

Fish community structure in Lake Erie: continued rehabilitation or a return to degradation?



J.D. Conroy^{1,2}, S.A. Ludsin¹, K. Kayle², J.T. Tyson², R.L. Knight², and D.A. Culver¹

1 – Dept. of EEOB, OSU

2 – DOW, ODNR



Roadmap

- **Introduction:** Identifying LE fish community threats to established goals
- Methods
- Results
- Discussion

Lake Erie fish community goals

- Great Lakes Fishery Commission: Harmonic cool-water percid community

Lake Erie fish community goals

- Great Lakes Fishery Commission: Harmonic cool-water percid community
- To achieve balance:
 - » External P load target = 11,000 metric tonnes (11 Gg)
 - » Western basin [TP] target = 15 mg m⁻³
 - » Central basin [TP] target = 10 mg m⁻³

Lake Erie fish community goals

- Great Lakes Fishery Commission: Harmonic cool-water percid community
- To achieve balance:
 - » External P load target = 11,000 metric tonnes (or Gg)
 - » Western basin [TP] target = 15 mg m⁻³
 - » Central basin [TP] target = 10 mg m⁻³
- Expected outcomes
 - » Controlled phytoplankton abundance (PP)
 - » Year-round aerobic central basin hypolimnion (not realistic)
 - » Adequate Lower Trophic Level and Forage Fish base

