WDFW SOS Analysis

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Contents

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Requirements

All analyses require the R software (v3.4.3) for data retrieval, data processing, and summarizing model results, and the Stan Software for Hamiltonian Monte Carlo (HMC) simulation.

Functions

We also need a couple of helper functions which we will load from the functions folder, which we will load using the walk() function from the purrr package (which we will install if it is not already installed).

```
#=========================================
# Source function files in functions folder
#=========================================
if(!require("purrr")) {
  install.packages("purrr")
  library("purrr")
}else(library(purrr))
```

```
## [1] "purrr"     "stats"     "graphics"  "grDevices" "utils"     "datasets"  "methods"   "base"
```

```
path <- "functions/"
files <- paste0(path, list.files(path))
purrr::walk(files, source)
```

Packages

In addition to purr, We also need a few packages that are not included with the base installation of R, so we begin by installing them (if necessary) and then loading them.

```
#=============================================
# Load packages, install and load if not already
#=============================================
using("tidyverse",
      "rstan",
      "reshape2",
      "plotly",
      "reshape2",
      "metR",
      "directlabels",
      "RColorBrewer",
      "MASS",
      "tidyr",
      "ggrepel",
      "readxl",
      "ggforce",
      "readr",
      "ggplot2",
      "gridExtra",
      "tinytex"
      )
```

