

PACIFIC SALMON COMMISSION
JOINT CHINOOK TECHNICAL COMMITTEE REPORT
REVIEW OF THE UNCERTAINTY AND VARIANCE IN CATCH AND RELEASE
ESTIMATES OF CHINOOK SALMON FISHERIES
TCCHINOOK (22)-01

March 28, 2022

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List of Acronyms and Abbreviations

A	Available	MSF	Mark-Selective Fisheries
AABM	Aggregate Abundance-Based Management	NA	Not Available
ADF&G	Alaska Department of Fish & Game	NFL	Nose to Fork Length
BC	British Columbia	NOAA	National Oceanic and Atmospheric Administration
CRITFC	Columbia River Inter-Tribal Fish Commission	NWIFC	Northwest Indian Fisheries Commission
CIG	Chinook Interface Group	ODFW	Oregon Department of Fish & Wildlife
CNR	Chinook Non-Retention	OR	Oregon
CPUE	Catch-Per-Unit-Effort	ORBS	Ocean Recreational Boat Survey
CR	Chinook Retention	PA	Potentially Available
CSAS	Canadian Science Advisory Secretariat	PIT	Passive Integrated Transponder
CTC	Chinook Technical Committee	PSC	Pacific Salmon Commission
CV	Coefficient of Variation	PST	Pacific Salmon Treaty
CWT	Coded-Wire Tag	QIN	Quinault Indian Nation
DFO	Fisheries and Oceans Canada	RM	Release Mortality
DN	Does Not Apply	RT	Ratio method
ELS	Electronic Reporting System	SEAK	Southeast Alaska Cape Suckling to Dixon Entrance
ERA	Exploitation Rate Analysis	SWHS	Statewide Harvest Survey
ESA	Endangered Species Act	TST	Taku and Stikine Rivers
ESU	Evolutionary Significant Unit	TTC	Transboundary Technical Committee
FN	First Nations	UAF	University of Alaska Fairbanks
FNC	First Nations Caucus	UN	Unknown
FSC	Food, Social, Ceremonial Catch	U.S.	United States
FW	Freshwater	USFWS	U.S. Fish & Wildlife Service
GSI	Genetic Stock Identification	WA	Washington
GST	Strait of Georgia	WCVI	West Coast Vancouver Island excluding Area 20
IM	Incidental Mortality	WDFW	Washington Department of Fish and Wildlife
iREC	Internet Recreational Effort and Catch Reporting Program		
ISBM	Individual Stock-Based Management		
ITQ	Individual Transferrable Quotas		
JDF	Strait of Juan de Fuca		
MEF	Mideye to Fork		

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EXECUTIVE SUMMARY

The Chinook Technical Committee (CTC) was tasked to “recommend standards for the desired level of precision and accuracy of data required to estimate incidental fishing mortality” as outlined in Paragraph 4(c) of the 2019 Pacific Salmon Treaty Agreement. The CTC identified a range of potential tasks related to this assignment including, 1) reviewing agency-specific methods to estimate incidental mortality (IM), 2) developing precision estimates around reported releases, 3) developing standards for release estimates, 4) developing requirements for reporting release estimates, 5) developing a matrix of fisheries that ranks the relative uncertainty and magnitude of fishery-specific release estimates, and 6) assessing sources of uncertainty in CTC modeling that may contribute to variation in incidental mortality estimates.

The CTC first conducted a literature review of current incidental mortality rates, and the initial draft was completed and submitted to the Chinook Interface Group (CIG) of the Pacific Salmon Commission (PSC) on December 14, 2020 (Appendix E). Updates to the distributed literature review include a glossary and additional figures for improved clarity and understanding of terms. The literature review includes an overview of factors that influence incidental mortality rates, followed by detailed reviews of studies on current rates of IM for each fishery gear type (i.e., recreational hook and line, troll, gill and tangle nets, and seine nets) and covers some information about drop-off and drop-out studies. In general, the CTC found that there was not much evidence to support changing the rates of IM that are currently used for each gear type. However, it was noted that more research is required for troll fisheries, where no studies were found since the 2004 CTC evaluation of IM rates (CTC 2004). Additional research into net fisheries, where IM rates are known to vary considerably based on the type of net used, is also recommended.

The second half of this assignment is a report on agency-specific methodologies for estimating fishery encounters and recommending levels of precision and accuracy for those encounters estimates. To address this, the CTC sent out a survey to collect information on Chinook fisheries in the Pacific Salmon Treaty area and compiled the results into a report referred to as the Catch Estimates Report.

This report includes a matrix of fisheries that ranks the relative uncertainty and magnitude of fishery-specific release estimates that fall under the Pacific Salmon Treaty (PST) jurisdiction and includes an appendix that reviews the agency-specific methods to estimate encounters (Appendix A). Fisheries were categorized by type and area to identify which tend to have the greatest number of incidental mortalities and uncertainty around incidental mortality estimates (in the form of coefficients of variation, CV). Legal kept catch had the greatest number of survey responses and the most data available for CVs, whereas sublegal kept catch had the least amount of survey responses. Additionally, sport fisheries were found to have the greatest ratios of releases, whereas commercial fisheries (troll and net) kept the majority of their catch, presumed to be in part due to fishery regulations. It is important to note that this report only analyzed the magnitude and uncertainty of catch estimates, and there are several other important aspects that should be examined prior to assigning where improvements for incidental mortality estimates should be made.

Changes to the incidental mortality rates currently used by the CTC or the incorporation of external estimates of incidental mortalities for sublegal fish in retention fisheries into the Exploitation Rate Analysis (ERA) and the Model could be part of the additional improvements for Phase III of the Base Period Calibration. However, the CTC is aware of some of the potential ramifications of such changes (e.g., possible modification of Tables 1 and 2 of the 2019 PST Agreement), thus requiring careful examination of how such changes can affect Chapter 3 implementation.

Summary of CTC Recommendations:

- Additional studies would be required in order to determine if troll fishery IM rates need updating.
- Additional research into net fishery IM rates is also recommended, as they are known to vary considerably based on the type of net used. As currently structured, however, CTC analyses (ERA, PSC Chinook Model) cannot accommodate multiple IM rates for net fisheries and additional effort would be required in order to implement this.
- The results of the literature review found that while the IM rates currently used in CTC analysis are static, this is not reflective of real world scenarios.
 - To better improve IM rate estimates, the CTC could look into additional research for how to incorporate time varying IM rates into this analysis, although this would require a substantial effort and resource commitment.
- Further evaluation is required in order to determine which fisheries need improvement for IM precision and accuracy standards.
 - Active fisheries that have large numbers of releases or did not provide release catch estimates and have high amounts of uncertainty around those estimates or do not currently monitor the precision and accuracy around their estimates, should be reviewed to determine whether or not implementing additional monitoring programs would be of significance to incidental mortality rates.
 - While the ranks resulting from this assessment should help to identify fisheries where improvements could be made, each fishery and its ranking should be considered carefully, as there are instances where aggregation of numerous fine scale fisheries can lead to misleadingly poor rankings for the overall aggregate fishery.
 - Identification of fisheries with either a high number of incidental mortalities or a high ratio of incidental mortality to kept fish could be used to prioritize funding for sampling efforts to improve those estimates.
 - Benefits and associated costs of more stringent monitoring and reporting of release estimates and uncertainty should be considered prior to implementing any changes for agency reporting requirements, along with the feasibility of enforcing additional protocols for data collection.
- Considerations of the implications to the Pacific Salmon Treaty are essential prior to making any changes to the IM rates currently used in CTC analyses.
- Further review of fishery catch stock composition could be useful in determining impacts of incidental mortality on stocks of concern.

1. INTRODUCTION

Per Chapter 3, Paragraph 4c of the 2019 Pacific Salmon Treaty (PST) Agreement, the Chinook Technical Committee (CTC) was tasked with “recommending standards for the desired level of precision and accuracy of data required to estimate incidental fishing mortality.” The Incidental Mortality Workgroup identified a range of potential tasks related to this task including, 1) reviewing agency-specific methods to estimate incidental mortality (IM), 2) developing precision estimates around reported releases, 3) developing standards for release estimates, 4) developing requirements for reporting release estimates, 5) developing a matrix of fisheries that ranks the relative uncertainty and magnitude of fishery-specific release estimates, and 6) assessing sources of uncertainty in CTC modeling that may contribute to variation in IM estimates. There are currently no PST or analytical requirements for providing precision around incidental mortality estimates for Chinook salmon fisheries managed under the PST.

Upon consideration of these potential tasks, the Chinook Interface Group (CIG) of the Pacific Salmon Commission (PSC) directed the Incidental Mortality Workgroup to 1) develop a matrix of fisheries that ranks the relative uncertainty and magnitude of fishery-specific release estimates that fall under the PST jurisdiction and 2) review the agency-specific methods to estimate encounters. The CIG acknowledged that additional tasks would likely be time consuming, may require additional staff outside of the CTC, and could be considered following the completion of the requested two tasks.

Given direction provided by the CIG, the CTC produced an inventory of available estimates of Chinook catch (kept and released) from PSC Chinook Model fisheries¹ coastwide using a survey. The survey concerning Chinook catches and releases was distributed to CTC members, who then contacted fishery managers and relevant agency personnel. The purpose of the survey was to determine and document where data is available for fishery release estimates and the uncertainty around those estimates, and to identify fishery areas relevant to CTC analyses where information is missing either due to a lack of study design, monitoring, or resources. In total, responses for 50 fisheries were received by the Incidental Mortality Workgroup on the survey. Among responses for troll fisheries, release estimates are available only for Alaska, Central British Columbia (BC), and Strait of Georgia. Contrarily, among the net fisheries for which responses were received, estimates of releases are available for all but Juan De Fuca. Puget Sound North Net and Puget Sound Other Net had estimates of releases available but were not provided by the survey deadline. Among the sport fisheries for which responses were received, estimates of releases were available for most fishery areas excluding Alaska Taku and Stikine Rivers Terminal Sport, Central BC Freshwater, Puget Sound Freshwater, Washington Coast Freshwater, and South of Falcon (Oregon) Freshwater.

The number of Chinook caught and the associated precision by PSC Chinook Model-structured fishery/fishery type (troll, net, sport) were provided by survey respondents. There were significant challenges in aligning the stratification of fisheries with differences in regional sampling plans. Fisheries were categorized by type and area to identify which tend to have the

¹ The PSC Chinook Model is comprised of 48 distinctive fisheries (CTC 2021). For this analysis, we added two additional fisheries: Johnstone Strait sport and Washington coast freshwater sport, due to survey responses.

greatest number of incidental mortalities and uncertainty around incidental mortality estimates. Based on the survey responses, precision estimates in the form of coefficients of variation (CV) for kept and released estimates are provided. The objective of this task was to rank fishery types and individual fisheries based on their relative magnitudes and uncertainty around these estimates.

The second objective, a review the agency-specific methods to estimate encounters, is provided in Appendix A.

2. METHODOLOGY

The survey was distributed to CTC members in the summer of 2021 (Appendix A). Agency representatives were requested to indicate categorically where estimates of catch and associated variance were either: A) available, B) potentially available, or C) not available, and to include the estimates if possible (2009–2019 average) or identify them as not available (NA). After information from the survey was collected, fisheries were ranked based on two categories:

- 1) Size of the fishery (number of kept and released catch estimates),
- 2) Coefficient of variation associated with each estimate, or identified as NA.

Fisheries were categorized as having high, medium, or low uncertainty based on the number of releases and their corresponding precision estimates. For example, a fishery with a high number of releases and high or unknown precision estimates would receive a high ranking, and fisheries that have unknown releases and unknown precision estimates would have the highest ranking due to lack of data (Table 1).

Table 1: Matrix for ranking fisheries most in need of improvement for estimating incidental mortality impacts. Definitions for Low to High quintiles are available by catch estimate type (legal kept/released, sublegal kept/released) in the tables below.

CV	Catch (Kept or Released) Estimate						
	Low	Low-Medium	Medium	Medium-High	High	Potentially Available	Not Available
Low	1	2	3	4	5	6	7
Low-Medium	2	3	4	5	6	7	8
Medium	3	4	5	6	7	8	9
Medium-High	4	5	6	7	8	9	10
High	5	6	7	8	9	10	11
Potentially Available	6	7	8	9	10	11	12
Not Available	7	8	9	10	11	12	13

Data were sorted based on type of catch (legal kept, legal released, sublegal kept and sublegal released) and percentiles were calculated for all fisheries together. Each fishery was associated with ascending quintiles and scores for its estimate and variance. Included in the score were the

categories “potentially available” and “not available”, which had scores of 6 and 7, respectively. Each fishery was given a ranking from Table 1 based on its two scores.

Table 2: Ranking scheme for legal kept catch.

	Legal Kept					
	Estimate	Quintile	Score	CV	Quintile	Score
Min	0			0%		
Q20 (Low)	1518	0–1518	1	0%	0%	1
Q40 (Low-Medium)	12264	1519–12264	2	0%	0%	1
Q60 (Medium)	22767	12265–22767	3	4%	0.1–4%	2
Q80 (Medium-High)	57743	22768–57743	4	11%	4.1–11%	3
Q100 (High)	221646	57744–221646	5	37%	11.1–37%	4
Potentially Available	PA		6	PA		6
Not Available	NA		7	NA		7

Table 3: Ranking scheme for legal released catch.

	Legal Released					
	Estimate	Quintile	Score	CV	Quintile	Score
Min	0			0%		
Q20 (Low)	238	0–238	1	0%	0%	1
Q40 (Low-Medium)	2147	239–2147	2	0%	0%	1
Q60 (Medium)	9892	2148–9892	3	11%	0.1–11%	2
Q80 (Medium-High)	23868	9893–23868	4	17%	11.1–17%	3
Q100 (High)	66182	23869–66182	5	40%	17.1–40%	4
Potentially Available	PA		6	PA		6
Not Available	NA		7	NA		7

Table 4: Ranking scheme for sublegal kept catch.

	Sublegal Kept					
	Estimate	Quintile	Score	CV	Quintile	Score
Min						
Q20	0		1	0%	0%	1
Q40	0		1	0%	0%	1
Q60	0		1	0%	0%	1
Q80 (Low)	276	0–276	1	0%	0%	1
Q100 (Low-Medium)	2570	277–2570	2	45%	0.1–45%	2
Potentially Available	PA		6	PA		6
Not Available	NA		7	NA		7

Table 5: Ranking scheme for sublegal released catch.

	Sublegal Released					
	Estimate	Quintile	Score	CV	Quintile	Score
Min						
Q20 (Low)	80	0–80	1	0%	0%	1
Q40 (Low-Medium)	808	81–808	2	0%	0%	1
Q60 (Medium)	6532	809–6532	3	10%	0.1–10%	2
Q80 (Medium-High)	23799	6533–23799	4	17%	10.1–17%	3
Q100 (High)	131909	23800–131909	5	76%	17.1–76%	4
Potentially Available	PA		6	PA		6
Not Available	NA		7	NA		7

3. RESULTS

Each PSC Chinook Model fishery¹ is made up of component fisheries which are listed in Appendix A. Please note that component fisheries may include several different regional fisheries with varying sampling and monitoring programs. Not all of the 50 fisheries that were surveyed are active/had data that could be applied in this survey. Central BC Freshwater Net, Georgia Strait Freshwater Net and Fraser Freshwater Net did not have catches that were applicable to this survey (labeled as DN = does not apply).

Table 6: Count of overall survey responses. “A” was an “Available” estimate where the number was provided in the survey response for either the Estimate or CV. “NA” and “PA” are “Not Available” and “Potentially Available”, respectively, and reasons for selecting NA or PA for that fishery are provided in Appendix A. For fisheries where a particular category is not relevant (i.e., sublegals in a fishery without a size limit), a “DN” (Does Not Apply) was the response.

	Legal Kept Catch		Legal Released Catch		Sublegal Kept Catch		Sublegal Released Catch	
	Estimate	CV	Estimate	CV	Estimate	CV	Estimate	CV
A	45	23	29	18	17	17	28	20
NA	1	13	6	15	13	19	13	17
PA	1	11	12	14	15	9	4	8
DN	3	3	3	3	5	5	5	5

Table 7: Count of survey responses by fishery type.

	Legal Kept Catch		Legal Released Catch		Sublegal Kept Catch		Sublegal Released Catch	
	Estimate	CV	Estimate	CV	Estimate	CV	Estimate	CV
Troll								
A	7	5	4	3	1	1	4	3
NA	0	2	2	3	3	6	3	3
PA	0	0	1	1	3	0	0	1
DN	0	0	0	0	0	0	0	0

	Legal Kept Catch		Legal Released Catch		Sublegal Kept Catch		Sublegal Released Catch	
	Estimate	CV	Estimate	CV	Estimate	CV	Estimate	CV
Net								
A	17	5	10	6	7	7	11	7
NA	0	5	1	5	3	6	3	6
PA	0	7	6	6	6	3	2	3
DN	3	3	3	3	4	4	4	4
Sport								
A	21	13	15	9	9	9	13	10
NA	1	6	3	7	7	7	7	8
PA	1	4	5	7	6	6	2	4
DN	0	0	0	0	1	1	1	1

3.1 LEGAL KEPT AND RELEASED CATCH

Legal kept catch had the most survey responses, with estimates being provided in 45 of the 50 surveyed fisheries (Table 6). CVs were provided for 23 of the legal kept catch estimates, with 5 troll, 5 net, and 13 sport fisheries reporting CVs (Table 7). Troll fisheries had the highest rate (5 of 7) of fisheries reporting legal kept CVs. Most net fisheries (4 of 5) that reported legal kept CVs were in Southeast Alaska (SEAK). Legal kept CVs were reported more frequently for marine sport fisheries (11 of 13) than freshwater sport fisheries (2 of 10) (Table 7).

There were 29 legal released catch estimates provided, and 18 of those included a CV (Table 6). Of those fisheries reporting a legal released CV, there were 3 troll fisheries, 6 net fisheries, and 9 sport fisheries (Table 7). Of those troll fisheries reporting a CV, all were in the BC area. For those net fisheries reporting a CV, 3 did not have legal releases and 2 had releases reported with 100% sampling. Therefore, these fisheries had a CV of 0%. Marine sport fisheries in SEAK and BC were more likely to have legal release CVs reported than for Southern U.S. or Freshwater fisheries.

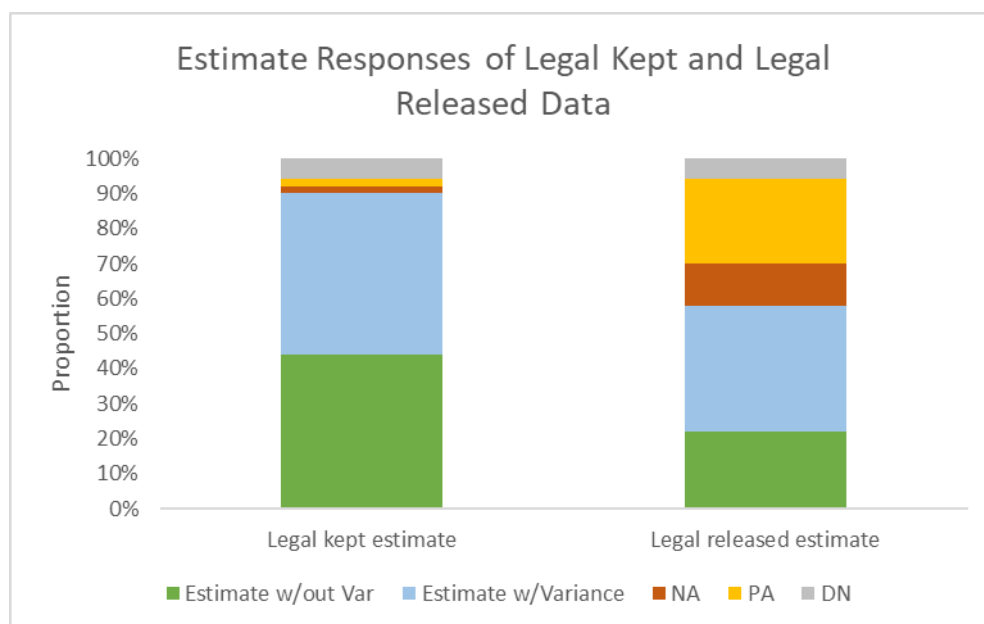


Figure 1: Estimate Responses of Legal Kept and Released Data.

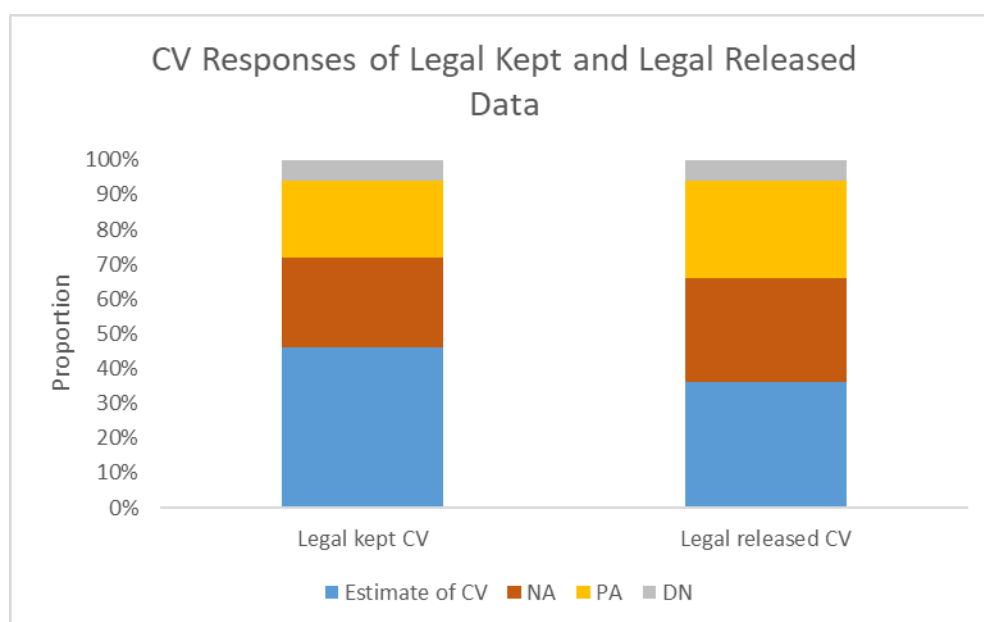


Figure 2: Coefficient of Variation (CV) Responses of Legal Kept and Released Data.

3.2 SUBLEGAL KEPT AND RELEASED CATCH

Sublegal kept catch had the least amount of data as it did not apply to many fisheries. Seventeen fisheries provided an estimate for sublegal kept catch, but they all had CVs (Table 6). Only 1 of 7 troll fisheries surveyed had estimates of kept sublegal catch, Alaska Troll (Table 7). Washington Coast Net, Puget Sound Freshwater Net, Washington Coast Freshwater Net all indicated that catch estimates were available, but that their estimate and CVs were 0 because

there are no size regulations for Chinook catch and therefore no sublegals. As in earlier categories, estimates and CVs were more likely to be available for marine sport fisheries (9 of 13) than freshwater sport fisheries (0 of 10).

There were 28 fisheries that had sublegal released catch data (13 sport, 11 net, 4 troll), and 20 of these (3 troll, 7 net, 10 sport) also provided CVs. Of the three troll fisheries reporting sublegal release CVs, all occurred in BC (Northern, West Coast Vancouver Island [WCVI], Strait of Georgia). Many net fisheries reported sublegal release CVs of 0% due to not having a size limit. Nine of the ten sport fisheries with sublegal release CVs were marine fisheries.

