Appendix B: Population Size and Complexity—Interior Columbia Chinook and Steelhead ESUs

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Background

The Interior Columbia Basin TRT has identified the basic population structure of these ESUs in a previous report. The tributary drainages used by populations within Interior Basin ESUs vary considerably in terms of size and complexity. Table B-1 summarizes the range in drainage area associated with Interior Basin ESU populations of Spring/Summer Chinook and steelhead. The intent of this analysis is to develop and apply an approach for characterizing the relative size and complexity of Interior Columbia Basin stream type chinook and steelhead populations based on available GIS data layers and empirically derived fish/habitat relationships. The results will be used by the Interior Columbia Technical Recovery Team to: 1) adapt viability curves (abundance/productivity criteria) to reflect population size, and; 2) contribute to the development of spatial structure/diversity criteria

Population Size Categories

Interior Columbia basin tributary habitats accessible to anadromous salmonids vary considerably in their ability to support spawning and rearing. We assigned populations identified within each of the ESA listed Interior Columbia ESUs to size categories based on an analysis of the amount of habitat that could support spawning and associated juvenile rearing. The following sections summarize the methods used to generate estimates of population size and to identify population size categories. The resulting population assignments are also summarized for each ESU.

Table B-1. Relative size (tributary drainage area) of extant populations within Interior Columbia Basin listed stream type Chinook and steelhead ESUs.

ESU	Extant Populations (#)	Basin Drainage Area (km^2)	
		Smallest	Largest
Snake River Spring/Summer Chinook	29	130	4,400
Upper Columbia Chinook	3	1,100	4,700
Snake River Steelhead	24	630	6,800
Mid-Columbia Steelhead	17	600	9,600
Upper Columbia Steelhead	3 (+1?)	1,100	4,700

Examples of populations occupying smaller drainages include Asotin Creek and Sulphur Creek (Snake River Steelhead and Spring/Summer Chinook ESUs); Rock Creek and Fifteen Mile Creek (Middle Columbia Steelhead ESU) and the Entiat River (Upper Columbia Steelhead and Spring Chinook ESUs). Populations using relatively large, complex tributaries include Upper John Day steelhead, Wenatchee and Methow River steelhead and spring chinook; and Lemhi River steelhead and spring/summer chinook. This natural variation in size and complexity suggests that even historically, populations likely varied in their relative robustness or resilience to perturbations.

Estimating Historical Population Size

We developed a method for assigning a relative weight to stream reaches based on physical characteristics (Appendix C). Using GIS layers, we mapped the physical characteristics for each 200 m reach within the tributary habitat associated with specific chinook and steelhead populations and assigned a weighted intrinsic potential using a simple model based on available measures of physical habitat characteristics. That model is driven by estimates of stream width, gradient, and valley width derived from a GIS-based analysis of the tributary habitat associated with each population. Each accessible 200-m reach within the tributary habitat associated with a specific population is assigned an intrinsic productivity rating based on the particular combination of physical habitat parameters listed above. Four categories were used: high, moderate, low, and not rated or zero potential. For application to yearling type chinook, sufficient information was available to add a negligible category. A weighted estimate of the total amount of rated habitat historically available to each population was constructed by summing the habitat by rating category, multiplying each sum by a relative weighting factor (1 = high, .5 = moderate, and .25 = low), and totaling the weighted sums. For this calculation, reaches rated as negligible were assigned a relative weight of zero.

Assigning Populations to Size Categories

Populations of stream type chinook and steelhead were tabulated (by species) in order of estimated total weighted stream kilometers of rearing habitat. Four general groupings of populations (Basic, Intermediate, Large and Very Large) were identified based upon relatively large increases in weighted spawning habitat between adjacent pairs of populations in the ordered list (Figure B-1).

We adapted the approach to accommodate the biological characteristics and available data for Snake River Fall Chinook and Snake River Sockeye populations, respectively.

Spring and Spring/Summer Chinook Size Categories

Basic Size Category: Chinook

A group of the smallest populations was identified based on a relatively large gap in relative size between the estimates for the Entiat and Chamberlain Creek populations. The median estimate of weighted historical spawning area for this category was 230,000 sq meters. Populations in this size category were relatively simple in terms of spatial structure (Table B-2).

