Assessment of 2019 mixed-stock fisheries for coho salmon in northern and central British Columbia, Canada via parentage-based tagging and genetic stock identification

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Abstract

Genetic stock identification (GSI) and parentage-based tagging (PBT) are being increasingly applied to salmon fisheries and hatchery broodstock management and assessment in Canada. GSI and PBT were applied to assessment of 2019 coho salmon fisheries in British Columbia (BC), Canada, with 6,391 individuals successfully genotyped in fishery samples and 2,194 PBT identifications made. The observed number of fishery PBT identifications per population corresponded closely with the expected number based upon genetic tagging rate in the populations. We conclude that a genetic approach can improve upon the results available from the current CWT program for assessment and management of coho salmon fisheries in BC, and provide information critical to aid in implementation of Canada's Policy for Conservation of Wild Pacific Salmon.

Introduction

Coho salmon (*Oncorhynchus kisutch*) are caught in commercial, recreational, and First Nations fisheries in British Columbia, and determination of the impact of these fisheries is of fundamental importance to status assessment for wild populations and management of large-scale hatchery production. Current and historical assessment of fisheries impacts has been conducted with the application of coded-wire tags (CWTs; Jefferts et al. 1963). CWTs are applied to juvenile fish prior to their hatchery release and recovered from adult fish heads collected from fisheries, hatchery broodstocks, and in-river escapement sampling. Once recovered, the tags are decoded to determine the hatchery origin and age of the individual fish. Originally, only coho salmon marked with a CWT also received an adipose fin clip prior to hatchery release, with the externally-visible clip mark allowing CWT-marked fish to be identified visually and sampled from fisheries or river collections.

Since the late 1990s, all coho salmon released from many hatcheries in southern British Columbia (BC), Washington, and Oregon have received an adipose fin clip (termed mass marking) in order to facilitate mark-selective fisheries intended to harvest hatchery salmon only, with most clipped individuals carrying no CWT. This approach has resulted in reduced exploitation of naturally-spawned coho salmon, especially in sport fisheries, but the presence of many adipose-clipped salmon without a CWT has impaired the efficiency of CWT recovery. In spite of implementation of an electronic tag detection system to pre-screen a portion of the commercial catch to identify salmon with a CWT, the processing of many heads without a CWT from voluntary recreational recoveries and the increasing costs of CWT application and recovery have eroded the effectiveness of the current CWT-based coho salmon assessment program in BC.

Current assessment of coho salmon in BC is based on life history, marine distribution, and exploitation information obtained from CWT 'indicator' populations. The assumption of an indicator population is fundamental to the current CWT program applied to assessment and management of coho and Chinook Salmon (O. *tshawytscha*) in both Canada and the United States of America. The concept of using indicator populations is based on an expectation of biological homogeneity over the geographic region represented by the indicator population. Often, indicator populations are hatchery-supplemented and only a portion of the hatchery-origin component of the population is tagged, and is assumed to be representative of the entire population, both of hatchery- and natural-origin. In particular, tagged indicator populations are used to estimate exploitation rates and fishery contributions.

The fundamental question to consider is whether CWT-based assessment techniques for coho salmon, developed in the past 35 years since the signing in 1985 of the Pacific Salmon Treaty (PST) between Canada and the United States of America, still meets the requirements for fishery management in BC in the 2020s and beyond. In 1998, following a decline in coho salmon abundance which led to severe restrictions of fisheries in BC (Beacham et al. 2001), the Minister of Fisheries and Oceans (DFO) directed that the management of Canadian fisheries was to be conducted with the objective of achieving a zero mortality of stocks of conservation concern. Fisheries were only allowed to be conducted if it could be demonstrated that there was minimal impact on stocks of conservation concern. There was no practical way to obtain this information from CWTs, and thus genetic stock identification (GSI) analysis of mixed-stock fishery samples was the sole method employed. In 2005, the Wild Salmon Policy for Pacific salmon (WSP) was established in Canada with the goal of maintaining and restoring healthy and diverse Pacific salmon populations, making conservation of wild salmon and their habitats the

highest priority for resource management decision-making (DFO, 2005). Under the WSP, wild salmon populations are identified and maintained in Conservation Units (CUs) that are identified based on genetic traits, biogeographic distribution, life-history characteristics, and local knowledge where available.

Beacham (2021) suggested that a genetics-based system of fishery assessment based upon genetic stock identification (GSI) and parentage-based tagging (PBT) was a choice for coho salmon fisheries assessment in BC in the 2020s. As initially proposed by Anderson and Garza (2005) and subsequently outlined by Steele et al. (2019), PBT uses molecular-based approaches to conduct large-scale parentage assignments and has resulted in the unprecedented ability to identify genetically millions of hatchery-origin salmonids. Initial application of a large-scale GSI-PBT system of identification of coho salmon in BC provided high-resolution estimates of stock composition, catch, and exploitation rate by CU or population, providing an alternate and more effective method in the assessment and management of Canadian-origin coho salmon relative to CWTs (Beacham et al. 2019a). A second large-scale application of a combined GSI-PBT approach to coho salmon fishery assessment in BC confirmed that a genetic approach to coho fishery assessment was indeed a viable alternative to CWT-based assessment for BC coho salmon fisheries (Beacham et al. 2020a). As outlined by Beacham (2021), the PSC considers that the current fishery monitoring, management, and modeling system for coho salmon is based solely on CWT technology, regardless of the limitations of the technology, and by implication is the preferred method for BC coho salmon fishery assessment in the 2020s and beyond.

The overall objective of the current study was:

Estimate stock compositions of coho salmon in 2019 northern and central coastal fisheries in British Columbia.

METHODS

Fishery sample collection

In brief, samples were grouped by general geographic area as outlined by Beacham et al. (2019a) (Figure 1). In 2019, for the northern (Area F) freezer troll fishery, selected freezer boats were required to keep heads of all coho salmon caught, with the mark type (adipose fin clipped or not) unknown for an individual head. Upon landing, the heads were counted and checked electronically for CWTs, and randomly sampled to a maximum of 50 heads per delivery. If a CWT was detected, the head was sent to a central CWT head recovery laboratory in Vancouver, BC where the tissue sample for DNA extraction was subsequently taken. Field tissue samples for DNA extraction were taken only from individuals with no CWTs detected. For the northern ice boat troll fishery, samples of coho salmon with known clip status were obtained as an ancillary aspect of standard Fisheries and Oceans Canada contract catch sampling for CWTs. Both adipose fin clipped and unclipped individuals were examined through this program, with similar sampling protocols as outlined in the northern freezer troll sampling described above. Clipped fish not containing a CWT were sampled in the field through this program, and heads containing a CWT were sent to the head recovery laboratory in Vancouver.

Recreational fishery samples originated from voluntary head recoveries of adipose fin-clipped coho salmon from fisheries in BC, and direct sampling of the catch in some recreational fisheries. Samples from the recreational fishery in southern BC were derived from clipped individuals, but they may not have been marked with a CWT when delivered to the CWT head recovery laboratory. Samples in 2019 were obtained from all individuals that would be routinely

processed under the CWT recovery program for coho salmon in BC. For each sample analyzed over all BC fisheries, the number of individuals identified via PBT relative to the total genotyped individuals in the sample was tabulated, and summarized over sample, fishery, and month.

GSI-PBT baseline

When PBT-based sampling of the hatchery broodstocks was originated in 2014, 20 broodstocks from southern BC were included in the analysis, generating a PBT baseline comprising 6,061 genotyped individuals (Beacham et al., 2017). In 2016, the program had expanded to include 30 broodstocks from both northern and southern BC, and included 7,013 genotyped individuals. By 2018, the program had continued to expand to include sampling from 40 hatchery broodstocks in BC, and including 7,805 genotyped individuals. In 2019, 34 hatchery broodstocks encompassing 7,408 coho salmon were genotyped.

As well as the PBT portion of the baseline having expanded, the GSI portion of the baseline was increased beyond the 117 populations and 20,242 individuals genotyped reported by Beacham et al. (2017). As outlined by Beacham et al. (2020b), the combined GSI-PBT baseline applied in the current analysis consisted of 57,982 genotyped coho salmon from 332 populations from Russia, Alaska, BC, Washington, Oregon, and California. Estimates of stock composition by CU as defined under Canada's WSP are possible based solely on GSI (Beacham et al. 2020b), and when combined with assignment of individuals via PBT, provided a powerful technique for assignment of individuals of unknown origin to some populations. Boundaries of the CUs were outlined in Figure 1 in Beacham et al. (2020b).

Genotyping

The detailed procedure for library preparation and genotyping was outlined by Beacham et al. (2017), and a summarized version provided by Beacham et al. (2019a). The process involved loading amplified DNA from 768 individuals (up to 480 amplicons per individual) on an Ion Torrent Proton P1 chip (v3; Thermo Fisher) with an Ion Chef. Two chips are loaded consecutively with one run of the Ion Chef, then loaded on to an Ion Torrent Proton sequencer. Genotyping was conducted using the Torrent Suite Variant Caller® at one SNP site in each amplicon defined by a hotspot file and previously described (Beacham et al., 2019a). Genotypes at all available, predefined SNP sites per individual were assembled to provide multi-locus genotypes that were the basic input for PBT analysis.

Identification of individuals

PBT was used to identify individuals in fishery and broodstock samples by matching the genotype of the individual to the genotypes of prospective parents (COLONY; Jones and Wang, 2010; Wang, 2016). COLONY was utilized to assign offspring to parents, as it can produce assignments even when the one of the parents is putatively missing from the dataset, either due to a missing parental sample, or failure to produce sufficient coverage of the parental genotype from an existing sample.

