2022 Chesapeake Bay Blue Crab Advisory Report

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EXECUTIVE SUMMARY

Each year, from November to March, the Maryland Department of Natural Resources (MDNR) and the Virginia Institute of Marine Science (VIMS) conduct the Blue Crab Winter Dredge Survey (WDS) to estimate the abundance of blue crabs in Chesapeake Bay. The estimated abundance of mature females from the WDS and female harvest estimates from each jurisdiction are used to assess blue crab stock status relative to female-specific management reference points. The Chesapeake Bay Stock Assessment Committee (CBSAC) meets each spring to review the results of the latest WDS and the previous season's harvest estimates to develop management recommendations for the jurisdictions.

In 2022, the WDS indicated that the total abundance of all crabs (males and females of all ages) was approximately 227 million individuals. Recruitment, or the number of age 0 crabs (less than 60 mm carapace width), was estimated at 101 million. Approximately 97 million age 1+ (mature) female crabs were estimated to be present in the Bay at the start of the 2022 crabbing season, which is above the abundance threshold of 72.5 million adult females, but below the target of 196 million. The percentage of female crabs (age 0+) removed by fishing (exploitation rate) in 2021 was estimated at 26%. This exploitation rate is below the target (28%) and the threshold (37%) for the 14th consecutive year since 2008.

Although these results suggest that the blue crab population is not depleted and overfishing is not occurring relative to the reference points, juvenile abundance has not responded to previous increases in female abundance as expected based on the current understanding of the population dynamics. Therefore, CBSAC recommends precautionary management measures in an effort to ensure that neither the female-specific management thresholds, nor the male conservation trigger, are exceeded to maintain a healthy spawning stock and to protect a sufficient fraction of this year's juvenile cohort to reach maturity and reproduce. CBSAC also recommends a new benchmark stock assessment be conducted to take into account newly available data, evaluate revisions to the current model structure, and revise the biological reference points used in management. Given concerns about the lower juvenile abundances in recent years, CBSAC has committed to conducting a blue crab workshop that will address science gaps related to juvenile recruitment success and population dynamics that will inform potential enhancements to the stock assessment. The workshop is planned for September 2022.

1. INTRODUCTION

1.1 Background

Management of the blue crab stock is coordinated among the jurisdictions by the Sustainable Fisheries Goal Implementation Team (SFGIT). The SFGIT, one of six goal implementation teams within the Chesapeake Bay Program structure, is led by an Executive Committee of senior fisheries managers from the Maryland Department of Natural Resources (MDNR), the Virginia Marine Resources Commission (VMRC), the Potomac River Fisheries Commission (PRFC), the Atlantic States Marine Fisheries Commission, and the DC Department of Energy and Environment.

The Chesapeake Bay Stock Assessment Committee (CBSAC) serves as a technical subcommittee of the SFGIT, and is coordinated by the NOAA Chesapeake Bay Office (NCBO). CBSAC combines the expertise of state resource managers and scientists from agencies and universities around 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 the Blue Crab Winter Dredge Survey (WDS) and the previous season's harvest data to develop management recommendations for the three Chesapeake Bay jurisdictions: the State of Maryland, the Commonwealth of Virginia, and PRFC.

1.2 Management Framework

Three benchmark stock assessments of the Chesapeake Bay blue crab have been conducted since 1997. The most recent benchmark assessment was completed by scientists at the University of Maryland Center for Environmental Science (UMCES), the Virginia Institute of Marine Science (VIMS), and MDNR in 2011 (Miller et al. 2011). The 2011 assessment recommended biomass and exploitation reference points based on maximum sustainable yield (MSY) for female blue crabs only. These female-specific reference points were formally adopted by all three management jurisdictions in December 2011. Management seeks to control the fishery such that the number of adult females in the population remains above the minimum abundance defined by the overfished (depleted) threshold. Ideally, the fishery should operate to meet target values and should never surpass the exploitation rate threshold and never fall below the abundance threshold.

1.3 Stock Assessment Updates

A stock assessment update was conducted in 2017 that utilized the model from the 2011 benchmark stock assessment and incorporated abundance data through 2017 and harvest data through 2016. The results of the update showed similar scale and trends in estimated abundance compared to the 2011 benchmark assessment, indicating appropriate model structure and stability, but the estimated reference points were slightly different (Table 1). In November 2020, the three jurisdictions formally adopted the new reference points from the 2017 stock

assessment update as these estimates constitute the best available science by which the stock should be assessed and managed.

Table 1. Biological reference points generated by the 2011 benchmark stock assessment and the 2017 stock assessment update. The jurisdictions formally adopted the 2017 reference points in November 2020.

Stock Assessment	Female Abundance (Age 1+) (millions)		Female Exploitation Rate (Age 0+) (per year)	
	Target	Threshold	Target	Threshold
2011	215	70	25.5%	34%
2017	196	72.5	28%	37%

In 2020, CBSAC recommended that annual model runs be conducted to monitor model performance and help guide the decision process for timing of the next benchmark stock assessment. These model runs use the same data sources and methodologies set forth by the 2011 benchmark assessment. The population and fishery parameters incorporated into the model – natural mortality, recruitment sex ratio, fraction of juveniles recruited to the fishery, recreational harvest fraction – are also the same. CBSAC is currently discussing a standard operating procedure (i.e., methods, timeline, etc.) for updating the reference points in the future. CBSAC aims to have these guidelines finalized and approved by the SFGIT by the end of 2022.

1.4 Data Sources

Blue crab abundance is estimated from the annual Bay-wide Winter Dredge Survey (WDS) conducted by MDNR and VIMS. CBSAC adopted the WDS as the primary indicator of blue crab stock status in 2006 because it is the most comprehensive and statistically robust of the blue crab surveys conducted in the Bay (Sharov et al. 2003). The WDS measures the density of crabs (number/1,000 m^2) at approximately 1,500 sites throughout the Bay each year. The measured densities of crabs are adjusted to account for the efficiency of the sampling gear and expanded to the area of Chesapeake Bay (9,812 km^2). This provides an annual estimate of the total number of crabs overwintering in the Bay by age and sex. The survey also provides an estimate of overwintering mortality based on the percentage of dead crabs found in the WDS each year. Blue crab data from trawl surveys conducted by MDNR and VIMS also inform the stock assessment model.

Commercial and recreational harvest information are collected annually by the three jurisdictions (MDNR, VMRC, PRFC) to determine Bay-wide exploitation rates. The female exploitation rate is calculated as the 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. For this calculation, the juvenile component of the total estimated abundance 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 WDS as the stock assessment that generated the reference points. Thus, empirical estimates of exploitation can be compared with the target and threshold reference points derived from the assessment model. Note that exploitation rate estimates in this report are preliminary and will be updated when the harvest data are finalized.

2. POPULATION SIZE (ABUNDANCE)

2.1 All Crabs

The WDS estimate of total abundance of all blue crabs (males and females of all ages) in Chesapeake Bay was 227 million in 2022 (Figure 1). This was a decrease from the 2021 estimate of 282 million, and is the lowest abundance observed over the history of the WDS.

