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## 2019 Chesapeake Bay Blue Crab Advisory Report

CBSAC Meeting Date: May 30, 2019

Report Final: June 24, 2019

### EXECUTIVE SUMMARY

The Chesapeake Bay Stock Assessment Committee (CBSAC) meets annually to review the results of the Chesapeake Bay blue crab surveys and harvest data, and to develop management advice. 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. Based on survey estimates, the total abundance of all crabs (males and females of all ages) was estimated at 594 million crabs in 2019. Recruitment, or the number of age 0 crabs (less than 60 mm or 2.4 inches carapace width), was estimated as 324 million crabs in 2019. Approximately 191 million age 1+ female crabs were estimated to be present in the Bay at the start of the 2019 crabbing season, which is well above the abundance threshold of 70 million crabs, and near the target of 215 million crabs. The 2011 benchmark assessment recommended a control rule based on biological reference points for the female component of the population. The percentage of female crabs (ages 0+) removed by fishing (exploitation fraction) in 2018 was approximately 23%. This exploitation fraction is below the target of 25.5% and the threshold of 34% for the 11<sup>th</sup> consecutive year since 2008. Therefore, overfishing is not occurring and the population is not depleted.

Based on analysis of the 2019 winter dredge survey results, CBSAC concludes that fishery restrictions by management are not warranted, but the jurisdictions should maintain a cautious, risk-averse approach in the 2019 season. CBSAC recommends that the jurisdictions implement procedures that provide accurate accountability of all commercial and recreational harvest moving forward, as this is an important component for accurately assessing stock health.

## 1. INTRODUCTION

### 1.1 Background: Management and Science

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 NOAA Chesapeake Bay Office (NCBO), the SFGIT is led by an Executive Committee of senior fisheries managers from Maryland Department of Natural Resources (MDNR), Virginia Marine Resource Commission (VMRC), Potomac River Fisheries Commission (PRFC), the Atlantic States Marine Fisheries Commission (ASMFC), and the District Department of the Environment (DDOE).

The Chesapeake Bay Stock Assessment Committee (CBSAC) combines the expertise of state representatives and scientists from the Chesapeake Bay region, as well as 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, the Commonwealth of Virginia, and the PRFC.

Three benchmark stock assessments of the Chesapeake Bay blue crab have been conducted since 1997. The most recent [assessment](#) was completed in 2011<sup>1</sup> with support from VMRC, MDNR, and PRFC. 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). 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.

An update to the 2011 assessment was completed with data through 2017. This update was submitted to CBSAC for peer review.

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<sup>2</sup>. The WDS measures the density of crabs (number per 1,000 square meters) at approximately 1,500 sites throughout the Bay. 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 overwintering crabs by age and sex<sup>2</sup>. An estimate of the mortality during winter is also obtained from the survey results.

## **1.2 Stock Status and Current Management Framework**

Under the current framework, annual estimates of exploitation fraction are calculated as the annual harvest of female crabs in a given year (not including discards, bycatch, or unreported losses) divided by the total number of female crabs (age 0+) estimated in the population at the start of the season. As part of this calculation, the juvenile component of the total estimated number of crabs is scaled up by a factor of 2.5 so that the empirical estimate of exploitation uses the same assumption about juvenile susceptibility to the survey as the stock assessment that generated the reference points. Thus, the empirical estimates of exploitation rate can be compared with the target and threshold reference points derived from the assessment model.

Crab abundance is estimated from the WDS each year. The current framework recommends monitoring the abundance of spawning-age female crabs (age 1+) in comparison to female-specific abundance reference points. Management seeks to control the fishery such that the number of crabs in the population remains above the minimum set by the overfished (depleted) threshold. Ideally, the fishery should operate to meet target values, never surpass the exploitation fraction threshold value, and never go below the abundance threshold value.

## 2. POPULATION SIZE (ABUNDANCE)

### 2.1 All Crabs (both sexes, all ages)

Based on survey estimates, the total abundance of all crabs (males and females of all ages) increased by almost 60% from 372 million crabs in 2018 to 594 million crabs in 2019 (Figure 1) and was above the long-term average (geometric mean<sup>1</sup>). Since 2008, the stock has demonstrated strong interannual variation, as expected for the species.

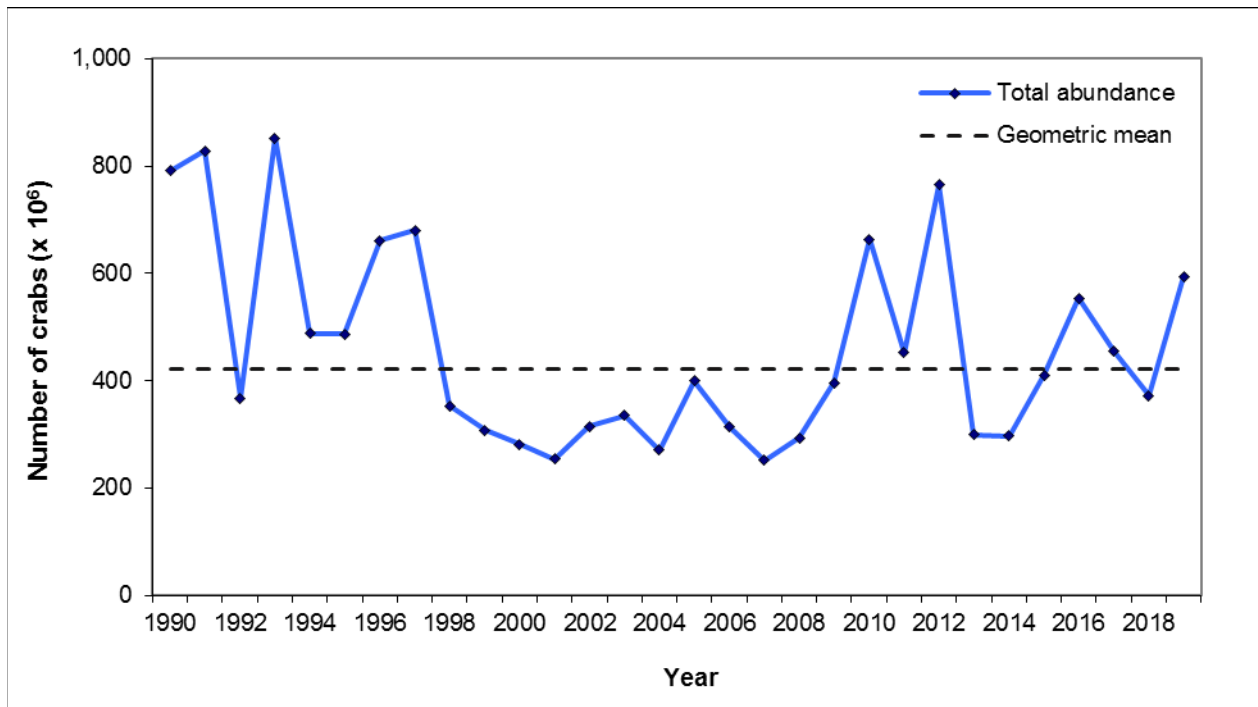


Figure 1. Winter dredge survey estimate of abundance of all crabs (both sexes, all ages) in Chesapeake Bay, 1990-2019.

### 2.2 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. Based on survey estimates, the abundance of age 0 crabs was 323 million crabs in 2019, the 3<sup>rd</sup> highest estimate since female-specific management measures were put in place (Figure 2). This year's estimate was above the time series average of 224 million crabs (geometric mean) and in the top 27% of time series estimates.