The baseline for individuals sampled in the 2019 fisheries and hatchery broodstocks included all broodstocks sampled in 2015, 2016, and 2017, with each year class run separately in the COLONY analysis. COLONY was run with all broodstocks sampled each year as a single unit for analysis of fishery and escapement samples, with no differentiation among populations. Although the COLONY assumption of a single population in the parent pool was therefore violated, analysis of known-origin samples indicated that very high levels of accuracy were

achieved in assignments when pooling of potential parents in contributing populations was conducted (Beacham et al., 2019a). Two-parent assignments were accepted only when both assigned parents originated from the same population. Two-parent assignments were accepted only when the probability of correct assignment was ≥ 0.85 as determined by COLONY for the parent pair, and single-parent assignments > 0.97. An additional constraint on the single-parent assignment before it was accepted was that both the PBT assignment and GSI assignment corresponded to populations in the same CU. Polygamous mating was assumed for the COLONY analysis. Simple pairwise comparisons between offspring and potential parents were conducted. Genotypes had to be available for at least 150 SNPs for an individual to be retained in the baseline. An estimated genotyping error rate of 1% was used for COLONY assignments. Previously, Beacham et al. (2017) had reported that an average genotyping error rate of 1.07% (1,220 discrepancies in 114,105 comparisons) or an allele error rate of 0.53% (1,220 discrepancies in 228,210 comparisons) was observed over the 304 SNPs scored. The parent pair output file was the basic file used in subsequent analyses.

SNP panel performance

The performance of the SNP panel and subsequent analyses in providing PBT identifications was evaluated as follows. Samples were grouped by fishery and month, and the expected number of PBT identifications for hatchery populations was calculated as the number of individuals genotyped in the adipose fin-clipped portion of the catch in a fishery * (estimated stock composition by population) summed over all fisheries and months. The expected number of PBT identifications was split between the age classes in the fishery sample. This expected number incorporated an implicit assumption of a 100% genetic tagging rate for all populations

and year of broodstock sampling. As this assumption was not met, the expected number of PBT identifications by age was adjusted by the observed genetic tagging rate in the hatchery and age as follows:

Adjusted expected number of PBT identifications=original expected number of PBT identifications * (genetic tagging rate by population and age)

This adjusted expected value was then summed over all ages observed in all fishery samples for the population and compared with the actual number of PBT identifications summed across all months and fisheries. Genetic tagging rates were estimated as = 1-(proportion of broodstock not genotyped)^2 for the appropriate hatchery broodstock (Satterthwaite et al. 2015).

Comparison of CWT and genetic stock compositions for the same fishery

Differences in seasonal stock composition derived from CWT-tagged individuals and GSI of randomly sampled catch of the northern troll fishery (Area F) were evaluated by Fisher's exact test (Fisher 1954), with exclusion of any CU or region where fewer than five individuals (CWTs plus genetics) were estimated to be present. The sampled individuals were distributed among the remaining 28 CUs or regions ranging from southeast Alaska to the Columbia River.

Results

Application of GSI and PBT to fishery samples

There were 14 Canadian populations where CWTs were recovered from 2019 Canadian fishery sampling, with 741 CWTs recovered among the populations (Table 1). PBT identifications in the fishery sampling were observed in 27 populations, with 2,194

identifications observed. Three populations (Inch Creek, Robertson Creek, Quinsam River) accounted for 72% of all Canadian CWTs recovered from fishery sampling, but these same three populations accounted for only 37% of fishery PBT identifications. The greatest number of PBT identifications was observed in the Chilliwack River population (528), but as this population was not marked with CWTs, no CWTs from this population were recovered in fishery sampling.

CWT recoveries and PBT identifications were concurrently observed in eight populations, with greater numbers of PBT identifications than CWTs recovered in six of the eight populations. After expansion of PBT identifications to account for genetic tagging rate (Inch Creek 0.7399, Coldwater River 0.8499), only the Coldwater River population, in which all individuals are marked with CWTs upon hatchery release, displayed more CWT recoveries (24) than expanded PBT identifications (20).

The observed number of fishery PBT identifications per population corresponded closely with the expected number based upon genetic tagging rate in the populations (Figure 2), illustrating that PBT identifications were made at expected rates in mixed-origin samples. If an individual in the mixed-stock fishery sample was present that was a progeny from a hatchery population that had been previously genotyped, the individual was subsequently identified via PBT analysis at the rate that was expected, confirming suitable performance of the SNP panel and subsequent analysis for PBT identifications.

Comparison of stock composition of the northern troll fishery between CWTs and genetics

The 2019 northern troll fishery (Area F) catch was sampled for individuals containing CWTs as well as direct genetic sampling of other individuals. Stock compositions derived from direct genetic sampling were outlined in Supplementary Table S1, and those from sampling only CWT-marked or adipose fin-clipped individuals in Supplementary Table S2. Substantial

differences in stock composition of the catch were observed between CWTs and genetics when sampling was restricted to only those individuals containing a CWT versus direct sampling of other individuals (χ^2_{27}=648.8, P<0.0001). Given the paucity of CWT marking of central and northern coastal populations, it was hardly surprising that genetic analysis indicated that 42% of the catch was derived from three central and north coast CUs (Haida Gwaii-Graham Island Lowlands, Hecate Strait Mainland, Douglas Channel-Kitimat Arm), while little was allocated to these CUs via CWTs (Figure 3). Conversely, about 42% of the sampled individuals sent to a central laboratory for CWT recovery were derived from Washington and the Columbia River, whereas about 4% of the catch was estimated to have been derived from the same areas via genetics. CWTs did not provide an accurate representation of the catch in this fishery, owing to the fact that major components of this fishery were not marked with CWTs.

PBT applied to fishery sampling

In 2019, there were 2,194 PBT identifications made in the 6,942 individuals genotyped (31.6% identification rate) from fishery samples, and the identifications ranged over 27 populations (Table 1). The distribution of hatchery-origin coho salmon at the time of interception in fisheries varied depending on the population of origin. The Quinsam River and Puntledge River populations from the ECVI, as well as the Robertson Creek population on the WCVI ranged widely, with individuals from these populations observed in northern commercial troll and recreational fisheries through to the Juan de Fuca Strait recreational fishery at the south end of Vancouver Island (Table 2). For example, 37.9% of the Quinsam River PBT identifications were made in the northern troll and recreational fisheries, as were 20.8% of the Puntledge River identifications and 4.9% of the Robertson Creek identifications.

In contrast to the previous wide-ranging distribution of fishery PBT identifications, some populations displayed a geographically-restricted distribution of identifications. As noted previously, 99.5% of the Conuma River population PBT identifications were observed in WCVI fisheries. PBT marine fishery identifications for two major hatchery production facilities on the Capilano River and Chilliwack River were quite restricted geographically. For example, 59.3% of all marine PBT identifications of Capilano River coho salmon occurred in the Strait of Georgia recreational fishery, as did 31.7% of the marine PBT identifications of the Chilliwack River population. Freshwater fishery PBT identifications were made for the Inch Creek, Norrish Creek, and Chilliwack River populations in the lower Fraser River drainage, all of which contribute substantially to localized fisheries.

Estimation of catch of hatchery-origin populations

For marine fisheries, hatchery contributions to the adipose fin-clipped catch were estimated to be the largest in the WCVI recreational fishery, with the Robertson Creek (22.1%), Chilliwack River (6.8%), and Capilano River (2.2%) populations the largest Canadian contributors to the catch (Table 3). The freshwater fishery catch for lower Fraser River hatchery populations is a typical annual occurrence, and in the case of the Chilliwack River population, can contribute significantly to a fishery (Table 3).

Discussion

Genetic technologies applied in the current study allowed stock identification of coho salmon sampled from mixed-stock fisheries, regardless of whether the individuals sampled originated from hatcheries or wild spawning, thus enabling assessment of fishery impacts by CU

for conservation-based management as envisaged in the Wild Salmon Policy. Assessment of coho salmon fisheries impacts in BC has been traditionally conducted using CWTs. However, as CWTs are not applied to releases from some of the largest hatcheries in southern BC due to funding limitations or logistical constraints, the contributions of these hatcheries to mixed-stock ocean fisheries remained unknown. In addition, little production from the smaller hatcheries in BC is marked with CWTs, rendering the production functionally invisible in CWT-based assessment. It would clearly be desirable to base an assessment method in which the twin objectives of fishery and hatchery assessment could be met, and could be applied to all hatcheries, not only a subset. The results from this study further demonstrate the importance of this concept, given the differences among hatcheries including aspects such as marine distribution and range of interception in fisheries, straying rates, and use of hatchery fish within subsequent year broodstock. Clearly the interpretation of results from a subset of hatcheries extended to all hatcheries is not ideal.

Limitations of CWT-based assessments

The assessment of the northern troll fishery via only CWTs is a prime example of the misrepresentation of fishery impacts that may occur if only CWTs are used to assess impacts. When over 40% of a fisheries catch is virtually unrepresented by indicator populations, it should be clear, even to management agencies determined to assess impacts via CWTs, that such an approach is rooted in the past, and not in tune with today's management requirements. For example, in 2005 Canada responded to concerns over declining wild population abundance by developing the WSP (DFO 2005) with the goal of maintaining and restoring healthy and diverse Pacific salmon populations, making conservation of wild salmon and their habitats the highest

priority for resource management decision-making. Here was a policy change that should have required a re-evaluation of coho salmon fishery assessment methods in BC, as the CWT program, as currently operated, cannot meet the expectation of making conservation of wild coho salmon the highest priority for resource management decision making. That was obvious more than 20 years ago when, following a dramatic decline in coho salmon abundance, fisheries were only allowed to be conducted if it could be demonstrated that there was minimal impact on wild stocks of coho salmon of conservation concern. CWTs and the management models used for assessment failed to provide this information, and GSI analysis of mixed-stock fishery samples was the sole method employed, with results outlined by Beacham et al. (2001). The current dissatisfaction of Canadian managers of northern and central coastal coho salmon fisheries based on CWT assessment, deservedly so given the biased insights that can accrue from solely using CWTs for assessment, highlight the need for an improved management regime that responds to fishery management challenges in the 2020s.

