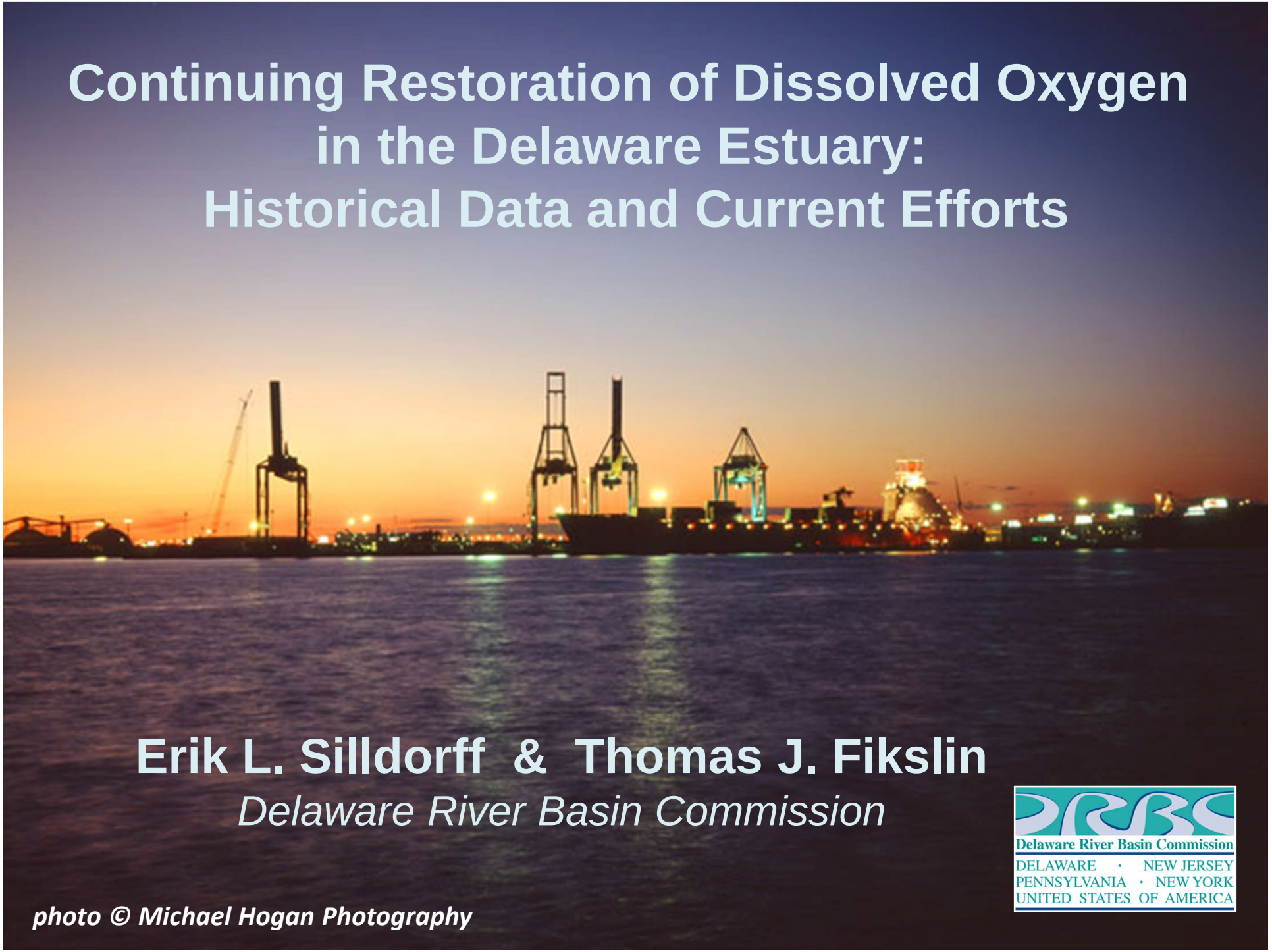
Continuing Restoration of Dissolved Oxygen in the Delaware Estuary: Historical Data and Current Efforts



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Delaware River Basin Commission

