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2023 PSC Chinook Model Calibration

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List of Acronyms and Abbreviations[1]

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
CBC	Central British Columbia
CEI	Ceiling File
CLB	Calibration
CNR	Chinook Non-retention
CPUE	Catch Per Unit Effort
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
ENH	Enhancement File
ERA	Exploitation Rate Analysis
ETS	Exponentially Smoothed
EV	Environmental Variable scalar
FCS	Forecast File
FI	Fishery Index
FNC	First Nations Caucus
FP	Fishery Policy
FSC	Food, Social and Ceremonial
GLM	General linear model
HRI	Harvest Rate Index
IDF&G	Idaho Department of Fish and Game
IDL	Interdam Loss
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
MPE	Mean Percent Error
MRE	Mean Relative Error
NA	Not Available
NBC	Northern British Colombia Dixon Entrance to Kitimat including Haida Gwaii
NOAA	National Oceanic and Atmospheric Administration
NWIFC	Northwest Indian Fisheries Commission
ODFW	Oregon Department of Fish & Wildlife
OR	Oregon
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
STK	Stock Cohort Sizes File
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	Washington
WCVI	West Coast Vancouver Island excluding Area 20
WDFW	Washington Department of Fish and Wildlife

[1] Stock acronyms can be found in Table 1.1 and Appendix A.

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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 (PST 2020). 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 2022 and pre-season AIs through 2023 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 of escapement or terminal run used as inputs to the PSC Chinook Model. The 2019 PST Agreement applies to all analyses and Model calibration results for 2019 through 2028.

Model Calibration Output and Associated Catches

Paragraphs 6(a) and (b) of the 2019 PST Agreement define 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 PSC Chinook 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 of the PST. Beginning in 2019, the pre-season ACL for the SEAK AABM fishery was 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"*. For the current year (2023), the pre-season ACL for the SEAK AABM fishery was calculated based on a new multivariate model adopted by the PSC in February 2023 in conjunction with 17 tiers.

Abundance Indices for 2021–2023 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. For SEAK, the values used to set pre-season annual catch limits (ACLs) are provided in parentheses.

	SEAK		NBC		WCVI	
Year	**Pre-season[1]**	**Post-season**	**Pre-season**	**Post-season**	**Pre-season**	**Post-season**
2021	1.28 (3.85)	1.23	1.27	1.21	0.76	0.73
2022	1.16 (7.02)	1.04	1.17	1.08	0.88	0.99
2023	1.15 (1.42)		1.16		1.02	

[1] For 2021 and 2022 the values in parentheses represent the CPUE statistic, which was used in conjunction with Table 2 of Chapter 3 of the 2019 PST Agreement to determine pre-season ACLs. For 2023, the value provided in parentheses represents the predicted AI derived using the multivariate model adopted by the PSC in February 2023, which was used in conjunction with a 17 tier table (Appendix G3) to determine the pre-season ACL.

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 2021–2023 in the table below.

Pre-season annual catch limits (ACLs) (2021–2023), and post-season ACLs and actual catches (2021–2022) 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[1]	Post-season ACL	Actual Catch	Pre-season ACL	Post-season ACL	Actual Catch	Pre-season ACL	Post-season ACL	Actual Catch
2021	205,165	140,323	202,082	153,800	147,200	90,987	88,000	84,800	75,776
2022	266,585	140,323	238,621	142,800	133,000	83,153	100,700	112,400	95,288
2023	206,027			141,700			115,500		

[1] For 2021 and 2022 the SEAK pre-season ACL was determined using the CPUE statistic in conjunction with Table 2 of Chapter 3 of the 2019 PST Agreement. For 2023, the SEAK pre-season ACL was determined using the predicted AI derived using the multivariate model and 17 tier structure adopted by the PSC in February 2023.

Performance of Aggregate Abundance-Based Management Fisheries

Catch overages and underages in AABM fisheries are tracked relative to pre-season and post-season 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).

Overages and underages in AABM fishery 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 2022, actual landed catch was less than the pre-season ACL by 27,964 fish (10%) in SEAK, 59,647 fish (42%) in NBC, and 5,412 fish (5%) in WCVI due to in-season management; thus, no payback was necessary for the 2023 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 domestic constraints in both WCVI and NBC troll fisheries to protect stocks of concern such as Fraser River Chinook.

In terms of the post-season ACLs for evaluation of the provisions of paragraph 7(b), 2022 actual catches were more than the post-season ACLs by 98,298 fish in SEAK (70%), and less than post-season ACLs by 49,847 (37%) in NBC and 17,112 (15%) in WCVI.

For the SEAK AABM fishery in 2020 and 2021, both the pre-season ACL and the observed catch exceeded the post-season ACL, requiring further action as identified in subparagraphs 7(b)(i) and 7(b)(ii) of the 2019 PST Agreement. As a result, the PSC adopted a new multivariate model that utilizes the PSC Chinook Model pre-season AI (Pre AI), the CPUE from the SEAK early winter power troll fishery in district 113 for stat weeks 41–48 , and the one-year-ahead projected AI from the prior year's PSC Chinook Model calibration (Projection) in conjunction with 17 tiers to generate the 2023 pre-season AI and associated ACL for the SEAK AABM fishery (CTC *In prep*).

For the NBC AABM fishery, the observed catch was 62% and 63% of the post-season ACL in 2021 and 2022 respectively. Since neither of these is greater than 110%, this does not require any further action regarding the NBC AABM fishery per subparagraphs 7(b)(i) and 7(b)(ii).

For the WCVI AABM fishery, the observed catch was 89% and 85% of the post-season ACL in 2021 and 2022, respectively. Since neither of these is greater than 110%, this does not require any further action regarding the WCVI AABM fishery per subparagraphs 7(b)(i) and 7(b)(ii).

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), 2021–2022.

Positive values indicate an overage and negative values indicate an underage. Colored cells indicate AABM fishery performance relative to Treaty obligations for the two most recent years; 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)						
2021	-3,083	-2%	64,842	46%	61,759	44%
2022	-27,964	-10%	126,262	90%	98,298	70%
NBC (Troll, Sport)						
2021	-62,813	-41%	6,600	4%	-56,213	-38%
2022	-59,647	-42%	9,800	7%	-49,847	-37%
WCVI (Troll, Sport)						
2021	-12,224	-14%	3,200	4%	-9,024	-11%
2022	-5,412	-5%	-11,700	-10%	-17,112	-15%

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 (PST 2020). 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 (CLB) process and results, including post-season abundance indices (AIs) through 2022 and pre-season AIs through 2023 used for coastwide management of Chinook stocks. Management includes both aggregate abundance-based management (AABM) fisheries and individual stock-based management (ISBM) fisheries. The PSC Chinook Model is assessed and adjusted (i.e., 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. Also included is an evaluation of AABM fishery performances as they relate to the terms of the 2019 PST Agreement (Section 3), PSC Chinook Model validation, evaluations of model error, and a summary of model improvements (Section 4). The Parties rely upon the PSC Chinook Model to generate annual indices of abundance for AABM fisheries, and to produce estimates of calendar year exploitation rates (CYER) in ISBM fisheries (Figure 1.1).

The pre-season AIs determine the annual catch limits (ACLs) for two of the three 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 was determined by the SEAK early winter District 113 troll fishery catch per unit effort (CPUE) metric in conjunction with Table 2 of Chapter 3 of the 2019 PST Agreement, which has seven tiers. These pre-season ACLs drive pre-season and in-season management of AABM fisheries and are used to evaluate fishery performance including management error. In addition to generating pre-season AIs, the PSC Chinook 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 post-season fishery limits from which model error can be evaluated.

The results of the pre-season model calibration for 2023 are based on the CTC's annual exploitation rate analysis (ERA) using coded-wire tag (CWT) data through catch year 2022 (2021 for southern U.S. stocks) along with coastwide data on catch, spawning escapements, and age structure through 2022; the pre-season model then forecasts Chinook salmon returns expected in 2023. This report includes: (1) estimated post-season AIs for 1979 through 2022 and the pre-season AIs for 2023 for the AABM fisheries; (2) estimated stock composition for 1979–2022 and a projection for 2023 for the AABM and other fisheries; (3) estimated fishery indices (harvest rates) for the AABM fisheries; (4) an evaluation of AABM fishery performance relative to the 2019 PST Agreement; and (5) a validation of the PSC Chinook Model and summary of model improvement activities.

More detailed results associated with the four sections of this report are included in eight appendices. 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 F present additional output from the PSC Chinook 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, 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 a tabular summary of forecast error for PSC Chinook Model stocks. Calibration methodology is detailed in Appendix G. Issues with, and changes to PSC Chinook Model calibration, as well as their resolution, are detailed in Appendix H.

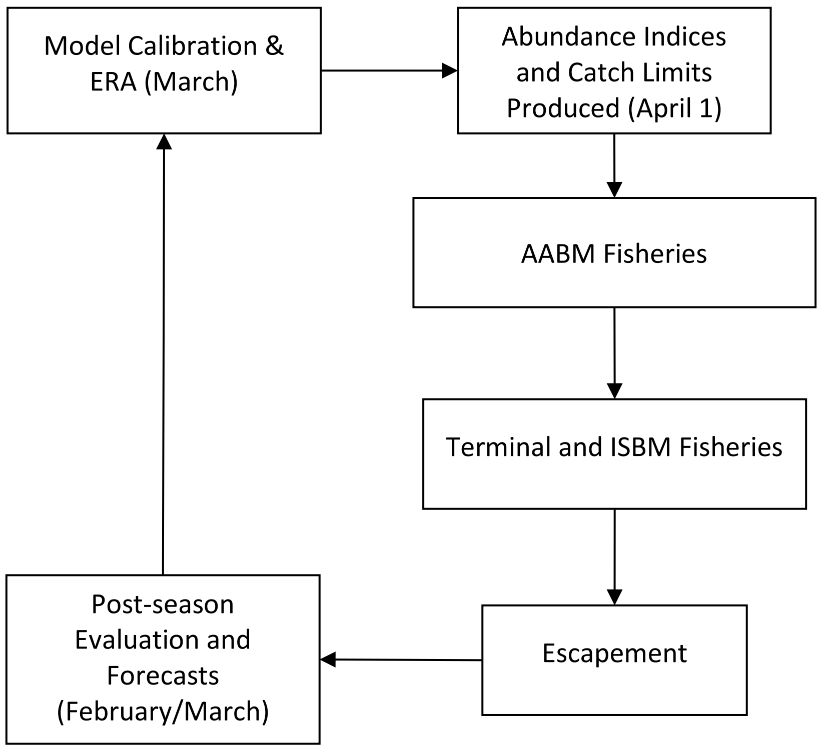

Figure 1.1.—Pacific Salmon Treaty (PST) Chinook management and fishery process.

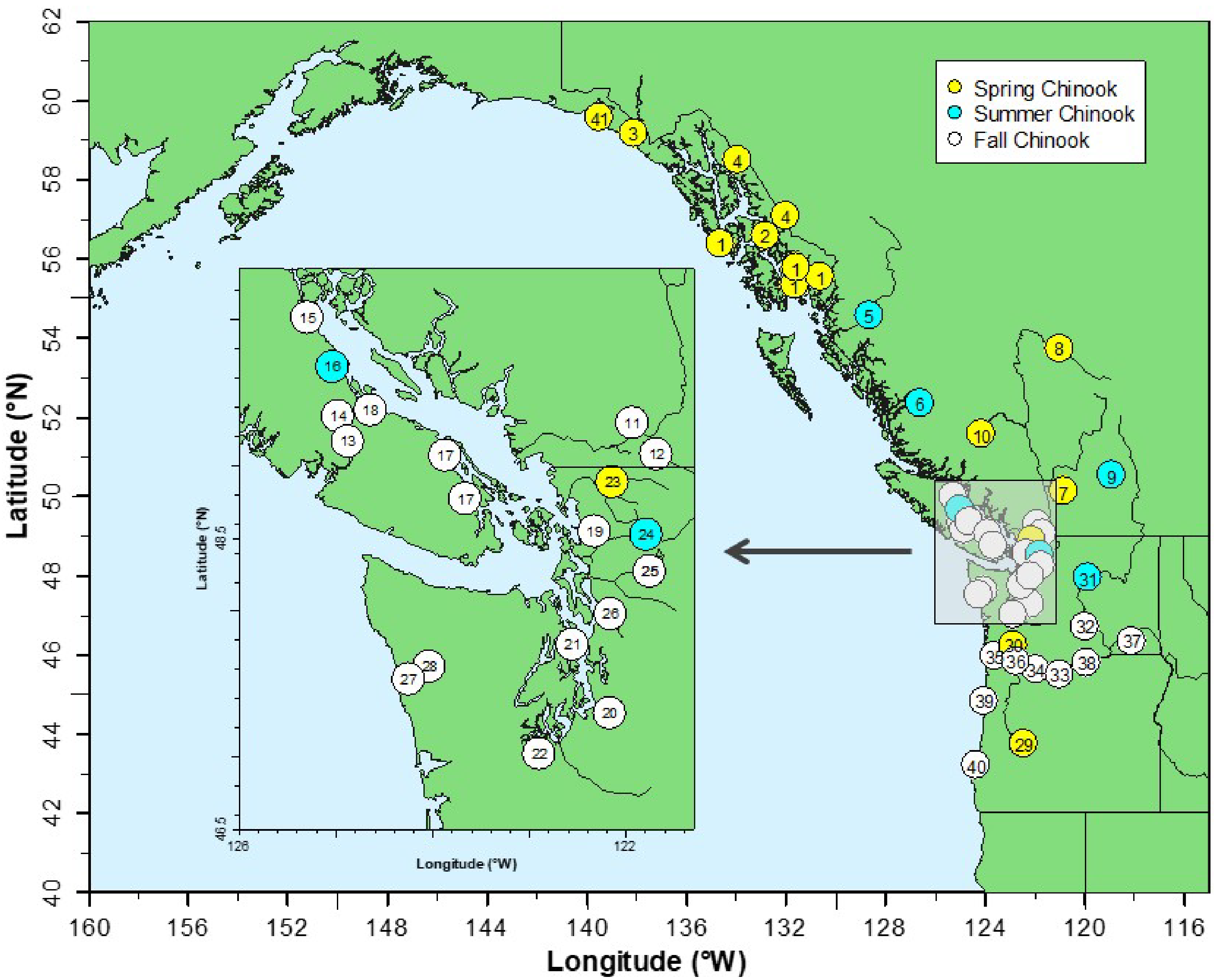

Figure 1.2.—Geographical locations of Phase II Pacific Salmon Commission Chinook Model stock groups.

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 Pacific Salmon Commission Chinook Model, associated coded-wire tag (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 AIs and post-season AIs for the previous year for the three AABM fisheries. The time series of pre-fishery abundances vulnerable to AABM fisheries produced by the PSC Chinook Model are the basis for the computation of AIs. AIs are a relative measure of abundance calculated as the ratio of AABM pre-fishery abundance in a given year and the average abundances during the 1979–1982 base period. Pre-season AIs are used to determine the ACLs of Treaty Chinook salmon in the NBC and WCVI AABM fisheries for 2023. The 2023 pre-season ACL for the SEAK AABM fishery is determined from a multi-variate model that incorporates the SEAK early winter District 113 Troll fishery CPUE metric, the pre-season AI, and the projection AI in combination with 17 tiers (see Appendix G for a more in-depth description). Post-season AIs are used to determine the previous season's (2022) post-season ACLs for all three AABM fisheries and to evaluate PSC Chinook Model performance. For additional calibration details, including key input data, procedures, and output data, see Appendix G. For details on improvements to the PSC Chinook Model, see Section 4.

2.1 OVERVIEW OF 2023 CALIBRATION PROCESS

The CTC Analytical Work Group (AWG) met in March 2023 to perform the PSC Chinook Model calibration. Unlike the previous three years, the AWG met in-person and preliminary calibrations were available by the end of the meeting week. The following week, the AWG agreed to endorse calibration CLB 2304 which was subsequently accepted by the full CTC in late March. The CTC produced its annual memo to the PSC detailing the 2022 post-season AIs and the 2023 pre-season AIs and ACLs for the AABM fisheries based on CLB 2304 and the SEAK AABM multivariate model by April 1 as required by the 2019 PST Agreement (see details in Appendix G). PSC Chinook Model calibrations are named with the last two digits of the year (23) and the iteration of the calibration (04).

2.2 AABM ABUNDANCE INDICES

The AABM fishery management regime relies on data for catches and incidental mortality, fishing effort, fishery impacts (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).

Since 1999, the PST has specified that AABM fisheries are to be managed using pre-season AIs, where a fishery's AI corresponds to a specific ACL for each AABM fishery (Table 1 of Chapter 3 of the 2019 PST Agreement [PST 2020]). The 2019 PST Agreement continued the use of pre-season AIs for NBC and WCVI AABM fisheries but established a CPUE metric to set ACLs for the SEAK AABM fishery. Pre-season AIs are listed in Table 2.1 since 1999 along with the SEAK CPUE metric since 2019. In 2023, a new multivariate method for forecasting the post-season AI and a new 17-tier table for setting the SEAK AABM fishery pre-season ACL was adopted by the Commission on a trial basis.

Post-season AIs are a better index of abundance for the AABM fisheries than are the pre-season AIs because they contain additional observed return data and are less reliant on forecasts. Thus, the Treaty also establishes post-season fishery limits (*a posteriori* limits to which the already prosecuted fishery is held accountable) based on the first post-season AI that is calculated each year, although as further catches from these cohorts are observed in subsequent years the AI estimates become even more accurate. Post-season AIs for 1999–2022 are listed in 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. Similarly, in response to coastwide concerns over Chinook productivity and an emerging concern over the viability of the Southern Resident Killer Whale population which has a diet mostly reliant on Chinook salmon (Ford et al. 1998, Hanson et al. 2010, Hanson et al. 2021), 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 additional 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 (AIs) for 1999–2023 for the Southeast Alaska (SEAK), Northern British Columbia (NBC), and West Coast Vancouver Island (WCVI) aggregate abundance-based management (AABM) fisheries. Post-season values reported for each year are from the first post-season calibration following the fishing year. For SEAK the values used to set the pre-season ACLs are in parentheses.

	SEAK		NBC		WCVI	
Year	**Pre-season[5]**	**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)	1.04	0.96	0.94	0.61	0.58
2020[4]	1.13 (4.83)	1.11	1.08	1.16	0.75	0.67
2021	1.28 (3.85)	1.23	1.27	1.21	0.76	0.73
2022	1.16 (7.02)	1.04	1.17	1.08	0.88	0.99
2023	1.15 (1.42)		1.16		1.02	

[1] Due to changes in calibration procedures (reviewed in section Appendix G), 2012 post-season (Calibration [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 1601 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] For 2019-2022 the SEAK pre-season ACL was determined using the CPUE statistic in conjunction with Table 2 of Chapter 3 of the 2019 PST Agreement. For 2023, the SEAK pre-season ACL was determined using the predicted AI derived using the multivariate model and 17 tier structure adopted by the PSC in February 2023.

2.3 Stock composition of abundances available in AABM fisheries, 1979–2022

Most catches in each AABM fishery are comprised of the small subset of geographically similar stocks or stock aggregates listed in Appendix A. Figure 2.1–Figure 2.3 show the post-season AIs (resulting from CLB 2304) 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.

For additional stock composition information, see Appendix B which partitions catches by the 41 PSC Chinook Model stock stratification. For the percent stock composition of AIs partitioned by the 41 PSC Chinook Model stock stratification, please see the PSC website in the CTC Technical Reports section.

For additional fishery information, see Appendix C for model-generated stock composition estimates for all fisheries (AABM and ISBM).

Table 2.2.—Stock groupings comprising aggregate abundance-based management (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, North and Central British Columbia and Washington Coast (Figure 2.1). Since 1999, the average contribution to the SEAK AIs for these stock groups has been 47%, 25%, 15%, 12%, 11% and 11% respectively.

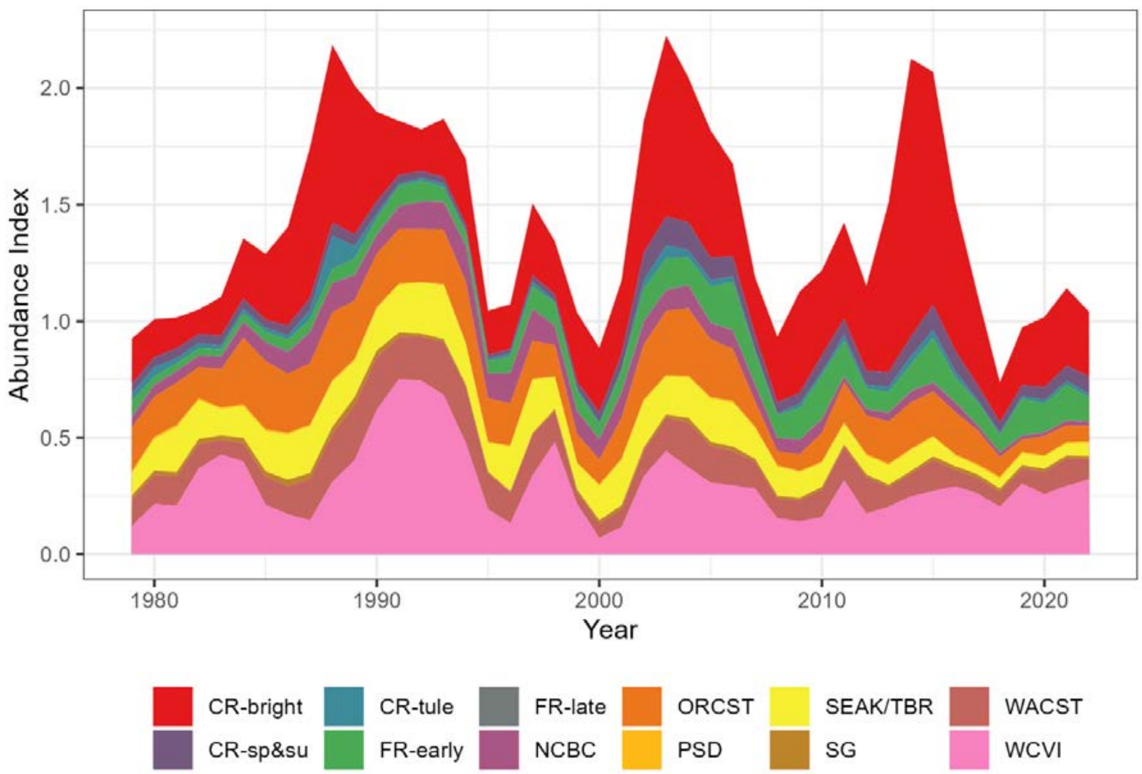

Figure 2.1.—Stock composition of the annual abundance indices for the Southeast Alaska (SEAK) Troll fishery from Calibration (CLB) 2304.

The major stock groups contributing to the NBC AIs are Columbia River Brights, Oregon Coast, Fraser Early, Columbia Spring/Summer, Washington Coast and WCVI (Figure 2.2). Since 1999, the average contribution to the NBC AIs for these stock groups has been 31%, 30%, 19%, 15%, 15% and 15% respectively.

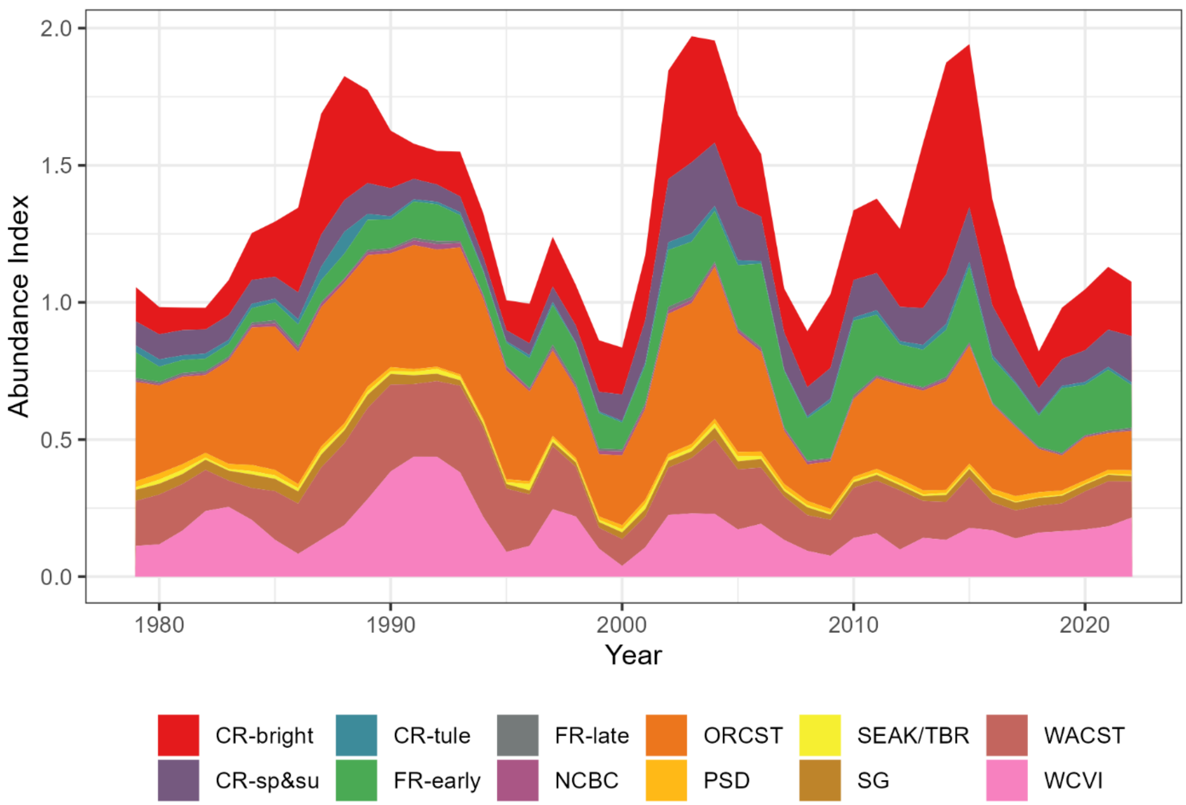

Figure 2.2.—Stock composition of the abundance indices for the Northern British Columbia (NBC) Troll fishery from Calibration (CLB) 2304.

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 21%, 20%, 17%, 8% and 7% respectively.

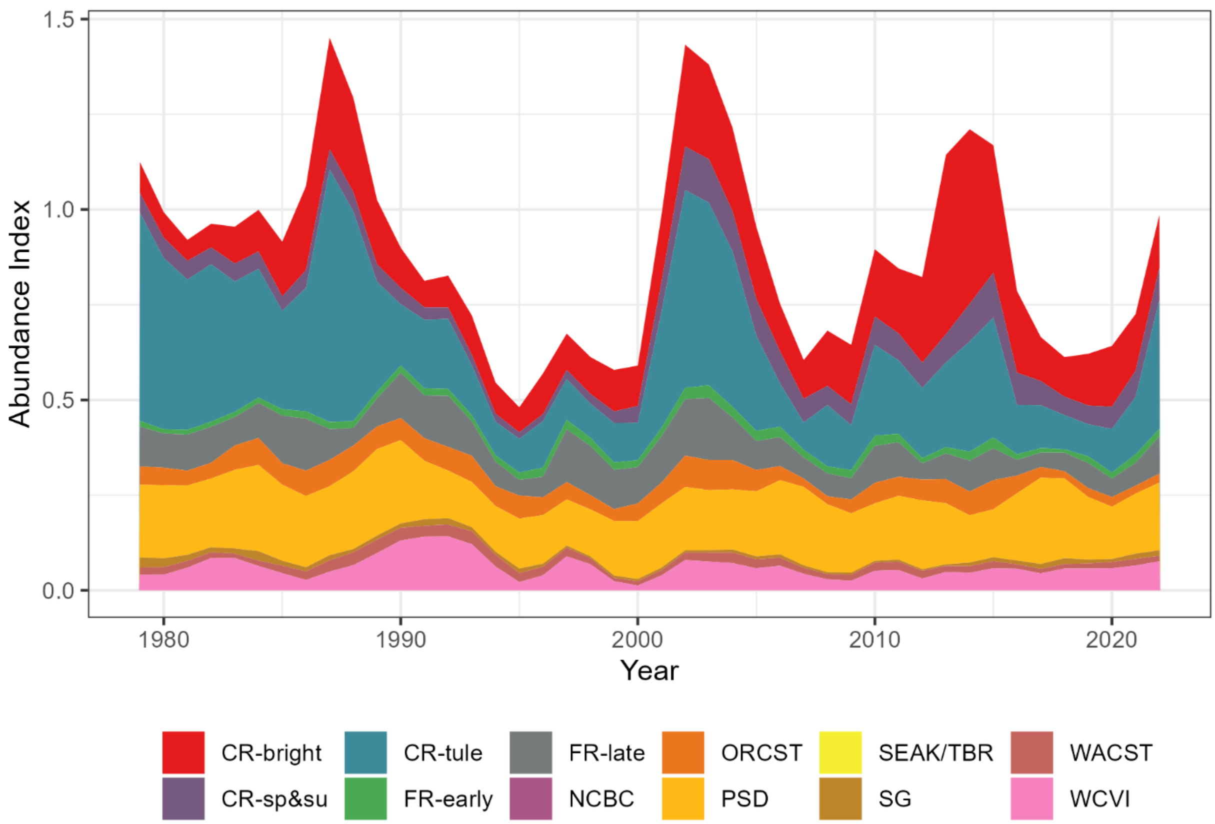

Figure 2.3.—Stock composition of the abundance indices for the West Coast Vancouver Island (WCVI) Troll fishery from Calibration (CLB) 2304.

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 for Chinook salmon: (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 annually evaluating AABM fishery performance relative to the obligations set forth in paragraphs 6 and 7 (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, ACLs for each of the three fisheries were determined from Table 1 in Chapter 3 of the 1999 and 2009 PST Agreements (PST 2000, 2010). In the 2009 and 2019 PST Agreements, the relationships between the 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 to reflect these changes. Furthermore, the 2019 PST Agreement introduced a new process for determining SEAK ACLs: 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 of the 2019 PST Agreement. The post-season tier level for SEAK was determined using Table 2 and the SEAK AI from the post-season calibration of the PSC Chinook Model. On February 16, 2023, the PSC agreed to suspend the use of the CPUE method to set pre-season catch limits for the SEAK AABM fishery and adopted a new multivariate model for setting SEAK AABM catch limits in conjunction with a new 17 tier structure for the 2023 fishing season (Appendix G). The post-season tier level for the SEAK AABM fishery is determined using this new 17 tier structure and the SEAK AI from the post-season calibration of the PSC Chinook Model. For further details on the multivariate model, please refer to Appendix G.

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 (Table 3.2): 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 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*. Composite error is calculated using the difference between the actual catch and the post-season ACL, or more simply adding model and management error together. Composite error is generally greatest when management error and model error are in the same direction. Low composite error 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 on composite error is evaluated by inspecting model or management error over the total composite error.

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 will conduct "*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.

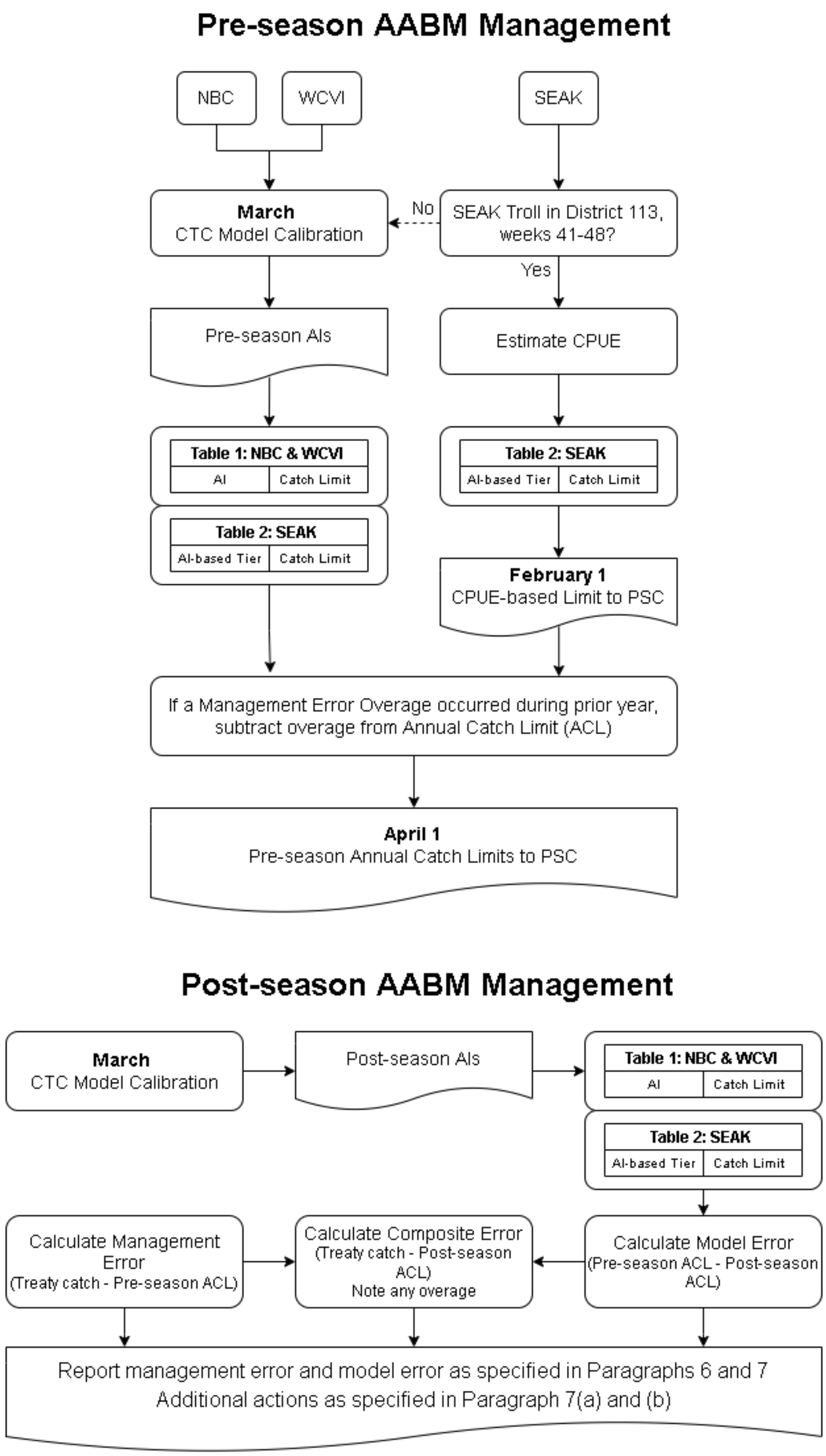

Figure 3.1.—Flow diagrams depicting the sequence of steps for pre-season (top) and post-season (bottom) aggregate abundance-based management (AABM) fisheries management framework under the 2019 Pacific Salmon Treaty (PST) Agreement.

3.2 ACTUAL CATCHES VS PRE-SEASON AND POST-SEASON ANNUAL CATCH LIMITS

In 2022, the actual landed 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 27,964 fish in SEAK, 59,647 fish in NBC, and 5,412 fish in WCVI. In terms of the post-season ACLs for evaluation of the provisions of the PST (paragraph 6(g)), 2022 actual catches were greater than the post-season ACL by 98,298 fish in SEAK, and less than the post-season ACL by 49,847 fish in NBC and 17,112 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). Zero or negative values for management and model error indicate that there were fewer fish caught than the modelled catch limits (pre- and post-season). Any errors that are positive indicate an "overage". For AABM fisheries in 2022, management error (the difference between actual catch and pre-season ACL, actual catch – pre-season ACL) was negative with catches in all three fisheries below the ACL. Percent differences of actual catch from the pre-season ACL ([actual catch – pre-season ACL]/pre-season ACL) were -10% in SEAK, -42% in NBC, and -5% in WCVI. The management error in NBC and WCVI was a result of precautionary opening time restrictions that were applied in WCVI and NBC fisheries to protect at-risk Fraser Chinook stocks and to provide increased availability of not-at-risk Chinook salmon for First Nations harvest opportunities.

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, pre-season ACL – post-season ACL) ranged from -11,700 in WCVI to 126,262 in SEAK, with the post-season ACL lower for SEAK and NBC AABM fisheries and higher for the WCVI AABM fishery. Percent differences of the pre-season ACL from the post-season ACL ([pre-season ACL – post-season ACL]/post-season ACL) were 90% in SEAK, 7% in NBC, and -10% in WCVI. Composite error (the difference between actual catch and post-season ACL, actual catch – post-season ACL) ranged from -49,847 in NBC to 98,298 in SEAK. Percent differences of actual catch from the post-season ACL ([actual catch – post-season ACL]/post-season ACL) were 70% in SEAK, -37% in NBC, and -15% in WCVI. In 2022, 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 were 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.

Table 3.1.—Pre-season annual catch limits (ACLs) for 1999–2023, and post-season ACLs and actual catches for 1999–2022, for aggregate abundance-based management (AABM) fisheries: Southeast Alaska (SEAK), Northern British Columbia (NBC), and West Coast of Vancouver Island (WCVI). 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[1]	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
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[2]	439,400	378,600	435,195	290,300	262,600	216,901	205,400	191,700	192,705
2015[2]	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	140,323	140,307	124,800	122,200	88,026	79,900	76,000	73,482
2020[4]	205,165	140,323	204,624	133,000	141,700	36,183	87,000	78,500	43,581
2021	205,165	140,323	202,082	153,800	147,200	90,987	88,000	84,800	75,776
2022	266,585	140,323	238,621	142,800	133,000	83,153	100,700	112,400	95,288
2023	206,027			141,700			115,500		

[1] For 2019-2022 the SEAK pre-season ACL was determined using the CPUE statistic in conjunction with Table 2 of Chapter 3 of the 2019 PST Agreement. For 2023, the SEAK pre-season ACL was determined using the predicted AI derived using the multivariate model and 17 tier structure adopted by the PSC in February 2023.

[2] Due to a disagreement over model calibration 1503, the Commission agreed to use output from Calibration (CLB) 1601 to estimate the catches associated with the 2014 and 2015 post-season abundance indices (AIs) and 2016 pre-season AIs.

[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), 2019–2022.

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%
2021	-3,083	-2%	64,842	46%	61,759	44%
2022	-27,964	-10%	126,262	90%	98,298	70%
NBC (Troll, Sport)						
2019	-36,774	-29%	2,600	2%	-34,174	-28%
2020	-96,817	-73%	-8,700	-6%	-105,597	-75%
2021	-62,813	-41%	6,600	4%	-56,213	-38%
2022	-59,647	-42%	9,800	7%	-49,847	-37%
WCVI (Troll, Sport)						
2019	-6,418	-8%	3,900	5%	-2,518	-3%
2020	-43,419	-50%	8,500	11%	-34,919	-44%
2021	-12,224	-14%	3,200	4%	-9,024	-11%
2022	-5,412	-5%	-11,700	-10%	-17,112	-15%

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%. Average management error was 1% in the 1999–2008 time period and 2% across the 2009–2018 time period (Figure 3.2). The increase 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 (composite error) 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 2022, management error was -10% and model error was 90% (Table 3.2). Management error in 2022 was largely driven by high fuel prices and abundant chum salmon nearshore.

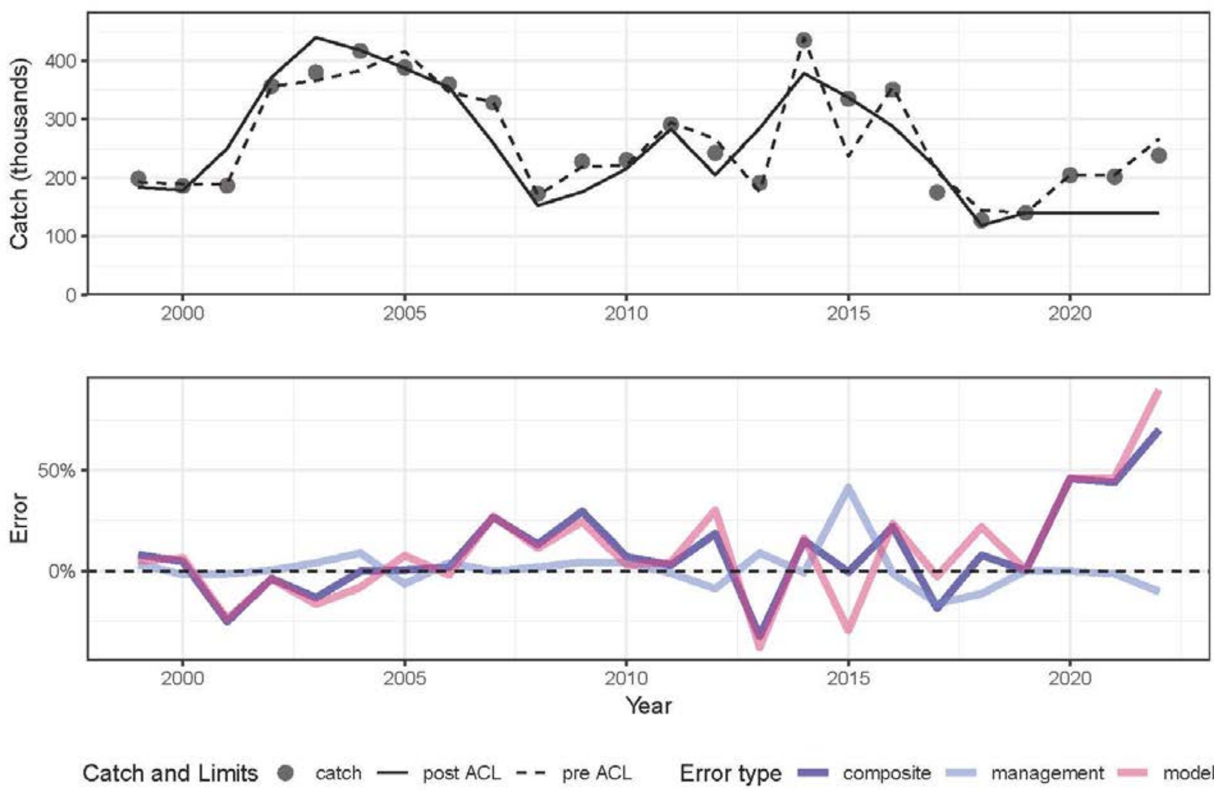

Figure 3.2.— Performance of the Southeast Alaska aggregate abundance-based management (AABM) fishery from 1999–2022. The top panel compares pre- and post-season annual catch limits (ACLs) with the actual catch over time. Circles indicate actual catch while dashed lines indicate pre-season ACLs and solid lines indicate post-season ACLs. The bottom panel compares composite, management and model errors over time. The pink line indicates model error, the blue line indicates management error and the purple line indicates composite error.

