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JOINT CHINOOK TECHNICAL COMMITTEE REPORT

2023 Exploitation Rate Analysis

TCCHINOOK (2023)-06

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List of Acronyms and Abbreviations[1]

3YA	Running 3-year Calendar Year Exploitation Rate Average	**IDF&G**	Idaho Department of Fish and Game
AABM	Aggregate Abundance-Based Management	**IM**	Incidental Mortality
ADF&G	Alaska Department of Fish & Game	**ISBM**	Individual Stock-Based Management
AEQ	Adult Equivalent	**MDT**	Mortality Distribution Table
AWG	Analytical Working Group of the CTC	**MRP**	Mark Recovery Program
BC	British Columbia	**MSF**	Mark-Selective Fishery
BY	Brood Year	**N**	Net
BYER	Brood Year Exploitation Rate	**NBC**	Northern BC Dixon Entrance to Kitimat including Haida Gwaii
CAS	Cohort Analysis System	**NOAA**	National Oceanic and Atmospheric Administration
CAMP	Chinook Analysis and Modelling Platform database	**NWIFC**	Northwest Indian Fisheries Commission
CBC	Central British Columbia	**ODFW**	Oregon Department of Fish & Wildlife
CCT	Confederated Colville Tribes	**OR**	Oregon
CETL	Chinook Extract, Transform, and Load Executable	**PFMA**	Pacific Fishery Management Area
CIG	Chinook Interface Group	**PFMC**	Pacific Fishery Management Council
CNR	Chinook Nonretention	**PSC**	Pacific Salmon Commission
CRITFC	Columbia River Intertribal Fish Commission	**PST**	Pacific Salmon Treaty
CTC	Chinook Technical Committee	**QIN**	Quinault Indian Nation
CWT	Coded-wire Tag	**RM**	Release Mortality
CY	Calendar Year	**RMIS**	Regional Mark Information System
CYER	Calendar Year Exploitation Rate	**ROM**	Ratio of Means
CYER WG	Calendar Year Exploitation Rate Work Group	**S**	Sport
CYM	Calendar Year Mortalities	**SACE**	Stock Aggregate Cohort Evaluation
DFO	Department of Fisheries and Oceans Canada	**SEAK**	Southeast Alaska Cape Suckling to Dixon Entrance
DIT	Double Index Tag	**SFEC**	Selective Fishery Evaluation Committee
EIS	Escapement Indicator Stock	**SIT**	Single Index Tag
ERA	Exploitation Rate Analysis	**SPFI**	Stratified Proportional Fishery Index
ERIS	Exploitation Rate Indicator Stock	**SSRAA**	Southern Southeast Regional Aquaculture Association
ETD	Electronic tag detection	**T**	Troll
FI	Fishery indices	**TAM**	Terminal Adjustment Methods
FNC	First Nations Caucus	**TBD**	To Be Determined
		TBR	Transboundary Rivers

[1] Stock acronyms can be found in Table 2.1 and Appendix A.

UAF	University of Alaska Fairbanks
U.S.	United States
USFWS	U.S. Fish & Wildlife Service
WA	Washington
WCVI	West Coast Vancouver Island excluding Area 20
WDFW	Washington Department of Fish and Wildlife

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EXECUTIVE SUMMARY

Chapter 3 of the 2019 Pacific Salmon Treaty (PST) Agreement requires the Chinook Technical Committee (CTC) to report annual catches, harvest rate indices, estimates of incidental mortality (IM) and exploitation rates for all Chinook salmon fisheries and stocks harvested within the Treaty area. The CTC provides annual reports to the Pacific Salmon Commission (PSC) to fulfill this obligation under Chapter 3 of the Treaty. This report contains five sections: an introduction and description of the Chapter 3 2019 PST Agreement requirements related to the annual exploitation rate analysis (ERA) based on coded-wire tag (CWT) data (Section 1); a review of the ERA methods (Section 2); a review of the results from the annual ERA (Section 3); a performance evaluation of individual stock-based management (ISBM) fisheries (Section 4); and CWT analyses for mark-selective fisheries (MSFs; Section 5). This report includes the results of the 2023 annual ERA using CWT data through 2021 for Southern U.S. stocks and 2022 for Alaskan and Canadian stocks.

Exploitation Rate Analysis

Section 2 of this report provides an overview of the ERA methodology. The CTC currently monitors 45 CWT ERA stocks, of which 31 are listed in Attachment I as calendar year exploitation rate (CYER) indicators of ISBM fishery performance. The ERA relies on cohort analysis of CWT recoveries, a procedure that reconstructs the cohort size and exploitation history of a given stock and brood year (BY) using representative CWT data as a proxy (CTC 1988). The ERA provides brood- and stock-specific estimates of total, age- and fishery-specific exploitation rates, maturation rates, smolt to age-2 or age-3 survival rates, annual distributions of fishery mortalities used to compute CYERs, and fishery indices for aggregate abundance-based (AABM) fisheries.

Estimates of age- and fishery-specific exploitation and maturation rates and adult equivalent estimates from the ERA are combined with data on catches, escapements, and incidental mortalities to complete the annual calibration of the PSC Chinook Model.

Section 3 of this report provides:

1) calendar year (CY) percent distribution of the total mortality that accrued to escapement, based on CWT data Appendix C).
2) brood year exploitation rates (BYERs) based on total mortality (catch plus incidental mortality) of complete broods (Appendix D), and
3) cohort survival rates, calculated to age 2 for stocks that are released usually in the spring following spawning (subyearlings, or ocean type), and to age 3 for stocks that are released in the spring in the year after spawning (yearlings or stream type) (Appendix E).

The most recent calendar year for percent distribution of total mortality in escapement is 2021 for Southern U.S. stocks and 2022 for Alaskan and Canadian stocks. However, because BYERs and survival rates use data for a fully returned cohort of fish, the most recent brood year of data reported for those statistics varies according to regional data availability and stock life history (yearling vs. subyearling).

Coastwide, BYERs generally showed declining trends compared to the long-term medians. In Alaska, including transboundary rivers, all stocks showed a decrease in BYERs except for Northern Southeast Alaska Spring. In Canada, all stocks except Phillips River Fall showed a decrease in BYERs. In the Southern U.S., all stocks showed a decrease in BYERs except for Grays Harbor Fall, Quillayute Fall, Hoh Fall, Queets Fall, and Lyons Ferry Yearling.

With regards to survival rates, changes compared to the long-term medians were highly variable. In Alaska, including transboundary rivers, all stocks showed declining trends in survival with the exception of Chilkat River and Unuk River. More than half of Canadian stocks showed increases in survival. The highest percent changes in survival rates were for Robertson Creek Fall, Nicola River Spring, and Chilliwack River Fall. In the Southern U.S., just over half of the stocks showed decreases in survival. The largest increase was for Columbia summers, while the largest decrease was for Willamette spring.

Coastwide, calendar year percent escapement generally showed increasing trends when comparing the mean of available years during the 2019 PST Agreement to the mean from the 2009 PST Agreement. In Alaska, including transboundary rivers, Northern Southeast Alaska Spring was the only stock that showed a decrease in calendar year percent escapement during the 2019 PST Agreement compared to the 2009 PST Agreement. In Canada, all stocks showed increasing calendar year percent escapement with the exception of Robertson Creek, Quinsam River Fall, East Vancouver Island North, and Chilliwack River Fall. Similarly, in the Southern U.S., all stocks exhibited increases in calendar year percent escapement with the exception of Hoko Fall Fingerling, Grays Harbor Fall, Queets Fall, Hoh Fall, Skagit Spring Fingerling, George Adams Fall Fingerling, and South Umpqua.

Summary of statistics generated by the 2023 exploitation rate analysis. Statistics include brood year exploitation rates (BYERs), cohort survival rates (age 2 or 3), and calendar year (CY) percent distribution of total mortality in escapement for 2022 (in Alaska [Panel A] and Canada [Panel B]) and 2021 (in Southern U.S. stocks [Panel C]).

For each statistic, the values are heat mapped, with low to high BYERs ranging from green to red, respectively, and low to high survival rates and % to escapement ranging from red to green, respectively. Relative changes between the longer-term averages and last full broods (or all years available since 2019 in the case of % escapement) are shown by tertile class symbols, where red diamonds indicate the largest relative increases for BYERs, and largest relative decreases for survival rates and % escapement, yellow triangles indicate intermediate changes, and green circles indicate the largest relative decreases for BYERs, and largest relative increases for survival rates and % escapement.

A) Southeast Alaska and Transboundary Stocks

Region	Indicator Stock ID/Name		BYER (total mortality)			Age 2 or 3 Survival Rate			Calendar Year % Escapement		
			Mean	Last Full Brood[1]	Points Change	Median	Last Full Brood[1]	% Change	Mean % 2009-18	Mean % 2019-Last	Points Change
SEAK/TBR	SSA	Southern SEAK Spring[2]	39%	19%	● -20	5.2%	4.6%	↘ -12%	45%	60%	↗ 15
	NSA	Northern SEAK Spring[2]	36%	51%	◆ 15	3.1%	1.3%	↓ -58%	54%	51%	↘ -3
	CHK	Chilkat River	16%	3%	▲ -13	7.3%	9.3%	→ 28%	85%	96%	↗ 11
	STI	Stikine River	34%	22%	▲ -12	3.7%	3.1%	↘ -17%	73%	89%	↗ 16
	TAK	Taku River	16%	5%	▲ -11	5.4%	4.7%	↘ -14%	82%	94%	↗ 12
	TST	Taku and Stikine Rivers	20%	9%	▲ -11	5.4%	4.1%	↘ -24%	76%	92%	↗ 16
	UNU	Unuk River	29%	20%	▲ -9	6.9%	10.5%	→ 54%	65%	80%	↗ 15

B) Canadian Stocks

Region	Indicator Stock ID/Name		BYER (total mortality)			Age 2 or 3 Survival Rate			Calendar Year % Escapement		
			Mean	Last Full Brood[1]	Points Change	Median	Last Full Brood[1]	% Change	Mean % 2009-18	Mean % 2019-Last	Points Change
Northern BC	KLM	Kitsumkalum	44%	22%	● -22	0.7%	0.1%	↓ -82%	61%	74%	↗ 13
	ATN	Atnarko	39%	30%	▲ -9	1.9%	1.9%	↘ 1%	59%	71%	↗ 12
WCVI	RBT	Robertson Creek Fall[2, 3]	42%	26%	▲ -16	4.1%	6.3%	→ 55%	45%	29%	↓ -16
	NWVI	Northwest Vancouver Island (RBT adj.)[2]	42%	26%	▲ -16	4.1%	6.3%	→ 55%	64%	68%	→ 4
	SWVI	Southwest Vancouver Island (RBT adj.)[2]	42%	26%	▲ -16	4.1%	6.3%	→ 55%	64%	68%	→ 4
Strait of Georgia	BQR	Big Qualicum River Fall	57%	45%	▲ -12	0.7%	1.1%	→ 63%	58%	59%	→ 1
	COW	Cowichan River Fall	65%	31%	● -34	1.1%	1.0%	↘ -15%	37%	62%	↑ 25
	PPS	Puntledge River Summer	50%	43%	▲ -7	0.8%	1.0%	→ 28%	62%	73%	↗ 11
	QUI	Quinsam River Fall	54%	47%	▲ -7	1.2%	1.5%	↘ 24%	58%	54%	↘ -4
	EVIN	East Vancouver Island North (QUI adj.)[2]	42%	28%	▲ -14	1.2%	1.5%	↘ 24%	61%	56%	↘ -5
	PHI	Phillips River Fall	28%	34%	◆ 6	4.1%	2.9%	↘ -28%	69%	74%	→ 5
Fraser	CHI	Chilliwack River Fall	40%	32%	▲ -8	10.6%	12.4%	↘ 17%	69%	64%	↘ -5
	HAR	Harrison River	44%	21%	● -23	2.1%	1.3%	↓ -38%	74%	78%	→ 4
	NIC	Nicola River Spring	25%	6%	● -19	1.9%	2.8%	→ 48%	78%	90%	↗ 12
	SHU	Lower Shuswap River Summer	50%	25%	● -25	2.8%	3.4%	↘ 21%	56%	76%	↑ 20

C) Southern U.S. Stocks

Region	Indicator Stock ID/Name		BYER (total mortality)			Age 2 or 3 Survival Rate			Calendar Year % Escapement			
			Mean	Last Full Brood[1]	Points Change	Median	Last Full Brood[1]	% Change	Mean % 2009-18	Mean % 2019-Last	Last % to Esc[2]	Points Change
WA Coast	HOK	Hoko Fall Fingerling	33%	29%	-4	1.2%	2.4%	105%	69%	66%	69%	-3
		Grays Harbor Fall (QUE adj.)[2]	43%	46%	3	2.6%	4.2%	65%	37%	36%	31%	-1
	QUE	Queets Fall Fingerling	60%	70%	10	2.6%	4.2%	65%	38%	25%	21%	-13
		Quillayute Fall (QUE adj.)[2]	43%	46%	3	2.6%	4.2%	65%	30%	36%	31%	6
	Hoh	Hoh Fall (QUE adj.)[2]	43%	46%	3	2.6%	4.2%	65%	39%	28%	26%	-11
	SOO	Tsoo-Yess Fall Fingerling	36%	9%	-27	0.5%	0.1%	-72%	72%	79%	83%	7
	ELW	Elwha River[2]	54%	22%	-32	0.5%	0.5%	0%	64%	71%	63%	7
Puget Sound	NSF	Nooksack Spring Fingerling[2]	39%	22%	-17	1.3%	1.6%	29%	56%	64%	70%	8
	SAM	Samish Fall Fingerling[2]	43%	36%	-7	1.4%	0.9%	-34%	29%	30%	31%	1
	SKF	Skagit Spring Fingerling[2]	28%	19%	-9	1.4%	1.0%	-29%	57%	54%	56%	-3
	SSF	Skagit Summer Fingerling[2]	35%	33%	-2	1.2%	0.3%	-74%	47%	58%	24%	11
	STL	Stillaguamish Fall Fingerling[2]	47%	32%	-15	1.5%	2.1%	37%	52%	59%	54%	7
	SKY	Skykomish Fall Fingerling[2]	32%	26%	-6	0.9%	1.0%	11%	66%	69%	54%	3
	SPS	South Puget Sound Fall Fingerling[2]	46%	37%	-9	2.1%	1.4%	-33%	59%	63%	61%	4
	NIS	Nisqually Fall Fingerling[2]	41%	33%	-8	1.5%	1.6%	3%	47%	49%	52%	2
	GAD	George Adams Fall Fingerling[2]	45%	32%	-13	1.4%	2.2%	55%	46%	38%	57%	-8
Columbia River	CWF	Cowlitz Fall Tule[2]	36%	15%	-21	0.4%	0.3%	-36%	67%	77%	65%	10
	HAN	Hanford Wild Brights	50%	29%	-21	0.8%	0.7%	-13%	45%	65%	61%	20
	LRH	Lower River Hatchery Tule	59%	58%	-1	0.6%	0.3%	-47%	37%	51%	51%	14
	LRW	Lewis River Wild	44%	41%	-3	1.5%	1.8%	18%	48%	54%	49%	6
	LYF	Lyons Ferry Fingerling	35%	29%	-6	1.4%	0.6%	-58%	64%	76%	84%	12
	LYY	Lyons Ferry Yearling	47%	48%	1	4.2%	1.3%	-69%	49%	58%	65%	9
	SMK	Similkameen Summer Yearling	34%	24%	-10	4.0%	4.6%	17%	55%	77%	73%	22
	SPR	Spring Creek Tule	72%	61%	-11	1.3%	0.9%	-36%	29%	38%	33%	9
	SUM	Columbia River Summers	50%	36%	-14	1.3%	3.8%	184%	49%	71%	60%	22
	URB	Columbia Upriver Bright	51%	38%	-13	1.8%	1.5%	-20%	53%	65%	60%	12
	WSH	Willamette Spring[2]	11%	5%	-6	2.5%	0.5%	-78%	58%	69%	55%	11
Oregon Coast	ELK	Elk River[2]	22%	19%	-3	6.2%	6.0%	-2%	52%	56%	56%	4
		South Umpqua (ELK adj.)[2]	22%	19%	-3	6.2%	6.0%	-2%	56%	54%	55%	-2
		Coquille (ELK adj.)[2]	22%	19%	-3	6.2%	6.0%	-2%	58%	61%	72%	3
	SRH	Salmon River[2]	36%	26%	-10	5.5%	5.3%	-4%	44%	56%	47%	12
		Nehalem (SRH adj.)[2]	36%	26%	-10	5.5%	5.3%	-4%	54%	61%	49%	7
		Siletz (SRH adj.)[2]	36%	26%	-10	5.5%	5.3%	-4%	50%	51%	42%	1
		Siuslaw (SRH adj.)[2]	36%	26%	-10	5.5%	5.3%	-4%	45%	45%	41%	0

[1] For 2023, the most recent brood is 2017 for subyearling stocks in Canada, and 2016 for yearling stocks in Alaska and Canada (KLM, NIC) and all stocks in the southern US, except LYY and WSH yearlings (2014).
[2] BYER is ocean exploitation rate only to better represent natural spawner BYER in the presence of terminal fisheries targeting hatchery fish.
[3] Terminal adjustments to CYER applied because fishing mortality on hatchery fish does not represent fishing mortality on wild fish.

ISBM Fisheries Performance Under the 2019 PST Agreement

Section 4 of this report provides an assessment of annual and multi-year ISBM fisheries performance. Attachment I of Chapter 3 identifies CYER limits applicable to ISBM obligations for 31 stocks; of these, CYER limits apply to 17 stocks for Canadian ISBM fisheries and 22 stocks for U.S. ISBM fisheries. Sixteen of the Attachment I indicator stocks have management objectives[2]. The CTC has evaluated status towards achieving PSC-agreed management objectives for the 16 stocks in Attachment I with identified management objectives for which

[2] Attachment I of the 2019 PST Agreement has a total of 38 stocks of which 31 are subject to ISBM obligations. There are currently 22 stocks with management objectives and 16 of those are subject to ISBM obligations.

CYER limits are applicable (CTC 2020). In 2021, there were five stocks that did not achieve their management objectives (Atnarko, Harrison, Skagit Summer/Fall, Grays Harbor Fall, and Siuslaw), so CYER limits apply to them as per paragraph 5(a).

Annual Canadian ISBM obligations were met for 11 of the 15 stocks that could be evaluated; three met their management objectives and thus had no applicable CYER limits (Cowichan, Lower Shuswap, and Skagit Spring), one did not meet its management objective but had a CYER below its limit (Atnarko), and seven had no management objectives but had CYERs below their limits. Annual CYER obligations were not met for four stocks—East Coast Vancouver Island North (EVIN), Phillips, Harrison, and Skagit Summer/Fall.

Relative to U.S. ISBM fisheries annual performance for 2021, annual ISBM obligations were met for 16 of the 22 stocks listed in Attachment I; 10 that met their management objectives and thus had no applicable CYER limits, and six that had CYERs that were below the applicable limits. Annual CYER obligations were not met for six stocks: Harrison, Nooksack Spring, Skagit Summer/Fall, Stillaguamish, Snohomish, and Siuslaw.

Review of annual performance in the Pacific Salmon Treaty Individual Stock-Based Management (ISBM) fisheries, 2021. NA indicates the obligation does not exist for that stock and country combination.

Attachment I Escapement Indicator Stock	Canadian Obligation Met?	U.S. Obligation Met?
Skeena	Yes	NA
Atnarko	Yes	NA
NWVI Natural Aggregate	Yes	NA
SWVI Natural Aggregate	Yes	NA
East Vancouver Island North	No	NA
Phillips	No	NA
Cowichan	Yes	Yes
Nicola	Yes	Yes
Chilcotin	NA	NA
Chilko	NA	NA
Lower Shuswap	Yes	NA
Harrison	No	No
Nooksack Spring	Yes	No
Skagit Spring	Yes	Yes
Skagit Summer/Fall	No	No
Stillaguamish	Yes	No
Snohomish	Yes	No
Hoko	NA	Yes
Grays Harbor Fall	NA	Yes
Queets Fall	NA	Yes
Quillayute Fall	NA	Yes
Hoh Fall	NA	Yes
Upriver Brights	NA	Yes
Lewis River Fall	NA	Yes
Coweeman	NA	Yes
Mid-Columbia Summers	NA	Yes
Nehalem	NA	Yes
Siletz	NA	Yes
Siuslaw	NA	No
South Umpqua	NA	Yes
Coquille	NA	Yes

For each escapement indicator stock identified in Attachment I, the CTC is reporting the running 3-year average (3YA) CYER for the first time as data from catch years 2019–2021 are available from both Parties' ISBM fisheries (Footnote 17, 2019 PST Agreement). For Attachment I stocks without a management objective, all years shall be used to calculate the running 3YA as per paragraph 7(c). For Attachment I indicator stocks with a management objective, three years of CYERs that meet the criteria for inclusion specified in paragraph 7(c) are used to calculate the running 3YA CYER as agreed to by the PSC.[3]

For the running 3YA CYER specified in paragraph 7(c) of the PST Agreement, Canadian ISBM obligations were met for 10 of the 12 stocks that could be evaluated; the 3YA CYER for EVIN and Harrison exceeded their limit by more than 10% (limit + 10% of the limit). Per the provisions of the 2019 PST Agreement, this requires further action, as identified in subparagraphs 7(c)(i) and 7(c)(ii).

Performance of Canadian ISBM fisheries relative to three-year average (3YA) CYERs, as specified in paragraph 7(c) in Chapter 3 of the 2019 PST Agreement. Note: The 'Paragraph 7(c) Obligation Met' column indicates whether the provisions of paragraph 7(c) were met for each stock, specifically whether the 3YA CYER for a given stock was less than (green) or exceeded (red) the CYER limit by more than ten percent.

Escapement Indicator	Years Included in 3YA	CYER 3YA	CYER Limit	Paragraph 7(c) Obligation Met?
Skeena	2019, 2020, 2021	0.096	0.146	Yes
Atnarko	2019, 2020, 2021	0.253	0.274	Yes
NWVI Natural	2019, 2020, 2021	0.071	0.085	Yes
SWVI Natural	2019, 2020, 2021	0.071	0.085	Yes
EVIN	2019, 2020, 2021	0.189	0.150	No
Phillips	2019, 2020, 2021	0.088	0.101	Yes
Cowichan	2020, 2021	NA	0.380	NA
Nicola	2019, 2020, 2021	0.116	0.164	Yes
Chilcotin	NA	NA	NA	NA
Chilko	NA	NA	NA	NA
Lower Shuswap	2019, 2020, 2021	0.144	0.199	Yes
Harrison	2019, 2020, 2021	0.172	0.101	No
Nooksack Spring	2019, 2020, 2021	0.092	0.130	Yes
Skagit Spring	2019	NA	0.070	NA
Skagit Sum/Fall	2019, 2021	NA	0.082	NA
Stillaguamish	2019, 2020, 2021	0.092	0.110	Yes
Snohomish	2019, 2020, 2021	0.078	0.077	Yes

[3] The Chinook Interface Group (CIG) will return to the discussion of options on how to deal with years with missing data for future years and make a recommendation to the PSC.

For the 3YA CYER in U.S. ISBM fisheries, paragraph 7(c) obligations were met for 15 of the 16 stocks that could be evaluated; only the 3YA CYER for Nooksack Spring exceeded the CYER limit by more than 10% (limit + 10% of the limit). Per the provisions of the 2019 PST Agreement, this requires further action, as identified in subparagraphs 7(c)(i) and 7(c)(ii).

Performance of U.S. ISBM fisheries relative to three-year average (3YA) CYERs, as specified in paragraph 7(c) in Chapter 3 of the 2019 PST Agreement. Note: The 'Paragraph 7(c) Obligation Met' column indicates whether the provisions of paragraph 7(c) were met for each stock, specifically whether the 3YA CYER for a given stock was less than (green) or exceeded (red) the CYER limit by more than ten percent.

Escapement Indicator	Years Included in 3YA	CYER 3YA	CYER Limit	Paragraph 7(c) Obligation Met?
Cowichan	2019, 2020, 2021	0.043	0.103	Yes
Nicola	2019, 2020, 2021	0.015	0.039	Yes
Harrison	2019, 2020, 2021	0.073	0.073	Yes
Nooksack Spring	2019, 2020, 2021	0.166	0.103	No
Skagit Spring	2020	NA	0.254	NA
Skagit Sum/Fall	2019, 2020, 2021	0.153	0.164	Yes
Stillaguamish	2019, 2020, 2021	0.184	0.168	Yes
Snohomish	2019, 2020, 2021	0.159	0.185	Yes
Hoko	2019, 2020, 2021	0.043	0.100	Yes
Grays Harbor	2019, 2020, 2021	0.095	0.160	Yes
Queets	NA	NA	0.142	NA
Quillayute	2019, 2020, 2021	0.105	0.214	Yes
Hoh	2021	NA	0.154	NA
Upriver Brights (URB)	2019, 2020, 2021	0.168	0.228	Yes
Upriver Brights (HAN)	2019, 2020, 2021	0.120	0.249	Yes
Lewis	2019, 2020, 2021	0.062	0.195	Yes
Coweeman	2019, 2020, 2021	0.119	0.206	Yes
Mid-Columbia Summers	2019, 2020	NA	0.263	NA
Nehalem	2019, 2020	NA	0.131	NA
Siletz	2020	NA	0.173	NA
Siuslaw	2019, 2021	NA	0.204	NA
South Umpqua	2019, 2020, 2021	0.289	0.268	Yes
Coquille	2019, 2020, 2021	0.223	0.224	Yes

Mark-Selective Fisheries

Section 5 of this report contains harvest information by region from MSFs. MSFs occurred in the Columbia River, Puget Sound, and Canadian Strait of Juan de Fuca and Vancouver Island inside in 2021. The magnitude of impact of a MSF relative to the total exploitation of a stock can be measured using the percentage of the total landed catch in net, sport, and troll fisheries of tagged and marked PSC indicator stocks that occurs in MSFs. Traditionally, the CTC has used PSC indicator stocks that have been double index tagged (DIT) to evaluate the impact of MSFs on the unmarked stocks represented by the unmarked tag group in a DIT pair[4]; however, many CWT indicator stocks do not have a DIT pair. Additionally, coastwide application of electronic tag detection (ETD) and the associated recovery of DIT releases is inconsistent. Accordingly, an approach was applied to estimate mortality distributions for natural stocks that have single index tag (SIT) indicator stocks under conditions where the MSF impacts mainly occur on mature SIT fish proximal to their terminal area. Under MSFs, marked CWT release groups experience different patterns of fishing mortality than unmarked fish. In the future, as MSFs for Chinook become more widely employed, estimation procedures and reporting for marked and unmarked fish for purposes of the ERA (including estimates of BYERs, CYERs, and fishery indices) will change substantially.

[4] A DIT group consists of at least two paired CWT release groups, one with the mass mark (or adipose fin clip) and one without the mark. These 2 tag groups are supposed to be identical except for the mark, and differences in recoveries at escapement are assumed to be due to the MSFs—assuming there is no mark induced mortality occurring prior to recruitment to the fisheries.

1. INTRODUCTION

Chapter 3 of the 2019 Pacific Salmon Treaty (PST) Agreement requires the Chinook Technical Committee (CTC) to report catch and escapement data and modeling results used to manage Chinook salmon fisheries and stocks harvested within the Treaty area annually. To fulfill this obligation, the CTC provides a series of annual reports to the Pacific Salmon Commission (PSC). This annual report provides an overview of the annual exploitation rate analysis (ERA), the ERA results, and includes calendar year exploitation rates (CYER) which are the metric used to evaluate performance of individual stock-based management (ISBM) fisheries under the 2019 PST Agreement. The results of the ERA are relevant to the PSC's fishery management framework for ISBM fisheries and used as inputs to the PSC Chinook Model calibration (see CTC 2023a for details).

Paragraph 3(b) of the 2019 PST Agreement defines ISBM fisheries as "*a regime that constrains the annual impacts within the fisheries of a jurisdiction for a naturally spawning Chinook salmon stock or stock group.*" Per paragraph 5(a) "ISBM fisheries shall be managed to limit the total adult equivalent mortality for stocks listed in Attachment I that are not meeting agreed biologically-based management objectives, or that do not have agreed management objectives, to no more than the limits identified in Attachment I." The CTC is tasked with evaluating ISBM fishery performance relative to the obligations set forth in paragraphs 5 and 7 annually using the CYER metric to monitor total mortality.

Section 2 of this report describes the methods used to perform the ERA using coded-wire tag (CWT) data provided by management agencies throughout the PST area. Section 3 contains the annual results of the ERA. The results of the 2023 ERA are based on CWT data through catch year 2022 for Alaskan and Canadian stocks and 2021 for southern U.S. stocks. As data are now available, Section 4 contains a performance evaluation of ISBM fisheries relative to the 2019 PST Agreement. Section 5 is a summary of catch in mark-selective fisheries (MSFs) and methods used to evaluate their impacts.

Appendix A shows the relationship between the exploitation rate indicator stocks, escapement indicator stocks, model stocks, and PST Attachment I stocks. Appendix B provides a description of notations found throughout this report. Appendix C through Appendix H present additional output from the ERA beyond the summaries presented in the main body of the report. Appendix C provides information about the percent distribution of total mortality by catch year for exploitation rate indicator stocks and includes a link to this data set. Appendix D presents methods for estimating brood year exploitation rate (BYER) accompanied by BYER plots by stock. For Appendix D, only complete brood years are shown. Appendix E presents methods for estimating smolt-to-youngest age survival and associated plots by stock. Appendix F displays the data used to adjust ERA results for stocks where a terminal area adjustment was applied (see Section 2.1.3.1 for details). Appendix G shows exploitation rates by stock and age for each aggregate abundance-based management (AABM) fishery. CYERs are provided in Appendix H. CWT data quality and ERA documentation are detailed in Appendix I. Appendix J describes the pseudo recovery inclusion assessment which was the process utilized to account for the untagged/unmarked Chinook released from seven Canadian indicator stocks in 2019.

2. Exploitation Rate Analysis Methods

The CTC currently monitors 45 CWT exploitation rate indicator stocks (Figure 2.1; Table 2.1). The ERA relies on cohort analysis, a procedure that reconstructs the age-specific cohort size and exploitation history of a given stock for each brood year (BY) using CWT release and recovery data (CTC 1988). The ERA provides stock-specific estimates of BY total, age-, and fishery-specific exploitation rates, maturation rates, smolt-to-age-2 or age-3 survival rates, annual distributions of fishery mortalities, and separate fishery indices for AABM and ISBM fisheries (Table 2.2). Then, in Stock Aggregate Cohort Evaluation (SACE), age-specific CWT indicator stock estimates of pre-terminal fishing mortality rates from the ERA are combined with age-specific estimates of stock aggregate terminal return to reconstruct stock aggregate age-specific cohorts and maturation rates for the PSC Chinook Model. Finally, estimates of age-and fishery-specific exploitation and maturation rates from these cohort analyses are combined with data on catches, escapements, and incidental mortalities to complete the annual calibration of the PSC Chinook Model (CTC 2023a).

Indicator stocks used for the ERA and the estimates derived for each stock are shown in Table 2.2. Relationships between the exploitation rate indicator stocks, model stocks, and escapement indicator stocks are provided in Appendix A, as well as a list of historic indicator stocks. A list of CWT codes used in the 2023 ERA can be found on the PSC website: https://www.psc.org/publications/technical-reports/technical-committee-reports/chinook/ctc-data-sets/.

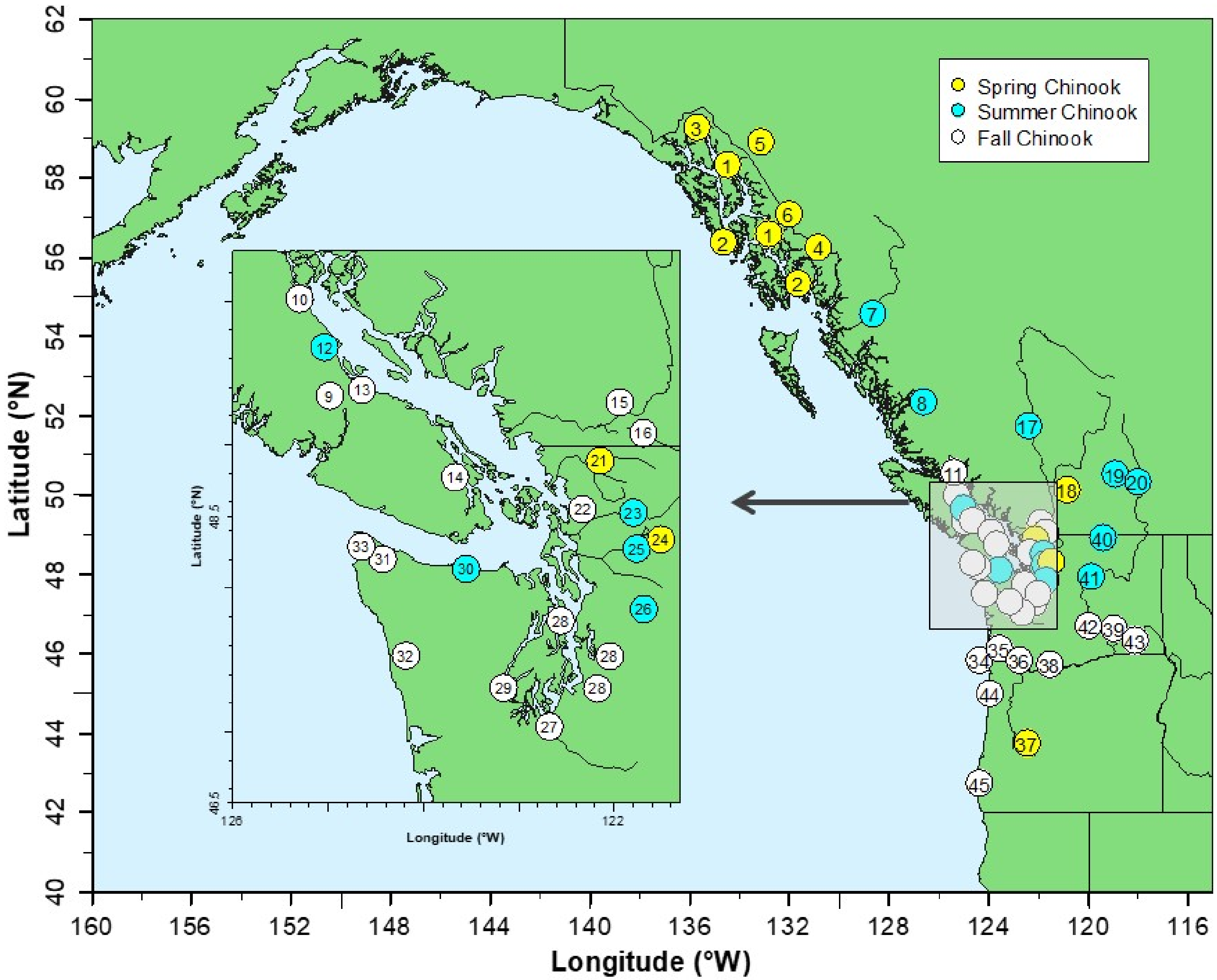

Figure 2.1—Geographical locations of current Chinook salmon coded-wire tag (CWT) exploitation rate indicator stocks.

Note: See Table 2.1 for the full stock names associated with each number. *The southern BC and Puget Sound area, where concentration of the CWT indicators is greatest, is shown in the expanded view.*

Table 2.1—Summary of current coded-wire tag (CWT) exploitation rate indicator stocks, location, run type, and smolt age.

Stock/Area	Exploitation Rate Indicator Stock	Hatchery	Run Type	Smolt Age	Map No.
Southeast Alaska	Northern Southeast Alaska (NSA)	Crystal Lake (ACI)	Spring	Age 1	1
	Southern Southeast Alaska (SSA)	Herring Cove (AHC), Little Port Walter (ALP), Deer Mountain (ADM), Neets Bay (ANB)	Spring	Age 1	2
	Chilkat (CHK)	Wild	Spring	Age 1	3
	Unuk (UNU)	Wild	Spring	Age 1	4
Transboundary Rivers	Taku and Stikine (TST)	Wild	Spring	Age 1	5,6
North/Central BC	Kitsumkalum (KLM)	Deep Creek	Summer	Age 1	7
	Atnarko (ATN)	Snootli	Summer	Age 0	8
WCVI	Robertson Creek (RBT)	Robertson Creek	Fall	Age 0	9
Strait of Georgia	Quinsam (QUI)	Quinsam	Fall	Age 0	10
	Phillips (PHI)	Gillard Pass	Summer/Fall	Age 0	11
	Puntledge (PPS)	Puntledge	Summer	Age 0	12
	Big Qualicum (BQR)	Big Qualicum	Fall	Age 0	13
	Cowichan (COW)[1]	Cowichan	Fall	Age 0	14
Fraser River	Harrison (HAR)	Chehalis	Fall	Age 0	15
	Chilliwack (CHI)[1]	Chilliwack	Fall	Age 0	16
	Chilko (CKO) - *In Development*	Spius Creek, Chehalis	Summer	Age 1	17
	Nicola (NIC)	Spius Creek	Spring	Age 1	18
	Lower Shuswap (SHU)[1]	Shuswap Falls	Summer	Age 0	19
	Middle Shuswap (MSH)	Shuswap Falls	Summer	Age 0	20
North Puget Sound	Nooksack Spring Fingerling (NSF)	Kendall Creek	Spring	Age 0	21
	Samish Fall Fingerling (SAM)[2]	Samish	Summer/Fall	Age 0	22
	Skagit Summer Fingerling (SSF)	Marblemount	Summer	Age 0	23
	Skagit Spring Fingerling (SKF)	Marblemount	Spring	Age 0	24
Central Puget Sound	Stillaguamish Fall Fingerling (STL)[3]	Stillaguamish Tribal	Summer/Fall	Age 0	25
	Skykomish Summer Fingerling (SKY)[2,3]	Wallace	Summer/Fall	Age 0	26
South Puget Sound	Nisqually Fall Fingerling (NIS)[2]	Clear Creek	Summer/Fall	Age 0	27
	South Puget Sound Fall Fingerling (SPS)[2]	Soos/Grovers/Issaquah creeks	Summer/Fall	Age 0	28
Hood Canal	George Adams Fall Fingerling (GAD)[2]	George Adams	Summer/Fall	Age 0	29
Juan de Fuca	Elwha Fall Fingerling (ELW)	Lower Elwha	Summer/Fall	Age 0	30
North Washington Coast	Hoko Fall Fingerling (HOK)	Hoko Makah National Hatchery	Fall	Age 0	31
	Queets Fall Fingerling (QUE)	Wild, Salmon River (WA)	Fall	Age 0	32
	Tsoo-Yess Fall Fingerling (SOO)[4]	Makah National Fish Hatchery	Fall	Age 0	33
Lower Columbia River	Columbia Lower River Hatchery (LRH)[2]	Big Creek	Fall Tule	Age 0	34
	Cowlitz Tule (WA) (CWF)	Cowlitz	Fall Tule	Age 0	35
	Lewis River Wild (LRW)	Wild	Fall Bright	Age 0	36
	Willamette Spring (WSH)[1]	Willamette Hatcheries	Spring	Age 1	37
	Spring Creek Tule (WA) (SPR)[2]	Spring Creek National Hatchery	Fall Tule	Age 0	38
Upper Columbia River	Hanford Wild (HAN)	Wild	Fall Bright	Age 0	39
	Similkameen Summer Yearling (SMK)	Similkameen and Omak Pond	Summer	Age 1	40
	Columbia Summers (WA) (SUM)	Wells	Summer	Age 0/1	41

Stock/Area	Exploitation Rate Indicator Stock	Hatchery	Run Type	Smolt Age	Map No.
	Columbia Upriver Brights (URB)[2]	Priest Rapids	Fall Bright	Age 0	42
Snake River	Lyons Ferry Fingerling (LYF)[5]	Lyons Ferry	Fall Bright	Age 0	43
	Lyons Ferry Yearling (LYY)[2]	Lyons Ferry	Fall Bright	Age 1	
North Oregon Coast	Salmon (SRH)	Salmon	Fall	Age 0	44
Mid Oregon Coast	Elk River (ELK)	Elk River	Fall	Age 0	45

[1] Historical releases with double index tags (DIT); DIT component not currently maintained.

[2] DIT releases associated with this stock.

[3] Though stock is composed of both summer and fall-run components, references to both summer-run and fall-run stocks are used interchangeably throughout document.

[4] The name for the Sooes River and hatchery was changed to Tsoo-Yess in 2015.

[5] Subyearlings have been CWT-tagged since BY 1986, except for brood years 1993–1997.

Table 2.2—Coded-wire tag (CWT) exploitation rate indicator stocks used in the exploitation rate analysis (ERA) and data derived from them: fishery indices, individual stock-based management (ISBM) calendar year exploitation rates (CYER)—(ISBM CYER Limit), survival indices, brood year exploitation rates (BYER), and stock catch distribution (Dist) with escapement estimates (Esc) and base period (1979–1982) tag recoveries (Base Recoveries).

Exploitation Rate Indicator Stock	Fishery Index	ISBM CYER Limit	Survival Index	BYER[1]	Dist	Esc	Base Recoveries
Northern Southeast Alaska (NSA)	Yes[2]	—	Yes	Ocean	Yes	Yes	Yes
Southern Southeast Alaska (SSA)	Yes[2]	—	Yes	Ocean	Yes	Yes	Yes
Chilkat (CHK)	—	—	Yes	Total	Yes	Yes	—
Taku and Stikine (TST)	—	—	Yes	Total	Yes	Yes	Yes
Unuk (UNU)	—	—	Yes	Total	Yes	Yes	—
Kitsumkalum (KLM/KLY)	—	Yes (KLM)	Yes	Total	Yes	Yes	—
Atnarko (ATN)	Yes	Yes	Yes	Total	Yes	Yes	Yes
Robertson Creek (RBT)	Yes	Yes[5]	Yes	Ocean	Yes	Yes	Yes
Quinsam (QUI)	Yes	Yes[5]	Yes	Total	Yes	Yes	Yes
Phillips River Fall (PHI)	—	Yes	—	—	Yes	—	—
Puntledge (PPS)	Yes	—	Yes	Total	Yes	Yes	Yes
Big Qualicum (BQR)	Yes	—	Yes	Total	Yes	Yes	Yes
Cowichan (COW)	Yes	Yes	Yes	Total	Yes	Yes	—
Chilliwack (CHI)	Yes	—	Yes	Total	Yes	Yes	—
Chilko (CKO)	—	—	—	Total	Yes	Yes	Yes
Harrison (HAR)	—	Yes	Yes	Total	Yes	Yes	—
Lower Shuswap (SHU)	Yes	Yes	Yes	Total	Yes	Yes	Yes
Middle Shuswap (MSH)	—	—	Yes	Total	Yes	Yes	—
Nicola (NIC)	—	Yes	Yes	Total	Yes	Yes	—
Nooksack Spring Fingerling (NSF)	—	Yes	Yes	Ocean	Yes	Yes	Yes
Samish Fall Fingerling (SAM)[4]	Yes	—	Yes	Ocean	Yes	Yes[3]	Yes
Skagit Spring Fingerling (SKF)	—	Yes	Yes	Ocean	Yes	Yes	—
Skagit Summer Fingerling (SSF)	—	Yes	Yes	Ocean	Yes	Yes	—
Skykomish Summer Fingerling (SKY)	—	Yes	Yes	Ocean	Yes	Yes	—
Stillaguamish Summer Fingerling (STL)	—	Yes	Yes	Ocean	Yes	Yes	—
Nisqually Fall Fingerling (NIS)	—	—	Yes	Ocean	Yes	Yes	Yes
South Puget Sound Fall Fingerling (SPS)	Yes	—	Yes	Ocean	Yes	Yes[3]	Yes
George Adams Fall Fingerling (GAD)	Yes	—	Yes	Ocean	Yes	Yes[3]	Yes
Elwha Fall Fingerling (ELW)	—	—	Yes	Ocean	Yes	—	—
Hoko Fall Fingerling (HOK)	—	Yes	Yes	Total	Yes	Yes	—
Queets Fall Fingerling (QUE)	—	Yes[5]	Yes	Total	Yes	—	Yes
Tsoo-Yess Fall Fingerling (SOO)	—	—	Yes	Total	Yes	Yes	—
Columbia Lower River Hatchery (LRH)[4]	Yes	—	Yes	Total	Yes	Yes	Yes
Cowlitz Tule (CWF)	Yes	Yes	Yes	Ocean	Yes	Yes	Yes
Lewis River Wild (LRW)	Yes	Yes	Yes	Total	Yes	Yes	Yes
Spring Creek Tule (SPR)[4]	Yes	—	Yes	Total	Yes	Yes	Yes
Willamette Spring (WSH)	Yes	—	Yes	Ocean	Yes	Yes	Yes
Columbia Summers (SUM)	Yes	Yes	Yes	Total	Yes	Yes	Yes
Columbia Upriver Brights (URB)	Yes	Yes	Yes	Total	Yes	Yes	Yes
Hanford Wild (HAN)	—	—	Yes	Total	Yes	Yes	—

Exploitation Rate Indicator Stock	Fishery Index	ISBM CYER Limit	Survival Index	BYER[1]	Dist	Esc	Base Recoveries
Similkameen Summer Yearling (SMK)	—	—	Yes	Total	Yes	Yes	—
Lyons Ferry Fingerling (LYF)	—	—	Yes	Total	Yes	Yes	—
Lyons Ferry Yearling (LYY)	—	—	Yes	Total	Yes	Yes	—
Salmon River (SRH)	Yes	Yes[5]	Yes	Ocean	Yes	Yes	Yes
Elk River (ELK)	Yes	Yes[5]	Yes	Ocean	Yes	Yes	Yes

[1] For stocks of hatchery origin and subject to terminal fisheries directed at harvesting surplus hatchery production, ocean fisheries do not include terminal net fisheries. Otherwise, total fishery includes terminal net fisheries.

[2] Northern Southeast Alaska (NSA) and Southern Southeast Alaska (SSA) were used in the stratified proportional fishery index for the Phase II Pacific Salmon Commission Chinook Model.

[3] Only hatchery rack recoveries are included in escapement.

[4] Stock of hatchery origin not used to represent naturally spawning stock.

[5] The CYER limits includes terminal adjustments.

2.1 Overview of Coded-Wire Tag-Based Exploitation Rate Analyses

The ERA calculates several important metrics, listed in Table 2.2. The details for calculating each metric are outlined in Appendix C, Appendix D, Appendix E, and Appendix F. Described here are a few key details of the ERA; each have additional information which can be found in the referenced material.

2.1.1 Description of Incidental Mortality

Management strategies have changed considerably for fisheries of interest to the PSC since the PST was signed in 1985. Regulatory changes have included size limit changes, extended periods of Chinook Non-Retention (CNR) fisheries, mandatory release of Chinook salmon caught in some net fisheries, and MSFs under various retention restrictions. Fisheries indices can be reported as either total mortality, or its components: catch mortality and incidental mortality (IM). Here we report total mortality for ISBM fisheries, but the indices are split into components for AABM fisheries. Estimates of IM are essential for assessment of total fishery impacts, yet they cannot be determined directly from CWT recovery data. IM is estimated for both legal and sub-legal sized fish by accounting for each of the following: (1) drop-off mortality of legal-sized fish in retention fisheries (CTC 2022a), (2) mortality of legal-size fish in CNR fisheries, (3) mortality of sublegal-size fish in both retention and CNR fisheries.

Additional details about the methods used to estimate IM have been described by the CTC Analytical Work Group (AWG) (CTC AWG Unpublished), CTC (2004), and CTC (2022b).

2.1.2 Calendar Year Exploitation Rates

Beginning with fishing year 2019, the 2019 PST Agreement outlines a new metric for the evaluation of ISBM fisheries. The calendar year exploitation rate is now used to monitor total mortality in ISBM fisheries and for limiting total adult equivalent (AEQ) mortality (paragraph 5(e)) on Attachment I stocks. Performance analysis is dependent on the recovery of CWTs and, for some stocks, estimates of harvest rates in specific terminal fisheries (particularly in-river). The CTC provides evaluation for ISBM fisheries on a post-season basis, with a two-year lag for Southern U.S. stocks' CWT processing. See Appendix H and Section 4 for calculation and evaluation of the CYER metric, including a description of the three-year running CYER average.

2.1.3 Assumptions of the CWT Exploitation Rate Analyses

Assumptions for the procedures used in the ERA are summarized below and are discussed in more detail in a previous publication (CTC 1988); SACE, which estimates maturation rates for stock aggregates that replace the CWT indicator stock maturation rates for use in the PSC Chinook Model, is described in the 2019 Base Period Calibration documentation (CTC 2021b; CTC 2021c; CTC 2023b):

1. CWT recovery data are obtained in a consistent manner from year to year or can be adjusted to be made comparable.
2. Use of ratios may reduce or eliminate the effect of data biases that are consistent from year to year. Many of the analyses rely upon indices that are computed as the ratio of a statistic in a particular year to the value associated with a base period.

3. For ocean age-2 and older fish, natural mortality varies by age but is constant across years. Natural mortality rates applied by age are: age 1 → age 2, 40%; age 2 → age 3, 30%; age 3 → age 4, 20%; and age 4 → age 5 and older 10% (e.g., after pre-terminal fishing mortality and maturation of the age 4 cohort, 10% of the remaining immature fish die due to natural causes before moving to the next age class and before the commencement of fishing the next year).
4. All stocks within a fishery have the same size distribution at age, and the distribution of any individual stock across fisheries is constant across years.
5. The spatial and temporal catch distribution of sublegal-size fish and legal-size fish is the same for a given stock and age.
6. IM rates per encounter are constant among years. The rates vary by fish size (legal or sublegal) and fishery, and rates for troll and sport fisheries were published by the CTC (1997), updated in 2004 (CTC 2004), and re-examined in 2022 (CTC 2022a).
7. The procedures for estimating the mortality of legal-size CWT fish during periods of CNR assume that for any year the stock distribution during CNR periods is the same as during legal catch retention periods. To account for this in Canadian fisheries, the number of legal encounters during the CNR fishery was adjusted by a selectivity factor (i.e., the proportion of fishing areas that remain open during CNR periods). A factor of 0.34 was used across years for the West Coast Vancouver Island (WCVI) and Strait of Georgia troll fisheries. This value was the average selectivity factor calculated from three years of observer data in the Alaska troll fishery; however, because Alaska provides an independent estimate of legal and sublegal encounters each year, this 3-year average selectivity factor is not needed for the Southeast Alaska (SEAK) troll fishery. A factor of 0.20 was used in the North/Central British Columbia (BC) troll fishery.
8. Maturation rates for BYs in which all ages have not matured (incomplete broods) are equal to the most recent six-year average of completed BYs. Maturation rates are stock- and age-specific.
9. Age 4 (age 5 for spring stocks) and older Chinook salmon recovered in ocean net fisheries are assumed to be mature fish.
10. When using the fishery indices as a measure of change in fishery harvest rates among years, the temporal and spatial distribution of stocks in and among fisheries and years is assumed to be stable.
11. CWT recoveries used in the ERA are from adipose-clipped fish. There is no adjustment to the estimate of mortality in the ERA on adipose-intact fish that must be released in fisheries under adipose-clipped mark-selective regulations.
12. The general assumption used for assessment, termed the "gorilla assumption" by the CWT Expert Panel (Expert Panel 2005), is that the vulnerability to—and distribution amongst fisheries of each CWT indicator stock—is the same as the associated model stock that it represents. Similarly, the maturation rate schedule implicit in age-specific terminal returns are assumed to be the best such estimates for stock aggregates in SACE.

2.1.3.1 Terminal Area Adjustments

Attachment I of Chapter 3 of the 2019 PST Agreement identifies 11 CWT exploitation rate indicator stocks that require adjustments to CWT recovery rates in terminal fisheries to accurately represent the fishery impacts on the associated escapement indicator stock. Terminal adjustment methods (TAM) rely on auxiliary information to address differing fishery harvest rates of CWT indicator stocks relative to associated wild stocks in order to adjust terminal harvest rates for escapement indicator stocks. This is accomplished by substituting terminal CWT recoveries with terminal harvest and escapement estimates for the escapement indicator stock (CYER WG 2021). Terminal area adjustments can substantially adjust/improve the estimated CYER in ISBM fisheries (CYER WG 2019), especially when differences in the return location, run timing, or other factors result in a terminal harvest rate on the CWT indicator stock different than on the associated escapement indicator stock (CTC 2019a): these terminal adjustments to CWT recoveries are a more accurate reflection of the harvest rate on the associated escapement indicator stock (Appendix F).

BYER statistics for TAM stocks cannot be calculated at this time because the program the CTC uses to report this statistic does not support the TAM. Ocean BYERs are reported instead, which are not altered by TAM. The CTC intends to modify its BYER program to report total BYERs in the following ERA report (2024).

3. EXPLOITATION RATE ANALYSIS RESULTS

In this section, key ERA results are reviewed on a region-by-region basis and discussed briefly in terms of general patterns and trends at the stock and stock group level. Results are presented for the following ERA metrics: BYER (total or ocean, depending on stock), early marine survival rate, and mortality distribution. Although some of this content is germane to assessments of the effectiveness of the PST, such evaluations necessitate that other information also be considered (e.g., performance of escapement indicator stocks, AABM and ISBM fisheries, etc.). Thus, the emphasis of this section is on describing patterns and trends only, not on drawing inferences about cause-effect relationships due to changing management regimes.

3.1 SOUTHEAST ALASKA AND TRANSBOUNDARY STOCKS

There are four wild, one wild aggregate, and two hatchery aggregate CWT indicator stocks in the SEAK and transboundary regions. The four wild stocks are the Chilkat River (CHK), Stikine River (STI), Taku River (TAK), and Unuk River (UNU). The one wild aggregate stock is the Taku and Stikine Rivers (TST). The TST indicator stock is used to represent the Taku and Stikine River PSC Chinook Model stock. The CHK and UNU CWT indicator stocks are not currently used to represent SEAK stocks in the PSC Chinook Model; however, these data are used to evaluate the efficacy of the hatchery indicator stock assumption. Southern Southeast Alaska Spring (SSA) is composed of CWT data from three SEAK hatcheries (Little Port Walter, Deer Mountain, and Herring Cove) and Northern Southeast Alaska Spring (NSA) is composed of CWT data from the Crystal Lake hatchery. The SSA and NSA CWT indicator stocks are used in the PSC Chinook Model. These SEAK and transboundary wild and hatchery stocks enter the ocean as yearlings; age 3 is the youngest age at which CWTs are recovered.

3.1.1 Brood Year Exploitation Rates

The BYERs computed for CHK, STI, TAK, TST, and UNU include recoveries from ocean and terminal fisheries. The BYERs computed for NSA and SSA do not include terminal recoveries because terminal exploitation rates on hatchery fish are not representative of SEAK wild stock exploitation rates. Overall, the SSA BYER estimates have usually exceeded 30%; since 1976, only BYs 1996–1999, 2004–2007, and 2013–2016 were less than 30% (Table 3.1; Appendix D1). NSA BYER estimates have also usually exceeded 30%; since 1979, only BYs 1987, 1994–1997, and 2012–2014 were less than 30% (Table 3.1; Appendix D1). The BYERs for wild stocks CHK and TAK are usually less than 20% which includes recent BYs. After the brood years 1998–2006, BYERs for the STI wild stock have been less than 30% for BYs 2007–2015. The BYERs for the UNU wild stock exceeded 30% for BYs 2009–2012 but have been less than 30% for the 4 most recent complete BYs (Table 3.1; Appendix D2).

In calendar year 2019, age 4 fish (BY 2015) of the NSA stock were estimated to have higher than normal IM. Most of this IM is from sublegal size Chinook in the purse seine fishery. This large, estimated IM from 2019 was mainly due to a very large number of sublegal CNR encounters (the largest since 1994), which was due to high abundance of sublegal size Chinook and extrapolating the high encounter rate to a long CNR period for the purse seine fishery. In subsequent years for which the CTC currently has data (2020–2022), sublegal CNR encounters decreased back to typical estimates and it is expected that the subsequent complete broods reverted to a more typical ratio of IM to Total Mortality.

3.1.2 Survival Rates

Survival rates for SEAK and transboundary stocks (Table 3.1; Appendix E1; Appendix E2) were computed at age 3 because these stocks enter the ocean predominately as yearlings. The CHK survival rates ranged from 1% to 8% since BY 1999, including 9.3% for the most recent complete BY (2016). The STI survival rates ranged from 1% to 7% since BY 1998, including 3.1% for the most recent complete BY (2016). The TAK survival rates ranged from 2% to 29% since BY 1991, including 4.7% for the most recent BY (2016). The UNU survival rates ranged from 2–14% since BY 1982, including 10.5% for the most recent BY (2016). The NSA survival rates ranged from 1–24% since BY 1979, including 1.3% for the most recent BY (2016, Appendix E1). The SSA survival rates ranged from 2–26% since BY 1976 including 4.6% for the most recent BY (2016, Appendix E1).

3.1.3 Mortality Distributions

Distribution of mortalities for SEAK wild, transboundary wild, and SEAK hatchery stock groups in the 2009–2018 and 2019–present Treaty annex periods are illustrated in Table 3.1 and Figure 3.1. Overall, beginning with the 1999 Agreement, there was a high calendar year percent escapement for CHK (2004–2022 average 85%; Appendix C4), STI (2003–2022 average 68%; Appendix C51), TAK (1999–2022 average 82%; Appendix C54), and UNU (1999–2022 average 71%; Appendix C56), and otherwise mostly in SEAK AABM sport, troll, and net fisheries. Within the SEAK AABM fisheries in the 1999–2022 period, the SEAK troll fishery caught a higher percentage of STI fish (average 6% of total mortalities), TAK fish (average 4%), and UNU fish (average 14%), whereas the SEAK net fishery caught a higher percentage of CHK fish (average 6%). Outside of the SEAK AABM fishery, a few STI and UNU mortalities have occurred in the NBC AABM fishery. Approximately 54% and 47% of NSA and SSA mortalities, respectively, occurred as escapement in the 1999–2022 period, with remaining mortalities occurring in the SEAK AABM and terminal fisheries (Appendix C24; Appendix C49). For the 1999–2022 period, the SEAK AABM troll fishery accounted for an average of 21% of the SSA total mortalities, followed by SEAK AABM net fisheries averaging 7%.; SEAK AABM troll averaged 19% of NSA mortality, and SEAK AABM net averaged 14%; SEAK AABM sport fisheries accounted for 4% and 5% of the NSA and SSA stock groups mortality, respectively. For the same time period, SEAK terminal fisheries combined (troll, net, sport) accounted for 9% of total NSA mortality and 18% of SSA total mortality (Appendix C24; Appendix C49).

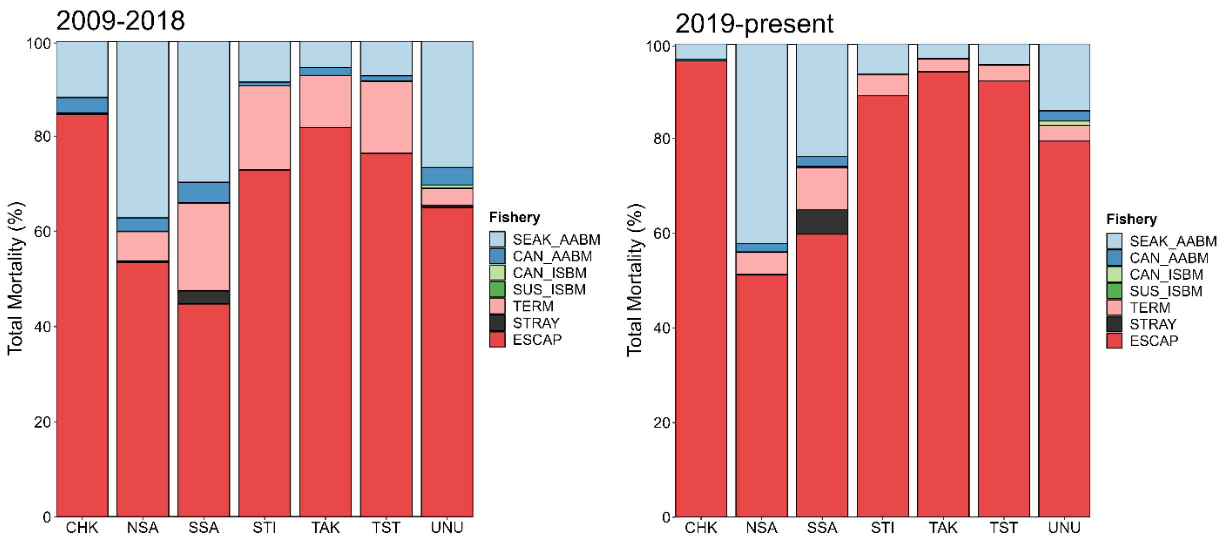

Figure 3.1—Distribution of total mortality for Southeast Alaska indicator stocks from the 2009 (2009–2018) and 2019 (2019–2028) Pacific Salmon Treaty Agreement periods.

3.1.4 Regional Summary for Southeast Alaska Stocks

Table 3.1—Summary of statistics generated by the 2023 coded-wire tag (CWT) cohort analysis for Southeast Alaska and transboundary river indicator stocks. Statistics include total mortality (catch plus incidental mortality), brood year exploitation rate (BYER), cohort survival rate to age 3, and calendar year (CY) percent distribution of the total mortality in escapement.