<sup>1</sup> A geometric mean ( $GM_{\bar{x}} = \sqrt[n]{\prod x_1, x_2, \dots, x_n}$ ) was used because it is not as sensitive to fluctuation from a single large value.

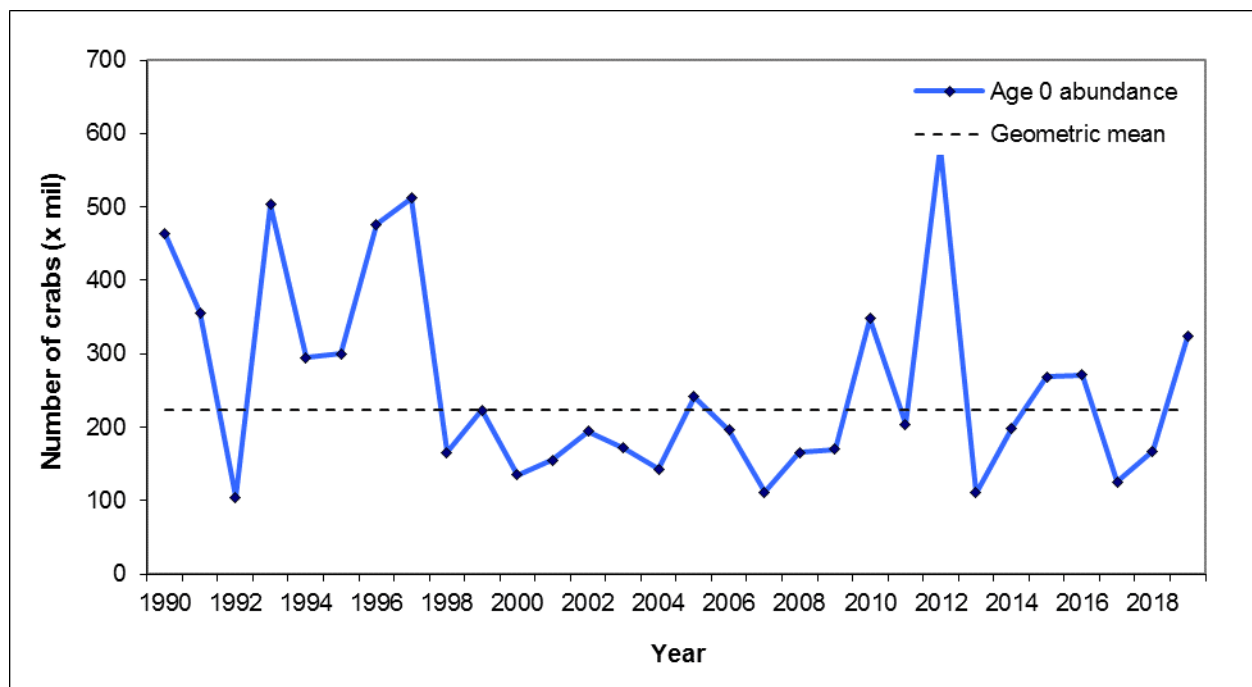


Figure 2. Winter dredge survey estimate of abundance of juvenile blue crabs (age 0), 1990-2019, calculated without the catchability adjustment for juveniles (section 1.2). These are male and female crabs measuring less than 60 mm across the carapace.

### 2.3 Overwintering Mortality

Overwintering mortality in 2019 was below average and among the lowest values observed in recent years (Table 1).

Table 1. Percent dead crabs found in late winter dredge samples each year from 2014-2019 and the average for 1996-2019.

Bay-wide Age/sex group	1996-2019 average	2014	2015	2016	2017	2018	2019
All crabs	4.71%	3.79%	15.68%	1.95%	1.15%	6.37%	1.80%
Juveniles	1.25%	0.89%	10.84%	0.50%	0.00%	0.87%	0.15%
Adult Females	8.40%	7.68%	19.25%	2.99%	1.37%	11.06%	1.87%
Adult males	9.66%	13.58%	28.11%	1.06%	2.29%	13.66%	7.83%

### 3. HARVEST

#### 3.1 Commercial and Recreational Harvest

Annual blue crab commercial harvest increased slightly in 2018. The three management jurisdictions maintained harvest measures similar to those in 2017 (Appendix B). The 2018 commercial harvest for both males and females from the Bay and its tributaries was reported as 32.6 million pounds in Maryland, 22.9 million pounds in Virginia, and 3.2 million pounds in the Potomac River. Relative to 2017, annual female harvest decreased in Virginia and the Potomac River, but increased in Maryland. Annual male harvest was stable in Maryland and Potomac River, and increased in Virginia. The total 2018 Bay-wide commercial harvest of approximately 55 million pounds was below the 1990-2018 average and similar to the 2017 Bay-wide commercial harvest of approximately 54 million pounds (Figures 3-4).

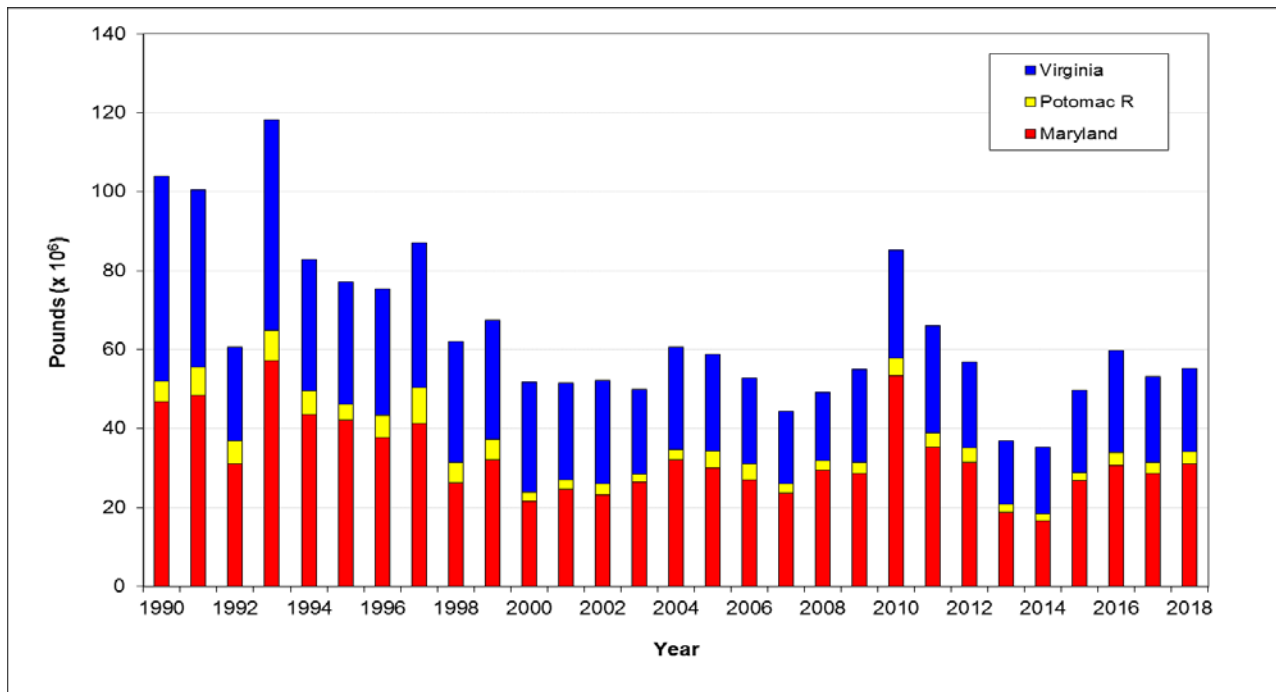


Figure 3. Total commercial blue crab landings (all market categories) in Chesapeake Bay, 1990-2018.

