



**Assessment of the *Degradation of Phytoplankton and Zooplankton Populations* Beneficial Use Impairment
Thunder Bay Area of Concern**

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STATUS OF PLANKTON BUI

1991 Stage 1 RAP - *Impaired*

Assumption of degradation of plankton populations due to both degraded water quality and benthos communities. Accidental introductions of exotics also a concern.

2004 Stage 2 RAP - *Impaired*

Recommend that studies be carried out to obtain baseline measurements. Alternatively, gather the opinion of an expert panel to determine if studies verify impairment.

2010 Status of BUI – *Requires Further Assessment*

Redesignation pending results of 2005 study.

PLANKTON WORKSHOPS

- 2004 BUI Monitoring Workshop
- 2010 Phyto/zooplankton Workshop
- 2014 RAP Implementation Workshop

LINES OF EVIDENCE

- Nutrient Assessments
- Top-down, bottom-up approach
 - Water quality
 - Fish community index monitoring
- Effluent Monitoring and Effluent Limit Regulations
 - Toxicity
 - Loading
- Reduced loadings
 - Thunder Bay WPCP treatment upgrades
 - Industrial closures
- Invasive species strategies

NUTRIENT ASSESSMENTS

- Nutrient studies conducted in the nearshore and offshore
- Highest levels of nutrients in the deltic area of the Kaministiquia River ([TP] > PWQO)
- No nuisance algae has been reported in the study areas
- Good assimilative capacity of the Kaministiquia River and Lake Superior

TOP-DOWN, BOTTOM-UP APPROACH

- Screening level assessment
- **Assumption:** the plankton trophic level would be assumed to be healthy and sustainable if the trophic levels above and below were healthy
- Bottom-up: water quality indicators
- Top-down: fish community health

BOTTOM-UP

2005 TP/Chlorophyll Study

- to determine if TP and chlorophyll-a data were indicative of a healthy plankton population



BOTTOM-UP

- Highest concentrations of water quality parameters at the Kaministiquia delta
- Low Chlorophyll-a concentrations → oligotrophic system
- The trophic status index showed that there was less chlorophyll-a than predicted by TP concentrations, therefore indicating limited algal productivity
- There is good mixing of River and Harbour water with open lake water

TOP-DOWN

- MNRF's Fish Community Index data (2009-2014)
- Thunder Bay supports a more diverse fish community than adjacent areas
- Catch per unit effort was the same within and outside the AOC
- Abundance and biomass of native and non-native planktivorous fish in the Thunder Bay AOC mirrors the results from USGS lake-wide study
 - Overall decline in abundance and biomass at all trophic levels, but other indicators suggest populations in AOC are healthy

CONCLUSION

- From the bottom-up:
 - Algal populations are likely limited by light and temperature, rather than TP
 - Offshore areas remain oligotrophic
- From the top-down:
 - The presence of pelagic and transient fish in the nearshore waters of the AOC suggest habitable conditions and adequate food source.
- Overall:
 - Little basis to continue the assessment of the plankton BUI

