2013 Chesapeake Bay Blue Crab Advisory Report
CBSAC Meeting Date: May 13th, 2013
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1. INTRODUCTION

1.1 Background

The Chesapeake Bay Stock Assessment Committee (CBSAC) combines the expertise of state agencies and scientists from the Chesapeake Bay region with that of federal fisheries scientists from the National Marine Fisheries Service 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: 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 (approximately every five years). 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, that 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). Similarly, 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 has adopted the Bay-wide Winter Dredge Survey (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 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 to reflect the area of Chesapeake Bay, providing an annual estimate of the number of over-wintering crabs by age and sex[2].

1.2 Background: Previous and Current Management Framework

A comparison of the current female-specific and previous (both sexes combined) biological reference points for the Chesapeake Bay blue crab fishery is presented in Table 1 (below). The exploitation fraction is the estimated percentage of crabs removed from the population by commercial and recreational fisheries. While this was previously calculated as the removal of both male and female crabs, under 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 2013 exploitation fraction cannot be calculated until the completion of the 2013 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 and replaces the previous abundance target and threshold for all age-1+ crabs of both sexes. 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 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.

Control Rule	**Reference Points**			**Stock Status**			
	Period	**Target**	**Threshold**	**2010**	**2011**	**2012**	**2013**
Exploitation Fraction	Current, Female-specific	25.5%	34% (max)	18%	25%	10%	**TBD**
	Former, Sexes-Combined	46%	53% (max)	39%	45%	23%	**TBD**
Abundance (millions of crabs)	Current, Female-Specific	215	70 (min)	251	190	97	147
	Former, Sexes-Combined	200	86 (min)	315	254	178	189

(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[7.] 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 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. Within 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 estimations to the modeled data.

2.2 Male Conservation Points of Reference

In 2011, CBSAC recommended that in order to ensure that male abundance does not decline to a critical level relative to female abundance, a conservation trigger, based on male abundance, should be explored.

To address these concerns, in 2012, CBSAC suggested a precautionary approach that would maintain the fishery within historical levels of male exploitation and ratios of male to female crabs. This would ensure that the male component of the stock would not become more heavily fished, relative to the female component observed since 1990. These conservation points of reference were identified as a male exploitation fraction not to exceed 66% and a male to female operational sex ratio to be maintained above historical values of 0.57 (meaning the number of mature males to every mature female).

At the 2013 CBSAC Blue Crab Advisory Report meeting, the committee reviewed this previous recommendation and after application to the 2013 WDS results, determined that these points of reference, regressed upon each other, were not biologically meaningful. There is no identifiable relationship between operational sex ratio, as calculated from the WDS, and male exploitation rate.

Accordingly, CBSAC recommends a simpler approach which sets conservation triggers for male crabs based on male exploitation and on the former management framework. Conservation measures, by the management jurisdictions, should be considered for male blue crabs if either of the following occurs:

1) The current male exploitation rate exceeds 62% 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 has occurred in the last 23 years.

2) If female exploitation is below the established overfishing threshold of 34% 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 4). The 2012 male exploitation fraction is estimated as 11%. This fraction is not above the male conservation trigger of 62% male exploitation. The total exploitation rate (23%, both sexes) does not exceed the interim threshold of 53%. 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 147 million female spawning-age crabs were estimated to be present in the Bay at the start of the 2013 crabbing season (Figure 5). The 2013 estimate of total spawning age female crabs represented a 54.7% increase with respect to the over-wintering population of 97 million in 2012. This number is below the recommended target but remains above the new threshold.

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

In 2013, the total abundance of female crabs, as measured by the WDS declined 48% to 206.4 million crabs from the 2012 estimate of 400 million crabs (Figure 6). 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. The effects of this juvenile scaling factor on total female abundance are directly related to the strength of the year class. When the juvenile scalar is included in the estimation of total female abundance, the exploitable

female stock declined 66% from 858 million crabs in 2012 to 296 million crabs in 2013 (Figure 7).

3.3 Age-1+ Male

In 2013, 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 42 million crabs (Figure 8). This represents a 48% decline in male abundance from 2012.

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. Without applying the scalar as describe in section 2.1, the estimate of age 0 crabs decreased from 581 million in 2012 to 111 million in 2013 (Figure 9). These estimates are assumed to underestimate the true population as they incorporate neither the vulnerability of juveniles to WDS gear nor the juvenile scalar of 2.5. The recruitment estimate for 2012 was the largest recruitment event recorded in the 24 years of the WDS. The number of recruits observed in the 2013 WDS was substantially lower. CBSAC notes the observed drop in 2013 is within historical bounds of the WDS and is likely a characteristic of natural recruitment variability resulting from blue crab biology.

4. HARVEST

4.1 2012 Commercial and Recreational Harvest

Based on continued evidence of inflated harvest reports, Maryland's 2012 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 Bay[6]. The 2012 Maryland commercial crab harvest from the Bay and its tributaries was estimated as 31 million pounds. Maryland's 2012 reported commercial harvest of 38.7 million pounds was 23% higher than the estimated harvest.