User Inputs

We need to specify data source file names, list some manual data filter conditions, and specify which ESUs and DPSs we would like to analyze to estimate trends and smoothed abundances for:

```
#=========================
#designate data file names
#=========================
```

```
#CA flatfile name
CAfilename<-"ca-data-all 09-10-2020 15 36.xlsx"

#data not in CA
NONCAfilename<-"Raw data for pops not in CA_11.10.2020.csv"

#ESU_DPS_list file name (also lists which ESUs to use CA for)
ESU_DPS_list<-"ESU_DPS_List_2020_09_17.csv"

#ESU_DPS_list file name
ESU_DIP_list_all<-"ESU_DIP_list_all.csv"

#Recovery_Goals file name
Recovery_Goals<-"Recovery goals_formatted_9.21.2020.csv"
WDFW_Salmonid_Stock_Inventory_Population_Recovery_Goals<-"WDFW-Salmonid_Stock_Inventory_Population_Reco
WDFW_Salmonid_Stock_Inventory_Populations<-"WDFW-Salmonid_Stock_Inventory_Populations.csv"
Recovery_Goals_LUT_edited<-"recoverygoals_LUT_edited.csv"

#=======================================
#set date stamp for file names and  plots
#=======================================
#set data date--this will name files and folders and tell the analysis code which date's data to use
data_date = "2020-11-10"


#=======================================
#set manual filter conditions for CA data
#=======================================
#list of pops by ESAPOPNAME that 1) do not have NOSAIJ or NOSAEJ data AND 2) TSAIJ and TSAEJ have too m
#the program will look for NOSAIJ or NOSAEJ data first and then proceed to TSAIJ and TSAEJ data only if
HatchPops<-c("Steelhead (Puget Sound DPS) Green River - winter" #total spawners includes substantial ha
             ,"Salmon, Chinook (Lower Columbia River ESU) North Fork Lewis River - spring" #total spawn
             ,"Salmon, Chinook (Puget Sound ESU) Mid-Hood Canal - fall"#total spawners includes substan
             ,"Steelhead (Puget Sound DPS) East Hood Canal Tributaries - winter" #total spawners includ
             ,"Steelhead (Puget Sound DPS) Skokomish River - winter" #total spawners include lots of la
             ,"Steelhead (Puget Sound DPS) West Hood Canal Tributaries - winter"#total spawners include
)
#=============================================================================================================
#POPFIT_exceptions list of pops where POPFIT != 1 but is "close enough" that we should use anyway; list
#=============================================================================================================
POPFIT_exceptions<-c(NA,
                     NA,
                     "Grays and Chinook Rivers - fall Chinook salmon", #no chinook river
                     "Kalama River - spring Chinook salmon", #only above KFH
                     "Lower Cowlitz River - late Coho salmon", #no mainstem
                     "Lower Cowlitz River - winter Steelhead", #no mainstem
                     "Upper Gorge Tributaries - fall Chinook salmon", #WA only; use 1/2 goal
                     "Upper Gorge Tributaries - late Coho salmon", #WA only; use 1/2 goal
                     "Lower Gorge Tributaries - late Coho salmon", #WA only; use 1/2 goal
                     "Toutle River - fall Chinook salmon", #assumes no fish spawn in NF and mainstem to
                     "Upper Cowlitz River - spring Chinook salmon" # some years mislabled as partial in

)
```

```
#=============================================================================================
#special cases to remove in order to get 1 abundance data pt per pop per year; these are supplied as a
#=============================================================================================
specialcaselist<-list(
  #1: this dataset is a duplicate Joseph Creek dataset; newer Nez Perce Tribe PIT based estimate...use
  quote(!COMMONPOPNAME%in%c("GRJOS-s")),
  #2: #below dams estimate is sketchy
  quote(!ESAPOPNAME=="Salmon, Chinook (Lower Columbia River ESU) Lower Gorge Tributaries - fall"),
  #3: #duplicate; use WDFW estimates rather than USFWS estimates
  quote(
    !(ESAPOPNAME=="Salmon, Chinook (Upper Columbia River spring-run ESU) Entiat River - spring"
      & CONTACTAGENCY=="U.S. Fish and Wildlife Service")
  ),
  #4: duplicate; use colville tribe estimate for 2005
  quote(
    !(ESAPOPNAME=="Steelhead (Upper Columbia River DPS) Okanogan River - summer"
      & METHODNUMBER==2
      & SPAWNINGYEAR == 2005)
  ),
  #5lower gorge coho use WDFW only, not ODFW data
  quote(
    !(ESAPOPNAME=="Salmon, coho (Lower Columbia River ESU) Lower Gorge Tributaries - late"
      & SUBMITAGENCY=="ODFW")
  ),
  #6: Entiat data lists both patch occupancy and old method as best...use old method until they get pat
  quote(
    !(ESAPOPNAME=="Steelhead (Upper Columbia River DPS) Entiat River - summer"
      & METHODNUMBER==2)
  ),
  #7: Elwha chinook data loaded as of 9/17/2020 is wrong--use data Neala Kendall got from NOAA/Tribe/Jo
  quote(
    !(ESAPOPNAME=="Salmon, Chinook (Puget Sound ESU) Elwha River - fall")
  ),
  #8: Sammammish Fall chinook data loaded as of 9/17/2020 is wrong...popfit should be partial, therefor
  quote(
    !(ESAPOPNAME=="Salmon, Chinook (Puget Sound ESU) Sammamish River - fall")
  )

)

#================================================
#Set parameters for summarization of results
#================================================
#Only include population in ESU summary statistics that include recovery goals?
Withgoalsonly="yes"
#Number of years to calculate geomean of smoothed abundance for comparison with recovery goals
geomeanyears = 5
#last year in geomean abundance calculations
lastyear=2019
#set number of years for forward projection of ESUs
futureyears = 5
#exlcude populations from geomean smoothed abundance calculation that have no new observed data in peri
filtergeomeansforpopswithnonewdata="No"
```

