

Chesapeake Bay Program | Indicator Analysis and Methods Document
Blue Crab Management | Updated 6/2/2021

Indicator Title: Blue Crab Management

Relevant Outcome(s): Blue Crab Management and Blue Crab Abundance

Relevant Goal(s): Sustainable Fisheries

Location within Framework (i.e. Influencing Factor, Output, or Performance):
Performance

A. Data Set and Source

- (1) Describe the data set. What parameters are measured? What parameters are obtained by calculation? For what purpose(s) are the data used?

The blue crab management indicator provides information about the annual exploitation rate of female blue crabs in the Chesapeake Bay. The female exploitation rate is the percent of female crabs harvested from the population in a given year, and is informed by harvest reports that crabbers send to the management jurisdictions (Maryland Department of Natural Resources, Virginia Marine Resources Commission, Potomac River Fisheries Commission) and abundance data from the Winter Dredge Survey. The Winter Dredge Survey collects blue crab density data (number of crabs/1,000 m²) at 1,500 sites throughout the Bay each year. Bay-wide blue crab abundance is then calculated by multiplying the total crab density by the total area (m²) of the Bay. To calculate the female exploitation rate, harvest of female crabs (not including discards, bycatch, or unreported losses) is divided by the total number of female crabs (age 0+) estimated in the population at the start of the crabbing season. To compare the estimated exploitation rate with the biological reference points, the juvenile component of total crab abundance is scaled up by a factor of 2.5 to account for the assumption of reduced juvenile susceptibility to the Winter Dredge Survey, a method that was also implemented in the model-based stock assessment that generated the reference points.

- (2) List the source(s) of the data set, the custodian of the source data, and the relevant contacts at the Chesapeake Bay Program.
- Source(s): Maryland Department of Natural Resources, Virginia Institute of Marine Science, Virginia Marine Resources Commission, Potomac River Fisheries Commission
 - Custodian: Glenn Davis (MDNR), Rom Lipcius (VIMS)
 - Chesapeake Bay Program Contacts (name, email address, phone number): Mandy Bromilow, mandy.bromilow@noaa.gov, 410-267-5667

Bruce Vogt, bruce.vogt@noaa.gov, 410-267-5655

- (3) Please provide a link to the location of the data set. Are metadata, data-dictionaries, and embedded definitions included?

The Chesapeake Bay Stock Assessment Committee's (CBSAC) annual [Blue Crab Advisory Report](#) includes the abundance and harvest data, and is made publicly available on the Chesapeake Bay Program website after approval by the Sustainable Fisheries Goal Implementation Team, usually in late June/early July. The data and methods are also provided by MDNR and VIMS on the following websites:
<http://dnr.maryland.gov/fisheries/Pages/blue-crab/dredge.aspx>
http://www.vims.edu/research/units/programs/bc_winter_dredge/index.php

B. Temporal Considerations

- (4) Data collection date(s): Blue crab abundance data have been collected annually December-March since the start of the Winter Dredge Survey in 1990. Annual exploitation rates are reported for the previous year because the exploitation rate cannot be calculated until the fishery closes at the end of the year. For example, in 2021, abundance estimates were reported from the 2021 Winter Dredge Survey (conducted December 2020-March 2021), but the exploitation fraction was reported for the 2020 harvest season.
- (5) Planned update frequency (e.g. annual, biannual, etc.):
- Source Data: Annual
 - Indicator: Annual
- (6) Date (month and year) next data set is expected to be available for reporting:
June 2022

C. Spatial Considerations

- (7) What is the ideal level of spatial aggregation (e.g. watershed-wide, river basin, state, county, hydrologic unit code)?

Each jurisdiction (MDNR, VMRC, PRFC) collects harvest biomass information each year which, in combination with the abundance data from the Winter Dredge Survey, is used to estimate a Bay-wide female exploitation rate.

