Sockeye Salmon (*Oncorhynchus nerka*)

Supporting documentation and summary for Red List assessments at species and subpopulation levels

The Salmonid Specialist Group (SSG) of the Species Survival Commission of IUCN World Conservation Union has been focusing on range-wide status assessments of salmonids. This assessment represents the first effort to add an anadromous (that is, sea-run) Pacific salmon to the IUCN Red List of Threatened Species. We considered extinct and extant populations throughout the native range of the species, including the United States of America (States of Washington, Idaho, Oregon and Alaska), Canada (Province of British Columbia, Yukon Territory) and the Russia Federation (Kamchatka, Koryakia, Magadan, Chukotka). We assembled data on range and adult abundance (over 12 years, representing three generations) for sockeye salmon *Oncorhynchus nerka* from 243 separate spawning sites across the Pacific Rim. Using this database and some additional information, we evaluated the status of anadromous sockeye salmon at both global and subpopulation scales according to IUCN Red List criteria version 3.1.

We provide Red List categories for sockeye salmon at both the global population level and for a total of 80 subpopulations defined by freshwater and marine ecoregional groupings and genetic differentiation. The subpopulations, as a result of guidelines stipulated by IUCN, represent coarse units defined by extremely low rates of geneflow (less than or equal to one effective migrant exchanged per year) and, as a result, may contain numerous spawning sites supporting sockeye salmon adapted to specific nursery lakes or river reaches. For our global population assessment, we relied on IUCN Red List geographic-range criteria, and concluded that the species as a whole is not threatened and, thus, assess its current status as Least Concern. Out of the total of 80 subpopulations making up the global population, we were unable to assess the status of 26 of them and list them as Data Deficient. We identified five subpopulations as Extinct. Of the remaining subpopulations, nearly 35% are assessed as threatened (17 out of a total of 49 evaluated subpopulations), and an additional two as Nearly Threatened.

We quantified the trend in adult abundance (that is, the rate of change or “change rate”) for all spawning sites for which we had data. In some cases we characterized the status of a given subpopulation based on the change rate from a single spawning site. In cases where we had trend data from two or more sites, we estimated the decline rate applied to the subpopulations as the median rate of change across all spawning sites. This change rate was converted to status based on rules established by the IUCN: Vulnerable – 30-50% rate of decline, Endangered – 50-80% rate of decline, and

Critically Endangered – greater than 80% rate of decline. Subpopulations shown to be stable or increasing in abundance were identified as Least Concern. Additional IUCN criteria were applied that relate to extent of range, absolute abundance, and the quality of habitat to arrive at a final listing.

Here we assess two subpopulations as Near Threatened, three as Vulnerable, 10 as Endangered, and four as Critically Endangered. While all of the countries listed above contained threatened subpopulations, the greatest number and concentration of threatened subpopulations were located in the Province of British Columbia, Canada. Two subpopulations in the Columbia River, one that spawns in the USA and the other in Canada, show relative stability in their abundance; however, we have assessed these as Near Threatened given the degree of habitat fragmentation and the degraded quality of their migratory habitat resulting from hydropower development in the region. We present the listings in table form below (Tables 1, 2) and in the form of two maps (Figures 3a, 3b).

The key threats to the species identified by the SSG were:

- Mixed stock fishing leading to over fishing small, less productive populations
- Changing river and ocean conditions that are likely linked to global climate change, expressed in poor marine survival rates and increased incidence of disease in adult spawners
- Negative effects of hatcheries and construction of artificial spawning habitat

It is important to note that in many cases, the causes for declines in some specific sockeye salmon subpopulations remain unknown.

Needed conservation measures identified by the SSG include:

- Emphasize the pivotal role that Fisheries and Oceans Canada play in protecting sockeye salmon, and encourage them to fully implement their Wild Salmon Policy and underscore the importance of building partnerships to achieve their conservation goals
- Shift fishing pressure from coastal and lower river locations to more terminal, upriver locations to prevent mixed stock fishery effects on small, unproductive populations
- Enact rules that require measuring stock composition of catch in fisheries
- Reform and/or expand current monitoring programs where needed to improve tracking of status at a more localized, spawning site scale
- Curtail or modify enhancement activities that have been shown to lead to declines in neighboring small, unproductive stocks to reduce their threat to wild salmon
- Given we have little, direct control over ocean conditions that may lead to reduced salmon survival rates, pursue new research that focuses on other agents of mortality at different life stages to help illuminate new ways of conserving the species.

This effort sets a new precedent for identifying threatened Pacific salmon populations and helps raise awareness of wild salmon conservation at the international level. The assessment document has been formally submitted to IUCN, and, if approved by the IUCN, the species will be added to the 2008 IUCN Red List later this year.

Table 1. IUCN Red List assessments for *O. nerka* subpopulations by region

Region	Total subpopulations	Summary of assessment categories							
		Extinct	Extinct in the Wild	Critically Endangered	Endangered	Vulnerable	Near Threatened	Data Deficient	Least Concern
Russia	12				1			10	1
Transboundary (RU/AK)	1								1
Alaska	20				1	1		10	8
Transboundary (AK/BC or AK/BC/Yukon)	4				1				3
British Columbia	33			3	7	2		6	15
Transboundary (BC/WA)	3	1					1		1
State of Idaho	2	1		1					
State of Oregon	2	2							
State of Washington	3	1					1		1
TOTAL	**80**	**5**	**0**	**4**	**10**	**3**	**2**	**26**	**30**

Table 2. IUCN Red List assessments for *O. nerka* subpopulations by major river/watershed

River / Watershed	Total subpopulations	Summary of assessment categories							
		Extinct	Extinct in the Wild	Critically Endangered	Endangered	Vulnerable	Near Threatened	Data Deficient	Least Concern
Bristol Bay (Alaska)	1								1
Kodiak Island (Alaska)	1								1
Cook Inlet (Alaska)	1								1
Copper River (Alaska)	1								1
Stikine River (AK/BC Transboundary)	1								1
Nass River (BC)	1								1
Skeena River (BC)	5			1	1	1		1	1
Barkley Sound (BC)	1								1
Fraser River (BC)	11			1	3	1			6
Columbia River (BC/WA/OR/ID)	8	5		1			2		

Status assessment overview

We evaluated the status of sockeye salmon at both global population and subpopulation scales according to IUCN Red List criteria version 3.1 (IUCN 2001). The global population assessment was based on its current spatial distribution relative to 'extent of occurrence' and 'area of occupancy' thresholds defined under Red List criteria B1 and B2 (Table 3). We evaluated the status of sockeye salmon at the subpopulation level based on recent trends in abundance across indicator spawning sites relative to the quantitative decline thresholds defined by IUCN (Table 3). In addition, we applied B2 criteria (B2ab(v)) based on area of occupancy, the number of extant locations, and the rate of change in the number of mature individuals. In cases where there has been substantial declines in freshwater habitat quality, we evaluated status against B2b(iii). In addition we documented subpopulations that are 'Extinct' based on literature sources.

Below, we provide documentation on the data used in our Red List assessment, describe the methods used to define subpopulations, and characterize the analytical approaches for quantifying status and trends at the site, subpopulation, and global population levels.

Table 3. Quantitative criteria used for the global population (B1, B2) and the subpopulation (A2, B2 and D) IUCN Red List assessments of sockeye salmon. CR = Critically Endangered, EN = Endangered, VU = Vulnerable. Subpopulations identified by number in the table can be referenced in Appendix 1.

Criterion	Threshold by category		
	CR	EN	VU
A2. Percent decline over last 3 generations	80	50	30
B1. Extent of occurrence (km²)[a]	100	5,000	20,000
B2. Area of occupancy (km²)[a]	10	500	2,000
B2a. Number of locations[b]	1	≤ 5	≤ 10
D. Absolute abundance	50	500	1,000

[a]The global population did not qualify for a threatened category. We evaluated specific subpopulations (73, 74, 75) against B2 sub-criteria (B2ab(iii,v)) pertaining to fragmentation, habitat quality and absolute numbers of mature individuals (see IUCN 2001 for details).

[b]Number of sockeye juvenile nursery lakes and distinct spawning regions within a subpopulation.

Global Population Evaluation

Commercial and management organizations collect abundance data on sockeye salmon but the level of monitoring effort is not uniform across the natural range of the species (see Appendix 1). We therefore used distributional data from Augerot (2005), which covers the breeding range for the species (i.e., freshwater, relying on approach described in Standards and Petitions Working Group 2006). Distribution for the species was defined for Alaska using the Alaskan Department of Fish and Game Anadromous Waters Catalog (ADFG 2003), for British Columbia using the Department of Fisheries and Oceans' Fisheries Information Summary System (DFO 2001), for the US Pacific Northwest (Washington, Oregon, and Idaho) using Streamnet (2003), and for Russia based on the judgment of local and regional experts, as well as published accounts. Landlocked sockeye, or kokanee, exist in Japan but were not considered in this assessment. Occurrence was defined at a watershed scale using HYDRO-1K units (HYDRO-1K, 1998), a globally available GIS basin coverage derived from GTOPO-30 digital elevation model data (GTOPO-30 is based on a 30-arcsecond resolution). Extent of occurrence of the species was estimated from the total area of a convex polygon that encompassed all HYDRO-1K basins where sockeye salmon were known at one time to have occurred (ca. 150 years before present); area of occupancy was estimated from the sum of the area of all currently occupied HYDRO-1K basins (current refers to approximately 10 years before present). Estimated values were compared to the thresholds defined under Red List criteria B1 and B2 (Table 3).