Prior to 2009, recreational harvest had been assumed to be approximately 8% of the total Bay-wide commercial harvest based on Ashford and Jones (2001, 2003, 2005, 2011).<sup>5,6,7,8</sup> 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 commercial male harvest in those jurisdictions. 2018 Bay-wide recreational harvest was estimated as 3.4 million pounds, similar to the 2017 recreational harvest estimate of 3.6 million pounds. Combining the commercial and recreational harvest, approximately 59 million pounds of blue crabs were harvested from Chesapeake Bay and its tributaries during the 2018 crabbing season.

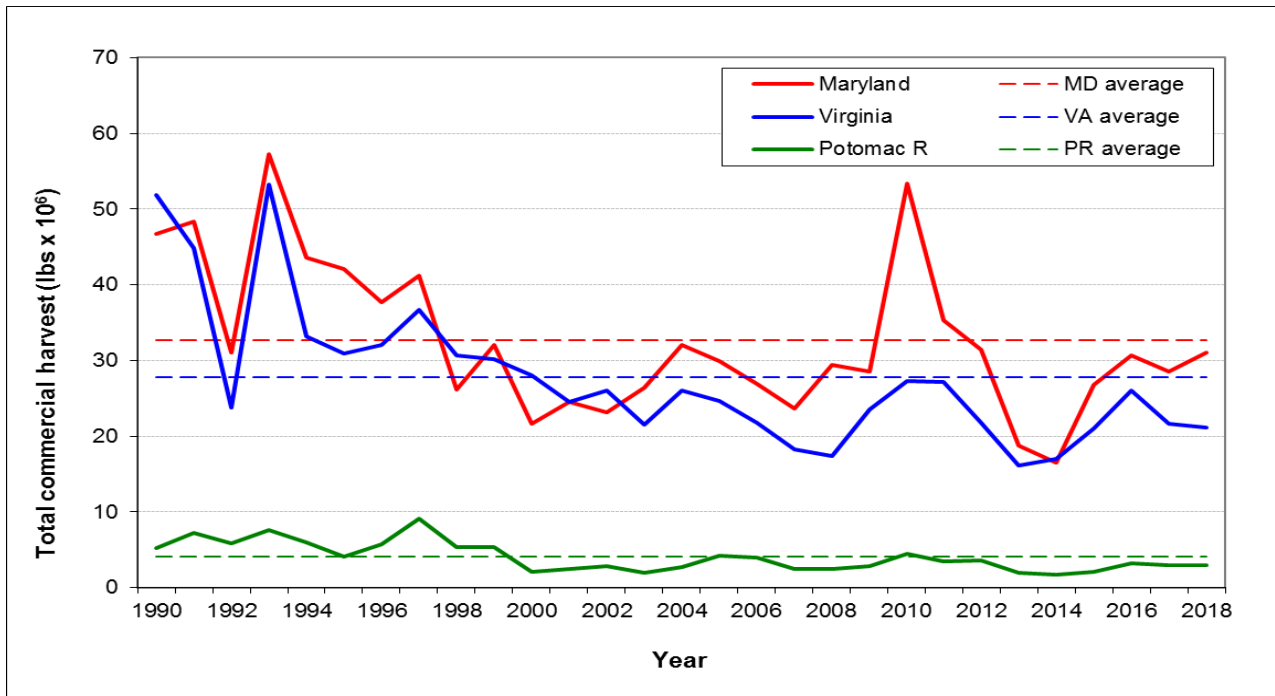


Figure 4. Maryland, Virginia, and Potomac River commercial blue crab harvest in millions of pounds from Chesapeake Bay, all market categories, 1990-2018. Corresponding average lines represent the arithmetic mean.

## 4. STOCK STATUS

### 4.1 Female Reference Points

The 2011 benchmark assessment recommended a control rule based on biological reference points for the female component of the population. The current female-specific targets and thresholds were developed using an MSY approach.  $U_{MSY}$  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 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  $N_{0.75*U_{MSY}}$  (target) and  $50\% N_{MSY}$  (threshold).

### 4.2 Exploitation Fraction

The percentage of all female crabs (ages 0+) removed by fishing (exploitation fraction) in 2018 was approximately 23%. This exploitation fraction is below the target of 25.5% and the threshold of 34% for the 11<sup>th</sup> consecutive year since 2008, when female-specific management measures were implemented (Figure 5).

### 4.3 Spawning Stock Abundance

The abundance reference point for the spawning stock was set at a threshold abundance of 70 million spawning-age (age 1+) female crabs and a target abundance of 215 million. Approximately 191 million age 1+ female crabs were estimated to be present in the Bay at the start of the 2019 crabbing season, a 30% increase from the 2018 estimate of 147 million (Figure 6). The 2019 abundance of spawning-age female crabs is well above the threshold (272% of threshold value) and close to the target (88% of the target).



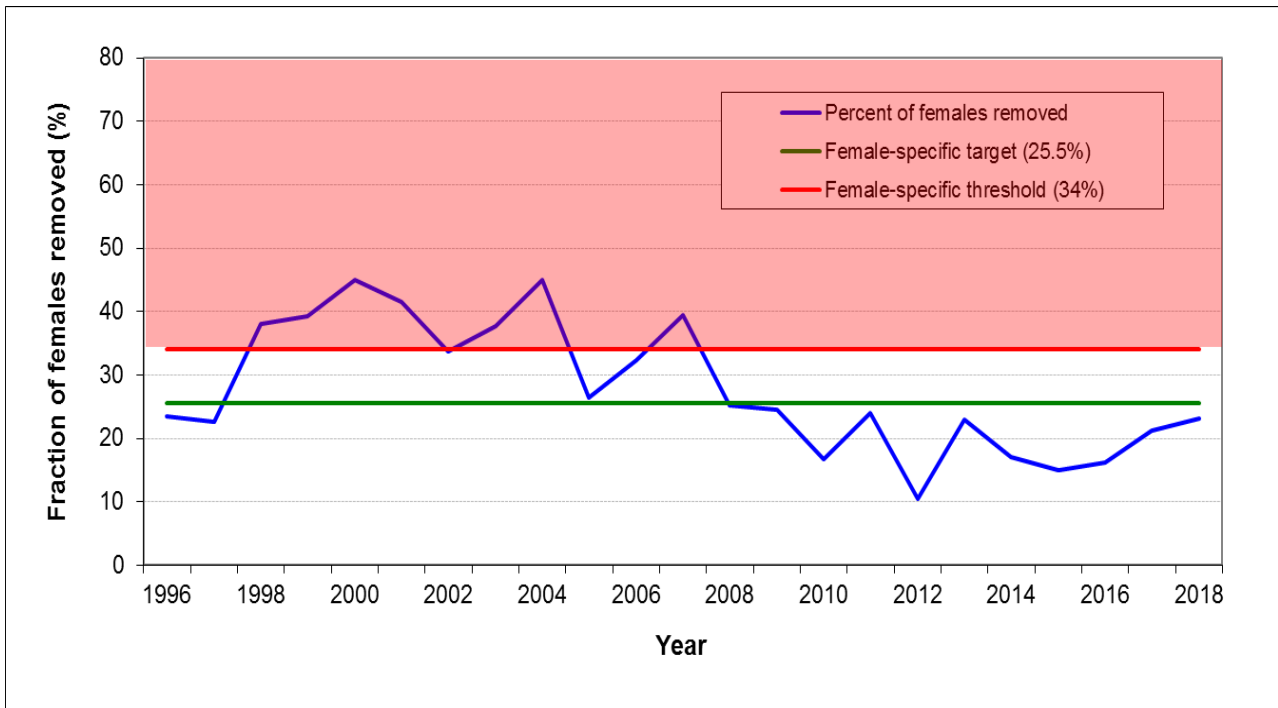


Figure 5. The percentage of all female blue crabs removed from the population each year by fishing relative to the female-specific target (25.5%) and threshold (34%) exploitation rates, 1990-2018. Exploitation rate (proportion removed) is the number of female crabs harvested within a year divided by the female population (age 0+) estimated by the WDS at the beginning of the year.

