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

Indicator Title: Blue Crab Abundance

Relevant Outcome(s): Sustainable Fisheries

Relevant Goal(s): Blue Crab Abundance

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?

Blue crab abundance data for the Chesapeake Bay are collected by the annual Winter Dredge Survey, which is conducted by the Maryland Department of Natural Resources (MDNR) and the Virginia Institute of Marine Science (VIMS). The Winter Dredge Survey provides information that is essential for management of the species, including the estimated number of crabs overwintering in the Bay and the number of juveniles entering the population each year. The number of mature adult females is also estimated and is an important indicator of future spawning potential. Estimating the total number of crabs in the Bay allows the jurisdictions to calculate the percentage of the population that is removed by harvest each year.

All crabs collected in the Winter Dredge Survey are measured from spine to spine across the top shell (carapace width) and weighed. The sex of each crab is determined and female maturity is noted. Winter Dredge Survey results 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 m^2). Crab density is then used to calculate an overall estimate of blue crab abundance, in addition to estimates by age and maturity. Additional information about how abundance is calculated can be found on the MDNR website.

(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
- Custodian(s): 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.

(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)?

The Winter Dredge Survey collects blue crab data in three strata of the Chesapeake Bay: Lower Bay, Middle Bay, and Upper Bay/Tributaries. A map of sampling stations can be found here. The data from each strata are aggregated to determine Bay-wide blue crab abundance.

(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. Each year, the Winter Dredge Survey randomly samples a total of 1,500 sites in Chesapeake Bay waters deeper than 5 feet. The number of sites sampled in each of the three strata is proportional to its area. The data from each strata are aggregated to determine Bay-wide blue crab abundance.

Please submit any appropriate examples of how this information has been mapped or otherwise portrayed geographically in the past.

These data are not currently mapped, but could be, in consultation with MDNR and VIMS, to show the relative densities of crabs sampled at each station for a given year.

D. Communicating the Data

(10) 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. From 2012 through 2020, abundance 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 threshold abundance of 70 million mature adult female crabs (age 1+) increased to 72.5 million, and the target abundance of 215 million adult females decreased to 196 million. The target abundance is the ideal abundance of adult females in the population to maximize the sustainable yield of the fishery, i.e. the number of spawning-age females needed to naturally replenish the population while allowing for sustainable harvest. Therefore, managers aim to maintain the abundance of adult females **at or above** the target reference point. While an estimated abundance below the target is not ideal, the population would not be considered depleted (overfished) unless the abundance falls below the threshold of 72.5 million. At that point, further management actions, such as increased fishery restrictions, could be required to improve the stock.

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

The 2021 estimate of 158 million adult female crabs is above the new threshold of 72.5 million, but below the new target of 196 million. Based on analysis of the 2020-2021 survey data, the Chesapeake Bay blue crab stock is currently not depleted. Therefore, CBSAC concludes that substantial changes in management are not necessary at this time.

(12) 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 abundance target from the 2011 assessment was 215 million adult females, and the threshold was 70 million. 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 a target of 196 million adult females 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.

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

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

Blue crab population abundance is expected to fluctuate from year to year due to natural variability in the species' biology and environmental conditions which influence recruitment, growth, and mortality. The Chesapeake Bay blue crab population experienced relatively low levels of abundance from the early 1990s through the 2000s. In 2008, managers implemented female-specific management measures in an attempt to increase the natural resiliency of the population by protecting spawning females. This resulted in a substantial increase in female abundance in 2009, and a higher mean female abundance post-2008 compared to pre-2008. The abundance of mature adult females has remained within the reference points since 2015 and reached a record high in 2017.

(15) 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 2021 abundance estimate of 158 million adult female crabs represents a 12% increase from the 2020 estimate of 141 million. Blue crab populations exhibit natural variability due to their biology and to environmental factors such as temperature, coastal currents, weather patterns, and predation. Blue crab abundance in the Chesapeake Bay is expected to exhibit annual fluctuations as a result of this natural variability, as seen in recent years.

(16) 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. Managers aim to

regulate the fishery by maintaining a population abundance above the minimum set by the depleted (overfished) threshold. A decrease in abundance of mature adult females below this threshold would warn managers of potential stock collapse and can be used to trigger more restrictive management measures that would allow the population to rebuild. Collapse of the stock would not only affect the fishery and economy, but also the ecology of the Chesapeake Bay ecosystem, as blue crabs are both a key predator and prey species within the Bay. It is also important to note, however, that blue crab populations are naturally variable due to biological and environmental factors (i.e. temperature, precipitation, currents, habitat availability) that affect their survival, recruitment, and abundance. The recent fluctuations in the Chesapeake Bay blue crab population can likely be attributed to such external factors affecting recruitment success and survival.

E. Adaptive Management

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

In addition to harvest, a number of ecological and environmental factors affect blue crab abundance, including temperature, coastal currents, weather patterns, and predation.

(18) 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 2021 Blue Crab Advisory Report provides more information about management efforts.

(19) 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.

(20) 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.

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

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 m^2). Managers estimate abundance, or the number of crabs, living in the Chesapeake Bay by multiplying the total crab density by the total area (m^2) 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.

(22) 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, estimating abundance from density data is common. Additional information about how abundance is calculated can be found on the MDNR website. For more information about the Winter Dredge Survey and how it is 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

(23) 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.

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

The estimated abundance target from the 2011 assessment was 215 million adult females, and the threshold was 70 million. However, a 2017 stock assessment update, which included abundance data through 2017 and harvest data through 2016, generated new female-specific reference points with a target of 196 million adult females and a threshold of 72.5 million. These reference points were developed and recommended based on the theory of maximum sustainable yield, a widespread convention in fisheries management.

(25) 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 m^2). Bay-wide blue crab abundance is calculated by multiplying the total crab density by the

total area (m^2) 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 is 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 more information:

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

(26) 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.**

(27) *If applicable:* Are the sampling, analytical, and data processing procedures accepted as scientifically and technically valid? **Yes, see links above.**

(28) *If applicable:* What documentation describes the sampling and analytical procedures used? **See links above.**

(29) *If applicable:* To what extent are procedures for quality assurance and quality control of the data documented and accessible? **See links above.**

(30) Are descriptions of the study design clear, complete, and sufficient to enable the study to be reproduced? **Yes, see links above.**

(31) 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.

(32) 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.

(33) 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.

(34) 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**

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

H. Additional Information (*Optional)*

(36) 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