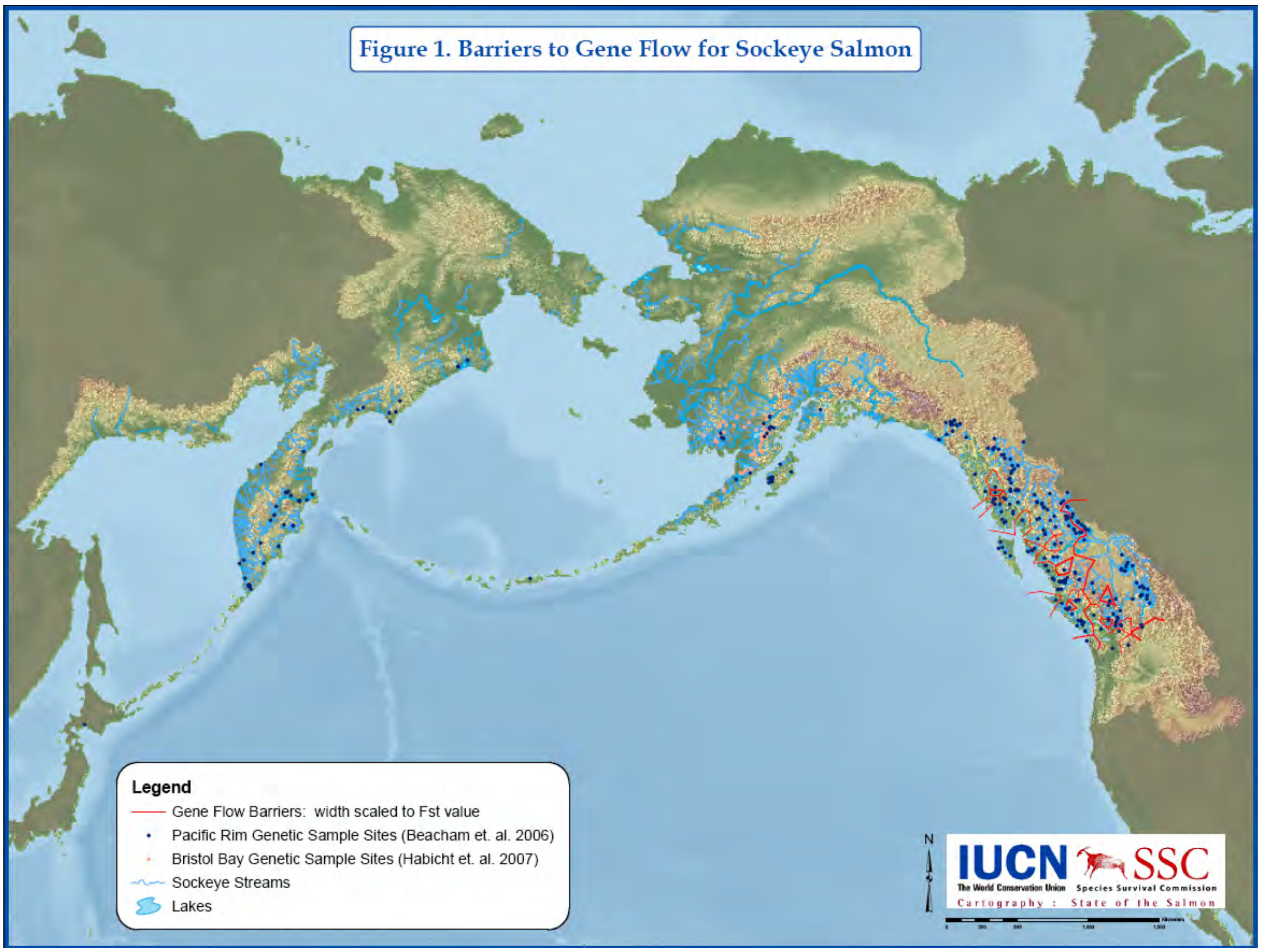
Subpopulation Evaluation

IUCN recognizes *subpopulations* as geographically or otherwise distinct groups in the global population where there is little demographic or genetic exchange. Subpopulations may, however, contain multiple local populations, which we will refer to in this assessment as *spawning sites.* The subset of all spawning sites that yield abundance data for this assessment will be referred to as *monitoring sites*. A total of 80 subpopulations were identified in this assessment (Appendix 1). We defined a total of 75 geographically distinct, extant subpopulations using a two-tiered, hierarchical filtering approach. Five other subpopulations were considered Extinct. In most cases, we identified subpopulations based on coarsely defined ecoregional groupings and then refined these units based on freshwater ecological zones (in British Columbia) and where published genetic data suggested that finer-scale divisions were warranted. We used only natural subpopulations in our assessments; no introduced subpopulations were included. The five subpopulations that were identified as Extinct were based on Gustafson *et al*. (2007).

We used the Level IV 'Salmon Ecoregions' of Augerot (2005) for our initial *subpopulation* groupings. We refer the reader to Augerot (2005) for more information on salmon ecoregions. First, in order to reduce the candidate set of Level IV ecoregions to the subset containing sockeye salmon, we selected only those ecoregions known to support the species. We made finer divisions in large watersheds in British Columbia (specifically the Skeena and Fraser Rivers) based on delineated freshwater ecoregions developed for British Columbia (http://www.pac.dfo-mpo.gc.ca/species/salmon/wsp/consultation/wspcumethod.pdf). This provides a broad habitat template that helps capture important ecological variables that drive the process of local adaptation in sockeye salmon. The units that result after consideration of marine and freshwater zonation are hereafter referred to as ecoregions. We further subdivided these ecoregions based on evidence of marked genetic differentiation. Specifically, we identified the degree of independence among putative *subpopulations* within each ecoregion using information on neutral (i.e., non-coding) DNA alleles. While we acknowledge that it is not straightforward to ascribe demographic or geographic distinctness based on observed genetic distances, we feel it is the most appropriate methodology given the scale of our assessment and the paucity of observations of stray rates among the spawning locations considered in this assessment. We acquired data from two sources to identify barriers to gene flow within an ecoregion. Our primary data source was a microsatellite-DNA baseline that represents most of the range of the species (Beacham *et al*. 2006a,b). These data include 300 spawning sites across the US, Canada, Russia and Japan (Figure 1). Our second data source was a matrix of *FST* values based on microsatellite-DNA from the Alaska Department of Fish and Game Gene Conservation Lab for 55 spawning sites in Bristol Bay, Alaska (Habicht *et al*. 2007, Figure 1). We determined geographic coordinates for all the spawning sites using a combination of agency information, topographic maps, and input from regional biologists. To determine the degree of differentiation among putative *subpopulations*, we examined the data as a matrix of *FST* values following Cavalli-Sforza chord distances (using PHYLIP v.3.63). We analyzed these data using a computational geometry that identifies both the location and direction of barriers to gene flow (using Monmonier's maximum difference algorithm implemented in BARRIER software; Manni *et al*. 2004).

Ecoregions were subdivided based on the existence of significant barriers to gene flow. This threshold was established at 0.04 *FST* across neighboring *spawning sites*. We arrived at this threshold by applying the Wright-Fisher island model with the following key assumptions: 1) a census population of

6000 individuals (computed as the median population size across all *spawning sites* in our data base), 2) a Ne:Ncensus of 0.2 (Allendorf *et al*. 1997), and 3) a threshold exchange rate between units of <0.5%. We computed barriers based on a network consisting of Thiessen polygons with each genetic sampling point represented at the center of a polygon. Wherever the threshold *FST* value was reached between two *spawning sites*, a barrier was identified in the form of an isopleth with the line centered equidistant from the two *spawning sites* (i.e. a line derived from one side of a Thiessen polygon). Once barriers were identified, we derived topographic barriers by aligning the geometric lines developed from the network to drainage boundaries based on digital elevation data. This was conducted in a total of seven ecoregions where significant genetic heterogeneity was observed (Transboundary Fjords, Nass-Skeena Estuary, Skeena River ecoregions, Hecate Strait, Puget Sound, Fraser River ecoregions, and Columbia River). Extinct *subpopulations* were identified by Gustafson *et al*. (2007).



Our analysis of barriers to gene flow revealed that heterogeneity among *spawning sites* exists within the Province of British Columbia and the State of Washington as well as among *spawning sites* near the transboundary area of the State of Alaska and the Province of British Columbia. This heterogeneity likely results from three phenomena: 1) this region likely served as a primary refugium for the species during the last major glacial period, 2) there is a high degree of reproductive isolation among populations due to the isolation of lakes and the sockeye's high level of natal-lake fidelity, and 3) the region supports many small lake populations that experience genetic drift (Figure 1). There appears to be much less genetic heterogeneity throughout most of the rest of the species range, including most of the State of Alaska and the Russia Far East. For example, Bristol Bay sockeye were relatively homogenous based on our analysis and that reported by Habicht *et al*. (2007). We relied on ecoregional boundaries to define subpopulations throughout Alaska and Russia parts of the species' natural range. Our analysis yielded a total of 80 subpopulations, including five Extinct subpopulations. A total of 50 (Appendix 1) had adequate data for a quantitative assessment of population decline.

Subpopulation dataset characterization

In order to quantify abundance trends for subpopulations, we used adult-abundance data available for all monitoring sites within its boundary (Figure 2). Data for monitoring sites within subpopulations consist of a series of annual escapement estimates, either in the form of absolute abundance or a standardized index of abundance (e.g., sightings per unit time). Together, 'escapement' and 'catch' comprise the total number of adults headed to the spawning grounds. Escapement is therefore the portion of the returning adults that passes (i.e., 'escapes') a fishery and thus potentially contributes to the next generation. Our analysis does not distinguish the type of fishery involved; for example, it does not account for take by commercial, aboriginal, recreational or illegal fisheries. Instead, it treats 'take' as part of environmental variation (e.g. McClure *et al*. 2003) or as an agent of 'natural mortality'. The field methods for estimating escapement vary widely, and include different methods such as aerial and foot surveys, tower, weir, sonar and combinations thereof, as well as different levels of intensity such as a single aerial survey on a river and repeated aerial surveys on another river.

