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FRAMEWORK FOR IMPLEMENTATION OF THE WILD SALMON POLICY: INITIAL LISTS OF CONSERVATION UNITS FOR BRITISH COLUMBIA

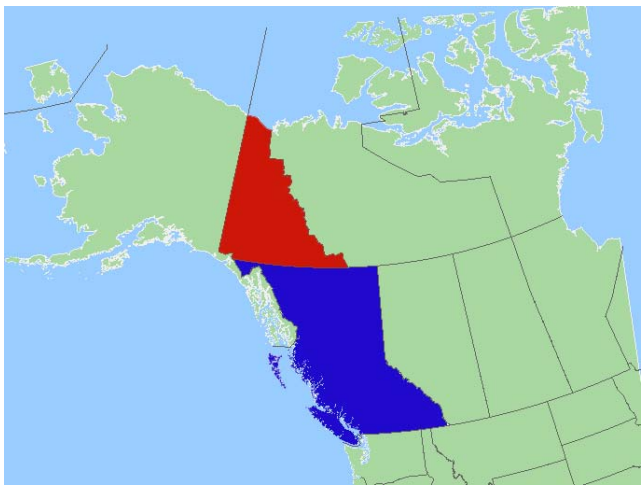

Figure 1: The Pacific-Yukon Region of Western Canada consists of the Yukon Territory (red) and the province of British Columbia (blue). This document pertains to those portions of the Region inhabited by anadromous Pacific Salmon.

Context

In 2005, the Department of Fisheries and Oceans (DFO) adopted Canada's Policy for the Conservation of Wild Salmon Policy (the WSP) (DFO 2005). Implementation of the WSP consists of six strategies, the first of which requires the standardized monitoring of wild salmon status. Standardized monitoring begins with the identification of species-specific Conservation Units or CUs. The CUs serve two roles under the WSP. First, each CU is, in some sense, a significant element of biodiversity that the WSP seeks to conserve and manage. Second, each CU is a unit for reporting on the success (or failure) of actions taken under the WSP to conserve wild Pacific salmon. Subsequent steps in the Policy's implementation, including the characterizing of the biological, habitat and ecological status of each CU are contingent on providing a consistent, objective, defensible and operational definition of the CU that is both practicable and will insure that the important elements of salmon biodiversity can be conserved and managed.

*A method has been developed to identify the Conservation Units of the five species of Pacific salmon (*Oncorhynchus *spp.) that are present in Canada and under federal jurisdiction (Holtby and Ciruna 2007) . This paper presents the results of applying the method to the salmon of British Columbia. CUs for the Yukon River and Mackenzie River remain to be identified.*

SUMMARY

- Conservation Units or CUs are groups of from one to about 170 salmon populations that are fundamental units of diversity to be conserved and managed under Canada's Policy for the Conservation of Wild Pacific Salmon or the WSP.

- A method was developed to identify these units and applied to the wild Pacific salmon of British Columbia

- The Pacific salmon of British Columbia are extraordinarily diverse with 420 CUs identified.

- Lake-type sockeye are the most diverse of the seven species and life-history types considered with 214 CUs. Most of the CUs were located in the small coastal lakes on the Central and Northern Coasts.

- 68 CUs of chinook salmon were identified. The chinook salmon of the large rivers particularly the Fraser and Skeena Rivers were particularly diverse.

- 43 CUs of coho salmon were identified. Of interest, the COSEWIC designated Interior Fraser coho comprise five CUs, illustrating the general conclusion that CUs are nested within the Designatable Units of COSEWIC.

- 39 CUs of chum salmon and 32 CUs of pink salmon were identified. Interestingly, the least diverse species are numerically the most abundant.

- Chum salmon and chinook salmon also occur in the Canadian portions of the Yukon River, in the Mackenzie River and possibly in some of the coastal streams of the western Arctic. CUs for those areas are yet to be identified.

INTRODUCTION

The initial steps in protecting biological diversity and also the primary roles of scientific research, are to identify the diversity and then take inventory of the units of diversity that require conservation (Wood 2001). Consequently, the first of six strategies in the Canada's Policy for the Conservation of Wild Pacific Salmon (the WSP) (DFO 2005) concerns the identification of the units for conservation and determining their conservation status.

This is the second of two Science Advisory Reports summarizing Holtby and Ciruna (2007). The first report summarized the methodology used to identify Conservation Units for Pacific salmon (DFO 2008). This report summarizes the Conservation Units that were identified using that methodology.

ANALYSIS

A method for identifying Conservation Units (Holtby and Ciruna 2007) was systematically applied to the five species of Pacific salmon (*Oncorhynchus* spp*.)* under federal jurisdiction that are found in British Columbia (chinook–*O. tshawytscha*, chum–*O. keta*, coho–*O. kisutch*, pink–*O. gorbuscha*, and sockeye–*O. nerka*). Pink salmon have a fixed two-year life cycle and even-year and odd-year pink salmon are reproductively isolated and were treated as separate

species. The life-history types of sockeye (anadromous lake-type, non-anadromous kokanee, and anadromous river-type) have various levels of reproductive isolation but are so adaptively different that treating them as separate “species” was important to the identification and protection of diversity. Kokanee were not considered because it is under provincial jurisdiction.

The method is a series of sequential analyses that use ecotypology, molecular genetics, life-history and behavioral traits and ecological characteristics of their habitats to identify significant diversity. First, a large suite of hydrological, climatological, geographical, and zoogeographical variables was used to divide the freshwater, estuarine, and near-shore marine habitats of British Columbia into “adaptive zones”. Our hypothesis is that the salmon of any one zone are adapted to the unique characteristics of that zone and are not adapted (or are not adapted as well) to other adaptive zones. In other words, we hypothesized that salmon are interchangeable within a zone but not between zones. Should an extirpation occur in such an adaptive zone, the vacated habitat would be more rapidly recolonized by fish from the same zone than by fish from outside the zone (Holtby and Ciruna 2007). The adaptive zones actually occupied by an individual salmon species were deemed the ecotypic Conservation Units of that species and, in the absence of any other information, would become that species’ Conservation Units.

A variety of other information was then used to refine the characterization of diversity provided by the ecotypic CUs. That information, which included molecular genetics, migration and spawning timing, life history information and detailed ecological information, was used to identify transformations of ecotypic CUs that would lead to “better” characterizations of diversity. In this context “better” meant increased within-CU homogeneity and increased between-CU heterogeneity. The transformations of ecotypic CUs allowed splitting (an ecotypic CU was split into two or more CUs), grouping (two or more ecotypic CUs were merged), or splitting followed by grouping (some part of an ecotypic CU was merged with another ecotypic CU). However, most of the transformations were splits.

The tables and maps that follow summarize the outcome of the method applied to the Pacific salmon of British Columbia. Chinook and chum salmon CUs for the Yukon and Mackenzie Rivers and the western Arctic remain to be identified.

Even-year pink salmon (*Oncorhynchus gorbuscha*)

Table 1. A summary of the 13 Conservation Units of even-year pink salmon. Pink salmon are not persistently found in the Yukon River or Arctic Canada so this list comprises all Canadian CUs. Little information was available for pink salmon in the northern transboundary rivers. The CU recognized in that area is speculative and based on its MAZ ecotype. The number of sites indicated is the total in our database and should be not interpreted as the number of sites where even-year pink salmon are persistently found.

Even-Year Pink Salmon Conservation Units						
Conservation Unit	Acronym	Index	Number of Sites	Number of Genetic Clusters	Classification Step	Comments
Georgia Strait	GStr	1	55	no Information	ecotypic/timing	
West Vancouver Island	WVI	2	83	no Information	ecotypic	Confirmed by Timing
Northwest Vancouver Island	NWVI	3	24	no Information	ecotypic	Confirmed by Timing
Southern Fjords	SFj	4	92	2	ecotypic/timing	
Hecate Lowlands	HStr-HecLow	5	163	7	ecotypic/timing	
Hecate Strait-Fjords	HStr-Fj	6	145	7	ecotypic/timing	
Nass-Skeena Estuary	NSKEst	7	150	6	ecotypic/timing	
Middle-Upper Skeena	M&U-SKNA	8	45	1	ecotypic/timing	
North Queen Charlotte Islands	NQCI	9	15	1	genetic	
East Queen Charlotte Islands	EQCI	10	95	1	genetic	Also distinctive timing
West Queen Charlotte Islands	WQCI	11	59	1	genetic	
Upper Nass	UNASS	12	5	1	ecotypic/timing	Distinctive timing
Transboundary Fjords	TBFj	13	1	no information	ecotypic	No information is available for even-year pink in this JAZ

