

Delaware River Basin Commission

“Analysis of Attainability”

A Strategy to Determine Highest Attainable Dissolved Oxygen Condition

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Delaware River Estuary

WQ Assessment Units:

Zone 1: Non-tidal (Upstream from Trenton)

Estuary:

Zone 2 - 5: Tidal Delaware River

Zone 6: Delaware Bay

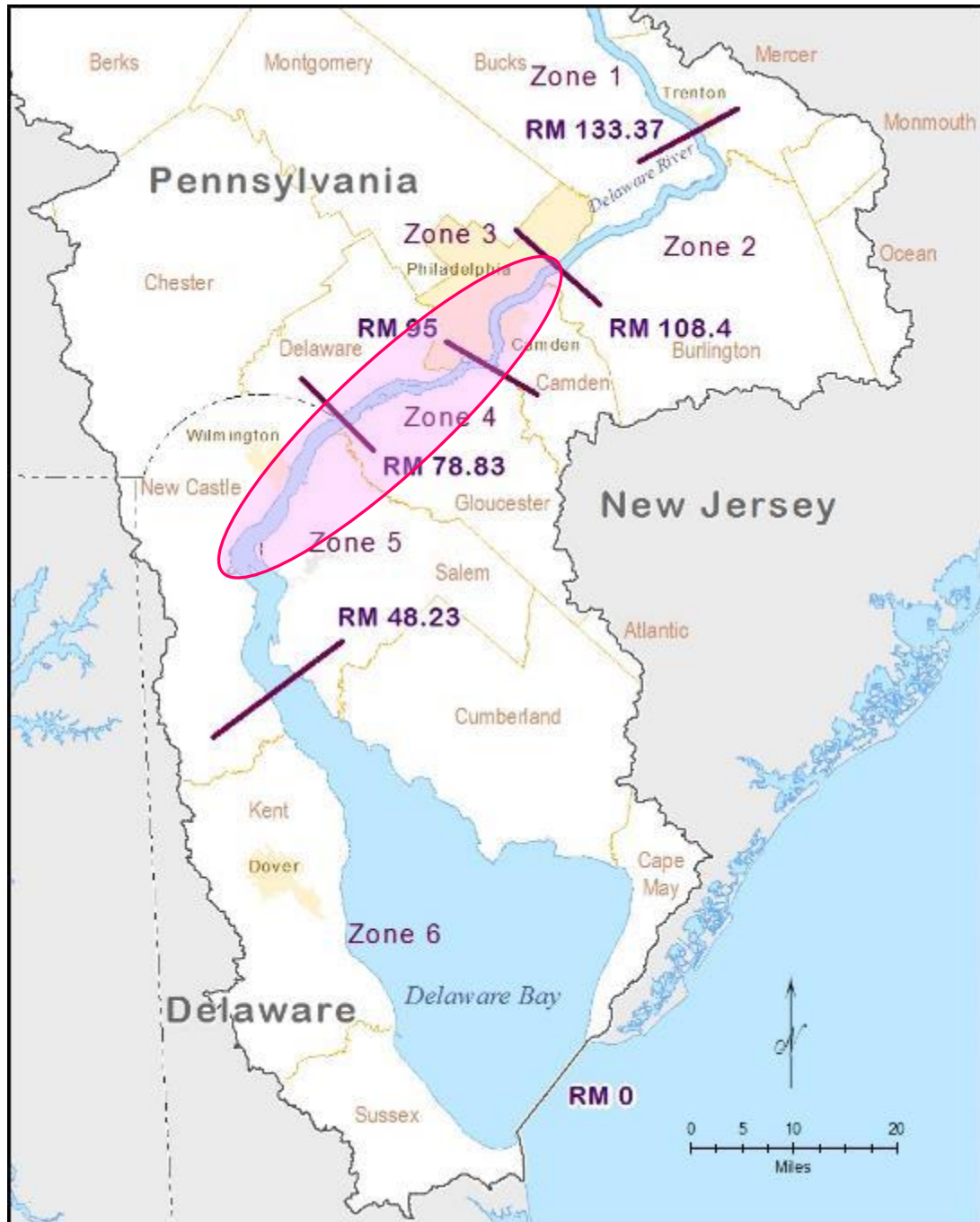
River Miles:

