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Evaluation of Fraser River Sockeye salmon (*Oncorhynchus nerka*) spawning distribution following COSEWIC and IUCN Redlist guidelines

Évaluation de la répartition des lieux de reproduction du saumon rouge (*Oncorhynchus nerka*) du fleuve Fraser suivant les directives du COSEPAC et des listes rouges de l'IUCN

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ABSTRACT

Sockeye salmon (*Oncorhynchus nerka*) from the Fraser River are scheduled to be assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 2013. Information on the spatial distribution of Sockeye salmon populations is required for COSEWIC quantitative criteria B and D. Fraser River sockeye populations have been organized into 24 Conservation Units (CUs) in support of Fisheries and Oceans Canada's (DFO) Wild Salmon Policy. For each of the 24 CUs, we estimated: the number of spawning locations (defined as individual spawning streams or whole lakes or large branches of lakes); the extent of occurrence (defined as polygons encompassing all spawning areas in each CU); the area of occupancy (a measure of the habitat actually occupied for spawning, and assessed using grid techniques); and the biological area of occupancy (a measure of occupancy not constrained by grid methodology). We also estimated the extent of occurrence, area of occupancy and biological area of occupancy for the entire distribution of Fraser River Sockeye salmon spawners**.** Estimates were based on observations of spawner distributions from 2008 to 2011. Data on the number of locations were available from 1992 to 2011, which allowed trends in spatial distribution to be examined. We identified spawning sites that contained potential vagrants, and evaluated the effect of removing these sites from all analyses. We explored a number of alternative means for calculating extent of occurrence and area of occupancy statistics, but found in most cases the method of analysis had little effect on the value of statistics relative to thresholds defined by COSEWIC.

RÉSUMÉ

En 2013, il est prévu que le Comité sur la situation des espèces en péril au Canada (COSEPAC) procède à une évaluation concernant le saumon rouge (*Oncorhynchus nerka*) du fleuve Fraser. Pour ce faire, des renseignements sur l'aire de répartition des populations de saumons rouges seront nécessaires pour les critères quantitatifs B et D du COSEPAC. Les populations de saumons rouges du fleuve Fraser ont été divisées en 24 unités de conservation à l'appui de la Politique concernant le saumon sauvage de Pêches et Océans Canada (MPO). Pour chacune de ces 24 unités de conservation, nous avons évalué le nombre de lieux de reproduction (cours d'eau de fraye, lacs ou bras de lac), la zone de présence des populations (c'est-à-dire les zones en forme de polygone incluant toutes les zones de fraye dans chacune des unités de conservation), la zone d'occupation (mesure de l'habitat actuellement occupée pour la reproduction, évaluée au moyen de techniques de quadrillage) et la zone d'occupation biologique (mesure de l'occupation non limitée par les techniques de quadrillage). Nous avons aussi évalué la zone de présence des populations, la zone d'occupation et la zone d'occupation biologique pour toute la répartition de saumons rouges géniteurs**.** Les évaluations sont fondées sur les observations des répartitions de géniteurs de 2008 à 2011. Les données sur le nombre de lieux étaient disponibles à partir des observations effectuées entre 1992 et 2011, ce qui a permis d'examiner les tendances quant à l'aire de répartition. Nous avons repéré des lieux de reproduction contenant des saumons rouges vagabonds, et nous avons évalué l'incidence d'exclure ces lieux de toutes les analyses. Nous avons essayé plusieurs méthodes pour calculer les statistiques relatives à la zone de présence des populations et à la zone d'occupation, mais dans la plupart des cas, nous avons trouvé que la méthode d'analyse n'avait que peu d'incidence sur la valeur des statistiques relatives aux seuils établis par le COSEPAC.

1 INTRODUCTION

The purpose of this document is to provide an analysis of distributional metrics for 24 Conservation Units (CU) of Fraser River Sockeye salmon (*Onchorhynchus nerka*), as described in Grant et al. (2011), as well as for the entire Fraser River distribution. These metrics inform an assessment of the status of each CU using criterion B (Small Distribution Range and Decline or Fluctuation), and criterion D (Very Small or Restricted Total Population) of the quantitative criteria for the status assessment of wildlife species used by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2010). We assess the extent of occurrence (EO), the area of occupancy (AO) and number of locations for each CU using a variety of methods for their calculation.

The concepts of extent of occurrence and area of occupancy as two distinct types of measures of a population's distribution or range were first articulated by Gaston (1991). Extent of occurrence is defined by the International Union for Conservation of Nature (IUCN) as "the area contained within the shortest continuous imaginary boundary which can be drawn to encompass all the known, inferred or projected sites of present occurrence of a taxon, excluding cases of vagrancy" (IUCN 2001). The IUCN defines the area of occupancy as "the area within [the] extent of occurrence which is occupied by a taxon, excluding cases of vagrancy" (IUCN 2011*a*). COSEWIC uses these definitions in its instructions for the preparation of status reports (COSEWIC 2010).The area of occupancy, by definition, cannot be greater than the extent of occurrence. The extent of occurrence is intended to be a metric of the geographic spread of a population, used to assess the degree to which it may be at risk from potential threats. The area of occupancy addresses the fact that a population may not occur at all locations within its extent of occurrence, and is a measure of the amount of occupied habitat and is thus expected to be more closely correlated with population size than the extent of occurrence is.

There are multiple ways in which to measure both the area of occupancy and extent of occurrence of a population, and the method chosen largely depends on the purpose and nature of the assessment. The objective of assessing the area of occupancy is to provide an indication of the degree of habitat restriction and of the population size, both of which are assumed to be correlated with extinction risk (IUCN 2011*b*). Because it is essential in assigning categorical levels of risk to multiple populations and species, a standardised method of measuring area of occupancy has been recommended. Both IUCN and COSEWIC require that the area of occupancy be assessed by overlaying the extent of occurrence of a population with a grid of 2x2 km cells and summing the area of cells in which the population occurs. COSEWIC also allows area of occupancy to be assessed using 1x1 km cells (COSEWIC 2010), though the IUCN warns that this can lead to a bias toward higher risk categorisations (IUCN 2011*a*). While largely in agreement with the IUCN guidelines, COSEWIC differs in that it distinguishes between two types of area of occupancy: the biological area of occupancy (BAO), and the index area of occupancy (IAO). The biological area of occupancy is more closely related to the actual area occupied by individuals within a population, and can be calculated as the product of the average individual (non-overlapping) territory size and of the population size. The IAO is intended to be independent of scale and is estimated using the grid method. IAO will hereafter be referred to simply as AO. There is currently no specific, standardised prescribed method for estimating BAO.

There are two largely accepted techniques of determining extent of occurrence: the minimum convex polygon (MCP), and α-hull methods, which are a generalisation of the MCP method. In the context of the EO the MCP is "the smallest polygon in which no internal angle exceeds 180 degrees and which contains all sites of occurrence" (COSEWIC 2010). The α-hull method is similar to the MCP but can result in a polygon where some of the internal angles may exceed

180 degrees, thus allowing the extent of occurrence to better track the shape of a population's distribution. The IUCN suggests that when the extent of occurrence is used to assess changes over time the α-hull method is preferable, because it is less susceptible to the presence of outliers than the MCP is. However, COSEWIC's *Instructions for the Preparation of Status Report*s only prescribes the use of MCPs, and not the use of α-hulls (COSEWIC 2010), so we assess extent of occurrence here using the MCP method. As well, we are not able to assess extent of occurrences over time, so the use of the MCP method is appropriate.

Because the extent of occurrence is defined by a polygon where each corner is an outermost occurrence of a population, it can contain large areas of unsuitable habitat. Both the IUCN and COSEWIC state that "discontinuities or disjunctions within the overall distribution of the taxa" may be excluded from the extent of occurrence (COSEWIC 2010, IUCN 2011). However, in its most recent guidelines on implementing the Red List criteria, the IUCN recommends not excluding any areas within the polygon bounding all locations of occurrence. In a review of the application of extent of occurrence and area of occupancy measures, Gaston and Fuller (2009) also states that no exclusions should be permitted because this would cause the extent of occurrence metric to become more similar to, and less distinct from, the area of occupancy metric. The IUCN explains that "disjunctions and outlying occurrences accurately reflect the extent to which a large range size reduces the chance that the entire population of the taxon will be affected by a single threatening process" (Standards and Petitions Working Group 2006). This is currently a subject of debate in the IUCN, and was one of the topics discussed at a recent workshop on species mapping, the proceedings of which may be available in the near future (C. Hilton-Taylor, Manager, UK Office & Red List Unit Species Programme, IUCN, Cambridge, United Kingdom, personal communication, 2012).

Minimum convex polygons as estimates of extents of occurrence, have been criticised for potentially including large areas of unsuitable habitat, requiring at least three records to yield an area estimate, being dependent on the shape of a population's distribution, not accounting for differences in the biogeography of populations, and generally overestimating a population's extent of occurrence (Burgman and Fox 2003, Simaika and Samways 2010, Ebner et al. 2010). Some of these criticisms are particularly pertinent to aquatic species where occupied habitat may be confined to water bodies, the shape of which influences the resulting MCP. To address these concerns, Simaika and Samways (2010) suggest a new definition of extent of occurrence as "the sum of the smallest hydrological units identified, of presently known, inferred or projected occurrences of a taxon, excluding cases of vagrancy, that are used to estimate the threat to a taxon". The hydrological unit they use is the quaternary catchment. Following this example, we present two alternate estimates of extent of occurrence based on two levels of catchment area. The first method, hereafter referred to as EOa, was based on catchment areas (3rd order) which were groupings of smaller, 1st order catchments. The 3rd order catchments are approximately 3 000 ha in size and are typically complete drainage areas. The second alternate EO method, hereafter referred to as EOb, was estimated using the smaller 1st order catchments, which are the drainage areas for individual stream segments. Segments are defined as the lengths of stream between confluences.

Migration poses a problem to the assessment of extent of occurrence and area of occupancy. For example, including the entire extent of a highly migratory species' distribution in an assessment would likely greatly underestimate the degree of risk or population decline occurring in a population. To address this, the IUCN and COSEWIC recommend that only one life stage of the species be used in the assessment. For example, the IUCN suggests that the extent of occurrence should encompass either the breeding or non-breeding areas that a population occupies, depending on which is smaller (IUCN 2011*a*), while COSWIC states that "the area of occupancy is the smallest area essential at any stage to the survival of existing populations"

(COSEWIC 2010). Thus, the choice of life stage is an important factor in the process of estimating extent of occurrence and area of occupancy. We chose to analyse the distribution of breeding (spawning) areas as this area is likely smaller than the non-breeding area for Fraser River Sockeye salmon, which would include both freshwater and marine environments. However, we also assessed EO and AO based on both spawning areas and juvenile rearing distributions (discussed below).

COSEWIC's quantitative criteria use number of locations in its assessment criteria B.2.a and D.2. COSEWIC uses the IUCN definition of location as "a geographically or ecologically distinct area in which a single threatening event can rapidly affect all individuals of the taxon present. The size of the location depends on the area covered by the threatening event and may include part of one or many subpopulations. Where a taxon is affected by more than one threatening event, location should be defined by considering the most serious plausible threat (COSEWIC 2010, IUCN 2001)". Number of locations is thus driven by the distribution of perceived threats. If one population is affected by different threats in different areas, then the number of locations would reflect the number of threats. Alternatively, if an entire population experiences the same threat throughout its range, then the location number would reflect this singularity. Because the definition of a location is driven by perception and knowledge of threats, different definitions and interpretations of locations for a population could occur.

For this analysis we defined locations as individual streams or lakeshores used regularly by spawning salmon. We assumed that the primary threats to each CU would occur at watershed levels, resulting from events such as forest fires, landslides, chemical spills or other human activities near water. A number of alternative definitions could be envisioned, and the data we present will permit analysts to use a higher level of organization, if desired.

The status of the global distribution of Sockeye salmon has recently been assessed by the IUCN (IUCN 2011*b*). IUCN defined 22 subpopulations in the Fraser watershed that differ slightly from the CUs listed in Grant et al. (2011). The extent of occurrence was calculated as a polygon that encompassed all watersheds that a particular subpopulation had occupied in the past ~150 years. Area of occupancy was calculated by overlaying a 1x1km grid over both the rearing lakes and stream habitats used for spawning and rearing. Location was defined as both the number of nursery lakes and "separate, distinct spawning regions", though the latter was not defined in any detail.

Our assessment differs from the IUCN assessment in several important ways. We analyse Fraser River Sockeye Conservation Units, rather than the IUCN's subpopulations. Conservation Units were developed under the Wild Salmon Policy and so the current assessment will be relevant to future Fraser River Sockeye conservation work by Fisheries and Oceans Canada (DFO). We also use different data to determine the extent of occurrence and area of occupancy. The IUCN assessment used distribution data from Augerot (2005), and DFO (2001) while we use distribution data collected from 2008 to 2011 by DFO Salmon Stock Assessment. We thus provide more current information on the distribution of Fraser River Sockeye salmon. In addition to the analysis of the distribution of spawning areas we include a separate analysis of the distribution of spawning and freshwater rearing areas combined, analogous to the IUCN assessment.

Residence is defined in SARA as a "dwelling-place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating". Residence is interpreted by DFO as a site where individuals make an investment (energy, time, defence), and the site contributes to the success of the individual (DFO 2010). If such a residence is damaged there should be some loss in fitness (DFO 2010). Based on these criteria

DFO (2010) identifies salmon redds as residences as they are constructed, defended, and if damaged the immobile egg or alevin stages would be impacted.

Our objectives are six-fold. First, we estimate the extent of occurrence for each CU of Fraser River Sockeye salmon using the MCP, as well as using two alternative extent of occurrence methods based on catchment areas. Second, we estimate the area of occupancy using three grid placement methods and two grid sizes: 2x2 km and 1x1 km. Third, we estimate the biological area of occupancy using a river channel surface area method. Fourth, we enumerate the number of spawning locations present in each CU and assess extreme fluctuation or decline over three time periods: 1992-1995, 2000-2003 and 2008-2011. In all estimates we evaluate the effect of removing potentially vagrant individuals from the data. Fifth, we evaluate the EO, AO, and BAO for the entire distribution of Fraser River Sockeye. And finally, we estimate the EO and AO for each CU and the entire distribution of Fraser River Sockeye salmon based on the distribution of both rearing and spawning areas, rather than just the spawning areas (which is what all other analyses are based on). In assembling the spawner distribution data to conduct these analyses, we generate a dataset which could be used to describe the residence of Fraser River sockeye. We conclude by presenting the distribution metrics required by COSEWIC to assess parts of Criterion B and D, and by discussing some of the caveats associated with these analyses.

2 METHODS

2.1 DATA SOURCES

2.1.1 Distribution data

DFO Stock Assessment began collecting spatial coordinate data on Fraser River Sockeye salmon spawning distribution (SD) in 2001. Spatial survey data coverage is complete for all CUs beginning in 2008, thus spawning distribution data from 2008 to 2011 was used in the current assessment. Four years of data (about one generation) were used to minimise the effect of inter-annual variability, due to changes in spawner abundance, on EO and AO estimates. Spawner distributions were defined as the greatest extent of spawning observed in these four years; spawning may not have occurred in all areas in all years. Spawner locations were based on visual observations from boats, aircraft or the margins of lakes or rivers. In some cases, it was not always possible to determine all spawning locations for CUs where visibility was limited due to spawning occurring in deep or highly turbid waters. CUs where the inventory of spawning locations may be incomplete include: Cultus-L, Chilliwack-ES, Nahatlatch-ES and Taseko-ES. Lake spawning was sometimes observed using remotely operated underwater vehicles. Rearing lakes associated with each CU were those described in Grant et al. (2011). Widgeon and Harrison-DS CU's have the river-rearing life history and the freshwater rearing area was calculated as the wetted area of the river downstream of the spawning areas (including the lower Fraser River), and the area of the Fraser River estuary.

The number of sockeye returning to the Fraser River was greater in 2010 than in any year following the Hell's Gate landslide in 1913 (Grant et al. 2011). The inclusion of spawner distribution data in 2010 in our dataset has several implications. The distributional metrics we estimate may over-represent recent (but pre-2010) distributions. This could potentially lead to an underestimation of level of endangerment of each CU. As well, fluctuations in the number of locations might be greater in the 2008-2011 time period than in previous time periods.

Spawning distribution data were organised at two levels of resolution. High resolution data were mapped using polygons to represent spawning areas, while low resolution data were mapped using either start and end points of spawning, or using continuous lines along streams. The distribution of spawners was recorded as continuous, scattered or unknown. Scattered and continuous distributions were differentiated by spawning pairs being more or less than 50 m apart, respectively. When spawning density was unknown, producing low resolution data, only the start and extent of spawning was recorded. This resulted in three types of spawner distribution data: 1) low resolution data with scattered spawning where start and end points of spawning were recorded; 2) low resolution data with continuous spawning recorded with digitised line features representing continuous sections of streams; 3) high resolution data of scattered and continuous spawning recorded with digitised polygon features representing individual areas within streams or lakes. Because the EO and AO metrics do not incorporate density, all classes of spawner density were treated as presence/absence data.

Spawner abundance was estimated by DFO Stock Assessment for each spawning site within each CU. A list of all assessed sites by CU is provided in Appendix 3. We considered streams, where the escapement estimate was less than 100 in all four years of observations may have been generated by strays from larger spawning area and thus may not have been a self-sustaining spawning group. These spawning areas were classified as sites containing vagrants. It is important to note that this definition of vagrants is somewhat arbitrary, and is intended to address COSEWIC guidelines rather than provide a necessarily biologically meaningful designation.

2.1.2 Freshwater Atlas stream network and watersheds

The Freshwater Atlas (FWA) provides a 1:20,000 scale hydrographic network for BC, containing all rivers, lakes, artificial water bodies, and wetlands (GeoBC 2011). It was created as a replacement for the 1:50 000 scale Watershed Atlas, providing more detail and a hierarchical watershed code that allows for analysis of water flow through any part of the system. The FWA was derived from the province's 1:20,000 scale topographic base maps. The FWA is publically available to download from GeoBC. For the purposes of this analysis, a number of FWA datasets were used (Table 1). All datasets were bounded by the extent of the Fraser Basin drainage area.

2.1.3 Point placement

The GPS-collected spawning distributions were converted to points on the FWA stream network for subsequent analysis. This conversion required a unique approach for each of the three types of spawner distribution data. A spacing of 50 m between points was chosen as this was the distance used by Stock Assessment to distinguish between scattered and continuous spawning.

Low resolution, spawning distributions – Point pairs representing the start and end of spawning along a stream were translated into actual stream segments using the FWA stream network. Because the points were recorded manually by digitising their locations from a map or by using a GPS collected point, they first had to be matched up to the FWA stream network. Using ArcGIS, the points were snapped (i.e. repositioned) to their nearest stream lines and checked to ensure they had been assigned to their correct stream. The stream lines were then split at the spawning start and end points, and only the stream segments between each pair of points were extracted into a new layer. CU name and site name attributes were added for each set of stream segments. The stream segments were converted to points by sampling every 50 m along the stream line using the ET Geowizards Station Point tool.

The low resolution, continuous spawner distribution data were already provided as line features, so did not need to be matched up to the FWA stream network before being converted to points using the same 50 m sampling point method described above. The high resolution scattered and continuous SDs were provided as polygon features, representing areas of streams or lakes where spawning had been identified. Two methods of converting these features to points were explored, one involving a net of points and the second involving a polygon outline of points. Rearing lakes were incorporated by overlaying the lake boundaries from the FWA stream network with points, following both the net and outline methods.

The Jenness Enterprises Repeating Shapes tool was used to generate a net of points (triangular network, points spaced 50 m apart) within each polygon for each CU. Small polygons and narrow, sinuous polygons were under-represented by points using this method, and some polygons, particularly those narrower than 50 m, contained no points at all. To capture and populate these polygons, a center line was generated for each polygon using the 'Polygon To Centerline' tool from ESRI ArcGIS Resource Center and converted to 50 m spaced points. The centreline tool, however, also missed some of the smaller polygons, and when combined with the net of points, over-represented points within the SD polygons (i.e. points were closer than 50 m to each other).

The polygon outline method involved converting the spawner distribution polygons into polyline features, which lined the perimeter of the polygons. These perimeter lines were converted to 50 m spaced points. This method captured all the polygons with at least one point, but also over-represented some polygons where the width of the polygon was less than 50 m. This method was chosen as the most reliable way of converting all the polygons into point features without under-representing or missing any of the spawning areas.

2.2 CALCULATION OF DISTRIBUTION METRICS

2.2.1 Extent of Occurrence (EO)

EO was estimated for each CU using R code (provided by M. Burgman), described in Burgman and Fox (2003), which estimates the MCP encompassing a set of points. Input data consisted of easting and northing coordinates of points describing either as only the spawner distribution or as both the spawner and freshwater rearing distributions (described above). All area estimates are presented in km^2. The EO was also estimated for the entire distribution of Fraser River Sockeye salmon.

2.2.2 Alternate Extent of occurrence (EOa, EOb)

Alternative EOs were calculated using two scales of watershed area for comparison to the MCP EO method. First order catchments in the FWA are areas that contain the watershed of stream segments. Stream segments are part of a stream between two confluences, and are usually 400 m in length (Carver and Gray 2009). Third order catchments are an amalgamation of 1st order catchments. Groupings have a target size of approximately 3,000 ha, and typically includes complete watersheds, which contain all land that drains to one point (Carver and Gray 2009). The first extent of occurrence metric, EOa, was calculated by intersecting spawner distribution points for each CU with the FWA Assessment catchments (which approximated 3rd order watersheds), and summing the resulting catchment area. EOa is a measure of the whole watershed area that spawning areas were situated in. The second alternate extent of occurrence, EOb, involved intersecting the SD points for each CU with the FWA catchments (approximating 1st order catchments) and summing the resulting catchment area. Thus, EOb is a measure of the area of land that drains directly into a stream segment that contains spawners.

These alternate, catchment-based EO methods were expected to yield a measure of EO that was linked directly to the streams where spawning occurred than the MCP method. Using the stream catchments to encompass the SD points meant that any land area included in the EO was in the catchment of the spawning locations as opposed to the MCP method which may have included land from other drainage basins.

2.2.3 Area of Occupancy (AO)

The calculation of AO based on 2x2 km grids may be affected by the starting point, or origin, of the grid network. To assess the impact of different grid origins on AO estimates, three 2x2 km grids were developed with varying origins. To compute the AO for each CU, the areas of 2x2 km cells that contained at least one spawner distribution point were summed. This process was repeated after excluding spawning areas that were defined as sites containing potential vagrants. The three grid placement methods are (Figure 1):

Fraser Basin origin – The FWA Watershed Group dataset was used to select and dissolve all Fraser Basin watersheds into one feature representing the full extent of the Fraser Basin drainage area. Using the ArcGIS 'Grid Index Features' tool, a single 2x2 km grid of polygons was generated covering the extent of the Fraser Basin.

FWA Watershed Group origin – For each CU, a 2x2 km grid was generated covering the extent of the FWA Watershed Groups that contained the spawner distribution points.

CU Extent origin – For each CU, the 2x2 km grid was generated using one of the spawner distribution points at the edge of the distribution in the CU as the origin.

IUCN guidelines state that grids should be positioned to minimise the resulting AO. We tested for significant differences in ranking among the three grid placement methods using the non-parametric Friedman Chi squared test for repeated measures. The grid placement method that generated the smallest AOs, on average, was also used to position a 1x1 km grid to assess the impact of increasing grid resolution on AO estimates. This grid placement method was also used to estimate: 1) the AO for the entire distribution of Fraser River Sockeye salmon as the sum of the AOs of each CU, and 2) the AO of each CU including rearing lakes.

2.2.4 Biological Area of Occupancy (BAO)

Biological AO was calculated using the surface area of each spawning area. BAO is intended to be a more accurate measure than AO of the area of habitat that is actually used. For high resolution, scattered and continuous SDs, the polygon area was used to calculate BAO. For low resolution, scattered and continuous SDs, an average stream width was applied based on stream order, so that a stream area could be calculated. Field Data Information System (FDIS) data were used to calculate a single channel width for each stream order, averaged across all FDIS sampling points within the Fraser Basin.

2.2.4.1 Field Data Information System (FDIS)

FDIS is a tool for capturing data and reporting on fish and fish habitat (MoE 2012). FDIS also contains stream survey and sampling information which has channel size attributes recorded for each of the sampling locations. The provincial FDIS dataset was converted from a spreadsheet into a spatial GIS dataset using the easting and northing coordinates for sampling sites.

For each sampling site, the FDIS dataset contains attributes for both channel width (from one bank to another) as well as wetted channel width (the width of the stream at the time the sample was taken). This analysis used the channel width attribute to calculate an average stream width, rather than wetted channel width which would be affected by seasonal variations. The method for calculating average stream widths is given below.

2.2.4.2 Calculating average stream widths

There is a strong correlation between stream order and channel width (Horton 1945; Miller et al. 2003) which can be used to apply an average stream width based on stream order to the low resolution SDs. The FDIS dataset contains information on stream width at a large number of stream sampling locations throughout the province, but does not contain information on stream order. To calculate an average stream width for each stream order, the FDIS locations were first matched to their respective streams in the FWA stream network.

In total, 3,786 stream sampling locations within the Fraser Basin, together with information on stream width at these locations, were extracted from the FDIS dataset and converted into GIS points using the coordinates given for each location. There were a limited number of FDIS points that actually matched up to the SD streams, so all 3,786 FDIS points were used to calculate average stream widths within the entire Fraser Basin. These points were spatially joined to the FWA stream network (i.e. the attributes belonging to the stream closest to a FDIS point were added to the FDIS point's attributes).

This process assigned a stream order to each FDIS point, along with a distance from each point to its nearest stream segment. This point-to-stream distance could be used to identify mismatched points. For example, where the FDIS sampling was carried out on a stream that is not recorded in the FWA stream network, the spatial join would have assigned this point to whichever FWA stream was closest. These mismatches will have a large point-to-stream distance and were not used to calculate average stream width as it is likely that they were assigned an incorrect stream order. After removing mismatched points, the average channel width for each stream order was calculated (Table 2).

2.2.4.2 Calculating BAO

Low resolution continuous SD points were spatially joined to the FWA stream network, and a stream order attribute was assigned to each point. The low resolution continuous SD lines were then updated with the attributes of the point dataset, thereby transferring the stream order attribute into the line dataset. These stream lines were then buffered according to the average channel width corresponding to their stream order (Table 2). The low resolution scattered SDs were previously generated from the FWA stream network, and were buffered in the same manner. Any lake spawning lines in the low resolution datasets were buffered to a 50 m width as this was the average width of the high resolution lake SD polygons. Three low resolution SDs occurred along 7th order streams for which there was no average channel width calculated from the FDIS data. For these SDs, the FWA river polygons were used. BAO was calculated for each CU by summing the combined area of the buffered low resolution SDs, FWA river polygons, and high resolution polygon SDs. The BAO for the entire distribution of Fraser River Sockeye salmon was estimated as the sum of the BAOs for each CU. BAO was only calculated using spawning distribution and not rearing lake data.

2.3 NUMBER OF LOCATIONS

Number of locations is defined here by the number of distinct spawning areas in each CU. Spawner abundance and occurrence was assessed by DFO Stock Assessment at a 'site' level (individual rivers, tributaries or spawning areas within lakes), and, in some cases, several sites were combined to create a 'location'. For example, all spawning sites within a lake (or a large section of a lake) were grouped into one location, while spawning sites in individual tributaries were each considered a separate location**.** To assess change in number of locations over time, spawning sites in 1992-1995, 2000-2003 and 2008-2011 were enumerated. Units of four years were assessed to capture a complete generation, and minimise variation due to inter-annual variation in abundance. The span of the data was chosen to exceed three generations. Similar to the spawning distribution data, the number of locations reported represents the greatest number of spawning locations: not all locations contained spawners in each year within the four-year time periods.

Because resolution in data reporting and (or) survey effort was not consistent among the three time periods, the change in number of spawning sites may not have been associated with an actual change in distribution. For example, in the Bowron-ES CU, spawners were reported at two sites in 2008-2011, but only one site (which included both sites assessed as one site) was surveyed in 1992-1995 and 2000-2003. To address this issue, two methods of screening the data were used. First, only CUs with consistent resolution in data reporting and (or) survey effort in all spawning sites over all time periods were considered. For the second method, only spawning sites within CUs with consistent survey effort in all time periods were considered. The number of locations for the entire distribution of Fraser River Sockeye salmon using the several screening methods is shown in Table 8.

2.4 COSEWIC THRESHOLDS

COSEWIC quantitative criteria for status assessments based on range size are provided in Table 3, and for small or restricted populations in Table 4. Graphs of EO and AO results were plotted with the thresholds for an endangered classification shown in red.

3 RESULTS

Spawning distributions generated from stock assessment spawner survey data for all Fraser River Sockeye salmon CUs are shown in Figure 2. As examples, all EO, AO and BAO estimates for Anderson-Seton-ES and Shuswap Complex-L are shown in Figure 3 and Figure 4, respectively. The spawner distribution data used for analyses could also be used to describe potential residences for Fraser River Sockeye salmon.

It should be noted that for the four CUs where visibility was poor and complete observation of spawning distributions was not possible (Cultus-L, Chilliwack-ES, Nahatlatch-ES and Taseko-ES), the EO and AOs calculated based on spawning distribution alone may be underestimations of the actual metrics. The actual spawning distribution could potentially be as large as each of the lakes in which spawning was observed, thus the metrics that include rearing lakes provide an upper bound for each metric calculated.

3.1 EXTENT OF OCCURRENCE

EOs, as estimated using Minimum Convex Polygons and spawner distribution data, ranged from 0.007 km^2 to 7 363 km^2, with a median of 72.7 km^2 and an average of 1 138.1 km^2 (Figure 5). Excluding potential vagrants from the data did not have a large effect, with EOs ranging from 0.006 km^2 to 7 363 km^2, with a median of 48.4 km^2 and an average of 1 050.4 km^2 (Figure 5). Ten of the 24 CUs contained potential vagrants, and for seven of these CUs the EO was affected by their exclusion. Seton-L displayed the largest proportional difference in EO, with a reduction of 79% when potential vagrants were excluded, while the average reduction of affected CUs was 39%. As expected, the EO for the entire distribution of Fraser River Sockeye salmon was larger than all the EOs for each CU (Table 5).

EOs, as estimated using Minimum Convex Polygons and using both spawner and freshwater rearing distribution areas, ranged from 8.0 km^2 to 7336.2 km^2, with a median of 582.1 km^2 and an average of 1 783.9 km^2 (Figure 5). As with the EOs based on spawner distribution data alone, the EO for the entire distribution of Fraser River Sockeye salmon was much larger than the EOs of the constituent CUs (Table 5).

3.2 ALTERNATE EXTENT OF OCCURRENCE

The two alternate EO estimates, based on catchment areas, yielded two sets of area estimates that differed by an order of magnitude. EOa, based on all catchments linked to the spawning areas, produced values similar to those estimated by the MCP EO. In general, EOa was smaller than the MCP EO for larger CUs. For CUs with smaller numbers of spawning areas, EOa was much larger than the MCP EO (e.g. Figure 3). This occurred because MCP-based EO enclosed only spawning areas whereas EOa included the upstream catchment for each spawning area. EOb, based on data that approximates 1st order catchments, was much smaller than EOa, and produced values similar to those estimated using the 2x2 km grid AO method (Figure 6**,** Figure **7**).

3.3 AREA OF OCCUPANCY

For AOs estimated using only the spawner distribution data, the three methods of 2x2 km grid placement were not significantly different (Friedman Chi squared test = 2.658, df = 2, p = 0.265 including vagrants, and Friedman Chi squared test = 5.681, df = 2, p = 0.058 excluding vagrants; Figure 8). When different grid placements yield different AOs, the IUCN recommends that the smallest AOs be used. In this case, the CU Spawning Extent method yielded the smallest AOs on average. Many of the AOs were larger than the EO calculated using the MCP method (Table 5, Table 6). The AO estimated using 1x1km grid and following the CU Spawning Extent grid placement method yielded values generally smaller than the AOs generated using the 2x2 km method (Figure 9). The AO for the entire distribution of Fraser River Sockeye salmon is reported in Table 5. The AOs estimated using spawner and rearing distribution data were larger than AOs estimated using only spawner distribution data (Figure 8).

3.4 BIOLOGICAL AREA OF OCCUPANCY

BAOs were all much smaller than the AOs calculated using the grid method and using only spawner distribution data (Figure 10). On average, the BAOs were 1% of the AOs (range: 0.1% to 6%) for both the estimates with and without vagrants (Figure 11). The BAO for the entire distribution of Fraser River Sockeye salmon was 1.3% of the AO (from Table 5).

3.5 NUMBER OF LOCATIONS

The number of spawning sites in each CU is reported in Table 8. Including all sites, 17 CUs contained less than five locations, three CUs contained between five and ten locations, and four CUs contained more than ten locations. When all CUs with inconsistent effort were excluded, all remaining CUs contained less than five locations in all time periods. When all sites within each CU that were not consistently surveyed were excluded, 19 CUs contained less than five locations, one CU contained between five and ten locations, and four CUs contained more than ten locations (Table 8). All CUs displayed relatively constant numbers of locations across the three time periods.

4 DISCUSSION

4.1 DATA LIMITATIONS

Several aspects of the data limit how useful it can be in informing an assessment of Criteria B or D. The incomplete spawner distribution data for Cultus-L, Chilliwack-ES, Nahatlatch-ES and Taseko-ES, due to poor visibility in these lakes, means that the metrics estimated using spawner distribution alone are likely underestimates. The EO and AOs estimates that included rearing lakes provide maximum values of what the metrics could be based on spawner distribution alone.

Interpretation of the relative number of locations among CUs and of the changes in number of locations over time is also made more difficult due to variability in survey techniques among CUs and over time. Some of these issues are addressed in Table 8 where inconsistently surveyed locations are removed, however controlling for variation in number of locations due to differences in survey techniques is more difficult. However, that the fact that entire lakes or branches of lakes were considered as a single location, regardless of the number of distinct spawning sites within, should minimise variability caused by differences in survey effort.

4.2 EXTENT OF OCCURRENCE

The large variation in extent of occurrence estimates reflects the variation in spatial distribution of spawning areas among the CUs. For some CUs spawning occurred in a single stream, while for others it was spread across a large basin. Using the standard MCP method and only the spawner distribution data, all but two CUs fell below the 5000 km^2 criteria used by COSEWIC criterion B.1. When we combined the spawning streams and freshwater rearing areas, only one less CU fell below the COSEWIC threshold for endangerment. Because the IUCN-prescribed α-hull technique will result in EOs smaller than those obtained using the COSEWIC-prescribed MCP technique, the use of the α-hull method would have little effect on the overall assessments relative to the COSEWIC thresholds, though it may affect the two CUs that were above the COSEWIC threshold using the MCP EO. The exclusion of spawning areas classed as containing potential vagrants had little impact on the overall statistics, although it did significantly reduce the extent of occurrence of some CUs. The EO calculated for the entire distribution of Fraser River Sockeye salmon was substantially greater than the COSEWIC threshold for endangerment.

IUCN (2011*b*) and Simaika and Samways (2010) use watershed area to estimate extent of occurrence, and we found that use of this method yielded results that differed from those obtained using the MCP method. For CUs with fewer spawning areas, or with spawner areas that were close to each other, the MCP-based extent of occurrences were much smaller than those derived from watershed areas that could include headwater areas not occupied by Sockeye salmon. The estimates were more similar for large CUs where the spawning areas were spread throughout the catchment. The alternate EOb method is based on catchment area immediately adjacent to the spawning stream and generated much smaller areas than either the MCP or EOa methods. EOb may in fact be more appropriately described as an alternate method to estimate the area of occupancy, rather than extent of occurrence, given its close relationship to actual spawning area.

4.3 AREA OF OCCUPANCY

Similar to the extent of occurrence estimates, the area of occupancy estimates displayed large variations in size and only one CU exceeded the COSEWIC criterion B.2 threshold of 500 km^2, based on the 2x2 km grid and spawner distribution data alone. We evaluated the potential effect of grid placement and found it to be negligible, suggesting that any grid placement method used should be robust. All CUs had smaller AOs when the 1x1km grid method was used. The size of the grid had a larger impact on the number of CUs that fell below the D.2. criterion for area of occupancy (< 20 km^2), with 13 of 22 CUs falling below the threshold based on the 1x1 km grid compared to only 7 when the 2x2 km grid was used (Table 4, Table 5). Removal of spawning areas classed as being used by potential vagrants had only slight impact on the area of occupancy values. Inclusion of rearing areas in the AO estimate using the 2x2 km grid (and not excluding potential vagrants) resulted in eight CUs being above the COSEWIC criterion of endangerment. Similarly to the EO, the AO calculated for the entire distribution of Fraser River Sockeye salmon was larger than the COSEWIC threshold for endangerment.

Some of the area of occupancy estimates (using either grid resolution) were larger than the MCP extent of occurrence estimates. Figure 3 illustrates an instance of this. By definition area of occupancy cannot exceed the extent of occurrence of a population (IUCN 2011*a*), however we have presented unadjusted area of occupancy values. The IUCN advises that the extent of occurrence estimates should replace the area of occupancy values in these cases.

4.4 BIOLOGICAL AREA OF OCCUPANCY

There is currently no method recommended by COSEWIC for estimating the biological area of occupancy, nor a criterion for its assessment. We used a surface area method which was based on stream channel area and utilised areas of lakes. While it is not directly used in COSEWIC's quantitative criteria of risk, it is often reported in assessments, and may be useful as an indicator of habitat use. As well, the biological area of occupancy could help indicate the degree to which the area of occupancy, calculated using the 2x2 km grid, can underestimate the actual level of potential risk that a population experiences, when the biological area of occupancy is much smaller than the area of occupancy for example. We found that the biological area of occupancy was 94% to 99.9% smaller than the area of occupancy, for all CUs and including the analysis done on the entire Fraser River distribution, demonstrating the degree to which the grid method of area of occupancy estimation overestimates actual habitat use.

4.5 NUMBER OF LOCATIONS

We defined spawning streams or lakes as locations because some of the threats to CUs are likely to occur at this scale. Multiple spawning sites within lakes, or large branches of lakes, were grouped into one location based on the assumption that threats are likely to occur at the water body (either lake or stream) level. We found that 17 CUs had ≤5 locations (the B.2.a criterion for Endangered) and three CUs had between five and up to ten locations (the B.2.a. criterion for Threatened). Locations could be combined if a threat is perceived to act at a scale larger than the separation of spawning locations. For example, the recent IUCN assessment of the global distribution of Sockeye salmon defined locations at the larger level of "each nursery lake or separate, distinct spawning region" (IUCN 2011b). This highlights the importance of evaluating the appropriate level at which locations should be defined. However creating a larger, more encompassing, definition of location would not greatly affect the risk classification as many of the CUs fell below the threshold for endangered or threatened classification when location was defined as the number of spawning sites. Locations could potentially be split, for example lakes could be split into their constituent spawning sites, however historical data (pre-2008) are not available for a finer scale resolution of locations.

4.6 RANGE DECLINE OR FLUCTUATION CRITERIA

Criterion B.2.b relies on estimates of decline in the extent of occurrence, area of occupancy, the number of locations, the extent of quality of habitat, or the number of mature individuals. Criterion B.2.c evaluates extreme fluctuations in each of these measures. Unfortunately, detailed spatial data on extent of occurrence and area of occupancy are only available for the most recent generation, and no analysis of trend or fluctuation is currently possible (Table 3). No quantitative information is available for all CUs on the quality of habitats, although increasing trends in water temperature in the Fraser River mainstem represent a threat to nearly all CUs (Patterson et al. 2007). Trends and fluctuations in the abundance of mature adults have been evaluated by Grant et al. (2011).

We were able to assess trends in the location measure by evaluating the number of locations used per generation for three periods between 1992 and 2011. Overall, there were few consistent trends and no evidence of extreme fluctuations. It should be noted that inconsistent survey effort over the 20 year interval acted to reduce the total number of locations that could be compared over time. For some CUs this affected the ability to assess trends as many of the smaller sites were not consistently assessed in the past.

4.7 ALTERNATIVE LIFE STAGES

We chose spawning habitats for one method of calculating the spatial metrics based on guidance provided by the IUCN that states that for migratory species the minimum of breeding or non-breeding areas (but not both) should be used to estimate the extent of occurrence. For the area of occupancy, the smallest area essential at any life stage to the survival of the population should be used. Although we did not quantify the extent of the other habitats, it is unlikely that either freshwater rearing or marine feeding areas are smaller than the spawning area.

We estimated EO and AO metrics using two methods (spawner distribution only and both spawner and rearing lake distribution) to provide for two possible interpretations of COSEWIC and IUCN guidelines. The IUCN assessment of the global distribution of Sockeye salmon analysed the distribution of both spawning and rearing areas (IUCN 2011b). We primarily used spawner distribution data collected by DFO Stock Assessment and organised in an electronic format, and interpreted the IUCN and COSEWIC guidelines as intending that either the breeding or the non-breeding habitat should be analysed. However, the IUCN does state that EO should not be based on both habitats "because such species [with separate breeding and non-breeding habitats] are dependent on both areas, and the bulk of the population is found in only one of these areas at any time" (IUCN 2011a). Because Sockeye salmon use a number of habitats throughout their life cycle, and different cohorts can exist in these habitats at any one time, the majority of any Sockeye salmon population may not occur in a single habitat. Thus, the IUCN assessment appeared to have been based on the premise that both spawning and rearing habitat was a better indicator of occurrence and occupancy than spawning habitat alone because the population is distributed among both habitats. This approach is appropriate for threats that are transient in nature (such as a non-persistent chemical spill) as only the cohort present in that habitat would be at risk, and the impact of the threat on the population would be buffered by the presence of other, unaffected cohorts that would use the impacted habitat at a later time. However, this buffering will not occur if the effects of the threat persist longer than the generation time of the species (e.g. a landslide that covered a spawning area). In the latter case, our approach of considering the most limiting habitat type is appropriate for characterising the relative risk to spatially-based threats. The potential for differing interpretations and the resulting differences in EO and AO metrics relative to COSEWIC endangerment thresholds highlights the importance of detailed guidelines for assessments, and the difficulty of ensuring standardised approaches.