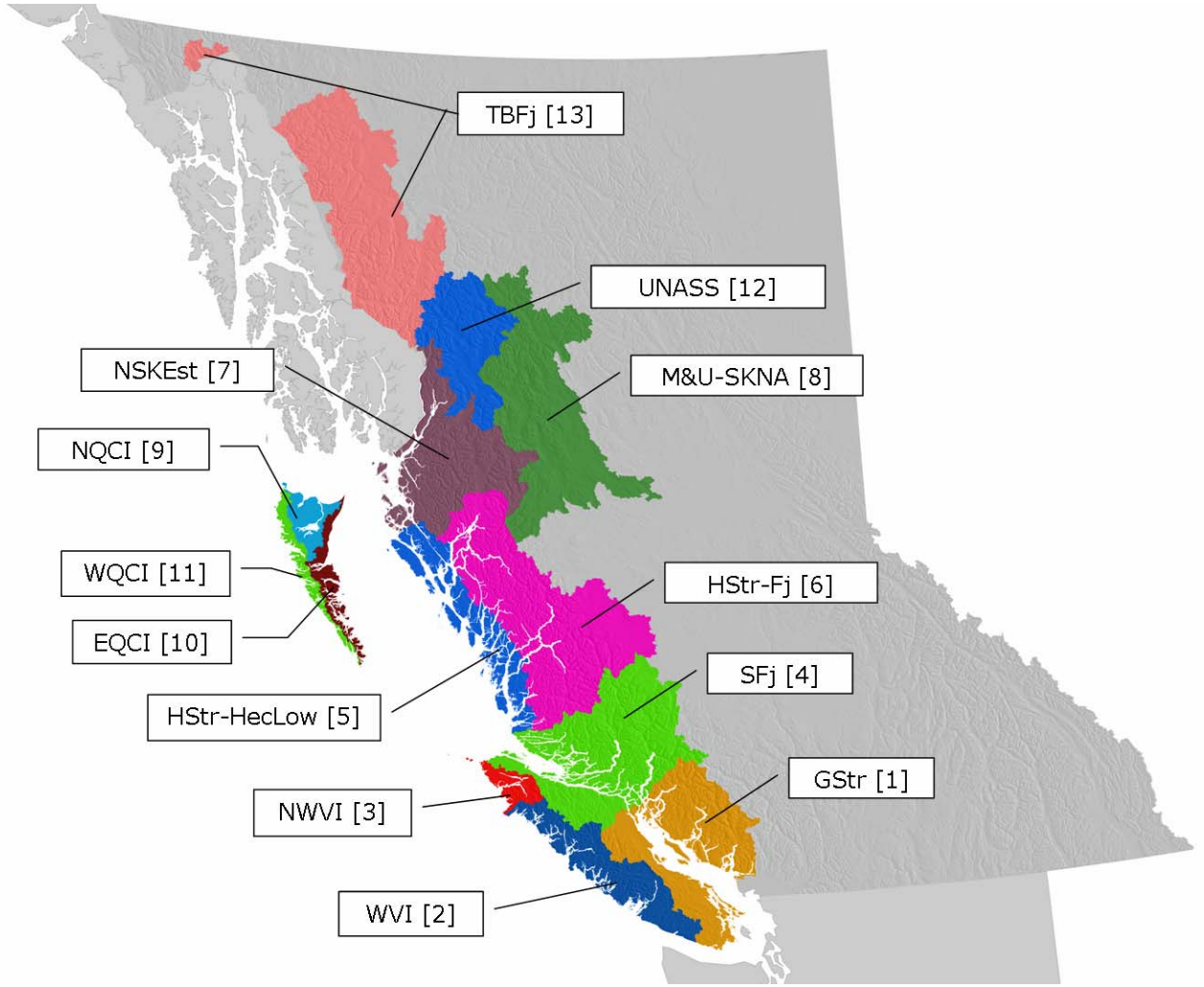

Figure 2. The 13 Conservation Units of even-year pink salmon in Canada. The CUs are labeled by their acronym and index number.

Odd-year pink salmon (*O. gorbuscha*)

Table 2. A summary of the 19 Conservation Units of odd-year pink salmon. Pink salmon are not persistently found in the Yukon or Arctic Canada so this list comprises all Canadian CUs. Little information was available for pink salmon in the northern transboundary rivers. The CU recognized in that area is speculative and based on its MAZ ecotype. The number of sites indicated is the total in our database and should not be interpreted as the number of sites where even-year pink salmon are persistently found.

Odd-Year Pink Salmon Conservation Units

Conservation Unit	Acronym	Index	Number of Sites	Number of Genetic Clusters	Classification Step	Comments
Fraser River	FR	1	69	1	genetic/timing	Genetically Homogeneous, No Timing Differences
East Howe Sound-Burrard Inlet	EHOWE-BUR	2	10	1	genetic	Genetic Cluster with Specific Geography. Area Is CU in Other Species
Georgia Strait	Gstr	3	64	2	genetic/timing	Genetically Homogeneous, No Timing Differences
EVI-Johnstone Strait	EVI-Jstr	4	12	1	ecotypic/genetic	
Nahwitti	Nahwitti	5	21	1	ecotypic/genetic	Genetics Conforms to Provincial Eco-Section
West Vancouver Island	WVI	6	49	no information	ecotypic	Based on MAZ
Southern Fjords	SC+Sfj	7	47	1	ecotypic/genetic	Northern Boundary of SC+Sfj JAZ Shifted South to Tribune Channel to Accommodate Genetic Clusters
Homathko-Klinaklini-Rivers-Smith-Bella Coola Dean	HK-RSI-BCD	8	56	4	ecotypic/genetic	Predominant Genetic Clusters in Closely Related FAZ
East Queen Charlotte Islands	EQCI	9	80	1	ecotypic/genetic	Distinctive Genetic Cluster in Specific JAZ
North Queen Charlotte Islands	NQCI	10	14	No information	ecotypic	Speculative in Absence of Genetic Information Although No Differences in Timing Across the QC Islands
West Queen Charlotte Islands	WQCI	11	30	no information	ecotypic	Speculative in Absence of Genetic Information Although No Differences in Timing Across the QC Islands
Hecate Strait-Lowlands	HStr-HecLow	12	165	6	ecotypic/timing	timing differences with HStr-Fj led to separate

Conservation Unit	Acronym	Index	Number of Sites	Number of Genetic Clusters	Classification Step	Comments
						management
Hecate Strait-Fjords	HStr-Fj	13	97	10	ecotypic/timing	
Nass-Skeena Estuary	NSKEst	14	33	2	ecotypic/timing	distinctive timing within the MAZ
Lower Skeena| River	LSK	15	54	2	genetics/timing	Skeena is genetically distinct and LSK timing is distinctive
Middle & Upper Skeena River	M&USK	16	49	1	genetics/timing	see comment for LSK
Nass-Portland-Observatory	NR-PORT-OBS	17	57	3	ecotypic/genetic	no habitat model and no timing differences across the JAZ
Upper Nass	UNASS	18	4	1	ecotypic/timing	upper Nass has distinctive timing
Transboundary Fjords	TBFj	19	?	no information	ecotypic	speculative since no information available for sites in this CU. JAZ were grouped on MAZ

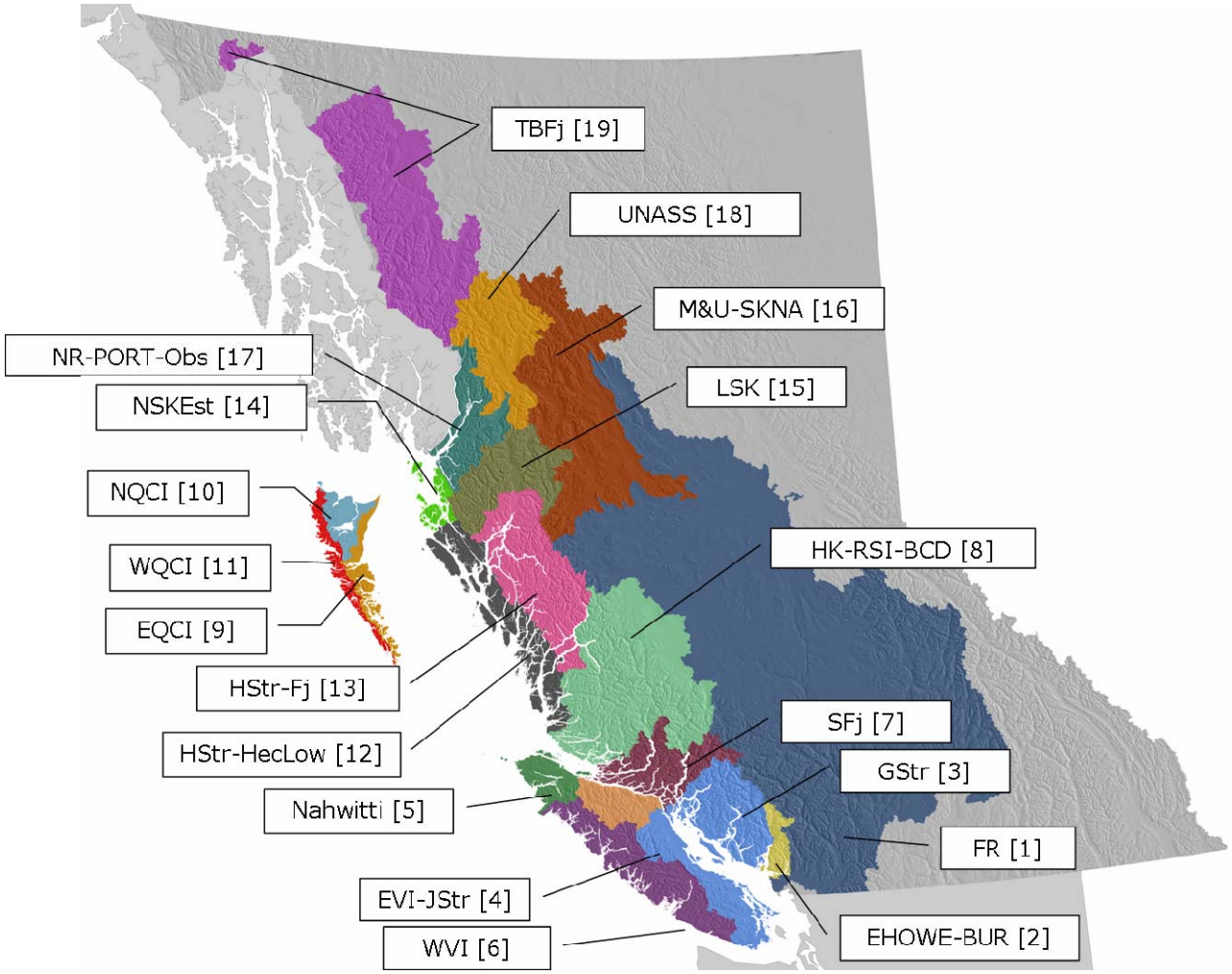

Figure 3. The 19 Conservation Units of odd-year pink salmon in Canada. The CUs are labeled by their acronym and index number.

Chum Salmon (*O. keta*)

Table 3. A summary of the 39 Conservation Units for chum salmon in British Columbia. Chum salmon are found in both the Yukon and Mackenzie Rivers. The CUs in those areas and possibly in Arctic Canada have not yet been identified. The number of sites indicated is the total in our database and should not be interpreted as the number of sites where chum salmon are persistently found.