RM 0.0 = Atlantic Ocean

RM 70 = City of Wilmington

RM 100 = Ben Franklin Bridge, Philadelphia / Camden

RM 133 = "Head of Tide", Trenton, NJ



Aquatic Life Designated Uses in Current DRBC Regulations since 1967

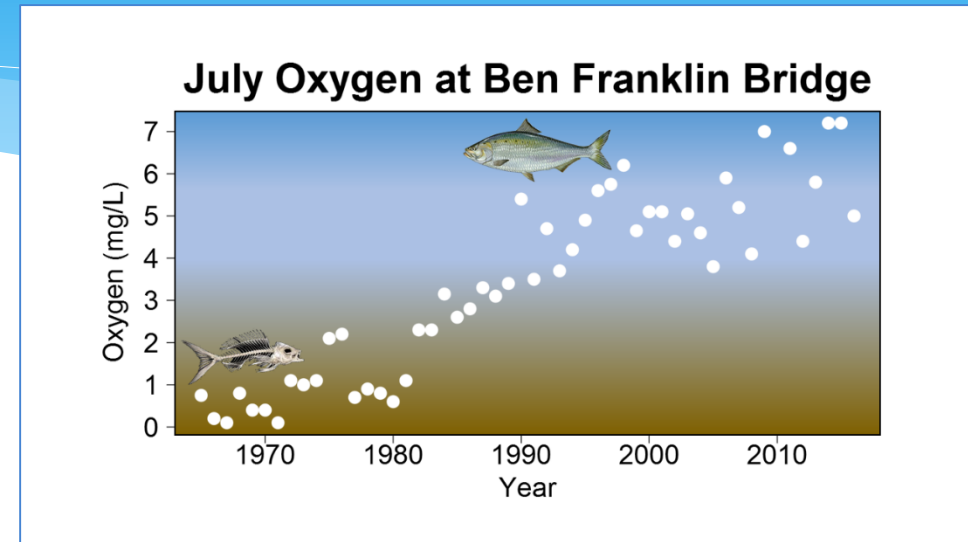
Urbanized portion of Delaware Estuary

The Delaware Bay

| Zone | River Mile | Aquatic Life Use | Migratory Fishes | 24-hour average D.O. Criteria |
|------|---------------|---|-----------------------------------|-------------------------------|
| 2 | 108.4 – 133.4 | maintenance and propagation of resident fish and other aquatic life | passage of anadromous fish | 5.0 mg/l |
| 3 | 95 – 108.4 | maintenance of resident fish and other aquatic life | passage of anadromous fish | 3.5 mg/l |
| 4 | 78.8 – 95 | maintenance of resident fish and other aquatic life | passage of anadromous fish | 3.5 mg/l |
| 5 | 70 – 78.8 | maintenance of resident fish and other aquatic life | passage of anadromous fish | 3.5 mg/l |
| | 48.2 – 70 | maintenance and propagation of resident fish and other aquatic life | passage of anadromous fish | 4.5 – 6.0 mg/l |
| 6 | 0 – 48.2 | maintenance and propagation of resident fish and other aquatic life maintenance and propagation of shellfish | passage of anadromous fish | 6.0 mg/l |

Evaluation of Existing Use

- Fishery propagation
 - Some degree of propagation has been observed
 - Full attainment of propagation has not been demonstrated
- The goals established in 1967 have been exceeded
 - Dissolved oxygen exceeds 3.5 mg/L as a daily average concentration
 - Fisheries enhanced due to improved dissolved oxygen condition



- DO-sensitive species that currently exhibit some degree of propagation
 - American shad
 - Atlantic sturgeon
 - Channel catfish
 - Largemouth bass
 - Shortnose sturgeon
 - Striped bass
 - White perch
 - Yellow perch

