Total Phosphorus Loading to the Great Lakes

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Objectives

- Understand that no lakewide TP loading estimates have been made since the early 1990s (except Erie)

- Show what has been done for Lake Erie and could be extended to other lakes

- Raise Issues

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Sources for Estimates of Total Phosphorus Loading Rates to the Laurentian Great Lakes

- From the Book Chapter "The North American Great Lakes: A Laurentian Great Lakes Focus", Volume 2 of The Lakes Handbook. Lake Restoration and Rehabilitation. Edited by P. E. O'Sullivan and C. S. Reynolds. Blackwell Publishing. 2004.

- Graphs are redrawn from Chapra (1977) and from Neilson et al. (1995). Lake Erie data for 1991-2001 are from Dolan and McGunagle (2005).

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Things to notice

- Left panel is the model "hindcast", i.e. what the loads must have been to achieve concentrations observed in the early 1970s.

- Right panel is the observed loading history. Note that it ends in the early 1990s, except Lake Erie.

- For all lakes except Lake Erie, right panel suggests the load was increasing when load estimation ended. (Or so Dave says). Do you agree? Don't you wish we knew what happened next?!

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Estimates of Total Phosphorus Loading Rates to the Laurentian Great Lakes

Lake Superior

Target load

Estimates of Total Phosphorus Loading Rates to the Laurentian Great Lakes
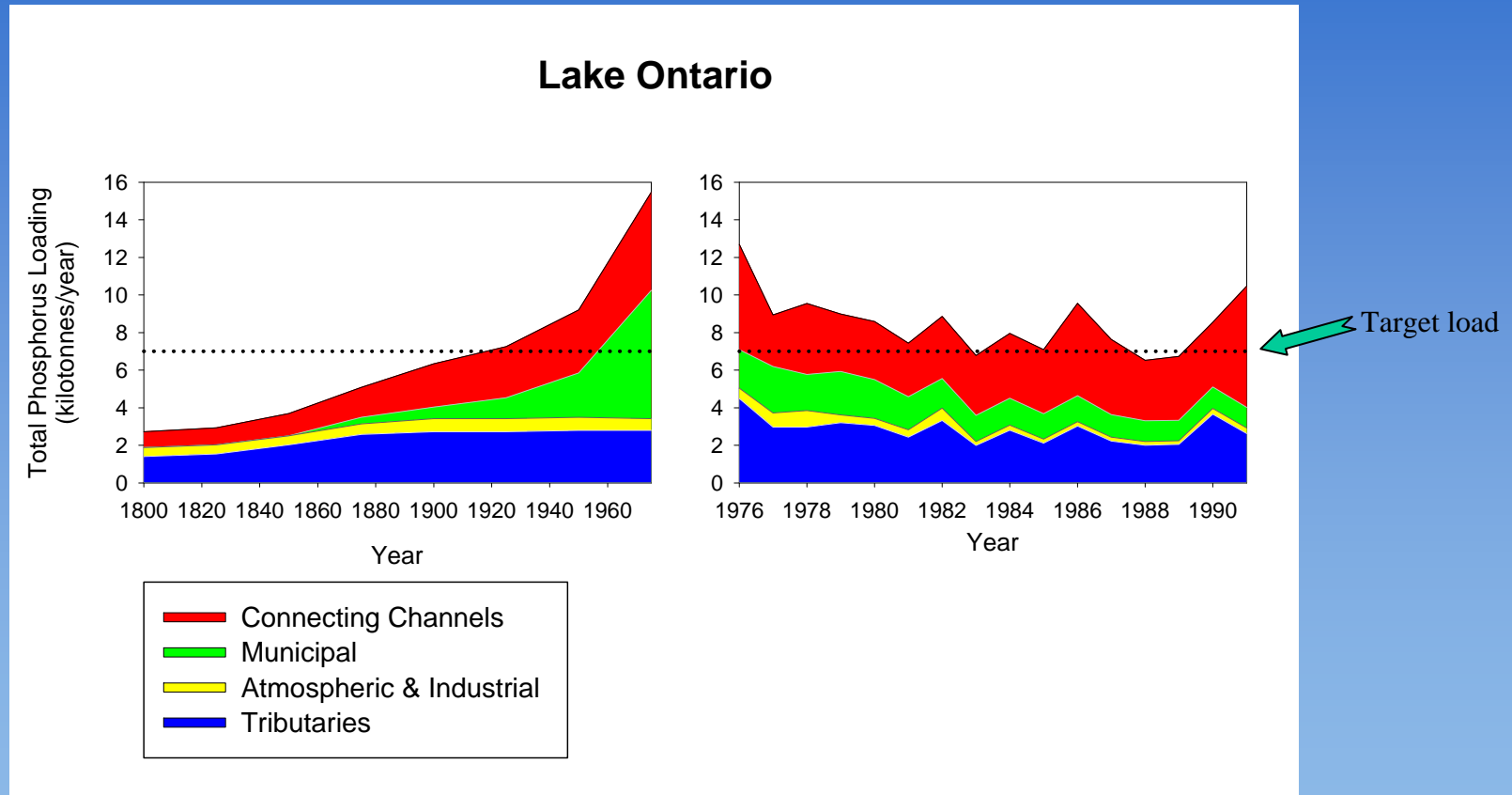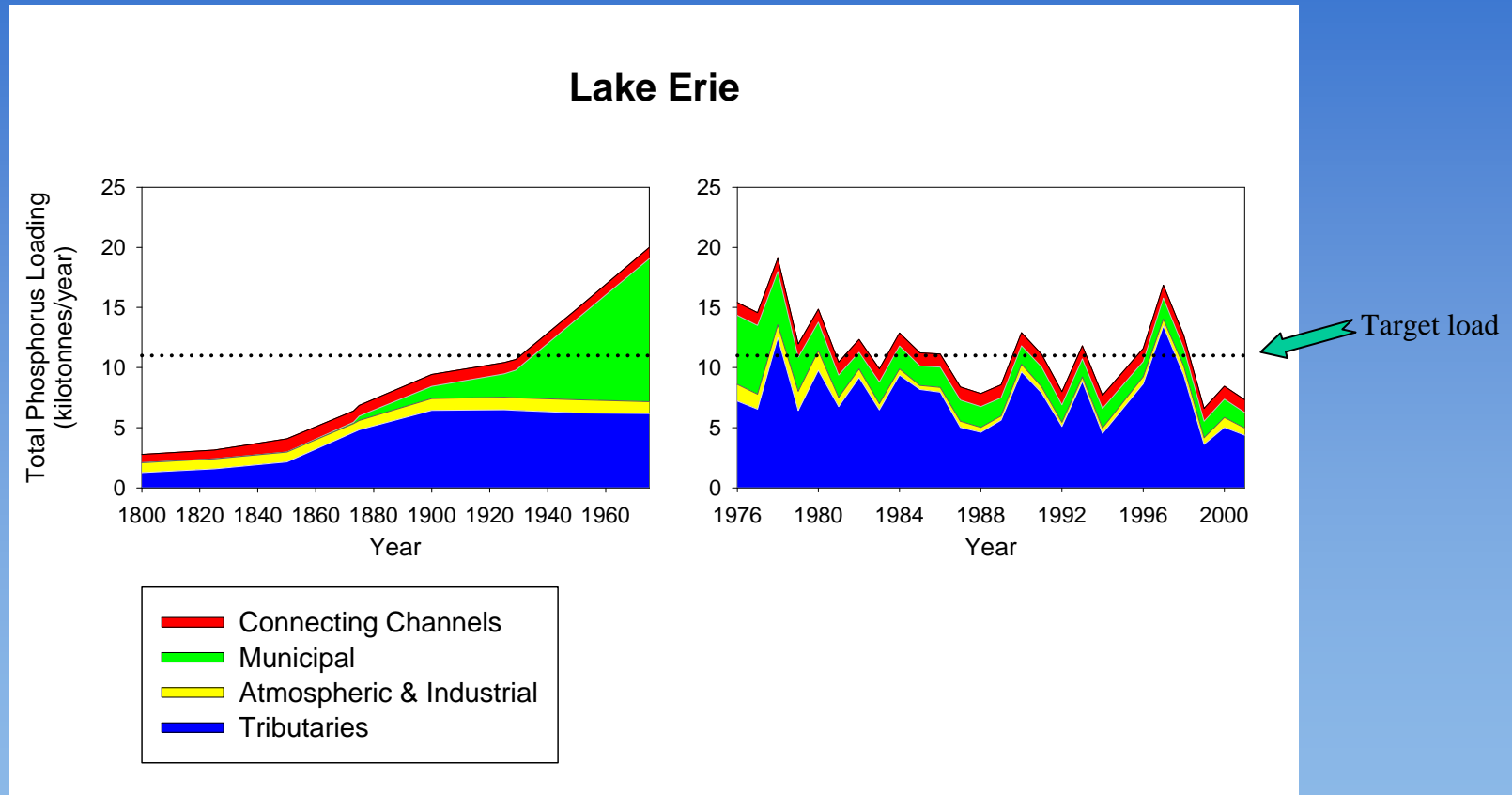

