Skeena Salmon: Lake Sockeye
Conservation Unit (CU)
Bear

Version 1.2, February 2014

Introduction

This habitat report card was developed by the Pacific Salmon Foundation with technical support from ESSA Technologies. This project summarizes pressures on habitat used by Skeena sockeye for migration, spawning, and rearing, as well as their relative vulnerability to those pressures. For an explanation of the indicators shown here, please see the accompanying *Report Card Summaries*. Full methods and results can be found in the main report, *Skeena Lake Sockeye Conservation Units: Habitat Report Cards* (2013). An online interactive version of this information is available at www.skeenasalmonprogram.ca.

Definitions

Conservation Unit (CU): A group of wild salmon sufficiently isolated from other groups that, if extirpated, is very unlikely to re-colonize naturally within an acceptable timeframe.

Pressure indicator: Measurable extent/intensity of natural processes or human activities that can induce changes in habitat condition/state.

Vulnerability indicator: Measures of habitat quantity or quality used to represent the intrinsic habitat vulnerability/sensitivity to watershed disturbances for each life-stage.

Zone of influence (ZOI): Areas adjacent to and upstream/upslope of habitats used by salmon CUs that represent the geographic extent for capture/measurement of pressure and vulnerability indicators.

Status: Condition of habitat relative to a defined indicator benchmark.

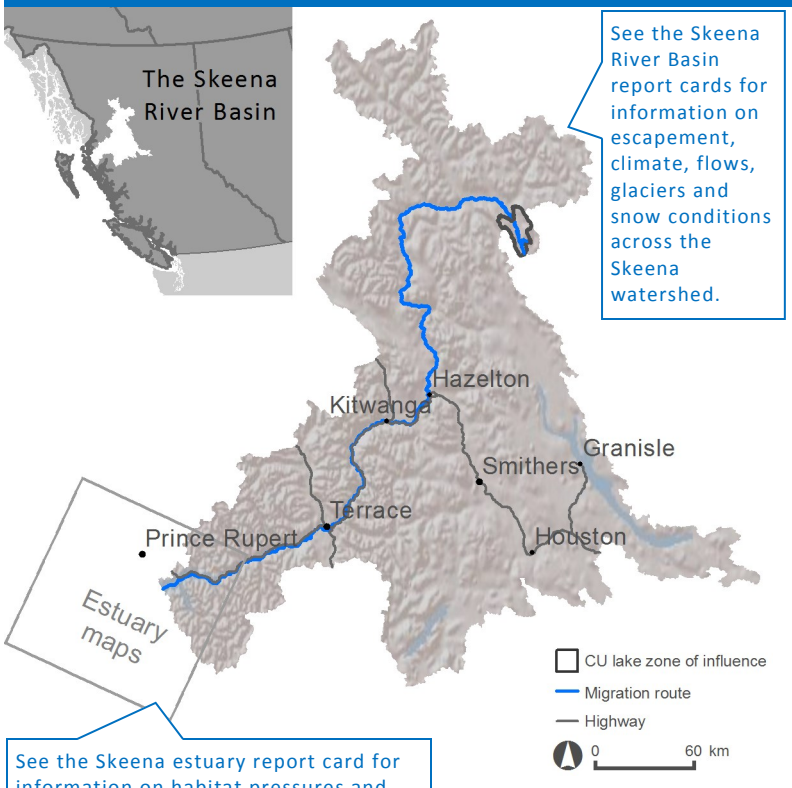
Risk: Risk of adverse effects to salmon habitats within a defined zone of influence. Levels of increasing risk are defined based on the extent/ intensity of impacts relative to defined benchmarks of concern.

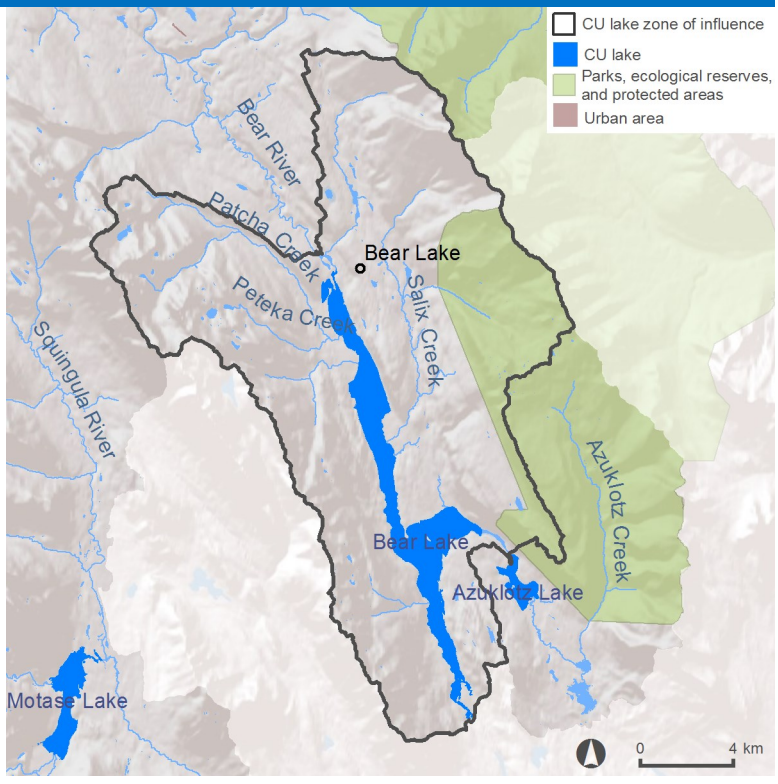
Benchmark: A standard (quantified metric) against which habitat condition can be measured or judged, and by which status can be compared over time and space to determine the risk of adverse effects.

Narrative

* Bear Lake headwaters Bear River.
* Principal sockeye spawning grounds are the shallow and deepwater locales on western shoreline of Bear Lake with minor spawning in Salix Creek and Bear river downstream of the lake outlet.
* Snowmelt dominates hydrological regime. Clear water, warm, moderately deep and multi-basin, dimictic, oligotrophic with high productivity. Preferred sockeye macrozooplankton community is present.
* Fry recruitment is limited by very low adult escapement and rearing habitat generally underutilized. Adjusted PR model results indicate optimum escapement of 82,800 sockeye adults.
* Habitat issues center on the BC Rail corridor that has impacted access into tributaries, caused sedimentation via landslides and bank failures, and functions as a contaminated linear corridor.

Location





CU overview of habitat vulnerabilities & pressures

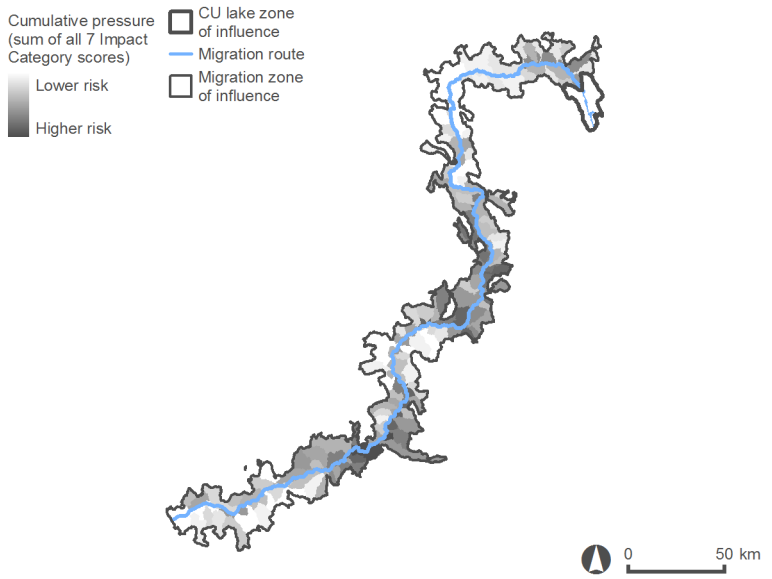
Pressure indicators were grouped into seven relatively independent habitat "impact categories" representing key factors affecting general watershed condition:

- Hydrologic Processes (Forest disturbance; ECA)
- Vegetation Quality (Insect and disease defoliation; Riparian disturbance)
- Surface Erosion (Road development)
- Fish passage/Habitat connectivity (Stream crossing density)
- Water quantity (Water licenses)
- Human development footprint (Total land cover alteration; Impervious surfaces; Linear development; Mining development)
- Water quality (Mining development acid generating; Wastewater discharges)

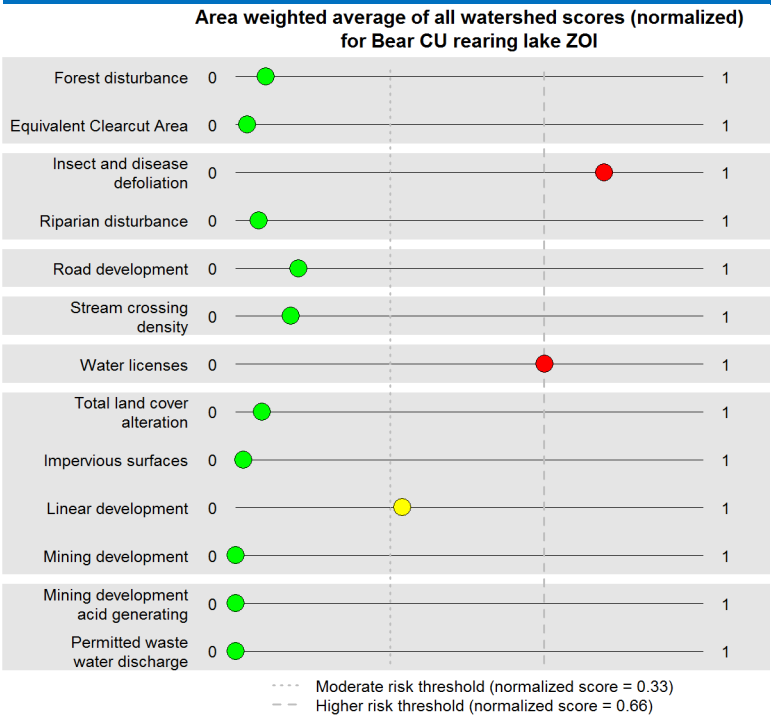
Indicators were also developed reflecting relative vulnerability to habitat pressures within the life stage-specific "zones of influence" defined for each lake sockeye CU:

- Migration (Total migration distance; Length & % of migration route summer flow sensitive)
- Spawning (Total spawning length; Spawning length in tributary, lake or mainstem; Ratio of lake influenced to total spawning length; Length of accessible habitat)
- Rearing (Rearing lake area, Rearing lake productive capacity)

