PHILADELPHIA WATER DEPARTMENT
Randy E. Hayman, Esq., Water Commissioner

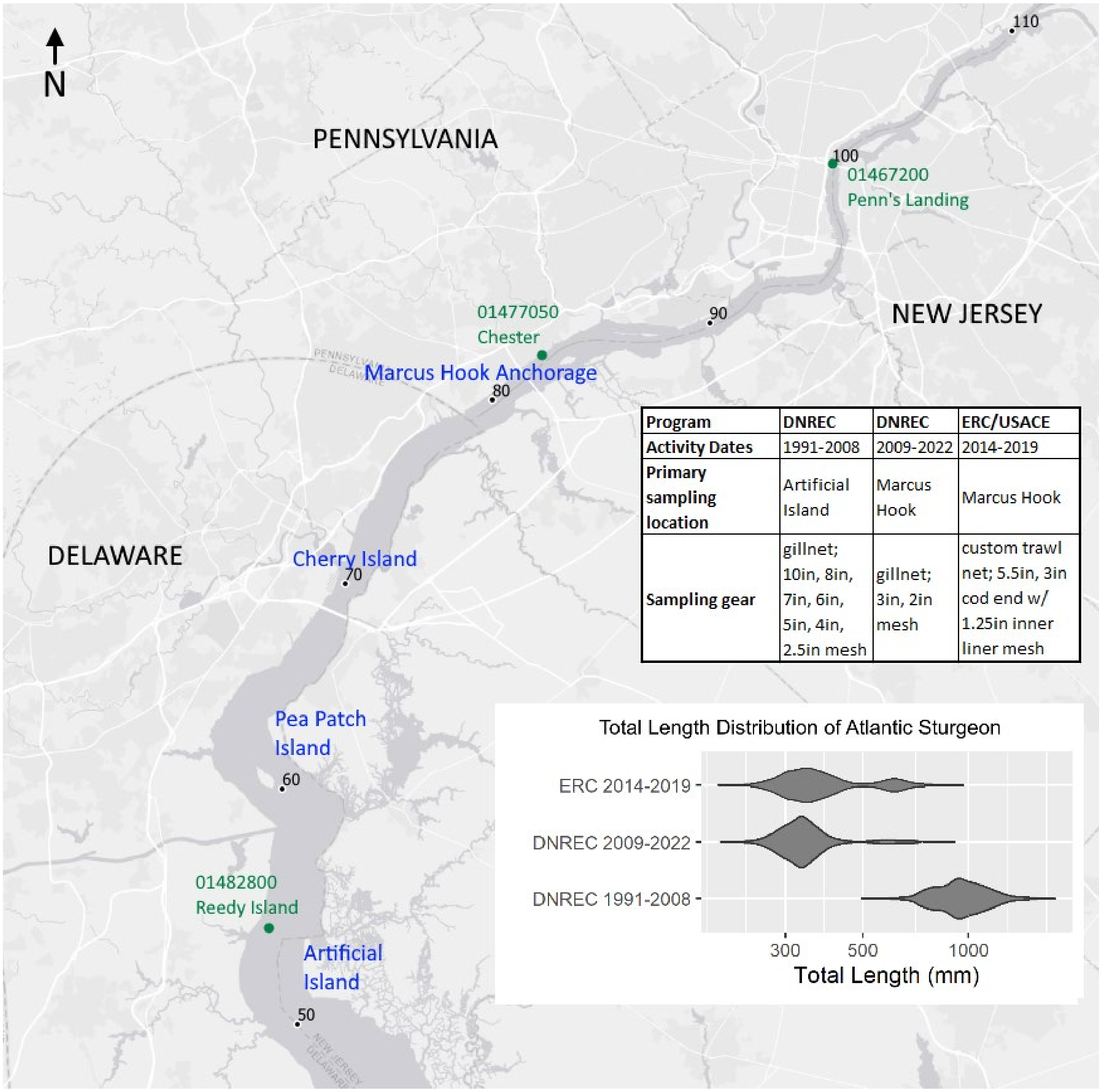
January 27, 2024

PWD's Position Statement on Sturgeon Science to Inform Water Quality Standards for the Delaware River