Intermediate Size Category: Chinook

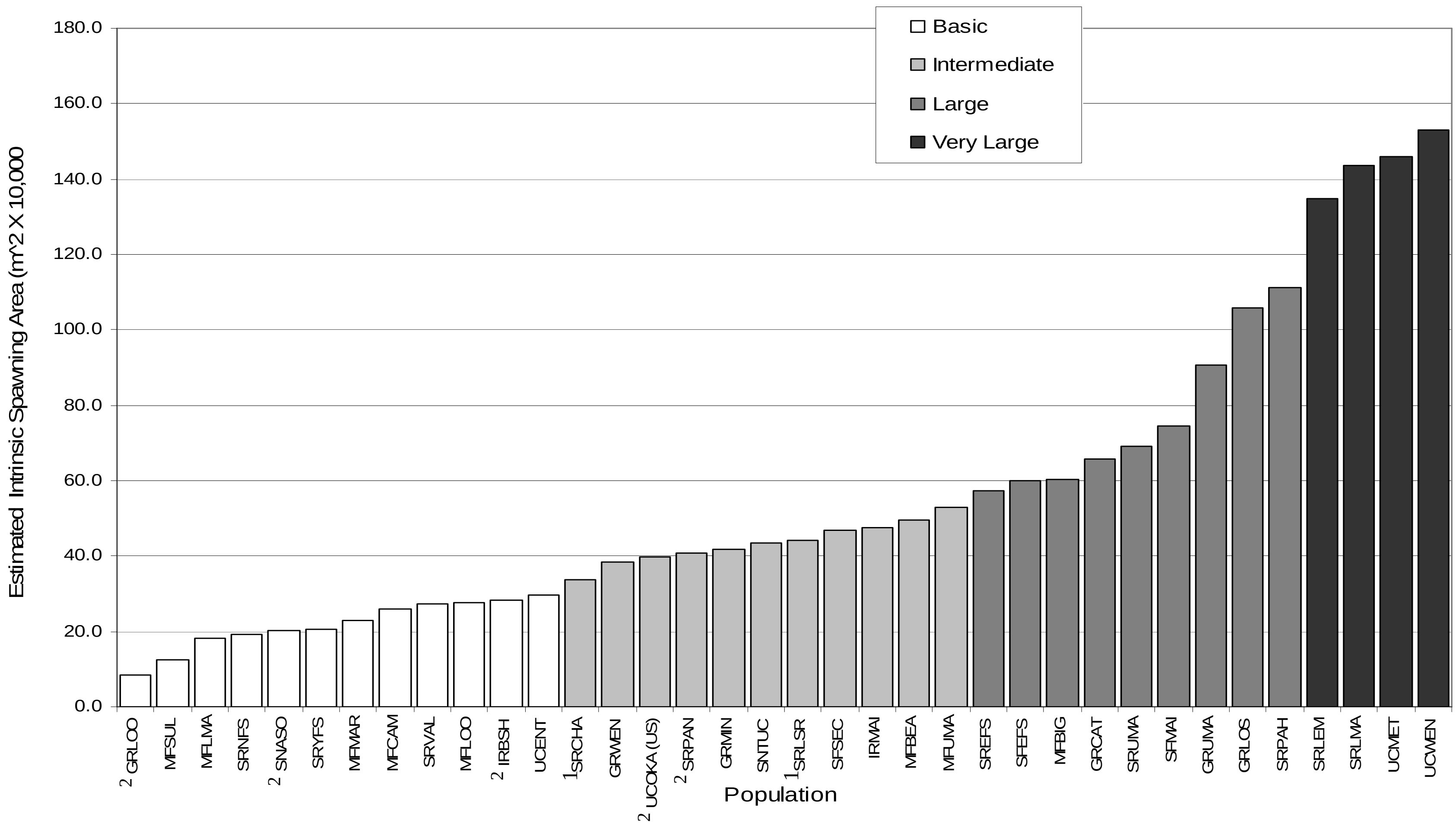
A grouping of 10 extant populations of intermediate size and complexity was defined by the breakpoints separating the groups of smaller and larger populations. The proportional range in population size within each of the three groupings was relatively consistent, with populations varying in size by roughly a factor of two (Table B-2).

Large Size Category: Chinook

Nine extant Spring/Summer Chinook populations were identified in a third grouping—the Large population size category. The median size (based on estimated historical potential) of populations in this category was roughly twice the median for the Intermediate size category. Populations in this category were also relatively more complex—the median number of Major Spawning Areas for populations in this category was three, compared to a median of one for the Intermediate size category (Table B-2).

Very Large Size Category: Chinook

The four largest extant populations were assigned to this size category. The principle difference between populations in this category and those in the Large category was overall size (weighted spawning area). The median size of populations in this category was twice that of the populations in the Large size category. The median number of MaSAs for this size category (four) was greater than that of the other categories (Table B-2).



[1]**Abundance and productivity for these populations can be evaluated against the minimum abundance threshold for the next lowest size category level based on the amount of historical habitat in the core tributary area.**

[2]**Population is extirpated or functionally extirpated.**

Figure B-1. Interior Columbia Basin Stream Type Chinook populations ordered by intrinsic potential (km of weighted spawning/rearing habitat). Bar shading distinguishes the different size categories (Basic, Intermediate, Large, Very Large).

Table B-2. Spring and Spring/Summer Chinook extant populations' (Upper Columbia Spring and Snake River Spring/Summer ESUs) summary statistics for population size categories. Estimates are based on the ICTRT historical intrinsic potential analysis.

Stream Type Chinook Populations		Tributary Spawning Habitat—Population Size Categories			
		Basic	Intermediate	Large	Very Large
Number of extant populations in the category		9	10	9	4
Spawning area (X 10,000 m2)	Median	23.0	43.9	69.2	144.8
	Range	(12.5-29.6)	(33.9-52.8)	(57.2-111.1)	(134.8-153.0)
Relative density at threshold abundance					
Spwners/10,000m^2		21.7	17.1	14.4	13.8
Ratio to Basic			0.79	0.67	0.64
Number of Major Spawning Areas per population					
	Median	1	1	3	4
	Range	(0-1)	(1-3)	(1-5)	(3-5)

Steelhead Size Categories

Steelhead tributary population areas were generally larger than the areas associated with Spring/Summer Chinook, reflecting the wider range of spawning conditions characteristic of steelhead. We identified four groups of steelhead populations based on ‘breaks’ in the cumulative size distribution across the forty seven populations incorporated into the analysis of historical potential. The four size groupings were generally reflected in our basic measure of within population spatial structure—the number of MSAs. (Figure B-2; Table B-3).

