

APPENDIX 7C

ECOLOGICAL ATTRIBUTES AND RELATED SURVIVAL FACTORS

Definition of Attributes

Table 1: Definition of Environmental Correlates (Level 2)

Table 2: Definition of Survival Factors (Level 3) for Chinook Salmon

Matrix between Level 2 and Level 3

Table 3: Primary and Modifying Environmental Correlates (Level 2's) used in the development of the "Bio-rules" for each Chinook Survival Factor (Level 3) by Life Stage

Table 1

Definition of Environmental Correlates (Level 2)

Table 1. Definition of Environmental Correlates (Level 2)

Correlate	Correlate Definition	Index Value 0	Index Value 1	Index Value 2	Index Value 3	Index Value 4
Alkalinity	Alkalinity of water (conductivity can be used as a surrogate) (at moderate flows)	Very low (average value typically would be 0-5 mg/l)	Moderately low (average value typically would be 5-25 mg/l)	Moderately high (average value typically would be 25-50 mg/l)	High (average value typically would be 50-150 mg/l)	High (average value typically would be 150-250 mg/l)
Bed scour	Average depth and frequency of scour on small-cobble/gravel riffles during high flow events. The term "frequent" indicates at least one event every 1-2 years. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et al. (1991): gravel (0.2 to 2.9 inch diameter), small cobble (2.9 to 7 inch diameter), large cobble (7 to 11.9 inch diameter), boulder (>11.9 inch diameter).	Pool tailouts and riffles generally very stable, characteristic of conditions prevailing in largely spring fed streams.	Infrequent scour, averaging depths < 10 cm	Frequent scour, averaging depths < 10 cm	Frequent scour, averaging depths > 10 cm and < 25 cm	Frequent scour, averaging depths exceeding 25 cm

Table 1 continued. Definition of Environmental Correlates (Level 2)

Correlate	Correlate Definition	Index Value 0	Index Value 1	Index Value 2	Index Value 3	Index Value 4
Benthos diversity and production	Measure of the diversity and production of the benthos community.	Macroinvertebrates abundant, multiple species of families Ephemeroptera, Plecoptera, and Trichoptera are present.	Intermediate	Macroinvertebrates common or abundant but 1-2 families among Ephemeroptera, Plecoptera, and Trichoptera are not present.	Intermediate	Macroinvertebrates are present only at extremely low densities and/or biomass.
Channel length	Length of the primary channel contained within the stream reach -- Note: this attribute will not be given by a categories but rather will be a point estimate. Length of channel is given for the main channel only--multiple channels do not add length.					

Table 1 continued. Definition of Environmental Correlates (Level 2)

Correlate	Correlate Definition	Index Value 0	Index Value 1	Index Value 2	Index Value 3	Index Value 4
Channel width - month maximum width (ft)	Average width of the wetted channel during peak flow month (average monthly conditions). If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels. Note: Categories are not to be used for calculation of wetted surface area; categories here are used to designate relative stream size.	< 15 ft	> 15 ft and < 60 ft	> 60 ft and < 100 ft	> 100 ft and 360 ft	> 360 ft
Channel width - month minimum width (ft)	Average width of the wetted channel. If the stream is braided or contains multiple channels, then the width would represent the sum of the wetted widths along a transect that extends across all channels. Note: Categories are not to be used for calculation of wetted surface area; categories here are used to designate relative stream size.	< 15 ft	> 15 ft and < 60 ft	> 60 ft and < 100 ft	> 100 ft and 360 ft	> 360 ft

Table 1 continued. Definition of Environmental Correlates (Level 2)

Correlate	Correlate Definition	Index Value 0	Index Value 1	Index Value 2	Index Value 3	Index Value 4
Confinement - Hydromodifications	The extent that man-made structures within or adjacent to the stream channel constrict flow (as at bridges) or restrict flow access to the stream's floodplain (due to streamside roads, revetments, diking or levees) or the extent that the channel has been ditched or channelized.	The stream channel within the reach is essentially fully connected to its floodplain. Very minor structures may exist in the reach that do not result in flow constriction or restriction. Note: this describes both a natural condition within a naturally unconfined channel as well as the natural condition within a canyon.	Some portion of the stream channel, though less than 10%, is disconnected from its floodplain along one or both banks due to man-made structures or ditching.	More than 10% and less than 40% of the entire length of the stream channel within the reach is disconnected from its floodplain along one or both banks due to man-made structures or	More than 40% and less than 80% of the entire length of the stream channel within the reach is disconnected from its floodplain along one or both banks due to man-made structures or	Greater than 80% of the entire length of the stream channel within the reach is disconnected from its floodplain along one or both banks due to man-made structures or ditching.

Table 1 continued. Definition of Environmental Correlates (Level 2)

Correlate	Correlate Definition	Index Value 0	Index Value 1	Index Value 2	Index Value 3	Index Value 4
Confinement - natural	The extent that the valley floodplain of the reach is confined by natural features—determined as the ratio between the width of the valley floodplain and the bankfull channel width. Note: this attribute addresses the natural (pristine) state of valley confinement only. The extent that reaches are confined by hydromodifications (e.g., diking) is addressed under a separate attribute.	Reach mostly unconfined by natural features -- Average valley width > 4 channel widths.	Reach comprised approximately equally of unconfined and moderately confined sections.	Reach mostly moderately confined by natural features -- Average valley width 2 - 4 channel widths.	Reach comprised approximately equally of moderately confined and confined sections.	Reach mostly confined by natural features -- Average valley width < 2 channel widths.
Dissolved oxygen	Average dissolved oxygen within the water column for the specified time interval.	> 8 mg/L (allows for all biological functions for salmonids without impairment at temperatures ranging from 0-25 C)	> 6 mg/L and < 8 mg/L (causes initial stress symptoms for some salmonids at temperatures ranging from 0-25 C)	> 4 and < 6 mg/L (stress increased, biological function impaired)	> 3 and < 4 mg/L (growth, food conversion efficiency, swimming performance adversely affected)	< 3 mg/L
Embeddedness	The extent that larger cobbles or gravel are surrounded by or covered by fine sediment.	< 10% of surface covered by fine sediment	> 10 and < 25 % covered by fine sediment	> 25 and < 50 % covered by fine sediment	> 50 and < 90 % covered by fine sediment	> 90% covered by fine sediment