3.2.2 Northern British Columbia Aggregate Abundance-Based Management Fishery

NBC actual catch was consistently below the pre-season ACL by an average of -22% from 1999–2018 (range -1% to -75%; Figure 3.3). The average NBC catch was -26% of the pre-season ACLs from 1999–2008 and -19% from 2009–2018. Negative management errors in NBC were the result of Canada's domestic efforts to protect at-risk Fraser River stream-type Chinook, to allow passage of Fraser River not-at-risk Chinook for First Nations food, social and ceremonial (FSC) purposes, and to limit exploitation of WCVI-origin Chinook. Management error in the NBC fishery was near zero from 2003 to 2006 and in 2015 and 2017; but catches were below the post-season ACL in all other years except 2005 to 2007 and 2016 (Figure 3.3). Management actions in NBC cancelled out any positive model errors in most years to an average of 0% (1999–2018), which has widened in recent years to an average composite error of -47% (2019–2021) between the observed catch and the post-season ACL. In 2022, model error was 7% and conservative management actions resulted in an actual catch 42% (management error) and 37% (composite error) below the pre- and post-season ACLs, respectively (Table 3.2).

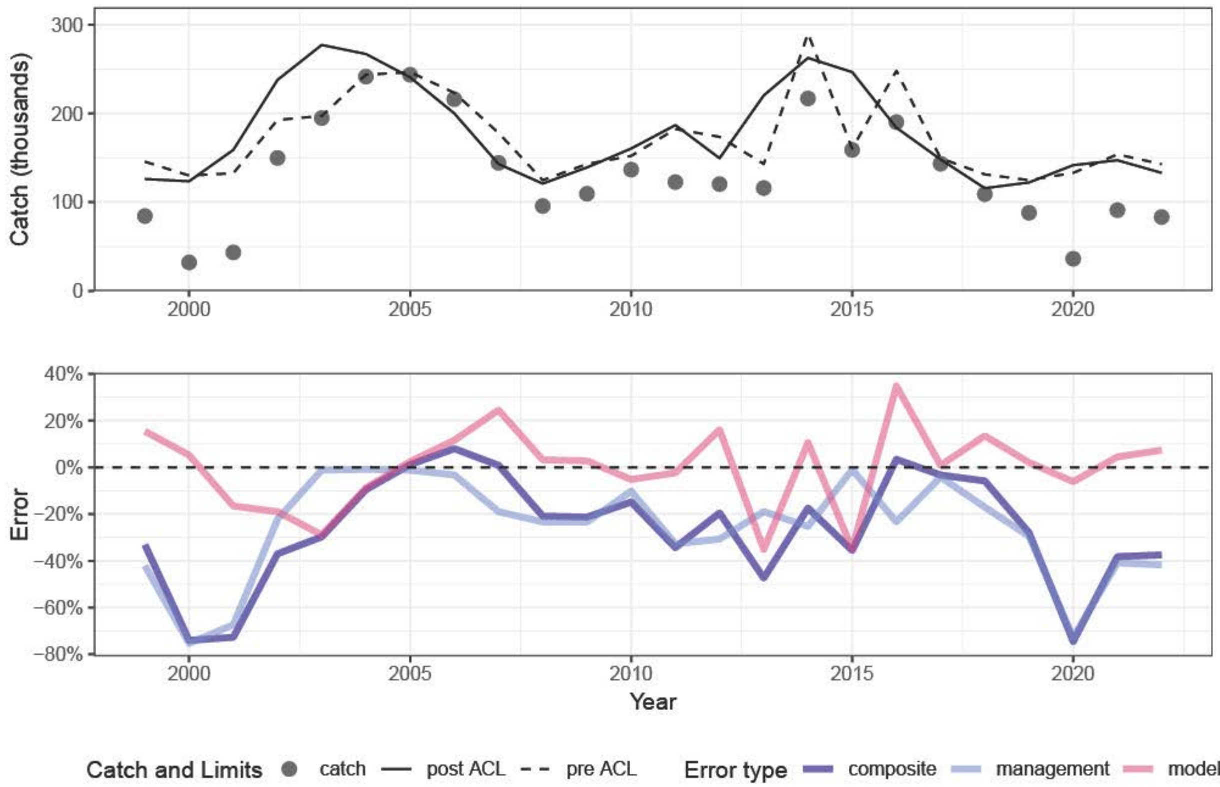

Figure 3.3.— Performance of the Northern British Columbia aggregate abundance-based management (AABM) fishery from 1999–2022. The top panel compares pre- and post-season annual catch limits (ACLs) with the actual catch over time. Circles indicate actual catch while dashed lines indicate pre-season ACLs and solid lines indicate post-season ACLs. The bottom panel compares composite, management and model errors over time. The pink line indicates model error, the blue line indicates management error and the purple line indicates composite error.

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). The deviations of actual catch from the post-season ACL in WCVI (composite error) ranged from -64% to 52% across the 1999–2018 time period. 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 2022, management error was -5% and model error was -10%.

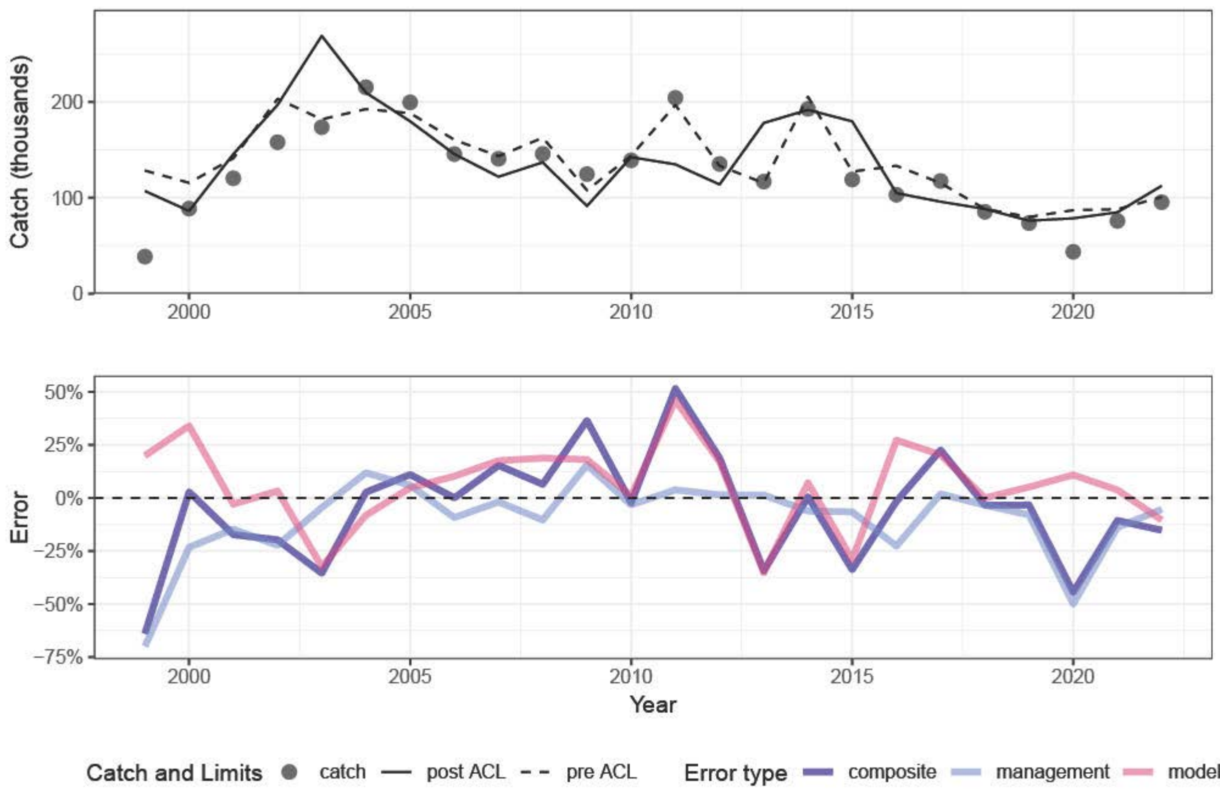

Figure 3.4.— Performance of the West Coast Vancouver Island aggregate abundance-based management (AABM) fishery from 1999–2022. The top panel compares pre- and post-season annual catch limits (ACLs) with the actual catch over time. Circles indicate actual catch while dashed lines indicate pre-season ACLs and solid lines indicate post-season ACLs. The bottom panel compares composite, management and model errors over time. The pink line indicates model error, the blue line indicates management error and the purple line indicates composite error.

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 2022, none of the three AABM fisheries had catches that 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 2021 and 2022, the pre-season limit exceeded the post-season limit in five of six cases, with SEAK having the largest of the exceedances in both 2021 and 2022 (46% and 90%; Table 3.3), the magnitude of which is largely a function of the CPUE-based method used for determination of pre-season ACLs and the tiered approach in Table 2 of Chapter 3 of the 2019 PST Agreement. Model error is described in detail in section 4.3 of this report.

Table 3.3.—Model error (calculated as (pre-season annual catch limit [ACL] – post-season ACL) / post-season ACL) for the past two years for aggregate abundance-based management (AABM) fisheries: Southeast Alaska (SEAK), Northern British Columbia (NBC), and West Coast Vancouver Island (WCVI).

Fishery	2021	2022
SEAK	46%	90%
NBC	4%	7%
WCVI	4%	-10%

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%*." In order to not exceed the post-season limits by more than 10% for NBC and WCVI AABM fisheries, the observed catch cannot be greater than 110% of the post-season ACL.

For the SEAK AABM fishery in 2021 and in 2022, both the pre-season ACL and the observed catch exceeded the post-season ACL. Thus, in the SEAK AABM fishery there is a second instance (the first occurrence was for 2020–2021) of two consecutive years where the pre-season ACL and the observed catch exceeded the post-season ACL (Table 3.3). Per the provisions of the 2019 PST Agreement this requires further action, as identified in subparagraphs 7(b)(i) and 7(b)(ii).

In response to triggering paragraph 7(b) in 2022 due to exceedances in the 2020 and 2021 fishing years, the PSC agreed on February 16, 2023 to suspend implementation of the CPUE method used to set pre-season ACLs for the SEAK AABM fishery. As an alternative, after considering recommendations from both the Alaska Department of Fish and Game (per subparagraph 7(b)(i)) and the CTC (per subparagraph 7(b)(ii)), the PSC adopted a new multivariate model in conjunction with a new 17-tier structure for setting the 2023 pre-season ACL for the SEAK AABM fishery (CTC *In prep*). Given this, and the uncertainty in methods moving forward, it is currently unclear whether further action is required from the management entity or the CTC per subparagraphs 7(b)(i) and 7(b)(ii), respectively, in response to the second instance of triggering paragraph 7(b) based on exceedances in the 2021 and 2022 fishing years.

For the NBC AABM fishery, the observed catch was 62% and 63% of the post-season ACL in 2021 and 2022, respectively. Since neither of these is greater than 110% this does not require any further action regarding the NBC AABM fishery per subparagraphs 7(b)(i) and 7(b)(ii).

For the WCVI AABM fishery, the observed catch was 89% and 85% of the post-season ACL in 2021 and 2022, respectively. Since neither of these is greater than 110%, this does not require any further action regarding the WCVI AABM fishery per subparagraphs 7(b)(i) and 7(b)(ii).

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: Southeast Alaska (SEAK), Northern British Columbia (NBC), and West Coast Vancouver Island (WCVI).

Fishery	2021	2022
SEAK	44%	70%
NBC	-38%	-37%
WCVI	-11%	-15%

4. PSC Chinook Model Validation and Improvement

The reliability of model outputs, including abundance index predictions, are dependent on many factors including model parameters (e.g., base period exploitation rates), model structure (e.g., spatio-temporal fishery strata), and annual CWT, catch, and run-size inputs (forecast or post-season estimates) used for calibration. In the following sections, annual comparisons of model-based fishery indices (FI) versus CWT-based FIs, pre-season (forecast) versus post-season run size estimates, and pre-season versus post-season calibration AIs are presented.

4.1 Evaluation of Fishery Indices

FIs based on the PSC Chinook Model for all model stocks can be compared to FIs based on the estimates of landed catch or total mortality of CWT exploitation rate indicator stocks (Appendix G). Model- and CWT-based FIs use the same equation (see Appendix G); however, CWT estimates are more empirical. 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.

CWT-based FIs 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. 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 stratified FIs for these two AABM fisheries problematic. Therefore, in 2019, the CTC decided that ROMs were more appropriate FIs for the WCVI and NBC troll fisheries (CTC 2023). Comparisons between the SPFI (SEAK) or the CWT-based ROM FIs (NBC and WCVI), and the model-based FIs are provided in this section.

4.1.1 Southeast Alaska Troll Fishery Exploitation Rate Indices

The SEAK Troll FI based on PSC Chinook Model estimates closely follows the trend of the CWT-based SPFI from 1979 through 1989 whether calculated using landed catch or total mortality (Figure 4.1 and Figure 4.2). Between 1990 and 2000, the model-based estimates using either the landed catch or total mortality FIs were lower than the CWT-based estimates for most years. However, since 2001, the model estimates have typically been higher. Since 1990, the model-based estimates show less year-to-year variability than the CWT-based indices. The CWT-based 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.

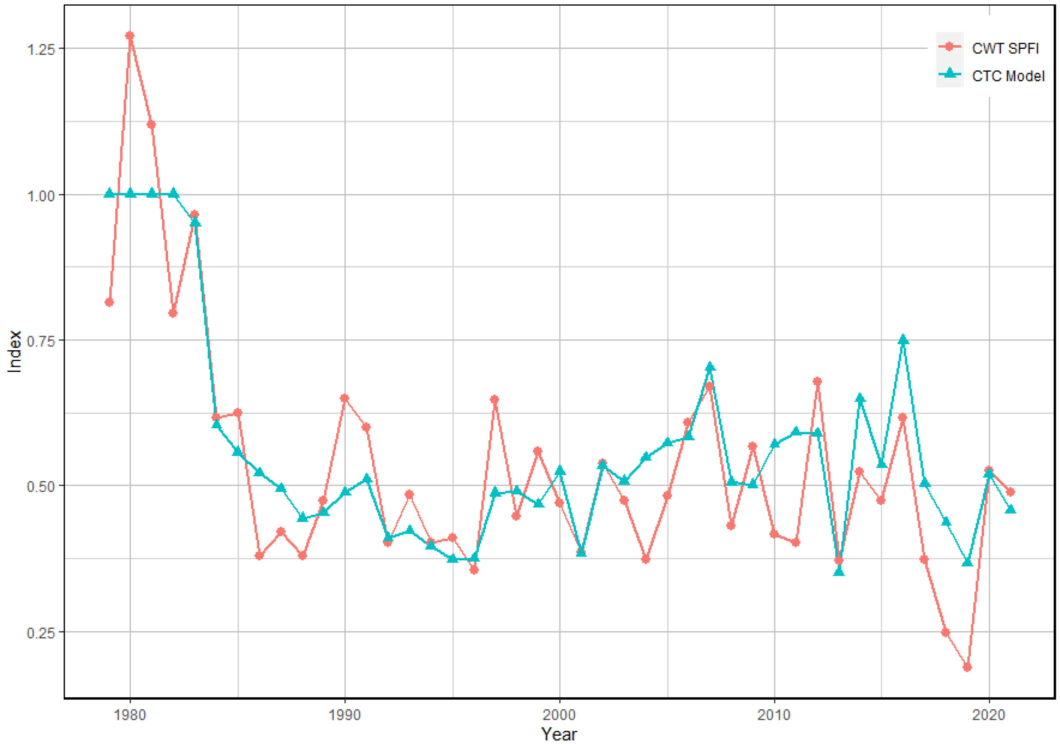

Figure 4.1.—Estimated coded-wire tag (CWT)-based stratified proportional fishery index (SPFI) and Pacific Salmon Commission Chinook Model-based fishery indices for landed catch in the Southeast Alaska (SEAK) troll fishery through 2021.

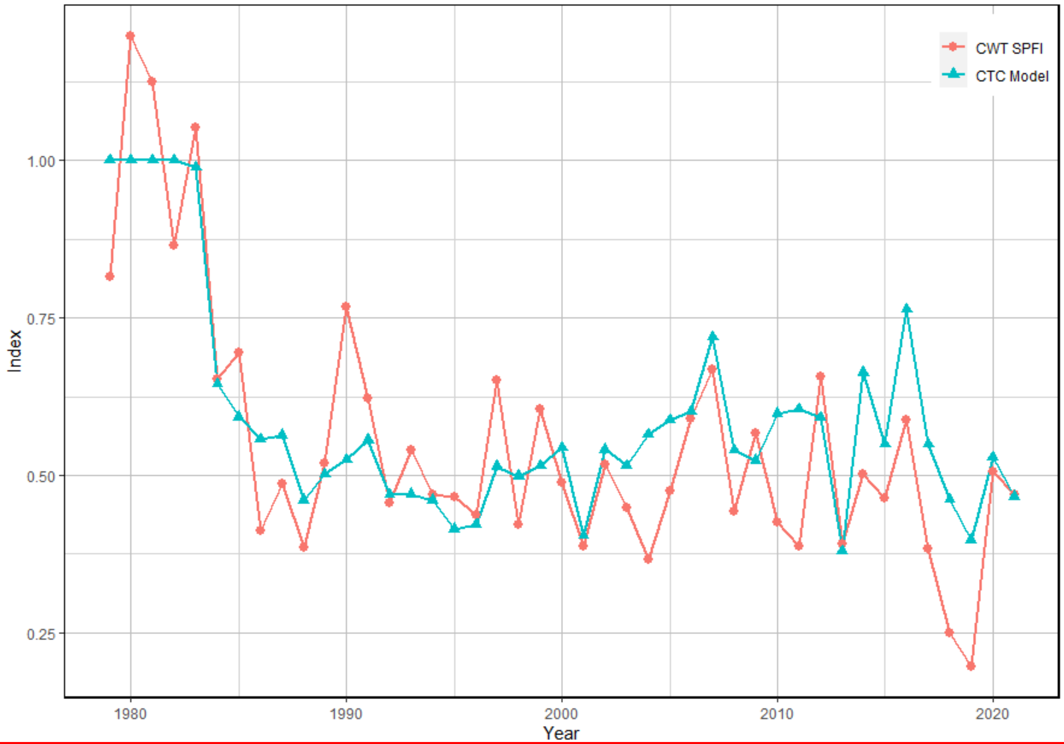

Figure 4.2.—Estimated coded-wire tag (CWT)-based stratified proportional fishery index (SPFI) and Pacific Salmon Commission Chinook Model-based fishery indices for total mortality in the Southeast Alaska (SEAK) troll fishery through 2021.

4.1.2 Northern British Columbia Troll Fishery Indices

The model-based FIs for NBC troll fishery generally follow the same trend as the CWT-based ROM FIs (Figure 4.3 and Figure 4.4). In 2018, the CWT-based FI was much higher than the model-based FI for both landed catch and total mortality. Since 2019, the differences between the indices were smaller, though the CWT-based FI was still slightly higher in all years.

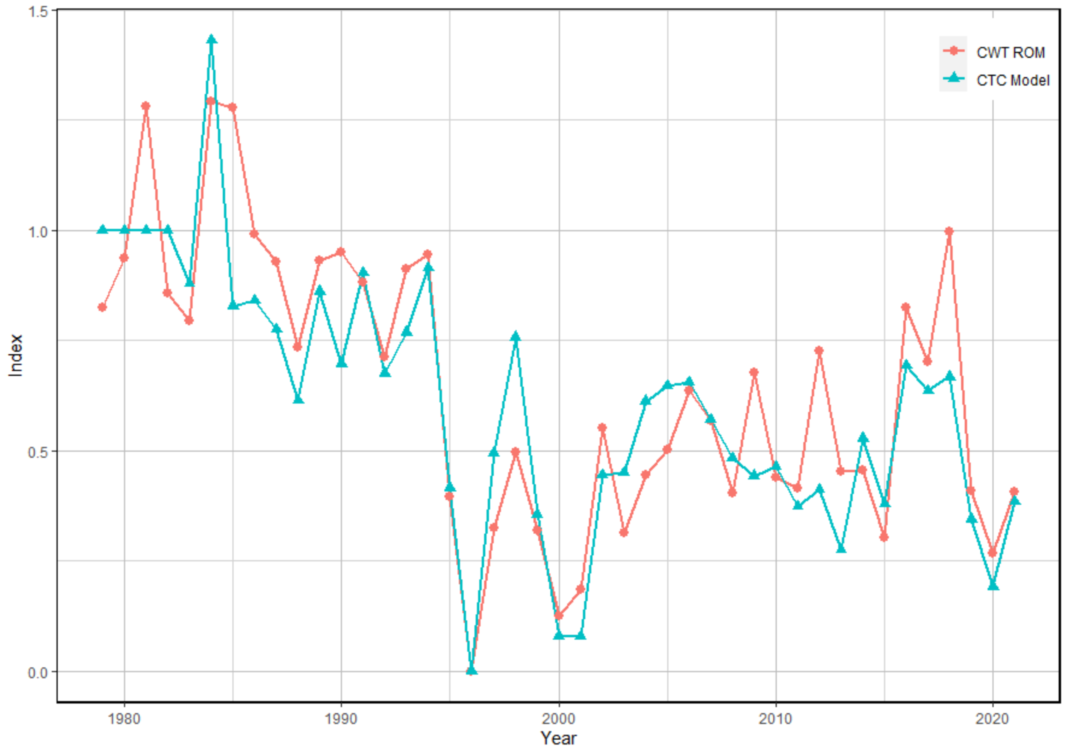

Figure 4.3.—Estimated coded-wire tag (CWT) ratio of means (ROM) and Pacific Salmon Commission Chinook Model fishery indices for landed catch in the Northern B.C. (NBC) troll fishery through 2021.

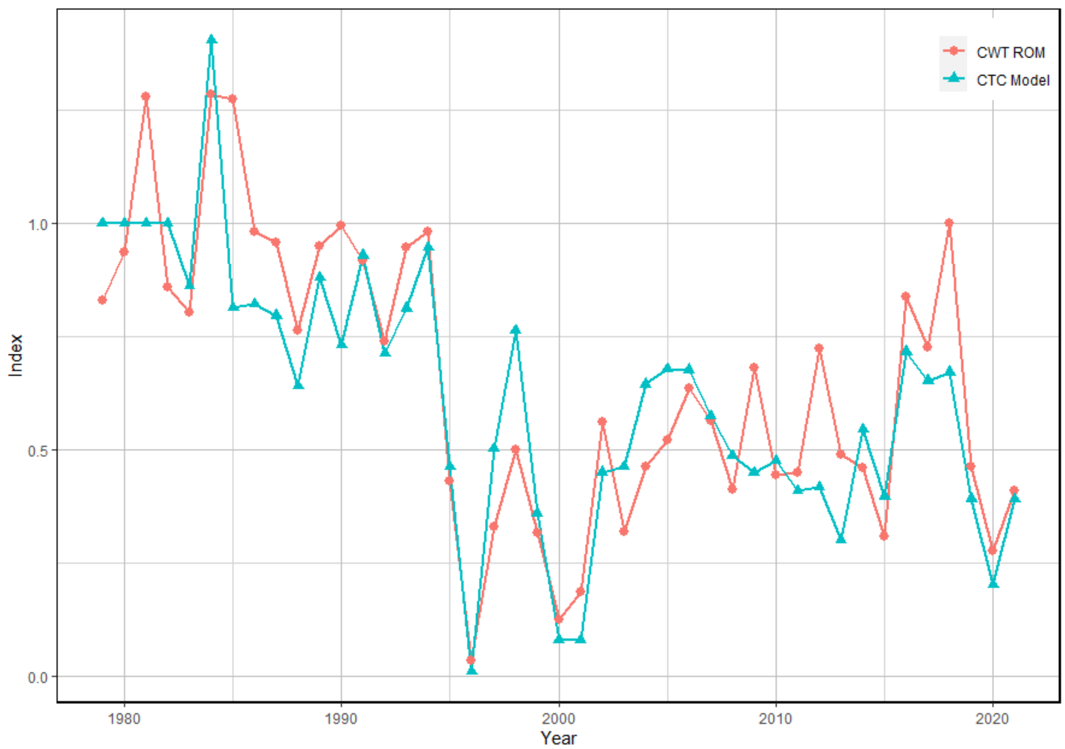

Figure 4.4.—Estimated coded-wire tag (CWT) ratio of means (ROM) and Pacific Salmon Commission Chinook Model fishery indices for total mortality in the Northern British Columbia (NBC) troll fishery through 2021.

4.1.3 West Coast Vancouver Island Troll Fishery Indices

For the WCVI troll fishery, correspondence between the model-based FI and the CWT-based ROM FI was very close from the start of the time series (1979) to the mid-1990s for both landed catch (Figure 4.5) and total mortality (Figure 4.6). Starting in 2000, model-based and CWT-based ROM FIs diverged noticeably, with the CWT-based 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). The CWT-based FI has corresponded more closely with the model-based FI since 2009 (Figure 4.5 and Figure 4.6).

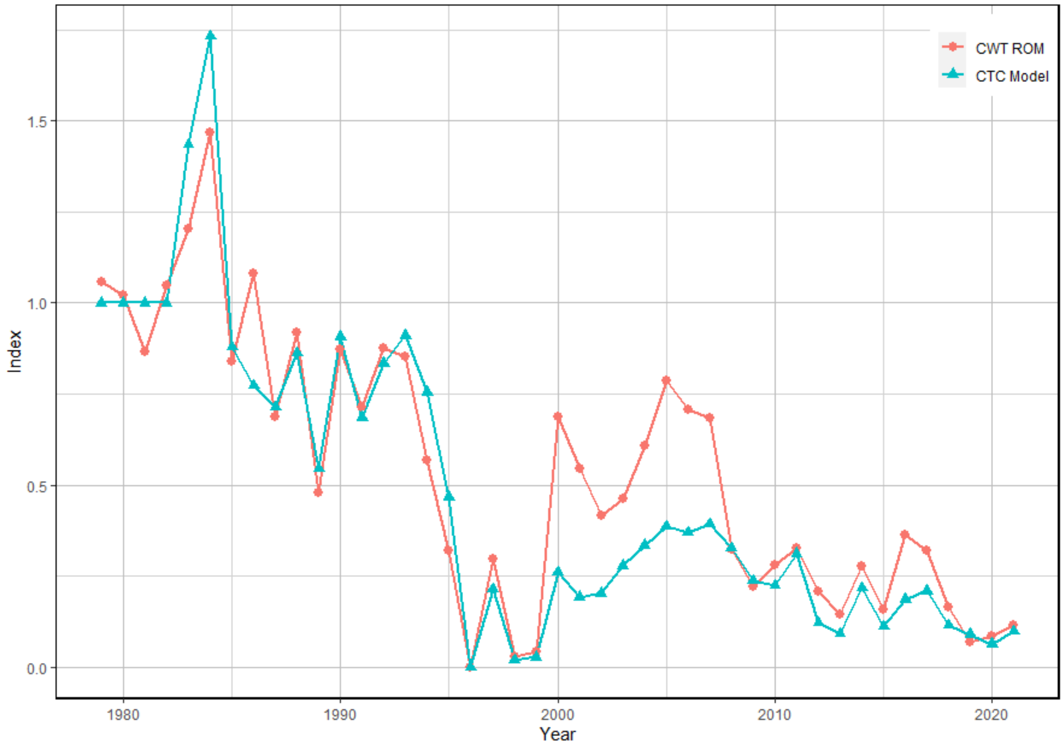

Figure 4.5.—Estimated coded-wire tag (CWT)-based ratio of means (ROM) fishery index (FI) and model-based FI for landed catch in the West Coast Vancouver Island (WCVI) Troll fishery through 2021.

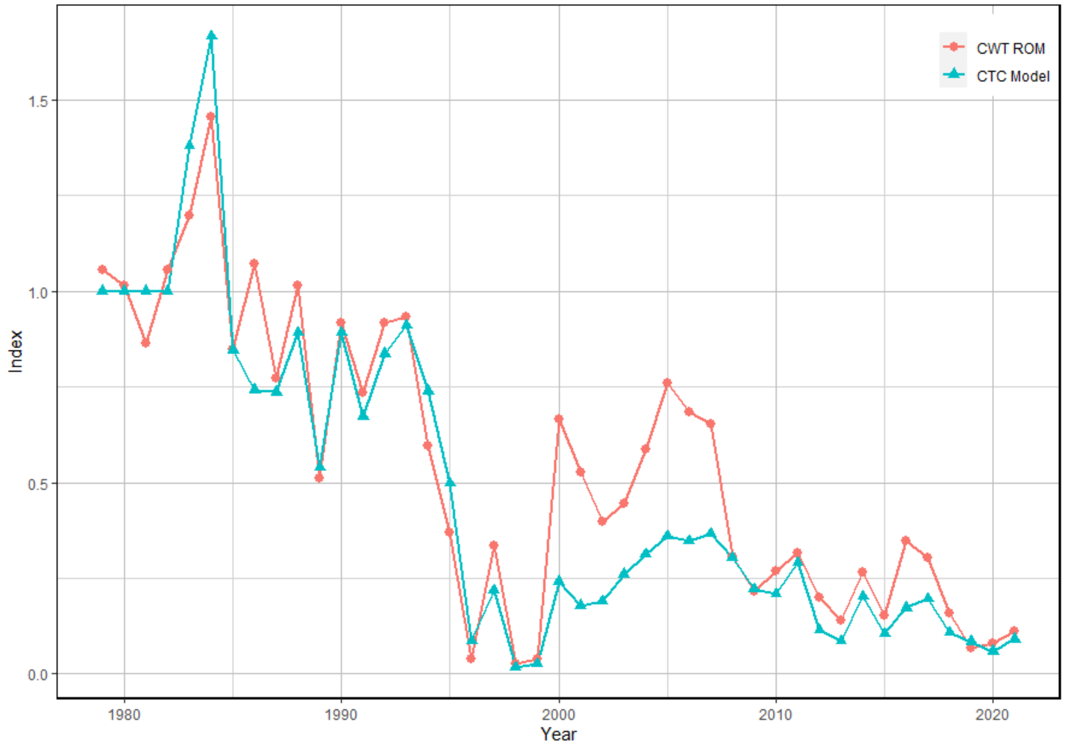

Figure 4.6.—Estimated coded-wire tag (CWT)-based ratio of means (ROM) fishery index (FI) and Pacific Salmon Commission Chinook Model FI for total mortality in the West Coast Vancouver Island (WCVI) troll fishery through 2021.

4.1.4 Comparison of Fishery Indices

In Figure 4.1 and Figure 4.2 (SEAK troll) 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 (NBC troll) 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 (WCVI troll) the model-based fishery indices generally track the CWT-based ROM indices, particularly in 2009, 2020, and 20212 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 (PST 2000). During these years the WCVI CWT ROM indices are consistently higher than 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, whereas 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

The ability of the PSC Chinook Model to accurately predict Chinook salmon ocean abundance in AABM fisheries depends on the ability of the model to predict the returns of Chinook salmon (in terms of ocean escapement or spawning escapement) in the forecast year. For each year's model calibration, all available agency-produced forecasts for model stocks are inputs to the model. Thus, for model stocks with agency-produced forecasts, the variation between model forecasts and actual returns can be broken into two parts: the ability of the model to fit the agency-produced forecasts used as inputs, and the ability of the agency-produced 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 through 2022, is shown in Appendix F. 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 F 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 2021a.

Overall, since transitioning to the Phase II model in 2020, the model forecasts have been similar to the agency-produced forecasts. This result is strongly influenced by the incorporation of the agency-produced forecasts into the model calibration procedure. The mean percent error (MPE) and mean absolute percent error (MAPE) for model forecasts relative to agency-produced forecasts were -0.6% and 12.9%, respectively, meaning that, on average, they were quite precise, and the model forecasts were close to but slightly lower than the agency-produced forecasts. For 2020–2022 (the only years with both forecasts and actual returns since transitioning to the Phase II model), the agency-produced forecasts were, on average, biased slightly low but fairly precise compared to the actual returns, with MPE of -5.7% and MAPE of 27.4%. Similarly, the MPE and MAPE for model forecasts relative to actual returns were -2.2% and 32.3%, respectively.

In the 2023 calibration of the PSC Chinook Model (CLB 2304) the post-season aggregate abundance for 2022 was lower than the forecast (CLB 2203) for SEAK and NBC and higher than the forecast for WCVI. For SEAK and NBC, the AIs decreased from pre-season estimates of 1.16 and 1.17 to post-season estimates of 1.04 and 1.08, respectively. For WCVI the AI increased from a pre-season estimate of 0.88 to a post-season estimate of 0.99. The accuracy of forecasts relative to actual returns is one of the primary factors that affects the accuracy of pre-season AIs compared to post-season AIs. For 2022, the forecast performance was mixed for many of the far-north migrating stocks that drive SEAK and NBC AIs (Figure 4.7, Figure 4.8, Appendix F). For WCVI, the increase in the post-season AI was likely driven by the large return of the Spring Creek Hatchery stock (SPR), which is the largest contributor to the WCVI AI and returned in numbers greater than 2.5 times the forecast (Figure 4.7, Figure 4.8, Appendix F). It is important to note, however, that there are other factors (e.g., forecasted maturation rates) that play a role in how well the pre- and post-season AIs align in a given year, which can sometimes counteract the effect of forecast performance. Figure 4.7 displays forecast error by stock arranged from north to south and allows for identification of regional trends in forecast performance. Figure 4.8 compares the agency-produced forecast with the actual return for each stock, ordered by the magnitude of the absolute difference. Agency-produced forecasts were supplied and used in the model calibration for all stocks with the exception of the five SEAK and transboundary (TBR) stocks, which used the forecast generated by the PSC Chinook Model (Figure 4.7).

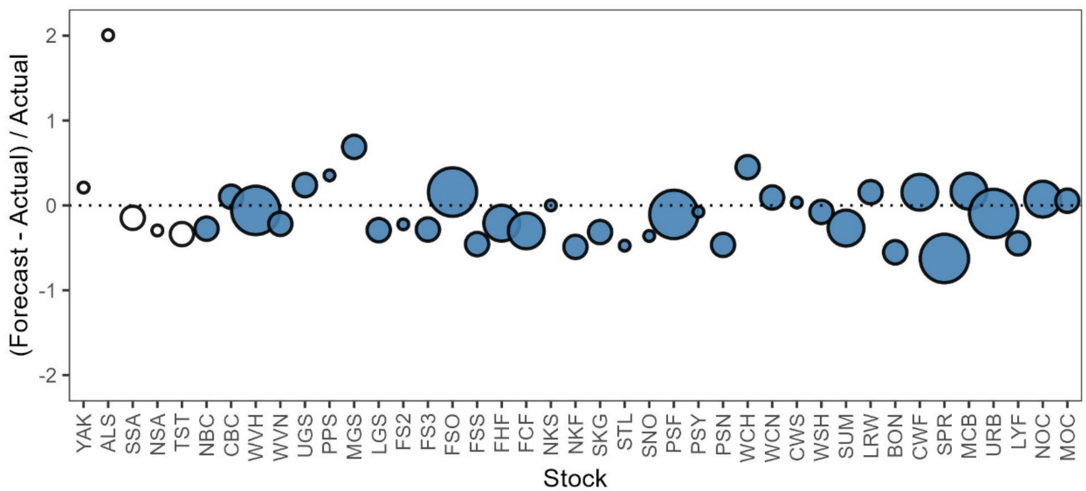

Figure 4.7.—2022 forecast error relative to the actual return for stocks represented in the Pacific Salmon Commission (PSC) Chinook Model.

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-produced 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.

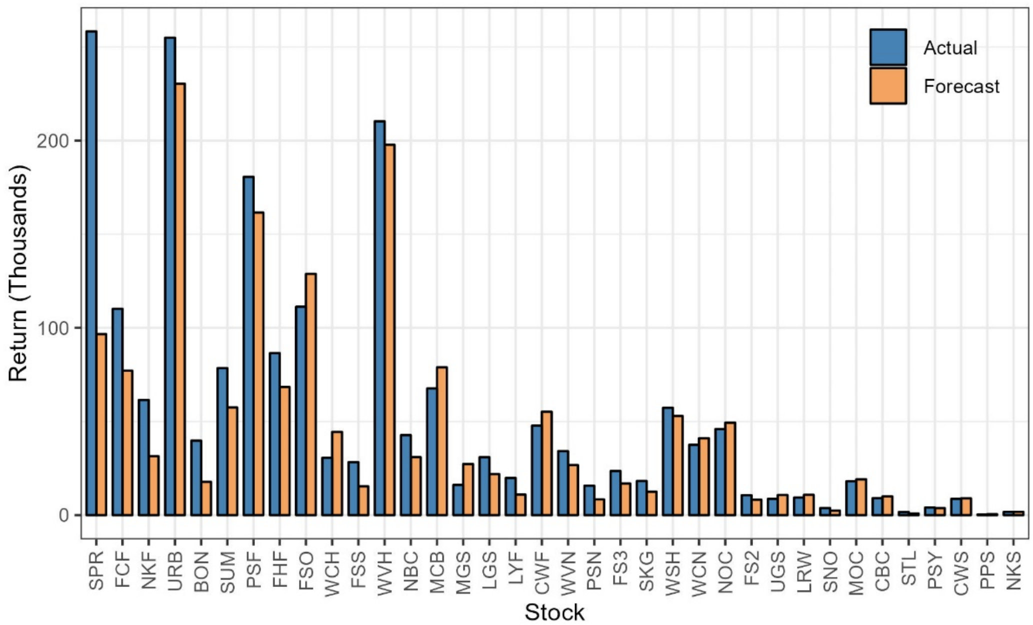

Figure 4.8.—Comparison of agency-produced forecasts to actual returns for Pacific Salmon Commission (PSC) Chinook Model stocks where an agency-produced forecast was supplied, 2022.

Note: Stocks are arranged from left to right along the x-axis based on the absolute value of the difference between the forecast and the actual return according to the model stock acronyms in Appendix A.

4.3 Model Error

For the purposes of this section, model error will refer to the difference between model-generated pre-season AIs for each of the three AABM fisheries and the respective first post-season AIs produced in the following year's model calibration. The yearly percent deviations between pre-season and post-season AIs for the three AABM fisheries are illustrated in Figure 4.9. 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. In 2022, the pre-season AIs were 12% and 8% greater than the first post-season AIs for SEAK and NBC, respectively, and 11% lower than the first post-season AI for WCVI.

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 reality but, as an input to the PSC Chinook Model, is assumed to be 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.

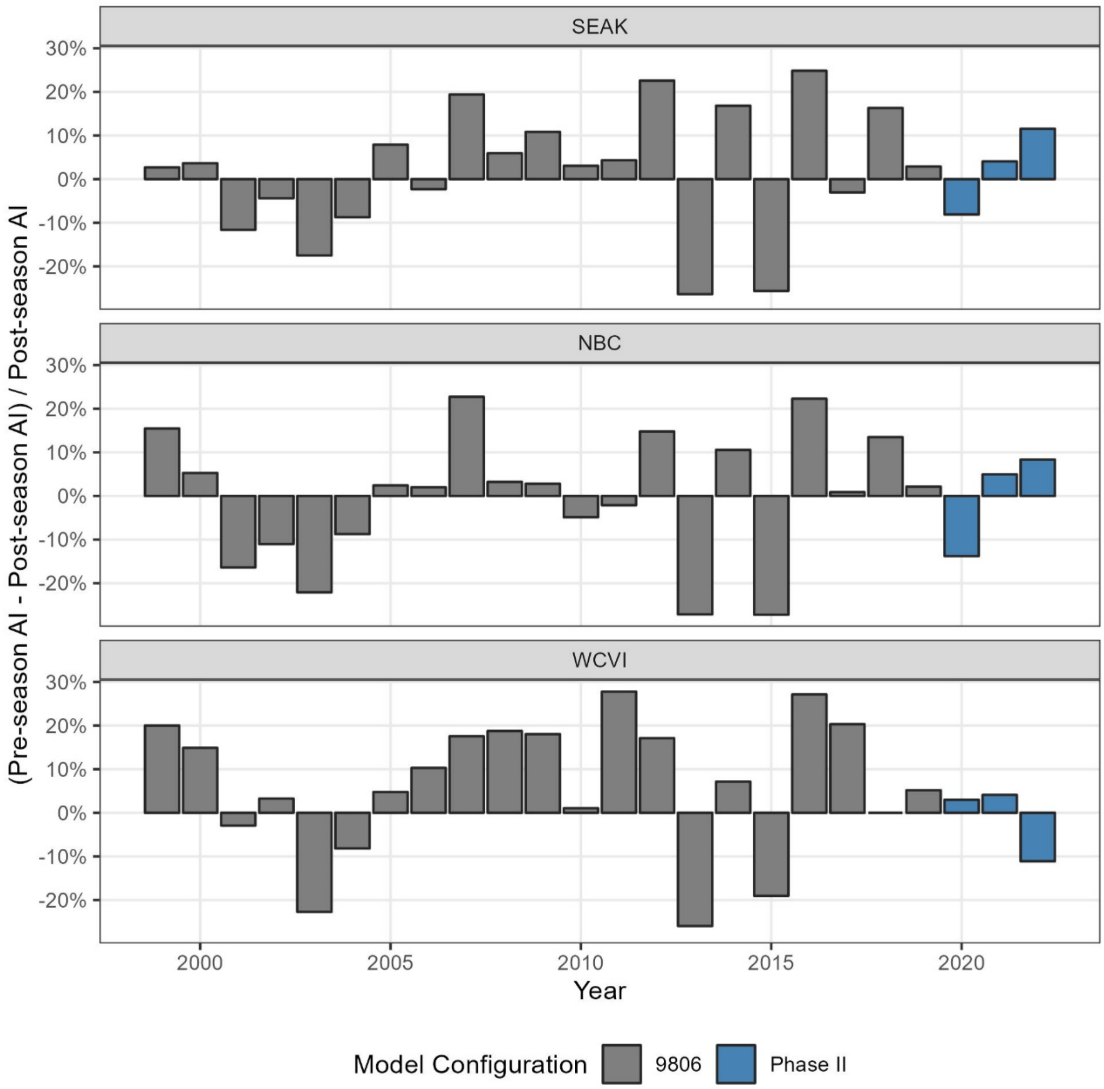

Figure 4.9.—Deviation between pre- and post-season abundance indices (AIs) for the three aggregate abundance-based management (AABM) fisheries, 1999–2022.

Note: Due to a disagreement over model calibration 1503, the Commission agreed to use CLB 1601 to estimate the 2014 and 2015 post-season AIs and 2016 pre-season AI.

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 metric for setting pre-season ACLs in lieu of the pre-season AI.