Lake Erie changes: Planned management



Lake Erie changes: Un-planned threats

Spiny water flea

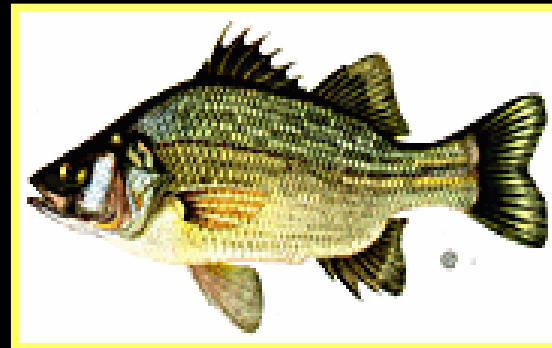


Dreissenids



1970

**Phosphorus
abatement**



White perch

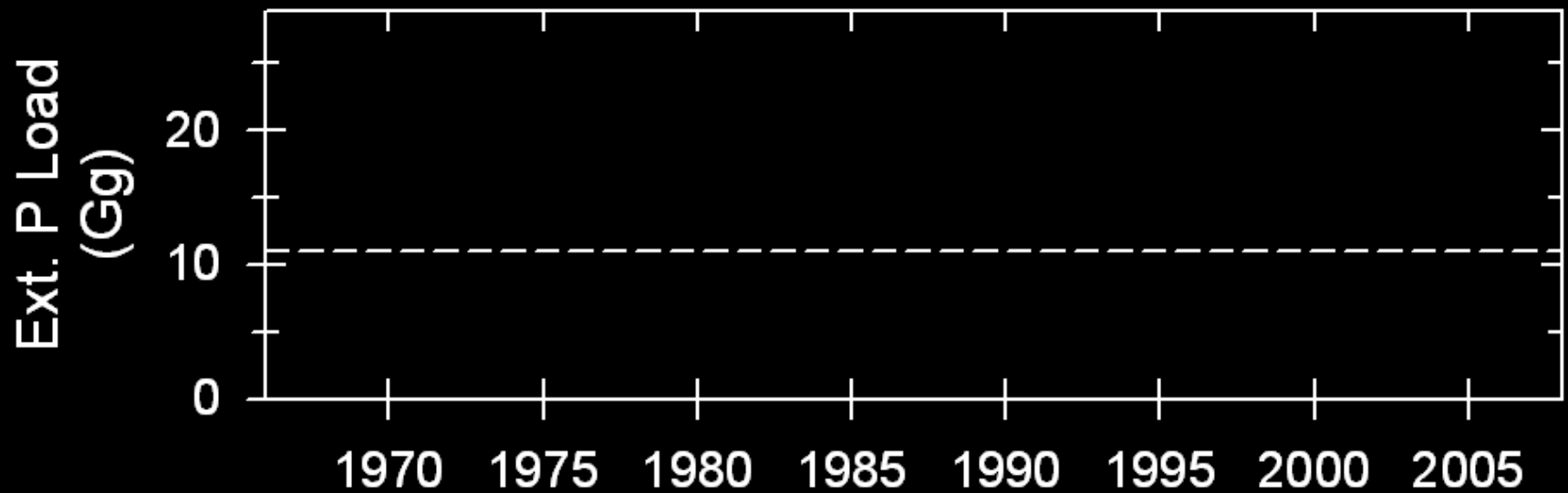
2000



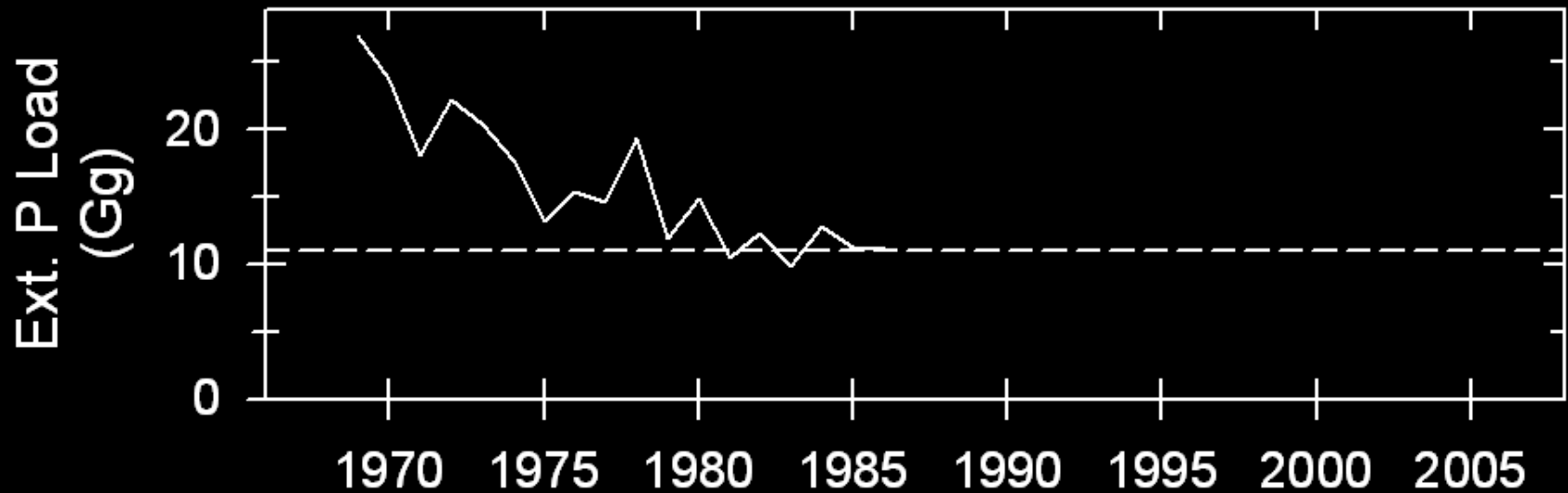
Round goby

Phosphorus load changes

Phosphorus load changes

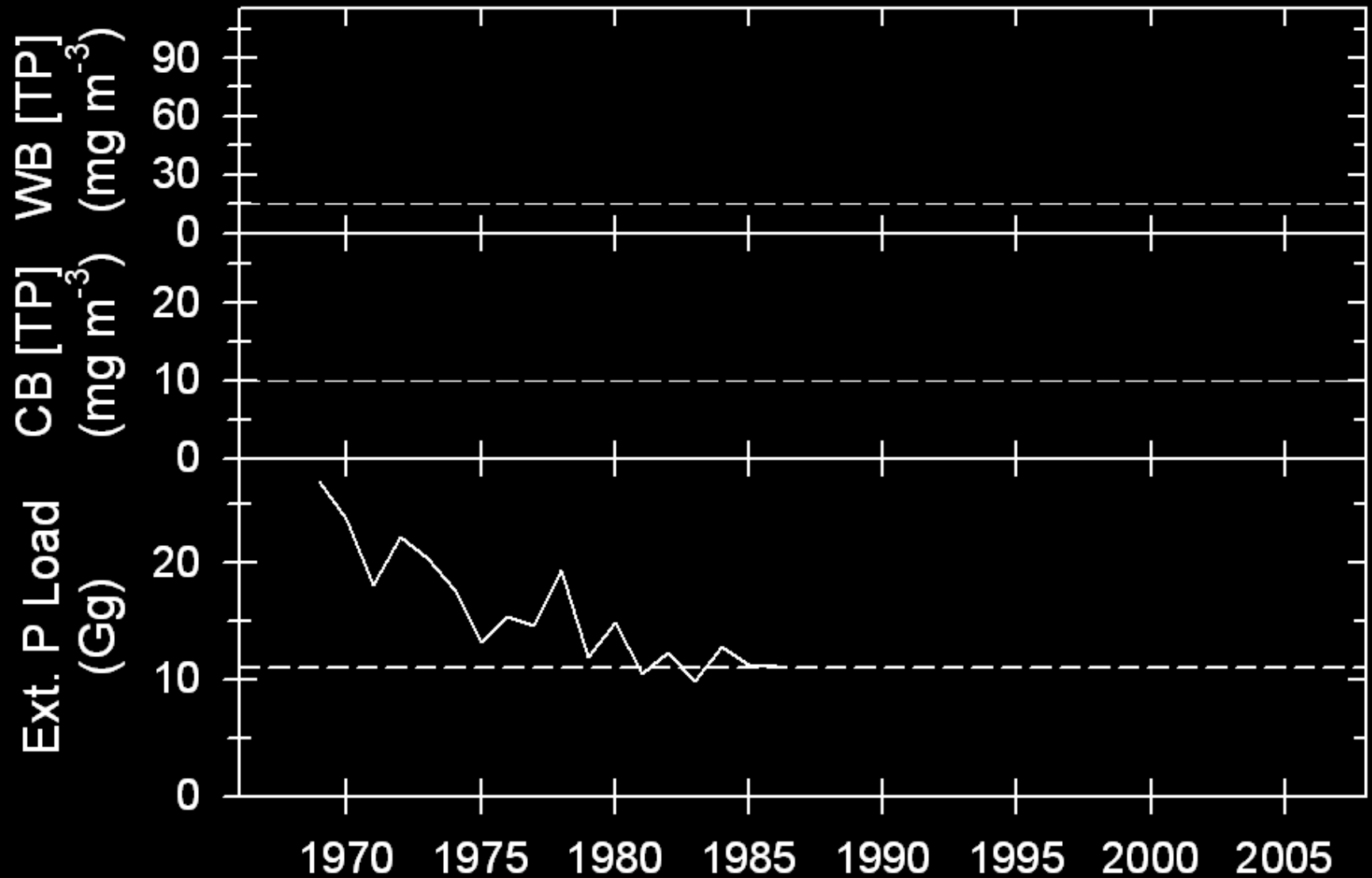


Phosphorus load changes

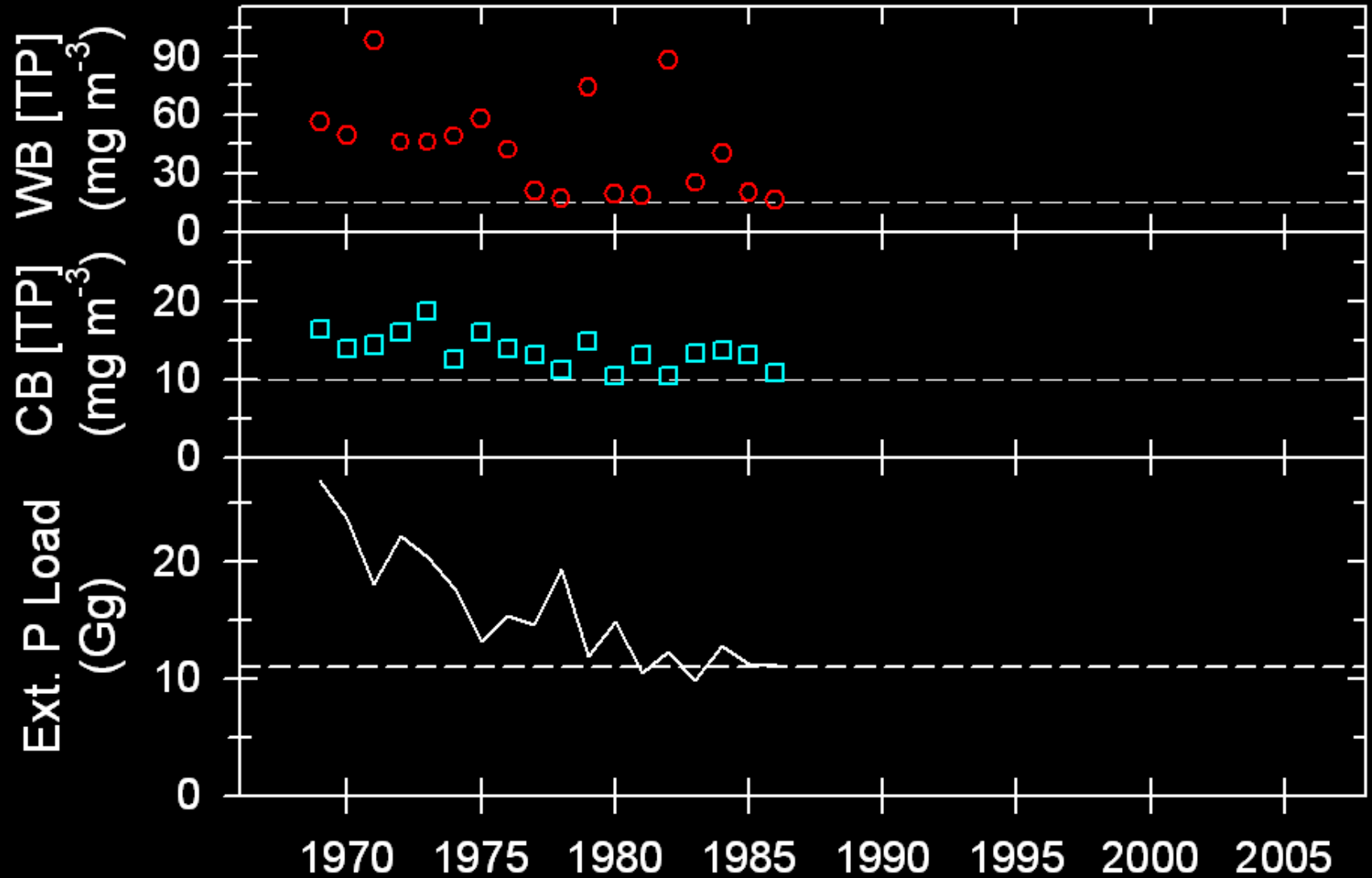


Data from Dolan 1993, Dolan pers. comm.