Summary

PBT merged with GSI provided a very powerful and versatile tool that was applied across a broad spectrum of applications for both fisheries and hatchery broodstock assessment. The current study outlined the application of GSI and PBT to identify BC-origin coho salmon to specific Canadian hatcheries and CUs. The advantage of a genetic-based assessment of coho salmon in Canadian fisheries, aside from the economic advantage of being more cost-efficient than the existing CWT program (Beacham 2021), is the flexibility of assessment options that are available with its application. If the objective of fishery sampling is to evaluate contributions of mass-marked hatchery populations or lightly-marked indicator populations, sampling can be

confined strictly to adipose fin-clipped individuals. If the objective of the sampling is to evaluate contributions of wild populations or unmarked hatchery populations, sampling can be confined to those individuals with an intact adipose fin. Should both objectives be considered of value, as in the northern BC troll fishery, direct sampling of both adipose fin-clipped and intact individuals can be undertaken. Genetic analysis of fishery samples can continue to provide the routine estimation of exploitation rates and catch at age for current management models, but it also provides the ability to assess fishery impacts on populations or CUs that are invisible to the current CWT program, as they are not currently marked with CWTs (Beacham et al. 2019a). As well as providing routine fishery assessment information, GSI and PBT applied in combination can provide family-specific information on distribution, catch, and productivity currently unavailable with the current CWT program in Canada (Beacham et al. 2019b), and thus provide information on productivity and migration.

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Table 1. Number of observed coded-wire tags (CWT) recovered and number of parentage-based tagging identifications (PBT) made by population for Canadian-origin coho salmon sampled in 2019 Canadian fisheries.

Conservation Unit	Population	CWT	PBT
Lower Nass	Zolzap	48	0
Upper Skeena	Damshilgwit	1	0
Middle Skeena	Kitwanga	18	0
	Toboggan	26	0
Lower Skeena	Zymacord	13	17
Northern Coastal Streams	Hartley Bay	0	1
Juan de Fuca-Pachena	Nitinat	0	12
West Vancouver Island	Robertson	155	388
	Conuma	0	188
East Vancouver Island-Georgia Strait	Keogh	35	0
	Quinsam	109	174
	Black	21	0
	Puntledge	4	24

	Rosewall	0	19
	Nanaimo	0	12
	Goldstream	0	8
Georgia Strait Mainland	Sliammon	0	3
Howe Sound-Burrard Inlet	Tenderfoot	0	36
	Mamquam	0	20
	Capilano	0	121
	Seymour	14	17
Lower Fraser	Inch	270	245
	Alouette	0	6
	Norrish	0	285
	Chilliwack	0	528
	Chehalis	0	34
	Stave	0	16
	Coquitlam	0	2
	Kanaka	0	5
Lower Thompson	Coldwater	24	17
South Thompson	Eagle	3	4
Boundary Bay	Nicomekl	0	6
	Serpentine	0	6

Total	741	2,194

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Table 2. PBT assignments by hatchery population for fisheries in BC during 2019 sampling of Canadian fisheries. Fisheries were: 1) northern troll; 2) northern sport; 3) central sport; 4) Johnstone Strait sport; 5) northern Strait of Georgia sport; 6) southern Strait of Georgia sport; 7) Juan de Fuca Strait sport; 8) southwest coast Vancouver Island sport and troll; 9) northwest coast Vancouver Island sport and troll; 10) Barkley Sound and Alberni Inlet sport, commercial and First Nations; 11) freshwater sport; and 12) all fisheries.

Population	Fishery											
	1	2	3	4	5	6	7	8	9	10	11	12
Zymacord	11	5										17[1]
Hartley Bay		1										1
Nitinat		1	1				1	8	1			12
Robertson	11	8	1	5	1		6	205	30	119	2	388
Conuma					1			21	166			188
Quinsam	58	8	6	10	19		1	8	15		49	174
Puntledge	2	3	1	2	10		1	2	3			24
Rosewall		1	4		12			2				19
Nanaimo	1				4	1	3	3				12
Goldstream							5	3				8
Sliammon	1			1	1							3
Tenderfoot		1	4	2	6	4	3	10	6			36
Mamquam				1	5	8		6				20
Capilano					22	48	24	19	5		3	121
Seymour					9	2	3	3				17

Inch					4	4	3	8	1		225	245
Alouette								1				6
Norrish					6	5	1	3			270	285
Chilliwack				3	60	18	40	53	9		345	528
Chehalis					8	1	5	10	2		8	34
Stave					5	2	4	4	1			16
Coquitlam							1	1				2
Kanaka						1		3	1			5
Coldwater			1		7	1	4	4				17
Eagle	1						1	2				4
Nicomekl					3	2		1				6
Serpentine					2		2	2				6
Total	85	28	18	24	190	97	108	382	240	119	902	2194

[1] includes one identification made in catch of lower Skeena river gillnet test fishery

Table 3. Adipose fin clipped-catch of hatchery-origin coho salmon by population for fisheries in BC during 2018 with catch derived from GSI-PBT for eight fisheries in BC. Population-specific hatchery-origin catch was estimated as (hatchery-origin catch) * (population-specific monthly stock composition) summed over all fisheries and months. Fisheries were: 1) northern troll, 2) northern sport, 3) Johnstone Strait sport, 4) Strait of Georgia-north sport, 5) Strait of Georgia-south sport, 6) Juan de Fuca Strait sport, 7) southwest coast Vancouver Island sport and troll, 8) northwest coast Vancouver Island sport and troll, 9) Alberni Inlet and/or escapement surplus to spawning requirement fishery, 10) freshwater sport, 11) all fisheries. N is the total number of individuals across months included in the monthly sample for estimated stock composition of the catch. N-PBT is the number of individuals in the sample identified via PBT.

Population	CU	1	2	3	4	5	6	7	8	9	10	11
Catch		8,179	454	837	3,294	2,109	7,480	12,330	1,714	4,764	16,301	
N		572	157	87	265	141	218	869	392	123	1,009	
N-PBT		82	21	27	190	97	108	377	240	121	897	
Zymacord	CO-32	397	11	0	0	0	0	0	0	0	0	408
Toboggan	CO-33	273	2	0	0	0	0	0	0	0	0	275
Sliammon	CO-11	14	0	23	24	0	2	0	1	0	0	64
Capilano	CO-10	0	0	0	258	767	674	266	30	0	0	1,995

Mamquam	CO-10	0	0	3	71	81	3	93	0	0	0	251
Seymour	CO-10	0	0	0	118	75	108	59	0	0	0	360
Tenderfoot	CO-10	0	4	49	76	41	166	171	28	0	0	535
Big Qualicum	CO-13	0	4	0	0	0	0	2	0	0	0	6
Goldstream	CO-13	1	0	0	0	0	379	131	0	0	0	511
Nanaimo	CO-13	0	0	0	66	9	274	83	4	0	0	436
Puntledge	CO-13	68	7	30	179	10	20	37	73	0	0	424
Quinsam	CO-13	890	26	103	222	0	25	133	120	0	50	1,569
Rosewall	CO-13	53	4	26	159	0	0	66	0	0	0	308
Conuma	CO-17	0	0	10	7	0	0	340	1019	0	0	1376
Robertson	CO-17	160	17	50	21	15	194	2729	107	4,764	0	8,057
Nitinat	CO-16	0	2	0	0	0	41	119	12	11	0	185
Alouette	CO-47	1	0	0	97	0	0	19	0	0	0	117
Chehalis	CO-47	0	0	0	117	9	223	131	7	0	22	509
Chilliwack	CO-47	0	0	47	944	340	1930	838	34	0	14,300	18,433
Coquitlam	CO-47	0	0	0	0	0	67	48	0	0	0	115

Inch	CO-47	0	0	0	60	52	173	182	4	0	937	1,408
Kanaka	CO-47	0	0	0	0	12	0	55	6	0	0	73
Norrish	CO-47	0	0	0	128	193	55	57	0	0	983	1,416
Stave	CO-47	0	0	0	60	17	166	45	4	0	0	292
Coldwater	CO-7	0	0	0	105	8	186	58	0	0	0	357
Eagle	CO-8	10	0	0	0	0	40	33	0	0	0	83
Nicomekl	CO-1	0	0	0	49	25	0	20	0	0	0	94
Serpentine	CO-1	0	0	0	18	0	65	67	0	0	0	150
All PBT populations		1,596	75	341	2,779	1,654	4,791	5,782	1,447	1,449	15,049	39,807

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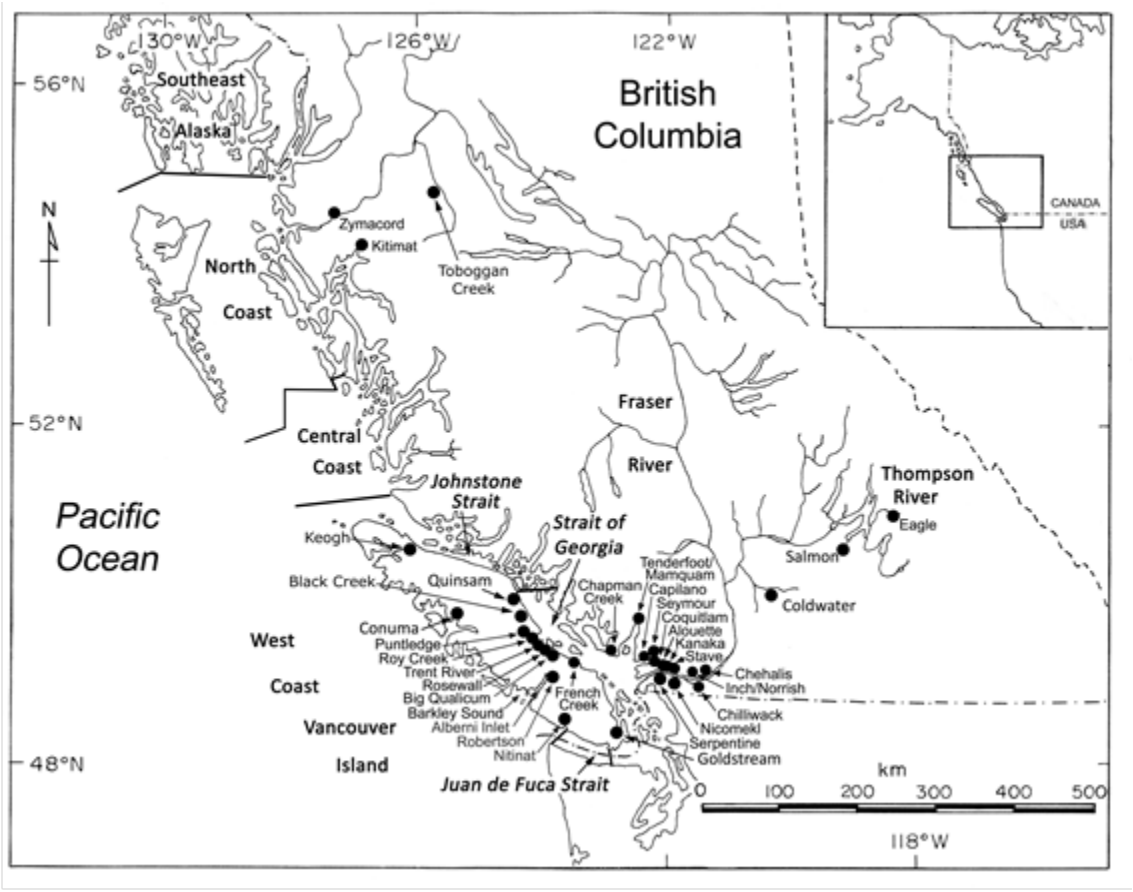
458 Figure 1