4.4 MODEL IMPROVEMENT ACTIVITIES

4.4.1 Integrated MATAEQ R program

Maturation rates and adult equivalent factors (hereafter MATAEQs) provided to the Chinook model are generated from a number of different sources, depending on stock- and year-specific information. In 2022, the Visual Basic (VB) program for selecting the correct MATAEQs was replaced with an R-based program, found in the matadj package (demo_mataeq_script). The R-based program was designed to mimic the VB maturation rate selection procedure and streamline the process into fewer steps.

Briefly, the program first collates then selects between maturation rates generated from the base period Phase II model calibration, the current year's cohort analysis (i.e., output from the Exploitation Rate Analysis), the Stock Aggregate Cohort Evaluation (SACE) procedure, and historical invariant data used for select stocks. The program then forecasts maturation rates for incomplete broods using an exponential smoothing model known as an ETS (error, trend, seasonality) model. This modelling step is identical to what was used previously but is now integrated into one package. Next, the program calculates adult equivalent factors from the selected maturation rates. Finally, the program writes a file of MATAEQs to be supplied as input to the Model Calibration procedure.

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APPENDIX A: RELATIONSHIP BETWEEN EXPLOITATION RATE INDICATOR STOCKS, ESCAPEMENT INDICATOR STOCKS, AND MODEL STOCKS

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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)	NA	NA	Alsek	ALS
Southeast Alaska (SEAK)		Yes	Situk (500–1,000)	NA	NA	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).

<table>
<tr><th>Region</th><th>Run</th><th>Attachment I stock</th><th>Escapement Indicator (PSC Management Objective)</th><th colspan="2">Exploitation Rate Indicator/Acronym</th><th colspan="2">Model Stock /Acronym</th></tr>
<tr><td rowspan="3">Northern BC (NBC)</td><td rowspan="3">Summer</td><td>No</td><td>Nass</td><td rowspan="3">Kitsumkalum (Deep Creek Hatchery)</td><td rowspan="3">KLM</td><td rowspan="3">Northern BC</td><td rowspan="3">NBC</td></tr>
<tr><td>Yes</td><td>Skeena (TBD)</td></tr>
<tr><td>No</td><td>Kitsumkalum</td></tr>
<tr><td rowspan="3">Central BC (CBC)</td><td>Fall</td><td>No</td><td>Wannock</td><td rowspan="3">Atnarko (Snootli Hatchery)</td><td rowspan="3">ATN</td><td rowspan="3">Central BC</td><td rowspan="3">CBC</td></tr>
<tr><td rowspan="2">Summer</td><td>No</td><td>Chuckwalla and Killbella</td></tr>
<tr><td>Yes</td><td>Atnarko (5,009)</td></tr>
<tr><td rowspan="3">West Coast Vancouver Island (WCVI)</td><td rowspan="3">Fall</td><td>Yes</td><td>North West Vancouver Island Aggregate (Colonial-Cayeagle, Tashish, Artlish, Kaouk) (TBD)</td><td rowspan="2">Robertson Creek Hatchery</td><td rowspan="2">RBT (adj)[1]</td><td rowspan="2">West Coast Vancouver Island Natural</td><td rowspan="2">WVN</td></tr>
<tr><td>Yes</td><td>South West Vancouver Island Aggregate (Bedwell/Ursus, Megin, Moyeha) (TBD)</td></tr>
<tr><td>No</td><td>West Coast Vancouver Island Aggregate (14 Streams)</td><td>Robertson Creek Hatchery</td><td>RBT</td><td>West Coast Vancouver Island Hatchery</td><td>WVH</td></tr>
</table>

[1]Coded-wire tag indicator stocks and fishery adjustments described in CTC 2021b.

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
Fraser River	Spring	No	Fraser Spring 1.2	Nicola (Spius Creek Hatchery)	NIC	Fraser Spring 1.2	FS2
Fraser River	Spring	No	NA	Dome (Penny Creek Hatchery)[1]	DOM	Fraser Spring 1.3	FS3
Fraser River	Spring	Yes	Chilcotin (TBD)	Lower Chilcotin (in development)	LCT	Fraser Spring 1.3	FS3
Fraser River	Summer	Yes	Lower Shuswap (12,300)	Lower Shuswap (Shuswap Falls Hatchery)	SHU	Fraser Summer Ocean-type 0.3	FSO
Fraser River	Summer	No	NA	Middle Shuswap (Shuswap Falls Hatchery)	MSH	Fraser Summer Ocean-type 0.3	FSO
Fraser River	Summer	Yes	Chilko (TBD)	Chilko (in development)	CKO	Fraser Summer Stream-type 1.3	FSS
Fraser River	Fall	No	NA	Chilliwack Hatchery	CHI	Fraser Chilliwack Fall Hatchery	FCF
Fraser River	Fall	Yes	Harrison (75,100)	Harrison (Chehalis Hatchery)	HAR	Fraser Harrison Fall	FHF
North Strait of Georgia	Fall	No	TBD	Quinsam Hatchery[2]	QUI	Upper Strait of Georgia	UGS
North Strait of Georgia	Fall	Yes	East Vancouver Island North (TBD)	Quinsam Hatchery[2]	QUI (adj)	Upper Strait of Georgia	UGS
North Strait of Georgia	Fall	Yes	Phillips	Phillips (Gillard Pass Hatchery)[3]	PHI	Upper Strait of Georgia	UGS
South Strait of Georgia	Fall	No	Cowichan (6,500)	Big Qualicum Hatchery	BQR	Middle Strait of Georgia	MGS
South Strait of Georgia	Fall	Yes	Cowichan (6,500)	Cowichan Hatchery	COW	Lower Strait of Georgia	LGS
South Strait of Georgia	Fall	No	Cowichan (6,500)	Nanaimo Hatchery[4]	NAN	Lower Strait of Georgia	LGS
South Strait of Georgia	Summer	No	Cowichan (6,500)	Puntledge Hatchery	PPS	Puntledge Hatchery	PPS

[1]DOM was discontinued as an exploitation rate indicator stock as of brood year (BY) 2002.
[2]CWT indicator stocks and fishery adjustments described in CTC 2021b.
[3]PHI will be discontinued as an exploitation rate indicator stock once all age classes from the 2019 brood have been recovered (i.e., 2024).
[4]NAN was discontinued as an exploitation rate indicator stock as of BY 2004.

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	NA	NA
	Fall	No	NA	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 Summer Fingerling (Wallace Hatchery)	SKY	Snohomish	SNO
Central and Southern Puget Sound	Spring	No	NA	White River Hatchery Spring Yearling[2]	WRY	NA	NA
	Fall	No	NA	SPS Fall Yearling[2]	SPY	Puget Sound Hatchery Yearling	PSY
		No	NA	University of Washington Accelerated[2]	UWA		
		No	Green	Green River Fingerling[1] (Soos Creek Hatchery)	GRN	Puget Sound Hatchery Fingerling & Puget Sound Natural Fingerling	PSF & PSN
		No	Lake Washington	SPS Fall Fingerling[1]	SPS		
		No	NA	Nisqually Fall Fingerling (Clear Creek Hatchery)	NIS		
Hood Canal		No	NA	George Adams Hatchery Fall Fingerling	GAD		

[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.
[2]This stock has been discontinued and is no longer analyzed on an annual basis. For more information, see Appendix I of CTC 2022.

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	No	NA	Elwha Fall Fingerling (Lower Elwha Hatchery)	ELW	NA	NA
Washington Coast (WAC)	Fall	Yes	Hoko (TBD)	Hoko Fall Fingerling (Hoko Falls Hatchery)	HOK	NA	NA
Washington Coast (WAC)	Fall	Yes	Queets Fall (2,500)	Queets Fall Fingerling (Salmon River brood stock)	QUE (adj)[2]	WA Coastal Wild	WCN
Washington Coast (WAC)	Fall	Yes	Grays Harbor Fall (13,326)	Queets Fall Fingerling (Salmon River brood stock)	QUE (adj)[2]	WA Coastal Wild	WCN
Washington Coast (WAC)	Fall	Yes	Quillayute Fall (3,000)	Queets Fall Fingerling (Salmon River brood stock)	QUE (adj)[2]	WA Coastal Wild	WCN
Washington Coast (WAC)	Fall	Yes	Hoh Fall (1,200)	Queets Fall Fingerling (Salmon River brood stock)	QUE (adj)[2]	WA Coastal Wild	WCN
Washington Coast (WAC)	Fall	No	NA	Queets Fall Fingerling (Salmon River brood stock)	QUE (adj)[2]	WA Coastal Hatchery	WCH
Washington Coast (WAC)	Fall	No	NA	Tsoo-Yess Fall Fingerling (Makah National Fish Hatchery)	SOO	NA	NA
Washington Coast (WAC)	Spring	No	Grays Harbor Spring[1]	NA	NA	NA	NA
Washington Coast (WAC)	Spring/ Summer	No	Queets Spring/Summer (700)[1]	NA	NA	NA	NA
Washington Coast (WAC)	Summer	No	Quillayute Summer[1]	NA	NA	NA	NA
Washington Coast (WAC)	Spring/ Summer	No	Hoh Spring/Summer (900)[1]	NA	NA	NA	NA

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

[2] Coded-wire tag indicator stocks and fishery adjustments described in CTC 2021b.

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

<table>
<tr><th>Region</th><th>Run</th><th>Attachment I stock</th><th>Escapement Indicator (PSC Management Objective)</th><th colspan="2">Exploitation Rate Indicator/Acronym</th><th colspan="2">Model Stock /Acronym</th></tr>
<tr><td rowspan="13">Columbia River</td><td rowspan="2">Spring</td><td>No</td><td>NA</td><td>Cowlitz/Kalama/Lewis Springs</td><td>CWS</td><td>Cowlitz Spring Hatchery</td><td>CWS</td></tr>
<tr><td>No</td><td>NA</td><td>Willamette Spring (Hatchery Complex)</td><td>WSH</td><td>Willamette River Hatchery</td><td>WSH</td></tr>
<tr><td rowspan="2">Summer</td><td>Yes</td><td>Mid-Columbia Summers (12,143)</td><td>Columbia Summers (Wells Hatchery)</td><td>SUM</td><td>Columbia River Summers</td><td>SUM</td></tr>
<tr><td>No</td><td>NA</td><td>Similkameen Summer Yearling</td><td>SMK</td><td></td><td></td></tr>
<tr><td rowspan="9">Fall</td><td>No</td><td>NA</td><td rowspan="2">Columbia Upriver Brights (Priest Rapids Hatchery)</td><td rowspan="2">URB</td><td>Mid-Columbia Brights</td><td>MCB</td></tr>
<tr><td rowspan="2">Yes</td><td rowspan="2">Upriver Brights (40,000)</td><td rowspan="2">Columbia Upriver Brights</td><td rowspan="2">URB</td></tr>
<tr><td>Hanford Wild</td><td>HAN</td></tr>
<tr><td>No</td><td>NA</td><td>Lyons Ferry Fingerling</td><td>LYF</td><td>Lyons Ferry Hatchery</td><td>LYF</td></tr>
<tr><td>No</td><td>NA</td><td>Lyons Ferry Yearling</td><td>LYY</td><td></td><td></td></tr>
<tr><td>Yes</td><td>Lewis (5,700)</td><td>Lewis River Wild</td><td>LRW</td><td>Lewis River</td><td>LRW</td></tr>
<tr><td>Yes</td><td>Coweeman (TBD)</td><td>Cowlitz Hatchery Fall Tule</td><td>CWF</td><td>Cowlitz Hatchery</td><td>CWF</td></tr>
<tr><td>No</td><td>NA</td><td>Spring Creek National Fish Hatchery</td><td>SPR</td><td>Spring Creek</td><td>SPR</td></tr>
<tr><td>No</td><td>NA</td><td>Lower River Hatchery (Big Creek Hatchery)</td><td>LRH</td><td>Bonneville Hatchery</td><td>BON</td></tr>
<tr><td rowspan="3">North Oregon Coast (NOC)</td><td rowspan="5">Fall</td><td>Yes</td><td>Nehalem (6,989)</td><td rowspan="3">Salmon River Hatchery (adj)</td><td rowspan="3">SRH (adj)[1]</td><td rowspan="3">North Oregon Coast</td><td rowspan="3">NOC</td></tr>
<tr><td>Yes</td><td>Siletz (2,944)</td></tr>
<tr><td>Yes</td><td>Siuslaw (12,925)</td></tr>
<tr><td rowspan="2">Mid-Oregon Coast (MOC)</td><td>Yes</td><td>South Umpqua (TBD)</td><td rowspan="2">Elk River Hatchery (adj)</td><td rowspan="2">ELK (adj)[1]</td><td rowspan="2">Mid-Oregon Coast</td><td rowspan="2">MOC</td></tr>
<tr><td>Yes</td><td>Coquille (TBD)</td></tr>
</table>

[1]CWT indicator stocks and fishery adjustments described in CTC 2021b.

Appendix B: Model stock composition estimates for the aggregate abundance-based management and individual stock-based management fisheries in 2022 and the 1985–2021 average

This appendix shows the model stock composition estimates of catch for the three AABM fisheries (Appendix B1, Appendix B2 and Appendix B3) and all ISBM fisheries by country (Appendix B4 and Appendix B5). These estimates are based on summing the 41 model stock contributions for each model fishery aggregate, expressed as a percentage of the total catch.

The estimated stock composition 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 which may not reflect the current stock composition in the fishery, amongst the 41 model stocks.
2. The distribution of certain 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 are 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 total catch of the fisheries in Appendix B1 to Appendix 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.

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Appendix B5– U.S. individual stock-based management (ISBM) troll, net, and sport fisheries. 54

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

FISHERY:	**SE ALASKA AABM TROLL NET AND SPORT**				
	2022	**Average (1985–2021)**			
Model Stock	**% of Fishery Catch**	**% of Fishery Catch**	**% of Stock Catch**	**% of Stock Total Return**	**Associated Escapement Indicator Stocks**[1]
Upriver Brights	17.50%	19.08%	21.57%	11.82%	Upriver Brights
WCVI Hatchery	23.23%	15.87%	28.51%	13.37%	NA
North Oregon Coast	6.08%	9.45%	21.78%	11.85%	Nehalem Siletz Siuslaw
Northern BC	2.27%	5.98%	67.50%	13.21%	Skeena
Fraser Summer Ocean-type 0.3	11.19%	7.60%	32.22%	12.14%	Lower Shuswap
WA Coastal Wild	5.39%	5.79%	33.90%	15.68%	Grays Harbor Fall Queets Fall Quillayute Fall Hoh Fall
Mid Columbia River Brights	6.23%	5.47%	19.24%	11.08%	Not Represented
Taku and Stikine	1.13%	4.89%	55.42%	10.75%	Taku Stikine
Southern SE AK	3.32%	3.95%	96.69%	32.36%	Unuk
WA Coastal Hatchery	4.48%	3.58%	33.06%	13.64%	NA
Columbia River Summer	6.64%	3.35%	18.45%	9.94%	Mid-Columbia Summers
Northern SE AK	1.43%	2.70%	99.63%	46.06%	Chilkat
Yakutat Forelands	0.02%	2.16%	0.00%	33.74%	Situk
WCVI Natural	4.48%	2.28%	30.61%	16.14%	NWVI Natural Aggregate SWVI Natural Aggregate
Mid-Oregon Coast	0.80%	1.95%	10.99%	5.52%	South Umpqua Coquille
Upper Georgia Strait	0.77%	1.15%	41.26%	13.50%	East Vancouver Island North Phillips
Willamette River Spring	1.15%	0.95%	6.43%	2.69%	NA
Fall Cowlitz Hatchery	0.83%	0.86%	3.23%	1.65%	NA
Central BC	0.22%	0.61%	28.96%	6.79%	Atnarko
Lewis River Wild	0.45%	0.59%	16.21%	5.62%	Lewis
Middle Georgia Strait	0.50%	0.42%	9.92%	3.13%	NA
Harrison Fall	0.49%	0.32%	1.87%	0.54%	Harrison
Puget Sound Fingerling	0.33%	0.20%	0.38%	0.22%	NA

Fraser Summer Stream-type 1.3	0.23%	0.16%	3.36%	1.06%	Chilko
Skagit Wild	0.18%	0.11%	3.87%	1.35%	Skagit Summer/Fall
Spring Cowlitz Hatchery	0.07%	0.08%	1.64%	0.82%	NA
Alsek	0.04%	0.08%	46.10%	2.70%	Alsek
Lower Georgia Strait	0.20%	0.11%	2.95%	1.22%	Cowichan
Lyons Ferry	0.14%	0.07%	1.96%	1.19%	Not Represented
Nooksack Fall	0.09%	0.06%	0.30%	0.20%	Not Represented
Puget Sound Natural Fall	0.02%	0.02%	0.34%	0.18%	NA
Chilliwack Fall Hatchery	0.04%	0.02%	0.20%	0.07%	NA
Nooksack Spring	0.03%	0.02%	4.95%	1.66%	Nooksack Spring
Puget Sound Yearlings	0.00%	0.01%	0.26%	0.16%	NA
Fraser Spring 1.2	0.01%	0.01%	0.47%	0.14%	Nicola
Puntledge Summers	0.01%	0.01%	5.91%	1.73%	NA
Snohomish Wild	0.01%	0.01%	1.03%	0.23%	Snohomish
Stillaguamish Wild	0.00%	0.00%	1.03%	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 fisheries.

FISHERY:	NORTH BC AABM TROLL AND SPORT				
	2022	Average (1985–2021)			
Model Stock	**% of Fishery Catch**	**% of Fishery Catch**	**% of Stock Catch**	**% of Stock Total Return**	**Associated Escapement Indicator Stocks[1]**
North Oregon Coast	16.88%	20.58%	31.08%	17.59%	Nehalem Siletz Siuslaw
Upriver Brights	21.16%	17.46%	12.74%	7.12%	Upriver Brights
Fraser Summer Ocean-type 0.3	8.69%	12.09%	33.44%	13.90%	Lower Shuswap
WCVI Hatchery	10.97%	10.30%	10.69%	5.36%	NA
WA Coastal Wild	5.93%	7.70%	28.22%	13.76%	Grays Harbor Fall Queets Fall Quillayute Fall Hoh Fall
Mid-Oregon Coast	3.20%	6.35%	22.31%	11.50%	South Umpqua Coquille
Columbia River Summer	12.97%	6.37%	22.78%	12.79%	Mid-Columbia Summers
WA Coastal Hatchery	4.89%	4.79%	28.50%	12.42%	NA
Mid Columbia River Brights	3.76%	3.63%	8.90%	5.32%	Not Represented
Willamette River Spring	2.62%	2.14%	9.28%	4.06%	NA
WCVI Natural	2.00%	1.39%	10.90%	6.17%	NWVI Natural Aggregate SWVI Natural Aggregate
Upper Georgia Strait	0.46%	0.94%	20.45%	7.27%	East Vancouver Island North Phillips
Fall Cowlitz Hatchery	0.76%	0.87%	2.11%	1.12%	NA
Middle Georgia Strait	0.63%	0.65%	9.69%	3.23%	NA
Fraser Summer Stream-type 1.3	0.59%	0.48%	6.13%	2.04%	Chilko
Northern BC	0.13%	0.37%	2.89%	0.58%	Skeena
Puget Sound Fingerling	0.71%	0.48%	0.63%	0.36%	NA
Taku and Stikine	0.17%	0.47%	3.61%	0.68%	Taku Stikine
Lewis River Wild	0.22%	0.38%	6.01%	2.25%	Lewis
Central BC	0.16%	0.31%	9.64%	2.32%	Atnarko
Lyons Ferry	0.64%	0.33%	6.30%	3.96%	Not Represented
Spring Cowlitz Hatchery	0.24%	0.29%	3.72%	1.96%	NA

Skagit Wild	0.41%	0.29%	6.15%	2.24%	Skagit Summer/Fall
Harrison Fall	0.29%	0.26%	0.82%	0.25%	Harrison
Chilliwack Fall Hatchery	0.41%	0.23%	1.11%	0.44%	NA
Lower Georgia Strait	0.56%	0.24%	2.57%	1.25%	Cowichan
Southern SE AK	0.19%	0.19%	2.99%	0.99%	Unuk
Nooksack Fall	0.11%	0.09%	0.27%	0.18%	Not Represented
Puget Sound Natural Fall	0.03%	0.05%	0.42%	0.23%	NA
Lower Bonneville Hatchery	0.02%	0.05%	0.22%	0.11%	NA
Puntledge Summers	0.02%	0.05%	10.86%	3.44%	NA
Nooksack Spring	0.06%	0.05%	6.85%	2.47%	Nooksack Spring
Spring Creek Hatchery	0.07%	0.04%	0.07%	0.06%	NA
Fraser Spring 1.2	0.02%	0.03%	0.53%	0.17%	Nicola
Snohomish Wild	0.02%	0.03%	1.98%	0.47%	Snohomish
Stillaguamish Wild	0.02%	0.02%	2.12%	0.86%	Stillaguamish
Northern SE AK	0.00%	0.02%	0.17%	0.08%	Chilkat
Puget Sound Yearlings	0.00%	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 fisheries.

FISHERY:	**WCVI AABM TROLL AND SPORT**				
	2022	**Average (1985–2021)**			
Model Stock	**% of Fishery Catch**	**% of Fishery Catch**	**% of Stock Catch**	**% of Stock Total Return**	**Associated Escapement Indicator Stocks[1]**
Puget Sound Fingerling	9.56%	13.00%	17.72%	10.65%	NA
Upriver Brights	16.79%	14.06%	10.41%	5.97%	Upriver Brights
Spring Creek Hatchery	26.67%	10.50%	20.13%	15.57%	NA
Fall Cowlitz Hatchery	4.41%	8.14%	21.48%	11.97%	NA
Lower Bonneville Hatchery	4.84%	6.41%	32.26%	18.44%	NA
Harrison Fall	3.32%	5.63%	18.65%	6.07%	Harrison
WCVI Hatchery	4.72%	5.44%	5.86%	3.13%	NA
Chilliwack Fall Hatchery	6.18%	5.20%	24.76%	10.46%	NA
Mid Columbia River Brights	2.31%	4.22%	10.77%	6.68%	Not Represented
Columbia River Summer	4.13%	3.74%	16.42%	9.49%	Mid-Columbia Summers
North Oregon Coast	4.31%	4.04%	6.39%	3.62%	Nehalem Siletz Siuslaw
Nooksack Fall	2.07%	2.89%	10.37%	6.92%	Not Represented
Puget Sound Natural Fall	0.85%	2.37%	21.56%	12.71%	NA
Mid-Oregon Coast	1.41%	1.76%	7.03%	3.74%	South Umpqua Coquille
WA Coastal Wild	0.66%	1.50%	5.84%	2.88%	Grays Harbor Fall Queets Fall Quillayute Fall Hoh Fall
Puget Sound Yearlings	0.22%	1.32%	13.82%	9.12%	NA
Fraser Summer Stream-type 1.3	0.87%	1.32%	17.20%	5.98%	Chilko
Lyons Ferry	1.24%	1.08%	20.09%	13.46%	Not Represented
WA Coastal Hatchery	0.55%	0.97%	6.09%	2.72%	NA
Skagit Wild	0.64%	0.94%	21.28%	8.11%	Skagit Summer/Fall
Lewis River Wild	0.29%	0.81%	14.71%	5.73%	Lewis
Willamette River Spring	0.55%	0.79%	3.62%	1.62%	NA
Spring Cowlitz Hatchery	0.43%	0.74%	9.69%	5.51%	NA
Fraser Summer Ocean-type 0.3	0.47%	0.71%	2.22%	0.96%	Lower Shuswap
Lower Georgia Strait	1.10%	0.74%	9.53%	4.65%	Cowichan

WCVI Natural	0.81%	0.58%	5.84%	3.47%	NWVI Natural Aggregate SWVI Natural Aggregate
Middle Georgia Strait	0.25%	0.38%	5.69%	1.98%	NA
Snohomish Wild	0.08%	0.18%	18.20%	4.53%	Snohomish
Fraser Spring 1.2	0.07%	0.18%	4.20%	1.40%	Nicola
Stillaguamish Wild	0.07%	0.13%	17.91%	7.62%	Stillaguamish
Nooksack Spring	0.07%	0.10%	15.93%	5.82%	Nooksack Spring
Fraser Spring 1.3	0.03%	0.06%	1.03%	0.26%	Chilcotin
Puntledge Summers	0.01%	0.02%	7.21%	2.24%	NA
Upper Georgia Strait	0.01%	0.02%	0.55%	0.21%	East Vancouver Island North Phillips
Central BC	0.00%	0.01%	0.36%	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) net and sport fisheries.

FISHERY:	CANADA ISBM TROLL NET AND SPORT				
	2022	Average (1985–2021)			
Model Stock	**% of Fishery Catch**	**% of Fishery Catch**	**% of Stock Catch**	**% of Stock Total Return**	**Associated Escapement Indicator Stocks[1]**
WCVI Hatchery	36.62%	29.99%	54.54%	26.10%	NA
Harrison Fall	4.75%	7.51%	38.85%	13.19%	Harrison
Puget Sound Fingerling	6.39%	6.18%	12.96%	7.61%	NA
Fraser Summer Stream-type 1.3	2.08%	3.52%	67.77%	22.52%	Chilko
Fraser Summer Ocean-type 0.3	6.34%	6.09%	28.28%	11.13%	Lower Shuswap
Nooksack Fall	6.20%	5.31%	29.01%	19.32%	Not Represented
Lower Georgia Strait	9.61%	5.30%	76.62%	43.25%	Cowichan
Chilliwack Fall Hatchery	7.68%	4.28%	36.01%	16.63%	NA
WCVI Natural	6.13%	4.16%	52.30%	28.30%	NWVI Natural Aggregate
					SWVI Natural Aggregate
Fraser Spring 1.3	1.06%	3.65%	83.16%	22.07%	Chilcotin
Northern BC	0.48%	2.85%	29.61%	5.98%	Skeena
Middle Georgia Strait	3.14%	3.36%	72.27%	29.32%	NA
Fraser Spring 1.2	0.36%	3.17%	86.73%	31.10%	Nicola
Upriver Brights	0.68%	2.50%	3.48%	2.08%	Upriver Brights
Fall Cowlitz Hatchery	0.92%	1.55%	6.07%	3.26%	NA
Columbia River Summer	1.85%	1.56%	11.38%	6.28%	Mid-Columbia Summers
Central BC	0.34%	1.25%	60.94%	14.58%	Atnarko
Upper Georgia Strait	0.27%	1.12%	37.74%	14.66%	East Vancouver Island North
					Phillips
Skagit Wild	1.02%	1.06%	37.24%	14.02%	Skagit Summer/Fall
Puget Sound Natural Fall	0.51%	0.97%	14.45%	8.16%	NA
Puget Sound Yearlings	0.23%	0.83%	14.18%	9.39%	NA
Spring Creek Hatchery	1.81%	0.85%	2.73%	2.08%	NA
Mid Columbia River Brights	0.19%	0.68%	3.91%	2.65%	Not Represented
Lower Bonneville Hatchery	0.54%	0.50%	3.89%	2.08%	NA
North Oregon Coast	0.00%	0.32%	0.87%	0.49%	Nehalem
					Siletz
					Siuslaw
Snohomish Wild	0.12%	0.23%	35.68%	8.64%	Snohomish
Nooksack Spring	0.24%	0.24%	57.67%	20.70%	Nooksack Spring
Puntledge Summers	0.10%	0.18%	76.03%	29.43%	NA

Lewis River Wild	0.05%	0.17%	4.31%	1.68%	Lewis
Stillaguamish Wild	0.11%	0.16%	35.79%	14.90%	Stillaguamish
WA Coastal Wild	0.04%	0.13%	0.85%	0.42%	Grays Harbor Fall
					Queets Fall
					Quillayute Fall
					Hoh Fall
Spring Cowlitz Hatchery	0.06%	0.11%	2.20%	1.14%	NA
WA Coastal Hatchery	0.03%	0.09%	0.89%	0.42%	NA
Lyons Ferry	0.04%	0.05%	2.64%	1.91%	Not Represented
Willamette River Spring	0.00%	0.03%	0.22%	0.11%	NA
Mid-Oregon Coast	0.00%	0.01%	0.06%	0.03%	South Umpqua
					Coquille
Southern SE AK	0.00%	0.01%	0.32%	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– U.S. individual stock-based management (ISBM) troll, net, and sport fisheries.

FISHERY:	US ISBM TROLL NET AND SPORT				
	2022	Average (1985–2021)			
Model Stock	% of Fishery Catch	% of Fishery Catch	% of Stock Catch	% of Stock Total Return	Associated Escapement Indicator Stocks[1]
Upriver Brights	16.02%	17.78%	51.80%	28.69%	Upriver Brights
Puget Sound Fingerling	14.51%	13.44%	68.31%	39.04%	NA
Spring Creek Hatchery	31.37%	10.78%	77.07%	58.53%	NA
Fall Cowlitz Hatchery	3.12%	6.90%	67.11%	36.47%	NA
North Oregon Coast	2.92%	6.70%	39.87%	21.52%	Nehalem
					Siletz
					Siuslaw
Mid Columbia River Brights	6.25%	6.27%	57.17%	33.88%	Not Represented
Willamette River Spring	2.56%	5.16%	80.46%	36.32%	NA
Mid-Oregon Coast	1.38%	4.36%	59.61%	30.60%	South Umpqua
					Coquille
Nooksack Fall	4.69%	4.58%	60.04%	38.97%	Not Represented
Lower Bonneville Hatchery	3.14%	3.47%	63.63%	34.68%	NA
Harrison Fall	1.63%	3.21%	39.81%	12.85%	Harrison
Columbia River Summer	3.99%	2.45%	30.96%	17.11%	Mid-Columbia Summers
WA Coastal Wild	0.96%	2.20%	31.19%	14.52%	Grays Harbor Fall
					Queets Fall
					Quillayute Fall
					Hoh Fall
Puget Sound Yearlings	0.42%	1.94%	71.70%	45.86%	NA
Puget Sound Natural Fall	0.79%	1.93%	63.24%	35.10%	NA
Chilliwack Fall Hatchery	2.17%	1.95%	37.92%	15.48%	NA
Spring Cowlitz Hatchery	0.69%	1.76%	82.75%	45.62%	NA
WA Coastal Hatchery	0.58%	1.51%	31.46%	13.45%	NA
Lewis River Wild	0.36%	0.99%	58.76%	23.15%	Lewis
Lyons Ferry	0.93%	0.89%	69.00%	44.64%	Not Represented
Skagit Wild	0.35%	0.36%	31.46%	11.04%	Skagit Summer/Fall
Fraser Summer Ocean-type 0.3	0.37%	0.32%	3.84%	1.51%	Lower Shuswap
Fraser Spring 1.3	0.08%	0.26%	15.81%	3.85%	Chilcotin
Lower Georgia Strait	0.41%	0.21%	8.34%	4.07%	Cowichan
Snohomish Wild	0.05%	0.12%	43.11%	10.41%	Snohomish
Fraser Summer Stream-type 1.3	0.06%	0.11%	5.54%	1.91%	Chilko

WCVI Hatchery	0.08%	0.09%	0.40%	0.18%	NA
Stillaguamish Wild	0.04%	0.08%	43.15%	17.83%	Stillaguamish
Fraser Spring 1.2	0.02%	0.08%	8.08%	2.54%	Nicola
Middle Georgia Strait	0.03%	0.04%	2.43%	0.83%	NA
Nooksack Spring	0.02%	0.02%	14.60%	5.16%	Nooksack Spring
WCVI Natural	0.01%	0.01%	0.35%	0.18%	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
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
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 PACIFIC SALMON COMMISSION CHINOOK MODEL-GENERATED STOCK COMPOSITION OF ACTUAL LANDED CATCH FOR ALL (AGGREGATE ABUNDANCE-BASED MANAGEMENT AND INDIVIDUAL STOCK-BASED MANAGEMENT) MODEL FISHERIES, 1979–2022

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 Add-on, 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 Add-on by fishery F and year Y for the SEAK and TBR stock groups. Results with and without the Alaska Hatchery Add-on 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

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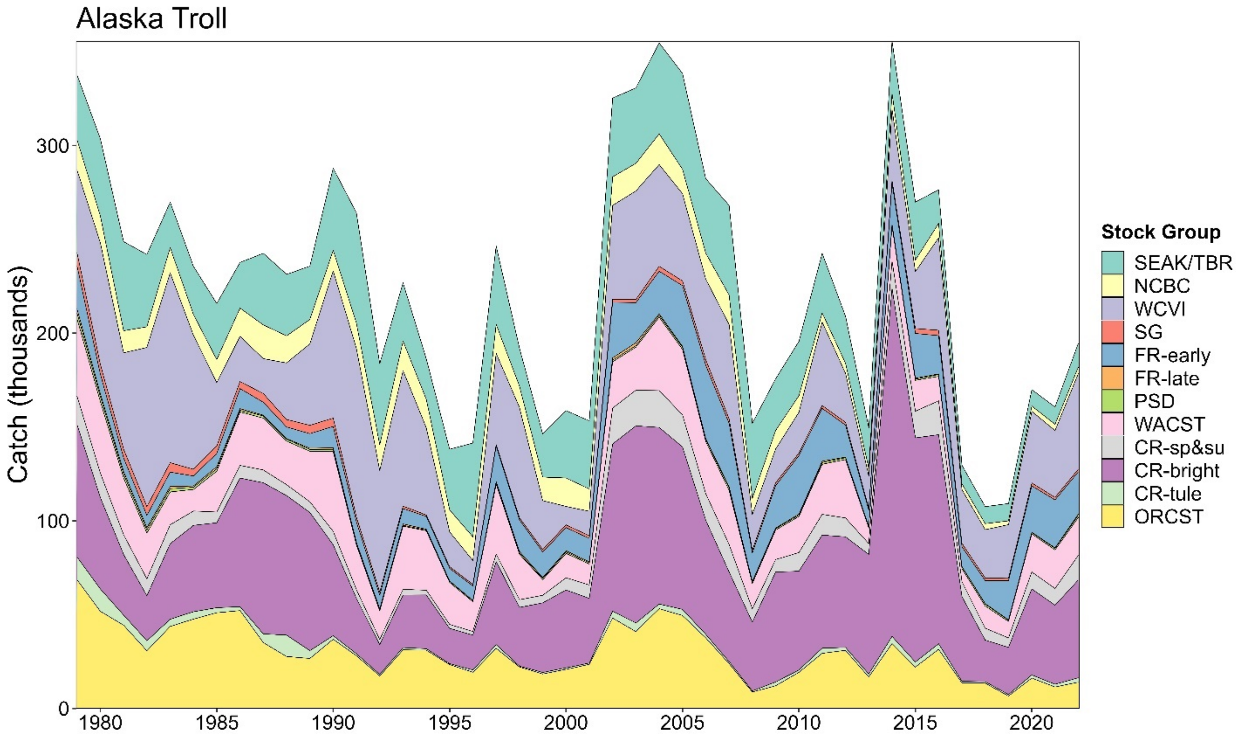
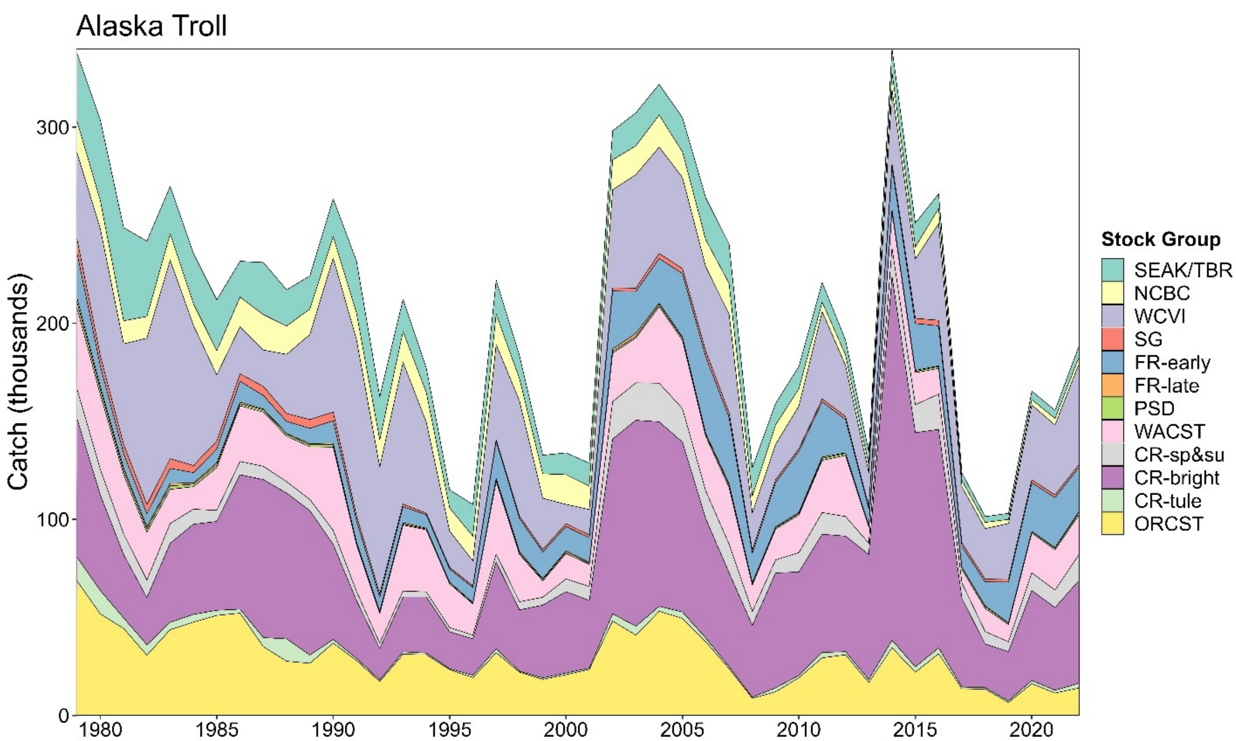
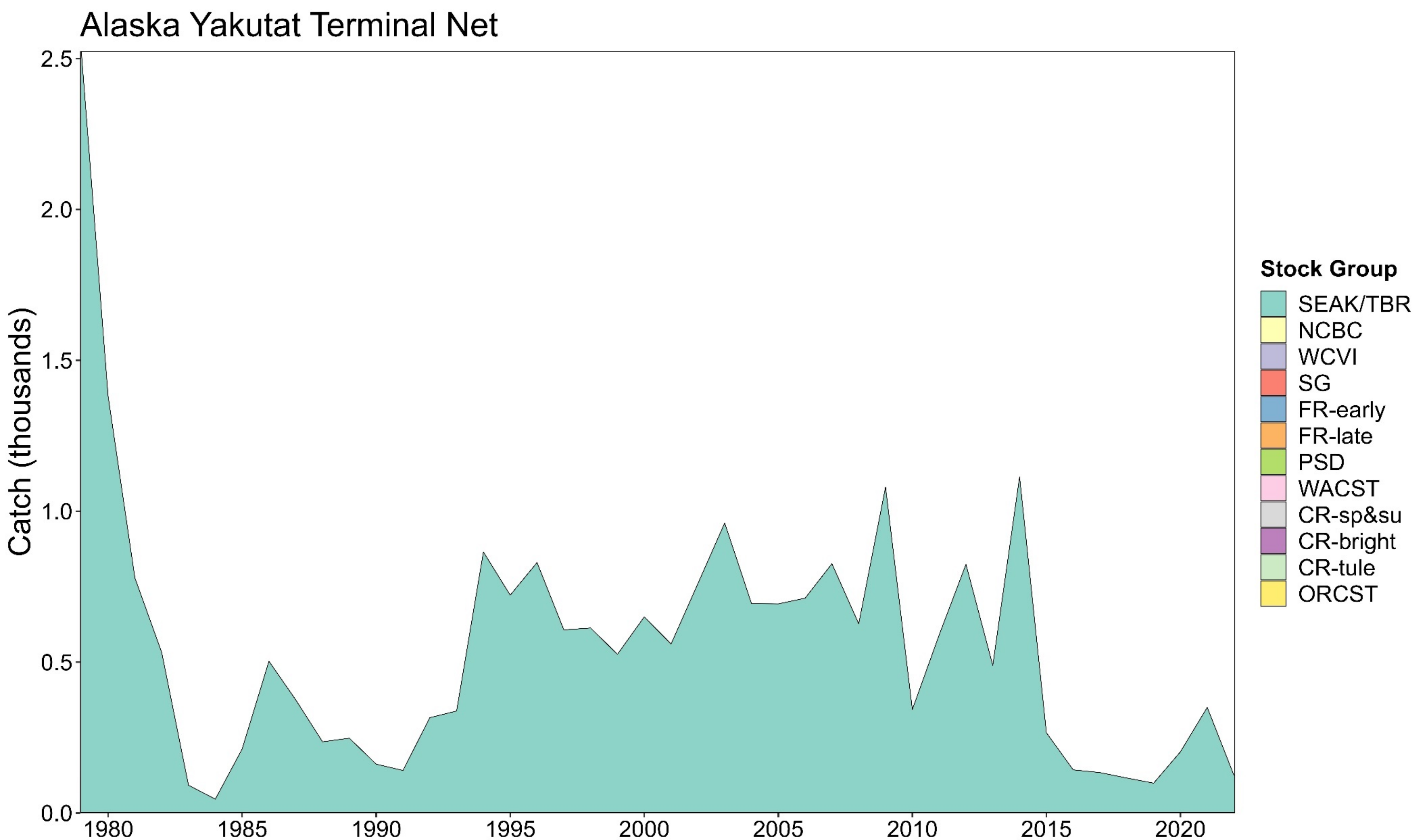
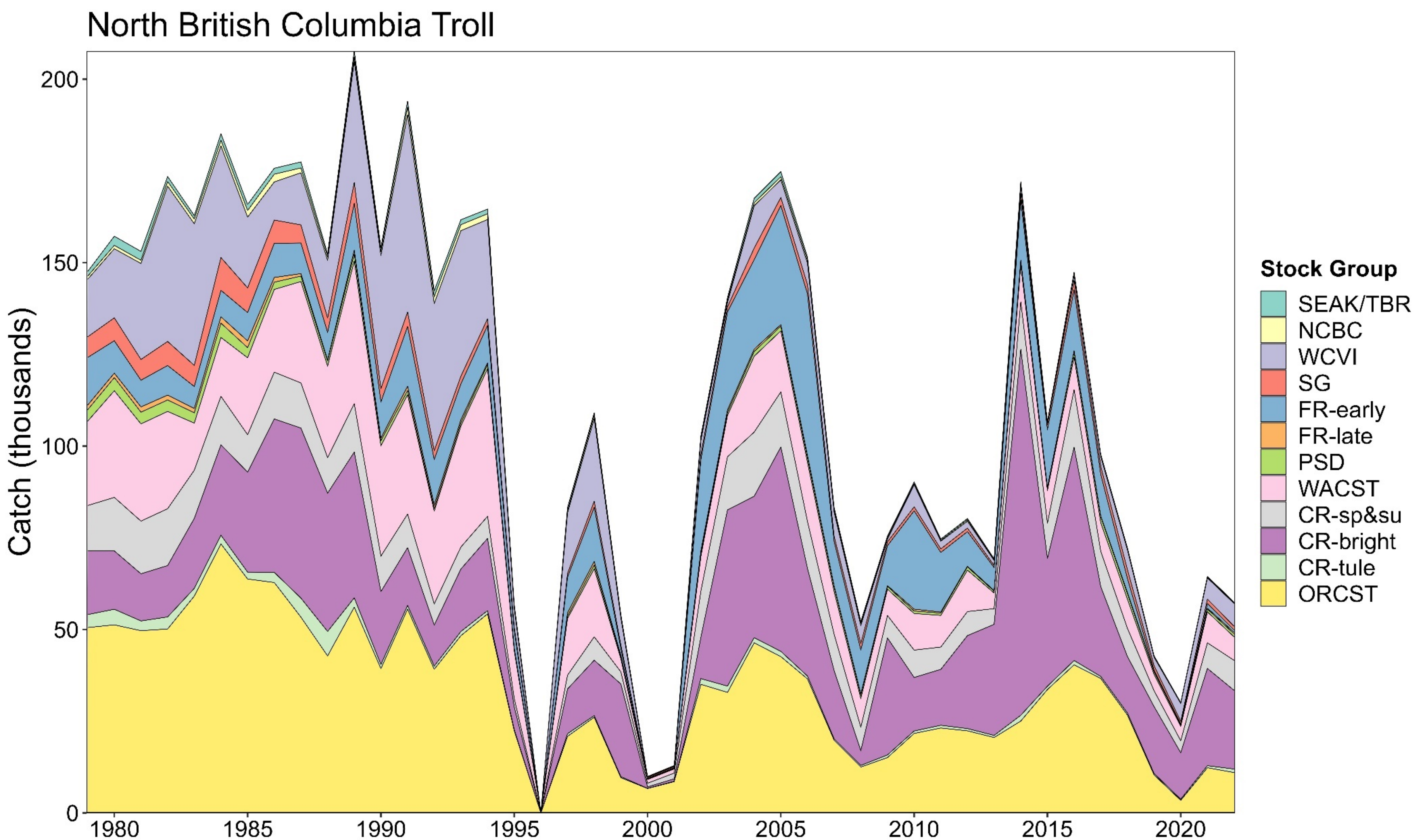




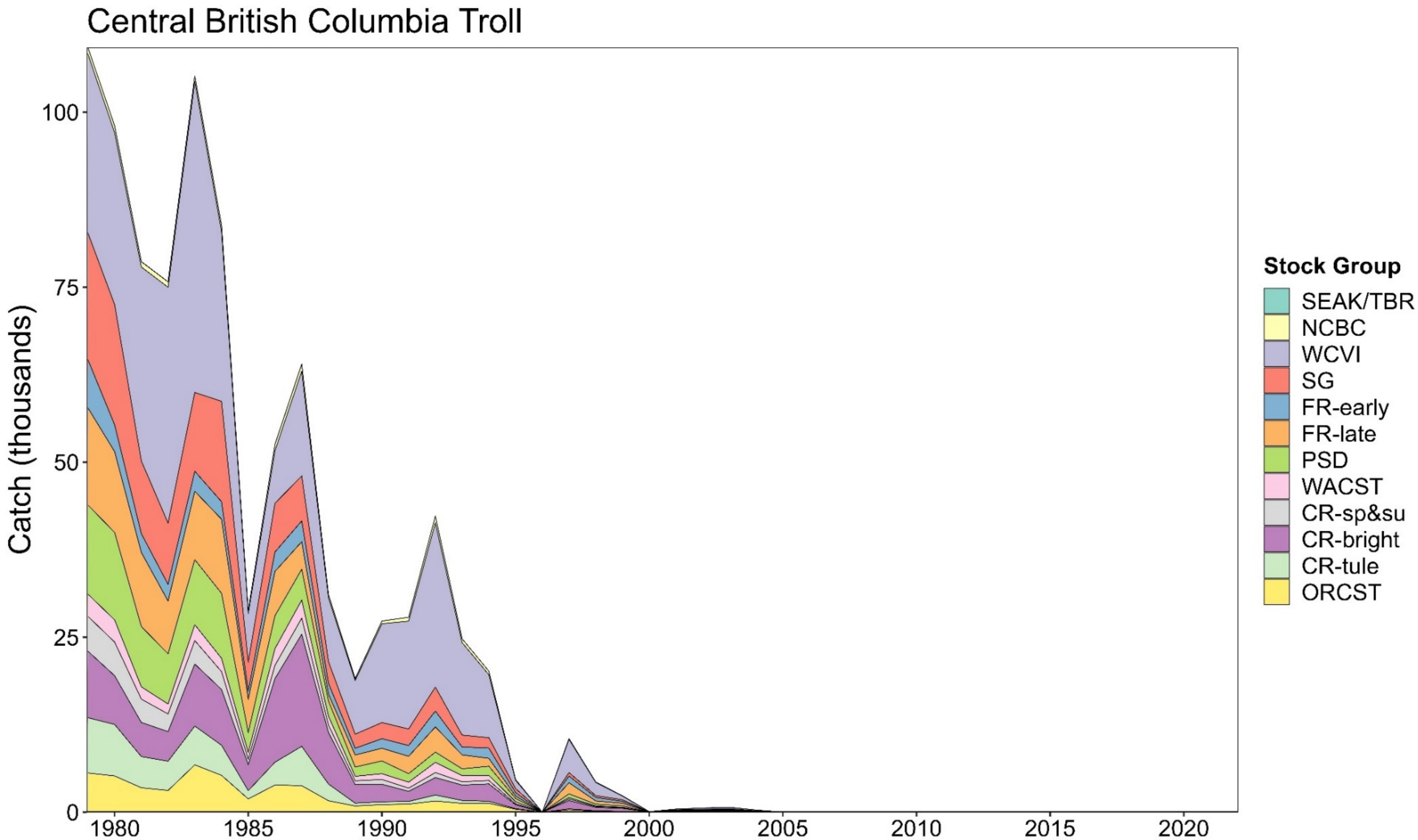
Appendix C2— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for Alaska Yakutat Terminal Net, 1979–2022.