Phosphorus load changes

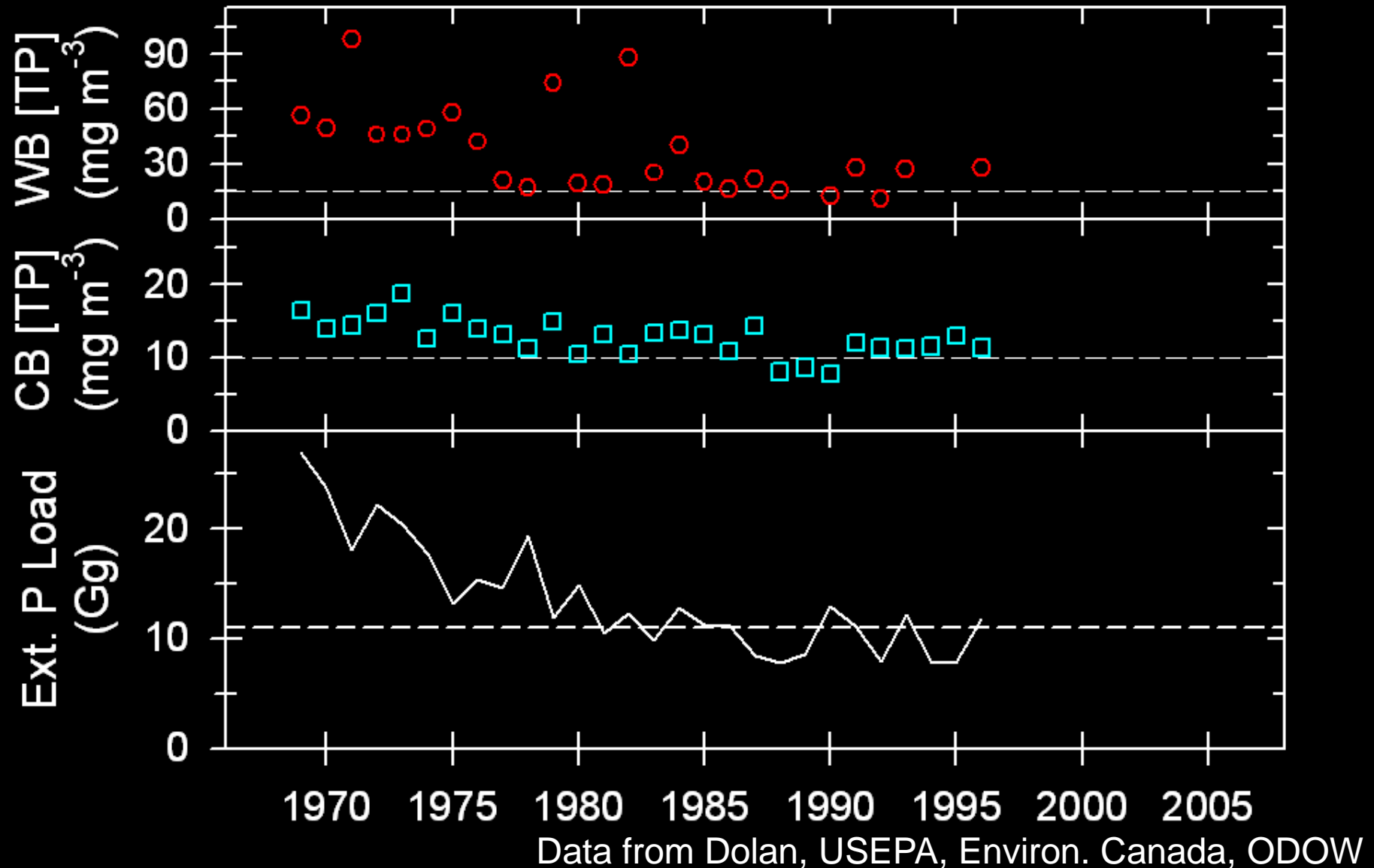


Phosphorus load changes

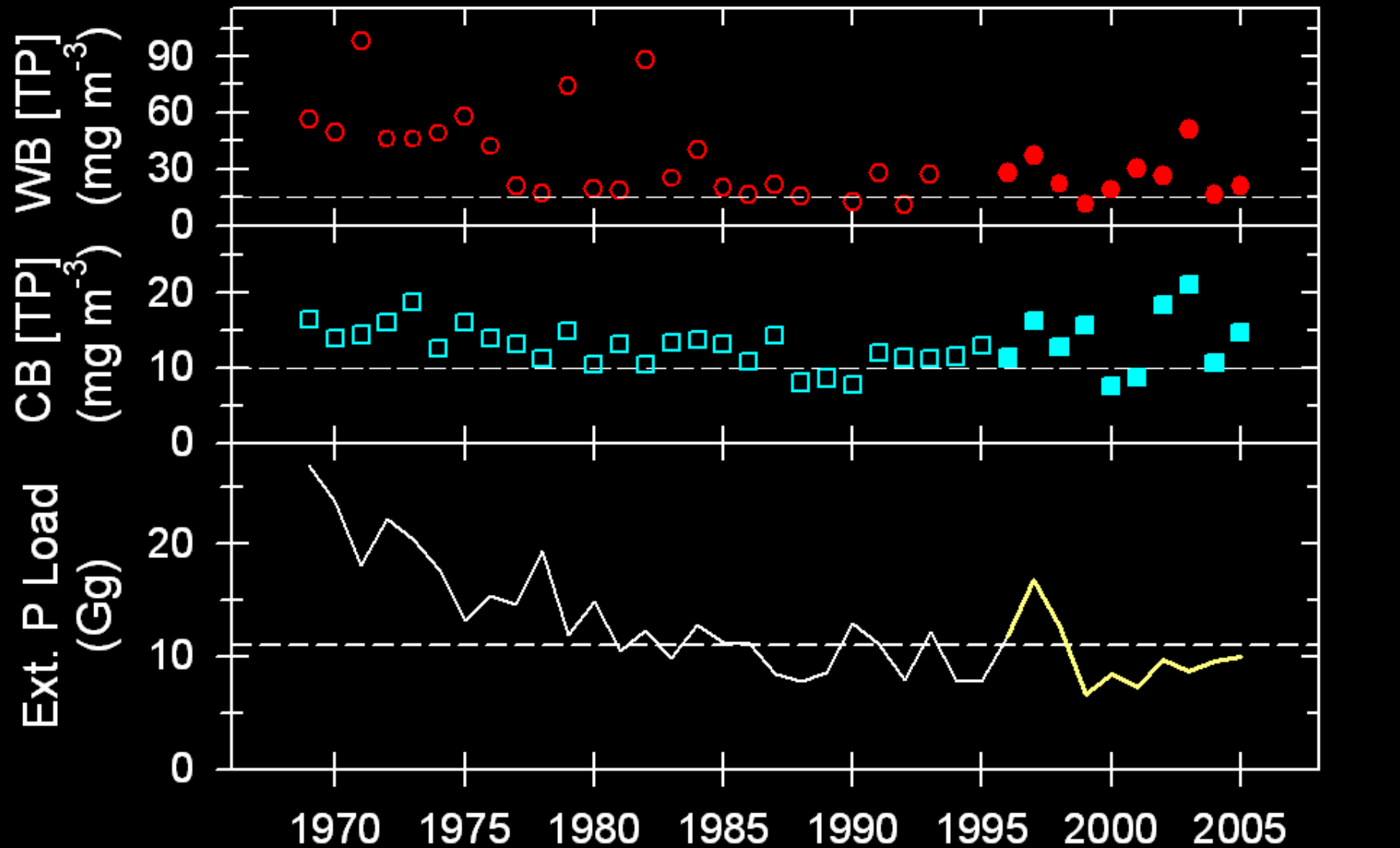


Data from USEPA, Environ. Canada, ODOW

Phosphorus load changes

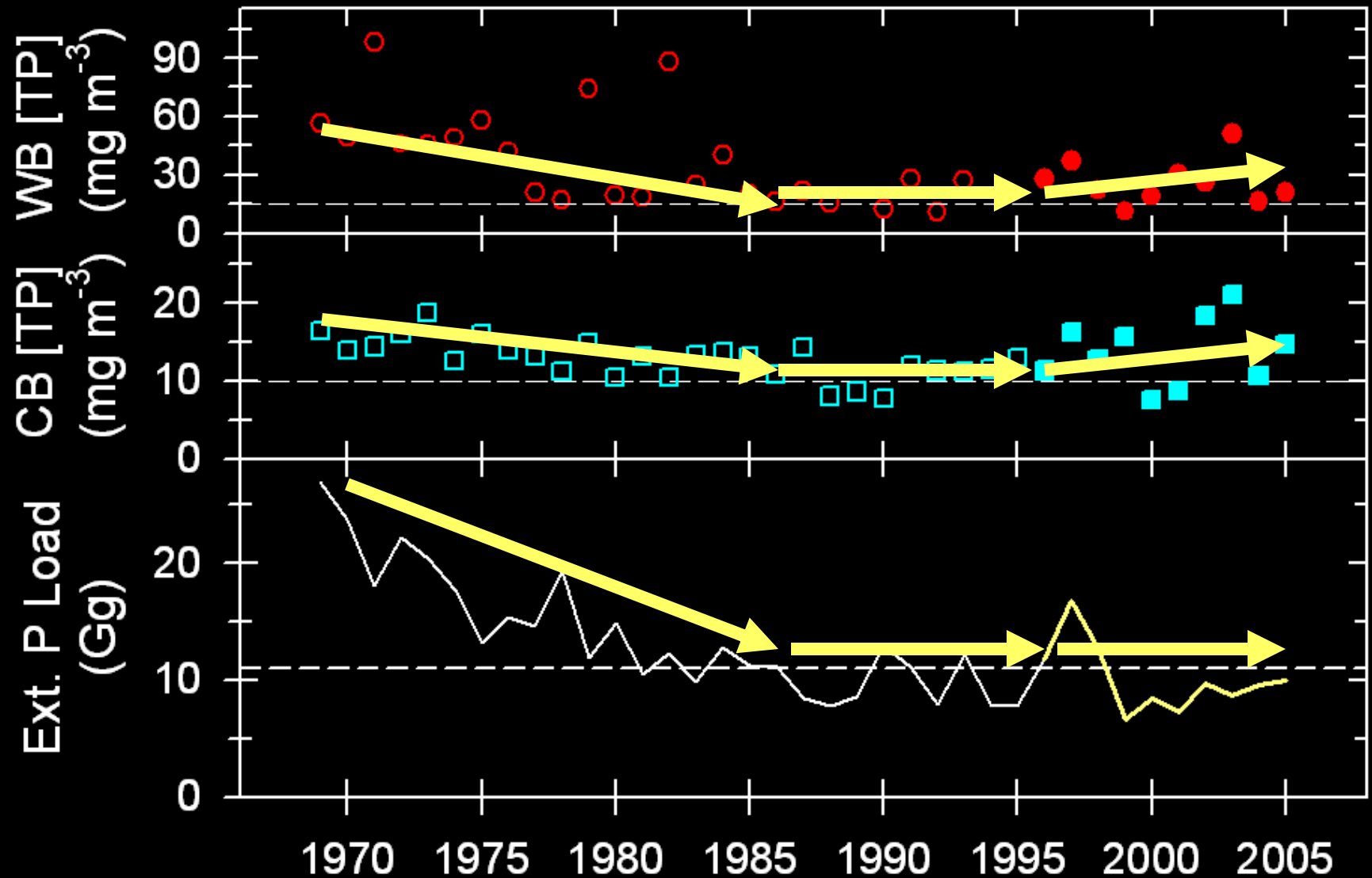


Phosphorus load changes

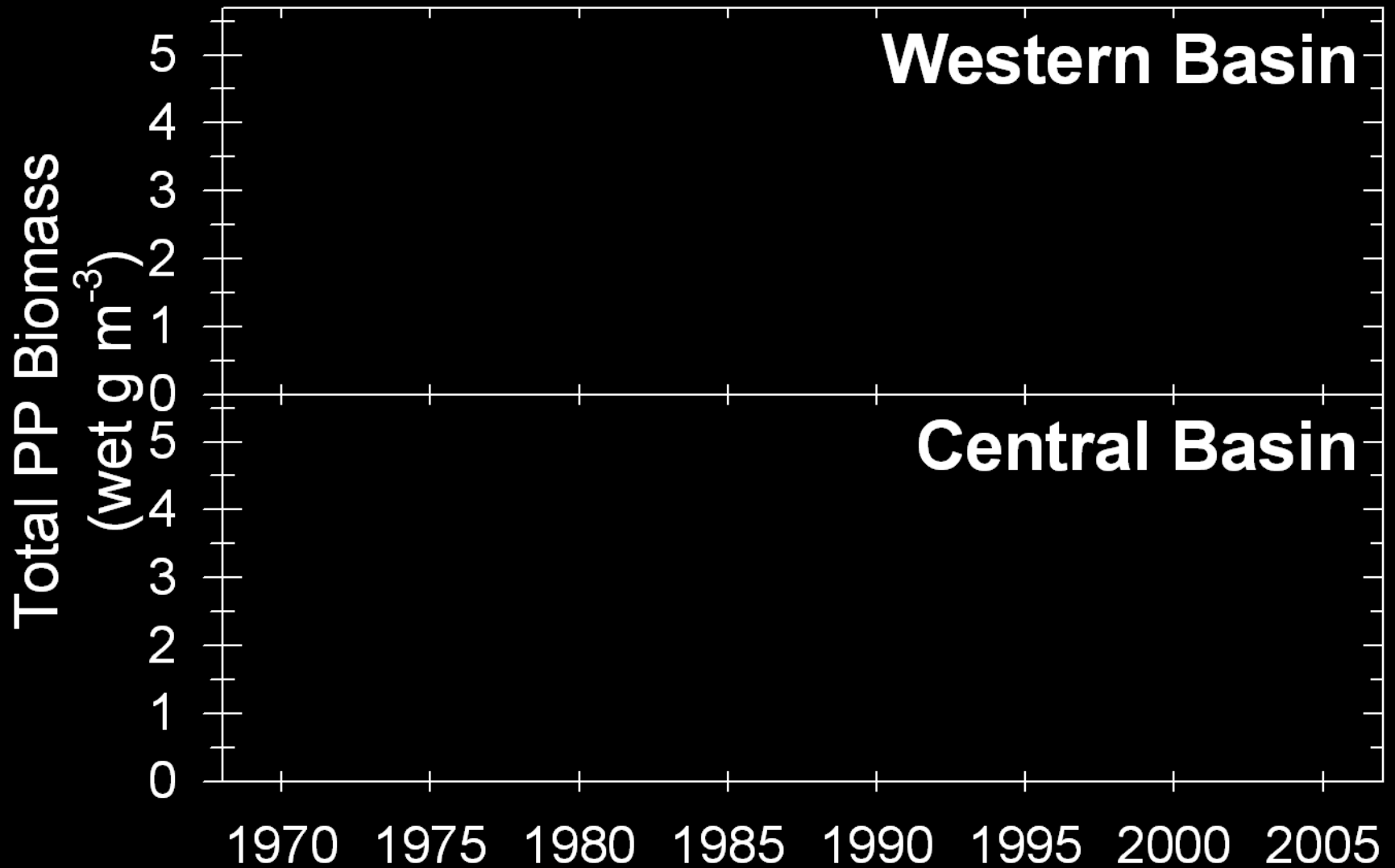


Data from Dolan & McGunagle, USEPA, Environ. Canada, ODOW

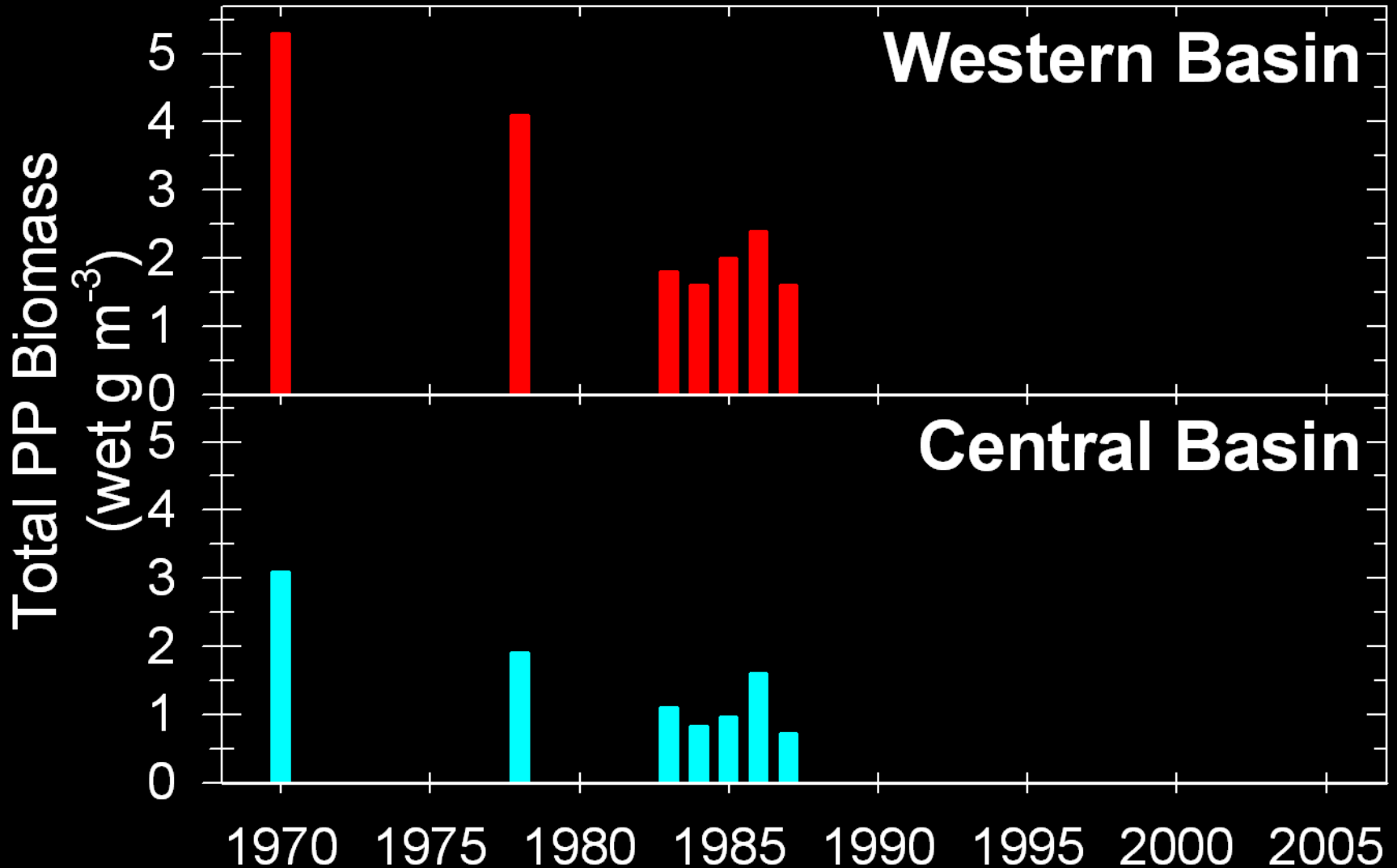
Phosphorus load changes



Phytoplankton community changes

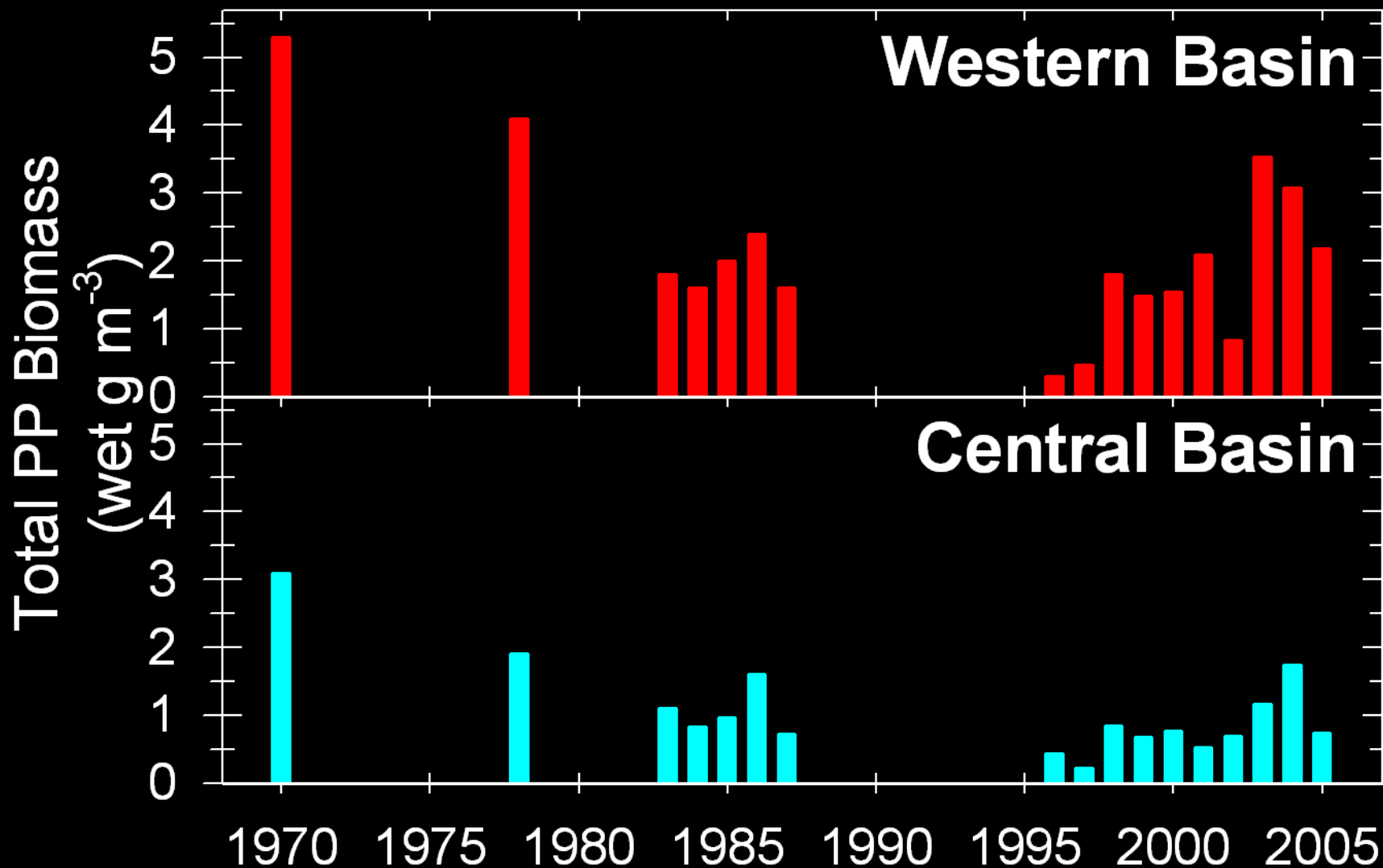


Phytoplankton community changes