Basic Size Category: Steelhead

A group of the smallest populations was identified based on a relatively large gap in relative size between the estimates for the Joseph Creek and Touchet River (Walla Walla basin) populations. The median estimate of weighted historical spawning area across the 13 populations in this category was approximately 141,000 sq meters. Populations in this size category were relatively simple in terms of spatial structure (Table B-3). The median number of MaSAs per population in this category was one.

Intermediate Size Category: Steelhead

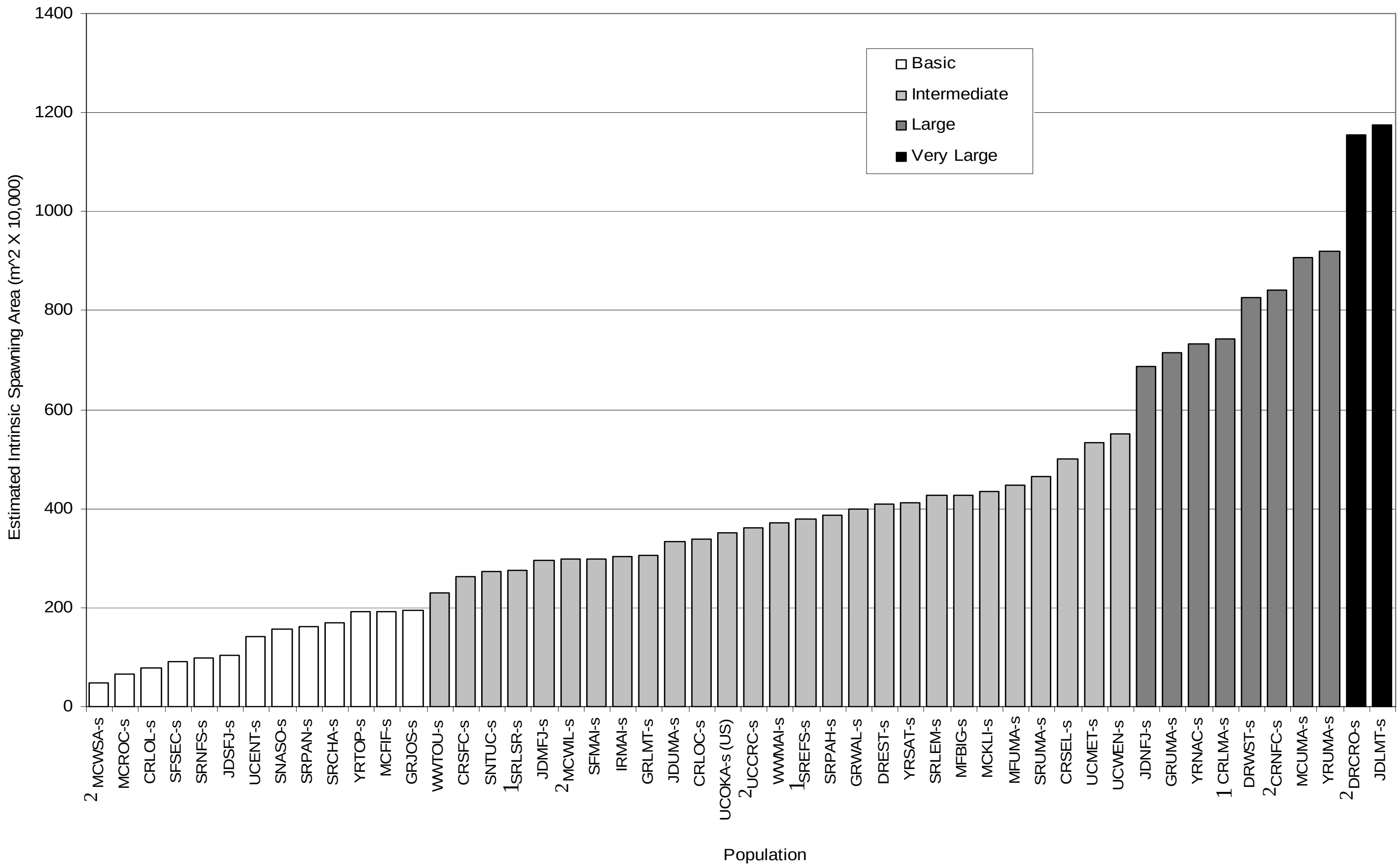
This category contained the largest number of extant populations (24). The Touchet River was the smallest population in this category. The Wenatchee River population defined the upper end of this category based on a relatively large increase to the next population in sequence (North Fork John Day River). The median population size for this category was 382,000 sq. meters, more than double the relative amount of habitat for the Basic category (Table B-3).

Large Size Category: Steelhead

Seven extant steelhead populations were identified in a third category, the Large population size category. The median size of populations in this category (743,000 square meters) was roughly twice the median for the Intermediate size category. The seven extant populations in this category are characterized by relatively high spatial complexity—the median number of MaSAs per population was eight (Table B-3).

Very Large Size Category: Steelhead

The largest extant population, the Lower Mainstem John Day River, was assigned to this category (the extirpated Deschutes Crooked River population also belongs to this category). The principle difference between populations in this category and those in the Large category was overall size (weighted spawning area). The spawning area of this category was approximately 1.5 times that of the populations in the Large category (Table B-3).



[1]**Abundance and productivity for these populations can be evaluated against the minimum abundance threshold for the next lowest size category level based on the amount of historical habitat in the core tributary area.**

[2]**Population is extirpated or functionally extirpated.**

Figure B-2. Interior Columbia Basin Steelhead populations ordered by intrinsic potential (km of weighted spawning/rearing habitat). Bar shading distinguishes the different size categories (Basic, Intermediate, Large, Very Large).