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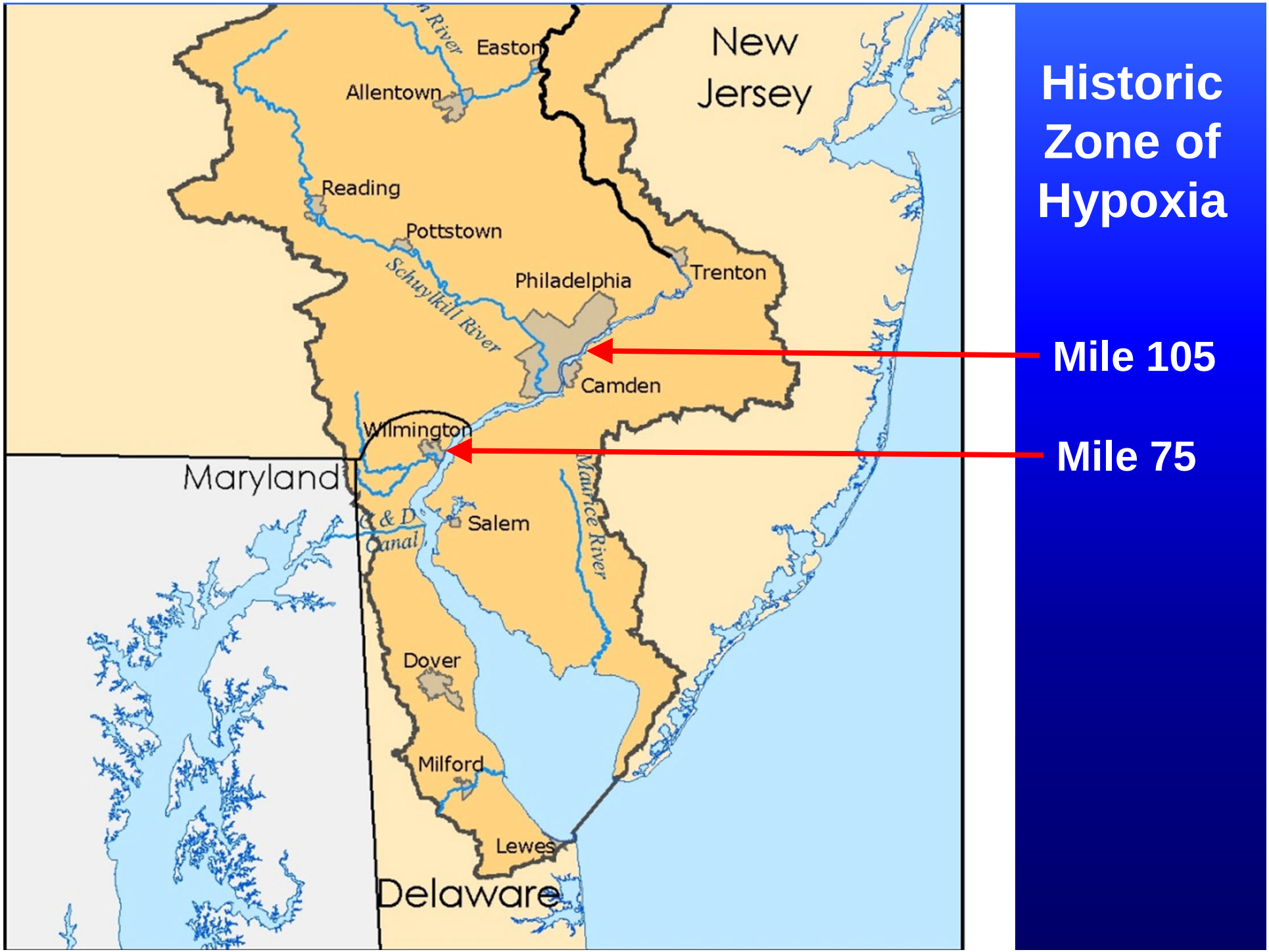
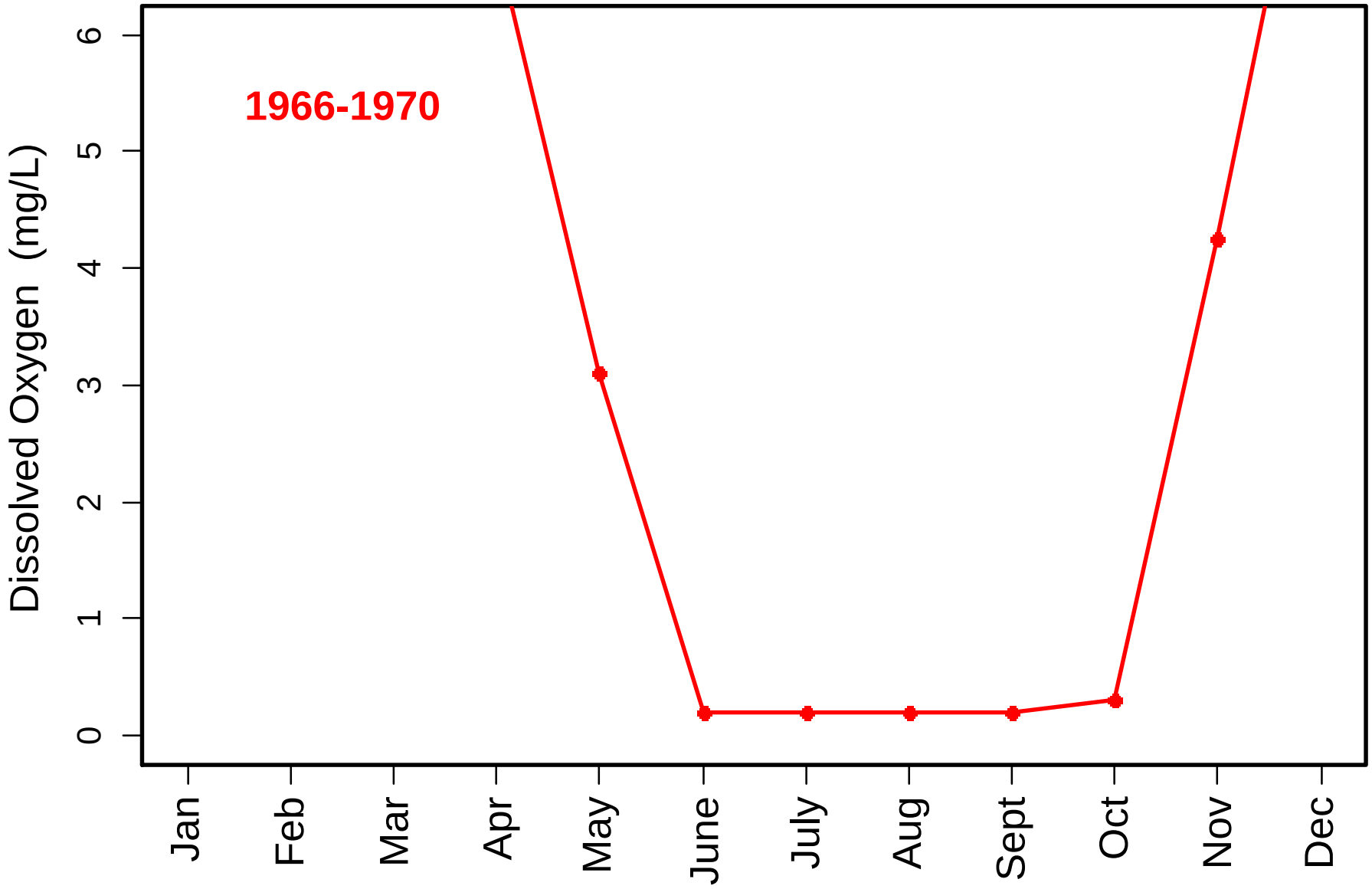
UNITED STATES OF AMERICA


