Blue Crab Workshop and Stock Assessment Planning

Mandy Bromilow
NOAA Chesapeake Bay Office
Winter 2023 Sustainable Fisheries GIT Meeting

Blue Crab Stock Status

- Significant recent declines in abundance and recruitment
  - 2022 total abundance = 227 million crabs (lowest ever)
  - Juvenile abundance at an all-time low in 2021
- Disconnect between spawning stock, recruitment, and fishery performance

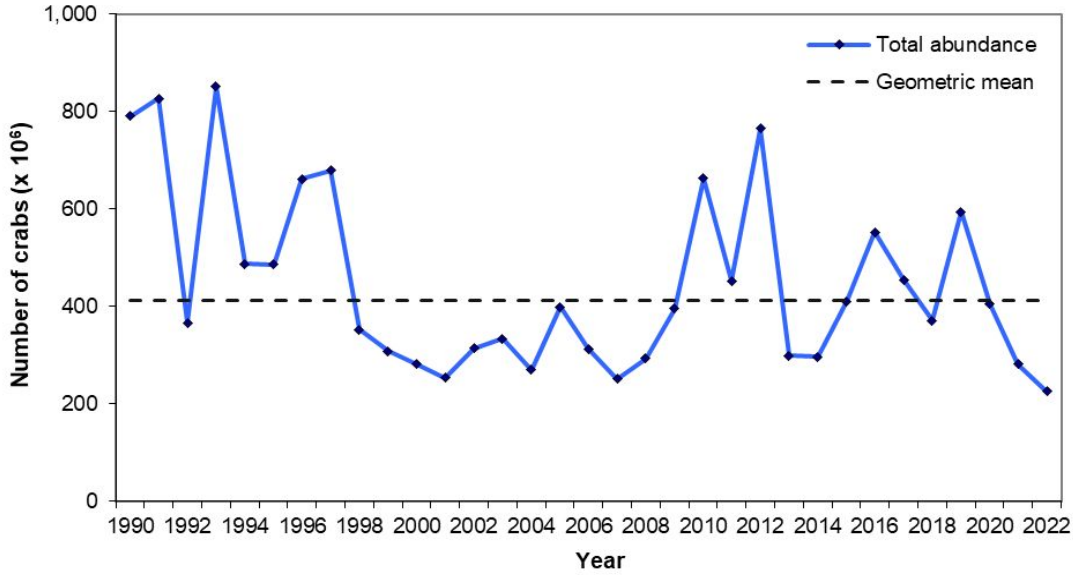

Figure 1. Winter Dredge Survey estimate of abundance of all crabs (both sexes, all ages) in Chesapeake Bay, 1990-2022.

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September 2022 Workshop

Objectives:

1) Identify and discuss potential mechanisms, data needs and available sources, and analytical methods to better understand drivers of blue crab population dynamics in the Bay
2) Discuss the assumptions for the current blue crab stock assessment model and evaluate other options that could be incorporated into a benchmark stock assessment

Workshop Participation

DNREC DIVISION OF
FISH AND WILDLIFE

CHESAPEAKE BAY
FOUNDATION
Saving a National Treasure

VIMS | WILLIAM & MARY
VIRGINIA INSTITUTE OF MARINE SCIENCE

Smithsonian Environmental
Research Center

University of Maryland
CENTER FOR ENVIRONMENTAL SCIENCE

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Workshop Outline

- **Day 1 - Blue Crab Population Drivers**
  - Environmental factors
  - Habitat availability
  - Predation and prey availability
  - Intrinsic biological factors
- Day 2 - Stock Assessment Model Assumptions
  - Spawning assumptions
  - Winter Dredge Survey and catch estimate mismatch

Environmental Factors

- **Coastal conditions** (e.g., wind, currents, freshwater outflow) affect blue crab recruitment success
  - Favorable winds (out of NE) facilitate larval ingress
  - Strong freshwater outflow could reduce larval survival and ingress
- **Hypoxia** alters blue crab physiology, behavior, and distribution
  - More susceptible to disease
  - More vulnerable at higher densities in the shallows
- **Water temperature** regulates the seasonal life cycle and growth of blue crabs

Habitat Availability

- **Nursery habitats** (e.g., SAV, marsh) provide food and refuge for juvenile blue crabs
- **Shoreline hardening** reduces the availability of natural, shallow-water foraging and refuge habitats for blue crabs
  - VIMS study identified a negative, monotonic relationship between percent hardened shoreline and juvenile blue crab abundance

