PHILADELPHIA WATER DEPARTMENT

# PWD Documentation to Support 8/11/2025 Meeting with the U.S. Office of Information and Regulatory Affairs

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**PWD Comments on Proposed Consent Decree in *Delaware Riverkeeper Network et al. v. U.S. EPA et al.***

PHILADELPHIA WATER DEPARTMENT

Lee Zeldin
Administrator
Environmental Protection Agency
Office of Water
1200 Pennsylvania Avenue NW
Washington, DC 20460
Re: Proposed Consent Decree in *Delaware Riverkeeper Network et al. v. U.S. EPA et al*., Docket No. 2:24-cv-05308 (E.D. Pa.)

Dear Administrator Zeldin:

The Philadelphia Water Department (PWD) has reviewed the proposed consent decree between Delaware Riverkeeper Network and the U.S. EPA Environmental Protection Agency (EPA).[1] PWD has substantial concerns with the proposed consent decree, including:

- the flawed scientific basis for the proposed water quality standards,
- massive potential infrastructure costs for wastewater treatment that would be needed to achieve those standards, and
- the rushed timeline that the consent decree establishes for EPA to adopt a final rule.

The proposed consent decree forces the EPA to finalize a rule establishing water quality standards based on flawed science that fails to properly consider the significant effect it will have on household water bills.

PWD respectfully requests that the EPA withdraw consent to the proposed decree until such time as EPA has addressed all comments and concerns of the regulated community, demonstrated that the proposed rule is necessary and scientifically sound, and fulfilled all of its responsibilities required for federal water quality standards. PWD believes that the comments below disclose facts and considerations that indicate consent to the proposed decree is inappropriate, improper, inadequate, and inconsistent with the requirements of the Clean Water Act. Please also see attached PWD's previous comments on the proposed rulemaking at issue in the proposed consent decree.[2] The majority of PWD's comments and technical comments have not been addressed by EPA and are incorporated by reference here. (PWD 2024a, PWD 2024b, PWD 2024c).

[1] Proposed Consent Decree in *Delaware Riverkeeper Network et al. v. U.S. EPA et al*., Docket No. 2:24-cv-05308 (E.D. Pa.)
[2] See attachments PWD2024a, PWD2024b, and PWD2024c for PWD's previous comments.

**1. EPA underestimated the costs of the proposed rule by billions of dollars.**

The EPA used outdated and incorrect information to conclude that the costs of the proposed rule for PWD ratepayers would be only $78 million per year. PWD's engineering studies used actual PWD flow rates and infrastructure requirements to determine that the actual costs of compliance with the proposed rule would be **$274 million per year for PWD ratepayers alone**.[3] Water utilities are facing unprecedented challenges with infrastructure repair and replacement, stringent new regulations, and ratepayer affordability. The proposed rule would impose massive opportunity costs and other undesired consequences on utilities through increased operation, maintenance, energy, and chemical demands. PWD estimated the direct costs of the rule to be **$266 per year to each household.**[4]

**2. The proposed rule is a significant regulatory action requiring EPA to perform a robust benefit-cost analysis; EPA erred in its determination otherwise.**

EPA's underestimation of costs that would be borne by water ratepayers under the proposed rule resulted in an erroneous determination that the proposed rule was not "section 3(f)(1) significant," and therefore failed to perform the required benefit-cost analysis.[5] As described in further detail below, the proposed water quality standards are **not based on sound scientific rationale** and may have **limited or even no benefit to the sturgeon sub-population in the Delaware Estuary**. These facts make it critical that the proposed rule receives appropriate scrutiny through unbiased benefit-cost and regulatory policy analysis.

An independent benefit-cost analysis should be performed by the Office of Management and Budget (OMB) Office of Information and Regulatory Affairs, or other appropriate agency. Furthermore, benefit-cost analysis "baseline" existing conditions should reflect the following facts:

- Rule-related costs to PWD's ~500,000 ratepayer households could be $266 per year[6] or more for highly uncertain or non-existent benefits.
- Based on recapture rates of 1-2% for tagged fish, the best scientific data available suggest thousands or tens of thousands of juvenile sturgeon use the Delaware Estuary every year.
- These fish are comparable in size and other measures of health to sturgeon in similar estuaries.
- For years with adequate data, there was no observed correlation between existing DO conditions and measures of sturgeon growth and health.

**3. The proposed rule is not based on sound scientific rationale and may have broad policy implications outside the Delaware Estuary.**

EPA developed the proposed rule using a novel and extremely complex bioenergetic model approach that has not been peer-reviewed for water quality standards development. The approach used

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[3] As of February 2024
[4] As of February 2024
[5] Exec. Order No. 12866 (1993), *as amended by* Exec. Order No. 14094 (2023).
[6] As of February 2024

by EPA was not consistent with published EPA Guidance for developing water quality criteria for protection of aquatic life (USEPA 1985). The model includes more than 30 parameters, many of which are estimated or based on flawed and inadequate laboratory studies, as described below. The model relates dissolved oxygen (DO) levels with the growth and survival of Atlantic sturgeon, an endangered fish that spawns in tidal estuaries from Canada to Northern Florida. The EPA's proposed DO levels are more stringent than many current states' water quality standards for warm water estuary habitats. In addition to the Delaware Estuary, where multiple billions of dollars of potential wastewater treatment plant costs are at stake, if adopted the proposed rule could cause a wave of environmentalist challenges to permits and state water quality standards along the entire Eastern coast of the U.S., even where naturally occurring DO conditions do not achieve the more stringent proposed criteria.

**4. EPA repeatedly failed to follow its own scientific guidance for using results from laboratory studies when developing the proposed rule.**

EPA's fish bioenergetic model for the proposed rule is based on laboratory studies that were **technically flawed** and **do not meet the EPA's own minimum requirements for use in criteria development**. The primary study that was used by EPA to derive critical levels of dissolved oxygen (DO) for Atlantic sturgeon survival and growth (Niklitschek and Secor 2009, "N&S") was an incomplete factorial study design that did not test all levels of exposure to DO and temperature. The experiments included variable levels of salinity as a confounding stressor and exposed fish to hypoxia for 10 days rather than the typical 96 hours. The number of individual fish and DO level treatments tested in the experiments were inadequate to ensure the reliability of the findings and would be considered **"not acceptable for use"** for criteria development using EPA's 2024 technical guidance document "Standard Operating Procedures for Systematic Review of Ecological Toxicity Data in Support of Ambient Water Quality Criteria, Benchmark and Screening Value Derivation for Aquatic Life and Aquatic Dependent Wildlife" (EPA 2024a and references therein).

Critical input parameters for EPA's model are based on **statistically invalid study results**. The N&S study had small sample sizes and lacked statistical power to compare results between treatments. Some treatments used only two or three fish, far less than the recommended ten individuals, or even the seven suggested to be the minimum acceptable number of individuals for each treatment in toxicity tests (USEPA 2016). For example, it is completely inappropriate and statistically invalid to compare the survival or growth of two juvenile fish raised at typical summer maximum (~28 $^{o}$C) temperatures in 40% DO saturation versus 13 juvenile fish raised at 70% saturation. This situation would be like comparing weights of two players on one football team to 13 players on another football team and concluding that one of the team's players were heavier.

Similarly, the N&S study only tested the levels of 40% and 70% at typical Delaware River summer temperatures, a large and coarse range of DO values equivalent to 3.6 and 6.4 mg/L at 20 $^{o}$C. The lack of resolution in the treatments results in an unacceptable level of uncertainty for the model parameters relating DO to fish survival and growth. EPA proposes that wastewater utilities in the Delaware Estuary impose multiple billions of dollars of new infrastructure costs on their ratepayers based primarily on modeled fish mortality rates estimated from the data below (Figure 7 from EPA 2024b).

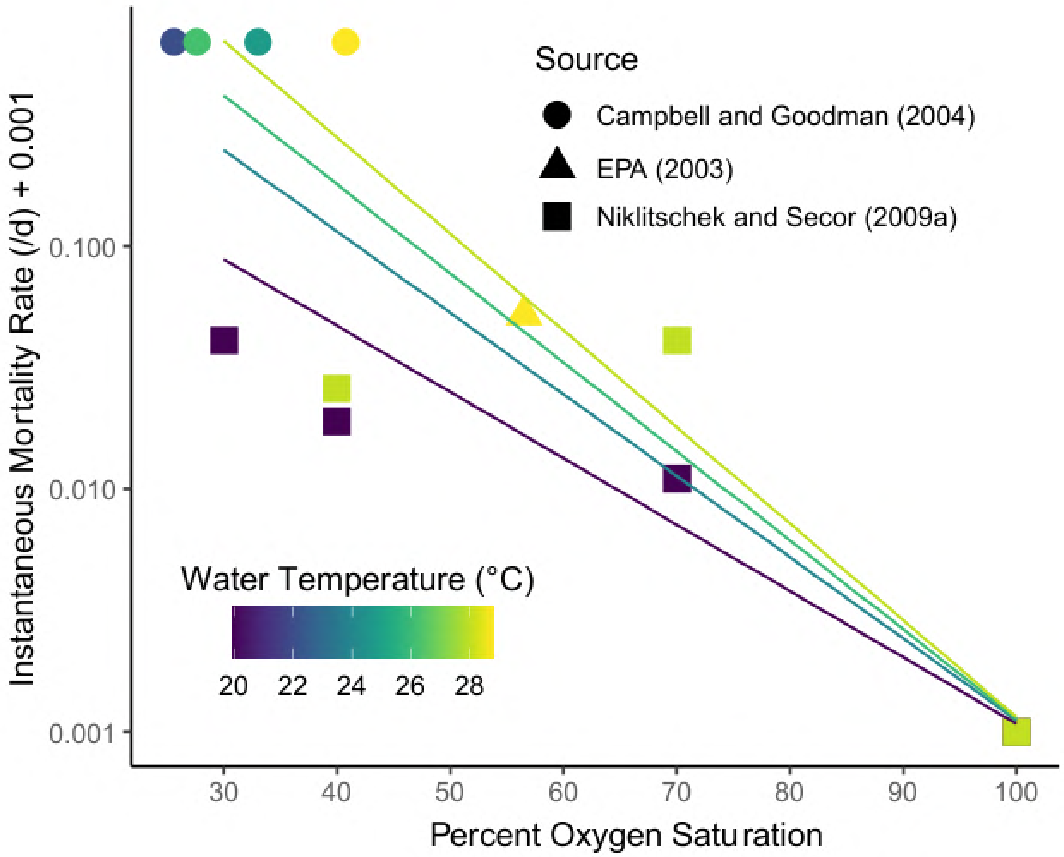
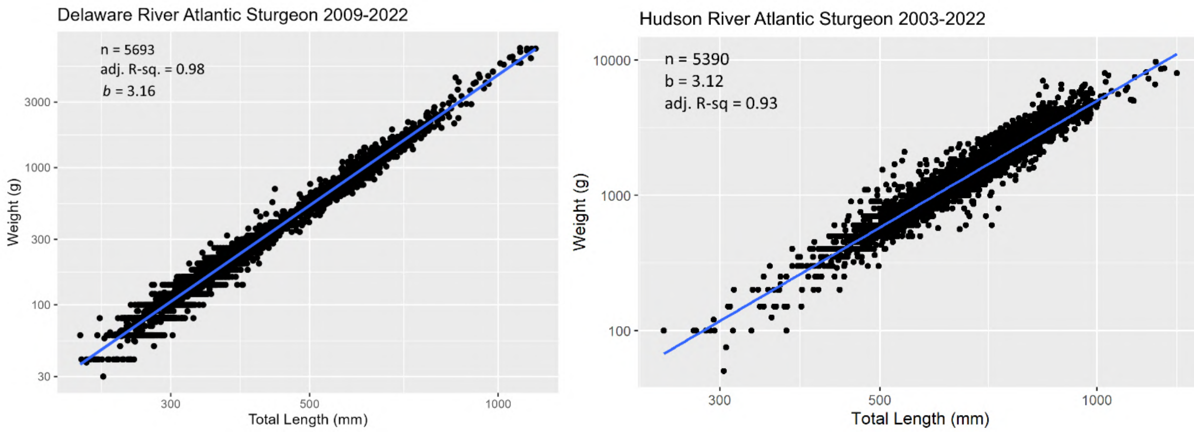



Figure 7 (above) reproduced from USEPA 2024b demonstrating sparseness and lack of fit between modeled mortality rate and lab results. Note mortality rate at 28 ºC is lower for 40% DO saturation than 70%.

**<u>5. Despite repeated requests for EPA to consider all available data, EPA has continued to ignore scientific evidence.</u>**

In 2022, PWD learned of a source of information for more than 5,000 juvenile Atlantic sturgeon collected by Environmental Research and Consulting (ERC), a sub-contractor hired by the U.S. Army Corps of Engineers' contractor during dredging and deepening activities in the mainstem Delaware River navigation channel. PWD combined the ERC data with data from the Delaware Department of Natural Resources and Environmental Control Division of Fish and Wildlife. These records show that year after year Atlantic sturgeon spawn in the Delaware River – tiny eggs hatched in spring grow to 12-14 inch fish by late fall (average 13.5 inches). PWD found that Delaware River fish are as large and as “plump” as Atlantic sturgeon in other rivers with higher DO conditions, such as the Hudson River. PWD also found that the size of the fish did not show any correlation with DO conditions. For more information on these analyses, please see PWD’s Technical Comments on the Evidence for Hypoxia as a Stressor on Delaware River Atlantic Sturgeon (PWD 2024b).




Comparison of Weight vs. Length of 5,693 Delaware River and 5,390 Hudson River Atlantic sturgeon.

In 2024, PWD identified an error in EPA's source data used for the 2023 Draft Technical Support Document (TSD) for the proposed rule and made available on GitHub (USEPA 2023). PWD notified EPA in January 2024 that the input source data included only a subset of 72 fish that were collected and recaptured by DNREC Division of Fish and Wildlife, rather than the full database of juvenile sturgeon collected by DNREC (PWD 2024c). PWD explained that EPA's Figure 6 in the TSD for the proposed rule included too few fish point observations. Several lines corresponding to years when fish were collected, but no specimens were recaptured, were incorrectly symbolized as having no fish observations (PWD 2024b). PWD stressed that the missing data in Figure 6 would be critical to include when the technical document was provided for peer review of the TSD and NOAA National Marine Fisheries Service (NMFS) consultation under the Endangered Species Act. In the final report published July 8, 2024, EPA modified the figure *caption,* but did not correct the other errors (Appendix 1).

## Conclusion

PWD understands that fisheries and water quality management are complex, involving multiple stakeholders and difficult decisions that must be made to balance protection of aquatic life with the economic and social well-being of our communities. It is critical that decisionmakers have the best scientific information available, which is why it is so troubling that EPA has yet to fully recognize the existence of thousands of additional records of juvenile sturgeon, correct errors, or remove false statements in the supporting documentation for the proposed rule. Additionally, newly disclosed information necessitates a re-evaluation of the proposed rule and its purported impact on the Atlantic sturgeon in the Delaware River. PWD supports the revision of Delaware River water quality standards to reflect the levels of DO that are actually being achieved and supporting successful spawning of Atlantic sturgeon and other aquatic life. However, due to numerous serious scientific and technical flaws, PWD does not support the proposed rule to revise DO water quality standards in its current form. We urge the EPA to withdraw its consent to the proposed decree.

**Works Referenced**


Niklitschek, E.J., & Secor, D.H. 2009. Dissolved oxygen, temperature and salinity effects on the ecophysiology and survival of juvenile Atlantic sturgeon in estuarine waters: I. Laboratory results. Journal of Experimental Marine Biology and Ecology, 381.

PWD. 2024a. PWD Comments on Draft EPA Rulemaking. February 20, 2024 Letter to EPA Administrator Michael S. Regan. 44p. Philadelphia, PA. https://downloads.regulations.gov/EPA-HQ-OW-2023-0222-0446/attachment_1.pdf

PWD. 2024b. PWD Technical Comments on the Evidence for Hypoxia as a Stressor on Delaware River Atlantic Sturgeon. February 20, 2024 Letter to EPA Administrator Michael S. Regan. 54p. Philadelphia, PA. https://downloads.regulations.gov/EPA-HQ-OW-2023-0222-0317/attachment_1.pdf

PWD. 2024c. PWD emails to USEPA, DNREC, and DRBC staff regarding incorrect raw DNREC data input file for USEPA 2023 Technical Support Document. https://downloads.regulations.gov/EPA-HQ-OW-2023-0222-0281/attachment_1.pdf

USEPA. 1985. Guidelines for Deriving Numerical Water Quality Criteria for Protection of Aquatic Organisms and Their Uses. U.S. Environmental Protection Agency. Office of Research and Development. Environmental Research Laboratories. PB85-227049.

USEPA. 2011. Evaluation Guidelines for Ecological Toxicity Data in the Open Literature: Procedures for Screening, Reviewing, and Using Published Open Literature Toxicity Data in Ecological Risk Assessments. Office of Pesticide Programs. May 9, 2011.

USEPA. 2016a. OCSPP 850.1075: Freshwater and saltwater fish acute toxicity test. Ecological effects test guidelines. Office of Chemical Safety and Pollution Prevention. EPA 712-C-16-007. October 2016.

USEPA. 2023. Technical Support Document: Proposed Rule to Establish Protective Water Quality Standards for Aquatic Life in the Delaware River. U.S. Environmental Protection Agency. Washington, D.C. 72p.

USEPA. 2024a. Standard Operating Procedures for Systematic Review of Ecological Toxicity Data in Support of Ambient Water Quality Criteria, Benchmark and Screening Value Derivation for Aquatic Life and Aquatic Dependent Wildlife. EPA EPA-822-R-24-008 Office of Water Office of Science and Technology Health and Ecological Criteria Division Ecological Risk Assessment Branch.

USEPA 2024b. Quantifying Dissolved Oxygen Thresholds for Growth and Survival of Juvenile Atlantic Sturgeon in the Tidal-Fresh Delaware River using a Bioenergetic Modeling Approach." Revised Final Version July 8, 2024. USEPA Office of Research and Development, Center for Environmental Measurement and Modeling, Atlantic Coastal Environmental Science Division, Narragansett, RI. EPA/600/R-24/002. 63 pp.

**Appendix 1: Comparison of Figures Demonstrating Discrepancies in Data**

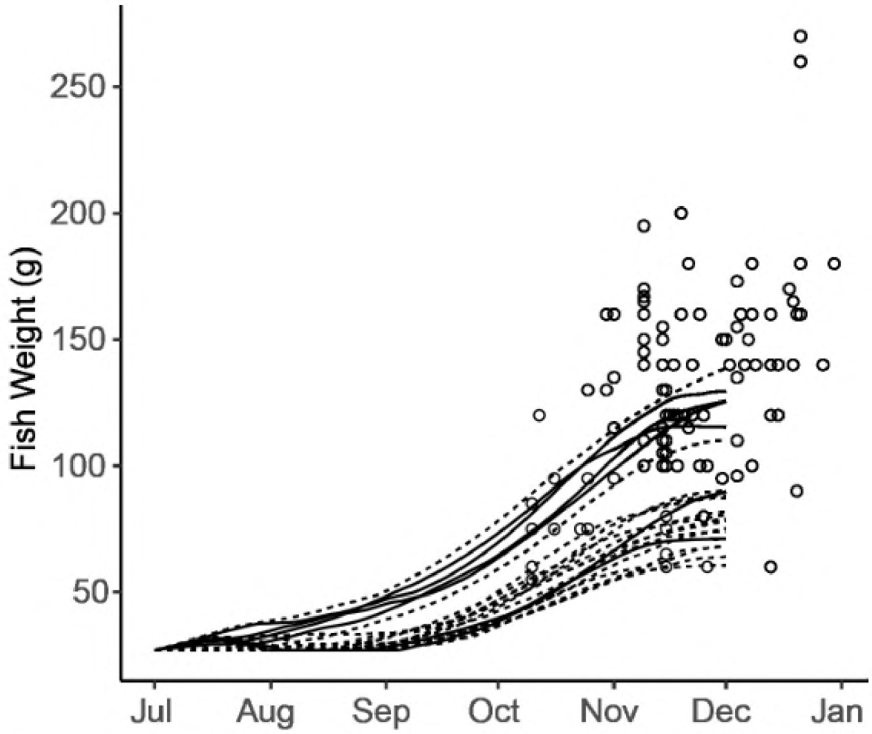



**Figure 6: Simulated Fish Weight based on Water Quality at Chester (lines) and Fish Capture Data (circles) for the Years 2002-2022.** Fish capture data are from juvenile abundance surveys conducted by DNREC; captures and re-captures of fish were generally in the vicinity of Marcus Hook, near Chester, PA, on the date indicated. Solid lines show model predictions for years in which fish were captured and their weights shown on the graph. Dotted lines show predictions for years without observed fish sizes. Colors differentiate data by year.

**Figure 1: Original Version of Figure 6 from USEPA Technical Support Document (USEPA 2023).**

As described in PWD comments (PWD 2024b), the data used to create figure six were limited to 72 fish that were captured and recaptured, not the entire DNREC database and not including the approximately 4,500 additional juvenile sturgeon records collected by ERC. The six solid lines and caption falsely portray the number of years in which juvenile fish were captured, implying that there were years with no fish observed.

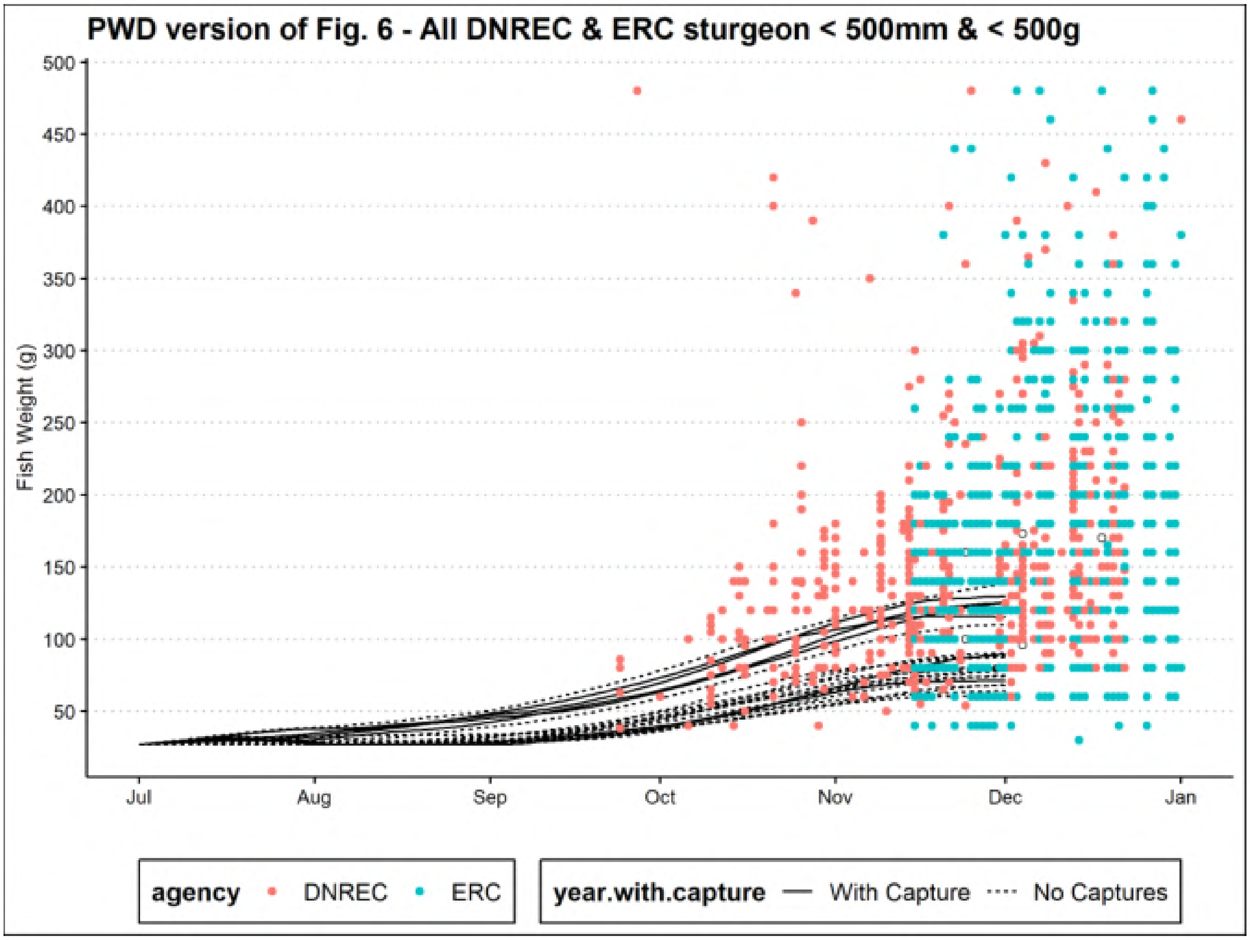



**Figure 2: PWD Revised version of EPA Figure 6 from PWD Technical Comments showing availability of additional sturgeon records (PWD 2024b).**

PWD recreated a version of EPA Figure 6 including all DNREC and ERC records to illustrate the fact that there were many more fish observed than originally plotted in EPA's Figure 6.

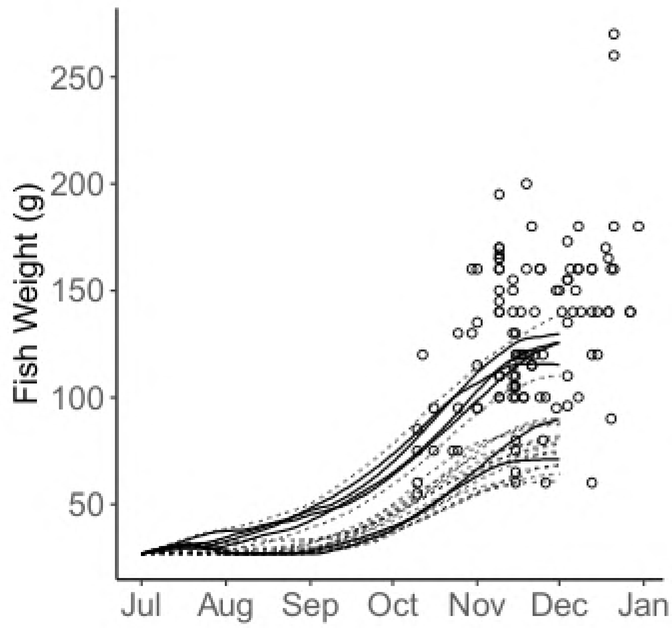



FIGURE 6. FISH WEIGHT SIMULATED BASED ON WATER QUALITY AT CHESTER, PA FOR 2002-2022 (LINES) AND FISH WEIGHTS FROM CAPTURES OR RE-CAPTURES OF FISH, GENERALLY IN THE VICINITY OF MARCUS HOOK, ON THE DATE INDICATED. SOLID LINES SHOW MODEL PREDICTIONS FOR YEARS IN WHICH FISH WERE CAPTURED AND THEIR WEIGHTS SHOWN ON THE GRAPH. DOTTED LINES SHOW PREDICTIONS FOR YEARS WITHOUT OBSERVED FISH SIZES.

**Figure 3: Final July 8, 2024 Version of Figure 6 from USEPA 2024 Technical Support Document.**

EPA partially revised the caption for Figure 6 in response to comments but did not correct the figure to include available data provided by PWD or revise information about whether juvenile fish were observed in years 2002-2022.

## Appendix 2: Errata for PWD Comments on Draft EPA Rulemaking and PWD Technical Comments on the Evidence for Hypoxia as a Stressor on Delaware River Atlantic Sturgeon.

After PWD submitted comments on EPA's proposed rulemaking (docket ID EPA-HQ-OW-2023-0222), PWD became aware of several errors and typographical errors in our comments. Original comment text, figures, and tables are presented below along with corrected versions. PWD believes that these corrections do not substantially alter the basic meaning or intent of our comments as submitted.

**Section 1: Corrections of original PWD Comments on Draft EPA Rulemaking, listed in order of occurrence.**

Page 12: USGS monitoring station name error

<u>Original text</u>: "Calibration results from 2012 show a root mean squared error (RMSE) for dissolved oxygen of 0.9 mg/L at Pennypack Woods, 0.75 mg/L at Penn's Landing Franklin, and 0.93 mg/L at Chester (DRBC Water Quality Model Report)."

<u>Correction</u>: "Calibration results from 2012 show a root mean squared error (RMSE) for dissolved oxygen of 0.9 mg/L at Pennypack Woods, 0.75 mg/L at Penn's Landing ~~Franklin~~, and 0.93 mg/L at Chester (DRBC Water Quality Model Report)."

Page 21: Grammatical error

<u>Original text</u>: "23. The estimated annual costs incurred by PWD is 250% higher than EPA's estimate."

<u>Correction</u>: "23. The estimated annual costs incurred by PWD **<u>are</u>** 250% higher than EPA's estimate."

Page 22: Incomplete citation to draft DRBC document

<u>Original text</u>: "The second methodology attempts to estimate the actual residential burden by assuming that the residential user class would only be responsible for 15 percent of the costs based on the residential class generating 15 percent of the wastewater volume based on a wastewater flow analysis conducted by DRBC in the 2022 DRBC Social and Economic Factors."

<u>Correction</u>: "The second methodology attempts to estimate the actual residential burden by assuming that the residential user class would only be responsible for 15 percent of the costs based on the residential class generating 15 percent of the wastewater volume based on a wastewater flow analysis conducted by DRBC in the 2022 DRBC draft report *<u>Social and Economic Factors Affecting the Attainment of Aquatic Life Uses in the Delaware River Estuary</u>*."

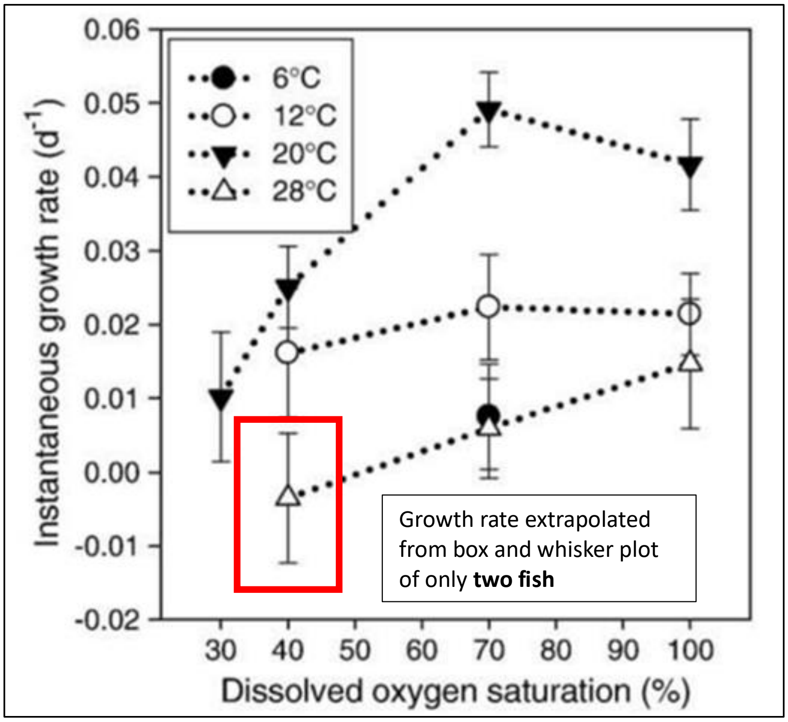
Page 24: Incorrect date for DRBC document

<u>Original text</u>: "There has been no analysis of affordability and economic impacts beyond the 2021 DRBC Social & Economic Factors report, on which PWD provided detailed comments and critiques concerning the scope, methodologies and findings and never received any response from DRBC or EPA."

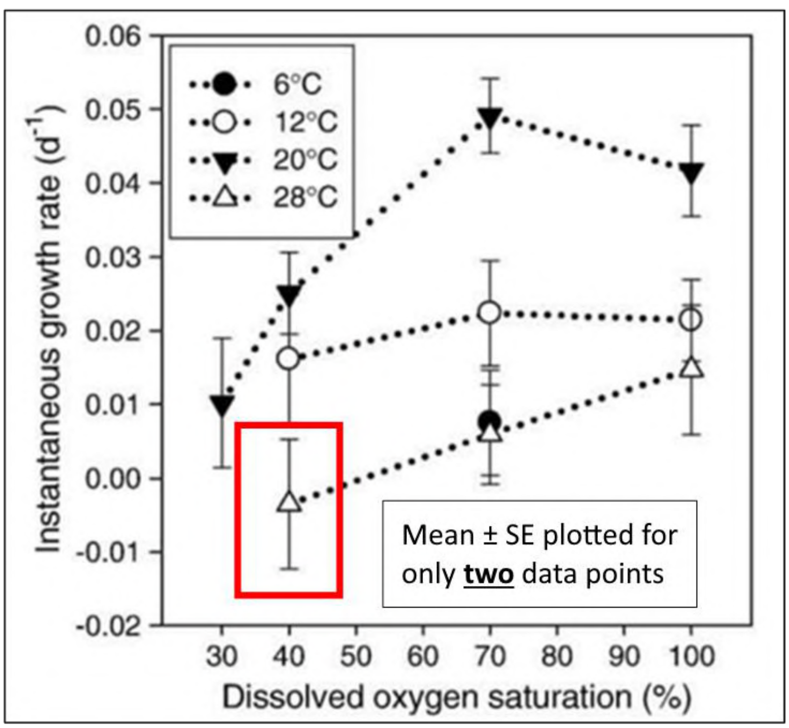
<u>Correction</u>:" There has been no analysis of affordability and economic impacts beyond the **<u>2022</u>** DRBC Social & Economic Factors report, on which PWD provided detailed comments and critiques concerning the scope, methodologies and findings and never received any response from DRBC or EPA."

Page 35: Incorrect annotation in Figure 4

Original figure:




Correction:



Page 36: Sentence with a missing word

Original text: "If fish collected from the Delaware River were under stress from low dissolved oxygen levels, it highly unlikely they would have a similar relationship between weight and length – an indicator of how healthy, or plump the fish are – to the Hudson River".

Correction: "If fish collected from the Delaware River were under stress from low dissolved oxygen levels, it **is** highly unlikely they would have a similar relationship between weight and length – an indicator of how healthy, or plump the fish are – to the Hudson River".

Page 38: Incorrect statement RE: DNREC fish counts for 2012

Original text: "In 2010 and 2012, DNREC did not collect any YOY or juvenile sturgeon, but sampling efforts were much lower than in subsequent years."

Correction: **"DNREC did not collect any YOY or juvenile sturgeon in 2010. In 2012 DNREC collected 22 sturgeon, of which only 3 were YOY (<500mm). DNREC sampling efforts in 2010 and 2012 were much lower than in subsequent years."**

Page 39: Table 12 featured incorrect fish data counts due to typographic errors and inconsistency in assigning fish collected after January 1st to appropriate cohort year

Original table:

**Table 1: Summary of Evidence for Successful Propagation of Atlantic Sturgeon in the Delaware River**

| Year/ Period | Propagation? | Sample Days | Net Hours | DNREC | ERC | YOY | Notes / Evidence for Successful Propagation |
|---|---|---|---|---|---|---|---|
| 1991-2008 | NA | NA | NA | NA | NA | | Habitat sampled and gill net mesh not effective at collecting YOY |
| 2009 | YES | 9 | 30.77 | 33 | NA | 23 | |
| 2010 | NO | 1 | 1.92 | 0 | NA | 0 | Very low sampling effort |
| 2011 | YES | 9 | 26.95 | 50 | NA | 49 | |
| 2012 | NO | 6 | 21.43 | 1 | NA | 3 | Low sampling effort |
| 2013 | YES | 0 | 0 | 0 | 36 | 29 | Not sampled by DNREC; ERC feasibility study collected 36 fish, incl. 27 <500mm in winter 2014 |
| 2014 | YES | 15 | 52.67 | 184 | NA | 47 | |
| 2015 | YES | 22 | 108.08 | 61 | 775 | 271 | |
| 2016 | YES | 11 | 51.42 | 2 | 391 | 103 | |
| 2017 | YES | 18 | 87.68 | 88 | 2506 | 2396 | |
| 2018 | YES | 15 | 75.66 | 221 | 771 | 1528 | |
| 2019 | YES | 16 | 70.42 | 11 | NA | 5 | Large 2019 yearling cohort in 2020 |
| 2020 | YES | 16 | 79.5 | 69 | NA | 20 | |
| 2021 | YES | 16 | 79.61 | 107 | NA | 105 | |
| 2022 | YES | 16 | 87.85 | 48 | NA | 15 | |

Correction:

**Table 2: Summary of Evidence for Successful Propagation of Atlantic Sturgeon in the Delaware River**

| Year/ Period | Propagation? | Sample Days | Net Hours | DNREC | ERC | YOY | Notes / Evidence for Successful Propagation |
|---|---|---|---|---|---|---|---|
| 1991-2008 | NA | NA | NA | NA | NA | | Habitat sampled and gill net mesh not effective at collecting YOY |
| 2009 | YES | 9 | 30.77 | **52** | NA | 23 | |
| 2010 | NO | 1 | 1.92 | 0 | NA | 0 | Very low sampling effort |
| 2011 | YES | 9 | 26.95 | **52** | NA | 49 | |
| 2012 | NO | 6 | 21.43 | **22** | NA | 3 | Low sampling effort |
| 2013 | YES | 0 | 0 | **9** | **34** | 29 | **Low sampling effort by DNREC**; ERC feasibility study collected 34 fish, incl. 27 <500mm in winter 2014 |
| 2014 | YES | 15 | 52.67 | **50** | NA | 47 | |
| 2015 | YES | 22 | 108.08 | **50** | **697** | 271 | |
| 2016 | YES | 11 | 51.42 | **32** | **323** | **102** | |
| 2017 | YES | 18 | 87.68 | **133** | **2414** | 2396 | |
| 2018 | YES | 15 | 75.66 | **227** | **1344** | 1528 | |
| 2019 | YES | 16 | 70.42 | **13** | **228** | **169** | Large 2019 yearling cohort in 2020 |
| 2020 | YES | 16 | 79.5 | **66** | NA | 20 | |
| 2021 | YES | 16 | 79.61 | **106** | NA | 105 | |
| 2022 | YES | 16 | 87.85 | **44** | NA | 15 | |

**Section 2: Corrections of PWD Technical Comments on the Evidence for Hypoxia as a Stressor on Atlantic Sturgeon in the Delaware River, listed in order of occurrence.**

Page 3: Missing comma

Original text: "The overall result of L-W regression for all observed Delaware River Atlantic sturgeon collected between 2009 and 2022 with valid length and weight measurements had L-W regression slope b parameter 3.16, which was within the range of observed values for four Distinct Population Segments (DPS) of Atlantic sturgeon in the Atlantic States Marine Fisheries Commission (ASMFC) 2017 Atlantic Sturgeon Benchmark Stock Assessment and Peer Review Report (ASMFC 2017) for Atlantic sturgeon (Figure 3 Table 2)."

Correction: "The overall result of L-W regression for all observed Delaware River Atlantic sturgeon collected between 2009 and 2022 with valid length and weight measurements had L-W regression slope b parameter 3.16, which was within the range of observed values for four Distinct Population Segments (DPS) of Atlantic sturgeon in the Atlantic States Marine Fisheries Commission (ASMFC) 2017 Atlantic Sturgeon Benchmark Stock Assessment and Peer Review Report (ASMFC 2017) for Atlantic sturgeon (Figure 3**,** Table 2)."

Page 14: Incorrect year referenced

Original text: "Again, it is possible that the other fish less than 500mm in length may have corresponded to a yearling 2014 cohort or other (*e.g.*, fall spawning) cohort."

Correction: "Again, it is possible that the other fish less than 500mm in length may have corresponded to a yearling **2015** cohort or other (*e.g.*, fall spawning) cohort."

Page 18: Misplaced comma

Original text: “However, due to the relatively short window of length measurements during the growing season and inadequate 60-day comment period allowed by EPA for review of the proposed rule PWD, was unable to fully investigate more appropriate specific growth rates as a function of body size.”

Correction: “However, due to the relatively short window of length measurements during the growing season and inadequate 60-day comment period allowed by EPA for review of the proposed rule, PWD was unable to fully investigate more appropriate specific growth rates as a function of body size.”

# PWD Comments on Draft EPA Rulemaking

February 20, 2024

Michael S. Regan
Administrator
Environmental Protection Agency
Office of Water
1200 Pennsylvania Avenue NW
Washington, DC 20460

Re: Water Quality Standards to Protect Aquatic Life in the Delaware River
Docket ID No. EPA–HQ–OW–2023–0222

Dear Administrator Regan,

The Philadelphia Water Department (PWD) appreciates the opportunity to submit comments on EPA's Proposed Water Quality Standards to Protect Aquatic Life in the Delaware River dated December 21, 2023, Docket ID No. EPA–HQ–OW–2023–0222, referred to here as the EPA proposed rulemaking.

PWD provides drinking water, stormwater and wastewater services to over 1.5 million people in Philadelphia County and surrounding areas. Municipal wastewater treatment plants operated by PWD and other cities in the Delaware River basin have not only achieved the goals set by Delaware River Basin Commission (DRBC) for water quality, but exceeded them, with substantial financial assistance from the federal government. PWD fully supports upgrading the aquatic life use of the Delaware River from 'fish maintenance' to 'fish propagation' to recognize that fish, including endangered Atlantic and shortnose sturgeon, have been propagating in the Delaware River in the vicinity of Philadelphia for many years now.

Our review of the EPA proposed rulemaking Technical Support Document, Economic Analysis, and Environmental Justice Analysis, however, finds these reports lacking in scientific and technical rigor, especially given the financial and environmental justice consequences that the rule would have for our ratepayers. PWD has the following concerns with the rulemaking, which are described in detail within our comments:

- EPA greatly misrepresented costs of the proposed rule on PWD ratepayers. Infrastructure costs are underestimated by $1.4-2.5 billion. The financial impact of the proposed rule would be untenable for many ratepayers ($22/month ($266/annually)), more than 20% of whom live below the federal poverty line.
- The proposed treatment plant modifications would have massive opportunity costs, forcing PWD to redirect resources from maintaining our current infrastructure and addressing issues such as flooding, lead pipes, PFAS, and CSOs that directly affect public health and daily lives of Philadelphians.
- EPA relied on draft DRBC technical studies that were never finalized. Many serious concerns expressed by PWD and others throughout DRBC's Analysis of Attainability remain unaddressed.
- EPA's proposed DO criteria are much more stringent than current levels that already support propagation of fish in the Delaware River and more stringent than state DO criteria approved by EPA in other east coast rivers.
- EPA used a novel approach to developing DO criteria and provided only 60 days to review.
- The DO and fish models used by EPA are flawed and produced incorrect, unreliable results.
- Water quality modeling by PWD, DRBC, and even EPA suggests that the proposed DO levels may not even be attainable for the Delaware estuary natural warmwater habitat.

PWD shares the goals of ensuring that fish and other aquatic life can not only survive, but thrive, and rebuilding populations of our iconic native species such as Atlantic sturgeon, striped bass and American shad. Prior to the proposed rulemaking, PWD has voluntarily worked to implement technology to reduce our ammonia loading to the estuary via sidestream treatment at our Southwest plant and are pleased that groundbreaking will begin in 2024. As PWD demonstrates the operation and impacts of ammonia reducing technology, there will likely be other wastewater plants that follow a similar course.

Along with this comment document, PWD is submitting Technical Comments on the Evidence for Hypoxia as a Stressor on Delaware River Atlantic Sturgeon, a compendium of the numerous comments PWD has made during the DRBC Analysis of Attainability process over the past several years, and a data set that represents the best available scientific information on spawning and growth of Atlantic sturgeon in the Delaware River. PWD urges EPA to fully consider our comments on the wide-ranging implications of setting unprecedentedly stringent DO criteria for the Delaware River. PWD technical staff are available to discuss our analyses, findings, and recommendations.

Sincerely,

Randy E. Hayman

Commissioner and Chief Executive Officer

Philadelphia Water Department

## Introductory Comments

1. **The Delaware River is already achieving the fishable goal of the Clean Water Act under existing water quality conditions.**

Current dissolved oxygen conditions in the Delaware River support spawning and growth of juvenile Atlantic sturgeon as well as other aquatic life. As described in further detail in PWD's Technical Comments on the Evidence for Hypoxia as a Stressor on Delaware River Atlantic Sturgeon, spawning of Atlantic sturgeon was observed every year during the period 2009-2022 with sufficient sampling effort. Furthermore, measures of growth and health for juvenile sturgeon were within the normal range for the species and similar to other river systems where sturgeon spawn. Each year sturgeon spawn in the Delaware River during spring, laying small eggs that sink and stick to the hard bottom. Eggs hatch into larval fish that grow rapidly, attesting to the supportive levels of dissolved oxygen and adequate food and habitat available in the Delaware River. By late fall and early winter when sampled by fisheries scientists, most of these "young-of-year" (YOY) fish that began as tiny eggs in spring will have attained lengths of more than 300mm (12 inches). The average length of 4,500 YOY sturgeon collected from the Delaware River between 2009 and 2022 was 345 mm, or 13.5 inches long. These rapid rates of growth, which are observed consistently from year to year from thousands of fish collected and measured, would simply be impossible if sturgeon lacked adequate levels of dissolved oxygen.

