2014 Chesapeake Bay Blue Crab Advisory Report
CBSAC Meeting Date: May 12th, 2014
Report Final Draft: June 30th, 2014

1. INTRODUCTION

1.1 Background

The Chesapeake Bay Stock Assessment Committee (CBSAC) combines the expertise of state representatives and scientists from the Chesapeake Bay region with federal fisheries scientists from the National Marine Fisheries Service's Northeast and Southeast Fisheries Science Centers. This committee has met each year since 1997 to review the results of annual Chesapeake Bay blue crab surveys and harvest data, and to develop management advice for Chesapeake Bay jurisdictions: the state of Maryland, Commonwealth of Virginia, and the Potomac River Fisheries Commission (PRFC).

Three benchmark stock assessments of the Chesapeake Bay blue crab have been conducted since 1997. The most recent assessment was completed in 2011[1] with support from the Virginia Marine Resources Commission (VMRC), Maryland Department of Natural Resources (MD DNR), and the NOAA Chesapeake Bay Office (NCBO). The 2011 assessment recommended revision of the former overfishing reference point, which had been based on conserving a fraction of the maximum spawning potential (MSP), to one based on achieving the maximum sustainable yield (MSY) (Table 1). The 2011 stock assessment recommended replacing the empirically-estimated overfished age-1+ (both sexes) abundance threshold and target with an MSY-based threshold and target based solely on the abundance of female age-1+ crabs.

Female-specific reference points were formally adopted by all three management jurisdictions in December 2011. Management of the blue crab stock is coordinated among the jurisdictions by the Chesapeake Bay Program's Sustainable Fisheries Goal Implementation Team (SFGIT). Organized by the Chesapeake Bay Program and chaired by the NOAA Chesapeake Bay Office, the SFGIT is led by an executive committee of senior fisheries managers from the MD DNR, VMRC, PRFC, the Atlantic States Marine Fisheries Commission (ASMFC), and the District Department of the Environment (DDOE).

CBSAC adopted the Bay-wide Winter Dredge Survey (WDS) as the primary indicator of blue crab population health in 2006, because it is the most comprehensive and statistically robust of the blue crab surveys conducted in the Bay[2]. The WDS measures the density of crabs (number per 1,000 square meters) at approximately 1,500 sites around the Bay (Figure 1). The measured densities of crabs are adjusted to account for the efficiency of the sampling gear and are expanded based on the area of Chesapeake Bay, providing an annual estimate of the number of over-wintering crabs by age and sex[2]. An estimate of the mortality during winter is also obtained from the survey results.

1.2 Background: Previous and Current Management Framework

The current framework annual estimates of exploitation fraction are calculated as the annual harvest of female crabs in a given year divided by the total number of female crabs (age 0+) estimated in the population at the start of the season. The 2014 exploitation fraction cannot be calculated until the completion of the 2014 fishery and is therefore listed as *TBD*. Crab abundance is estimated from the WDS each year. The current framework recommends monitoring the abundance of female age-1+ crabs in comparison to female-specific abundance reference points. Management seeks to control the fishery such that the overfishing threshold is not exceeded, resulting in a larger number of crabs than required by the overfished (depleted) threshold. Ideally, the fishery should operate to meet target values and should never surpass threshold values. Stock status levels that do not exceed threshold values are shown in green, exploitation values exceeding or abundance estimates beneath threshold are shown in red.

Control Rule	**Reference Points**			**Stock Status**			
	Period	**Target**	**Threshold**	**2011**	**2012**	**2013**	**2014**
Exploitation Fraction	Current, Female-specific	25.5%	34% (max)	24%	10%	23%	**TBD**
Abundance (millions of crabs)	Current, Female-Specific	215	70 (min)	190	97	147	68.5

(Table 1)

2. CONTROL RULES

2.1 Control Rule from 2011 Benchmark Assessment

The 2011 benchmark assessment recommended a revised control rule based on biological reference points for the female component of the population (Figure 2). The application of a control rule to management of the blue crab fisheries was first adopted by the Bi-State Blue Crab Advisory Committee in 2001[3]. The current female-specific targets and thresholds were developed using the MSY concept. U_{MSY} is defined as the level of fishing (expressed as the percentage of the population harvested) that achieves the largest average catch that can be sustained over time without risking stock collapse. Following precedent adopted by the New England Fishery and Mid-Atlantic Fishery