Table B-3. Steelhead extant population (Upper Columbia, Middle Columbia and Snake River ESUs) summary statistics for population size categories. Estimates are based on the ICTRT historical intrinsic potential analysis.

Steelhead Populations		**Tributary Spawning Habitat—Population Size Categories**			
		Basic	**Intermediate**	**Large**	**Very Large**
Number of extant populations in the category		12	25	7	1
Spawning area (X 10,000 m2)	Median	141.0	382.3	743.0	1175.4
	Range	(66.6–193.7)	(229.3–550.5)	(686.7–921.0)	(1175.4-1175.4)
Relative density at threshold abundance	Spwners/10,000m^2	3.5	2.6	2.0	1.9
	Ratio to Basic	---	0.74	0.57	0.54
Number of Major Spawning Areas per population	Median	1	4	8	13
	Range	(1-3)	(1-7)	(5-14)	(13-13)

Table B-4. Size category assignments for steelhead populations organized by ESU. Populations with substantial areas subject to possible temperature limitations are identified.

ESU	MPG	Basic	Intermediate	Large	Very Large
Upper Columbia Steelhead	***Upper Columbia Steelhead***	Entiat[2]	Wenatchee[2] Methow[2] Okanogan (US portion)[2]		
Middle Columbia Steelhead	***Cascade Eastern Slope Tributaries***	Fifteenmile[2] Rock[2] White Salmon[1]	Deschutes Eastside[2] Klickitat	Deschutes Westside	Crooked River[1]
	John Day River	JD South Fork	JD Upper Mainstem JD Middle Fork	JD North Fork	JD Lower Mainstem[2]
	Umatilla and Walla Walla		Walla Walla[2] Touchet[2] Willow[1]	Umatilla[2]	
	Yakima River Group	Toppenish[2]	Satus[2]	Upper Yakima Naches[2]	
Snake River Steelhead	***Lower Snake***	Asotin[2]	Tucannon[2]		
	Clearwater River	Lolo	Lochsa South Fork Selway	Lower Mainstem[2] North Fork Clearwater[1]	
	Grande Ronde	Joseph	Lower Grande Ronde Wallowa	Upper Grande Ronde	
	Salmon River	Chamberlain Panther Secesh North Fork	Lemhi Upper Salmon East Fork. Upper Salmon Mainstem Upper Middle Fork Lower Middle Fork Pahsimeroi Little Salmon[2] South Fork		
	Imnaha River		Imnaha		
	Hells Canyon	Hells Canyon Tributaries[1,2]			

[1]**Population is extirpated.** [2]**Potential for extensive temperature limitations (>10% of intrinsic spawning kms)**

Other Size Category Considerations for Stream Type Chinook and Steelhead Populations

Temperature limitations

The population size categories were based on physical measures of habitat—stream gradient and width were the determining factors for steelhead spawning potential. Other factors can substantially affect the relative productivity of a particular reach or watershed, including temperature conditions and aquatic productivity. We do not have a comprehensive data set representing historical (pre 1850) stream temperatures for Interior Columbia tributaries. We used regression models based on available stream temperature-elevation data to characterize reach specific temperature regimes. Those projections reflect the factors driving stream temperatures during the periods of observation and are not necessarily representative of historical conditions. However temperature mapping based on those relationships can be used to identify populations that are subject to relatively high stream temperatures during key rearing (and spawning periods).

Incorporating a summer temperature maximum constraint (weekly maximum less than 22 deg. C) substantially reduced the estimated amount of spawning habitat for many Mid-Columbia ESU and lower Snake River steelhead populations (Table B-4). In most cases the reductions in spawning area were associated with lower Mainstem small tributaries. The intrinsic spawning or rearing potential estimates for populations exhibiting relatively high potential temperature impacts should be validated using alternative information wherever possible.

Core Area Considerations

Many populations include mainstem and tributary habitat between core spawning reaches and adjoining downstream populations. In some cases these dispersed habitats contain a significant proportion of total intrinsic weighted area, but may have provided only limited connectivity between populations. The ICTRT summed weighted intrinsic potential for both the total population and for core spawning watersheds. If it was determined that; 1) limited connectivity existed; and 2) the core-only sum fell into a lower size category, then the minimum threshold was adjusted downward to reflect a more realistic biological scenario.

Four populations were affected by the core area considerations described above:

- Chamberlain Creek Spring/Summer Chinook population—minimum threshold abundance can be set at 500 (Basic) or 750 (Intermediate)

- Little Salmon River Spring/Summer Chinook population—minimum threshold abundance can be set at 500 (Basic) or 750 (Intermediate)

- Westside Deschutes River Steelhead population—minimum threshold abundance can be set at 1000 (Intermediate) or 1500 (Large)

- Little Salmon River Steelhead population—minimum threshold abundance can be set at 1000 (Intermediate) or 500 (Basic)

Wide Mainstem Considerations

Our estimates of historical population size are based on the intrinsic potential analysis described in Appendix C. The habitat ratings in that analysis were largely derived from empirical data reflecting the relationships between spawning abundance and physical habitat conditions in tributaries less than 15m to 20m in width. We extended the ratings to cover wider tributary mainstem type habitats based on relatively sparse empirical data. Wide mainstem type habitat is a significant component of the total intrinsic potential for some steelhead populations. The ability to support spawning in these sections may depend on additional environmental conditions not included in our intrinsic habitat model. The potential for historical spawning in these areas should be explicitly considered in population specific assessments. Populations with substantial mainstem habitat include the Okanogan in the Upper Columbia ESU; Satus Creek and the Lower John Day in the Mid-Columbia ESU; and the Lochsa, Little Salmon River and Lower Mainstem Clearwater River in the Snake River ESU. In addition, the mainstem Yakima River above the confluence of Satus Creek flows through an alluvial basin. Historically the combination of braided mainstem habitats and the constant input of relatively cold groundwater could have supported substantial production. Given the tributary origin of our criteria, this particular combination is not assigned a high rating. The possibility that this extensive reach may have supported substantial production should be taken into account.

