EPOSTER: Mathematical Modeling of Fish Density and Habitat Relations

Paul Johnson[1] (PJohnson@biostatsoftware.com) and Kate E Johnson[2] (KaeJohnson@ucdavis.edu)

Clinical SAS Programmer, Davis [1] University of California Davis[2]

BACKGROUND

Important components in a Stream /River Fish and Wildlife Restoration program include river habitat typing and fish/habitat relationships (see Roni, 2014). A part of any monitoring system should include the identification of key habitat variables, which are known to influence fish populations. The dependent variable of interest is the density of the fish age specific species. The grouping variable is the habitat type group (see Table below).

DEFINITIONS

Habdef	Habitat type group (glides, pools, riffles)
FishSp	Fish Species
age	Species age specific (0+, 1+, 2+, juveniles etc.)
Velocity	Current velocity
Temp	Water temperature
mDepth	Mean depth
maxDepth	Maximum depth
Covcomp	Cover Complexity
Aquaveg	Percent Aquatic Vegetation Cover
PBedrock	Percent bedrock substrate
pBouldr	Percent boulder substrate
pCobble	Percent cobble substrate
pCover	Percent (pool escape) cover
pEmbedd	Percent embeddedness
pFines	Percent fines sediment
pGravel	Percent gravel substrate
pWD	Percent woody debris
pVeg	Percent vegetation cover
Shade	Percent shade
Turb	Turbidity
pH	pH
Overall	Overall habitat change (from previous years)

OBJECTIVES

The objectives of the analysis are to identify associations between fish density and specific physical characteristics of sampled rivers and streams.

METHODS

The nonparametric Bootstrap is used for variable selection. 1,000 Bootstrap replications are carried out (Efron and Tibshirani, 1994). The model fit is a general linear model that finds the 'best' model for fitting the density of the fish, age specific data for each of the habitat type group classifications. A prior simulation is run to provide the sample data containing a subset of the independent habitat variables. The 'best' model is defined as the one that minimizes Mallow's Cp (SAS/STAT, 2018). Other criteria, such as the Akaike Information Criterion (AIC) or the Bayesian Schwarz Information Criterion (BIC) could be used. The distribution of the number of times each variable is selected is output. This information is then used to obtain final overall ('ovrl') models, and models by habitat.

The question of interest is:

Which of the habitat variables are of the greatest importance in the association between fish densities and habitat conditions?

RESULTS

The Table to the right shows the distribution of the number of times each variable is selected. Models can then be developed for each habitat classification based upon the results. In this example we find 'pcover' appears 82.1% of the time in the best fitting models for the 'pool' habitat type. An example model based upon the bootstrap results for overall predicting the density of this particular age specific fish density, y are:

Density of y = –0.0745 + 0.0667385*mDepth + 0.0039964*Shade + 0.005354*pCover – 0.0042632*pCover*mDepth–.00358596* Shade*mDepth+ .000048646*Shade*pBouldr

The analysis can then be carried out and models fit for each of the habitat classifications. Stepwise regression models indicate which of the key habitat variables for each of the species and life stage combinations are most strongly associated with changes in fish densities. Stepwise regression models identify which of the key habitat variables enter the model first. (See SAS/STAT, 2018).

For pools cover complexity and percent woody debris should also be included; for riffles percent embeddedness and percent woody debris should be examined.

Variable	glide	pool	riffle	ovrl
Aquaveg	43	114	242	187
Covcomp	341	670	285	236
mDepth	552	479	206	453
pBedrock	457	155	101	194
pBouldr	698	375	709	609
pCobble	158	105	236	347
pCover	262	821	735	890
pEmbedd	78	231	445	358
pFines	144	121	186	44
pGravel	119	100	249	113
pWD	133	497	548	212
pVeg	57	128	317	378
Shade	260	176	137	550

CONCLUSIONS

Shade, mean depth, percent cover, and percent boulder substrate are important habitat variables associated with the density of age specific/fish species density y (e.g., juvenile steelhead). A positive regression coefficient indicates that increases in shade, percent cover and mean depth are associated with increases in density. There are significant interaction effects included. The Bootstrap provides a useful tool for variable selection.

REFERENCES/ACKNOWLEDGEMENT

Please contact Author[1] for list of references and SAS code. SAS is a registered trademark of SAS Institute Inc. in the USA and other countries. ® indicates USA registration.

The authors would also like to thank Caroline Johnson for help in preparing this poster.