Attachment #5: Temperature Estimate Methods

Attachment 5: Temperature Calculation Memos (P. Leinenbach to Rochelle Labiosa, USEPA, Jan 2021) describing methods used to measure stream temperature conditions along designated Critical Habitats in Idaho including: 1) create subsets of temperature sensor locations, 2) summarized temperature sensor data, and 3) estimate temperatures (daily means and maximums) of Critical Habitat streams by stream order. This process was conducted for each of 6 salmonid critical habitats (Spring/summer Chinook, Fall Chinook, Steelhead, Sockeye, Bulltrout FMO, and Bulltrout SR). One memo for each Critical Habitat is included in this Attachment.

Attachment #5: Temperature Estimate Methods

Memorandum January 10, 2022

To: Rochelle Labiosa R10USEPA, and Lil Herger R10USEPA

From: Peter Leinenbach R10USEPA

Subject: Measured stream temperature conditions along designated Spring/Summer Chinook Critical Habitat (SSC_CH) streams in Idaho.

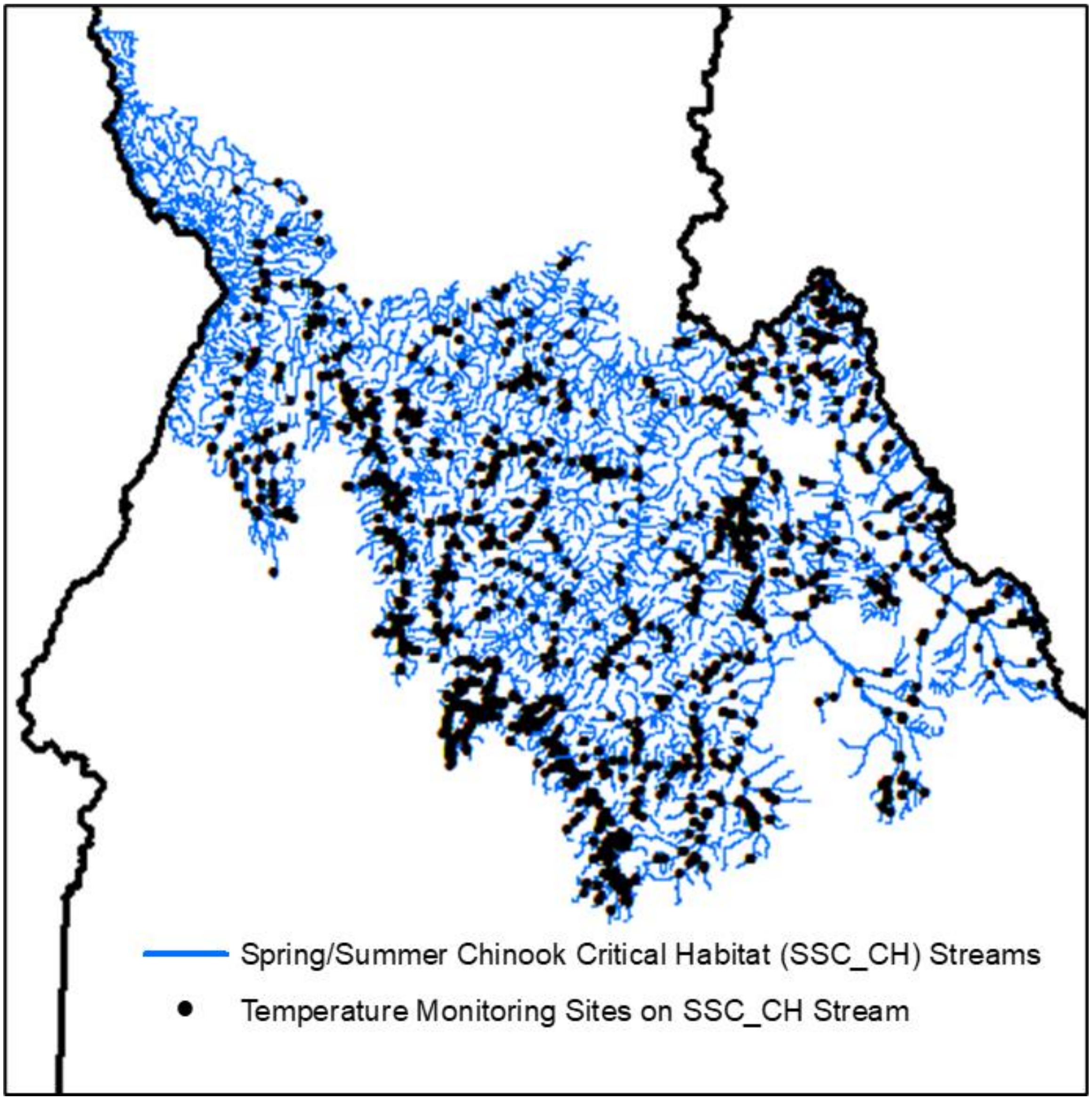
There are approximately 15,898 kilometers of streams in Idaho that are designated as Spring/Summer Chinook Critical Habitat (SSC_CH) (**Figure 1**). There are 1,667 individual temperature monitoring locations (n) situated along designated SSC_CH streams in Idaho, and these sites contain 4,447 seasons of data (n'). Observed stream temperatures at these sites reached maximums during the summer period and stream temperatures were generally warmer at sites with larger stream order designations (**Figure 2**).

Approximately 34% of Idaho SSC_CH streams are also classified as Salmon Spawning Designated Use (SalSpa_DU), which corresponds to approximately 5,397 stream kilometers of streams (see purple lines in top image in **Figure 3**). (Alternatively, approximately 10,501 kilometers (i.e., 66%) of designated SSC_CH streams are **not** also classified as SalSpa_DU (see grey lines in top image in **Figure 3**).) Approximately 37% of the temperature monitoring sites along SSC_CH are situated on stream reaches that are also designated as a SalSpa_DU streams, which corresponds closely to the distribution of stream overlap between these two stream classifications (i.e., 34%).

Observed temperatures were slightly warmer for SSC_CH sites also designated as a SalSpa_DU stream, as compared to SSC_CH sites **not** located along SalSpa_DU designated streams (**Figure 4**). This result is likely due to different stream order distributions associated with these two groups (see bottom image in **Figure 3).** That is, the weighted average stream order associated with temperature monitoring sites located on designated SSC_CH/SalSpa_DU streams was 3.1, while it was 2.7 at temperature sites located on streams only designated as SSC_CH.

Attachment #5: Temperature Estimate Methods

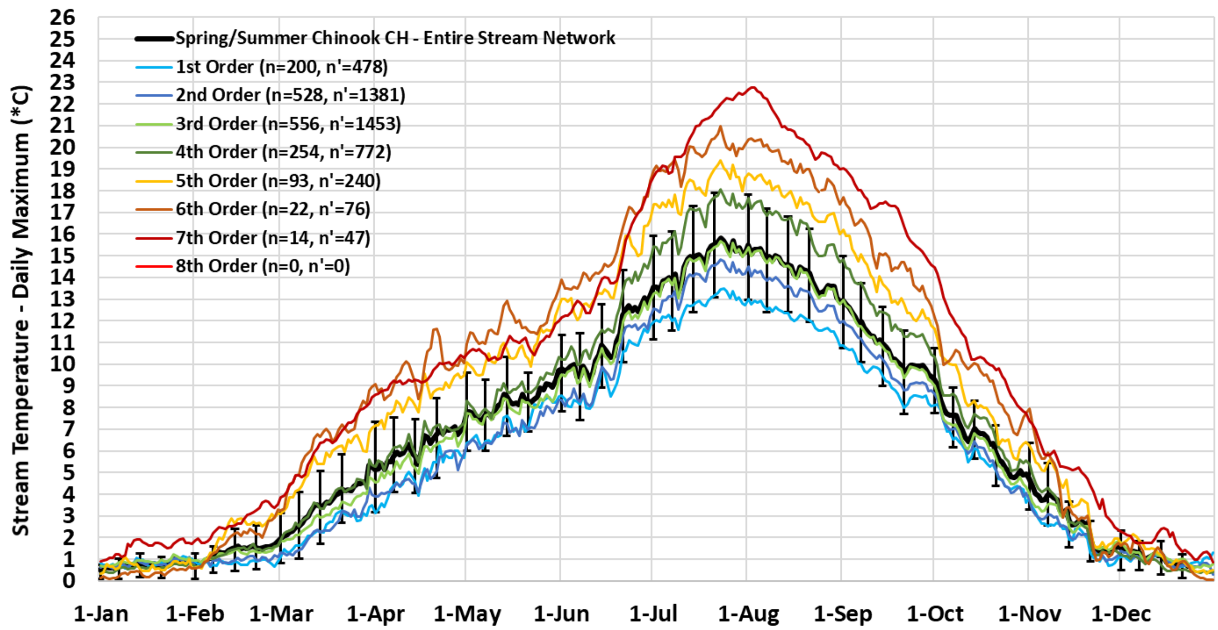
Figure 1. Designated Spring/Summer Chinook Critical Habitat Streams (SSC_CH) in Idaho, and temperature monitoring locations along these stream reaches.

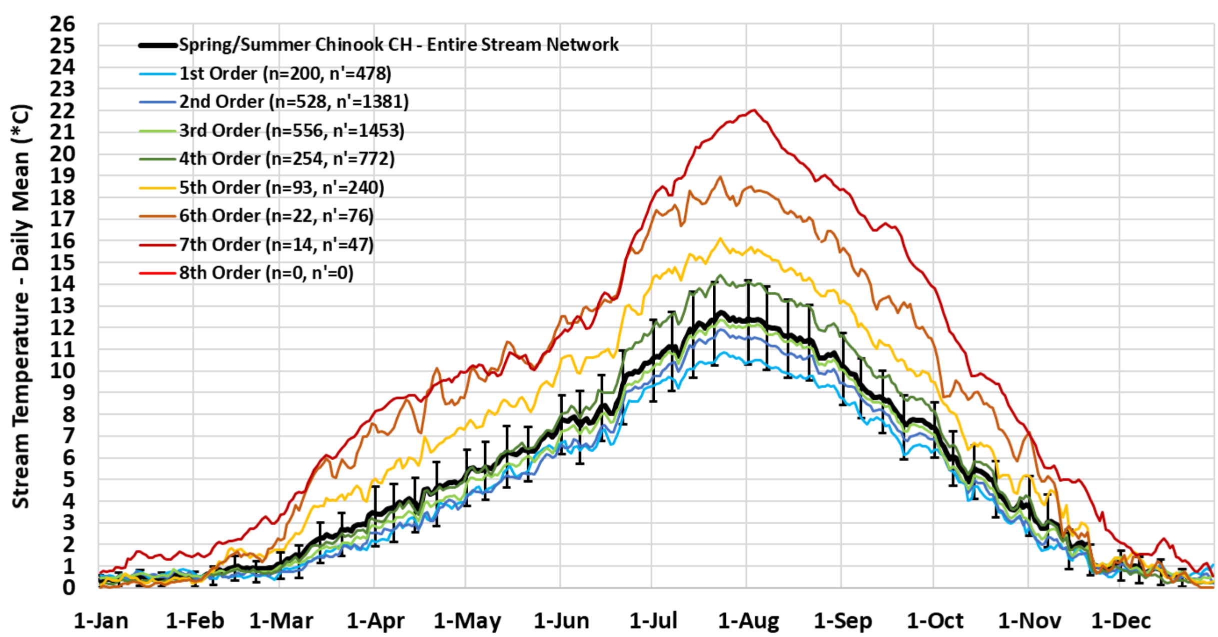


Attachment #5: Temperature Estimate Methods

Figure 2. Seasonal stream temperature distribution, reported by Stream Order, observed at monitoring sites along designated Spring/Summer Chinook Critical Habitat (SSC_CH) streams in Idaho between 1994 through 2016

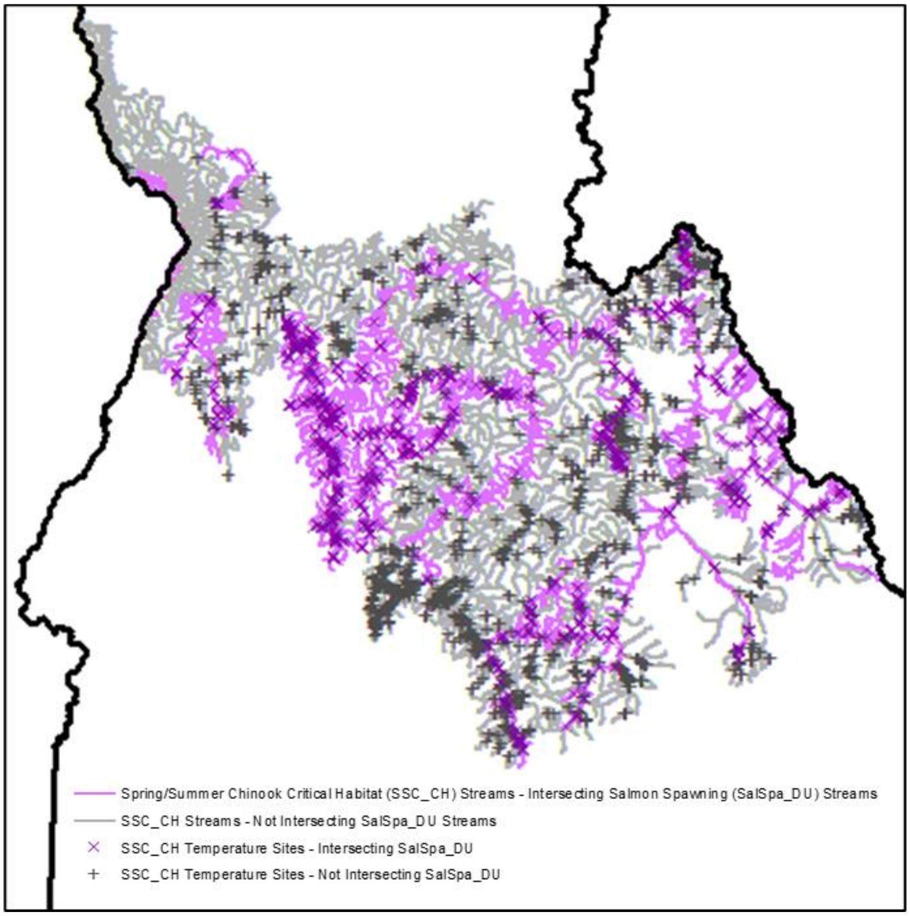
[Top image illustrates Daily Maximum Temperatures and bottom image daily mean temperatures. n represents the number of sites and n' represents the number of seasons of data for each stream order. The bars represent 75th and 25th percentile values, and these percentile values are reported for the 1st, 7th, 14th, and 21st day of the month]

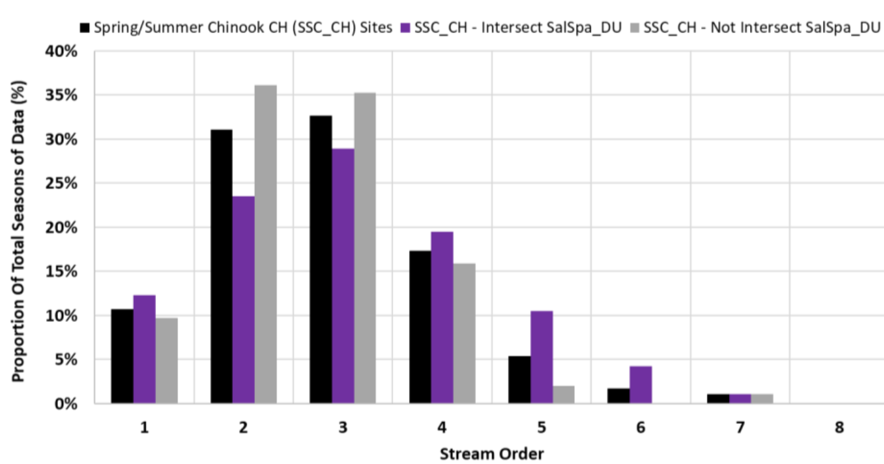




Attachment #5: Temperature Estimate Methods

Figure 3. Designated Spring/Summer Chinook Critical Habitat Streams (SSC_CH) in Idaho, temperature monitoring locations along these streams (1994 through 2016), reported as either 1) Intersected or 2) Not Intersected Salmon Spawning Designated Use (SalSpa_DU) streams, and the proportional distribution of these sites based on Stream Order.

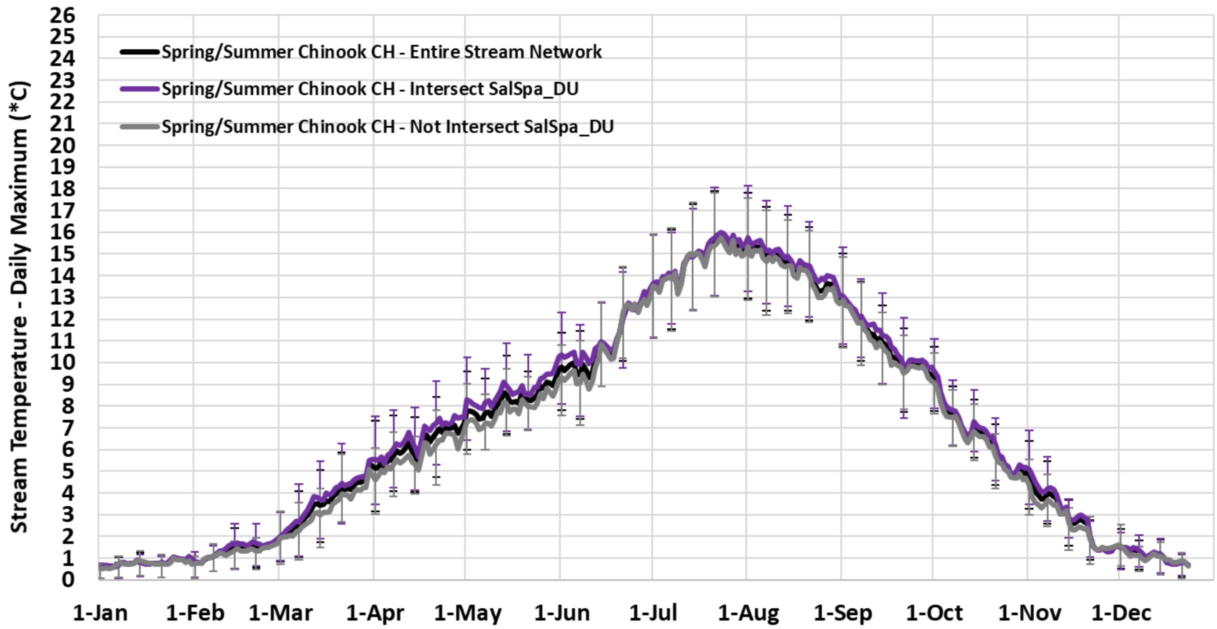


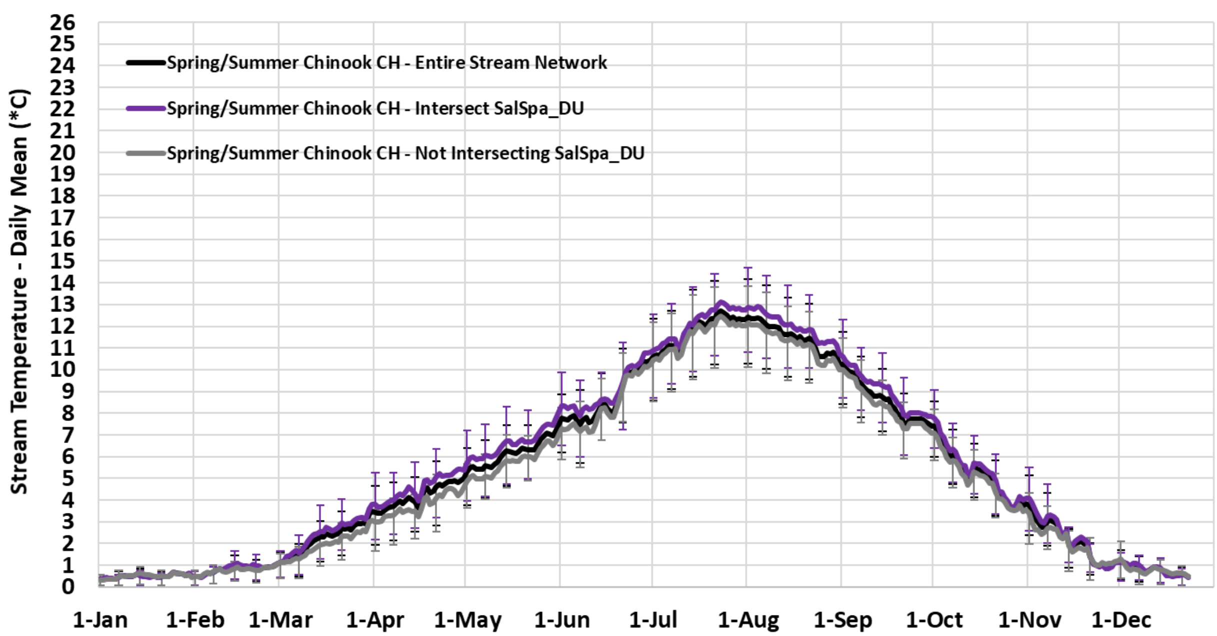


Attachment #5: Temperature Estimate Methods

Figure 4. Seasonal stream temperature distribution observed at monitoring sites along Spring/Summer Chinook Critical Habitat (SSC_CH) streams in Idaho between 1994 through 2016

[Top image illustrates Daily Maximum Temperatures and bottom image daily mean temperatures. The bars represent 75th and 25th percentile values, and these percentile values are reported for the 1st, 7th, 14th, and 21st day of the month]





Attachment #5: Temperature Estimate Methods

Methods

Unless otherwise stated below, all processing steps outlined below were implemented using available tools and extensions in ArcGIS 10.3.

Datasets

Critical Habitat (CH) shapefiles for the various species were obtained from the R10 SharePoint site - https://usepa.sharepoint.com/sites/R10/wqsu/SitePages/Home.aspx?RootFolder=%2Fsites%2FR10%2Fwqsu%2FShared%20Documents%2FWQS%20Idaho%2FTemperature%20ESA%2FCritical%20Habitat%20GIS&FolderCTID=0x0120006895FD0A08B1174780732435DE1E031E&View=%7B8572996D%2D7BCB%2D44F3%2D9728%2D9F5D06EAEADB%7D (Zipped files in the folder named – "Critical Habitat GIS").

Beneficial Uses (BU) shapefiles for "Cold", Warm" and "Salmon Spawning" stream designations were obtained from the same R10 SharePoint site used to obtain the CH shapefiles. (Files in the subfolder – "Bundle_BE_IDTemperature/Data/IDAPA").

Temperature Data and sampling location shapefiles were downloaded from the NorWeST website - www.fs.fed.us/rm/boise/AWAE/projects/NorWeST/StreamTemperatureDataSummaries.shtml. This data contains information from 1994 to 2011.

Obtained an additional temperature database from the USFS group responsible for the NorWeST project and this data contain information from 2011 through 2016.

Calculating Overlap Between Critical Habitat and Designation Uses -

The specifics of the steps outlined below reflect the fact that the topology is different between the Critical Habitat (CH) shapefile and the Salmon Spawning Designated Use (SalSpa_DU) shapefile (That is, CH shapefiles do not line up with the SalSpa_DU shapefile). Accordingly, it was not possible to do a simple overlay to determine overlap distance/length between the datasets, however the steps outlined below provided an estimate of the percentage of overlap between these datasets despite these topology issues. (Note – steps listed below are processed for each of the CH stream shapefile (i.e., Bull Trout SR, Bull Trout FMO, and Bull Trout Unknown, Steelhead, Chinook, etc).

The SalSpa_DU designations were used for all of the CH comparisons. However, for Bull Trout CH designations (i.e., SR, FMO, Unknown), two additional overlap designations were determined in addition to the SalSpa_DU comparison: 1) overlap of Idaho State Rule Waters Designated Use (ISRW_DU) with BT_CH, and 2) overlap of ISRW_DU and SalSpa_DU with BT_CH.

The first step is to create points at equal distances along the CH shapefile through the following steps:

1) Make sure the CH shapefile is the same projection as the DU stream shapefile that will be used in the comparisons described below.
2) Create one line feature of the multiple part CH shapefile: Create a new column in the CH shapefile's VAT and populate the added column with the same value/text. Use this added column as a unique identifier in the Dissolve tool (i.e., Dissolve the multipart line into one line segment). It was important to separate the Bull Trout CH shapefile into three separate shapefiles based on the values in the "H_Use_Type" column. i.e., SR, FMO, UKN) and these use these values as the unique identifier in the dissolve tool.

Attachment #5: Temperature Estimate Methods

3) Create a point shapefile in ArcCatalog and define the projection as the other CH shapefile.
4) Add this created point shapefile and the created dissolved line shapefile to a new ArcMap project.
5) Make sure to select the point shapefile in the TOC (This will not show any points in the project but this is needed for the next step).
6) Start editing the point shapefile and select the "Create Feature" feature in the edit tool, and make sure that the point shapefile is selected in the opened feature.
7) Then select the line feature using the select tool (all of the lines will be highlighted because will merged the lines to a single line in the second step above)
8) Then select the "Construct Points…" tool in the edit tool dropdown and use 30-meter point creation distance, and save edits after processing. (The computer/program was able to process 30 meter point distance, but was having problems with a finer resolution.)
9) Open the newly created point shapefile in a new ArcMap project and create a new column (Long Integer) and populate the column with the FID attribute in the VAT. This column will be used to join the sampling results produced below in the two shapefiles into one shapefile (This was done because FID columns can be subsequently modified by ArcMap processes without user input and the FID was the unique Identifier produced in the steps listed above.)

The next step is to "move" these created points representing the "Critical Habitat" shapefile to the CH shapefiles (once again, these two shapefiles have a different topology). This step was accomplished using the "Near" tool using the following steps:

1) Open a new ArcMap project and add 1) **<u>a copy of</u>** the point shapefile representing the Critical Habitat that was created in the previous step and 2) the SalSpa_DU line shapefile (make sure that they are the same projection). (Use a copy of the point shapefile because this tool will modify the VAT of the point shapefile and you will be using this file for another "near" assessment with BT_CH layers.)
2) Open the "Near" tool and designate that point shapefile is "Input Feature" and the other shapefile is the "Near Feature". Set the "Search Radius" to 100 meters (Visual inspection of the these datasets indicated that generally the maximum distance in topology between these datasets was around 100 meters) and select the "Location" option (This will create X,Y values for each moved point and this information could be used to plot the locations of the moved points in the future).
3) Create a new column (Float) in the shape after running this tool and populate this column with the "NEAR_Dist" attribute - Give the column a more informative name, something like "NearSalSpa", because it will be necessary join two shapefiles for the BT_CH comparisons and need to have unique column names.

The "Near" tool will create three new columns in the VAT of the point shapefile "Near_Dist", "Near_X" and "Near_Y", which represent the distance between the point and the target shapefile, and the Longitude and Latitude of the moved points, respectively. Importantly, this tool will attribute "-1" for points that are located further than 100 meters from the "target" within the created columns. In other words, these "-1" points indicate locations where there is not an overlap between the two shapefiles. Using the proportions of these points provides a means to estimate the precent overlap between the two shapefiles.

Attachment #5: Temperature Estimate Methods

<u>Supplementing sampling location information</u>

The steps below will add attribute information into the monitoring location shapefile. Adding this information at this step will result in useful information to support subsequent assessments described below. Methods used to calculate three added attributes (i.e., Stream Order, Elevation, and Level 2 and 3 Ecoregions) for each sampling location are described below.

<u>Stream Order Sampling</u>

The Idaho NHD Flowlines shapefile for Idaho was downloaded from the USGS site was separated into four shapefiles. The first step was to merge these four shapefiles into one shapefile by using the "merge" tool. It can be important to let the file save to the default geodatabase location (Saving results of large processing step not within the default geodatabase can result in processing errors).

The next step is to clip out any streams located outside of the Idaho state boundary. Use a projected (same projection as the NHD Flowlines shapefile) state boundary shapefile to clip out all streams located outside of Idaho through using the "clip" tool. It can be important to let the file save to the default geodatabase location (Saving results of large processing step not within the default geodatabase can result in processing errors).

Using the "Project" tool, the next step is to re-project the clipped Flowline stream shapefile to the projection of the NorWeST shapefiles. It can be important to let the file save to the default geodatabase location (Saving results of large processing step not within the default geodatabase can result in processing errors).