Lake Michigan

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Lake Huron

Estimates of Total Phosphorus Loading Rates to the Laurentian Great Lakes
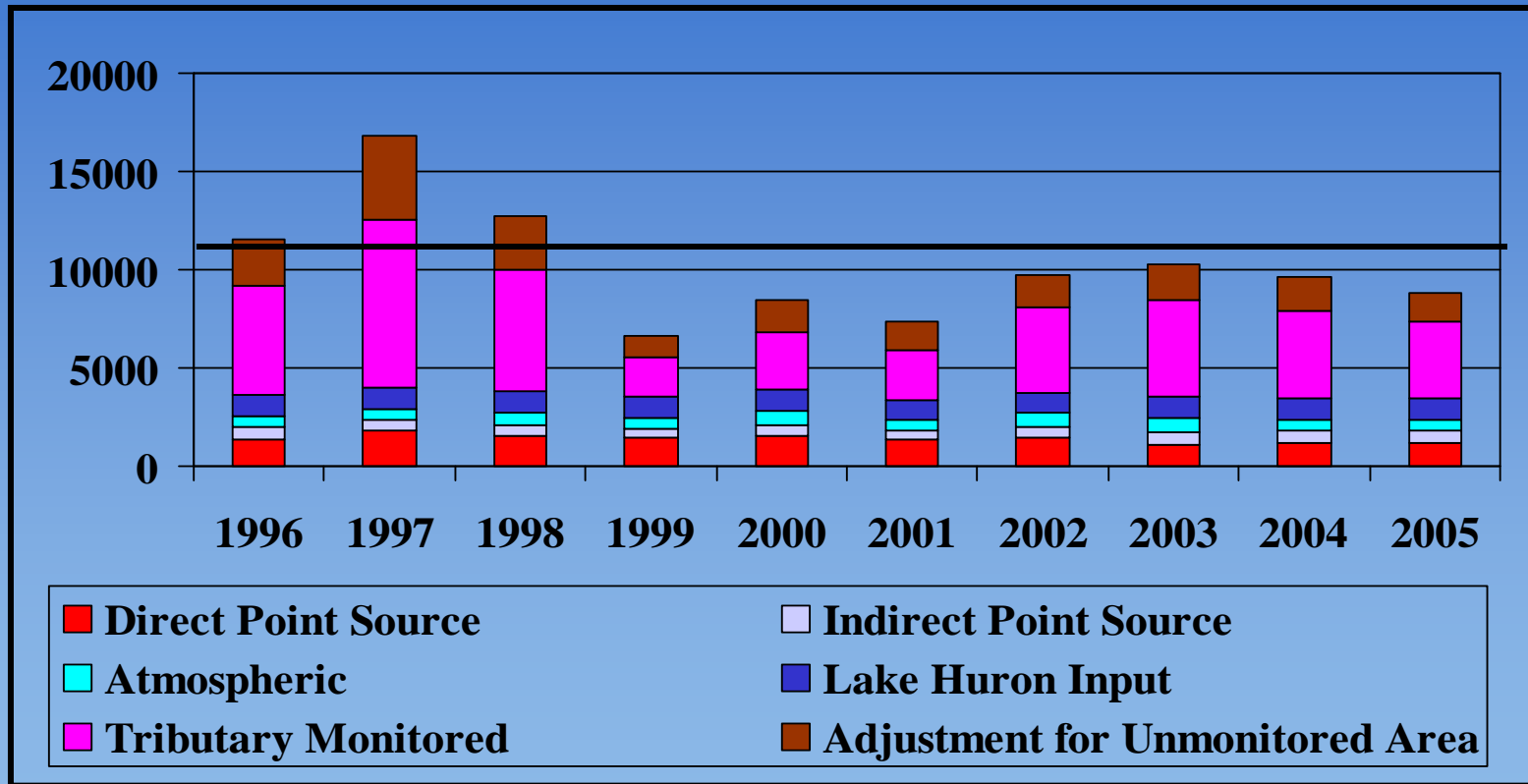

