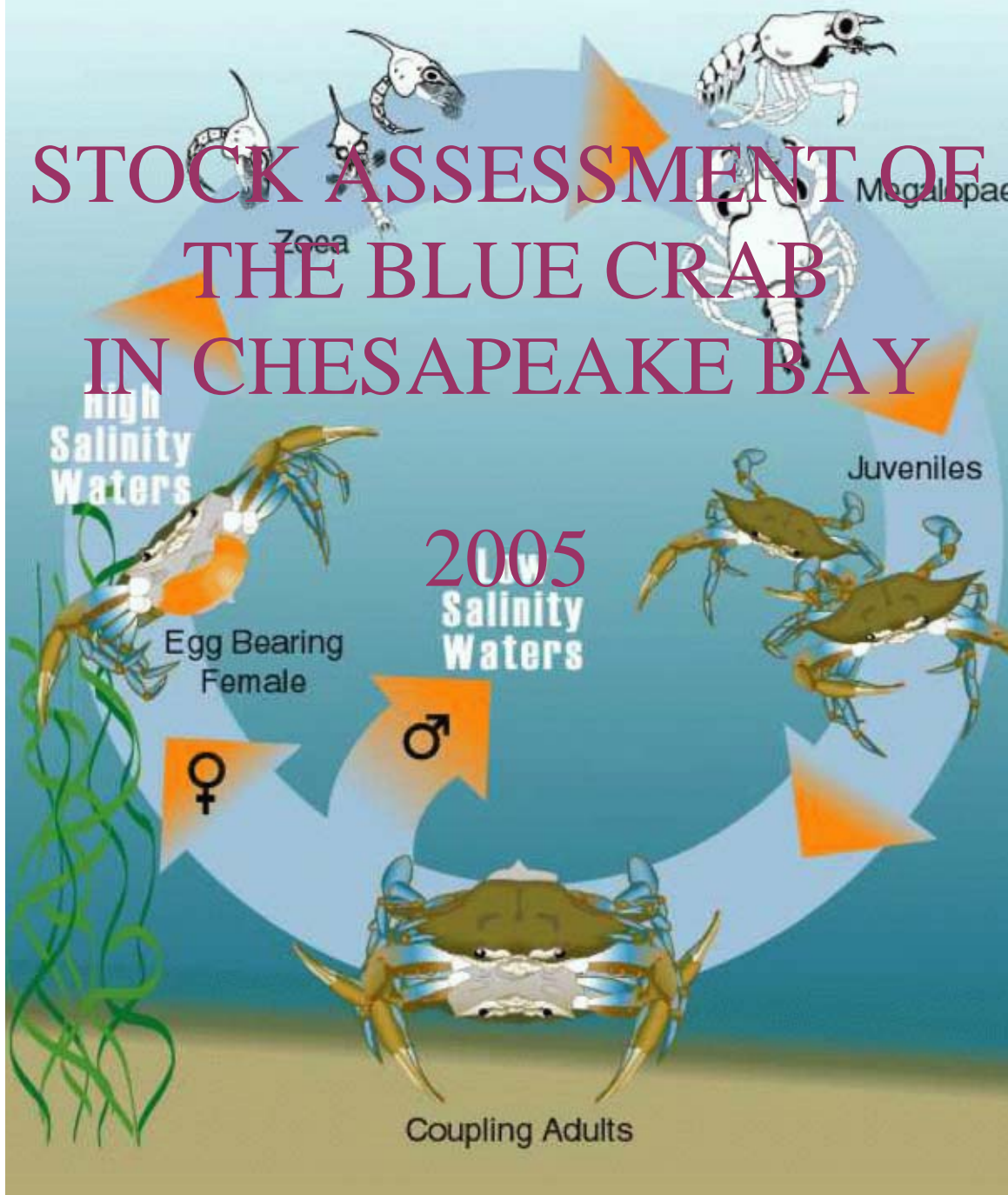


# STOCK ASSESSMENT OF THE BLUE CRAB IN CHESAPEAKE BAY



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## Final Report

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## Executive Summary

The blue crab (*Callinectes sapidus*) is an icon for the Chesapeake Bay region. The commercial fisheries for blue crab in the Bay remain one of the most valuable fishery sectors in the Bay. Ecologically, blue crab is an important component of the Chesapeake Bay ecosystem. Thus, sound management to ensure the sustainability of this resource is critical.

The first bay wide assessment for blue crab was undertaken in 1995 and completed in 1997. It concluded that the stock was moderately to fully exploited and at average levels of abundance. Subsequent to this assessment concerns over the continuing status of blue crab were raised because of declines in abundance and harvests. In response to concerns from stakeholders, a Bi-State Blue Crab Advisory Committee was established in 1996. Work by this committee led to the establishment in 2001 of biomass and exploitation thresholds and an exploitation target reference points. Since 2001, the status of the blue crab stock has been updated annually and its status determined relative to the reference points. Over the ensuing years, the approach to determining the status of blue crab in the Chesapeake Bay has been modified, but a new inclusive assessment has not been conducted.

In 2003, we proposed and were funded to complete a thorough revision of the stock assessment for the blue crab in Chesapeake Bay. The following terms of reference were adopted to guide our assessment activities. We sought to (i) assess and quantify the life history and vital rates of blue crab in the Chesapeake Bay that are relevant to an assessment of the stock, (ii) describe and quantify patterns in fishery-independent surveys of blue crab abundance, (iii) describe and quantify patterns in catch and effort by sector and region, (iv) develop and implement assessment models for the Chesapeake blue crab fisheries, and (v) re-evaluate, and where necessary, update control rules for Chesapeake Bay blue crab fishery.