Data Preparation

Here we will use a data filtering algorithm described in the full report to select appropriate natural origin spawner abundance data for use in the status and trend analysis, we will prepare analysis input files, and we will plot the raw abundance data:

```
#prep and filter ca data
dat<-prepCAdata(CAfilename = CAfilename,
                data_date = data_date,
                ESU_DPS_list = ESU_DPS_list,
                Recovery_Goals = Recovery_Goals,
                POPFIT_exceptions = POPFIT_exceptions,
                specialcaselist = specialcaselist)
```

```
## [1] "number of pops included: 86"
## [1] "number of populations not filtered that have no suitable data: 0"
## [1] "Number of duplicate entries (>1 value per year and pop): 0"
```

```
#prep NON CA data (data must be pre-filtered/final )
dat2<-prepNONCAdata(data_date=data_date,
                    NONCAfilename = NONCAfilename,
                    ESU_DPS_list = ESU_DPS_list)

#make analysis files for status and trend analysis (we use bind_rows to combine CA and Non-CA data)
makefiles(data=bind_rows(dat[,colnames(dat)%in%colnames(dat2)],dat2),
          data_date=data_date)

#make plots of raw abundance data by population and ESU/DPS
plotfunc(data=bind_rows(data=dat[,colnames(dat)%in%colnames(dat2)],dat2),
         data_date=data_date,
         ESU_DPS_list=ESU_DPS_list,
         Recovery_Goals=Recovery_Goals,
         Withgoalsonly=Withgoalsonly)
```

```
##                                      ESU_DPS                            COMMONPOPNAME2 goal
## 1  Salmon, Chinook (Lower Columbia River ESU)      Cispus River - spring Chinook salmon   NA
## 2  Salmon, Chinook (Lower Columbia River ESU)        Salmon Creek - fall Chinook salmon   NA
## 3  Salmon, Chinook (Lower Columbia River ESU) Upper Cowlitz River - fall Chinook salmon   NA
## 4           Salmon, Chinook (Puget Sound ESU)       White River - spring Chinook salmon   NA
## 5           Salmon, chum (Columbia River ESU)           Salmon Creek - fall Chum salmon   NA
## 6     Salmon, coho (Lower Columbia River ESU) Cispus River - early and late Coho salmon   NA
## 7     Salmon, coho (Lower Columbia River ESU)           Salmon Creek - late Coho salmon   NA
## 8     Salmon, coho (Lower Columbia River ESU) Tilton River - early and late Coho salmon   NA
## 9        Steelhead (Lower Columbia River DPS)           Cispus River - winter Steelhead   NA
## 10       Steelhead (Lower Columbia River DPS) North Fork Lewis River - summer Steelhead   NA
## 11       Steelhead (Lower Columbia River DPS)           Salmon Creek - winter Steelhead   NA
## 12               Steelhead (Puget Sound DPS)      Nookachamps Creek - winter Steelhead   NA
## 13               Steelhead (Puget Sound DPS)  Sauk River - summer and winter Steelhead   NA
```

```
## pdf
##   2
```

Run Status and Trend Analysis

Here we will run the status and trend analysis using Stan via rstan. We will then tidy up the results to prepare for summarization and plotting. You must have rtools installed and stan installed for this to work:

```
#run analysis for any populations it is not yet complete for (un-comment section of code below inluding

# analyzedata(data_date=data_date,
#             ESUsubset= c(# "Lower Columbia coho"
#                # ,"Lower Columbia Chinook"
#                # ,"Lower Columbia steelhead"
#                # ,"Mid-Columbia steelhead"
#                # ,"Snake River spring and summer Chinook"
#                # ,"Snake River steelhead"
#                # ,"Upper Columbia spring Chinook"
#                # ,"Upper Columbia steelhead"
#                # ,"Snake River fall Chinook"
#                # ,"Puget Sound steelhead"
#                # ,"Puget Sound Chinook"
#                # ,"Ozette Lake sockeye"
#                # ,"Hood Canal summer chum"
#                # ,"Lower Columbia chum"
#               ),
#             ESU_DPS_list=ESU_DPS_list,
#             cores=4,
#             chains = 4,
#             iter = 2000,
#             warmup= 1000,
#             thin = 1,
#             control=list(adapt_delta=0.9995)
#             )

#combine results output
combineresults(data_date=data_date,Recovery_Goals=Recovery_Goals)#ESU_DIP_list_all=ESU_DIP_list_all

#merge results with raw data
resultsdata<-makeresultsdata(data_date=data_date,
                             data=bind_rows(dat[,colnames(dat)%in%colnames(dat2)],dat2),
                             ESU_DPS_list=ESU_DPS_list,Recovery_Goals=Recovery_Goals,
                             Smoothed_Abundance=Smoothed_Abundance)
```

```
## [1] "datasets with no smoothed abundance estimates: "
## [1] ESU_DPS        COMMONPOPNAME2 SA
## <0 rows> (or 0-length row.names)
```

