

Blue Crab Trends: Policy vs Ecosystem?

How summer water quality and fishery regulation shaped Chesapeake Bay blue crab recovery in 25 years



Figures and analyses created by Python

Introduction

Chesapeake Bay blue crab populations declined sharply from the late 1990s. Following a 2008 Federal Disaster Declaration, Maryland and Virginia shifted from passive to positive action, reducing female harvest by 34%. While this rebuilt the spawning stock, 2025 shows record-low juvenile recruitment. This study uses a lagged regression model to analyze 25 years of data (2000–2025) to evaluate how summer water quality drive different life stages and assess if 2008's policy success justifies the 2025 proposal to reopen restrictions, or if environmental volatility is a risk for crab's sustainability.

Data Collection and Methods

Data Collection

Biological Data
Winter Dredge Survey: 2000 - 2025

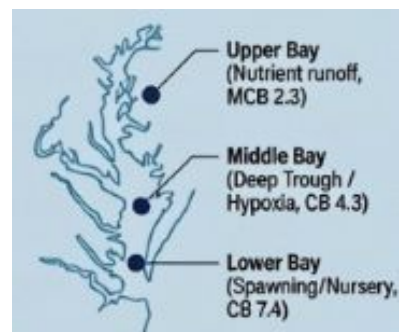
Environmental Data
Source: Chesapeake Bay Water Quality Survey

Metrics: Dissolved Oxygen (DO), Salinity, Water Temperature, PH, Dissolved Organic Nitrogen (DON)

Policy Indicator

Passive Action (2000 - 2008): 0
Positive Action (2009 - 2025): 1

Aggregation



Temporal Lag: Filtered for summer months (Jun - Aug)

Data Merge: Summer parameters merged with subsequent crab data

Modeling

$$\begin{aligned} Pop_t &= \beta_0 + \beta_1(Reg_t) \\ &+ \beta_2(DO_{t-1}) + \beta_3(DON_{t-1}) \\ &+ \beta_4(pH_{t-1}) + \beta_5(Sal_{t-1}) \\ &+ \beta_6(Temp_{t-1}) + \epsilon \end{aligned}$$