Table 1 continued. Definition of Environmental Correlates (Level 2)

Correlate	Correlate Definition	Index Value 0	Index Value 1	Index Value 2	Index Value 3	Index Value 4
Fine sediment	Percentage of fine sediment within pool-tailouts and riffles.	< 6% fines < 0.85 mm particle size	> 6% and < 11% fines < 0.85 mm particle size	> 11% and < 18% fines < 0.85 mm particle size	> 18% and < 30% fines < 0.85 mm particle size	> 30% fines < 0.85 mm particle size
Fish community richness	Measure of the richness of the fish community (no. of fish taxa).	2 or fewer fish taxa	3-7 fish taxa	8-17 fish taxa	18-25 fish taxa	> 25 fish taxa
Fish pathogens	The presence of pathogenic organisms (relative abundance and species present) having potential for affecting survival of stream fishes.	No historic or recent fish stocking in drainage and no known incidences of whirling disease, C. shasta, IHN, or IPN	Historic fish stocking, but no fish stocking records within the past decade, or sockeye population currently existing in drainage, or known incidents of viruses among kokanee populations within the watershed.	On-going periodic, frequent, or annual fish stocking in drainage or known viral incidents within sockeye, chinook, or steelhead populations in the watershed.	Operating hatchery within the reach or in the reach immediately downstream or upstream	Known presence of whirling disease or C. shasta within the watershed.

Table 1 continued. Definition of Environmental Correlates (Level 2)

Correlate	Correlate Definition	Index Value 0	Index Value 1	Index Value 2	Index Value 3	Index Value 4
Fish species introductions	Extent of introductions of exotic fish species in the vicinity of the stream reaches under consideration.	No non-native species reported or known to be in the sub-drainage of interest.	1-2 non-native species reported or known to be in the sub-drainage of interest.	3-7 non-native species reported or known to be in the sub-drainage of interest.	8-14 non-native species reported or known to be in the sub-drainage of interest.	15 or more non-native species reported or known to be in the sub-drainage of interest.
Flow - change in interannual variability in high flows	A measure of between year variation in magnitude of high flow levels and/or the extent of change in overall high flow level during a month relative to an undisturbed watershed of comparable size, geology, and geography (or as would have existed in the pristine state).	Pronounced decreases in high flow levels and/or amount of between year variation in high flow levels relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest).	Some evidence of decreases in high flow levels and/or amount of between year variation in high flow levels relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest).	Typical high flow levels and amount of variation in high flows between years relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest).	Some evidence of increases in high flow levels and/or amount of between year variation in high flow levels relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest).	Pronounced increases in high flow levels and/or amount of between year variation in high flow levels relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest).

Table 1 continued. Definition of Environmental Correlates (Level 2)

Correlate	Correlate Definition	Index Value 0	Index Value 1	Index Value 2	Index Value 3	Index Value 4
Flow - changes in interannual variability in low flows	A measure of between year variation in the severity of low flow discharge during a month. Variation in low flows as applied here is relative to an undisturbed watershed of comparable size, geology, and geography (or as would have existed in the pristine state).	Pronounced increases in low flow levels and between year stability in low flow levels relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest). This index level indicates a marked increase in both low flow and stability compared to pristine conditions.	Some evidence of increased low flow levels and between year stability in low flow levels relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest). This index level some evidence exists of an increase in both low flow and stability compared to pristine conditions.	Typical low flows and between year variation in low flows relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest).	Some evidence of reduced low flows and/or between year variation in low flow levels relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest).	Pronounced reductions in low flows and/or between year variation in low flow levels relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest)..

Table 1 continued. Definition of Environmental Correlates (Level 2)

Correlate	Correlate Definition	Index Value 0	Index Value 1	Index Value 2	Index Value 3	Index Value 4
Flow - Intra daily (diel) variation	Varibility in flow level during a daily period. This attribute is informative mainly for regulated rivers or when flow patterns are influenced by storm water runoff.	Essentially no variation in discharge during a 24-hr period. During a month, this condition would characterize most flow patterns not associated with flow ramping by a hydro project or storm-water runoff.	Little variation, on average, in discharge during a 24-hr period--typical of natural runoff pattern during relatively small rainfall storm	Moderate variation, on average, in discharge during a 24-hr period--typical of low ramping rate associated with hydro facilities or natural change in discharge associated with an average to above average rainfed freshet.	Some evidence of increased variation in discharge during a 24-hr period compared to natural runoff pattern. This pattern typical of moderate ramping condition associated with flow regulation.	Extreme variation on average over a 24-hr period during month. This pattern typical of severe ramping condition associated with flow regulation or highly urbanized areas.
Flow - intra-annual flow pattern	The average extent of intra-annual flow variation during a month -- a measure of a stream's "flashiness" during a season.	Pronounced decreases in variation in daily flow during a month (intra-annual) relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest).	Some evidence of decreased variation in daily flow during a month (intra-annual) relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest).	Typical variation in flow variation during a month (intra-annual) in an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest).	Some evidence of increased variation in daily flow during a month (intra-annual) relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest).	Pronounced increases in variation in daily flow during a month (intra-annual) relative to an undisturbed watershed of similar size, geology, and geography (or as would occur in the pristine state for the watershed of interest).