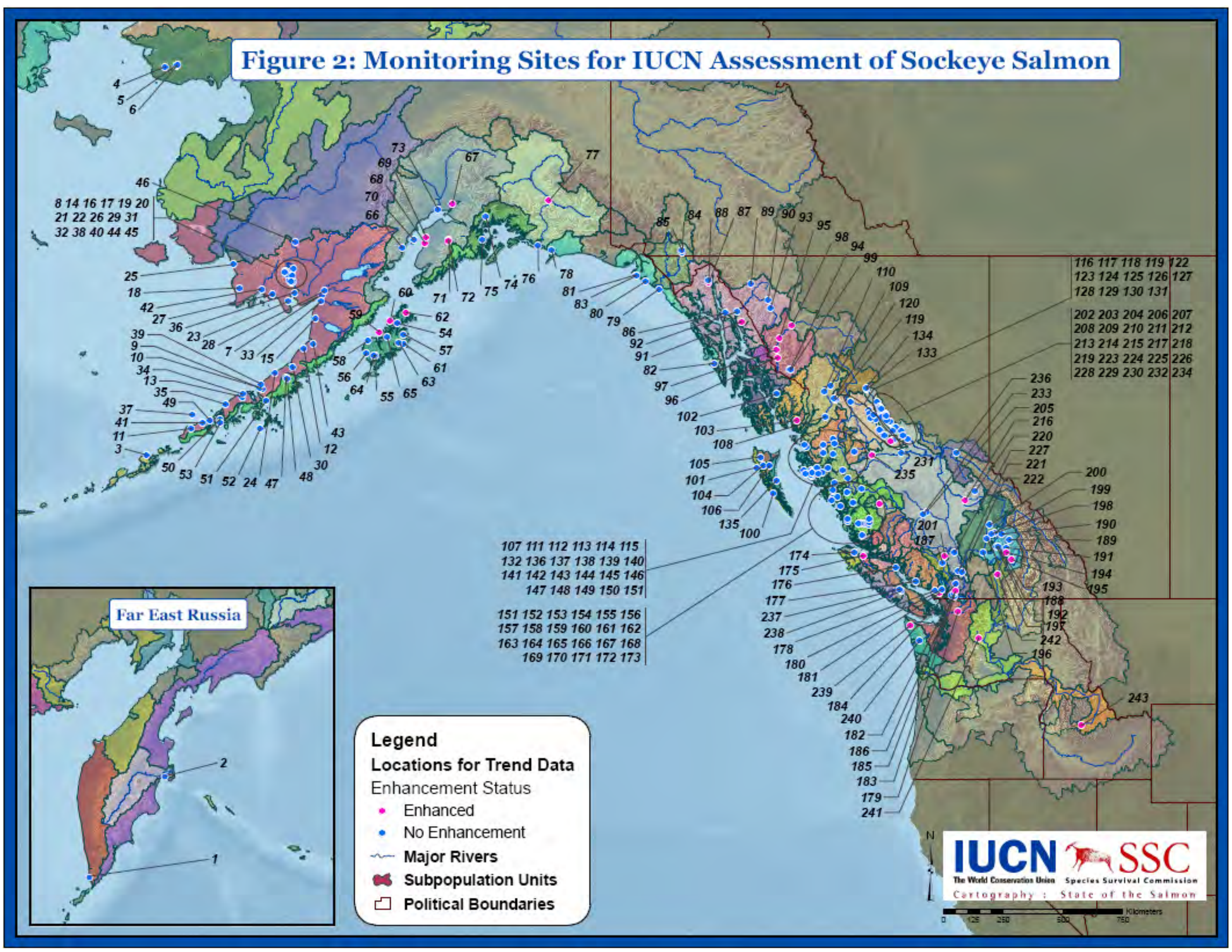


Figure 2: Monitoring Sites for IUCN Assessment of Sockeye Salmon

Although we identify monitoring sites as enhanced, through either hatchery releases or the construction of artificial spawning channels, or not enhanced (Figure 2), we do not partition escapement into those adults produced by natural versus enhanced means due to lack of adult identification in the majority of cases. Additionally, our evaluation includes datasets originating from escapement monitoring conducted at two levels of biological organization: Tier 3 is higher resolution and includes data on individual spawners on, or in close proximity to, the spawning sites (analogous to populations, local populations, and/or demes), while Tier 2 monitoring represent a more aggregated count of spawners that may represent individuals migrating to more than one spawning site (akin to metapopulations). We treated Tier 3 and Tier 2 data similarly in our assessment; however, in cases where there were nested tiers within a given subpopulation (i.e. where a Tier-2 monitoring effort encompassed one or more Tier3 datasets within the same subpopulation) we used Tier 3 over Tier 2 data due to its finer biological resolution.

Within subpopulations, we included only those spawning sites that have been monitored using documented methods on a long-term (12 years) and continuous basis (complete data for at least 60% of the time series). Given these inclusion criteria, 49 of the 80 delineated subpopulations have adequate data for quantitative assessment (Appendix 1). The 49 subpopulations assessed had escapement time-series data for an average of five monitoring sites (standard deviation = 8; Appendix 1; data sources are listed below).

A2 criteria: We analyzed recent escapement trends at the scale of individual *monitoring sites* and scaled these results upwards to characterize the Red-List status of *subpopulations* against A2 criteria (i.e., decline-based where the reduction or its causes may not have ceased or may not be understood or many not be reversible, Table 3; IUCN 2001).

There were a number of subpopulations for which escapement data were collected on both an absolute and index basis (Appendix 2). For purposes of this analysis, we estimated the decline rate of the subpopulation as the median rate of change across all monitoring sites within the subpopulation boundary. Thus, all monitoring sites contribute equally to the assessment of each subpopulation, recognizing the important of maintaining population heterogeneity as fundamental to the conservation of sockeye salmon (sensu Hilborn *et al*. 2003). In the following section, we characterize our analysis methods for individual monitoring sites followed by a description of our subpopulation-scaling approach.

Within subpopulations, we estimated the average abundance (i.e., escapement, N) change over the most recent three generations (i.e., 12 years) for individual monitoring sites using a least-squares regression approach. Before estimating population change, however, we attempted to minimize the influence of observer variability on results by using a simple error-filtering approach. In particular, given that escapement data are prone to an unknown but high degree of random observer error (e.g., due to incomplete census information, age-structure variation, methodological limitations, and other factors; Holmes 2001; Paulsen *et al*. 2007), we transformed each data series of length l years (where l = 15 yrs) to one comprised of four-year running averages and a length l-3 (i.e., 12 yrs). We then estimated the average three-generation change in escapement based on the fitted relationship between loge(N) and year (t); the rate of change across a three-generation time window was estimated based on predicted abundance at t=0 and $t=t_{max}$ [i.e., % change = $(Nt0-Nt_{max})/ Nt0*100$].

Before scoring three-generation trends for subpopulations against A2 criteria (decline-rate criteria, see Table 3; IUCN 2001), we had to characterize their status quantitatively based on estimated (i.e., regression-based) abundance changes for their constituent monitoring sites. We assigned each subpopulation the three-generation change rate (%) equivalent to the median (i.e. 50^{th} percentile) of its constituent monitoring site change-rate distribution. In application, if the median decline rate for a subpopulation was greater than the A2 threshold for critically endangered (CR), endangered (EN), or vulnerable (VU), we classified that subpopulation accordingly. A threatened status against A2 criteria was deemed unnecessary otherwise (i.e., Least Concern, LC, was assigned).

B2 criteria: In addition, we applied B criteria to all subpopulations. To be considered threatened under B criteria, it was necessary to determine if the geographic range falls below a certain threshold, if the subpopulation is severely fragmented or know to exist at a limited number of locations, and whether the subpopulation is declining in the number of mature individuals. We conclude that salmon do not undergo "extreme fluctuations" (criterion B2c) and hence we did not consider that criteria in this assessment. Geographic range (i.e., area of occupancy) was estimated for the evaluated subpopulation based on a one square kilometer grid overlaid on all known nursery lakes and river segments identified as spawning and rearing habitat. Locations, as defined by IUCN, "… defines a geographically or ecologically distinct area in which a single threatening event can rapidly affect all individuals of the taxon present". In this assessment, we consider each nursery lake or separate, distinct spawning region as a location. Subpopulations qualify for listing under B2 if the area of occupancy and the number of locations fall below the defined thresholds established by IUCN (Table 3) and the number of mature adults in the subpopulation are known to be in decline (criteria B2ab(v)).

For subpopulations known to have experienced substantial decline in freshwater habitat quality, we applied B2a,b(iii). This criteria was applied in cases where there has been extensive hydropower development that has resulted in degraded migratory habitat and altered ecosystem function.

D criteria: Finally, we considered the absolute number of mature adults (D criteria) in our assessment. If the population estimate, determined as an average escapement count over the past generation, fell below the threshold established by IUCN (Table 3), we identified them as threatened under the appropriate IUCN category.

Status

Global Population Status

At the global population level, sockeye salmon are assigned a Red List status of Least Concern (LC). With an estimated geographic range of 11.5 million km², there is no evidence of threat to the global population under criterion B1 (Table 3). Similarly, at 1.9 million km² of current occupancy (freshwater basin area), there is no evidence of threat under criterion B2 (Table 3). Approximately 7% of the historical range of sockeye salmon has been lost due to localized extinction events, but we conclude the species is not threatened globally.

Subpopulation Status

Results: Estimates of loge(N) vs. year (t) regression parameter estimates escapement dataset details for each monitoring site assessed appear in Appendix 2. Subpopulation summary statistics (including number of assessed sites, median of 3-generation change rates) and status categories against, A, B and D criteria are provided in Table 4. Finally, the Red List categories assigned to each subpopulation are presented in Table 4 and in the form of a map in Figures 3a and 3b. We briefly describe below some broad-scale patterns of our results.

Overview of status: Consistent with previous qualitative information and expert opinion (see Augerot 2005 for a review), we found that sockeye populations inhabiting southern portions of their range are in decline whereas those in northerly regions are generally stable (Figure 3a). *Subpopulations* using lake-river systems in the Hecate Strait-Queen Charlotte Sound, Georgia Basin/Vancouver Island Area, Skeena River and Fraser River, for instance, decreased in abundance considerably over the last three generations (Table 4, Figure 3b). Towards the northern end of their distribution, sockeye were generally characterized by stable-to-increasing trends in adult abundance (Table 4; for within-subpopulation exceptions at the scale of individual spawning sites, see Appendix 2; Figure 3a). There were several notable exceptions to the north-to-south risk gradient, including subpopulations in the Columbia and in eastern Washington State. It should be noted that many of these are supported through some level of artificial enhancement that may mask declines in wild populations (e.g., >200,000 hatchery juveniles released per year in Wenatchee and Okanogan subpopulations; Fish Passage Center online hatchery database, www.fpc.org, Figure 2). Further, even within large subpopulations that contain a majority of spawning sites that have stable or increasing abundance, some monitoring sites have revealed abundance declines and remain depressed in recent years (Appendix 2).

Table 4. Subpopulation (Subpop) status based on IUCN Red List Criteria A, B and D. A '--' denotes that a criterion was not assessed for a subpopulation. CR = Critically Endangered, EN = Endangered, VU = Vulnerable, LC = Least Concern, NT = Near Threatened.

Subpopulation short name	Subpop ID	Sites assessed	% 3-gen change[a]	A status	B status	D status	Overall status
WKamCur	4	1	-9	LC A2	LC B2ab(v)	LC D1	**LC**
KamRiver	7	1	-73	EN A2	LC B2ab(v)	LC D1	**EN**
BeringAKmix	13	1	186	LC A2	LC B2ab(v)	LC D1	**LC**
YukonInf	18	3	35	LC A2	LC B2ab(v)	LC D1	**LC**
SEBering	20	39	21	LC A2	LC B2ab(v)	LC D1	**LC**
Kuskokwim	21	1	-25	LC A2	LC B2ab(v)	LC D1	**LC**
WGulfAlaska	22	7	86	LC A2	LC B2ab(v)	LC D1	**LC**
Kodiak	23	12	11	LC A2	LC B2ab(v)	LC D1	**LC**
Cook	24	8	27	LC A2	LC B2ab(v)	LC D1	**LC**
PWS	25	2	113	LC A2	LC B2ab(v)	LC D1	**LC**
Copper	26	2	35	LC A2	LC B2ab(v)	LC D1	**LC**
EGulfAlaska	27	6	-46	VU A2	LC B2ab(v)	LC D1	**VU**
Alsek	28	2	37	LC A2	LC B2ab(v)	LC D1	**LC**
TF_North	29	8	12	LC A2	LC B2ab(v)	LC D1	**LC**
Stikine_Lower	35	6	26	LC A2	LC B2ab(v)	LC D1	**LC**
QCI_Outer	36	2	44	LC A2	LC B2ab(v)	LC D1	**LC**
NassSkeena_North	37	1	-58	EN A2	LC B2ab(v)	LC D1	**EN**
NassSkeena_Hugh	38	1	-49	VU A2	EN B2ab(v)	LC D1	**EN**
NassSkeena_Grah	39	3	-13	LC A2	LC B2ab(v)	LC D1	**LC**
Nass	40	5	-18	LC A2	LC B2ab(v)	LC D1	**LC**
Skeena_Lower	41	4	-45	VU A2	VU B2ab(v)	LC D1	**VU**
Skeena_Middle	43	16	128	LC A2	LC B2ab(v)	LC D1	**LC**
Skeena_Nan	44	1	-90	CR A2	EN B2ab(v)	LC D1	**CR**
Skeena_Upper	45	2	-64	EN A2	EN B2ab(v)	LC D1	**EN**
Hecate_Strait	46	9	49	LC A2	LC B2ab(v)	LC D1	**LC**
Hecate_Lowe	47	1	-36	VU A2	EN B2ab(v)	LC D1	**EN**
Hecate_Kitl	48	6	10	LC A2	LC B2ab(v)	LC D1	**LC**
Hecate_QCS	49	22	-63	EN A2	LC B2ab(v)	LC D1	**EN**
Hecate_Atn	51	1	-33	VU A2	EN B2ab(v)	LC D1	**EN**
PgtGeorgia_Quatse	52	1	1317	LC A2	LC B2ab(v)	LC D1	**LC**
PgtGeorgia_Nimpk	53	1	-3	LC A2	LC B2ab(v)	LC D1	**LC**
PgtGeorgia_Sakinaw	58	3	-93	CR A2	VU B2ab(v)	LC D1	**CR**
PgtGeorgia_Baker	59	1	81	LC A2	LC B2ab(v)	LC D1	**LC**
Fraser_Widg	60	1	136	LC A2	LC B2ab(v)	VU D1	**VU**
Fraser_Pitt	61	1	1148	LC A2	LC B2ab(v)	LC D1	**LC**
Fraser_Chill	62	2	-43	VU A2	EN B2ab(v)	LC D1	**EN**
Fraser_Lower	63	3	692	LC A2	LC B2ab(v)	LC D1	**LC**
Fraser_Birkenhead	64	1	0	LC A2	LC B2ab(v)	LC D1	**LC**
Fraser_Sthompson	65	9	191	LC A2	LC B2ab(v)	LC D1	**LC**
Fraser_Nthompson	66	4	135	LC A2	LC B2ab(v)	LC D1	**LC**
Fraser_Gat	67	1	-82	CR A2	EN B2ab(v)	LC D1	**CR**
Fraser_Middle	68	33	-77	EN A2	LC B2ab(v)	LC D1	**EN**
Fraser_Nad	69	1	170	LC A2	LC B2ab(v)	LC D1	**LC**
Fraser_Bowron	70	1	-31	VU A2	EN B2ab(v)	LC D1	**EN**
VanclslCoast	71	2	60	LC A2	LC B2ab(v)	LC D1	**LC**
SeasUpwell	72	2	229	LC A2	LC B2ab(v)	LC D1	**LC**
Columbia_Wen	73	1	174	LC A2	NT B2ab(iii)[b]	LC D1	**NT**
Columbia_Okan	74	1	466	LC A2	NT B2ab(iii)[b]	LC D1	**NT**
Columbia_Red	75	1	-81	CR A2	EN B2ab(v)	CR D	**CR**

