**Chesapeake Bay Program | Indicator Analysis and Methods Document**
*Blue Crab Abundance | Updated 6/15/2020*

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 Chesapeake Bay are produced by the annual Winter Dredge Survey 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 the 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 spawning-age females is also estimated and is an important indicator of future spawning potential. Estimates of the total number of crabs in the Bay allow 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/1000 $m^2$). Crab density is then used to calculate an overall estimate of blue crab abundance, in addition to estimates by age and maturity (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: Glenn Davis (MDNR)
- Chesapeake Bay Program Contacts (name, email address, phone number):
  Bruce Vogt, bruce.vogt@noaa.gov, 410-267-5655
  Mandy Bromilow, mandy.bromilow@noaa.gov, 410-267-5667

(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 (2020 report here) includes the abundance, harvest, and exploitation rate data. The full data set and calculations are provided by the blue crab management jurisdictions 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
http://www.vims.edu/research/units/programs/bc_winter_dredge/methods/index.php

**B. Temporal Considerations**

(4) Data collection date(s): 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 2021

**C. Spatial Considerations**

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

Chesapeake Bay mainstem and tributaries (map of sampling stations can be found here).

(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.

(10) 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**

(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 the female-specific reference points for abundance. The female-specific reference points were developed and recommended in the most recent benchmark stock assessment in 2011, which was conducted by the Maryland Department of Natural Resources (MDNR), Virginia Marine Fisheries Commission (VMRC), and NOAA Chesapeake Bay Office (NCBO). The reference points were formally adopted by the three management jurisdictions (MDNR, VMRC, Potomac River Fisheries Commission – PRFC) in December 2011, and include a target of 215 million spawning-age females and a threshold of 70 million spawning-age females. The target abundance is the ideal abundance of age-1+ 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 spawning-age 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 70 million. At that point, further management actions, such as increased fishery restrictions, would be required to improve the stock.

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

The 2020 estimate of 141 million spawning-age female crabs is above the threshold of 70 million, but below the target of 215 million. Based on analysis of the 2019-2020 survey 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.

(13) Has a new goal, target, threshold, or expected outcome been established since the last reporting period? Why? **No.**

(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)?

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 spawners. 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 spawning-age females has remained within the reference points since 2015 and reached a record high in 2017.

(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 2020 abundance estimate of 141 million spawning-age females represents a -26% decrease from the 2019 estimate of 191 million but is similar to the 2018 estimate of 147 million spawning-age females. Blue crab populations exhibit natural variability due to their biology and environmental factors such as temperature, coastal currents, weather patterns, and predation. Blue crab abundance in Chesapeake Bay is expected to exhibit annual fluctuations as a result of this natural variability, as seen in recent years.

(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 the 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 spawning-age 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 their biology 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**

(18) 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.

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

The three blue crab management jurisdictions (State of Maryland, Commonwealth of Virginia, and Potomac River Fisheries Commission) have agreed that a benchmark stock assessment is not necessary at this time. However, MDNR has agreed to perform annual stock assessment updates to include in CBSAC's Blue Crab Advisory Report along with the Winter Dredge Survey results to inform when a future benchmark stock assessment will be necessary. CBSAC is also 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 2020 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 stock is coordinated 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 three jurisdictions. Specifically, stock status is used to discuss, identify, and coordinate management response across the three jurisdictions to improve consistency and effectiveness 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 fraction estimates. It is the maintenance of the annual exploitation fraction 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 stock assessment updates to include in CBSAC's Blue Crab Advisory Report along with the Winter Dredge Survey results. These annual updates will help determine the status of the stock, monitor model performance, and 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 priority science and management needs.
- Use the best available science to update stock assessment models and estimate the blue crab population.
- Discuss the management response when female abundance and/or exploitation fraction 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.

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/1000 $m^2$). Managers estimate abundance, or the number of crabs, living in Chesapeake Bay by multiplying the total crab density by the total area ($m^2$) of the Bay. Each year, the overwintering mortality, or the number of crabs that die in the winter, is also estimated and the abundance estimate is adjusted for that loss (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 Winter Dredge Survey is the most comprehensive and statistically robust of the blue crab surveys conducted in the Bay and estimating density from abundance data is common. For more information, 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

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

Female-specific reference points were formally adopted by the three Chesapeake Bay management jurisdictions following the benchmark stock assessment in 2011, including female abundance. This indicator is informed by data from the Winter Dredge Survey, which is the most comprehensive and statistically robust of all blue crab surveys conducted in the Bay. These data are therefore the most reliable and representative data available to estimate the blue crab population in Chesapeake Bay.

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

The 2011 benchmark stock assessment recommended female-specific reference points for blue crab abundance, which included a target of 215 million spawning-age females and a threshold of 70 million spawning-age females. These reference points were developed and recommended based on widespread convention in fisheries management and were formally adopted by all three management jurisdictions in December 2011. A stock assessment update was conducted in 2017 to examine the suitability of the model and reference points for the survey and harvest data through 2016-2017. The results of this assessment were presented to the Chesapeake Bay Program's Sustainable Fisheries Goal Implementation Team (SFGIT) at the biannual meeting in June 2019. Management leadership of the SFGIT decided not to adopt the updated reference points in 2019, but discussions regarding the new reference points continue in 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)?

The Winter Dredge Survey is the most comprehensive and statistically robust of the blue crab surveys conducted in the Bay, and estimating density from abundance data is common. For more information, 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
http://www.vims.edu/research/units/programs/bc_winter_dredge/methods/details/index.php

Chesapeake Bay Stock Assessment Committee's Blue Crab Advisory Report:
https://www.chesapeakebay.net/documents/CBSAC_2018_Crab_Advisory_Report_Final.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 the method details in the following link:

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

(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 conducts the survey in the Maryland portion of the Bay and the Virginia Institute of Marine Science 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 on priority science needs, which has recently focused on 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.

(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/2020_Blue_Crab_Advisory_Report_Final_06-22-20.pdf