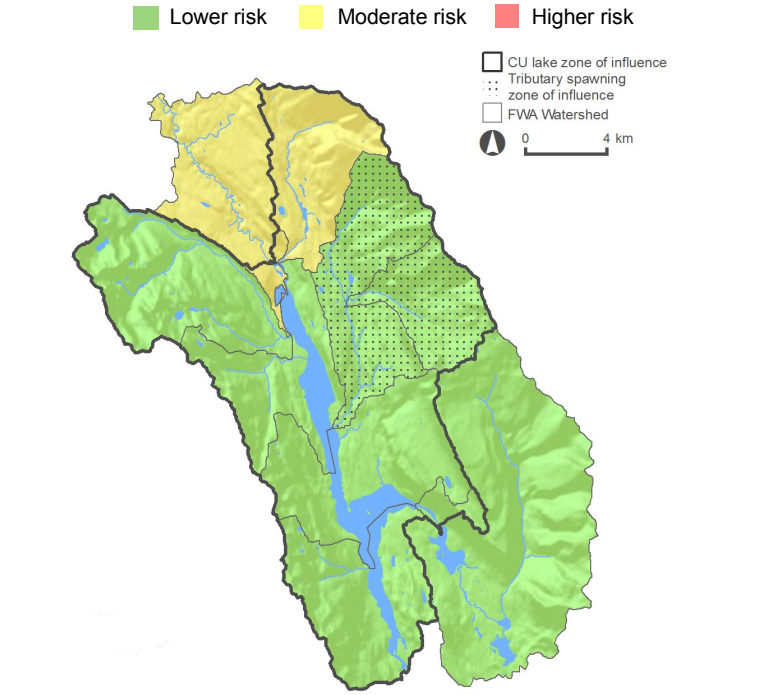
Cumulative pressure—migration



Summary of pressure indicators—rearing

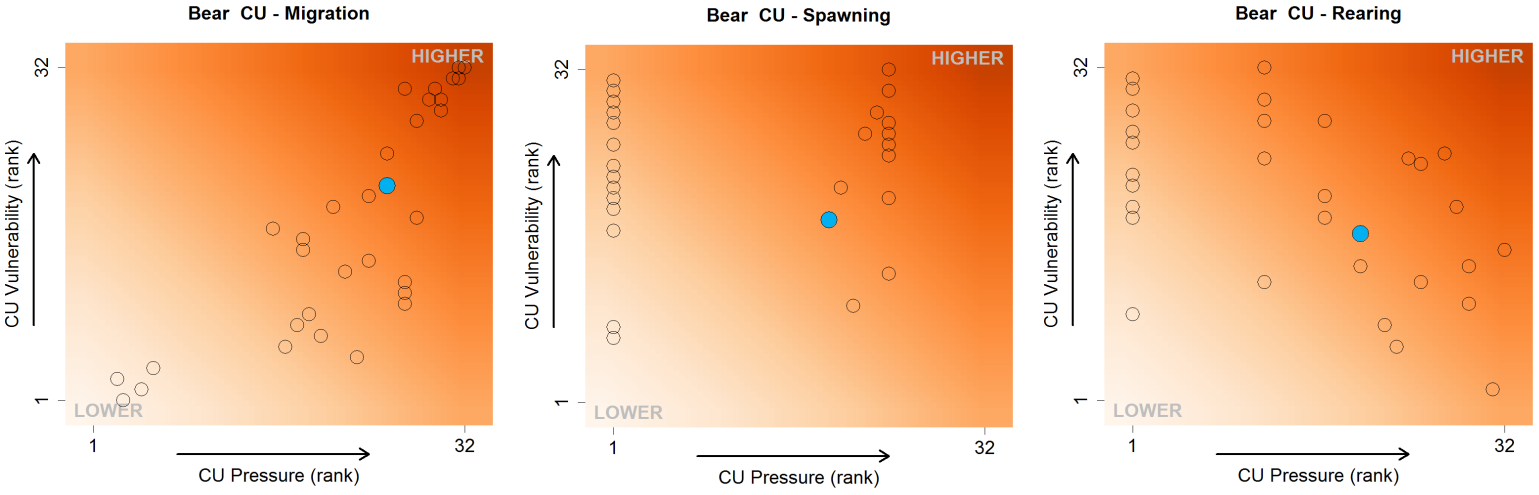


Cumulative pressure—rearing & spawning



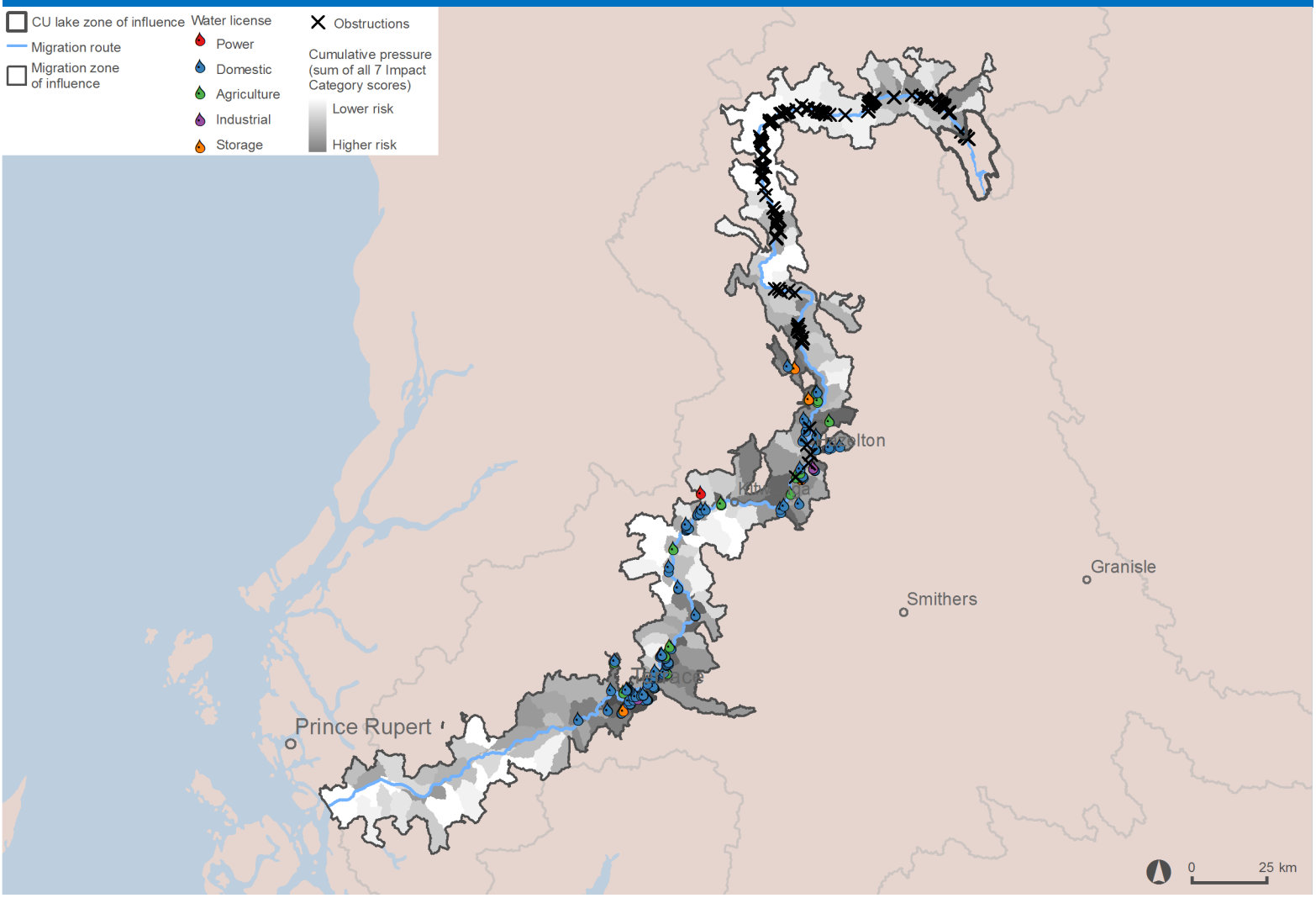
Integrated vulnerability/habitat pressures—migration, spawning, & rearing

● = Bear ○ = other Skeena lake sockeye CUs

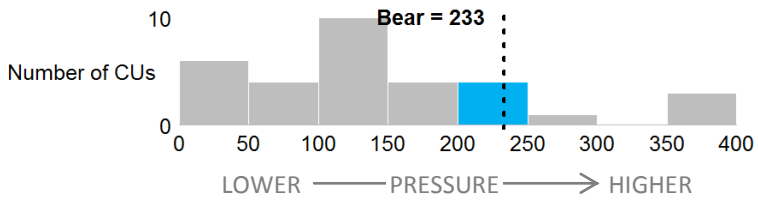


Migration vulnerability & pressure

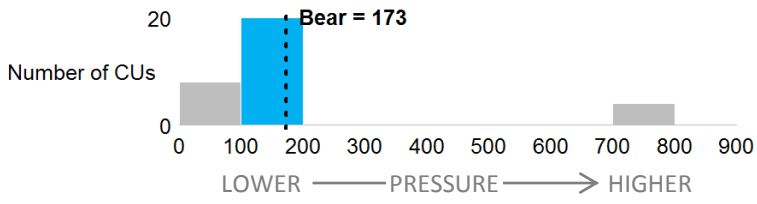
Migration period pressures



Number of obstructions along migration route

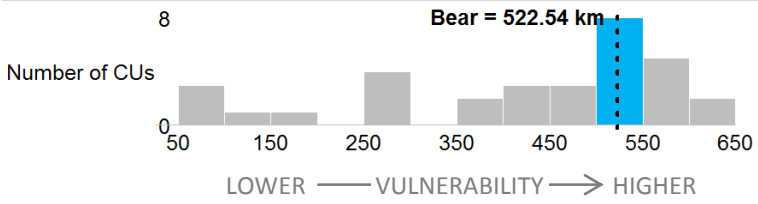


Number of water licenses along migration ZOI

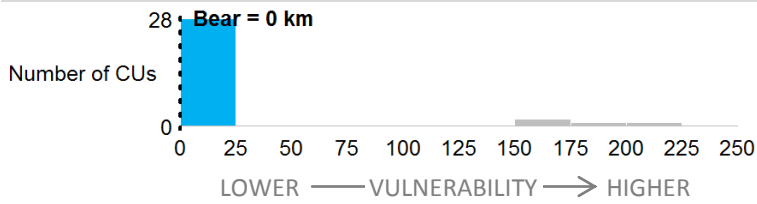


Migration period vulnerability

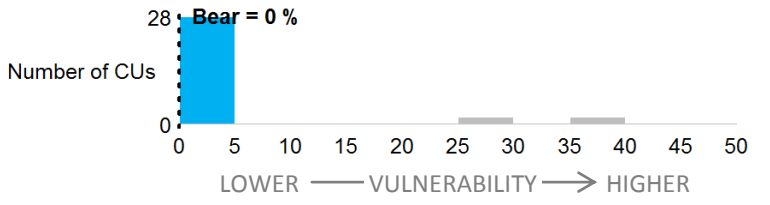
Migration distance (km)



Migration route - summer low flow sensitive (km)



