

# Introduction to PBSawatea

Rowan Haigh, Andrew M. Edwards, and Paul J. Starr

June 29, 2023

## 1 What is PBSawatea?

**PBSawatea** provides tools for running population models using Awatea, a variant of Coleraine (Hilborn et al. 2003), which is maintained by Allan Hicks (Northwest Fisheries Science Center, Seattle WA). This package is not intended for public distribution – lots of code has been taken and modified from other packages and R code, including `rScape.r` by Rob Kronlund and Paul Starr (modified by Allan Hicks), and Arni Magnusson and Ian Taylor’s **scape** and **plotMCMC** (formerly(**scapeMCMC**) packages. We have not fully credited the original sources of functions that we have modified.

In this package, we introduce a Sweave approach, which, via  $\text{\LaTeX}$ , produces a single .pdf file that contains multiple figures and tables of output. This enables easy comparison of stock assessment model runs, as well as direct insertion of the results and tables (with automated captions) into the final stock assessment document.

## 2 What is PBS?

The initials **PBS** refer to the [Pacific Biological Station](#), a major fisheries laboratory operated by Fisheries and Oceans Canada on the Pacific coast in Nanaimo, British Columbia, Canada.

## 3 Where is the User’s Guide?

The R directory `.../library/PBSawatea/doc` includes a User’s Guide `PBSawatea-UG.pdf`; however, this is not meant to be thorough and for now just automatically documents the functions.

## 4 Running the PBSawatea code

### 4.1 Load the package

```
require("PBSawatea")
```

The current version of **PBSawatea** includes the namespace functions from the following packages: **methods**, **PBSmodelling**, **scape**, **plotMCMC**, **xtable**, and **lattice**.

Additionally, select functions from the following namespaces have been imported: **mcmc** from **coda**, **plotCI** from **gplots**, **Cbind** and **panel.xyplot** from **Hmisc**.

Note that the namespace support functions are only accessible by the **PBSawatea** code; users will not have command line access to these functions unless they explicitly load the packages (e.g., `require(PBSmodelling)`).

## 4.2 Running the model

See the `PBSawatea-commands-SPP-AREA.rwh` file in each folder for the actual functions (and options) to run for species (SPP) and assessment area (AREA). Basically there are five stages to running the model, illustrated below using Queen Charlotte Sound (5ABC) Pacific Ocean Perch (POP). The input file is called `POP-5ABC-04.txt`.

### 4.2.1 runADMB – Mode of Posterior Distribution (MPD)

The binary executable `awatea.exe` (built by ADMB) is called from a user-selected base directory (e.g. `C:/Awatea/POP/5ABC`); therefore, (i) the executable needs to be on the path or its directory must be specified by the argument `awateaPath`, and (ii) R's working directory must be set to the base directory (check using `getwd()`). All Awatea calculations occur in the base directory. The function `runADMB` runs through the number of reweights specified (if any) and automatically puts the original and modified input files, along with various output files, into a new subdirectory. Assuming that the input file is `POP-5ABC-04.txt`, the new subdirectory will be `C:/Awatea/POP/5ABC/POPrun04`:

```
out = runADMB("POP-5ABC-04.txt", strSpp="POP", runNo=4, doMPD=TRUE,
  N.reweight=3, mean.age=TRUE, cvpro=0.2, clean=TRUE)}
```

### 4.2.2 runSweave – Run Sweave on MPD Results

To see the MPD results, run Sweave on the results to generate figures and tables and to create postscript and pdf files containing all the results:

```
runSweave(strSpp="POP", filename="POP-5ABC-04.txt", runNo=4, rwtNo=3,
  Nsex=2, Ncpue=0, Nsurvey=3, Sapos=c(TRUE,TRUE,FALSE),
  Snames=c("GIG.historical","QCS.synoptic","QCS.shrimp"))
```

Or you can run a wrapper function `runMPD` that calls `runSweave` using multiple runs and/or multiple reweights:

```
runMPD(strSpp="POP", prefix=c("POP","5ABC"), runs=4, rwts=0:3,
```

```
Nsex=2, Ncpue=0, Nsurvey=3, SApos=c(TRUE,TRUE,FALSE), delim="-",
Snames=c("GIG.historical","QCS.synoptic","QCS.shrimp"))
```

This creates one or more subdirectories (in this case, C:/Awatea/POP/5ABC/POPrun04/MPD.run.rwt, where run=04 and rwt=c(00,01,02,03)), each of which contains a customized Sweave file (e.g., POPrun04-3.Snw), the compiled latex file (POPrun04-3.tex), and a postscript document file (POPrun04-3.pdf), along with the numerous .eps image files used in making the .pdf file.