					CY % Escapement[1]		
	BYER (total mortality)		Survival rate		2009-2018	2019-current	
Indicator Stock Name	**Mean (range)**	**Last complete BY**	**Median (range)**	**Last complete BY**	**Mean (range)**	**Mean (range)**	**Last CY (year)**
Southern Southeast Alaska Spring (SSA)[2]	39% (19%-62%)	19% (2016)	5.24% (1.40-25.33%)	4.62% (2016)	45% (31-61%)	60% (39-75%)	39% (2022)
Northern Southeast Alaska Spring (NSA)[2]	36% (15%-65%)	51% (2016)	3.14% (0.67-23.98%)	1.33% (2016)	54% (40-75%)	51% (23-81%)	81% (2022)
Chilkat River (CHK)	16% (3%-30%)	3% (2016)	7.28% (2.70-18.73%)	9.30% (2016)	85% (72-95%)	96% (94-98%)	98% (2022)
Stikine River (STI)	34% (7%-81%)	22% (2016)	3.69% (1.27-7.57%)	3.06% (2016)	73% (57-92%)	89% (84-93%)	93% (2022)
Taku River (TAK)	16% (3%-37%)	5% (2016)	5.40% (1.47-28.80%)	4.66% (2016)	82% (60-96%)	94% (91-96%)	93% (2022)
Taku and Stikine Rivers (TST)	20% (4%-50%)	9% (2016)	5.39% (1.37-28.80%)	4.07% (2016)	76% (58-94%)	92% (90-94%)	93% (2022)
Unuk River (UNU)	29% (15%-54%)	20% (2016)	6.86% (1.78-14.02%)	10.54% (2016)	65% (41-85%)	80% (76-83%)	76% (2022)

[1] % Escapement is not a measure of performance for the escapement indicator stock(s) associated with a given CWT indicator stock.

[2] BYER is ocean exploitation rate only.

3.2 North and Central British Columbia Stocks

There are two hatchery CWT indicator stocks for North and Central BC: Kitsumkalum and Atnarko. The North/Central BC Model stock (NTH) was split into North (NBC) and Central (CBC) Model stocks in the Phase II PSC Chinook Model. NBC includes Nass and Skeena escapements and is represented by the Kitsumkalum hatchery indicator stock (KLM), which is composed of tagged fish from the Deep Creek Hatchery. The CBC Model stock includes the Atnarko, Wannock, and Chuckwalla-Kilbella escapements, and this stock is represented by the Atnarko stock (ATN), which is composed of tag recoveries from the Snootli Hatchery. Kitsumkalum Chinook enter the ocean as yearlings and age 3 is the youngest age at which CWTs are recovered, whereas Atnarko Chinook enter the ocean as subyearlings and age 2 is the youngest age recovered. The KLM time series begins in BY 1979, and the ATN time series begins in BY 1986. There were no KLM CWT releases in 1982 and 2019, and no ATN CWT releases in 2003, 2004 and 2019.

3.2.1 Brood Year Exploitation Rates

The BYERs computed for KLM and ATN include recoveries from both ocean and terminal fisheries. The total BYER for KLM has been generally decreasing from 69% in 1989 to approximately 22% for BY 2016, the last complete brood year, though there have been oscillations of varying length (Appendix D3). KLM BYER averaged 44% (Table 3.2). The BYER for ATN was 60% for BY 2006 and has generally declined since. It was 30% in 2017, the last complete brood year (Appendix D3). ATN total BYER averaged 39% (Table 3.2). Incidental mortalities within the total KLM BYER range from 5 to 12% and average 7%, and within the total ATN BYER range from 2 to 5% and average 3% (Appendix D3).

3.2.2 Survival Rates

The survival rate of KLM is survival to age 3 because the fish enter the ocean as yearlings, whereas the survival rate of ATN is survival to age 2 because the fish enter the ocean as subyearlings. Brood years included in the survival rate analyses of KLM were 1979 to 1981 and 1983 to 2016. Brood years included for the analyses of ATN were 1986 to 2002 and 2005 to 2017. The KLM survival rates have averaged 0.78% and ranged from 0.12–1.95% with a rate of 0.12% for the last complete BY, 2016 (Appendix E3; Table 3.2). The ATN survival rates have averaged 2.21% and ranged from 0.50–5.88% with a survival rate of 1.91% for the last complete BY, 2017 (Appendix E3; Table 3.2).

3.2.3 Mortality Distributions

Escapement accounted for an average of 56.3 of the KLM total mortality across the entire mortality distribution time series which began in catch year 1985. The percent attributable to escapement has increased through time overall. Average mortality in the escapement was 61.0% in KLM during 2009–2018 and 73.7% during 2019–2022. Catch and IM in NBC & CBC ISBM sport has historically been a large mortality component for KLM (2009–2018 average: 9.7%; 2019: 11.3%; 2020: 8.3%) but has decreased to 0% in each of 2021 and 2022. SEAK AABM troll mortality has declined (2009–2018 average: 11.7%; 2019–2022 average: 5.7%) but SEAK AABM net (2009–2018 average: 1.9%; 2019–2022 average: 6.5%) has increased and SEAK AABM mortality component averages 15.4% under the current agreement (16.4% in 2009–18). NBC AABM troll and ISBM Canada net fisheries were large mortality components for KLM during 1985–1995, accounting for 9.8% (AABM troll) and 14.4% (ISBM terminal net) of the total mortality on average, but their magnitude has decreased in recent years (Appendix C15; Appendix C16). No terminal sport mortality (0%) occurred for KLM from 2018–2022.

Escapement accounted for an average of ~60.9% of the ATN total mortality across the entire mortality distribution time series which began in catch year 1990. Average mortality in the escapement was 59.5% for ATN during 2009–2018 and 70.8% during 2019–2022. Canadian ISBM (2019–2022 average: 14.9% made up of 11.9% net and 3.0% sport) and terminal fisheries (2019–2022 average: 6.6% made up of 5.0% net and 1.6% sport) were the largest mortality components for ATN, with SEAK AABM and Canadian AABM making up a lower percentage in 2019–2022 compared to 2009–2018, though SEAK AABM troll accounted for 9.9% of ATN mortality in 2022, the largest percentage since 2012, and NBC sport accounted for 4.2%, the highest percentage since 2005 (Appendix C1; Figure 3.2).

There are essentially no strays for KLM and ATN.

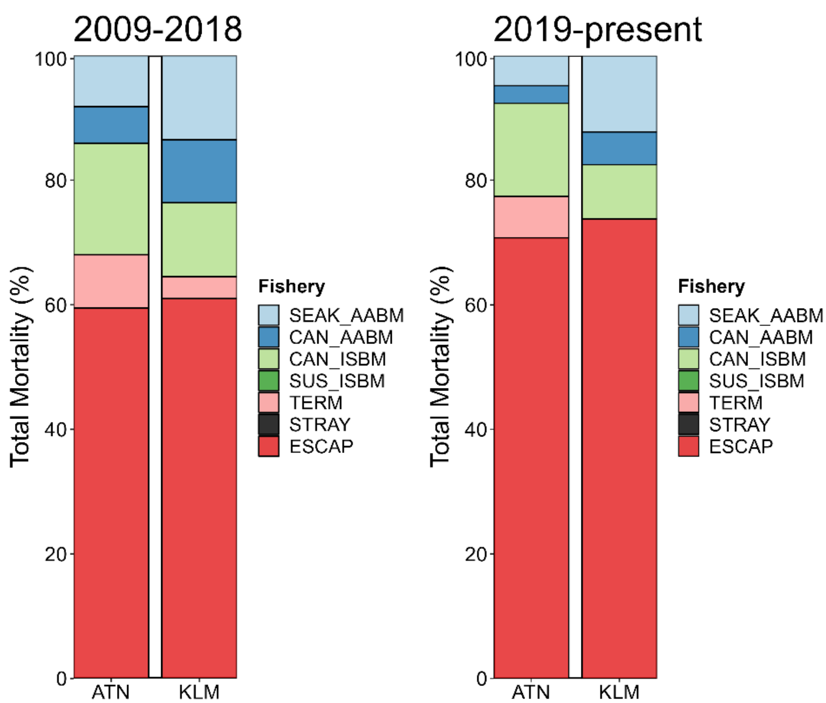

Figure 3.2—Distribution of total mortality for North (KLM) and Central (ATN) British Columbia indicator stocks from the 2009 (2009–2018) and 2019 (2019–2028) Pacific Salmon Treaty Agreement periods.

3.3 West Coast Vancouver Island Stocks

There is one hatchery CWT indicator stock to represent wild and hatchery WCVI Chinook. The Robertson Creek Fall (RBT) indicator stock is composed of tag recoveries from the Robertson

Creek hatchery, and it is used to represent the WCVI model stocks WVH (hatchery) and WVN (natural). WCVI Chinook enter the ocean as subyearlings and age 2 is the youngest age recovered. The RBT time series begins in BY 1973 and the latest complete BY is 2017 (Appendix D4). RBT is used as an ocean exploitation rate indicator for two other WCVI escapement indicator stocks: Northwest Vancouver Island and Southwest Vancouver Island. Terminal adjustments are applied to these stocks for the CYER calculations in order to account for differential terminal fishery harvest rates (see section 3.3.4).

3.3.1 Brood Year Exploitation Rates

The BYER computed for RBT only includes recoveries from ocean fisheries. The total BYER for RBT has decreased from approximately 67% for BY 1973 to 26% for BY 2017, with an average of 42% over the entire time series (Appendix D4). Most of the BYER is attributed to landed catch (17% – 57%), with IM estimates ranging from only 2% to 30%. The exception was in BY 1991, when IM was higher than landed catch (30% versus 23%, respectively). The most recent complete BY (2017) had the third lowest landed catch in the time series at 20% and a moderate IM of 6%.

3.3.2 Survival Rates

The survival rate of RBT represents survival to age 2 because the juveniles enter the ocean as subyearlings and age 2 fish are the youngest recovered. RBT survival rates vary widely, but have generally declined over time, ranging from 20% for BY 1974 to 0.03% for BY 1992, and averaging 5%. The last complete BY (2017) has a survival rate of 6% (Appendix E4).

3.3.3 Mortality Distributions

Total mortality attributed to escapement for RBT declined from an average of 45% during 2009–2018 to 28% during 2019–2022; prior to 2009, average escapement mortality of the preceding four 10-year periods (1979–1984, 1985–1995, 1996–1998, and 1999–2008) averaged 37% (Appendix C34; Figure 3.3).

Most of the total mortality for RBT during the recent 2019–2022 period is attributed to catch and IM in Canadian terminal fisheries (40%) which is a substantial increase from the previous period (19% during 2009–2018). Of the Canadian terminal fisheries, net fisheries accounted for most of the recent period total mortality (average 33% during 2019–2022), which increased from the previous period (average 10% during 2009–2018). Canadian terminal sport fisheries contribute a small amount to the total mortality for RBT and have been relatively consistent over both periods (average 9% during 2009–2018; average 7% during 2019–2022).

Total mortality attributed to all AABM fisheries declined slightly from 26% for 2009–2018 to 23% for 2019–2022. SEAK troll fisheries continue to make up the highest proportion of AABM mortality, though this proportion has declined on average from the previous period (11%) to the current (7%). SEAK net (averaging 3% during 2009–2018 and 5% during 2019–2022) and sport (averaging 3% during 2009–2018 and 2% during 2019–2022) fisheries account for a moderate amount of the RBT mortality. NBC AABM troll and sport fisheries accounted for similarly moderate portions of AABM mortalities, with sport (averaging 5% during 2009–2018 and 3% during 2019–2022) contributing slightly more than troll (averaging 2% during 2009–2018 and 3% during 2019–2022). WCVI AABM troll (averaging 1% during 2009–2018 and 2019–2022) and sport (averaging 3% during 2009–2018 and 2% during 2019–2022) fisheries account for a minimal portion of RBT total mortality.

RBT total mortality across all non-terminal ISBM fisheries declined slightly between the previous and current periods (averaging 10% during 2009–2018 and 9% during 2019–2022). Southern BC sport accounts for most of the non-terminal ISBM fisheries mortality, averaging 6% during 2009–2018 and 2019–2022, while NBC/CBC sport contribute moderately (averaging 3% during 2009–2018 and 2019–2022) and all other ISBM fisheries are negligible (<1%).

Observed strays make up a very small percentage of the total mortality for RBT (average 0.2% during 2009–2018; average 0.4% during 2019–2022). The largest percentage of the total mortality represented by strays in RBT was 1% in 2017 and again in 2020.

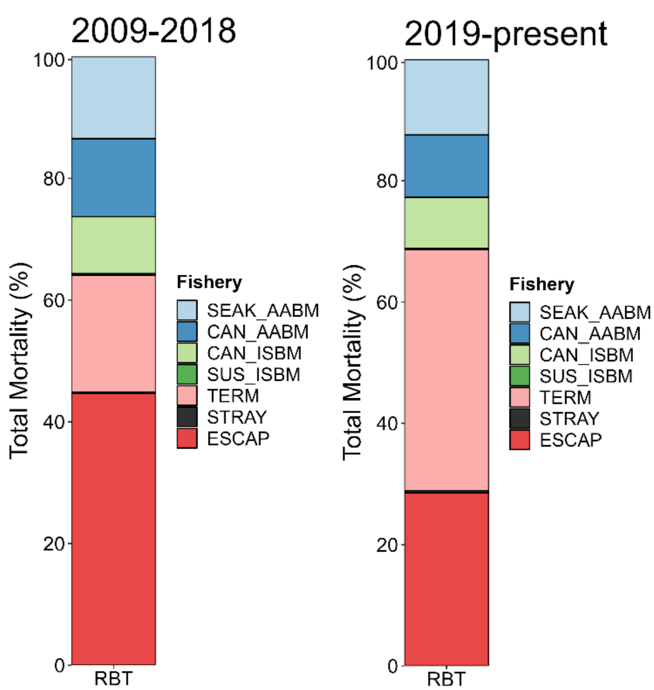

Figure 3.3—Distribution of total mortality for West Coast Vancouver Island indicator stock from the 2009 (2009–2018) and 2019 (2019–2028) Pacific Salmon Treaty Agreement periods.

3.3.4 Terminal Area Adjustments

Unadjusted and adjusted mortality estimates are given for the RBT CWT indicator to bound the likely range of ISBM (and other) fishery impacts applicable to the escapement indicator stocks comprising the aggregate. The adjusted estimates were obtained by subtracting the terminal fishery CWT estimates specific to RBT from the ISBM fishery total and adding them to the escapement. Recalculation of the percentage distribution of mortality results in some adjustment to each category. Recent WCVI terminal fishery assessments provide estimates of the catch of natural-origin stocks for a number of terminal fisheries along the WCVI (Luedke et al. 2019), however the analysis was not conducted at the scale of the Southwest Vancouver Island (SWVI; Appendix C36) and Northwest Vancouver Island (NWVI; Appendix C35) escapement indicator stocks (Figure 3.4). Natural WCVI origin stocks are not targeted in the terminal areas.

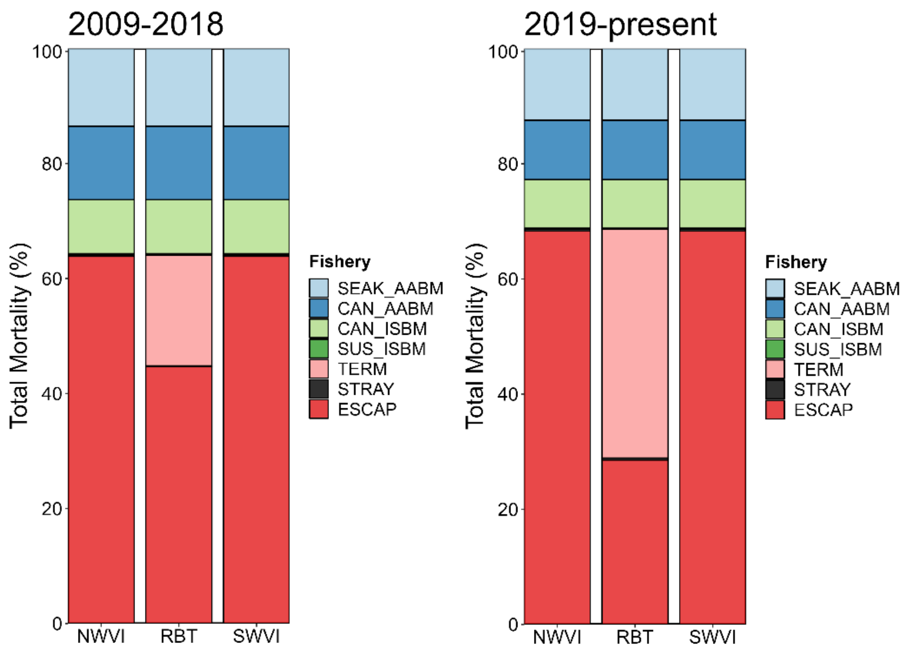

Figure 3.4—Distribution of total mortality for the West Coast Vancouver Island hatchery indicator stock before applying the terminal area adjustment (Robertson Creek Fall [RBT]) and after the terminal area adjustments for the escapement indicator stocks (Northwest Vancouver Island [NWVI] and Southwest Vancouver Island [SWVI]) for the 2009 (2009–2018) and 2019 (2019–2028) Pacific Salmon Treaty Agreement periods.

3.4 Strait of Georgia Stocks

Strait of Georgia model stocks are segregated into Upper Strait of Georgia (UGS), Middle Strait of Georgia (MGS), Lower Strait of Georgia (LGS), and Puntledge Summers (PPS) in the Phase II PSC Chinook Model (Appendix A3).

There is one hatchery CWT indicator stock for UGS (Quinsam [QUI]), one for MGS (Big Qualicum [BQR]), and one for LGS (Cowichan [COW]), in addition to Puntledge (PPS) representing the PPS Model stock. QUI comprises tag recoveries from the Quinsam Hatchery. COW comprises tag recoveries from the Cowichan, whereas PPS and BQR comprise tag recoveries from the Puntledge and Big Qualicum hatcheries, respectively. Strait of Georgia Chinook enter the ocean as subyearlings and age 2 is the youngest age at which CWTs are recovered. The QUI time series begins in brood year 1974, COW in 1985, PPS in 1975, and BQR in 1973. QUI is also used as an ocean exploitation rate indicator for the Strait of Georgia escapement indicator stock East Vancouver Island North. Terminal adjustments are applied to this stock for the CYER calculations in order to account for differential terminal fishery harvest rates (see section 3.4.4).

3.4.1 Brood Year Exploitation Rates

The BYERs computed for Strait of Georgia stocks include recoveries from ocean fisheries and terminal fisheries. BYER figures for all Strait of Georgia stocks are provided in Appendix D5.

The total BYER for QUI (representing UGS) has generally decreased overall, from 71% in BY 1974 to 47% in BY 2017, averaging 54% over the entire time series and ranging from 29% for BY 1997 to 85% for BY 1977. After dropping to 29% in BY 1997, BYER remained relatively constant, averaging 42% (ranging from 30% for BY 2004 to 51% for BY 2005). IM accounts for, on average, 11% of the exploitation rate (from 5% in BY 2012 to 43% in BY 1991); the last complete brood year IM was 12% (2017). IM was only higher than landed catch exploitation rate in BY 1991 (43% versus 38%, respectively).

The total BYER for BQR (representing MGS) has generally decreased over the full time series, from 84% in BY 1974 to 45% in BY 2017. It has averaged 57%, ranging from 29% in BY 2014 to 85% in BY 1978. IM accounts for, on average, 13% of the exploitation rate (from 8% in BY 1974 to 28% in BY 1990); the last complete brood year IM was 16% (2017).

LGS has historically been represented by COW and Nanaimo (NAN). However, given that NAN has been discontinued as an exploitation rate indicator stock for LGS following the last complete BY of 2004, this section will focus on COW; see the 2021 ERA (CTC 2022b) for NAN summary information. The total BYER for COW has been variable across the time series, from 89% in BY 1985 to 31% in BY 2017. Over the time series it has averaged 65%, ranging from 31% in BY 2017 to 89% in BY 1985; note the most recent complete brood year (2017) has the lowest total mortality on record. IM accounts for, on average, 19% of the exploitation rate (ranging from 9% in BY 2003 to 33% in BY 1990); the last complete brood year IM was 13% (2017). Note that data are missing for BYs 1986 and 2004 for COW.

Finally, the total BYER for PPS declined from 85% in BY 1975 to 13% in BY 1998 but has increased moderately since then to 43% in BY 2017. Over the time series it has averaged 50%, ranging from 13% in BY 1998 to 88% in BY 1985. IM accounts for, on average, 11% of the exploitation rate (from 3% in BY 1998 to 24% in BY 1992). The last complete brood year IM was 10% (2017), and the exploitation rate for IM was higher than for landed catch in BY 2004 (9% versus 4%, respectively). Note that data are missing for BY 1995 for PPS.

3.4.2 Survival Rates

The survival rates of Strait of Georgia (GST) CWT indicator stocks represent survival to age 2 because fish enter the ocean as subyearlings. All of these stocks show a clear declining trend in survival rates (Appendix E5). The QUI survival rates (representing UGS) have averaged 1.96% and ranged from 0.16% for BY 2006 to 9.11% for BY 1974. The survival rate for the last complete brood (2017) was 1.46%. In the case of the MGS CWT indicator stock, BQR survival rates have averaged 2.10% and ranged from 0.12% in BY 1992 to 25.14% for BY 1974 (the highest observed for GST stocks). The survival rate for the last complete brood year (2017) was 1.11%. LGS survival rates represented by COW have averaged 1.75% and ranged from 0.33% (BY 2002) to 6.83% (BY 1990). The survival rate for the last complete brood (2017) was 0.97%. NAN has been discontinued as an exploitation rate indicator stock for LGS following the last complete BY of 2004; see the 2021 ERA for NAN survival rate summary statistics (CTC 2022b).

Finally, survival rates for the PPS indicator stock (representing the PPS Model stock) have averaged 1.15% and ranged from 0.10% (BY 1992) to 12.76% (BY 1976). The survival rate for the last complete brood year (2017) was 0.96%.

3.4.3 Mortality Distributions

Escapement contributes the majority of total mortality for all Strait of Georgia indicator stocks for the current period (2019–2022), ranging from 54% for QUI to 73% for PPS (Figure 3.5; Appendix C1; Appendix C32; Appendix C27). This is largely unchanged from the previous period with the exception of COW which has seen an increase in escapement mortalities from 37% (2009–2018) to 62% (2019–2022). PPS has also seen a slight increase in escapement mortalities, from 62% (2009–2018) to 73% (2019–2022).

Total mortality attributed to Canadian AABM fisheries has declined for most stocks except QUI where it has remained fairly constant (approximately 3% of total mortality in both recent periods) and is largely driven by the NBC AABM sport fishery (2% of total mortality in both periods). SEAK AABM total mortalities have been constant for COW and QUI. For BQR they have declined from 7% during 2009–2018 to 5% in 2019–2022, primarily due to a reduction in troll fishery mortalities (5% during 2009–2018, 3% in 2019–2022). In contrast, they have increased for QUI from 19% during 2009–2018 to 22% in 2019–2022, primarily due to an increase in net fisheries mortalities (6% during 2009–2018, 9% in 2019–2022).

Total mortality attributed to Canadian ISBM fisheries has been variable between periods and among indicator stocks. The most notable change was for PPS, which exhibited a drop from 28% to 17% in the current period. This was primarily driven by a decrease in Southern BC ISBM sport fishery mortality (25% during 2009-2018, 11% during 2019-2022); with mortality in this fishery being near 0% in 2022. Total mortalities in Southern U.S. ISBM fisheries have also varied between periods. The most notable change was for COW, for which total mortalities declined from 6% in the previous period to 2% in the current period, primarily due to a decline in Puget Sound ISBM sport fishery mortality (4% during 2009–2018, 2% during 2019–2022).

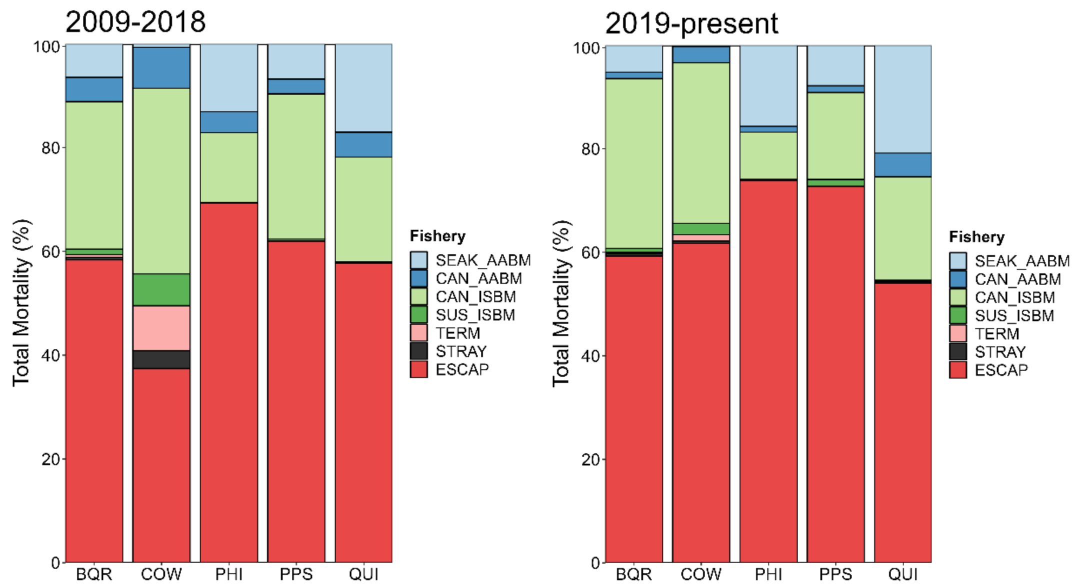

Figure 3.5—Distribution of total mortality for Strait of Georgia indicator stocks from the 2009 (2009–2018) and 2019 (2019–2028) Pacific Salmon Treaty Agreement (PST) periods.

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3.4.4 Terminal Area Adjustments

Terminal area adjustments for the Strait of Georgia stocks only occur on the Quinsam stock to adjust for the East Vancouver Island North (EVIN) escapement indicator stock (Figure 3.6, Appendix C33). Work is ongoing to identify the most suitable escapement indicator stock for the EVIN area.

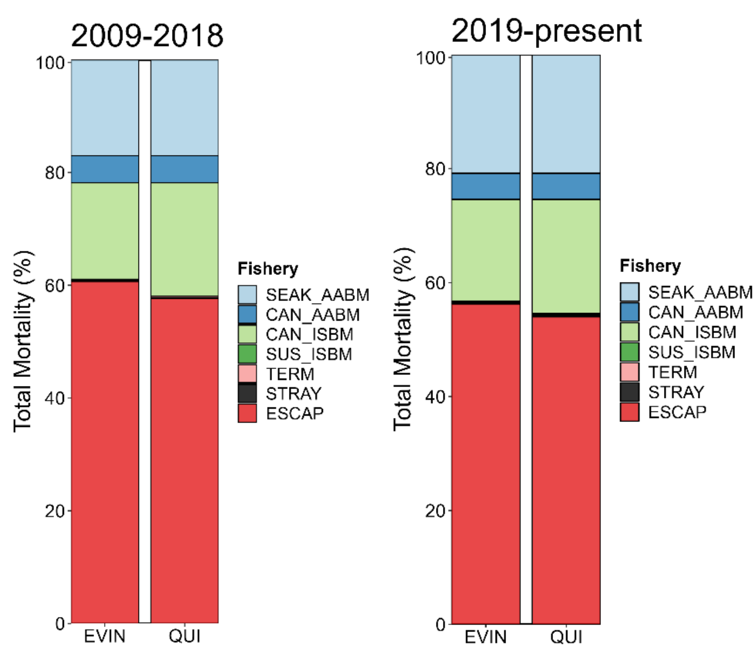

Figure 3.6—Distribution of total mortality for the Upper Strait of Georgia hatchery indicator stock before applying the terminal area adjustment (Quinsam [QUI]) and after the terminal area adjustments for the escapement indicator stock (East Vancouver Island North [EVIN]) for the 2009 (2009–2018) and 2019 (2019–2028) Pacific Salmon Treaty Agreement periods.

3.5 Fraser River Stocks

Fraser River Chinook are represented by 6 model stocks, Fraser Spring-run 1.2 (FS2), Fraser Spring-run 1.3 (FS3), Fraser Summer-run Yearling 1.3 (FSS), Fraser Summer-run Subyearling 0.3 (FSO), Fraser Harrison Fall (FHF) and Fraser Chilliwack Fall (FCF). The CWT exploitation rate indicator stocks (ERIS) represent different combinations of run timing and life history, with the Nicola (NIC) representing FS2, the Lower Shuswap (SHU) representing FSO, Harrison (HAR) representing FHF, and Chilliwack (CHI) representing FCF. Currently, there is no CWT ERIS for FSS and FS3; however, the Chilko and Lower Chilcotin sites are being developed for these model stocks, respectively. The Middle Shuswap (MSH) is another ERIS in the FSO model stock, but the SHU is used to represent the entire FSO model stock. The FCF, FHF, and FSO enter the ocean as subyearlings and age 2 is the youngest age at which CWTs are recovered, whereas the FS2, FS3, and FSS enter the ocean as yearlings with age 3 as the youngest age at which CWTs are recovered. The time series of recoveries for the CHI and HAR starts with BY 1981, NIC with BY 1985, SHU with BY 1984 and MSH with BY 1985. Since the 2020 ERA report (CTC 2021d), historic CWT data have been assembled, reviewed and standardized for MSH and 17 more brood years (1985–2001) were added to the ERA.

3.5.1 Brood Year Exploitation Rates

The BYERs computed for Fraser River stocks include recoveries from ocean fisheries and freshwater fisheries within the Fraser River and tributaries. The BYER plots for all Fraser stocks are available in Appendix D.

BYERs for the fall-run stocks, from BY 1981 to BY 2017, have decreased from approximately 72% to 31% for CHI and from approximately 76% to 29% for HAR (Appendix D6). CHI BYER averaged 40% and ranged from 22% for BY 1995 to 83% for BY 1982, whereas HAR BYERs averaged 44% and ranged from 19% for BY 1995 to 86% for BY 1982. Within BYERs, the percentage of the BYER comprised of IM for CHI averaged 21% over the entire time series, and increased during the first 15 years, reaching 31% for BY 1995, and then decreased substantially to average levels for subsequent BYs; however, BY 2015 and 2016 are exceptions at 31% and 34% respectively. The BY 2016 IM rate is the highest IM rate of the time series. Similarly, the percentage of the HAR BYER that results from IM averaged 21% and also increased during the first 15 years of the time series, reaching 37% for BY 1994, followed by fluctuations around the average level ranging from 12% in 2001 to 32% in 1999.

For the spring-run stocks, no clear trend is apparent for NIC (Appendix D7) and there is currently no indicator stock for the FS3 or FSS model stocks. NIC BYERs are the lowest among Fraser River and all other Canadian ERIS. Estimated BYERs for NIC averaged approximately 25% and ranged from 3% for BY 1992 to approximately 60% for BY 2003 (Appendix D7). The percentage of the NIC BYER that results from IM remained relatively stable, averaging approximately 14% for the entire time series, and ranging from 3% for BYs 2003 and 2016 to 24% for BY 1991.

The BYER has been decreasing for the subyearling summer-run stocks since BY 2001 for SHU and since BY 2008 for MSH. Estimated BYERs for MSH averaged approximately 39% and ranged from 15% to 74% (Appendix D7). The percentage of MSH BYER attributed to IM averaged 14% and ranged from 8% to 28%, peaking in the early 1990s but declining since then. Lastly, BYER for SHU averaged 50%, and ranged from 23% for BY 2016 to 80% for BY 1989. The proportion of the SHU BYER represented by IM has remained relatively stable, averaging 18% for the entire time series and ranging from 12% for BY 1998 and 2017 to 34% for BY 1992.

3.5.2 Survival Rates

Plots of early marine survival rate estimates by stock and year are available in Appendix E. Estimated survival rates for CHI, HAR, MSH and SHU represent survival to age 2 because juveniles from those stocks enter the ocean as subyearlings and age 2 is the youngest age recovered. Estimated survival rates for NIC represent survival to age 3 because smolts from this stock enter the ocean as yearlings and age 3 is the youngest age recovered.

For CHI, survival averaged 11.7%, with a range of 1.7% for BY 1991 to 30.6% for BY 1981 (the highest observed for any Fraser River stock). Estimated survival rates for HAR averaged 3.3% and ranged from 24.0% in BY 1981 to a low of 0.4% for BY 1991. NIC survival rates averaged 2.8% with a range of 0.1–12.5%. MSH survival rates averaged 3% with a range of 0.4–12.2%, and the SHU survival rates averaged 3.0% with a range of 0.7–8.1% (Appendix E7). The survival rate for the last completed brood of the time series was 12.4% for CHI, 1.3% for HAR, 2.8% for NIC, 1.6% for MSH and 3.4% for SHU.

3.5.3 Mortality Distributions

For the fall-run ERIS, escapement represented an average of 60% of the CHI total mortality (Figure 3.7; Appendix C3) and 58% of the HAR mortality (Figure 3.7; Appendix C13) between 1985 and 2022 (mortality distribution time series for both stocks began in 1985). The CHI average mortality proportioned to escapement remained approximately the same from the 1999–2008 period (70%) and 2009–2018 period (70%) to the 2019–2022 period (63.8%). The HAR average mortality in the escapement increased from the 1999–2008 period (60%) to the 2009–2018 period (74%) and has remained similar in the 2019–2022 period (78%). For CHI, fishing mortality was attributed to catch and IM in the Canadian terminal sport (1999–2008 and 2009–2018 averages: 6% and 6% respectively; 2019–2022 average: 10%), ISBM Puget Sound sport (1999–2008 average: 2%; 2009–2018 average: 2%; 2019–2022 average: 3%), the ISBM Southern BC sport (1999–2008 average: 5%; 2009–2018 average: 11%; 2019–2022 average: 16%), the ISBM North of Falcon troll (1999–2008 average: 6%; 2009–2018 average: 3%; 2019–2022 average: 2%), and the WCVI AABM troll (1999–2008 average: 6%; 2009–2018: 2%; 2019–2022 average: 1%) fisheries. Between 1985 and 1995, the ISBM Southern BC (Strait of Georgia) troll fishery was a large component of the total mortality for CHI (average 6%); however, that fishery for Chinook salmon ceased from 1996 onward. For HAR, most of the fishing mortality from 1999–2008 was associated with catch and IM in the WCVI AABM troll fishery (average: 13%), which declined to 2% during 2009–2018 period and to 1% in the 2019–2022 period; other large components of the total mortality were the North Falcon troll ISBM fishery (1999–2008 average: 10%; 2009–2018 average: 4%; 2019–2022 average: 2%) and the Southern BC sport ISBM fishery, which is a large mortality component for HAR, ranging from 4% to 32% of the total mortality during 1985–1998 and from 3% to 16% from 2019–2022 (1999–2008 average: 6%; 2009–2018 average: 10%; 2019–2022 average: 11%). There is only limited terminal recreational fishing opportunity on HAR.

Among the ERIS for the spring- and summer-runs, escapement represented a larger amount of the total mortality distribution during the 2019–2022 period than the 2009–2018 and the 1999–2008 period for NIC (90% vs 78% and 74%, respectively; Figure 3.7; Appendix C22), MSH (79% vs 55% and 68% respectively; Figure 3.7; Appendix C21), and SHU total mortality (76% vs 56% and 54% respectively; Figure 3.7; Appendix C38). During 2019 to 2022, the largest components of the total fishing mortality for SHU occurred in the terminal net fishery (average: 6%), followed by the terminal sport fishery (average: 4%), the SEAK AABM troll fishery (average: 4%) and the ISBM Southern BC sport fishery (average: 4%). MSH is part of the same stock group as SHU; however, for MSH the largest component of the total fishing mortality during 2019–2022 occurred in the terminal sport and net (average: 6% and 5% respectively), followed by the Southeastern Alaskan troll and sport fisheries (average: 2.4% and 1.2% respectively), and the NBC and CBC ISBM sport fishery (average: 1%; Figure 3.7; Appendix C21). During 2019 to 2022, the largest components of the total fishing mortality for NIC occurred in the terminal net and sport fisheries (average: 7% and 1% respectively), followed by the ISBM Puget Sound sport (average: 1%).

Strays to other escapement locations made an average 1.0% of the total mortality for CHI during 1985–2022, with a high of 5.6% in 2003, and for HAR, strays made only 0.3% of the total mortality during 1985–2022 with a high of 4.6% in 1995. Strays also represented a very small percentage of the total mortality in NIC (average 0% during 1989–2022). The largest percentage of the total mortality represented by strays in NIC was 1.7% in 1990. Similarly, strays made up only a small percentage of the total mortality in SHU (1988–2022 average: 0.5%) and MSH (2012–2022 average: 2.1%). The largest percentage of the total mortality represented by strays in SHU was 2.5% in 2021 and it was 5% for MSH in 2015, 2016 and 2019.

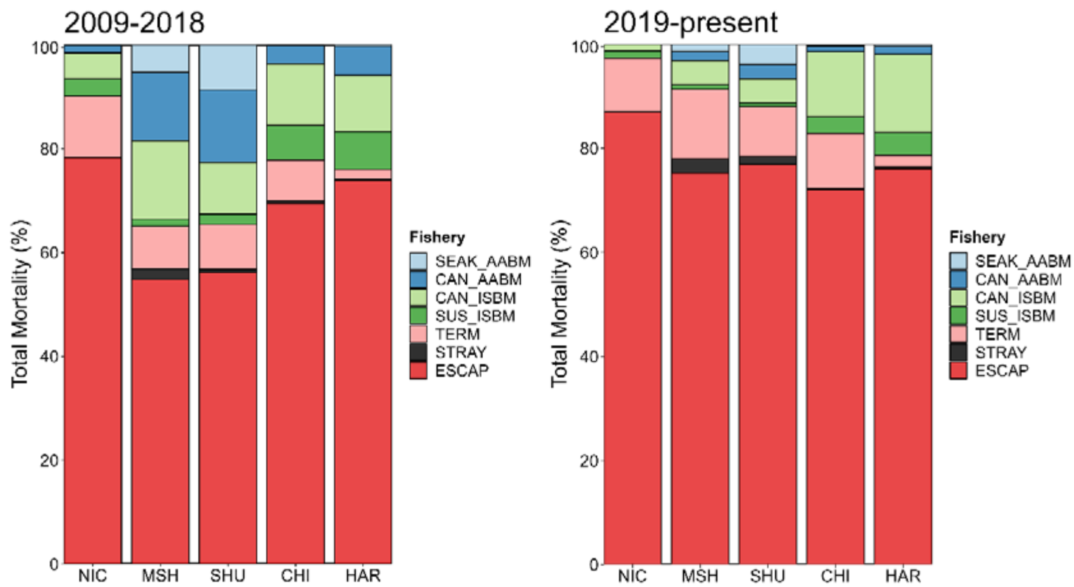

Figure 3.7—Distribution of total mortality for Fraser River indicator stocks from the 2009 (2009–2018) and 2019 (2019–2028) Pacific Salmon Treaty Agreement periods.

3.6 Regional Summary for Canada

With exception of the RBT indicator stock, for which BYER represents ocean fishing mortality, BYERs in Canadian indicator stocks represent fishing mortality in both ocean and terminal fisheries. BYERs of most Canadian indicator stocks have been generally declining. Strait of Georgia stocks have experienced the largest BYERs among Canadian indicator stocks with Lower Strait of Georgia natural stock COW experiencing an average BYER greater than 60%. BYERs for the last complete BY of all Canadian stocks were lower than their long-term averages (Table 3.2).

Median survival rates to age 2 (to age 3 for KLM) are lower than 5% for all Canadian indicator stocks, except for CHI, which has the largest median survival rate at 10.59% (Table 3.2). CHI also experienced the largest estimated survival rate (30.6% in 1981) for any given BY among all Canadian stocks. Other stocks that have experienced BY survival rates greater than 20% earlier in the time series are RBT, BQR, and HAR. Survival rates for these stocks have clearly decreased relative to those high values. The lowest survival rate for the last complete BY (2016 or 2017) among all Canadian indicator stocks, was 0.12% for KLM. Survival rates for the last complete BY increased for 7 out of 14 Canadian stocks.

In terms of calendar year statistics for 2009–2018 and 2019–current, the average percentage of total mortality occurring in the escapement was greater than 50% for most Canadian indicator stocks. Differences in average escapement percentages of the total mortality between PST Agreement periods 2009–2018 and the current Agreement were small in most cases, although COW had a large increase from 37% to 62% (Table 3.2). Average escapement percentages increased for most stocks from the 2009–2018 to 2019–current except for RBT which decreased from 45% to 29%, QUI which decreased from 58% to 54%, and CHI which decreased from 69% to 64%. In 2009–2018, RBT and CHI experienced average escapement percentages of the total mortality below 50% (45% and 37%, respectively). From 2019–current, RBT and CHI also had an average escapement percentage of total mortality below 50% (32% and 42%, respectively). Escapement percentages by calendar year lower than 20% have previously occurred in COW (2009). The largest escapement percentages of the total mortality in 2022 occurred in NIC (98%) and HAR (91%).

Table 3.2—Summary of statistics generated by the 2023 coded-wire tag (CWT) cohort analysis for Canadian indicator stocks by region. Statistics include total mortality (catch plus incidental mortality) brood year exploitation rate (BYER), cohort survival rate to age 2 (age 3 for Kitsumkalum), and calendar year (CY) percent distribution of the total mortality and the escapement.

						CY % Escapement[1]		
		BYER (total mortality)		Survival rate		2009-2018	2019-current	
Region	**Indicator Stock**	**Mean (range)**	**Last complete BY**	**Median (range)**	**Last complete BY**	**Mean (range)**	**Mean (range)**	**Last CY % (year)**
North/ Central BC	Kitsumkalum River Summer (KLM)	44% (22%-69%)	22% (2016)	0.66% (0.12-1.95%)	0.12% (2016)	61% (49-86%)	74% (66-85%)	75% (2022)
	Atnarko River (ATN)	39% (27%-60%)	30% (2017)	1.89% (0.50-5.88%)	1.91% (2017)	59% (37-75%)	71% (62-76%)	74% (2022)
WCVI	Robertson Creek Fall (RBT)[2,3,4]	42% (23%-67%)	26% (2017)	4.09% (0.03-20.10%)	6.32% (2017)	45% (27-64%)	29% (23-32%)	32% (2022)
NWVI	Northwest Vancouver Island (RBT adj.)[3]	42% (23%-65%)	26% (2017)	4.09% (0.03-20.10%)	6.32% (2017)	64% (56-70%)	68% (61-74%)	61% (2022)
SWVI	Southwest Vancouver Island (RBT adj.)[3]	42% (23%-65%)	26% (2017)	4.09% (0.03-20.10%)	6.32% (2017)	64% (56-70%)	68% (61-74%)	61% (2022)
Strait of Georgia	Big Qualicum River Fall (BQR)	57% (29%-85%)	45% (2017)	0.68% (0.12-25.14%)	1.11% (2017)	58% (43-73%)	59% (50-76%)	76% (2022)
	Cowichan River Fall (COW)	65% (31%-89%)	31% (2017)	1.14% (0.33-6.83%)	0.97% (2017)	37% (18-51%)	62% (37-82%)	62% (2022)
	Puntledge River Summer (PPS)	50% (13%-88%)	43% (2017)	0.75% (0.10-12.76%)	0.96% (2017)	62% (40-76%)	73% (51-83%)	80% (2022)
	Quinsam River Fall (QUI)[4]	54% (29%-85%)	47% (2017)	1.18% (0.16-9.11%)	1.46% (2017)	58% (50-70%)	54% (48-61%)	55% (2022)

Region	Indicator Stock	BYER (total mortality) Mean (range)	BYER (total mortality) Last complete BY	Survival rate Median (range)	Survival rate Last complete BY	CY % Escapement[1] 2009-2018 Mean (range)	CY % Escapement[1] 2019-current Mean (range)	CY % Escapement[1] 2019-current Last CY % (year)
	East Vancouver Island North (QUI adj.)[3]	42% (19%-75%)	28% (2017)	1.18% (0.16-9.11%)	1.46% (2017)	61% (53-71%)	56% (49-65%)	57% (2022)
	Phillips River Fall (PHI)	28% (15%-36%)	34% (2017)	4.05% (1.00-9.80%)	2.91% (2017)	69% (63-76%)	74% (65-83%)	66% (2022)
Fraser River	Chilliwack River Fall (CHI)	40% (22%-83%)	32% (2017)	10.59% (1.68-30.55%)	12.36% (2017)	69% (58-80%)	64% (42-78%)	42% (2022)
	Harrison River (HAR)	44% (19%-86%)	21% (2017)	2.07% (0.40-23.97%)	1.28% (2017)	74% (57-84%)	78% (70-91%)	91% (2022)
	Nicola River Spring (NIC)	25% (3%-60%)	6% (2017)	1.86% (0.10-12.51%)	2.76% (2016)	78% (45-90%)	90% (71-98%)	98% (2022)
	Lower Shuswap River Summer (SHU)	50% (22%-80%)	25% (2017)	2.80% (0.73-8.13%)	3.38% (2017)	56% (50-65%)	76% (73-80%)	75% (2022)

[1] % Escapement is not a measure of performance for the escapement indicator stock(s) associated with a given CWT indicator stock.
[2] Does not include BY 1992 from which there were no CWT recoveries in the catch due to extremely low survival rates.
[3] BYER is ocean exploitation rate only.
[4] Terminal adjustments to CYER applied because fishing mortality on the hatchery stock does not represent fishing mortality on wild stocks.

3.7 Washington Coast Stocks

The CTC uses coded-wire tag data from three facilities on the Washington Coast to represent natural fall Chinook salmon production in the rivers between the Columbia River in the south to the Strait of Juan de Fuca in the north. These indicator stocks include the Queets River (QUE, released from Quinault Division of Natural Resources Salmon River Hatchery) and Tsoo-Yess River (SOO, released from the U.S. Fish and Wildlife Service Makah National Fish Hatchery) on the coast, and the Hoko River at the western end of the Strait of Juan de Fuca (HOK, released from Makah’s Hoko Falls Hatchery). Queets, Tsoo-Yess, and Hoko indicator stocks share a common life history; they are ocean type (subyearling fingerling releases), fall-timed fish with a maximum age at maturity of 6. These 3 stocks also have extensive historical tagging and recovery coverage (30+ completed BYs), with Queets records starting in 1977 and Hoko and Tsoo-Yess records starting in 1985. Queets is used as an ocean exploitation rate indicator for three other Washington Coastal escapement indicator stocks: Grays Harbor, Quillayute, and Hoh. Terminal adjustments are applied to these stocks for the CYER calculations in order to account for differential terminal fishery harvest rates (see section 3.7.4).

3.7.1 Brood Year Exploitation Rates

Hoko, Queets, and Tsoo-Yess BYER patterns are considered in terms of total exploitation (ocean and terminal; Table 3.3; Appendix D8). BYERs for Hoko and Tsoo-Yess indicator stocks have similar long-term averages, around 35%. Approximately 20% of all fishery-related mortality for Hoko and Tsoo-Yess is in the form of non-landed, incidental impacts (Appendix D8). Across its 38 complete BYs, the total BYER for the Queets indicator stock has averaged 60%, ranging between 37% and 82%, but has not displayed any obvious or notable temporal trends. The BYER for the last complete Queets BY (2016) is 70%.

Table 3.3—Summary of statistics generated by the 2023 coded-wire tag (CWT) cohort analysis for Washington Coast indicator stocks. Statistics include total mortality (catch plus incidental mortality) brood year exploitation rate (BYER), cohort survival rate to age 2, and calendar year (CY) percent distribution of the total mortality in the escapement.

					CY % Escapement[1]		
	BYER (total mortality)		Survival rate		2009-2018	2019-current	
Indicator Stock	Mean (range)	Last complete BY	Median (range)	Last complete brood year	Mean (range)	Mean (range)	Last CY % (year)
Hoko Fall Fingerling (HOK)	33% (16%-64%)	29% (2016)	1.18% (0.15-3.14%)	2.42% (2016)	69% (44-85%)	66% (63-69%)	69% (2020)
Tsoo-Yess Fall Fingerling (SOO)	36% (9%-61%)	9% (2016)	0.46% (0.01-1.92%)	0.13% (2016)	72% (63-84%)	79% (55-99%)	83% (2021)
Quillayute Fall (QUE adj.)[2]	43% (24%-65%)	46% (2016)	2.55% (0.59-5.65%)	4.20% (2016)	30% (21-43%)	36% (31-40%)	31% (2021)
Hoh Fall (QUE adj.)[2]	43% (24%-65%)	46% (2016)	2.55% (0.59-5.65%)	4.20% (2016)	39% (18-52%)	28% (26-32%)	26% (2021)
Queets Fall Fingerling (QUE)	60% (37%-82%)	70% (2016)	2.55% (0.59-5.65%)	4.20% (2016)	38% (20-50%)	25% (21-27%)	21% (2021)
Grays Harbor Fall (QUE adj.)[2]	43% (24%-65%)	46% (2016)	2.55% (0.59-5.65%)	4.20% (2016)	37% (24-52%)	36% (31-42%)	31% (2021)

[1] % Escapement is not a measure of performance for the escapement indicator stock(s) associated with a given CWT indicator stock.

[2] BYER is ocean exploitation rate only.

3.7.2 Survival Rates

CWT data indicate that release-to-age-2 survival for Chinook salmon on the Washington Coast indicator stocks is highly variable across stocks and years (Appendix E8; Table 3.3). Tsoo-Yess Chinook salmon, for instance, consistently experience some of the lowest survivals of any CWT indicator stock evaluated by the CTC. The series-wide median survival from release to age 2 for this stock is 0.46%, but it has ranged more than 2 orders of magnitude (0.01–1.92%). The Queets Chinook salmon indicator stock exhibits the highest survival rates among the 3 Washington Coast indicator stocks, with a range of 0.59–5.65%, and a median of 2.55%. Across their time series, there is little evidence of a long-term trend in early marine survival. In terms of more recent brood years, the survival rates of all three stocks have been variable, falling both above and below the long-term median.

3.7.3 Mortality Distributions

Washington Coast indicator stocks exhibit a mortality distribution consistent with a far north migration pattern. Most fishery-related mortality results from fisheries occurring north of the southern border between the U.S. and Canada. The majority of these fishery-related mortalities occur in the SEAK and NBC AABM troll fisheries (Figure 3.8; Appendix C14; Appendix C28; Appendix C42). Escapement recoveries for the 3 stocks have averaged between approximately 21% (Queets) and 83% (Tsoo-Yess) of the total distribution in recent years (Table 3.3). With only two years of ERA results for the current PST Agreement period (2019 and 2020) for Hoko, it is too early to make comparisons to the previous PST Agreement period (2009–2018). For Queets, there has been an increase in the percentage of fisheries-related mortalities in AABM and ISBM fisheries, including terminal fisheries, and a decrease in escapement since the previous PST agreement. Tsoo-Yess, in contrast, has a greater percentage of fish in escapement.

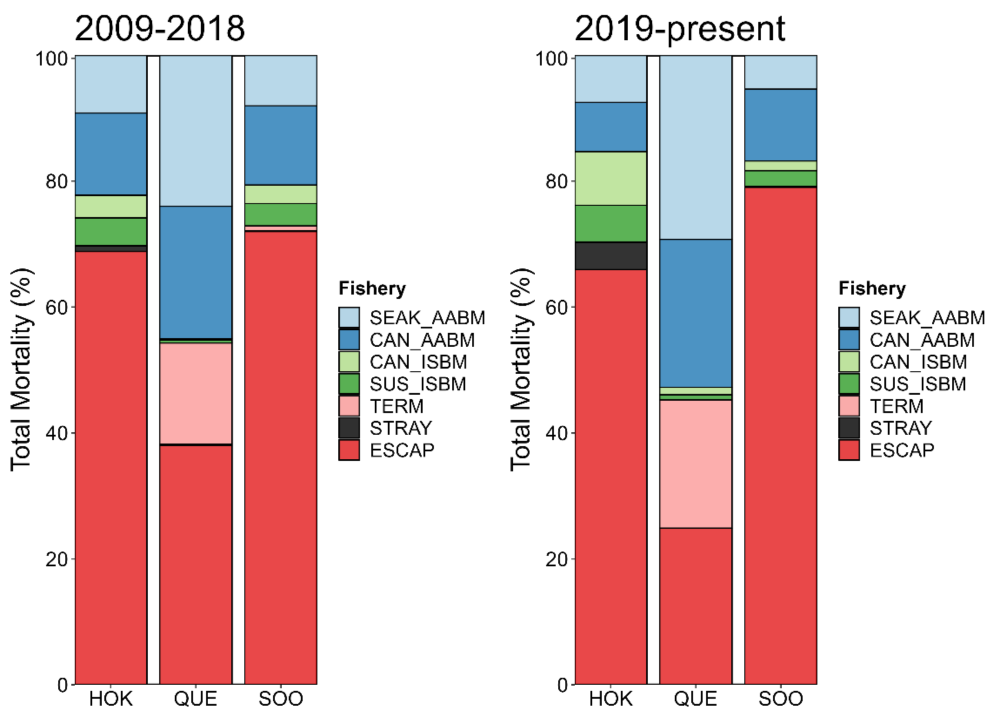

Figure 3.8—Distribution of total mortality for Washington Coast indicator stocks from the 2009 (2009–2018) and 2019 (2019–2028) Pacific Salmon Treaty Agreement periods. The figure on the right contains data from 2019 through 2021.

3.7.4 Terminal Area Adjustments

The terminal harvest rate for Queets River is adjusted to account for differential harvest rates that occur on the Grays Harbor, Hoh, and Quillayute Fall Chinook escapement indicator stocks (Appendix F3). For Grays Harbor, the terminal harvest rates on naturally spawning fish are calculated using the co-manager run reconstruction and represent all net and sport fisheries in the Grays Harbor basin. For Hoh and Quillayute, terminal harvest rates are calculated for naturally spawning fish from data in Tables B-33 and B-36 in the Pacific Fishery Management Council's annual Review of Ocean Salmon Fisheries document (PFMC 2022). Between 2009–2018 the proportion of total mortality occurring in terminal fisheries was similar in the Queets, Grays Harbor, and Hoh basins, averaging around 16% (Figure 3.9; Appendix C28; Appendix C30; Appendix C31) and slightly higher in the Quillayute basin, averaging around 25% (Appendix C29).

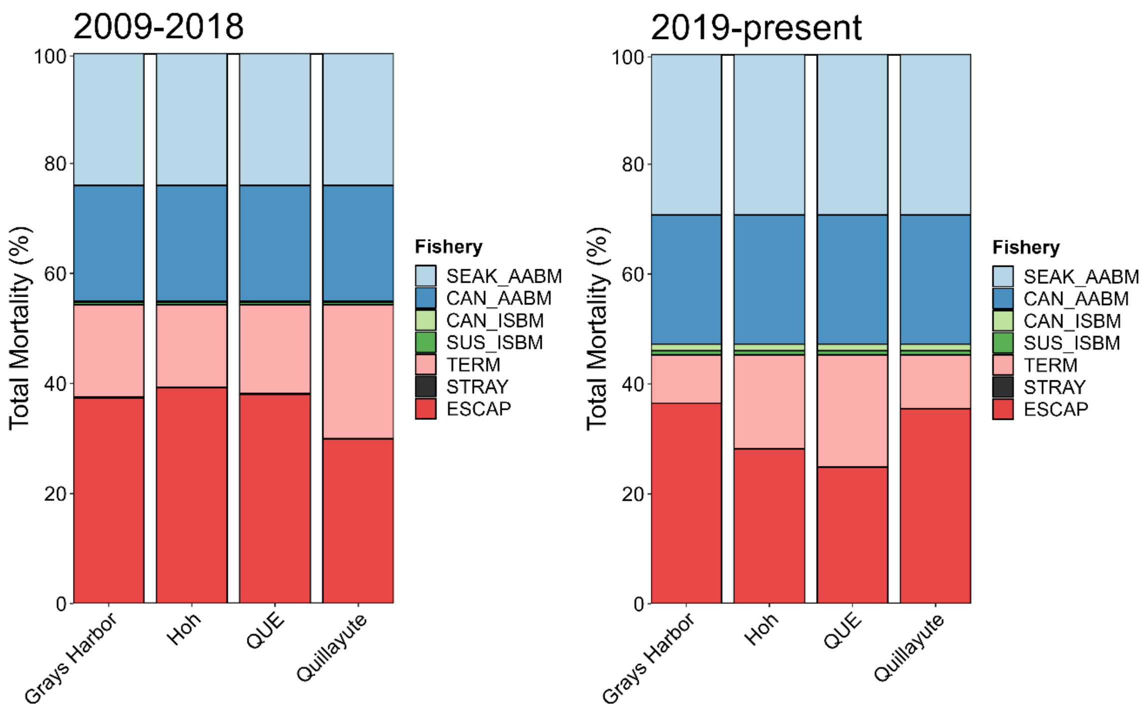

Figure 3.9—Distribution of total mortality for the Washington Coastal hatchery indicator stock before applying the terminal area adjustment (Queets [QUE]) and after the terminal area adjustments for the escapement indicator stocks (Grays Harbor, Hoh, and Quillayute) for the 2009 (2009–2018) and 2019 (2019–2028) Pacific Salmon Treaty Agreement periods. The figure on the right contains data from 2019 through 2021.

3.8 Salish Sea Stocks

There are currently 10 CWT indicator stocks within the Washington Salish Sea that are analyzed on an annual basis. The indicator stocks are a mixture of traditional hatchery production for harvest purposes and natural stock supplementation programs from brood stock collected on the spawning grounds. Current non-tribal sport fisheries for Chinook salmon within Puget Sound are almost exclusively under MSF regulations. Since these CWT indicator groups are adipose-clipped (marked) and therefore available for retention in MSFs, estimates of fishing mortality from these adipose-clipped CWT recoveries may overestimate the fishing mortality and, in turn, the BYER estimates of unmarked natural-origin fish that must be released. MSFs or directed fisheries on hatchery surplus may create a differential terminal fishery structure for these indicator groups; hence, BYERs are expressed in terms of ocean fisheries for all of these indicators. Details on the CWT indicator stock groups and influence of mark-selective and terminal fisheries on the estimates are presented in the regional subsections below.

Four other Salish Sea CWT indicator stocks that have previously been discontinued are no longer included in this report: Nooksack River Spring Yearling (NKS), Skagit River Spring Yearling (SKS), South Puget Sound Fall Yearling (SPY), and White River Spring Yearling (WRY). Information on these stocks and final analysis results are included in the CTC's 2021 ERA Report (CTC 2022b).

3.8.1 North Puget Sound

Indicator stocks in Northern Puget Sound include spring fingerling tag groups from the Nooksack (NSF) and Skagit (SKF) rivers and summer/fall fingerling tag groups from the Samish (SAM) and Skagit (SSF) rivers. The Nooksack Spring (NSF), Skagit Spring (SKF), and Skagit Summer/Fall (SSF) stocks are included in Chapter 3 Attachment I of the 2019 PST Agreement, each of which have associated ISBM fishery limits. The primary purpose of the Nooksack Spring hatchery program is natural supplementation and supporting a small tribal subsistence fishery in the river. The SAM indicator does not represent an associated natural production but is important for evaluating the large hatchery production program from the Samish Hatchery. The primary purpose of the Skagit spring program is harvest augmentation; the returning fish are subjected to terminal net fisheries and a mark-selective sport fishery in the area near the hatchery. The goal of the SSF group is evaluation of fishery impacts to the natural stock in the system. Spawning ground recoveries are the source of brood stock for the SSF program. Releases of Nooksack and Skagit River Spring Yearling stocks were discontinued following the 1996 and 2010 BY, respectively.

For NSF, there was a regulatory shift in the terminal net fishery during the evaluation period, where a portion of the fishery shifted from non-selective to mark-selective beginning in 2013. Because mark-selective fishery algorithms are not yet accounted for in the ERA, exploitation rate shifts may not accurately reflect impacts on wild stocks.

3.8.1.1 Brood Year Exploitation Rates

Brood year exploitation rate figures for North Puget Sound stocks are presented in Appendix D9. While not all North Puget Sound stocks have CWT releases that extend back to the late 1970s and early 1980s, those that do indicate that BYERs in ocean fisheries were high, exceeding 50% (additionally see NKS and SKS in Appendix D9 of CTC 2022b. Between the mid-1980s and mid-1990s, ocean BYERs declined and have generally been in the 25% to 50% range since. The most recent ocean BYERs are for BY 2016 and ranged from 19% (SKF) to 36% (SAM; Table 3.4).

3.8.1.2 Survival Rates

Plots depicting survival to age 2 for North Puget Sound stocks are presented in Appendix E9. For the four North Puget Sound stocks there are no discernable trends in survival during the time series of available data, which is similar to the pattern seen for Central and South Puget Sound stocks. Over the most recent decade, mean survival of these stocks has ranged between 1% and 2%, with poor years around 0.5% and the highest rates around 3.5%.