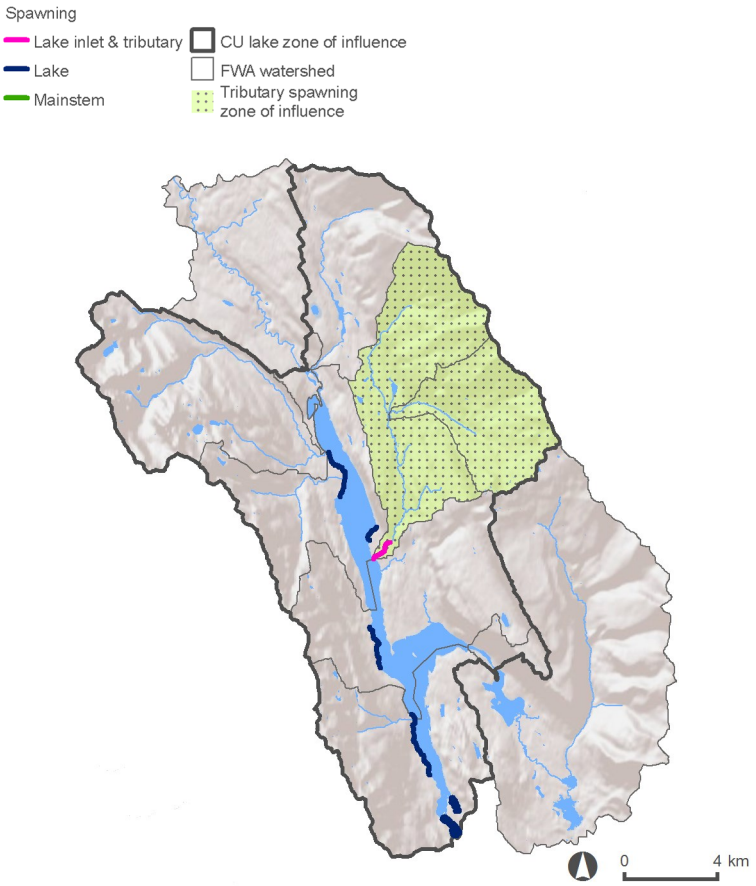
Migration route - summer low flow sensitive (%)



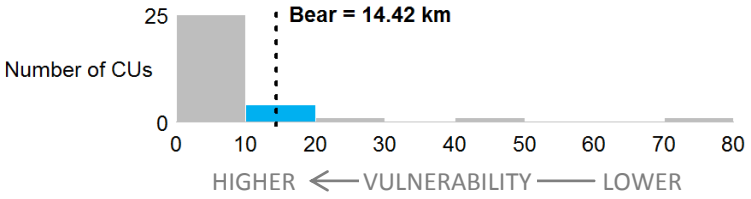
Spawning & rearing vulnerability

Spawning period vulnerability

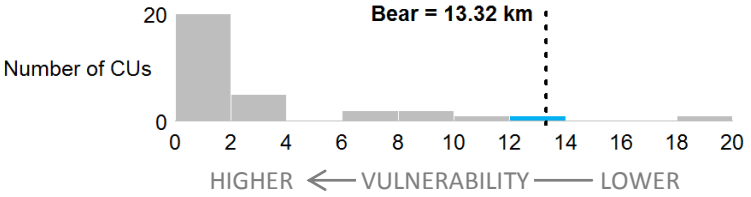
Spawning locations



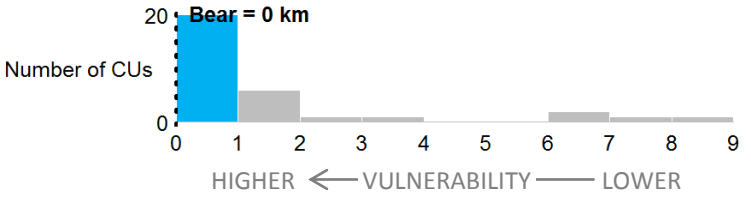
Total (mainstem, trib & lake) spawning length (km)



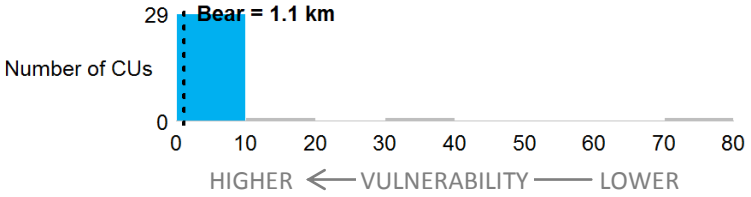
Length of lake shore spawning areas (km)



Mainstem spawning length (km)

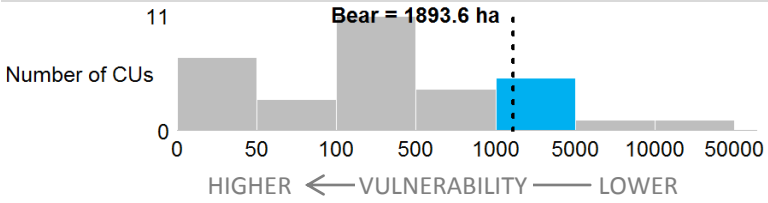


Tributary and lake inlet spawning length (km)

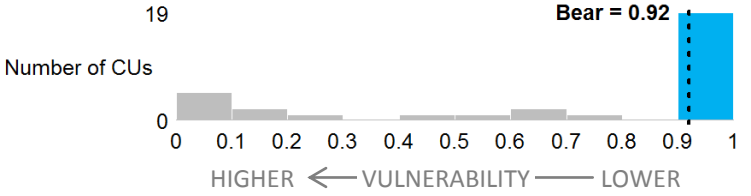


Rearing period vulnerability

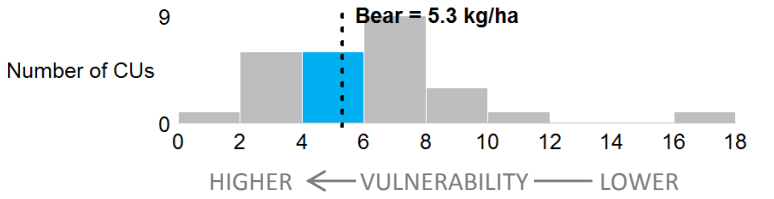
Area of nursery lakes (ha)



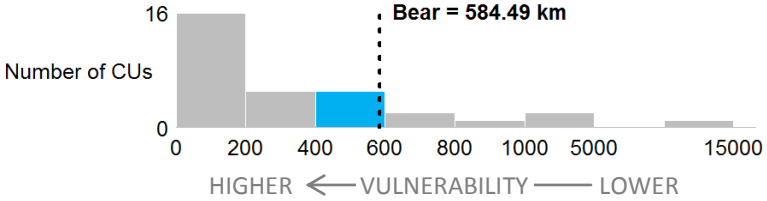
Ratio of lake influenced to total spawning



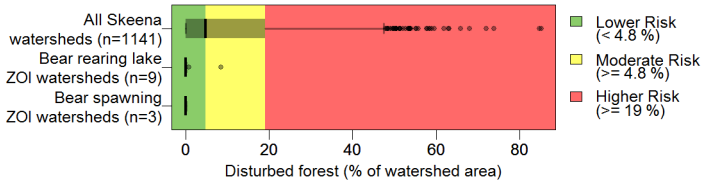
Nursery lake productive capacity (Rmax est. kg/ha)

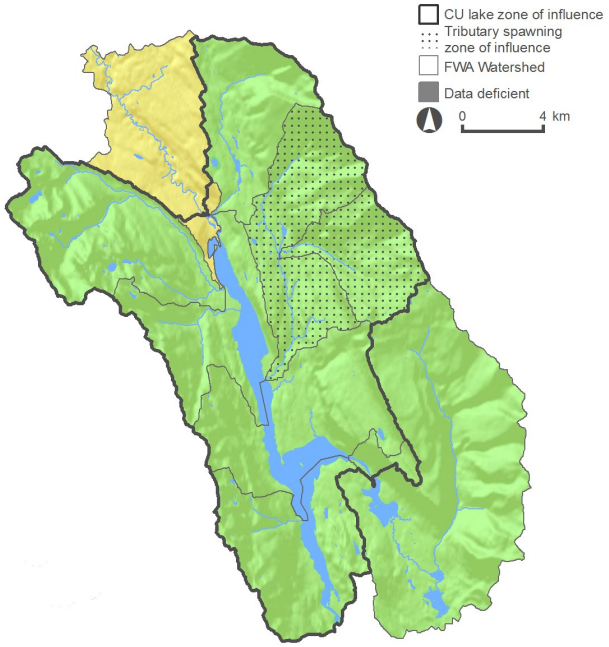


Fish accessible habitat (km)