Do Not Distribute

DRBC Resolution 2017-04

Studies Required Before Rulemaking

Fish/DO Studies

6(a). Input on the **dissolved oxygen requirements of aquatic species**

6(b). Field studies of the occurrence, spatial and temporal distribution of the life stages of Estuary fish species

6(c). Input from consultations pursuant to the **Endangered Species Act** ("ESA")

Modeling Studies

6(d). Development and calibration of a **eutrophication model** for the Delaware River Estuary and Bay;

6(e). Determination of the nutrient **loadings from point and non-point sources** necessary to support key aquatic species;

Cost/Feasibility Studies

6(f). Evaluation of the **capital and operating costs for treatment** capable of achieving higher levels of dissolved oxygen;

6(g). Evaluation of the physical, chemical, biological, **social and economic factors affecting the attainment of uses,**

6. "Analysis of Attainability"

6(h). Preparation of a **draft report and final report** containing findings and conclusions.

Dissolved Oxygen Thresholds to Support Fish

- Three types of thresholds identified
 - Unsuitable – survival (lethality)
 - Suitable – growth/health (non-lethal)
 - Basis for full support of use
 - Optimal – no further improvements
- Fish targets are still under evaluation by DRBC and will likely change
- Approach is similar to TNC methodology

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Atlantic Sturgeon Young-of-Year Growth: Dissolved Oxygen