Historic Zone of Hypoxia
Mile 105
Mile 75
New Jersey
Maryland
Delaware
Easton
Allentown
Reading
Pottstown
Philadelphia
Trenton
Schuylkill River
Camden
Wilmington
C & D Canal
Salem
Maurice River
Dover
Milford
Lewes

RM 100

Ben Franklin D.O. - Medians of Daily Values



Hypoxia in the Delaware Estuary

Causes

- untreated & poorly treated municipal and industrial wastewater

Solutions

(1) DRBC Water Quality Standards (1967)

Uses - "maintenance of resident fish and other aquatic life"
and "passage of anadromous fish"

Dissolved Oxygen Criteria

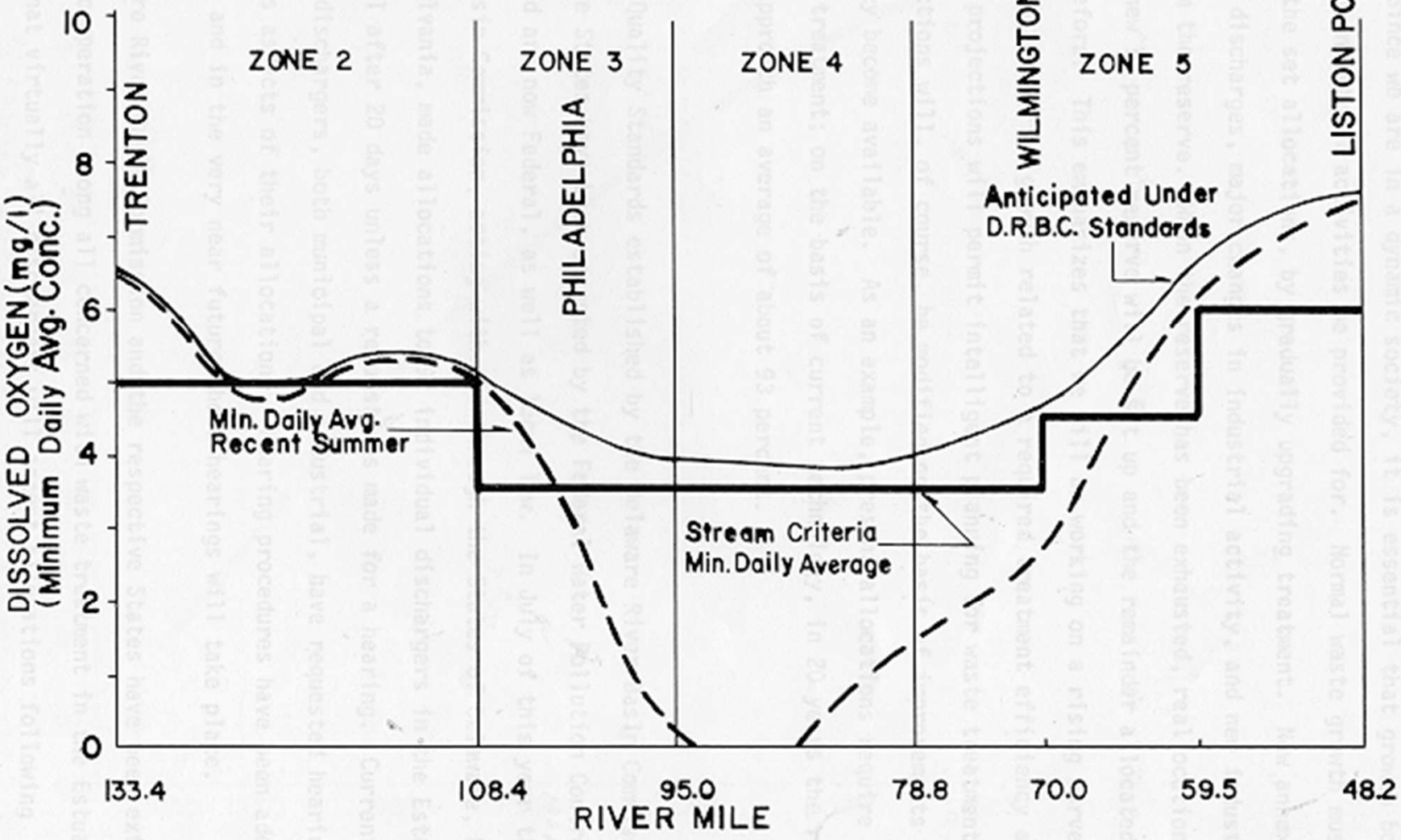
- 6.5 mg/L seasonal average during spring & fall migrations
- 3.5 mg/L daily average at all times