### 4.2.3 Run MCMC Sampling for Posterior Distribution

It's best to run the MCMC calculations on a stand-alone power desktop. Use the reweight input file that best suits the data (e.g., getting SDNRs close to 1), transfer this to the desktop where the same version of awatea.exe is available, and issue the commands:

```
awatea -ind POP-5ABC.04.03.txt -mcmc 10000000 -mcsave 10000
awatea -ind pop-5ABC.04.03.txt -mceval
```

The first command will take many hours to complete; therefore, the second command is issued after the first is completed. Next, copy the resulting output files (e.g., .pst, .out, Awatea.psv, etc.) files *twice* into two new subdirectories on your workstation:

```
C:/Awatea/POP/5ABC/POPrun04/MCMC.04.03
C:/Awatea/POP/5ABC/POPrun04/MCMC.04.03/PRJ.04.03
```

### 4.2.4 Maximum Sustainable Yield (MSY)

Next, calculate maximum sustainable yield for each of your posterior samples.

```
out = runADMB("POP-5ABC-04.txt", strSpp="POP", runNo=4, rwtNo=3,
doMSY=TRUE, msyMaxIter=15000, msyTolConv=0.01, endStrat=0.301,
stepStrat=0.001)
```

### 4.2.5 runSweaveMCMC – Run Sweave on MCMC Results

As with the MPD output, run Sweave on the MCMC output to generate figures and tables and to create postscript and pdf files containing all the MCMC results:

```
runSweaveMCMC(strSpp="POP", filename="POP-5ABC-04.txt", runNo=4,
rwtNo=3, skip.last.year=FALSE)
```

The final argument in the above call defaults to skip.last.year=TRUE for all assessments to remove the last year of projections. The POP 5ABC assessment in 2010 requires that the last year of projections be kept.

There is also a wrapper function called `runMCMC` for `runSweaveMCMC` that loops through runs and reweights:

```
runMCMC(prefix=c("POP","5ABC"), runs=4, rwts=3)
```

*Note:* For details of all **PBSawatea** functions, see the package documentation help files.

## 5 Previous assessments

Input .txt files are available for recent assessments, enabling reproduction of the results (including figures and tables). Directory years indicate the year of the assessment review meeting (not the year of publication).

The original saved results are available (from Andrew Edwards or Rowan Haigh at present) as compressed archives (either .zip or .7z files), that may also contain .RData or .rda files containing the outputs in R format.

### 5.1 2010 Pacific Ocean Perch in 5ABC

Published document: Edwards et al. (2012b)

Area 5ABC covers Queen Charlotte Sound (QCS) and lower Hecate Strait. Four model runs were presented in the CSAS Research Document. These are in the R-installation directory:

C:/Apps/R/Rdev/library/PBSawatea/input/2010.7z

- POP-5ABC-04.txt : fixed steepness  $h$  and fixed natural mortalities  $M_s$ ,
- POP-5ABC-11.txt : fixed steepness  $h$  and estimated natural mortalities  $M_s$ ,
- POP-5ABC-16.txt : estimated steepness  $h$  and fixed natural mortalities  $M_s$ ,
- POP-5ABC-23.txt : estimated steepness  $h$  and estimated natural mortalities  $M_s$ .

The latter two (that estimated steepness  $h$ ) were put forward for advice in the resulting Science Advisory Report. We recommend the final one (that also estimated natural mortalities) for use in future work, since the mortalities could be estimated by the model (and this approach was used in the later Pacific Ocean Perch assessments).

