Indicator(s) Title(s): Female Blue Crab Abundance and Harvest

Relevant Outcome(s): 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?

Blue crab abundance data for the Chesapeake Bay are collected from the annual Winter Dredge Survey (WDS), which is conducted by the Maryland Department of Natural Resources (MDNR) and the Virginia Institute of Marine Science (VIMS). The WDS measures the density of crabs (number/1,000 m²) at approximately 1,500 sites throughout the Bay each year. All crabs sampled in the survey are measured from spine to spine across the top shell (i.e., carapace width) and weighed. The sex and maturity of each crab are also noted. Measured crab densities are then expanded to the area of the Chesapeake Bay (9,812 km²), providing an annual estimate of the total number of blue crabs in the Bay by age, sex, and maturity. The WDS also provides an estimate of overwintering mortality based on the percentage of dead crabs found in the survey each year.

The WDS provides information that is essential for blue crab management in the Chesapeake Bay, including the number of juveniles entering the population each year and the number of mature adult females present; these are important indicators of the population’s recruitment and spawning potential, respectively. When paired with harvest data from each of the three jurisdictions, WDS estimates of abundance also allow managers to estimate exploitation rates, which are calculated as crab harvest (not including discards, bycatch, or unreported losses) divided by the total number of crabs (age 0+) estimated in the population at the start of the crabbing season. Managers assess the blue crab stock status annually by comparing the WDS estimates of adult female abundance and female exploitation rate to female-specific management 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
- **Custodian(s):** Glenn Davis (MDNR), Rom Lipcius (VIMS)
- **Chesapeake Bay Program Contacts (name, email address, phone number):**
  - Mandy Bromilow, mandy.bromilow@noaa.gov, 240-653-9028
  - Bruce Vogt, bruce.vogt@noaa.gov, 240-628-4812

(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 abundance and harvest data for each year since the Winter Dredge Survey began in 1990. The Advisory Report 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://dnr.maryland.gov/fisheries/Pages/blue-crab/dredge.aspx)

**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 (WDS) in 1990. Annual exploitation rates (harvest) 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 2022, abundance estimates were reported from the 2022 WDS (conducted December 2021-March 2022), but the exploitation fraction was reported for the 2021 harvest season (April – December 2021).

(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 2023

**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 (WDS) collects blue crab data at a total of 1,500 sites (>5 feet deep) across three strata of the Chesapeake Bay: Lower Bay, Middle Bay, and Upper Bay/Tributaries. 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 annually. The jurisdictions collect harvest biomass information each year which, in combination with the abundance data from the WDS, 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.
No.

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

Blue crab abundance 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 target or threshold measured by this indicator? How was it established?

The female abundance indicator provides information about the status of the Chesapeake Bay blue crab population based on female-specific reference points for adult female 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 fisheries scientists at the University of Maryland Center for Environmental Science (UMCES), MDNR, VIMS, Virginia Marine Resources Commission (VMRC), and the NOAA Chesapeake Bay Office (NCBO). In November 2020, the three jurisdictions that manage blue crab harvest in the Chesapeake Bay (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 abundance data through 2017 and harvest data through 2016. 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.
With the acceptance of the new reference points, the threshold abundance of 70 million 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 overfished (i.e., depleted) 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. For the female harvest indicator, stock status is also determined by assessing estimates of female exploitation rate relative to a target (28%) and threshold (37%). Managers aim to restrain fishery harvest below the threshold exploitation rate to prevent overfishing.

(12) What is the current status in relation to the target established in the outcome?
   Why? Would you define our outlook\(^1\) toward achieving the outcome as on course, off course, uncertain, or completed? Upon what basis are you forecasting the outlook?

