

1. INTRODUCTION

1.1 Background

The Chesapeake Bay Stock Assessment Committee combines the expertise of scientists from the Chesapeake Bay region, with that of Federal fisheries scientists from the Northeast and Southeast Fisheries Science Centers of the National Marine Fisheries Service. This group meets each year to review the results of annual Chesapeake Bay blue crab surveys and harvest data, and to develop management advice for the Bay jurisdictions: Maryland, Virginia and the Potomac River Fisheries Commission.

With support from the Virginia Marine Resources Commission, Maryland DNR, and the NOAA Chesapeake Bay Office, benchmark stock assessments of the Chesapeake Bay blue crab have been conducted every 3-7 years since 1992. The most recent assessment, completed in 2011, generated new reference points for the female component of the blue crab population. These MSY-based female reference points are recommended as replacements for the current Maximum Spawning Potential overfishing reference points (Table 1.1). Similarly, the 2011 stock assessment recommends replacing the empirical overfished age 1+ (both sexes) abundance threshold and interim target with an MSY-based threshold and target based solely on female age 1+ crabs.

1.2 Terms of Reference

With the completion of the 2011 benchmark blue crab stock assessment, the Chesapeake Bay Sustainable Fisheries Goal Implementation Team has requested that CBSAC address the following terms of reference within this report:

- 1) Provide guidance for the management agencies on:
 - a. Implementation of the biological reference points developed within the 2011 assessment.
 - b. Methods for determining appropriate reference points for the male component of the population.
- 2) Provide a description of how the reference points recommended under task one differ from the current reference points.
- 3) Prioritize research needs and science gaps – as identified in the 2011 assessment and Center for Independent Experts (CIE) review.

The second term of reference requesting a comparison of current and recommended reference points is addressed below and stock status is updated according to both sets of reference points. Within this report and future reports, annual updates of population size and exploitation fraction will be calculated directly from the annual results of the winter

dredge survey (WDS) and from annual estimates of harvest and compared to the new reference points. CBSAC has adopted the WDS as the primary indicator of blue crab population health because it is the most comprehensive and statistically robust of the blue crab surveys conducted in the Bay². The WDS measures the density of crabs (number per 1,000 square meters – Figure 1) at approximately 1,500 sites around the Bay. The measured densities of crabs are adjusted to account for the efficiency of the sampling gear and then are expanded to reflect the area of Chesapeake Bay, providing an annual estimate of the number of over-wintering crabs by age and gender².

Table 1.1: A comparison of the current (sexes combined) and recommended female-specific biological reference points for Chesapeake Bay blue crab. The exploitation fraction is the percentage of all crabs removed from the population by commercial and recreational fisheries. Under the current framework, annual estimates of exploitation fraction are calculated as the annual harvest of crabs divided by the total number of crabs (age 0+) estimated in the population at the start of the season. The population estimate is derived from the winter dredge survey. When calculating female-specific exploitation, the annual female harvest is divided by the total number of female crabs (age 0+) estimated in the population at the start of the season. The recommended, female-specific target and threshold abundance refer to the number of female crabs age one and older estimated to be in the population according to the winter dredge survey. The 2011 exploitation fraction cannot be calculated until the completion of the 2011 fishery and estimation of harvest.

| | | Target | Threshold | 2010 Stock Status | 2011 Stock Status |
|-------------------------------|-----------------------------|--------|-----------|-------------------|-------------------------|
| Exploitation Fraction | Current | 46% | 53% | 39% | <i>To be determined</i> |
| | Recommended female-specific | 25.5% | 34% | 18% | <i>To be determined</i> |
| Abundance (millions of crabs) | Current | 200 | 86 | 315 | 254 |
| | Recommended female-specific | 215 | 70 | 251 | 190 |

2. CONTROL RULES

2.1 Recommended Control Rule from 2011 Benchmark Assessment

The 2011 Benchmark assessment recommends a new framework (control rule) based on biological reference points for the female component of the population (Figure 2). The recommended targets and thresholds for exploitation (U) and abundance (N) were developed using the concept of maximum sustainable yield (MSY). U_{MSY} is defined as the annual rate of exploitation by the fisheries that achieves the largest average catch that can be sustained over time without risking stock collapse. Following Federal guidelines, the 2011 assessment recommended a target exploitation rate that is associated with 75% of U_{MSY} and a threshold set equal to U_{MSY} . The female-specific, age 1+ abundance target and threshold were set accordingly at abundances associated with fishing levels at 75%

N_{MSY} (target) and 50% N_{MSY} (threshold). Annual exploitation was calculated as the number of female crabs removed by the fisheries divided by the total number of age-0 and age-1+ female crabs estimated to be in the Bay at the beginning of the fishing season. Within this calculation, the juvenile component (age 0) of the total estimated number of crabs was scaled up by a factor of 1.6 to achieve the best fits of the model to the observed data. The recommended target and threshold reference points are presented in Table 1.1 of this document.