- (8) Is there geographic (GIS) data associated with this data set? If so, indicate its format (e.g., point, line polygon). **No.**
- (9) Are there geographic areas that are missing data? If so, list the areas. **N/A**

(10) Please submit any appropriate examples of how this information has been mapped or otherwise portrayed geographically in the past. **N/A**

D. Communicating the Data

(11) What is the goal, target, threshold, or expected outcome for this indicator? How was it established?

This indicator provides information about the status of the Chesapeake Bay blue crab population based on female-specific reference points for abundance and exploitation rate (percentage of females harvested). From 2012 through 2020, abundance and harvest estimates were assessed relative to reference points that were established in the 2011 benchmark stock assessment, which was conducted by scientists at the University of Maryland Center for Environmental Science (UMCES) with support from the Maryland Department of Natural Resources (MDNR), Virginia Marine Resources Commission (VMRC), and NOAA Chesapeake Bay Office (NCBO). In November 2020, the three jurisdictions (MDNR, VMRC, Potomac River Fisheries Commission [PRFC]) formally adopted new female-specific reference points generated by the 2017 blue crab stock assessment update, which included more recent data. The target female exploitation rate increased from 25.5% to 28%, and the threshold increased from 34% to 37%. The target abundance of 215 million mature adult female crabs (age 1+) decreased to 196 million, and the threshold abundance of 70 million adult females increased to 72.5 million.

Managers aim to maintain adult female abundance (age 1+) **at or above** the target reference point and restrain fishery harvest **below** the threshold exploitation rate. If the abundance of adult females falls below the threshold of 72.5 million, the population would be considered depleted (overfished). If the exploitation rate exceeds the threshold, overfishing is occurring. In both these scenarios, further management actions, such as increased fishery restrictions, could be required to improve the stock. Table 1 shows the female-specific reference points used to manage the blue crab population and the status of the stock relative to those reference points over the last five years.

Table 1. Blue crab stock status over the last five years, based on the updated reference points for age 0+ (exploitation rate) and age 1+ (abundance) female crabs. Recent stock status levels that did not exceed threshold values are shown in green.

Control Rule	Reference Points		Stock Status					
	Target	Threshold	2016	2017	2018	2019	2020	2021
Exploitation Fraction (percent of age 0+ females)	28%	37% (max)	16%	21%	23%	17%	19%	TBD
Abundance (millions of age 1+ females)	196	72.5 (min)	194	254	147	191	141	158

(12) What is the current status in relation to the goal, target, threshold, or expected outcome?

The estimated female exploitation rate, or percentage of female crabs removed by harvest, was approximately 19% in 2020. This is below both the target (now 28%) and threshold (now 37%) for the 13th consecutive year since female-specific management measures were implemented in 2008, which suggests that management has been effective. Based on analysis of the 2020-2021 abundance and harvest data, the Chesapeake Bay blue crab stock is currently not depleted and overfishing is not occurring. Therefore, CBSAC concludes that substantial changes in management are not necessary at this time.

(13) Has a new goal, target, threshold, or expected outcome been established since the last reporting period? Why?

Yes, new female-specific reference points were established since the 2020 Blue Crab Advisory Report. The 2011 benchmark stock assessment developed the first female-specific reference points for blue crab management in the Chesapeake Bay, which have been used to assess the population through 2020. The estimated female exploitation reference points from the 2011 assessment were 25.5% (target) and 34% (threshold), and the estimated female abundance reference points were 215 million (target) and 70 million (threshold). However, a more recent stock assessment update in 2017, which included abundance data through 2017 and harvest data through 2016, generated new female-specific reference points with an exploitation target of 28% and a threshold of 37%, and an abundance target of 196 million and a threshold of 72.5 million. Given that

they were generated using more recent data, CBSAC determined that these new reference points constitute the best available science by which the stock should be assessed and managed. Therefore, the jurisdictions (MDNR, VMRC, PRFC) formally adopted the new reference points in November 2020.

(14) Has the methodology of data collection or analysis changed since the last reporting period? How? Why? **No.**

(15) What is the long-term data trend (since the start of data collection)?