Table 1 continued. Definition of Environmental Correlates (Level 2)

Correlate	Correlate Definition	Index Value 0	Index Value 1	Index Value 2	Index Value 3	Index Value 4
Gradient	Average gradient of the main channel of the reach over its entire length.	0 - 0.1%	>0.10% and <0.5%	>0.5% and <1%	>1% and <2%	>2% and <4%
Habitat type - backwater	Percentage of the wetted channel surface area comprising backwater pools. Backwater pools are habitat units located along the channel margins but are otherwise enclosed—though still connected to the main channel (or side channel). Note: backwater pools as defined here include "alcoves" as described by Nickleson et al. (1992).	0 - <0.25% of wetted surface area encompasses this habitat type	>0.25% and <5% of wetted surface area encompasses this habitat type	>5% and <25% of wetted surface area encompasses this habitat type	>25% and <50% of wetted surface area encompasses this habitat type	>50% of wetted surface area encompasses this habitat type
Habitat type - beaver ponds	Percentage of the wetted channel surface area comprising beaver ponds. Note: this includes only those sites associated with the main channel or its side channels. Off-channel sites are addressed through the Off-Channel Habitat Factor.	0 - <0.25% of wetted surface area encompasses this habitat type	>0.25% and <5% of wetted surface area encompasses this habitat type	>5% and <25% of wetted surface area encompasses this habitat type	>25% and <50% of wetted surface area encompasses this habitat type	>50% of wetted surface area encompasses this habitat type

Table 1 continued. Definition of Environmental Correlates (Level 2)

Correlate	Correlate Definition	Index Value 0	Index Value 1	Index Value 2	Index Value 3	Index Value 4
Habitat type - glides	Percentage of the wetted channel surface area comprising glides. A glide is defined as having moderately low velocities (approx. 10-20 cm/sec) with little or no surface turbulence. Glides generally are characterized as relatively shallow type habitat.	0 - <0.25% of wetted surface area encompasses this habitat type	>0.25% and <5% of wetted surface area encompasses this habitat type	>0.5% and <1%	>25% and <50% of wetted surface area encompasses this habitat type	>50% of wetted surface area encompasses this habitat type
Habitat type - large cobble/boulder riffles	Percentage of the wetted channel surface area comprising large cobble/boulder riffles. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et al. (1991): gravel (0.2 to 2.9 inch diameter), small cobble (2.9 to 7 inch diameter), large cobble (7 to 11.9 inch diameter), boulder (>11.9 inch diameter).	0 - <0.25% of wetted surface area encompasses this habitat type	>0.25% and <5% of wetted surface area encompasses this habitat type	>5% and <25% of wetted surface area encompasses this habitat type	>25% and <50% of wetted surface area encompasses this habitat type	>50% of wetted surface area encompasses this habitat type

Table 1 continued. Definition of Environmental Correlates (Level 2)

Correlate	Correlate Definition	Index Value 0	Index Value 1	Index Value 2	Index Value 3	Index Value 4
Habitat type - off-channel habitat factor	A multiplier used to estimate the amount of off-channel habitat based on the wetted surface area of the all combined in-channel habitat. Off-channel habitat consist of oxbows, backswamps, riverine ponds, and the channels that connect them to the main channel or its side channels.	No off-channel habitat present	>0 X and < 0.05 X	>0.05 X and < 0.25 X	>0.25 X and < 0.5 X	>0.5 X
Habitat type - pool tailouts	Percentage of the wetted channel surface area comprising pool tailouts.	0 - <0.25% of wetted surface area encompasses this habitat type	>0.25% and <5% of wetted surface area encompasses this habitat type	>5% and <25% of wetted surface area encompasses this habitat type	>25% and <50% of wetted surface area encompasses this habitat type	>50% of wetted surface area encompasses this habitat type
Habitat type - primary pools	Percentage of the wetted channel surface area comprising pools, excluding beaver ponds.	0 - <0.25% of wetted surface area encompasses this habitat type	>0.25% and <5% of wetted surface area encompasses this habitat type	>5% and <25% of wetted surface area encompasses this habitat type	>25% and <50% of wetted surface area encompasses this habitat type	>50% of wetted surface area encompasses this habitat type

Table 1 continued. Definition of Environmental Correlates (Level 2)

Correlate	Correlate Definition	Index Value 0	Index Value 1	Index Value 2	Index Value 3	Index Value 4
Habitat type - small cobble/gravel riffles	Percentage of the wetted channel surface area comprising small cobble/gravel riffles. Particle sizes of substrate modified from Platts et al. (1983) based on information in Gordon et al. (1991): gravel (0.2 to 2.9 inch diameter), small cobble (2.9 to 7 inch diameter), large cobble (7 to 11.9 inch diameter), boulder (>11.9 inch diameter).	0 - <0.25% of wetted surface area encompasses this habitat type	>0.25% and <5% of wetted surface area encompasses this habitat type	>5% and <25% of wetted surface area encompasses this habitat type	>25% and <50% of wetted surface area encompasses this habitat type	>50% of wetted surface area encompasses this habitat type
Harassment	The relative extent of poaching and/or harassment of fish within the stream reach.	Reach is distant from human population centers, no road access or no local concentration of human activity.	Reach is distant from human population centers, but with partial road access or little local concentration of human activity.	Reach is near human population center, but has limited public access (through roads or boat launching sites).	Extensive road and/or boat access to the reach with localized concentrations of human activity.	Reach is near human population center or has extensive recreational activities, and has extensive road access and/or opportunities for boat access.