Population Minimum Abundance Thresholds by Size Category

Because populations with fewer than 500 individuals are at higher risk for inbreeding depression and a variety of other genetic concerns (McClure et al. 2003 discusses this topic further), the ICTRT does not consider any population with fewer than 500 individuals to be viable, regardless of its intrinsic productivity. Therefore we set the threshold level (minimum acceptable long term average spawning abundance) for the smallest category of drainages at 500 spawners.

Incrementally higher spawning abundance thresholds were established for the remaining three population size categories (Table B-5). Increased thresholds for larger populations promote achieving the full range of abundance objectives including utilization of multiple spawning areas, avoiding problems associated with low population densities (e.g., Allee effects) and maintaining populations at levels where compensatory processes are functional. We set thresholds for the Very Large and Large size categories so that the expected average density at threshold abundance would be approximately ½ the density associated with 500 spawners for the median Basic population. Threshold levels for application to populations in the intermediate size category were set so as to achieve median spawner densities at approximately half the range between the median population size for Basic and Large population categories.

The approach of assigning incremental minimum thresholds based on four categories of population size represents a balance between two alternatives for setting a minimum abundance consistent with the objectives described above. One approach would be to set the minimum abundance threshold at 500, the number corresponding to preserving genetic characteristics assuming a randomly intermixed spawning population. Larger populations are generally more complex in terms of watershed structure. A minimum abundance threshold of 500 in a large population would translate to average densities of spawners much lower than 500 spawners in a Basic sized population. In addition, the basic assumption of a randomly intermixed population inherent in calculating the minimum estimate of 500 spawners would be questionable given the complexity of larger populations. Metapopulation effects associated with relatively low numbers of spawners in isolated sub watersheds of many populations would likely result in substantial increases in risk for larger populations at a minimum abundance level of 500.

An alternative approach that would emphasize equivalent seeding levels across tributary habitat would be to set the minimum threshold for smaller populations at 500 and set minimum abundance thresholds for the remaining populations at levels proportional to the relative amount of tributary spawning habitat. As an example, the Wenatchee population is approximately 8 times the historical tributary habitat relative to the median Basic sized population; the minimum abundance threshold for the Wenatchee would be set at 8 X 500, or 4,000. Under this approach, the resulting average spawning density within a population would be constant across populations with more historical habitat than the median sized Basic population. The minimum abundance levels set for larger populations would arguably correspond to substantially reduced risks relative to the corresponding levels for Basic or Intermediate populations.

Table B-5. Minimum abundance thresholds by species and historical population size (spawning area) for extant Interior Columbia Basin stream type chinook and steelhead populations. Median weighted area and corresponding spawners per kilometer are provided for populations in each size category.

Population Size Category	**Stream Type Chinook** (Upper Columbia Spring, Snake Spring/Summer ESUs)			**Steelhead** (Upper Columbia, Middle Columbia & Snake River ESUs)		
	Threshold	**Median Weighted Area (m X 10,000)**	**Spawners per KM (weighted)**	**Threshold**	**Median Weighted Area (m X 10,000)**	**Spawners per KM (weighted)**
Basic	**500**	23	21.7	**500**	141	3.6
Intermediate	**750**	44	17.1	**1,000**	371	2.7
Large	**1,000**	69	14.4	**1,500**	784	1.9
Very Large	**2,000**	145	13.8	**2,250**	1165	1.9

Fall Chinook and Sockeye Population Sizes

We established minimum abundance thresholds for stream type Chinook and steelhead populations based on our empirical intrinsic potential analyses and generalized minimum population recommendations from the literature. We do not have the same level of comparative habitat production potential information for fall Chinook (historically dominated by stream type production) or sockeye. We have established relative size categories for fall Chinook and sockeye populations consistent with our recommendations for yearling type Chinook and steelhead, incorporating recommendations from previous recovery planning efforts for those Snake River ESUs (NMFS, 1995).

Fall Chinook

Snake River fall chinook exhibit important life history differences relative to yearling Chinook and steelhead. Snake River fall Chinook spawned primarily in large mainstem reaches and the dominant juvenile life history pattern was for subyearling migration.

The ICTRT has designated three historical populations of Snake River fall Chinook, two of which occupied areas above the Hells Canyon dam complex, a total block to anadromous migration. The two extirpated populations represented the bulk of historical production within this ESU.

The intrinsic habitat potential analysis described in attachment B was developed based on empirical information for ocean type chinook and steelhead populations. The specific biological information used in analysis do not directly apply to the relationship between habitat conditions and spawning/rearing use by Snake River fall chinook. The ICTRT adapted the approach for identifying major and minor spawning areas as follows to reflect biological characteristics of Snake River fall chinook.