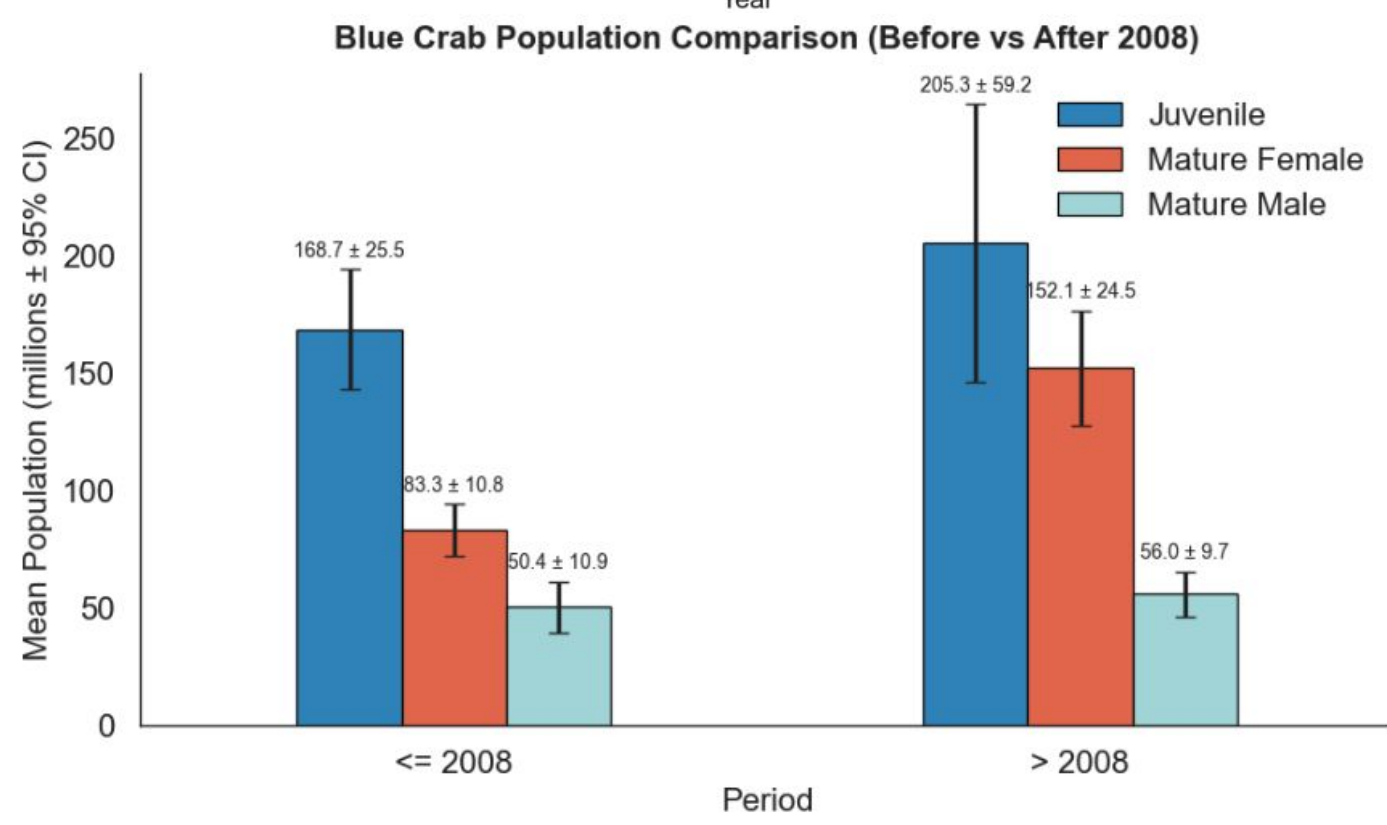
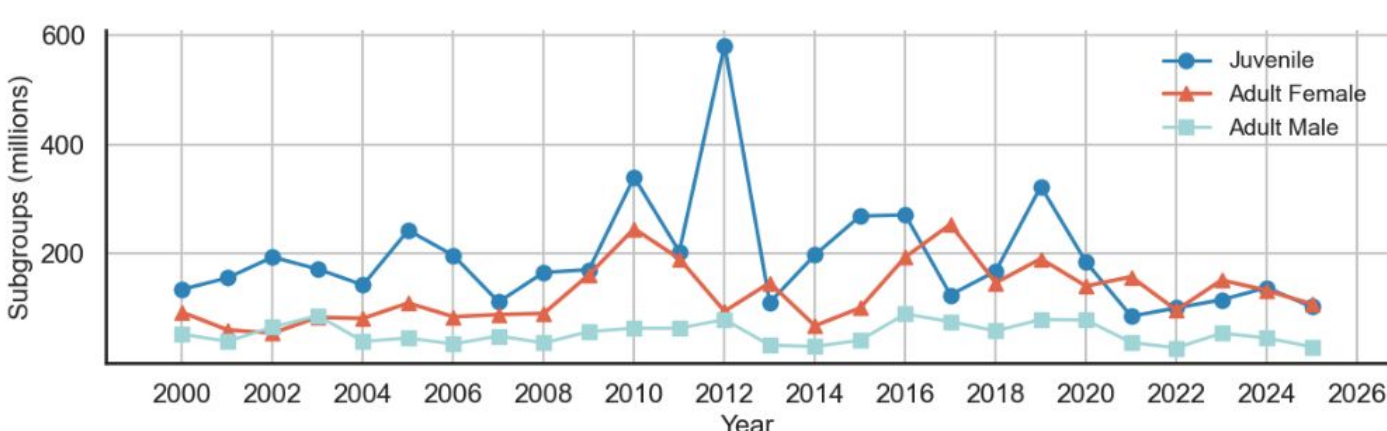
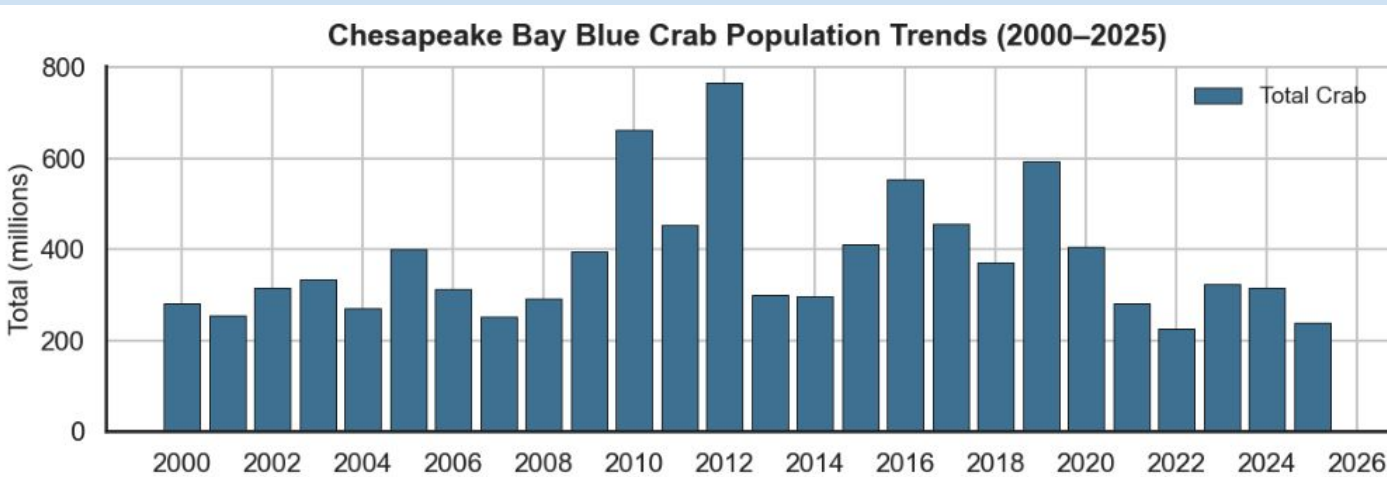
Two Parallel Models