Fraser River Sockeye salmon are somewhat unique compared to other wildlife species in that many populations are likely equally vulnerable to threats in constricted migratory routes, both in freshwater and in coastal ocean areas. The Hell's Gate slides of the early 1900s serve as evidence for these risks, and one could envision similar risks from human activities that could affect all CUs during their migration. Our analysis does not consider these types of risks; however, we suggest they are best evaluated under Criterion A (Decline in Total Number of Mature Individuals), rather than B or D, which deal with the spatial distribution of populations and their threats.

4.8 RESIDENCE

Based on the definition of residence in the SARA and on guidance from DFO (2010), the locations of spawning redds within the sockeye salmon CUs can be considered as residences for the species. The GPS-based mapping of spawning locations provides the most detailed information on the location of residences and some guidance on their relative density at each spawning location. We acknowledge that the definition of residence, in particular with reference to migratory marine species, is a complex and difficult issue, and that it is likely to evolve as more species and populations are assessed by COSEWIC and potentially listed under the SARA.

4.9 CONCLUSIONS

- We were able to successfully estimate both the extent of occurrence and the area of occupancy, and the number of locations, for all Fraser River Sockeye salmon CUs based on spawner distribution data collected from 2008-2011.
- No decline or extreme fluctuation in number of locations was observed from 1992 to 2011.
- Evaluations of a variety of techniques and alternate measures of extent of occurrence and area of occupancy demonstrate little change relative to most COSEWIC thresholds, though the inclusion of rearing areas did decrease the number of CUs that fell below the endangerment threshold for AO values.
- The exclusion of sites containing potential vagrants had no overall effect on classification levels suggesting that data including sites where few spawners were observed could be used.
- The statistics required for assessing parts of COSEWIC Criterion B and D for the distribution of Fraser sockeye CUs are found in Tables 5 and 7.

4.10 RECOMMENDATIONS

- Limitations of the data, in particular with respects to the completeness of spawner distribution data, are important to consider when interpreting the metrics assessed.
- The extent of occurrences estimated using MCPs, and not the alternate extent of occurrences based on catchment areas, should be used, as this is the standardised method of COSEWIC assessments.
- Area of occupancy should be calculated using the 2x2 km grid so as to be consistent with IUCN recommendations. The method of grid placement is not critical, although using the CU-specific grid placement does yield slightly lower values.
- The stream channel area method of estimating the biological area of occupancy could be used to estimate occupied spawning habitat, although there are no assessment thresholds for this metric.
- The collection of spatial data to permit further analysis of Fraser River sockeye salmon freshwater distribution should continue. Simple surveys of spawning areas for stream width would improve the BAO estimates.

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FIGURES

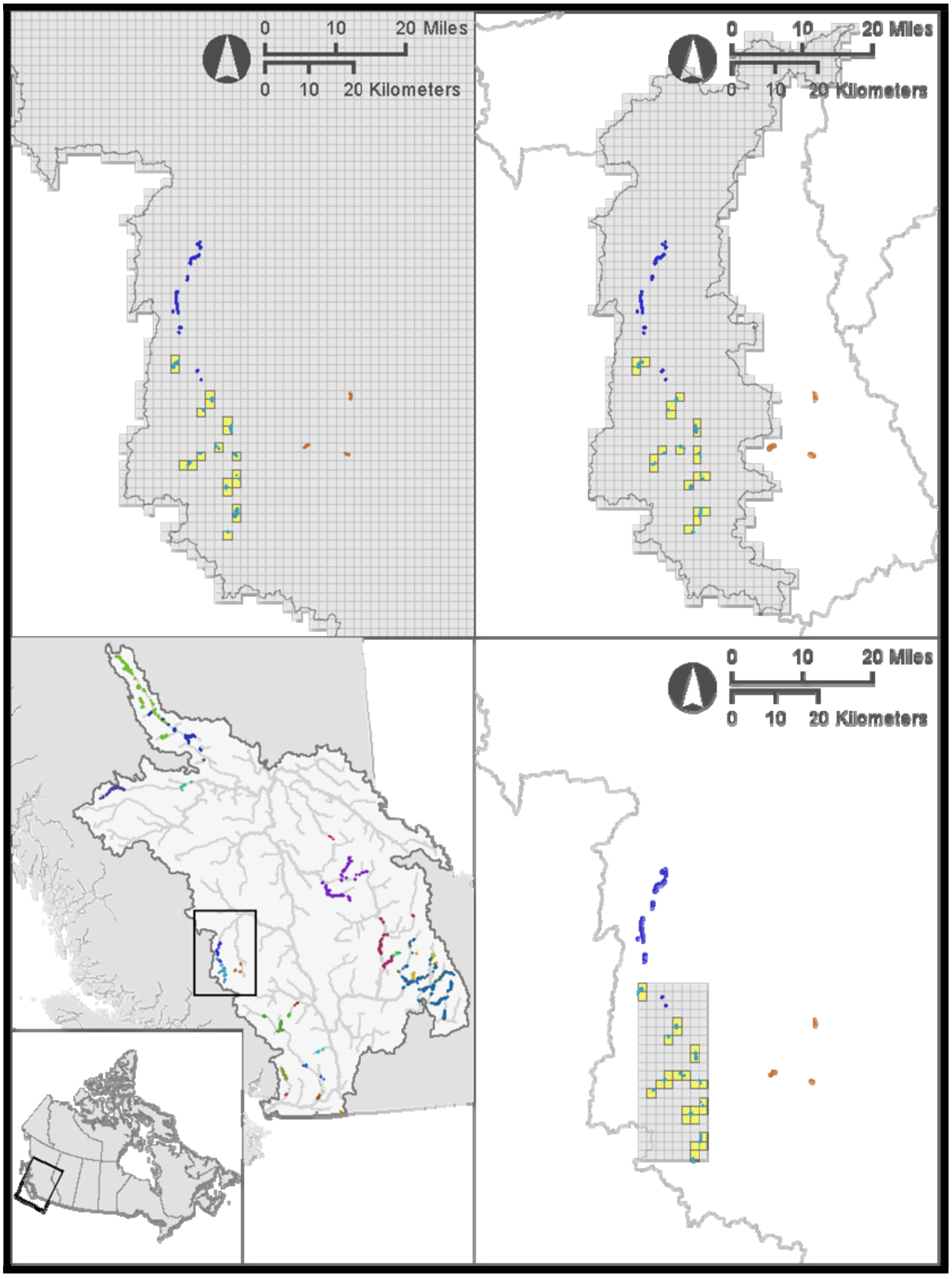


Figure 1. *Illustration of the three methods of 2x2 km grid placement, using the Chilko-ES CU as an example. Lower left: the Fraser Basin showing the location of the CU. Top left: the portion of the grid established for the whole Fraser Basin. Top right: grid based on the FWA Watershed Group for the Chilko watershed. Bottom right: grid based on the spawning locations in the CU (CU Extent grid placement method).*

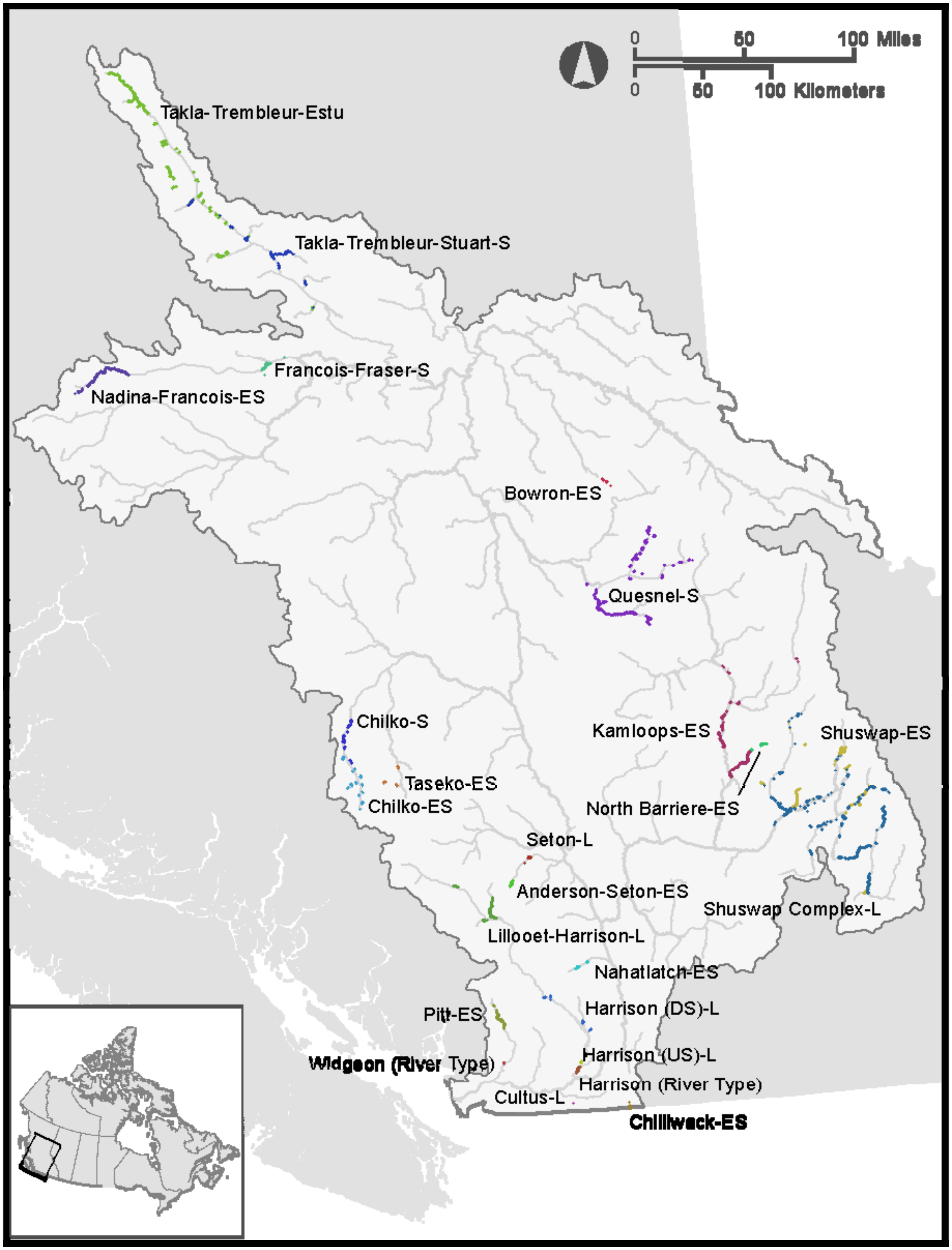


Figure 2. *Spawning distributions of Fraser River Sockeye salmon CUs. Different colours represent different CUs*

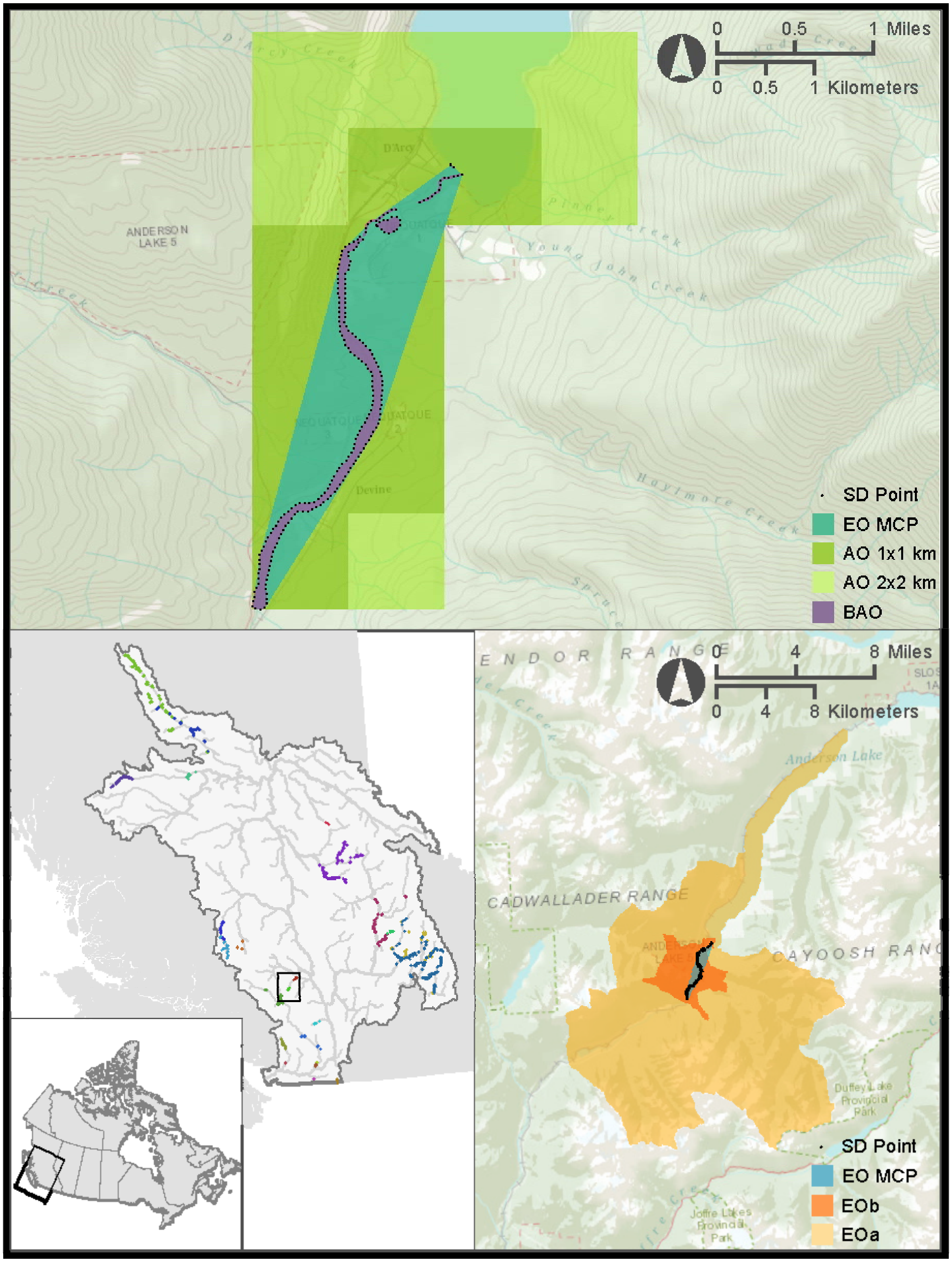


Figure 3. *Distribution metrics for the Anderson-Seton-ES CU highlighted in the lower right panel. Top: AO using 1x1 km and 2x2 km and BAO. Bottom right: alternate EOs estimated using the FWA catchments (EOa) as well as approximates of 1st order catchments (EOb).*

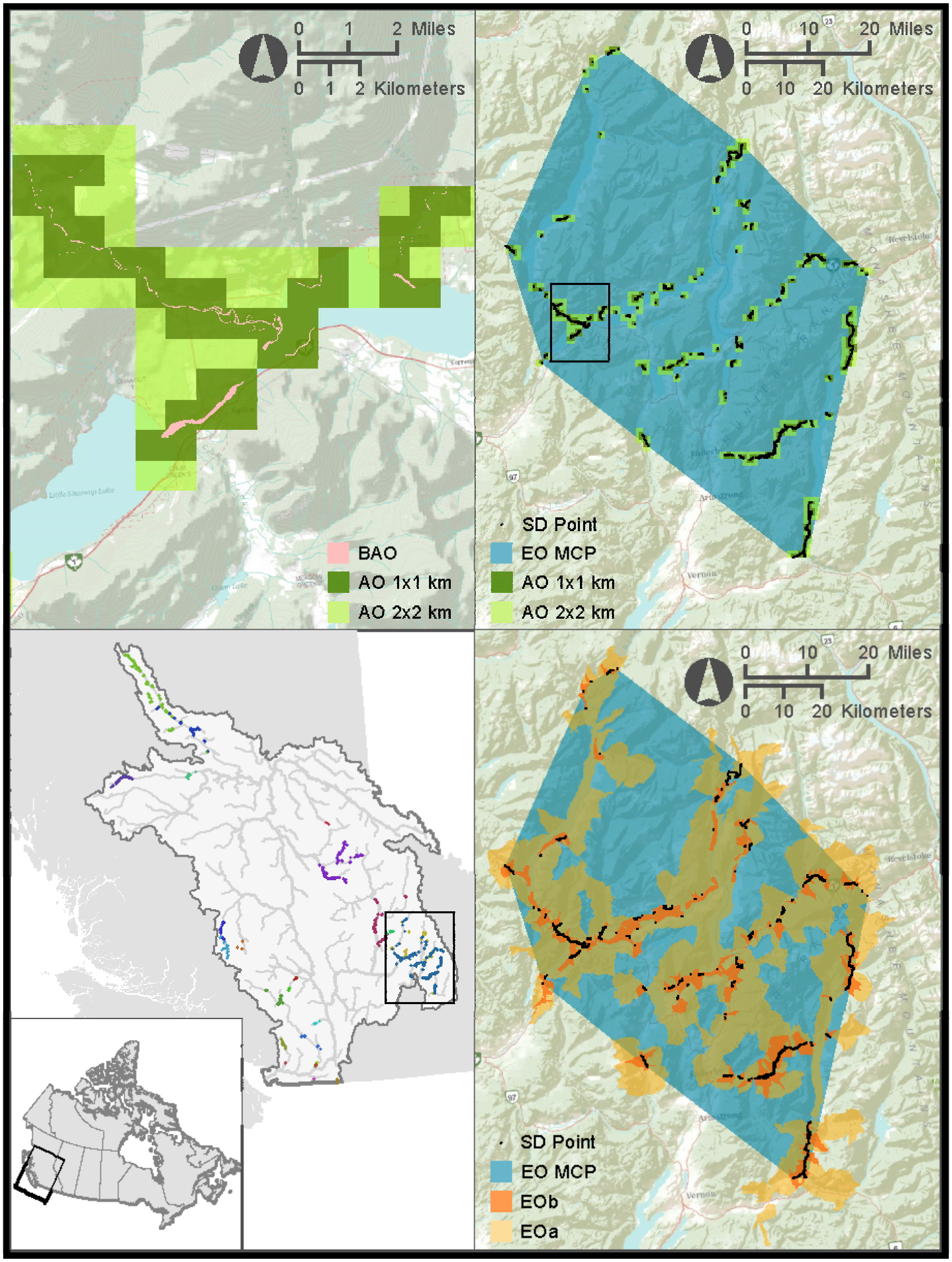


***Figure 4**. Distribution metrics for the Shuswap Complex-L CU. Top left: AO using 1x1 km and 2x2 km grids and BAO for spawning distributions contained in the rectangle in the top right panel. Top right: MCP EO and the two AOs. Bottom right: MCP EO as well as the two alternate EO measures based on the two catchment sizes.*

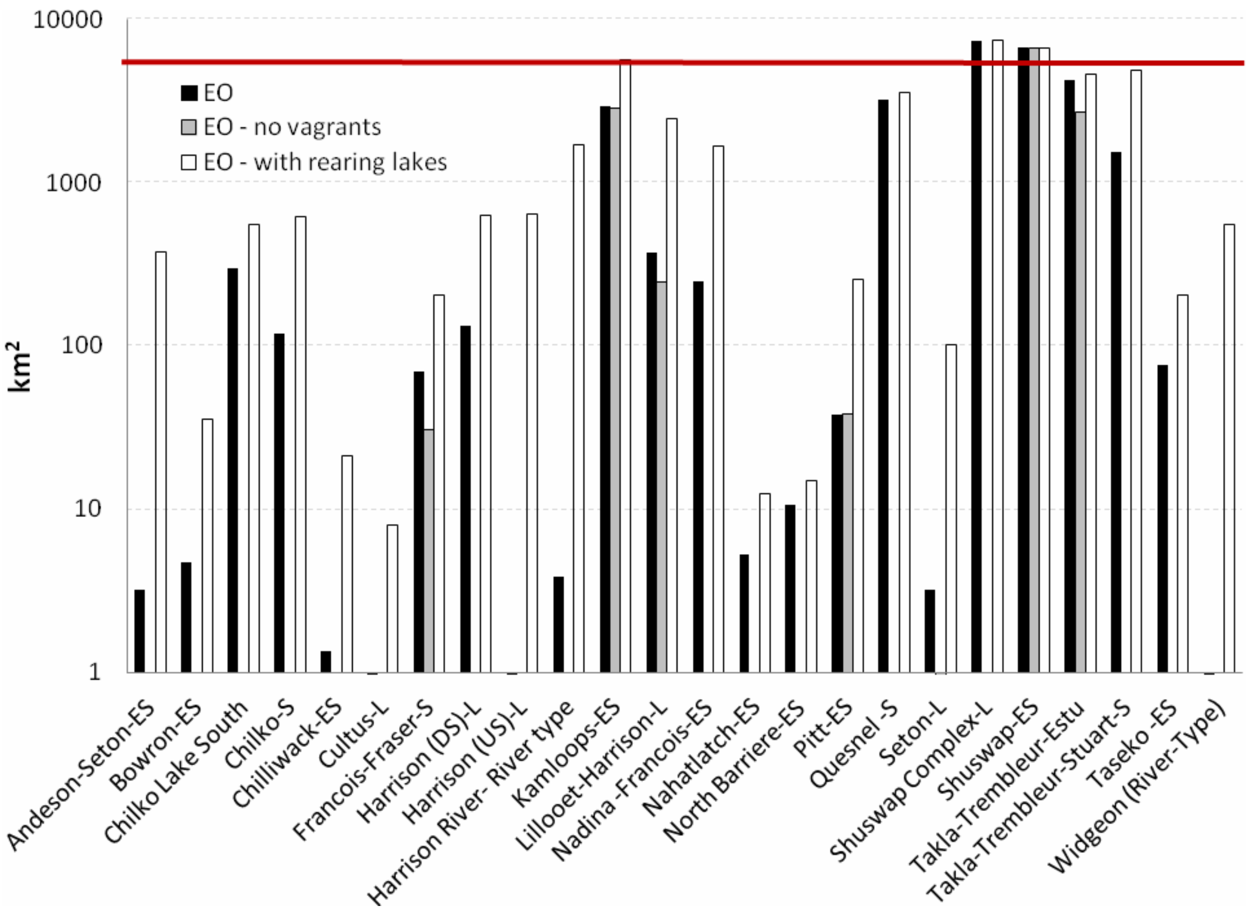


Figure 5. *Extent of occurrence (EO) for each Fraser River Sockeye salmon CU, estimated using the Minimum Convex Polygon technique. Black and grey bars represent EO based on spawning areas with and without potential vagrants, respectively. White bars represent EO calculated including freshwater rearing areas (lakes and river areas for the 2 River-type CUs). Red line is the COSEWIC threshold below which a population can be classified as endangered. Values for all CUs are in Table 5 and 6. Note the log scale on the y-axis. The EO for Takla-Trembleur-Stuart-S fell just below the threshold for endangerment, at 4,902.2* km^2.

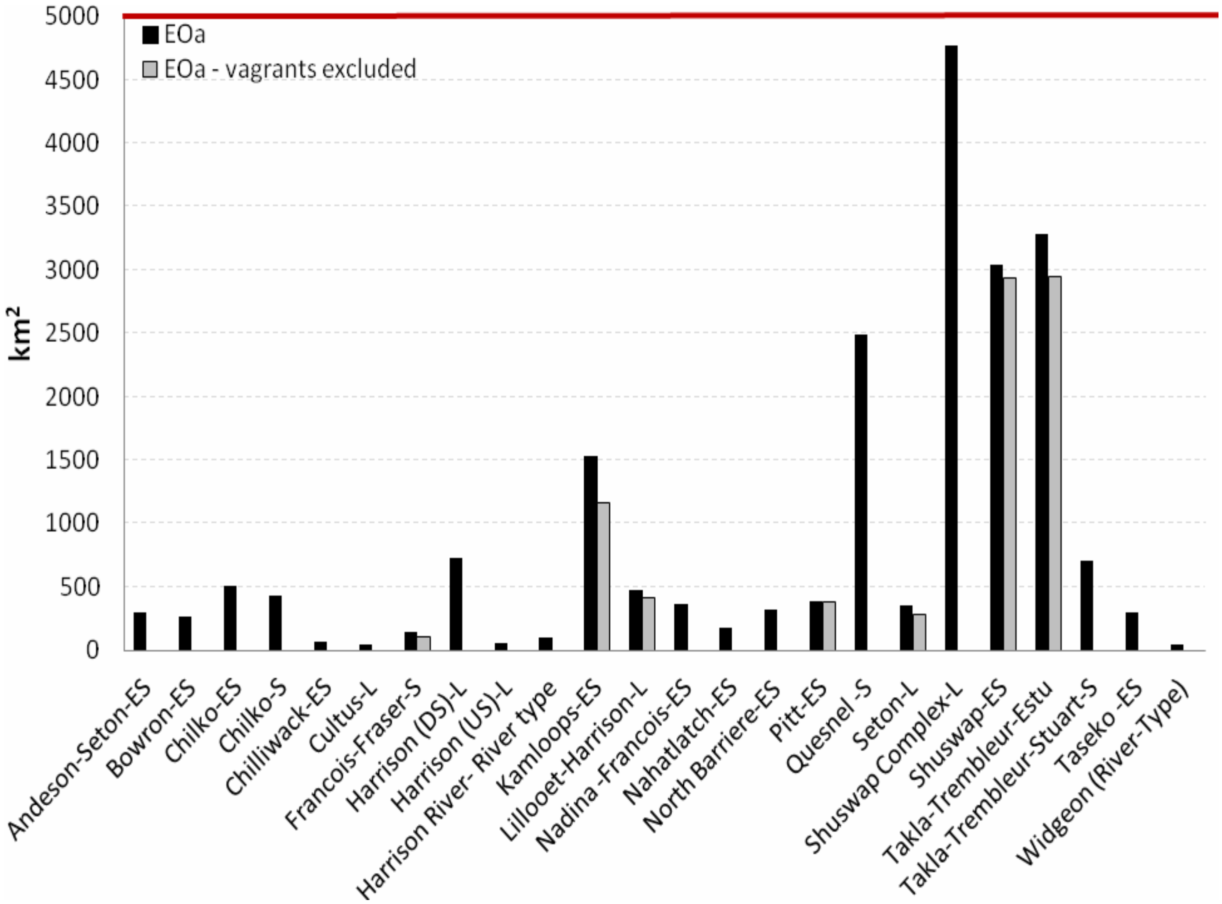


Figure 6. *As in Figure 5, except the extent of occurrence (EOa) was estimated using FWA approximation of 3rd order catchments.*

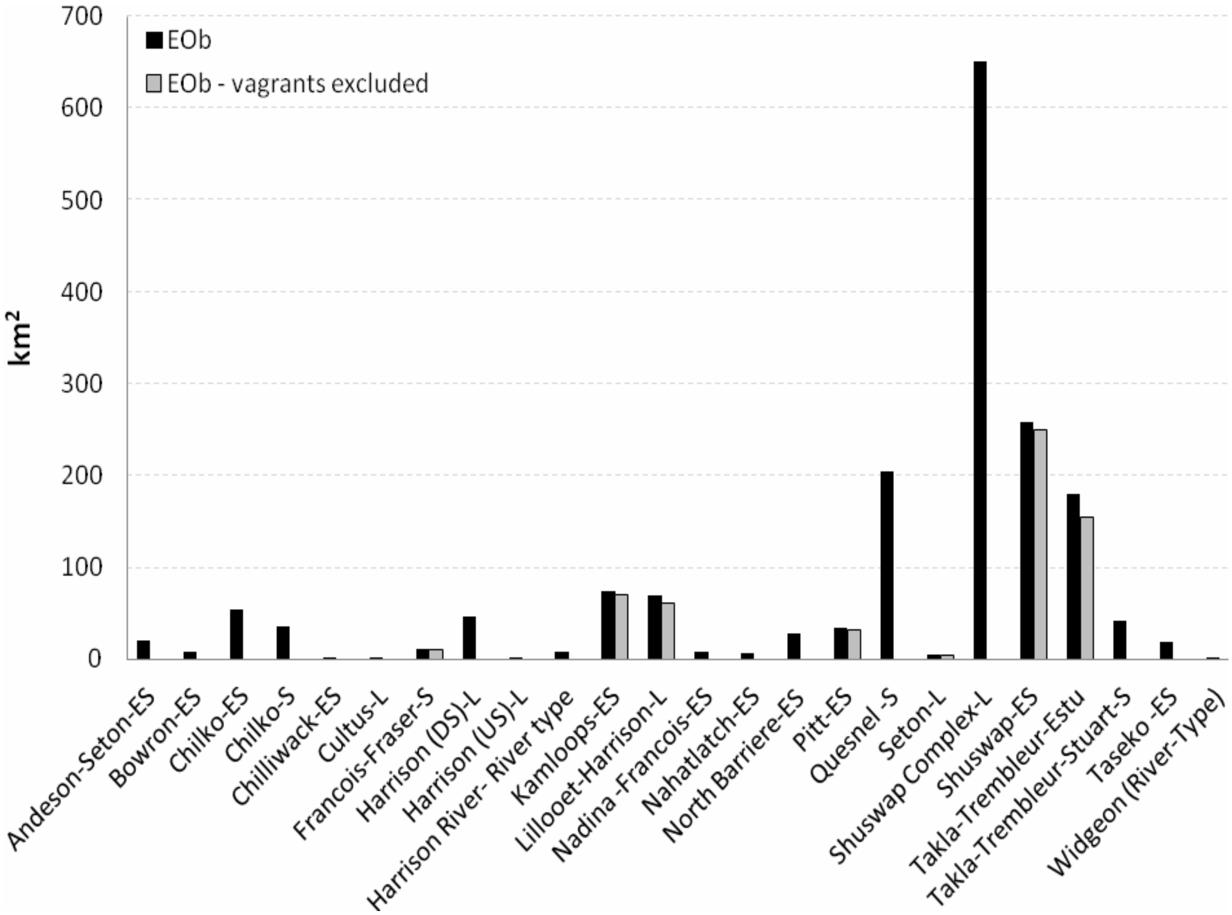


Figure 7. *As in Figure 5 except extent of occurrence (EOb) estimated using the FWA approximation of 1st order catchments.*

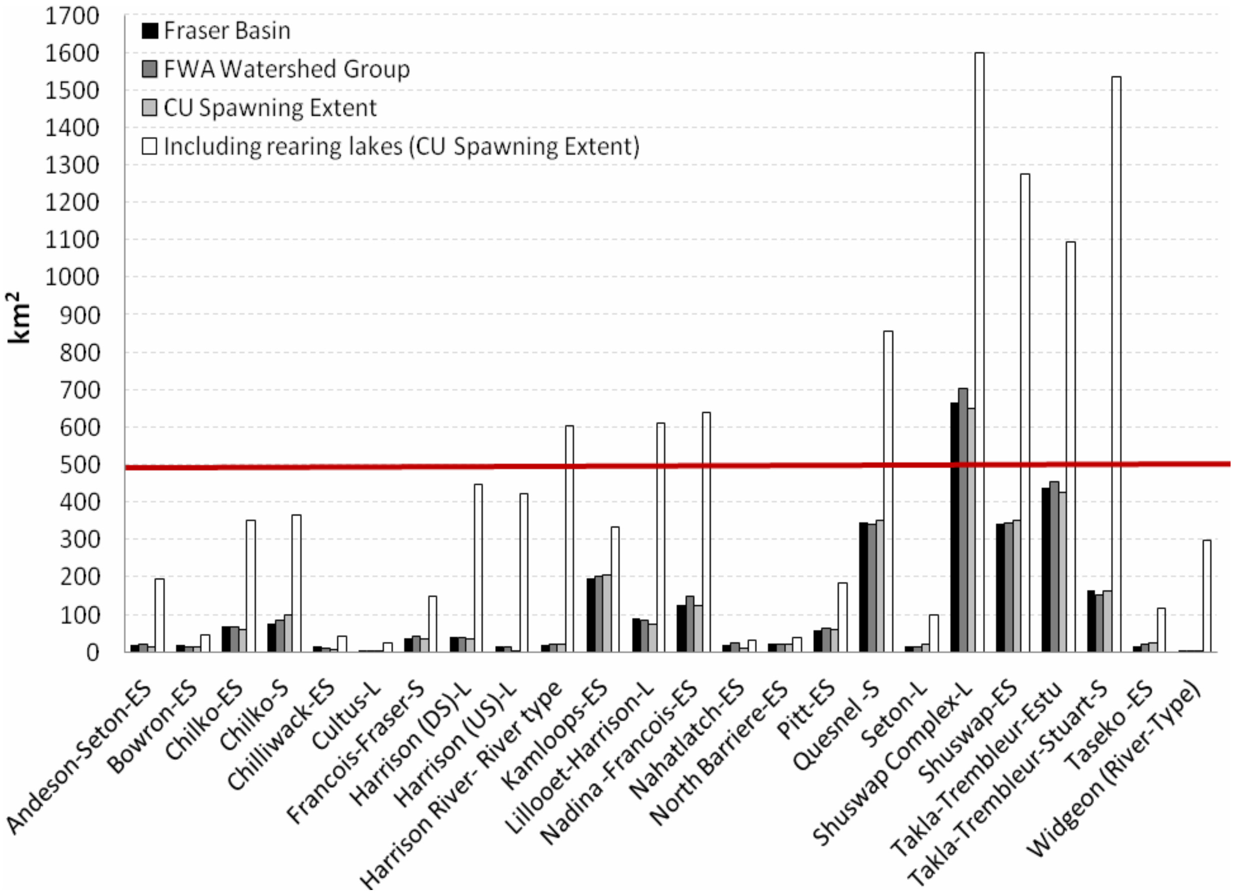


Figure 8. *Area of occupancy estimated using a 2x2km grid and three grid placement methods: Fraser Basin, FWA Watershed Group, CU Spawning Extent. AO estimated including spawning distribution and freshwater rearing areas using the CU Spawning Extent method and 2x2km grid is also shown. Red line is the COSEWIC threshold below which a population can be classified as endangered. Results excluding vagrants are not shown but values are found in Table 5 and Table 7.*

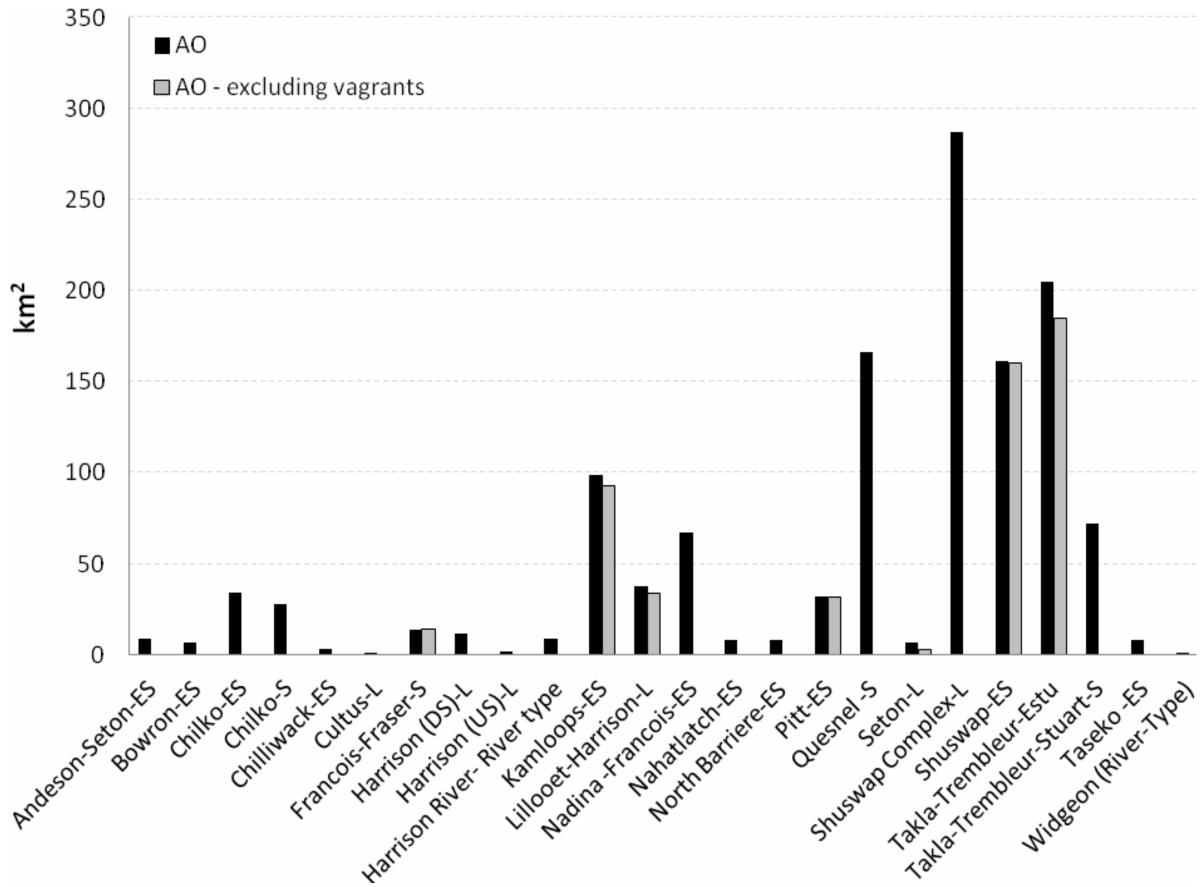


Figure 9. *Area of Occupancy estimated using a 1x1km grid and the CU Spawning Extent grid placement method. Grey bars are CUs with vagrants sites excluded.*

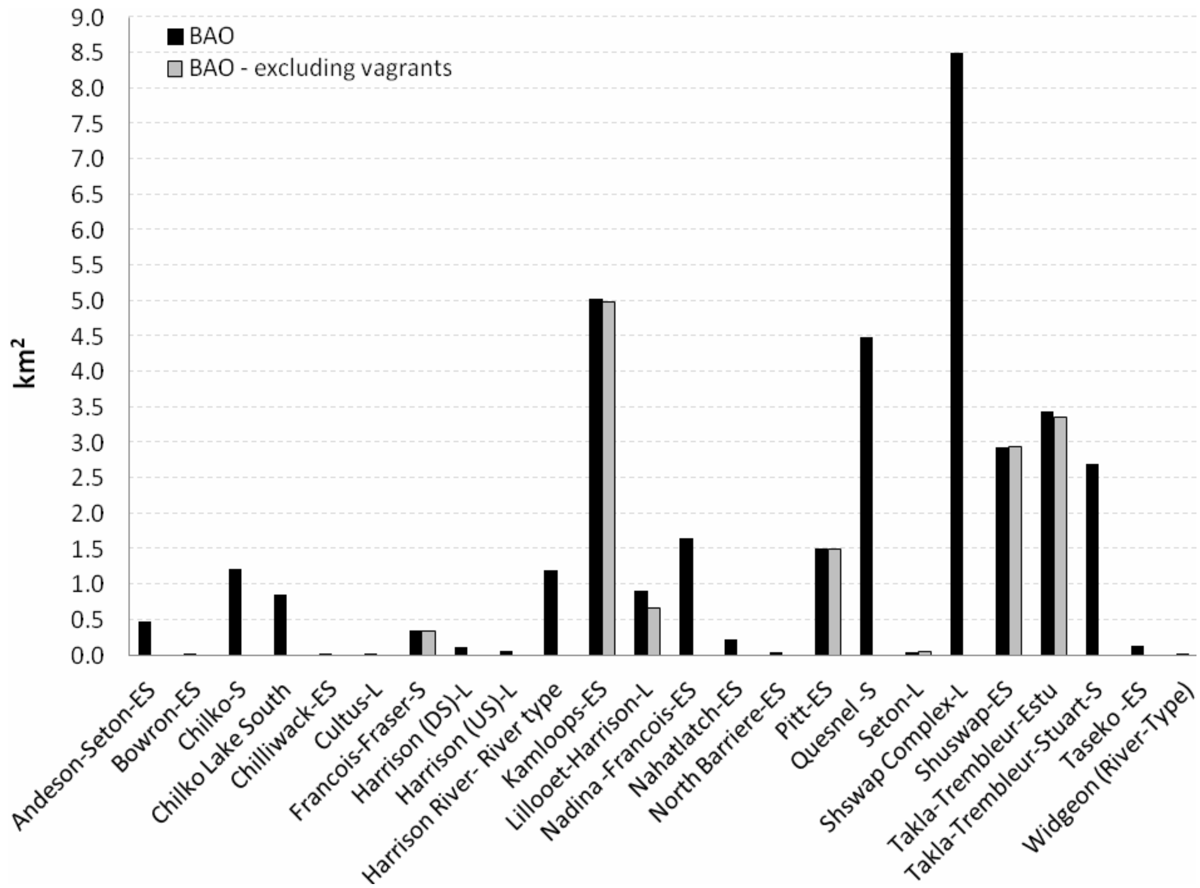


Figure 10. *Biological area of occupancy (BAO) estimated using the river channel surface area method, including and excluding vagrants. Only BAOs of CUs where vagrant sites were present are shown.*

