Spatial Stock Assessment Assumptions and Environmental Data Capabilities Within Stock Synthesis

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Background

The 2007 stock assessment for black rockfish (*Sebastes melanops*) off Oregon and California found spatial differences in the fishery age-compositions.

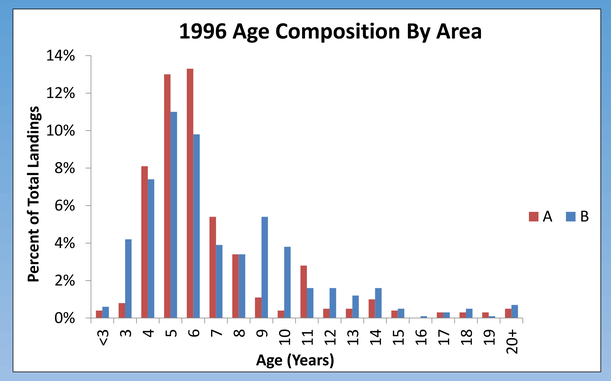

Figure 1. Age compositions of recreationally caught black rockfish from northern (A) and southern (B) Oregon.

For simplicity most stock assessments ignore spatial structure. Data are summarized across locations and status is assessed for the entire stock (Fig. 2).

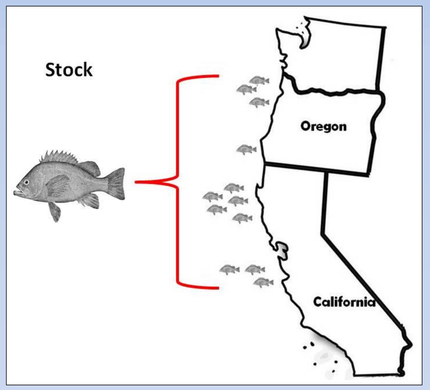

Figure 2.

The current method provides little detailed information on the subpopulations that make up the stock.

For species such as black rockfish there is limited movement of young fish after they settle. In this case, environmental dispersal of larvae pre- settlement, coupled with non-uniform spatial harvesting, can generate spatially structured subpopulations.

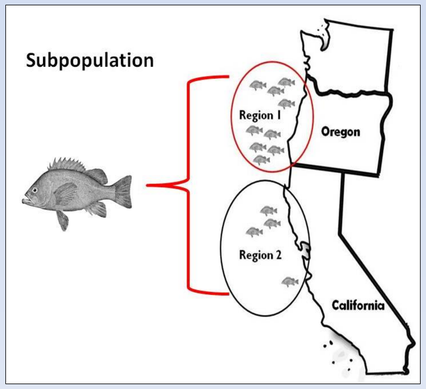

Figure 3. A stock in our study can be broken down into subpopulations . For simplicity we consider the stock to reside in two regions with no exchange of post-settlement fish.

Objectives

To explore the influence of the assumptions regarding spatial structure and the environment we determine which combinations of the following factors provide the most reliable stock assessment results:
(a) the underlying processes driving the population dynamics, specifically a time trend in a single environmental variable, and
(b) simplifying spatial assumptions in the estimation methods.

Methods

Data are simulated using an operating model containing two subpopulations for which true stock characteristics are known.

Recruits are distributed to the two populations based on one of three temporal environmental patterns (Fig. 4):

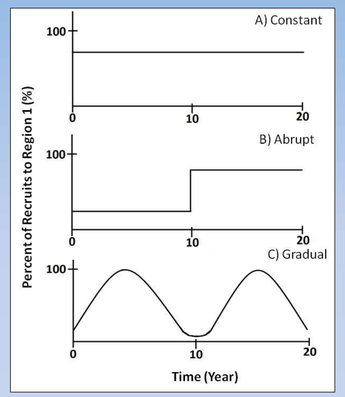

Figure 4. Conceptual models for three environmental factors used in the operating model (random variability around averages included in the actual model).