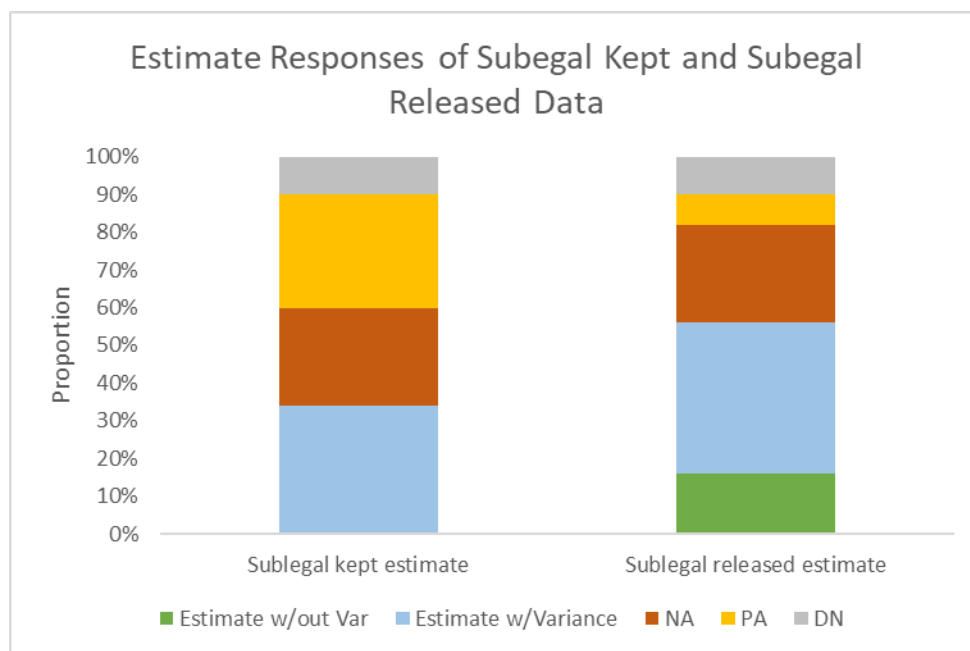


Figure 3: Estimate Responses of Sublegal Kept and Released Data.

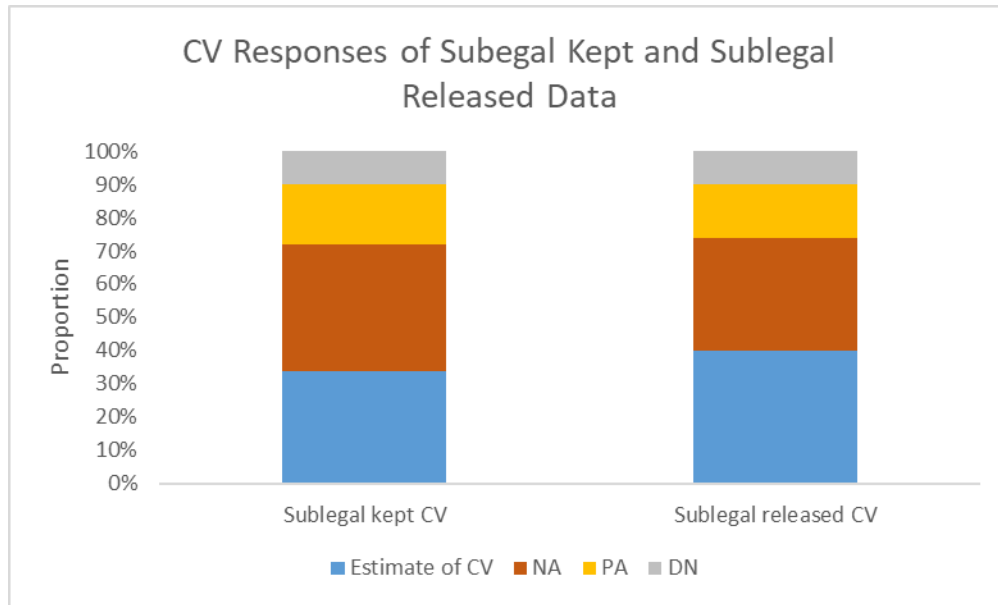


Figure 4: Coefficient of Variation (CV) responses of Sublegal Kept and Released Data.

Sublegal kept catch and variance did not apply to 5 fisheries and were removed from analysis. Estimates of sublegal kept catch and variance were provided or noted as available for a total of 17 fisheries, 1 troll, 7 net, and 9 sport fisheries (Table 7). Estimates and variances were potentially available for 9 fisheries (3 net and 6 sport fisheries), and an additional 6 net fisheries indicated that estimates were potentially available but estimates of variance were not. There were 12 fisheries where no estimate of sublegal kept catch or a variance was available and an additional 4 where no estimate of variance was available. Two sport fisheries indicated that estimates of variance did not apply (Table 8).

Table 8: Status of kept sublegal catch estimates and variances. *Italic text indicates fishery is present in both estimate and variance availability.*

Sublegal Kept Catch		Not Available	Potentially Available	Available	Does Not Apply
Troll Fisheries	Estimates	<i>CENTRL T</i> <i>S FALCON T</i> <i>N FALCON T</i> <i>NORTH T</i>	WCVI T GEO ST T	<i>ALASKA T</i>	
	Variance	<i>CENTRL T</i> <i>S FALCON T</i> GEO ST T <i>NORTH T</i> WCVI T <i>N FALCON T</i>		<i>ALASKA T</i>	
Net Fisheries	Estimates	<i>CENTRL N</i> <i>J DE F N</i>	<i>TAK TST N</i> NORTH N WCVI N JNST N	<i>WASH CST N</i> <i>TPS FN</i> <i>TWAC FN</i> <i>TAK YAK N</i>	

Sublegal Kept Catch		Not Available	Potentially Available	Available	Does Not Apply
			<i>PGSDN N</i> <i>PGSDO N</i>	<i>TBC TST FN</i> <i>TYK YAK FN</i> <i>ALASKA N</i>	
	Variance	<i>CENTRL N</i> <i>J DE F N</i> <i>NORTH N</i> <i>WCVI N</i> <i>JNST N</i>	<i>TAK TST N</i> <i>PGSDN N</i> <i>PGSDO N</i>	<i>WASH CST N</i> <i>TPS FN</i> <i>TWAC FN</i> <i>TAK YAK N</i> <i>TBC TST FN</i> <i>TYK YAK FN</i> <i>ALASKA N</i>	
Sport Fisheries	Estimates	<i>N FALCON S</i> <i>TCOL R S</i> <i>TNORTH FS</i> <i>TCENTRAL FS</i> <i>TWCVI FS</i> <i>TSF FS</i> <i>WAC FS</i>	<i>TGS FS</i> <i>PGSDN S</i> <i>PGSDO S</i> <i>TPS FS</i> <i>TAK TST S</i> <i>S FALCON S</i>	<i>ALASKA S</i> <i>CBC S</i> <i>NBC AABM S</i> <i>NBC ISBM S</i> <i>WCVI AABM S</i> <i>WCVI ISBM S</i> <i>GEO ST S</i> <i>BC JF S</i> <i>JOHN ST S</i>	
	Variance	<i>TNORTH FS</i> <i>TCENTRAL FS</i> <i>TWCVI FS</i> <i>TSF FS</i> <i>WAC FS</i>	<i>TGS FS</i> <i>PGSDN S</i> <i>PGSDO S</i> <i>TPS FS</i> <i>TAK TST S</i> <i>S FALCON S</i>	<i>ALASKA S</i> <i>CBC S</i> <i>NBC AABM S</i> <i>NBC ISBM S</i> <i>WCVI AABM S</i> <i>WCVI ISBM S</i> <i>GEO ST S</i> <i>BC JF S</i> <i>JOHN ST S</i>	<i>N FALCON S</i> <i>TCOL R S</i>

Respondents provided estimates of sublegal released catch and associated variance or indicated they were available for 20 fisheries (3 troll, 7 net, and 10 sport fisheries). An additional 10 fisheries had estimates but no variance (1 troll, 4 net, and 5 sport fisheries). There were 4 fisheries where estimates and variances were potentially available, with an additional 6 fisheries where variance was potentially available. Each of those 6 fisheries had estimates available. Ten fisheries did not have estimates of sublegal released catch or variances, and an additional 4 where only variance was not available. These 4 fisheries did have estimates of sublegal catch available (Table 9).

Table 9: Status of sublegal released catch estimates and variance. Italic text indicates fishery is present in both estimate and variance availability.

Sublegal Released Catch		Not Available	Potentially Available	Available	Does Not Apply
Troll Fisheries	Estimates	<i>CENTRL T</i> <i>N FALCON T</i> <i>S FALCON T</i>		<i>ALASKA T</i> <i>GEO ST T</i> <i>NORTH T</i>	

Sublegal Released Catch		Not Available	Potentially Available	Available	Does Not Apply
				WCVI T	
	Variance	CENTRL T N FALCON T S FALCON T	ALASKA T	GEO ST T NORTH T WCVI T	
Net Fisheries	Estimates	CENTRL N J DE F N	PGSDN N PGSDO N	WASH CST N TPS FN TWAC FN TAK YAK N TBC TST FN TYK YAK FN ALASKA N TAK TST N NORTH N WCVI N JNST N	
	Variance	CENTRL N J DE F N NORTH N WCVI N JNST N	PGSDN N PGSDO N ALASKA N	WASH CST N TPS FN TWAC FN TAK YAK N TBC TST FN TYK YAK FN TAK TST N	
Sport Fisheries	Estimates	S FALCON S TCENTRAL FS TWCVI FS TSF FS WAC FS	TPS FS TAK TST S	ALASKA S CBC S NBC AABM S NBC ISBM S WCVI AABM S WCVI ISBM S GEO ST S BC JF S JOHN ST S TGS FS PGSDN S PGSDO S N FALCON S TCOL R S TNORTH FS	
	Variance	S FALCON S TCENTRAL FS TWCVI FS TSF FS WAC FS TNORTH FS	TPS FS TAK TST S PGSDN S PGSDO S N FALCON S TCOL R S	ALASKA S CBC S NBC AABM S NBC ISBM S WCVI AABM S WCVI ISBM S GEO ST S BC JF S JOHN ST S TGS FS	

3.3 FISHERY RANKINGS

Fisheries were ranked based on their relative kept and released magnitudes and associated CVs for each gear type (troll, net, and sport; Table 1). Fisheries with smaller estimates and lower CVs in those estimates were given the lowest rankings. The majority of fisheries that are ranked high (10–13) are a result of either a higher relative kept or released estimate than other fisheries or CVs being unknown. Note that in some cases a categorization of unknown was assigned to fisheries where estimates and CVs were available for the majority of the fishery, but not for spatial or temporal subcomponents of a fishery. Additionally, some fisheries were categorized as potentially available either because the information is collected but not calculated due to logistical constraints or regional biologists were not able to provide data prior to the deadline of the survey. Given the comprehensive nature of the present analysis, obtaining such estimates requires an extensive query to a large number of regional datasets along the coast, and gaps in the survey are sometimes more indicative of a non-response rather than a lack of available data. Information regarding specific fisheries is available in Appendix A, which highlights some of the caveats described above and should be referred to prior to assigning the overall importance of the fishery in terms of ‘in need of improvement’ for incidental mortality.

3.3.1 Troll Fisheries

Of the 7 troll fisheries examined, the highest overall rankings were in the sublegal kept categories as both estimates and CVs were classified as “unknown” or “potentially available” for 6 of the 7 fisheries. Rankings were next highest for the legal released and sublegal released catch categories. Average estimates and CVs for individual troll fisheries are available in Appendix C (Appendix C1).

Table 10: Rankings for troll fisheries.

Fishery Area (abb.)	Annual Average Legal Catch (2009–2019)		Annual Average Sublegal Catch (2009–2019)	
	Kept	Released	Kept	Released
	Ranking		Ranking	
ALASKA T	5	10	1	10
NORTH T	5	4	12	4
CENTRL T	1	2	13	13
WCVI T	5	2	12	3
N FALCON T	11	13	13	13
S FALCON T	11	13	13	13
GEO ST T	1	12	12	2

3.3.2 Net Fisheries

As in troll fisheries, the highest rankings in net fisheries were for the sublegal kept category. Because of the differences in regulations in net fisheries relative to sport and troll, many categories received a rank of ‘1’ because no fish were released or no size limits exist in some

fisheries. For these fisheries, this results in low estimates of releases and sublegals. Average estimates and CVs for individual net fisheries are available in Appendix C (Appendix C2).

Table 11: Rankings for net fisheries.

Fishery Area (abb.)	Annual Average Legal Catch (2009–2019)		Annual Average Sublegal Catch (2009–2019)	
	Kept	Released	Kept	Released
	Ranking		Ranking	
ALASKA N	4	8	2	9
NORTH N	8	12	12	9
CENTRL N	8	8	13	13
WCVI N	9	12	12	8
J DE F N	6	13	13	13
PGSDN N	7	11	11	11
PGSDO N	9	11	11	11
WASH CST N	8	11	1	1
TCOL R N	11	7	13	13
TPS FN	9	1	1	1
TWAC FN	7	1	1	1
TAK YAK N	1	4	3	5
TAK TST N	4	1	11	1
TBC TSR FN	2	1	2	1
TCENTRAL FN				
TGEO ST FN				
TFRAS FN				
TYK YAK FN	1	1	1	1
JNST N	7	12	12	9
FRASER N	8	7	13	13

3.3.3 Sport Fisheries

In general, the highest rankings for sport fisheries were in freshwater sport fisheries, which corresponds with a greater frequency of “unknown” or “potentially available” responses for those fisheries. Similar to net and troll fisheries, kept sublegals had higher rankings on average than the other categories examined. Average estimates and CVs for individual net fisheries are available in Appendix C (Appendix C3).

Table 12: Rankings for sport fisheries.

Fishery Area (abb.)	Annual Average Legal Catch (2009–2019)		Annual Average Sublegal Catch (2009–2019)	
	Kept	Released	Kept	Released
	Ranking		Ranking	
ALASKA S	6	8	3	6
CBC S	6	6	1	6
NBC AABM S	6	7	1	6
NBC ISBM S	5	6	1	5
WCVI AABM S	5	6	1	7
WCVI ISBM S	5	5	1	5

Fishery Area (abb.)	Annual Average Legal Catch (2009–2019)		Annual Average Sublegal Catch (2009–2019)	
	Kept	Released	Kept	Released
	Ranking		Ranking	
N FALCON S	10	11	13	13
S FALCON S	7	7	11	13
PGSDN S	4	9	11	9
PGSDO S	4	10	11	10
GEO ST S	8	6	1	6
BC JF S	6	7	1	7
TCOL R S	11	8	13	13
TPS FS	4	11	11	11
TAK TST S	5	11	11	11
TNORTH FS	8	12	13	8
TCENTRAL FS	7	12	0	13
TWCVI FS	13	13	13	13
TFRASER FS	8	8		
TGS FS	11	11	11	5
TSF FS	10	13	13	13
TWAC S	8	13	13	13
JOHN ST S	4	5	1	6

Note: BC Marine sport fisheries are based on years when iREC (Internet Recreational Effort and Catch) and creel surveys were available in order to provide CV estimates (2015–2019).

3.4 FISHERY MAGNITUDE, RELATIVE CV, AND RATIO OF KEPT TO RELEASED CATCH

Figure 5 depicts the magnitude of each fishery relative to each other based on the blue fill in each cell (legal kept, legal released and sublegal released catch estimates). The figure also includes a heat map where the CVs of each fishery are colour-coded from green to red, with green representing the lowest CVs and red the highest. The final two columns of Figure 5 show ratios of legal released and sublegal released estimates to legal kept catch, which also uses a heat map and is similarly colour-coded from green to red, with green representing the lowest ratio and red the highest.

Fisheries with the largest numbers of releases are of most significance to incidental mortality, but the magnitude of releases should also be considered in the context of the magnitude of retention. Fisheries with a large number of retentions tend to have a larger number of releases, as a large number of releases may be indicative of greater fishing effort. Therefore, we compared ratios of legal and sublegal released catch with legal kept catch (Legal Rel/Kept and Sublegal Rel/Kept, respectively) to determine which fisheries had the greatest numbers of releases compared to legal kept catch. The ratio of legal released to legal kept catch varied from 0–1.55 while the ratio of sublegal released to legal kept catch had much higher ratios and varied from 0–10.80.

All reported ratios, along with any comparisons and subsequent inference should be interpreted with caution because of the high amount of uncertainty associated with the estimated ratios. This uncertainty will be more pronounced in the recreational fisheries since

the denominator (legal kept catch) is often estimated. The amount of uncertainty will depend largely on the CVs; however, even if one estimate has a low CV (i.e., <10%), the ratio could still be poorly estimated if the other estimate used to compute the ratio has a medium to large CV.

Overall, the majority of fisheries with high ratios of released to kept catch were all in the sport fishery category. Regulations are important to consider when examining this data because mark-selective fisheries are designed to release legal-sized wild fish. Additionally, commercial (troll and net) fisheries had the lowest ratios as they rarely release fish and therefore had very few releases compared to kept catch. When examining Legal Rel/Kept and Sublegal Rel/Kept ratios metrics, it should be considered that ratios are difficult to compare across fisheries due to differing incidental mortality rates. If one fishery has an incidental mortality rate of 5% and one has an incidental mortality rate of 50%, just examining the number of releases would be less informative because, given an equal number of releases, the incidental mortalities would be ten times higher for the fishery with a 50% incidental mortality rate relative to the fishery with a 5% incidental mortality rate.

Fishery	Estimate			CV			Ratio	
	Legal Kept	Legal Released	Sublegal Released	Legal Kept	Legal Rel	Sub Rel	Legal Rel/Kept	Sublegal Rel/Kept
ALASKA T	211153	45264	62898	0%			0.21	0.30
NORTH T	93525	14377	10462	0%	0%	0%	0.15	0.11
CENTRL T	0	662		0%	0%			
WCVI T	71457	334	3864	0%	0%	0%	0.00	0.05
N FALCON T	75292							
S FALCON T	57428							
GEO ST T	0		91	0%		0%		
ALASKA N	42023	5368	19847	0%			0.13	0.47
NORTH N	1907		1599					0.84
CENTRL N	3959	886					0.22	
WCVI N	16766		381					0.02
J DE F N	823							
PGSDN N	3495							
PGSDO N	46229							
WASH CST N	12330		0			0%		0.00
TCOL R N	221646	533					0.00	
TPS FN	33242	93	0		0%	0%	0.00	0.00
TWAC FN	12164	0	0		0%	0%	0.00	0.00
TAK YAK N	586	80	107	0%	40%	76%	0.14	0.18
TAK TST N	1257	0	0	15%	0%	0%	0.00	0.00
TBC TST FN	5491	72	72	0%	0%	0%	0.01	0.01
TCENTRAL FN								
TGEO ST FN								
TFRAS FN								
TYK YAK FN	111	0	0	0%	0%	0%	0.00	0.00
JNST N	112		1213					10.80
FRASER N	15039	1250					0.08	
ALASKA S	59005	26866	52926	4%	23%	7%	0.46	0.90
CBC S	20077	15683	5549	7%	16%	27%	0.78	0.28
NBC AABM S	47947	59951	1335	5%	12%	30%	1.25	0.03
NBC ISBM S	5470	3170	728	16%	30%	71%	0.58	0.13
WCVI AABM S	51987	19251	25509	5%	11%	11%	0.37	0.49
WCVI ISBM S	54156	10464	23043	4%	9%	9%	0.19	0.43
N FALCON S	26802	27880					1.04	
S FALCON S	8266	2140					0.26	
PGSDN S	18394	21870	16404	4%			1.19	0.89
PGSDO S	17940	27740	26404	4%			1.55	1.47
GEO ST S	103855	66182	131909	7%	6%	5%	0.64	1.27
BC JF S	31976	10215	24303	5%	17%	11%	0.32	0.76
TCOL R S	63284	2174					0.03	
TPS FS	17339			4%				
TAK TST S	1442			30%				
TNORTH FS	1537		256					0.17
TCENTRAL FS	1108							
TWCVI FS								
TFRASER FS	13034	8602					0.66	
TGS FS			828			15%		
TSF FS	108742							
TWAC FS	8757							
JOHN ST S	12661	2703	11229	7%	15%	11%	0.21	0.89

Figure 5: Magnitude of each fishery and heat map showing where the highest CVs or ratios occur. Light grey = does not apply, dark grey = unknown, and black = blank.

4. DISCUSSION

The objective of this report was to provide a high-level overview of the availability and precision of catch estimates for Chinook fisheries along the west coast in a consistent manner, only falling short of this due to 3 factors: 1) lack of specificity in the request and outreach; 2) lack of clarity, transparency, consistency received from respondents, and/or 3) no strategic reconciliation or enforceability measures available to the CTC to verify individual domestic responses. The information in this report provides a preliminary identification of fisheries where improved monitoring of release estimates could be assigned, with Appendix A giving additional details regarding the specifics of each fishery area and the component fisheries that make up the catch and precision estimates. However, while magnitude and uncertainty around catch estimates are the two factors that were focused on in this report, there are several other important aspects that should be considered relative to each fishery prior to assigning where improvements should be made.

In terms of uncertainty, we chose to examine the precision around catch estimates in the form of CVs in this report. Understanding the precision associated with catch estimates is vital for the development of precision and accuracy standards for incidental mortality rates, but there are other metrics and sources of biases that should not be overlooked. For example, some agencies may use sample expansion factors in their catch estimate calculations, which could lead to a sampling bias. Methods for estimating catch are described in Appendix A.

Management around strict limitations are of the first importance for mixed-stock fisheries where there are high catches of stocks of concern (e.g., U.S. Endangered Species Act [ESA]-listed Evolutionary Significant Units [ESU]). In Columbia River fisheries, for example, elaborate efforts/accounting of separate impacts on the many listed ESUs are required under the ESA as well as under U.S. v. Oregon court opinions, and measures of variance/CV may be more critical. In U.S. management, PSC Chinook Model abundance outputs are used to inform the Pacific Fishery Management Council model pre-season estimates which guide fishery management, particularly around stocks of concern. However, even a fishery that is large with many releases may not be of particularly high policy concern depending on the proportion of stocks of concern.

In addition to the estimate of released fish, rates of incidental mortality also vary and should be considered as in the CTC's review of IM rates (Appendix E). The present analysis could be paired with the results of the literature review to identify fisheries with an overall high number of incidental mortalities. For example, a sport fishery with a high ratio of legal releases to kept catch could be investigated to see if improvements could be made to the IM rates by recommending different gear types. Another example could be a net fishery with a large variance around the catch estimates where improved monitoring programs could be considered. Identification of these types of fisheries with either a high number of incidental mortalities or a high ratio of incidental mortality to kept fish could be used to prioritize funding for sampling efforts to improve those estimates.

Note that fishery regulations are not captured in the survey and should be considered as readers review results. For example, in a mark-selective fishery, it is expected that the ratio of kept to released fish would be greater than in a non-selective fishery. Therefore, mark-selective

fisheries may have greater incidental mortality impacts than non-selective fisheries occurring under the same fishing conditions. However, because wild fish are released in mark-selective fisheries, it is hoped that wild mortalities may be lower overall than in an equivalent non-selective fishery, even if incidental mortalities are greater. This assumption is most likely to be true if incidental mortality rates are low because released fish are more likely to survive and if encountered mark rates are high because fewer fish would theoretically be released to achieve bag limits.