2.2 Former Control Rule

The former control rule was adopted by the Bi-State Blue Crab Advisory Committee in 2001³ and updated in the 2005 Benchmark Stock Assessment⁴ (Figure 3). This control rule represents the relationship between removals by fisheries (exploitation fraction) and the number of spawning-age crabs (both sexes combined), compared with established target and threshold reference points for exploitation and abundance. In 2006, the CBSAC defined the minimum safe number (overfished threshold) of spawning-age crabs to be 86 million crabs. This threshold value was applied based on a lack of historical evidence that a sustainable fishery can be maintained at lower abundances than the minimum observed abundance in the WDS, which occurred in 1999. A threshold or maximum level of exploitation was determined to be 53%, based on the consensus that a minimum of 10% of the spawning potential of an unfished population must be preserved to minimize the risk of recruitment failure and stock collapse. Therefore, if more than 53% of crabs were removed in a given year, overfishing would be occurring. The established target exploitation fraction of 46%, maintained over several years, represents an exploitation fraction that would preserve 20% of the unfished spawning potential.

In January 2008, CBSAC established an interim target of 200 million spawning-age (1+) crabs. This target was established based on analyses suggesting that 200 million age 1+ crabs is the lowest abundance associated with consistently higher levels of recruitment.^{5,6} The target level of 200 million was meant to be a goal for initial rebuilding of the stock.

3. POPULATION SIZE (ABUNDANCE)

3.1 Spawning-age Female Crabs: Recommended Reference Points

The 2011 benchmark assessment recommends replacing the current interim target of 200 million total spawning-age crabs with a target of 215 million female spawning-age crabs. Approximately 190 million female age 1+ crabs were estimated to be present in the Bay at the start of the 2011 crabbing season. This number is below the recommended target but more than twice the recommended threshold number of 70 million female spawning-age crabs (Figure 4). CBSAC notes that, according to the recommended female-specific abundance threshold of 70 million crabs, the blue crab stock would have been classified as overfished for three years between 1999 and 2002 (Figure 4), whereas based on the former control rule the blue crab stock has not been overfished within the last two decades (Figure 5). CBSAC also notes that the estimated abundance in 2011 was lower than observed in 2010. This decline in abundance of age 1+ was the result of substantial

over-winter mortality, particularly in Maryland. Approximately 30% of adult crabs estimated to be in the Maryland waters of Chesapeake Bay perished due to a precipitous drop in December water temperature, followed by sustained below-average temperatures for the remainder of the 2010-2011 winter (Figure 6).

3.2 Spawning-age Male and Female Crabs: Current Reference Points

The number of spawning-age crabs (age 1+) is a key indicator of population health and is used to determine if the population abundance is too low (i.e., is overfished - see section 4 – Control Rules). Approximately 245 million spawning-age crabs (sexes combined) were estimated to be in the Bay at the beginning of the 2011 crabbing season (Figure 5). This represents a 19% decrease from the 2010 estimate of 315 million. Despite the mortality event noted above, the number of spawning-age male and female crabs remained above the former interim target of 200 million for the third consecutive year.

3.3 Age 1+ Male and Age 0 Crabs

In 2011, the number of age 1+ male crabs (greater than 60 mm or 2.4 inches carapace width) estimated to be present in the Bay was approximately 63 million crabs (Figure 7). Although this represents a 70% increase from male abundance in 2008, the number of male crabs remains below the survey average of 87 million crabs. CBSAC notes that male abundance has not increased proportionally to female abundance because the recent management actions promoted recovery and conservation of the female spawning stock. Recruitment, as measured by the number of age 0 crabs (less than 60 mm or 2.4 inches carapace width) appears to have increased, since the female-specific conservation measures were implemented (Figure 8). The number of recruits dropped from 345 million in 2010 to 207 million in 2011 (Figure 8), which was not unexpected given the vagaries of recruitment.