The 2012 commercial harvest in Virginia Chesapeake area was reported to be 21 million pounds, and 3.5 million pounds were reported to have been harvested from the jurisdictional waters of the PRFC (Figure 10). Maryland's 2012 commercial harvest declined 11% from 2011. Commercial harvest in 2012 in Virginia decreased by 26%, while Potomac River remained stable, compared to 2011 levels. Prior to 2008, recreational harvest had been assumed to be 8% of the total Bay wide commercial harvest.[3,4,5] 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, 2012 Bay-wide recreational harvest was estimated to be 3.9 million pounds. Combining these categories, approximately 60.0 million pounds were harvested from Chesapeake Bay

and its tributaries during the 2012 crabbing season. Despite decreasing by almost 12 million pounds, the 2012 Bay-wide harvest was near the average harvest of the most recent ten years.

4.2 Exploitation Fraction: Reference Points

The percentage of crabs removed by fishing (exploitation fraction) of female (ages 0 and 1+) crabs in 2012 was approximately 10% and well below the target of 25.5% and the threshold of 34% (Figure 6).

When considering the previous reference points, the percentage of male and female crabs removed by fishing (exploitation fraction) was approximately 25%, which is well below the previous (sexes combined) target of 46% and below the previous threshold of 53% (Figure 4).

5. STOCK STATUS

The Chesapeake Bay blue crab stock is currently **not overfished,** and **overfishing is not occurring** (Figure 2). These conclusions remain true under current as well as the former control rule using both sexes. 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

The female exploitation fraction in 2012 was below the recommended target of 25.5% for the sixth consecutive year. Although the abundance of adult female crabs has increased in 2013, recruitment was low in 2013 and the exploitable female stock declined by 66%. Additionally, the survival of 2012 recruits seems to have been very poor. Future catches could depend heavily on the survival and successful reproduction of the 2013 age-1^{+} females. 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

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

6.3 Impacts of 2013 catches on exploitation fraction

The 2013 exploitation fraction that will be reported in next year's CBSAC report will be calculated as the 2013 Bay-wide commercial and recreational harvest of female crabs divided by the exploitable female stock measured in the 2012-2013 WDS. If the 2013 harvest is equal to the 2012 harvest, the 2013 exploitation fraction will be 29%, which is above the target, but below the threshold. To achieve the target exploitation fraction of 25.5%, 2013 harvest levels should be 10% lower than the estimated 2012 harvest.

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 Effort Control

The blue crab fishery is currently managed under effort control with limited entry, size limits, catch limits, and seasonal closures as the principal tools. However, 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 sytem and a bay wide survey of crab pot effort to estimate the total, spatial, and temporal patterns of the crab pot fishery.

7.3 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 continued efforts be made to estimate and monitor the level and possible re-entry of latent effort into the fishery. In addition to increases in latent effort, CBSAC also recognizes that temporal and seasonal shifts in estimated 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 and better understood as a part of this recommendation.

8. 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. Below, CBSAC has identified the following list of fishery dependent and independent data needs as well as the benefits provided to management. CBSAC is planning on meeting mid July 2013, to begin 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: 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.

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. 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. However, it is anticipated that considerable progress can be made by exchanging assigned sample stations between the two jurisdictions rather than adding new stations. Additional manpower may be required to analyze the results of the comparisons.

8.3 Over-wintering mortality: Examine WDS data to see if there are available data that may better describe overwintering mortality. This data mining exercise could provide CBSAC and managers with a more complete understanding of the variability in natural mortality year to year 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 Recruitment: Based on the results of the 2012-2013 WDS, a large number of recruits disappeared from the stock since the 2011-2012 WDS. Based on the stock assessment and pilot field experiments by VIMS and the Smithsonian Environmental Research Center, a large fraction of juveniles in shallow water is not sampled by the WDS. For the former, CBSAC recommends analyzing pertinent environmental and ecological variables to erect and examine potential hypotheses to explain the poor survival of this record recruitment event. Anticipated time to completion is three to four months. 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 an analysis of 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. This data mining project is of high priority as the potential for sperm limitation would first be observed by analyzing the proportion of second and third year females in the WDS results. From this discussion, CBSAC has identified that this analysis could be completed from existing WDS data and would require only staff time to support further analysis.

8.6 Operational sex ratio: There is no identifiable relationship between operational sex ratio, as calculated from the WDS, and male exploitation rate. Furthermore, CBSAC decided that the WDS abundance data are unsuitable for representing the Bay-wide operational sex ratio, and a summer month survey would provide a more accurate depiction. CBSAC recommends that this summer survey should be explored.

8.7 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.

8.8 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		

* 2012 Bay-wide commercial harvest and exploitation rate are preliminary.