Length Based Population Dynamics Analysis of Mako Sharks on the West Coast of North America

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Aims
In this project I plan to construct a length-based population model for mako sharks off the coast of California and Baja California.
• I intend to determine the number of breeding stocks and the degree of admixture using microsatellite analysis.
• I will conduct a stock assessment(s) on the mako shark population(s)
• I intend to build a length-based matrix model to determine the dynamics of the population
• I will use elasticity analysis to determine which classes have the largest impact on the population dynamics

Methods
Number of populations and admixture rates will be determined using the program STRUCTURE on genetic data from sharks caught throughout the region. The results will determine relevant population boundaries, and whether the modeling portions of the project should be done for a single population, multiple independent populations, or as a network of interconnected populations of mako shark.

I will use CPUE data from commercial fisheries logs, Mexican artisanal studies, and NMFS surveys to estimate population size using the depletion method. I will also use effective population size from genetic analysis as a prior for Bayesian population size estimates, which should be more robust to the lack of data in the system.

Length-based matrix models will be constructed for each determined population. The matrices will be based on Leslie age-based models, using length as a proxy for age. The number of classes and the length per age will be determined from comparing von Bertalanffy growth curves established in Natanson et al. 2006 and Bishop et al. 2006.

Survival and fecundity will be estimated from fishery catch data as well as from literature analysis of both mako and other similar species. I will run the models in Matlab7 determine the intrinsic growth rate for each population. Model extensions will include a simulation analysis of the effects of density dependence.

I will then run elasticity analysis on each of the matrix parameters in order to determine which have the largest impact on the population growth rate and where research and conservation efforts are best used. To do this, I will change each parameter by ten percent in each direction while holding all other parameters constant, and record the changes in the intrinsic growth rate.

Preliminary Results and Discussion
To obtain a basic understanding of the dynamics of mako sharks in this system, I ran a highly simplified, preliminary model based on data from the literature. Sharks were grouped into seven binned size classes and density dependence was not included, which may be inappropriate if fishing has reduced the population to a size which is small relative to the potential carrying capacity. I estimated initial abundances based on a size distribution of female mako from Atlantic, Canadian waters (Campana et al. 2005). The initial distribution was bimodal with peaks at size class 2 and class 4. After running the model for 10 years, the distribution remained bimodal, but with peaks in size classes 1 and 7.

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I calculated the intrinsic rate of increase for the population to be 0.986. Since this is less than one, it suggests that the population is in decline. A subsequent elasticity analysis comparing von Bertalanffy growth curves suggested that the class that had the largest impact on the population was age class 7, which was the only class in the model with a fecundity larger than 0.0. This suggests that research and conservation efforts would best be focused on mature mako sharks.

Elasticity analysis

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Survival 1</th>
<th>Survival 2</th>
<th>Survival 3</th>
<th>Survival 4</th>
<th>Survival 5</th>
<th>Survival 6</th>
<th>Survival 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>.979</td>
<td>.981</td>
<td>.982</td>
<td>.980</td>
<td>.976</td>
<td>.937</td>
<td>.944</td>
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<tr>
<td>High</td>
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<td>.991</td>
<td>.990</td>
<td>.993</td>
<td>.996</td>
<td>.998</td>
<td>1.03</td>
</tr>
</tbody>
</table>

The intrinsic rates of increase of the modeled population after either increasing or decreasing each parameter by 10%. The parameter that had the largest impact on the model output was the survival of size class 7 individuals.

Literature Cited

Initial age/stage abundances
![Initial age/stage abundances](Image)

Final age/stage abundances
![Final age/stage abundances](Image)