Lake Erie Nutrient Loading Estimation: "The Dolan Approach"

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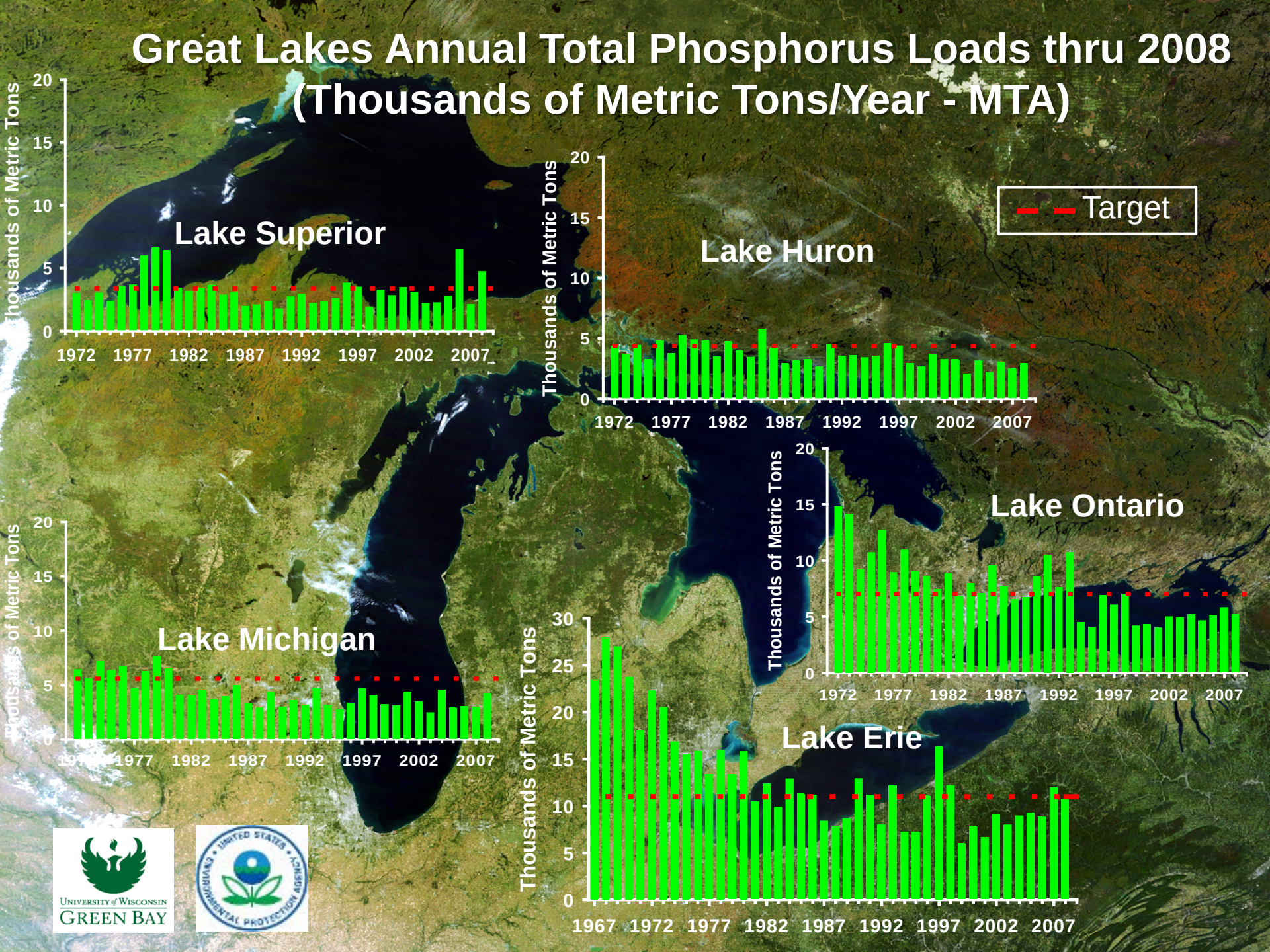
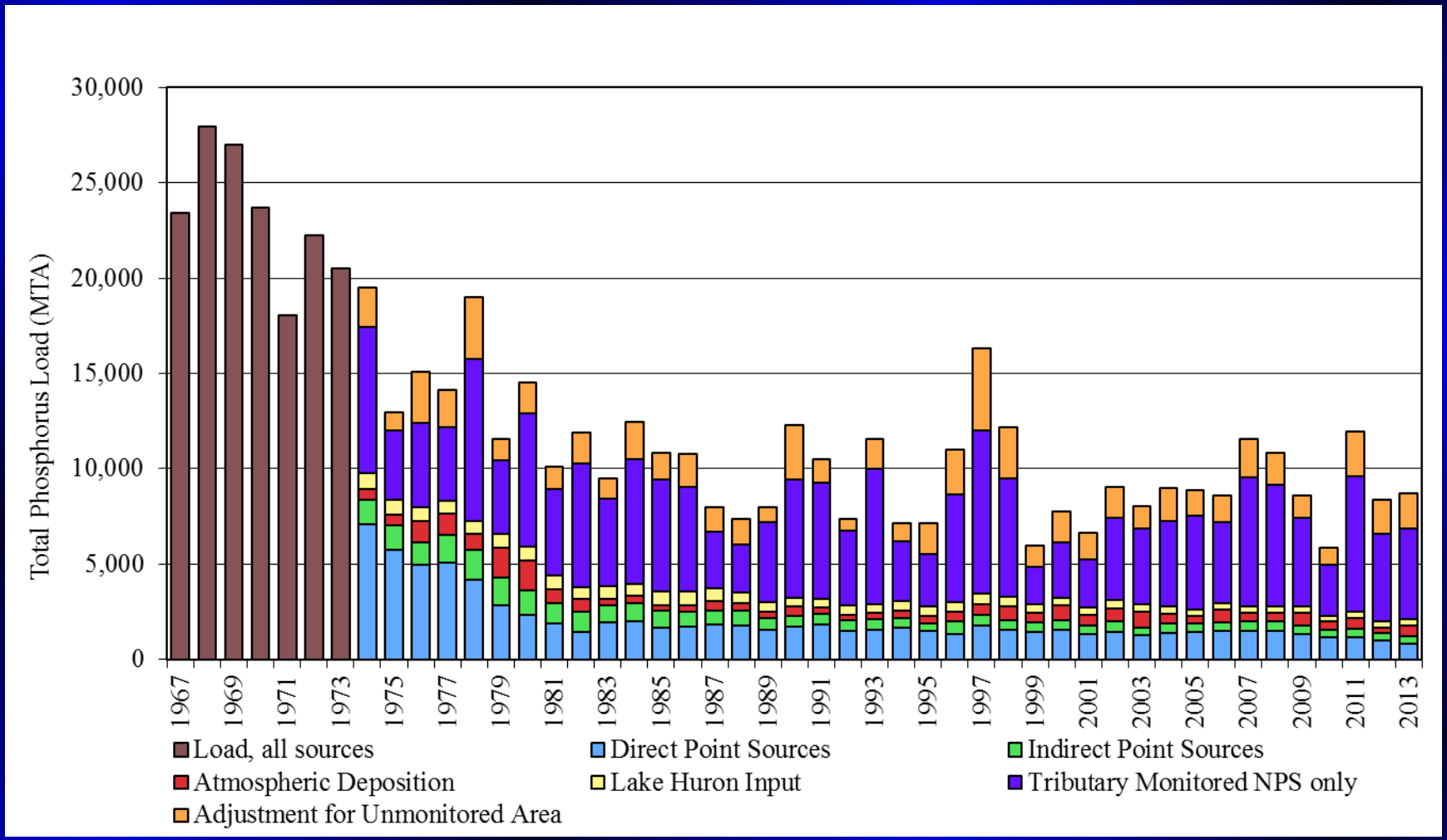
History

