8. Conclusions and Recommendations

8.1. Conclusions

1. In 2003, the blue crab stock was not experiencing overfishing, nor was it overfished. However, exploitation rates were still higher than target exploitation rates.
2. The blue crab stock did experience a period of overfishing from 1998-2002, which was associated with below average abundances of crab. There is yet to be convincing signs of recovery from this period of low abundance.
3. Analyses indicate that the blue crab stock experienced overfishing during the early 1970's which was associated with low levels of abundance similar to those observed currently.
4. Analyses indicate that the blue crab stock was at relatively high levels of abundance during the 1980's, a period when exploitation rates were lower than those currently observed.
5. Independent analyses indicate that the most likely value for natural mortality (M) ~0.9 yr^{-1}, based on an analysis of empirical results from Chesapeake and Delaware Bays, life history analysis and the stock assessment model developed herein. Values less than 0.6 or above 1.2 do not appear credible.
6. Data on the maximum age of crabs was reviewed, and the assessment determined that uncertainties associated with this value make it unsuitable as the sole foundation for calculation of natural mortality rate.
7. Fishery independent surveys were an important component of the analyses presented here. In our analyses of the principal fishery-independent surveys we found that the individual year effects did not mask the ability of the survey to track cohorts.
8. Despite the finding above, size-at-age is highly variable, and concern over assigning cohort membership is still warranted.
9. The survey of the spawning stock abundance indicates that the spawning stock is at a low level of abundance. Trends in spawning stock abundance are particularly worthy of monitoring.
10. Reporting changes have had a significant impact on the level of landings reported, and corrections must be applied to accurately represent the historical pattern of removals. Appropriately adjusted time series indicate that recent landings of blue crab in the Chesapeake Bay are at historical low levels.
11. Exploitation fractions, whether quantified through direct empirical approaches, or with the assessment model increased from 1990-1999, and those estimated by the model were high compared to those for the previous decade. Exploitation fractions have declined in more recent years.
12. There is a strong negative relationship between exploitation fraction and abundance, whether determined through direct empirical approaches, or with the assessment model, which indicates that a greater proportion of the population is harvested when abundance levels are low. This pattern does not promote sustainability.

13. The method for calculating fishing pressure was changed from one based on fishing mortality rate, F, to one based on exploitation fraction, μ. The advantage of the changes is that estimates of μ are not reliant on estimates of M.
14. A new μ-based overfishing reference point was developed as $\mu_{10\%}$=0.53. A parallel μ-based target reference point, $\mu_{20\%}$=0.46, was also developed.

8.2 Recommendations

1. Research that quantifies size-dependent, spatially-dependent and inter-annual patterns in natural mortality would greatly improve future assessments.
2. Reproductive information (e.g., maturity, fecundity and batch production) for blue crab was collected during a period of relatively high crab abundance. No recent estimates of reproductive parameters are available. Research that quantifies the pattern of maturation, the number of zoea released and the frequency of spawning would be helpful.
3. Future assessments would benefit for information on spatial and inter-annual variation in crab growth in Chesapeake Bay.
4. Fishery-independent surveys are critical to the assessment. Additional analysis of the survey time series to understand their coherence, and their ability to track population variation would be beneficial. A thorough evaluation of survey efficiency and options for enhancing their utility should be undertaken.
5. The monitoring of removals by the different fisheries has improved. However, we recommend that attention be given to ensuring that the biological characteristics of each fishery be quantified, and that the spatial and temporal distribution of the removals be quantified.
6. Reconstruction of landings was difficult because at the time that reporting changes were implemented little considerations was given to the cross-validation of alternative reporting systems. Should future changes in reporting systems be implemented, cross validation studies should be conducted.
7. Regional agencies should strive to ensure that high quality information on the temporal and spatial distribution of effort in the fisheries be collected to obtain reliable catch-per-effort estimates which may be useful in developing surplus production models.
8. Given the importance of the blue crab fishery to the Chesapeake Bay region, greater coordination of the management of fishery-independent and fishery-dependent data is recommended.
9. We recommend management be based on reference points developed from exploitation rates. A reexamination of reference points based on preserving 10% (threshold) to 20% (target) of the maximum spawning potential may be warranted.
10. Given the negative relationship between exploitation fraction and abundance, the use of an estimate of abundance as a trigger for action, above the overfished threshold, to limit fishing pressure should be considered.
11. Given differences in exploitation between male and female crabs, a sex-specific assessment of the blue crab stock, which might include individual sex-specific control rules, should be considered in the future.