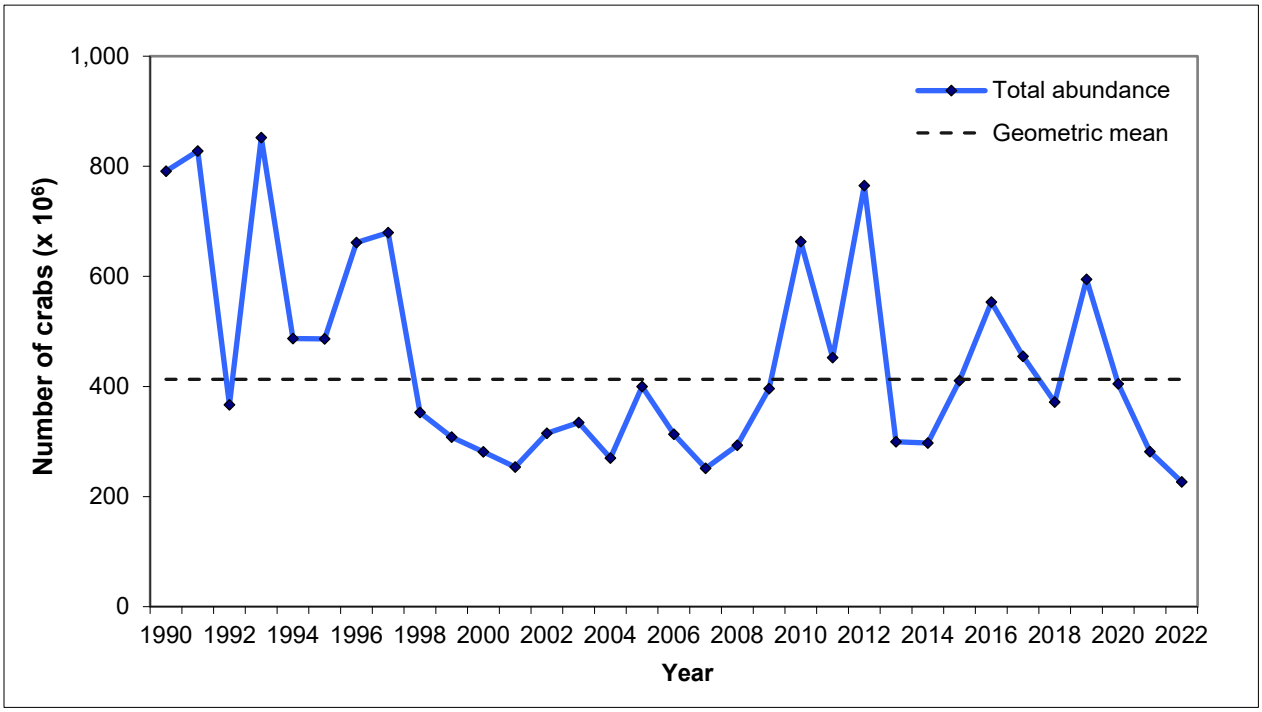

Figure 1. Winter Dredge Survey estimate of abundance of all crabs (both sexes, all ages) in Chesapeake Bay, 1990-2022.

2.2 Juvenile Crabs (Age 0)

Recruitment is estimated as the number of age 0 crabs (less than 60 mm carapace width) in the WDS. The abundance of juvenile crabs in 2022 was 101 million, an increase from the 2021 abundance of 86 million (Figure 2). However, this year's recruitment estimate was well below the average of 214 million juveniles (geometric mean). The 2021 estimate recruitment was the lowest observed in the history of the WDS, and the 2022 recruitment estimate is the second lowest in the time series.

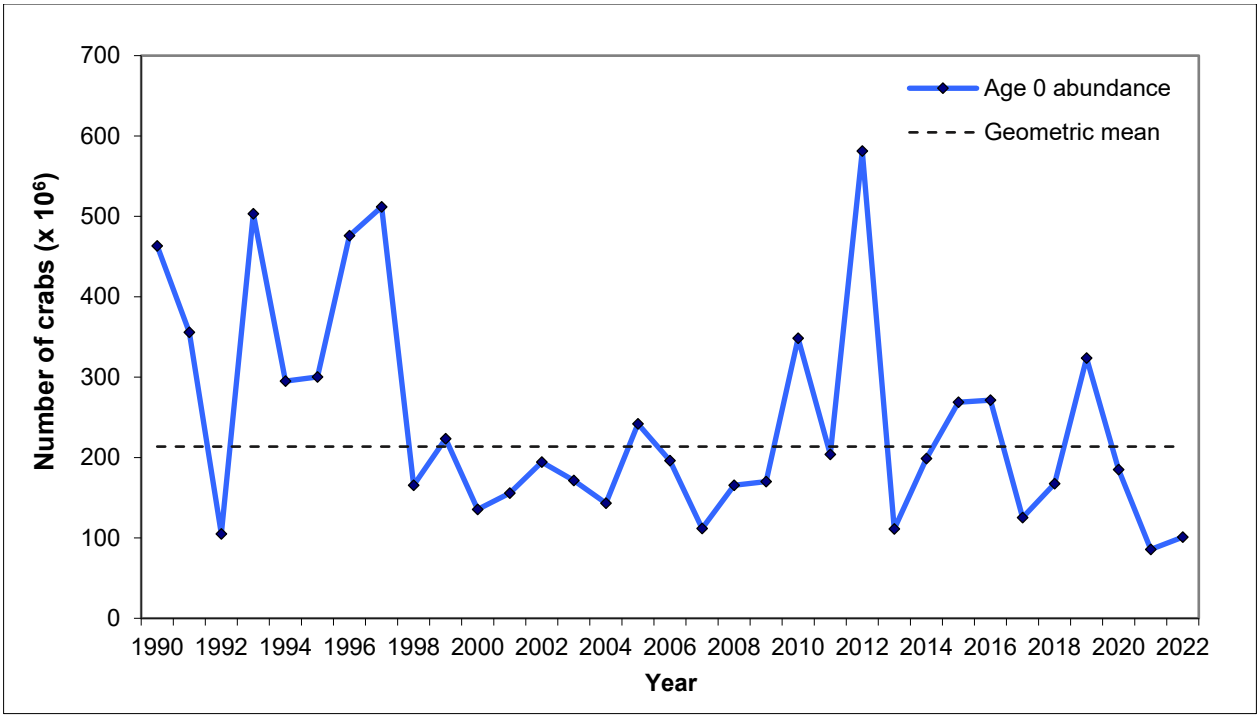

Figure 2. Winter Dredge Survey estimate of abundance of juvenile blue crabs (age 0), 1990-2022, calculated without the catchability adjustment for juveniles (section 1.4). These are male and female crabs measuring less than 60 mm (2.4 in) across the carapace.

2.3 Adult Males (Age 1+)

The WDS estimate of age 1+ male crabs (greater than 60 mm carapace width) in 2022 was 28 million, a decrease from the 2021 estimate of 36 million adult males (Figure 3). This was below the time series average of 62 million (geometric mean), and is the lowest in the time series (Figure 3).