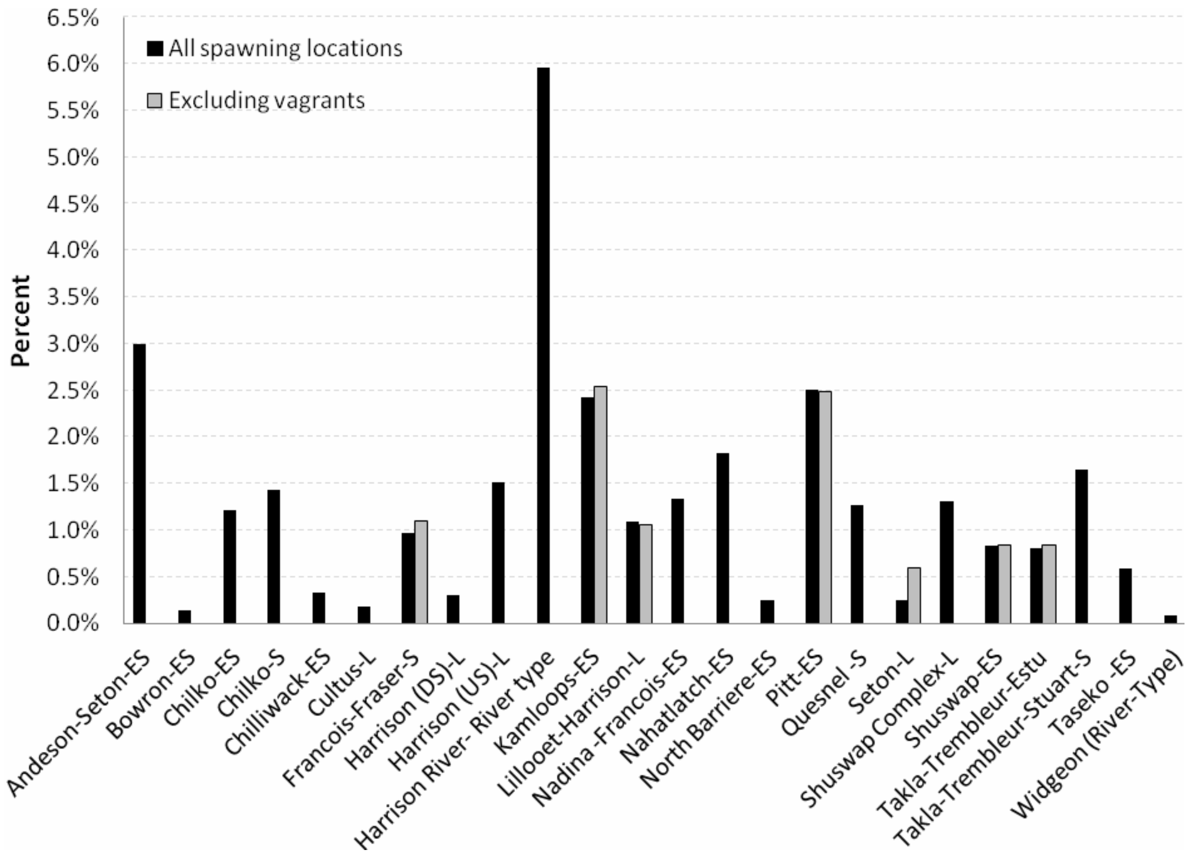


Figure 11. *Percent of area of occupancy covered by the biological area of occupancy (estimated using only spawner distribution data).*

TABLES

Table 1. *Description and online locations of Freshwater Atlas datasets used.*

Dataset	Description	Source
Stream Network	Single-line streams and rivers with associated stream order and magnitude.	https://apps.gov.bc.ca/pub/geometadata/metadataDetail.do?recordUID=50648&recordSet=ISO19115
Watershed Groups	Polygons delimiting the watershed group boundary, which is a collection of drainage areas.	https://apps.gov.bc.ca/pub/geometadata/metadataDetail.do?recordUID=50651&recordSet=ISO19115
Assessment Watersheds (3rd order)	Polygons representing a drainage area where hill, slope and channel processes remain well linked, designed to replace the 3rd order 1:50K watersheds (previously used by the BC Government). Assessment watersheds are groupings of 1st order watersheds (drainage areas for individual stream segments), with a target size of between 2 000 ha and 10 000 ha. Assessment watersheds are typically entire drainage areas.	http://apps.gov.bc.ca/pub/geometadata/metadataDetail.do?recordUID=57079&recordSet=ISO19115
Watersheds (1st order)	These watersheds represent the largest scale drainage and area associated with individual stream segments. Stream segments are defined as the area between two confluences. They are defined by the topography of the land, and approximate 1st order watersheds.	https://apps.gov.bc.ca/pub/geometadata/metadataDetail.do?recordUID=50652&recordSet=ISO19115
Rivers	River polygons.	https://apps.gov.bc.ca/pub/geometadata/metadataDetail.do?recordUID=50646&recordSet=ISO19115

Table 2. *Average stream channel width for each stream order, calculated from FDIS sampling locations within the Fraser Basin.*

Stream Order	Average Channel Width (m)
1	2.35
2	2.41
3	3.92
4	6.30
5	10.60
6	29.79

Table 3. *Range metrics used in COSEWIC quantitative criteria for small distribution range and decline or fluctuation.*

COSEWIC Criteria B	Endangered	Threatened	Information contained in report?
B1. Extent of occurrence estimated to be	< 5 000 km^2	< 20 000 km^2	Yes
Or			
B2. Index of area of occupancy estimated to be	< 500 km^2	< 2 000 km^2	Yes
and at least 2 of the following (a, b and/or c)			
a. Severely fragmented or known to exist at	≤ 5 locations	≤ 10 locations	Yes
b. Continuing decline, observed, inferred or projected, in any of:			
(i) extent of occurrence			Partial – no time trend
(ii) index area of occupancy			Partial – no time trend
(iii) area, extent and/or quality of habitat			No
(iv) number of locations or populations			Yes
(v) number of mature individuals			No – escapement estimates over time are not provided
c. Extreme fluctuations in any of:			
(i) extent of occurrence			Partial – no time trend
(ii) index of area of occupancy			Partial – no time trend
(iii) number of locations or populations			Yes
(iv) number of mature individuals			No – escapement estimates over time are not provided

Table 4. *Range metrics used in COSEWIC quantitative criteria for very small or restricted total population.*

COSEWIC Criteria D	Endangered	Threatened	Information contained in report?
D. Total number of mature individuals very small or restricted in the form of either of the following:			
D1. Population estimated to have	<250 mature individuals	<1000 mature individuals	No
OR			
D2. For threatened only: Population with a very restricted area of occupancy (typically <20 km^2) or number of locations (typically ≤5) such that it is prone to the effects of human activities or stochastic events within a very short time period in an uncertain future and is thus capable of becoming endangered or extinct in a very short time period.	Does not apply	AO <20 km^2 **Or** ≤5 locations	Yes

Table 5. *Distribution metrics recommended for use in COSEWIC's quantitative criteria for status assessment. Area of occupancy used the CU Spawning Extent grid origin method for two grid sizes. Values obtained when vagrants were excluded are included in parentheses. BAO is included as COSEWIC allows this to be reported, however it is not included directly in their criteria.*

CU	EO		AO 2x2 km		AO 1x1 km		BAO	
Anderson-Seton-ES	3.2		16		9		0.48	
Bowron-ES	4.7		16		7		0.02	
Chilko-ES	297.2		100		34		1.22	
Chilko-S	118.6		60		28		0.86	
Chilliwack-ES*	1.4		8		3		0.03	
Cultus-L*	0.006		4		1		0.01	
Francois-Fraser-S	69.1	(30.7)	36	(32)	14	(14)	0.35	(0.35)
Harrison (DS)-L	133.4		36		12		0.11	
Harrison (US)-L	0.7		4		2		0.06	
Harrison River- River type	3.8		20		9		1.19	
Kamloops-ES	2914.3	(2854.9)	208	(196)	99	(93)	5.04	(4.99)
Lillooet-Harrison-L	372.5	(247.9)	84	(64)	38	(34)	0.91	(0.68)
Nadina -Francois-ES	249		124		67		1.65	
Nahatlatch-ES*	5.3		12		8		0.22	
North Barriere-ES	10.5		20		8		0.05	
Pitt-ES	37.9	(37.9)	60	(60)	32	(32)	1.50	(1.49)
Quesnel -S	3186.7		352		166		4.49	
Seton-L	3.2	(0.7)	20	(8)	7	(3)	0.05	(0.05)
Shswap Complex-L	7363		652		287		8.51	
Shuswap-ES	6680.6	(6680.6)	352	(348)	161	(160)	2.94	(2.94)
Takla-Trembleur-Estu	4249.2	(2712)	428	(400)	205	(185)	3.44	(3.36)
Takla-Trembleur-Stuart-S	1534.2		164		72		2.70	
Taseko –ES*	76.2		24		8		0.14	
Widgeon (River-Type)	0.007		4		1		0.004	
Entire distribution	211,408		2804	(2724)	1278	(1243)	35.97	(35.60)

***** *NOTE: Metrics estimated for Cultus-L, Chilliwack-ES, Nahatlatch-ES and Taseko-ES CUs are likely underestimates due to poor visibility of spawning due to spawning in deep or turbid waters.*

Table 6. *Distribution metrics recommended for use in COSEWIC's quantitative criteria for status assessment estimated using spawner distribution and freshwater rearing areas combined. Area of occupancy used the CU Spawning Extent grid origin method for two grid sizes..*

CU	EO	AO 2x2 km
Andeson-Seton-ES	374.6	196
Bowron-ES	35.4	48
Chilko-ES	550.9	352
Chilko-S	613.3	368
Chilliwack-ES*	21.4	44
Cultus-L*	8.0	24
Francois-Fraser-S	205.5	148
Harrison (DS)-L	634.9	448
Harrison (US)-L	640.3	424
Harrison River- River type	1,697.7	604
Kamloops-ES	5,633.0	336
Lillooet-Harrison-L	2,481.8	612
Nadina -Francois-ES	1,660.8	640
Nahatlatch-ES*	12.4	32
North Barriere-ES	15.0	40
Pitt-ES	257.0	184
Quesnel -S	3,548.5	856
Seton-L	102.1	100
Shswap Complex-L	7,366.2	1600
Shuswap-ES	6,691.7	1276
Takla-Trembleur-Estu	4,605.0	1096
Takla-Trembleur-Stuart-S	4,902.2	1536
Taseko –ES*	205.8	116
Widgeon (River-Type)	549.5	300
Entire distribution	226,585.6	11380

***** *NOTE: Metrics estimated for Cultus-L, Chilliwack-ES, Nahatlatch-ES and Taseko-ES CUs are upper limits to the metrics calculated for these CUs based on spawning distributions alone.*

Table 7. *Alternative distribution metrics estimated using different methods to those contained in COSEWIC's guidelines. EOa was estimated using FWA Assessments Watershed database of 3rd order catchment areas, EOb was estimated using FWA watersheds that approximate 1st order catchments. AOs 1 and 2 were estimated using the Fraser Basin (FB) and FWA Watershed Group (FWA) methods, respectively, to determine the point of origin for the 2x2 km grid. Values obtained when vagrants were excluded are included in parentheses. All values are based on spawner distribution data alone.*

CU	EOa		EOb		AO 1 FB		AO 2 FWA	
Anderson-Seton-ES	342.7		22.4		20		20	
Bowron-ES	262.2		6.2		20		16	
Chilko-ES	685.3		65.2		76		84	
Chilko-S	556.3		59.9		68		68	
Chilliwack-ES*	71.1		3.5		16		12	
Cultus-L*	47.1		3.4		4		4	
Francois-Fraser-S	139.8	(105.6)	18.6	(17.5)	36	(32)	44	(40)
Harrison (DS)-L	99.9		17.0		40		40	
Harrison (US)-L	657.4		50.2		16		16	
Harrison River- River type	59.6		1.7		20		20	
Kamloops-ES	1,844.3	(1,552.4)	186.2	(181.57)	196	(180)	204	(188)
Lillooet-Harrison-L	469.6	(383.2)	99.1	(80.16)	100	(80)	88	(68)
Nadina -Francois-ES	715.6		73.6		128		148	
Nahatlatch-ES*	272.2		12.3		20		24	
North Barriere-ES	339.0		33.9		24		20	
Pitt-ES	343.7	(434.7)	52.9	(52.9)	60	(60)	64	(64)
Quesnel –S	2,954.0		339.1		348		340	
Seton-L	335.0	(266.05)	7.7	(6.1)	16	(12)	16	(12)
Shuswap Complex-L	5,576.1		909.5		668		704	
Shuswap-ES	3,116.7	(3,116.69)	367.0	(367.0)	344	(340)	344	(340)
Takla-Trembleur-Estu	3,156.6	(2,945.64)	237.0	(227.9)	440	(416)	456	(432)
Takla-Trembleur-Stuart-S	812.5		107.4		164		152	
Taseko –ES*	354.3		19.6		16		20	
Widgeon (River-Type)	42.9		0.7		4		4	

** NOTE: Metrics estimated for Cultus-L, Chilliwack-ES, Nahatlatch-ES and Taseko-ES CUs are likely underestimates due to poor visibility of spawning due to spawning in deep or turbid waters.*

Table 8. *Number of locations (streams or lakes) in each CU where spawning has been observed for three time periods. Also shown are results for CUs where all locations were consistently surveyed as well as results for all CUs that include location that were consistently surveyed in all time periods.* ***Note that in some cases several spawning 'sites' within a lake or large branch of a lake have been combined to create one 'location' (see Methods and Appendix3).***

	Total			**Excluding inconsistently surveyed CUs**			**Excluding inconsistently surveyed locations**		
CU	1992-95	2000-03	2008-11	1992-95	2000-03	2008-11	1992-95	2000-03	2008-11
Anderson-Seton-ES	2	2	2	2	2	2	2	2	2
Bowron-ES	1	1	2	-	-	-	1	1	1
Chilko-ES	1	1	1	1	1	1	1	1	1
Chilko-S†	3	3	2	3	3	2	3	3	2
Chilliwack-ES*	2	2	2	2	2	2	2	2	2
Cultus-L*	1	1	1	1	1	1	1	1	1
Fraser-Francois-S	3	3	1	-	-	-	1	1	1
Harrison (D/S)-L	1	6	5	-	-	-	1	1	1
Harrison (U/S)-L	2	2	2	2	2	2	2	2	2
Harrison River (River-Type)	1	1	1	1	1	1	1	1	1
Kamloops-ES	3	8	10	-	-	-	3	3	3
Lillooet-Harrison-L	3	4	4	-	-	-	3	3	3
Nadina-Francois-ES	2	3	3	-	-	-	2	2	2
Nahatlatch-ES*	2	2	2	2	2	2	2	2	2
North Barriere-ES	2	2	2	2	2	2	2	2	2
Pitt-ES	2	2	6	-	-	-	2	2	2
Quesnel-S	21	40	20	-	-	-	20	23	18
Seton-L	1	1	2	-	-	-	1	1	1
Shuswap-ES	16	19	28	-	-	-	16	15	17
Shuswap Complex-L	24	28	37	-	-	-	24	27	29
Takla-Trembleur-Estu	39	40	37	-	-	-	39	38	35
Takla-Trembleur-Stuart-S	7	8	7	-	-	-	7	7	7
Taseko-ES*	1	1	3	-	-	-	1	1	1
Widgeon (River-Type)	1	1	1	1	1	1	1	1	1
Entire distribution	141	181	181	17	17	16	138	142	137

** NOTE: Number of locations estimated for Cultus-L, Chilliwack-ES, Nahatlatch-ES and Taseko-ES CUs may be erroneous due to poor visibility of spawning due to spawning in deep or turbid waters*

†NOTE: The decrease in number of Chilko-S locations from 2 to 3 from 2000-03 to 2008-11 was due to a reduction in survey effort rather than any biological process.

APPENDIX 1

Definition of Terms

Area of Occupancy: The area within 'extent of occurrence' that is occupied by a taxon, excluding cases of vagrancy. The measure reflects the fact that the extent of occurrence may contain unsuitable or unoccupied habitats. In some cases (e.g. irreplaceable colonial nesting sites, crucial feeding sites for migratory taxa) the area of occupancy is the smallest area essential at any stage to the survival of existing populations of a taxon (in such cases, this area of occupancy does not need to occur within Canada). The size of the area of occupancy will be a function of the scale at which it is measured, and should be at a scale appropriate to relevant biological aspects of the taxon, the nature of threats and the available data. To avoid inconsistencies and bias in assessments caused by estimating area of occupancy at different scales, it may be necessary to standardize estimates by applying a scale-correction factor. Different types of taxa have different scale-area relationships. (COSWIC 2010, IUCN 2001)

Extent of Occurrence: The area included in a polygon without concave angles that encompasses the geographic distribution of all known populations of a wildlife species (COSEWIC 2010).

Location: A geographically or ecologically distinct area in which a single threatening even can rapidly affect all individuals of the taxon present. The size of the location depends on the area covered by the threatening event and may include part of one or many subpopulations. Where a taxon is affected by more than one threatening event, location should be defined by considering the most serious plausible threat. (COSEWIC 2010, IUCN 2001)

Minimum convex polygon (MCP): The smallest polygon in which no internal angle exceeds 180 degrees and which contains all sites of occurrence" (COSEWIC 2010).

APPENDIX 2

Stock assessment names of all spawning locations used in the current report. Spawning site was the level at which spawner densities were estimated by stock assessment (see Appendix 3). Some sites were combined into one 'location' (see Methods). The number of spawning locations listed here does not necessarily match the number of locations listed in Table 8 as not all locations contained spawning in all three four year time periods. CUs composed of spawning locations containing potential vagrants are marked with an asterix, as well as the sites potentially containing vagrants. Indented spawning sites are those contained in a lake or large branch of a lake, which were defined as a location (indicated in bold).

CU	Spawning location
Anderson-Seton-ES	Gates Channel
	Gates Creek
Bowron-ES	Bowron River
	Huckey Creek
Chilko-ES	Chilko Lake South End
Chilko-S	Chilko River
	Chilko Lake North End
Chilliwack-ES	Chilliwack Lake
	Dolly Varden Creek
Cultus-L	Cultus Lake
Francois-Fraser-S	Nithi River
	Ormonde Creek
	Stellako River
Harrison (D/S)-L	Big Silver Creek
	Cogburn Creek
	Douglas Creek
	Sloquet Creek
	Tipella Creek
Harrison (U/S)-L	Weaver Channel
	Weaver Creek
Harrison River (River-Type)	Harrison River
Kamloops-ES	Barriere River
	Clearwater River
	Finn Creek
	Hemp Creek
	Lemieux Creek
	Lion Creek
	Mann Creek
	Moul Creek
	North Thompson River
	Raft River
Lillooet-Harrison-L	Birkenhead River
	Green River
	Pemberton Creek

CU	Spawning location
	Sampson Creek (aka Railroad)
Nadina-Francois-ES	Glacier Creek Nadina Channel Nadina River
Nahatlatch-ES	Nahatlatch Lake Nahatlatch River
North Barriere-ES	Fennell Creek Harper Creek
Pitt-ES	Corbold Creek Fish Hatchery Creek Slough Creek South Boise Creek Upper Pitt Channel Upper Pitt River
Quesnel-S	Cameron Creek Hazeltine Creek Horsefly Channel Horsefly River Little Horsefly River McKinley Creek (Upper and Lower) Mitchell River Penfold Creek **North Arm:** -Bear Beach - Shore -Betty Frank's - Shore -Bowling Point -Deception Point -Devoe Creek - Shore -Goose Point - Shore -Grain Cr. - Shore -Watt Cr. - Shore -Long Cr. - Shore -North Arm - unnamed cove -Roaring R. – Shore Wasko Creek Grain Creek Isaiah Creek Roaring River Watt Creek Junction Creek **South East Arm:** -Lynx Shore -Big Slide - Shore -Bill Miner Cr. - Shore -Blue Lead Cr. - Shore -Bouldery Cr. - Shore

CU	Spawning location
	-Bouldery Cr. - Shore 2 km east
	-Elysia - Shore
	Lynx Creek
	Bill Miner Creek
	Blue Lead Creek
	Summit Creek
Seton-L	Lost Valley Creek Shore
	Portage Creek
Shuswap-ES	Adams Channel
	Adams River
	Anstey River
	Bear Creek (Huihill Creek)
	Bessette Creek
	Blueberry Creek
	Burton Creek
	Cayenne Creek
	Celista Creek
	Craigellachie Creek
	Crazy Creek
	Eagle River
	Four Mile Creek
	Gold Creek (Nikwikwaia Creek)
	Hunakwa Creek
	Loftus Creek
	McNomee Creek
	Middle Shuswap River
	Momich River
	Onyx Creek
	Pass Creek
	Perry River
	Scotch Creek
	Seymour River
	Two Mile Creek - shore
	Unnamed Creek
	Upper Adams River
	Yard Creek
Shuswap Complex-L	
	Mara Lake
	Shuswap Lake South West Arm
	-Adams River - shore
	-Cruikshank Pt. West - shore
	-Hlina Creek - shore
	-Lee Creek - shore
	-Onyx Creek - shore
	-Ross Creek - shore
	-Scotch Creek - shore
	Shuswap Lake North East Arm
	-Anstey River - shore
	-Four Mile Creek - shore

CU	Spawning location
	-Queest Creek - shore
	-Vanishing Creek - shore
	-Bush Creek - shore
	-Pass Creek - shore
	Shuswap Lake South East Arm
	-Knight Creek - shore
	-Reinecker Creek - shore
	Shuswap Lake North West Arm
	-Fowler Point
	-Steamboat Bay
	-Encounter Point
	Adams Channel
	Adams River
	Anstey River
	Bear (Huihill) Creek
	Bessette Creek
	Blurton Creek
	Bush Creek
	Canoe Creek
	Celista Creek
	Crazy Creek
	Eagle River
	Gold (Nikwikwaia) Creek
	Hunakwa Creek
	Johnson Creek
	Kingfisher Creek
	Little River
	Lower Shuswap River
	Middle Shuswap River
	Momich River
	Noisy Creek
	Pass Creek
	Perry River
	Ross Creek
	Salmon River
	Scotch Creek
	Seymour River
	Sicamous Creek
	South Thompson River
	Tappen Creek
	Tsuius Creek
	Tsuius Creek - Shore
	Upper Adams River
	Wap Creek
	Yard Creek
Takla-Trembleur-Estu	15 Mile Creek
	25 Mile Creek
	5 Mile Creek
	Ankwill Creek
	Bivouac Creek
	Blackwater Creek
	Blanchette Creek

CU	Spawning location
	Crow Creek
	Driftwood River
	Dust Creek
	Felix Creek
	Fleming Creek
	Forfar Creek
	Forsythe Creek
	Frypan Creek
	Gluske Creek
	Hooker Creek
	Hudson Bay Creek
	Kazchek Creek
	Kotsine Creek
	Kynock Creek
	Leo Creek
	Lion Creek
	McDougall Creek
	Middle River
	Narrows Creek
	Paula Creek
	Point Creek
	Porter Creek
	Rossette Creek
	Sakeniche River
	Sandpoint Creek
	Shale Creek
	Sinta Creek
	Sowchea Creek
	Takla Lake - shore
	Tildesley Creek
Takla-Trembleur-Stuart-S	Kazchek Creek
	Kuzkwa Creek
	Middle River
	Pinchi Creek
	Sakeniche River
	Sowchea Creek
	Tachie River
Taseko-ES	Taseko Lake
	Yoheta Creek, lower
	Yoheta Creek, upper
Widgeon (River-Type)	Widgeon Slough

APPENDIX 3

Spawning escapement for each spawning site in 2008 to 2011 as estimated by DFO Stock Assessment. Sites with less than 100 spawners in all years of observations were deemed to contain potential vagrants.

CU	Spawning site	Year	Total
Anderson-Seton-ES	Gates Channel	2008	9532
Anderson-Seton-ES	Gates Creek	2008	5486
Anderson-Seton-ES	Gates Channel	2009	5704
Anderson-Seton-ES	Gates Creek	2009	5152
Anderson-Seton-ES	Gates Channel	2010	13496
Anderson-Seton-ES	Gates Creek	2010	8935
Anderson-Seton-ES	Gates Channel	2011	18330
Anderson-Seton-ES	Gates Creek	2011	39107
Bowron-ES	Bowron River	2008	1005
Bowron-ES	Huckey Creek	2008	0
Bowron-ES	Bowron River	2009	1792
Bowron-ES	Huckey Creek	2009	22
Bowron-ES	Bowron River	2010	8291
Bowron-ES	Huckey Creek	2010	148
Bowron-ES	Bowron River	2011	4004
Bowron-ES	Huckey Creek	2011	97
Chilko-S / Chilko-ES	Chilko River	2008	250583
Chilko-S / Chilko-ES	Chilko River	2009	217778
Chilko-S / Chilko-ES	Chilko River	2010	2462975
Chilko-S / Chilko-ES	Chilko River	2011	918537
Chilliwack-ES	Chilliwack Lake	2008	5340
Chilliwack-ES	Dolly Varden Creek	2008	62482
Chilliwack-ES	Chilliwack Lake	2009	504
Chilliwack-ES	Dolly Varden Creek	2009	5083
Chilliwack-ES	Chilliwack Lake	2010	2104
Chilliwack-ES	Dolly Varden Creek	2010	691
Chilliwack-ES	Chilliwack Lake	2011	3836
Chilliwack-ES	Dolly Varden Creek	2011	657
Cultus-L	Cultus Lake	2008	360
Cultus-L	Cultus Lake	2009	1441
Cultus-L	Cultus Lake	2010	10297
Cultus-L	Cultus Lake	2011	7183
Francois-Fraser-S	Nithi River	2008	16
Francois-Fraser-S	Ormonde Creek	2008	0
Francois-Fraser-S	Stellako River	2008	159749
Francois-Fraser-S	Nithi River	2009	0
Francois-Fraser-S	Ormonde Creek	2009	0
Francois-Fraser-S	Stellako River	2009	27627
Francois-Fraser-S	Nithi River	2010	22
Francois-Fraser-S	Ormonde Creek	2010	277
Francois-Fraser-S	Stellako River	2010	202803
Francois-Fraser-S	Nithi River	2011	65
Francois-Fraser-S	Ormonde Creek	2011	0
Francois-Fraser-S	Stellako River	2011	84318
Harrison (D/S)-L	Big Silver Creek	2008	2446
Harrison (D/S)-L	Cogburn Creek	2008	0
Harrison (D/S)-L	Douglas Creek	2008	171
Harrison (D/S)-L	Sloquet Creek	2008	4
Harrison (D/S)-L	Tipella Creek	2008	0
Harrison (D/S)-L	Big Silver Creek	2009	6053
Harrison (D/S)-L	Cogburn Creek	2009	288
Harrison (D/S)-L	Douglas Creek	2009	263

CU	Spawning site	Year	Total
Harrison (D/S)-L	Sloquet Creek	2009	16
Harrison (D/S)-L	Tipella Creek	2009	11
Harrison (D/S)-L	Big Silver Creek	2010	10090
Harrison (D/S)-L	Cogburn Creek	2010	238
Harrison (D/S)-L	Douglas Creek	2010	700
Harrison (D/S)-L	Tipella Creek	2010	7
Harrison (U/S)-L	Weaver Channel	2008	1477
Harrison (U/S)-L	Weaver Creek	2008	1336
Harrison (U/S)-L	Weaver Channel	2009	27475
Harrison (U/S)-L	Weaver Creek	2009	8498
Harrison (U/S)-L	Weaver Channel	2010	36886
Harrison (U/S)-L	Weaver Creek	2010	24377
Harrison (U/S)-L	Weaver Channel	2011	45637
Harrison (U/S)-L	Weaver Creek	2011	27133
Harrison River (River-Type)	Harrison River	2008	6750
Harrison River (River-Type)	Harrison River	2009	307373
Harrison River (River-Type)	Harrison River	2010	761668
Harrison River (River-Type)	Harrison River	2011	644014
Kamloops-ES	Barriere River	2008	7
Kamloops-ES	Clearwater River	2008	158
Kamloops-ES	Finn Creek	2008	4
Kamloops-ES	Hemp Creek	2008	0
Kamloops-ES	Lemieux Creek	2008	439
Kamloops-ES	Lion Creek	2008	4
Kamloops-ES	Mann Creek	2008	41
Kamloops-ES	Moul Creek	2008	0
Kamloops-ES	North Thompson River	2008	3226
Kamloops-ES	Raft River	2008	10406
Kamloops-ES	Barriere River	2009	437
Kamloops-ES	Clearwater River	2009	1179
Kamloops-ES	Finn Creek	2009	2
Kamloops-ES	Hemp Creek	2009	45
Kamloops-ES	Lemieux Creek	2009	108
Kamloops-ES	Lion Creek	2009	0
Kamloops-ES	Mann Creek	2009	0
Kamloops-ES	Moul Creek	2009	40
Kamloops-ES	North Thompson River	2009	3186
Kamloops-ES	Raft River	2009	11464
Kamloops-ES	Barriere River	2010	457
Kamloops-ES	Clearwater River	2010	630
Kamloops-ES	Finn Creek	2010	0
Kamloops-ES	Hemp Creek	2010	0
Kamloops-ES	Lemieux Creek	2010	0
Kamloops-ES	Lion Creek	2010	0
Kamloops-ES	Mann Creek	2010	0
Kamloops-ES	Moul Creek	2010	0
Kamloops-ES	North Thompson River	2010	6957
Kamloops-ES	Raft River	2010	5119
Kamloops-ES	Barriere River	2011	103
Kamloops-ES	Clearwater River	2011	419
Kamloops-ES	Finn Creek	2011	0
Kamloops-ES	Hemp Creek	2011	0
Kamloops-ES	Lemieux Creek	2011	202
Kamloops-ES	Lion Creek	2011	0
Kamloops-ES	Mann Creek	2011	0
Kamloops-ES	Moul Creek	2011	0

CU	Spawning site	Year	Total
Kamloops-ES	North Thompson River	2011	4205
Kamloops-ES	Raft River	2011	9243
Lillooet-Harrison-L	Birkenhead River	2008	19861
Lillooet-Harrison-L	Sampson Creek	2008	169
Lillooet-Harrison-L	Birkenhead River	2009	54156
Lillooet-Harrison-L	Green River	2009	2
Lillooet-Harrison-L	Sampson Creek	2009	1003
Lillooet-Harrison-L	Birkenhead River	2010	128465
Lillooet-Harrison-L	Green River	2010	0
Lillooet-Harrison-L	Sampson Creek	2010	1557
Lillooet-Harrison-L	Birkenhead River	2011	194496
Lillooet-Harrison-L	Green River	2011	5179
Lillooet-Harrison-L	Sampson Creek	2011	1751
Lillooet-Harrison-L	Pemberton Creek	2011	144
Nadina-Francois-ES	Glacier Creek	2008	221
Nadina-Francois-ES	Nadina Channel	2008	33251
Nadina-Francois-ES	Nadina River	2008	32503
Nadina-Francois-ES	Glacier Creek	2009	0
Nadina-Francois-ES	Nadina Channel	2009	4394
Nadina-Francois-ES	Nadina River	2009	7008
Nadina-Francois-ES	Glacier Creek	2010	0
Nadina-Francois-ES	Nadina Channel	2010	21359
Nadina-Francois-ES	Nadina River	2010	4783
Nadina-Francois-ES	Glacier Creek	2011	0
Nadina-Francois-ES	Nadina Channel	2011	6523
Nadina-Francois-ES	Nadina River	2011	3535
Nahatlatch-ES	Nahatlatch Lake	2008	280
Nahatlatch-ES	Nahatlatch River	2008	293
Nahatlatch-ES	Nahatlatch Lake	2009	336
Nahatlatch-ES	Nahatlatch River	2009	1103
Nahatlatch-ES	Nahatlatch Lake	2010	510
Nahatlatch-ES	Nahatlatch River	2010	4910
Nahatlatch-ES	Nahatlatch Lake	2011	1781
Nahatlatch-ES	Nahatlatch River	2011	5188
North Barriere-ES	Fennell Creek	2008	2270
North Barriere-ES	Harper Creek	2008	0
North Barriere-ES	Fennell Creek	2009	1170
North Barriere-ES	Harper Creek	2009	0
North Barriere-ES	Fennell Creek	2010	10669
North Barriere-ES	Harper Creek	2010	139
North Barriere-ES	Fennell Creek	2011	9884
North Barriere-ES	Harper Creek	2011	104
Pitt-ES	Upper Pitt River	2008	16921
Pitt-ES	Upper Pitt River	2009	31042
Pitt-ES	Corbold Creek	2010	12260
Pitt-ES	South Boise Creek	2010	1043
Pitt-ES	Upper Pitt Channel	2010	268
Pitt-ES	Upper Pitt River	2010	3247
Pitt-ES	Corbold Creek	2011	13756
Pitt-ES	Fish Hatchery Creek	2011	1319
Pitt-ES	Slough Creek	2011	90
Pitt-ES	South Boise Creek	2011	502
Pitt-ES	Upper Pitt Channel	2011	833
Pitt-ES	Upper Pitt River	2011	40031
Quesnel-S	Big Slide - Shore	2008	0
Quesnel-S	Bill Miner Cr. - Shore	2008	0

CU	Spawning site	Year	Total
Quesnel-S	Bill Miner Creek	2008	0
Quesnel-S	Blue Lead Cr. - Shore	2008	54
Quesnel-S	Blue Lead Creek	2008	18
Quesnel-S	Bouldery Cr. - Shore	2008	0
Quesnel-S	Bouldery Creek	2008	0
Quesnel-S	Cameron Creek	2008	0
Quesnel-S	Deception Point	2008	34
Quesnel-S	Goose Point - Shore	2008	0
Quesnel-S	Grain Cr. - Shore	2008	0
Quesnel-S	Grain Creek	2008	0
Quesnel-S	Horsefly River	2008	5324
Quesnel-S	Isaiah Creek	2008	0
Quesnel-S	Little Horsefly River	2008	0
Quesnel-S	Lynx Cr. - Shore	2008	0
Quesnel-S	Lynx Creek	2008	0
Quesnel-S	McKinley Creek - Lower	2008	77
Quesnel-S	McKinley Creek - Upper	2008	0
Quesnel-S	Mitchell River	2008	1564
Quesnel-S	Penfold Creek	2008	0
Quesnel-S	Roaring R. - Shore	2008	0
Quesnel-S	Roaring River	2008	0
Quesnel-S	Summit Creek	2008	20
Quesnel-S	Wasko Creek, lower	2008	0
Quesnel-S	Watt Cr. - Shore	2008	0
Quesnel-S	Watt Creek	2008	0
Quesnel-S	Bear Beach - Shore	2009	198
Quesnel-S	Betty Frank's - Shore	2009	65
Quesnel-S	Big Slide - Shore	2009	394
Quesnel-S	Bill Miner Cr. - Shore	2009	101
Quesnel-S	Bill Miner Creek	2009	0
Quesnel-S	Blue Lead Cr. - Shore	2009	916
Quesnel-S	Blue Lead Creek	2009	693
Quesnel-S	Bouldery Cr. - Shore	2009	1253
Quesnel-S	Bouldery Cr. - Shore 2 km east	2009	13
Quesnel-S	Bouldery Creek	2009	0
Quesnel-S	Bowling Point	2009	455
Quesnel-S	Cameron Creek	2009	234
Quesnel-S	Deception Point	2009	8296
Quesnel-S	Devoe Creek - Shore	2009	40
Quesnel-S	Elysia - Shore	2009	36
Quesnel-S	Goose Point - Shore	2009	1114
Quesnel-S	Grain Cr. - Shore	2009	545
Quesnel-S	Grain Creek	2009	556
Quesnel-S	Hazeltine Creek	2009	0
Quesnel-S	Horsefly Channel	2009	8162
Quesnel-S	Horsefly River	2009	56605
Quesnel-S	Isaiah Creek	2009	32
Quesnel-S	Junction Creek	2009	45
Quesnel-S	Little Horsefly River	2009	6089
Quesnel-S	Long Cr. - Shore	2009	724
Quesnel-S	Lynx Cr. - Shore	2009	95
Quesnel-S	Lynx Creek	2009	140
Quesnel-S	McKinley Creek - Lower	2009	9621
Quesnel-S	McKinley Creek - Upper	2009	1906
Quesnel-S	Mitchell River	2009	45741
Quesnel-S	North Arm - unnamed cove	2009	1003

CU	Spawning site	Year	Total
Quesnel-S	Penfold Creek	2009	90
Quesnel-S	Roaring R. - Shore	2009	382
Quesnel-S	Roaring River	2009	0
Quesnel-S	Summit Creek	2009	418
Quesnel-S	Wasko Creek, lower	2009	3107
Quesnel-S	Wasko Creek - Upper	2009	16
Quesnel-S	Watt Cr. - Shore	2009	281
Quesnel-S	Watt Creek	2009	101
Quesnel-S	Bear Beach - Shore	2010	122
Quesnel-S	Betty Frank's - Shore	2010	124
Quesnel-S	Big Slide - Shore	2010	311
Quesnel-S	Bill Miner Cr. - Shore	2010	166
Quesnel-S	Bill Miner Creek	2010	22
Quesnel-S	Blue Lead Cr. - Shore	2010	1067
Quesnel-S	Blue Lead Creek	2010	423
Quesnel-S	Bouldery Cr. - Shore	2010	382
Quesnel-S	Bouldery Creek	2010	0
Quesnel-S	Bowling Point	2010	473
Quesnel-S	Cameron Creek	2010	243
Quesnel-S	Deception Point	2010	6349
Quesnel-S	Devoe Creek - Shore	2010	36
Quesnel-S	Elysia - Shore	2010	0
Quesnel-S	Goose Point - Shore	2010	648
Quesnel-S	Grain Cr. - Shore	2010	556
Quesnel-S	Grain Creek	2010	459
Quesnel-S	Hazeltine Creek	2010	0
Quesnel-S	Horsefly Channel	2010	22493
Quesnel-S	Horsefly River	2010	124074
Quesnel-S	Isaiah Creek	2010	97
Quesnel-S	Junction Creek	2010	22
Quesnel-S	Little Horsefly River	2010	4068
Quesnel-S	Long Cr. - Shore	2010	842
Quesnel-S	Lynx Cr. - Shore	2010	72
Quesnel-S	Lynx Creek	2010	76
Quesnel-S	McKinley Creek - Lower	2010	1289
Quesnel-S	McKinley Creek - Upper	2010	245
Quesnel-S	Mitchell River	2010	74320
Quesnel-S	North Arm - unnamed cove	2010	403
Quesnel-S	Penfold Creek	2010	466
Quesnel-S	Roaring R. - Shore	2010	491
Quesnel-S	Roaring River	2010	887
Quesnel-S	Summit Creek	2010	214
Quesnel-S	Wasko Creek, lower	2010	4829
Quesnel-S	Wasko Creek - Upper	2010	0
Quesnel-S	Watt Cr. - Shore	2010	166
Quesnel-S	Watt Creek	2010	151
Quesnel-S	Bear Beach - Shore	2011	0
Quesnel-S	Betty Frank's - Shore	2011	0
Quesnel-S	Big Slide - Shore	2011	14
Quesnel-S	Bill Miner Cr. - Shore	2011	0
Quesnel-S	Bill Miner Creek	2011	0
Quesnel-S	Blue Lead Cr. - Shore	2011	164
Quesnel-S	Blue Lead Creek	2011	25
Quesnel-S	Bouldery Cr. - Shore	2011	31
Quesnel-S	Bowling Point	2011	11
Quesnel-S	Cameron Creek	2011	0

CU	Spawning site	Year	Total
Quesnel-S	Deception Point	2011	497
Quesnel-S	Elysia - Shore	2011	0
Quesnel-S	Goose Point - Shore	2011	63
Quesnel-S	Grain Cr. - Shore	2011	0
Quesnel-S	Grain Creek	2011	0
Quesnel-S	Hazeltine Creek	2011	79
Quesnel-S	Horsefly Channel	2011	2362
Quesnel-S	Horsefly River	2011	29666
Quesnel-S	Isaiah Creek	2011	0
Quesnel-S	Junction Creek	2011	0
Quesnel-S	Little Horsefly River	2011	286
Quesnel-S	Long Cr. - Shore	2011	0
Quesnel-S	Lynx Cr. - Shore	2011	4
Quesnel-S	Lynx Creek	2011	22
Quesnel-S	McKinley Creek - Lower	2011	72
Quesnel-S	McKinley Creek - Upper	2011	0
Quesnel-S	Mitchell River	2011	11542
Quesnel-S	North Arm - unnamed cove	2011	0
Quesnel-S	Penfold Creek	2011	16
Quesnel-S	Roaring River	2011	113
Quesnel-S	Roaring R. - Shore	2011	11
Quesnel-S	Summit Creek	2011	149
Quesnel-S	Wasko Creek - Upper	2011	0
Quesnel-S	Wasko Creek, lower	2011	248
Quesnel-S	Watt Cr. - Shore	2011	43
Quesnel-S	Watt Creek	2011	18
Seton-L	Portage Creek	2008	97
Seton-L	Portage Creek	2009	1836
Seton-L	Lost Valley Creek Shore	2010	25
Seton-L	Portage Creek	2010	57845
Seton-L	Portage Creek	2011	1114
Shuswap Complex-L	Adams Channel	2008	0
Shuswap Complex-L	Adams Lake - misc. east side shore	2008	0
Shuswap Complex-L	Adams Lake - misc. north end shore	2008	0
Shuswap Complex-L	Adams Lake - misc. south end shore	2008	0
Shuswap Complex-L	Adams River	2008	149
Shuswap Complex-L	Adams River - shore	2008	0
Shuswap Complex-L	Anstey River	2008	0
Shuswap Complex-L	Bear Creek	2008	0
Shuswap Complex-L	Bessette Creek	2008	0
Shuswap Complex-L	Bush Creek	2008	0
Shuswap Complex-L	Bush Creek - shore	2008	0
Shuswap Complex-L	Canoe Creek	2008	0
Shuswap Complex-L	Celista Creek	2008	0
Shuswap Complex-L	Eagle River	2008	2
Shuswap Complex-L	Four Mile Creek - shore	2008	0
Shuswap Complex-L	Gold Creek	2008	0
Shuswap Complex-L	Hlina Creek - shore	2008	0
Shuswap Complex-L	Hunakwa Creek	2008	0
Shuswap Complex-L	Knight Creek - shore	2008	0
Shuswap Complex-L	Lee Creek - shore	2008	0
Shuswap Complex-L	Little River	2008	2
Shuswap Complex-L	Lower Shuswap River	2008	11
Shuswap Complex-L	Middle Shuswap River	2008	0
Shuswap Complex-L	Momich River	2008	0
Shuswap Complex-L	Noisy Creek	2008	0