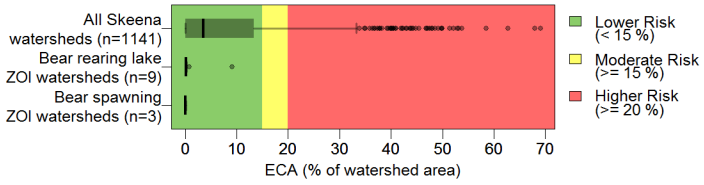


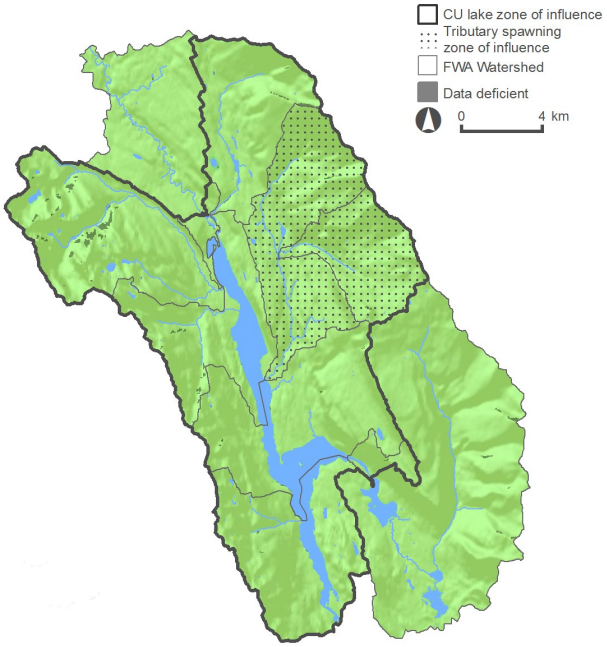
Forest disturbance





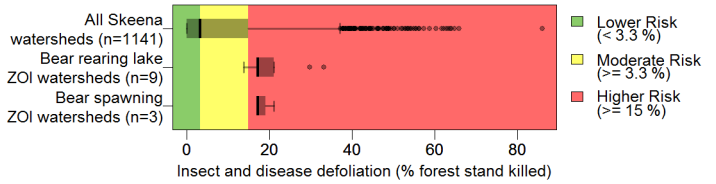
Equivalent Clear-cut Area

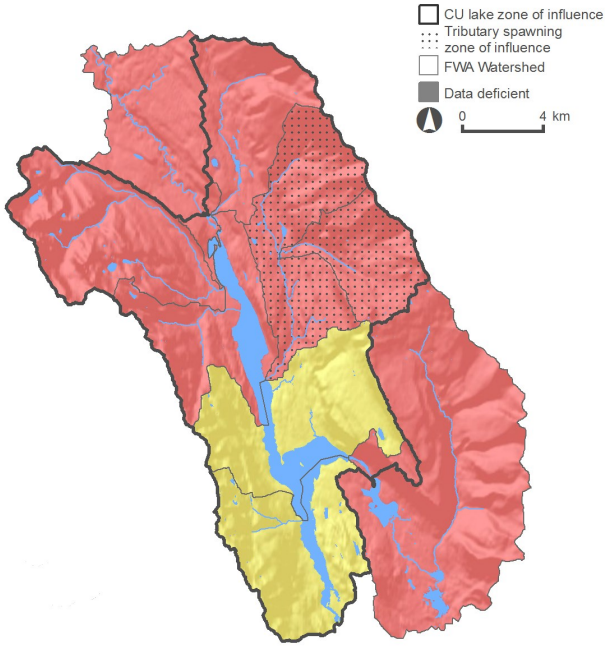




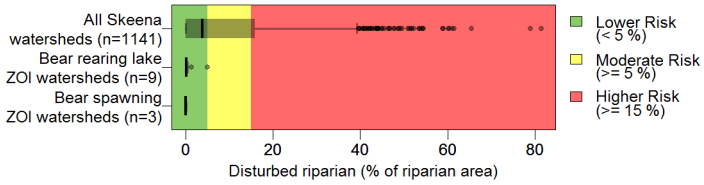
Vegetation Quality

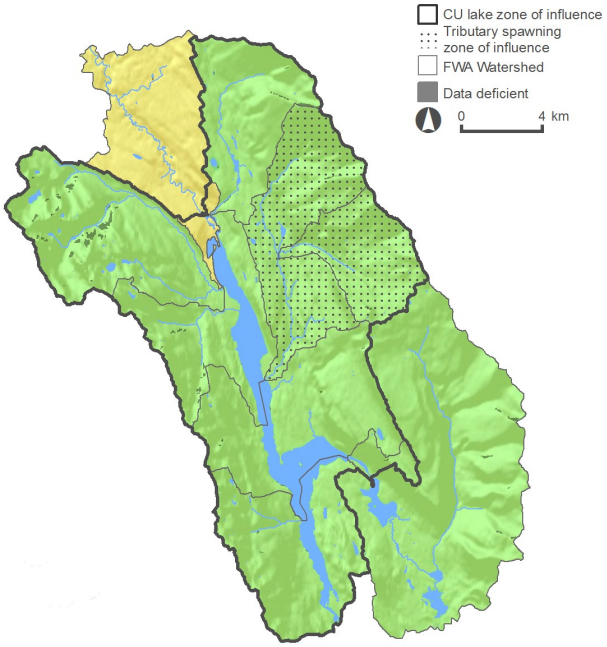
Insect and disease defoliation





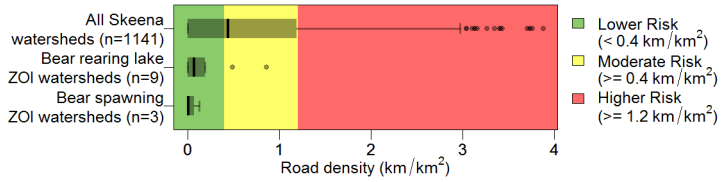
Riparian disturbance

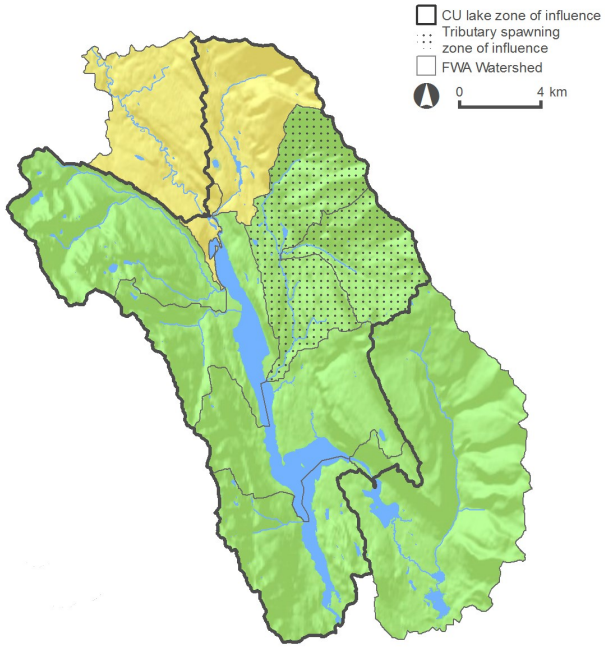




Su

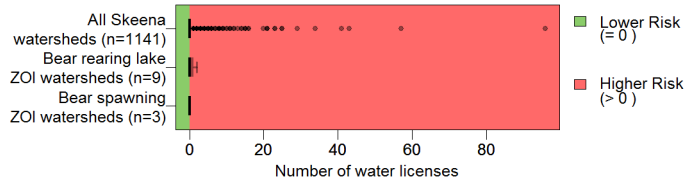
Road development

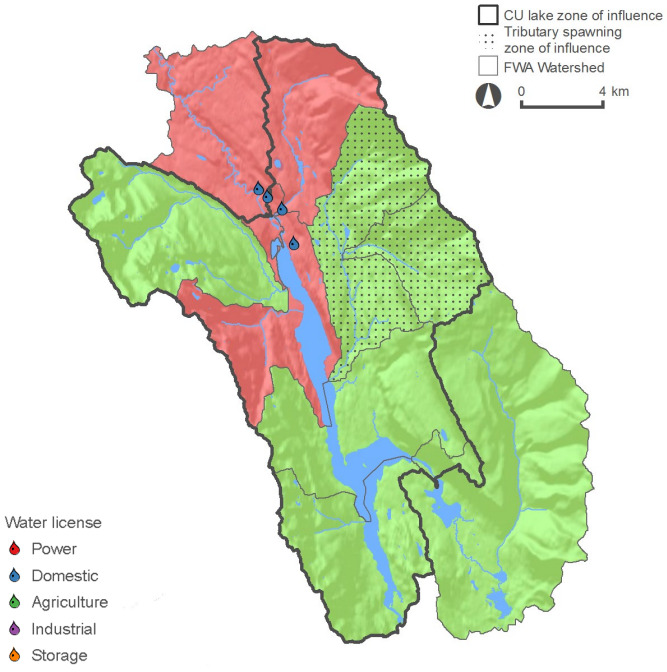




Water Quantity

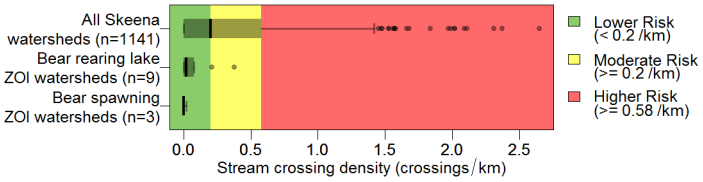
Number of water licenses

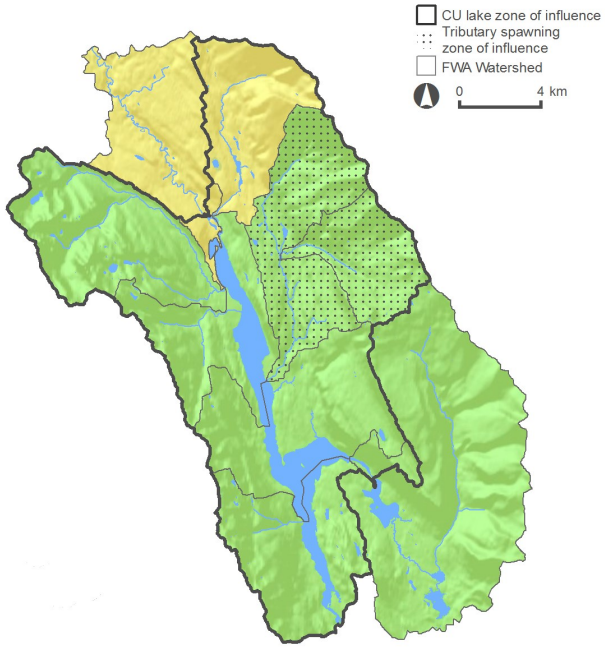




Fish Passage/Habitat Connectivity

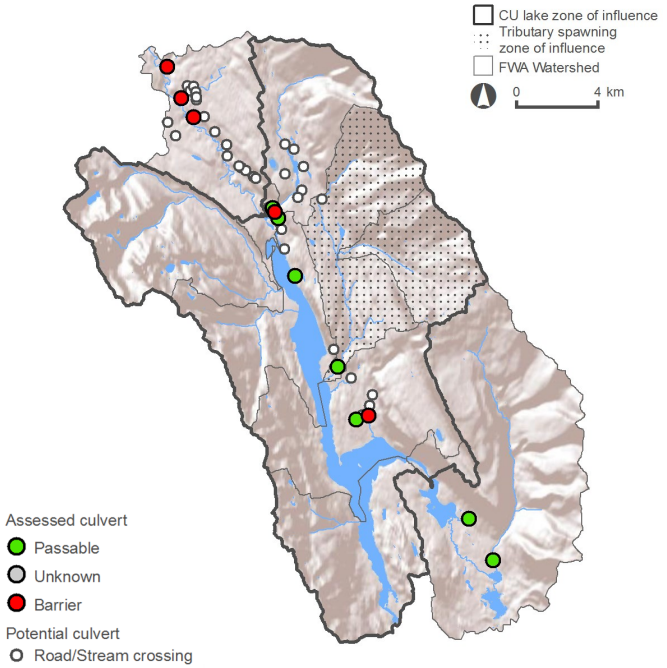
Stream crossing density



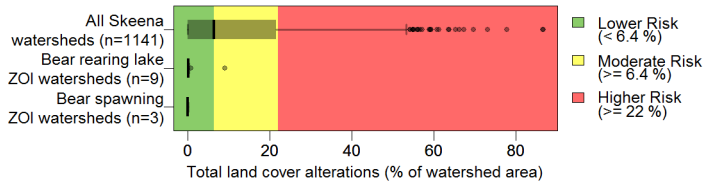


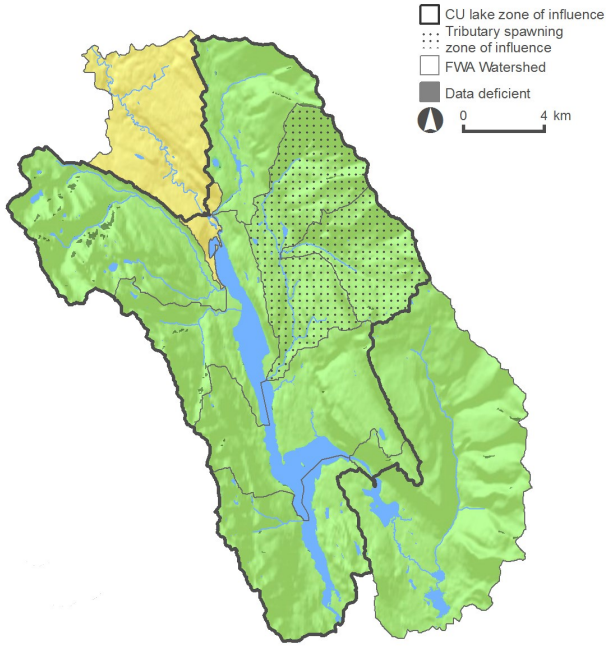
Culvert passability

Stream crossings assessed in local Skeena Fish Passage and Culvert Inspection (FPCI) reports.

