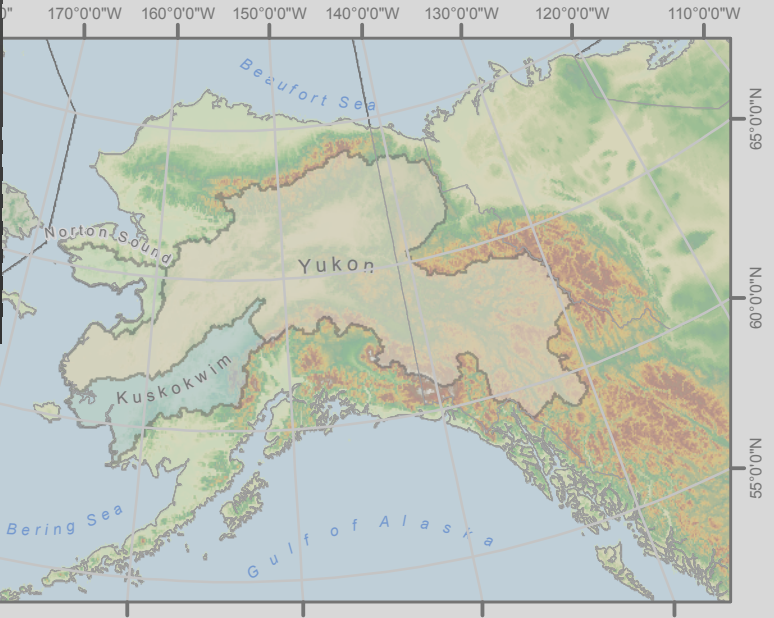


# Landscape Genetics Map for Salmon in the Rivers, and Norton Sound

US Fish and Wildlife Service  
Conservation Genetics Laboratory, Anchorage Alaska

Introduction:  
Landscape genetics, an integration of molecular population genetics and landscape ecology, provides a framework to evaluate how habitat, landscape features, and historic events (e.g., glaciation, stream capture), influence genetic diversity at different spatial scales. Multi-species studies using landscape genetic techniques are particularly informative for conservation because they can highlight landscape variables that influence genetic diversity in a variety of species. We used this approach to evaluate the interacting role of life history and habitat on population structure in Chinook, chum and coho salmon from three watersheds (Norton Sound and the Yukon and Kuskokwim) near the northern extent of the species range in North America. Our objectives were threefold. First, we assessed if the pattern of population divergence from least to most was chum < coho < chinook as predicted based on their life history differences. Second, we assessed if the spatial pattern of population structure in each species was organized hierarchically around the three watersheds. Third, generally, we assessed if the patterns of hierarchical population structure in each species were congruent. Finally, we assessed and mapped the extent to which nine habitat features from four general categories (spatial isolation, habitat size, climate, and ecology) influenced population structure in each species. The results were presented in the context of current management and conservation with the goal of providing a basis on environmental perturbations from factors such as climate change.

US Fish and Wildlife Service Conservation Genetics Laboratory  
Yukon Kuskokwim Sustainable Salmon Initiative  
US Fish and Wildlife Service Office of Subsistence Management  
Department of Fish and Game Gene Conservation Laboratory  
Department of Fisheries and Oceans, Canada,  
Marine Genetics Laboratory



## Landscape Genetics Map for Salmon in the Yukon and Kuskokwim Rivers, and Norton Sound

### Introduction and Instructions

Welcome to the interactive PDF map depicting the geospatial source layers and results of this study. This map is viewable in Adobe Acrobat Reader. It has been tested in versions 9.0 and 9.1. If you are using an older version, then you may get some unexpected results. You can download the newest version for free from Adobe.

This document consists of an interactive map page, a project results page and metadata pages describing the mapping layers. The interactive map page is divided into three main maps, one for each salmon species studied Coho, Chum and Chinook. The mapping extent of each map is the same, encompassing all three drainages of the study. There is a fourth map that depicts the study area's general location at a smaller scale. The layers and content of each panel can be controlled in one of two ways, the Layers panel and the Bookmarks panel. Each of these can be accessed on the left hand margin of the Adobe Reader window.

### Layer Panel

The layer panel can be used to turn individual geospatial layers on and off in any of the three maps. This panel is exposed by clicking on the layers icon in the left margin. When opened, the layer panel displays the layer "tree" that contains all of the mapping layers organized into the three species' maps. A layer is turned on by clicking the "eye" icon in left hand side of the panel next to the layer. The layers are displayed in the order of the list, so if multiple polygon layers are turned on, only the topmost layer will be visible. In this case, you must turn off the overlying layers to "expose" the hidden layer.

### Bookmarks Panel

Bookmarks are a set of pre-defined maps with specific layers turned off and on. The Bookmarks panel is opened by clicking on the Bookmarks icon in the left margin. If you would like to view one of these standard maps, simply click on the bookmark and the map display will change.