CU	Spawning site	Year	Total
Shuswap Complex-L	Onyx Creek - shore	2008	0
Shuswap Complex-L	Pass Creek	2008	0
Shuswap Complex-L	Pass Creek - shore	2008	0
Shuswap Complex-L	Queest Creek - shore	2008	0
Shuswap Complex-L	Reinecker Creek - shore	2008	0
Shuswap Complex-L	Ross Creek - shore	2008	0
Shuswap Complex-L	Salmon River	2008	0
Shuswap Complex-L	Scotch Creek	2008	0
Shuswap Complex-L	Scotch Creek - shore	2008	0
Shuswap Complex-L	Seymour River	2008	0
Shuswap Complex-L	Shuswap L. - Salmon Arm north side	2008	0
Shuswap Complex-L	Shuswap L. - Salmon Arm south side	2008	0
Shuswap Complex-L	Shuswap Lake - Seymour Arm	2008	0
Shuswap Complex-L	South Thompson River	2008	0
Shuswap Complex-L	Tappen Creek	2008	0
Shuswap Complex-L	Tsuius Creek	2008	0
Shuswap Complex-L	Upper Adams River	2008	0
Shuswap Complex-L	Vanishing Creek - shore	2008	0
Shuswap Complex-L	Wap Creek	2008	0
Shuswap Complex-L	Adams Lake - misc. east side shore	2009	0
Shuswap Complex-L	Adams Lake - misc. south end shore	2009	7
Shuswap Complex-L	Adams River	2009	37861
Shuswap Complex-L	Adams River - shore	2009	0
Shuswap Complex-L	Anstey River	2009	40
Shuswap Complex-L	Bear Creek	2009	0
Shuswap Complex-L	Bessette Creek	2009	18
Shuswap Complex-L	Bush Creek	2009	0
Shuswap Complex-L	Bush Creek - shore	2009	0
Shuswap Complex-L	Canoe Creek	2009	0
Shuswap Complex-L	Cruikshank Pt. West - shore	2009	0
Shuswap Complex-L	Eagle River	2009	1721
Shuswap Complex-L	Four Mile Creek - shore	2009	157
Shuswap Complex-L	Gold Creek	2009	0
Shuswap Complex-L	Hlina Creek - shore	2009	70
Shuswap Complex-L	Hunakwa Creek	2009	95
Shuswap Complex-L	Knight Creek - shore	2009	0
Shuswap Complex-L	Lee Creek - shore	2009	117
Shuswap Complex-L	Little River	2009	19750
Shuswap Complex-L	Lower Shuswap River	2009	9448
Shuswap Complex-L	Middle Shuswap River	2009	529
Shuswap Complex-L	Noisy Creek	2009	0
Shuswap Complex-L	Onyx Creek - shore	2009	0
Shuswap Complex-L	Pass Creek	2009	63
Shuswap Complex-L	Pass Creek - shore	2009	0
Shuswap Complex-L	Perry River	2009	5
Shuswap Complex-L	Queest Creek - shore	2009	0
Shuswap Complex-L	Reinecker Creek - shore	2009	16
Shuswap Complex-L	Ross Creek	2009	0
Shuswap Complex-L	Ross Creek - shore	2009	686
Shuswap Complex-L	Salmon River	2009	0
Shuswap Complex-L	Scotch Creek	2009	25
Shuswap Complex-L	Scotch Creek - shore	2009	414
Shuswap Complex-L	Seymour River	2009	0
Shuswap Complex-L	Shuswap L. - Main Arm south side	2009	0
Shuswap Complex-L	Shuswap L. - Salmon Arm north side	2009	0
Shuswap Complex-L	Shuswap L. - Salmon Arm south side	2009	0

CU	Spawning site	Year	Total
Shuswap Complex-L	Shuswap Lake - Seymour Arm	2009	0
Shuswap Complex-L	South Thompson River	2009	229
Shuswap Complex-L	Tappen Creek	2009	0
Shuswap Complex-L	Tsuius Creek	2009	14
Shuswap Complex-L	Upper Adams River	2009	0
Shuswap Complex-L	Vanishing Creek - shore	2009	0
Shuswap Complex-L	Wap Creek	2009	79
Shuswap Complex-L	Yard Creek	2009	0
Shuswap Complex-L	Adams Channel	2010	2592
Shuswap Complex-L	Adams Lake - misc. east side shore	2010	693
Shuswap Complex-L	Adams Lake - misc. north end shore	2010	20
Shuswap Complex-L	Adams Lake - misc. south end shore	2010	1606
Shuswap Complex-L	Adams River	2010	3859983
Shuswap Complex-L	Adams River - shore	2010	4518
Shuswap Complex-L	Anstey River	2010	2621
Shuswap Complex-L	Anstey River - shore	2010	229
Shuswap Complex-L	Bear Creek	2010	3294
Shuswap Complex-L	Bessette Creek	2010	2806
Shuswap Complex-L	Blurton Creek	2010	27
Shuswap Complex-L	Bush Creek	2010	52
Shuswap Complex-L	Bush Creek - shore	2010	378
Shuswap Complex-L	Canoe Creek	2010	128
Shuswap Complex-L	Celista Creek	2010	841
Shuswap Complex-L	Crazy Creek	2010	1076
Shuswap Complex-L	Cruikshank Pt. West - shore	2010	1035
Shuswap Complex-L	Eagle River	2010	232401
Shuswap Complex-L	Four Mile Creek - shore	2010	4687
Shuswap Complex-L	Gold Creek	2010	4567
Shuswap Complex-L	Hlina Creek - shore	2010	767
Shuswap Complex-L	Hunakwa Creek	2010	3202
Shuswap Complex-L	Johnson Creek	2010	124
Shuswap Complex-L	Kingfisher Creek	2010	814
Shuswap Complex-L	Knight Creek - shore	2010	367
Shuswap Complex-L	Lee Creek - shore	2010	4027
Shuswap Complex-L	Little River	2010	422378
Shuswap Complex-L	Lower Shuswap River	2010	2586211
Shuswap Complex-L	Mara Lake - shore	2010	205
Shuswap Complex-L	Middle Shuswap River	2010	310664
Shuswap Complex-L	Momich River	2010	29
Shuswap Complex-L	Noisy Creek	2010	785
Shuswap Complex-L	Onyx Creek - shore	2010	1960
Shuswap Complex-L	Pass Creek	2010	4752
Shuswap Complex-L	Pass Creek - shore	2010	175
Shuswap Complex-L	Perry River	2010	153
Shuswap Complex-L	Queest Creek - shore	2010	558
Shuswap Complex-L	Reinecker Creek - shore	2010	2142
Shuswap Complex-L	Ross Creek	2010	767
Shuswap Complex-L	Ross Creek - shore	2010	13100
Shuswap Complex-L	Salmon River	2010	392
Shuswap Complex-L	Scotch Creek	2010	16677
Shuswap Complex-L	Scotch Creek - shore	2010	2990
Shuswap Complex-L	Seymour River	2010	1255
Shuswap Complex-L	Shuswap L. - Main Arm south side	2010	13
Shuswap Complex-L	Shuswap L. - Salmon Arm north side	2010	1431
Shuswap Complex-L	Shuswap L. - Salmon Arm south side	2010	292
Shuswap Complex-L	Shuswap Lake - Seymour Arm	2010	610

CU	Spawning site	Year	Total
Shuswap Complex-L	Sicamous Creek	2010	11
Shuswap Complex-L	South Thompson River	2010	1512
Shuswap Complex-L	Tappen Creek	2010	740
Shuswap Complex-L	Tsuius Creek	2010	1517
Shuswap Complex-L	Tsuius Creek - Shore	2010	450
Shuswap Complex-L	Upper Adams River	2010	139
Shuswap Complex-L	Vanishing Creek - shore	2010	43
Shuswap Complex-L	Wap Creek	2010	14218
Shuswap Complex-L	Yard Creek	2010	52
Shuswap Complex-L	Adams Lake - misc. east side shore	2011	4
Shuswap Complex-L	Adams Lake - misc. north end shore	2011	0
Shuswap Complex-L	Adams Lake - misc. south end shore	2011	0
Shuswap Complex-L	Adams River	2011	1
Shuswap Complex-L	Adams River - shore	2011	131042
Shuswap Complex-L	Anstey River	2011	29
Shuswap Complex-L	Anstey River - shore	2011	0
Shuswap Complex-L	Bear Creek	2011	0
Shuswap Complex-L	Bessette Creek	2011	0
Shuswap Complex-L	Blurton Creek	2011	0
Shuswap Complex-L	Bush Creek - shore	2011	0
Shuswap Complex-L	Canoe Creek	2011	0
Shuswap Complex-L	Celista Creek	2011	0
Shuswap Complex-L	Crazy Creek	2011	0
Shuswap Complex-L	Cruikshank Pt. West - shore	2011	13
Shuswap Complex-L	Eagle River	2011	1895
Shuswap Complex-L	Four Mile Creek - shore	2011	11
Shuswap Complex-L	Gold Creek	2011	25
Shuswap Complex-L	Hlina Creek - shore	2011	0
Shuswap Complex-L	Hunakwa Creek	2011	4
Shuswap Complex-L	Johnson Creek	2011	0
Shuswap Complex-L	Kingfisher Creek	2011	0
Shuswap Complex-L	Knight Creek - shore	2011	0
Shuswap Complex-L	Lee Creek - shore	2011	15
Shuswap Complex-L	Little River	2011	3956
Shuswap Complex-L	Lower Shuswap River	2011	10420
Shuswap Complex-L	Mara Lake - shore	2011	0
Shuswap Complex-L	Middle Shuswap River	2011	648
Shuswap Complex-L	Momich River	2011	0
Shuswap Complex-L	Noisy Creek	2011	0
Shuswap Complex-L	Onyx Creek - shore	2011	0
Shuswap Complex-L	Pass Creek	2011	23
Shuswap Complex-L	Pass Creek - shore	2011	4
Shuswap Complex-L	Perry River	2011	0
Shuswap Complex-L	Queest Creek - shore	2011	0
Shuswap Complex-L	Reinecker Creek - shore	2011	25
Shuswap Complex-L	Ross Creek - shore	2011	40
Shuswap Complex-L	Salmon River	2011	5
Shuswap Complex-L	Scotch Creek	2011	288
Shuswap Complex-L	Scotch Creek - shore	2011	14
Shuswap Complex-L	Seymour River	2011	22
Shuswap Complex-L	Shuswap L. - Main Arm south side	2011	0
Shuswap Complex-L	Shuswap L. - Salmon Arm north side	2011	0
Shuswap Complex-L	Shuswap L. - Salmon Arm south side	2011	0
Shuswap Complex-L	Shuswap Lake - Seymour Arm	2011	0
Shuswap Complex-L	Sicamous Creek	2011	0
Shuswap Complex-L	South Thompson River	2011	0

CU	Spawning site	Year	Total
Shuswap Complex-L	Tappen Creek	2011	7
Shuswap Complex-L	Tsuius Creek	2011	0
Shuswap Complex-L	Upper Adams River	2011	2
Shuswap Complex-L	Vanishing Creek - shore	2011	0
Shuswap Complex-L	Wap Creek	2011	14
Shuswap Complex-L	Yard Creek	2011	0
Shuswap-ES	Adams Channel	2008	0
Shuswap-ES	Adams River	2008	0
Shuswap-ES	Anstey River	2008	119
Shuswap-ES	Bear Creek	2008	0
Shuswap-ES	Burton Creek	2008	135
Shuswap-ES	Cayenne Creek	2008	313
Shuswap-ES	Celista Creek	2008	0
Shuswap-ES	Craigellachie Creek	2008	0
Shuswap-ES	Crazy Creek	2008	0
Shuswap-ES	Eagle River	2008	1345
Shuswap-ES	Gold Creek	2008	0
Shuswap-ES	Hunakwa Creek	2008	0
Shuswap-ES	Loftus Creek	2008	0
Shuswap-ES	McNomee Creek	2008	113
Shuswap-ES	Momich River	2008	139
Shuswap-ES	Perry River	2008	0
Shuswap-ES	Scotch Creek	2008	654
Shuswap-ES	Seymour River	2008	1237
Shuswap-ES	Upper Adams River	2008	805
Shuswap-ES	Yard Creek	2008	128
Shuswap-ES	Adams Channel	2009	0
Shuswap-ES	Adams River	2009	0
Shuswap-ES	Anstey River	2009	410
Shuswap-ES	Burton Creek	2009	0
Shuswap-ES	Cayenne Creek	2009	232
Shuswap-ES	Celista Creek	2009	0
Shuswap-ES	Crazy Creek	2009	7
Shuswap-ES	Eagle River	2009	2038
Shuswap-ES	Hunakwa Creek	2009	0
Shuswap-ES	Loftus Creek	2009	0
Shuswap-ES	McNomee Creek	2009	29
Shuswap-ES	Momich River	2009	0
Shuswap-ES	Perry River	2009	65
Shuswap-ES	Scotch Creek	2009	5770
Shuswap-ES	Seymour River	2009	5598
Shuswap-ES	Upper Adams River	2009	36
Shuswap-ES	Yard Creek	2009	56
Shuswap-ES	Adams Channel	2010	32
Shuswap-ES	Adams River	2010	7520
Shuswap-ES	Anstey River	2010	39920
Shuswap-ES	Bear Creek	2010	5360
Shuswap-ES	Bessette Creek	2010	11
Shuswap-ES	Blueberry Creek	2010	133
Shuswap-ES	Burton Creek	2010	0
Shuswap-ES	Cayenne Creek	2010	279
Shuswap-ES	Celista Creek	2010	8824
Shuswap-ES	Craigellachie Creek	2010	148
Shuswap-ES	Crazy Creek	2010	2367
Shuswap-ES	Eagle River	2010	257463
Shuswap-ES	Four Mile Creek	2010	272

CU	Spawning site	Year	Total
Shuswap-ES	Gold Creek	2010	4027
Shuswap-ES	Hunakwa Creek	2010	812
Shuswap-ES	Loftus Creek	2010	2684
Shuswap-ES	McNomee Creek	2010	19001
Shuswap-ES	Middle Shuswap River	2010	90
Shuswap-ES	Momich River	2010	0
Shuswap-ES	Onyx Creek	2010	275
Shuswap-ES	Pass Creek	2010	551
Shuswap-ES	Perry River	2010	10080
Shuswap-ES	Scotch Creek	2010	522367
Shuswap-ES	Seymour River	2010	533133
Shuswap-ES	Two Mile Creek - shore	2010	4
Shuswap-ES	Unnamed Creek	2010	11
Shuswap-ES	Upper Adams River	2010	2822
Shuswap-ES	Yard Creek	2010	10607
Shuswap-ES	Adams River	2011	29
Shuswap-ES	Anstey River	2011	2495
Shuswap-ES	Bear Creek	2011	86
Shuswap-ES	Burton Creek	2011	0
Shuswap-ES	Cayenne Creek	2011	14
Shuswap-ES	Celista Creek	2011	0
Shuswap-ES	Crazy Creek	2011	0
Shuswap-ES	Eagle River	2011	10676
Shuswap-ES	Four Mile Creek	2011	0
Shuswap-ES	Gold Creek	2011	29
Shuswap-ES	Hunakwa Creek	2011	0
Shuswap-ES	Loftus Creek	2011	40
Shuswap-ES	McNomee Creek	2011	346
Shuswap-ES	Momich River	2011	0
Shuswap-ES	Pass Creek	2011	0
Shuswap-ES	Perry River	2011	1237
Shuswap-ES	Scotch Creek	2011	33814
Shuswap-ES	Seymour River	2011	16110
Shuswap-ES	Upper Adams River	2011	538
Shuswap-ES	Yard Creek	2011	916
Takla-Trembleur-Estu	15 Mile Creek	2008	0
Takla-Trembleur-Estu	25 Mile Creek	2008	0
Takla-Trembleur-Estu	5 Mile Creek	2008	0
Takla-Trembleur-Estu	Ankwill Creek	2008	216
Takla-Trembleur-Estu	Bivouac Creek	2008	193
Takla-Trembleur-Estu	Blackwater Creek	2008	0
Takla-Trembleur-Estu	Blanchette Creek	2008	0
Takla-Trembleur-Estu	Crow Creek	2008	356
Takla-Trembleur-Estu	Driftwood River	2008	391
Takla-Trembleur-Estu	Dust Creek	2008	475
Takla-Trembleur-Estu	Felix Creek	2008	4619
Takla-Trembleur-Estu	Fleming Creek	2008	389
Takla-Trembleur-Estu	Forfar Creek	2008	3522
Takla-Trembleur-Estu	Forsythe Creek	2008	0
Takla-Trembleur-Estu	Frypan Creek	2008	310
Takla-Trembleur-Estu	Gluske Creek	2008	2495
Takla-Trembleur-Estu	Hooker Creek	2008	0
Takla-Trembleur-Estu	Hudson Bay Creek	2008	0
Takla-Trembleur-Estu	Kazchek Creek	2008	0
Takla-Trembleur-Estu	Kotsine Creek	2008	0
Takla-Trembleur-Estu	Kynock Creek	2008	11111

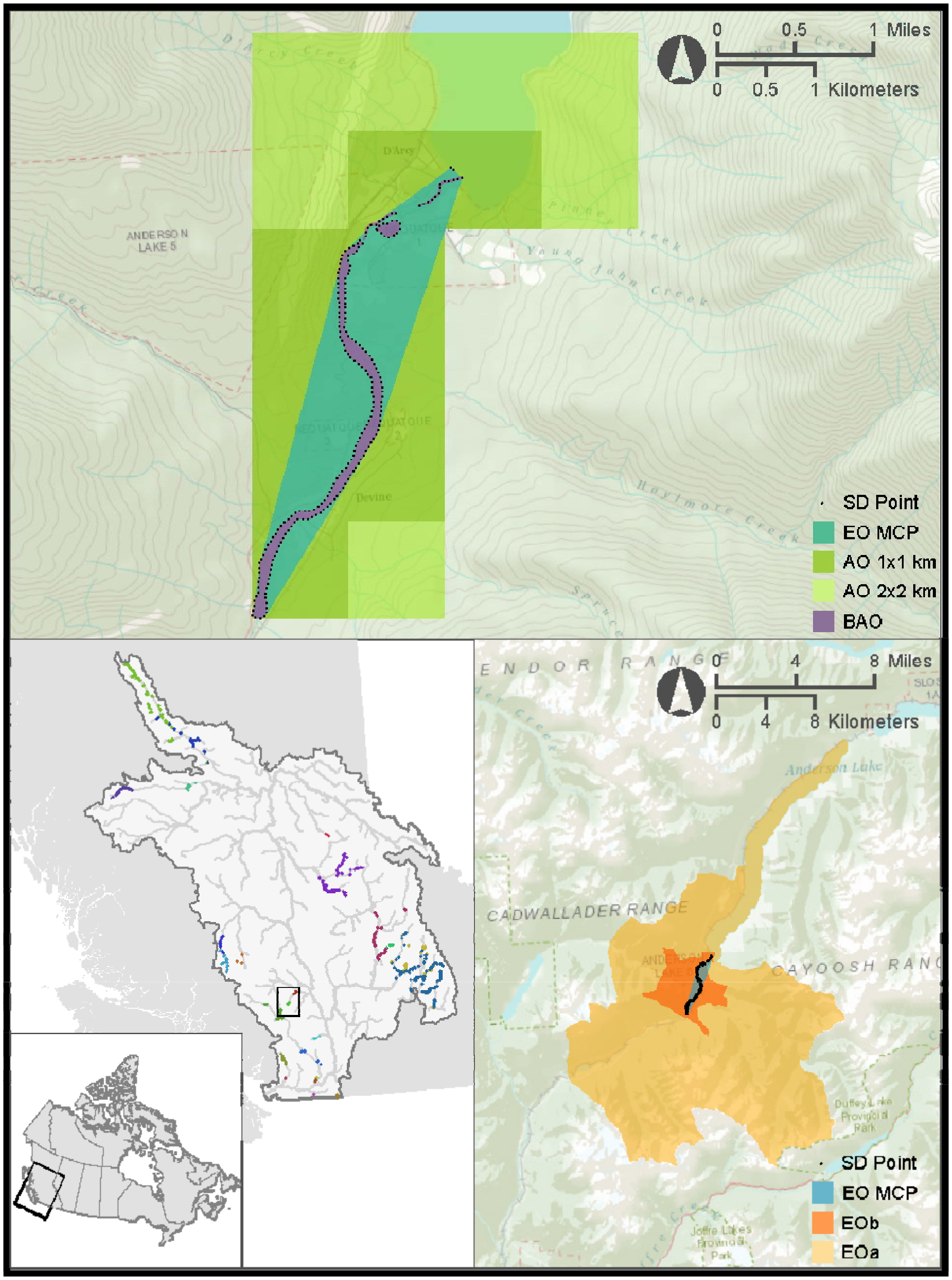
CU	Spawning site	Year	Total
Takla-Trembleur-Estu	Leo Creek	2008	16
Takla-Trembleur-Estu	Lion Creek	2008	0
Takla-Trembleur-Estu	McDougall Creek	2008	0
Takla-Trembleur-Estu	Middle River (Rossette Bar)	2008	216
Takla-Trembleur-Estu	Narrows Creek	2008	719
Takla-Trembleur-Estu	Paula Creek	2008	1242
Takla-Trembleur-Estu	Point Creek	2008	155
Takla-Trembleur-Estu	Porter Creek	2008	293
Takla-Trembleur-Estu	Rossette Creek	2008	2467
Takla-Trembleur-Estu	Sakeniche River	2008	76
Takla-Trembleur-Estu	Sandpoint Creek	2008	337
Takla-Trembleur-Estu	Shale Creek	2008	76
Takla-Trembleur-Estu	Sinta Creek	2008	0
Takla-Trembleur-Estu	Sowchea Creek	2008	32
Takla-Trembleur-Estu	Takla Lake - shore	2008	59
Takla-Trembleur-Estu	Tildesley Creek	2008	151
Takla-Trembleur-Estu	15 Mile Creek	2009	123
Takla-Trembleur-Estu	25 Mile Creek	2009	0
Takla-Trembleur-Estu	5 Mile Creek	2009	35
Takla-Trembleur-Estu	Ankwill Creek	2009	1579
Takla-Trembleur-Estu	Bivouac Creek	2009	1384
Takla-Trembleur-Estu	Blackwater Creek	2009	6
Takla-Trembleur-Estu	Blanchette Creek	2009	0
Takla-Trembleur-Estu	Crow Creek	2009	549
Takla-Trembleur-Estu	Driftwood River	2009	6531
Takla-Trembleur-Estu	Dust Creek	2009	2318
Takla-Trembleur-Estu	Felix Creek	2009	7230
Takla-Trembleur-Estu	Fleming Creek	2009	422
Takla-Trembleur-Estu	Forfar Creek	2009	3570
Takla-Trembleur-Estu	Forsythe Creek	2009	702
Takla-Trembleur-Estu	Frypan Creek	2009	1846
Takla-Trembleur-Estu	Gluske Creek	2009	2130
Takla-Trembleur-Estu	Hooker Creek	2009	144
Takla-Trembleur-Estu	Hudson Bay Creek	2009	38
Takla-Trembleur-Estu	Kazchek Creek	2009	34
Takla-Trembleur-Estu	Kotsine Creek	2009	187
Takla-Trembleur-Estu	Kynock Creek	2009	4438
Takla-Trembleur-Estu	Leo Creek	2009	531
Takla-Trembleur-Estu	Lion Creek	2009	301
Takla-Trembleur-Estu	McDougall Creek	2009	69
Takla-Trembleur-Estu	Middle River	2009	0
Takla-Trembleur-Estu	Narrows Creek	2009	2491
Takla-Trembleur-Estu	Paula Creek	2009	2896
Takla-Trembleur-Estu	Point Creek	2009	320
Takla-Trembleur-Estu	Porter Creek	2009	1267
Takla-Trembleur-Estu	Rossette Creek	2009	1829
Takla-Trembleur-Estu	Sakeniche River	2009	530
Takla-Trembleur-Estu	Sandpoint Creek	2009	1078
Takla-Trembleur-Estu	Shale Creek	2009	435
Takla-Trembleur-Estu	Sinta Creek	2009	246
Takla-Trembleur-Estu	Sowchea Creek	2009	6
Takla-Trembleur-Estu	Takla Lake - shore	2009	0
Takla-Trembleur-Estu	Tildesley Creek	2009	32
Takla-Trembleur-Estu	15 Mile Creek	2010	241
Takla-Trembleur-Estu	25 Mile Creek	2010	243
Takla-Trembleur-Estu	5 Mile Creek	2010	0

CU	Spawning site	Year	Total
Takla-Trembleur-Estu	Ankwill Creek	2010	3600
Takla-Trembleur-Estu	Bivouac Creek	2010	54
Takla-Trembleur-Estu	Blackwater Creek	2010	45
Takla-Trembleur-Estu	Blanchette Creek	2010	16
Takla-Trembleur-Estu	Crow Creek	2010	103
Takla-Trembleur-Estu	Driftwood River	2010	19834
Takla-Trembleur-Estu	Dust Creek	2010	682
Takla-Trembleur-Estu	Felix Creek	2010	5541
Takla-Trembleur-Estu	Fleming Creek	2010	130
Takla-Trembleur-Estu	Forfar Creek	2010	3692
Takla-Trembleur-Estu	Forsythe Creek	2010	828
Takla-Trembleur-Estu	Frypan Creek	2010	1933
Takla-Trembleur-Estu	Gluske Creek	2010	0
Takla-Trembleur-Estu	Hooker Creek	2010	43
Takla-Trembleur-Estu	Hudson Bay Creek	2010	124
Takla-Trembleur-Estu	Kazchek Creek	2010	85
Takla-Trembleur-Estu	Kotsine Creek	2010	3285
Takla-Trembleur-Estu	Kynock Creek	2010	10055
Takla-Trembleur-Estu	Leo Creek	2010	0
Takla-Trembleur-Estu	Lion Creek	2010	4
Takla-Trembleur-Estu	McDougall Creek	2010	0
Takla-Trembleur-Estu	Middle River	2010	0
Takla-Trembleur-Estu	Narrows Creek	2010	2255
Takla-Trembleur-Estu	Paula Creek	2010	776
Takla-Trembleur-Estu	Point Creek	2010	346
Takla-Trembleur-Estu	Porter Creek	2010	2615
Takla-Trembleur-Estu	Rossette Creek	2010	3139
Takla-Trembleur-Estu	Sakeniche River	2010	184
Takla-Trembleur-Estu	Sandpoint Creek	2010	0
Takla-Trembleur-Estu	Shale Creek	2010	373
Takla-Trembleur-Estu	Sinta Creek	2010	36
Takla-Trembleur-Estu	Sowchea Creek	2010	0
Takla-Trembleur-Estu	Takla Lake - shore	2010	0
Takla-Trembleur-Estu	Tildesley Creek	2010	0
Takla-Trembleur-Estu	15 Mile Creek	2011	2
Takla-Trembleur-Estu	25 Mile Creek	2011	0
Takla-Trembleur-Estu	5 Mile Creek	2011	0
Takla-Trembleur-Estu	Ankwill Creek	2011	0
Takla-Trembleur-Estu	Bivouac Creek	2011	0
Takla-Trembleur-Estu	Blackwater Creek	2011	0
Takla-Trembleur-Estu	Blanchette Creek	2011	0
Takla-Trembleur-Estu	Crow Creek	2011	0
Takla-Trembleur-Estu	Driftwood River	2011	12
Takla-Trembleur-Estu	Dust Creek	2011	117
Takla-Trembleur-Estu	Felix Creek	2011	51
Takla-Trembleur-Estu	Fleming Creek	2011	0
Takla-Trembleur-Estu	Forfar Creek	2011	128
Takla-Trembleur-Estu	Forsythe Creek	2011	0
Takla-Trembleur-Estu	Frypan Creek	2011	7
Takla-Trembleur-Estu	Gluske Creek	2011	32
Takla-Trembleur-Estu	Hooker Creek	2011	0
Takla-Trembleur-Estu	Hudson Bay Creek	2011	0
Takla-Trembleur-Estu	Kazchek Creek	2011	0
Takla-Trembleur-Estu	Kotsine Creek	2011	0
Takla-Trembleur-Estu	Kynock Creek	2011	171
Takla-Trembleur-Estu	Leo Creek	2011	0

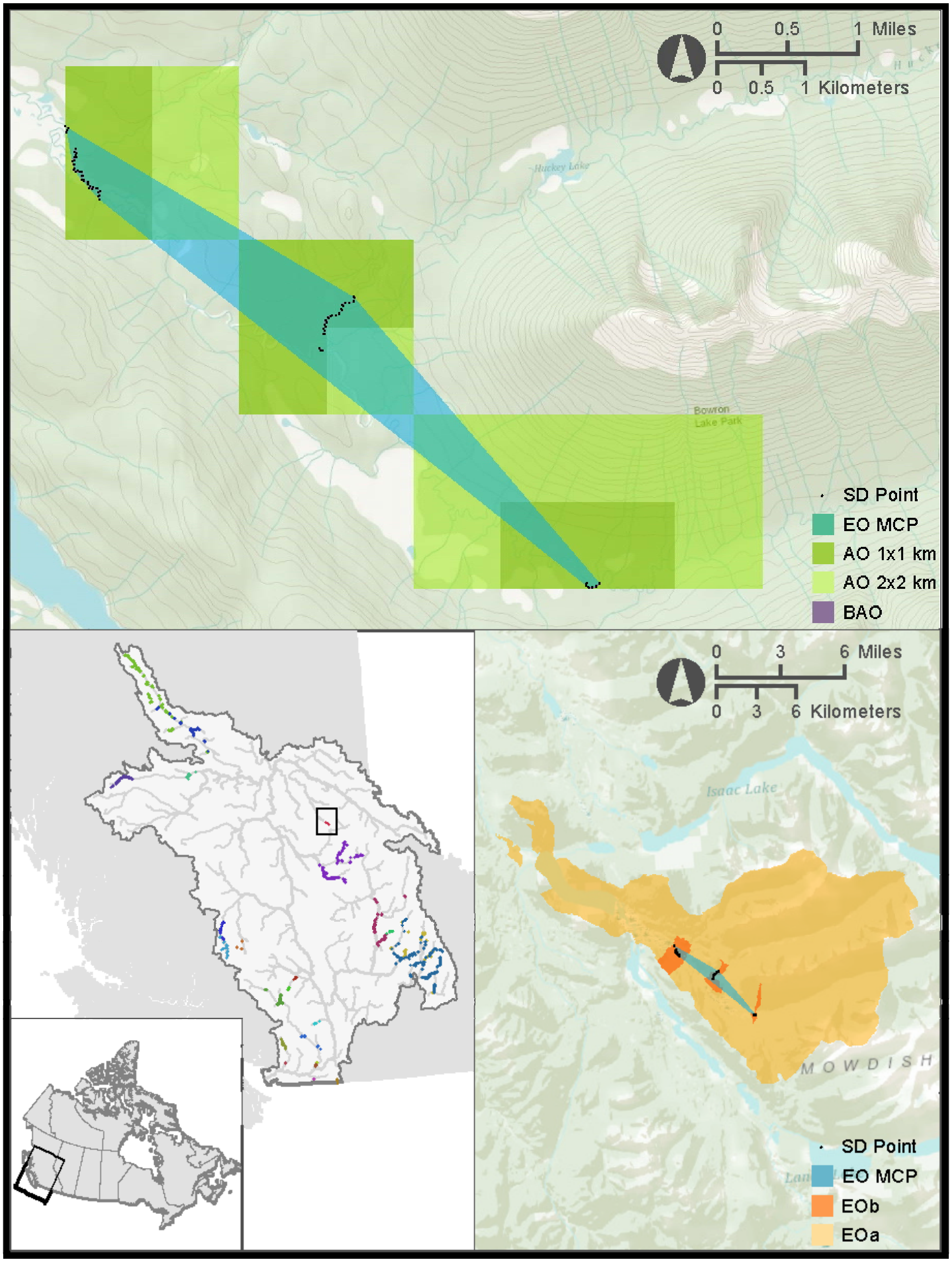
CU	Spawning site	Year	Total
Takla-Trembleur-Estu	Lion Creek	2011	0
Takla-Trembleur-Estu	McDougall Creek	2011	0
Takla-Trembleur-Estu	Middle River	2011	0
Takla-Trembleur-Estu	Narrows Creek	2011	69
Takla-Trembleur-Estu	Paula Creek	2011	48
Takla-Trembleur-Estu	Point Creek	2011	0
Takla-Trembleur-Estu	Porter Creek	2011	0
Takla-Trembleur-Estu	Rossette Creek	2011	114
Takla-Trembleur-Estu	Sakeniche River	2011	0
Takla-Trembleur-Estu	Sandpoint Creek	2011	0
Takla-Trembleur-Estu	Shale Creek	2011	0
Takla-Trembleur-Estu	Sinta Creek	2011	0
Takla-Trembleur-Estu	Sowchea Creek	2011	0
Takla-Trembleur-Estu	Takla Lake - shore	2011	0
Takla-Trembleur-Estu	Tildesley Creek	2011	0
Takla-Trembleur-Stuart-S	Kazchek Creek	2008	194
Takla-Trembleur-Stuart-S	Kuzkwa Creek	2008	7268
Takla-Trembleur-Stuart-S	Middle River	2008	5616
Takla-Trembleur-Stuart-S	Pinchi Creek	2008	10566
Takla-Trembleur-Stuart-S	Sakeniche River	2008	0
Takla-Trembleur-Stuart-S	Sowchea Creek	2008	0
Takla-Trembleur-Stuart-S	Tachie River	2008	123014
Takla-Trembleur-Stuart-S	Kazchek Creek	2009	1271
Takla-Trembleur-Stuart-S	Kuzkwa Creek	2009	4109
Takla-Trembleur-Stuart-S	Middle River	2009	28831
Takla-Trembleur-Stuart-S	Pinchi Creek	2009	5276
Takla-Trembleur-Stuart-S	Sakeniche River	2009	58
Takla-Trembleur-Stuart-S	Sowchea Creek	2009	4
Takla-Trembleur-Stuart-S	Tachie River	2009	47452
Takla-Trembleur-Stuart-S	Kazchek Creek	2010	32
Takla-Trembleur-Stuart-S	Kuzkwa Creek	2010	3610
Takla-Trembleur-Stuart-S	Middle River	2010	13340
Takla-Trembleur-Stuart-S	Pinchi Creek	2010	365
Takla-Trembleur-Stuart-S	Sakeniche River	2010	0
Takla-Trembleur-Stuart-S	Sowchea Creek	2010	7
Takla-Trembleur-Stuart-S	Tachie River	2010	57935
Takla-Trembleur-Stuart-S	Kazchek Creek	2011	16
Takla-Trembleur-Stuart-S	Kuzkwa Creek	2011	616
Takla-Trembleur-Stuart-S	Middle River	2011	603
Takla-Trembleur-Stuart-S	Pinchi Creek	2011	338
Takla-Trembleur-Stuart-S	Sakeniche River	2011	0
Takla-Trembleur-Stuart-S	Sowchea Creek	2011	0
Takla-Trembleur-Stuart-S	Tachie River	2011	2457
Taseko-ES	Taseko Lake	2008	60
Taseko-ES	Taseko Lake	2009	40
Taseko-ES	Taseko Lake	2010	673
Taseko-ES	Yoheta Creek, lower	2010	302
Taseko-ES	Yoheta Creek, upper	2010	142
Taseko-ES	Taseko Lake	2011	960
Taseko-ES	Yoheta Creek, upper	2011	4
Widgeon (River-Type)	Widgeon Slough	2008	85
Widgeon (River-Type)	Widgeon Slough	2009	1559
Widgeon (River-Type)	Widgeon Slough	2010	1015

APPENDIX 4

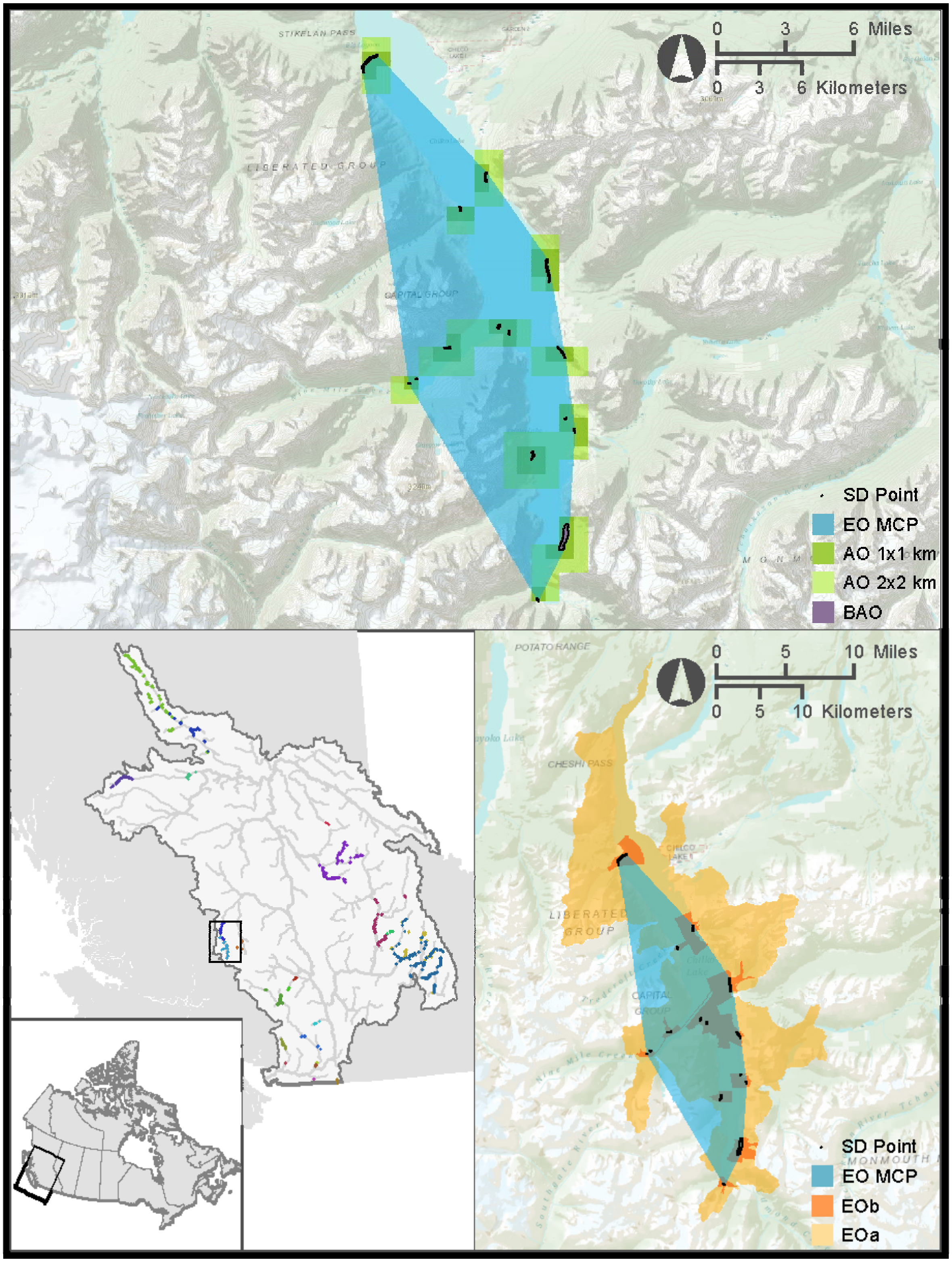
Maps of each CU showing EO, AO, BAO, EOa and EOb estimated based on spawning area. CU location is also shown.



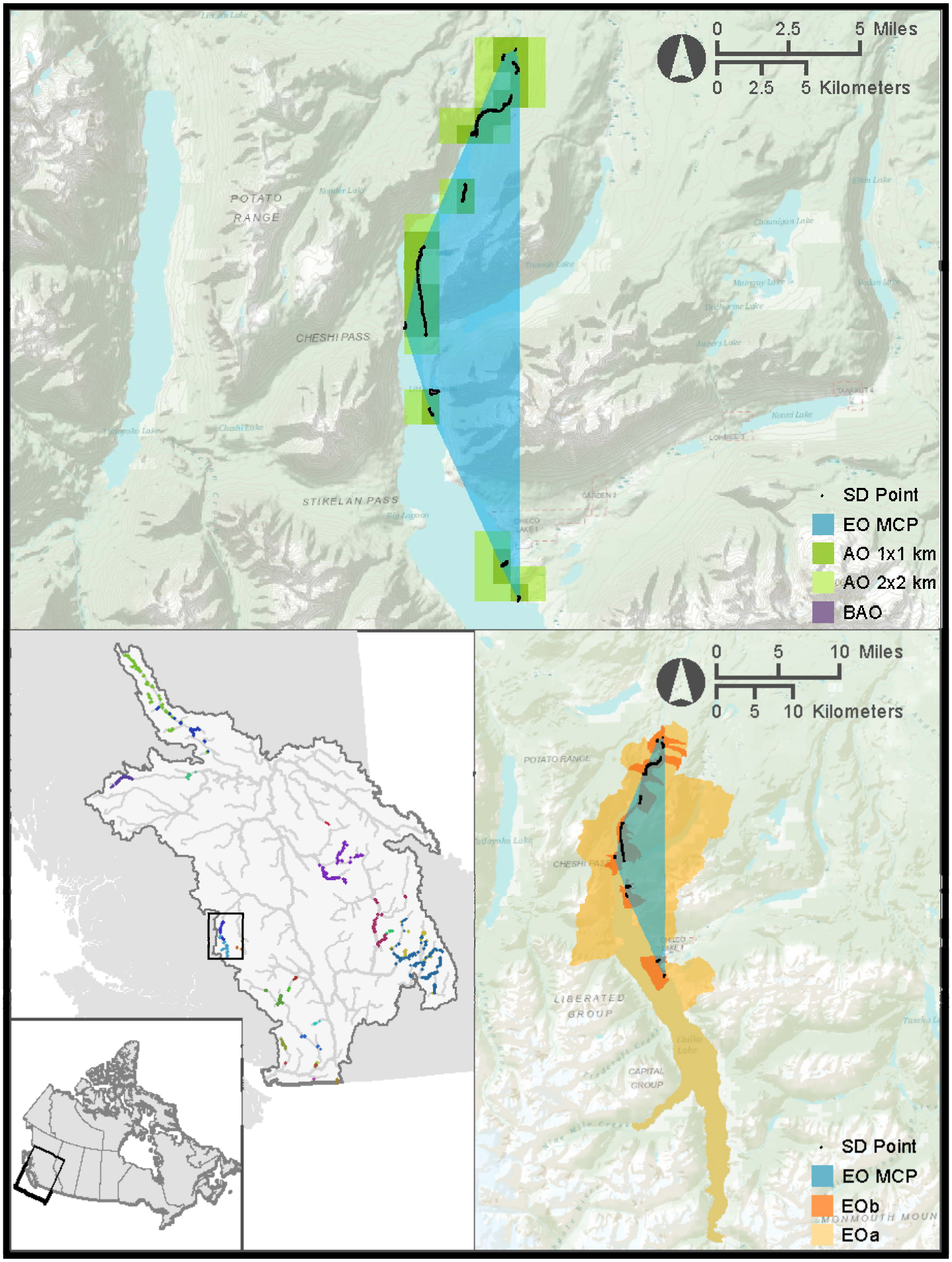
Map 1. *Anderson-Seton-ES*.