2. **Dissolved oxygen levels do not appear to be adversely affecting sturgeon in the Delaware River under existing conditions.**

For the last 12 years of monitoring with adequate data for the Delaware River, PWD thoroughly investigated but could find no significant correlation between dissolved oxygen levels and measurements of sturgeon growth and health. While there is variability from year to year, there is no evidence that hypoxia is significantly negatively affecting the propagation or growth of sturgeon in the Delaware River or that further dissolved oxygen improvements are required or scientifically justifiable, let alone cost-effective or appropriate given other policy considerations. More information on the analysis of hypoxia as a potential stressor on sturgeon in the Delaware River is available in PWD's Technical Comments on the Evidence for Hypoxia as a Stressor on Delaware River Atlantic Sturgeon.

3. **The draft dissolved oxygen criteria proposed by EPA are excessively stringent and ignore precedent and alignment with the evidence-based conclusions documented by DRBC, and EPA- approved dissolved oxygen criteria established for other areas within the Delaware River Basin, the Chesapeake Bay, the New York Bight, and the Carolinas.**

The draft criteria expressed as 66% dissolved oxygen saturation at a 10% frequency and a 74% dissolved oxygen saturation at 50% frequency (equivalent to 5.4 mg/L and 6.1 mg/L at 25º C, respectively) during the Juvenile Development Period are *excessively stringent* compared to the 4.3 mg/L minimum suitable dissolved oxygen concentration identified by DRBC and EPA-Approved state water quality standards along the Atlantic Coast that range from 4.3-5.0 mg/L.

The 2022 DRBC Literature Review, "Linking Aquatic Life Uses with Dissolved Oxygen Conditions in the Delaware River Estuary" reviewed a range of sources, including EPA and NOAA Fisheries sources, for information on the dissolved oxygen levels needed to support sturgeon and other sensitive species of aquatic life in the Delaware River. The study concluded that the evidence overall supports a year-round minimum of 4.3 mg/L and a minimum of 5.0 mg/L during the May 1 to June 30 spawning period.

Additionally, the EPA 2003 Ambient Water Quality Criteria for Dissolved Oxygen for the Chesapeake Bay are based on multiple studies including evidence from NOAA Fisheries that support a minimum of 4.3

mg/L under temperatures greater than 29°C and a minimum of 3.2 mg/L at lower temperatures. A 60% dissolved oxygen saturation (5.0 mg/L at 25°C) is cited as providing "protection from nonlethal effects."

Further, federal research from the EPA Ambient Aquatic Life Water Quality Criteria for Dissolved Oxygen (Saltwater): Cape Cod to Cape Hatteras (2000), commonly referred to as the Virginian Province Document, determines the lower level of dissolved oxygen needed for aquatic life in the Virginian Province, which extends from Cape Cod, MA to Cape Hatteras, NC and includes the Delaware River Basin. The study determines a minimum allowable dissolved oxygen condition for Juvenile and Adult Survival as 2.3 mg/L dissolved oxygen for continuous exposure. It also indicates that the maximum dissolved oxygen condition required where growth effects are not impacted for most species is 4.8 mg/L for continuous exposure.

The proposed criteria are not based on dissolved oxygen levels actually observed to support aquatic life but appear to reflect EPA's subjective preference for even more stringent dissolved oxygen levels in the Delaware River than the levels that have been developed by other U.S. States and approved by EPA for other river systems. EPA has provided no sound scientific rationale why higher dissolved oxygen levels are needed for the Delaware River than in other rivers occupied by many of the same species, including Atlantic sturgeon. Some key examples of existing dissolved oxygen criteria that protect aquatic species are summarized below and in Table 1 and Table 2. Emphasis has been added to note EPA-approved state water quality criteria along the Atlantic coast that are all less stringent than the EPA proposed criteria for the Delaware River. DRBC used these sources in its analysis that identified a minimum DO criterion of 4.3 mg/L in the Delaware River[1,2].

[1] ANALYSIS OF ATTAINABILITY: IMPROVING DISSOLVED OXYGEN AND AQUATIC LIFE USES IN THE DELAWARE RIVER ESTUARY; Technical Report No. 2022-X; September 2022 DRAFT.
https://www.nj.gov/drbc/library/documents/AnalysisAttainability/AnalysisAttainability_DRAFTsept2022.pdf

[2] LINKING AQUATIC LIFE USES WITH DISSOLVED OXYGEN CONDITIONS IN THE DELAWARE RIVER ESTUARY Technical Report No. 2022-X November 2022 DRAFT
https://www.nj.gov/drbc/library/documents/AnalysisAttainability/LinkingALDU-DO_DRAFTnov2022.pdf

**Table 1: Summary of Selected PADEP, DRBC, and EPA Dissolved Oxygen Criteria, Outlined Cells Represent Standards less than EPA Proposed Criteria**

| Agency | Guideline and Reference | Type of Water | (Critical) Designated Use* | Numeric Criteria – Average* | Numeric Criteria – Minimum* | Numeric Criteria - Seasonal |
|---|---|---|---|---|---|---|
| PADEP | Title 25 Ch. 93 7/29/2023 | Flowing Freshwater | Cold Water Fishes (CWF): Maintenance or propagation, or both, of fish species including the family Salmonidae | 6.0 mg/L (7-day) | 5.0 mg/L | 9.0 mg/L (7-day avg), 8.0 mg/L minimum; applies to "naturally reproducing salmonid early life stages", Oct 1 - May 31 |
| PADEP | Title 25 Ch. 93 7/29/2023 | Flowing Freshwater | Warm Water Fishes (WWF): Maintenance and propagation of fish species | 5.5 mg/L (7-day) | 5.0 mg/L | N/A |
| PADEP | Title 25 Ch. 93 7/29/2023 | Flowing Freshwater | Trout Stocking (TSF): Maintenance of stocked trout from February 15 to July 31 and maintenance and propagation of fish species | 5.5 mg/L (7-day) | 5.0 mg/L | 6.0 mg/L (7-day avg), 5.0 mg/L minimum; applies Feb 15 - July 31 |
| DRBC | Water Code 12/7/2022 | "interstate streams - tidal" (Zone 2 - freshwater) | Propagation of resident fish and other aquatic life | 5.0 mg/L (24-hr) | N/A | 6.5 mg/L (seasonal avg April 1 - June 15 and Sept 16 - Dec 31) |
| DRBC | Water Code 12/7/2022 | "interstate streams - tidal" (portions of Zones 3-5 - freshwater/brackish) | Maintenance of resident fish and aquatic life; passage of anadromous fish | 3.5 mg/L (24-hr) | N/A | 6.5 mg/L (seasonal avg April 1 - June 15 and Sept 16 - Dec 31) |
| DRBC | Water Code 12/7/2022 | "interstate streams - tidal" (portions of Zone 5) | Propagation of resident fish and other aquatic life | 4.5-6.0 mg/L (24-hr) | N/A | 6.5 mg/L (seasonal avg April 1 - June 15 and Sept 16 - Dec 31) |
| DRBC | Water Code 12/7/2022 | "interstate streams - tidal" (Zone 6 - Delaware Bay) | Propagation of resident fish and other aquatic life; propagation of shellfish | 6.0 mg/L (24-hr) | 5.0 mg/L | N/A |
| DRBC | Water Code 12/7/2022 | "interstate streams - nontidal" (Zones 1A, E, W1, W2, N2, C3, C5) | Propagation of resident game fish and other aquatic life; propagation of trout; spawning and nursery habitat for anadromous fish | 6.0 mg/L (24-hr) | 5.0 mg/L | 7.0 mg/L minimum "in spawning areas whenever temperatures are suitable for trout spawning" |
| DRBC | Water Code 12/7/2022 | "interstate streams - nontidal" (Zones 1B, 1C, 1D, 1E, N1, C1, C2, C4, C6, C7, C8) | Propagation of resident game fish and other aquatic life; spawning and nursery habitat for anadromous fish | 5.0 mg/L (24-hr) | 4.0 mg/L | N/A |

| Agency | Guideline and Reference | Type of Water | (Critical) Designated Use* | Numeric Criteria – Average* | Numeric Criteria – Minimum* | Numeric Criteria - Seasonal |
|---|---|---|---|---|---|---|
| DRBC | Highest Attainable dissolved oxygen Condition[3] | "Fish Maintenance Area", portions of zones 3-5 | "Propagation of one or more dissolved oxygen-sensitive species in the Delaware Estuary" | N/A | 4.3 mg/L | N/A |
| | Propagation Finding[4] | Delaware Estuary | Propagation of Atlantic Sturgeon and Shortnose Sturgeon | See Tables 2-1 and 4-1 | 4.3 mg/L | 5.0 mg/L min (May 1 - June 30) |
| EPA | Guidance adopted by Delaware[5] | Chesapeake Bay watershed | Propagation of Atlantic Sturgeon and Shortnose Sturgeon | N/A | 3.2 mg/L for T < 29°C; 4.3 mg/L for T >= 29°C | N/A |
| | Guidance Document [6] | Chesapeake Bay watershed | Propagation of Atlantic Sturgeon and Shortnose Sturgeon | N/A | 60% saturation | N/A |
| | Guidance Document[7] | Saltwater from Cape Cod, MA to Cape Hatteras, NC | N/A | 2.3 mg/L(24-hr) Juv./Adult, 4.8 mg/L growth | N/A | N/A |

*Red outlined criteria are LOWER than EPA proposed criteria for Delaware River

[3] ANALYSIS OF ATTAINABILITY: IMPROVING DISSOLVED OXYGEN AND AQUATIC LIFE USES IN THE DELAWARE RIVER ESTUARY; Technical Report No. 2022-X; September 2022 DRAFT. https://www.nj.gov/drbc/library/documents/AnalysisAttainability/AnalysisAttainability_DRAFTsept2022.pdf

[4] LINKING AQUATIC LIFE USES WITH DISSOLVED OXYGEN CONDITIONS IN THE DELAWARE RIVER ESTUARY Technical Report No. 2022-X November 2022 DRAFT https://www.nj.gov/drbc/library/documents/AnalysisAttainability/LinkingALDU-DO_DRAFTnov2022.pdf

[5] Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries, EPA 903-R-03-002, April 2003 https://d38c6ppuviqmfp.cloudfront.net/content/publications/cbp_13142.pdf

[6] Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries, EPA 903-R-03-002, April 2003 https://d38c6ppuviqmfp.cloudfront.net/content/publications/cbp_13142.pdf

[7] https://www.epa.gov/sites/default/files/2018-10/documents/ambient-al-wqc-dissolved-oxygen-cape-code.pdf

**Table 2: Dissolved oxygen Criteria Applicable to Atlantic Sturgeon Distinct Population Segment Waters, Outlined Cells Represent Standards less than EPA Proposed Criteria (from Table 4-1, DRBC 2022, emphasis added)**

| Atlantic Sturgeon Distinct Population Segment (DPS) | State | Classification / Use | Criteria | Duration | Conditions |
|---|---|---|---|---|---|
| Chesapeake Bay | MD VA | migratory fish spawning and nursery use | 6 mg/L | 7-d avg (Feb 1 to May 31) | salinity <0.5 ppt |
| | | surivival/growth of larval/juvenile fish incl T&E | 5.0 mg/L | minimum (Feb 1 to May 31) | |
| | | open water fish and shellfish growth of larval, juvenile and adult fish incl T&E | 5.5 mg/L | 30-d avg | salinity <0.5 ppt |
| | | | 5.0 mg/L | 30-d avg | salinity >0.5 ppt |
| | | | 4 mg/L | 7-d avg | |
| | | | 3.2 mg/L* | minimum | temperature < 29°C |
| | | | 4.3 mg/L* | minimum | temperature > 29°C |
| NY Bight | PA | Passage, maintenance and propagation of warmwater, anadromous and catadromous fishes | 5.5 mg/L | 7-d avg | tidal |
| | | | 5 mg/L | minimum at any time | |
| | NJ | Maintenance, migration and propagation of the natural and established biota | 5 mg/L | 24-hr avg | freshwater nontrout |
| | | | 4 mg/L | minimum at any time | freshwater and estuarine |
| | NY | fish propagation and survival | 5 mg/L | daily avg | freshwater nontrout |
| | | | 4 mg/L | at any time | |
| | | fish propagation and survival | 4.8 mg/L | daily avg with allowabe excursions | estuarine |
| | | | 3.0 to 4.8 mg/L | allowable excursions** | |
| | | fish propagation and survival | 4 mg/L | at any time | estuarine fishing |
| | CT | marine fish including larval recruitment | 3.0 mg/L | at any time | estuarine: good to excellent |
| | | | 3.0 to 3.5 mg/L | up to 2 days | |
| | | | 3.5 to 4.0 mg/L | up to 7 days | |
| | | | 4.0 to 4.5 mg/L | up to 14 days | |
| | | | 4.5 to 4.8 mg/L | up to 30 days | |
| Carolinas | NC | aquatic life | 5.0 mg/L | daily avg | freshwater/estuarine |
| | | | 4.0 mg/L | instantaneous minimum | freshwater |
| | SC | survival and propagation of balanced indigenous aquatic community of fauna and flora | 5.0 mg/L | daily avg | freshwater and estuarine |
| | | | 4.0 mg/L | instantaneous minimum | |

* Established by USEPA specifically to protect sturgeon species (including Atlantic sturgeon) and other T&E

** The DO concentration may fall below 4.8 mg/L for a limited number of days, as defined by the formula:
DOi = 13.0/2.80 + 1.84*e-0.1*ti
where: DOi = DO concentration in mg/L between 3.0-4.8 mg/L; and ti = time in days.
This equation is applied by dividing the DO range of 3.0-4.8 mg/L into a number of equal intervals. DOi is the lower bound of each interval (i) and ti is the allowable number of days that the DO concentration can be within that interval. The actual number of days that the measured DO concentration falls within each interval (i) is divided by the allowable number of days that the DO can fall within interval (ti). The sum of the quotients of all intervals (i...n) cannot exceed 1.0: i.e.,
nti (actual)
Σ< 1.0
i=1ti (allowed)
The DO concentration may not fall below the acute standard of 3.0 mg/L at any time.

4. **PWD recommends revising the proposed dissolved oxygen criteria during the juvenile development season to 4.5 mg/L with a 10% exceedance and 5.0 with a 50% exceedance to align with precedent along the Atlantic Coast and within the Delaware River Basin.**

EPA, DRBC and many other well-intentioned parties want to see fishable standards achieved in the Delaware River. PWD shares in this objective. In the process to upgrade an old, outdated water quality standard (of 3.5 mg/L) EPA has lost sight of the fact that the Delaware River is already fishable, supporting propagation, and *has water quality attaining comparable standards to other estuaries along the Atlantic coast.*

Existing water quality far surpasses the current criterion of 3.5 mg/L, which should be revised to reflect the conditions that are currently supporting fish propagation. PWD does not support the EPA proposed criteria *magnitude* and offers the alternative concentration-based criteria revision presented in Table 3 for consideration, especially given:

A. Precedent of existing dissolved oxygen criteria, already approved by EPA, in the Delaware River Basin, Chesapeake Bay, New York Bight, and Carolinas ranging from 4.3 – 5.0 mg/L (Comment 3).
B. Identification of 4.3 mg/L as the minimum suitable dissolved oxygen condition by DRBC (Comment 3).
C. Demonstration of fish propagation under existing water quality conditions (Comments 33 and 48).
D. Demonstration of over-calculation of the criteria magnitude due to over-estimation of "restored" dissolved oxygen carried through EPA criteria selection methodology of approximately 1 mg/L (Comment 12).
E. Lack of attainability of EPA proposed criteria following implementation of extensive nutrient controls (Comments 13-14).
F. Lack of affordability of EPA proposed criteria (Comments 5, 7, 22-27)

**Table 3: PWD Recommended Dissolved Oxygen Standard for Delaware River Zones 3, 4, and upper Zone 5**

| Season* | Magnitude, (mg/L) | Duration | Exceedance Frequency |
|---|---|---|---|
| Spawning and Larval Development *(March 1 – June 30)* | 5.6 | Daily Average | 10% *(12 Days Cumulative)* |
| Juvenile Development *(July 1 – October 31)* | 4.5 | Daily Average | 10% *(12 Days Cumulative)* |
| | 5.0 | Daily Average | 50% *(61 Days Cumulative)* |
| Overwintering *(November 1 – February 28/29)* | 7.0 | Daily Average | 10% *(12 Days Cumulative)* |

*Recommend including 1 in 3 year exceedance frequency to all proposed criteria, see comment below

PWD also supports including a 1 in 3 year exceedance frequency to the revised dissolved oxygen criteria given the uncertainty associated with dissolved oxygen variability in the Delaware River. As noted by EPA throughout their technical support document, dissolved oxygen in the Delaware River is highly variable and influenced by many factors beyond flow and temperature such as sediment oxygen demand, reaeration, and algal dynamics. These complex interactions introduce uncertainty into water quality modeling simulations, criteria selection, and the expected response of dissolved oxygen to reduced ammonia loading from wastewater plants. A 1 in 3 year rolling exceedance frequency is an appropriate regulatory mechanism to accommodate uncertainty in dissolved oxygen dynamics when revising dissolved oxygen criteria.

5. **The EPA affordability assessment of Philadelphia is deeply flawed and does not correctly forecast the increased financial burden of the proposed rule. PWD estimates the EPA proposed rulemaking will cost ratepayers an additional $22.17 per month, not $1.50 per month as calculated by EPA.**

The discrepancies in economic inputs, methodology, and ultimately results between the EPA Economic Analysis assumptions and PWD's own understanding of its costs, operations and billing practices are detailed in Comments 22-32. These errors lead to a gross misunderstanding of PWD facilities, operations and billing practices culminating in the difference in estimates of monthly billing increases needed to fund the EPA proposed rulemaking. PWD estimates compliance with the proposed rulemaking to cost an additional $22.17 per month per residential ratepayer, which is 15 times more than the erroneous estimate of $1.50/month provided by EPA in their Economic Analysis.

To summarize, Table 4 presents differences in EPA and PWD estimated economic inputs and results.

**Table 4: Discrepancies between EPA and PWD estimates of economic analysis inputs and results**

| **Economic Analysis Inputs** | **EPA Estimates** | **PWD Estimates** |
|---|---|---|
| PWD total costs for ammonia removal for compliance with proposed rule | $1.05 billion | $3.6 billion |
| PWD total annual cost of compliance with proposed rule | $77.9 million | $274 million* |
| | | |
| **Economic Analysis Results** | **EPA Estimates** | **PWD Estimates** |
| Annual incremental cost per Philadelphia household | $18.07/yr | $266/yr |
| Monthly bill increase per Philadelphia household | $1.50/month | $22.17/month |

*Annual compliance cost + O&M

Further, EPA's decision to limit its economic and environmental justice analyses to the City of Philadelphia as a "case study" underestimates the overall affordability challenges created by the Proposed Rule, particularly in communities like Camden and Trenton, NJ, where a significant number of households likely face affordability challenges.

EPA's choice of Philadelphia as a case study is premised on the fact that PWD will face the highest compliance costs. However, this choice ignores the relative impact of compliance costs on smaller urban wastewater treatment systems (e.g., Camden, City of Trenton). EPA's assumption that other wastewater utilities could simply adopt PWD-style customer assistance programs to offset customer affordability impacts is not supported by any evidence.[8]

6. **The PWD costs of the proposed rulemaking are more than double the benefits estimated in the EPA Economic Analysis.**

The benefits of the proposed rulemaking are estimated by EPA to be $112.8 million per year and do not come close to equaling or exceeding the $274 million per year costs attributed only to PWD. This imbalance will further grow by adding in the costs of other wastewater dischargers in the Delaware River such as Camden, NJ, Delaware County, PA, and Wilmington, DE.

[8] See Environmental Justice Analysis at Section 3.4.

7. **The Bipartisan Infrastructure Law does not provide enough funding to ensure affordability for PWD compliance with the proposed rulemaking.**

The Bipartisan Infrastructure Law provides $44 billion over five years for wastewater, water, and water quality projects, or about $9 billion annually. The federal fiscal year 2022 amount was $7.4 billion, of which Pennsylvania's allocation was $240 million. Of that $240 million, $74.2 million was designated for Clean Water Act related projects across Pennsylvania in 2022. Assuming this distribution holds for five years, the five-year estimated total Pennsylvania share of Clean Water Act related funding would be $371 million, which is just 10.3% of the estimated $3.6 billion in nutrient reduction capital costs estimated for PWD to comply with the proposed rulemaking. It is not realistic to assume that PWD would obtain *all* wastewater funding from this law in Pennsylvania for *all* five years. Even if that assumption were true, such funds would only pay for 10.3% of the funding needed for PWD to comply with the EPA proposed rulemaking.

This working example is insightful, because it is easy to overstate the ability of the Bipartisan Infrastructure Law to pay for the proposed rulemaking. The Bipartisan Infrastructure Law does not provide enough funding to make PWD compliance with the proposed rulemaking affordable. Should this rulemaking lead to overly stringent criteria, EPA should work with Congress and other stakeholders to ensure adequate funding is made available for this rulemaking to be more affordable for impacted ratepayers in environmental justice communities.

8. **The plant modifications to achieve the proposed rulemaking for ammonia and dissolved oxygen will more than double PWD's electricity use and increase greenhouse gas (GHG) emissions by 99%.**

While this rulemaking strives to improve one aspect of the environment (water quality), it is doing so at the expense of another environmental concern (climate).

Estimates from PWD's wastewater plant-specific engineering evaluations indicate that the addition of ammonia removal treatment at each plant will result in a 147% increase in electricity use and a 99% increase in Scope 1 & 2 GHG emissions. The estimates are presented in Table 5 below. These increases are far beyond what any renewable energy technology could properly offset. PWD recommends that EPA consider this rulemaking in a holistic environmental context to understand other impacts on the environment, now and into the future.

**Table 5: PWD Wastewater Plant Ammonia Removal Alternatives Energy Summary (1.5 MG/L $NH_3$-N, Monthly Average Scenario)**

| Parameter | Northeast Plant | Southeast Plant | Southwest Plant | Total |
|---|---|---|---|---|
| Estimated Electricity Use (kWh/Year)[1]: | 36,003,170 | 20,887,104 | 119,017,000 | 175,907,274 |
| % Change from Existing Electricity Use[2]: | 68% | 118% | 240% | 147% |
| Estimated GHG Emissions (mt CO2e/Year)[3]: | 9,032 | 3,003 | 30,269 | 42,304 |
| % Change from Existing GHG Emissions[4]: | 50% | 50% | 163% | 99% |

[1]Represents the estimated electricity use for the proposed ammonia removal process; does not include infrastructure for dissolved oxygen control; does not include existing wastewater plant electricity use.
[2]Represents the change in electricity use based on average annual electricity use from FY2021, FY2022, and FY2023.
[3]Represents the estimated GHG emissions for the proposed ammonia removal process; does not include infrastructure for dissolved oxygen control; does not include existing wastewater plant electricity use.
[4]Existing Scope 1 and 2 GHG emissions (i.e., from purchased electricity, process emissions, and fleet) for each wastewater plant are based on 2021 eGRID values.

*PWD is concerned that the year-round operation of the final effluent reaeration facilities may be unnecessary and result in excess energy usage.* The year-round effluent aeration is overly conservative and would require wastewater treatment plants to operate energy- and chemical-intense processes during times of the year when water quality conditions in the Delaware estuary are optimal for aquatic life, increasing the climate impacts of this rulemaking.

## Treatment and Infrastructure Comments

9. **EPA has underestimated costs for major wastewater treatment plant modifications for PWD facilities by $1.3-$2.5 billion dollars.**

Concurrent with the Kleinfelder Engineering Evaluation used by EPA and DRBC to estimate compliance costs, PWD engaged firms to conduct engineering evaluations for mainstream ammonia removal at PWD's three wastewater plants, which included AACE Class 4 Cost Estimates (+50%/-30%). The evaluations incorporated historical treatment process data, intensive sampling data, and PWD's validated BioWin process models to verify treatment alternatives. Within Table 6 are the findings from PWD's evaluations which we are requesting be considered for use by the EPA. Note that these estimates do not include the costs associated with increased solids production or the costs to increase effluent dissolved oxygen at our wastewater plants.

**Table 6: Estimated Costs for Ammonia Removal at PWD's Wastewater Plants (EPA, PWD)**

| PWD Plant | EPA/Kleinfelder | PWD – Annual Average Permitting Scenario[1,2] | PWD – Monthly Average Permitting Scenario[1,2] |
|---|---|---|---|
| Southwest Plant[3] | $ 361,200,000 | $ 1,658,813,202 | $ 2,725,193,118 |
| Southeast Plant[3] | $ 240,800,000 | $ 213,275,983 | $ 260,670,646 |
| Northeast Plant[3] | $ 445,100,000 | $ 485,795,295 | $ 592,433,287 |
| **Total** | **$ 1,047,100,000** | **$ 2,357,884,480** | **$ 3,578,297,051** |
| **PWD estimated cost difference (additional costs)** | | **$ +1,310,784,480** | **$ +2,531,197,051** |

[1]Due to uncertainty surrounding implementation of permitting while scoping PWD's evaluations in 2018, PWD created two scenarios for each plant – one that evaluated the costs under a monthly average (MA) permitting structure, and one that evaluated the costs under an annual average (AA) permitting structure.

[2]These reports were finalized in 2020, but PWD escalated the costs to October 2023 using Engineering News Record Construction Cost Index (ENRCCI) value 13498.

[3]After internal discussions regarding different technologies, PWD ultimately decided that the best technology approach for each plant would be to expand the existing activated sludge processes to ensure effective nitrification could occur, with the caveat that this selection also included the conversion of the aeration system at the Southwest plant from high purity oxygen (HPO) to diffused air.

10. **There are significant inaccuracies in technical assumptions that led to the gross underestimation of the costs of removing ammonia from the effluent of PWD's Wastewater Plants.**

As specified in Section 3.2 of the Economic Analysis, the EPA has based their economic analysis on the work detailed in Kleinfelder (2021) and Kleinfelder (2023). Many of these inaccuracies were previously communicated by PWD to DRBC and remain unaddressed by Kleinfelder and/or DRBC. The inaccuracies are summarized below.

a. Kleinfelder used Integrated Fixed film Activated sludge (IFAS) as the technological basis for PWD's Northeast and Southeast wastewater plant cost estimates. IFAS technology is not applicable for Northeast or Southeast.
b. Ammonia removal requires additional solids (sludge) handling; Kleinfelder did not account for these costs in their Engineering Evaluation.
c. Costly site preparations – specifically grading and sludge lagoon remediation – were not accounted for in Kleinfelder's Engineering Evaluation.

d. There are more final settling tanks ("clarifiers") required to preserve biomass in PWD's wastewater plants than what was estimated in Kleinfelder's Engineering Evaluation.
e. The addition of final effluent reaeration considered in the DRBC's Analysis of Attainability requires additional plant-specific feasibility, hydraulic, and operability studies, which may introduce costs for infrastructure that were not considered.
f. PWD does not believe that the conceptual layouts described in Kleinfelder (2021, 2023) align with necessary climate change adaptation efforts, which can increase the capital cost of a project due to additional infrastructure. The absence of EPA addressing climate impacts in this rulemaking is particularly troubling given the EPA September 28, 2023 Climate Enforcement and Compliance Strategy memo, which calls for EPA to "include climate adaptation and resilience in case conclusions"[9]. EPA did not consider mitigation nor adaptation measures as part of this rulemaking.
g. More cost-effective technologies may exist, yet evaluating and proving the effectiveness of such technologies is a costly and time-consuming endeavor. PWD believes that piloting is a key requirement to vet vendor claims, inform elements of system design, and allow for permitting new technologies with the region's regulatory agencies. PWD has found that cost-effective technologies simply may not be viable for many of the older systems in the area. The EPA and external partners should consider separate grant funding for these efforts at PWD and other dischargers to help facilitate cost-effective solutions to achieve lower levels of ammonia.

11. **Based on PWD's cost estimation, the revised annual compliance costs will require review of the proposed rule by the Office of Management and Budget Executive Order.**

Executive Order 12866 (58 FR 51735)[10] as amended by Executive Order 14094 (88 FR 21879), provides that "significant regulatory actions" be submitted for review to the Office of Information and Regulatory Affairs in the Office of Management and Budget ("OMB"). A "significant regulatory action" is generally any regulatory action that is likely to result in a regulation that may have an annual effect on the economy of $200 million or greater, ***or***, among other things, adversely affect in a material way the economy, a sector of the economy, or a state, local, territorial, or Tribal government or communities.

EPA has concluded that this proposed rulemaking is not deemed significant, which is contrary to the high-level assessment for annual costs, developed by PWD, based on PWD internally developed capital cost projections, more specifically outlined in Comment 5 and Comments 22-27 of this document. Not only do the estimated annual costs ($274 million per year) exceed the $200 million per year threshold requiring OMB review, but the information provided by PWD undeniably shows that the proposed regulation affects in a material way the economy and those communities situated along the applicable stretch of the Delaware River subject to the proposed regulation.

[9] https://www.epa.gov/system/files/documents/2023-09/epasclimateenforcmentandcompliancestrategy.pdf
[10] https://www.epa.gov/laws-regulations/summary-executive-order-12866-regulatory-planning-and-review

## Water Quality and Criteria Development

12. **The methodology determining the dissolved oxygen criteria from the Habitat Suitability Index (HSI) model is likely *overestimating the criteria* because the dissolved oxygen data used as the basis for the HSI is itself over-estimated in two ways: 1) DRBC 3D modeling and 2) by subsequent extrapolation in the EPA Generalized Additive Model (GAM).**

The EPA proposed criteria were calculated based on dissolved oxygen data extrapolated from DRBC 3D model results. As discussed below, both 1) the DRBC model results themselves and 2) the EPA GAM method used to extrapolate "restored" time series tend to over-estimate dissolved oxygen by a combined offset of approximately 1 mg/L. This is based on the sum of the bias in the DRBC 3D model and the bias between the DRBC 3D model and the EPA GAM predicted dissolved oxygen. PWD methodology to calculate this bias and supplementary information on how EPA GitHub information was used is available upon EPA request.

The HSI model used to set the proposed dissolved oxygen criteria depends on which dissolved oxygen data points are used to generate the EPA GAM, because the GAM is an input to the HSI. This leads to variability in the HSI critical percent saturation at the $10^{th}$ and $50^{th}$ percentiles which define the criteria. The EPA HSI model is likely over-estimating the percent dissolved oxygen saturation required for habitat suitability by approximately 1 mg/L, *and therefore the criteria*, due to uncertainties in the application of the HSI model itself and the over-estimation of the dissolved oxygen inputs within that model.

**12.a. Dissolved oxygen over-estimation factor one: DRBC 3D water quality model results have documented uncertainty that leads to over-prediction of dissolved oxygen.**

The DRBC 3D EFDC-WASP model used as a basis for attainability and criteria setting by EPA (via the EPA GAM) has been calibrated to the hydrologic years 2012, 2018 and 2019. Calibration results from 2012 show a root mean squared error (RMSE) for dissolved oxygen of 0.9 mg/L at Pennypack Woods, 0.75mg/L at Penn's Landing Franklin, and 0.93 mg/L at Chester (DRBC Water Quality Model Report). Statistical bias at these stations ranges between 0.12 mg/L and 0.55mg/L with the model results over-predicting.

These statistics document that the model is consistently over-predicting the dissolved oxygen in the Delaware River. This model's uncertainty was known before it was used by EPA to establish attainability and before it was used by EPA or DRBC to quantify dissolved oxygen response to removing ammonia from wastewater discharges.

PWD submitted extensive comments to DRBC in February 2022 and November 2022 following a thorough review of their hydrodynamic and water quality model. It is unknown if any updates to the model were made based on PWD or other recommendations and if any updates have been made that would improve model performance beyond what is already documented. For the purposes of reviewing this EPA proposed rulemaking, PWD is assuming that the DRBC model remains unchanged from the version reviewed in 2022.

Summary of previous PWD comments on the DRBC 3D eutrophication model of the Delaware River:

i. PWD is concerned that the 3D calibrated eutrophication model's dissolved oxygen budget may not be accurately representing the processes in the river. The model may be overstating the influence of nitrification and sediment oxygen demand on dissolved oxygen sinks in the model and understating the influence of phytoplankton (algae).

- PWD requested additional sensitivity studies to determine the principal dissolved oxygen sink impacting modeled dissolved oxygen in the absence of ammonia dischargers.
- PWD also requested DRBC to elaborate on the impact of combined sewers on dissolved oxygen improvement in their sensitivity analyses.
- PWD requested that DRBC provide the modeled nitrification rates in the 3D model scenarios used to establish restored dissolved oxygen datasets.

ii. The dissolved oxygen benefits of effluent controls may be overstated since the DRBC AA15 scenario did not exhibit improvements over the 5.0 mg/L threshold. If the primary cause of the dissolved oxygen deficit in the fish management area (FMA) is effluent ammonia load (as is implied by DRBC in the development of the scenarios), it follows that reducing effluent ammonia to near the limit of technology should significantly reduce the dissolved oxygen sag. This is not the case as seen in Figure 5-4 of the DRBC Analysis of Attainability Report. *Instead, the model results indicate that the dissolved oxygen sag remains below 5 mg/L and does not change when flow rates are reduced from permitted to observed.*

iii. PWD has documented significant variability in observed nitrification rates and sediment oxygen demand in the Delaware River. This variability in observed data requires sensitivity analysis to quantify uncertainties posed by the data itself. PWD has requested a sensitivity study to determine other principal dissolved oxygen sinks impacting dissolved oxygen in the absence of ammonia dischargers. PWD cautions against a potential to overestimate the benefits to dissolved oxygen in combined sewer management, and to overstate the impact of nitrification and sediment oxygen demand in the model.

iv. Key information is necessary to establish confidence in the hydrodynamic model on which DRBC's 3D water quality model is built. The DRBC Hydrodynamic Model Report lacks model spatial grid configuration and validation metrics in the upper estuary around Philadelphia, and lacks details on temperature, solar radiation, and solute transport phenomena which will impact nutrient loads and dissolved oxygen transport. The lack of hydrodynamic validation metrics in the upper Delaware Estuary around Philadelphia prevents a thorough review of the hydrodynamics and the impact in the water quality constituent transport.

**12.b. Dissolved oxygen over-estimation factor two: The EPA GAM extrapolation methodology further overestimates "restored" dissolved oxygen compared to the DRBC "restored" 3D model results it is created from.**

EPA developed a statistical model (generalized additive model or GAM) from the DRBC water quality model "restored" results from 2012, 2018 and 2019, observed dissolved oxygen at Penn's Landing (or Chester) and streamflow at Trenton. The EPA GAM was used to extrapolate "restored" dissolved oxygen for 20 years between 2002 and 2022, because DRBC modeling was only available for 3 years. "Restored" implies water quality resulting from stringent nutrient controls applied to all major wastewater plants in the tidal Delaware River, simulated as effluent containing 1.5 mg/L ammonia by the DRBC water quality model. The 20 years of EPA GAM "restored" dissolved oxygen results are then fed into an ecological model that assesses habitat suitability (HSI) at different dissolved oxygen conditions. The ecological model results are used to establish the new proposed criteria.

This approach creates two "restored" dissolved oxygen results for the years 2012, 2018 and 2019, EPA GAM extrapolated values and DRBC 3D model results, for comparison. A perfect GAM would result in dissolved oxygen results that are the same as, or statistically similar to, the DRBC model results for each year. If the EPA GAM results are higher than the DRBC results, then it is evident that the GAM is over-predicting dissolved oxygen.  As presented below in Figure 1, the EPA GAM results *are* higher than the DRBC results.

**Significant Methodology Limitation: EPA GAM Model Overstates Dissolved Oxygen Improvement from Applied Nutrient Controls**

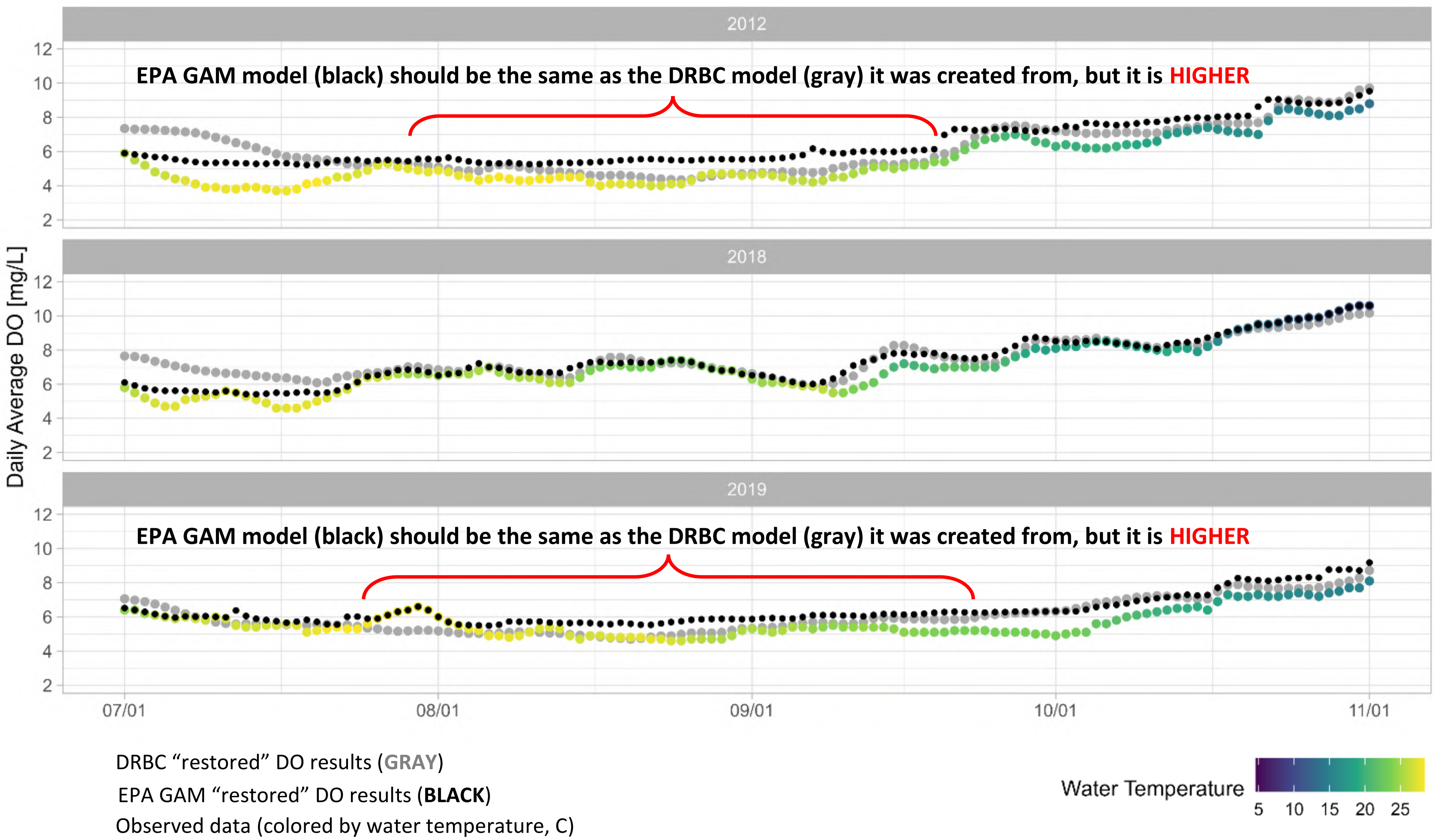



**Figure 1: Comparison of two versions of "restored" dissolved oxygen to observed data at Penn's Landing, DRBC Model and the EPA GAM which was created from the DRBC Model**

13. **The proposed EPA criteria are *not attainable* according to DRBC's "restored" water quality model results.**

Results from the DRBC "restored" model are presented below in Table 7 for the years available; 2012, 2018 and 2019. Two out of three years, 2012 and 2019, do not attain the proposed criteria. 2019 is represented as attaining by EPA in the Economic Analysis and Technical Support Documentation. Yet from analysis of DRBC's "restored" model results, the proposed criteria is *not attainable*.

**Table 7: Performance of "Restored" Results from the DRBC 3D Models During Juvenile Development Period for 2012, 2018, and 2019 for Penn's Landing.**

| Year | DRBC "Restored" Dissolved Oxygen Results Juvenile Development (July 1 - Oct 31)* | | |
|---|---|---|---|
| | 1st Percentile, [mg/L] | 10th Percentile, % Oxy Sat. | 50th Percentile, % Oxy Sat. |
| 2012 | 4.4 | 59.0 | 70.4 |
| 2018 | 5.9 | 78.2 | 84.9 |
| 2019 | 4.7 | 62.8 | 70.0 |

*DRBC "restored" model results, gray shading indicates not in compliance with EPA proposed criteria, 66% saturation at 10th percentile and 74% saturation at 50th percentile

The unattainability of the proposed criteria with the "restored" 3D model results suggests that maximum management practices will not be sufficient to meet the proposed criteria. *This is compounded by the fact that the DRBC model is slightly over-predicting both dissolved oxygen and the benefits of ammonia loading removal* (see comments above). Removing this over-estimation of the modeled dissolved oxygen would further reduce the proposed criteria.

14. **The proposed EPA criteria are *not attainable* according to EPA's own "restored" dissolved oxygen results from their GAM model. EPA cannot expect dischargers to spend billions of dollars on a criterion that is demonstrated by DRBC *and* EPA to be unattainable.**

The proposed EPA criteria are *not attainable* according to EPA's own "restored" dissolved oxygen results from their GAM model. While the EPA Economic Analysis evaluated attainability of the proposed criteria in the year 2019, significant interannual variability exists within the Delaware River's historical record, and EPA's "restored" dissolved oxygen dataset for 2002-2022 demonstrates this variability. An examination of EPA's "restored" dissolved oxygen results, derived from the EPA GAM, demonstrate that EPA's own criteria is *not attainable eight out of twenty years examined by the rulemaking*.

PWD methodology to calculate these statistics from EPA GitHub information is available upon EPA request.

Table 8 compares proposed criteria to the predicted "restored" dissolved oxygen and percent oxygen saturation results from the EPA GAM. Years with values below proposed percent oxygen saturation criteria are shaded in gray.

**Table 8: Performance of Predicted "Restored" Scenario from the EPA GAM During Juvenile Development Period 2002-2022 compared to dissolved oxygen thresholds.**

| Year | EPA GAM "Restored" Dissolved Oxygen Results Juvenile Development (July 1 - Oct 31)* | | |
|---|---|---|---|
| | 1st Percentile, [mg/L] | 10th Percentile, % Oxy Sat. | 50th Percentile, % Oxy Sat. |
| 2002 | 4.7 | 62.9 | 67.0 |
| 2003 | 5.4 | 69.3 | 79.5 |
| 2004 | 4.9 | 64.6 | 76.6 |
| 2005 | 4.6 | 58.9 | 64.1 |
| 2006 | 4.9 | 66.6 | 74.1 |
| 2007 | 5.1 | 65.8 | 72.3 |
| 2008 | 4.7 | 62.2 | 67.0 |
| 2009 | 5.1 | 71.5 | 81.0 |
| 2011 | 4.9 | 73.0 | 88.2 |
| 2012 | 4.8 | 63.5 | 69.9 |
| 2013 | 5.6 | 69.5 | 73.8 |
| 2014 | 5.9 | 71.9 | 75.4 |
| 2015 | 5.5 | 71.2 | 77.1 |
| 2016 | 5.0 | 66.6 | 74.1 |
| 2017 | 5.8 | 73.4 | 76.0 |
| 2018 | 5.5 | 74.5 | 86.4 |
| 2019 | 5.5 | 68.9 | 74.6 |
| 2020 | 4.8 | 66.4 | 73.5 |
| 2021 | 5.2 | 71.6 | 78.8 |
| 2022 | 5.1 | 69.2 | 74.5 |
| Average | 5.1 | 68.1 | 75.2 |

*EPA GAM results, gray shading indicates NO compliance with EPA proposed criteria, 66% saturation at 10th percentile and 74% saturation at 50th percentile.
**The year 2010 is not included here because EPA did not include 2010 in their analysis due to a lack of data.

EPA's own "restored" dissolved oxygen results show their proposed criteria is not met in eight out of twenty years examined. There are multiple back-to-back years where the 66% oxygen saturation and 74% oxygen saturation standards would not be met even with a 1-in-3 year exception. *It is unacceptable to develop a criteria that is unattainable with treatment measures implemented.*

It is important to note that the nutrient controls applied to reach "restored" dissolved oxygen are extremely strict, a 1.5 mg/L ammonia effluent limit at all major dischargers in the tidal Delaware River. Such nutrient controls at PWD are estimated to cost up to $3.6 billion, an enormous expense for the Delaware River to *not attain* this scientifically flawed, unattainable criteria, as demonstrated in Table 8.

15. **The Delaware River water quality effects of PWD's sidestream treatment ammonia removal facility have yet to be observed and are expected to be significant.**

PWD is currently constructing a fully designed $70 million sidestream treatment facility to reduce 20% - 25% of the ammonia load from the Southwest Water Pollution Control Plant to the Delaware River. This facility will treat a relatively small, but ammonia-rich, source of flow from the sludge dewatering process at PWD's centralized Biosolids Recycling Center (BRC), which processes the sludge from all three of PWD's plants. The innovative new process selected will use a deammonification process to reduce most of the ammonia in the concentrated stream. PWD has been coordinating with PADEP to seek alternative funding for this project via PENNVEST.