Adult Female

Juvenile

1. Population Trends

- Total abundance is driven by juvenile recruitment.
- Juveniles were the most variable group
- Adult females showed steadier post-2008 recovery, consistent with harvest protection.

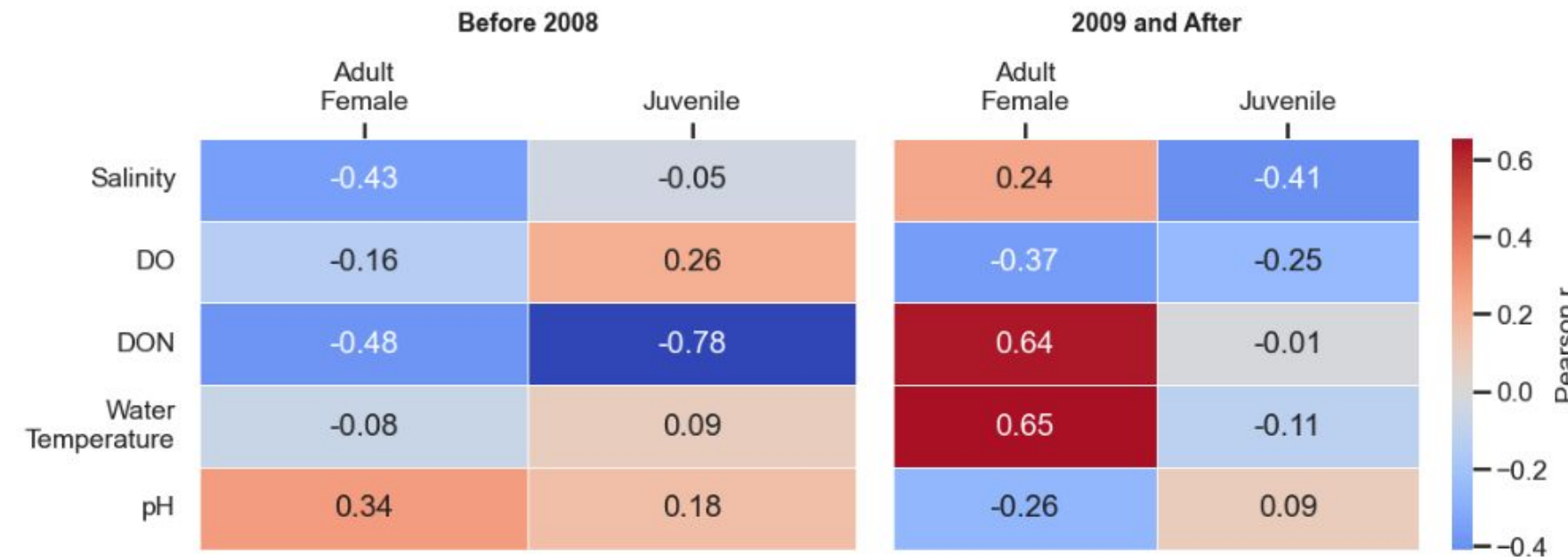


2. Regulation vs Summer Water Quality Factors

While the 2008 Regulation was success for adult female crabs, it is not enough to protect the juvenile. The juveniles are facing more complicated environmental challenges.

