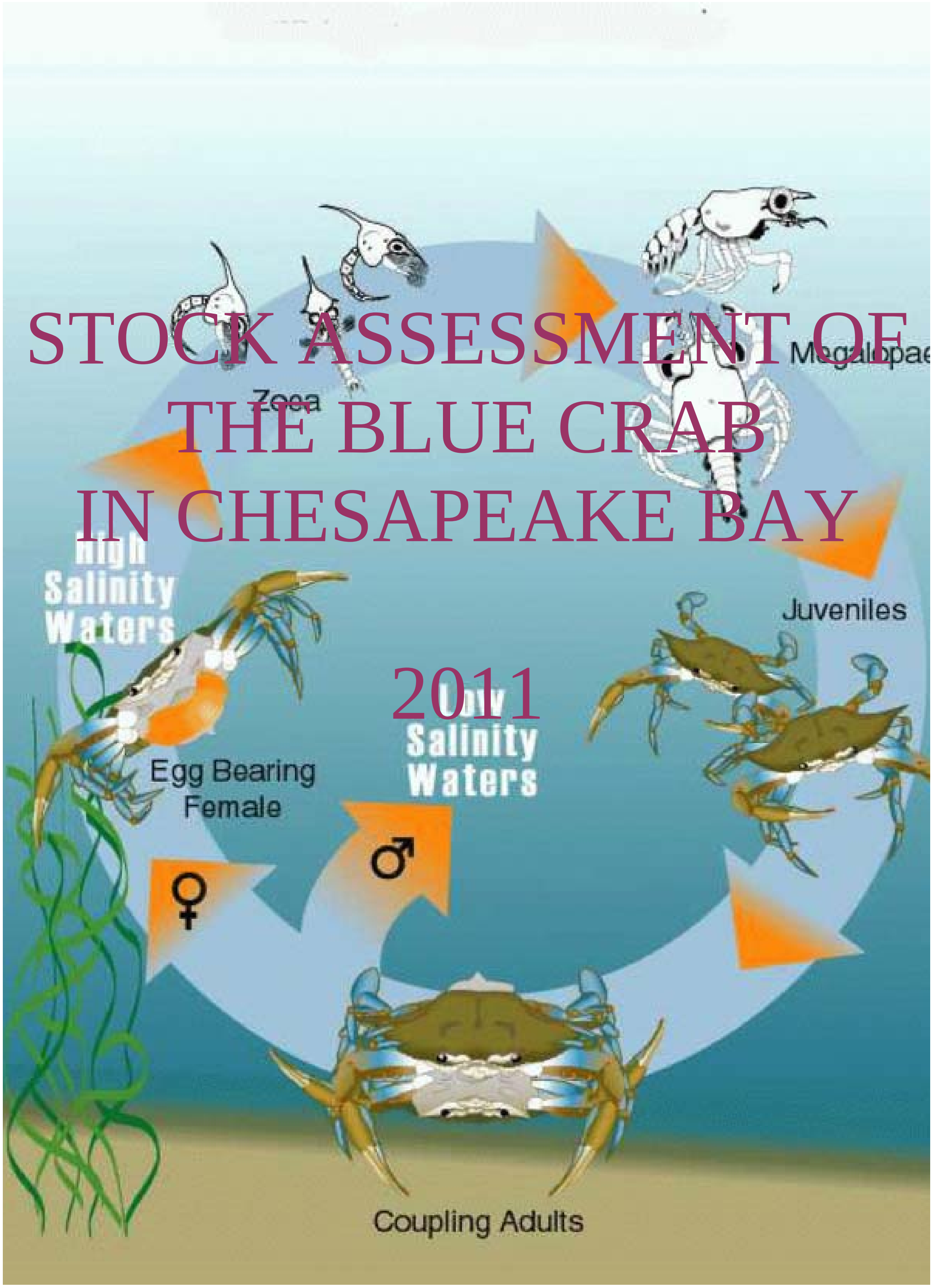
STOCK ASSESSMENT OF THE BLUE CRAB IN CHESAPEAKE BAY

2011



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 completed by Rugolo et al. 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 point. The stock was assessed again in 2005 by Miller et al. This assessment analyzed fishery-dependent and fishery-independent data to assess the status of the blue crab population in the Chesapeake Bay. Population status was compared to reference points developed from an individual-based yield per recruit analysis which used the exploitation rates equivalent to maintaining 10% and 20% of the virgin spawning potential. The assessment recommended adoption of an exploitation fraction based management regime with an overfishing definition equivalent to $F_{10\%} = U_{threshold} = 53\%$ of all available crabs and a target exploitation rate of $F_{20\%} = U_{target} = 46\%$. Based on these reference points, the assessment concluded that exploitation rates in the fishery were too high. Since 2005, the status of the blue crab stock has been updated annually and its status determined relative to these reference points.

In 2009, 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) critically assess and where necessary revise the life history and vital rates of blue crab in the Chesapeake Bay that are relevant to an assessment of the stock, (ii) evaluate and recommend biological reference points for the Chesapeake Bay blue crab population. The potential for implementing sex-specific reference points should be evaluated. (iii) describe and quantify patterns in fishery-independent surveys. Analyses should include an evaluation of the impacts of environmental and abiotic factors on survey catches, to maximize the information content of resultant survey time series. (iv) describe and quantify patterns in catch, effort and survey-based estimates of exploitation by sector and region, including analyses that examine the impacts of reporting changes and trends in CPUE, (v) develop and implement assessment models for the Chesapeake blue crab fisheries. In particular, models that permit estimates of the trends and status of the crab population and fisheries on a sex-specific basis should be evaluated. (vi) examine density-dependent exploitation patterns derived from survey-based and model-based

approaches, (vii) characterize scientific uncertainty with respect to assessment inputs and stock status and (viii) evaluate stock status with respect to reference points.