Much of the **PBSawatea** software was written after this assessment. Re-running the MPD results (August 2014) yields exactly the same results as the original runs. Using the `runSweaveMCMC` function to generate figures and tables from the original MCMC results yields quantiles of parameter values and variables that agree almost exactly with the original published results. The slight differences most likely arise because the original results were tabulated as quantiles using the software platform Stata, whereas these are using the R platform, and there are different options for generating quantiles – see the R help for `quantile()`.

Full results (including MCMC) from original model runs are available from AE or RH.

## 5.2 2011 Yellowmouth Rockfish coastwide

Published document: Edwards et al. (2012a)

This was a coastwide stock assessment and recovery potential assessment (that used criteria from COSEWIC, the Committee on the Status of Endangered Wildlife in Canada). Two model runs were presented in the Research Document (and accepted for the resulting Science Advisory Report). These are in the R-installation directory

C:/Apps/R/Rdev/library/PBSawatea/input/2011.7z

for the base runs:

- input-ymr.29.01.txt : estimates steepness  $h$  and natural mortalities  $M_s$ ,
- input-ymr.30.01.txt : estimates steepness  $h$  and fixes natural mortalities  $M_s$ .

These analyses were done performed prior to the creation of **PBSawatea**. During the Yellowmouth assessment, we automated the re-weighting scheme between abundance data and age structure data, and developed a system of building and saving model runs into MPD and MCMC folders. Later, we also converted to a standardised input filename convection using a three-letter code for species followed by an area code and a run number (e.g., YMR-CST-01.txt). The YMR analyses could likely be re-run, but we advise changing the input file names using the convention outlined above. (If necessary, ask AE or RH to look into their ymrrun-master.Snw and ymrrun-masterMCMC.Snw (or similar) files that were used at the time.)

Full results (including MCMC) from original model runs are available from AE or RH.

## 5.3 2012 Pacific Ocean Perch in 3CD

Published document: Edwards et al. (2013b)

Area 3CD covers the west coast of Vancouver Island (WCVI). One model run was presented in the CSAS Research Document, in the R-installation directory

C:/Apps/R/Rdev/library/PBSawatea/input/2012.7z

for the base run:

- pop-3CD.20.01.txt

See runHistory-POP-3CD.tex for details of sensitivity runs, and  
PBSawatea-commands-POP-3CD.rwh for the commands to re-run the code in R.

## 5.4 2012 Pacific Ocean Perch in 5DE

Published document: Edwards et al. (2013a)

Area 5DE covers the north and west coasts of Haida Gwaii (WCHG). One model run was presented in the CSAS Research Document, in the R-installation directory

C:/Apps/R/Rdev/library/PBSawatea/input/2012.7z

for the base run:

- pop-5DE.20.01.txt

See runHistory-POP-5DE.tex for details of sensitivity runs, and  
PBSawatea-commands-POP-5DE.rwh for the commands to re-run the code in R.

## 5.5 2013 Silvergray Rockfish coastwide

Published document: Starr et al. (2016)

See the R-installation directory

C:/Apps/R/Rdev/library/PBSawatea/input/2013.7z

for the base run:

- SGR-CST.16.03.txt

and the runHistory.tex and PBSawatea-commands-SGR-CST.rwh files within.

In this assessment and the following, **PBSawatea** first implemented a number of switches in the Sweave code to deal with variations in the number of sexes and surveys, and whether CPUE and historical reference points are used.

## 5.6 2013 Rock Sole in 5AB and 5CD

Published document: Holt et al. (2016)

See the R-installation directory

C:/Apps/R/Rdev/library/PBSawatea/input/2013.7z

for the base runs:

- ROL-5AB.22.03.txt
- ROL-5CD.08.03.txt

and the runHistory.tex and PBSawatea-commands-ROL-<5AB|5CD>.rwh files within.

## 5.7 2014 Yellowtail Rockfish coastwide

Published document: DFO (2015)

See the R-installation directory

C:/Apps/R/Rdev/library/PBSawatea/input/2014.7z

for the base run:

- YTR-CST1F.09.02.txt

and the runHistory.tex and PBSawatea-commands-YTR-CST1F.rwh files within.