The simulated data are assessed under two spatial assumptions using Stock Synthesis[1] (Fig. 5):

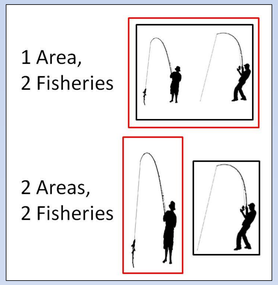

Figure 5. The generated data are assessed as 1 area, 2 fisheries, represented by the two fishermen within one box. It is also assessed as 2 areas, 2 fisheries represented by the two separate boxes and two separate fishermen.

The operating and estimation models (includes variability in observations) produce a number of indicators of stock status and model behavior.

Indicator	Definition
B_0	Virgin Biomass
$B_{current}$	Ending Biomass
Depletion Overall	Ratio of the ending biomass compared to the virgin biomass for both region 1 and region 2
Total negative log likelihood	A measure of fit for the observed indices to the selected models

Comparison of the operational (Θ) and estimated ($\hat{\Theta}$) indicators, provide a measure of relative bias and mean total negative log likelihood.

$$Relative\ Bias = \frac{\hat{\Theta} - \Theta}{\Theta}$$

Results

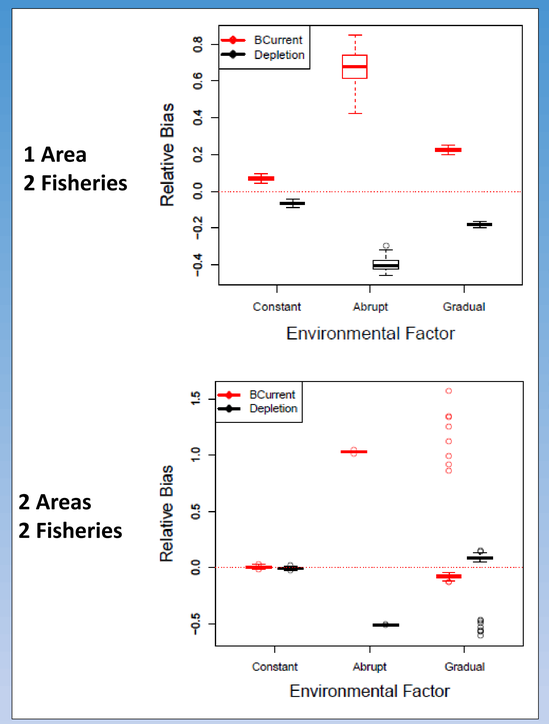

Figure 6. The spread of the bias of results, $B_{current}$ and Depletion from the estimation model relative to the operating model. The horizontal line at a relative bias of zero represents zero difference between the operating model and estimation model estimates.

Table 1. The total negative log likelihood values for the operating model compared by spatial assumption and environmental factor.

Table 1. Operating model total negative log likelihoods

Spatial Assumption	Environmental Factor		
	Constant	*Abrupt*	*Gradual*
1 Area 2 Fisheries	1,310	2,336	3,056
2 Areas, 2 Fisheries	0.765591	2,949	1,189

Table 2. The mean total negative log likelihood values from the estimation models compared by spatial assumption and environmental factor.

Table 2. Estimation model mean total negative log likelihood

Spatial Assumption	Environmental Factor		
	Constant	*Abrupt*	*Gradual*
1 Area 2 Fisheries	20,258	547,135	96,822
2 Areas, 2 Fisheries	1,135	1,500,000	534,398

Discussion

The results shown are preliminary and have brought our attention to patterns and inconsistencies in data that will be explored further:

- Environmental factors have an effect on the estimation of depletion and $B_{current}$ (Fig. 6)
- Greater spread of bias w/ one area spatial assumption, greater magnitude of bias in two areas assumption(Fig. 6)
- Assumption of better fits to data when the model is not collapsed into one area does not hold as expected (Table 1 and 2).

Acknowledgements

We would like to thank the NOAA Living Marine Resources Cooperative Science Center, Dr. Jessica Miller, Dr. Andi Stephens and Dr. Alix Gitelmen. Also, thank you to the Oregon State University Graduate School Diversity Advancement Pipeline Fellowship.

[1]Methot Jr, R. D. and C. R. Wetzel (2013). "Stock synthesis: A biological and statistical framework for fish stock assessment and fishery management." Fisheries Research **142(0): 86-99.**