Appendix C3— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for North British Columbia Troll, 1979–2022.



Appendix C4— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for Central British Columbia Troll, 1979–2022.



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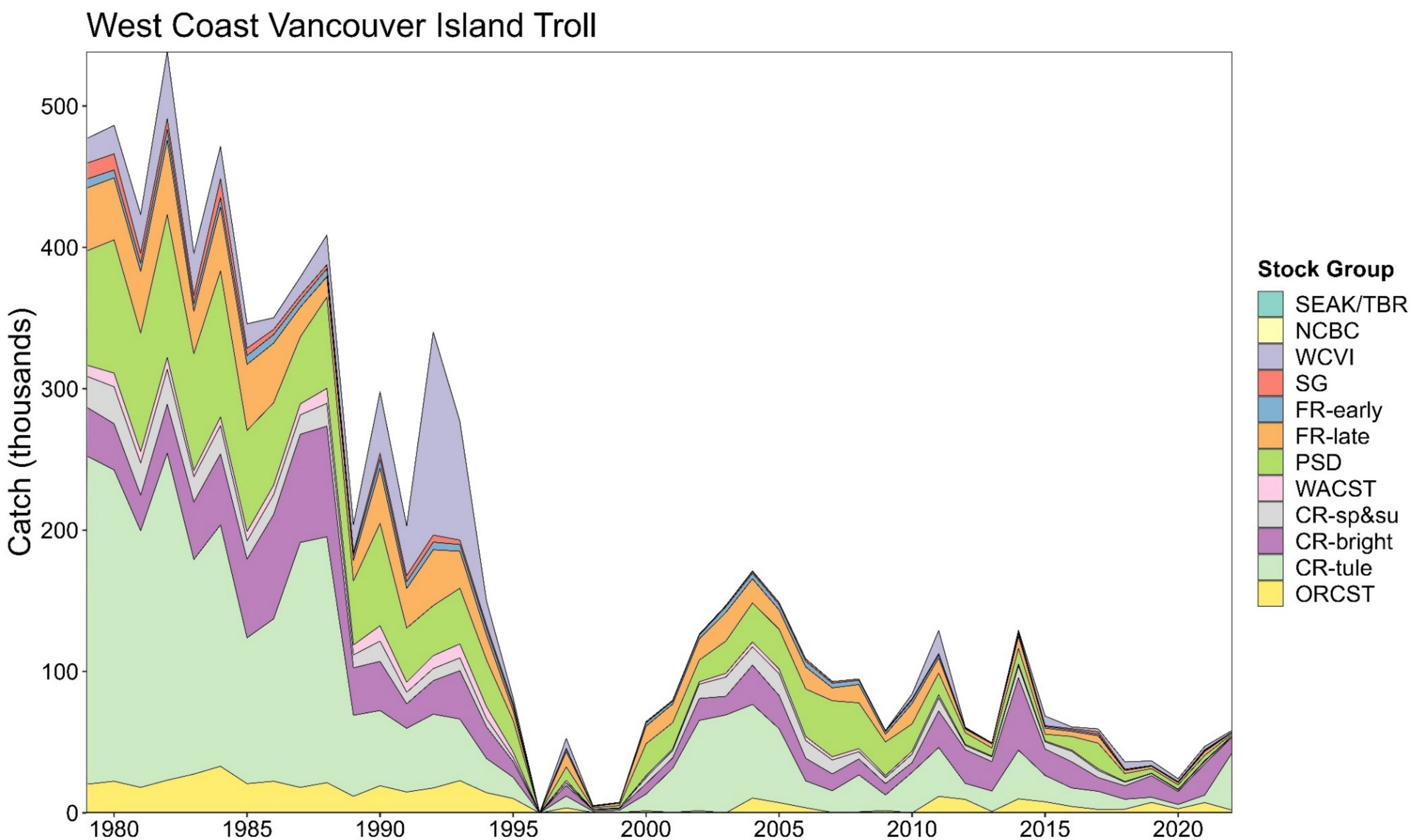
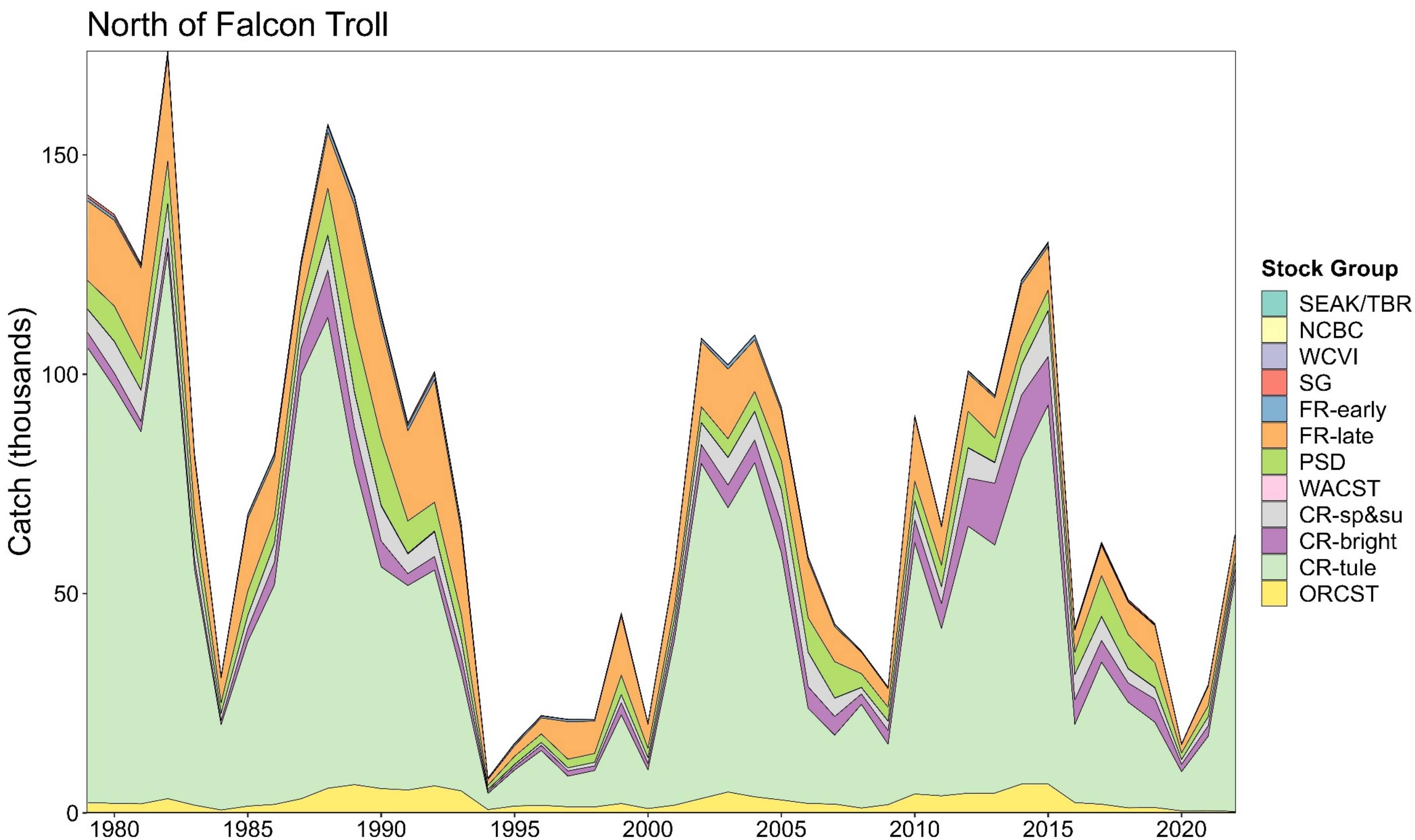
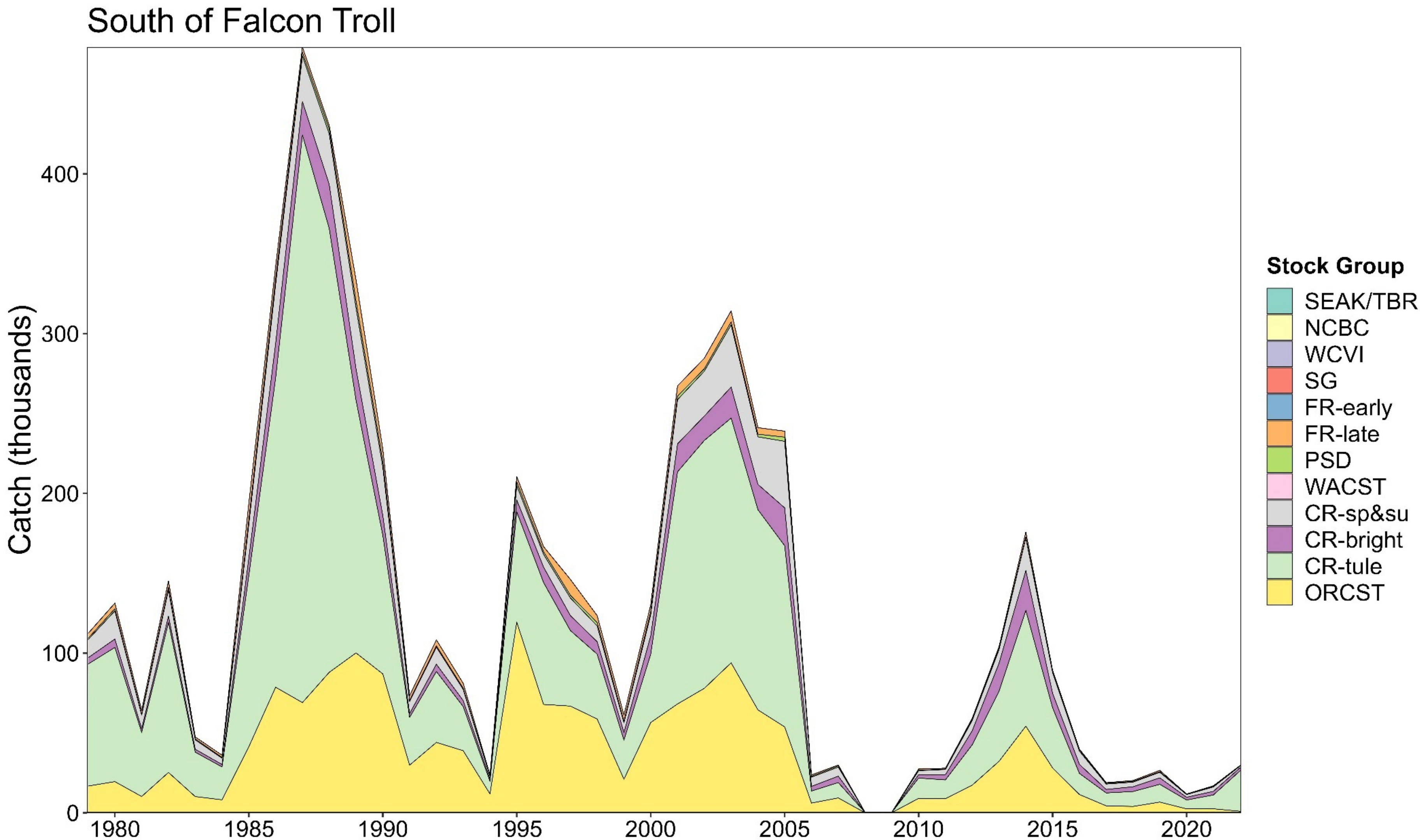


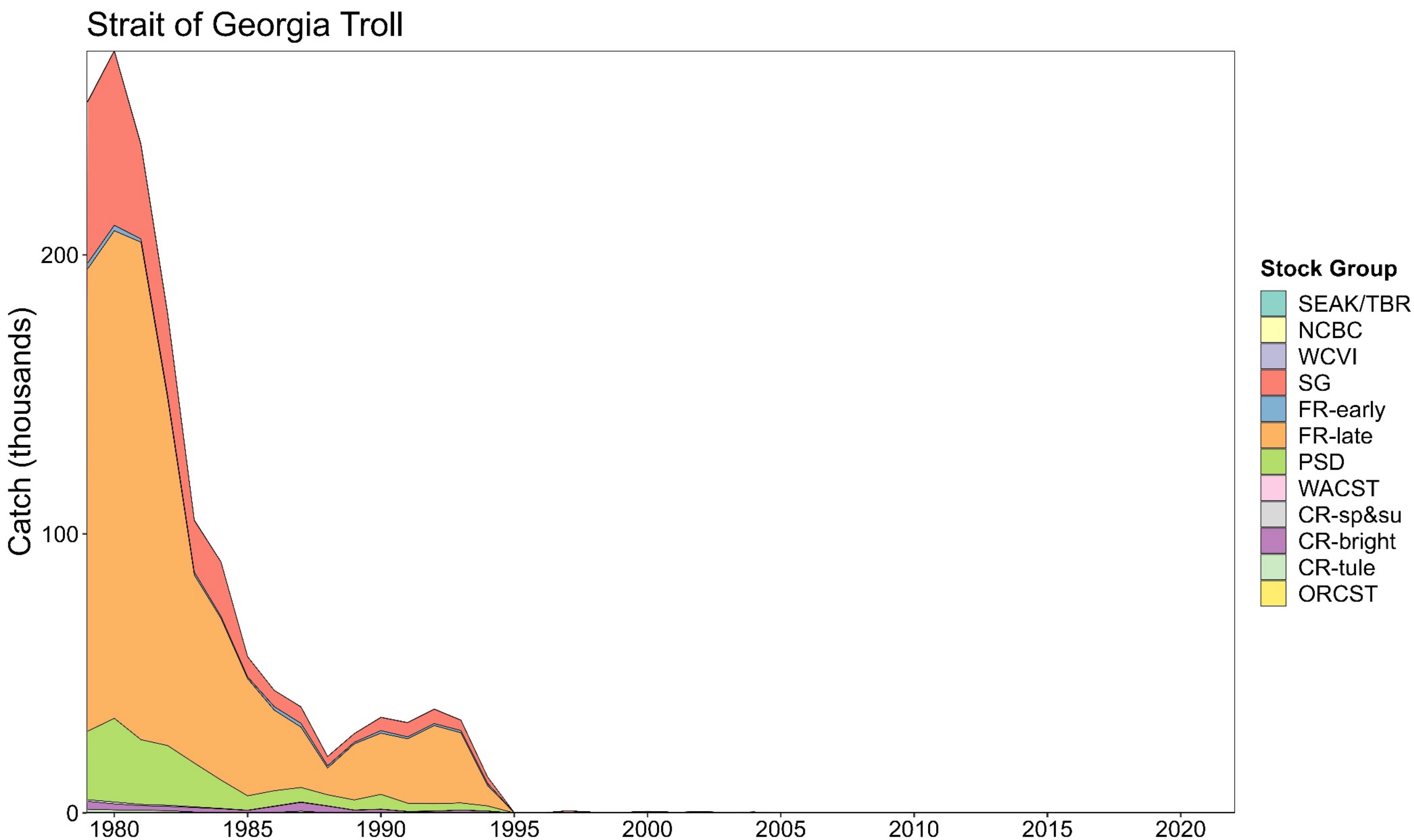
Appendix C6— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for North of Falcon Troll, 1979–2022.



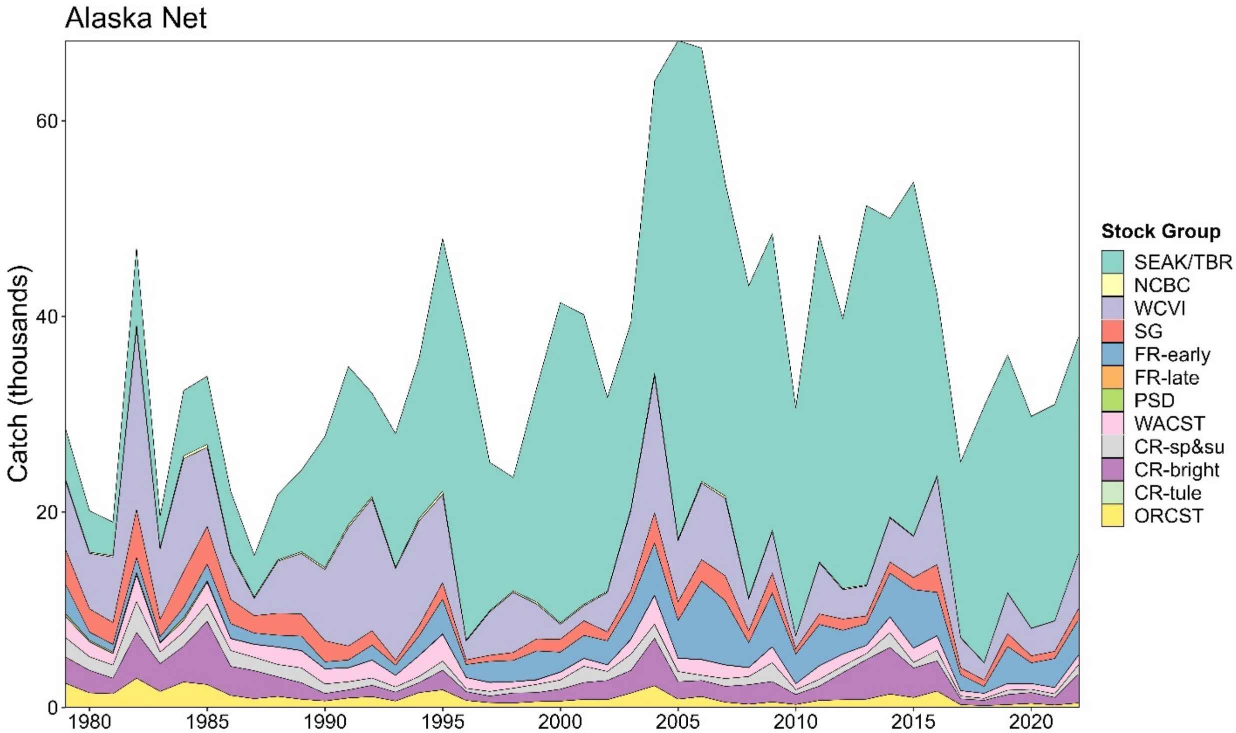
Appendix C7— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for South of Falcon Troll, 1979–2022.

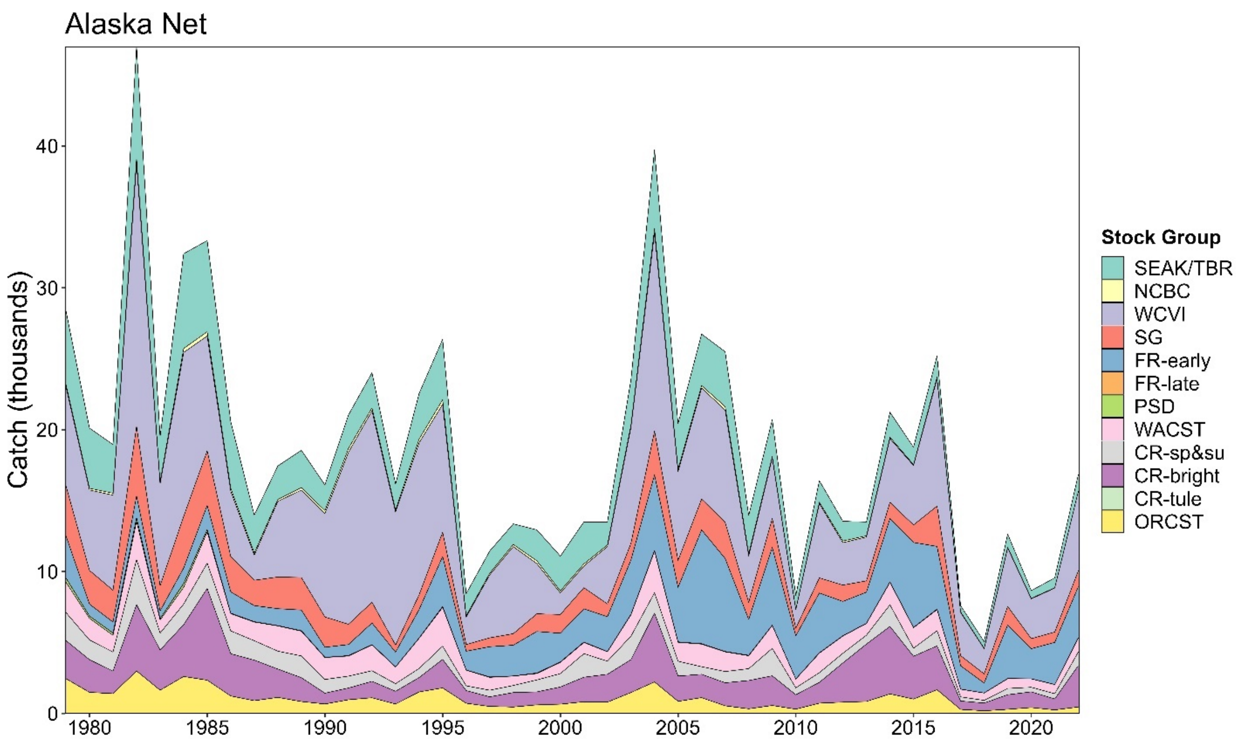


Appendix C8— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for Strait of Georgia Troll, 1979–2022.

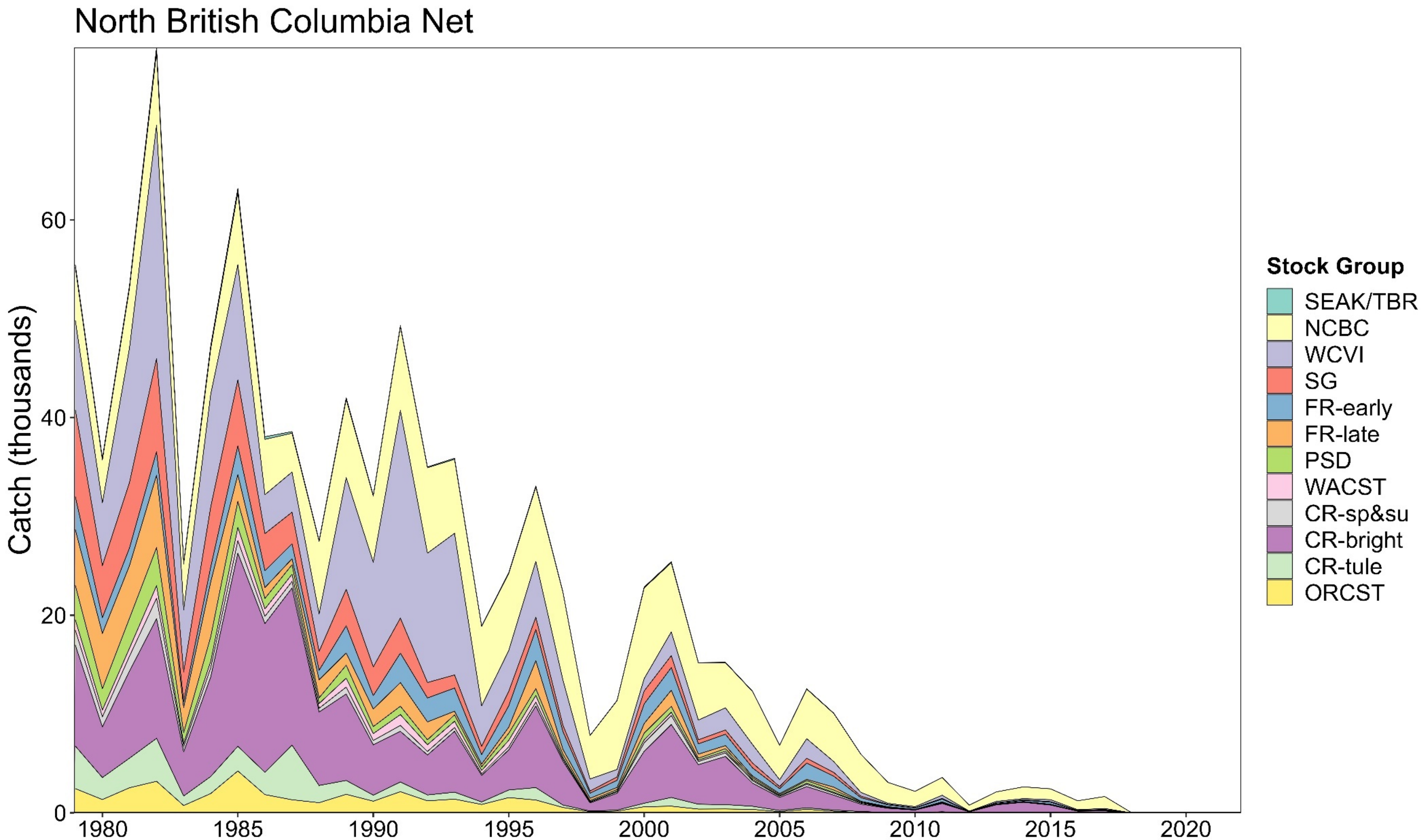


Appendix C9— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for Alaska net with (upper) and without (lower) hatchery add-on and terminal exclusion, 1979–2022.

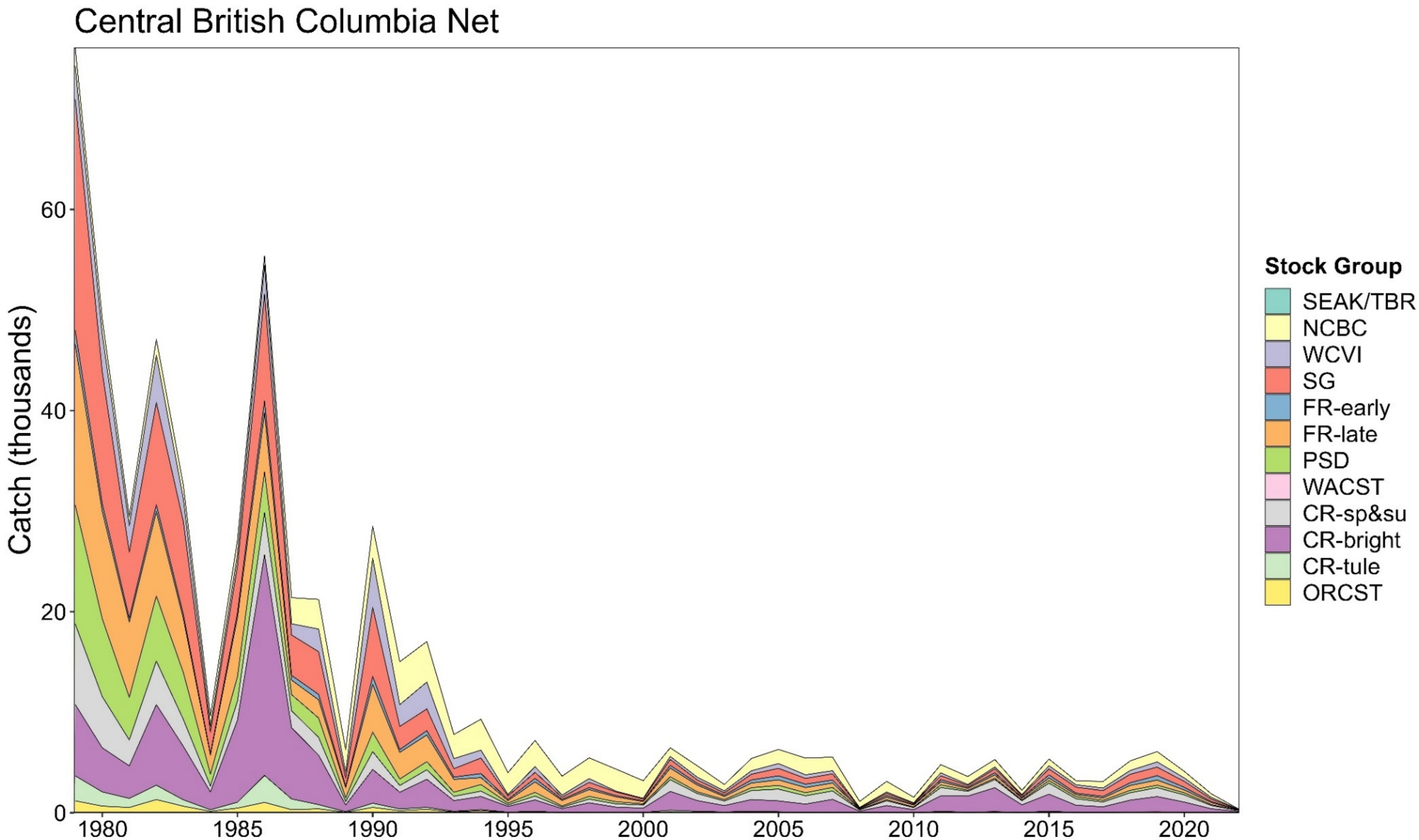




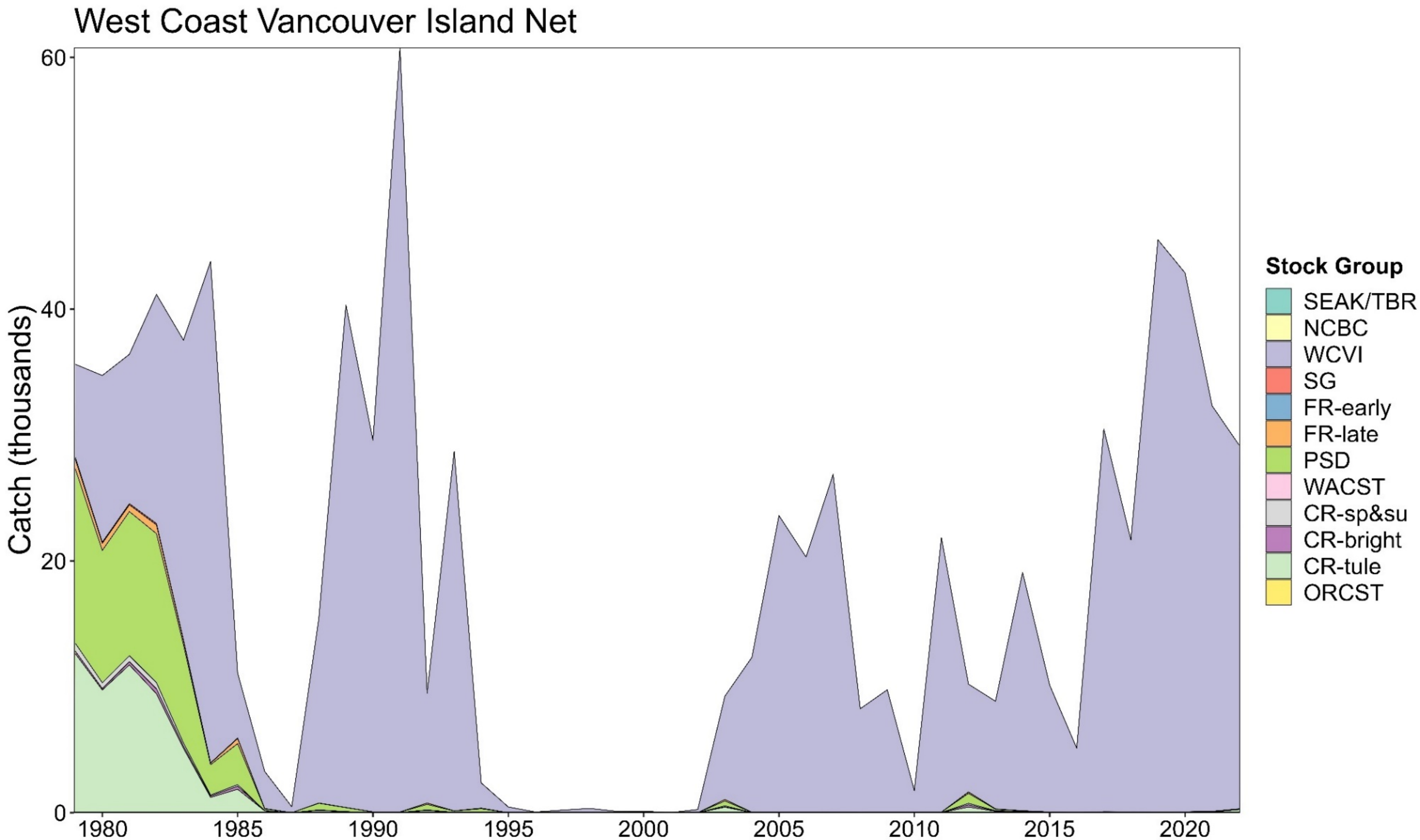
Appendix C10— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for North British Columbia Net, 1979–2022.



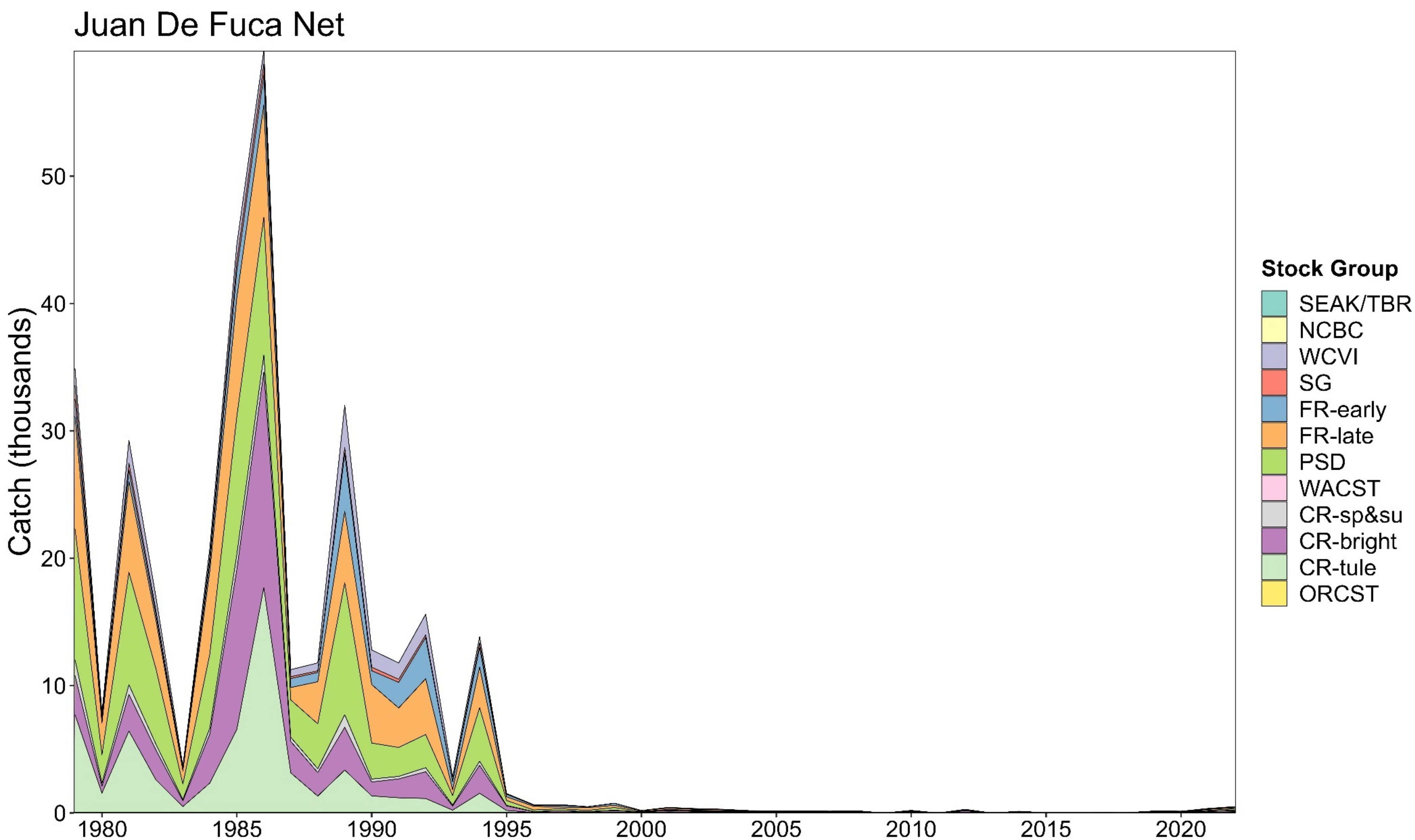
Appendix C11— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for Central British Columbia Net, 1979–2022.