## 5.8 2017 Pacific Ocean Perch in 5ABC

Published document: Haigh et al. (2018)

See the R-installation directory

C:/Apps/R/Rdev/library/PBSawatea/input/2017.7z  
for the base run:

- POP-5ABC.09.03.txt

and the runHistory.tex and PBSawatea-commands-POP-5ABC.rwh files within.

## 5.9 2018 Redstripe Rockfish in 5DE and 3CD5ABC

Published document: Starr and Haigh (2021a)

See the R-installation directory

C:/Apps/R/Rdev/library/PBSawatea/input/2018.7z  
for the base runs:

- RSR-5DE.16.01.txt
- RSR-3CD5ABC.16.02.txt

and the runHistory.tex and PBSawatea-commands-RSR- $\langle$ 5DE | 3CD5ABC $\rangle$ .rwh files within.

## 5.10 2019 Widow Rockfish coastwide

Published document: Starr and Haigh (2021b)

See the R-installation directory

C:/Apps/R/Rdev/library/PBSawatea/input/2019.7z  
for the base runs:

- WWR-BC.01.01.txt :  $M=0.07$ ,  $A=40$
- WWR-BC.02.01.txt :  $M=0.07$ ,  $A=45$
- WWR-BC.03.01.txt :  $M=0.07$ ,  $A=50$
- WWR-BC.04.01.txt :  $M=0.08$ ,  $A=40$
- WWR-BC.05.01.txt :  $M=0.08$ ,  $A=45$  (central run)
- WWR-BC.06.01.txt :  $M=0.08$ ,  $A=50$
- WWR-BC.07.01.txt :  $M=0.09$ ,  $A=40$
- WWR-BC.08.01.txt :  $M=0.09$ ,  $A=45$
- WWR-BC.09.01.txt :  $M=0.09$ ,  $A=50$

and the runHistory.tex and PBSawatea-commands-WWR-BC.rwh files within.

## 5.11 2019 Bocaccio coastwide

Published document: Starr and Haigh (2022a)

See the R-installation directory

C:/Apps/R/Rdev/library/PBSawatea/input/2019.7z  
for the base runs:

- BOR-2F.01.01.txt :  $M=0.07$ ,  $A=50$
- BOR-2F.02.01.txt :  $M=0.08$ ,  $A=50$  (central run)
- BOR-2F.03.01.txt :  $M=0.09$ ,  $A=50$

and the runHistory.tex and PBSawatea-commands-BOR-2F.rwh files within.

## 5.12 2020 Rougheye/Blackspotted Rockfish coastwide

Published document: Starr and Haigh (2022b)

See the R-installation directory

C:/Apps/R/Rdev/library/PBSawatea/input/2020.7z  
for the REBS North base case:

- BSR-2F.49.01.txt :  $M=0.035$ ,  $c_p=0.10$
- BSR-2F.50.01.txt :  $M=0.035$ ,  $c_p=0.2759$
- BSR-2F.51.01.txt :  $M=0.035$ ,  $c_p=0.40$
- BSR-2F.47.01.txt :  $M=0.045$ ,  $c_p=0.10$
- BSR-2F.46.01.txt :  $M=0.045$ ,  $c_p=0.2759$  (REBS N central run)
- BSR-2F.48.01.txt :  $M=0.045$ ,  $c_p=0.40$
- BSR-2F.52.01.txt :  $M=0.055$ ,  $c_p=0.10$
- BSR-2F.53.01.txt :  $M=0.055$ ,  $c_p=0.2759$
- BSR-2F.54.01.txt :  $M=0.055$ ,  $c_p=0.40$

for the REBS South base case:

- RER-2F.18.02.txt :  $M=0.035$ ,  $c_p=0.10$
- RER-2F.12.02.txt :  $M=0.035$ ,  $c_p=0.2759$
- RER-2F.15.02.txt :  $M=0.035$ ,  $c_p=0.40$
- RER-2F.11.02.txt :  $M=0.045$ ,  $c_p=0.2759$  (REBS S central run)
- RER-2F.14.02.txt :  $M=0.045$ ,  $c_p=0.40$
- RER-2F.16.02.txt :  $M=0.055$ ,  $c_p=0.40$

and the runHistory.tex and PBSawatea-commands-<BSR|RER>-2F.rwh files within.