### Disclaimer:

*The findings and conclusions presented here are those of the author(s) and do not necessarily represent the views of the U.S. Fish and Wildlife Service.*

US Fish and Wildlife Service  
Conservation Genetics Laboratory, Anchorage Alaska



Coho

Chum

Chinook



## **Landscape Genetics Map for Salmon in Norton Sound, Yukon, and Kuskokwim Rivers**

### **Brief Summary of Results:**

- The level of population structure in coho salmon was significantly larger than the level of population structure in chum and Chinook salmon. For comparison, open the layers titled Fst for each species and compare the legend values. The levels of population structure for Chinook and chum salmon were not significantly different.
- The spatial patterns of population structure were not organized hierarchically around the three watersheds. The analysis incorporating genetic and geographic data suggests hierarchical population structure for each species occurs primarily along a latitudinal axis (east – west) which is dominated by the Yukon River, rather than the much shorter longitudinal axis (north-south) that defines the relative position of the three major watersheds. This result is evidenced by the large single coastal population group in each species that includes populations from Norton Sound, the lower Yukon River and most of the Kuskokwim River. The other population groups occur primarily within the Yukon River. For comparison and more information, open the layers titled Landscape Genetic Groups for each species and refer to the meta data.
- Further evidence of a strong latitudinal (or coastal – inland) pattern for each species was revealed when the first principle component (PC1) of genetic variation from each population was extrapolated across the three watersheds using ordinary Kriging. For comparison and more information, open the layers titled PC1\_Kriging for each species and refer to the meta data.
- Nine variables representing habitat were evaluated: waterway distance to the coast, median pairwise waterway distance from each location to all other locations (similar to connectivity), elevation, migration difficulty (waterway distance to the coast x elevation), home subbasin area, home river length, mean annual precipitation, ecoregion, and permafrost region. No single habitat variable was strongly correlated to population structure (as measured by populations specific Fst) in any species. However, the variable mean annual precipitation was one of two or three variables that, in combination, may partially explain the population structure of each species. The other variables were waterway distance to the coast and home subbasin area (Chinook), elevation (chum), and median pairwise waterway distance from each location to all other locations (coho). For comparison and more information open the environmental background layers and refer to the meta data for the Fst layers.

US Fish and Wildlife Service  
Conservation Genetics Laboratory, Anchorage Alaska

# Landscape Genetics Map for Salmon in Norton Sound, Yukon and Kuskokwim Rivers

[US Fish and Wildlife Service Conservation Genetics Laboratory, Anchorage, Alaska](#)

## Title: Chinook\_Fst

**Abstract:** This layer is exported from LG\_Chinook layer from the Conservation Genetics Laboratory, US Fish and Wildlife Service, Anchorage, Alaska. The layer depicts population specific Fst values computed using the method described by Foll and Gaggiotti 2006, Genetics 174:875-893 as implemented in the computer program GESTE version 2.0. Larger values (red) denote populations that are more genetically isolated whereas smaller values (green) denote populations that are less genetically isolated. The population specific values were used in an analysis to assess and compare the extent to which nine habitat features from four general categories (spatial isolation, habitat size, climate, and ecology) explain the degree of genetic isolation. The analysis was performed using GESTE version 2.0 and the nine habitat variables included: waterway distance to the coast, median pairwise waterway distance from each location to all other locations (similar to connectivity), elevation, migration difficulty (waterway distance to the coast x elevation), home subbasin area, home river length, mean annual precipitation, ecoregion, and permafrost region. The results suggest that the spatial distribution of population-specific Fst values for Chinook salmon may be partially explained by a combination of mean annual precipitation, waterway distance to the coast, and home subbasin area. No single variable was strongly correlated to the Fst values.

**Purpose:** To assess and compare the extent to which habitat features from four general categories (spatial isolation, habitat size, climate, and ecology) explain population structure in Chinook, chum and coho salmon from Norton Sound and the Yukon and Kuskokwim rivers.

### Supplemental:

**Publication Date:** October 2009

**Originator:** USFWS, Conservation Genetics Laboratory, 1011 East Tudor Road, Anchorage, Alaska 99503

### Bounding coordinates:

**West:** -166.598972

**East:** -128.543802

**North:** 67.376555

**South:** 57.789373

**Place Keywords:** Yukon River, Kuskokwim River, Norton Sound, Alaska, Yukon

**Theme Keywords:** salmon, genetics, Chinook, Chum, Coho

**Projection:** NAD\_1983\_Alaska\_Albers

**Geographic:** GCS\_North\_American\_1983

**Metadata date:** 20090827

*Geographic Resource Solutions*

# Landscape Genetics Map for Salmon in Norton Sound, Yukon and Kuskokwim Rivers

[US Fish and Wildlife Service Conservation Genetics Laboratory, Anchorage, Alaska](#)

## Title: Chinook\_Kriging

**Abstract:** This layer is exported from LG\_Chinook\_Kriging\_ClipAlb83 layer from the Conservation Genetics Laboratory, US Fish and Wildlife Service, Anchorage, Alaska. The layer depicts the predicted spatial distribution of the first principle component (PC1), which represents 31% of the total genetic variation in Chinook salmon across three watersheds (Norton Sound and the Yukon and Kuskokwim rivers) of subarctic North America. The PC1 values were derived for each population from allele frequency data and then extrapolated to the entire area (Norton Sound, and the Yukon and Kuskokwim rivers) using the ordinary kriging function in the Geostatistical Analyst tool in ArcGIS (ESRI) version 9.2. The latitudinal trend in color change suggests variation in genetic diversity occurs mainly along an east - west (or coastal - inland) axis.

**Purpose:** To assess the spatial pattern of genetic variation in Chinook salmon from Norton Sound and the Yukon and Kuskokwim rivers and to assess if the spatial patterns of genetic variation in Chinook, chum, and coho salmon are congruent.

