Evaluation of the Statistical Properties of Grand Canyon Humpback Chub Abundance and Trend Estimates Produced from ASMR and Alternative Mark-Recapture Models

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Goals and Objectives:

- Construct a Monte Carlo simulation model to evaluate the statistical performance of estimators of annual adult and recruitment in the Grand Canyon humpback chub population under different sets of assumptions about sampling designs, annual survival schedules, movement dynamics, and age misclassification, and capture probabilities.
- Make recommendations on:
  - preferred estimators and sampling designs conditional on the current set of simulation scenarios,
  - additional simulations that would improve assessment of the robustness of the models, and
  - how the simulation model could be employed as a helpful decision-making tool in the HBC monitoring program.

Progress:

Simulation models were parameterized using empirical information from published literature and estimates from additional analyses that we performed. We assumed that during the annual cycle, the HBC population occupied 2 discrete river reaches within the Grand Canyon: the lower 15 km of the lower Colorado River (LCR) and the reach of the mainstem (MS) of the Colorado River that extends 9 km upstream and 11 km downstream from the confluence with the LCR. We assumed an age-structured population with age classes from 2 – 24 years.

The simulation model ran in 4 stages: generation of complete life histories for all individuals in the population, generation of data from sampling designs, estimation of parameters, and summarization of results. The statistical software *R* controlled the entire process. Three types of codes were called by *R* to do the model fitting and numerical analysis necessary for estimation: 1) closed form estimators calculated "by hand" in *R*, 2) a specialized Jolly-Seber type estimator (ASSA) calculated by calling Program MARK code from *R*, 3) estimators from the ASMR model developed by Coggins et al (2006) were generated by converting Excel spreadsheet models to AD Model Builder.

We evaluated 4 different concurrent (sampling in both reaches simultaneously) designs: 1) February, March, April , 2) February, March, April, May, 3) August, September, October, 4) August, September, October, November. We included a fifth design that has been used by the GCMRC: April, May, September, October (LS only) and July, August (MS only).

Conclusions and Recommendations:

The best overall statistical performance was achieved by sampling concurrently in 3 consecutive months from February to April. Fall sampling designs tended to produce results with larger bias. The GCMRC design generally produced estimates with relatively large bias and poor precision. The addition of a fourth sampling month to the spring and fall concurrent designs was not deemed cost-effective. There was no meaningful difference in performance between the ASMR and ASSA estimators, although the lack of straightforward methods for estimation of sampling precision, and an inability to utilize formal model assessment and selection techniques are disadvantages of the ASMR method.

Although a simulation model mimics only the most salient characteristics of a complex biological monitoring program, it can be a valuable tool for decision-making because it provides insight into the performance of alternative choices when the correct answers are known. The exercise is particularly informative when existing data are adequate for making reasonable decisions about the structure and parameterization of population processes and demographics, such as the case for the Grand Canyon HBC population. Simulation exercises can have value in the initial and subsequent adaptive stages of a monitoring program, as a tool to facilitate critical thinking about decision criteria, precisely stated objectives, cost efficiency, and alternative program designs.