The female exploitation rate has varied from 1990-2020. The exploitation rate was above the overfishing threshold (then 34%) from the mid-1990s through the early 2000s. Since female-specific management measures were implemented in 2008, the exploitation fraction has remained below both the target (now 28%) and threshold (now 37%).

(16) What change(s) does the most recent data show compared to the last reporting period? To what do you attribute the change? Is this actual cause or educated speculation?

The female exploitation rate increased from 17% to 19% from 2019 to 2020. This change is reflective of the variation typically seen in blue crab harvest from year to year.

(17) What is the key story told by this indicator?

This indicator provides information about the status of the Chesapeake Bay blue crab population based on female-specific reference points for abundance and exploitation rate. If adult female abundance falls below the threshold of 72.5 million, the stock would be considered depleted (overfished). If the female exploitation rate exceeds the 37% threshold, overfishing would be occurring. Management seeks to control the fishery by maintaining a population abundance above the minimum set by the overfished threshold. Ideally, the fishery would operate to meet the female abundance target while keeping the exploitation rate below the threshold (Table 1). In 2020, the exploitation rate was below both the target and threshold for the 13th consecutive year, which suggests that overfishing has not occurred since female-specific management was implemented in 2008.

E. Adaptive Management

(18) What factors influence progress toward the goal, target, threshold, or expected outcome?

Abundance estimates from the annual Winter Dredge Survey inform management when considering regulations for the next crabbing season. In addition to harvest, a number of

environmental factors affect blue crab abundance, including temperature, coastal currents, weather patterns, and predation.

(19) What are the current gaps in existing management efforts?

The three blue crab management jurisdictions (MDNR, VMRC, PRFC) have agreed that a benchmark stock assessment is not necessary at this time. However, MDNR has agreed to perform annual model runs to monitor the performance and suitability of the analytical framework and help guide the decision process for timing of the next benchmark stock assessment. CBSAC remains interested in developing a blue crab population model that would examine environmental drivers of blue crab productivity in the Bay. Such a model would provide a better understanding of population dynamics and could inform stock assessment model improvements to ensure that management is based on the best available science. The management jurisdictions also have ongoing efforts to improve the quality of catch and fishing effort data submitted by commercial and recreational crabbers. The [2021 Blue Crab Advisory Report](#) provides more information about management efforts.

(20) What are the current overlaps in existing management efforts?

Management of the blue crab population is facilitated among the three jurisdictions by the Chesapeake Bay Program's Sustainable Fisheries Goal Implementation Team (SFGIT). As a workgroup under the SFGIT, the Chesapeake Bay Stock Assessment Committee (CBSAC) meets each year to review the results of the Winter Dredge Survey and harvest data, and to develop management advice for the jurisdictions. Specifically, stock status is used to discuss, identify, and coordinate management actions across the three jurisdictions to improve consistency and effectiveness of the management response at a Bay-wide scale.

(21) According to the management strategy written for the outcome associated with this indicator, how will we (a) assess our performance in making progress toward the goal, target, threshold, or expected outcome, and (b) ensure the adaptive management of our work?

From the [management strategy](#) (page 11): Biological monitoring and assessing the progress toward the Blue Crab Abundance Outcome will occur through CBSAC's annual review of blue crab survey data and through its annual determination of population status relative to biological reference points. In particular, the jurisdictions will closely monitor annual exploitation rate estimates. It is the maintenance of the annual exploitation rate at or near target levels that maximizes the probability of achieving and maintaining the target abundance level. The continuation of the annual Bay-wide Winter Dredge Survey will be essential for monitoring the stock and determining whether management changes are needed to maintain fishing at target levels.

While the management jurisdictions have decided that a benchmark stock assessment is not necessary at this time, MDNR has agreed to perform annual model runs to monitor the performance and suitability of the analytical framework and help guide the decision process for timing of the next benchmark stock assessment

The jurisdictions, with input from CBSAC, will use the following approaches to ensure adaptive management:

- Conduct research and modeling exercises to address high-priority science and management needs;
- Use the best available science to update stock assessment models and estimate the blue crab population; and
- Discuss the management response when female abundance and/or exploitation rate fall outside the established reference point boundaries.