Chum salmon Conservation Units					
Conservation Unit	acronym	index	number of sites	classification step	comments
Fraser Canyon	FRCany	1	13	habitat	suggested by genetics
Lower Fraser	LFR	2	81	habitat	2 ecotypic CUs merged
Howe Sound-Burrard Inlet	HOWE	3	55	genetic	
Georgia Strait	GStr-SFj	4	140	genetic	2 ecotypic CUs merged
East Vancouver Island	NEVI	5	20	ecotypic	confirmed by genetics
Loughborough	LOUGH	6	37	genetic	
Bute Inlet	BUTE	7	5	genetic	
Southern Coastal Streams	SCS	8	51	genetic	
Upper Knight	UKNIGHT	9	6	timing	ecotype split
Southwest Vancouver Island	SWVI	10	171	timing	
Northwest Vancouver Island	NWVI	11	61	timing	
Smith Inlet	SMITH	12	10	genetic	ecotype split
Rivers Inlet	RIVERS	13	14	timing	ecotype split
Wannock	WANNOCK	14	1	timing	
Spiller-Fitz Hugh-Burke	SpilFitz	15	54	genetic/timing	suggested by genetics/confirmed by timing
Bella Coola - Dean Rivers	BCD	16	30	timing	ecotype split
Bella Coola River - Late	BCR-LATE	17	1	timing	
Hecate Lowlands	NCC-coastal	18	136	ecotypic	confirmed by genetics
Mussel-Kynoch	MuKy	19	12	genetic/timing	suggested by genetics/confirmed by timing
Douglas-Gardner	DOUG	20	61	genetic/timing	suggested by genetics/confirmed by timing
East QCI	EQCI	21	98	ecotypic	confirmed by genetics
Skidegate	SKID	22	43	genetic	ecotype split
West QCI	WQCI	23	59	ecotypic	confirmed by genetics
North QCI	NQCI	24	11	ecotypic	confirmed by genetics

Chum salmon Conservation Units

Conservation Unit	acronym	index	number of sites	classification step	comments
North QCI-Stanley Creek	Stanley	25	1	genetic/timing	unique timing
Skeena Estuary	SKEST	26	16	ecotypic	confirmed by genetics
Lower Skeena	LSK	27	33	ecotypic	
Middle Skeena	MSK	28	9	ecotypic	
Upper Skeena	USK	29	1	ecotypic	confirmed by genetics
Portland Inlet	PortIN	30	13	habitat	supported by genetics
Lower Nass	LNASS	31	19	genetic/habitat	
Portland Canal-Observatory	PCOb	32	14	genetic	
Unuk	UNUK	33	?	ecotypic	
Lower Stikine	LStk	34	?	ecotypic	
Whiting	WHTNG	35	?	ecotypic	
Taku	TAKU	36	5	ecotypic	confirmed by genetics
Lynn Canal	LYNN	37	?	ecotypic	
Teslin	TESLIN	38	1	ecotypic	
Lower Liard	LIARD	39	?	ecotypic	
Yukon‡	YUK	?	0	ecotypic	
Mackenzie River‡	MACR	?	0	ecotypic	Peel River is genetically distinctive; other CUs within the Mackenzie are possible.

† The Teslin River headwaters is likely part of an Upper Yukon CU whose structure has yet to be determined
‡ There are likely several CUs of chum salmon in the Yukon River and at least one in the Mackenzie River in addition to the lower Liard. Their structure has yet to be determined.

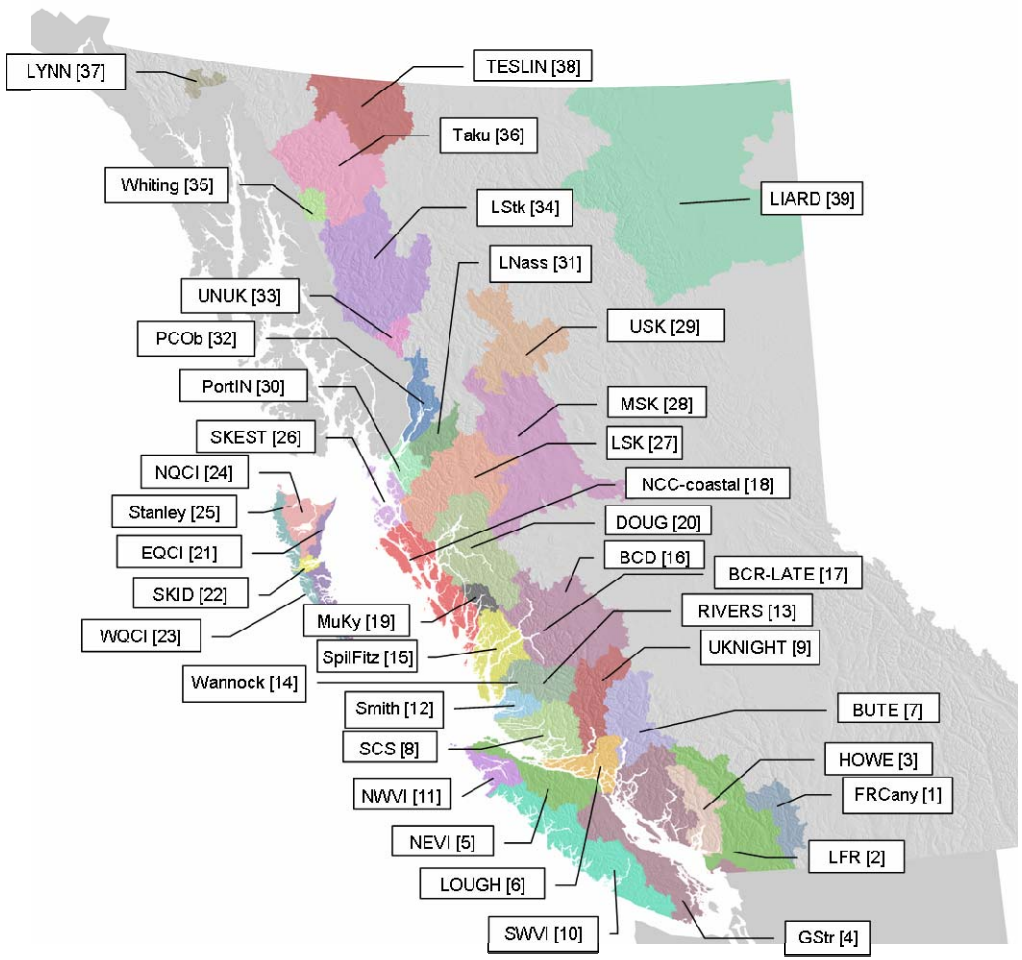

Figure 4. The 39 Conservation Units of chum salmon in British Columbia. Conservation Units in the Mackenzie River and Yukon River drainages are not shown, except for the Teslin CU[36], which may change when the Yukon River CUs are fully described. The Liard River CU [39] is in the Mackenzie River drainage and might change when the chum salmon in that drainage are fully described.

Coho Salmon (*O. kisutch*)

Table 4. A summary of the 43 Conservation Units for coho salmon. Coho salmon are not persistently found in the Canadian portions of the Yukon River or in Arctic Canada so this list is currently thought to comprise all Canadians CUs. The number of sites indicated is the total in our database and should not be interpreted as the number of sites where coho salmon are persistently found.

Conservation Unit	acronym	index	number of sites	classification step	comments
Boundary Bay	BB	1	1	ecotypic	
Lower Fraser	LFR-A	2	77	habitat	suggested by genetics
Lower Fraser-B	LFR-B	3	15	habitat	suggested by genetics
Lillooet	LILL	4	13	ecotypic	confirmed by genetics
Fraser Canyon	FRCany	5	9	ecotypic	confirmed by genetics
Middle Fraser	MFR	6	12	timing	three CUs in the same genetic cluster
Lower Thompson	LTHOM	7	7	habitat	
South Thompson	STHOM	8	40	habitat	
North Thompson	NTHOM	9	38	ecotypic	
Howe Sound-Burrard Inlet	Howe-Burrard	10	51	genetic	
Georgia Strait Mainland	SC+GStr	11	47	ecotypic	
Southern Coastal Streams| QCStr-JStr-SFjords	SC+SFj	12	95	ecotypic	confirmed by genetics
Georgia Strait-East Vancouver Island	EVI+GStr	13	100	ecotypic	confirmed by genetics
East Vancouver Island |JStr-SFjords	EVI+SFj	14	13	ecotypic	confirmed by timing
Nahwitti Lowland	Nahwitti	15	67	genetic	
Juan de Fuca-Pachena	JdF	16	25	genetic	
West Vancouver Island	WVI	17	108	genetic	
Clayoquot	CLAY	18	45	genetic	
Homathko - Klinaklini Rivers	HK	19	4	ecotypic	confirmed by genetics
Smith Inlet	Smith	20	11	genetic	
Rivers Inlet	Rivers	21	23	genetic	
Bella Coola - Dean Rivers	BCD	22	23	ecotypic	confirmed by genetics
Queen Charlottes | Hecate Strait - Q.C.	EQCI	23	117	ecotypic	confirmed by genetics

Conservation Unit	acronym	index	number of sites	classification step	comments
Sound					
Queen Charlottes | Outer Graham Island	WQCI	24	56	ecotypic	confirmed by genetics
QCI-Graham Island Lowlands	NQCI	25	28	genetic	
Mussel-Kynoch	MusKyn	26	12	genetic	
Hecate Strait Mainland	HecLow+HStr	27	165	ecotypic	confirmed by genetics
Brim-Wahoo	BRIM	28	2	genetic/habitat	suggested by genetics
Douglas Channel-Kitimat Arm	DOUG	29	31	genetic/habitat	suggested by genetics
Northern Coastal Streams	NCS	30	57	ecotypic	
Skeena Estuary	SKEst	31	21	ecotypic	confirmed by genetics
Lower Skeena	LSKNA	32	74	ecotypic	confirmed by genetics
Middle Skeena	MSKNA	33	76	ecotypic	confirmed by genetics
Upper Skeena	USKNA	34	12	ecotypic	confirmed by genetics
Lower Nass	LNASS	35	22	habitat	suggested by genetics
Upper Nass	UNASS	36	13	ecotypic	confirmed by genetics
Portland Sound-Observatory Inlet-Portland Canal	PORT	37	24	habitat	suggested by genetics
Unuk River	UNUK	38	0	ecotypic	
Lower Stikine	LSTK	39	3	ecotypic	
Whiting River	Whiting	40	0	ecotypic	
Taku	Taku	41	4	ecotypic	
Lynn Canal	LYNN	42	0	ecotypic	
Alsek	Alsek	43	1	ecotypic	confirmed by genetics