Table 1 continued. Definition of Environmental Correlates (Level 2)

Correlate	Correlate Definition	Index Value 0	Index Value 1	Index Value 2	Index Value 3	Index Value 4
Hatchery fish outplants	The magnitude of hatchery fish outplants made into the drainage over the past 10 years.	No stocking records in the past decade.	No more than two instances of fish releases in the past decade in the drainage.	Fish releases made into the drainage every 1-3 years at isolated locations within the drainage.	Fish releases made at multiple sites in the drainage, but only in 1-3 years during the past decade. When the species released is the same as focus species, chance for some superimposition can occur here.	Fish releases made every 1-3 years and at multiple sites in the drainage. When the species released is the same as focus species, superimposition can occur here.
Hydrologic regime - natural	The natural flow regime within the reach of interest. Flow regime typically refers to the seasonal pattern of flow over a year; here it is inferred by identification of flow sources. This applies to an unregulated river or to the pre-regulation state of a regulated river.	Groundwater-source-dominated; strongly buffered peak flows (as in a springbrook or in river like the Metolius in central Oregon)	Spring snowmelt dominated, non-glacial; temporally consistent and moderate peak and low flows	Rain-on-snow transitional; consistent spring peak and low flows with inconsistent and flashy winter or early spring rain-on-snow	Rainfall-dominated; flashy winter and early spring peaks, consistently low summer flows and variable spring and fall flows.	Glacial runoff system; high, turbid low flows, generally buffered peak flows except with occasional outburst floods and infrequent rain-on-snow events

Table 1 continued. Definition of Environmental Correlates (Level 2)

Correlate	Correlate Definition	Index Value 0	Index Value 1	Index Value 2	Index Value 3	Index Value 4
Hydrologic regime - regulated	The change in the natural hydrograph caused by the operation of hydroelectric facilities in a watershed. Definition does not take into account daily flow fluctuations (See Flow-Intra-daily Variation Correlate)	The project is located off the main channel. The project diverts on average less than 50% of the river/stream in any given month. The project has little impact on peak flows or median monthly flows, except in the bypass reach. Flow is always present in the bypass reach.	The project is located off the main channel. The project diverts on average more than 50% of the river/stream in any given month. The project has little impact on peak flows or median monthly flows, except in the bypass reach. Flow may or may not be present in the bypass reach during some periods.	The project is located in the channel, is operated in run-of-river mode, and therefore has little storage or flood control capability. This results in no variation in the natural hydrograph regime of the basin.	The project is located in the channel, operated as a run-of-river project under flood control constraints. Median monthly flows in general mimic the natural flow regime but the 5, 10, and 20-year peak flows would be reduced by more than 25%.	Project operations have resulted in a major shift in median flows between months or seasons. Typically spring flows (in snow melt systems) have been reduced and winter flows increased in order to meet power demands. However, the pattern varies based on the hydrologic regime of the basin. Peak flows (5, 10, 20-year) have been reduced by more than 25%.

Table 1 continued. Definition of Environmental Correlates (Level 2)

Correlate	Correlate Definition	Index Value 0	Index Value 1	Index Value 2	Index Value 3	Index Value 4
Icing	Extent (magnitufe and frequency) of icing events.	Anchor ice and icing events occur rarely, having little or no impact to physical structure of stream, in-stream structure, and stream banks/bed. No anchor ice nor ice jams or icing events that result short term impacts; these may have long-term beneficial effects.	Intermediate to codes 0 and 1.	Some anchor ice and/or icing events that have a moderate to high probability of occurrence but effects on stream, in-stream structure, and stream banks/beds low to moderate.	Intermediate to codes 2 and 4.	Likelihood of severe anchor ice or overbank ice jams is high, having major effects on stream, in-stream structure, and stream banks. (frequency and severity)
Metals - in water column	The extent of dissolved heavy metals within the water column.	No toxicity expected due to dissolved heavy metals to salmonids under prolonged exposure (1 month exposure assumed).	May exert some low level chronic toxicity to salmonids (1 month exposure assumed).	Consistently chronic toxicity expected to salmonids(1 month exposure assumed).	Usually acutely toxic to salmonids (1 month exposure assumed).	Always acutely toxic to salmonids (1 month exposure assumed).

Table 1 continued. Definition of Environmental Correlates (Level 2)

Correlate	Correlate Definition	Index Value 0	Index Value 1	Index Value 2	Index Value 3	Index Value 4
Metals/Pollutants - in sediments/soils	The extent of heavy metals and miscellaneous toxic pollutants within the stream sediments and/or soils adjacent to the stream channel.	Metals/pollutants at natural (background) levels with no or negligible effects on benthic dwelling organisms or riparian vegetation (under continual exposure).	Deposition of metals/pollutants in low concentrations such that some stress symptoms occur to benthic dwelling organisms or riparian vegetation root/shoot growth is impaired (under continual exposure).	Stress symptoms increased or biological functions moderately impaired to benthic dwelling organisms; or few areas within the riparian zone present where no vegetation exists (slickens); ecotonal to these areas occupied only by tolerant species; horizons containing metals/pollutant concentrations influencing root growth and composition are common within the riparian corridor.	Growth, food conversion, reproduction, or mobility of benthic organisms severely affected; or large areas of the riparian zone devoid of vegetation; ecotonal areas occupied only by metals/pollutant-tolerant species; few areas in the riparian zones which are unaffected.	Metals/pollutant concentrations in sediments/soils are lethal to large numbers of the benthic species and/or riparian zone is practically devoid of vegetation.

Table 1 continued. Definition of Environmental Correlates (Level 2)

Correlate	Correlate Definition	Index Value 0	Index Value 1	Index Value 2	Index Value 3	Index Value 4
Miscellaneous toxic pollutants - water column	The extent of miscellaneous toxic pollutants (other than heavy metals) within the water column.	No substances present that may periodically be at or near chronic toxicity levels to salmonids.	One substance present that may only periodically rise to near chronic toxicity levels (may exert some chronic toxicity) to salmonids.	More than one substance present that may periodically rise to near chronic toxicity levels or one substance present > chronic threshold and < acute threshold (consistently chronic toxicity) to salmonids.	One or more substances present > acute toxicity threshold but < 3X acute toxicity threshold (usually acutely toxic) to salmonids.	One or more substances present with > 3X acute toxicity (always acutely toxic) to salmonids.
Nutrient enrichment	The amount of nutrient enrichment consisting of such items as ammonia, nitrogen, phosphorous.	No enrichment.	Intermediate	Some enrichment with possible positive production response for some species (possibly negative for others).	Intermediate	Super enrichment (e.g., discharge of sewage in the summer with high densities of grazing animals)
Obstructions to fish migration	Obstructions to fish passage by physical barriers (not dewatered channels or hinderances to migration caused by pollutants or lack of oxygen).	None documented or inferred.	One or barriers to juvenile migrants at certain flow levels.	One or barriers to juvenile migrants at all flow levels.	One or barriers to juvenile migrants at all flow levels and barrier(s) to adult migration at certain flow levels.	One or more barriers to all fish migration at all flow levels.