We developed and implemented a sex-specific catch, multiple survey model to develop integrated estimates of management reference points and stock status. This model represented the blue crab population in Chesapeake Bay of being composed of four stages: (i) age-0 male crabs, (ii) age-0 female crabs, (iii) age-1+ male crabs and (iv) age-1+ female crabs. Crabs in all stages were differentially vulnerable to the fisheries. Natural mortality was assumed to be stage and sex- independent and constant. We employed credible estimates of the rate of natural mortality such that $0.6 < M < 1.2$. Reproduction was modeled as a Ricker-type renewal process with stock productivity being dependent on the abundance of age-1+ females only, but population density-dependence was relative to the abundance of age-1+ crabs overall. Based on empirical evidence we assumed a sex-ratio at recruitment of 52% female. The model employed standardized time series of fishery independent abundance (1968-2009) and was fit to time series of total (1968-1993) and sex-specific catches (1994-2009) using a penalized log likelihood scheme. The model was able to replicate time series of total catch, sex-specific catch and sex-specific abundances for the baywide winter dredge survey, the Virginia trawl survey and the Maryland trawl survey. The model used the abundance of age-1+ crabs in the winter dredge survey as estimates of absolute abundance. Abundances in all other stages and surveys were considered as time series of relative abundances. The best fitting model indicated a coefficient of proportionality between the abundance of age-0 crabs in the winter dredge survey and total abundance of $q_0=0.4$. This estimate leads to considerable changes in the interpretation of reference points and trajectory of the stock.

In implementing the model, we developed female-specific exploitation rate and female-specific abundance reference points. We recommend that all exploitation-based reference points should be based on an estimate of the exploitation fraction of age-0+ female crabs – the exploitable stock. Further, we recommend that all abundance-based reference points should be expressed in terms of the abundance of age-1+ female crabs – an index of the spawning stock. We recommend the following management reference points

1) The overfishing limit in the Chesapeake Bay blue crab fishery should be defined as the exploitation rate of age-0+ crabs that coincides with maximum sustainable yield. The best estimate of U_{MSY} for age-0+ female crabs is $U_{MSY}=0.34$.
2) We consider blue crab as a data poor species. Following precedent from Restrepo et al., the New England Fishery Management Council and the Mid-Atlantic Fishery Management Council, we recommend a target exploitation rate be established equivalent to $0.75^* U_{MSY}$. Our best estimate of the the target exploitation rate is $U_{0.75^*U_{MSY}}=0.255$ age -0+ female crabs.
3) We recommend an overfished abundance threshold be established based on the estimate of 0.5^*N_{MSY}. Our best estimate of the overfished definition is 70

million age-1+ female crabs. This is equivalent to a total population abundance of approximately 135 million age-1+ crabs if the pattern of exploitation is the same for males and females.

4) We recommend that a target abundance reference point be established equivalent to the equilibrium abundance expected if the target exploitation rate is achieved. Specifically, the target abundance should be defined as $N_{0.75*U_{MSY}}$. Our best estimate of the target abundance is 215 million age-1+ female crabs. This is a level of abundance that was observed in the population in the mid 1980s. The recommended target is equivalent to a total population abundance of approximately 415 million age-1+ crabs if the pattern of exploitation is the same for males and females.

We recommend that the management control rules defined above are implemented using empirical data from the winter dredge survey. Based on this approach, in 2009 the blue crab stock in the Chesapeake Bay was not overfished, nor was it experiencing overfishing. More specifically, the exploitation rate in 2009 (U_{2009} =0.24 age-0+ female crabs) was below the U_{target} = 0.255. Also, the blue crab population in 2009 was above the overfished definition of 70 million age-1+ females. The best estimate of the abundance in 2009 (N_{2009} = 174.3 million age-1+ female crabs) was lower than the target abundance. We note that the abundance of crabs in the winter dredge survey of 2009-2010 suggest that the population was above target abundance in 2010. Inspection of the stock trajectory indicated that the stock had experienced overfishing from 1998-2004 and was technically overfished from 2001-2003.

Effective conservation of the blue crab requires an understanding of the relationships between exploitation rate, catch, and population abundance. Our analyses of temporal patterns in abundance and exploitation indicated that they were approximately mirror images of each other, suggesting depensatory exploitation. Consequently, precautionary management measures will be required when the blue crab population is at low abundance to prevent population collapse.

Our analyses indicate that the stock responded favorably to management measures aimed at conserving female crabs. Management measures likely led to an increase in the abundance of age-1+ female crabs such that the recommended abundance target was exceeded for the first time since the early 1990s. We note that the female specific management measures appear to have changed the ratio of sex-specific exploitation rates in the population. Model results indicate that this will likely be associated with higher levels of sustainable harvests – with projected increases from 400 million crabs annually from 1994-2007, to almost 600 million crabs currently. However, the long-term response of the ratio in sex-specific exploitation rates is not known. We caution that if there continues to be a pattern favoring male-specific exploitation rates, management may have to consider increasing abundance targets.