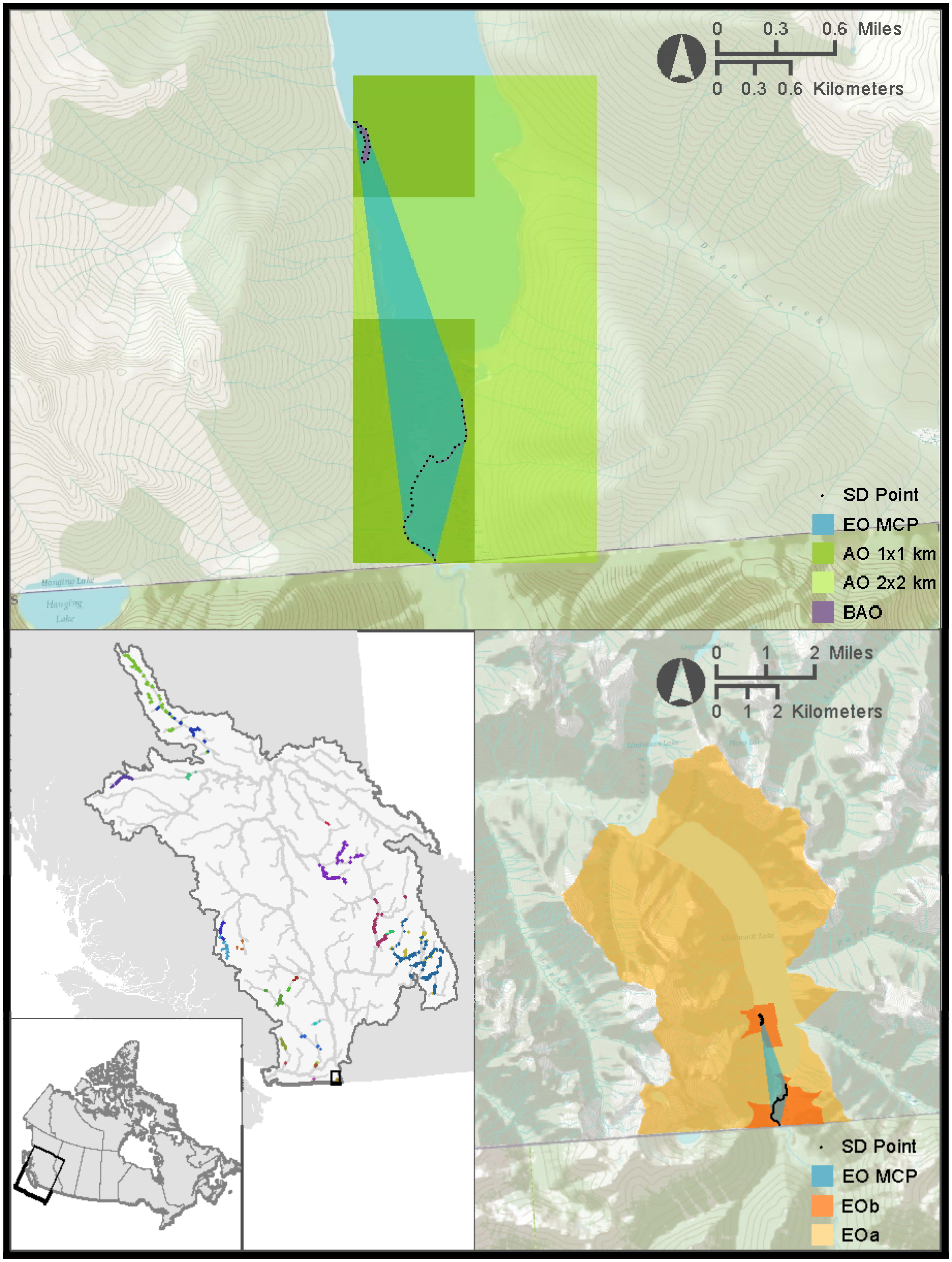
Map 2. *Bowron-ES.*



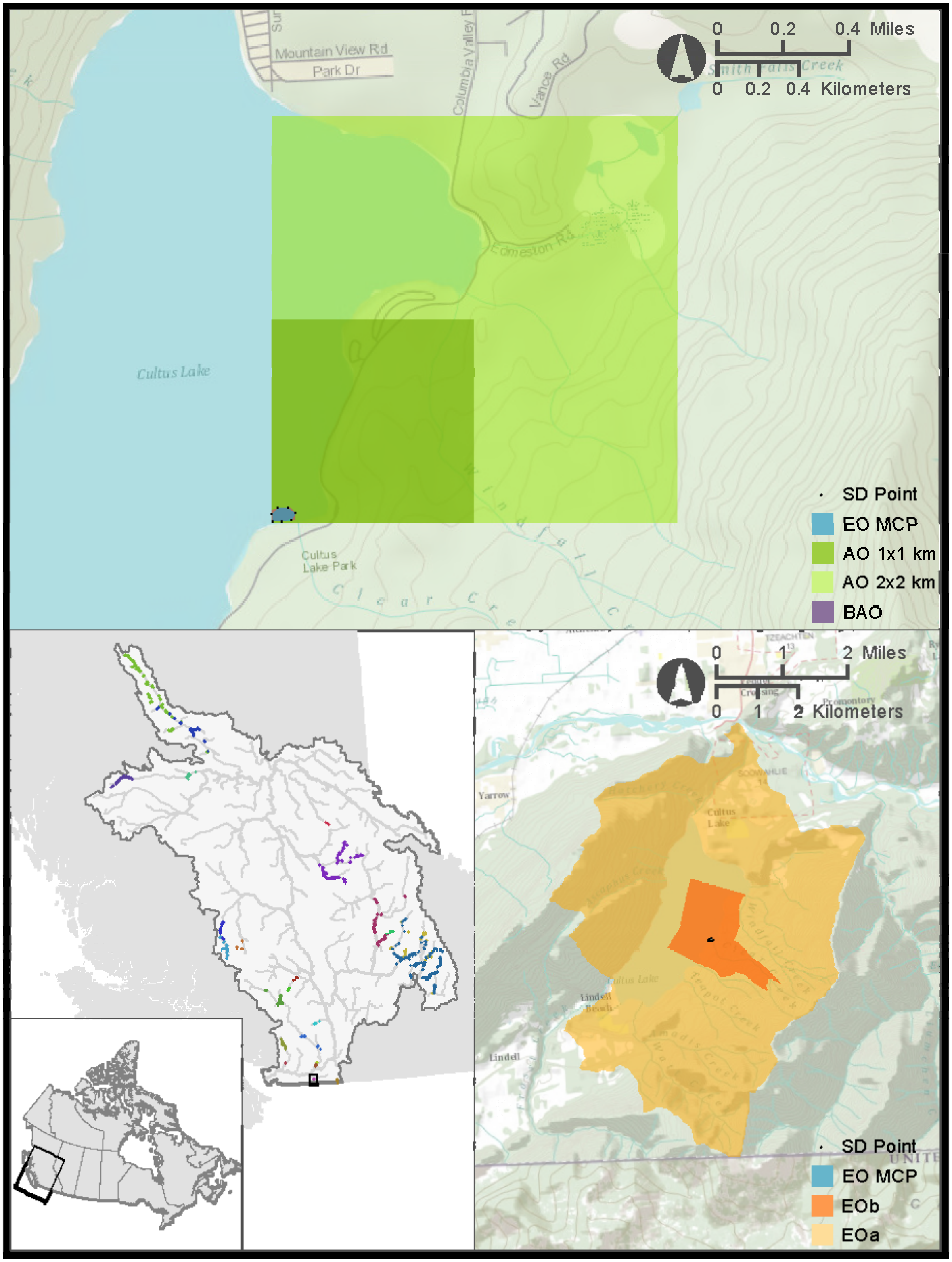
Map 3. *Chilko-ES.*



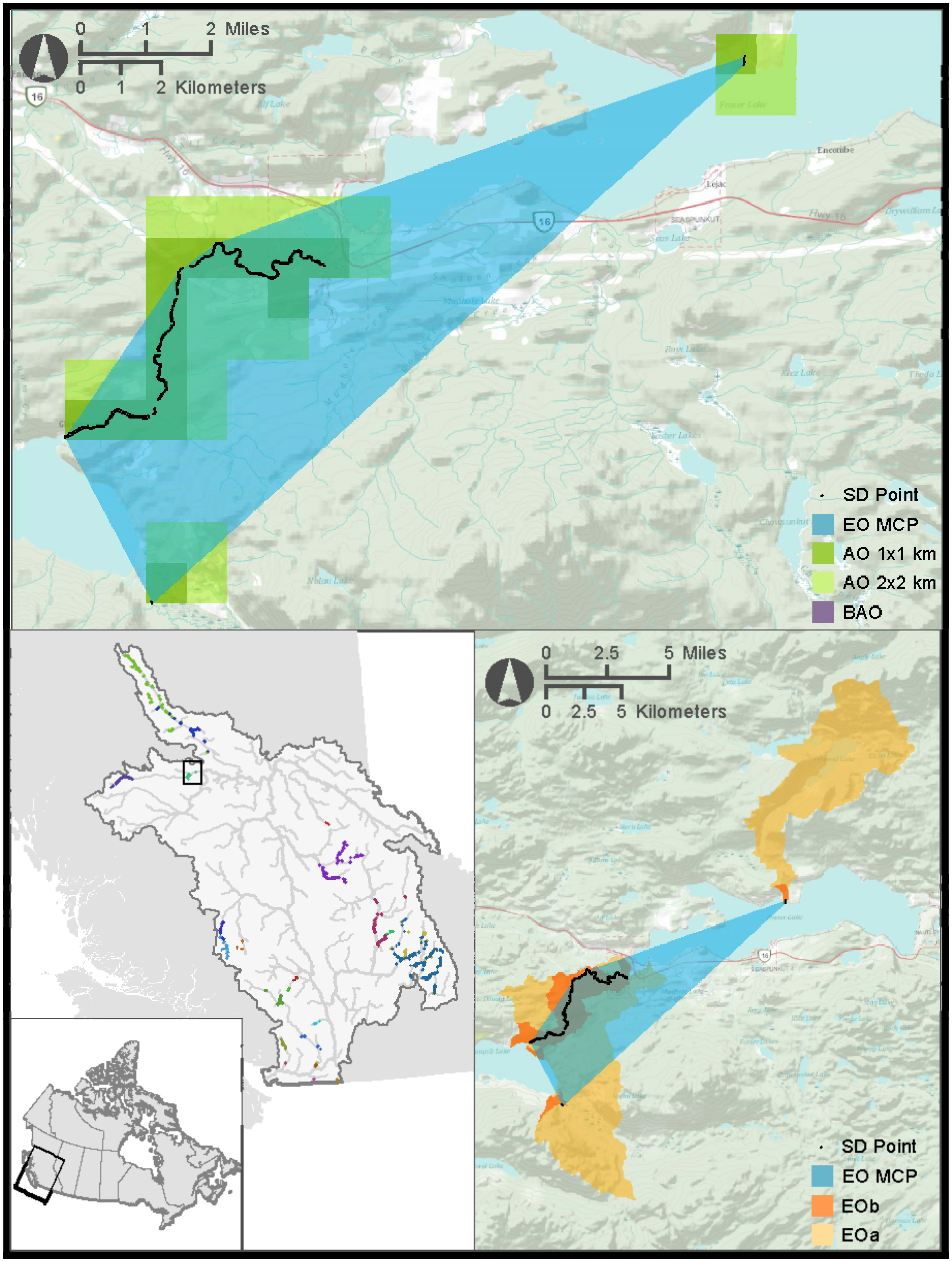
Map 4. *Chilko-S.*



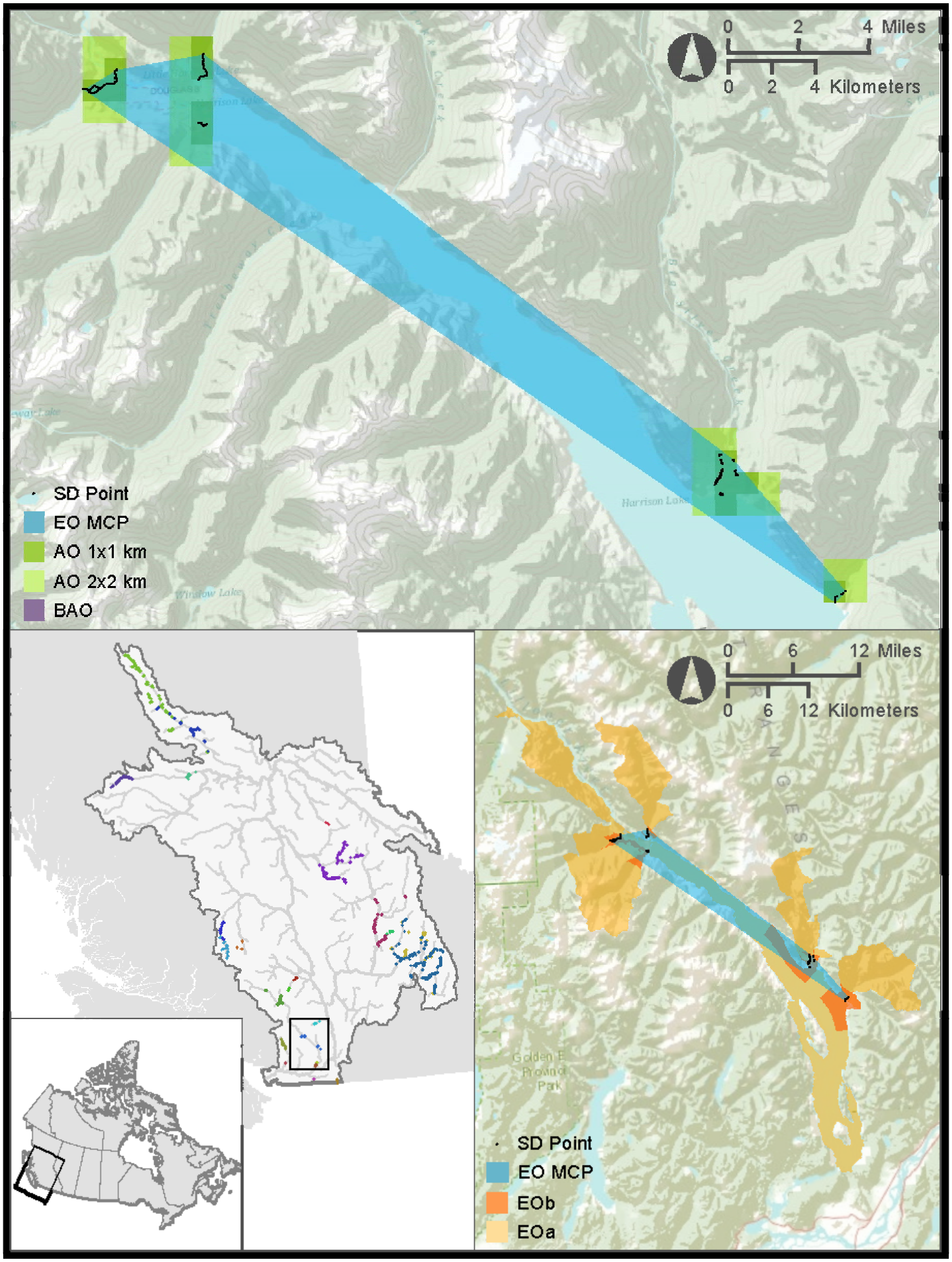
Map 5. *Chilliwack-ES.*



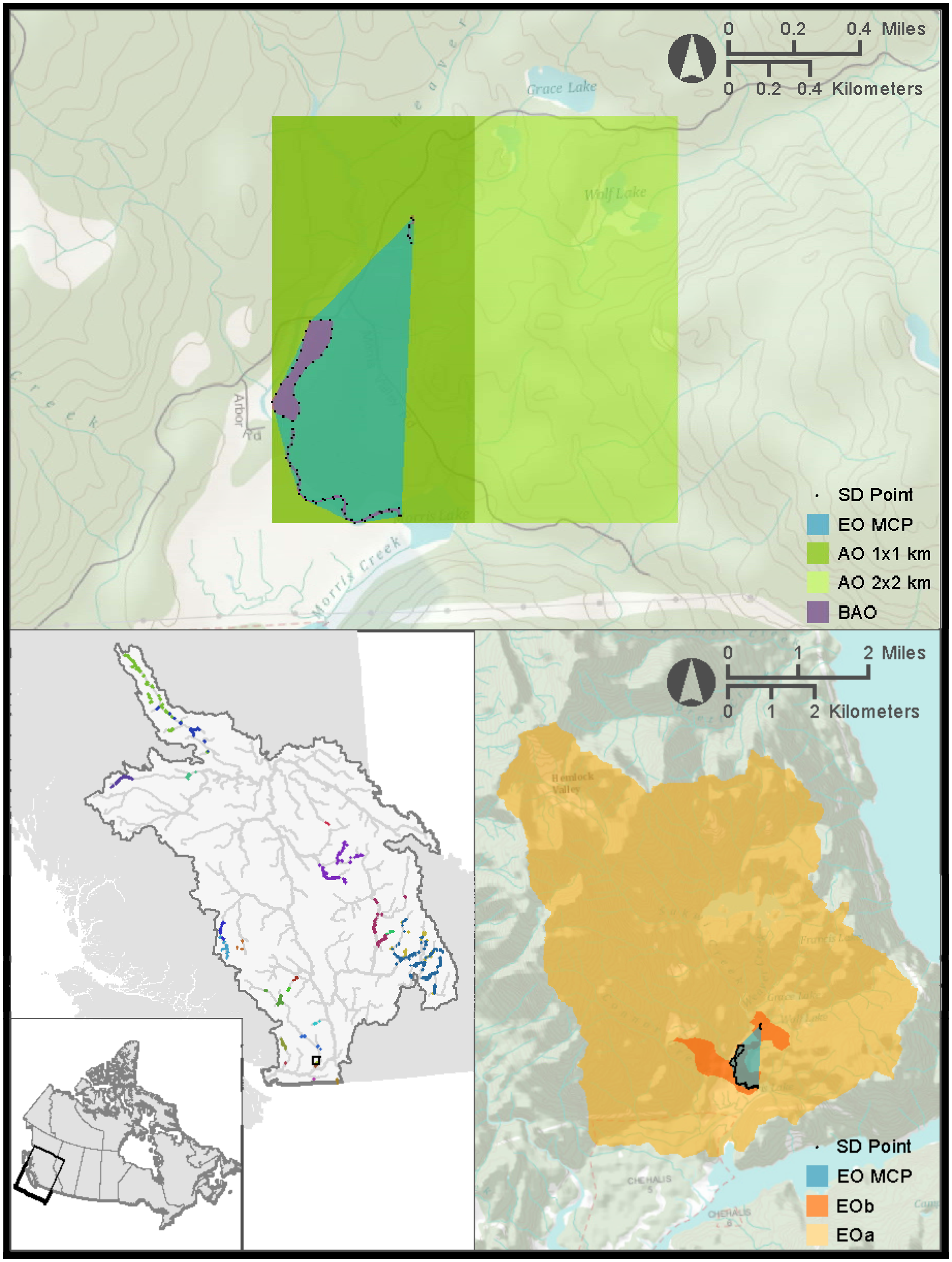
Map 6. *Cultus-L.*



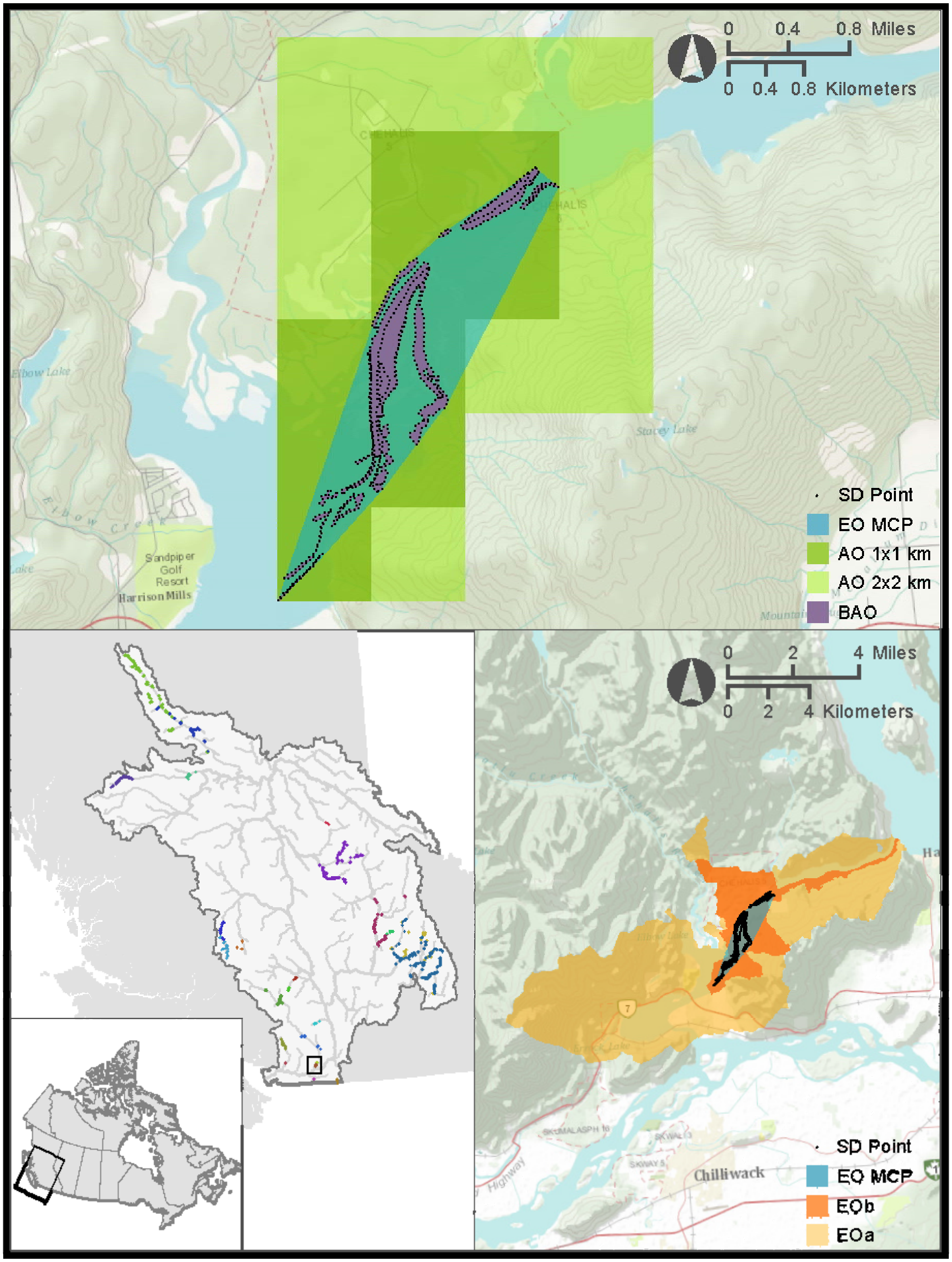
Map 7. *Francois-Fraser-S.*



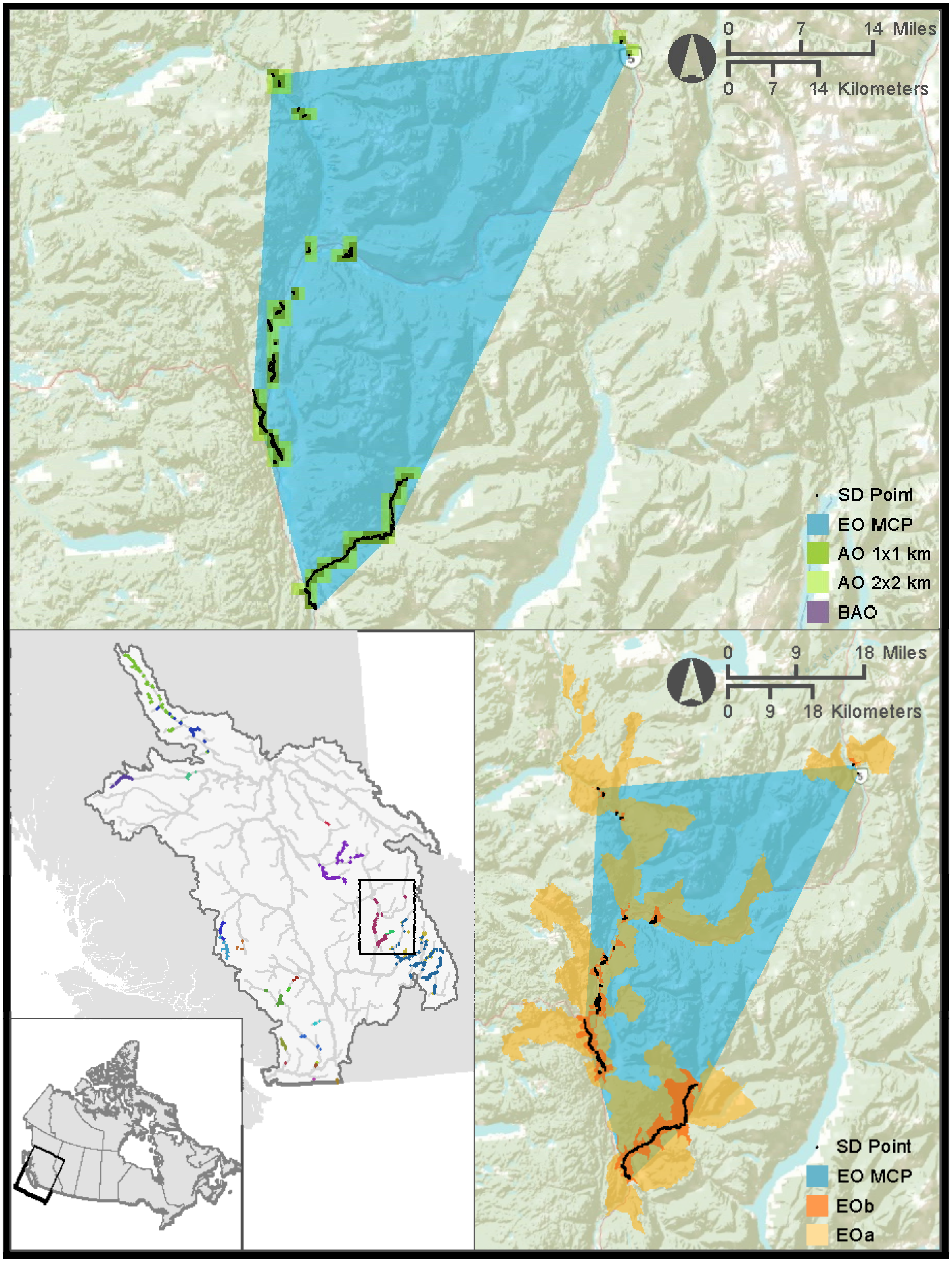
Map 8. *Harrison-(D/S)-L.*



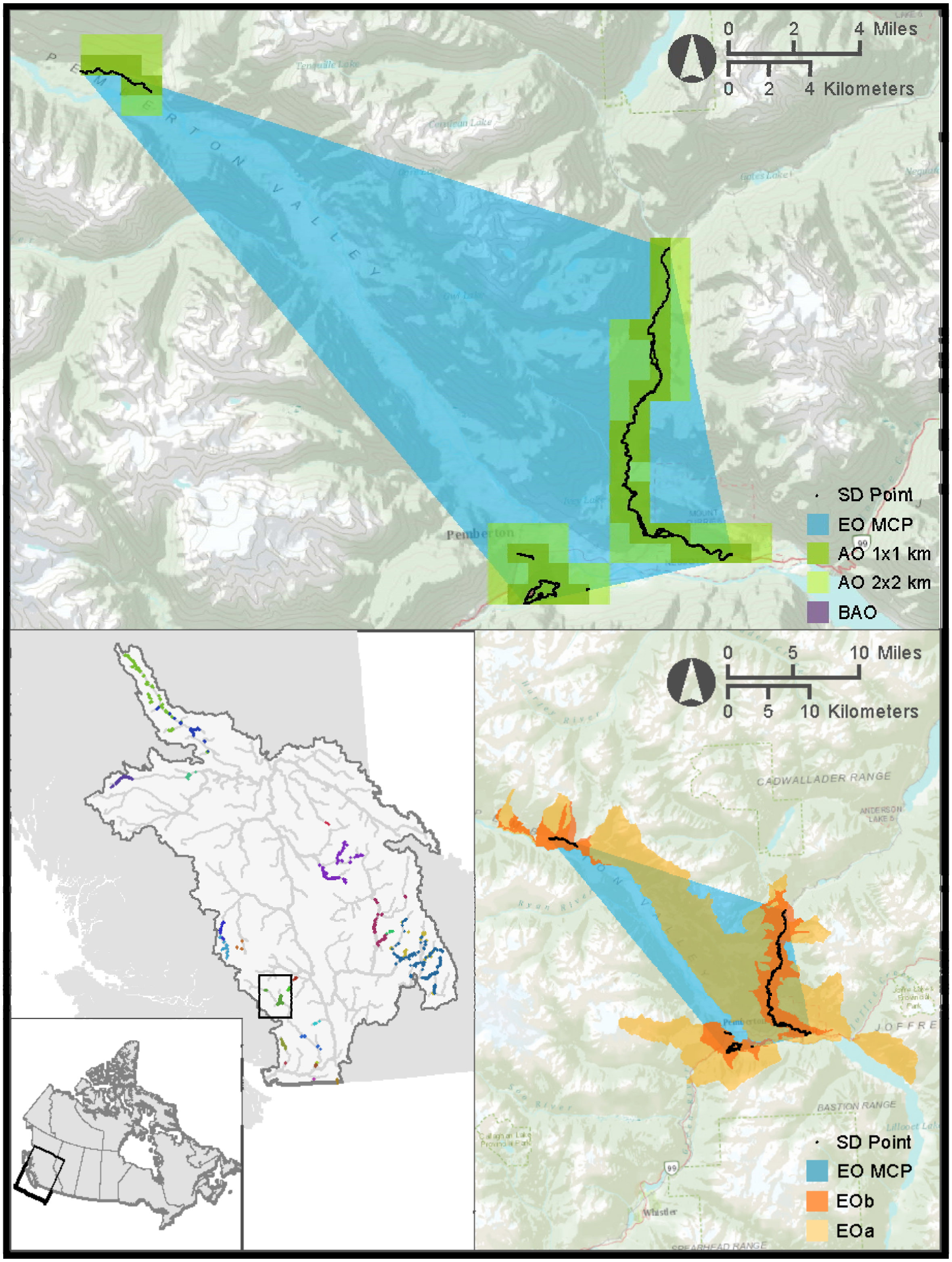
Map 9. *Harrison-(U/S)-L.*



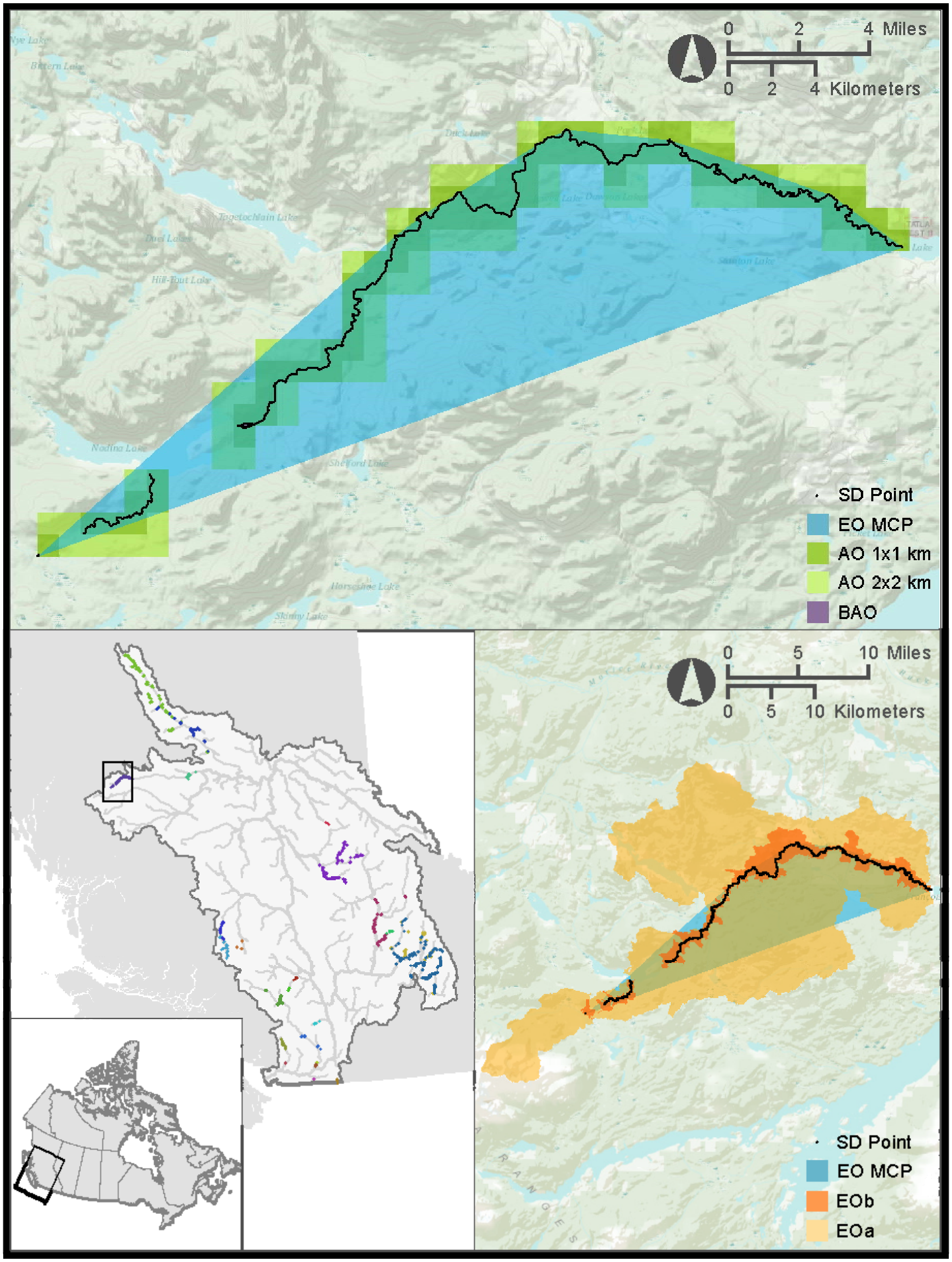
Map 10. Harrison River – River Type.