Similarly, the location of fishing and stocks encountered by a fishery are not considered in the present analysis. Total incidental mortalities in a fishery may be of less interest if the fishery is primarily encountering a hatchery or healthy stock rather than wild or low abundance stocks. As an increased number of fish from stocks of concern are encountered in fisheries, the need for improved monitoring and greater certainty around estimates produced may increase.

Though this analysis represents an inventory of catch estimates along the west coast, there was a loss of information resulting from using the PSC Chinook Model fishery definitions as a means to define a fishery that falls under the jurisdiction of the PST. PSC Chinook Model fisheries often represent aggregate regional fisheries that can span multiple agencies, areas, and regulations. For the purposes of this analysis, if there was a single sub-component fishery that did not have estimates or variance, then the entire PSC Chinook Model fishery was classified as “potentially available” or “not available,” even if the majority of the PSC Chinook Model fishery did have estimates available. Several fisheries that did not respond in time or that had catches not applicable to the survey were classified as DN in the survey (Table 6). If more time had been provided for this request, perhaps more fisheries would have been classified as PA. There was also some confusion among survey respondents about the designation of PSC Chinook Model fisheries. Some respondents interpreted this request to only include fisheries that appear in the PSC Chinook Model, and consequently not all Chinook fisheries that fall under the jurisdiction of the PST were reported on. There was also some confusion regarding whether this assignment was specific to Chinook-directed fisheries only, again as a result of how fisheries were defined in the survey. For details about a particular fishery, readers should review Appendix A and Appendix B for additional details regarding sampling protocols and potential data availability.

In the present analysis, the highest released to kept ratios occurred in the sport fisheries, which can be closed for Chinook retention (or closed to salmon fishing outright) but open for the retention of other salmonid species (i.e., a Chinook non-retention [CNR] fishery). Troll and net fisheries had very low ratios of legal released to kept fish, since most fish that are caught in commercial fisheries are retained. In addition to being a commercial fishery, release regulations often do not prevent mortality in net fisheries during and following capture.

The PSC Chinook Model incorporates landed catch estimates for some fisheries in the ceiling file and in the Chinook non-retention (CNR) file. One of the methods used in the CNR file incorporates both landed catch and incidental mortalities from legal and sublegal CNR encounter estimates from external sources. However, there is currently no ability to incorporate external estimates of sublegal in a retention fishery.

As in the Chinook Model, one of the three CNR methods used in the Exploitation Rate Analysis (ERA) proportion sublegal file incorporates both landed catch and legal and sublegal CNR

encounter estimates from external sources. However, like the PSC Chinook Model, there is currently no ability to incorporate external estimates of sublegal incidental mortalities (i.e., sublegals) in a retention fishery.

Currently the ERA has three methods of estimating legal and sublegal encounters in CNR fisheries. The first method is the effort/season length method that multiplies the expanded coded-wire tag (CWT) recoveries by the ratio of non-retention effort to retention effort times a selectivity factor to account for the fact that Chinook aren't being targeted in the CNR fishery. The second method multiplies the expanded CWT recoveries by the ratio of external estimates of CNR encounters to landed catch to estimate the CNR encounters. The third method is the catchability coefficient method that is used when there is CNR but there was no retention fishery and is based on the effort in the CNR fishery and the catchability coefficient.

The PSC Chinook Model also incorporates an effort/season length CNR method and an external estimate of CNR encounters method but does not have a catchability coefficient method. In addition, the Model has a CNR method known as the ratio, or RT, method that computes the difference between observed catch in a particular year and the catch that would have been observed if the fishery had operated under base period exploitation rates. It is assumed that this difference is the magnitude of fish available to be encountered during the CNR fishery.

Both the Model and the ERA estimate sublegal during a retention fishery by multiplying the ratio of the sum of the non-vulnerable cohorts by stock and age to the sum of the vulnerable cohorts times the catch in the fishery. Methods for incorporating external estimates of sublegals have been proposed but have not been implemented to date.

Lastly, in both the ERA and the PSC Chinook Model, an assumed drop-off rate is applied to all catch, sublegals, legal CNR encounters, and sublegal CNR encounters to estimate the number of drop-offs in each of these categories.

Changes to the incidental mortality rates currently used by the CTC or the incorporation of external estimates of incidental mortalities for sublegal fish in retention fisheries into the ERA and the Model could be part of the additional improvements for Phase III of the Base Period Calibration. However, the CTC is aware of some of the potential ramifications of such changes (e.g., possible modification of Tables 1 and 2 of the 2019 PST Agreement), thus requiring careful examination of how such changes can affect Chapter 3 implementation.

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APPENDIX A: DESCRIPTION OF METHODS USED BY AGENCIES TO ESTIMATE ENCOUNTERS

A.1 ALSEK AND SITUK RIVERS

An overview of sampling programs by component fisheries for U.S. and Canadian Chinook fisheries in the Alsek and Situk rivers is shown in Appendix A1, with descriptive narratives provided below. Information is presented by PSC model fishery and further broken down into component fisheries.

Appendix A1: Overview of the component fisheries and sampling programs for catch and incidental mortality in PSC Chinook fisheries in the Alsek and Situk Rivers.

PSC Fishery	Component Fisheries	Kept Large Catch Estimates	Released Large Catch Estimates	Non-Large Estimates	Large Size (MEF ¹)
Alaska Yakutat Net	Situk Freshwater Sport	SWHS ² /Creel Census	SWHS ² /Creel Census	SWHS ² /Creel Census	28 inches (TTL ³)
	Situk Setnet	Fish Tickets	No Estimate ⁴	NA	26 inches
	Situk Subsistence	Permit	None	None	26 inches
	Alsek Freshwater Sport	SWHS ¹	SWHS ¹	SWHS ¹	28 inches (TTL ³)
	Alsek Setnet	Fish Tickets			26 inches
	Alsek Subsistence	Permit			26 inches
Yukon/British Columbia	Aboriginal				26 inches
	Recreational				26 inches

¹MEF = mid-eye to fork length

²SWHS = statewide harvest survey

³TTL = total length (tip of the snout to the tip of the tail).

⁴CNR may be implemented when the Situk escapement is less than 730 fish.

A.1.1 Alsek River Fisheries

Chinook salmon returning to the Alsek River drainage are jointly managed by the U.S. and Canada (i.e., DFO, Champagne & Aishihik First Nation and ADF&G) through the joint Transboundary Technical Committee (TTC) of the PSC. The principal U.S. fishery that targets these fish is a commercial set gillnet fishery that operates in Alaska near Dry Bay, located approximately 20 km up the Alsek River from the Gulf of Alaska. Small U.S. subsistence and sport fisheries also operate in the lower portions of the Alsek River downriver of the U.S./Canada border in Alaska. The U.S. commercial fishery operates from early June through late August targeting sockeye and coho salmon; however, Chinook salmon are caught incidentally in June and July during the sockeye salmon season. Inseason, the Dry Bay commercial catch is sampled weekly by ADF&G personnel for age (scales), sex, length, and tissue (genetic stock identification). Post-season sport catch is estimated using the statewide harvest survey (SWHS) and subsistence catch is determined using a permit system.

The principal Canadian fisheries occur in the upper Tatshenshini River drainage located in the

Yukon Territory and British Columbia. An Aboriginal fishery catches Chinook salmon primarily in the Klukshu River, and to a lesser extent, in Village Creek, the Blanchard River, and Goat Creek. Recreational fisheries take place primarily on the Tatshenshini River near Dalton Post and in the Takhanne and Blanchard rivers. Inseason the Aboriginal and recreational fisheries are opportunistically sampled for age (scales), sex, and length.

A.1.2 Situk River Fisheries

Chinook salmon returning to the Situk River are managed by ADF&G and most harvest occurs in a commercial set gillnet fishery, which operates in the estuary and in sport and subsistence fisheries located inriver and in the estuary. The U.S. commercial fishery operates from early June through early September targeting sockeye and coho salmon; however, Chinook salmon are caught incidentally in June and July during the sockeye salmon season. Inseason, commercial catch is sampled weekly by ADF&G personnel for age (scales), sex, and length information. A creel sampling program is also conducted inseason to gather information from the sport fishery. Post-season, sport catch is estimated using the SWHS and subsistence catch is determined using a permit system.

A.2 TAKU AND STIKINE RIVERS

An overview of sampling programs by component fisheries for Alaska and British Columbia Chinook salmon fisheries in the Taku and Stikine (TST) rivers is shown in

Appendix A2, with descriptive narratives provided below. Information is presented by PSC model fishery and further broken down into component fisheries.

Appendix A2: Overview of the component fisheries and sampling programs for catch and incidental mortality in PSC Chinook fisheries in the Taku and Stikine (TST) Rivers.

PSC Fishery	Component Fisheries	Kept Large Catch Estimates	Released Large Catch Estimates	Non-Large Estimates	Large Size
Alaska TST Net	District 108 Gillnet ⁵	Fish Tickets/GSI ²	None	Partially available ³	26 inches (MEF ¹)
	District 111 Gillnet ⁶	Fish Tickets/GSI ²	None	Partially available ³	26 inches (MEF ¹)
Alaska TST Sport	Stikine Subsistence	Permit	No Estimate	No Estimate	NA
	District 108 Sport ⁵	SWHS ⁴ /Creel Census/GSI ²	SWHS ⁴ /Creel Census/GSI ²	SWHS ⁴ /Creel Census/GSI ²	28 inches (TTL ⁸)
	District 108 Troll ⁵	Fish Tickets/GSI ²	No CNR	Partially available ⁷	26 inches
	Taku Personal Use	Permit	No Estimate	No Estimate	NA
	District 111 Sport ⁶	SWHS ⁴ /Creel Census/GSI ²	SWHS ⁴ /Creel Census/GSI ²	SWHS ⁴ /Creel Census/GSI ²	28 inches (TTL ⁸)
	District 111 Troll ⁶	Fish Tickets/GSI ²	No CNR	Partially available ⁷	26 inches
British Columbia TST	NA				26 inches
	NA				26 inches

Freshwater Net	NA				26 inches
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¹MEF = mid-eye to fork length

²GSI = Genetic stock identification data are used to identify the proportion of Taku and Stikine fish harvested

³Non-large kept catch data not available but could estimated. There are no non-large releases in this fishery.

⁴SWHS = statewide harvest survey

⁵District 108 net, troll, and sport harvest from statistical weeks 18-29.

⁶District 111 net, troll, and sport harvest from statistical weeks 18-29.

⁷There are no non-large kept catch in this fishery. Non-legal releases data are not available.

⁸TTL = total length (tip of the snout to the tip of the tail).

A.2.1 Stikine River Fisheries

Chinook salmon returning to the Stikine River drainage are jointly managed by the U.S. and Canada (i.e., DFO, Tahltan First Nation and ADF&G) through the joint TTC of the PSC. Stikine River Chinook salmon were coded wire tagged in the 1970s, early 1980s and consistently each year since 2000. This work, combined with marine sport and commercial sampling programs, indicates these fish are caught throughout SEAK in commercial (i.e., troll, drift gillnet and seine) and sport fisheries. Small numbers are also caught in subsistence fisheries in the freshwaters of the U.S. portion of the Stikine River. Stikine River Chinook salmon are a far north migrating stock, and with few exceptions, are only encountered in Southeast Alaska and inriver between March and July during their spawning migration.

In years of surplus of Stikine River Chinook salmon production, directed Chinook salmon fisheries can occur in the terminal marine waters of District 108 near Petersburg and Wrangell, Alaska. Directed fisheries include the commercial drift gillnet and troll fisheries and the liberalized sport fishery.

Inseason, sport and commercial catch sampling programs are conducted and ADF&G personnel sample for age (scales), sex, length, adipose fin clips (CWTs) and tissue (genetic stock identification). Post-season sport catch is determined using the SWHS and subsistence catch is determined using a permit system.

A.2.2 Taku Rivers Fisheries

Chinook salmon returning to the Taku River drainage are jointly managed by the U.S. and Canada (i.e., DFO, Taku Tlingit First Nation and ADF&G) through the joint TTC of the PSC. Taku River Chinook salmon were coded wire tagged from the mid-1970s to early 1980s and consistently each year since 1993. This work, combined with marine sport and commercial sampling programs, indicates these fish are caught throughout SEAK in commercial (i.e., troll, drift gillnet and seine) and sport fisheries. Small numbers are also caught in personal use fisheries in the freshwaters of the U.S. portion of the Taku River. Taku River Chinook salmon are a far north migrating stock, and with rare exception, are only encountered in Southeast Alaska and inriver between March and July during their spawning migration.

In years of surplus of Taku River Chinook salmon production, directed Chinook salmon fisheries

can occur in the terminal marine waters of District 111 near Juneau, Alaska. Directed fisheries include the commercial drift gillnet and the liberalized sport fishery.

Inseason, sport and commercial catch sampling programs are conducted and ADF&G personnel sample for age (scales), sex, length, adipose fin clips (CWTs) and tissue (genetic stock identification). Post-season sport catch is determined using the SWHS and personal use catch is determined using a permit system.

A.3 SOUTHEAST ALASKA

An overview of sampling programs by component fisheries for Southeast Alaska Chinook fisheries is shown in Appendix A3, with descriptive narratives provided below. Information is presented by PSC model fishery and further broken down into component fisheries.

Appendix A3: Overview of the component fisheries and sampling programs for catch and incidental mortality in PSC Chinook fisheries in Southeast Alaska.

PSC Fishery	Component Fisheries	Kept Catch Estimates	Release Estimates	Sublegal Estimates	Legal Size (Total Length)
SEAK Troll	Summer Troll	Fish Tickets	Logbook/Obs Verified	Logbook/Obs Verified	28 inches
	Winter Troll	Fish Tickets	No CNR	Logbook in 2003	28 inches
	Spring Troll	Fish Tickets	No CNR	Logbook in 2004	28 inches
SEAK Sport	Spring/Summer Marine Sport	SWHS ¹ /Creel Census/Charter Logbooks	SWHS ¹ /Creel Census/Charter Logbooks	SWHS ¹ /Creel Census/Charter Logbooks	28 inches
	Winter Marine Sport	SWHS ¹	SWHS ¹	SWHS ¹	28 inches
	Yakutat Freshwater Sport	NA	SWHS ¹	SWHS ¹	NA
SEAK Net	Purse Seine CR ² > 28"	Fish Tickets	NA	Ratio of Encounters to Landed Catch Verified ³	28 inches
	Seine CNR >28"	NA	Ratio of Encounters to Landed Catch Verified ³	Ratio of Encounters to Landed Catch Verified ³	<=21 inches
	Seine CR ⁴ > 21"<28"	Fish Tickets (partial count)	Ratio of Encounters to Landed Catch Verified ³	Ratio of Encounters to Landed Catch Verified ³	>21"<28"
	Seine CR ⁵ <=21"	Fish Tickets (partial count)	NA	NA	<=21 inches
	Drift Gillnet	Fish Tickets	NA	NA	No Size Limit
	Yakutat Setnet	Fish Tickets	No Estimate ⁶	NA	No Size Limit
	Other Subsistence/per sonal use ⁷	Permit	No Estimate	No Estimate	NA

¹SWHS = statewide harvest survey.

²CR = Chinook Retention

³An observer program for the SEAK net fisheries was implemented in 2004.

⁴Chinook greater than 21" or less than 28" are legal to retain for personal use but not to sell at all times in the seine fishery. Normally, only a portion is accounted for on fish tickets.

⁵Chinook less than or equal to 21" are legal at all times in the seine fishery and are normally included as a portion of the pink salmon catch on fish tickets.

⁶CNR may be implemented when the Situk escapement is less than 730 fish.

⁷No directed subsistence/personal use fisheries for Chinook in marine fisheries SEAK. Minimal incidental harvest not included in SEAK catch.

A.3.1 Southeast Alaska Troll

Logbook/observer programs to estimate incidental encounter/mortality in the SEAK troll fisheries currently (and historically) estimate encounters only in the summer season from July 1–September 30. Since 1998, observer and logbook programs have been in place; estimates are calculated using the methods in Bloomquist and Carlile (2001). Observers and logbook programs were also implemented from 1985–1989. The program has been expanded into the winter and spring fisheries beginning in the 2004 accounting period, which started in October 2003. The estimates of the number of sublegal Chinook encountered in the troll retention fisheries are made using estimates of the catch of sublegal Chinook per boat day of effort in the retention and non-retention fishery as recorded by the observer and logbook programs. A ratio of the number of sublegal Chinook in the non-retention fishery to that in the retention fishery is calculated. This ratio is used to multiply the estimate of the number of sublegals per boat day previously estimated. This is then expanded using the number of boat days of effort in the retention fishery.

A.3.2 Southeast Alaska Net

An overview of sampling programs by component fisheries for the SEAK net fishery is shown in Appendix A3. A regression of landed catch on the encounter estimates was developed from an observer program that was in place from 1985 through 1987 (Van Alen and Seibel 1986, 1987; Rowse and Marshall 1990). Incidental CNR encounters in the purse seine fishery of both large (>28 inch) and small (<28 inch) Chinook and retention period encounters for Chinook > 21 inches are currently estimated using this regression. External estimates of seine incidental mortality use the size-specific rates recommended in CTC (1997). However, in the PSC Chinook Model, a generic rate of 90% mortality is used for both seine and gillnet encounters because the gear types are not separated in the model.

Incidental mortality estimates are not made for the SEAK gillnet fishery. There is presently no directed harvest of Chinook in the drift gillnet fishery, but incidental catches of Chinook salmon can be landed with no size restrictions. The Southeast Alaska Chinook management plan calls for CNR fishing to be imposed if gillnet landings exceed the annual gillnet allocation (Thynes et al. 2021), but these annual limits have not been exceeded. Thus, there have not been any Chinook non-retention periods or reported CNR in the drift gill-net fishery. To maintain landed catch within the annual limits, area restrictions are used on an annual basis and nighttime closures of gillnet fishing may be imposed to reduce incidental catch of Chinook. No external estimate has been made for drop-off mortality. The CTC model also does not currently incorporate any estimate of drop-off mortality for gillnet catch.

A.3.3 Southeast Alaska Sport

An overview of sampling programs by component fisheries for the SEAK sport fishery is shown in Appendix A3. Data are available from three data sources to compile Chinook encounter estimates for Southeast Alaska. Comprehensive coverage is provided by estimates derived from a SWHS which is sent to a random sample of sport anglers annually. The SWHS has compiled estimates of harvested Chinook salmon by size class since 1977 as well as released Chinook salmon by size class since 1990. Estimates from the SWHS are not available until six to nine months after the season is completed. Additional details about the SWHS results referenced in the main body of this report can be found in annual ADF&G reports (Jennings et al. 2011a, 2011b, 2015; Romberg et al. *in prep* a, b, c, d; Romberg et al. 2021). Creel survey data from interviews of anglers returning to boat launches and harbors are also available from a number of fisheries. These surveys estimate the numbers of Chinook salmon harvested and released by size class. Creel census data have been available since 1983 although there are some gaps in coverage. More details about the creel census studies can be found in annual ADF&G regional operational plan documents (Bingham et al. 2013, Jaenicke et al. 2014, 2015, 2017, 2019). A third data source is a mandatory logbook program for marine charter vessels, which was first implemented in 1998. Although the data are derived from only one segment of the fishery, they provide an additional crosscheck with the first two data sources. Additional details about the logbook program can be found in the annual ADF&G operational plans (Sigurdsson 2013, 2014; Powers 2015).

Because Alaska hatchery terminal fisheries are directed at hatchery returns which do not include stocks of treaty concerns, catches encounters that occur in these fisheries are not included in the treaty catch. Alaska hatchery terminal fisheries include the Blind Slough shoreline fishery, the Wrangell Narrows boat fishery near Petersburg, and shoreline fisheries at the head of Auke Bay and at Gastineau (Macaulay) Hatchery near Juneau. Although substantial boat fisheries also occur in marine terminal hatchery areas near Juneau and Ketchikan, these data are not excluded from the treaty catch because total catches and harvests in these areas include fish from stocks of treaty concern which currently cannot be separated from hatchery terminal harvests in the SWHS or creel surveys. Data were compiled for eight primary SWHS areas in Southeast Alaska, although the Glacier Bay and Yakutat areas were lumped for some analyses. Freshwater fishing for Chinook salmon is prohibited in Southeast Alaska except in the Yakutat area and in hatchery terminal areas.

A.4 NORTHERN AND CENTRAL BRITISH COLUMBIA

An overview of sampling programs by component fisheries for North and Central British Columbia Chinook fisheries is shown in Appendix A4, with descriptive narratives provided below. Information is presented by PSC model fishery and further broken down into component fisheries.

Appendix A4: Overview of the component fisheries and sampling programs for kept and released catch in PSC Chinook fisheries in North and Central British Columbia.

PSC Fishery	Component Fisheries	Kept Catch Estimates	Released Catch Estimates	Sublegal Catch Estimates	Minimum Length (NFL ¹)
NBC Net	Seine	Hails, Fish slips	Phone-in logbook	NA	No
	Gillnet ²	Hails, Fish slips	Phone-in logbook	NA	No
	Tyee Test fishery	All fish are sampled	All fish are sampled	All fish are sampled	No
CBC Net	Summer Gillnet ²	Fish slips	NA	NA	No
	Fall Gillnet ²	Fish slips	NA	NA	No
	Purse Seine	Fish slips	Partial–Total CNR	NA	No
CBC Freshwater Net	No PST related fishery	NA	NA	NA	NA
NBC Troll	Area 1-5 troll	Mandatory logbook reporting/dockside validation	Mandatory logbook reporting	Mandatory logbook reporting	67 cm
CBC Troll	Area 6-12 & 130 troll	Mandatory logbook reporting	Logbook	NA	67 cm
NBC AABM Sport	Area 1-2	Creel, lodge logbooks and iREC survey	Creel and iREC surveys	iREC surveys	45 cm
NBC ISBM Sport	Area 3-5 marine	Creel and iREC surveys	Creel and iREC surveys	iREC surveys	45 cm
CBC ISBM Sport	Area 6–10 marine	Lodge, charter logbooks and iREC survey	iREC survey	iREC survey	45 cm
NBC Freshwater Sport	Area 1 - 5	Creel survey in lower Skeena River; Nass Chinook are estimated by a fill procedure	Creel	Creel	30 cm
CBC Freshwater Sport	Area 6–10 freshwater	Regression between estimated CWT Atnarko Chinook and observed non-tidal sport catch	NA	NA	NA

¹NFL = nose to fork length

²Gillnets voluntarily release Chinook where possible

A.4.1 Northern and Central British Columbia Net

The Northern British Columbia (NBC) net fishery is composed of three fisheries separated by gear type. The components are seine, gillnet, and test fisheries. There are no size limits in the net fisheries.

A.4.1.1 Gillnet Fisheries

Commercial gillnet catches are estimated from fish sales slip and hail data. A small number of Chinook are released from gillnets voluntarily, and these are recorded in hail data as phone-in logbooks.

A.4.1.2 Seine Fisheries

Since 1999, all seine fisheries operating in the Northern and Central BC (NCBC) have been required to release all Chinook and to brail catches to minimize handling effects. Seine catch

data are obtained from fish slips and hail data. Hail data are provided by charter patrols at sea, and releases are reported by satellite phone-in logbook records.