Download the NHDPlus attributes files (https://www.epa.gov/waterdata/get-nhdplus-national-hydrography-dataset-plus-data#v2datamap) and join the "PlusFlowLineVAA.dbf" file to the new ArcMap project. Then add the projected FlowLine shapefile that was produced in the previous step to the ArcMap project. Using the "Join" tool, join the PlusFlowLineVAA.dbf attribute information to the VAT of the shapefile using the "Reach Code" attribute – make sure to use the "Keep all Records" option with this tool. Save this joined shapefile as a new shapefile. Finally, delete the processing steps described above (They take a lot of memory space on the disc and these preliminary result files will not be used in subsequent steps).

The next step is to "move" points in the monitoring location shapefile in order to subsequently "sample" the stream order information to these monitoring locations. This step was necessary because these two shapefiles have a different topology and therefore do not line exactly on top of each other. This step was accomplished using the "Near" tool using the following steps: 1) Open a new ArcMap project and add 1) **<u>a copy of</u>** the point shapefile representing the monitoring locations and 2) the Stream Order line shapefile created above (make sure that they are the same projection). (Use a copy of the point shapefile because this tool will modify the VAT of the point shapefile.) 2) Open the "Near" tool and designate that point shapefile is "Input Feature" and the line shapefile is the "Near Feature". Set the "Search Radius" to 100 meters (Visual inspection of the these datasets indicated that generally the maximum distance in topology between these datasets was around 100 meters) and select the "Location" option (This will create X,Y values for each moved point and this information could be used to plot the

locations of the moved points in the future). The "Near" tool will create three new columns in the VAT of the point shapefile "Near_Dist", "Near_X" and "Near_Y", which represent the distance between the point and the target shapefile, and the Longitude and Latitude of the moved points, respectively. Importantly, this tool will attribute "-1" for points that are located further than 100 meters from the "target" within the created columns. In other words, these "-1" points indicate locations where there is not an overlap between the two shapefiles. Export the VAT from the point shapefile implemented in the previous step as a table (.csv). Add this file to the ArcMap project and use the "Display x,y" tool on this file to create an event shapefile through using the Near_X and Near_Y attributes created in the previous step. Save this event as a new shapefile. In a new ArcMap project, add the "near" monitoring point shapefile created above and the stream order line shapefile. Using the "Spatial Join" tool, sample the stream order attribute into the monitor point shapefile. These shapefiles should not be located on top of each other as a result of the previous step and therefore do not need to include a search radius with this tool (Do not use search radius with the "Spatial Join" tool because it does not sample the nearest segment if there is more than segment that is located within the search radius, while the "Near" picks the nearest segment.)

At "-1" sites, the Stream Order attribute were manually populated based on visual review of the stream order shapefile. In addition, there are several segments in the PlusFlowLineVAA.dbf database that report "0" stream order and monitoring locations with a reported "0" stream order was also manually sampled. This last manual step can take a lot of time to implement.

<u>Elevation Sampling</u>

Downloaded the NHDPlus DEM files Version (https://nhdplus.com/NHDPlus/NHDPlusV1_home.php) and mosaic them together for the state of Idaho. It is important to use version 1 because stream lines are not burned into this version of the DEM. Make sure that the project of the NorWeST point shapefiles is identical to the DEM file. Using the "Sampling" tool sample the DEM for each point shapefile – make sure to use the default setting in this tool (i.e., output location, nearest sample, and unique Identifier as the FID) because this tool can sometimes not work correctly if any changes to these settings are implemented. Join the results of the sampling tool to the VAT of the NorWeST point shapefile in the previous step (i.e., Stream Order is added to the VAT) and save as new shapefile. Convert the values to meters by creating a "float" column in the newly created shapefile VAT and make the conversion calculation for this new column.

<u>Ecoregion Sampling</u>

Download the Level III Ecoregion shapefile (https://www.epa.gov/eco-research/ecoregions-north-america). Project this shapefile to that of the NorWeST sampling point shapefiles. Remove all columns in the VAT of the projected shapefile except for NA_L2KEY, and NA_L3KEY. Then run a spatial join between the NorWeST sampling point shapefiles created in the previous step with the projected Ecoregion shapefile (i.e., move the attributes from the Ecoregion VAT to the VAT of the NorWeST shapefile VAT.)

Attachment #5: Temperature Estimate Methods

Subsampling the Temperature Databases

The steps listed below will subsample the temperature databases in order to evaluate the temperature difference between different stream conditions (i.e., critical habitat, designated uses). The temperature databases are separated into 5 parts and many of the steps listed below need to be repeated for each database part.

The first step is to select all monitoring points located along the Critical Habitat shapefile (for example, Steelhead Critical Habitat) using the following steps. Using the "Select by Location" tool, select NorWeST sites in the modified shapefiles (i.e., containing Stream Order, Elevation, Ecoregion information) that are located within 30 meters of the Critical Habitat line shapefile and save as a new shapefile. This created point shapefile represents all of the monitoring locations situated on Critical Habitat stream designation.

This new shapefile is subsequently subsampled to refine the categories to critical habitat monitoring sites located on Salmon Spawning Designated Uses (SalSpa_DU) steams or not so. Once again, use the Select by Location" tool to select sites created in the step above that also are located within 100 meters of SalSpa_DU stream designation. Save this file as a new shapefile. Switch the selected sites to develop a shapefile with sites that are not associated with SalSpa_DU stream designation. Save this file also.

Using these subsetted monitoring point location shapefiles, the temperature databases were subsetted using the following steps.

The temperature databases are MS Excel format but this format does not merge well into ArcGIS (This information needs to be added to ArcGIS project during the next sampling steps). This conversion step is implemented using MS Access because of row limitations within MS Excell can truncate the dataset and therefore result in lost data. First, open MS Assess and Import the Excel file containing the temperature data into a new Access project (i.e., "New Data Sources from File"). Open the added table in the Access database and highlight all cells in the table, and then export the added file to a dbase format (i.e., ".dbf") using the "Export to dbase file" in MS Assess.

Load the temperature database dbf file into a new ArcMap project and then add the subset point shapefiles created above. Run the "Join Data" tool between the temperature database and one of the subsetted shapefile (use OBSRED_ID for NorWeST databases, and SBSP_ID for the USFS post 2011 database) – Make sure that "Keep only Matching Records" is selected in the tool. After each join, save the database as a new table. Remove the join and repeat for the other subsetted point shapefile.

Slightly different methods for the Post 2011 Temperature sites were required because this database was organized slightly differently than the NorWeST database. Specifically, it was necessary to also add an additional attribute to this point shapefile – The "PERMAFID" is the unique site identifier and is going to be subsequently used to join temperature information between the two temperature databases. Specifically, the unique site attribute (i.e., PERMA_FID) was not included with the point shapefile associated with the Post 2011 data. The steps described below outline how the PERMA_FID attribute was assigned for these post-2011 sites.

> In a new ArcMap project, load the Original NorWeST point shapefile for an assessment area (i.e., Clearwater). Delete all attributes in the VAT except for the "PERMA_FID" column. Then add the point shapefile associated with the post-2011 sites (i.e., the created shapefile above with stream

order, elevation, and Ecoregion included in the VAT). Make sure that the projections are the same between the two datasets. Run Spatial Join on the two datasets in order to copy attributes from the original NorWeST VAT to the other datasets, using a 30m search radius for the tool. All sites with a value in the PERMA_FID column of the joined shapefile are sites that have data for both per and post 2011 data. All sites without any information in this column are only post 2011 sites and a unique PERMA_FID value is required for these sites - the PERMA_FID was assigned a unique value (something like - 900000 plus the "CBSP_ID" value), so that we can know that these sites were not associated with pre2011 values (i.e., any PERMA_FID value that is greater than 900,000). (Finally, spot check if the join worked correctly by comparing the two "Permanent_" columns in the final VAT – one version comes from each shapefile and these values should be the same).

Each subsetted temperature database is opened in Microsoft Excel and pivot tables were used to summarize the temperature data associated with these sites.

Attachment #5: Temperature Estimate Methods

Memorandum January 7, 2022

To: Rochelle Labiosa R10USEPA, and Lil Herger R10USEPA

From: Peter Leinenbach R10USEPA

Subject: Measured stream temperature conditions along designated Fall Chinook Critical Habitat (FallC_CH) streams in Idaho.

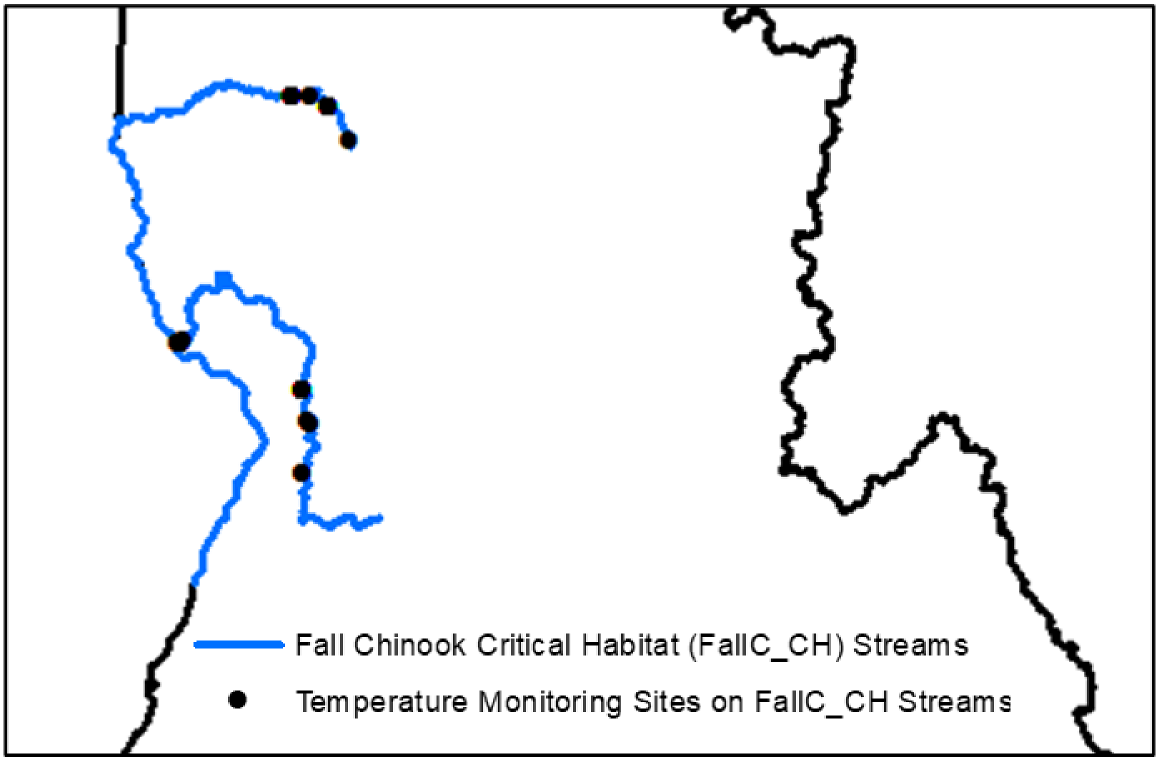
There are approximately 434 kilometers of streams in Idaho that are designated as Fall Chinook Critical Habitat (FallC_CH) (**Figure 1**). There are 15 individual temperature monitoring locations (n) situated along designated StH_CH streams in Idaho, and these sites contain 74 seasons of data (n'). Observed stream temperatures at these sites reached maximums during the summer period and stream temperatures were generally warmer at sites with larger stream order designations (**Figure 2**).

Approximately 41% of Idaho FallC_CH streams are also classified as Salmon Spawning Designated Use (SalSpa_DU), which corresponds to approximately 177.9 stream kilometers of streams (see purple lines in top image in **Figure 3**). (Alternatively, approximately 256.1 kilometers (i.e., 59%) of designated FallS_CH streams are **not** also classified as SalSpa_DU (see grey lines in top image in **Figure 3**).) Approximately 61% of the temperature monitoring sites along FallC_CH are situated on stream reaches that are also designated as a SalSpa_DU streams.

Observed temperatures were cooler for FallC_CH sites also designated as a SalSpa_DU stream, as compared to FallC_CH sites **not** located along SalSpa_DU designated streams (**Figure 4**). This result is likely due to different stream order distributions associated with these two groups (see bottom image in **Figure 3).** That is, the weighted average stream order associated with temperature monitoring sites located on designated StH_CH/SalSpa_DU streams was 6.4, while it was 7.0 at temperature sites located on streams only designated as StH_CH.

Attachment #5: Temperature Estimate Methods

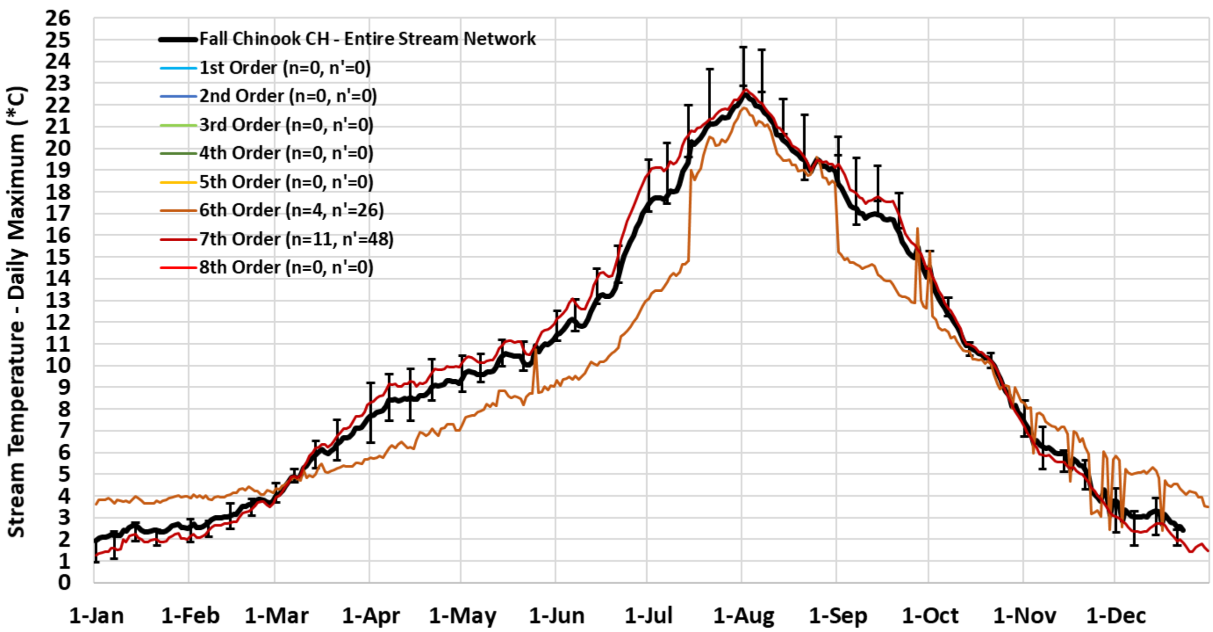
Figure 1. Designated Fall Chinook Critical Habitat Streams (FallC_CH) in Idaho, and temperature monitoring locations along these stream reaches.

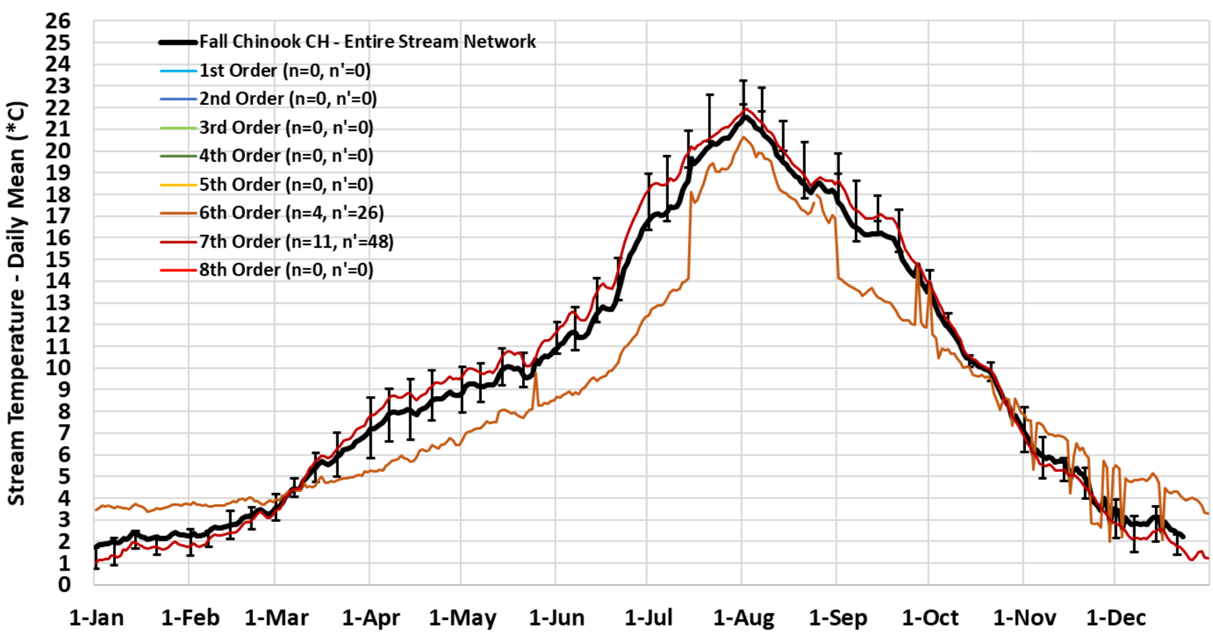


Attachment #5: Temperature Estimate Methods

Figure 2. Seasonal stream temperature distribution, reported by Stream Order, observed at monitoring sites along Fall Chinook Critical Habitat (FallC_CH) streams in Idaho between 1994 through 2016

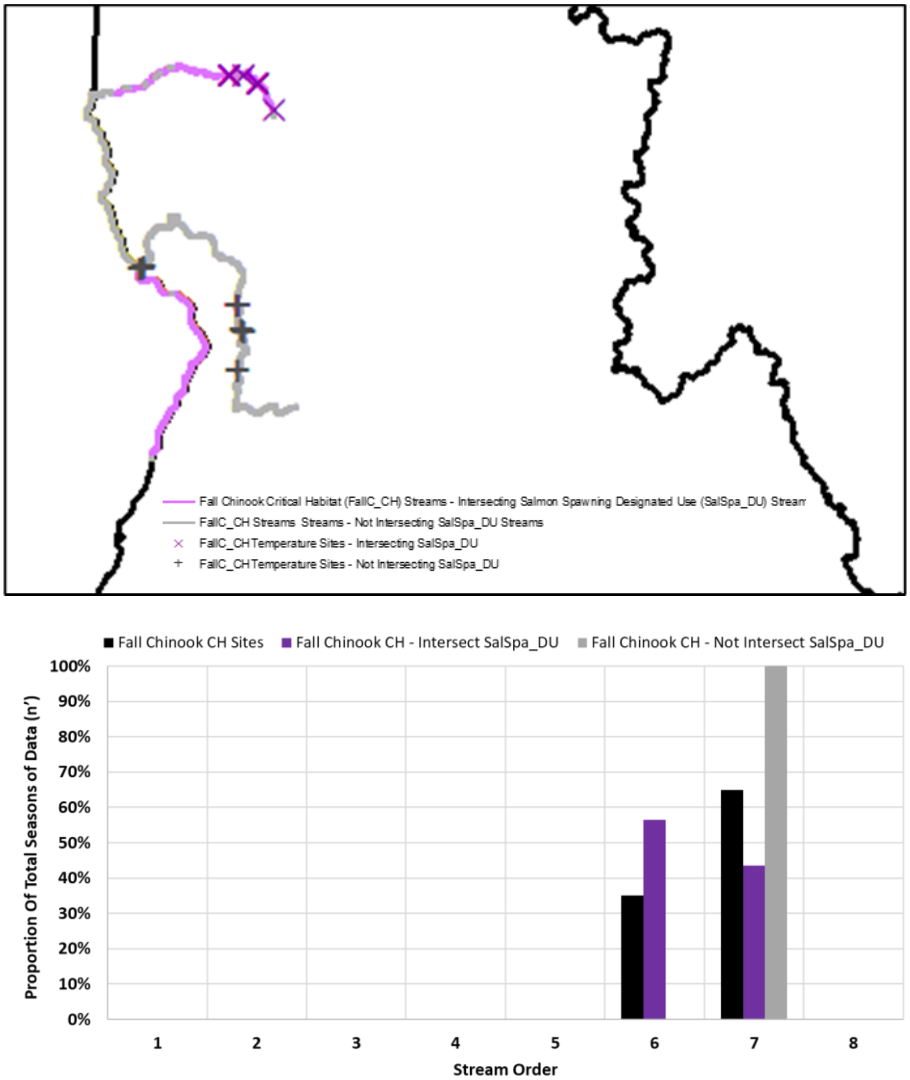
[Top image illustrates Daily Maximum Temperatures and bottom image daily mean temperatures. n represents the number of sites and n' represents the number of seasons of data for each stream order. The bars represent 75th and 25th percentile values, and these percentile values are reported for the 1st, 7th, 14th, and 21st day of the month]





Attachment #5: Temperature Estimate Methods

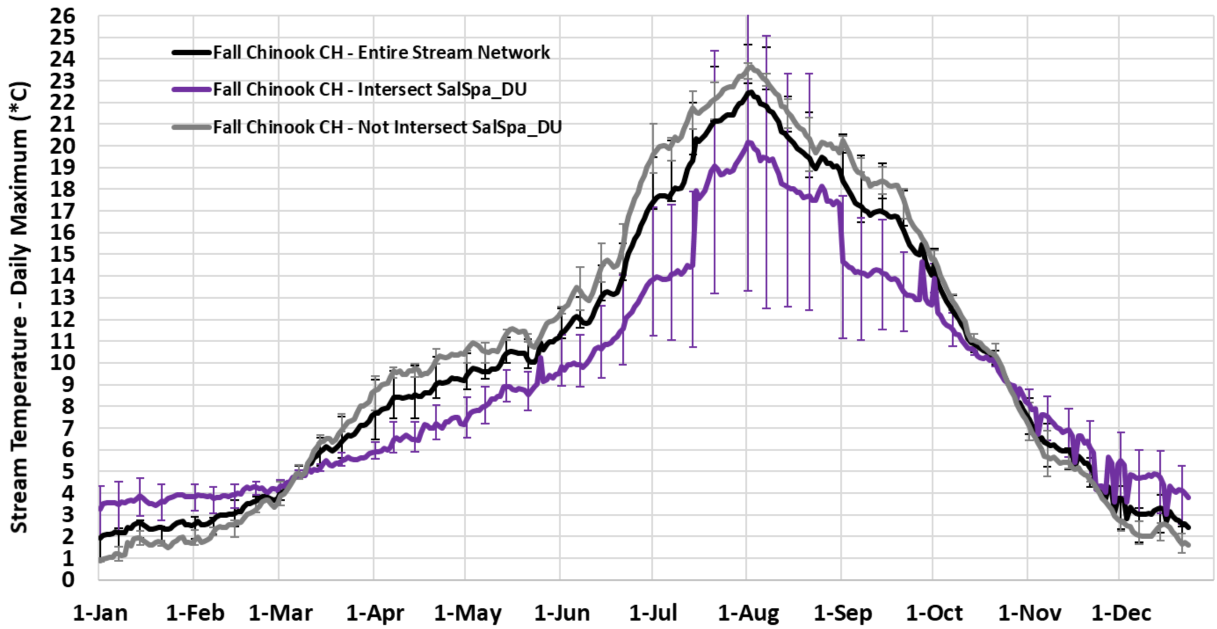
Figure 3. Designated Fall Chinook Critical Habitat Streams (FallC_CH) in Idaho, temperature monitoring locations along these streams (1994 through 2016), reported as either 1) Intersected or 2) Not Intersected Salmon Spawning Designated Use (SalSpa_DU) streams, and the proportional distribution of these sites based on Stream Order.

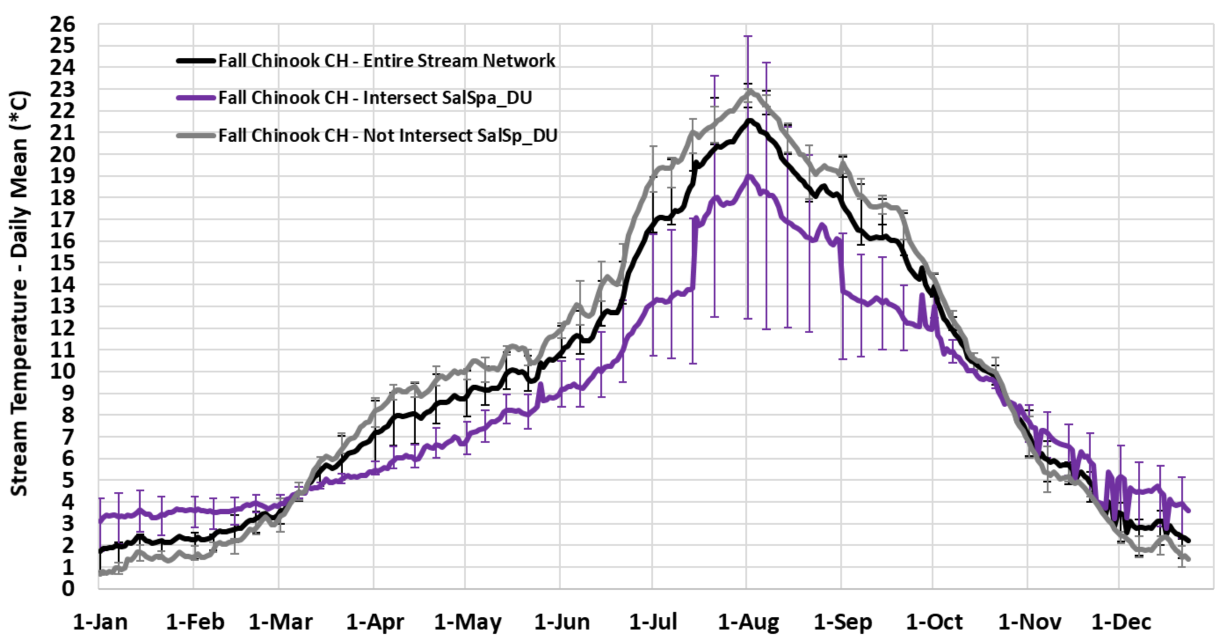


Attachment #5: Temperature Estimate Methods

Figure 4. Seasonal stream temperature distribution observed at monitoring sites along Fall Chinook Critical Habitat (FallC_CH) streams in Idaho between 1994 through 2016

[Top image illustrates Daily Maximum Temperatures and bottom image daily mean temperatures. The bars represent 75th and 25th percentile values, and these percentile values are reported for the 1st, 7th, 14th, and 21st day of the month]





Attachment #5: Temperature Estimate Methods

Methods

Unless otherwise stated below, all processing steps outlined below were implemented using available tools and extensions in ArcGIS 10.3.

Datasets

Critical Habitat (CH) shapefiles for the various species were obtained from the R10 SharePoint site - https://usepa.sharepoint.com/sites/R10/wqsu/SitePages/Home.aspx?RootFolder=%2Fsites%2FR10%2Fwqsu%2FShared%20Documents%2FWQS%20Idaho%2FTemperature%20ESA%2FCritical%20Habitat%20GIS&FolderCTID=0x0120006895FD0A08B1174780732435DE1E031E&View=%7B8572996D%2D7BCB%2D44F3%2D9728%2D9F5D06EAEADB%7D (Zipped files in the folder named – "Critical Habitat GIS").

Beneficial Uses (BU) shapefiles for "Cold", Warm" and "Salmon Spawning" stream designations were obtained from the same R10 SharePoint site used to obtain the CH shapefiles. (Files in the subfolder – "Bundle_BE_IDTemperature/Data/IDAPA").

Temperature Data and sampling location shapefiles were downloaded from the NorWeST website - www.fs.fed.us/rm/boise/AWAE/projects/NorWeST/StreamTemperatureDataSummaries.shtml. This data contains information from 1994 to 2011.

Obtained an additional temperature database from the USFS group responsible for the NorWeST project and this data contain information from 2011 through 2016.