3.8.1.3 Mortality Distributions

For North Puget Sound stocks, the proportion of total AEQ mortality occurring in fisheries can vary notably from year to year but averaged between 40% and 50% since 2009 for NSF, SKF, and SSF, and was closer to 70% for SAM (Figure 3.10). On average, between 2009 and 2018 nearly half of the total fishery mortalities occurred in AABM fisheries for NSF and SSF, with more occurring in SEAK for SSF compared to NSF. Slightly more than half of the fishery mortalities for these two stocks occurred in ISBM fisheries, with more typically occurring in Canadian fisheries for NSF and more in U.S. fisheries for SSF. For the other North Puget Sound stocks (SAM, SKF), since 2009 the majority of fishery mortality, approximately 60–70% of the total, has occurred in U.S. ISBM fisheries, with only 10–15% occurring in AABM fisheries.

3.8.2 Central Puget Sound

Indicator stocks in Central Puget Sound, from north to south, include fingerling tag groups from the Stillaguamish River (STL) and the Skykomish River (SKY), a tributary in the Snohomish Basin. The Stillaguamish and Snohomish stocks are listed as indicator stocks with ISBM fishery limits in Chapter 3 Attachment I of the 2019 PST Agreement. The primary purposes of the Stillaguamish Fall CWT program are the evaluation of fishery impacts, and natural supplementation. Brood stock for this program is captured on the spawning grounds. The primary purpose of the Skykomish program, which uses returns of summer-run fish to the Wallace Salmon Hatchery for brood stock, is for fishery evaluation, and it also provides limited harvest in the in-river mark-selective sport fishery when abundance is favorable.

3.8.2.1 Brood Year Exploitation Rates

Brood year exploitation rate figures for Central Puget Sound stocks are presented in Appendix D10. Ocean BYERs declined dramatically for STL between the late 1970s and mid-1990s, ranging from highs greater than 90% to lows of approximately 20%. Since the lows of the mid-1990s, the ocean BYERs for STL have increased with an estimate of 32% for the most recent complete BY (2016). Beginning with BY 2000, ocean BYERs for SKY have generally ranged between 20% and 40%, with a most recent complete BY (2016) estimate of 26%.

3.8.2.2 Survival Rates

Plots depicting survival to age 2 for Central Puget Sound stocks are presented in Appendix E10. Similar to the North and the South Puget Sound fingerling stocks, there do not appear to be any trends in survival rates for Central Puget Sound stocks during the years for which data are available. Over the past decade of releases, survival rates have averaged just over 1% and ranged from 0.5% to 3%.

3.8.2.3 Mortality Distributions

For Central Puget Sound stocks, the proportion of total AEQ mortality occurring in fisheries has averaged 42% for STL and 32% for SKY since 2009 (Figure 3.10). Of those fishery mortalities, since 2009 roughly 30% (STL) and 20% (SKY) were in AABM fisheries, most of which occurred in WCVI. Of the remaining fishery mortalities, roughly 30% occurred in Canadian ISBM fisheries and 40% (STL) and 50% (SKY) occurred in U.S. ISBM fisheries. Terminal fisheries are limited on both stocks, and the majority of U.S. ISBM fishery mortality occurs in Puget Sound marine sport fisheries, which operate predominantly under mark-selective regulations.

3.8.3 South Puget Sound

The indicator stocks in Southern Puget Sound are South Puget Sound Fall Fingerling (SPS) and Nisqually Fall Fingerling (NIS). The SPS indicator group is an aggregate of several CWT indicator programs, currently composed of tag releases from Soos Creek Hatchery in the Green River Basin and Grovers Creek Hatchery on the western shore of Puget Sound across from Seattle. The SPS indicator is intended to represent mixed stock fishery impacts that occur on the Green River and Lake Washington stocks. However, it should not be used to represent terminal fisheries due to the varying intensity with which they occur on stocks within the SPS aggregate and on those the aggregate is intended to represent. In addition, because stocks originating in South Puget Sound are exposed to a number of MSFs, exploitation rates measured from marked tag recoveries may overestimate the impacts on unmarked natural stocks. The NIS stock is the southernmost indicator tag group in Puget Sound. Releases of South Puget Sound Fall Yearlings and White River Spring Yearlings were discontinued following the 2013 and 2015 BY, respectively.

3.8.3.1 Brood Year Exploitation Rates

Brood year exploitation rate figures for South Puget Sound stocks are presented in Appendix D11. Similar to trends observed for North and Central Puget Sound stocks, South Puget Sound stocks exhibited a pattern of high ocean BYERs in the late 1970s and early 1980s, often in the range of 60% to 80%, followed by a decline through the mid- to late-1990s. For SPS, ocean BYERs reached a low of approximately 20% with BY 1996, and have increased slightly since, generally ranging between 30% and 50%. The ocean BYER for the most recent complete BY (2016) was 37%. Ocean BYERs for NIS continued to decline into the mid-2000s and have since stabilized in the range of 20% to 35%. The ocean BYER for the most recent complete BY (2016) was 33%. It is important to note that these values reflect ocean fisheries only and a total BYER for SPS and NIS would include additional mortalities from freshwater fisheries, which can be substantial.

3.8.3.2 Survival Rates

Plots depicting survival to age 2 for South Puget Sound stocks are presented in Appendix E11. As with other Puget Sound stocks there do not appear to be any significant temporal trends in survival rates for the South Puget Sound stocks across the time series of available data. Survival rates to age 2 track closely for SPS and NIS, which in the most recent decade have averaged around 2% and generally ranged between 1% and 3.5%.

3.8.3.3 Mortality Distributions

For South Puget Sound stocks, the proportion of total AEQ mortalities occurring in fisheries since 2009 has averaged 40% for SPS and 52% for NIS (Figure 3.10). A higher proportion of the total fishery mortality occurs in U.S. ISBM fisheries for these stocks compared to some of the other Central and North Puget Sound stocks, averaging approximately 67% for SPS and 86% for NIS. The majority of U.S. ISBM fishery impacts on these stocks occur in Puget Sound mark-selective sport fisheries and/or in terminal net fisheries, both of which are designed to target large-scale hatchery production.

3.8.4 Juan de Fuca and Hood Canal

Chinook salmon releases from the Washington Department of Fish and Wildlife (WDFW) Elwha Hatchery (ELW) are used in the annual ERA, but releases of adipose-clipped and CWT Chinook salmon were insufficient for analysis between BYs 1994 and 2011. Tagging of adipose-clipped Elwha River Fall Fingerling stock in Juan de Fuca was discontinued with the 1994 BY. Between 1994 and 2011, a hatchery program continued using brood stock collected from the spawning grounds and from the hatchery rack. The Elwha Hatchery program has now shifted to a stock restoration and recovery program with the removal of the Elwha River dams that began in September 2011. Marking and tagging of this stock resumed with the 2012 BY as part of monitoring and evaluation of the restoration project. The George Adams (GAD) indicator stock is used to represent fishery and escapement distribution of natural fall fingerlings in Hood Canal tributaries, primarily the Skokomish River at the southern end of the Hood Canal.

3.8.4.1 Brood Year Exploitation Rates

Brood year exploitation rate figures for Juan de Fuca and Hood Canal stocks are presented in Appendix D12. These stocks show exploitation trends similar to Puget Sound stocks, with high ocean BYERs in the 1970s and 1980s, frequently greater than 60%, followed by declines into the mid-1990s. For GAD, the ocean BYERs reached a low of approximately 22% with BY 1994 and have generally ranged between 25% and 40% since. The ocean BYER for the most recent complete BY (2016) was 32%. Ocean BYERs for ELW were also high in earlier years, however, there were no ad-clipped CWT releases for BY 1995 through 2011. Since 2012 the ocean BYERs have been between 25% and 40%, with the most recent complete BY (2016) estimated at 22%.

3.8.4.2 Survival Rates

Plots depicting survival to age 2 for Juan de Fuca and Hood Canal stocks are presented in Appendix E12. Since marking and tagging resumed for ELW with BY 2012, survival to age 2 has been poor, averaging around 0.5%. Survival for GAD was particularly poor for eight consecutive BYs between 1988 and 1995 but has since rebounded, averaging over 2.5% over the most recent decade and ranging from 1% to 5%.

3.8.4.3 Mortality Distributions

For Hood Canal and Juan de Fuca stocks, the proportion of total AEQ mortalities occurring in fisheries since 2009 has averaged 56% for GAD and 31% for ELW, although since the ELW program only resumed with BY 2012, CY estimates of mortality distribution are only available beginning in 2015 (Figure 3.10). Similar to some of the South Puget Sound stocks, a lower proportion of the total fishery mortality has occurred in Alaska and Canada for GAD (approximately 20% since 2009), with the majority of fishery mortality occurring in U.S. ISBM fisheries, particularly marine sport and terminal net fisheries. For ELW, recent mortality distribution appears to be more similar to some of the North and Central Puget Sound stocks, with a larger portion (~30%) of the fishery mortality occurring in AABM fisheries, split almost evenly between SEAK and Canadian fisheries. The remaining fishery mortality occurs in ISBM fisheries, with nearly twice as much occurring in U.S. ISBM fisheries compared to Canadian ISBM fisheries. The majority of Southern U.S. fishery impacts on ELW occur in mark-selective marine sport fisheries, as the terminal fishery impact on this stock is minimal.

3.8.5 Regional Summary for Washington Salish Sea Stocks

For Washington Salish Sea stocks, BYER is measured in terms of ocean mortality only because terminal fisheries may not properly reflect the impacts on the natural stock represented by the CWT indicator. Some terminal fisheries are designed as hatchery fish target zones which would exceed the impacts on any natural stocks in the basin. Additionally, some river sport fisheries are now managed under MSF regulations that may overestimate impacts on natural stocks. The ocean fishery BYERs contain estimates of exploitation in the Puget Sound marine area mark-selective sport fisheries which have grown significantly since 2003. Consequently, these BYERs for Puget Sound stocks, especially those from Central and Southern Puget Sound, may overestimate the exploitation relative to that of the natural stocks they are intended to represent. Therefore, because of the exclusion of terminal fisheries and the inclusion of Puget Sound marine area MSFs, the ocean fishery BYERs for Washington Salish Sea stocks will not reflect total fishery impacts on natural stocks.

Summaries of Washington Salish Sea stock-specific BYERs are presented in Table 3.4, with more detail available in Appendix D. The BYERs for Washington Salish Sea Stocks have averaged 43% (per stock average range of 32–54%) for the fall stocks (SAM, SSF, STL, SKY, SPS, NIS, ELW, and GAD) and 33% (range 28–39%) for the spring stocks (NSF, SKF; Figure 3.10) over the long term. Relative to the long term, BYERs over the most recent decade are lower, averaging 35% for the fall stocks and 29% for the spring stocks.

Summaries of Washington Salish Sea stock-specific survival rates are presented in Table 3.4, with more detail available in Appendix E, all of which depict survival to age 2. Survival rates for Washington Salish Sea Fall and spring fingerling stocks averaged between 0.7–2.5%, which is similar to the rates commonly observed for fingerling type stocks. The trend in survival rates for those stocks with a long continuous time series of analysis (e.g., SAM, SPS, GAD) shows the lowest survival rates occurring for the late 1980s to early 1990s broods, with somewhat improved survivals beginning in the early 2000s.

The distribution of total AEQ mortality across fisheries and escapement for Washington Salish Sea stocks is presented in Figure 3.10, with more detailed information available in Appendix C. The distribution across fisheries varies by stock, with stocks from Central and North Puget Sound tending to have higher interception rates in Alaskan and Canadian fisheries. The proportion of total mortality that has occurred in fisheries since 2009 differs by stock, averaging 56% for stocks exposed to notable terminal fisheries (SAM, SKF, NIS, GAD) and 39% for stocks where terminal fishery impacts are lower (NSF, SSF, STL, SKY, SPS, ELW).

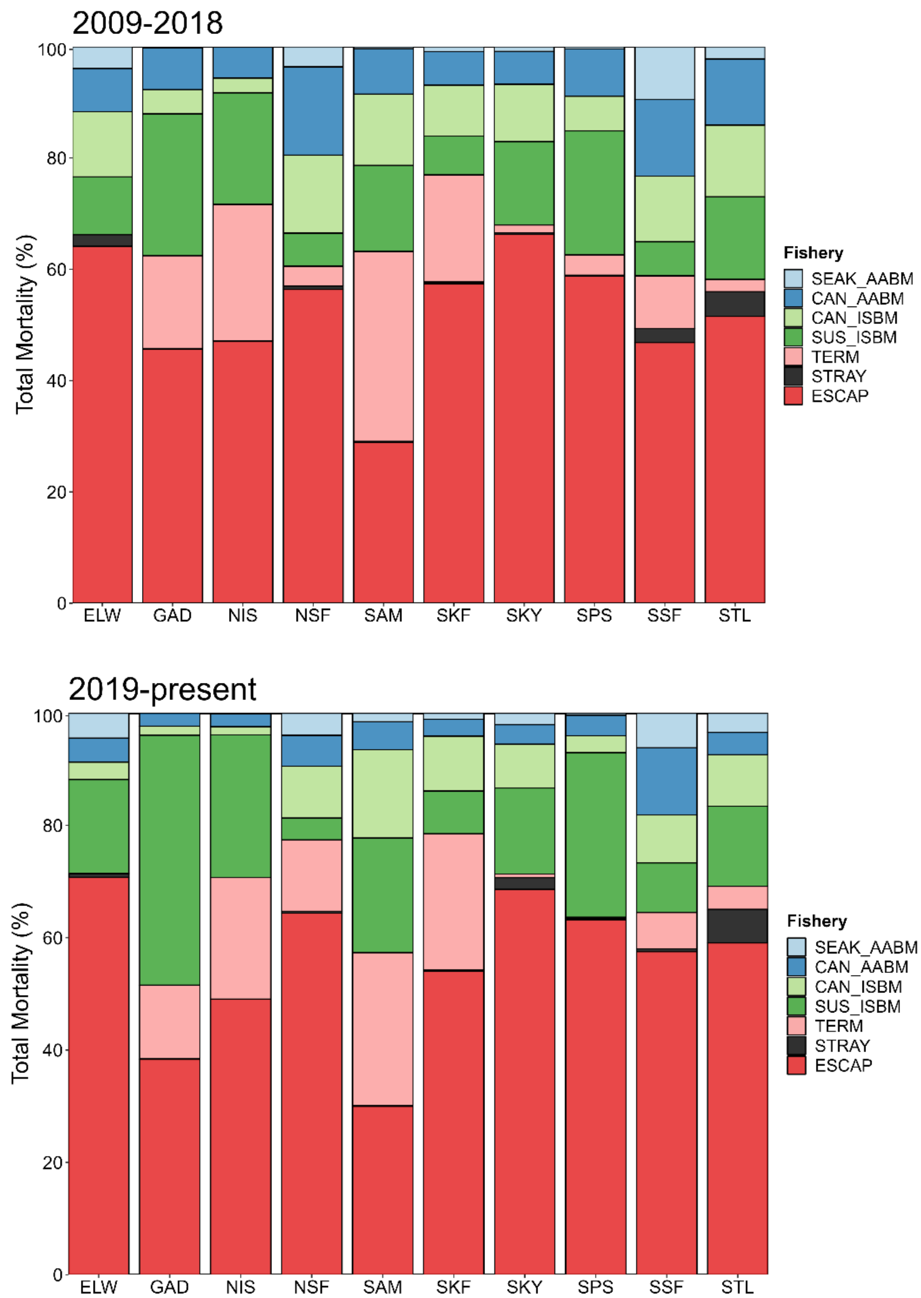

Figure 3.10—Distribution of total mortality for Puget Sound indicator stocks from the 2009 (2009–2018) and 2019 (2019–2028) Pacific Salmon Treaty Agreement periods. The figure on the right contains data from 2019 through 2021.

Table 3.4—Summary of statistics generated by the 2023 coded-wire tag (CWT) cohort analysis for Washington Salish Sea indicator stocks by region. Statistics include brood year exploitation rate (BYER), cohort survival rate to age 2 (age 3 for yearling stocks), and calendar year (CY) percent of total mortality in escapement.

Subregion	Indicator Stock	BYER(total mortality)		Survival rate		CY % Escapement[1] 2009-2018	CY % Escapement[1] 2019-current	
		Mean (range)	Last complete BY	Median (range)	Last complete BY	Mean (range)	Mean (range)	Last CY % (year)
North Puget Sound	Nooksack Spring Fingerling (NSF)[2]	39% (22%-61%)	22% (2016)	1.27% (0.27-4.60%)	1.64% (2016)	56% (37-72%)	64% (58-70%)	70% (2021)
	Samish Fall Fingerling (SAM)[2]	43% (27%-68%)	36% (2016)	1.39% (0.31-14.47%)	0.92% (2016)	29% (18-39%)	30% (27-32%)	31% (2021)
	Skagit Spring Fingerling (SKF)[2]	28% (13%-49%)	19% (2016)	1.43% (0.67-4.11%)	1.02% (2016)	57% (46-70%)	54% (46-60%)	56% (2021)
	Skagit Summer Fingerling (SSF)[2]	35% (21%-56%)	33% (2016)	1.16% (0.22-3.35%)	0.30% (2016)	47% (30-72%)	58% (24-78%)	24% (2021)
Central Puget Sound	Stillaguamish Fall Fingerling (STL)[2]	47% (21%-91%)	32% (2016)	1.51% (0.28-6.97%)	2.07% (2016)	52% (28-68%)	59% (52-71%)	54% (2021)
	Skykomish Fall Fingerling (SKY)[2]	32% (19%-43%)	26% (2016)	0.93% (0.43-3.01%)	1.03% (2016)	66% (56-77%)	69% (54-78%)	54% (2021)
South Puget Sound	South Puget Sound Fall Fingerling (SPS)[2]	46% (23%-75%)	37% (2016)	2.11% (0.41-9.51%)	1.42% (2016)	59% (46-70%)	63% (59-70%)	61% (2021)
	Nisqually Fall Fingerling (NIS)[2]	41% (23%-84%)	33% (2016)	1.54% (0.11-4.29%)	1.58% (2016)	47% (38-72%)	49% (28-67%)	52% (2021)
Juan de Fuca/ Hood Canal	Elwha (ELW)[2]	54% (22%-100%)	22% (2016)	0.46% (0.01-2.32%)	0.46% (2016)	64% (54-69%)	71% (63-79%)	63% (2021)
	George Adams Fall Fingerling (GAD)[2]	45% (22%-83%)	32% (2016)	1.40% (0.04-5.87%)	2.17% (2016)	46% (24-55%)	38% (27-57%)	57% (2021)

[1] % Escapement is not a measure of performance for the escapement indicator stock(s) associated with a given CWT indicator stock.
[2] BYER is ocean exploitation rate only.

3.9 Columbia River Stocks

The Columbia River CWT ERA indicator stocks come from the Willamette River tributary, the Lower Columbia, the Upper Columbia, and the Snake River tributary. The Willamette River Spring Chinook CWT indicator (WSH) is an aggregation of yearling releases from several Willamette basin hatcheries. Lower Columbia CWT stocks include three tule fall Chinook CWT indicator stocks from hatcheries, and one wild bright stock below Bonneville Dam. The three tule indicator stocks are Lower River Hatchery (LRH, now released from Big Creek/Bonneville Hatchery), Cowlitz Hatchery (CWF), and Spring Creek Hatchery (SPR). The Lewis River Wild (LRW) indicator stock is a bright stock and is one of few wild stock tagging programs. Tule Chinook are distinguished by their dark coloration and advanced stage of maturation. Bright Chinook typically have a later freshwater entry and are bright in color like ocean caught fish. Upper Columbia CWT indicator stocks include two bright fall and two summer Chinook stocks: Columbia Upriver Brights (URB, from Priest Rapids Hatchery), Hanford Wild (HAN, from Hanford

Reach), Mid-Columbia Summers (SUM, from Wells Hatchery, including subyearling and yearling releases), and Similkameen (SMK, from the Okanogan watershed). For the Snake River, Lyons Ferry Hatchery releases both subyearling (LYF) and yearling (LYY) CWT indicators, but only the subyearlings are representative of the natural production. For all of these Columbia River stocks, Table 3.5 shows long term mean, range and most recent brood year BYERs, long-term median, range and most recent brood year survival rates, and means, ranges, and most recent calendar year of the percentage of total mortality accruing to escapement.

3.9.1 Brood Year Exploitation Rates

For each of the CWT indicator stocks BYERs are calculated. For WSH and CWF only ocean BYER is reported, since the wild components that these stocks represent experience high MSF exploitation in terminal fisheries targeting hatchery production. Over the last 10 years, ocean BYERs have averaged about 8% for WSH with 2% IM, and 17% for CWF with 4% IM.

Three hatchery stocks in the lower Columbia River (CWF, LRH, and SPR) showed a decline in BYERs from high levels during the late 1970s (over 65%) to lower levels during the early to mid–1990s (Appendix D13). Over the last 10 years, BYERs for LRH and SPR averaged 55–65%, and IM averaged 6–9%.

The LRW and SUM stock BYERs reached highs in the early 1980s (70%, 81%), lows in the 1990s (17–18%), and returned to higher rates in the 2000s. URB BYERs also reached a high in the 1980s (80%), hit a low in 1991 (16%), and were then also higher in the 2000s. Coded-wire tagging of wild bright fall Chinook in the Hanford Reach (HAN) and of LYF both began in 1984. BYERs for HAN average a little higher than for URB (42% vs. 40% recent 10-year average), while BYERs for LYF and LYY are lower (32%). Over the last 10 years, BYERs for LRW, URB, HAN, and SUM have averaged about 40%, LYF, LYY, and SMK BYERs averaged 32-35%, and IM for all stocks except WSH and LRH has averaged 4–7%. WSH ocean IM is lower at 2% and LRH IM is higher at 9%.

3.9.2 Survival Rates

Survival rates for WSH (to age 3 as a spring stock) have been somewhat cyclical, with 13 of 15 broods from 1975–1989 above 3% (averaging 4%), 1–2% for the next seven broods, 3–7% (averaging 4%) for the next four broods, and back down to 1–2% for most broods since 2000 (Appendix E13). The most recent complete brood (2015) showed a notable drop to only 0.54% (Table 3.5).

Lower Columbia River stocks, specifically both CWF and LRH, have suffered from persistently low survival throughout the time series available for CWT survival analysis (1977–1978 through 2018). Recent survival rates remain well below 1%. Survival rates for SPR were 0–1% for 17 of 18 broods before 1998. Since 1998, nine of the next 14 broods had improved survivals, including six broods (1998–2001, 2007 and 2011) with rates of 3–4%, however recent survival rates have declined to under 2%. Survival rates for LRW declined from an average of 2.8% for the 1982–1992 broods, to under 2% for all but one of the next 23 broods.

In the Upper Columbia River, SUM had survival rates less than 1.3% until 1997, except for 1985 (2.2%), averaging only 0.7%. Since then, survival rates improved to 1.0–5.4%. A 5.4% survival for

2011 is the highest value for SUM, while it was the 2010 brood that excelled for URB (7.9%), HAN (5.8%) and LYY (5.9%). URB survival rates were 2–7% for 1975–1985 broods (averaging 4%), below 3% from 1986–2008 (averaging 1%), improving to 3–8% from 2009–2012 (averaging 5%), before again dropping to less than 2%. HAN survival rates were 0–2% for 20 of 21 broods from 1986–2006, (averaging 1%), and then averaged 3% for 6 broods, before declining to well under 1% for recent broods. LYF and SMK have data gaps through the 2002 brood, and highly variable survival rates bouncing back and forth between 2–4% and up to 8–11% since 2003. Recent broods for LYF are all under 2% survival, with the latest two complete broods at only about 0.5%. SMK survivals are around 3–5%. LYY, which are yearlings, had 4–5% survival rates for 12 of 16 broods (averaging 5%), before decreasing to about 2–3%, and with the latest complete brood (2015) dropping to 1.3%.

3.9.3 Mortality Distributions

The distribution of mortality for each stock can be found in Appendix C. For Columbia River stocks, sport data take two years to complete, thus the most recent numbers are for 2021. For most far-north migrating stocks (LRW, URB, HAN, SUM, and SMK), average total mortality in AABM fisheries was about 20–30% for 2009-2018, occurring primarily in SEAK. For the current annex period, average AABM percent total mortality has decreased to about 10–20% for URB, HAN, SUM and SMK. WSH and CWF are also northern migrating and have most AABM fishery impacts in SEAK troll, but at lower levels of 5–10%. Most mortalities for WSH are in SUS ISBM sport fisheries, decreasing from an average of 29% for 2009–2018 to 21% for the recent annex. SPR and LRH AABM fishery impacts are primarily in the WCVI AABM fishery, with about 5–15% total mortalities. Average AABM total mortality impacts decreased by roughly half since the last annex period for SPR (7 to 4%) and LRH (13 to 7%) tule Chinook, and for SUM (21 to 11%) and SMK (19 to 8%) summer Chinook, primarily due to decreases in WCVI harvest but for SUM and SMK, decreases in NBC also.

Figure 3.11 demonstrates changes in the proportion of CY total mortality in fisheries and escapement. Impacts in Southern U.S. ISBM fisheries since 2018 were lower than usual for most Columbia River stocks, and correspondingly, the recent average proportion passing through to escapement for most Columbia River stocks has increased from the 2009–2018 average.

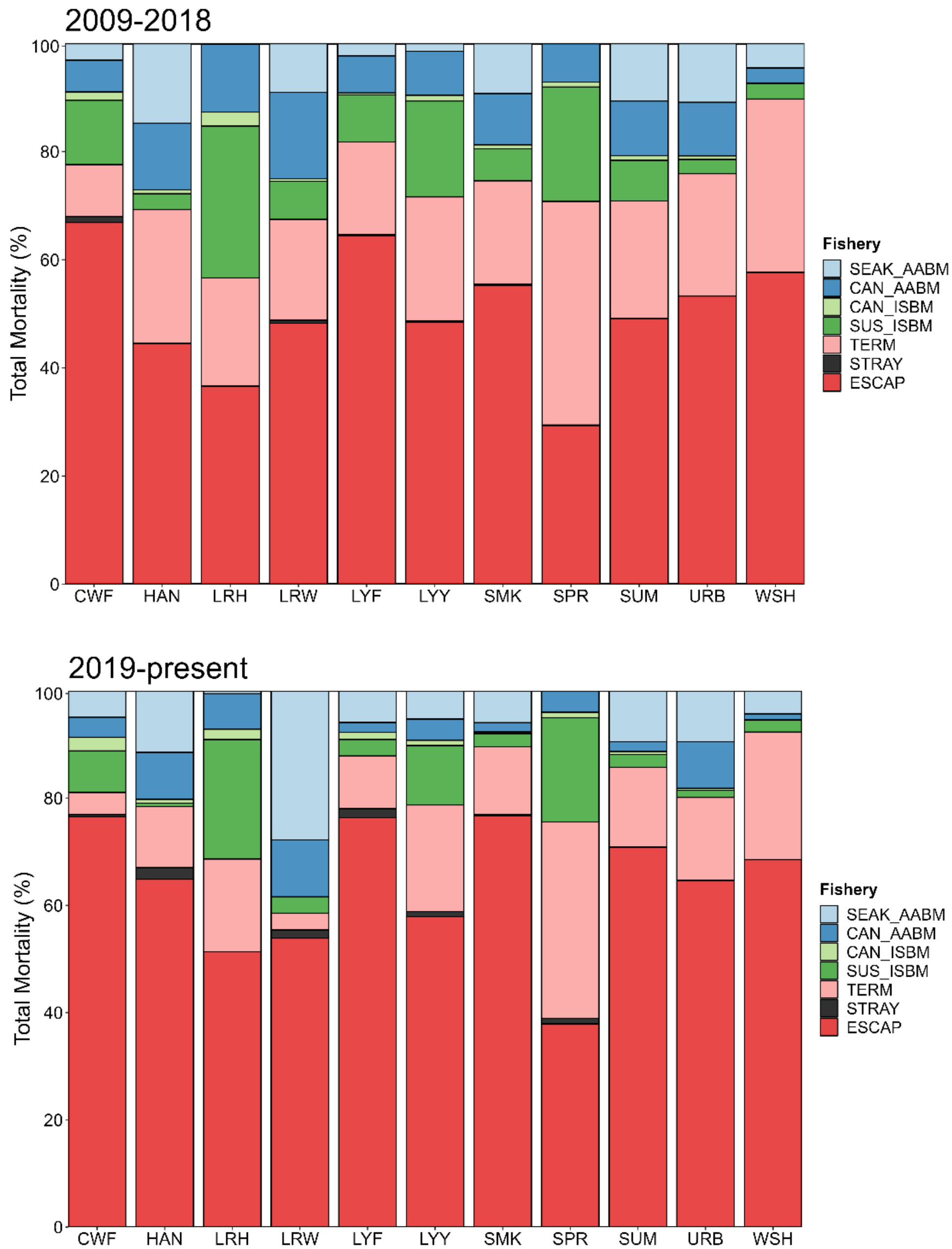

Figure 3.11—Distribution of total mortality for Columbia River and tributaries indicator stocks from the 2009 (2009–2018) and 2019 (2019–2028) Pacific Salmon Treaty Agreement periods. The figure on the bottom contains data from 2019 through 2021.

3.9.4 Regional Summary for Columbia River Stocks

Most Columbia River stocks typically have survival rates from 0–3%, with more successful broods surviving at 6–8% (Appendix E13). Currently, recent survival rates are showing substantial declines to well under 2% for all stocks except SUM and SMK Summer Chinook, which are currently 3–5% survival.

Except for WSH, averaging a BYER of 11%, and LRH and SPR, with higher rates of around 60–70%, Columbia River stocks had BYERs of about 35–50%. BYERs for WSH and CWF are ocean exploitation rates that do not include terminal harvest impacts (Table 3.5). Percent escapement is usually about 55–75% for CWF and WSH. SPR and LRH tules have lower percent escapement of about 30–50%. For the remaining stocks (SUM, SMK, LRW, URB, HAN, LYF, and LYY), percent escapement seems to be increasing. It averaged about 50-60% for 2009–2018, averaged about 55–75% for 2019–2021, and was about 50–85% for 2021. Except for SUM and SMK, Columbia River stocks showed survival rates less than 2% for the most recent complete brood.

Table 3.5—Summary of statistics generated by the 2023 coded-wire tag (CWT) cohort analysis for Columbia River indicator stocks. Statistics include total mortality (catch plus incidental mortality), brood year exploitation rate (BYER), cohort survival rate to age 2, and calendar year (CY) percent distribution of the total mortality in the escapement.

	BYER (total mortality)		Survival rate		CY % Escapement[1]		
					2009-2018	2019-current	
Indicator Stock	Mean (range)	Last complete BY	Median (range)	Last complete BY	Mean (range)	Mean (range)	Last CY % (year)
Cowlitz Fall Tule (CWF)[2]	36% (11%-68%)	15% (2016)	0.42% (0.06-3.54%)	0.27% (2016)	67% (48-90%)	77% (65-83%)	65% (2021)
Hanford Wild Brights (HAN)	50% (29%-72%)	29% (2016)	0.84% (0.14-5.81%)	0.73% (2016)	45% (11-68%)	65% (61-68%)	61% (2021)
Lower River Hatchery Tule (LRH)	59% (20%-82%)	58% (2016)	0.58% (0.02-9.59%)	0.31% (2016)	37% (28-44%)	51% (45-58%)	51% (2021)
Lewis River Wild (LRW)	44% (17%-70%)	41% (2016)	1.54% (0.23-6.91%)	1.81% (2016)	48% (31-67%)	54% (44-69%)	49% (2021)
Lyons Ferry Fingerling (LYF)	35% (8%-67%)	29% (2016)	1.38% (0.08-7.88%)	0.58% (2016)	64% (41-89%)	76% (64-84%)	84% (2021)
Lyons Ferry Yearling (LYY)	47% (24%-75%)	48% (2015)	4.20% (0.96-14.69%)	1.29% (2015)	49% (33-72%)	58% (52-65%)	65% (2021)
Similkameen Summer Yearling (SMK)	34% (11%-53%)	24% (2016)	3.98% (0.18-11.65%)	4.64% (2015)	55% (47-60%)	77% (73-79%)	73% (2021)
Spring Creek Tule (SPR)	72% (46%-94%)	61% (2016)	1.32% (0.12-8.26%)	0.85% (2016)	29% (22-46%)	38% (33-42%)	33% (2021)
Columbia Summer (SUM)	50% (14%-78%)	36% (2016)	1.34% (0.01-5.60%)	3.80% (2016)	49% (44-56%)	71% (60-83%)	60% (2021)
Columbia River Upriver Brights (URB)	51% (24%-80%)	38% (2016)	1.82% (0.08-8.03%)	1.45% (2016)	53% (34-66%)	65% (60-71%)	60% (2021)
Willamette Spring Hatchery (WSH)[2]	11% (2%-32%)	5% (2015)	2.49% (0.54-6.34%)	0.54% (2015)	58% (44-68%)	69% (55-78%)	55% (2021)

[1] % Escapement is not a measure of performance for the escapement indicator stock(s) associated with a given CWT indicator stock.

[2] BYER is ocean exploitation rate only.

3.10 Oregon Coast Stocks

There are two hatchery-origin CWT ERISs representing exploitation and survival of Chinook salmon on the Oregon coast, the Salmon River Hatchery (SRH) release group and the Elk River Hatchery (ELK) release group. Both groups are fall ocean type subyearling stocks with earliest recoveries at the total age of 2. The SRH release group represents the Northern Oregon Coast (NOC) aggregate, and the ELK release group represents the Mid-Oregon Coast (MOC) aggregate. The SRH has consistently released CWT groups every year since 1976, with the exception of 1981. Releases from SRH have averaged 197,000 over the past 10 years and 196,000 over the past 20 years. There have been consistent, although sometimes small (prior to 1989), releases from the ELK since 1977. Average CWT release group size for ELK between 1977 and 1989 was approximately 37,000, and between 1990 and 2007 this increased to an average of approximately 184,000. Since 2007, after a two-year decline of coded-wire tagged ELK releases in 2008–2009 (average 40,000), the release size increased to an average of 284,000 in 2010–2016. SRH is used as an ocean exploitation rate indicator for three other escapement indicator stocks (EIS); Nehalem, Siletz and Siuslaw. ELK is used as the ocean exploitation rate indicator for both the South Umpqua and Coquille EIS. Terminal adjustments are applied to these EIS stocks for CYER calculations to account for different terminal exploitation (Figure 3.13; Figure 3.14).

3.10.1 Brood Year Exploitation Rates

BYERs for both the SRH and ELK ERISs include only those mortalities attributable to ocean fisheries, excluding the Port Orford bubble fishery (Appendix D14; Table 3.6). The BYER has averaged 36% (range 24–63%) for the SRH releases. BYER for the ELK has averaged 22% (range 10–31%) for the time series, excluding brood years 1977 and 1978. There is no discernible trend through time regarding the percentage of IM occurring in ocean fisheries for either SRH or ELK hatchery releases. For the last complete brood year, SRH (26%) showed greater ocean BYER compared to ELK (19%). In general, the SRH stock has displayed higher ocean exploitation rate than the ELK stock throughout the observed time series.

3.10.2 Survival Rates

Survival rates for both SRH and ELK hatchery stocks are to age 2. Generally, survival rates for ELK have been variable, yet robust, with a median of 6% (range of 1–33%; Appendix E14; Table 3.6). From 2014–2016 (the last year with complete broods from which survival can be calculated), survival has been below average. Brood years 2017 and 2018 are represented by incomplete brood data but continue to exhibit lower than average survival. Survival rates for SRH generally increased through 2012 with a long-term median of 5%. Recently, the survival of the SRH stock has declined from a historic high of 19% in 2012 to a historic low of 1% during the 2013–2015 brood years. Available (yet incomplete) information on the 2017 and 2018 brood years indicate there has been an increase in survival following the prior 3-year decline (Appendix E14).

3.10.3 Mortality Distributions

An average of 56% of SRH (Appendix C45) mortality, and 56% of the ELK (Appendix C7) mortality, is attributed to escapement for the 2009–present time series (Table 3.6). Both stocks exhibit variation in the proportion which escapes to spawn through the time series. SRH has trended to higher proportion in escapement since 1979, but ELK has shown no trend over the full time period. According to the 2009–2018 CY data, the largest ocean harvest mortality on the SRH stock occur in terminal sport (22%), SEAK troll fisheries (14%), NBC troll (11%), and NBC sport (3%). During the same time period, the largest impacts on the ELK stock occur in terminal sport (15%), terminal troll fisheries (11%), SEAK troll (6%), and NBC troll (5%). In the early years, WCVI troll was responsible for a larger component of the impacts on SRH (6%:1979-1984), as well as the largest impact (6%: 1979–1984) outside of the terminal river sport fishery on ELK, but WCVI troll impact has been greatly reduced over the years to low levels currently for both SRH (1% 2009-2018) and ELK (2%: 2009–2018). Recent impact distributions are displayed in Figure 3.12.

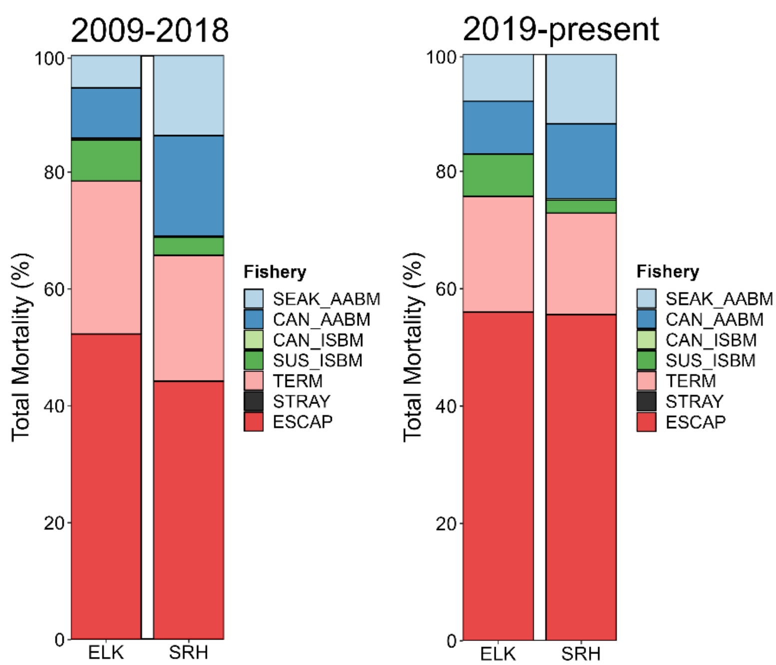

Figure 3.12—Distribution of total mortality for Oregon Coast indicator stocks from the 2009 (2009–2018) and 2019 (2019–2028) Pacific Salmon Treaty Agreement periods. The figure on the right contains data from 2019 through 2021.

3.10.4 Terminal Area Adjustments

Terminal area adjustments are needed to adequately depict the harvest in the areas of the escapement indicator stocks, as there of often intensive terminal fisheries focused on those hatchery stocks (SRH, ELK) which are not representative of those terminal fisheries which occur on their natural counterparts within their modeled aggregate (NOC and MOC). The terminal harvest rate for the Salmon River Hatchery stock (NOC ERIS) is adjusted to account for differential harvest rates that occur on the Nehalem, Siletz, and Siuslaw rivers. As seen in Figure 3.13, the total harvest mortality of the terminal fishery in these stocks during the 2009–2018 period was generally similar, but lower than that experienced by SRH. More recently (2019 to present) terminal harvest mortality was more variable among the EIS stocks. The Elk River

Hatchery stock (MOC ERIS) is adjusted to account for the differential harvest rates that occur in the Umpqua (South Umpqua) and Coquille river basins (Figure 3.14). There currently is no directed harvest in the South Umpqua basin and has not been in decades. All of the harvest in the Umpqua basin occurs in the full basin drainage. In recent years the spawning escapement in the Coquille river has been quite depressed, leading to the closure of the terminal fishery on naturally produced fish. Reductions to terminal harvest are seen between the 2009 and 2018 vs the 2019 to present periods in both the Elk and Coquille basins, with the harvest in the Umpqua basin remaining similar between the two periods (Figure 3.14).

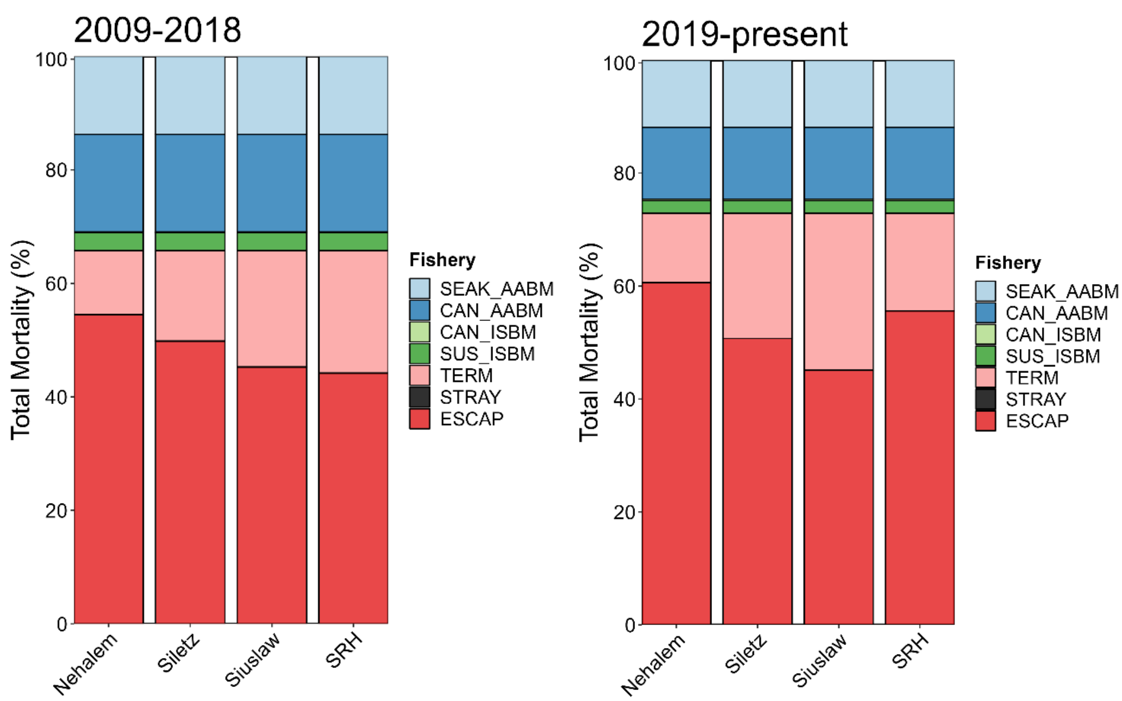

Figure 3.13—Distribution of total mortality for the North Oregon Coast hatchery indicator stock before applying the terminal area adjustment (Salmon River [SRH]) and after the terminal area adjustments for the escapement indicator stocks (Siletz, Siuslaw, and Nehalem) for the 2009 (2009–2018) and 2019 (2019–2028) Pacific Salmon Treaty Agreement periods. The figure on the right contains data from 2019 through 2021.

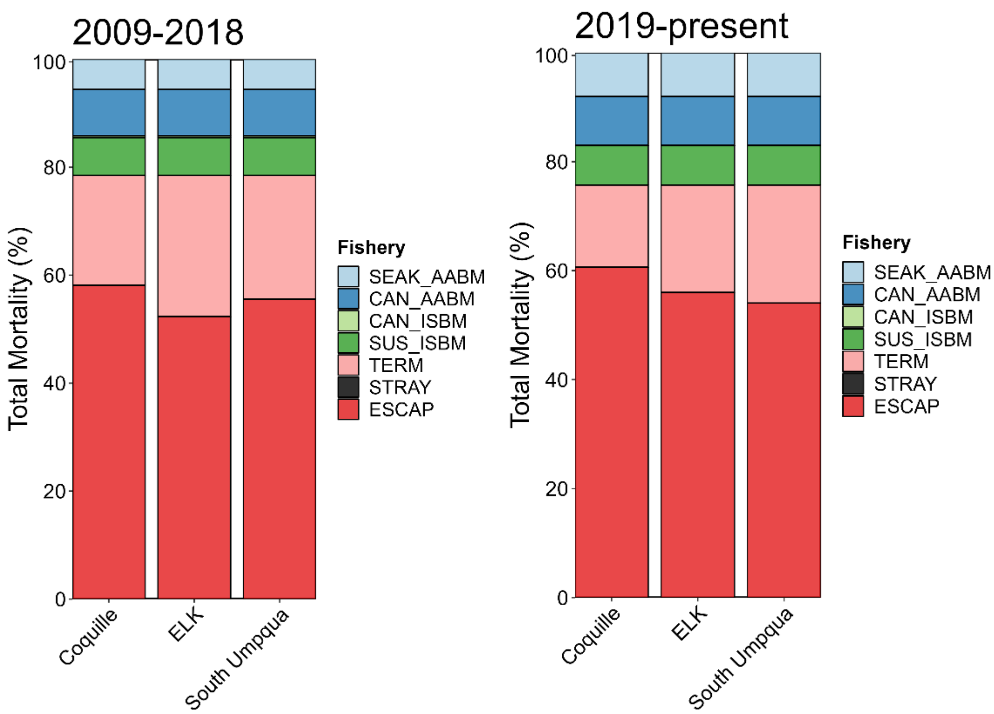

Figure 3.14—Distribution of total mortality for the Mid-Oregon Coast hatchery indicator stock before applying the terminal area adjustment (Elk River [ELK]) and after the terminal area adjustments for the escapement indicator stocks (Coquille and South Umpqua) for the 2009 (2009–2018) and 2019 (2019–2028) Pacific Salmon Treaty Agreement periods. The figure on the right contains data from 2019 through 2021.

3.10.5 Regional Summary for Oregon Coast Stocks

There are dynamic changes that have occurred to both NOC and MOC stocks, and those fisheries which capitalize upon them, through the period of observation and reporting for this document (2009 to present). Both aggregates have experienced survival declines recently (Appendix E14). Survival has fluctuated more for SRH than for ELK, varying from the highest survival to the worst survival observed in recent years (Appendix E14). Not surprisingly, NOC stocks have experienced a patchwork of escapement goal attainment and failure over the same period; MOC stocks do not have CTC-approved escapement goals but have exhibited similar variability. Escapement performance most likely cannot be attributed to one fishery's exploitation over another, although terminal fisheries are likely playing an increasingly large part in the performance of these stocks, and terminal fisheries management has become crucial in meeting escapement goals in recent years.

Table 3.6—Summary of statistics generated by the 2023 coded-wire tag (CWT) cohort analysis for Oregon Coast indicator stocks. Statistics include total mortality (catch plus incidental mortality) brood year exploitation rate (BYER), cohort survival rate to age 2, and calendar year (CY) percent distribution of the total mortality.

	BYER (total mortality)		Survival rate		CY % Escapement[1]		
					1999–2008	2009–present	
Indicator Stock	**Mean (range)**	**Last complete BY**	**Median (range)**	**Last complete BY**	**Mean (range)**	**Mean (range)**	**Last CY % (year)**
Elk River (ELK)[2]	22% (10%-31%)	19% (2016)	6.15% (1.04-32.90%)	6.0% (2016)	52% (42-65%)	56% (55-57%)	56% (2021)
South Umpqua (ELK adj.)[2]	22% (10%-31%)	19% (2016)	6.15% (1.04-32.90%)	6.0% (2016)	56% (47-72%)	54% (48-58%)	55% (2021)
Coquille (ELK adj.)[2]	22% (10%-31%)	19% (2016)	6.15% (1.04-32.90%)	6.0% (2016)	58% (32-77%)	61% (34-76%)	72% (2021)
Salmon River (SRH)[2]	36% (24%-63%)	26% (2016)	5.48% (0.63-18.67%)	5.25% (2016)	44% (22-57%)	56% (47-60%)	47% (2021)
Nehalem (SRH adj.)[2]	36% (24%-63%)	26% (2016)	5.48% (0.63-18.67%)	5.25% (2016)	54% (24-69%)	61% (49-69%)	49% (2021)
Siletz (SRH adj.)[2]	36% (24%-63%)	26% (2016)	5.48% (0.63-18.67%)	5.25% (2016)	50% (22-70%)	51% (42-61%)	42% (2021)
Siuslaw (SRH adj.)[2]	36% (24%-63%)	26% (2016)	5.48% (0.63-18.67%)	5.25% (2016)	45% (17-59%)	45% (40-55%)	41% (2021)

[1] % Escapement is not a measure of performance for the escapement indicator stock(s) associated with a given CWT indicator stock.

[2] BYER is ocean exploitation rate only.

4. ISBM FISHERY PERFORMANCE

4.1 ISBM MANAGEMENT FRAMEWORK UNDER 2019 PST AGREEMENT

Under the 2019 PST Agreement Chapter 3, paragraph 5(a), "*U.S. and Canadian ISBM fisheries shall be managed to limit the total adult equivalent mortality for stocks listed in Attachment I that are not meeting agreed biologically-based management objectives, or that do not have agreed management objectives, to no more than the limits identified in Attachment I.*" The CYER is the metric the PSC uses to monitor total mortality in ISBM fisheries and for limiting total AEQ mortality (paragraph 5(e)). The CTC is tasked with evaluating ISBM fishery performance relative to the obligations set forth in paragraphs 5 and 7 annually.

Paragraph 5(d) of Chapter 3 of the 2019 PST Agreement requires that *"actual ISBM fishery performance relative to the obligations set out in this paragraph shall be evaluated by the CTC and reported annually to the Commission. Because the performance analysis is dependent on recovery of CWT, the CTC shall provide the evaluation for ISBM fisheries on a post-season basis.*" Thus, the CTC is required to annually compute and report the CYERs for ISBM fisheries and using *"the best available post-season data and analysis, report performance to the Commission of those metrics and the obligations set out in this Chapter*."

The CTC interprets "*best available post-season data and analysis*" to mean that escapement, annual CYER, and base period CYER values used to evaluate ISBM obligations are updated annually based on results from the most current ERA and reported in Appendix H. A retrospective evaluation of CYER values from the 2017–2022 ERA (CTC 2018, CTC 2019a, CTC 2021d, CTC 2021e, CTC 2022b) showed that annual and base period CYER values change over time. Future changes to some of these values are anticipated by the CTC, particularly as MSF algorithms are incorporated into the ERA. Major changes to CYER data will be documented in Appendix H. For ISBM fishery evaluation, Attachment I ISBM indicator stocks, management objectives, and CYER limits are shown in Table 4.1; the steps to evaluate the ISBM management framework are diagrammed in Figure 4.1. SEAK stocks are excluded because they are not subject to ISBM fishery provisions. ISBM fisheries subject to the Treaty are listed in Table 4.2.

Table 4.1—Attachment I individual stock-based management (ISBM) indicator stocks, management objectives, and calendar year exploitation rate (CYER) limits as percentages of the 2009–2015 average CYER. To represent naturally spawning stocks, some exploitation rate indicators require adjustment for impacts of terminal fisheries targeting hatchery-origin fish.

Escapement Indicator	Management Objective[1]	Exploitation Rate Indicator	ISBM CYER Limits (%)	
			Canadian	U.S.
Skeena	TBD	KLM	100%	
Atnarko	5,009[3,4]	ATN	100%	
NWVI Natural Aggregate[7]	TBD	RBT adj.	95%	
SWVI Natural Aggregate[8]	TBD	RBT adj.[5]	95%	
E. Vancouver Island North	TBD	QUI adj.[5] (TBD)[2]	95%	
Phillips	TBD	PHI	100%	
Cowichan	6,500	COW	95%	95%
Nicola	TBD	NIC	95%	95%
Chilcotin	TBD	TBD[2]	95%	
Chilko	TBD	CKO[2]	95%	
Lower Shuswap	12,300[3]	SHU	100%	
Harrison	75,100	HAR	95%	95%
Nooksack Spring	TBD	NSF	87.5%	100%
Skagit Spring	690[3]	SKF	87.5%	95%
Skagit Summer/Fall	9,202[3]	SSF	87.5%	95%
Stillaguamish	TBD	STL	87.5%	100%
Snohomish	TBD	SKY	87.5%	100%
Hoko	TBD	HOK		10% CYER[6]
Grays Harbor Fall	13,326	QUE adj.[5]		85%
Queets Fall	2,500	QUE		85%
Quillayute Fall	3,000	QUE adj.[5]		85%
Hoh Fall	1,200	QUE adj.[5]		85%
Upriver Brights	40,000	HAN/URB		85%
Lewis River Fall	5,700	LRW		85%
Coweeman	TBD	CWF		100%
Mid-Columbia Summers	12,143	SUM		85%
Nehalem	6,989	SRH adj.[5]		85%
Siletz	2,944	SRH adj.[5]		85%
Siuslaw	12,925	SRH adj.[5]		85%
South Umpqua	TBD	ELK adj.[5]		85%
Coquille	TBD	ELK adj.[5]		85%

[1] TBD = to be determined after review specified in paragraph 2(b)(iv) of Chapter 3 of 2019 Pacific Salmon Treaty.
[2] TBD = to be determined because the requisite data are not available; in development.
[3] Agency escapement goal has the same status as Chinook Technical Committee agreed escapement goal for implementation of Chapter 3.
[4] Natural origin spawners.
[5] Coded-wire tag stocks and adjustments described in CTC (2016), CTC (2019b), CYER WG (2021), and CTC (2021b).
[6] ISBM limit set at 10% in recognition of closure of the Hoko River to Chinook salmon fishing in 2009–2015.
[7] NWVI Natural Aggregate consists of Colonial-Cayeagle, Tashish, Artlish, and Kaouk.
[8] SWVI Natural Aggregate consists of Bedwell-Ursus, Megin, and Moyeha.

Table 4.2—Chinook Technical Committee (CTC) exploitation rate analysis fisheries included in individual stock-based management (ISBM) metrics by country.

Canada	**United States**
Troll	
Central BC Troll Georgia Strait Troll	North of Falcon Troll South of Falcon Troll Oregon Coast (Port Orford) Terminal Troll
Net	
North BC Net North BC Terminal Net Central BC Net Central BC Terminal Net West Coast Vancouver Island Terminal Net West Coast Vancouver Island Net Strait of Georgia Net North BC Terminal Freshwater net Central BC Freshwater Net Georgia Strait Freshwater Net Fraser Freshwater Net Johnstone Strait Net BC Juan de Fuca Net Fraser Net Fraser Terminal Net	Puget Sound North Net Puget Sound North Terminal Net U.S. Juan de Fuca Net Puget Sound Other Net Puget Sound Other Terminal Net Washington Coast Net Columbia River Net Puget Sound Freshwater Net Washington Coast Freshwater Net
Sport	
Central BC Sport Central BC Terminal Sport North BC ISBM Sport North BC Terminal Sport West Coast Vancouver Island ISBM Sport West Coast Vancouver Island Terminal Sport Johnstone Strait Sport Johnstone Strait Terminal Sport Georgia Strait Sport Georgia Strait Terminal Sport BC Juan de Fuca Sport BC Juan de Fuca Terminal Sport North BC Freshwater Sport Central BC Freshwater Sport West Coast Vancouver Island Freshwater Sport Fraser River Freshwater Sport Georgia Strait Freshwater Sport	North of Falcon Sport North of Falcon Terminal Sport South of Falcon Sport South of Falcon Terminal Sport Puget Sound North Sport Puget Sound North Terminal Sport Puget Sound Other Sport Puget Sound Other Terminal Sport Columbia River Sport Puget Sound Freshwater Sport South of Falcon Freshwater Sport

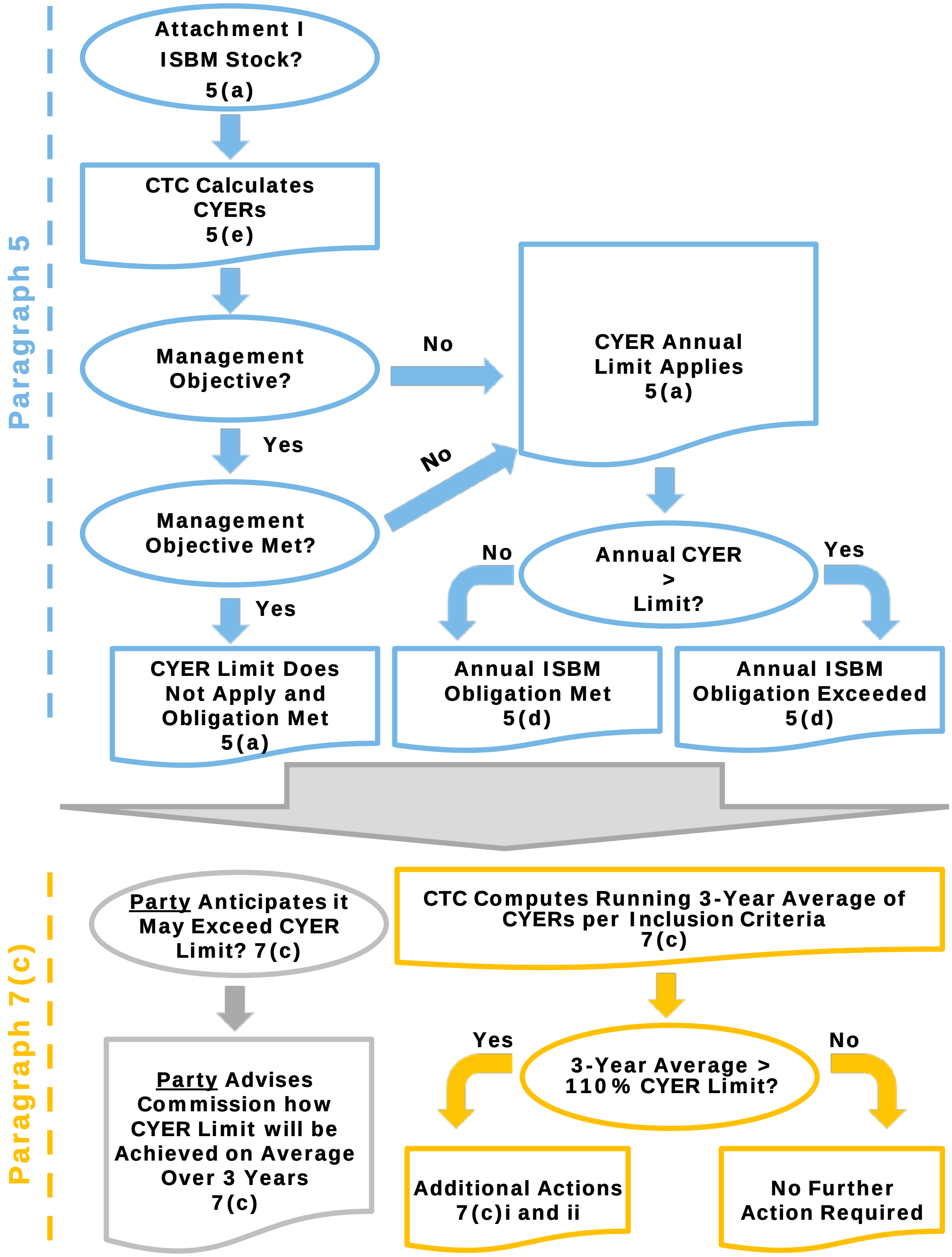

Figure 4.1—Flow diagram depicting the sequence of steps for individual stock-based management (ISBM) fisheries management framework under the 2019 Pacific Salmon Treaty Agreement.

Effective in 2023, the CTC is now reporting annual CYERs (Chapter 3, paragraph 5) and the running 3-year average (3YA) CYER from catch years 2019–2021 as data are now available from both Parties' ISBM fisheries (Footnote 17, 2019 PST Agreement). The 3YA was calculated for the 2023 ERA based on three years of CYERs that meet the criteria for inclusion specified in paragraph 7(c) as agreed to by the PSC. For stocks in Attachment I without agreed management objectives, paragraph 7(c) specifies that all years shall be used to calculate the running 3YA. For stocks in Attachment I with an agreed management objective, the 3YA will include "*all years in which the management objective is not achieved, and the years in which the management objective is achieved with a CYER that is less than or equal to the ISBM obligation identified in paragraph 5.*" At their October 2022 meeting, the Commission provided guidance that the 3YA must include three years of CYERs that meet the criteria for inclusion specified in paragraph 7(c). Thus, in cases where there are years that do not meet the criteria for inclusion in the 3YA, the running 3YA will span a time frame greater than three years.

For stocks that have a running 3YA of CYERs that exceeds 110% of the CYER limit, the Commission "*shall request that the management entities responsible for the management of the ISBM fishery take necessary actions to minimize the deviation between the three-year CYER average and the CYER limits in Attachment I*" (Chapter 3, subparagraph 7(c)(i)). The Commission will discuss proposals from the management entities regarding actions that will be taken and expected outcomes prior to implementation. Meanwhile, the CTC "*shall provide to the Commission a plan to improve the performance of pre-season, in-season and other management tools so that the deviations between the CYERs and the CYER limits are narrowed to a maximum level of 10% when limits apply (Attachment I)*" (Chapter 3, subparagraph 7(c)(ii)).

The PSC will review the CYER metric per paragraph 5(e) "*to make a decision on its continued application or the use of an alternative metric. In the absence of a Commission decision to use an alternative metric, the use of the CYER metric continues*."

4.2 ISBM Performance Evaluation for 2021

Implementation of the newly revised PST Agreement began with fishing year 2019. Attachment I identifies CYER limits applicable to ISBM obligations for 31 stocks. Of those, 15 do not have management objectives so the CYER limit automatically applies to this subset of stocks as per paragraph 5(d). The remaining 16 stocks have management objectives[5] and for these stocks, the annual CYER limit only applies when the management objective is not met (Table 4.1).

The CTC evaluated whether management objectives were achieved for the 16 stocks in Attachment I with identified management objectives (CTC 2021f, Table 2.1). In 2021 five stocks did not achieve their management objectives (Atnarko, Harrison, Skagit Summer/Fall, Grays Harbor Fall, and Siuslaw), so CYER limits apply to them for both Canadian and U.S. ISBM fisheries, where applicable.