A.4.1.3 Tyee Test Net Fishery

The Tyee test fishery is a structured fishery operated with a multi-panel gillnet. All Chinook caught are kept and counted. Catch estimates are available but were not included in the Catch Estimates Report, as this fishery is beyond the scope of this document and not relevant to CTC analyses.

A.4.1.4 Central British Columbia Net

The Central British Columbia (CBC) net fisheries are focused in Areas 7 and 8, and target primarily chum stocks but are permitted to retain Chinook bycatch. Kept and released catches must be recorded in logbooks submitted annually. In-season catch data is recorded by hails using phone-in logbooks.

There is a Chinook directed terminal fishery in June targeting Atnarko River Chinook in the Bella Coola area. It is gillnet only and captures are recorded by phone-in hails. Kept and released catch estimates are unexpanded tallies of the catches reported through logbook returns.

A.4.2 Northern British Columbia Troll

The NBC Troll aggregate abundance-based management (AABM) fishery (Area F) encompasses Areas 1-5, 101-110 and 142. Directed Chinook individual transferrable quota (ITQ) openings are currently restricted to Areas 1, 101, 2W and 142. The magnitude of the troll fishery was greatly reduced in 2001 due to domestic conservation concerns for Chinook stocks from the west coast of Vancouver Island, and coho stocks in the upper Skeena River and interior Fraser River drainages. In 2019, the magnitude of the troll fishery was further reduced to allow the passage of Fraser River stocks. The size limit in the northern troll fishery is 67 cm fork length.

Mandatory dockside validation records provide kept catch estimates; no expansion is needed as all landing are validated. Released catches are estimated using the mandatory logbook program catch records.

A.4.3 Central British Columbia Troll

There are no Chinook directed troll fisheries in Central B.C., but there are a small number of Chinook that are released in the form of bycatch during Central Coast limited effort coho demonstration fishery, which are recorded in the mandatory logbook program.

A.4.4 Central British Columbia Sport

Central British Columbia individual stock-based management (ISBM) Sport encompasses Areas 6-10. A combination of data sources including lodge reports, charter logbooks and the iREC program were utilized to produce a total estimate of average Chinook catches for 2015–2019.

A.4.5 Northern British Columbia AABM Sport

NBC AABM sport includes Haida Gwaii (Areas 1, 2, 101, 102 and 142) and catches are estimated through the Haida creel survey, iREC surveys, and lodge logbook data. The combination of these

data sources provides a total estimate of average Chinook catches. The recreational size limit in this area is 45 cm fork length. For the purposes of this report, the combination of these data sources were utilized to produce a total estimate of average Chinook catches for 2015–2019.

A.4.6 Northern British Columbia ISBM Sport

NBC ISBM sport includes the Chatham Sound area around Prince Rupert (Areas 3 to 5, 103-105). CBC ISBM sport includes the waters approaching Kitimat (Area 6, 106) and the waters south of Kitimat to Cape Caution (Areas 7 to 10, 107-110).

Catches are estimated through an Area 3-4 creel and lodge catch reports as part of the dockside monitoring program and iREC surveys. The recreational size limit in this area is 45 cm fork length. The iREC survey provides separate estimates by mark status, size category, and disposition (kept/released). The creel surveys also develop released catch estimates, though these are not size- or mark-specific.

For the purposes of this report, the combination of these data sources were utilized to produce a total estimate of average Chinook catches for 2015–2019.

A.4.7 Northern British Columbia Freshwater Sport

There is a creel in the lower Skeena River (Area 4). Nass River sport catch is estimated by a fill procedure (Area 3).

A.4.8 Central British Columbia Freshwater Sport

A linear regression between Atnarko Chinook estimated escapement CWTs and non-tidal sport catch is performed for Central BC freshwater sport catch estimates. The regression has been used since 2011 in years where there is no catch monitoring.

A.5 WEST COAST VANCOUVER ISLAND AND BRITISH COLUMBIA SOUTH COAST

An overview of sampling programs by component fisheries for West Coast Vancouver Island and BC South Coast Chinook fisheries is shown in Appendix A5, with descriptive narratives given below.

Appendix A5: Overview of the component fisheries and sampling programs for kept and released catch in PSC Chinook fisheries in West Coast Vancouver Island and BC South Coast Chinook.

PSC Fishery	Component Fisheries	Legal Kept Catch Estimates	Legal Released Catch Estimates	Sublegal Catch Estimates	Minimum Size (NFL ¹)
WCVI Troll	Spring Troll	eLogbook, Logbook and dockside monitoring program	eLogbook, Logbook	Releases from eLogbook, Logbook and observer program (historically)	55 cm

PSC Fishery	Component Fisheries	Legal Kept Catch Estimates	Legal Released Catch Estimates	Sublegal Catch Estimates	Minimum Size (NFL¹)
	Summer Troll	eLogbook, Logbook and dockside monitoring program	eLogbook, Logbook	Releases from eLogbook, Logbook and observer program (historic)	55 cm
	Fall Troll	eLogbook, Logbook and dockside monitoring program	eLogbook, Logbook	Releases from eLogbook, Logbook and observer program (historic)	55 cm
	Winter Troll	eLogbook, Logbook and dockside monitoring program	eLogbook, Logbook	Releases from eLogbook, Logbook and observer program (historic)	55 cm
WCVI AABM Sport		iREC, Creel surveys and voluntary logbooks	iREC, Creel surveys and logbooks	iREC, Creel surveys and logbooks	NA
WCVI ISBM Sport		iREC, Creel surveys and logbooks	iREC, Creel surveys and logbooks	iREC, Creel surveys and logbooks	NA
WCVI Freshwater Sport	Not relevant to PST management	NA	NA	NA	NA
WCVI Net	Summer Net	Logbook, Fish slips	Logbook, Observer verified	Logbook, Observer verified	55 cm
	Fall Net	Logbook Fish slips	Logbook Observer verified	Logbook Observer verified	55 cm
GST Troll	Summer Troll (Test Fishery)	Phone-in/ logbooks	No CNR	Phone-in/ logbooks	NA
GST Sport	Spring/Summer Sport	iREC and Creel surveys	iREC and Creel surveys	iREC and Creel surveys	45/62 cm
	Fall Sport (GST)	iREC and Creel surveys	iREC and Creel surveys	iREC and Creel surveys	62 cm
	Winter Sport	iREC and Creel surveys	iREC and Creel surveys	iREC and Creel surveys	62 cm
GST Freshwater Sport	Campbell-Quinsam	Creel	Creel	Creel	30 cm
BC Juan de Fuca Sport		iREC and Creel surveys	iREC and Creel surveys	iREC and Creel surveys	45 cm
GST Net	Summer Net	Logbooks/ Sales slips	Logbook/ Obs. verified	Logbook/ Obs. verified	55 cm
	Fall Net	Logbooks/ Sales slips	Logbook/ Obs. verified	Logbook/ Obs. verified	55 cm
GST Freshwater Net	FSC ²	NA	NA	NA	NA
JST Sport	Spring/Summer	iREC and Creel Survey	iREC and Creel Survey	iREC and Creel Survey	62 cm
	Fall/Winter	iREC	iREC	iREC	
JST Net	Summer Test Fishery (chum and sockeye)	Observer Record	Observer Record	Observer Record	NA

¹NFL = nose to fork length

²FSC = Food, Social, and Ceremonial

A.5.1 WCVI Troll

WCVI troll fishery currently takes place in Areas 123-127 in the months of August to September. Historically this fishery has had spring, summer, fall and winter harvest periods for both ISBM and AABM Chinook stocks, and is managed as part of the PST. Mandatory logbook and eLogbook monitoring programs estimate releases of legal and sublegal kept and released Chinook in the WCVI troll fisheries. The estimates of the number of sub-legal Chinook encountered in the Chinook directed troll fisheries are made using logbook release estimates expanded using the number of boat days of effort in the retention fishery. Observer and logbook programs have been in place since 1998, however the observer program has been discontinued. Dockside monitoring programs are also in place to independently estimate catch from the Area G troll fishery.

A.5.2 WCVI AABM Sport

Recreational catch estimates are available for all areas and times from the iREC survey, and for certain higher effort areas and times from the creel survey. The iREC and creel surveys provides separate estimates by mark status, size category, and disposition (kept/released). Voluntary logbooks are submitted by lodges and guides which are also used to estimate catch in certain times and areas for WCVI.

For the purposes of this report, the combination of these data sources were utilized to produce a total estimate of average Chinook catches for 2015–2019.

A.5.3 WCVI ISBM Sport

Recreational catch estimates are available for all areas and times from the iREC survey, and for certain higher effort areas and times from the creel survey. The iREC and creel surveys provides separate estimates by mark status, size category, and disposition (kept/released). Voluntary logbooks are submitted by lodges and guides which are also used to estimate catch in certain times and areas for WCVI.

For the purposes of this report, the combination of these data sources were utilized to produce a total estimate of average Chinook catches for 2015–2019.

A.5.4 WCVI Freshwater Sport

There are currently no freshwater catch monitoring programs for WCVI freshwater sport, although the implementation of a freshwater iREC survey has been discussed.

A.5.5 WCVI Net

Most net fisheries in the WCVI area take place in areas and during times where there is virtually no impact on AABM Chinook stocks. The mandatory logbook program is used to estimate releases of legal and sub-legal Chinook in the WCVI net fisheries. These monitoring programs provide estimates of Chinook releases, and associated mortalities are subsequently calculated. WCVI net fisheries take place Barkley Sound (seines and gillnets), Nootka Sound (gillnets), and

Nitinat historically (seines and gillnets). There are dockside monitoring programs in place for kept catch as well. Targeted Chinook net fisheries exist in Barkley Sound and Nootka Sound, and Chinook are also caught as bycatch in net fisheries targeting other salmon species and mostly have mandatory non-retention for Chinook.

Releases in the WCVI net fisheries of both legal (>55 cm) and sublegal (<55 cm) Chinook are currently estimated from the logbook program.

A.5.6 Strait of Georgia Sport

Recreational catch estimates are available for all areas and times from the iREC survey, and for higher effort areas and times from the creel survey determined through heat mapping. The iREC and creel surveys provides separate estimates by mark status, size category, and disposition (kept/released).

Estimates of encounters for both sub-legal (<62 cm total length) and legal (≥62 cm total length) Chinook salmon in Strait of Georgia (GST) mixed stock ISBM fisheries are generated directly from creel survey data. Estimates of encounters of both sub-legal (<45 cm total length) and legal (≥45 cm total length) Chinook salmon in Juan de Fuca (JDF) sport ISBM fisheries are also generated directly from creel survey data.

For the purposes of this report, the combination of these data sources were utilized to produce a total estimate of average Chinook catches for 2015–2019.

A.5.7 Strait of Georgia Freshwater Sport

Freshwater sport fisheries for Chinook salmon vary between years but are generally focused on hatchery systems such as the Big Qualicum and Little Qualicum Rivers. Since 2019, the Campbell and Puntledge Rivers have also been included. On the Campbell there is a maximum size restriction of 85 cm. Adult Chinook are defined by a 50 cm or greater fork length while a generic minimum size limit of 30 cm applies if not specified. Adult Chinook must be recorded on a freshwater (FW) license and are limited to 10 per year. A creel survey is conducted on both the Campbell and Quinsam Rivers, providing kept and released catch estimates while a pilot program was also run on the Puntledge River in 2021.

A.5.8 Strait of Georgia Net

GST net fisheries take place in statistical areas 14, 18, 19 and 20 targeting sockeye and chum runs. Most net fisheries in the GST area take place in areas and during times where there virtually no impact on AABM Chinook stocks, and all net fisheries have mandatory non-retention for Chinook. The mandatory logbook program provides estimates of kept and released Chinook catch in the net fisheries.

Catch estimates are available but were not included in the Catch Estimates Report, as this fishery is beyond the scope of this document and not relevant to PST management.

A.5.8.1 Strait of Georgia Freshwater Net

There are only FSC net fisheries in this area that occur in the Campbell River. These fisheries are beyond the scope of this document and not relevant to PST management.

A.5.9 Johnstone Strait Net

JST net fisheries take place in statistical Areas 12 and 13 targeting sockeye and chum runs. Most net fisheries in the JST area take place in areas and during times where there virtually no impact on AABM Chinook stocks, and all net fisheries have mandatory non-retention for Chinook. The mandatory logbook program provides estimates of kept and released Chinook catch in the net fisheries.

Catch estimates are available but were not included in the Catch Estimates Report, as this fishery is beyond the scope of this document and not relevant to CTC analyses.

A.5.10 Johnstone Strait Sport

Recreational catch estimates are available for all areas and times from the iREC survey, and for higher effort areas and times from the creel survey determined through heat mapping. The iREC and creel surveys provides separate estimates by mark status, size category, and disposition (kept/released).

Estimates of encounters of both sub-legal (<62 cm total length), legal (62-80 cm total length), and supra-legal (>80cm for portions of the year) Chinook salmon in the Johnstone Strait ISBM fisheries are generated directly from creel survey data.

For the purposes of this report, the combination of these data sources were utilized to produce a total estimate of average Chinook catches for 2015–2019.

A.6 FRASER RIVER FISHERIES

An overview of sampling programs for Fraser River Chinook fisheries is shown in Appendix A6, with descriptive narratives below.

Appendix A6: Overview of the component fisheries and programs for estimating kept and released catch in the PSC Chinook fisheries for the Fraser River.

PSC Fishery	Component Fisheries	Kept Catch Estimates	Released catch Estimates	Sublegal Catch Estimates ¹
Fraser Net and Freshwater Net	First Nation (FN) Lower Fraser ¹	Net Creel survey, effort estimation of set and drift gillnets CPUE ² Interviews, Catch Reports, observers during FN economic opportunity beach seine fisheries	Yes	NA as no minimum size limit
	First Nation Upper Fraser ³	Gillnet and dipnet Creel surveys, effort estimation of set gillnets and dipnets, catch diary reporting, economic opportunity fisheries have mandatory landing sites with dockside monitoring		
	Gillnet Test Fishery	On-board observers		
	Commercial Gillnet	Mandatory logbook, aerial surveys, hauls during the fishery, some observer coverage when the fishery targets chum salmon		

PSC Fishery	Component Fisheries	Kept Catch Estimates	Released catch Estimates	Sublegal Catch Estimates ¹
Fraser Freshwater Sport	Recreational	Creel (iREC covers the tidal portion only)	Yes	NA, kept and released catches estimated for jack and adult size strata

¹No sub-legal size categories for Fraser River fisheries.

²CPUE = catch-per-unit-effort

³Chinook retention is permitted in all First Nation and gillnet fisheries; CNR estimates not developed for CNR recreational fisheries.

A.6.1 Fraser Net and Freshwater Net

The Fraser Net catch estimates are from both upstream and downstream of Mission and include the Fraser freshwater net fisheries which are downstream of Mission. To avoid double counting of catch estimates, the Fraser Freshwater Net fishery was recorded as “does not apply” in this report. This includes a terminal First Nation fishery in the lower Fraser that historically runs from March to November, but recently the majority of catch happens from August to September because of specific time- and area-closures to reduce harvests on Chinook stocks of concern. Gillnets and dipnets are used in the Fraser River, and beach seines are used in the Harrison River and parts of the Fraser River near the city of Chilliwack. Catch estimates are developed by access point creel survey interview, with aerial effort surveys of set and drift nets, and vehicle counts are used in some parts of the watershed. There is no minimum size limit, so catch estimates are not divided by size category, and there are essentially no releases, so released catch is assumed to be zero in most cases, with some exceptions.

The upper Fraser River First Nation fishery generally occurs from April through October. Set gillnets and actively fished dipnets are the main fishing gears used in the Fraser River mainstem, and several gear types are used on the tributary systems (mainly rod and reel, dipnet, and gaff). For tributary systems, individual fishers and First Nation Band administrations are contracted to estimate kept and released catch, which are based on a variety of methods including creel survey designs, catch diaries, and post-season phone surveys with community fishers.

Commercial gillnet fisheries are directed at sockeye from July through September and at chum in October and November and occur from the Fraser River mouth (parts of Area 29-9 and 29-10) upstream to Mission Bridge (Area 29-16). The sockeye fishery uses ~5 1/4 inch mesh and the chum fishery uses ~6 3/4 inch mesh. There are no Chinook non-retention regulations for this fishery. Essentially all Chinook caught during the sockeye fishery are retained; however, some are released during the chum fishery.

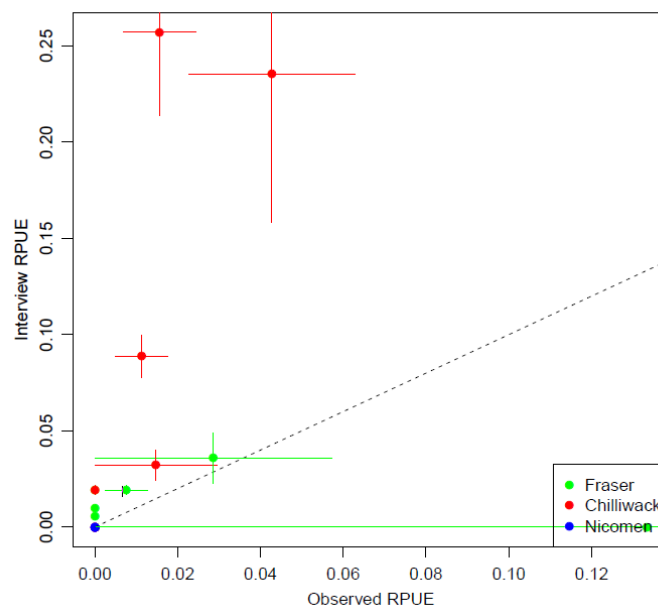
Chinook catch are generally estimated through phone reports, and hail surveys are used on occasion. Effort is estimated from aerial surveys during the sockeye fishery and from boat surveys by Fishery Officers during the chum fishery.

A.6.1.1 Fraser River Freshwater Sport

The lower Fraser River sport fishery historically occurred from May through October, but recently it has been limited to periods from August to October due to area- and time-specific fishery closures to reduce impacts on Chinook stocks of concern.

In the Fraser River Freshwater Sport fishery, all fish are legal size so there is no sublegal size category available for these catch estimates, but there are estimates of jack and adult sized catch. However, in the current estimates age 2 data were not included because it cannot be incorporated into the PSC Chinook Model but these data are used for CWT estimation and the Exploitation Rate Analysis.

Creel surveys estimate the number of adult Chinook kept, adult Chinook released, jack Chinook kept, and jack Chinook released. These estimates are not separated by legal or sublegal since all Chinook are mature. There do not appear to be any studies or direct estimates of drop-off mortality rates in freshwater fisheries. Sampling biases have not been investigated thoroughly for the creel surveys, but are perceived to be minor. There is some evidence of over-reporting of Chinook releases, perhaps from prestige bias, at two locations which have creel surveys, annually. Increased aerial surveys would improve precision and accuracy of effort and catch estimates.



Appendix A7: Comparison of Release Per Unit Effort reported by anglers and observed by creel survey technicians in three creel survey locations in the Fraser River watershed. The diagonal 1:1 line identifies equality.

A.7 PUGET SOUND, WASHINGTON AND OREGON COASTS

An overview of sampling programs by component fisheries for Puget Sound and the Washington and Oregon Coast Chinook fisheries is shown in Appendix A8, with descriptive narratives given below.

Appendix A8: Overview of the component fisheries and sampling programs for catch and incidental mortality in PSC Chinook fisheries for Puget Sound and the Washington (WA) and Oregon (OR) coasts.

PSC Fishery	Component Fisheries	Kept Catch Estimates	Released Catch Estimates	Sublegal Catch Estimates
Puget Sound North Net	Areas 4B-7A, excluding Area 6B, Gillnet, Purse Seine, Reef Net	Fish Tickets	Observers	NA-no size limit
Puget Sound North Sport	Areas 5-7	Creel Survey (Areas 5 in the summer, 6 in the winter, and 7 year-round), Angler Harvest Cards (5 in the winter, 6 in the summer), Aerial Surveys (Area 7)	Creel Survey (Areas 5 in the summer, 6 in the winter, and 7 year-round), Dockside survey (all areas), Mail-In Survey (voluntary trip reports; all areas), Test Fisheries (Area 7), Aerial Surveys (Area 7)	Creel Survey (Areas 5 in the summer, 6 in the winter, and 7 year-round), Dockside survey (5 in the winter, 6 in the summer), Mail-In Survey (voluntary trip reports), Test Fisheries (Area 7), Aerial Surveys (Area 7)
Puget Sound Other Net	Areas 8-13 and Area 6B, Gillnet, Purse Seine, Beach Seine	Fish Tickets	Observers	NA-no size limit
Puget Sound Other Sport	Areas 8-13	Creel Survey (Areas 9, 10, 11), Angler Harvest Cards (12, 13), Aerial Surveys (Area 9)	Creel Survey (Area 9, 10, 11), Dockside survey (All Areas), Mail-In Survey (voluntary trip reports; all areas), Test Fisheries (Areas 9, 10, 11), Aerial Surveys (Area 9)	Creel Survey (Area 9, 10, 11), Dockside survey (All Areas), Mail-In Survey (voluntary trip reports; all areas), Test Fisheries (Areas 9, 10, 11), Aerial Surveys (Area 9)
Puget Sound Terminal FW Sport		Creel Survey, Mail-In Survey	Creel Survey, Mail-In Survey	Creel Survey, Mail-In Survey
Puget Sound FW Net	Includes FW Net and Marine Areas 7B-D	Fish Tickets, Observers (Lummi Tribal Nation)	NA, Observers (Lummi Tribal Nation; Area 7B-D)	NA-no size limit
Washington Coast Net	Grays Harbor, Willapa Bay Gillnet and Tanglenet	Fish Tickets	Observers (Willapa), NA (Grays Harbor)	NA-no size limit
Washington Coast Freshwater Net	Freshwater Treaty Gillnet	Fish Tickets	NA	NA-no size limit
North of Falcon Sport	Areas 1-4 Ocean Sport	In-Season Estimates, Mail-In Survey	On water observations, Dockside Interviews	On water observations, Dockside Interviews
South of Falcon Sport	Cape Falcon to OR/CA border	In-Season Estimates	Dockside Interviews	No estimate

PSC Fishery	Component Fisheries	Kept Catch Estimates	Released Catch Estimates	Sublegal Catch Estimates
North of Falcon Troll	Areas 1-4, (WA) Non-Treaty Troll	In-Season Estimates, Fish Tickets	Dockside Interviews or Logbooks	Dockside Interviews or Logbooks
	Areas 2-4, (WA) Treaty Troll	Fish Tickets	On-Water Observations and Logbooks	On-Water Observations and Logbooks
South of Falcon Troll	Areas 1-5 (OR) Ocean Troll	Fish Tickets	NA	No estimate
South of Falcon Freshwater Sport	NOC ¹ , MOC ² Stocks (Cape Falcon to Humbug Mtn)	Angler Harvest Cards, Electronic Reporting via Cell-phone since 2019	NA	NA

¹NOC = North Oregon Coast

²MOC = Mid-Oregon Coast

A.7.1 North of Falcon Troll

Retained catch in North of Falcon troll fisheries is accounted for through reporting on fish tickets at the time of landing. Incidental mortalities in troll fisheries are related to the duration of retention and non-retention periods, size limit regulations, and gear types. Non-retention periods for Chinook are very rare and have not occurred in many years. Size limits have been used extensively for these fisheries and have changed only a few times since 1979. Troll fisheries have been allowed to retain fish larger than 24 inches since the mid-1980's, however, sublegal-sized releases are not reported. 'Sorting,' the release of legal fish in order to retain a larger fish later, is a source of mortality associated with hook and line gear not currently accounted for in model-generated estimates.