In conducting the assessment we sought to overcome some of the challenges that the biology of and fisheries for blue crab present. For example, uncertainties in estimates of natural mortality and growth dynamics produced concerns over the reliability of previous population models. Furthermore, interpretation of data on the historical harvest of blue crab in the Chesapeake has been made more difficult because of changes in the way in which harvests are reported to the individual jurisdictions. Thus, we see the following elements of the assessment we have developed as representing substantial advances that increase the chance of maintaining a sustainable blue crab fishery. We have re-evaluated estimates of natural mortality rates using both empirical and life history-based approaches. We have applied time series analysis to adjust historical landings for the known reporting changes. We developed a new assessment model that uses the corrected landings and data from all relevant fishery-independent surveys to understand changes in abundance and exploitation pressure of blue crab. Previous reference points were based on the rate of fishing mortality,  $F$ . Calculation of these reference points and the status of the stock relative to them required an estimate of the rate of natural mortality,  $M$ . Changes in the estimate of  $M$  would cause changes in the

reference points and of our understanding of the historical pattern of exploitation that had operated in the fishery. To overcome this problem, we developed an individual-based spawning potential per recruit model to estimate reference points based on the fraction of the vulnerable population that was harvested each year.

Our review of the biology of the blue crab in Chesapeake Bay supported the assumption that there was a single unit stock of blue crab in the bay. While there is likely to be exchange of individuals with neighboring populations (e.g., Delaware Bay), the data indicate that these are likely not a substantial or persistent feature of the dynamics of the Chesapeake Bay population. Our review of the life history of blue crab indicated that the most likely value for  $M = 0.9$ . This estimate is supported by direct, empirical estimates from tagging studies in Chesapeake Bay, by an analysis of life history patterns in the species generally, and by the relationship between the rate of total mortality and effort in Delaware Bay.

Our review of relevant fishery-independent surveys indicated that the blue crab population in Chesapeake Bay is likely at below average abundances. Although some indices have increased in the most recent years, the majority of indices still indicate the population is below its average abundance levels. In particular, the low abundance of spawning females in the lower Chesapeake Bay is worthy of close monitoring. We noted that changes to size-at-age conventions used to convert size-specific abundance information to age classes implemented since the last assessment have improved the ability of these surveys to track changes in the population. However, our understanding of the dynamics of the blue crab in Chesapeake Bay would benefit from a rigorous evaluation of the size structure data in these surveys.

We applied time series techniques to adjust for the effects of reporting changes on estimated landings. We found that the 1993 reporting change in Virginia and the 1981 and 1993 reporting changes in Maryland all significantly affected the estimates of landings. The reporting change in Virginia led to an average 20.3% decrease in estimated landings prior to 1993. The reporting changes in Maryland led to an 84% change in the estimated landings. Our reconstructed estimate of total baywide landings suggest that the average landings for 1945-2003 was  $34,887 \pm 5,490$  MT. The reconstructed landings indicate that removals have been 16.7% higher than previously reported. The highest recorded baywide harvest was 47,719 MT in 1966. The lowest recorded baywide harvest was 21,539 MT in 2001. Landings in the three years 2000 – 2002 all set record lows for the time series.

We analyzed data from the winter dredge survey to estimate the proportion of the vulnerable population that is harvested each year. This was termed the exploitation fraction,  $\mu$ . Estimates of  $\mu$  have varied from 33% in 1991 to 71% in 1999. Current estimates of  $\mu$  indicate that less than 50% of the vulnerable crabs are being caught each year. Importantly, the estimates of  $\mu$  are independent of estimates of  $M$ , and will not change if estimates of  $M$  are changed by subsequent research. This is not the case with estimates of  $F$ , calculated from the same data. Thus, we recommend adoption of  $\mu$  as the measure of fishing pressure for future assessments.

We developed an extension of the Collie Sissenwine Catch Survey model that permitted multiple fishery-independent time series to be used in assessing the population. The new catch-multiple survey (CMS) model utilized three fishery-independent surveys and the reconstructed commercial catch time series. Comparison of the predictions from the model with observed patterns of abundance and empirical estimate of exploitation fraction indicated that values of natural mortality  $0.9 < M < 1.2$  were most likely. In all cases, the model indicated a disturbing pattern of exploitation in which the fraction exploited increases as abundance decreases. This depensatory pattern presents challenges to the sustainable management of the resource.

We used an individual-based model which captured the discrete nature of crab growth and the diverse sectors in the blue crab fishery to estimate exploitation fraction reference points using spawning potential per recruit criteria. The exploitation fraction threshold reference point was determined to be 53%, based on maintaining 10% of the virgin spawning potential. The exploitation fraction target reference point was determined to be 46%, based on maintaining 20% of the virgin spawning potential. We maintained the previously endorsed biomass threshold of the lowest abundance observed in fishery-independent time series. Based on these revised thresholds, we conclude that the blue crab stock is not overfished (i.e., it is at a higher level of abundance than the threshold), nor is it currently experiencing overfishing (i.e., the exploitation fraction is below the threshold). However, results indicate the stock did experience overfishing recently. As a result of this overfishing, the stock is currently at a relatively low level of abundance. Importantly, when exploitation fractions similarly to values currently observed have been seen in the past, abundances were substantial higher. This suggests potential for future short-term increases in abundance if the lower exploitation fractions are maintained.