**Supplemental:**

**Publication Date:** October 2009

**Originator:** USFWS, Conservation Genetics Laboratory, 1011 East Tudor Road, Anchorage, Alaska 99503

**Bounding coordinates:**

**West:** -169.887469

**East:** -123.459309

**North:** 69.367870

**South:** 56.914884

**Place Keywords:** Yukon River, Kuskokwim River, Norton Sound, Alaska, Yukon

**Theme Keywords:** salmon, genetics, Chinook, Chum, Coho

**Projection:** NAD\_1983\_Alaska\_Albers

**Geographic:** GCS\_North\_American\_1983

**Metadata date:** 20090827

*Geographic Resource Solutions*



# Landscape Genetics Map for Salmon in Norton Sound, Yukon and Kuskokwim Rivers

[US Fish and Wildlife Service Conservation Genetics Laboratory, Anchorage, Alaska](#)

## Title: Chinook\_Sites

**Abstract:** This layer is exported from LG\_Chinook GIS layer from the Conservation Genetics Laboratory, US Fish and Wildlife Service, Anchorage, Alaska. The layer depicts landscape genetic population groups defined by genetic and geographic data using Spatial Analysis of Molecular Variance (SAMOVA, Dupanloup et al. 2002 Molecular Ecology 11:1271-1281). This method incorporates spatial data (e.g., latitude and longitude) to group populations such that the genetic difference among populations within groups is minimized while the genetic difference among population groups is maximized. The result is often groups of populations that are both geographically and genetically distinct. Our results revealed six population groups, of which three were relatively large in terms of population number and area. The largest group (group one, 25 populations) included coastal populations from Norton Sound, the lower Yukon River and most of the Kuskokwim River. Population groups two (8 populations) and four (10 populations) were also relatively large and occurred in the middle and upper Yukon River, respectively. The remaining three groups consisted of one or two isolated inland populations. This analysis suggests that hierarchical population structure occurs primarily along a latitudinal axis (east-west) which is dominated by the Yukon River, rather than the much shorter longitudinal axis (north-south) that defines the relative position of the three major watersheds (Norton Sound and the Yukon and Kuskokwim rivers). This spatial orientation (coastal - inland) was also observed in chum and coho salmon. The layer also contains collection site data including values from overlaying environmental layers and summary genetic data (principle component, mean Fst using the method of Foll and Gaggiotti 2006 Genetics 174:875-891, mean heterozygosity) for Chinook salmon.

**Purpose:** To assess if the three major watersheds (Norton Sound and the Yukon and Kuskokwim rivers) are the primary determinant of hierarchical population structure for Chinook salmon and to assess if the patterns of hierarchical structure in Chinook, chum, and coho salmon are congruent.

### Supplemental:

**Publication Date:** October 2009

**Originator:** USFWS, Conservation Genetics Laboratory, 1011 East Tudor Road, Anchorage, Alaska 99503

### Bounding coordinates:

**West:** -166.598972

**East:** -128.543802

**North:** 67.376555

**South:** 57.789373

**Place Keywords:** Yukon River, Kuskokwim River, Norton Sound, Alaska, Yukon

**Theme Keywords:** salmon, genetics, Chinook, Chum, Coho

**Projection:** NAD\_1983\_Alaska\_Albers

**Geographic:** GCS\_North\_American\_1983

**Metadata date:** 20090827

*Geographic Resource Solutions*

# Landscape Genetics Map for Salmon in Norton Sound, Yukon and Kuskokwim Rivers

[US Fish and Wildlife Service Conservation Genetics Laboratory, Anchorage, Alaska](#)

## Title: Chum\_Fst

**Abstract:** This layer is exported from LG\_Chum layer from the Conservation Genetics Laboratory, US Fish and Wildlife Service, Anchorage, Alaska. The layer depicts population specific Fst values computed using the method described by Foll and Gaggiotti 2006, Genetics 174:875-893 as implemented in the computer program GESTE version 2.0. Larger values (red) denote populations that are more genetically isolated whereas smaller values (green) denote populations that are less genetically isolated. The population specific values were used in an analysis to assess and compare the extent to which nine habitat features from four general categories (spatial isolation, habitat size, climate, and ecology) explain the degree of genetic isolation. The analysis was performed using GESTE version 2.0 and the nine habitat variables included: waterway distance to the coast, median pairwise waterway distance from each location to all other locations (similar to connectivity), elevation, migration difficulty (waterway distance to the coast x elevation), home subbasin area, home river length, mean annual precipitation, ecoregion, and permafrost region. The results suggest that the spatial distribution of population-specific Fst values for Chinook salmon may be partially explained by a combination of mean annual precipitation and elevation. No single variable was strongly correlated to the Fst values.

**Purpose:** To assess and compare the extent to which habitat features from four general categories (spatial isolation, habitat size, climate, and ecology) explain population structure in Chinook, chum and coho salmon from Norton Sound and the Yukon and Kuskokwim rivers.

### Supplemental:

**Publication Date:** July, 2009

**Originator:** USFWS, Conservation Genetics Laboratory, 1011 East Tudor Road, Anchorage, Alaska 99503

### Bounding coordinates:

**West:** -166.509318

**East:** -130.788798

**North:** 67.186676

**South:** 58.072988

**Place Keywords:** Yukon River, Kuskokwim River, Norton Sound, Alaska, Yukon

**Theme Keywords:** salmon, genetics, Chinook, Chum, Coho

**Projection:** NAD\_1983\_Alaska\_Albers

**Geographic:** GCS\_North\_American\_1983

**Metadata date:** 20090827

*Geographic Resource Solutions*

# Landscape Genetics Map for Salmon in Norton Sound, Yukon and Kuskokwim Rivers

[US Fish and Wildlife Service Conservation Genetics Laboratory, Anchorage, Alaska](#)