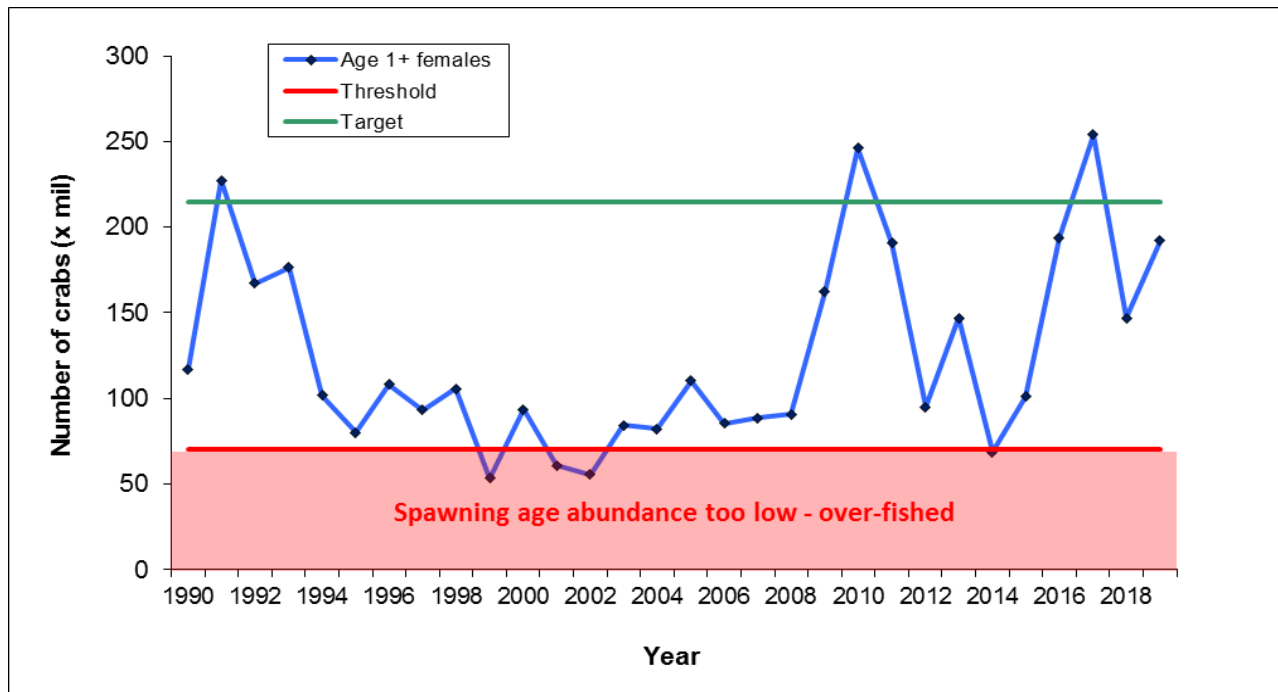


Figure 6. Winter dredge survey estimate of abundance of spawning-age female blue crabs (age 1+), 1990-2019, with female-specific reference points. These are female crabs measuring greater than 60 mm across the carapace and are considered the 'exploitable stock' that could spawn within this year.

#### 4.4 Control Rules

Figure 7 shows the status of the blue crab stock for each year relative to both the female age 0+ exploitation ( $\mu$ ) reference points and the female age 1+ abundance (N) reference points (explained in sections 4.2 and 4.3). The red areas show where the thresholds for the female exploitation fraction and female abundance are exceeded. The intersection of the green lines shows where both the abundance and exploitation fraction targets would be reached. The figure includes data through 2018. 2019 data will be added at the completion of the 2019 fishery.

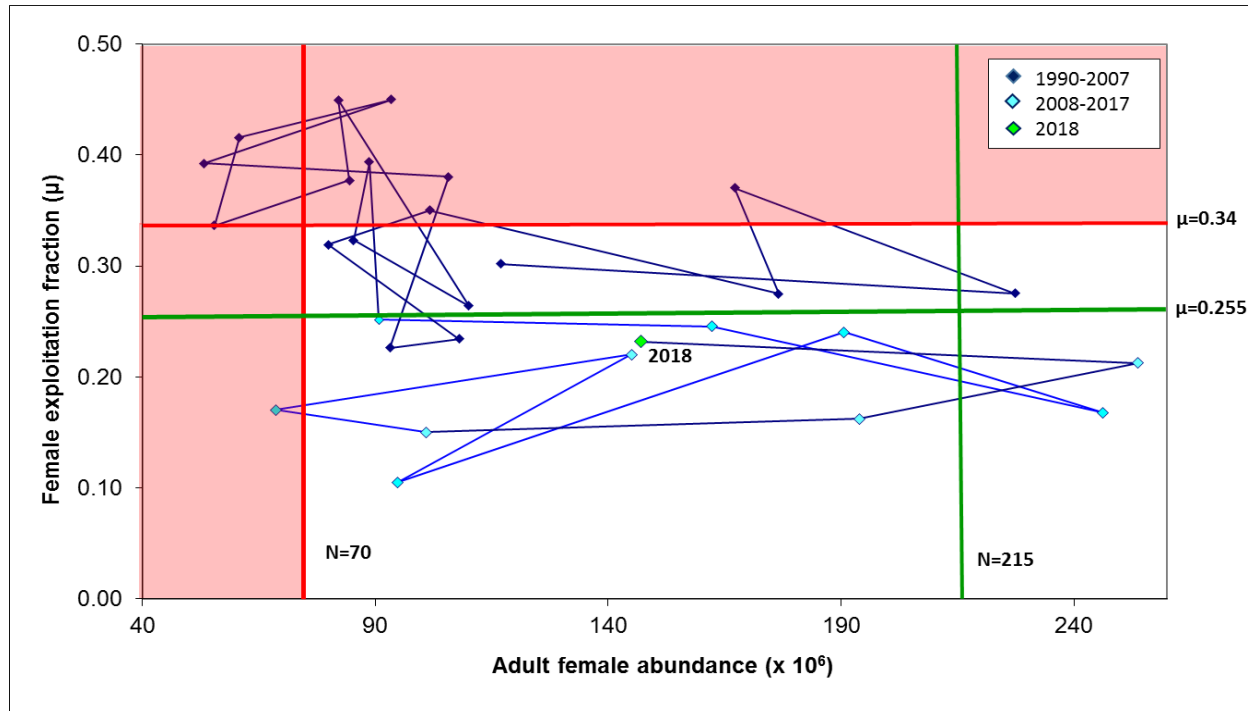


Figure 7. Status of the stock for the Chesapeake Bay blue crab fishery prior to and after implementation of initial female-specific management measures in 2008. The current female-specific management framework was formally adopted in 2011. In 2018, adult female abundance (N) was 147 million, which was above the 70 million threshold but below the 215 million target. The 2018 female exploitation fraction (U) was 23%, which was below the 25.5% target and 34% threshold.