Summarize Status and Trend Results

Here we will summarize our status and trend results, first at the population level, and then at the ESU/DPS level. This code may take up to 5-15 minutes to run; adjust expectations accordingly.

```r
#make plots of raw abundance data by population and ESU/DPS with smoothed abundances added as lines
resultsplots<-plotfunc2(resultsdata=resultsdata,
Recovery_Goals=Recovery_Goals,Withgoalsonly=Withgoalsonly,data_date=data_date)

# #make ESU and DIP Results
ESU_DIP_results<-make_ESU_DIP_results(resultsdata=resultsdata,lastyear=lastyear,data_date = data_date,g

#plot results (this p)
esu_results_plot(ESU_DIP_results=ESU_DIP_results,
                 data_date=data_date,
                 futureyears=futureyears,
                 resultsplots=resultsplots,
                 bypopsplots="No"
                 )
```

```
##  [1] "Salmon, Chinook (Lower Columbia River ESU)"
##  [2] "Salmon, Chinook (Puget Sound ESU)"
##  [3] "Salmon, Chinook (Snake River fall-run ESU)"
##  [4] "Salmon, Chinook (Snake River spring/summer-run ESU)"
##  [5] "Salmon, Chinook (Upper Columbia River spring-run ESU)"
##  [6] "Salmon, chum (Columbia River ESU)"
##  [7] "Salmon, chum (Hood Canal summer-run ESU)"
##  [8] "Salmon, coho (Lower Columbia River ESU)"
##  [9] "Salmon, sockeye (Ozette Lake ESU)"
## [10] "Steelhead (Lower Columbia River DPS)"
## [11] "Steelhead (Middle Columbia River DPS)"
## [12] "Steelhead (Puget Sound DPS)"
## [13] "Steelhead (Snake River Basin DPS)"
## [14] "Steelhead (Upper Columbia River DPS)"
## [1] "datasets unable to assess for trend"
##                                       ESU_DPS
## 1  Salmon, Chinook (Lower Columbia River ESU)
## 2  Salmon, Chinook (Lower Columbia River ESU)
## 3  Salmon, Chinook (Lower Columbia River ESU)
## 4  Salmon, Chinook (Lower Columbia River ESU)
## 5           Salmon, Chinook (Puget Sound ESU)
## 6           Salmon, Chinook (Puget Sound ESU)
## 7           Salmon, chum (Columbia River ESU)
## 8           Salmon, chum (Columbia River ESU)
## 9           Salmon, chum (Columbia River ESU)
## 10          Salmon, chum (Columbia River ESU)
## 11          Salmon, chum (Columbia River ESU)
## 12          Salmon, chum (Columbia River ESU)
## 13    Salmon, coho (Lower Columbia River ESU)
## 14       Steelhead (Lower Columbia River DPS)
## 15       Steelhead (Lower Columbia River DPS)
## 16       Steelhead (Lower Columbia River DPS)
## 17       Steelhead (Lower Columbia River DPS)
## 18      Steelhead (Middle Columbia River DPS)
## 19                Steelhead (Puget Sound DPS)
## 20                Steelhead (Puget Sound DPS)
## 21                Steelhead (Puget Sound DPS)
## 22                Steelhead (Puget Sound DPS)
```

```
## 23                Steelhead (Puget Sound DPS)
## 24                Steelhead (Puget Sound DPS)
## 25                Steelhead (Puget Sound DPS)
## 26                Steelhead (Puget Sound DPS)
## 27                Steelhead (Puget Sound DPS)
## 28                Steelhead (Puget Sound DPS)
## 29                Steelhead (Puget Sound DPS)
## 30                Steelhead (Puget Sound DPS)
## 31                Steelhead (Puget Sound DPS)
## 32                Steelhead (Puget Sound DPS)
## 33                Steelhead (Puget Sound DPS)
## 34                Steelhead (Puget Sound DPS)
## 35                Steelhead (Puget Sound DPS)
## 36                Steelhead (Puget Sound DPS)
##                                                COMMONPOPNAME2
## 1                 Lower Gorge Tributaries - fall Chinook salmon
## 2                North Fork Lewis River - spring Chinook salmon
## 3                          Tilton River - spring Chinook salmon
## 4                          Toutle River - spring Chinook salmon
## 5                          Mid-Hood Canal - fall Chinook salmon
## 6                         Sammamish River - fall Chinook salmon
## 7                              Cowlitz River - fall Chum salmon
## 8                            Cowlitz River - summer Chum salmon
## 9                            Elochoman River - fall Chum salmon
## 10                              Kalama River - fall Chum salmon
## 11                               Lewis River - fall Chum salmon
## 12      Mill, Abernathy, and Germany Creeks - fall Chum salmon
## 13                   Upper Gorge Tributaries - late Coho salmon
## 14                       Lower Cowlitz River - winter Steelhead
## 15                   Lower Gorge Tributaries - winter Steelhead
## 16                    North Fork Lewis River - winter Steelhead
## 17                   North Fork Toutle River - winter Steelhead
## 18                        White Salmon River - summer Steelhead
## 19                    Baker River - summer and winter Steelhead
## 20                              Canyon Creek - summer Steelhead
## 21                               Cedar River - winter Steelhead
## 22                                Deer Creek - summer Steelhead
## 23                Drayton Harbor Tributaries - winter Steelhead
## 24               East Hood Canal Tributaries - winter Steelhead
## 25        East Kitsap Peninsula