The sidestream treatment project at PWD Southwest - which pre-dates this proposed rulemaking and is being undertaken voluntarily by PWD - is cost-efficient for this specific wastewater plant and is expected to improve dissolved oxygen in the Delaware River. An adaptive management approach would allow time for this project to be constructed, studied and observed. The proposed rulemaking is relying on compounded modeling uncertainties to estimate dissolved oxygen improvement by nutrient control. Given these uncertainties, it would be much more appropriate to observe an actual project and the water quality response to further understand Delaware River dissolved oxygen dynamics and the implications of ammonia load reduction on interannual dissolved oxygen variability.

16. **PWD requests more thorough documentation of the calibrated scenarios in the DRBC water quality model and the "restored" scenario that was updated with projected discharge modifications used to support the EPA GAM.**

PWD requests that EPA/DRBC provide sufficient detail on the process of developing "restored" 3D model results to clarify model configuration. It is not clear what DRBC 3D water quality model results were used to produce the EPA GAM "restored" 2002-2022 dataset; the "restored" model scenarios in the existing Attainability Analysis Report (DRBC 2022) are not thoroughly documented, and in addition it is not clear what if any changes were made to the model configuration in response to public comments.

PWD requests more information, clarification, and documentation on the "restored" model to better understand how the model was developed with effluent flows and loads. Since the modeled dissolved oxygen from the DRBC "restored" model is only marginally higher than the observed dissolved oxygen, it would be helpful to see the results of the DRBC calibrated models for 2012, 2018, 2019, in comparison with the "restored" scenarios. The improvement in dissolved oxygen should be interpreted from the difference between the "restored" and calibrated models, not between the "restored" model and observed data, due to influences on observed dissolved oxygen by factors not represented in the models. PWD requests the validation, baseline, and "restored" model results for 2012, 2018, 2019 to understand the simulated improvement of dissolved oxygen from the baseline scenario to the "restored" scenario.

17. **PWD encourages the exploration of alternative pathways to enhance fish condition and populations in the Delaware River.**

Cost prohibitive infrastructure projects should not be considered the only means to enhance the populations of sturgeon in the Delaware River. It is widely recognized that Atlantic and shortnose sturgeon are presently reproducing in the Delaware River under existing water quality conditions. Increasing these populations with locally raised hatchlings is an alternative to ammonia reduction that should be considered.

18. **If it is determined that additional ammonia reductions are required to achieve water quality standards, EPA, DRBC and the states should engage with dischargers to identify an adaptive management approach.**

PWD encourages adaptability in the approach to support fisheries. The attainability scenarios presented by EPA suggest an ammonia limit near 1.5 mg/L is needed at the large wastewater plants discharging to the Delaware River to achieve compliance with the proposed criteria. While EPA has indicated that this is not an implication of how nutrient controls are ultimately intended to be implemented, considerable uncertainty remains in the water quality modeling relating to the impacts of algae blooms, sediment oxygen demand and nitrification as sinks of dissolved oxygen in the Delaware River. Given that analysis of the EPA GAM "restored" scenario results shared by EPA suggest that the proposed criteria is overestimated and would not be met in every year even after implementation, PWD advocates for an adaptive management approach to improving dissolved oxygen in the Delaware River.

Adaptability may include considerations of affordability in a phased implementation approach with varied timing of requirements at the individual wastewater plants or planning horizons beyond the usual five-year permit cycles. Some facilities may be able implement nutrient controls more affordably than others, achieving the same targeted, system-wide reduction in ammonia loading. Integrated planning should also be considered for prioritizing the implementation of various Clean Water Act requirements. PWD would like to work with PADEP to determine adaptive and efficient compliance pathways and implementation schedules to increase dissolved oxygen in the Delaware River, if necessary.

## Responses to Criteria Alternatives 1-3

19. **Alternative 1 – PWD supports the criteria being expressed as a concentration as opposed to a % saturation based on precedent.**

There is local and regional precedent for dissolved oxygen water quality criteria to be expressed as a concentration, as opposed to percent saturation. Locally, the DRBC Water Code expresses dissolved oxygen criteria as a concentration in both Delaware River Zone 2 and lower Zone 5 which bookend Zones 3, 4, and upper Zone 5 subject to the EPA proposed rulemaking. Regionally, dissolved oxygen criteria for Connecticut, New York, the Chesapeake Bay, and the Carolinas are all expressed as a concentration. Previously in this document, Comment 3 provides Table 1 and Table 2 detailing existing local and regional dissolved oxygen criteria for reference.

20. **Alternative 2 – PWD supports a dual criterion during the juvenile development season with 10% and 50% exceedance frequency components.**

The existing EPA proposed rulemaking includes a dual criterion for the Juvenile Development season from July 1 to October 31, and PWD supports maintaining this structure to better define the central tendency and variability of dissolved oxygen levels protective of aquatic life. However, PWD does not support the EPA proposed criteria *magnitude* and offers the alternative concentration-based criteria revision presented in Table 9 for consideration, especially given reasons A-F detailed in Comment 4.

**Table 9: PWD Recommended Dissolved Oxygen Standard for Delaware River Zones 3, 4, and upper Zone 5**

| Season* | Magnitude, (mg/L) | Duration | Exceedance Frequency |
|---|---|---|---|
| Spawning and Larval Development *(March 1 – June 30)* | 5.6 | Daily Average | 10% *(12 Days Cumulative)* |
| Juvenile Development *(July 1 – October 31)* | 4.5 | Daily Average | 10% *(12 Days Cumulative)* |
| | 5.0 | Daily Average | 50% *(61 Days Cumulative)* |
| Overwintering *(November 1 – February 28/29)* | 7.0 | Daily Average | 10% *(12 Days Cumulative)* |

*Recommend including 1 in 3 year exceedance frequency to all proposed criteria, see comment below

21. **Alternative 3 - PWD supports the inclusion of a 1 in 3 year exceedance frequency to the proposed criteria.**

PWD supports a 1 in 3 year exceedance frequency for the EPA proposed dissolved oxygen criteria and PWD alternative dissolved oxygen criteria given the uncertainty associated with dissolved oxygen variability in the Delaware River. As noted by EPA throughout their technical support document, dissolved oxygen in the Delaware River is highly variable and influenced by many factors beyond flow and temperature such as sediment oxygen demand, reaeration, and algal dynamics. These complex interactions introduce uncertainty into water quality modeling simulations, criteria selection, and the expected response of dissolved oxygen to reduced ammonia loading from wastewater plants. A 1 in 3 year rolling exceedance frequency is an appropriate regulatory mechanism to accommodate uncertainty in dissolved oxygen dynamics when revising dissolved oxygen criteria.

## Economic Analysis and Environmental Justice

22. **The EPA affordability assessment for Philadelphia is deeply flawed and does not correctly forecast the increased financial burden of the proposed rule. PWD estimates the EPA proposed rulemaking will cost ratepayers an additional $22.17 per month, not $1.50 per month.**

The discrepancies in economic inputs, methodology, and ultimate results between the EPA Economic Analysis assumptions and PWD's own understanding of its costs, operations and billing practices are detailed in Comments 23-29. These errors lead to a gross misunderstanding of PWD facilities, operations and billing practices culminating in the difference in estimates of monthly billing increases needed to fund the EPA proposed rulemaking. PWD estimates compliance with the proposed rulemaking to cost an additional $22.17 per month per residential ratepayer, which is an enormous increase compared to the erroneous estimate of $1.50/month provided by EPA in their Economic Analysis.

**Table 10: Discrepancies between EPA and PWD estimates of economic analysis inputs and results**

| **Economic Analysis Inputs** | **EPA Estimates** | **PWD Estimates** |
|---|---|---|
| PWD total costs for ammonia removal for compliance with proposed rule | $1.05 billion | $3.6 billion |
| PWD total annual cost of compliance with proposed rule | $77.9 million | $274 million* |
| | | |
| **Economic Analysis Results** | **EPA Estimates** | **PWD Estimates** |
| Annual incremental cost per Philadelphia household | $18.07/yr | $266/yr |
| Monthly bill increase per Philadelphia household | $1.50/month | $22.17/month |

*Annual compliance cost + O&M

This comment and Table 10 are presented again to highlight differences in EPA and PWD estimated economic inputs and results. EPA conducted its financial capability assessment using the current water bill of $897.72 per year, including wastewater, stormwater and drinking water services for a typical PWD residential customer, and an annual estimated cost of compliance of $77.9 million to estimate the annual incremental cost for each household. This analysis is incorrect for several reasons detailed in Comments 23-29.

23. **The estimated annual costs incurred by PWD is 250% higher than EPA's estimate.**

The estimated annual cost of compliance for Philadelphia of $77.9 million (EPA Environmental Justice report at page 33) is *inappropriate* in the context of affordability and financial capability. This annualized cost is a net present value calculation calculated using DRBC's capital and O&M cost estimates. The use of a net present value calculation can be appropriate for regulatory cost-benefit analyses in certain cases. However, this metric does not provide a meaningful estimate of the annual costs that the proposed rule would impose on PWD and its rate payers.

PWD calculated the annual cost of compliance assuming minimum dissolved oxygen and seasonal ammonia limits are imposed at all three wastewater plants. Using PWD capital and incremental O&M cost estimates, the projected *annual* costs incurred by PWD would be approximately $274 million, *which is more than 250 percent higher* than EPA's estimate of $77.9 million.

24. **EPA methodology grossly underestimates the true economic burden of the proposed rulemaking on PWD ratepayers. 20% of which are below the poverty line.**

EPA incorrectly calculates the annual costs. Noting uncertainty in the distribution of water bills between residential and non-residential customers, EPA calculates the estimated annual costs using two methodologies.

- The first methodology uses the number of Census households in Philadelphia (646,608) to derive an annual incremental cost of $120.47, conservatively assuming that 100 percent of the incremental cost is attributed to residential water customers. Using this calculation methodology, EPA estimates wastewater plant modifications would cost Philadelphia residents $10.04 per month. This is, as EPA notes, a conservative upper bound on the cost, as not all of the cost will be borne by residential customers. However, PWD notes that despite this conservative assumption, this cost significantly underestimates the financial burden due to its significant underestimate of the capital and O&M costs and the inappropriate use of the net present value calculation.

- The second methodology attempts to estimate the actual residential burden by assuming that the residential user class would only be responsible for 15 percent of the costs based on the residential class generating 15 percent of the wastewater volume based on a wastewater flow analysis conducted by DRBC in the 2022 DRBC Social and Economic Factors. Rather than using billed water consumption data by user classes, DRBC used a technically problematic methodology resulting in an estimation of non-residential wastewater flow in Philadelphia of 85% (Figure 9 of the DRBC report). Using this assumption, EPA estimates that the annual burden will be $18.07, a mere $1.50 per month.

*The result of this factually incorrect calculation methodology grossly understates the true economic burden that wastewater plant modifications will impose on PWD ratepayers.*

- Additionally, the two methods EPA used (as described above) rely on a residential burden of 15% and 100%, instead of a better estimate of the actual residential share of costs based on PWD's detailed cost of service study, a figure which was 49.7% based upon the corresponding FY 2022 analysis. It is much more accurate to capture the burden felt on the residential class by using the actual share of such costs based on factual billing information than flawed flow estimates. Based upon the FY 2024 cost of service analysis, residential customers are allocated 51.6% of total wastewater costs.

- In a letter from DRBC to PWD dated June 29, 2021, DRBC requested data from PWD to support DRBC's effort's to "evaluate the social and economic factors affecting the attainment of aquatic life uses in the Delaware River estuary." PWD responded with a letter, dated September 28, 2021, which specifically contained the FY22 residential allocation of the share of cost to be 49.7 percent. This residential share of cost was not used in any of EPA's cost analyses.

25. **PWD's preliminary assessment of the annual and monthly rate increases that would be required to comply with the new rule is more than 120 percent higher than EPA's highest cost estimate**.

A more robust and appropriate methodology, than the EPA utilized, for forecasting the impact on water and sewer rates evaluates the increased revenue required to cover the projected capital and O&M costs associated with wastewater plant modifications.

PWD is not yet certain when wastewater plant modifications associated with the proposed rule would be required. However, as a simplistic example, fiscal 2024 wastewater (including stormwater) revenues were projected to be $529 million.[11] With combined incremental annual compliance costs of approximately $274 million associated with the wastewater plant modifications to comply with the proposed rule ($238m compliance cost + $36m O&M), the total revenue requirements would increase to $803 million, representing a *52 percent increase* over fiscal 2024 revenue requirements.

PWD estimates that the typical combined annual wastewater and stormwater cost for a typical single-family residence is $515 in 2024[12]. A rate increase proportionate to the increase in revenue requirement of 52 percent would raise the typical single family residence annual bill by $266, or $22.17 per month. When compared with EPA's highest estimate of $120.47 per year, this represents a significant increase – *more than 120 percent* - in the overall cost of compliance that must be incurred by PWD ratepayers. The total annual cost per household would amount to $781. Note that this differs from the 250% increase described in Comment 23 because this is impacted by EPA's calculation methodology that assumed an upper limit of 100% of the costs of the nutrient upgrade will be borne by the residential class.

26. **The increased capital and O&M expenditures required to meet anticipated effluent limitations resulting from the proposed rule will significantly impact PWD's debt service.**

PWD completed a detailed cost estimate for wastewater plant modifications at each of its three facilities to meet the anticipated effluent limitations: a monthly average ammonia limit of 1.5 mg/L and a minimum dissolved oxygen concentration of 6 mg/L. The estimated capital costs are $3.6 billion, and the estimated incremental operation and maintenance (O&M) costs are $36 million per year over PWD's existing O&M costs. The capital costs would result in new debt service costs of around $238 million (assuming a 30 year bond at 5 percent and excluding debt service coverage targets). These capital costs of $238 million combined with the $36 million O&M cost equals the $274 million annual compliance cost.

PWD compared the impact of this $3.6 billion additional capital cost to PWD's existing debt service based on information contained in PWD's September 2023 bond prospectus. PWD's current outstanding total debt service for 2024 through 2055 (all bonds) is $5.5 billion[13]. Thirty years of the $238 million debt service payments anticipated to be required to pay for the capital expenditures associated with the wastewater plant modifications would total $7.1 billion.

In addition, the projected PWD capital improvements for 2024 – 2029 total $4.6 billion. The $3.6 billion for nutrient controls is an amount equaling 80 percent of the entire PWD capital budget for six years (Series 2023B Official Statement Table 5).

27. **Costly modifications to PWD facilities required to comply with the proposed rulemaking would result in a <u>high burden</u> on PWD ratepayers when coupled with the costs of existing Clean Water Act obligations.**

In addition to the wastewater plant modifications required to comply with the proposed rulemaking, PWD has numerous existing financial obligations associated with its Clean Water Act compliance program. To integrate current and future projected financial obligations, PWD has developed a financial resource modeling tool to estimate the potential impacts of future regulatory requirements and capital

[11] Source: Black & Veatch Schedule BV-2 Water & Wastewater Cost of Service Report January 2023 Tables 6-11,6-12,6-13,6-15

[12] https://water.phila.gov/drops/new-rate-information-effective-september-2023/

[13] Source: Bond Official Statement for $564,835,000 City of Philadelphia, Pennsylvania Water and Wastewater Revenue Bonds, Series 2023B Table 1 (page 8).

improvement programs on annual costs, revenue requirements and by inference, rates, and annual costs per typical household. The model is configured to evaluate financial capability following the EPA 2023 Financial Capability Assessment Guidance[14]. Results are intended for compliance planning and are not intended to directly inform rate setting, bond issuance, or other near-term utility financial considerations.

PWD's financial resource model was used to evaluate the impact of the anticipated wastewater plant modifications required to comply with the proposed rule in addition to currently planned regulatory obligations that will impact ratepayers. These costs include:

- Wastewater plant modifications required to meet the anticipated effluent limitations associated with the proposed rule (1.5 mg/L ammonia and 6 mg/L dissolved oxygen). PWD detailed cost estimates indicate an annual compliance cost of $274 million, which includes $36 million in O&M, is required to meet anticipated effluent limits.
- Compliance with PWD's 2011 Consent Order and Agreement (COA). Total projected spending on the COA between 2011 and 2036 is $4.5 billion, as stated in PWD's September 2023 bond prospectus. Of this, $3.5 billion represents capital spending and $1.0 billion represents operation and maintenance spending.
- Additional PWD expenditures on the storm flood relief program and ongoing sewer rehabilitation work, which is estimated $1.25 billion between 2024 and 2035 based on current expenditures in PWD's Capital Improvement Plan.

PWD applied its financial resource model to forecast the combined impact of these costs on the Residential Indicator (RI) metric used in EPA's 2023 Financial Capability Assessment Guidance. *The wastewater plant modifications, when layered on top of existing regulatory obligations, result in a <u>high burden</u> on PWD ratepayers based on EPA guidance.*

The regulatory agencies (EPA, DEP, and DRBC) must work with PWD towards the shared goals of improving the water quality and aquatic habitat of the Delaware River in the context of the economic realities facing Philadelphia. Philadelphia has the highest poverty rate (21.7 percent[15]) of the 10 largest American cities, and 34.7 percent of households[16] in Philadelphia have annual incomes of less than $35,000.

28. **The Economic Analysis does not address ratepayer affordability, permittee financial capability or the potential substantial and widespread economic and social impacts that would be considered in a use attainability analysis.**

The EPA Economic Analysis and Environmental Justice reports address affordability in a superficial and technically questionable manner. There has been no analysis of affordability and economic impacts beyond the 2021 DRBC Social & Economic Factors report, on which PWD provided detailed comments and critiques concerning the scope, methodologies and findings and never received any response from DRBC or EPA.

EPA's affordability analysis (EJA at p. 33 et seq) departs from the DRBC methodology and is more narrow. Notably, while DRBC essentially followed the multi-step analytical process specified in EPA's

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[14] <u>Clean Water Act Financial Capability Assessment Guidance</u> USEPA 800b21001 February 2023
[15] 2022 American Community Survey Table S1701
[16] 2022 American Community Survey Table S1901

updated *Clean Water Act Financial Capability Assessment Guidance* (February 2023), EPA curiously departs from the analytical methodology required by the Agency's own Guidance.

Specifically, in its 2023 Financial Capability Assessment (FCA) Guidance, EPA recommends the following expanded multi-step approach to evaluate economic impacts for Water Quality Standards (WQS) decisions (2023 FCA Guidance at 34):

1. Determine the Initial Economic Impact using the Municipal Preliminary Screener (MPS) and Secondary Score (SS) as recommended by the 1995 WQS Guidance (the MPS is the cost per household as a percentage of community MHI, equivalent to the Residential Indicator in EPA's 1997 Guidance).
2. Determine the Lowest Quintile Poverty Indicator (LQPI) score.
3. Perform a Financial Alternatives Analysis.
4. Combine the results of the Initial Economic Impact and the LQPI score in an Expanded Economic Impact Matrix.

*The affordability analysis provided by EPA is limited to only the first step in this multi-prong assessment.* EPA did not undertake a LQPI scoring calculation, did not conduct a Financial Alternatives Analysis, and did not combine the results of the previous analyses to generate an Expanded Economic Impact Matrix. EPA also seemingly compares total water and wastewater costs in its calculation of the MPS/Residential Indicator, rather than wastewater and Clean Water Act compliance costs alone.

Curiously, EPA appears to have ignored DRBC's assessment of affordability that pursued many of these analyses. EPA provides no justification for its departure from applicable EPA guidance or its decision to ignore DRBC's methodology and conclusions.

29. **The EPA Economic Analysis does not consider the economic impact of other regulatory obligations, including PWD's Consent Order and Agreement to manage combined sewers.**

PWD commented extensively on DRBC's "Social and Economic Factors Affecting the Attainment of Aquatic Life Uses in the Delaware Estuary" report. In this study, DRBC did not include the other Clean Water Act regulatory mandates that would simultaneously erode affordability and financial capability. This is an issue that was not addressed following PWD comments on DRBC's analysis. From PWD comments in November 2022:

> *"Cost estimates in the draft AA and Socio-economic Reports are only a snapshot of utility costs and do not include projected rate increases associated with implementation of CSO LTCPs or other major anticipated regulatory compliance costs. If the future costs of CSO compliance and other regulatory responsibilities are not included in the socio-economic analysis, the ability of impacted utilities and ratepayers to pay for nutrient-related capital investments will be significantly overestimated. All financial commitments of utilities should be considered when determining the burden category."*

PWD examples of its additional regulatory obligations include (but are not limited to):

- $3.18 billion in capital expenditures related to compliance with the COA through 2035[17]

[17] Source: Bond Official Statement for $564,835,000 City of Philadelphia, Pennsylvania Water and Wastewater Revenue Bonds, Series 2023B indicates the 25-year capital cost of the COA is approximately $4.5 billion, of which approximately $3.5 billion are capital related costs and $1 billion are operation and maintenance costs, and that the total capital expenditure between July 1, 2011 and June 30, 2022 was $323 million.

- Ongoing storm flood relief is currently budgeted at $15 million annually in the Capital Improvement Plan
- Ongoing sewer rehabilitation is currently budgeted between $72.9 million and $102 million in the Capital Improvement Plan
- Upcoming lead service line replacement requirements (drinking water)
- Upcoming PFAS proposed rulemaking coming from EPA in March 2024 (drinking water)
- Planned major capital improvements for the water and wastewater systems
- Asset renewal for aging infrastructure

These improvements are required to meet PWD's regulatory obligations and must be included in any assessment of the ability of PWD ratepayers to pay for water and wastewater plant modifications that will result from the EPA proposed rulemaking.

30. **Uncertainty and incorrect methodology used by EPA over-estimate the total benefits of the proposed rulemaking.**

EPA's benefits assessment uses a meta regression model (MRM) to estimate average annual household willingness to pay (WTP) for the water quality improvements expected under the proposed WQS. In conducting this analysis, EPA assumes a benefit transfer area (referred to as the market extent) that includes all Census Block Groups (CBGs) within 100 miles of the water quality improvement area. This means that all households within 100 miles would be willing to pay the average amount estimated by the model for the specified water quality improvement. The benefit transfer area includes 14.96 million households.

A. The average annual household WTP under the primary model applied by EPA (Model 1) amounts to $8.18.[18] This reflects the amount households are willing to pay for water quality improvements that would attain the proposed criteria; however, as noted above, it is not possible to attain the criteria every year. Thus, the $8.18 overestimates the value of expected benefits.
B. While the EPA meta regression model (MRM) accounts for the inverse relationship between distance from the improvements and average annual household willingness to pay (WTP), the 14.96 million households included the transfer area overwhelm this inverse relationship. The 100-mile radius assumption is based on the rationale that this distance represents a reasonable drive time; thus, the 14.96 million households within this range would find the site a reasonable substitute for recreational activities. This assumption does not consider that the site of the improvements within the City of Philadelphia is largely industrial/commercial, with limited access points (i.e., does not account for the quality of the recreation experience).
C. The 100-mile radius assumption is based on substitutes for use values only. However, a high percentage of households included in the transfer area likely only hold non-use value for the

[18] We were not able to exactly replicate this result because we do not readily have access to the CBG data necessary for two of the MRM variable inputs: 1. The size of the resource (i.e., improvement area) relative to available substitutes - calculated as the ratio of the reach miles in the specified zones of the Delaware River within 100 miles of the CBG to the total reach miles within 100 miles of the CBG that are stream order 5 or greater; and 2. Median household income (MHI). In applying a reasonable range for these variables to the MRM, we obtained a result close to $8.18 per household for a one point change, rather than the 0.319-point change indicated in the report.

resource. The WTP accounts for differences in non-use and use values, but the transfer area does not.

D. The benefits value is quite sensitive to the area assumption. The variable in the model that accounts/controls for the transfer area represents the natural log of the ratio of the transfer area relative to the effected resource area. The baseline value used in the MRM is the natural log of 11.37. When the ratio is reduced by 50% (essentially cutting the transfer area in half), average WTP increases by 11% but the total benefit value (WTP multiplied by number of households in the smaller transfer area, assuming the same housing density as in the larger/original transfer area) decreases by 72%.
E. EPA's analysis does not consider the impact of upcoming improvements to wastewater processes, including the proposed sidestream treatment facility at the Southwest wastewater plant. As planned, this facility will treat dewatering centrate from PWD's biosolids treatment process, which currently makes up 20% to 30% of the influent ammonia load to Southwest wastewater plant. Thus, EPA's benefit analysis again overestimates the incremental benefits associated with the proposed WQS, resulting in an inflated estimate of WTP and total benefits.
F. EPA's example of increased housing values as a separate benefit is incorrect and would double count the total benefits. Property value increases associated with water quality improvements are reflective of how individuals value those improvements – they measure WTP, albeit in a different way (using hedonic analysis rather than a MRM based on contingent valuation studies).
G. WTP for water quality improvements for the purpose of improving habitat is not completely separate from WTP for protection of endangered species (i.e., they are not wholly additive and likely would result in some double counting if added).

Given these various factors and uncertainties, the benefits of the proposed rulemaking estimated by EPA to be $112.8 million per year, are likely overstated.

31. **EPA inappropriately assumes that the PWD Tiered Assistance Program (TAP) is a mechanism to alleviate the economic impact of the proposed ruling, or any future regulatory burdens.**

Both EPA reports discuss PWD's TAP as a mechanism to limit the financial impact of wastewater plant modifications required to meet the proposed dissolved oxygen criteria. EPA notes that participation in TAP has been lower than anticipated when the program was designed, and that it is likely that many eligible customers that are eligible are not participating. EPA suggests that additional work should be done to increase participation, such as by automatically enrolling households that are on other assistance programs (such as SNAP) or "ensuring a user-friendly process."

However, EPA did not demonstrate in its Environmental Justice Analysis Report the financial feasibility of using TAP to alleviate the financial burden of these modifications and ignores the fact the funds for rate relief for the low-income TAP participants ***comes solely from the TAP surcharge paid by the remaining ratepayers***. The costs of expanding the TAP program benefits sufficiently to offset the estimated $274 million in incremental annual costs, the rate impacts on households not currently eligible to participate and the increase in the number of TAP eligible households that could result from the increased annual costs warrant a careful evaluation.

The TAP is not a mechanism for federal, or other regulatory agencies to evade EPA's own financial capability guidelines that identify metrics, such as 2% of the median household income (MHI), to determine the upper limit of a community's financial capability to implement Clean Water Act control measures. EPA creates a disincentive for utilities who may be interested in creating low-income customer support programs by firstly implying the PWD TAP is a mechanism that shields low-income ratepayers from unaffordable regulations, and secondly implying the PWD TAP shields EPA from *their own guidance* to protect communities from unaffordable regulations.

32. **Significant increases in wastewater bills will exacerbate challenges for households earning more than the TAP-eligible income but who likely face affordability challenges.**

While the TAP program provides significant assistance to those earning less than 150% of the Federal Poverty Level (in addition to those who qualify for Special Hardship exemptions), many households in Philadelphia earning more than this amount still struggle to meet basic needs. Table 11 below shows the hourly wage associated with 150% of the Federal Poverty Level (FPL) by household size and makeup, compared to the Living Wage for Philadelphia County. The Living Wage is a measurement developed by the Massachusetts Institute of Technology (MIT) that accounts for geography-specific expenditures to calculate the amount of money (hourly wage) that an individual(s) must earn to be able to support themselves and their family. It differs from the FPL in that it varies based on the ages and work status of household members and includes costs for food, childcare, health insurance, housing, transportation, and other essential items to determine the minimum employment earnings necessary to meet a family's basic needs.

**Table 11: Hourly Living Wage rate for Philadelphia County compared to TAP maximum income level hourly wage (150% FPL), by household size/characteristics[19]**

| # of Adults | 1 Adult | | | | 2 Adults (1 working) | | | | 2 Adults (Both working)[20] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # of Children | 0 | 1 | 2 | 3 | 0 | 1 | 2 | 3 | 0 | 1 | 2 | 3 |
| Living Wage | $17.53 | $36.94 | $48.10 | $62.94 | $27.83 | $34.42 | $39.21 | $43.39 | $27.84 | $40.94 | $52.28 | $62.98 |
| TAP Income (150% FPL) | $10.52 | $14.22 | $17.93 | $21.63 | $14.22 | $17.93 | $21.63 | $25.34 | $14.22 | $17.93 | $21.63 | $25.34 |
| % Difference | 66.7% | 159.8% | 168.3% | 190.9% | 95.7% | 92.0% | 81.2% | 71.2% | 96% | 128% | 142% | 148% |

The hourly wages shown above indicate that across all household sizes, the TAP (150% FPL) income limits are not enough to meet basic needs, the Living Wage estimates are 67% to 190% higher. In many cases, the MHI hourly wage in Philadelphia County of $27.17 (based on County MHI of $56,517 in 2022) is not sufficient to achieve financial independence. While the TAP program provides significant assistance to those earning less than 150% of the Federal Poverty Level on their monthly bill, many households in Philadelphia earning more than this amount still struggle to meet basic needs and are not eligible for such assistance. These households are sensitive to rate increases associated with the proposed rulemaking, estimated by PWD to be $22.17 per month.

[19] Both hourly wage calculations assume 2,080 working hours per year.
[20] The Living Wage in this category reflects what both adults would need to earn (combined) to be able to directly compare to 150% poverty income.

## Fisheries Science

33. **Current levels of dissolved oxygen in the Delaware River do not appear to be limiting the propagation or growth of Atlantic sturgeon. There is no correlation between dissolved oxygen levels and observed fish population.**

With the exception of years 2010 and 2012 in which sampling efforts were nonexistent or relatively low, Atlantic sturgeon have been documented successfully propagating in the Delaware River every year since the Delaware Department of Natural Resources and Environmental Control (DNREC) originally began targeting YOY and juvenile sturgeon for sampling in the Marcus Hook area in 2009. The rapid rates of growth observed, with juvenile fish reaching 300mm (12 inches) or more in one summer would not be possible if the sturgeon lacked adequate levels of dissolved oxygen. The average length (345mm or 13.5 inches) for nearly 5000 young-of-year sturgeon measured between 2009 and 2022 was within the normal range for the species and comparable to other rivers. Other measures of sturgeon growth and health were also normal and compared favorably with similar age and size fish in the Hudson River, where dissolved oxygen is relatively higher. PWD compared a variety of sturgeon measurements against dissolved oxygen statistics in more than 500 statistical correlation tests and did not find any statistically significant correlations. More information is available in PWD's Technical Comments on the Evidence for Hypoxia as a Stressor on Delaware River Atlantic Sturgeon.

34. **EPA's Atlantic sturgeon cohort model is completely unnecessary. Observed data clearly and unambiguously demonstrate successful propagation and growth of sturgeon in the Delaware River.**

While EPA's bioenergetic fish cohort model may be of academic interest, in its current state the model so drastically underpredicts the observed data on sturgeon growth rates that the model is of no practical use, especially in a regulatory rulemaking context. Additional detailed comments on EPA's sturgeon cohort model are included in Comments 40-44. PWD recommends that EPA discontinue the use of the Atlantic sturgeon cohort model for regulatory purposes and focus on readily available real-world observed data for the Delaware River.

35. **EPA misrepresents and does not fully utilize the observed data for juvenile sturgeon collected by DNREC**

As seen in Figure 6 on pg. 32 of the TSD and documented in the EPA R code which was made available on GitHub[21], EPA only included observed weight for a small subset (n = 72) of sturgeon that were marked and recaptured by DNREC, for a total of 144 weight measurements that were compared to model-simulated growth from the fish cohort model. EPA's Appendix 3: Juvenile Atlantic Sturgeon Abundance Survey Data includes tables summarizing more than 900 Atlantic sturgeon collection records by DNREC, including more than 750 YOY fish collected between 2009-2022 from nursery habitat near Marcus Hook anchorage (TSD Table A3-4). The complete DNREC juvenile sturgeon data set must be included in any scientific evaluation of water quality conditions needed to support aquatic life in the Delaware River. PWD is providing along with our comments a compilation of DNREC data that PWD transcribed from DNREC grant reports and obtained directly from DNREC under a data sharing agreement. PWD encourages EPA to obtain the full data set from DNREC and coordinate a thorough review and QA/QC process with Delaware River Basin stakeholders, including PWD, to establish the best scientific data available from DNREC's monitoring activities.

[21] https://github.com/USEPA/DelawareRiverDO

36. **EPA also inexplicably failed to utilize more than 5,000 records of juvenile sturgeon collected during the Delaware Navigation Channel Deepening Project.**

The NOAA-permitted relocation trawling program conducted by Environmental Research and Consulting, Inc. (ERC) from 2014-2019 also collected an unprecedented number of young-of-year and juvenile sturgeon that were measured and tagged for research purposes. PWD has repeatedly urged regulators[22], including EPA, to utilize these data when evaluating sturgeon populations and water quality conditions in the Delaware River. As the largest and most comprehensive sampling for Atlantic and shortnose sturgeon in the Delaware River, the complete ERC relocation trawling data set must be included in any scientific evaluation of water quality conditions needed to support propagation and growth of sturgeon. PWD is providing along with our comments a compilation of ERC data that PWD transcribed from ERC final reports that were obtained from NOAA via a Freedom of Information Act request. PWD encourages EPA to obtain the full data set from ERC and coordinate a thorough review and QA/QC process with Delaware River Basin stakeholders, including PWD, to establish the best scientific data available from ERC's monitoring activities.

37. **Federal water quality standards are required to be based on "sound scientific rationale" (40 CFR §113.22(c), 40CFR §113.11).**

EPA's proposed rule and TSD fail to use the full DNREC and ERC data sets described above. Rather, EPA used a flawed fish cohort model that greatly underpredicts even the small subset of available data on observed fish weight for the Delaware that were included. The complete DNREC and ERC data sets must be used for the federal WQS to be based on "sound scientific rationale." Together, the DNREC and ERC data sets represent more than 6,000 records of individual sturgeon collected in the Delaware, along with measurements of length and weight. Sound science dictates that the results of the EPA fish cohort model, and more broadly the need for proposed dissolved oxygen criteria be evaluated using these readily available data.

38. **DNREC and ERC data represent the "best scientific and commercial data available" and must be included for National Marine Fisheries Service (NMFS) Section 7 Consultation under the Endangered Species Act.**

As stated in the proposed rule, EPA is required to consult with NMFS under Section 7(a)(2) of the Endangered Species Act. In developing a Biological Opinion on whether the proposed rule may affect a listed species, NMFS must use the "best scientific and commercial data available," which in this case includes the full DNREC and ERC data sets.

39. **The complete DNREC and ERC data sets must be made available to EPA's third-party peer reviewer for the fish cohort model and dissolved oxygen criteria development.**

EPA has coordinated a third-party independent peer review of the fish cohort model and dissolved oxygen criteria development procedure. The peer review process is only possible if EPA's reviewer has access to the complete DNREC and ERC data sets. Reviewing the fish cohort model and TSD without access to all available data could lead to incomplete or incorrect conclusions about EPA's model, the underlying assumptions regarding the status and health of Atlantic sturgeon populations in the Delaware, or the need for more stringent dissolved oxygen criteria.

[22] PWD transmittal letter of DRBC Analysis of Attainability comments 1/20/2023, PWD sturgeon webinar for WRA-DRB 3/14/2023 in which EPA staff were in attendance, and personal communication w/ Greg Voigt, EPA R3.

40. **EPA's fish cohort model has not been published or substantively reviewed by the scientific community and as such cannot be used as the basis of new dissolved oxygen criteria.**

PWD was disappointed that EPA provided only 60 days for review of the proposed rule and denied the request – from numerous stakeholders, including PWD – to extend the comment period by 30 days. With 74 pages of highly technical material, the TSD for the proposed rule exemplifies one of the reasons that an extended review period is needed. While PWD appreciates EPA's provision of underlying model R code and data sets used for developing the model, the model's mathematical complexity and underlying assumptions require a thorough investigation and evaluation compared to different input data sets to determine if the model represents a "sound scientific rationale" for the effects of hypoxia on juvenile sturgeon.

41. **EPA's fish cohort model is needlessly complex for the purpose of determining protective dissolved oxygen criteria.**

Most State and EPA recommended water quality criteria are determined based on the direct effects of the stressor, such as a toxicant or water quality characteristic in controlled laboratory tests. When appropriate, integrative effects and other factors can and should be included in formulating water quality criteria where the interactions between a stressor and other co-acting factors (e.g., synergistic, mitigative, etc.) are reasonably well defined. However, EPA's fish cohort model-based method for the proposed rule goes much further in terms of complexity, integrating the effects of temperature, salinity, growth, and mortality in a habitat suitability index (HSI). PWD is unaware of this level of complexity being employed in developing any other water quality criteria. To PWD's knowledge, EPA has not developed any guidance for the development, testing, and review of multiparameter water quality bioenergetic models for the purposes of developing water quality criteria. The level of complexity in EPA's fish cohort model is excessive.

42. **EPA's fish cohort model includes assumptions for Atlantic sturgeon mortality and growth that are based on flawed and inappropriate laboratory studies.**

Unbalanced designs and inadequate sample sizes in laboratory experiments used by EPA as inputs to their cohort model result in a great deal of uncertainty in results. The fitted relationships for instantaneous mortality and growth as a function of dissolved oxygen saturation and temperature do not appear to fit the data well, and the underlying data themselves are incomplete, inconsistent, and often counterintuitive. PWD has expressed concerns to DRBC[23,24] and EPA[25] regarding the use of laboratory studies that used inadequate sample sizes and inadequate or excessively large ranges of exposure treatments.

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[23] PWD (2018). February 9, 2018 Letter to John Yagecic, DRBC, regarding DRBC/ANS draft *Methodology for Evaluating Dissolved Oxygen Requirements of Species in the Delaware Estuary.* 3 pgs.

[24] PWD. (2022b). March 28, 2022 Letter to Jake Bransky, DRBC, PWD Comments on DRBC draft report *Linking Aquatic Life Uses with Dissolved Oxygen Conditions in the Delaware River Estuary.* 24 pgs.

[25] PWD. (2023a). January 19, 2023 Letter to Radhika Fox, et al., EPA, Concerning EPA Administrator's Determination and transmitting previous comments on DRBC draft report *Analysis of Attainability: Improving Dissolved Oxygen and Aquatic Life Uses in the Delaware River Estuary*

43. **Mortality rates in the EPA fish cohort model are incorrect due to flawed and inappropriate laboratory studies.**

It is clear from PWD's review of EPA's fish cohort model that: 1.) mortality is a critical component of EPA's fish cohort model, 2.) the availability and consistency of observed data used to parameterize the mortality functions are limited at best, and 3.) the overall effect of these issues results in a high degree of uncertainty in results. The mortality data themselves are inconsistent, such as a higher mortality rate 0.04/d at 70% saturation and 28ºC than the 0.025/d mortality rate at 40% saturation and 28ºC. The lines fit to model the relationship between mortality and dissolved oxygen do not fit the data well, which is unsurprising because there does not appear to be much of a consistent relationship within the data (Figure 2).

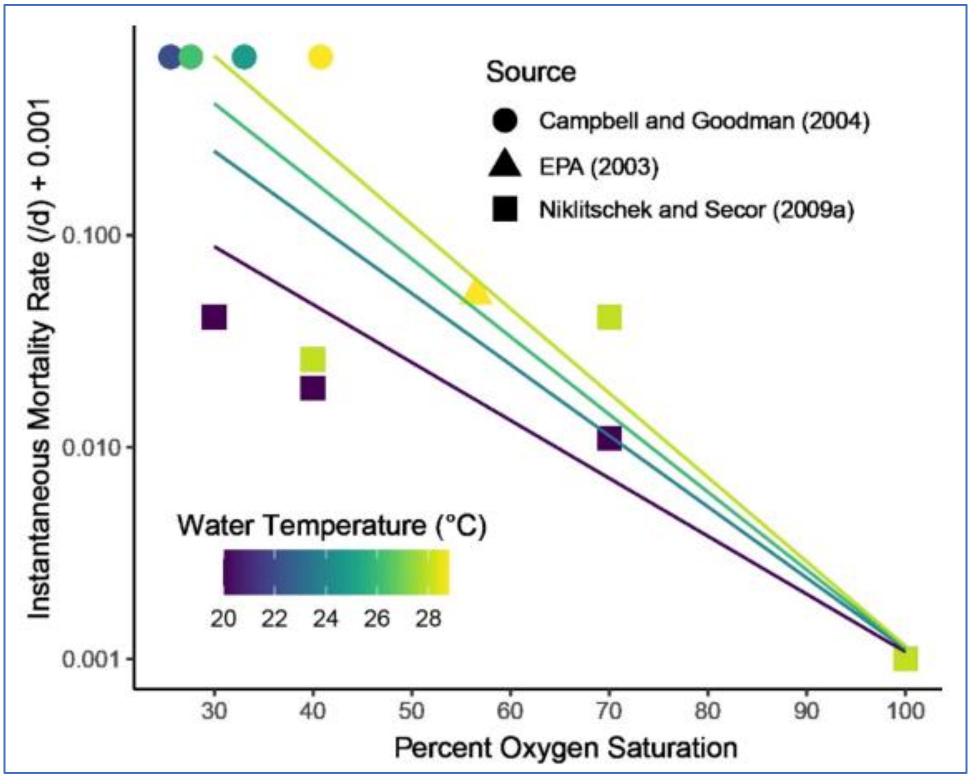



**Figure 2: EPA fish cohort model instantaneous mortality rate vs. dissolved oxygen saturation (source: EPA TSD fig. 3)**

44. **Small sample size and an inadequate range of exposures also limit the accuracy of the growth component of EPA's fish cohort model.**

Fitted relationships for growth rates in TSD figure A4-5 show a poor fit to the data, which lack resolution in the crucial area between 40% and 70% saturation which is most relevant to the Delaware River. The observed point for 40% saturation at 28 ºC, which critically defines one of the most influential range of conditions under which growth will be negative or positive in the fish cohort model, is based on *only two fish* (Figure 3, Niklitschek 2001[26]).

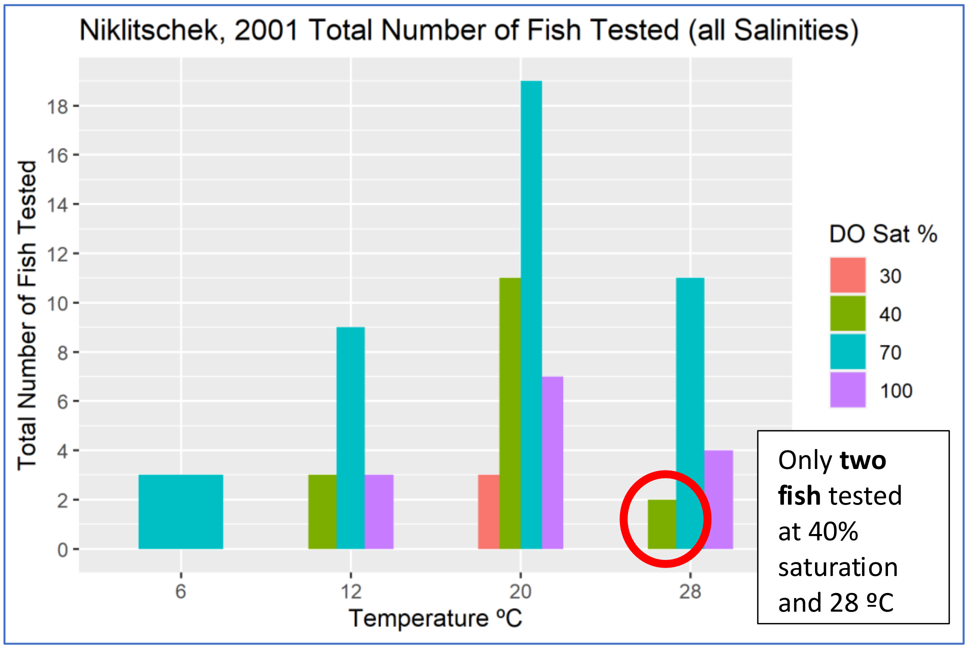



**Figure 3: PWD analysis of original sample design from Niklitschek, 2001**

The original plot in Figure 1 of Niklitschek and Secor 2009[27] shown below (Figure 4), includes standard error whiskers and points for mean values. Keeping in mind that only *two fish* were tested at 40% saturation and 28 ºC, the relatively large standard error, with the upper whisker above 0 indicates that one of the two fish measured had a positive growth rate and one fish had a negative growth rate. If the original data points had been plotted rather than the mean and standard error bars, it would be clear that the sample size and extremely different results make this portion of the growth curve unreliable. With only two fish tested at 40% saturation compared to 11 fish at 70% saturation (Niklitschek 2001[26]), the difference in growth rates at 28 ºC cannot be determined to be different from that which may have occurred due to random chance.

[26] Niklitschek, E.J. (2001). Bioenergetics modeling and assessment of suitable habitat for juvenile Atlantic and shortnose sturgeons (*Acipenser oxyrhinchus* and *A. brevirostrum*) in the Chesapeake Bay.