## Title: Chum\_Kriging

**Abstract:** This layer is exported from LG\_Chum\_Kriging\_ClipAlb83 layer from the Conservation Genetics Laboratory, US Fish and Wildlife Service, Anchorage, Alaska. The layer depicts the predicted spatial distribution of the first principle component (PC1), which represents 43% of the total genetic variation in chum salmon across three watersheds (Norton Sound and the Yukon and Kuskokwim rivers) of subarctic North America. The PC1 values were derived for each population from allele frequency data and then extrapolated to the entire area (Norton Sound, and the Yukon and Kuskokwim rivers) using the ordinary kriging function in the Geostatistical Analyst tool in ArcGIS (ESRI) version 9.2. The latitudinal trend in color change suggests variation in genetic diversity occurs mainly along an east - west (or coastal - inland) axis.

**Purpose:** To assess the spatial pattern of genetic variation in chum salmon from Norton Sound and the Yukon and Kuskokwim rivers and to assess if the spatial patterns of genetic variation in Chinook, chum, and coho salmon are congruent.

**Supplemental:**

**Publication Date:** October 2009

**Originator:** USFWS, Conservation Genetics Laboratory, 1011 East Tudor Road, Anchorage, Alaska 99503

**Bounding coordinates:**

**West:** -169.887469

**East:** -123.459309

**North:** 69.367870

**South:** 56.914884

**Place Keywords:** Yukon River, Kuskokwim River, Norton Sound, Alaska, Yukon

**Theme Keywords:** salmon, genetics, Chinook, Chum, Coho

**Projection:** NAD\_1983\_Alaska\_Albers

**Geographic:** GCS\_North\_American\_1983

**Metadata date:** 20090827

*Geographic Resource Solutions*

# Landscape Genetics Map for Salmon in Norton Sound, Yukon and Kuskokwim Rivers

[US Fish and Wildlife Service Conservation Genetics Laboratory, Anchorage, Alaska](#)

## Title: Chum\_Sites

**Abstract:** This layer is exported from LG\_chum GIS layer from the Conservation Genetics Laboratory, US Fish and Wildlife Service, Anchorage, Alaska. The layer depicts landscape genetic population groups defined by genetic and geographic data using Spatial Analysis of Molecular Variance (SAMOVA, Dupanloup et al. 2002 Molecular Ecology 11:1271-1281). This method incorporates spatial data (e.g., latitude and longitude) to group populations such that the genetic difference among populations within groups is minimized while the genetic difference among population groups is maximized. The result is often groups of populations that are both geographically and genetically distinct. Our results revealed six population groups, of which two were relatively large in terms of population number and area. The largest group (group one, 32 populations) included coastal populations from Norton Sound, the lower Yukon River and most of the Kuskokwim River. Population group two (14 populations) was also relatively large and included populations from the middle and upper Yukon River. The remaining four groups consisted of one or two isolated populations in the upper Kuskokwim and Yukon rivers. This analysis suggests that hierarchical population structure occurs primarily along a latitudinal axis (east-west) which is dominated by the Yukon River, rather than the much shorter longitudinal axis (north-south) that defines the relative position of the three major watersheds (Norton Sound and the Yukon and Kuskokwim rivers). This spatial orientation (coastal - inland) was also observed in Chinook and coho salmon. The layer also contains collection site data including values from overlaying environmental layers and summary genetic data (principle component, mean Fst using the method of Foll and Gaggiotti 2006 Genetics 174:875-891, mean heterozygosity) for chum salmon.

**Purpose:** To assess if the three major watersheds (Norton Sound and the Yukon and Kuskokwim rivers) are the primary determinant of hierarchical population structure for chum salmon and to assess if the patterns of hierarchical structure in Chinook, chum, and coho salmon are congruent.

### Supplemental:

**Publication Date:** October 2009

**Originator:** USFWS, Conservation Genetics Laboratory, 1011 East Tudor Road, Anchorage, Alaska 99503

### Bounding coordinates:

**West:** -166.509318

**East:** -130.788798

**North:** 67.186676

**South:** 58.072988

**Place Keywords:** Yukon River, Kuskokwim River, Norton Sound, Alaska, Yukon

**Theme Keywords:** salmon, genetics, Chinook, Chum, Coho

**Projection:** NAD\_1983\_Alaska\_Albers

**Geographic:** GCS\_North\_American\_1983

**Metadata date:** 20090827

*Geographic Resource Solutions*

# Landscape Genetics Map for Salmon in Norton Sound, Yukon and Kuskokwim Rivers

[US Fish and Wildlife Service Conservation Genetics Laboratory, Anchorage, Alaska](#)

## Title: Coho\_Fst

**Abstract:** This layer is exported from LG\_Coho layer from the Conservation Genetics Laboratory, US Fish and Wildlife Service, Anchorage, Alaska. The layer depicts population specific Fst values computed using the method described by Foll and Gaggiotti 2006, Genetics 174:875-893 as implemented in the computer program GESTE version 2.0. Larger values (red) denote populations that are more genetically isolated whereas smaller values (green) denote populations that are less genetically isolated. The population specific values were used in an analysis to assess and compare the extent to which nine habitat features from four general categories (spatial isolation, habitat size, climate, and ecology) explain the degree of genetic isolation. The analysis was performed using GESTE version 2.0 and the nine habitat variables included: waterway distance to the coast, median pairwise waterway distance from each location to all other locations (similar to connectivity), elevation, migration difficulty (waterway distance to the coast x elevation), home subbasin area, home river length, mean annual precipitation, ecoregion, and permafrost region. The results suggest that the spatial distribution of population-specific Fst values for Chinook salmon may be partially explained by a combination of mean annual precipitation and median pairwise waterway distance from each location to all other locations. No single variable was strongly correlated to the Fst values.