Calculating Overlap Between Critical Habitat and Designation Uses -

The specifics of the steps outlined below reflect the fact that the topology is different between the Critical Habitat (CH) shapefile and the Salmon Spawning Designated Use (SalSpa_DU) shapefile (That is, CH shapefiles do not line up with the SalSpa_DU shapefile). Accordingly, it was not possible to do a simple overlay to determine overlap distance/length between the datasets, however the steps outlined below provided an estimate of the percentage of overlap between these datasets despite these topology issues. (Note – steps listed below are processed for each of the CH stream shapefile (i.e., Bull Trout SR, Bull Trout FMO, and Bull Trout Unknown, Steelhead, Chinook, etc).

The SalSpa_DU designations were used for all of the CH comparisons. However, for Bull Trout CH designations (i.e., SR, FMO, Unknown), two additional overlap designations were determined in addition to the SalSpa_DU comparison: 1) overlap of Idaho State Rule Waters Designated Use (ISRW_DU) with BT_CH, and 2) overlap of ISRW_DU and SalSpa_DU with BT_CH.

The first step is to create points at equal distances along the CH shapefile through the following steps:

10) Make sure the CH shapefile is the same projection as the DU stream shapefile that will be used in the comparisons described below.
11) Create one line feature of the multiple part CH shapefile: Create a new column in the CH shapefile's VAT and populate the added column with the same value/text. Use this added column as a unique identifier in the Dissolve tool (i.e., Dissolve the multipart line into one line segment). It was important to separate the Bull Trout CH shapefile into three separate shapefiles based on the values in the "H_Use_Type" column. i.e., SR, FMO, UKN) and these use these values as the unique identifier in the dissolve tool.

12) Create a point shapefile in ArcCatalog and define the projection as the other CH shapefile.
13) Add this created point shapefile and the created dissolved line shapefile to a new ArcMap project.
14) Make sure to select the point shapefile in the TOC (This will not show any points in the project but this is needed for the next step).
15) Start editing the point shapefile and select the "Create Feature" feature in the edit tool, and make sure that the point shapefile is selected in the opened feature.
16) Then select the line feature using the select tool (all of the lines will be highlighted because will merged the lines to a single line in the second step above)
17) Then select the "Construct Points…" tool in the edit tool dropdown and use 30-meter point creation distance, and save edits after processing. (The computer/program was able to process 30 meter point distance, but was having problems with a finer resolution.)
18) Open the newly created point shapefile in a new ArcMap project and create a new column (Long Integer) and populate the column with the FID attribute in the VAT. This column will be used to join the sampling results produced below in the two shapefiles into one shapefile (This was done because FID columns can be subsequently modified by ArcMap processes without user input and the FID was the unique Identifier produced in the steps listed above.)

The next step is to "move" these created points representing the "Critical Habitat" shapefile to the CH shapefiles (once again, these two shapefiles have a different topology). This step was accomplished using the "Near" tool using the following steps:

4) Open a new ArcMap project and add 1) **<u>a copy of</u>** the point shapefile representing the Critical Habitat that was created in the previous step and 2) the SalSpa_DU line shapefile (make sure that they are the same projection). (Use a copy of the point shapefile because this tool will modify the VAT of the point shapefile and you will be using this file for another "near" assessment with BT_CH layers.)
5) Open the "Near" tool and designate that point shapefile is "Input Feature" and the other shapefile is the "Near Feature". Set the "Search Radius" to 100 meters (Visual inspection of the these datasets indicated that generally the maximum distance in topology between these datasets was around 100 meters) and select the "Location" option (This will create X,Y values for each moved point and this information could be used to plot the locations of the moved points in the future).
6) Create a new column (Float) in the shape after running this tool and populate this column with the "NEAR_Dist" attribute - Give the column a more informative name, something like "NearSalSpa", because it will be necessary join two shapefiles for the BT_CH comparisons and need to have unique column names.

The "Near" tool will create three new columns in the VAT of the point shapefile "Near_Dist", "Near_X" and "Near_Y", which represent the distance between the point and the target shapefile, and the Longitude and Latitude of the moved points, respectively. Importantly, this tool will attribute "-1" for points that are located further than 100 meters from the "target" within the created columns. In other words, these "-1" points indicate locations where there is not an overlap between the two shapefiles. Using the proportions of these points provides a means to estimate the precent overlap between the two shapefiles.

Attachment #5: Temperature Estimate Methods

<u>Supplementing sampling location information</u>

The steps below will add attribute information into the monitoring location shapefile. Adding this information at this step will result in useful information to support subsequent assessments described below. Methods used to calculate three added attributes (i.e., Stream Order, Elevation, and Level 2 and 3 Ecoregions) for each sampling location are described below.

<u>Stream Order Sampling</u>

The Idaho NHD Flowlines shapefile for Idaho was downloaded from the USGS site was separated into four shapefiles. The first step was to merge these four shapefiles into one shapefile by using the "merge" tool. It can be important to let the file save to the default geodatabase location (Saving results of large processing step not within the default geodatabase can result in processing errors).

The next step is to clip out any streams located outside of the Idaho state boundary. Use a projected (same projection as the NHD Flowlines shapefile) state boundary shapefile to clip out all streams located outside of Idaho through using the "clip" tool. It can be important to let the file save to the default geodatabase location (Saving results of large processing step not within the default geodatabase can result in processing errors).

Using the "Project" tool, the next step is to re-project the clipped Flowline stream shapefile to the projection of the NorWeST shapefiles. It can be important to let the file save to the default geodatabase location (Saving results of large processing step not within the default geodatabase can result in processing errors).

Download the NHDPlus attributes files (https://www.epa.gov/waterdata/get-nhdplus-national-hydrography-dataset-plus-data#v2datamap) and join the "PlusFlowLineVAA.dbf" file to the new ArcMap project. Then add the projected FlowLine shapefile that was produced in the previous step to the ArcMap project. Using the "Join" tool, join the PlusFlowLineVAA.dbf attribute information to the VAT of the shapefile using the "Reach Code" attribute – make sure to use the "Keep all Records" option with this tool. Save this joined shapefile as a new shapefile. Finally, delete the processing steps described above (They take a lot of memory space on the disc and these preliminary result files will not be used in subsequent steps).

The next step is to "move" points in the monitoring location shapefile in order to subsequently "sample" the stream order information to these monitoring locations. This step was necessary because these two shapefiles have a different topology and therefore do not line exactly on top of each other. This step was accomplished using the "Near" tool using the following steps: 1) Open a new ArcMap project and add 1) **<u>a copy of</u>** the point shapefile representing the monitoring locations and 2) the Stream Order line shapefile created above (make sure that they are the same projection). (Use a copy of the point shapefile because this tool will modify the VAT of the point shapefile.) 2) Open the "Near" tool and designate that point shapefile is "Input Feature" and the line shapefile is the "Near Feature". Set the "Search Radius" to 100 meters (Visual inspection of the these datasets indicated that generally the maximum distance in topology between these datasets was around 100 meters) and select the "Location" option (This will create X,Y values for each moved point and this information could be used to plot the

locations of the moved points in the future). The "Near" tool will create three new columns in the VAT of the point shapefile "Near_Dist", "Near_X" and "Near_Y", which represent the distance between the point and the target shapefile, and the Longitude and Latitude of the moved points, respectively. Importantly, this tool will attribute "-1" for points that are located further than 100 meters from the "target" within the created columns. In other words, these "-1" points indicate locations where there is not an overlap between the two shapefiles. Export the VAT from the point shapefile implemented in the previous step as a table (.csv). Add this file to the ArcMap project and use the "Display x,y" tool on this file to create an event shapefile through using the Near_X and Near_Y attributes created in the previous step. Save this event as a new shapefile. In a new ArcMap project, add the "near" monitoring point shapefile created above and the stream order line shapefile. Using the "Spatial Join" tool, sample the stream order attribute into the monitor point shapefile. These shapefiles should not be located on top of each other as a result of the previous step and therefore do not need to include a search radius with this tool (Do not use search radius with the "Spatial Join" tool because it does not sample the nearest segment if there is more than segment that is located within the search radius, while the "Near" picks the nearest segment.)

At "-1" sites, the Stream Order attribute were manually populated based on visual review of the stream order shapefile. In addition, there are several segments in the PlusFlowLineVAA.dbf database that report "0" stream order and monitoring locations with a reported "0" stream order was also manually sampled. This last manual step can take a lot of time to implement.

Elevation Sampling

Downloaded the NHDPlus DEM files Version (https://nhdplus.com/NHDPlus/NHDPlusV1_home.php) and mosaic them together for the state of Idaho. It is important to use version 1 because stream lines are not burned into this version of the DEM. Make sure that the project of the NorWeST point shapefiles is identical to the DEM file. Using the "Sampling" tool sample the DEM for each point shapefile – make sure to use the default setting in this tool (i.e., output location, nearest sample, and unique Identifier as the FID) because this tool can sometimes not work correctly if any changes to these settings are implemented. Join the results of the sampling tool to the VAT of the NorWeST point shapefile in the previous step (i.e., Stream Order is added to the VAT) and save as new shapefile. Convert the values to meters by creating a "float" column in the newly created shapefile VAT and make the conversion calculation for this new column.

Ecoregion Sampling

Download the Level III Ecoregion shapefile (https://www.epa.gov/eco-research/ecoregions-north-america). Project this shapefile to that of the NorWeST sampling point shapefiles. Remove all columns in the VAT of the projected shapefile except for NA_L2KEY, and NA_L3KEY. Then run a spatial join between the NorWeST sampling point shapefiles created in the previous step with the projected Ecoregion shapefile (i.e., move the attributes from the Ecoregion VAT to the VAT of the NorWeST shapefile VAT.)

Attachment #5: Temperature Estimate Methods

<u>Subsampling the Temperature Databases</u>

The steps listed below will subsample the temperature databases in order to evaluate the temperature difference between different stream conditions (i.e., critical habitat, designated uses). The temperature databases are separated into 5 parts and many of the steps listed below need to be repeated for each database part.

The first step is to select all monitoring points located along the Critical Habitat shapefile (for example, Steelhead Critical Habitat) using the following steps. Using the "Select by Location" tool, select NorWeST sites in the modified shapefiles (i.e., containing Stream Order, Elevation, Ecoregion information) that are located within 30 meters of the Critical Habitat line shapefile and save as a new shapefile. This created point shapefile represents all of the monitoring locations situated on Critical Habitat stream designation.

This new shapefile is subsequently subsampled to refine the categories to critical habitat monitoring sites located on Salmon Spawning Designated Uses (SalSpa_DU) steams or not so. Once again, use the Select by Location" tool to select sites created in the step above that also are located within 100 meters of SalSpa_DU stream designation. Save this file as a new shapefile. Switch the selected sites to develop a shapefile with sites that are not associated with SalSpa_DU stream designation. Save this file also.

Using these subsetted monitoring point location shapefiles, the temperature databases were subsetted using the following steps.

The temperature databases are MS Excel format but this format does not merge well into ArcGIS (This information needs to be added to ArcGIS project during the next sampling steps). This conversion step is implemented using MS Access because of row limitations within MS Excell can truncate the dataset and therefore result in lost data. First, open MS Assess and Import the Excel file containing the temperature data into a new Access project (i.e., "New Data Sources from File"). Open the added table in the Access database and highlight all cells in the table, and then export the added file to a dbase format (i.e., ".dbf") using the "Export to dbase file" in MS Assess.

Load the temperature database dbf file into an new ArcMap project and then add the subset point shapefiles created above. Run a spatial joint between the temperature database and one of the subsetted shapefile (use OBSRED_ID for NorWeST databases, and SBSP_ID for the USFS post 2011 database) – Make sure that "Keep only Matching Records" is selected in the tool. After each join, save the database as a new table. Remove the joint and repeat for the other subsetted point shapefile.

Slightly different methods for the Post 2011 Temperature sites were required because this database was organized slightly differently than the NorWeST database. Specifically, it was necessary to also add an additional attribute to this point shapefile – The "PERMAFID" is the unique site identifier and is going to be subsequently used to join temperature information between the two temperature databases. Specifically, the unique site attribute (i.e., PERMA_FID) was not included with the point shapefile associated with the Post 2011 data. The steps described below outline how the PERMA_FID attribute was assigned for these post-2011 sites.

> In a new ArcMap project, load the Original NorWeST point shapefile for an assessment area (i.e., Clearwater). Delete all attributes in the VAT except for the "PERMA_FID" column. Then add the point shapefile associated with the post-2011 sites (i.e., the created shapefile above with stream

order, elevation, and Ecoregion included in the VAT). Make sure that the projections are the same between the two datasets. Run Spatial Join on the two datasets in order to copy attributes from the original NorWeST VAT to the other datasets, using a 30m search radius for the tool. All sites with a value in the PERMA_FID column of the joined shapefile are sites that have data for both per and post 2011 data. All sites without any information in this column are only post 2011 sites and a unique PERMA_FID value is required for these sites - the PERMA_FID was assigned a unique value (something like - 900000 plus the "CBSP_ID" value), so that we can know that these sites were not associated with pre2011 values (i.e., any PERMA_FID value that is greater than 900,000). (Finally, spot check if the join worked correctly by comparing the two "Permanent_" columns in the final VAT – one version comes from each shapefile and these values should be the same).

Each subsetted temperature database is opened in Microsoft Excel and pivot tables were used to summarize the temperature data associated with these sites.

Attachment #5: Temperature Estimate Methods

Memorandum

January 5, 2022

To: Rochelle Labiosa R10USEPA, and Lil Herger R10USEPA

From: Peter Leinenbach R10USEPA

Subject: Measured stream temperature conditions along designated Steelhead Critical Habitat (StH_CH) streams in Idaho.

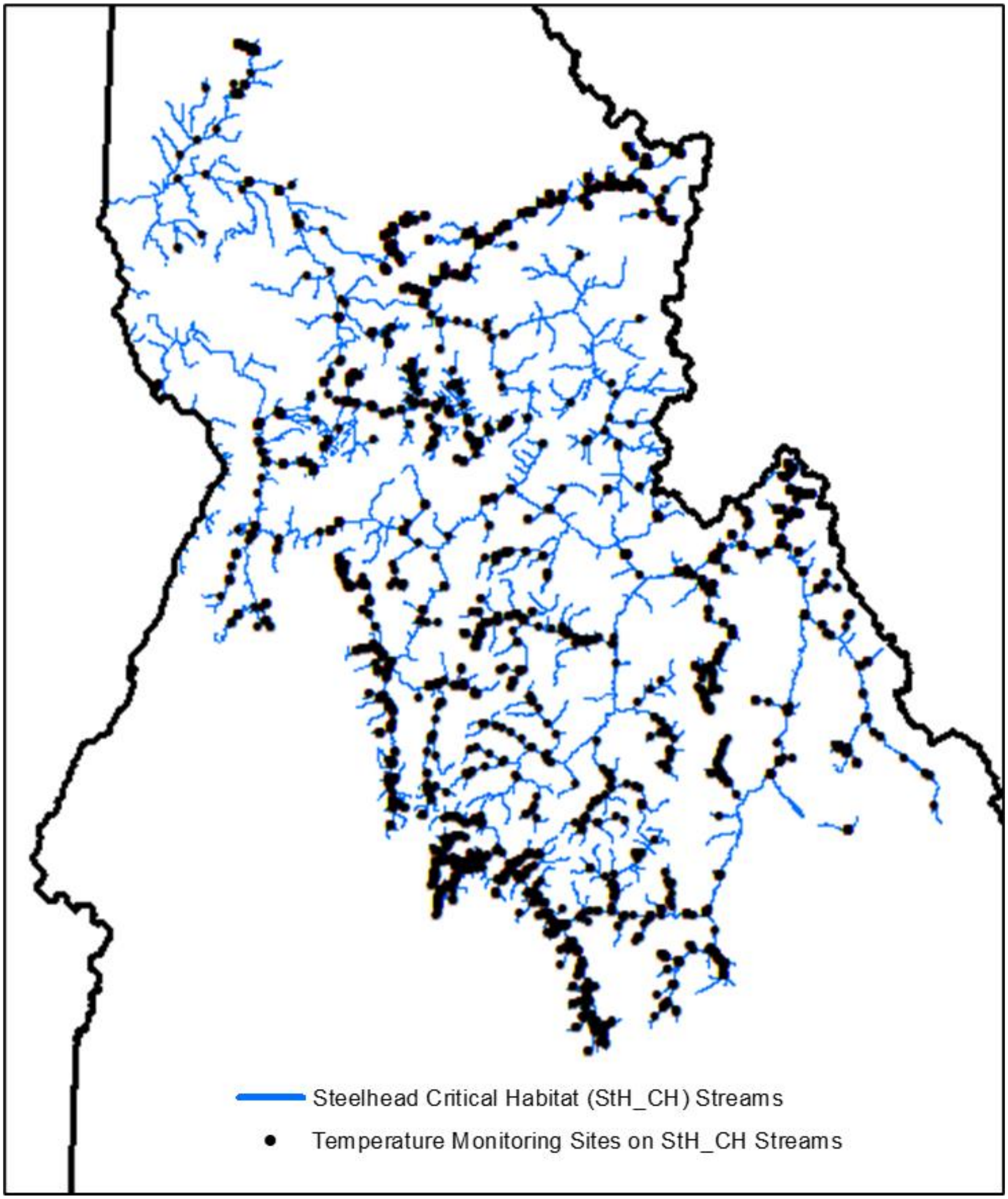
There are approximately 8,483 kilometers of streams in Idaho that are designated as Steelhead Critical Habitat (StH_CH) (**Figure 1**). There are 1,475 individual temperature monitoring locations (n) situated along designated StH_CH streams in Idaho, and these sites contain 4,917 seasons of data (n'). Observed stream temperatures at these sites reached maximums during the summer period and stream temperatures were generally warmer at sites with larger stream order designations (**Figure 2**).

Approximately 40% of Idaho StH_CH streams are also classified as Salmon Spawning Designated Use (SalSpa_DU), which corresponds to approximately 3,393.2 stream kilometers of streams (see purple lines in top image in **Figure 3**). (Alternatively, approximately 5,089.8 kilometers (i.e., 60%) of designated StH_CH streams are **not** also classified as SalSpa_DU (see grey lines in top image in **Figure 3**).) Approximately 39% of the temperature monitoring sites along StH_CH are situated on stream reaches that are also designated as a SalSpa_DU streams, which corresponds closely to the distribution of stream overlap between these two stream classifications (i.e., 40%).

Observed temperatures were slightly warmer for StH_CH sites also designated as a SalSpa_DU stream, as compared to StH_CH sites **not** located along SalSpa_DU designated streams (**Figure 4**). This result is likely due to different stream order distributions associated with these two groups (see bottom image in **Figure 3).** That is, the weighted average stream order associated with temperature monitoring sites located on designated StH_CH/SalSpa_DU streams was 3.5, while it was 2.8 at temperature sites located on streams only designated as StH_CH.

Attachment #5: Temperature Estimate Methods

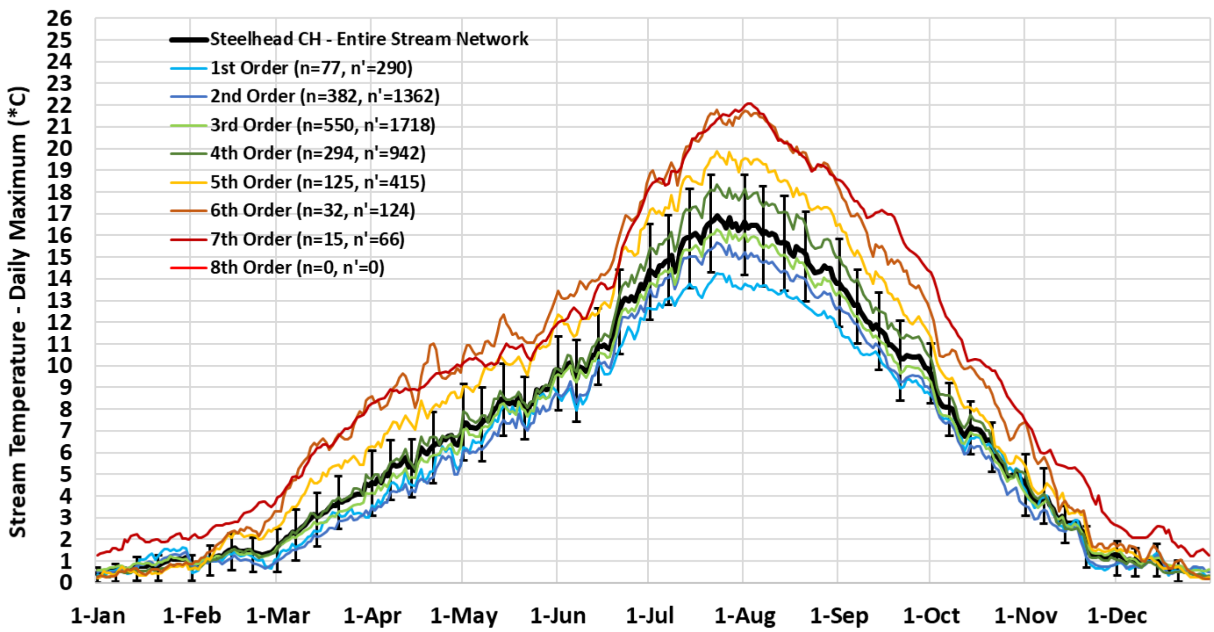
Figure 1. Designated Steelhead Critical Habitat Streams (StH_CH) in Idaho, and temperature monitoring locations along these stream reaches.

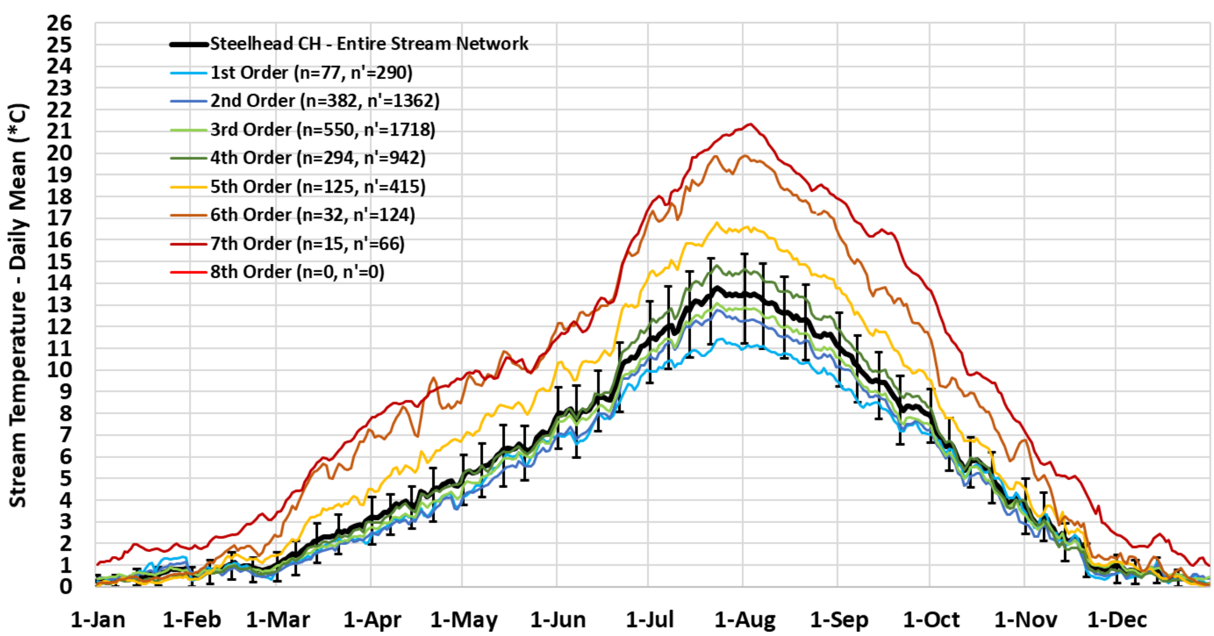


Attachment #5: Temperature Estimate Methods

Figure 2. Seasonal stream temperature distribution, reported by Stream Order, observed at monitoring sites along Steelhead Critical Habitat (StH_CH) streams in Idaho between 1994 through 2016

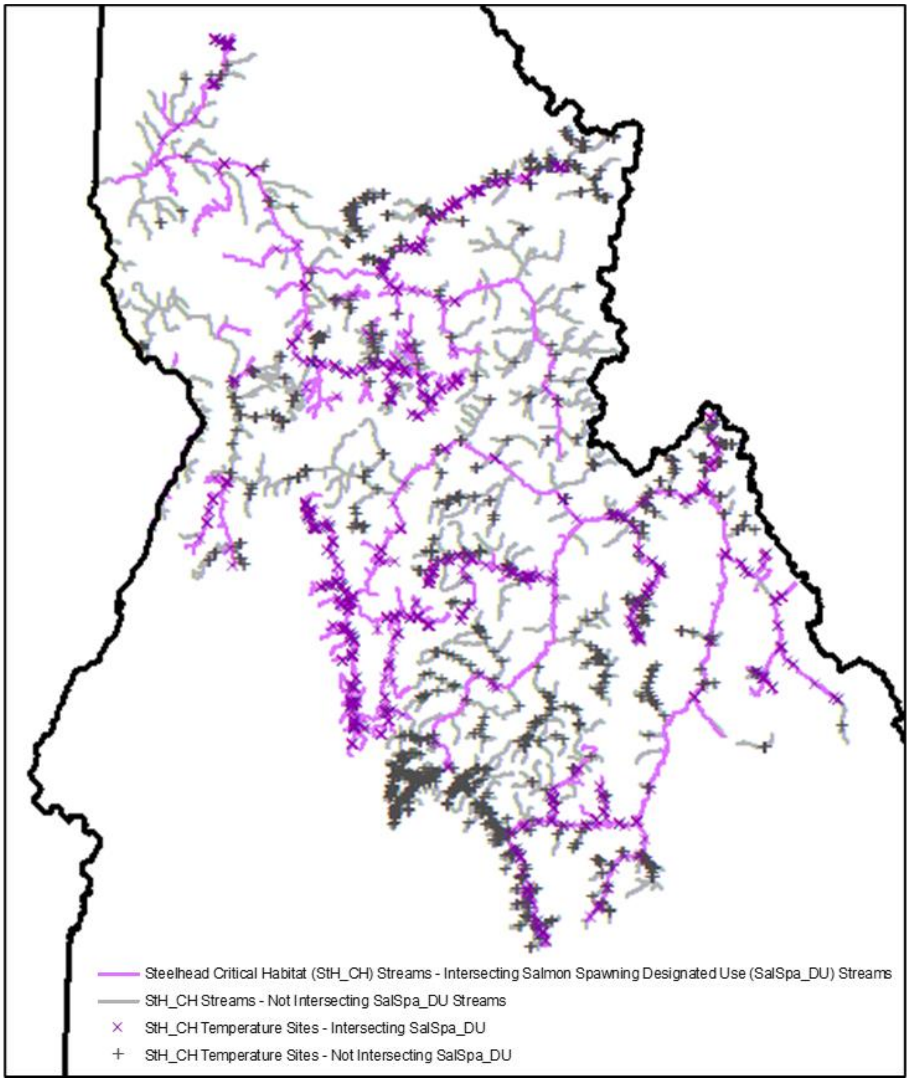
[Top image illustrates Daily Maximum Temperatures and bottom image daily mean temperatures. n represents the number of sites and n' represents the number of seasons of data for each stream order. The bars represent 75th and 25th percentile values, and these percentile values are reported for the 1st, 7th, 14th, and 21st day of the month]

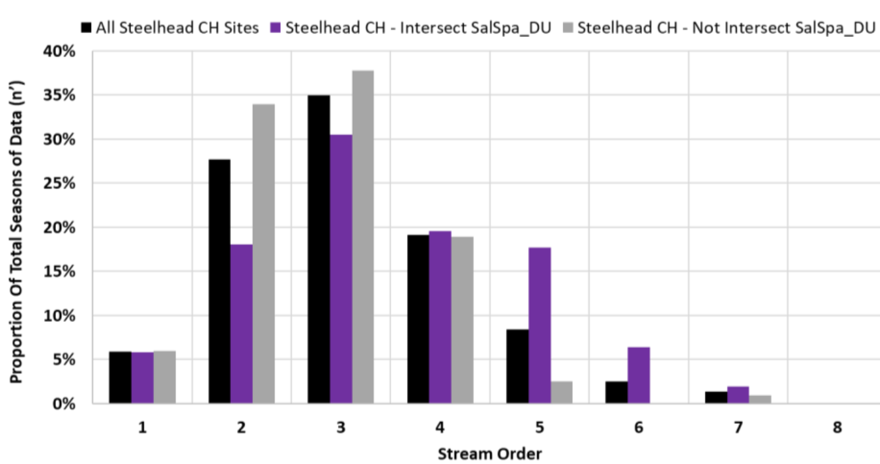




Attachment #5: Temperature Estimate Methods

Figure 3. Designated Steelhead Critical Habitat Streams (StH_CH) in Idaho, temperature monitoring locations along these streams (1994 through 2016), reported as either 1) Intersected or 2) Not Intersected Salmon Spawning Designated Use (SalSpa_DU) streams, and the proportional distribution of these sites based on Stream Order.

