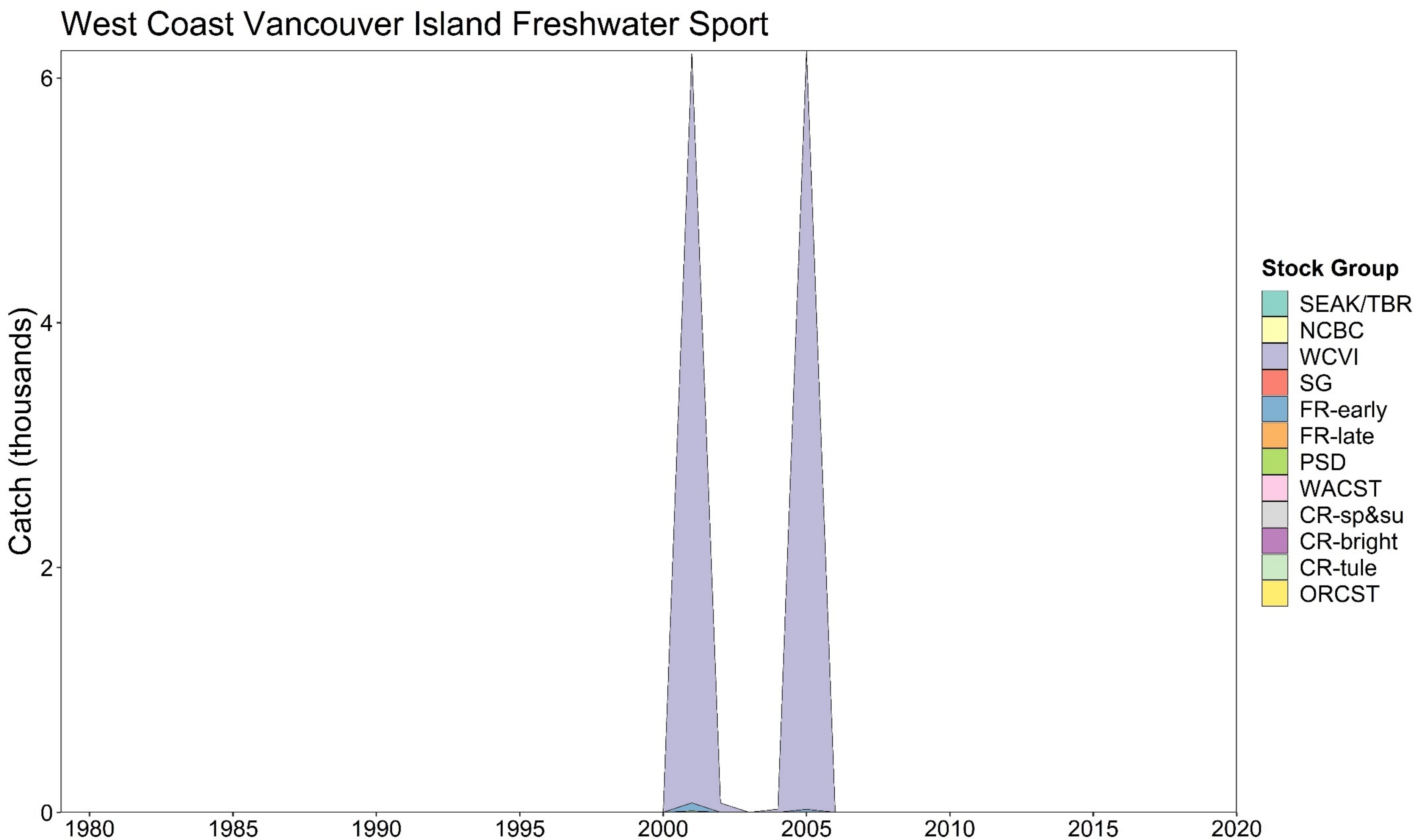
Appendix C41— PSC Chinook Model estimates of landed catch stock composition for North British Columbia Freshwater Sport, 1979–2020.



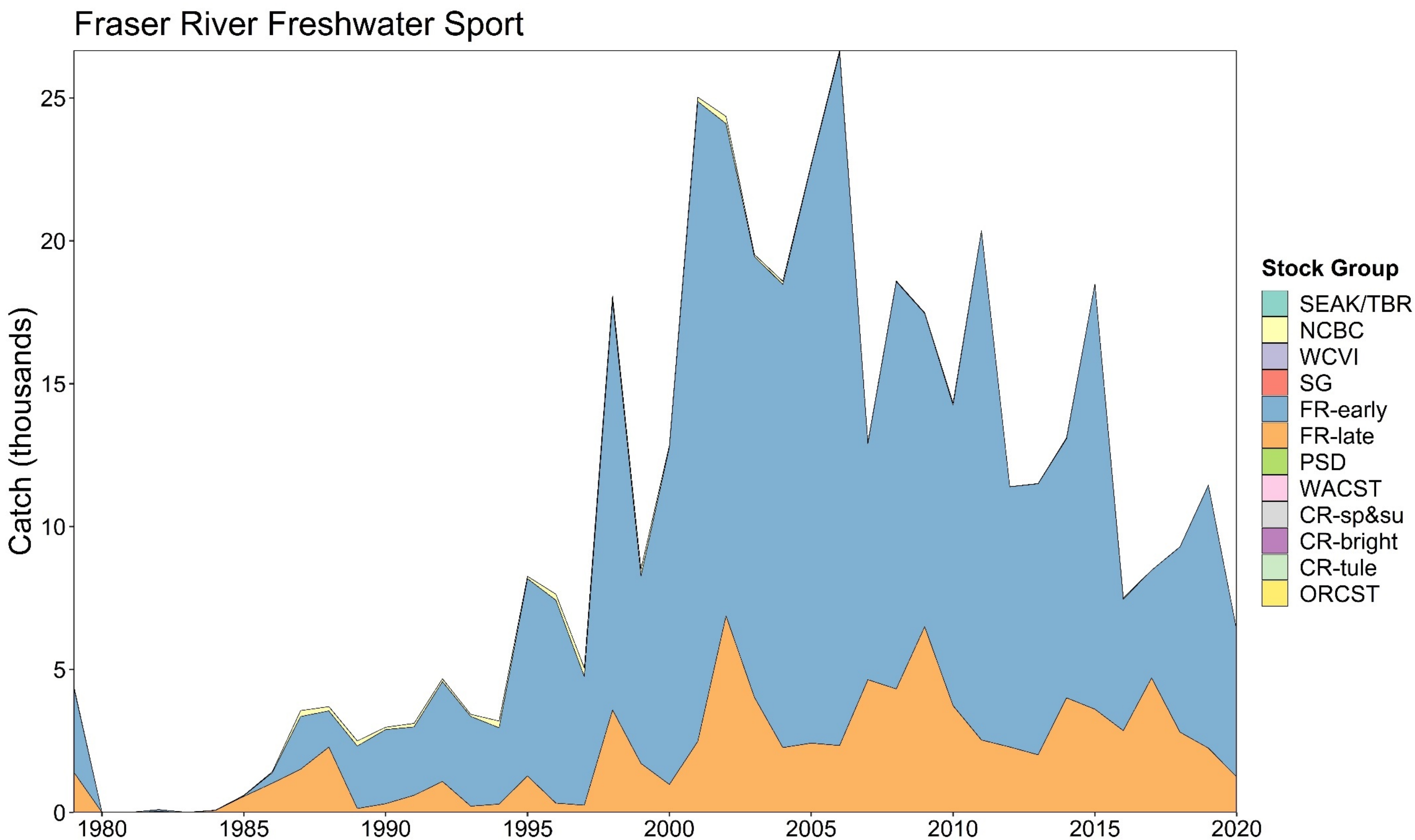
Appendix C42— PSC Chinook Model estimates of landed catch stock composition for Central British Columbia Freshwater Sport, 1979–2020.



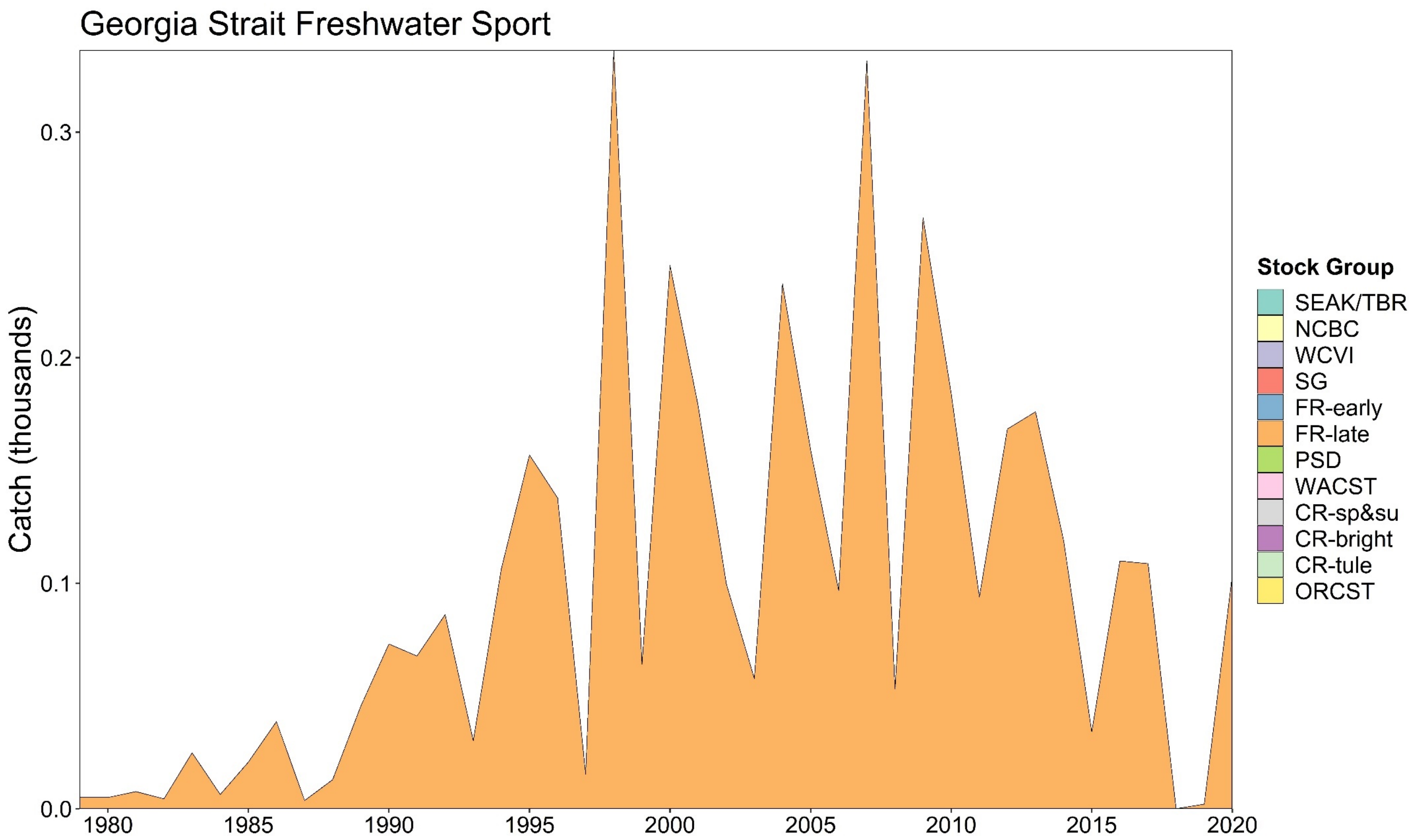
Appendix C43— PSC Chinook Model estimates of landed catch stock composition for West Coast Vancouver Island Freshwater Sport, 1979–2020.