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461 Figure 2

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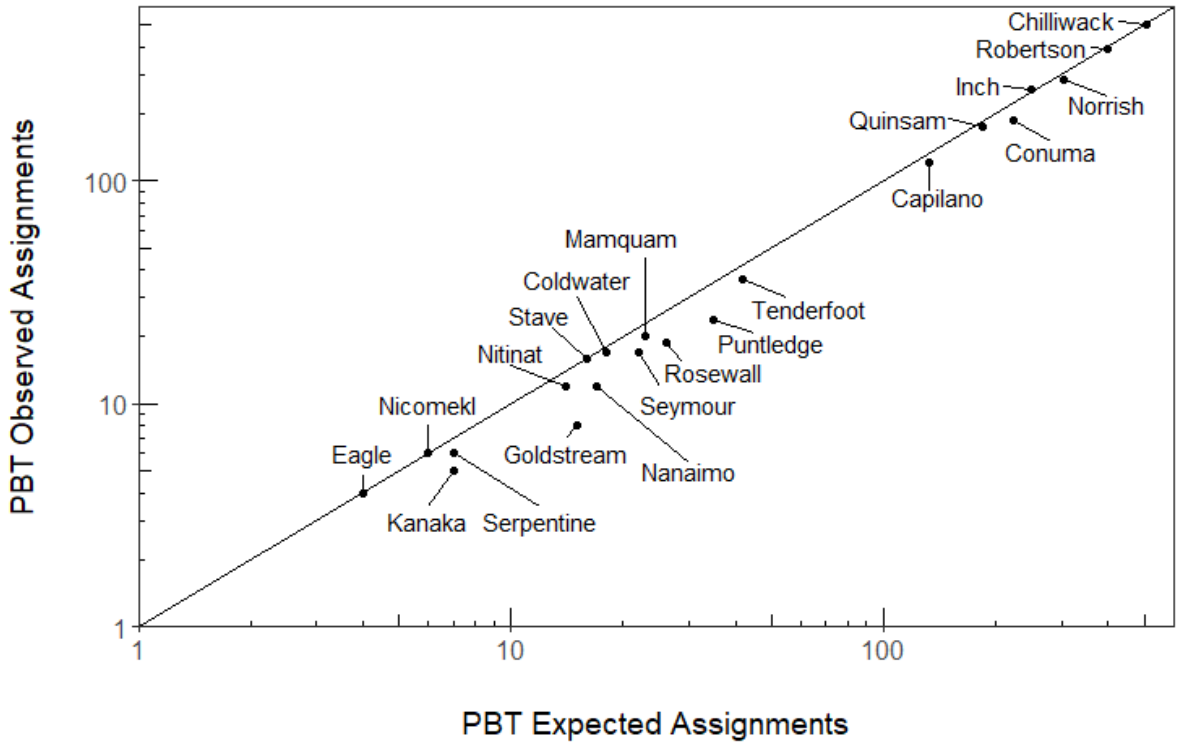

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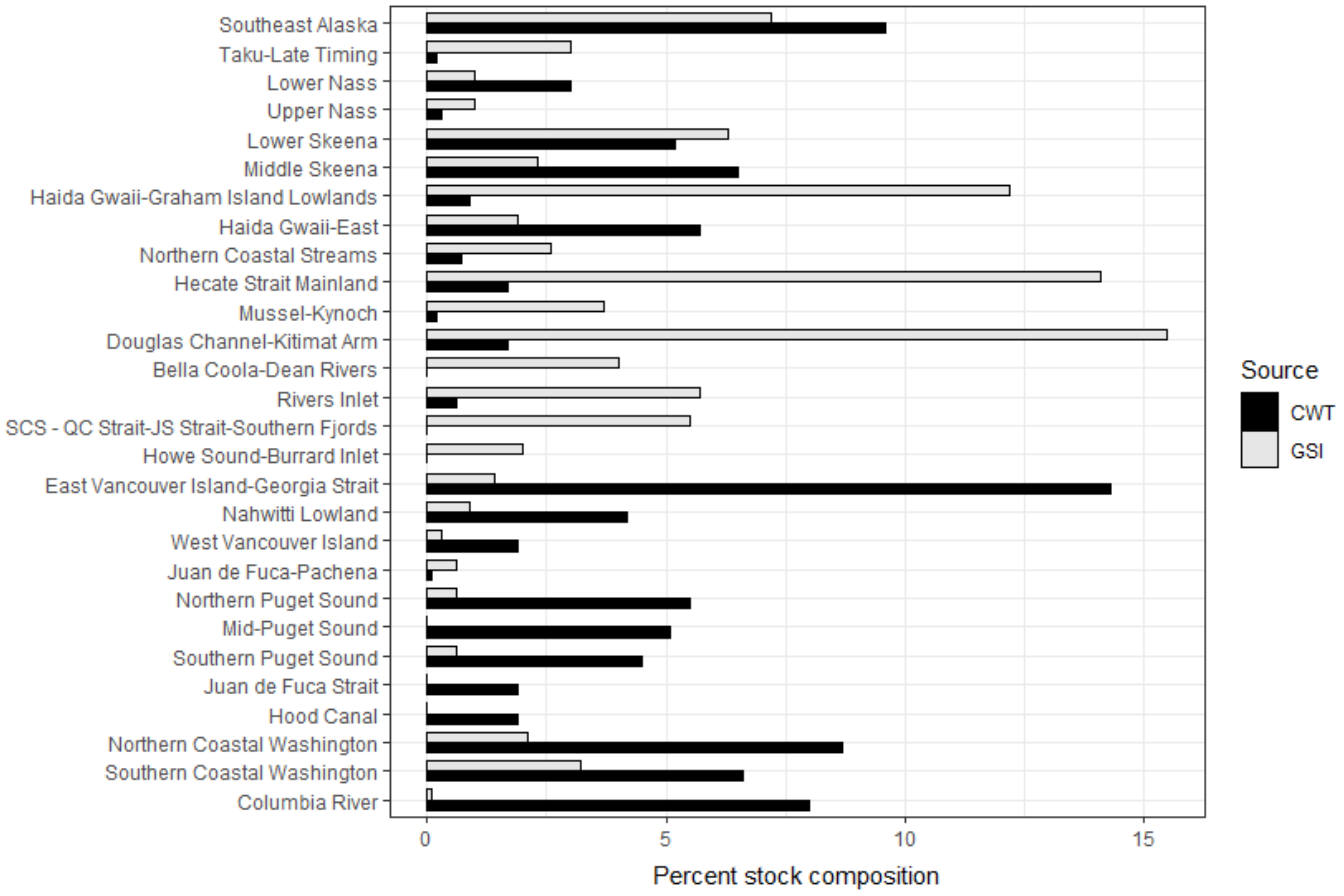
464 Figure 3



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Supplementary Table 1. Percentage stock composition by geographic region or CU of 2019 northern Area F freezer troll, Area F ice boat troll fishery, Langara recreational fishery, central coast recreational fishery (primarily Area 8), central coast commercial freezer troll fishery (Areas 6, 7, 8, and 107), and Johnstone Strait (Round Island) test fishery. Standard deviation is in parentheses. N-PBT is the number of individuals identified in the sample via PBT.

Region/Conservation Unit	Freezer troll		Ice boat troll			Langara sport (Area 1)			
	July 19-27	Aug 10-27	July 19-26	Aug 9-31	Sept 1-5	June	July	August	September
Sample size	4	94	313	338	10	188	303	307	121
N-PBT	0	0	3	0	0	2	2	2	0
Southeast Alaska	0.1 (3.7)	6.9 (4.7)	6.6 (1.8)	8.1 (1.9)	0.5 (2.6)	4.0 (2.0)	9.9 (2,0)	6.9 (1.8)	5.7 (2.8)
Alsek River	0.0 (0.7)	0.0 (0.1)	0.0 (0.0)	0.0 (0.0)	0.0 (0.5)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.1)
Taku-Late Timing	2.0 (7.6)	0.0 (0.3)	2.5 (1.3)	4.1 (1.4)	0.2 (1.9)	0.0 (0.2)	0.0 (0.2)	1.5 (1.0)	1.9 (1.9)
Lower Stikine	0.0 (0.8)	0.0 (0.1)	0.0 (0.0)	0.0 (0.0)	0.0 (0.5)	0.0 (0.0)	0.0 (0.1)	0.0 (0.0)	0.0 (0.2)
Lower Nass	0.0 (1.6)	0.0 (0.4)	1.1 (1.2)	1.1 (0.7)	0.0 (0.7)	0.3 (1.3)	0.0 (0.2)	3.4 (1.3)	6.3 (2.9)
Upper Nass	0.0 (1.0)	1.6 (1.6)	2.0 (0.9)	0.0 (0.0)	0.0 (0.4)	7.3 (2.1)	8.5 (1.7)	0.0 (0.0)	0.0 (0.0)
Portland Sound-Observatory Inlet-Portland Canal	0.0 (1.1)	0.0 (0.1)	0.0 (0.0)	0.0 (0.0)	0.0 (0.5)	0.0 (0.0)	0.3 (0.3)	0.0 (0.0)	0.0 (0.0)
Skeena Estuary	0.0 (0.9)	0.0 (0.1)	0.0 (0.0)	0.0 (0.0)	0.0 (0.5)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Lower Skeena	0.1 (3.9)	2.2 (2.7)	4.0 (1.8)	9.3 (1.9)	0.1 (2.1)	5.0 (2.0)	11.6 (2.0)	8.6 (1.9)	3.8 (3.1)
Middle Skeena	0.0 (3.4)	0.1 (0.4)	2.7 (1.0)	2.5 (0.9)	0.0 (1.4)	4.4 (1.7)	7.7 (1.6)	2.8 (1.0)	0.0 (0.2)
Upper Skeena	0.0 (2.0)	0.0 (0.2)	0.0 (0.1)	0.0 (0.0)	0.0 (0.9)	3.3 (1.7)	0.1 (0.4)	0.0 (0.1)	0.0 (0.1)