(2) 1968 CBOD Wasteload Allocation

- zone specific
- 85% to 90% removal rates

(3) Clean Water Act grants & loans for upgraded treatment

DISSOLVED OXYGEN PROFILES
DELAWARE ESTUARY



Delaware Estuary D.O. Recovery

Upgraded Secondary Treatment at POTWs

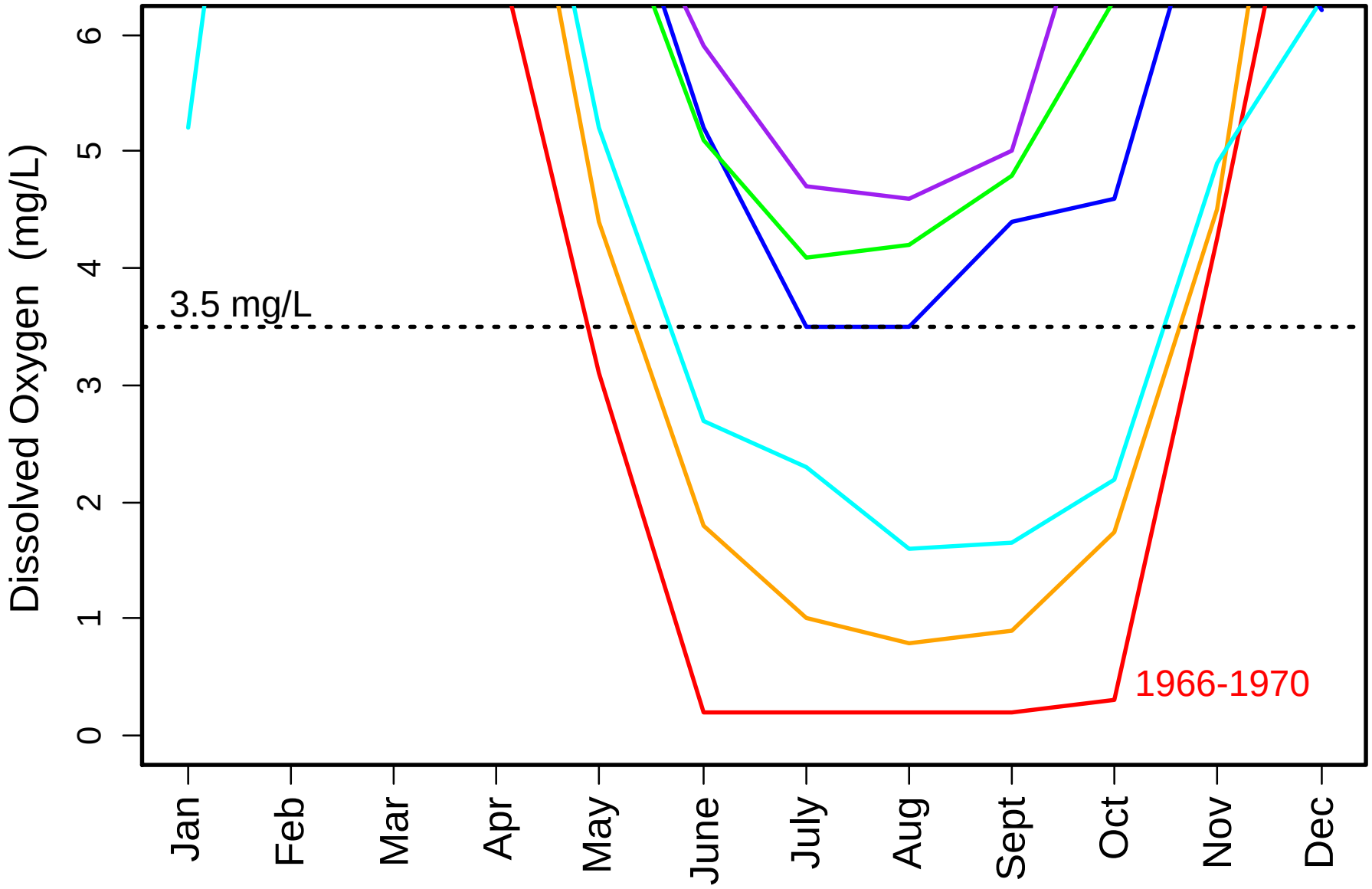
- Wilmington: 1974
- Philadelphia: SW in 1980, NE in 1985, SE in 1986
- DELCORA: 1980
- Camden: 1987

