Chesapeake Bay Program | Indicator Analysis and Methods Document
[Blue Crab Management] | Updated [6/25/2018]

Indicator Title: Blue Crab Management

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

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 shows the annual exploitation fraction (percent harvested) of female blue crabs in the Chesapeake Bay. Annual estimates of exploitation fraction are calculated as the annual 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 is reported by crabbers to the management jurisdictions and crab abundance is estimated by the Winter Dredge Survey. As part of this calculation, the juvenile component of the total estimated number of crabs was scaled up by a factor of 2.5 so that the empirical estimate of exploitation uses the same assumption about juvenile susceptibility to the survey as the model-based stock assessment that generated the reference points. Thus, the empirical estimates of exploitation rate can be compared with the assessment model derived target (25.5%) and threshold (34%) reference points.

(2) List the source(s) of the data set, the custodian of the source data, and the relevant contact at the Chesapeake Bay Program.

- Source: Maryland Department of Natural Resources, Virginia Institute of Marine Science and Virginia Marine Resources Commission, Potomac River Fisheries Commission
- Custodian: Glenn Davis (MDDNR)
- Chesapeake Bay Program Contact (name, email address, phone number): 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 annual Blue Crab Advisory Report (2018 Report here) includes the abundance, harvest and exploitation rate data. The full data set and calculations are provided by the blue crab management jurisdictions.

Abundance data (Winter Dredge Survey)
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 are reported from 1990-present. 1990 is when the Winter Dredge Survey began. Annual exploitation fraction data are reported for the previous year because the exploitation fraction cannot be calculated until the end of the year after the fishery closes. For example, in 2018, abundance estimates were reported from the 2018 winter dredge survey, but the exploitation fraction was reported for 2017 harvest.

(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: May/June 2019

C. Spatial Considerations

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

Baywide (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?

The 2011 blue crab benchmark stock assessment recommended new female-
specific reference points based on achieving the maximum sustainable yield
(MSY). 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} (25.5%) and a threshold exploitation level set equal to
U_{MSY} (34%). The female-specific, age-1+ abundance target and threshold were
set accordingly at abundance levels associated with $N_{0.75*UMSY}$ (target=215
million) and 50% N_{MSY} (threshold=70 million). These female-specific reference
points were formally adopted by all three management jurisdictions in
December 2011.

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	2012	2013	2014	2015	2016	2017	2018
Exploitation Fraction (age 0+ female crabs)	Current, Female-specific	25.5%	34% (max)	10%	23%	17%	15%	16%	**21%**	TBD
Abundance (millions of age 1+ female crabs)	Current, Female-Specific	215	70 (min)	97	147	68.5	101	194	254	**147**

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

The exploitation fraction (percentage of all female crabs (ages 0+) removed by fishing) in 2017 was approximately 21%. This exploitation fraction is below the target of 25.5% and the threshold of 34% for the tenth consecutive year since female-specific management measures were implemented in 2008.

(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)?

From 1990-2017, the female exploitation fraction has varied. 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?

The 2017 exploitation fraction of 21% shows an increase over the last several years. The three management jurisdictions implemented additional commercial harvest restrictions, mostly lower bushel limits, for females for the 2014 season in response to the depleted abundance of females in 2014. Maryland increased these bushel limits in 2015 and 2016. The Potomac River Fisheries Commission and Virginia have maintained the levels set in 2014. All three jurisdictions extended the season in 2016.

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

The status of the of the Chesapeake Bay blue crab population is based on the female-specific reference points for abundance and exploitation fraction. If the estimated 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. The Chesapeake Bay blue crab stock is currently not depleted and overfishing is not occurring. Management seeks to control the fishery such that the number of crabs in the population remains above the minimum set by the overfished (depleted) threshold. Ideally, the fishery should operate to meet target values and should never surpass the exploitation fraction threshold value and never go below the abundance threshold value (Table 1).

E. Adaptive Management

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

A number of environmental factors contribute to crab abundance, including winter temperatures, coastal currents, weather patterns and natural predators. Harvest also contributes to abundance levels. Abundance estimates from the annual Winter Dredge Survey inform management when considering regulations for the next crabbing season.

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

The three blue crab management jurisdictions (the state of Maryland, Commonwealth of Virginia, and the Potomac River Fisheries Commission (PRFC) are currently discussing the next blue crab stock assessment to combine the most recent information on blue crab biology and the blue crab fishery to provide guidance on the health and management of the population, including additional guidance on the female reference points if necessary. Timing, assessment details, and funding have not been identified for the stock assessment.

The management jurisdictions also have ongoing efforts to improve the quality of catch and fishing effort information submitted by commercial and recreational harvesters. The 2018 Blue Crab Advisory Report provides more information.