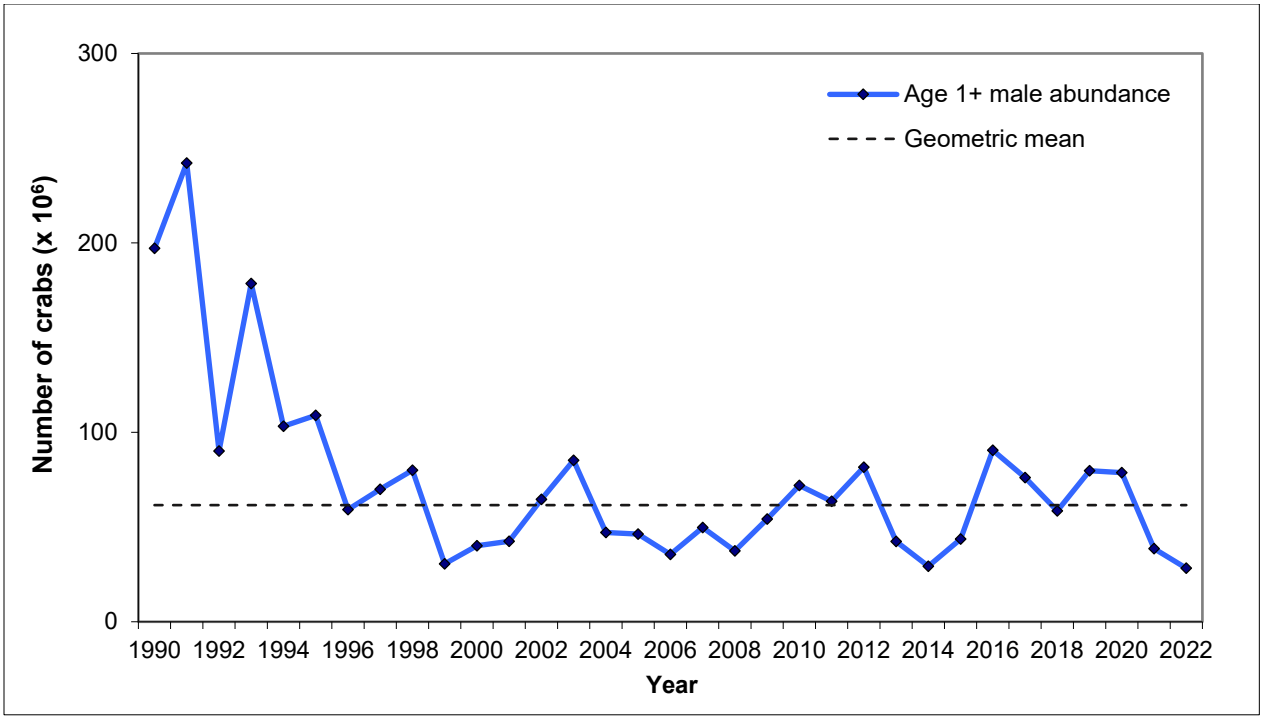

Figure 3. Winter Dredge Survey estimate of abundance of adult male blue crabs (age 1+), 1990-2022. These are male crabs measuring greater than 60 mm (2.4 in) across the carapace and are considered the "exploitable stock" capable of mating within the year.

2.4 Overwintering Mortality

Overwintering conditions affect the survival and year-class strength of marine and estuarine species such as the blue crab. For adult blue crabs, overwintering mortality is highly correlated to temperature and salinity, with mortality increasing at lower temperatures and salinities. Annual abundance estimates from the WDS are adjusted for loss due to overwintering mortality, which is estimated as the percentage of dead crabs found in the survey. In 2022, overwintering mortality estimates were slightly below the long-term average for all crabs in Chesapeake Bay (Table 2). However, juvenile and adult female mortality estimates were relatively high in 2022 compared to the last three years. The increase in overwintering mortality for mature females may have been due to the below-average water temperatures in January and February in the lower Bay where females reside, as indicated by NCBO's Winter 2021-2022 Seasonal Summary.

Table 2. Percentage of dead crabs found Bay-wide in WDS samples each year from 2018 to 2022 and the average for 1996-2022.

Age/Sex Grouping	1996-2022 Average	2018	2019	2020	2021	2022
All Crabs	4.42%	6.37%	1.80%	0.36%	2.80%	3.57%
Juveniles	1.11%	0.87%	0.15%	0.00%	0.11%	0.39%
Adult Females	7.77%	11.06%	1.87%	0.47%	2.12%	6.33%
Adult Males	9.10%	13.66%	7.83%	0.78%	8.39%	5.35%

3. HARVEST

3.1 Commercial Harvest

Preliminary reports indicated a decrease in Bay-wide commercial blue crab harvest in 2021, with an estimated total of 36.3 million pounds harvested, which is well below the long-term average of approximately 61 million pounds (Figure 4). Initial harvest estimates for each jurisdiction were as follows: 17.2 million pounds in Maryland, 16.6 million pounds in Virginia, and 2.5 million pounds in the Potomac River (Figure 4). The estimates for both Maryland and Virginia are the second lowest in their respective time series. Commercial blue crab harvest was likely impacted by the COVID-19 pandemic in 2021. The pandemic continued to limit restaurant patronage, and picking houses experienced labor shortages like many other sectors. Constituents also informed jurisdictions that there was a general decline in the availability of blue crabs to harvest in 2021.

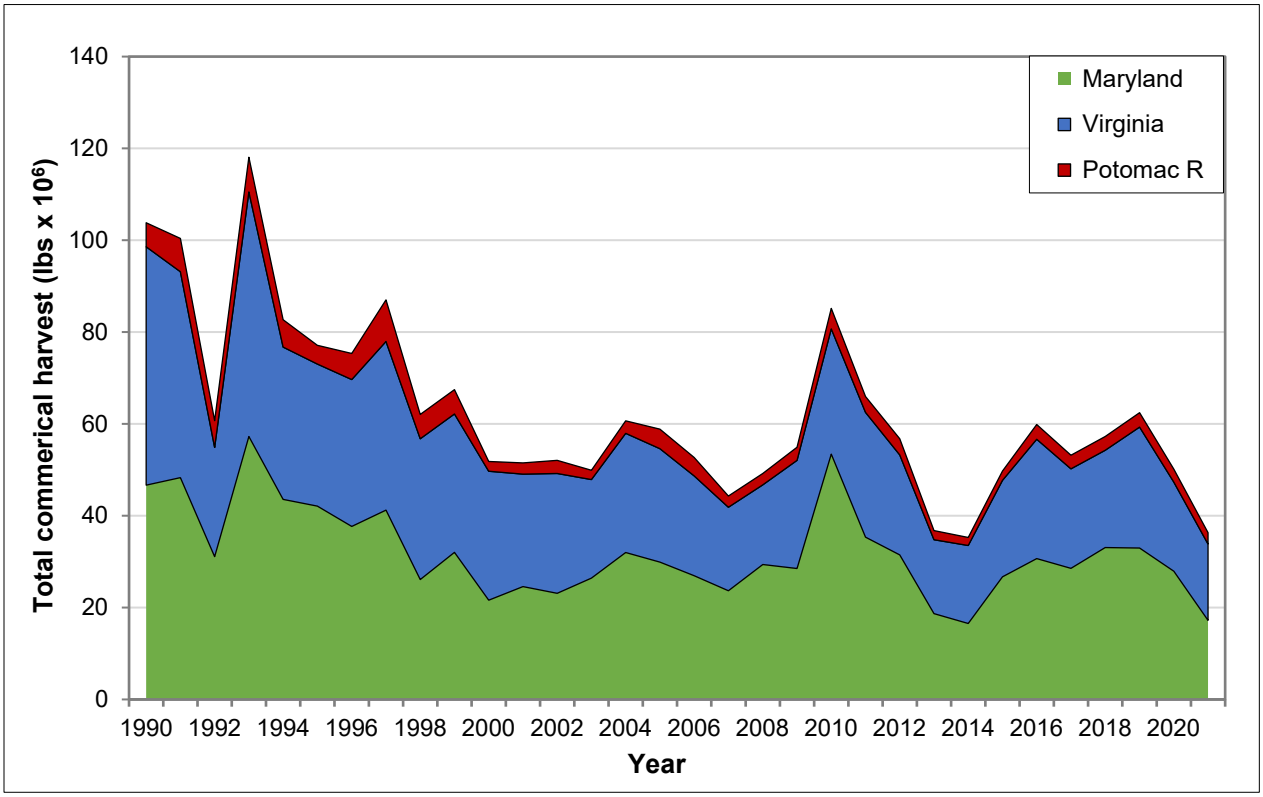

Figure 4. Commercial harvest of Chesapeake Bay blue crabs in millions of pounds (all market categories), 1990-2021.