Table 1 continued. Definition of Environmental Correlates (Level 2)

Correlate	Correlate Definition	Index Value 0	Index Value 1	Index Value 2	Index Value 3	Index Value 4
Predation risk	Level of predation risk on fish species due to presence of top level carnivores or unusual concentrations of other fish eating species. This is a classification of per-capita predation risk, in terms of the likelihood, magnitude and frequency of exposure to potential predators (assuming other habitat factors are constant).	Many or most native predators are depressed or rare, none are greatly increased over natural levels, and there may be some numerical survival advantage to fish as a result compared to historical predator abundance.	Intermediate	Diversity and per-capita abundance of predators exists so that predation risk is at near-natural level and distribution.	Intermediate	Excessive population density or concentrated population of predator species exists due to artifacts of human alteration of the environment (e.g., top-down food web effects, habitat manipulations).
Riparian function	A measure of riparian function that has been altered within the reach.	Strong linkages with no anthropogenic influences.	>75-90% of functional attributes present (overbank flows, vegetated streambanks, groundwater interactions typically present).	50-75% functional attribute rating- significant loss of riparian functioning- minor channel incision, diminished riparian vegetation structure and inputs etc.	25-50% similarity to natural conditions in functional attributes- many linkages between the stream and its floodplain are severed.	< 25% functional attribute rating: complete severing of floodplain-stream linkages

Table 1 continued. Definition of Environmental Correlates (Level 2)

Correlate	Correlate Definition	Index Value 0	Index Value 1	Index Value 2	Index Value 3	Index Value 4
Salmon Carcasses	Relative abundance of andromous salmonid carcasses within watershed (e.g., HUC 5 level) that can serve as nutrient sources for juvenile salmonid production.	Super abundant -- an average number of carcasses per total miles of main channel habitat >800.	Very abundant -- an average number of carcasses per total miles of main channel habitat >400 and < 800.	Moderately abundant -- an average number of carcasses per total miles of main channel habitat >200 and < 400.	Not abundant -- an average number of carcasses per total miles of main channel habitat >25 and <200.	Very few or none -- an average number of carcasses per total miles of main channel habitat <25.
Temperature - daily maximum (by month)	Maximum water temperatures within the stream reach reach during a month.	Warmest day < 10 C	Warmest day >10 C and <16 C	> 1 d with warmest day 22-25 C or 1-12 d with >16 C	> 1 d with warmest day 25-27.5 C or > 4 d (non-consecutive) with warmest day 22-25 C or >12 d with >16 C	> 1 d with warmest day 27.5 C or 3 d (consecutive) >25 C or >24 d with >21 C
Temperature - daily minimum (by month)	Minimum water temperatures within the stream reach reach during a month.	Coldest day >4 C	< 7 d with <4 C and minimum >1 C	1 to 7 d < 1 C	8 to 15 days < 1 C	> 15 winter days < 1 C

Table 1 continued. Definition of Environmental Correlates (Level 2)

Correlate	Correlate Definition	Index Value 0	Index Value 1	Index Value 2	Index Value 3	Index Value 4
Temperature - spatial variation	The extent of water temperature variation within the reach as influenced by inputs of groundwater.	Groundwater discharge into surface waters is the major source of flow in reach.	Abundant sites of groundwater discharge into surface waters.	Intermittent sites of groundwater discharge into surface waters and total quantity of groundwater discharge not a major source of flow in reach.	Infrequent sites of groundwater discharge into surface waters and total quantity of groundwater discharge not a major source of flow in reach.	No evidence of concentrated groundwater inputs.

Table 1 continued. Definition of Environmental Correlates (Level 2)

Correlate	Correlate Definition	Index Value 0	Index Value 1	Index Value 2	Index Value 3	Index Value 4
Turbidity	The relative extent of turbidity episodes within the stream reach. Note: turbidity here is described by suspended sediment, measured as mg/L instead of the more usual unit of NTU. It is recognized that relationships between NTU and suspended sediment differ by sediment particle type.	Clear with infrequent (short duration-- several days per year) concentrations of suspended sediment (i.e., <50 mg/L) (a spring creek).	Occasional episodes (days to several weeks--not continuous--annually) of low to moderate concentrations (<500 mg/L), though short duration episodes (<7 days) may occur with of higher concentrations (500 to 1000). These concentrations are always sublethal to juvenile and adult salmonids-though some behavioral modification may occur.	Occasional episodes (days to several weeks) of moderate to relatively high concentrations (>500 and <1000 mg/L), though short duration episodes (<2 weeks) may occur with higher concentrations (500-2000 mg/L). The higher concentrations stated can result in major behavioral modification, some stress and reduced forage success. This condition be associated with various types of land uses where some remedial measures are in place and normal conditions for glacial runoff in many glacial fed rivers in western Washington.	On-going or occasional episodes (periodic events annually lasting several weeks at a time)) of high concentrations of suspended sediment (>1000 and <4000 mg/L), though shorter duration episodes typically occur with higher concentrations (>4000 and <8000 mg/L). These conditions result in prolonged stress to fish unless some form of refuge found and significant loss of forage success.	Extended periods (months) of very high concentrations (>4000 and <8000 mg/L) or shorter durations exceeding 8000 mg/L. These represent extremely severe conditions for survival of fish species.

Table 1 continued. Definition of Environmental Correlates (Level 2)

Correlate	Correlate Definition	Index Value 0	Index Value 1	Index Value 2	Index Value 3	Index Value 4
Water withdrawals	The number and relative size of water withdrawals in the stream reach.	No withdrawals.	Very minor water withdrawals with or without screening (entrainment probability considered very low).	Several of significant water withdrawals along reach though all sites known or believed to be screened with effective screening devices. (Note: one site that withdrawals substantial portion of flow without screening falls into this category.)	Several sites of significant water withdrawals along reach without screening or screening believed to be ineffective. (Note: one site that withdrawals substantial portion of flow without screening falls into this category.)	Frequent sites of significant water withdrawals along reach without screening or screening believed to be ineffective.