Lake Ontario
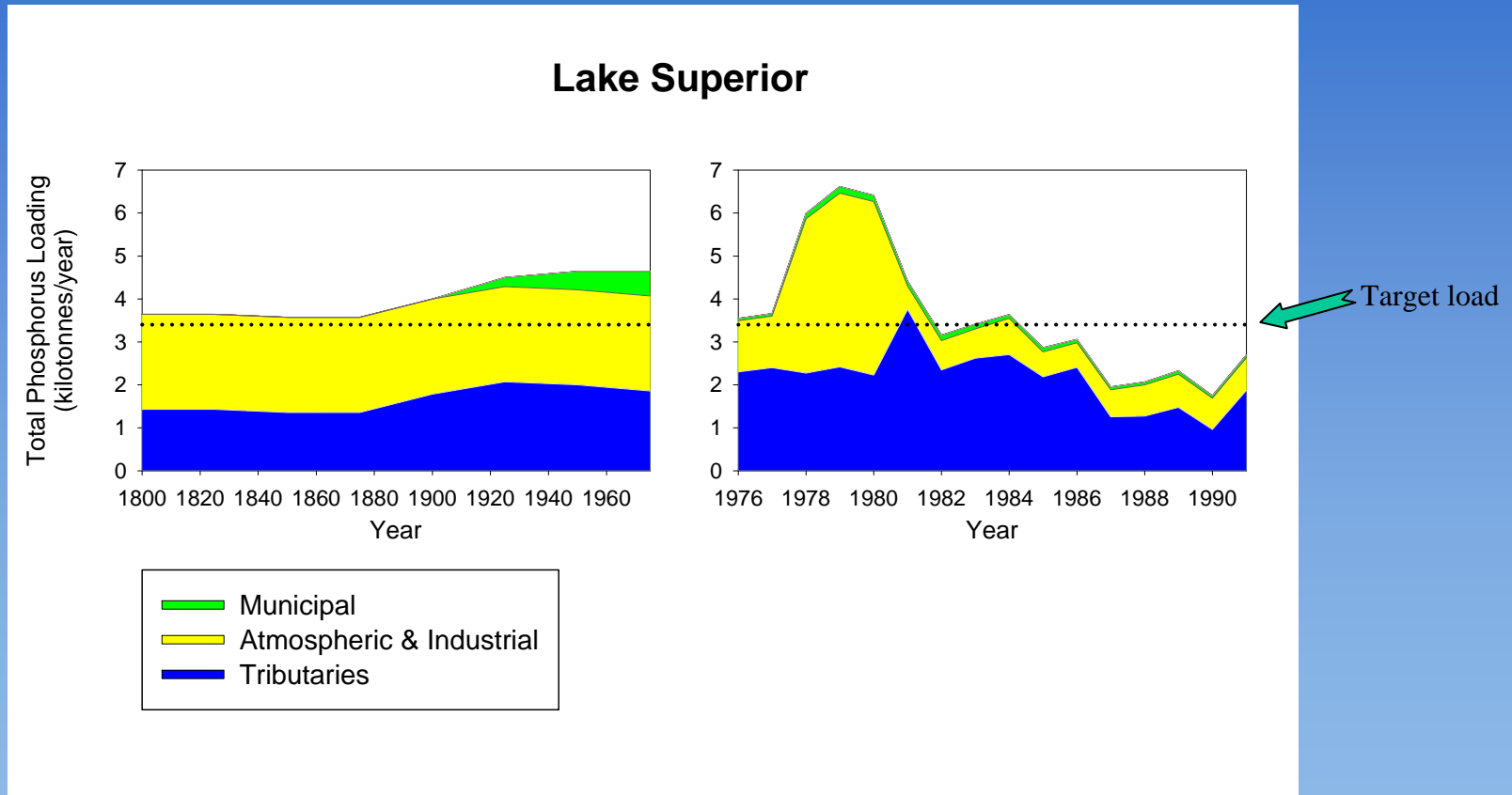