3.2 Recreational Harvest

Recreational blue crab harvest in Chesapeake Bay is typically assumed to be approximately 8% of total commercial harvest (Ashford & Jones 2011). In 2009, however, MDNR prohibited the recreational harvest of females such that recreational harvest is better described as 8% of male commercial harvest in this jurisdiction. Preliminary estimates indicate a decrease in Bay-wide recreational harvest, from 3.1 million pounds in 2020 to 2.3 million pounds in 2021.

4. STOCK STATUS

4.1 Female-Specific Reference Points

The current blue crab management framework employs MSY-based female-specific targets and thresholds to assess the stock. U_{MSY} is the exploitation rate, or the level of fishing (expressed as the percentage of the population harvested each year), 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 blue crab stock assessment recommended a target exploitation rate that was associated with 75% of the value of U_{MSY} and a threshold exploitation rate equivalent to U_{MSY}. Overfishing occurs when the exploitation rate exceeds this threshold. The adult female (age 1+) abundance reference points were set at levels associated with $N_{0.75*UMSY}$ (target) and 50% N_{MSY} (threshold). The stock is considered overfished (or depleted) when the abundance of mature females falls below this threshold.

4.2 Exploitation Rate

The preliminary estimate of the female exploitation rate, or the percentage of all female crabs (age 0+) removed by fishing, was approximately 26% in 2021 (Figure 5). This exploitation rate is below the target of 28% and the threshold of 37%. However, as more harvest data are finalized, this estimate may increase and exceed the target.

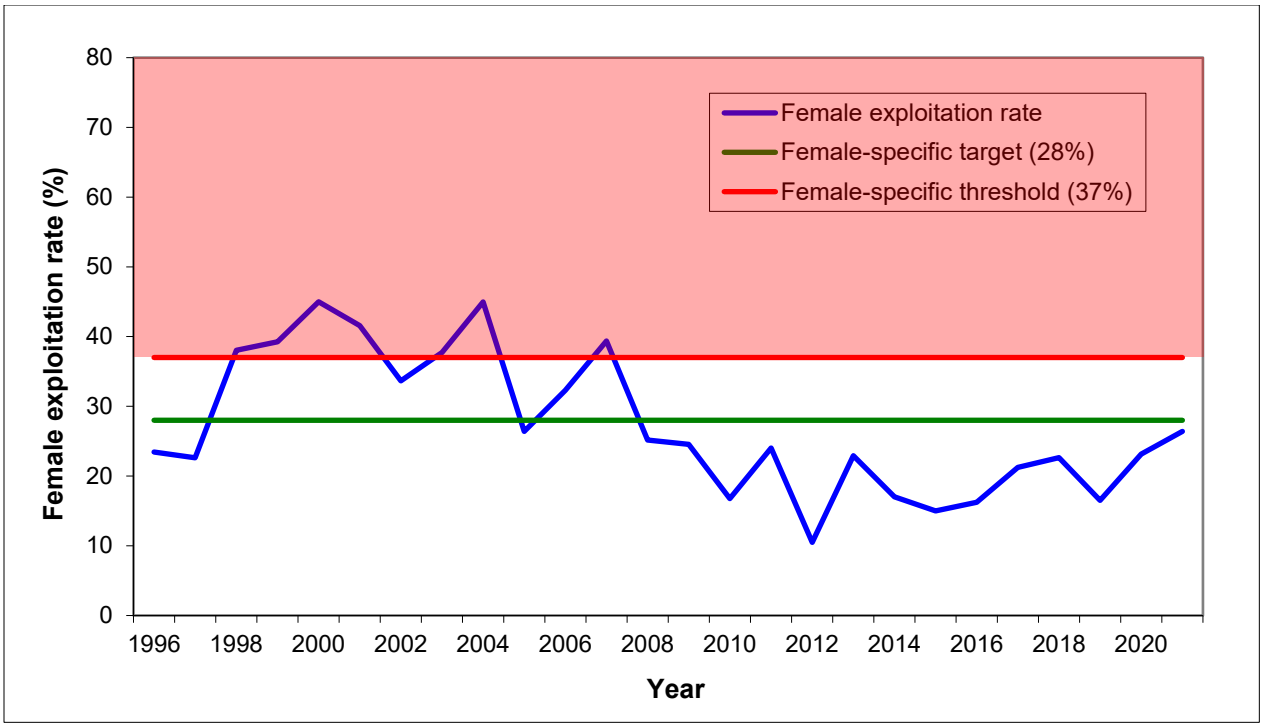

Figure 5. Estimated female exploitation rate relative to the female-specific target (28%) and threshold (37%), 1990-2021. The female exploitation rate is the number of female crabs harvested in a given year divided by the female abundance estimate (age 0+) at the beginning of the year.

4.3 Spawning Stock Abundance

Approximately 97 million age 1+ female crabs (i.e., the spawning stock) were estimated to be present in the Bay at the start of the 2022 crabbing season, which is above the threshold of 72.5 million, but below the target of 196 million (Figure 6). This abundance estimate is below the average abundance since 2008 (after female-specific management measures were enacted), and only slightly higher than the average abundance for the 14-year period preceding those measures.