- Adult females: power of regulation
- Juvenile: protected by regulation, but challenged by environmental parameters

Environmental Correlations Before and After Regulation

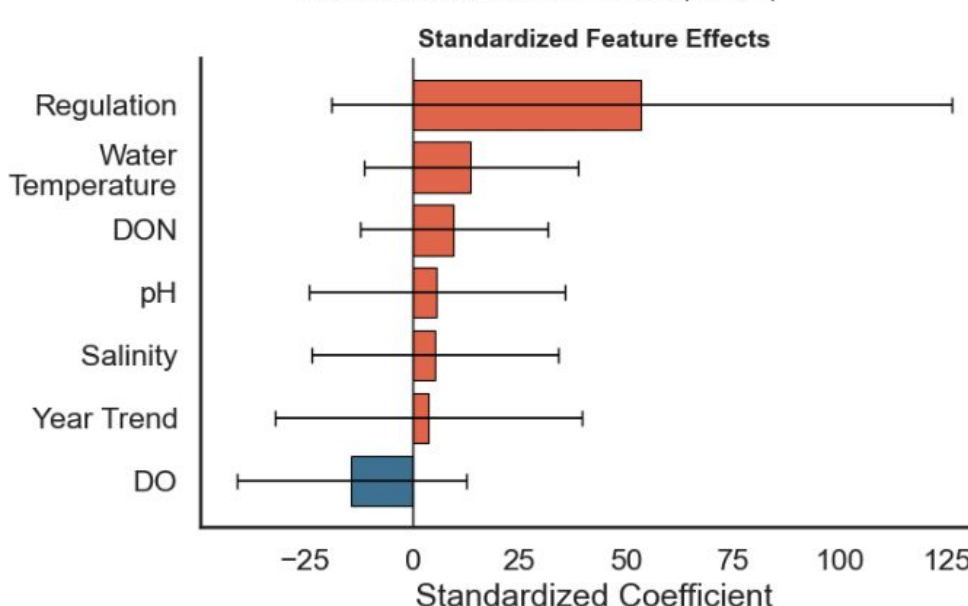
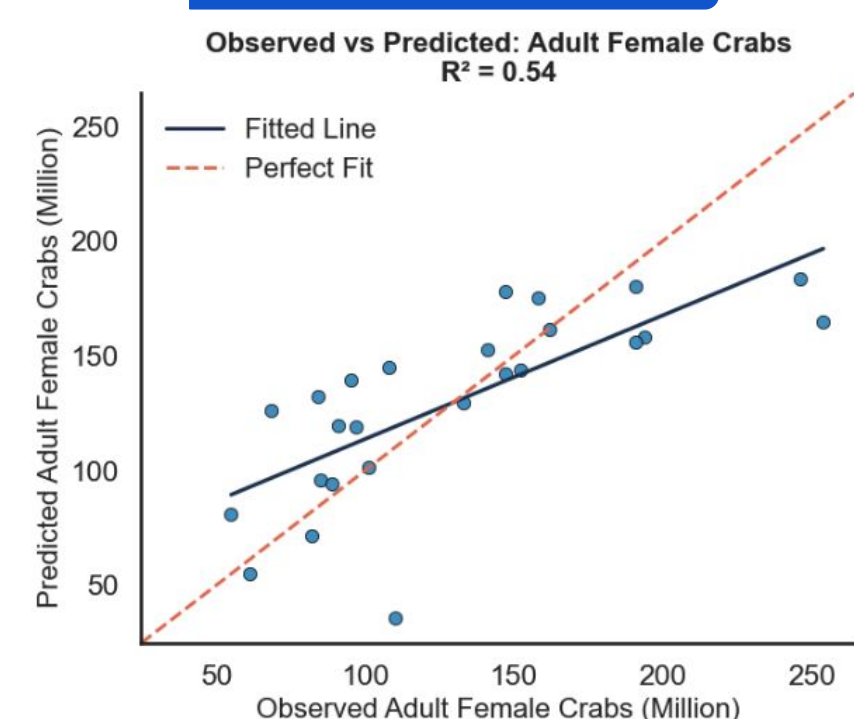


After Regulation

Adult Female Resilience: Policy allowed females to survive summer stressors and utilize warmer waters for growth.

Juvenile Risk: Sensitive to the saltiness and oxygen of their specific nursery habitats.