[27] Niklitschek, E., and D. Secor. (2009). Dissolved oxygen, temperature and salinity effects on the ecophysiology and survival of juvenile Atlantic sturgeon in estuarine waters: I. Laboratory results. Journal of Experimental Marine Biology and Ecology 381:S150-S160

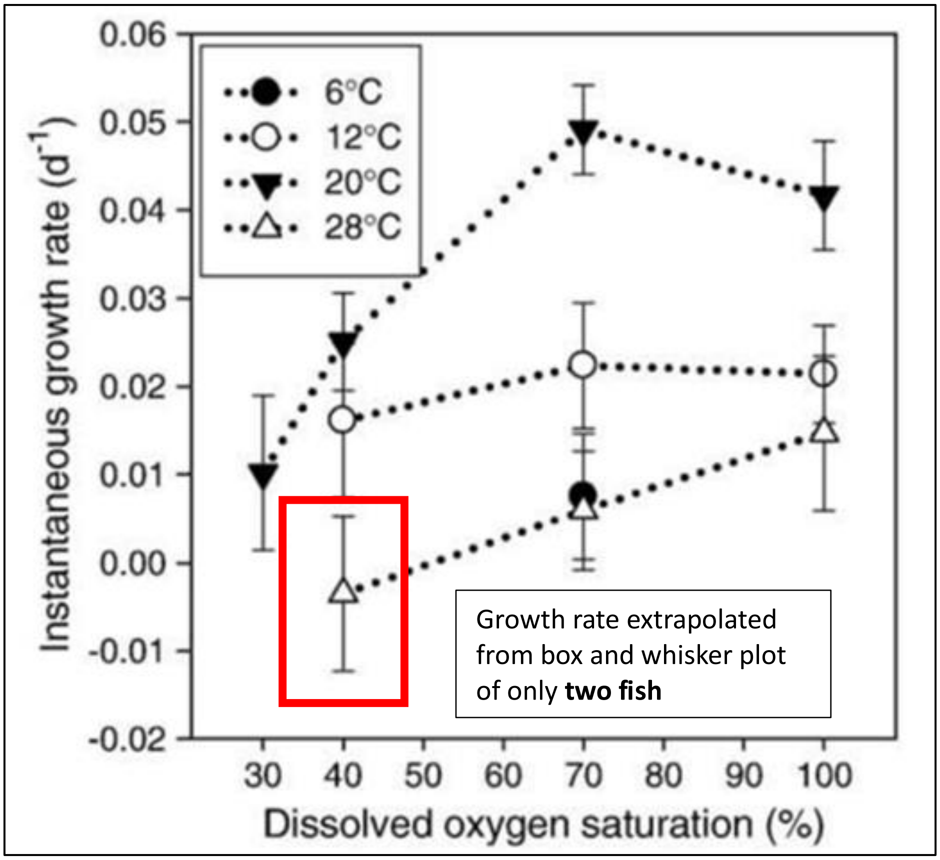



**Figure 4: Instantaneous growth rate vs dissolved oxygen saturation (reproduced from Niklitshek & Secor 2009[27] Fig. 1)**

Overall, the fish cohort model is sensitive to the assumptions regarding growth and mortality. In its current state, poor fits to laboratory-derived growth and mortality rates are causing substantial underprediction of the observed data in the model. The uncertainty in observed data, inappropriate, inadequate, and flawed laboratory experimental designs; and poor model fit to mortality and growth data all demonstrate that the fish cohort model is inappropriate for use in a regulatory rulemaking context.

45. **Measures of sturgeon growth and health in the Delaware River are similar to the Hudson River, where dissolved oxygen is relatively higher, suggesting that the Delaware River dissolved oxygen levels are adequate.**

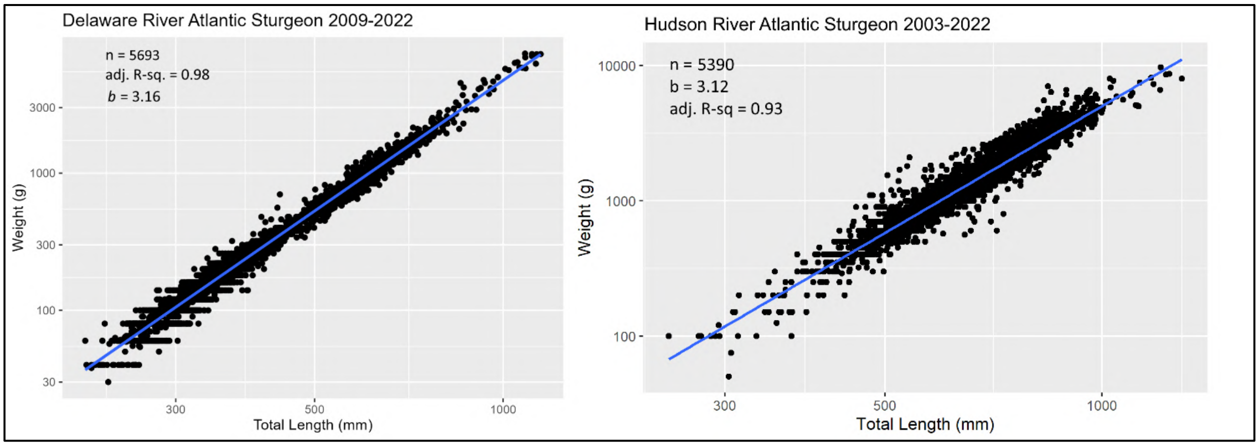



**Figure 5: Weight-Length linear regression analysis for Atlantic sturgeon collected from the Delaware River and Hudson River**

PWD compared the Delaware and Hudson River populations of sturgeon using a standard fisheries method of linear regression of weight vs length ("W-L" regression). W-L slope parameter *b* values more than 3 indicate that the fish are becoming "plumper" as length increases (Figure 5) and are usually interpreted as a positive measure of fish population health and well-being. PWD compared the two rivers in multiple ways, finding some small but statistically significant differences in slope between the Delaware River and Hudson with the Delaware usually having a steeper slope. If fish collected from the Delaware River were under stress from low dissolved oxygen levels, it highly unlikely they would have a similar relationship between weight and length – an indicator of how healthy, or plump the fish are – to the Hudson River. Dissolved oxygen stress or poor health would be indicated by "skinny" fish with a lower slope of the weight to length relationship, which was not observed for the Delaware River. Additional details and some important caveats for the comparison between the Delaware River and Hudson River are available in PWD's Technical Comments on the Evidence for Hypoxia as a Stressor on Delaware River Atlantic Sturgeon.

46. **EPA inappropriately discounts the influence of temperature as a key independent factor in determining habitat suitability for Atlantic sturgeon.**

On page 15 of the TSD, EPA wrote "The importance of dissolved oxygen for defining Atlantic Sturgeon habitat suitability within the relevant zones of the Delaware River reflects the fact the salinity and water temperature are generally in a suitable range." This statement is not consistent with literature values documenting the effects of high temperature on Atlantic and shortnose sturgeon. Observed summer temperature values for the Delaware River may exceed 28ºC, a suggested value for growth effects in studies where high temperature was paired with suitable dissolved oxygen levels. Temperature must be considered as an independent stressor, not merely a surrogate or co-occurring stressor alongside dissolved oxygen. Markin and Secor (2020[28]) proposed that "supraoptimal" temperatures greater than 28º C might be responsible for reduced growth, poor recruitment and/or dual spawning date strategies for Atlantic sturgeon in the South Atlantic Distinct Population Segment.

When high temperature and low dissolved oxygen occur together in natural settings it is impossible to conclusively attribute effects to either dissolved oxygen or temperature alone. It is possible that temperature may be an equally important or more important factor than dissolved oxygen for sturgeon growth and health.

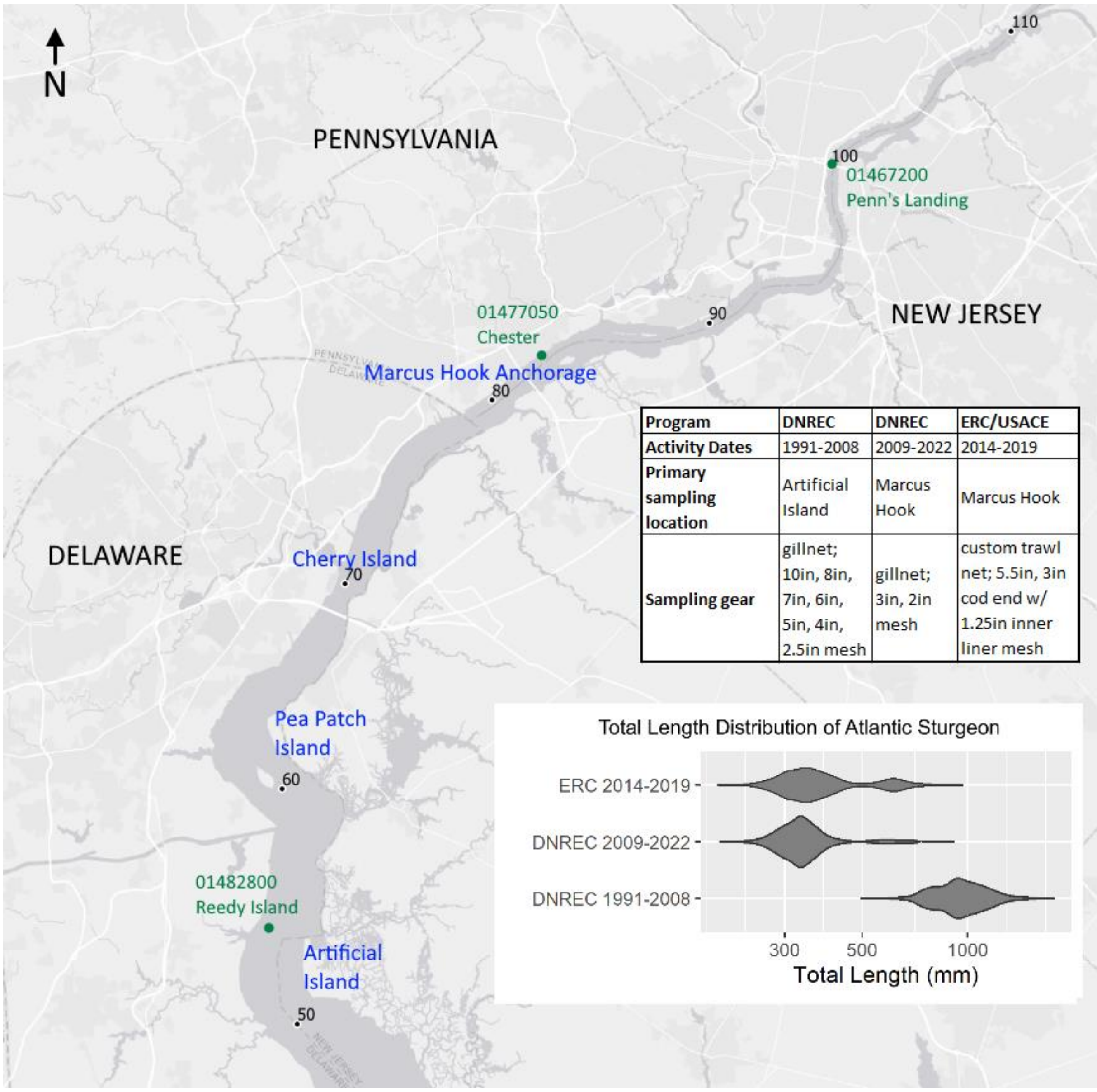
47. **Propagation of Atlantic sturgeon in the Delaware River should not be evaluated prior to 2009, due to mesh size and sampling location factors.**

Prior to 2008-2009, DNREC primarily sampled higher-salinity mesohaline habitats, centered around Artificial Island, DE, approximately 30 river miles downstream of Marcus Hook. *Prior to 2008-2009 the habitats sampled near Artificial Island and relatively large mesh of gillnets used would have been unlikely to capture YOY sturgeon* (Figure 6; Shirey 1999[29], Fisher 2011[30]) and therefore should not be utilized in evaluations.

[28] Markin, E. L., & Secor, D. H. (2020). Growth of juvenile Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) in response to dual-season spawning and latitudinal thermal regimes. Fishery Bulletin, 118(1), 74-87.

[29] Shirey, C.A., Martin, A.C., Stetzar, E.J. (1999). Atlantic sturgeon abundance and movement in the lower Delaware River. Final Report. NOAA Project No. AGC-9N. Grant No. A86FA0315. Delaware Division of Fish and Wildlife. Dover, DE.

[30] Fisher, M. (2011). Atlantic Sturgeon Final Report. State Wildlife Grant Project T-4-1 Period covered: October 1, 2006 to October 15, 2010. Delaware Division of Fish and Wildlife. Smyrna, DE.




| Program | DNREC | DNREC | ERC/USACE |
|---|---|---|---|
| Activity Dates | 1991-2008 | 2009-2022 | 2014-2019 |
| Primary sampling location | Artificial Island | Marcus Hook | Marcus Hook |
| Sampling gear | gillnet; 10in, 8in, 7in, 6in, 5in, 4in, 2.5in mesh | gillnet; 3in, 2in mesh | custom trawl net; 5.5in, 3in cod end w/ 1.25in inner liner mesh |

**Figure 6: Landmarks, mile markers, and monitoring locations for sturgeon sampling and water quality monitoring in the Delaware River. Inset table summarizes sampling program locations and gear. Inset chart figure shows total length distribution of Atlantic sturgeon collected by three major sampling programs.**

48. **Propagation of Atlantic sturgeon has been conclusively demonstrated for the Delaware River for every year from 2009-2022 in which adequate sampling occurred.**

With the exception of years 2010 and 2012 in which sampling effort was relatively low, Atlantic sturgeon have been documented successfully propagating in the Delaware River every year since DNREC originally began targeting YOY and juvenile sturgeon for sampling in the Marcus Hook area in 2009. In 2010 and 2012, DNREC did not collect any YOY or juvenile sturgeon, but sampling efforts were much lower than in subsequent years. Sampling methods and effort were relatively consistent from 2014-2022 (Table 12, Figure 6, TSD Table A3-4).

**Table 12: Summary of Evidence for Successful Propagation of Atlantic Sturgeon in the Delaware River**

| Year/ Period | Propagation? | Sample Days | Net Hours | DNREC | ERC | YOY | Notes / Evidence for Successful Propagation |
|---|---|---|---|---|---|---|---|
| 1991-2008 | NA | NA | NA | NA | NA | | Habitat sampled and gill net mesh not effective at collecting YOY |
| 2009 | YES | 9 | 30.77 | 33 | NA | 23 | |
| 2010 | NO | 1 | 1.92 | 0 | NA | 0 | Very low sampling effort |
| 2011 | YES | 9 | 26.95 | 50 | NA | 49 | |
| 2012 | NO | 6 | 21.43 | 1 | NA | 3 | Low sampling effort |
| 2013 | YES | 0 | 0 | 0 | 36 | 29 | Not sampled by DNREC; ERC feasibility study collected 36 fish, incl. 27 <500mm in winter 2014 |
| 2014 | YES | 15 | 52.67 | 184 | NA | 47 | |
| 2015 | YES | 22 | 108.08 | 61 | 775 | 271 | |
| 2016 | YES | 11 | 51.42 | 2 | 391 | 103 | |
| 2017 | YES | 18 | 87.68 | 88 | 2506 | 2396 | |
| 2018 | YES | 15 | 75.66 | 221 | 771 | 1528 | |
| 2019 | YES | 16 | 70.42 | 11 | NA | 5 | Large 2019 yearling cohort in 2020 |
| 2020 | YES | 16 | 79.5 | 69 | NA | 20 | |
| 2021 | YES | 16 | 79.61 | 107 | NA | 105 | |
| 2022 | YES | 16 | 87.85 | 48 | NA | 15 | |

The relocation trawling effort that was performed by ERC under contract to the USACE in 2014-2019 also provides a source of information to augment and compare with DNREC gillnetting results. DNREC did not perform gillnetting in 2013, but the feasibility study that was conducted by ERC over eight days in February-March 2014 to investigate relocation trawling collected 36 Atlantic sturgeon, 27 of which were 200-500mm, corresponding to the 2013 YOY cohort (Brundage and O'Herron 2014[31]). Cessation of ERC sampling after completion of the rock blasting phase of channel deepening reduced effective sampling effort beginning with the fall 2019 cohort. While DNREC collected only 11 YOY sturgeon in 2019, the fall 2020 sample included approximately 45 yearling sturgeon 500-800mm in length, corresponding to the 2019 YOY cohort.

Evidence for successful spawning and growth is not limited to a few individuals, but often hundreds of fish actually collected and measured. The length distribution of fish collected strongly suggests the presence of two distinct age cohorts in most years, providing further evidence that sturgeon are spawning and recruiting into the population (Figure 5). Successful spawning is recognized by NMFS (2022[32]) using similar types of evidence for the Delaware River as other rivers determined to have relatively small but consistently observed spawning populations (*e.g.*, Altamaha and Savannah Rivers,

[31] Brundage, H.M. and O'Herron, J.C. (2014). Report of a Study to Determine the Feasibility of Relocating Sturgeons out of the Blasting Area for the Delaware River Main Channel Deepening Project. Environmental Research and Consulting, Inc. (ERC) Kennett Square, PA.

[32] National Marine Fisheries Service. (2022). New York Bight Distinct Population Segment of Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*), 5-Year Review: Summary and Evaluation. February 17, 2022.

GA, Edisto R., SC, James R., VA, Baker et al. 2023[33], Schueller & Peterson 2010[34], Balazik and Musick 2015[35], Takacs 2022[36]).

49. **The preamble for the EPA proposed rule and TSD contain several examples of editorial bias and commentary regarding the status of the Delaware River Atlantic sturgeon population that are not only factually incorrect but also completely inappropriate.**

Environmentalist groups have alleged the fact that DNREC either 1.) collected no fish or 2.) failed to collect an arbitrary number of fish of a certain size in a given year is evidence that certain year-classes of sturgeon were "eliminated" or that "year-class failure" occurred (Moberg and DeLucia 2016[37], written comments and public statements by Maya Van Rossum, Erik Silldorff, and Tracey Carluccio of Delaware River Network). One particularly egregious example concerns the year 2013, in which DNREC *did not perform any gillnetting at all*, yet activists refer to this year as having "recruitment not observed" (Moberg and DeLucia 2016[37]). It is also a misrepresentation for activists to claim that recruitment was not observed in 2005-2008 when DNREC either: 1.) did not sample at all, or 2.) only sampled in habitats that would not have been likely to produce young-of-year sturgeons. EPA was somewhat more circumspect in the proposed rule and TSD, but nevertheless refers to reduced or lack of sturgeon propagation success, alludes to dissolved oxygen levels causing “mortality” in the Delaware River, and references the Moberg and DeLucia 2016[37] publication containing false information and interpretations multiple times. For example:

> Proposed Rule page 14 (and TSD page 10): “NOAA Fisheries also noted studies linking age 0-1 Atlantic Sturgeon capture rates in the fall to the preceding summer dissolved oxygen conditions in the Delaware River, providing further evidence that low dissolved oxygen levels are a contributor to the mortality of juvenile Atlantic Sturgeon.” [citing Moberg and DeLucia 2016 in the footnote and implying that low dissolved oxygen levels are causing “mortality” without any supporting evidence]
>
> TSD page. 27 “…juvenile Atlantic Sturgeon have successfully utilized this habitat in recent years when water quality was unusually good (*e.g.*, Moberg and DeLucia 2016)” [editorializing by implying that sturgeon only use the habitat when water quality is “unusually good”]

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[33] Baker, M. A., Ingram, E. C., Higginbotham, D. L., Irwin, B. J., & Fox, A. G. (2023). Refining capture-recapture recruitment estimation methods for Atlantic sturgeon. Endangered Species Research, 51, 203-214.

[34] Schueller, P., & Peterson, D. L. (2010). Abundance and recruitment of juvenile Atlantic sturgeon in the Altamaha River, Georgia. Transactions of the American Fisheries Society, 139(5), 1526-1535.

[35] Balazik, M. T., & Musick, J. A. (2015). Dual annual spawning races in Atlantic sturgeon. PLoS One, 10(5), e0128234.

[36] Takacs, M. K. (2022). Abundance and growth of juvenile Atlantic Sturgeon in the Edisto River, SC.

[37] Moberg, T., & DeLucia, M. (2016). Potential impacts of dissolved oxygen, salinity, and flow on the successful recruitment of Atlantic Sturgeon in the Delaware River. The Nature Conservancy, Philadelphia.

> Proposed Rule page 15: "…dissolved oxygen levels in the summer remain low enough to limit the growth and survival of oxygen-sensitive species and life stages, such as juvenile Atlantic Sturgeon" [unsupported claim that Delaware River dissolved oxygen is low enough to limit "survival"]

PWD urges EPA to review all the available scientific evidence regarding sampling methods and results. EPA has the opportunity to clarify the record regarding sturgeon propagation in the Delaware River based on factual information, rather than continuing to repeat false claims.

50. **Catch per unit effort (CPUE), a primary metric used to analyze fish population status and health, is highly variable and potentially unreliable.**

PWD recognizes and greatly appreciates the staff of the Delaware Department of Natural Resources and Environmental Control (DNREC) for their hard work collecting high-quality sturgeon data in very challenging, typically cold winter conditions. PWD also appreciates DNREC's willingness to share data collected under NOAA NMFS Section 6 grants NA10NMF4720030[38] and NA16NMF4720357[39] to advance the science of fish propagation in the Delaware River. Our comments regarding the DNREC gillnetting activities in the Delaware River are in relation to the use and misuse of the data themselves, not the professionalism of DNREC staff that conducted the sampling.

Simply put, gillnetting is a form of fishing, and while the fisheries scientists conducting the sampling have extensive skill and experience, and in some cases used acoustic-tagged "sentinel" fish to guide sampling, the decision of exactly where, when, and how to deploy gill nets involves some subjective judgment. The number of fish collected in a given net, at a given site, on a given day, in a given year is subject to substantial variability, as is the case with nearly all forms of fishing or sampling freely roaming wild animals in their natural habitat environment.

While the raw count of fish collected each year (often expressed as standardized "Catch Per Unit Effort" or CPUE) provides some information, PWD believes it is critical to look at the growth rate of fish cohorts and condition of the individual fish themselves by examining measurements of length and weight. CPUE essentially boils down all the information collected (*i.e.*, detailed measurements on potentially thousands of fish) each year to a single number. CPUE must not be used as the primary way to assess the status and health of the Atlantic sturgeon population in the Delaware River or the need for more stringent dissolved oxygen criteria to protect aquatic life.

51. **PWD compiled and analyzed more than 5,000 recent juvenile sturgeon collection records from the Delaware River to test various hypotheses regarding the effects of hypoxia on Atlantic sturgeon.**

PWD's Technical Comments on the Evidence for Hypoxia as a Stressor on Delaware River Atlantic Sturgeon provides detailed information on PWD's analysis of hypoxia as a stressor on the Delaware River population of Atlantic sturgeon. The conclusions suggest that more research is needed to understand the necessary levels of dissolved oxygen to protect sturgeon spawning and juvenile growth in the

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[38] Fisher, M. (2015). Conservation and Recovery of Juvenile Sturgeons in the Delaware River. Final Report. Section 6 Species Recovery Grant No: NAI0NMF4720030. Delaware Division of Fish and Wildlife. Dover, DE.

[39] Park, I. (2020). Conservation and Recovery of Juvenile Sturgeons in the Delaware River. Final Report. Section 6 Species Recovery Grant No: NA16NMF4720072. Delaware Division of Fish and Wildlife. Dover, DE.

Delaware River, especially given the potential enormous costs of treatment changes to meet more stringent ammonia effluent limitations. In PWD's view, the question of whether – and to what extent – hypoxia is affecting spawning and growth of juvenile sturgeon can be informed by formulating and testing hypotheses scientifically using factual information. PWD has repeatedly urged DRBC and EPA to consider the available data and science on actual fish spawning in the Delaware River when evaluating the need for higher dissolved oxygen levels.

52. **PWD requests EPA provide a list of documents in EPA's possession but not considered in drafting the proposed regulation.**

PWD requests that EPA provide a list of documents in its possession that are germane to the proposed regulation that EPA did not consider. And a list of any documents that were reviewed by EPA and contain information that contradicts EPA's findings, recommendations, or conclusions presented in the proposed regulations.

# PWD Comments on Draft EPA Rulemaking

**Technical Comments on the Evidence for Hypoxia as a Stressor on Atlantic Sturgeon in the Delaware River**

February 20, 2024

PHILADELPHIA WATER DEPARTMENT

Michael S. Regan
Environmental Protection Agency
Office of Water
1200 Pennsylvania Avenue NW
Washington, DC 20460

Re: Water Quality Standards to Protect Aquatic Life in the Delaware River
Docket ID EPA–HQ–OW–2023–0222

Dear Administrator Regan,

The Philadelphia Water Department (PWD) appreciates the opportunity to submit comments on EPA's Proposed Water Quality Standards to Protect Aquatic Life in the Delaware River dated December 21, 2023, Docket ID No. EPA–HQ–OW–2023–0222. PWD has reviewed the rule proposing federal water quality standards for protection of aquatic life in zones 3, 4, and upper zone 5 of the Delaware River. We have also reviewed the supporting document entitled *Technical Support Document for the Proposed Rule: Water Quality Standards to Protect Aquatic Life in the Delaware River*, ("TSD") which describes a fish cohort model developed by EPA for the purpose of developing DO criteria protective of juvenile Atlantic sturgeon.

PWD found the TSD to be deficient in failing to utilize the best scientific information available on Atlantic sturgeon for the Delaware River. PWD is providing along with our comments a compilation of data for observations of more than 5000 juvenile sturgeon from the Delaware River collected by the Delaware Department of Natural Resources and Environmental Control Division of Fish and Wildlife (DNREC) and Environmental Resources Consulting (ERC) under contract to the U.S. Army Corps of Engineers. We are also providing detailed comments regarding the evidence for hypoxia as a stressor on Atlantic sturgeon in the Delaware River.

If EPA has any questions regarding PWD's comments and the accompanying analysis and data set, please contact Jason Cruz (jason.cruz@phila.gov).

Sincerely,

Randy E. Hayman

Commissioner and Chief Executive Officer

Philadelphia Water Department

**Attachments**
Microsoft Excel file containing sturgeon records from Delaware River compiled by PWD.

## Technical Comments on the Evidence for Hypoxia as a Stressor on Atlantic Sturgeon in the Delaware River

**1.) PWD compiled and analyzed more than 5,000 recent juvenile sturgeon collection records from the Delaware River to test various hypotheses regarding the effects of hypoxia on Atlantic sturgeon. These data have not been fully used by EPA in its analysis underlying the proposed rule.**

PWD's technical comments herein provide detailed information on PWD's analysis of hypoxia as a stressor on the Delaware River population of Atlantic sturgeon. The conclusions suggest that more research using the entire available data set is critical to understand the necessary levels of DO to protect Atlantic sturgeon spawning and juvenile growth in the Delaware River, especially given the potential enormous costs of treatment plant modifications changes to meet more stringent ammonia effluent limitations and the substantial and widespread economic impact of the proposed rule. In PWD's view, the question of whether – and to what extent – hypoxia is affecting spawning and growth of juvenile Atlantic sturgeon can be informed by formulating and testing hypotheses scientifically using factual information. PWD has repeatedly urged DRBC and EPA to consider the available data and scientific information on actual fish spawning in the Delaware River when evaluating the need for higher DO levels (PWD 2023).

**2.) Total length measurements of young-of-year (YOY) Delaware River Atlantic sturgeon were found to be within the expected range for the species, consistent with normal healthy growth given the thermal regime of the Delaware River.**

PWD compiled total length (TL) measurements for 4,593 YOY (*i.e.*, < 500mm) Atlantic sturgeon collected from the Delaware River. Overall, fish collected during 2009-2022 had average TL 345mm, or 13.5 inches. Expected annual variability was observed in YOY total lengths, however the number of fish captured and measured varied over two orders of magnitude (Table 1). For the YOY cohort years 2015-2018 when samples were collected by both the Delaware Department of Natural Resources and Environmental Control (DNREC) and Environmental Research and Consulting, Inc. (ERC), the ERC fish collected in winter had slightly longer TL, suggesting that fish continued to grow, albeit more slowly, during fall and winter when temperatures are not ideal for growth. Given the location of the Delaware River between the spawning populations of Atlantic sturgeon in the Chesapeake Bay and Hudson River, the average overall YOY total length and annual ranges from 2009-2022 were within the expected range reported by Markin and Secor (2020) based on values from literature review, a laboratory experiment simulating the thermal regime of different sturgeon habitats, and a simple fish growth model based on accumulated growing degree days (GDD; Figure 1). There was no evidence from the TL analysis for the years 2009-2022 that the Delaware River Atlantic sturgeon population had smaller fish than would be expected for the Delaware River's position along a latitude and temperature gradient of spawning Atlantic sturgeon populations.

**Table 1.) Annual average total length measurements for Delaware River YOY Atlantic sturgeon collected by DNREC and ERC 2009-2022**

| Year | Total YOY Captured and Measured | Mean TL (mm) | Sample Size, DNREC | Mean TL, DNREC (mm) | Sample Size, ERC | Mean TL, ERC (mm) |
|---|---|---|---|---|---|---|
| 2009 | 23 | 287 | 23 | 287 | - | - |
| 2011 | 49 | 290 | 49 | 290 | - | - |
| 2013 | 29 | 368 | - | - | 27 | 372 |
| 2014 | 47 | 315 | 47 | 315 | - | - |
| 2015 | 271 | 370 | 15 | 353 | 256 | 370 |
| 2016 | 97 | 330 | 18 | 326 | 79 | 330 |
| 2017 | 2396 | 338 | 127 | 324 | 2269 | 339 |
| 2018 | 1528 | 358 | 221 | 335 | 1307 | 362 |
| 2019 | 5 | 347 | 5 | 347 | - | - |
| 2020 | 20 | 326 | 20 | 326 | - | - |
| 2021 | 105 | 329 | 105 | 329 | - | - |
| 2022 | 15 | 384 | 15 | 384 | - | - |

NOTE: number of samples may not match exactly between all total length and weight tables. Some samples may have lacked total length or weight.

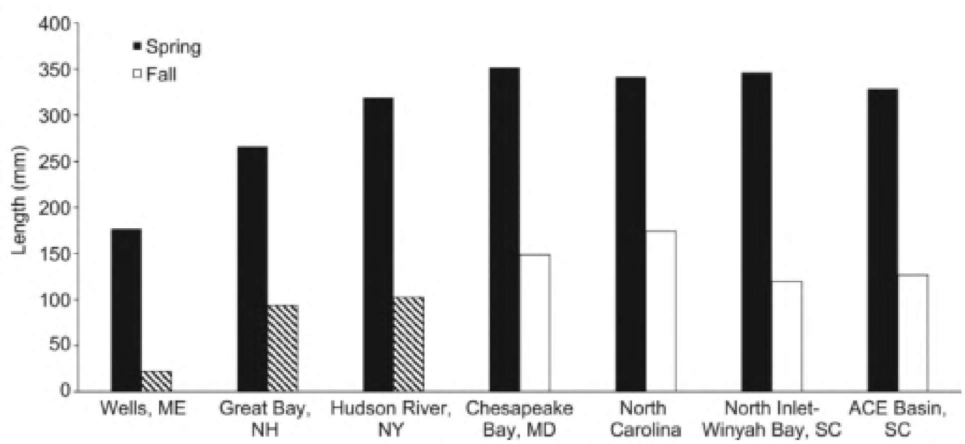


**Figure 6**

Total lengths of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) that spawned in spring and fall at the onset of winter (1 January), by the thermal regimes to which they were exposed across a latitudinal range. Water temperature data used for thermal regimes were collected from National Estuarine Research Reserve System sites from Maine to South Carolina during 2008–2012. Open bars represent the cohort that spawns in fall, and black bars represent the cohort that spawns in spring. The bars with diagonal lines indicate a hypothetical scenario of spawning occurring in fall in those locations. The southernmost site is the Ashepoo–Combahee–Edisto Basin (ACE Basin) in South Carolina.

**Figure 1.) Total lengths of Atlantic sturgeon from seven spawning rivers along the U.S. east coast arranged along a latitudinal gradient (reproduced from Figure 6 in Markin and Secor 2020).**

**3.) Delaware River Atlantic sturgeon consistently exhibit growth rates expected for the species under existing DO conditions based on length-weight regression models.**

PWD analyzed the relationship between total length and weight of Atlantic sturgeon collected from the Delaware River using a standard fisheries science method of linear regression of weight vs length ("L-W" regression). Log-transformed values log(weight) and log(total length) are typically used due to the relationship between length and weight being non-linear (Le Cren 1951). Since the increase in length is on a one-dimensional linear scale, while the increase in weight is related to the increase in volume (*i.e.*, cross-sectional area of the fish extending, enclosing space in three dimensions), a L-W regression slope parameter (*b*) value of 3 indicates *isometric growth*, in which the relationship between weight and length remains constant as the fish gets larger. L-W slope parameter *b* values less than or greater than 3 indicate *allometric growth*, or the condition when the overall relationship between fish weight and fish length changes as length increases. L-W slope parameter *b* values less than 3 indicate that the fish tends to get leaner as it grows longer, while slope parameter *b* values greater than 3 indicate that the fish is becoming "plumper" as length increases (Figure 2). L-W regression slope *b* parameter values greater than 3 are usually interpreted as a positive measure of fish population health and well-being (Blackwell *et al*. 2000, Hillborn and Walters 2001, Ogle 2013).

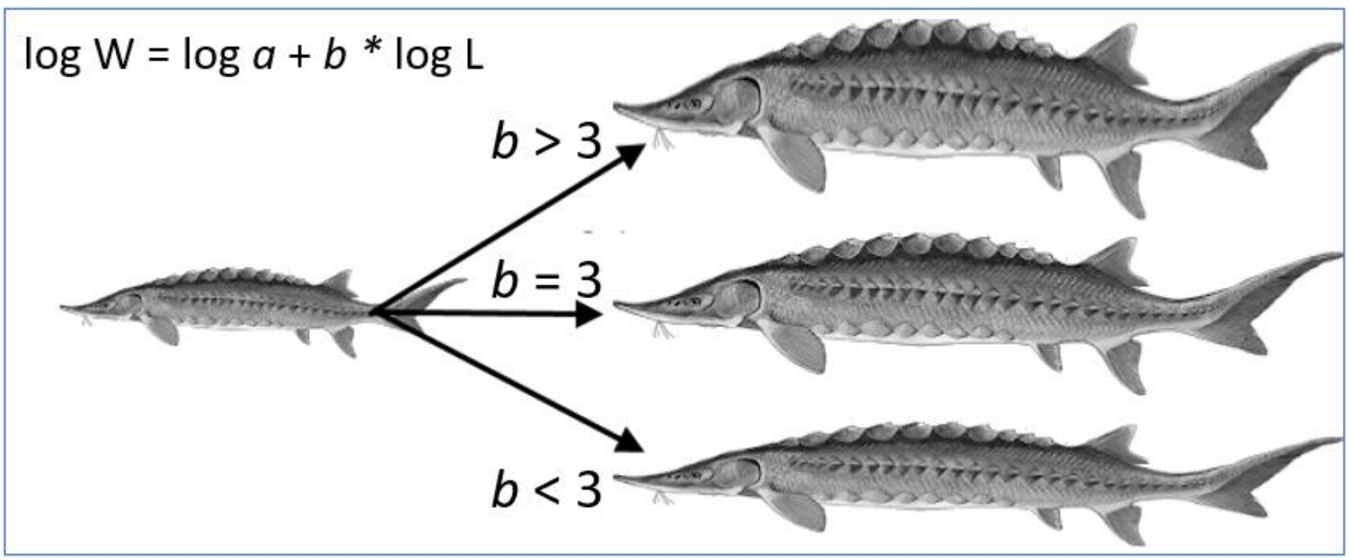


**Figure 2.) Conceptual diagram of isometric (*b* = 3) and allometric (*b* < 3 or *b* > 3) growth in Atlantic sturgeon**

The overall result of L-W regression for all observed Delaware River Atlantic sturgeon collected between 2009 and 2022 with valid length and weight measurements had L-W regression slope *b* parameter 3.16, which was within the range of observed values for four Distinct Population Segments (DPS) of Atlantic sturgeon in the Atlantic States Marine Fisheries Commission (ASMFC) 2017 Atlantic Sturgeon Benchmark Stock Assessment and Peer Review Report (ASMFC 2017) for Atlantic sturgeon (Figure 3 Table 2). The slope parameter *b* estimate for all observed Delaware River fish was statistically significantly higher than 3 indicating healthy, positive allometric growth (Student's t-test $p < 2.23e-139$) with 95% confidence limits for the *b* estimate 3.14 to 3.17 (Table 3).

The Delaware River sample predominantly consisted of YOY and yearling sturgeon, with very few fish >800mm. Although the L-W regression had a good fit to the data (adjusted $R^2$ value 0.98, $p < 0.000000001$), young sturgeon grow more rapidly than adults, so the comparison to parameter values computed for samples from a larger range of fish sizes, including mature adults, may not be appropriate. The main conclusion from the L-W length regression for all Delaware River data was that there is very strong evidence that the Delaware fish experience allometric growth during the first two years of life, becoming "plumper" as they grow longer, consistent with a healthy population growing in the normal range of growth for the species.

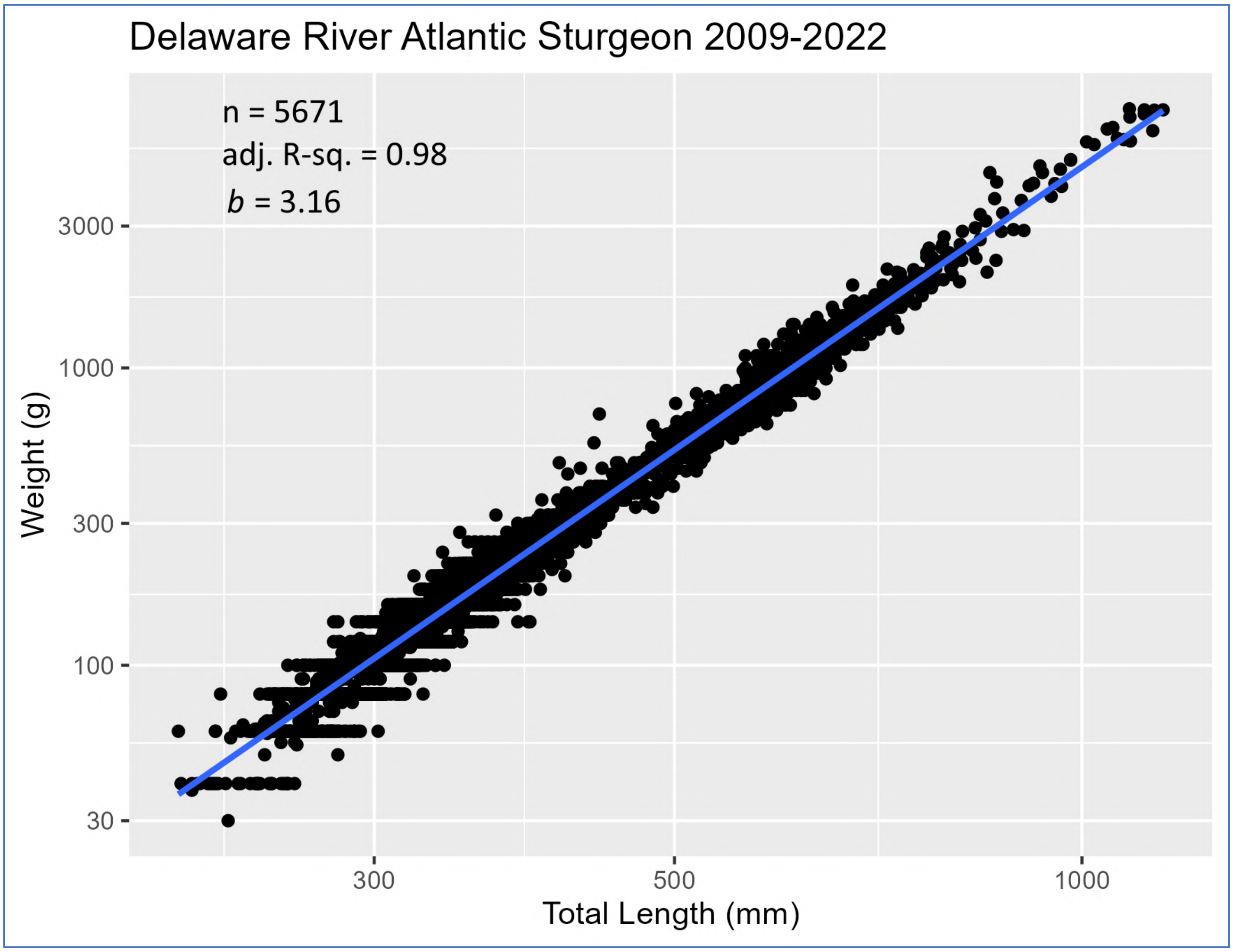


**Figure 3.) Weight and Length of Delaware River Atlantic sturgeon collected 2009-2022 with L-W linear regression line and fit statistics.**

**Table 2.) L-W regression parameter estimates for four Atlantic sturgeon Discrete Population Segments. Reproduced from Table 2 in ASMFC 2017 Atlantic Sturgeon Benchmark Stock Assessment and Peer Review Report.**

**Table 2.** Parameters estimates and associated standard errors of the total length (cm)-weight (g) relationship for Atlantic sturgeon by DPS.

| DPS | n | a | SE[a] | b | SE[b] |
|---|---|---|---|---|---|
| All | 6,304 | 0.00513 | 0.000286 | 3.05 | 0.0107 |
| Gulf of Maine | 618 | 0.0119 | 0.00211 | 2.85 | 0.0354 |
| New York Bight | 735 | 0.0235 | 0.00428 | 2.76 | 0.0345 |
| Chesapeake Bay | 190 | 0.00549 | 0.00306 | 3.06 | 0.109 |
| Carolina | 4,761 | 0.00186 | 0.000119 | 3.25 | 0.0129 |

**Table 3.) Student's t-test for allometric growth, slope parameter *b* estimate based on L-W regression analysis for all Delaware River Atlantic sturgeon**

| term | Null Hypothesis ($H_0$) Value | Estimate | SE | t-statistic | df | p-value | 95% conf low | 95% conf high |
|---|---|---|---|---|---|---|---|---|
| 2 | 3 | 3.16 | 0.006 | 25.85 | 5669 | 2.23E-139 | 3.15 | 3.17 |

PWD also analyzed L-W relationships for Atlantic sturgeon YOY (< 500mm) fish only (Table 4, Figure 4) and for both the complete data set and the YOY subset of the data on an annual basis (Tables 5 and 6; Figures 6 and 7). The L-W regression slope *b* parameter estimate for the YOY subset of the 2009-2022 data was 3.19 and also determined to be statistically significantly greater than 3, indicating healthy allometric growth (Student's t-test, p <4.92e-42, Table 4).