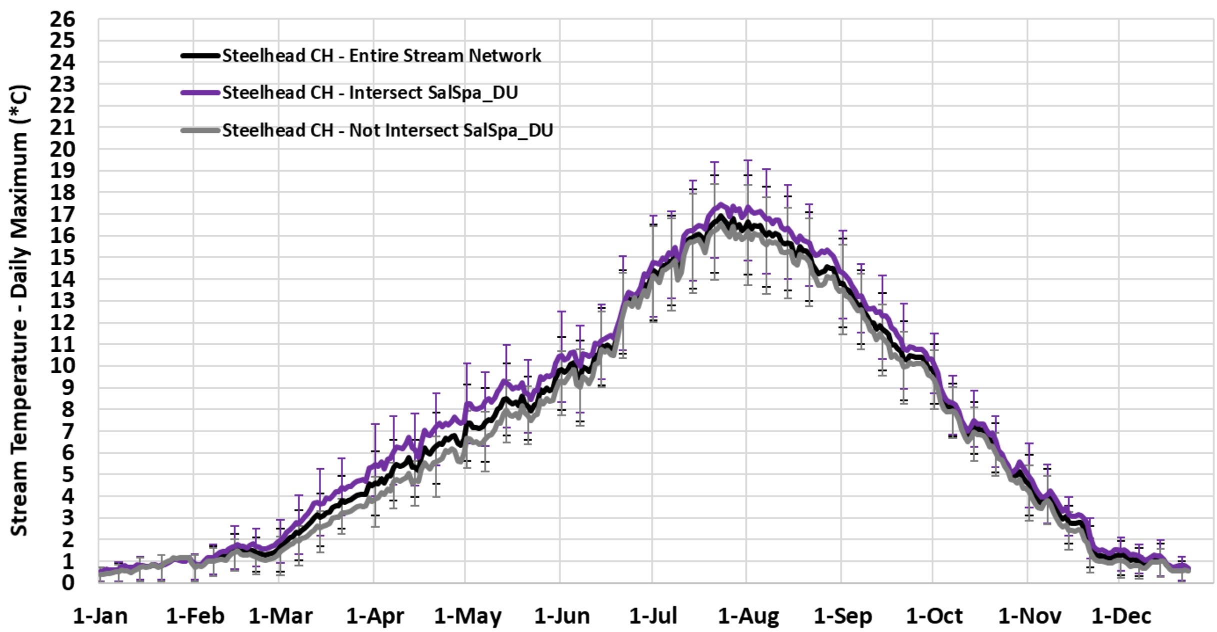


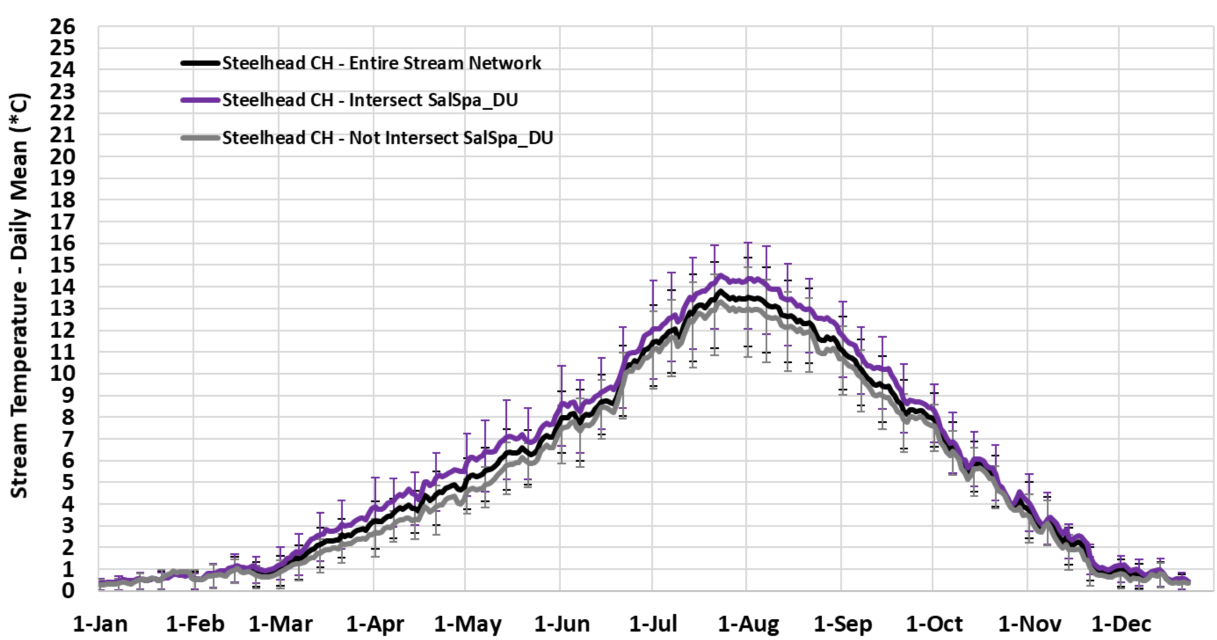


Attachment #5: Temperature Estimate Methods

Figure 4. Seasonal stream temperature distribution observed at monitoring sites along Steelhead Critical Habitat (StH_CH) streams in Idaho between 1994 through 2016

[Top image illustrates Daily Maximum Temperatures and bottom image daily mean temperatures. The bars represent 75th and 25th percentile values, and these percentile values are reported for the 1st, 7th, 14th, and 21st day of the month]





Attachment #5: Temperature Estimate Methods

Methods

Unless otherwise stated below, all processing steps outlined below were implemented using available tools and extensions in ArcGIS 10.3.

Datasets

Critical Habitat (CH) shapefiles for the various species were obtained from the R10 SharePoint site - https://usepa.sharepoint.com/sites/R10/wqsu/SitePages/Home.aspx?RootFolder=%2Fsites%2FR10%2Fwqsu%2FShared%20Documents%2FWQS%20Idaho%2FTemperature%20ESA%2FCritical%20Habitat%20GIS&FolderCTID=0x0120006895FD0A08B1174780732435DE1E031E&View=%7B8572996D%2D7BCB%2D44F3%2D9728%2D9F5D06EAEADB%7D (Zipped files in the folder named – "Critical Habitat GIS").

Beneficial Uses (BU) shapefiles for "Cold", Warm" and "Salmon Spawning" stream designations were obtained from the same R10 SharePoint site used to obtain the CH shapefiles. (Files in the subfolder – "Bundle_BE_IDTemperature/Data/IDAPA").

Temperature Data and sampling location shapefiles were downloaded from the NorWeST website - www.fs.fed.us/rm/boise/AWAE/projects/NorWeST/StreamTemperatureDataSummaries.shtml. This data contains information from 1994 to 2011.

Obtained an additional temperature database from the USFS group responsible for the NorWeST project and this data contain information from 2011 through 2016.

Calculating Overlap Between Critical Habitat and Designation Uses -

The specifics of the steps outlined below reflect the fact that the topology is different between the Critical Habitat (CH) shapefile and the Salmon Spawning Designated Use (SalSpa_DU) shapefile (That is, CH shapefiles do not line up with the SalSpa_DU shapefile). Accordingly, it was not possible to do a simple overlay to determine overlap distance/length between the datasets, however the steps outlined below provided an estimate of the percentage of overlap between these datasets despite these topology issues. (Note – steps listed below are processed for each of the CH stream shapefile (i.e., Bull Trout SR, Bull Trout FMO, and Bull Trout Unknown, Steelhead, Chinook, etc).

The SalSpa_DU designations were used for all of the CH comparisons. However, for Bull Trout CH designations (i.e., SR, FMO, Unknown), two additional overlap designations were determined in addition to the SalSpa_DU comparison: 1) overlap of Idaho State Rule Waters Designated Use (ISRW_DU) with BT_CH, and 2) overlap of ISRW_DU and SalSpa_DU with BT_CH.

The first step is to create points at equal distances along the CH shapefile through the following steps:

19) Make sure the CH shapefile is the same projection as the DU stream shapefile that will be used in the comparisons described below.
20) Create one line feature of the multiple part CH shapefile: Create a new column in the CH shapefile's VAT and populate the added column with the same value/text. Use this added column as a unique identifier in the Dissolve tool (i.e., Dissolve the multipart line into one line segment). It was important to separate the Bull Trout CH shapefile into three separate shapefiles based on the values in the "H_Use_Type" column. i.e., SR, FMO, UKN) and these use these values as the unique identifier in the dissolve tool.

Attachment #5: Temperature Estimate Methods

21) Create a point shapefile in ArcCatalog and define the projection as the other CH shapefile.
22) Add this created point shapefile and the created dissolved line shapefile to a new ArcMap project.
23) Make sure to select the point shapefile in the TOC (This will not show any points in the project but this is needed for the next step).
24) Start editing the point shapefile and select the "Create Feature" feature in the edit tool, and make sure that the point shapefile is selected in the opened feature.
25) Then select the line feature using the select tool (all of the lines will be highlighted because will merged the lines to a single line in the second step above)
26) Then select the "Construct Points…" tool in the edit tool dropdown and use 30-meter point creation distance, and save edits after processing. (The computer/program was able to process 30 meter point distance, but was having problems with a finer resolution.)
27) Open the newly created point shapefile in a new ArcMap project and create a new column (Long Integer) and populate the column with the FID attribute in the VAT. This column will be used to join the sampling results produced below in the two shapefiles into one shapefile (This was done because FID columns can be subsequently modified by ArcMap processes without user input and the FID was the unique Identifier produced in the steps listed above.)

The next step is to "move" these created points representing the "Critical Habitat" shapefile to the CH shapefiles (once again, these two shapefiles have a different topology). This step was accomplished using the "Near" tool using the following steps:

7) Open a new ArcMap project and add 1) **<u>a copy of</u>** the point shapefile representing the Critical Habitat that was created in the previous step and 2) the SalSpa_DU line shapefile (make sure that they are the same projection). (Use a copy of the point shapefile because this tool will modify the VAT of the point shapefile and you will be using this file for another "near" assessment with BT_CH layers.)
8) Open the "Near" tool and designate that point shapefile is "Input Feature" and the other shapefile is the "Near Feature". Set the "Search Radius" to 100 meters (Visual inspection of the these datasets indicated that generally the maximum distance in topology between these datasets was around 100 meters) and select the "Location" option (This will create X,Y values for each moved point and this information could be used to plot the locations of the moved points in the future).
9) Create a new column (Float) in the shape after running this tool and populate this column with the "NEAR_Dist" attribute - Give the column a more informative name, something like "NearSalSpa", because it will be necessary join two shapefiles for the BT_CH comparisons and need to have unique column names.

The "Near" tool will create three new columns in the VAT of the point shapefile "Near_Dist", "Near_X" and "Near_Y", which represent the distance between the point and the target shapefile, and the Longitude and Latitude of the moved points, respectively. Importantly, this tool will attribute "-1" for points that are located further than 100 meters from the "target" within the created columns. In other words, these "-1" points indicate locations where there is not an overlap between the two shapefiles. Using the proportions of these points provides a means to estimate the precent overlap between the two shapefiles.

Attachment #5: Temperature Estimate Methods

<u>Supplementing sampling location information</u>

The steps below will add attribute information into the monitoring location shapefile. Adding this information at this step will result in useful information to support subsequent assessments described below. Methods used to calculate three added attributes (i.e., Stream Order, Elevation, and Level 2 and 3 Ecoregions) for each sampling location are described below.

<u>Stream Order Sampling</u>

The Idaho NHD Flowlines shapefile for Idaho was downloaded from the USGS site was separated into four shapefiles. The first step was to merge these four shapefiles into one shapefile by using the "merge" tool. It can be important to let the file save to the default geodatabase location (Saving results of large processing step not within the default geodatabase can result in processing errors).

The next step is to clip out any streams located outside of the Idaho state boundary. Use a projected (same projection as the NHD Flowlines shapefile) state boundary shapefile to clip out all streams located outside of Idaho through using the "clip" tool. It can be important to let the file save to the default geodatabase location (Saving results of large processing step not within the default geodatabase can result in processing errors).

Using the "Project" tool, the next step is to re-project the clipped Flowline stream shapefile to the projection of the NorWeST shapefiles. It can be important to let the file save to the default geodatabase location (Saving results of large processing step not within the default geodatabase can result in processing errors).

Download the NHDPlus attributes files (https://www.epa.gov/waterdata/get-nhdplus-national-hydrography-dataset-plus-data#v2datamap) and join the "PlusFlowLineVAA.dbf" file to the new ArcMap project. Then add the projected FlowLine shapefile that was produced in the previous step to the ArcMap project. Using the "Join" tool, join the PlusFlowLineVAA.dbf attribute information to the VAT of the shapefile using the "Reach Code" attribute – make sure to use the "Keep all Records" option with this tool. Save this joined shapefile as a new shapefile. Finally, delete the processing steps described above (They take a lot of memory space on the disc and these preliminary result files will not be used in subsequent steps).

The next step is to "move" points in the monitoring location shapefile in order to subsequently "sample" the stream order information to these monitoring locations. This step was necessary because these two shapefiles have a different topology and therefore do not line exactly on top of each other. This step was accomplished using the "Near" tool using the following steps: 1) Open a new ArcMap project and add 1) **<u>a copy of</u>** the point shapefile representing the monitoring locations and 2) the Stream Order line shapefile created above (make sure that they are the same projection). (Use a copy of the point shapefile because this tool will modify the VAT of the point shapefile.) 2) Open the "Near" tool and designate that point shapefile is "Input Feature" and the line shapefile is the "Near Feature". Set the "Search Radius" to 100 meters (Visual inspection of the these datasets indicated that generally the maximum distance in topology between these datasets was around 100 meters) and select the "Location" option (This will create X,Y values for each moved point and this information could be used to plot the

locations of the moved points in the future). The "Near" tool will create three new columns in the VAT of the point shapefile "Near_Dist", "Near_X" and "Near_Y", which represent the distance between the point and the target shapefile, and the Longitude and Latitude of the moved points, respectively. Importantly, this tool will attribute "-1" for points that are located further than 100 meters from the "target" within the created columns. In other words, these "-1" points indicate locations where there is not an overlap between the two shapefiles. Export the VAT from the point shapefile implemented in the previous step as a table (.csv). Add this file to the ArcMap project and use the "Display x,y" tool on this file to create an event shapefile through using the Near_X and Near_Y attributes created in the previous step. Save this event as a new shapefile. In a new ArcMap project, add the "near" monitoring point shapefile created above and the stream order line shapefile. Using the "Spatial Join" tool, sample the stream order attribute into the monitor point shapefile. These shapefiles should not be located on top of each other as a result of the previous step and therefore do not need to include a search radius with this tool (Do not use search radius with the "Spatial Join" tool because it does not sample the nearest segment if there is more than segment that is located within the search radius, while the "Near" picks the nearest segment.)

At "-1" sites, the Stream Order attribute were manually populated based on visual review of the stream order shapefile. In addition, there are several segments in the PlusFlowLineVAA.dbf database that report "0" stream order and monitoring locations with a reported "0" stream order was also manually sampled. This last manual step can take a lot of time to implement.

Elevation Sampling

Downloaded the NHDPlus DEM files Version (https://nhdplus.com/NHDPlus/NHDPlusV1_home.php) and mosaic them together for the state of Idaho. It is important to use version 1 because stream lines are not burned into this version of the DEM. Make sure that the project of the NorWeST point shapefiles is identical to the DEM file. Using the "Sampling" tool sample the DEM for each point shapefile – make sure to use the default setting in this tool (i.e., output location, nearest sample, and unique Identifier as the FID) because this tool can sometimes not work correctly if any changes to these settings are implemented. Join the results of the sampling tool to the VAT of the NorWeST point shapefile in the previous step (i.e., Stream Order is added to the VAT) and save as new shapefile. Convert the values to meters by creating a "float" column in the newly created shapefile VAT and make the conversion calculation for this new column.

Ecoregion Sampling

Download the Level III Ecoregion shapefile (https://www.epa.gov/eco-research/ecoregions-north-america). Project this shapefile to that of the NorWeST sampling point shapefiles. Remove all columns in the VAT of the projected shapefile except for NA_L2KEY, and NA_L3KEY. Then run a spatial join between the NorWeST sampling point shapefiles created in the previous step with the projected Ecoregion shapefile (i.e., move the attributes from the Ecoregion VAT to the VAT of the NorWeST shapefile VAT.)

Attachment #5: Temperature Estimate Methods

Subsampling the Temperature Databases

The steps listed below will subsample the temperature databases in order to evaluate the temperature difference between different stream conditions (i.e., critical habitat, designated uses). The temperature databases are separated into 5 parts and many of the steps listed below need to be repeated for each database part.

The first step is to select all monitoring points located along the Critical Habitat shapefile (for example, Steelhead Critical Habitat) using the following steps. Using the "Select by Location" tool, select NorWeST sites in the modified shapefiles (i.e., containing Stream Order, Elevation, Ecoregion information) that are located within 30 meters of the Critical Habitat line shapefile and save as a new shapefile. This created point shapefile represents all of the monitoring locations situated on Critical Habitat stream designation.

This new shapefile is subsequently subsampled to refine the categories to critical habitat monitoring sites located on Salmon Spawning Designated Uses (SalSpa_DU) steams or not so. Once again, use the Select by Location" tool to select sites created in the step above that also are located within 100 meters of SalSpa_DU stream designation. Save this file as a new shapefile. Switch the selected sites to develop a shapefile with sites that are not associated with SalSpa_DU stream designation. Save this file also.

Using these subsetted monitoring point location shapefiles, the temperature databases were subsetted using the following steps.

The temperature databases are MS Excel format but this format does not merge well into ArcGIS (This information needs to be added to ArcGIS project during the next sampling steps). This conversion step is implemented using MS Access because of row limitations within MS Excell can truncate the dataset and therefore result in lost data. First, open MS Assess and Import the Excel file containing the temperature data into a new Access project (i.e., "New Data Sources from File"). Open the added table in the Access database and highlight all cells in the table, and then export the added file to a dbase format (i.e., ".dbf") using the "Export to dbase file" in MS Assess.

Load the temperature database dbf file into an new ArcMap project and then add the subset point shapefiles created above. Run a spatial joint between the temperature database and one of the subsetted shapefile (use OBSRED_ID for NorWeST databases, and SBSP_ID for the USFS post 2011 database) – Make sure that "Keep only Matching Records" is selected in the tool. After each join, save the database as a new table. Remove the joint and repeat for the other subsetted point shapefile.

Slightly different methods for the Post 2011 Temperature sites were required because this database was organized slightly differently than the NorWeST database. Specifically, it was necessary to also add an additional attribute to this point shapefile – The "PERMAFID" is the unique site identifier and is going to be subsequently used to join temperature information between the two temperature databases. Specifically, the unique site attribute (i.e., PERMA_FID) was not included with the point shapefile associated with the Post 2011 data. The steps described below outline how the PERMA_FID attribute was assigned for these post-2011 sites.

> In a new ArcMap project, load the Original NorWeST point shapefile for an assessment area (i.e., Clearwater). Delete all attributes in the VAT except for the "PERMA_FID" column. Then add the point shapefile associated with the post-2011 sites (i.e., the created shapefile above with stream

order, elevation, and Ecoregion included in the VAT). Make sure that the projections are the same between the two datasets. Run Spatial Join on the two datasets in order to copy attributes from the original NorWeST VAT to the other datasets, using a 30m search radius for the tool. All sites with a value in the PERMA_FID column of the joined shapefile are sites that have data for both per and post 2011 data. All sites without any information in this column are only post 2011 sites and a unique PERMA_FID value is required for these sites - the PERMA_FID was assigned a unique value (something like - 900000 plus the “CBSP_ID” value), so that we can know that these sites were not associated with pre2011 values (i.e., any PERMA_FID value that is greater than 900,000). (Finally, spot check if the join worked correctly by comparing the two “Permanent_” columns in the final VAT – one version comes from each shapefile and these values should be the same).

Each subsetted temperature database is opened in Microsoft Excel and pivot tables were used to summarized the temperature data associated with these sites.

Attachment #5: Temperature Estimate Methods

Memorandum January 7, 2022

To: Rochelle Labiosa R10USEPA, and Lil Herger R10USEPA

From: Peter Leinenbach R10USEPA

Subject: Measured stream temperature conditions along designated Sockeye Critical Habitat (Sockeye_CH) streams in Idaho.

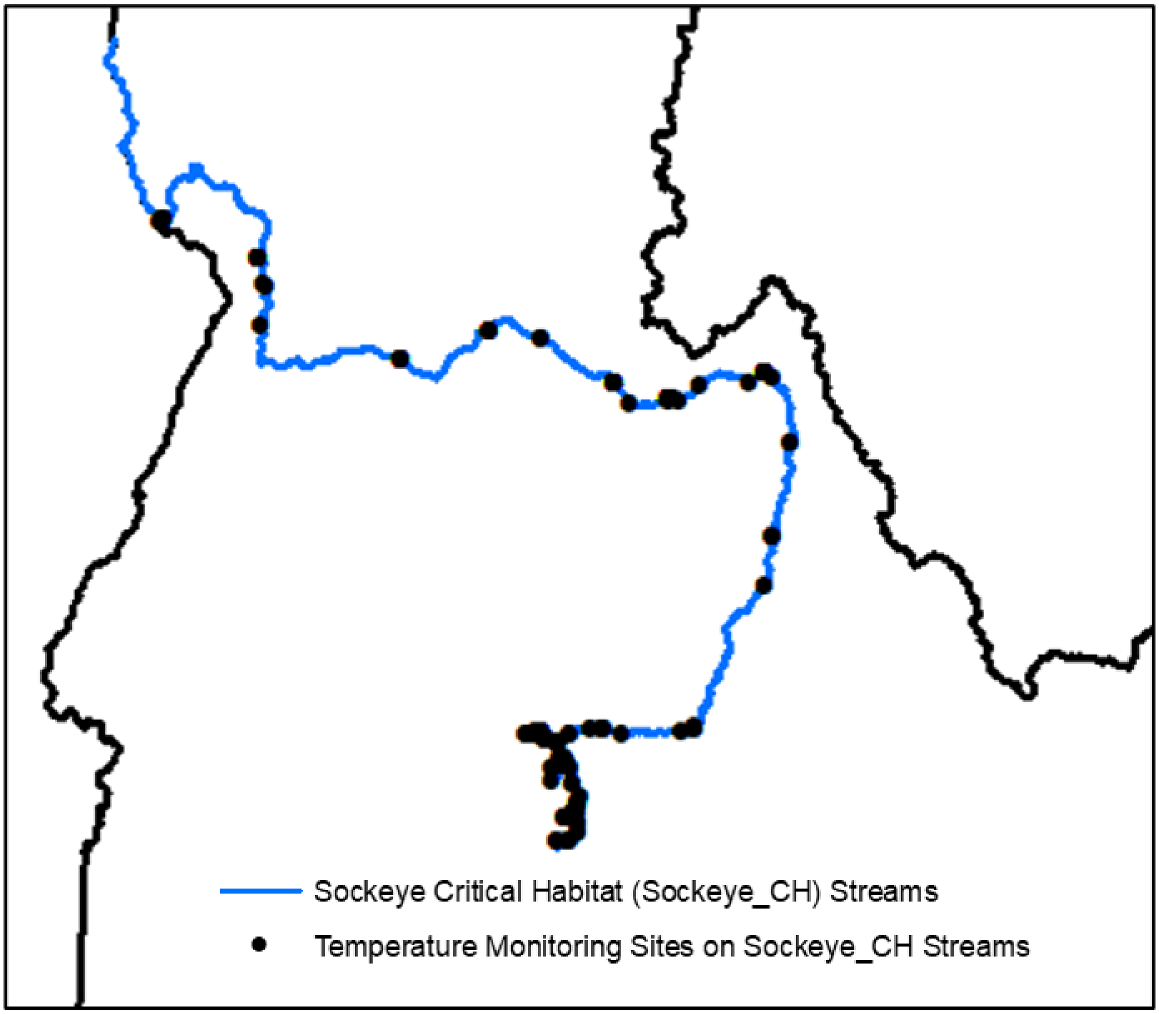
There are approximately 898 kilometers of streams in Idaho that are designated as Sockeye Critical Habitat (Sockeye_CH) (**Figure 1**). There are 91 individual temperature monitoring locations (n) situated along designated Sockeye_CH streams in Idaho, and these sites contain 248 seasons of data (n'). Observed stream temperatures at these sites reached maximums during the summer period and stream temperatures were generally warmer at sites with larger stream order designations (**Figure 2**).

Approximately 55% of Idaho Sockeye_CH streams are also classified as Salmon Spawning Designated Use (SalSpa_DU), which corresponds to approximately 493.9 stream kilometers of streams (see purple lines in top image in **Figure 3**). (Alternatively, approximately 404.1 kilometers (i.e., 45%) of designated Sockeye_CH streams are **<u>not</u>** also classified as SalSpa_DU (see grey lines in top image in **Figure 3**).) Approximately 54% of the temperature monitoring sites along StH_CH are situated on stream reaches that are also designated as a SalSpa_DU streams, which corresponds closely to the distribution of stream overlap between these two stream classifications (i.e., 55%).

Observed temperatures were slightly warmer for Sockeye_CH sites also designated as a SalSpa_DU stream, as compared to Sockeye_CH sites **<u>not</u>** located along SalSpa_DU designated streams (**Figure 4**). This result is likely due to different stream order distributions associated with these two groups (see bottom image in **Figure 3).** That is, the weighted average stream order associated with temperature monitoring sites located on designated Sockeye_CH/SalSpa_DU streams was 5.5, while it was 4.3 at temperature sites located on streams only designated as Sockeye_CH.

Attachment #5: Temperature Estimate Methods

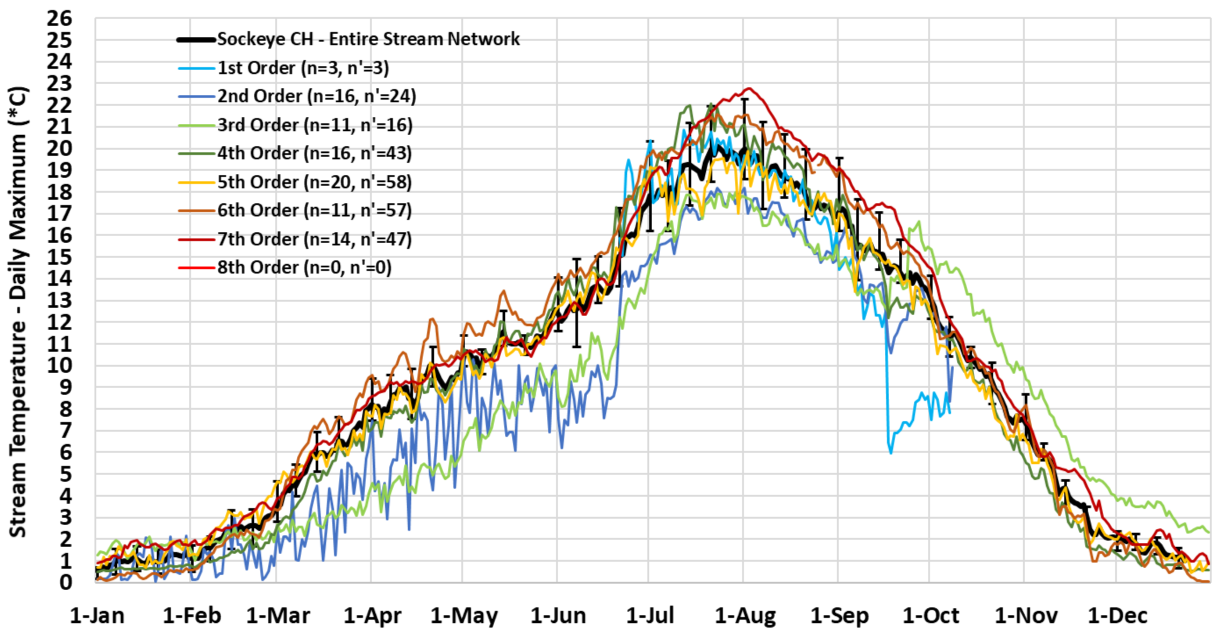
Figure 1. Designated Sockeye Critical Habitat Streams (Sockeye_CH) in Idaho, and temperature monitoring locations along these stream reaches.