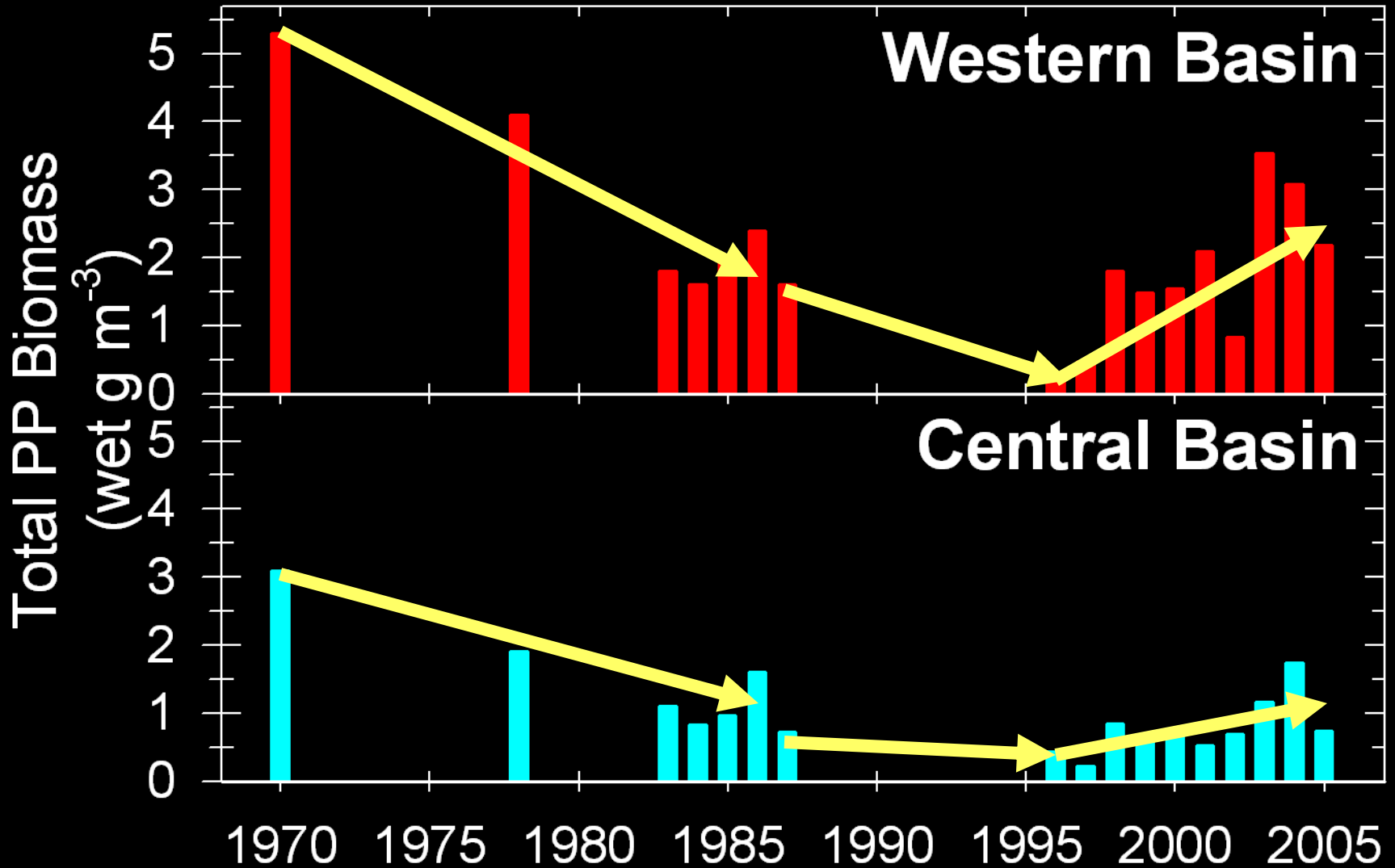
Data from Munawar & Munawar 1976, DeVault & Rockwell 1986,
Makarewicz 1993

Phytoplankton community changes



Data from Munawar & Munawar 1976, DeVault & Rockwell 1986, Makarewicz 1993, Conroy et al. 2005, unpub. LEPAS data

Phytoplankton community changes



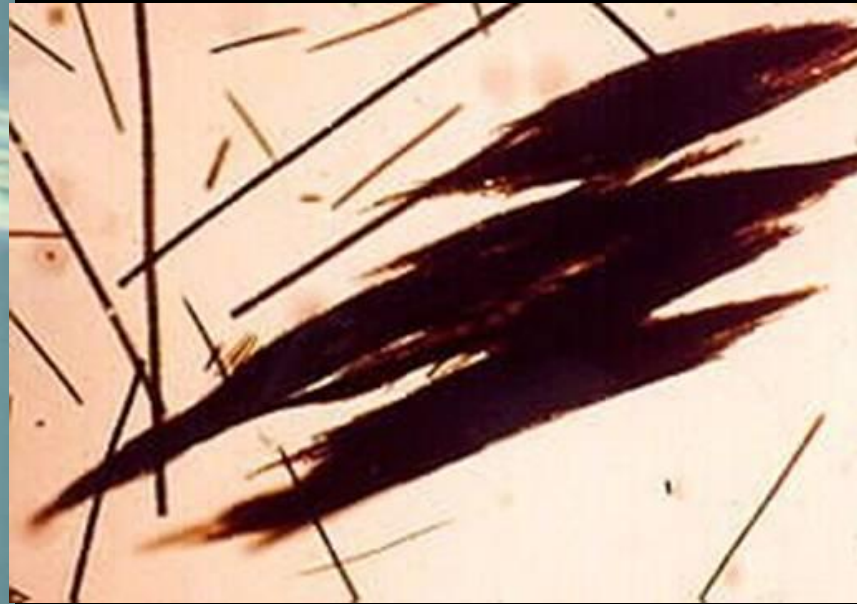
Data from Munawar & Munawar 1976, DeVault & Rockwell 1986, Makarewicz 1993, Conroy et al. 2005, unpub. LEPAS data

Phytoplankton community changes

Anabaena
“Annie”

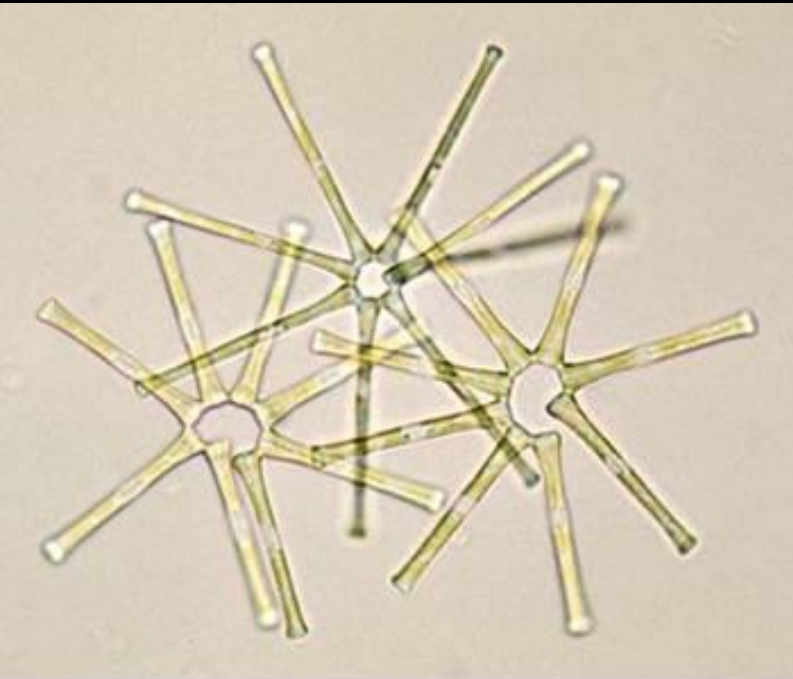


Aphanizomenon
“Fannie”