F. Analysis and Interpretation

Please provide appropriate references and location(s) of documentation if hard to find.

(22) What method is used to transform raw data into the information presented in this indicator? Please cite methods and/or modeling programs.

Female exploitation rate is calculated as the number of female crabs harvested in a given year (from jurisdiction harvest reports and 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 (from the Winter Dredge Survey). To compare the estimated exploitation rate with the biological reference points, the juvenile component of total crab abundance is scaled up by a factor of 2.5 to account for the assumption of reduced juvenile susceptibility to the Winter Dredge Survey, a method that was also implemented in the model-based stock assessment that generated the reference points.

The results of the Winter Dredge Survey are reported as crab density, or the average number of crabs found within a 1,000 meter by 1,000 meter area (crabs/1,000 m²). Managers estimate abundance, or the number of crabs, living in the Chesapeake Bay by multiplying the total crab density by the total area (m²) of the Bay. Each year, the overwintering mortality (the number of crabs that die in the winter) is also estimated and the abundance estimate is adjusted for that loss. Additional information about how abundance is calculated can be found on the [MDNR website](#).

(23) Is the method used to transform raw data into the information presented in this indicator accepted as scientifically sound? If not, what are its limitations?

Yes, the reference points were developed based on widespread convention in fisheries management. The Winter Dredge Survey and CBSAC's annual review of stock status

represent the best available science and expertise on blue crab population in the Chesapeake Bay.

(24) How well does the indicator represent the environmental condition being assessed?

This indicator is informed by data from the Winter Dredge Survey, which is one of the most comprehensive and statistically robust of all fisheries surveys conducted in the Bay. These data are therefore the most reliable and representative data available to estimate abundance of the blue crab population in the Chesapeake Bay.

(25) Are there established reference points, thresholds, ranges, or values for this indicator that unambiguously reflect the desired state of the environment?

Female-specific reference points, including female abundance and exploitation rate, have been used to evaluate the status of the Chesapeake Bay blue crab population since 2012, following their formal adoption by the jurisdictions in December 2011. These reference points were developed based on the theory of maximum sustainable yield (MSY), a widespread convention in fisheries management. 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 benchmark stock 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 abundance reference points were set accordingly at levels associated with 75% N_{UMSY} (target) and 50% N_{MSY} (threshold).

A stock assessment update was conducted in 2017, which included abundance data through 2017 and harvest data through 2016. The update generated new female-specific reference points. Following the same precedent above, the exploitation rate reference points changed to 28% (target) and 37% (threshold), and the female abundance reference points changed to 196 million (target) and 72.5 million (threshold). Given that they were generated using more recent data, CBSAC determined that these new reference points constitute the best available science by which the stock should be assessed and managed. Therefore, the jurisdictions (MDNR, VMRC, PRFC) formally adopted the new reference points in November 2020.

(26) How far can the data be extrapolated? Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g. statistical survey inference, no generalization is possible)?

Each year, the Winter Dredge Survey randomly samples 1,500 sites in three strata of the Chesapeake Bay, collecting crab density data (number of crabs/1,000 m²). Bay-

wide blue crab abundance is calculated by multiplying the total crab density by the total area (m²) of the Bay. The stratified random design of the Winter Dredge Survey ensures that these Bay-wide estimates of abundance are statistically robust. For more information about the Winter Dredge Survey and how it's used to determine blue crab abundance, see the following publication:

Sharov, A.F., J.H. Volstad, 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.
<http://www.ingentaconnect.com/content/umrsmas/bullmar/2003/00000072/00000002/art00021>

G. Quality

Please provide appropriate references and location(s) of documentation if hard to find.