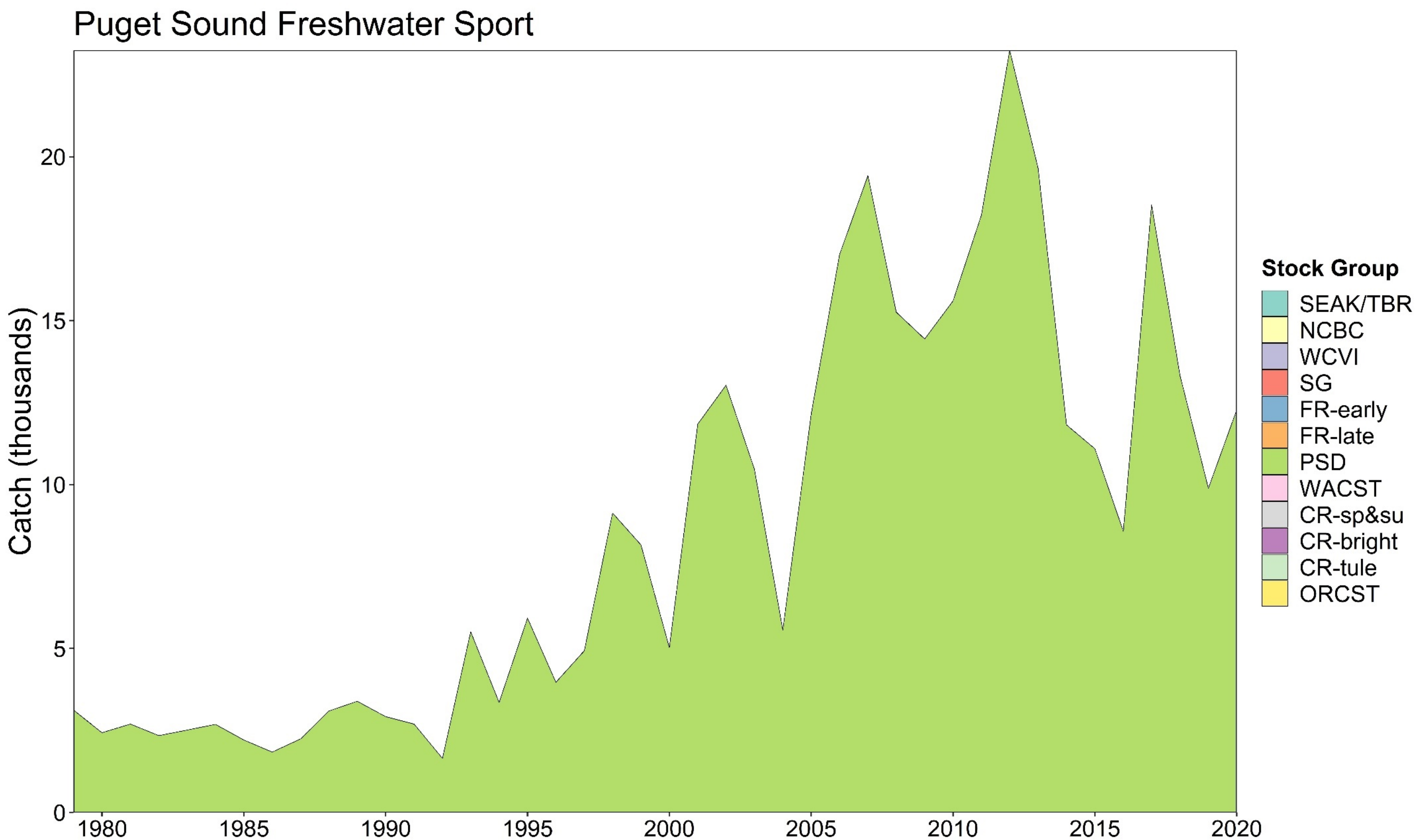
Appendix C44— PSC Chinook Model estimates of landed catch stock composition for Fraser River Freshwater Sport, 1979–2020.



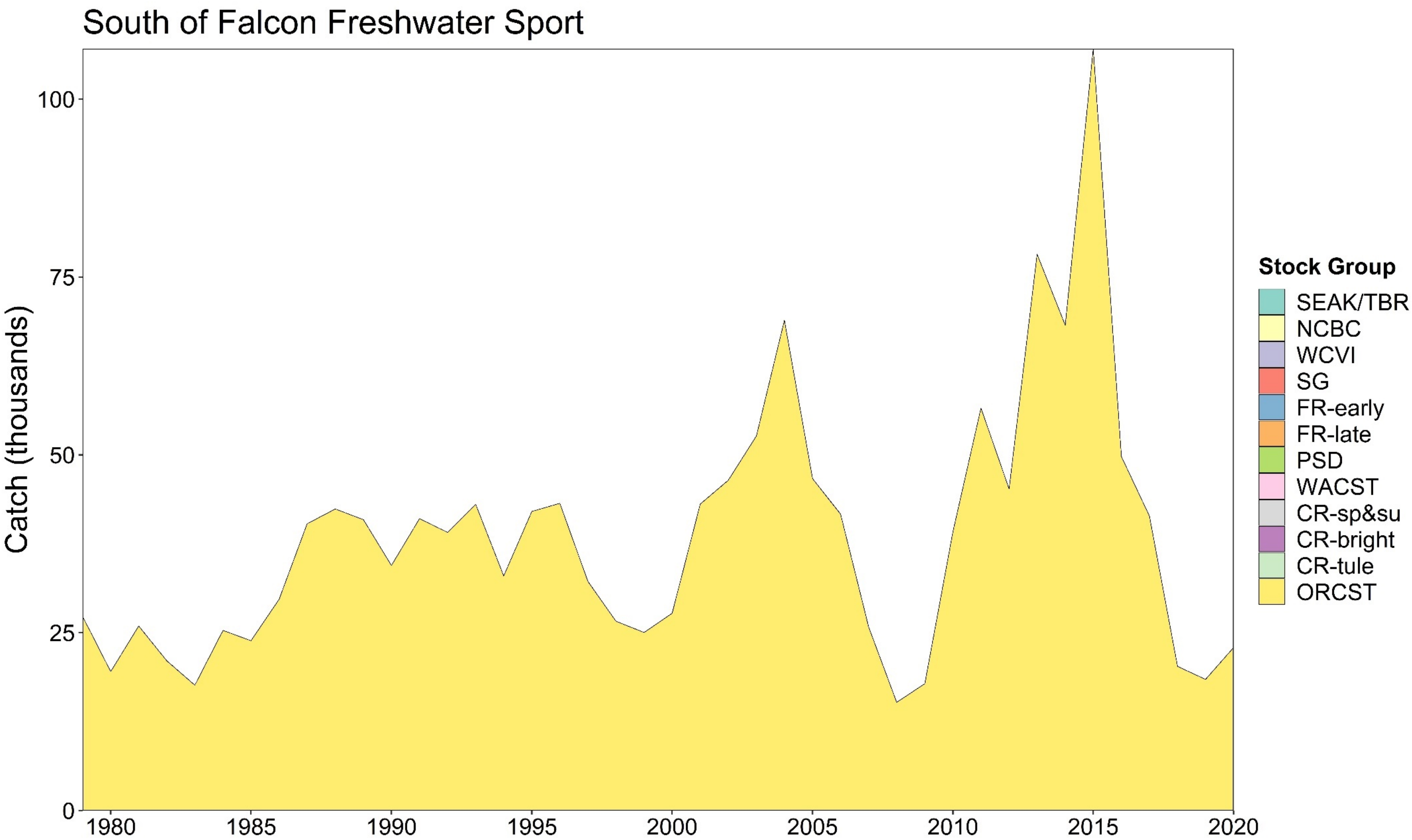
Appendix C45— PSC Chinook Model estimates of landed catch stock composition for Strait of Georgia Freshwater Sport, 1979–2020.



Appendix C46— PSC Chinook Model estimates of landed catch stock composition for Puget Sound Freshwater Sport, 1979–2020.



Appendix C47— PSC Chinook Model estimates of landed catch stock composition for South of Falcon Freshwater Sport, 1979–2020.



APPENDIX D: INCIDENTAL MORTALITY RATES APPLIED IN THE PSC CHINOOK MODEL

Appendix D— Incidental mortality rates applied in the Phase II PSC Chinook Model. Rates in original model were applied to all years. In the current model, rates in some fisheries vary in accordance to changes in management regulations.

Fishery Number	Fishery	Rates applied in Model CLB 2104 Sublegal Rate	Legal Rate	Dropoff	Applicable Years
1	Alaska Troll	0.255	0.211	0.008	All
2	Alaska Yakutat Terminal Net	0.9	0.9	0	All
3	North Troll	0.255	0.211	0.017	1979–1995
3	North Troll	0.22	0.185	0.016	1996–Current
4	Central Troll	0.255	0.211	0.017	1979–1995
4	Central Troll	0.22	0.185	0.016	1996–Current
5	West Coast Vancouver Island Troll	0.255	0.211	0.017	1979–1997
5	West Coast Vancouver Island Troll	0.22	0.185	0.016	1998–Current
6	North of Falcon Troll	0.255	0.211	0.017	1979–1983
6	North of Falcon Troll	0.22	0.185	0.016	1984–Current
7	South of Falcon Troll	0.255	0.211	0.017	1979–1983
7	South of Falcon Troll	0.22	0.185	0.016	1984–Current
8	Strait of Georgia Troll	0.255	0.211	0.017	1979–1985, 1987–1997
8	Strait of Georgia Troll	0.22	0.185	0.016	1986, 1998–Current
9	Alaska Net	0.9	0.9	0	All
10	North Net	0.9	0.9	0	All
11	Central Net	0.9	0.9	0	All
12	West Coast Vancouver Island Net	0.9	0.9	0	All
13	Juan de Fuca Net	0.9	0.9	0	All
14	Puget Sound North Net	0.9	0.9	0	All
15	Puget Sound Other Net	0.9	0.9	0	All
16	Washington Coast Net	0.9	0.9	0	All
17	Columbia River Net	0.9	0.9	0	All
18	Alaska Transboundary River Terminal Net	0.9	0.9	0	All
19	Canada Transboundary River Freshwater Net	0.9	0.9	0	All
20	Central B.C. Freshwater Net	0.9	0.9	0	All
21	Strait of Georgia Freshwater Net	0.9	0.9	0	All
22	Fraser Freshwater Net	0.9	0.9	0	All
23	Puget Sound Freshwater Net	0.9	0.9	0	All
24	Washington Coast Freshwater Net	0.9	0.9	0	All
25	Johnstone Strait Net	0.9	0.9	0	All
26	Fraser Net	0.9	0.9	0	All

Appendix D continued. Incidental mortality rates applied in the Phase II PSC Chinook Model. Rates in original model were applied to all years. In the current model, rates in some fisheries vary in accordance to changes in management regulations.

		Rates applied in Model CLB 2104			
Fishery Number	Fishery	Sublegal Rate	Legal Rate	Dropoff	Applicable Years
27	Alaska Sport	0.123	0.123	0.036	All
28	Central B.C. Sport	0.123	0.123	0.036	All
29	North B.C. AABM Sport	0.123	0.123	0.036	All
30	North B.C. ISBM Sport	0.123	0.123	0.036	All
31	West Coast Vancouver Island AABM Sport	0.123	0.123	0.069	All
32	West Coast Vancouver Island ISBM Sport	0.123	0.123	0.069	All
33	North of Falcon Sport	0.123	0.123	0.069	All
34	South of Falcon Sport	0.123	0.123	0.069	All
35	Puget Sound North Sport	0.123	0.123	0.145	All
36	Puget Sound Other Sport	0.123	0.123	0.145	All
37	Canada Yakutat Freshwater Net	0.9	0.9	0	All
38	Strait of Georgia Sport	0.322	0.322	0.069	1979–1981
38	Strait of Georgia Sport	0.123	0.123	0.069	1982–Current
39	B.C. Juan de Fuca Sport	0.322	0.322	0.069	All
40	Columbia River Sport	0.123	0.123	0.069	All
41	Alaska Transboundary River Terminal Sport	0.123	0.123	0.069	All
42	North B.C. Freshwater Sport	0.123	0.123	0.069	All
43	Central B.C. Freshwater Sport	0.123	0.123	0.069	All
44	West Coast Vancouver Island Freshwater Sport	0.123	0.123	0.069	All
45	Fraser River Freshwater Sport	0.123	0.123	0.069	All
46	Strait of Georgia Freshwater Sport	0.123	0.123	0.069	All
47	Puget Sound Freshwater Sport	0.123	0.123	0.069	All
48	South of Falcon Freshwater Sport	0.123	0.123	0.069	All

APPENDIX E: TIME SERIES OF ABUNDANCE INDICES

Appendix E— Time series of abundance indices from 1979–2021 for aggregate abundance-based management troll fisheries as estimated by PSC Chinook Model calibrations CLB 2104.