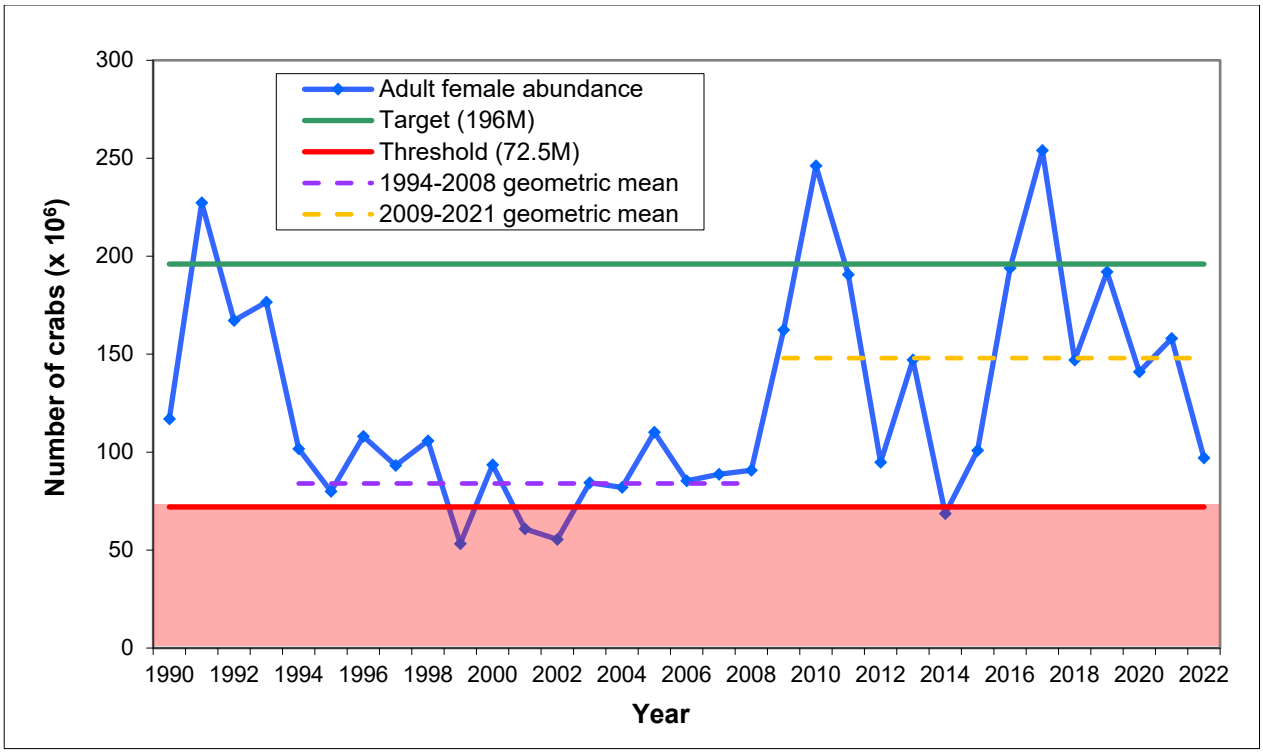

Figure 6. Winter Dredge Survey estimate of abundance of mature female blue crabs (age 1+), 1990-2022, relative to the female-specific reference points. These are female crabs measuring greater than 60 mm (2.4 in) across the carapace and are considered the "exploitable stock" capable of spawning within the year. The dashed lines represent the geometric mean of adult female abundance during two time periods: 2009-2022, after the current management framework was implemented (yellow dashes); and 1994-2008, the period of low abundance which prompted the management changes (purple dashes).

4.4 Control Rules

Each year, the status of the Chesapeake Bay blue crab stock is assessed relative to the control rules, i.e., the female exploitation rate (U) and adult female abundance (N) reference points. Figure 7 shows the status of the blue crab stock relative to these reference points each year since 1990. The 2022 estimate of spawning stock abundance is above the threshold of 72.5 million adult females, but below the target of 196 million. The preliminary estimate of the female exploitation rate in 2021 was 26%, which is below both the target (28%) and the threshold (37%). Therefore, the Chesapeake Bay blue crab stock is currently not considered overfished (depleted) nor is overfishing occurring (Figure 7; Table 3).

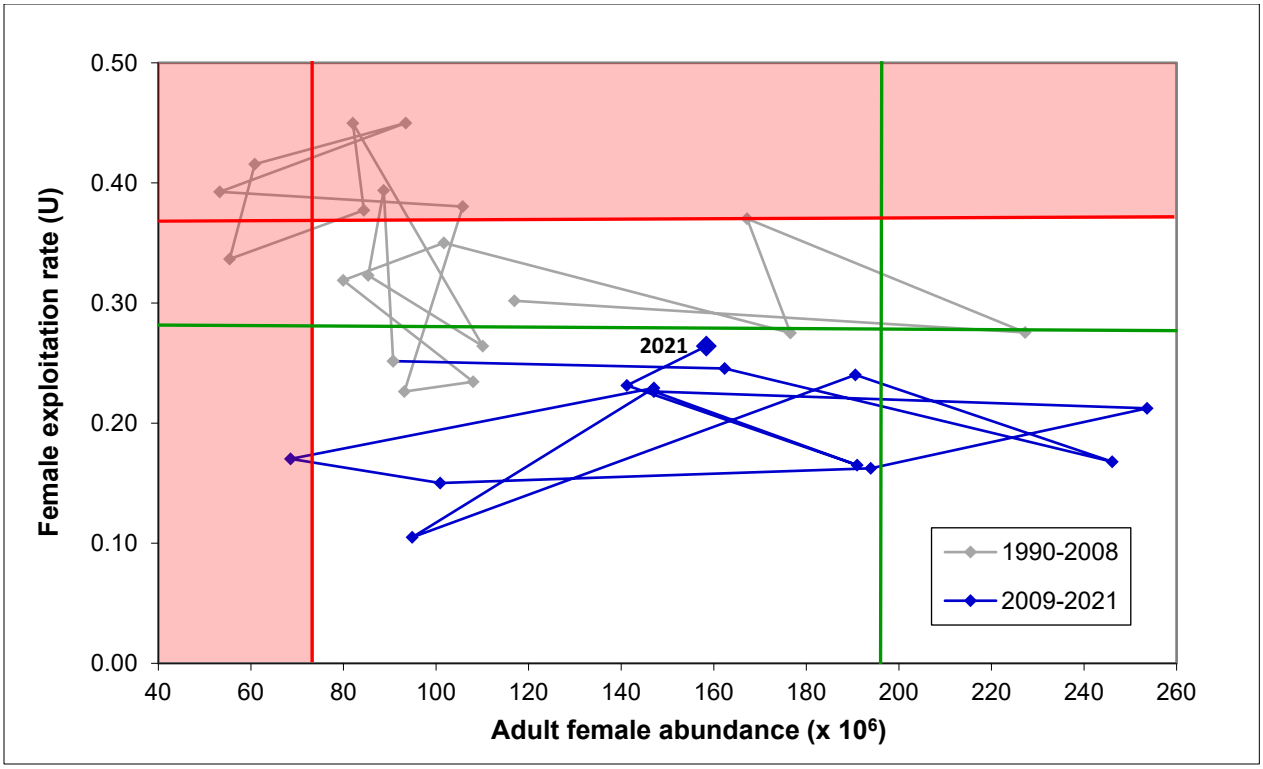

Figure 7. Stock status of the Chesapeake Bay blue crab prior to and after implementation of female-specific management measures in 2008. The female-specific management framework was formally adopted in December 2011, and revised biological reference points were adopted in November 2020. The shaded red areas show where the thresholds for the exploitation rate and/or abundance are exceeded. The intersection of the green lines shows both the abundance and exploitation targets. This figure includes data through 2021; the 2022 data point will be added at the completion of the 2022 fishery.

Table 3. Blue crab stock status over the last five years, based on the exploitation and abundance reference points for female crabs. Green shading indicates that the threshold was not exceeded.

Control Rule	Reference Points		Stock Status				
	Target	Threshold	2018	2019	2020	2021	2022
Exploitation Rate (percentage of age 0+ females removed)	28%	37% (max)	23%	17%	23%	**26%**	TBD
Abundance (millions of age 1+ females)	196	72.5 (min)	147	191	141	158	**97**

4.5 Male Conservation Trigger

Although the current blue crab management framework does not have reference points for males, CBSAC adopted a conservation trigger for male crabs in 2013. Under this trigger, conservation measures should be considered for male crabs if the male exploitation rate exceeds 34% (calculated with the juvenile scalar as described in section 1.4), which is the second-highest exploitation rate observed for male crabs since 1990. Choosing the second-highest value in the time series is a precautionary measure that provides a buffer from the maximum observed exploitation rate. This value does not represent a fishing threshold or target, but instead, will ensure that the male component of the stock is not more heavily exploited than has occurred in 30 of the last 32 years. Additional harvest data from recent years were incorporated into this year's analysis and revealed that the male exploitation rate exceeded the conservation trigger in 2017 and 2018. In 2021, the preliminary estimate of the male exploitation rate was 31%, approaching the conservation trigger (Figure 8). As more harvest data are finalized, the male exploitation rate may again exceed the conservation trigger.