For all questions in Section G, please refer to the following websites for information on the Winter Dredge Survey and the status of the stock:

Maryland Department of Natural Resources:
<http://dnr.maryland.gov/fisheries/Pages/blue-crab/dredge.aspx>

Virginia Institute of Marine Science:
http://www.vims.edu/research/units/programs/bc_winter_dredge/index.php

Chesapeake Bay Stock Assessment Committee's Blue Crab Advisory Report:
https://www.chesapeakebay.net/documents/2021_Blue_Crab_Advisory_Report_Final_06-22-21.pdf

- (27) Were the data collected and processed according to a U.S. Environmental Protection Agency-approved Quality Assurance Project Plan? If so, please provide a link to the QAPP and indicate when the plan was last reviewed and approved. **If not, please complete questions 28-31. No.**
- (28) *If applicable:* Are the sampling, analytical, and data processing procedures accepted as scientifically and technically valid? **Yes, see links above.**
- (29) *If applicable:* What documentation describes the sampling and analytical procedures used? **See links above.**
- (30) *If applicable:* To what extent are procedures for quality assurance and quality control of the data documented and accessible? **See links above.**
- (31) Are descriptions of the study design clear, complete, and sufficient to enable the study to be reproduced? **Yes, see links above.**

(32) Were the sampling, analytical, and data processing procedures performed consistently throughout the data record?

The Winter Dredge Survey design was slightly modified in the early 1990s but has been consistent since 1994. See method details at the following link:
http://www.vims.edu/research/units/programs/bc_winter_dredge/methods/details/index.php

The status of the stock has been determined based on female-specific reference points since 2012, after being developed and adopted in 2011. This year, 2021, was the first year that the new reference points from the 2017 stock assessment update were used to assess stock status.

(33) If data sets from two or more sources have been merged, are the sampling designs, methods, and results comparable? If not, what are the limitations?

Yes. The Maryland Department of Natural Resources (MDNR) conducts the survey in the Maryland portion of the Bay and the Virginia Institute of Marine Science (VIMS) conducts the survey in the Virginia portion of the Bay. The survey is a coordinated effort between the jurisdictions and they use the same sampling design and methods. Data are combined from both jurisdictions to calculate a Bay-wide population estimate. Estimates of gear efficiency differ between the jurisdictions, but catchability coefficients have been calculated to adjust for vessel differences over the years and between jurisdictions. Scientists continue to discuss and compare these estimates each year and are considering future studies to further compare gear efficiency and selectivity between Maryland and Virginia.

(34) Are levels of uncertainty available for the indicator and/or the underlying data set? If so, do the uncertainty and variability impact the conclusions drawn from the data or the utility of the indicator?

Estimating, managing, and reporting uncertainty is an ongoing priority of the blue crab management jurisdictions and CBSAC. CBSAC's annual Blue Crab Advisory Report provides advice to management and identifies high-priority science needs, such as reducing uncertainty in abundance estimates generated by the Winter Dredge Survey. CBSAC has also recommended further research on the effectiveness of the dredge gear at sampling crabs of various sizes in differing sediment types. In terms of exploitation estimates, all three management jurisdictions have ongoing efforts to improve the quality of catch and fishing effort data submitted by commercial and recreational harvesters.

(35) For chemical data reporting: How are data below the MDL reported (i.e., reported as 0, censored, or as < MDL)? If parameter substitutions are made (e.g., using

orthophosphate instead of total phosphorus), how are data normalized? How does this impact the indicator? **N/A**

(36) Are there noteworthy limitations or gaps in the data record? **No.**

H. Additional Information (*Optional*)

(37) Please provide any further information you believe is necessary to aid in communication and prevent any potential misrepresentation of this indicator.

For more information, please refer to the following:

Maryland Department of Natural Resources:

<http://dnr.maryland.gov/fisheries/Pages/blue-crab/dredge.aspx>

Virginia Institute of Marine Science:

http://www.vims.edu/research/units/programs/bc_winter_dredge/index.php

Chesapeake Bay Stock Assessment Committee's Blue Crab Advisory Report:

https://www.chesapeakebay.net/documents/2021_Blue_Crab_Advisory_Report_Final_06-22-21.pdf