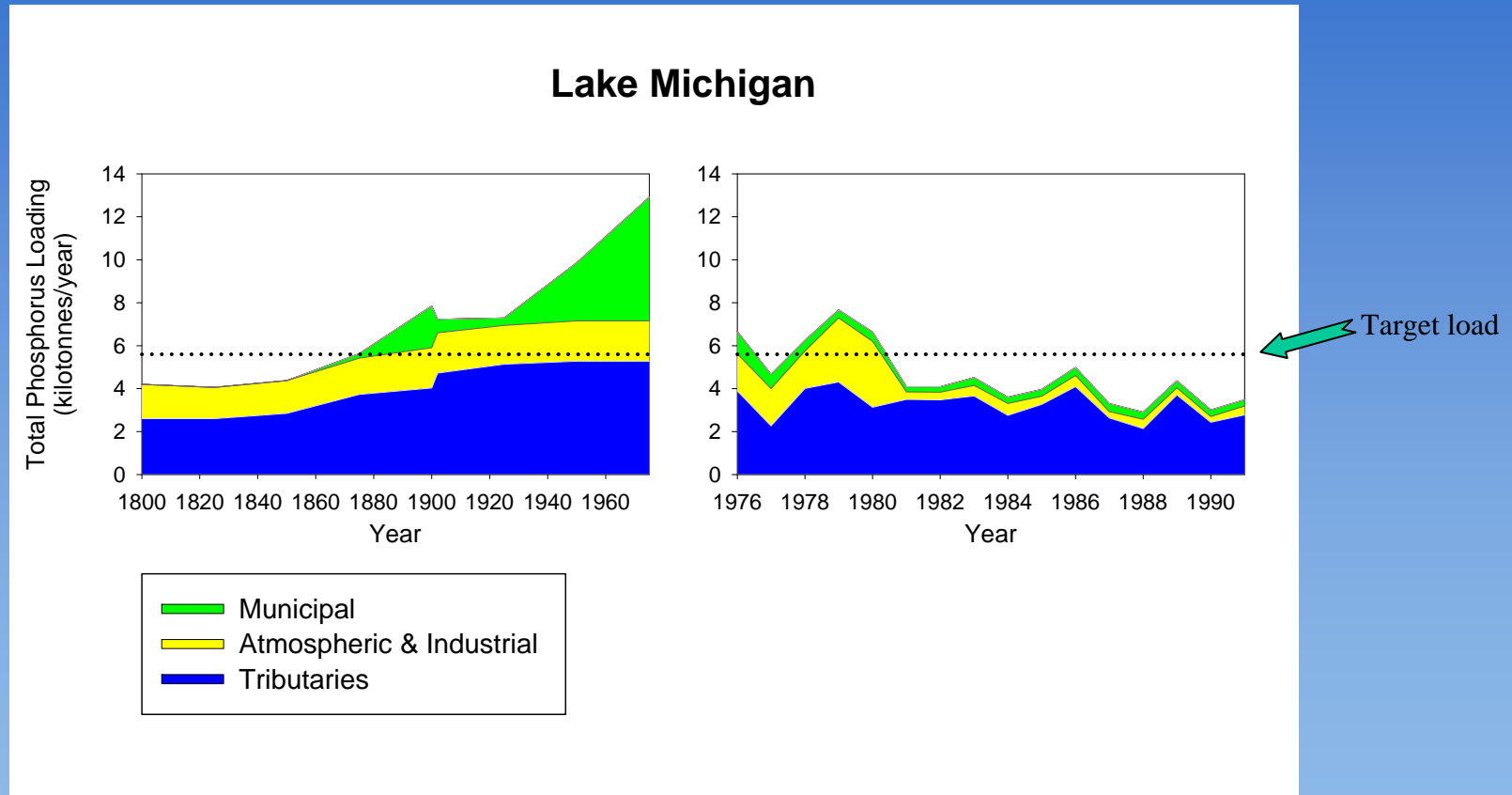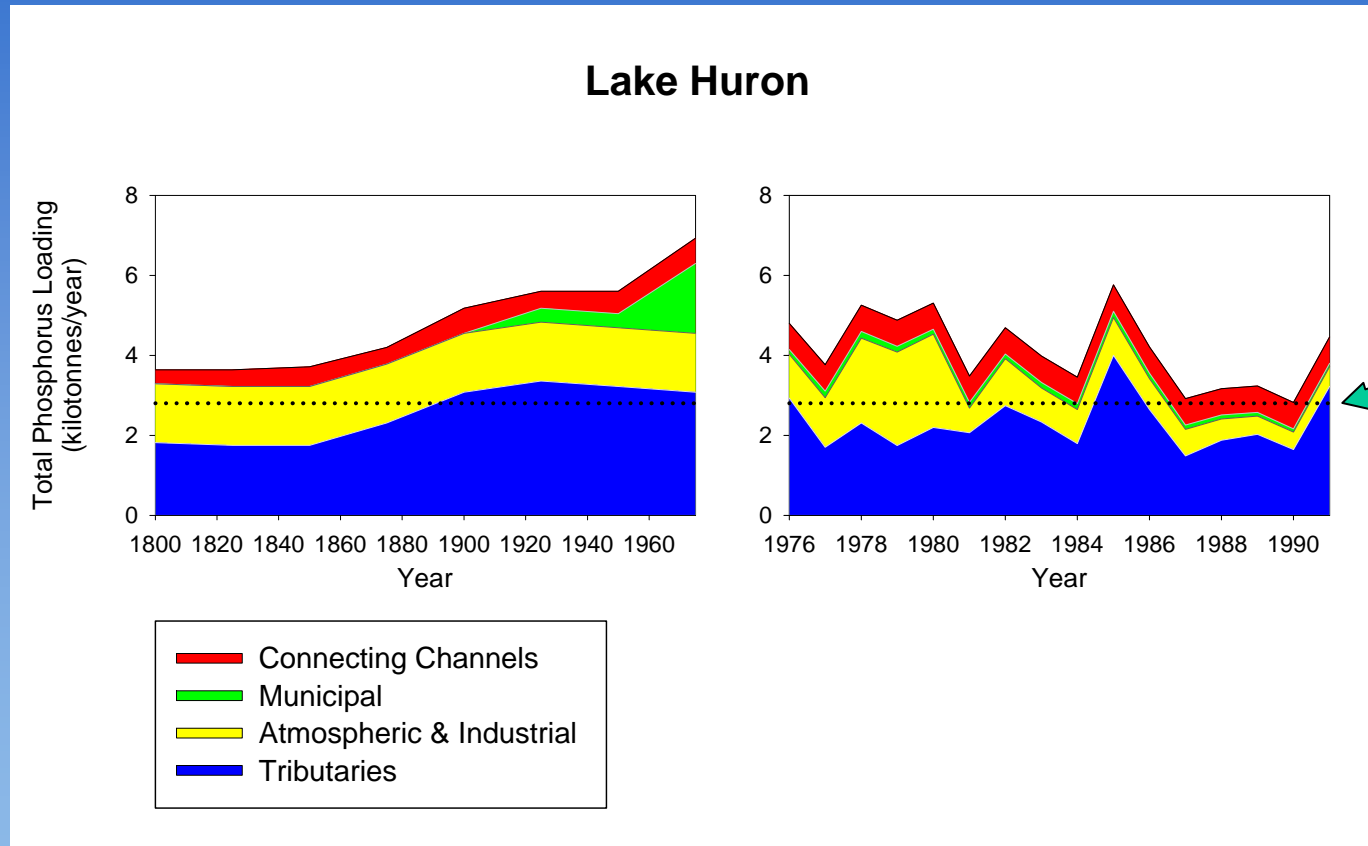
Estimates of Total Phosphorus Loading Rates to the Laurentian Great Lakes