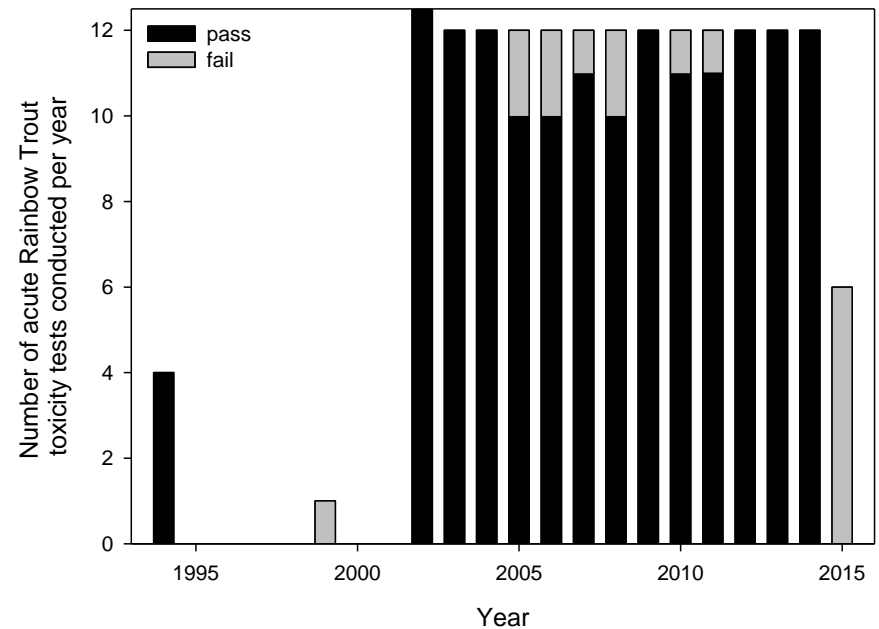
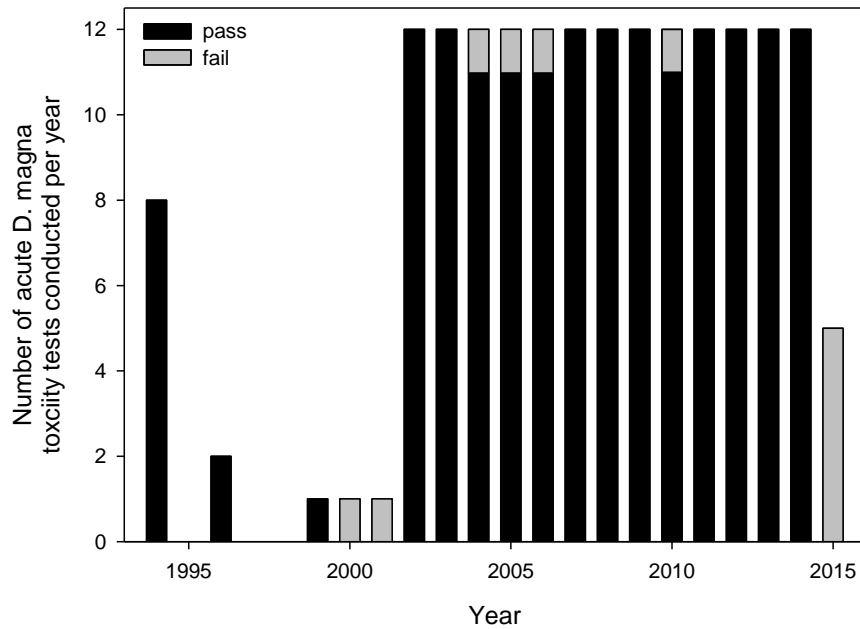
EFFLUENT MONITORING AND EFFLUENT LIMITS REGULATIONS

- Effluent Monitoring and Effluent Limit Regulations (EMEL) regulates industrial discharges into surface water via:
 - Loading limits
 - Toxicity limits
 - Parameter limits
 - Monitoring schedules
- Two regulations apply to sectors in AOC:
 - Pulp and paper (Resolute)
 - Electric power generation (OPG)