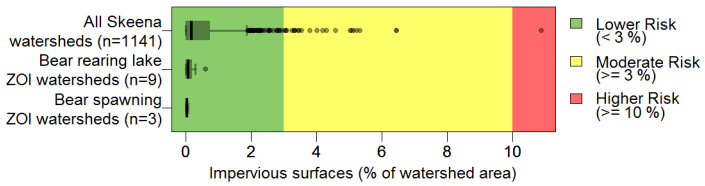


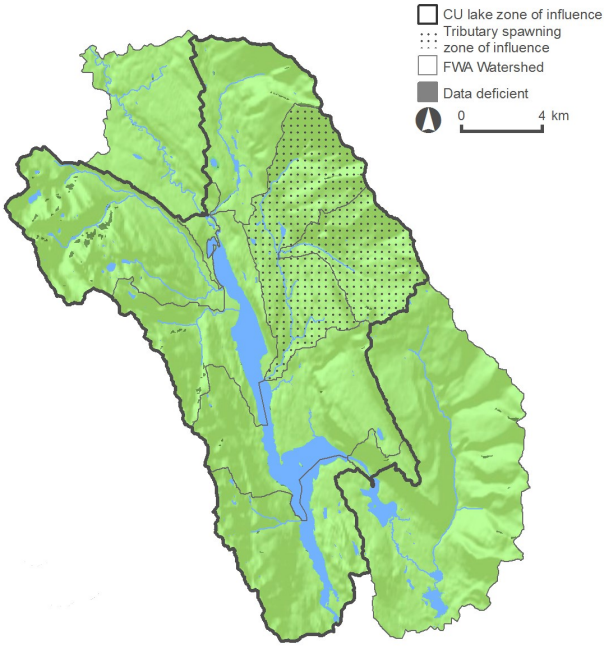
To



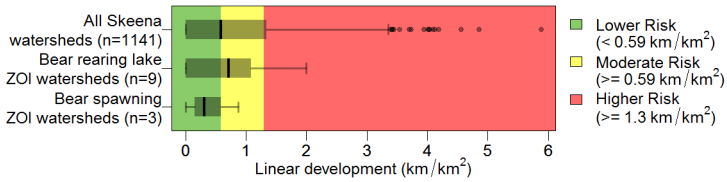


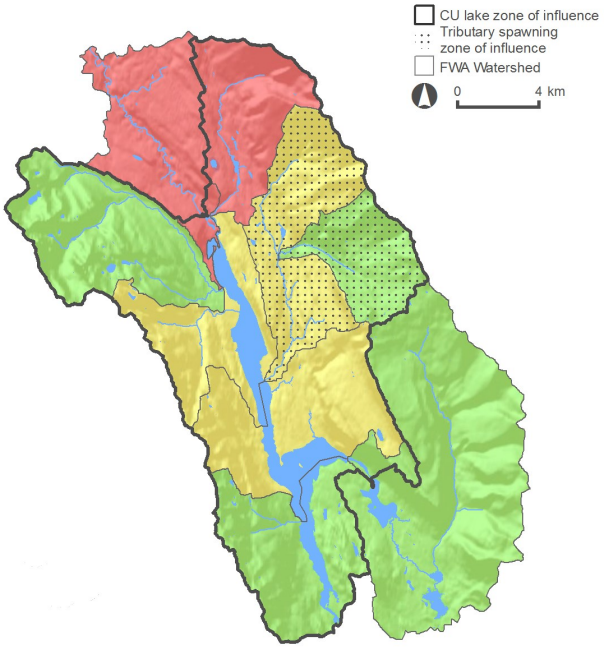
Impervious surfaces



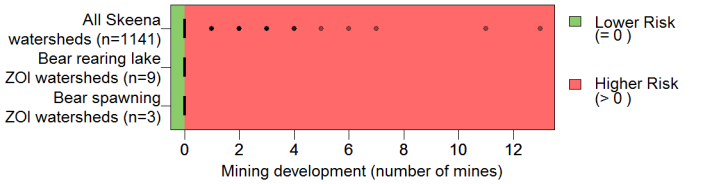


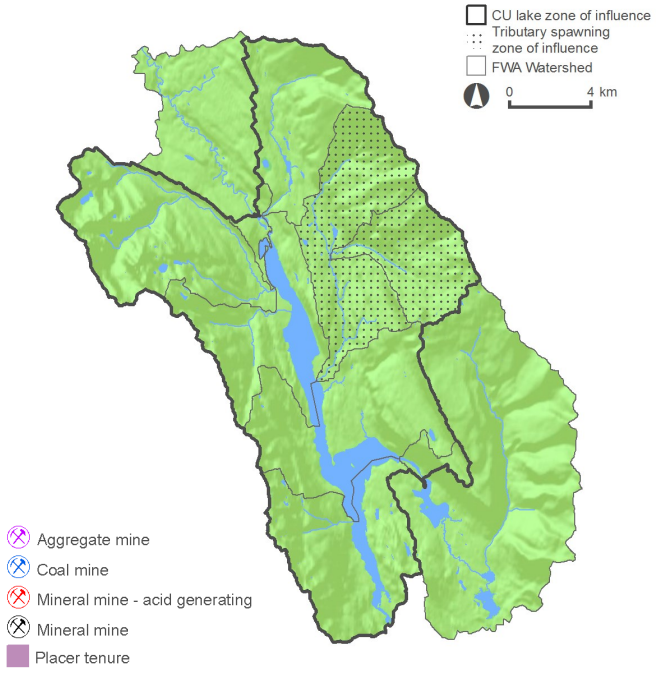
Linear development





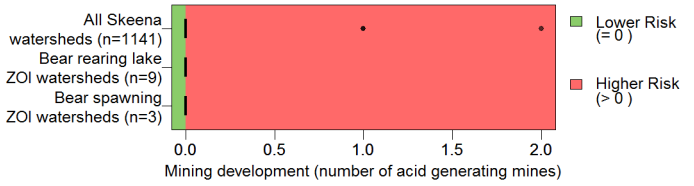
Mining development (total number of mines)

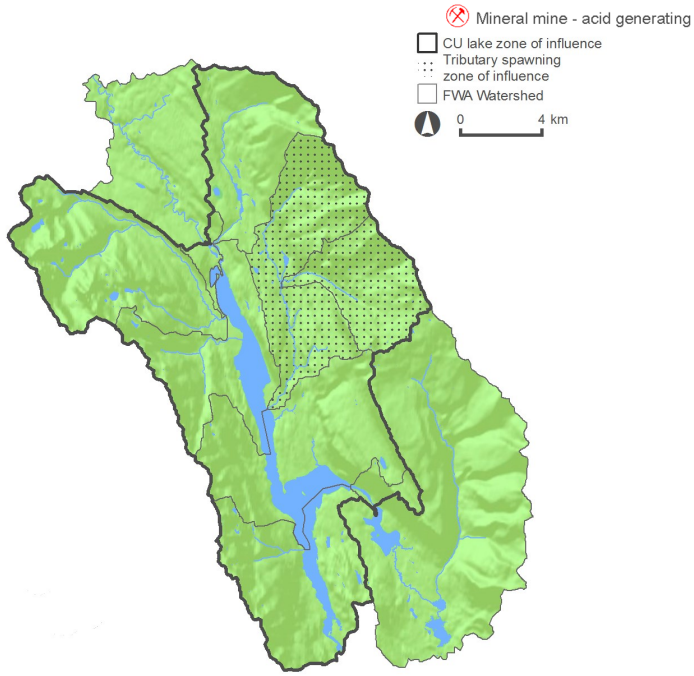




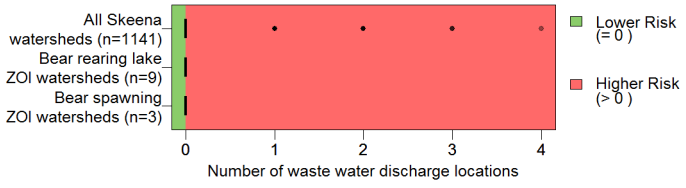
Water Quality

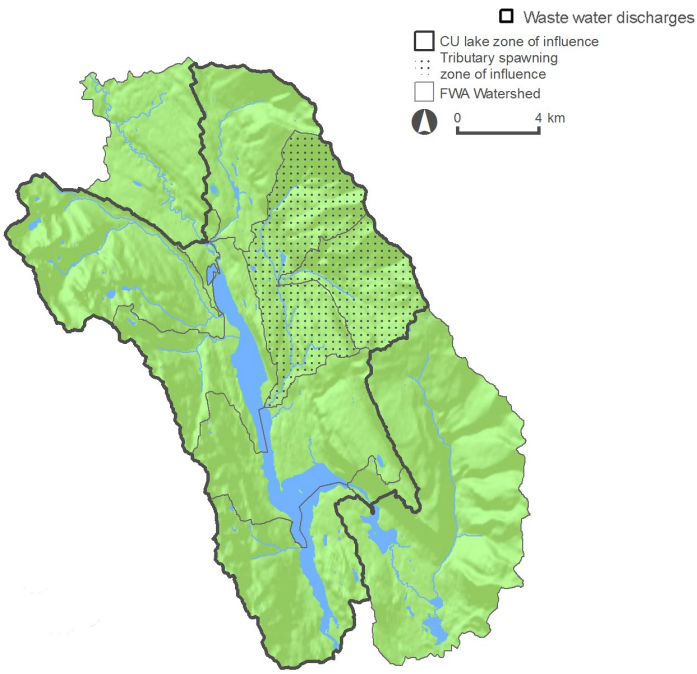
Mining development (acid generating mines)