How He Does It…

- Direct point sources (industrial and municipal), indirect point sources (i and m), tributary loads, atmospheric, connecting channel, unmonitored areas

- Subtract indirect point sources from tributary loads to get non-point loads

- Apply non-point tributary loads to adjacent unmonitored areas on a unit area basis

- Add them up

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Total Phosphorus Loadings 1996-2005 (Draft)

Total Phosphorus Loadings Partitioned by Basin
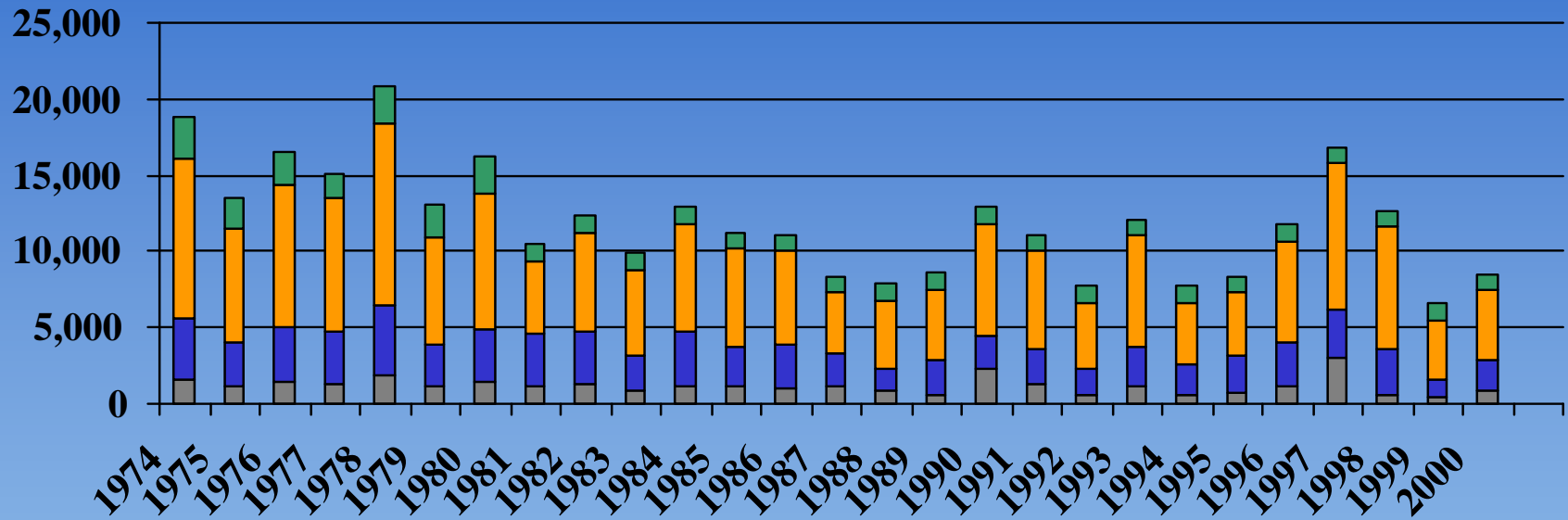
Legend:
- Lake Huron
- Western Lake Erie
- Central Lake Erie
- Eastern Lake Erie