[5] Attachment I of the 2019 PST Agreement has a total of 38 stocks of which 31 are subject to ISBM obligations. There are currently 22 with management objectives and 16 of those are subject to ISBM obligations.

4.2.1 Canadian ISBM Fisheries Performance

There are 17 Attachment I indicator stocks subject to Canadian ISBM fisheries performance evaluation. Of those, 11 stocks do not have management objectives listed in Attachment I and exploitation rate indicators for two stocks (Chilcotin and Chilko) are currently under development and cannot be evaluated; therefore, CYER limits apply to nine of the 11 stocks without management objectives. For Canadian ISBM obligations, there are six stocks with management objectives listed in Attachment I and CYER limits apply when these management objectives are not met. In 2021, Atnarko, Harrison, and Skagit Summer/Fall had escapements below their management objectives. For 2021, CYER limits apply to 12 stocks —the three stocks that did not meet their 2021 management objectives and the nine stocks without management objectives for which CYERs can be evaluated (Table 4.3).

Annual Canadian ISBM obligations were met for 11 of the 15 stocks that could be evaluated; three met their management objectives and thus had no applicable CYER limits (Cowichan, Lower Shuswap, and Skagit Spring), one did not meet its management objective but had a CYER below its limit (Atnarko), and 7 had no management objectives but had CYERs below their limits. Annual CYER obligations were not met for four stocks—East Coast Vancouver Island North, Phillips, Harrison, and Skagit Summer/Fall.

Table 4.3—Review of annual performance in the Canadian individual stock-based management (ISBM) fisheries, 2021.

Note: Grey shaded cells indicate that the calendar year exploitation rate (CYER) qualifies for inclusion in the running 3-year average (3YA) per paragraph 7(c). Green/red shaded cells indicate whether annual CYER obligations were met for a particular stock. NA = No or insufficient data available.

Escapement Indicator	Mgmt. Obj.	2021 Escape-ment	Mgmt. Obj. Met?	CYER Limit	2021 CYER	Annual CYER Obligation Met?
Skeena	TBD	20,097		0.146	0.040	Yes
Atnarko	5,009	4,779	No	0.274	0.185	Yes
NWVI Natural Aggregate	TBD	2,171		0.085	0.063	Yes
SWVI Natural Aggregate	TBD	536		0.085	0.063	Yes
East Coast Vancouver Island North	TBD	NA		0.150	0.203	No
Phillips	TBD	2,202		0.101	0.145	No
Cowichan	6,500	12,902	Yes	0.380	0.269	Yes
Nicola	TBD	4,010		0.164	0.052	Yes
Chilcotin				NA	NA	NA
Chilko				NA	NA	NA
Lower Shuswap	12,300	29,507	Yes	0.199	0.128	Yes
Harrison	75,100	36,449	No	0.101	0.164	No
Nooksack Spring	TBD	NA		0.130	0.038	Yes
Skagit Spring	690	1,602	Yes	0.070	0.096	Yes
Skagit Summer/Fall	9,202	9,177	No	0.082	0.104	No
Stillaguamish	TBD	555		0.110	0.075	Yes
Snohomish	TBD	2,999		0.077	0.077	Yes

For the running 3YA specified in paragraph 7(c) of the 2019 PST Agreement, Canadian ISBM obligations were met for 10 of the 12 stocks that could be evaluated; the 3YA for EVIN and Harrison exceeded their limit by more than 10% (limit + 10% of the limit). Per the provisions of the 2019 PST Agreement this exceedance stipulates further action, as identified in Chapter 3, subparagraphs 7(c)(i) and 7(c)(ii).

Table 4.4—Review of performance in the Canadian individual stock-based management (ISBM) fisheries relative to three-year average (3YA) calendar year exploitation rates (CYERs), as specified in paragraph 7(c) in Chapter 3 of the 2019 Pacific Salmon Treaty Agreement.

Note: Green/red shaded cells indicate whether 3YA CYER obligations were met for a particular stock. NA = No or insufficient data available.

Escapement Indicator	Years Included in 3YA	CYER 3YA	CYER Limit	Paragraph 7(c) Obligation Met?
Skeena	2019, 2020, 2021	0.096	0.146	Yes
Atnarko	2019, 2020, 2021	0.253	0.274	Yes
NWVI Natural	2019, 2020, 2021	0.071	0.085	Yes
SWVI Natural	2019, 2020, 2021	0.071	0.085	Yes
EVIN	2019, 2020, 2021	0.189	0.150	No
Phillips	2019, 2020, 2021	0.088	0.101	Yes
Cowichan	2020, 2021	NA	0.380	NA
Nicola	2019, 2020, 2021	0.116	0.164	Yes
Chilcotin	NA	NA	NA	NA
Chilko	NA	NA	NA	NA
Lower Shuswap	2019, 2020, 2021	0.144	0.199	Yes
Harrison	2019, 2020, 2021	0.172	0.101	No
Nooksack Spring	2019, 2020, 2021	0.092	0.130	Yes
Skagit Spring	2019	NA	0.070	NA
Skagit Sum/Fall	2019, 2021	NA	0.082	NA
Stillaguamish	2019, 2020, 2021	0.092	0.110	Yes
Snohomish	2019, 2020, 2021	0.078	0.077	Yes

4.2.2 U.S. ISBM Fishery Performance

There are 22 Attachment I indicator stocks, including three of Canadian origin, that are subject to U.S. ISBM fisheries performance evaluation. Of the 22 Attachment I indicator stocks, eight stocks do not have management objectives listed in Attachment I, and therefore, CYER limits apply to them. The remaining 14 stocks have PSC agreed management objectives and annual CYER limits only apply when these management objectives are not met. In 2021, four of these 14 stocks were below their management objectives (Harrison, Skagit Summer/Fall, Grays Harbor Fall, and Siuslaw). For 2021, CYER limits apply to twelve stocks—four stocks that did not meet their management objectives and eight stocks without management objectives (Table 4.4).

For 2021, annual U.S. ISBM obligations were met for 16 of the 22 stocks listed in Attachment I; 10 that met their management objectives and thus had no applicable annual CYER limits, and six that had CYERs below the Attachment I limits. Treaty obligations were not met for six stocks—Harrison, Nooksack Spring, Skagit Summer/Fall, Stillaguamish, Snohomish, and Siuslaw.

Table 4.5—Review of annual performance in the United States individual stock-based management (ISBM) fisheries, 2021.

Note: Grey shaded cells indicate that the calendar year exploitation rate (CYER) qualifies for inclusion in the running 3-year average (3YA) per paragraph 7(c). Green/red shaded cells indicate whether annual CYER obligations were met for a particular stock.

Escapement Indicator	Mgmt. Obj.	2021 Escape-ment	Mgmt. Obj. Met?	CYER Limit	2021 CYER	Annual CYER Obligation Met?
Cowichan	6,500	12,902	Yes	0.103	0.033	Yes
Nicola	TBD	4,010		0.039	0.010	Yes
Harrison	75,100	36,449	No	0.073	0.113	No
Nooksack Spring	TBD	NA		0.103	0.149	No
Skagit Spring	690	1,602	Yes	0.254	0.276	Yes
Skagit Summer/Fall	9,202	9,177	No	0.164	0.276	No
Stillaguamish	TBD	555		0.168	0.229	No
Snohomish	TBD	2,999		0.185	0.275	No
Hoko	TBD	868		0.100	0.010	Yes
Grays Harbor Fall	13,326	13,207	No	0.160	0.075	Yes
Queets Fall	2,500	3,187	Yes	0.142	0.184	Yes
Quillayute Fall	3,000	5,568	Yes	0.214	0.077	Yes
Hoh Fall	1,200	2,622	Yes	0.154	0.133	Yes
Upriver Brights (URB)[1]	40,000	117,493	Yes	0.228	0.163	Yes
Upriver Brights (HAN)[1]				0.249	0.176	Yes
Lewis River Fall	5,700	12,430	Yes	0.195	0.074	Yes
Coweeman	TBD	669		0.206	0.153	Yes
Mid-Columbia Summers	12,143	52,076	Yes	0.263	0.263	Yes
Nehalem	6,989	7,067	Yes	0.131	0.181	Yes
Siletz	2,944	3,668	Yes	0.173	0.251	Yes
Siuslaw	12,925	5,565	No	0.204	0.269	No
South Umpqua	TBD	3,447		0.268	0.243	Yes
Coquille	TBD	371		0.224	0.079	Yes

[1]Attachment I to Chapter 3 of the 2019 PST Agreement identifies two exploitation rate indicator stocks to represent the Upriver Bright escapement indicator stock (URB, HAN). In the event the Upriver Bright management objective is not met in a given year, the URB CYER will be used to assess U.S. ISBM fishery performance.

For the running three-year average (3YA) as specified in Paragraph 7(c) of the PST Agreement, U.S. ISBM obligations were met for 15 of the 16 stocks that could be evaluated; only the 3YA for Nooksack Spring exceeded the CYER limit by more than the 10% buffer (limit + 10% of the limit)

Per the provisions of the 2019 PST Agreement this exceedance stipulates further action, as identified in Chapter 3, subparagraphs 7(c)(i) and 7(c)(ii).

Table 4.6—Review of performance in the United States individual stock-based management (ISBM) fisheries relative to three-year average (3YA) calendar year exploitation rates (CYERs), as specified in paragraph 7(c) in Chapter 3 of the 2019 Pacific Salmon Treaty Agreement.

Note: Green/red shaded cells indicate whether 3YA CYER obligations were met for a particular stock. NA = No or insufficient data available.

Escapement Indicator	Years Included in 3YA	CYER 3YA	CYER Limit	Paragraph 7(c) Obligation Met?
Cowichan	2019, 2020, 2021	0.043	0.103	Yes
Nicola	2019, 2020, 2021	0.015	0.039	Yes
Harrison	2019, 2020, 2021	0.073	0.073	Yes
Nooksack Spring	2019, 2020, 2021	0.166	0.103	No
Skagit Spring	2020	NA	0.254	NA
Skagit Sum/Fall	2019, 2020, 2021	0.153	0.164	Yes
Stillaguamish	2019, 2020, 2021	0.184	0.168	Yes
Snohomish	2019, 2020, 2021	0.159	0.185	Yes
Hoko	2019, 2020, 2021	0.043	0.100	Yes
Grays Harbor	2019, 2020, 2021	0.095	0.160	Yes
Queets	NA	NA	0.142	NA
Quillayute	2019, 2020, 2021	0.105	0.214	Yes
Hoh	2021	NA	0.154	NA
Upriver Brights (URB)	2019, 2020, 2021	0.168	0.228	Yes
Upriver Brights (HAN)	2019, 2020, 2021	0.120	0.249	Yes
Lewis	2019, 2020, 2021	0.062	0.195	Yes
Coweeman	2019, 2020, 2021	0.119	0.206	Yes
Mid-Columbia Summers	2019, 2020	NA	0.263	NA
Nehalem	2019, 2020	NA	0.131	NA
Siletz	2020	NA	0.173	NA
Siuslaw	2019, 2021	NA	0.204	NA
South Umpqua	2019, 2020, 2021	0.289	0.268	Yes
Coquille	2019, 2020, 2021	0.223	0.224	Yes

5. Coded-Wire Tag Analysis and Mark-Selective Fisheries

Chinook salmon released from Puget Sound hatcheries and spring-run hatchery Chinook salmon in the Columbia River have been mass marked since BY 1998. Mass marking of Columbia River Fall Chinook salmon started with BY 2005, and for BY 2009 onwards most of the Chinook salmon production intended for harvest released in Washington and Oregon has been mass marked (SFEC 2009). Mark-selective fisheries have been in place on the Columbia River since 2001, in Puget Sound (including U.S. Strait of Juan de Fuca) since 2003, in some terminal fishing areas along the Oregon coast between 2002 and 2018 and Washington coast since 2006, and in BC Strait of Juan de Fuca since 2008. Additionally, small mark-selective Chinook salmon fisheries occurred in the ocean sport fishery off the Washington Coast (Areas 1–4) between 2010 and 2015 and in the Alaska troll fishery (during periods that would have otherwise been non-retention) during 2016 and 2017.

5.1 Catch in Mark-Selective Fisheries

Regulations for MSFs allow for the retention of salmon missing a fin (i.e., fish that are marked; usually the adipose fin is clipped to identify marked hatchery fish) and require the release of fish with an intact adipose fin (i.e., fish that are unmarked). As a consequence, exploitation rates from MSFs are different between marked and unmarked Chinook salmon. The benefits of MSF regulations to reduce impacts on unmarked (e.g., natural) stocks relative to a non-selective fishery of equivalent effort depend on the proportion of the total number of fish available to the fishery that are marked (though not necessarily tagged).

Coded-wire tag analysis based on recoveries of marked and tagged Chinook salmon will only reflect the exploitation on the marked fish in an MSF. Because unmarked fish are not retained, and their CWTs not recovered, the exploitation rate of this group must be inferred using other analytical techniques. One method of estimating exploitation rates on unmarked fish is to express it as a function of the release mortality (RM) rate and encounter events of adipose fin clipped CWT fish in an MSF. As a stock is exposed to more MSFs, the difference in exploitation rate between marked and unmarked fish increases, and CWT analysis of marked Chinook salmon recoveries will likely overestimate the exploitation rate on the unmarked fish. Consequently, the assumption that marked and tagged hatchery fish can properly represent the exploitation rate on associated natural stocks has an increasing amount of error as the MSF exploitation rate increases on marked fish. Differences in return-to-escapement proportions between marked and unmarked components of a double index tag (DIT) release group can be tested for significance for stocks susceptible to all MSFs in aggregate.

Details on proposed MSFs for 2021 can be found in the 2021 SFEC Annual Report (SFEC 2021). Information on whether the proposed fishery was fished or not can be found in the following year's SFEC Annual Report (SFEC 2022). Here, we summarize the extent of the MSFs on Chinook salmon in areas governed by the PST.

As mass marking of hatchery production increased in Washington and Oregon, so did the gradual implementation of MSFs. Implementation of MSF regulations began in 2001 on the Columbia River. Landed catch in sport fisheries during the spring run migration period are now almost entirely under MSF regulations, with a lower proportion during the summer and fall run migrations (Figure 5.1). In 2012, the first fall period MSF occurred in the mainstem Columbia River sport fishery, although MSFs occurred in the tributaries prior to 2012. MSFs have gradually increased during the summer/fall fisheries on the Columbia River, though the majority of the catches still occur under non-selective regulations.

Puget Sound sport fisheries (including U.S. Strait of Juan de Fuca) began implementing MSF regulations in 2003. Since then, the landed catch under MSF regulations has increased to equal nearly all the total landed catch of Chinook salmon in Puget Sound marine sport fisheries and a majority in freshwater fisheries (Figure 5.2).

In Oregon, a Chinook salmon MSF restriction occurred within the 15-fathom curve off of Tillamook Bay from March through July. There were concurrent non-selective Chinook salmon seasons open in adjacent ocean waters that allowed vessels to fish both areas on the same trip as long as no unmarked Chinook were retained or in possession while gear was deployed within the restricted area. The sport MSF in this area began in 2002 and the commercial MSF began in 2011. These limitations ended after 2018. At time of landing, catch from both the mark-selective “Tillamook bubble” fishery and the nonselective fishery outside of the bubble is combined. Therefore, although numbers of landed catch and released Chinook are recorded, they cannot be assigned specifically to the individual MSFs occurring within the bubble.

In Canada, the Strait of Juan de Fuca MSF has occurred from about the beginning of March to mid-June since 2008, with MSF regulations extending into July since 2020. Waters included in this fishery are those near Victoria, including Pacific Fishery Management Area (PFMA) Subareas 19–1 to 19–4 (excluding 19-2 since 2016) and 20–4 to 20–7. Typically, the regulations in this MSF allow retention of both marked and unmarked Chinook between 45 and 67 cm in length, but only marked fish over 67 cm (with a minimum size limit of 45 cm). Retained catches (2008-2022) in this fishery have ranged from 98 to 3,769 marked fish and 0 to 3,612 unmarked fish. Strait of Georgia, Queen Charlotte and Johnstone Straits (portions of Areas 13 to 17) had MSFs allowing the retention of both marked and unmarked Chinook, with a maximum 80 cm size limit for unmarked Chinook from 2020–2022, with no maximum size limit on hatchery marked Chinook. The minimum size for all Chinook in Area 12 (excluding Subarea 12–14) was 62 cm in 2021 and 2022. These management measures were implemented for the protection of spring and summer run Fraser Chinook.

Beginning in 2010 and continuing through 2015, small-scale MSF fisheries for Chinook salmon on the Washington and Oregon coast (north of Cape Falcon, Oregon) occurred prior to the traditional summer period sport fishery. These 2-week sport MSFs north of Cape Falcon have started as early as May 30 and as late as June 18. From 2010–2015, landed catch was highest in 2012, with 7,382 hatchery Chinook salmon landed in Washington, and 290 landed in Oregon. Catch was lowest in 2015, with 1,135 hatchery Chinook salmon landed in Washington, and 36 landed in Oregon. In Washington, the number of released Chinook ranged from a low of 1,361 in 2015 to a high of 7,852 in 2012. In Oregon, the number of released Chinook ranged from a low of 11 in 2015 to a high of 1,039 in 2011. No Washington or Oregon coastal mark-selective Chinook fisheries have occurred north of Cape Falcon since 2015.

Alaska held its first experimental Chinook MSF in a coho-directed troll fishery from September 4–30, 2016. During this fishery, 457 marked Chinook salmon were retained. In 2017, Alaska conducted a second experimental MSF from July 5–21, also occurring during a coho-directed troll fishery. In 2017, 2,680 marked Chinook salmon were retained. No MSFs have occurred in Alaska since 2017.

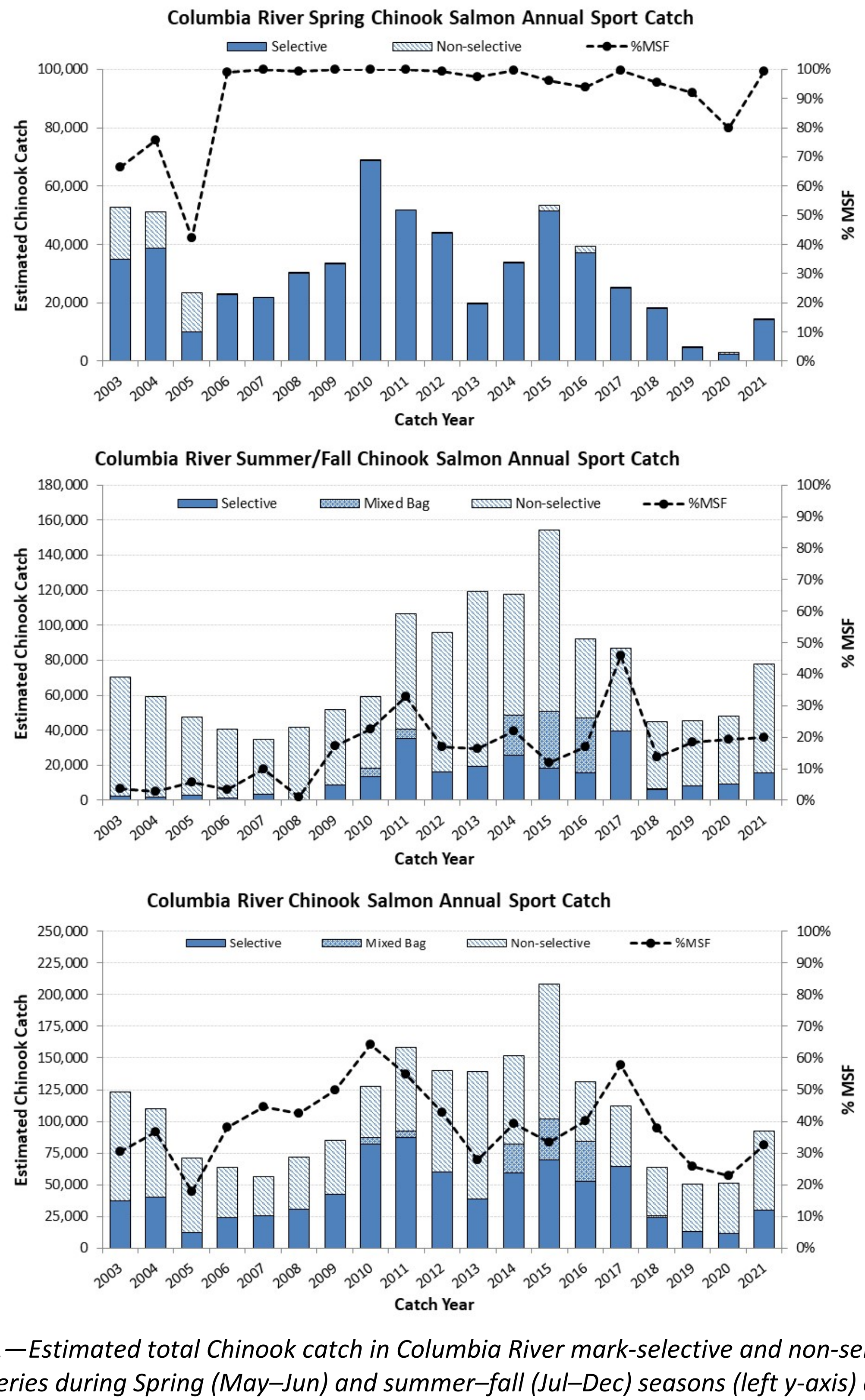

Figure 5.1—Estimated total Chinook catch in Columbia River mark-selective and non-selective sport fisheries during Spring (May–Jun) and summer–fall (Jul–Dec) seasons (left y-axis) and percent of catch in mark-selective fisheries (MSFs) (right y-axis) for catch years 2003–2021.

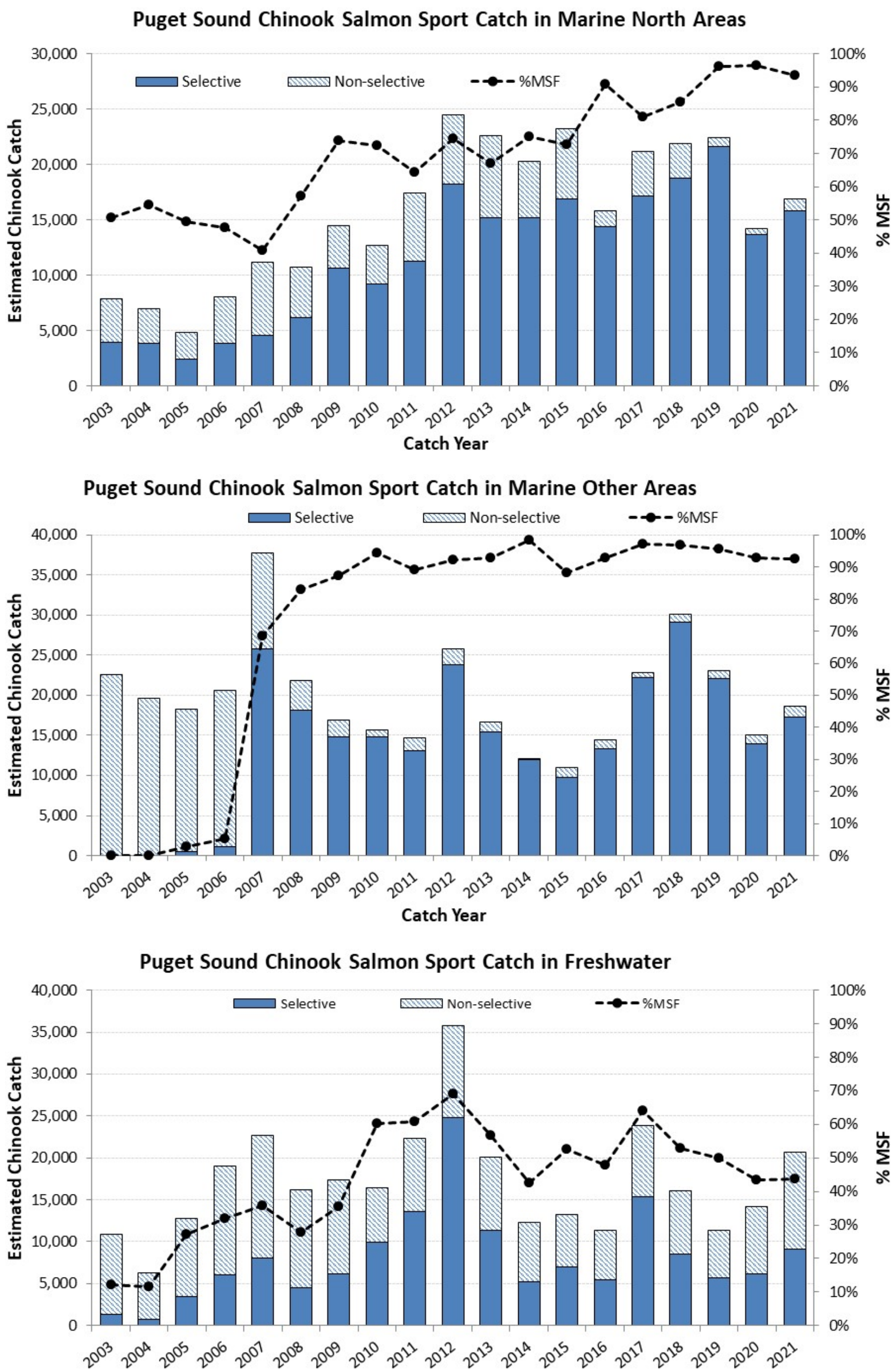

Figure 5.2—Estimated total Chinook catch in mark-selective and non-selective Puget Sound sport fisheries (left y-axis) and percent of catch in mark-selective fisheries (MSFs) (right y-axis) for catch years 2003–2021.

As an alternative to pure MSFs, some agencies have implemented “mixed” bag limit regulations whereby different proportions of marked to unmarked fish are allowed in the landed catch. In the most common configuration, mixed bag limits allow no more than 1 unmarked fish to be retained as part of the total bag limit. Since 2006, mixed bag MSFs have occurred in some terminal fishing areas along the Oregon and Washington coasts and in the BC portion of the Strait of Juan de Fuca. In 2011 and 2013, sport fisheries in the upper Columbia River for summer Chinook salmon were implemented under mixed-bag limit regulations. In recent years, Canada has implemented a variation of mixed bag limits in the marine areas around the southern tip of Vancouver Island by allowing only hatchery-marked fish to be retained above a certain fork length measurement. The benefits of reduced exploitation on unmarked (e.g., natural) stocks is usually minor (e.g., Figure 5.3) for mixed bag limit fisheries but mixed bag limits do allow for additional retention of hatchery origin fish (R. Houtman, personal communication, August 16, 2021).

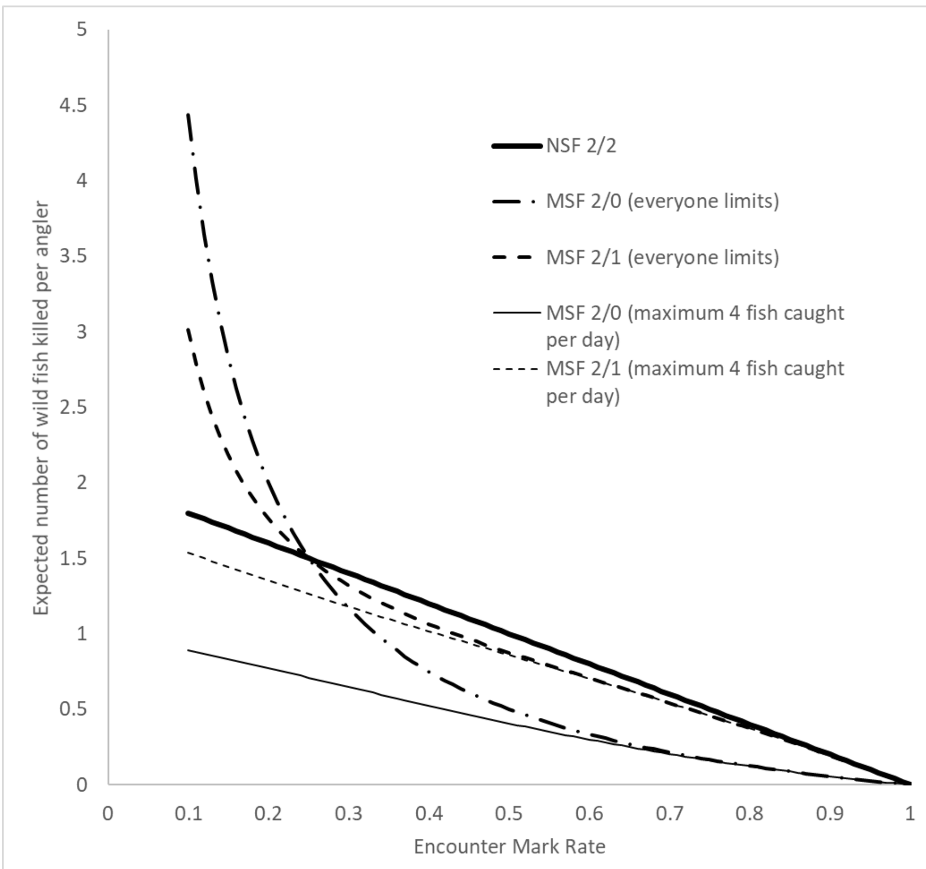

Figure 5.3—Average number of wild fish killed under alternative mark-selective fishery (MSF) regulations, with release mortality rate equal to 0.25.

Note: Regulation notations show total Chinook daily bag limits / total daily limit of wild Chinook (i.e., unmarked). For example, a notation of 2/1 means fishers can retain up to 2 Chinook of which a maximum of 1 can be unmarked. Lines described as “limit out” are for cases when fishers keep fishing until their bag limit is reached. Lines described as “max 4 fish” are for cases where fishers encounter four fish maximum and end their fishing trip, regardless of meeting bag limits.

5.2 METHODS TO ESTIMATE THE IMPACT OF MARK-SELECTIVE FISHERIES ON UNMARKED CHINOOK SALMON STOCKS

The magnitude of impact of an MSF relative to the total exploitation of a stock can be measured using the percentage of the total landed catch in net, sport, and troll fisheries of tagged and marked PSC indicator stocks that occurs in MSFs. Percentages were calculated for the PSC indicator stocks (Table 5.1) by summarizing CWT recovery records obtained through a query of the Regional Mark Information System (RMIS) database according to three code values present in the 'adclip_selective_fishery' data field – "N" for recoveries caught under non-selective fishery regulations, "S" for recoveries caught under MSF regulations, and "M" for recoveries caught under mixed-bag regulations. Use of the 'adclip_selective_fishery' recovery field was the only feasible means of calculating the percentages, however, the accuracy of this field varies regionally. For example, CWT recoveries from the BC Juan de Fuca sport fishery have all been assigned the code "N" (for non-selective) regardless of whether MSF or mixed-bag regulations were in effect when and where individual recoveries were obtained. Thus, for stocks intercepted in the BC Juan de Fuca sport fishery, the percentages presented in Table 5.1 and Figure 5.4 are likely biased low.

5.2.1 Double Index Tag Methods

PSC indicator stocks that have been double index tagged may be used to evaluate the impact of MSFs on the unmarked stocks represented by the unmarked tag group in a DIT pair. A DIT group consists of at least two tag groups, one with the mass mark (or adipose fin clip) and one without the mark. These two tag groups are treated identically except for the mark, and differences in mortality should be due to the MSFs—assuming there is no mark mortality occurring prior to recruitment to the fisheries. A comparison of the unmarked-to-marked ratio, referred to as lambda (λ), at release and at escapement can be used in a test of the null hypothesis that there is no difference in proportional return of marked and unmarked groups. A positive test statistic occurs when a statistically higher proportion of unmarked fish return to hatchery escapement; this is consistent with the larger harvest of marked fish compared to unmarked fish through MSFs. A negative test statistic occurs when an equal or higher proportion of marked fish return, which could be indicative of sampling problems in the hatchery (i.e., the sampling procedure fails to detect all CWTs from unmarked fish present in the sample), or incorrect assumptions about release mortality rates, multiple encounters, or mark recognition errors. This is a concern when patterns occur over many BYs for a stock or hatchery. If stock-specific MSF impacts are small, then random variation in the CWT sampling procedures or simply random variability in processes, like survival, could result in both positive and negative test statistics in a random pattern across broods.

Table 5.1—Estimated landed catch of tagged and marked Pacific Salmon Commission (PSC) Chinook indicator stocks in British Columbia, Washington, and Oregon, in all net, troll, and sport fisheries for catch years 2019–2021, along with averages for 2009–2018, and the percent of the total tagged and marked catch landed in mark-selective fisheries (MSFs).

Note: Data for catch years 2009–2018 can be found in CTC 2021d.

Region	Stock	2009 – 2018 Avg		2019		2020		2021	
Southeast Alaska	AK Hatcheries	2,544	0%	1,498	0%	1,717	0%	2,210	0%
	Chilkat	34	0%	12	0%	11	0%	1	0%
	Stikine	51	0%	13	0%	38	0%	17	0%
	Taku	31	0%	9	0%	19	0%	35	0%
	Unuk	69	0%	48	0%	61	0%	78	0%
	Total	**2,725**	**0%**	**1,579**	**0%**	**1,845**	**0%**	**2,340**	**0%**
British Columbia	Atnarko Summer	766	0%	797	0%	721	0%	485	0%
	Big Qualicum	309	1%	132	0%	158	0%	114	3%
	Chilliwack Fall	1,697	5%	1,809	5%	2,335	8%	2,427	9%
	Cowichan Fall	1,006	3%	671	4%	412	8%	466	2%
	Nicola River Spring	160	1%	66	13%	447	3%	47	15%
	Puntledge Summer	114	1%	37	0%	122	0%	43	13%
	Quinsam Fall	431	0%	968	0%	572	0%	869	0%
	Robertson Creek	1,900	0%	9,149	0%	7,330	0%	6,736	0%
	Lower Shuswap River Summers	1,211	1%	995	4%	1,522	1%	944	1%
	Chehalis (Harrison Fall Stock)	484	6%	463	6%	293	13%	773	13%
	Kitsumkalum Summer	146	0%	132	0%	36	0%	27	0%
	Total	**8,225**	**2%**	**15,218**	**1%**	**13,949**	**2%**	**12,932**	**3%**
North Puget Sound	Nooksack Spring Fingerling	470	5%	350	9%	497	9%	406	11%
	Samish Fall Fingerling	903	7%	472	11%	428	25%	592	11%
	Skagit Spring Fingerling	626	17%	647	15%	436	10%	797	7%
	Skagit Summer Fingerling	328	6%	294	13%	83	0%	341	17%
	Skykomish Fall Fingerling	224	27%	135	36%	101	26%	325	37%
	Stillaguamish Fall Fingerling	333	14%	454	20%	180	20%	282	29%
	Total	**2,884**	**11%**	**2,353**	**15%**	**1,724**	**15%**	**2,741**	**16%**
South Puget Sound	George Adams Fall Fingerling	1,104	23%	1,395	18%	473	56%	767	30%
	Green River Fall Fingerling	435	20%	366	51%	89	45%	221	54%
	Grovers Creek Fall Fingerling	565	30%	482	41%	237	61%	598	65%
	Nisqually Fall Fingerling	808	22%	794	25%	130	39%	585	41%
	Total	**2,912**	**24%**	**3,037**	**27%**	**928**	**54%**	**2,171**	**45%**
Washington Coast	Hoko Fall Fingerling	212	8%	313	22%	298	3%	106	0%
	Queets Fall Fingerling	1,124	0%	836	1%	668	0%	897	0%
	Tsoo-Yess Fall Fingerling	169	3%	104	11%	3	0%	37	0%
	Total	**1,505**	**2%**	**1,253**	**7%**	**969**	**1%**	**1,040**	**0%**
Columbia River	Columbia Lower River Hatchery	616	5%	299	10%	388	15%	1,041	4%
	Columbia Summers	3,969	13%	1,976	43%	2,645	25%	3,577	34%
	Cowlitz Fall Tule	162	16%	115	9%	192	8%	468	3%
	Hanford Wild	566	2%	76	0%	206	0%	217	3%
	Lewis River Wild	99	5%	63	0%	105	0%	115	0%
	Lyons Ferry	814	7%	116	0%	220	2%	309	0%
	Spring Creek Tule	2,231	3%	966	5%	1,158	4%	1,925	4%
	Upriver Brights	3,381	3%	1,158	1%	2,863	2%	4,052	0%
	Willamette Spring	3,348	67%	535	59%	807	61%	1,398	75%

Region	Stock	2009 – 2018 Avg		2019		2020		2021	
	Total	**15,186**	**20%**	**5,304**	**24%**	**8,585**	**16%**	**13,101**	**18%**
Oregon	Elk River	1,619	0%	1,302	0%	1,931	22%	1,872	21%
	Salmon River	2,914	4%	774	0%	1,146	0%	1,527	0%
	Total	**4,533**	**3%**	**2,076**	**0%**	**3,077**	**14%**	**3,399**	**11%**

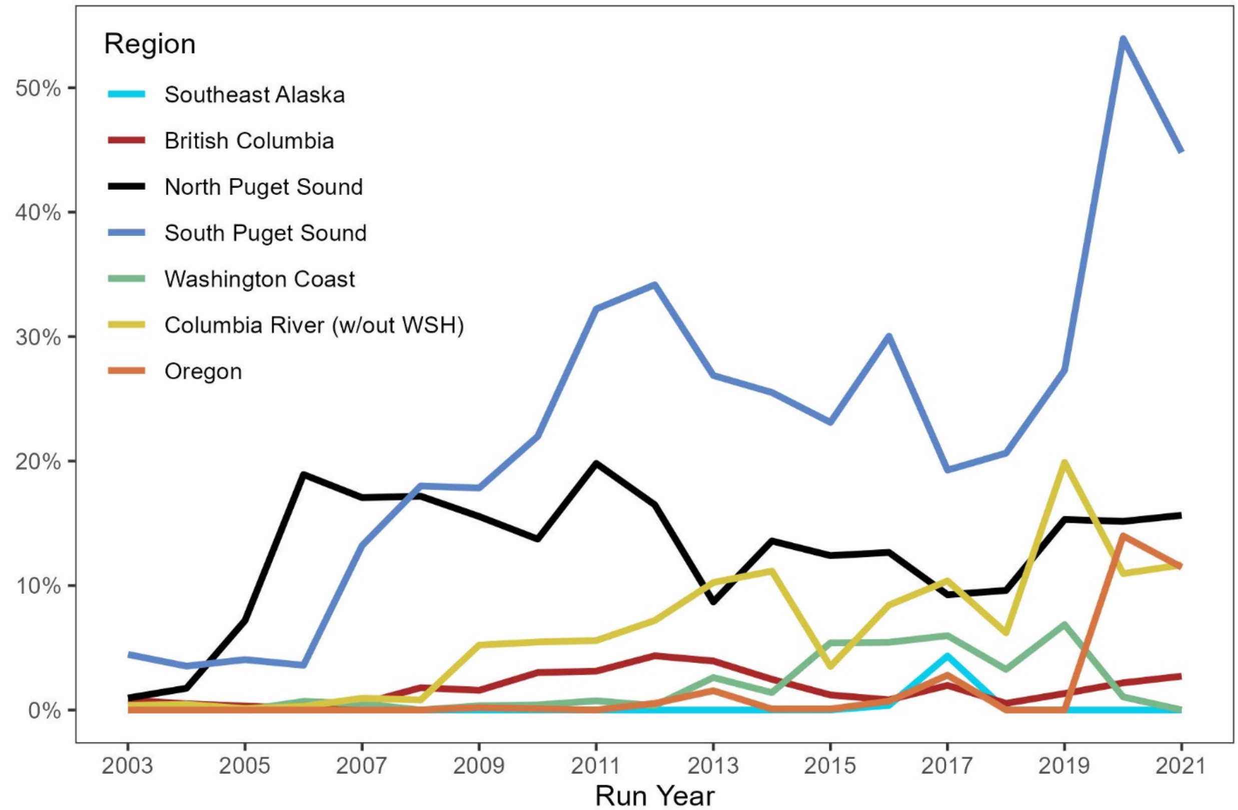

Figure 5.4—Percent of total fishery coded-wire tag (CWT) recoveries in mark-selective fisheries (MSFs) for regional groupings of Chinook indicator stocks, 2003–2021.

Note: Percentages are based off the regional mark information system (RMIS) 'adclip_selective_fishery' field and do not include recoveries in mixed-bag fisheries. The Columbia River group does not include the Willamette River Spring stock (WSH).

5.2.2 Single Index Tag Methods

Techniques to estimate reduced fishing impacts of MSFs have largely involved DIT programs. However, this is a substantial issue for many of the stocks in BC and Alaska that do not currently have DIT programs, and for locations where DIT programs proved impractical (i.e., Chilliwack, Lower Shuswap, and Cowichan). Given these circumstances, an approach was developed in 2018 (CTC 2018) to estimate mortality distributions for natural stocks that have single index tag (SIT) indicator stocks under conditions where the MSF impacts mainly occur on mature SIT fish proximal to their terminal area. The method was applied to three SIT stocks from the Fraser River (Nicola [NIC], Lower Shuswap [SHU], and Middle Shuswap [MSH]).

The approach uses SIT CWT recoveries in MSFs to represent the number of unmarked pseudo-CWT fish encountered and released in the fishery and these pseudo-CWTs are multiplied by the survival rate ($Surv_{s,f} = 1\text{-}RM_{s,f}$), where *RM* is the release mortality rate for legal-sized fish released in the fishery (e.g., 12.3% for ocean sport fisheries, Appendix F). The pseudo-CWT MSF survivors are subtracted from fishery-specific Total Mortality AEQ CWTs in the mortality distribution tables (MDT) and then added to the terminal run fisheries and escapement, since these are assumed to be mature fish that are encountered on their return migration:

$$MSF\ Survivors_{s,f,CY} = (CWT\ Recoveries_{s,f,CY} * Surv_f)$$

Equation 5.1

The estimated incidental CWT mortalities in these fisheries were not adjusted because those values represent the sum of release mortalities based on the minimum size limit and drop-off mortalities, and these impacts would be the same for marked and unmarked fish. After passage through the MSFs, the pseudo-CWT survivors were assumed to not be encountered in subsequent ocean fisheries and they were assumed to survive to the river mouth. Further analysis would be needed to represent additional mortalities due to multiple encounters in ocean fisheries. The pseudo-CWT survivors were then distributed to the terminal fisheries and escapement by using the proportions from the original MDTs, thus some of the pseudo-CWT survivors were harvested in terminal fisheries. Additional adjustments would be needed for any terminal MSFs; however, all the Fraser River terminal fisheries were NSF from 2008–2022, and for the 2002 MSF at the mouth of the Nicola River, the pseudo-CWT survivors were added to the escapement.

The MSFs in marine waters of Southern BC and Washington have occurred mainly during the period when Fraser spring and summer stocks return to the Fraser River and there have been very few CWT recoveries outside of this timeframe (CTC 2018). In comparison, the Fraser fall stocks have been encountered throughout the year in these areas and there are more frequent CWT recoveries of age 2 and 3 fish (CTC 2018; Table 5.2–Table 5.7). The differences in the CWT recovery patterns by age indicate the MSFs in these areas encounter both immature and mature fish from the Fraser fall stocks, but mainly mature fish from the Fraser spring and summer stocks. Accordingly, this approach for SIT stocks was not appropriate for or applied to the fall stocks.

The MSF CWT recoveries were identified using a different approach for U.S. fisheries than Canadian fisheries because each country identifies MSF CWT recoveries differently in the RMIS and Mark Recovery Program (MRP) databases. For U.S. fisheries, the RMIS *adclip_selective* field identified MSF CWT recoveries; however, the Canadian MSF CWT recoveries cannot be identified correctly using this field. Thus, for Canadian MSFs, the Fisheries and Oceans Canada (DFO) annual fishing plans and DFO Fishery Notices were reviewed to identify when and where MSF regulations were used. All Canadian ocean MSFs occurred in the Juan de Fuca (JDF) sport fishery since 2008, or in the Nicola River mouth sport MSF in 2002. For the Fraser spring and summer stocks, all U.S. MSF CWT recoveries occurred in sport fisheries either in Puget Sound or the North of Falcon areas.

For the Canadian JDF sport fishery, both MSF and non-selective fishery regulations were used for specific dates, fishery management subareas, and fish length categories; this necessitated the review of date, area, and fish length data for every JDF sport CWT recovery with respect to the regulations described in the DFO Fishery Notices. Some JDF sport recoveries had incomplete date, location, or fish length data. One recovery was within the time period and size range of the MSF, but the area recorded (PFMA 20) omitted the subarea, and the MSF regulations occurred only in some subareas of PFMA 20. Two CWT recoveries were recorded in PFMA 20–7 (near Sooke, an area located west of Victoria, southern Vancouver Island), which was assumed to be part of the MSF area as described by points of land identifying the MSF regulation area in the Fishery Notice although 20–7 was not one of the subareas listed in the Fishery Notice. Length was not recorded for 12 recoveries that were identifiable to the times and locations of the MSF regulations. Due to the incomplete data, these recoveries could not be accurately identified as caught in the MSF or non-selective fishery. To account for this, the data analysis proceeded with two assumptions resulting in two MDTs. First, all the incomplete data recoveries were assumed to have been caught in the MSF. Second, all these recoveries were assumed to be caught in the non-selective fishery. Reporting both sets of data provides a range of the MSF impacts and captures some of the uncertainty due to incomplete data recording. Among the CWT recoveries with dates during the MSF periods, 3 Nicola CWTs, 4 Middle Shuswap CWTs and 5 Lower Shuswap CWTs had incomplete data.

The percentages between the original MDTs (representing the marked fish) and new MDTs (representing unmarked fish) were used to estimate the reduction in fisheries impacts and increased escapement for unmarked fish (Table 5.2–Table 5.5). Mortality distribution table exploitation rates did not change for other ocean non-selective fisheries. The average adjustments were minor, 0.5% or less, to the MDTs for these stocks in the MSFs, terminal fisheries, and escapement (Table 5.8). These minor adjustments reflect the relatively small proportion of the total mortality that was measured in MSFs, similar to the findings for the analysis of several of the DIT stocks in section 5.2.1 (Table 5.3). The largest adjustments occurred when the CWT recoveries with incomplete data were assumed to have been caught in MSFs (Table 5.8).

Table 5.2—Percent distribution of Nicola River adult equivalent (AEQ) total fishing mortalities and escapement to represent unmarked fish when recoveries with incomplete data were assumed to have been caught in non-selective fisheries.

Note: Troll, Net, and Sport (T,N,S) were combined for Southeast Alaska (SEAK), Northern British Columbia (NBC), and West Cost Vancouver Island (WCVI) aggregate abundance-based management (AABM) fisheries; S Falcon individual stock-based management (ISBM) fishery; and SEAK and Southern U.S. Terminal. The green shading identifies the calendar year exploitation rate (CYER) values where mark-selective fisheries (MSFs) did not change from the original mortality distribution tables (MDTs) for the marked stock and the yellow shading identifies revised CYERs.

			AABM Fishery			ISBM Fishery										Terminal Fishery				Escapement	
	Est		SEAK	NBC	WCVI	NBC & CBC	Southern BC			N Falcon		S Falcon	WAC	Puget Sd		SEAK	Canada		US South		
Catch Year	# of CWT	Ages	T,N,S	T,S	T,S	T,N,S	T	N	S	T	S	T & S	N	N	S	T,N,S	N	S	T,N,S	Stray	Esc.
2002	2319	3,4,5,6	0.0	1.8	0.6	0.2	0.0	0.0	1.1	0.7	0.2	0.1	0.0	0.0	0.0	0.0	4.0	0.6	0.0	0.0	90.6
2008	624	3,4,5,6	0.0	2.1	0.0	0.0	0.0	0.0	4.0	2.2	0.3	0.0	0.0	0.0	0.0	0.0	11.4	3.5	0.5	0.0	76.0
2009	293	3,4,5,6	0.0	0.3	0.0	0.0	0.0	0.0	8.2	3.4	0.0	0.0	0.0	0.0	2.8	0.0	19.0	20.4	0.0	0.0	45.9
2010	2328	3,4,5,6	0.4	1.7	0.1	0.0	0.0	0.0	1.8	0.8	0.0	0.0	0.0	0.0	0.2	0.0	4.6	0.0	0.0	0.0	90.5
2011	683	3,4,5,6	0.0	0.9	0.4	0.0	0.0	0.4	4.4	2.0	0.3	0.0	0.0	0.0	1.5	0.0	3.8	2.5	0.0	0.0	83.7
2012	722	3,4,5,6	0.0	1.4	0.0	0.0	0.0	0.6	4.0	8.2	0.0	0.6	0.0	0.0	0.0	0.0	17.2	0.8	0.0	0.0	67.3
2013	1466	3,4,5,6	0.0	1.2	0.2	0.2	0.0	0.5	4.6	3.3	0.3	0.0	0.0	0.0	1.0	0.0	1.6	0.0	0.0	0.0	87.0
2014	436	3,4,5,6	0.0	0.0	2.1	0.0	0.0	1.6	0.9	1.6	0.0	0.0	0.0	0.0	0.0	0.0	9.2	0.9	0.0	0.0	83.7
2015	1549	3,4,5,6	0.0	0.5	0.3	0.0	0.0	0.9	3.1	0.9	0.2	0.0	0.0	0.2	0.6	0.0	10.0	0.0	0.0	0.0	83.4
2016	975	3,4,5,6	0.2	1.7	1.0	0.0	0.0	0.7	10.3	1.0	0.0	0.0	0.0	0.0	0.0	0.0	10.1	0.0	0.0	0.0	75.0
2017	1085	3,4,5,6	0.0	0.9	1.2	0.0	0.0	0.2	2.5	1.8	0.0	0.0	0.0	0.0	0.0	0.0	7.7	0.0	0.0	0.0	85.6
2018	1371	3,4,5,6	0.0	0.2	0.7	0.0	0.0	0.8	2.1	1.0	0.0	0.0	0.0	0.1	0.3	0.0	11.6	0.0	0.0	0.0	83.2
2019	2057	3,4,5,6	0.0	0.0	0.0	0.0	0.0	0.3	0.6	0.7	0.5	0.0	0.0	0.0	0.3	0.0	1.2	0.0	0.0	0.0	96.3
2020	2017	3,4,5,6	0.0	0.0	0.0	0.0	0.0	0.9	0.8	0.2	0.1	0.0	0.0	0.0	0.8	0.0	23.3	2.6	0.0	0.0	71.2
2021	3144	3,4,5,6	0.0	0.0	0.0	0.0	0.0	0.7	0.4	0.1	0.3	0.0	0.0	0.0	0.4	0.0	4.0	0.0	0.0	0.0	94.0
2022	3978	3,4,5,6	0.0	0.1	0.0	0.0	0.0	0.3	0.2	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.8	0.2	0.0	0.0	98.0
09–18	1091	0	0.1	0.9	0.6	0.0	0.0	0.6	4.2	2.4	0.1	0.1	0.0	0.0	0.6	0.0	9.5	2.5	0.0	0.0	78.5
19–22	2799	0	0.0	0.0	0.0	0.0	0.0	0.6	0.5	0.2	0.3	0.0	0.0	0.0	0.4	0.0	7.4	0.7	0.0	0.0	89.9

Table 5.3—Percent distribution of Nicola River adult equivalent (AEQ) total fishing mortalities and escapement to represent unmarked fish when recoveries with incomplete data were assumed to have been caught in mark-selective fisheries (MSFs).

Note: Troll, Net, and Sport (T,N,S) were combined for Southeast Alaska (SEAK), Northern British Columbia (NBC), and West Cost Vancouver Island (WCVI) aggregate abundance-based management (AABM) fisheries; S Falcon individual stock-based management (ISBM) fishery; and SEAK and Southern U.S. Terminal. The green shading identifies the calendar year exploitation rate (CYER) values where mark-selective fisheries (MSFs) did not change from the original mortality distribution tables (MDTs) for the marked stock and the yellow shading identifies revised CYERs.

			AABM Fishery			ISBM Fishery										Terminal Fishery				Escapement	
Catch	Est # of		SEAK	NBC	WCVI	NBC & CBC	Southern BC			N Falcon		S Falcon	WAC	Puget Sd		SEAK	Canada		US South		
Year	CWT	Ages	T,N,S	T,S	T,S	T,N,S	T	N	S	T	S	T & S	N	N	S	T,N,S	N	S	T,N,S	Stray	Esc.
2002	2319	3,4,5,6	0.0	1.8	0.6	0.2	0.0	0.0	1.1	0.7	0.2	0.1	0.0	0.0	0.0	0.0	4.0	0.6	0.0	0.0	90.6
2008	624	3,4,5,6	0.0	2.1	0.0	0.0	0.0	0.0	4.0	2.2	0.3	0.0	0.0	0.0	0.0	0.0	11.4	3.5	0.5	0.0	76.0
2009	293	3,4,5,6	0.0	0.3	0.0	0.0	0.0	0.0	8.2	3.4	0.0	0.0	0.0	0.0	2.8	0.0	19.0	20.4	0.0	0.0	45.9
2010	2328	3,4,5,6	0.4	1.7	0.1	0.0	0.0	0.0	1.5	0.8	0.0	0.0	0.0	0.0	0.2	0.0	4.6	0.0	0.0	0.0	90.7
2011	683	3,4,5,6	0.0	0.9	0.4	0.0	0.0	0.4	4.4	2.0	0.3	0.0	0.0	0.0	1.5	0.0	3.8	2.5	0.0	0.0	83.7
2012	722	3,4,5,6	0.0	1.4	0.0	0.0	0.0	0.6	4.0	8.2	0.0	0.6	0.0	0.0	0.0	0.0	17.2	0.8	0.0	0.0	67.3
2013	1466	3,4,5,6	0.0	1.2	0.2	0.2	0.0	0.5	3.9	3.3	0.3	0.0	0.0	0.0	1.0	0.0	1.6	0.0	0.0	0.0	87.7
2014	436	3,4,5,6	0.0	0.0	2.1	0.0	0.0	1.6	0.9	1.6	0.0	0.0	0.0	0.0	0.0	0.0	9.2	0.9	0.0	0.0	83.7
2015	1549	3,4,5,6	0.0	0.5	0.3	0.0	0.0	0.9	3.1	0.9	0.2	0.0	0.0	0.2	0.6	0.0	10.0	0.0	0.0	0.0	83.4
2016	975	3,4,5,6	0.2	1.7	1.0	0.0	0.0	0.7	9.2	1.0	0.0	0.0	0.0	0.0	0.0	0.0	10.2	0.0	0.0	0.0	75.9
2017	1085	3,4,5,6	0.0	0.9	1.2	0.0	0.0	0.2	2.5	1.8	0.0	0.0	0.0	0.0	0.0	0.0	7.7	0.0	0.0	0.0	85.6
2018	1371	3,4,5,6	0.0	0.2	0.7	0.0	0.0	0.8	2.1	1.0	0.0	0.0	0.0	0.1	0.3	0.0	11.6	0.0	0.0	0.0	83.2
2019	2057	3,4,5,6	0.0	0.0	0.0	0.0	0.0	0.3	0.6	0.7	0.5	0.0	0.0	0.0	0.3	0.0	1.2	0.0	0.0	0.0	96.3
2020	2017	3,4,5,6	0.0	0.0	0.0	0.0	0.0	0.9	0.8	0.2	0.1	0.0	0.0	0.0	0.8	0.0	23.3	2.6	0.0	0.0	71.2
2021	3144	3,4,5,6	0.0	0.0	0.0	0.0	0.0	0.7	0.4	0.1	0.3	0.0	0.0	0.0	0.4	0.0	4.0	0.0	0.0	0.0	94.0
2022	3978	3,4,5,6	0.0	0.1	0.0	0.0	0.0	0.3	0.2	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.8	0.2	0.0	0.0	98.0
09–18	1091	0	0.1	0.9	0.6	0.0	0.0	0.6	4.0	2.4	0.1	0.1	0.0	0.0	0.6	0.0	9.5	2.5	0.0	0.0	78.7
19–22	2799	0	0.0	0.0	0.0	0.0	0.0	0.6	0.5	0.2	0.3	0.0	0.0	0.0	0.4	0.0	7.4	0.7	0.0	0.0	89.9

Table 5.4—Percent distribution of Lower Shuswap River adult equivalent (AEQ) total fishing mortalities and escapement to represent unmarked fish when recoveries with incomplete data were assumed to have been caught in non-selective fisheries.

Note: Troll, Net, and Sport (T,N,S) were combined for Southeast Alaska (SEAK), Northern British Columbia (NBC), and West Cost Vancouver Island (WCVI) aggregate abundance-based management (AABM) fisheries; S Falcon individual stock-based management (ISBM) fishery; and SEAK and Southern U.S. Terminal. The green shading identifies the calendar year exploitation rate (CYER) values where mark-selective fisheries (MSFs) did not change from the original mortality distribution tables (MDTs) for the marked stock and the yellow shading identifies revised CYERs.

			AABM Fishery			ISBM Fishery										Terminal Fishery				Escapement	
	Est		SEAK	NBC	WCVI	NBC & CBC	Southern BC			N Falcon		S Falcon	WAC	Puget Sd		SEAK	Canada		US South		
Catch Year	# of CWT	Ages	T,N,S	T,S	T,S	T,N,S	T	N	S	T	S	T & S	N	N	S	T,N,S	N	S	T,N,S	Stray	Esc.
2008	1771	2,3,4,5	9.4	15.8	1.6	0.0	0.0	0.0	7.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9	3.0	0.0	0.0	60.1
2009	1691	2,3,4,5	10.5	9.8	3.1	0.6	0.0	0.0	8.9	0.1	0.0	0.0	0.0	0.0	0.1	0.0	10.0	6.2	0.0	0.2	50.5
2010	2026	2,3,4,5	11.4	13.6	0.5	0.3	0.0	0.0	9.1	0.2	0.1	0.1	0.0	1.2	0.0	0.0	9.5	1.9	0.3	1.2	50.7
2011	1852	2,3,4,5	10.0	12.1	2.0	0.0	0.0	1.2	8.2	0.5	0.0	0.0	0.0	0.3	0.3	0.0	9.3	2.9	0.0	0.1	53.2
2012	1945	2,3,4,5	9.4	11.9	2.3	0.8	0.0	0.4	9.9	0.2	0.1	0.2	0.0	0.1	1.9	0.0	4.5	5.0	0.0	0.0	53.4
2013	8225	2,3,4,5	8.0	11.0	1.2	0.3	0.0	1.6	10.2	0.6	0.0	0.0	0.0	0.3	0.4	0.0	2.5	2.1	0.0	0.9	60.9
2014	4670	2,3,4,5	12.1	9.8	4.9	0.2	0.0	3.0	4.9	1.9	0.4	0.1	0.0	0.5	0.5	0.0	8.1	1.8	0.0	0.9	50.8
2015	5012	2,3,4,5	7.2	5.2	1.8	0.7	0.0	0.5	8.0	2.4	0.5	0.0	0.0	0.8	0.7	0.0	2.9	3.1	0.1	1.4	64.8
2016	2153	2,3,4,5	12.1	11.7	2.8	0.6	0.0	0.4	5.8	0.3	0.0	0.0	0.0	0.0	0.0	0.0	2.6	1.9	0.3	0.0	61.6
2017	3042	2,3,4,5	14.1	11.2	3.4	0.0	0.0	0.2	10.8	0.2	0.3	0.0	0.0	0.0	0.8	0.0	2.5	1.7	0.1	0.5	54.2
2018	5089	2,3,4,5	5.1	5.9	2.8	0.1	0.0	1.4	8.9	0.2	0.2	0.0	0.0	0.5	0.6	0.0	5.0	2.6	0.0	0.2	66.6
2019	6951	2,3,4,5	3.3	1.5	0.6	1.0	0.0	0.5	4.2	0.3	0.1	0.0	0.0	0.2	0.3	0.0	3.4	2.7	0.0	0.9	80.8
2020	6850	2,3,4,5	5.4	0.5	1.1	0.0	0.0	0.9	3.1	0.0	0.1	0.0	0.0	0.0	0.1	0.0	9.2	5.4	0.0	1.1	73.1
2021	5457	2,3,4,5	5.7	1.2	1.5	1.1	0.0	0.8	2.9	0.0	0.0	0.0	0.0	0.1	0.1	0.0	5.9	3.4	0.0	3.1	74.0
2022	3185	2,3,4,5	7.2	2.6	0.5	0.6	0.0	0.9	4.4	0.6	0.0	0.0	0.0	0.0	0.0	0.0	7.1	5.3	0.0	0.7	70.1
09–18	3570	0	10.0	10.2	2.5	0.4	0.0	0.9	8.4	0.7	0.2	0.0	0.0	0.4	0.5	0.0	5.7	2.9	0.1	0.5	56.7
19–22	5611	0	5.4	1.5	0.9	0.7	0.0	0.8	3.7	0.2	0.1	0.0	0.0	0.1	0.1	0.0	6.4	4.2	0.0	1.4	74.5

Table 5.5—Percent distribution of Lower Shuswap River adult equivalent (AEQ) total fishing mortalities and escapement to represent unmarked fish when recoveries with incomplete data were assumed to have been caught in mark-selective fisheries (MSFs).