Utilizing funding from the U.S. CTC and ride-along observations, the Makah Tribe monitored Chinook encounter rates in tribal troll fisheries from 1998 through 2006. Similarly, WDFW monitored Chinook encounter rates in non-tribal troll fisheries between 2003 and 2007. These data have been incorporated into pre-season fisheries modeling.

All North of Falcon troll fisheries have a barbless hook requirement and, thus, are modeled in CTC analyses using the hooking mortality rate of 22.0% for sub-legal sized Chinook. The CTC rate of 18.5% would be used for any regulations requiring release of legal sized Chinook. The CTC (1997) recommended drop-off rate for North of Falcon troll is 1.6%.

A.7.2 South of Falcon Troll

This includes Oregon ocean areas 3-6 (Cape Falcon to Oregon/California border). Legal-sized Chinook landed are required to be reported by buyers in pounds and estimates of numbers of fish are extrapolated by multiplying by the average number of Chinook/pound. Since 2016, actual numbers of Chinook landed have been reported. Sublegal size releases are not reported. Typically (barring special seasonal closures owing to conservation concerns) non-mark selective Chinook fishing is open from March 20 to October 31, but with some days/weeks closed during this period, with 28 inch minimum legal size. Chinook not originating from Oregon streams, chiefly from California, are among the catches. A special fall bubble fishery takes place at Port Orford late in the year (October 15–December 31) targeting Elk River Hatchery returns.

All South of Falcon troll fisheries have a barbless hook requirement and, thus, are modeled in CTC analyses using the hooking mortality rate of 22% for sub-legal sized Chinook. The CTC rate of 18.5% would be used for any regulations requiring release of legal sized Chinook. The CTC (1997) recommended drop-off rate for South of Falcon troll is 2.5%. The CTC currently uses a drop-off rate for South of Falcon troll of 1.6% (Appendix F).

A.7.3 North of Falcon Sport

Recreational fisheries have been allowed to retain fish larger than 24 inches since the mid-1980s, with retention of fish larger than 22 inches in select subareas beginning in 2020. Estimates of sublegal encounters of Chinook are generated from dockside interviews. Beginning in 1999, anglers were surveyed for both Chinook and coho sublegal encounters separately, but historically only total number of encounters (all salmon combined) were surveyed. Beginning in 1998, extra sampling effort was expended for the ocean recreational fisheries to monitor the impacts from mark-selective regulations on coho salmon. This effort included on-the-water observations of encounters and ride-along observations on charter boats. A voluntary trip reporting program was implemented in 2002. Although this effort was directed at the evaluation of coho regulations, information on Chinook encounters was also collected. For more detailed information on the methods used to generate estimates for the North of Falcon sport fishery, see:

<https://www.recfin.org/wp-content/uploads/2017/11/Washington-Ocean-Sampling-Program-OSP-Overview-for-RECFIN-UPDATEDNOV-2....pdf>.

A.7.4 Puget Sound Recreational Fisheries

In-depth information is available on techniques and estimation methods used in Puget Sound Recreational fisheries here:

<https://wdfw.wa.gov/sites/default/files/publications/01357/wdfw01357.pdf>

Puget Sound marine recreational fisheries utilize a wide range of sampling techniques, depending upon the area and season of fishing. All marine areas use dockside angler surveys, the collection of voluntary trip reports, and the collection of catch record cards. Full Murthy estimation, Reduced Murthy estimation or “baseline sampling” techniques are employed depending upon the area-season fished, which are used for developing both catch and release estimates by type of fish encountered (marked legal, unmarked legal, marked sublegal, unmarked sublegal). In some marine areas (Areas 7, 9, 10, 11; year-round), test fishing is used to verify or supplement voluntary trip reports and dockside sampling catch and release data. Aerial surveys are also conducted in Marine Areas 7 and 9 to estimate total fishery effort.

For the purposes of the fishery questionnaire, catch and release estimates in Puget Sound marine recreational fisheries were available and provided, however variances around legal and sublegal releases were designated as “potentially available.” Variances around release estimates are available for those area-seasons that utilize Full Murthy or Reduced Murthy estimation techniques but would have to be calculated for those areas that utilize a “baseline” sampling design (Areas 5 Winter, 6 Summer, 12 year round, and 13 year round). Sublegal

retentions were not provided for the questionnaire but could be calculated using dockside sampling data.

A.7.5 South of Falcon Sport

This includes Cape Falcon to Humbug Mountain. Legal-sized Chinook landed are surveyed in dockside interviews and estimates of numbers of fish are extrapolated by effort (Ocean Recreational Boat Survey, ORBS (Schindler et al. 2021)). Presently the ORBS project samples at the top ten to eleven ocean access points. Sublegal releases are estimated from angler interviews. Typically (barring special seasonal closures owing to conservation concerns) non-mark selective Chinook fishing is open from March 20 to October 31, with 24 inch minimum legal size. Chinook not originating from Oregon streams, chiefly from California, are among the catches.

A.7.6 South of Falcon Freshwater Sport

This includes streams from Cape Falcon to Humbug Mountain, from late summer (returning Fall Chinook enter estuaries) to the end of the year up to the deadlines (subject to annual regulation; further downstream in projected low run years). Angling is hook-and-line, and daily bag limits are generally 1 or 2 adults and 5 jacks, with seasonal limit often set at 10 or at 20 adults, depending on projected run size for the rivers of the local area. Catch is estimated using harvest cards ("Punch-cards"); anglers are required to note adults at time of capture (not jacks) but are not required to return their harvest card, thus catch estimates are expanded for non-reporting. However, in 2019 ODFW's Electronic Reporting System (ELS) began, and anglers can report catch on cell-phones and that catch record is immediately available. Fishing effort, and thus harvest rate, is particularly high in the Salmon and Elk Rivers which have high production hatcheries.

A.7.7 Puget Sound and Washington Coastal Freshwater Recreational Fisheries

While some freshwater systems have had sporadic creel surveys, most freshwater recreational fisheries in Puget Sound and on the Washington Coast are monitored using catch record cards. Catch record cards are a mandatory self-reporting system for anglers that are required to be mailed in at the end of a fishing year (<https://wdfw.wa.gov/licenses/fishing/catch-record-card>). While catch record cards are used to estimate a total number of Chinook caught, releases are estimated using creel surveys or historic creel information. Variance estimates are available via the catch record card system for Chinook catch but are not currently available for release estimates.

Beginning in 2021, WDFW committed to large scale freshwater monitoring to validate salmon and gamefish fisheries which could have incidental impacts on adult Chinook when they are potentially present in-river. Therefore, it is likely that historic freshwater monitoring methodologies will not be representative of future sampling efforts.

A.7.8 Puget Sound and Washington Coastal Net Fisheries

Note that for marine net fisheries in Puget Sound, estimates of releases are available, but have not been included in the IM survey. CTC staff were working with regional staff to compile these estimates, but regional staff were not able to provide estimates prior to the due date of this report.

Non-treaty and Treaty gillnet fisheries in Washington do not have a non-retention regulation because release mortality is assumed to be 100%. Incidental mortalities related to this gear-type are due to net drop-off and marine mammal interactions. No direct estimates are made for either of these sources of mortality. In 1996, the minimum gill net mesh size for chum fisheries was increased to 6-1/4 from 5-3/4 inch mesh, in order to reduce the incidental catch of immature Chinook.

Most of the non-treaty purse seine fisheries have a Chinook non-retention regulation, and the only seine fishery directed at Chinook occurs in Bellingham /Samish Bay. Non-treaty fishers also conduct a reef net fishery in Areas 7 and 7A and a beach seine fishery in Area 12H. Non-treaty tanglenet fisheries directed at Chinook occur in Willapa Bay (prior to September 16th) and directed at other species in some years in Gray's Harbor. Estimates of Chinook encounters in non-treaty purse seine, reef net, tanglenet, and gillnet fisheries primarily come from observers on-board fishing vessels. While fishing seasons occur, a boat-based WDFW sampling crew randomly boards commercial fishing vessels to observe a single set. Set observations are used to develop catch or encounters per set and can be used in conjunction with fish tickets to expand sampled fish to a total number of landed and released fish by species.

Since 1973, non-treaty fishery regulations have required that purse seines incorporate a strip of larger mesh at the top of the bunt to allow immature Chinook to escape. In 1997, all purse seine fisheries required release of all Chinook. In 1998, shoreline closures in Rosario Strait (Area 7) were adopted, designed to reduce impacts on Chinook salmon while still providing opportunities during sockeye and pink-directed fisheries. In 1999, purse seines were required to use brailers or hand dip nets to remove salmon from seine nets during sockeye and pink directed fisheries in Areas 7 and 7A to reduce by-catch mortality (R. Bernard, WDFW, pers comm. October 19, 2000).

Since 2013, Treaty fishers have conducted a tanglenet fishery in the Nooksack River. This fishery is actively monitored by observers on the water and, as capture events are identified, trained biologists harvest marked fish and remove unmarked fish from the net. Unmarked fish are sampled, monitored in a recovery box, and released back into the water. All encounters are observed and the fishery has a relatively low number of encounters. Experimental mark-selective net fisheries of varying types have also occurred on Nisqually River since 2011. More information on these fisheries is available via the annual Puget Sound Chinook Comprehensive Harvest Management Plan documents, but on average between 2009 and 2019, these experimental fisheries have had 72 releases.

A.8 COLUMBIA RIVER

An overview of sampling programs by component fisheries for Columbia River Chinook fisheries is shown in Appendix A9, with descriptive narratives given below.

Appendix A9: Overview of the component fisheries and sampling programs for catch and incidental mortality in PSC Chinook fisheries for the Columbia River.

PSC Fishery	Component Fisheries	Kept Catch Estimates	Released Catch Estimates	Sublegal Catch Estimates
Columbia River Net	Spring Zone 1-5 Gillnet	Fish tickets	NA	NA- No Size Limit
	Spring Zone 1-5 Tangle Net	Fish tickets	NA	Yes (25%)
	Fall Zone 1-5 Gillnet	Fish tickets	NA	NA- No Size Limit
	Fall Zone 6 Net	Fish tickets and Surveys	NA	NA- No Size Limit
	Fall Treaty Ceremonial & Subsistence	Surveys	NA	NA- No Size Limit
	Other gillnet (sockeye & shad gillnet) in Zone 1-5.	Fish tickets and surveys	Yes (35%)	NA- No Size Limit
Columbia River Sport	Buoy 10 (fall) Legal (>24 inches)	Dockside sampling (creel surveys) and boat count surveys	Yes - barbed (16%) or barbless (14%) hooks	Yes - barbed(16%) or barbless (14%) hooks
	Buoy 10 (fall) Sub-Legal (<24 inches)	Ratio of Encounters to Landed Catch (Angler Interviews)	Yes (14-16%)	Yes (14-16%)
	Spring Zone 1-5	Dockside sampling (creel surveys) and boat count surveys	NA	Yes—10%
	Summer Zone 1-5	Dockside sampling (creel surveys) and boat count surveys	NA	Yes—10%
	Fall Zone 1-5	Dockside sampling (creel surveys) and boat count surveys	NA	Yes—10%
	Mainstem above Bonneville (summer)	Dockside sampling (creel surveys) and boat count surveys	NA	Yes—10%
	Mainstem above Bonneville (fall)	Dockside sampling (creel surveys) and boat count surveys	NA	Yes—10%
	Spring Tributary	Punch card Creel	NA	Yes—10%
	Fall tributary	Punch card Creel	NA	Yes—10%
	Summer Tributary	Punch card Creel	NA	Yes—10%

There are three main Chinook fishery management periods in the Columbia River: spring, summer, and fall. The spring fishery runs from January through mid-June, the summer fishery runs from mid-June through July, and the fall fishery begins August 1 and runs through the remainder of the year. With the exception of the Buoy 10 fall-season recreational fishery, harvest of subadult-sized Chinook is allowed when a fishery is open to the retention of Chinook. Prior to mass-marking of Chinook, there was limited opportunity in the spring recreational and commercial fisheries. Implementation of mark-selective fishery (MSF) regulations (plus live-capture techniques in the commercial fishery) allowed for expanded recreational and

commercial fisheries beginning in 2001 and 2002, respectively. Target Chinook fisheries during summer season did not occur from 1965–2004 (commercial) and 1974–2001 (recreational). Typically, recreational fisheries operate under MSF regulations during the summer season while commercial fisheries are full retention. Estimates of incidental mortality vary depending on the time and area of the fishery. The commercial mainstem Zones 1-5 spring and summer net fisheries last operated in 2016. Commercial net fisheries in the Select Areas (off-channel fishing areas located in the estuary) operate during each of the three fishing seasons and primarily catch locally-reared hatchery fish.

Fall-season recreational and commercial fisheries have operated for decades and are primarily full-retention for Chinook.

A.8.1 Columbia River Sport Fisheries

An overview of sampling programs for Chinook salmon incidental mortality in sport fisheries in the Columbia River basin is shown in Appendix A9. A variety of season-/species-specific post-release mortality rates are used to estimate mortality associated with non-retention of adult and sub-adult fishes. These rates can be found in the Biological Assessment produced by the *U.S. v. OR* Technical Advisory Committee regarding the current *U.S. v. OR* Management Agreement. The Pacific Marine Fisheries Council, Salmon Technical Team advised 19% and 29% incidental hooking mortality rates for barbless and barbed hooks, respectively, which is used to estimate incidental mortality in the Buoy 10 sport fishery at the mouth of the Columbia River.

A.8.2 Columbia River Net Fisheries

An overview of sampling programs for Chinook salmon incidental mortality in net fisheries in the Columbia River basin is shown in Appendix A9. Direct estimates of incidental Chinook mortality for Columbia River net fisheries are not available. Traditionally, there have not been legal size limits, so, there are no mortalities associated with intentional release of sub-adult fish.

There is probably some small percentage of gillnet drop-off fish that are caught but escape prior to landing, but it is not possible to design a study to estimate the mortality resulting from having “almost” been caught. Unaccounted mortalities also occur due to predation of fish that were caught, prior to retrieval from the net. There is no adjustment made for these drop-out mortalities. Neither of these potential sources of incidental mortality (drop-off and predation) are estimated for Columbia River recreational or commercial fisheries.

APPENDIX B: AGENCY SPECIFIC CATCH ESTIMATE METHODS AND PROGRAMS

Definitions of catch estimation programs utilized by managers for estimating catch (kept and released) of Chinook salmon in this survey.

Agency	Catch Estimation Program	Description	Variance Available (Yes/PA/No/0)
DFO	Access point Creel survey	Interviewers are stationed at boat access points (marinas, boat ramps, etc.) and sport fishing parties are interviewed at the end of their just-completed boat trips. Catch (kept and released) per boat trip estimates are developed from these interviews. A separate survey of instantaneous counts of boats fishing is used estimate average boat trips per day. The product of these two estimates represents total catch per day. Estimates are stratified by day-type and creel subareas.	Yes
DFO	Commercial Salmon Mandatory Logbook Catch Reporting Program	In B.C., all commercial salmon license vessels (troll, gill, and seine net) are required to maintain a logbook record of daily kept and released catch of all salmon, by species. Further, they are required to submit their logbooks within 1 month after their license year end. Tallies of these records are used (in some cases after expansion for non-reporting vessels) to represent commercial catch estimates for these fisheries.	Census (no sampling error).
DFO	Creel	The actual catch from the fishery is determined from the proportion of daily fishing effort occurring during the benchmark period and the daily catch per unit effort.	No
DFO	eLogbook	Currently in use, a proportion of active troll vessels provide their catches electronically (satellite phone, etc) through a third party service provider and are not required to submit a paper record of catch. Daily catch and annual catch estimates are expanded to effort estimates from the active fishery.	No
DFO	Mandatory Dockside Validation	In Northern Troll, all landings with Chinook kept catch must have their Chinook validated by a dockside monitor. The tally of these records represent the best estimate of catch for this fishery	Census (no sampling error).
DFO	Net Creel survey	Creel survey that counts nets instead of boats (occurs on the Fraser)	No
DFO	Observer Program (WCVI historic)	A proportion of WCVI troll fleet had observers on randomly stationed troll vessels to provide independent catch and release estimates for Area G troll, but observer reports were discontinued for WCVI in approximately the early 2000's.	
DFO	Fish slips	A fish slip is completed by a license holder and includes catch information that DFO uses to assess fish stocks and manage fisheries. For salmon, a fish slip includes both the number of fish caught and the weight (lbs).	No
DFO	iREC survey ("Internet Recreational Effort and Catch survey")	Marine recreational license holders report fishing activity, and Chinook catch for each Area and Date fished, by mark status, sublegal and legal size category, and disposition, on an online reporting program. Fishers are selected, at the time of license purchase, to report for a particular month. Reported catches are expanded to total catches for a particular Area and month using the total license sales as the total fisher population size.	Yes

Agency	Catch Estimation Program	Description	Variance Available (Yes/PA/No/0)
DFO	Voluntary lodge and charter logbook program	Lodges and charter operators are encouraged to keep complete records of kept (and in some cases released) catches, and provide these intermittently to DFO. These estimates are used without expansion, or in some cases with expansion for non-reporting lodges, to represent the total catch. However, they likely underestimate the catch as it is not possible to fully expand for non-reporting lodges and especially charter operators, or for incomplete records for those that do report.	No
WDFW	Aerial Survey	Aerial surveys are used in some marine areas (7 and 9) to create estimates of sport fishing effort and to identify locations of fishing effort.	NA
WDFW	Catch Record Cards	Mandatory catch reporting system required to fish for salmon in Washington State. Anglers are required to record catch, including date of capture, catch area, species, and mark status. Catch record cards are mailed in annually. Catch record cards can produce retention estimates, but are not typically used to develop release estimates as releases are not recorded. Additional information available here: https://wdfw.wa.gov/sites/default/files/publications/01357/wdfw01357.pdf Note: in Table A8, this has been classified as a "Angler Harvest Cards"	Yes
WDFW	Creel Survey	Methodology described in: https://wdfw.wa.gov/sites/default/files/publications/01357/wdfw01357.pdf Used to produce estimates of retentions and releases in several Washington sport fisheries. Utilizes angler interviews.	Yes
WDFW	Fish Tickets	Mandatory catch reporting system for commercial fisheries in Washington. Used to develop retention estimates for all commercial fisheries in the state, but releases are not recorded on Fish Tickets, so release estimates typically are derived from other sources.	Yes (100% recorded)
WDFW	Mail-in Survey (Voluntary Trip Reports)	Voluntary trip reports are recreational angler self-reported estimates of retention and release, by species and mark status. It can be used to inform ratios of marked, unmarked, legal, and sublegal fish in areas where either dockside information is insufficient or test fishing produced limited data.	NA
WDFW	Observers	Utilized in commercial fisheries in Washington state, observers sample a portion of vessels fishing. Estimates of releases are expanded to create a total release estimate, based on the number of releases per catch.	PA
WDFW	Test Fishing	Test fishing is conducted in several areas to produce estimates of legal, sublegal, marked, and unmarked ratios in recreational fisheries. It can be used to bolster or validate information from dockside sampling and/or voluntary trip reports.	NA
ODFW	Angler Harvest Cards	Electronic reporting via cell phones	
ODFW	Angler Interviews	The ratio of encounters to landed catch is expanded to an estimate of the anglers fishing that river/reach: # of anglers*fish/angler(interviewed).	
ODFW	Dockside Interview	Census (1st) or creel (2nd) for boat fishers. Known (census) or estimated (creel) boat count*fish/boat interviewed. Collecting basic catch and effort data (i.e., # anglers in boat, hours fished, target species, fish handled by species and life stage)	No

Agency	Catch Estimation Program	Description	Variance Available (Yes/PA/No/0)
ODFW	Dockside sampling (Access-point creel survey)	Refers to the collection of biological data from the catch (i.e., CWT, scale sample, fork length).	
ODFW	Fish Tickets	Landed catch in pieces estimated by dividing the landed weight by the average weight per fish. Average weight information is obtained from a sample of the landed fish.	
ODFW	Ratio of Encounters to Landed Catch (Angler Interviews)	Metrics (including an expansion factor) are used to estimated catch from boat and bank anglers	
ADFG	Statewide harvest survey (SWHS)	The Sport Fish Division has conducted a mail survey to estimate sport fishing total harvest (fish kept) since 1977 and total catch (fish kept plus fish released) since 1990. The estimates derived from this survey are available online through this application for study years 1996 through 2020.	

APPENDIX C: SURVEY RESPONSES

Additional tables and figures.

Appendix C1: Average (2009–2019) troll fishery estimates and CVs for legal kept, legal released, sublegal kept, and sublegal released Chinook.

Fishery Area (abb.)	Annual Average Legal Catch (2009–2019)				Annual Average Sublegal Catch (2009–2019)			
	Kept		Released		Kept		Released	
	Estimate	CV	Estimate	CV	Estimate	CV	Estimate	CV
ALASKA T	211153	0.0%	45264	UN	1	0.0%	62898	UN
NORTH T	93525	0.0%	14377	0.0%	UN	UN	10462	0.0%
CENTRL T	0	0.0%	662	0.0%	UN	UN	UN	UN
WCVI T	71457	0.0%	334	0.0%	UN	UN	3864	0.0%
N FALCON T	75292	UN	UN	UN	UN	UN	UN	UN
S FALCON T	57428	UN	UN	UN	UN	UN	UN	UN
GEO ST T	0	0.0%	UN	UN	UN	UN	91	0.0%

Appendix C2: Average (2009–2019) net fishery estimates and CVs for legal kept, legal released, sublegal kept, and sublegal released Chinook.

Fishery Area (abb.)	Annual Average Legal Catch (2009–2019)				Annual Average Sublegal Catch (2009–2019)			
	Kept		Released		Kept		Released	
	Estimate	CV	Estimate	CV	Estimate	CV	Estimate	CV
ALASKA N	42023	0.0%	5368	UN	1819	0.0%	19847	UN
NORTH N	1907	UN	UN	UN	UN	UN	1599	UN
CENTRL N	3959	UN	886	UN	UN	UN	UN	UN
WCVI N	16766	UN	UN	UN	UN	UN	381	UN
J DE F N	823	UN	UN	UN	UN	UN	UN	UN
PGSDN N	3495	UN	UN	UN	UN	UN	UN	UN
PGSDO N	46229	UN	UN	UN	UN	UN	UN	UN
WASH CST N	12330	UN	UN	UN	0	0.0%	0	0.0%
TCOL R N	221646	UN	533	UN	UN	UN	UN	UN
TPS FN	33242	UN	93	0.0%	0	0.0%	0	0.0%
TWAC FN	12164	UN	0	0.0%	0	0.0%	0	0.0%
TAK YAK N	586	0.0%	80	40.0%	345	45.0%	107	76.0%
TAK TST N	1257	15.0%	0	0.0%	UN	UN	0	0.0%
TBC TSR FN	5491	0.0%	72	0.0%	1622	0.0%	72	0.0%
TCENTRAL FN	DN	DN	DN	DN	DN	DN	DN	DN
TGEO ST FN	DN	DN	DN	DN	DN	DN	DN	DN
TFRAS FN	DN	DN	DN	DN	DN	DN	DN	DN
TYK YAK FN	111	0.0%	0	0.0%	0	0.0%	0	0.0%
JNST N	112	UN	UN	UN	UN	UN	1213	UN
FRASER N	15039	UN	1250	UN	DN	DN	DN	DN

Appendix C3: Average (2009–2019) sport fishery estimates and CVs for legal kept, legal released, sublegal kept, and sublegal released Chinook.