Year	Alaska Troll	North Troll	West Coast Vancouver Island Troll
1979	0.93	1.05	1.12
1980	1.01	0.98	0.99
1981	1.02	0.98	0.92
1982	1.05	0.98	0.96
1983	1.11	1.08	0.90
1984	1.35	1.24	0.97
1985	1.28	1.28	0.90
1986	1.39	1.29	1.05
1987	1.76	1.68	1.44
1988	2.17	1.81	1.28
1989	2.00	1.75	1.01
1990	1.88	1.62	0.89
1991	1.84	1.58	0.81
1992	1.78	1.55	0.82
1993	1.82	1.55	0.72
1994	1.69	1.33	0.54
1995	1.04	1.02	0.48
1996	1.10	1.00	0.57
1997	1.55	1.25	0.67
1998	1.36	1.07	0.61
1999	1.06	0.86	0.58
2000	0.90	0.83	0.58
2001	1.20	1.17	0.98
2002	1.89	1.84	1.43
2003	2.25	1.97	1.38
2004	2.07	1.96	1.21
2005	1.83	1.69	0.95
2006	1.69	1.54	0.74
2007	1.20	1.05	0.60
2008	0.94	0.89	0.68
2009	1.14	1.02	0.65
2010	1.23	1.33	0.89
2011	1.42	1.38	0.83
2012	1.15	1.27	0.82
2013	1.52	1.59	1.14
2014	2.13	1.89	1.20
2015	2.06	1.94	1.17
2016	1.51	1.38	0.78
2017	1.12	1.06	0.66
2018	0.73	0.82	0.60
2019	0.96	1.01	0.62
2020	1.11	1.16	0.67
2021	1.28	1.27	0.76

Note: This time series is NOT the first post-season AI for each year and is for trend analysis only. For evaluation of overage and underage, use the first post-season AI instead (Source CLB 2104 PABD file).

APPENDIX F: ABUNDANCE INDICES IN TOTAL AND BY MODEL STOCK FOR AABM FISHERIES, FROM CALIBRATION 2104

LIST OF APPENDIX F TABLES

Appendix F1– Acronyms used in Abundance Indices (AIs) tables in Appendix F.

Stock Name	Acronym	Stock Name	Acronym
Southern Southeast Alaska	SSA	Puget Sound Yearling	PSY
Northern Southeast Alaska	NSA	Nooksack Spring	NKS
Alsek	ALS	Skagit Wild	SKG
Taku and Stikine	TST	Stillaguamish Wild	STL
Northern British Columbia	NBC	Snohomish Wild	SNO
Central British Columbia	CBC	Washington Coastal Hatchery	WCH
Fraser Spring 1.2	FS2	Washington Coastal Natural	WCN
Fraser Spring 1.3	FS3	Willamette River Spring	WSH
Fraser Ocean-type 0.3	FSO	Cowlitz Spring Hatchery	CWS
Fraser Summer Stream-type 1.3	FSS	Columbia River Summer	SUM
Fraser Harrison Fall	FHF	Upriver Brights	URB
Fraser Chilliwack Fall Hatchery	FCF	Spring Creek Hatchery	SPR
West Coast Vancouver Island Hatchery	WVH	Lower Bonneville Hatchery	BON
West Coast Vancouver Island Natural	WVN	Fall Cowlitz Hatchery	CWF
Upper Strait of Georgia	UGS	Lewis River Wild	LRW
Puntledge Summers	PPS	Lyons Ferry	LYF
Lower Strait of Georgia	LGS	Mid-Columbia River Brights	MCB
Middle Strait of Georgia	MGS	North Oregon Coast	NOC
Nooksack Fall	NKF	Mid-Oregon Coast	MOC
Puget Sound Fingerling	PSF	Yakutat Forelands	YAK
Puget Sound Natural Fall	PSN		

Appendix F2– Abundance indices (AIs) for the Southeast Alaska Troll fishery by model stock and year, from CLB 2104. Numbers shown represent the portion of the AI total estimated for each model stock; the summation across all 41 stock groups equals the AI total for each calendar year.

Year	SSA	NSA	ALS	TST	NBC	CBC	FS2	FS3	FSO	FSS	FHF	FCF	WVH	WVN	UGS	PPS	LGS	MGS	NKF	PSF	PSN	AI Total
2009	0.04	0.03	0.00	0.03	0.07	0.01	0.00	0.00	0.13	0.00	0.00	0.00	0.11	0.03	0.01	0.00	0.00	0.01	0.00	0.00	0.00	1.14
2010	0.04	0.02	0.00	0.03	0.07	0.01	0.00	0.00	0.18	0.00	0.00	0.00	0.13	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	1.23
2011	0.03	0.02	0.00	0.04	0.03	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.27	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	1.42
2012	0.02	0.02	0.00	0.04	0.02	0.01	0.00	0.00	0.08	0.00	0.00	0.00	0.15	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	1.15
2013	0.03	0.02	0.00	0.03	0.03	0.01	0.00	0.00	0.08	0.00	0.00	0.00	0.17	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	1.52
2014	0.03	0.02	0.00	0.04	0.04	0.01	0.00	0.00	0.11	0.00	0.00	0.00	0.20	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	2.13
2015	0.03	0.02	0.00	0.03	0.03	0.01	0.00	0.00	0.18	0.00	0.00	0.00	0.22	0.05	0.01	0.00	0.00	0.01	0.00	0.00	0.00	2.06
2016	0.02	0.01	0.00	0.01	0.04	0.01	0.00	0.00	0.10	0.00	0.00	0.00	0.24	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00	1.51
2017	0.02	0.01	0.00	0.01	0.02	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.21	0.05	0.01	0.00	0.00	0.00	0.00	0.01	0.00	1.12
2018	0.02	0.01	0.00	0.01	0.02	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.17	0.03	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.73
2019	0.02	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.27	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.96
2020	0.02	0.02	0.00	0.02	0.01	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.25	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00	1.11
2021	0.02	0.01	0.00	0.02	0.01	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.32	0.06	0.01	0.00	0.00	0.00	0.00	0.00	0.00	1.28

Year	PSY	NKS	SKG	STL	SNO	WCH	WCN	WSH	CWS	SUM	URB	SPR	BON	CWF	LRW	LYF	MCB	NOC	MOC	YAK	AI Total
2009	0.00	0.00	0.00	0.00	0.00	0.03	0.05	0.01	0.00	0.04	0.32	0.00	0.00	0.02	0.01	0.00	0.11	0.05	0.02	0.00	1.14
2010	0.00	0.00	0.00	0.00	0.00	0.04	0.08	0.02	0.00	0.05	0.28	0.00	0.00	0.02	0.01	0.00	0.07	0.09	0.03	0.00	1.23
2011	0.00	0.00	0.00	0.00	0.00	0.06	0.08	0.02	0.00	0.05	0.31	0.00	0.00	0.03	0.01	0.00	0.09	0.13	0.04	0.00	1.42
2012	0.00	0.00	0.00	0.00	0.00	0.07	0.09	0.01	0.00	0.05	0.26	0.00	0.00	0.02	0.01	0.00	0.09	0.14	0.03	0.00	1.15
2013	0.00	0.00	0.00	0.00	0.00	0.04	0.05	0.01	0.00	0.05	0.51	0.00	0.00	0.02	0.01	0.00	0.21	0.16	0.03	0.00	1.52
2014	0.00	0.00	0.00	0.00	0.00	0.06	0.06	0.01	0.00	0.07	0.88	0.00	0.00	0.03	0.02	0.00	0.28	0.16	0.04	0.00	2.13
2015	0.00	0.00	0.00	0.00	0.00	0.06	0.07	0.02	0.00	0.09	0.78	0.00	0.00	0.03	0.02	0.00	0.19	0.14	0.05	0.00	2.06
2016	0.00	0.00	0.00	0.00	0.00	0.04	0.04	0.01	0.00	0.08	0.51	0.00	0.00	0.03	0.01	0.00	0.11	0.16	0.02	0.00	1.51
2017	0.00	0.00	0.00	0.00	0.00	0.04	0.04	0.01	0.00	0.05	0.31	0.00	0.00	0.01	0.01	0.00	0.06	0.13	0.01	0.00	1.12
2018	0.00	0.00	0.00	0.00	0.00	0.03	0.04	0.01	0.00	0.04	0.13	0.00	0.00	0.01	0.00	0.00	0.03	0.08	0.01	0.00	0.73
2019	0.00	0.00	0.00	0.00	0.00	0.04	0.05	0.01	0.00	0.04	0.14	0.00	0.00	0.01	0.01	0.00	0.05	0.06	0.01	0.00	0.96
2020	0.00	0.00	0.00	0.00	0.00	0.05	0.07	0.01	0.00	0.04	0.17	0.00	0.00	0.01	0.02	0.00	0.10	0.09	0.01	0.00	1.11
2021	0.00	0.00	0.00	0.00	0.00	0.04	0.06	0.01	0.00	0.06	0.27	0.00	0.00	0.02	0.02	0.00	0.09	0.11	0.01	0.00	1.28

Appendix F3– Abundance indices (AIs) for the Northern BC Troll fishery by stock and year, from CLB 2104. Numbers shown represent the portion of the AI total estimated for each model stock; the summation across all 41 stock groups equals the AI total for each calendar year.

Year	SSA	NSA	ALS	TST	NBC	CBC	FS2	FS3	FSO	FSS	FHF	FCF	WVH	WVN	UGS	PPS	LGS	MGS	NKF	PSF	PSN	AI Total
2009	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.19	0.01	0.00	0.00	0.06	0.01	0.01	0.00	0.00	0.01	0.00	0.01	0.00	1.02
2010	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.26	0.01	0.00	0.00	0.12	0.02	0.01	0.00	0.00	0.01	0.00	0.01	0.00	1.33
2011	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.21	0.01	0.00	0.00	0.13	0.02	0.01	0.00	0.00	0.01	0.00	0.01	0.00	1.38
2012	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.08	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.00	1.27
2013	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.01	0.00	0.00	0.12	0.02	0.01	0.00	0.00	0.01	0.00	0.01	0.00	1.59
2014	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.16	0.01	0.00	0.00	0.11	0.02	0.01	0.00	0.00	0.01	0.00	0.01	0.00	1.89
2015	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.26	0.01	0.00	0.00	0.15	0.03	0.01	0.00	0.00	0.01	0.00	0.01	0.00	1.94
2016	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.14	0.03	0.02	0.00	0.00	0.01	0.00	0.01	0.00	1.38
2017	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.12	0.02	0.01	0.00	0.00	0.01	0.00	0.01	0.00	1.06
2018	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.14	0.02	0.01	0.00	0.01	0.01	0.00	0.01	0.00	0.82
2019	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.15	0.03	0.02	0.00	0.00	0.01	0.00	0.01	0.00	1.01
2020	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.17	0.03	0.01	0.00	0.00	0.01	0.00	0.01	0.00	1.16
2021	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.18	0.03	0.01	0.00	0.00	0.01	0.00	0.01	0.00	1.27

