Addressing Uncertainty in Rockfish Assessments

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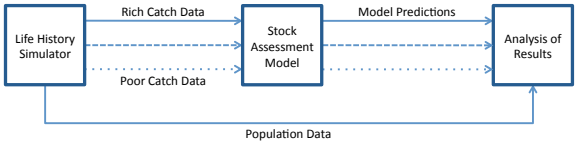
Introduction

- Stock assessment models are quantitative tools that use catch data to estimate the population levels of harvested fish species. These estimates inform policy decisions in fishery management, such as establishing catch limits and whether to shut down a fishery to allow recovery.
- The effectiveness of the decisions depends on the accuracy of the models, which are unknown due to the lack of information on actual population sizes.
- The amount and type of catch data vary across fisheries, from overall biomass caught to catch composition by age, length, etc., introducing additional model uncertainty in low data assessments.
- Quantifying the accuracy of the models is especially important for rockfish species due to the small amount of data available and their slow recovery from overfishing.
- Our research attempts to quantify the accuracy of these models under different amounts of data. We do so with a life history simulator which creates population data and several levels of catch data for an artificial fished rockfish population. The catch data will be input into the stock assessment model, and the model output will be compared to the population data. The accuracy of the model under a range of available catch data can be quantified to determine the validity of the stock assessment estimates.



Rockfish Life History

Photographed by Jeanne Luce

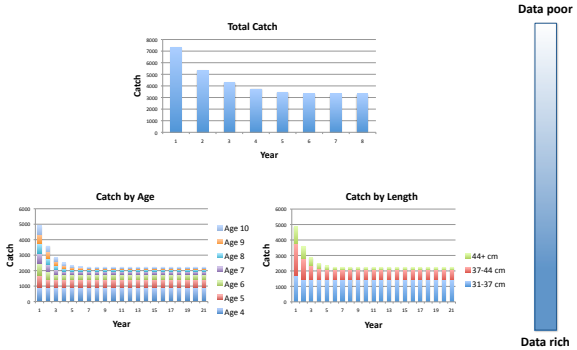
- Rockfish fertilize their eggs internally and bear live young. Following their larval and juvenile stages, they become sexually mature between ages two and twenty-two, depending on the species.
- Maximum age also varies by species, ranging from eleven to over one hundred years. The larger species generally grow slower and live longer.

Photographed by Steve Lonhart

- The type and size of a habitat vary greatly by species.
- There are many species off the coast of California, though they are found in both the Atlantic and Pacific Oceans.
- Longer, heavier, older fish produce more eggs.

Life History Simulator

The simulator is constructed as a discrete time dynamical system that tracks the age, length, and location of the population through time. The population size within a region changes as a result of mortality, recruitment and migration. Populations are run to a steady state to obtain virgin biomass before fishing is introduced to the system. The simulator tracks the population by length, age, region over time; and can create time series for catch across any of these compositions. This allows data poor and data rich time series to be generated.

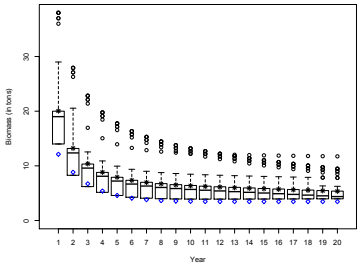


Example Assessment

We illustrate the use of the simulator with a simple stock assessment example which estimates population biomass over 20 years of catch data. We ran the simulator to generate time series for total catch and an index of abundance (a lognormal perturbation of the true biomass), using life history parameters similar to chilipepper (*Sebastes goodei*). Since the index of abundance is comprised of random variables, several time series are used as input to create a distribution of assessment estimates of biomass. The time series, and subsets of them, were input into the stock assessment model to study the accuracy of the model with increasing amounts of data.

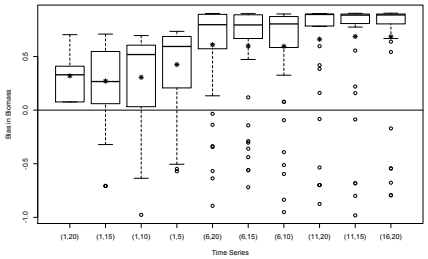
Simulator Framework	Example Assessment Framework
Age structured model	Production model
Beverton-Holt recruitment	Logistic production
Size-dependent natural mortality (increased mortality on small fish)	Constant natural mortality
Size-selective fishing mortality (increased mortality on large fish)	Constant fishing mortality
Biomass tracked by age, length, region and time	Biomass tracked by time

Example Assessment Results



The stock assessment biomass estimates (boxplots) show significant overestimation of the true population biomass (blue diamonds) even under the full time series. There is increased variance in the estimate distributions earlier in the time series when the model tries to estimate virgin biomass.

The bias of the stock assessment estimates over different years of time series data, where bias measures the degree of over or under-estimation. There is increased over-estimation of population biomass under shorter time series, and those excluding the onset of fishing.



Discussion

- Production models can lead to overestimation when not taking into account length or age structure in the population dynamics. By failing to account for length or age, the model is treating all population biomass the same. So when fishing removes the more productive spawners in the simulation due to fishing, the assessment model treats the biomass removal as distributed evenly among the overall reproductive biomass, when it actually targets the largest contributors towards future biomass.
- The estimate uncertainty is heavily dependent on the length of the time series, as well as the particular years analyzed in the stock assessment. Thus not all data are the same in terms of their utility towards assessment. Time series that include the introduction of fishing provide improved accuracy over those that exclude the initial years.

Acknowledgements

This research was supported by CSTAR. and received input from Marc Mangel[1], Steve Ralston[2], Alec MacCall[2], and E.J. Dick[2].

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