Table 1 continued. Definition of Environmental Correlates (Level 2)

Correlate	Correlate Definition	Index Value 0	Index Value 1	Index Value 2	Index Value 3	Index Value 4
Wood	The amount of wood within the reach. Note definition of "large wood" under terms/clarification.	A complex mixture of single large pieces and accumulations consisting of all sizes, decay classes, and species origins; cross-channel jams are present where appropriate vegetation and channel conditions facilitate their existence; large wood pieces are a dominant influence on channel diversity (e.g., pools, gravel bars, and mid-channel islands) where channel gradient and flow allow such influences.	Complex array of large wood pieces but fewer cross channel bars and fewer pieces of sound large wood due to reduced recruitment; influences of large wood and jams are a prevalent influence on channel morphology where channel gradient and flow allow such influences.	Few pieces of large wood and their lengths are reduced and decay classes older; small debris jams poorly anchored in place; large wood habitat and channel features of large wood origin are uncommon where channel gradient and flow allow such influences.	No pieces of large wood and the natural function of wood pieces limited due to diminished quantities, sizes, decay classes and the capacity of the riparian streambank vegetation to retain pieces where channel gradient and flow allow such influences.	No wood present.

Table 2

**Definition of Survival Factors (Level 3)
for Chinook Salmon**

Table 2. *Level 3 Survival Factors*. These factors are defined as the relative survival or productivity of the focal species by life stage. These factors act as "umbrella attributes", combining the effects of Level 2 correlates on the species..

Factor	Definition
Channel stability	The effect of stream channel stability (within reach) on the relative survival or performance of the focus species; the extent of channel stability is with respect to its streambed, banks, and its channel shape and location.
Chemicals	The effect of toxic substances or toxic conditions on the relative survival or performance of the focus species. Substances include chemicals and heavy metals. Toxic conditions include low pH.
Competition (with hatchery fish)	The effect of competition with hatchery produced animals on the relative survival or performance of the focus species; competition might be for food or space within the stream reach.
Competition (with other species)	The effect of competition with other species on the relative survival or performance of the focus species; competition might be for food or space.
Flow	The effect of the amount of stream flow, or the pattern and extent of flow fluctuations, within the stream reach on the relative survival or performance of the focus species. Effects of flow reductions or dewatering due to water withdrawals are to be included as part of this correlate.
Food	The effect of the amount, diversity, and availability of food that can support the focus species on the its relative survival or performance.
Habitat diversity	The effect of the extent of habitat complexity within a stream reach on the relative survival or performance of the focus species.
Harassment	The effect of harassment, poaching, or non-directed harvest (i.e., as can occur through hook and release) on the relative survival or performance of the focus species.
Key habitat	The relative quantity of the primary habitat type(s) utilized by the focus species during a life stage; quantity is expressed as percent of wetted surface area of the stream channel.
Obstructions	The effect of physical structures impeding movement of the focus species on its relative survival or performance within a stream reach; structures include dams and waterfalls.
Oxygen	The effect of the concentration of dissolved oxygen within the stream reach on the relative survival or performance of the focus species.
Pathogens	The effect of pathogens within the stream reach on the relative survival or performance of the focus species. The life stage when infection occurs is when this effect is accounted for.
Predation	The effect of the relative abundance of predators species on the relative survival or performance of the focus species, apart from the influence of the amount of cover habitat used by the focus species.
Salinity	The effect of the concentration of salts within the reach on the relative survival or performance of the focus species.
Sediment load	The effect of the amount of the amount of fine sediment present in, or passing through, the stream reach on the relative survival or performance of the focus species.
Temperature	The effect of water temperature with the stream reach on the relative survival or performance of the focus species.
Withdrawals (or entrainment)	The effect of entrainment (or injury by screens) at water withdrawal structures within the stream reach on the relative survival or performance of the focus species. This effect does not include dewatering due to water withdrawals, which is covered by the flow correlate.

Table 3

**Primary and Modifying Environmental Correlates (Level 2's)
used in the development of the "Bio-rules" for each
Chinook Survival Factor (Level 3) by
Life Stage**

Table 3. Primary and Modifying Environmental Correlates (Level 2's) used in the development of the "Bio-rules" for each Chinook Survival Factor (Level 3) by Life Stage.

Life stage	Survival Factor (Level 3)	Environmental Correlates (Level 2)						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
Spawning	Channel stability	no effects						
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/ Pollutants - in sediments/soils	Nutrient enrichment			
	Competition (with hatchery fish)	Hatchery fish outplants						
	Competition (with other species)	Fish community richness						
	Flow	Flow - Intra daily (diel) variation						
	Food	no effects						
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydro-modifications	Riparian function	Wood		
	Harvest	Harassment	Habitat type - primary pools	Riparian function	Turbidity	Wood		
	KeyHabitat	All habitat types incorporated						
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						

Table 3 continued. Primary and Modifying Environmental Correlates (Level 2's) used in the development of the "Bio-rules" for each Chinook Survival Factor (Level 3) by Life Stage.

Life stage	Survival Factor (Level 3)	Environmental Correlates (Level 2)						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Flow - changes in interannual variability in low flows					
	Sediment load	Turbidity	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
Incubation	Channel stability	Bed scour	Icing	Riparian function	Wood	Confinement – Hydro-modifications	Flow - change in interannual variability in high flows	Flow - intra-annual flow pattern
	Chemicals	Miscellaneous toxic pollutants - water column	Metals/ Pollutants - in sediments/soils	Metals - in water column	Nutrient enrichment			
	Competition (with hatchery fish)	Hatchery fish outplants						
	Competition (with other species)	Fish community richness						
	Flow	Flow - Intra daily (diel) variation						
	Food	no effects						
	Harvest	Harassment						

Table 3 continued. Primary and Modifying Environmental Correlates (Level 2's) used in the development of the "Bio-rules" for each Chinook Survival Factor (Level 3) by Life Stage.