Note: Troll, Net, and Sport (T,N,S) were combined for Southeast Alaska (SEAK), Northern British Columbia (NBC), and West Cost Vancouver Island (WCVI) aggregate abundance-based management (AABM) fisheries; S Falcon individual stock-based management (ISBM) fishery; and SEAK and Southern U.S. Terminal. The green shading identifies the calendar year exploitation rate (CYER) values where mark-selective fisheries (MSFs) did not change from the original mortality distribution tables (MDTs) for the marked stock and the yellow shading identifies revised CYERs.

			AABM Fishery			ISBM Fishery											Terminal Fishery				Escapement	
	Est		SEAK	NBC	WCVI	NBC & CBC	Southern BC			N Falcon		S Falcon	WAC	Puget Sd		SEAK	Canada		US South		
Catch Year	# of CWT	Ages	T,N,S	T,S	T,S	T,N,S	T	N	S	T	S	T & S	N	N	S	T,N,S	N	S	T,N,S	Stray	Esc.
2008	1771	2,3,4,5	9.4	15.8	1.6	0.0	0.0	0.0	7.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9	3.0	0.0	0.0	60.1
2009	1691	2,3,4,5	10.5	9.8	3.1	0.6	0.0	0.0	8.9	0.1	0.0	0.0	0.0	0.0	0.1	0.0	10.0	6.2	0.0	0.2	50.5
2010	2026	2,3,4,5	11.4	13.6	0.5	0.3	0.0	0.0	8.8	0.2	0.1	0.1	0.0	1.2	0.0	0.0	9.5	1.9	0.3	1.2	50.9
2011	1852	2,3,4,5	10.0	12.1	2.0	0.0	0.0	1.2	8.2	0.5	0.0	0.0	0.0	0.3	0.3	0.0	9.3	2.9	0.0	0.1	53.2
2012	1945	2,3,4,5	9.4	11.9	2.3	0.8	0.0	0.4	9.9	0.2	0.1	0.2	0.0	0.1	1.9	0.0	4.5	5.0	0.0	0.0	53.4
2013	8225	2,3,4,5	8.0	11.0	1.2	0.3	0.0	1.6	10.2	0.6	0.0	0.0	0.0	0.3	0.4	0.0	2.5	2.1	0.0	0.9	60.9
2014	4670	2,3,4,5	12.1	9.8	4.9	0.2	0.0	3.0	4.9	1.9	0.4	0.1	0.0	0.5	0.5	0.0	8.1	1.8	0.0	0.9	50.8
2015	5012	2,3,4,5	7.2	5.2	1.8	0.7	0.0	0.5	8.0	2.4	0.5	0.0	0.0	0.8	0.7	0.0	2.9	3.1	0.1	1.4	64.8
2016	2153	2,3,4,5	12.1	11.7	2.8	0.6	0.0	0.4	5.8	0.3	0.0	0.0	0.0	0.0	0.0	0.0	2.6	1.9	0.3	0.0	61.6
2017	3042	2,3,4,5	14.1	11.2	3.4	0.0	0.0	0.2	10.5	0.2	0.3	0.0	0.0	0.0	0.8	0.0	2.5	1.7	0.1	0.5	54.5
2018	5089	2,3,4,5	5.1	5.9	2.8	0.1	0.0	1.4	8.6	0.2	0.2	0.0	0.0	0.5	0.6	0.0	5.0	2.6	0.0	0.2	66.9
2019	6951	2,3,4,5	3.3	1.5	0.6	1.0	0.0	0.5	4.2	0.3	0.1	0.0	0.0	0.2	0.3	0.0	3.4	2.7	0.0	0.9	80.8
2020	6850	2,3,4,5	5.4	0.5	1.1	0.0	0.0	0.9	3.1	0.0	0.1	0.0	0.0	0.0	0.1	0.0	9.2	5.4	0.0	1.1	73.1
2021	5457	2,3,4,5	5.7	1.2	1.5	1.1	0.0	0.8	2.9	0.0	0.0	0.0	0.0	0.1	0.1	0.0	5.9	3.4	0.0	3.1	74.0
2022	3185	2,3,4,5	7.2	2.6	0.5	0.6	0.0	0.9	4.4	0.6	0.0	0.0	0.0	0.0	0.0	0.0	7.1	5.3	0.0	0.7	70.1
09–18	3570	0	10.0	10.2	2.5	0.4	0.0	0.9	8.4	0.7	0.2	0.0	0.0	0.4	0.5	0.0	5.7	2.9	0.1	0.5	56.8
19–22	5611	0	5.4	1.5	0.9	0.7	0.0	0.8	3.7	0.2	0.1	0.0	0.0	0.1	0.1	0.0	6.4	4.2	0.0	1.4	74.5

Table 5.6—Percent distribution of Middle Shuswap River adult equivalent (AEQ) total fishing mortalities and escapement to represent unmarked fish when recoveries with incomplete data were assumed to have been caught in non-selective fisheries.

Note: Troll, Net, and Sport (T,N,S) were combined for Southeast Alaska (SEAK), Northern British Columbia (NBC), and West Cost Vancouver Island (WCVI) aggregate abundance-based management (AABM) fisheries; S Falcon individual stock-based management (ISBM) fishery; and SEAK and Southern U.S. Terminal. The green shading identifies the calendar year exploitation rate (CYER) values where mark-selective fisheries (MSFs) did not change from the original mortality distribution tables (MDTs) for the marked stock and the yellow shading identifies revised CYERs.

			AABM Fishery			ISBM Fishery										Terminal Fishery				Escapement	
	Est		SEAK	NBC	WCVI	NBC & CBC	Southern BC			N Falcon		S Falcon	WAC	Puget Sd		SEAK	Canada		US South		
Catch Year	# of CWT	Ages	T,N,S	T,S	T,S	T,N,S	T	N	S	T	S	T,S	N	N	S	T,N,S	N	S	T,N,S	Stray	Esc.
2011	58	2,3	8.6	10.3	0.0	0.0	0.0	1.7	5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.9	1.7	0.0	0.0	46.6
2012	288	2,3,4	10.1	19.4	2.4	0.3	0.0	0.7	13.9	2.1	0.0	0.0	0.0	0.0	0.0	0.0	9.8	2.8	0.0	1.4	37.1
2013	1700	2,3,4,5	2.9	11.5	0.9	0.1	0.0	1.1	14.7	0.1	0.0	0.0	0.0	0.0	0.0	0.0	3.1	3.7	0.0	1.3	60.6
2014	1226	2,3,4,5	10.2	12.3	5.2	0.5	0.0	1.5	7.7	0.8	0.0	0.0	0.0	0.0	0.0	0.0	3.8	4.8	0.0	0.5	52.7
2015	2078	2,3,4,5	4.7	3.8	2.7	0.3	0.0	0.7	13.5	1.7	0.1	0.0	0.0	0.2	0.6	0.0	1.7	3.4	0.0	4.8	61.7
2016	417	2,3,4,5	4.1	11.3	0.7	2.4	0.0	0.5	13.4	0.7	0.0	0.0	0.0	0.0	0.0	0.0	11.8	0.7	0.0	4.8	49.6
2017	471	2,3,4,5	9.8	8.1	1.5	0.8	0.0	0.0	15.5	0.4	0.0	0.0	0.0	0.4	0.0	0.0	3.8	3.8	0.0	0.8	55.0
2018	1325	2,3,4,5	1.2	2.9	3.0	0.0	0.0	1.2	15.8	0.3	0.0	0.0	0.0	0.1	0.0	0.0	6.7	1.8	0.0	0.8	66.1
2019	1058	2,3,4,5	0.5	0.9	0.7	0.7	0.0	0.5	1.9	0.2	0.0	0.0	0.0	0.0	0.2	0.0	2.4	3.8	0.0	5.0	83.4
2020	1817	2,3,4,5	2.6	0.0	0.0	1.9	0.0	1.3	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.3	9.6	0.0	1.8	69.6
2021	756	2,3,4,5	3.3	0.0	0.3	1.9	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.6	8.1	0.0	1.3	78.2
2022	745	2,3,4,5	7.8	2.8	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	4.0	0.0	0.0	84.6
09–18	1072		6.1	9.9	2.4	0.6	0.0	0.8	13.5	0.9	0.0	0.0	0.0	0.1	0.1	0.0	5.8	3.0	0.0	2.1	54.7
19–22	1094		3.6	0.9	0.2	1.1	0.0	0.9	1.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	4.9	6.4	0.0	2.0	78.9

Table 5.7—Percent distribution of Middle Shuswap River adult equivalent (AEQ) total fishing mortalities and escapement to represent unmarked fish when recoveries with incomplete data were assumed to have been caught in mark-selective fisheries (MSFs).

Note: Troll, Net, and Sport (T,N,S) were combined for Southeast Alaska (SEAK), Northern British Columbia (NBC), and West Cost Vancouver Island (WCVI) aggregate abundance-based management (AABM) fisheries; S Falcon individual stock-based management (ISBM) fishery; and SEAK and Southern U.S. Terminal. The green shading identifies the calendar year exploitation rate (CYER) values where mark-selective fisheries (MSFs) did not change from the original mortality distribution tables (MDTs) for the marked stock and the yellow shading identifies revised CYERs.

			AABM Fishery			ISBM Fishery										Terminal Fishery				Escapement	
	Est		SEAK	NBC	WCVI	NBC & CBC	Southern BC			N Falcon		S Falcon	WAC	Puget Sd		SEAK	Canada		US South		
Catch Year	# of CWT	Ages	T,N,S	T,S	T,S	T,N,S	T	N	S	T	S	T,S	N	N	S	T,N,S	N	S	T,N,S	Stray	Esc.
2011	58	2,3	8.6	10.3	0.0	0.0	0.0	1.7	5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.9	1.7	0.0	0.0	46.6
2012	288	2,3,4	10.1	19.4	2.4	0.3	0.0	0.7	12.5	2.1	0.0	0.0	0.0	0.0	0.0	0.0	10.1	2.9	0.0	1.4	38.2
2013	1700	2,3,4,5	2.9	11.5	0.9	0.1	0.0	1.1	14.7	0.1	0.0	0.0	0.0	0.0	0.0	0.0	3.1	3.7	0.0	1.3	60.6
2014	1226	2,3,4,5	10.2	12.3	5.2	0.5	0.0	1.5	7.7	0.8	0.0	0.0	0.0	0.0	0.0	0.0	3.8	4.8	0.0	0.5	52.7
2015	2078	2,3,4,5	4.7	3.8	2.7	0.3	0.0	0.7	13.5	1.7	0.1	0.0	0.0	0.2	0.6	0.0	1.7	3.4	0.0	4.8	61.7
2016	417	2,3,4,5	4.1	11.3	0.7	2.4	0.0	0.5	13.4	0.7	0.0	0.0	0.0	0.0	0.0	0.0	11.8	0.7	0.0	4.8	49.6
2017	471	2,3,4,5	9.8	8.1	1.5	0.8	0.0	0.0	13.6	0.4	0.0	0.0	0.0	0.4	0.0	0.0	3.9	3.9	0.0	0.8	56.6
2018	1325	2,3,4,5	1.2	2.9	3.0	0.0	0.0	1.2	15.2	0.3	0.0	0.0	0.0	0.1	0.0	0.0	6.8	1.8	0.0	0.8	66.6
2019	1058	2,3,4,5	0.5	0.9	0.7	0.7	0.0	0.5	1.9	0.2	0.0	0.0	0.0	0.0	0.2	0.0	2.4	3.8	0.0	5.0	83.4
2020	1817	2,3,4,5	2.6	0.0	0.0	1.9	0.0	1.3	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.3	9.6	0.0	1.8	69.6
2021	756	2,3,4,6	3.3	0.0	0.3	1.9	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.6	8.1	0.0	1.3	78.2
2022	745	2,3,4,6	7.8	2.8	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	4.0	0.0	0.0	84.6
09–18	1,072		6.1	9.9	2.4	0.6	0.0	0.8	12.9	0.9	0.0	0.0	0.0	0.1	0.1	0.0	5.9	3.0	0.0	2.1	55.2
19–22	1094		3.6	0.9	0.2	1.1	0.0	0.9	1.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	4.9	6.4	0.0	2.0	78.9

Table 5.8—Average absolute changes in Nicola, Lower Shuswap, and Middle Shuswap calendar year exploitation rates (CYERs) (2002, 2008–2022) when coded-wire tag (CWT) recoveries with incomplete data were assumed to have been caught in non-selective fisheries or mark-selective fisheries (MSFs).

Indicator Stock	Southern BC Sport	Puget Sound Sport	N Falcon Sport	Canada Terminal Net	Canada Terminal Sport	Escapement
Caught in NSF						
Nicola	-0.2%	-0.2%	0.0%	~0.0%	~0.0%	+0.3%
Lower Shuswap	-0.3%	-0.2%	~0.0%	~0.0%	~0.0%	+0.4%
Middle Shuswap	-0.1%	-0.1%	-0.1%	~0.0%	~0.0%	+0.2%
Caught in MSF						
Nicola	-0.3%	-0.2%	0.0%	+0.1%	~0.0%	+0.4%
Lower Shuswap	-0.3%	-0.2%	~0.0%	~0.0%	~0.0%	+0.5%
Middle Shuswap	-0.4%	-0.1%	-0.1%	~0.0%	~0.0%	+0.4%

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LIST OF APPENDICES

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

LIST OF APPENDIX A TABLES

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

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

[1] TST is an aggregate of the Taku (TAK) and Stikine (STI) exploitation rate indicator stocks and is used by the PSC Chinook Model to represent the TST Model Stock aggregate.
[2] NSA is an aggregate of Crystal Lake (ACI) and Douglas Island Pink and Chum (DIPAC)/Macaulay (AMC) hatcheries and is used by the PSC Chinook Model to represent the NSA Model Stock aggregate.
[3] SSA is an aggregate of Little Port Walter (ALP), Neets Bay (ANB), Whitman Lake (AHC), and Deer Mountain (ADM) hatcheries and is used by the PSC Chinook Model to represent the SSA Model Stock aggregate.

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

Region	Run	Attachment I stock	Escapement Indicator (PSC Management Objective)	Exploitation Rate Indicator/Acronym		Model Stock /Acronym	
Northern BC (NBC)	Summer	No	Nass	Kitsumkalum (Deep Creek Hatchery)	KLM	Northern BC	NBC
		Yes	Skeena (TBD)				
		No	Kitsumkalum			NA	NA
	Spring	No	NA	Kitsumkalum Yearling[2]	KLY	NA	NA
Central BC (CBC)	Fall	No	Wannock	Atnarko (Snootli Hatchery)	ATN	Central BC	CBC
	Summer	No	Chuckwalla and Killbella				
		Yes	Atnarko (5,009)				
West Coast Vancouver Island (WCVI)	Fall	Yes	NWVI Natural Aggregate (Colonial-Cayeagle, Tashish, Artlish, Kaouk) (TBD)	Robertson Creek Hatchery[1]	RBT (adj)	West Coast Vancouver Island Natural	WVN
		Yes	SWVI Natural Aggregate (Bedwell/Ursus, Megin, Moyeha) (TBD)				
		No	West Coast Vancouver Island Aggregate (14 Streams)		RBT	West Coast Vancouver Island Hatchery	WVH

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

[2] Kitsumkalum Yearling is not included as in Attachment I or the NBC Model stocks but is monitored for stock status in annual reporting.

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

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

[2] PHI will be discontinued as an exploitation rate indicator stock once all age classes from the 2019 brood have been recovered (i.e., 2024). A new exploitation rate indicator is TBD.

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 Fingerling (Wallace Hatchery)	SKY	Snohomish	SNO
Central and Southern Puget Sound	Fall	No	Green	SPS Fall Fingerling[1]	SPS	Puget Sound Hatchery Fingerling & Puget Sound Natural Fingerling	PSF & PSN
		No	Lake Washington				
		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 River), Grovers, and Issaquah hatcheries. The Soos Creek (Green tag group) are included in the SPS exploitation rate indicator.

Appendix A5– Indicator stocks for the Washington Coast.

Region	Run	Attachment I stock	Escapement Indicator (PSC Management Objective)	Exploitation Rate Indicator/Acronym		Model Stock /Acronym	
Juan de Fuca	Fall	No	NA	Elwha Fall Fingerling (Lower Elwha Hatchery)	ELW[3]	NA	NA
Washington Coast (WAC)	Fall	Yes	Hoko (TBD)	Hoko Fall Fingerling (Hoko Falls Hatchery)	HOK	NA	NA
		Yes	Queets Fall (2,500)	Queets Fall Fingerling (Salmon River brood stock)[2]	QUE	WA Coastal Wild	WCN
		Yes	Grays Harbor Fall (13,326)		QUE (adj)		
		Yes	Quillayute Fall (3,000)				
		Yes	Hoh Fall (1,200)				
		No	NA			WA Coastal Hatchery	WCH
		No	NA	Tsoo-Yess Fall Fingerling (Makah National Fish Hatchery)	SOO[4]	NA	NA
	Spring	No	Grays Harbor Spring[1]	NA	NA	NA	NA
	Spring/ Summer	No	Queets Spring/Summer (700)[1]	NA	NA	NA	NA
	Summer	No	Quillayute Summer[1]	NA	NA	NA	NA
	Spring/ Summer	No	Hoh Spring/Summer (900)[1]	NA	NA	NA	NA

[1] Escapement indicator stock is not included in Attachment I or the Washington Coastal Model stocks but is monitored for stock status in annual reporting.
[2] Coded-wire tag indicator stocks and fishery adjustments described in CTC 2021g.
[3] The Elwha is not included in Attachment I or Juan de Fuca Model stocks but is monitored for stock status in annual reporting.
[4] The Tsoo-Yess Fall Fingerling is not included in Attachment I or Washington Coast Model stocks but is monitored for stock status in annual reporting.

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

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

[1] Pending the review specified in paragraph 5(b) of Chapter 3 and a subsequent Commission decision.
[2] Coded-wire tag indicator stocks and fishery adjustments described in CTC 2021g.
[3] The Lyons Ferry Yearling is not included in Attachment I or Columbia River Model stocks but is monitored for stock status in annual reporting.

Appendix A7– Historic exploitation rate indicator stocks that are no longer reported.

Region	Historic exploitation rate indicator (Acronym)	Model stock (Acronym)	Last year included in ERA report	Reason stock is no longer reported
Southeast Alaska	Alaska Spring (AKS)	NA	2020	Indicator stock stratified into Southern Southeast Alaska (SSA) and Northern Southeast Alaska (NSA)
Southeast Alaska	Chickamin (CHM)	Southern Southeast Alaska (SSA)	2020	Tagging discontinued
Central BC	Atnarko Yearling (ATS)	NA	2014	Tagging discontinued (2011)
Fraser River	Dome -Penny Creek Hatchery (DOM)	Fraser Spring 1.3 (FS3)	2021	Tagging discontinued
South Strait of Georgia	Nanaimo (NAN)	Lower Strait of Georgia (LGS)	2021	Tagging discontinued
North Puget Sound	Nooksack Spring Yearling (NKS)	Nooksack Spring (NKS)	2021	Tagging discontinued
North Puget Sound	Skagit Spring Yearling (SKS)	NA	2021	Reduced hatchery production
Central and Southern Puget Sound	Stillaguamish Summer Fingerling	Stillaguamish (STL)	2012	Indicator stock was subsumed into Stillaguamish Fall Fingerling (STL)
Central and Southern Puget Sound	White River Spring Yearling (WRY)	NA	2021	Tagging discontinued
Central and Southern Puget Sound	South Puget Sound Fall Yearling (SPY)	Puget Sound Hatchery Yearling (PSY)	2021	Tagging discontinued
Central and Southern Puget Sound	Squaxin Net Pens Fall (SQP)	Puget Sound Hatchery Yearling (PSY)	2021	Tagging discontinued
Central and Southern Puget Sound	Green River Fingerling (GRN)	Puget Sound Hatchery Fingerling (PSF) & Puget Sound Natural Fingerling (PSN)	2016	Stock is a part of South Puget Sound (SPS) indicator stock
Central and Southern Puget Sound	University of Washington Accelerated (UWA)	Puget Sound Hatchery Yearling (PSY)	2021	Tagging discontinued

APPENDIX B: PARAMETERS USED IN THE 2023 EXPLOITATION RATE ANALYSIS

The following two tables summarize the notations used throughout this report.

LIST OF APPENDIX B TABLES

Appendix B1— Parameter definitions for all equations except those used for the Stratified Proportional Fishery Index (SPFI).

Parameter	Description
a	age class
A	set of all ages that meet selection criteria
$AEQ_{BY,a,f}$ $AEQ_{BY,Maxage,f}$=1.0	adult equivalent factor in brood year *BY*, age *a*, and fishery *f* (for terminal fisheries, AEQ = 1.0 for all ages)
$AEQ_{s,BY,a,f}$	adult equivalent factor for stock *s*, brood year *BY*, age *a*, and fishery *f*
$AvgMatRte_a$	average maturation rate for age *a*
$BPYR$	base period year
$BYER_{BY,f}$	brood year exploitation rate in adult equivalents for brood year *BY* and fishery *f*
BY	brood year
$Cohort_{BY,a}$	cohort by brood year *BY* and age *a* (*where stock is implied from context*)
$Cohort_{s,BY,a}$	cohort by stock *s*, brood year *BY* and age *a* (*where stocks are defined explicitly in a summation*)
$CohSurv_{BY,a=2or3}$	cohort survival of CWT fish to age 2 or 3 for brood year *BY*
CY	calendar year
$CYDist_{CY,F}$	proportion of total stock mortality (or escapement) in a calendar year *CY* attributable to a fishery or a set of fisheries *F*
$d_{t,s,a}$	distribution parameter for time step *t*, stock *s*, and age *a*
$Esc_{Y,a}$	escapement past all fisheries for either brood year *BY* or calendar year *CY* and age *a*
$ER_{s,a,f,CY}$	exploitation rate at age *a* divided by cohort size at age *a* for stock *s* in fishery *f* in year *CY*
$EV_{n,BY}$	the stock productivity scalar for iteration *n* and brood year *BY*
f	a single fishery or escapement
$f \in \{F\}$	a fishery *f* within the set of fisheries *F = Preterminal or Terminal*
$f \in \{F_{p,ISBM}\}$	a fishery *f* within the set of each party's (*p*) ISBM fisheries *F*
$FI_{f,CY}$	fishery exploitation rate index for fishery *f* in year *CY*

Parameter	Description
$MatRte_{BY,a}$	maturity rate of age *a* for brood year *BY*
Maxage	maximum age of stock (generally age 6 for stream type stocks, age 5 for ocean type stocks)
Minage	minimum age of stock (generally age 3 for stream type stocks, age 2 for ocean type stocks)
$Morts_{Y,a,f}$	landed or total fishing-related mortality for brood year *BY* or calendar year *CY,* age *a*, and fishery *f*
NM_a	annual natural mortality prior to fishing on age *a* cohort
Numfisheries	total number of fisheries
s	a particular stock
S	set of all stocks that meet selection criteria
$Surv_a$	survival rate (1-NM_a) by age
$TotCWTRelease_{BY}$	total number of fish released with coded-wire tags for a given brood year
$TotMorts_{s,Y,a,f}$	total fishing related mortality for stock *s*, brood year *BY* or calendar year *CY*, age *a*, and fishery *f*
$RepMorts_{BY,a,f}$	reported fishing-related mortality for brood year *BY* or calendar year *CY* or during the base period BPER and age *a* in fishery *f*

Appendix B2— Parameter descriptions for equations used for the stratified proportional fishery index (SPFI).

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

APPENDIX C: PERCENT DISTRIBUTION OF LANDED CATCH AND TOTAL MORTALITY AND ESCAPEMENT FOR EXPLOITATION RATE INDICATOR STOCKS BY CALENDAR YEAR

Mortality distribution tables show the percent of estimated landed catch or total mortality for individual stocks attributed to specific fisheries (T = troll, N = net, S = sport). Landed catch mortalities are calculated from catch estimation and CWT sampling programs. Total mortality includes landed catch and incidental mortality (i.e., release mortality) which occurs in both retention and non-retention fisheries; incidental mortalities are estimated based on sampling data and/or algorithms within the ERA (i.e., size-at-age vulnerability algorithms and gear-specific mortality rates). Mortality distribution within a calendar year sums to 100%.

For mortality distribution among fisheries, we report total mortality; calendar years that do not meet a minimum criteria of at least 3 ages and 105 estimated CWT recoveries are shaded or in some cases omitted. If only 1 age class was present in a calendar year, data from that year were omitted. If 2 age classes or less than 105 estimated CWTs were present in a calendar year, data from that year were shaded, but excluded from the calculation of the time period averages found at the bottom rows of the table. Where relevant, escapement includes inter-dam loss mortalities (i.e., Columbia River stocks). Complete time series of mortality distributions, as well as tables of landed catch mortalities, can be found on the PSC website: https://www.psc.org/publications/technical-reports/technical-committee-reports/chinook/ctc-data-sets/.

The distributions of mortalities (reported catch and total) among fisheries and escapement in a catch year were calculated for each stock to determine the exploitation patterns. The distributions were computed if at least two BYs contributed to the CWT recoveries for a catch year. Distributions were computed for each fishery across all ages present in the catch year as:

$$CYDist_{CY,F} = \frac{\sum_{a=Minage}^{Maxage} \sum_{f\epsilon\{F\}} Morts_{CY,a,f} * AEQ_{BY=CY-a,a,f}}{\sum_{a=Minage}^{Maxage} \sum_{f=1}^{Numfisheries} Morts_{CY,a,f} * AEQ_{BY=CY-a,a,f} + Esc_{CY,a}}$$

Equation C.1

Calculated mortality distributions may not indicate the true geographic distribution of an indicator stock. For example, no CWTs will be recovered if a fishery area is closed but this would not necessarily indicate zero abundance of a given stock in that fishing area.

Mortality distribution tables for stocks with terminal area adjustments are also included in the excel file posted on the PSC website (https://www.psc.org/publications/technical-reports/technical-committee-reports/chinook/ctc-data-sets/).

APPENDIX D: BROOD YEAR EXPLOITATION RATE PLOTS

The brood year exploitation rate measures the cumulative impact of fisheries on all ages for a given stock and brood year. The BYER is computed by dividing AEQ total fishing mortality by AEQ total fishing mortality plus escapement.

$$BYER_{BY,f} = \frac{\sum_{a=Minage}^{Maxage} \sum_{f \in \{F\}} Morts_{BY,a,f} * AEQ_{BY,a,f}}{\sum_{a=Minage}^{Maxage} \sum_{f=1}^{Numfisheries} Morts_{BY,a,f} * AEQ_{BY,a,f} + Esc_{BY,a}}$$

Equation D.1

All terms are defined in Appendix B. The AEQ factor represents the proportion of fish of a given age that would, in the absence of fishing, leave the ocean to return to the terminal area. The AEQ factor is calculated as:

$$AEQ_{BY,a,f} = \begin{cases} MatRte_{BY,a} + \left(1 - MatRte_{BY,a}\right) * Surv_{a+1} * AEQ_{BY,a+1,f}, & a < \text{Maxage} \\ 1, & a = \text{Maxage} \end{cases}$$

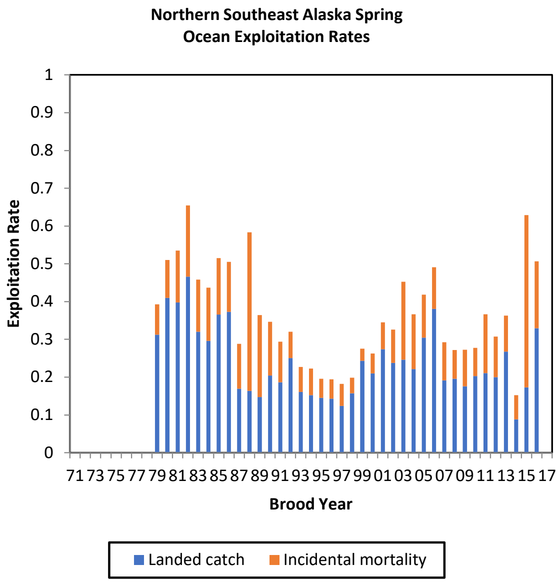
Equation D.2

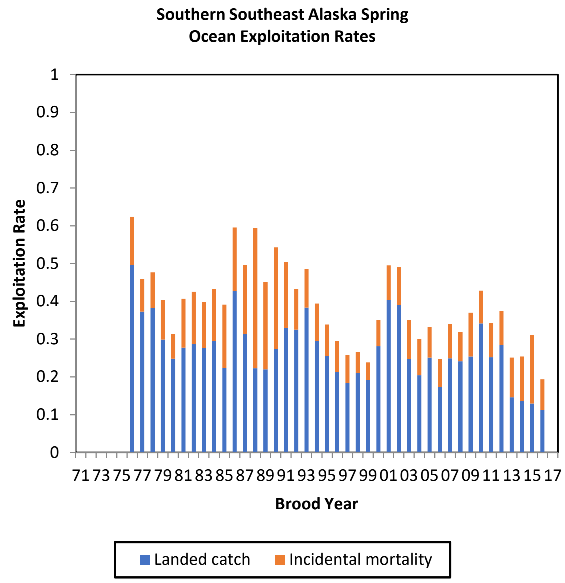
The AEQ factor is equal to 1 for the oldest age and for all ages in terminal fisheries. The BYER is further partitioned into AEQ landed catch and incidental mortality. BYERs are not reported for incomplete BYs.

If a hatchery indicator stock is subject to directed terminal fisheries, its BYER will no longer equal the BYER of the corresponding wild stock it's supposed to represent (i.e., a violation of the indicator stock assumption). This issue is addressed by reporting the BYER in the ocean fisheries (i.e., excludes the terminal fishery impacts). The type of BYER statistic reported for each exploitation rate indicator stock are described in Table 2.2 and in the subtitles of the following figures.

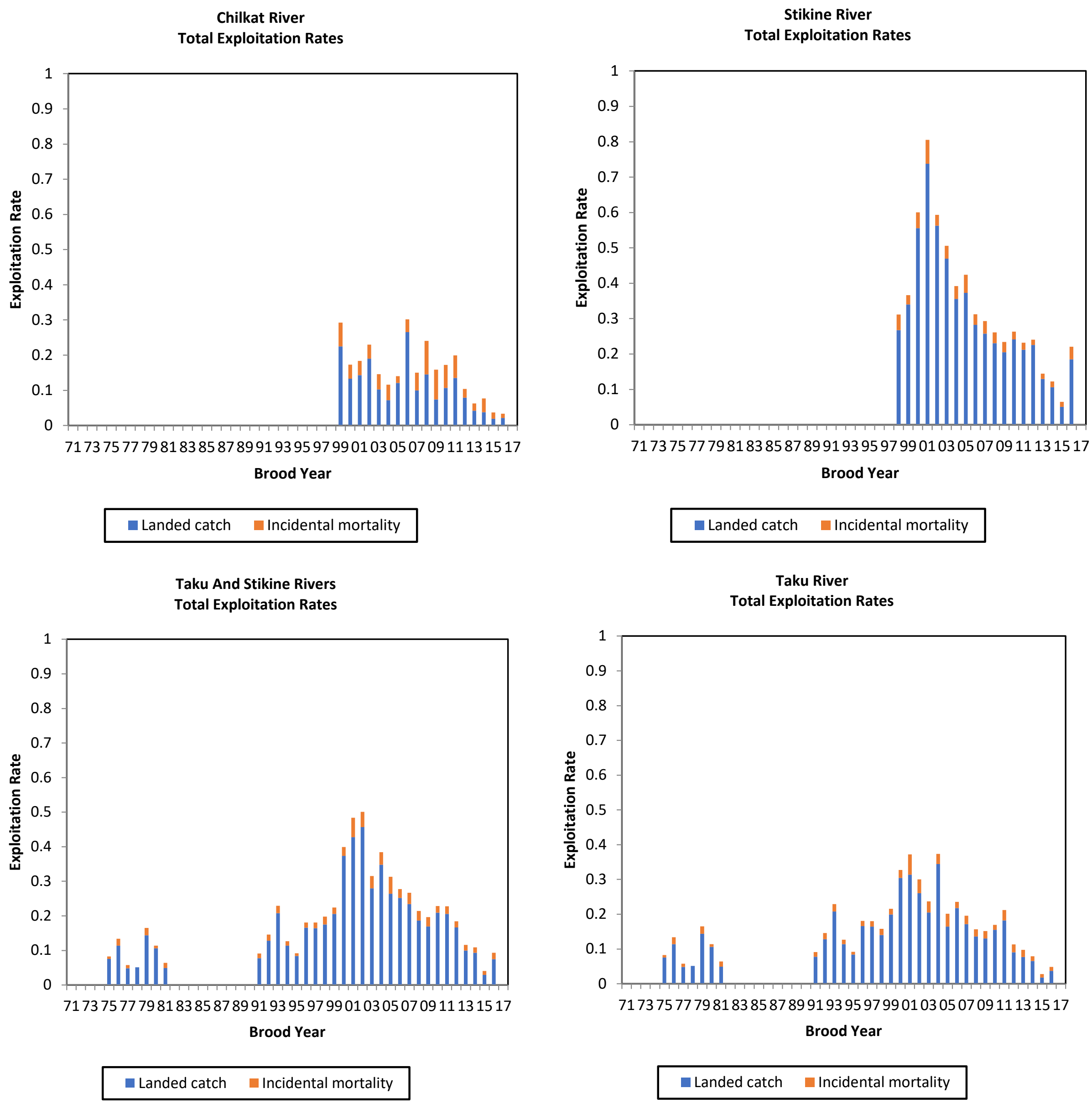
LIST OF APPENDIX D TABLES

Appendix D1— Brood year exploitation rates for Southeast Alaska hatchery indicator stocks. Catch and incidental mortality are shown. Only completed brood years are included.

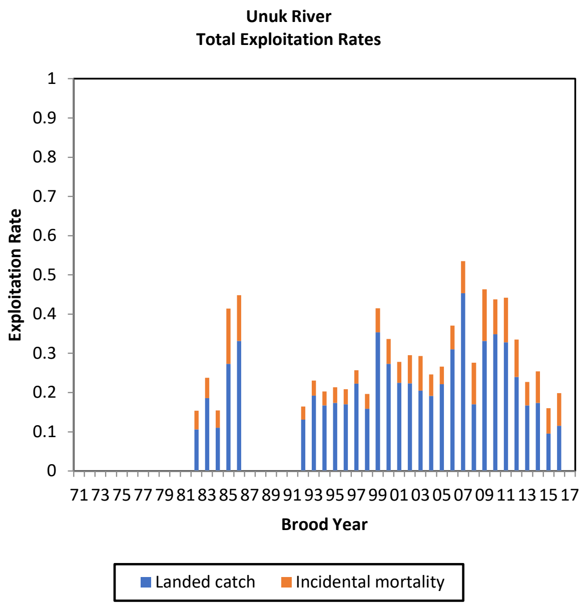




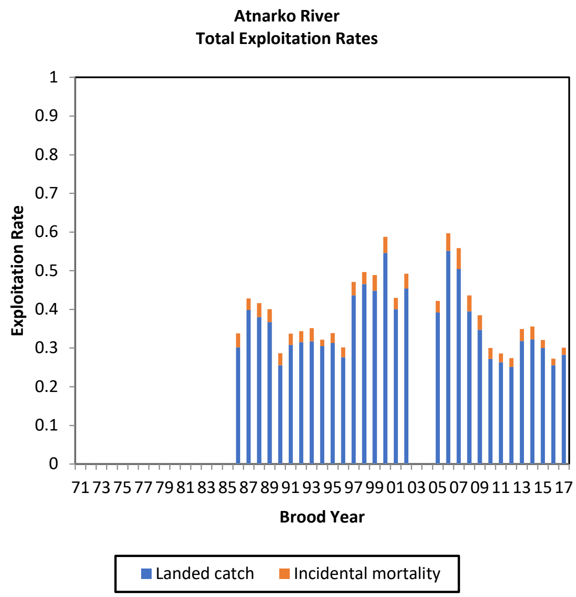
Appendix D2— Brood year exploitation rate for Southeast Alaska and transboundary wild indicator stocks. Catch and incidental mortality are shown. Only completed brood years are included.

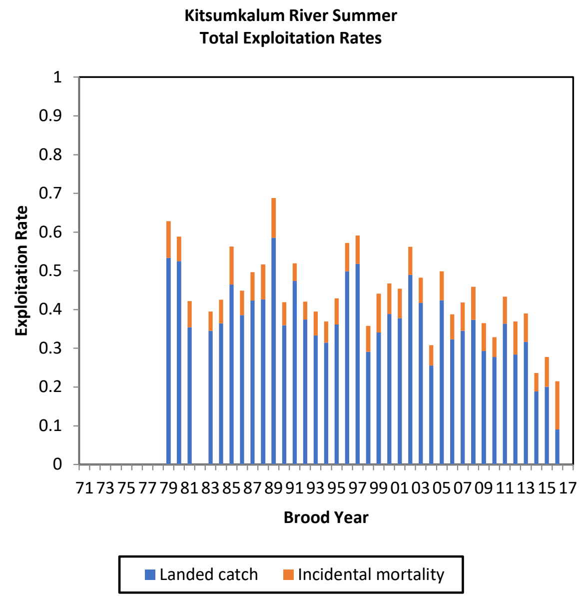


Appendix D2 continued.

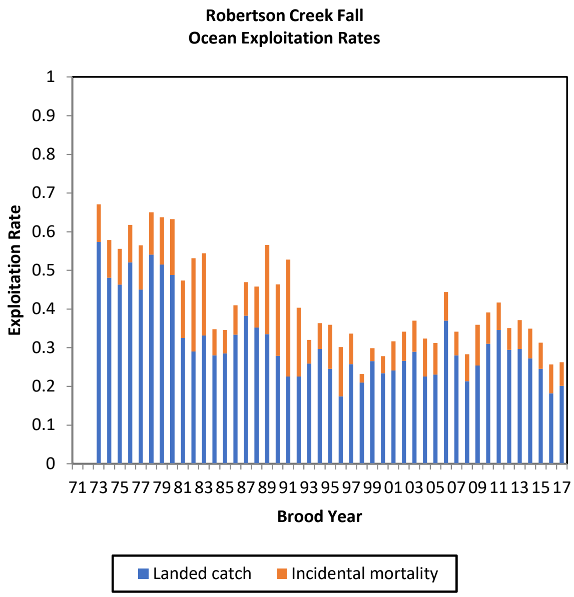


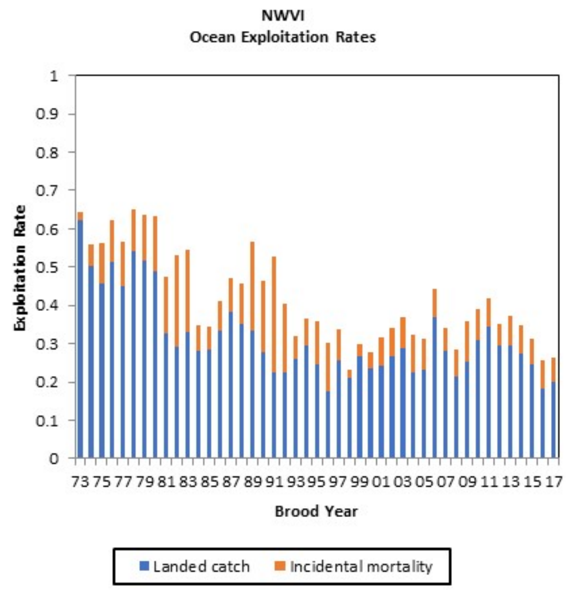
Appendix D3—Brood year exploitation rate for North and Central British Columbia stocks. Catch and incidental mortality are shown. Only completed brood years are included.

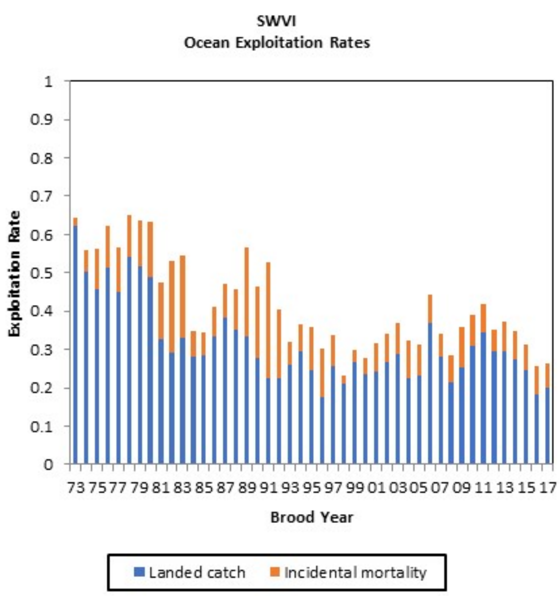




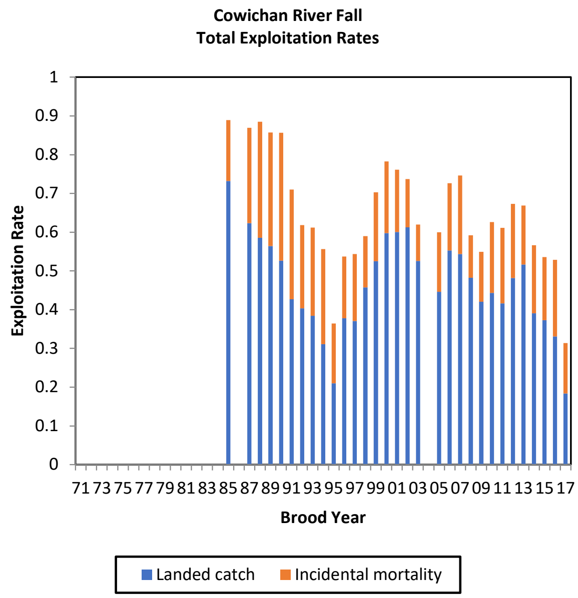
Appendix D4— Brood year exploitation rates for West Vancouver Island stocks. Catch and incidental mortality are shown. Only completed brood years are included.

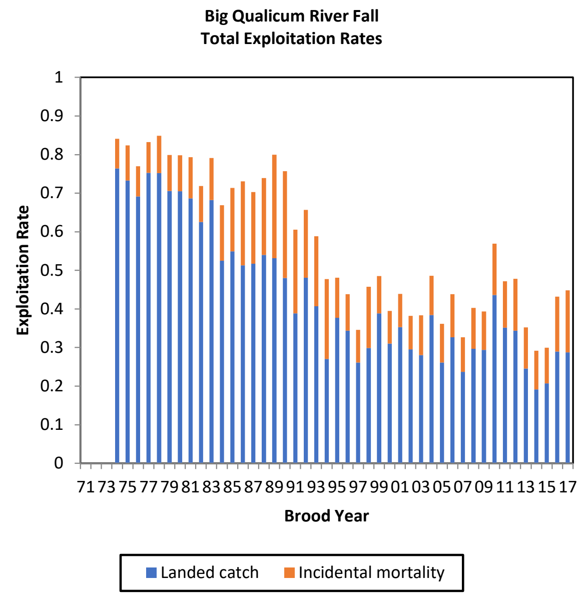


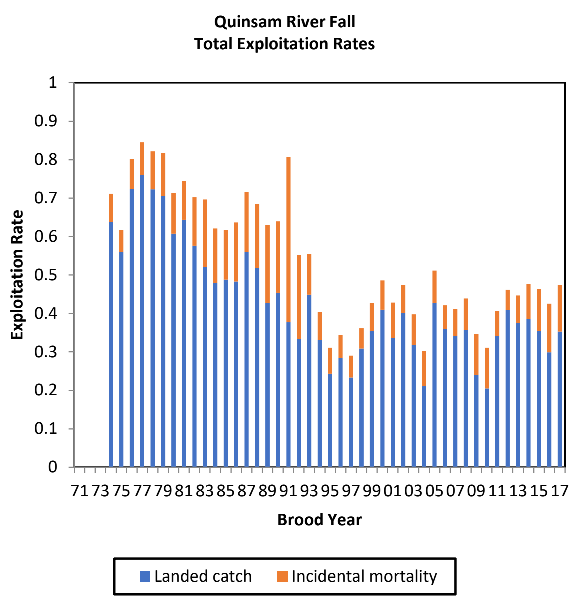


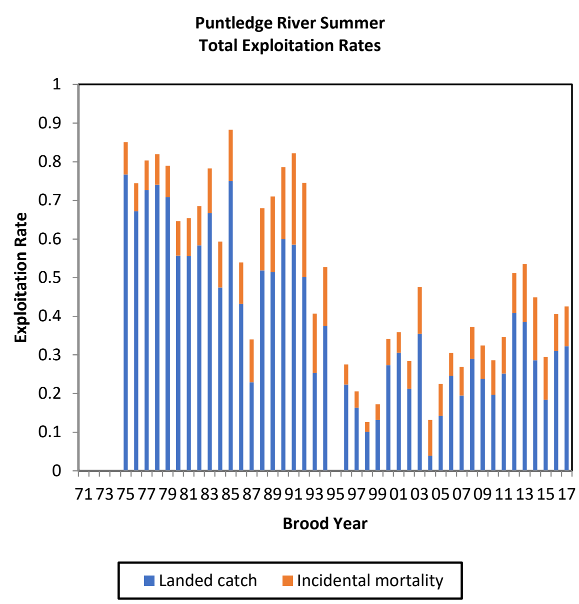


Appendix D5— Brood year exploitation rate for the Strait of Georgia indicator stocks. Catch and incidental mortality are shown. Only completed brood years are included.









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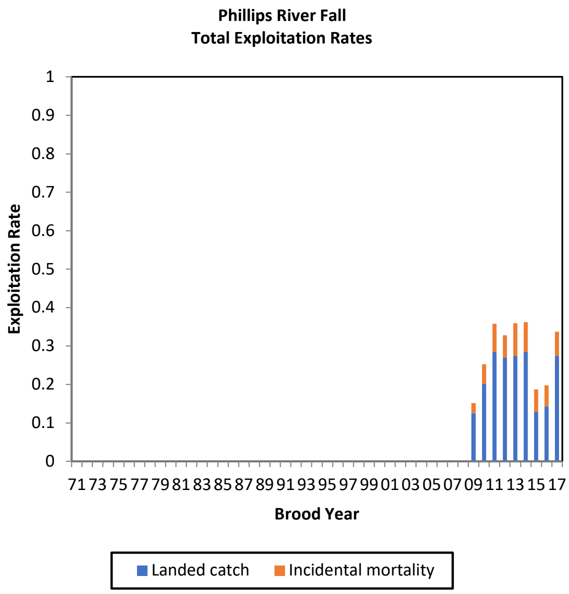
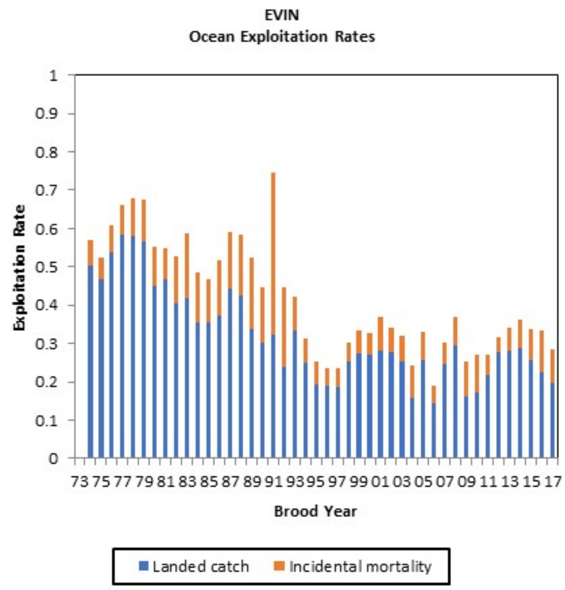
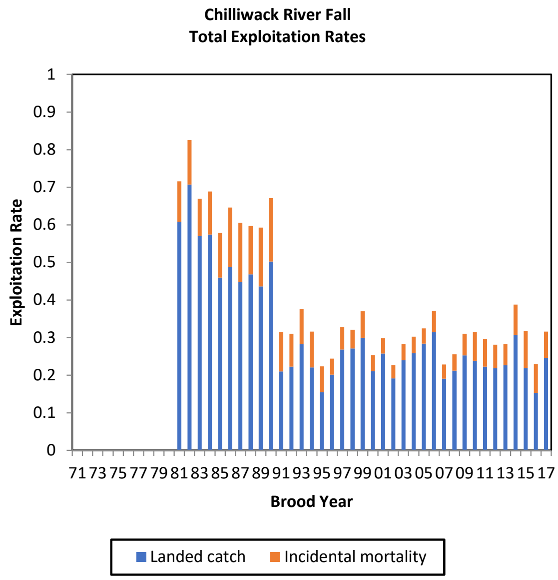
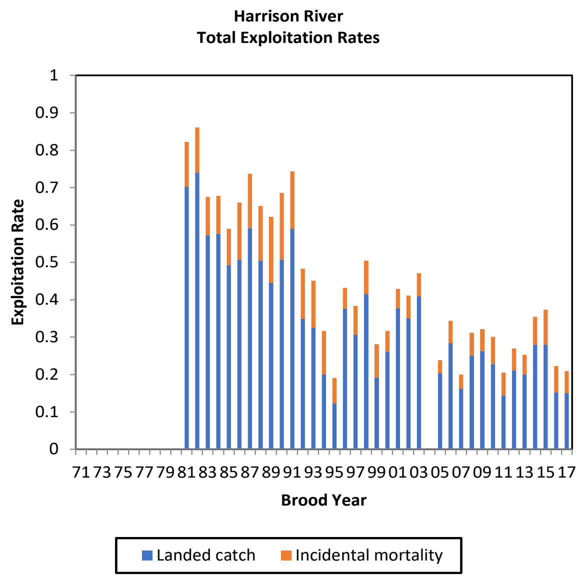


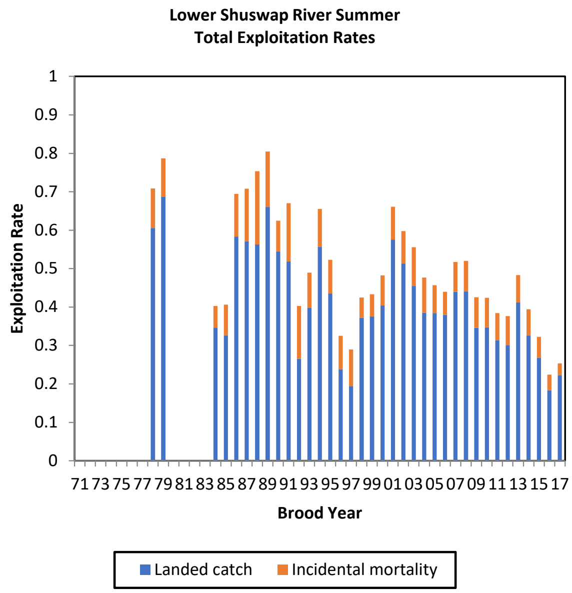


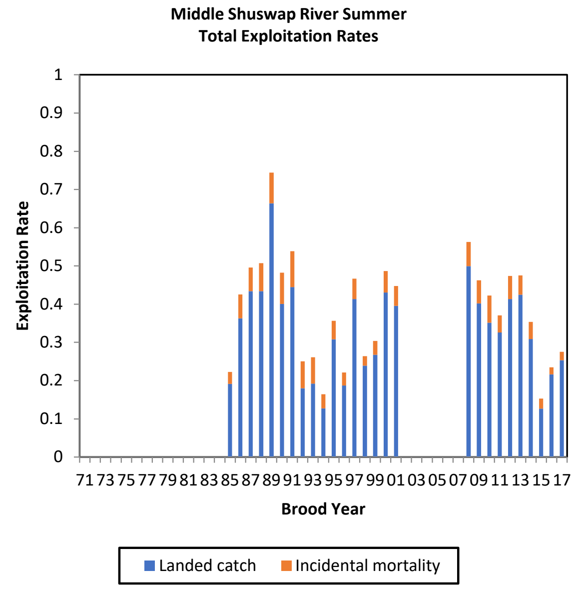
Appendix D6— Brood year exploitation rate for Fraser fall-run stocks. Catch and incidental mortality are shown. Only completed brood years are included.

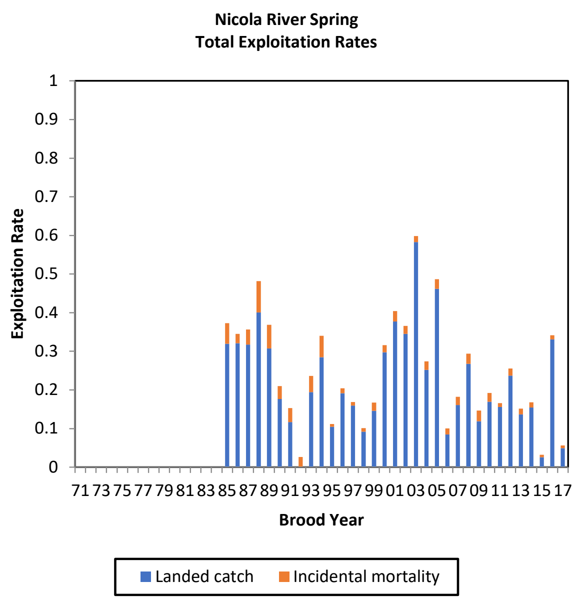




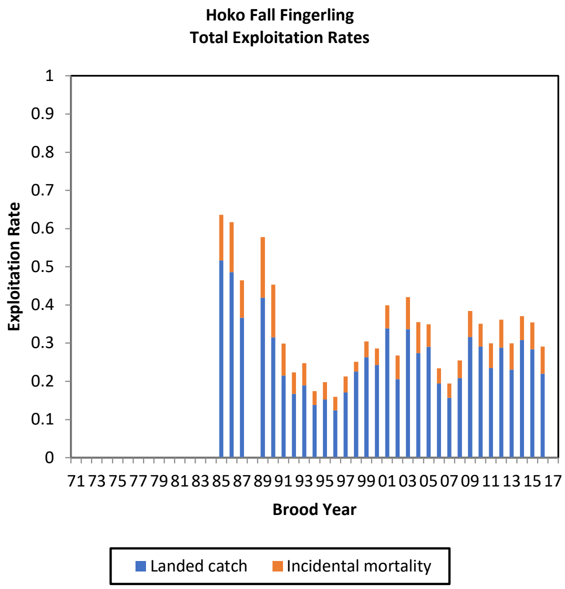
Appendix D7— Brood year exploitation rate for Fraser spring- and summer-run stocks. Catch and incidental mortality are shown. Only completed brood years are included.

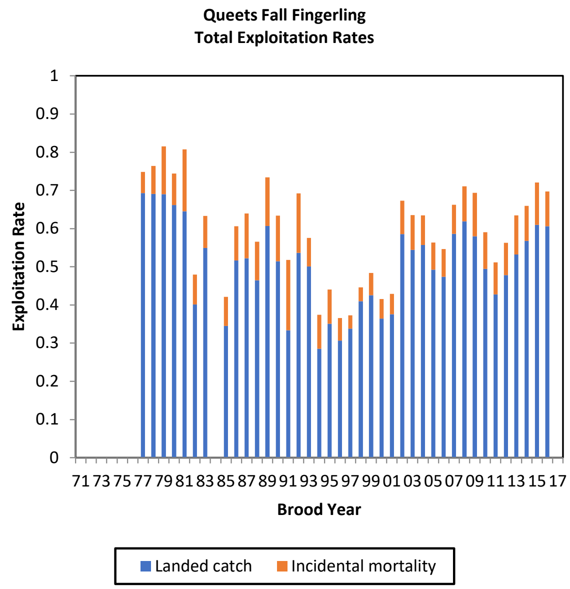


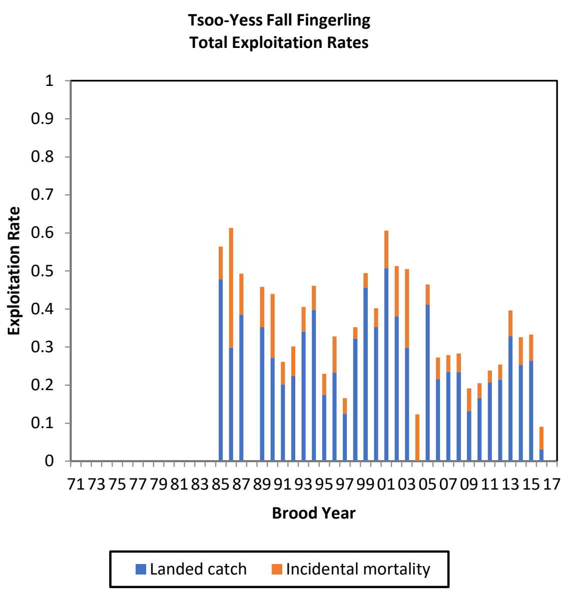


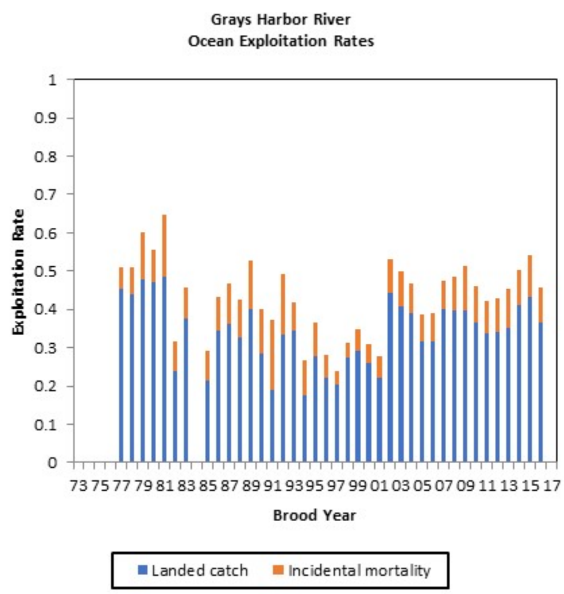


Appendix D8— Brood year exploitation rate in terms of landed catch and incidental mortality for Washington Coast indicator stocks.









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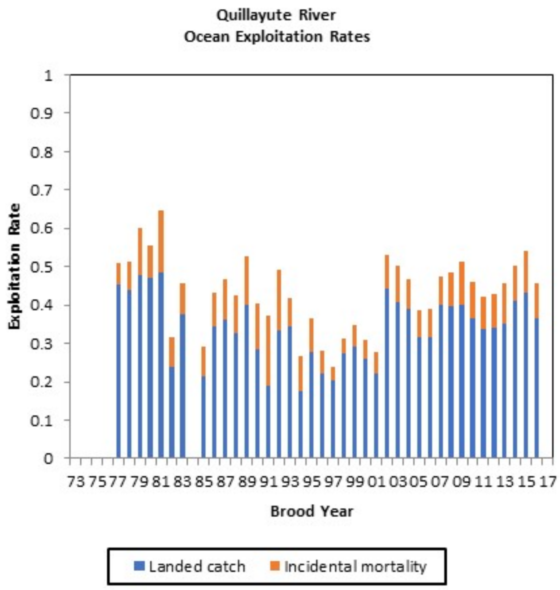
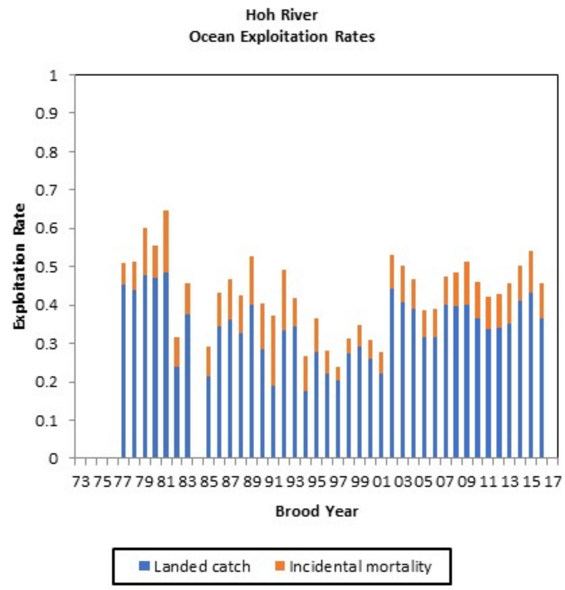
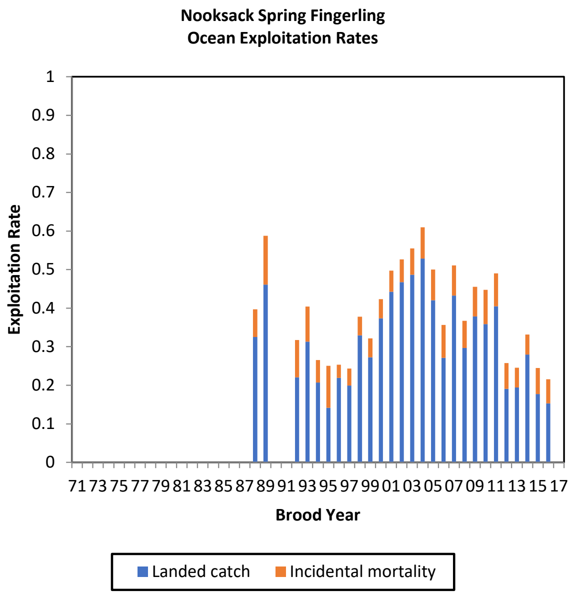
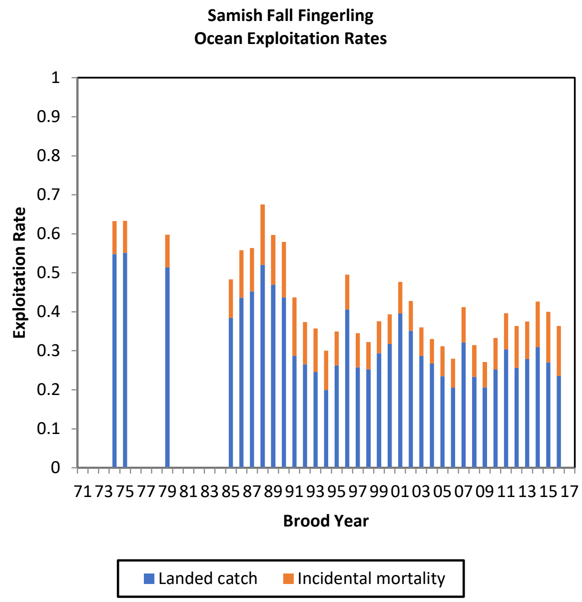
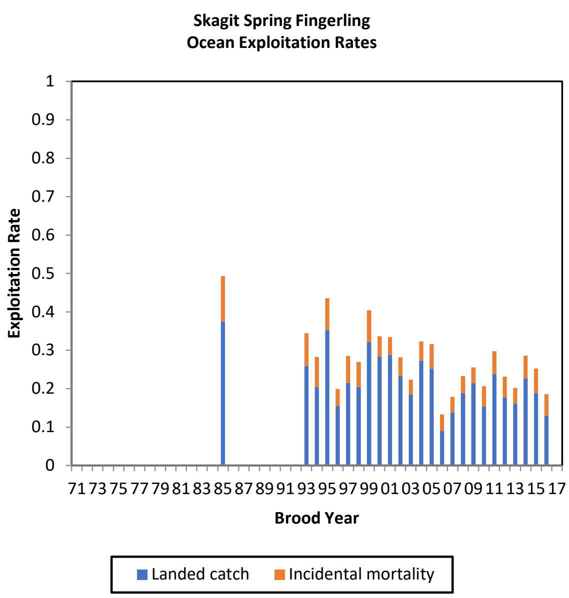


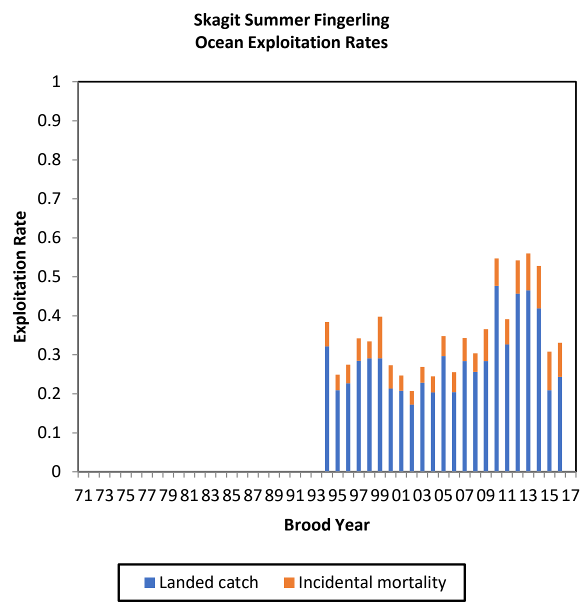


Appendix D9— Brood year exploitation rate in terms of landed catch and incidental mortality for Northern Puget Sound coded-wire tag indicator stocks.