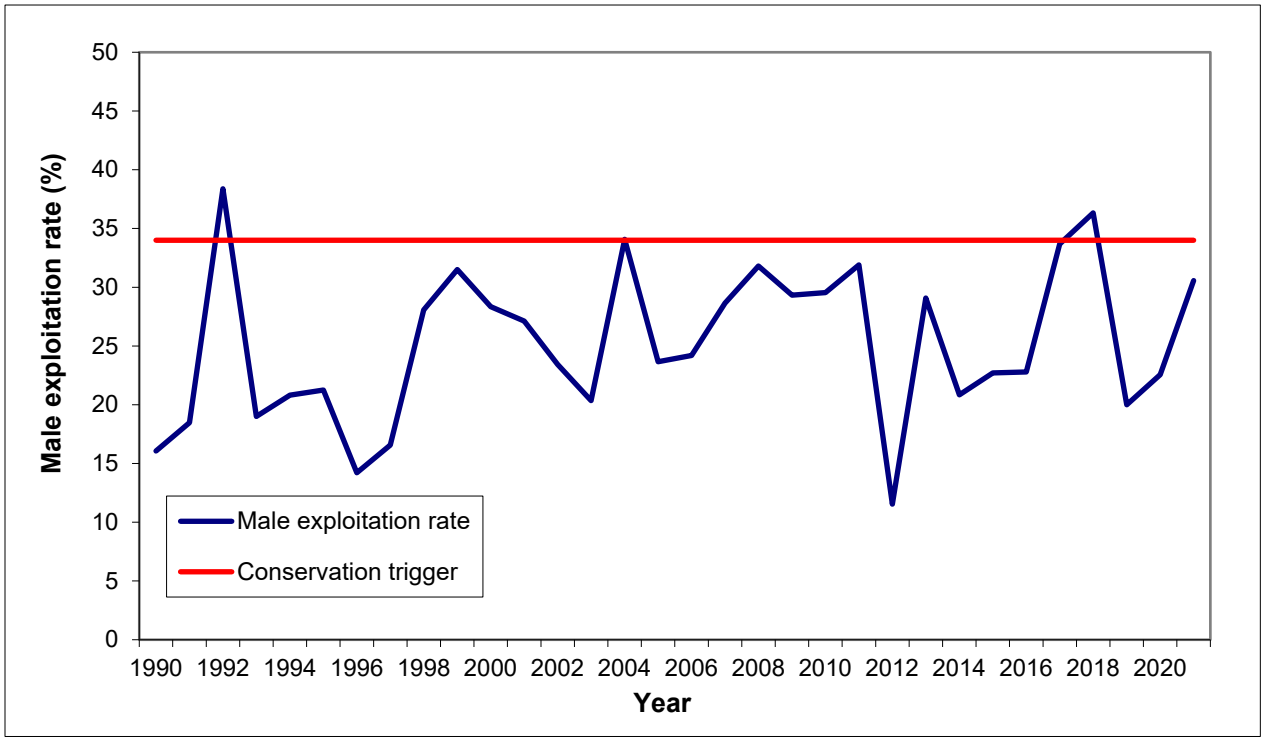

Figure 8. Estimated male exploitation rate relative to the male conservation trigger, 1990-2021. The male exploitation rate is the number of male crabs harvested in a given year divided by the male abundance estimate (age 0+) at the beginning of the year, calculated with the juvenile scalar (section 1.4).

4.6 Potential Management Impact

Female exploitation rates from 1990 to 2007 were much higher than the exploitation rates from 2008 to 2021 (Figure 9a). The lower female exploitation rates over the last two decades illustrate the influence of the female-specific management measures implemented by the jurisdictions in 2008. Additionally, the rapid increase in female abundance in 2009-2010, and again in 2014-2016, indicates that the female-specific management framework allowed the stock to regain some of its natural resilience to environmental changes. Male exploitation rates have not shown the same pattern (Figure 9b).

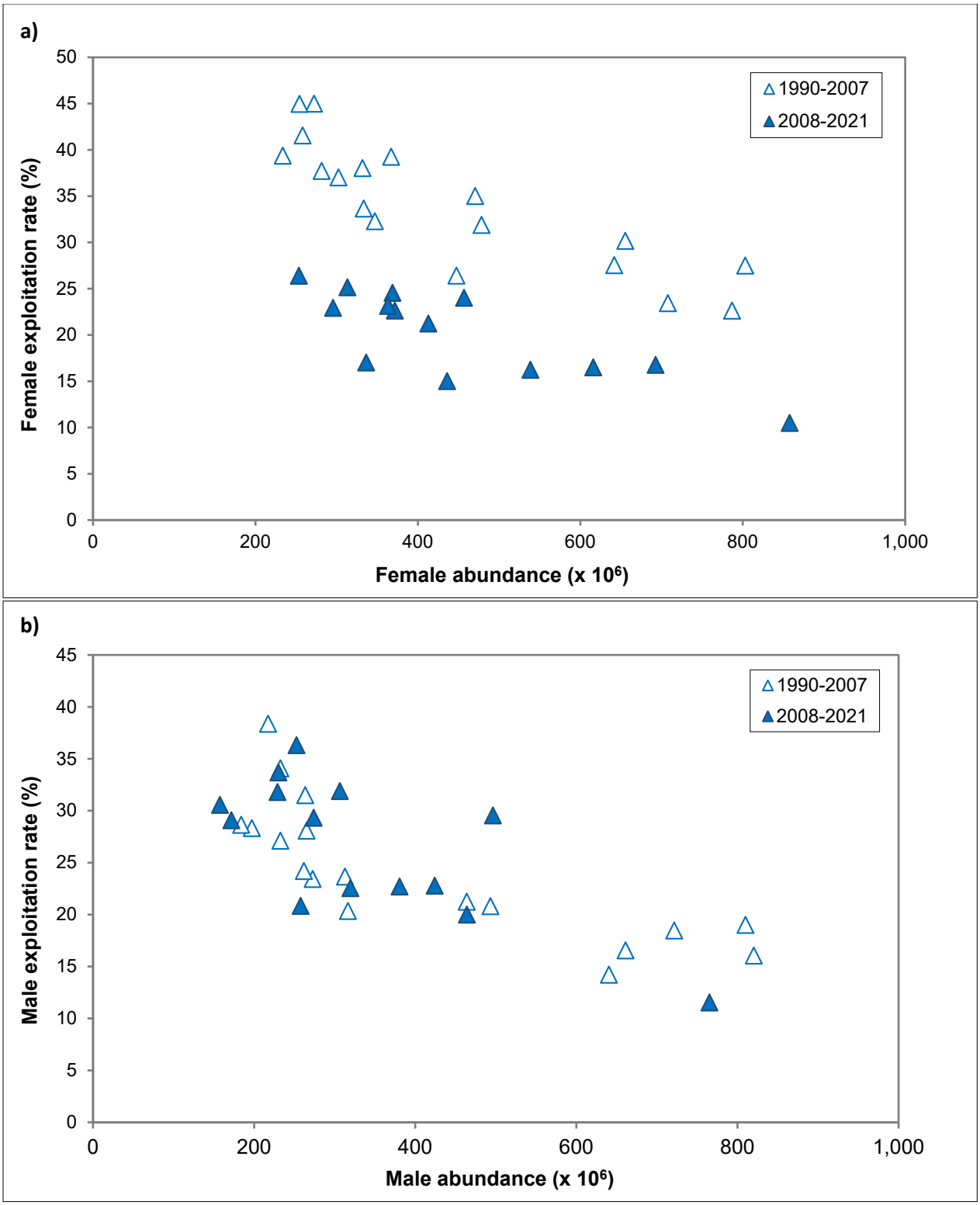

Figure 9. Comparison of female (a) and male (b) exploitation rates during the time periods prior to and after the 2008 implementation of female-specific management measures.