**Purpose:** To assess and compare the extent to which habitat features from four general categories (spatial isolation, habitat size, climate, and ecology) explain population structure in Chinook, chum and coho salmon from Norton Sound and the Yukon and Kuskokwim rivers.

### Supplemental:

**Publication Date:** October 2009

**Originator:** USFWS, Conservation Genetics Laboratory, 1011 East Tudor Road, Anchorage, Alaska 99503

### Bounding coordinates:

**West:** -166.975811

**East:** -138.705063

**North:** 68.147504

**South:** 58.864537

**Place Keywords:** Yukon River, Kuskokwim River, Norton Sound, Alaska, Yukon

**Theme Keywords:** salmon, genetics, Chinook, Chum, Coho

**Projection:** NAD\_1983\_Alaska\_Albers

**Geographic:** GCS\_North\_American\_1983

**Metadata date:** 20090827

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# Landscape Genetics Map for Salmon in Norton Sound, Yukon and Kuskokwim Rivers

[US Fish and Wildlife Service Conservation Genetics Laboratory, Anchorage, Alaska](#)

## Title: Coho\_Kriging

**Abstract:** This layer is exported from LG\_Coho\_Kriging\_ClipAlb83 layer from the Conservation Genetics Laboratory, US Fish and Wildlife Service, Anchorage, Alaska. The layer depicts the predicted spatial distribution of the first principle component (PC1), which represents 75% of the total genetic variation in chum salmon across three watersheds (Norton Sound and the Yukon and Kuskokwim rivers) of subarctic North America. The PC1 values were derived for each population from allele frequency data and then extrapolated to the entire area (Norton Sound, and the Yukon and Kuskokwim rivers) using the ordinary kriging function in the Geostatistical Analyst tool in ArcGIS (ESRI) version 9.2. The latitudinal trend in color change suggests variation in genetic diversity occurs mainly along an east - west (or coastal - inland) axis.

**Purpose:** To assess the spatial pattern of genetic variation in chum salmon from Norton Sound and the Yukon and Kuskokwim rivers and to assess if the spatial patterns of genetic variation in Chinook, chum, and coho salmon are congruent.

**Supplemental:**

**Publication Date:** October 2009

**Originator:** USFWS, Conservation Genetics Laboratory, 1011 East Tudor Road, Anchorage, Alaska 99503

**Bounding coordinates:**

**West:** -169.887469

**East:** -123.459309

**North:** 69.367870

**South:** 56.914884

**Place Keywords:** Yukon River, Kuskokwim River, Norton Sound, Alaska, Yukon

**Theme Keywords:** salmon, genetics, Chinook, Chum, Coho

**Projection:** NAD\_1983\_Alaska\_Albers

**Geographic:** GCS\_North\_American\_1983

**Metadata date:** 20090827

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# Landscape Genetics Map for Salmon in Norton Sound, Yukon and Kuskokwim Rivers

[US Fish and Wildlife Service Conservation Genetics Laboratory, Anchorage, Alaska](#)

## Title: Coho\_Sites

**Abstract:** This layer is exported from LG\_coho GIS layer from the Conservation Genetics Laboratory, US Fish and Wildlife Service, Anchorage, Alaska. The layer depicts landscape genetic population groups defined by genetic and geographic data using Spatial Analysis of Molecular Variance (SAMOVA, Dupanloup et al. 2002 Molecular Ecology 11:1271-1281). This method incorporates spatial data (e.g., latitude and longitude) to group populations such that the genetic difference among populations within groups is minimized while the genetic difference among population groups is maximized. The result is often groups of populations that are both geographically and genetically distinct. Our results revealed two population groups. Group one, 20 populations) included coastal populations from Norton Sound, the lower Yukon River and most of the Kuskokwim River. Population group two (14 populations) included populations from the middle and upper Yukon River and upper Kuskokwim River. This analysis suggests that hierarchical population structure occurs primarily along a latitudinal axis (east-west) which is dominated by the Yukon River, rather than the much shorter longitudinal axis (north-south) that defines the relative position of the three major watersheds (Norton Sound and the Yukon and Kuskokwim rivers). This spatial orientation (coastal - inland) was also observed in Chinook and chum salmon. The layer also contains collection site data including values from overlaying environmental layers and summary genetic data (principle component, mean Fst using the method of Foll and Gaggiotti 2006 Genetics 174:875-891, mean heterozygosity) for coho salmon.

**Purpose:** To assess if the three major watersheds (Norton Sound and the Yukon and Kuskokwim rivers) are the primary determinant of hierarchical population structure for coho salmon and to assess if the patterns of hierarchical structure in Chinook, chum, and coho salmon are congruent.