Management Councils, the 2011 assessment recommended a target exploitation level that was associated with 75% of the value of U_{MSY} and a threshold exploitation level set equal to U_{MSY}. The female-specific, age-1+ abundance target and threshold were set accordingly at abundance levels associated with 75% N_{MSY} (target) and 50% N_{MSY} (threshold). The annual exploitation is calculated empirically as the number of female crabs harvested divided by the total number of age-0+ female crabs in the Bay at the beginning of the fishing season, as estimated by the WDS. As part of this calculation, the juvenile component of the total estimated number of crabs was scaled up by a factor of 2.5 to achieve the best fits of the empirical estimates to the modeled data.

2.2 Male Conservation Points of Reference

In 2011 CBSAC recommended that male abundance should not be allowed to decline to a critically low level relative to female abundance and a conservation trigger based on male abundance should be developed. The reference points from former management framework are used to develop the conservation points of reference below.

Previously, estimates of male exploitation were presented that did not utilize the juvenile scalar in calculations, as it has been when calculating female exploitation. The Male Conservation Points of Reference below have been revised to include the scalar (described in Section 2.1), so it is consistent with Female Reference Points that came out of the 2011 Stock Assessment. This change has no impact on the performance of the metrics or the application of the Male Conservation Points of Reference described below. Exploitation of males and females combined were calculated without the juvenile scalar so those values could be related to the prior management framework .

CBSAC recommended conservation triggers for male crabs based on male exploitation and on the former management framework. Under these triggers conservation measures should be considered for male blue crabs if <u>either</u> of the following occurs:

1) The male exploitation rate exceeds 33% (calculated with the juvenile scalar as described in section 2.1) which is the second highest exploitation fraction observed for male crabs since 1990. Choosing the second highest value in the time series ensures a buffer from the maximum observed value of exploitation. It should be noted that this value does not represent a biologically significant fishing threshold or target. Rather, this trigger will ensure that the male component of the stock is not more heavily exploited, relative to females, than at levels that have occurred in the last 23 years.

2) If female exploitation is below the established overfishing threshold of 34% (Figure 10) and the total annual exploitation rate of male and female crabs exceeds the threshold defined by the previous control rule (53% of crabs, both sexes, Figure 11).

The 2013 male exploitation fraction is estimated as 29%. This fraction is not above the male conservation trigger. The total exploitation rate does not exceed the interim

threshold. No management action is recommended at this time specific to male blue crabs.

3. POPULATION SIZE (ABUNDANCE)

3.1 Spawning-age Female Crabs: Reference Points

The 2011 benchmark assessment recommended a threshold abundance of 70 million female spawning-age (age 1+) crabs and a target abundance of 215 million female spawning-age crabs. Approximately 68.5 million female spawning-age crabs were estimated to be present in the Bay at the start of the 2014 crabbing season (Figure 9). The 2014 estimate of total spawning age female crabs represented a 53% decline with respect to the over-wintering population of 147 million in 2013, and represents a return to abundance levels observed during the period between 1994 and 2008 when adult female abundance remained just above the threshold level, and dipped below that level in several years between 1999 and 2002. This 2014 abundance of spawning-age female crab is lower than the recommended threshold, placing the population in **depleted** status.

3.2 Exploitable Female Stock – Abundance of Female crabs Aged-0^{+}

The total abundance of female crabs increased by 13.5% from 296 million crabs in 2013 to 336 million crabs in 2014 (Figure 3). However, the 2014 abundance is still comparable to that observed during the period of low female abundance from 1998-2008. The total population of female crabs forms the basis for the annual calculation of the exploitation rate of female crabs relative to the established target of 25.5% and threshold of 34%. The juvenile component of the female stock is scaled up by a factor of 2.5 when calculating the annual exploitation fraction as described in section 2.1.

3.3 Age-1+ Male

In 2014, 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 30.4 million crabs. The 2014 WDS estimate indicates that age 1+ males declined by approximately 30% from the level observed in 2013 and is among the lowest values in the time series.