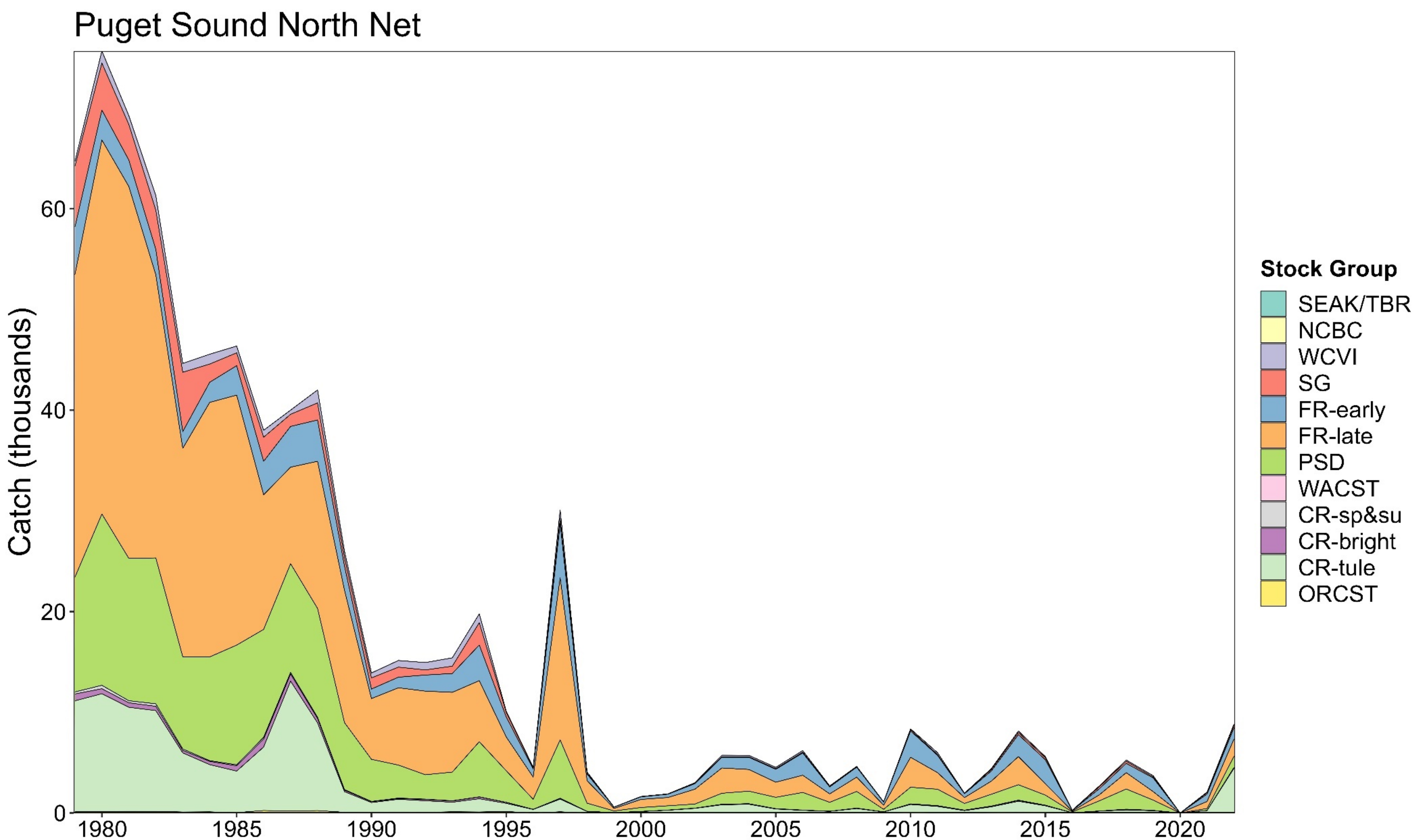
Appendix C12— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for West Coast Vancouver Island Net, 1979–2022.



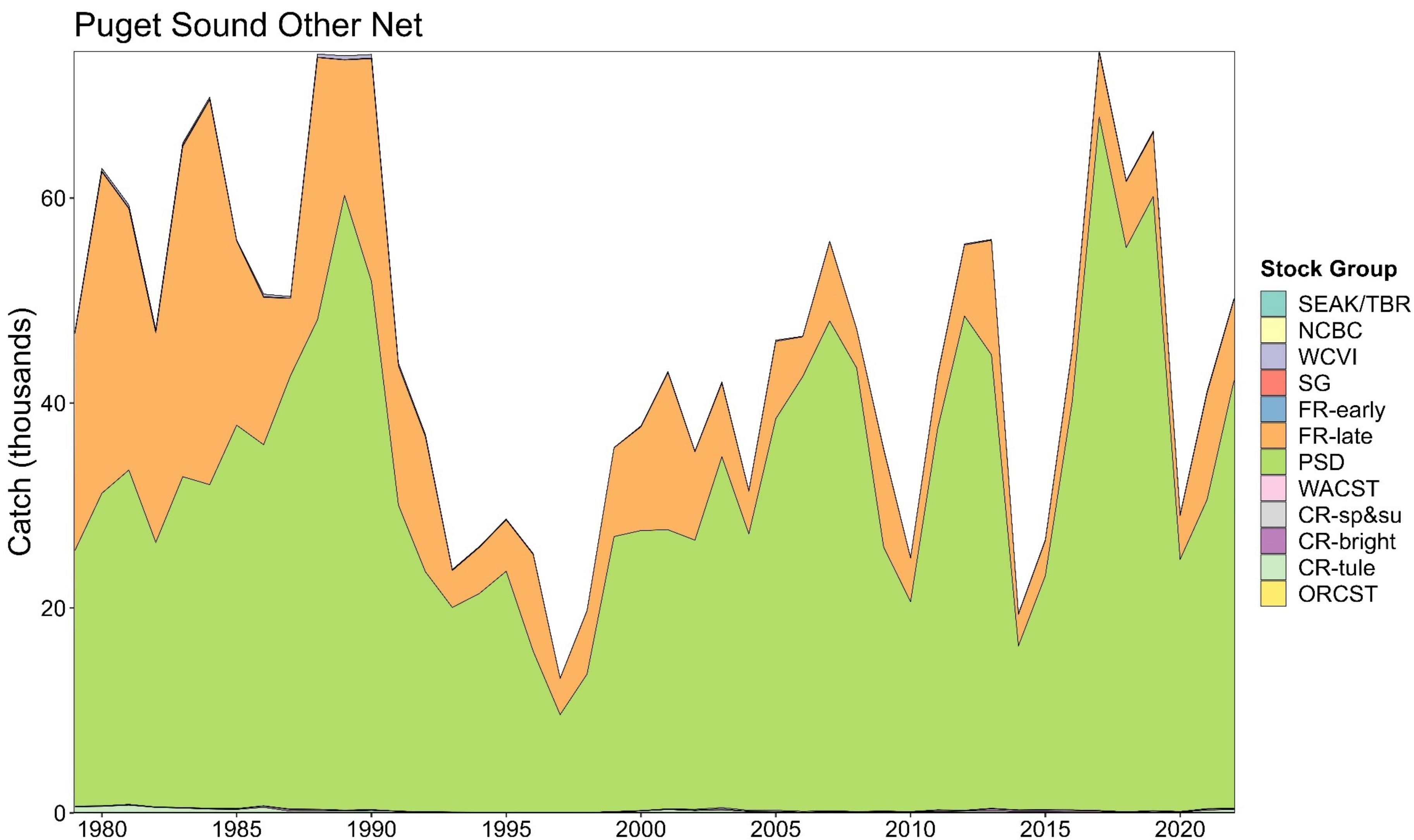
Appendix C13— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for Juan De Fuca Net, 1979–2022.



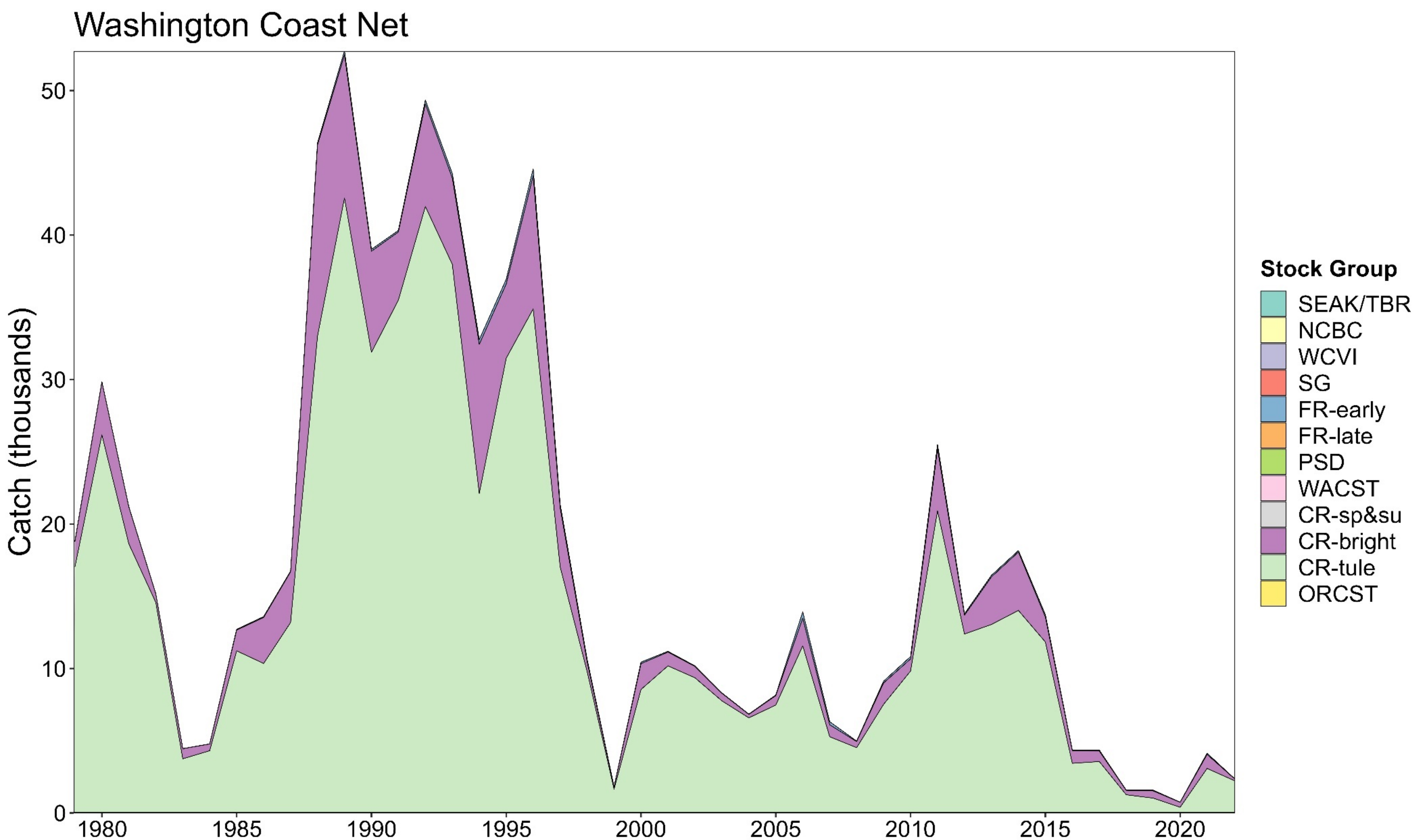
Appendix C14— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for Puget Sound North Net, 1979–2022.



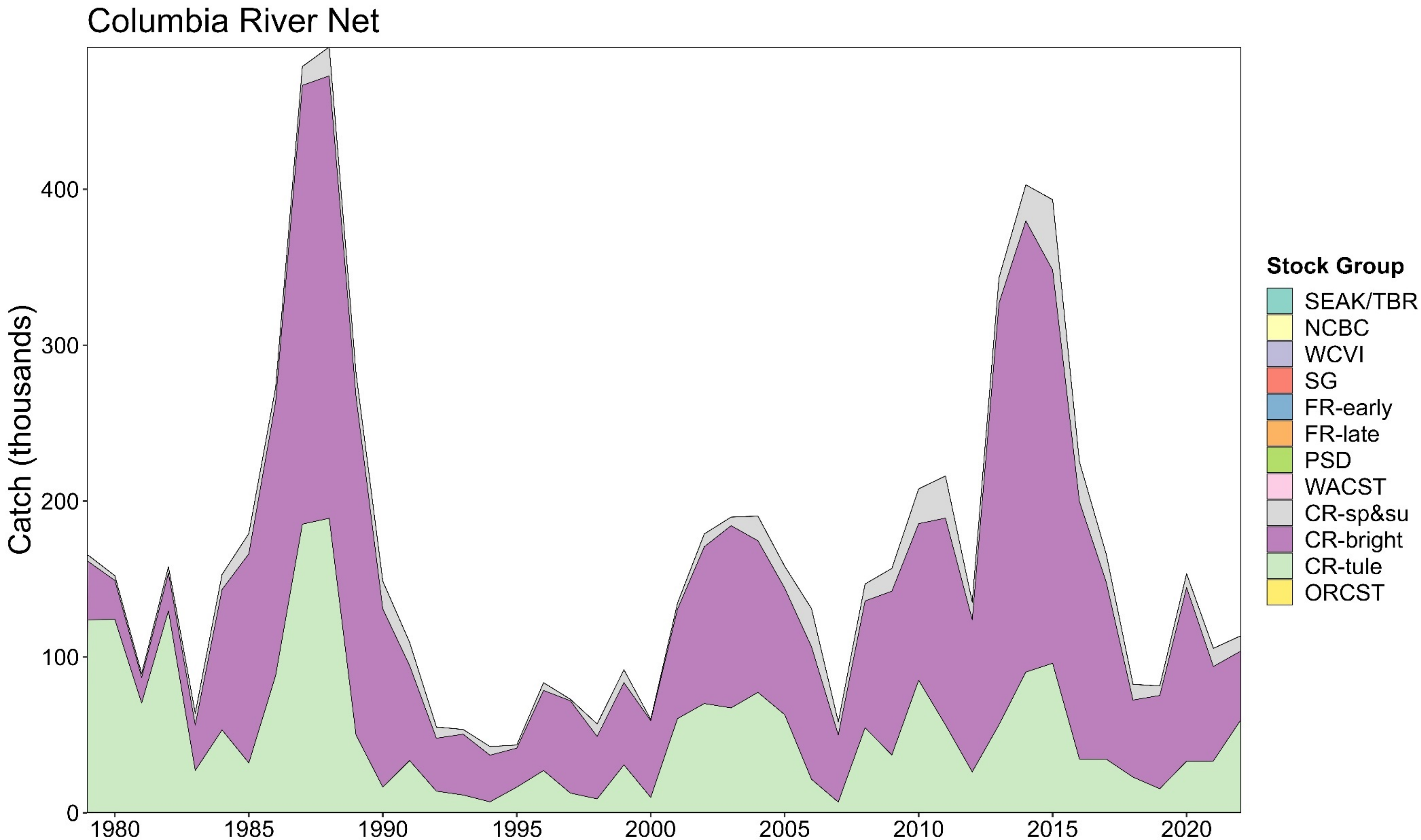
Appendix C15— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for Puget Sound Other Net, 1979–2022.



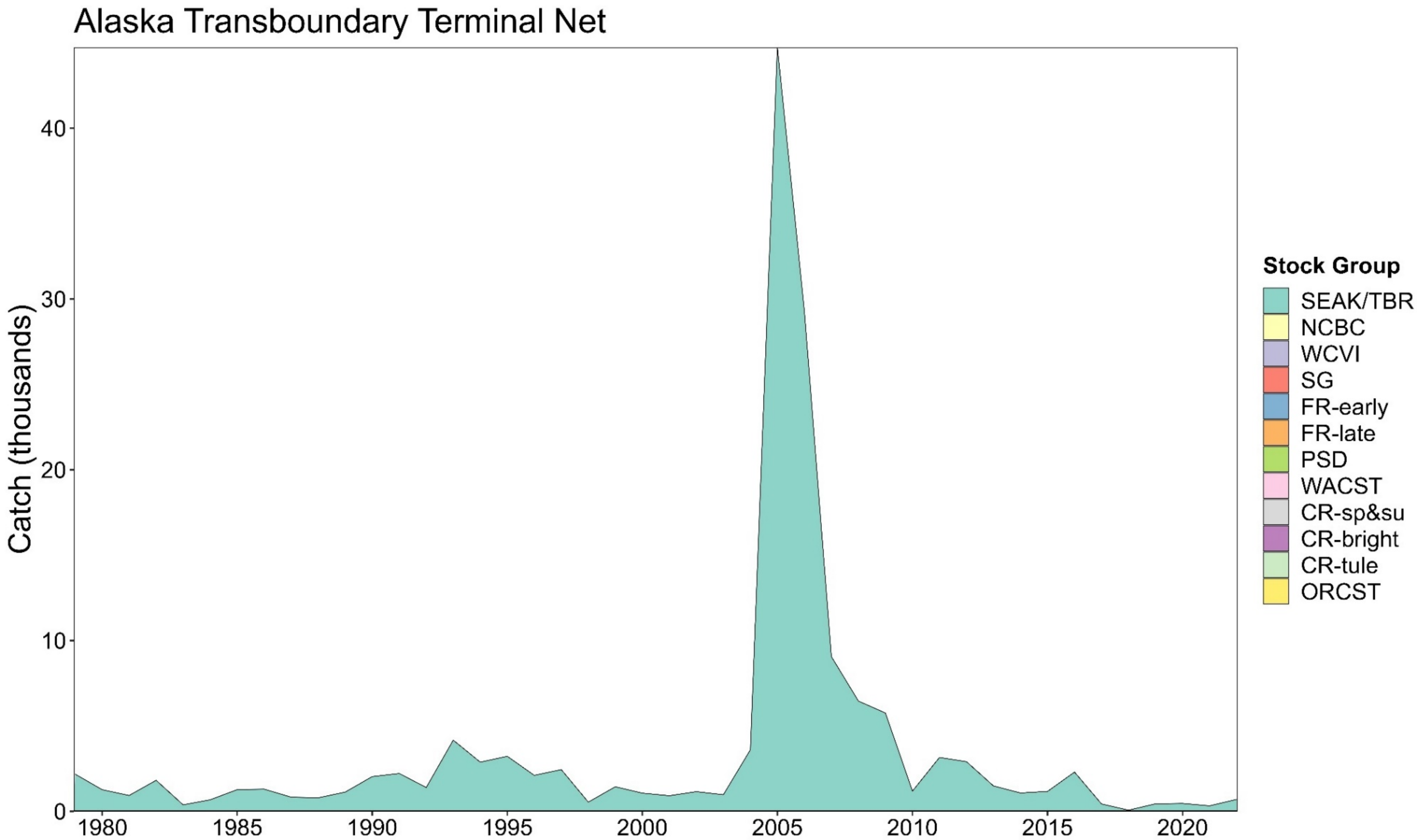
Appendix C16— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for Washington Coast Net, 1979–2022.



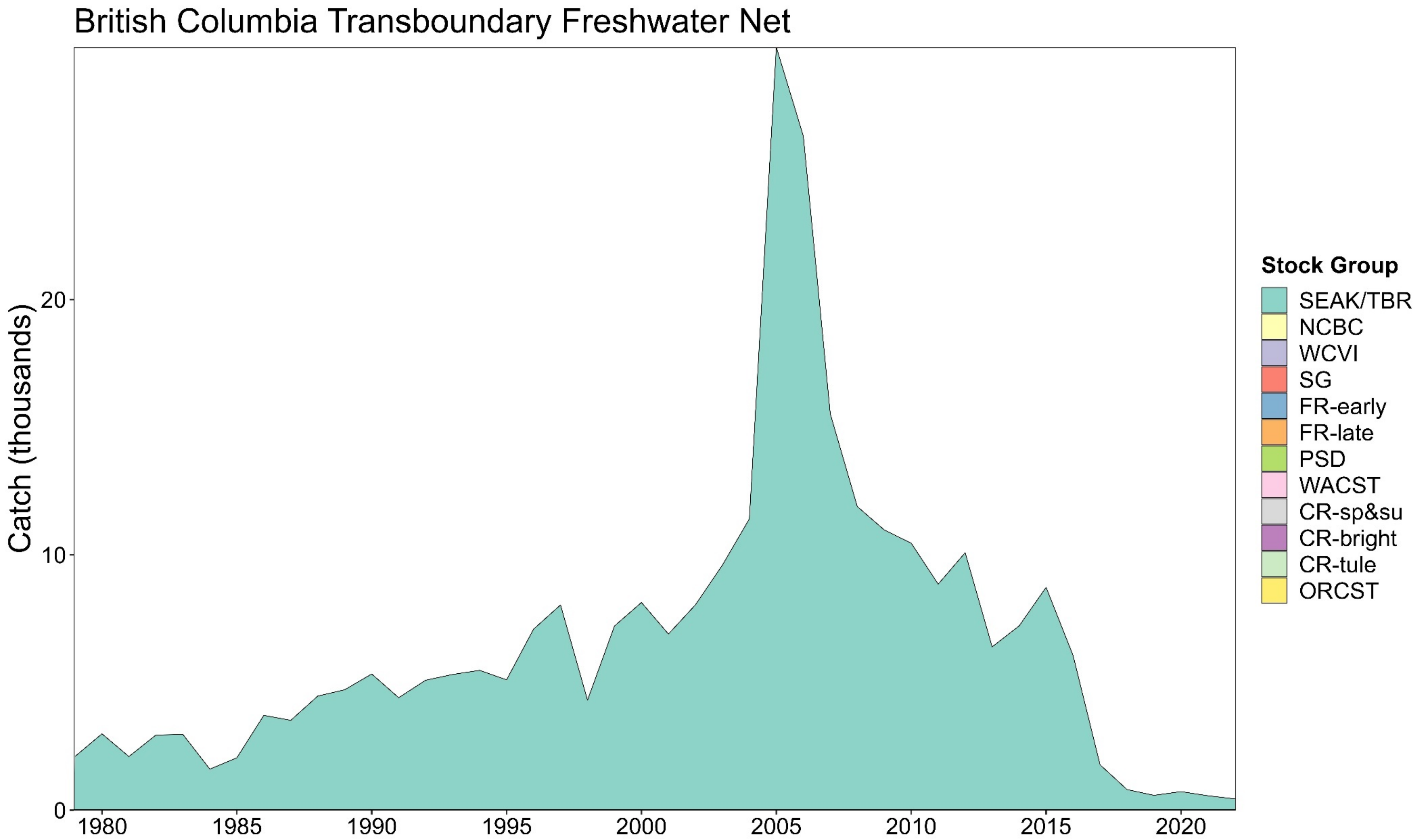
Appendix C17— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for Columbia River Net, 1979–2022.



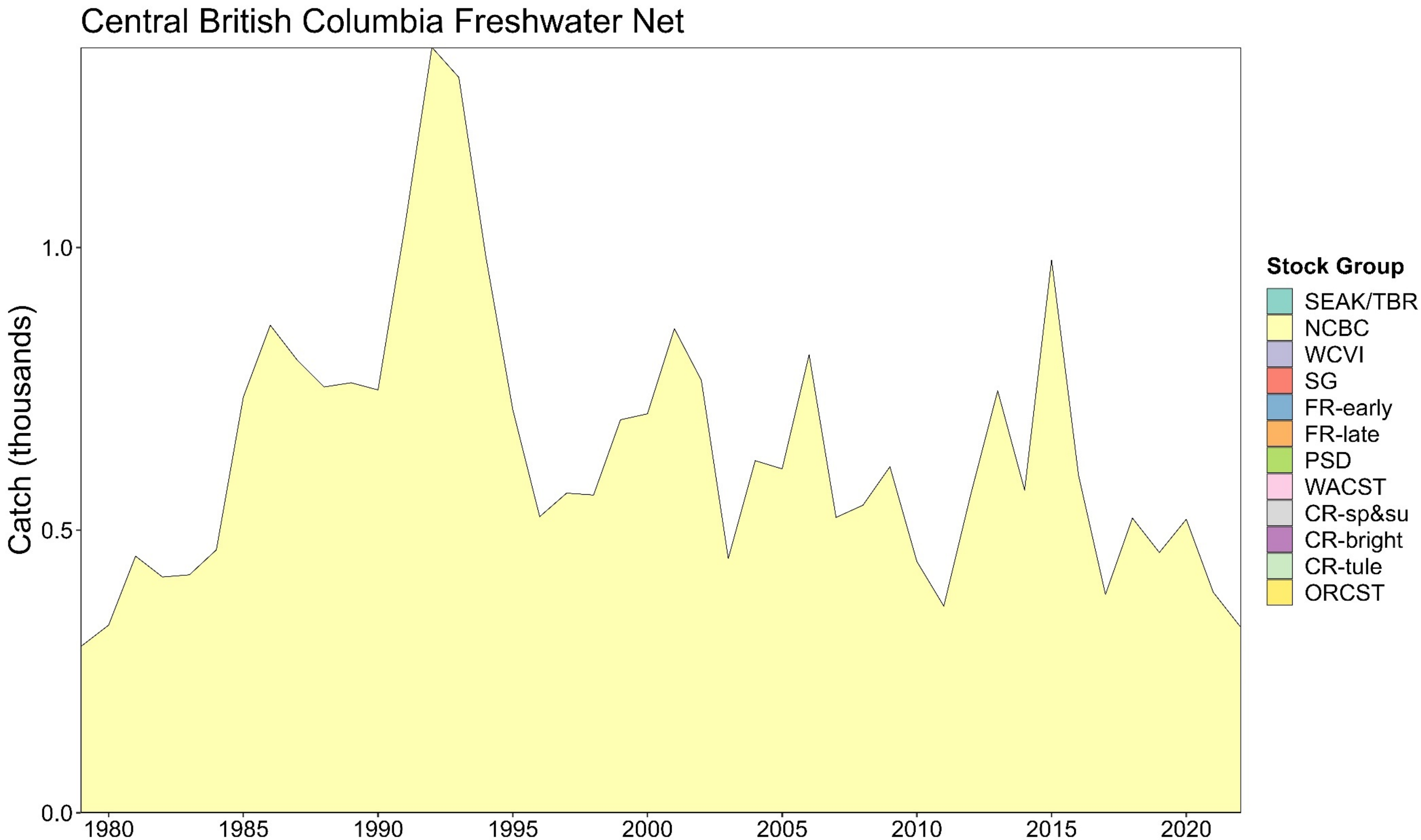
Appendix C18— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for Alaska Transboundary River Terminal Net, 1979–2022.



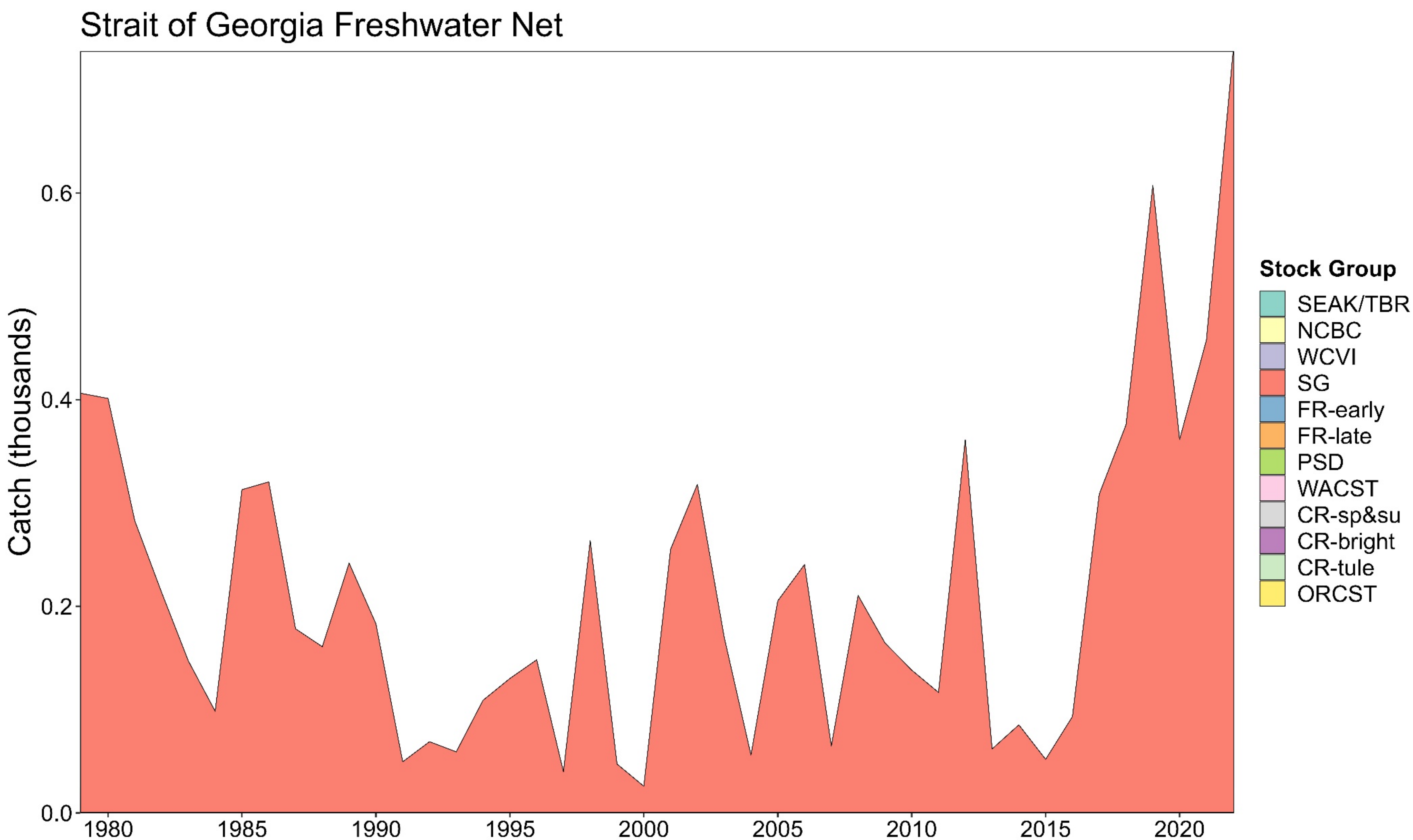
Appendix C19— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for Canada Transboundary River Freshwater Net, 1979–2022.



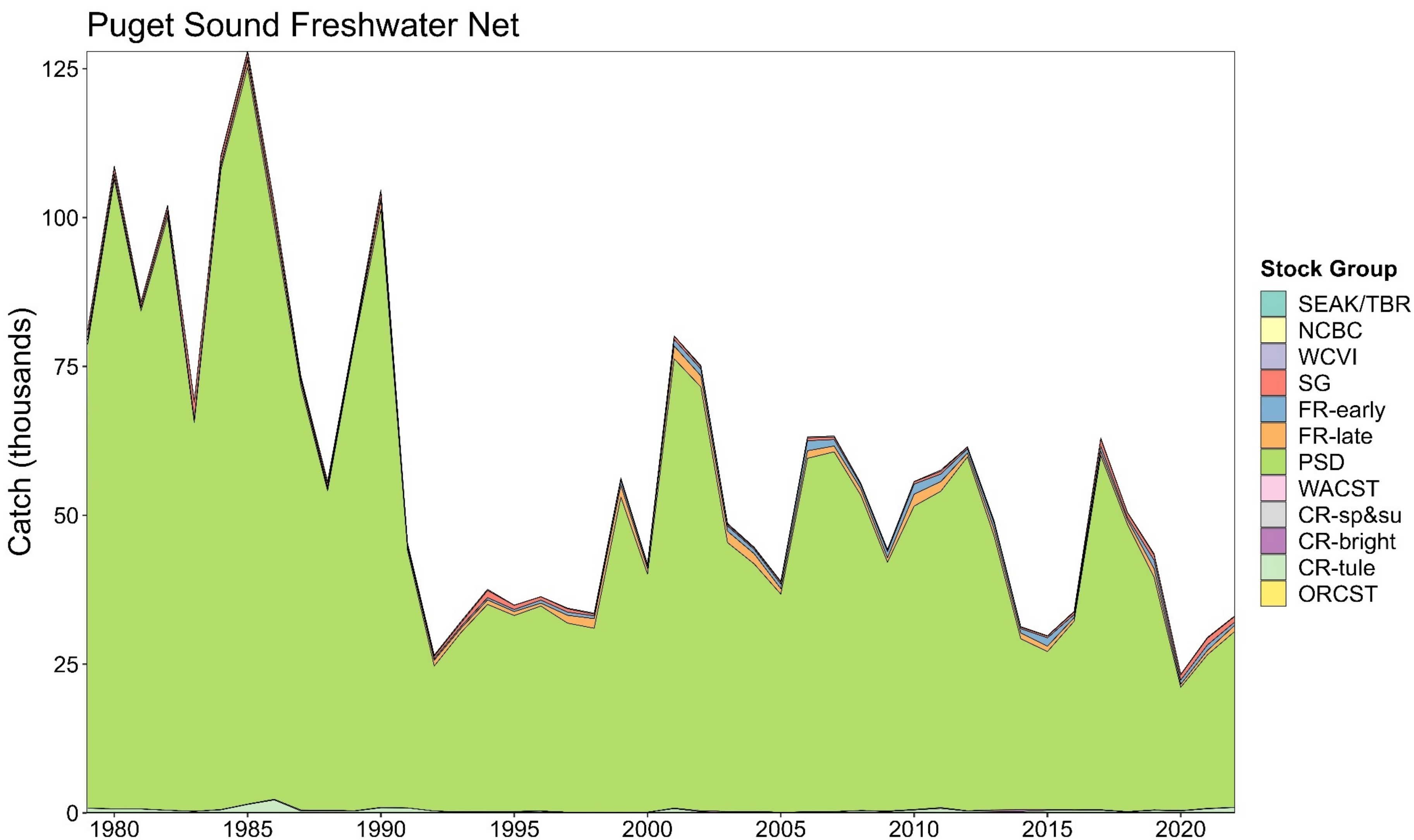
Appendix C20— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for Central British Columbia Freshwater Net, 1979–2022.



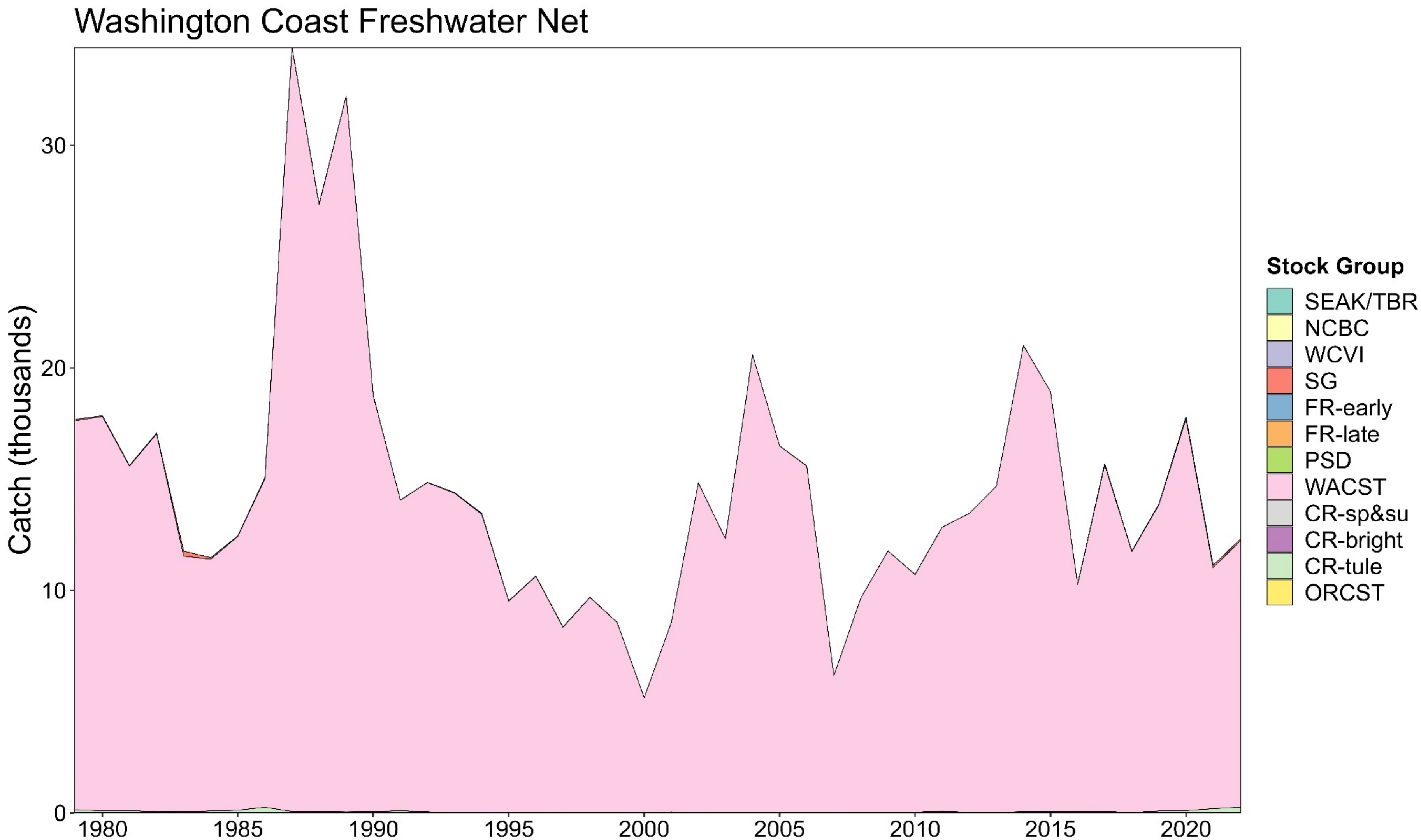
Appendix C21— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for Strait of Georgia Freshwater Net, 1979–2022.



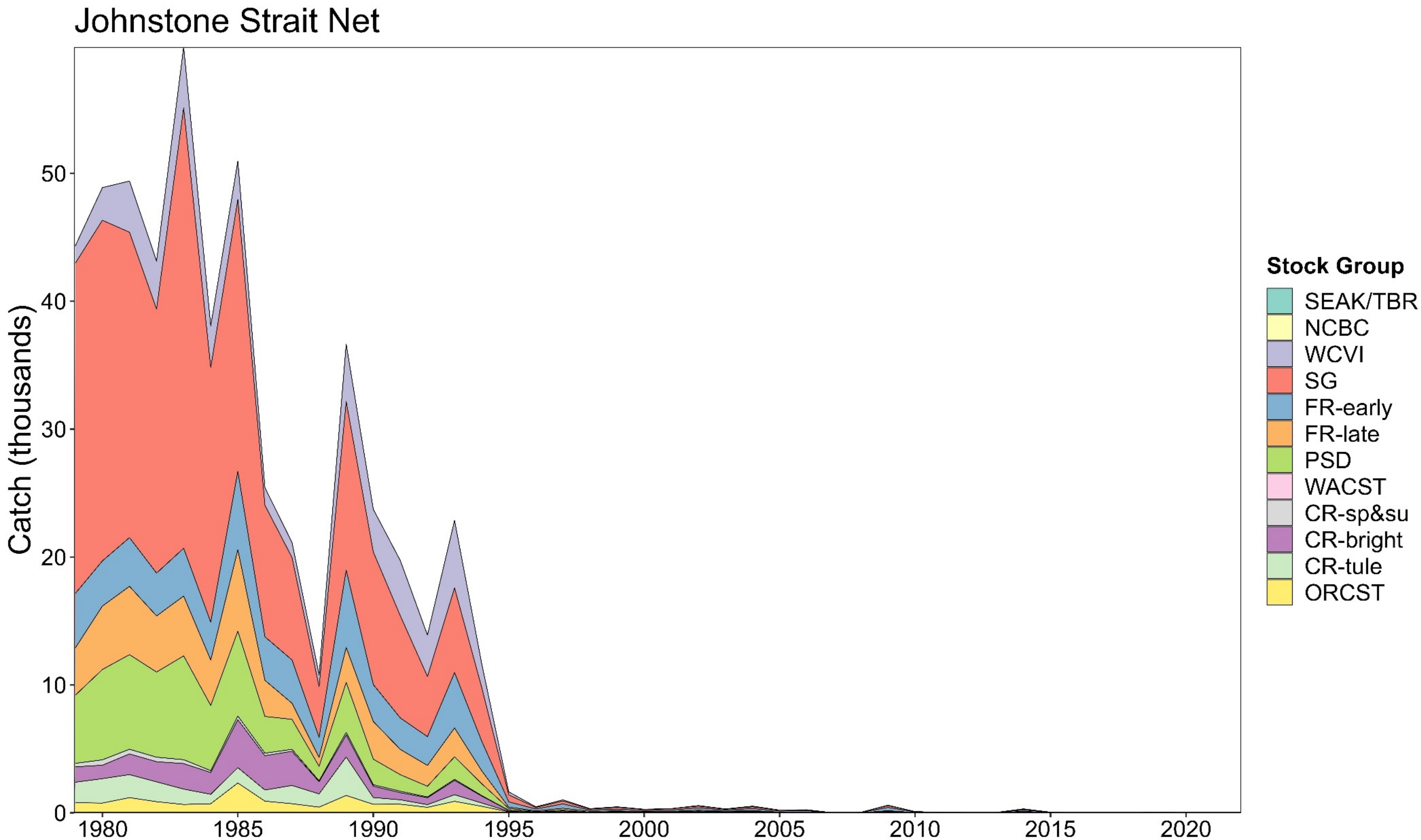
Appendix C22— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for Puget Sound Freshwater Net, 1979–2022.