5. MANAGEMENT RECOMMENDATIONS

5.1 Implement Precautionary Management Measures

In 2022, abundance of both mature male and female blue crabs decreased, and juvenile abundance remained low. Harvest rates also increased for both males and females in the 2021 season. Although the 2022 results suggest that the blue crab stock is not overfished and overfishing is not occurring at this time, the reduced abundances, low recruitment, and higher male exploitation rates (near the conservation trigger) are of concern. Maintaining a robust spawning stock is necessary to replenish the population with new recruits each year. High fishing pressure can remove too many mature and soon-to-be-mature crabs from the population, negatively impacting recruitment success in the following years. To ensure a productive population and sustainable fishery, CBSAC recommends precautionary management measures be implemented to protect new recruits (age 0 crabs) that will enter the fishery in the second half of 2022 and represent the spawning stock for 2023. See Appendix B for more information about previous changes in harvest regulations by year.

5.2 Plan and Conduct a New Benchmark Stock Assessment

The current blue crab management framework is centered around reference points for adult female abundance and female exploitation rate, and stock status is assessed relative to these reference points. Fishery exploitation rates have been low, but both adult abundance and recruitment have not increased consistently as expected. This apparent disconnect between the spawning stock, recruitment, and fishery performance indicates a clear and pressing need to re-evaluate the stock assessment model. In many fisheries, benchmark stock assessments are conducted every five years; it has been a decade since the last benchmark for blue crabs in Chesapeake Bay. A new benchmark assessment could evaluate the effects of the substantial environmental and biological changes in the Chesapeake Bay ecosystem in the last decade on the blue crab population, and would also provide an opportunity to address many of CBSAC's priority science needs. For example, a new benchmark could explore various spatial and temporal scales in the model to fully take advantage of existing datasets, and could be paired with an existing effort to develop a blue crab population simulation model (section 6.2). CBSAC recommends a new benchmark stock assessment be conducted in the immediate future, as soon as funding allows.

6. SCIENCE AND DATA NEEDS

CBSAC has identified the following prioritized list of science and data needs that will improve management of the Chesapeake Bay blue crab population. To address some of these needs, CBSAC is pursuing funding opportunities through the Chesapeake Bay Program's Goal Implementation Team (GIT) Project Initiative, which provides funds to advance Bay Program goals and outcomes stipulated by the 2014 Chesapeake Bay Watershed Agreement, including the Blue Crab Abundance and Management Outcomes.

6.1 Quantifying Drivers of Blue Crab Population Dynamics

Given the recent declines in blue crab abundance, CBSAC has prioritized the need to better understand drivers of blue crab population dynamics, particularly recruitment success. Factors of interest include habitat availability (e.g., SAV, marsh), predation (e.g., red drum, blue catfish), food availability (e.g., clams), environmental conditions (e.g., water temperature, salinity, hypoxia), oceanic conditions (e.g., wind and tidal currents), and disease. By quantifying drivers of juvenile recruitment, CBSAC may be able to predict future recruitment success based on environmental and/or ecological conditions during the year. In addition to quantifying the impacts of these factors on recruitment success, CBSAC is also interested in re-examining the stock-recruitment relationship to better understand the connection between the spawning stock and juvenile recruitment. To address these science gaps, CBSAC is currently planning a workshop for September 2022 in which the workgroup will identify available data sources and evaluate hypotheses related to blue crab recruitment success and population dynamics.

Unknown and unquantified sources of mortality are also a major component of blue crab population dynamics that CBSAC needs to address. In addition to predation and disease impacts, CBSAC is particularly interested in quantifying sources of incidental mortality, such as sponge crab discards and unreported losses from the peeler fishery. An analysis of non-harvest mortality could improve reliability of exploitation rate estimates and inform future stock assessments.

6.2 Population Simulation Model for Management Strategy Evaluation

In 2021, CBSAC proposed a GIT-funded study to develop a spatially-explicit blue crab population simulation model that can be used to evaluate performance of the stock assessment model and fishery management under various hypotheses (e.g., differential natural mortality by sex, catchability of the WDS). This project would provide a better understanding of the current assessment model performance and a foundation for management strategy evaluation by which alternative management approaches for the blue crab population can be compared. The results of this modeling exercise could confirm the robustness of the current stock assessment and management framework. The simulation model could also test the response of recruitment indices to management, which is of particular interest given the continued low recruitment in

recent years. This project was accepted for funding by the Chesapeake Bay Trust and will begin in Summer 2022.

The new population simulation model will complement a current study conducted by VIMS researchers (and funded by the National Science Foundation) to develop a stage-structured population dynamics model, which is being calibrated with WDS and VIMS trawl survey data. The VIMS model is being used to examine the effects of depensatory exploitation, changes in reproductive output due to climate change, and habitat effects on the blue crab population and fishery. VIMS is also working to make this model spatially-explicit.

6.3 Harvest Reporting, Effort, and Catch Composition

Accurate harvest data for the commercial and recreational blue crab fisheries are necessary to obtain the most accurate exploitation rate each year and to better support mid-season management changes. To improve harvest reporting, the jurisdictions have been working to implement new 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. MDNR is continuing to expand the use of this system for the commercial crabbing fleet. VMRC implemented electronic reporting in 2009 as an alternative mandatory harvest reporting option, but growth was initially slow. Participation of commercial crab harvesters increased over time through cooperative work among VMRC, Virginia Sea Grant, and various industry groups. Beginning in 2022, VMRC is requiring all crab harvest to be reported through the online system to increase reporting efficiency. In 2021, PRFC received a grant from the Atlantic Coastal Cooperative Statistics Program to develop a pilot project for electronic harvest reporting, which began this spring. The details of each jurisdiction's harvest reporting efforts and challenges are outlined in CBSAC's Blue Crab Harvest Reporting Document.

In addition to commercial harvest reporting, a survey of recreational catch would be useful to ensure the reliability of recreational removal estimates. The most recent estimate of recreational harvest in Maryland was generated from a tagging study in Maryland waters in 2014-2015, which suggested that recreational harvest was approximately 6.5% of commercial harvest (Semmler et al. 2021). The last available estimates of recreational harvest for Virginia are from 2002. Future surveys should ensure that recreational harvest from the Potomac River is also included. A license or registration for all recreational crabbing in all jurisdictions would greatly increase the accuracy of catch and effort estimates.