## References

- DFO (2015). Yellowtail Rockfish (*Sebastes flavidus*) stock assessment for the coast of British Columbia, Canada. *DFO Can. Sci. Advis. Sec. Sci. Advis. Rep.*, 2015/010:14 p.
- Edwards, A. M., Haigh, R., and Starr, P. J. (2012a). Stock assessment and recovery potential assessment for Yellowmouth Rockfish (*Sebastes reedi*) along the Pacific coast of Canada. *DFO Can. Sci. Advis. Sec. Res. Doc.*, 2012/095:iv + 188 pp.
- Edwards, A. M., Haigh, R., and Starr, P. J. (2013a). Pacific Ocean Perch (*Sebastes alutus*) stock assessment for the north and west coasts of Haida Gwaii, British Columbia. *DFO Can. Sci. Advis. Sec. Res. Doc.*, 2013/092:vi + 126 pp.
- Edwards, A. M., Haigh, R., and Starr, P. J. (2013b). Pacific Ocean Perch (*Sebastes alutus*) stock assessment for the west coast of Vancouver Island, British Columbia. *DFO Can. Sci. Advis. Sec. Res. Doc.*, 2013/093:vi + 135 pp.
- Edwards, A. M., Starr, P. J., and Haigh, R. (2012b). Stock assessment for Pacific ocean perch (*Sebastes alutus*) in Queen Charlotte Sound, British Columbia. *DFO Can. Sci. Advis. Sec. Res. Doc.*, 2011/111:viii + 172 pp.
- Haigh, R., Starr, P. J., Edwards, A. M., King, J. R., and Lecomte, J.-B. (2018). Stock assessment for Pacific Ocean Perch (*Sebastes alutus*) in Queen Charlotte Sound, British Columbia in 2017. *DFO Can. Sci. Advis. Sec. Res. Doc.*, 2018/038:v + 227 p.
- Hilborn, R., Maunder, M., Parma, A., Ernst, B., Payne, J., and Starr, P. (2003). Coleraine: A generalized age-structured stock assessment model. User's manual version 2.0. University of Washington Report SAFS-UW-0116. Technical report, University of Washington.
- Holt, K. R., Starr, P. J., Haigh, R., and Krishka, B. (2016). Stock assessment and harvest advice for Rock Sole (*Lepidopsetta* spp.) in British Columbia. *DFO Can. Sci. Advis. Sec. Res. Doc.*, 2016/009:ix + 256 pp.
- Starr, P. J. and Haigh, R. (2021a). Redstripe Rockfish (*Sebastes proriger*) stock assessment for British Columbia in 2018. *DFO Can. Sci. Advis. Sec. Res. Doc.*, 2021/014:vii + 340 p.
- Starr, P. J. and Haigh, R. (2021b). Widow Rockfish (*Sebastes entomelas*) stock assessment for British Columbia in 2019. *DFO Can. Sci. Advis. Sec. Res. Doc.*, 2021/039:vi + 238 p.
- Starr, P. J. and Haigh, R. (2022a). Bocaccio (*Sebastes paucispinis*) stock assessment for British Columbia in 2019, including guidance for rebuilding plans. *DFO Can. Sci. Advis. Sec. Res. Doc.*, 2022/001:vii + 292 p.
- Starr, P. J. and Haigh, R. (2022b). Rougheye/Blackspotted Rockfish (*Sebastes aleutianus* / *melanostictus*) stock assessment for British Columbia in 2020. *DFO Can. Sci. Advis. Sec. Res. Doc.*, 2022/20:vii + 385 p.
- Starr, P. J., Haigh, R., and Grandin, C. (2016). Stock assessment for Silvergray Rockfish (*Sebastes brevispinis*) along the Pacific coast of Canada. *DFO Can. Sci. Advis. Sec. Res. Doc.*, 2016/042:vi + 170 pp.