**Table 4) Student's t-test for allometric growth, slope parameter *b* estimate based on L-W regression analysis for YOY Delaware River Atlantic sturgeon.**

| term | $H_0$ Value | Estimate | SE | t-statistic | df | p-value | 95% conf low | 95% conf high |
|---|---|---|---|---|---|---|---|---|
| 2 | 3 | 3.19 | 0.013 | 13.72 | 4589 | 4.92E-42 | 3.16 | 3.22 |

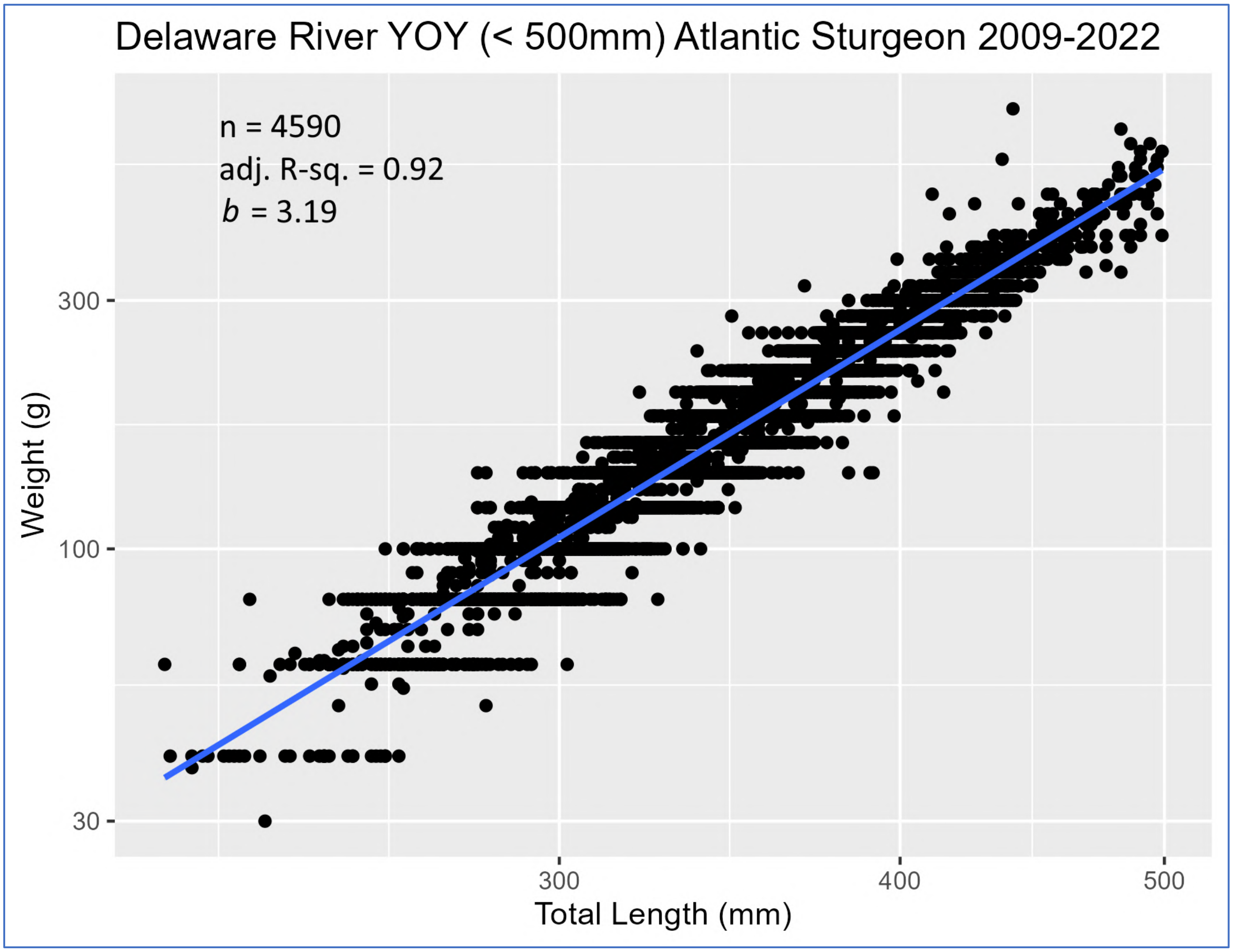


**Figure 4.) Weight and Length of YOY (<500mm) Delaware River Atlantic sturgeon collected 2009-2022 with L-W linear regression line and fit statistics**

As with the complete 2009-2022 and 2009-2022 YOY subset data sets, L-W regression slope *b* parameter values estimated on an annual basis were greater than 3, indicating positive allometric growth. Only two of 25 annual data sets (*i.e.*, the full 2022 and YOY subset 2013 data sets) had slope parameter *b* estimates less than 3 (Tables 5 and 6. Regression models for annual data sets using the complete range of length and weight were fit very well with the linear models, with adjusted $r^2$ values from 0.95 to 0.99. More variability was observed in linear model fits for the smaller annual data sets for YOY sturgeon, which also exhibited more heteroscedasticity; smaller fish were affected by lack of precision in weight measurements (See comment 4, below). Goodness-of-fit adjusted $r^2$ values for the YOY annual data sets ranged from 0.82 to 0.97. All observed fish data model fits were significant at an alpha value of p <0.001. Standard errors of the slope parameter estimates varied as expected, with higher error associated with smaller sample sizes (Tables 5 and 6).

**Table 5) Annual L-W regression statistics for all Delaware River Atlantic sturgeon records with total length and weight measurements 2009-2022.**

| Combined cohort year | n | slope | SE | $r^2$ | p-value |
|---|---|---|---|---|---|
| 2009 | 52 | 3.28 | 0.04 | 0.99 | 8.27E-57 |
| 2011 | 52 | 3.23 | 0.04 | 0.99 | 5.04E-57 |
| 2012* | 22 | 3.29 | 0.07 | 0.99 | 6.30E-22 |
| 2013 | 43 | 3.14 | 0.07 | 0.98 | 3.06E-37 |
| 2014 | 50 | 3.28 | 0.12 | 0.94 | 1.15E-30 |
| 2015 | 746 | 3.20 | 0.01 | 0.98 | 0 |
| 2016 | 355 | 3.04 | 0.02 | 0.99 | 0 |
| 2017 | 2547 | 3.16 | 0.01 | 0.96 | 0 |
| 2018 | 1571 | 3.06 | 0.02 | 0.94 | 0 |
| 2019 | 13 | 3.18 | 0.07 | 0.99 | 3.71E-14 |
| 2020 | 66 | 3.11 | 0.04 | 0.99 | 2.04E-62 |
| 2021 | 104 | 3.07 | 0.08 | 0.93 | 5.36E-62 |
| 2022 | 44 | 2.99 | 0.08 | 0.97 | 3.57E-34 |

* DNREC 2012 records mostly from summer 2012, transcribed from Fisher 2015 Appendix A Table 5.1

**Table 6.) Annual L-W regression statistics for Delaware River Atlantic sturgeon, YOY (< 500mm) only.**

| Combined cohort year | n | slope | SE | $r^2$ | p-value |
|---|---|---|---|---|---|
| 2009 | 23 | 3.12 | 0.32 | 0.82 | 3.40E-09 |
| 2011 | 49 | 3.14 | 0.08 | 0.97 | 7.95E-37 |
| 2013 | 29 | 2.74 | 0.20 | 0.87 | 1.38E-13 |
| 2014 | 47 | 3.18 | 0.21 | 0.84 | 2.75E-19 |
| 2015 | 271 | 3.43 | 0.06 | 0.92 | 2.14E-150 |
| 2016 | 103 | 3.02 | 0.07 | 0.95 | 1.10E-69 |
| 2017 | 2396 | 3.20 | 0.02 | 0.92 | 0 |
| 2018 | 1528 | 3.05 | 0.02 | 0.91 | 0 |
| 2019* | 5 | 3.21 | 0.14 | 0.99 | 0.000171 |
| 2020 | 20 | 3.05 | 0.13 | 0.97 | 4.95E-15 |
| 2021 | 105 | 3.07 | 0.08 | 0.93 | 5.36E-62 |
| 2022 | 15 | 3.02 | 0.14 | 0.97 | 9.68E-12 |

* 2019 is included for completeness, but had only 5 YOY records with total length and weight

The slope *b* parameter estimate for YOY sturgeon for 2015 was investigated as an outlier, as the value of 3.43 was substantially larger than estimated for other YOY subsets of the data. The 2015 DNREC data had been obtained later in the data analysis workflow than the 2009-2014 or 2016-2022 due to a miscommunication from PWD to DNREC. PWD reviewed the data and concluded that although the linear model fit $R^2$ value was somewhat lower than other YOY fits and there appeared to be some outliers there was no reason to reject the 2015 YOY slope parameter estimate. The year 2018 was also checked as the slope parameter *b* value estimates for 2018 were lower than other years in which ERC collected substantially larger data sets. Hydrologic conditions during 2018 were also somewhat unusual with relatively high discharge throughout spring, an early summer dry period, and consistently high discharge from August through the remainder of 2018 (Figure 4).

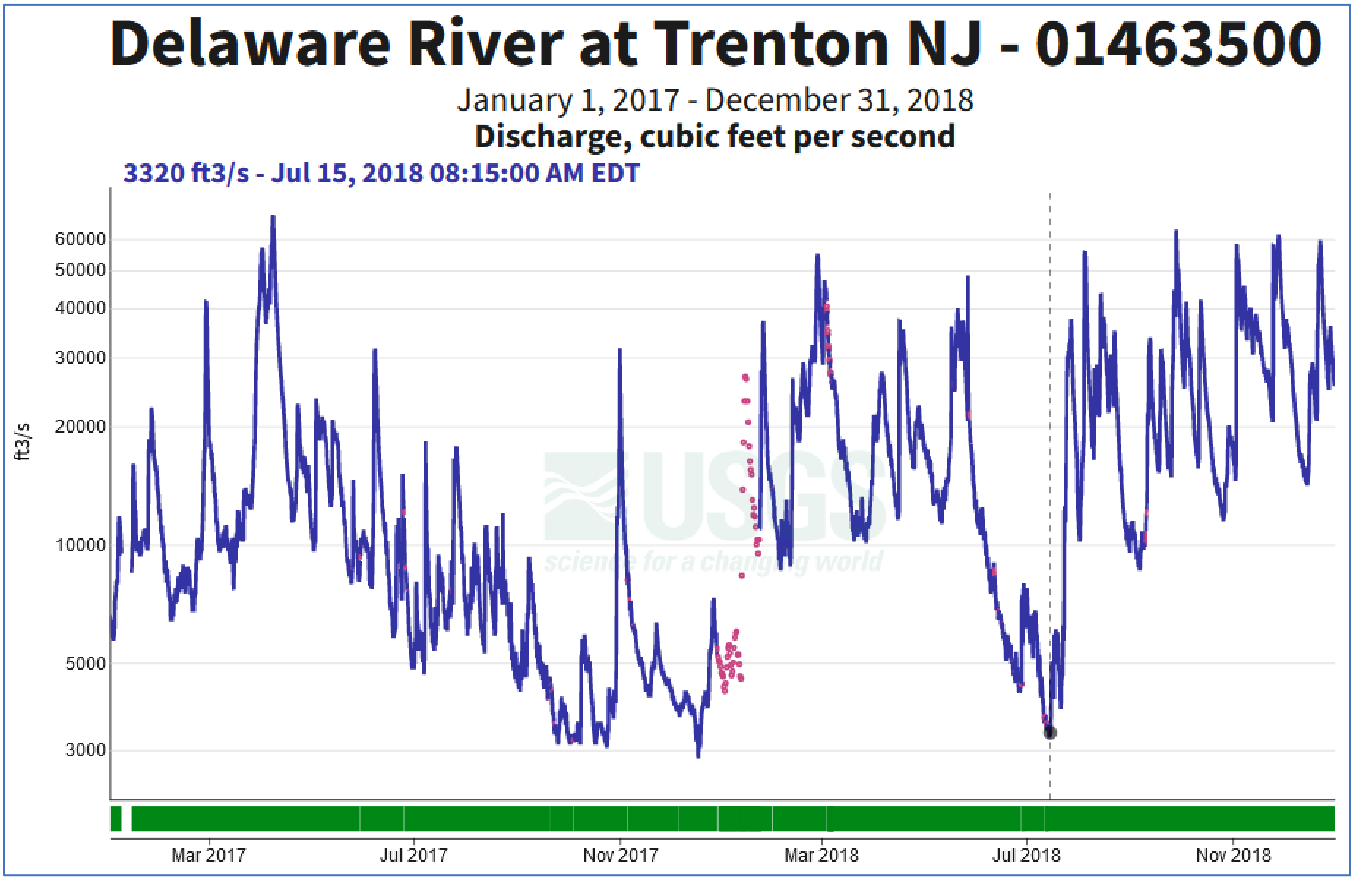


**Figure 4.) Discharge for USGS Station 01463500 Delaware River at Trenton, NJ 2017-2018.**

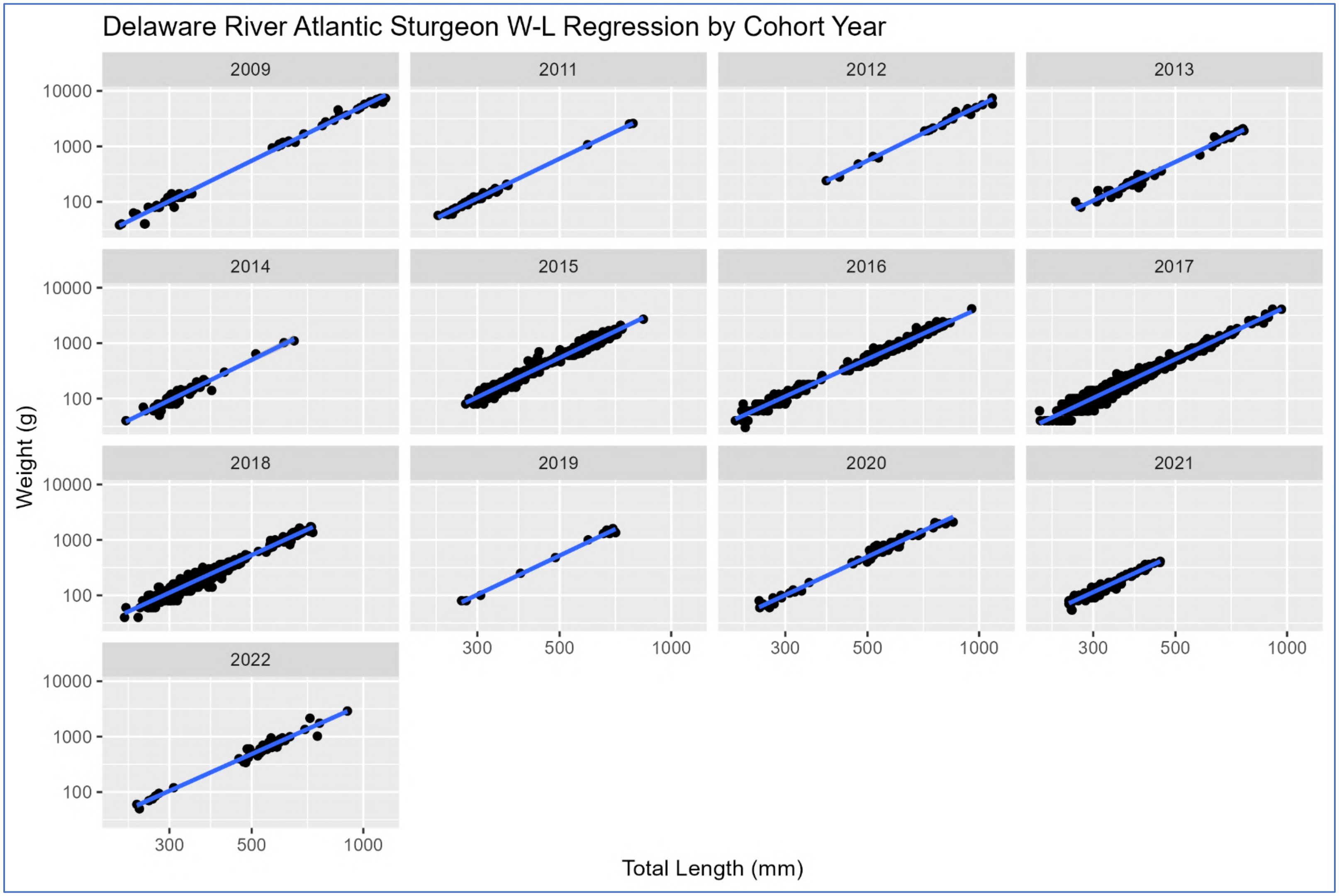


**Figure 6.) Weight and Length of Delaware River Atlantic sturgeon collected 2009-2022 with L-W linear regressions by cohort year.**

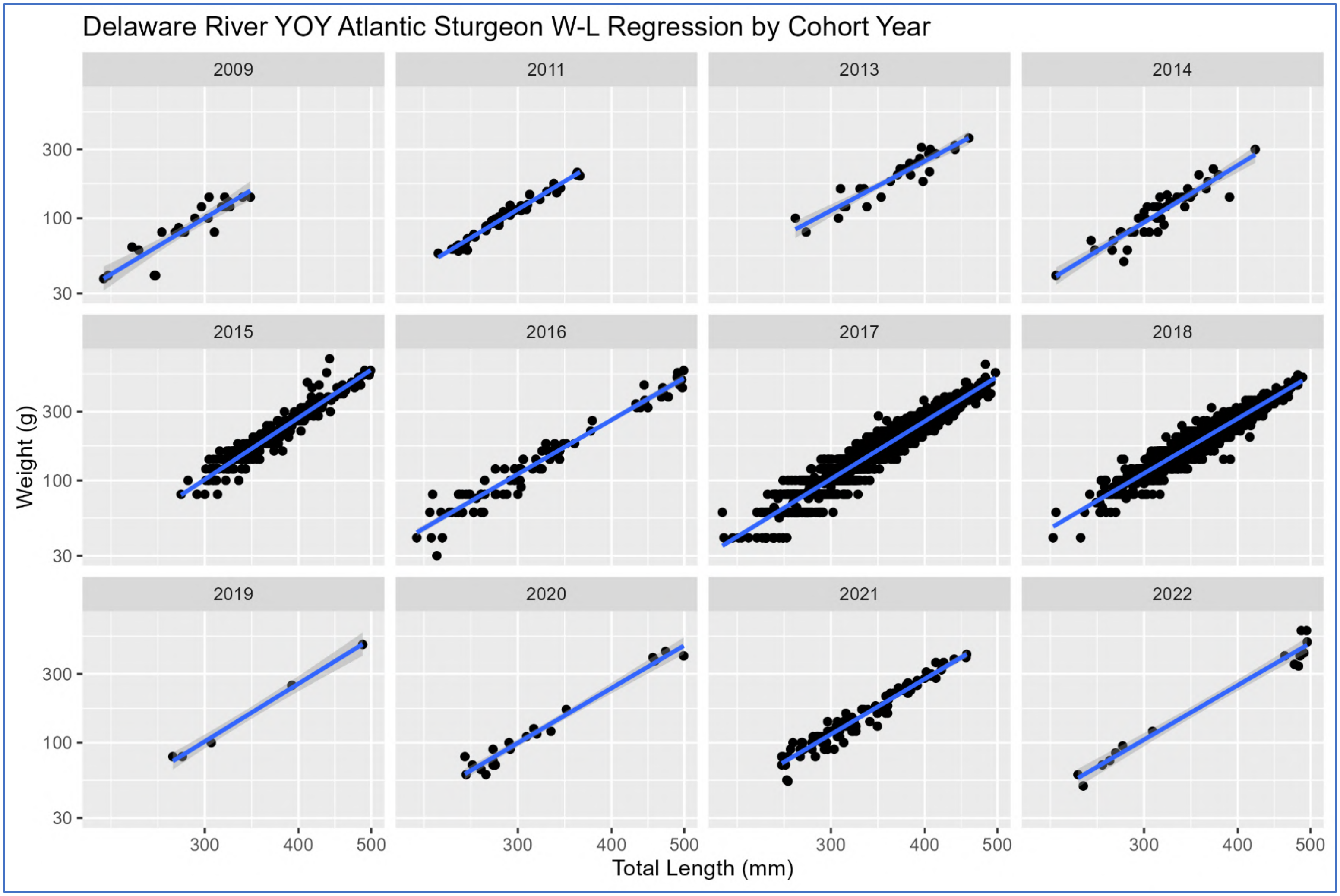


**Figure 7.) Weight and Length of YOY (<500mm) Delaware River Atlantic sturgeon collected 2009-2022 with L-W linear regression by YOY cohort year. 2012 not shown; 2019 (n = 5) is included for continuity.**

**4.) Weight measurements for Delaware River Atlantic sturgeon were found to be within the appropriate range for the species; YOY weight was consistently and strongly underpredicted by EPA's fish cohort model.**

Measured weights of Atlantic sturgeon collected from the Delaware River were subject to substantial measurement error and lack of precision when compared to length measurements, which were very precise (*i.e.*, nearest 1mm). Likely owing to the logistical constraints of measuring wet weight of fish with a very large range of sizes aboard moving vessels, sturgeon weights reported for the Delaware River by DNREC and ERC were recorded to the nearest 5g or 20g, respectively (Figure 8.) Imprecise weight measurements more strongly affected small fish, as the weight increments represented a greater proportion of body size. ERC weights reported in final reports did not match the weight precision values described in Materials and Methods, but PWD was unable to resolve this discrepancy. If EPA and/or NMFS are able to obtain the raw data from ERC for QAQC purposes, the more precise weight measurements described in report methods may be available.

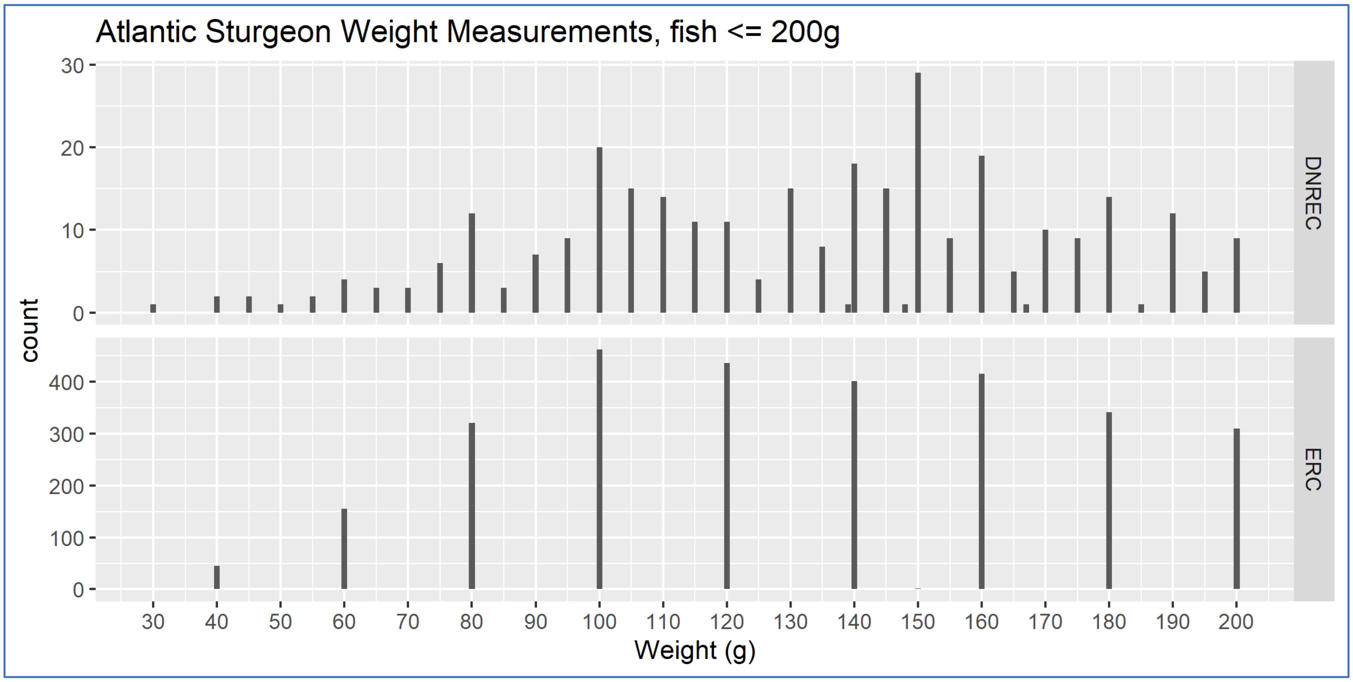


**Figure 8.) Example of imprecise weight increments from measurements of YOY and juvenile sturgeon collected by DNREC and ERC, fish less than or equal to 200g only.**

The average weight of 4,590 YOY (*i.e.*, <500mm) Delaware River Atlantic sturgeon was 178g, while the median value was 160g. Annual variability was observed in weight measurements, however total annual sample sizes for YOY varied over two orders of magnitude (Table 7). Similar to the total length analysis, for the YOY cohort years 2015-2018 when samples were collected by both DNREC and ERC, the ERC fish collected in winter had slightly higher weight in three of the four years monitored, suggesting that fish continued to grow, albeit more slowly, during fall and winter when temperatures are not ideal for growth.

**Table 7.) Annual average weight measurements for Delaware River YOY Atlantic sturgeon collected by DNREC and ERC 2009-2022**

| Cohort year | n | Average weight (g) | n DNREC | DNREC avg wt. (g) | n ERC | ERC avg wt. (g) |
|---|---|---|---|---|---|---|
| 2009 | 23 | 93 | 23 | 93 | - | - |
| 2011 | 49 | 107 | 49 | 107 | - | - |
| 2013 | 27 | 213 | - | - | 27 | 213 |
| 2014 | 47 | 116 | 47 | 116 | - | - |
| 2015 | 271 | 225 | 15 | 214 | 256 | 225 |
| 2016 | 102 | 180 | 20 | 185 | 82 | 179 |
| 2017 | 2396 | 162 | 127 | 139 | 2269 | 163 |
| 2018 | 1528 | 201 | 221 | 160 | 1307 | 208 |
| 2019 | 5 | 198 | 5 | 198 | - | - |
| 2020 | 20 | 153 | 20 | 153 | - | - |
| 2021 | 105 | 163 | 105 | 163 | - | - |
| 2022 | 15 | 278 | 15 | 278 | - | - |

NOTE: number of samples may not match between total length and weight tables. Some samples may have lacked total length or weight

In EPA's Technical Support Document (TSD) for the proposed rule (EPA 2023a), EPA's fish cohort model-predicted growth rates were plotted against a subset of DNREC data (TSD Figure 6) for 72 fish that were marked and recaptured. EPA made the model code and data sets used in the fish cohort model available in a GitHub repository (EPA 2023b), allowing PWD to obtain the EPA results for comparison against the full set of DNREC and ERC data (Figure 9).

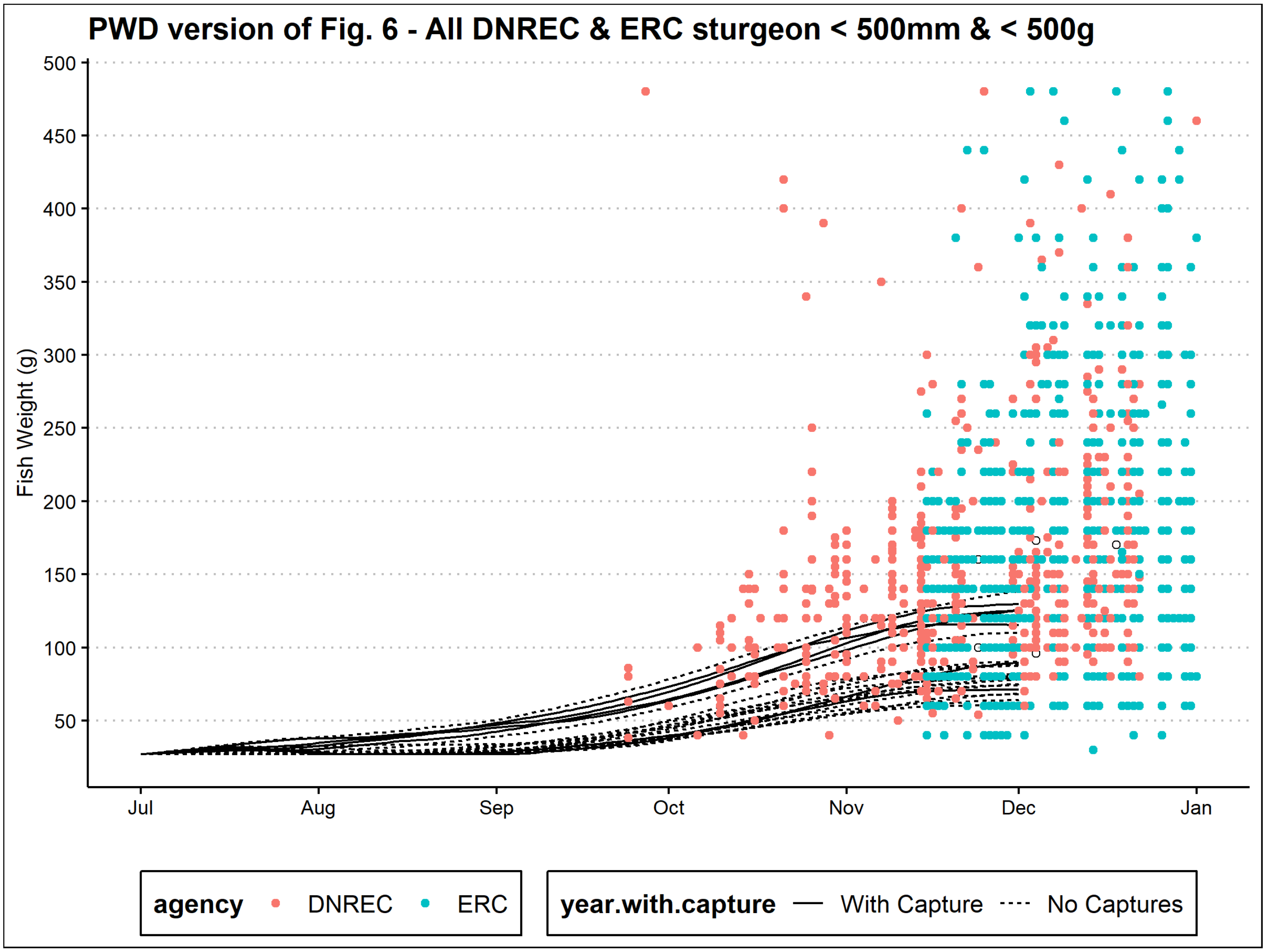


**Figure 9.) EPA-modeled growth of Atlantic sturgeon cohorts from 2002-2021 compared to observed weight of YOY Atlantic sturgeon collected by DNREC and ERC 2009-2022.**

Annual fish cohorts were modeled by EPA through December 1st of each year. Only DNREC data were available for the cohort years 2009, 2011, 2014, and 2020-2022, and DNREC data did not extend beyond December 1st, facilitating a direct comparison of observed data to the modeled fish cohort results (Figure 10). EPA's fish cohort model achieved a reasonably good fit for the center of the distribution of observed data for 2009 and 2014, but underpredicted the observed data for 2011 and 2021. The years 2020 and 2022 had relatively few observed data points for YOY sturgeon and appeared to have a bimodal distribution in weight. EPA's model was a reasonably good fit for the weight measurements with a grouping around 100g for these years. If the smaller fish are assumed to represent a relatively low weight YOY cohort and the heavier fish a yearling (or possibly fall-spawned, different cohort), the model fit the observed data reasonably well for 2020 and 2022. With such small sample sizes, it is not possible to determine if the fish weights came from a bimodal distribution with two different cohorts or were just the result of collecting a random sample from a continuous distribution that happened to have a cluster of small and large values.

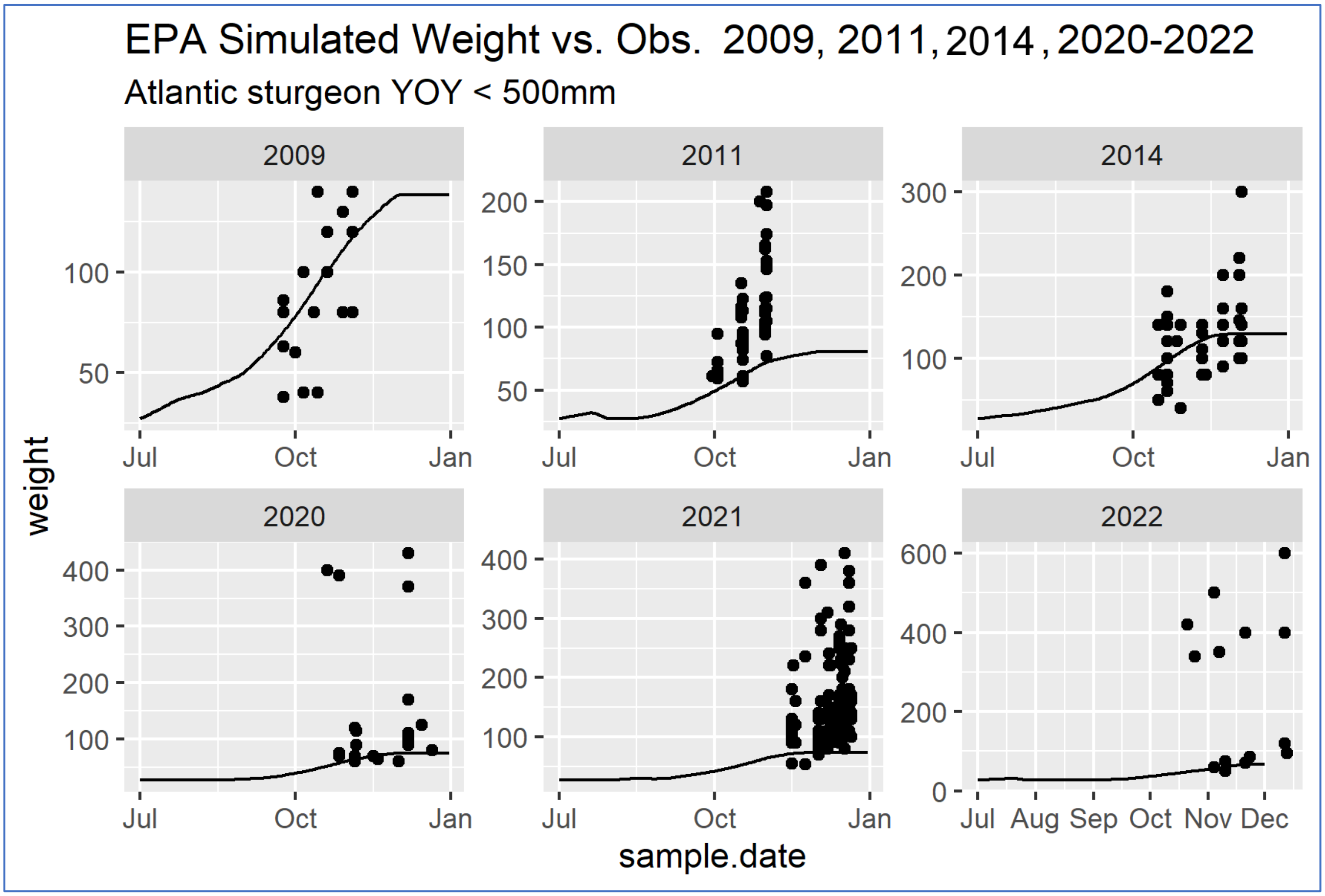


**Figure 10.) EPA modeled growth of Atlantic sturgeon cohorts (black line) compared to observed weight of YOY Atlantic sturgeon collected by DNREC and ERC 2009, 2011, 2014, and 2020-2022.**

Most of the ERC sturgeon data were collected in winter, in the next calendar year after spawning was assumed to occur, so PWD extended the x-axis of plots of the observed fish weight to include additional days for analysis. Annual fish cohorts were modeled by EPA through December 1st of each year, but to facilitate visual interpretation, PWD extrapolated the final value for modeled fish weight from December 1st through March 31st to represent no additional growth. PWD recognizes that EPA's model may have predicted additional growth or reduced growth, so the horizontal lines in figures 11 through 14 are presented only as a reference for the modeled fish weight on December 1st and not intended to represent EPA model results.

When compared to the generally larger data sets for the combined data from DNREC and ERC for the cohort years 2015-2018, the final December 1st value for EPA fish cohort model generally strongly underpredicted the observed data for 2015, 2017 and 2018 – years with the most available data on observed fish weight. The year 2016 was a less extreme example of the bimodal distribution in weight values seen in 2020 and 2022, although the data distribution was more continuous. The final model value from December 1st of approximately 100g was within the center of the range of the grouping of lower fish weight. Again, it is possible that the other fish less than 500mm in length may have corresponded to a yearling 2014 cohort or other (*e.g.*, fall spawning) cohort.

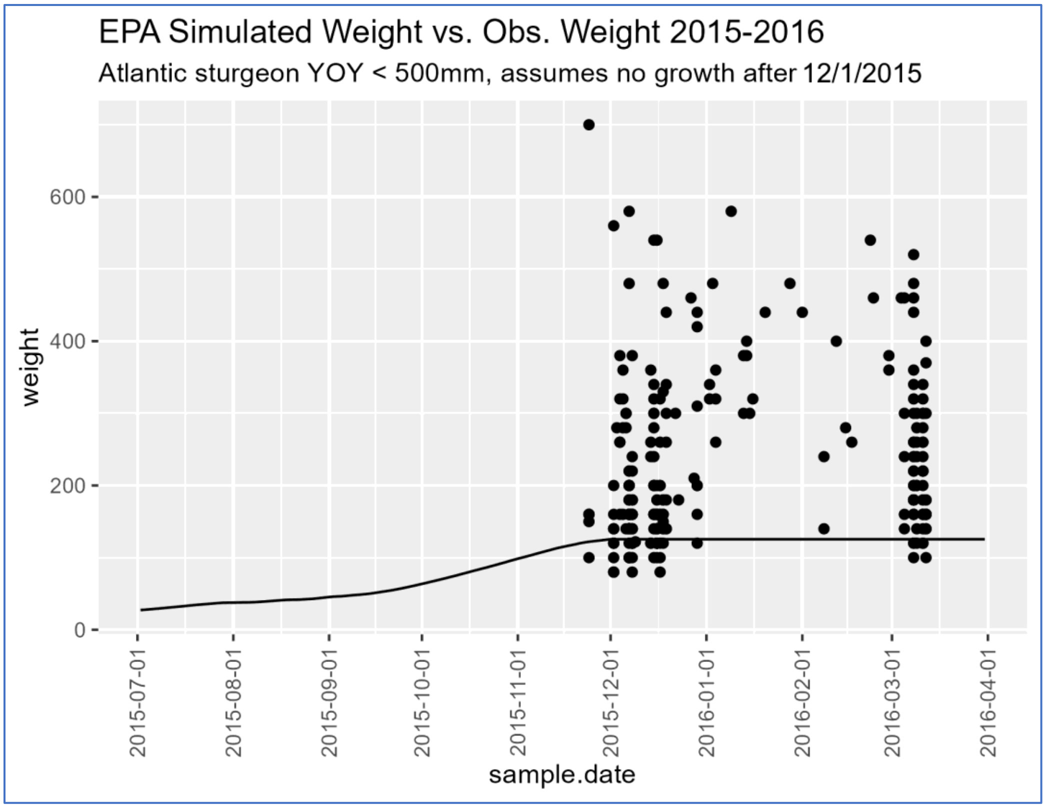


**Figure 11.) EPA fish cohort model simulated weight (black line) vs. observed DNREC and ERC data for YOY Atlantic sturgeon collected 2015-2016**

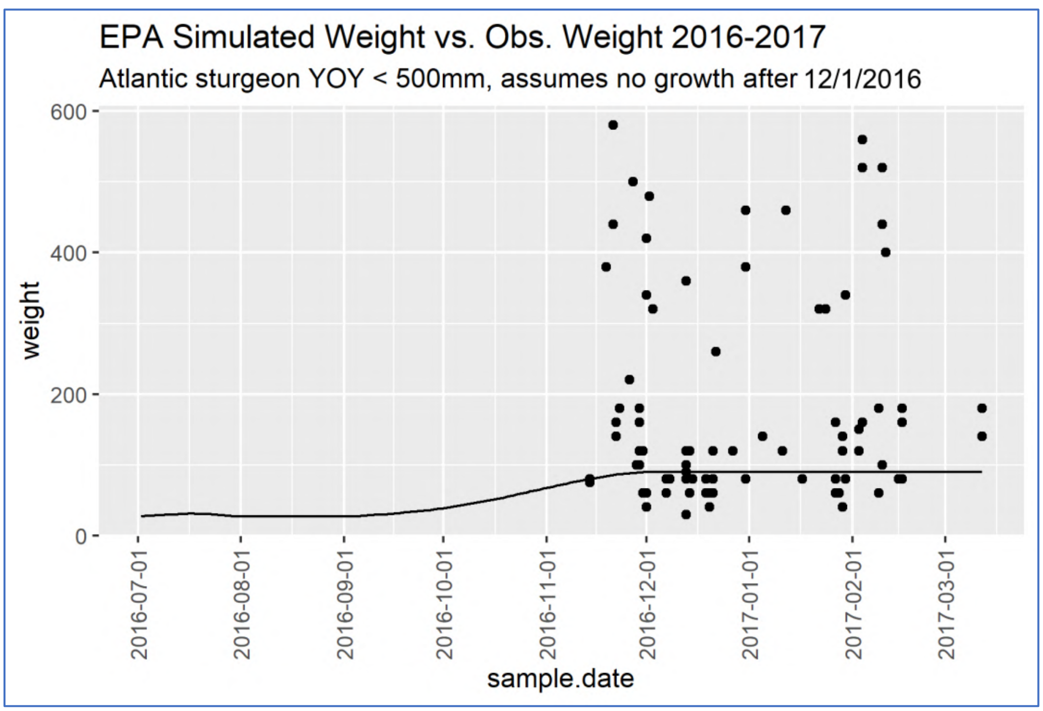


**Figure 12.) EPA fish cohort model simulated weight (black line) vs. observed DNREC and ERC data for YOY Atlantic sturgeon collected 2016-2017**

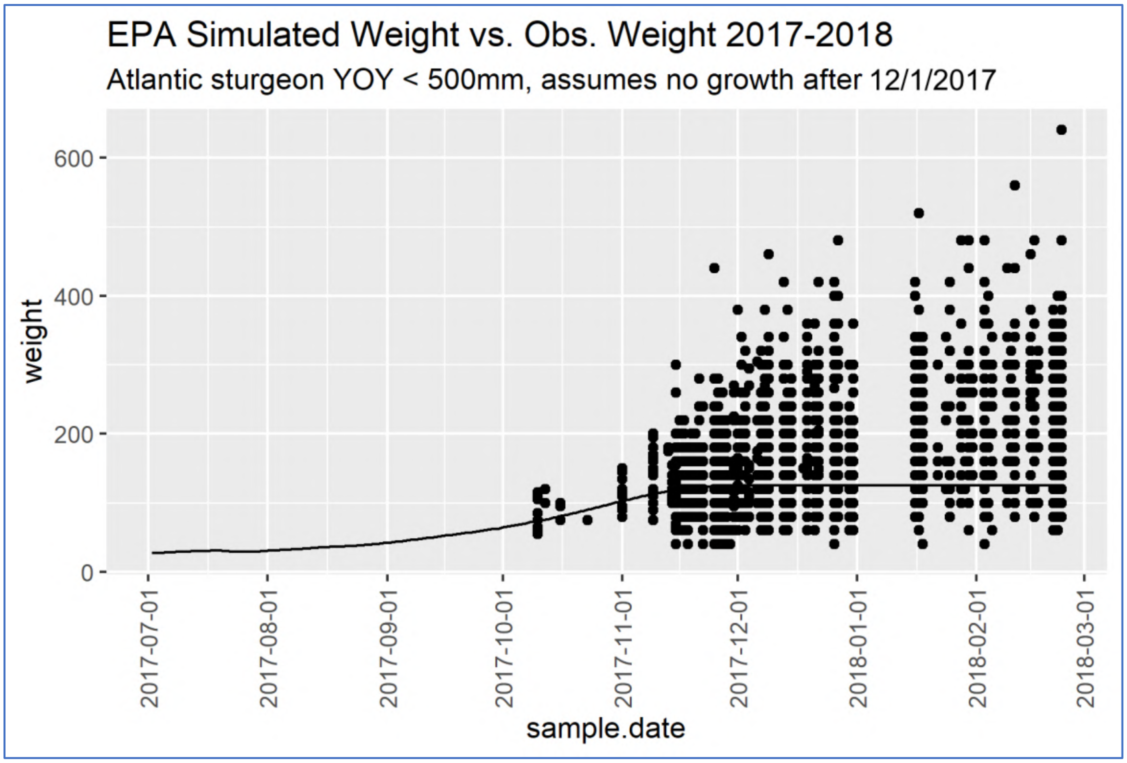


**Figure 13.) EPA fish cohort model simulated weight (black line) vs. observed DNREC and ERC data for YOY Atlantic sturgeon collected 2017-2018**

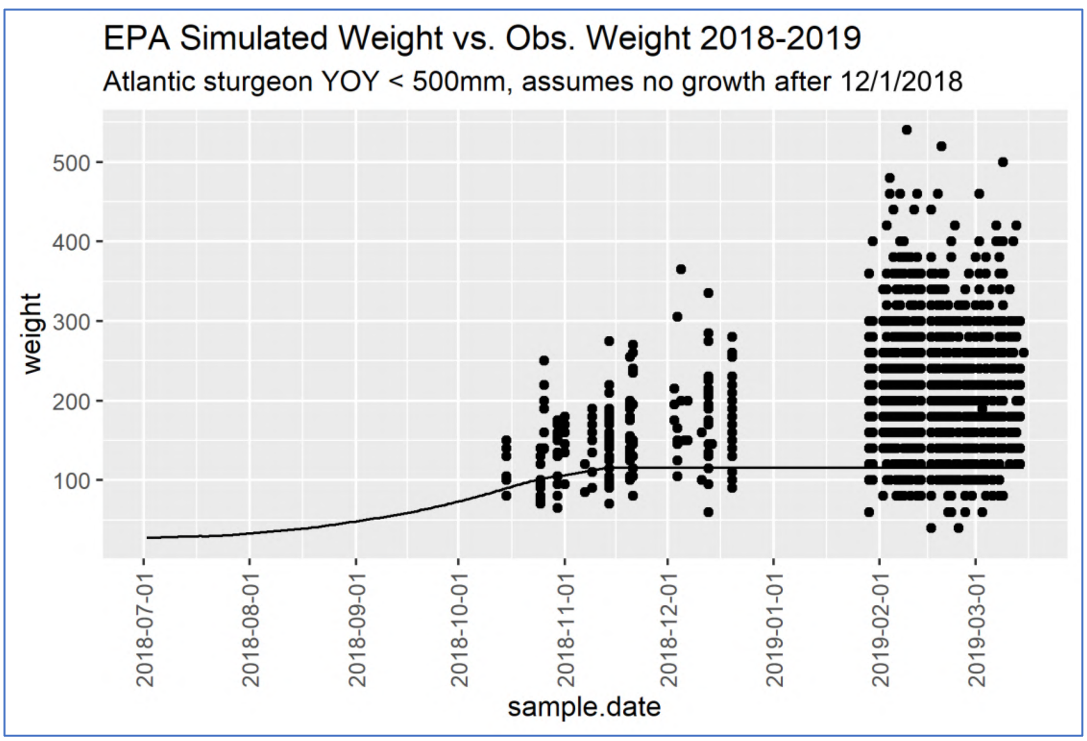


**Figure 14.) EPA fish cohort model simulated weight (black line) vs. observed DNREC and ERC data for YOY Atlantic sturgeon collected 2018-2019**

**5.) Atlantic sturgeon growth rates simulated by EPA's fish cohort model are much lower than growth rate estimates calculated from observed data in the Delaware River.**

As described above, EPA provided R code and input data sets for the fish cohort model, allowing PWD to compare modeled growth rates with growth rate estimates for observed data. PWD estimated growth rates for observed data using two different methods:

1.) Assume fish were 27g and 100mm on July 1st and calculate linear growth rates from observed data

2.) Assume fish spawned May 1st as suggested by literature on Delaware River Atlantic sturgeon

For method 2 PWD assumed that fish were 0.1g on the hatch date of May 1st. For analyzing growth in length for scenario 1, PWD assumed that fish were 100mm long on July 1st based on a linear regression model of log(weight) - log(length) and EPA's assumption that fish were 27g on July 1st. The linear regression model had adjusted $r^2$ value of 0.978 (See Figure 3 and further discussion in Comment 3). Additionally, for each of the two growth calculation methods, PWD calculated growth for fish collected in winter by ERC either directly as observed based on the collection date, or with an alternative "capped" scenario where the observed fish length or weight was assumed to have been achieved by January 1st. Combining the two methods of assumptions for starting conditions with the alternative methods of accounting for winter growth resulted in four different scenarios that were evaluated for changes in weight and length over time.