Year	PSY	NKS	SKG	STL	SNO	WCH	WCN	WSH	CWS	SUM	URB	SPR	BON	CWF	LRW	LYF	MCB	NOC	MOC	YAK	AI Total
2009	0.00	0.00	0.00	0.00	0.00	0.05	0.08	0.04	0.00	0.07	0.19	0.00	0.00	0.01	0.00	0.01	0.06	0.11	0.07	0.00	1.02
2010	0.00	0.00	0.00	0.00	0.00	0.06	0.11	0.04	0.00	0.09	0.19	0.00	0.00	0.01	0.00	0.01	0.05	0.18	0.10	0.00	1.33
2011	0.00	0.00	0.00	0.00	0.00	0.09	0.11	0.03	0.00	0.10	0.20	0.00	0.00	0.02	0.01	0.01	0.06	0.23	0.11	0.00	1.38
2012	0.00	0.00	0.00	0.00	0.00	0.10	0.12	0.02	0.01	0.10	0.20	0.00	0.00	0.01	0.00	0.01	0.07	0.26	0.08	0.00	1.27
2013	0.00	0.00	0.00	0.00	0.00	0.06	0.08	0.02	0.00	0.11	0.42	0.00	0.00	0.02	0.01	0.01	0.15	0.28	0.09	0.00	1.59
2014	0.00	0.00	0.00	0.00	0.00	0.08	0.08	0.04	0.00	0.14	0.57	0.00	0.00	0.02	0.01	0.01	0.17	0.27	0.13	0.00	1.89
2015	0.00	0.00	0.00	0.00	0.00	0.09	0.10	0.03	0.01	0.16	0.47	0.00	0.00	0.02	0.01	0.01	0.11	0.29	0.14	0.00	1.94
2016	0.00	0.00	0.00	0.00	0.00	0.06	0.06	0.02	0.01	0.15	0.30	0.00	0.00	0.01	0.00	0.01	0.07	0.24	0.07	0.00	1.38
2017	0.00	0.00	0.00	0.00	0.00	0.06	0.06	0.02	0.01	0.10	0.17	0.00	0.00	0.01	0.00	0.01	0.03	0.21	0.04	0.00	1.06
2018	0.00	0.00	0.00	0.00	0.00	0.05	0.06	0.01	0.00	0.07	0.09	0.00	0.00	0.01	0.00	0.01	0.03	0.14	0.03	0.00	0.82
2019	0.00	0.00	0.00	0.00	0.00	0.05	0.07	0.02	0.00	0.07	0.10	0.00	0.00	0.01	0.01	0.01	0.04	0.13	0.03	0.00	1.01
2020	0.00	0.00	0.00	0.00	0.00	0.08	0.10	0.02	0.00	0.09	0.14	0.00	0.00	0.01	0.01	0.01	0.06	0.16	0.04	0.00	1.16
2021	0.00	0.00	0.00	0.00	0.00	0.06	0.09	0.02	0.00	0.12	0.19	0.00	0.00	0.01	0.01	0.01	0.05	0.20	0.04	0.00	1.27

Appendix F4– Abundance indices (AIs) for the West Coast Vancouver Island Troll fishery by stock and year, from CLB 2104. Numbers shown represent the portion of the AI total estimated for each model stock; the summation across all 41 stock groups equals the AI total for each calendar year.

Year	SSA	NSA	ALS	TST	NBC	CBC	FS2	FS3	FSO	FSS	FHF	FCF	WVH	WVN	UGS	PPS	LGS	MGS	NKF	PSF	PSN	AI Total
2009	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.03	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.02	0.11	0.01	0.65
2010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.04	0.06	0.04	0.01	0.00	0.00	0.00	0.00	0.02	0.11	0.01	0.89
2011	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.05	0.04	0.05	0.01	0.00	0.00	0.00	0.00	0.02	0.12	0.01	0.83
2012	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.02	0.13	0.01	0.82
2013	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.04	0.04	0.01	0.00	0.00	0.00	0.00	0.02	0.12	0.01	1.14
2014	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.03	0.05	0.04	0.01	0.00	0.00	0.01	0.00	0.02	0.09	0.01	1.20
2015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.05	0.04	0.05	0.01	0.00	0.00	0.01	0.00	0.01	0.09	0.01	1.17
2016	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.03	0.05	0.01	0.00	0.00	0.00	0.00	0.01	0.14	0.01	0.78
2017	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.02	0.04	0.01	0.00	0.00	0.01	0.00	0.01	0.19	0.01	0.66
2018	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.03	0.05	0.01	0.00	0.00	0.01	0.00	0.01	0.17	0.01	0.60
2019	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.05	0.05	0.01	0.00	0.00	0.01	0.00	0.01	0.13	0.01	0.62
2020	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.04	0.06	0.01	0.00	0.00	0.00	0.00	0.01	0.11	0.01	0.67
2021	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.03	0.06	0.01	0.00	0.00	0.00	0.00	0.01	0.13	0.01	0.76

Year	PSY	NKS	SKG	STL	SNO	WCH	WCN	WSH	CWS	SUM	URB	SPR	BON	CWF	LRW	LYF	MCB	NOC	MOC	YAK	AI Total
2009	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.05	0.11	0.05	0.01	0.06	0.00	0.01	0.03	0.02	0.02	0.00	0.65
2010	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.06	0.12	0.13	0.03	0.07	0.01	0.01	0.03	0.03	0.03	0.00	0.89
2011	0.01	0.00	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.06	0.11	0.08	0.03	0.07	0.01	0.02	0.03	0.03	0.02	0.00	0.83
2012	0.01	0.00	0.01	0.00	0.00	0.01	0.01	0.00	0.01	0.06	0.14	0.08	0.04	0.06	0.01	0.02	0.05	0.03	0.02	0.00	0.82
2013	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.00	0.00	0.07	0.33	0.11	0.02	0.08	0.01	0.02	0.11	0.04	0.03	0.00	1.14
2014	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.08	0.33	0.15	0.03	0.10	0.01	0.02	0.09	0.03	0.03	0.00	1.20
2015	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.10	0.25	0.18	0.03	0.11	0.01	0.02	0.06	0.04	0.04	0.00	1.17
2016	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.00	0.01	0.07	0.16	0.04	0.01	0.07	0.00	0.01	0.03	0.03	0.02	0.00	0.78
2017	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.00	0.01	0.05	0.08	0.05	0.02	0.04	0.00	0.01	0.02	0.02	0.01	0.00	0.66
2018	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.00	0.00	0.04	0.06	0.03	0.02	0.03	0.00	0.01	0.02	0.01	0.01	0.00	0.60
2019	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.00	0.00	0.04	0.07	0.03	0.01	0.04	0.01	0.01	0.03	0.02	0.01	0.00	0.62
2020	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.00	0.00	0.05	0.10	0.04	0.02	0.04	0.01	0.01	0.04	0.02	0.01	0.00	0.67
2021	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.00	0.00	0.07	0.12	0.07	0.03	0.05	0.01	0.01	0.03	0.03	0.01	0.00	0.76

APPENDIX G: PSC CHINOOK MODEL FORECAST PERFORMANCE

Note: there was no CTC consensus on the 2015 and 2016 model calibrations (CLB 1503 and 1601). Outputs from CLB 1503 were used by the Commission to configure AABM fisheries in 2015. Abundances indices for AABM fisheries generated from CLB 1601 were accepted by the Commission. For each stock group in Appendix G, pre-season PSC Model forecasts for 2015 are from CLB 1503 and forecasts for 2016 are from CLB 1601.

Data in Appendix G1 are used to evaluate PSC Chinook Model and Agency Forecasts. The following terminology is used:

- Model Forecast. The Model forecast for a stock is from that year's calibration (e.g., 2021 is from CLB 2104). These data do not change from year-to-year and can be found in a given year's model calibration out files. [source: stage 2 checkCLB.out file]
- Agency Forecast. The Agency forecast (FCS) for a stock is what was provided to the CTC for use with that year's Model calibration. These data do not change from year-to-year and can be found in a given year's model calibration input file. [source: OCNyear.FCS files]
- Post-season Return. The post-season return is the most up to date estimate of either the terminal return or the escapement, depending on how the stock is reported in the FCS file. [source: checkCLB.out or FCS file]

In the Appendix G1 tables, the column labeled '*Model/Agency*' shows the ratio of the model prediction and the agency forecast as a percentage. The column labeled '*Agency/Post-season*' shows the ratio of the agency forecast and the actual return as a percentage. The column labeled '*Model/Post-season*' shows the ratio of the model prediction and the actual return as a percentage. A value of 100% would indicate that the predicted and actual values were the same.

With the transition to the Phase II PSC Chinook Model base period, the stock structure and number of stocks represented in the model have changed. As 2020 represents the first year that this model was used for pre-season planning, Appendix G1 below contains model and agency forecasts, in addition to post-season returns for Phase II model stocks from 2020 to present. For information on forecasts and post-season returns prior to 2020, see Appendix G1 in CTC 2021d.

The figures in Appendix G2 display forecast error relative to the post-season ("actual") returns over time where information is available for each stock. Stocks are listed geographically from north to south. Gray shading indicates that an agency provided forecast was used for that particular stock/year, where orange shading indicates that the forecast used was model-derived. The shape of the symbol denotes whether the 9806 model (circle) or the Phase II model (diamond). Values in red indicate instances where the error value for a given stock/year exceeded the upper limit of the y-axis. Information used in these figures for 2020 can be found in Appendix G1. For information on forecast performance for years prior to 2020, see Appendix G1 in CTC 2021d.

With the change to model stock structure that occurred, it becomes difficult to represent stock-specific forecast performance across the transition to the Phase II model. Listed below are three categories of Phase II model stocks as they relate to the 9806 model configuration, which will help with interpretation of the Appendix G2 figures. For information on Phase II model stock acronyms, see Appendix A. For information on 9806 model stock acronyms, see Table 1 in CTC 2021b.

1. *Stocks that were added to the Phase II model that were not represented in the 9806 model configuration (e.g., YAK, ALS, TST, MOC).* In these cases, only one data point is available (2020), as forecasts do not exist for these stocks prior to implementation of the Phase II model.
2. *Stocks that were split from a single 9806 model stock into two or more component stocks in the Phase II model (e.g., AKS split into NSA and SSA, NTH split into NBC and CBC, etc.).* In these cases there are multiple panels, with one that shows performance through 2019 for the 9806 model stock (acronym in brackets followed by the corresponding Phase II model stocks in parentheses; e.g., "[AKS] (NSA+SSA)"), followed by others that present the 2020 values for each of the corresponding Phase II model stocks.
3. *Stocks that were unchanged between the two models.* In these cases, the entire time series (1999 – 2020) is contained within a single panel. Since there were instances where the stock acronym did change, the Phase II model stock acronym is followed by the 9806 model stock acronym in brackets (e.g., NOC [ORC]).

LIST OF APPENDIX G TABLES

Appendix G1. Forecasts and post-season returns for Phase II model stocks, 2020 to present. (Page 1 of 3)

Stock Name	Year	Model Forecast	Agency Forecast	Post-season Return	Model/ Agency	Agency/ Post-season	Model/ Post-season
Yakutat Forelands[1] (YAK)	2020	4,377	NA	4,113	NA	NA	106%
	2021	5,460	NA	NA	NA	NA	NA
	Avg	NA	NA	NA	NA	NA	106%
Alsek[1] (ALS)	2020	10,787	NA	5,241	NA	NA	206%
	2021	9,526	NA	NA	NA	NA	NA
	Avg	NA	NA	NA	NA	NA	206%
Southern SEAK[1] (SSA)	2020	9,252	NA	9,211	NA	NA	100%
	2021	10,599	NA	NA	NA	NA	NA
	Avg	NA	NA	NA	NA	NA	100%
Northern SEAK[1] (NSA)	2020	3,232	NA	5,175	NA	NA	62%
	2021	3,343	NA	NA	NA	NA	NA
	Avg	NA	NA	NA	NA	NA	62%
Transboundary Rivers[1] (TST)	2020	38,347	NA	37,681	NA	NA	102%
	2021	33,300	NA	NA	NA	NA	NA
	Avg	NA	NA	NA	NA	NA	102%
Northern BC[1] (NBC)	2020	20,691	34,971	29,515	59%	118%	70%
	2021	21,483	37,577	NA	57%	NA	NA
	Avg	NA	NA	NA	58%	118%	70%
Central BC[1] (CBC)	2020	6,785	11,463	14,262	59%	80%	48%
	2021	8,066	13,438	NA	60%	NA	NA
	Avg	NA	NA	NA	60%	80%	48%
WCVI Hacthery[2] (WVH)	2020	163,921	152,227	189,043	108%	81%	87%
	2021	196,007	172,955	NA	113%	NA	NA
	Avg	NA	NA	NA	111%	81%	87%
WCVI Natural[2] (WVN)	2020	25,671	22,531	29,846	114%	75%	86%
	2021	29,472	26,511	NA	111%	NA	NA
	Avg	NA	NA	NA	113%	75%	86%
Upper Georgia Strait[1] (UGS)	2020	5,227	11,779	18,886	44%	62%	28%
	2021	7,786	17,196	NA	45%	NA	NA
	Avg	NA	NA	NA	45%	62%	28%
Puntledge River Summer[1] (PPS)	2020	646	563	412	115%	137%	157%
	2021	590	569	NA	104%	NA	NA
	Avg	NA	NA	NA	109%	137%	157%
Middle Georgia Strait[1] (MGS)	2020	24,214	23,595	22,005	103%	107%	110%
	2021	23,027	23,283	NA	99%	NA	NA
	Avg	NA	NA	NA	101%	107%	110%
Lower Georgia Strait[2] (LGS)	2020	14,779	14,821	13,099	100%	113%	113%
	2021	7,692	10,576	NA	73%	NA	NA
	Avg	NA	NA	NA	86%	113%	113%
Fraser Early Spring 1.2[2] (FS2)	2020	6,105	6,220	9,138	98%	68%	67%
	2021	9,080	9,138	NA	99%	NA	NA
	Avg	NA	NA	NA	99%	68%	67%
Fraser Early Spring 1.3[2] (FS3)	2020	19,142	23,332	17,588	82%	133%	109%
	2021	17,605	17,588	NA	100%	NA	NA
	Avg	NA	NA	NA	91%	133%	109%