### Supplemental:

**Publication Date:** October 2009

**Originator:** USFWS, Conservation Genetics Laboratory, 1011 East Tudor Road, Anchorage, Alaska 99503

### Bounding coordinates:

**West:** -166.975811

**East:** -138.705063

**North:** 68.147504

**South:** 58.864537

**Place Keywords:** Yukon River, Kuskokwim River, Norton Sound, Alaska, Yukon

**Theme Keywords:** salmon, genetics, Chinook, Chum, Coho

**Projection:** NAD\_1983\_Alaska\_Albers

**Geographic:** GCS\_North\_American\_1983

**Metadata date:** 20090827

*Geographic Resource Solutions*

# Landscape Genetics Map for Salmon in Norton Sound, Yukon and Kuskokwim Rivers

[US Fish and Wildlife Service Conservation Genetics Laboratory, Anchorage, Alaska](#)

## Title: Collection\_Sites

**Abstract:** This Layer is exported from LS\_Collection\_Sites GIS layer from the Conservation Genetics Laboratory, US Fish and Wildlife Service, Anchorage, Alaska. This Layer contains collection site data and values from overlaying environmental layers as well as summary genetic data (principle component, mean Fst using the method of Foll and Gagiotti 2006 Genetics 174:875-891, mean heterozygosity) for Chinook, chum, and coho salmon.

**Purpose:** To conduct a multispecies landscape genetic study of Chinook, chum, and coho salmon from three major watersheds (Norton Sound and the Yukon and Kuskokwim rivers) in subarctic North America.

**Supplemental:**

**Publication Date:** October 2009

**Originator:** USFWS, Conservation Genetics Laboratory, 1011 East Tudor Road, Anchorage, Alaska 99503

**Bounding coordinates:**

**West:** -166.975811

**East:** -127.840274

**North:** 68.147504

**South:** 57.789373

**Place Keywords:** Yukon River, Kuskokwim River, Norton Sound, Alaska, Yukon

**Theme Keywords:** salmon, genetics, Chinook, Chum, Coho

**Projection:** NAD\_1983\_Alaska\_Albers

**Geographic:** GCS\_North\_American\_1983

**Metadata date:** 20090827

*Geographic Resource Solutions*

# Landscape Genetics Map for Salmon in Norton Sound, Yukon and Kuskokwim Rivers

[US Fish and Wildlife Service Conservation Genetics Laboratory, Anchorage, Alaska](#)

## Title: Drainages

**Abstract:** Made by dissolving the preliminary 5th-level watershed delineations available here: <http://agdcftp.wr.usgs.gov/pub/projects/AWSHED/> for the Kusko and Norton Sound drainages. Only the lower Yukon followed this method where the drainage borders the other two drainages. For the remainder of the Yukon, the international drainage boundary was used. This Yukon drainage boundary is available here: <http://agdc.usgs.gov/data/usgs/water/yukon.html>

**Purpose:** To provide a cartographic reference for the approximate boundaries of the Yukon River, Kuskokwim River, and Norton Sound drainages.

**Supplemental:**

**Publication Date:** October 2009

**Originator:** Tyler G USFWS 1011 East Tudor Road, Anchorage, Alaska 99503

**Bounding coordinates:**

**West:** -168.095187

**East:** -129.180974

**North:** 69.077791

**South:** 58.626900

**Place Keywords:** Yukon River, Kuskokwim River, Norton Sound, Alaska, Yukon

**Theme Keywords:** salmon, genetics, Chinook, Chum, Coho

**Geographic:** GCS\_North\_American\_1983

**Metadata date:** 20090827

*Geographic Resource Solutions*

# Landscape Genetics Map for Salmon in Norton Sound, Yukon and Kuskokwim Rivers

[US Fish and Wildlife Service Conservation Genetics Laboratory, Anchorage, Alaska](#)

## Title: Ecoregions

**Abstract:** This data layer is a merging of the Yukon River ecoregion data for the Canadian Yukon only with Alaska ecoregion data for Norton Sound and the US Yukon and Kuskokwim rivers (USGS 1995). The USGS National Stream Quality Accounting Network (NASQAN) program studies the water quality of large rivers of the United States. From 2001 to 2005, NASQAN will study the water quality of the Yukon River. Located in Canada and Alaska, the Yukon River drains approximately 330,000 square miles and is the fourth largest watershed in North America. As part of this water quality study, a number of Geographical Information System (GIS) data sets are being created. [Edited by TG to add ecoregion names to the attribute table from values found in the metadata and the Canadian Ecological Framework (<http://sis.agr.gc.ca/cansis/nsdb/ecostrat/index.html>). Canadian Ecoregions in British Columbia were appended, they were missing from the NASQAN dataset. The dataset was then dissolved on the Ecoregion Name, primarily to consolidate cross-border regions.]

**Purpose:** The purpose of the GIS datasets of the Yukon River Basin is to provide scientists working on the Yukon River study the information needed to do basic spatial analysis. This GIS coverage is one of 16 coverages created for the Yukon study.

**Supplemental:** Procedures\_Used Ecoregions of the Yukon River Basin were created by obtaining a statewide coverage of Alaska developed by Gallant and others (1995) and obtaining a Canadian coverage of ecoregions developed by the Ecological Stratification Working Group (1995). Once these two coverages were obtained, the ecoregions of the Yukon River Basin was created by clipping the coverages with the watershed boundary of the Yukon River Basin. The Alaska coverage and the Canadian coverages were then edgematched and joined. The ecoregions coverage of the Yukon River Basin was projected into an Albers Equal Area projection with the following parameters: Projection ALBERS Units METERS Datum NAD27 Parameters: 1st standard parallel 55 00 00 2nd standard parallel 65 00 00 Central meridian -154 00 00 latitude of projection's origin 50 00 00 false easting (meters) 0.0000 false northing (meters) 0.0000 Other\_References\_Cited: Gallant, A.L., Binnian, E.F., Omernik, J.M., and Shasby, M.B., 1995, Ecoregions of Alaska: U.S. Geological Survey Professional Paper 1567, 73 p., 1 plate. Ecological Stratification Working Group, 1995, A national ecological framework for Canada: Hull, Ottawa, Agriculture and Agri-Food Canada and Environment Canada, Report and National Map, scale 1:7,500,000.