Predation and Prey Availability

- **Blue catfish** consumed an estimated 2.3M blue crabs annually in a ~200 km^2 area of the James River (VIMS)
- **Red drum** are a primary consumer of blue crabs in the northern Gulf of Mexico
- Other predator species of interest:
  - Striped bass
  - Speckled trout
  - Atlantic croaker
  - Cobia
- Blue crabs feed primarily on **benthic invertebrates** (e.g., soft-shell clams)

Intrinsic Biological Factors

- **Diseases** (i.e., parasites, bacterial infections, viruses) affect blue crab mortality, but little is known about their role in blue crab population dynamics
- **Sperm limitation and sex ratios** are of concern with a male-targeted fishery
  - Sperm limitation can reduce female reproductive output
- **Fecundity and spawning** affect overall population productivity
  - The number of eggs per brood is highly variable and size-dependent
  - Preliminary studies indicate female size-at-maturity is decreasing

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Spawning Assumptions

- **Pre-spawning mortality rates** are currently set at 60% F and 50% M occurring between Nov - Jun
  - Shifts in harvest intensity can impact productivity
- **Timing of spawning** is currently set as July 1
  - Females could be spawning earlier with warming water temperatures
- The current **stock-recruitment model** assumes a Ricker function based on the abundance of mature females
  - Other functions could be explored

WDS and Catch Estimate Mismatch

- **WDS efficiency estimates** could be a source of bias between the MD and VA surveys
  - Comparative studies have been conducted but questions about the effects of depth, bottom type, and other factors remain
- **Sex ratio at recruitment** is currently assumed to be 52:48 (F:M)
  - Not a major concern, but can be empirically estimated in the benchmark assessment

WDS and Catch Estimate Mismatch

- A constant **natural mortality rate** is currently assumed for all ages and sexes
  - Consider functions that vary by crab size and/or over time
- **Fishery selectivity** does not seem a likely significant source of bias to account for the mismatch
  - Estimating selectivity using length-based data from jurisdictions would be a significant advancement
- Accurate **catch reporting** is critical to the stock assessment model (biased data = biased estimates)
  - CBSAC prioritizing collection of effort and catch composition data across the jurisdictions

Research Needs and Data Gaps

- Quantify relationships between blue crabs and environmental factors
  - Wind events, freshwater flow (larval/juvenile abundance)
  - Hypoxic volume/duration (blue crab abundance, prey abundance)
  - Hypoxia distribution (blue crab habitat use)
  - Nursery habitat availability (blue crab abundance/production)
- Need better info about blue crab habitat use, movement, and juvenile abundance

Research Needs and Data Gaps

- Quantify predation impacts on blue crab natural mortality rates
  - Examine correlations between predator (e.g., blue catfish, red drum, striped bass) and blue crab population trends
- Lacking Bay-wide indices of predator abundance
- Shallow-water fisheries surveys (e.g., gill nets, trammel nets) would be useful

Research Needs and Data Gaps

- Other research needs
  - Blue crab brood production (e.g., # broods/female, # eggs/brood)
  - Sperm quantity and viability
  - Sperm:egg ratios required for fertilization
- Needs to inform stock assessment
  - Factors affecting WDS efficiency (e.g., temperature, habitat, deployed chain)
  - Magnitude of mortality in the peeler fishery
  - Proportion of SSB harvested Nov - Jun
  - Variation in fishing mortality (F)

Stock Assessment Planning

Blue Crab Benchmark Stock Assessment Timeline	
Subcommittee develops draft TORs	Feb. 15, 2023
CBSAC technical review of TORs	Feb. 22, 2023
Final TOR review/approval by jurisdictions	Mar. 1, 2023
Data workshop	June 2023
Stock assessment model development	Sep. 2023 - 2025
CIE peer review	Tentatively late 2025
Final stock assessment report complete	Tentatively 2025

Terms of Reference

2023 Blue Crab Benchmark Stock Assessment
Terms of Reference (TORs)

TOR 1:
Critically review and estimate life history parameters and vital rates of blue crab in the Chesapeake Bay that are relevant to the stock assessment. In particular, the assessment should evaluate the extent and scale of interannual variation in life history parameters and vital rates of blue crab in the Chesapeake Bay.

TOR 2:
Describe and quantify patterns in fishery-independent surveys to develop indices of abundance and characterize the size composition of the population. Analyses should include:

- A comprehensive evaluation of the utility of fishery-independent surveys to inform the stock assessment;
- Consideration of index standardization which may include effects of environmental and abiotic factors on survey catches; and
- Characterization of uncertainty in indices of abundance.