Appendix G1. Forecasts and post-season returns for Phase II model stocks, 2020 to present. (Page 2 of 3)

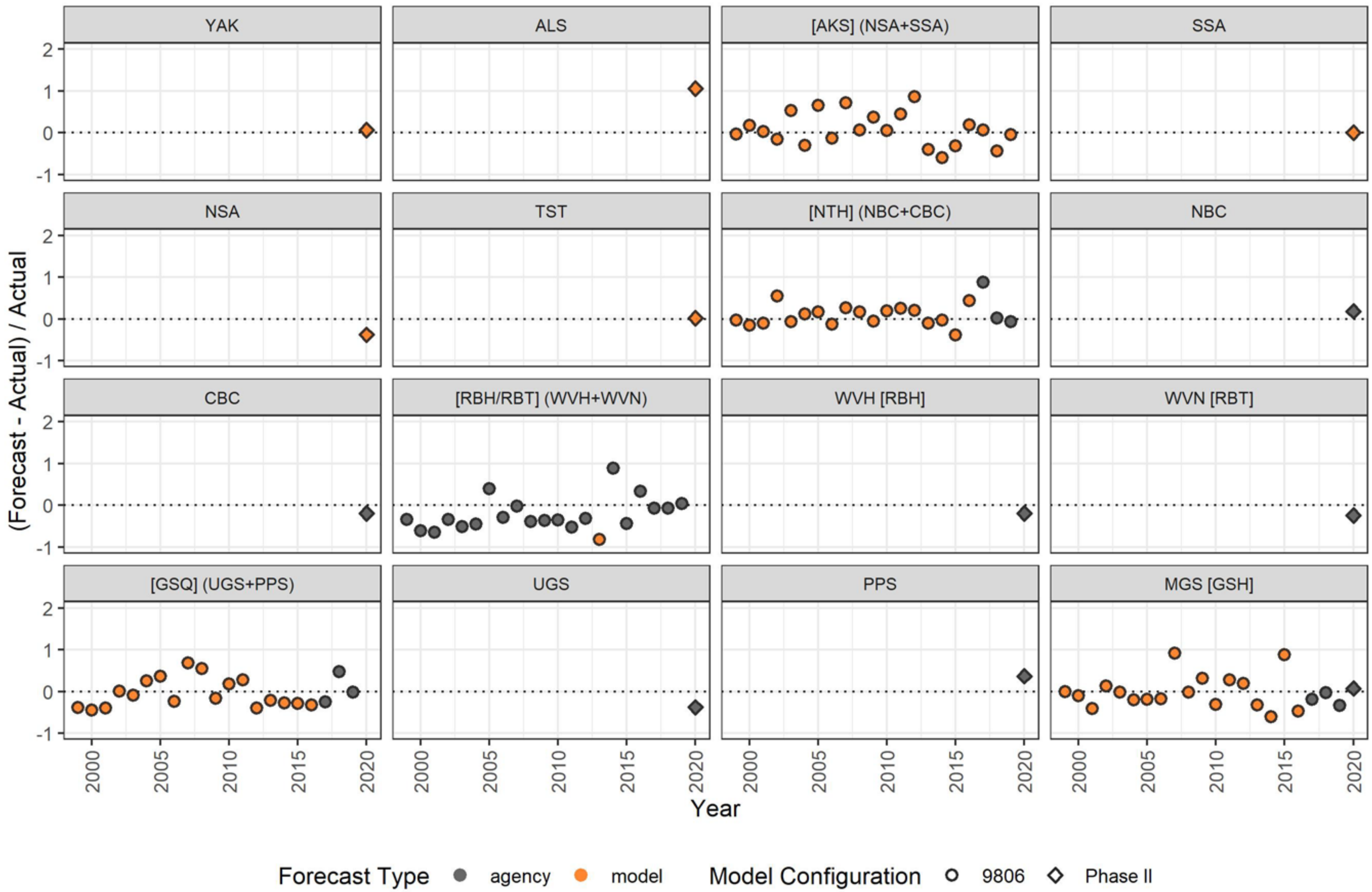
Stock Name	Year	Model Forecast	Agency Forecast	Post-season Return	Model/ Agency	Agency/ Post-season	Model/ Post-season
Fraser Early Summer 0.3[1] (FSO)	2020	119,340	114,566	147,937	104%	77%	81%
	2021	128,148	108,611	NA	118%	NA	NA
	Avg	NA	NA	NA	111%	77%	81%
Fraser Early Summer 1.3[2] (FSS)	2020	10,044	10,737	14,490	94%	74%	69%
	2021	14,446	14,490	NA	100%	NA	NA
	Avg	NA	NA	NA	97%	74%	69%
Fraser Late Natural (Harrison) [1] (FHF)	2020	53,584	59,745	43,499	90%	137%	123%
	2021	30,852	35,150	NA	88%	NA	NA
	Avg	NA	NA	NA	89%	137%	123%
Fraser Late Hatchery (Chilliwack) [1] (FCF)	2020	44,589	31,077	44,692	143%	70%	100%
	2021	36,766	39,593	NA	93%	NA	NA
	Avg	NA	NA	NA	118%	70%	100%
Nooksack Spring[1] (NKS)	2020	1,510	1,479	NA	102%	NA	NA
	2021	769	499	NA	154%	NA	NA
	Avg	NA	NA	NA	128%	NA	NA
Nooksack/Samish Fall[2] (NKF)	2020	15,764	16,858	12,058	94%	140%	131%
	2021	18,313	19,412	NA	94%	NA	NA
	Avg	NA	NA	NA	94%	140%	131%
Skagit Summer/Fall Wild[2] (SKG)	2020	14,031	12,877	13,062	109%	99%	107%
	2021	11,305	10,461	NA	108%	NA	NA
	Avg	NA	NA	NA	109%	99%	107%
Stillaguamish Summer/Fall Wild[1] (STL)	2020	727	762	938	95%	81%	78%
	2021	922	876	NA	105%	NA	NA
	Avg	NA	NA	NA	100%	81%	78%
Snohomish Summer/Fall Wild[2] (SNO)	2020	2,556	2,978	2,890	86%	103%	88%
	2021	2,939	2,922	NA	101%	NA	NA
	Avg	NA	NA	NA	93%	103%	88%
Puget Sound Fingerling[2,3] (PSF)	2020	206,668	186,117	110,000	111%	169%	188%
	2021	159,464	160,088	NA	100%	NA	NA
	Avg	NA	NA	NA	105%	169%	188%
Puget Sound Yearling[2,3] (PSY)	2020	4,604	4,059	2,335	113%	174%	197%
	2021	4,163	4,030	NA	103%	NA	NA
	Avg	NA	NA	NA	108%	174%	197%
Puget Sound Natural[2,3] (PSN)	2020	7,731	7,132	5,441	108%	131%	142%
	2021	8,980	8,225	NA	109%	NA	NA
	Avg	NA	NA	NA	109%	131%	142%
Washington Coastal Hatchery[2] (WCH)	2020	29,135	32,802	42,983	89%	76%	68%
	2021	40,339	42,953	NA	94%	NA	NA
	Avg	NA	NA	NA	91%	76%	68%
Washington Coastal Natural[2] (WCN)	2020	30,576	30,130	49,029	101%	61%	62%
	2021	46,314	41,395	NA	112%	NA	NA
	Avg	NA	NA	NA	107%	61%	62%
Cowlitz Spring[2] (CWS)	2020	3,738	3,843	3,984	97%	96%	94%
	2021	6,076	6,384	NA	95%	NA	NA
	Avg	NA	NA	NA	96%	96%	94%

Appendix G1. Forecasts and post-season returns for Phase II model stocks, 2020 to present. (Page 3 of 3)

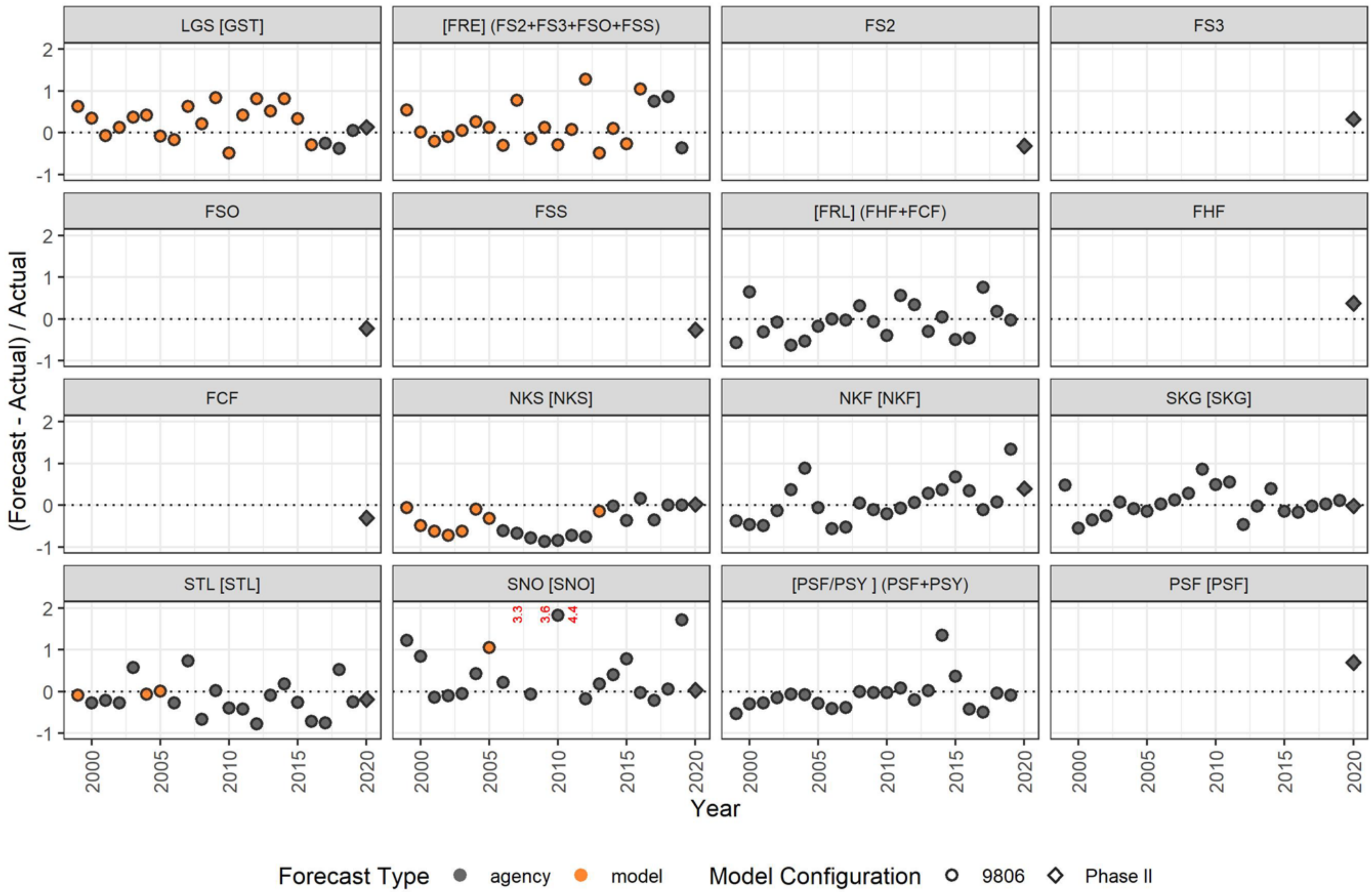
Stock Name	Year	Model Forecast	Agency Forecast	Post-season Return	Model/ Agency	Agency/ Post-season	Model/ Post-season
Willamette Spring[2] (WSH)	2020	43,814	43,430	47,327	101%	92%	93%
	2021	51,482	52,400	NA	98%	NA	NA
	Avg	NA	NA	NA	100%	92%	93%
Columbia River Summer[2] (SUM)	2020	36,194	38,300	65,494	95%	58%	55%
	2021	73,414	77,600	NA	95%	NA	NA
	Avg	NA	NA	NA	95%	58%	55%
Lewis River Wild[2] (LRW)	2020	22,290	19,700	35,397	113%	56%	63%
	2021	27,614	20,000	NA	138%	NA	NA
	Avg	NA	NA	NA	126%	56%	63%
Lower Bonneville Hatchery[2] (BON)	2020	14,940	16,500	18,110	91%	91%	82%
	2021	17,207	18,100	NA	95%	NA	NA
	Avg	NA	NA	NA	93%	91%	82%
Fall Cowlitz Hatchery[2] (CWF)	2020	34,100	34,500	59,754	99%	58%	57%
	2021	48,767	55,000	NA	89%	NA	NA
	Avg	NA	NA	NA	94%	58%	57%
Spring Creek Hatchery[2] (SPR)	2020	46,779	47,500	52,686	98%	90%	89%
	2021	46,242	46,780	NA	99%	NA	NA
	Avg	NA	NA	NA	99%	90%	89%
Mid-Columbia Bright[2] (MCB)	2020	78,988	78,200	109,077	101%	72%	72%
	2021	84,306	86,200	NA	98%	NA	NA
	Avg	NA	NA	NA	99%	72%	72%
Columbia Upriver Bright[2] (URB)	2020	212,281	220,600	299,337	96%	74%	71%
	2021	338,574	354,218	NA	96%	NA	NA
	Avg	NA	NA	NA	96%	74%	71%
Snake River Wild[2] (LYF)	2020	12,984	10,902	12,282	119%	89%	106%
	2021	12,485	10,991	NA	114%	NA	NA
	Avg	NA	NA	NA	116%	89%	106%
North Oregon Coast[1] (NOC)	2020	55,940	44,809	76,901	125%	58%	73%
	2021	68,923	67,593	NA	102%	NA	NA
	Avg	NA	NA	NA	113%	58%	73%
Mid-Oregon Coast[1] (MOC)	2020	25,427	28,140	26,512	90%	106%	96%
	2021	25,514	25,900	NA	99%	NA	NA
	Avg	NA	NA	NA	94%	106%	96%