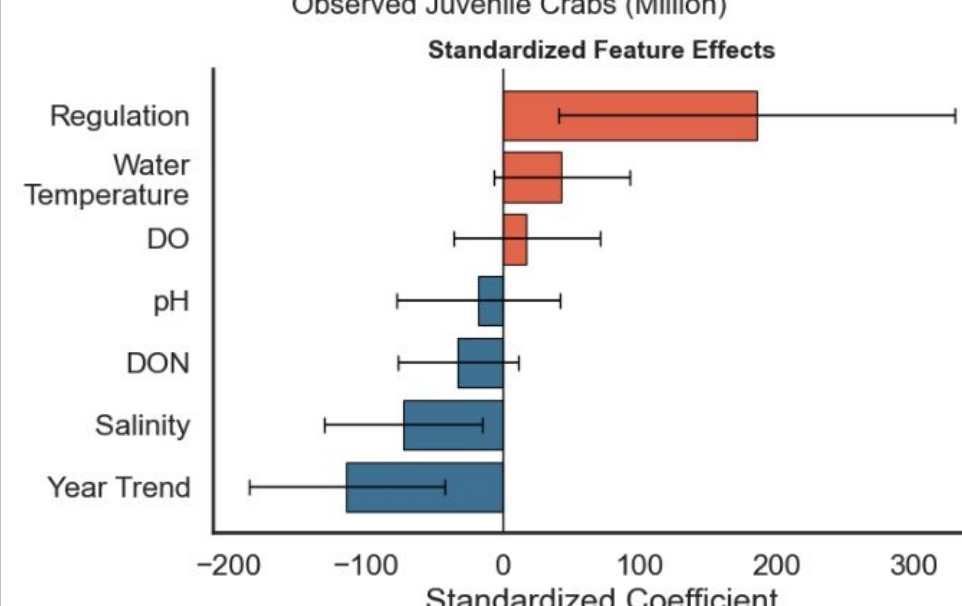
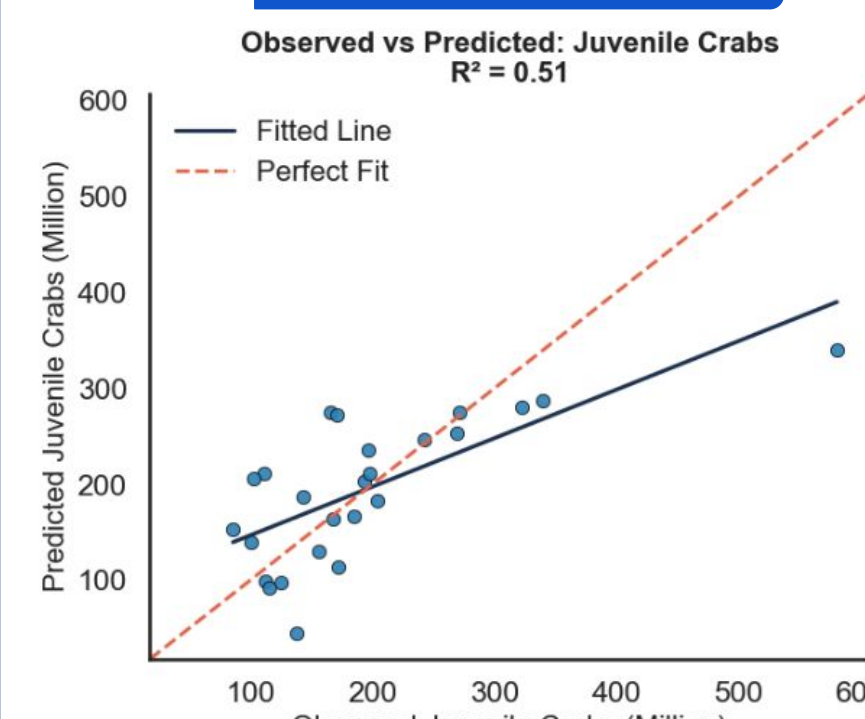
Adult Female Crab



Model explains **54% of the variance** in adult female abundance; A positive regulation coefficient shows positive action helped female population recovery.