Lake Erie 1970's

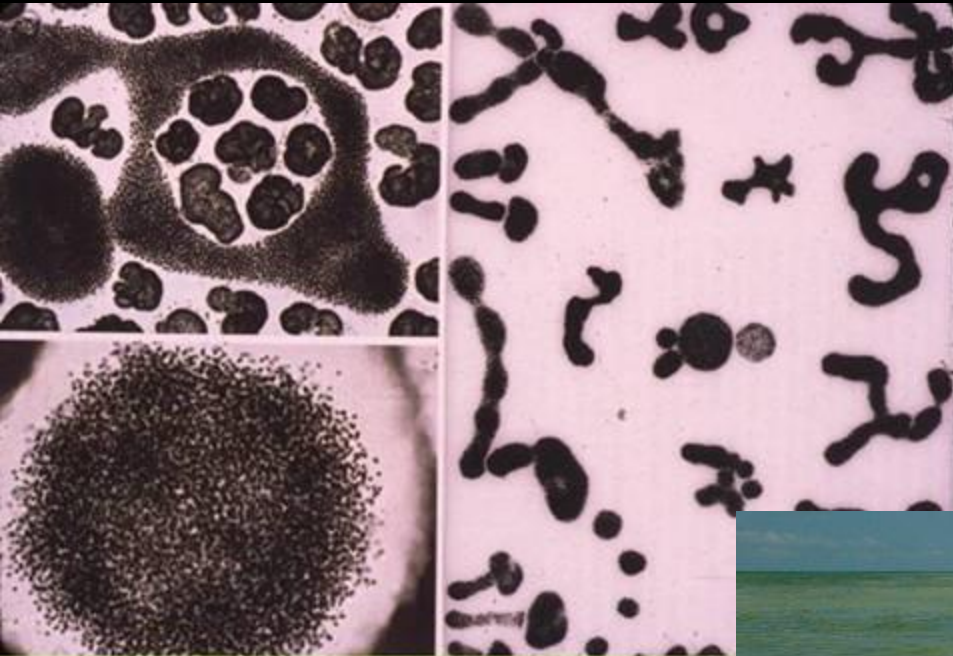
Phytoplankton community changes



Lake Erie 1980s



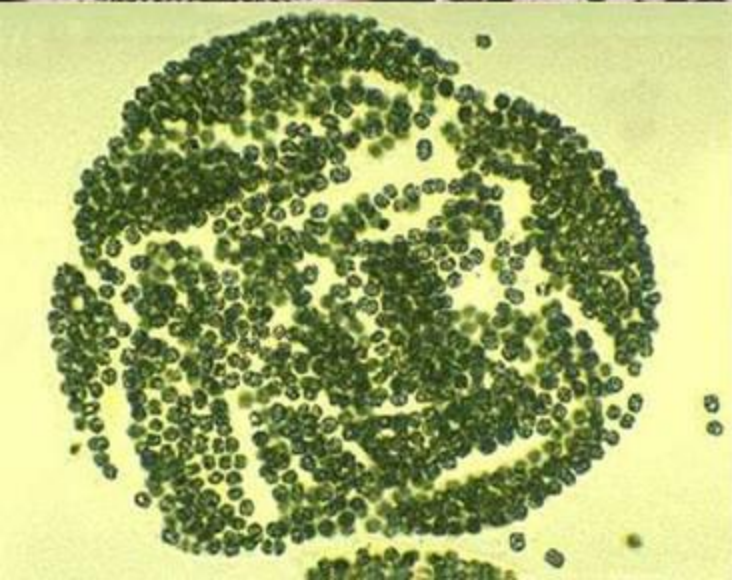
Phytoplankton community changes



Microcystis

“Mike”