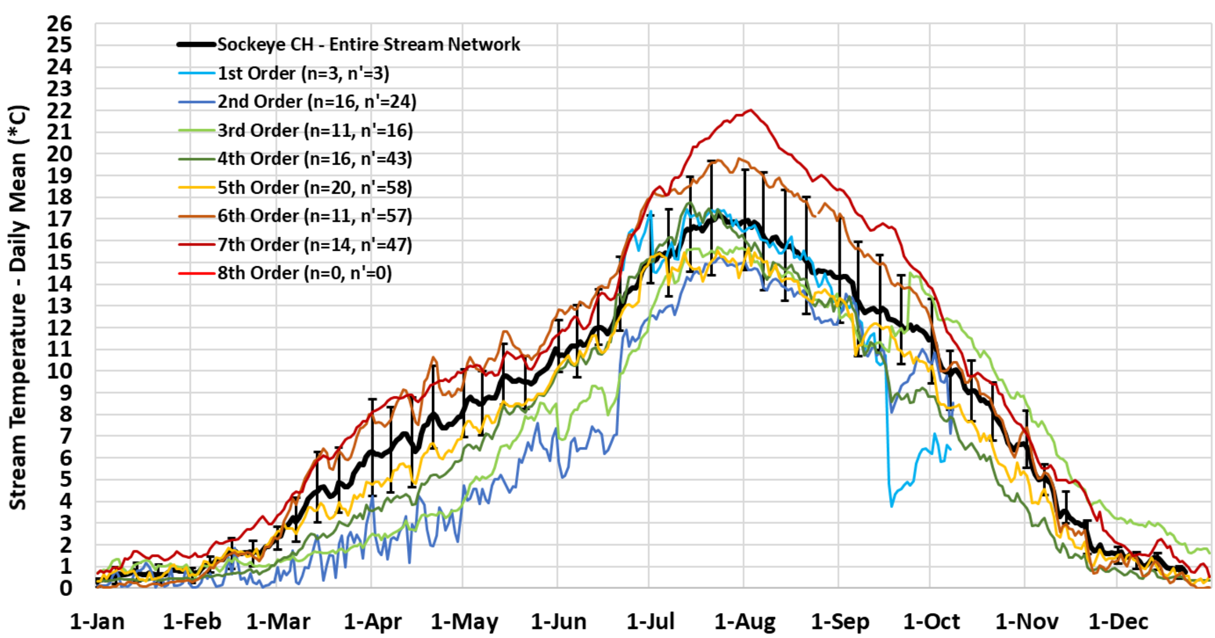


Attachment #5: Temperature Estimate Methods

Figure 2. Seasonal stream temperature distribution, reported by Stream Order, observed at monitoring sites along Sockeye Critical Habitat (Sockeye_CH) streams in Idaho between 1994 through 2016

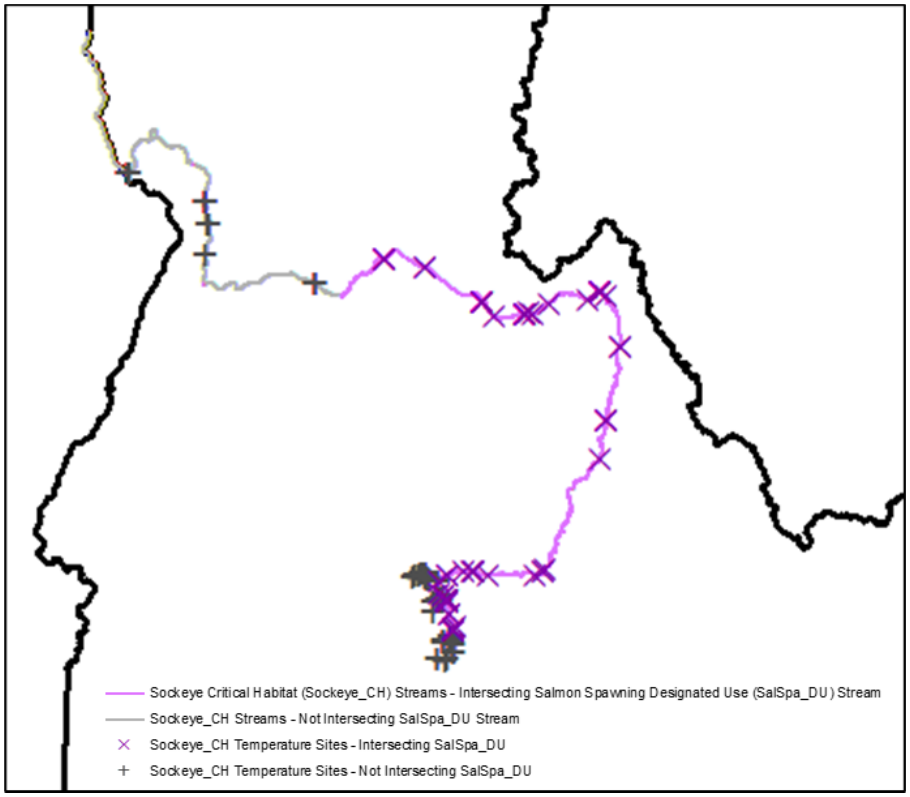
[Top image illustrates Daily Maximum Temperatures and bottom image daily mean temperatures. n represents the number of sites and n' represents the number of seasons of data for each stream order. The bars represent 75th and 25th percentile values, and these percentile values are reported for the 1st, 7th, 14th, and 21st day of the month]

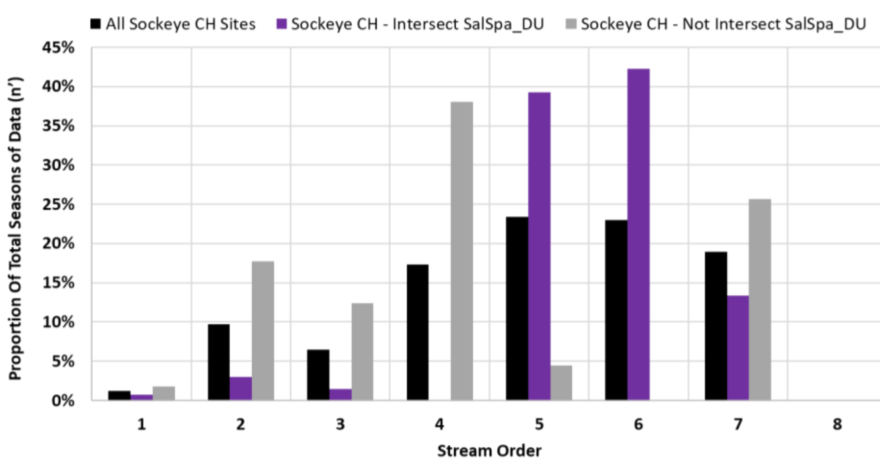




Attachment #5: Temperature Estimate Methods

Figure 3. Designated Sockeye Critical Habitat Streams (Sockeye_CH) in Idaho, temperature monitoring locations along these streams (1994 through 2016), reported as either 1) Intersected or 2) Not Intersected Salmon Spawning Designated Use (SalSpa_DU) streams, and the proportional distribution of these sites based on Stream Order.

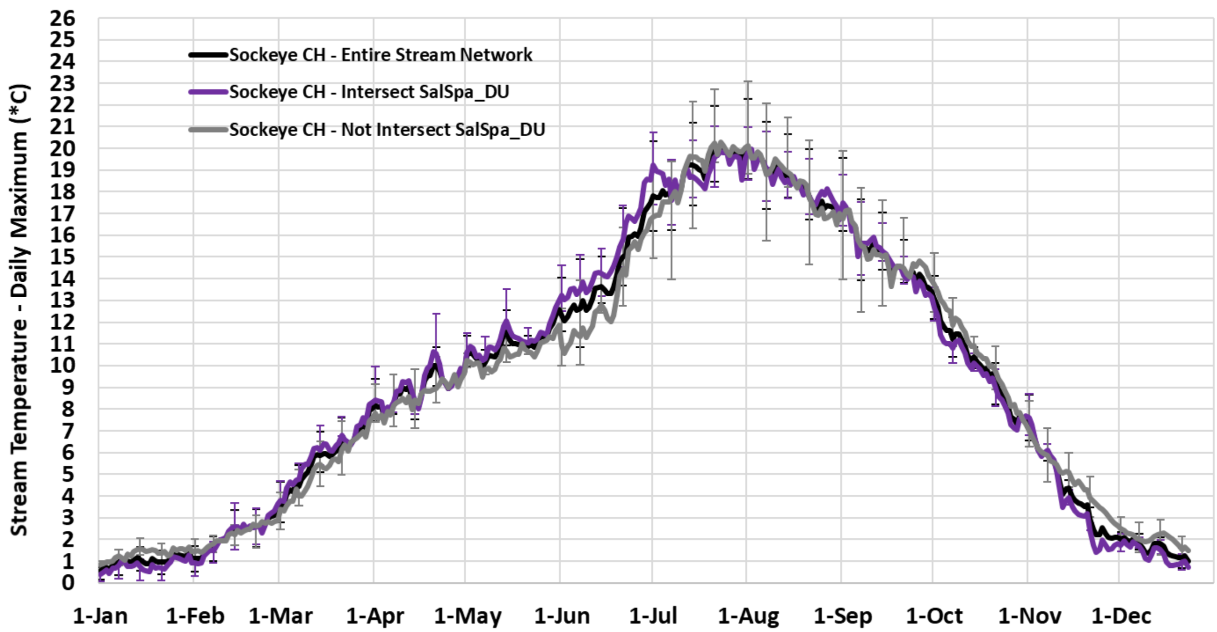


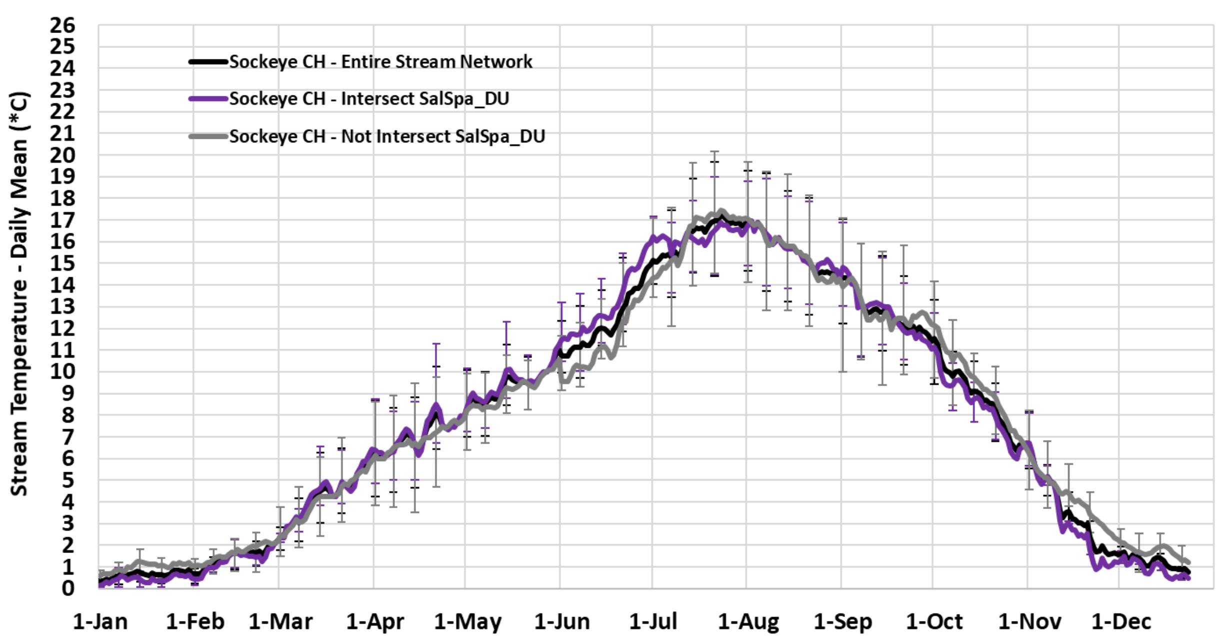


Attachment #5: Temperature Estimate Methods

Figure 4. Seasonal stream temperature distribution observed at monitoring sites along Sockeye Critical Habitat (Sockeye_CH) streams in Idaho between 1994 through 2016

[Top image illustrates Daily Maximum Temperatures and bottom image daily mean temperatures. The bars represent 75th and 25th percentile values, and these percentile values are reported for the 1st, 7th, 14th, and 21st day of the month]





Attachment #5: Temperature Estimate Methods

Methods

Unless otherwise stated below, all processing steps outlined below were implemented using available tools and extensions in ArcGIS 10.3.

Datasets

Critical Habitat (CH) shapefiles for the various species were obtained from the R10 SharePoint site - https://usepa.sharepoint.com/sites/R10/wqsu/SitePages/Home.aspx?RootFolder=%2Fsites%2FR10%2Fwqsu%2FShared%20Documents%2FWQS%20Idaho%2FTemperature%20ESA%2FCritical%20Habitat%20GIS&FolderCTID=0x0120006895FD0A08B1174780732435DE1E031E&View=%7B8572996D%2D7BCB%2D44F3%2D9728%2D9F5D06EAEADB%7D (Zipped files in the folder named – “Critical Habitat GIS”).

Beneficial Uses (BU) shapefiles for “Cold”, Warm” and “Salmon Spawning” stream designations were obtained from the same R10 SharePoint site used to obtain the CH shapefiles. (Files in the subfolder – “Bundle_BE_IDTemperature/Data/IDAPA”).

Temperature Data and sampling location shapefiles were downloaded from the NorWeST website - www.fs.fed.us/rm/boise/AWAE/projects/NorWeST/StreamTemperatureDataSummaries.shtml. This data contains information from 1994 to 2011.

Obtained an additional temperature database from the USFS group responsible for the NorWeST project and this data contain information from 2011 through 2016.

Calculating Overlap Between Critical Habitat and Designation Uses -

The specifics of the steps outlined below reflect the fact that the topology is different between the Critical Habitat (CH) shapefile and the Salmon Spawning Designated Use (SalSpa_DU) shapefile (That is, CH shapefiles do not line up with the SalSpa_DU shapefile). Accordingly, it was not possible to do a simple overlay to determine overlap distance/length between the datasets, however the steps outlined below provided an estimate of the percentage of overlap between these datasets despite these topology issues. (Note – steps listed below are processed for each of the CH stream shapefile (i.e., Bull Trout SR, Bull Trout FMO, and Bull Trout Unknown, Steelhead, Chinook, etc).

The SalSpa_DU designations were used for all of the CH comparisons. However, for Bull Trout CH designations (i.e., SR, FMO, Unknown), two additional overlap designations were determined in addition to the SalSpa_DU comparison: 1) overlap of Idaho State Rule Waters Designated Use (ISRW_DU) with BT_CH, and 2) overlap of ISRW_DU and SalSpa_DU with BT_CH.

The first step is to create points at equal distances along the CH shapefile through the following steps:

28) Make sure the CH shapefile is the same projection as the DU stream shapefile that will be used in the comparisons described below.
29) Create one line feature of the multiple part CH shapefile: Create a new column in the CH shapefile’s VAT and populate the added column with the same value/text. Use this added column as a unique identifier in the Dissolve tool (i.e., Dissolve the multipart line into one line segment). It was important to separate the Bull Trout CH shapefile into three separate shapefiles based on the values in the “H_Use_Type” column. i.e., SR, FMO, UKN) and these use these values as the unique identifier in the dissolve tool.

30) Create a point shapefile in ArcCatalog and define the projection as the other CH shapefile.
31) Add this created point shapefile and the created dissolved line shapefile to a new ArcMap project.
32) Make sure to select the point shapefile in the TOC (This will not show any points in the project but this is needed for the next step).
33) Start editing the point shapefile and select the "Create Feature" feature in the edit tool, and make sure that the point shapefile is selected in the opened feature.
34) Then select the line feature using the select tool (all of the lines will be highlighted because will merged the lines to a single line in the second step above)
35) Then select the "Construct Points…" tool in the edit tool dropdown and use 30-meter point creation distance, and save edits after processing. (The computer/program was able to process 30 meter point distance, but was having problems with a finer resolution.)
36) Open the newly created point shapefile in a new ArcMap project and create a new column (Long Integer) and populate the column with the FID attribute in the VAT. This column will be used to join the sampling results produced below in the two shapefiles into one shapefile (This was done because FID columns can be subsequently modified by ArcMap processes without user input and the FID was the unique Identifier produced in the steps listed above.)

The next step is to "move" these created points representing the "Critical Habitat" shapefile to the CH shapefiles (once again, these two shapefiles have a different topology). This step was accomplished using the "Near" tool using the following steps:

10) Open a new ArcMap project and add 1) **<u>a copy of</u>** the point shapefile representing the Critical Habitat that was created in the previous step and 2) the SalSpa_DU line shapefile (make sure that they are the same projection). (Use a copy of the point shapefile because this tool will modify the VAT of the point shapefile and you will be using this file for another "near" assessment with BT_CH layers.)
11) Open the "Near" tool and designate that point shapefile is "Input Feature" and the other shapefile is the "Near Feature". Set the "Search Radius" to 100 meters (Visual inspection of the these datasets indicated that generally the maximum distance in topology between these datasets was around 100 meters) and select the "Location" option (This will create X,Y values for each moved point and this information could be used to plot the locations of the moved points in the future).
12) Create a new column (Float) in the shape after running this tool and populate this column with the "NEAR_Dist" attribute - Give the column a more informative name, something like "NearSalSpa", because it will be necessary join two shapefiles for the BT_CH comparisons and need to have unique column names.

The "Near" tool will create three new columns in the VAT of the point shapefile "Near_Dist", "Near_X" and "Near_Y", which represent the distance between the point and the target shapefile, and the Longitude and Latitude of the moved points, respectively. Importantly, this tool will attribute "-1" for points that are located further than 100 meters from the "target" within the created columns. In other words, these "-1" points indicate locations where there is not an overlap between the two shapefiles. Using the proportions of these points provides a means to estimate the precent overlap between the two shapefiles.

Attachment #5: Temperature Estimate Methods

<u>Supplementing sampling location information</u>

The steps below will add attribute information into the monitoring location shapefile. Adding this information at this step will result in useful information to support subsequent assessments described below. Methods used to calculate three added attributes (i.e., Stream Order, Elevation, and Level 2 and 3 Ecoregions) for each sampling location are described below.

<u>Stream Order Sampling</u>

The Idaho NHD Flowlines shapefile for Idaho was downloaded from the USGS site was separated into four shapefiles. The first step was to merge these four shapefiles into one shapefile by using the “merge” tool. It can be important to let the file save to the default geodatabase location (Saving results of large processing step not within the default geodatabase can result in processing errors).

The next step is to clip out any streams located outside of the Idaho state boundary. Use a projected (same projection as the NHD Flowlines shapefile) state boundary shapefile to clip out all streams located outside of Idaho through using the “clip” tool. It can be important to let the file save to the default geodatabase location (Saving results of large processing step not within the default geodatabase can result in processing errors).

Using the “Project” tool, the next step is to re-project the clipped Flowline stream shapefile to the projection of the NorWeST shapefiles. It can be important to let the file save to the default geodatabase location (Saving results of large processing step not within the default geodatabase can result in processing errors).

Download the NHDPlus attributes files (https://www.epa.gov/waterdata/get-nhdplus-national-hydrography-dataset-plus-data#v2datamap) and join the “PlusFlowLineVAA.dbf” file to the new ArcMap project. Then add the projected FlowLine shapefile that was produced in the previous step to the ArcMap project. Using the “Join” tool, join the PlusFlowLineVAA.dbf attribute information to the VAT of the shapefile using the “Reach Code” attribute – make sure to use the “Keep all Records” option with this tool. Save this joined shapefile as a new shapefile. Finally, delete the processing steps described above (They take a lot of memory space on the disc and these preliminary result files will not be used in subsequent steps).

The next step is to “move” points in the monitoring location shapefile in order to subsequently “sample” the stream order information to these monitoring locations. This step was necessary because these two shapefiles have a different topology and therefore do not line exactly on top of each other. This step was accomplished using the “Near” tool using the following steps: 1) Open a new ArcMap project and add 1) **<u>a copy of</u>** the point shapefile representing the monitoring locations and 2) the Stream Order line shapefile created above (make sure that they are the same projection). (Use a copy of the point shapefile because this tool will modify the VAT of the point shapefile.) 2) Open the “Near” tool and designate that point shapefile is “Input Feature” and the line shapefile is the “Near Feature”. Set the “Search Radius” to 100 meters (Visual inspection of the these datasets indicated that generally the maximum distance in topology between these datasets was around 100 meters) and select the “Location” option (This will create X,Y values for each moved point and this information could be used to plot the

locations of the moved points in the future). The “Near” tool will create three new columns in the VAT of the point shapefile “Near_Dist”, “Near_X” and “Near_Y”, which represent the distance between the point and the target shapefile, and the Longitude and Latitude of the moved points, respectively. Importantly, this tool will attribute “-1” for points that are located further than 100 meters from the “target” within the created columns. In other words, these “-1” points indicate locations where there is not an overlap between the two shapefiles. Export the VAT from the point shapefile implemented in the previous step as a table (.csv). Add this file to the ArcMap project and use the “Display x,y” tool on this file to create an event shapefile through using the Near_X and Near_Y attributes created in the previous step. Save this event as a new shapefile. In a new ArcMap project, add the “near” monitoring point shapefile created above and the stream order line shapefile. Using the “Spatial Join” tool, sample the stream order attribute into the monitor point shapefile. These shapefiles should not be located on top of each other as a result of the previous step and therefore do not need to include a search radius with this tool (Do not use search radius with the “Spatial Join” tool because it does not sample the nearest segment if there is more than segment that is located within the search radius, while the “Near” picks the nearest segment.)

At “-1” sites, the Stream Order attribute were manually populated based on visual review of the stream order shapefile. In addition, there are several segments in the PlusFlowLineVAA.dbf database that report “0” stream order and monitoring locations with a reported “0” stream order was also manually sampled. This last manual step can take a lot of time to implement.

Elevation Sampling

Downloaded the NHDPlus DEM files Version (https://nhdplus.com/NHDPlus/NHDPlusV1_home.php) and mosaic them together for the state of Idaho. It is important to use version 1 because stream lines are not burned into this version of the DEM. Make sure that the project of the NorWeST point shapefiles is identical to the DEM file. Using the “Sampling” tool sample the DEM for each point shapefile – make sure to use the default setting in this tool (i.e., output location, nearest sample, and unique Identifier as the FID) because this tool can sometimes not work correctly if any changes to these settings are implemented. Join the results of the sampling tool to the VAT of the NorWeST point shapefile in the previous step (i.e., Stream Order is added to the VAT) and save as new shapefile. Convert the values to meters by creating a “float” column in the newly created shapefile VAT and make the conversion calculation for this new column.

Ecoregion Sampling

Download the Level III Ecoregion shapefile (https://www.epa.gov/eco-research/ecoregions-north-america). Project this shapefile to that of the NorWeST sampling point shapefiles. Remove all columns in the VAT of the projected shapefile except for NA_L2KEY, and NA_L3KEY. Then run a spatial join between the NorWeST sampling point shapefiles created in the previous step with the projected Ecoregion shapefile (i.e., move the attributes from the Ecoregion VAT to the VAT of the NorWeST shapefile VAT.)

Attachment #5: Temperature Estimate Methods

Subsampling the Temperature Databases

The steps listed below will subsample the temperature databases in order to evaluate the temperature difference between different stream conditions (i.e., critical habitat, designated uses). The temperature databases are separated into 5 parts and many of the steps listed below need to be repeated for each database part.

The first step is to select all monitoring points located along the Critical Habitat shapefile (for example, Sockeye Critical Habitat) using the following steps. Using the "Select by Location" tool, select NorWeST sites in the modified shapefiles (i.e., containing Stream Order, Elevation, Ecoregion information) that are located within 30 meters of the Critical Habitat line shapefile and save as a new shapefile. This created point shapefile represents all of the monitoring locations situated on Critical Habitat stream designation.

This new shapefile is subsequently subsampled to refine the categories to critical habitat monitoring sites located on Salmon Spawning Designated Uses (SalSpa_DU) steams or not so. Once again, use the Select by Location" tool to select sites created in the step above that also are located within 100 meters of SalSpa_DU stream designation. Save this file as a new shapefile. Switch the selected sites to develop a shapefile with sites that are not associated with SalSpa_DU stream designation. Save this file also.

Using these subsetted monitoring point location shapefiles, the temperature databases were subsetted using the following steps.

The temperature databases are MS Excel format but this format does not merge well into ArcGIS (This information needs to be added to ArcGIS project during the next sampling steps). This conversion step is implemented using MS Access because of row limitations within MS Excell can truncate the dataset and therefore result in lost data. First, open MS Assess and Import the Excel file containing the temperature data into a new Access project (i.e., "New Data Sources from File"). Open the added table in the Access database and highlight all cells in the table, and then export the added file to a dbase format (i.e., ".dbf") using the "Export to dbase file" in MS Assess.

Load the temperature database dbf file into an new ArcMap project and then add the subset point shapefiles created above. Run a spatial joint between the temperature database and one of the subsetted shapefile (use OBSRED_ID for NorWeST databases, and SBSP_ID for the USFS post 2011 database) – Make sure that "Keep only Matching Records" is selected in the tool. After each join, save the database as a new table. Remove the joint and repeat for the other subsetted point shapefile.

Slightly different methods for the Post 2011 Temperature sites were required because this database was organized slightly differently than the NorWeST database. Specifically, it was necessary to also add an additional attribute to this point shapefile – The "PERMAFID" is the unique site identifier and is going to be subsequently used to join temperature information between the two temperature databases. Specifically, the unique site attribute (i.e., PERMA_FID) was not included with the point shapefile associated with the Post 2011 data. The steps described below outline how the PERMA_FID attribute was assigned for these post-2011 sites.

> In a new ArcMap project, load the Original NorWeST point shapefile for an assessment area (i.e., Clearwater). Delete all attributes in the VAT except for the "PERMA_FID" column. Then add the point shapefile associated with the post-2011 sites (i.e., the created shapefile above with stream order, elevation, and Ecoregion included in the VAT). Make sure that the projections are the

same between the two datasets. Run Spatial Join on the two datasets in order to copy attributes from the original NorWeST VAT to the other datasets, using a 30m search radius for the tool. All sites with a value in the PERMA_FID column of the joined shapefile are sites that have data for both per and post 2011 data. All sites without any information in this column are only post 2011 sites and a unique PERMA_FID value is required for these sites - the PERMA_FID was assigned a unique value (something like - 900000 plus the "CBSP_ID" value), so that we can know that these sites were not associated with pre2011 values (i.e., any PERMA_FID value that is greater than 900,000). (Finally, spot check if the join worked correctly by comparing the two "Permanent_" columns in the final VAT – one version comes from each shapefile and these values should be the same).

Each subsetted temperature database is opened in Microsoft Excel and pivot tables were used to summarize the temperature data associated with these sites.

Attachment #5: Temperature Estimate Methods

Memorandum

January 10, 2022

To: Rochelle Labiosa R10USEPA, and Lil Herger R10USEPA

From: Peter Leinenbach R10USEPA

Subject: Measured stream temperature conditions along designated Bull Trout FMO Critical Habitat (BTFMO_CH) streams in Idaho.

There are approximately 4,754 kilometers of streams in Idaho that are designated as Bull Trout FMO Critical Habitat (BTFMO_CH) (**Figure 1**). There are 682 individual temperature monitoring locations (n) situated along designated BTFMO_CH streams in Idaho, and these sites contain 2,056 seasons of data (n'). Observed stream temperatures at these sites reached maximums during the summer period and stream temperatures were generally warmer at sites with larger stream order designations (**Figure 2**).