Data & Documentation

- USGS Continuous Water Quality stations
  - → 2 stations in Hypoxia Zone (Ben Franklin, Chester)
  - → 30 min intervals
  - → begun in 1961
- Monthly Boat Surveys w/ DNREC
  - → March thru November
  - → 1 to 3 surveys each month
  - → center-channel for 130 mile length of estuary

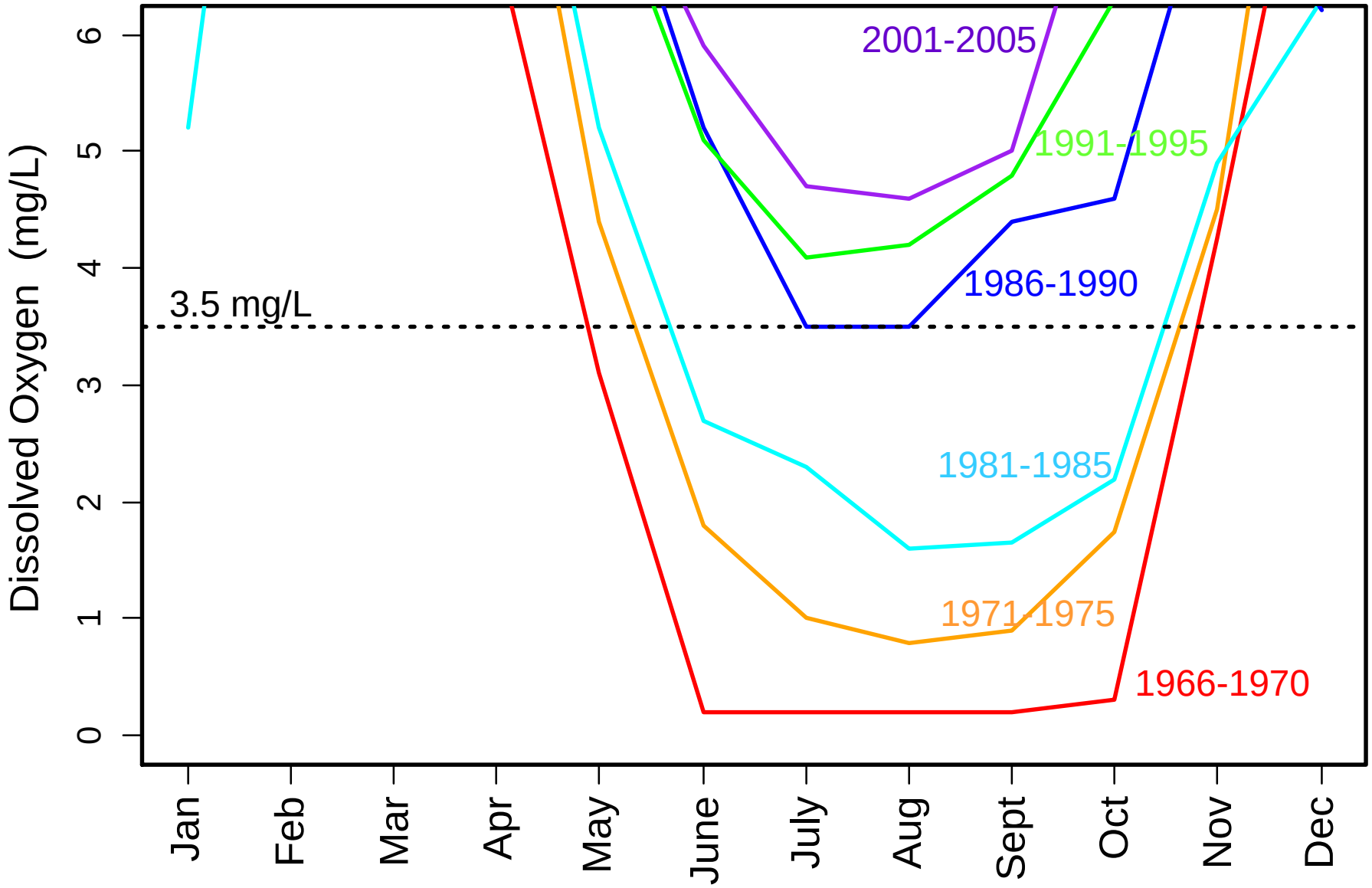
RM 100

Ben Franklin D.O. - Medians of Daily Values



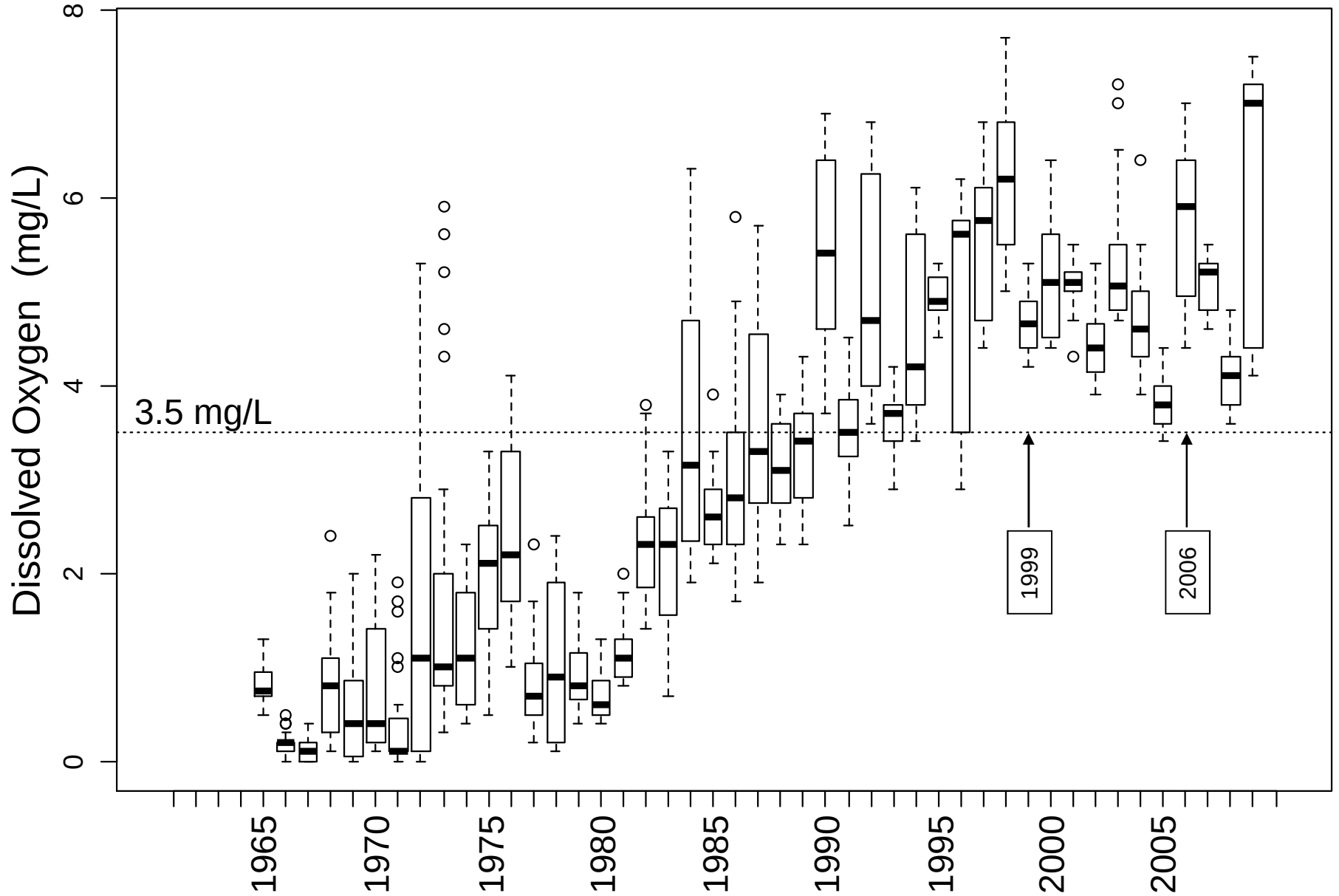
RM 100

Ben Franklin D.O. - Medians of Daily Values

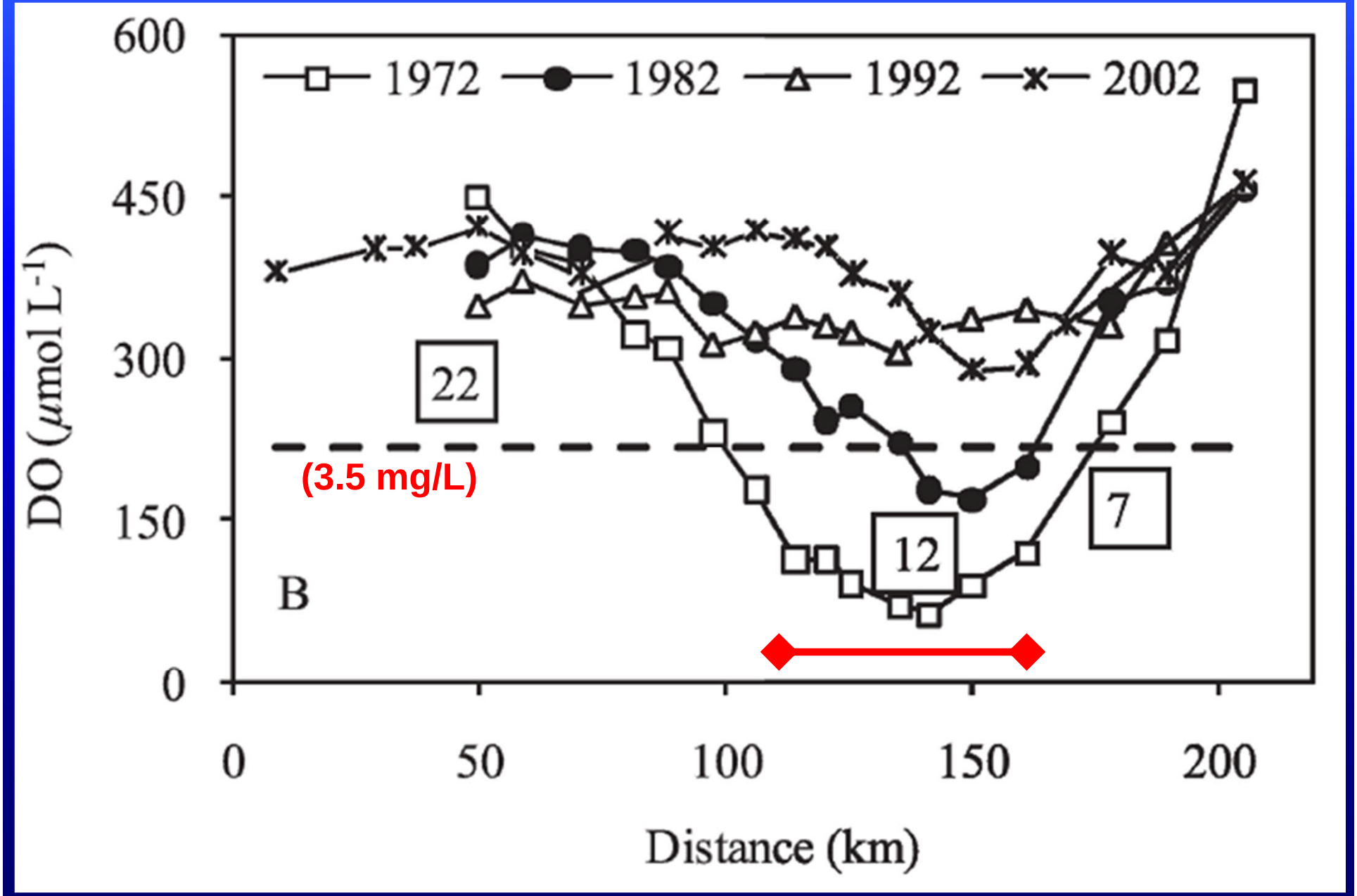


RM 100

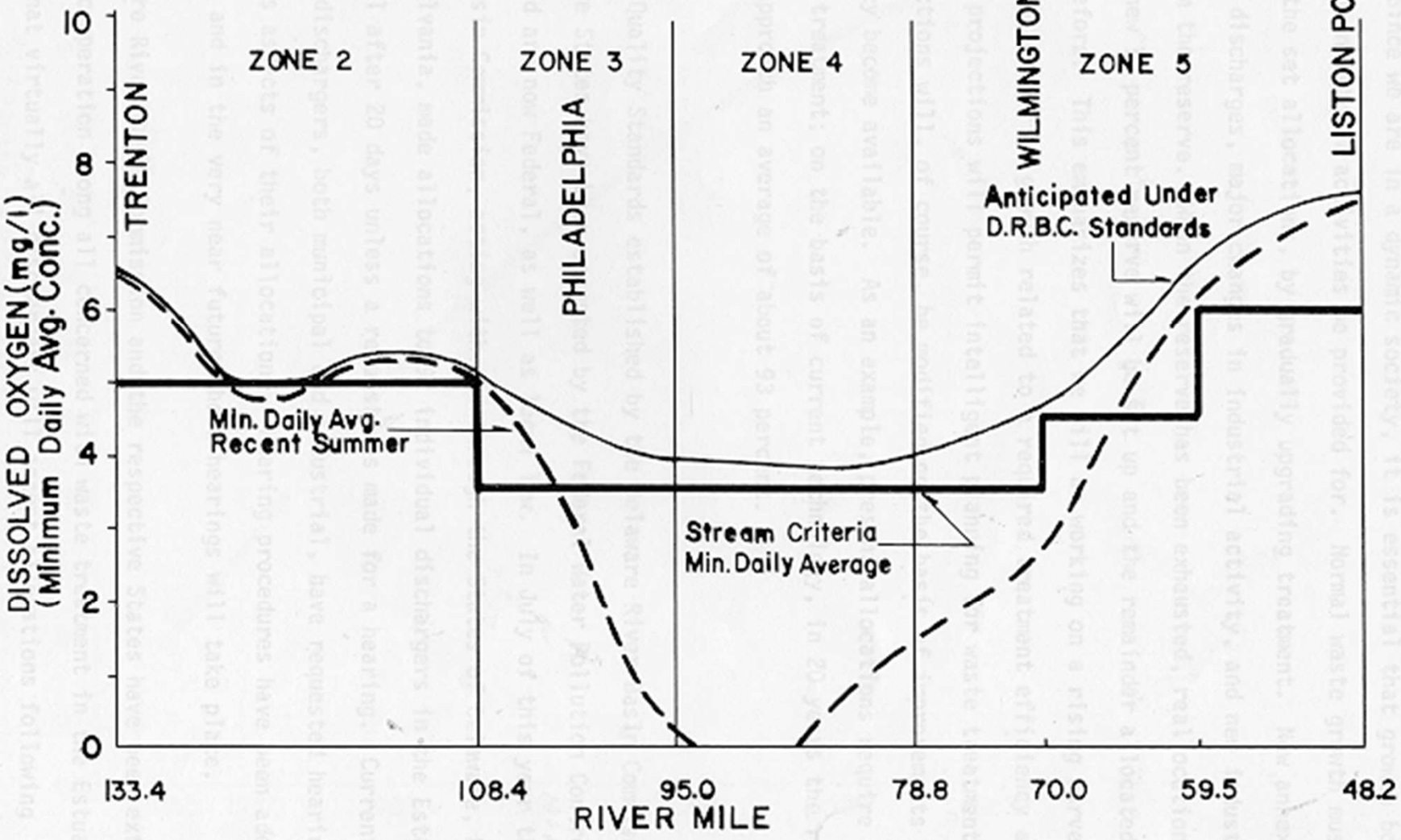
Ben Franklin D.O. - July Data



Boat Run Data (*graph from Sharp 2010*)



DISSOLVED OXYGEN PROFILES
DELAWARE ESTUARY



