Chesapeake Bay Program | Indicator Analysis and Methods Document
Blue Crab Management | Updated 6/16/2020

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 fraction (percent harvested) of female blue crabs in Chesapeake Bay.
Exploitation fraction estimates are 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. Harvest
data are reported to the management jurisdictions by crabbers, and crab abundance is
estimated by the Winter Dredge Survey. To calculate the exploitation fraction, 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 survey, a method that was also
implemented in the model-based stock assessment that generated the reference points.
Therefore, exploitation rate estimates can be compared with the model-derived
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)
- 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): Blue crab abundance data have been collected annually December-March since the start of the Winter Dredge Survey in 1990. Annual exploitation fraction data are reported for the previous year because the exploitation fraction cannot be calculated until the fishery closes at the end of the year. For example, in 2020, abundance estimates were reported from the 2020 Winter Dredge Survey, but the exploitation fraction was reported for the 2019 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 2021

C. Spatial Considerations

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

Bay-wide (where crabs are harvested) and by jurisdiction.

(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
fishery based on the female-specific reference points for abundance and the percentage
of the population harvested (exploitation fraction). Following precedent adopted by the
New England and Mid-Atlantic Fishery Management Councils, the female-specific
reference points were 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 new reference points were developed based on maximum sustainable
yield, i.e. maximizing catch over time without risking stock collapse, and were formally
adopted by the three management jurisdictions (MDNR, VMRC, Potomac River Fisheries
Commission – PRFC) in December 2011. The recommended target exploitation fraction
(i.e. the percentage of the population harvested) is 25.5% and the recommended
threshold (or maximum percent harvested) is 34%.

The recommended target <u>abundance</u> of spawning-age females is 215 million and the
threshold is 70 million. Managers aim to maintain age 1+ female abundance at or above
the target reference point and restrain fishery harvest below the threshold exploitation
fraction. If the abundance falls below the threshold, the population would be
considered depleted (overfished); if the exploitation fraction exceeds the threshold,
overfishing is occurring. In both these scenarios, further management actions would be
required to increase harvest restrictions 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 seven years.

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

Control Rule	Reference Points			Stock Status						
	Period	Target	Threshold	2014	2015	2016	2017	2018	2019	2020
Exploitation Fraction (age 0+ female crabs)	Current, Female-Specific	25.5%	34% (max)	17%	15%	16%	21%	23%	**17%**	TBD

Abundance (millions of age 1+ female crabs)	Current, Female-Specific	215	70 (min)	68.5	101	194	254	147	191	**141**

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

The exploitation fraction, or percentage of age 0+ female crabs removed by fishing, was approximately 17% in 2019. This is below both the target of 25.5% and the threshold of 34% for the 12th consecutive year since female-specific management measures were implemented in 2008, which suggests that management has been effective. 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. CBSAC recommends that the jurisdictions implement procedures that provide accurate accountability of all commercial and recreational harvest moving forward, as this is an important component for accurately assessing exploitation rates and stock health.

(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)?

The female exploitation fraction has varied from 1990-2019. The exploitation fraction was above the overfishing threshold (34%) from the mid-1990s through the early 2000s. Since female-specific management measures were implemented in 2008, the exploitation fraction has remained below the target (25.5%) and the threshold (34%).

(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?

Although the exploitation fraction had been increasing steadily the last few years, the exploitation fraction (expressed as the percentage of the females removed by fishing) decreased from 23% to 17% from 2018 to 2019. Despite increased harvest, the decrease in exploitation may have been a result of above average recruitment in 2019. High recruitment results in a greater estimate of total blue crab abundance in the Bay, but the smaller juveniles are not harvested within the fisheries. Because the exploitation

fraction is the number of females removed by fishing divided by the total number of female crabs in the population, and not the total number of harvestable females, the exploitation rate decreases when there is above average recruitment.

(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 and exploitation fraction. If female abundance falls below the threshold of 70 million, the stock would be considered depleted. If the female exploitation rate exceeds the 34% threshold, the stock would be considered overfished. Management seeks to restrain the fishery by maintaining a population abundance above the minimum set by the depleted (overfished) threshold. Ideally, the fishery would operate to meet the abundance target value while keeping the exploitation fraction below the threshold (Table 1). In 2020, the exploitation fraction was below both the target and threshold for the 12th 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 contribute to 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 determine if a benchmark stock assessment is 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 management jurisdictions also have ongoing efforts to improve the quality of catch and fishing effort data submitted by commercial and recreational harvesters. 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.

Estimated exploitation fraction 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. Harvest data are reported to the management jurisdictions by crabbers, and crab abundance is estimated by the Winter Dredge Survey. To calculate the exploitation fraction, 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 survey, a method that was also implemented in the model-based stock assessment that generated the reference points. Therefore, exploitation rate estimates can be compared with the model-derived reference points.

(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. 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 based on the recommendations from the 2011 benchmark stock assessment. The Winter Dredge Survey and CBSAC's annual review of stock status represent the best available science and expertise on Chesapeake Bay blue crabs.

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

This indicator represents the stock status of the Chesapeake Bay blue crab and 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. The indicator is therefore based on the most reliable and representative data source available to estimate the blue crab population. Management aims to control the fishery by maintaining the abundance of age 1+ females above the threshold of 70 million. Ideally, the fishery should operate to meet target values and maintain values below the exploitation fraction threshold and above the abundance threshold.

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

The 2011 blue crab stock assessment recommended a control rule based on female-specific reference points. These female-specific reference points were developed using an MSY approach. U_{MSY} is defined as the level of fishing (expressed as the percentage of the population harvested) that achieves the largest average catch that can be sustained over time without risking stock collapse. Following precedent adopted by the New

England and Mid-Atlantic Fishery Management Councils, the 2011 assessment recommended a target exploitation level that was associated with 75% of the value of U_{MSY} and a threshold exploitation level set equal to U_{MSY}. The female-specific age 1+ abundance 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 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

For information on the analysis and methods used to support the Chesapeake Bay Program indicator of Blue Crab Abundance, please visit: http://www.chesapeakeprogress.com/abundant-life/blue-crab-abundance.

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/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 websites above for specific method details. The status of the stock has been determined based on the female-specific reference points since 2012, after being developed and adopted in 2011.

(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. In terms of exploitation fraction 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/2020_Blue_Crab_Advisory_Report_Final_06-22-20.pdf