[1] Forecast unit is escapement
[2] Forecast unit is terminal run
[3] Puget Sound post-season returns for the most recent year are preliminary projections based on partial return information.

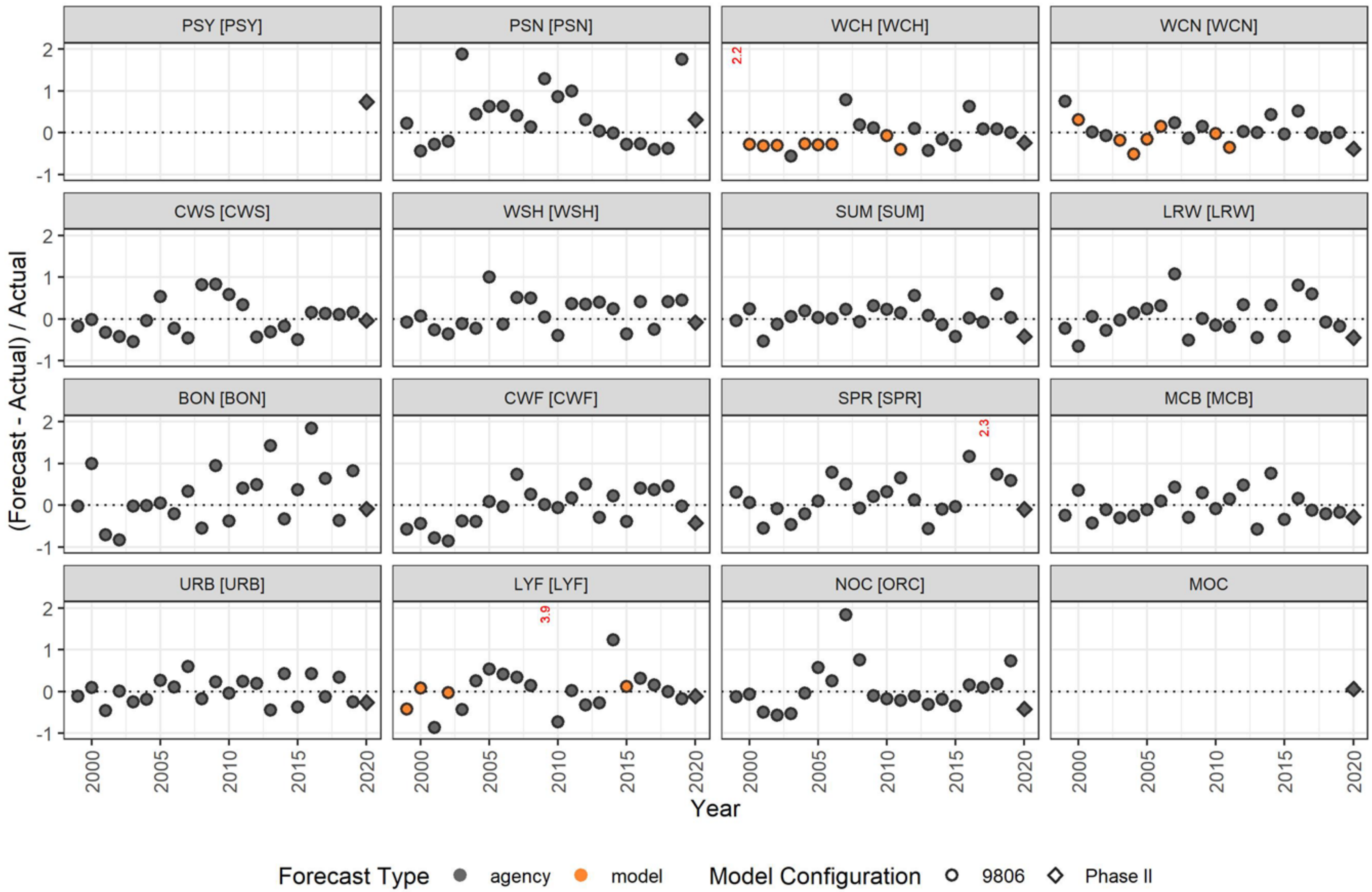
Appendix G2. Forecast performance for 9806 and Phase II PSC Chinook Model stocks, 1999–2020. (Page 1 of 3)



Appendix G2. Forecast performance for PSC Chinook Model stocks, 1999–2020. (Page 2 of 3)



Appendix G2. Forecast performance for PSC Chinook Model stocks, 1999–2020. (Page 3 of 3)



APPENDIX H: MODEL CALIBRATION METHODS

This section describes the calibration data and procedures used. For reference, a list of indicator stocks and fisheries in the model is provided in Appendix A. Estimation of the model base period parameters is described in CTC *In prep*. For 2021, the new "Phase II" model was used for estimating pre- and post-season AIs (see CTC 2021a and CTC 2021b for details on the Phase II transition).

Calibration Data

The first step in the annual calibration process is to gather new or revised data to update the model input files. For example, the file containing run size data is updated as pre-season forecasts and post-season run size estimates become available. Model predictions of the AIs are sensitive to pre-season forecasts and post-season estimates of terminal runs. Months in which forecasts are available for each stock, and the month the final return estimate becomes available, are presented in Appendix H1.

The model is recalibrated annually to incorporate observed data from the previous year (or years if post-season estimates are corrected) and available abundance forecasts for the current year (2021). In addition, recalibration may also occur when significant changes in one or more of the following model input files are made.

1. BSE (base): This file contains basic information describing the structure of the model (i.e., the number and names of stocks and fisheries, age classes, the base period identification of terminal fisheries, and stock production parameters). This file may be modified annually to incorporate productivity parameters that correspond to new CTC-agreed escapement goals.
2. CEI (ceiling): This file contains historical catch data for the 25 fisheries that are modeled as ceiling or catch quota fisheries (as opposed to fisheries modeled solely through control of exploitation rates) through the most recent fishing season.
3. CNR (Chinook salmon non-retention): Data used by the model to estimate mortalities during CNR periods are read from the CNR file. The data in the CNR file depends on which method is used to calculate CNR mortality. It may include direct estimates of encounters during the CNR period or indicators of fishing effort in the CNR period relative to the retention period.
4. ENH (enhancement file): For 13 hatchery stocks and one natural stock (Lower Strait of Georgia) with supplementation, this file contains productivity parameters as well as the differences (positive or negative) in annual smolt production relative to the base period. However, differences in smolt production relative to the base period have not been updated in over 10 years (other than a few stocks). The environmental variable (EV) scalars can instead provide the functionality of matching cohort numbers of the various stocks to observed terminal return and escapement. Additional discussion of the productivity parameters may be found in the draft model documentation (CTC 1991).
5. FCS (forecast): Agency supplied annual estimates of terminal run sizes or escapements

as well as pre-season forecasts are contained in the FCS file. Age-specific information is used for those stocks and years with age data (Appendix H2). For those stocks with forecasts of abundance provided externally by agencies in 2021, management agencies used three approaches to predict terminal returns or escapements:

a. Sibling Regression Models: Empirical time-series relationships between abundance (commonly measured as terminal run or spawner escapement numbers) of age *a* fish in calendar year (CY) and the comparable abundance of age *a*+1 fish in year CY+1 are used to predict age-structured abundance from estimated age-structured terminal return or escapement (forecast type S in Appendix H2).
b. Average Return Rate Models: Previous year age-specific return rates of adults per spawner or adults per smolt are applied to estimates of spawners or smolts from the brood years contributing to the coming year's return (forecast type R in Appendix H2).
c. CTC program ForecastR: ForecastR relies on the open-source statistical software R to generate age-specific or total-abundance forecasts of escapement or terminal run using a variety of generic models including (i) simple and complex sibling regressions with the ability to include environmental covariates, (ii) time series models such as auto regressive integrated moving average (ARIMA), exponential smoothing, and naïve models (based on preceding one year, three years or five years in abundance time series), and (iii) mechanistic models such as average return rate models. ForecastR enables users to perform the following interactive tasks: (a) the selection of forecasting approaches from a wide set of statistical and/or mechanistic models for forecasting terminal run or escapement; (b) the selection of several measures of retrospective forecast performance (e.g., mean relative error [MRE], mean absolute error [MAE], mean absolute percent error [MAPE], mean absolute scaled error [MASE], root mean squared error [RMSE]); (c) the comparison of best forecasting models and model ranking based on the selected performance metrics; and, (d) the reporting of forecasting results (point forecasts and interval forecasts) and diagnostics. For both age-structured and non-age-structured data, Akaike Information Criterion (AIC)-based model selection takes place within model types prior to model ranking across model types based on the above-mentioned metrics of retrospective evaluation. ForecastR has been used to produce agency forecasts in 2016–2021 for Canada and Oregon Model stocks (forecast type F in Appendix H2).

6. FP: This file contains scalars specific to year, fishery, stock, and age that are applied to base period fishery exploitation rates, primarily in terminal fisheries. The FPs are used to scale annual fishery exploitation rates relative to the model base period and can be used for a variety of purposes. For example, for the ocean areas of the Washington and Oregon North of Cape Falcon (WA/OR) troll fishery, the FPs are used to model differential impacts on Columbia River and Puget Sound stocks as the proportion of the catch occurring in the Strait of Juan de Fuca varies. The source of the FPs is generally the reported catch fishery index (Ratio of Means approach) computed from CWT data in the

annual ERA, or the ratios of harvest rates computed from terminal area run reconstructions.