Summary: Delaware Estuary D.O. Recovery

- Achieved goals (use & criteria) set in 1967
- Earlier recovery near PA / DE state line (ca. 1990)
- Continued recovery at Philadelphia until more recently
- Biological Response
  - → Striped bass spawning
  - → American shad run restoration
  - → Atlantic Sturgeon spawning in 2009 (first in 50 yrs)

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Is the story over? Is the job finished?

Delaware Estuary D.O. Recovery

- **3.5 mg/L ≈ 45% saturation at summer temperatures (26 C)**
- **1967 Use: *maintenance only..... not full aquatic life use***
- **50-100% mortality of juvenile Atlantic Sturgeon at 25 C with ~ 3.5 mg/L D.O. (Secor & Gunderson 1998)**
- **50% mortality of juvenile Shortnose Sturgeon at 25-30 C with ~3.0 mg/L D.O. (Campbell & Goodman 2004)**

Outstanding Issues

(1) NBOD

- **Antiquated discharge limits of 35 mg/L NH_3**
- **Hydroqual 1998 study:** "Oxidation of ammonia is the principal factor decreasing river dissolved oxygen levels and produces a maximum decrease in dissolved oxygen of approximately 2 mg/L during summer low flow conditions. Point source inputs of ammonia account for about 85% of the total ammonia inputs to the study area"

(2) Nutrient Enrichment

- **Delaware Estuary recognized for among the highest nutrient loading rates in the United States**
- **Some algal blooms in upper estuary, but limited**
- **Uncertain effects from nutrients on D.O., other endpoints**

Current Efforts

(1) Capture Progress

- **set use to “existing use”**
- **appropriate D.O. criteria to match change in use**

(2) Identify “Highest Attainable Use”

- **similar to a Use Attainability**
- **set D.O. criteria to match the Highest Attainable Use**
- **demonstrate biological benefits for restoration steps**
- **will involve Estuary Model & extensive monitoring**

Acknowledgements

Tom Fikslin (co-author) & John Yagecic @ DRBC

Members of the Nutrient Management Subcommittee & Water Quality Advisory Committee

USGS Partners for 50 yrs of Data Collaboration

DNREC Partners for 40+ yrs of Data Collaboration

Citations:

Albert, R.C. 1988. Estuaries 11(2): 99-107

Sharp, J.H. 2010. Limn. & Ocean. 55(2): 535-548