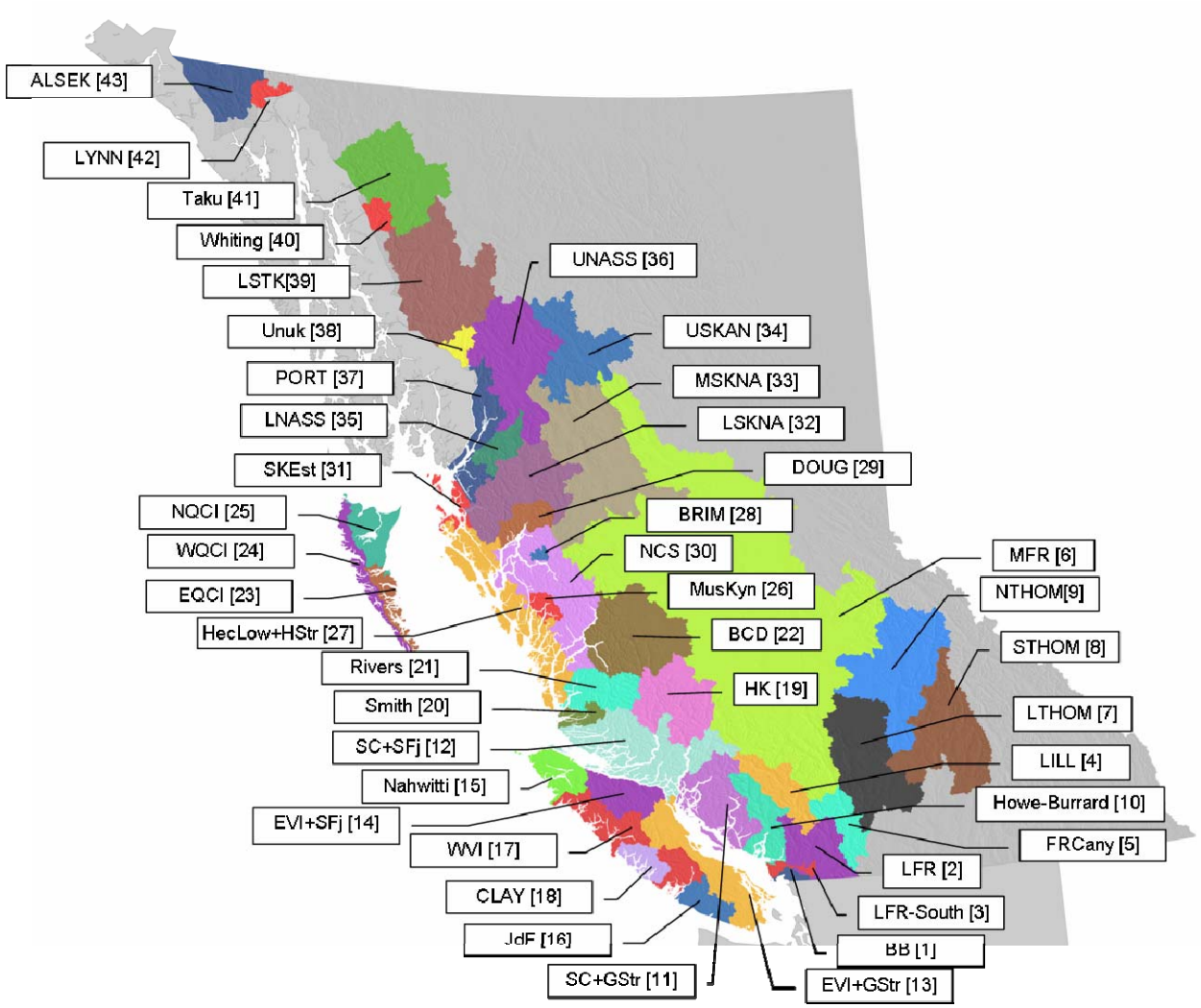

Figure 5. A map showing the 43 CUs of coho salmon in Canada. One CU (ALSEK #43) may extend into the Yukon Territory.

Chinook Salmon (*O. tshawytscha*)

Table 5. A summary of the 68 Conservation Units of chinook salmon in British Columbia. Additional CUs remain to be described in the Yukon and Mackenzie River drainages. The number of sites indicated is the total in our database and should not be interpreted as the number of sites where chinook salmon are persistently found.

Conservation Unit	Acronym	index	number of sites	classification step	comments
Okanagan	OK	1	1	ecotypic	confirmed by genetics
Boundary Bay	BB	2	2	ecotypic	confirmed by genetics
LFR fall white	LFR-fall	3	1	genetics/life-history/timing	hatchery and feral populations have established elsewhere in the LFR
LFR spring	LFR-spring	4	3	genetics/life-history/timing	includes native populations in Chehalis and Stave
LFR Upper Pitt	LFR-UPITT	5	1	genetics/timing	intermediate timing between true springs and summer runs
LFR summer	LFR-summer	6	10	genetics/life-history/timing	
Maria Slough	Maria	7	1	genetics/life-history	
FR Canyon-Nahatlatch	NAHAT	8	1	ecotypic	
MFR Portage	Portage	9	1	genetics/life-history	
MFR springs	MFR-spring	10	21	ecotypic/habitat	headwater streams
MFR summers	MFR-summer	11	19	ecotypic/habitat	headed by large lake
UFR springs	UFR-spring	12	38	ecotypic	confirmed by genetics
STh summer age 0.3	STh-0.3	13	7	genetics/life-history/timing	does not include 2 sites in upper Shuswap River with similar life history and age
STh summer age 1.3	STh-1.3	14	3	genetics/life-history/timing	
Shuswap River summer age 0.3	STh-SHUR	15	2	genetics/life-history	genetically and geographically distinct from CU#10
STh Bessette Creek	STh-BESS	16	3	genetics/life-history	similar to CU#11 but different age (1.2). Different optimum for adult size?
LTHOM spring age 1.2	LTh	17	9	ecotypic	confirmed by genetics and life history
NTHOM spring age 1.3	NTh-spr	18	6	ecotypic/timing	confirmed by genetics and life history, headwater streams
NTHOM summer age 1.3	NTh-sum	19	7	ecotypic/timing	confirmed by genetics and life history, headed by large lakes
South Coast-Georgia Str	SC+GStr	20	35	ecotypic/timing	confirmed by genetics

Conservation Unit	Acronym	index	number of sites	classification step	comments
E Vancouver Island-Goldstream	Goldstr	21	1	genetics/timing	status as wild CU uncertain
E Vancouver Island-Cowichan&Koksilah	CWCH-KOK	22	3	genetics/timing/other	relatively unimpacted by hatchery interventions
E Vancouver Island-Nanaimo Spring	NanR-Spr	23	?	genetics/timing	only spring population in JAZ
E Vancouver Island-Nanaimo Summer	NanR-Sum	24	?	genetics/timing	one of 2 summer populations in JAZ
E Vancouver Island-Nanaimo & Chemainus Fall	midEVI-Fall	25	4	genetics/timing	includes Chemainus R
E Vancouver Island-Puntledge Summer	PuntR-Sum	26	?	genetics/timing	one of 2 summer populations in JAZ
E Vancouver Island-Qualicum Puntledge Fall	QP-Fall	27	13	genetics/timing	heavily impacted by hatchery interventions and habitat loss
S Coast-Southern Fjords	SC+SFj	28	22	timing/habitat	
NE Vancouver Island	NEVI	29	12	timing/habitat	
Port San Juan	PSJ	30	3	timing/habitat	San Juan and Gordon Rivers
SW Vancouver Island	SWVI	31	49	timing/habitat	excludes feral populations associated with Robertson Creek hatchery
Nootka & Kyuquot	NoKy	32	49	timing/habitat	
NW Vancouver Island	NWVI	33	14	ecotypic	confirmed by genetics
Homathko	HOMATH	34	2	genetics	
Klinaklini	KLINA	35	2	genetics	
Docee	DOCEE	36	1	genetics/life-history	
Rivers Inlet	RI	37	13	genetics/life-history/habitat	
Wannock	WANN	38	1	genetics/life-history/habitat	
Bella Coola-Bentinck	BCR-BENT	39	7	life history/habitat	ocean type, coastal climate
Dean River	DEAN	40	3	life history/habitat	stream type, transitional climate
NCC-late timing	NCC-lake	41	10	timing/habitat	
NCC-early timing	NCC-stream	42	31	timing/habitat	
QCI-North	QCIN	43	2	ecotypic	confirmed by genetics
QCI-East	QCIE	44	5	ecotypic	confirmed by genetics; excludes Pallant Creek
Skeena Estuary	SKEst	45	3	ecotypic	
Ecstall	ECST	46	4	genetics	
Gitnadoix	GITN	47	5	genetics	