4. HARVEST

4.1 2010 Commercial and Recreational Harvest

The 2010 Maryland commercial crab harvest from the Bay and its tributaries was estimated as 53.4 million pounds. The 2010 commercial harvest in Virginia was reported to be 26.9 million pounds (Figure 9). An additional 4.5 million pounds were reported harvested from the jurisdictional waters of the Potomac River Fisheries Commission. Recreational harvest is assumed to be 8% of the total Bay wide commercial harvest.^{7a, b, c} Therefore, the 2010 Bay-wide recreational harvest was estimated to be 6.8 million pounds. Combining these categories, approximately 91.6 million pounds were harvested from Chesapeake Bay and its tributaries during the 2010 crabbing season. This is the highest harvest since 1994, and is 22% above the long-term (1990-2010) average of 75 million pounds.

Based on continued evidence of inflated harvest reports, Maryland's 2010 commercial harvest was estimated from fishery-independent data sources including the Maryland

commercial reference fleet and an annual survey of crab pot effort in the Maryland portion of Chesapeake Bay⁸. The difference between Maryland's 2010 estimated harvest of 53.4 million pounds and reported harvest of 57.7 million pounds was less than in the two previous years. However, Maryland's 2010 harvest represents a departure from the historic proportion of each jurisdiction's harvest. In recent years, Maryland's commercial harvest has accounted for approximately 53%, by weight, of the Bay-wide harvest. In 2010, that fraction was 59.7%, affected more so by males, whose catch increased by 92.8% from 2009.

4.2 Exploitation Fraction: Recommended and Current Reference Points.

Despite the elevated 2010 harvest, the percentage of female crabs removed by fishing (exploitation fraction) in 2010 was approximately 18%, well below both the new recommended target of 25.5% and threshold of 34% (Figure 10). When considering the former reference points, the percentage of crabs removed by fishing (exploitation fraction) was approximately 39%, compared to the former target of 46% and threshold of 53% (Figure 11).

5. STOCK STATUS

The Chesapeake Bay blue crab stock is currently not overfished and overfishing is not occurring. This is true according to both the new recommended female-only framework developed in the 2011 Benchmark assessment and the former management framework.

6. TERMS OF REFERENCE

6.1 Provide Guidance for the Management Agencies on Implementation of the Biological Reference Points Developed within the 2011 Assessment.

The CBSAC recommends that the jurisdictions place primary management focus on the female-specific target exploitation fraction. If the annual female exploitation fraction is, on average, equal to the target of 25.5%, the assessment model predicts that female abundance should vary around the target level of 215 million crabs. However, given the uncertainty in the abundance component of the model, jurisdictions should focus primarily on the exploitation fraction when deliberating on management strategies, as long as the abundance of age 1+ female crabs is not substantially lower than the target for consecutive years.

The CBSAC recommends that the jurisdictions adopt the female-specific target and threshold reference points developed in the 2011 Benchmark Blue Crab Stock Assessment. The CBSAC suggests that the recommended female-specific reference points be reviewed in the 2012 CBSAC report, relative to model refinements that were recommended by the CIE peer review panel, and which will be undertaken during the coming year.

Finally, the CBSAC stresses the importance of updating benchmark assessments every four to six years. This is necessary to fully evaluate the newly adopted reference points relative to stock status and to incorporate important new data and science into the assessment.

In implementing female-specific reference points, annual estimates of spawning-age female abundance and female exploitation fraction can be derived directly from results of the winter dredge survey and annual estimates of harvest. These calculations can be compared to the new framework to determine stock status, thereby eliminating the need to run the full assessment model each year.

The CBSAC notes that overall crab abundance was 30% lower at the beginning of the 2011 crabbing season than it was at the start of the 2010 season. Although this decrease in abundance was due to lower recruitment and higher winter mortality, rather than elevated fishing pressure during the 2010 crabbing season, having fewer crabs at the start of the 2011 season elevates the risk that the 2011 harvest will exceed the recommended female harvest target of 25.5%. If the 2011 Bay-wide harvest of female crabs is equal to the 2010 female harvest of 27.9 million pounds, the resulting exploitation fraction will be near the target level of 25.5%. Given this, the CBSAC recommends that the jurisdictions closely monitor the 2011 harvest prior to adjusting management measures.