**Table 8.) Estimated change in total length of Atlantic sturgeon based on observed data and four scenarios of starting length and growth period duration.**

| YOY Cohort Year | Growth estimate July 1st (mm/d) | Growth estimate May 1st (mm/d) | Growth estimate July 1st capped* (mm/d) | Growth estimate May 1st capped* (mm/d) |
|---|---|---|---|---|
| 2009 | 1.72 | 1.69 | 1.72 | 1.69 |
| 2011 | 1.70 | 1.68 | 1.70 | 1.68 |
| 2013 | 1.17 | 1.26 | 1.51 | 1.54 |
| 2014 | 1.68 | 1.66 | 1.68 | 1.66 |
| 2015 | 1.45 | 1.49 | 1.58 | 1.60 |
| 2016 | 1.29 | 1.37 | 1.38 | 1.44 |
| 2017 | 1.42 | 1.47 | 1.48 | 1.52 |
| 2018 | 1.21 | 1.30 | 1.46 | 1.51 |
| 2019 | 1.75 | 1.72 | 1.75 | 1.72 |
| 2020 | 1.62 | 1.62 | 1.62 | 1.62 |
| 2021 | 1.43 | 1.49 | 1.43 | 1.49 |
| 2022 | 2.05 | 1.91 | 2.05 | 1.91 |

* NOTE: "capped" scenarios assume that fish collected in winter reached maximum TL value on Jan 1st.

**Table 9.) Estimated change in weight of Atlantic sturgeon based on observed data and four scenarios of starting weight and growth period duration.**

| YOY Cohort year | Growth estimate July 1st (g/d) | Growth estimate May 1st (g/d) | Growth estimate July 1st capped* (g/d) | Growth estimate May 1st capped* (g/d) |
|---|---|---|---|---|
| 2009 | 0.59 | 0.54 | 0.59 | 0.54 |
| 2011 | 0.70 | 0.62 | 0.70 | 0.62 |
| 2013 | 0.77 | 0.70 | 1.01 | 0.87 |
| 2014 | 0.68 | 0.60 | 0.68 | 0.60 |
| 2015 | 1.05 | 0.89 | 1.15 | 0.97 |
| 2016 | 0.87 | 0.76 | 0.93 | 0.80 |
| 2017 | 0.77 | 0.69 | 0.82 | 0.72 |
| 2018 | 0.80 | 0.72 | 0.98 | 0.84 |
| 2019 | 1.19 | 0.97 | 1.19 | 0.97 |
| 2020 | 0.91 | 0.76 | 0.91 | 0.76 |
| 2021 | 0.84 | 0.73 | 0.84 | 0.73 |
| 2022 | 1.79 | 1.37 | 1.79 | 1.37 |

* NOTE: "cap" scenarios assume that fish collected in winter reached maximum value on Jan 1st.

Mean growth in length was greater than 1mm/day for all the scenarios tested (Table 8), which provides solid evidence that sturgeon are growing in the Delaware River. PWD recognizes that sturgeon growth is likely non-linear. However, due to the relatively short window of length measurements during the growing season and inadequate 60-day comment period allowed by EPA for review of the proposed rule PWD, was unable to fully investigate more appropriate specific growth rates as a function of body size.

Estimated growth based on change in weight was much more variable than observed for length measurements, likely due to the lack of precision and measurement error for weight of small specimens (Figure 8, Table 9). Most cohort years experienced growth in weight by more than 0.5g/day, with estimates for some cohort years closer to 1g/day. As with length growth estimates, PWD recognizes that sturgeon growth in weight is likely highly non-linear. PWD was unable to fully investigate more appropriate specific growth rates as a function of body size. EPA's initial weight estimate of 27g for fish in the hypothetical cohort on July 1st is likely conservatively high. Assuming spawning occurs in April or May, actual reported growth rates for larval Atlantic sturgeon spawned and grown in laboratory conditions suggest that sturgeon would be closer to 5-10g at 60 days post-hatch (Secor and Gunderson 1998). More consistent reporting of age, length, and weight would be beneficial, as many studies only reported one or two of these factors rather than all three consistently.

**6.) Empirical growth rate estimates calculated from observed data on marked and recaptured fish were highly variable, but otherwise generally corroborated growth rate estimates from observed data.**

PWD estimated that there were approximately 230 instances in which a fish tagged by DNREC or ERC was recaptured and measured a second time, allowing for calculation of empirical growth rates. Most recapture intervals involved a very short time "at large" and were observed during the fall and winter when growth rates tend to be slower overall. As mentioned previously, weight measurements for small fish in the ERC data set lacked precision, typically having been measured in 20g increments. Negative growth is feasible for both weight and length, but length was measured more precisely and conceptually it is less likely for fish to lose appreciable length. Negative growth (*i.e.*, weight loss) would tend to be more likely to occur in the colder fall and winter.

Based on breaks in the data set, PWD estimated that rates > 2mm/d or 2g/d, may be erroneous whether positive or negative. Approximately 16% of the calculated empirical growth rates appeared to be spurious high outliers, with positive growth rates in total length greater than 2mm/day or weight increase greater than 2g/day. (Table 10). Approximately 13% of the data appeared to be spurious low outliers, with negative growth rates exceeding -2mm/d or -2g/d. The central tendency of the growth data set was relatively well constrained and generally corroborated the finding from seasonal growth rate calculation estimates that positive growth continued to occur outside the summer growing season (Figure 15).

**Table 10.) Summary of potential spurious outliers from empirical growth estimates based on mark-recapture data**

| Total recaptures | n, change in TL >2mm/d | proportion, change in TL >2mm/d | n, change in TL < -2 mm/d | proportion, change in TL <-2mm/d | n, change in W >2g/d | proportion, change in W >2g/d | n, change in W < -2 g/d | proportion, change in W <-2mm/d |
|---|---|---|---|---|---|---|---|---|
| 234 | 9 | 0.04 | 10 | 0.04 | 29 | 0.12 | 20 | 0.09 |

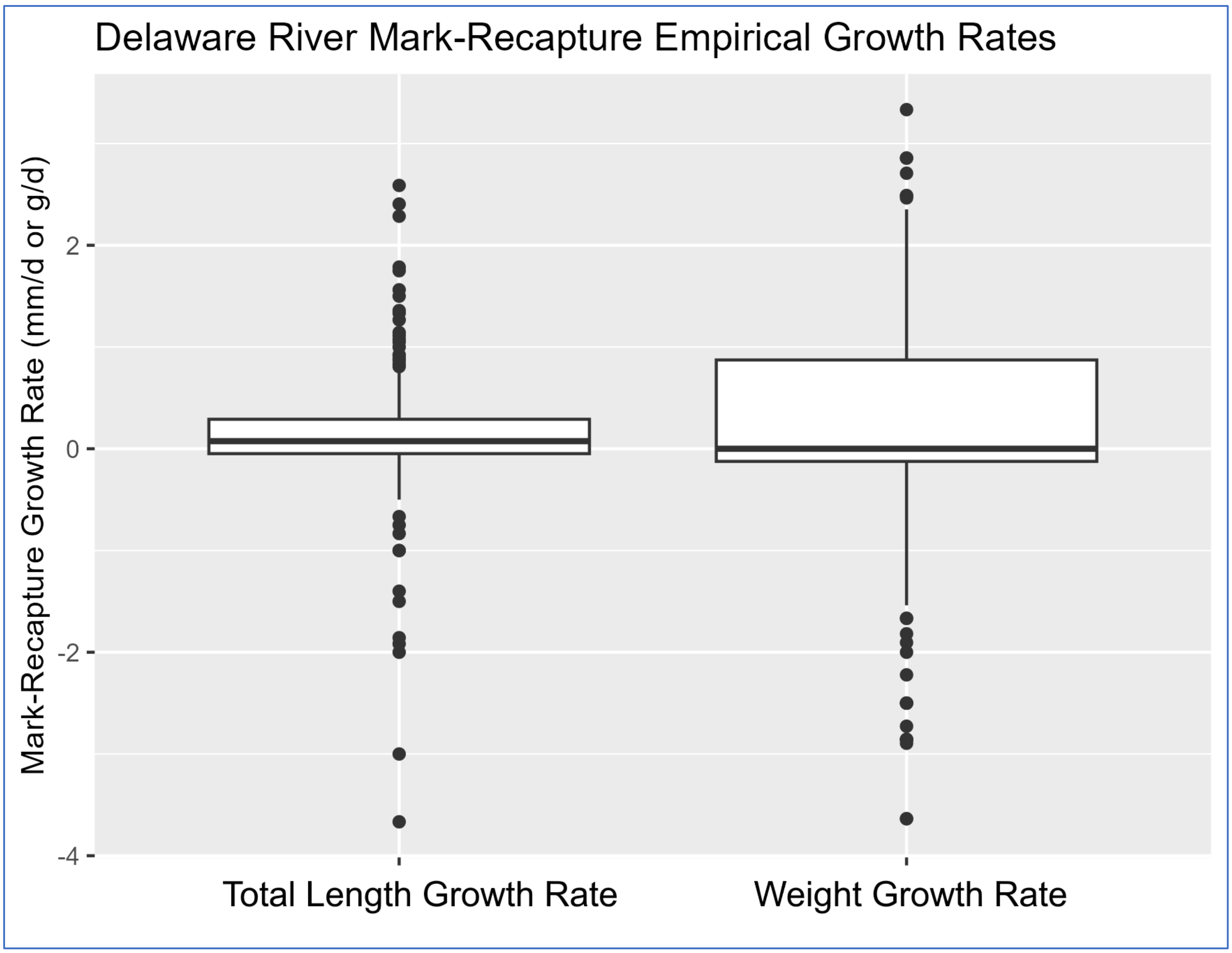


**Figure 15.) Delaware River empirical growth rates from observed mark-recapture data**

Only 12 marked and recaptured fish were at large 300days or more, representing nearly a full year of growth for yearling or older sturgeon (Figure 16). With longer time at large and certainty that the mark-recapture period included at least one complete growing season, these estimates of empirical growth rate are potentially more reliable, although they may still include a substantial period of fall and winter growth. One of the 12 mark-recapture records over 300 days at large is believed to be an error as the mark-recapture data suggested that the fish lost 82mm in length and 140g in weight over 363 days with condition factor remaining relatively constant at $K_{TL}$ = 0.40.

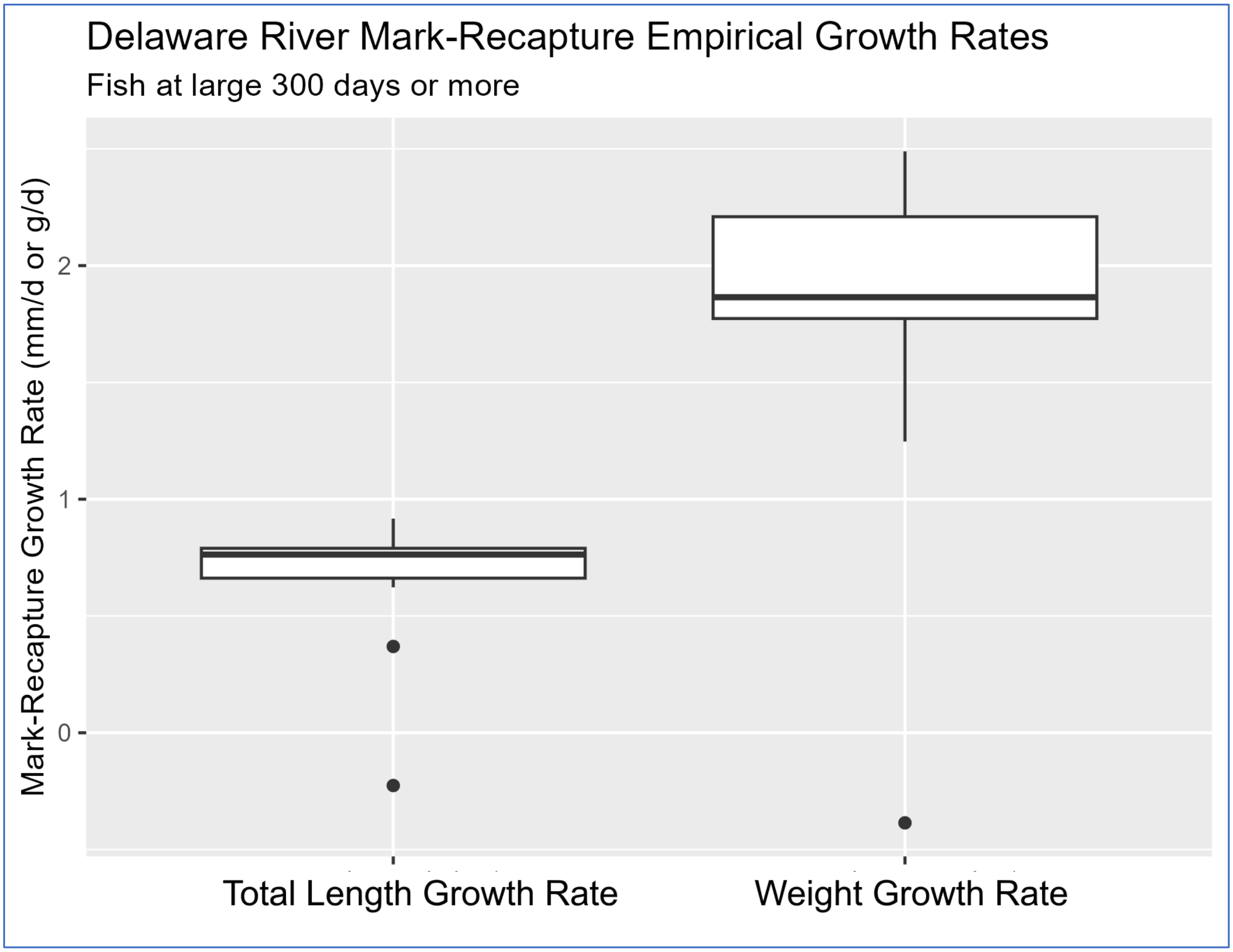


**Figure 16.) Delaware River empirical growth rates from observed mark-recapture data, fish at large 300 days or more**

**7.) EPA's fish cohort model substantially underpredicts production for hypothetical cohorts of YOY Atlantic sturgeon as measured by change in biomass.**

PWD compared the biomass estimates from EPA's fish cohort model against the total mass of observed YOY sturgeon in 2009-2022. EPA's fish cohort model includes two primary mechanisms by which biomass may change – mortality and growth. The cohort is limited to 10,000 hypothetical individuals, which decreases due to mortality on a daily time step and cannot increase. Growth, as implemented in the model, can be negative or positive. The ultimate measure of production is expressed as a Habitat Suitability Index, which indicates whether there would be a net increase or decrease in fish biomass for a given cohort year. Because the observed data for each cohort year come from a population of unknown size, direct comparison of the biomass of the hypothetical cohort and observed data is inappropriate. It is possible, however, to evaluate whether EPA's fish cohort model predicted an increase or decrease in biomass for each year along with the observed biomass for the sample from the unknown population. The biomass sample from fish that were collected is obviously an under-estimate of the true population biomass.

**Table 11.) EPA HSI (change in biomass) compared to observed biomass of observed population sample for YOY Atlantic sturgeon by cohort year**

| YOY Cohort year | EPA TSD HSI | Observed YOY biomass(g)* |
|---|---|---|
| 2009 | 0.45 | 2,137 |
| 2011 | -0.30 | 52,59.3 |
| 2013 | 0.17 | 6,030 |
| 2014 | -0.01 | 5,455 |
| 2015 | 0.22 | 60,862 |
| 2016 | -0.48 | 18,995 |
| 2017 | 0.27 | 387,855 |
| 2018 | 0.56 | 307,069 |
| 2019 | -0.96 | 990 |
| 2020 | -1.92 | 3,060 |
| 2021 | -1.61 | 16,964 |
| 2022 | -1.04 | 4,165 |

* Note: Biomass only for YOY fish < 500mm, not all fish collected

EPA's fish cohort model predicted a negative net change in biomass for observed DO and temperature conditions at Chester in seven of the twelve years with adequate observed data (Table 11). The HSI model did predict the largest net increase in biomass for 2018, which was the second largest observed biomass from fish actually collected. Due to differences in sampling effort, biomass totals are not comparable from year to year. The primary conclusion from the biomass analysis is that EPA's HSI predicts a net decrease in biomass for several years that in fact had strong evidence of spawning, growth and a net increase in biomass.

**8.) PWD compared several measures of observed fish growth and condition to DO statistics and found no statistically significant correlations that would indicate DO levels are adversely affecting sturgeon**

PWD investigated the hypothesis that hypoxia in the Delaware River adversely affected sturgeon by comparing several DO statistics (Table 12) to measures of observed fish growth and condition for data observed 2009-2022 (Table 13). Before performing statistical tests, PWD evaluated whether the DO and sturgeon response metrics had a relatively large enough range, such that practical interpretations of the data would be feasible and appropriate. For example, if all the DO measurements were relatively very high or very low from year to year with no years of observed variability in DO conditions, there might be not enough available data over the range of DO exposures to both low and high DO for any correlation to be apparent in the correlation analysis.

**Table 12.) Key to abbreviations used for DO statistics observed for Chester USGS station 2009-2022**

| Abbreviation | Description |
|---|---|
| crit.1.sat | critical season 1st percentile DO saturation |
| crit.2.sat | critical season 2nd percentile DO saturation |
| crit.5.sat | critical season 5th percentile DO saturation |
| crit.10.sat | critical season 10th percentile DO saturation |
| crit.mean.sat | critical season mean DO saturation |
| crit.med.sat | critical season median DO saturation |
| crit.min.sat | critical season minimum DO saturation |
| crit.pct.50 | critical season % of DO > 50% saturation |
| crit.pct.60 | critical season % of DO > 60% saturation |
| crit.pct.70 | critical season % of DO > 70% saturation |
| grow.1.sat | growing season 1st percentile DO saturation |
| grow.2.sat | growing season 2nd percentile DO saturation |
| grow.5.sat | growing season 5th percentile DO saturation |
| grow.10.sat | growing season 10th percentile DO saturation |
| grow.mean.sat | growing season mean DO saturation |
| grow.med.sat | growing season median DO saturation |
| grow.min.sat | growing season minimum DO saturation |
| grow.pct.50 | growing season % of DO > 50% saturation |
| grow.pct.60 | growing season % of DO > 60% saturation |
| grow.pct.70 | growing season % of DO > 70% saturation |

**Table 13.) Key to abbreviations used for sturgeon growth and condition metrics**

| Abbreviation | Description |
|---|---|
| YOY.grow.5.1.TL | YOY growth in length from May 1st |
| YOY.grow.5.1.TL.cap* | YOY growth in length from May 1st, winter growth to Jan 1st |
| YOY.grow.5.1.W | YOY growth in weight from May 1st |
| YOY.grow.5.1.W.cap* | YOY growth in weight from May 1st, winter growth to Jan 1st |
| YOY.grow.7.1.TL | YOY growth in length from 100mm July 1st |
| YOY.grow.7.1.TL.cap* | YOY growth in length from 100mm July 1st, winter growth to Jan 1st |
| YOY.grow.7.1.W | YOY growth in weight from 27g July 1st |
| YOY.grow.7.1.W.cap* | YOY growth in weight from 27g July 1st, winter growth to Jan 1st |
| YOY.mean.TL | YOY mean total length in mm |
| YOY.mean.W | YOY mean total weight in g |
| mean.K.YOY | YOY mean condition factor K |
| mean.K.all | mean condition factor K for all fish collected |
| slope.b.YOY | slope parameter b for L-W regression, YOY only |
| slope.b.all | slope parameter b for L-W regression, all fish collected |

* See comment 5 for description of "capped" scenarios for fish growth

Some independent DO statistic metrics exhibited relatively large ranges, with expected higher variability in higher percentiles, such as the percent of DO values above 70% or 60% saturation. Conversely, there was little variability in the percent of data above 50% saturation, as 50% DO saturation was almost always achieved. Measurements that correspond to the central tendency of the data had a moderate to low amount of variability (Figure 17). There was relatively good coverage of the range in DO variability between 50-60%, which likely represents the range of suitable DO conditions based on the consistent propagation and normal growth that was observed each year. Notably, other than the DO minima, which may represent a very transient condition, there was no substantial or extended exposure to DO saturation levels lower than 50% saturation.

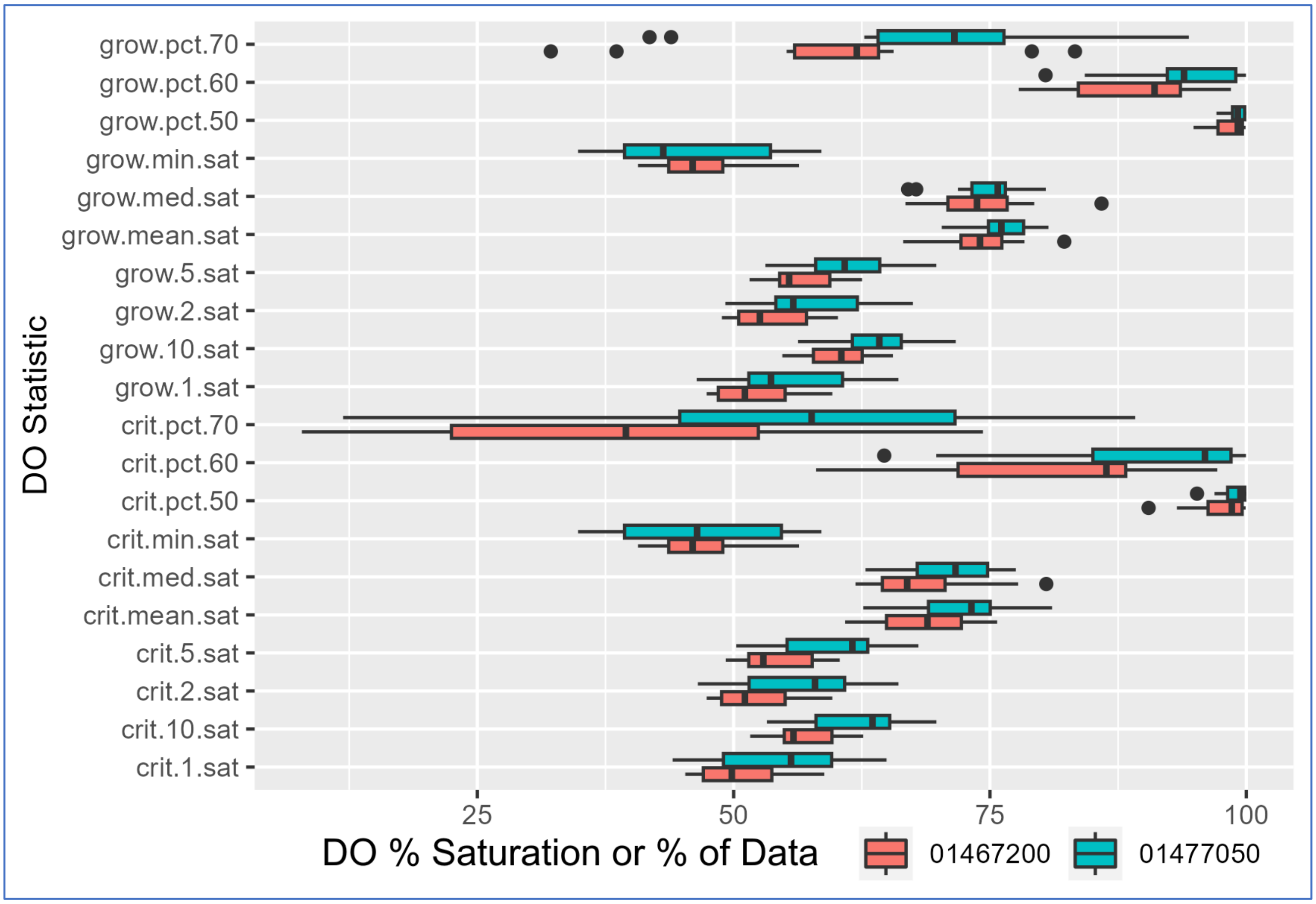


**Figure 17.) Variability in DO condition metrics 2009-2022 for USGS Monitoring stations at Penn's Landing (01467200) and Chester, PA (01477050) in two seasonal periods**

Outliers were observed for very high YOY growth rates in the year 2012 in which DNREC sampled mostly larger fish during the summer (Table 5). The year 2012 was excluded from the final correlation analysis as being unrepresentative compared to the rest of the data set, especially as the sample size for YOY was so small (n = 3), growth metrics were high outliers, and DO metrics were in the low range. To ensure that excluding 2012 did not bias the results, PWD performed correlation tests both with and without 2012 and did not find substantial differences in the results. The year 2009 was also an outlier with relatively high growth rates observed for YOY sturgeon. Although some 2009 samples were collected relatively early in the season, which would tend to increase estimates of growth rate calculated from fixed start dates, and theoretically the growth rate period observed would encapsulate a greater proportion of the most optimal warm growing conditions compared to fall and winter samples, PWD examined the growth rates and did not find sufficient justification to remove 2009 data from the correlation analysis.

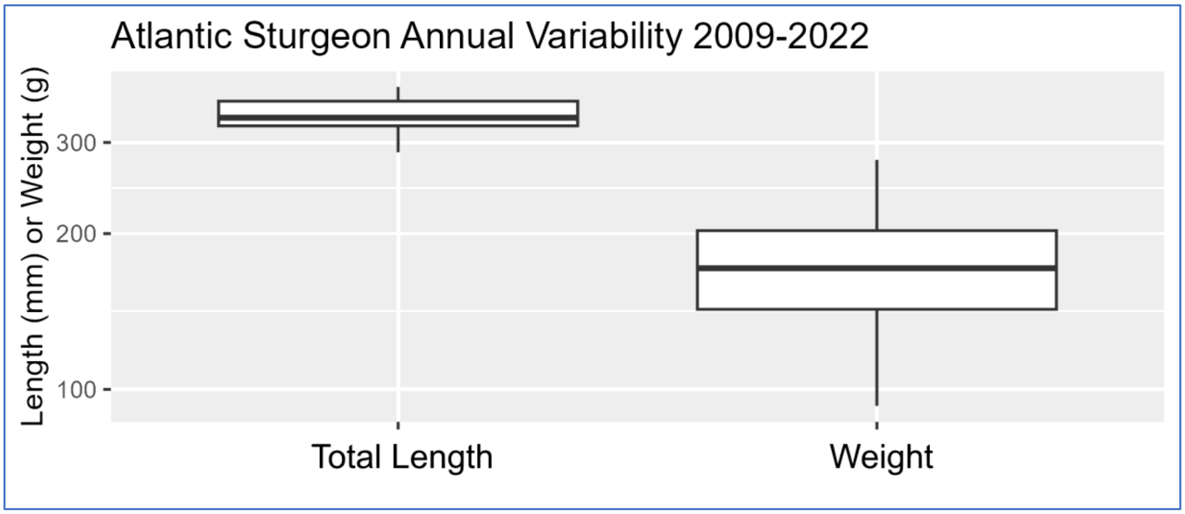


**Figure 18.) Observed variability in YOY sturgeon total length and weight metrics used in DO-sturgeon growth correlation analysis**

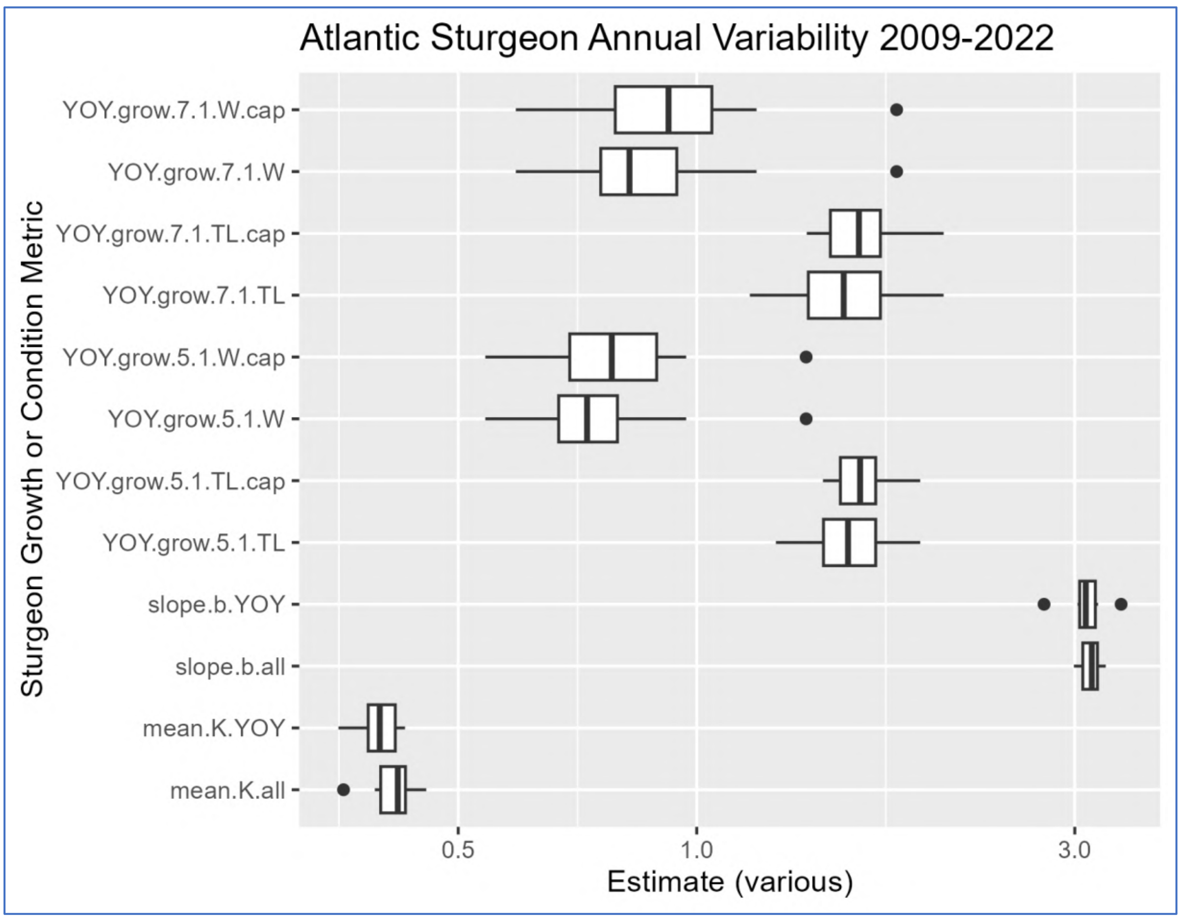


**Figure 19.) Observed variability in sturgeon growth and condition metrics used in DO-sturgeon growth correlation analysis**

PWD compared fish growth to different DO summary statistics for every year that large enough samples of fish were collected in a factorial design as shown in Table 14. The slope parameter b values from L-W regressions and mean condition factor K were computed separately for groups of all sturgeon collected in each combined cohort year and a subset of YOY sturgeon collected in each cohort year for comparison against DO statistics. Sturgeon response variables that were related to growth (*i.e.*, mean length, mean weight, growth as change in length, and growth as change in weight) were only evaluated for YOY. Overall, the factorial design resulted in 560 separate combinations of the factors DO Variable, USGS station, season, sturgeon response variable, and data set type (YOY or all data) (Table 14). Correlation was assessed using the nonparametric Spearman rank correlation coefficient, as it was not expected that the response between DO and a sturgeon response would be linear. The Spearman rank correlation coefficient evaluates whether the relationship between the two variables (here DO and sturgeon condition or growth) exhibits a monotonic trend.

**Table 14) Conceptual factorial design of comparisons between DO statistics and measures of sturgeon growth and condition**

| **Independent DO Variable** | | **USGS Station** | | **Season** | | **Dependent Variable** | | **Data Set** |
|---|---|---|---|---|---|---|---|---|
| Minimum | | | | | | | | |
| 1st percentile | | | | | | | | |
| 2nd percentile | | | | | | Slope *b* parameter | | |
| 5th percentile | X | Penn's Landing 01467200 | X | Growing: May - Oct | X | Mean condition factor K | X | YOY |
| 10th percentile | | Chester 01477050 | | Critical: Jul - Sep | | Mean length* | | All data |
| Mean | | | | | | Mean weight* | | |
| Median | | | | | | Growth in length* | | |
| Percent > 50% | | | | | | Growth in weight* | | |
| Percent > 60% | | | | | | | | |
| Percent > 70% | | | | | | | | |

* Denotes sturgeon growth parameters that were only evaluated for YOY.

With 560 comparisons made, it was expected that spurious results would occur due to random chance. Ordinarily when making a large number of comparisons, p values should be adjusted to take into account the likelihood of false positives, or the "family-wise error rate". With only 12 years of data, the statistical power of the correlation test to reject the null hypothesis that the correlation between the DO and sturgeon metrics is different from zero was also limited. Adjustments to the alpha level from the typical 0.05 to 0.1 and specification of the test as a one-sided test with the alternative hypothesis being "greater", (*i.e.*, positive) correlation would potentially help address the sample size issue, but relaxing the alpha value is inappropriate in the context of performing hundreds of tests.

With p values unadjusted for multiple comparisons, nine (<2%) of the 560 comparison correlation tests were significant at p <0.05, however these results were for spurious strong negative correlation between DO and sturgeon growth metrics at the Penn's Landing USGS station (Table 15). Only four (<1%) of the 560 correlation tests associated with positive correlation coefficients would have been statistically significant at p < 0.1 (Table 15).

**Table 15.) Summary of DO-sturgeon metric correlation tests with significant negative correlation at p <0.05 or positive correlation test significant at p <0.1**

| USGS station | DO Statistic | Sturgeon metric | cor (rho) | statistic | p-value | method |
|---|---|---|---|---|---|---|
| 1467200 | crit.med.sat | YOY.grow.5.1.W | -0.75 | 384 | 0.0119 | Spearman |
| 1467200 | crit.med.sat | YOY.grow.7.1.W | -0.75 | 384 | 0.0119 | Spearman |
| 1467200 | crit.mean.sat | YOY.grow.5.1.W | -0.69 | 372 | 0.0231 | Spearman |
| 1467200 | crit.mean.sat | YOY.grow.7.1.W | -0.69 | 372 | 0.0231 | Spearman |
| 1467200 | crit.pct.70 | YOY.grow.5.1.W | -0.65 | 362 | 0.037 | Spearman |
| 1467200 | crit.pct.70 | YOY.grow.7.1.W | -0.65 | 362 | 0.037 | Spearman |
| 1467200 | grow.pct.70 | YOY.grow.5.1.W | -0.65 | 362 | 0.037 | Spearman |
| 1467200 | grow.pct.70 | YOY.grow.7.1.W | -0.65 | 362 | 0.037 | Spearman |
| 1477050 | crit.10.sat | YOY.grow.5.1.TL | -0.65 | 362 | 0.037 | Spearman |
| Positive Correlations at p < 0.1 | | | | | | |
| 1467200 | crit.mean.sat | slope.b.all | 0.57 | 94 | 0.0706 | Spearman |
| 1467200 | crit.pct.50 | slope.b.YOY | 0.55 | 98 | 0.0816 | Spearman |
| 1467200 | crit.min.sat | slope.b.YOY | 0.53 | 102.7332 | 0.0913 | Spearman |
| 1467200 | grow.min.sat | slope.b.YOY | 0.53 | 102.7332 | 0.0913 | Spearman |

Approximately 35% (197 of 560) of the comparisons had a positive correlation coefficient, while 63% were negative (353 of 560; percentages do not exactly add to 100% because 10 correlation tests had correlation coefficient zero). The overall distribution of correlation coefficients and p values demonstrated that there was no statistically significant evidence for the hypothesis that DO levels in the Delaware River were correlated with the observed growth and condition metrics over the years 2009-2022 that were studied (Figure 20).

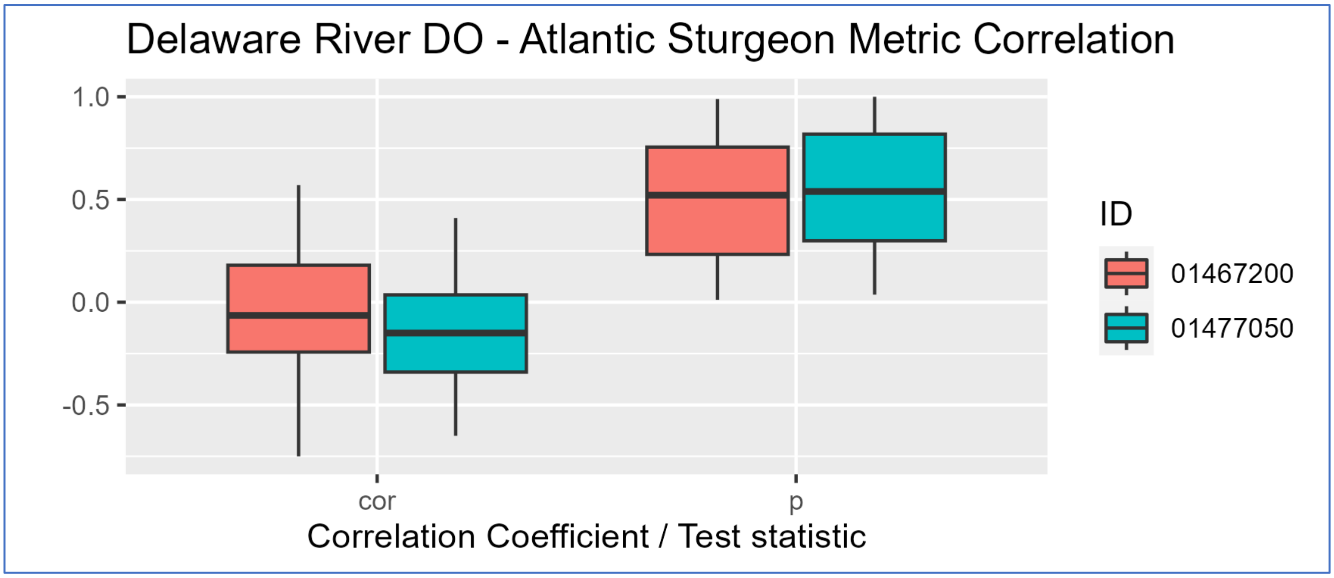


**Figure 20.) Correlation coefficients and correlation test p-values for 560 Delaware River DO statistic vs Atlantic sturgeon growth and condition correlation comparisons 2009-2022 for USGS stations at Penn's Landing (01467200) and Chester, PA (01477050).**

The strongest observed positive correlation between a DO statistic and a sturgeon growth response was for the comparison between the critical season (Jul-Sep) mean percent DO saturation with the slope parameter *b* of the L-W regression for all fish, with Spearman correlation coefficient 0.57 (Table 16, Figure 21). Three other DO statistics (critical season percent of DO values above 50% saturation, critical season minimum DO saturation, and growing season minimum DO saturation) also had positive correlations with the slope parameter *b* for YOY sturgeon, with Spearman correlation coefficients 0.53-0.55 (Table 17, Figure 22). Many other DO statistic comparisons for the slope parameter *b* of the L-W regression for all fish or for YOY sturgeon were not as strongly correlated (Tables 16 & 17, Figures 21 & 22). Additional plots of the correlation between DO statistics and Atlantic sturgeon growth and condition are presented in Appendix A Figures 1 through 12.