Conservation Unit	Acronym	index	number of sites	classification step	comments
Lower Skeena	LSK	48	16	genetics/timing	
Kalum-Early	KALUM-E	49	5	genetics/timing	
Kalum-Late	KALUM-L	50	4	genetics/timing	
Lakelse	Lakelse	51	5	timing	
Middle Skeena	MSK	52	8	timing/habitat	late timing small lakes
Middle Skeena-large lakes	MSK-LGLKS	53	17	timing/habitat	late timing; includes some sites in the USK JAZ
Middle Skeena mainstem tributaries	MSK-M/S	54	6	timing	very early timing
Upper Bulkley River	MSK-UprBulk	55	4	timing	middle timing; considerable hatchery intervention-wild status uncertain
Upper Skeena	USK	56	3	genetics/timing	the most interior of sites in the USK JAZ
Portland Sound-Observatory Inlet-Lower Nass	LNR-P	57	13	genetics/timing	in the Nass River, includes sites upstream to but not including the Tseax River
Upper Nass	UNR	58	16	genetics/timing	Tseax and upstream
Unuk	UNUK	59	?	ecotypic/ecology	age 1.4; late timing; inside rearing
Stikine-early timing	LSTK-early	60	6	timing/habitat	age 1.4/;early June timing; outside rearing
Stikine-late timing	LSTK-late	61	3	timing/habitat	early July timing; smaller fish than early run
Whiting	WHITING	62	?	ecotypic	no information beyond presence
Taku-early timing	TAKU-early	63	3	timing/habitat	age 1.3; mid-May timing; outside rearing
Taku-mid timing	TAKU-mid	64	1	timing/habitat	age 1.3; mid-June timing; outside rearing
Taku-late timing	TAKU-late	65	4	timing/habitat	age 1.3; early July timing; outside rearing
Lynn Canal	LYNN	66	?	ecotypic	age 1.4early July timing; late July spawning; inside rearing
Alsek	Alsek	67	2	ecotypic/timing/ecology	some sites in the Yukon Territory
Yukon River-Teslin headwaters	Teslin	68	4	genetics	some sites in the Yukon Territory

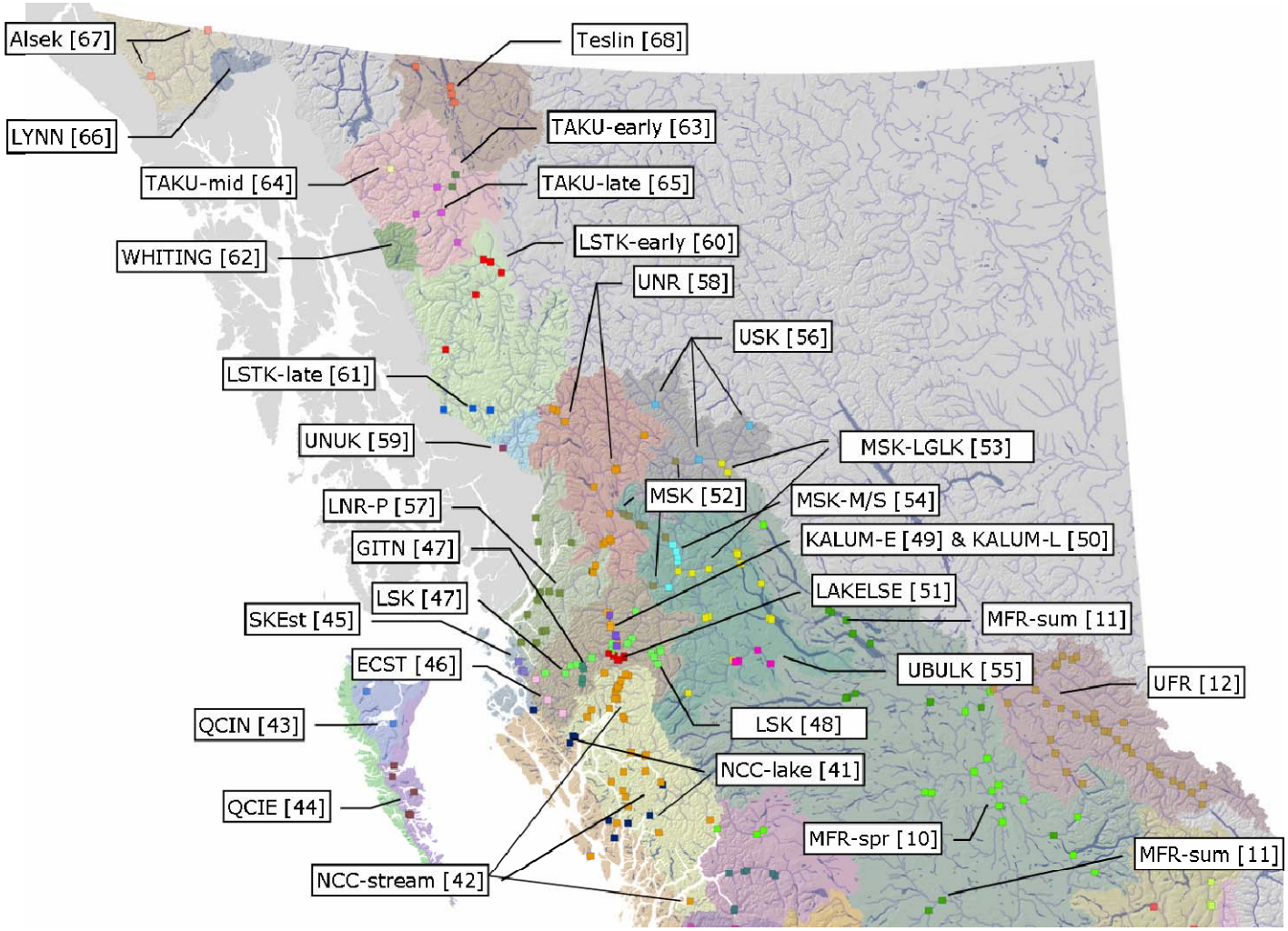

Figure 6. A map showing chinook CUs #41 to #68 in northern British Columbia and the three CUs in the middle and upper Fraser River (#10-#12). All sites within each CU are shown with color-coded symbols. The labels identify each CU by pointing to a site in the CU. The number in brackets is the CU index number

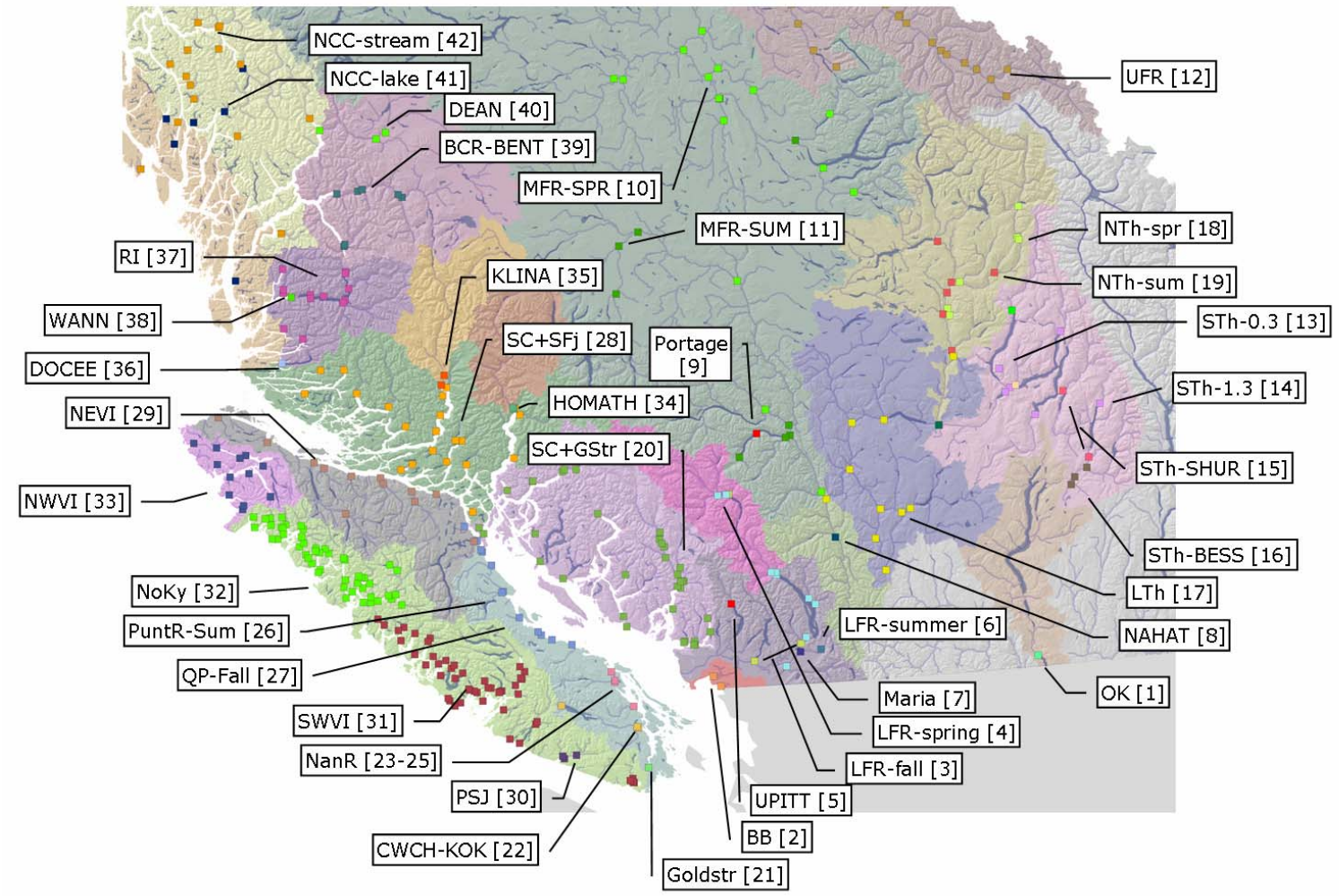

Figure 76. A map showing chinook CUs #1 to #40 in southern and central British Columbia. The northerly sites of CUs #10 to #12 (middle and upper Fraser River) are on the previous figure. All sites within each CU are shown with color-coded symbols. The labels identify each CU by pointing to a site in the CU. The number in brackets is the CU index number.

Sockeye salmon (*O. nerka*) – river type

Table 6. The 24 Conservation Units of river-type sockeye within British Columbia. Sockeye salmon are not found in the Canadian portions of the Yukon River, the Mackenzie River or Arctic Canada so this comprises all Canadian CUs. The existence of two of the CUs (UFR and SKNA-HI) is uncertain since both consist of one population of unknown status. The number of sites indicated is the total in our database and should not be interpreted as the number of sites where river-type sockeye salmon are persistently found.