Haida Gwaii-Graham Island Lowlands	25.9 (18.2)	10.0 (3.9)	16.8 (2.2)	8.4 (1.6)	3.7 (7.2)	2.1 (1.0)	1.5 (0.8)	11.5 (1.9)	17.4 (3.4)
Haida Gwaii-East	0.3 (2.9)	3.4 (2.5)	2.2 (0.8)	1.5 (0.7)	0.0 (1.2)	0.5 (0.5)	0.0 (0.1)	0.4 (0.4)	3.4 (1.6)
Haida Gwaii-West	0.0 (1.8)	0.0 (0.2)	0.0 (0.0)	0.0 (0.0)	0.0 (0.8)	0.5 (0.5)	0.0 (0.0)	0.0 (0.1)	0.8 (0.8)
Northern Coastal Streams	4.8 (11.2)	6.9 (5.2)	0.9 (1.0)	3.6 (2.4)	0.3 (3.2)	1.9 (2.0)	9.0 (2.2)	4.0 (1.8)	2.4 (2.6)
Hecate Strait Mainland	59.9 (23.5)	14.2 (8.3)	15.1 (2.5)	10.9 (2.4)	14.4 (9.9)	16.9 (3.5)	6.8 (1.7)	17.5 (2.7)	11.9 (4.2)
Mussel-Kynoch	0.0 (1.3)	12.9 (5.0)	0.3 (0.3)	5.8 (1.7)	0.0 (0.8)	1.0 (0.8)	0.8 (0.9)	2.9 (1.5)	5.5 (3.2)
Douglas Channel-Kitimat Arm	0.1 (2.0)	17.9 (7.9)	16.5 (2.6)	15.1 (2.8)	2.3 (9.6)	17.7 (3.6)	15.3 (2.6)	13.7 (2.5)	11.9 (3.9)
Bella Coola-Dean Rivers	1.2 (6.3)	3.8 (3.4)	4.0 (1.4)	3.0 (1.5)	25.1 (9.9)	13.4 (3.0)	7.0 (1.8)	2.1 (1.0)	0.9 (1.2)
Rivers Inlet	0.5 (4.1)	6.2 (3.7)	5.6 (1.7)	6.8 (2.1)	0.1 (1.3)	4.8 (2.0)	2.5 (0.9)	5.9 (1.7)	3.4 (2.7)
Smith Inlet	0.0 (2.1)	0.0 (0.1)	0.3 (0.4)	0.0 (0.0)	0.0 (1.0)	0.0 (0.1)	0.0 (0.1)	0.0 (0.0)	0.1 (0.4)
Southern Coastal Streams-Queen Charlotte Strait-Johnstone Strait-Southern Fjords	0.1 (2.6)	1.7 (3.3)	7.4 (2.0)	3.9 (1.9)	0.3 (2.2)	5.7 (2.2)	6.9 (2.1)	2.3 (1.5)	9.2 (3.5)
Homathko-Klinaklini Rivers	0.1 (2.3)	0.4 (1.2)	0.1 (0.5)	0.3 (0.8)	1.7 (4.0)	2.8 (2.0)	3.5 (1.4)	4.1 (1.3)	3.1 (1.9)
Georgia Strait Mainland	0.1 (2.2)	0.4 (1.0)	0.0 (0.1)	0.0 (0.4)	0.0 (0.8)	0.0 (0.1)	0.3 (0.6)	0.0 (0.0)	0.1 (0.5)
Howe Sound-Burrard Inlet	0.1 (3.6)	0.1 (0.7)	0.4 (0.7)	4.5 (1.4)	0.0 (1.6)	3.5 (1.9)	2.4 (1.0)	0.2 (0.5)	0.1 (0.4)
East Vancouver Island-Georgia Strait	0.6 (5.6)	1.6 (2.0)	2.5 (1.1)	1.1 (0.7)	0.1 (1.9)	0.0 (0.2)	2.5 (1.2)	2.3 (1.0)	0.4 (0.6)
East Vancouver Island-Johnstone Strait-Southern Fjords	0.0 (2.2)	2.6 (2.2)	0.2 (0.4)	0.0 (0.0)	0.0 (0.5)	1.4 (0.9)	0.0 (0.0)	0.0 (0.0)	0.0 (0.1)
Nahwitti Lowland	0.2 (3.9)	0.1 (0.8)	2.0 (0.9)	0.1 (0.3)	0.0 (1.6)	0.0 (0.2)	0.9 (0.7)	1.5 (1.0)	0.0 (0.3)
West Vancouver Island	0.1 (3.3)	0.0 (0.3)	0.2 (0.5)	0.6 (0.7)	0.1 (1.8)	0.6 (0.6)	0.8 (0.6)	0.7 (0.5)	1.6 (1.1)
Clayoquot	3.1 (9.6)	0.0 (0.3)	0.0 (0.0)	0.0 (0.0)	10.3 (9.8)	1.4 (1.1)	0.0 (0.2)	0.0 (0.0)	0.0 (0.1)
Juan de Fuca-Pachena	0.2 (2.8)	0.1 (0.6)	1.0 (0.0)	0.0 (0.1)	12.8 (0.8)	0.0 (0.2)	0.0 (0.1)	0.0 (0.0)	0.0 (0.1)

Lower Fraser	0.2 (5.6)	0.0 (0.5)	0.7 (0.6)	0.2 (0.3)	0.0 (2.4)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)	0.9 (0.9)
Lillooet	0.0 (1.5)	0.0 (0.2)	0.6 (0.5)	0.0 (0.0)	0.0 (1.0)	0.0 (0.0)	0.0 (0.0)	0.3 (0.3)	0.0 (0.1)
Fraser Canyon	0.0 (1.3)	0.0 (0.2)	0.0 (0.0)	0.0 (0.0)	0.0 (0.7)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Interior Fraser	0.0 (2.2)	0.0 (0.2)	0.0 (0.0)	0.0 (0.0)	0.0 (1.2)	0.0 (0.1)	0.0 (0.0)	0.3 (0.3)	0.0 (0.1)
Lower Thompson	0.0 (1.8)	0.0 (0.2)	0.0 (0.0)	0.0 (0.0)	0.0 (0.9)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.1)
North Thompson	0.0 (4.4)	0.0 (0.4)	0.0 (0.1)	0.0 (0.1)	0.0 (2.0)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)	0.0 (0.2)
South Thompson	0.0 (4.0)	0.0 (0.4)	0.2 (0.3)	0.0 (0.1)	0.0 (1.8)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)	0.0 (0.2)
Boundary Bay	0.0 (1.5)	0.0 (0.2)	0.0 (0.0)	0.0 (0.0)	0.0 (0.8)	0.0 (0.1)	1.0 (0.6)	0.0 (0.1)	0.0 (0.1)
Northern Puget Sound	0.1 (4.2)	0.6 (1.6)	0.7 (0.7)	0.2 (0.3)	0.0 (1.4)	0.3 (0.5)	0.0 (0.1)	0.3 (0.7)	0.2 (0.6)
Mid-Puget Sound	0.0 (2.1)	0.0 (0.3)	0.1 (0.2)	0.1 (0.3)	0.0 (1.0)	0.0 (0.1)	0.2 (0.4)	0.0 (0.1)	0.8 (0.9)
Southern Puget Sound	0.0 (2.2)	0.1 (0.5)	0.0 (0.2)	0.9 (0.6)	0.0 (1.4)	0.0 (0.1)	0.0 (0.1)	0.0 (0.0)	0.0 (0.1)
Juan de Fuca Strait	0.0 (1.1)	0.2 (0.6)	0.0 (0.0)	0.0 (0.0)	0.2 (1.1)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.1)
Hood Canal	0.0 (1.9)	0.0 (0.2)	0.0 (0.0)	0.0 (0.1)	0.0 (0.9)	0.0 (0.1)	0.0 (0.2)	0.0 (0.1)	0.0 (0.1)
Northern Coastal Washington	0.0 (2.1)	5.6 (3.3)	1.9 (0.8)	2.1 (0.9)	3.3 (7.3)	1.0 (0.8)	0.0 (0.1)	2.1 (1.0)	2.5 (1.5)
Southern Coastal Washington	0.0 (2.2)	0.3 (0.9)	0.2 (0.4)	5.7 (1.3)	24.4 (9.9)	0.1 (0.2)	0.3 (0.3)	4.1 (1.2)	5.8 (2.1)
Columbia River	0.0 (2.8)	0.0 (0.3)	0.3 (0.3)	0.0 (0.1)	0.0 (1.4)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)	0.0 (0.2)
Oregon	0.0 (3.6)	0.0 (0.3)	0.6 (0.5)	0.0 (0.1)	0.0 (1.5)	0.0 (0.1)	0.0 (0.1)	0.3 (0.3)	0.0 (0.1)
Northern California	0.0 (1.5)	0.0 (0.2)	0.0 (0.0)	0.0 (0.0)	0.0 (0.5)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.1)
California	0.0 (1.9)	0.0 (0.2)	0.0 (0.0)	0.0 (0.0)	0.0 (1.2)	0.0 (0.1)	0.0 (0.0)	0.0 (0.0)	0.0 (0.1)

Supplementary Table 1 continued.