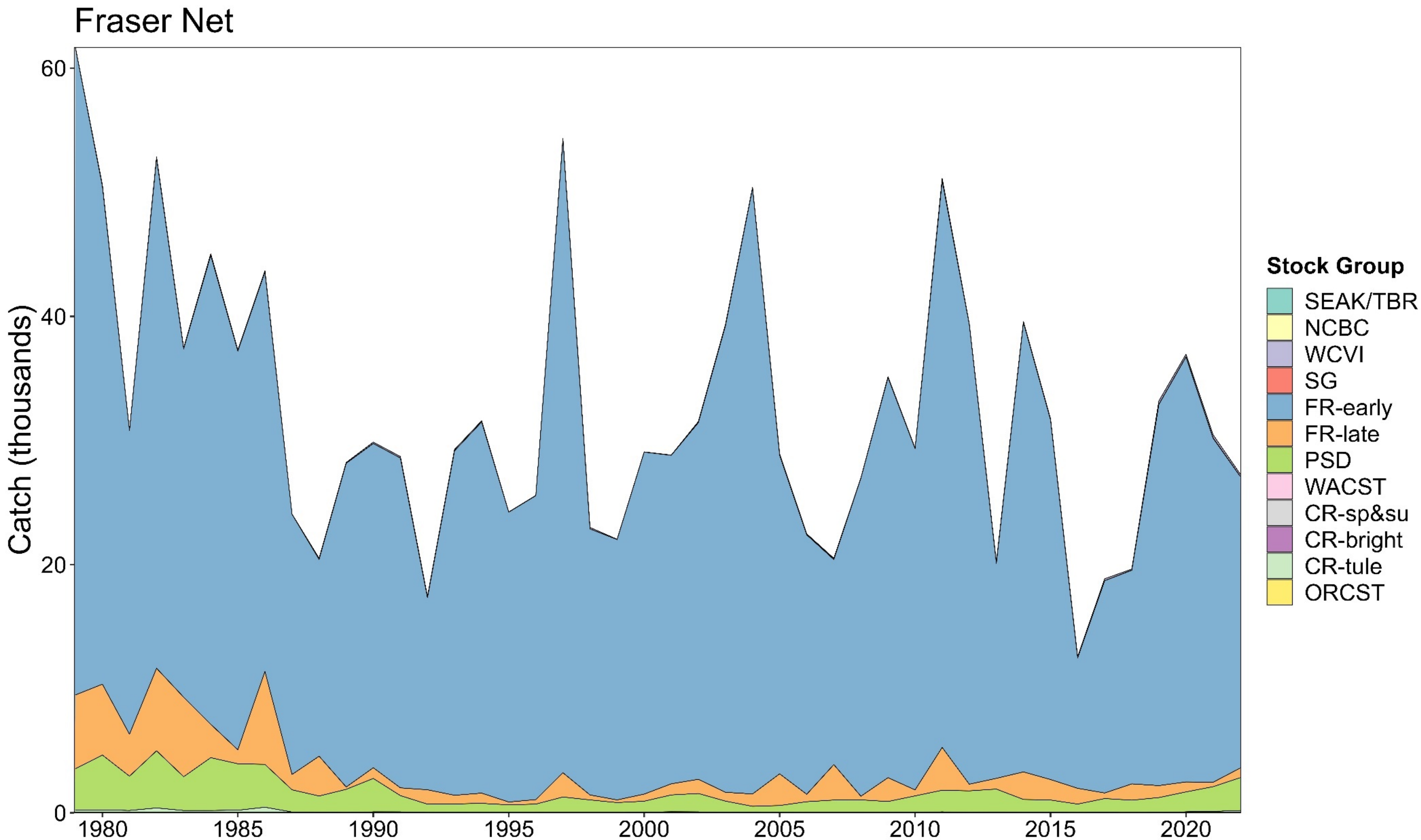
Appendix C23— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for Washington Coast Freshwater Net, 1979–2022.



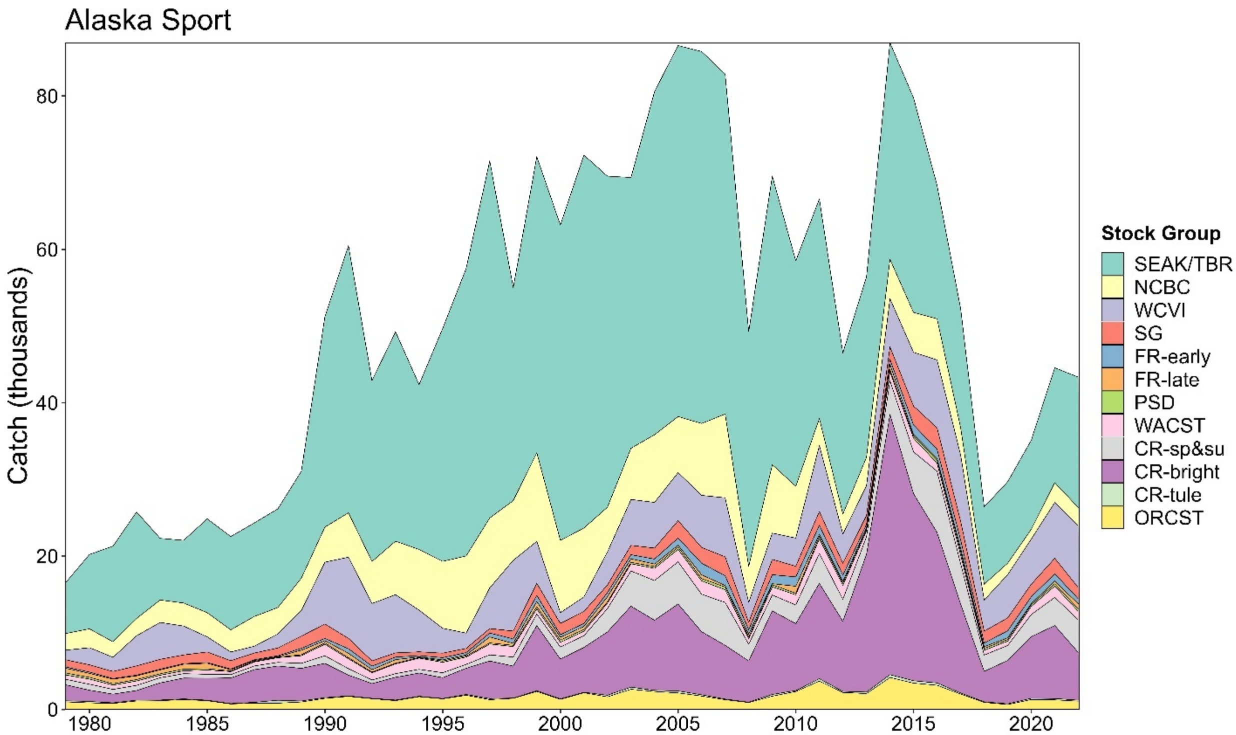
Appendix C24— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for Johnstone Strait Net, 1979–2022.

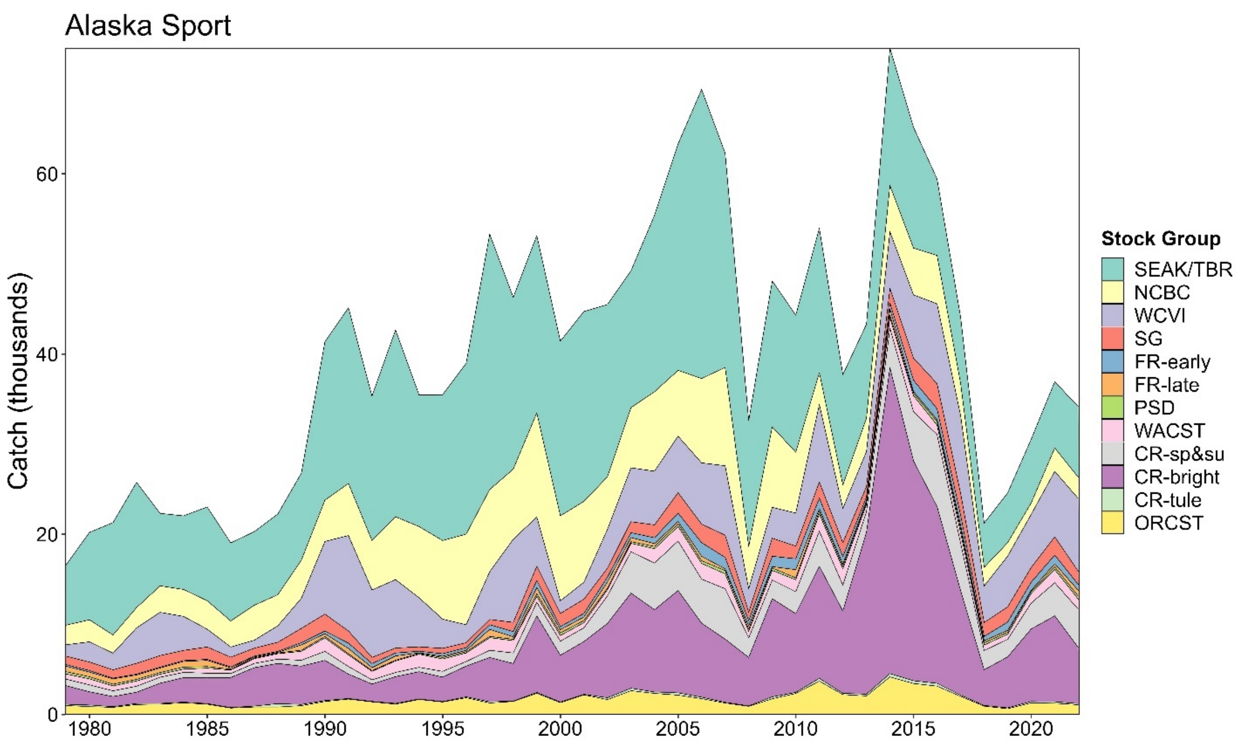


Appendix C25— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for Fraser Net, 1979–2022.

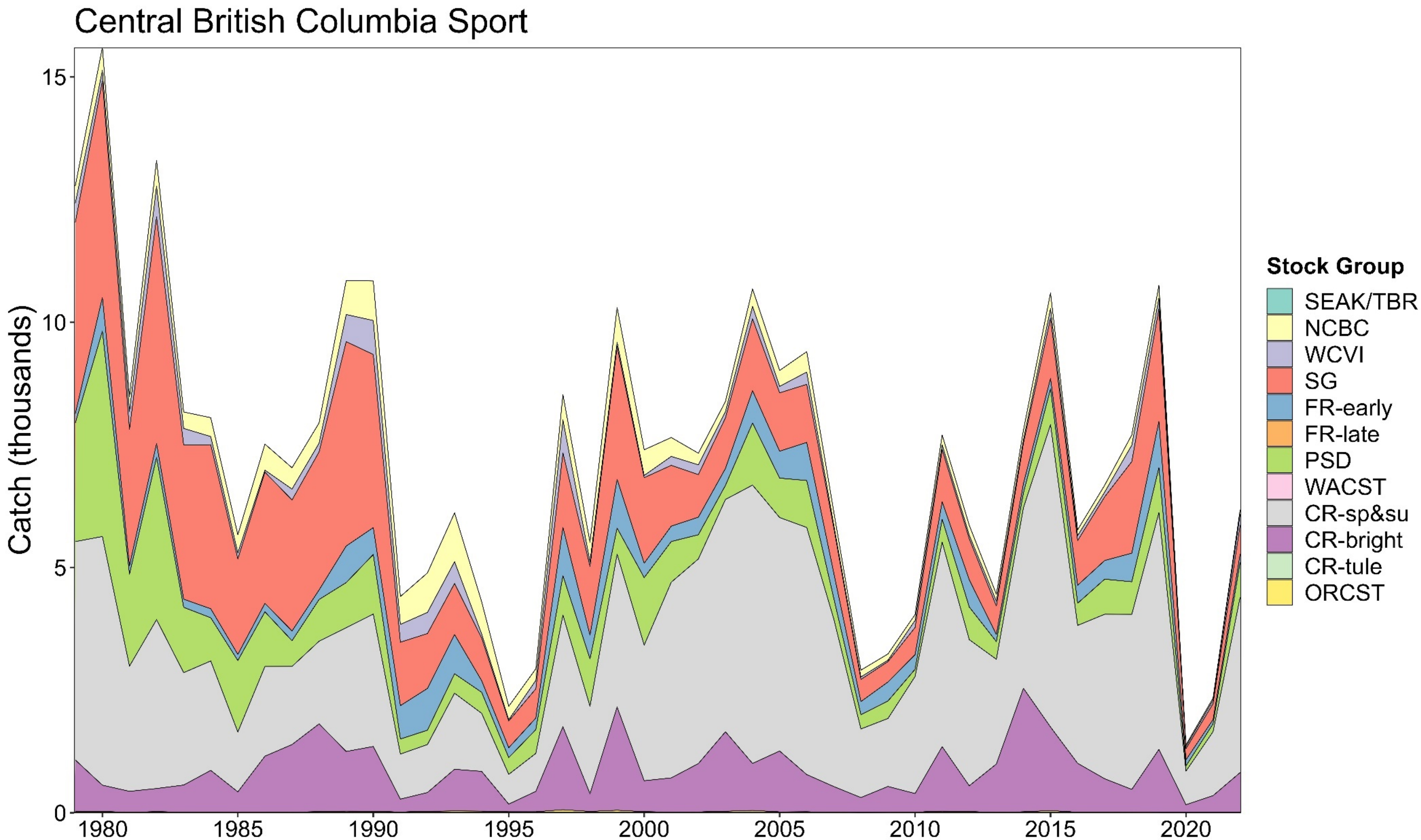


Appendix C26— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for Alaska sport with (upper) and without (lower) Alaska hatchery add-on and terminal exclusion, 1979–2022.

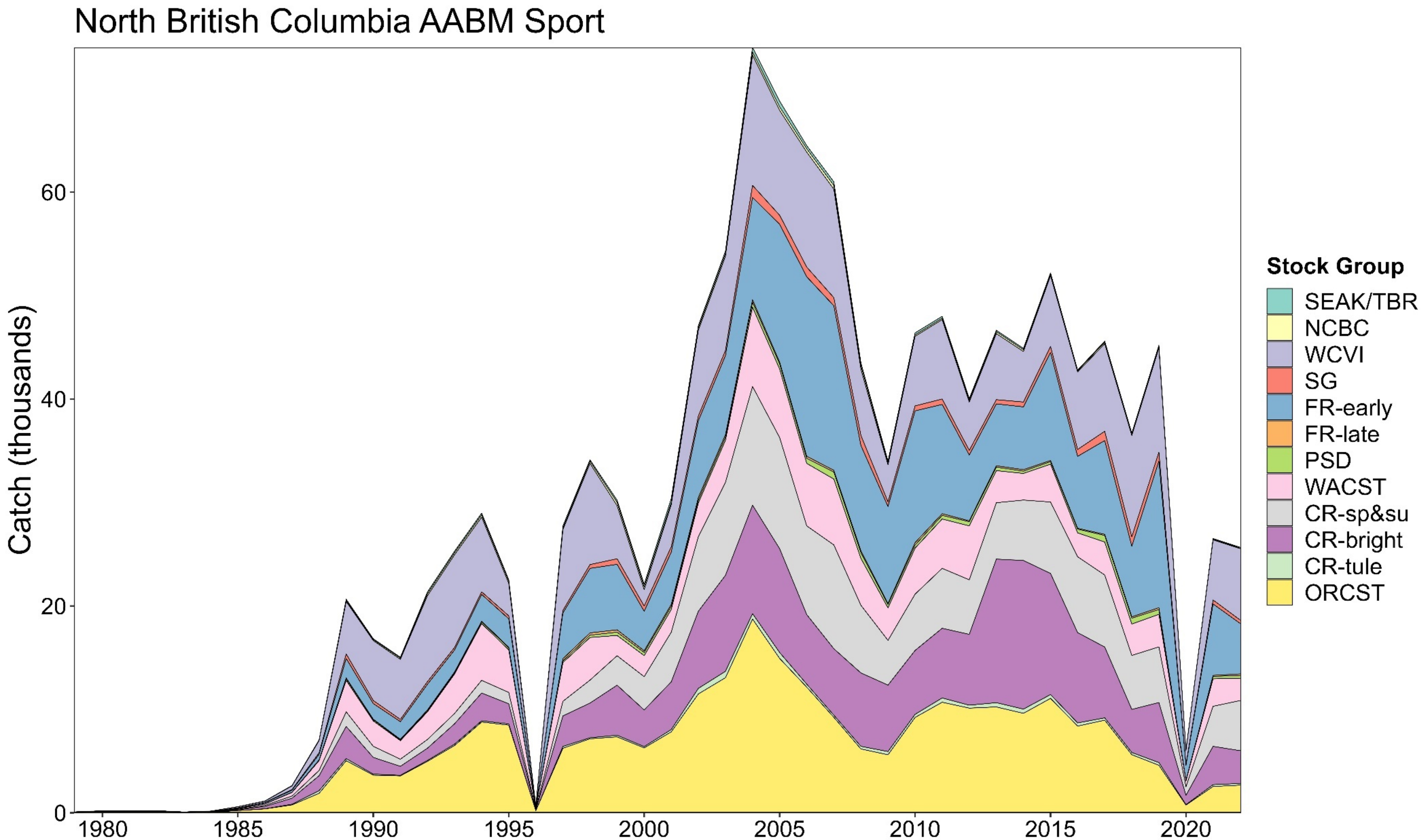




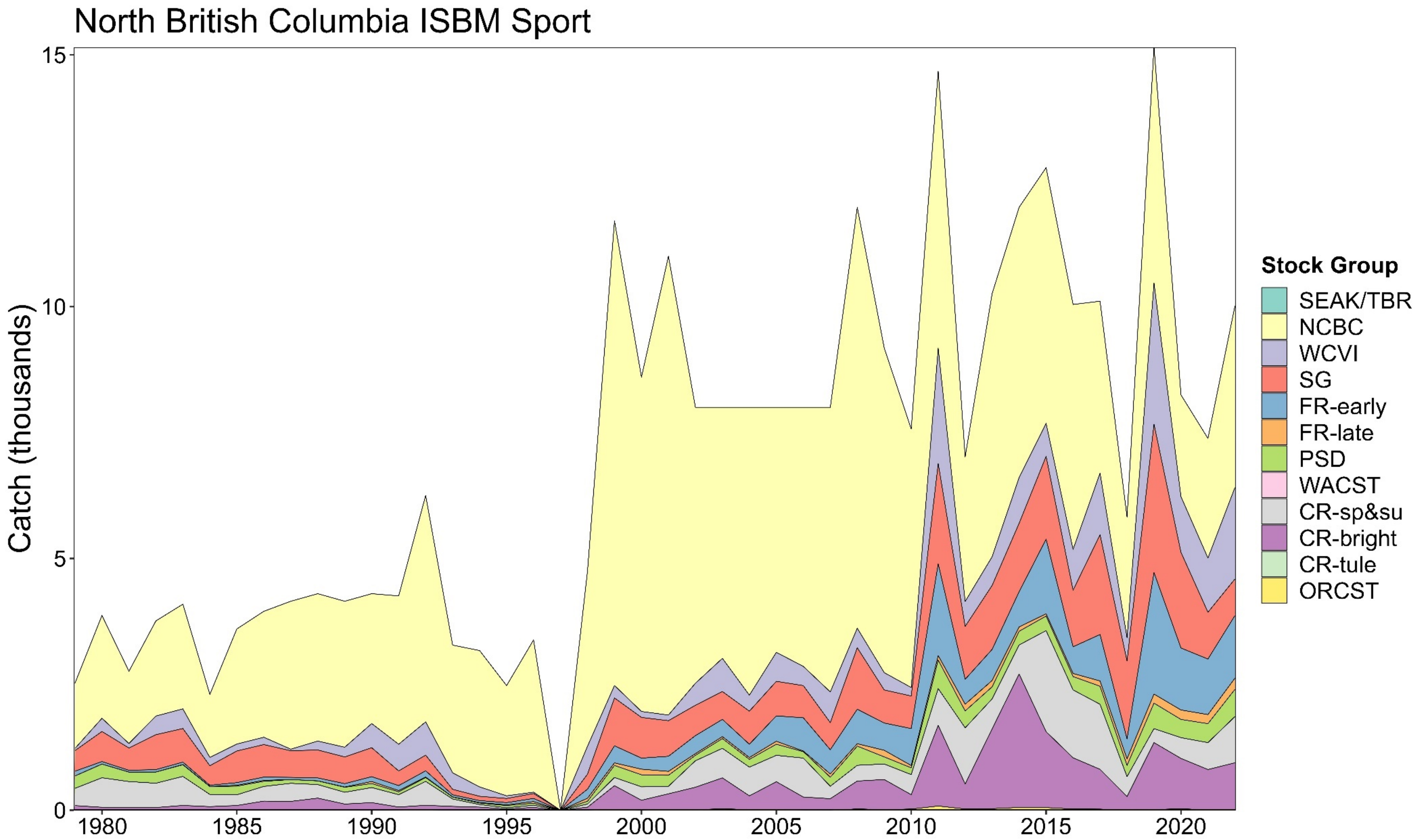
Appendix C27— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for Central British Columbia Sport 1979–2022.



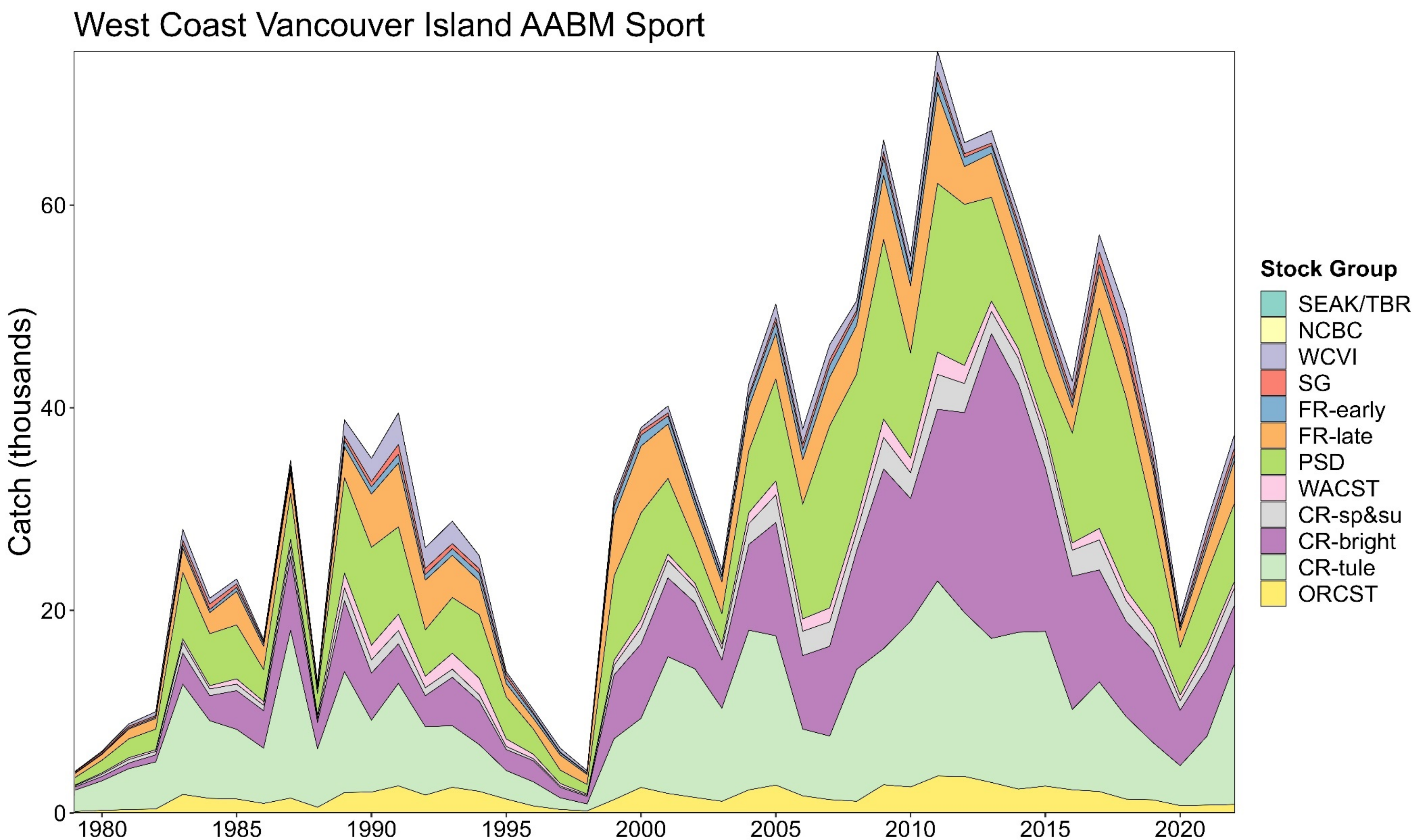
Appendix C28— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for North British Columbia AABM Sport, 1979–2022.



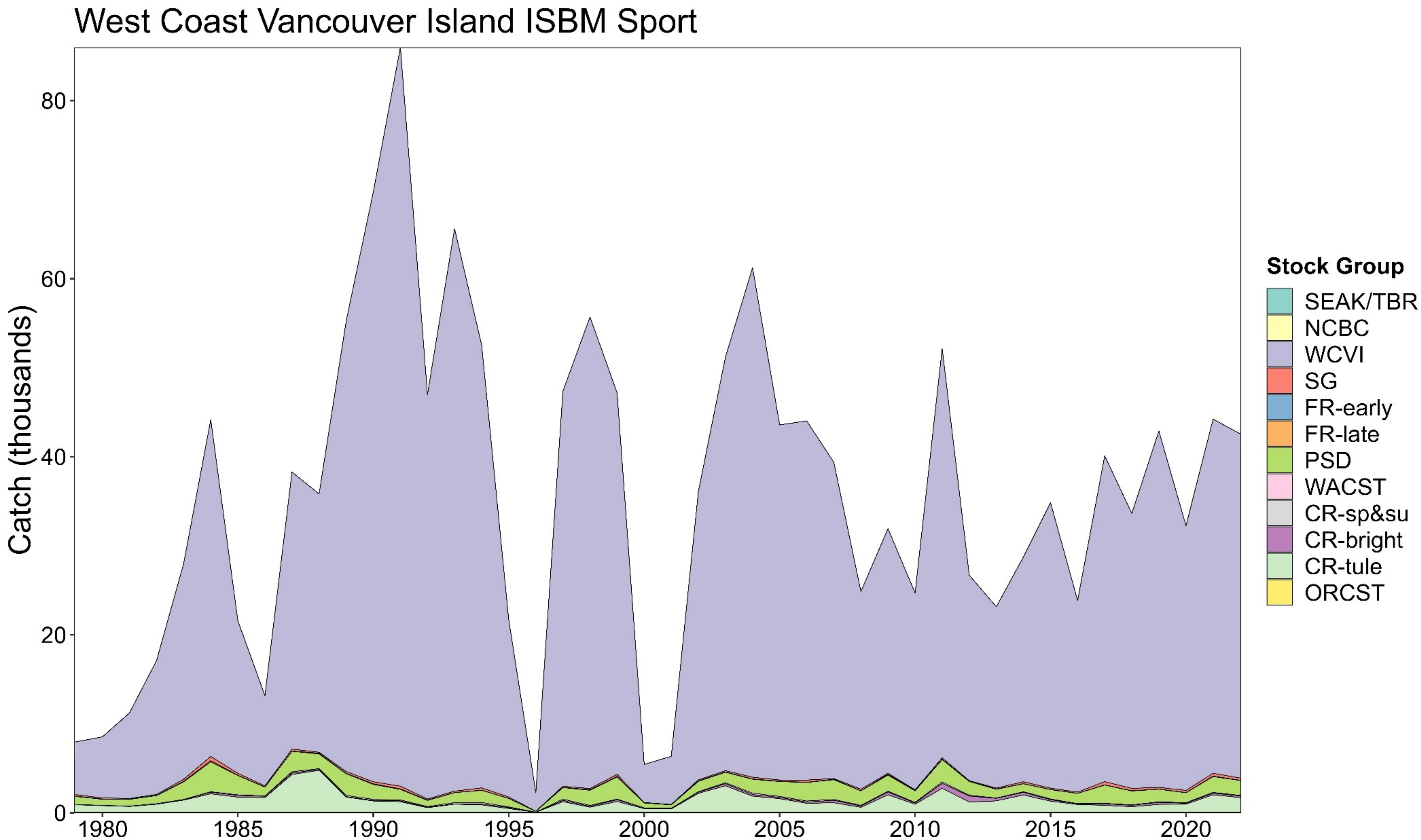
Appendix C29— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for North British Columbia ISBM Sport 1979–2022.



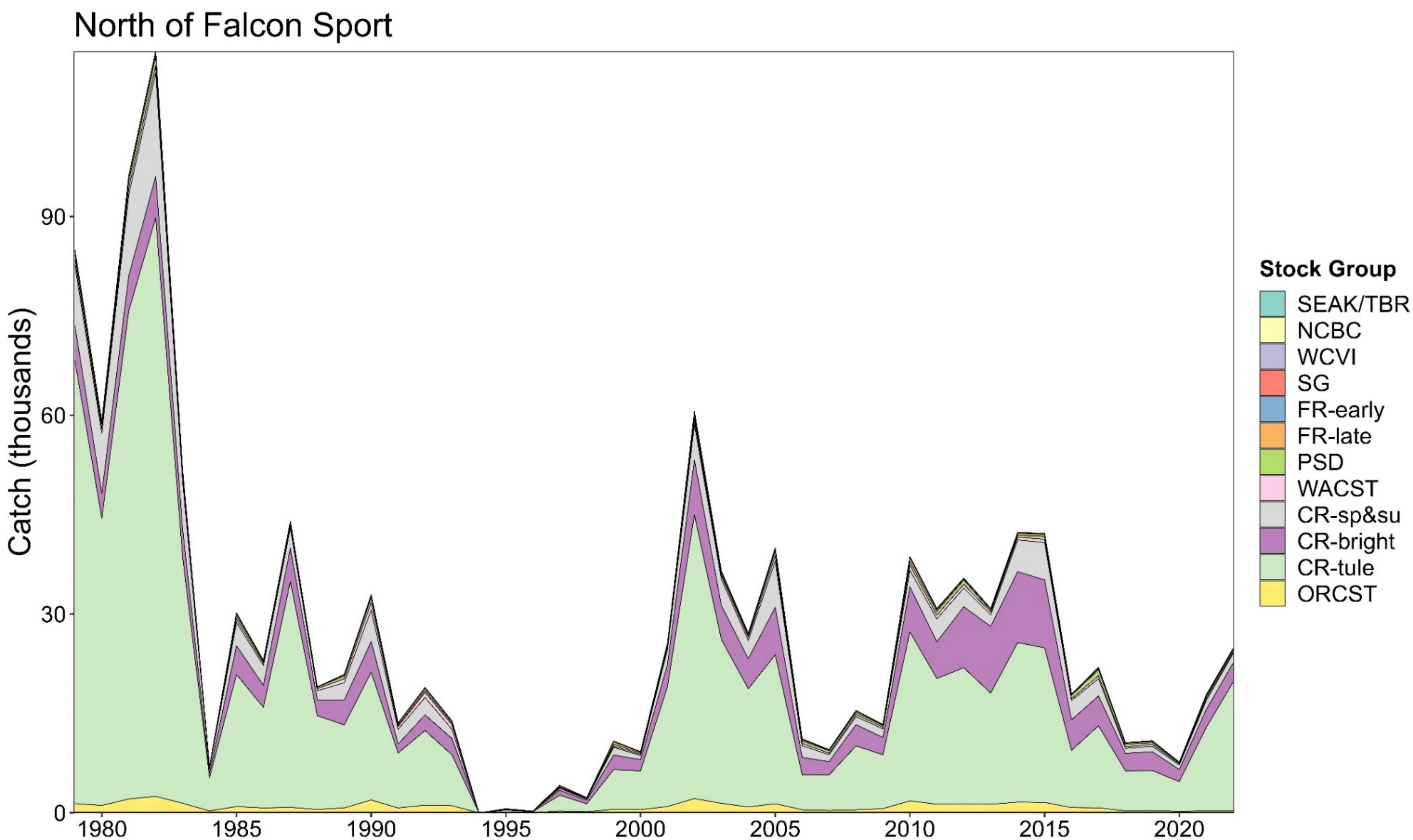
Appendix C30— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for West Coast Vancouver Island AABM Sport, 1979–2022.



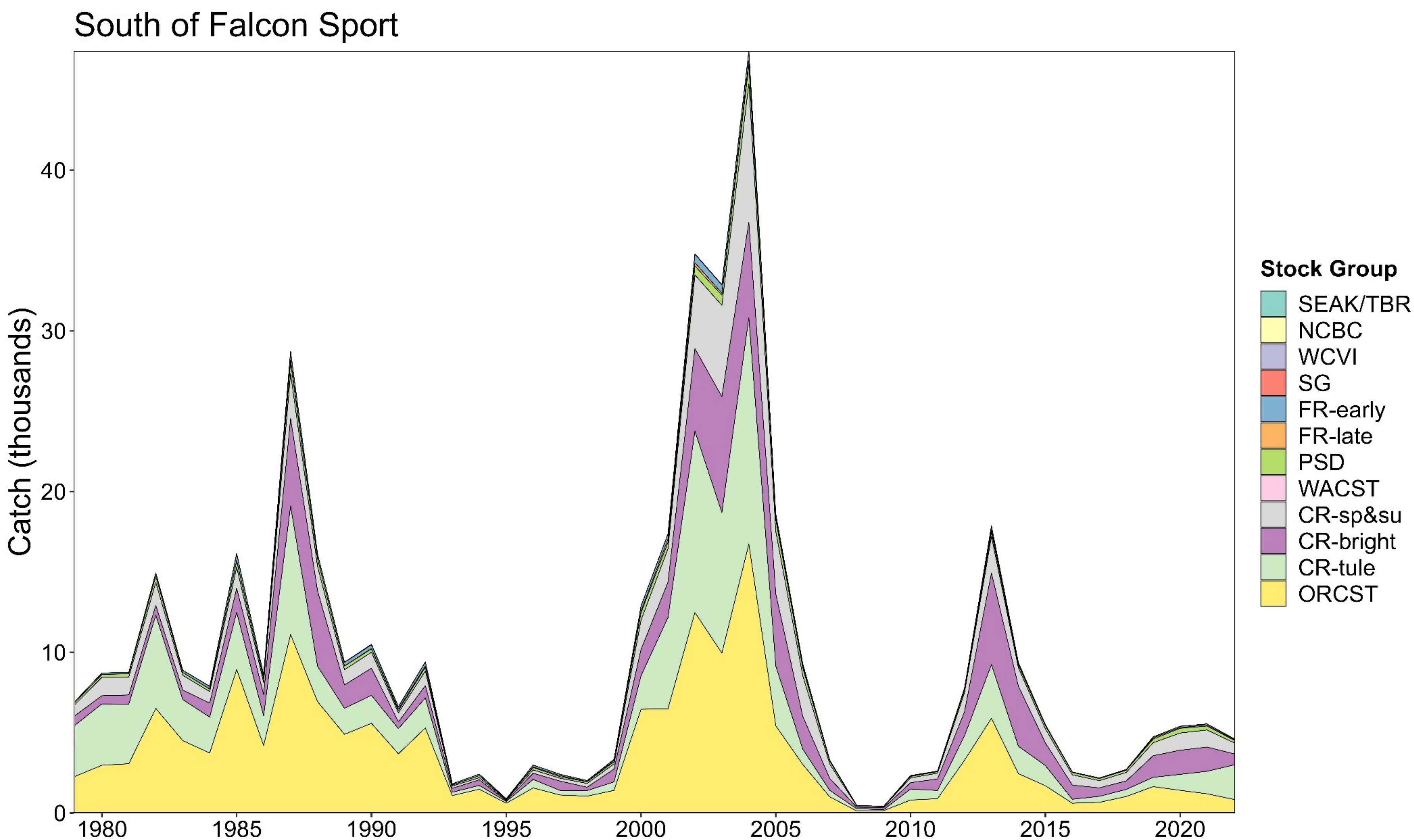
Appendix C31— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for West Coast Vancouver Island ISBM Sport, 1979–2022.



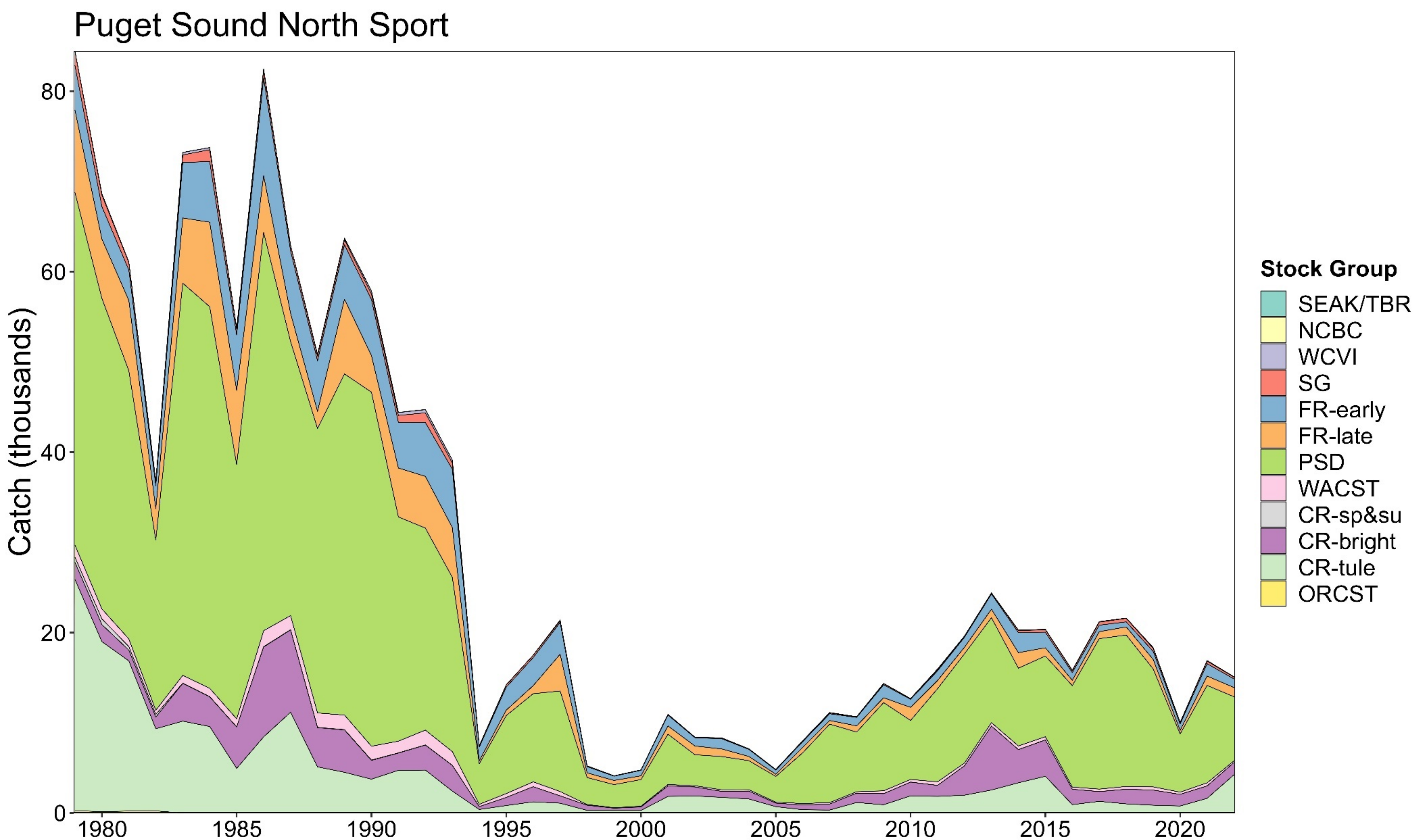
Appendix C32— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for North of Falcon Sport, 1979–2022.



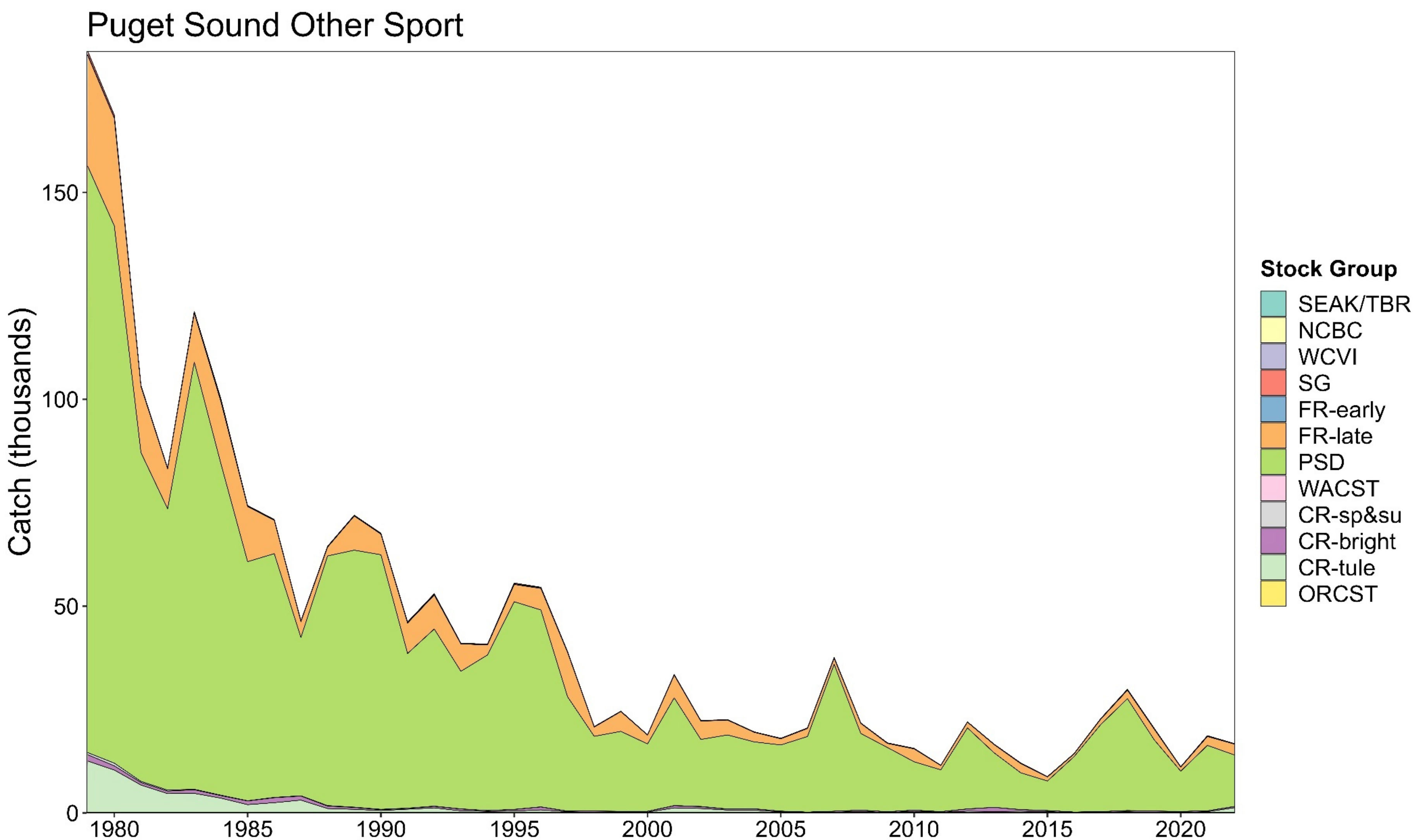
Appendix C33— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for South of Falcon Sport, 1979–2022.