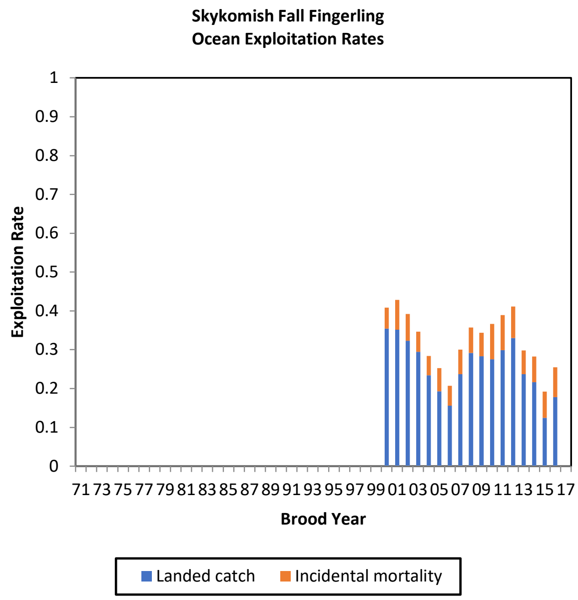


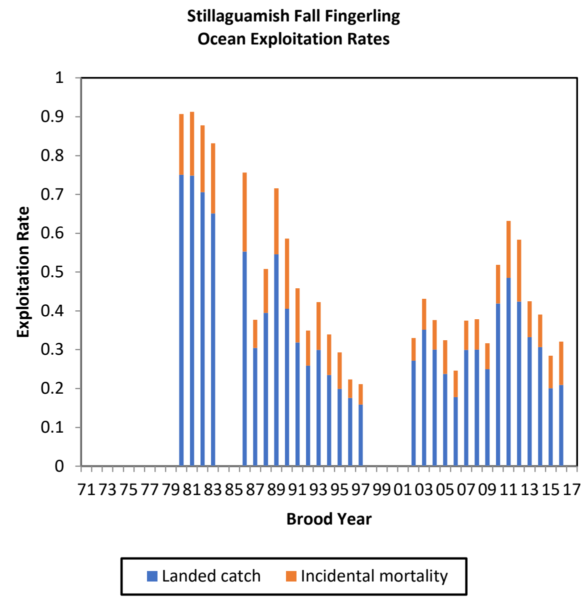




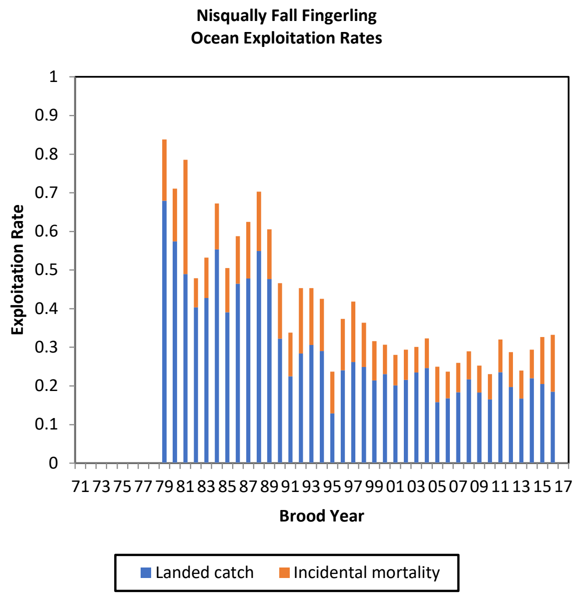


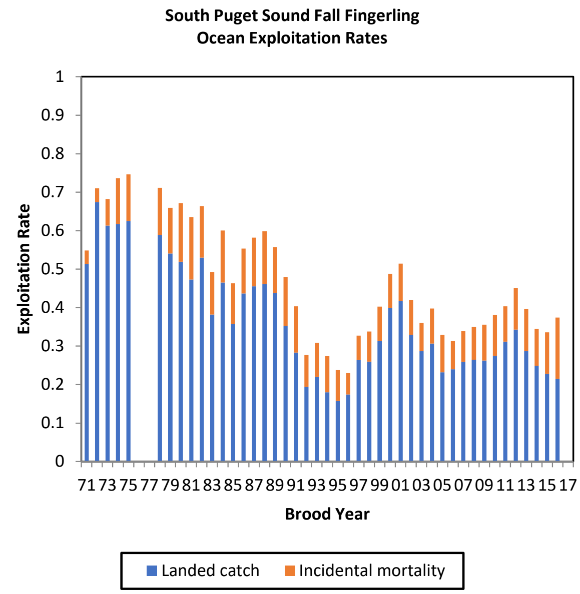
Appendix D10— Brood year exploitation rate in terms of landed catch and incidental mortality for Central Puget Sound coded-wire tag indicator stocks Stillaguamish Fall and Skykomish Summer Fingerling.



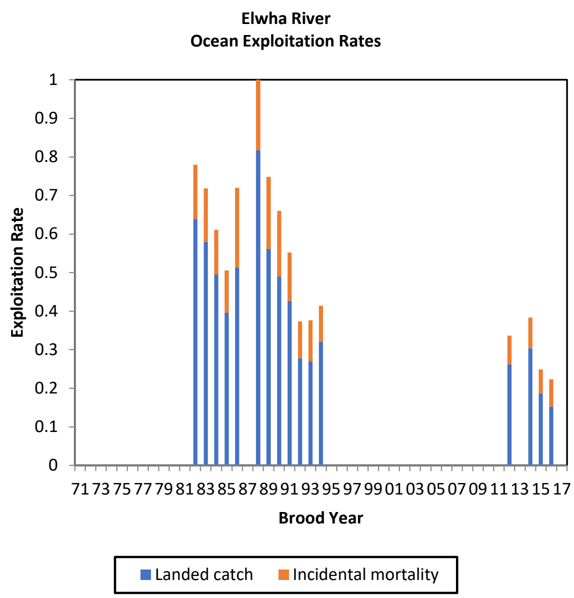


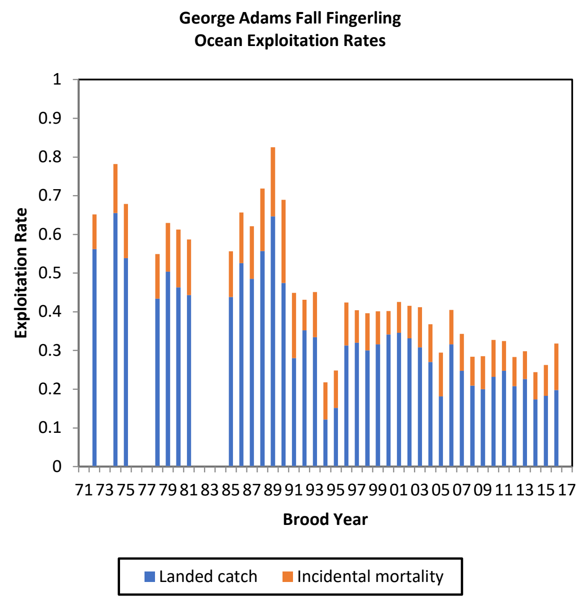
Appendix D11— Brood year exploitation rate in terms of landed catch and incidental mortality for Southern Puget Sound coded-wire tag indicator stocks.



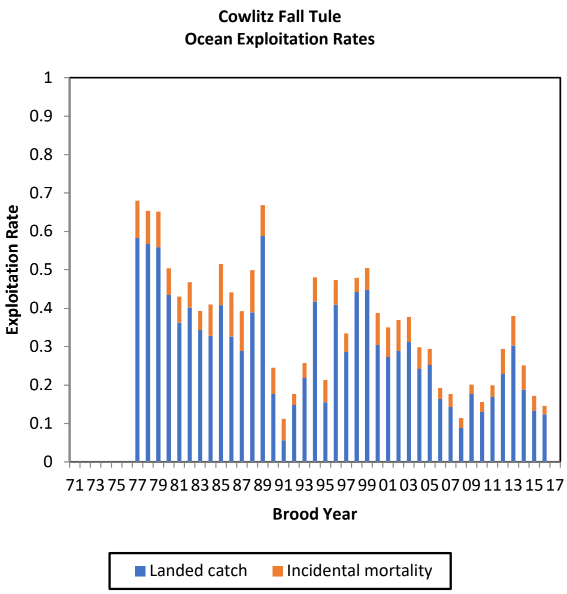


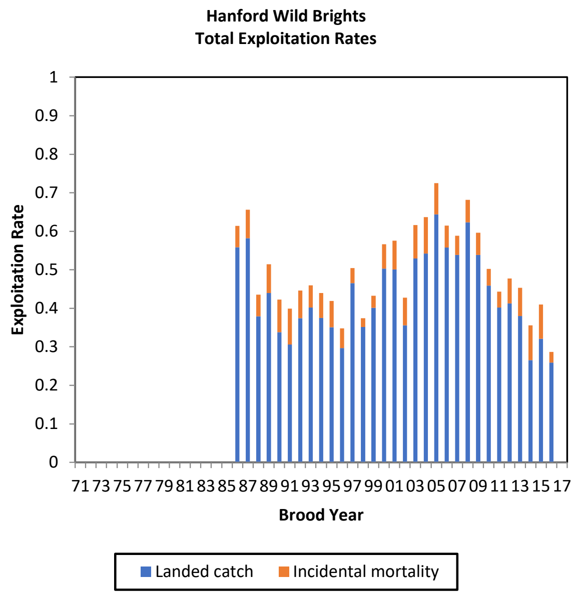
Appendix D12— Brood year exploitation rate in terms of landed catch and incidental mortality for Juan de Fuca and Hood Canal coded-wire tag indicator stocks Elwha and George Adams (Skokomish River) Fall Fingerling.

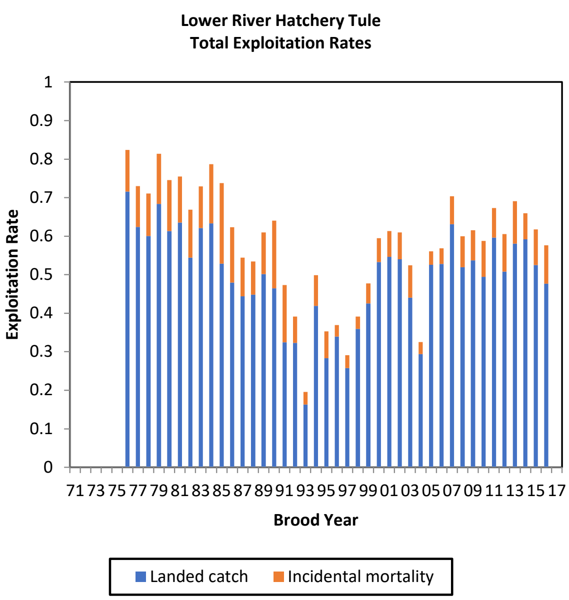


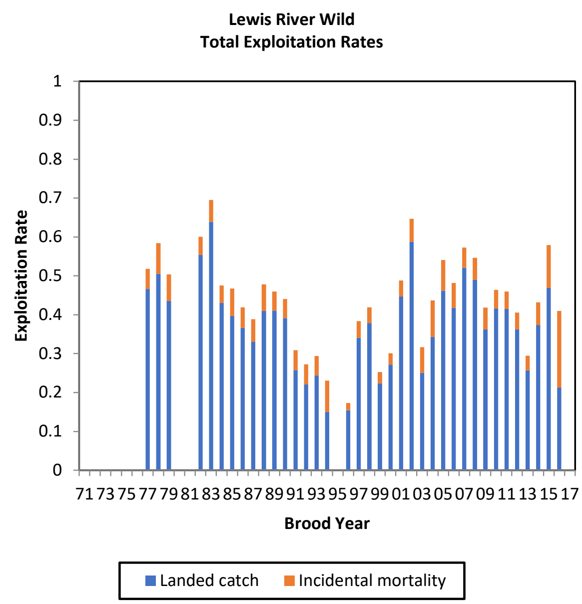


Appendix D13— Brood year exploitation rate for summer and fall Columbia River coded-wire tag indicator stocks, including Willamette and Snake River Chinook. Catch and incidental mortality are shown. Only completed brood years are included.









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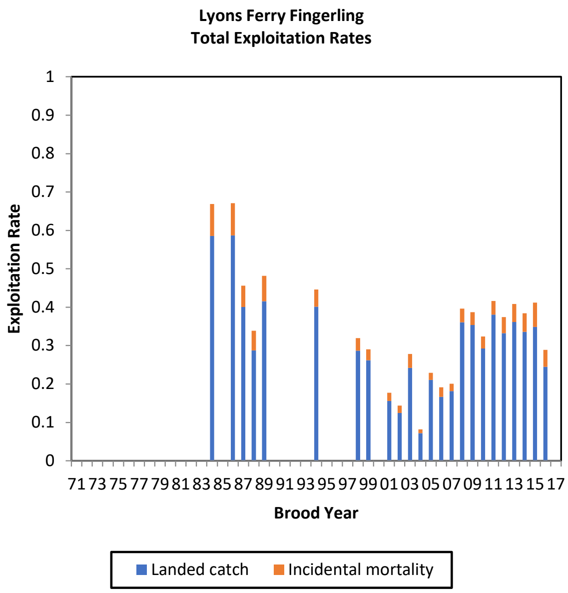

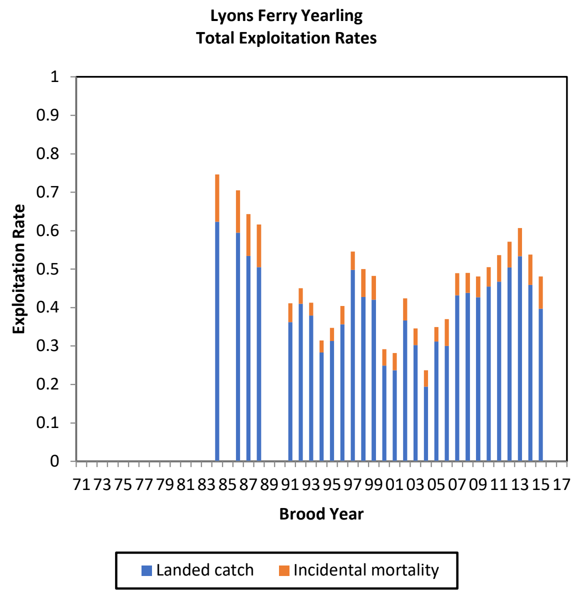

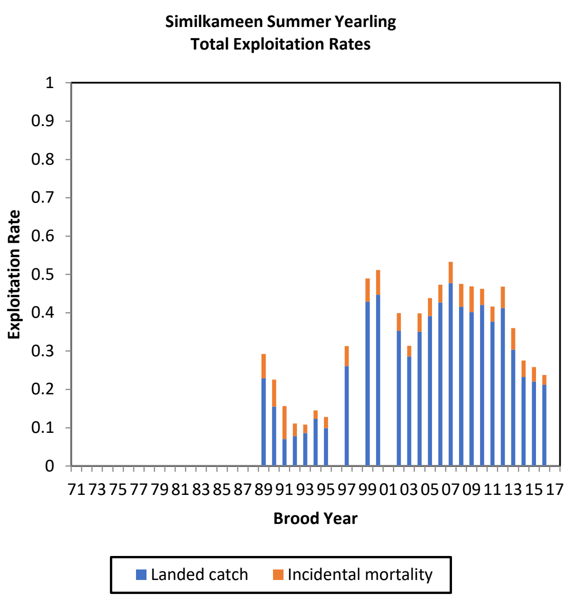

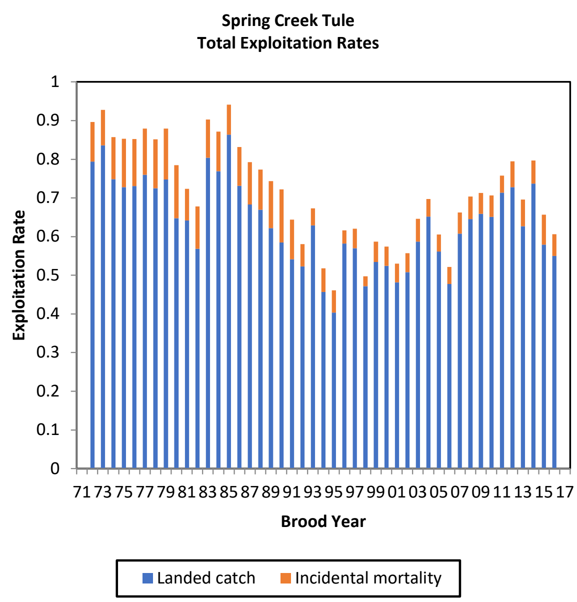

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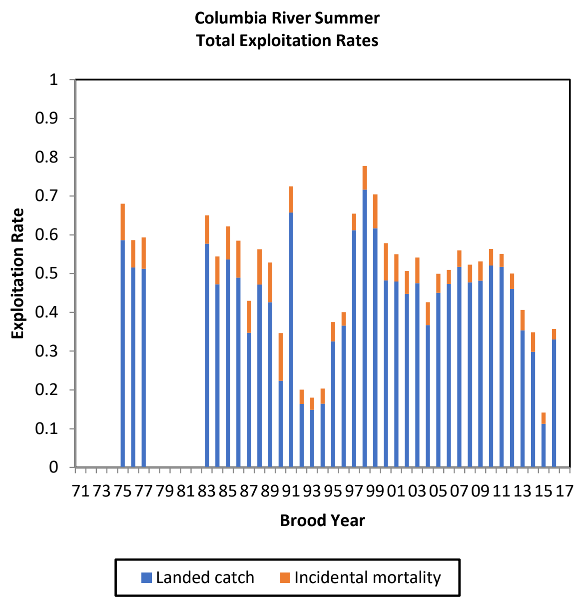
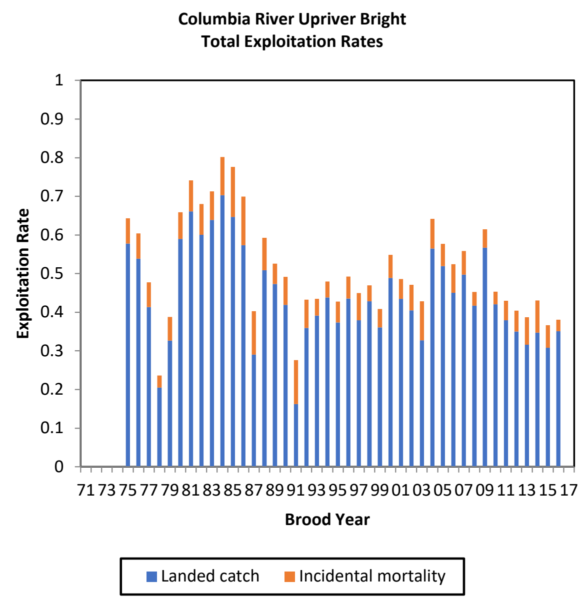
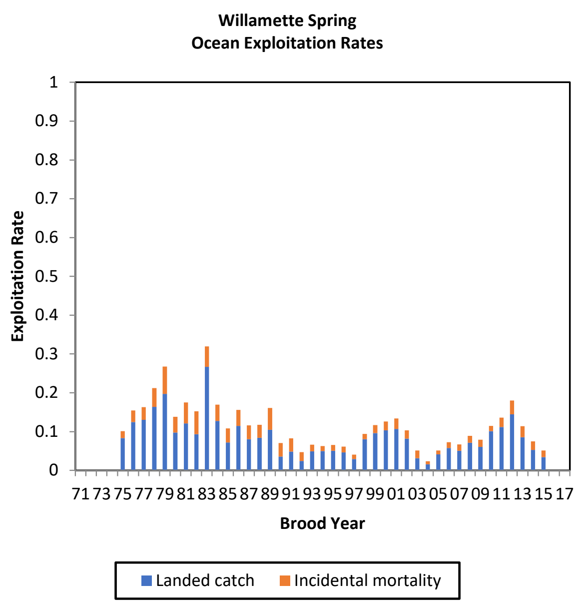
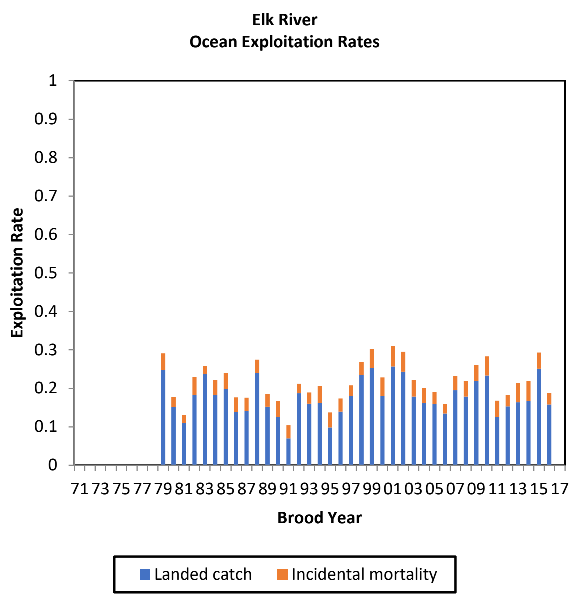
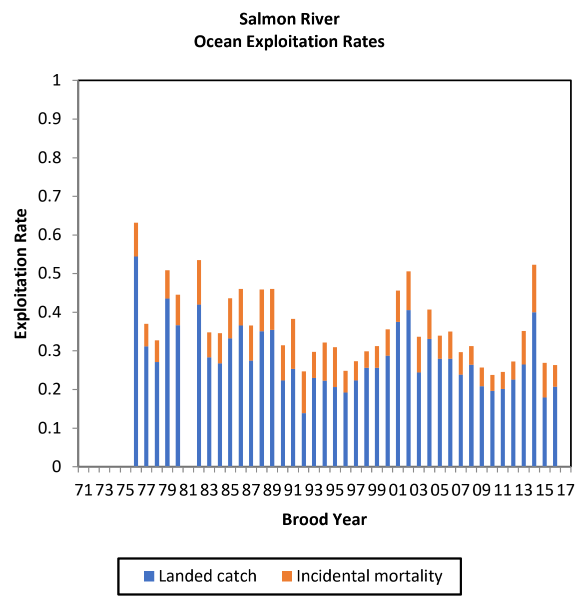


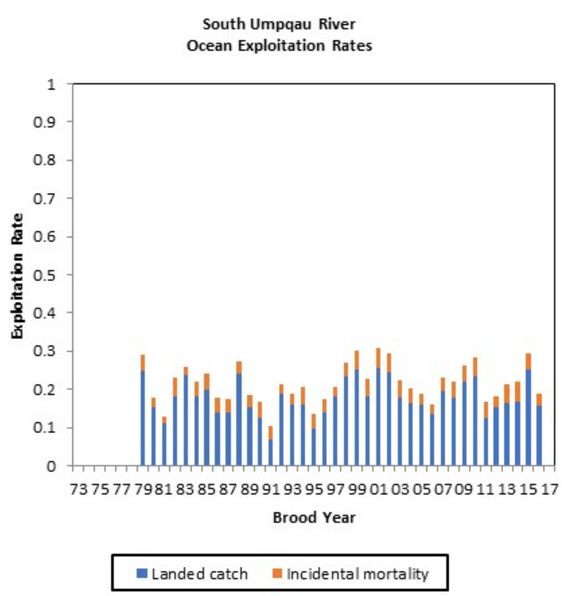


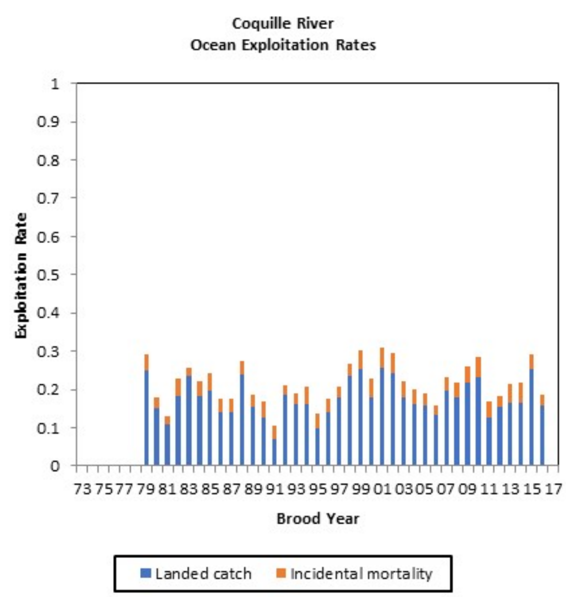


Appendix D14— Brood year exploitation rate (ocean only) for Oregon Coast coded-wire tag indicator stocks. Catch and incidental mortality are shown. Only completed brood years are included.









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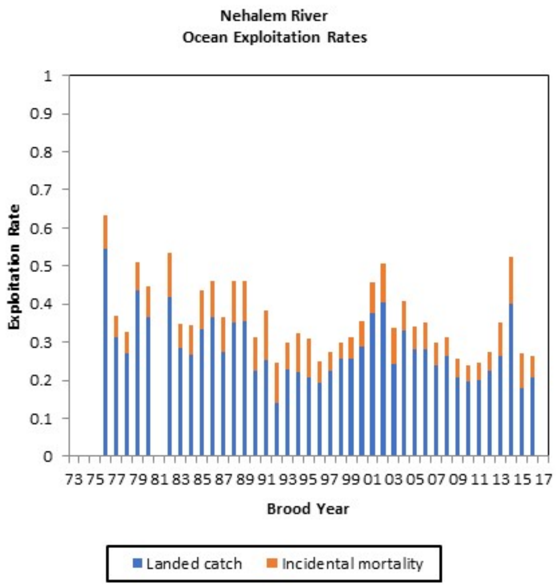
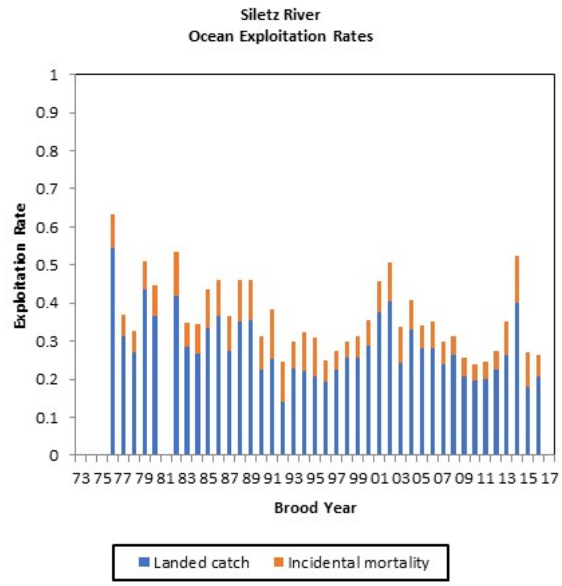
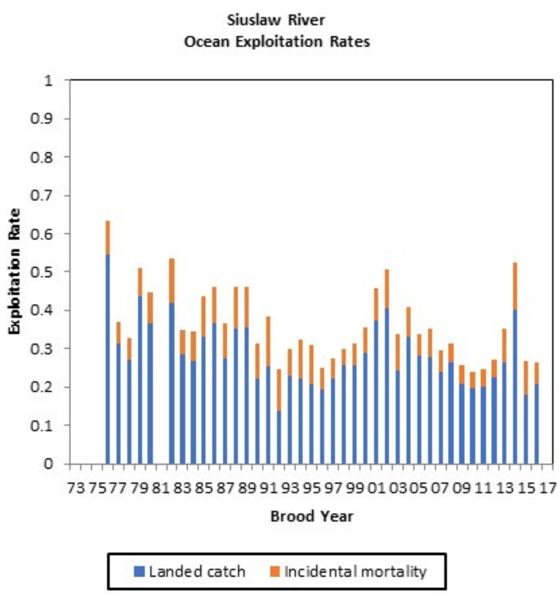






APPENDIX E: SURVIVAL RATE PLOTS

The BY smolt-to-age 2 or 3 survival of CWT-tagged juveniles after release is calculated for most exploitation rate indicator stocks (Table 2.2). This survival rate is frequently referred to as the early marine survival of the tag group and is calculated using the youngest age's cohort size before fishing and maturation or escapement mortality processes begin; for subyearling stocks, this is age 2 and for yearling stocks this is age 3. The CWT-based estimate is our most direct measure of early marine survival and is not final until all ages from that brood have returned to spawn. Preliminary estimates are generated and are displayed in Appendix E1–Appendix E14 by using available CWT data and average maturation rates but are not reported in average survival estimates.

The BY survival rate for a fingerling stock is the estimated age 2 cohort (determined from the cohort analysis) divided by the number of CWT fish released; for yearling stocks, rate is calculated using the estimated age 3 cohort:

$$CohSurv_{BY,a=Minage} = \frac{Cohort_{BY,a=Minage}}{TotCWTRelease_{BY}} \qquad \textit{Equation E.1}$$

where $Cohort_{BY,a}$ is calculated recursively from the oldest age to the youngest age using:

$$Cohort_{BY,a} = \frac{\sum_{f=1}^{Numfisheries} TotMorts_{BY,a,f} + Esc_{BY,a} + Cohort_{BY,a+1}}{1-NM_a} \qquad \textit{Equation E.2}$$

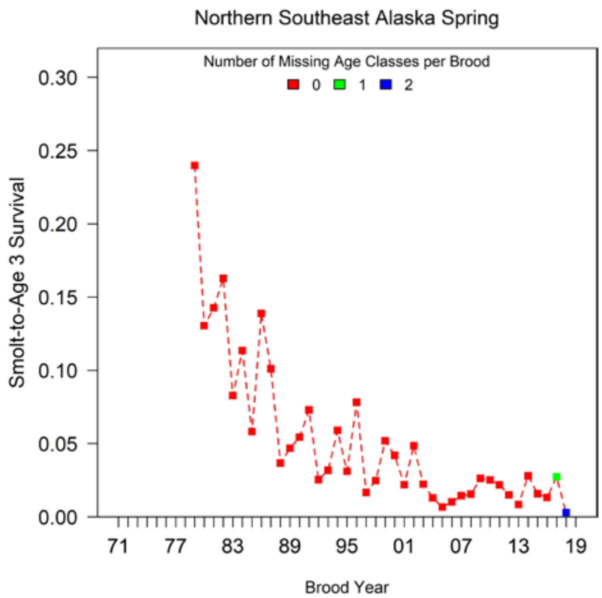
If there are no CWT recoveries for the oldest ocean age of a stock, the next youngest cohort size is estimated using:

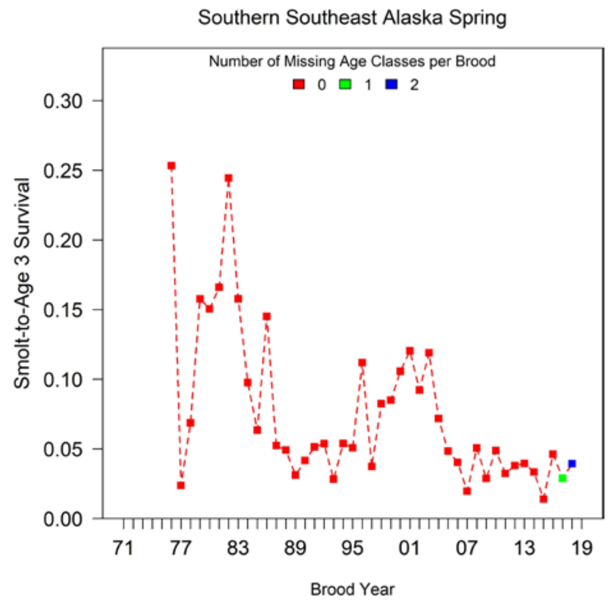
$$Cohort_{BY,Maxage-1} = \frac{\sum_{f\in Preterminal} TotMorts_{BY,Maxage-1,f} + \frac{Esc_{BY,Maxage-1} + \sum_{f\in Terminal} TotMorts_{BY,Maxage-1,f}}{AvgMatRte_{Maxage-1}}}{1-NM_{Maxage-1}}$$

Equation E.3

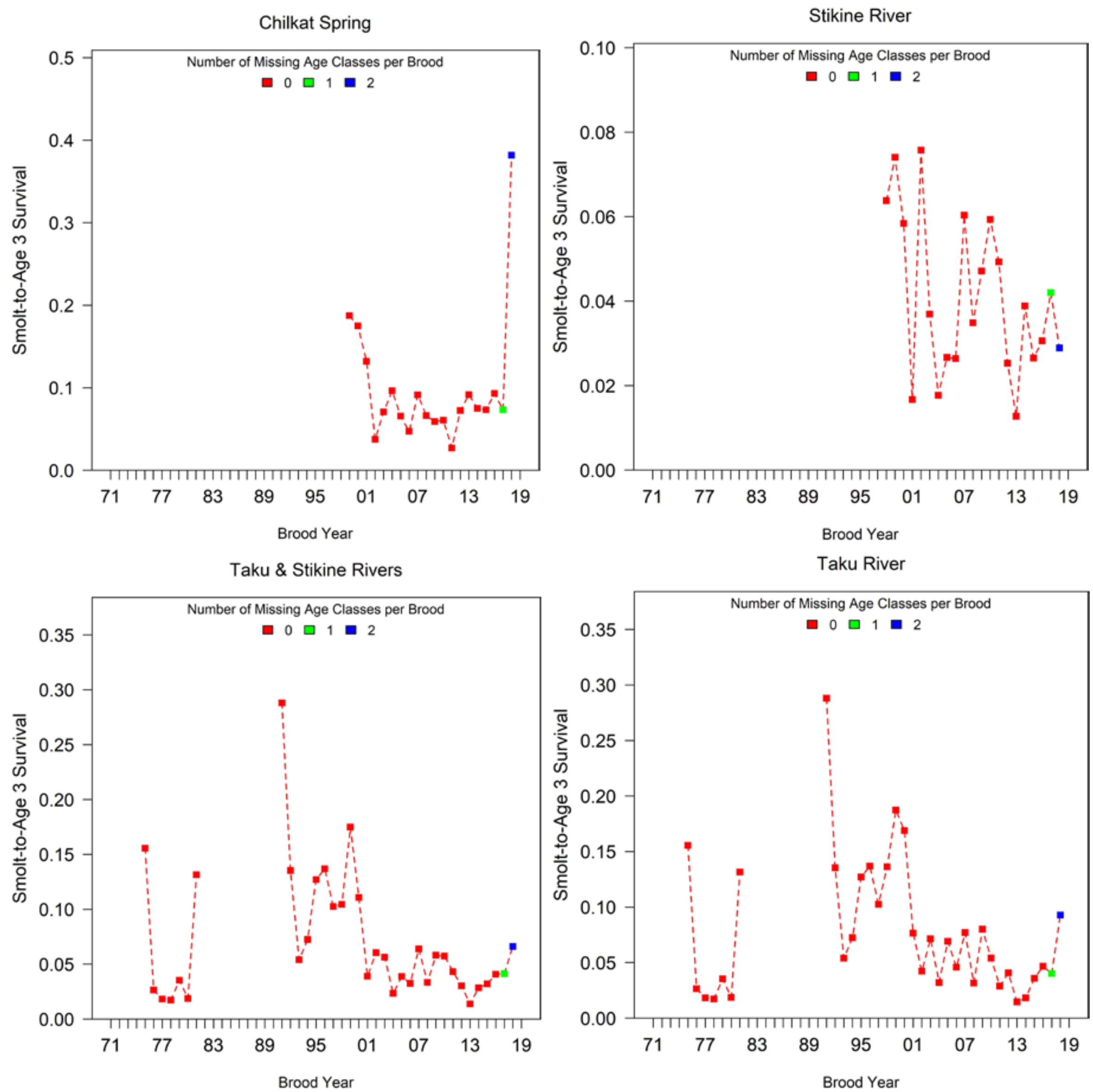
LIST OF APPENDIX E FIGURES

Appendix E1— Smolt-to-youngest age survival rates for the Southeast Alaska hatchery indicator stocks.





Appendix E2— Smolt-to-youngest age survival rates for Southeast Alaska *and transboundary wild indicator stocks*.



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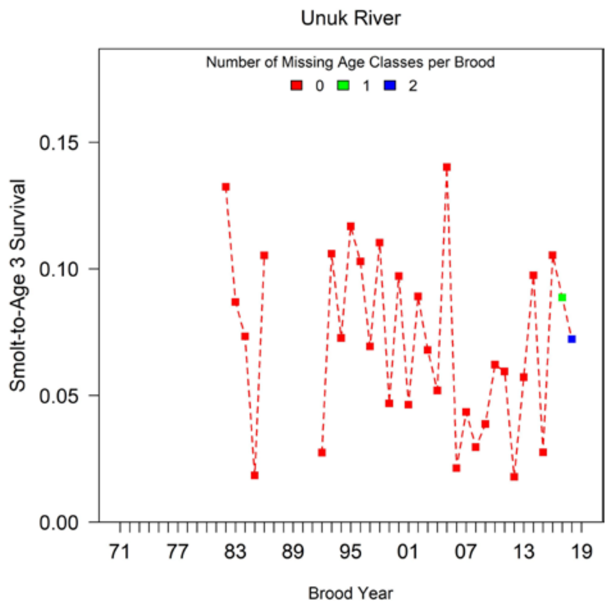
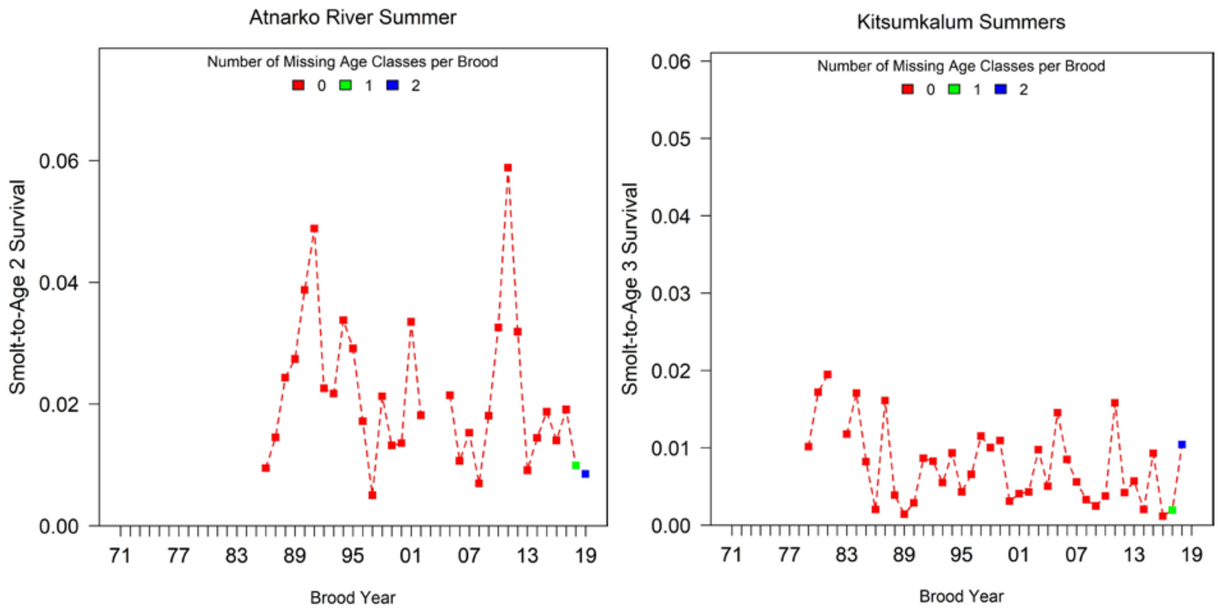
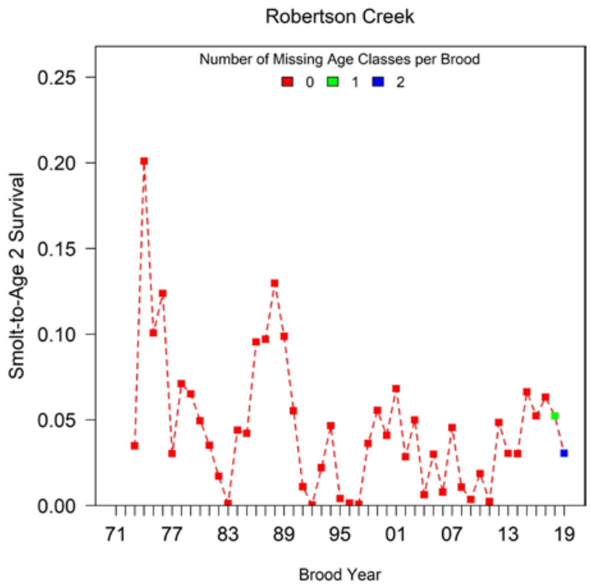


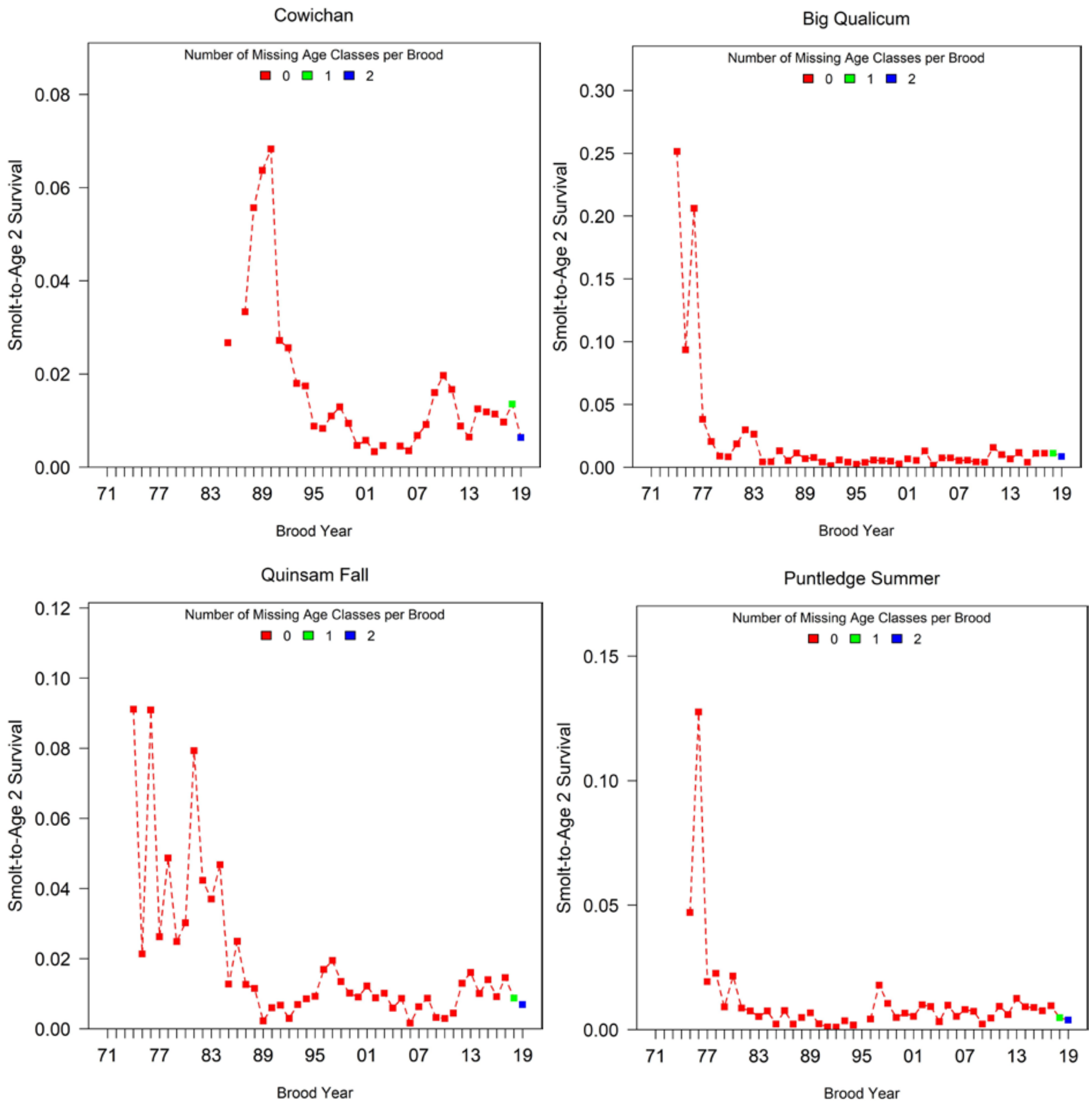
Appendix E3— Smolt-to-age 3 survival rates for Northern and Central British Columbia stocks.



Appendix E4— Smolt-to-age 2 survival rates for Robertson Creek Fall.



Appendix E5— Smolt-to-age 2 survival rates for Strait of Georgia stocks.



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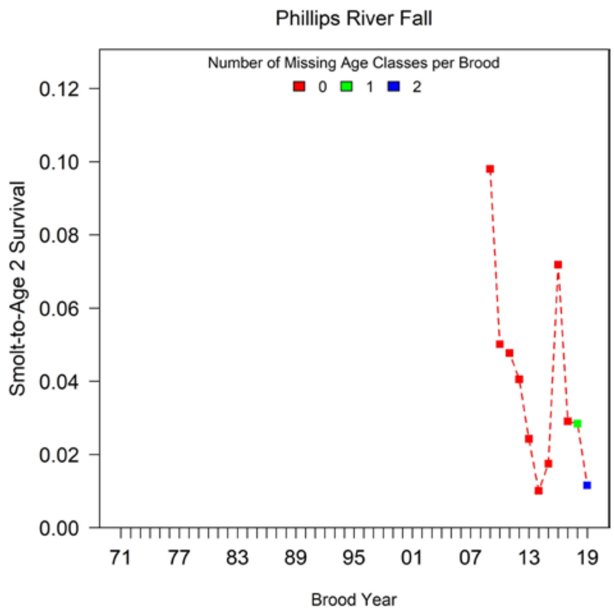
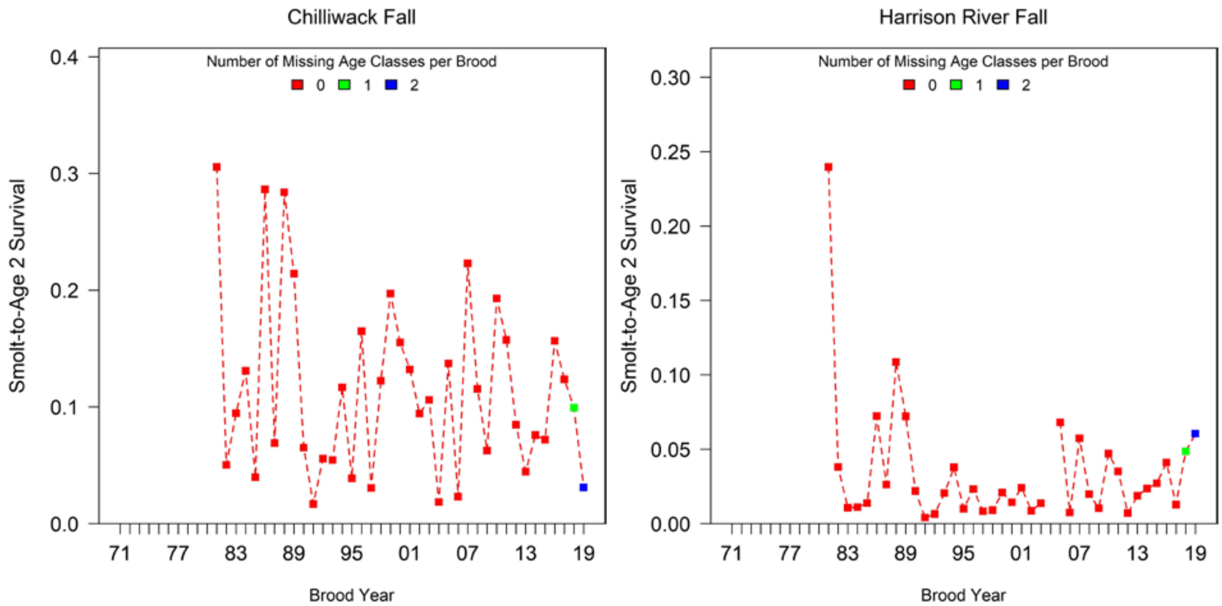
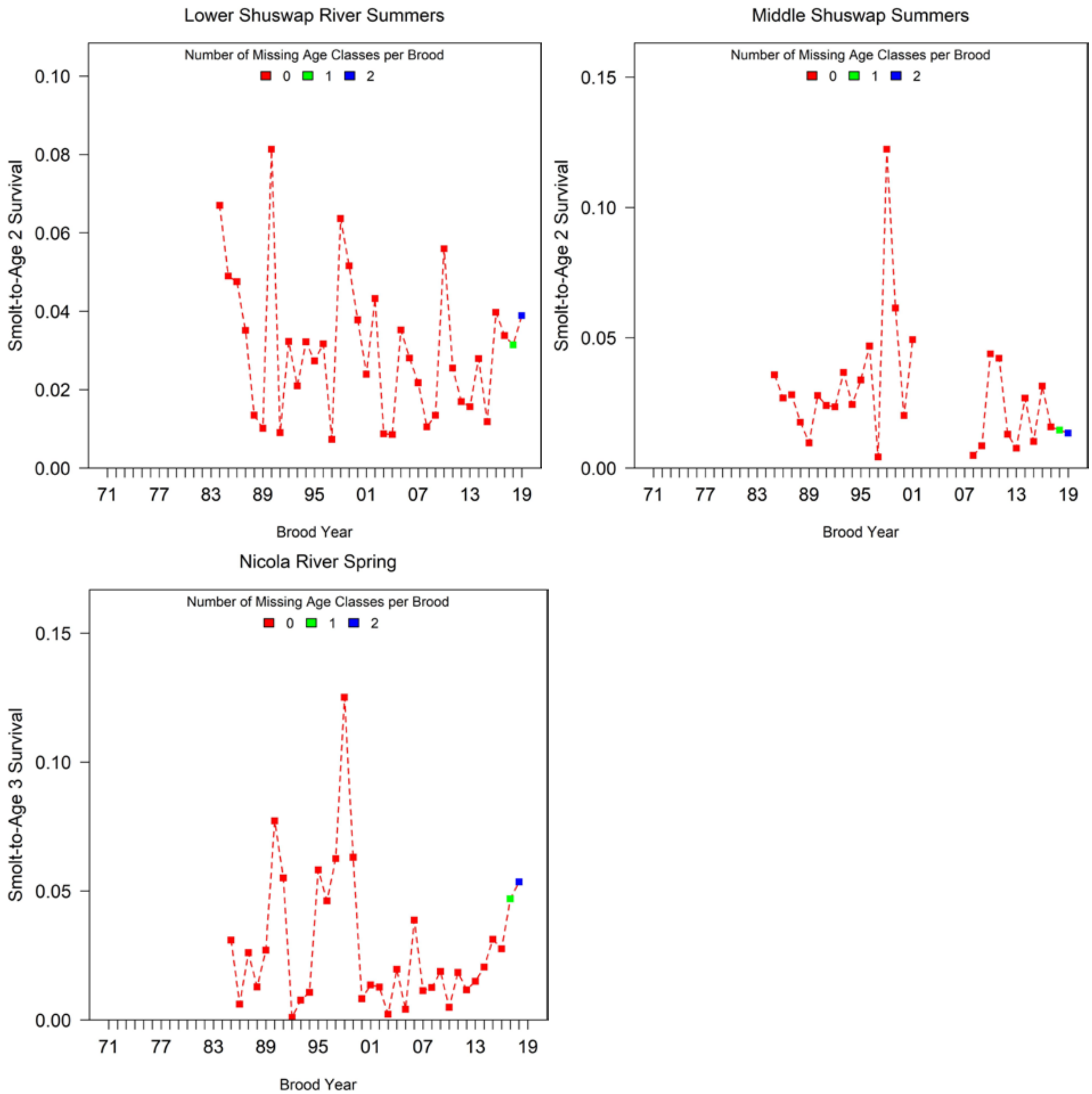


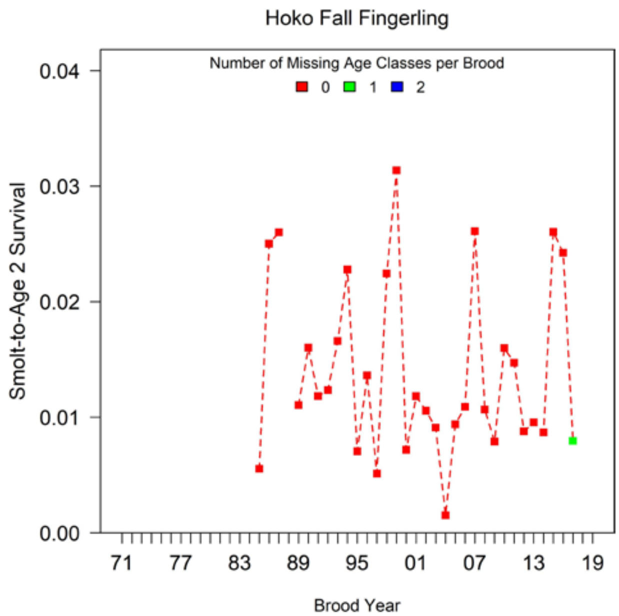
Appendix E6— Smolt-to-youngest age survival rates for Fraser fall-run stocks.

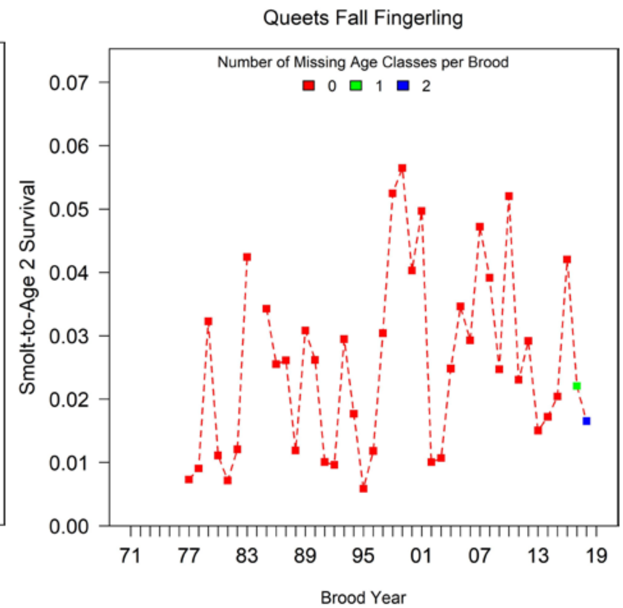


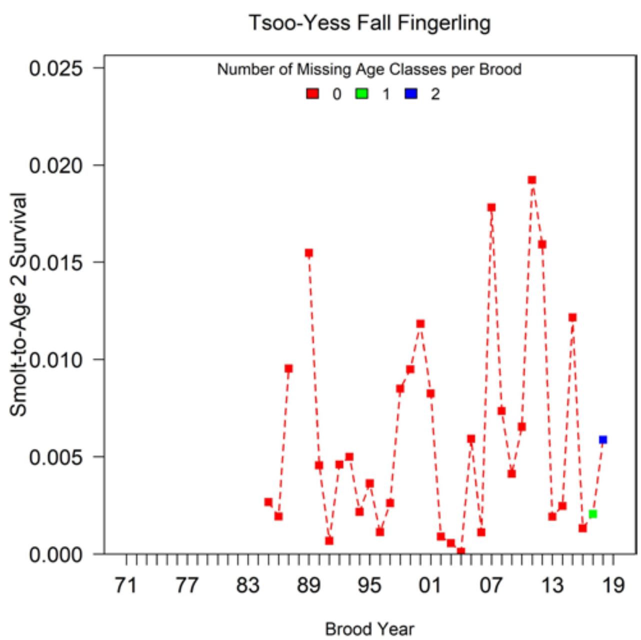
Appendix E7— Smolt-to-youngest age survival rates for Fraser spring- and summer-run stocks.



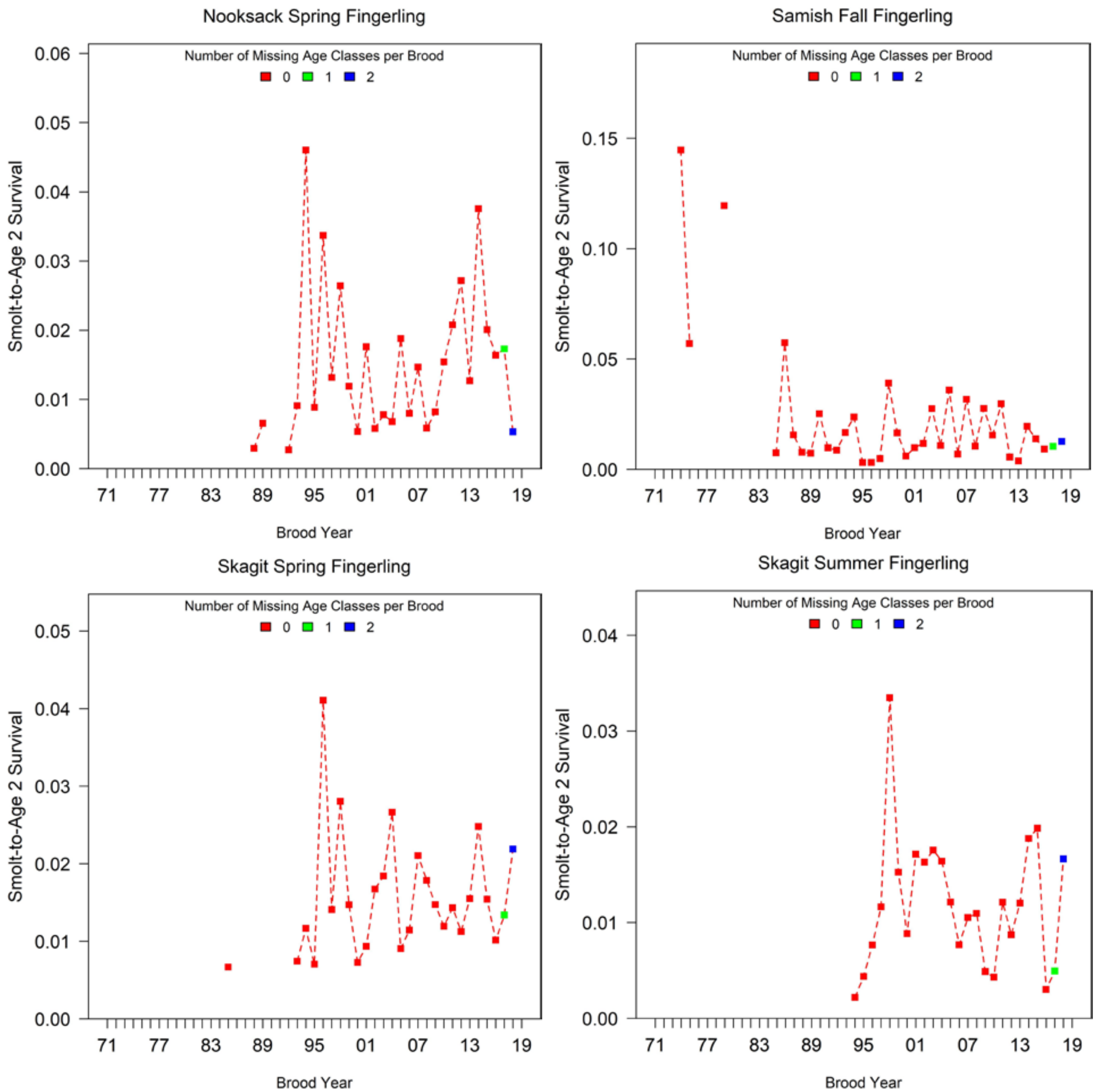
Appendix E8— Smolt-to-youngest age survival rates for Washington Coast coded-wire tag indicator stocks of Hoko, Queets, and Tsoo-Yess Fall Fingerling.