Region/Conservation Unit	Area 3/4 sport								L. Skeena test fishery
	Port Edwards			Eagle Point		Haa-Nee-Naa	Dolphins		
	June	July	August	July	August	August	July	August	Seasonal
Sample size	8	93	87	19	53	133	115	122	173
N-PBT	0	0	1	0	0	0	0	0	1
Southeast Alaska	0.0 (2.1)	1.4 (1.4)	0.9 (2.0)	0.1 (0.9)	29.0 (6.5)	28.6 (4.9)	2.9 (2.0)	8.0 (3.1)	1.2 (0.8)
Alsek River	0.0 (0.6)	0.0 (0.0)	0.0 (0.1)	0.0 (0.3)	0.0 (0.1)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Taku-Late Timing	0.0 (1.4)	0.0 (0.3)	0.0 (0.3)	0.0 (0.7)	0.0 (0.3)	6.9 (3.3)	0.3 (0.7)	1.6 (1.9)	0.0 (0.1)
Lower Stikine	0.0 (0.6)	0.0 (0.1)	0.0 (0.1)	0.0 (0.4)	0.0 (0.3)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)	0.0 (0.0)
Lower Nass	0.0 (0.8)	0.2 (0.6)	0.1 (1.0)	0.0 (0.6)	0.1 (0.4)	3.0 (2.4)	0.3 (0.8)	1.8 (2.3)	0.0 (0.2)
Upper Nass	0.0 (0.4)	7.8 (3.0)	10.9 (3.5)	26.3 (9.6)	9.2 (4.0)	2.1 (1.8)	22.1 (4.1)	25.1 (4.1)	3.4 (1.6)
Portland Sound-Observatory Inlet-Portland Canal	0.0 (0.3)	0.0 (0.0)	0.0 (0.1)	5.3 (4.9)	0.0 (0.1)	0.4 (0.6)	3.5 (1.7)	1.6 (1.1)	0.0 (0.0)
Skeena Estuary	0.0 (0.6)	0.0 (0.1)	0.0 (0.0)	0.0 (0.2)	0.0 (0.1)	0.0 (0.1)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Lower Skeena	0.0 (1.8)	10.3 (3.9)	6.0 (3.3)	0.0 (1.2)	12.3 (5.3)	13.4 (3.6)	6.7 (2.8)	6.9 (2.9)	19.2 (3.2)
Middle Skeena	37.5 (15.0)	17.0 (4.1)	14.5 (4.2)	10.5 (6.6)	1.6 (1.8)	4.9 (2.1)	11.2 (3.2)	11.0 (3.1)	62.3 (4.6)
Upper Skeena	0.0 (1.6)	0.3 (1.1)	0.2 (1.7)	0.0 (0.5)	0.0 (0.3)	1.1 (1.6)	2.0 (2.5)	7.1 (2.7)	13.6 (3.7)
Haida Gwaii-Graham Island Lowlands	0.0 (1.7)	2.3 (1.6)	0.0 (0.2)	0.0 (0.9)	0.0 (0.3)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)
Haida Gwaii-East	0.0 (1.5)	3.4 (1.9)	0.0 (0.3)	0.0 (0.8)	0.0 (0.3)	0.0 (0.1)	0.0 (0.3)	0.0 (0.1)	0.0 (0.1)
Haida Gwaii-West	0.0 (1.1)	0.0 (0.1)	0.0 (0.1)	0.0 (0.5)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)

Northern Coastal Streams	0.2 (3.0)	6.3 (3.7)	1.8 (1.8)	0.1 (1.5)	7.9 (6.4)	3.0 (3.6)	2.1 (3.0)	2.6 (2.7)	0.0 (0.3)
Hecate Strait Mainland	0.0 (2.1)	9.2 (4.1)	23.8 (5.6)	7.9 (7.1)	5.3 (7.6)	14.8 (4.9)	4.8 (2.5)	3.7 (3.0)	0.0 (0.1)
Mussel-Kynoch	0.0 (0.7)	3.0 (1.8)	1.4 (1.6)	0.9 (2.8)	0.0 (0.2)	0.0 (0.3)	2.3 (1.6)	1.0 (1.0)	0.0 (0.2)
Douglas Channel-Kitimat Arm	61.9 (16.0)	21.7 (5.2)	25.6 (5.9)	48.5 (11.3)	24.6 (7.0)	16.6 (4.4)	26.5 (4.7)	21.6 (4.5)	0.0 (0.1)
Bella Coola-Dean Rivers	0.2 (2.2)	11.4 (4.2)	0.1 (0.7)	0.1 (1.1)	0.1 (0.6)	0.0 (0.2)	12.3 (3.6)	5.3 (2.5)	0.1 (0.3)
Rivers Inlet	0.0 (1.3)	0.0 (0.2)	6.7 (4.6)	0.0 (0.7)	0.5 (2.2)	4.4 (3.7)	0.3 (1.1)	0.0 (0.2)	0.0 (0.1)
Smith Inlet	0.0 (1.0)	0.0 (0.1)	0.0 (0.1)	0.0 (0.5)	0.0 (0.2)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)
Southern Coastal Streams-Queen Charlotte Strait-Johnstone Strait-Southern Fjords	0.0 (1.6)	0.1 (0.4)	5.0 (3.8)	0.0 (0.7)	0.2 (1.0)	0.2 (0.6)	0.2 (1.1)	2.6 (2.3)	0.0 (0.1)
Homathko-Klinaklini Rivers	0.1 (1.2)	4.4 (2.9)	1.2 (1.2)	0.0 (0.4)	7.0 (4.2)	0.0 (0.1)	0.0 (0.2)	0.0 (0.2)	0.0 (0.1)
Georgia Strait Mainland	0.0 (0.9)	0.0 (0.1)	0.0 (0.2)	0.0 (0.4)	0.0 (0.2)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)	0.0 (0.0)
Howe Sound-Burrard Inlet	0.0 (1.8)	1.0 (1.8)	1.1 (1.8)	0.1 (1.3)	0.2 (1.2)	0.0 (0.2)	2.4 (1.6)	0.0 (0,1)	0.0 (0.1)
East Vancouver Island-Georgia Strait	0.0 (2.5)	0.0 (0.3)	0.4 (1.0)	0.0 (1.2)	0.2 (0.8)	0.1 (0.5)	0.0 (0.2)	0.0 (0.2)	0.0 (0.1)
East Vancouver Island-Johnstone Strait-Southern Fjords	0.0 (0.6)	0.0 (0.1)	0.0 (0.2)	0.0 (0.2)	0.0 (0.1)	0.0 (0.0)	0.0 (0.1)	0.0 (0.0)	0.0 (0.0)
Nahwitti Lowland	0.0 (2.3)	0.0 (0.2)	0.1 (0.5)	0.1 (1.2)	1.5 (2.8)	0.0 (0.2)	0.0 (0.2)	0.0 (0.2)	0.0 (0.1)
West Vancouver Island	0.0 (1.5)	0.1 (0.5)	0.0 (0.2)	0.0 (0.6)	0.0 (0.4)	0.0 (0.1)	0.0 (0.1)	0.0 (0.2)	0.0 (0.1)
Clayoquot	0.0 (1.6)	0.0 (0.2)	0.0 (0.2)	0.0 (0.6)	0.0 (0.3)	0.2 (0.5)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)
Juan de Fuca-Pachena	0.0 (1.4)	0.0 (0.1)	0.0 (0.3)	0.0 (0.5)	0.0 (0.3)	0.1 (0.5)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)

Lower Fraser	0.0 (2.9)	0.0 (0.3)	0.0 (0.3)	0.0 (1.4)	0.0 (0.6)	0.0 (0.2)	0.0 (0.2)	0.0 (0.2)	0.0 (0.2)
Lillooet	0.0 (0.8)	0.0 (0.1)	0.0 (0.1)	0.0 (0.6)	0.0 (0.2)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)
Fraser Canyon	0.0 (0.5)	0.0 (0.1)	0.0 (0.1)	0.0 (0.3)	0.0 (0.1)	0.0 (0.0)	0.0 (0.1)	0.0 (0.1)	0.0 (0.0)
Interior Fraser	0.0 (1.4)	0.0 (0.1)	0.0 (0.1)	0.0 (0.5)	0.0 (0.3)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)
Lower Thompson	0.0 (1.2)	0.0 (0.1)	0.0 (0.1)	0.0 (0.7)	0.0 (0.2)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)
North Thompson	0.0 (2.2)	0.0 (0.3)	0.0 (0.3)	0.0 (1.0)	0.0 (0.4)	0.0 (0.2)	0.0 (0.2)	0.0 (0.2)	0.0 (0.1)
South Thompson	0.0 (2.3)	0.0 (0.2)	0.0 (0.3)	0.0 (1.1)	0.0 (0.4)	0.0 (0.1)	0.0 (0.2)	0.0 (0.2)	0.0 (0.1)
Boundary Bay	0.0 (0.8)	0.0 (0.2)	0.0 (0.1)	0.0 (0.6)	0.0 (0.2)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)	0.0 (0.0)
Northern Puget Sound	0.0 (1.5)	0.0 (0.2)	0.0 (0.2)	0.0 (0.8)	0.0 (0.3)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)
Mid-Puget Sound	0.0 (1.2)	0.0 (0.1)	0.0 (0.1)	0.0 (0.5)	0.0 (0.2)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)
Southern Puget Sound	0.0 (1.4)	0.0 (0.1)	0.0 (0.1)	0.0 (0.7)	0.0 (0.2)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)
Juan de Fuca Strait	0.0 (0.8)	0.0 (0.1)	0.0 (0.1)	0.0 (0.4)	0.0 (0.2)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)	0.0 (0.0)
Hood Canal	0.0 (1.1)	0.0 (0.1)	0.0 (0.1)	0.0 (0.4)	0.0 (0.2)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)
Northern Coastal Washington	0.0 (1.1)	0.0 (0.1)	0.0 (0.1)	0.0 (0.5)	0.0 (0.2)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)
Southern Coastal Washington	0.0 (0.9)	0.0 (0.1)	0.0 (0.1)	0.0 (0.5)	0.0 (0.2)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)
Columbia River	0.0 (1.6)	0.0 (0.2)	0.0 (0.2)	0.0 (0.8)	0.0 (0.3)	0.0 (0.1)	0.0 (0.2)	0.0 (0.1)	0.0 (0.1)
Oregon	0.0 (2.1)	0.0 (0.2)	0.0 (0.2)	0.0 (0.9)	0.0 (0.3)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)
Northern California	0.0 (1.2)	0.0 (0.1)	0.0 (0.1)	0.0 (0.3)	0.0 (0.2)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)	0.0 (0.0)
California	0.0 (1.2)	0.0 (0.1)	0.0 (0.1)	0.0 (0.6)	0.0 (0.3)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)

Supplementary Table 1 concluded.