Name	Acronym	index	number of sites	classification step	comments
Boundary Bay	BB	R01	1	ecotypic	Data limited
Widgeon	Widgeon	R02	1	genetics	Very distinctive genetically
Lower Fraser	LFR	R03	4	genetics	
Fraser Canyon	FRCany	R04	6	ecotypic	
Middle Fraser	MFR	R05	6	timing	Supported by genetics
Upper Fraser	UFR	R06	1	ecotypic	Status of the single site is uncertain
Thompson River	THOM	R07	2	ecotypic/timing	Genetically similar to other in MFR but timing different
East Vancouver Island & Georgia Strait	EVI-GStr	R08	25	genetics/other	Timing and timing residuals are uniform & there is only 1 genetic sample. We assumed the genetic patterning of the lake-type populations in the region
Southern Fjords	SFj	R09	11	genetics/other	
West Vancouver Island	WVI+WQCI	R10	60	timing	
NW Vancouver Island	NWVI	R11	7	timing	
Rivers - Smith Inlets	RSI	R12	4	ecotypic/other	Data limited. We assumed the same genetic patterning as lake-type, where Rivers Inlet populations are distinctive.
E Queen Charlotte Islands	EQCI	R13	5	ecotypic	weakly supported by timing
W Queen Charlotte Islands	WQCI	R14	7	ecotypic	
N Queen Charlotte Islands	NQCI	R15	3	ecotypic	
Northern Coastal Fjords	NCFj	R16	48	timing/other	Includes BCD and NC+HStr JAZ. Timing is distinctive as are the genetics of the lake-type populations.
Northern Coastal	NC	R17	20	timing/other	The HecLow+HStr JAZ. Timing is distinctive. Lake-type populations are genetically distinctive. Includes 1 site from the HecLow+NSKEst, for which there is no information.

Name	Acronym	index	number of sites	classification step	comments
Skeena River	SKNA	R18	9	genetics/timing	Includes the LSK and MSK JAZ. No differences in timing or genetics
Skeena River-high interior	SKNA-HI	R19	1	ecotypic	Only 1 site with no information and unknown status.
Lower Nass - Portland	LNR-P	R20	7	ecotypic/timing	Distinctive timing
Upper Nass River	UNR	R21	3	ecotypic/timing	Distinctive timing
Northern Transboundary Fjords	TBFj	R22	22	genetics	Includes Taku and LSTK JAZ as well as Unuk and Whiting Rivers if river-type populations are found there. No timing information. Within watershed genetic differentiation at the class-3 and class-4 levels is apparent in both major watersheds and can be explained by a simple habitat model in the Taku. Beacham et al. (2004) found no genetic differentiation in the river-type sockeye of these two systems so we have combined them all into one CU
Chilkat River	CHILKAT	R23	1	ecotypic	supported by genetics
Alsek River	ALSEK	R24	7	ecotypic	No timing information. No habitat explanation of the genetic structure at level-4 of the hierarchy. Some sites in this CU are located in the Yukon Territory.

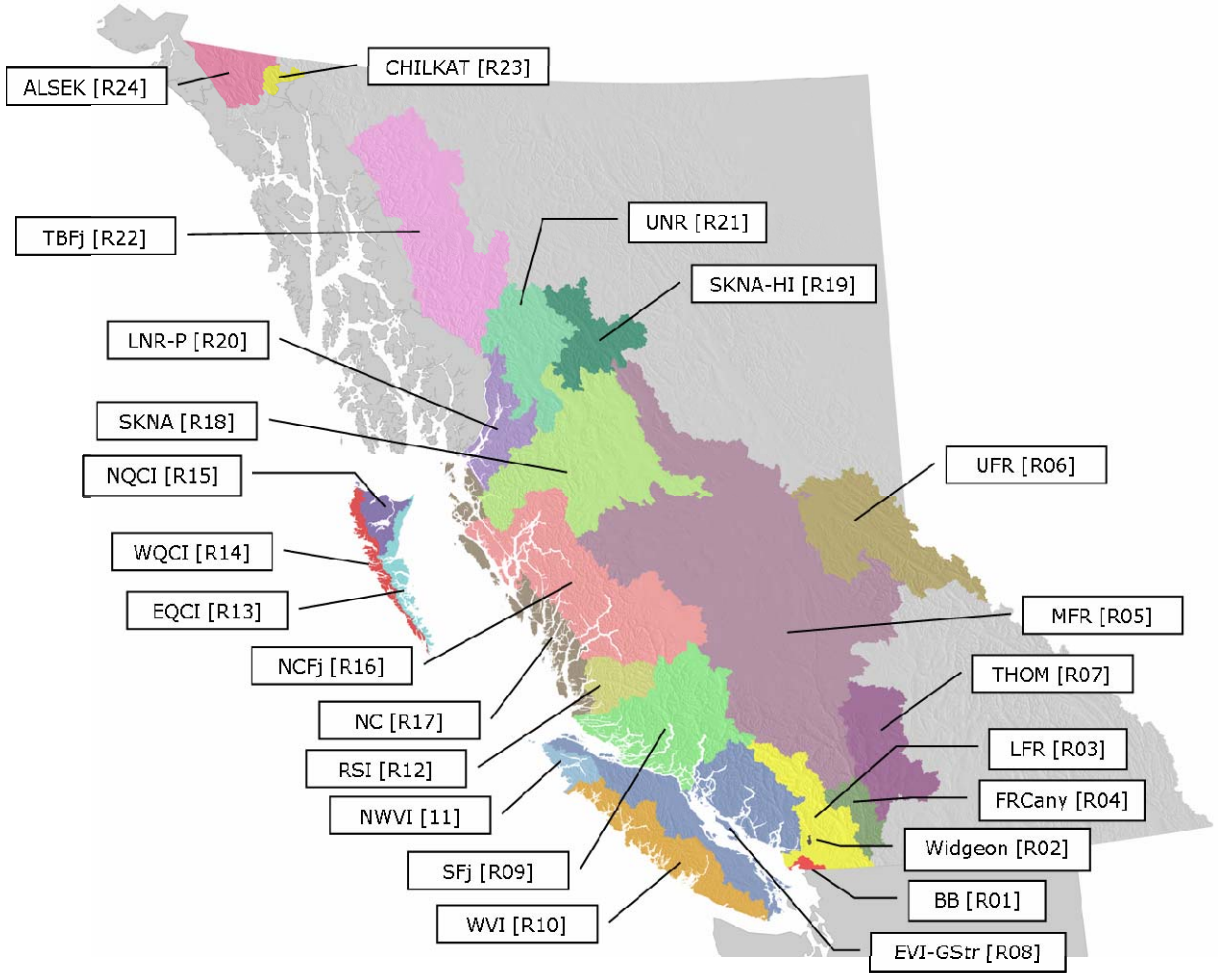

Figure 8. A map showing the 24 CUs of river-type sockeye salmon in Canada.

Sockeye salmon (*O. nerka*) – lake type

Table 7. This table contains summary information for all of the lake-type sockeye CUs in British Columbia. CUs were named after the primary nursery lake(s). In cases where the lake was unnamed, the CU is named after the stream or another geographical locator such as a local shoreline feature. The CU index identifies the type ("L"), the Freshwater Adaptive Zone of the spawning streams in the CU (not necessarily the same as the lake), and a unique number within that zone. In the Fraser River, a run-timing designation is used to describe CUs and to distinguish CUs where there are two in the same nursery lake. In chronological order, the run-timing designations are EStu (Early Stuart), ES (Early Summer), S (Summer) and L (Late or Fall). Many CUs, especially those in the Hecate Lowlands, consist of more than one nursery lake. In many cases, the lakes within a CU were small and closely hydrologically coupled. This was not always the case however. For example, the Shuswap Complex in the Thompson River drainage consists of eight lakes that are all large and that are not tightly coupled. A great deal of information was available for these lakes and their sockeye and we were unable to find any characteristics that allowed us to discriminate among the sockeye or the lakes. In other words, there was considerable gene flow, migration and spawn timing was the same, age and size were the same, and the lakes themselves were indistinguishable using the climatic, hydrologic, and geomorphologic characters that were considered. Consequently, sockeye were combined into one CU. After the CU list was finalized, table entry L-6-11 was disallowed as a CU because it is a transplanted population. The number of sites indicated is the number of sites in our database where sockeye of the associated CU are known to spawn and should not be interpreted as the total number of sites in the CU where sockeye are persistently present.

CU index	Conservation Unit	Freshwater Adaptive Zone	number of lakes	number of sites	total surface area (ha)
L-1-1	Osoyoos	Okanagan	1	1	1512
L-3-1	Chilliwack-Es	Lower Fraser	1	2	1182
L-3-2	Cultus-L	Lower Fraser	1	1	631
L-3-3	Harrison (D/S)-L	Lower Fraser	1	8	22192
L-3-4	Harrison (U/S)-L	Lower Fraser	1	4	22192
L-3-5	Pitt-Es	Lower Fraser	1	2	5348
L-4-1	Lillooet-L	Lillooet	1	8	3220
L-5-1	Kawkawa-L	Fraser Canyon	1	2	76
L-5-2	Nahatlatch-Es	Fraser Canyon	1	2	303
L-6-1	Anderson -Es	Middle Fraser	1	2	2872
L-6-2	Chilko-Es	Middle Fraser	1	1	18447
L-6-3	Chilko-S	Middle Fraser	1	3	18447
L-6-4	Francois-Es	Middle Fraser	1	3	25164
L-6-5	Francois-S	Middle Fraser	1	3	25164
L-6-6	Fraser-Es	Middle Fraser	1	2	5385
L-6-7	Fraser-S	Middle Fraser	1	1	5385
L-6-8	Mckinley-S	Middle Fraser	1	1	513
L-6-9	Nadina-Es	Middle Fraser	1	1	930
L-6-10	Quesnel-S	Middle Fraser	4	65	32863
L-6-11	Seton-L	Middle Fraser	1	1	2475
L-6-12	Stuart-Estu	Middle Fraser	1	2	35919
L-6-13	Stuart-S	Middle Fraser	1	5	35919
L-6-14	Takla/Trembleur-Estu	Middle Fraser	2	42	36253
L-6-15	Takla/Trembleur-S	Middle Fraser	2	4	36253
L-6-16	Taseko-Es	Middle Fraser	1	2	2124
L-7-1	Bowron-Es	Upper Fraser	1	2	1021