**Table 16.) Summary Statistics for Spearman correlation tests for Delaware River seasonal DO statistics and Atlantic sturgeon L-W regression slope parameter *b*, 2009-2022**

| | 1467200 | | | 1477050 | | |
|---|---|---|---|---|---|---|
| **DO Statistic** | **cor (rho)** | **statistic** | **p-value** | **cor (rho)** | **statistic** | **p-value** |
| crit.1.sat | 0.11 | 196 | 0.755 | -0.18 | 260 | 0.595 |
| crit.10.sat | 0.36 | 140 | 0.273 | -0.082 | 238 | 0.818 |
| crit.2.sat | 0.1 | 198 | 0.776 | -0.15 | 252 | 0.673 |
| crit.5.sat | 0.13 | 192 | 0.714 | -0.16 | 256 | 0.634 |
| crit.mean.sat | 0.57 | 94 | 0.0706 | 0.14 | 190 | 0.694 |
| crit.med.sat | 0.42 | 128 | 0.203 | 0.027 | 214 | 0.946 |
| crit.min.sat | 0.087 | 201 | 0.8 | 0 | 220 | 1 |
| crit.pct.50 | 0.23 | 170 | 0.503 | -0.24 | 272 | 0.485 |
| crit.pct.60 | 0.46 | 118 | 0.154 | -0.055 | 232 | 0.881 |
| crit.pct.70 | 0.5 | 110 | 0.121 | -0.0091 | 222 | 0.989 |
| grow.1.sat | 0.12 | 194 | 0.734 | -0.2 | 264 | 0.558 |
| grow.10.sat | 0.41 | 130 | 0.214 | -0.018 | 224 | 0.968 |
| grow.2.sat | 0.19 | 178 | 0.576 | -0.2 | 264 | 0.558 |
| grow.5.sat | 0.37 | 139 | 0.264 | -0.0091 | 222 | 0.989 |
| grow.mean.sat | 0.33 | 148 | 0.327 | 0.32 | 150 | 0.341 |
| grow.med.sat | 0.27 | 160 | 0.418 | 0.045 | 210 | 0.903 |
| grow.min.sat | 0.087 | 201 | 0.8 | -0.027 | 226 | 0.946 |
| grow.pct.50 | 0.17 | 182 | 0.614 | -0.39 | 306 | 0.237 |
| grow.pct.60 | 0.45 | 120 | 0.163 | -0.082 | 238 | 0.818 |
| grow.pct.70 | 0.43 | 126 | 0.193 | 0.045 | 210 | 0.903 |

**Table 17.) Summary Statistics for Spearman correlation tests for Delaware River seasonal DO statistics and YOY Atlantic sturgeon L-W regression slope parameter *b*, 2009-2022**

| | Penn's Landing (1467200) | | | Chester (1477050) | | |
|---|---|---|---|---|---|---|
| **DO Statistic** | **cor (rho)** | **statistic** | **p-value** | **cor (rho)** | **statistic** | **p-value** |
| crit.1.sat | 0.43 | 126 | 0.193 | -0.18 | 260 | 0.595 |
| crit.10.sat | 0.49 | 112 | 0.129 | -0.064 | 234 | 0.86 |
| crit.2.sat | 0.44 | 124 | 0.183 | -0.2 | 264 | 0.558 |
| crit.5.sat | 0.46 | 118 | 0.154 | -0.15 | 254 | 0.654 |
| crit.mean.sat | 0.34 | 146 | 0.313 | 0.018 | 216 | 0.968 |
| crit.med.sat | 0.24 | 168 | 0.485 | -0.13 | 248 | 0.714 |
| crit.min.sat | 0.53 | 102.7332 | 0.0913 | -0.091 | 240 | 0.797 |
| crit.pct.50 | 0.55 | 98 | 0.0816 | -0.27 | 280 | 0.418 |
| crit.pct.60 | 0.53 | 104 | 0.1 | -0.15 | 252 | 0.673 |
| crit.pct.70 | 0.32 | 150 | 0.341 | -0.15 | 254 | 0.654 |
| grow.1.sat | 0.47 | 116 | 0.146 | -0.29 | 284 | 0.386 |
| grow.10.sat | 0.38 | 136 | 0.248 | -0.045 | 230 | 0.903 |
| grow.2.sat | 0.52 | 106 | 0.107 | -0.29 | 284 | 0.386 |
| grow.5.sat | 0.5 | 109.7491 | 0.116 | -0.082 | 238 | 0.818 |
| grow.mean.sat | 0.25 | 164 | 0.451 | 0.34 | 146 | 0.313 |
| grow.med.sat | 0.027 | 214 | 0.946 | 0.15 | 188 | 0.673 |
| grow.min.sat | 0.53 | 102.7332 | 0.0913 | -0.073 | 236 | 0.839 |
| grow.pct.50 | 0.48 | 114 | 0.137 | -0.35 | 296 | 0.299 |
| grow.pct.60 | 0.51 | 108 | 0.114 | -0.26 | 278 | 0.435 |
| grow.pct.70 | 0.17 | 182 | 0.614 | 0.018 | 216 | 0.968 |

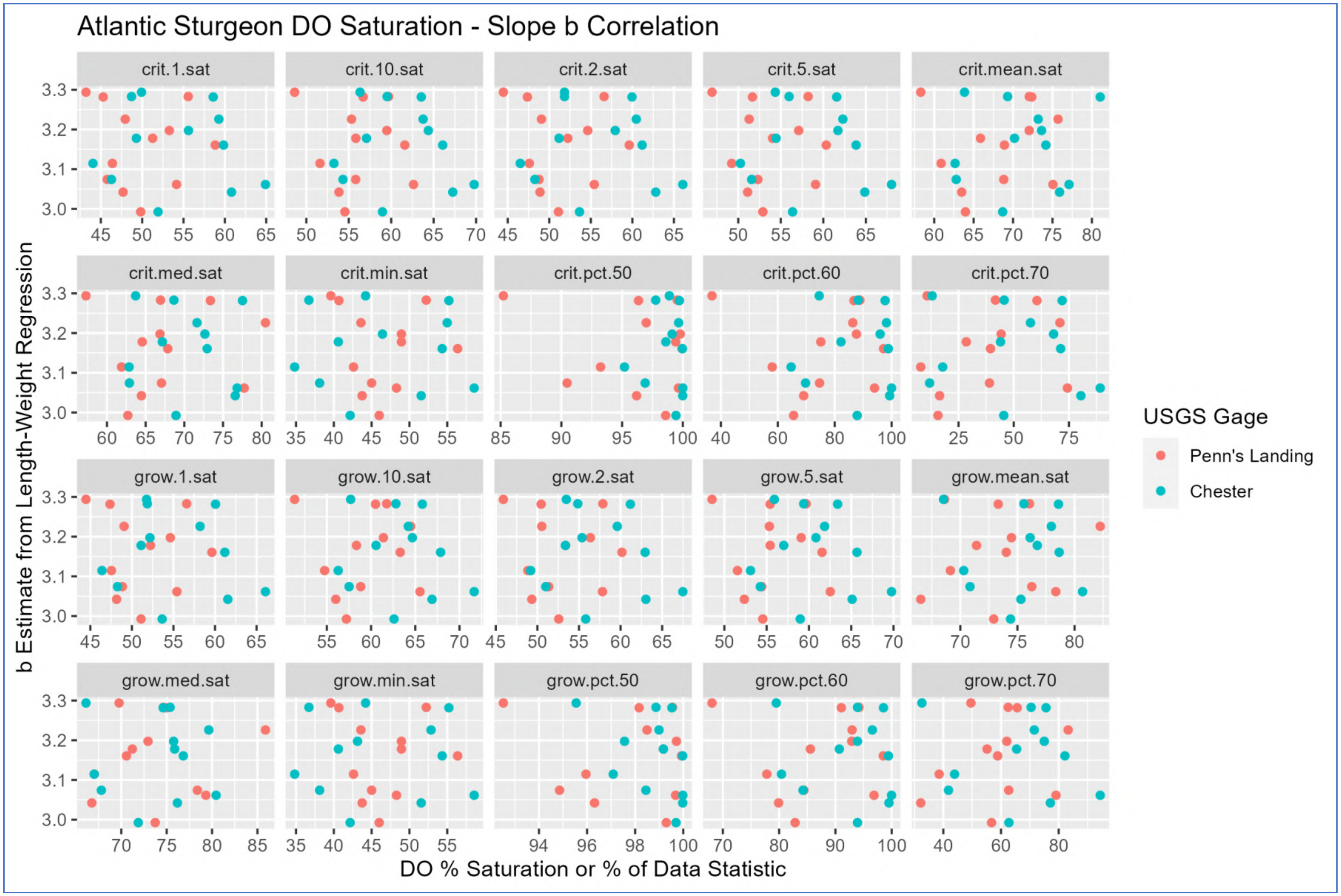


**Figure 21.) Correlation for Delaware River seasonal DO statistics and YOY Atlantic sturgeon L-W regression slope parameter *b*, 2009-2022**

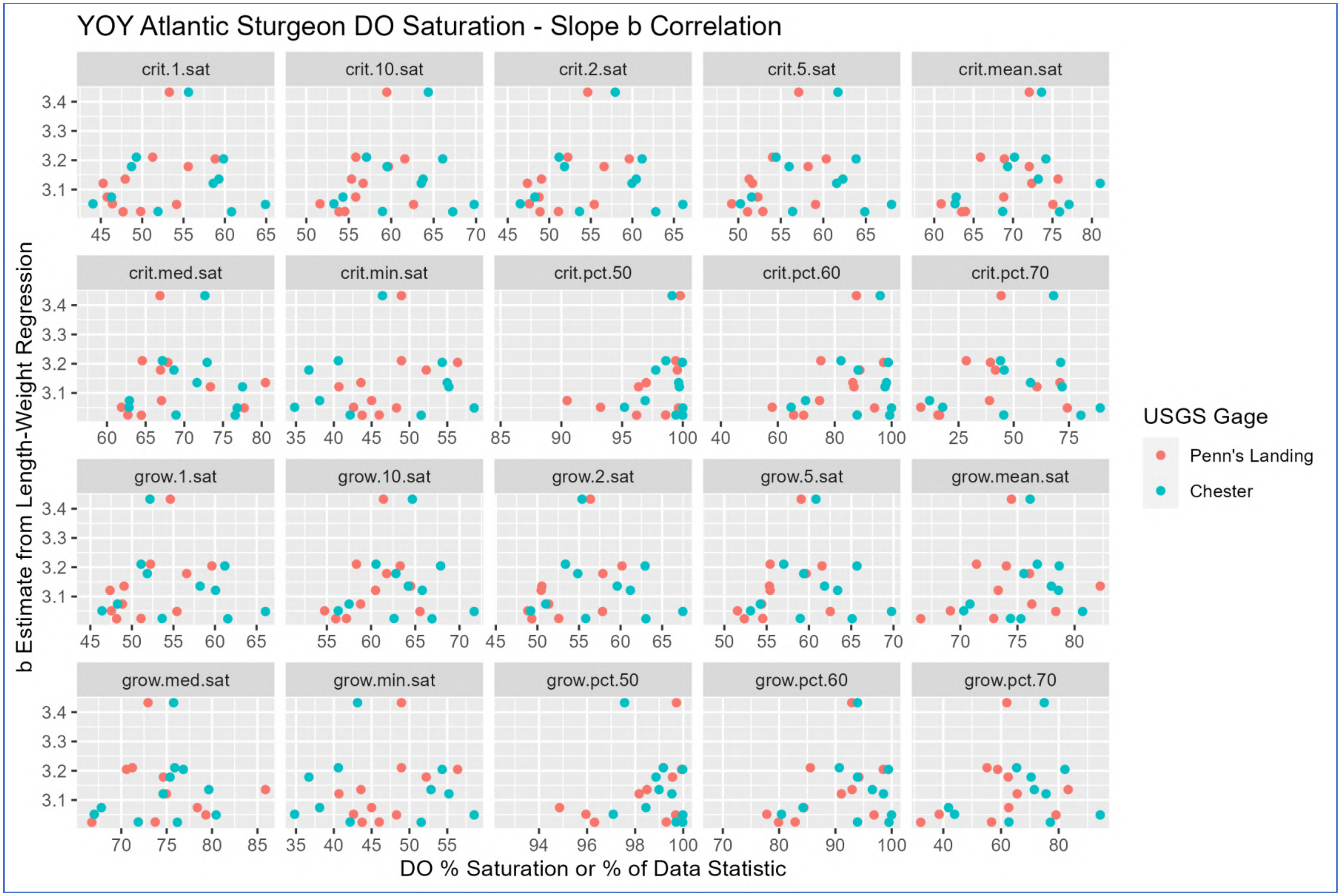


**Figure 22.) Correlation for Delaware River seasonal DO statistics and YOY Atlantic sturgeon L-W regression slope parameter *b*, 2009-2022**

**9.) Many growth and condition characteristics of the Delaware River Atlantic sturgeon population are similar or compare favorably to those for Atlantic sturgeon collected in the Hudson River, which typically has higher DO levels than the Delaware River and is considered attaining water quality standards for DO.**

PWD compiled and analyzed more than 5,000 recent juvenile sturgeon collection records from the New York Hudson River. The Hudson River supports reproduction of both Atlantic and shortnose sturgeons. The Hudson River stock has been described as the largest extant group of Atlantic sturgeon, not only in the New York Bight Distinct Population Segment, but in the entire U.S. PWD obtained Hudson River sturgeon data from the New York State Department of Environmental Conservation (NYSDEC) Gillnet Juvenile Relative Abundance Survey (2003-2022) and Hudson River Generators Fall Shoals Survey (FSS) Annual Reports from 2001-2020. CPUE from the NYSDEC relative abundance survey has varied over the past two decades (Figure 22). DO levels measured in the Hudson River at Haverstraw and Newburgh Bays are consistently greater than 5mg/L (Sweka *et al.* 2007) and have remained relatively constant over the past 40-50 years (TI 1976).

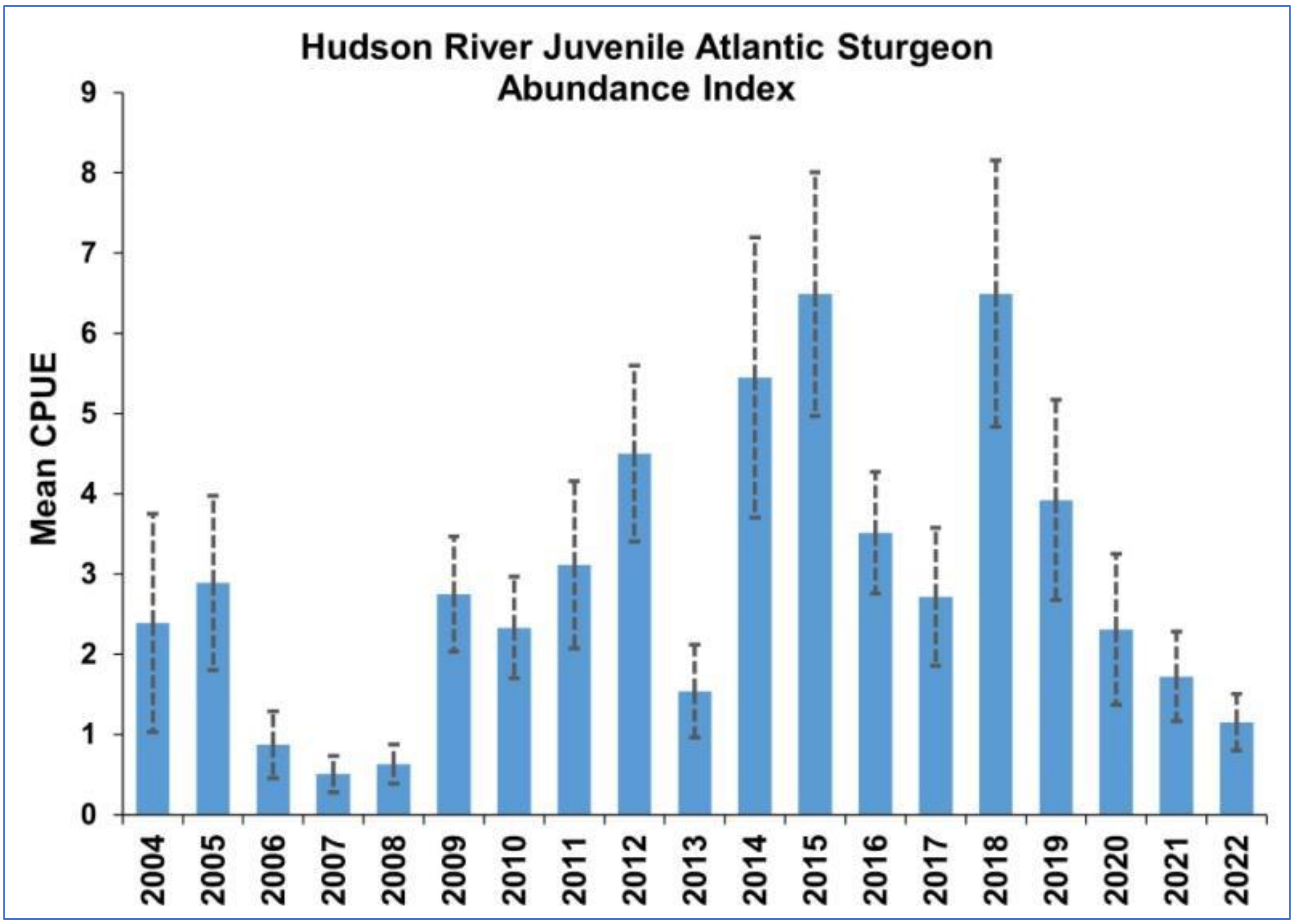


**Figure 22.) NYSDEC Hudson River Juvenile Atlantic Sturgeon Abundance index 2004-2022. (https://dec.ny.gov/nature/animals-fish-plants/hudson-delaware-marine-fisheries/atlantic-sturgeon)**

There was a significant difference in fish growth observed by comparing the slope *b* estimates from log(weight)-log(length) linear regression models for Delaware and Hudson River fish, with the Delaware River having a steeper slope when all fish from both river systems were included in the analysis (p = 0.001, Figure 23, Table 17). The difference in slopes was small, but with such large sample sizes (11,083 fish total) even small differences can be detected. As the Hudson River program primarily sampled juvenile sturgeons greater than ~500 mm, PWD also compared the growth patterns of only yearling or larger fish (> 500 mm) between the two systems, finding no significant differences (Figure 24, Table 18).

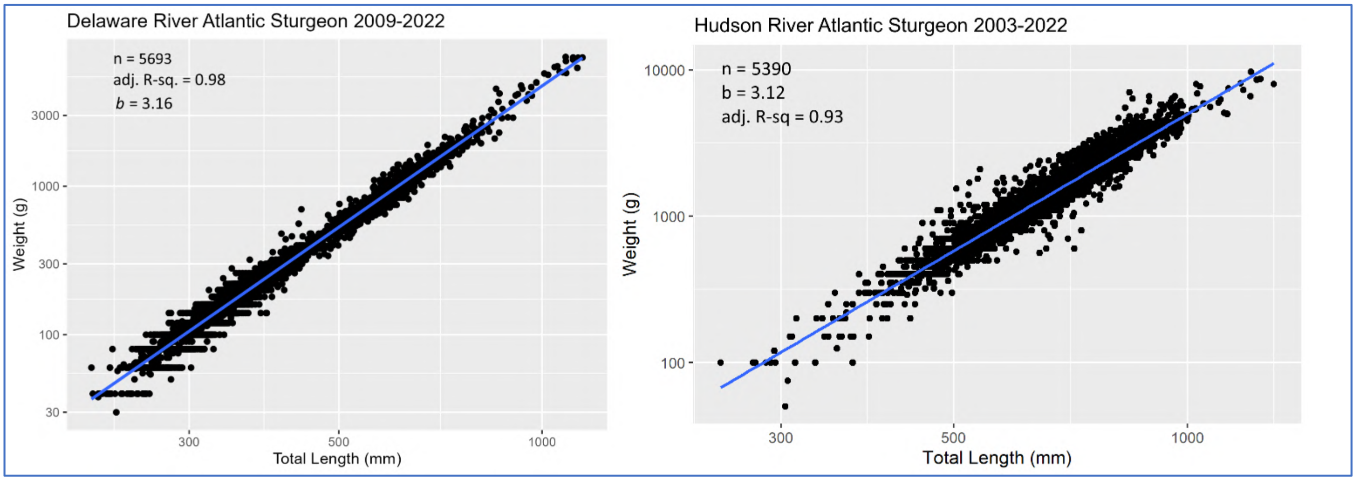


**Figure 23.) Weight-Length Relationships for Atlantic sturgeon collected from the Delaware River (n = 5693) and Hudson River (n = 5390).**

**Table 17.) ANOVA results for L-W regression slope *b* estimates for Delaware and Hudson River Atlantic sturgeon using all fish in data set**

| Effect | DFn | DFd | F Statistic | p-value | p<.05 | Effect size (GES) |
|---|---|---|---|---|---|---|
| log.tl | 1 | 10972 | 288256.4 | 0 | * | 0.963 |
| river | 1 | 10972 | 380.115 | 2.99E-83 | * | 3.30E-02 |
| log.tl:river | 1 | 10972 | 10.443 | 0.001 | * | 0.000951 |

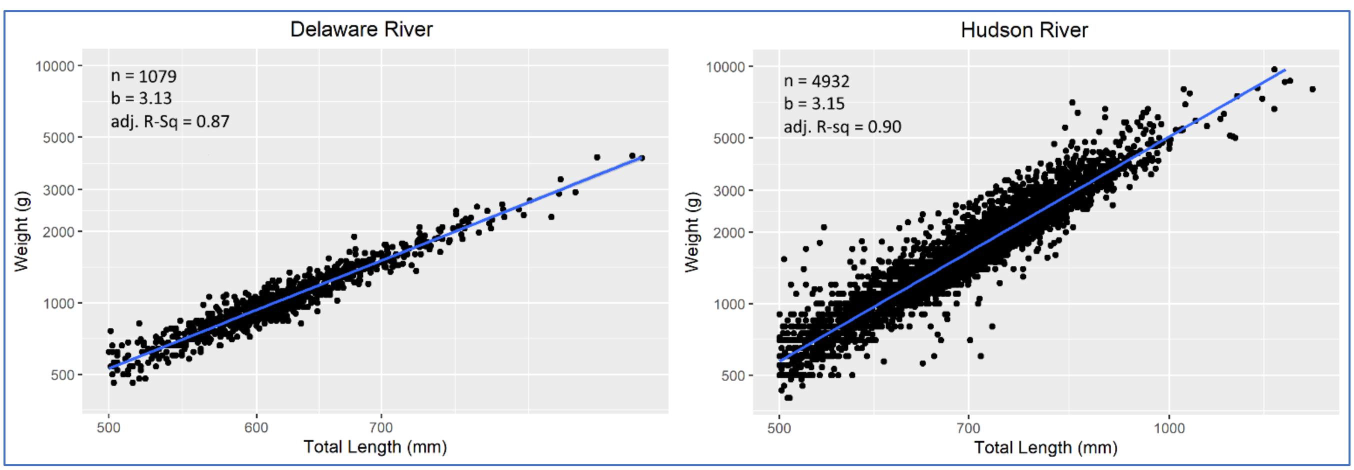


**Figure 24.) Weight-Length Relationships for Yearling (500 mm) or larger Atlantic sturgeon collected from the Delaware River (n = 1079) and Hudson River (n = 4932).**

**Table 18.) ANOVA results for L-W regression slope *b* estimates for yearling (>500mm) Delaware and Hudson River Atlantic sturgeon**

| Effect | DFn | DFd | F Statistic | p-value | p<.05 | Effect size (GES) |
|---|---|---|---|---|---|---|
| log.tl | 1 | 5951 | 57876.7 | 0 | * | 0.907 |
| river | 1 | 5951 | 238.42 | 9.08E-53 | * | 0.039 |
| log.tl:river | 1 | 5951 | 3.156 | 0.076 | | 0.00053 |

**Table 19.) ANOVA results for L-W regression slope b estimates for YOY Delaware and Hudson River Atlantic sturgeon**

| Effect | DFn | DFd | F Statistic | p-value | p<.05 | Effect size (GES) |
|---|---|---|---|---|---|---|
| log.tl | 1 | 5001 | 49282.47 | 0 | * | 0.908 |
| river | 1 | 5001 | 148.065 | 1.36E-33 | * | 2.90E-02 |
| log.tl:river | 1 | 5001 | 0.48 | 0.488 | | 9.60E-05 |

When compared on an annual basis for all size fish, The Delaware River had significantly higher slope parameter b estimate values than the Hudson River (Wilcox test p= 0.004, Table 20, Figure 25). The test for YOY fish did not find a statistically significant difference between the Delaware and Hudson Rivers (Table 21 Figure 25)

**Table 20.) Summary of Wilcox test for L-W regression slope *b* parameter estimates for Delaware and Hudson River Atlantic sturgeon using all fish in the data set**

| estimate | group1 | group2 | n1 | n2 | statistic | p | conf.low | conf.high | method | alternative |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.13 | Delaware | Hudson | 12 | 20 | 193 | 0.004 | 0.04 | 0.21 | Wilcoxon | two.sided |

**Table 21.) Summary of Wilcox test for L-W regression slope *b* parameter estimates for YOY Atlantic sturgeon from the Delaware and Hudson Rivers**

| estimate | group1 | group2 | n1 | n2 | statistic | P | conf.low | conf.high | method | alternative |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.09 | Delaware | Hudson | 12 | 20 | 165 | 0.08 | -0.02 | 0.22 | Wilcoxon | two.sided |

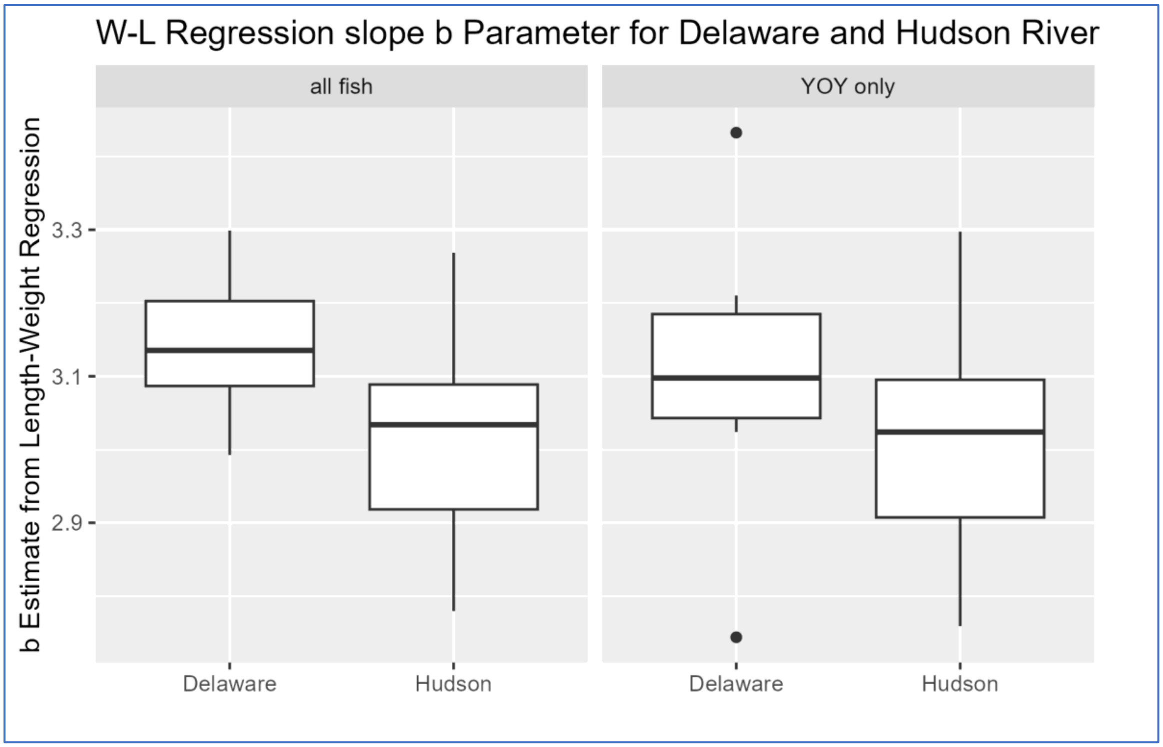


**Figure 25.) Comparison of annual L-W regression slope parameter *b* estimates from Delaware and Hudson Rivers.**

<u>**Summary**</u>

**PWD compiled and evaluated several lines of evidence for the strength of the association between hypoxia and measures of Atlantic sturgeon condition and health in the Delaware River and made the following conclusions:**

- Delaware River Atlantic sturgeon collected 2009-2022 showed no evidence of reduced growth (size) that would indicate poor health. Observed length for each YOY cohort was in the range of expected values, consistent with the Delaware River's latitude and other spawning populations on the Atlantic coast.
- Inferred growth rates based on estimated spawning date are in the expected range and are corroborated by observed mark-recapture empirical growth rates.
- YOY Atlantic sturgeon consistently attain lengths of more than 300mm (345mm or 13.5 inches on average) due to apparent rapid growth during the summer juvenile development period. This level of growth was observed every year 2009-2022 for which there was adequate sampling effort. Mean length of YOY was not correlated with any statistics of DO conditions.
- The full data set, all YOY, and 23 of 25 annual data sets had positive allometric growth ($b > 3$). The annual slope parameter *b* estimates (n = 12) were not significantly correlated with DO conditions.
- Despite performing 560 separate correlation tests across a large range of observed DO statistics and sturgeon metrics, PWD found no statistically significant evidence for correlation between DO and sturgeon growth or condition.
- Measures of growth and condition are similar between the Delaware and Hudson Rivers. The Hudson River has favorable DO and exhibits interannual variability in sturgeon abundance.

Based on the strength of these six lines of evidence and the lack of any substantial evidence to the contrary, PWD concludes that hypoxia was not an important stressor to Atlantic sturgeon in 2009-2022 as evaluated with the best available scientific data. Existing DO levels supported sturgeon propagation and growth.

## References

Atlantic States Marine Fisheries Commission (2017). Atlantic Sturgeon Benchmark Stock Assessment and Peer Review Report. Washington, DC, USA.

Baker, M. A., Ingram, E. C., Higginbotham, D. L., Irwin, B. J., & Fox, A. G. (2023). Refining capture-recapture recruitment estimation methods for Atlantic sturgeon. Endangered Species Research, 51, 203-214.

Balazik, M. T., & Musick, J. A. (2015). Dual annual spawning races in Atlantic sturgeon. PLoS One, 10(5), e0128234.

Blackwell, B. G., M. L. Brown, and D. W. Willis. (2000). Relative weight (Wr) status and current use in fisheries assessment and management. Reviews in Fisheries Science 8:1–44

Brown, J. J., & Murphy, G. W. (2010). Atlantic sturgeon vessel-strike mortalities in the Delaware Estuary. Fisheries, 35(2), 72-83.

Brundage, H.M. and O'Herron, J.C. (2014). Report of a Study to Determine the Feasibility of Relocating Sturgeons out of the Blasting Area for the Delaware River Main Channel Deepening Project. Environmental Research and Consulting, Inc. (ERC) Kennett Square, PA.

EPA. (2023a) Technical Support Document: Proposed Rule to Establish Protective Water Quality Standards for Aquatic Life in the Delaware River. U.S. Environmental Protection Agency. Washington, D.C. 72p.

EPA. (2023b). DelawareRiverDO. Code supporting development of dissolved oxygen criteria for the Delaware River by the US Environmental Protection Agency. https://github.com/USEPA/DelawareRiverDO

ERC. (2016). Report of Sturgeon Monitoring and Protection during Rock Removal for the Delaware River Main Channel Deepening Project, December 2015-March 2016. Environmental Research and Consulting, Inc. (ERC) Kennett Square, PA.

ERC. (2017). Report of Sturgeon Monitoring and Protection during Rock Removal for the Delaware River Main Channel Deepening Project, November 2016-March 2017. Environmental Research and Consulting, Inc. (ERC) Kennett Square, PA.

ERC. (2018). Report of Sturgeon Monitoring and Protection during Rock Removal for the Delaware River Main Channel Deepening Project, November 2017-February 2018. Environmental Research and Consulting, Inc. (ERC) Kennett Square, PA.

ERC. (2019). Report of Sturgeon Monitoring and Protection during Rock Removal for the Delaware River Main Channel Deepening Project, January-March 2019. Environmental Research and Consulting, Inc. (ERC) Kennett Square, PA.

Fisher, M. (2011). Atlantic Sturgeon Final Report. State Wildlife Grant Project T-4-1 Period covered: October 1, 2006 to October 15, 2010. Delaware Division of Fish and Wildlife. Smyrna, DE.

Fisher, M. (2015). Conservation and Recovery of Juvenile Sturgeons in the Delaware River. Final Report. Section 6 Species Recovery Grant No: NAI0NMF4720030. Delaware Division of Fish and Wildlife. Dover, DE.

Fox, D., Hale E., and Sweka J. (2020). Examination of Atlantic sturgeon vessel strikes in the Delaware River Estuary. Final Report. NOAA-NMFS Award No. NA16NMF4720357. Final Report. 36 p.

Hale, E. A., Park, I. A., Fisher, M. T., Wong, R. A., Stangl, M. J., & Clark, J. H. (2016). Abundance estimate for and habitat use by early juvenile Atlantic sturgeon within the Delaware River Estuary. *Transactions of the American Fisheries Society*, 145(6), 1193-1201.

Hilborn, R. and C. J. Walters. (2001). Quantitative Fisheries Stock Assessment: Choice, Dynamics, & Uncertainty. 2nd edition, Chapman and Hall, New York, 570 pp

Kassambara, A. (2023). rstatix: Pipe-Friendly Framework for Basic Statistical Tests. R package version 0.7.2. https://CRAN.R-project.org/package=rstatix

Le Cren, E. D. (1951). The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (Perca flavescens). Journal of Animal Ecology. 20:201–219.

Moberg, T., & DeLucia, M. (2016). Potential impacts of dissolved oxygen, salinity, and flow on the successful recruitment of Atlantic Sturgeon in the Delaware River. The Nature Conservancy, Philadelphia.

Markin, E. L., & Secor, D. H. (2020). Growth of juvenile Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) in response to dual-season spawning and latitudinal thermal regimes. Fishery Bulletin, 118(1), 74-87.

National Marine Fisheries Service. (2022). New York Bight Distinct Population Segment of Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*), 5-Year Review: Summary and Evaluation. February 17, 2022. https://www.fisheries.noaa.gov/resource/document/new-york-bight-distinct-population-segment-atlantic-sturgeon-5-year-review

Niklitschek, E.J. (2001). Bioenergetics modeling and assessment of suitable habitat for juvenile Atlantic and shortnose sturgeons (*Acipenser oxyrhinchus* and *A. brevirostrum*) in the Chesapeake Bay.

Niklitschek, E., and D. Secor. (2009). Dissolved oxygen, temperature and salinity effects on the ecophysiology and survival of juvenile Atlantic sturgeon in estuarine waters: I. Laboratory results. Journal of Experimental Marine Biology and Ecology 381:S150-S160

Ogle, D. (2013) fishR Vignette - Length-Weight Relationships. Northland College. http://derekogle.com/fishR/examples/oldFishRVignettes/LengthWeight.pdf

Ogle, D. (2022). FSAmisc: Miscellaneous functions for simple fisheries stock assessment methods. R package version 0.0.3. https://github.com/droglenc/FSAmisc

Park, I. (2020). Conservation and Recovery of Juvenile Sturgeons in the Delaware River. Final Report. Section 6 Species Recovery Grant No: NA16NMF4720072. Delaware Division of Fish and Wildlife. Dover, DE.

PWD (2018). February 9, 2018 Letter to John Yagecic, DRBC, regarding DRBC/ANS draft *Methodology for Evaluating Dissolved Oxygen Requirements of Species in the Delaware Estuary.* 3 pgs.

PWD. (2020). August 7, 2020 Letter to John Yagecic, DRBC, PWD comments on DRBC/Kleinfelder draft report *Nitrogen Reduction Cost Estimation Study: Plant Specific Cost Estimates.* 4pgs.

PWD. (2021). November 30, 2021 Letter to Namsoo Suk, DRBC, PWD Suggestions for Technical Documentation of Hydrodynamic Model Validation. 15 pgs.

PWD. (2022a). February 14, 2022 Letter to Thomas Amidon, DRBC, PWD comments on DRBC draft report *Modeling Eutrophication Processes in the Delaware Estuary: Three-Dimensional Hydrodynamics Model for the Delaware Estuary.* 18 pgs.

PWD. (2022b). March 28, 2022 Letter to Jake Bransky, DRBC, PWD Comments on DRBC draft report *Linking Aquatic Life Uses with Dissolved Oxygen Conditions in the Delaware River Estuary.* 24 pgs.

PWD. (2022c). November 27, 2022 Letter to Namsoo Suk, DRBC, PWD comments on DRBC draft report *Analysis of Attainability: Improving Dissolved Oxygen and Aquatic Life Uses in the Delaware River Estuary.* 42 pgs.

PWD. (2022d). December 16, 2022 Letter to Thomas Amidon, DRBC, PWD comments on DRBC draft report *Linking Aquatic Life Uses with Dissolved Oxygen Conditions in the Delaware River Estuary.* 8pgs.

PWD. (2023a). January 19, 2023 Letter to Radhika Fox, et al., EPA, Concerning EPA Administrator's Determination and transmitting previous comments on DRBC draft report *Analysis of Attainability: Improving Dissolved Oxygen and Aquatic Life Uses in the Delaware River Estuary*, as well as related technical reports prepared by DRBC staff pursuant to DRBC Resolution 2017-04.

PWD. (2023b). May 30, 2023 Letter to John Yagecic, DRBC, PWD comments on DRBC/Kleinfelder draft report *Nitrogen Reduction Cost Estimation Study Addendum 2 Technical Memorandum.* 50pgs.

R Core Team (2023). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Schueller, P., & Peterson, D. L. (2010). Abundance and recruitment of juvenile Atlantic sturgeon in the Altamaha River, Georgia. Transactions of the American Fisheries Society, 139(5), 1526-1535.

Shirey, C.A., Martin, A.C., Stetzar, E.J. (1998). Final Report. Abundance of Sub-adult Atlantic Sturgeon and Areas of Concentration Within the Lower Delaware River Grant No. NA66F60326 Delaware Division of Fish and Wildlife. Dover, DE.

Shirey, C.A., Martin, A.C., Stetzar, E.J. (1999). Atlantic sturgeon abundance and movement in the lower Delaware River. Final Report. NOAA Project No. AGC-9N. Grant No. A86FA0315. Delaware Division of Fish and Wildlife. Dover, DE.

Sweka, J.A., Mohler, J., Millard, M.J., Kehler, T., Kahnle, A., Hattala, K., Kenney, G. and Higgs, A. (2007). Juvenile Atlantic sturgeon habitat use in Newburgh and Haverstraw Bays of the Hudson River: Implications for population monitoring. *North American Journal of Fisheries Management*, *27*(4), pp.1058-1067.

Takacs, M. K. (2022). Abundance and growth of juvenile Atlantic Sturgeon in the Edisto River, SC.

Texas Instruments, Inc. (1976). Hudson River Ecological Study in the area of Indian Point thermal effects report. Report for Consolidated Edison Company. New York, USA.

White, S. L., Kazyak, D. C., Darden, T. L., Farrae, D. J., Lubinski, B. A., Johnson, R. L., ... & Wirgin, I. I. (2021). Establishment of a microsatellite genetic baseline for North American Atlantic sturgeon (Acipenser o. oxyrhinchus) and range-wide analysis of population genetics. *Conservation Genetics*, *22*, 977-992.

White, S. L., Johnson, R. L., Lubinski, B. A., Eackles, M. S., & Kazyak, D. C. (2023). *Genetic population assignments of Atlantic sturgeon provided to National Marine Fisheries Service, 2022* (No. 2023-1054). US Geological Survey.

Wirgin, I., Grunwald, C., Stabile, J., & Waldman, J. (2007). Genetic evidence for relict Atlantic sturgeon stocks along the mid-Atlantic coast of the USA. *North American Journal of Fisheries Management*, *27*(4), 1214-1229.

Wirgin, I. and R.C. Chambers. (2018). An Experimental Approach to Evaluate the Effects of Low Dissolved Oxygen Acting Singly and in Binary Combination with Toxicants on Larval Atlantic Sturgeon, *Acipenser oxyrinchus oxyrinchus*. 46 p.

## Appendix A: Correlation Analyses for Observed DO Conditions and Atlantic Sturgeon Measures of Growth and Condition

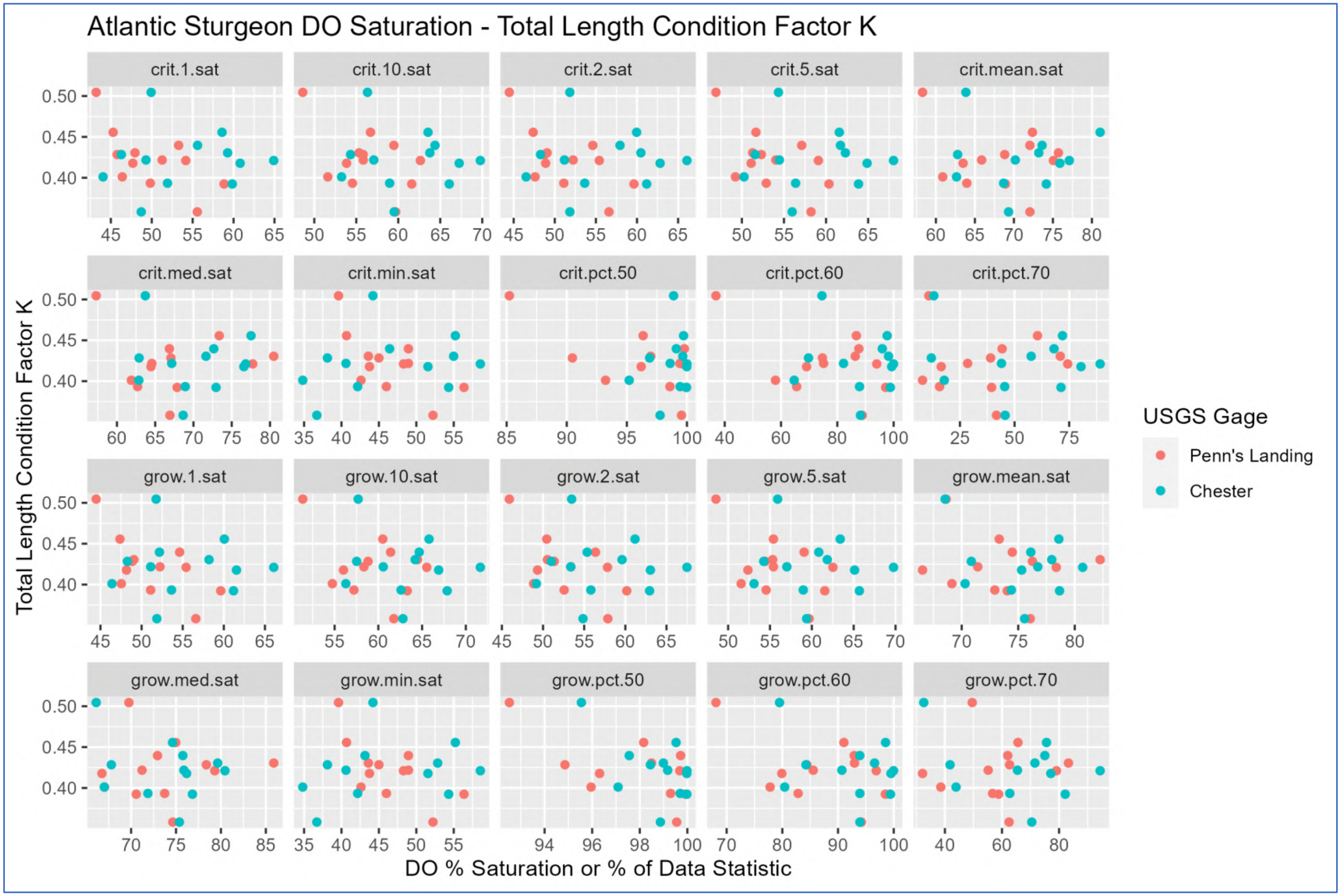


**Figure 1.) Correlation for Delaware River seasonal DO statistics and Atlantic sturgeon total length condition factor K, 2009-2022**

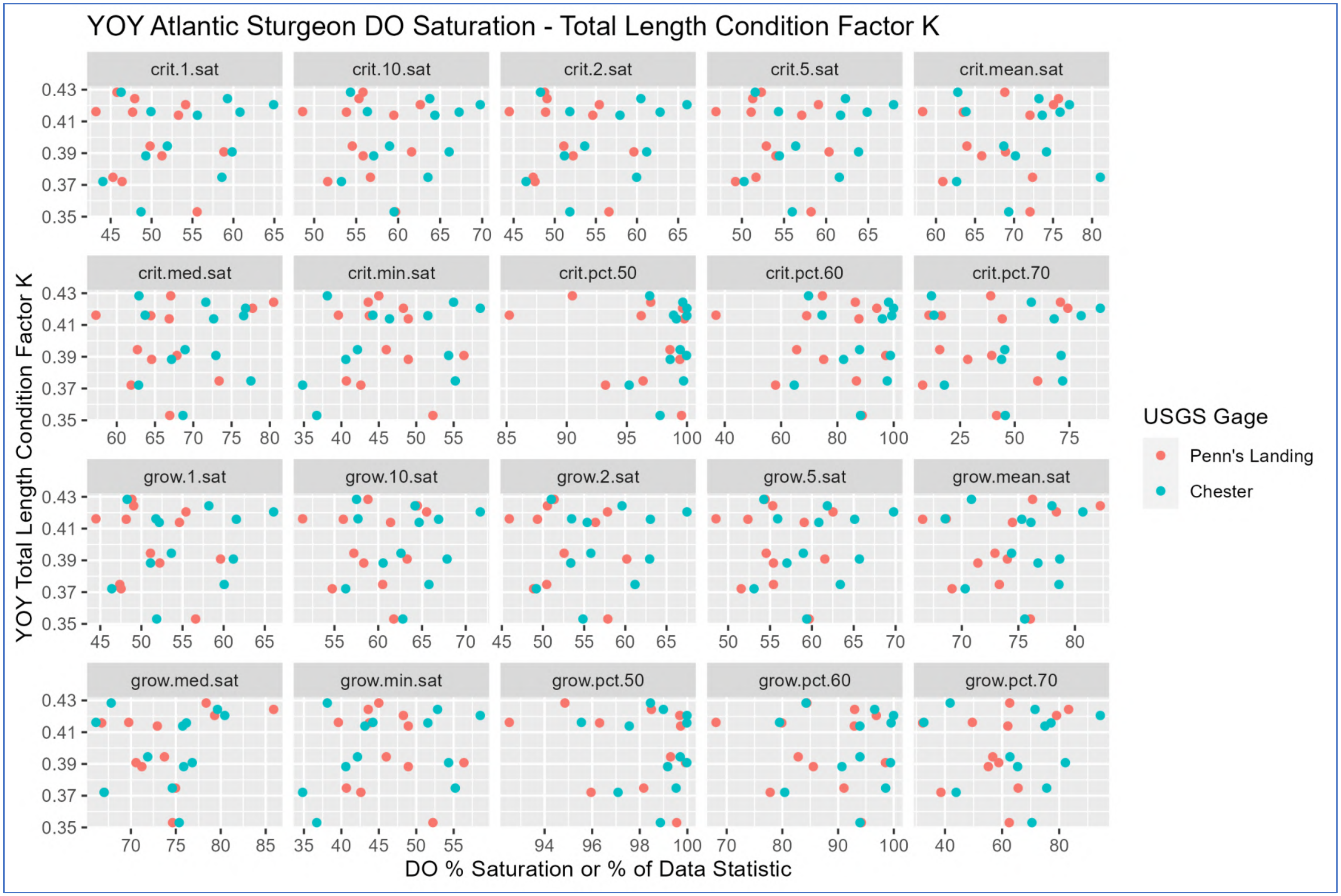


**Figure 2.) Correlation for Delaware River seasonal DO statistics and YOY Atlantic sturgeon total length condition factor K, 2009-2022**