In 2022, 97 million adult female blue crabs were estimated to be present in the Chesapeake Bay. This estimate is below the management target of 196 million adult females, but above the threshold of 72.5 million. Because the abundance of adult females is above the threshold, the population is not considered overfished or unsustainable, and therefore, the outlook toward achieving the Blue Crab Abundance Outcome remains on course. Additionally, the initial estimate of the female exploitation rate for the 2021 harvest season was 26%, which is below the exploitation threshold, indicating that overfishing is not occurring. However, CBSAC is concerned with the recent declines in blue crab abundance and is in the process of identifying and addressing potential causes.

(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 Chesapeake Bay blue crab population experienced relatively low levels of abundance from the early 1990s through the 2000s. In 2008, fisheries managers implemented female-specific management measures in an attempt to increase the
natural resiliency of the population by protecting spawning-age females (age 1+). This resulted in a substantial increase in female abundance in 2009, and a higher mean female abundance post-2009 compared to pre-2009. The abundance of mature adult females has remained within the reference points since 2015 and reached a record high in 2017. In the last few years, however, the abundance of mature females has declined. The 2022 estimate is the lowest since 2014, when female abundance fell below the management threshold (then 70 million adult females). The female exploitation rate was above the overfishing threshold from the mid-1990s through the early 2000s, but has remained below both the target and threshold since 2008.

(16) What change(s) does the most recent data show compared to the last reporting period? To what do you attribute the change? Would you characterize that change in the recent progress as an increase, decrease, no change, or completed for this outcome?

The 2022 abundance estimate of 97 million adult female blue crabs represents a 39% decrease from the 2021 estimate of 158 million. Although it is well-known that blue crab populations exhibit natural annual variability due to their biology and other environmental factors, CBSAC is interested in better understanding how these factors drive blue crab population dynamics. CBSAC is in the process of identifying the key drivers to be addressed and will discuss how these factors might be incorporated into future stock assessments at a workshop in September 2022.

The preliminary estimate of female exploitation rate (harvest) was approximately 26% in 2021, which was a slight increase from the 2020 estimate of 23%. Although estimated harvest of female crabs increased, the exploitation rate was still below the target (28%) and threshold (37%), indicating that overfishing was not occurring.

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

These indicators provide information about the status of the Chesapeake Bay blue crab population based on female-specific reference points for abundance and harvest rate. Managers aim to regulate the fishery by maintaining a female abundance at or above the target (196 million), or at minimum, above the overfished threshold (72.5 million). 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.

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 population dynamics, including temperature, hypoxia, coastal currents, habitat availability, predation, and disease. These factors, in addition to their basic biology (i.e., short life span), contribute to the natural variability common in blue crab populations. Additional information about factors influencing progress toward this outcome can be found in the Blue Crab Management Strategy.

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

With the recent declines in blue crab abundance, CBSAC is concerned about the population’s lack of response to management actions. This apparent disconnect has led to CBSAC’s recommendation for a new benchmark stock assessment, which would reassess model assumptions and potentially take into consideration the effects of key population drivers. Therefore, CBSAC is working to better understand the ecological and environmental factors that affect blue crab population dynamics and identify the ones that may be driving the recent declines in abundance. Reliable harvest reporting has also remained a key data gap for accurate assessment of the blue crab stock. Additional information about CBSAC’s management recommendations and science gaps can be found in the 2022 Blue Crab Advisory Report.

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

Management of the blue crab stock is coordinated among the three jurisdictions (MDNR, VMRC, and PRFC) by the Sustainable Fisheries Goal Implementation Team (SFGIT). The Chesapeake Bay Stock Assessment Committee (CBSAC), a technical workgroup of the SFGIT, meets each year to review the results of the Winter Dredge Survey and harvest data, and to develop management recommendations 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?