The current fall chinook run is predominately associated with Snake River mainstem habitat between the upper end of the Lower Granite Dam reservoir (near Asotin, Washington)and Hells Canyon Dam. That section of the Snake River mainstem is approximately 163 km in length and can be classified into three distinct reaches based on physical characteristics (Groves and Chandler, 1999). The uppermost reach, from Hells Canyon dam downstream to the mouth of the Salmon River, is characterized by a relatively narrow channel with short, deep pools interspersed with rapids. The middle reach, between the Salmon and Grand Ronde River confluences, widens considerably from a relatively narrow canyon section at its upper end and is characterized by lower gradients. Flows in this reach are augmented by the inflow from the Salmon River drainage. The lowest of the three mainstem reaches extends from the confluence with the Grand Ronde to the upper end of Lower Granite Pool. This reach is characterized by a wide channel with low shorelines, deep pools and relatively few rapids. Flow and turbidity are the most variable in this reach.

We evaluated recent redd distribution data in the context of the physical conditions described above. Redd distributions indicate a consistent gap (encompassing the middle reach as described above) in mainstem spawning between the confluences with the Salmon and Grand Ronde Rivers. Based on the distribution of physical habitat characteristics and the patterns in redd deposition, we defined two historical major spawning areas (MaSAs) in the mainstem Snake River upstream of the Lower Granite Reservoir (Figure B-3). One mainstem MaSA extends from the confluence of the Clearwater River upstream to the confluence of the Salmon River. The second mainstem MaSA extends from the confluence of the Salmon River upstream to the general vicinity of Hells Canyon Dam. We concluded that each of these mainstem reaches has the physical capacity to support a minimum of 500 spawners (extrapolated from habitat analyses in Connor et. al, 2001 and Groves & Chandler, 1999). Historically, there may have been an additional relatively contiguous reach capable of supporting spawning in the lower section of the Snake mainstem now inundated by the three lowermost Snake River dams.

The lower reaches of the five major Snake River tributaries entering the mainstem below Hells Canyon dam have been surveyed for fall chinook spawning in recent years. Significant numbers of redds have been located in three tributaries (the Clearwater, Tucannon and Grand Ronde River). Based on physical conditions and current redd densities, we conclude that all three of these lower tributary reaches should be considered as MaSAs in assessing the Snake River fall chinook population status. Although the core spawning area for this population was the mainstem, the alternative spawning locations in the lower mainstems of tributary rivers provide alternative sources of production when mainstem conditions are poor (e.g., low flows and/or high turbidity).

> *Based on these evaluations, the extant Snake River fall chinook population includes five MaSAs: the two mainstem reaches described above along with the lower reaches of the Clearwater, Grand Ronde and Tucannon Rivers. The lower reaches of the Imnaha and Salmon Rivers may have supported relatively low levels of fall chinook spawning and are considered part of the upper mainstem MaSA.*

We established a minimum abundance threshold for the extant fall chinook population consistent with the general abundance/productivity objectives summarized in the July 2003 ICTRT Viability Draft Report. We adapted the recommendations summarized in NMFS (1995) to assign a minimum long term average spawning abundance threshold for the extant population. We are recommending a minimum abundance threshold of 3,000 natural origin spawners for the extant Snake River fall chinook population. No fewer than 2,500 of those natural origin spawners should be distributed in mainstem Snake River habitat.