*Note: The 2013 point was moved slightly for display purposes, as it fell under the point for 2018.*

The Chesapeake Bay blue crab stock is currently **not depleted and overfishing is not occurring** (Table 2). The 2019 estimated abundance of the spawning stock is above the threshold of 70 million age 1+ female crabs but below the target of 215 million age 1+ female crabs outlined in the current management framework. The 2018 exploitation fraction of 23% was below the target (25.5%) and threshold (34%). Abundance, harvest, and exploitation of all crabs are summarized in Appendix A and in the preceding sections.

Table 2. Stock status based on reference points for age 0+ (exploitation fraction) and age 1+ (abundance) female crabs. Recent stock status levels that did not exceed threshold values are shown in green, whereas exploitation values or abundance estimates exceeding thresholds are shown in red.

Control Rule	Reference Points			Stock Status						
	Period	Target	Threshold	2013	2014	2015	2016	2017	2018	2019
<b>Exploitation Fraction</b> (age 0+ female crabs)	Current, Female-specific	25.5%	34% (max)	23%	17%	15%	16%	21%	23%	TBD
<b>Abundance</b> (millions of age 1+ female crabs)	Current, Female-Specific	215	70 (min)	147	68.5	101	194	254	147	191

#### 4.5 Male Conservation Trigger

In 2013, CBSAC recommended a conservation trigger for male crabs based on the history of male exploitation. Under this trigger, conservation measures should be considered for male blue crabs if male exploitation rate exceeds 34% (calculated with the juvenile scalar as described in section 1.2), 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 fishing threshold or target. Rather, this trigger will ensure that the male component of the stock is not more heavily exploited than has occurred in 24 of the last 26 years. The 2018 male exploitation fraction was estimated at 33%, just below the male exploitation rate conservation trigger and lower than the 2017 estimate (Figure 8). Immediate management action is not necessary at present.

#### 4.6 Age 1+ Males

The survey estimate of age 1+ male crabs (greater than 60 mm or 2.4 inches carapace width) in 2019 was 80 million crabs, a 37% increase from the 2018 estimate of 58 million adult male crabs (Figure 9). Age 1+ male abundance is above the time series mean of 66 million (geometric mean) but does not exhibit the same variable pattern of abundance compared to adult females.

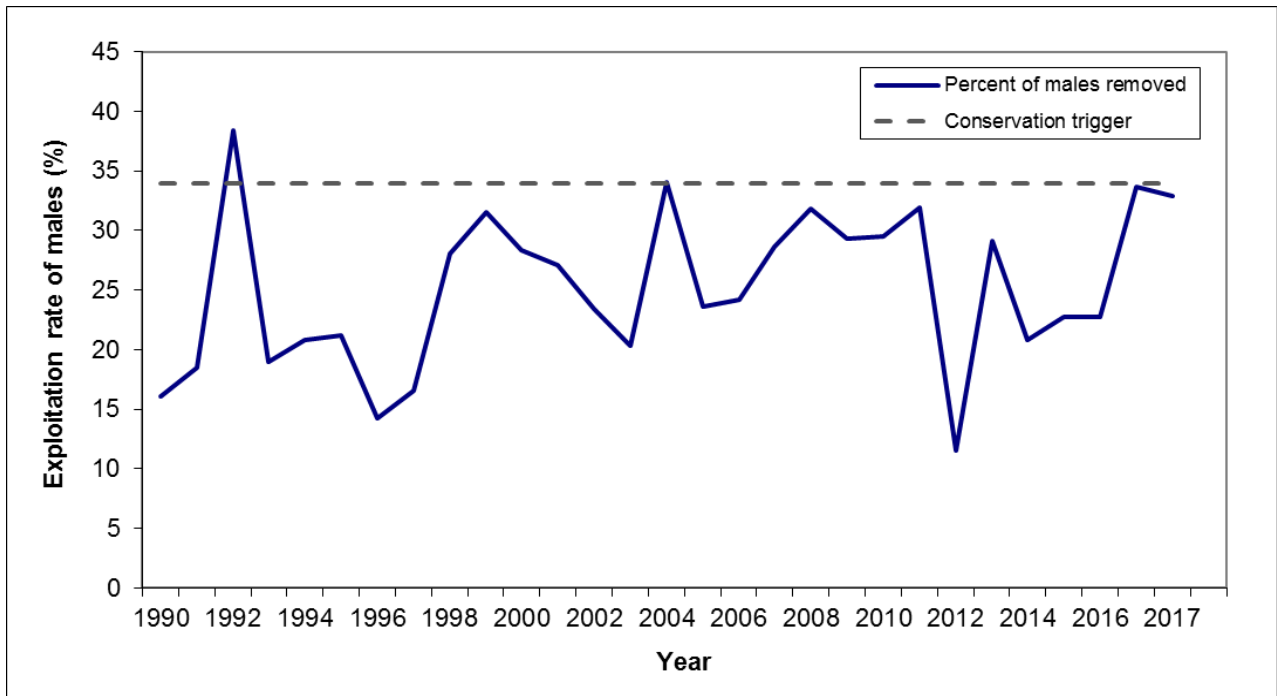


Figure 8. The percentage of male crabs removed from the population each year by fishing, 1990-2018. Exploitation rate (proportion removed) is the number of male crabs harvested within a year divided by the male population estimate (age 0+) at the beginning of the year, calculated with the juvenile scalar.