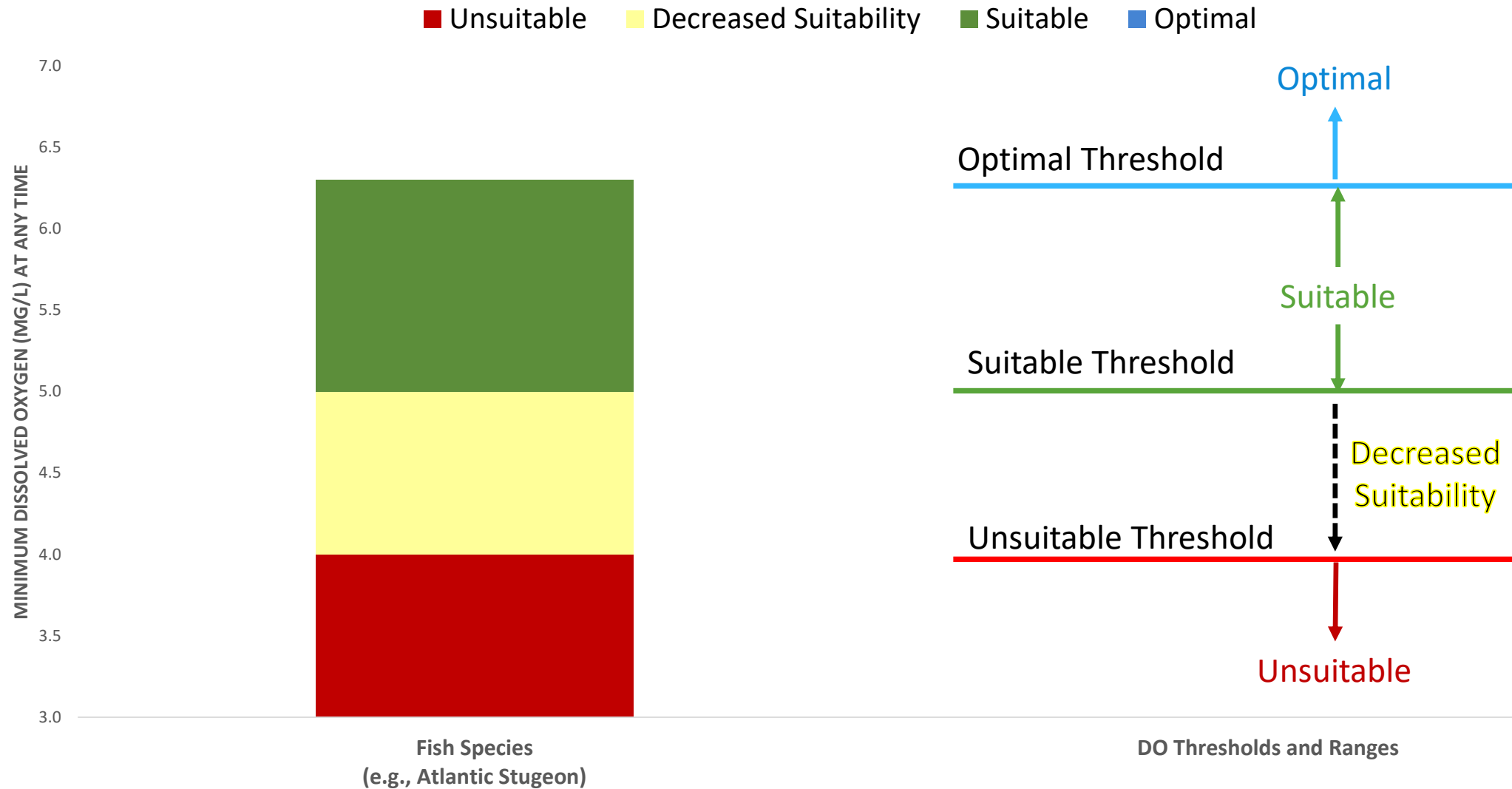
| | DO (mg/l) | Support in literature | Context |
|-----------------|-----------|--|-----------------------------------|
| <i>Optimal</i> | > 6.0 | <ul style="list-style-type: none"> • In laboratory studies, YOY growth rates were maximized when dissolved oxygen concentration was above 70% (6 mg/L @ 25 C) (Niklitschek and Secor 2009). • Optimal DO for YOY life stage > 5 mg/L (Greene et al. 2009) | Laboratory, Atlantic sturgeon |
| <i>Suitable</i> | 5.0 | <ul style="list-style-type: none"> • Interpreting existing data and studies, a 60% saturation level, or 5 mg/L @ 25 C was determined to protect sturgeon from nonlethal effects in the Chesapeake (EPA 2003). | Meta-analysis; Atlantic sturgeon |
| | 4.7 | <ul style="list-style-type: none"> • YOY (30 to 200 days) experience reduced metabolic and feeding rates with less than 60 % oxygen saturation (4.3 to 4.7 mg/L @ 22C to 27 C)(Secor and Niklitschek 2001). | Laboratory; Atlantic sturgeon |
| | 4.3 | | |
| <i>Impaired</i> | 4.0 | <ul style="list-style-type: none"> • Based on existing literature and preliminary data on habitat use and recruitment, not likely support growth and survival of Atlantic Sturgeon YOY (Kahn and Fisher 2012). | Delaware River, Atlantic sturgeon |
| <i>Lethal</i> | 3.3 | <ul style="list-style-type: none"> • Mortality observed during summer temperatures and DO < 3.3 mg/L (Secor and Niklitschek 2001). | Laboratory, Atlantic sturgeon |
| | 3.0 | <ul style="list-style-type: none"> • Significant mortality observed (85%) in YOY (90 days) held at 26 C and 3.0 mg/L for 10 days (Secor and Gunderson 1998). During the DO sag in the Delaware, YOY are younger (30 to 60 days) and more sensitive (Campell and Goodman 2004) to change. Also, river temperatures exceed those in the study (30 C in recent years Kahn and Fisher 2012)). | Laboratory, Atlantic sturgeon |

Figure 8.