Fishery Area (abb.)	Annual Average Legal Catch (2009–2019)				Annual Average Sublegal Catch (2009–2019)			
	Kept		Released		Kept		Released	
	Estimate	CV	Estimate	CV	Estimate	CV	Estimate	CV
ALASKA S	59005	4.0%	26866	23.0%	2570	27.0%	52926	7.0%
CBC S	20077	7.3%	15683	15.6%	0	0.0%	5549	27.3%
NBC AABM S	47947	5.2%	59951	11.9%	0	0.0%	1335	29.9%
NBC ISBM S	5470	16.0%	3170	30.3%	0	0.0%	728	70.9%
WCVI AABM S	51987	4.9%	19251	11.2%	0	0.0%	25509	10.6%
WCVI ISBM S	54156	4.4%	10464	9.3%	0	0.0%	23043	9.0%
N FALCON S	26802	UN	27880	UN	UN	UN	UN	UN
S FALCON S	8266	UN	2140	UN	UN	UN	UN	UN
PGSDN S	18394	4.5%	21870	UN	UN	UN	16404	UN
PGSDO S	17940	4.2%	27740	UN	UN	UN	26404	UN
GEO ST S	103855	7.4%	66182	5.6%	0	0.0%	131909	4.8%
BC JF S	31976	5.3%	10215	17.4%	0	0.0%	24303	11.3%
TCOL R S	63284	UN	2174	UN	UN	UN	UN	UN
TPS FS	17339	3.8%	UN	UN	UN	UN	UN	UN
TAK TST S	1442	30.0%	UN	UN	UN	UN	UN	UN
TNORTH FS	1537	UN	UN	UN	UN	NA	256	UN
TCENTRAL FS	1108	UN	UN	UN	UN	UN	UN	UN
TWCVI FS	UN	UN	UN	UN	UN	UN	UN	UN
TFRASER FS	13034	UN	8602	UN	DN	DN	DN	DN
TGS FS	UN	UN	UN	UN	UN	UN	828	15.0%
TSF FS	108742	UN	UN	UN	UN	UN	UN	UN
TWAC S	8757	UN	UN	UN	UN	UN	UN	UN
JOHN ST S	12661	7.2%	2703	14.7%	0	0.0%	11229	10.9%

APPENDIX D: SURVEY SENT TO CTC MEMBERS IN SUMMER 2021

Survey Purpose			
To determine where data is available for fishery release estimates and the uncertainty around those estimates.			
Answer Options			
Instructions for survey	Information Type		Average Annual Catch (2009 - 2019)
	Drop down or fill in for Availability Row	Available (A)	Estimates are available but would require work to acquire them.
		Potentially Available (PA)	Estimates may be available but are not yet calculated.
		Not Available (NA)	Estimates are not available due to lack of monitoring or other reason (please indicate the reason if possible/known).
	Drop down or fill in for Estimate row	Catch and Variance Estimate	Include an actual estimates and variance if possible (e.g. 500 releases, 13%CV).
			If approximate catch is known, use Catch Ranges : <50, 50 - 100, 500 - 1000, 1000 - 2000, 2000 - 5000, 5000 - 10000, >10000.
			If approximate variance is known use, Variance Ranges : <5%, 5 - 10%, 10 - 20%, 20 - 40%, 40 - 60%, 60 - 80%, 80 - 90%, 90 - 95%, >95%
			Put UN if catch and variance estimates are unknown .

Outcome
A review of existing methods to estimate Chinook fishery releases, to identify sources of bias and uncertainty in those estimates, and the development of corresponding precision and accuracy standards for exploitation rate analysis fisheries.

Definitions	
Catch	Fish that are brought under control of the fisher
Kept	Fish that are retained
Released	Fish that are released
Variance	The amount of variance around the estimate (precision). The goal is to have precision estimates as CV's for each fishery.

#	Abbreviation	Model Fishery	Comments (e.g., where data is from or area, rough estimate of type of releases)	Information Type	Annual Average Legal Catch (2009 - 2019)				Annual Average Sublegal Catch (2009 - 2019)			
					Kept		Released		Kept		Released	
					Estimate	Variance	Estimate	Variance	Estimate	Variance	Estimate	Variance
#	EA	Example A	Small fishery with 50-100 legal catches with moderate variance (10-20%), releases are sporadically monitored, so estimates are not currently available.	Availability	A	A	PA	PA	A	A	PA	PA
Description		A fishery where the legal and sublegal kept estimates for and associated variance are readily available and an estimate range is able to be provided. The legal and sublegal estimates for releases and associated variance may be available, but have not been calculated.		Estimate	50 - 100	10 - 20%	UN	UN	50 - 100	10 - 20%	UN	UN
##	EB	Example B	Fishery is sampled in Area 7A, but estimates are extrapolated to other areas that are not sampled.	Availability	A	NA	A	NA	PA	PA	NA	NA
Description		Legal: A fishery where the kept and released catch estimates are available but would require work to access them. In this example, the variance associated with the catch estimates are not available. Sublegal: A fishery where the kept catch estimates and variances are potentially available, while the released catch estimates and variance are not available. For both legal and sublegal fisheries, the Estimate is UN because the actual number is not readily		Estimate	UN	UN	UN	UN	UN	UN	UN	UN

#	Abbr eviation	Model Fishery	Comments (e.g., where data is from or area, rough estimate of type of releases)	Information Type	Annual Average Legal Catch (2009 - 2019)				Annual Average Sublegal Catch (2009 - 2019)			
					Kept		Released		Kept		Released	
					Estimate	Variance	Estimate	Variance	Estimate	Variance	Estimate	Variance
		available.										
###	EC	Example C	Fishery sampled year round by creel survey, high data quality.	Availability	A	A	A	A	A	A	NA	NA
Description		A fishery where the average legal kept and released catches for 2009-19 are known and easily accessible, along with the variance. The Sublegal Kept catch was able to provide ranges for their estimate and variance, while the released was Unavailable and Unknown .		Estimate	400	12%	28	6%	500 - 1000	10 - 20%	UN	UN

APPENDIX E: REVIEW OF RECENT LITERATURE OF INCIDENTAL MORTALITY RATES IN CHINOOK SALMON FISHERIES

PACIFIC SALMON COMMISSION
CHINOOK TECHNICAL COMMITTEE

REVIEW OF RECENT LITERATURE OF INCIDENTAL MORTALITY RATES IN CHINOOK SALMON
FISHERIES

December 14, 2020

Glossary

Release mortality	A fish that dies before or after being released.
Drop-off mortality	Includes all mortality mechanisms of fish that come into contact with fishing gear but are not captured. These mortalities may occur prior to separation from the gear, by depredation while on the gear, or after escaping the fishing gear (by predation or from injury). Thus, drop-off mortality represents more mortality mechanisms than strictly mortality of fish that drop-off the hook (or “drop-out” of a net).
Fishery Encounter	Fish influenced by fishing activity, whether or not it comes in contact with the gear.
Physical gear contact	Fish that are hooked or netted.
Catch	Fish that are brought under the fisher’s control.
Kept/Retained Catch	Fish that are kept.
Pre-release mortality	A released fish that was dead at the point of release.
Post-release mortality	Fish that die after release as a result of being captured.
Released Catch	Fish that are caught and subsequently released by the fisher.
Depredation	Mortality of fish after a predator removes it from the fishing gear. Distinguished from “predation” which occurs when a predator kills a fish that is not in contact with the gear.
Escape Mortality	All drop-off mortality other than that due to depredation. Thus, this category includes fish that die during physical gear contact due to the contact and then drop-off/out of the gear, and fish that die after drop-off/out due to injury, stress, or elevated predation rate due to the physical gear contact.
Avoidance Mortality	Fish that die due to a fishery encounter, without physical gear contact. For example, fish encountering a fishery may incur higher predation rates if predators have recruited to the fishery or the fishing activity distracts the fish.

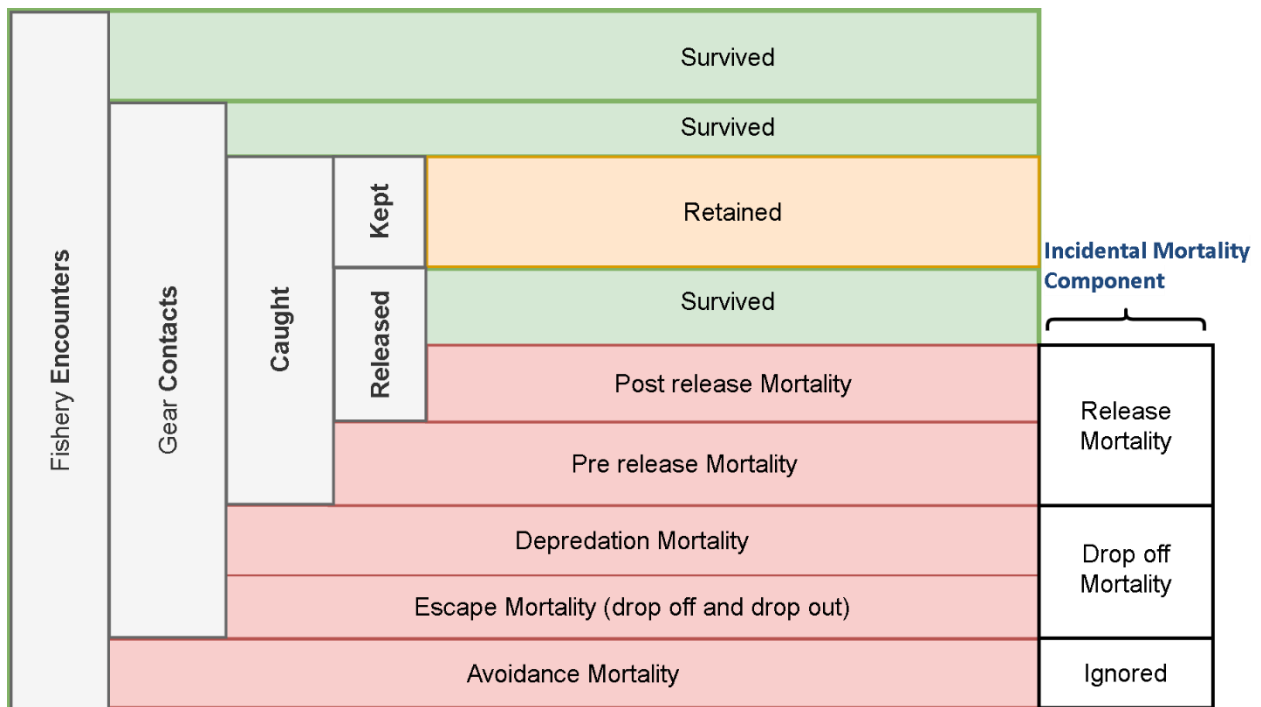


Figure 1. Components of incidental mortality and the potential outcomes for a fish that experiences a Fishery Encounter.

INTRODUCTION

Purpose

Annex IV, Chapter 3, Paragraph 4 of the 2019 Pacific Salmon Treaty Agreement includes several reporting requirements related to incidental mortalities (IM) of Chinook salmon in fisheries. Additionally, per Paragraph 4(c), the Chinook Technical Committee (CTC) was tasked with recommending “standards for the desired level of precision and accuracy of data required to estimate incidental fishing mortality.” Critical to estimating IM are two pieces: (1) estimates of mortality rates and (2) estimates of the number of fish kept and released. This report contains a literature review of IM rate studies that have been conducted since the CTC’s previous 1997 (TCCHINOOK (97)-1) and 2004 (TCCHINOOK (04)-1) incidental fishing mortality reviews. Results of these studies are summarized in the appendices of this report to aid in determining whether changes are recommended to the current suite of assumed gear and size-specific IM rates used in CTC analyses. In a subsequent report, currently scheduled for completion in October 2021, the CTC will provide an assessment of current methods used to estimate the number of Chinook encountered and released in fisheries, along with recommended levels of accuracy and precision in these estimates.

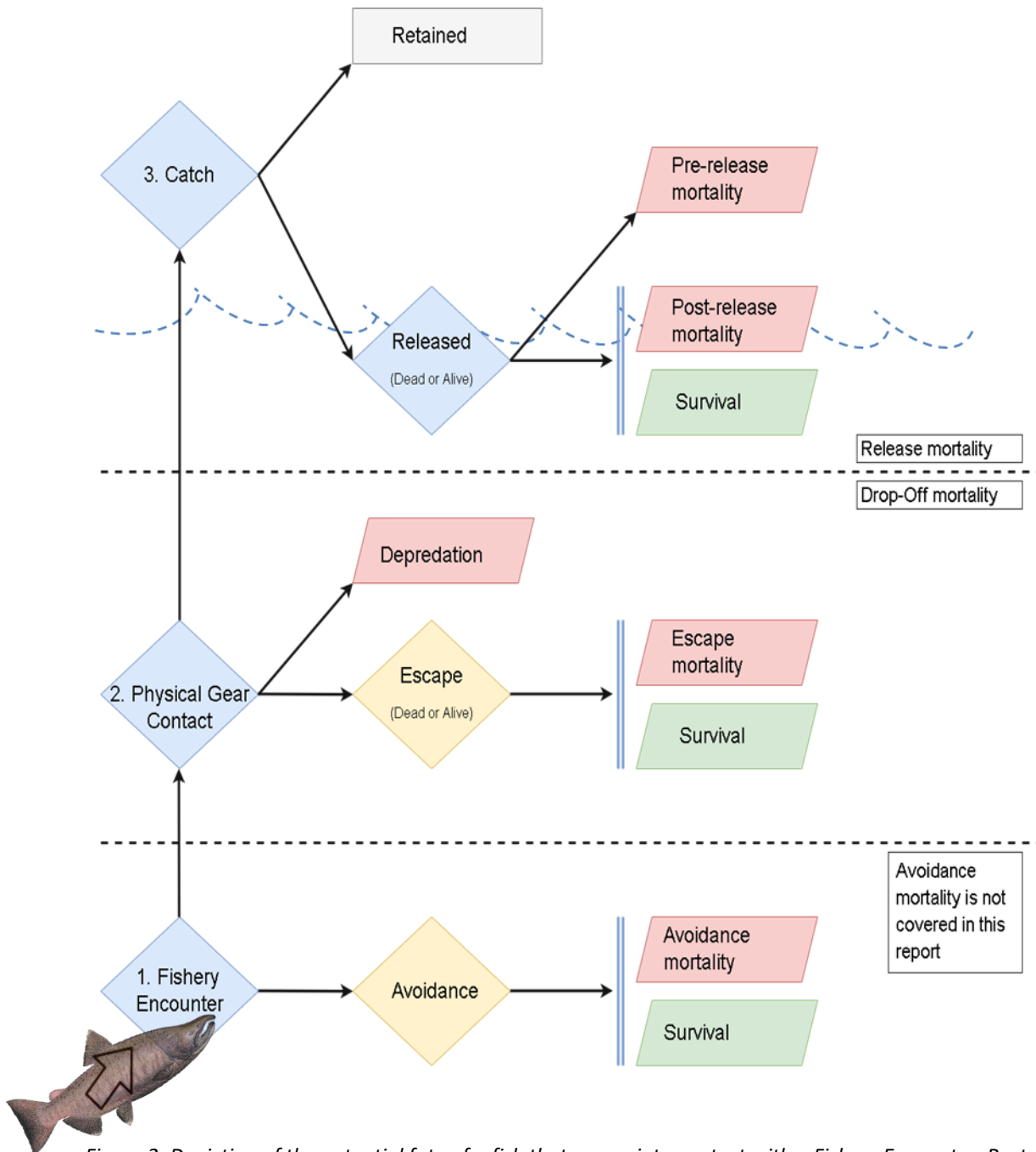
Overview

Robust accounting of mortality associated with pre-terminal and terminal salmon fisheries must include both landed catch and estimates of IM, which includes release mortality (on-board and post-release) and drop-off mortality. Pre-release mortality occurs as fish that would otherwise be released due to size limit, mark-selective fishery (MSF) regulations, or other reasons die during capture or subsequent handling. Post-release mortality occurs as fish that have encountered fishing gear succumb to physical or physiological injuries caused by the capture, handling, and release, or experience elevated risk of predation due to their capture experience. Drop-off mortality includes a wide range of mortality mechanisms acting on fish that physically encounter the gear but are not caught, such as depredation mortality and escape mortality. Drop-out mortality refers to fish that are entangled and die during capture, but then fall off fishing gear prior to capture (See CSAS(2017) for additional mortality definitions and details). Avoidance mortality applies to fish that die as a result of avoiding a fishery encounter. There are a number of IM terms used throughout the literature, but the CTC uses terms as defined in Canadian Science Advisory Secretariat (CSAS) (2017) (<https://waves-vagues.dfo-mpo.gc.ca/Library/40602758.pdf>). For simplicity, the Glossary and Figure 1 have been provided as a review and reference of the IM terms referred to in this report. The potential scenarios that may occur during an angling encounter are depicted in Figure 2 where a fish will either:

- 1) Avoid the encounter, and may survive or die as a result of injuries, predation or physiological stress (CTC 1997),
- 2) Drop-off, where the fish is netted/hooked but not captured due to depredation or escape. Fish that escape the encounter by actively freeing themselves from the gear will either succumb to their injuries or physiological stress, or they may recover and

survive. Dead fish may “escape” the gear by being knocked loose from the gear or washed out of nets (Drop-out).

- 3) Be captured and released, where they will either survive or die as a result of injuries, depredation or physiological stress (post-release mortality), or recover and survive.
- 4) Die during or immediately after being captured due to injuries or physiological stress (pre-release mortality).
- 5) Be captured and retained.



Incidental mortality components are depicted in red, while fish survival (including acute or sub-lethal effects) are in green. The diagram is separated into three sections by dashed lines. Starting at the bottom is avoidance mortality, which is ignored in this report as it is assumed to be negligible. The mid-section is drop-off mortality, which is discussed in Section 4 of this report, and the top section is release mortality, which describes the mortality associated with a fish being caught (Adapted from CSAS 2017).

Increasing utilization of MSFs places further importance on IM rates used. As MSFs are conducted, a greater number of releases and drop-offs are expected relative to a non-selective fishery of equivalent fishery effort. Therefore, ensuring that the best scientifically-justified IM rates are used is significant because these rates are acting on a greater number of encounters. This report will focus on estimations of IM rates by gear type, and review the methods used to produce these estimates.

Methods for Estimating IM Rates

The product of the number of releases of a given gear type and a release mortality rate yields an estimate of release mortalities (number of fish that die after being released). In addition, a number of fish that die due to drop-off mortality is calculated as the number of legal and sublegal fish captured multiplied by the fishery-specific drop-off mortality rate. Currently, the CTC Exploitation Rate Analysis (ERA) and Chinook Model both estimate four categories of IM: 1) release mortality of legal-sized fish in Chinook Non-Retention (CNR) fisheries, 2) release mortality of sublegal-sized fish in CNR fisheries, 3) release mortality of sublegal-sized fish released in Chinook retention fisheries with a size limit, and 4) drop-off mortality in all these fisheries, separately estimated for legal and sublegal-sized fish. These analyses assume that all legal-sized Chinook that are captured in Chinook retention fisheries are retained, and therefore IM estimates for this group are not required. Note that avoidance mortality, which is defined as “mortality of fish that encounter fishing gear but actively avoid the gear without direct physical contact, resulting in fatigue and stress (e.g., gear avoidance through difficult passage areas; CSAS 2017)”, is not currently considered in the ERA and Chinook Model.

The CTC applies a drop-off mortality rate to both kept and released catches when estimating the drop-off mortality of sublegal-sized Chinook captured in retention fisheries, and legal- and sublegal-sized Chinook captured in non-retention fisheries. There are several methods for gathering catch data, including using fisher reported data, on-board observers, dockside sampling, test fishing, and surrogate fisheries. The IM rates applied to these numbers also come from a variety of sources. These sources include studies conducted in the fishery itself, rates borrowed from similar fisheries, expert opinion, or combinations of sources. Incidental mortality rate studies are notoriously difficult, expensive, context-specific, and time-consuming to conduct. Additionally, estimates of release- and drop-off mortality rates can vary greatly across study conditions.

Geographic Considerations for Methodology

Current methodology used to estimate the number of fish captured can differ greatly by geographic area and management agency. Puget Sound sport fisheries provide a good introductory example. For the marine fishery, an estimate of Chinook released per angler-trip is first produced for each catch area-month combination according to the sampling data collected

(baseline and/or creel). Next, the estimate of released Chinook per angler-trip is expanded by the number of angler trips (estimated from creel or Washington Catch Record Cards) in each area-month combination to produce a total estimate of Chinook released. For freshwater sport fisheries, sampling efforts are sporadic and do not occur every year. Average ratios of the number of Chinook released per the number of Chinook kept are used from periods when freshwater sampling did occur, and these ratios are applied to the number of kept Chinook to estimate releases, with ratios used differing for MSFs and non-selective fisheries.

In Southeast Alaska (SEAK) recreational fisheries, an annual mail out survey (Statewide Harvest Survey) is randomly distributed to chosen individuals who purchased a fishing license. This survey provides estimates of legal (≥ 28 inches) and sublegal (< 28 inches) Chinook salmon releases in SEAK recreational fisheries. Reported releases from the survey are compiled and expanded by the ratio of known sport fishing licenses to valid survey questionnaire responses. Chinook releases in the purse seine fishery are estimated for both Chinook retention and CNR periods. Sublegal capture estimates for the retention period are based on either reported numbers from fish tickets or ratios of releases to landed catch determined from encounter studies that took place from 1985–1988 and 2004–2005. Legal and sublegal releases in the CNR periods are based on legal catch during the retention periods, ratios of effort between retention and CNR periods and the historical distribution of Chinook catch-per-unit-effort (CPUE) across statistical fishing weeks. Chinook releases in the troll fishery are estimated for both the Chinook retention and CNR periods. Sublegal capture estimates for the retention periods are based on a regression that predicts sublegal captures based on effort. The regression was developed using data from 1998–2006 when observer and logbook encounter studies were in place. Legal and sublegal capture estimates for the CNR periods are also based on regressions that predict the number of fish captured based on effort. The regressions were developed using years when observer and logbook encounter studies were in place. The sublegal regression was developed using data from 1985–1988 and 1998–2001. The legal regression was developed using data from 1985–1988 and 1998–2006.

In British Columbia (B.C.) recreational fisheries, a variety of methods are used to estimate kept and released catches. Creel surveys (with paired aerial counts to estimate total effort) are conducted in some areas and months, concentrated in the marine waters of Johnstone Strait, Strait of Georgia, and West Coast Vancouver Island, and freshwater fisheries in the Fraser River and other southern B.C. indicator streams, during late spring and summer months. Given this concentration, these surveys account for a substantial fraction of the annual Individual Stock Based Management (ISBM) fishery catch. These creel surveys estimate both retained catch and released catch of legal and sublegal-sized Chinook salmon. In central and northern B.C., tallies of lodge and guide logbook records are used to estimate retained catch; however, these estimates are not expanded to account for non-reporting (or underreporting) of lodges and guides, or for catch of non-guided fishers. Finally, the internet Recreational Effort and Catch (iREC) survey of tidal water license holders provides kept and released catch estimates, by size category, for all month-management area combinations. Estimates from this survey have been used in IM calculations since 2012 for southern BC marine sport fisheries. In B.C. commercial salmon fisheries, catch estimates are based on fisher recorded catch logbooks. These logbooks record releases and in troll logbooks, record sublegal- and legal-sized releases separately. There

is some expansion for missing logbooks and for underreporting based on observer programs (Velez-Espino et al. 2010).