3.4 Age-0 Crabs

Recruitment is estimated as the number of age 0 crabs (less than 60 mm or 2.4 inches carapace width) in the WDS. After applying the scalar as described in section 2.1, the estimate of age 0 crabs increased by 78% from 111 million in 2013 to 198 million crabs in 2014 (Figure 9). The abundance estimate of age-0 crabs in 2014 was similar to those levels observed between 1994 and 2008 when adult female abundance was low and sometimes below the threshold and fishing levels exceeded the threshold in numerous

years. High recruitment variability is a characteristic of blue crab populations, although a sustained return to low levels seen prior to 2008 would be of concern.

4. HARVEST

4.1 2013 Commercial and Recreational Harvest

The 2013 Maryland commercial crab harvest from the Bay and its tributaries was estimated as 18.7 million pounds. The 2013 commercial harvest in Virginia's Chesapeake area was reported as 16.1 million pounds, and 2.0 million pounds were reported to have been harvested from the jurisdictional waters of the PRFC (Figure 8). Maryland's 2013 commercial harvest declined 41% from 2012. Commercial harvest in 2013 in Virginia decreased by 24%, while Potomac River dropped 44%, when compared to 2012 levels. The bay-wide commercial harvest of almost 37 million pounds is the lowest harvest recorded in the last 25 years.

Prior to 2008, recreational harvest had been assumed to be 8% of the total Bay wide commercial harvest.[4,5,6] Since recreational harvest of female blue crabs is no longer allowed in Maryland or in the Maryland tributaries of the Potomac River, recreational harvest is better described as 8% of male harvest in those jurisdictions. Therefore, 2013 Bay-wide recreational harvest was estimated to be 3.9 million pounds. Combining the commercial and recreational harvest, approximately 40.7 million pounds were harvested from Chesapeake Bay and its tributaries during the 2013 crabbing season. The 2013 Bay-wide blue crab harvest was the lowest seen this century.

4.2 Exploitation Fraction: Reference Points

The percentage of crabs removed by fishing (exploitation fraction) of female (ages 0 and 1+) crabs in 2013 was approximately 23%. This exploitation fraction is below the target of 25.5% and the threshold of 34%, for the sixth consecutive year (Figure 10).

5. STOCK STATUS

The Chesapeake Bay blue crab stock is currently below the abundance threshold of 70 million age 1+ female crabs outlined in the current management framework. The stock is **depleted** but **overfishing is not occurring** (Figure 9). Abundance, harvest, and exploitation of all crabs are summarized in Table 2.

6. MANAGEMENT ADVICE-SHORT TERM

6.1 Monitor fishery performance and stock status relative to recommended reference points and maintain a risk-averse management approach protecting 2014 recruits

The female exploitation fraction in 2013 was below the recommended target of 25.5% for the sixth consecutive year. Although the abundance of adult female crabs decreased in 2014, juvenile crab abundance increased in 2014 and the exploitable female stock increased by 13.5%. Additionally, the number of recruits year to year remains highly variable. Future catches and ability for the blue crab stock to reach abundance targets could depend heavily on the survival and successful reproduction of the 2014 exploitable female stock. Protection of this year class is expected to increase the number of spawning age crabs in 2015 thereby lowering the probability of continued poor recruitment. CBSAC finds this as further justification for a risk-averse and cautious management approach that ensures harvest is adequately constrained relative to abundance.

6.2 Catch Reports

CBSAC again recommends that the jurisdictions implement procedures that provide accurate accountability of all commercial and recreational harvest. If the jurisdictions continue with a sex-specific regulatory strategy, CBSAC again recommends greater efforts to determine the biological characteristics of all catch, both harvested and discarded. CBSAC also recommends that the jurisdictions implement additional harvest validation protocols.

6.3 Shifting management time frame: July to July

CBSAC recommends management jurisdictions consider a July to July adaptive management framework that allows for the results of the Winter Dredge Survey and the Blue Crab Advisory report to be utilized in the year immediately following the completion of the WDS as well as the Advisory Report. This timeline would support management by providing the most current abundance information to be considered by managers in the following crabbing season.