6.2 Provide Guidance for the Management Agencies on Methods for Determining Appropriate Reference Points for Male Blue Crabs

In order to ensure that male abundance does not drop below a critical level relative to female abundance, the CBSAC recommends development of threshold reference points for male crabs that would provide management with a trigger for male conservation. One possibility to explore is a ratio of male to female abundance, which could be derived from annual winter dredge survey results. To properly define a threshold based on an abundance ratio, several key analytical issues need to be addressed and the results of ongoing research on crab reproductive biology need to be reviewed. These issues include: estimation procedures of winter dredge survey gear efficiency, estimation of winter dredge survey gear selectivity for differing sizes of crabs, crab reproductive biology (sperm limitation) and estimation procedures for over-wintering mortality. The CBSAC suggests addressing these issues and to explore appropriate male reference points during a workshop that could be convened in late May or early June of 2012.

In the near term, the CBSAC recommends that management jurisdictions monitor the ratio of the number male crabs greater than 60 mm in carapace width to the number of immature female crabs greater than 60 mm, as calculated from the dredge survey, to ensure that annual ratios stay within the range observed since 1990 (Figure 12). This represents the best estimate of an operational sex ratio, which refers to the relative numbers of sexually mature male crabs (greater than 110 mm) and pre-molt female crabs who are actively seeking mates. Because there is no current evidence of sperm limitation in the population, maintaining the sex ratio within observed values should ensure

maintenance of sufficient males for reproduction. Refining this ratio should be a primary topic during the proposed workshop mentioned above.

Finally, to ensure that male reproductive capacity is not compromised in the face of female conservation measures, CBSAC recommends maintaining current male conservation measures such as size limits. Size limits are important in that they ensure that males have an opportunity to mate prior to being harvested.

6.3 Prioritize research needs and science gaps – as identified in the 2011 assessment and Center for Independent Experts (CIE) review.

The Center of Independent experts thoroughly reviewed the 2011 blue crab benchmark stock assessment with positive results. Dr. Cathy Dichmont, whose comments were consistent with the panel, said in her review: *“This assessment is a valid approach and an improvement on the previous assessments and therefore should be adopted as the basis for management advice.”* However, several gaps in the current knowledge of the blue crab and the fisheries were noted by the CIE review panel. The CBSAC has prioritized the review panel’s findings.

The three highest priorities for research and surveys are:

1. Implement monitoring to characterize the sex, size, and life-stage composition of the commercial harvest Bay-wide. This is of the highest priority given the sex-specific nature of the current management framework.
2. A recreational survey is high priority as it is likely that recreational effort may be increasing with improved stock status.
3. Continue the winter dredge survey and work to refine gear efficiency and over-winter mortality calculations as this could impact reference point values. The CBSAC recommends a workshop is held to address issues such as gear efficiency, selectivity of the dredge gear and dredge survey sex ratios as a reference point.

Other important research projects would include:

- Analysis of existing reported effort data to get at spatial and temporal patterns in CPUE for specific gears and fishery sectors.
- Design a shallow-water complement to the winter dredge survey to estimate the fraction of crabs that are not vulnerable to the winter dredge survey due to their shallow water residence. Pilot studies are ongoing.
- Sex-specific natural mortality rates (research based).
- Variations in fecundity based on season and size (ongoing).
- Determine threshold sex ratio when sperm limitation becomes a problem (research - ongoing).

In addition to recommending research areas to improve critical knowledge of the blue crab population and fisheries, all three peer reviewers had specific concerns that they felt needed to be addressed within the model as a high priority. Therefore, CBSAC recommends that, within the next 12 months, the assessment team explore the impacts of the following modifications to the model:

- 1) Incorporate an internal correction factor for the time series of commercial harvest from Virginia and Maryland. In both jurisdictions, there have been significant changes to the reporting systems, which appear to have artificially impacted reported harvest. Currently, the time series of harvest is corrected for changes in reporting procedure externally to the model. Although the method appears reasonable, the very large effect on the resultant harvest time series should be validated. Ideally, a reporting change parameter (with variances) should be included in the model so that the sensitivity of the parameter on results can be explored and error can be accounted for within the model.
- 2) Provide probability distributions around the recommended reference points. This will provide a clear picture for managers and stakeholders of the model-based uncertainty surrounding the recommended reference points and will be important for managers when crafting decision rules and deliberating on adjusting management strategies.
- 3) Include a sensitivity analysis for various levels of recreational harvest. Given the poorly quantified recreational harvest, it is essential that managers understand a range of potential impacts from recreational harvest. This will assist in crafting management actions including the design of recreational crabbing licenses.
- 4) Modify the stock-recruitment relationship that is used in the model to include a penalty for male-biased abundance sex ratios.