Region/Conservation Unit	Upper Nass test fishery	Central coast sport (Area 9)		Central coast troll	Taaq-wihaak
	Seasonal	July	August	August	July
Sample size	21	157	230	237	10
N-PBT	0	0	0	4	5
Southeast Alaska	0.0 (0.8)	0.0 (0.1)	0.0 (0.1)	0.0 (0.2)	0.0 (1.4)
Alsek River	0.0 (0.3)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.4)
Taku-Late Timing	0.0 (0.6)	0.0 (0.1)	0.0 (0.1)	0.0 (0.2)	0.0 (1.4)
Lower Stikine	0.0 (0.2)	0.0 (0.1)	0.0 (0.0)	0.0 (0.1)	0.0 (0.4)
Lower Nass	0.0 (0.3)	0.0 (0.1)	0.0 (0.0)	0.0 (0.0)	0.0 (0.8)
Upper Nass	99.2 (5.1)	0.0 (0.0)	0.0 (0.0)	0.0 (0.2)	0.0 (0.4)
Portland Sound-Observatory Inlet-Portland Canal	0.0 (0.2)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.4)
Skeena Estuary	0.0 (0.2)	0.0 (0.1)	0.0 (0.0)	0.0 (0.0)	0.0 (0.4)
Lower Skeena	0.0 (0.8)	0.0 (0.2)	0.2 (0.6)	0.0 (0.1)	0.0 (1.7)
Middle Skeena	0.0 (0.9)	0.0 (0.1)	0.8 (0.6)	0.3 (0.6)	0.0 (1.5)
Upper Skeena	0.8 (2.9)	0.0 (0.1)	0.0 (0.0)	0.0 (0.2)	0.0 (1.0)
Haida Gwaii-Graham Island Lowlands	0.0 (0.7)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)	0.0 (1.3)
Haida Gwaii-East	0.0 (0.6)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)	0.0 (1.1)
Haida Gwaii-West	0.0 (0.5)	0.0 (0.1)	0.0 (0.0)	0.0 (0.0)	0.0 (1.2)
Northern Coastal Streams	0.0 (0.9)	8.3 (3.4)	2.3 (2.1)	5.4 (3.3)	0.0 (2.1)
Hecate Strait Mainland	0.0 (0.7)	3.0 (1.6)	8.0 (2.0)	25.6 (3.7)	0.0 (1.7)
Mussel-Kynoch	0.0 (0.3)	0.0 (0.4)	0.0 (0.1)	4.9 (1.8)	0.0 (0.6)

Douglas Channel-Kitimat Arm	0.0 (0.4)	6.6 (4.0)	1.3 (2.8)	22.7 (3.6)	0.0 (0.5)
Bella Coola-Dean Rivers	0.0 (0.6)	28.7 (4.3)	26.1 (3.5)	14.5 (2.9)	0.0 (1.2)
Rivers Inlet	0.0 (0.5)	18.4 (3.8)	40.4 (4.2)	7.6 (2.8)	0.0 (1.2)
Smith Inlet	0.0 (0.4)	3.0 (1.4)	1.9 (1.0)	0.9 (0.6)	0.0 (0.9)
Southern Coastal Streams-Queen Charlotte Strait-Johnstone Strait-Southern Fjords	0.0 (0.7)	7.7 (3.2)	5.5 (2.5)	3.3 (2.3)	0.0 (1.4)
Homathko-Klinaklini Rivers	0.0 (0.4)	14.2 (3.3)	6.2 (2.2)	2.0 (1.8)	0.0 (1.0)
Georgia Strait Mainland	0.0 (0.4)	0.0 (0.1)	0.0 (0.2)	0.0 (0.2)	0.0 (0.8)
Howe Sound-Burrard Inlet	0.0 (0.9)	7.1 (2.4)	3.9 (1.6)	4.3 (1.8)	10.0 (8.5)
East Vancouver Island-Georgia Strait	0.0 (1.1)	0.1 (0.5)	2.7 (1.2)	4.1 (1.4)	0.0 (2.0)
East Vancouver Island-Johnstone Strait-Southern Fjords	0.0 (0.2)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.5)
Nahwitti Lowland	0.0 (1.0)	1.5 (1.1)	0.1 (0.4)	0.8 (0.7)	0.0 (1.6)
West Vancouver Island	0.0 (0.6)	0.0 (0.1)	0.0 (0.1)	0.0 (0,1)	40.0 (13.9)
Clayoquot	0.0 (0.6)	0.0 (0.1)	0.0 (0.1)	1.0 (1.2)	0.0 (1.2)
Juan de Fuca-Pachena	0.0 (0.5)	0.9 (0.8)	0.0 (0.1)	1.1 (0.8)	0.0 (1.2)
Lower Fraser	0.0 (1.0)	0.0 (0.2)	0.0 (0.1)	0.5 (0.5)	15.7 (11.3)
Lillooet	0.0 (0.4)	0.0 (0.1)	0.0 (0.0)	0.0 (0.0)	0.0 (0.9)
Fraser Canyon	0.0 (0.3)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.9)
Interior Fraser	0.0 (0.6)	0.0 (0.1)	0.0 (0.1)	0.0 (0.0)	0.0 (1.1)
Lower Thompson	0.0 (0.5)	0.0 (0.1)	0.0 (0.0)	0.0 (0.0)	0.0 (0.8)

North Thompson	0.0 (1.1)	0.0 (0.2)	0.0 (0.1)	0.4 (0.4)	0.0 (2.0)
South Thompson	0.0 (1.1)	0.6 (0.6)	0.4 (0.4)	0.0 (0.1)	0.0 (1.8)
Boundary Bay	0.0 (0.3)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)	0.0 (0.9)
Northern Puget Sound	0.0 (0.6)	0.0 (0.1)	0.0 (0.1)	0.5 (0.5)	9.5 (11.4)
Mid-Puget Sound	0.0 (0.5)	0.0 (0.1)	0.0 (0.0)	0.0 (0.1)	3.8 (6.7)
Southern Puget Sound	0.0 (0.6)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)	1.1 (3.7)
Juan de Fuca Strait	0.0 (0.3)	0.0 (0.0)	0.0 (0.0)	0.0 (0.1)	1.2 (4.7)
Hood Canal	0.0 (0.4)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)	0.0 (0.9)
Northern Coastal Washington	0.0 (0.5)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)	8.7 (8.6)
Southern Coastal Washington	0.0 (0.3)	0.0 (0.1)	0.0 (0.0)	0.0 (0.0)	0.0 (0.9)
Columbia River	0.0 (0.8)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)	10.0 (8.4)
Oregon	0.0 (0.8)	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)	0.0 (1.5)
Northern California	0.0 (0.2)	0.0 (0.1)	0.0 (0.0)	0.0 (0.0)	0.0 (0.8)
California	0.0 (0.6)	0.0 (0.1)	0.0 (0.0)	0.0 (0.1)	0.0 (0.9)

Supplementary Table 2. Percentage stock composition by geographic region or CU of 2019 fishery samples sent to a central laboratory for potential CWT recovery. All individuals from recreational fishery samples were presumed adipose fin clipped, and some individuals would also be marked with a CWT. N-PBT is the number of individuals identified in the sample via PBT.

Region/Conservation Unit	Northern troll			Northern sport				Central coast sport	
	July	August	September	June	July	August	September	July	August
Sample size	298	270	4	16	45	64	32	17	8
N-PBT	42	40	0	3	8	8	2	9	3
Southeast Alaska	4.8 (1.3)	15.1 (2.3)	25.4 (20.6)	12.0 (7.5)	5.2 (3.6)	6.6 (3.4)	9.3 (4.9)	0.0 (1.0)	0.0 (1.8)
Alsek River	0.0 (0.0)	0.0 (0.0)	0.0 (1.2)	0.0 (0.4)	0.0 (0.1)	0.0 (0.1)	0.0 (0.2)	0.0 (0.3)	0.0 (0.4)
Taku-Late Timing	0.2 (0.4)	0.1 (0.3)	7.4 (15.8)	0.0 (0.9)	0.0 (0.6)	0.0 (0.2)	0.0 (0.5)	0.0 (0.8)	0.0 (1.3)
Lower Stikine	0.0 (0.1)	0.0 (0.1)	0.0 (1.0)	0.0 (0.3)	0.0 (0.2)	0.0 (0.1)	0.0 (0.3)	0.0 (0.2)	0.0 (0.5)
Lower Nass	2.4 (1.1)	3.5 (1.7)	0.0(1.4)	0.0 (0.6)	0.5 (2.2)	4.1 (2.7)	0.0 (0.3)	0.0 (0.4)	0.0 (0.9)
Upper Nass	0.6 (0.5)	0.0 (0.0)	0.0 (0.9)	0.0 (0.5)	0.0 (0.2)	0.1 (0.5)	0.0 (0.2)	0.0 (0.3)	0.0 (0.5)
Portland Sound-Observatory Inlet-Portland Canal	0.0 (0.0)	0.0 (0.0)	0.0 (1.0)	0.0 (0.3)	0.0 (0.1)	0.0 (0.1)	0.0 (0.2)	0.0 (0.5)	0.0 (0.9)
Skeena Estuary	0.0 (0.0)	0.0 (0.0)	0.0 (1.3)	0.0 (0.3)	0.0 (0.2)	0.0 (0.1)	0.0 (0.1)	0.0 (0.3)	0.0 (0.5)
Lower Skeena	2.5 (1.1)	8.7 (2.1)	0.2 (4.5)	12.6 (7.8)	7.4 (4.1)	0.3 (1.1)	0.0 (0.5)	0.0 (1.2)	0.0 (1.7)
Middle Skeena	6.0 (1.4)	7.2 (1.6)	0.0 (3.1)	6.1 (5.7)	5.6 (3.4)	1.6 (1.5)	0.0 (0.5)	0.0 (0.6)	0.0 (1.6)
Upper Skeena	0.1 (0.5)	0.0 (0.1)	0.0 (2.3)	0.0 (0.7)	0.1 (0.3)	0.0 (0.2)	0.0 (0.3)	0.0 (0.6)	0.0 (1.0)
Haida Gwaii-Graham Island Lowlands	1.0 (0.6)	0.7 (0.5)	0.0 (2.8)	0.0 (0.8)	0.0 (0.3)	0.0 (0.2)	0.0 (0.6)	0.0 (1.0)	0.0 (1.5)
Haida Gwaii-East	9.0 (1.6)	2.2 (0.9)	0.0 (2.8)	0.0 (0.8)	2.3 (2.2)	0.0 (0.3)	6.3 (4.1)	0.0 (0.7)	0.0 (1.3)
Haida Gwaii-West	0.0 (0.0)	0.0 (0.0)	0.0 (1.6)	0.2 (1.7)	2.2 (2.2)	0.0 (0.1)	0.0 (0.3)	0.0 (0.6)	0.0 (0.9)