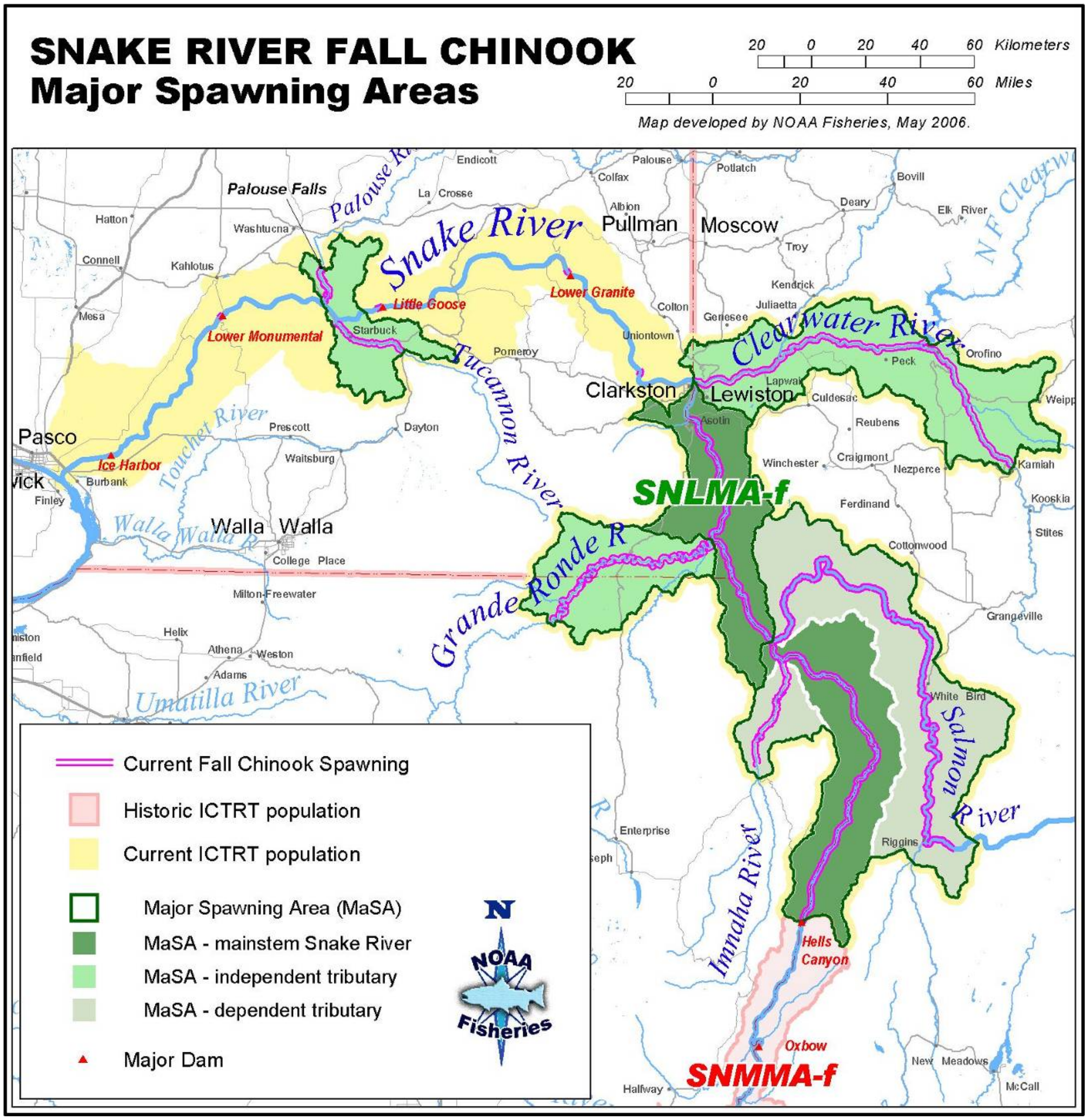


Figure B-3. Snake River Fall Chinook population. Current distribution of spawning areas.

Sockeye

Snake River sockeye have declined to extremely low levels and are currently associated with a single lake in the Stanley Lakes Basin. In previous TRT analyses (ICTRT 2003, McClure et al. 2005) we have concluded that at least three lakes in the Stanley Lakes Basin supported independent sockeye populations (Redfish Lake, Alturas Lake and Stanley Lake). Two other small lakes (Pettit Lake and Yellowbelly Lake) may have supported sockeye production, however currently available information is insufficient to support definitive conclusions regarding whether or not they supported additional sockeye populations.

Sockeye production is believed to be generally related to lake area, although other factors (e.g., temperature regime, relative aquatic productivity) strongly influence production levels (e.g., Burgner, 1991). Historically, sockeye production was supported in a number of lakes throughout the Columbia Basin (Gustafson et al. 1997, Waples et al., 1991). These lake systems varied considerably in size (Figure B-4). Sockeye supporting lakes in the Columbia basin can be classified into four categories based on estimated historical surface areas. The smallest size category (less than 250 hectares surface area) includes most of the Stanley Basin lakes along with Suttle Lake (Deschutes drainage). Alturas Lake and Redfish Lake fall into a second category along with Lake Wenatchee (Upper Columbia). A number of lakes outside of the Stanley Basin have current surface areas ranging from 1500 to approximately 2500 hectares. In addition to the lakes included in Figure B-4, there were several much larger lakes in Canada that have been substantially increased in area due to impoundments, including Lake Okanogan and the Arrow Lake complex. Each of these lake systems most likely exceeded 10,000 hectares in surface area. These systems constitute a fourth surface area category.

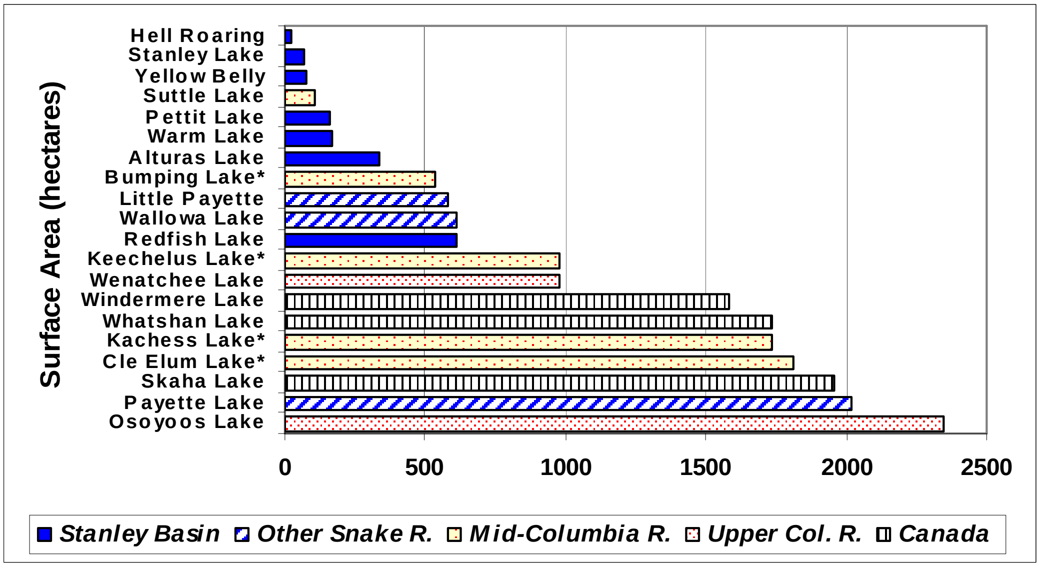


Figure B-4. Surface area (hectares) of lakes within the Columbia basin (not including major Canadian reservoirs impounded by dams). Solid bars: Snake River sockeye ESU ICTRT designated populations (Stanley Lakes basin in Idaho). Dashed fill bars: Possible additional Stanley Lakes basin historical sockeye populations. Dotted fill bars: Columbia basin lakes outside of the Stanley lakes basin currently (or historically) supporting sockeye production. Asterisk indicates current area expanded as a result of dam.