7. MANAGEMENT ADVICE- LONG TERM

7.1 Catch Control

A management strategy that sets annual catch levels based on estimates of abundance from the WDS and that accounts for sex-specific seasonal distribution of crabs could potentially balance annual harvests with highly variable recruitment events. The CBSAC recommends that jurisdictions evaluate the benefits of quota-based management 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

7.2 Annual sanctuary and complementary management measures

CBSAC recommends that the jurisdictions consider establishing a year-round sanctuary for mature females in the lower Bay, and complementary sanctuaries or other management measures in the upper Bay and Potomac River that would promote survival of mature females in their first and subsequent spawning seasons. Protection of mature females in multiple spawning seasons should bolster the spawning stock and recruitment, and provide a buffer for the population from the combined effects of environmental disturbance and high fishing pressure.

7.3 Abundance specific exploitation

In the upcoming 2016 stock assessment CBSAC recommends the development of variable targets and thresholds based on the fluctuating abundance of all sectors of the female segment of the population. Development of abundance based variable targets and thresholds should be considered in the upcoming assessment.

7.4 Jurisdictional Management Controls

The blue crab fishery is primarily managed under an effort control framework with limited entry, size limits, and seasonal closures serving as the principal tools. Additionally, the blue crab fishery is also managed by output controls such as harvest and bushel limits. In many cases, the amount of effort expended in the fishery remains poorly quantified. CBSAC recommends an increased investment in Bay-wide effort monitoring that should include actions in all jurisdictions to implement a pot marking system and a bay wide survey of crab pot effort to estimate the total, spatial, and temporal patterns of the crab pot fishery. Should efforts to develop and implement real time verifiable harvest reporting as described in section 7.1 be successful, this recommendation can be ignored.

7.5 Latent effort

In both states, significant numbers of commercial crabbing licenses are unused. An increase in the blue crab population may increase the use of licenses that have, for some time, been inactive. CBSAC recommends that the level and possible re-entry of latent effort into the fishery be estimated and monitored. In addition to increases in latent effort, CBSAC also recognizes that temporal and seasonal shifts in blue crab abundance may alter existing effort exerted by active licenses. The impact of inherent variability of blue crab abundance on both latent and active effort should be investigated as a part of this recommendation.

8. CRITICAL DATA AND ANALYSIS NEEDS

Blue crab management now employs sex-specific regulatory strategies. Given this, current efforts could be expanded to better quantify sex ratios and size compositions of the harvest specifically in the peeler crab fishery. CBSAC has identified the following list of fishery-dependent and fishery-independent data needs as well as the benefits provided to management. CBSAC is planning on meeting mid July 2013, to discuss the prioritization of the needs identified below as well as the potential investigators, cost and duration of the projects.

8.1 Increased accountability and harvest reporting for both commercial and recreational fisheries:

CBSAC recommends jurisdictions continue to develop, explore, and evaluate implementation of real time electronic reporting systems to increase the accuracy of commercial and recreational landings. Improving commercial and recreational blue crab harvest accountability would provide managers with a more accurate exploitation fraction each year and better support mid-season management changes. Maryland will be implementing an electronic reporting system in 2015 for all commercial harvesters that will include daily random catch verification and a "hail–in, hail-out" protocol, which should greatly improve the accuracy of landings data. Virginia implemented an electronic reporting program in 2009 as an optional reporting method for harvesters. The majority of harvesters still prefer the original paper version of the Virginia Mandatory Reporting Program, but an increase in crab harvesters signing up for electronic reporting has been reported.

8.2 Gear efficiency pertaining to selectivity of WDS methods:

The WDS survey methods to estimate gear efficiency differ between the two states. CBSAC recommends continuation of a comprehensive comparison between MD and VA WDS methodologies and gear efficiency and selectivity with regard to age 0 and age 1+ crabs.

Following the comprehensive comparison, the accuracy and reliability of current scalars and efficiency corrections should be reevaluated. MD-DNR and VIMS will meet to discuss survey design in an attempt to develop this comparison over the course of the next year. Costs and required time are unknown.

In 2013-2014 a new framework was tested to determine and evaluate the accuracy of the current depletion method used to quantify gear selectivity in the dredge survey. The experimental selectivity methodology compared the previous depletion design of continuously sampling the exact area until zero crabs were captured from the selected site. The new design employed an overlapping dredge pattern where perpendicular tracks were used to derive a selectivity estimate.