Atlantic sturgeon have been collected in the Delaware River by fisheries scientists since the 1980s, but sampling efforts have not been consistent until fairly recently. The lower river habitats surveyed and relatively large mesh size of nets used by Delaware Department of Natural Resources and Environmental Control (DNREC) and other early sampling programs were limited in their effectiveness to capture young-of-year and juvenile sturgeon (Figure 1). However, starting in approximately 1998, DNREC began sampling more consistently with smaller-mesh gear. Sampling in 2009 targeted upstream juvenile habitat hotspots in the area of Marcus Hook Anchorage approximately 30 miles upstream of Artificial Island and exclusively used smaller 2-3 inch mesh nets to more effectively collect juveniles.

DNREC sampling methods have been consistent since 2014 and are now being used to compute an annual Juvenile Abundance Index (JAI) for Atlantic sturgeon. More information on DNREC sampling locations and gear is available in DNREC reports (Shirey *et al*. 1998, Shirey *et al*. 1999, Fisher 2011, Fisher 2015, Park 2020).

Since 2014, relatively large numbers of age 0-1 juvenile sturgeon have been collected from the Delaware River every year with adequate sampling effort. In addition to DNREC efforts, a commercial fishing vessel was hired to capture and relocate sturgeon during rock blasting for the Army Corps Navigational Channel deepening project from 2014-2019. The relocation program was very effective at collecting young-of-year and yearling juvenile sturgeon (Brundage and O'Herron 2014, ERC 2016-2019). While the raw numbers of fish collected varied from year to year due to sampling effort, two distinct cohorts representing young-of-year and age 1 Atlantic sturgeon were observed each year from 2014-2022 (Figure 2). The median length of the young-of year cohort was approximately 300-350mm (~12-14 inches), demonstrating the rapid growth potential of juvenile sturgeon.



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 1. 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.