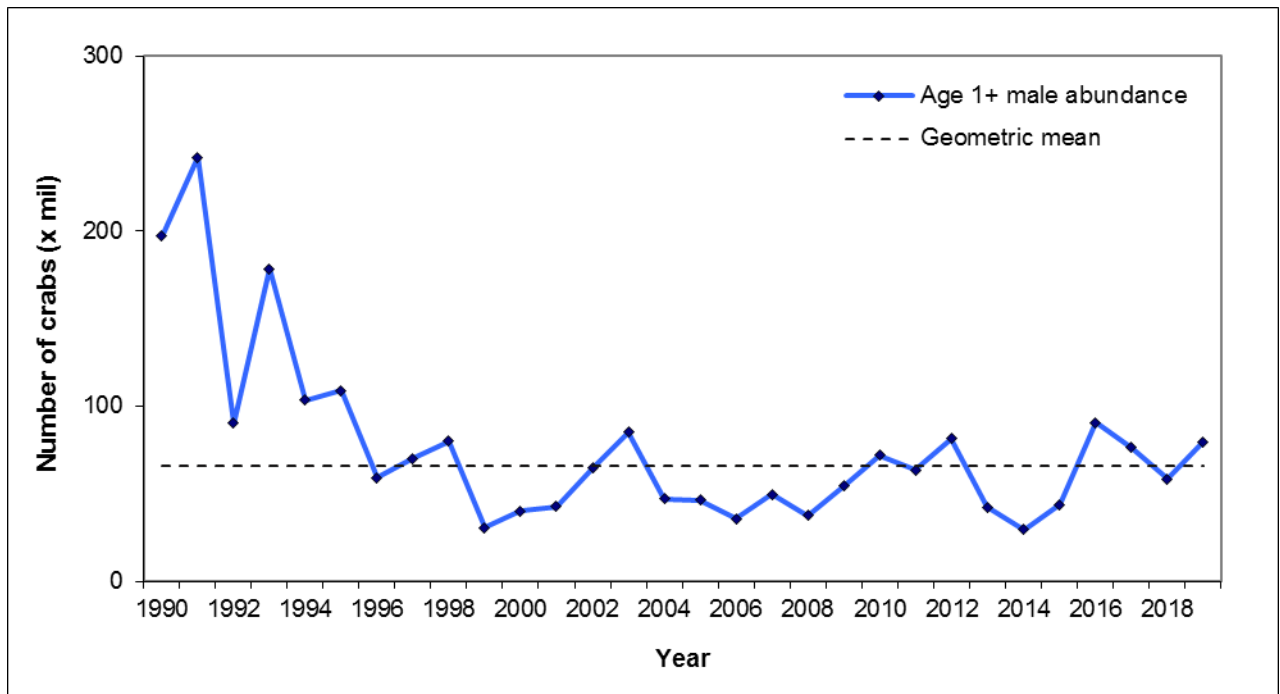


Figure 9. Winter dredge survey estimate of abundance of age 1+ male blue crabs, 1990-2019. These are male crabs measuring greater than 60 mm across the carapace and are considered the 'exploitable stock' capable of mating within this year.

## 4.7 Management Impact

Female exploitation fractions from 1990-2007 were much higher than the exploitation fractions from 2008-2018. These lower female exploitation fractions in recent years illustrate the influence of the female-specific management measures implemented by the jurisdictions starting in 2008. Male exploitation fractions have not shown the same pattern, which was expected because management action was targeted toward females (Figure 10). Additionally, the rapid increase in abundance from 2008-2010 and again from 2014-2016 indicate that the current management framework has allowed the stock to regain some of its expected resilience to environmental changes.

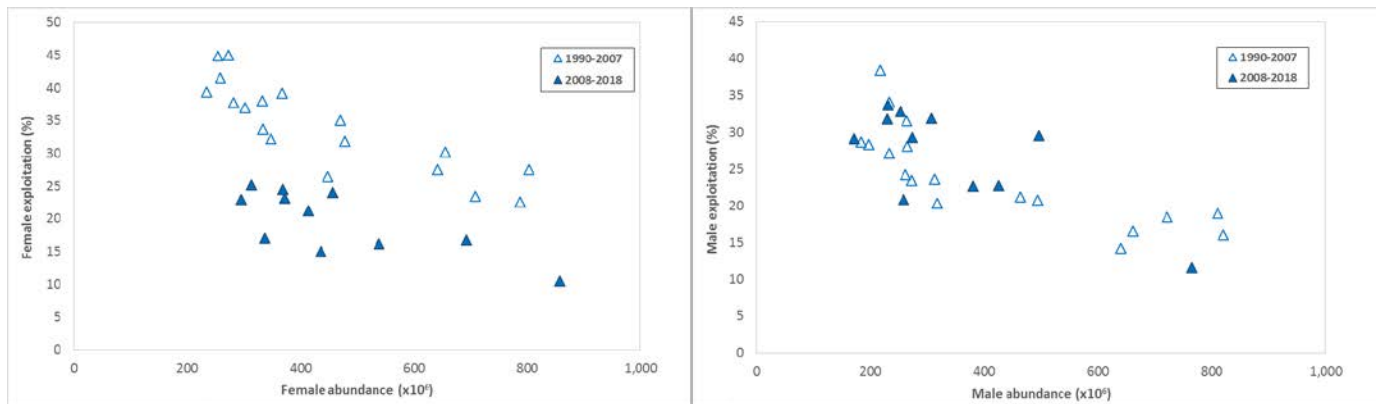


Figure 10. Female (left) and male (right) exploitation rate comparison of the time periods prior to and after the 2008 implementation of female-specific management measures.

## **5. MANAGEMENT ADVICE**

### **5.1 Monitor Fishery and Stock Status Relative to Reference Points**

The female exploitation fraction in 2018 was below the target of 25.5% for the 11<sup>th</sup> consecutive year. The abundance of adult female crabs increased and remained well above the threshold in 2019. The abundance of juveniles increased and was above the long-term average. Based on analysis of the 2019 winter dredge survey results, CBSAC concludes that fishery restrictions by management are not warranted, but the jurisdictions should maintain a cautious, risk-averse approach in the 2019 season. Past harvest regulations are summarized in Appendix B.

Large variations in recruitment (age 0 abundance) are a characteristic of blue crab biology and not unexpected. However, it should be the goal of management to maintain a robust spawning stock, thereby increasing the resiliency of the population to downturns in recruitment.

### **5.2 Catch Reports and Quantifying Effort**

CBSAC again recommends that the jurisdictions implement procedures that provide accurate accountability of all commercial and recreational harvest. All three Chesapeake Bay management jurisdictions have programs in place to gather more accurate catch and effort information submitted by commercial and recreational harvesters. Most blue crab regulations focus on effort control in the form of limited entry, size limits, daily time limits, pot limits, spatial closures, spatial gear restrictions, and seasonal closures. To determine the efficacy of these management measures, detailed effort data that would reveal the spatial and temporal patterns of gear-specific effort should be a part of any system used to improve harvest data. Maryland, Virginia, and PRFC all require daily harvest reports to be submitted on a regular basis and are collaborating with industry groups to pursue new reporting technologies. Maryland has implemented an electronic reporting program that allows for daily harvest reporting in real time and harvest validation. Virginia continues to promote its online reporting system that began in 2009. PRFC is exploring the use of electronic reporting to potentially begin in the next few years.

While implementing systems for greater accuracy, efforts should also be made, where possible, to better determine the biological characteristics of the catch, both landed and discarded. Note that when changes in reporting requirements are implemented, it is vital to quantify the impact of these changes on the current estimates of harvest. Efforts should also be undertaken to assess the reliability of estimates of recreational harvest Bay-wide.

## **6. CRITICAL DATA AND ANALYSIS NEEDS**

CBSAC has identified the following prioritized list of fishery-dependent and fishery-independent data needs as well as the benefits provided to management.

In addition to specific data needs, CBSAC recognizes the importance of future stock assessments in providing in-depth analyses of the Chesapeake Bay blue crab population and scientific guidance to managers. MDNR conducted a stock assessment update in 2017 using the 2011 stock assessment model, which CBSAC recommends be considered for adoption, providing a new framework for management. CBSAC also recommends annual runs of the stock assessment model be undertaken to aid in determining stock status. Given new information and issues with fishery performance, improvements to the current model should be pursued. A thorough evaluation concerning the need for a benchmark will be produced by the end of the year.

### **6.1 Efficacy of WDS as an Index of Abundance**

The winter dredge survey is a key tool used by managers for determining the status of the stock and management decisions. It is also utilized by researchers in stock assessments for setting targets and thresholds. There are several aspects of survey design and interpretation that should be further explored and improved upon. At least three approaches using winter dredge data have been proposed to estimate relative abundance (Sharov et al 1993, Jensen and Miller 2005, Liang et al. 2018). The relative reliability of the means and variances of abundance estimated from these different approaches have never been evaluated. CBSAC recommends conducting a data workshop evaluating the performance of these and other analytical approaches. The workshop would provide guidance in evaluating the design of the survey to produce the most reliable estimates. Another outcome would be to recommend targeted studies to improve the survey.