Tributaries - winter Steelhead
## 26                               Elwha River - winter Steelhead
## 27                North Fork Skykomish River - summer Steelhead
## 28 North Lake Washington and Lake Sammamish - winter Steelhead
## 29                Puyallup River/Carbon River - winter Steelhead
## 30        Sequim/Discovery Bays Tributaries - winter Steelhead
## 31                             Skokomish River - winter Steelhead
## 32                 South Fork Nooksack River - summer Steelhead
## 33             South Puget Sound Tributaries - winter Steelhead
## 34                         Stillaguamish River - winter Steelhead
## 35       Strait of Juan de Fuca Tributaries - winter Steelhead
## 36                West Hood Canal Tributaries - winter Steelhead
## [1] "datasets unable to assess for status"
##                                       ESU_DPS
## 1  Salmon, Chinook (Lower Columbia River ESU)
```

```
## 2  Salmon, Chinook (Lower Columbia River ESU)
## 3  Salmon, Chinook (Lower Columbia River ESU)
## 4  Salmon, Chinook (Lower Columbia River ESU)
## 5           Salmon, Chinook (Puget Sound ESU)
## 6           Salmon, Chinook (Puget Sound ESU)
## 7           Salmon, chum (Columbia River ESU)
## 8           Salmon, chum (Columbia River ESU)
## 9           Salmon, chum (Columbia River ESU)
## 10          Salmon, chum (Columbia River ESU)
## 11          Salmon, chum (Columbia River ESU)
## 12          Salmon, chum (Columbia River ESU)
## 13    Salmon, coho (Lower Columbia River ESU)
## 14       Steelhead (Lower Columbia River DPS)
## 15       Steelhead (Lower Columbia River DPS)
## 16       Steelhead (Lower Columbia River DPS)
## 17       Steelhead (Lower Columbia River DPS)
## 18      Steelhead (Middle Columbia River DPS)
## 19                Steelhead (Puget Sound DPS)
## 20                Steelhead (Puget Sound DPS)
## 21                Steelhead (Puget Sound DPS)
## 22                Steelhead (Puget Sound DPS)
## 23                Steelhead (Puget Sound DPS)
## 24                Steelhead (Puget Sound DPS)
## 25                Steelhead (Puget Sound DPS)
## 26                Steelhead (Puget Sound DPS)
## 27                Steelhead (Puget Sound DPS)
## 28                Steelhead (Puget Sound DPS)
## 29                Steelhead (Puget Sound DPS)
## 30                Steelhead (Puget Sound DPS)
## 31                Steelhead (Puget Sound DPS)
## 32                Steelhead (Puget Sound DPS)
## 33                Steelhead (Puget Sound DPS)
## 34                Steelhead (Puget Sound DPS)
## 35                Steelhead (Puget Sound DPS)
## 36                Steelhead (Puget Sound DPS)
##                                             COMMONPOPNAME2
## 1                 Lower Gorge Tributaries - fall Chinook salmon
## 2               North Fork Lewis River - spring Chinook salmon
## 3                         Tilton River - spring Chinook salmon
## 4                         Toutle River - spring Chinook salmon
## 5                         Mid-Hood Canal - fall Chinook salmon
## 6                        Sammamish River - fall Chinook salmon
## 7                             Cowlitz River - fall Chum salmon
## 8                           Cowlitz River - summer Chum salmon
## 9                           Elochoman River - fall Chum salmon
## 10                             Kalama River - fall Chum salmon
## 11                              Lewis River - fall Chum salmon
## 12      Mill, Abernathy, and Germany Creeks - fall Chum salmon
## 13                  Upper Gorge Tributaries - late Coho salmon
## 14                      Lower Cowlitz River - winter Steelhead
## 15                  Lower Gorge Tributaries - winter Steelhead
## 16                   North Fork Lewis River - winter Steelhead
## 17                  North Fork Toutle River - winter Steelhead
## 18                       White Salmon River - summer Steelhead
```

```
## 19                   Baker River - summer and winter Steelhead
## 20                             Canyon Creek - summer Steelhead
## 21                              Cedar River - winter Steelhead
## 22                               Deer Creek - summer Steelhead
## 23               Drayton Harbor Tributaries - winter Steelhead
## 24              East Hood Canal Tributaries - winter Steelhead
## 25        East Kitsap Peninsula Tributaries - winter Steelhead
## 26                               Elwha River - winter Steelhead
## 27                North Fork Skykomish River - summer Steelhead
## 28 North Lake Washington and Lake Sammamish - winter Steelhead
## 29               Puyallup River/Carbon River - winter Steelhead
## 30        Sequim/Discovery Bays Tributaries - winter Steelhead
## 31                            Skokomish River - winter Steelhead
## 32                 South Fork Nooksack River - summer Steelhead
## 33             South Puget Sound Tributaries - winter Steelhead
## 34                        Stillaguamish River - winter Steelhead
## 35       Strait of Juan de Fuca Tributaries - winter Steelhead
## 36               West Hood Canal Tributaries - winter Steelhead

## pdf
##   2
```