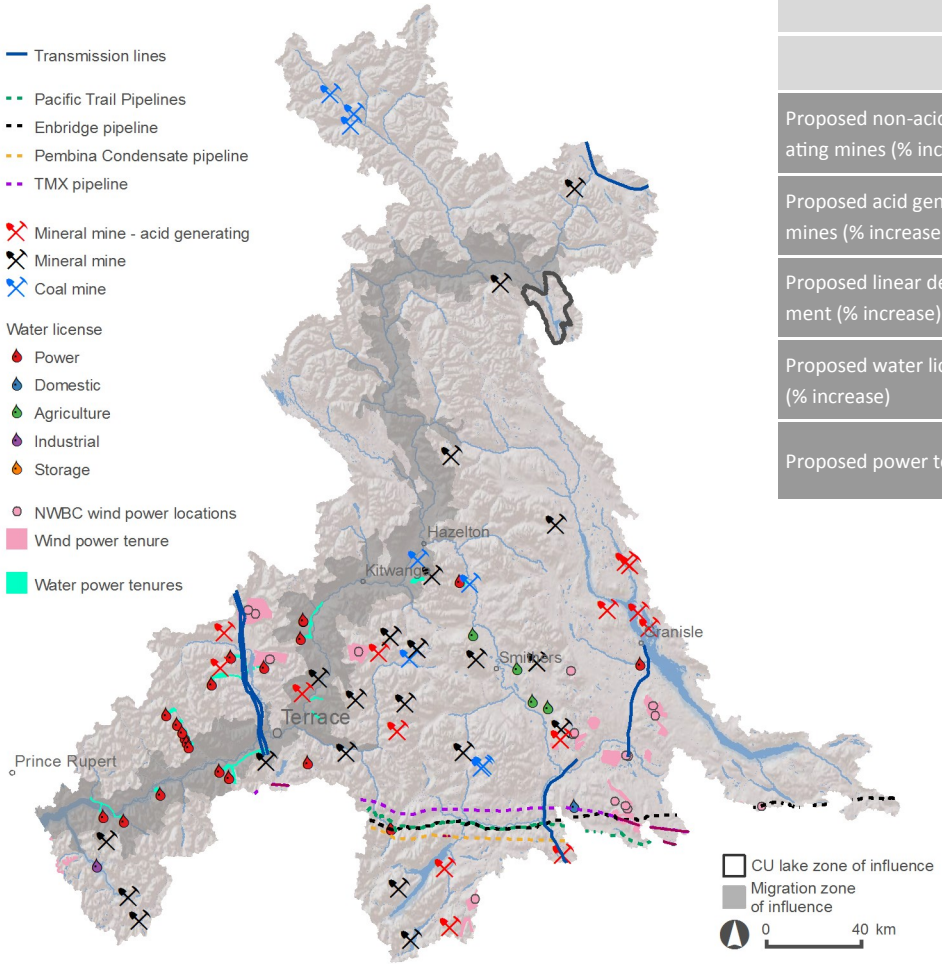




Permitted waste water discharges



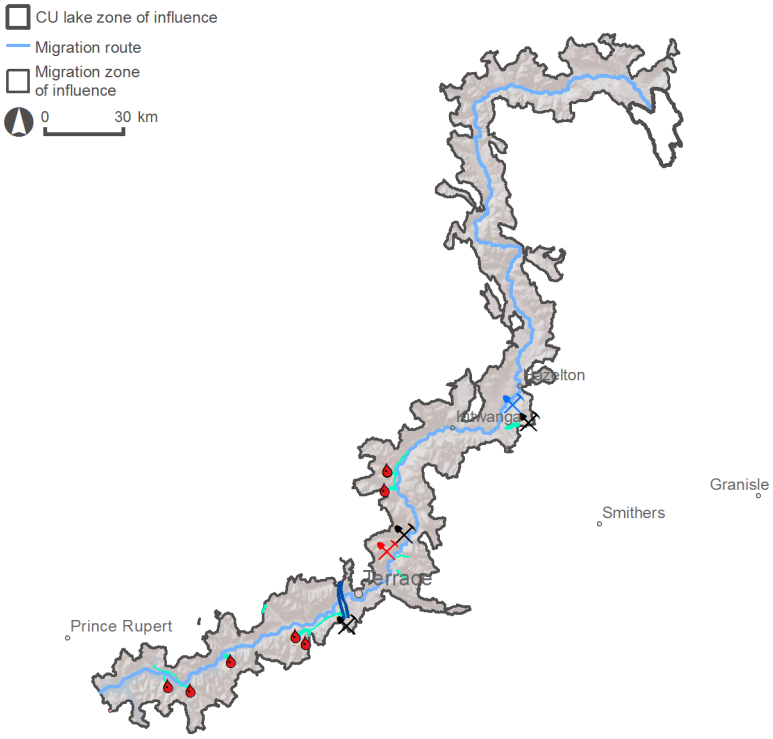




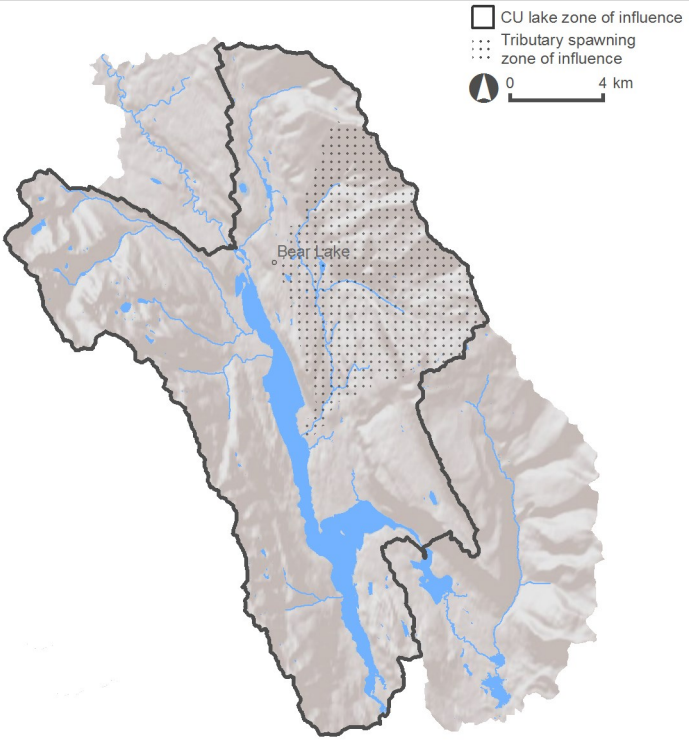
Bear Lake Sockeye CU summary

	Migration	Spawning	Rearing
Proposed non-acid generating mines (% increase)	4 (7%)	0 (0%)	0 (0%)
Proposed acid generating mines (% increase)	1 (50%)	0 (0%)	0 (0%)
Proposed linear development (% increase)	0.003 km/km^2 (0.3%)	0 km/km^2 (0%)	0 km/km^2 (0%)
Proposed water licenses (% increase)	10 (6%)	0 (0%)	0 (0%)
Proposed power tenures	63.06 km^2	0 km^2	0 km^2

Proposed resource development projects in the CU migration ZOI



Proposed resource development projects in the CU spawning and rearing ZOI



Skeena Salmon

CU Habitat Report Card Summaries – Lake Sockeye

Version 1.2, February 2014

These CU habitat report cards are intended to allow assessment and comparison of CU habitat 'status' based on a combination of: (1) intrinsic vulnerability of CU freshwater habitats and (2) intensity and extent of human pressures/stressors on those habitats. A full description of indicators and data sources used can be found in the main report (*Skeena Lake Sockeye Conservation Units: Habitat Report Cards*. Porter et al. 2013) available from PSF at: www.skeenasalmonprogram.ca.

Page 1

1. Introduction and Definitions. Brief description of the CU reporting exercise being undertaken for assessing sockeye CU habitats and definitions for key terms that are used throughout the reporting.

2. CU narratives. Short bulleted descriptions of key issues affecting the CU. This includes the principal habitat pressures on CU habitats as determined from the broad-scale analyses undertaken here, as well as more localized habitat impacts affecting the CU as identified by Skeena regional experts.

3. Location (a): Map showing location of the CU rearing lake within the Skeena drainage, and the location of the Skeena drainage within BC. The nursery lake is shaded blue and its defined 'zone of influence' (ZOI) is indicated in black outline. The migration route between the mouth of the Skeena River and the CU rearing lake outlet is indicated by the blue river line.

4. Location (b): More detailed zoomed map of the CU rearing lake showing general features of the area and the defined 'zone of influence' (ZOI) capturing the drainage area upstream from the rearing lake outlet (black outline).

Page 2

CU overview of habitat vulnerabilities & pressures

5. Description of terms. Identification of the GIS-based habitat pressure indicators, habitat pressure 'Impact Categories', and habitat vulnerability indicators developed and used for analyses of sockeye CU habitat status.

6. Cumulative habitat pressures (migration corridor). Map of cumulative habitat pressure scores for watersheds located along the CU migration corridor zone of influence[1]. Given the more diffuse nature of potential impacts along the migration route cumulative pressures scores are assigned to migration corridor watersheds based on the sum of the seven individual Impact Category scores for each watershed (rather than through a categorical rule set across Impact Categories)[2]. Within each watershed each Impact Category is scored as 0 (for a green Impact Category), 1 (for an amber Impact Category) or 2 (for a red Impact Category). The cumulative pressure scores for the migration corridor watersheds can therefore range from 0 to 14 and are colour gradated accordingly. Darker shaded watersheds represent areas along the migration corridor where relatively higher risk habitat impacts may be occurring.

7. CU rearing lake pressures overview 'slider'. Area weighted average of all watershed pressure indicator scores for 1:20K FWA assessment watersheds within or intersecting the CU rearing lake's ZOI. The area weighted average score is normalized for each indicator so that the lower to moderate risk threshold (t_1) occurs at 0.33 (s_m) and the moderate to higher risk threshold (t_2) is at 0.66 (s_h) on a scale of 0 to 1[3]. The greyed areas within the figure represent the separation of the individual indicators into the seven Impact Category groupings.

[1] The zone of influence for the migration corridor is defined as the 1:20K FWA assessment watersheds that either directly adjoin the CU's mainstem migration route (from lake outlet to Skeena River estuary) or that are located within 1 km of the mainstem route

[2] Note that the scoring approach to risk classifications (green, amber, red) for each Impact Category is based on the same defined indicator roll-up rule set that is used for watersheds within spawning and rearing ZOIs.

[3] Where the average score $\bar{s} < t_1$, the normalized score $\bar{s}_n = \bar{s}(0.33/t_1)$; where $\bar{s} \geq t_1$, $\bar{s}_n = s_m + (s_h - s_m)[(\bar{s} - t_1)/(t_2 - t_1)]$.

8. Cumulative habitat pressures (rearing lakes & tributary spawning). Map of cumulative risk from habitat pressures for each watershed found with the ZOIs for CU rearing lakes and tributary spawning areas[4]. The cumulative risk rating is based on the risk scoring of 7 habitat pressure indicator Impact Categories (hydrologic processes, vegetation quality, surface erosion, fish passage/habitat connectivity, water quantity, human development footprint, and water quality). Categorical roll-up rule set for watersheds in rearing & spawning zones of influence: if ≥ 3 impact categories are rated as higher risk, then the watershed's cumulative risk classification = red (higher risk), else if ≥ 5 Impact Categories are rated as (lower risk) then the watershed's cumulative risk classification = green (lower risk), else the watershed's cumulative risk classification = amber (moderate risk).