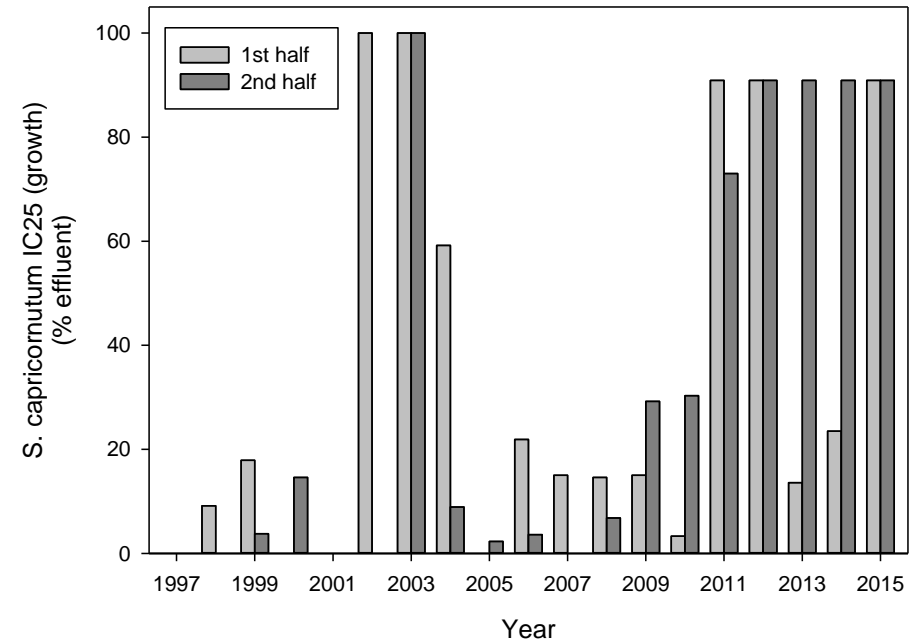
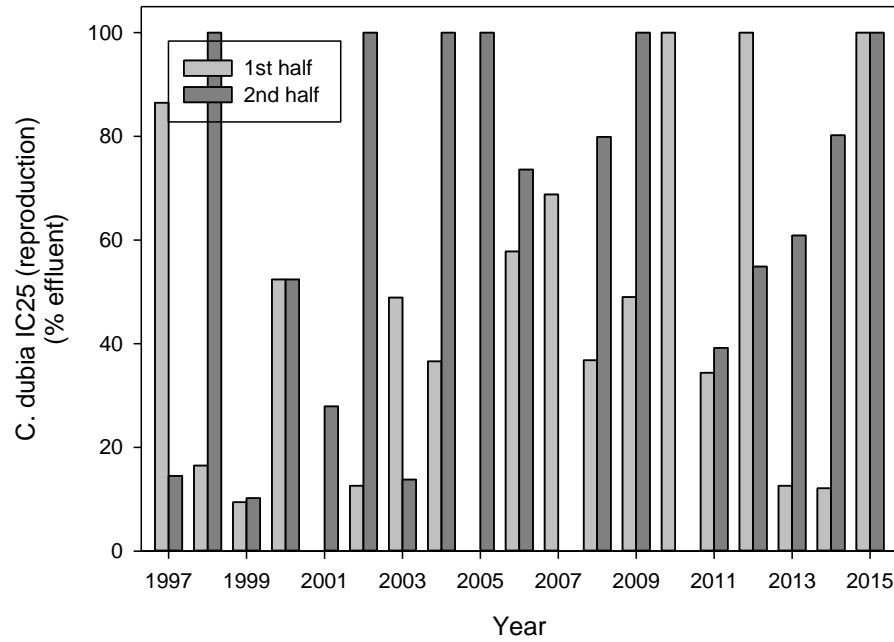
EMEL - TOXICITY

- Acute Toxicity:
 - mortality of *Daphnia magna* and Rainbow Trout does not exceed 50% (LC50) when exposed to 100% effluent
 - Monthly testing
 - Once 12 consecutive passes is achieved → quarterly testing
- Chronic Toxicity:
 - Sub-chronic endpoints for:
 - Fathead Minnow (growth)
 - *Ceriodaphnia dubia* (reproduction and survivability)
 - *Selenastrum capricornutum* (growth)
 - IC25
 - Semi-annual testing