[a]Value reflects the 50th percentile (median) of the decline-rate distribution for monitored spawning sites within a subpopulation.
[b]These subpopulations were close to qualifying for threatened status based on B2 criteria (see text for details).

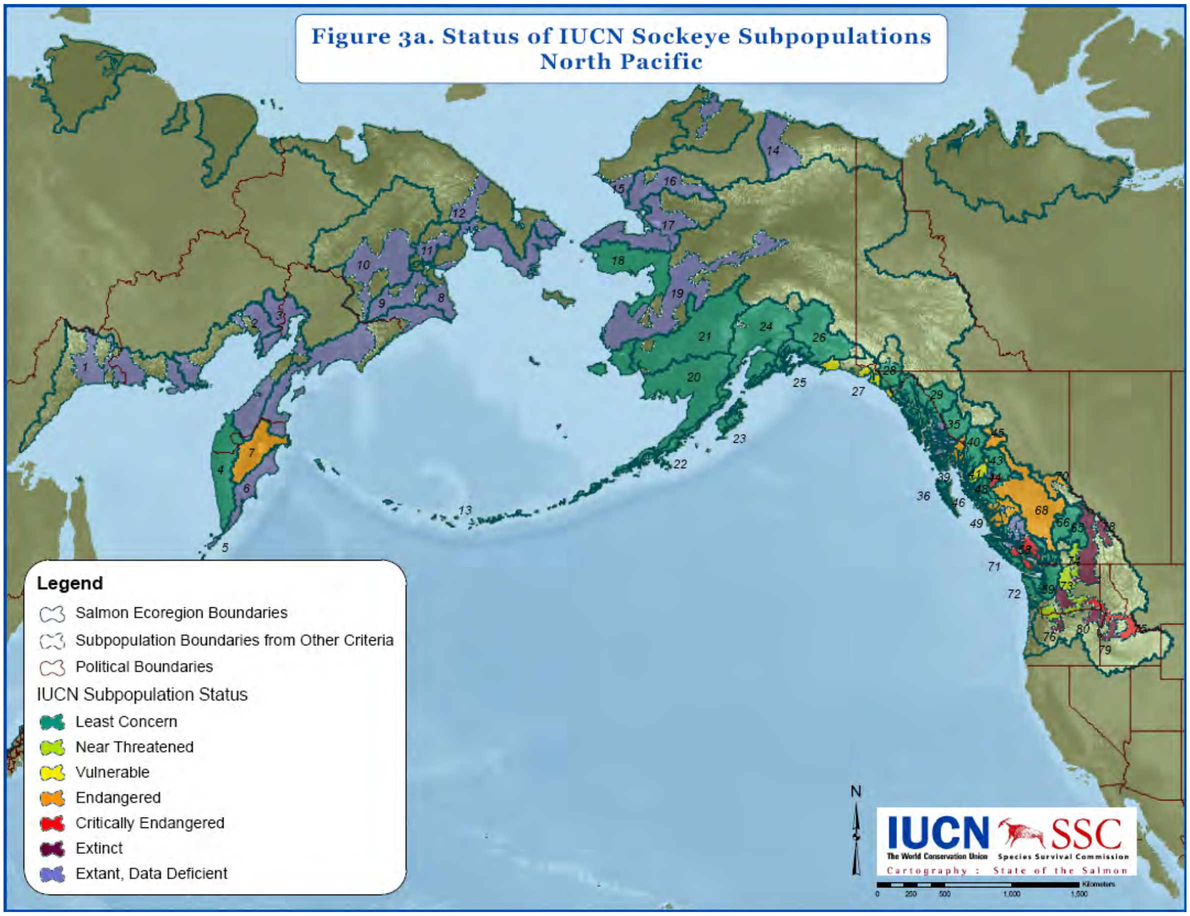


Figure 3a. Status of IUCN Sockeye Subpopulations North Pacific

In addition to abundance decline-based criteria, we considered geographic area in the context of extinction risk. A total of 11 subpopulations were determined to be threatened against B2 criteria (2 as VU, 9 as EN). In addition, we determined that subpopulations 73 and 74 (Wenatchee and Okanogan subpopulations, respectively) nearly qualified against B2 criterion considering the declining quality of the freshwater habitat supporting these subpopulations, particularly as a result of hydropower development that fragments their habitat and alters natural ecosystem function. We conclude that these two subpopulations qualify as Near Threatened because they nearly qualify against B2ab(iii) criteria.

In five cases (subpopulations 38, 47, 51, 62, and 70) B criteria returned the highest threat category based on limited area of occupancy, relatively few locations where the taxon is present, and an observed decline in mature adults.

Finally, we considered those subpopulations with abundance low enough to qualify for listing against D criteria. We conclude only two subpopulations qualify: subpopulation 60 (Widgeon Slough, as VU) and subpopulation 75 (Redfish Lake, as CR).

In summary, we propose two subpopulations to be listed as Near Threatened, three as Vulnerable, 10 as Endangered, and four as Critically Endangered (Table 4). Thus nearly 35% of assessed subpopulations are considered threatened against IUCN criteria. Further, 39% of all extant subpopulations are considered Data Deficient, and hence their status is not known. While all of the countries listed above contained threatened subpopulations, the greatest number and concentration of threatened subpopulations were located in the Province of British Columbia, Canada. Two subpopulations in the Columbia River, one that spawns in the USA and the other in Canada, show relative stability in their abundance; however, we propose to add them to the Red List as Near

Threatened given the degree of habitat fragmentation and the degraded quality of their migratory habitat resulting from hydropower development in the region. Listings for all the subpopulations are presented in Table 4 and are displayed in Figures 3a and 3b.

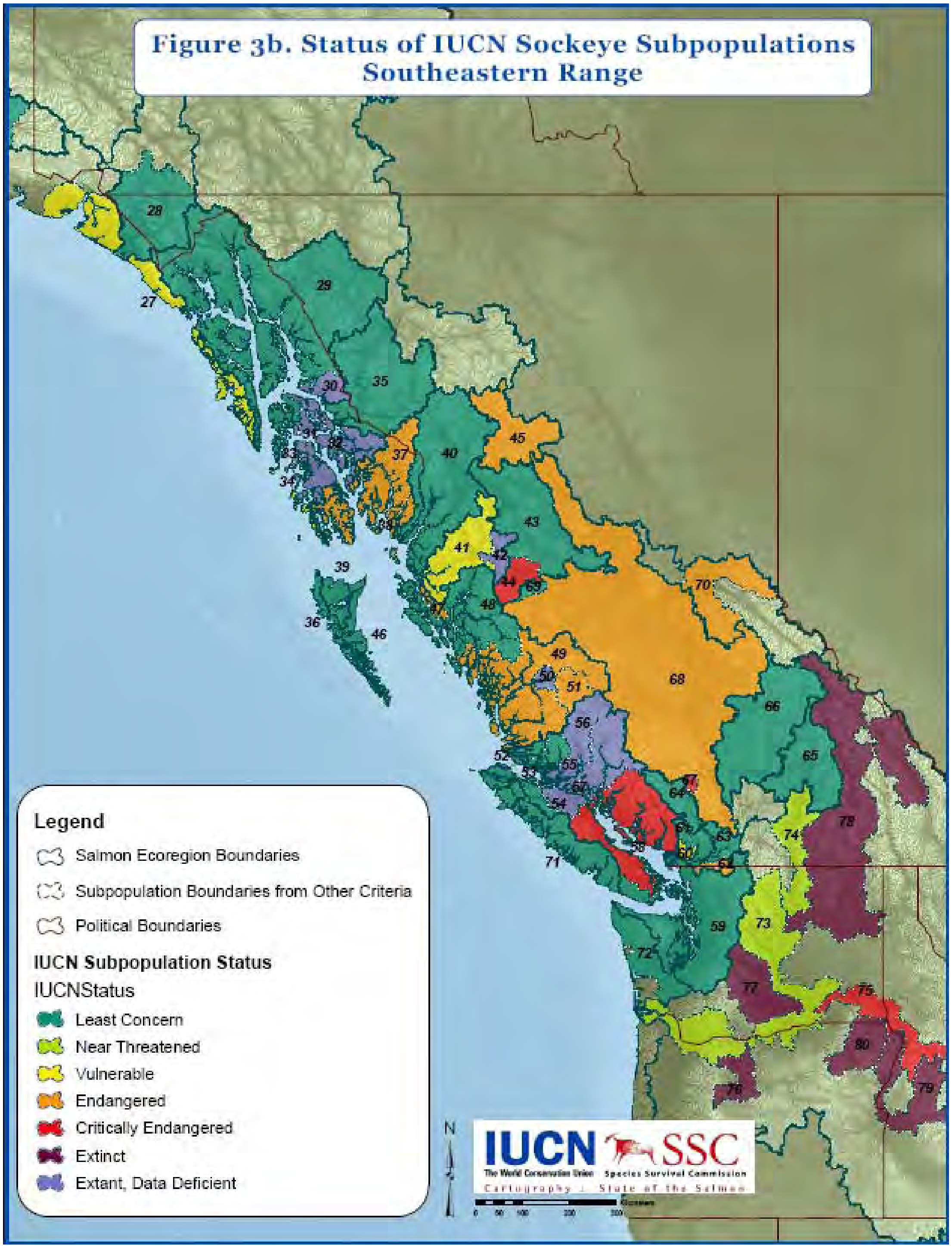


Figure 3b. Status of IUCN Sockeye Subpopulations Southeastern Range

Data sources and references

Escapement data sources:

The analysis of decline rates for this assessment relied exclusively on escapement data, defined here as that portion of a group of reproductively mature individuals in a given subpopulation that pass (‘escape’) the fishery (coastal or in-river) and are capable of spawning. Although we identified subpopulations that are enhanced through either hatchery releases or the construction of artificial spawning channels (Figure 2), we did not partition the escapement data between wild and hatchery- or spawning channel-origin individuals due to data limitations. In addition, we defined subpopulation monitoring at two discrete levels: Tier 3, which represents an individual, spawning location, and Tier 2, which represents an aggregate escapement count that integrates numerous spawning locations. For the purposes of our status assessment, we treated both Tier 2 and Tier 3 subpopulations identically in our analysis and criteria evaluation. Below we identify our sources of data:

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Bugaev, V.F. 1995. Sockeye salmon *Oncorhynchus nerka*: freshwater life period, structure of local runs, and number dynamics, Moscow, 1995.