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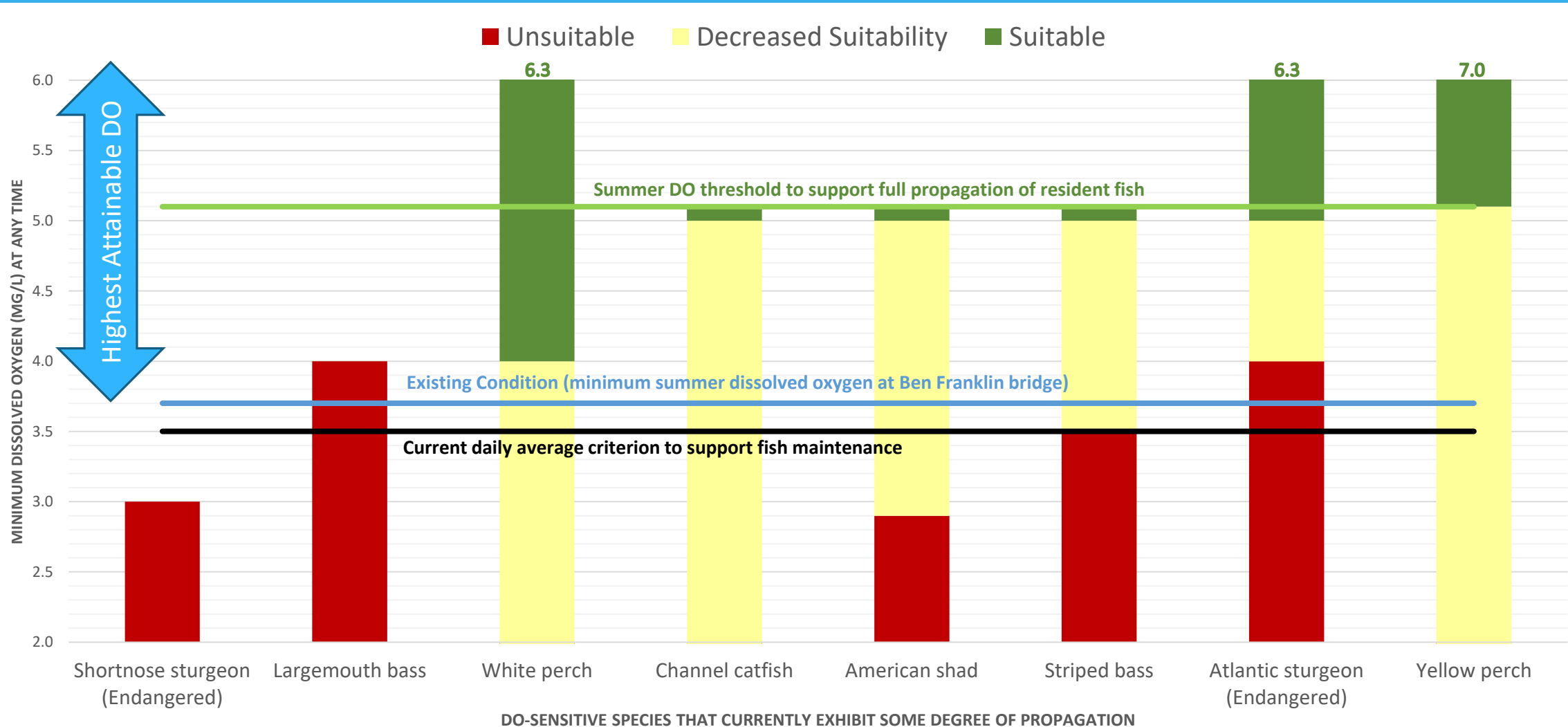
Potential Impacts of Dissolved Oxygen, Salinity and Flow on the Successful Recruitment of Atlantic Sturgeon in the Delaware River, TNC 2016

Conceptual Model Relating Dissolved Oxygen to Use



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Conceptual Model Applied to Zone 3 in Summer



Do Not Distribute (Draft)

What is an “Analysis of Attainability?”