Approximately 69% of Idaho BTFMO_CH streams are also classified as Salmon Spawning Designated Use (SalSpa_DU), which corresponds to approximately 3,280.4 stream kilometers of streams (see purple lines in top image in **Figure 3**). (Alternatively, approximately 1,473.6 stream kilometers (i.e., 31%) of designated BTFMO_CH streams are **not** also classified as SalSpa_DU (see grey lines in top image in **Figure 3**).) Approximately 67% of the temperature monitoring sites along BTFMO_CH are situated on stream reaches that are also designated as a SalSpa_DU streams, which corresponds closely to the distribution of stream overlap between these two stream classifications (i.e., 69%).

Observed temperatures were slightly warmer for BTFMO_CH sites also designated as a SalSpa_DU stream, as compared to BTFMO_CH sites **not** located along SalSpa_DU designated streams (**Figure 4**). This result is likely due to different stream order distributions associated with these two groups (see bottom image in **Figure 3).** That is, the weighted average stream order associated with temperature monitoring sites located on designated BTFMO_CH/SalSpa_DU streams was 4.4, while it was 3.7 at temperature sites located on streams only designated as BTFMO_CH.

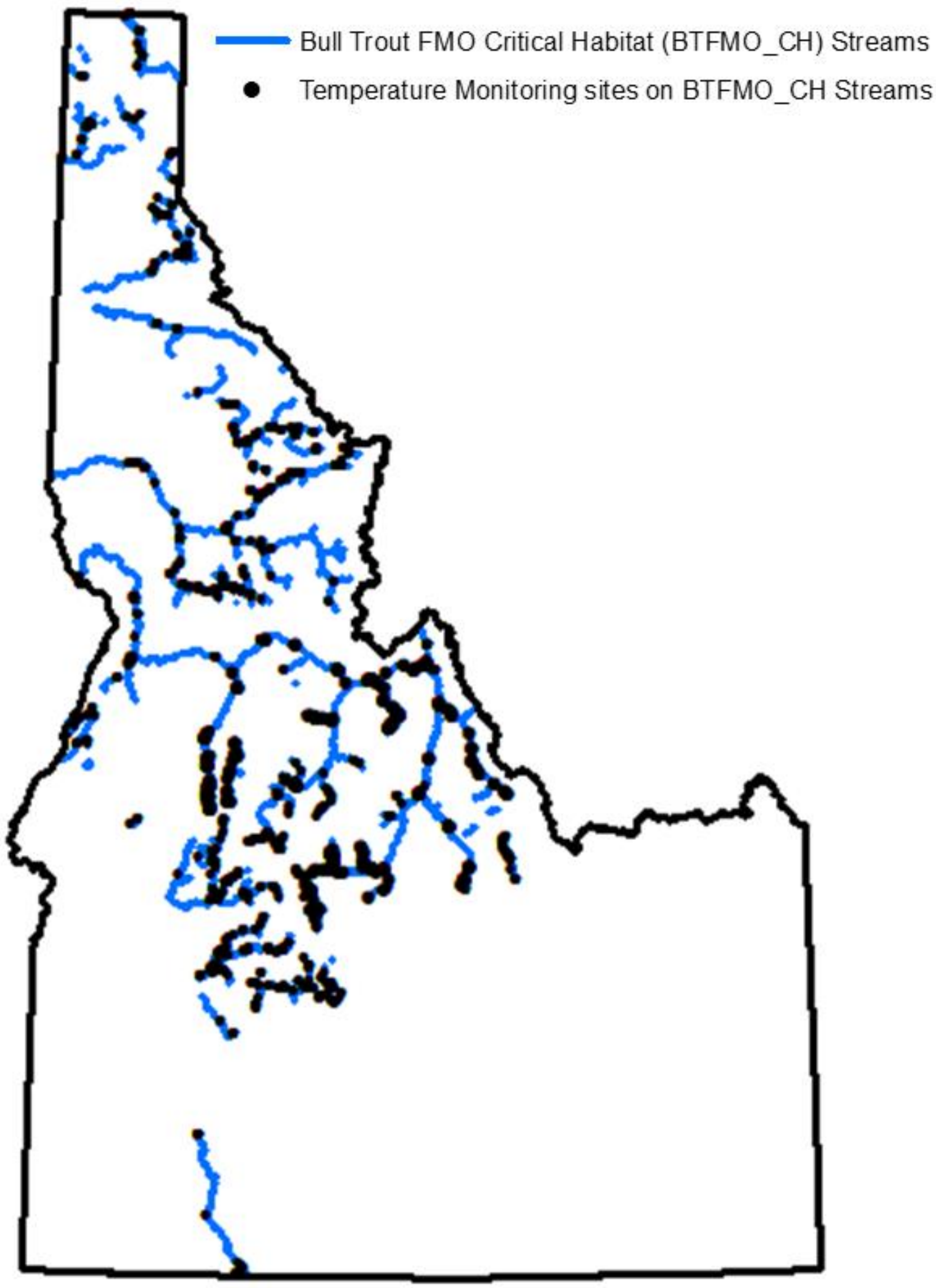
In addition, approximately 54% of Idaho BTFMO_CH streams are also classified as Idaho State Rule Waters Designated Use (ISRW_DU), which corresponds to approximately 2,567.3 stream kilometers. Approximately 74% of the temperature monitoring sites along BTFMO_CH are situated on stream reaches that are also designated as a ISRW_DU streams (**Figure 5**), indicating that the temperature data for BTFMO_CH streams is slightly skewed (i.e., 54% vs. 74%) towards representing ISRW_DU conditions.

Observed temperatures were slightly cooler for BTFMO_CH sites also designated as ISRW_DU stream, as compared to BTFMO_CH sites **not** located along ISRW_DU designated streams (**Figure 6**). This result is likely due to different stream order distributions associated with these two groups (see bottom image in **Figure 5).** That is, the weighted average stream order associated with temperature monitoring sites located on designated BTFMO_CH/ISRW_DU streams was 3.8, while it was 5.0 at temperature sites located on streams only designated as BTFMO_CH.

Finally, approximately 86% of designated BTFMO_CH streams in Idaho are also designated as either SalSpa_DU or ISWR_DU (**Table 1**). However, the proportion of the "SalSpa_DU/BTFMO_DU" group resulting in overlap by itself was twice as much than associated with the "ISRW_DU/BTFMO_CH" group (i.e., 38% vs. 19%), while 43% of the overlap areas are designated as "SalSpa_DU/ISRW_DU/BTSR_CH".

Attachment #5: Temperature Estimate Methods

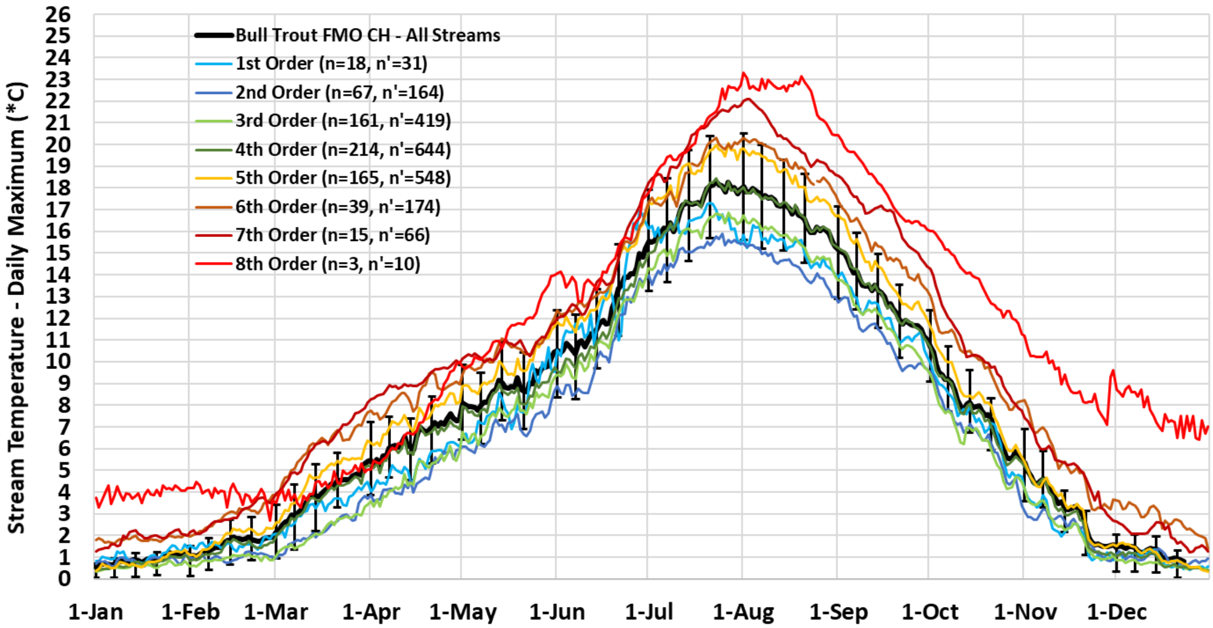
Figure 1. Designated Butt Trout FMO Critical Habitat Streams (BTFMO_CH) in Idaho, and temperature monitoring locations along these stream reaches.

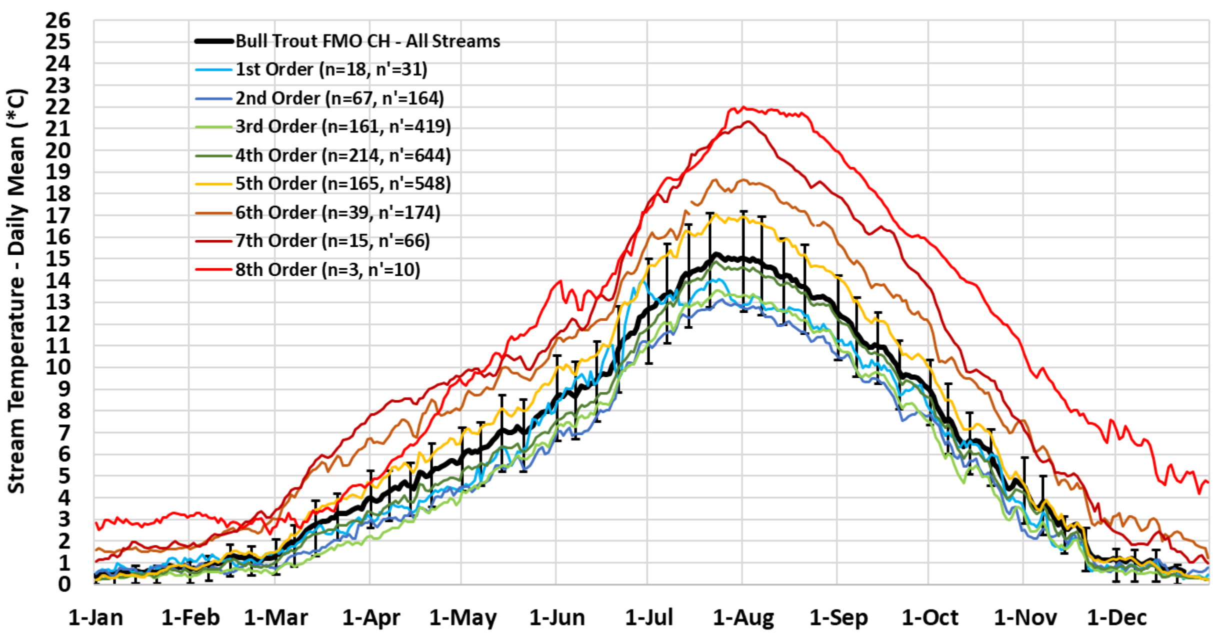


Attachment #5: Temperature Estimate Methods

Figure 2. Seasonal stream temperature distribution, reported by Stream Order, observed at monitoring sites along Bull Trout FMO Critical Habitat (BTFMO_CH) streams in Idaho between 1994 through 2016

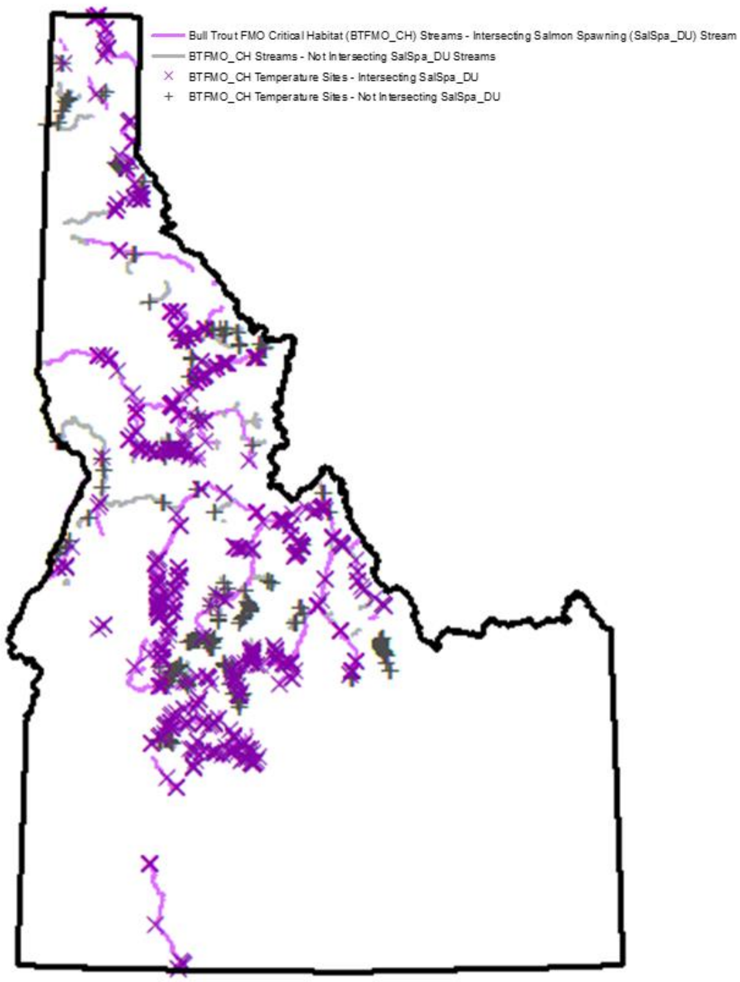
[Top image illustrates Daily Maximum Temperatures and bottom image daily mean temperatures. n represents the number of sites and n' represents the number of seasons of data for each stream order. The bars represent 75th and 25th percentile values, and these percentile values are reported for the 1st, 7th, 14th, and 21st day of the month]

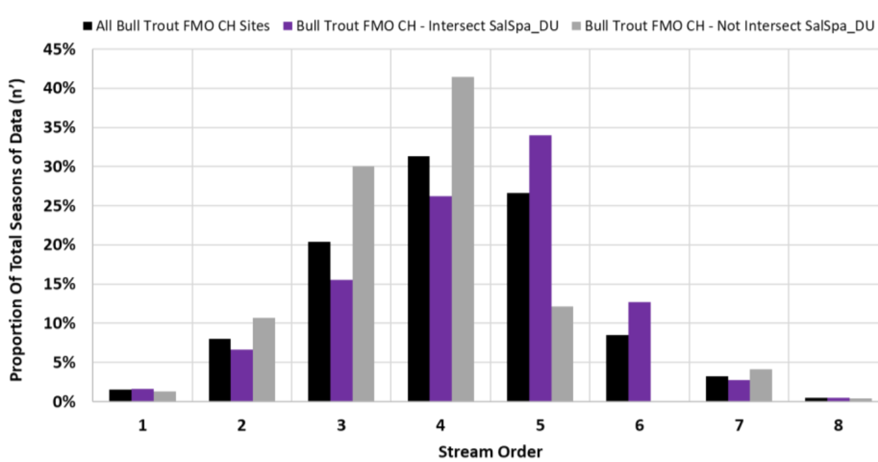




Attachment #5: Temperature Estimate Methods

Figure 3. Designated Bull Trout FMO Critical Habitat Streams (BTFMO_CH) in Idaho, temperature monitoring locations along these streams (1994 through 2016), reported as either 1) Intersected or 2) Not Intersected Salmon Spawning Designated Use (SalSpa_DU) streams, and the proportional distribution of these sites based on Stream Order.

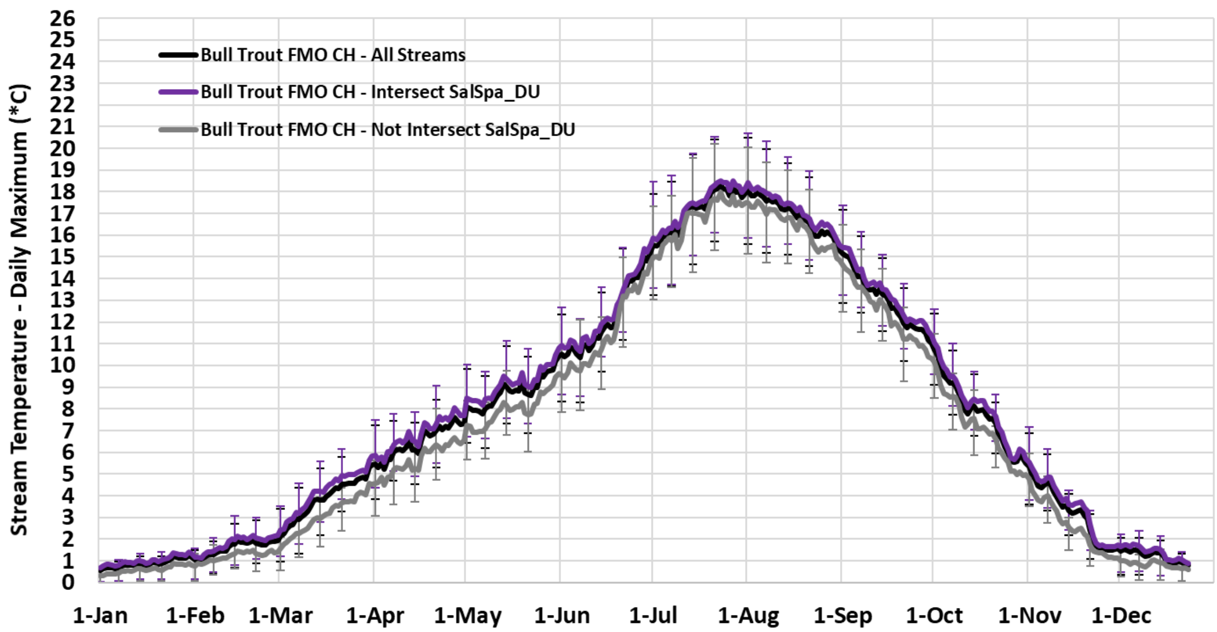


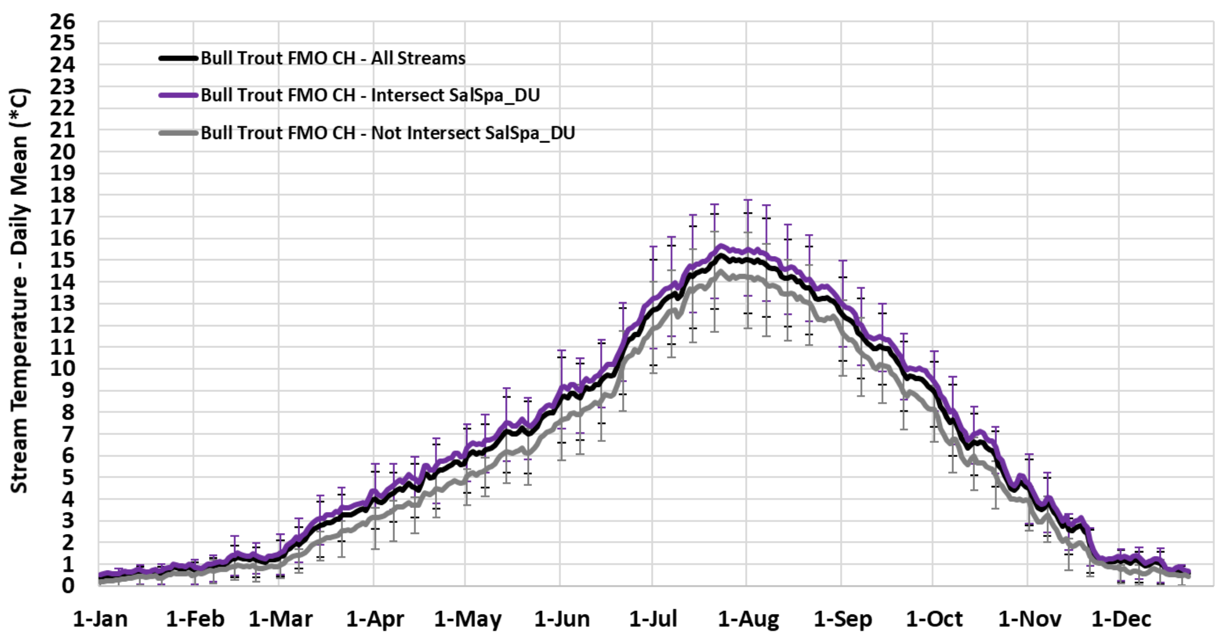


Attachment #5: Temperature Estimate Methods

Figure 4. Seasonal stream temperature distribution observed at monitoring sites along Bull Trout FMO Critical Habitat (BTFMO_CH) streams in Idaho between 1994 through 2016, categorized based on Salmon Spawning Designated Use (SalSpa_DU) designation.

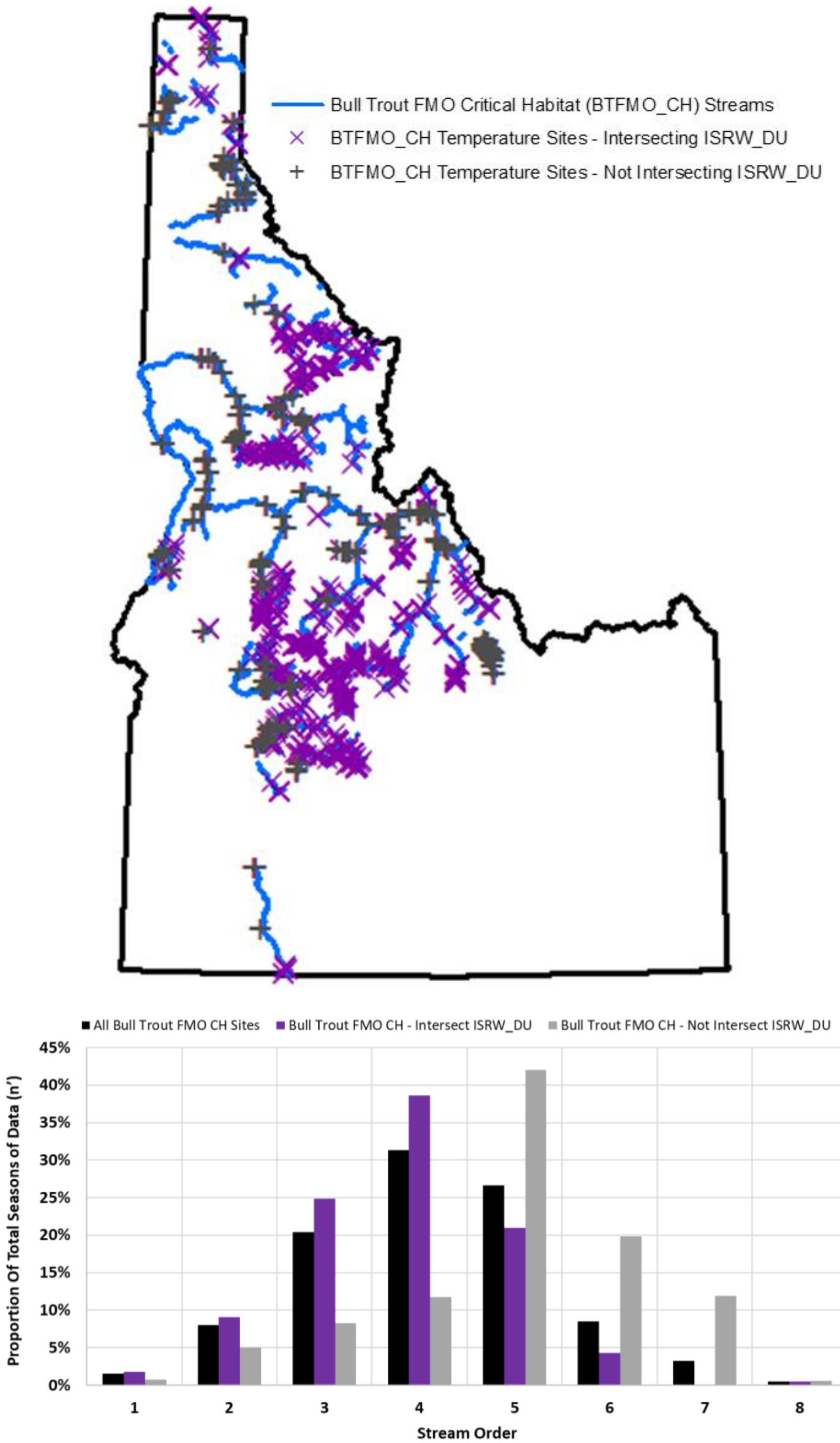
[Top image illustrates Daily Maximum Temperatures and bottom image daily mean temperatures. The bars represent 75th and 25th percentile values, and these percentile values are reported for the 1st, 7th, 14th, and 21st day of the month]





Attachment #5: Temperature Estimate Methods

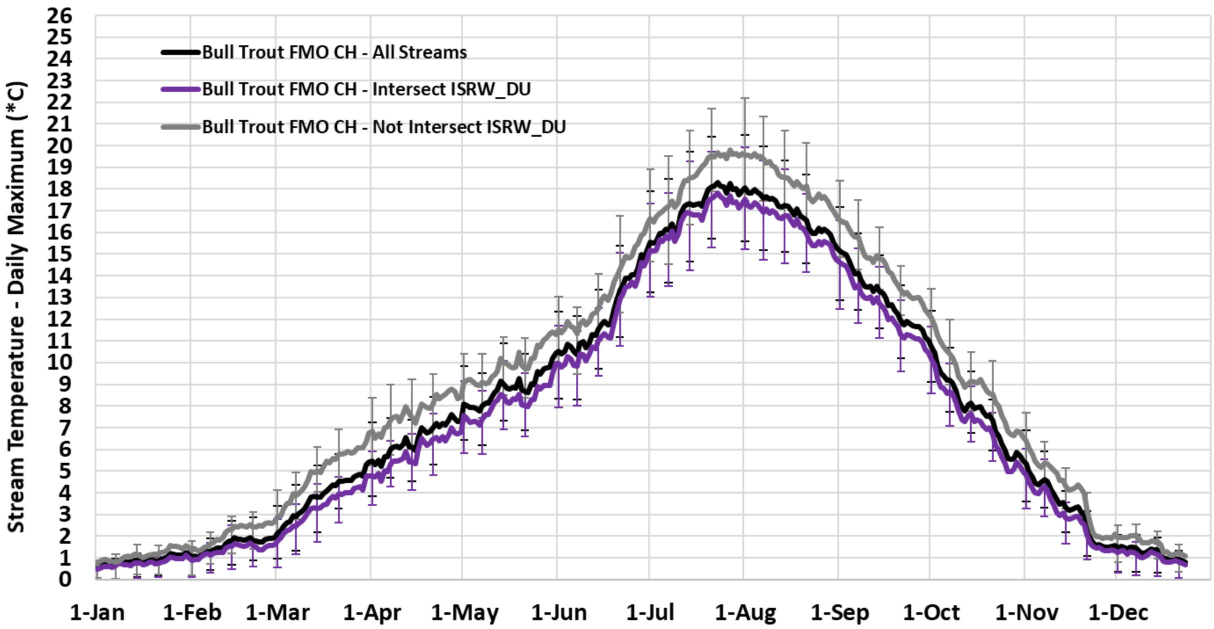
Figure 5. Designated Bull Trout FMO Critical Habitat Streams (BTFMO_CH) in Idaho, temperature monitoring locations along these streams (1994 through 2016), reported as either 1) Intersected or 2) Not Intersected Idaho State Rule Waters Designated Use (ISRW_DU) streams, and the proportional distribution of these sites based on Stream Order.