Feature	Coef	Std Err	t	p-value
Intercept	-2456.75	3032.16	-0.81	0.43
Salinity	3.95	7.43	0.53	0.60
DO	-48.09	25.45	-1.89	0.08
DON	649.88	582.04	1.12	0.28
Water Temperature	25.08	15.76	1.59	0.13
PH	115.97	159.17	0.73	0.48
Regulation (Y/N)	53.46	22.99	2.32	0.03*
Year	0.51	1.54	0.33	0.74

Juvenile Crab



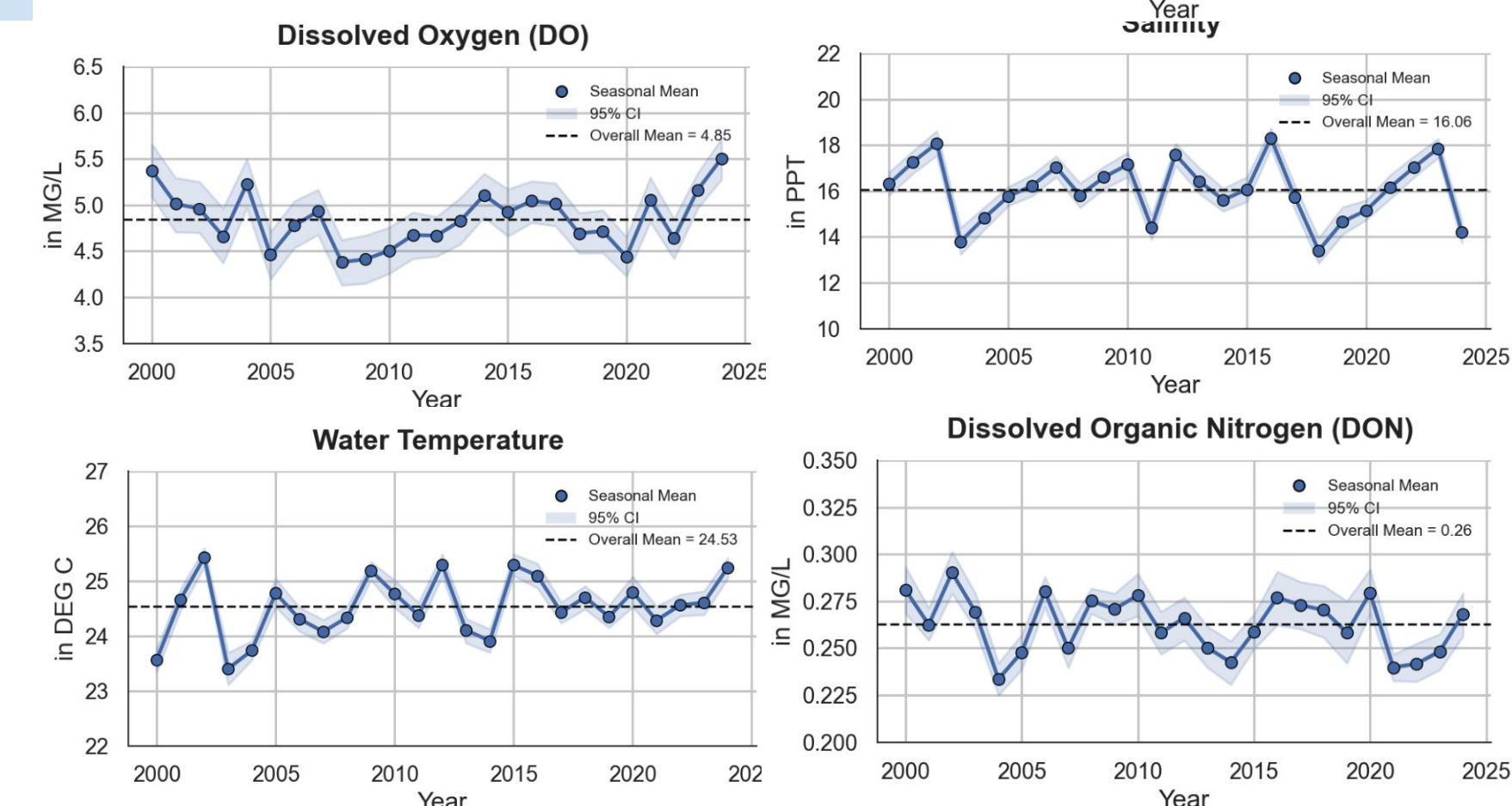
Model explains **51% of the variance** in juvenile abundance; Even though regulation protect baby crabs, they face environmental stress such as salinity, dissolved organic nitrogen and PH level.