Life stage	Survival Factor (Level 3)	Environmental Correlates (Level 2)						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	KeyHabitat	All habitat types incorporated						
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Sediment load	Fine sediment						
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
Fry colonization	Channel stability	Bed scour	Icing	Riparian function	Wood	Confinement – Hydro-modifications	Flow - change in interannual variability in high flows	Flow - intra-annual flow pattern
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/- Pollutants - in sediments/soils	Nutrient enrichment			
	Competition (with hatchery fish)	Hatchery fish outplants						
	Competition (with other species)	Fish community richness	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		
	Flow	Flow - change in interannual variability in high flows	Confinement - natural	Confinement – Hydro-modifications	Gradient		Riparian function	Wood
	Food	Benthos diversity and production	Alkalinity	Riparian function	Salmon Carcasses			

Table 3 continued. Primary and Modifying Environmental Correlates (Level 2's) used in the development of the "Bio-rules" for each Chinook Survival Factor (Level 3) by Life Stage.

Life stage	Survival Factor (Level 3)	Environmental Correlates (Level 2)						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Habitat diversity	Gradient	Confinement - natural	Confinement – Hydro-modifications	Riparian function	Wood	Icing	
	Harvest	no effects						
	KeyHabitat	All habitat types incorporated						
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)	Flow - changes in interannual variability in low flows	Hatchery fish outplants	
	Sediment load	Turbidity	Embeddedness					
	Temperature	Temperature - daily minimum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
0-age resident rearing	Channel stability	Bed scour	Icing	Riparian function	Wood			
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/ Pollutants - in sediments/soils	Nutrient enrichment			
	Competition (with hatchery fish)	Hatchery fish outplants	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		

Table 3 continued. Primary and Modifying Environmental Correlates (Level 2's) used in the development of the "Bio-rules" for each Chinook Survival Factor (Level 3) by Life Stage.

Life stage	Survival Factor (Level 3)	Environmental Correlates (Level 2)						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Competition (with other species)	Fish community richness	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		
	Flow	Flow - changes in interannual variability in low flows	Embeddedness	Habitat type - backwater pools	Habitat type - beaver ponds	Habitat type - primary pools	Confinement - natural	Confinement – Hydro-modifications
	Food	Benthos diversity and production	Alkalinity	Riparian function	Salmon Carcasses			
	Habitat diversity	Gradient	Confinement - natural	Confinement – Hydro-modifications	Riparian function	Wood	Icing	
	Harvest	Harassment	Habitat type - primary pools	Riparian function	Turbidity	Wood		
	KeyHabitat	All habitat types incorporated						
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)	Flow - changes in interannual variability in low flows	Hatchery fish outplants	
	Sediment load	Turbidity	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						

Table 3 continued. Primary and Modifying Environmental Correlates (Level 2's) used in the development of the "Bio-rules" for each Chinook Survival Factor (Level 3) by Life Stage.

Life stage	Survival Factor (Level 3)	Environmental Correlates (Level 2)						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
0-age transient rearing	Channel stability	Bed scour	Icing	Riparian function	Wood			
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/ Pollutants - in sediments/soils	Nutrient enrichment			
	Competition (with hatchery fish)	Hatchery fish outplants	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		
	Competition (with other species)	Fish community richness	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		
	Flow	Flow - changes in interannual variability in low flows	Embeddedness	Habitat type - backwater pools	Habitat type - beaver ponds	Habitat type - primary pools	Confinement - natural	Confinement - Hydro-modifications
	Food	Benthos diversity and production	Alkalinity	Riparian function	Salmon Carcasses			
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydro-modifications	Riparian function	Wood	Icing	
	Harvest	Harassment	Habitat type - primary pools	Riparian function	Turbidity	Wood		
	KeyHabitat	All habitat types incorporated						
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)	Flow - changes in interannual variability in low	Hatchery fish outplants	

Table 3 continued. Primary and Modifying Environmental Correlates (Level 2's) used in the development of the "Bio-rules" for each Chinook Survival Factor (Level 3) by Life Stage.

Life stage	Survival Factor (Level 3)	Environmental Correlates (Level 2)						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
						flows		
	Sediment load	Turbidity	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
0-age migrant	Channel stability	no effects						
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/ Pollutants - in sediments/soils	Nutrient enrichment			
	Competition (with hatchery fish)	Hatchery fish outplants						
	Competition (with other species)	Fish community richness						
	Flow	Flow - changes in interannual variability in low flows						
	Food	no effects						
	Habitat diversity	Gradient	Confinement - natural	Confinement – Hydro-modifications	Riparian function	Wood		
	Harvest	Harassment						
	KeyHabitat	<all habitat types applied equally>						

Table 3 continued. Primary and Modifying Environmental Correlates (Level 2's) used in the development of the "Bio-rules" for each Chinook Survival Factor (Level 3) by Life Stage.

Life stage	Survival Factor (Level 3)	Environmental Correlates (Level 2)						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)	Flow - changes in interannual variability in low flows	Hatchery fish outplants	
	Sediment load	Turbidity	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily minimum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
Inactive	Channel stability	Bed scour	Icing	Riparian function	Wood	Confinement – Hydro-modifications	Flow - change in interannual variability in high flows	Flow - intra-annual flow pattern
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/ Pollutants - in sediments/soils	Nutrient enrichment			
	Competition (with hatchery fish)	Hatchery fish outplants						
	Competition (with other species)	Fish community richness						
	Flow	Flow - change in interannual variability in high flows	Confinement - natural	Confinement – Hydro-modifications	Gradient		Riparian function	Wood

Table 3 continued. Primary and Modifying Environmental Correlates (Level 2's) used in the development of the "Bio-rules" for each Chinook Survival Factor (Level 3) by Life Stage.