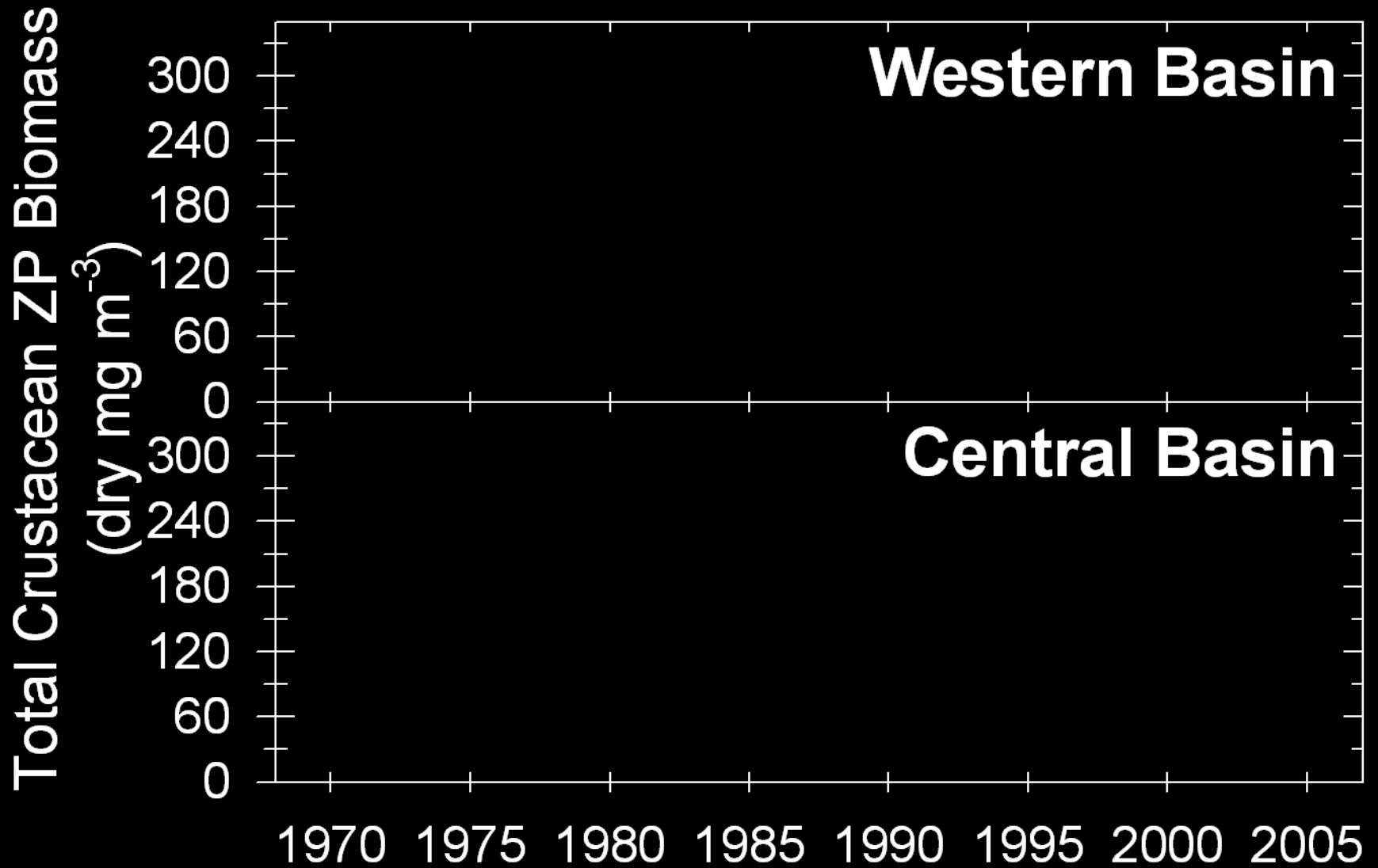
Lake Erie Now



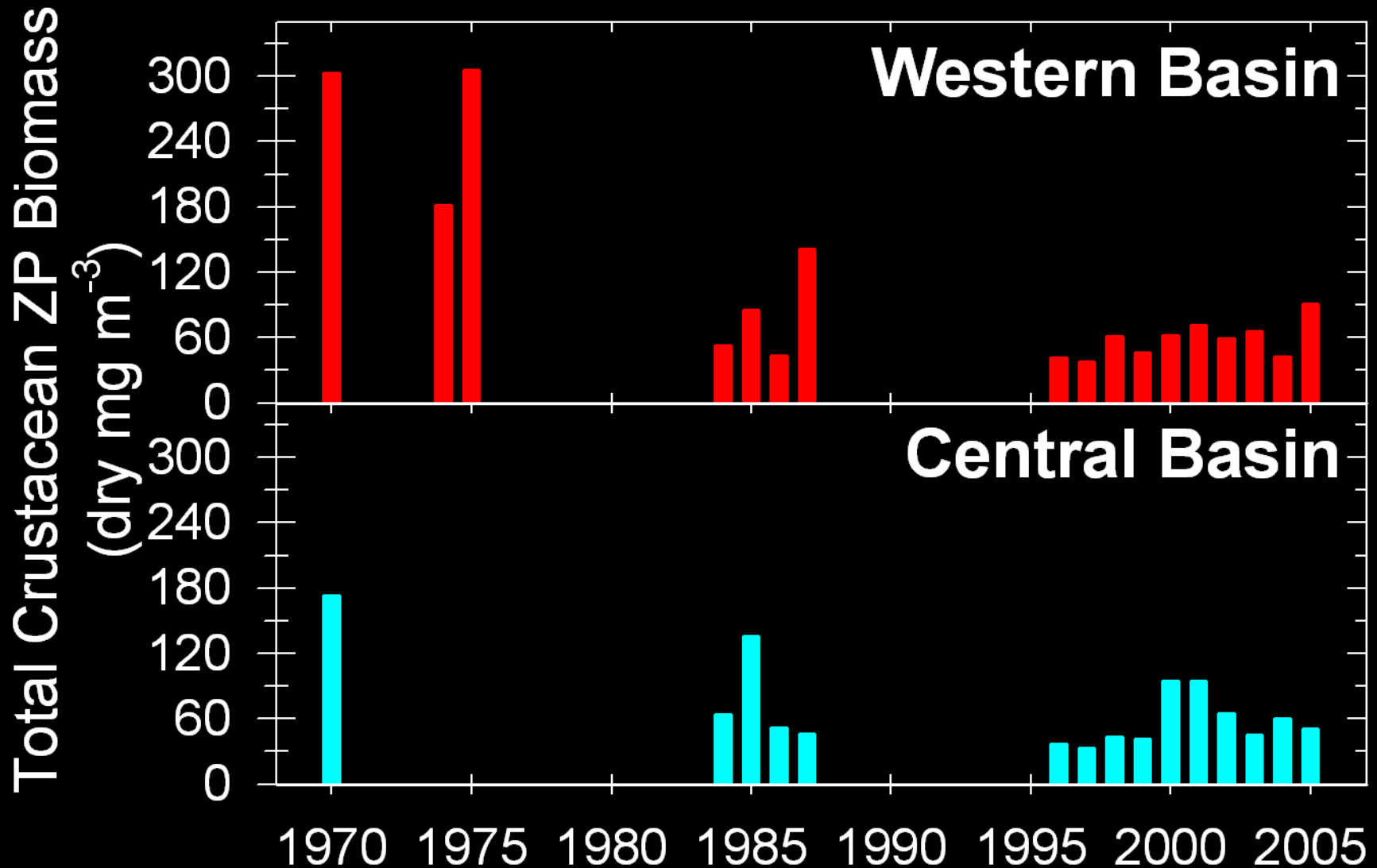
Lake Erie
August 2009

Zooplankton community changes

Zooplankton community changes

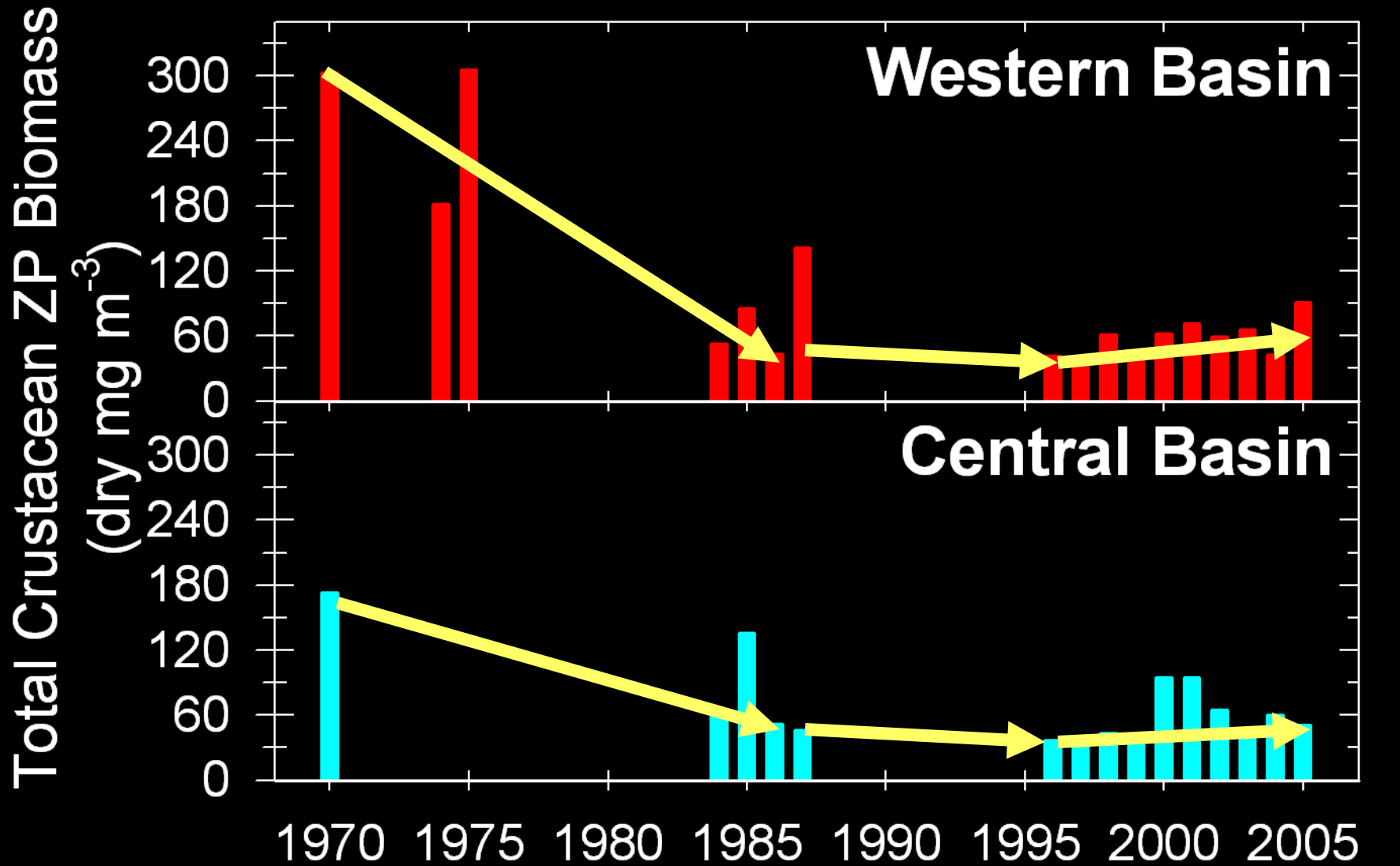


Zooplankton community changes



Data from Watson & Carpenter 1976, unpub. CLEAR data, Makarewicz 1993, Conroy et al. 2005, unpub. LEPAS data

Zooplankton community changes



Data from Watson & Carpenter 1976, unpub. CLEAR data, Makarewicz 1993, Conroy et al. 2005, unpub. LEPAS data

Hypotheses

- Recent increased [TP], Phytoplankton, and Zooplankton lead to:

Hypotheses

- Recent increased [TP], Phytoplankton, and Zooplankton lead to:
- H_1 : Shift from benthivore to planktivore dominance

Hypotheses

- Recent increased [TP], Phytoplankton, and Zooplankton lead to:
- H_1 : Shift from benthivore to planktivore dominance
- H_2 : Shift to bottom-up control of the fish community

Roadmap

- Introduction
- **Methods: Determining fish community response**
- Results
- Discussion

Approach

- Synthetic, systemic
 - » Abiotic/biotic patterns and processes
 - » Internal/external forcing functions
 - » Density-dependent & independent controls

Approach

- Synthetic, systemic
 - » Abiotic/biotic patterns and processes
 - » Internal/external forcing functions
 - » Density-dependent & independent controls

- Today, therefore:

- » Will focus on bottom-up signal detection
- » Will directly compare post-1996 to pre-1996 periods

Ludsin et al. 2001. Life after death in Lake Erie: nutrient controls drive fish species richness, rehabilitation. *Ecol. Appl.* 11: 731–746.

Their findings for 1969-1996:

Declining tolerant fish spp., increasing intolerant spp.

Approach

- Synthetic, systemic
 - » Abiotic/biotic patterns and processes
 - » Internal/external forcing functions
 - » Density-dependent & independent controls
- Today, therefore:
 - » Will focus on bottom-up signal detection
 - » Will directly compare post-1996 to pre-1996 periods
 - Ludsin et al. 2001. Life after death in Lake Erie: nutrient controls drive fish species richness, rehabilitation. *Ecol. Appl.* 11: 731–746.

Examining life after “Life after death in Lake Erie”

Data sources

- DOW bottom trawls
 - » October 1969–2008
 - » Western & central basins

Data sources

- DOW bottom trawls
 - » October 1969–2008
 - » Western & central basins
- Community analyses
 - » Walleye age-0 prey species: planktivores vs. benthivores