To assess progress toward the Blue Crab Abundance Outcome, CBSAC conducts an annual review of the Winter Dredge Survey (WDS) data and the jurisdictions’ harvest data. The estimates of adult female abundance and female exploitation rate are then compared with the established management reference points to determine blue crab stock status. If the estimate of female abundance provided by the WDS is above the threshold, the population is considered to be at a sustainable level; if the abundance estimate is below the threshold, the population is considered overfished, and the outcome is no longer on target. Although the female exploitation rate is not technically
part of the Blue Crab Abundance Outcome, it is important to track, as the maintenance
of the annual exploitation rate at or near target levels maximizes the probability of
achieving and maintaining the target abundance level.

CBSAC will use the following approaches to ensure adaptive management of the
Chesapeake Bay blue crab population:

• Annually estimate blue crab stock status using the best available data
• Regularly evaluate the performance of the stock assessment model and update
  the management reference points as needed
• Identify, prioritize, and address science needs that will improve stock assessment
  and understanding of blue crab population dynamics
• Discuss management response when/if the stock becomes overfished and/or
  overfishing is occurring

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 Winter Dredge Survey (WDS) data 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 measured crab density by the total area (m²) of the Bay. Each year, the
overwintering mortality (i.e., the number of crabs that die in the winter) is also
estimated and the abundance estimate is adjusted for that loss.

The female exploitation rate is calculated as the number of female crabs harvested in a
given year (from jurisdictional 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 WDS). 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 WDS, a method that was also implemented in the model-
based stock assessment that generated the reference points.

Additional information about data collection and statistical methods can be found on
the MDNR and VIMS websites, and in the following publication:

Abundance and exploitation rate of the blue crab (*Callinectes sapidus*) in Chesapeake
(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, estimating abundance from density data is common. In addition, reference points for adult female abundance and exploitation rate 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 assess 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?

The current management reference points for adult female abundance (age 1+) include a target of 196 million females and a threshold of 72.5 million females. Blue crab stock status is also determined by the female exploitation rate (i.e., percentage removed from the population in a year) relative to a target of 28% and a threshold of 37%. These reference points were developed and recommended based on the theory of maximum sustainable yield, a widespread convention in fisheries management.

(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 (WDS) 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 WDS ensures that these Bay-wide estimates of abundance are statistically robust. More information about the WDS and how it is used to determine blue crab abundance can be found on the MDNR and VIMS websites, and in the following publication:

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

(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. Information about data collection and statistical methods can be found on the MDNR and VIMS websites, and in the following publication:


(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 Blue Crab Advisory Report:
https://www.chesapeakebay.net/documents/2022_Blue_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?
N/A.
(31) Are descriptions of the study design clear, complete, and sufficient to enable the study to be reproduced?
Yes. Information about data collection and statistical methods can be found on the MDNR and VIMS websites.

(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

Blue crab stock status has been determined based on female-specific reference points since 2012, after being developed and adopted in the 2011 benchmark stock assessment. Last 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. MDNR conducts the Winter Dredge Survey (WDS) in the Maryland portion of the Bay and VIMS conducts the survey in the Virginia portion of the Bay. The WDS is a coordinated effort between the jurisdictions; 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 for blue crab managers and CBSAC. CBSAC’s annual Blue Crab Advisory Report provides management recommendations 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. All three management jurisdictions have ongoing efforts to improve the quality of catch and fishing effort data submitted by commercial and recreational harvesters as outlined in CBSAC’s Blue Crab Harvest Reporting Document.
(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.

N/A.

1Outlook: Outlook is the forecasted trajectory for whether the Chesapeake Bay Program is on course to achieving the outcome. An outcome's outlook may be on course, off course, uncertain, or completed. This information will be incorporated into the outcome's progress page. An outcome's course outlook is reviewed and updated during the outcome's Strategy Review System (SRS) Quarterly Progress Meeting in addition to when recent progress is assessed.

2Recent Progress: Recent Progress describes the change in the indicator based on the most recent data collected since the last reporting period. The recent progress icon will reflect this change as an increase, decrease, no change, or completed, depending upon this progress. This information will be discussed at the outcome's Strategy Review System (SRS) Quarterly Progress Meeting.