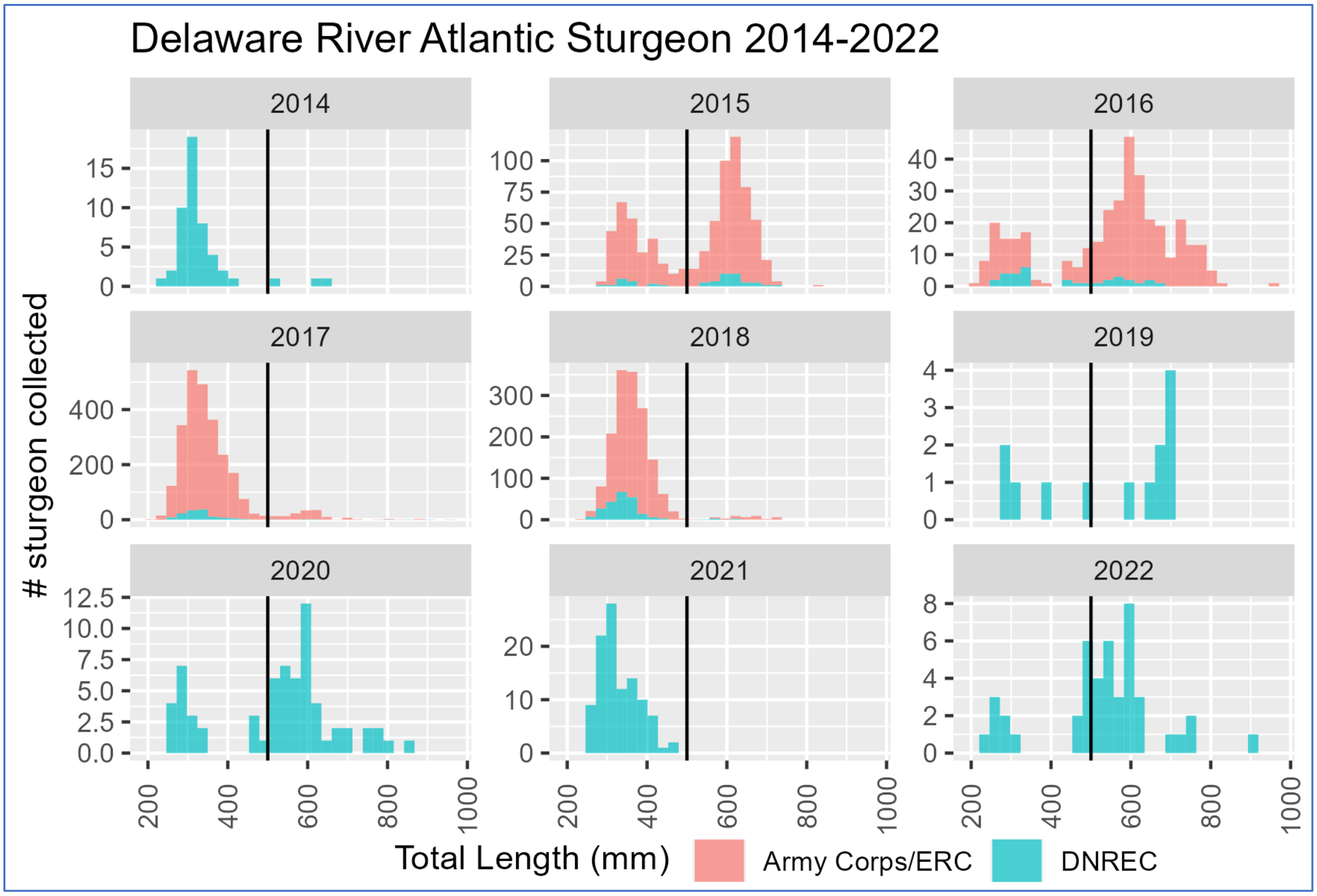


Figure 2. Histograms of number of sturgeon collected from the Delaware River 2014-2022 vs. total length in millimeters. Data are presented by collection year with different y axis scales. The two different agencies (DNREC and ERC) are differentiated by color. Note: some ERC data were collected in winter (January-March). YOY collected in winter by ERC likely correspond to previous year cohort.

Yearly totals of sturgeon collected in the Delaware River from 1991-2022 are shown below in Figure 3 along with summer (Jul-Aug) daily average DO levels at the Chester USGS monitoring station. The Chester station is located close to Marcus Hook, where spawning occurs and juvenile age 0-1 fish are typically collected. The Delaware River Basin Commission (DRBC) criterion for DO is 3.5 mg/L, but actual observed DO at Chester is typically much higher, with the summer median daily DO concentration exceeding 5 mg/L in most years. While sturgeon may be found throughout the urban estuary, PWD generally considers Chester to be the most relevant monitoring station for evaluating effects of hypoxia on spawning and juvenile growth (Hale *et al*. 2016).