Format Data for Data.wa.gov

Here we will merge our raw population name list, recovery goals, and final abundance data used for analysis with the population name list used by data.wa.gov in order to display the data on the web. Unfortunately, this portion of the program involves two manual steps. First, a lookup table ("recoverygoals_LUT_raw.csv") is created to compare the population set from the SOS analysis with that in data.wa.gov using the function make_data_wa_gov_recover_goals_lut. This lookup table uses character matching to match names and needs manual inspection and proofing. Once this function is done, open, inspect, and edit as necessary "recoverygoals_LUT_raw.csv" and re-save as "recoverygoals_LUT_edited.csv" in the data folder. You many then run the following 3 functions: make_data_wa_gov_recovery_goals, make_escapement_data_wa_gov,make_population_data_wa_gov. The final file these functions creates ("Population_Data_For_data_wa_gov_raw.csv") will have missing information for populations that are not listed in the inventory of populations on data.wa.gov. This file should be downloaded, inspected, edited, and re-sawed as "Population_Data_For_data_wa_gov.csv" and is then ready for upload to data.wa.gov

```
#============================
#make tables for data.wa.gov
#============================
make_data_wa_gov_recovery_goals_LUT(data_date = data_date,
                                    Recovery_Goals=Recovery_Goals,
                                    WDFW_Salmonid_Stock_Inventory_Population_Recovery_Goals=WDFW_Salmoni
                                   )
make_data_wa_gov_recovery_goals(data_date = data_date,
                                Recovery_Goals=Recovery_Goals,
                                Recovery_Goals_LUT_edited=Recovery_Goals_LUT_edited,
                                ESU_DPS_list
                                )
make_escapement_data_wa_gov(data_date=data_date,
                            Recovery_Goals_LUT_edited=Recovery_Goals_LUT_edited
                            )
```

```
make_population_data_wa_gov(data_date=data_date,
                            Recovery_Goals=Recovery_Goals,
                            Recovery_Goals_LUT_edited=Recovery_Goals_LUT_edited,
                            WDFW_Salmonid_Stock_Inventory_Populations=WDFW_Salmonid_Stock_Inventory_Popu
                            )
```

Reproducing this pdf or html page

In order to reproduce this pdf or html page you need to have a LaTex application installed. Running this snippet of code will automatically install tinytex on your machine so you can render pdfs and html:

```
#tinytex::install_tinytex()
```