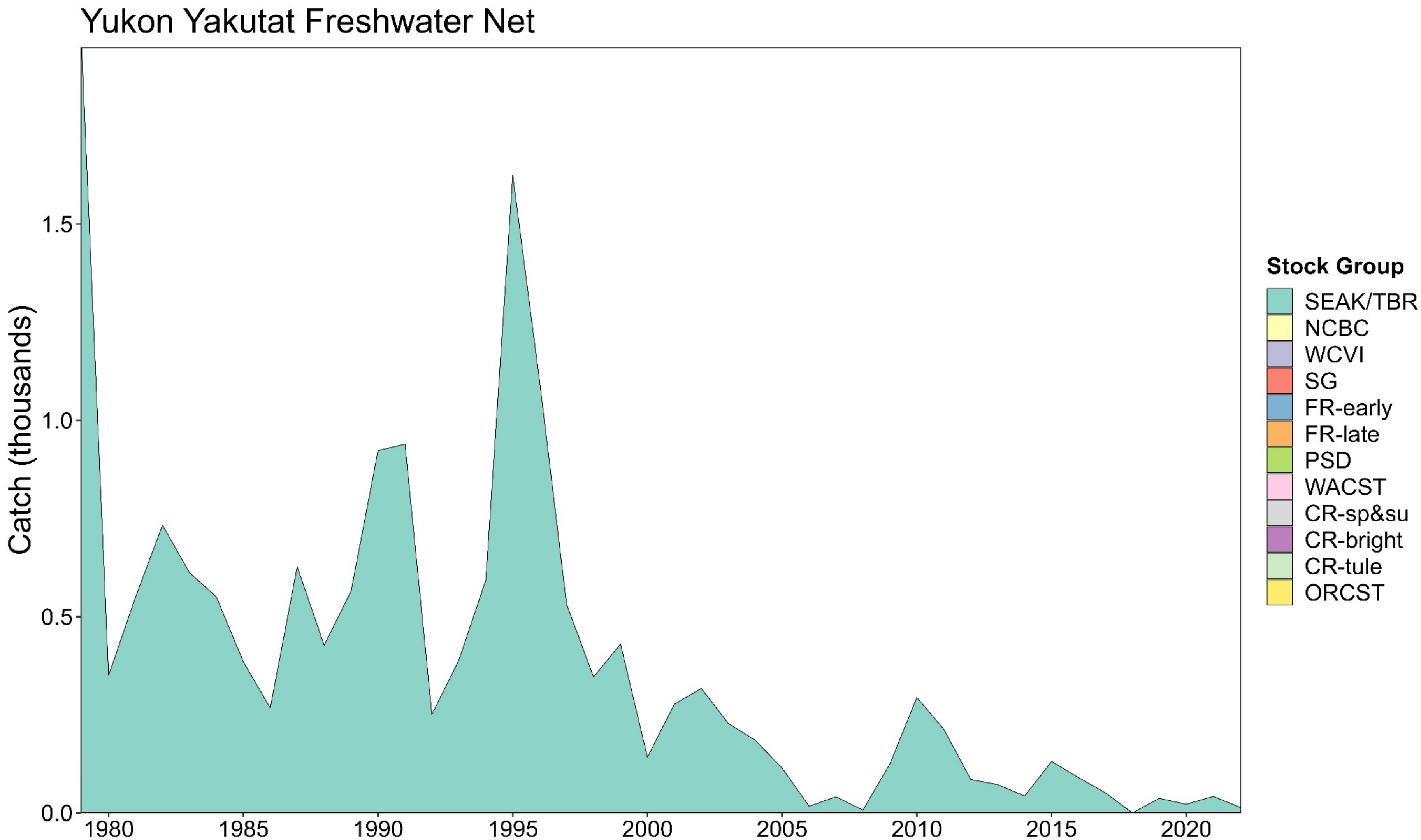
Appendix C34— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for Puget Sound North Sport, 1979–2022.



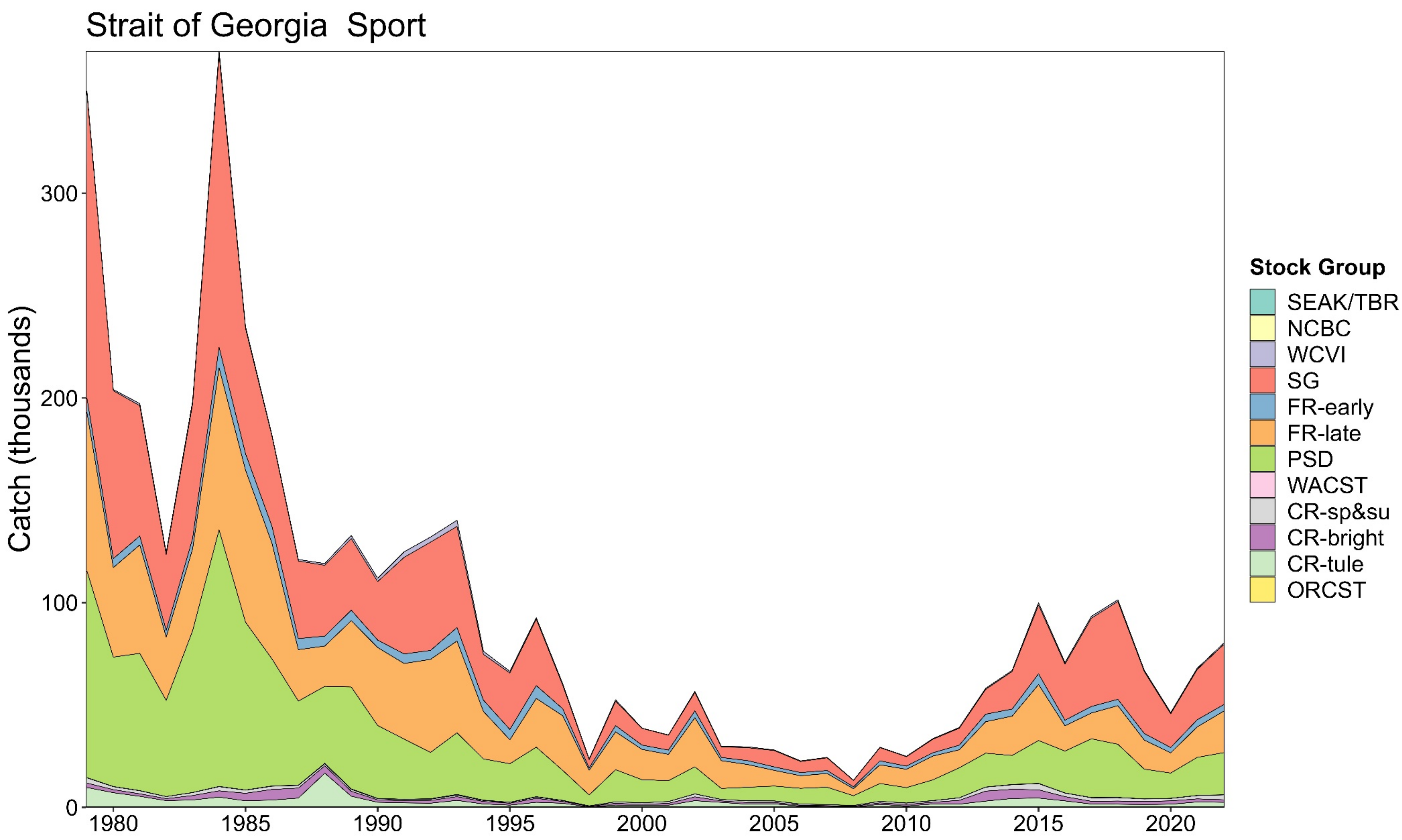
Appendix C35— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for Puget Sound Other Sport, 1979–2022.



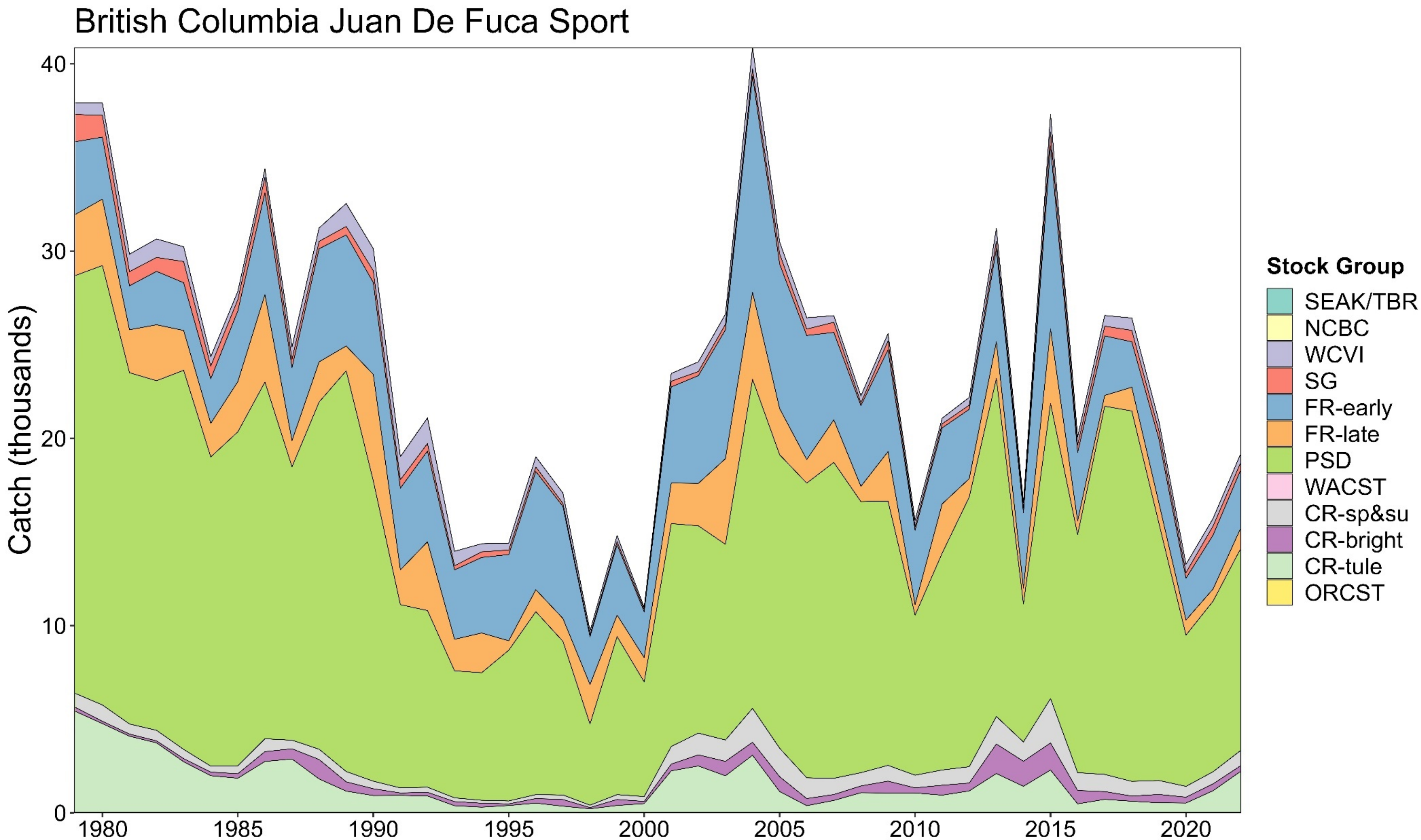
Appendix C36— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for Terminal Yukon Alsek Freshwater Net, 1979–2022.



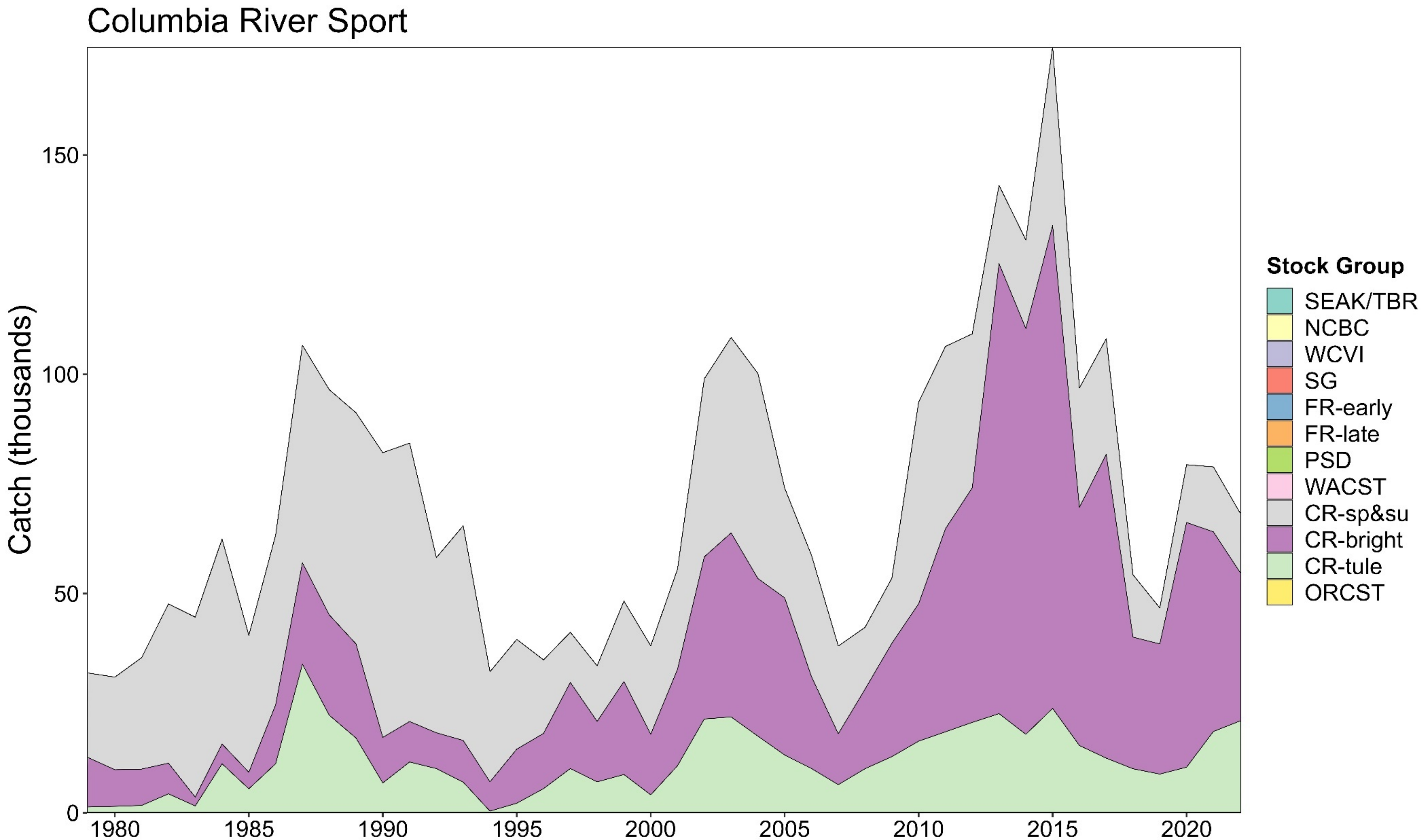
Appendix C37— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for Strait of Georgia Sport, 1979–2022.



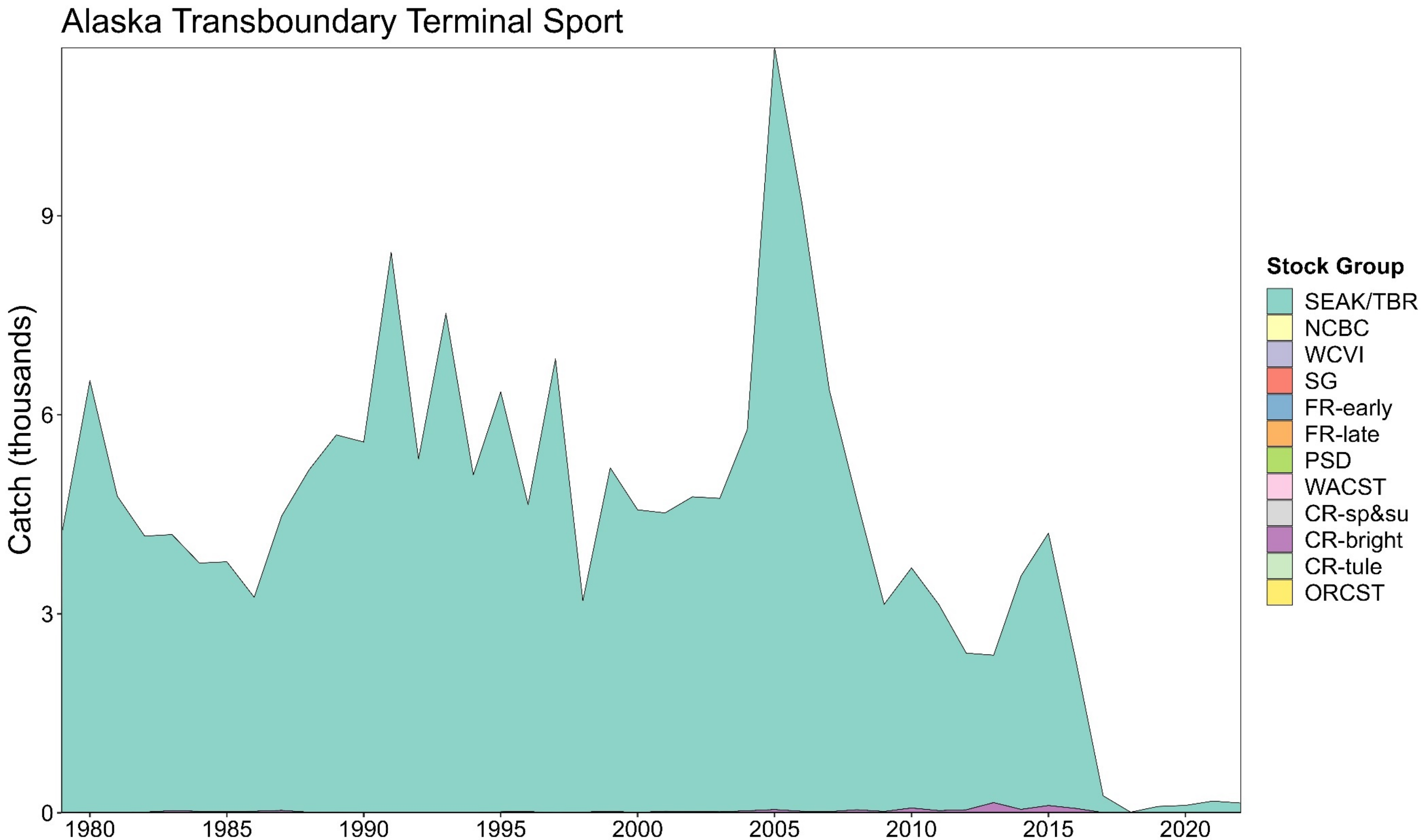
Appendix C38— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for British Columbia Juan De Fuca Sport, 1979–2022.



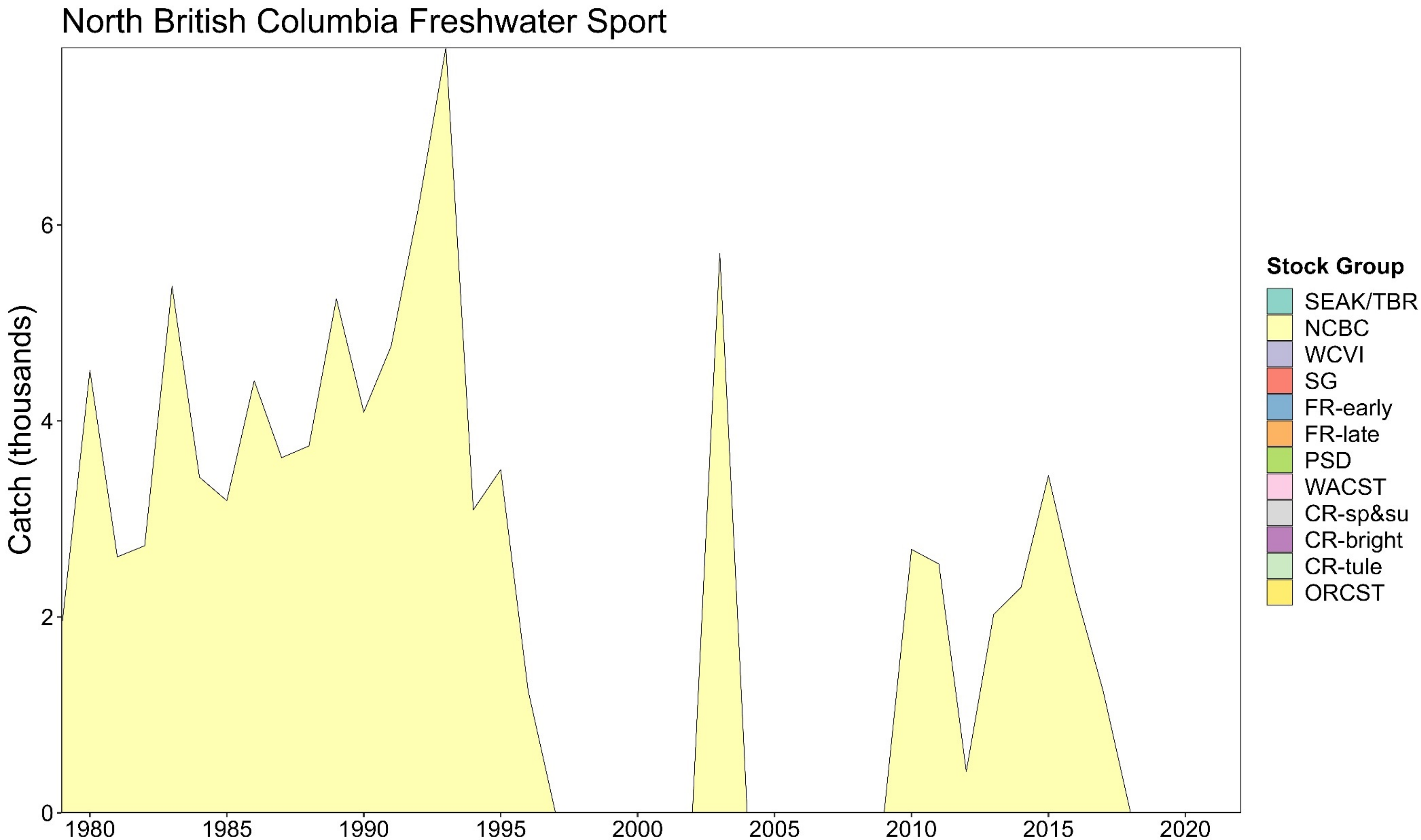
Appendix C39— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for Columbia River Sport, 1979–2022.



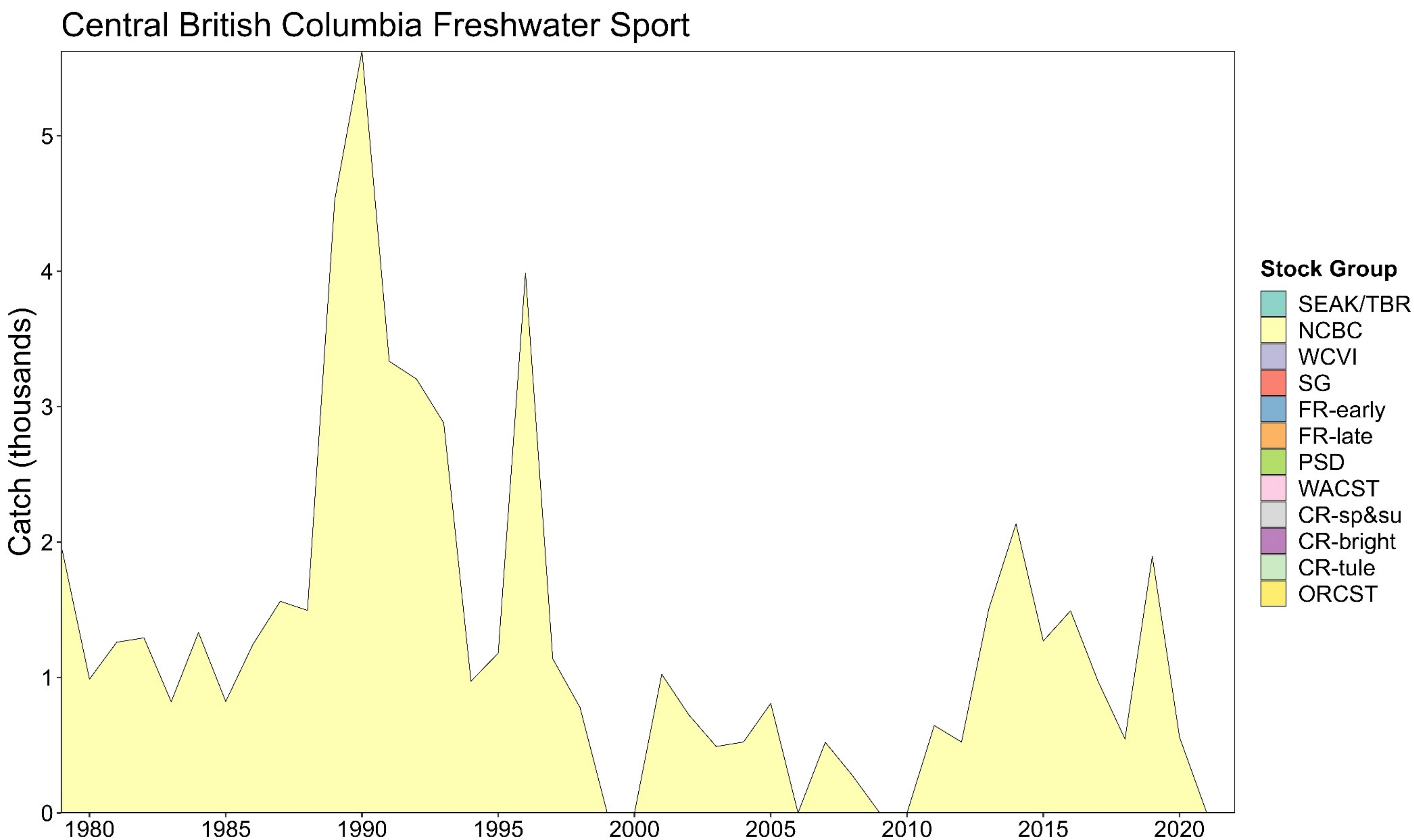
Appendix C40— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for Alaska Transboundary River Terminal Sport, 1979–2022.



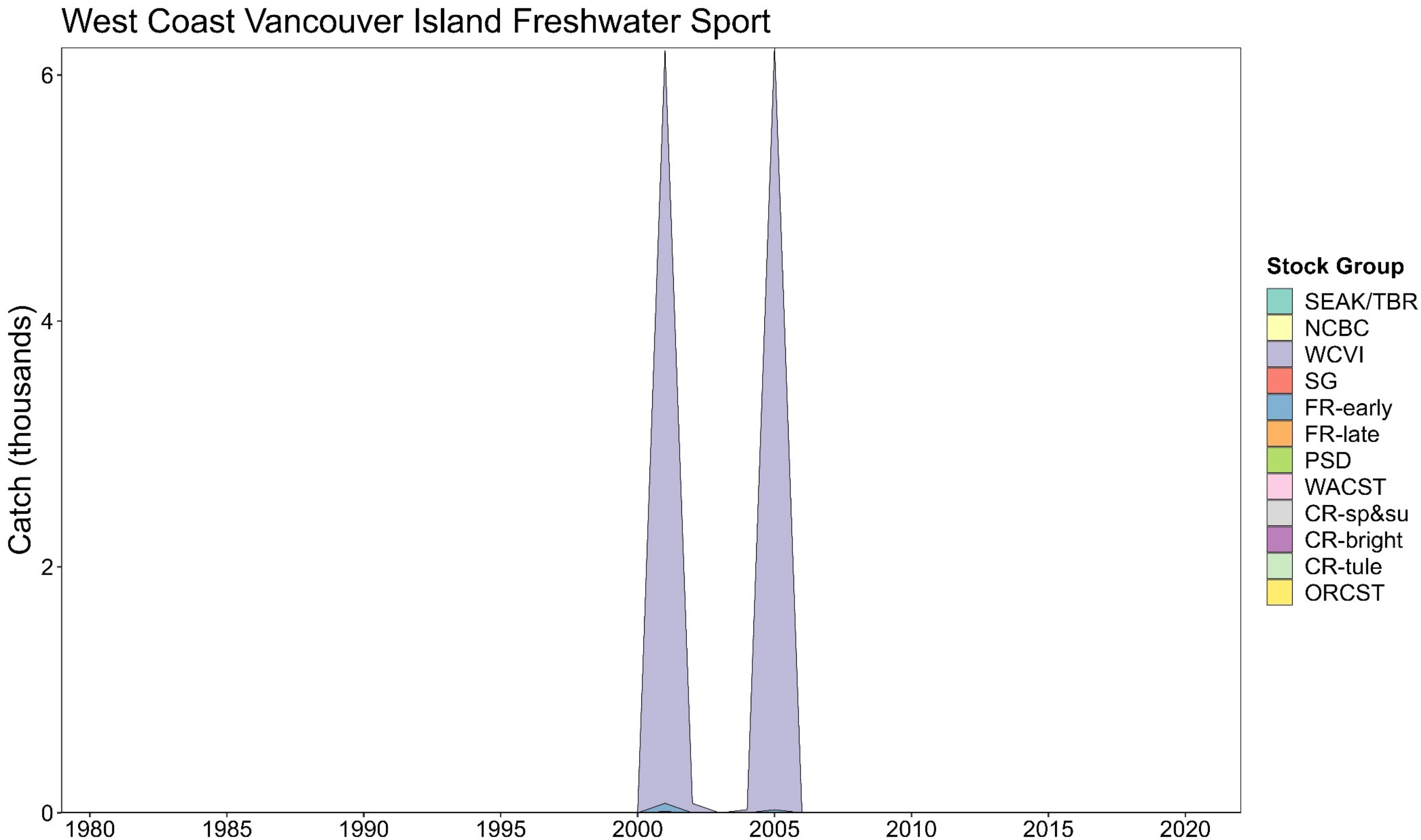
Appendix C41— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for North British Columbia Freshwater Sport, 1979–2022.



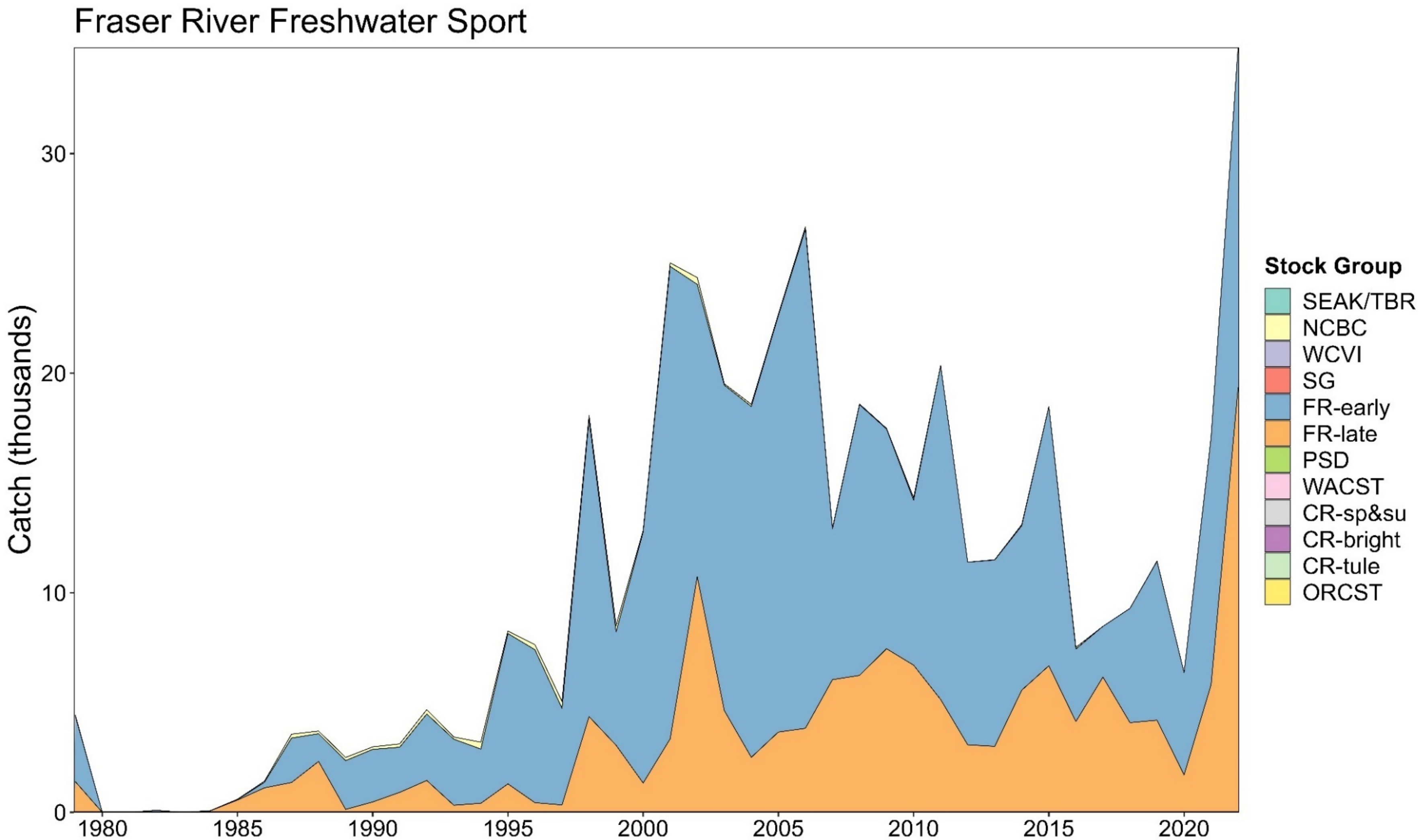
Appendix C42— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for Central British Columbia Freshwater Sport, 1979–2022.



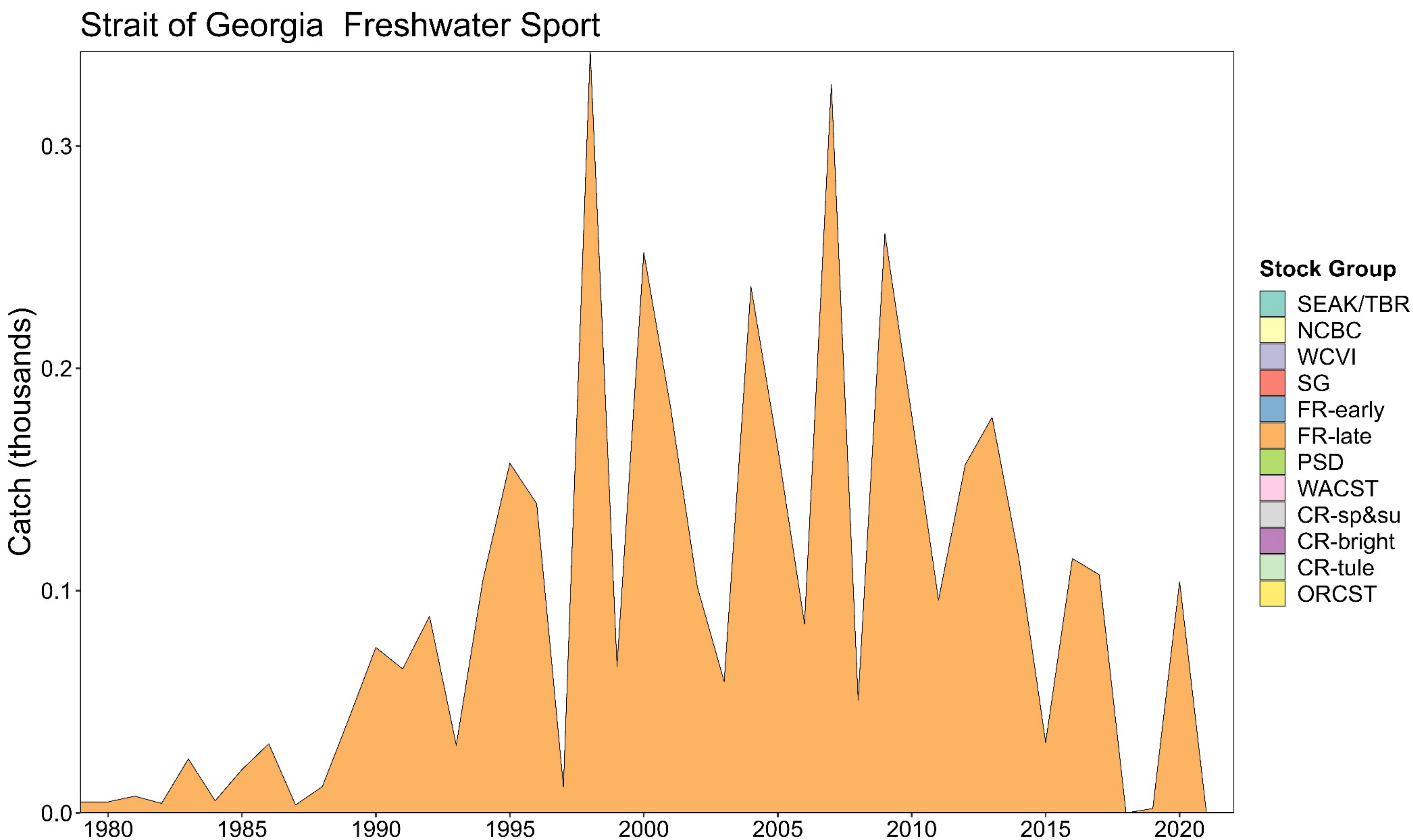
Appendix C43— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for West Coast Vancouver Island Freshwater Sport, 1979–2022.



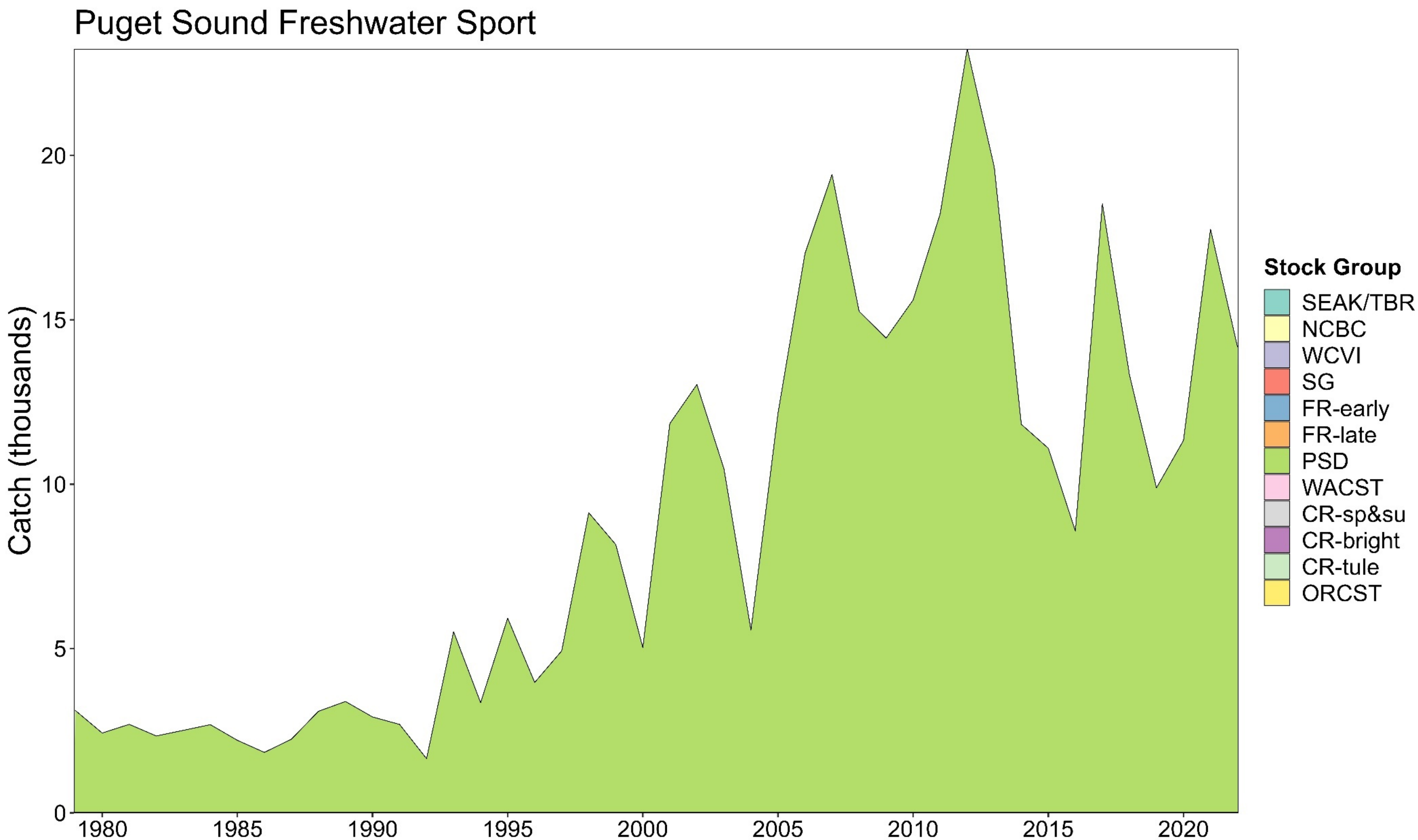
Appendix C44— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for Fraser River Freshwater Sport, 1979–2022.