Bugaev, V.F. and Dubynin, V.A. 2002. Factors affecting biological indicators and abundance dynamics of sockeye in the Ozernoye and Kamchatka Rivers. KamchatNIRO, Petopavlovsk-Kamchatsky, Russia.

***State of Alaska, USA**:*

University of Washington, Alaska Salmon Program, Seattle, Washington (Contact: T. Quinn)

Natural Resources Consultants, Seattle, Washington (Contact: G. Ruggerone)

Alaska Department of Fish and Game (primarily data obtained from Area Management Reports)

***British Columbia**:*

Department of Fisheries and Oceans, Nanaimo, British Columbia (NuSEDS data base)

LGL, Limited, Sydney, British Columbia (Contact: Karl English)

***State of Washington, USA**:*

Washington Department of Fisheries and Wildlife (SASI data base)

Columbia River Intertribal Fish Commission, Portland, Oregon, USA (Contact: Jeff Fryer)

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Appendix 1

Subpopulation (SP) metadata

'Assessment status' corresponds to whether or not the status of a given subpopulation could be assessed using quantitative criteria ('DD' = Data Deficient, 'E' = evaluated, 'EX' = Extinct).

The value provided under 'Sites assessed' is the number of spawning sites for which trend data were available for the assessment.

The position of the subpopulations are indicated in separate columns (continent, country, and state/province/oblast). Transboundary subpopulations are indicated using slashes, and if listing for the subpopulation is based solely on spawning sites assessed in a single jurisdiction, the names of the continent, country or state/province/oblast where the locations are found are provided in parentheses.

Nomenclature used for full names of Sockeye subpopulations is based on the following rules: 1) names in upper case indicate marine/freshwater ecoregional groupings (Augerot *et al*. 2006, BC Provincial freshwater zones); 2) for those ecoregions delineated further based on either genetic divergence criteria or extinct evolutionarily significant units described by Gustafson *et al*. (2007), the ecoregion is followed by a colon and a name in proper case referring to rivers or lakes supporting the species.

Names of water bodies were listed separately if water bodies are distinct, but are separated by a slash if water bodies are contiguous. In cases where more than two water bodies exist as distinct sites in the subpopulation, we either: 1) list the two water bodies that bracket the longitudinal extent of their distribution along the river network and separated the names by the word 'to'; or 2) provide a regional name. AS = Asia, NA = North America, RUS = Russian Federation, US = United States of America, CAN = Canada, WA = State of Washington, ID = State of Idaho, OR = State of Oregon, BC = Province of British Columbia, YK = Yukon Territory.

Subpopulation short name	Subpop ID	Subpopulation name[a]	Continent	Country	St./Prov./Oblast	Assessment status	Sites assessed
OkhotskCold	1	SEA OF OKHOTSK CURRENT (COLD)	AS	RUS	Khabarovsk/ Magadan	DD	0
Shelikhov	2	SHELIKHOV GULF (COLD)	AS	RUS	Magadan/ Koryakia	DD	0
PenzIntracoast	3	PENZHINA INTRACOASTAL	AS	RUS	Magadan/ Koryakia	DD	0
WKamCur	4	WESTERN KAMCHATKA CURRENT (WARM)	AS	RUS	Kamchatka/ Koryakia	E	1
OkOyMix	5	OKHOTSK-OYASHIO MIXING	AS	RUS	Kamchatka	DD	0
BeringKam	6	BERING SLOPE/KAMCHATKA CURRENTS	AS	RUS	Kamchatka/ Koryakia/ Chukotka	DD	0
KamRiver	7	KAMCHATKA RIVER	AS	RUS	Kamchatka	E	1
AnadyrCur	8	ANADYR CURRENT	AS	RUS	Chukotka	DD	0
Velikaya	9	VELIKAYA RIVER	AS	RUS	Chukotka	DD	0
AnadyrRiver	10	ANADYR RIVER	AS	RUS	Chukotka	DD	0
KanchRiver	11	KANCHALAN RIVER	AS	RUS	Chukotka	DD	0
WestArcCurr	12	WESTERN ARCTIC CURRENT (COLD)	AS	RUS	Chukotka	DD	0
BeringAKmix	13	BERING-ALASKAN MIXING	NA/AS (NA)	US/RUS (US)	Kamchatka/AK (AK)	E	1
EastArc	14	EASTERN ARCTIC (COLD)	NA	US	AK	DD	0
EastArcCurr	15	EASTERN ARCTIC CURRENT (WARM)	NA	US	AK	DD	0

Subpopulation short name	Subpop ID	Subpopulation name[a]	Continent	Country	St./Prov./Oblast	Assessment status	Sites assessed
Noatak	16	NOATAK RIVER	NA	US	AK	DD	0
Kobuk	17	KOBUK RIVER	NA	US	AK	DD	0
YukonInf	18	YUKON RIVER INFLUENCE	NA	US	AK	E	3
YukonRiver	19	YUKON RIVER	NA	US	AK	DD	0
SEBering	20	SOUTHEAST BERING SEA INNER SHELF	NA	US	AK	E	39
Kuskokwim	21	KUSKOKWIM RIVER	NA	US	AK	E	1
WGulfAlaska	22	ALASKA COASTAL DOWNWELLING, WESTERN GULF OF ALASKA	NA	US	AK	E	7
Kodiak	23	KODIAK ISLAND	NA	US	AK	E	12
Cook	24	COOK INLET	NA	US	AK	E	8
PWS	25	PRINCE WILLIAM SOUND	NA	US	AK	E	2
Copper	26	COPPER RIVER	NA	US	AK	E	2
EGulfAlaska	27	ALASKA COASTAL DOWNWELLING, EASTERN GULF OF ALASKA	NA	US	AK	E	6
Alsek	28	ALSEK RIVER	NA	CAN/US (CAN)	AK/BC/YK (YK)	E	2
TF_North	29	TRANSBOUNDARY FJORDS: North	NA	CAN/US	AK/BC	E	8
TF_Petersburg	30	TRANSBOUNDARY FJORDS: Petersburg Lk/N Kupreanof Is	NA	US	AK	DD	0
TF_Kah	31	TRANSBOUNDARY FJORDS: Kah Sheets Lk/S Kupreanof Is	NA	US	AK	DD	0
TF_Mid	32	TRANSBOUNDARY FJORDS: Kunk Lk/E Etolin Is	NA	US	AK	DD	0
TF_Shipley	33	TRANSBOUNDARY FJORDS: Shipley Lk/N Kosciusko Is	NA	US	AK	DD	0
TF_South	34	TRANSBOUNDARY FJORDS: South	NA	US	AK	DD	0
Stikine_Lower	35	STIKINE RIVER, LOWER	NA	CAN/US (CAN)	AK/BC (BC)	E	6
QCI_Outer	36	OUTER GRAHAM ISLAND	NA	CAN	BC	E	2
NassSkeena_North	37	NASS-SKEENA ESTUARY: North of Nass	NA	CAN/US (US)	AK/BC (AK)	E	1
NassSkeena_Hugh	38	NASS-SKEENA ESTUARY: Hugh Smith Lk/Boca de Quadra	NA	US	AK	E	1
NassSkeena_Grah	39	NASS-SKEENA ESTUARY: N Graham Is	NA	CAN	BC	E	3
Nass	40	NASS RIVER	NA	CAN	BC	E	5
Skeena_Lower	41	SKEENA R, LOWER: Kitsukalum, Lakelse, Gitnadoix R	NA	CAN	BC	E	4
Skeena_McDon	42	SKEENA R, LOWER: McDonnel Lk/Zymoetz R		CAN	BC	DD	0
Skeena_Middle	43	SKEENA R, MIDDLE: Babine, Kispiox R	NA	CAN	BC	E	16
Skeena_Nan	44	SKEENA R, MIDDLE: Nanika Lk/Morice R	NA	CAN	BC	E	1
Skeena_Upper	45	SKEENA R, UPPER	NA	CAN	BC	E	2
Hecate_Strait	46	HECATE STRAIT-Q.C. SOUND: Hecate Strait	NA	CAN	BC	E	9
Hecate_Lowe	47	HECATE STRAIT-Q.C. SOUND: Lowe Lk/Granville Ch	NA	CAN	BC	E	1
Hecate_Kitl	48	HECATE STRAIT-Q.C. SOUND: Kitimat to Kitlope R	NA	CAN	BC	E	6