Feature	Coef	Std Err	t	p-value
Intercept	34032.57	11430.78	2.98	0.01*
Salinity	-55.64	23.41	-2.38	0.03*
DO	58.27	49.84	1.17	0.26
DON	-2205.33	646.32	-3.41	0.003*
Water Temperature	78.89	32.56	2.42	0.03*
PH	-363.06	336.65	-1.08	0.30
Regulation (Y/N)	185.25	72.41	2.56	0.02*
Year	-15.84	5.02	-3.16	0.006*

Environmental Parameters

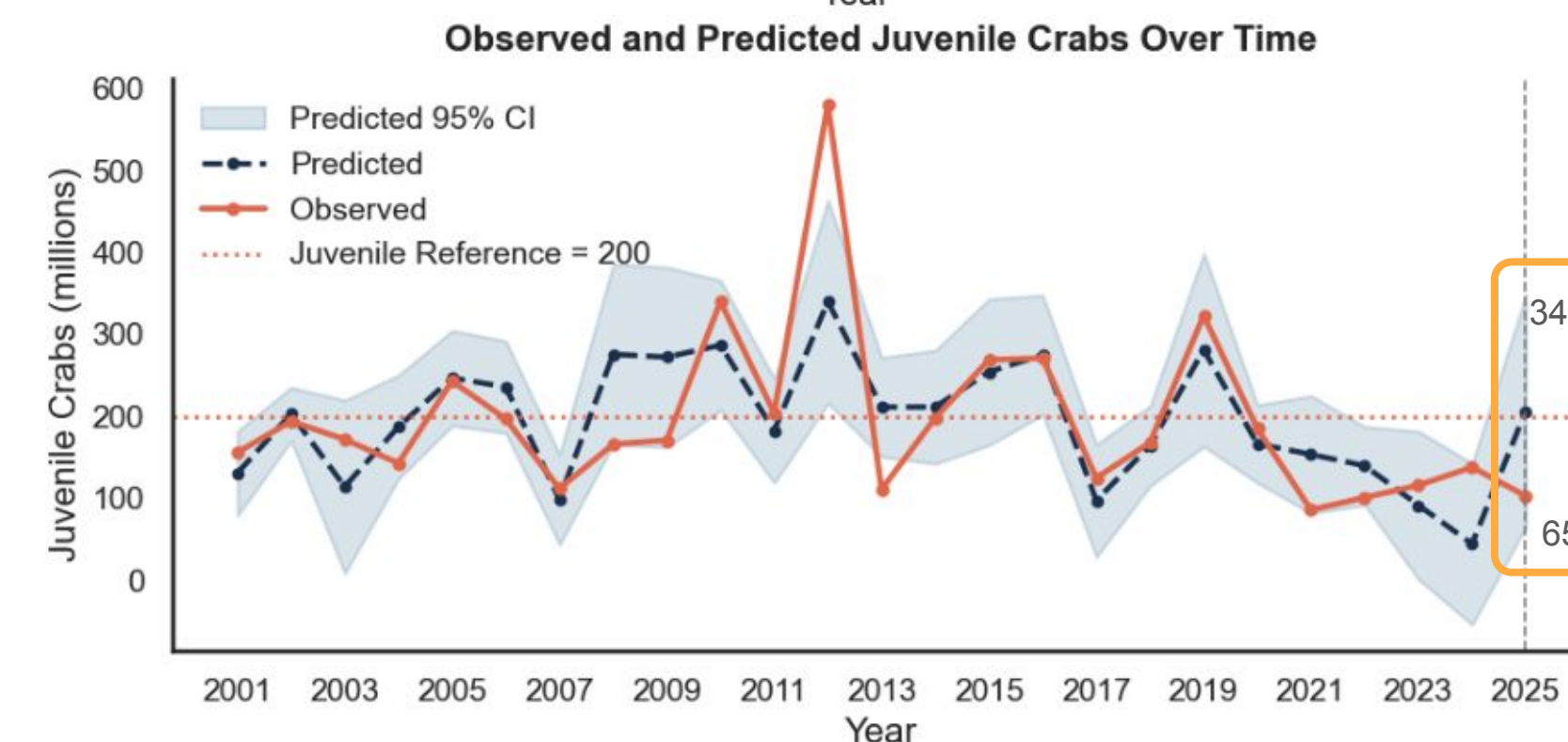
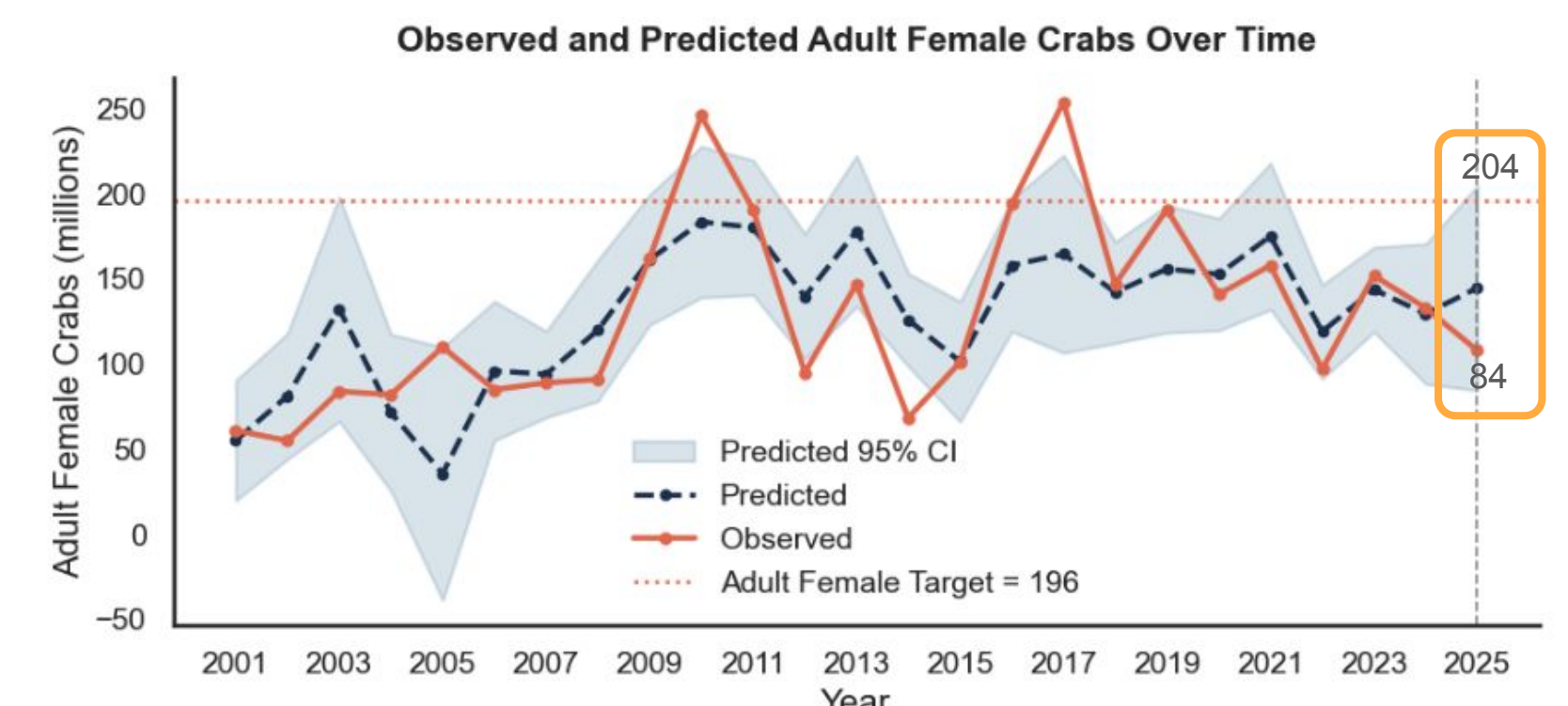
Year over year trending

- Summer water temperature shows a slight long term warming trend
- Short term ups and downs in multiple parameters likely capture storm driven events during summer



3. Prediction & Risk Assessment

While observed population is lower than the predicted mean, the observed value sits within the 95% CI for both adult female and the juvenile.



4. Discussion

- **Life-Stage Sensitivity:** Regression coefficients indicate that adult females are resilient, while juvenile stability is sensitive to environmental volatility. Harvest rules alone cannot offset the impact of poor water quality in nursery habitats.
- **Model Validation:** 2025 observed data fell within the 95% Confidence Interval, proving the model accurately predicted crab numbers. However, the 2025 record low indicates that environmental factors are critical for crab recovery.

References
https://www.chesapeakebay.net/files/2025_Blue-Crab-Advisory-Report_FINAL-DRAFT.pdf
<https://rga.lis.virginia.gov/Published/2025/RD983/PDF>
<https://datahub.chesapeakebay.net/WaterQuality>
<https://dnr.maryland.gov/fisheries/pages/blue-crab/dredge.aspx>

Conclusion: The 2008 Regulation successfully rebuilt a resilient adult female population, but juvenile recovery is offset by environmental conditions.