Northern Coastal Streams	1.6 (1.4)	0.9 (1.1)	1.3 (5.2)	0.0 (1.2)	1.0 (1.8)	0.1 (0.6)	0.1 (1.0)	0.8 (3.4)	0.0 (2.0)
Hecate Strait Mainland	0.2 (0.3)	3.0 (1.3)	0.1 (3.5)	0.3 (1.5)	0.3 (1.3)	0.1 (0.7)	3.1 (2.9)	0.1 (1.2)	0.5 (4.1)
Mussel-Kynoch	0.0 (0.1)	0.1 (0.4)	2.1 (8.5)	0.0 (0.9)	0.5 (1.3)	0.2(1.0)	0.0 (0.4)	0.7 (2.7)	0.0 (0.8)
Douglas Channel-Kitimat Arm	1.0 (1.0)	0.8 (1.2)	0.1 (1.4)	0.0 (0.7)	0.0 (0.1)	4.2 (3.1)	0.0 (0.2)	0.3 (1.7)	0.0 (0.7)
Bella Coola-Dean Rivers	0.0 (0.2)	0.0 (0.1)	0.0 (2.6)	0.0 (0.7)	6.0 (3.8)	0.0 (0.2)	0.0 (0.3)	0.0 (0.8)	0.1 (1.7)
Rivers Inlet	0.0 (0.2)	1.1 (1.0)	0.1 (3.1)	0.0 (0.7)	0.0 (0.3)	0.0 (0.3)	0.0 (0.3)	0.4 (2.9)	10.6 (9.0)
Smith Inlet	0.0 (0.0)	0.0 (0.1)	0.0 (1.9)	0.0 (0.5)	0.0 (0.2)	0.0 (0.2)	0.0 (0.3)	0.0 (0.7)	0.0 (1.1)
Southern Coastal Streams-Queen Charlotte Strait-Johnstone Strait-Southern Fjords	0.2 (0.6)	0.2 (0.5)	0.1 (3.0)	0.0 (0.9)	0.0 (0.6)	0.0 (0.4)	0.0 (0.6)	3.4 (4.7)	8.8 (11.1)
Homathko-Klinaklini Rivers	0.0 (0.0)	0.0 (0.1)	0.0 (1.4)	0.0 (0.6)	0.0 (0.5)	0.0 (0.1)	0.0 (0.3)	0.1 (1.0)	13.3 (13.4)
Georgia Strait Mainland	0.5 (0.4)	0.0 (0.1)	0.0 (1.7)	0.0 (0.5)	0.0 (0.2)	0.0 (0.1)	0.0 (0.3)	0.0 (0.5)	0.0 (1.1)
Howe Sound-Burrard Inlet	0.0 (0.1)	0.0 (0.1)	13.2 (15.7)	0.0 (1.0)	0.0 (0.4)	1.7 (1.7)	0.0 (0.5)	32.4 (11.0)	0.0 (1.7)
East Vancouver Island-Georgia Strait	15.2 (2.1)	14.3 (2.3)	0.0 (4.6)	6.3 (5.6)	13.9 (5.1)	12.7 (4.4)	10.4 (5.8)	26.3 (10.8)	33.4 (13.8)
East Vancouver Island-Johnstone Strait-Southern Fjords	0.0 (0.0)	0.0 (0.0)	0.0 (1.3)	0.0 (0.5)	0.0 (0.2)	0.0 (0.1)	0.0 (0.2)	0.0 (0.4)	0.0 (0.5)
Nahwitti Lowland	6.2 (1.5)	2.4 (1.0)	0.0 (3.2)	0.0 (1.2)	0.0 (0.4)	3.1 (2.2)	0.9 (2.6)	1.5 (4.7)	22.2 (12.3)
West Vancouver Island	1.7 (0.8)	2.2 (0.9)	0.0 (2.6)	6.3 (5.5)	2.2 (2.2)	4.7 (2.6)	3.1 (2.9)	6.8 (6.4)	0.0 (1.5)
Clayoquot	0.0 (0.0)	0.0 (0.0)	0.0 (2.4)	0.0 (0.7)	0.0 (0.2)	0.0 (0.2)	0.0 (0.4)	4.0 (5.8)	0.0 (1.1)
Juan de Fuca-Pachena	0.3 (0.6)	0.0 (0.1)	0.0 (1.9)	0.0 (0.8)	0.1 (0.7)	0.0 (0.4)	3.2 (2.9)	0.2 (2.0)	0.0 (1.6)
Lower Fraser	0.0 (0.2)	0.1 (0.3)	0.0 (4.5)	0.0 (1.8)	0.0 (0.6)	0.0 (0.5)	0.1 (1.0)	0.4 (2.5)	0.0 (2.6)
Lillooet	0.0 (0.0)	0.0 (0.0)	0.0 (1.7)	0.0 (0.5)	0.0 (0.2)	0.0 (0.1)	0.0 (0.2)	0.0 (0.5)	0.0 (1.0)
Fraser Canyon	0.0 (0.0)	0.0 (0.0)	0.0 (1.5)	0.0 (0.5)	0.0 (0.2)	0.0 (0.1)	0.0 (0.2)	0.0 (0.4)	0.0 (0.5)
Interior Fraser	0.0 (0.0)	0.0 (0.0)	0.0 (2.7)	0.0 (0.8)	0.0 (0.2)	0.0 (0.2)	0.0 (0.4)	0.0 (0.6)	0.0 (1.2)

Lower Thompson	0.0 (0.0)	0.0 (0.0)	0.0 (2.1)	0.0 (0.5)	0.0 (0.2)	0.0 (0.1)	0.0 (0.3)	5.9 (5.1)	0.0 (0.9)
North Thompson	0.0 (0.1)	0.0 (0.1)	0.0 (4.1)	0.0 (1.2)	0.0 (0.5)	0.0 (0.3)	0.0 (0.7)	0.0 (1.2)	0.0 (2.2)
South Thompson	0.3 (0.3)	0.0 (0.1)	0.0 (3.8)	0.0 (1.3)	0.0 (0.5)	0.0 (0.4)	0.0 (0.7)	0.0 (1.1)	0.0 (2.1)
Boundary Bay	0.0 (0.0)	0.0 (0.1)	0.0 (1.9)	0.0 (0.6)	0.0 (0.2)	0.0 (0.2)	0.0 (0.3)	0.0 (0.8)	0.0 (0.8)
Northern Puget Sound	5.8 (2.0)	5.6 (1.8)	0.0 (2.4)	5.8 (5.8)	19.6 (6.7)	0.8 (1.8)	0.3 (2.4)	7.2 (7.2)	0.0 (1.4)
Mid-Puget Sound	5.2 (2.6)	5.8 (1.9)	0.0 (1.7)	0.4 (2.1)	4.9 (5.4)	4.1 (4.8)	6.8 (5.5)	0.2 (1.2)	0.1 (2.0)
Southern Puget Sound	7.5 (1.9)	0.0 (0.3)	0.0 (2.4)	12.2 (7.9)	6.7 (5.6)	2.3 (3.2)	0.0 (0.4)	3.6 (5.8)	0.4 (1.6)
Juan de Fuca Strait	0.9 (1.2)	2.6 (1.3)	0.0 (1.5)	0.1 (1.0)	0.7 (2.1)	0.1 (0.7)	0.1 (1.0)	0.0 (0.4)	0.7 (3.0)
Hood Canal	2.9 (1.4)	0.6 (0.7)	0.0 (1.7)	0.0 (0.7)	0.4 (1.3)	0.4 (1.4)	7.5 (6.1)	0.1 (1.7)	7.3 (9.3)
Northern Coastal Washington	9.3 (2.0)	7.4 (1.8)	25.0 (16.7)	18.9 (9.0)	7.6 (5.4)	21.2 (5.3)	5.0 (6.6)	0.1 (1.6)	1.6 (4.4)
Southern Coastal Washington	5.2 (1.5)	8.6 (1.9)	25.0 (16.5)	0.1 (0.9)	5.9 (4.1)	26.7 (5.7)	40.2 (8.7)	1.5 (3.5)	0.9 (3.5)
Columbia River	9.4 (1.7)	6.7 (1.5)	0.0 (3.4)	18.8 (9.0)	6.7 (3.7)	4.7 (2.7)	3.5 (3.2)	0.0 (0.9)	0.0 (1.5)
Oregon	0.0 (0.1)	0.0 (0.1)	0.0 (3.1)	0.0 (0.9)	0.0 (0.4)	0.0 (0.3)	0.0 (0.5)	3.8 (5.4)	0.0 (1.7)
Northern California	0.0 (0.0)	0.0 (0.0)	0.0 (1.7)	0.0 (0.4)	0.0 (0.1)	0.0 (0.1)	0.0 (0.2)	0.0 (0.6)	0.0 (0.7)
California	0.0 (0.0)	0.0 (0.0)	0.0 (2.2)	0.0 (0.6)	0.0 (0.3)	0.0 (0.2)	0.0 (0.3)	0.0 (0.5)	0.0 (1.1)