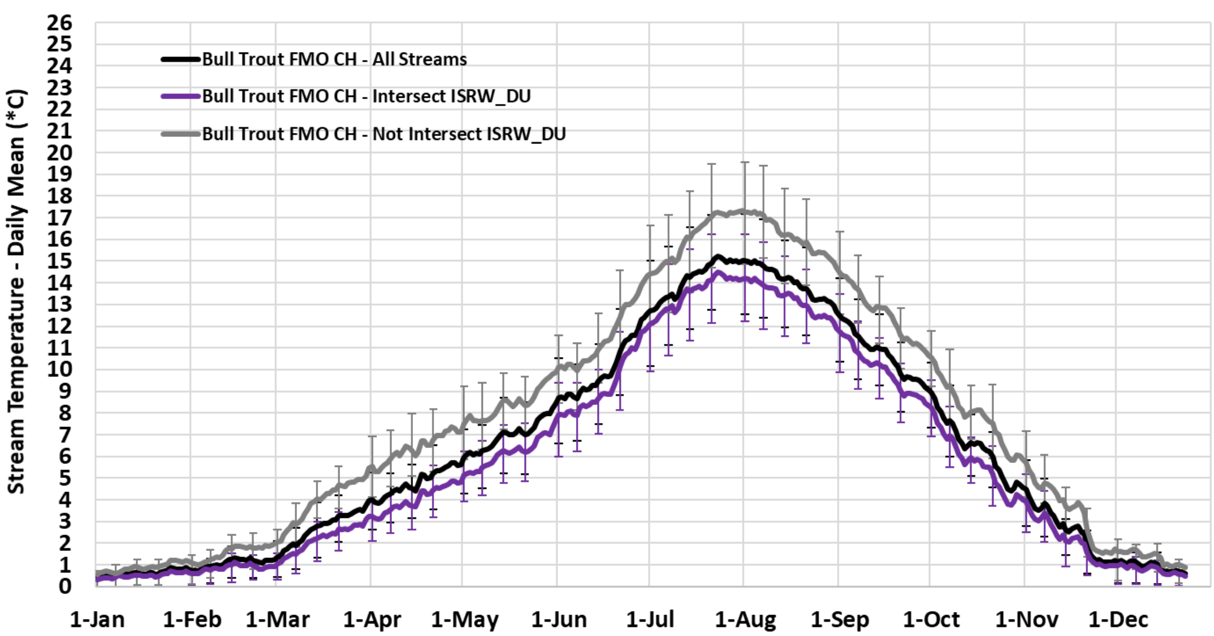


Attachment #5: Temperature Estimate Methods

Figure 6. Seasonal stream temperature distribution observed at monitoring sites along Bull Trout FMO Critical Habitat (BTFMO_CH) streams in Idaho between 1994 through 2016, categorized based on Idaho State Water Rule Designated Use (ISRW_DU) designation.

[Top image illustrates Daily Maximum Temperatures and bottom image daily mean temperatures. The bars represent 75th and 25th percentile values, and these percentile values are reported for the 1st, 7th, 14th, and 21st day of the month]





Attachment #5: Temperature Estimate Methods

Table 1. Approximate Overlap of Bull Trout FMO CH Designated Streams with Salmon Spawning Designated Use (SalSpa_DU) and Idaho State Rule Waters Designated Use (ISRW_DU) in Idaho						
Critical Habitat Designation	Overlapped with SalSpa_DU	Overlapped with ISRW_DU	**Combined Overlap**	*Proportion of Combined Overlap SalSpa_DU Only*	*Proportion of Combined Overlap ISRW_DU Only*	*Proportion of Combined Overlap Both*
BTFMO_CH	69%	54%	**86%**	***38%***	***19%***	***43%***

Methods

Unless otherwise stated below, all processing steps outlined below were implemented using available tools and extensions in ArcGIS 10.3.

Datasets

Critical Habitat (CH) shapefiles for the various species were obtained from the R10 SharePoint site - https://usepa.sharepoint.com/sites/R10/wqsu/SitePages/Home.aspx?RootFolder=%2Fsites%2FR10%2Fwqsu%2FShared%20Documents%2FWQS%20Idaho%2FTemperature%20ESA%2FCritical%20Habitat%20GIS&FolderCTID=0x0120006895FD0A08B1174780732435DE1E031E&View=%7B8572996D%2D7BCB%2D44F3%2D9728%2D9F5D06EAEADB%7D (Zipped files in the folder named – "Critical Habitat GIS").

Beneficial Uses (BU) shapefiles for "Cold", Warm" and "Salmon Spawning" stream designations were obtained from the same R10 SharePoint site used to obtain the CH shapefiles. (Files in the subfolder – "Bundle_BE_IDTemperature/Data/IDAPA").

Temperature Data and sampling location shapefiles were downloaded from the NorWeST website - www.fs.fed.us/rm/boise/AWAE/projects/NorWeST/StreamTemperatureDataSummaries.shtml. This data contains information from 1994 to 2011.

Obtained an additional temperature database from the USFS group responsible for the NorWeST project and this data contain information from 2011 through 2016.

Calculating Overlap Between Critical Habitat and Designation Uses -

The specifics of the steps outlined below reflect the fact that the topology is different between the Critical Habitat (CH) shapefile and the Salmon Spawning Designated Use (SalSpa_DU) shapefile (That is, CH shapefiles do not line up with the SalSpa_DU shapefile). Accordingly, it was not possible to do a simple overlay to determine overlap distance/length between the datasets, however the steps outlined below provided an estimate of the percentage of overlap between these datasets despite these topology issues. (Note – steps listed below are processed for each of the CH stream shapefile (i.e., Bull Trout SR, Bull Trout FMO, and Bull Trout Unknown, Steelhead, Chinook, etc).

The SalSpa_DU designations were used for all of the CH comparisons. However, for Bull Trout CH designations (i.e., SR, FMO, Unknown), two additional overlap designations were determined in addition to the SalSpa_DU comparison: 1) overlap of Idaho State Rule Waters Designated Use (ISRW_DU) with BT_CH, and 2) overlap of ISRW_DU and SalSpa_DU with BT_CH.

The first step is to create points at equal distances along the CH shapefile through the following steps:

37) Make sure the CH shapefile is the same projection as the DU stream shapefile that will be used in the comparisons described below.
38) Create one line feature of the multiple part CH shapefile: Create a new column in the CH shapefile's VAT and populate the added column with the same value/text. Use this added column as a unique identifier in the Dissolve tool (i.e., Dissolve the multipart line into one line segment). It was important to separate the Bull Trout CH shapefile into three separate shapefiles based on the values in the "H_Use_Type" column. i.e., SR, FMO, UKN) and these use these values as the unique identifier in the dissolve tool.
39) Create a point shapefile in ArcCatalog and define the projection as the other CH shapefile.
40) Add this created point shapefile and the created dissolved line shapefile to a new ArcMap project.
41) Make sure to select the point shapefile in the TOC (This will not show any points in the project but this is needed for the next step).
42) Start editing the point shapefile and select the "Create Feature" feature in the edit tool, and make sure that the point shapefile is selected in the opened feature.
43) Then select the line feature using the select tool (all of the lines will be highlighted because will merged the lines to a single line in the second step above)
44) Then select the "Construct Points…" tool in the edit tool dropdown and use 30-meter point creation distance, and save edits after processing. (The computer/program was able to process 30 meter point distance, but was having problems with a finer resolution.)
45) Open the newly created point shapefile in a new ArcMap project and create a new column (Long Integer) and populate the column with the FID attribute in the VAT. This column will be used to join the sampling results produced below in the two shapefiles into one shapefile (This was done because FID columns can be subsequently modified by ArcMap processes without user input and the FID was the unique Identifier produced in the steps listed above.)

The next step is to "move" these created points representing the "Critical Habitat" shapefile to the CH shapefiles (once again, these two shapefiles have a different topology). This step was accomplished using the "Near" tool using the following steps:

13) Open a new ArcMap project and add 1) **<u>a copy of</u>** the point shapefile representing the Critical Habitat that was created in the previous step and 2) the SalSpa_DU line shapefile (make sure that they are the same projection). (Use a copy of the point shapefile because this tool will modify the VAT of the point shapefile and you will be using this file for another "near" assessment with BT_CH layers.)
14) Open the "Near" tool and designate that point shapefile is "Input Feature" and the other shapefile is the "Near Feature". Set the "Search Radius" to 100 meters (Visual inspection of the these datasets indicated that generally the maximum distance in topology between these datasets was around 100 meters) and select the "Location" option (This will create X,Y values for each moved point and this information could be used to plot the locations of the moved points in the future).

15) Create a new column (Float) in the shape after running this tool and populate this column with the “NEAR_Dist” attribute - Give the column a more informative name, something like “NearSalSpa”, because it will be necessary join two shapefiles for the BT_CH comparisons and need to have unique column names.

The “Near” tool will create three new columns in the VAT of the point shapefile “Near_Dist”, “Near_X” and “Near_Y”, which represent the distance between the point and the target shapefile, and the Longitude and Latitude of the moved points, respectively. Importantly, this tool will attribute “-1” for points that are located further than 100 meters from the “target” within the created columns. In other words, these “-1” points indicate locations where there is not an overlap between the two shapefiles. Using the proportions of these points provides a means to estimate the precent overlap between the two shapefiles.

Attachment #5: Temperature Estimate Methods

<u>Supplementing sampling location information</u>

The steps below will add attribute information into the monitoring location shapefile. Adding this information at this step will result in useful information to support subsequent assessments described below. Methods used to calculate three added attributes (i.e., Stream Order, Elevation, and Level 2 and 3 Ecoregions) for each sampling location are described below.

<u>Stream Order Sampling</u>

The Idaho NHD Flowlines shapefile for Idaho was downloaded from the USGS site was separated into four shapefiles. The first step was to merge these four shapefiles into one shapefile by using the "merge" tool. It can be important to let the file save to the default geodatabase location (Saving results of large processing step not within the default geodatabase can result in processing errors).

The next step is to clip out any streams located outside of the Idaho state boundary. Use a projected (same projection as the NHD Flowlines shapefile) state boundary shapefile to clip out all streams located outside of Idaho through using the "clip" tool. It can be important to let the file save to the default geodatabase location (Saving results of large processing step not within the default geodatabase can result in processing errors).

Using the "Project" tool, the next step is to re-project the clipped Flowline stream shapefile to the projection of the NorWeST shapefiles. It can be important to let the file save to the default geodatabase location (Saving results of large processing step not within the default geodatabase can result in processing errors).

Download the NHDPlus attributes files (https://www.epa.gov/waterdata/get-nhdplus-national-hydrography-dataset-plus-data#v2datamap) and join the "PlusFlowLineVAA.dbf" file to the new ArcMap project. Then add the projected FlowLine shapefile that was produced in the previous step to the ArcMap project. Using the "Join" tool, join the PlusFlowLineVAA.dbf attribute information to the VAT of the shapefile using the "Reach Code" attribute – make sure to use the "Keep all Records" option with this tool. Save this joined shapefile as a new shapefile. Finally, delete the processing steps described above (They take a lot of memory space on the disc and these preliminary result files will not be used in subsequent steps).

The next step is to "move" points in the monitoring location shapefile in order to subsequently "sample" the stream order information to these monitoring locations. This step was necessary because these two shapefiles have a different topology and therefore do not line exactly on top of each other. This step was accomplished using the "Near" tool using the following steps: 1) Open a new ArcMap project and add 1) **<u>a copy of</u>** the point shapefile representing the monitoring locations and 2) the Stream Order line shapefile created above (make sure that they are the same projection). (Use a copy of the point shapefile because this tool will modify the VAT of the point shapefile.) 2) Open the "Near" tool and designate that point shapefile is "Input Feature" and the line shapefile is the "Near Feature". Set the "Search Radius" to 100 meters (Visual inspection of the these datasets indicated that generally the maximum distance in topology between these datasets was around 100 meters) and select the "Location" option (This will create X,Y values for each moved point and this information could be used to plot the

locations of the moved points in the future). The “Near” tool will create three new columns in the VAT of the point shapefile “Near_Dist”, “Near_X” and “Near_Y”, which represent the distance between the point and the target shapefile, and the Longitude and Latitude of the moved points, respectively. Importantly, this tool will attribute “-1” for points that are located further than 100 meters from the “target” within the created columns. In other words, these “-1” points indicate locations where there is not an overlap between the two shapefiles. Export the VAT from the point shapefile implemented in the previous step as a table (.csv). Add this file to the ArcMap project and use the “Display x,y” tool on this file to create an event shapefile through using the Near_X and Near_Y attributes created in the previous step. Save this event as a new shapefile. In a new ArcMap project, add the “near” monitoring point shapefile created above and the stream order line shapefile. Using the “Spatial Join” tool, sample the stream order attribute into the monitor point shapefile. These shapefiles should not be located on top of each other as a result of the previous step and therefore do not need to include a search radius with this tool (Do not use search radius with the “Spatial Join” tool because it does not sample the nearest segment if there is more than segment that is located within the search radius, while the “Near” picks the nearest segment.)

At “-1” sites, the Stream Order attribute were manually populated based on visual review of the stream order shapefile. In addition, there are several segments in the PlusFlowLineVAA.dbf database that report “0” stream order and monitoring locations with a reported “0” stream order was also manually sampled. This last manual step can take a lot of time to implement.

Elevation Sampling

Downloaded the NHDPlus DEM files Version (https://nhdplus.com/NHDPlus/NHDPlusV1_home.php) and mosaic them together for the state of Idaho. It is important to use version 1 because stream lines are not burned into this version of the DEM. Make sure that the project of the NorWeST point shapefiles is identical to the DEM file. Using the “Sampling” tool sample the DEM for each point shapefile – make sure to use the default setting in this tool (i.e., output location, nearest sample, and unique Identifier as the FID) because this tool can sometimes not work correctly if any changes to these settings are implemented. Join the results of the sampling tool to the VAT of the NorWeST point shapefile in the previous step (i.e., Stream Order is added to the VAT) and save as new shapefile. Convert the values to meters by creating a “float” column in the newly created shapefile VAT and make the conversion calculation for this new column.

Ecoregion Sampling

Download the Level III Ecoregion shapefile (https://www.epa.gov/eco-research/ecoregions-north-america). Project this shapefile to that of the NorWeST sampling point shapefiles. Remove all columns in the VAT of the projected shapefile except for NA_L2KEY, and NA_L3KEY. Then run a spatial join between the NorWeST sampling point shapefiles created in the previous step with the projected Ecoregion shapefile (i.e., move the attributes from the Ecoregion VAT to the VAT of the NorWeST shapefile VAT.)

Attachment #5: Temperature Estimate Methods

<u>Subsampling the Temperature Databases</u>

The steps listed below will subsample the temperature databases in order to evaluate the temperature difference between different stream conditions (i.e., critical habitat, designated uses). The temperature databases are separated into 5 parts and many of the steps listed below need to be repeated for each database part.

The first step is to select all monitoring points located along the Critical Habitat shapefile (for example, Steelhead Critical Habitat) using the following steps. Using the "Select by Location" tool, select NorWeST sites in the modified shapefiles (i.e., containing Stream Order, Elevation, Ecoregion information) that are located within 30 meters of the Critical Habitat line shapefile and save as a new shapefile. This created point shapefile represents all of the monitoring locations situated on Critical Habitat stream designation.

This new shapefile is subsequently subsampled to refine the categories to critical habitat monitoring sites located on Salmon Spawning Designated Uses (SalSpa_DU) steams or not so. Once again, use the Select by Location" tool to select sites created in the step above that also are located within 100 meters of SalSpa_DU stream designation. Save this file as a new shapefile. Switch the selected sites to develop a shapefile with sites that are not associated with SalSpa_DU stream designation. Save this file also.

Using these subsetted monitoring point location shapefiles, the temperature databases were subsetted using the following steps.

The temperature databases are MS Excel format but this format does not merge well into ArcGIS (This information needs to be added to ArcGIS project during the next sampling steps). This conversion step is implemented using MS Access because of row limitations within MS Excell can truncate the dataset and therefore result in lost data. First, open MS Assess and Import the Excel file containing the temperature data into a new Access project (i.e., "New Data Sources from File"). Open the added table in the Access database and highlight all cells in the table, and then export the added file to a dbase format (i.e., ".dbf") using the "Export to dbase file" in MS Assess.

Load the temperature database dbf file into an new ArcMap project and then add the subset point shapefiles created above. Run a spatial joint between the temperature database and one of the subsetted shapefile (use OBSRED_ID for NorWeST databases, and SBSP_ID for the USFS post 2011 database) – Make sure that "Keep only Matching Records" is selected in the tool. After each join, save the database as a new table. Remove the joint and repeat for the other subsetted point shapefile.

Slightly different methods for the Post 2011 Temperature sites were required because this database was organized slightly differently than the NorWeST database. Specifically, it was necessary to also add an additional attribute to this point shapefile – The "PERMAFID" is the unique site identifier and is going to be subsequently used to join temperature information between the two temperature databases. Specifically, the unique site attribute (i.e., PERMA_FID) was not included with the point shapefile associated with the Post 2011 data. The steps described below outline how the PERMA_FID attribute was assigned for these post-2011 sites.

> In a new ArcMap project, load the Original NorWeST point shapefile for an assessment area (i.e., Clearwater). Delete all attributes in the VAT except for the "PERMA_FID" column. Then add the point shapefile associated with the post-2011 sites (i.e., the created shapefile above with stream

order, elevation, and Ecoregion included in the VAT). Make sure that the projections are the same between the two datasets. Run Spatial Join on the two datasets in order to copy attributes from the original NorWeST VAT to the other datasets, using a 30m search radius for the tool. All sites with a value in the PERMA_FID column of the joined shapefile are sites that have data for both per and post 2011 data. All sites without any information in this column are only post 2011 sites and a unique PERMA_FID value is required for these sites - the PERMA_FID was assigned a unique value (something like - 900000 plus the "CBSP_ID" value), so that we can know that these sites were not associated with pre2011 values (i.e., any PERMA_FID value that is greater than 900,000). (Finally, spot check if the join worked correctly by comparing the two "Permanent_" columns in the final VAT – one version comes from each shapefile and these values should be the same).

Each subsetted temperature database is opened in Microsoft Excel and pivot tables were used to summarize the temperature data associated with these sites.

Attachment #5: Temperature Estimate Methods

Memorandum **January 10, 2022**

To: Rochelle Labiosa R10USEPA, and Lil Herger R10USEPA

From: Peter Leinenbach R10USEPA

Subject: Measured stream temperature conditions along designated Bull Trout SR Critical Habitat (BTSR_CH) streams in Idaho.

There are approximately 8,067 kilometers of streams in Idaho that are designated as Bull Trout SR Critical Habitat (BTSR_CH) (**Figure 1**). There are 1,634 individual temperature monitoring locations (n) situated along designated BTSR_CH streams in Idaho, and these sites contain 4,633 seasons of data (n'). Observed stream temperatures at these sites reached maximums during the summer period and stream temperatures were generally warmer at sites with larger stream order designations (**Figure 2**).

Approximately 36% of Idaho BTSR_CH streams are also classified as Salmon Spawning Designated Use (SalSpa_DU), which corresponds to approximately 2,904.2 stream kilometers of streams (see purple lines in top image in **Figure 3**). (Alternatively, approximately 5,162.8 stream kilometers (i.e., 64%) of designated BTSR_CH streams are **not** also classified as SalSpa_DU (see grey lines in top image in **Figure 3**).) Approximately 40% of the temperature monitoring sites along BTSR_CH are situated on stream reaches that are also designated as a SalSpa_DU streams, which corresponds closely to the distribution of stream overlap between these two stream classifications (i.e., 36%).

Observed temperatures were very similar for sites designated as (1) BTSR_CH/SalSpa_DU, and (2) only BTSR_CH (**Figure 4**). Stream order was very similar between these two groups (i.e., 2.4 vs. 2.5, respectively - bottom image in **Figure 3**) and, possibly as a result, observed stream temperatures were similar between these two groups.

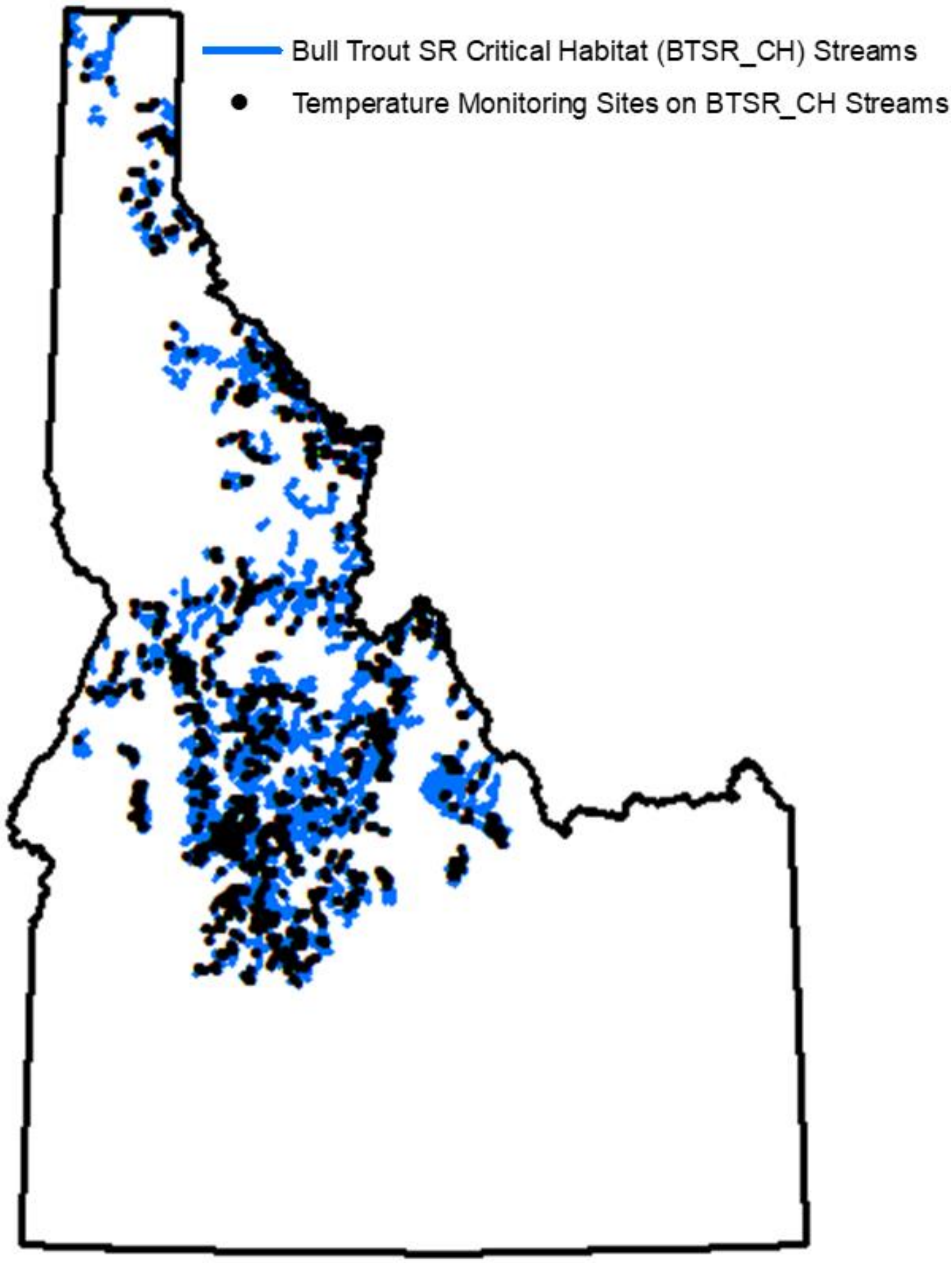
In addition, approximately 90% of Idaho BTSR_CH streams are also classified as Idaho State Rule Waters Designated Use (ISRW_DU), which corresponds to approximately 7,260.6 stream kilometers. Approximately 87% of the temperature monitoring sites along BTFMO_CH are situated on stream reaches that are also designated as ISRW_DU streams (**Figure 5**), which corresponds closely to the distribution of stream overlap between these two stream classifications (i.e., 90%).

Observed temperatures were slightly cooler for BTSR_CH sites also designated as ISRW_DU stream, as compared to BTSR_CH sites **not** located along ISRW_DU designated streams (**Figure 6**). This result is likely due to different stream order distributions associated with these two groups (see bottom image in **Figure 5).** That is, the weighted average stream order associated with temperature monitoring sites located on designated BTSR_CH/ISRW_DU streams was 2.4, while it was 2.9 at temperature sites located on streams only designated as BTSR_CH.

Finally, approximately 93% of designated BTSR_CH streams in Idaho are also designated as either SalSpa_DU or ISWR_DU (**Table 1**). However, the proportion of the "ISRW_DU/BTSR_DU" group resulting in overlap by itself was over 20 times as much than associated with the "SalSpa_DU/BTSR_CH" group (i.e., 61% vs. 3%), while 36% of the overlap areas are designated as "SalSpa_DU/ISRW_DU/BTSR_CH".

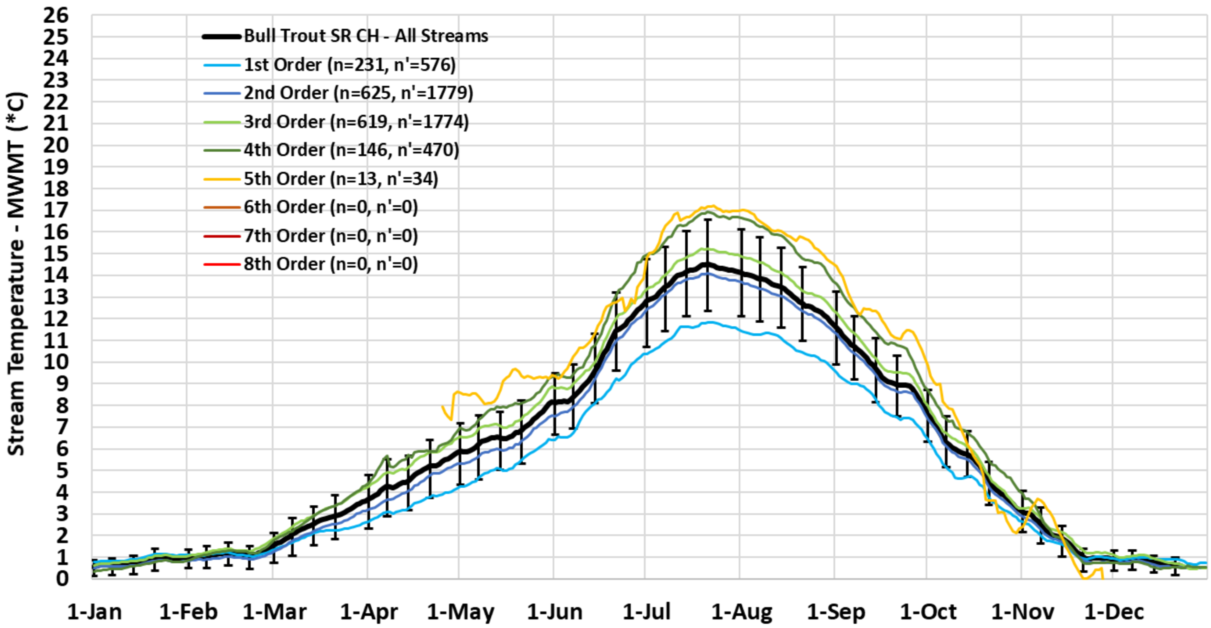
Attachment #5: Temperature Estimate Methods

Figure 1. Designated Butt Trout SR Critical Habitat Streams (BTSR_CH) in Idaho, and temperature monitoring locations along these stream reaches.