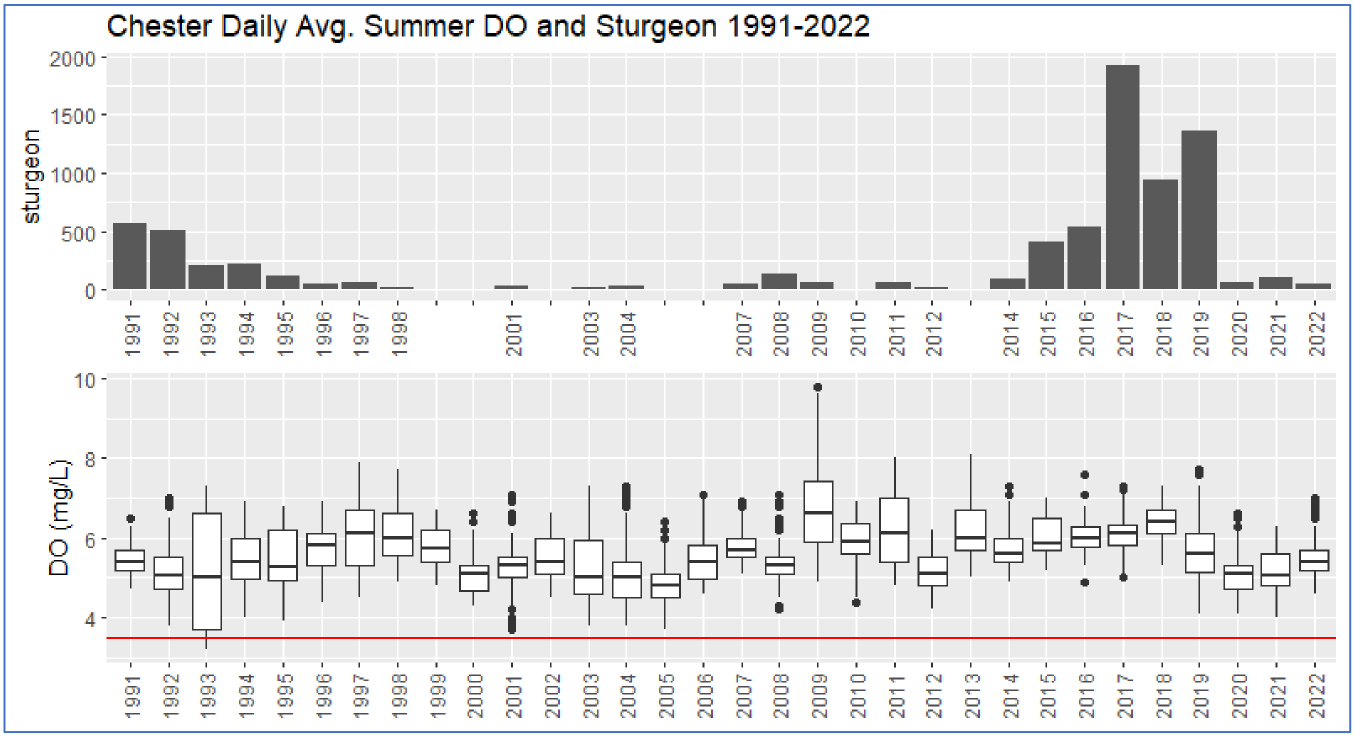


Figure 3. Summer (Jul-Sep) Daily Average DO for Chester USGS station 01477050 and number of sturgeon collected by DNREC gillnet sampling and/or U.S. Army Corps relocation trawling. Red line at 3.5 mg/L on DO chart represents current DRBC daily average DO criterion. Note that overall level of sampling effort, habitats, and methods were not consistent; sturgeon numbers are intended to show availability of data, not trends in abundance. No sturgeon sampling occurred in 1999, 2000, 2002, 2005, 2006, or 2013.

PWD compiled and analyzed more than 5,000 recent juvenile sturgeon collection records from the Delaware River and a similar sample from the Hudson River to test the hypothesis that sturgeon health was affected by dissolved oxygen levels. 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 important to look at the growth rate of fish cohorts and condition of the individual fish themselves by examining measurements of length and weight.

Comparing the relationship between fish weight and length in this way is similar to how a human doctor measures growth percentiles for children or Body Mass Index (BMI). But instead of being concerned about obesity, fish scientists usually consider "plumper" fish, with a slope parameter *b* greater than 3, to be healthier. There was a significant difference in the fish growth estimated by the slope *b* of log(weight)-log(length) linear regression models for the Delaware and Hudson Rivers, with the Delaware River having a steeper slope (Figure 4, $p = 0.001$). The difference in slopes was very 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 fish larger than 500 mm between the two systems, finding no significant differences (Figure 5).