FACTORS INFLUENCING INCIDENTAL MORTALITY RATES

There are many intrinsic, fishery-related, or environmental factors that can influence IM rates, including environmental (extrinsic) conditions, biological conditions of the species and individual fish being captured, and fishery characteristics. These factors are briefly described for salmonids in the paragraphs below, with a focus on Chinook specifically depending on available studies. Some examples of environmental, biological, and fishing conditions that may influence IM rates are:

- Environmental cofactors: water temperature, dissolved oxygen, turbidity, salinity, hydrology, predator abundance, predator behaviour, and time of year,
- Intrinsic cofactors: physiological condition, pre-capture injury, size/age, maturity/sex, and species/population,
- Fishing cofactors: gear used, capture duration, gear avoidance, catch density, catch composition, degree of movement restriction, handling practices, air exposure duration, target species/origin, and retention size limits.

Interactions among these factors affect IM rates, and it is difficult and expensive to quantify the effects of such interactions. Furthermore, many of these factors are not static and their variability can be expected to have implications on IM rates. Examples of imminent or ongoing changes that could affect IM rates relative to historic studies include predator density and behaviour, climate change, varying abundance among distinct salmon stocks, and alteration in fisheries management.

Intrinsic factors are those that affect the condition of an individual fish or individual stock. Pre-existing conditions such as physical injuries or elevated physiological stress can reduce the chances of survival following capture. Fish with pre-existing physical injuries may have to exert more physical effort to escape capture or may already have a compromised physiological state (e.g., blood loss). Those that are physiologically stressed prior to capture may have elevated physiological parameters that are closer to hazardous conditions relative to non-stressed fish (Barton et al., 1986). Fish who have been infected with parasites, such as the myxosporean kidney parasite *Parvicapsula minibicornis*, may be more impacted by the stresses associated with capture as their abilities to recover as quickly as non-infected fish may be compromised (Wagner et al., 2005). The size or age of fish captured can affect IM rates as hooks are likely to cause greater damage to small-sized fish (Wertheimer et al., 1989). Wertheimer et al. (1989) and McNair (1999) also suggested the relationship between size and IM may be a quadratic in nature, with very large fish also having higher mortality rates as they are more likely to swallow hooks and become hooked in critical locations. Additionally, there is evidence that as fish mature, they are more resilient to capture (Rosseland et al., 1982; Ruggerone and June, 1996) and that fish scales are less likely to be removed by capture the closer a fish is to spawning (J. Jorgensen, Quinault Indian Nation Fish Biologist, personal communication). It is possible that certain stocks may be better adapted to surviving and recovering from fishery capture, due to faster maturation rates in river, larger average body size (Wertheimer et al., 1989), run-timing

differences (Donaldson et al., 2010), or traits that make exhaustion less likely (e.g., stocks from fast flowing rivers of origin, wider optimal thermal ranges, or with longer freshwater migrations; Farrell et al., 2008; Eliason et al., 2013), but this last concept is poorly understood for Chinook with little stock-specific research currently available.

Environmental factors can contribute to increased risk of exhaustion or physiological damage, increasing the risk of mortality during or after an interaction with fishing gear. One of the most well-documented environmental factors that affects IM rates is water temperature (Gale et al., 2011; Gale et al., 2013). Dissolved oxygen concentrations of the capture location may affect IM rates as oxygen is needed to correct metabolic, ionic, and chemical imbalances caused by capture and restore oxygen and phosphate stores to the tissue (Lee et al., 2003). For example, fish that are captured when water temperatures are higher (with low dissolved oxygen concentrations), can experience higher IM rates or stress than fish caught in colder waters with higher concentrations of dissolved oxygen. Under these types of capture conditions, a fish may have to utilize anaerobic respiration which leads to a rapid depletion of energy stores along with a build up of toxic metabolic by-products (Raby et al., 2015). Fish are adapted to operate within a certain thermal range and deviation from this optimum range can cause physiological stress that may be compounded by fisheries capture (Gale et al., 2011). Increased water temperature may also result in pathogens being present in the environment in greater quantities (Stocking et al., 2006), as they are able to replicate more rapidly (Bettge et al., 2009), and temperature is also correlated to the severity of infection (Wagner et al., 2005).

Hydrological or topographical features of a location are also hypothesized to increase the risk of IM. For example, if a river system has particularly fast moving flow, fish encountering fishing gear may already be experiencing physiological exhaustion relative to those encountering gear in slow moving flow. Additionally, studies have suggested that rough seas may increase the likelihood of drop-out in marine net fisheries (Thompson et al., 1970; Jewell 1970). High turbidity is known to produce a physiological stress response in salmon (Redding et al., 1987) and it is possible that encountering fishing gear could have a compounding effect in spatio-temporal periods of high turbidity, though this topic is poorly understood. One environmental factor that is of particular significance to IM rates is predator abundance. Predator abundance and behavior can vary by location and timing, contributing to the likelihood of IM events (Beach et al., 1985; Diewert et al., 2002). There are likely many environmental factors that are not described in this paragraph such as season, water quality (pH, alkalinity, salinity, pollution), and more that warrant additional research to better understand how environmental conditions can affect IM rates.

In addition to intrinsic and environmental factors, fishery-related factors can affect IM rates. All types of salmon fishing gear can cause physical or physiological damage during capture, with the severity of injury determined by gear type (Davis, 2002). Fish encountering recreational or troll gear may be injured by hooks, with the potential degree of damage varying by hooking location (Lindsay et al., 2004; Cowen et al., 2007) and type of hook (Butler and Loeffel, 1972; McNair, 1997; Diewert et al., 2002; Grover et al., 2002). The majority (90–95%) of recreational IMs occur within the first 48 hours of being hooked (Falk et al., 1974; Hunsaker et al., 2002), and fish with heavy bleeding as a result of being hooked in critical body locations usually perish within the first 24 hours (Mongillo 1984; Muoneke and Childress, 1994). IM rates during gill net

capture vary according to net mesh size as smaller mesh sizes have a greater likelihood of entangling fish by the snout, and these fish are more likely to survive capture than those entangled by the gills or body due to decreased scale removal and calmer behavior in the net (Vander Haegen et al., 2004). In all gear types, IM is more likely for periods of long capture duration (Buchanan et al., 2002; Gale et al., 2011), as fish experiencing greater physiological stress are more likely to incur physical injury trying to escape fishing gear. In addition, the movement of these fish can be impaired for a greater period of time which increases the risk of depredation. Handling practices such as longer air exposure or in-water handling periods can be associated with higher IM rates (Cook et al., 2014). Sublethal stress may also impact a fish even if it survives an angling encounter, with potential long-term effects on spawning success (Cowen et al., 2007) or the fitness of subsequent offspring.

CSAS (2017) contains an excellent review on how capture duration, handling duration, injury, water temperature, and predator presence may influence IM rates. Therefore, for additional details related to how these key factors affect IM, please refer to section 2.2.3 and Appendix A in that document. Interested readers should also see section 2.2.4 of CSAS (2017) for information on potential interaction effects between factors, which is an important topic discussed extensively in that review (Barton et al., 1986; Côté et al., 2016; CSAS, 2017).

Literature Review²

1. Recreational Studies:

Recreational IM rates are typically associated with catch and release fishing. Catch and release regulations are increasingly being implemented as a means to maintain fishing opportunities and related economies in recreational fisheries that encounter stocks with conservation concerns. In some areas, anglers can harvest adipose fin-clipped (marked) hatchery fish within size and bag limits, but all fish with intact adipose fins (unmarked) must be released in an effort to limit impacts on wild stocks. In other areas, regulations require non-retention for both marked and unmarked Chinook but allow for directed fisheries on other salmon species. These regulations are designed to allow for continued recreational fishing opportunity in areas where impacts on wild stocks are a concern and fisheries with non-selective Chinook retention are not a viable option. There have been many studies completed to date that review IM rates in recreational fisheries, especially for Pacific salmon. In general, recreational fisheries have lower IM rates than other types of fisheries, although this depends on many factors including gear types and environmental conditions. Recreational IM rates can vary widely (5–30% based on research from 1980–1999; Cox-Rogers et al., 1999), and significant effort has been made since 2002 to further understanding of the mechanisms behind IM and improving the methods to estimate IM rates.

In the CTC's 1997 IM Report (CTC 1997), they determined that data were not conclusive or consistent enough to warrant different IM rates for barbed vs barbless hooks. They

² Sections 1, 2 and 3 are strictly related to release mortality (RM), however, for the purposes of these sections the CTC uses the term incidental mortality (IM) to include release mortality.

recommended utilizing two hook-and-release mortality rates for different Chinook size categories: 12.3% for ≥ 33 cm and 32.2% for < 33 cm (Table 13). In general, the CTC uses the rate for larger sized fish in its calculations, because they are the most common age class in PSC recreational fisheries (CTC 1997). However, when the smaller size fish make up a significant portion of encounters ($>1\%$), the CTC will weight the rates as necessary.

Table 13. Recreational fishery release mortality rates by fish size currently used in CTC analyses, as recommended in CTC (1997).

Fishery	Barbed/Barbless Hooks	
	Chinook ≥ 33 cm	Chinook < 33 cm
Recreational (All Regions)	12.3%	32.2%

This literature review identified three recent studies (

Appendix E1), which were reviewed to summarize new information about recreational IM rate estimates and whether updates to the rates currently used by the CTC (Table 13) are recommended. Generally, the studies found IM rates similar to those that the CTC is currently using. However, the studies also identified critical factors that may influence IM rates in recreational fisheries, which are described below, including some recommendations which may help decrease IM rates for recreational fisheries in the future.

In freshwater sport fisheries, being hooked in a critical body location is the major determinant of mortality (Gjernes et al., 1993; NRC, 1994; Bartholomew and Bohnsack, 2005). Critical hooking locations include deep in the mouth, esophagus, stomach, heart or gill arches, which commonly result in heavy bleeding, often more than the fish can replace (Cox-Rogers et al., 1999; Diewert et al., 2002). Hooking locations that are not typically associated with mortality include the jaw or outer mouth. In cases where the fish dies as a result of lethal injuries, it is usually due to significant blood loss or the toxic build up of anabolic metabolism by-products (Cox-Rogers et al., 1999; CTC, 2004).

Anglers who implement fishing techniques such as “feeding the line” may result in the fish taking the hook deeper with a greater likelihood of injury and blood loss. The length of time it takes an angler to land a fish also influences the probability of the fish dying from exhaustion or being vulnerable to predators (Atkinson et al., 1998; Diewert et al., 2005). Non-landed fish that escape because they were not hooked deeply have a higher chance of survival compared to fish hooked more deeply that escape by breaking the line, although this is challenging to quantify.

Experience, education, fishing technique, and fishing gear all influence recreational IM rates. Promoting best fishing practices and handling techniques along with angler education can help to reduce recreational IM rates.

2. Troll Studies:

After rearing and making the journey to salt water, Chinook salmon will generally spend several years in the open ocean along the coast of the Pacific Northwest. During that period, Chinook

salmon are most susceptible to troll fisheries. Troll fisheries occur off the coast of the Pacific Northwest, throughout the entire area subject to the Pacific Salmon Treaty. Some of these fisheries, specifically the West Coast Vancouver Island troll fishery, North B.C. troll fishery, and the Southeast Alaska troll fishery, are representative of the larger scale Aggregate Abundance Based Management (AABM) fisheries that are of primary importance to the CTC and the PSC.

The CTC's 1997 IM review cited several studies that were used to determine IM rates for troll fisheries. These rates varied depending on whether the fishery used barbed or barbless hooks and whether the fish captured was of legal or sublegal size (Table 14). The IM rates recommended in CTC (1997) represent combined on-board and post-release mortality, with post-release mortality standardized to a 6-day period following capture. There were five studies used to estimate release mortality for troll gear, which can be found in tables 4 and 5 of CTC (1997).

Table 14. Troll fishery release mortality rates by hook type and fish size currently used in CTC analyses, as recommended in CTC (1997).

Fishery	Barbed Hooks		Barbless Hooks	
	Legal Size	Sublegal Size	Legal Size	Sublegal Size
Troll (All Regions)	21.1%	25.5%	18.5%	22.0%

The CTC has only identified one study relevant to troll gear and IM that was completed after 1997, however, the study did not specifically examine IM rates, rather, it evaluated potential bias in reported releases using logbook data. However, the goal of this study was to investigate captures and releases in troll fisheries during Chinook retention periods, which may be helpful for reevaluating capture and release rates used by the CTC. The annotated notes of this study can be found in Appendix E2.

3. Net Studies:

Seine, gill net and tangle net gear types are combined into a single “net” fishery for the purpose of CTC analyses (ERA and Chinook model), so only one IM rate is applied to all net releases, regardless of gear type. Currently the net IM rate used by the CTC is 90% release mortality for legal and sublegal Chinook salmon (CTC 2019; Table 15). These rates do not include drop-off mortality, which is discussed in a subsequent section of this document. Drop-out mortality includes fish that escape (dead or alive) from the nets, while release mortality (RM) rates represent both pre- and post-release mortality.

3.1. Gill and tangle net studies:

Gill net IM is often quite high, and it is also quite variable, depending on soak time, mesh size, net tension, and condition of the fish (CSAS, 2017). The most recent CTC review of gill net release mortality (CTC, 1997) found insufficient information to update their previous assumption of 90% release mortality for gill nets. Tangle nets are similar to gill nets but with smaller mesh sizes, typically capturing the fish by the snout or teeth, allowing the fish to respire when entangled, decreasing the IM rate (Vander Haegan et al., 2004).

The CTC identified two new studies on IM of Chinook in gill net and tangle net fisheries completed since the 1997 and 2004 CTC reviews (Vander Haegan et al., 2004; Ashbrook, 2008). The annotated notes of these studies can be found in Appendix E3.

3.2. Seine net studies:

Seine IM rates recommended in CTC (1997) were 49% for pre-release mortality and 23% for post-release mortality, summing to an estimated release mortality rate of 72% (Appendix E3; Table 15). However, as noted previously, current modeling structures only allow for one IM rate to be applied to all net fishery gear types, thus, these recommended rates are not currently used in CTC analyses. The IM rates recommended were based on five on-board mortality and three post-release mortality studies. Note that post-release mortality studies were generally shorter in duration than for many other gear types (ranging between 2 and 50 hours), so RM rates should be considered short-term. Since the CTC's 1997 and 2004 IM reviews, there have been three studies published on seine IM rates. The findings of these studies are summarized below, with additional detail provided in Appendix E3.

Studies referenced in CTC 1997 found that several factors can influence mortality rates during seine capture. Candy et al. (1996) found that longer times spent in fishing gear from the onset of gear retrieval to processing was associated with higher post-release mortality rates. Chinook released in Ruggerone and June (1996) had low post-release mortality rates, which the authors attributed as being likely due to the fish captured being near spawning (30-45 days from maturation) and more resilient to capture and handling. Additionally, by combining data sets from several pre-release mortality studies (Rowse and Marshall, 1989; Rowse 1990), CTC (1997) concluded that Chinook pre-release mortality for seine nets varied according to fish body size, with larger fish being more resilient to capture. Considering these factors, CTC (1997) recommended that IM rates should be adjusted if size-specific capture data are available or if fishing occurs close to stock maturity.

Beach seines are designed to corral fish into shallow water. There is minimal handling time to the fish, and the mucus layer is generally unaffected, resulting in less damage to the fish provided that the net is maintained at an adequate depth with water flow while the fish are being removed (Raby et al., 2014). If this is not the case, then oxygen can quickly become depleted based on the density of fish in the net, resulting in increased stress or mortality (Raby et al., 2014). Survival rates for beach seines have been noted to range from 52% (Fraser River sockeye, Donaldson et al., 2011) to 74% (Fraser River coho, Raby et al., 2012). A post-release survival rate was estimated as 95% for salmon captured via beach seines (Bass et al. 2018).

Cox et al. (2019) and Liedtke et al. (2014) reported extremely low RM rates (2.1% and approximately 10%) compared to past studies. Low IM rates observed in Columbia River fisheries may be due to regulations that require fish to be left in the water during sorting and restrict the ability to brail catch onto vessel decks (Cox et al., 2019). These rates contrast fishing practices in the post-release mortality rates currently used which were derived from Candy et al. (1996). For pre-release mortality, Cox et al. (2019) noted that they used purse seines with mesh sizes that were too small to gill or entangle fish regularly. Previous studies have suggested that larger mesh sizes may be detrimental to fish survival and lead to higher rates of IM (Matthews, 2012). Therefore, if fishery regulations require in-water sorting and mesh sizes too

small to gill-capture Chinook, a lower IM rate than currently used CTC rate (Appendix F) may be warranted.

Table 15. Incidental Mortality rates used by the Chinook Technical Committee for net fisheries (adapted from CTC 2004).

Specific Fishery/Gear	Mortality Type	Fish Size category		
		Small Chinook < 53 cm	Medium Chinook 53-71cm	Large Chinook >71 cm
Gillnet (general)	Total	90.0% (all sizes)		
Seine (general)	Immediate	62.8%	50.5%	28.0%
	Delayed	23.0%	23.0%	23.0%
	Total	85.8%	73.5%	51.0%
	Total	72.0% (all sizes comb.)		
Terminal Seine (<60d to spawning)	Delayed (immediate as above)	1.1%	1.1%	1.1%
	Total	63.9%	51.6%	29.1%
Northern BC Seine (DFO areas 3-4; brailed)	24 hr	71.6%	48.3%	21.0%

Note that there was one additional research article on purse seine IM that was excluded from the above literature search (Holowatz et al., 2014), as the author noted that some key assumption in that paper were violated in a later research output (Cox et al., 2019).

4. Drop-Off and Drop-Out Studies:

The CTC recognizes that literature uses varying terms to describe drop-off mortality, however, consistent with other sections of this document, the definitions provided in the Glossary of this report shall be referred to. In summary, drop-off mortality includes all mortality mechanisms for a fish that comes into contact with fishing gear but are not captured, whereas drop-out mortality specifically refers to fish that escape the fishing gear or are washed out from nets (dead or alive).

For recreational fisheries, CTC (1997) computed individual rates for escape mortality and depredation mortality (Table 16). For troll fisheries, the escape mortality rate was estimated for barbed and barbless hooks separately (

Table 17). For net fisheries, CTC (1997) acknowledged that drop-off mortality rates were poorly understood and highly variable depending on region of fishing, predator abundance, species netted, type of gear used, and fishing intensity. Currently used drop-off mortality rates by the CTC vary by area and are based on previous studies (Appendix F).

Table 16. Recreational hook-and-line drop-off rates expressed as a percentage of salmon captured, as recommended by the CTC (1997).

Specific Fishery	Escape Mortality	Depredation	Total Drop-off Mortality
Puget Sound	5.0 %	9.5 %	14.5%
Oregon Coast	1.5 %	1.2 %	2.7%
Southeast Alaska	-	0.4 %	3.6% ¹
Average	3.2 %	3.7 %	6.9%

¹ Assumes average escaped mortality rate.

Table 17. Commercial troll drop-off rates expressed as a percentage of salmon captured, as recommended by the CTC (1997).

Specific Fishery	Barbed hook	Barbless hook
Southeast Alaska Troll	0.8 %	-
Oregon Coast Troll	-	2.5%
Average Troll	1.7 %	1.6 %

Table 18. Regional-specific drop-out mortality rates in gill net fisheries. Rates shown are additional mortality due to drop-out as a percentage of Chinook caught in gill net fisheries (from CTC 2004).

Region	Drop-out Mortality Rate
SEAK	2%
Fraser River	8%
Puget Sound	8%
Washington Coast	2%
Columbia River	3%

One challenge the CTC has identified for modeling release and drop-off mortality rates is the interaction between fisheries-related mortality and natural mortality. Depredation mortality is a major component to drop-off mortality. Similarly, released or escaping Chinook may be physically exhausted and may be less likely to escape predators. Therefore, fisheries capture can directly result in a predation event and is incorporated into the Chinook model as increased fishing mortality. However, fishery-induced predation events cannot be accounted for in models if natural mortality rates remain static and within annual time strata. There is a caloric requirement for predators that, when met, should theoretically reduce time spent foraging.

Fish that succumb to fishery-induced predation events may reduce natural mortality rates temporarily in the area occupied by predators. Moreover, there is currently no accounting for growing or receding populations of predators nor the influence they may or may not exert since the time that many of the IM studies have been conducted.

While data on escape, drop-out, and depredation mortality rates are limited, the CTC has identified five studies conducted on salmonids that were not considered in the CTC's 1997 or 2004 IM reports. Many of the mortality studies conducted contain caveats in the study design that warrant caution when applying results to real world management. However, given that current CTC drop-off rates used are based on a combination of assumptions and historic data (hook-and-line) or previous studies (net), a review of the available literature is included in Appendix E4. Note that due to the lack of available studies and because previous sources used to derive rates are unknown, studies from all years have been included in this literature search.

The earliest study in this section of the literature review aimed to quantify the rates at which salmon escaped gill nets in Puget Sound and the Columbia river (Jewell, 1970). They did not find drop-out rates from gill nets to be a serious concern except for one case in Lake Washington sockeye, but did note that drop-out rates were significant under conditions such as when the swell is allowed to "work" the net due to a hard blow from the weight of the boat, or in cases where the gill net is exposed to strong riptides and opposing currents. Other studies, such as Beach et al., (1985) and Diewert et al., (2002), investigated depredation mortality interactions. However, it can be challenging to apply these to current conditions as pinniped populations have changed considerably since these studies were completed. California sea lions were noted as significant predators, and depredation rates can range from 2.2 to 28.6% depending on year and gear type (Weise and Harvey, 2005).

SUMMARY AND RECOMMENDATIONS

Recreational IM

The CTC identified three recreational IM studies conducted since the last literature review (CTC, 2004). In general, results were similar to current rates used. The exception to this was post-release mortality reported in Diewert et al. (2002) which was 50% but based on a small sample size ($n = 4$) and post-release mortality rates derived from this study differ from other studies examined. Based on these findings, the CTC does not recommend any changes to the recreational fishery IM rates currently being used.

Troll IM

No troll studies have been identified by the CTC since the last literature review in 2004 that specifically evaluated IM rates, thus, the CTC does not recommend any changes to the troll fishery IM rates currently being used.

Net IM

Research, including the PSC Chinook model and literature review, indicates that IM rates may vary considerably across these gear types. There is evidence to suggest that tangle net and seine RM rates may be substantially lower than those in gill nets, however, CTC modeling structures currently only allow for a single release mortality rate for all net fisheries combined. An investigation into the feasibility of stratifying total net IM estimates by net gear-type may be

warranted, however this would rely on the availability of release information by specific net gear-type and would need to be considered in perspective with other CTC priorities.

Two gill net IM study were identified by the CTC since the last literature review, with IM rates considerably lower than the currently used values. This may warrant additional investigation into the rates being used in the future, but there is currently insufficient evidence to warrant any updates to gill net IM rates.

The CTC identified three recent studies relevant to seine IM rate since the previous review. Two of these studies (Liedtke et al. 2014; Cox et al. 2019) indicated that seine IM rates could be much lower than those currently recommended by the CTC (Table 15) in situations where fishery regulations require in-water sorting and mesh sizes too small to gill-capture Chinook.