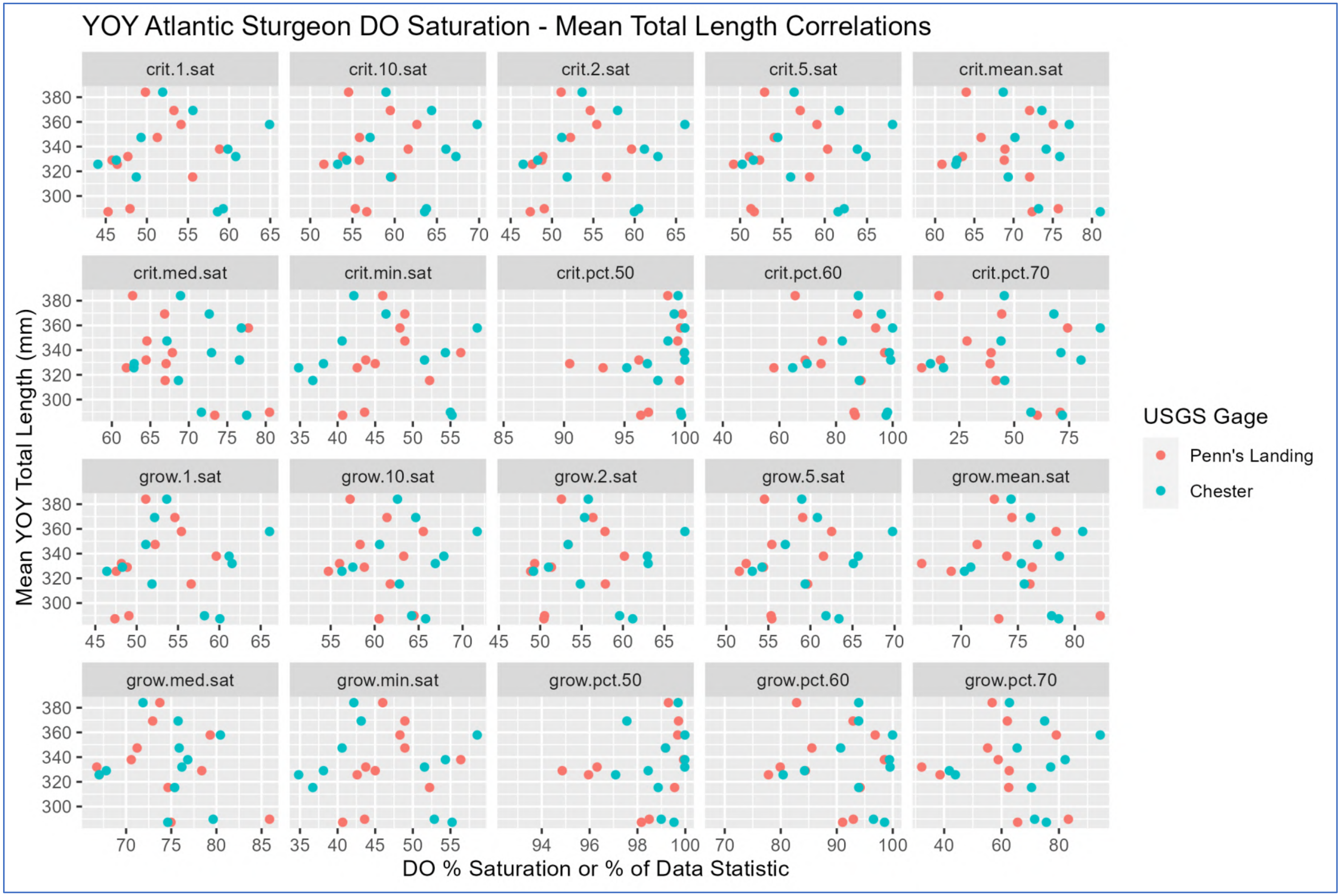


**Figure 3.) Correlation for Delaware River seasonal DO statistics and YOY Atlantic sturgeon mean total length, 2009-2022**

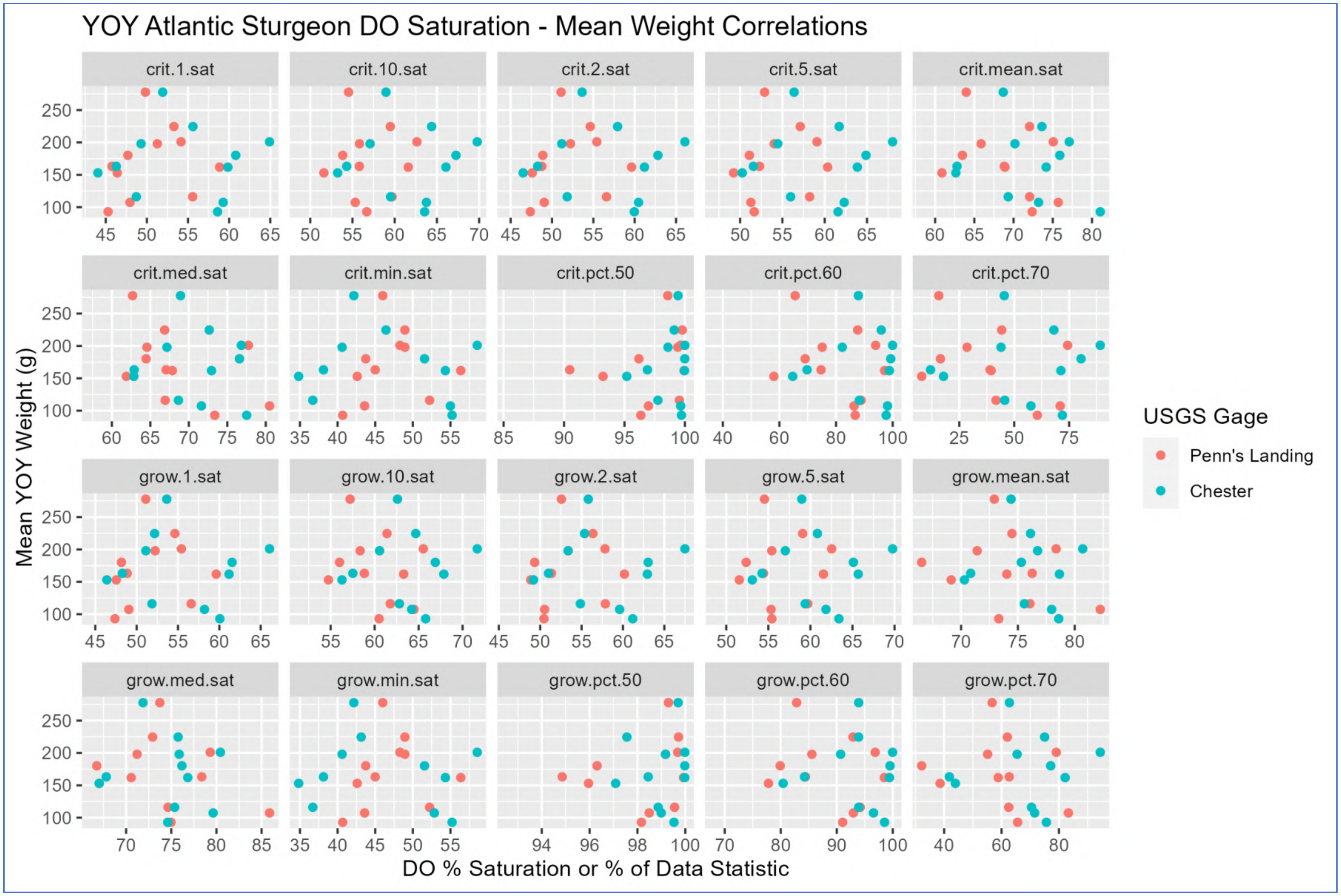


**Figure 4.) Correlation for Delaware River seasonal DO statistics and YOY Atlantic sturgeon mean weight, 2009-2022**

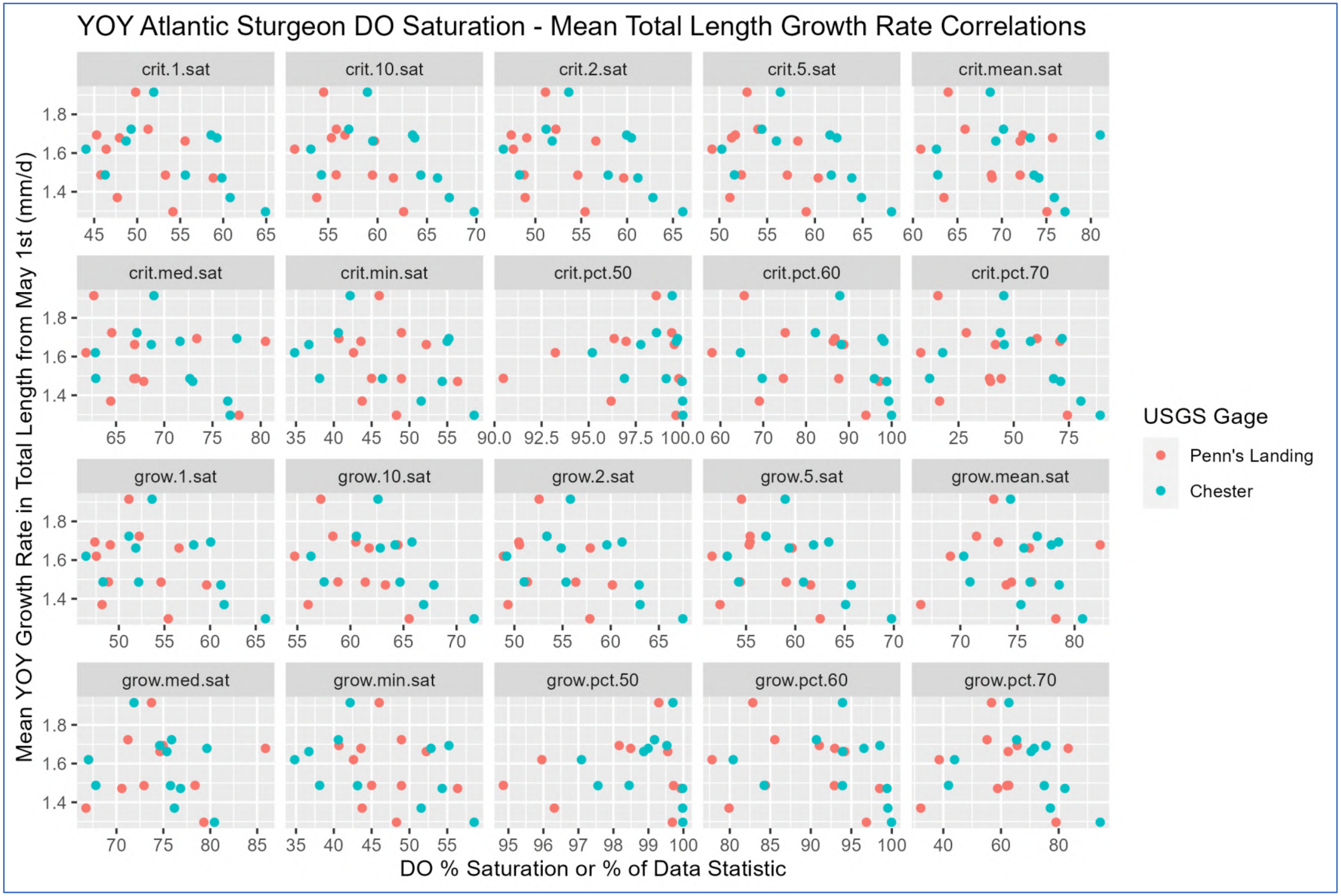


**Figure 5.) Correlation for Delaware River seasonal DO statistics and YOY Atlantic sturgeon mean growth in length from May 1st, 2009-2022**

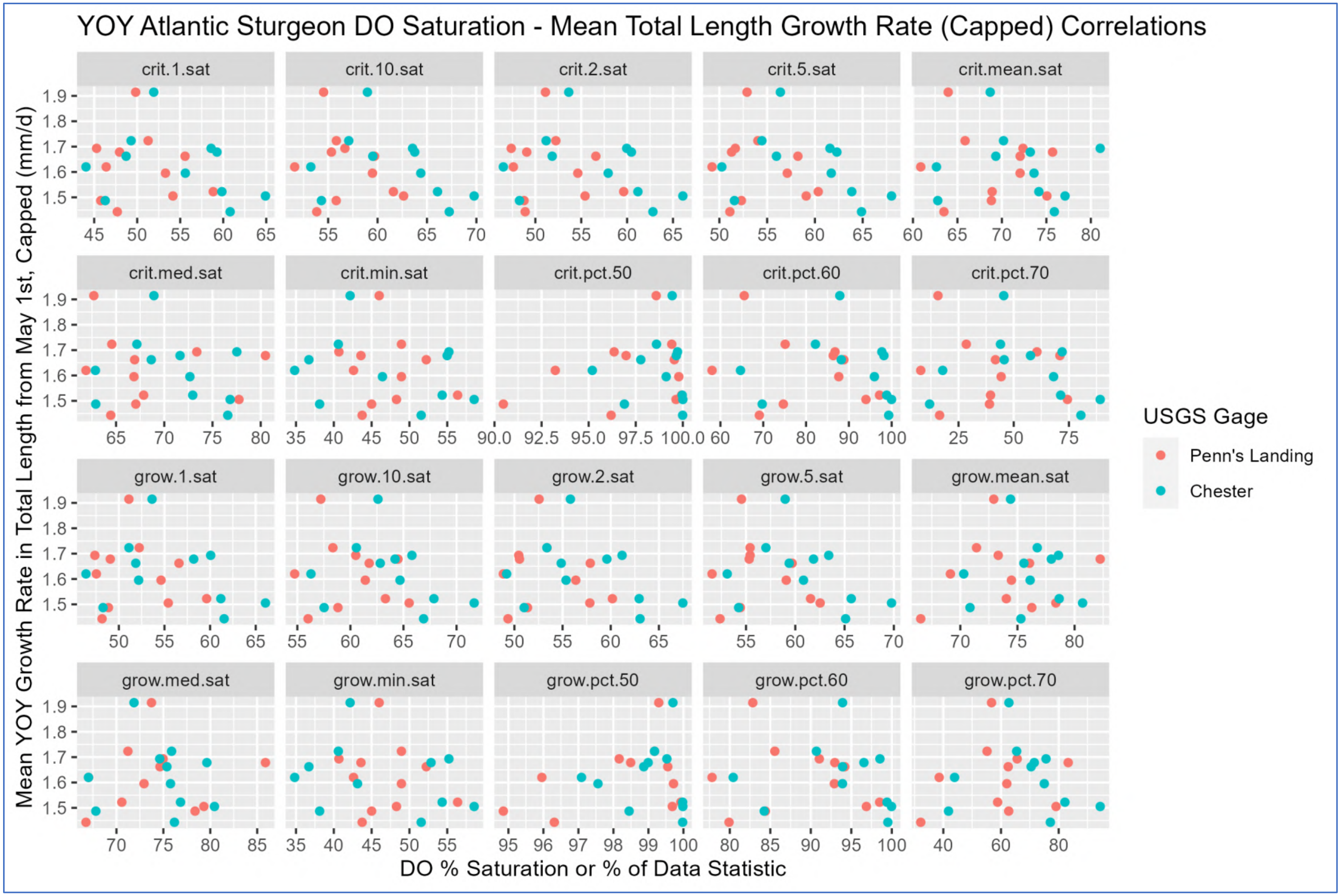


**Figure 6.) Correlation for Delaware River seasonal DO statistics and YOY Atlantic sturgeon mean growth in length from May 1st, "capped" assuming winter growth was complete by Jan 1st, 2009-2022**

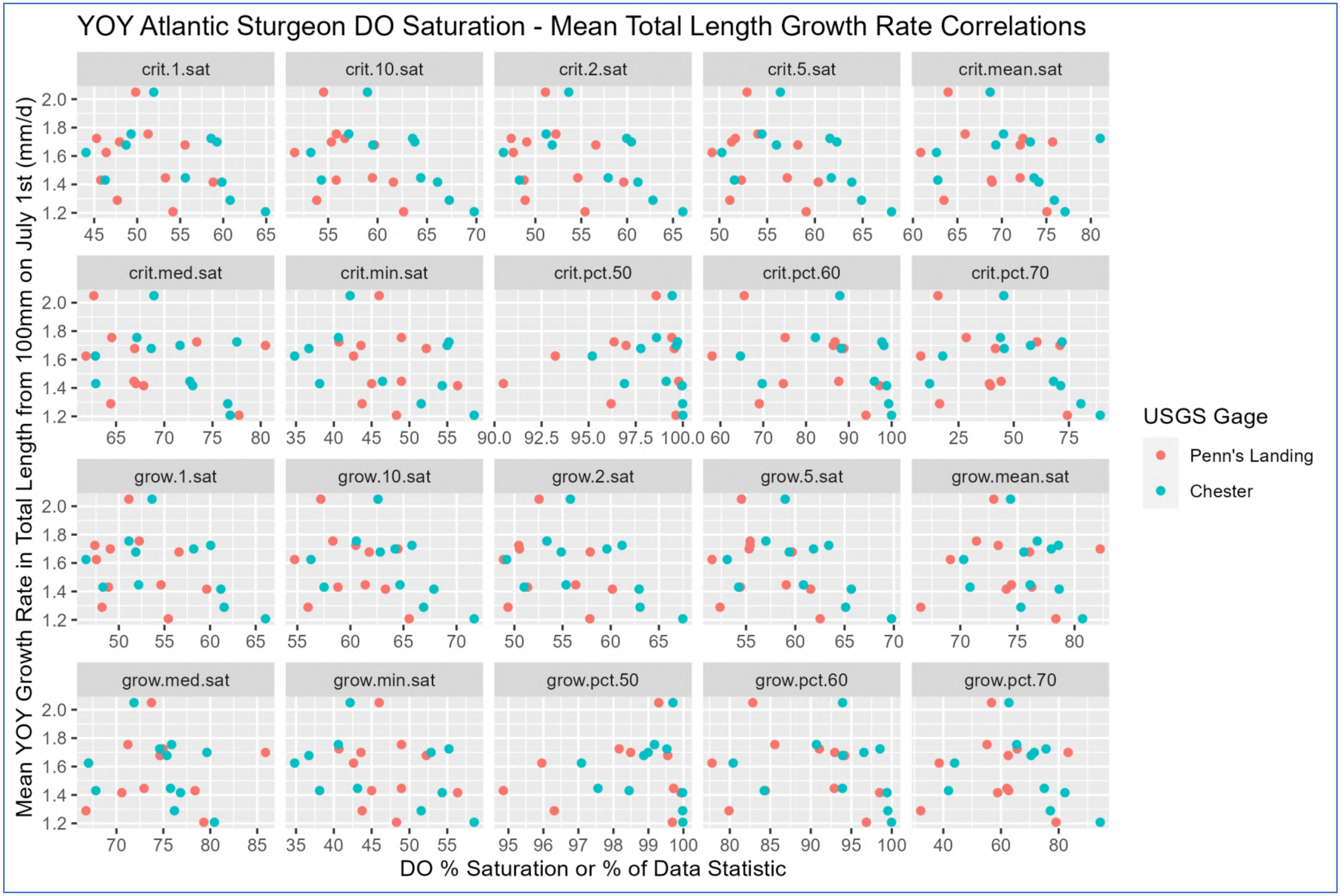


**Figure 7.) Correlation for Delaware River seasonal DO statistics and YOY Atlantic sturgeon mean growth in length assuming fish were 100mm on July 1st, 2009-2022**

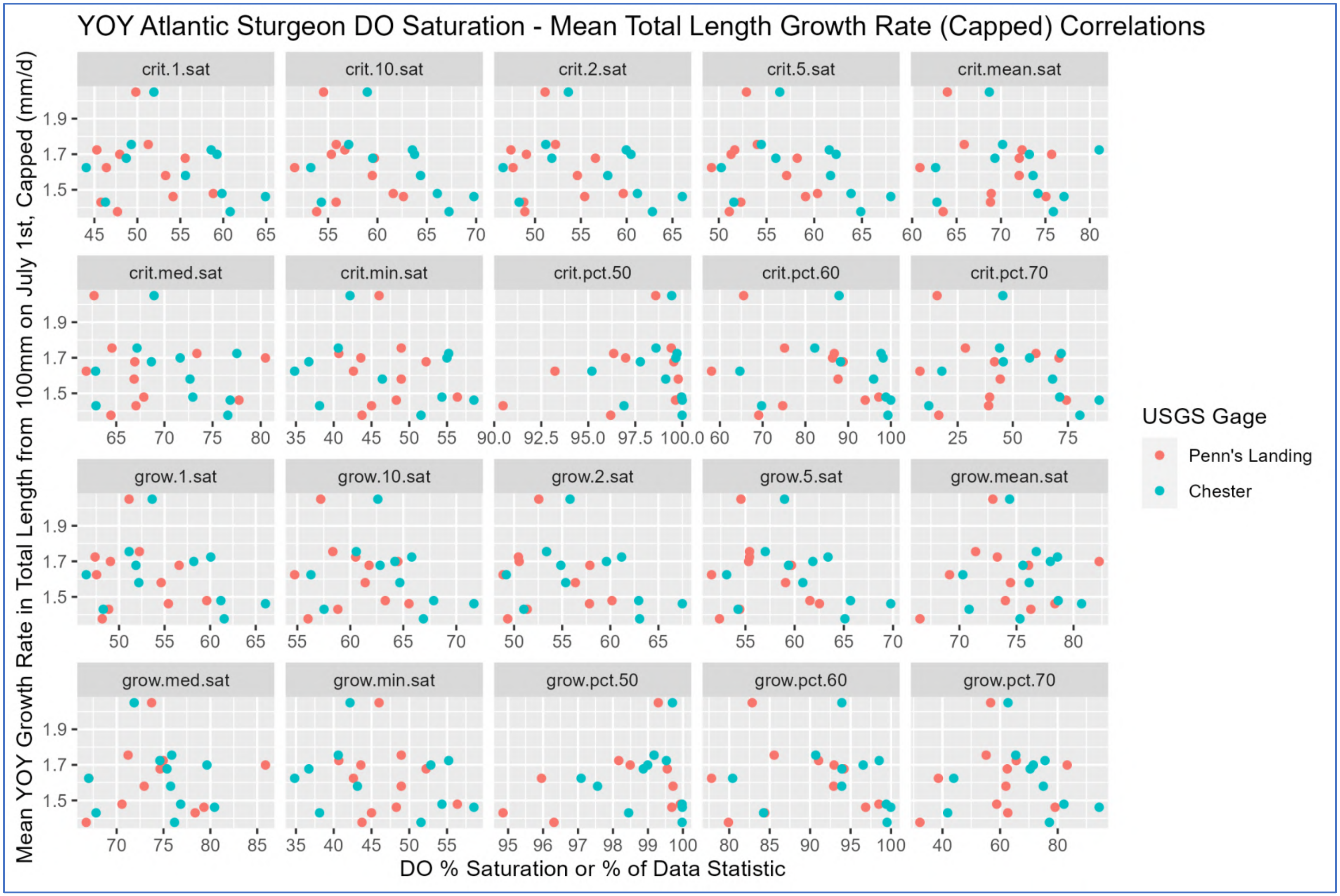


**Figure 8.) Correlation for Delaware River seasonal DO statistics and YOY Atlantic sturgeon mean growth in length assuming fish were 100mm on July 1st, "capped" assuming winter growth was complete by Jan 1st, 2009-2022**

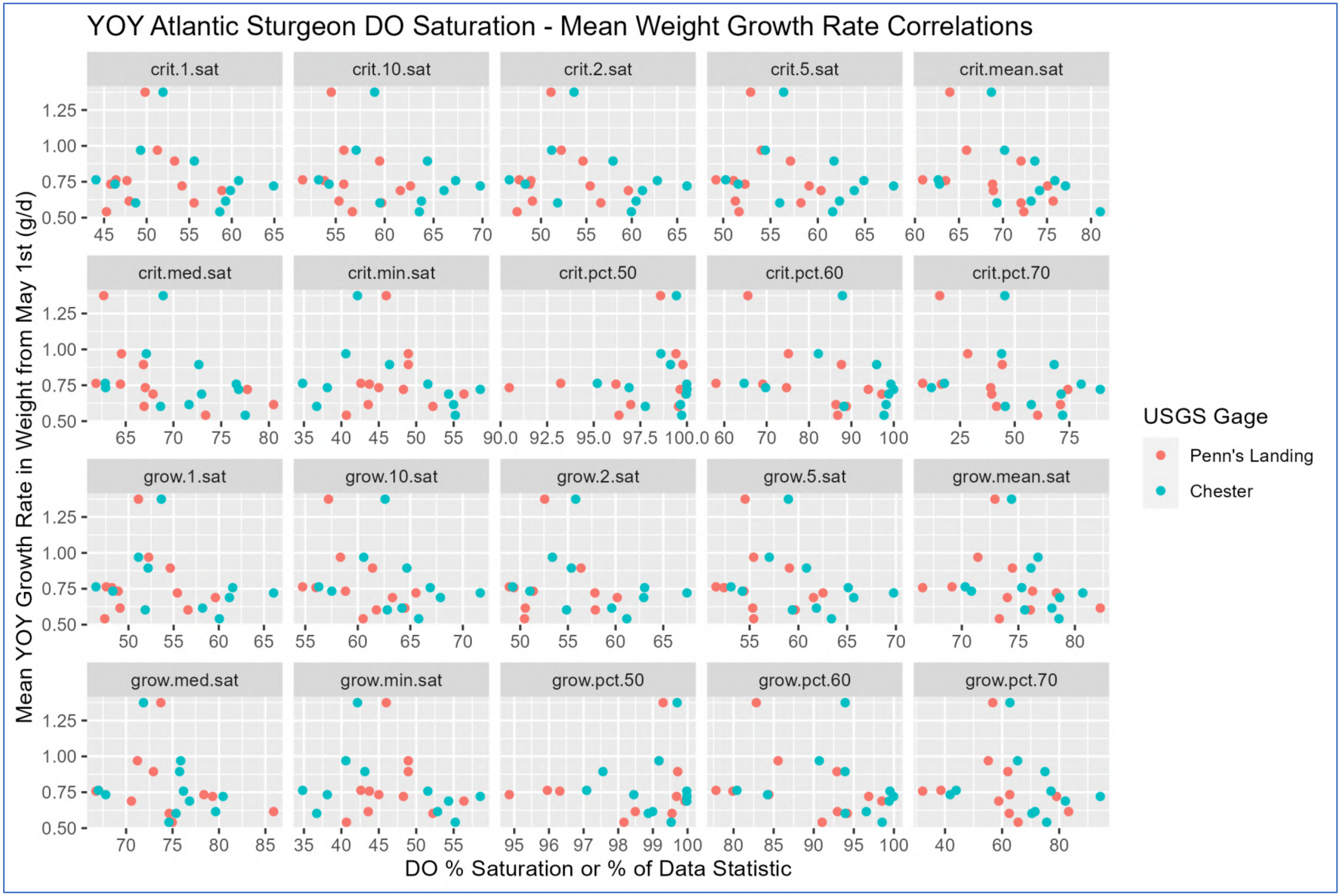


**Figure 9.) Correlation for Delaware River seasonal DO statistics and YOY Atlantic sturgeon mean growth in weight from May 1st, 2009-2022**

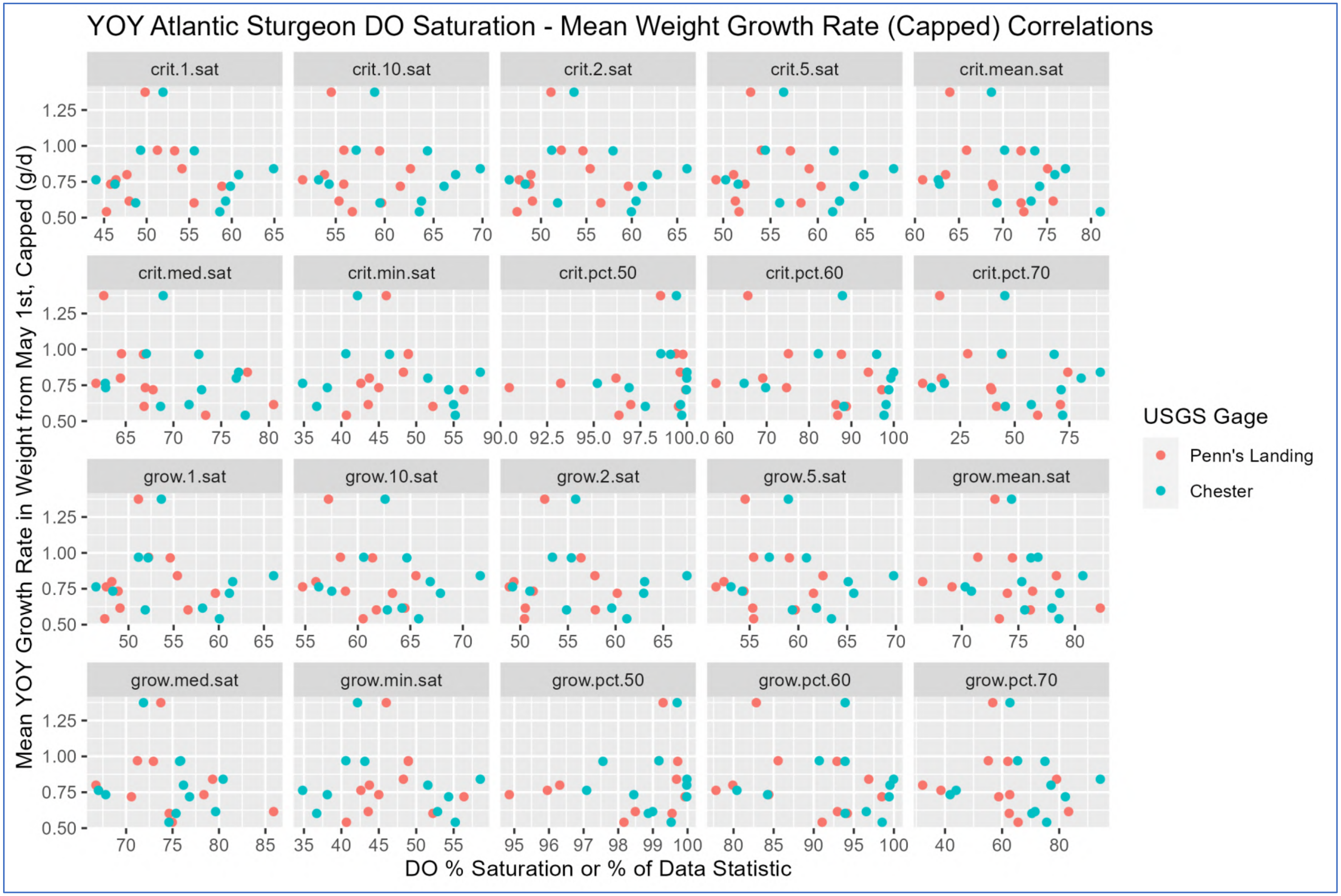


**Figure 10.) Correlation for Delaware River seasonal DO statistics and YOY Atlantic sturgeon mean growth in weight from May 1st, "capped" assuming winter growth was complete by Jan 1st, 2009-2022**

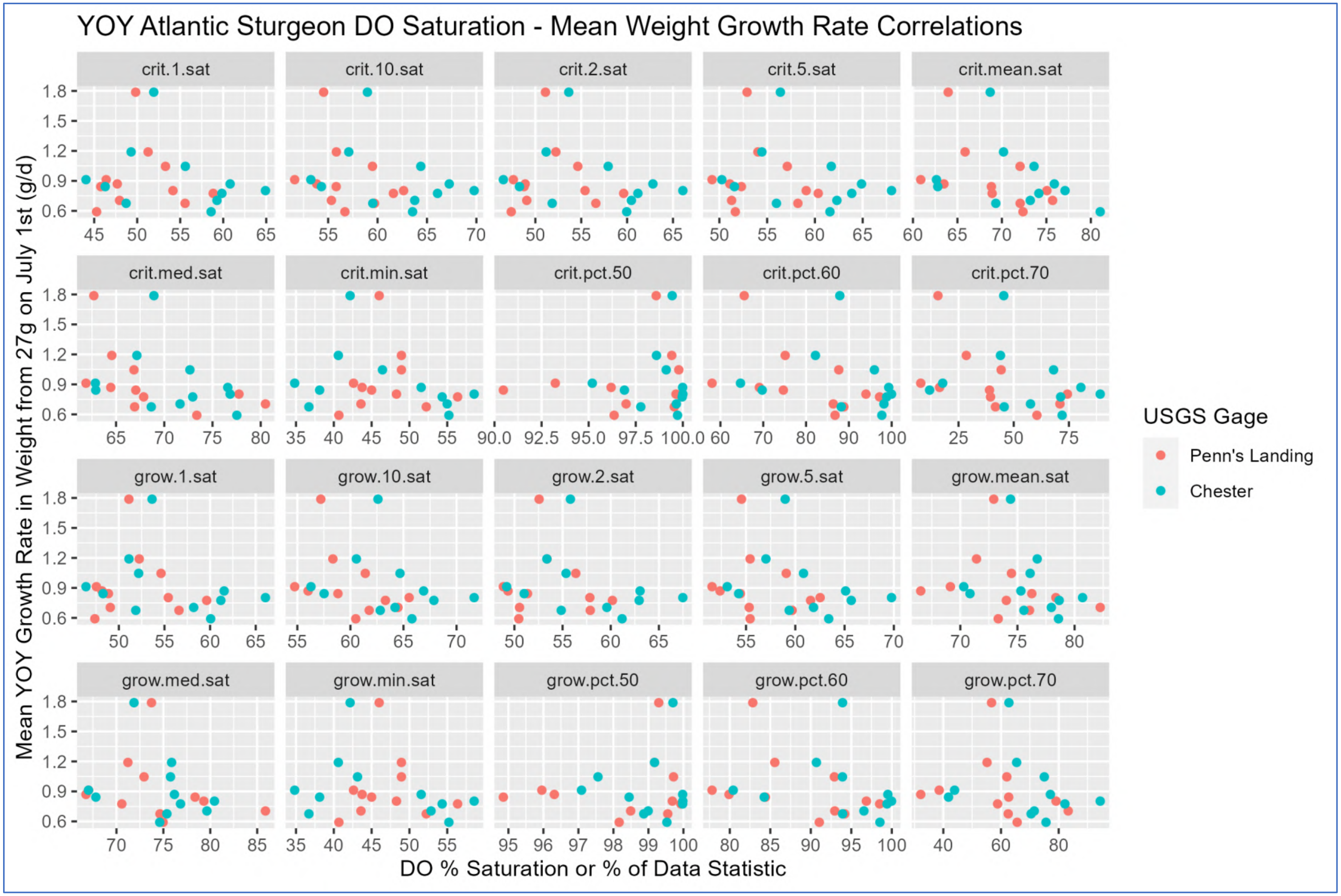


**Figure 11.) Correlation for Delaware River seasonal DO statistics and YOY Atlantic sturgeon mean growth in weight assuming fish were 27g on July 1st, 2009-2022**

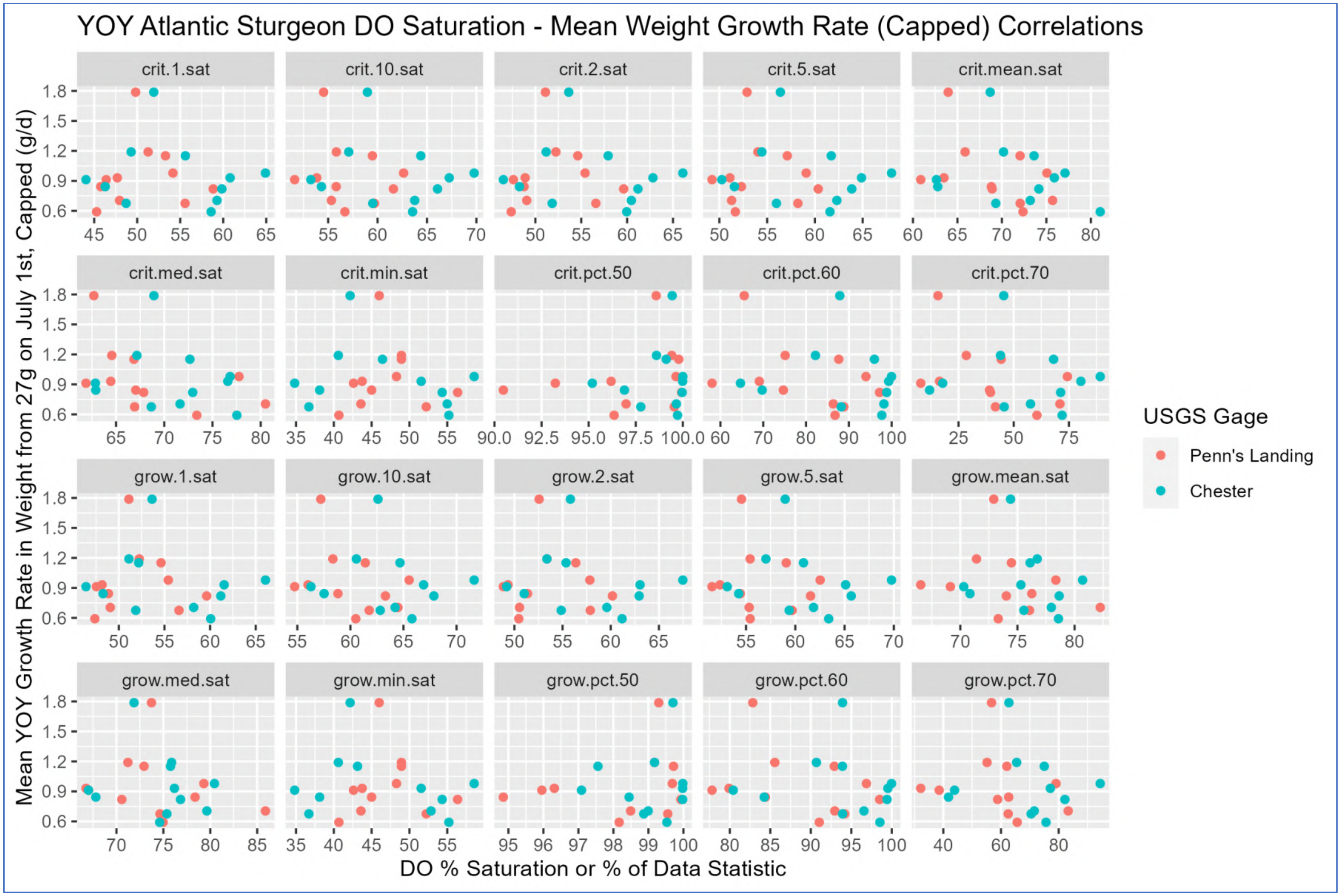


**Figure 12.) Correlation for Delaware River seasonal DO statistics and YOY Atlantic sturgeon mean growth in weight assuming fish were 27g on July 1st, "capped" assuming winter growth was complete by Jan 1st, 2009-2022**

PWD Testimony by Jay Cruz, EPA Public Hearing on the Proposed Rule Establishing Water Quality Standards for the Delaware River 2/6/2024

Yogi Berra once said: "You've got to be very careful - If you don't know where you're going, you might not get there". I'd like to paraphrase Yogi by saying "If you don't look for something, you might not find it". Such is the case with Atlantic sturgeon in the Delaware River. Going back to the 1970s and 80s scientists would occasionally find them in the Delaware River. In the 1990s scientists from The State of Delaware Division of Fish and Wildlife, or "DNREC", began collecting large numbers of sturgeon in a saltwater area of the river around Artificial Island. These fish were around three feet long, so not babies, but two or three years old and getting ready to swim out to the ocean.

Starting in 2008-2009 the DNREC scientists started sampling around Marcus Hook. They also changed the size of the mesh used in their nets to be able to catch smaller fish. This is a freshwater area of the river that also has the right kind of habitat for sturgeon spawning. DNREC scientists caught baby young of the year sturgeon in 2009. While it had been suspected that sturgeon were spawning in the Delaware, 2009 was definitive proof that Atlantic sturgeon were spawning in the Delaware River. Unfortunately, due to funding and other factors, sampling was not consistent between 2010 and 2013. The right size nets were being used but they only managed to sample a few days in some years or didn't even sample at all in 2013. We can't compare the years between 2010 and 2013 to today and certainly it's false to claim the fish all died in 2013 due to low DO when DNREC didn't even sample that year.

What we can say is for every year since 2009 when DNREC put out enough nets, juvenile sturgeon have been found – usually dozens, but sometimes hundreds of them. DNREC samples in November and December, so the young of year fish have grown from tiny eggs the size of a BB to 300mm or 12 inches long, with the average of about 13 and a half inches. These are big fish and they grow quickly. When the Army Corps of Engineers hired a commercial fishing boat to catch and relocate sturgeon when blasting rock in the area around Marcus Hook, the contractor ERC didn't just scoop up the fish and relocate them, ERC also measured and tagged them. When you add up the DNREC and ERC data there are more than 5000 records of juvenile sturgeon for the Delaware River. In their proposed water quality standards rule, EPA only used 72 fish that were tagged and recaptured, so only 144 measurements or 3% of the 5000 available.

Since the fish caught by DNREC and ERC were measured and weighed we can look at not just how many fish were caught, but how long they are, how much they weigh. Are they healthy looking and plump or really skinny? After one summer of rapid growth how big are the YOY in the Delaware compared to other rivers like the Hudson River in New York or in the warmer southern states where sturgeon also spawn? From PWD's point of view, we ought to be looking at the health of the fish themselves, not just how many were found. Since the Delaware River has a water quality monitor at Chester, right near the Marcus Hook habitat, we can also compare the size of the fish collected with the DO data collected while the juvenile fish were using this freshwater area as nursery habitat.

PWD was concerned that nobody seemed to be looking at the sturgeon data in this way. But while we had some ideas, we didn't know exactly what to look at. Is it more the average DO that affects the sturgeon? Or how low the DO levels get? Would we see a difference in how long the juvenile fish get, how much they weigh? Or maybe both, comparing length and weight like the way a human doctor measures Body Mass Index, or BMI. PWD used exploratory data analysis, where we set up hundreds of correlation tests, comparing all the different ways of looking at fish measurements, growth rates, how fat or skinny they are, with different statistics for the DO. We tried 560 different statistical correlation hypothesis tests that look for how much the fish correlated with DO. We didn't just limit it to a linear correlation where the variables relate in a straight line, just correlation when they change in the same direction. What PWD found was no statistically significant correlations. This doesn't mean that sturgeon aren't affected by DO, obviously fish and other aquatic life are affected by DO. It just means that there wasn't any effect from the DO that was observed over the years that were observed. The DO statistics varied and the sturgeon seemed to vary as well, but there was no correlation. We also found no statistically significant difference between the sturgeon in the Delaware and the sturgeon in the Hudson River where the DO levels are a lot higher.

Getting back to Yogi Berra, where are we going? How will we know if we get there? Are we really ready to spend billions of dollars, raising water bills by hundreds of dollars a year in one of the poorest cities in America without knowing whether it will even help the fish?

Thank you for the opportunity to comment at this public hearing. PWD will provide more details of our concerns with EPA's proposed rule in our official comments.

PHILADELPHIA WATER DEPARTMENT

Randy E. Hayman, Water Commissioner

# PWD Oral Comment for EPA Public Hearing on Proposed Rule: *Water Quality Standards To Protect Aquatic Life in the Delaware River*

The Philadelphia Water Department thanks EPA for the opportunity to provide oral comments on this proposed rule.

As the largest single source of treated wastewater in the Delaware Estuary, PWD is proud of the outstanding improvements in water quality that have occurred since the Delaware River Basin Commission was established in 1961 and the Clean Water Act was signed in 1972. Funded in part with financial assistance in the form of federal taxpayer funds, PWD's three Water Pollution Control Plants are partially responsible for this transformation. Today, iconic native species such as striped bass, American shad, and Atlantic sturgeon are now spawning in urban areas of the Delaware River once too deficient in dissolved oxygen to support propagation of fish.

PWD agrees that the available evidence clearly supports fish propagation as an existing use in the Delaware Estuary that must be protected. PWD is very disappointed, however, that in proposing new federal dissolved oxygen criteria to support propagation, EPA has relied on inappropriate laboratory and modeling studies while failing to evaluate and fully consider the most up-to-date scientific data on actual fish spawning and juvenile growth in the Delaware River.

PWD's preliminary analysis of more than 5,000 fish collected and measured in the Delaware River by state and federal agencies showed that sturgeon are already spawning and growing in Zones 3, 4 and 5 at current dissolved oxygen levels. Based on actual fish measurements, years with higher or lower dissolved oxygen levels showed no statistically significant difference in sturgeon growth or condition. The Delaware River sturgeon also appear to be growing as well as similar size fish in the Hudson River, where dissolved oxygen levels are typically higher.

In PWD's view, the new dissolved oxygen criteria proposed by EPA appear to reflect a preference toward overly conservative dissolved oxygen levels that are higher than needed to support fish propagation in the Delaware River. Proposed new wastewater processes needed to comply with strict ammonia limits would significantly impact water rates in Philadelphia and drastically affect PWD's ability to fund priority projects such as lead and copper, PFAS, bacteria, CSO management, climate change, salinity and drought management. Many of these pressing needs directly affect our customers' daily lives or have public health implications. Additionally, these new wastewater processes would have significant negative climate implications, through construction in future floodplain areas and major increases to energy consumption.

PWD supports recognition of the existing propagation use in the Delaware River but does not support raising dissolved oxygen criteria to the highest possible levels without more careful consideration of the benefits to fish species and the costs to PWD ratepayers.

The science and analyses presented as justification for this proposed regulation are deeply flawed. For example, EPA relied on cost estimations grounded in inaccurate assumptions, which significantly underestimate the true costs to build and indefinitely operate new ammonia removal processes at PWD's three Water Pollution Control Plants. PWD's written comments to EPA will provide accurate information related to:

a) PWD's costs to design, build, and operate new ammonia removal processes;
b) The financial impact to PWD ratepayers;
c) Applicable fish science and monitoring data in the Delaware River;
d) And modeling findings relating water quality improvements to wastewater technology.

We look forward to EPA's review and consideration of PWD's written comments. Thank you for the opportunity to provide oral comments on this proposed rule.