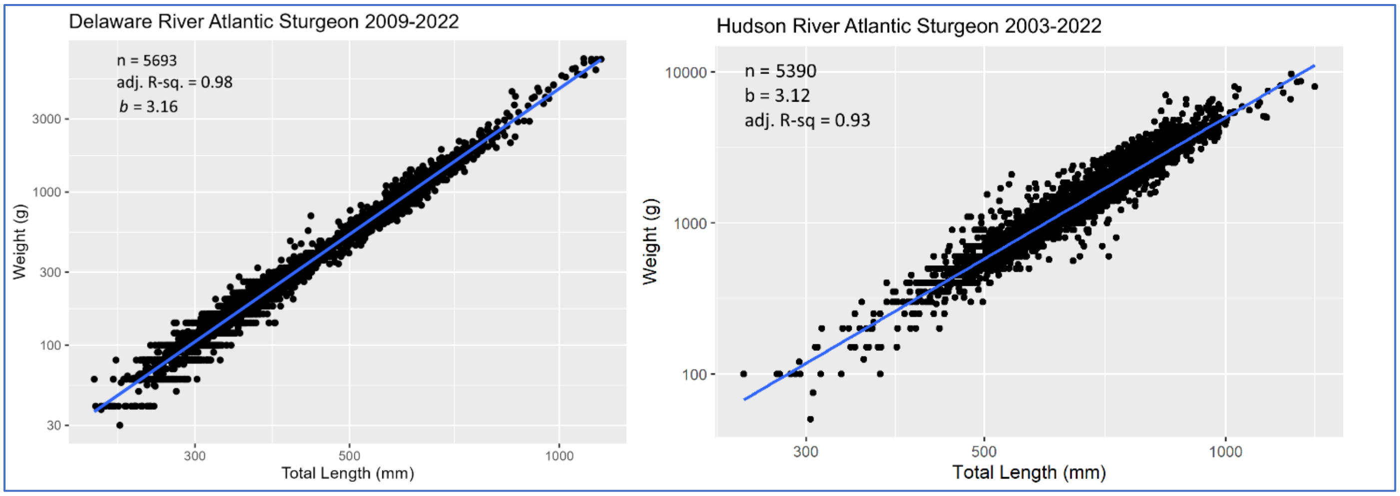


Figure 4. Weight-Length Relationships for Atlantic sturgeon collected from the Delaware River (n = 5693) and Hudson River (n = 5390).

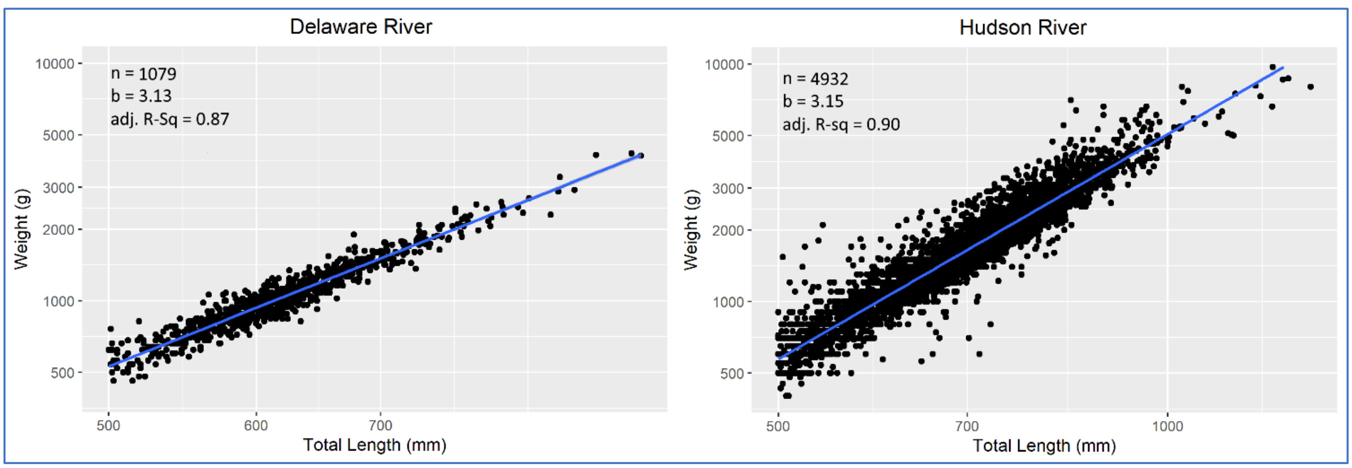


Figure 5. Weight-Length Relationships for Yearling (500 mm) or larger Atlantic sturgeon collected from the Delaware River (n = 1079) and Hudson River (n = 4932).

PWD investigated the hypothesis that hypoxia in the Delaware River adversely affected sturgeon by comparing observed measures of fish growth and condition to a variety of DO statistics for data observed 2009-2022 (Table 1). PWD performed more than 500 statistical correlation tests to evaluate whether there was any relationship between Delaware River DO and observed fish growth and condition. An example of DO statistics correlation analysis with the slope parameter *b* from W-L regression is presented in Figure 6. None of the 560 correlation tests that were performed resulted in a statistically significant result for positive correlation between DO and fish growth or condition, indicating that – at least for the years analyzed and DO conditions that occurred 2009-2022 – there was no evidence for a correlation between DO and Atlantic sturgeon growth or conditions in the Delaware River. PWD intends to fully document the analyses that were performed, including analyses based on empirical growth rates, length, weight, condition, and different subsets of the data, as supporting information in our comments on EPA's proposed rule.