Drop-off and drop-out IM

Drop-off and drop-out mortality rates vary by fishery and based on additional factors including predator abundance. Five studies were identified and reviewed since the previous literature review (CTC 2004). Currently, the CTC IM rates for drop-off or drop-out mortality vary among gear types. The studies reviewed suggest continuation of the use of the drop-off and drop-out rates used and re-evaluation of these rates based on increased predator abundance (Chasco et al., 2017), prioritizing funding projects to re-evaluate the rates used and predation mortality, especially in hook-and-line and net fisheries.

Influence of environmental factors on IM

While rates used in CTC analyses are static, the CTC acknowledges that IM rates can vary over time. Incorporating time varying IM rates into CTC analyses could be a long-term goal; however, additional research would be required. However, the CTC recognizes additional research on this theme would be required to incorporate environmental covariates in IM calculations. Although several of the relevant studies have been conducted on salmonids, research conducted specifically on Chinook salmon is still lacking. In addition, the development of pre-season estimates of IM would require forecasting of environmental factors through climatic projections and recent-year trends.

Final remarks

The CTC recognizes that updating the IM rates for various fisheries is a large task and the level of priority would need to be considered in relation to other items on the CTC's work plan. Implications to the ERA, the PSC Chinook Model, and implementation of the Pacific Salmon Treaty would need to be considered prior to making changes to the IM rates.

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Appendix E1. Recreational IM rate studies reviewed for this report

Study: Diewert et al., 2002

Gear Type: Trolling flashers and lures from downriggers, drift fishing with jigs, and trolling natural baits from a downrigger

Species: Chinook, coho

Locale: Southern Strait of Georgia

Mortality Rates Assessed: Catch and release fishing in southern Strait of Georgia

1. Immediate landed mortality rates for coho and Chinook
2. Short-term delayed mortality rates for coho and Chinook
3. Effects of several angling related factors on immediate and delayed mortality
4. Marine mammal encounter rates and estimated the resulting impact on non-landed mortality

Design Notes: The two recreational fishing sites selected for this study in the southern Strait of Georgia were Fisheries and Oceans Canada (DFO) statistical area 14 near French Creek (surveyed June 13–October 13, 2001) and DFO statistical area 17, which is directly off the city of Nanaimo (surveyed June 16–September 28, 2001). Marine mammal predation was reported as one of the following scenarios by anglers while fishing:

1. Salmon remains reeled in (partial carcass),
2. Salmon in predators' mouth,
3. Fish lost when being reeled in and then a fish is observed in marine mammals' mouth, or
4. Fish lost when being reeled in and marine mammal is present in the area

Potential Weaknesses: Anglers in this study were not randomly selected but instead were contacted through local sportsman clubs and tackle shops, and so they may not reflect the general level of handling expertise being exerted on the population in this area (Nanaimo). Furthermore, angler experience and hooking methods likely reflect common practices of this area only, and gear and fishing techniques are known to vary significantly in geographical areas. Additionally, the 12% landed-delayed mortality rate is based on a sample size of only four fish.

Notes on Results: The mortality rates for Chinook reported were landed immediate mortality (14%, 95% confidence level (CL) 7.6–24.8%), delayed mortality (data insufficient; 50%), and non-landed mortality (11%). The 2002 hooking mortality rate of 15% is likely an underestimate of true hooking mortality rates in Chinook recreational fisheries. Fish condition upon arrival (such as scale loss) to the net was significantly related to delayed mortality. Fish that were released alive were hooked in the outer mouth whereas immediate mortalities were observed in fish that had been deeply hooked and had heavy bleeding.

Chinook had a landing rate of 56.6% in both areas combined, and the marine mammal encounter rate per fishing trip was 0.20 per trip (144 fishing trips had a total of 29 marine mammal encounters). More harbour seals were encountered in the spring compared to later in the studies (August) and the encounter rate per hook-up for Chinook was 0.108 per trip (11 seals were encountered during 102 recorded hook-ups). The increased vulnerability to seal predation for Chinook may be a result of the longer average reel in time (6 min and 39 s) compared to coho (3 min and 45 s).

Study: Diewert et al., 2005

Gear Type: Hook and release

Species: Chinook, coho, other salmon, groundfish, rockfish and other

Locale: Strait of Georgia

Mortality Rates Assessed: Creel survey estimates

Design Notes: The study objective was to conduct an independent audit of release estimates generated by the creel survey, to assess the bias from the results of angler interviews. An independent observer program in 1998 assessed non-sampling errors that cause bias in accuracy of survey results of catch and release estimates.

Potential Weaknesses: Drop-off mortality was not included in the post-release mortality values and mortality from encounters was not analyzed in this study.

Notes on Results: Estimates of Chinook and coho releases derived from independent observer data were significantly higher than those derived from creel data, suggesting a bias towards underestimating releases when using creel data. Similar biases were not observed for kept fish. While this study did not address mortality rates, the findings are important and relevant to future CTC work involving standards for accuracy and precision of agency-specific estimates of kept and released fish. Stratifying the data by kept and released fish resulted in differences in creel survey and independent observer data being detected for released fish.

Study: Cowen et al., 2007

Gear Type: Mark-recovery study

Anglers used single barbless hooks size 1, 1/0, 2/0 and 4/0 baited with salmon roe treated with Pro-Cure borax, occasionally spinning lures.

Species: Summer-run Chinook

Locale: Nicola River

Mortality Rates Assessed: Immediate hooking mortality (0.9%) and subsequent spawning success. Assessed critical hook locations of roof of mouth, esophagus, gills, tongue or eye.

Design Notes: It was interesting to note that female fish dominated the early catches, and males dominated later catches.

Potential Weaknesses: The spawning success of Chinook was measured by collecting tagged female carcasses and recording how many eggs were retained post-spawning. This percent spawn rate for eggs might not reflect if the eggs were viable, or if they successfully hatched. It also does not account for any stress effects that might be passed down from the parents to the offspring. Also, while hook location and heavy bleeding was hypothesized to lead to a decrease in spawning success, fish that died due to these injuries would not have been able to spawn, so it would be impossible to include them in that portion of the analysis.

Notes on Results: While fish hooked in critical locations had high hooking mortality rates and heavy bleeding, 81% of angled fish were hooked in noncritical locations. Fish that survived heavy bleeding did not have reduced spawning success. Differences were noted between bait and lures with critical hooking location rates, which is hypothesized to be related to how aggressively the fish bites the bait (Mongillo 1984). Some studies, such as Lindsay et al. (2004) found that fish hooked on lures tended to be hooked in noncritical locations, and no fish caught on lures in their study were hooked in the esophagus-stomach. However, hooking mortality

rates by area did not necessarily differ by lures or bait. Bendock and Alexandersdottir (1993) also did not find differences in hooking mortality rates for fish caught on lures vs bait. In the Cowen et al. (2007) study, 22 fish were caught on lures and only three (14%) of them were hooked in critical locations, as opposed to 21% of fish caught on bait that were hooked in critical locations.

Appendix E2. Troll IM rate studies reviewed for this report

Study: Vélez-Espino et al., 2010

Gear Type: Commercial Troll

Species: Chinook

Locale: West Coast Vancouver Island

Mortality Rates Assessed: Release encounter rates assessed

Design Notes: The purpose of this study was not to directly evaluate underlying rates of mortality for released fish, but rather to determine the accuracy of releases recorded in logbooks. The study used 1998–2008 data collected by the observer and logbook programs for the West Coast Vancouver Island troll fishery. Statistical analyses were performed to assess any potential bias in the logbooks compared to observer data.

Potential Weaknesses: The study only evaluated releases during Chinook retention periods; periods of Chinook non-retention were excluded from the analysis. Therefore, despite a small number of legal releases, most releases in this study were sublegal fish. While not a weakness of the study, underreporting rates are not constant and fluctuate spatio-temporally as fisher perceptions about fishery data collection and management entities change.

Notes on Results: The authors report that there is likely a bias towards underreporting of releases in logbooks, recommending a correction factor between 1.33 and 1.67. While this study did not specifically address mortality rates, the findings are important and relevant to future CTC work involving standards for accuracy and precision of agency-specific estimates of kept and released fish.

Appendix E3. Net IM rate studies reviewed for this report

Study: Vander Haegen et al., 2004; Ashbrook, 2008

Gear Type: Gill net and tangle net

Species: Chinook

Locale: Columbia River Spring

Mortality Rates Assessed: On-Board and Post-Release Mortality

Design Notes: Fish were captured using either gill nets or tangle nets. Captured fish were released with jaw or passive integrated transponder (PIT) tags. If in a poor condition, captured fish were placed in a recovery box prior to release. Otherwise, fish were released immediately after tagging. A number of parameters were recovered at capture including entanglement location, species, sex (where possible), capture condition, net mesh size, and mark status. PIT tag detections occurred as fish passed dams. In contrast, jaw tags were recovered in fisheries, at the hatchery, and on the spawning grounds.

Potential Weaknesses: During capture, PIT readers often did not work properly, and fish could not be checked for a tag. It is therefore possible that some fish were double tagged during this study.

Notes on Results: Estimates of tangle net release mortality rates were between 8 and 32%. Estimates of gill net release mortality rates were between 43 and 49%. The study estimated that all instances of on-board mortality and some instances of release mortality were likely due to pinniped predation. The average soak time in the study was relatively short at 36 minutes, though the authors did not note any effect of soak time on mortality rates. Handling was conducted by trained commercial fishers. The authors noted that IM rates were dependent upon entanglement location, with fish entangled at the snout less likely to die following capture than those entangled around the gills or by the body.

Study: Cox et al., 2019

Gear Type: Purse Seine

Species: Fall Chinook and coho

Locale: Columbia River

Mortality Rates Assessed: 2.1% Short term (48-h) post-release mortality rate. No immediate mortalities were observed during the study.

Design Notes: Fishing was conducted in commercial fishing zone 5 (section immediately prior to Bonneville Dam). The average seine fishing time was 18 minutes (range = 10 to 26 minutes). Fish captured were transported via oxygenated tanks and held in net pens for 48 hours to assess recovery rates. Control fish were transported from Bonneville Dam and treated the same as seine-caught fish, with the exception of being anesthetized during handling and in some cases having a quicker transport time to net pens (average of 1.3 hours versus 2.2 hours for seine-caught fish).

Potential Weaknesses: Use of net pens eliminates the possibility of evaluating predation mortality post-release (though the authors did note that two Chinook in the pens were partially eaten and died during the study). Control and treatment fish were handled differently, with control fish being anesthetized and on average being transported quicker, both of which could

potentially contribute to IM rates. Holding times were relatively short (48 hours).

Notes on Results: Approximately 74% of Chinook captured in the study were classified as “vigorous” during capture. Temperature, life stage, transport time, and time in net were evaluated as factors potentially contributing to IM, but the authors reported little effect of these variables on IM rates. They considered that the inability to determine an effect of these factors may be due to high survival rates coupled with modest sample sizes (n = 175 Chinook).

Study: Ruggerone and June, 1997

Gear Type: Purse Seine

Species: Chinook

Locale: Southeast Alaska Marine

Mortality Rates Assessed: 9.2% post-release mortality rate (3 to 5 day holding period)

Design Notes: Fishing occurred in three areas of Sitka Sound (approximately 10, 23, and 28 miles from Medvejie Hatchery). Mesh size used in fishing was approximately 3.5 inches. Chinook captured were placed into a 7,500-gallon holding tank, with sea water being actively pumped into the tank. Fish were later transferred to a saltwater net pen and held for up to 5.5 days to monitor survival.

Potential Weaknesses: Use of net pens eliminates the possibility of evaluating predation mortality post-release. The study design did not include a control group.

Notes on Results: The average time on deck for Chinook was 1.9 minutes and the average time when Chinook were “bagged” was one minute. Towing and hauling of the seine averaged 40 minutes. Fish captured farther from spawning (outer Sitka Sound) appeared to have higher rates of mortality than those near spawning (inner Sitka Sound), though reported sample sizes were low for fish captured in outer Sitka Sound (n = 14). Fish captured in outer Sitka Sound had a greater occurrence of scale loss. 4% of fish captured had hook wounds near the mouth, indicating previous drop-off or release injuries from the recreational fleet.

Study: Liedtke et al., 2014

Gear Type: Purse Seine and Beach Seine

Species: Fall Chinook and coho

Locale: Columbia River

Mortality Rates Assessed: Estimated release mortality rates of 7% and 13% for beach seine-caught tule and bright Chinooks, respectively. Estimated release mortality rate of 11% and 10% for purse seine-caught tules and brights, respectively.

Design Notes: Fish were collected and tagged using beach and purse seines between river kilometers 166 and 238 on the Columbia River. Following capture, fish were tagged in a recovery container containing river water, and sex, fork length, subspecies (estimated), and condition were recorded. Fish were held in recovery containers for an additional 2-3 minutes following tagging then released. The movement of released fish was tracked using multiple methods, including fixed telemetry sites, active telemetry tracking, and PIT tags. Survival was assessed for a four-day period following release, with any of the following being considered a sign of short-term survival: detection at Bonneville Dam, harvest, arriving at a hatchery, entering a spawning tributary, or having movement recorded after four days of release.

Potential Weaknesses: Some fish were not detected as they passed Bonneville Dam, and therefore, survival could be bias low.

Notes on Results: Results were based on 333 tagged tule Chinook and 506 tagged bright Chinook.

Appendix E4. Drop-off and drop-out IM rate studies reviewed for this report

Study: Jewell, 1970

Gear Type: Marine gill net

Species: Chinook, coho, chum, sockeye

Locale: Puget Sound

Mortality Rates Assessed: Escape mortality (rates of escape)

Design Notes: Conducted in 1968 and 1969, in South Puget Sound (1968) and near Seattle (1969) using gill nets with mesh size from 5 to 8 inches. After one hour of fishing, an underwater light and camera were utilized to observe catch. However, the authors state that the use of the camera was generally inferior to using an onboard observer, due to the narrow field of vision of the camera. Net checks were performed every 30 minutes after the initial check. When a salmon was identified as being in the net, its position was marked. When the net was hauled, if there were no fish at a marked position, it was considered that the fish escaped.

Potential Weaknesses: It was unknown if the fish escaping were due to escapes or predation. The light was out of range for deeper fish and many observations were missed; the authors noted that the catch was over twice as high as the observations in 1968 and that a small portion of the catch was observed in Chinook directed fisheries in 1969, due to the deeper net set when targeting Chinook. As the first observation occurs an hour into fishing and because checks are only done periodically, it is possible that fish could have encountered the net and escaped prior to observation.

Notes on Results: There were few escapes observed for Chinook- or coho-directed fisheries, however, study design reduces confidence in results related to these species. In the Bellingham Bay Chinook-directed fishery, only 18% of fish were observed prior to capture. There was a relatively high escape rate for sockeye caught in the Lake Washington sockeye fishery (29%), but this was anomalous compared to other species and fisheries in the study. The authors did cite fisher observations that may be of value:

“From discussions with fishermen it appears that dropout can be excessive under two conditions: First, during a hard blow when the weight of the boat pulls the net around parallel to the wind and at right angles to the swell, allowing the swell to “work” the net... Second, dropout may occur when the gear passes through a strong riptide such that the opposing currents work the nets by stretching the different sections.”

Study: Beach et al., 1985

Gear Type: Gill net

Species: Chinook, coho, chum

Locale: Grays Harbor, Willapa Bay, Columbia River

Mortality Rates Assessed: Predation mortality

Design Notes: Used dockside sampling to assess rates of predator mortality during the 1980–1982 commercial fishery seasons in Grays Harbor, Willapa Bay, and the Columbia River.

Potential Weaknesses: This study is quite old, with pinniped populations increasing substantially since the 80s (Chasco et al., 2017). Due to the spatio-temporal variability in pinniped predation events, it is difficult to apply this study outside of the area of research.

Notes on Results: 18.0% of Chinook caught in Grays Harbor, 9.4% in Willapa Bay, and 1.2% of Chinook in the Columbia River had interactions with predators while in gill nets. Within each of these areas, predator encounter rates further varied by season.

Study: Diewert et al., 2002

Gear Type: Marine recreational

Species: Chinook and coho

Locale: Southern Strait of Georgia

Mortality Rates Assessed: Predation mortality

Design Notes: This study was conducted by participating recreational fishers who were trained in catch sampling, tagging, and data collection techniques by DFO. Trained observers were occasionally stationed onboard vessels. Fishing occurred in Southern Strait of Georgia, in the area directly outside of Nanaimo (Area 17) and in the marine area adjacent to French Creek (Area 14).

Potential Weaknesses: This study is dated, with pinniped populations increasing substantially since the early 2000s (Chasco et al., 2017). Due to the spatio-temporal variability in pinniped predation events, it is difficult to apply this study outside of the area of research.

Notes on Results: As with Beach et al. (1985), the study noted that pinniped interactions may vary temporally and spatially, with more seals present earlier in the fishing season in the Strait of Georgia and higher pinniped encounter rates occurring in Area 17 versus Area 14. The study found higher rates of pinniped predation on Chinook than coho, potentially due to a longer average angling time to land a Chinook than a coho. On average 10.8% and 3.2% of Chinook and coho angling events resulted in a pinniped interaction, respectively.

Study: Weise and Harvey, 2005

Gear Type: Troll and recreational (marine)

Species: Chinook

Locale: California coast

Mortality Rates Assessed: Predation mortality

Design Notes: Onboard surveys and dockside sampling was conducted on commercial trollers, recreational charter boats, and private recreational boats. Interactions between hooked salmon and pinnipeds were recorded. Marine mammal interactions were recorded as “surface takes,” when a predation event was observed directly, or as “probable takes,” when a predation event was not observed directly but there was evidence of predation. Evidence that qualified for predation was bent hooks, lost gear, or a sea lion surfacing. The study occurred in California between 1997 and 1999.

Potential Weaknesses: “Probable takes” were assumed to be due to pinnipeds and it is likely that some of these events were due to fish freeing themselves or breaking gear.

Notes on Results: Greater than 98% of pinniped predation events were due to California sea lions. Percentage of total catch lost varied by year and gear type, range from 2.2 to 28.6%, with percentage of legal catch lost being greater than percentage of total catch lost. The authors note that rates of predation had greatly increased in California from earlier studies.

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

Incidental mortality rates applied in the PSC Chinook Model during the 2021 analysis (calibration [CLB] 2104). Rates in original model were applied to all years. In the current model, rates in some fisheries vary in accordance to changes in management regulations.

#	Fishery Acronym	Fishery	Rates applied in Model CLB 2104			Applicable Years
			Sublegal Rate	Legal Rate	Drop off	
1	ALASKA T	Alaska Troll	0.255	0.211	0.008	All
2	TAK YAK N	Alaska Yakutat Terminal Net	0.9	0.9	0	All
3	NORTH T	North Troll	0.255	0.211	0.017	1979–1995
3	NORTH T	North Troll	0.22	0.185	0.016	1996–Current
4	CENTRAL T	Central Troll	0.255	0.211	0.017	1979–1995
4	CENTRAL T	Central Troll	0.22	0.185	0.016	1996–Current
5	WCVI T	West Coast Vancouver Island Troll	0.255	0.211	0.017	1979–1997
5	WCVI T	West Coast Vancouver Island Troll	0.22	0.185	0.016	1998–Current
6	N FALCON T	North of Falcon Troll	0.255	0.211	0.017	1979–1983
6	N FALCON T	North of Falcon Troll	0.22	0.185	0.016	1984–Current
7	S FALCON T	South of Falcon Troll	0.255	0.211	0.017	1979–1983
7	S FALCON T	South of Falcon Troll	0.22	0.185	0.016	1984–Current
8	GEO ST T	Strait of Georgia Troll	0.255	0.211	0.017	1979–1985, 1987–1997
8	GEO ST T	Strait of Georgia Troll	0.22	0.185	0.016	1986, 1998–Current
9	ALASKA N	Alaska Net	0.9	0.9	0	All
10	NORTH N	North Net	0.9	0.9	0	All
11	CENTRAL N	Central Net	0.9	0.9	0	All
12	WCVI N	West Coast Vancouver Island Net	0.9	0.9	0	All
13	J DE F N	Juan de Fuca Net	0.9	0.9	0	All
14	PGSDN N	Puget Sound North Net	0.9	0.9	0	All
15	PGSDO N	Puget Sound Other Net	0.9	0.9	0	All
16	WASH CST N	Washington Coast Net	0.9	0.9	0	All
17	TCOL R N	Columbia River Net	0.9	0.9	0	All
18	TAK TBR N	Alaska Transboundary River Terminal Net	0.9	0.9	0	All
19	TBC TBR FN	Canada Transboundary River Freshwater Net	0.9	0.9	0	All
20	TCENTRAL FN	Central B.C. Freshwater Net	0.9	0.9	0	All
21	TGEO ST FN	Strait of Georgia Freshwater Net	0.9	0.9	0	All
22	TFRAS FN	Fraser Freshwater Net	0.9	0.9	0	All
23	TPS FN	Puget Sound Freshwater Net	0.9	0.9	0	All
24	TWAC FN	Washington Coast Freshwater Net	0.9	0.9	0	All
25	JNST N	Johnstone Strait Net	0.9	0.9	0	All
26	FRASER N	Fraser Net	0.9	0.9	0	All

#	Fishery Acronym	Fishery	Rates applied in Model CLB 2104			Applicable Years
			Sublegal Rate	Legal Rate	Dropoff	
27	ALASKA S	Alaska Sport	0.123	0.123	0.036	All
28	CBC S	Central B.C. Sport	0.123	0.123	0.036	All
29	NBC AABM S	North B.C. AABM Sport	0.123	0.123	0.036	All
30	NBC ISBM S	North B.C. ISBM Sport	0.123	0.123	0.036	All
31	WCVI AABM S	West Coast Vancouver Island AABM Sport	0.123	0.123	0.069	All
32	WCVI ISBM S	West Coast Vancouver Island ISBM Sport	0.123	0.123	0.069	All
33	N FALCON S	North of Falcon Sport	0.123	0.123	0.069	All
34	S FALCON S	South of Falcon Sport	0.123	0.123	0.069	All
35	PGSDN S	Puget Sound North Sport	0.123	0.123	0.145	All
36	PGSDO S	Puget Sound Other Sport	0.123	0.123	0.145	All
37	TYK YAK FN	Canada Yakutat Freshwater Net	0.9	0.9	0	All
38	GEO ST S	Strait of Georgia Sport	0.322	0.322	0.069	1979–1981
38	GEO ST S	Strait of Georgia Sport	0.123	0.123	0.069	1982– Current
39	BC JF S	B.C. Juan de Fuca Sport	0.322	0.322	0.069	All
40	TCOL R S	Columbia River Sport	0.123	0.123	0.069	All
41	TAK TBR S	Alaska Transboundary River Terminal Sport	0.123	0.123	0.069	All
42	TNORTH FS	North B.C. Freshwater Sport	0.123	0.123	0.069	All
43	TCENTRAL FS	Central B.C. Freshwater Sport	0.123	0.123	0.069	All
44	TWCVI FS	West Coast Vancouver Island Freshwater Sport	0.123	0.123	0.069	All
45	TFRASER FS	Fraser River Freshwater Sport	0.123	0.123	0.069	All
46	TGS FS	Strait of Georgia Freshwater Sport	0.123	0.123	0.069	All
47	TPS FS	Puget Sound Freshwater Sport	0.123	0.123	0.069	All
48	TSF FS	South of Falcon Freshwater Sport	0.123	0.123	0.069	All