Quantifying effort is another important component for understanding fishery dynamics. 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 reveal the spatial and

temporal patterns of gear-specific effort should be included in any harvest reporting system or recreational catch survey.

In addition to accurate harvest reporting and quantification of fishing effort, improvements in management could be made using more detailed characterization of catch. Understanding catch composition by size, sex, and growth phase, both spatially and temporally, would help improve the effectiveness of regulations and ensure they are compatible at a Bay-wide level. MDNR collects some size and sex composition data through their Cooperative Data Collection Program, which enlists watermen to voluntarily sample their catch and/or permit an onboard biologist to sample their catch. CBSAC has been working with the jurisdictions to assess the potential of implementing similar fishery-dependent sampling programs at VMRC and PRFC.

6.4 Efficacy of the WDS as an Index of Abundance

The WDS is the primary data source used by managers to assess the status of the blue crab stock and make management decisions. Although the WDS is considered one of the most comprehensive and statistically sound fisheries surveys on the east coast, there are several aspects of survey design and interpretation that should be further explored and improved upon. At least three approaches using WDS data have been proposed to estimate relative blue crab abundance in Chesapeake Bay (Sharov et al. 2003, Jensen & Miller 2005, Liang et al. 2017). However, the relative reliability of the means and variances of abundance estimated from these different approaches has never been evaluated. In partnership with CBSAC, researchers at UMCES are currently working with graduate students to conduct this analysis, and expect it to be completed by Fall 2022.

6.5 Influence of Males on Population and Fishery Productivity

A previous study at UMCES suggested that sperm limitation is not a concern for Chesapeake Bay blue crabs under the current management framework (Rains et al. 2018). However, 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 consideration of a set of indicators that would help determine when management adjustments specific to male crabs would be warranted.

6.6 Improving Recruitment Estimates Using a Shallow Water Survey

Based on the 2011 stock assessment and field experiments by VIMS and SERC, a large fraction of juvenile blue crabs in shallow water is not sampled by the WDS (Ralph & Lipcius 2014). Currently, VIMS is evaluating trawl survey and WDS data as a relative measure of age 0 abundance, and the Patuxent Environmental and Aquatic Research Laboratory (PEARL) is finalizing 50 years of recruitment indices from the George Abbe Blue Crat Pot Survey.

6.7 Blue Crab Data Hub

To assist in stock assessments and analyses, CBSAC has discussed 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. The following steps would be necessary to implement such a data hub:

1) Create a data policy workgroup to develop policies to ensure all interests are protected;
2) Determine the best database design and structure; and
3) QA/QC all data prior to uploading into the database

6.8 Application of Fishery-Independent Survey Data

CBSAC continues to review existing fishery-independent survey data to identify potential applications that will address questions about blue crab population dynamics and complement the population estimates from the WDS. Characterizing the seasonal distribution, spatial patterns in recruitment and production, and sex-specific abundance of blue crabs remains important. In preparation for the workshop in September 2022, CBSAC is compiling a list of data sources that could be incorporated into a new blue crab stock assessment and other relevant analyses. The George Abbe Blue Crab Pot Survey conducted by PEARL is one example of a data source that could be used to assess and study the Chesapeake Bay blue crab population.

6.9 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 are key sources of uncertainty**.** A new VIMS study examining blue crab age structure, reproduction, and sperm limitation may provide some insight into these critical biological parameters of the Chesapeake Bay population.

Additional Online Resources

Maryland Department of Natural Resources:
https://dnr.maryland.gov/fisheries/pages/blue-crab/index.aspx
Potomac River Fisheries Commission: http://prfc.us/
Virginia Marine Resources Commission: http://www.mrc.state.va.us/
Virginia Institute of Marine Science:
https://www.vims.edu/research/units/programs/bc_winter_dredge/index.php
Chesapeake Progress:
https://www.chesapeakeprogress.com/abundant-life/blue-crab-abundance
https://www.chesapeakeprogress.com/abundant-life/blue-crab-management

CBSAC Members

Pat Geer (Chair)	Virginia Marine Resources Commission
Mandy Bromilow (Coordinator)	ERT/NOAA Chesapeake Bay Office
Bruce Vogt	NOAA Chesapeake Bay Office
Ingrid Braun	Potomac River Fisheries Commission
Glenn Davis	Maryland Department of Natural Resources
Alexa Galvan	Virginia Marine Resources Commission
Daniel Hennen	NMFS, Northeast Fisheries Science Center
Tom Ihde	Morgan State University, PEARL
Eric Johnson	University of North Florida
Rom Lipcius	Virginia Institute of Marine Science
Genine McClair	Maryland Department of Natural Resources
Tom Miller	UMCES, Chesapeake Biological Laboratory
Amy Schueller	NMFS, Southeast Fisheries Science Center
Mike Seebo	Virginia Institute of Marine Science
Alexei Sharov	Maryland Department of Natural Resources
Mike Wilberg	UMCES, Chesapeake Biological Laboratory

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Appendix A. Estimated abundance of blue crabs from the Chesapeake Bay-wide Winter Dredge Survey, total commercial harvest, and female exploitation rate, 1990-2022*. Juvenile crabs are age 0 and adult crabs are age 1+.

WDS Year (Year Ended)	Total Crab Abundance (millions)	Juvenile Crab Abundance (millions)	Adult Crab Abundance (millions)	Adult Female Abundance (millions)	Total Commercial Harvest (millions of pounds)	Female Exploitation Rate (%)
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	50	36
2004	270	143	122	82	60	46
2005	400	243	156	110	59	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	69	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	594	324	271	191	61	17
2020	405	185	220	141	42	19
2021	282	86	197	158	**36**	**26**
2022	**227**	**101**	**125**	**97**	TBD	TBD

*2022 estimates of commercial harvest and female exploitation rate will be determined after the 2022 harvest season.

Appendix B. Summary of changes in female blue crab harvest regulations in the three Chesapeake Bay jurisdictions (MDNR, VMRC, PRFC) since implementation of the female-specific management framework in 2008. Abundance estimates for all crabs, juvenile crabs (age 0), and adult females (age 1+) and the female exploitation rate are also provided for each year.

Year	Total Abundance (millions)	Juvenile Abundance (millions)	Adult Female Abundance (millions)	Female Exploitation Rate	MDNR	VMRC	PRFC
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	Total Abundance (millions)	Juvenile Abundance (millions)	Adult Female Abundance (millions)	Female Exploitation Rate	MDNR	VMRC	PRFC
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	Total Abundance (millions)	Juvenile Abundance (millions)	Adult Female Abundance (millions)	Female Exploitation Rate	MDNR	VMRC	PRFC
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 on 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.

Year	Total Abundance (millions)	Juvenile Abundance (millions)	Adult Female Abundance (millions)	Female Exploitation Rate	MDNR	VMRC	PRFC
2019	594	324	191	17%	Increased bushel limits for July - Nov. Season remained open through Nov 30.	Increased Nov bushel limits to the same limits as Apr-Oct. Continued closure of dredge fishery.	Status quo.
2020	405	185	141	19%	Increased bushel limits for one week in Nov in response to impacts related to COVID-19.	Extended hard crab pot season to Dec 19 in response to impacts related to COVID-19. Continued closure of dredge fishery.	Status quo.
2021	282	86	158	26%	Status quo.	Shortened hard crab pot season to November 30. Continued closure of dredge fishery.	Status quo.