Subpopulation short name	Subpop ID	Subpopulation name[a]	Continent	Country	St./Prov./Oblast	Assessment status	Sites assessed
Hecate_QCS	49	HECATE STRAIT-Q.C. SOUND: Queen Charlotte Sound	NA	CAN	BC	E	22
Hecate_BCR	50	HECATE STRAIT-Q.C. SOUND: Bella Coola R	NA	CAN	BC	DD	0
Hecate_Atn	51	HECATE STRAIT-Q.C. SOUND: Atnarko R	NA	CAN	BC	E	1
PgtGeorgia_Quatse	52	PUGET SOUND-GEORGIA BASIN: Quatse R/N Vancouver I	NA	CAN	BC	E	1
PgtGeorgia_Nimpk	53	PUGET SOUND-GEORGIA BASIN: Nimpkish, Mackenzie R	NA	CAN	BC	E	1
PgtGeorgia_Schoen	54	PUGET SOUND-GEORGIA BASIN: Schoen Ck/Davie R	NA	CAN	BC	DD	0
PgtGeorgia_Glend	55	PUGET SOUND-GEORGIA BASIN: Glendale Ck/Knight Inl	NA	CAN	BC	DD	0
PgtGeogria_Klin	56	PUGET SOUND-GEORGIA BASIN: Klinaklini River	NA	CAN	BC	DD	0
PgtGeorgia_Phil	57	PUGET SOUND-GEORGIA BASIN: Phillips R, Heydon Ck	NA	CAN	BC	DD	0
PgtGeorgia_Sakinaw	58	PUGET SOUND-GEORGIA BASIN: Village Bay Ck, Sakinaw	NA	CAN	BC	E	3
PgtGeorgia_Baker	59	PUGET SOUND-GEORGIA BASIN: Baker Lk/Puget Sound	NA	CAN/US (US)	BC/WA (WA)	E	1
Fraser_Widg	60	FRASER RIVER, LOWER: Widgeon Slough	NA	CAN	BC	E	1
Fraser_Pitt	61	FRASER RIVER, LOWER: Upper Pit R	NA	CAN	BC	E	1
Fraser_Chill	62	FRASER RIVER, LOWER: Cultus Lk, Chilliwack R	NA	CAN	BC	E	2
Fraser_Lower	63	FRASER RIVER, LOWER: Harrison Lake	NA	CAN	BC	E	3
Fraser_Lillooet	64	FRASER RIVER, BIRKENHEAD	NA	CAN	BC	E	1
Fraser_Sthompson	65	FRASER RIVER, SOUTH THOMPSON	NA	CAN	BC	E	9
Fraser_Nthompson	66	FRASER RIVER, NORTH AND LOWER THOMPSON	NA	CAN	BC	E	4
Fraser_Gat	67	FRASER RIVER, MIDDLE: Gates Ck	NA	CAN	BC	E	1
Fraser_Middle	68	FRASER RIVER, MIDDLE: Stuart to Nahatlatch R	NA	CAN	BC	E	33
Fraser_Nad	69	FRASER RIVER, MIDDLE: Nadina R	NA	CAN	BC	E	1
Fraser_Bowron	70	FRASER RIVER, BOWRON	NA	CAN	BC	E	1
VancIslCoast	71	VANCOUVER ISLAND COASTAL CURRENT	NA	CAN	BC	E	2
SeasUpwell	72	SEASONAL UPWELLING CLINE	NA	US	WA	E	2
Columbia_Wen	73	COLUMBIA RIVER: Wenatchee	NA	US	WA	E	1
Columbia_Okan	74	COLUMBIA RIVER: Okanogan R/Osoyoos Lk	NA	CAN/US	BC/WA	E	1
Columbia_Red	75	COLUMBIA RIVER: Redfish Lk	NA	US	ID	E	1
Columbia_Suttle	76	COLUMBIA RIVER: Suttle Lk/Deschutes R	NA	US	OR	EX	0
Columbia_Yakima	77	COLUMBIA RIVER: Yakima R	NA	US	WA	EX	0
Columbia_Upper	78	COLUMBIA RIVER: Upper, Headwater/Arrow, Whatsan Lk	NA	CAN/US	BC/WA	EX	0
Columbia_Payette	79	COLUMBIA RIVER: Payette R	NA	US	ID	EX	0
Columbia_Wallowa	80	COLUMBIA RIVER: Wallowa Lk	NA	US	OR	EX	0

[a]Name used in IUCN Red List to identify subpopulation

Appendix 2

Abundance trend and data set details for individual spawning sites assessed within subpopulations (SP)

The field 'Data type'indicates the type of abundance estimate that was available (T = total, I = Index). The value provided under 'Escapement' is the median observed over the period analyzed. Slope parameter (b1) estimates (standard error) from the regression of log(Escapement) against time and the associated estimate of three-generation percent change ('% change') are provided for site-level evaluation. Bold-faced slope estimates correspond to those parameters that differed significantly from zero at a = 0.10.

Subpop ID	Site name	Site ID	Latitude	Longitude	Data type	Years	Escapement (SD) *1000	β_1 (SE), ln(*N*) vs. *t*	% change
4	Ozernaya	1	51.499695	156.505173	T	89-04	1300 (1329.9)	-0.01 (0.03)	-9
7	Azabache	2	56.229115	162.536820	I	89-04	511 (336.8)	**-0.09 (0.02)**	-73
13	Mclees	3	53.997146	-66.723866	I	89-03	5.2 (16)	0.08 (0.07)	186
18	Glacial	4	64.863232	-165.704451	I	88-03	0.7 (0.6)	**0.02 (0.01)**	35
18	grand_central	5	64.895632	-165.077904	I	90-05	1 (0.8)	0.01 (0.03)	7
18	Salmon	6	64.902445	-165.016002	I	90-05	6.6 (11.9)	**0.17 (0.02)**	942
20	Alagnak	7	58.916085	-157.018522	T	91-06	828 (1538.8)	**0.16 (0.02)**	879
20	bear_cr	8	59.295708	-158.777410	I	90-05	3.5 (1.6)	**-0.02 (0.01)**	-29
20	bear_late	9	56.095786	-160.294745	T	91-06	139.8 (46.9)	**-0.02 (0.01)**	-28
20	bear_lk	10	56.133709	-160.451435	T	91-06	367 (80.6)	0 (0.01)	-5
20	Christianson	11	54.852568	-164.257405	T	90-05	41.8 (13.8)	**0.04 (0.01)**	74
20	Cinder	12	57.336334	-158.017439	T	91-06	46 (23.2)	-0.02 (0.02)	-23
20	davids_late	13	55.848557	-161.413453	T	91-06	4.5 (2.3)	0.01 (0.02)	15
20	eagle_cr	14	59.310227	-158.666222	I	90-05	0.8 (0.6)	**-0.09 (0.02)**	-70
20	Egegik	15	58.226577	-157.377833	T	91-06	1267 (327.4)	**-0.02 (0.01)**	-22
20	Elva	16	59.580661	-159.052669	I	90-05	0.1 (0.1)	0 (0.02)	-6
20	Fenno	17	59.422082	-158.810201	I	90-05	4.7 (5.2)	**0.11 (0.02)**	355
20	Goodnews	18	59.105661	-161.570374	T	90-05	44.4 (22.6)	0 (0.02)	-2
20	Hansen	19	59.321275	-158.701491	I	90-05	8.4 (5.6)	**-0.05 (0.02)**	-51
20	Happy	20	59.323345	-158.724784	I	90-05	8.6 (6.6)	-0.03 (0.02)	-32
20	hidden_lake	21	59.541101	-158.765084	I	90-05	2.3 (2.8)	**0.16 (0.02)**	865
20	Ice	22	59.329401	-158.814848	I	90-05	8.3 (7.9)	-0.03 (0.02)	-32
20	Igushik	23	58.713305	-158.873344	T	91-06	366 (129.7)	**-0.06 (0.01)**	-55
20	Ilnik	24	56.596966	-159.616139	T	91-06	70 (28.3)	**0.03 (0.01)**	59
20	Kanektok	25	59.763324	-161.921076	I	90-05	27.4 (26.4)	0.04 (0.02)	71
20	Kema	26	59.546494	-158.683613	I	90-05	0.6 (1.7)	**0.14 (0.04)**	582
20	Kulukak	27	58.924505	-159.743466	I	88-03	19 (11.1)	**-0.09 (0.01)**	-70
20	Kvichak	28	59.016083	-156.859658	T	91-06	2320 (2802.2)	**-0.1 (0.03)**	-75
20	Lynx	29	59.484455	-158.921683	I	90-05	1.9 (2.8)	**0.05 (0.01)**	105
20	Meshik	30	56.764557	-158.626409	T	90-05	55.6 (35.7)	**0.09 (0.02)**	229
20	Mission	31	59.274982	-158.598957	I	90-05	1.3 (1.1)	**-0.05 (0.01)**	-48
20	Moose	32	59.641866	-158.581729	I	90-05	1.9 (1.2)	**0.1 (0.01)**	307
20	Naknek	33	58.717779	-157.059847	T	91-06	1536 (473.8)	**0.06 (0.01)**	116
20	Nelson	34	55.936342	-161.380750	T	91-06	241.6 (88)	0.02 (0.02)	35
20	North	35	55.615775	-162.350130	T	90-05	9 (9.9)	**0.06 (0.02)**	124

Subpop ID	Site name	Site ID	Latitude	Longitude	Data type	Years	Escapement (SD) *1000	β1 (SE), ln(*N*) vs. *t*	% change
20	Nushagak	36	58.981415	-158.524762	T	91-06	503.7 (209.7)	**0.03 (0.01)**	46
20	pen_north	37	55.290897	-164.187197	T	91-06	885.1 (205.6)	0.01 (0.01)	23
20	Pick	38	59.550772	-159.063777	I	90-05	6 (2.5)	**0.02 (0.01)**	27
20	Sandy	39	56.244792	-160.376836	T	91-06	51 (30.1)	**-0.04 (0.02)**	-42
20	Stovall	40	59.458467	-158.635599	I	90-05	1.2 (0.8)	**0.11 (0.01)**	346
20	Swanson	41	55.021816	-163.614157	I	90-05	9.7 (5.2)	0.02 (0.02)	31
20	Togiak	42	59.072253	-160.338523	T	91-06	189 (64.1)	0.01 (0.01)	21
20	ugashik	43	57.484265	-157.489033	T	91-06	892 (431.5)	**-0.04 (0.01)**	-40
20	whitefish_big	44	59.266659	-158.685268	I	91-05	0.6 (0.6)	**0.01 (0.01)**	21
20	yako	45	59.276101	-158.706016	I	90-05	3 (2.6)	**0.07 (0.02)**	163
21	kogrukluk	46	60.396695	-158.480900	T	76-06	11 (15.8)	-0.02 (0.04)	-25
22	black	47	56.457835	-158.991598	T	90-05	396.7 (145.4)	-0.01 (0.01)	-14
22	chignik	48	56.415071	-158.945381	T	91-06	290.5 (68.6)	**-0.01 (0)**	-16
22	lagoon_middle	49	55.094184	-163.204739	I	90-05	23.6 (12.1)	**0.03 (0.01)**	57
22	mortensens	50	55.157149	-162.650696	I	90-05	6.4 (5.2)	**0.05 (0.03)**	98
22	orzinski	51	55.734877	-160.085480	T	90-05	31.2 (16.9)	**0.04 (0.02)**	86
22	pen_south	52	54.857013	-160.416993	T	91-06	104.4 (47.7)	**0.06 (0.02)**	124
22	thin_point	53	55.032296	-162.639541	I	90-05	25 (12.9)	**0.05 (0.03)**	99
23	afognak	54	58.081506	-152.829008	T	91-06	66.9 (37.4)	**-0.16 (0.02)**	-90
23	akulura	55	57.127683	-154.039937	T	91-06	12.4 (18.2)	**-0.12 (0.04)**	-80
23	ayakulik	56	57.191127	-154.531780	T	91-06	286.2 (83.6)	**-0.05 (0.01)**	-51
23	buskin	57	57.754218	-152.487290	T	91-06	14.8 (4.6)	**0.06 (0.01)**	121
23	karluk	58	57.570539	-154.455185	T	91-06	743.1 (169.3)	**0.02 (0.01)**	37
23	little_ak	59	57.818412	-153.827920	I	91-06	11 (18.1)	**0.11 (0.03)**	338
23	malina	60	58.172953	-153.216308	T	91-06	10.8 (8.7)	**0.06 (0.03)**	147
23	pasagshak	61	57.476513	-152.474503	I	91-06	8 (7.1)	0.03 (0.04)	56
23	pauls	62	58.390006	-152.340627	T	91-06	23.2 (10.4)	0.0 (0.02)	7
23	saltery	63	57.516200	-152.747725	T	91-06	43.9 (14.6)	-0.01 (0.01)	-16
23	station_upper	64	57.120712	-154.115796	T	91-06	232.5 (46.2)	**-0.02 (0.01)**	-21
23	uganik	65	57.669351	-153.389569	I	91-06	29 (21.8)	0.01 (0.03)	15
24	crescent	66	60.226742	-152.558566	T	91-06	62 (30.1)	**0.09 (0.01)**	271
24	fish	67	61.437113	-149.769530	T	91-06	48 (34.2)	-0.06 (0.03)	-55
24	kasilof	68	60.361847	-151.291542	T	91-06	256 (106.5)	**0.07 (0.01)**	163
24	kenai	69	60.524961	-151.233207	T	90-05	670 (236)	0.01 (0.01)	11
24	packers	70	60.449266	-151.911130	T	85-00	29.6 (7.8)	-0.02 (0.01)	-23
24	russian_early	71	60.461965	-149.983920	T	91-06	39.9 (19.6)	**0.04 (0.01)**	84
24	russian_late	72	60.435358	-149.992558	T	91-06	75 (35.1)	**0.03 (0.01)**	43
24	susitna	73	61.277377	-150.578568	T	90-05	205 (72.6)	**-0.02 (0.01)**	-23
25	coghill	74	61.070355	-147.921756	T	91-06	29.6 (16.8)	**0.06 (0.01)**	132
25	eshamy	75	60.452550	-148.104349	T	91-06	27.1 (13)	**0.05 (0.01)**	94
26	copper_delta	76	60.294456	-145.030940	I	90-05	75.7 (12.8)	0 (0.01)	7
26	copper_upper	77	61.506318	-144.422599	T	86-01	401.6 (121.7)	**0.04 (0.01)**	64
27	bering	78	60.176312	-144.274734	I	90-05	22.6 (11)	**-0.05 (0.01)**	-47
27	east_alsek	79	59.072662	-138.303315	T	90-05	46.8 (15.7)	**-0.04 (0.01)**	-45
27	italio	80	59.289676	-139.071897	T	87-02	3.4 (2.4)	**-0.05 (0.02)**	-52