9. Integrated vulnerability/habitat pressures – migration, spawning & rearing. Figures representing bivariate indices of the relative rankings across Skeena sockeye CUs for scored cumulative habitat pressures and scored vulnerability to these pressures within sockeye CU ZOIs for migration, spawning and rearing. Methods used for selecting scored CU cumulative habitat pressures and vulnerabilities are different for each life stage evaluated (see Porter et. al. 2013a). The larger solid blue circle in each figure represents the ranking of the particular CU relative to the other Skeena sockeye CUs and identifies its ranked position relative to a coloured gradation representing both increasing cumulative habitat pressure and increasing vulnerability to those pressures.

Migration vulnerability and pressure

Migration period pressure

10. Migration period pressures. Detailed map of the sockeye CU migration corridor showing cumulative risk scoring, the location of water licenses occurring within migration corridor ZOI watersheds, as well as the locations of identified obstructions along the CU migration route.

11. Number of obstructions. Total number of obstructions identified along the CU migration route. Obstructions can directly impede, delay or even block passage of adult migrating salmon. The figure indicates the total number of identified obstructions along the CU migration route and illustrates the intensity of this pressure (blue bar graph) relative to other sockeye CUs within the Skeena drainage. Data source: Provincial Obstacles to Fish Passage [updated daily – downloaded Dec 2012].

12. Licensed water allocations. Total number of permitted water licenses (for all activities) in watersheds within the migration corridor ZOI. Diverting water for human uses can reduce water flow in streams for fish at critical times, potentially hindering/delaying the passage of migrating adult salmon and/or increasing migration stress. The figure indicates the total number of water licenses within the CU migration route ZOI and illustrates the intensity of this pressure (blue bar graph) relative to other sockeye CUs within the Skeena drainage. Data source: BC POD with Water License Information [updated daily – Downloaded Dec 2012].

Migration period vulnerability

13. Migration distance. Total extent of CU migration, measured as distance between the mouth of the Skeena River and most downstream entrance to the CU nursery lake. Longer migrations increase the risk of exposure to various stressors along the migration route. The figure indicates the total migration distance for the CU and shows the degree of this vulnerability (blue bar graph) relative to other sockeye CUs within the Skeena drainage. Data source: DFO_BC_Sockeye_Lake_CU_V2 [2010], FWA Stream Network [2008].

14. Migration route – summer low flow sensitive (km). The total distance of the CU migration route that is considered prone to experiencing low summer water flows with associated potential for higher water temperatures. Low flow conditions experienced over extended distances can impact fish health and can increase encounters with flow related obstacles/delays to adult fish passage. The figure indicates the total migration distance for the CU that is considered to be within a zone of summer low flow sensitivity and illustrates the degree of this vulnerability (blue bar graph) relative to other sockeye CUs within the Skeena drainage. Data source: BC MOE ecoregional flow sensitivity map [Feb 23 2011].

15. Migration route – summer low flow sensitive (%). The total proportion of the CU migration route that is considered prone to experiencing low summer water flows with associated potential for higher water temperatures. Low flow conditions over extended distances can impact fish health and create obstacles/delays to adult fish passage. The figure indicates the total proportion of the CU migration route that is considered to be within a zone of summer low flow sensitivity and illustrates the degree of this vulnerability (blue bar graph) relative to other sockeye CUs within the Skeena drainage. Data source: [BC MOE ecoregional flow sensitivity mapping [Feb 23 2011].

[4] The zone of influence (ZOI) for the CU rearing lake is defined as encompassing all the 1:20K FWA fundamental watersheds located upstream from the lake outlet to the bounding height of land defining the drainage area. The ZOI for a tributary spawning area is defined as the 1:20K FWA assessment watershed in which spawning is occurring and all FSW watersheds upstream of the spawning watershed to the bounding height of land defining the drainage area.

Spawning and rearing vulnerability

Spawning period vulnerability

16. Spawning locations. Map of known spawning sites for lake sockeye (lake, mainstem, and lake inlet/tributary spawning locations) within the defined CU rearing lake ZOI. Data source: Skeena TAC [Dec 2012].

17. Total spawning length. The total length of all sockeye spawning reaches within the CU rearing lake ZOI (lake, mainstem or tributary spawning). Areas of lake spawning are also included and expressed as a linear length. This reflects the total amount of habitat known to be used for spawning by Skeena lake sockeye, with a greater length of spawning habitat indicating a lower CU vulnerability to habitat pressures.The figure indicates the total spawning length within the CU rearing lake ZOI and illustrates the degree of this vulnerability (blue bar graph) relative to other sockeye CUs within the Skeena drainage. Data source: Skeena TAC [Dec 2012].

18. Lakeshore spawning length. The total length of lake shore spawning occurring within the CU rearing lake. Areas of lake shore spawning are expressed as a linear length. This reflects the total amount of lake shore habitat known to be used by Skeena lake sockeye, with a greater length of spawning habitat indicating a lower CU vulnerability to habitat pressures.The figure indicates the lakeshore spawning length within the CU rearing lake and illustrates the degree of this vulnerability (blue bar graph) relative to other sockeye CUs within the Skeena drainage. Data source: Skeena TAC [Dec 2012].

19. Mainstem spawning length. The total length of all mainstem spawning reaches within the CU rearing lake ZOI. This reflects the total amount of mainstem habitat known to be used for spawning by Skeena lake sockeye, with a greater length of spawning habitat indicating a lower CU vulnerability to habitat pressures.The figure indicates the length of mainstem spawning within the CU rearing lake ZOI and illustrates the degree of this vulnerability (blue bar graph) relative to other sockeye CUs within the Skeena drainage. Data source: Skeena TAC [Dec 2012].

20. Tributary/lake inlet spawning length. The total length all trib/lake inlet spawning reaches occurring within the CU rearing lake ZOI. This reflects the total amount of trib/lake inlet habitat known to be used by Skeena lake sockeye, with a greater length of spawning habitat indicating a lower CU vulnerability to habitat pressures.The figure indicates the trib/lake inlet spawning length within the CU rearing lake ZOI and illustrates the degree of this vulnerability (blue bar graph) relative to other sockeye CUs within the Skeena drainage. Data source: Skeena TAC [Dec 2012].

21. Ratio of lake influenced to total spawning. The total length of spawning reaches that are buffered by lake influence (i.e., lake shore or mainstem spawning) relative to the total length of all spawning reaches within the CU rearing lake ZOI. This reflects the effect of lakes to buffer against upstream habitat impacts, such that lake-influenced spawning areas would be considered relatively less vulnerable to disturbances than tributary/lake inlet spawning areas. The figure indicates the lake influenced ratio within the CU rearing lake ZOI and illustrates the degree of this vulnerability (blue bar graph) relative to other sockeye CUs within the Skeena drainage. Data source: Skeena TAC [Dec 2012].

22. Fish accessible habitat. The total length all 1:20K defined stream reaches occurring within the CU rearing lake ZOI that are considered accessible to salmonids. This reflects the total amount of stream habitat that could 'potentially' be available to salmonids for spawning or rearing, with a greater accessible length indicating a lower CU vulnerability to habitat pressures. The figure indicates the accessible habitat length within the CU rearing lake ZOI and illustrates the degree of this vulnerability (blue bar graph) relative to other sockeye CUs within the Skeena drainage. Data source: BC MOE Fish Passage layer [Oct 2011]. Note that this layer is based on a model that defines stream accessibility to salmonids in general and is not specific to sockeye passage abilities/constraints.

Rearing period vulnerability

23. Area of nursery lakes. Total area of the sockeye CU nursery/rearing lake. Larger rearing lakes generally can provide more habitats to support a greater number of juvenile sockeye and should be more resilient to localized habitat impacts. The figure indicates the size of the CU rearing lake and illustrates the degree of this vulnerability (blue bar graph) relative to other sockeye CUs within the Skeena drainage. Data source: DFO_BC_Sockeye_Lake_CU_V2 [2010].

24. Nursery lake productivity. The annual biomass of smolts that could theoretically be produced in the CU nursery lake based on DFO's current photosynthetic rate (PR) model for estimating the intrinsic rearing capacity of Skeena lakes. Productivity (based on the amount of nutrients available) reflects the potential for growth and survival of juvenile sockeye, with more productive lakes presumably more resilient to localized habitat impacts. The figure indicates the estimated productivity of the CU rearing lake and illustrates the degree of this vulnerability (blue bar graph) relative to other sockeye CUs within the Skeena drainage. Data source: DFO - S. Cox-Rogers et al. [2010, 2012].

Spawning and rearing pressure

Hydrologic Processes

25. Forest disturbance. Percentage of disturbed forest (recently logged, selectively logged, and recently burned) in each watershed within the CU rearing lake and spawning areas ZOIs. Forest disturbance can impact salmon habitat through general changes to flow patterns and annual water yields. Defined benchmarks of concern (lower, moderate, higher) for forest disturbance are based on the relative distribution of values across all Skeena watersheds. Data source: VRI [updated annually, downloaded Dec 2012], RESULTS [updated daily, downloaded Dec 2012], FTEN [updated daily, downloaded Dec 2012].

26. Equivalent Clear-cut Area (ECA). The percentage of each watershed in the CU rearing lake and spawning areas ZOIs that is considered functionally/hydrologically equivalent to a clear-cut. ECA is a calculated term that reflects the potential cumulative impact on fish habitats of harvesting and second-growth forest regeneration effects on peak flow. Defined benchmarks of concern (lower, moderate, higher) for ECA are science and expert based (MOF 2001; Smith and Redding 2012). Data source: VRI [updated annually, downloaded Dec 2012], RESULTS [updated daily, downloaded Dec 2012], FTEN [updated daily, downloaded Dec 2012], LCC2000-V [2000].

Vegetation Quality

27. Insect & disease defoliation. Percentage of the forest stands in each watershed within the CU rearing lake and spawning areas ZOIs that has been defoliated by recent insect invasion or disease. Defoliation can impact salmon habitats through changes to flows and groundwater supplies from altered precipitation interception and reduced transpiration. Defined benchmarks of concern (lower, moderate, higher) for insect and disease defoliation are based on the relative distribution of values across all Skeena watersheds . Data source: VRI [updated annually, downloaded Dec 2012].

28. Riparian disturbance. Percentage of the riparian zone (defined by a 30m buffer around all water bodies) in each watershed within the CU rearing lake and spawning areas ZOIs that has been altered by land use activities. Disturbance to the riparian zone can alter stream shading, water temperature, organic matter inputs and bank stability. Defined benchmarks of concern (lower, moderate, higher) for riparian disturbance are science and expert based (Stalberg et al. 2009, Tripp and Bird (2004). Data source: VRI [updated annually, downloaded Dec 2012].