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

Management of the blue crab stock is coordinated among the 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 meets each year to review the results of annual Chesapeake Bay blue crab surveys and harvest data, and to develop management advice for the jurisdictions published in an annual Blue Crab Advisory Report.

(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 and Management Outcomes will occur through the 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 Baywide Winter Dredge Survey will

be essential for the biological monitoring of the stock and for determining whether management changes are needed to maintain fishing at target levels.

If a future benchmark stock assessment recommends refined estimates of biological reference points (fishing levels and abundance) the jurisdictions will assess fishery performance relative to these new benchmarks.

The jurisdictions with stakeholder input will use the following approaches to ensure adaptive management:
- The jurisdictions and CBSAC will continue to estimate the population of blue crabs by using the best available data and incorporating new data when available.
- Scientists who work on the benchmark stock assessments will continue to update stock assessment models and incorporate the best available data to address priority research and management needs.
- Management jurisdictions with stakeholder input will discuss management response when female population abundance and/or the exploitation fraction do not fall within the boundaries of the established reference points.

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.

Annual estimates of exploitation fraction are calculated as the annual 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 is reported by crabbers to the management jurisdictions and crab abundance is estimated by the Winter Dredge Survey. As part of this calculation, the juvenile component of the total estimated number of crabs was scaled up by a factor of 2.5 so that the empirical estimate of exploitation uses the same assumption about juvenile susceptibility to the survey as the stock assessment that generated the reference points. Thus, the empirical estimates of exploitation rate can be compared with the assessment model derived target (25.5%) and threshold (34%) 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. The female-specific reference points were formally adopted by all three management jurisdictions in December 2011 based on the recommendations from the 2001 blue crab benchmark stock assessment. These reference points were

developed and recommended based on widespread convention in fisheries management. The Winter Dredge Survey and Chesapeake Bay Stock Assessment Committee'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 status of the Chesapeake Bay blue crab stock. Management seeks to control the fishery such that the number of crabs in the population remains above the minimum set by the overfished (depleted) threshold. Ideally, the fishery should operate to meet target values and should never surpass the exploitation fraction threshold value and never go below the abundance threshold value.

(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 assessment recommended a control rule based on biological reference points for the female component of the population. The application of a control rule to management of the blue crab fisheries was first adopted by the Bi-State Blue Crab Advisory Committee in 2001[3]. The current female-specific targets and thresholds 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 target and threshold were set accordingly at abundance levels associated with $N_{0.75*UMSY}$ (target) and 50% N_{MSY} (threshold).

(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 Chesapeake Bay Stock Assessment Committee adopted the Baywide Winter Dredge Survey (WDS) as the primary indicator of blue crab population health in 2006 because it is the most comprehensive and statistically robust of the blue crab surveys conducted in the Bay. 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.

For information on the analysis and methods used to support the Chesapeake Bay Program indicator of Female Blue Crab Abundance, based on the WDS, please see 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 to the Blue Crab Advisory Report for information on 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 29-31.** No.

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

(29) *If applicable:* What documentation describes the sampling and analytical procedures used?

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 2018 Blue Crab Advisory Report:
https://www.chesapeakebay.net/documents/CBSAC_2018_Crab_Advisory_Report_Final.pdf

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

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

(32) Were the sampling, analytical and data processing procedures performed consistently throughout the data record? Yes. The Winter Dredge Survey design was slightly modified in the early 1990s as noted on the above websites. The status of the stock was determined based on the female-specific reference points starting in 2012 after they were developed and adopted.

(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 winter dredge survey has been designed to be a collection program that utilizes consistent collection patterns Baywide. Catchability coefficients have been determined to adjust for vessel differences over the years and between jurisdictions.

(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?

Uncertainty for abundance estimates is shown in the annual Blue Crab <u>Advisory Report</u>.

Identifying areas of uncertainty and developing strategies to address them are ongoing priorities of the Chesapeake Bay blue crab management jurisdictions. The annual CBSAC Blue Crab Advisory Reports contain advice to the Chesapeake Bay management jurisdictions on priority areas of uncertainty. Currently, priorities are focused on studies that would reduce uncertainty in estimates of crab abundance generated by the Baywide Winter Dredge Survey. Specifically, the CBSAC has recommended work to acquire a better understanding of the effectiveness of the dredge gear at sampling crabs of various sizes in differing sediment types. The CBSAC has also recommended that the jurisdictions continue to advance methods to improve the accounting of commercial harvest and to better understand recreational harvest in the jurisdictions. All three Chesapeake Bay management jurisdictions have ongoing efforts to improve the quality of catch and fishing effort information 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/CBSAC_2018_Crab_Advisory_Report_Final
.pdf