What We Know

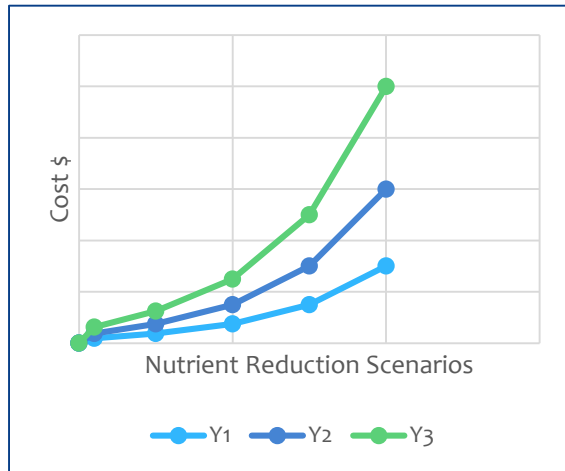
- Minimum Dissolved Oxygen conditions are critical to supporting fish propagation
- Existing DO condition supports some degree of propagation among resident fish
 - Since the degree of propagation associated with the existing DO condition is an Existing Use, it must be protected
 - Therefore, current minimum DO condition (3.7 mg/L) must be maintained or enhanced
- Higher minimum DO condition (i.e., more oxygen) will enhance the degree of fish propagation
 - Full propagation among resident fish would appear to be supported by a minimum DO of approximately 5 mg/L

What We Need to Determine

- How much can the DO condition be improved?
 - What would the DO condition be under “reference background” loading conditions?
 - What would the DO condition be under various levels of point and nonpoint source pollutant reductions?
 - Is it feasible to meet the minimum required DO to support propagation of all sensitive species?
- What would be the costs and benefits associated with the various point and nonpoint source reductions?
- DRBC must determine Highest Attainable Dissolved Oxygen (HADO) condition

Elements of "Attainability Analysis"

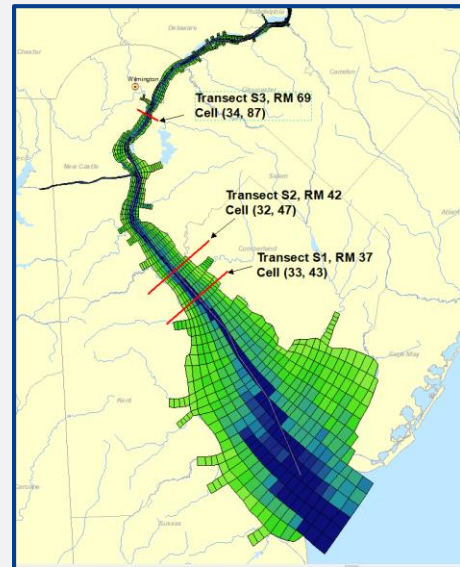
Point Source Nutrient Reduction Cost Evaluation



| Effluent Level |
|-------------------------------|
| NH ₃ -N – 10 mg/L |
| NH ₃ -N – 5 mg/L |
| NH ₃ -N – 1.5 mg/L |
| TN – 4 mg/L |



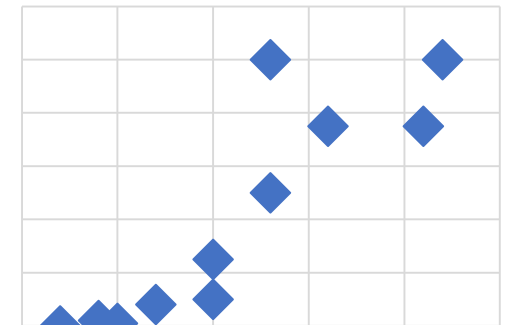
Eutro Model



Refined Candidate Scenarios



Points Represent Hypothetical Scenarios



How much would DO condition improve if:

- Each of the point source nutrient scenarios were implemented
- Tributary boundaries were reduced
- Nonpoint sources were reduced
- Various sources reduced

"Attainability"

- Natural condition
- Technological limitations
- Socioeconomic constraints and benefits

Summary and Discussion

- Results from seven studies identified in Resolution 2017-04 will guide “Attainability Analysis”
- Aquatic life use (degree of propagation) is directly related to dissolved oxygen conditions
- System supports some degree of propagation for a variety of critical species now
 - Current minimum DO condition and associated use must be maintained or enhanced
- System will support a much greater degree of propagation when Attainability Analysis is completed and implemented
 - Highest Attainable Dissolved Oxygen (HADO) condition will be determined based on cost and benefits in the fish maintenance zones
- Revised designated use will be the enhanced degree of propagation associated with the HADO condition

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