CU index	Conservation Unit	Freshwater Adaptive Zone	number of lakes	number of sites	total surface area (ha)
L-7-2	Indian/Kruger-Es	Upper Fraser	3	1	235
L-9-1	Kamloops-L	South Thompson	1	1	5517
L-9-2	Shuswap Complex-Es	South Thompson	8	22	66599
L-9-3	Shuswap Complex-L	South Thompson	6	45	40383
L-10-1	Kamloops-Es	North Thompson	2	9	6014
L-11-1	Fulmore	Southern Coastal Streams	1	1	867
L-11-2	Heydon	Southern Coastal Streams	1	1	799
L-11-3	Kakweiken	Southern Coastal Streams	1	1	32
L-11-4	Loose	Southern Coastal Streams	1	1	275
L-11-5	Mackenzie	Southern Coastal Streams	1	1	153
L-11-6	Phillips	Southern Coastal Streams	1	1	309
L-11-7	Sakinaw	Southern Coastal Streams	1	1	681
L-11-8	Tom Browne	Southern Coastal Streams	1	1	488
L-11-9	Tzoonie	Southern Coastal Streams	1	1	19
L-11-10	Village Bay	Southern Coastal Streams	1	1	101
L-12-1	Ida/Bonanza	East Vancouver Island	2	1	991
L-12-2	Nahwitti	East Vancouver Island	1	1	245
L-12-3	Nimpkish	East Vancouver Island	1	1	3679
L-12-4	Georgie/Songhees	East Vancouver Island	2	1	508
L-12-5	Quatse	East Vancouver Island	1	1	152
L-12-6	Schoen	East Vancouver Island	1	1	246
L-12-7	Shushartie	East Vancouver Island	1	1	25
L-12-8	Woss	East Vancouver Island	1	1	1379
L-13-1	Alice	West Vancouver Island	1	1	1074
L-13-2	Canoe Creek	West Vancouver Island	1	1	29
L-13-3	Cecilia	West Vancouver Island	2	1	46
L-13-4	Cheewat	West Vancouver Island	1	1	138
L-13-5	Clayoquot	West Vancouver Island	1	1	49
L-13-6	Deserted	West Vancouver Island	1	1	40
L-13-7	Fairy	West Vancouver Island	1	2	32
L-13-8	Great Central	West Vancouver Island	1	2	5328
L-13-9	Henderson	West Vancouver Island	1	1	1552
L-13-10	Hesquiat	West Vancouver Island	1	1	471
L-13-11	Hobiton	West Vancouver Island	1	1	363
L-13-12	Jansen	West Vancouver Island	1	1	54
L-13-13	Kanim	West Vancouver Island	1	1	120
L-13-14	Kennedy	West Vancouver Island	1	7	6542
L-13-15	Maggie	West Vancouver Island	1	1	238
L-13-16	Megin	West Vancouver Island	1	1	167
L-13-17	Muchalat	West Vancouver Island	1	3	531

CU index	Conservation Unit	Freshwater Adaptive Zone	number of lakes	number of sites	total surface area (ha)
L-13-18	Muriel	West Vancouver Island	1	1	162
L-13-19	Nitinat	West Vancouver Island	1	1	2733
L-13-20	O'Connell	West Vancouver Island	1	1	121
L-13-21	Owossitsa	West Vancouver Island	1	1	69
L-13-22	Park River	West Vancouver Island	2	1	24
L-13-23	Power	West Vancouver Island	1	1	65
L-13-24	Sooke	West Vancouver Island	1	1	589
L-13-25	Sproat	West Vancouver Island	1	1	4233
L-13-26	William/Brink	West Vancouver Island	2	1	208
L-15-1	Long	Rivers - Smith Inlets	1	3	2133
L-15-2	Owikeno	Rivers - Smith Inlets	1	9	9302
L-15-3	Owikeno-Late	Rivers - Smith Inlets	1	3	9302
L-15-4	Wannock[Owikeno]	Rivers - Smith Inlets	1	2	9302
L-16-1	South Atnarko Lakes	Bella Coola - Dean Rivers	1	3	9302
L-17-1	Ain/Skundale/Ian	Queen Charlottes	3	1	2084
L-17-2	Awun	Queen Charlottes	1	1	480
L-17-3	Fairfax	Queen Charlottes	1	3	35
L-17-4	Jalun	Queen Charlottes	1	2	105
L-17-5	Marian	Queen Charlottes	1	1	167
L-17-6	Mathers	Queen Charlottes	1	1	170
L-17-7	Mercer	Queen Charlottes	1	1	107
L-17-8	Skidegate	Queen Charlottes	1	1	712
L-17-9	Yakoun	Queen Charlottes	1	1	820
L-18-1	Backland	Northern Coastal Streams	1	1	101
L-18-2	Canoona	Northern Coastal Streams	1	1	348
L-18-3	Dome	Northern Coastal Streams	1	1	44
L-18-4	Evelyn	Northern Coastal Streams	1	1	57
L-18-5	Kainet Creek	Northern Coastal Streams	1	1	62
L-18-6	Kimsquit	Northern Coastal Streams	1	1	165
L-18-7	Kitkiata	Northern Coastal Streams	1	1	264
L-18-8	Kitlope	Northern Coastal Streams	1	1	1171
L-18-9	Pine River	Northern Coastal Streams	1	1	54
L-18-10	Soda Creek	Northern Coastal Streams	2	1	222
L-18-11	Whalen	Northern Coastal Streams	1	1	2140
L-19-1	Banks	Hecate Lowlands	1	1	164
L-19-2	Bloomfield	Hecate Lowlands	1	1	147
L-19-3	Bolton Creek	Hecate Lowlands	6	1	39
L-19-4	Bonilla	Hecate Lowlands	2	2	258
L-19-5	Borrowman Creek	Hecate Lowlands	2	1	26
L-19-6	Busey Creek	Hecate Lowlands	2	1	76
L-19-7	Cartwright Creek	Hecate Lowlands	2	1	46
L-19-8	Chic Chic	Hecate Lowlands	1	1	162
L-19-9	Citeyats	Hecate Lowlands	2	1	355
L-19-10	Fannie Cove	Hecate Lowlands	1	1	262
L-19-11	Curtis Inlet	Hecate Lowlands	1	1	275
L-19-12	Dallain Creek	Hecate Lowlands	2	1	20
L-19-13	Deer	Hecate Lowlands	4	1	326
L-19-14	Devon	Hecate Lowlands	1	1	173
L-19-15	Douglas Creek	Hecate Lowlands	2	1	11

CU index	Conservation Unit	Freshwater Adaptive Zone	number of lakes	number of sites	total surface area (ha)
L-19-16	Elizabeth	Hecate Lowlands	1	1	641
L-19-17	Elsie/Hoy	Hecate Lowlands	2	1	146
L-19-18	End Hill Creek	Hecate Lowlands	1	1	119
L-19-19	Evinrude Inlet	Hecate Lowlands	3	1	224
L-19-20	Freeda	Hecate Lowlands	2	1	205
L-19-21	Hartley Bay	Hecate Lowlands	2	1	283
L-19-22	Hevenor Inlet	Hecate Lowlands	2	1	114
L-19-23	Higgins Lagoon	Hecate Lowlands	1	1	13
L-19-24	Kadjusdis River	Hecate Lowlands	1	1	52
L-19-25	Kdelmashan Creek	Hecate Lowlands	3	1	43
L-19-26	Keecha	Hecate Lowlands	1	1	326
L-19-27	Kent Inlet Lagoon Creek	Hecate Lowlands	1	1	99
L-19-28	Kenzuwash Creeks	Hecate Lowlands	1	1	68
L-19-29	Keswar Creek	Hecate Lowlands	1	1	99
L-19-30	Kildidt Creek	Hecate Lowlands	1	1	96
L-19-31	Kildidt Lagoon Creek	Hecate Lowlands	1	1	50
L-19-32	Kisameet	Hecate Lowlands	1	1	134
L-19-33	Koeye	Hecate Lowlands	1	1	449
L-19-34	Kooryet	Hecate Lowlands	1	1	498
L-19-35	Kunsoot River	Hecate Lowlands	1	1	15
L-19-36	Kwakwa Creek	Hecate Lowlands	1	1	78
L-19-37	Lewis Creek	Hecate Lowlands	3	1	63
L-19-38	Limestone Creek	Hecate Lowlands	2	1	35
L-19-39	Lowe/Simpson/Weir	Hecate Lowlands	3	1	1686
L-19-40	Mary Cove Creek	Hecate Lowlands	1	1	31
L-19-41	McDonald Creek	Hecate Lowlands	4	1	23
L-19-42	Mcloughlin	Hecate Lowlands	1	1	23
L-19-43	Mikado	Hecate Lowlands	1	1	148
L-19-44	Monckton Inlet Creek	Hecate Lowlands	2	1	21
L-19-45	Namu	Hecate Lowlands	1	1	319
L-19-46	Port John	Hecate Lowlands	1	1	92
L-19-47	Powles Creek	Hecate Lowlands	2	1	49
L-19-48	Price Creek	Hecate Lowlands	1	1	93
L-19-49	Prudhomme	Hecate Lowlands	1	2	182
L-19-50	Roderick	Hecate Lowlands	1	1	595
L-19-51	Ryan Creek	Hecate Lowlands	2	1	46
L-19-52	Salter	Hecate Lowlands	1	1	65
L-19-53	Scoular/Kilpatrick	Hecate Lowlands	2	1	94
L-19-54	Shawatlan	Hecate Lowlands	1	1	163
L-19-55	Sheneeza Inlet	Hecate Lowlands	1	1	42
L-19-56	Ship Point Creek	Hecate Lowlands	1	1	39
L-19-57	Spencer Creek	Hecate Lowlands	1	1	50
L-19-58	Stannard Creek	Hecate Lowlands	5	1	39
L-19-59	Talamoosa Creek	Hecate Lowlands	2	1	53
L-19-60	Tankeeah River	Hecate Lowlands	1	1	150
L-19-61	Treneman Creek	Hecate Lowlands	4	1	36
L-19-62	Tsimtack/Moore/Roger	Hecate Lowlands	3	1	560