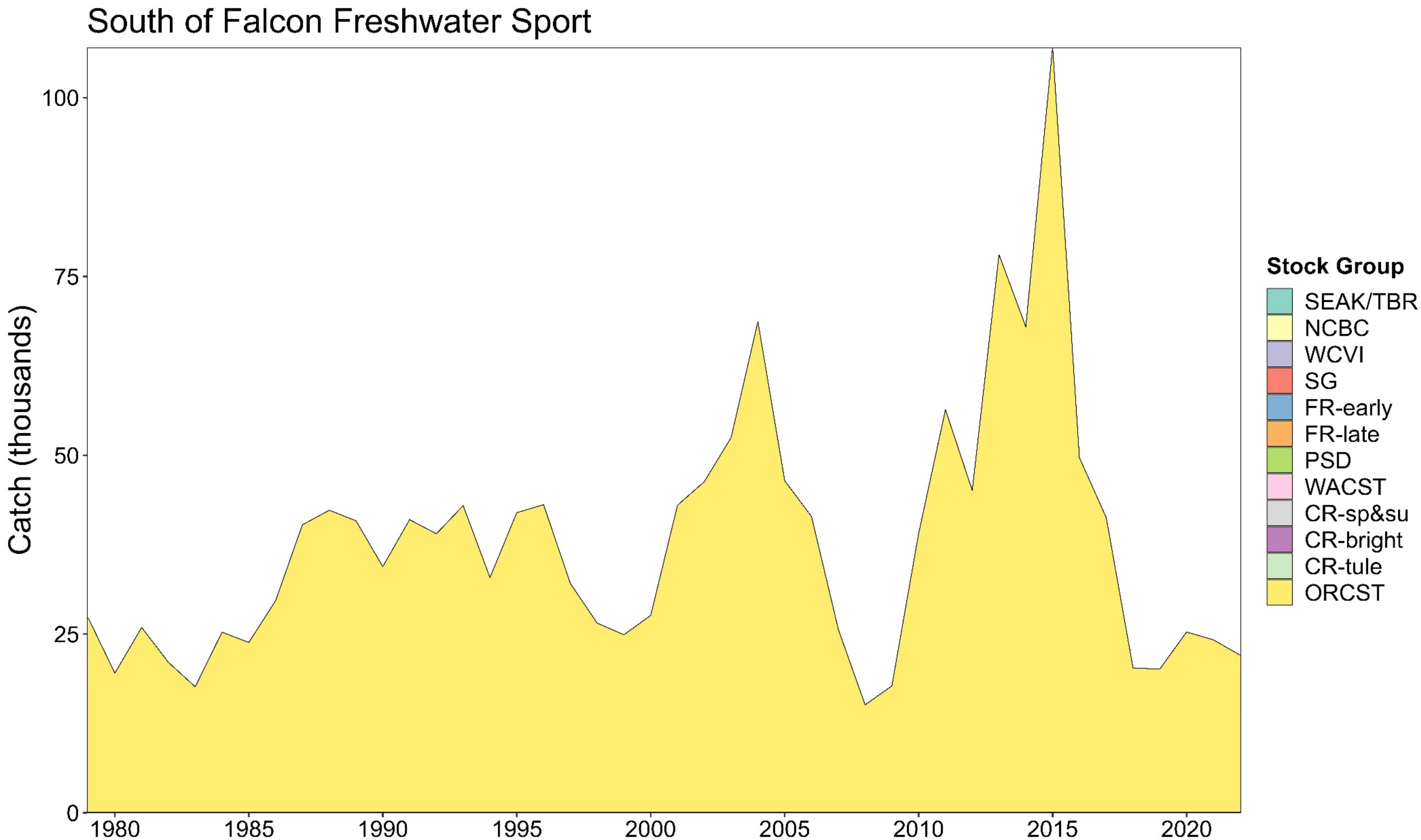
Appendix C45— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for Strait of Georgia Freshwater Sport, 1979–2022.



Appendix C46— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for Puget Sound Freshwater Sport, 1979–2022.



Appendix C47— Pacific Salmon Commission Chinook Model estimates of landed catch stock composition for South of Falcon Freshwater Sport, 1979–2022.



APPENDIX D: INCIDENTAL MORTALITY RATES APPLIED IN THE PACIFIC SALMON COMMISSION CHINOOK MODEL

Incidental mortality rates applied in the Phase II Pacific Salmon Commission (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 2304 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

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 2203 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

Time series of abundance indices from 1979–2023 for aggregate abundance-based management troll fisheries as estimated by PSC Chinook Model calibrations Calibration (CLB) 2304.

Year	Alaska Troll	North BC Troll	WCVI Troll
1979	0.93	1.06	1.12
1980	1.01	0.98	0.99
1981	1.02	0.98	0.92
1982	1.05	0.98	0.96
1983	1.10	1.08	0.95
1984	1.36	1.25	1.00
1985	1.29	1.29	0.92
1986	1.40	1.35	1.06
1987	1.75	1.69	1.45
1988	2.19	1.82	1.29
1989	2.01	1.77	1.03
1990	1.90	1.63	0.90
1991	1.86	1.58	0.81
1992	1.82	1.55	0.83
1993	1.87	1.55	0.72
1994	1.70	1.33	0.55
1995	1.04	1.01	0.48
1996	1.07	1.00	0.57
1997	1.51	1.24	0.67
1998	1.34	1.06	0.61
1999	1.04	0.86	0.58
2000	0.89	0.84	0.59
2001	1.18	1.17	0.99
2002	1.86	1.85	1.43
2003	2.23	1.97	1.38
2004	2.05	1.96	1.21
2005	1.82	1.68	0.95
2006	1.68	1.54	0.75
2007	1.19	1.05	0.60
2008	0.93	0.90	0.68
2009	1.13	1.03	0.64
2010	1.22	1.34	0.90
2011	1.42	1.38	0.85
2012	1.15	1.27	0.82

2013	1.51	1.58	1.14
2014	2.13	1.87	1.21
2015	2.07	1.94	1.17
2016	1.51	1.37	0.79
2017	1.11	1.06	0.67
2018	0.74	0.82	0.61
2019	0.97	0.98	0.62
2020	1.02	1.05	0.64
2021	1.14	1.13	0.73
2022	1.04	1.08	0.99
2023	1.15	1.16	1.02

APPENDIX F: PACIFIC SALMON COMMISSION CHINOOK MODEL FORECAST PERFORMANCE

Data in Appendix F1 are used to evaluate PSC Chinook Model and Agency Forecasts. The following terminology is used:

- Model Forecast. The model forecast (i.e., model output) for a stock is from that year's calibration (e.g., 2023 is from CLB 2304) [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 (i.e., model input) [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. Historic estimates can change from one year to the next based on agencies updating of catch and/or escapement data and estimates. [source: checkCLB.out or FCS file].

In the Appendix F1 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 F1 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 2021a.

The figures in Appendix F2 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-based. The shape of the symbol denotes whether the 9806 model (circle) or the Phase II model (diamond) was used. 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 to present can be found in Appendix F1. For information on forecast performance for years prior to 2020, see Appendix G1 in CTC 2021a.

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 F2 figures. For information on Phase II model stock acronyms, see Appendix A. For information on 9806 model stock acronyms, see Appendix A in CTC 2021c.

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, forecasts are only available beginning in 2020, as they 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 values beginning in 2020 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 – present) 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]).

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Appendix F1– Forecasts and post-season returns for Phase II model stocks, 2020 to present. (Page 1 of 5)

Stock Name	Year	Model Forecast	Agency Forecast	Actual Return	Model/ Agency	Agency/ Actual	Model/ Actual
Yakutat Forelands[1] (YAK)	2020	4,377	NA	4,113	NA	NA	106%
	2021	5,460	NA	2,011	NA	NA	272%
	2022	3,005	NA	2,483	NA	NA	121%
	2023	2,704	NA	NA	NA	NA	NA
	AVG				NA	NA	166%
Alsek[1] (ALS)	2020	10,787	NA	5,331	NA	NA	202%
	2021	9,526	NA	5,562	NA	NA	171%
	2022	10,073	NA	3,351	NA	NA	301%
	2023	6,505	NA	NA	NA	NA	NA
	AVG				NA	NA	225%
Southern SEAK[1] (SSA)	2020	9,252	NA	9,211	NA	NA	100%
	2021	10,599	NA	12,308	NA	NA	86%
	2022	11,705	NA	13,710	NA	NA	85%
	2023	17,601	NA	NA	NA	NA	NA
	AVG				NA	NA	91%
Northern SEAK[1] (NSA)	2020	3,232	NA	5,175	NA	NA	62%
	2021	3,343	NA	3,812	NA	NA	88%
	2022	3,271	NA	4,641	NA	NA	70%
	2023	5,909	NA	NA	NA	NA	NA
	AVG				NA	NA	74%
Transboundary Rivers[1] (TST)	2020	38,347	NA	37,681	NA	NA	102%
	2021	33,300	NA	28,297	NA	NA	118%
	2022	25,833	NA	39,029	NA	NA	66%
	2023	46,596	NA	NA	NA	NA	NA
	AVG				NA	NA	95%
Northern BC[1] (NBC)	2020	20,691	34,971	29,111	59%	120%	71%
	2021	21,483	37,577	34,131	57%	110%	63%
	2022	15,697	31,007	42,714	51%	73%	37%
	2023	19,123	35,388	NA	54%	NA	NA
	AVG				55%	101%	57%
Central BC[1] (CBC)	2020	6,785	11,463	14,262	59%	80%	48%
	2021	8,066	13,438	8,663	60%	155%	93%
	2022	5,639	10,003	9,075	56%	110%	62%
	2023	5,000	9,308	NA	54%	NA	NA
	AVG				57%	115%	68%
WCVI Hacthery[2] (WVH)	2020	163,921	152,227	183,906	108%	83%	89%
	2021	196,007	172,955	201,978	113%	86%	97%
	2022	216,396	197,795	210,288	109%	94%	103%
	2023	213,555	191,309	NA	112%	NA	NA
	AVG				111%	87%	96%
WCVI Natural[2] (WVN)	2020	25,671	22,531	28,081	114%	80%	91%
	2021	29,472	26,511	30,203	111%	88%	98%
	2022	29,705	26,762	34,188	111%	78%	87%
	2023	36,168	33,470	NA	108%	NA	NA
	AVG				111%	82%	92%

Appendix F1– Forecasts and post-season returns for Phase II model stocks, 2020 to present. (Page 2 of 5)

Stock Name	Year	Model Forecast	Agency Forecast	Actual Return	Model/ Agency	Agency/ Actual	Model/ Actual
Upper Georgia Strait[1] (UGS)	2020	5,227	11,779	18,659	44%	63%	28%
	2021	7,786	17,196	11,584	45%	148%	67%
	2022	4,543	10,756	8,679	42%	124%	52%
	2023	3,650	9,096	NA	40%	NA	NA
	AVG				43%	112%	49%
Puntledge River Summer[1] (PPS)	2020	646	563	412	115%	137%	157%
	2021	590	569	499	104%	114%	118%
	2022	581	516	381	113%	135%	152%
	2023	561	528	NA	106%	NA	NA
	AVG				109%	129%	143%
Middle Georgia Strait[1] (MGS)	2020	24,214	23,595	22,005	103%	107%	110%
	2021	23,027	23,283	30,917	99%	75%	74%
	2022	30,630	27,283	16,146	112%	169%	190%
	2023	19,583	19,880	NA	99%	NA	NA
	AVG				103%	117%	125%
Lower Georgia Strait[2] (LGS)	2020	14,779	14,821	13,099	100%	113%	113%
	2021	7,692	10,576	19,522	73%	54%	39%
	2022	22,072	21,917	30,933	101%	71%	71%
	2023	27,348	28,239	NA	97%	NA	NA
	AVG				92%	79%	75%
Fraser Early Spring 1.2[2] (FS2)	2020	6,105	6,220	9,125	98%	68%	67%
	2021	9,080	9,138	6,804	99%	134%	133%
	2022	8,081	8,293	10,672	97%	78%	76%
	2023	8,668	8,911	NA	97%	NA	NA
	AVG				98%	93%	92%
Fraser Early Spring 1.3[2] (FS3)	2020	19,142	23,332	17,653	82%	132%	108%
	2021	17,605	17,588	17,060	100%	103%	103%
	2022	17,024	16,876	23,571	101%	72%	72%
	2023	23,815	23,570	NA	101%	NA	NA
	AVG				96%	102%	95%
Fraser Early Summer 0.3[1] (FSO)	2020	119,340	114,566	147,984	104%	77%	81%
	2021	128,148	108,611	176,054	118%	62%	73%
	2022	136,667	128,800	111,260	106%	116%	123%
	2023	118,228	108,970	NA	108%	NA	NA
	AVG				109%	85%	92%
Fraser Early Summer 1.3[2] (FSS)	2020	10,044	10,737	14,423	94%	74%	70%
	2021	14,446	14,490	15,313	100%	95%	94%
	2022	15,593	15,398	28,302	101%	54%	55%
	2023	28,781	28,250	NA	102%	NA	NA
	AVG				99%	74%	73%
Fraser Late Natural (Harrison)[1] (FHF)	2020	53,584	59,745	43,498	90%	137%	123%
	2021	30,852	35,150	43,526	88%	81%	71%
	2022	60,347	68,388	86,519	88%	79%	70%
	2023	100,913	118,065	NA	85%	NA	NA
	AVG				88%	99%	88%

Appendix F1– Forecasts and post-season returns for Phase II model stocks, 2020 to present. (Page 3 of 5)

Stock Name	Year	Model Forecast	Agency Forecast	Actual Return	Model/ Agency	Agency/ Actual	Model/ Actual
Fraser Late Hatchery (Chilliwack) [1] (FCF)	2020	44,589	31,077	44,721	143%	69%	100%
	2021	36,766	39,593	67,663	93%	59%	54%
	2022	75,171	77,109	110,171	97%	70%	68%
	2023	86,191	73,160	NA	118%	NA	NA
	AVG				113%	66%	74%
Nooksack Spring[1] (NKS)	2020	1,510	1,479	3,189	102%	46%	47%
	2021	769	499	2,204	154%	23%	35%
	2022	1,962	1,789	1,789	110%	100%	110%
	2023	2,273	2,326	NA	98%	NA	NA
	AVG				116%	56%	64%
Nooksack/Samish Fall[2] (NKF)	2020	15,764	16,858	22,233	94%	76%	71%
	2021	18,313	19,412	37,723	94%	51%	49%
	2022	33,279	31,436	61,498	106%	51%	54%
	2023	50,780	46,375	NA	109%	NA	NA
	AVG				101%	59%	58%
Skagit Summer/Fall Wild[2] (SKG)	2020	14,031	12,877	11,171	109%	115%	126%
	2021	11,305	10,461	10,625	108%	98%	106%
	2022	14,114	12,508	18,232	113%	69%	77%
	2023	14,996	12,235	NA	123%	NA	NA
	AVG				113%	94%	103%
Stillaguamish Summer/Fall Wild[1] (STL)	2020	727	762	1,443	95%	53%	50%
	2021	922	876	732	105%	120%	126%
	2022	897	890	1,692	101%	53%	53%
	2023	1,402	1,214	NA	115%	NA	NA
	AVG				104%	75%	76%
Snohomish Summer/Fall Wild[2] (SNO)	2020	2,556	2,978	2,828	86%	105%	90%
	2021	2,939	2,922	2,046	101%	143%	144%
	2022	2,397	2,423	3,786	99%	64%	63%
	2023	3,531	3,362	NA	105%	NA	NA
	AVG				98%	104%	99%
Puget Sound Fingerling[2,3] (PSF)	2020	206,668	186,117	106,530	111%	175%	194%
	2021	159,464	160,088	157,151	100%	102%	101%
	2022	175,935	161,554	180,602	109%	89%	97%
	2023	182,367	160,604	NA	114%	NA	NA
	AVG				108%	122%	131%
Puget Sound Yearling[2,3] (PSY)	2020	4,604	4,059	1,821	113%	223%	253%
	2021	4,163	4,030	3,841	103%	105%	108%
	2022	4,584	3,770	4,079	122%	92%	112%
	2023	4,729	3,720	NA	127%	NA	NA
	AVG				116%	140%	158%
Puget Sound Natural[2,3] (PSN)	2020	7,731	7,132	9,452	108%	75%	82%
	2021	8,980	8,225	9,629	109%	85%	93%
	2022	11,149	8,427	15,757	132%	53%	71%
	2023	12,408	8,340	NA	149%	NA	NA
	AVG				125%	71%	82%

Appendix F1– Forecasts and post-season returns for Phase II model stocks, 2020 to present. (Page 4 of 5)

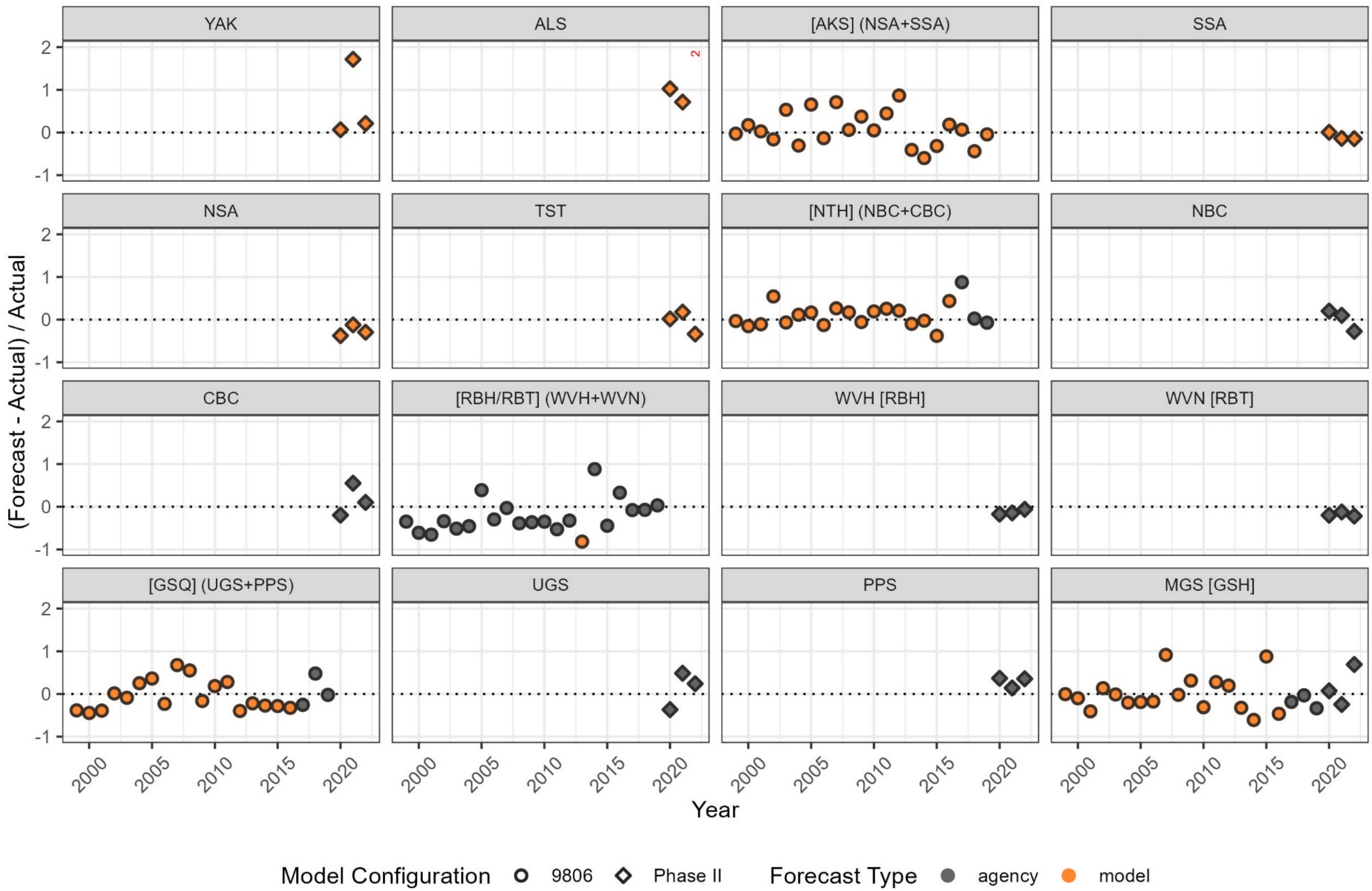
Stock Name	Year	Model Forecast	Agency Forecast	Actual Return	Model/ Agency	Agency/ Actual	Model/ Actual
Washington Coastal Hatchery[2] (WCH)	2020	29,135	32,802	48,794	89%	67%	60%
	2021	40,339	42,953	46,181	94%	93%	87%
	2022	53,794	44,440	30,634	121%	145%	176%
	2023	44,776	41,020	NA	109%	NA	NA
	AVG				103%	102%	108%
Washington Coastal Natural[2] (WCN)	2020	30,576	30,130	53,554	101%	56%	57%
	2021	46,314	41,395	37,072	112%	112%	125%
	2022	49,667	41,036	37,530	121%	109%	132%
	2023	47,304	39,413	NA	120%	NA	NA
	AVG				114%	92%	105%
Cowlitz Spring[2] (CWS)	2020	3,738	3,843	3,984	97%	96%	94%
	2021	6,076	6,384	8,201	95%	78%	74%
	2022	9,356	8,994	8,691	104%	103%	108%
	2023	14,020	16,093	NA	87%	NA	NA
	AVG				96%	93%	92%
Willamette Spring[2] (WSH)	2020	43,814	43,430	47,327	101%	92%	93%
	2021	51,482	52,400	43,148	98%	121%	119%
	2022	51,436	52,918	57,317	97%	92%	90%
	2023	73,858	73,019	NA	101%	NA	NA
	AVG				99%	102%	101%
Columbia River Summer[2] (SUM)	2020	36,194	38,300	65,494	95%	58%	55%
	2021	73,414	77,600	56,800	95%	137%	129%
	2022	65,264	57,500	78,494	114%	73%	83%
	2023	95,243	84,754	NA	112%	NA	NA
	AVG				104%	89%	89%
Lewis River Wild[2] (LRW)	2020	22,290	19,700	35,397	113%	56%	63%
	2021	27,614	20,000	16,935	138%	118%	163%
	2022	13,078	10,842	9,375	121%	116%	139%
	2023	8,317	8,553	NA	97%	NA	NA
	AVG				117%	96%	122%
Lower Bonneville Hatchery[2] (BON)	2020	14,940	16,500	18,099	91%	91%	83%
	2021	17,207	18,100	21,472	95%	84%	80%
	2022	19,145	17,800	39,774	108%	45%	48%
	2023	34,103	27,300	NA	125%	NA	NA
	AVG				105%	73%	70%
Fall Cowlitz Hatchery[2] (CWF)	2020	34,100	34,500	59,704	99%	58%	57%
	2021	48,767	55,000	53,232	89%	103%	92%
	2022	46,920	55,200	47,768	85%	116%	98%
	2023	41,186	49,800	NA	83%	NA	NA
	AVG				89%	92%	82%
Spring Creek Hatchery[2] (SPR)	2020	46,779	47,500	52,273	98%	91%	89%
	2021	46,242	46,780	73,659	99%	64%	63%
	2022	96,292	96,654	258,271	100%	37%	37%
	2023	142,711	136,054	NA	105%	NA	NA
	AVG				100%	64%	63%

Appendix F1– Forecasts and post-season returns for Phase II model stocks, 2020 to present. (Page 5 of 5)

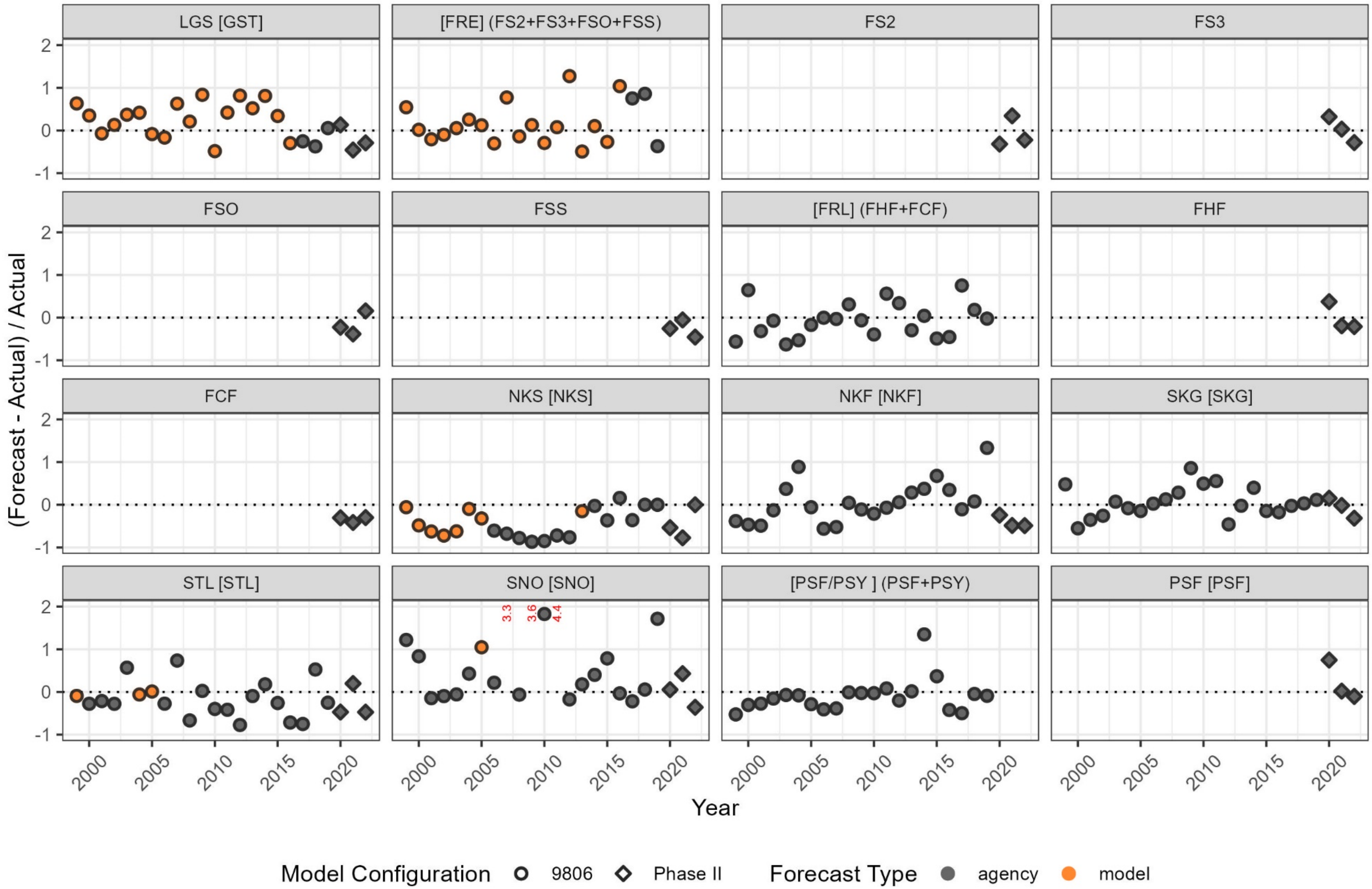
Stock Name	Year	Model Forecast	Agency Forecast	Actual Return	Model/ Agency	Agency/ Actual	Model/ Actual
Mid-Columbia Bright[2] (MCB)	2020	78,988	78,200	109,813	101%	71%	72%
	2021	84,306	86,200	73,893	98%	117%	114%
	2022	85,351	78,938	67,661	108%	117%	126%
	2023	55,479	52,647	NA	105%	NA	NA
	AVG				103%	102%	104%
Columbia Upriver Bright[2] (URB)	2020	212,281	220,600	299,031	96%	74%	71%
	2021	338,574	354,218	239,947	96%	148%	141%
	2022	253,488	230,360	254,881	110%	90%	99%
	2023	287,045	272,440	NA	105%	NA	NA
	AVG				102%	104%	104%
Snake River Wild[2] (LYF)	2020	12,984	10,902	12,282	119%	89%	106%
	2021	12,485	10,991	9,342	114%	118%	134%
	2022	11,559	10,965	19,845	105%	55%	58%
	2023	16,552	13,331	NA	124%	NA	NA
	AVG				116%	87%	99%
North Oregon Coast[1] (NOC)	2020	55,940	44,809	76,901	125%	58%	73%
	2021	68,923	67,593	42,497	102%	159%	162%
	2022	53,675	49,343	45,964	109%	107%	117%
	2023	57,431	52,242	NA	110%	NA	NA
	AVG				111%	108%	117%
Mid-Oregon Coast[1] (MOC)	2020	25,427	28,140	26,511	90%	106%	96%
	2021	25,514	25,900	16,410	99%	158%	155%
	2022	16,784	19,118	18,121	88%	106%	93%
	2023	23,641	22,124	NA	107%	NA	NA
	AVG				96%	123%	115%

[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.

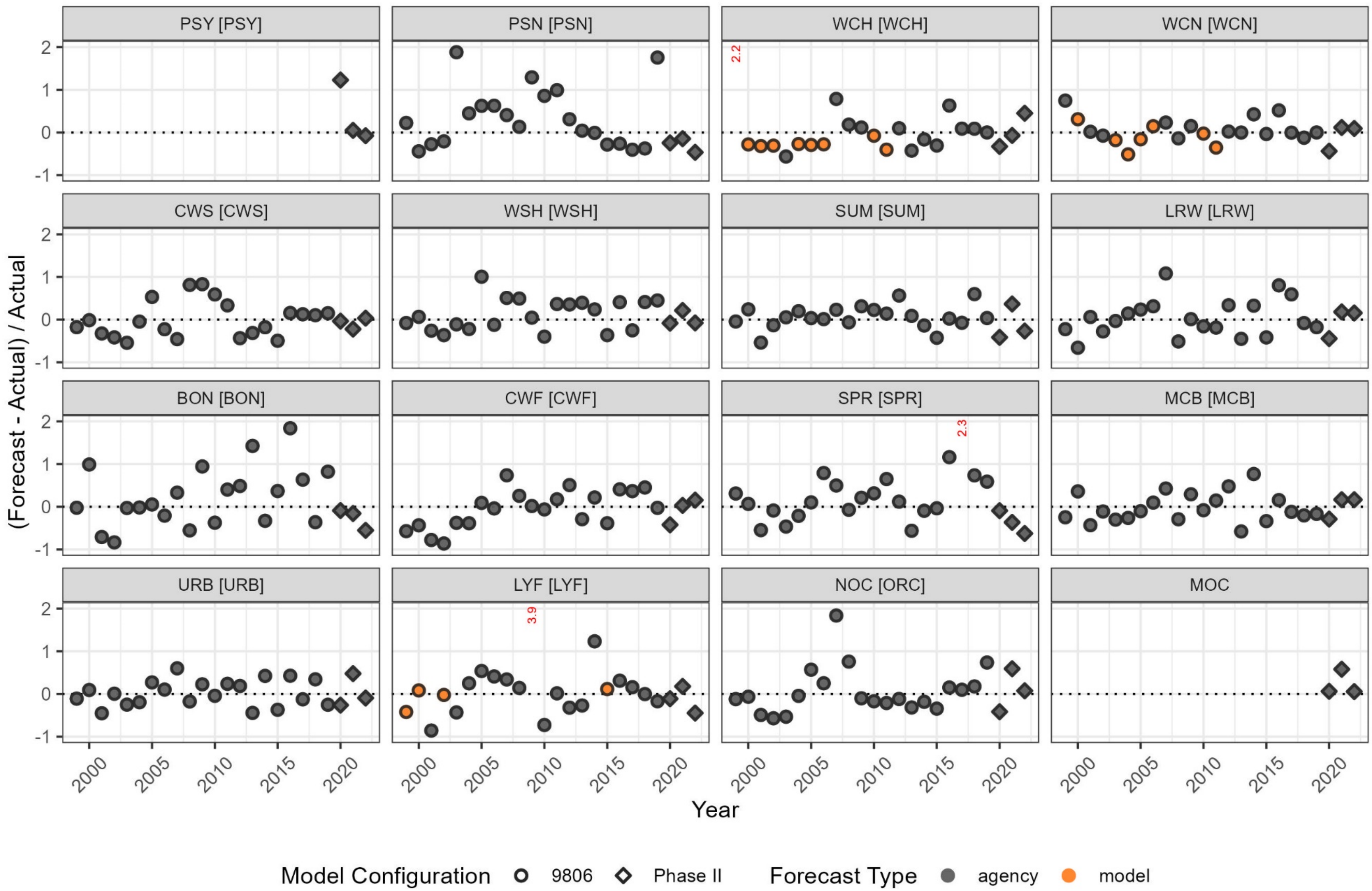
Appendix F2– Forecast performance for 9806 and Phase II Chinook model stocks, 1999–2022. (Page 1 of 3)



Appendix F2– Forecast performance for Chinook model stocks, 1999–2022. (Page 2 of 3)



Appendix F2– Forecast performance for Chinook model stocks, 1999–2021. (Page 3 of 3)



APPENDIX G: MODEL CALIBRATION METHODS

This section describes the PSC Chinook Model 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 2023. Since 2019, the new "Phase II" model was used for estimating pre- and post-season AIs (see CTC 2021c and CTC 2021d for details on the Phase II transition). Additionally, this section describes the calibration procedures for the multivariate model used to set the pre-season catch limit for the SEAK AABM fishery.

PSC Chinook Model 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.

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. 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. For those stocks with forecasts of abundance provided externally by agencies, 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 G1).
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 G1).
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., MRE [mean relative error], MAE [mean absolute error], MAPE, MASE [mean absolute scaled error], RMSE [root mean squared error]); (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 since 2016 for Canada and Oregon model stocks (forecast type F in Appendix G1).

6. FP (fishery policy): 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 between dams 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 unharvested 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 between dams is equal to 1 minus the conversion factor and does not include pre-spawning mortality between the last dam count and the spawning grounds.
8. IM (changes in incidental mortality 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 rates. Exponentially smoothed (ETS) forecasts 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 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. PNVs are not currently stock specific but that change is on the AWGs list of model improvements in the future.
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 G1— Characteristics used to forecast the abundance of stocks in the Pacific Salmon

Commission Chinook Model.

Model Stock	Forecast Characteristics			Comments
	Forecast Type[1]	Pre-season age-specific	Post-season age-specific	
Yakutat Forelands	F	Yes	Yes	Calibrated to escapement
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	
Mid-Oregon Coast	F	Yes	Yes	

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

PSC Chinook Model Calibration Procedures

The calibration uses an iterative algorithm to estimate EV scalars for each brood year 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. However, non-age specific data may also be used:

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 stock scalar 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:

$$SC_{BY} = \frac{\sum_{a=Minage}^{Maxage} (ObservedTerminal\,Run)_a}{\sum_{a=Minage}^{Maxage} (Model\,PredictedTerminal\,Run)_a}$$

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 and brood is less than a predetermined tolerance level (0.05). The tolerance level can be changed if more precise agreement is desired:

$$\left|\frac{EV_{n,BY} - EV_{n-1,BY}}{EV_{n-1,BY}}\right| < 0.05 \qquad \textit{Equation H.4}$$

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 current 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 current 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 1979–2021 using updated catch and escapement data through 2022. Average exploitation rate scalars ($\overline{FP}$) were then computed and used as input values for the 2022 and 2023 fisheries in the Stage 2 calibration, except that the forecasts for the WCVI and Fraser Late 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 G2):

$$\overline{FP}_{a,s,CY,f} = \frac{\sum_{CY=CY_{start}}^{CY_{end}} RT_{CY} * FP_{s,a,CY,f}}{(CY_{end} - CY_{start})} \qquad \textit{Equation H.5}$$

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 the current calibration are provided in Appendix H.

PSC Chinook Model 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 (PST 2000), 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:

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

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 pre-season ACL for the SEAK AABM fishery was based on the SEAK early winter District 113 troll fishery CPUE metric in conjunction with Table 2 of Chapter 3 of the 2019 PST Agreement. A new multivariate method in conjunction with a new 17 tier structure was used to set the SEAK AABM fishery pre-season ACL for 2023.

PSC Chinook Model 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 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 AEQs for both reported catch and total mortality (reported catch plus IM). The total mortality AEQ exploitation rate is estimated as:

$$ER_{s,a,f,CY} = \frac{TotMorts_{s,a,f,CY} * AEQ_{s,BY=CY-a,a,f}}{Cohort_{s,BY=CY-a,a} * (1 - NM_a)}$$

Equation H.7

whereas the reported catch AEQ exploitation rate is estimated as

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

Equation H.8

and a ROM estimator is used to calculate the FI

$$FI_{f,CY} = \frac{\sum_{s\in\{S\}}\sum_{a\in\{A\}} ER_{s,a,f,CY}}{\left(\frac{\sum_{BPYR=79}^{82}\sum_{s\in\{S\}}\sum_{a\in\{A\}} ER_{s,a,f,BPYR}}{4} \right)}$$

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 is the evolution of the seasonality of SEAK troll fishing. 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 G2 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

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

Equation H.13

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

Equation H.14

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

Equation H.15

Appendix G2— 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*

SEAK AABM Multivariate Model Calibration Procedures and Data

The PSC adopted a new multivariate model (Equation 1) in conjunction with 17 tiers (Appendix G3) on February 16, 2023 to determine the pre-season ACL for the SEAK AABM fishery in 2023. This multivariate model utilizes the PSC Chinook Model pre-season AI (Pre AI), the CPUE from the early winter power troll fishery in district 113 of Southeast Alaska for stat weeks 41–48, and the one-year-ahead projected AI from the prior year's PSC Chinook Model calibration (Projection).

$$Post\ AI = \beta_0 + \beta_1 Pre\ AI + \beta_2 \ln{(CPUE)} + \beta_3 Projection$$

Equation 1

For 2023, the multivariate model was fit with data from 2001 through 2022 (excluding 2006 and 2007 due to unavailable projection values: Appendix G4), resulting in the following coefficients:

- Intercept (β_0): -0.340

- Pre-season AI (β_1): 0.451
- Ln CPUE (β_2): 0.281
- Projection (β_3): 0.468

The inputs to the multivariate model used to determine the 2023 SEAK AABM fishery pre-season AI are shown in Appendix G5. The 2022 calibration of the multivariate model resulted in an abundance index of 1.42 and an annual catch limit of 206,027 (Tier 9, Appendix G3) for the SEAK AABM fishery.

Appendix G3— The 17 tiers used to determine the Southeast Alaska (SEAK) aggregate abundance-based management (AABM) fishery annual catch limit (ACL) in 2023.

Tier	Abundance Index Range	AI Midpoint	Catch Limits
1	Less than 0.895	NA	Commission Determination
2	Between 0.895 and 0.945	0.920	107,498
3	Between 0.945 and 0.985	0.965	111,888
4	Between 0.985 and 1.035	1.010	116,278
5	Between 1.035 and 1.105	1.070	127,130
6	Between 1.105 and 1.175	1.140	142,101
7	Between 1.175 and 1.245	1.210	157,072
8	Between 1.245 and 1.345	1.295	191,963
9	Between 1.345 and 1.455	1.400	206,027
10	Between 1.455 and 1.555	1.505	220,091
11	Between 1.555 and 1.665	1.610	252,358
12	Between 1.665 and 1.765	1.715	267,594
13	Between 1.765 and 1.875	1.820	282,830
14	Between 1.875 and 2.015	1.945	314,799
15	Between 2.015 and 2.145	2.080	335,288
16	Between 2.145 and 2.285	2.215	355,778
17	Greater than 2.285	2.285	373,801

Appendix G4— Data used to fit the multivariate model used to predict the 2023 post-season AI for the Southeast Alaska (SEAK) aggregate abundance-based management (AABM) fishery.

Year	Post-season AI	Pre-season AI	CPUE	Projection AI
2001	1.33	1.17	8.25	1.09
2002	1.89	1.80	16.88	1.55
2003	2.25	1.86	19.93	1.57
2004	2.14	1.95	8.03	1.47
2005	1.97	2.13	8.30	1.66
2006	1.79	1.75	10.26	NA
2007	1.38	1.65	3.43	NA
2008	1.04	1.10	2.34	1.44
2009	1.23	1.37	3.46	1.21
2010	1.35	1.39	4.34	1.29
2011	1.68	1.75	6.17	1.50
2012	1.27	1.57	5.00	1.46
2013	1.68	1.24	4.40	1.47
2014	2.29	2.68	7.44	1.81
2015	2.03	1.49	13.43	1.95
2016	1.71	2.13	11.12	1.47
2017	1.35	1.31	4.21	1.76
2018	0.94	1.10	3.58	1.24
2019	1.07	1.10	3.38	1.03
2020	1.11	1.13	4.83	1.02
2021	1.23	1.28	3.85	1.16
2022	1.04	1.16	7.02	1.22

Appendix G5— Inputs to the multivariate model used to determine the 2023 Southeast Alaska (SEAK) aggregate abundance-based management (AABM) fishery pre-season abundance index (AI) and annual catch limit (ACL).

Model Inputs	Values
PSC Chinook Model pre-season AI (*Pre AI*)	1.15
SEAK early winter catch per unit effort from the early winter power troll fishery in district 113 (*CPUE*)	9.20
One-year-ahead projected AI (*Projection*)	1.31

Appendix H: Issues with and changes to the Pacific Salmon Commission Chinook Model calibration

Changes to SACE Program

Among the ERIS indicators for the model stock aggregates, there were sometimes brood years (BYs) for which CWT recoveries were insufficient to calculate pre-terminal fishery mortality rates (PTFmortrate) for all ages. This was almost always for age 5, particularly for those CWT stocks that typically have very low age 5 numbers in pre-terminal catch and return (e.g., Columbia River LRH). The PTFmortrates of the CWT indicator are employed in SACE to estimate age-specific cohorts, followed by estimation of age-specific maturation rates, for the model stock aggregate. In such cases for which an age-specific PTFmortrate could not be calculated from a BY's CWT recovery data, an average of estimates for that age from other BYs of the ERIS was employed. The change to AABM management with the 1999 PST brought about significant changes in pre-terminal fishery management. To reflect this advent, any BY prior to 1999 with a missing age-specific PTFmortrate used the average of estimates for BYs prior to 1999, and a BY from 1999 or later missing an age-specific PTFmortrate used the average of estimates from BYs from 1999 or later. This approach generally yielded considerably better fit of model estimated-to-observed escapement/terminal run than instead using averages of all the other BY's CWT age-specific maturation rate, as had been done in the Model Calibrations of the two previous years.

Alaska Troll SPFI

In 2022, there were 0 CWT recoveries in the June Inside Troll strata, which is necessary to compute the SPFI. When there are no CWT recoveries, the necessary estimate of cohort size cannot be computed. In this case, we fit a general linear model (GLM) of the form log(Cohort) ~ factor(Strata) + factor(Year). This model was then fit, and an estimate of Cohort size was estimated in place of a CWT-based estimate.

Changes to NBC and CBC Escapement Time Series

In the previous PST Agreement, North and Central BC were compiled as one stock (NTH) for the old Chinook Model (9806) and the escapement data were composed of data from the Nass River, Skeena River, Yakoun River, Area 5, Kitimat River, Atnarko River, Dean River, Wannock River, and Chuckwalla and Kilbella Rivers. For the new Phase II Model, Northern BC (NBC) and Central BC (CBC) were split into separate stocks, with NBC being composed of only the Nass and Skeena Rivers. During the 2023 Model Calibration, it was found that the NBC escapement time series was incorrectly compiled for the 2203 Calibration. The time series was updated to only include escapement data from the Nass and Skeena Rivers to reflect the current stock composition of NBC for the Phase II Model, which affected several years in the time series; updated time series did not affect the base period years. The CBC escapement time series was also found to be compiled incorrectly for the 2203 Calibration for some years. The time series was updated to only include data from Atnarko River, Wannock River, and Chuckwalla and Kilbella Rivers to reflect the current stock composition of CBC for the Phase II Model. Data validation work was also completed to ensure that the escapement data were consistent between all files used in CTC processes which further altered the time series slightly; updated time series did not affect the base-period years. These changes impacted the FCS file and FP values used in the Chinook Model for the NBC and CBC stocks.

Changes to MATAEQ program after translation from VB to R

While the R-based program can produce identical output to the original VB program, a few improvements were made during the translation process. Namely, this program fills in missing data with a linear trend interpolation instead of using the long-term average of the whole dataset, as in the VB code. We applied a linear model with time series trend using the tslm function in the forecast package to missing values (Hyndman et al. 2023).