### **6.2 Increased Accountability and Harvest Reporting for 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 data. Improving commercial and recreational blue crab harvest accountability would provide managers with a more accurate exploitation fraction each year and better support midseason management changes.

The jurisdictions have been working to implement new harvest reporting technologies over the past few years. Since pilot efforts were introduced in 2012, MDNR has been using an electronic reporting system that allows commercial crabbers to enter each day's harvest from their vessel. The system includes random daily catch verification and a "hail-in, hail-out" protocol. Maryland is continuing to expand the use of this system for the commercial crabbing fleet.

Virginia implemented electronic reporting in 2009 as an alternative mandatory harvest reporting option, but growth has been slow. Through cooperative work among VMRC, Virginia Sea Grant, and various industry groups, promotional products were produced and participation of commercial crab harvesters has increased. PRFC will consider using an electronic reporting system in the next few years, given the interest among stakeholders.

CBSAC recommends a survey of recreational catch and effort be undertaken periodically to ensure the reliability of estimates of recreational removals, if at all possible. The last available estimate for Maryland waters was for 2011<sup>5,6,7,8</sup>. The last available estimate for Virginia was 2002<sup>5</sup>. Future surveys should ensure that recreational harvest from the Potomac River is also included. A license that would provide a valid sampling frame for recreational crabbing in all jurisdictions would greatly increase the accuracy of catch and effort estimates.

### **6.3 Improving Recruitment Estimate through a Shallow-Water Survey**

Based on the 2011 stock assessment and field experiments by VIMS and the Smithsonian Environmental Research Center, a large fraction of juvenile blue crabs in shallow water is not sampled by the WDS<sup>9</sup>. VIMS pursued funding at the state level to conduct a shallow-water survey concurrent with the Virginia WDS to assess the potential for interannual bias in the fraction of juveniles not sampled by the WDS, but was not successful. CBSAC will discuss applying this effort Bay-wide based on funding and initial findings of a complementary shallow-water survey conducted by VIMS in spring.

### **6.4 Investigation of the Influence of Male Abundance on Population and Fishery Productivity**

CBSAC recommends continued examination to quantify and better understand the influence of male crabs on reproductive success, the overall population, and fishery productivity. In lieu of biological metrics to determine the stock status of male blue crabs, CBSAC recommends evaluating replacement of the current male trigger with a more comprehensive set of criteria that would determine when management adjustments specific to male crabs would be warranted.

### **6.5 Quantifying Environmental Factors Related to Recruitment Variability**

CBSAC recommends continued examination of the environmental factors that may contribute to interannual recruitment variability. In particular, emphasis should be placed on prediction of future recruitment success based on environmental conditions during the year.

### **6.6 Blue Crab Data Hub**

To assist in stock assessments and analyses, CBSAC recommends exploring the creation of a data hub focused on Chesapeake Bay blue crab data. This would provide a consistent data



platform for all research and minimize the lengthy QA/QC process undertaken before any analyses can begin. Several steps would be necessary to implement such a data hub:

- A) data policy workgroup to develop policies to ensure all interests are protected
- B) determine best database design and structure
- C) data QA/QC prior to loading into database

## **6.7 Application of Fishery-Independent Survey Data**

CBSAC recommends continued review of existing fishery-independent survey data and potential application to provide additional information on the blue crab population, complementing the population estimates from the WDS. This would include incorporating data from new surveys, as well as performing additional analyses on existing data sets. Characterizing the spring through fall distribution and sex-specific abundance of blue crabs remains important.

## **6.8 Fishery-Dependent Data**

A verifiable electronic reporting system would collect much of the fishery-dependent data needed to improve management. In lieu of such a system, improvements in management could be made through a more detailed characterization of the catch. Mandatory harvest reporting is currently the only fishery-dependent data in Virginia and the Potomac River. Understanding catch composition, by size, sex, and growth phase, spatially and temporally, as well as effort characterization (mentioned in 6.2), would help improve the effectiveness of regulations and ensure compatibility at a Bay-wide level. VMRC conducted short-term fishery-dependent sampling in 2016-17 to provide some characterization of commercial harvest. CBSAC recommends that the jurisdictions consider options for future fishery-dependent sampling programs.

## **6.9 Other Sources of 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.

## **6.10 Biological Parameters**

Longevity, age structure, and growth rates, particularly with respect to the timing of recruitment to the fishery within the season, are not fully characterized and remain as sources of uncertainty.

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## Literature Cited

1. Miller, T. J. et al. 2011. Stock Assessment of Blue Crab in Chesapeake Bay. 2011. Final Report. Ref: [UMCES] CBL 11-011. UMCES Tech. Ser. No. TS-614-11-CBL.
2. Sharov, A. F., J. H. Vølstad, G. R. Davis, B. K. Davis, R. N. Lipcius, and M.M. Montane. 2003. Abundance and exploitation rate of the blue crab (*Callinectes sapidus*) in Chesapeake Bay. Bulletin of Marine Science 72:543-565.
3. Bi-State Blue Crab Advisory Committee. 2001. Taking Action for the Blue Crab: Managing and Protecting the Stock and its Fisheries. A report to the Chesapeake Bay Commission; Annapolis, Md, Richmond, Va. 24p.
4. ASMFC. 2016. Technical Support Group Guidance and Benchmark Stock Assessment Process. Report to NOAA Fisheries for NA15NMF4740069.
5. Ashford, J. R., and C. M. Jones. 2001. Survey of the blue crab recreational fishery in the Chesapeake Bay, 2001. Final Report to the Maryland Department of Natural Resources. Annapolis, MD. 61p.
6. Ashford, J. R., and C. M. Jones. 2003. Survey of the blue crab recreational fishery in Maryland and Virginia, 2002. Final report from Old Dominion University to the National Oceanic and Atmospheric Administration Chesapeake Bay Office, Annapolis, Maryland.
7. Ashford, J. R., and C. M. Jones. 2005. Survey of the blue crab recreational fishery in Maryland, 2005. Final Report to the Maryland Department of Natural Resources. Annapolis, MD. 31p.
8. Ashford, J. R., and C. M. Jones. 2011. Survey of the blue crab recreational fishery in Maryland, 2009. Final Report to the Maryland Department of Natural Resources. Annapolis, MD. 29p.
9. Ralph, G.M., and R.N. Lipcius. 2014. Critical habitats and stock assessment: age- specific bias In the Chesapeake Bay blue crab population survey. Transactions of the American Fisheries Society 143(4): 889-898.
10. Ogburn, M.B., P.M. Roberts, K.D. Richie, E.G. Johnson, and A.H. Hines. 2014. Temporal and spatial variation in sperm stores in mature female blue crabs (*Callinectes sapidus*) and potential effects on brood production in Chesapeake Bay. Marine Ecology Progress Series 507: 249-262.
11. Hines, A.H., and M.B. Ogburn. 2014. Evaluating population level impacts of sperm limitation on the Chesapeake blue crab stock. Final Report to NOAA Chesapeake Bay Office for NA11NMF4570230.
12. Rains, S.A. 2014. Potential for sperm limitation in blue crabs of Chesapeake Bay. M.S. thesis, University of Maryland.