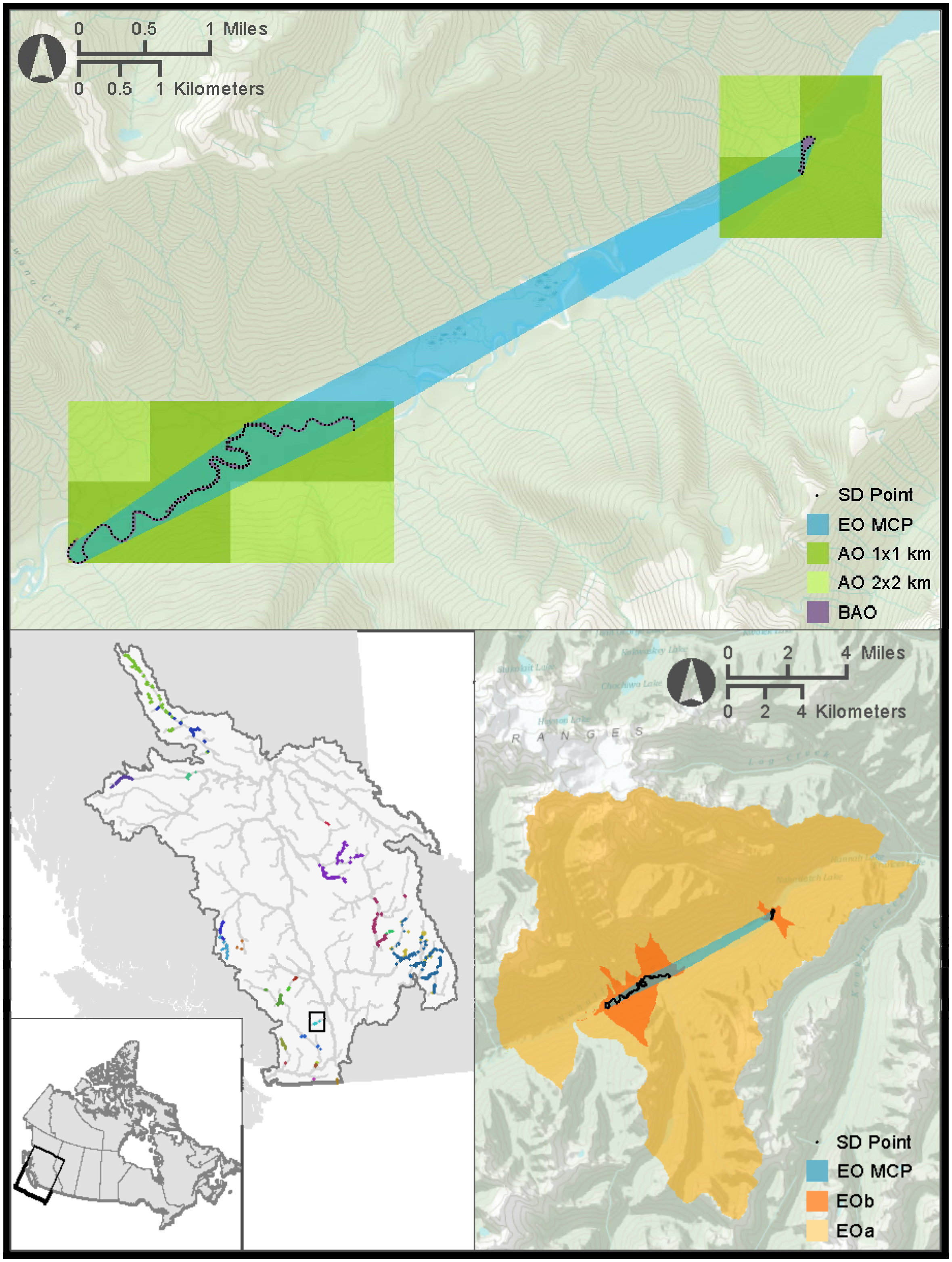
Map 11. *Kamloops-ES.*



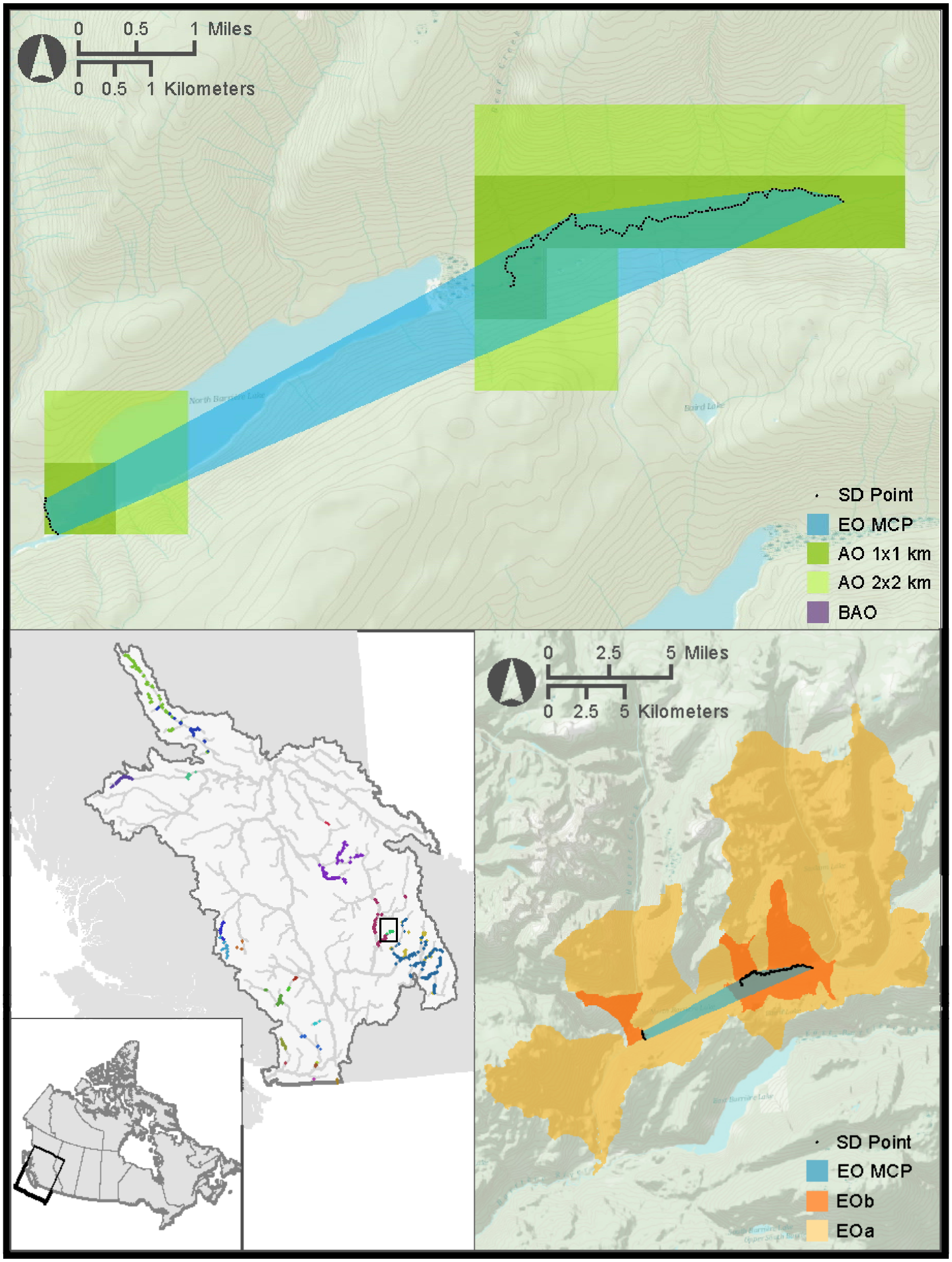
Map 12. *Lillooet-Harrison-L.*



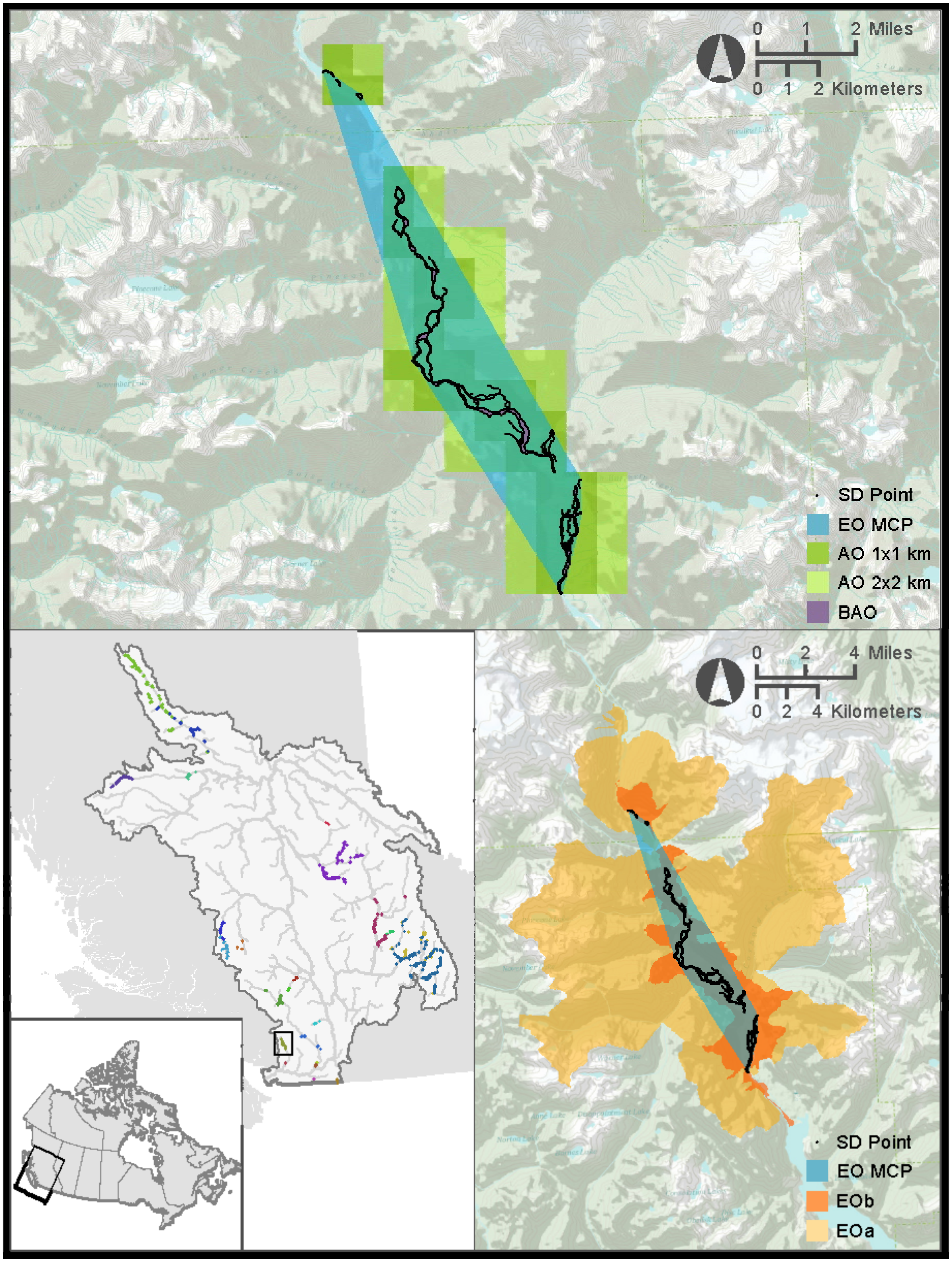
Map 13. *Nadina-Francois-ES.*



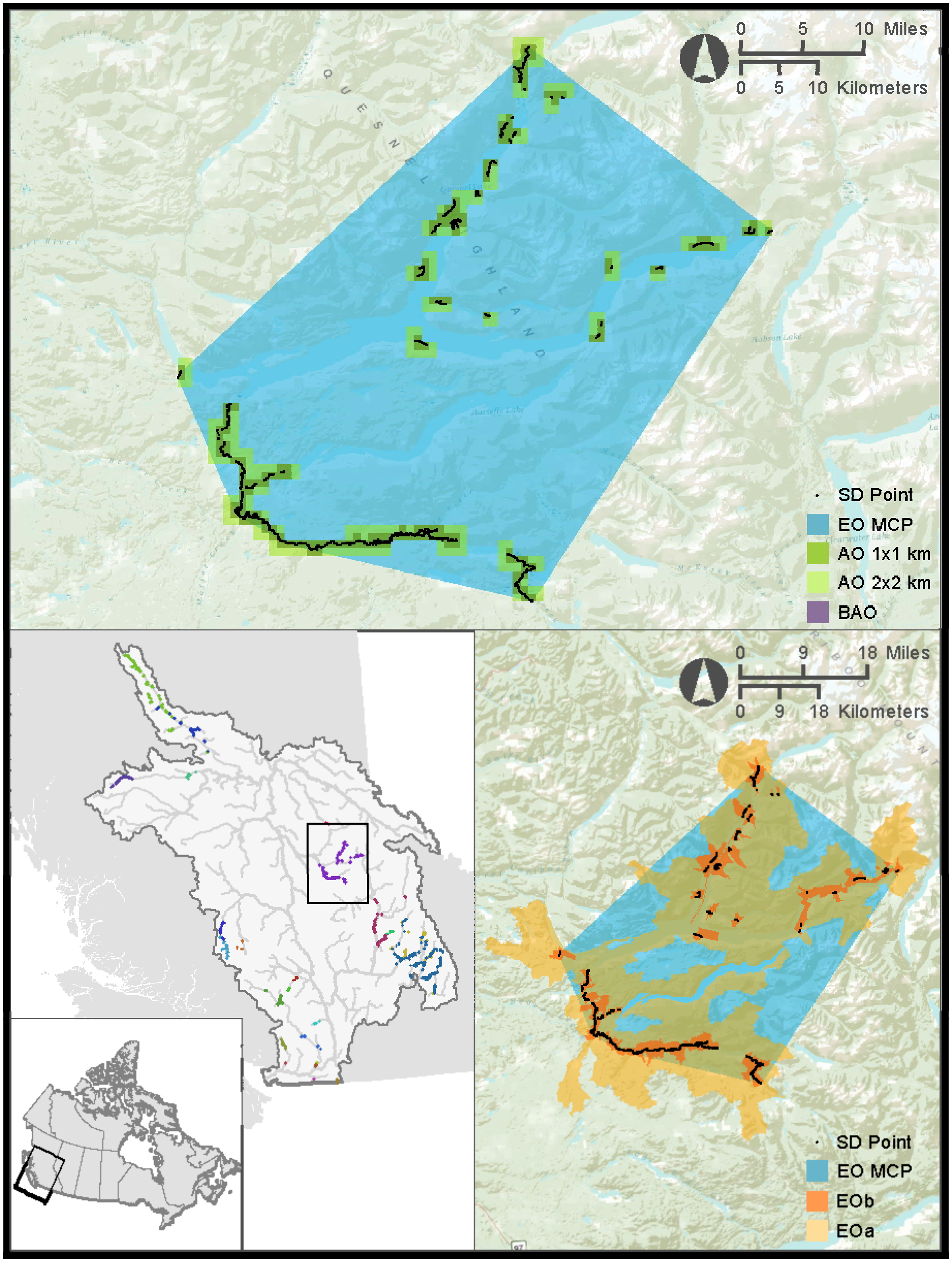
Map 14. *Nahatlatch-ES.*



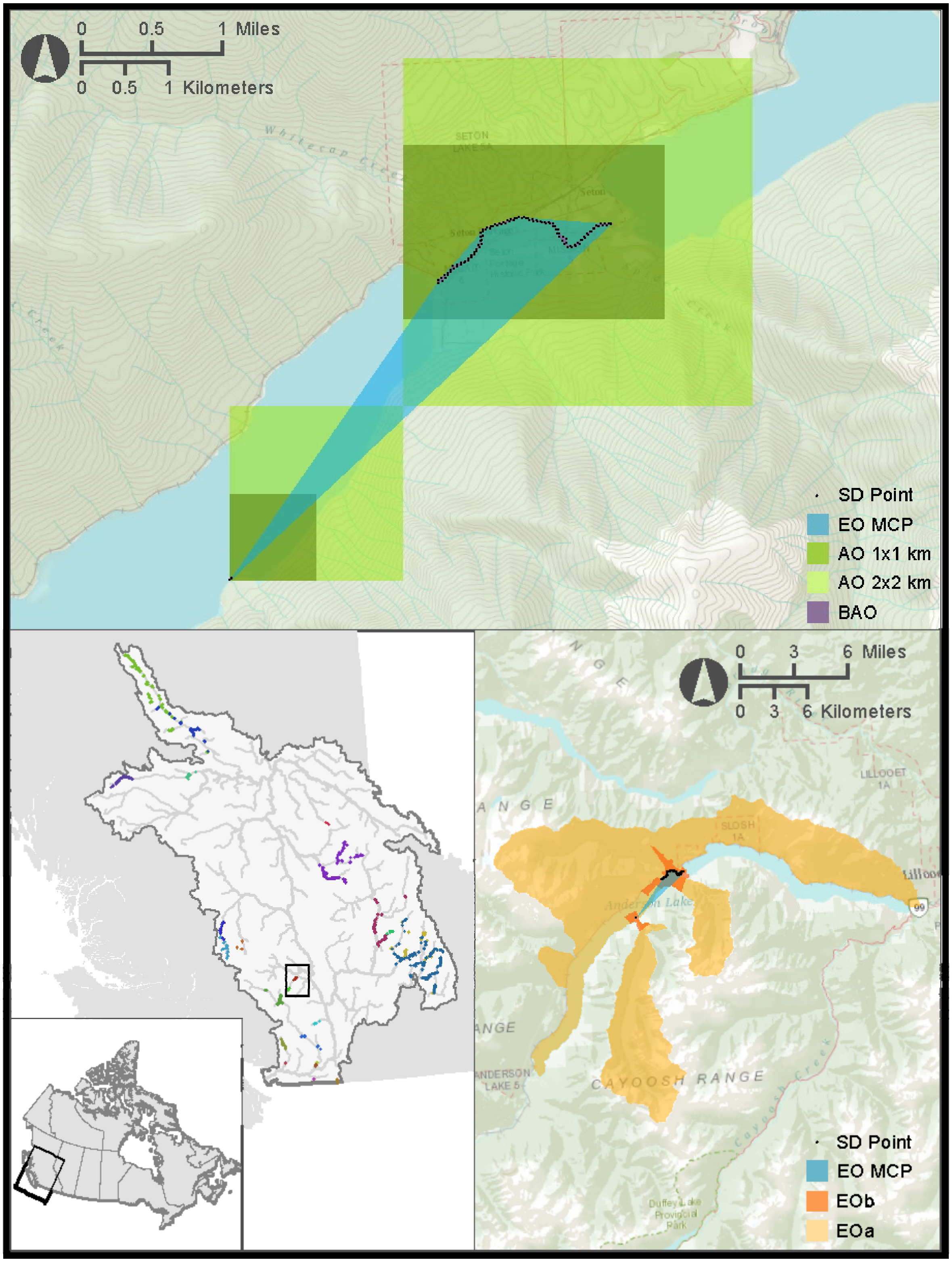
Map 15. *North Barriere-ES.*



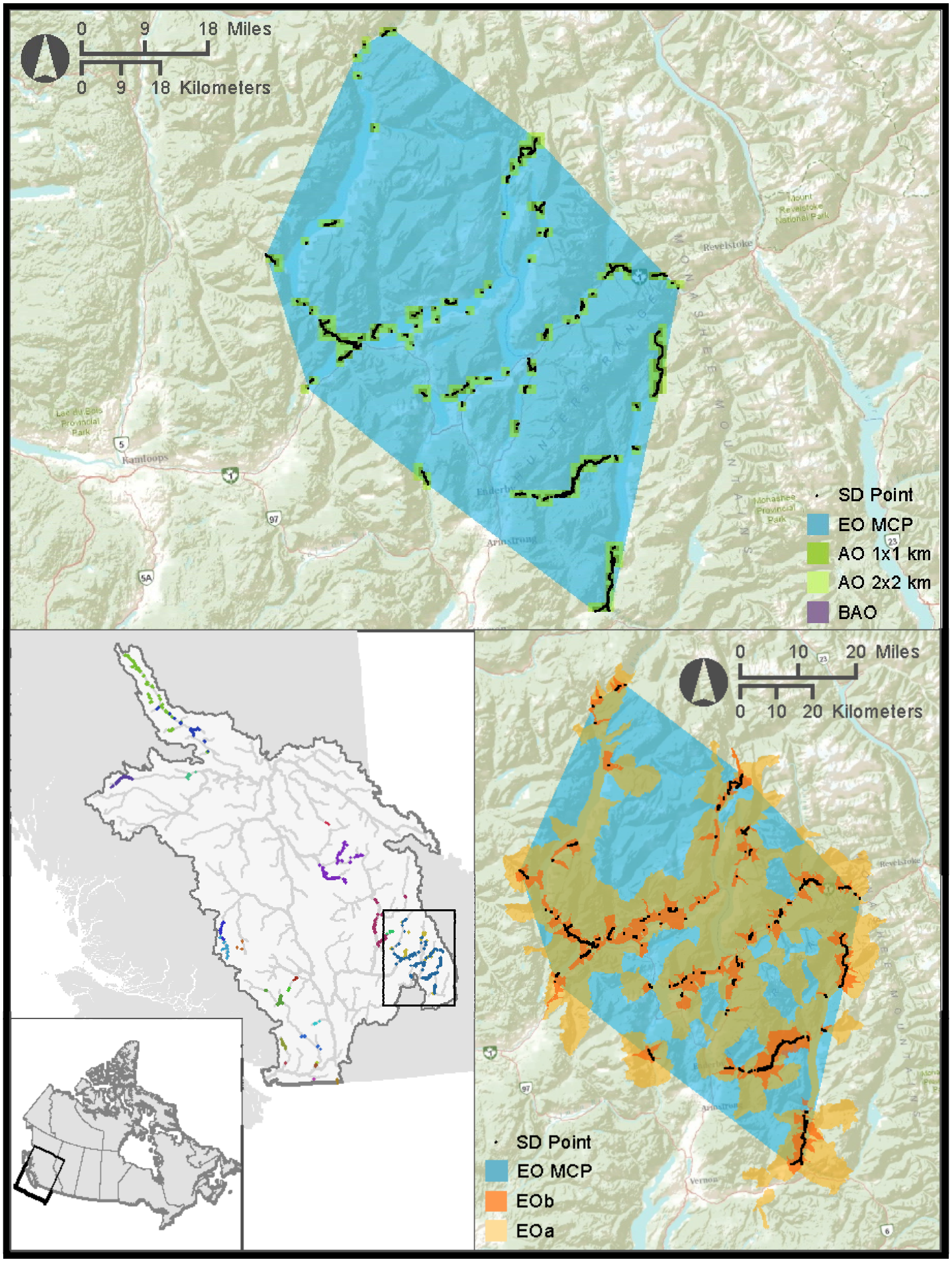
Map 16. *Pitt-ES.*



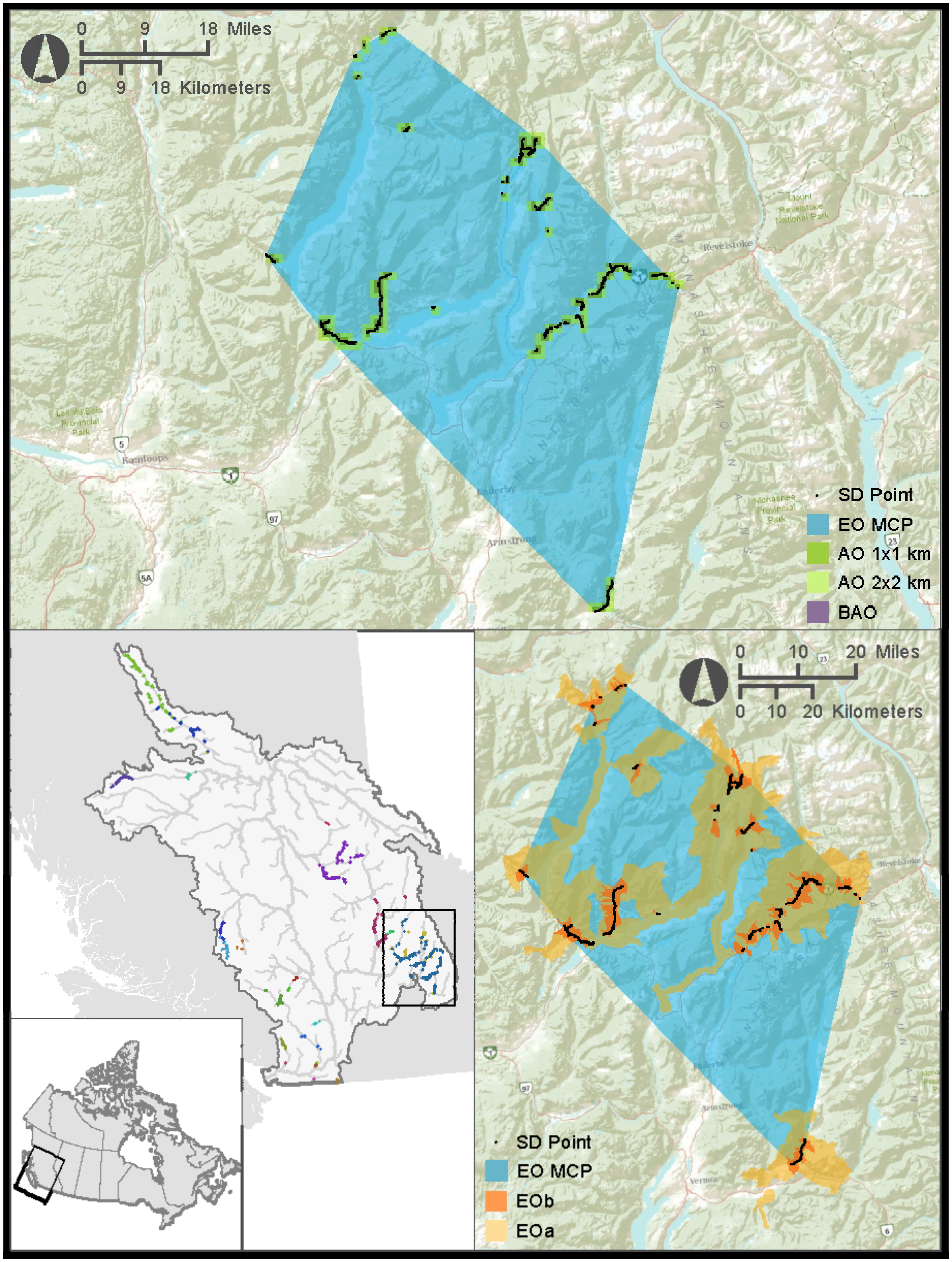
Map 17. *Quesnel-S.*



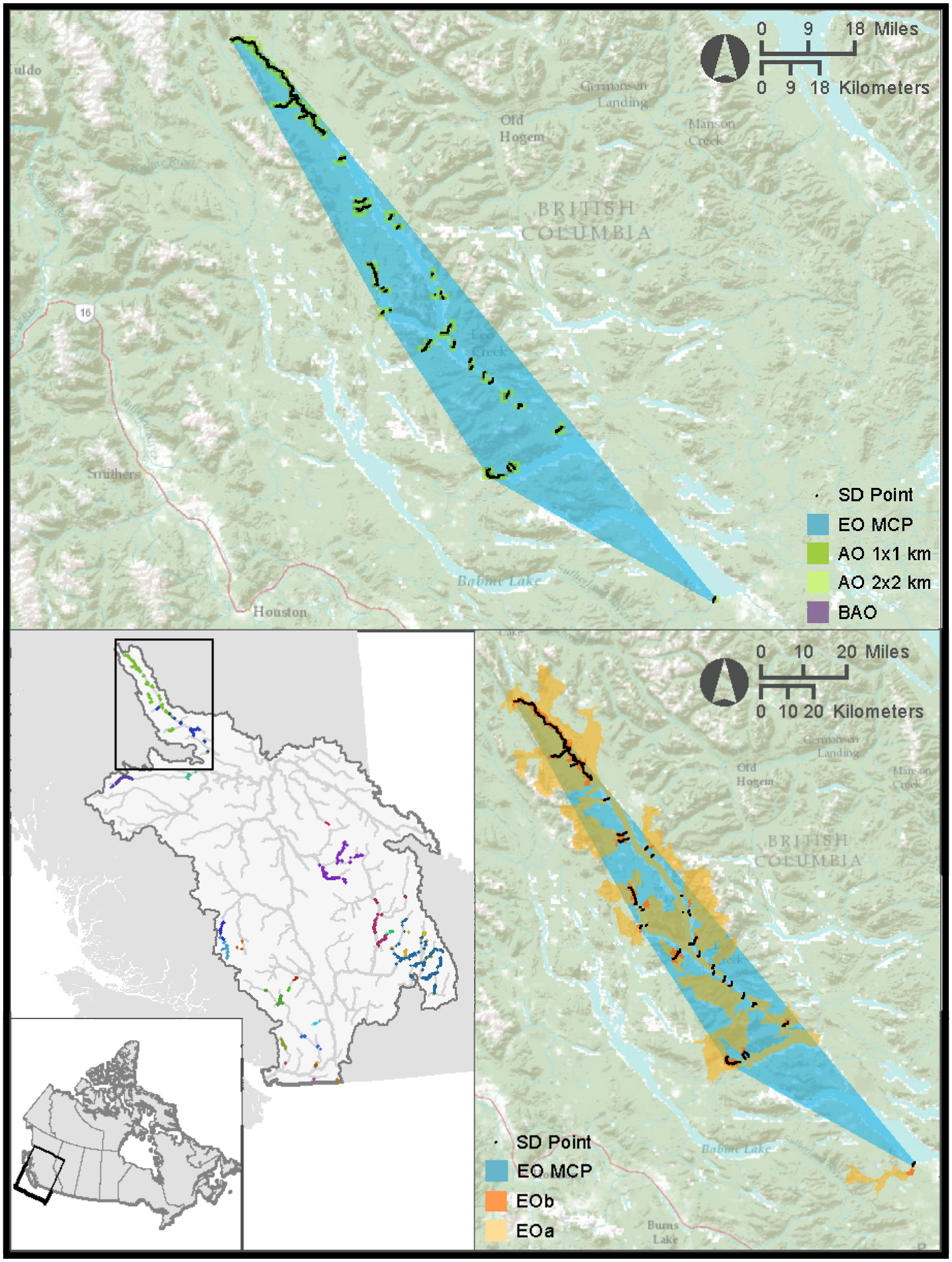
Map 18. *Seton-L.*



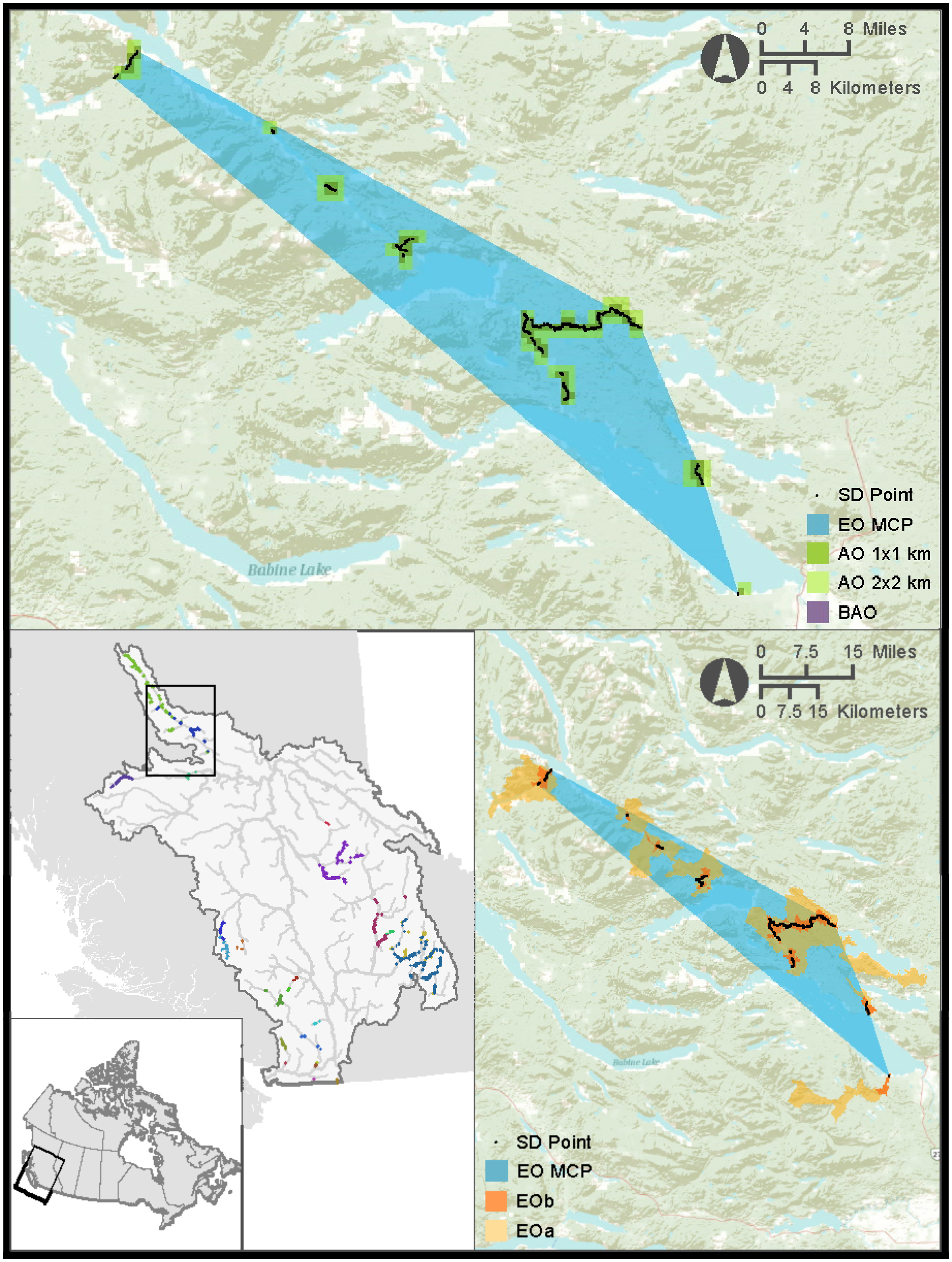
Map 19. *Shuswap Complex-L.*



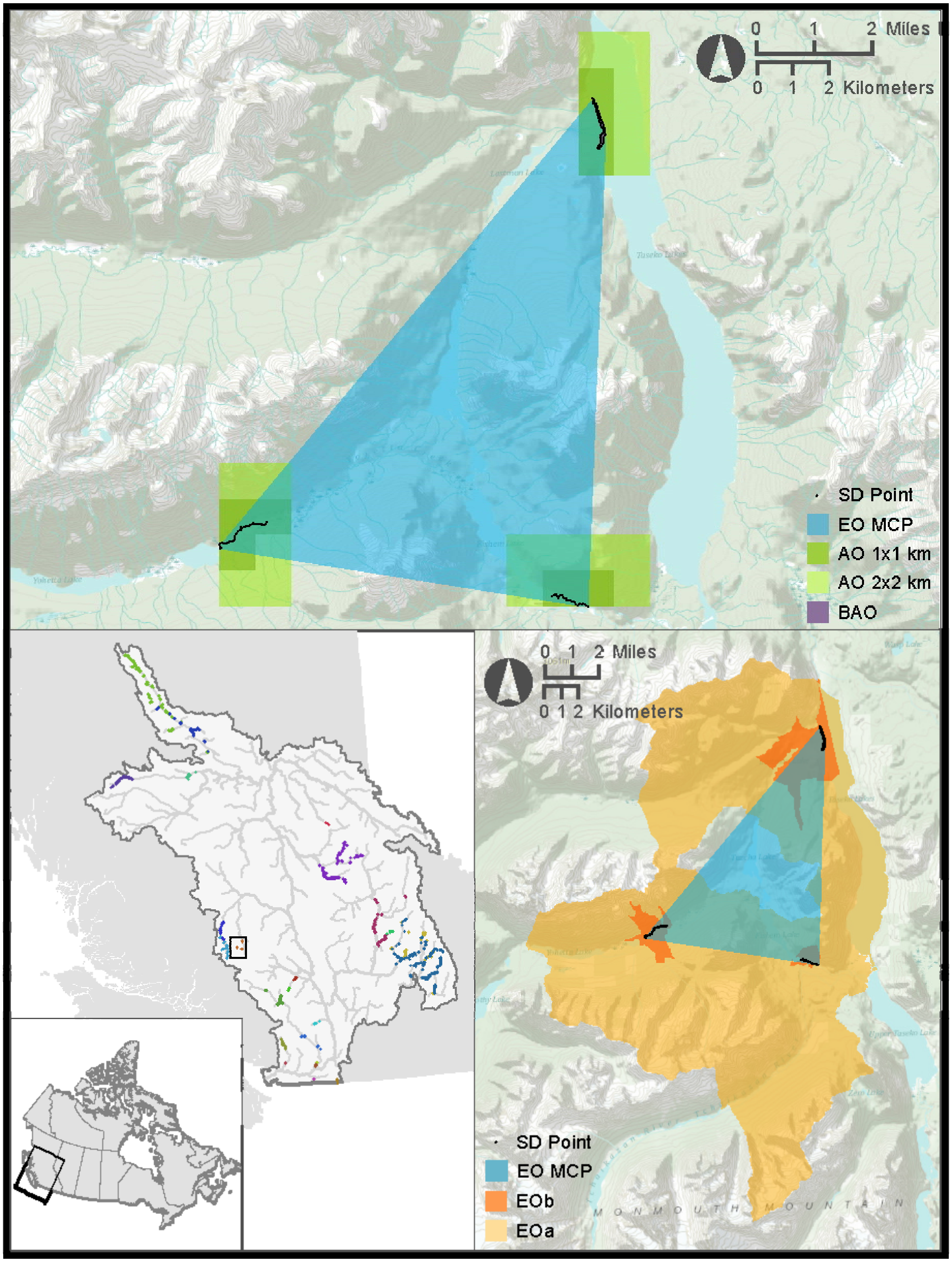
Map 20. *Shuswap-ES.*



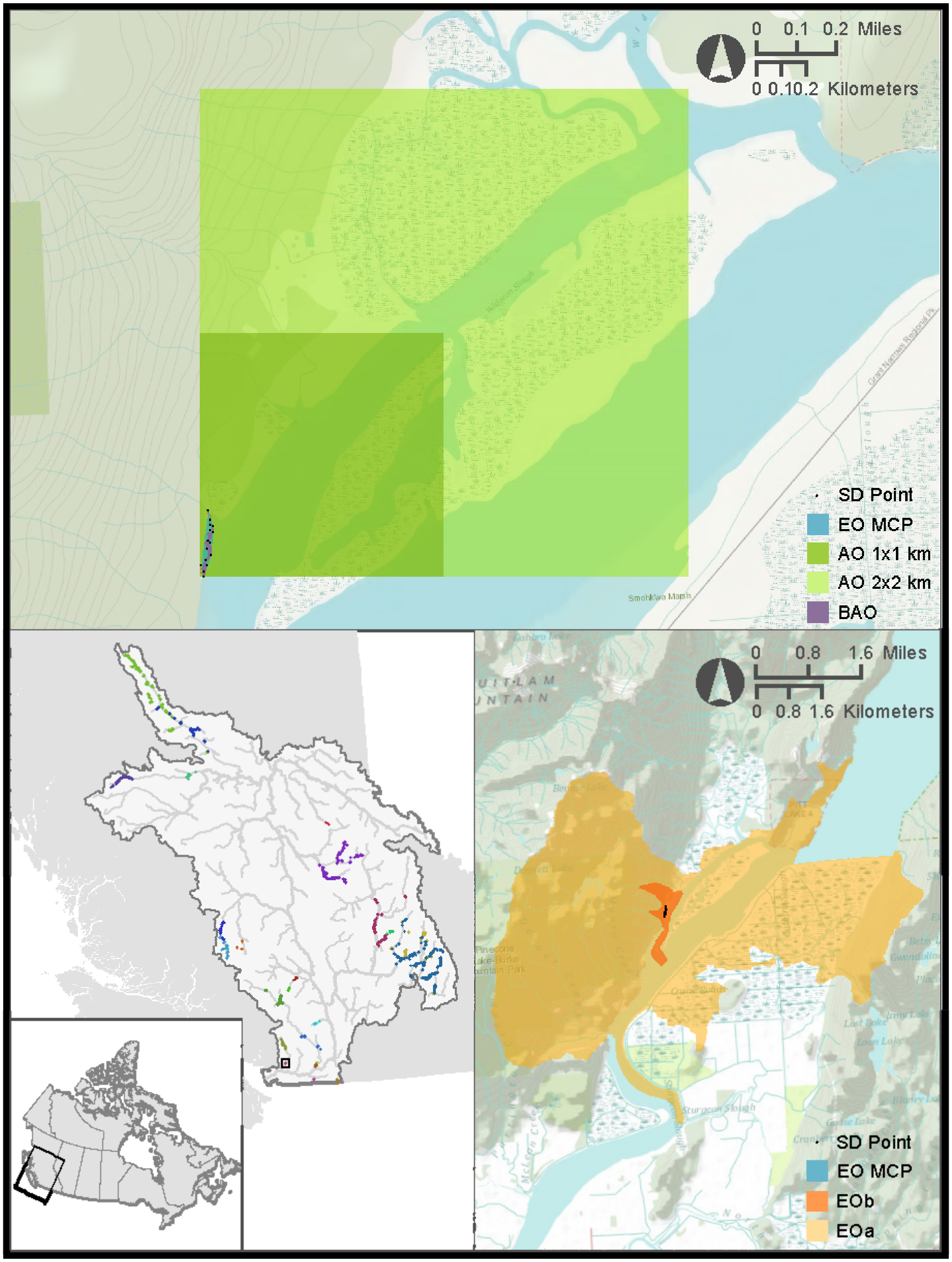
Map 21. *Takla-Trembleur-Estu.*



Map 22. *Takla-Trembleur-Stuart-S.*



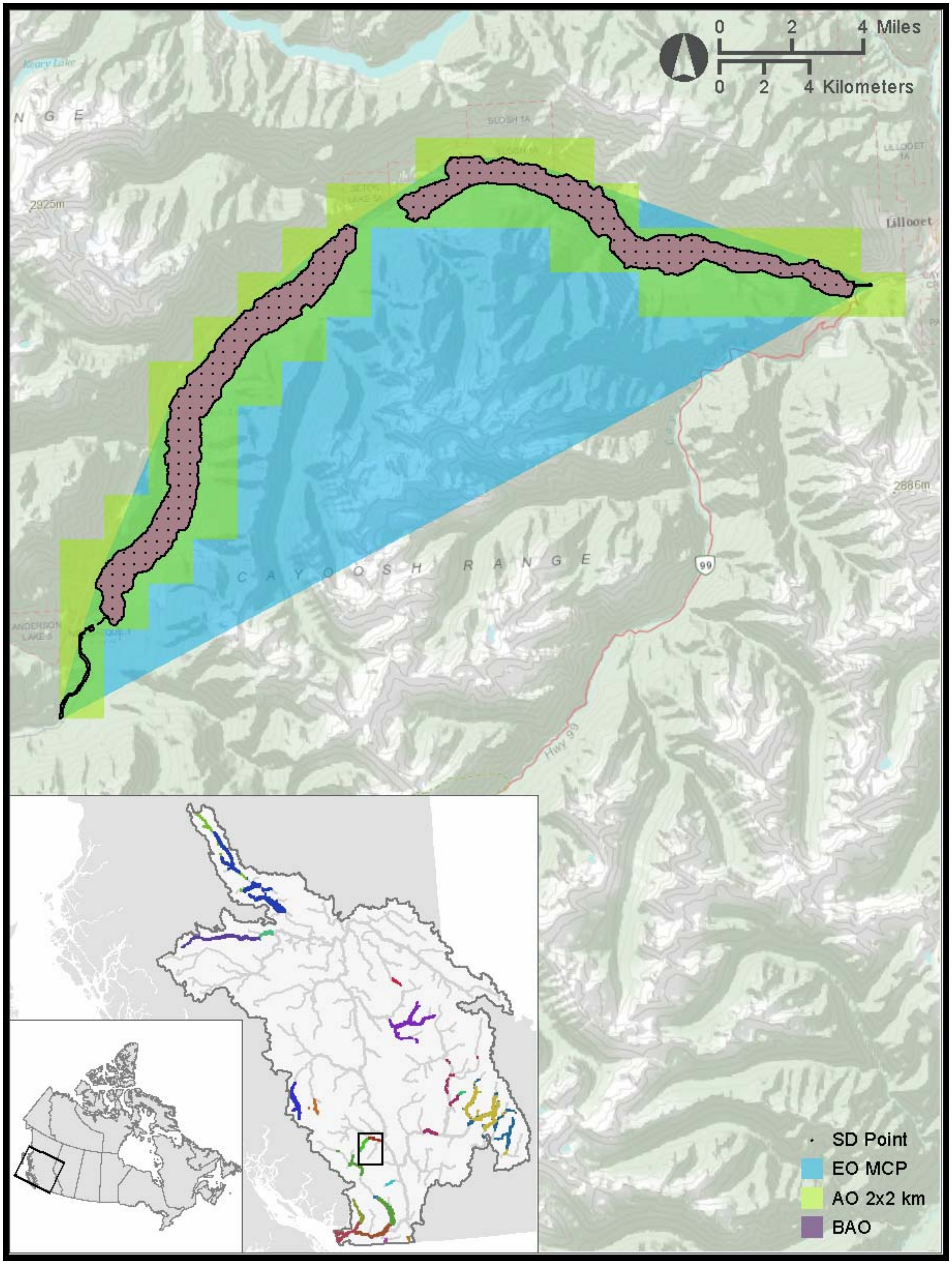
Map 23. *Taseko-ES.*



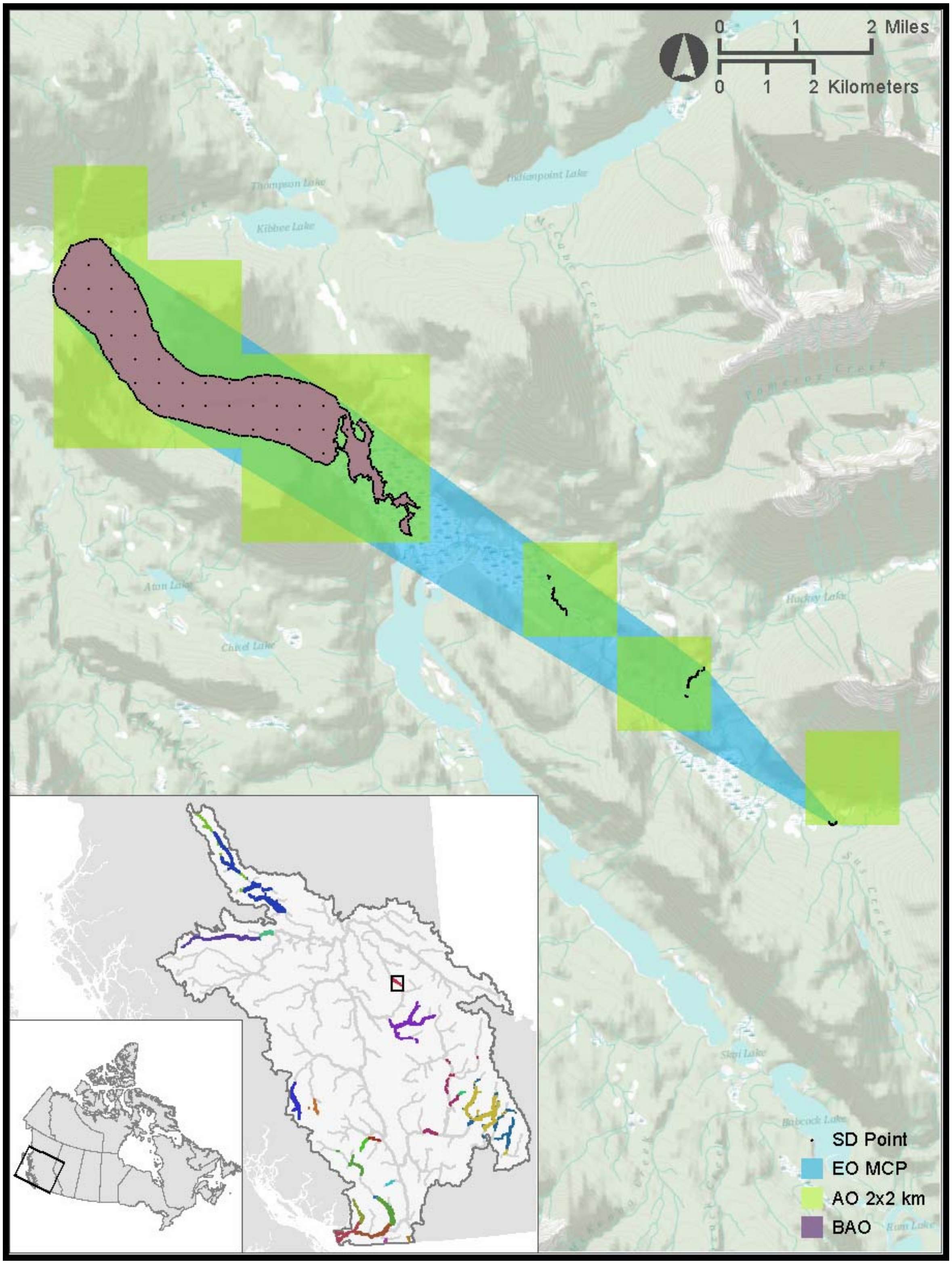
Map 24. *Widgeon (River-Type).*

APPENDIX 5

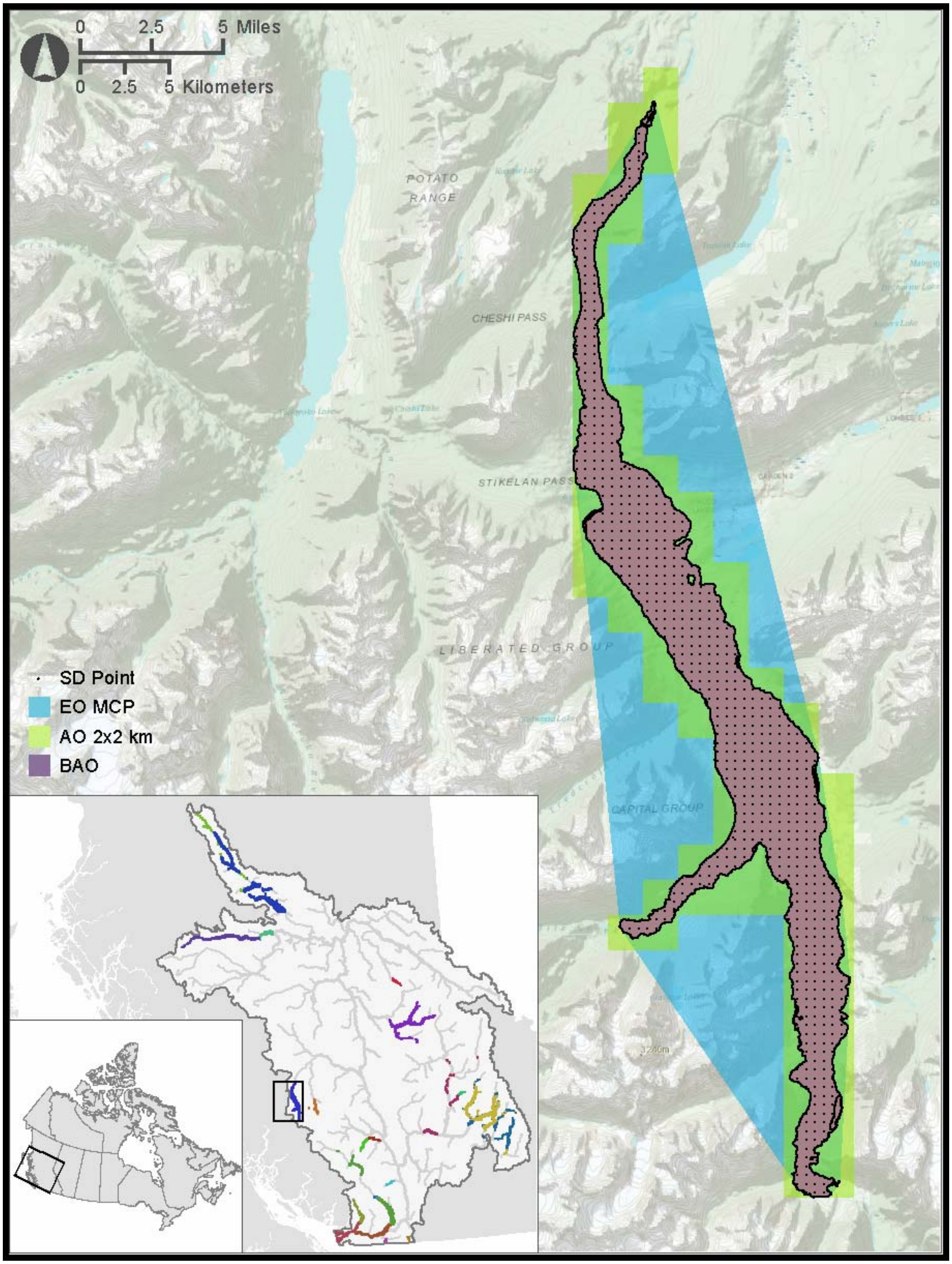
Maps of each CU showing EO, AO, and BAO estimated based on spawning area and rearing lakes. CU location is also shown.