Subpop ID	Site name	Site ID	Latitude	Longitude	Data type	Years	Escapement (SD) *1000	**β_1 (SE), ln(*N*) vs. *t***	% change
27	lost	81	59.466352	-139.617275	T	90-05	2.8 (2.5)	**-0.07 (0.02)**	-62
27	redoubt	82	56.887975	-135.250376	T	90-05	34.8 (23.7)	**0.06 (0.03)**	128
27	situk	83	59.454130	-139.573792	T	91-06	59.3 (17.2)	0.02 (0.01)	32
28	klukshu	84	60.116697	-137.024844	T	92-07	13.5 (7.6)	0.02 (0.03)	32
28	village_ck	85	60.164363	-137.058777	T	92-07	2.3 (2.4)	0.03 (0.03)	42
29	auke	86	58.379685	-134.645649	T	90-05	4 (2)	**-0.09 (0.02)**	-72
29	chilkat	87	59.249674	-135.575031	T	89-04	137.6 (65)	0 (0.02)	7
29	chilkoot	88	59.323887	-135.556934	T	90-05	51.2 (24.5)	0.04 (0.03)	79
29	kuthai	89	59.228646	-133.229038	T	91-05	4.8 (2.7)	**0.02 (0.01)**	34
29	little_trapper	90	58.773196	-132.267946	T	90-05	11.5 (6.7)	**0.07 (0.02)**	173
29	speel	91	58.135158	-133.719951	T	90-05	7.9 (9.3)	**-0.05 (0.03)**	-48
29	taku	92	58.424022	-133.971219	T	90-05	108 (26.4)	0.01 (0.01)	18
29	tatsamenie	93	58.534535	-132.142170	T	90-05	6 (5.2)	-0.01 (0.03)	-16
35	bronson	94	56.685564	-131.065519	I	90-05	<0.1 (<0.1)	**-0.18 (0.02)**	-92
35	chutine	95	57.650392	-131.632549	I	90-05	0.2 (0.1)	**0.05 (0.01)**	97
35	porcupine	96	57.062238	-131.738874	I	90-05	0.1 (0.1)	**0.04 (0.02)**	71
35	scud	97	57.279144	-131.821805	I	90-05	0.3 (0.3)	**-0.08 (0.01)**	-69
35	tahltan	98	58.013904	-130.953155	T	91-06	42.3 (20.8)	-0.02 (0.05)	-20
35	verret	99	56.692697	-131.002829	I	90-05	0.1 (0.1)	**0.06 (0.02)**	143
36	fairfax	100	52.717662	-131.981639	I	85-00	0.3 (0.4)	-0.03 (0.03)	-30
36	mercer	101	53.583129	-132.900153	I	90-05	2.5 (1)	**0.06 (0.03)**	119
37	mcdonald	102	55.931493	-131.803555	T	89-04	79.7 (37.6)	**-0.06 (0.01)**	-58
38	hugh_smith	103	55.098627	-130.661084	T	90-05	7.1 (16.1)	-0.05 (0.05)	-49
39	awun	104	53.653060	-132.522533	I	90-05	3.5 (1.6)	**0.05 (0.02)**	91
39	naden	105	53.933286	-132.681985	I	89-04	3 (1.9)	-0.01 (0.03)	-13
39	yakoun	106	53.647555	-132.203428	I	90-05	4.1 (2.6)	-0.01 (0.03)	-16
40	diana	107	54.240883	-130.148207	I	90-05	1.8 (1)	-0.01 (0.02)	-18
40	gingit	108	55.221973	-129.101975	I	90-05	1.1 (1)	**0.06 (0.02)**	124
40	kwinageese	109	56.193993	-128.795961	I	90-05	4.1 (4.4)	**-0.04 (0.02)**	-41
40	meziadin	110	56.024785	-129.148168	T	90-05	180.4 (127.8)	**-0.04 (0.02)**	-45
40	shawatlan	111	54.324520	-130.254829	I	90-05	2 (1.5)	**0.1 (0.02)**	329
41	alastair	112	54.068172	-129.191520	I	88-03	2.5 (1.6)	**-0.1 (0.03)**	-75
41	kitsumkalum	113	54.517776	-128.663573	I	90-05	4 (2)	**0.03 (0.01)**	56
41	schulbuckhand	114	54.362191	-128.573079	I	90-05	0.7 (1.7)	**-0.26 (0.03)**	-97
41	southend	115	54.317181	-129.209362	I	90-05	4 (2.6)	-0.01 (0.03)	-16
43	babine_four	116	55.419064	-126.688652	I	87-02	10 (6.7)	**0.07 (0.01)**	162
43	babine_onethree	117	55.336215	-126.635668	I	90-05	125 (165.7)	-0.01 (0.04)	-11
43	babine_unacc	118	55.697427	-127.686334	T	90-05	218.7 (118.4)	**-0.06 (0.02)**	-54
43	club_lower	119	55.760199	-128.535575	I	90-05	4 (2.1)	**0.06 (0.03)**	131
43	club_upper	120	55.792114	-128.622949	I	90-05	1 (1.5)	**-0.24 (0.01)**	-96
43	four_mile	121	54.473377	-125.314137	I	90-05	4 (4.7)	**0.06 (0.03)**	125
43	fulton	122	54.824893	-126.114646	T	90-05	402.8 (184.8)	-0.02 (0.01)	-21
43	morrison	123	55.135352	-126.282156	I	90-05	15 (13.1)	**0.17 (0.01)**	1049
43	nine_mile	124	55.201509	-126.579086	I	90-05	1.3 (4.4)	0.08 (0.06)	192
43	pierre	125	54.637811	-125.845760	I	90-05	21.3 (13.9)	**0.06 (0.02)**	129

Subpop ID	Site name	Site ID	Latitude	Longitude	Data type	Years	Escapement (SD) *1000	β_1 (SE), ln(*N*) vs. *t*	% change
43	pinkut	126	54.457121	-125.467680	T	90-05	158.3 (128.9)	**-0.11 (0.02)**	-80
43	Six_mile	127	54.469328	-125.373316	I	90-05	0.7 (3.1)	**0.24 (0.06)**	2973
43	sockeye_babine	128	54.749903	-125.979478	I	90-05	2.1 (6.4)	0.07 (0.06)	177
43	tachek	129	54.811161	-126.088371	I	90-05	2 (4.7)	0.07 (0.05)	156
43	tahlo	130	55.290509	-126.416623	I	90-05	4.5 (7.3)	0.06 (0.04)	128
43	twain	131	54.615074	-125.803675	I	90-05	7 (6.9)	0.01 (0.03)	21
44	nanika	132	54.093395	-127.476762	I	89-04	15 (13.5)	**-0.17 (0.03)**	-90
45	azuklotz	133	56.087681	-126.807586	I	89-04	1.8 (1.2)	**-0.1 (0.02)**	-74
45	salix	134	56.130754	-126.835622	I	90-05	0.2 (0.3)	**-0.06 (0.03)**	-54
46	copper_bc	135	53.161241	-131.800567	I	89-04	10.2 (4.4)	**0.09 (0.02)**	242
46	curtis	136	53.501057	-129.862886	I	89-04	5 (2.9)	**-0.11 (0.03)**	-80
46	devon	137	53.453064	-129.772433	I	89-04	3.5 (2.4)	0.02 (0.01)	39
46	keecha	138	53.309463	-129.829560	I	89-04	2 (1.3)	**0.04 (0.01)**	84
46	kingkown	139	53.510642	-130.296701	I	90-05	2.5 (2.1)	**0.19 (0.02)**	1387
46	kooryet	140	53.341980	-129.882910	I	89-04	2.5 (1.3)	**0.09 (0.01)**	253
46	mikado	141	53.431862	-129.827212	I	90-05	3 (1.2)	-0.01 (0.01)	-8
46	quitonsta	142	53.378173	-130.186867	I	85-00	2.5 (2.3)	-0.02 (0.04)	-25
46	tsimtack	143	53.380883	-129.465998	I	86-01	3 (2.6)	0.03 (0.04)	49
47	lowe	144	53.559859	-129.563218	I	88-03	2.8 (2)	-0.03 (0.03)	-36
48	canoona	145	53.073592	-128.569018	I	90-05	1.9 (0.9)	-0.01 (0.02)	-17
48	evelyn	146	53.584658	-128.954829	I	90-05	0.3 (0.4)	**0.18 (0.03)**	1133
48	hartley	147	53.426782	-129.253467	I	90-05	0.4 (0.2)	**0.02 (0.01)**	37
48	kemano	148	53.481535	-128.131220	I	84-99	0.1 (0.1)	-0.03 (0.03)	-35
48	kitimat	149	54.017347	-128.658023	I	90-05	2 (2.3)	**0.14 (0.04)**	569
48	kitlope	150	53.210927	-127.844712	I	90-05	9.5 (5.2)	**-0.07 (0.01)**	-61
49	amback	151	51.685760	-127.043862	T	90-05	10 (16.1)	**-0.1 (0.05)**	-75
49	ashlulm	152	51.675918	-126.888460	T	90-05	6.6 (6.8)	-0.07 (0.06)	-61
49	bloomfield	153	52.857016	-128.681975	I	90-05	0.4 (0.5)	**0.19 (0.01)**	1323
49	canoe	154	51.262805	-127.025367	T	90-05	17.1 (26.2)	**-0.12 (0.05)**	-81
49	dallery	155	51.683584	-127.035782	T	90-05	3.2 (4.8)	0 (0.07)	6
49	elcho	156	52.400625	-127.539457	I	87-02	<0.1 (<0.1)	**0.14 (0.01)**	609
49	genesee	157	51.669636	-126.679784	T	90-05	0.6 (3)	**-0.22 (0.09)**	-95
49	inziana	158	51.828548	-126.674361	T	90-05	8.2 (12.3)	**-0.11 (0.05)**	-77
49	kainet	159	52.755330	-127.882138	I	90-05	1 (0.6)	-0.03 (0.02)	-31
49	kimsquit	160	52.884006	-127.079765	I	85-00	13 (7.4)	**-0.08 (0.03)**	-67
49	koeye	161	51.780661	-127.863041	I	90-05	1 (0.6)	**0.12 (0.01)**	415
49	kwakwa	162	52.557458	-128.708611	I	90-05	1.5 (0.6)	**0.08 (0.02)**	206
49	mary_cove	163	52.617416	-128.434522	I	87-02	0.2 (0.1)	**0.09 (0.03)**	242
49	namu	164	51.856486	-127.865675	I	90-05	1 (0.5)	**0.07 (0.02)**	177
49	neechanz	165	51.647977	-126.692101	I	90-05	10 (8.4)	**-0.16 (0.03)**	-89
49	owikeno	166	51.678436	-127.179609	I	88-03	0.5 (2)	**-0.31 (0.03)**	-99
49	price	167	52.471907	-128.736299	I	87-02	0.4 (0.5)	**0.08 (0.02)**	219
49	sheemahant	168	51.736845	-126.636389	I	84-99	83 (101.5)	**-0.22 (0.02)**	-95
49	smokehouse	169	51.285148	-127.040568	T	90-05	39.9 (62.9)	-0.09 (0.05)	-71
49	tankeeah	170	52.297738	-128.261539	T	90-05	0.4 (0.4)	**0.14 (0.01)**	650