**Appendix A. 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	104	43
1991	828	356	457	227	100	40
1992	367	105	251	167	61	63
1993	852	503	347	177	118	28
1994	487	295	190	102	84	36
1995	487	300	183	80	79	36
1996	661	476	146	108	78	25
1997	680	512	165	93	89	24
1998	353	166	187	106	66	43
1999	308	223	86	53	70	42
2000	281	135	146	93	54	49
2001	254	156	101	61	54	42
2002	315	194	121	55	54	37
2003	334	172	171	84	49.5	36
2004	270	143	122	82	60	46
2005	400	243	156	110	58.5	27
2006	313	197	120	85	52	31
2007	251	112	139	89	43	38
2008	293	166	128	91	49	25
2009	396	171	220	162	54	24
2010	663	340	310	246	85	16
2011	452	204	255	191	67	24
2012	765	581	175	95	56	10
2013	300	111	180	147	37	23
2014	297	198	99	68.5	35	17
2015	411	269	143	101	50	15
2016	553	271	284	194	60	16
2017	455	125	330	254	53	21
2018	371	167	206	147	55	23
2019	<b>594</b>	<b>323</b>	<b>271</b>	<b>191</b>	<b>TBD*</b>	<b>TBD*</b>

\* 2018 Bay-wide commercial harvest and exploitation rate are preliminary (TBD= to be determined)  
*Bay-wide harvest totals and female exploitation rates listed on this page for 2010 and prior were updated in 2016 to reflect final Bay-wide harvest totals. Previous reports listed preliminary harvest data on this page.*

## Appendix B. Summary of Female Blue Crab Harvest Regulations in the Chesapeake Bay Jurisdictions 2008-2016

Starting in 2008, the jurisdictions (Maryland, Virginia, Potomac River Fisheries Commission) implemented female-specific management measures for the Chesapeake Bay blue crab fishery. The jurisdictions adopted the current female-specific reference points with targets and thresholds for spawning-age (age 1+) female abundance and female exploitation rate in December 2011. The chart below summarizes changes in spawning-age female management regulations each year from 2008-2016.

Year	All Crabs	Age 0 Juv Crabs	Age 1+ Female Crabs	%Female Crabs Harvested	Maryland Female Harvest Regulations	Virginia Female Harvest Regulations	Potomac River Fisheries Commission Female Harvest Regulations
2008	293	166	91	21%	34% reduction: restricted access to female fishery from Sept 1 to Oct 22 based on harvest history; created tiered bushel limits for females based on harvest history	34% reduction: closed winter dredge fishery; closed the fall season for females early on Oct 27 (five weeks early); eliminated the five-pot recreational crab license; required two additional/larger cull rings; reduced # pots per license by 15% as of May 1 and another 15% next year; reduced # peeler pots per license by 30% on May 1.	34% reduction: closed the mature female hard crab season early on Oct 22; established separate female daily bushel limits Sept 1 to Oct 22 for areas upstream of St. Clements Isl. And areas downstream of St. Clements Isl; reduced peeler & soft shell seasons; established that all hard males, hard females, peelers and soft shell crabs kept separate on catcher's boat.
2009	396	171	162	24%	Open access, with industry input created season-long bushel limits that vary by license type and through the season/ Created a 15-day June (1-15) closure and a 9 day fall (9/26 - 10/4) closure to female harvest	Closed crab sanctuary from May 1-Sept 15 (closed loopholes that prevented a uniform May 1 closure for entire sanctuary). Nov 21 harvest closure; waived proposed 15% reduction of pots per license class; reinstated 5-pot recreational license; continued closure of winter dredge fishery.	Maintained 2008 season dates. Did not continue female daily bushel limits from 2008.

Year	All Crabs	Age 0 Juv Crabs	Age 1+ Female Crabs	%Female Crabs Harvested	Maryland Female Harvest Regulations	Virginia Female Harvest Regulations	Potomac River Fisheries Commission Female Harvest Regulations
2010	663	340	246	16%	Same bushels limits as 2009, but eliminated the 9-day fall closure based on industry input	Continued moratorium on sale of new licenses; relaxed dark sponge crab regulation to allow possession as of July 1 (instead of July 16); continued closure of winter dredge fishery	Established three mature female hard crab closure periods: Sept 22-28 above 301 bridge; Sept 29-Oct 6 from 301 bridge to St. Clements Isl./Hollis Marsh; Oct 7-13 below St. Clements Isl./Hollis Marsh. Closed season Nov 30.
2011	452	204	191	24%	Increased bushel limits	Closed sanctuary May 16 instead of May 1; continued closure of winter dredge fishery.	Refined mature female closed seasons: Sept 20-30 above St. Clements Isl./Hollis Marsh; Oct 4-14 below St. Clements Isl./Hollis Marsh.
2012	765	581	95	10%	Decreased bushel limits to compensate for removal of June closure, which added 15 days (based on industry advice). 6-day emergency extension to offset days lost to Hurricane Sandy.	Extended fall season until Dec 15; 6-day emergency extension to offset days lost to Hurricane Sandy; continued closure of winter dredge fishery.	Maintained 2011 mature female closed seasons.
2013	300	111	147	23%	Decreased bushel limits.	Implemented daily bushel limits to offset 2012 fall extension; extended fall pot season to Dec 15; continue closure of winter dredge fishery.	Refined mature female closed seasons: Sept 18-Oct 2 above St. Clements Isl./Hollis Marsh; Oct 3-17 below St. Clements Isl./Hollis Marsh.

Year	All Crabs	Age 0 Juv Crabs	Age 1+ Female Crabs	%Female Crabs Harvested	Maryland Female Harvest Regulations	Virginia Female Harvest Regulations	Potomac River Fisheries Commission Female Harvest Regulations
2014	297	198	68.5	17%	Daily bushel limits the same as 2013; additional vessel bushel limit reduction of 12%.	10% reduction: reduced pot bushel and vessel limits; continued closure of winter dredge fishery.	10% reduction: Closed mature female hard crab season Nov 20 and extended closure periods: Sept 12-Oct 2 above St. Clements Isl./Hollis Marsh; Oct 3-23 below St. Clements Isl./Hollis Marsh.
2015	411	269	101	15%	Increase in min. peeler size April-July 14 due to low 2014 adult females. Daily bushel limited increased ~20% Sept-Nov 10 based on adult female increased abundance in 2015.	Maintained 2014 daily bushel limits; continued closure of winter dredge fishery. Redefined the blue crab sanctuary into 5 areas with separate closure dates	Set female daily bushel limits from April-June.
2016	553	271	194	16%	Extended season to Nov 30, adding 20 days. Increased bushel limits in Sept and Oct.	Extended season 3 weeks to Dec 20; maintained 2014 bushel limits; continued closure of winter dredge fishery.	Extended fall season through Dec 10. Set female daily bushel limits starting in July for the whole season.
2017	455	125	254	21%	Shortened season to Nov 20. Reduced bushel limits.	Shortened season to Nov 30. Continued closure of dredge fishery. Reduced Nov bushel limits.	Shortened season to Nov 30. Reduced bushel limits.
2018	372	167	147	23%	Extended season to Nov 30. Reduced bushel limits.	Continued closure of dredge fishery and Nov bushel limits. Added hard crab allowance for scrapers.	Status quo

Maryland Department of Natural Resources: <http://dnr.maryland.gov/fisheries/Pages/default.aspx>

Potomac River Fisheries Commission: <http://prfc.us/>

Virginia Marine Resources Commission: <http://www.mrc.virginia.gov/>