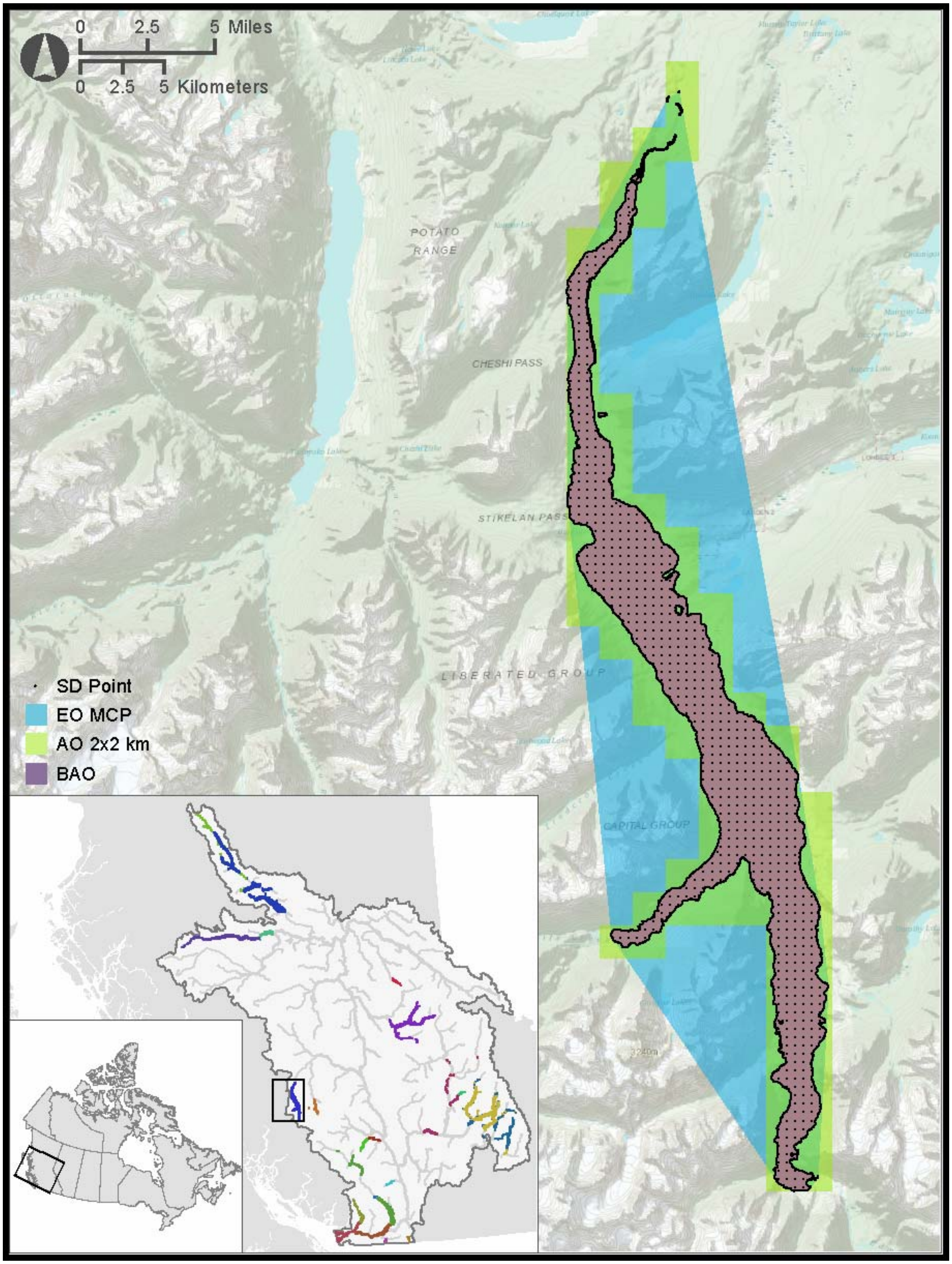
***Map 1**. Anderson-Seton-ES.*



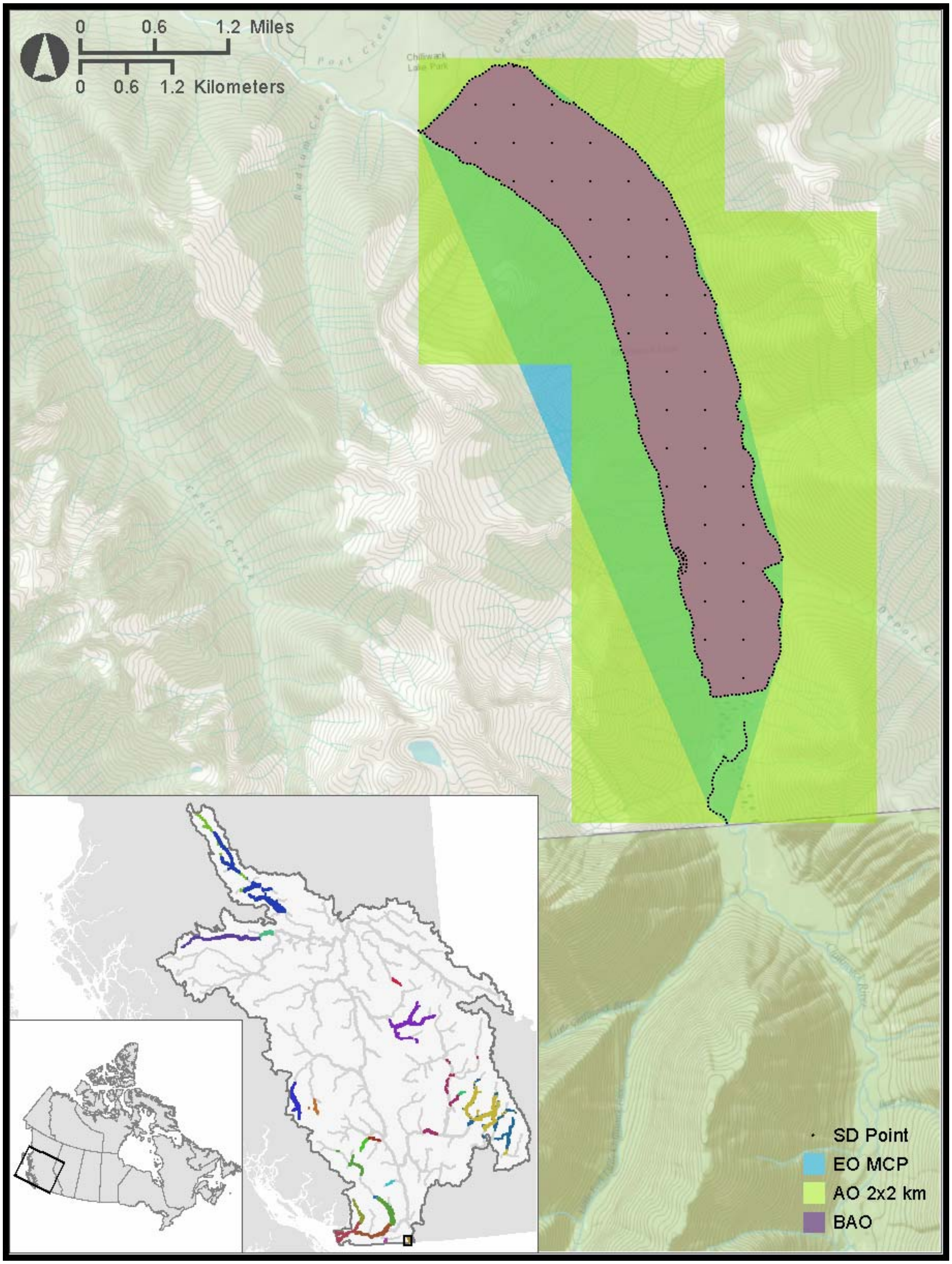
Map 2. *Bowron-ES.*



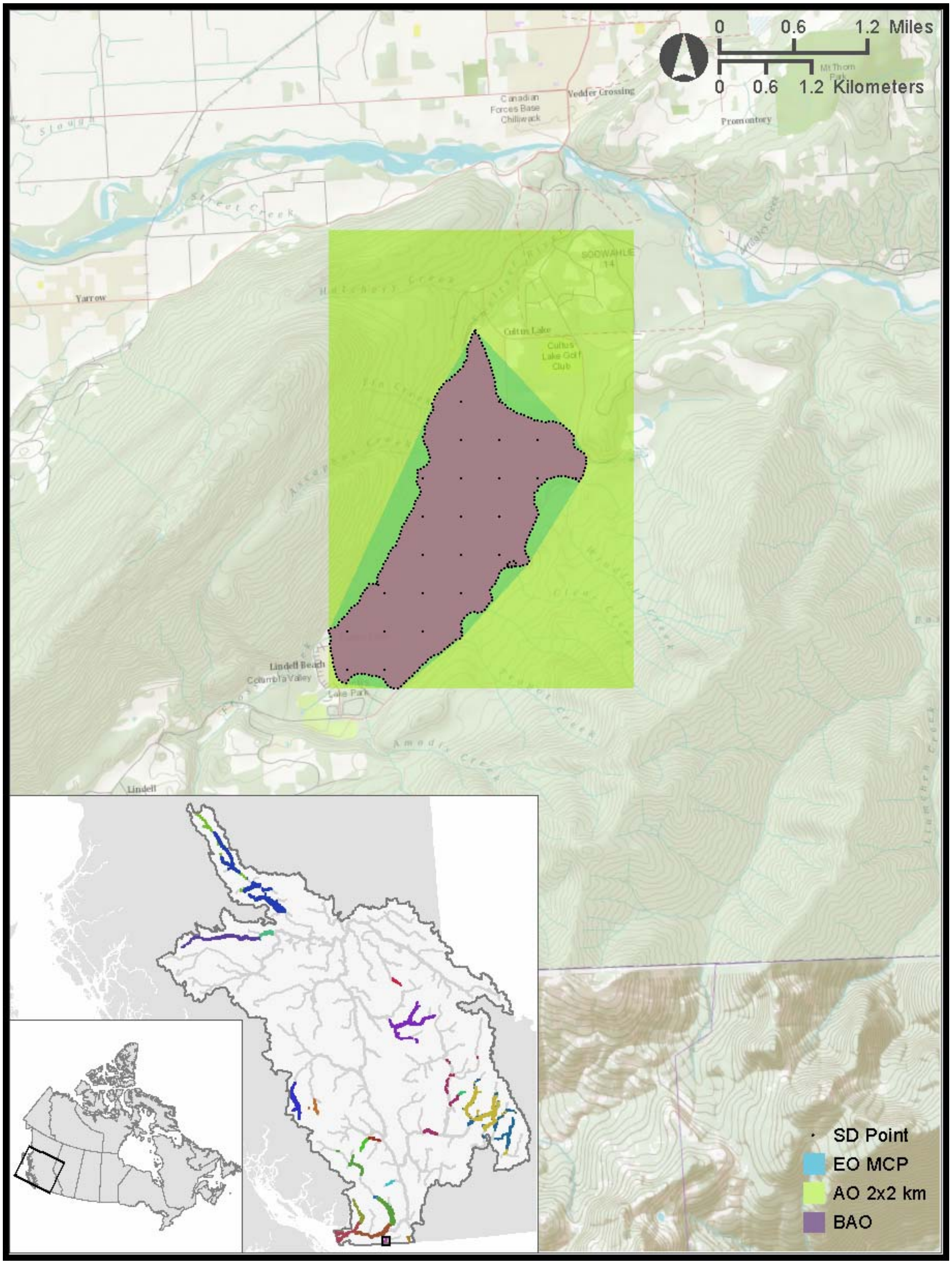
Map 3. *Chilko-ES.*



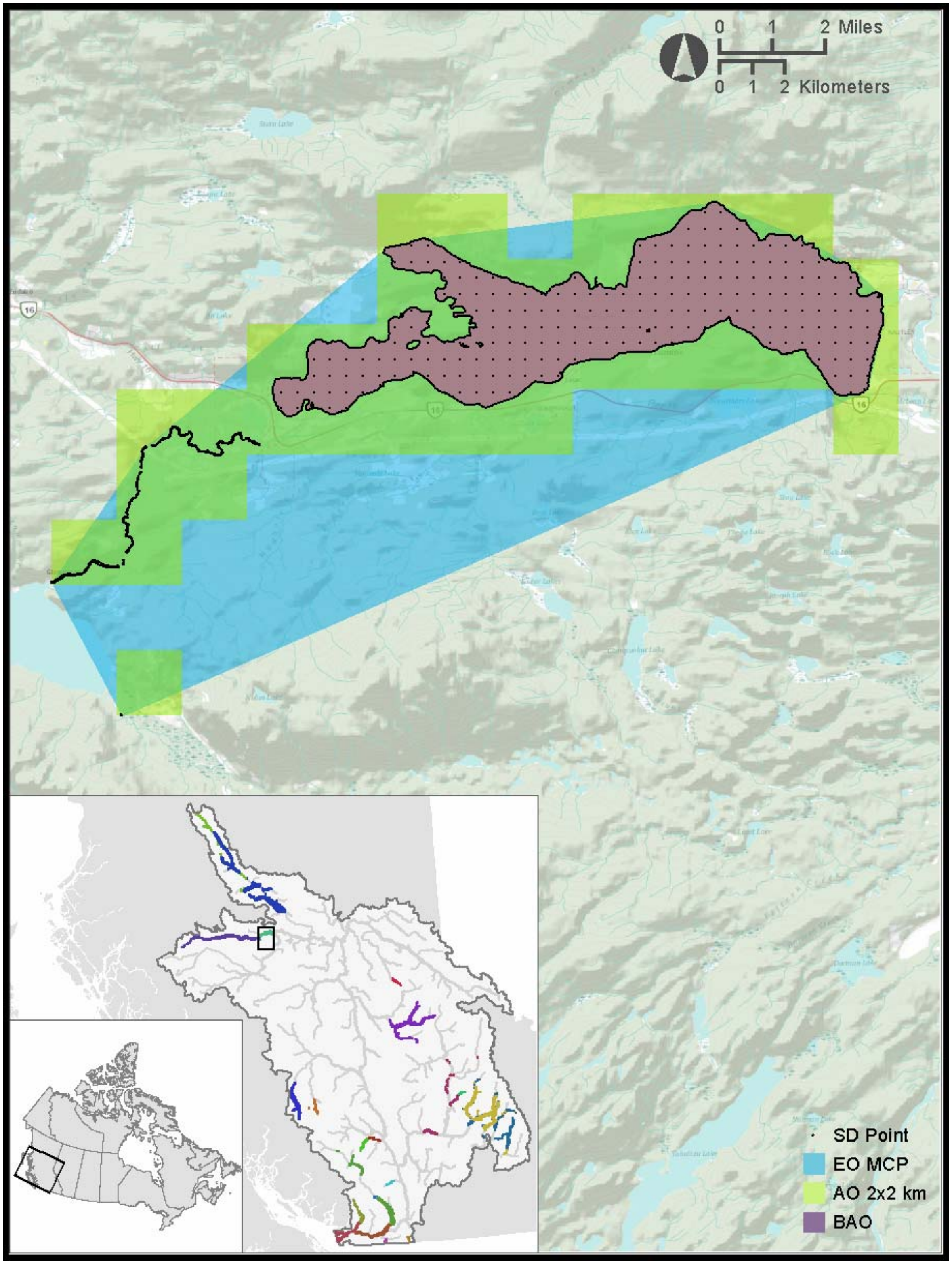
Map 4. *Chilko-S.*



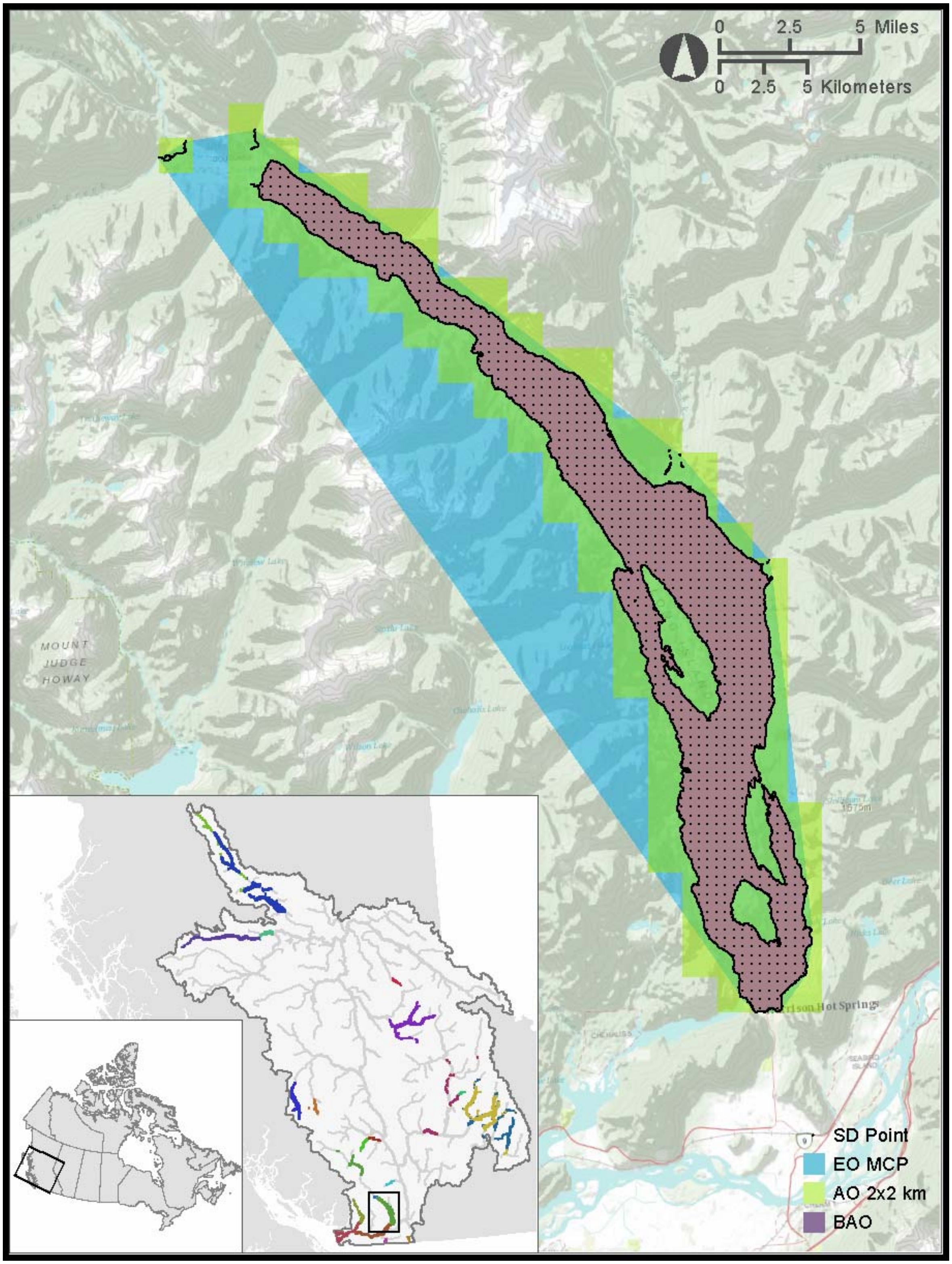
Map 5. *Chilliwack-ES.*



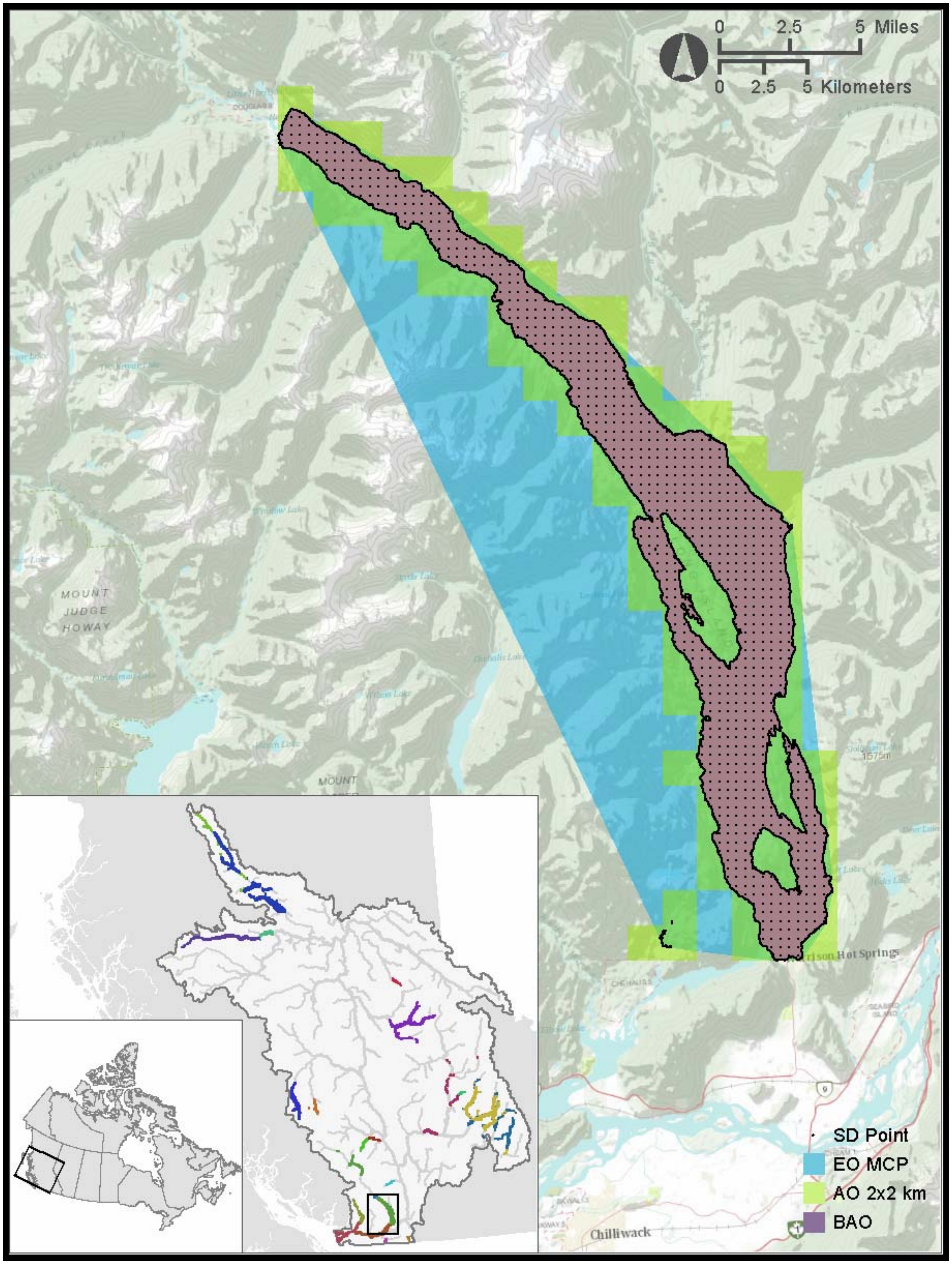
Map 6. *Cultus-L.*



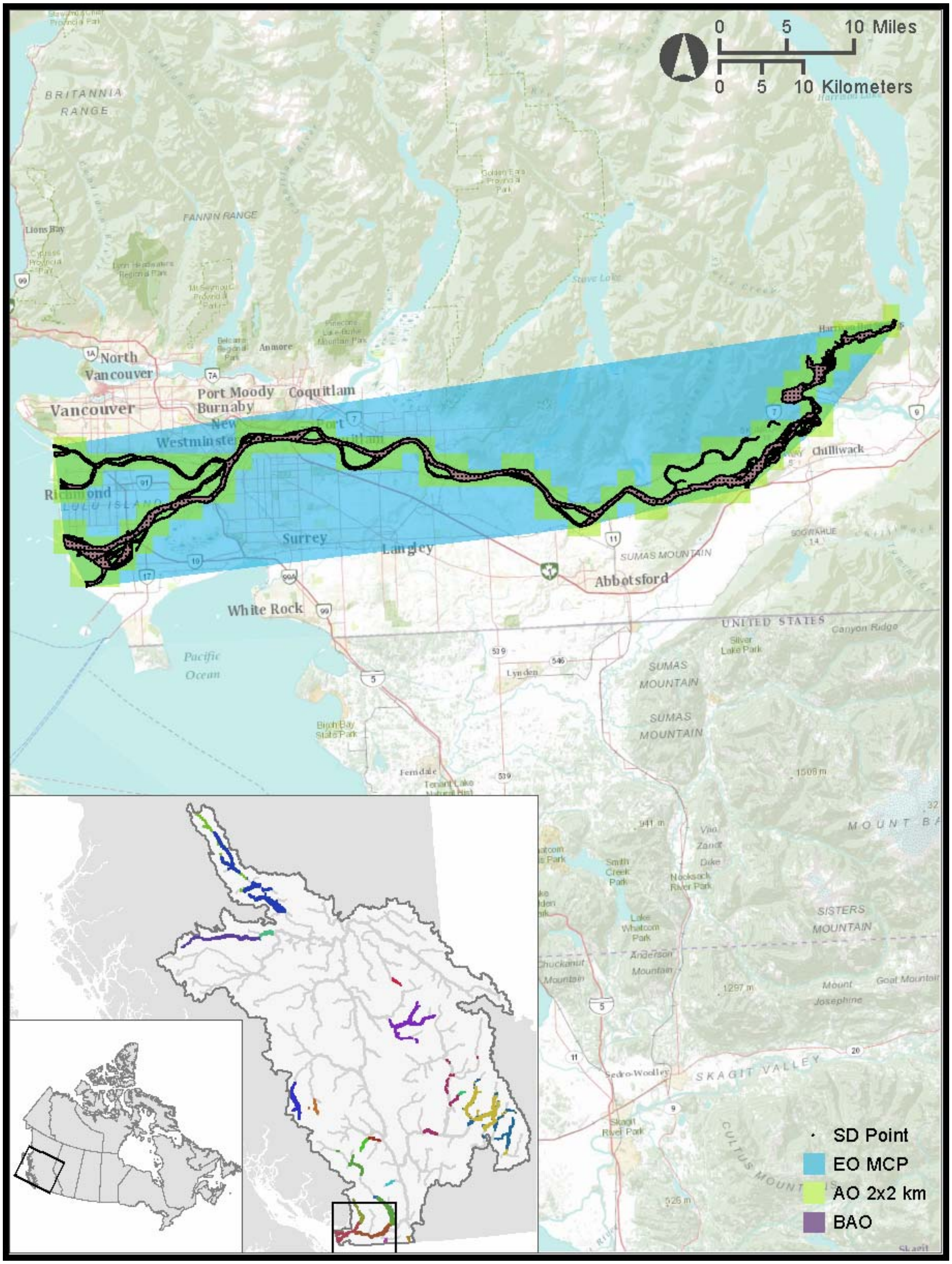
Map 7. *Francois-Fraser-S.*



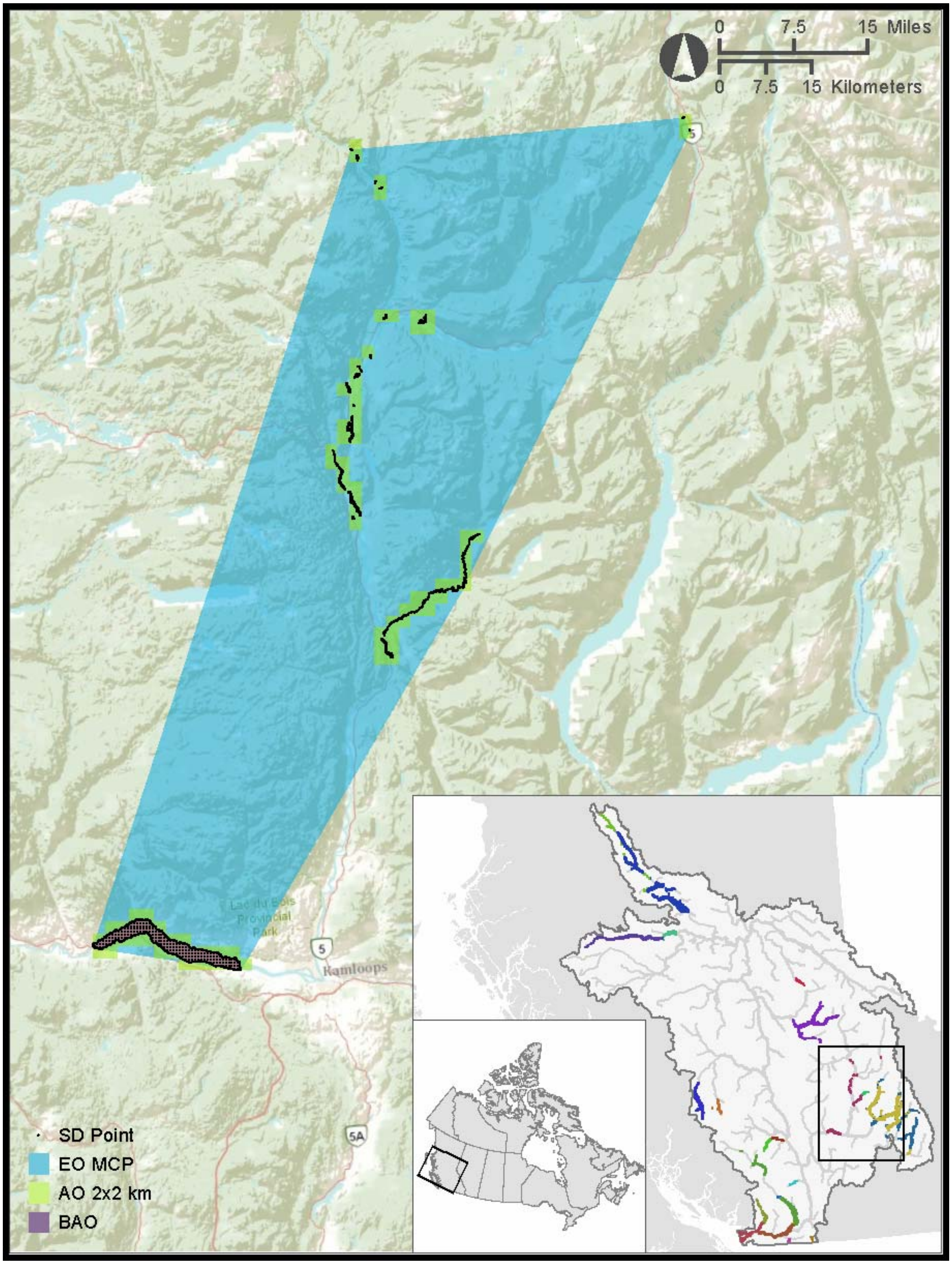
Map 8. *Harrison-(D/S)-L.*



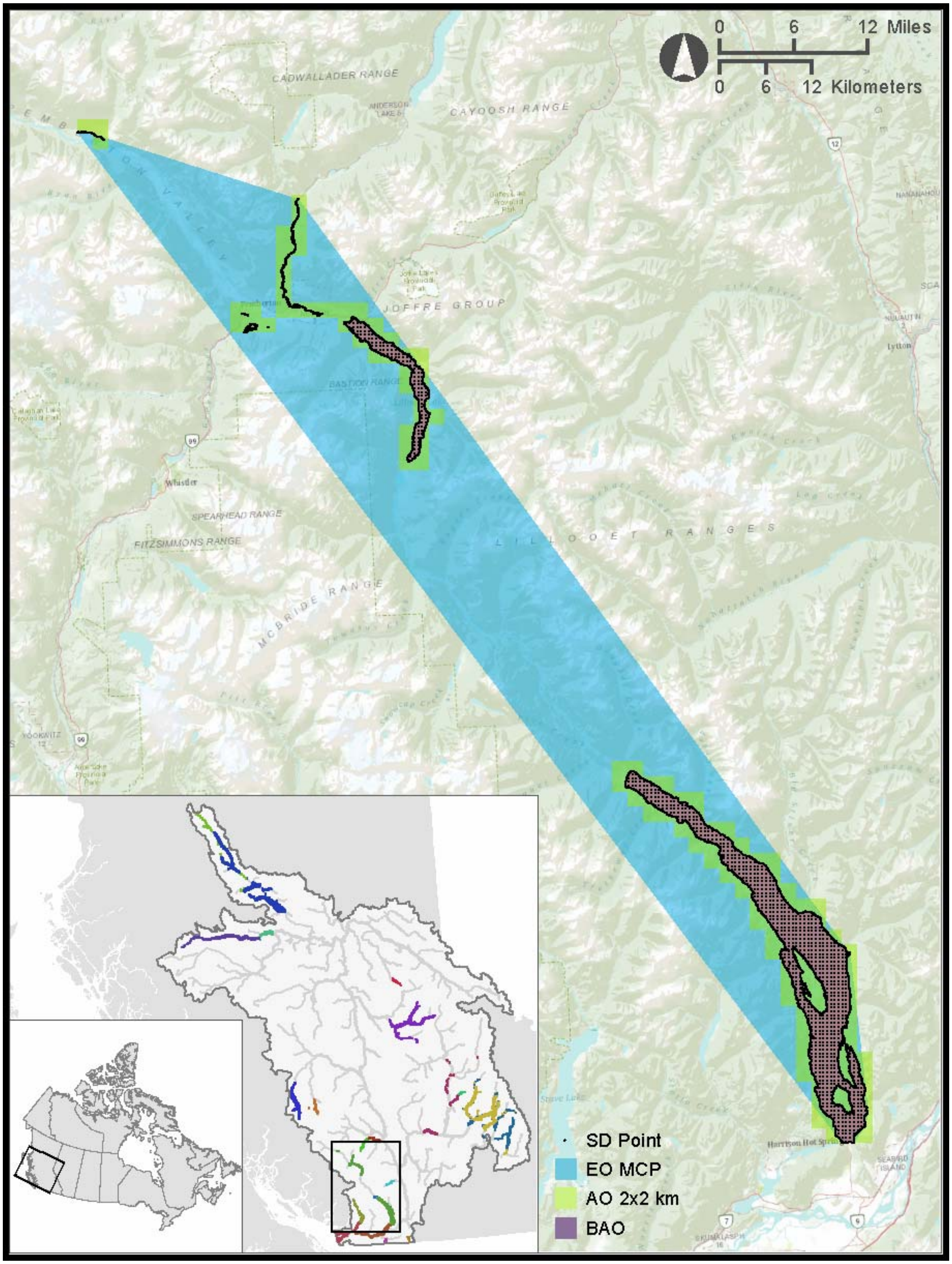
Map 9. *Harrison-(U/S)-L.*



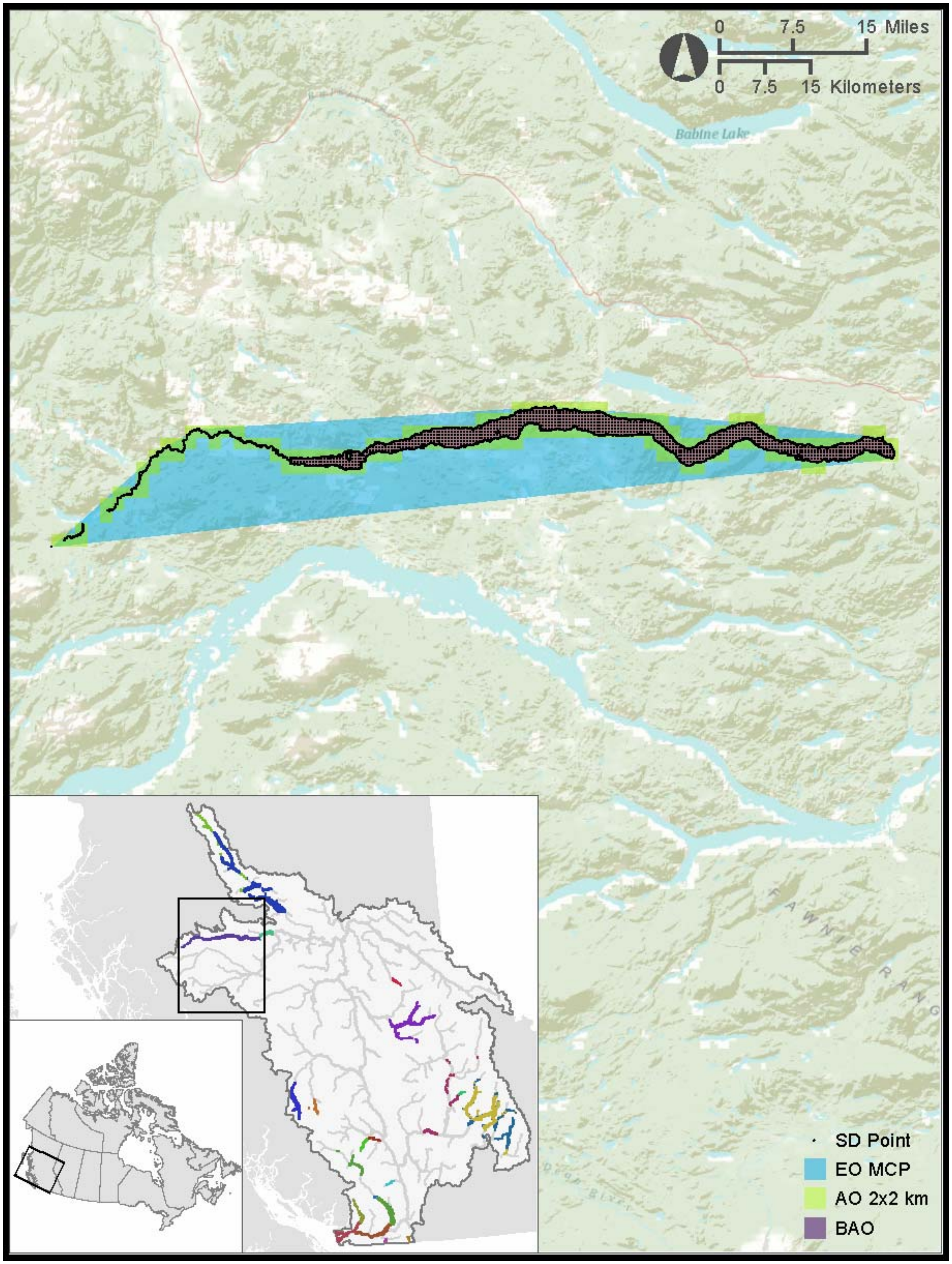
Map 10. *Harrison River – River Type.*



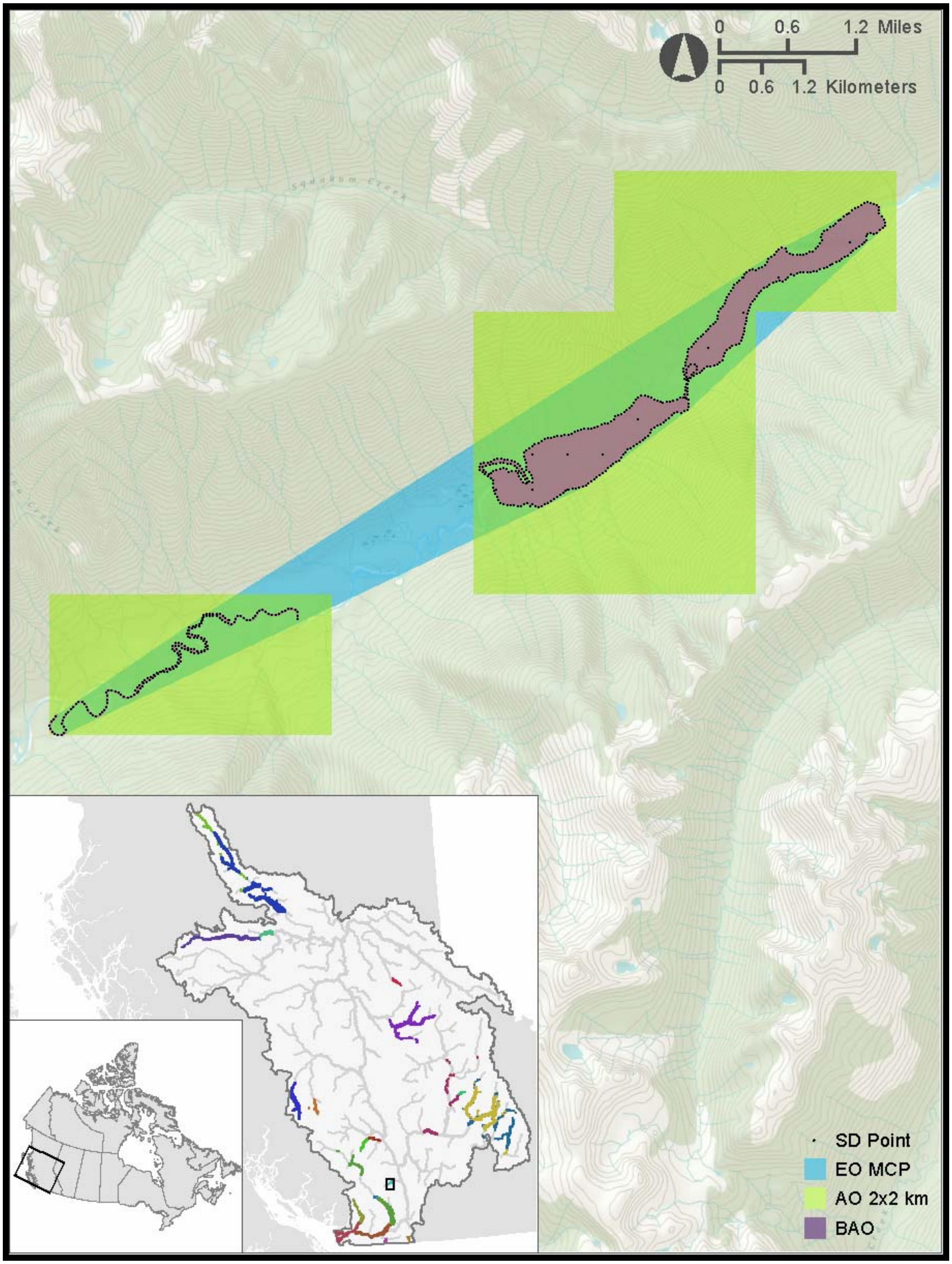
Map 11. *Kamloops-ES.*