**Publication Date:** 20020522

**Originator:** Dan Long, Tim Brabets

**Bounding coordinates:**

**West:** -168.092182

**East:** -129.177327

**North:** 69.077973

**South:** 58.626998

**Place Keywords:** Yukon River Basin, Alaska, Canada

**Theme Keywords:** Basin Boundary, NASQAN, Yukon River, Ecoregions

**Geographic:** GCS\_North\_American\_1983

**Metadata date:** 20090827

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# Landscape Genetics Map for Salmon in Norton Sound, Yukon and Kuskokwim Rivers

[US Fish and Wildlife Service Conservation Genetics Laboratory, Anchorage, Alaska](#)

## Title: Flowlines

**Abstract:** Flow lines were clipped from the National Hydrography Dataset (NHD) coverage for Norton Sound, the Alaska portion of the Yukon River, and the Kuskokwim River available from <http://nhd.usgs.gov/data.html>. In addition, flow lines for the Canadian portion of the Yukon River drainage were obtained from the Canadian National Hydro Network dataset available from <http://www.geobase.ca/geobase/en/index.html>. The flow lines clipped from the two datasets were merged to form a single flow line dataset for this project.

**Purpose:** To assess and compare the extent to which habitat features from four general categories (spatial isolation, habitat size, climate, and ecology) explain population structure in Chinook, chum and coho salmon from Norton Sound and the Yukon and Kuskokwim rivers.

**Supplemental:**

**Publication Date:** October, 2009

**Originator:** USFWS, Conservation Genetics Laboratory

**Bounding coordinates:**

**West:** -169.745776

**East:** -124.287846

**North:** 69.312060

**South:** 57.421113

**Place Keywords:** Yukon River, Kuskokwim River, Norton Sound, Alaska, Yukon

**Theme Keywords:** salmon, genetics, Chinook, Chum, Coho

**Projection:** NAD\_1983\_Alaska\_Albers

**Geographic:** GCS\_North\_American\_1983

**Metadata date:** 20090827

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# Landscape Genetics Map for Salmon in Norton Sound, Yukon and Kuskokwim Rivers

[US Fish and Wildlife Service Conservation Genetics Laboratory, Anchorage, Alaska](#)

## Title: Quaternary Glaciations - Extent and Chronology, Volume 2: Part II: North America

**Abstract:** Maximum extent of the most recent glaciation (~20,000 yr bp). This dataset was distributed with Quaternary Glaciations - Extent and Chronology, Volume 2: Part II: North America, eds. Jürgen Ehlers; Philip L Gibbard. This book is the second of three volumes in which the recent knowledge of the extent and chronology of Quaternary glaciations has been compiled on a global scale. The glacial limits were mapped in ArcView, the Geographical Information System (GIS) used by the work group. Included with the publication is a CD with digital maps, showing glacial limits, end moraines, ice-dammed lakes, glacier-induced drainage diversions and the locations of key sections through which the glacial limits are defined and dated. The last deglaciation is also shown in 500 year time-steps. The digital maps in this volume cover the USA and Canada and include Greenland and Hawaii. Both overview maps and more detailed maps at a scale 1: 1,000,000 are provided.

**Purpose:** This information is seen as a fundamental requirement, not only for the glacial community, but for the wider user-community of general Quaternary workers. In particular the need for accurate ice-front positions is a basic requirement for the rapidly growing field of palaeoclimate modelling. In order to provide the information for the widest-possible range of users in the most accessible form, a series of digital maps was prepared.

**Supplemental:** Maximum extent of the most recent glaciation (~20,000 yr bp). This dataset was distributed with Quaternary Glaciations - Extent and Chronology, Volume 2: Part II: North America, eds. Jürgen Ehlers; Philip L Gibbard.

**Publication Date:** July 29, 2004

**Originator:** Quaternary Glaciations - Extent and Chronology, Volume 2: Part II: North America, eds. Jürgen Ehlers; Philip L Gibbard.

**Bounding coordinates:**

**West:** -167.280469

**East:** -129.180974

**North:** 69.077791

**South:** 58.938910

**Place Keywords:**

**Theme Keywords:** glacial extent

**Geographic:** GCS\_North\_American\_1983

**Metadata date:** 20090827

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# Landscape Genetics Map for Salmon in Norton Sound, Yukon and Kuskokwim Rivers

[US Fish and Wildlife Service Conservation Genetics Laboratory, Anchorage, Alaska](#)

## Title: Permafrost\_Regions

**Abstract:** The Circum-Arctic permafrost and ground ice map is available via ftp in ESRI Shapefile format and Equal-Area Scalable Earth Grid (EASE-Grid) format. See the Format section for an explanation of the files provided via ftp. The circumpolar permafrost and ground ice data contribute to a unified international data set that depicts the distribution and properties of permafrost and ground ice in the Northern Hemisphere (20°N to 90°N). The re-gridded data set shows discontinuous, sporadic, or isolated permafrost boundaries. Permafrost extent is estimated in percent area (90-100%, 50-90%, 10-50%, <10%, and no permafrost). Relative abundance of ground ice in the upper 20 m is estimated in percent volume (>20%, 10-20%, <10%, and 0%). The data set also contains the location of subsea and relict permafrost. The gridded data are gridded at 12.5 km, 25 km, and 0.5 degree resolution. The shapefiles were derived from the original 1:10,000,000 paper map (Brown et al. 1997). Permafrost, or permanently frozen ground, is ground (soil, sediment, or rock) that remains at or below 0°C for at least two years (Permafrost Subcommittee, 1988). It occurs both on land and beneath offshore arctic continental shelves, and underlies about 22% of the Earth's land surface. For more information on the creation of the original map, see Heginbottom et al. (1993). The original paper map also includes information on the relative abundance of ice wedges, massive ice bodies and Pingos, ranges of permafrost temperature and thickness (Brown et al. 1997).