Life stage	Survival Factor (Level 3)	Environmental Correlates (Level 2)						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Food	Benthos diversity and production	Alkalinity	Riparian function	Salmon Carcasses			
	Habitat diversity	Gradient	Confinement - natural	Confinement – Hydro-modifications	Riparian function	Wood	Icing	
	Harvest	Harassment						
	KeyHabitat	All habitat types incorporated						
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily minimum (by month)	Flow - changes in interannual variability in low flows	Hatchery fish outplants	
	Sediment load	Embeddedness	Turbidity					
	Temperature	Temperature - daily minimum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
1-age resident rearing	Channel stability	Bed scour	Icing	Riparian function	Wood			
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/ Pollutants - in sediments/soils	Nutrient enrichment			

Table 3 continued. Primary and Modifying Environmental Correlates (Level 2's) used in the development of the "Bio-rules" for each Chinook Survival Factor (Level 3) by Life Stage.

Life stage	Survival Factor (Level 3)	Environmental Correlates (Level 2)						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Competition (with hatchery fish)	Hatchery fish outplants	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		
	Competition (with other species)	Fish community richness	Alkalinity	Benthos diversity and production	Riparian function	Salmon Carcasses		
	Flow	Flow - change in interannual variability in high flows	Confinement - natural	Confinement - Hydro-modifications	Gradient		Riparian function	Wood
	Food	Benthos diversity and production	Alkalinity	Riparian function	Salmon Carcasses			
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydro-modifications	Riparian function	Wood	Icing	
	Harvest	Harassment	Habitat type - primary pools	Riparian function	Turbidity	Wood		
	KeyHabitat	All habitat types incorporated						
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)	Flow - changes in interannual variability in low flows	Hatchery fish outplants	
	Sediment load	Turbidity	Temperature - daily maximum (by month)					
	Temperature	Temperature - daily minimum (by month)	Temperature - spatial variation					

Table 3 continued. Primary and Modifying Environmental Correlates (Level 2's) used in the development of the "Bio-rules" for each Chinook Survival Factor (Level 3) by Life Stage.

Life stage	Survival Factor (Level 3)	Environmental Correlates (Level 2)						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Withdrawals	Water withdrawals						
1-age migrant	Channel stability	no effects						
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/ Pollutants - in sediments/soils	Nutrient enrichment			
	Competition (with hatchery fish)	Hatchery fish outplants						
	Competition (with other species)	Fish community richness						
	Flow	Flow - changes in interannual variability in low flows						
	Food	no effects						
	Habitat diversity	Gradient	Confinement - natural	Confinement – Hydro-modifications	Riparian function	Wood	Icing	
	Harvest	Harassment						
	KeyHabitat	<all habitat types applied equally>						
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			

Table 3 continued. Primary and Modifying Environmental Correlates (Level 2's) used in the development of the "Bio-rules" for each Chinook Survival Factor (Level 3) by Life Stage.

Life stage	Survival Factor (Level 3)	Environmental Correlates (Level 2)						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	Predation	Predation risk	Fish community richness	Fish species introductions	Temperature - daily maximum (by month)	Flow - changes in interannual variability in low flows	Hatchery fish outplants	
	Sediment load	Turbidity	Flow - changes in interannual variability in low flows	Temperature - daily maximum (by month)				
	Temperature	Temperature - daily minimum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
Prespawning migrant	Channel stability	no effects						
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/- Pollutants - in sediments/soils	Nutrient enrichment			
	Competition (with hatchery fish)	Hatchery fish outplants						
	Competition (with other species)	Fish community richness						
	Flow	Flow - changes in interannual variability in low flows						
	Food	no effects						
	Habitat diversity	Gradient	Confinement - natural	Confinement - Hydro-modifications	Riparian function	Wood		
	Harvest	Harassment	Habitat type - primary pools	Riparian function	Turbidity	Wood		

Table 3 continued. Primary and Modifying Environmental Correlates (Level 2's) used in the development of the "Bio-rules" for each Chinook Survival Factor (Level 3) by Life Stage.

Life stage	Survival Factor (Level 3)	Environmental Correlates (Level 2)						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
	KeyHabitat	<all habitat types applied equally>						
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Flow - changes in interannual variability in low flows					
	Sediment load	Turbidity	Flow - changes in interannual variability in low flows	Temperature - daily maximum (by month)				
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						
Prespawning holding	Channel stability	no effects						
	Chemicals	Miscellaneous toxic pollutants - water column	Metals - in water column	Metals/- Pollutants - in sediments/soils	Nutrient enrichment			
	Competition (with hatchery fish)	Hatchery fish outplants						
	Competition (with other species)	Fish community richness						
	Flow	Flow - changes in interannual variability in	Embeddedness	Habitat type - backwater pools	Habitat type - beaver ponds	Habitat type - primary pools	Confinement - natural	Confinement - Hydro-

Table 3 continued. Primary and Modifying Environmental Correlates (Level 2's) used in the development of the "Bio-rules" for each Chinook Survival Factor (Level 3) by Life Stage.

Life stage	Survival Factor (Level 3)	Environmental Correlates (Level 2)						
		Primary	Modifying	Modifying	Modifying	Modifying	Modifying	Modifying
		low flows						modifications
	Food	no effects						
	Habitat diversity	Gradient	Confinement – Hydro-modifications	Riparian function	Wood			
	Harvest	Harassment	Habitat type - primary pools	Riparian function	Turbidity	Wood		
	KeyHabitat	All habitat types incorporated						
	Obstructions	Obstructions to fish migration						
	Oxygen	Dissolved oxygen						
	Pathogens	Fish pathogens	Fish species introductions	Temperature - daily maximum (by month)	Nutrient enrichment			
	Predation	Predation risk	Flow - changes in interannual variability in low flows					
	Sediment load	Turbidity	Flow - changes in interannual variability in low flows	Temperature - daily maximum (by month)				
	Temperature	Temperature - daily maximum (by month)	Temperature - spatial variation					
	Withdrawals	Water withdrawals						