- Load estimates began in 1967 for Lake Erie
- IJC began reporting estimates for all lakes in the 1970s
- Same data sources are used today
- Same methods are used today (IJC method)
  - 1978 PLUARG study improved methods for estimating unmonitored areas beginning in 1980-current
  - Provides a consistent long-term dataset for comparison with target loads

Great Lakes Annual Total Phosphorus Loads thru 2008
(Thousands of Metric Tons/Year - MTA)



Lake Erie Total Phosphorus Loading, 1967-2013



From: Maccoux, et al. (2016)

Load Breakdown

- Loads are typically reported annually by subbasin
  - Direct Point Sources, Municipal/Industrial
  - Indirect Point Sources, Municipal/Industrial
  - Monitored tributaries (nonpoint sources)
  - Adjustment for unmonitored areas
  - Atmospheric (over-lake)

- Can be broken down by tributary with same level of detail (1994-2008 Great Lakes update, 2003-2013 Lake Erie)

- Can be reported as average daily loads by tributary (Ecofore project)

DATA SOURCES

- Point Sources (TP):
  - Permit Compliance System (PCS) and Integrated Compliance Information System (ICIS)-USEPA
  - Municipal and Industrial Strategy for Abatement (MISA)-MOEE

- Tributary Flow:
  - National Water Information System (NWIS)-USGS
  - Water Survey Canada (HYDAT)-Environment and Climate Change Canada

- Tributary Concentrations (TP, DRP, etc):
  - NCWQR-Heidelberg University
  - STORET-USEPA/NWIS-USGS, individual state agencies
  - Provincial Water Quality Monitoring Network (PWQMN)-MOEE

- Atmospheric Flux (Rainfall and TP):
  - Environment and Climate Change Canada

DATA QUANTITY/QUALITY

- Point Sources:
  - All permitted P dischargers are requested/included
  - Monthly reporting by outfall
  - The best estimated source in terms of certainty
  - CSOs, RTBs, and WWSLs could be reported differently
    - Total discharge vs daily avg flow rates with no duration
- Tributary Flow:
  - Daily average flows
  - Good spatial coverage
- Tributary Concentrations:
  - Daily monitoring for 5 major tribs (NCWQR) (2 historic, 1 new)
  - Federal, state, and provincial monitoring programs
    - Monitoring efforts decreasing over time, recent uptick
    - Poor temporal coverage, e.g., every other month, missing years
    - TP ≥ SRP # of samples
- Atmospheric Flux:
  - Multiple stations for the Canadian lakes
  - Good data when birds aren't around

CALCULATION METHODOLOGIES

Loading (mass per unit time)=

Flow x P Concentration

- Point Sources: average monthly loads
- Tributaries: Beale's Stratified Ratio Estimator
- Atmospheric: average of monthly fluxes
- Unmonitored Areas: UAL adjusted for Indirect Point Sources
- Standard Error is estimated from the variances (MSE) for each load component
  - Standard error used for 95% CL

POINT SOURCES

- Municipal/Industrial dischargers NPDES or CoA permits
  - Data for these Point Sources are generally available
  - Average monthly values by pipe

- Direct Point Sources discharge:
  - Directly to the Great Lakes or their connecting channels
  - Downstream of the trib gauge/monitoring location
  - To a tributary that has been unmonitored for a particular year

- Indirect Point Sources discharge
  - To monitored tributaries
  - Upstream of the gauge/monitoring location
  - Are NOT included in the monitored trib load

NONPOINT SOURCES

- Monitored tributaries:
  - Use the daily monitored loads from NCWQR
  - All else: Beale's Stratified Ratio Estimator
    - Input daily average flows and concentration data
    - Sampled load / sampled flow x yearly flow x (bias adjustment)
    - Stratified based on flow/number of samples per stratum
- Unmonitored Areas:
  - Downstream of the trib gauge/monitoring location
  - Tributary that is unmonitored in a particular year
  - Use UAL from monitored trib and apply to unmonitored areas (downstream or adjacent watersheds)
  - Consistent with PLUARG
- Atmospheric:
  - Take average of the monthly fluxes for each station
  - Wet only, assume total = wet x 2 (wet = dry)

DISCUSSION POINTS

- Error and uncertainty
  - True load is unknown without daily sampling
  - Report statistical errors based on variance of data
  - Accuracy of estimates is dependent upon representative input data
- Adequacy of monitoring programs
  - Currently 75% of watershed area is monitored
  - Long-term trends vs load estimation
  - Capturing enough high flow events, total range of flows
  - Current programs increasing sampling efforts will improve tributary estimates
- Robust method
  - Beale's Stratified Ratio Estimator provides unbiased estimates with both systematic or event-based sampling
  - Used to estimate TP, DRP, TKN, NO2+NO3, TSS, Cl
  - Historical track record for all Great Lakes


Questions?
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