**Purpose:** scientific research

**Supplemental:**

**Publication Date:** 20020201

**Originator:** Brown, J., O.J. Ferrians, Jr., J.A. Heginbottom, and E.S. Melnikov.

**Bounding coordinates:**

**West:** -168.092182

**East:** -129.177327

**North:** 69.077973

**South:** 58.626998

**Place Keywords:** Geographic Region > Polar > Circumpolar

**Theme Keywords:** EARTH SCIENCE > Cryosphere > Frozen Ground > Ground Ice, EARTH SCIENCE > Cryosphere > Frozen Ground > Permafrost, EARTH SCIENCE > Land Surface > Frozen Ground > Ground Ice, EARTH SCIENCE > Land Surface > Frozen Ground > Permafrost, geoscientificinformation, imageryBaseMapsEarthCover, Boreholes, Continuous Permafrost, Discontinuous Permafrost, Mapping, Permafrost Extent

**Geographic:** GCS\_North\_American\_1983

**Metadata date:** 20090827

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# Landscape Genetics Map for Salmon in Norton Sound, Yukon and Kuskokwim Rivers

[US Fish and Wildlife Service Conservation Genetics Laboratory, Anchorage, Alaska](#)

## Title: Precipitation\_Regions

**Abstract:** This data layer is a merging of the Yukon River precipitation data for the Canadian Yukon only with Alaska precipitation data for Norton Sound and the US Yukon and Kuskokwim rivers. The USGS National Stream Quality Accounting Network (NASQAN) program studies the water quality of large rivers of the United States. From 2001 to 2005, NASQAN will study the water quality of the Yukon River. Located in Canada and Alaska, the Yukon River drains approximately 330,000 square miles and is the fourth largest watershed in North America. As part of this water quality study, a number of Geographical Information System (GIS) data sets are being created.

**Purpose:** The purpose of the GIS datasets of the Yukon River Basin is to provide scientists working on the Yukon River study the information needed to do basic spatial analysis. This GIS coverage is one of 16 coverages created for the Yukon study.

**Supplemental:** Procedures\_Used The coverage of precipitation regions for the Yukon River Basin was created by using a coverage of precipitation developed by Jones and Fahl (1994). This precipitation coverage includes both Alaska and northwest Canada. Using the watershed boundary of the Yukon River Basin, the precipitation regions for the Yukon River Basin were clipped from the Jones and Fahl coverage. The coverage was then projected into an Albers Equal Area projection with the following parameters: Projection ALBERS Units METERS Datum NAD27 Parameters: 1st standard parallel 55 00 00 2nd standard parallel 65 00 00 Central meridian -154 00 00 latitude of projection's origin 50 00 00 false easting (meters) 0.0000 false northing (meters) 0.0000 Other\_References\_Cited: Jones, S.H., and Fahl, C.B., 1994, Magnitude and frequency of floods in Alaska and conterminous basins of Canada: U.S. Geological Survey Water-Resources Investigations Report 93-4179, 122 p. + 2 pl.

**Publication Date:** 20020522

**Originator:** Dan Long, Tim Brabets

**Bounding coordinates:**

**West:** -168.091674

**East:** -129.177327

**North:** 69.077973

**South:** 58.626998

**Place Keywords:** Yukon River Basin, Alaska, Canada

**Theme Keywords:** Basin Boundary, NASQAN, Yukon River, Precipitation

**Geographic:** GCS\_North\_American\_1983

**Metadata date:** 20090827

*Geographic Resource Solutions*

# Landscape Genetics Map for Salmon in Norton Sound, Yukon and Kuskokwim Rivers

[US Fish and Wildlife Service Conservation Genetics Laboratory, Anchorage, Alaska](#)

## Title: Subbasins

**Abstract:** Created by Tyler G for cartographic use. Made by dissolving the preliminary 5th-level watershed delineations available here:

<http://agdcftp.wr.usgs.gov/pub/projects/AWSHED/> for the Kuskokwim and Norton Sound drainages. Only the lower Yukon followed this method where the drainage borders the other two drainages. For the remainder of the Yukon, the international drainage boundary was used. This Yukon drainage boundary is available here:  
<http://agdc.usgs.gov/data/usgs/water/yukon.html>

**Purpose:** To provide a cartographic reference for the approximate boundaries of the 4th-level subbasins within the Yukon River, Kuskokwim River, and Norton Sound drainages.

### Supplemental:

**Publication Date:** REQUIRED: The date when the data set is published or otherwise made available for release.

**Originator:** REQUIRED: The name of an organization or individual that developed the data set.

### Bounding coordinates:

**West:** -168.095187

**East:** -129.183590

**North:** 69.077750

**South:** 58.630550

**Place Keywords:** Yukon River, Kuskokwim River, Norton Sound, Alaska, Yukon

**Theme Keywords:** salmon, genetics, Chinook, Chum, Coho

**Geographic:** GCS\_North\_American\_1983

**Metadata date:** 20090827

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