Lake Michigan – Food Web

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Water Quality
Lake Michigan Spring
Total Phosphorus: 1983–2008

$y = -0.01x + 204$
$ho = -0.77$
$P < 0.0001$
Lake Michigan Total Phosphorus Loadings 1994-2008

Dave Dolan & Steve Chapra

The graph shows the total phosphorus loadings in Lake Michigan from 1994 to 2008. The loadings are categorized by year and source, including direct point source, indirect point source, tributary monitored, adjustment for unmonitored area, and atmospheric sources. The data highlights the trend and variation in phosphorus loadings over the years.
Lake Michigan Spring

$y = 0.02x + 42.1$
$ho = -0.34$
$P < 0.05$
Lake Michigan Total Dissolved Phosphorus Loadings 1994-2008

Dave Dolan & Steve Chapra

[Bar chart showing total phosphorus loadings from 1994 to 2008, with categories for direct and indirect point sources, tributary monitored, atmospheric, and adjustment for unmonitored area.]
Phosphorus Yields by HUC

2002 Total Phosphorus Delivered Accumulated Yield (kg/km²) by HUC8s

- 8 - 13
- 13 - 17
- 17 - 43
- 43 - 50
- 58 - 261

USGS SPARROW Mapper
MRB3 2002 Nutrient Models
Lake Michigan Nitrate Loadings 1994-2008

Dave Dolan & Steve Chapra

![Bar chart showing annual nitrate loadings in Lake Michigan from 1994 to 2008, with categories for Direct Point Source, Indirect Point Source, Tributary Monitored, Atmospheric, and Adjustment for Unmonitored Area.](chart.png)
Lake Michigan Spring
Are the algae changing?
Total spring phytoplankton
(biovolume)

Year (1996-2009)

KEY

variable

Year

(1996-2009)
Total spring phytoplankton (cells per mL)

Year (1996-2009)

KEY

variable
Changes in Chlorophyll

• Spring bloom has largely disappeared in Michigan and Huron
• Summer chlorophyll also reduced
• Seasonality very similar to Superior
  – Seasonal maximum occurs in autumn
• Spring 2010: MI = 0.89 µg Chl/L
  SU = 0.89 µg Chl/L
  HU = 0.79 µg Chl/L
Zooplankton
Crustacean Zooplankton Communities in Upper Lakes 1998-2006

Biomass (mg/m$^3$)

Year


Limnocalanus
Calanoids
Cyclopoids
Predatory Cladocerans
Daphnia
Non-daphnid Cladocerans
Dominant Rotifer Genera in Upper Lakes 1983-2006

Decreasing Trophic State
Changes in Zooplankton

- Cladocerans have declined precipitously in Huron and Michigan.
- Calanoids have increased, with a large % currently in *Limnocalanus*.
- Crustacean communities very similar to Superior in terms of size and composition.
- Rotifer genera shift towards more oligotrophic forms in Huron and Michigan.
Benthos
Diporeia Decline

1994/95

2000

2005

Diporeia spp.

Source: Thomas F. Nalepa; Great Lakes Environmental Research Laboratory, NOAA
1999-2009
Invasive Quaggas Rule

Source: Thomas F. Nalepa; Great Lakes Environmental Research Laboratory, NOAA
Benthos (excl. *Diporeia* and *Dreissena*) 1997-2010, 30-90 m (central and western Erie < 30 m)
‘Historic’ Trophic Gradient of Great Lakes

Increasing Trophic State

Superior

Huron

Michigan

Ontario

Erie
Increasing Trophic State

Trophic Pile-up?

Huron

Michigan

Ontario

Erie

Increasing Trophic State
CARP IS A FOUR LETTER WORD
Keep 'Em Great!