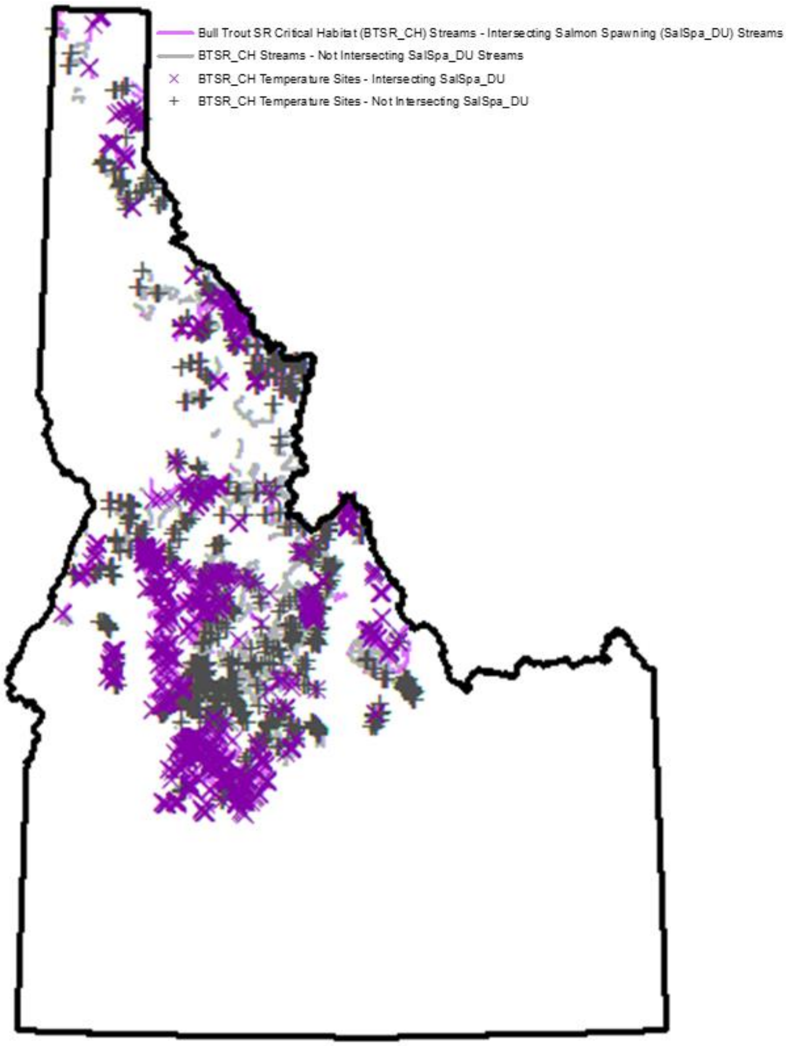
Attachment #5: Temperature Estimate Methods

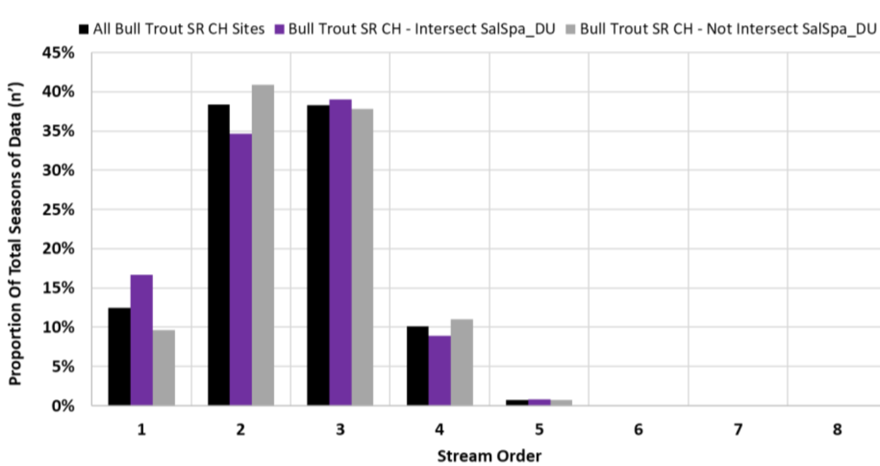
Figure 2. Seasonal stream temperature distribution, reported by Stream Order, observed at monitoring sites along Bull Trout SR Critical Habitat (BTSR_CH) streams in Idaho between 1994 through 2016
[Bars represent 75th and 25th percentile, and these percentile values are reported for the 1st, 7th, 14th, and 21st of the month]



Attachment #5: Temperature Estimate Methods

Figure 3. Designated Bull Trout SR Critical Habitat Streams (BTSR_CH) in Idaho, temperature monitoring locations along these streams (1994 through 2016), reported as either 1) Intersected or 2) Not Intersected Salmon Spawning Designated Use (SalSpa_DU) streams, and the proportional distribution of these sites based on Stream Order.

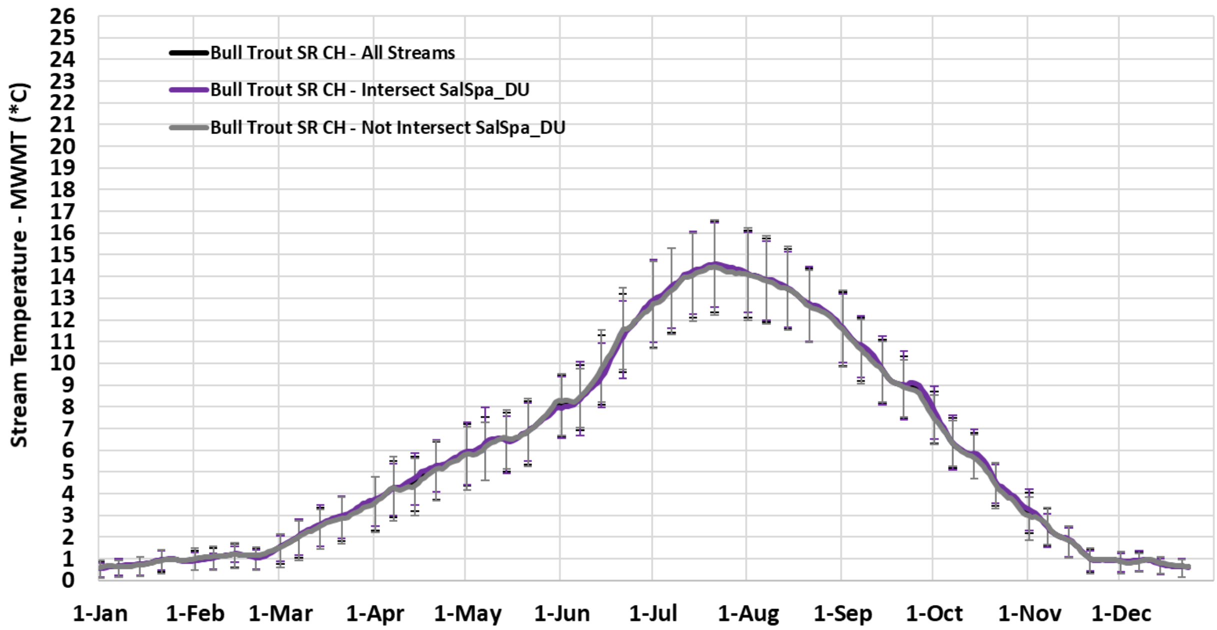




Attachment #5: Temperature Estimate Methods

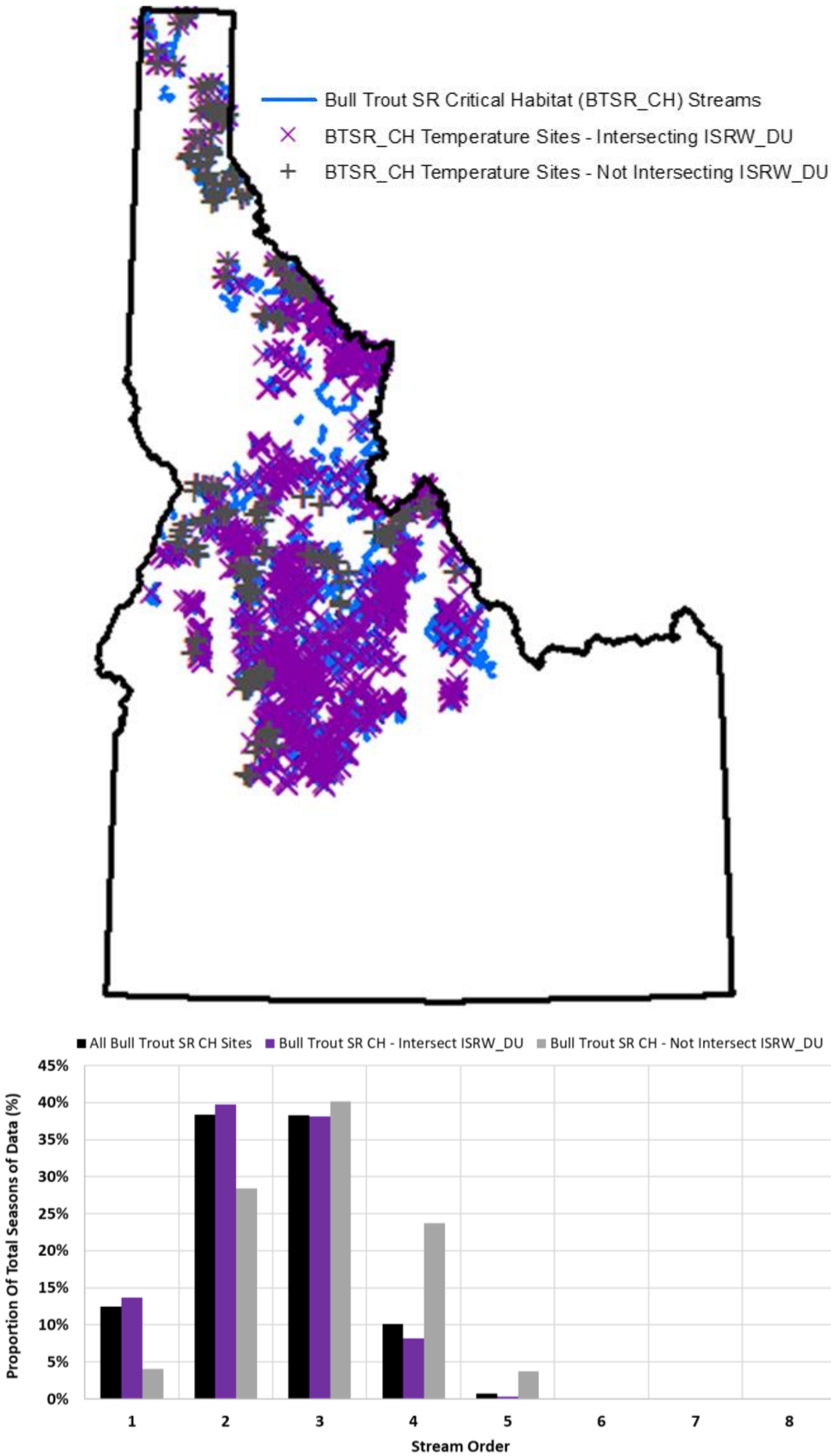
Figure 4. Seasonal stream temperature distribution observed at monitoring sites along Bull Trout SR Critical Habitat (BTSR_CH) streams in Idaho between 1994 through 2016, categorized based on Salmon Spawning Designated Use (SalSpa_DU) designation.

[Bars represent 75th and 25th percentile, and these percentile values are reported for the 1st, 7th, 14th, and 21st of the month]



Attachment #5: Temperature Estimate Methods

Figure 5. Designated Bull Trout SR Critical Habitat Streams (BTSR_CH) in Idaho, temperature monitoring locations along these streams (1994 through 2016), reported as either 1) Intersected or 2) Not Intersected Idaho State Rule Waters Designated Use (ISRW_DU) streams, and the proportional distribution of these sites based on Stream Order.



Attachment #5: Temperature Estimate Methods

Figure 5. Seasonal stream temperature distribution observed at monitoring sites along Bull Trout SR Critical Habitat (BTSR_CH) streams in Idaho between 1994 through 2016, categorized based on Idaho State Water Rule Designated Use (ISRW_DU) designation.

[Bars represent 75th and 25th percentile, and these percentile values are reported for the 1st, 7th, 14th, and 21st of the month]

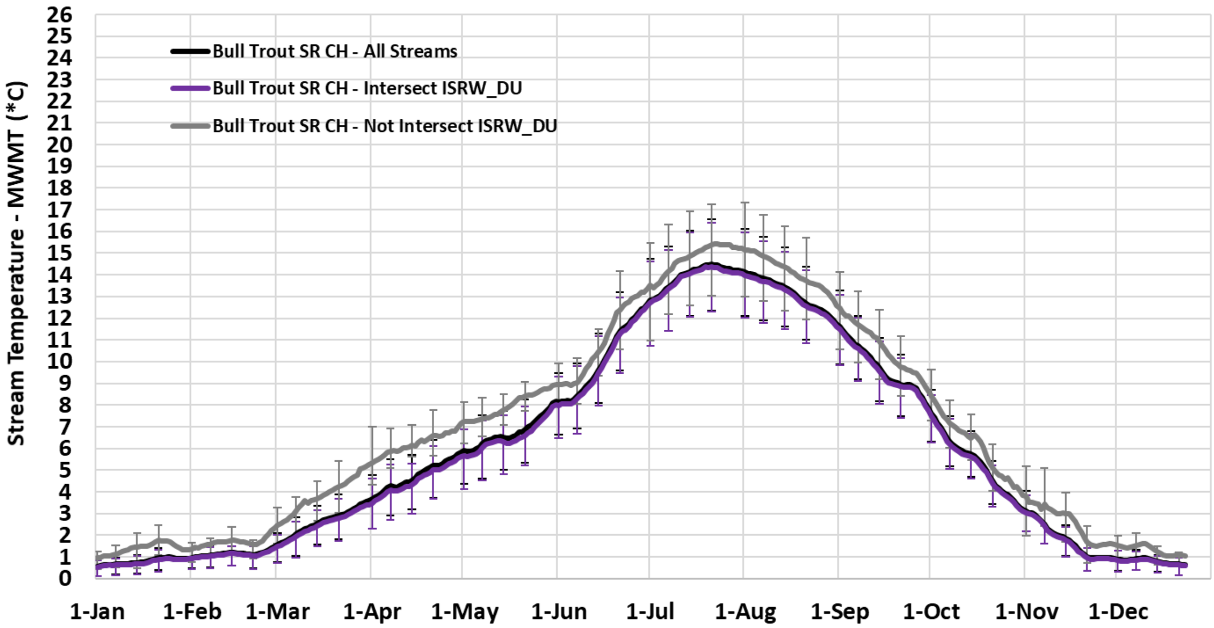


Table 1. Approximate Overlap of Bull Trout SR CH Designated Streams with Salmon Spawning Designated Use (SalSpa_DU) and Idaho State Rule Waters Designated Use (ISRW_DU) in Idaho

Critical Habitat Designation	Overlapped with SalSpa_DU	Overlapped with ISRW_DU	**Combined Overlap**	*Proportion of Combined Overlap SalSpa_DU Only*	*Proportion of Combined Overlap ISRW_DU Only*	*Proportion of Combined Overlap Both*
BTSR_CH	36%	90%	**93%**	***3%***	***61%***	***36%***

Attachment #5: Temperature Estimate Methods

Methods

Unless otherwise stated below, all processing steps outlined below were implemented using available tools and extensions in ArcGIS 10.3.

Datasets

Critical Habitat (CH) shapefiles for the various species were obtained from the R10 SharePoint site - https://usepa.sharepoint.com/sites/R10/wqsu/SitePages/Home.aspx?RootFolder=%2Fsites%2FR10%2Fwqsu%2FShared%20Documents%2FWQS%20Idaho%2FTemperature%20ESA%2FCritical%20Habitat%20GIS&FolderCTID=0x0120006895FD0A08B1174780732435DE1E031E&View=%7B8572996D%2D7BCB%2D44F3%2D9728%2D9F5D06EAEADB%7D (Zipped files in the folder named – "Critical Habitat GIS").

Beneficial Uses (BU) shapefiles for "Cold", Warm" and "Salmon Spawning" stream designations were obtained from the same R10 SharePoint site used to obtain the CH shapefiles. (Files in the subfolder – "Bundle_BE_IDTemperature/Data/IDAPA").

Temperature Data and sampling location shapefiles were downloaded from the NorWeST website - www.fs.fed.us/rm/boise/AWAE/projects/NorWeST/StreamTemperatureDataSummaries.shtml. This data contains information from 1994 to 2011.

Obtained an additional temperature database from the USFS group responsible for the NorWeST project and this data contain information from 2011 through 2016.

Calculating Overlap Between Critical Habitat and Designation Uses -

The specifics of the steps outlined below reflect the fact that the topology is different between the Critical Habitat (CH) shapefile and the Salmon Spawning Designated Use (SalSpa_DU) shapefile (That is, CH shapefiles do not line up with the SalSpa_DU shapefile). Accordingly, it was not possible to do a simple overlay to determine overlap distance/length between the datasets, however the steps outlined below provided an estimate of the percentage of overlap between these datasets despite these topology issues. (Note – steps listed below are processed for each of the CH stream shapefile (i.e., Bull Trout SR, Bull Trout SR, and Bull Trout Unknown, Steelhead, Chinook, etc).

The SalSpa_DU designations were used for all of the CH comparisons. However, for Bull Trout CH designations (i.e., SR, SR, Unknown), two additional overlap designations were determined in addition to the SalSpa_DU comparison: 1) overlap of Idaho State Rule Waters Designated Use (ISRW_DU) with BT_CH, and 2) overlap of ISRW_DU and SalSpa_DU with BT_CH.

The first step is to create points at equal distances along the CH shapefile through the following steps:

46) Make sure the CH shapefile is the same projection as the DU stream shapefile that will be used in the comparisons described below.
47) Create one line feature of the multiple part CH shapefile: Create a new column in the CH shapefile's VAT and populate the added column with the same value/text. Use this added column as a unique identifier in the Dissolve tool (i.e., Dissolve the multipart line into one line segment). It was important to separate the Bull Trout CH shapefile into three separate shapefiles based on the values in the "H_Use_Type" column. i.e., SR, SR, UKN) and these use these values as the unique identifier in the dissolve tool.

48) Create a point shapefile in ArcCatalog and define the projection as the other CH shapefile.
49) Add this created point shapefile and the created dissolved line shapefile to a new ArcMap project.
50) Make sure to select the point shapefile in the TOC (This will not show any points in the project but this is needed for the next step).
51) Start editing the point shapefile and select the "Create Feature" feature in the edit tool, and make sure that the point shapefile is selected in the opened feature.
52) Then select the line feature using the select tool (all of the lines will be highlighted because will merged the lines to a single line in the second step above)
53) Then select the "Construct Points…" tool in the edit tool dropdown and use 30-meter point creation distance, and save edits after processing. (The computer/program was able to process 30 meter point distance, but was having problems with a finer resolution.)
54) Open the newly created point shapefile in a new ArcMap project and create a new column (Long Integer) and populate the column with the FID attribute in the VAT. This column will be used to join the sampling results produced below in the two shapefiles into one shapefile (This was done because FID columns can be subsequently modified by ArcMap processes without user input and the FID was the unique Identifier produced in the steps listed above.)

The next step is to "move" these created points representing the "Critical Habitat" shapefile to the CH shapefiles (once again, these two shapefiles have a different topology). This step was accomplished using the "Near" tool using the following steps:

16) Open a new ArcMap project and add 1) **a copy of** the point shapefile representing the Critical Habitat that was created in the previous step and 2) the SalSpa_DU line shapefile (make sure that they are the same projection). (Use a copy of the point shapefile because this tool will modify the VAT of the point shapefile and you will be using this file for another "near" assessment with BT_CH layers.)
17) Open the "Near" tool and designate that point shapefile is "Input Feature" and the other shapefile is the "Near Feature". Set the "Search Radius" to 100 meters (Visual inspection of the these datasets indicated that generally the maximum distance in topology between these datasets was around 100 meters) and select the "Location" option (This will create X,Y values for each moved point and this information could be used to plot the locations of the moved points in the future).
18) Create a new column (Float) in the shape after running this tool and populate this column with the "NEAR_Dist" attribute - Give the column a more informative name, something like "NearSalSpa", because it will be necessary join two shapefiles for the BT_CH comparisons and need to have unique column names.

The "Near" tool will create three new columns in the VAT of the point shapefile "Near_Dist", "Near_X" and "Near_Y", which represent the distance between the point and the target shapefile, and the Longitude and Latitude of the moved points, respectively. Importantly, this tool will attribute "-1" for points that are located further than 100 meters from the "target" within the created columns. In other words, these "-1" points indicate locations where there is not an overlap between the two shapefiles. Using the proportions of these points provides a means to estimate the precent overlap between the two shapefiles.

Attachment #5: Temperature Estimate Methods

<u>Supplementing sampling location information</u>

The steps below will add attribute information into the monitoring location shapefile. Adding this information at this step will result in useful information to support subsequent assessments described below. Methods used to calculate three added attributes (i.e., Stream Order, Elevation, and Level 2 and 3 Ecoregions) for each sampling location are described below.

<u>Stream Order Sampling</u>

The Idaho NHD Flowlines shapefile for Idaho was downloaded from the USGS site was separated into four shapefiles. The first step was to merge these four shapefiles into one shapefile by using the "merge" tool. It can be important to let the file save to the default geodatabase location (Saving results of large processing step not within the default geodatabase can result in processing errors).

The next step is to clip out any streams located outside of the Idaho state boundary. Use a projected (same projection as the NHD Flowlines shapefile) state boundary shapefile to clip out all streams located outside of Idaho through using the "clip" tool. It can be important to let the file save to the default geodatabase location (Saving results of large processing step not within the default geodatabase can result in processing errors).

Using the "Project" tool, the next step is to re-project the clipped Flowline stream shapefile to the projection of the NorWeST shapefiles. It can be important to let the file save to the default geodatabase location (Saving results of large processing step not within the default geodatabase can result in processing errors).

Download the NHDPlus attributes files (https://www.epa.gov/waterdata/get-nhdplus-national-hydrography-dataset-plus-data#v2datamap) and join the "PlusFlowLineVAA.dbf" file to the new ArcMap project. Then add the projected FlowLine shapefile that was produced in the previous step to the ArcMap project. Using the "Join" tool, join the PlusFlowLineVAA.dbf attribute information to the VAT of the shapefile using the "Reach Code" attribute – make sure to use the "Keep all Records" option with this tool. Save this joined shapefile as a new shapefile. Finally, delete the processing steps described above (They take a lot of memory space on the disc and these preliminary result files will not be used in subsequent steps).

The next step is to "move" points in the monitoring location shapefile in order to subsequently "sample" the stream order information to these monitoring locations. This step was necessary because these two shapefiles have a different topology and therefore do not line exactly on top of each other. This step was accomplished using the "Near" tool using the following steps: 1) Open a new ArcMap project and add 1) **<u>a copy of</u>** the point shapefile representing the monitoring locations and 2) the Stream Order line shapefile created above (make sure that they are the same projection). (Use a copy of the point shapefile because this tool will modify the VAT of the point shapefile.) 2) Open the "Near" tool and designate that point shapefile is "Input Feature" and the line shapefile is the "Near Feature". Set the "Search Radius" to 100 meters (Visual inspection of the these datasets indicated that generally the maximum distance in topology between these datasets was around 100 meters) and select the "Location" option (This will create X,Y values for each moved point and this information could be used to plot the

locations of the moved points in the future). The “Near” tool will create three new columns in the VAT of the point shapefile “Near_Dist”, “Near_X” and “Near_Y”, which represent the distance between the point and the target shapefile, and the Longitude and Latitude of the moved points, respectively. Importantly, this tool will attribute “-1” for points that are located further than 100 meters from the “target” within the created columns. In other words, these “-1” points indicate locations where there is not an overlap between the two shapefiles. Export the VAT from the point shapefile implemented in the previous step as a table (.csv). Add this file to the ArcMap project and use the “Display x,y” tool on this file to create an event shapefile through using the Near_X and Near_Y attributes created in the previous step. Save this event as a new shapefile. In a new ArcMap project, add the “near” monitoring point shapefile created above and the stream order line shapefile. Using the “Spatial Join” tool, sample the stream order attribute into the monitor point shapefile. These shapefiles should not be located on top of each other as a result of the previous step and therefore do not need to include a search radius with this tool (Do not use search radius with the “Spatial Join” tool because it does not sample the nearest segment if there is more than segment that is located within the search radius, while the “Near” picks the nearest segment.)

At “-1” sites, the Stream Order attribute were manually populated based on visual review of the stream order shapefile. In addition, there are several segments in the PlusFlowLineVAA.dbf database that report “0” stream order and monitoring locations with a reported “0” stream order was also manually sampled. This last manual step can take a lot of time to implement.

Elevation Sampling

Downloaded the NHDPlus DEM files Version (https://nhdplus.com/NHDPlus/NHDPlusV1_home.php) and mosaic them together for the state of Idaho. It is important to use version 1 because stream lines are not burned into this version of the DEM. Make sure that the project of the NorWeST point shapefiles is identical to the DEM file. Using the “Sampling” tool sample the DEM for each point shapefile – make sure to use the default setting in this tool (i.e., output location, nearest sample, and unique Identifier as the FID) because this tool can sometimes not work correctly if any changes to these settings are implemented. Join the results of the sampling tool to the VAT of the NorWeST point shapefile in the previous step (i.e., Stream Order is added to the VAT) and save as new shapefile. Convert the values to meters by creating a “float” column in the newly created shapefile VAT and make the conversion calculation for this new column.

Ecoregion Sampling

Download the Level III Ecoregion shapefile (https://www.epa.gov/eco-research/ecoregions-north-america). Project this shapefile to that of the NorWeST sampling point shapefiles. Remove all columns in the VAT of the projected shapefile except for NA_L2KEY, and NA_L3KEY. Then run a spatial join between the NorWeST sampling point shapefiles created in the previous step with the projected Ecoregion shapefile (i.e., move the attributes from the Ecoregion VAT to the VAT of the NorWeST shapefile VAT.)

Attachment #5: Temperature Estimate Methods

Subsampling the Temperature Databases

The steps listed below will subsample the temperature databases in order to evaluate the temperature difference between different stream conditions (i.e., critical habitat, designated uses). The temperature databases are separated into 5 parts and many of the steps listed below need to be repeated for each database part.

The first step is to select all monitoring points located along the Critical Habitat shapefile (for example, Steelhead Critical Habitat) using the following steps. Using the "Select by Location" tool, select NorWeST sites in the modified shapefiles (i.e., containing Stream Order, Elevation, Ecoregion information) that are located within 30 meters of the Critical Habitat line shapefile and save as a new shapefile. This created point shapefile represents all of the monitoring locations situated on Critical Habitat stream designation.

This new shapefile is subsequently subsampled to refine the categories to critical habitat monitoring sites located on Salmon Spawning Designated Uses (SalSpa_DU) steams or not so. Once again, use the Select by Location" tool to select sites created in the step above that also are located within 100 meters of SalSpa_DU stream designation. Save this file as a new shapefile. Switch the selected sites to develop a shapefile with sites that are not associated with SalSpa_DU stream designation. Save this file also.

Using these subsetted monitoring point location shapefiles, the temperature databases were subsetted using the following steps.

The temperature databases are MS Excel format but this format does not merge well into ArcGIS (This information needs to be added to ArcGIS project during the next sampling steps). This conversion step is implemented using MS Access because of row limitations within MS Excell can truncate the dataset and therefore result in lost data. First, open MS Assess and Import the Excel file containing the temperature data into a new Access project (i.e., "New Data Sources from File"). Open the added table in the Access database and highlight all cells in the table, and then export the added file to a dbase format (i.e., ".dbf") using the "Export to dbase file" in MS Assess.

Load the temperature database dbf file into an new ArcMap project and then add the subset point shapefiles created above. Run a spatial joint between the temperature database and one of the subsetted shapefile (use OBSRED_ID for NorWeST databases, and SBSP_ID for the USFS post 2011 database) – Make sure that "Keep only Matching Records" is selected in the tool. After each join, save the database as a new table. Remove the joint and repeat for the other subsetted point shapefile.

Slightly different methods for the Post 2011 Temperature sites were required because this database was organized slightly differently than the NorWeST database. Specifically, it was necessary to also add an additional attribute to this point shapefile – The "PERMAFID" is the unique site identifier and is going to be subsequently used to join temperature information between the two temperature databases. Specifically, the unique site attribute (i.e., PERMA_FID) was not included with the point shapefile associated with the Post 2011 data. The steps described below outline how the PERMA_FID attribute was assigned for these post-2011 sites.

> In a new ArcMap project, load the Original NorWeST point shapefile for an assessment area (i.e., Clearwater). Delete all attributes in the VAT except for the "PERMA_FID" column. Then add the point shapefile associated with the post-2011 sites (i.e., the created shapefile above with stream

order, elevation, and Ecoregion included in the VAT). Make sure that the projections are the same between the two datasets. Run Spatial Join on the two datasets in order to copy attributes from the original NorWeST VAT to the other datasets, using a 30m search radius for the tool. All sites with a value in the PERMA_FID column of the joined shapefile are sites that have data for both per and post 2011 data. All sites without any information in this column are only post 2011 sites and a unique PERMA_FID value is required for these sites - the PERMA_FID was assigned a unique value (something like - 900000 plus the “CBSP_ID” value), so that we can know that these sites were not associated with pre2011 values (i.e., any PERMA_FID value that is greater than 900,000). (Finally, spot check if the join worked correctly by comparing the two “Permanent_” columns in the final VAT – one version comes from each shapefile and these values should be the same).

Each subsetted temperature database is opened in Microsoft Excel and pivot tables were used to summarize the temperature data associated with these sites.