TOR 3:
Describe and quantify patterns in catch, effort, and CPUE. Analyses should include:

- Estimation of catch and effort for each jurisdiction;
- Evaluation of the utility of a commercial CPUE index in the assessment;
- Examination of the impacts of reporting changes and trends in CPUE;
- Evaluation and quantification of bycatch and/or discard mortality, and recreational harvest using available data from the jurisdictions; and
- Characterization of uncertainty in the data.

TOR 4:
Evaluate the feasibility of, and if possible, implement blue crab stock assessment models that operate on sub-annual time steps and/or at spatial resolutions lower than that of the entire Chesapeake Bay to better represent population dynamics.

TOR 5:
Characterize uncertainty in assessment estimates (mortality and abundance).

TOR 6:
Update the sex-specific catch survey models used in the 2011 benchmark stock assessment with relevant new data. Characterize major changes in assumptions between the 2011 assessment model and the 2023 model.

TOR 7:
Based on assessment model results recommend appropriate biological reference points for management. To extent possible, evaluate the appropriateness and utility of

- Aggregate bay-wide reference points
- Sex-specific reference points
- Recruitment reference points

TOR 8:
Evaluate stock status relative to recommended reference points.

TOR 9:
Identify relevant ecosystem and climate influences (such as habitat, environmental drivers, prey availability, and predation/cannibalism) on blue crab population dynamics and fisheries, and explore other analyses that support the assessment.

TOR 10:
Identify existing data sources and gaps, and characterize the uncertainty in the relevant sources of data and their link to stock dynamics.

TOR 11:
Report on the status of research recommendations from the most recent benchmark assessment. Identify and prioritize research recommendations for future work.

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Thank You!