Table 1. Key to abbreviations used for DO statistics

Abbreviation	Description
crit.1.sat	critical season 1st percentile DO saturation
crit.10.sat	critical season 10th percentile DO saturation
crit.2.sat	critical season 2nd percentile DO saturation
crit.5.sat	critical season 5th 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.10.sat	growing season 10th percentile DO saturation
grow.2.sat	growing season 2nd percentile DO saturation
grow.5.sat	growing season 5th 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

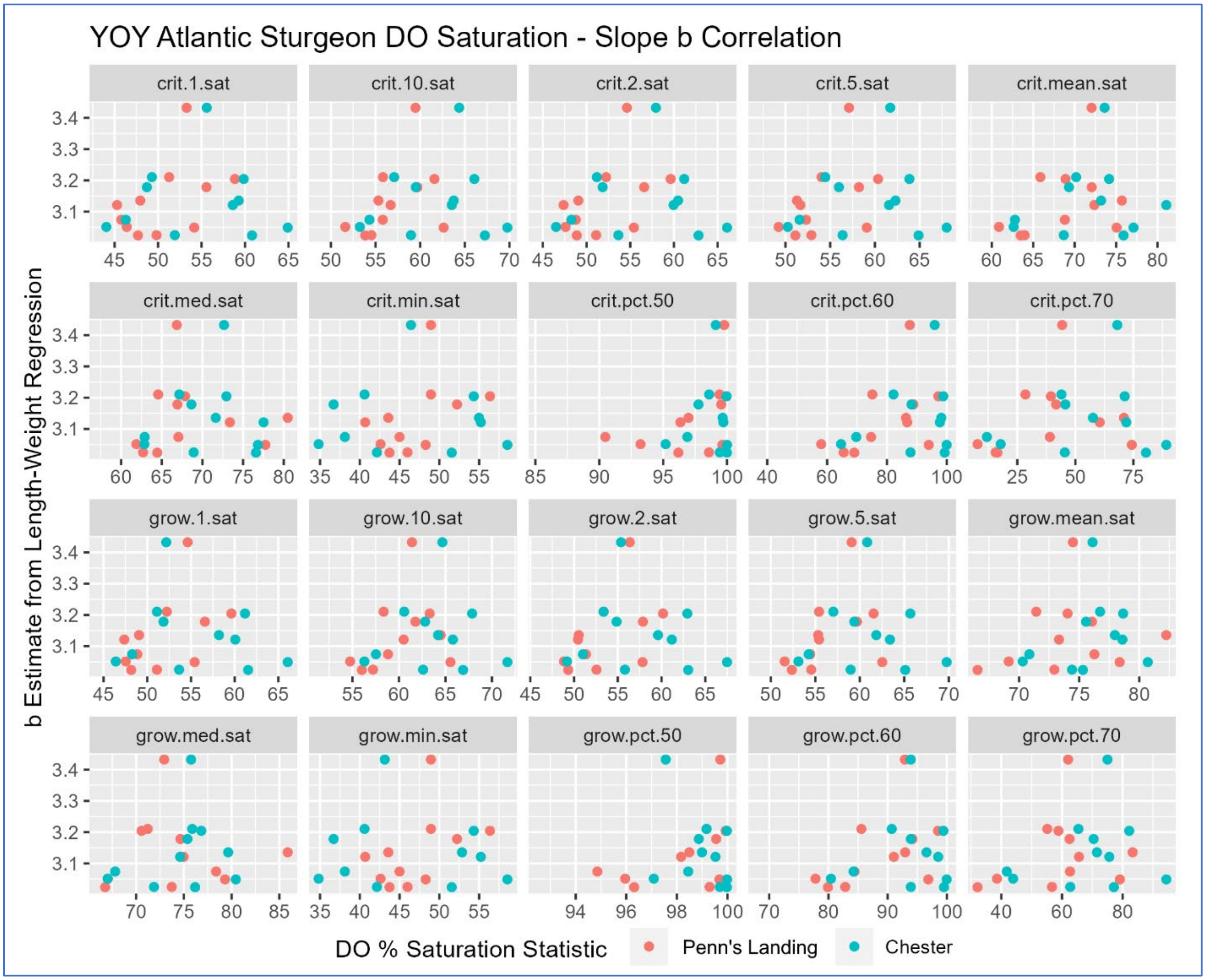


Figure 6. Example of correlation analysis for Delaware River seasonal DO statistics and YOY Atlantic sturgeon W-L regression slope parameter *b*, 2009-2022

Table 2. Summary Statistics for Spearman correlation tests for Delaware River seasonal DO statistics and YOY Atlantic sturgeon W-L regression slope parameter *b*, 2009-2022

		Penn's Landing - 01467200			Chester - 01477050		
DO Statistic	method	cor	statistic	p	cor	statistic	p
crit.1.sat	Spearman	0.43	126	0.193	-0.18	260	0.595
crit.10.sat	Spearman	0.49	112	0.129	-0.064	234	0.86
crit.2.sat	Spearman	0.44	124	0.183	-0.2	264	0.558
crit.5.sat	Spearman	0.46	118	0.154	-0.15	254	0.654
crit.mean.sat	Spearman	0.34	146	0.313	0.018	216	0.968
crit.med.sat	Spearman	0.24	168	0.485	-0.13	248	0.714
crit.min.sat	Spearman	0.53	103	0.0913	-0.091	240	0.797
crit.pct.50	Spearman	0.55	98	0.0816	-0.27	280	0.418
crit.pct.60	Spearman	0.53	104	0.1	-0.15	252	0.673
crit.pct.70	Spearman	0.32	150	0.341	-0.15	254	0.654
grow.1.sat	Spearman	0.47	116	0.146	-0.29	284	0.386
grow.10.sat	Spearman	0.38	136	0.248	-0.045	230	0.903
grow.2.sat	Spearman	0.52	106	0.107	-0.29	284	0.386
grow.5.sat	Spearman	0.5	110	0.116	-0.082	238	0.818
grow.mean.sat	Spearman	0.25	164	0.451	0.34	146	0.313
grow.med.sat	Spearman	0.02	214	0.946	0.15	188	0.673
grow.min.sat	Spearman	0.53	103	0.0913	-0.073	236	0.839
grow.pct.50	Spearman	0.48	114	0.137	-0.35	296	0.299
grow.pct.60	Spearman	0.51	108	0.114	-0.26	278	0.435
grow.pct.70	Spearman	0.17	182	0.614	0.018	216	0.968