7. IDL (interdam loss): The IDL file contains stock-specific pre-spawning mortality for the Columbia River Summer, Columbia Upriver Bright, Spring Creek Tule, and Snake River Fall stocks provided each year by Columbia River fishery managers. The factors represent the fraction of the stock that can be accounted for after mainstem dam passage in the Columbia River. Losses can be attributed to direct mortality at the various dams, mortality in the reservoirs between dams, fall-backs, tailrace spawning, and other factors (as observed through window counts at the various dams upriver). The pre-spawning mortality factor is equal to 1 minus the conversion factor.
8. IM (changes in incidental mortality [IM] rates): The IM file contains the IM rates by fishery for legal and sublegal fish. These rates differ from those used in the base period due to alterations in gear, regulations, or fishery conduct.
9. MAT (maturity [MAT] and adult-equivalent [AEQ] factors): The MATAEQ file has annual estimates of maturation rates and AEQ factors for 27 stocks (BON, CBC, CWF, FCF, FHF, FS2, FSO, LGS, LRW, MCB, MGS, MOC, NBC, NOC, NSA, SKG, SPR, SSA, SUM, TST, UGS, URB, WCH, WCN, WSH, WVH, WVN). These annual estimates replace the single (not age-specific) maturation schedule rates in the stock (STK) file with age-specific Average values are used for years beyond the last year for which estimates are available (due to incomplete broods and the one-year lag for completion of the annual ERA). The Analytical Working Group (AWG) anticipates changes to the file and program to estimate maturation rates in future years.
10. PNV (proportion non-vulnerable): A PNV file is created for each fishery for which a size limit change has occurred since the Model base period. Each file contains age-specific estimates of the proportion of fish not vulnerable to the fishing gear, or smaller in length than the minimum size limit. The PNVs were estimated from empirical size distribution data; in some instances, independent surveys of encounter rates were used to adjust the PNV for age-2 fish to account for the proportion of the cohort that was not vulnerable to the fishing gear. Note, PNVs are not stock specific and is on the AWG’s work schedule to change in future years.
11. STK (stock): This file contains the stock- and age-specific starting (base period) cohort sizes, the base period exploitation rates on the vulnerable cohort for each model fishery, and non-year specific maturation schedules and AEQ factors. This file is updated if new stocks or fisheries are added, new CWT codes are used to represent distribution patterns of existing model stocks, or a re-estimation of base period data occurs. Modification of this file will result in a model different from that used in the negotiations (CLB 9812).

The calibration is controlled through a file designated with an OP7 conversion extension.

Appendix H1— Month of the year when agencies are able to provide final estimates for the previous year and pre-season forecasts of abundance for the next fishing year.

Model Stock	Month Final Estimate Available	Month(s) Forecast Available
Southern SE Alaska	January	None[1]
Northern SE Alaska	January	None[1]
Alsek	January	None[1]
Taku and Stikine	January	None[1]
Northern British Columbia	November	February
Central British Columbia	November	February
Fraser Spring 1.2	February	February/March
Fraser Spring 1.3	February	February/March
Fraser Summer Ocean-type	February	February/March
Fraser Summer Stream-type	February	February/March
Fraser Harrison Fall	February	February/March
Fraser Chilliwack Fall Hatchery	February	February/March
WCVI Natural	January	February
WCVI Hatchery	January	February
Upper Strait of Georgia	January	February
Puntledge Summers	January	February
Lower Strait of Georgia	December	February
Middle Strait of Georgia	December	February
Nooksack Spring	June	February
Nooksack Fall (Samish)	June	February
Snohomish Wild	June	February
Skagit Wild	June	February
Puget Sound Natural Fingerling	June	February
Stillaguamish Wild	June	February
Puget Sound Hatchery Fingerling	June	February
Puget Sound Hatchery Yearling	June	February
Washington Coastal Wild	June	March[2]
Washington Coastal Hatchery	June	March[2]
Cowlitz Spring Hatchery	June	December
Willamette River Hatchery	June	December
Columbia River Summer	September	February
Fall Cowlitz Hatchery	February	February, April[3]
Spring Creek Hatchery	February	February, April[3]
Lower Bonneville Hatchery	February	February, April[3]
Upriver Brights	February	February, April[3]
Snake River Wild Fall	February	February
Mid-Columbia River Bright	February	February, April[3]
Lewis River Wild	February	February, April[3]
North Oregon Coast	February	March
Mid-Oregon Coast	February	March
Yakutat Forelands	January	None

[1] Forecast is internally estimated using the PSC Chinook Model; thus no agency forecast is provided.

[2] Normally forecasts are not available for the model calibration, but these were available in 2021.

[3] A preliminary ocean escapement forecast is released in February. An updated ocean escapement forecast reflecting the ocean fishery option adopted by the Pacific Fisheries Management Council is released in April.

Appendix H2— Characteristics used to forecast the abundance of stocks in the PSC Chinook Model.

Model Stock	Forecast Characteristics			Comments
	Forecast Type[1]	Pre-season age-specific	Post-season age-specific	
Southern SE Alaska	C	Yes	Yes	Calibrated to escapement
Northern SE Alaska	C	Yes	Yes	Calibrated to escapement
Alsek	C	Yes	Yes	Calibrated to escapement
Taku and Stikine	C	Yes	Yes	Calibrated to escapement
Northern British Columbia	F	No	No	Calibrated to escapement
Central British Columbia	F	No	No	Calibrated to escapement
Fraser Spring 1.2	F	No	No	Calibrated to terminal run
Fraser Spring 1.3	F	No	No	Calibrated to terminal run
Fraser Summer Ocean-type	F	Mixed	Yes	Calibrated to escapement
Fraser Summer Stream-type	F	No	No	Calibrated to terminal run
Fraser Harrison Fall	F	Yes	Yes	Calibrated to escapement
Fraser Chilliwack Fall Hatchery	F	Yes	Yes	Calibrated to escapement
WCVI Natural	F	Yes	Yes	Calibrated to terminal run
WCVI Hatchery	F	Yes	Yes	Calibrated to terminal run
Upper Strait of Georgia	F	No	No	Calibrated to escapement
Puntledge Summers	F	No	No	Calibrated to escapement
Lower Strait of Georgia Hatchery	F	Yes	Yes	Calibrated to terminal run
Middle Strait of Georgia	F	Yes	Yes	Calibrated to escapement
Nooksack Spring	R	No	No	Calibrated to escapement
Nooksack Fall (Samish)	R	No	No	Recent year average return rate
Snohomish Wild	R	No	No	Recruits per Spawner
Skagit Wild	R	Yes	Yes	Average cohort return rate
Puget Sound Natural Fingerling	R	No	No	Calibrated to terminal run
Stillaguamish Wild	R	No	No	Recruits per Spawner
Puget Sound Hatchery Fingerling	R	No	No	Age-specific forecasts not available for all components
Puget Sound Hatchery Yearling	R	No	No	Age-specific forecasts not available for all components
Washington Coastal Wild	R	No	No	Average return rate
Washington Coastal Hatchery	R	No	No	Average return rate
Cowlitz Spring Hatchery	S	Yes	Yes	Prediction is to mouth of tributary streams
Willamette River Hatchery	S	Yes	Yes	Prediction is to mouth of Willamette River
Columbia River Summer	S	No	No	Run reconstruction used to estimate Columbia River mouth return
Spring Creek Hatchery	S	Yes	Yes	Run reconstruction used to estimate Columbia River mouth return
Lower Bonneville Hatchery	S	Yes	Yes	Run reconstruction used to estimate Columbia River mouth return
Upriver Brights	S	Yes	Yes	Run reconstruction used to estimate Columbia River mouth return
Lyons Ferry (Snake River Wild Fall)	R	No	No	Run reconstruction used to estimate Columbia River mouth return

Model Stock	Forecast Characteristics			Comments
	Forecast Type[1]	Pre-season age-specific	Post-season age-specific	
Mid-Columbia River Bright	S	Yes	Yes	Run reconstruction used to estimate Columbia River mouth return
Lewis River Wild	S	Yes	Yes	Run reconstruction used to estimate Columbia River mouth return
North Oregon Coast	F	Yes	Yes	Individual river age structure from by-age/size recovery probability as well as age structure in nearby rivers
Mid-Oregon Coast	F	Yes	Yes	Individual river age structure from by-age/size recovery probability as well as age structure in nearby rivers
Yakutat Forelands	F	Yes	Yes	Calibrated to escapement

[1] Externally provided forecast type codes are S = sibling; R = return rate; F = ForecastR; C = PSC Chinook Model internally estimated projection.

Calibration Procedures

The calibration uses an iterative algorithm to estimate environmental variables (EV) scalars for each brood year (BY) and model stock to account for annual variability in natural mortality in the initial year of ocean residence. The EV scalars are used to adjust age-1 abundances estimated for each stock and BY to observed terminal return or escapement in combination with the base period spawner-recruit function. Fishing impacts and natural mortalities are then applied through model processes. The EVs also adjust for biases resulting from errors in the data or assumptions used to estimate the base period parameters for the spawner-recruit functions.

The EVs are estimated through the following steps for stocks calibrated to age-specific terminal run sizes:

1. Predicted terminal runs/escapements are first computed for each year using the input files discussed above and the base period stock-recruitment function parameters (i.e., EV stock productivity scalars set equal to 1).
2. The ratio (SC_{BY}) of the observed terminal run/escapement and the model predicted terminal run/escapement from the previous step is computed for each BY. For example, if the observed and model predicted terminal runs for the 1979 brood were 900 and 1,500 age-3 fish in 1982, 4,000 and 4,500 age-4 fish in 1983, and 1,000 and 1,500 age-5 fish in 1983, the ratio would be computed as:

$$SC_{BY} = \frac{\sum_{a=Minage}^{Maxage} (Observed Terminal Run)_a}{\sum_{a=Minage}^{Maxage} (Model Predicted Terminal Run)_a}$$

Equation H.1

$$SC_{BY} = \frac{900 + 4000 + 1000}{1500 + 4500 + 1500}$$

Equation H.2

In the absence of age-specific estimates of the terminal run, the components are computed by multiplying the total terminal run by the model predictions of age composition.

3. The EV for iteration *n* and brood year *BY* is computed as:

$$EV_{n,BY} = EV_{n-1,BY} * SC_{BY}$$

Equation H.3

4. Steps 1–3 are repeated iteratively, across all stocks, until the absolute change in the EVs for each stock is less than a predetermined tolerance level (0.05). The tolerance level can be changed if more precise agreement is desired:

$$\left| \frac{EV_{n,BY} - EV_{n-1,BY}}{EV_{n-1}} \right| < 0.05$$

Equation H.4

Several options for the calibration are provided in the OP7 control file. The options include the ability to control the BYs for which the EVs are estimated each iteration, and also the type of convergence criteria. For the 2021 pre-season calibration, EVs were estimated for all BYs each iteration. Convergence was defined at an EV change tolerance level of 0.05.

Stock-specific calibration options are specified in the FCS file:

- Minimum Number of Age Classes: Data for all age classes will not be available when the EVs are estimated for recent, incomplete broods. Since considerable uncertainty may exist in a single data point, application of the calibration algorithm can be restricted to cases in which a specific minimum number of age classes are present.
- Minimum Age: Considerable uncertainty often exists in the estimates of terminal runs or escapements for younger age classes, particularly age 2. The minimum age class to include in the calibration algorithm is specified in the FCS file.
- Estimation of Age Composition: Age-specific estimates of the terminal run or escapement may not be available. An option is provided to estimate the age composition using base period maturation and exploitation rates.

The 2021 calibration was completed in two stages (as it is normally conducted) to facilitate computation of the average exploitation rates and incorporation of the agency forecasts. The Stage 1 calibration provided initial estimates of exploitation rate scalars for fishing years 1979–2019 using updated catch and escapement data through 2020. Average exploitation rate scalars ($\overline{FP}$) were then computed and used as input values for the 2020 and 2021 fisheries in the Stage 2 calibration, except that the forecasts for the WCVI and Fraser Late (FRL) stocks already accounted for changes in the ocean fisheries.

The $\overline{FP}$ for each model fishery was obtained from the Stage 1 calibration using the following formula (subscripts follow those defined in Appendix H3):

$$\overline{FP}_{a,s,CY,f} = \frac{\sum_{CY=CY_{start}}^{CY_{end}} RT_{CY} * FP_{s,a,CY,f}}{(CY_{end} - CY_{start})}$$

Equation H.5

The term RT_{CY} refers to the ratio of the catch quota in the current year to the catch that would be predicted given current abundance, current size limits, and base period exploitation rates. The range of years used to compute the $\overline{FP}$ varied between stocks and was fishery- and age-specific. The input files used in the Stage 2 calibration were identical to those used in Stage 1 with two exceptions: the average exploitation rate scale factors for each fishery were inserted into the $\overline{FP}$ file for the penultimate year, and the Stage 1 EVs were used as starting values for the Stage 2 calibration.