Surface Erosion

Water Quantity

29. Road development. The density of all roads in each watershed within the CU rearing lake and spawning areas ZOIs. Extensive road development can interrupt overland flow and increase fine sediment generation, impacting downstream spawning and rearing habitats. Defined benchmarks of concern (lower, moderate, higher) for road density are science and expert based (MOF 1995a &b, Stalberg et al. 2009 & Porter et al. 2013a). Data source: DRA [updated monthly, downloaded Dec 2012], FTEN [updated daily, downloaded Dec 2012].

30. Water licenses. The total number of permitted water licenses (all types) for points of diversion in each watershed within the CU rearing lake and spawning areas ZOIs. Diverted water can potentially reduce flows in streams, thereby limiting fish access to or use of habitats and/or changing hydrological processes. The defined benchmark of concern (lower & higher) for water licenses is a binary measure based simply on presence/absence of the pressure in the watershed. Data source: BC Points of Diversion with Water License Information [updated daily, downloaded Dec 2012].

Fish Passage/Habitat Connectivity

31. Stream crossing density. Number of crossings per km of defined fish habitat in each watershed within the CU rearing lake and spawning areas ZOIs. Obstructions at stream crossings can impact salmon habitat conditions and hinder migration of fish or block access to useable habitats. Defined benchmarks of concern (lower, moderate, higher) for stream crossing density are based on the relative distribution of values across all Skeena watersheds. Data source: BC MOE Fish Passage layer [Oct 2011], FWA Stream Network [2008], DRA [updated monthly, downloaded Dec 2012].

32. Culvert passability. Fish passage classifications (passable - green, barrier - red, unknown - grey) for stream crossings that have been surveyed using provincial PSCIS culvert assessment protocols within the CU rearing lake and spawning areas ZOIs. Stream crossings on DRA defined roads that have not yet been surveyed are indicated by white circles. Data source: BC MOE PSCIS layer [Oct 2011], Skeena TAC [March 2013].

Page 7

Human Development Footprint

33. Total land cover alteration. Land alteration (agriculture, residential/agriculture mix, recently burned, recently logged, selectively logged, mining, recreation, and urban) as a percentage of watershed area for each watershed within the CU rearing lake and spawning areas ZOIs. Land cover alteration reflects a suite of potential changes to hydrological processes and sediment generation, with potential downstream impacts on spawning and rearing habitats. Defined benchmarks of concern (lower, moderate, higher) for land cover alteration are based on the relative distribution of values across all Skeena watersheds. Data source: LCC2000-V [2000], VRI [updated annually, downloaded Dec 2012], DRA [updated monthly, downloaded Dec 2012], FTEN [updated daily, downloaded Dec 2012], RESULTS [updated daily, downloaded Dec 2012], NTS [1998], Crown Tenure [updated daily, downloaded Dec 2012], Current Fire Perimeters [updated daily, downloaded Dec 2012], Historical Fire Perimeters [updated monthly, downloaded Dec 2012], BTM [1992].

34. Impervious surfaces. Percentage of each watershed within the CU rearing lake and spawning areas ZOIs that is considered impervious: a calculated term that reflects the area covered by hard man-made surfaces (e.g. asphalt, concrete, brick, etc.). Extensive impervious surfaces from urban/rural development in a watershed can impact rainwaters infiltration and groundwater recharge, and lead to stream habitat degradation through changes in geomorphology and hydrology. Impervious surfaces are also associated with increased loading of nutrients and contaminants in developed areas. Defined benchmarks of concern for impervious surfaces (lower, moderate, higher) are science and expert based (Paul and Meyer 2000; Smith 2005). Note that impervious surface co-efficients (ISC) for land surface types used for this exercise were not Skeena drainage specific but were instead generalized from those used in other jurisdictions. Data source: LCC2000-V [2000], VRI [updated annually, downloaded Dec 2012], DRA [updated monthly, downloaded Dec 2012], FTEN [updated daily, downloaded Dec 2012], NTS [1998].

35. Linear development. Density of all linear construction (e.g. roads, utility corridors, pipelines, right of ways, railways, etc.) in each watershed within the CU rearing lake and spawning areas ZOIs. Linear development is a general indicator of potential human impacts on fish habitats. Defined benchmarks of concern (lower, moderate, higher) for linear development are based on the relative distribution of values across all Skeena watersheds. Data source: DRA [updated monthly, downloaded Dec 2012], FTEN [updated daily, downloaded Dec 2012], NTS [1998].

36. Mining development (all mines). Total number of mines in each watershed within the CU rearing lake and spawning areas ZOIs. The general footprint of a mine and its associated processes of mining can change geomorphology and the hydrological processes of nearby water bodies. Mining can also generate deposition of fine sediments which can affect salmon survival and prey densities. The defined benchmark of concern (lower & higher) for mines is a binary measure based simply on presence/absence of the pressure in the watershed. Data source: BCGOV MEM & PR databases [updated regularly, accessed Dec 2012].

Page 8

Water Quality

37. Mining development (acid generating mines). Total number of acid generating mines in each watershed within the CU rearing lake and spawning areas ZOIs. Acid generating mines have increased risk for potential outflow of acidic water, heavy metals and other contaminants, with associated harm to fish habitats. The defined benchmark of concern (lower & higher) for acid generating mines is a binary measure based on presence/absence of the pressure in the watershed. Data source: BCGOV MEM & PR databases [updated regularly, accessed Dec 2012], Skeena TAC identification of acid generating mines [2012].

38. Permitted wastewater discharges. Total number of permitted wastewater discharge sites in each watershed within the CU rearing lake and spawning areas ZOIs. High levels of wastewater discharge have the potential to impact water quality through excessive nutrient enrichment or chemical contamination. The defined benchmark of concern (lower & higher) for wastewater discharge sites is a binary measure based simply on presence/absence of the pressure in the watershed. Data source: MOE Wastewater Discharge and Permits database [updated regularly, downloaded Dec 2012].

Page 9

Proposed resource development projects

39. Skeena overview map of the locations of new resource development projects proposed within the Skeena drainage (across a range of activities). Data source: Skeena TAC, extracted from multiple sources [2012].

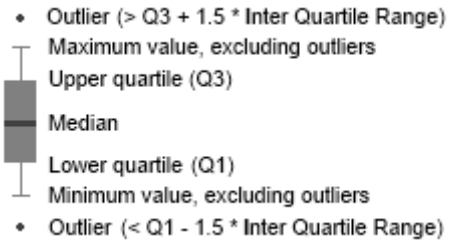
40. CU summary of resource development projects. The total number or extent of resource development related projects that are known to be proposed for future development within watersheds affecting the CU (i.e., within migration, spawning and/or rearing ZOIs) and the potential percentage increase in these pressures (if any) over the current baselines. Data source: Skeena TAC, extracted from multiple sources [2012].

41. Map of CU migration ZOI resource development projects. Detailed map showing locations of new resource development projects that have been proposed in watersheds within the CU migration ZOI. Data source: Skeena TAC, extracted from multiple sources [2012].

42. Map of CU spawning & rearing ZOIs resource development projects. Detailed map showing locations of new resource development projects that have been proposed in watersheds within the CU spawning and/or rearing ZOIs. Data source: Skeena TAC, extracted from multiple sources [2012].

Additional notes

Key to interpreting pressure indicator box plots:



Data deficient areas. Mapped areas delineated as "data deficient" are those that have incomplete coverage for the core VRI or LCC2000 GIS data used for generation of some habitat indicators. These areas are mapped explicitly to identify any watersheds that have some level of relative uncertainty around a particular habitat indicator value. These areas however have been supplemented (i.e., patched) with GIS data from alternate sources, sometimes at a coarser resolution, to allow indicator generation/scoring or else are areas lacking only minor elements of a larger suite of data components with limited influence on the final derived habitat indicator values.

References

Cox-Rogers, S., J.M.B. Hume, K.S. Shortreed, and B. Spilsted. 2010. A risk assessment model for Skeena River sockeye salmon. Can. Manuscr. Rep. Fish. Aquat. Sci. 2920.

Cox-Rogers, S. 2012. Habitat-based abundance benchmarks for Lake Sockeye CU's in the Skeena Watershed. DFO internal draft report: April 2012.

MOF (B.C. Ministry of Forests). 1995a. Interior watershed assessment procedure guidebook (IWAP).

MOF (B.C. Ministry of Forests). 1995b. Coastal watershed assessment procedure guidebook CWAP).

MOF (B.C. Ministry of Forests). 2001. Watershed assessment procedure guidebook. 2nd ed., Version 2.1, Forest Practices Branch, Ministry of Forests, Victoria, B.C. Forest Practices Code Guidebook.

Paul, M.J., and J.L. Meyer. 2001. Streams in the urban landscape. Annual Review of Ecological Systems. 32: 333-365.

Porter, M., S. Casley, D. Pickard, E. Snead, and K. Wieckowski. 2013a. Draft Version 3.2, May 2013. Tier 1 Watershed-level fish values monitoring protocol. Draft report prepared by ESSA Technologies Ltd. for BC British Columbia Ministry of Forests, Lands and Natural Resource Operations and BC Ministry of the Environment (MOE), Victoria, BC.

Porter, M., D. Pickard, S. Casley, and N. Ochoski. 2013b. Skeena Lake Sockeye Conservation Units: Habitat report cards. Prepared by ESSA Technologies Ltd. for the Pacific Salmon Foundation, Vancouver, BC.

Smith, C.J. 2005. Salmon habitat limiting factors in Washington State. Washington State Conservation Commission, Olympia, Washington.

Stalberg, H.C., R.B. Lauzier, E.A MacIsaac, M. Porter, and C. Murray. 2009. Canada's policy for conservation of wild pacific salmon: Stream, lake, and estuarine habitat indicators. Can. Manuscr. Fish. Aquat. Sci. 2859. http://www.dfo-mpo.gc.ca/Library/338996.pdf.

Tripp, D.B., and S. Bird. 2004. Riparian effectiveness evaluation. Ministry of Forests Research Branch, Victoria, BC.

Acknowledgements

The Pacific Salmon Foundation and ESSA Technologies Ltd. would like to sincerely thank the members of the Skeena Technical Advisory Committee (TAC) for giving of their time and knowledge to guide the development of these CU habitat report cards. Their assistance has been invaluable. The following people participated in one or more workshop and many also contributed data to the project: Mark Cleveland, Sandra Devcic, David DeWitt, Alana Dickson, Hannes Eddinger, Jessica Hawryshyn, Walter Joseph, Derek Kingston, Greg Knox, Siegi Kriegl, Chrissy Melymick, Lana Miller, Don Morgan, Johanna Pfalz, Ken Rabnett, and Bruce Watkinson.

We would also like to offer our thanks to the following additional people and organizations for generously providing data towards this project: Selina Agbayani (WWF-Canada), Matthew Beedle, James Casey (WWF-Canada), Barb Faggetter, North Coast-Skeena First Nations Stewardship Society, Craig Outhet (NCFSNSS), Ron Ptolemy, Skeena Wild Conservation Trust, Russell Smith, Jack Stanford, World Wildlife Fund Canada.

This project is funded by the Gordon and Betty Moore Foundation.