Roadmap

- Introduction
- Methods
- **Results: Detecting signals**
- Discussion

Walleye Prey Species

Planktivores

- preferred
- ↑ caloric value



Alewife

Emerald shiner
Spottail shiner
Gizzard shad
Rainbow smelt

Benthivores

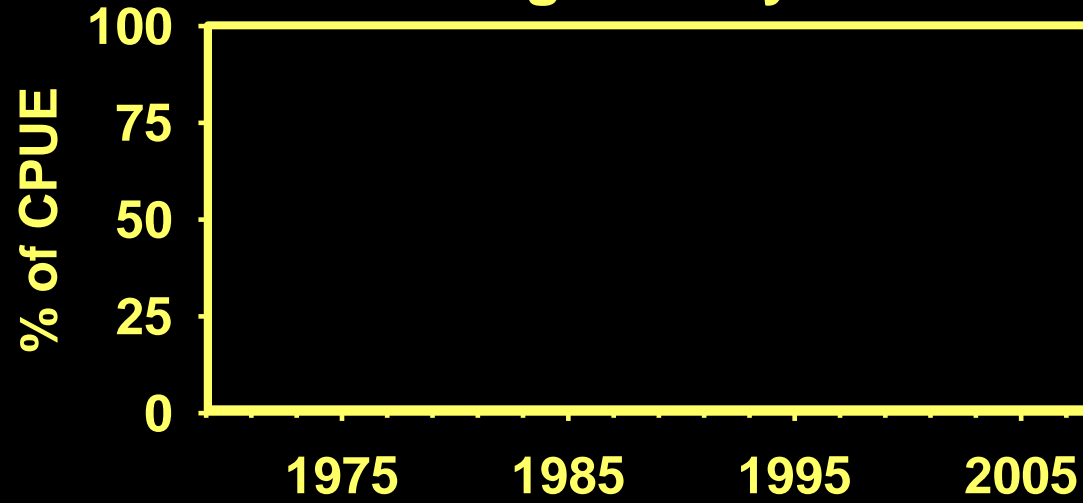
- non-preferred
- ↓ caloric value



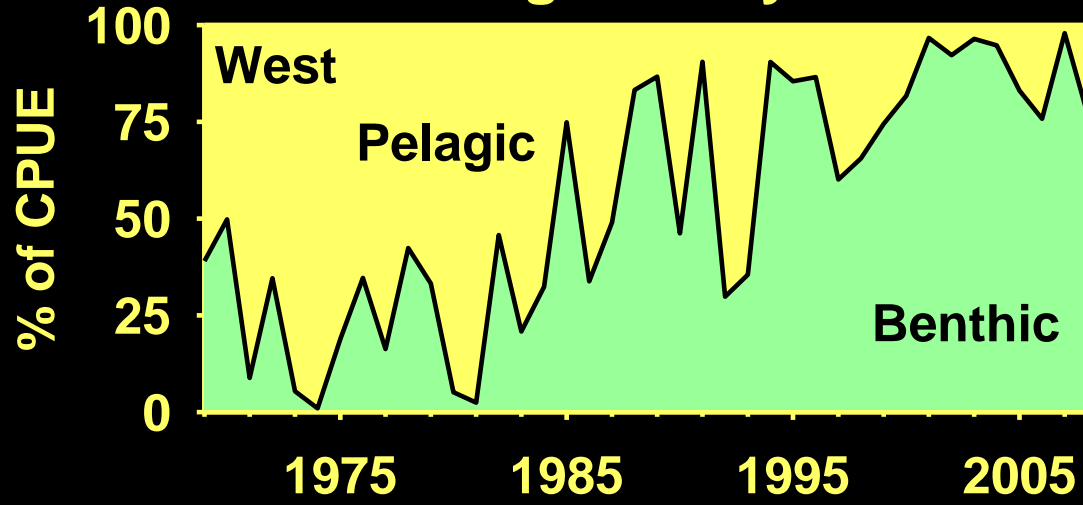
Freshwater drum

White bass
Yellow perch
Trout-perch
White perch
Round goby

Age-0 Prey

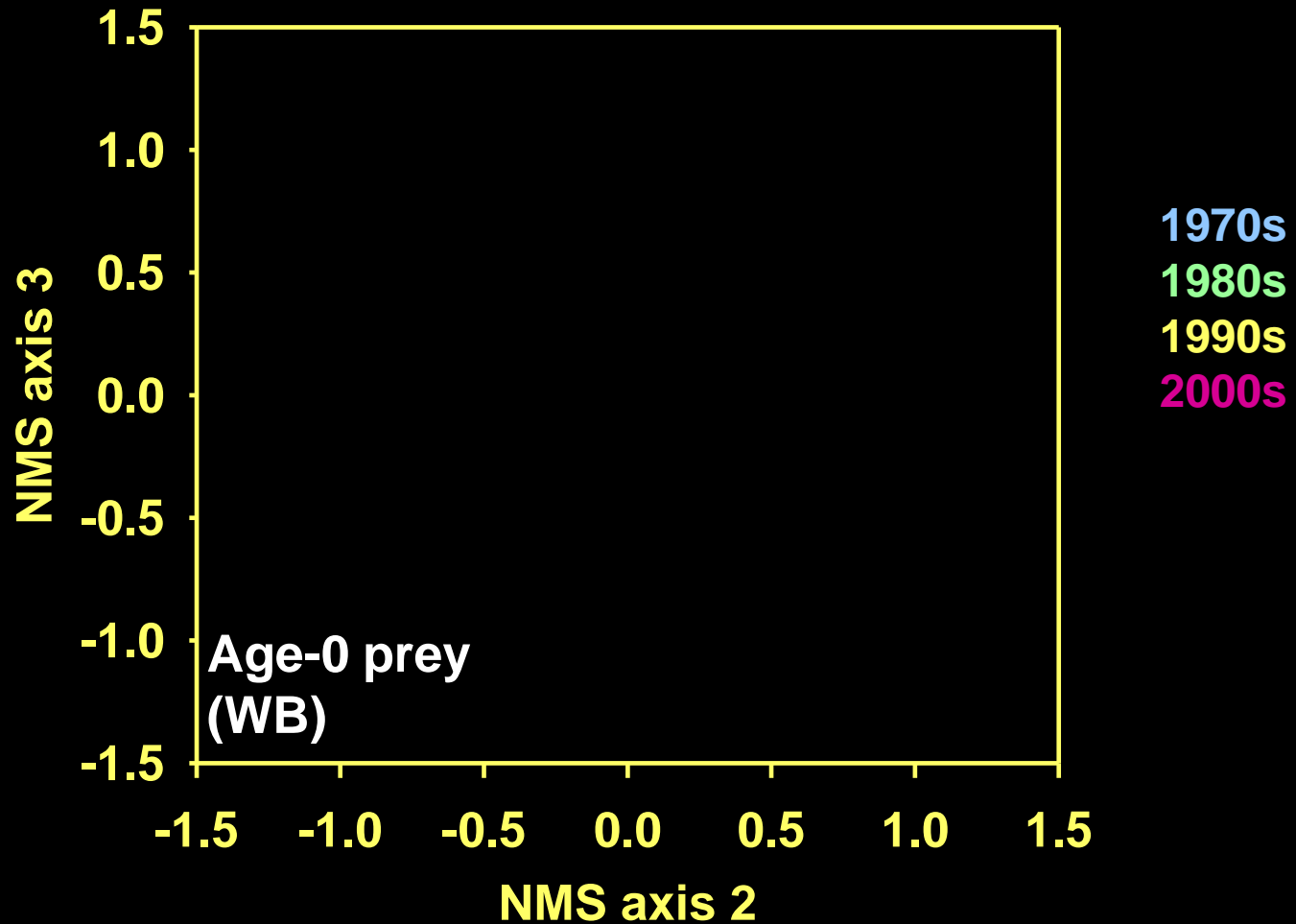


Age-0 Prey



Year

Walleye Prey Species



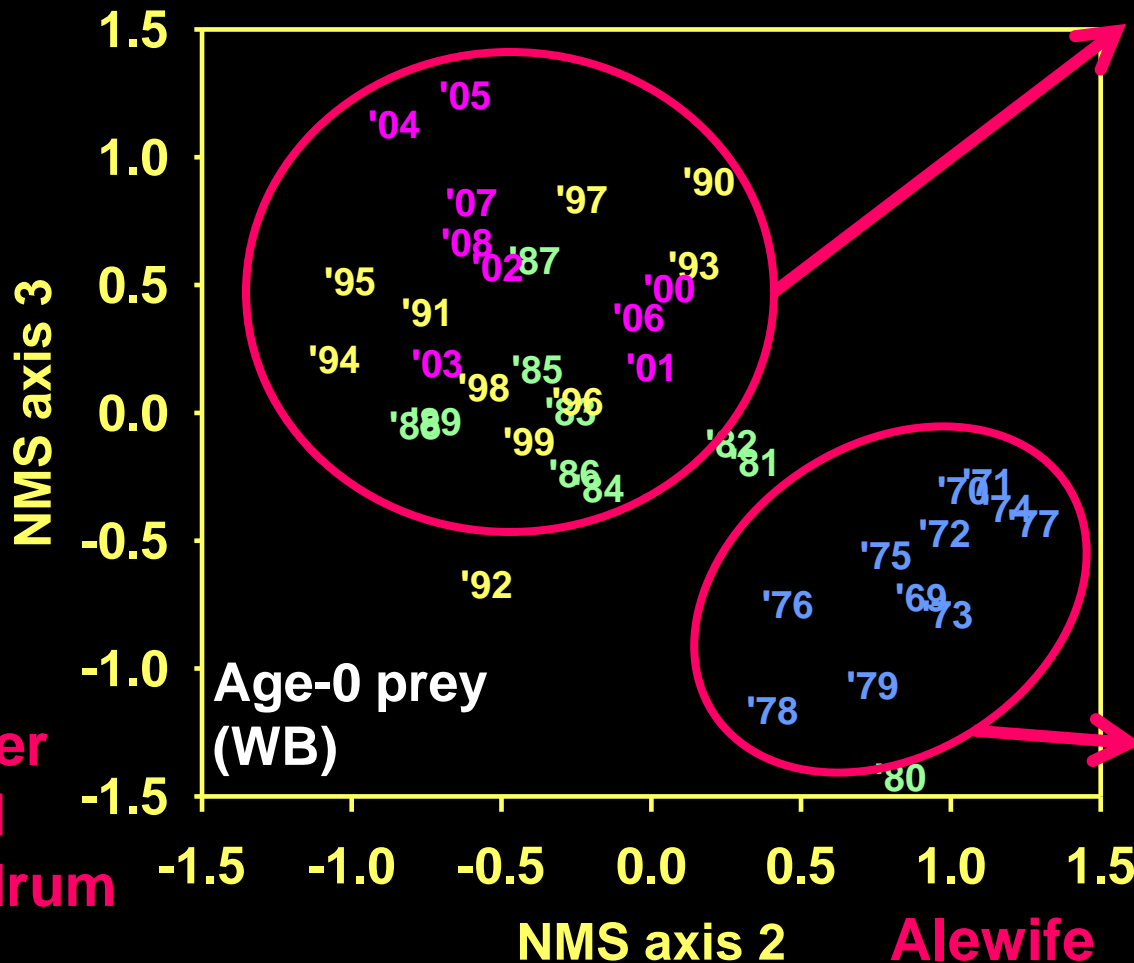
NMS ordination = non-metric multidimensional scaling

Walleye Prey Species

White perch
Trout perch

$R^2 = 0.30$

Alewife
Spottail shiner
Gizzard shad
Freshwater drum



Non-preferred,
Benthic

1970s
1980s
1990s
2000s

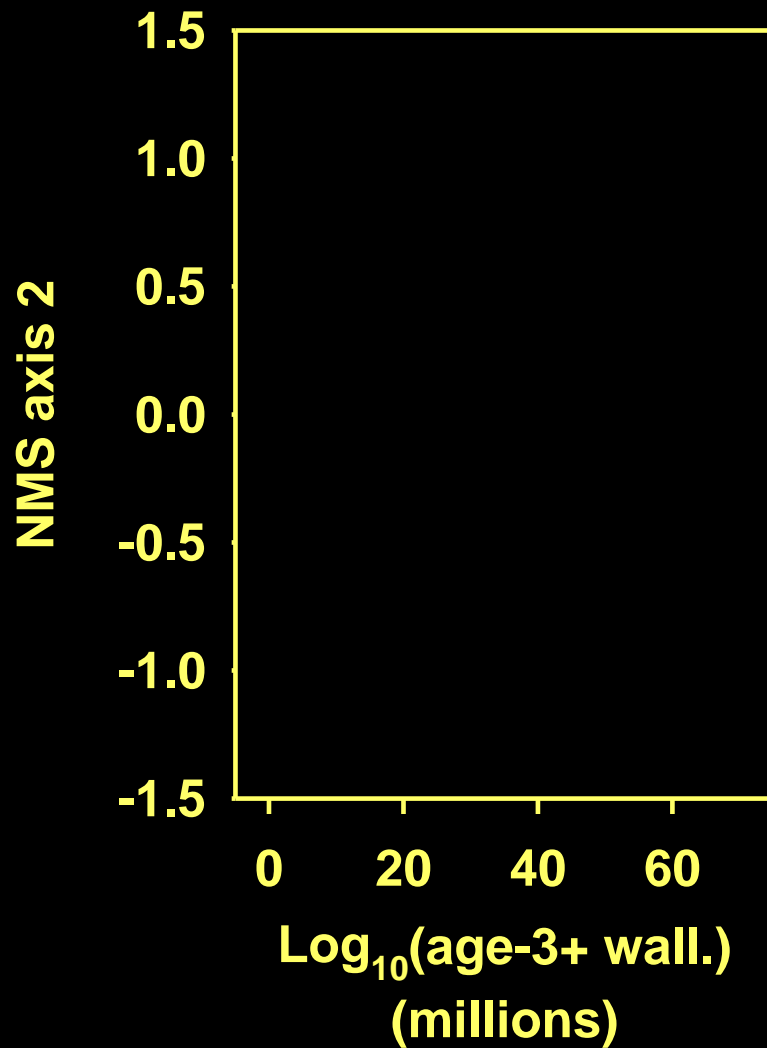
Preferred,
Pelagic

White perch
Trout perch

$R^2 = 0.59$

Alewife
Spottail shiner
Emerald shiner
Gizzard shad
White bass

Walleye Prey Species



Walleye Prey Species

Planktivores

Alewife

Spottail shiner

Emerald shiner

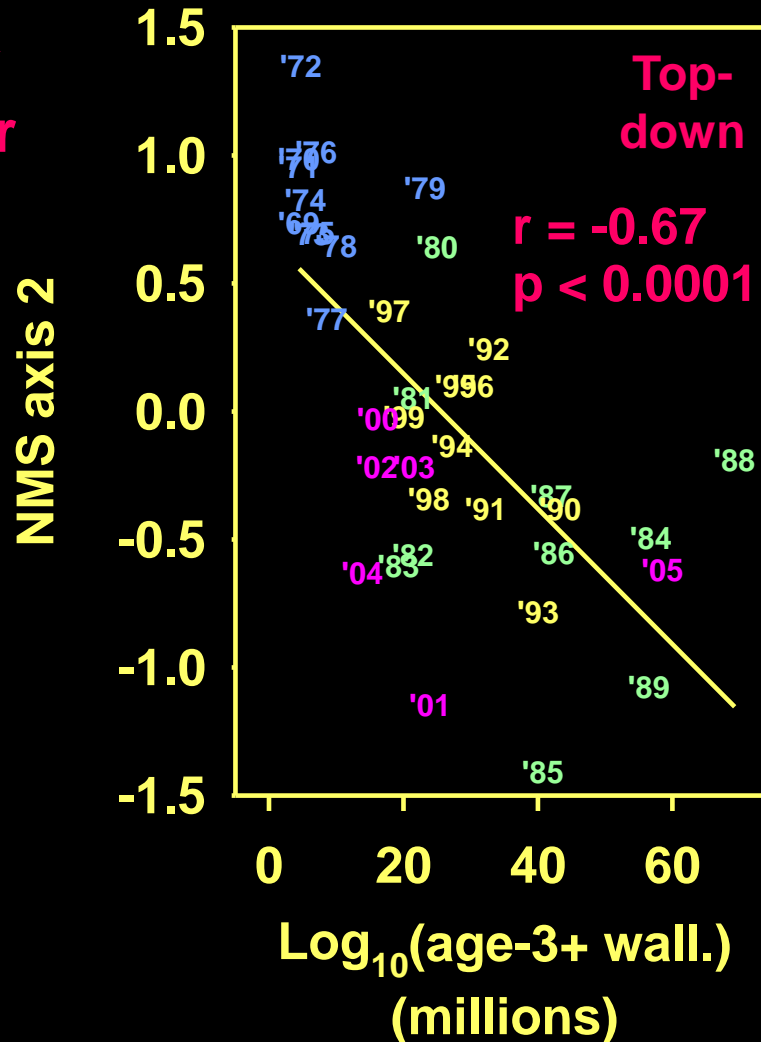
Gizzard shad

White bass

Benthivores

White perch

Trout perch



Summary

- Prey species' abundances changed
 - » WB: benthivore DOMINANCE
 - » CB: regular benthivore dominance
 - » Walleye regularly depend on less preferred, low quality prey