Considerable progress was made evaluating the new experimental design. Future analysis and discussion should be prioritized this summer to determine the efficacy and application of the new design. Additional personnel may be needed to analyze the results of the comparisons.

8.3 Over-wintering mortality:

The WDS data should be further examined to estimate overwintering mortality. Continuing this data mining exercise could provide CBSAC and managers with a more complete understanding of inter-annual variability in natural mortality and potentially improve future assessments. CBSAC recommends that initial efforts be focused on determining a statistical approach to use with existing data that can be developed to provide a more reliable bay-wide mortality estimate.

8.4 Improving recruitment estimate through shallow water survey:

Based on the results of the 2012-2013 WDS, a large number of recruits observed in the 2011-2012 WDS did not recruit to the fisheries in 2012-2013. Based on the stock assessment and pilot field experiments by VIMS and the Smithsonian Environmental Research Center, a large fraction of juvenile blue crabs (76-86%) in shallow water are not sampled by the WDS[7]. For the former, CBSAC recommends analyzing pertinent environmental and ecological variables to examine potential hypotheses to explain the poor survival of this record recruitment event and improve the accuracy of the WDS. Anticipated time to completion is three to four months; this examination includes the definition of viable hypotheses, not the assessment of their veracity. For the latter, CBSAC recommends that funding be pursued at the state and federal levels for shallow-water surveys to assess the potential for interannual bias in the fraction of juveniles that is not sampled by the WDS.

8.5 Investigation of the potential for sperm limitation:

CBSAC recommends continued examination to quantify and better understand the role male crabs on reproductive success and overall population productivity. The potential for sperm limitation resulting from a lower abundance of sexually mature male crabs is discussed in several recent studies[8,9,10]. Further clarity could be brought to this issue through an analysis of the age composition of mature females over the history of the WDS to determine whether the proportion of females in their second reproductive year has increased.

8.6 Other sources of incidental mortality:

CBSAC also recommends analyzing the magnitude of other sources of incidental mortality, specifically sponge crab discards, unreported losses after harvest from the peeler fishery, disease, and predation. An analysis of non-harvest mortality could improve reliability of exploitation fraction estimates and inform future assessments. Initial efforts should be focused on better defining analyses that could address the problem.

8.7 Prepping for next stock assessment:

CBSAC recommends that measures to secure funding, establish terms of reference, and identify any additional resources needed for the 2016 stock assessment begin over the next year.

8.8 Collaborative Bay-wide fishery independent survey:

A collaborative and coordinated Bay-wide, fishery-independent survey focused on the spring through fall distribution and sex-specific abundance of blue crabs remains important, especially if agencies are considering regional or spatially-explicit management strategies. Costs and time commitments are unknown.

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Table 2. Estimated abundance of blue crabs from the Chesapeake Bay-wide winter dredge survey, annual commercial harvest, and removal rate of female crabs.

Survey Year (Year Survey Ended)	Total Number of Crabs in Millions (All Ages)	Number of Juvenile Crabs in Millions (both sexes	Number of Spawning-Age Crabs in Millions (both sexes)	Number of spawning age Female crabs in Millions	Bay-wide Commercial Harvest (Millions of Pounds)	Percentage of Female Crabs Harvested
1990	791	463	276	117	96	44
1991	828	356	457	227	90	34
1992	367	105	251	167	53	60
1993	852	503	347	177	107	35
1994	487	295	190	102	77	28
1995	487	300	183	80	72	32
1996	661	476	146	108	69	20
1997	680	512	165	93	77	22
1998	353	166	187	106	56	40
1999	308	223	86	53	62	37
2000	281	135	146	93	49	43
2001	254	156	101	61	47	42
2002	315	194	121	55	50	34
2003	334	172	171	84	47	33
2004	270	143	122	82	48	42
2005	400	243	156	110	54	24
2006	313	197	120	85	49	29
2007	251	112	139	89	43	35
2008	293	166	128	91	49	24
2009	396	171	220	162	54	23
2010	663	340	310	246	85	18
2011	452	204	255	191	67	24
2012	765	581	175	95	56	10
2013	**300**	**111**	**180**	**147**	**37**	**23**
2014	**308**	**198**	**100**	**68.5**	**TBD**	**TBD**

* 2013 Bay-wide commercial harvest and exploitation rate are preliminary.