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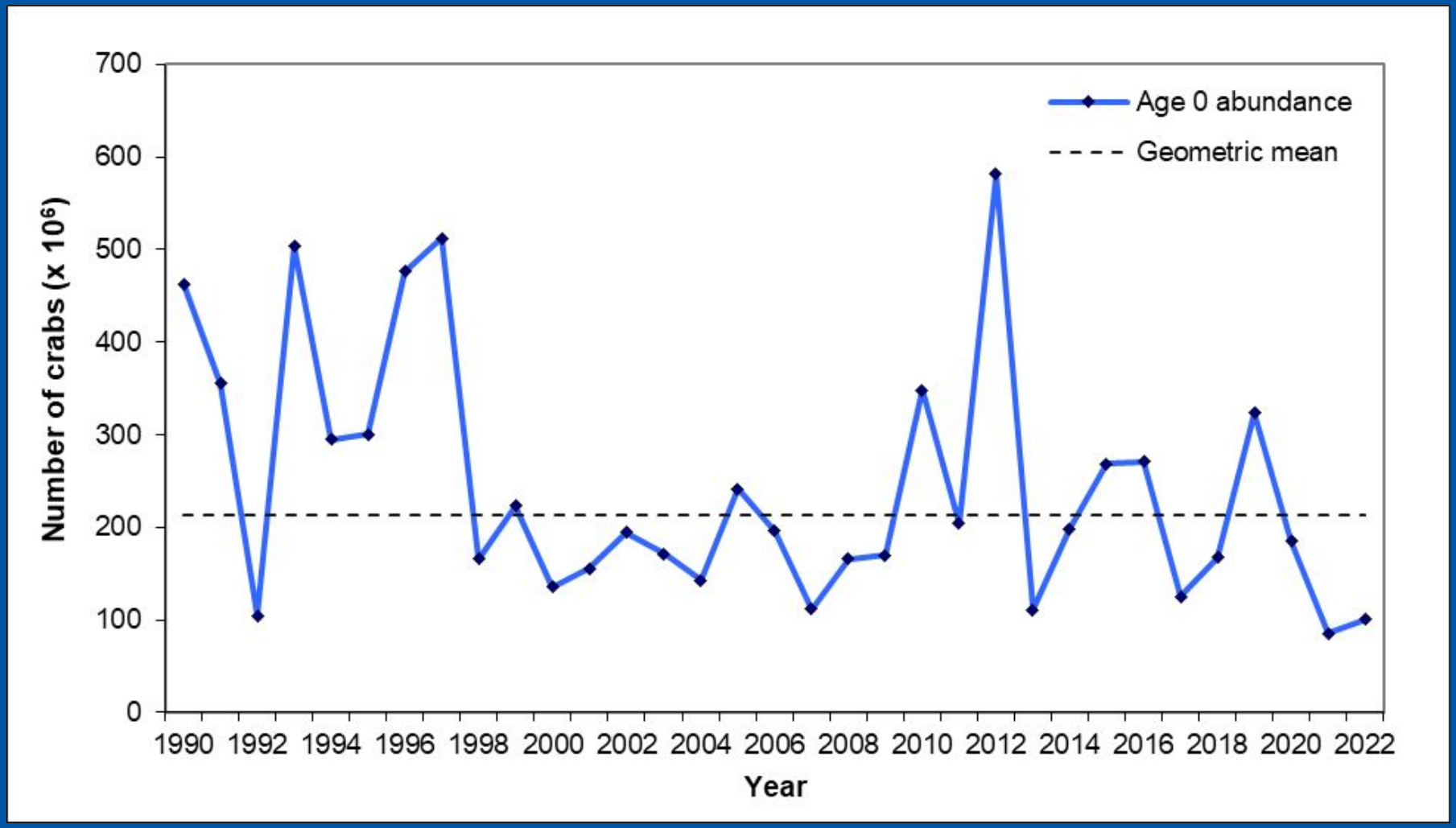
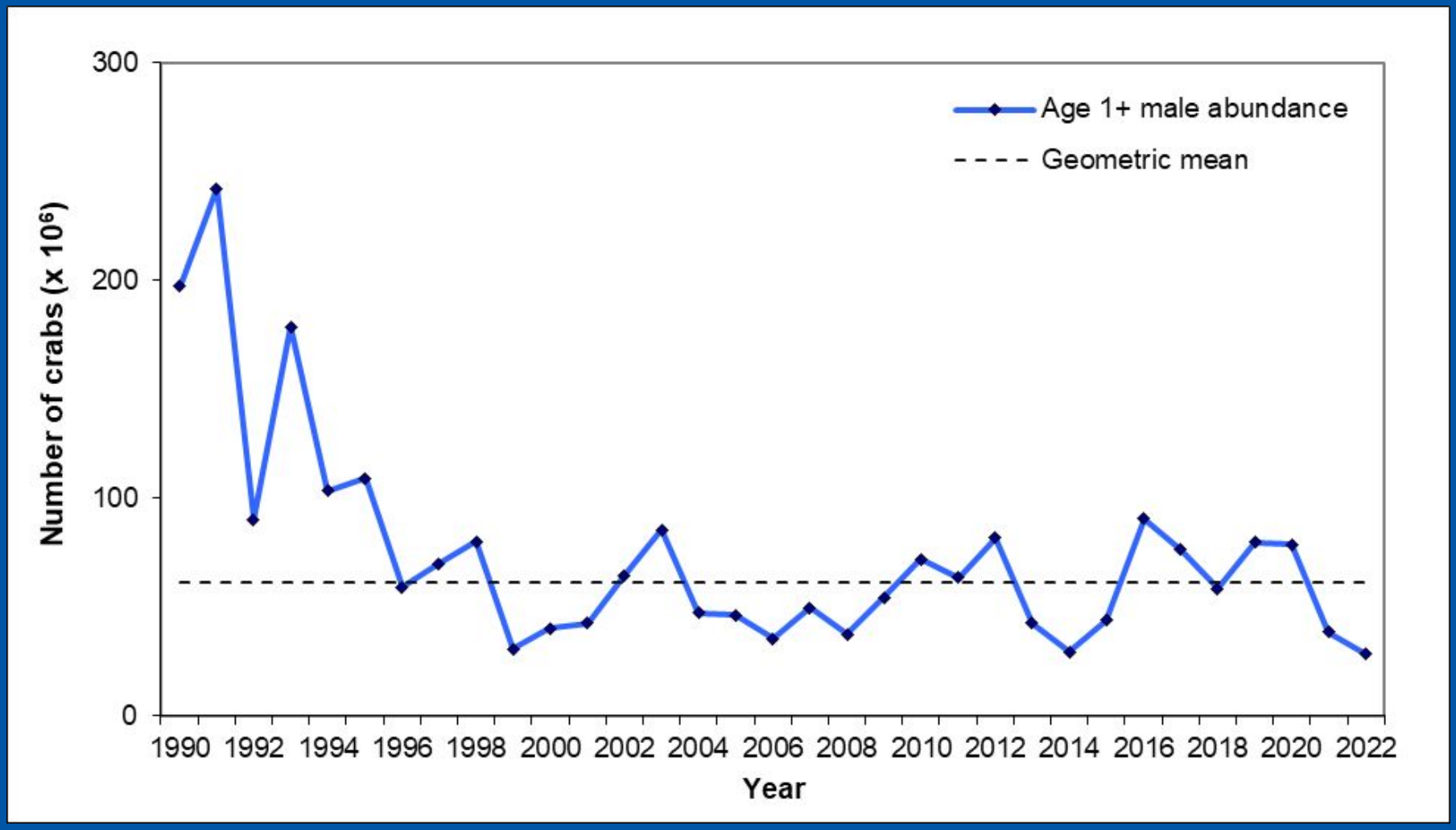
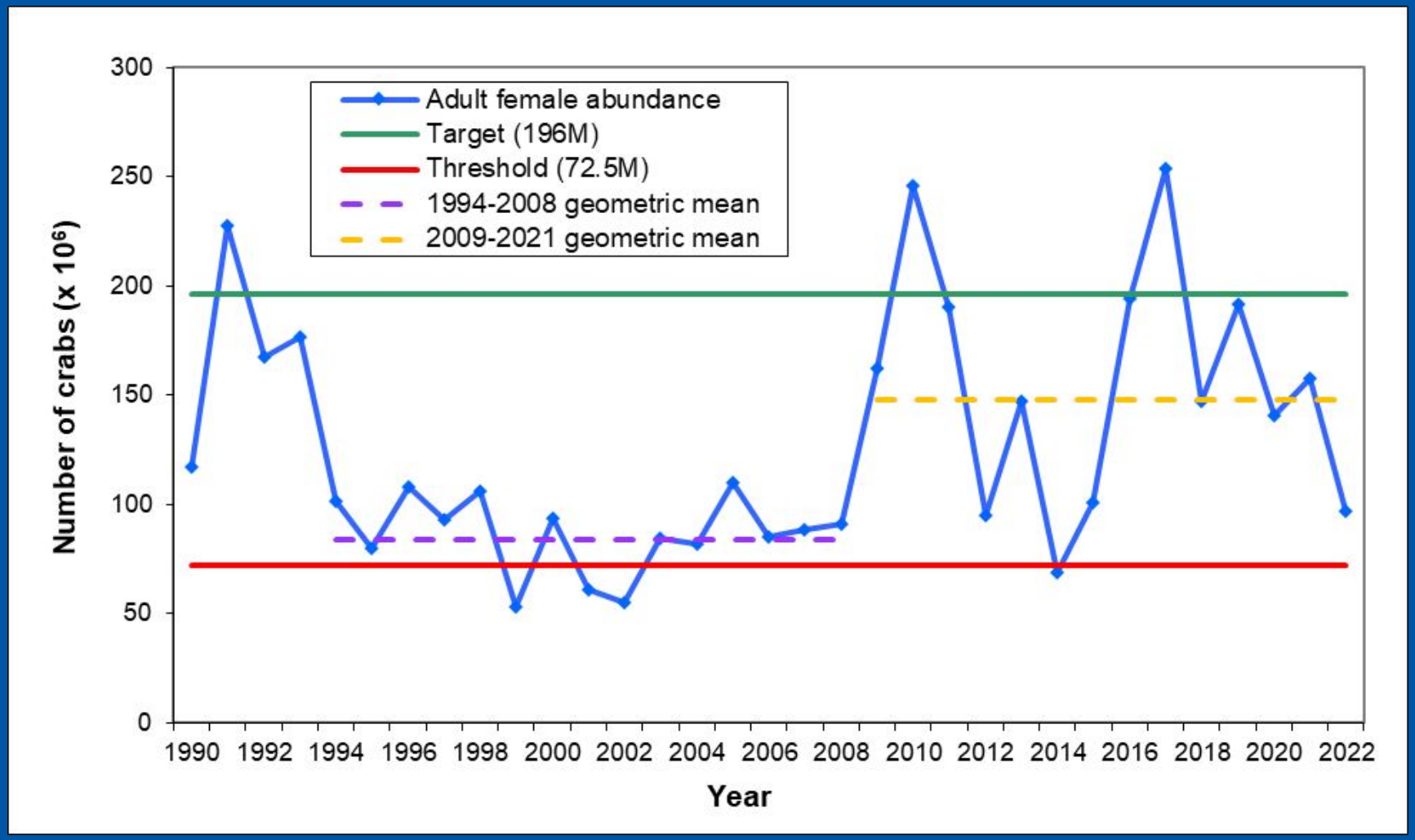

Age 0 abundance
Geometric mean
Number of crabs (x 10⁶)
700
600
500
400
300
200
100
0
1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020 2022
Year


Age 1+ male abundance
Geometric mean
Number of crabs (x 10⁶)
300
200
100
0
1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020 2022
Year


Adult female abundance
Target (196M)
Threshold (72.5M)
1994-2008 geometric mean
2009-2021 geometric mean
Number of crabs (x 10⁶)
300
250
200
150
100
50
0
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Year