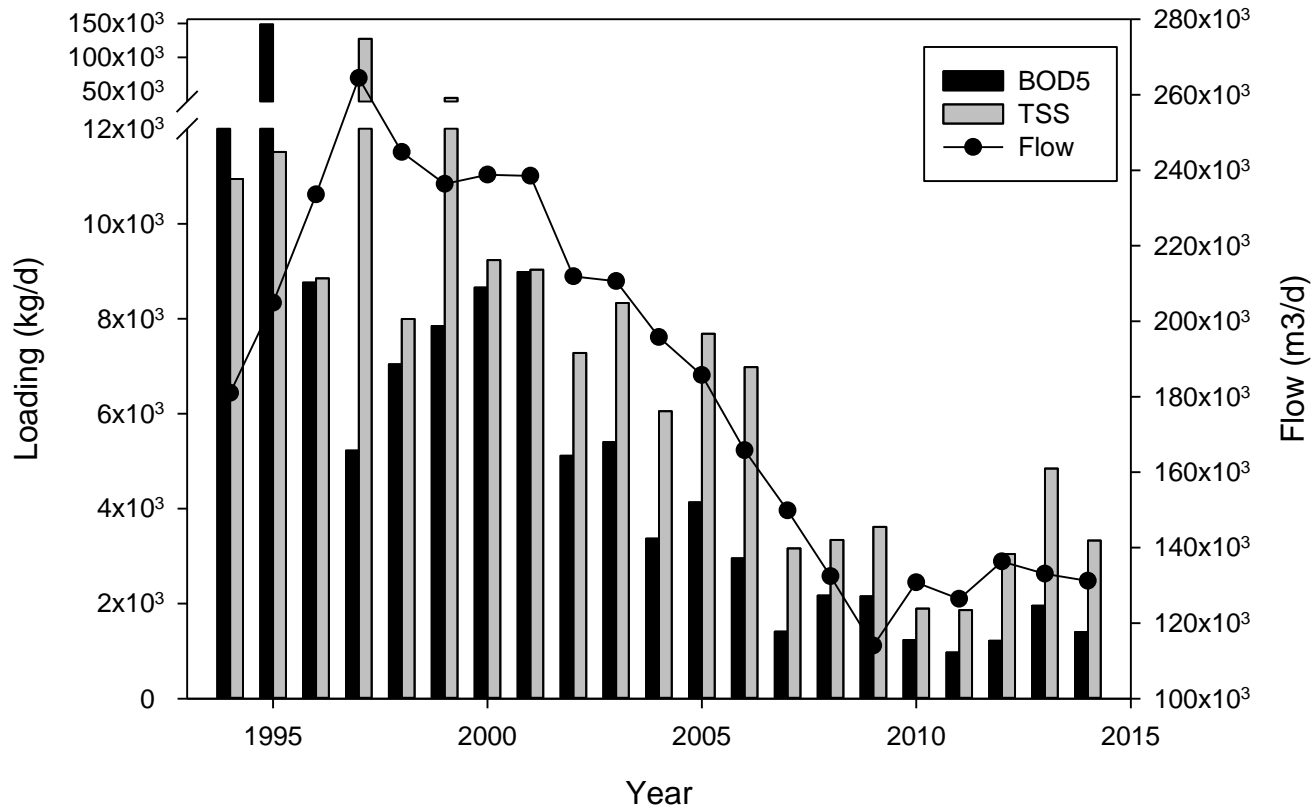
ACUTE TOXICITY - RESOLUTE



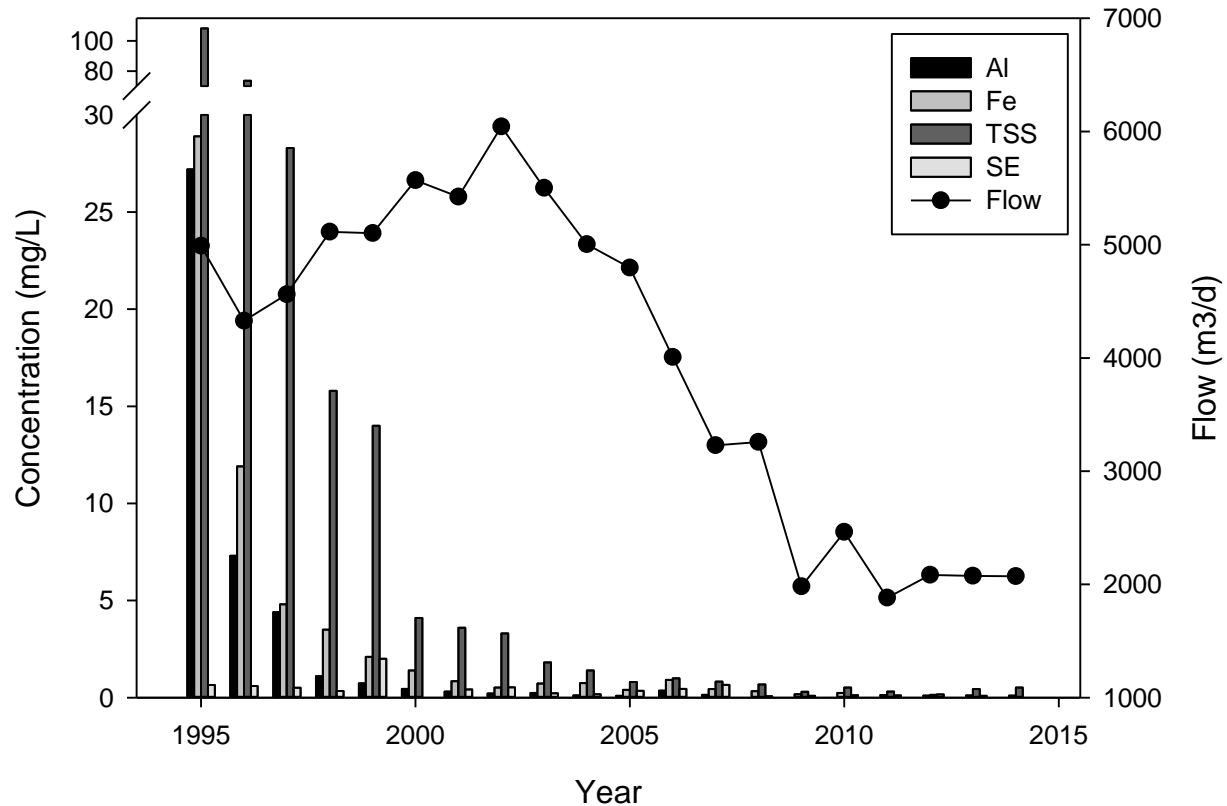
CHRONIC TOXICITY - RESOLUTE



LOADINGS - RESOLUTE



LOADINGS - OPG



RESOLUTE TREATMENT UPGRADES and PROCESS CHANGES

Mill Component	1990s	2000-2009	2010-2014
Paper machine	4 (no. 1 - 4) ^{1,2} @ 1300 mt/day	3 (no. 3 – 5) ³ @ 1500 mt/day	1 (no. 5) @ 615 mt/day
Market Kraft pulp mill	2 (A and B) @ 1600 mt/day	2 (A and B) ⁴ @ 1600 mt/day	1 (B) @ 1000 mt/day
Recycle plant	1 ⁵	1	0 ⁶
Thermo-mechanical pulp mill	1 ⁷	1	1