These results are preliminary and have not been peer-reviewed by fisheries experts. Nevertheless, the conclusions suggest that more research is needed to understand the necessary levels of DO to protect sturgeon spawning and juvenile growth in the Delaware River, especially given the potential enormous costs of wastewater treatment plant modifications 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. Additional information is available from genetic studies and laboratory experiments. However, laboratory tests must use appropriate methods and test biologically relevant experimental exposure conditions in order to be considered useful. 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 DO levels.

New information is also available about other threats to sturgeon populations from vessel strikes and commercial fishing. While Atlantic sturgeon spend two or three years in juvenile nursery areas in the Delaware River with potential hypoxia stress in warm summer conditions, mortality due to vessel strikes (Fox, *et al*. 2020) or unintentional bycatch in commercial fisheries (NMFS 2022) can affect many more age classes of sturgeon and may occur any time of year. As female sturgeon may take 15 or more years to mature, it has been estimated that the loss of even a few of these spawning females each year may hamper restoration efforts (Brown and Murphy 2010).

PWD supports and is willing to contribute funding toward hatchery programs (or feasibility studies to investigate the logistics and benefits of hatchery programs) to augment the existing natural spawning and growth of sturgeon in the Delaware River. Given the small population size, slow intrinsic growth rate, and multiple anthropogenic threats, hatchery programs may be a useful tool to rebuild the Delaware River population.

References

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.

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.

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

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.

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.