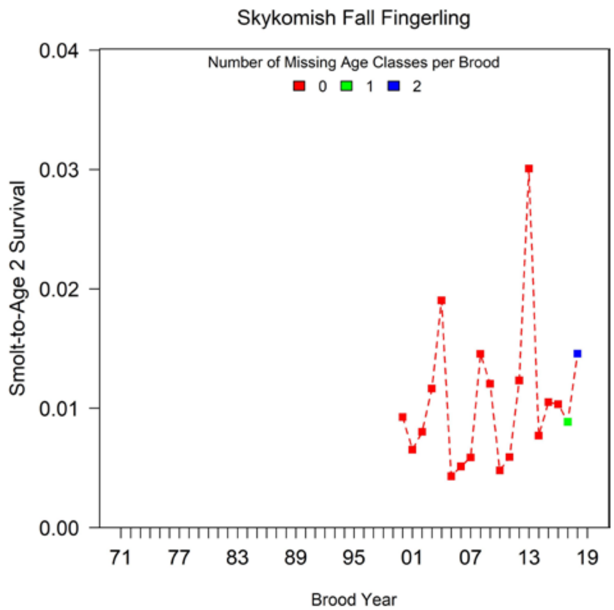


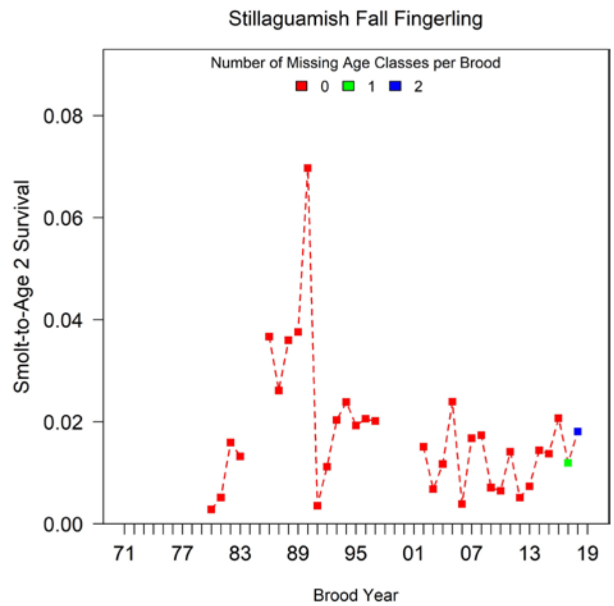


Appendix E9— Smolt-to-youngest age survival rates for Northern Puget Sound coded-wire tag indicator stocks.

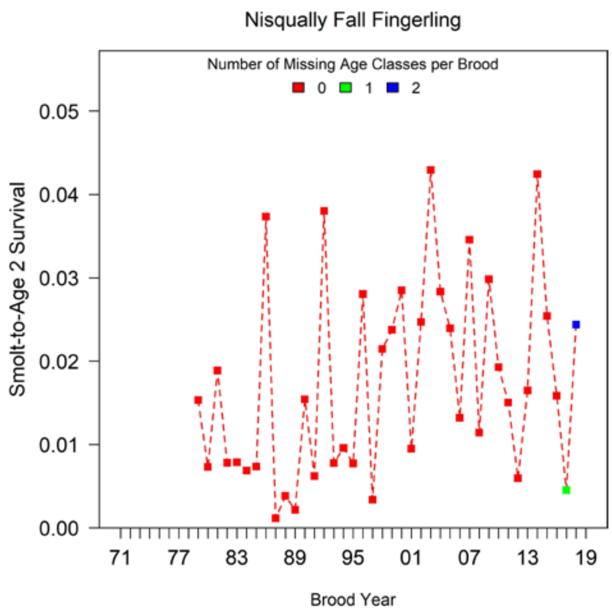


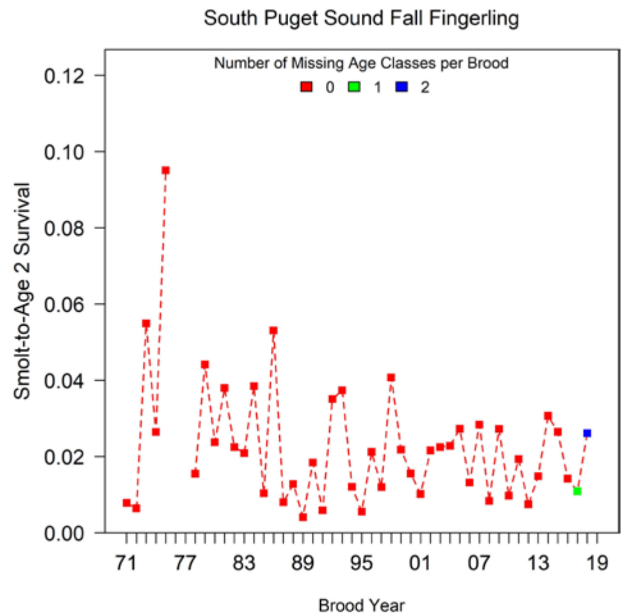
Appendix E10— Smolt-to-youngest age survival rates for Central Puget Sound coded-wire tag indicator stocks Stillaguamish Fall Fingerling and Skykomish Fall Fingerling.



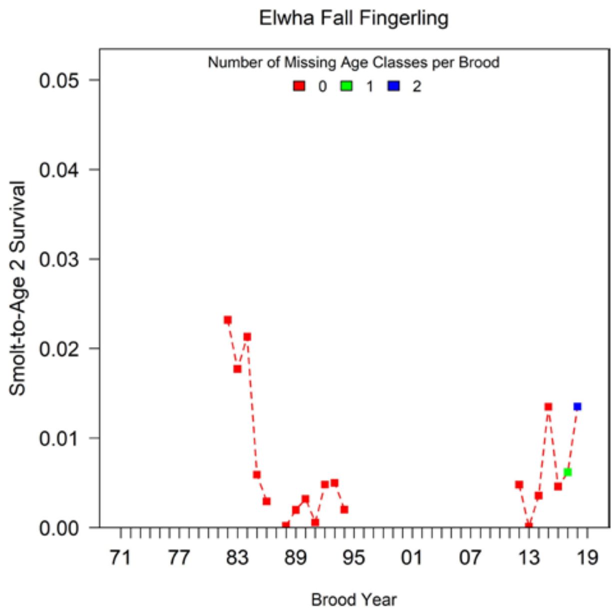


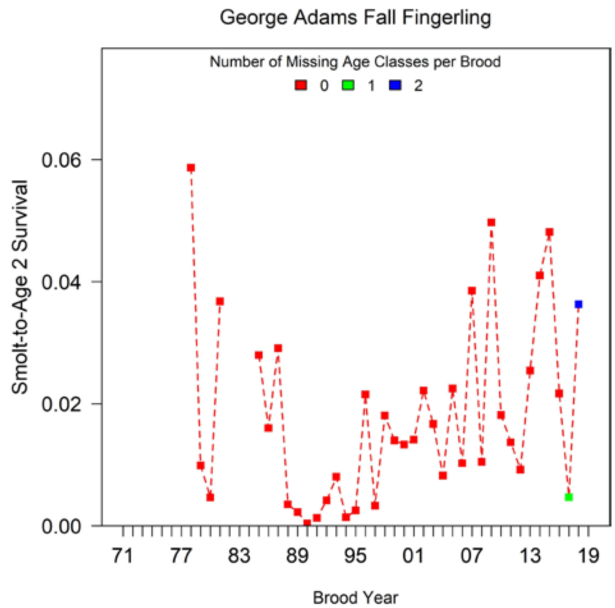
Appendix E11— Smolt-to-youngest age survival rates for Southern Puget Sound coded-wire tag indicator stocks.



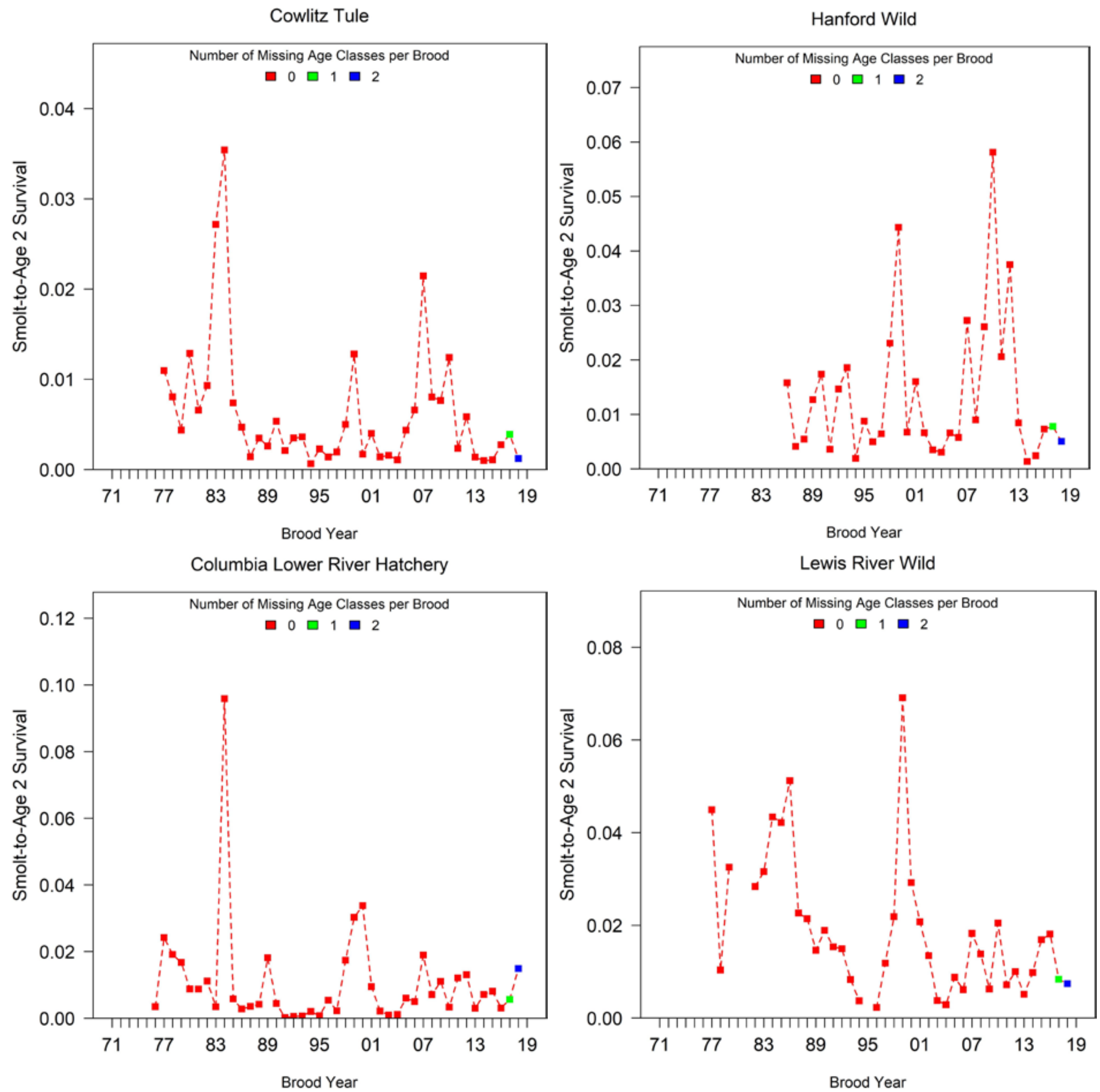


Appendix E12— Smolt-to-youngest age survival rates for Juan de Fuca and Hood Canal coded-wire tag indicator stocks Elwha River and George Adams (Skokomish River) Fall Fingerling.

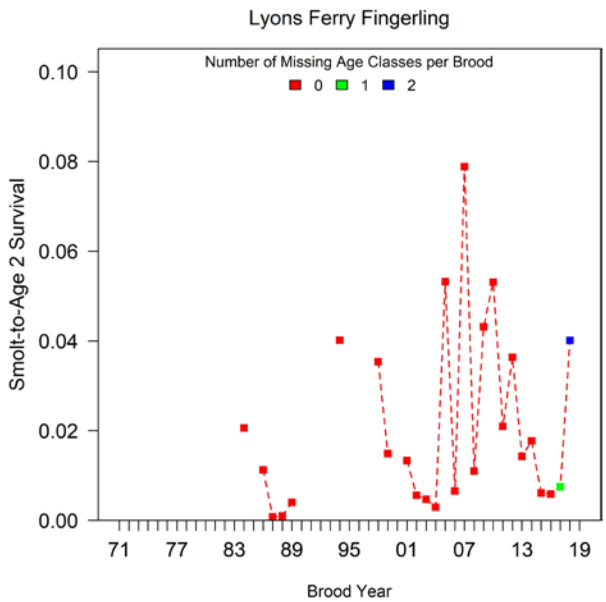


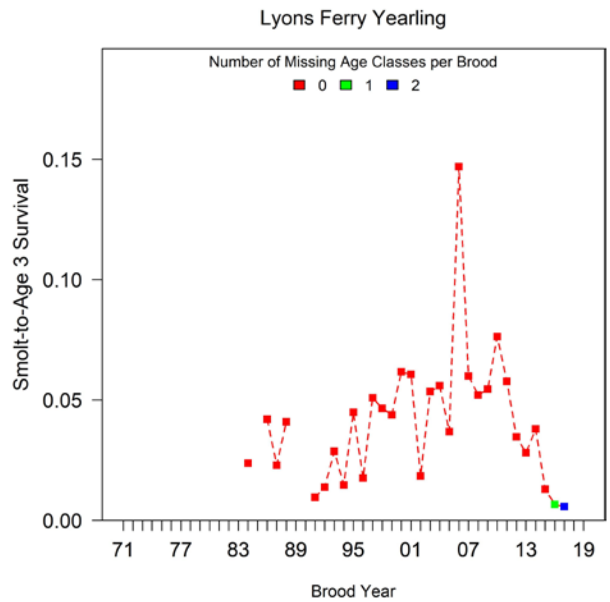


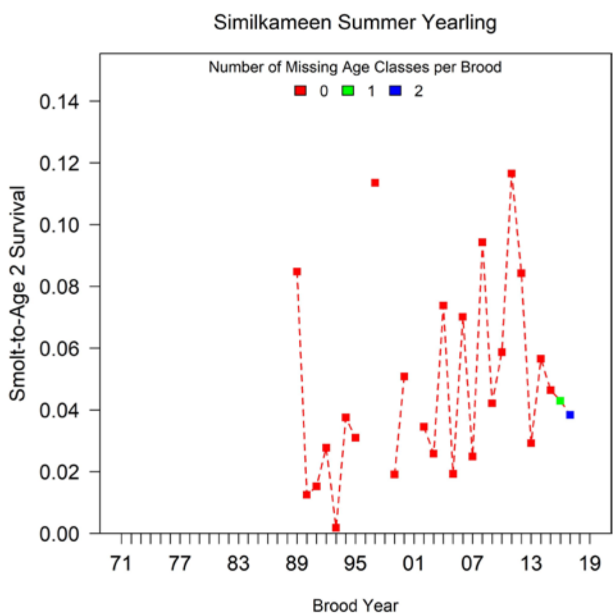
Appendix E13— Smolt-to-youngest age survival rates for summer and fall Columbia River, including Willamette Spring, Chinook coded-wire tag indicator stocks.

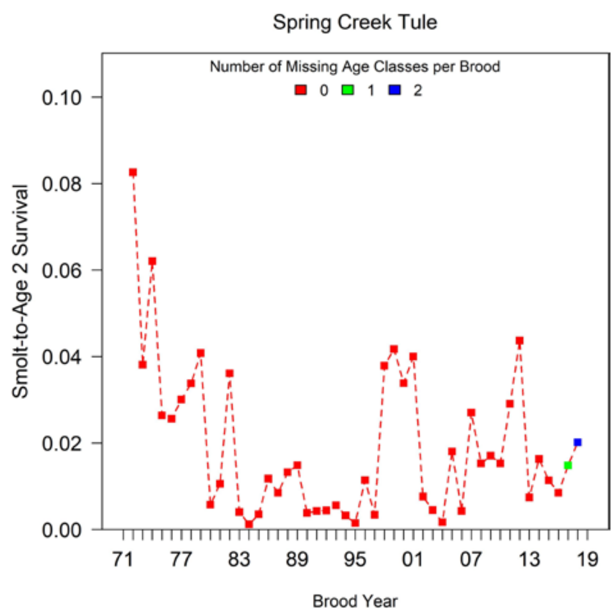


Appendix E13 continued.

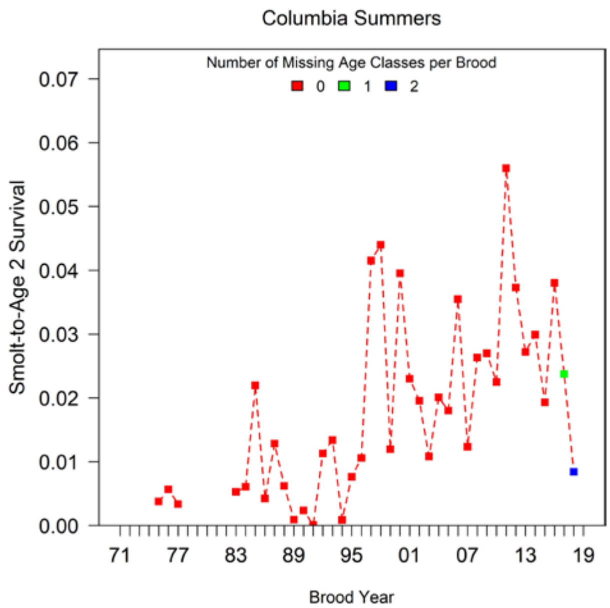


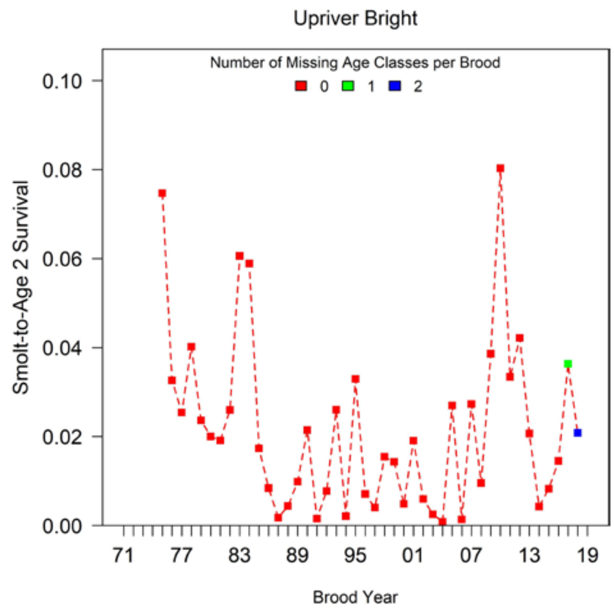


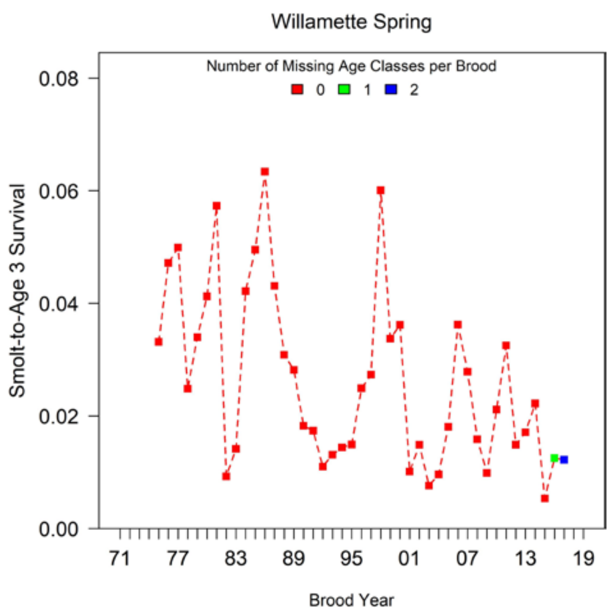




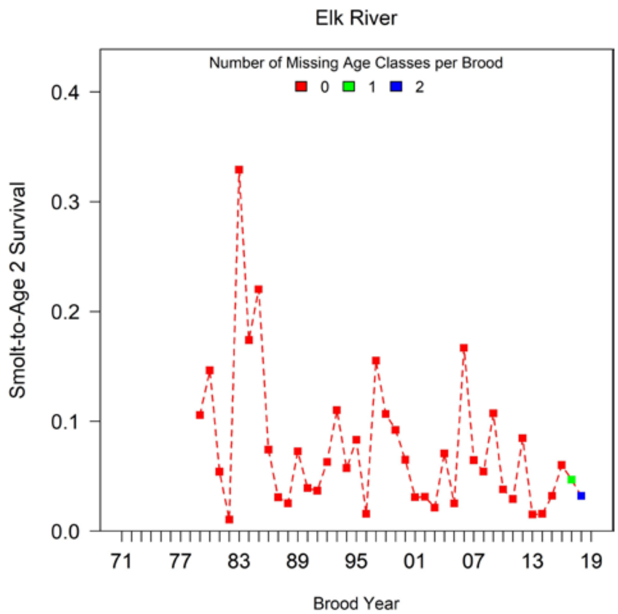
Appendix E13 continued.

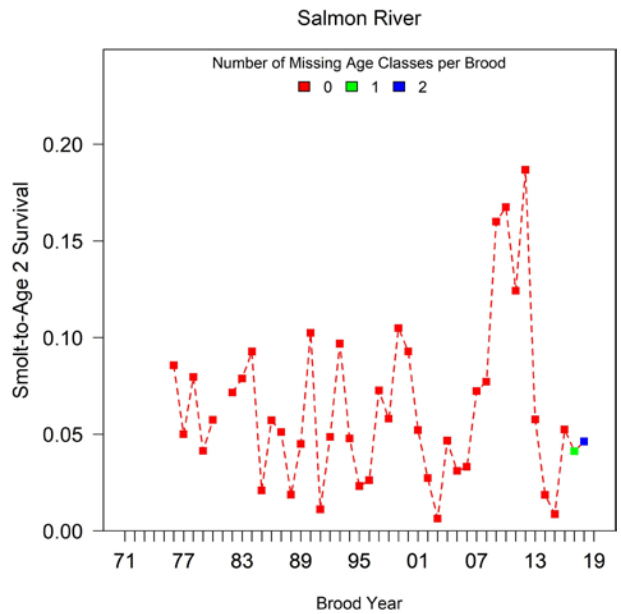






Appendix E14— Smolt-to-youngest age survival rates for North Oregon Coast coded-wire tag indicator stocks.





Appendix F: Terminal Area Adjustment Data

Attachment I of Chapter 3 of the 2019 PST Agreement identifies 11 escapement indicator stocks that require adjustments to CWT recovery rates in terminal fisheries for corresponding exploitation rate indicator stocks to accurately represent the fishery impacts on the associated escapement indicator stock. Details of terminal adjustment methodologies are available in CYER WG (2021).

Each table in this appendix presents the terminal harvest rates for a given exploitation rate indicator stock (left-most stock in the table) and the corresponding escapement indicator stocks. Terminal harvest rates are defined as terminal catch in each terminal fishery divided by the sum of all terminal catch and escapement. For exploitation rate indicator stocks the terminal harvest rates are derived directly from results of the CWT cohort analysis. For escapement indicator stocks, terminal harvest rates are derived externally and provided by the relevant management entities.

Fishery Acronym	ERA Fishery
TWCVI TERM N	West Coast Vancouver Island Terminal Net
TWCVI TERM S	West Coast Vancouver Island Terminal Sport
TWCVI FS	West Coast Vancouver Island Terminal Freshwater Sport
TJNST TERM S	Johnstone Strait Terminal Sport
TGS FS	Strait of Georgia Terminal Freshwater Sport
WA CST N	Washington Coast Net
TWAC FN	Washington Coast Terminal Freshwater Net
TNF TERM S	North of Falcon Terminal Sport
TSF TERM FS	South of Falcon Terminal Freshwater Sport
TOR TERM FS	Oregon Terminal Freshwater Sport

LIST OF APPENDIX F TABLES

Appendix F1— Robertson Creek Fall (RBT) harvest rate and terminally adjusted harvest rates for the Northwest Vancouver Island (NWVI) and Southwest Vancouver Island (SWVI) escapement indicator stocks, 1979–2022.

	Robertson Creek Fall			Northwest Vancouver Island			Southwest Vancouver Island		
Year	TWCVI TERM N	TWCVI TERM S	TWCVI FS	TWCVI TERM N	TWCVI TERM S	TWCVI FS	TWCVI TERM N	TWCVI TERM S	TWCVI FS
1979	0%	14%	1%	0%	0%	0%	0%	0%	0%
1980	28%	9%	0%	0%	0%	0%	0%	0%	0%
1981	36%	15%	1%	0%	0%	0%	0%	0%	0%
1982	42%	19%	0%	0%	0%	0%	0%	0%	0%
1983	55%	17%	1%	0%	0%	0%	0%	0%	0%
1984	41%	39%	0%	0%	0%	0%	0%	0%	0%
1985	3%	37%	0%	0%	0%	0%	0%	0%	0%
1986	1%	54%	0%	0%	0%	0%	0%	0%	0%
1987	0%	29%	0%	0%	0%	0%	0%	0%	0%
1988	11%	21%	1%	0%	0%	0%	0%	0%	0%
1989	26%	26%	1%	0%	0%	0%	0%	0%	0%
1990	14%	14%	0%	0%	0%	0%	0%	0%	0%
1991	25%	24%	0%	0%	0%	0%	0%	0%	0%
1992	1%	13%	0%	0%	0%	0%	0%	0%	0%
1993	14%	24%	1%	0%	0%	0%	0%	0%	0%
1994	22%	31%	1%	0%	0%	0%	0%	0%	0%
1995	9%	12%	0%	0%	0%	0%	0%	0%	0%
1996	0%	3%	0%	0%	0%	0%	0%	0%	0%
1997	9%	27%	0%	0%	0%	0%	0%	0%	0%
1998	7%	27%	0%	0%	0%	0%	0%	0%	0%
1999	10%	29%	0%	0%	0%	0%	0%	0%	0%
2000	0%	0%	0%	0%	0%	0%	0%	0%	0%
2001	0%	1%	0%	0%	0%	0%	0%	0%	0%
2002	10%	21%	0%	0%	0%	0%	0%	0%	0%
2003	11%	22%	0%	0%	0%	0%	0%	0%	0%
2004	18%	20%	0%	0%	0%	0%	0%	0%	0%
2005	51%	10%	1%	0%	0%	0%	0%	0%	0%
2006	36%	15%	0%	0%	0%	0%	0%	0%	0%
2007	45%	21%	0%	0%	0%	0%	0%	0%	0%
2008	27%	17%	0%	0%	0%	0%	0%	0%	0%
2009	11%	21%	2%	0%	0%	0%	0%	0%	0%
2010	6%	3%	1%	0%	0%	0%	0%	0%	0%
2011	27%	26%	0%	0%	0%	0%	0%	0%	0%
2012	22%	23%	0%	0%	0%	0%	0%	0%	0%
2013	0%	3%	0%	0%	0%	0%	0%	0%	0%
2014	0%	8%	0%	0%	0%	0%	0%	0%	0%
2015	15%	13%	0%	0%	0%	0%	0%	0%	0%
2016	10%	11%	0%	0%	0%	0%	0%	0%	0%
2017	25%	16%	0%	0%	0%	0%	0%	0%	0%
2018	44%	14%	0%	0%	0%	0%	0%	0%	0%
2019	52%	13%	0%	0%	0%	0%	0%	0%	0%
2020	53%	9%	0%	0%	0%	0%	0%	0%	0%
2021	46%	9%	0%	0%	0%	0%	0%	0%	0%
2022	39%	9%	0%	0%	0%	0%	0%	0%	0%

Appendix F2— Quinsam Hatchery (QUI) harvest rate and terminally adjusted harvest rates for the East Vancouver Island North (EVIN) escapement indicator stock, 1979–2022.

	Quinsam Hatchery		East Vancouver Island North	
Year	**TJNST TERM S**	**TGS FS**	**TJNST TERM S**	**TGS FS**
1979	1%	0%	0%	0%
1980	8%	0%	0%	0%
1981	0%	0%	0%	0%
1982	2%	0%	0%	0%
1983	4%	0%	0%	0%
1984	7%	0%	0%	0%
1985	1%	1%	0%	0%
1986	4%	0%	0%	0%
1987	9%	0%	0%	0%
1988	3%	0%	0%	0%
1989	1%	0%	0%	0%
1990	13%	0%	0%	0%
1991	8%	0%	0%	0%
1992	1%	0%	0%	0%
1993	6%	0%	0%	0%
1994	2%	0%	0%	0%
1995	5%	0%	0%	0%
1996	4%	0%	0%	0%
1997	6%	0%	0%	0%
1998	5%	0%	0%	0%
1999	16%	0%	0%	0%
2000	2%	0%	0%	0%
2001	0%	0%	0%	0%
2002	5%	0%	0%	0%
2003	7%	0%	0%	0%
2004	5%	0%	0%	0%
2005	12%	0%	0%	0%
2006	2%	0%	0%	0%
2007	5%	0%	0%	0%
2008	1%	0%	0%	0%
2009	3%	0%	0%	0%
2010	11%	0%	0%	0%
2011	5%	0%	0%	0%
2012	7%	0%	0%	0%
2013	3%	0%	0%	0%
2014	2%	0%	0%	0%
2015	2%	0%	0%	0%
2016	7%	0%	0%	0%
2017	6%	0%	0%	0%
2018	5%	0%	0%	0%
2019	1%	0%	0%	0%
2020	6%	0%	0%	0%
2021	3%	0%	0%	0%
2022	4%	0%	0%	0%

Appendix F3— Queets River Fall (QUE) harvest rate and terminally adjusted harvest rates for the Grays Harbor, Hoh River, and Quillayute River escapement indicator stocks, 1979–2021.

	Queets River Fall			Grays Harbor			Hoh			Quillayute		
Year	**WA CST N**	**TWAC FN**	**TNF TERM S**	**WA CST N**	**TWAC FN**	**TNF TERM S**	**WA CST N**	**TWAC FN**	**TNF TERM S**	**WA CST N**	**TWAC FN**	**TNF TERM S**
1979	NA	NA	NA	0%	19%	0%	0%	21%	1%	0%	38%	3%
1980	NA	NA	NA	0%	48%	0%	0%	21%	1%	0%	10%	2%
1981	0%	57%	0%	0%	42%	1%	0%	22%	0%	0%	15%	1%
1982	0%	53%	0%	0%	58%	1%	0%	22%	0%	0%	26%	1%
1983	0%	48%	0%	0%	39%	1%	0%	19%	5%	0%	42%	2%
1984	0%	60%	0%	0%	7%	2%	0%	24%	3%	0%	12%	1%
1985	0%	32%	0%	0%	35%	3%	0%	36%	1%	0%	24%	2%
1986	0%	13%	0%	0%	34%	2%	0%	14%	3%	0%	21%	4%
1987	0%	38%	0%	0%	38%	1%	0%	30%	5%	0%	38%	2%
1988	0%	24%	0%	0%	24%	5%	0%	37%	3%	0%	27%	4%
1989	0%	42%	0%	0%	50%	4%	0%	38%	3%	0%	40%	2%
1990	0%	19%	0%	0%	52%	5%	0%	31%	3%	0%	17%	2%
1991	0%	26%	0%	0%	44%	11%	0%	41%	5%	0%	13%	5%
1992	0%	33%	0%	0%	40%	8%	0%	19%	4%	0%	16%	2%
1993	0%	31%	0%	0%	46%	11%	0%	17%	6%	0%	8%	0%
1994	0%	41%	0%	0%	40%	12%	0%	6%	2%	0%	9%	5%
1995	0%	41%	1%	0%	41%	17%	0%	18%	6%	0%	9%	9%
1996	0%	22%	0%	0%	17%	22%	0%	21%	5%	0%	16%	5%
1997	0%	36%	0%	0%	31%	9%	0%	36%	5%	0%	6%	5%
1998	0%	18%	7%	0%	21%	14%	0%	16%	5%	0%	11%	4%
1999	0%	10%	0%	0%	16%	1%	0%	21%	14%	0%	26%	4%
2000	0%	4%	0%	0%	29%	11%	0%	16%	18%	0%	15%	8%
2001	0%	18%	0%	0%	33%	17%	0%	23%	14%	0%	23%	9%
2002	0%	30%	0%	0%	6%	18%	0%	20%	2%	0%	33%	3%
2003	0%	17%	0%	0%	5%	4%	0%	21%	8%	0%	15%	7%
2004	0%	14%	0%	0%	9%	14%	0%	18%	8%	0%	18%	20%
2005	0%	22%	0%	0%	11%	1%	0%	17%	4%	0%	17%	6%
2006	0%	22%	0%	0%	16%	6%	0%	26%	8%	0%	26%	0%
2007	1%	35%	0%	0%	16%	9%	0%	28%	8%	0%	22%	4%
2008	0%	29%	0%	0%	14%	2%	0%	16%	7%	0%	27%	4%
2009	0%	33%	0%	0%	24%	7%	0%	20%	5%	0%	41%	6%
2010	0%	22%	0%	0%	19%	9%	0%	10%	9%	0%	26%	8%
2011	0%	33%	0%	0%	24%	10%	0%	23%	17%	0%	29%	13%
2012	0%	51%	0%	0%	23%	17%	0%	28%	7%	0%	42%	5%
2013	0%	42%	0%	0%	15%	18%	0%	48%	14%	0%	29%	15%
2014	0%	25%	0%	0%	26%	5%	0%	23%	5%	0%	56%	6%
2015	0%	12%	0%	0%	31%	11%	0%	19%	7%	0%	36%	13%
2016	0%	21%	0%	0%	12%	14%	0%	4%	2%	0%	26%	1%
2017	0%	35%	0%	0%	14%	10%	0%	20%	8%	0%	50%	5%
2018	0%	29%	0%	0%	10%	12%	0%	5%	3%	0%	30%	11%
2019	0%	40%	0%	0%	12%	8%	0%	29%	11%	0%	15%	8%
2020	0%	48%	0%	0%	13%	6%	0%	30%	9%	0%	15%	7%
2021	0%	47%	0%	0%	13%	6%	0%	28%	5%	0%	10%	9%

Appendix F4— Salmon River Hatchery (SRH) harvest rate and terminally adjusted harvest rates for Nehalem, Siletz, and Siuslaw escapement indicator stocks, 1979–2021.

	Salmon River Hatchery	**Nehalem**	**Siletz**	**Siuslaw**
Year	**TSF TERM FS**	**TSF TERM FS**	**TSF TERM FS**	**TSF TERM FS**
1979	28%	5%	9%	18%
1980	32%	11%	10%	10%
1981	36%	4%	15%	14%
1982	36%	10%	10%	15%
1983	36%	9%	14%	35%
1984	33%	6%	10%	25%
1985	27%	4%	6%	13%
1986	68%	10%	7%	15%
1987	38%	14%	14%	22%
1988	19%	13%	8%	14%
1989	35%	11%	13%	18%
1990	39%	21%	8%	14%
1991	43%	25%	9%	17%
1992	22%	22%	9%	12%
1993	45%	40%	22%	52%
1994	27%	27%	6%	16%
1995	37%	35%	16%	24%
1996	62%	24%	11%	22%
1997	30%	18%	19%	32%
1998	33%	18%	9%	35%
1999	44%	15%	15%	16%
2000	25%	14%	15%	40%
2001	33%	19%	11%	29%
2002	48%	12%	10%	19%
2003	45%	11%	13%	17%
2004	37%	25%	45%	18%
2005	50%	18%	22%	23%
2006	58%	21%	17%	20%
2007	31%	18%	27%	44%
2008	20%	14%	25%	20%
2009	41%	1%	17%	22%
2010	55%	9%	7%	22%
2011	40%	16%	36%	33%
2012	38%	14%	18%	20%
2013	29%	19%	20%	36%
2014	27%	24%	20%	27%
2015	28%	28%	41%	36%
2016	18%	17%	21%	39%
2017	18%	19%	30%	36%
2018	29%	21%	29%	45%
2019	26%	14%	40%	51%
2020	18%	14%	16%	25%
2021	28%	24%	35%	38%

Appendix F5— Elk River Hatchery (ELK) harvest rate and terminally adjusted harvest rates for South Umpqua and Coquille escapement indicator stocks, 1979–2021.

	Elk River		South Umpqua		Coquille	
Year	**TOR TERM T**	**TSF TERM FS**	**TOR TERM T**	**TSF TERM FS**	**TOR TERM T**	**TSF TERM FS**
1979	NA	NA	0%	20%	0%	16%
1980	NA	NA	0%	22%	0%	12%
1981	NA	NA	0%	19%	0%	13%
1982	7%	76%	0%	21%	0%	8%
1983	8%	39%	0%	9%	0%	36%
1984	7%	24%	0%	9%	0%	11%
1985	4%	35%	0%	7%	0%	14%
1986	15%	25%	0%	15%	0%	11%
1987	8%	35%	0%	11%	0%	16%
1988	0%	47%	0%	10%	0%	13%
1989	15%	41%	0%	6%	0%	15%
1990	6%	45%	0%	10%	0%	13%
1991	0%	32%	0%	13%	0%	20%
1992	5%	45%	0%	10%	0%	12%
1993	15%	27%	0%	28%	0%	27%
1994	12%	41%	0%	11%	0%	24%
1995	9%	37%	0%	11%	0%	13%
1996	19%	14%	0%	13%	0%	18%
1997	16%	25%	0%	6%	0%	14%
1998	9%	12%	0%	43%	0%	19%
1999	19%	23%	0%	28%	0%	14%
2000	25%	23%	0%	26%	0%	20%
2001	11%	18%	0%	23%	0%	18%
2002	15%	15%	0%	14%	0%	17%
2003	23%	25%	0%	19%	0%	17%
2004	24%	9%	0%	20%	0%	19%
2005	25%	17%	0%	55%	0%	26%
2006	26%	16%	0%	37%	0%	23%
2007	23%	23%	0%	22%	0%	29%
2008	2%	24%	0%	20%	0%	15%
2009	2%	21%	0%	24%	0%	7%
2010	7%	14%	0%	31%	0%	10%
2011	21%	23%	0%	37%	0%	24%
2012	16%	21%	0%	35%	0%	28%
2013	23%	19%	0%	33%	0%	39%
2014	16%	18%	0%	30%	0%	25%
2015	22%	18%	0%	20%	0%	31%
2016	6%	19%	0%	36%	0%	19%
2017	11%	19%	0%	25%	0%	21%
2018	20%	18%	0%	24%	0%	58%
2019	13%	11%	0%	35%	0%	54%
2020	14%	18%	0%	28%	0%	6%
2021	8%	14%	0%	23%	0%	1%

APPENDIX G: FISHERY EXPLOITATION RATE INDICES BY STOCK, AGE AND FISHERY, BASED ON CODED-WIRE TAG DATA

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. Fishery indices (FI) provide a means to assess performance against this expectation. Relative to the 1979–1982 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. Fishery indices are used to measure relative changes in fishery harvest rates because it is not possible to directly estimate the fishery harvest rates.

Indices are presented for the AABM troll fisheries only, although allowable catch limits (ACLs) also apply to sport and net fisheries in SEAK, and sport fisheries in NBC and WCVI. CWT recoveries from the troll fisheries are used because they 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.

Ratio of Means

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 (see Appendix B2 for a description of notation):

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

Equation G.1

whereas the reported catch AEQ exploitation rate is estimated as

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

Equation G.2

and a ratio of means (ROM) estimator is used to calculate the FI:

$$FI_{f,CY} = \frac{\sum_{s\epsilon\{S\}} \sum_{a\epsilon\{A\}} ER_{s,a,f,CY}}{\left(\frac{\sum_{CY=1979}^{1982} \sum_{s\epsilon\{S\}} \sum_{a\epsilon\{A\}} ER_{s,a,f,CY}}{4}\right)}$$

Equation G.3

The ROM estimator of the fishery index constrains inclusion of stocks to those with adequate tagging during the 1979–1982 base period. However, 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).

Stratified Proportional Fishery Index

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

1. The index should measure changes in fishery harvest rates if the distribution of stocks is assumed to be 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 possibilities, the CTC concluded that the most appropriate index consisted 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) proposed this stratified proportional fishery indexwas the most accurate and precise index for estimating the harvest rate occurring in AABM fisheries. However, the SPFI was never fully implemented for the NBC and WCVI Troll fisheries for reasons described in CTC 2021a, which instead still rely on exploitation rate indices (Appendix G4–Appendix G8).

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 distribution parameter ($d_{t,s,a}$) is calculated (Equation G.4), and the result is substituted into Equation G.5 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 B for a description of notation):

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

Equation G.4

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

Equation G.5

The resulting unique solution is inserted into the following equations to compute the yearly harvest rates for each stratum (Equation G.8) and the overall fishery harvest rate (Equation G.9).

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

Equation G.6

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

Equation G.7

$$S_{t,CY} = H_{t,CY} \Big/ \left[\sum_{CY=1979}^{1982} H_{t,CY} \Big/ 4 \right]$$

Equation G.8

$$S_{CY} = H_{CY} \Big/ \left[\sum_{CY=1979}^{1982} H_{CY} \Big/ 4 \right]$$

Equation G.9

LIST OF APPENDIX G TABLES

Appendix G1– Exploitation rate stocks and age classes that contribute to the Alaska troll Stratified Proportion Fishery Index (SPFI).

Exploitation Rate Stock Identifiers	**Age Classes**		
Atnarko	Age 4	Age 5	
Elk	Age 4	Age 5	
Kitsumkalum	Age 5		
Northern Southeast Alaska	Age 5	Age 6	
Queets	Age 4	Age 5	
Quinsam	Age 4	Age 5	
Robertson Creek	Age 3	Age 4	Age 5
Shuswap	Age 3	Age 4	
Salmon River Hatchery	Age 3	Age 4	Age 5
Southern Southeast Alaska	Age 4	Age 5	Age 6
Skagit Summer Fingerling	Age 4		
Columbia River Summers	Age 4	Age 5	
Columbia Upriver Brights	Age 4	Age 5	
Willamette Spring Hatchery	Age 4	Age 5	

Appendix G2– Alaska troll Stratified Proportion Fishery Index (SPFI) values as landed catch, based on CWT data. OUT = outside waters, IN = inside waters.

YEAR	SP	WIN/SPR	JUNE OUT	JUNE IN	JULY OUT	JULY IN	FALL
1979	0.8	1.24	1.07	0.64	0.72	0.37	0.72
1980	1.2	0.63	0.94	1.45	1.59	1.82	1.59
1981	1.1	1.17	1.12	0.90	1.06	0.89	1.06
1982	0.8	0.96	0.87	1.01	0.64	0.92	0.64
1983	0.9	1.03	0.60	0.67	1.21	1.02	1.21
1984	0.6	0.39	0.97	0.97	0.49	0.25	0.49
1985	0.6	0.43	0.52	0.67	0.75	0.70	0.75
1986	0.3	0.44	0.14	0.32	1.20	0.49	1.20
1987	0.4	0.53	0.18	0.48	0.58	1.24	0.58
1988	0.3	1.31	0.00	0.14	0.64	1.22	0.64
1989	0.4	0.84	0.19	0.38	0.49	0.49	0.49
1990	0.6	0.61	0.10	0.83	1.13	1.10	1.13
1991	0.6	1.31	0.21	0.84	0.81	0.56	0.81
1992	0.4	1.14	0.07	0.44	0.41	0.23	0.41
1993	0.4	0.83	0.02	0.26	0.87	0.28	0.87
1994	0.4	0.72	0.04	0.11	0.63	0.16	0.63
1995	0.4	0.44	0.04	0.28	0.73	0.86	0.73
1996	0.3	0.50	0.08	0.50	0.53	0.44	0.53
1997	0.6	0.60	0.13	0.50	1.38	0.09	1.38
1998	0.4	0.76	0.05	0.17	0.94	0.45	0.94
1999	0.5	0.84	0.10	0.23	0.90	0.10	0.90
2000	0.4	1.04	0.08	0.10	1.37	0.05	1.37
2001	0.3	0.60	0.07	0.14	0.76	0.09	0.76
2002	0.5	0.83	0.06	0.13	1.36	0.18	1.36
2003	0.4	1.27	0.07	0.12	0.89	0.28	0.89
2004	0.3	0.74	0.06	0.16	0.89	0.31	0.89
2005	0.4	0.75	0.11	0.21	1.09	0.48	1.09
2006	0.6	1.29	0.11	0.61	1.19	0.12	1.19
2007	0.6	1.09	0.14	0.83	1.22	0.21	1.22
2008	0.4	0.79	0.08	0.77	0.77	0.11	0.77
2009	0.5	0.89	0.14	0.37	1.00	0.16	1.00
2010	0.4	1.16	0.06	0.28	0.78	0.09	0.78
2011	0.4	1.06	0.04	0.32	0.88	0.25	0.88
2012	0.6	1.41	0.09	0.21	1.32	0.10	1.32
2013	0.3	0.70	0.11	0.54	0.54	0.12	0.54
2014	0.5	1.31	0.08	0.53	0.94	0.14	0.94
2015	0.4	1.23	0.09	1.43	0.67	0.48	0.67
2016	0.6	2.05	0.11	0.65	1.09	0.15	1.09
2017	0.3	1.26	0.10	0.34	0.46	0.35	0.46
2018	0.2	0.48	0.04	0.01	0.76	0.30	0.76
2019	0.1	0.44	0.04	0.01	0.52	0.19	0.52
2020	0.5	0.71	0.09	0.02	1.02	0.21	1.02
2021	0.4	0.75	0.08	0.03	0.99	0.49	0.99

Appendix G3– Alaska troll Stratified Proportion Fishery Index (SPFI) values as total mortality, based on CWT data. OUT = outside waters, IN = inside waters.

YEAR	SPFI	WIN/SPR	JUNE OUT	JUNE IN	JULY OUT	JULY IN	FALL
1979	0.81	1.28	1.11	0.62	0.70	0.36	0.70
1980	1.20	0.62	0.90	1.50	1.43	1.75	1.43
1981	1.12	1.15	1.12	0.86	1.10	0.85	1.10
1982	0.86	0.95	0.86	1.02	0.78	1.04	0.78
1983	1.05	0.99	0.58	0.67	1.52	0.95	1.52
1984	0.65	0.38	0.97	0.97	0.58	0.38	0.58
1985	0.70	0.40	0.50	0.64	0.95	0.65	0.95
1986	0.41	0.42	0.13	0.31	1.36	0.50	1.36
1987	0.49	0.51	0.17	0.47	0.71	1.62	0.71
1988	0.39	1.28	0.00	0.14	0.64	1.32	0.64
1989	0.52	0.80	0.19	0.36	0.54	0.56	0.54
1990	0.77	0.63	0.11	0.89	1.38	1.14	1.38
1991	0.62	1.23	0.20	0.81	0.85	0.67	0.85
1992	0.46	1.10	0.06	0.43	0.57	0.23	0.57
1993	0.54	0.81	0.02	0.26	1.02	0.30	1.02
1994	0.47	0.69	0.03	0.12	0.80	0.17	0.80
1995	0.47	0.42	0.04	0.28	0.85	0.86	0.85
1996	0.44	0.48	0.08	0.50	0.68	0.48	0.68
1997	0.65	0.56	0.13	0.48	1.36	0.09	1.36
1998	0.42	0.72	0.04	0.17	0.87	0.41	0.87
1999	0.60	0.79	0.09	0.23	0.99	0.13	0.99
2000	0.49	1.00	0.08	0.10	1.43	0.08	1.43
2001	0.39	0.57	0.06	0.13	0.76	0.11	0.76
2002	0.52	0.76	0.06	0.13	1.27	0.18	1.27
2003	0.45	1.18	0.06	0.12	0.83	0.26	0.83
2004	0.37	0.71	0.06	0.16	0.86	0.30	0.86
2005	0.47	0.73	0.11	0.21	1.06	0.46	1.06
2006	0.59	1.23	0.10	0.60	1.13	0.12	1.13
2007	0.67	1.07	0.14	0.86	1.19	0.20	1.19
2008	0.44	0.75	0.07	0.75	0.80	0.13	0.80
2009	0.57	0.84	0.13	0.37	0.98	0.19	0.98
2010	0.43	1.15	0.06	0.29	0.80	0.09	0.80
2011	0.39	1.00	0.04	0.31	0.83	0.23	0.83
2012	0.66	1.36	0.09	0.21	1.24	0.12	1.24
2013	0.39	0.66	0.11	0.53	0.57	0.21	0.57
2014	0.50	1.24	0.08	0.53	0.88	0.14	0.88
2015	0.46	1.18	0.08	1.40	0.64	0.51	0.64
2016	0.59	1.91	0.10	0.65	1.02	0.15	1.02
2017	0.38	1.19	0.09	0.33	0.48	0.41	0.48
2018	0.25	0.45	0.04	0.01	0.76	0.28	0.76
2019	0.20	0.41	0.04	0.01	0.53	0.22	0.53
2020	0.51	0.68	0.09	0.02	0.95	0.20	0.95
2021	0.47	0.71	0.08	0.04	0.92	0.46	0.92

Appendix G4– List of stock acronyms used in landed catch and total mortality exploitation rate tables below (Appendices G4–G7).

Acronym	**Stock Name**
CWF	Cowlitz Fall Tule
GAD	George Adams Fall Fingerling
LRH	Lower River Hatchery
LRW	Lewis River Wild
QUE	Queets Fall Fingerling
QUI	Quinsam Fall
RBT	Robertson Creek Hatchery
SAM	Samish Fall Fingerling
SHU	Lower Shuswap
SPR	Spring Creek National Fish Hatchery
SPS	South Puget Sound Fall Fingerling
SRH	Salmon River Hatchery
SSA	Southern Southeast Alaska
SUM	Columbia River Summers
URB	Columbia Upriver Brights
WSH	Willamette Spring

Appendix G5– Landed catch exploitation rate indices by stock and age in the Northern British Columbia troll fishery, based on coded-wire tag (CWT) data. Values shaded in gray are averages across years.

Year	QUE Age 5	QUI Age 3	QUI Age 4	RBT Age 3	RBT Age 4	RBT Age 5	SHU Age 4	SRH Age 3	SRH Age 4	SRH Age 5	SSA Age 4	URB Age 4	URB Age 5	WSH Age 4	Fishery Index
1979		0.55	0.87	1.15	0.83	0.48		1.17				1.10		0.65	0.83
1980		0.79	0.98	1.05	0.85	0.77			0.93			1.02	1.14	1.18	0.94
1981		1.78	1.44	0.85	1.04	1.75		1.28		1.00		1.27	1.50	1.53	1.28
1982		0.88	0.71	0.95	1.28		1.00	0.55	1.07		1.00	0.61	0.36	0.64	0.86
2009			0.11	0.19	0.21		0.66	0.01	1.36	0.93		1.77		0.00	0.68
2010		0.00		0.13	0.09		0.81	0.21	1.10	0.42				0.14	0.44
2011		0.00	0.00	0.00	0.32		0.69	0.06	0.91	0.54		0.56		0.06	0.42
2012			0.10	0.08	0.21	0.36	0.96	0.04	1.40	0.70	0.22	1.46	2.48	0.09	0.73
2013			0.12	0.01	0.18	0.14	0.67	0.02	0.92	0.74		0.83		0.11	0.45
2014		0.00	0.00		0.24		0.62	0.08	0.72	0.28		0.95	1.53	0.17	0.46
2015		0.00	0.00	0.03		0.00	0.36	0.04	0.62	0.43		0.39	0.92	0.15	0.30
2016		0.00	0.04	0.09	0.17		0.99	0.06	2.06	0.91		1.58	1.91	0.33	0.82
2017		0.08	0.11	0.10	0.21	0.16	0.70	0.00	1.96	1.09		1.11	1.74	0.14	0.70
2018		0.11	0.32	0.24	0.50	0.36	0.40	0.06	3.25	1.58		1.56	2.11	0.25	1.00
2019		0.08	0.00	0.17	0.24		0.00	0.35	0.94	0.65		1.13		0.05	0.41
2020		0.07	0.23	0.20	0.17	0.34	0.00	0.12	0.79			0.68	0.27	0.06	0.27
2021		0.11	0.07	0.20	0.36	0.14	0.04	0.24	1.29	0.49		1.10	0.62	0.36	0.41
83-95	NA	0.49	0.87	0.43	0.85	0.94	1.11	0.21	0.86	0.95	0.93	1.26	1.90	0.39	0.90
96-98	NA	0.19	0.13	0.11	0.41	NA	0.40	0.09	0.40	0.26	0.00	0.25	1.09	0.04	0.27
99-08	NA	0.04	0.11	0.05	0.34	0.28	0.62	0.08	0.70	0.46	0.15	0.69	0.86	0.07	0.41
09-18	NA	0.03	0.09	0.10	0.24	0.20	0.69	0.06	1.43	0.76	0.22	1.13	1.78	0.14	0.60
19-21	NA	0.09	0.10	0.19	0.26	0.24	0.01	0.24	1.00	0.57	NA	0.97	0.45	0.16	0.36

Appendix G6– Total mortality exploitation rate indices by stock and age in the Northern British Columbia troll fishery, based on coded-wire tag (CWT) data. Values shaded in gray are averages across years.

Year	QUE Age 5	QUI Age 3	QUI Age 4	RBT Age 3	RBT Age 4	RBT Age 5	SHU Age 4	SRH Age 3	SRH Age 4	SRH Age 5	SSA Age 4	URB Age 4	URB Age 5	WSH Age 4	Fishery Index
1979		0.56	0.85	1.16	0.83	0.48		1.17				1.10		0.63	0.83
1980		0.79	0.98	1.02	0.85	0.77			0.94			1.03	1.14	1.14	0.94
1981		1.75	1.45	0.85	1.04	1.76		1.27		1.00		1.27	1.51	1.52	1.28
1982		0.89	0.72	0.96	1.28		1.00	0.56	1.06		1.00	0.60	0.35	0.70	0.86
2009			0.11	0.20	0.21		0.67	0.12	1.37	0.94		1.78		0.00	0.68
2010		0.00		0.16	0.09		0.82	0.26	1.11	0.42				0.14	0.44
2011		0.00	0.00	0.07	0.35		0.75	0.10	0.98	0.58		0.61		0.07	0.45
2012			0.10	0.13	0.21	0.38	0.96	0.09	1.41	0.71	0.25	1.43	2.47	0.10	0.72
2013			0.12	0.03	0.18	0.13	0.74	0.09	1.00	0.81		0.90		0.11	0.49
2014		0.00	0.00		0.24		0.63	0.13	0.73	0.28		0.96	1.52	0.17	0.46
2015		0.00	0.00	0.03		0.00	0.37	0.10	0.63	0.44		0.40	0.93	0.16	0.31
2016		0.00	0.04	0.11	0.17		1.00	0.31	2.09	0.92		1.62	1.91	0.31	0.84
2017		0.10	0.11	0.11	0.21	0.16	0.72	0.29	2.02	1.12		1.14	1.76	0.14	0.73
2018		0.15	0.33	0.27	0.51	0.36	0.41	0.25	3.25	1.59		1.55	2.13	0.27	1.00
2019		0.09	0.00	0.21	0.28		0.00	0.45	1.05	0.74		1.29		0.05	0.46
2020		0.09	0.22	0.23	0.18	0.36	0.00	0.17	0.81			0.70	0.26	0.07	0.28
2021		0.13	0.06	0.25	0.37	0.14	0.03	0.29	1.29	0.48		1.12	0.61	0.38	0.41
83-95	NA	0.56	0.89	0.54	0.86	0.95	1.14	0.33	0.88	0.96	1.04	1.29	1.91	0.42	0.93
96-98	NA	0.19	0.13	0.16	0.42	NA	0.41	0.15	0.41	0.27	0.11	0.28	1.07	0.06	0.29
99-08	NA	0.04	0.11	0.08	0.35	0.29	0.63	0.13	0.71	0.47	0.20	0.70	0.88	0.08	0.41
09-18	NA	0.04	0.09	0.12	0.24	0.21	0.71	0.17	1.46	0.78	0.25	1.16	1.79	0.15	0.61
19-21	NA	0.10	0.10	0.23	0.28	0.25	0.01	0.30	1.05	0.61	NA	1.04	0.44	0.16	0.38

Appendix G7– Landed catch exploitation rate indices by stock and age in the West Coast Vancouver Island (WCVI) troll fishery, based on coded-wire tag (CWT) data. Values shaded in gray are averages across years.

Year	CWF Age 4	GAD Age 3	GAD Age 4	LRH Age 3	LRH Age 4	LRW Age 4	RBT Age 3	RBT Age 4	RBT Age 5	SAM Age 3	SAM Age 4	SAM Age 5	SPR Age 3	SPR Age 4	SPS Age 3	SPS Age 4	SRH Age 3	SRH Age 4	SRH Age 5	SUM Age 4	URB Age 3	URB Age 4	WSH Age 4	Fishery Index
1979				1.16			1.17	1.26			1.00	1.00	0.97	0.84		1.13	1.57				1.12	1.63	1.03	1.06
1980				0.55	0.90		1.41	1.43					1.17	1.39				1.09		0.69	1.10	0.99	1.11	1.02
1981	0.79	0.73		1.14	0.79	0.85	0.67	0.58	1.00				0.94	0.63	0.72		0.43		1.00	1.31		0.99	0.63	0.87
1982	1.21	1.27	1.00	1.15	1.31	1.16	0.75	0.73		1.00			0.93	1.14	1.29	0.87		0.91			0.78	0.39	1.23	1.05
2009	0.00	0.64	0.52	0.19	0.22			0.00		0.67	0.16		0.16	0.06	0.57	0.19	0.04	0.04	0.10	0.40		0.11	0.15	0.22
2010	0.11	0.98	0.45	0.34			0.04	0.26		0.99	0.13		0.24	0.36	0.48	0.12	0.00	0.00	0.00	0.32	0.10		0.18	0.28
2011	0.07	0.43	0.22	0.41	0.75		0.00	0.00		0.00	0.42		0.25	0.59	0.05	0.21	0.12	0.56	0.43	0.21	0.00	0.33	0.41	0.33
2012	0.20	0.31	0.25	0.16	0.00		0.00	0.00	0.17	0.34	0.05		0.11	0.45	0.36	0.18	0.04	0.42	0.69	0.27	0.08	0.31	0.92	0.21
2013	0.06	0.20	0.24	0.18	0.14		0.00			0.14	0.09		0.15	0.14	0.03	0.20	0.04	0.07	0.00	0.18	0.04	0.25	0.22	0.15
2014	0.13	0.18	0.28	0.26		0.20		0.18		0.70	0.26		0.12	0.30	0.47	0.26	0.14	0.25	0.53	0.47	0.05	0.42	1.17	0.28
2015		0.08	0.09	0.21	0.33		0.01				0.15		0.09	0.22	0.23	0.12	0.09	0.14	0.36	0.07	0.03	0.09	0.12	0.16
2016	0.18	0.21	0.38	0.23	1.13		0.01	0.18			0.07		0.13	0.61	0.10	0.28	0.02	0.25	0.54	0.44	0.17	0.38	1.14	0.36
2017	0.33	0.46	0.18	0.52			0.12	0.13	0.15	0.81			0.32		0.42	0.22	0.00	0.18	0.29	0.39	0.25	0.21	1.13	0.32
2018	0.00	0.22	0.09	0.28			0.15	0.26		0.50	0.05		0.15		0.15	0.14		0.32	0.74	0.16	0.02	0.28	0.53	0.16
2019	0.08	0.11	0.03	0.07			0.14	0.13		0.19	0.06		0.09	0.00	0.25	0.06	0.12			0.00	0.06	0.23	0.00	0.07
2020	0.08	0.18	0.00	0.06	0.12	0.16	0.04	0.05	0.19	0.05	0.14		0.06		0.20	0.02	0.17	0.40		0.01	0.04	0.12	0.05	0.08
2021	0.14	0.21	0.00	0.15	0.14		0.17	0.13	0.00	0.31	0.04		0.08	0.00	0.15	0.08	0.64	0.84		0.07	0.17	0.32	0.12	0.11
83-95	0.90	0.82	0.84	1.10	1.24	0.74	0.69	0.90	1.64	0.49	0.60	1.09	0.78	0.79	0.75	0.65	0.79	0.72	1.88	1.02	0.54	1.14	0.44	0.84
96-98	0.19	0.10	0.37	0.00	NA	NA	0.00	0.02	NA	0.01	0.11	NA	0.17	0.20	0.01	0.11	0.00	0.01	0.00	0.02	0.01	0.03	0.02	0.11
99-08	0.46	0.41	0.90	0.36	1.09	0.31	0.01	0.01	0.00	0.48	0.56	NA	0.34	0.87	0.44	0.57	0.07	0.09	0.29	0.40	0.11	0.28	0.83	0.53
09-18	0.12	0.37	0.27	0.28	0.43	0.20	0.04	0.13	0.16	0.52	0.15	NA	0.17	0.34	0.29	0.19	0.06	0.22	0.37	0.29	0.08	0.27	0.60	0.25
19-21	0.10	0.16	0.01	0.09	0.13	0.16	0.11	0.11	0.09	0.18	0.08	NA	0.08	0.00	0.20	0.05	0.31	0.62	NA	0.03	0.09	0.22	0.06	0.09

Appendix G8– Total mortality exploitation rate indices by stock and age in the West Coast Vancouver Island (WCVI) troll fishery, based on coded-wire tag (CWT) data. Values shaded in gray are averages across years.