In addition, the CBSAC recommends that the following modifications to the assessment occur in the longer term:

- 1) Incorporate gear-specific harvest and partial recruitment.

7. Management Advice – Short Term

1) Monitor fishery performance and stock status relative to recommended reference points before adjusting regulations:

Management actions since 2008 continue to be effective at rebuilding the spawning component of the population. Empirical estimates of 2011 age 1+ female abundance are close to the recommended target level of 215 million crabs. The female exploitation fraction in 2010 was below the recommended target of 25.5% for the 3rd consecutive year. Management jurisdictions should carefully consider the performance of 2011 fisheries relative to the recommended female-specific reference points and the outcome of the 2011-2012 winter dredge survey before making regulatory adjustments. The CBSAC notes that overall crab abundance was 30% lower at the beginning of the 2011 crabbing season than it was at the start of the 2010 season. Although this decrease in abundance was due to lower recruitment and higher winter mortality, rather than elevated

fishing pressure during the 2010 crabbing season, having fewer crabs at the start of the 2011 season elevates the risk that the 2011 harvest will exceed the recommended female harvest target of 25.5%. If the 2011 Bay-wide harvest of female crabs is equal to the 2010 female harvest of 27.9 million pounds, the resulting exploitation fraction will be near the target level of 25.5%.

2) Catch Reports:

If management based on exploitation fraction continues, the CBSAC recommends that the jurisdictions implement procedures that allow accurate accountability of all commercial and recreational catches. If the jurisdictions continue with a sex-specific regulatory strategy, CBSAC recommends greater efforts to characterize the biological characteristics of all catch.

3) Recreational Catch and Effort:

Recreational catch and effort remains poorly quantified in Chesapeake Bay. The jurisdictions should consider methods for more precisely calculating recreational catch and effort, possibly through licensing systems.

4) Latent effort:

In both states, significant numbers of commercial crabbing licenses are unused. An increase in the blue crab population will likely increase the use of licenses that have, for some time, been inactive. During 2009 and 2010, both Maryland and Virginia have made headway addressing the amount of latent effort in the blue crab fishery. Federal fishery disaster relief money was used by both states to buy back commercial licenses.

5) Effort Control:

Controlling effort has been the foundation of crab management in recent years. The principal tools used by managers have been limited entry, size limits, catch limits, and seasonal closures. However, the total amount of effort expended in the fishery remains poorly quantified. Thus, the effectiveness of management actions remains difficult to quantify. Effort monitoring programs could be improved by incorporating pot tagging so that pot effort is measurable and enforceable.

8. Management Advice – Long Term

1) Catch Control:

A management strategy that sets annual catch levels based on estimates of abundance from the winter dredge survey could potentially balance annual harvests with highly variable recruitment. The CBSAC recommends that jurisdictions evaluate the benefits of quota-based systems. Allocating annual quotas to each jurisdiction would improve performance of a Bay-wide quota and lead to jurisdictional accountability of harvest relative to the Bay-wide exploitation target.

9. Critical Data and Analysis Needs

Blue crab management now employs sex-specific regulatory strategies. Given this, the lack of data describing sex ratio and size composition of the harvest will impede efforts to develop effective management strategies. CBSAC recommends that jurisdictions sample for biological characteristics in proportion to the magnitude of harvest from each harvest sector. A collaborative and coordinated Bay-wide, fishery-independent survey focused on the spring through fall distribution and abundance of blue crabs remains important, especially if agencies are considering regional or spatially-explicit management strategies. Finally, an assessment of the magnitude of incidental mortality due to various sources such as discarding female sponge crabs, the peeler fishery, predation effects and gear effects, would potentially improve reliability of exploitation estimates, and inform future assessments.

CBSAC Members:

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|---------------------|--|
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Other Attendees:

| | |
|-------------|--|
| Glenn Davis | Maryland Department of Natural Resources |
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