Summary

- Prey species' abundances changed
 - » WB: benthivore DOMINANCE
 - » CB: regular benthivore dominance
 - » Walleye regularly depend on less preferred, low quality prey

- Balance between top-down and bottom-up control


Roadmap

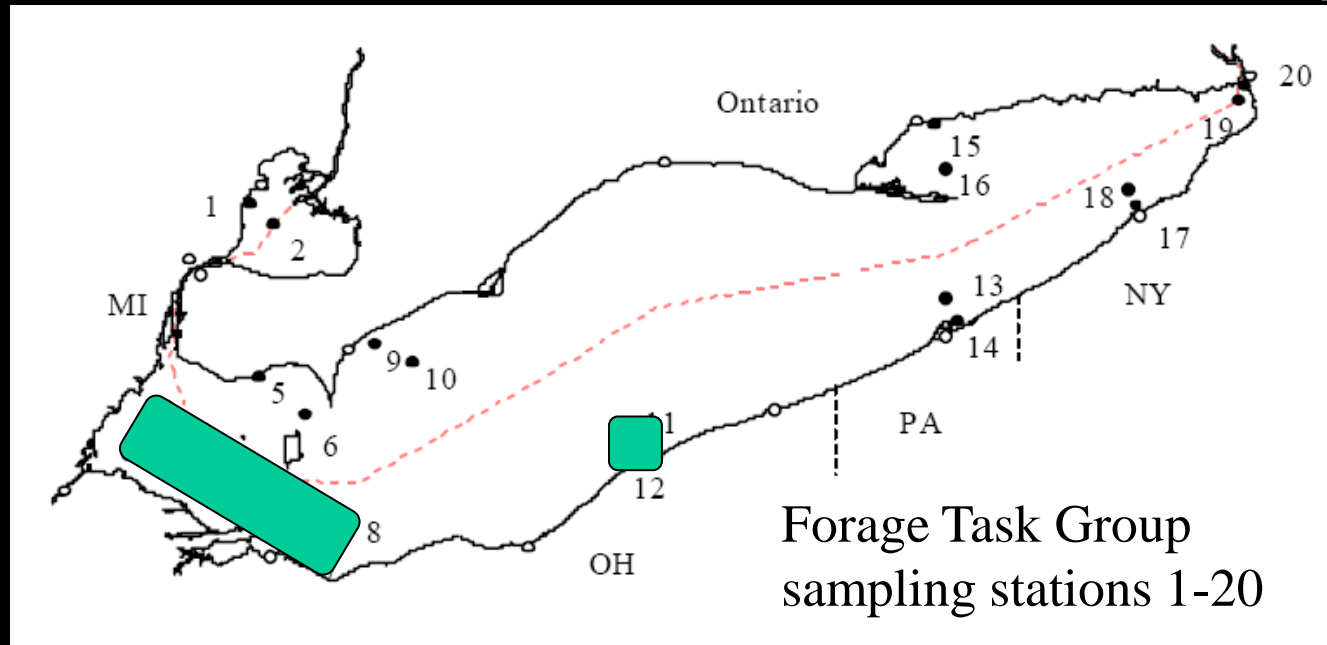
- Introduction
- Methods
- Results
- **Discussion: Continuing rehabilitation?**

Continued rehabilitation or degradation?

- Lake Erie LTLs show evidence for degradation
 - » [TP] > targets; [SRP]/[TP] is increasing

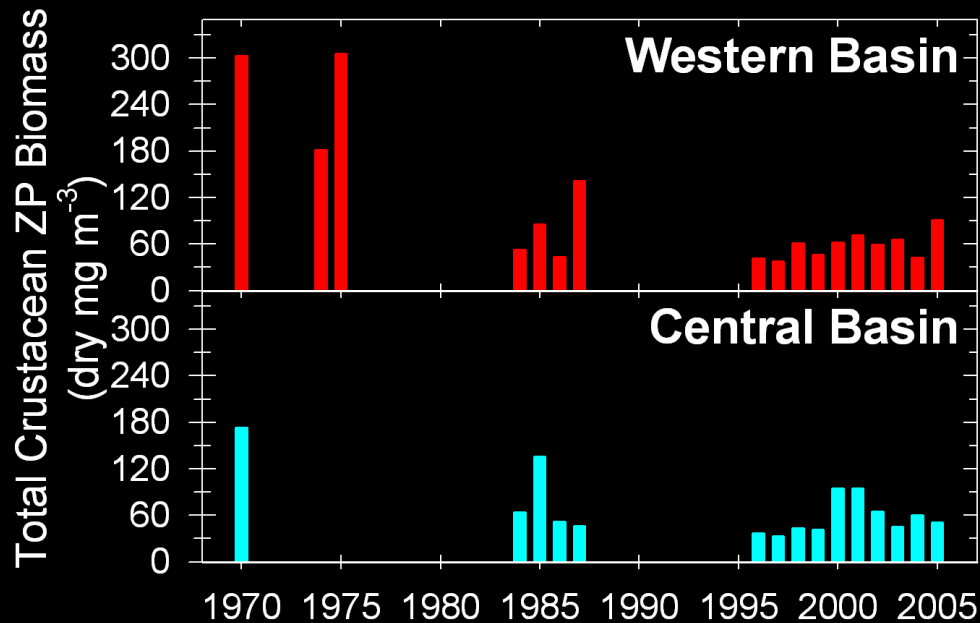
Continued rehabilitation or degradation?

- Lake Erie LTLs show evidence for degradation
 - » [TP] > targets; [SRP]/[TP] is increasing
 - » Phytoplankton biomass increasing, based on analysis of limited samples  and direct observation



Continued rehabilitation or degradation?

- Lake Erie LTLs show evidence for degradation
 - » [TP] > targets; [SRP]/[TP] is increasing
 - » Phytoplankton biomass increasing, based on analysis of limited samples
 - » Zooplankton biomass slightly increasing but still less than the 1970s



Continued rehabilitation or degradation?

- Lake Erie LTLs show evidence for degradation
 - » [TP] > targets ; [SRP]/[TP] is increasing
 - » Phytoplankton biomass increasing
 - » Zooplankton biomass slightly increasing

Continued rehabilitation or degradation?

- Lake Erie LTLs show evidence for degradation
 - » [TP] > targets ; [SRP]/[TP] is increasing
 - » Phytoplankton biomass increasing
 - » Zooplankton biomass slightly increasing
- Lake Erie forage fish community changing
 - » Shift to benthivore dominance
 - ↓ prey fish quality affecting WAE growth?

Continued rehabilitation or degradation?

- Lake Erie LTLs show evidence for degradation
 - » [TP] > targets
 - » Phytoplankton biomass increasing
 - » Zooplankton biomass slightly increasing or similar
- Lake Erie forage fish community changing
 - » Shift to benthivore dominance
 - ↓ prey fish quality affecting growth?
 - » Modified top-down/bottom-up balance
 - w/ ↓ planktivores and zooplankton?
 - How does re-eutrophication affect balance?

Continued rehabilitation or degradation?

- Lake Erie LTLs show evidence for degradation
 - » [TP] > targets
 - » Phytoplankton biomass increasing
 - » Zooplankton biomass slightly increasing or similar
- Lake Erie forage fish community changing
 - » Shift to benthivore dominance
 - ↓ prey fish quality affecting growth?
 - » Modified top-down/bottom-up balance
 - w/ ↓ planktivores, ZP?
 - How does re-eutrophication affect balance?
 - » ↑ occurrence/severity of hypoxia affecting intolerant species

Achieving fish community goals

Achieving fish community goals

- GLFC seeks harmonic cool-water percid community
 - » Nutrient input AND cycling affect outcome
 - P bioavailability (external & internal sources) important
 - » Harmful algal blooms, hypoxia, low trophic efficiency, etc.
 - Zooplankton do not eat much *Microcystis*

Achieving fish community goals

- GLFC seeks harmonic cool-water percid community
 - » Nutrient input AND cycling affect outcome
 - P bioavailability (from external & internal sources) impt.
 - » Harmful algal blooms, hypoxia, low trophic efficiency, etc.
- Need to better conceptualize and quantify connections between Lower Trophic Levels & fish
 - » Expand plankton sample analysis lake-wide
 - » Zooplankton **AND phytoplankton**

Achieving fish community goals

- GLFC seeks harmonic cool-water percid community
 - » Nutrient input AND cycling affect outcome
 - P bioavailability (from external & internal sources) impt.
 - » Harmful algal blooms, hypoxia, low trophic efficiency, etc.

- Need to better conceptualize and quantify connections between Lower Trophic Levels & fish
 - » Expand plankton sample analysis lake-wide
 - » Zooplankton AND phytoplankton
 - » 1,000 Forage Task Group phytoplankton samples yet to be analyzed
 - No more 10 year gaps! (e.g., 1986-1996)

Achieving fish community goals

- GLFC seeks harmonic cool-water percid community
 - » Nutrient input AND cycling affect outcome
 - P bioavailability (from external & internal sources) impt.
 - » Harmful algal blooms, hypoxia, low trophic efficiency, etc.
- Need to better conceptualize and quantify connections between Lower Trophic Levels & fish
 - » Expand plankton sample analysis lake-wide
 - » Zooplankton **AND phytoplankton**
 - » 1,000 Forage Task Group phytoplankton samples yet to be analyzed (1999-2009)
 - » GLRI plankton and benthos sampling by OEPA and USGS and National Coastal Assessment proposed for 2010-2015

Acknowledgements

- DOW Fairport & Sandusky Labs:
 - » Biologists, captains, technicians
- OSU Limnology Lab technicians:
 - » R. Briland, A. Martyn, M. Kulasa
- Federal Aid in Sport Fish Restoration Program