Further Phosphorus Load Partitioning (Lake Erie, EcoFore 2006 project)

- Temporal: Daily time series of loads
  - Actual or Estimated Tributary Load
  - Direct Point Source Daily Average Load
  - Daily Average Adjustments for Unmonitored Areas

- Spatial: 26 Nodes Corresponding to Ecosystem Model Inputs

Discussion

- Target load for Lake Erie first met in 1983, frequently since then

- Since 1991, year to year changes in loads are due primarily to weather impacts on nonpoint loads.

- Spikes (above the target) in Lake Erie loading in the late 1990s have been shown (Dolan & Richards) to be due to high tributary loading.

- Unusually high precipitation in the winter months has been shown (Richards & Dolan) to contribute disproportionately to annual loads, especially for the Maumee River.

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Issues

- Data Availability

- Connecting Channels (especially St. Clair/Detroit Corridor)

- Atmospheric Inputs

Key Questions

- What do we look for that indicates the connection between land-use and transported materials?
  - Different loads from different land uses. Large inter-annual variability
- What are key variables of concern? (stressor variables; response variables)
  - TP, DRP. Algae, hypoxia.
- Which variables could be used as land-based state indicators?
  - TP loads, P content of soils, land use - ag, urban, forest
- What would you say are acceptable ranges of these variables?
  - Target loads for TP exist for each lake, may need targets for DRP
- What databases are available? Measurement technology?
  - The technology is fine, it's just not being used to produce data!
- What are the research needs/land-based measurements?
  - Better understanding of/data on soil P content and distribution in soil column
- What is the role of watershed loading models in synthesizing information and data and in predicting the watershed response to source control actions?
  - Important potential, not yet realized. Critical for exploring alternative scenarios. The only way to sort out zebra mussels vs. tributary loading? See EcoFore 2006 project.

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THANKS!

Any Questions?

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Data Sources

- U.S. Point Sources: Permit Compliance System (PCS)

- U.S. Tributary Flow: U.S.G.S.

- U.S. Tributary Concentrations: Heidelberg College, STORET, and state agencies

- Canadian Point Sources: MOE

- Canadian Tributary Flow: Water Survey

- Canadian Tributary Concentrations: MOE

- Atmospheric Flux: Environment Canada

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Data Needs

- From Environment Canada:
  - Ontario Tributary Flows (2006 and beyond)
  - Atmospheric Flux Measurements (2005 and Beyond)
- From Ontario Ministry of Environment:
  - Ontario Point Sources (2004 and Beyond)

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Methods

- Point Sources: Daily Average of Monthly Loads

- Tributaries: Beale's Stratified Ratio Estimator and Seasonal Rating Curves

- Atmospheric: Daily Average of Monthly Fluxes

- Unmonitored Areas: UAL adjusted for Indirect Point Sources

Point Sources

- Retrieve from PCS and MISA annually
- QA/QC with data from previous years
- Sort into Direct and Indirect
- Direct is part of Total Lake Loading
- Indirect is used for Unmonitored Areas

Unmonitored Areas

- Select a neighboring monitored area
- Subtract Indirect point sources
- Estimate Unit Area Load (UAL)
- Apply to Unmonitored Area
- Point Sources in Unmonitored Areas are considered to be Direct