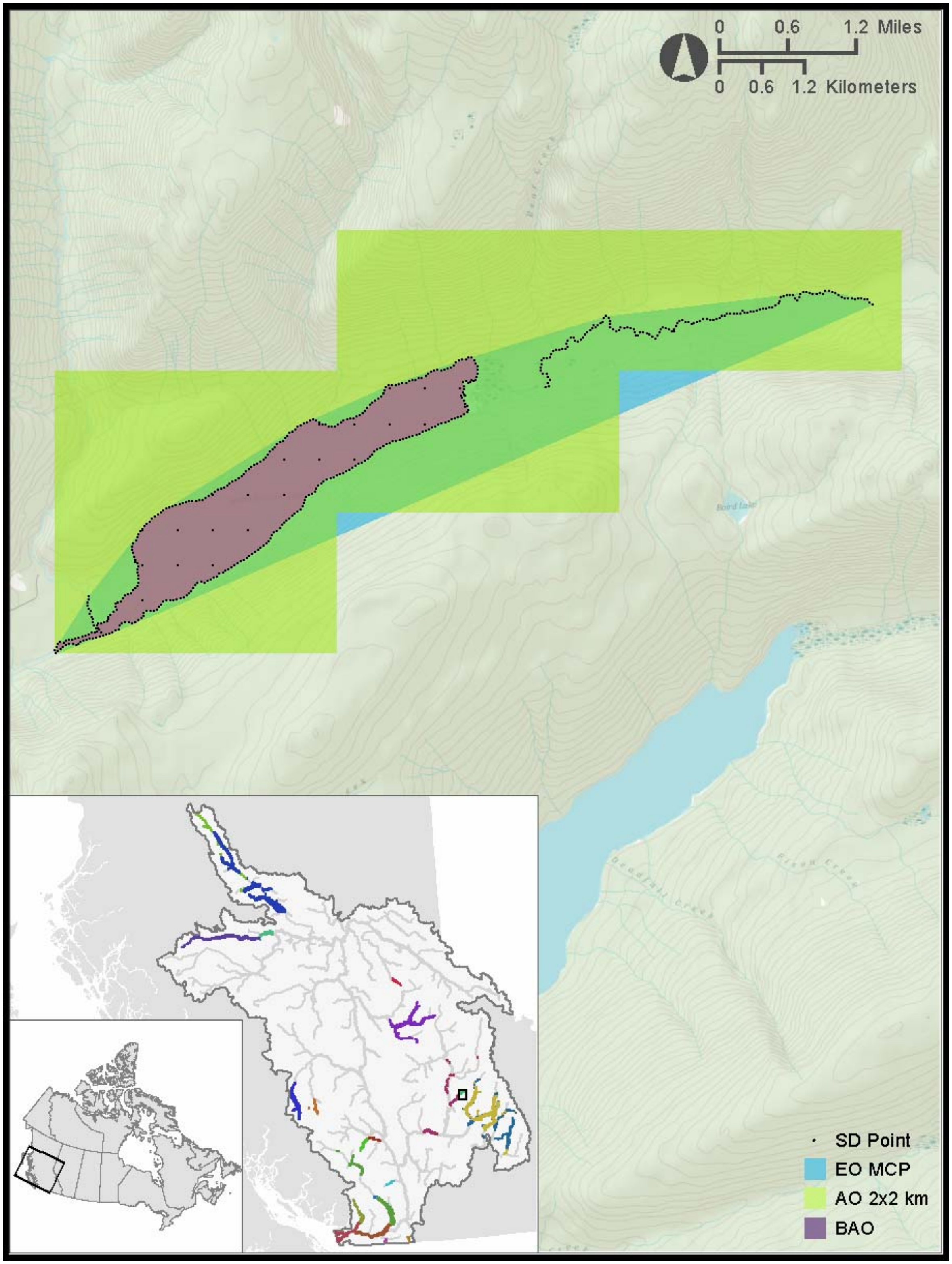
Map 12. *Lillooet-Harrison-L.*



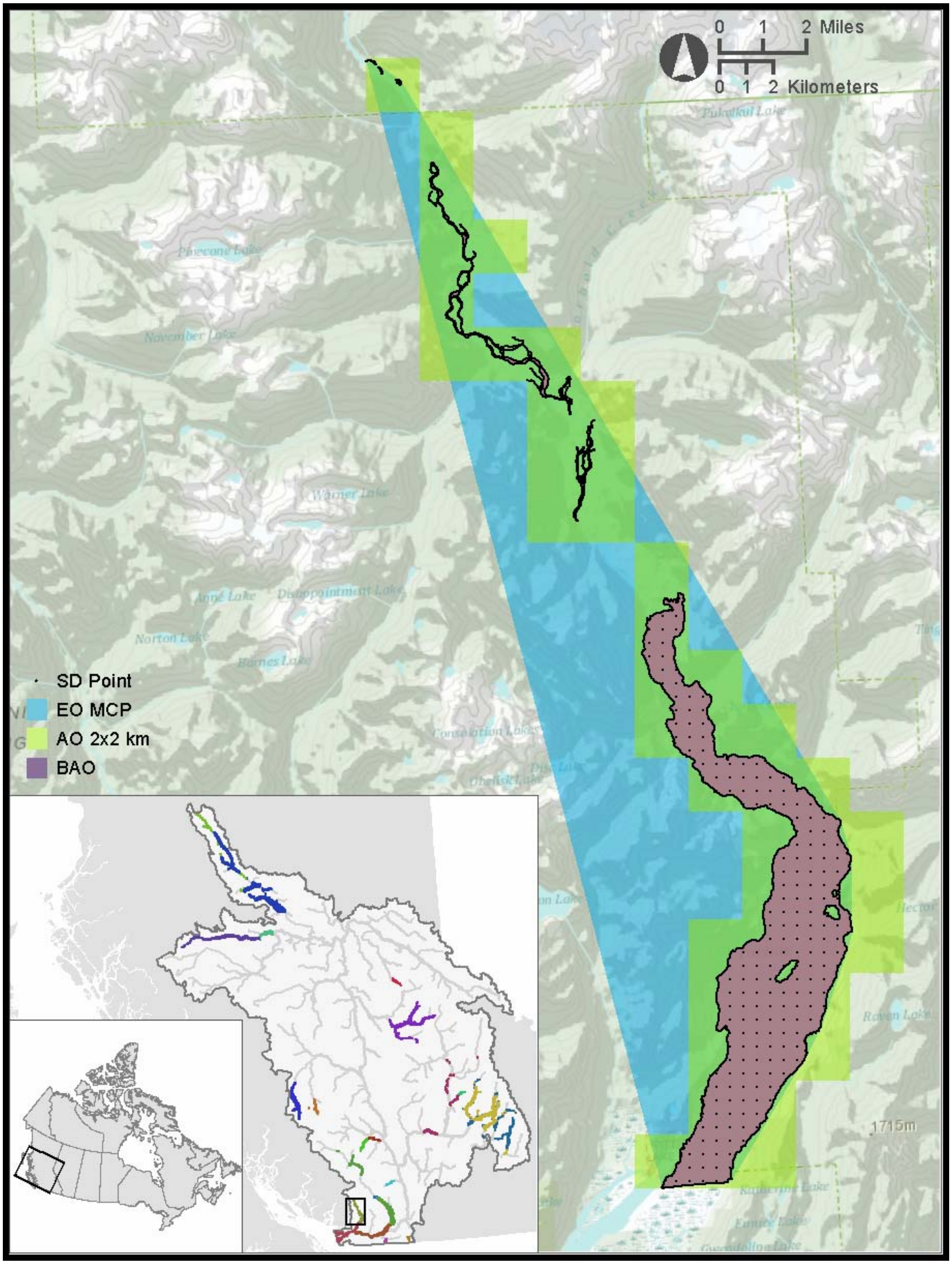
Map 13. *Nadina-Francois-ES.*



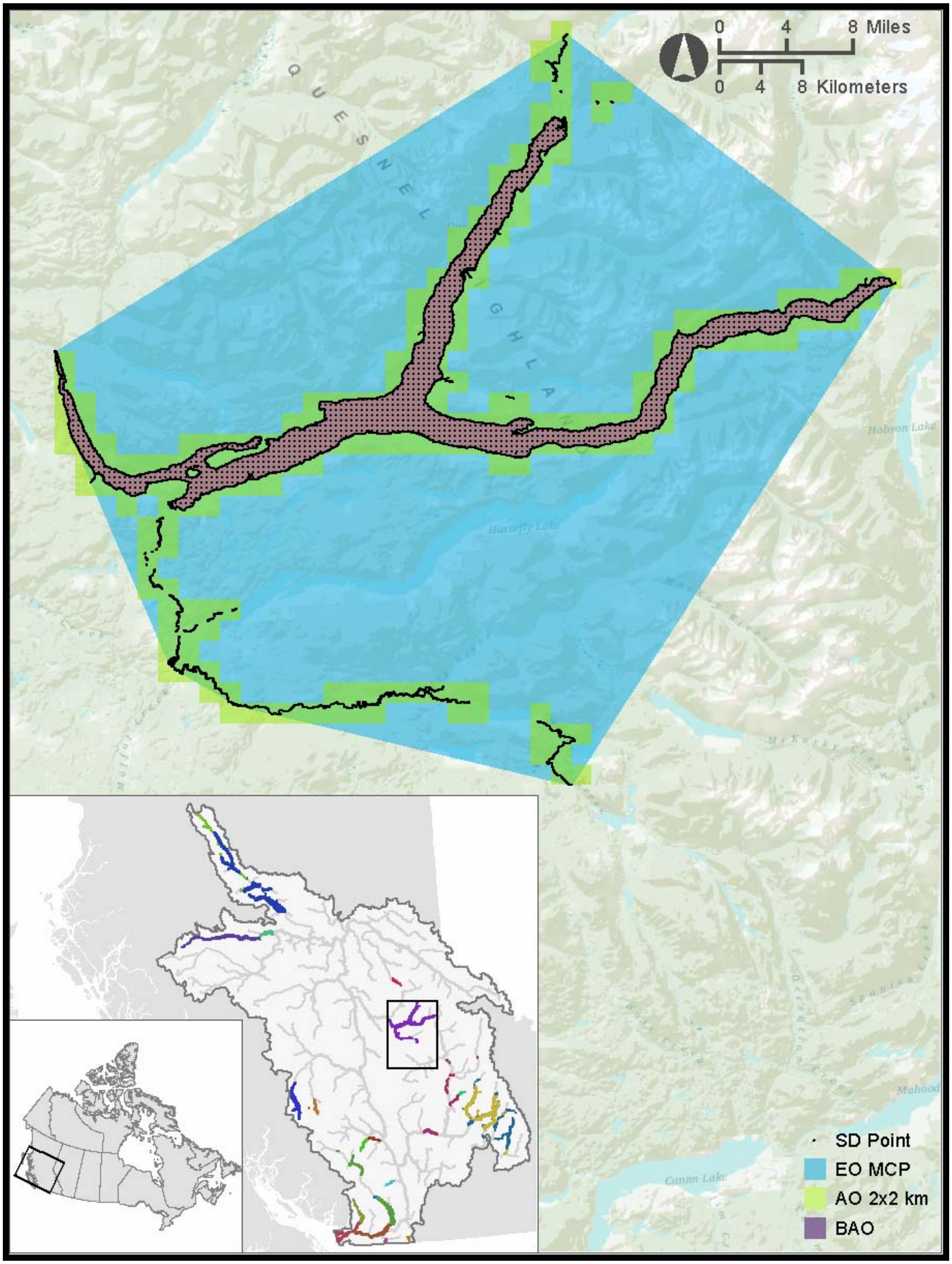
Map 14. *Nahatlatch-ES.*



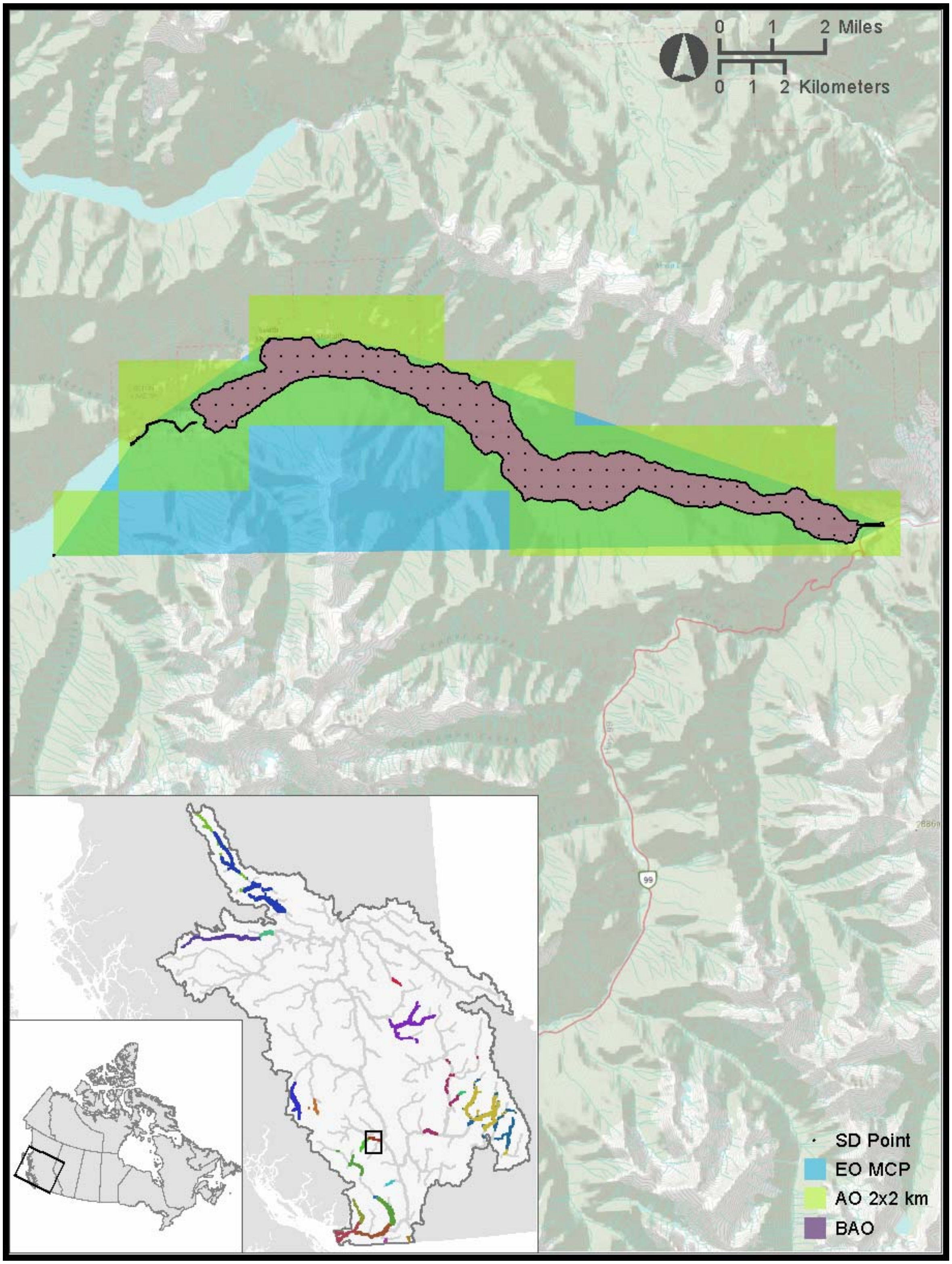
Map 15. *North Barriere-ES.*



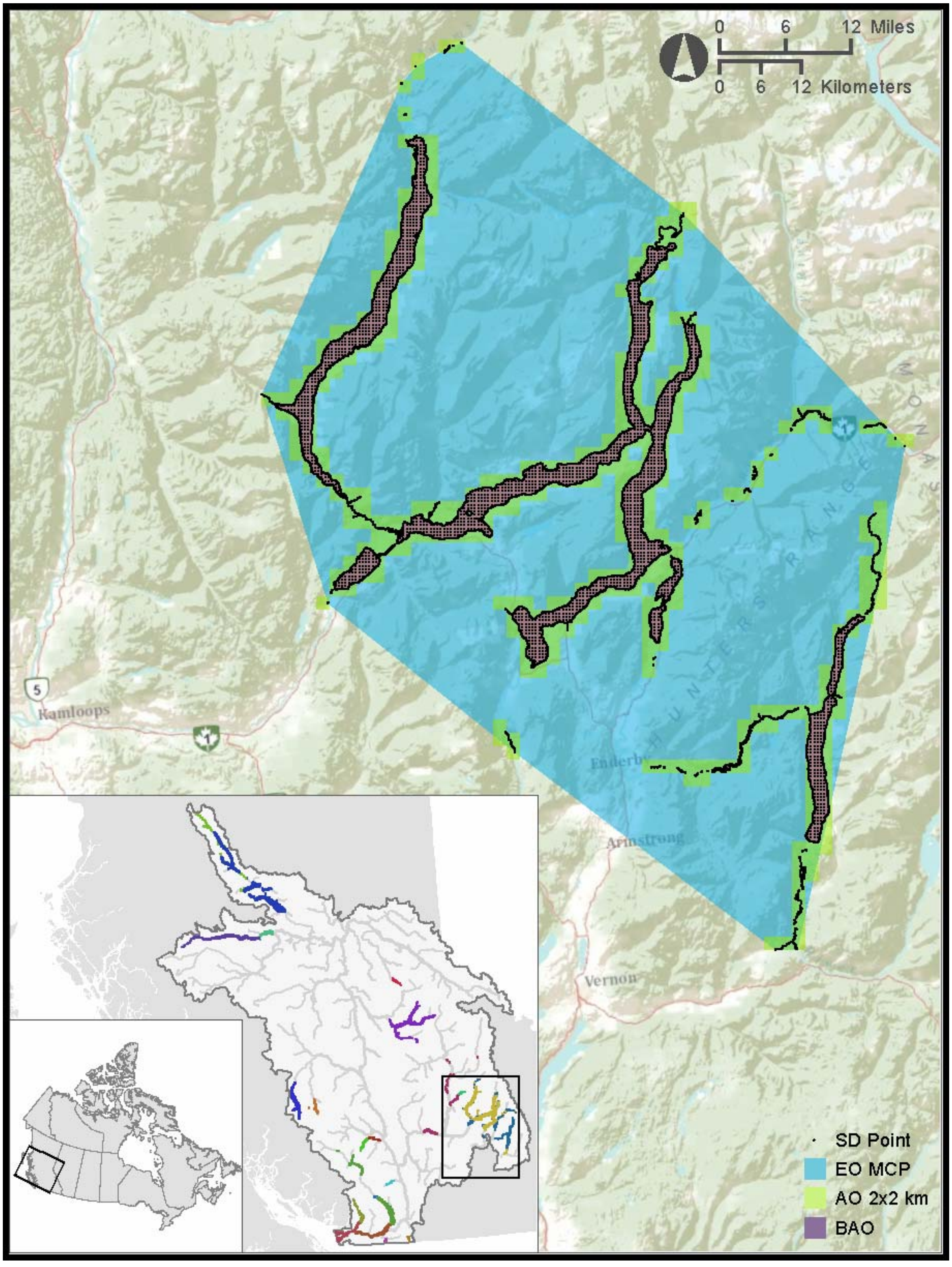
Map 16. *Pitt-ES.*



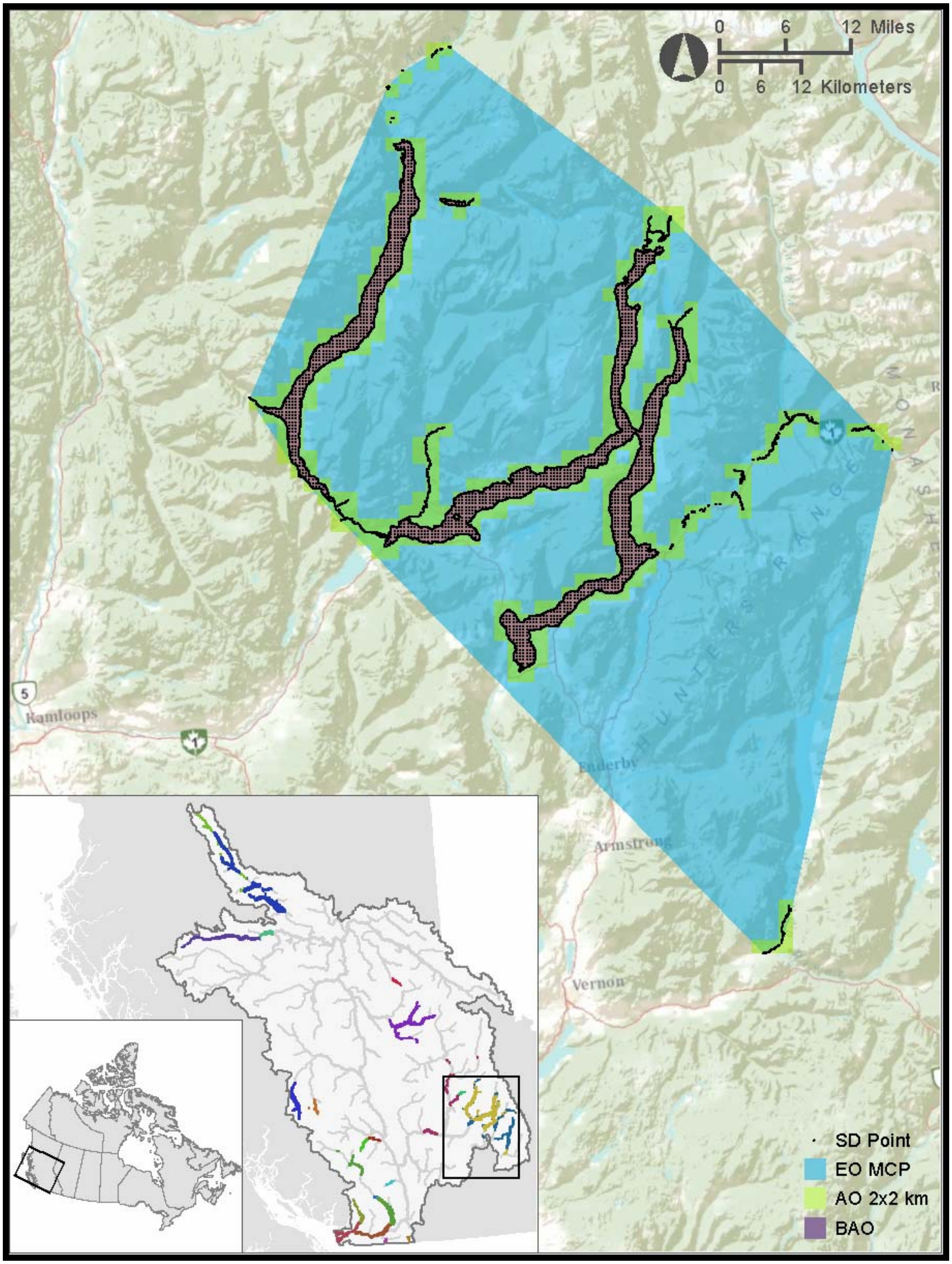
Map 17. *Quesnel-S.*



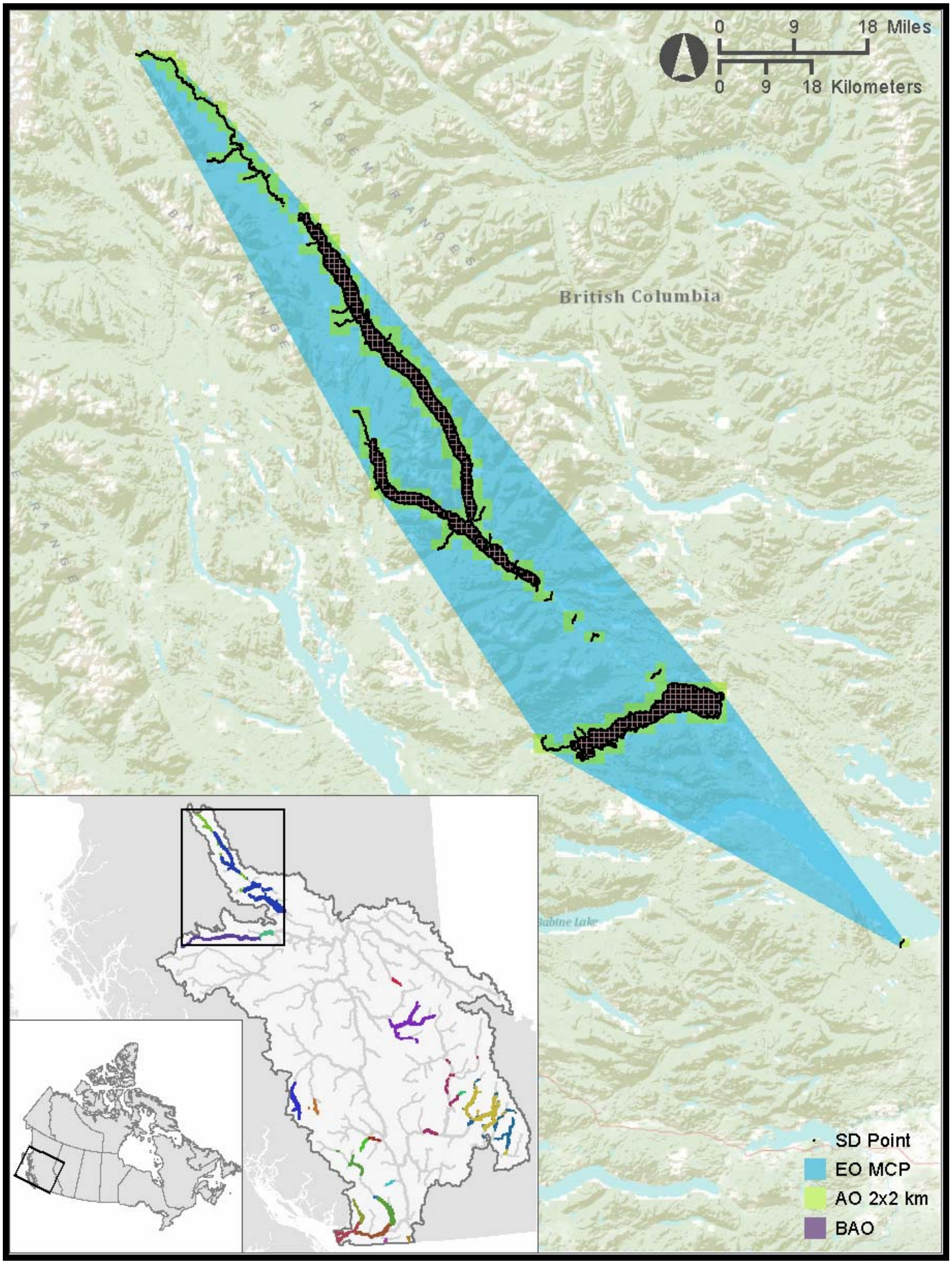
Map 18. *Seton-L.*



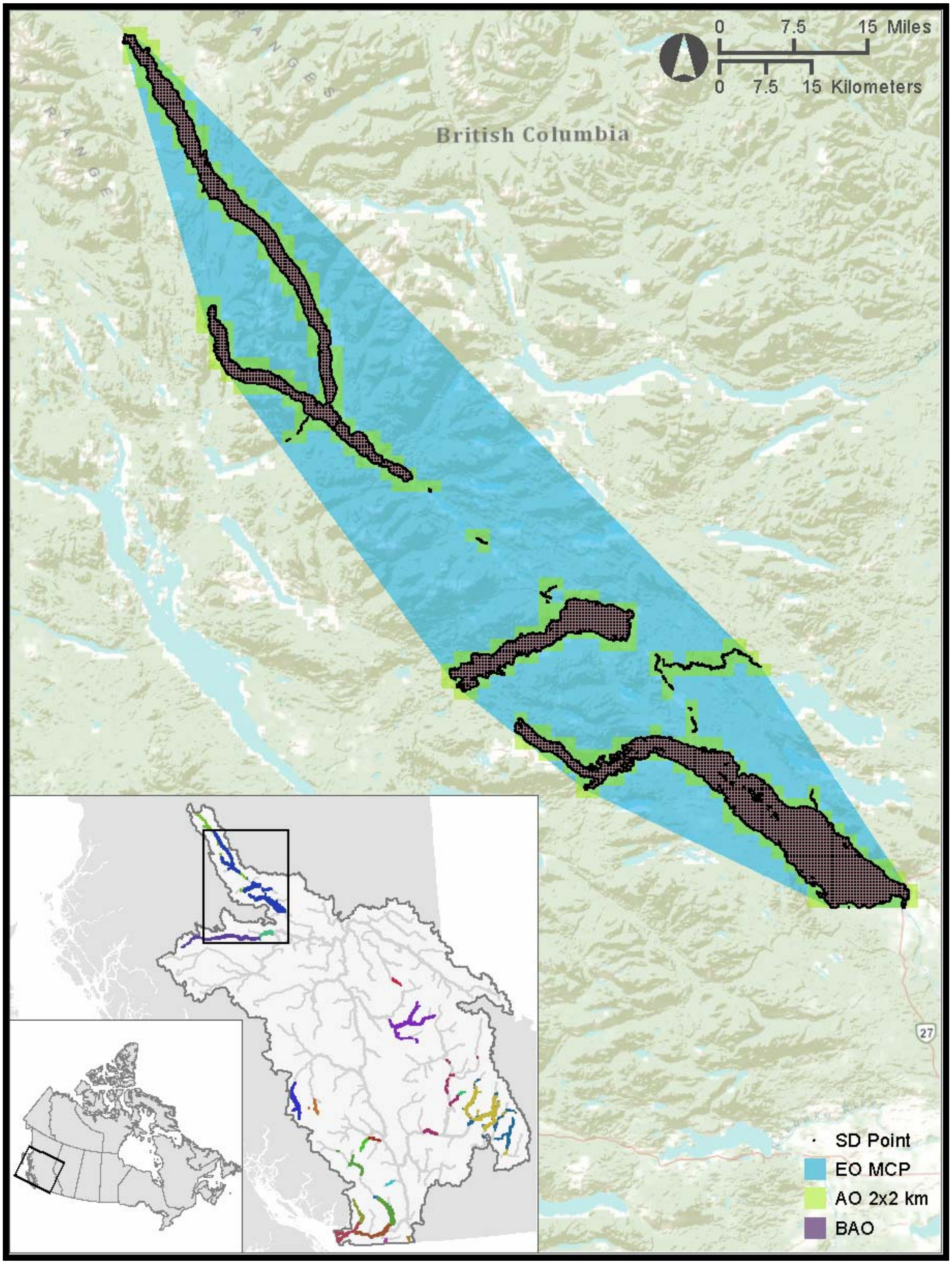
Map 19. *Shuswap Complex-L.*



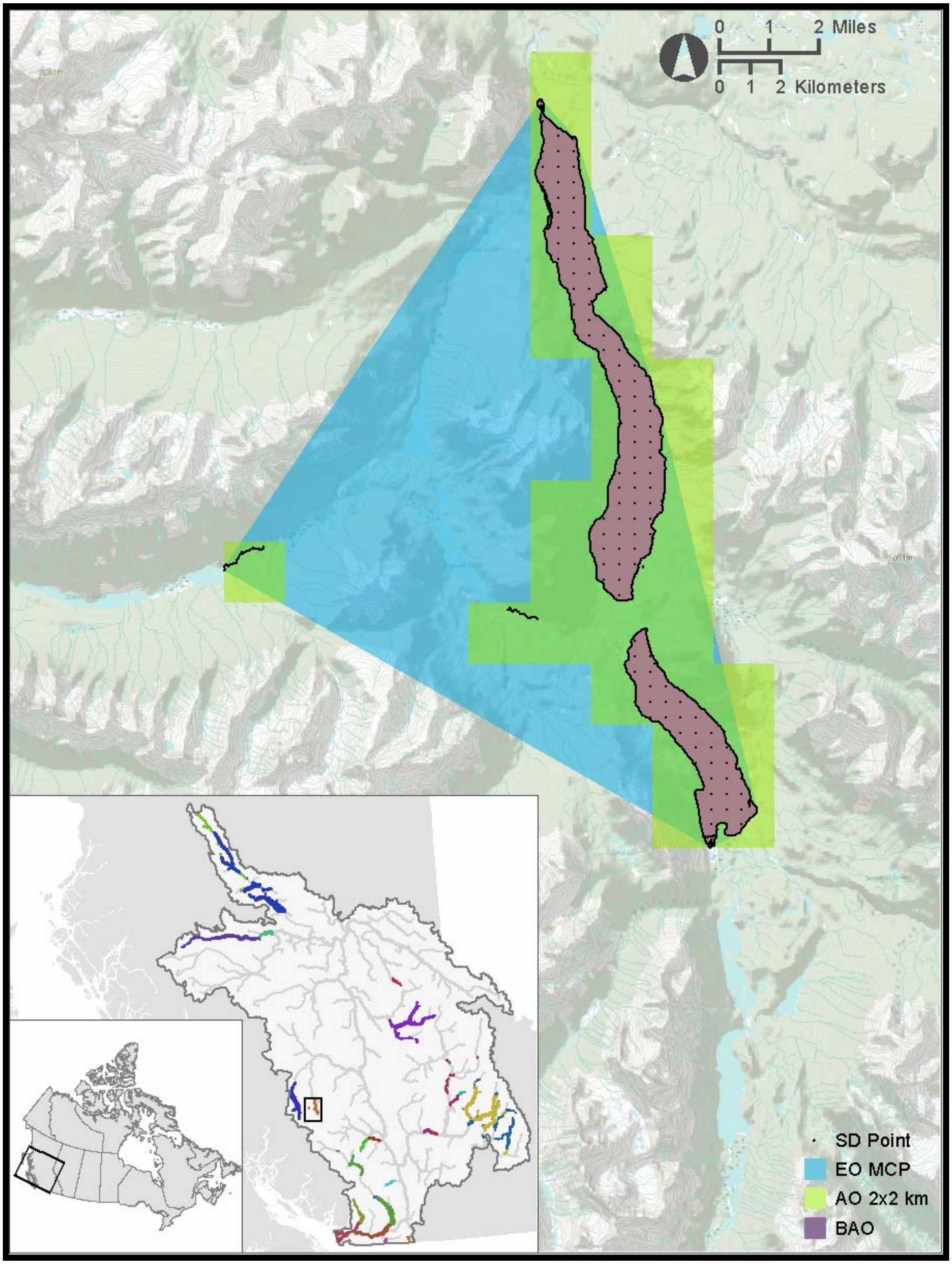
Map 20. *Shuswap-ES.*



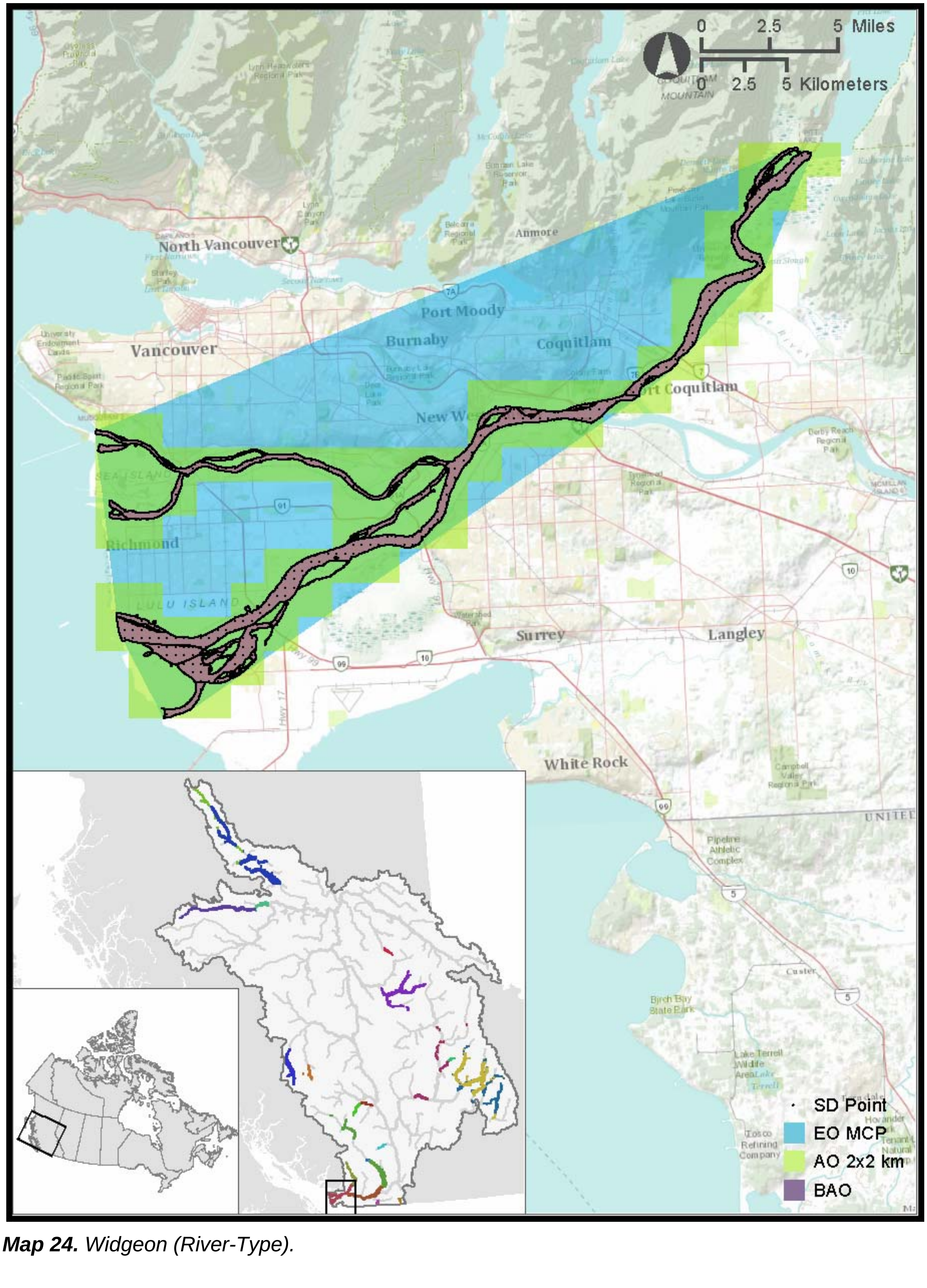
Map 21. *Takla-Trembleur-Estu.*



Map 22. *Takla-Trembleur-Stuart-S.*



Map 23. *Taseko-ES.*



Map 24. *Widgeon (River-Type).*