Subpop ID	Site name	Site ID	Latitude	Longitude	Data type	Years	Escapement (SD) *1000	β_1 (SE), ln(*N*) vs. *t*	% change
49	wannock	171	51.680259	-127.255023	I	84-99	80 (66.4)	**-0.18 (0.02)**	-92
49	washwash	172	51.853516	-126.665938	I	90-05	10.3 (9.1)	-0.08 (0.05)	-65
51	atnarko	173	52.38	-126.09	I	90-05	25 (15.2)	**-0.03 (0.01)**	-33
52	quatse	174	50.698869	-127.479318	I	91-06	0.2 (0.9)	**0.19 (0.08)**	1317
53	nimpkish	175	50.566897	-126.978780	I	91-06	32.4 (58.7)	0 (0.03)	-3
58	village_by	176	50.165137	-125.187495	T	91-06	0.1 (0.1)	**-0.3 (0.06)**	-99
58	sakinaw	177	49.651584	-124.068779	T	91-06	0.1 (0.3)	**-0.19 (0.04)**	-93
58	seymour	178	49.302605	-123.025236	I	90-05	21.1 (39.4)	0.01 (0.03)	14
59	baker	179	48.536315	-121.741403	T	91-06	4.9 (5.5)	**0.04 (0.01)**	81
60	widgeon	180	49.354468	-122.631126	I	90-05	0.1 (0.2)	0.06 (0.04)	136
61	pitt_upper	181	49.227677	-122.767776	T	90-05	42.6 (35.1)	**0.18 (0.02)**	1148
62	chilliwack_lk	182	49.127013	-122.099297	I	90-05	1.6 (2.3)	-0.01 (0.02)	-13
62	cultus	183	49.095383	-121.963005	T	90-05	1.9 (5.8)	**-0.09 (0.02)**	-72
63	big_silver	184	49.560227	-121.849480	I	90-05	3.6 (8.2)	**0.26 (0.02)**	3493
63	harrison	185	49.216298	-121.945725	I	90-05	8.6 (98.2)	**0.15 (0.05)**	692
63	weaver	186	49.313978	-121.875883	T	90-05	48.8 (29.3)	-0.04 (0.02)	-41
64	birkenhead	187	50.294974	-122.599037	T	90-05	54.4 (115.7)	0 (0.03)	0
65	adams_rv	188	50.892060	-119.542091	T	90-05	34.9 (968.5)	**0.13 (0.04)**	483
65	anstey	189	51.126585	-118.904747	I	90-05	1.9 (6.2)	**0.08 (0.03)**	191
65	cayenne	190	51.320584	-119.319005	I	93-05	0.2 (2.6)	**-0.25 (0.06)**	-94
65	eagle_rv	191	50.840887	-119.054802	I	90-05	2.1 (19.6)	**0.05 (0.02)**	111
65	little_bc	192	50.866420	-119.599187	I	90-05	9.1 (178.5)	**0.14 (0.03)**	576
65	scotch	193	50.897333	-119.495388	T	90-05	8.5 (29.2)	0.03 (0.02)	42
65	shuswap_lower	194	50.688531	-119.059346	I	90-05	4.7 (220.7)	**0.08 (0.03)**	208
65	shuswap_middle	195	50.425351	-118.765192	I	90-05	0.2 (28.6)	**0.13 (0.05)**	482
65	thompson_south	196	50.680861	-120.338490	I	90-05	0.1 (6.4)	**-0.11 (0.06)**	-79
66	barriere	197	51.173076	-120.139761	I	90-05	0.3 (0.4)	**0.09 (0.03)**	262
66	fennell	198	51.352431	-119.722840	I	90-05	8.7 (7.4)	**-0.07 (0.02)**	-62
66	harper	199	51.319021	-119.879817	I	90-05	0.1 (0.1)	0.01 (0.02)	9
66	raft	200	51.631515	-119.993047	I	90-05	7.2 (19.1)	**0.14 (0.04)**	607
67	gates	201	50.553134	-122.470970	T	90-05	16.4 (31.6)	**-0.12 (0.03)**	-82
68	ankwill	202	55.658051	-126.177983	I	90-05	1.2 (2.8)	**-0.12 (0.02)**	-80
68	bivouac	203	55.077532	-125.563832	I	90-05	1.3 (2.8)	**-0.14 (0.02)**	-87
68	blanchette	204	55.279999	-125.743192	I	90-05	0.2 (0.1)	-0.05 (0.04)	-50
68	chilko	205	52.096504	-123.459827	T	90-05	612.2 (262.3)	-0.03 (0.02)	-30
68	crow	206	55.279710	-125.999035	I	90-05	0.9 (1.3)	**-0.1 (0.02)**	-77
68	driftwood	207	55.698787	-126.230590	I	90-05	1.7 (104.5)	**-0.34 (0.06)**	-99
68	dust	208	55.308954	-126.019237	T	90-05	2.4 (21.7)	**-0.1 (0.03)**	-75
68	fifteen_mile	209	55.328374	-125.779462	I	90-05	0.3 (0.3)	**-0.07 (0.02)**	-60
68	fleming	210	54.765010	-125.366354	I	90-05	0.7 (3.6)	-0.06 (0.06)	-57
68	forfar	211	55.044272	-125.468602	T	90-05	8.1 (7)	**-0.13 (0.01)**	-83
68	forsythe	212	55.545079	-126.073427	I	90-05	0.6 (1.6)	**-0.11 (0.03)**	-79
68	frypan	213	55.522429	-126.055165	I	90-05	1.4 (1.6)	**-0.08 (0.02)**	-68
68	gluske	214	55.060975	-125.513146	T	90-05	4 (7)	**-0.14 (0.02)**	-86
68	hooker	215	55.268243	-125.990999	I	90-05	0.2 (0.4)	**-0.14 (0.02)**	-87

Subpop ID	Site name	Site ID	Latitude	Longitude	Data type	Years	Escapement (SD) *1000	β_1 (SE), ln(*N*) vs. *t*	% change
68	horsefly	216	52.485818	-121.351318	T	92-05	467.6 (611.8)	0.04 (0.03)	57
68	hudson	217	55.477996	-125.995436	I	90-05	0.2 (1.1)	**-0.18 (0.02)**	-91
68	kazchek	218	54.884924	-125.171909	I	90-05	0.5 (3.1)	-0.05 (0.03)	-48
68	kuzkwa	219	54.788400	-124.879757	T	90-05	4.3 (28.5)	**-0.12 (0.04)**	-80
68	mitchell	220	52.777790	-120.806978	T	89-04	88.9 (341.3)	**0.06 (0.03)**	140
68	nahatlatch_lk	221	50.007803	-121.714632	I	90-05	0.6 (0.9)	**-0.11 (0.03)**	-77
68	nahatlatch_rv	222	49.977859	-121.511337	I	90-05	3.5 (3)	0 (0.03)	4
68	narrows	223	55.170004	-125.721069	I	90-05	2.8 (3.7)	-0.03 (0.03)	-34
68	paula	224	54.774802	-125.359065	I	90-05	5.7 (6.4)	**-0.11 (0.02)**	-80
68	pinchi	225	54.525612	-124.532882	I	90-05	4.3 (7.2)	**0.06 (0.02)**	120
68	point	226	55.227820	-125.973228	I	90-05	0.5 (1)	**-0.15 (0.02)**	-88
68	portage_bc	227	50.682434	-121.925740	I	90-05	8.4 (7)	**-0.04 (0.02)**	-47
68	sakeniche	228	55.159040	-125.766804	I	90-05	0.7 (1)	**-0.11 (0.04)**	-78
68	sandpoint	229	55.124745	-125.678235	I	90-05	1.4 (2.2)	**-0.09 (0.02)**	-70
68	shale	230	55.274680	-125.736286	I	90-05	1.1 (0.7)	**-0.11 (0.01)**	-79
68	stellako	231	54.062869	-124.881558	T	90-05	136.8 (100.1)	**0.05 (0.02)**	89
68	tachie	232	54.640425	-124.787919	T	90-05	51.3 (344.7)	**-0.13 (0.02)**	-84
68	taseko	233	52.007432	-123.677225	I	90-05	0.7 (0.7)	0.01 (0.03)	22
68	twentyfive_mile	234	55.266589	-125.728489	I	90-05	0.6 (0.6)	**-0.24 (0.08)**	-96
69	nadina_late	235	53.976321	-126.499383	T	90-05	10.3 (48.9)	0.07 (0.06)	170
70	bowron	236	54.058574	-121.823441	I	90-05	4.9 (8.2)	-0.03 (0.04)	-31
71	gcl	237	49.362885	-124.976530	T	91-06	194.6 (88.1)	**0.05 (0.01)**	110
71	sproat	238	49.293011	-124.882433	T	91-06	169.6 (77.2)	0.01 (0.01)	10
72	pleasant	239	48.035951	-124.381867	I	88-03	0.6 (1)	**0.12 (0.03)**	464
72	quinault	240	47.475295	-123.869074	T	90-05	31 (17.4)	0 (0.03)	-5
73	wenatchee	241	47.569077	-120.588698	T	91-06	11 (13)	**0.07 (0.04)**	174
74	okanogan	242	49.904180	-119.545105	T	91-06	25.8 (22.4)	**0.12 (0.02)**	466
75	redfish	243	44.168444	-114.899754	T	87-02	<0.1 (<0.1)	**-0.12 (0.03)**	-81