Defining Within Population Structure

Spatial structure varies greatly both within and among ESA defined chinook and steelhead populations. Both temporal and geographic variations exist within occupied systems, resulting in a wide array of spawning configurations. These structural differences have implications for a population's intrinsic viability, and by analyzing spatial composition, planners have an opportunity to evaluate how sustainable production can be achieved.

In our approach for describing spatial structure, we designated the basic building block for salmonid populations as a *branch.* In our definition, a branch component can be any reach organization containing suitable spawning habitat within a sub watershed. The quantity and interrelatedness of branches within a watershed contribute to a population's level of risk in regards to sustainable production.

Additionally, the organizational variation and quantity of branch habitat within targeted populations determine the distribution of Major (MaSA) and Minor (MiSA) Spawning Areas. A rule set (Figure C-2) was developed in order to clearly define and delineate MaSA and MiSA structure. As with branches, it is crucial to understand the geographic composition of spawning areas, and their associated implications, to manage for sustainable productivity.

Moving Window Methodology

Branch development

Using GIS techniques, we developed a methodology for defining and displaying branches. We applied a *moving window* design for evaluating habitat within steelhead and chinook ESA reaches. Our moving window spatial parameters were inherited from minimum branch size definitions, which are equivalent to the amount of habitat required to sustain 50 spawners (approximately 1.25 km for spring/summer chinook, and 3.0 km for steelhead). These stream distances, then, became the calculated lengths for our moving window spatial theme.

Using linear referencing techniques, we compiled tabular descriptions for the moving window features (Table B-6). Each window was addressed with a "from," "to," and feature code attribute. The addresses were offset by 200m increments, so that for each reach, the window began at 0m and stopped at 3000m (steelhead) or 1250 m (Chinook), and then continued upstream at 200m, ending at 3200m (steelhead) or 1450 m (Chinook). This pattern continued until the headwaters of the hydrologic feature were reached. The result was a set of overlapping segments representing a *moving window* spatial theme (Figure B-5).

Table B-6. Address table for linear referencing of "moving windows."

FEATURE ID		BRANCHING PARAMETERS			
LLID	STREAM NAME	FROM CHINOOK(m)	TO CHINOOK(m)	FROM STEELHEAD(m)	TO STEELHEAD(m)
1190674487624	Pettijohn Creek	0	1250	0	3000
1190674487624	Pettijohn Creek	200	1450	200	3200
1190674487624	Pettijohn Creek	400	1650	400	3400
1190674487624	Pettijohn Creek	600	1850	600	3600
1190674487624	Pettijohn Creek	800	2050	800	3800

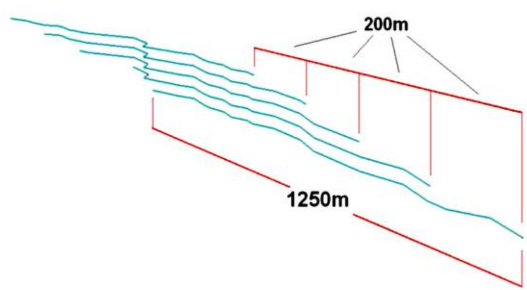


Figure B-5. Example of Spring Chinook "moving window" linear referencing

The second step was to identify each window's intrinsic values and calculate an average rating. The mean intrinsic calculation was our fundamental metric for determining which widows qualified for *branch* status. Because our definition stated that branches could only contain "high" or "moderate" values (and hence, the most productive habitat), it was necessary to determine the average intrinsic rating and attribute it to individual windows. We achieved this by intersecting our moving window features with those from our intrinsic potential analysis, and then summarizing the mean rating for the segments underlying each window. From this analysis, we queried for where the mean intrinsic value was at least equal to "moderate" and saved it as a new spatial theme. In this way, our moving windows are represented as a spatially derived moving average of intrinsic habitat quality.

Designation of Major and Minor Spawning Area

Once our branched distribution was spatially defined, we delineated MaSA and MiSA subwatersheds. Major spawning areas were defined as a system of one or more branches that contain sufficient habitat to support 500 spawners. For Spring/Summer Chinook, this value was 100,000m^2, and for steelhead it equaled 250,000m^2. We generated area values by using hydrology tools within the GIS. Most commonly, these tools are utilized for calculating hydrographic features such as flow direction and accumulation, and watershed delineation.

In our evaluation, we employed flow accumulation functions (using the weighted area calculations from the intrinsic analysis) to calculate potential salmonid production. Starting from the highest elevation within a hydrologic basin, the aggregation continued downstream, accumulating branch habitat until the watershed outlet was reached. This technique produced a hydrologically accumulated grid which was weighted by the quantity of moderate and high intrinsic habitat within our previously defined branches. Using spatial analyst, we then subtracted the topographically derived (unweighted) flow accumulation from the intrinsically weighted accumulation grid. These results were then divided by 250,000 (steelhead) or 100,000 (Chinook). The values in the resulting grid illustrated where the minimum habitat criteria for MaSAs were met, so that each increasing whole number identified a new potential MaSA (dependent upon other criteria within the rule set). With both branches, and MaSA/MiSA minimums defined, the rule set was applied in order to define individual MaSA (or MiSA) subbasins.

Literature Cited

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