Year	CWF Age 4	GAD Age 3	GAD Age 4	LRH Age 3	LRH Age 4	LRW Age 4	RBT Age 3	RBT Age 4	RBT Age 5	SAM Age 3	SAM Age 4	SAM Age 5	SPR Age 3	SPR Age 4	SPS Age 3	SPS Age 4	SRH Age 3	SRH Age 4	SRH Age 5	SUM Age 4	URB Age 3	URB Age 4	WSH Age 4	Fishery Index
1979				1.15			1.20	1.25			1.00	1.00	0.95	0.84		1.13	1.54				1.11	1.64	1.00	1.05
1980				0.56	0.88		1.38	1.42					1.16	1.39				1.11		0.69	1.10	1.00	1.09	1.02
1981	0.79	0.72		1.13	0.78	0.85	0.66	0.60	1.00				0.92	0.63	0.73		0.46		1.00	1.31		0.98	0.64	0.86
1982	1.21	1.28	1.00	1.17	1.34	1.15	0.75	0.72		1.00			0.97	1.14	1.27	0.87		0.89			0.79	0.38	1.27	1.06
2009	0.00	0.55	0.51	0.19	0.22			0.00		0.57	0.15		0.15	0.05	0.50	0.18	0.04	0.04	0.10	0.39		0.10	0.13	0.21
2010	0.11	0.83	0.44	0.31			0.03	0.26		0.86	0.13		0.22	0.34	0.43	0.12	0.00	0.00	0.00	0.32	0.09		0.17	0.27
2011	0.07	0.37	0.22	0.38	0.74		0.00	0.00		0.00	0.42		0.23	0.57	0.04	0.20	0.11	0.56	0.43	0.21	0.00	0.33	0.37	0.31
2012	0.20	0.26	0.24	0.14	0.00		0.00	0.00	0.17	0.30	0.05		0.10	0.43	0.32	0.17	0.04	0.43	0.69	0.27	0.07	0.30	0.83	0.20
2013	0.06	0.17	0.24	0.16	0.13		0.00			0.13	0.09		0.14	0.13	0.03	0.20	0.04	0.07	0.00	0.18	0.03	0.25	0.20	0.14
2014	0.13	0.14	0.27	0.24		0.20		0.17		0.60	0.25		0.11	0.29	0.42	0.25	0.13	0.25	0.54	0.47	0.05	0.42	1.06	0.26
2015		0.06	0.09	0.20	0.32		0.01				0.14		0.09	0.22	0.21	0.12	0.08	0.14	0.36	0.07	0.03	0.09	0.11	0.15
2016	0.18	0.17	0.37	0.20	1.11		0.01	0.18			0.07		0.12	0.59	0.09	0.28	0.02	0.25	0.54	0.44	0.16	0.38	1.04	0.35
2017	0.33	0.38	0.18	0.47			0.10	0.13	0.15	0.69			0.29		0.37	0.22	0.00	0.18	0.29	0.39	0.23	0.21	1.03	0.30
2018	0.00	0.19	0.09	0.27			0.14	0.26		0.43	0.05		0.14		0.13	0.14		0.34	0.74	0.16	0.01	0.27	0.49	0.16
2019	0.08	0.10	0.03	0.06			0.12	0.13		0.19	0.06		0.08	0.00	0.22	0.06	0.12			0.00	0.05	0.23	0.00	0.07
2020	0.08	0.15	0.00	0.06	0.12	0.15	0.03	0.05	0.19	0.05	0.14		0.06		0.18	0.02	0.16	0.40		0.01	0.04	0.11	0.04	0.08
2021	0.14	0.18	0.00	0.13	0.13		0.15	0.13	0.00	0.28	0.04		0.08	0.00	0.13	0.08	0.58	0.83		0.06	0.16	0.32	0.10	0.11
83-95	0.93	0.86	0.86	1.18	1.30	0.77	0.79	0.93	1.70	0.61	0.61	1.09	0.81	0.80	0.83	0.66	0.90	0.75	1.93	1.04	0.65	1.18	0.47	0.87
96-98	0.21	0.07	0.12	0.47	NA	NA	0.02	0.02	NA	0.08	0.12	NA	0.22	0.22	0.07	0.12	0.03	0.02	0.00	0.03	0.04	0.06	0.03	0.13
99-08	0.46	0.35	0.90	0.33	1.09	0.30	0.01	0.01	0.00	0.42	0.55	NA	0.32	0.85	0.39	0.57	0.06	0.09	0.29	0.40	0.10	0.28	0.75	0.51
09-18	0.12	0.31	0.27	0.26	0.42	0.20	0.04	0.12	0.16	0.45	0.15	NA	0.16	0.33	0.25	0.19	0.05	0.22	0.37	0.29	0.07	0.26	0.54	0.24
19-21	0.10	0.14	0.01	0.08	0.13	0.15	0.10	0.10	0.09	0.17	0.08	NA	0.07	0.00	0.18	0.05	0.28	0.61	NA	0.03	0.08	0.22	0.05	0.09

APPENDIX H: CALENDAR YEAR EXPLOITATION RATE METRICS

Calendar year exploitation rates were introduced with paragraph 5(e) of the 2019 PST Agreement as a way to monitor the total mortality in ISBM fisheries. CYERs are calculated for each calendar year and CTC fishery as:

$$CYDIST_{CY,F} = \frac{\sum_{a=Minage}^{Maxage} \sum_{f \in \{F_{ISBM}\}} Morts_{CY,a,f} * AEQ_{BY=CY-a,a,f}}{\sum_{a=Minage}^{Maxage} \left(\sum_{f=1}^{Numfisheries} Morts_{CY,a,f} * AEQ_{BY=CY-a,a,f} + Esc_{CY,a} \right)}$$

Equation notations can be found in Appendix B. CYER limits for each stock and ISBM fishery are laid out in Attachment I of the 2019 PST Agreement and are based on a base period average from 2009–2015 as shown in Appendix H1 and Appendix H2 below. ISBM fisheries are listed in Table 4.2. ISBM performance and CYER limit evaluation can be found in section 4.1.

LIST OF APPENDIX H TABLES

Appendix H1—Calculation of individual stock-based management (ISBM) calendar year exploitation rate (CYER) limits for all Canadian ISBM fisheries based on coded wire tag (CWT)-based exploitation rate analysis.

Note: Escapement indicator stocks correspond to Annex IV, Chapter 3, Attachment I of the 2019 Pacific Salmon Treaty Agreement.

Escapement Indicator	**CWT Indicator**	**CYER Obj.**	**Base Period CYER**								**CYER Limit**
			2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**Avg.**	
Skeena	KLM	100.0%	0.065	0.185	0.257	0.121	0.102	0.167	0.129	0.146	0.146
Atnarko	ATN	100.0%	0.372	0.289	0.368	0.278	0.228	0.213	0.169	0.274	0.274
NWVI Natural Aggregate	RBT adj	95.0%	0.112	0.074	0.076	0.083	0.107	0.067	0.111	0.090	0.085
SWVI Natural Aggregate	RBT adj	95.0%	0.112	0.074	0.076	0.083	0.107	0.067	0.111	0.090	0.085
East Coast Vancouver Island North	QUI adj	95.0%	0.144	0.233	0.149	0.141	0.080	0.092	0.265	0.158	0.150
Phillips	PHI	100.0%			0.150	0.214	0.067	0.109	0.128	0.101	0.101
Cowichan	COW	95.0%	0.486	0.424	0.242	0.377	0.366	0.492	0.415	0.400	0.380
Nicola	NIC	95.0%	0.471	0.064	0.111	0.226	0.070	0.126	0.143	0.173	0.164
Chilcotin											
Chilko											
Lower Shuswap	SHU	100.0%	0.256	0.211	0.215	0.206	0.168	0.184	0.152	0.199	0.199
Harrison	HAR	95.0%	0.074	0.071	0.066	0.110	0.090	0.190	0.141	0.106	0.101
Nooksack Spring	NSF	87.5%	0.190	0.050	0.143	0.149	0.159	0.237	0.111	0.149	0.130
Skagit Spring	SKF	87.5%	0.072	0.078	0.061	0.120	0.083	0.086	0.057	0.080	0.070
Skagit Summer/Fall	SSF	87.5%	0.083	0.081	0.067	0.028	0.082	0.186	0.129	0.094	0.082
Stillaguamish	STL	87.5%	0.067	0.101	0.119	0.085	0.125	0.216	0.164	0.125	0.110
Snohomish	SKY	87.5%	0.038	0.043	0.063	0.164	0.112	0.138	0.060	0.088	0.077

Appendix H2—Calculation of individual stock-based management (ISBM) calendar year exploitation rate (CYER) limits for all United States ISBM fisheries based on coded wire tag (CWT)-based exploitation rate analysis.

Note: Escapement indicator stocks correspond to Annex IV, Chapter 3, Attachment I of the 2019 Pacific Salmon Treaty Agreement.

Escapement Indicator	CWT	CYER	Base Period CYER								CYER
	Indicator	Obj.	2009	2010	2011	2012	2013	2014	2015	Avg.	Limit
Cowichan	COW	95.0%	0.101	0.110	0.130	0.158	0.141	0.072	0.047	0.108	0.103
Nicola	NIC	95.0%	0.072	0.012	0.038	0.087	0.046	0.016	0.019	0.041	0.039
Harrison	HAR	95.0%	0.033	0.078	0.064	0.093	0.108	0.095	0.065	0.077	0.073
Nooksack Spring	NSF	100.0%	0.058	0.064	0.075	0.196	0.133	0.126	0.070	0.103	0.103
Skagit Spring	SKF	95.0%	0.265	0.228	0.240	0.274	0.313	0.342	0.207	0.267	0.254
Skagit Summer/Fall	SSF	95.0%	0.372	0.123	0.268	0.041	0.195	0.120	0.090	0.173	0.164
Stillaguamish	STL	100.0%	0.152	0.177	0.098	0.068	0.258	0.264	0.159	0.168	0.168
Snohomish	SKY	100.0%	0.170	0.143	0.315	0.162	0.123	0.142	0.244	0.185	0.185
Hoko	HOK	10.0%	0.025	0.012	0.014	0.045	0.074	0.048	0.091	0.044	0.100
Grays Harbor Fall	QUE adj	85.0%	0.164	0.185	0.211	0.167	0.164	0.178	0.249	0.188	0.160
Queets Fall	QUE	85.0%	0.172	0.147	0.207	0.212	0.206	0.148	0.077	0.167	0.142
Quillayute Fall	QUE adj	85.0%	0.244	0.222	0.258	0.199	0.211	0.345	0.285	0.252	0.214
Hoh Fall	QUE adj	85.0%	0.127	0.126	0.251	0.152	0.296	0.158	0.160	0.181	0.154
Upriver Brights	URB	85.0%	0.276	0.275	0.314	0.211	0.340	0.243	0.214	0.268	0.228
Hanford Wild Brights	HAN	85.0%	0.526	0.164	0.273	0.288	0.306	0.257	0.235	0.293	0.249
Lewis River Fall	LRW	85.0%	0.051	0.185	0.320	0.271	0.426	0.203	0.150	0.229	0.195
Coweeman	CWF	100.0%	0.210	0.256	0.054	0.200	0.132	0.261	0.333	0.206	0.206
Mid-Columbia Summers	SUM	85.0%	0.215	0.332	0.337	0.288	0.289	0.341	0.366	0.310	0.263
Nehalem	SRH adj	85.0%	0.022	0.081	0.150	0.158	0.187	0.212	0.268	0.154	0.131
Siletz	SRH adj	85.0%	0.116	0.068	0.300	0.184	0.194	0.182	0.378	0.203	0.173
Siuslaw	SRH adj	85.0%	0.145	0.182	0.273	0.195	0.316	0.236	0.333	0.240	0.204
South Umpqua	Elk adj	85.0%	0.215	0.310	0.362	0.387	0.401	0.309	0.222	0.315	0.268
Coquille	Elk adj	85.0%	0.068	0.138	0.256	0.337	0.448	0.277	0.322	0.264	0.224

Appendix H3—Individual stock-based management (ISBM) calendar year exploitation rates (CYERs) for all Canadian fisheries based on coded wire tag (CWT)-based exploitation rate analysis under the 2019 Pacific Salmon Treaty (PST) Agreement. Values shaded in green indicate that the annual ISBM obligation was met for that stock in that year while values shaded in red indicate that the annual ISBM obligation was not met for that stock in that year.

Note: Escapement indicator stocks correspond to Annex IV, Chapter 3, Attachment I of the 2019 PST Agreement.

Escapement Indicator	**CYER**									
	2019	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**
Skeena	0.129	0.120	0.040							
Atnarko	0.324	0.251	0.185							
NWVI Natural Aggregate	0.097	0.053	0.063							
SWVI Natural Aggregate	0.097	0.053	0.063							
East Coast Vancouver Island North	0.259	0.104	0.203							
Phillips	0.077	0.043	0.145							
Cowichan	0.502	0.140	0.269							
Nicola	0.021	0.275	0.052							
Chilcotin										
Chilko										
Lower Shuswap	0.118	0.185	0.128							
Harrison	0.203	0.148	0.164							
Nooksack Spring	0.102	0.137	0.038							
Skagit Spring	0.051	0.146	0.096							
Skagit Summer/Fall	0.047	0.104	0.104							
Stillaguamish	0.140	0.060	0.075							
Snohomish	0.082	0.075	0.077							

Appendix H4—Individual stock-based management (ISBM) calendar year exploitation rates (CYERs) for all United States fisheries based on coded wire tag (CWT)-based exploitation rate analysis under the 2019 Pacific Salmon Treaty (PST) Agreement. Values shaded in green indicate that the annual ISBM obligation was met for that stock in that year while values shaded in red indicate that the annual ISBM obligation was not met for that stock in that year.

Note: Escapement indicator stocks correspond to Annex IV, Chapter 3, Attachment I of the 2019 PST Agreement.

Escapement Indicator	CYER									
	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Cowichan	0.07	0.03	0.033							
Nicola	0.02	0.02	0.01							
Harrison	0.06	0.05	0.113							
Nooksack Spring	0.17	0.18	0.149							
Skagit Spring	0.44	0.24	0.276							
Skagit Summer/Fall	0.12	0.06	0.276							
Stillaguamish	0.19	0.13	0.229							
Snohomish	0.1	0.1	0.275							
Hoko	0.11	0.01	0.01							
Grays Harbor Fall	0.11	0.1	0.075							
Queets Fall	0.2	0.25	0.184							
Quillayute Fall	0.13	0.11	0.077							
Hoh Fall	0.2	0.2	0.133							
Upriver Brights	0.18	0.16	0.163							
Hanford Wild Brights	0.05	0.14	0.176							
Lewis River Fall	0.03	0.08	0.074							
Coweeman	0.12	0.08	0.153							
Mid-Columbia Summers	0.11	0.15	0.263							
Nehalem	0.13	0.12	0.181							
Siletz	0.34	0.14	0.251							
Siuslaw	0.43	0.21	0.269							
South Umpqua	0.35	0.28	0.243							
Coquille	0.49	0.1	0.079							

APPENDIX I: ISSUES WITH AND CHANGES TO THE EXPLOITATION RATE ANALYSIS

Exclusion of Canadian Pseudo-Recovery Estimates in Washington Fisheries from the 2023 ERA analysis

Due to the two-year lag of CWT estimates for southern U.S. fisheries, Canada has produced interim estimates (described as pseudo-recoveries) of Canadian stocks in U.S. Juan de Fuca and Puget Sound fisheries since the 2016 analysis year. These values are used in the ERA (uploaded via auxiliary files) and replaced the following year, once the U.S. estimates became available.

Pseudo-recovery estimates are intended to represent potential recoveries, during the most recent fishery year, for Cowichan and the Fraser stocks: CHI, HAR, NIC, SHU, MSH. The pseudo-recoveries are identified in a unique fishery auxiliary file by stock-brood year in a fine-scale fishery represented by one proxy tag code. The extrapolation is based on mean recovery rate (relative to releases), by stock, age, and fine fishery for years after 2010. The age-specific pseudo-recoveries are the product of the age-specific mean recovery rate and brood year releases expected to have returns in this exploitation rate year. For more information about how pseudo-recoveries are estimated, see Appendix I4 of the 2021 ERA report (CTC 2022b.

To assess the utility of including these pseudo-recoveries in future ERA years, a retrospective evaluation was used to compare the historical pseudo-recovery estimates (ERA years 2016–2021, i.e., fishing years 2015–2020) to the agency reported values. First, all tag codes associated with pseudo stock-brood years were identified. The summed recovery of all related tag codes by fine scale fishery and recovery year were then compared to pseudo-recovery estimates.

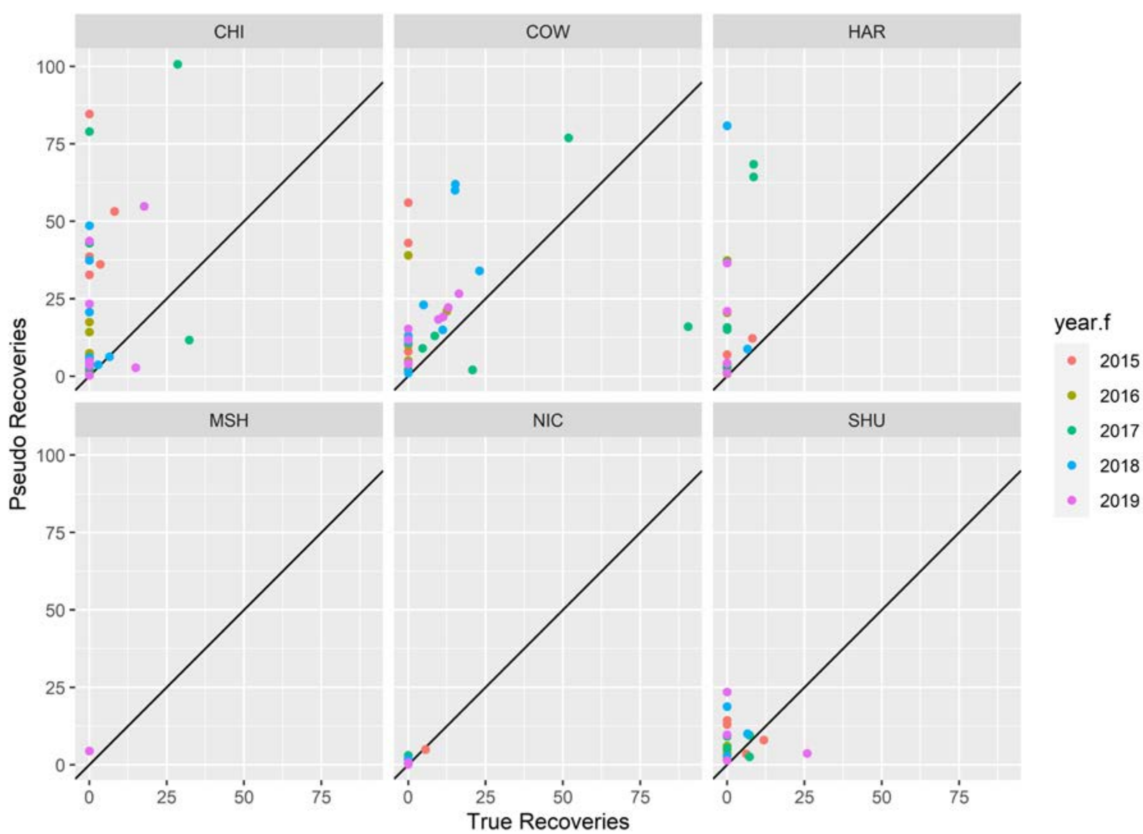
The table below indicates the number of fishery-year combinations, by stock, that have had pseudo recovery estimates (i.e., projected recovery values > 0); and, once the data became available, the proportion of those that had no recoveries. Of those fishery-year combinations that had pseudo-recoveries, over 60% were shown to have no recoveries once the data became available. Thus, the method was projecting recoveries in fisheries at a far greater rate than proved to be the case.

Stock	Number of fishery-year combinations	Proportion of fishery-years having zero recoveries once data available
CHI	42	0.81
COW	36	0.58
HAR	25	0.80
MSH	1	1.00
NIC	8	0.88
SHU	20	0.70

The multi-panel scatter plot below shows pseudo-recovery estimates versus the updated 'true' values. The diagonal line in each panel follows a slope equal to one. Points above the line are pseudo values that are over-estimated relative to the ‘true’ estimates. Overall, the projection method has consistently overestimated recoveries relative to the true value. While still biased high, the COW stock includes pseudo values more closely matching true estimates, as compared to Fraser stocks. This may be partly due to methodological differences. Differences between results may be attributable to one or more factors:

- Failure to include brood year-specific estimates of natural mortality
- Historically, the projection method for Fraser stocks has differed from that applied to COW (methods were standardized in the 2021 ERA)
- Identification of year-specific fishery closures
- Variation of fishery sampling rates
- Interannual changes to presence of Canadian stocks in these Puget Sound fisheries

The merit of including interim, pseudo-recovery estimates for these six stocks was discussed. For CHI, HAR, NIC, SHU, and MSH almost all recovery estimates remained below 13. Thus, their relative contribution to exploitation rate estimates is likely small. Cowichan is the one stock that includes numerous cases of recoveries exceeding 12, and thus pseudo recoveries may have value for ongoing representation in an auxiliary file. However, due to the consistent bias of pseudo-recovery estimates for all other stocks, the inclusion of pseudo-recoveries for all six stocks was stopped in the 2023 analysis year. Canada plans to introduce an alternative methodology in 2024.



Overview / Explanation of Chinook Extract, Transform, and Load (CETL) and new loading process

Traditionally, CWT recovery and release data was manually downloaded from RMIS and processed using CAS.exe (a VB.NET application). This application was migrated to an R package called CETL (Chinook Extract, Transform, and Load)[6]. CETL directly downloads, processes, and loads data from RMIS into the CAMP database. CETL replicates all of the logic that existed in CAS, including importing RMIS recovery and release data. Also, CETL extends upon CAS functionality by supporting a test mode and produces comparison/quality assurance reports to allow CTC members to see the impact of data changes before implementation. For the 2023 ERA, CETL version 1.5.4 was used to load CWT release and recovery data. A full set of changes made to the package is provided in the NEWS page of the code.

In addition to the CETL R Package, a new R Package called qccamp[7] was created to provide numerous data quality checks. The results of the data quality checks are reviewed by CTC members and addressed as needed before the final stock ERA analysis. Functionality and data quality checks incorporated into this package include:

- Comparison of summary data between two CAMP databases
- CWT recoveries that do not align with defined fisheries
- CWT recoveries with inconsistent ages
- Tag codes and fisheries with negative total CWT estimates

Tag Code Changes

CWF

For BY2013 a sixth Cowlitz Fall Chinook Hatchery CWT code (636668) was added to the five (636270, 636655, 636656, 636657, and 636658) that were included in previous years' ERAs.

SSA

Southern Southeast Regional Aquaculture Association (SSRAA) halted releases and sampling of Neet's Bay (ANB), which is part of the Southern Southeast Alaska (SSA) conglomerate. Because of this, we removed ANB from the conglomerate, which affects broods going back to 1981.

TST

Due to the movement to the Chinook Analysis and Modelling Platform database (CAMP), recoveries of several tag codes from 1979 were not downloaded from RMIS at least for last year, and potentially a few other years. These tag codes had been included

[6] https://gitlab.com/chinook-technical-committee/programs/r-packages/cetl

[7] https://gitlab.com/chinook-technical-committee/programs/r-packages/qccamp

in the .cds file and releases were loaded, but recoveries were not. This error has been corrected.

WSH

For the WSH stock, tag codes throughout the time series were edited (excised). A thorough historical review of the codes and releases from WSH hatcheries revealed the previous inclusion of groups which had out-of-basin releases and others which did not have sufficient terminal area recovery programs designed to appropriately sample those fish which had returned through time. The changes were mostly slight if at all perceptible in differential review of the resultant MDTs from the changed tag groups. One exception to this statement was found in catch years 1986 and 1987 where recovered tag numbers were significantly diminished (from 629 to 571 in 1986 and from 686 to 303 in 1987). This editing did not affect the ability to surpass criteria in each year for the production of our MDT products. It is expected that small variations in estimates produced by the model calibration will be seen throughout the time series due to the smaller number of tag releases being utilized for this year's ERA. The base period releases/those that would affect the base values were not edited.

HAR

For BY 2018, a sixth Harrison CWT code (185187) that was erroneously flagged as "experimental and production" was corrected and added to the five codes (185185, 185186, 198188, 185966, and 185967) that had been used in previous years' ERAs.

Auxiliary Files

Instead of the accustomed production of post-hoc expansions for WSH terminal releases, which has been typically accomplished with an update query applied to the CAMP database, auxiliary files were produced to reflect those needed expansion values for this year's ERA. The interaction between data loading from CETL and the need to ensure data integrity in CAMP precluded the utilization of the standardized query structure used for this task in the past. It's the aspiration to pursue this expansion process (for those terminal WSH recoveries) within the structure of CETL for next year's ERA.

Re-running of three Puget Sound Stocks

Following the completion of the ERA in early March, missing escapement recoveries were noticed for two Puget Sound stocks (STL and NSF) and the cause of unreasonable incidental mortality of SSF in a sport fishery was discovered. These stocks were re-run in the summer before the production of this report; different output was used for Chinook Model inputs than for this report. Both runs for each stock are archived for future reference. For STL and NSF, corrected RMIS escapement was uploaded to CAMP after STL escapement expansions were corrected and missing recoveries were uploaded for NSF. For SSF, the most recent tag code was excluded, as changes in accounting for jacks at the hatchery resulted in a perceived larger cohort of 2-year-old Chinook than previous years. This resulted in most incidental mortality in Puget Sound sport fisheries being attributed to SSF. A solution for dealing with the new method of jack counts is being developed.

APPENDIX J: PSEUDO RECOVERY INCLUSION ASSESSMENT

LIST OF APPENDIX J FIGURES/TABLES

Introduction

As a result of COVID-19 impacts to hatchery operations in 2020, the 2019 brood year of several Canadian Chinook indicator stocks were released without CWTs or adipose-fin-clip marks, or with insufficient numbers of tags and/or marks. In order to address this information gap, pseudo-recoveries (e.g., CWT recoveries that would have occurred had the 2019 broods been released with sufficient tags and/or marks) were estimated based on historical data. Pseudo-recoveries of age-2 fish in 2021 and age-3 fish in 2022 were estimated for seven and 10 impacted Canadian ERA indicator stocks, respectively. This process was described in a memo provided to the Chinook Interface Group (CIG) by the CTC on February 25, 2022 (CTC 2022c) to which a technical report describing and evaluating the methods used to estimate age-specific pseudo-recoveries was attached. This memo and attached technical report were included as supplementary materials to the 2022 ERA Report (CTC 2023c. Comparisons of 2021 calendar-year statistics derived from the 2022 ERA with and without age-2 pseudo-recoveries for the seven impacted Canadian ERA indicator stocks were included in Appendix J of the 2022 ERA report (CTC 2023d. This appendix presents comparisons of 2022 calendar-year statistics derived from the 2023 ERA run with and without age-3 pseudo-recoveries.

Methods

Methods used to estimate stock-specific escapement mortality, landed catch, and total fishery mortalities (landed catch plus incidental mortalities) attributed to component fisheries of ERA indicator stocks are described in Section 2 of this report.

The 2023 ERA was run for each of the 10 Canadian ERA indicator stocks missing age-3 recoveries from the 2019 brood year due to COVID-19 (Atnarko River (ATN), Big Qualicum (BQR), Chilliwack (CHI), Harrison (HAR), Kitsumkalum River Summer (KLM), Kitsumkalum Yearling (KLY), Middle Shuswap (MSH), Puntledge (PPS), Robertson Creek (RBT), and Lower Shuswap (SHU)) both with and without inclusion of age-3 pseudo-recoveries. Age-2 pseudo-recoveries from the 2021 calendar-year were included in both ERA runs. The results from each ERA run were then collated across all age classes to calculate stock- and calendar-year-specific total estimated CWT recoveries (escapement, stray, and total fishery mortalities combined), numeric and proportional escapement mortality, and total fisheries mortality. Total fisheries mortality was expressed as Canadian and U.S. calendar year mortalities (CYMs) and CYERs. Calendar year 2022 estimates of these metrics derived from ERA runs with and without age-3 pseudo-recoveries were then compared. Differences were calculated by subtracting ERA estimates derived without age-3 pseudo-recoveries (Est_{none}) from those derived with them ($Est_{pseudo-rec}$):

$$Diff = Est_{pseudo-rec} - Est_{none}$$

Therefore, positive proportional differences correspond to higher estimates when pseudo-recoveries were included in the ERA ($Est_{pseudo-rec} > Est_{none}$), and negative proportional differences correspond to lower estimates when pseudo-recoveries were included in the ERA ($Est_{pseudo-rec} < Est_{none}$). Summary figures and associated tables of these results are presented herein. Throughout, estimates derived with pseudo-recoveries are denoted "*Pseudo-Rec*" and those derived without pseudo-recoveries are denoted "*None*". This appendix focuses on estimated total combined mortality, escapement mortality, and total mortality from associated Canadian and U.S. ISBM and AABM fisheries (e.g., data from which CYM and CYER estimates are derived).

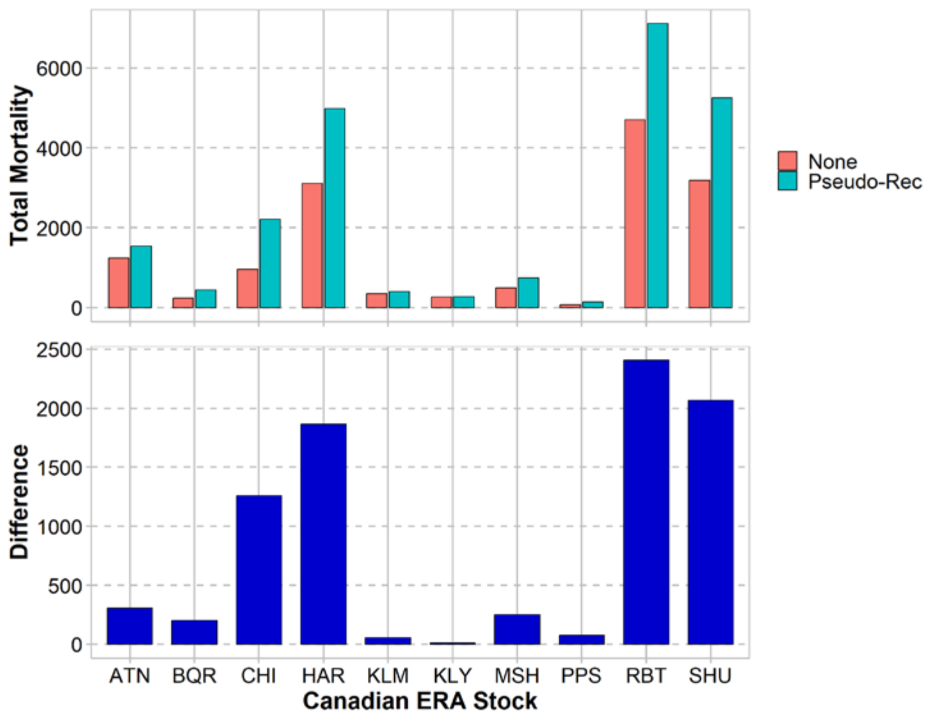
Results

The effects of including age-3 pseudo-recoveries on estimated CWT recoveries across all fisheries (Appendix J1; Appendix J3) and escapement mortalities (Appendix J2; Appendix J3) for the 10 Canadian ERA stocks were greater than those for age-2 pseudo-recoveries in 2021 (CTC 2023d). Inclusion of age-3 pseudo-recoveries added between 11 (KLY) and 2,407 (RBT) total mortalities to individual stocks, or between a 3.6% and 33.8% increase in the number of total mortalities, corresponding to a 2 (KLY) to 1,749 (SHU) increase in total escapement mortality, but relatively minor differences in proportional escapement mortality, ranging from -9.5% to 6.2% (mean = -1.7%).

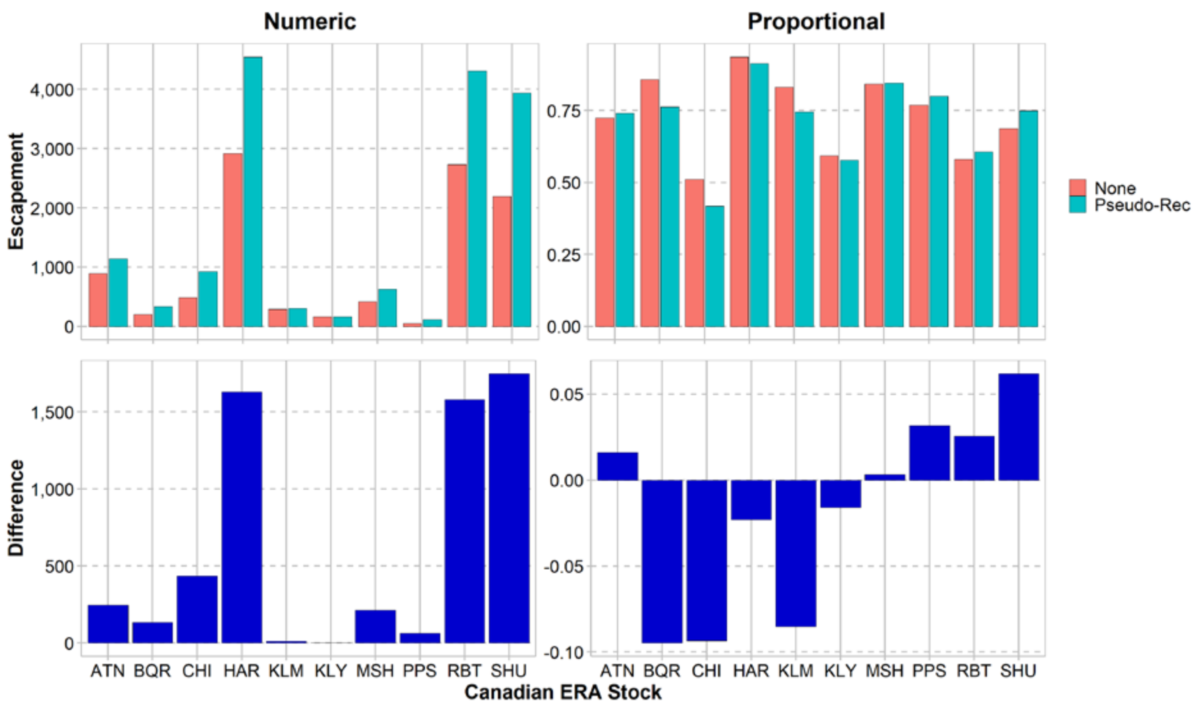
Overall differences in fishery mortalities (i.e., CYM) followed the same trend as total mortalities. Stock-specific total CYMs increased by between nine and 827 fish for combined Canadian and U.S. ISBM and AABM fisheries with the inclusion of age-3 pseudo recoveries, corresponding to a -5.9% to 11.1% (mean = 2.0 %) change in CYERs (Appendix J4 and Appendix J9).

Differences in Canadian and U.S. ISBM CYMs with and without age-3 pseudo-recoveries were largest for CHI (Canada and U.S.) followed by HAR (U.S.), RBT (Canada), and SHU (Canada and U.S.), with the relative differences being most pronounced for the U.S. CYMs (Appendix J5; Appendix J9). Canadian ISBM CYER estimates were higher with inclusion of age-3 pseudo-recoveries in all but four cases (KLY, MSH, RBT, and SHU), with differences ranging from -4.3% to 7.7% (mean 1.3%; Appendix J6; Appendix J9). Among the four Canadian stocks from which fish were caught in U.S. ISBM fisheries, CYER estimates were marginally higher with inclusion of pseudo-recoveries for three stocks (CHI, HAR, and SHU) but decreased marginally for RBT (<0.001%), with all differences being less than 2%. Differences in Canadian AABM CYMs and CYERs with and without age-3 pseudo-recoveries relative to those observed for ISBM fisheries, were typically smaller for Canadian fisheries and larger for U.S. fisheries, and greatest for CHI, HAR, RBT, and SHU in Canadian fisheries and RBT and SHU in U.S. fisheries (Appendix J7 and Appendix J8). However, despite the variable differences in CYM estimates, differences in CYERs were still relatively small, ranging from 2.8% to 3.3%. ISBM fishery CYERs were below annual limits and 10% buffers for ERA stocks stipulated in Attachment I of the PST regardless of inclusion of age-3 pseudo-recoveries, except Canadian estimates for RBT (Appendix J6).

Total mortalities for the 10 Canadian ERA stocks were observed in nine of the 21 associated component ISBM fisheries (i.e., 43%) and all seven AABM component fisheries. In line with the ERA stock-level results, the differences in estimates of CYM and CYER within these fisheries derived with and without inclusion of age-3 pseudo-recoveries were generally small (Appendix J9 and Appendix J10). Between zero and 488 age-3 pseudo-recoveries (mean = 34) were added to the total mortality estimates from individual ISBM fisheries resulting in differences in CYERs ranging from -5.8% to 12.8% (mean = 1.2%), with 7% of estimates being lower, 7% being higher, and 86% showing no difference when age-3 pseudo-recoveries were included. In general, differences in both CYM and CYER were larger and more variable for Canadian component ISBM fisheries relative to U.S. ones. Total differences in CYMs associated with AABM fisheries were generally smaller than those of ISBM fisheries, with between zero and 195 age-3 pseudo-recoveries (mean = 20.3) being added to the total mortality estimates from individual AABM fisheries with inclusion of age-3 pseudo-recoveries (Appendix J10) and equating to similarly small differences in CYER, ranging from -2.7% (PPS) to 2.3% (BQR).



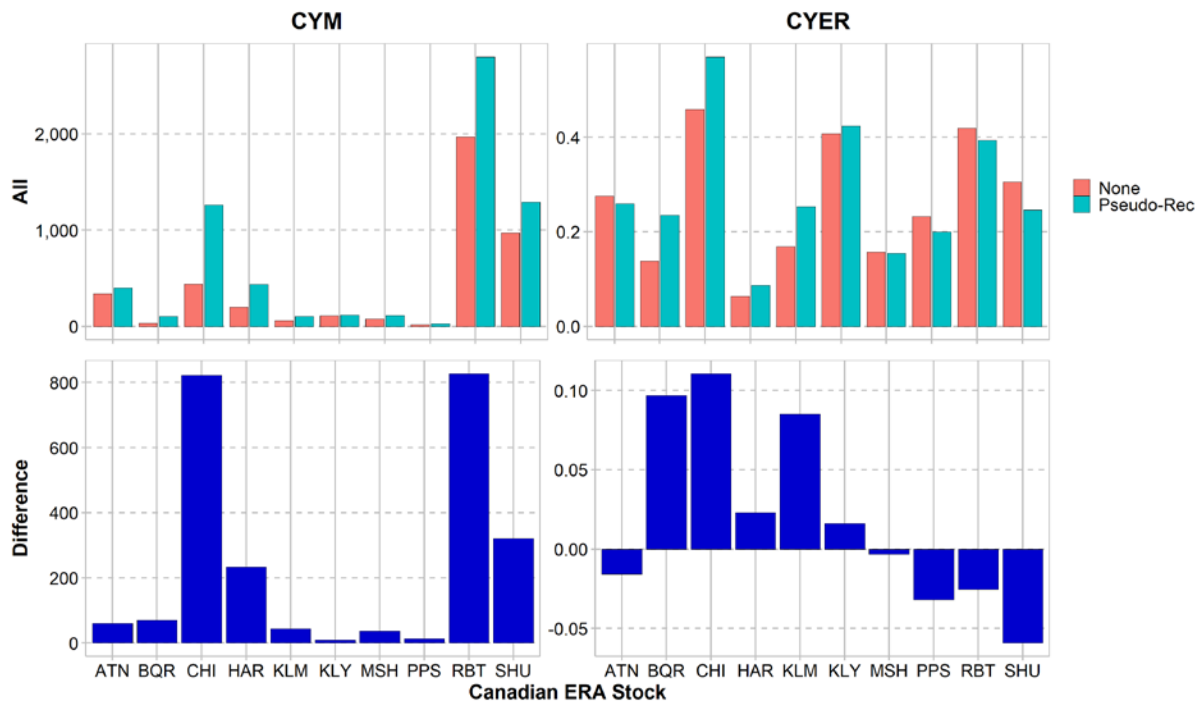
Appendix J1—Comparison of 2022 calendar-year stock-specific estimated coded wire tag recoveries derived with and without age-3 pseudo-recoveries across all fisheries and escapement for 10 Canadian exploitation rate analysis stocks (top) and differences between estimates (bottom).



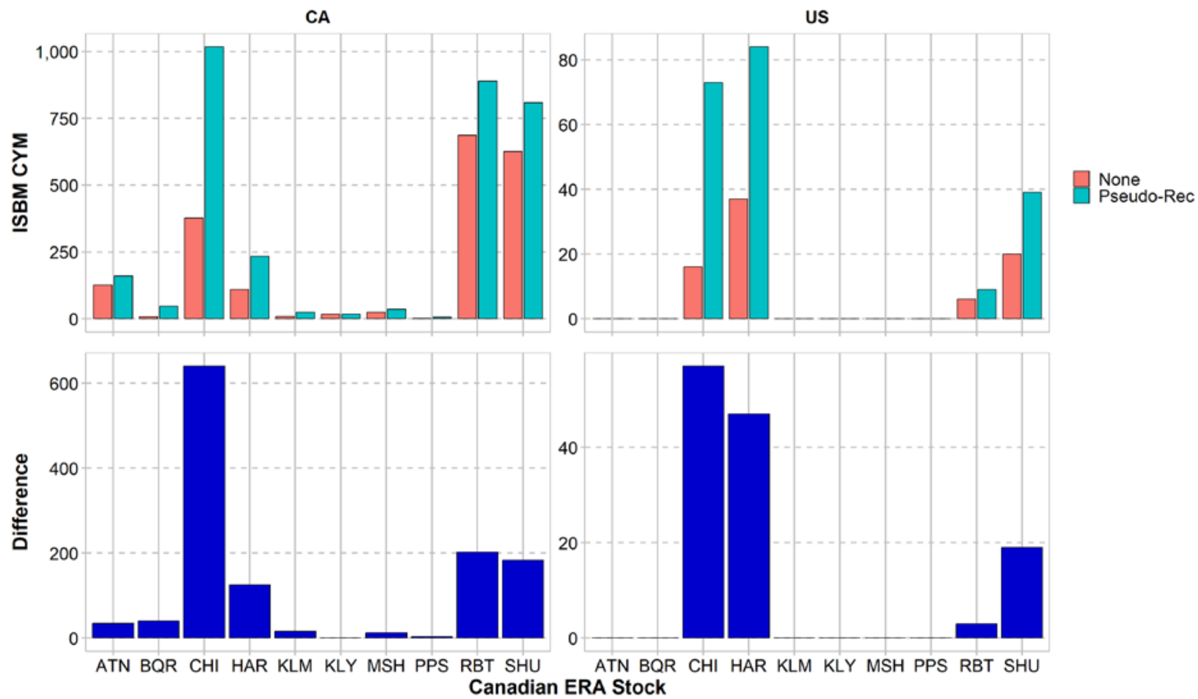
Appendix J2—2022 calendar-year stock-specific numeric and proportional escapement mortality estimates derived with and without age-3 pseudo-recoveries for 10 Canadian exploitation rate analysis stocks (top) and differences between numeric and proportional estimates (bottom).

Appendix J3—Summary of exploitation rate analysis 2022 calendar-year stock-specific estimated coded wire tag recoveries (mortalities) derived with and without age-3 pseudo-recoveries across all fisheries and escapement mortalities for 10 Canadian stocks.

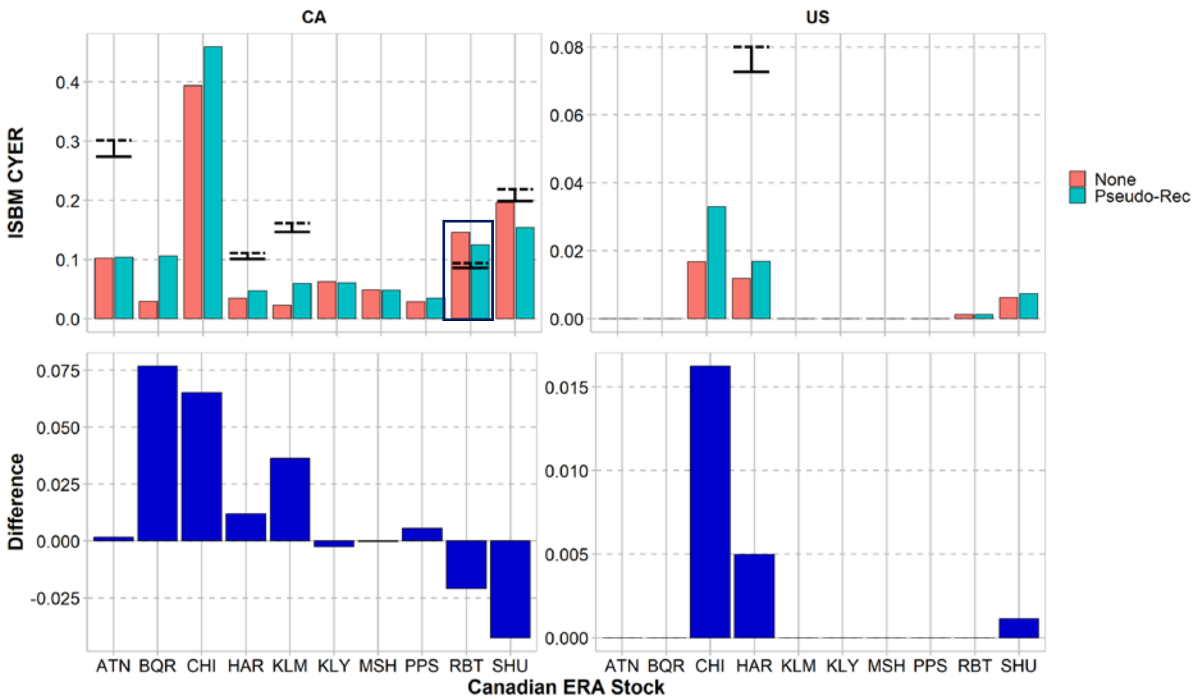
Estimated Total Mortality	Metric	Method	Mean	SD	Min	Max
All Fisheries	Numeric	None	1,462.0	1,617.9	69.0	4,705.0
		Pseudo-Rec	2,312.3	2,534.8	145.0	7,112.0
		Difference	850.3	949.4	11.0	2,407.0
Escapement	Numeric	None	1,035.0	1,127.1	53.0	2,917.0
		Pseudo-Rec	1,641.5	1,845.6	116.0	4,547.0
		Difference	606.5	734.3	2.0	1,749.0
	Proportional	None	0.733	0.139	0.511	0.936
		Pseudo-Rec	0.716	0.145	0.418	0.913
		Difference	-0.017	0.056	-0.095	0.062



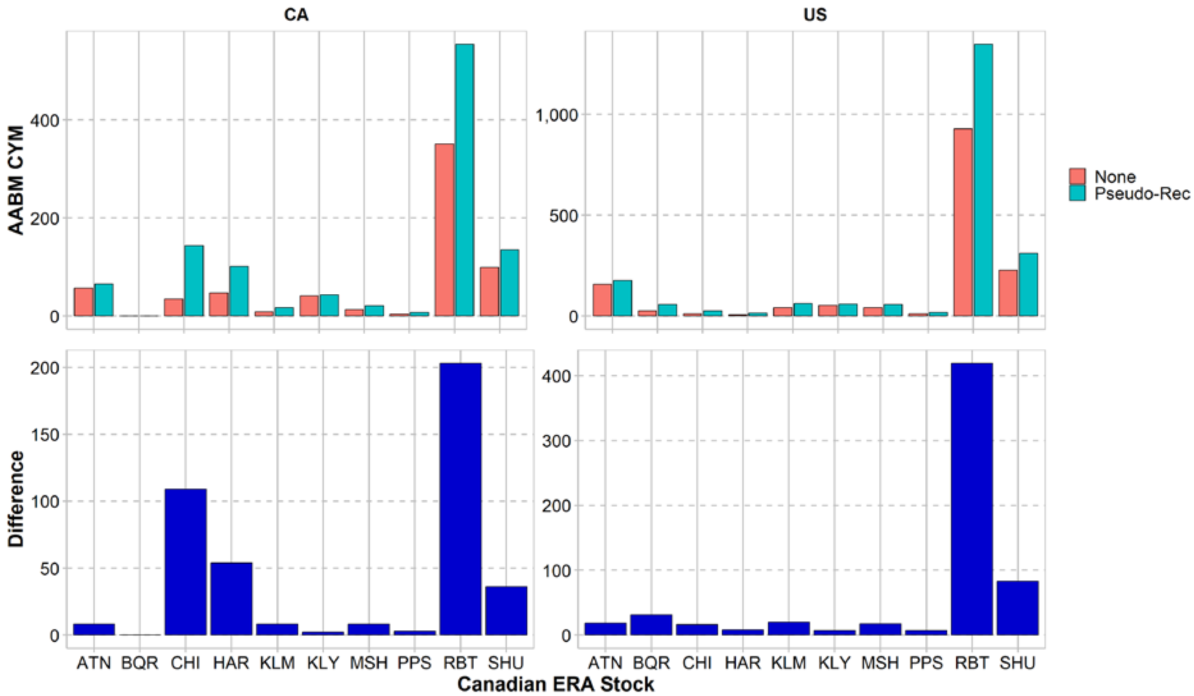
Appendix J4—Stock-specific total 2022 calendar year mortalities (CYM) and exploitation rates (CYER) derived with and without age-3 pseudo-recoveries for 10 Canadian exploitation rate analysis stocks (top) and differences between them (bottom) for abundance-based management regime (AABM) fisheries and individual stock-based management regime (ISBM) fisheries combined.



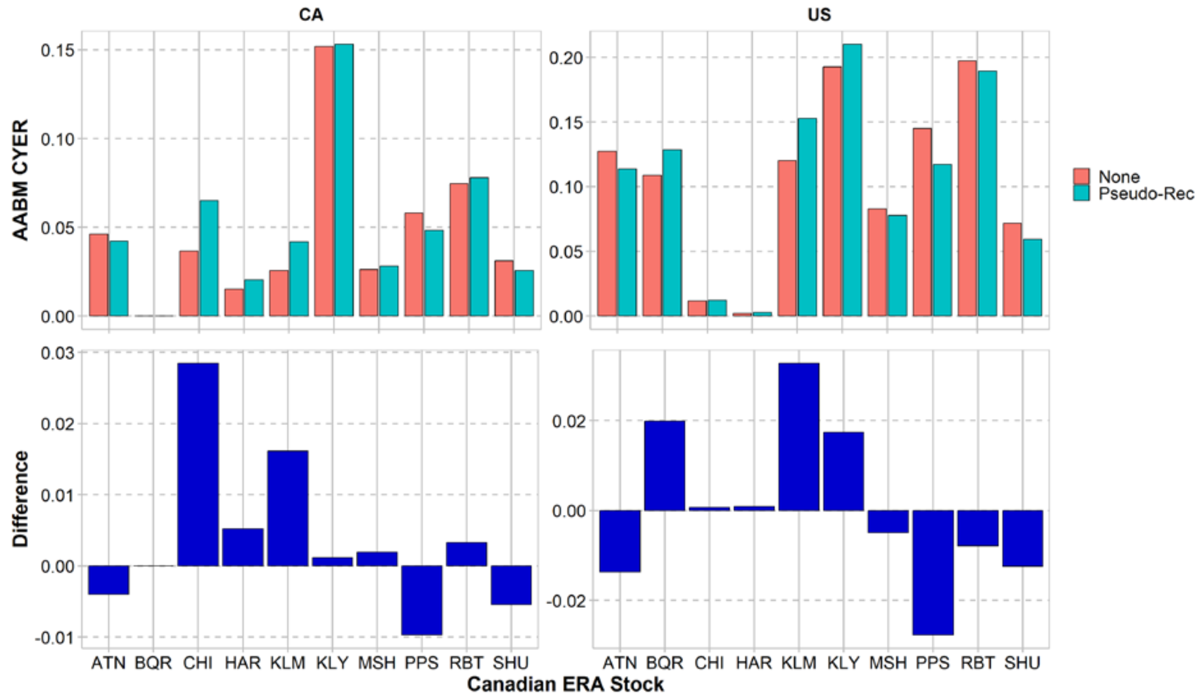
Appendix J5—Comparison of (top), and differences between (bottom) stock- and country-specific individual stock-based management regime (ISBM) total 2022 calendar year mortalities (CYM) derived with and without age-3 pseudo-recoveries for 10 exploitation rate analysis stocks.



Appendix J6—Comparison of (top), and differences between (bottom) stock- and country-specific individual stock-based management (ISBM) regime total 2022 calendar year exploitation rates (CYER) derived with and without age-3 pseudo-recoveries for 10 exploitation rate analysis stocks. Annual CYER limits for specific stocks from Attachment I of Chapter 3 of the Pacific Salmon Treaty are depicted by horizontal black lines (solid) with 10% upper buffers (dashed). Canadian ISBM CYER for Robertson Creek (RBT) are the only estimates that exceeded annual limits in 2022, regardless of inclusion of age-3 pseudo-recoveries (black box, top left panel).



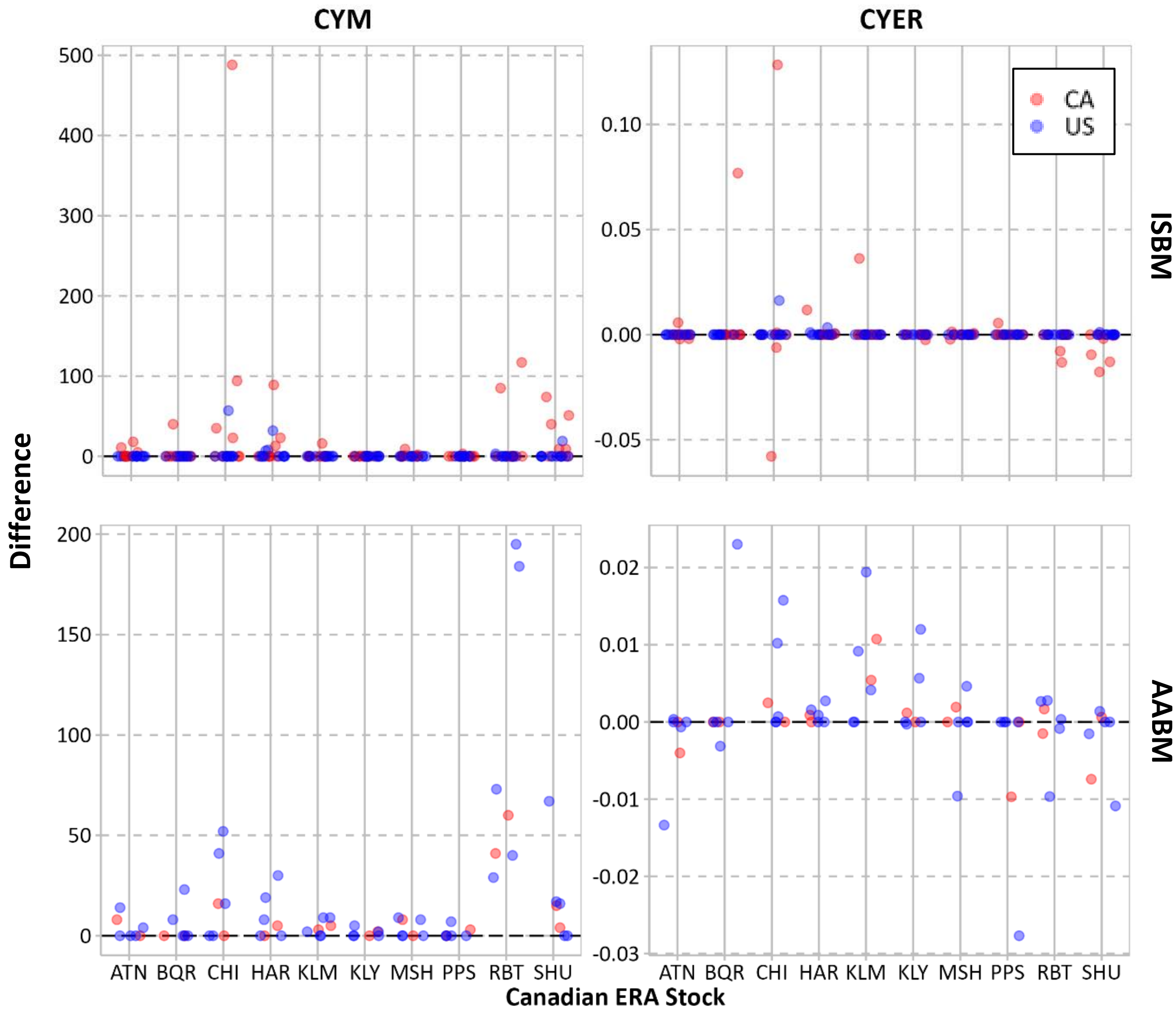
Appendix J7—Comparison of (top), and differences between (bottom) stock- and country-specific abundance-based management regime (AABM) total 2022 calendar year mortalities (CYM) derived with and without age-3 pseudo-recoveries for 10 exploitation rate analysis stocks.



Appendix J8—Comparison of (top), and differences between (bottom) stock- and country-specific abundance-based management regime (AABM) total 2022 calendar year exploitation rates (CYER) derived with and without age-3 pseudo-recoveries for 10 exploitation rate analysis stocks.

Appendix J9—Summary of ERA stock-specific estimates of total 2022 calendar year mortalities (CYM) and exploitation rates (CYER) across all associated individual stock-based management regime (ISBM) and aggregate abundance-based management regime (AABM) fisheries combined and all Canadian and U.S. ISBM and AABM fisheries separately.

Fisheries Group	Metric	Method	Mean	SD	Min	Max
All Fisheries	CYM	None	421.9	617.0	16.0	1,972.0
		Pseudo-Rec	665.7	886.0	29.0	2,799.0
		Difference	243.8	322.4	9.0	827.0
	CYER	None	0.263	0.134	0.064	0.459
		Pseudo-Rec	0.282	0.142	0.087	0.569
		Difference	0.0196	0.059	-0.059	0.111
Canada ISBM	CYM	None	198.3	267.0	2.0	687.0
		Pseudo-Rec	323.8	410.3	5.0	1,017.0
		Difference	125.5	195.8	0.0	640.0
	CYER	None	0.107	0.116	0.023	0.394
		Pseudo-Rec	0.120	0.125	0.034	0.459
		Difference	0.0131	0.037	-0.043	0.077
US ISBM	CYM	None	7.9	12.6	0.0	37.0
		Pseudo-Rec	20.5	33.0	0.0	84.0
		Difference	12.6	21.7	0.0	57.0
	CYER	None	0.004	0.006	0.000	0.017
		Pseudo-Rec	0.006	0.011	0.000	0.033
		Difference	0.0022	0.005	0.000	0.016
Canada AABM	CYM	None	65.6	104.7	0.0	351.0
		Pseudo-Rec	108.7	164.9	0.0	554.0
		Difference	43.1	65.8	0.0	203.0
	CYER	None	0.047	0.043	0.000	0.152
		Pseudo-Rec	0.050	0.042	0.000	0.153
		Difference	0.0037	0.011	-0.010	0.028
US AABM	CYM	None	150.1	282.8	6.0	928.0
		Pseudo-Rec	212.7	408.9	14.0	1,347.0
		Difference	62.6	127.2	7.0	419.0
	CYER	None	0.106	0.066	0.002	0.197
		Pseudo-Rec	0.106	0.069	0.003	0.210
		Difference	0.0005	0.018	-0.028	0.033



Appendix J8—Canadian and U.S. individual stock-based management regime (ISBM; top) and aggregate abundance-based management regime (AABM; bottom) Fishery-specific differences in total 2022 calendar year mortalities (CYM; left) and exploitation rates (CYER; right) derived with and without age-3 pseudo-recoveries for 10 ERA stocks.