To determine the acceptability of a calibration by the CTC (i.e., whether an annual calibration is deemed final by the CTC), several results are examined.

1. Accuracy of the reconstructed catches in the fisheries (these values will consistently differ from the actual catches if the calibration is not able to exactly recreate the actual catches in the years 1979 through 1984, the model years used prior to implementation of the ceiling algorithm);
2. Accuracy of model-predicted terminal runs or escapements relative to the data used for calibration of each stock;
3. Comparison of model-predicted age structure in terminal runs or escapements with the data used for calibration (consistent biases in age structure are addressed by changing maturation rates); and
4. Comparison of CWT-based and model estimates of fishery harvest rate indices.

Calibration usually involves an iterative process until a judgment is made by the CTC that an acceptable fit to all the data was achieved. This decision usually involves an inspection, discussion, and trial-and-error process. The determination of whether or not further calibrations are necessary is based principally on the significance of deviations from observed or estimated values for stocks and fisheries most relevant to the issues to be evaluated, and on the time constraints established for completion of the calibration.

Changes to model calibration procedures for 2021 are provided in Appendix I.

Key Calibration Outputs

The PSC Chinook Model was originally constructed as a tool to evaluate the effect of fishery management actions on the rebuilding of depressed Chinook salmon stocks. However, since the implementation of the 1999 PST Agreement, the primary purpose of the model has been to enable abundance-based management in the PST through the production of fishery abundance indices. The model generates pre-season projections of AIs for the SEAK, NBC, and WCVI AABM fisheries and post-season estimates of the AIs that enable evaluations of AABM performance (i.e., pre- versus post-season AI and annual catch comparisons). For each AABM fishery (*f*), an AI is computed for the upcoming fishing year (*CY*) as:

$$AI_{f,CY} = \frac{\sum_s \sum_a Cohort_{s,a,CY} ER_{s,a,f}(1-PNV_{a,f})}{\sum_s \sum_a Cohort_{s,a,BP} ER_{s,a,f}(1-PNV_{a,f})} \qquad \text{Equation H.6}$$

where $Cohort_{s,a,CY}$ and $Cohort_{s,a,BP}$ are pre-season (projected) and base period (*BP*, fishing years

1979–1982) abundances of model stock (*s*) by age (*a*), respectively. Thus, the AI is the ratio between the expected catch in the year of interest under base period exploitation patterns and the estimated average catch during the 1979–1982 base period. Given the pre-season AI projections, the ACLs are then set for the NBC and WCVI AABM fisheries according to the terms specified in Appendix C of Annex IV, Chapter 3 of the 2019 PST Agreement. Beginning in 2019, the ACL for the SEAK AABM fishery is based on the SEAK early winter District 113 Troll fishery CPUE metric and determined using Table 2 of Chapter 3 of the 2019 PST Agreement.

Fishery Indices

When the PST was originally signed in 1985, catch ceilings and increases in stock abundance were expected to reduce harvest rates in fisheries. The fishery index (FI) provided a means to assess performance against this expectation. Relative to the base period, an index less than 1.0 represents a decrease from base period harvest rates, whereas an index greater than 1.0 represents an increase. Although the determination of ACLs for AABM fisheries in the 2019 PST Agreement is different from the original PST catch ceilings, these fishery indices continue to provide a useful index of relative change in harvest rates in these fisheries. Fishery indices are used to measure relative changes in fishery harvest rates because it is not possible to directly estimate the fishery harvest rates.

Fishery indices are computed in adult equivalents (AEQs) for both reported catch and total mortality (reported catch plus IM). The total mortality AEQ exploitation rate is estimated as:

$$ER_{s,a,f,CY} = \frac{TotMorts_{s,a,f,CY} * AEQ_{s,BY=CY-a,a,f}}{Cohort_{s,BY=CY-a,a} * (1 - NM_a)} \qquad \textit{Equation H.7}$$

whereas the reported catch AEQ exploitation rate is estimated as

$$ER_{s,a,f,CY} = \frac{\mathrm{Re}\,pMorts_{s,a,f,CY} * AEQ_{s,BY=CY-a,a,f}}{Cohort_{s,BY=CY-a,a} * (1 - NM_a)} \qquad \textit{Equation H.8}$$

and a Ratio of Means (ROM) estimator is used to calculate the FI

$$FI_{f,CY} = \frac{\sum_{s\in\{S\}}\sum_{a\in\{A\}} ER_{s,a,f,CY}}{\left(\dfrac{\sum_{BPYR=79}^{82}\sum_{s\in\{S\}}\sum_{a\in\{A\}} ER_{s,a,f,BPYR}}{4}\right)} \qquad \textit{Equation H.9}$$

For AABM fisheries, fishery indices are presented for troll gear only, although the ACLs also apply to sport and net fisheries in SEAK and sport fisheries in NBC and WCVI. As in past years, CWT recoveries from the troll fisheries are used because these fisheries represent the majority of the catch and have the most reliable CWT sampling. In addition, there are data limitations in the base period for the sport fisheries (e.g., few observed recoveries in NBC due to small fishery size). Because the allocation of the catch among gear types has changed in some fisheries (e.g., the proportion of the catch harvested by the sport fishery has increased in all AABM fisheries), the indices may not represent the harvest impact of all gear types.

The CTC uses fishery indices to reflect changes in fishery impacts relative to the base period (catch years 1979–1982). The ROM estimator of the fishery index confines inclusion of stocks to those with adequate tagging during the base period, but fishing patterns for some fisheries have changed substantially since the base period and some stocks included in the index are no longer tagged (e.g., University of Washington Accelerated). One example of a recent change in the fishing pattern is the SEAK Troll fishery, where the catch during the winter season has increased, the spring fishery has been largely curtailed, and the summer season has become markedly shorter. Because stock distributions are dynamic throughout the year, stock-specific impacts of the SEAK fishery have likely changed over time.

To account for changes in stock composition and to include stocks without base period data, the CTC has created alternative derivations of fishery indices (CTC 1996). The CTC determined that a useful FI should have these characteristics:

1. The index should measure changes in fishery harvest rates if the distribution of stocks is unchanged from the base period.
2. The index should have an expected value of 1.0 for random variation around the base period fishery harvest rate, cohort size, and stock distributions.
3. The index should weight changes in stock distribution by abundance.

After exploring several alternatives, the CTC concluded that the best estimate for a fishery index would consist of the product of a fishery harvest rate index and an index of stock abundance weighted by average distribution (i.e., the proportion of a cohort vulnerable to the fishery). To that effect, a report by the CTC (2009) stated that for all AABM fisheries, the stratified proportional fishery index (SPFI) was the most accurate and precise index for estimating the harvest rate occurring in a fishery. However, the SPFI was never fully implemented for the NBC and WCVI Troll fisheries for reasons described in Section 4.1.

For computation of the SPFI, the CWT harvest rate ($h_{t,CY}$) must initially be set to an arbitrary value between 0 and 1. Then, the stock-age distribution parameter ($d_{t,s,a}$) is calculated (Equation H.10), and the result is substituted into Equation H.11 to recursively recalculate $h_{t,CY}$ and subsequently $d_{t,s,a}$. The largest stock-age distribution parameter in a stratum is then set to 1 to create a unique solution. See Appendix H3 for notation description.

$$d_{t,s,a} = \sum_{CY} r_{t,CY,s,a} \Big/ \sum_{CY} \left(h_{t,CY} * n_{CY,s,a}\right)$$

Equation H.10

$$h_{t,CY} = \sum_{s} \sum_{a} r_{t,CY,s,a} \Big/ \sum_{s} \sum_{a} \left(d_{t,s,a} * n_{CY,s,a}\right)$$

Equation H.11

The resulting unique solution is inserted into the following equations to compute the yearly harvest rates for each stratum (Equation H.14) and the overall fishery (Equation H.15).

$$H_{t,CY} = \left[\left(\frac{\sum_s \sum_a c_{t,CY,s,a}}{\sum_s \sum_a r_{t,CY,s,a}} \right) * \left(C_{t,CY} - A_{t,CY} \right) \right] \Big/ \left[\left(C_{t,CY} - A_{t,CY} \right) / h_{t,CY} \right]$$

Equation H.12

$$H_{.CY} = \sum_t \left[\left(\frac{\sum_s \sum_a c_{t,CY,s,a}}{\sum_s \sum_a r_{t,CY,s,a}} \right) * \left(C_{t,CY} - A_{t,CY} \right) \right] \Big/ \sum_t \left[\left(C_{t,CY} - A_{t,CY} \right) / h_{t,CY} \right]$$

Equation H.13

$$S_{t,CY} = H_{t,CY} \Big/ \sum_{CY=1979}^{1982} H_{t,CY}$$

Equation H.14

$$S_{.CY} = H_{.CY} \Big/ \sum_{CY=1979}^{1982} H_{.CY}$$

Equation H.15

Appendix H3— Parameter descriptions for equations used for the stratified proportional fishery index (SPFI).

Parameter	Description
$A_{t,CY}$	Alaska hatchery origin catch by strata *t*, year *CY*
$c_{t,CY,s,a}$	adult equivalent CWT catch by strata *t*, year *CY*, stock *s* and age *a*
$C_{t,CY}$	catch by strata *t*, year *CY*
$d_{t,s,a}$	distribution parameter by strata *t*, stock *s* and age *a*
$h_{t,CY}$	CWT harvest rate by strata *t*, year *CY*
H_{CY}	harvest rate by year *CY*
$H_{t,CY}$	harvest rate by strata *t*, year *CY*
$n_{CY,s,a}$	CWT cohort size by year *CY*, stock *s* and age *a*
$r_{t,CY,s,a}$	CWT recoveries by strata *t*, year *CY*, stock *s* and age *a*
$S_{.CY}$	SPFI by year *CY*
$S_{t,CY}$	SPFI by strata *t*, year *CY*

Appendix I: Issues with and changes to the PSC Chinook Model calibration

CBC Sport added to CNR file.

- CBC sport added because estimates are better compared to previous years
    - CBC = from recreational lodges.
    - NBC ISBM & NBC AABM = from Ivan.
    - WCVI AABM = from iREC + CREST (creel survey data, used to calibrate iRec; CREST from summer months).
    - WCVI ISBM = iREC (value of 0) + CREST.

1. NBC ISBM Sport data used to be duplicates of NBC AABM Sport data. We have decided to step away from this approach, and input actual NBC ISBM Sport data available.
2. WCVI ISBM Sport data used to be duplicates of WCVI AABM Sport data. Again, we have decided to input actual WCVI ISBM Sport data available.
3. GST Net does not have a fishery model # so we cannot add this one to the .CNR file.
4. CBC Sport was added.
    a. 28,100,2, FISHERY INDEX - CBC SPORT
    b. We chose 100 & 2 because all other sport fisheries had these numbers.

North Troll FPA file. SHU (model stock FSO) had 0 age 4 recoveries in North Troll. Decision made to manually replace FP with 0.005 value.

- AABM troll files can have values that are manually replaced; for SHU no recoveries in North Troll in 2019. When we know there is catch, but no recoveries, need to manually replace FPs otherwise model will generate 0 catch

Impact of QUE ERA auxiliary data on SACE / mat adj rates for 2020 ERA. This was handled properly in 2021, but not in 2020 and consequentially some changes in mat rates.

- 2020 era aux data not loaded correctly, tag codes with leading zeros not loaded. Files used for model calibration didn't include those tag codes. Corrected for final ERA, but not for model calibration in 2020 (Phase II values should be correct). WAS CORRECTED in 2021

Big change in MATAEQ program. Fixing mat rates from broods that contributed to the base period. These fixed rates are from the MATAEQ file used in the final Phase II model calibration that was used to translate Table 1. This ensures better consistency in base period cohort sizes.

Flow of data into MATAEQ process

Calculate adjusted mat rates -> external file -> read into program -> program does its thing
See section 4.4.1 for additional details.