CU index	Conservation Unit	Freshwater Adaptive Zone	number of lakes	number of sites	total surface area (ha)
L-19-63	Tuno Creek East	Hecate Lowlands	2	1	87
L-19-64	Tuno Creek West	Hecate Lowlands	2	1	44
L-19-65	Tyler Creek	Hecate Lowlands	2	1	60
L-19-66	Wale Creek	Hecate Lowlands	3	1	314
L-19-67	Watt Bay	Hecate Lowlands	1	1	53
L-19-68	West Creek	Hecate Lowlands	1	1	22
L-19-69	Yaaklele Lagoon	Hecate Lowlands	2	1	32
L-19-70	Yeo	Hecate Lowlands	1	1	83
L-20-1	Alastair	Lower Skeena	1	3	684
L-20-2	Aldrich	Lower Skeena	1	1	76
L-20-3	Dennis	Lower Skeena	1	1	89
L-20-4	Ecstall/Lower	Lower Skeena	2	1	125
L-20-5	Johnston	Lower Skeena	1	1	188
L-20-6	Kitsumkalum	Lower Skeena	1	6	1905
L-20-7	Lakelse	Lower Skeena	1	7	1368
L-20-8	Mcdonell	Lower Skeena	1	2	226
L-21-1	Atna	Middle Skeena	1	1	513
L-21-2	Babine	Middle Skeena	1	30	46499
L-21-3	Bulkley	Middle Skeena	1	1	240
L-19-4	Club	Hecate Lowlands	2	2	258
L-21-5	Kitwancool	Middle Skeena	1	1	777
L-21-6	Maxan	Middle Skeena	1	1	643
L-21-7	Morice	Middle Skeena	1	3	9708
L-21-8	Nilkitkwa	Middle Skeena	1	1	483
L-21-9	Stephens	Middle Skeena	1	2	189
L-21-10	Swan	Middle Skeena	1	5	1738
L-21-11	Tahlo/Morrison	Middle Skeena	2	2	1460
L-22-1	Asitika	Upper Skeena	1	1	37
L-22-2	Azuklotz	Upper Skeena	1	1	165
L-22-3	Bear	Upper Skeena	1	3	1894
L-22-4	Damshilgwit	Upper Skeena	1	1	32
L-22-5	Johanson	Upper Skeena	2	1	195
L-22-6	Kluatantan	Upper Skeena	1	1	27
L-22-7	Kluayaz	Upper Skeena	1	1	138
L-22-8	Motase	Upper Skeena	1	1	394
L-22-9	Sicintine	Upper Skeena	1	1	69
L-22-10	Slamgeesh	Upper Skeena	1	2	45
L-22-11	Spawning	Upper Skeena	1	1	20
L-22-12	Sustut	Upper Skeena	2	1	292
L-23-1	Clements	Lower Nass - Portland	1	1	17
L-23-2	Leverson	Lower Nass - Portland	1	1	116
L-24-1	Bowser	Upper Nass	1	1	3455
L-24-2	Damdochax	Upper Nass	1	1	204
L-24-3	Fred Wright	Upper Nass	1	1	388
L-24-4	Kwinageese	Upper Nass	1	1	258
L-24-5	Meziadin	Upper Nass	1	3	3603
L-24-6	Oweegee	Upper Nass	1	1	49
L-25-1	Border	Unuk River	1	1	41
L-26-1	Christina	Lower Stikine	1	1	147

CU index	Conservation Unit	Freshwater Adaptive Zone	number of lakes	number of sites	total surface area (ha)
L-26-2	Tahltan	Lower Stikine	1	1	486
L-28-1	Kuthai	Taku	1	1	154
L-28-2	Little Trapper/Trapper	Taku	1	1	201
L-28-3	Tatsamenie	Taku	2	1	2166
L-28-4	Tatsatua	Taku	1	1	77
L-30-1	Blanchard	Alsek	1	2	118
L-30-1	Klukshu	Alsek	1	2	118
L-30-3	Neskatahin	Alsek	1	1	-

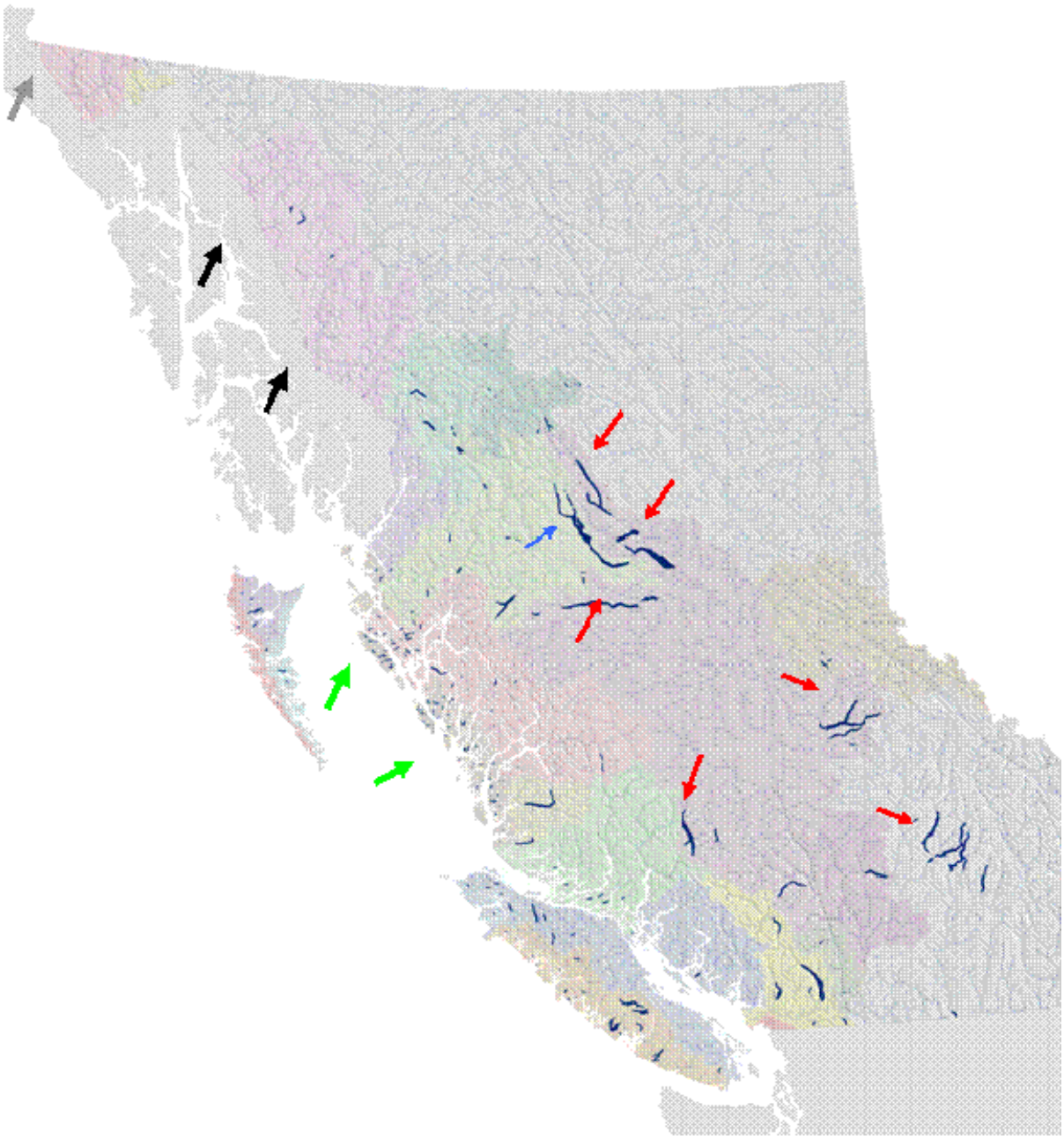

Figure 9. A map showing the nursery lakes of the 214 sockeye salmon CUs in British Columbia. Two lakes in the Yukon Territory that are in the Alsek River drainage (gray arrow) are not shown. Note the large number of small nursery lakes in the coastal areas at the center of the map (green arrows)and the relative absence of sockeye lakes in the northern transboundary area (black arrows). The large lakes of the Fraser River (red arrows) and Skeena River (blue arrow) drainages produce most of Canada's sockeye salmon.

CONCLUSION

The Pacific salmon of British Columbia and the southern Yukon Territory are extraordinarily diverse. We have identified 420 Conservation Units in Western Canada (exclusive of the Yukon and Mackenzie Rivers and the Arctic Coast). Sockeye salmon (238 CUs) and chinook salmon (68 CUs) are the most diverse and, in general, are the least abundant. In contrast, pink and chum salmon are the least diverse (32 and 39 CUs respectively) but by far the most abundant. Interestingly, there do not appear to be diversity "hot spots" except, possibly, lake-type sockeye in the central and northern coastal areas (i.e., between Cape Caution and the Skeena River).

For lake-type sockeye salmon the Conservation Unit will often be identical to the Designatable Unit of COSEWIC. For example, both of the COSEWIC designated populations (Cultus Lake and Sakinaw Lake) are also CUs (L-3-2 and L-11-7, respectively). For the other species, however, CUs will usually be nested within COSEWIC designated populations. For example, the COSEWIC designated coho population of the Interior Fraser comprises five CUs (#'s 5 to 9). This "finer" division of diversity is appropriate given the overarching objectives of the WSP. Defining the CU at a higher level in the continuum of diversity would not fully support the objectives of the WSP because the loss of a closed population (i.e., a Designative Unit) is not reversible within a reasonable time (Waples et al. 2001). Viewed from the reverse perspective, the loss of a CU might not appreciably increase the risk of extinction for the Designatable Unit and so would not necessarily result in invocation of SARA protections.

The described method is data intensive and we anticipate that the CUs identified will be regularly modified as new information becomes available and our interpretations of it improve.

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