¹ no. 1 and 2 shut down in 1991

² no. 5 started in 1991

³ no. 3 and 4 shut down in 2003 and 2009, respectively

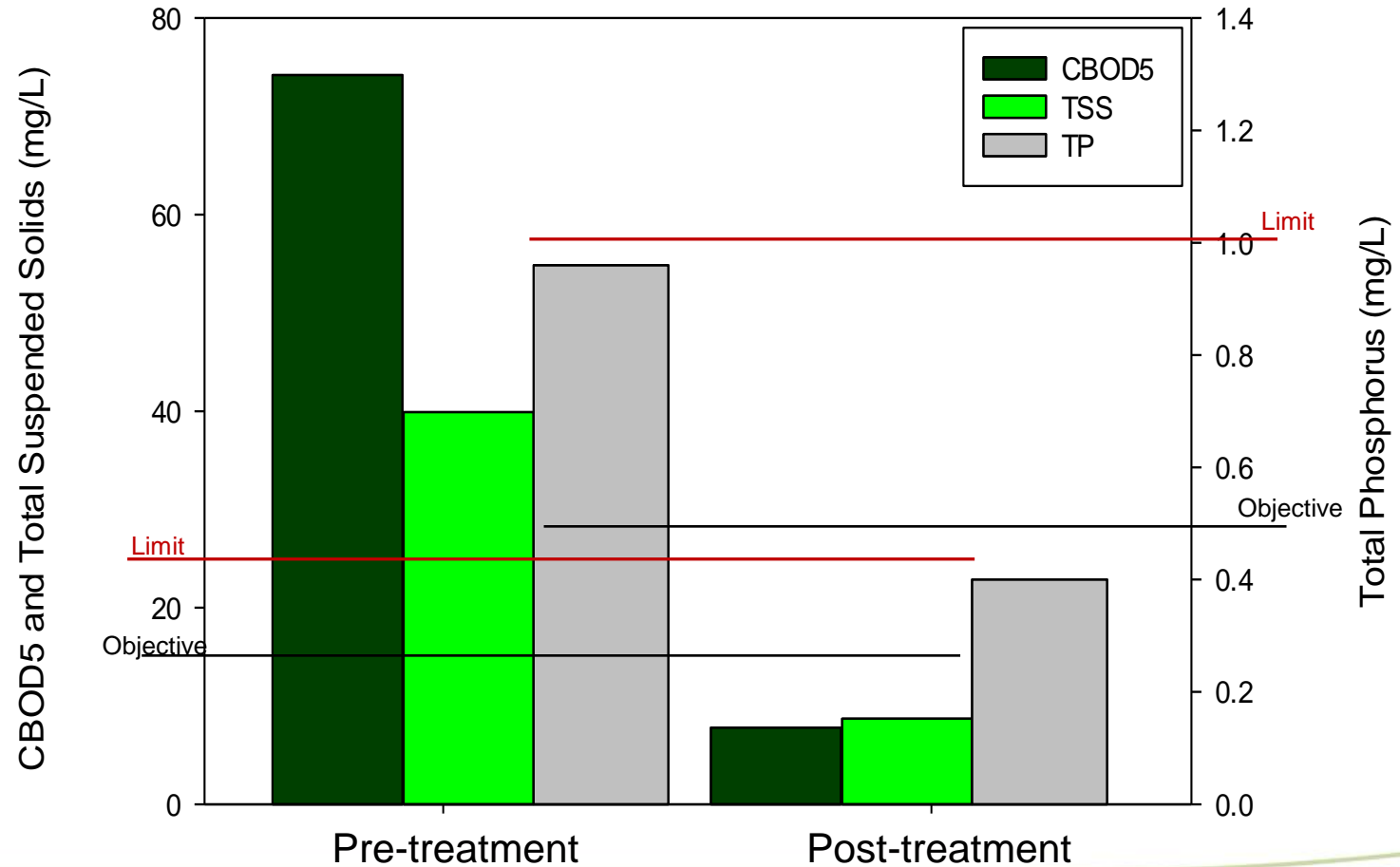
⁴ mill A shut down in 2006

⁵ started in 1992

⁶ shut down in 2011

⁷ started in 1991

WPCP TREATMENT UPGRADES



INDUSTRIAL CLOSURES

- Kaministiquia River:
 - Riverside Grain Products Inc. (Olgilvie Mills)
 - Arclin Canada Ltd. (Reichhold Limited)
 - Abitibi-Consolidated – Fort William Division
- Inner Harbour:
 - Northern Wood Preservers Inc.
 - Superior Fine Papers



INVASIVE SPECIES STRATEGIES

Bythotrephes longimanus



- AKA spiny waterflea
- Identified in LS in 1987
- Present lake-wide
- Preys on native zooplankton
- Reduces food for small fish
- Fouls fishing equipment
- Prevalent in late summer and fall

Dreissena polymorpha



- AKA zebra mussel
- Identified in T. Bay in 1998
- Form dense colonies
- Present in nearshore areas
- Filter plankton from water
- Increase water clarity and alter growth pattern of algae

ZEBRA MUSSELS

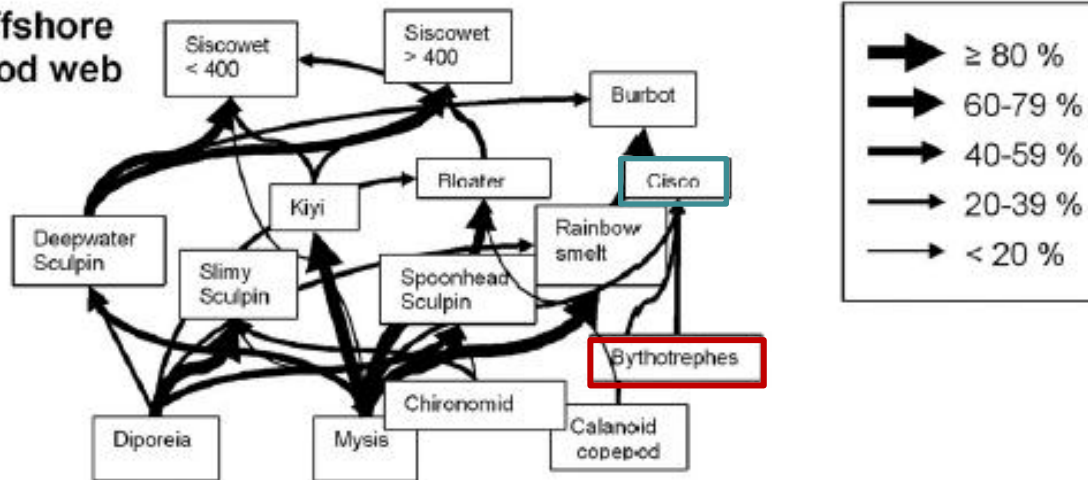
- *Diporeia* and *Mysis* are the primary diet of fish communities in Lake Superior
- In lower lakes, abundance of dreissenid mussels have decreased the *Diporeia* populations
- *Mysis* and *Diporeia* not at risk due to limited invasions of dreissenids



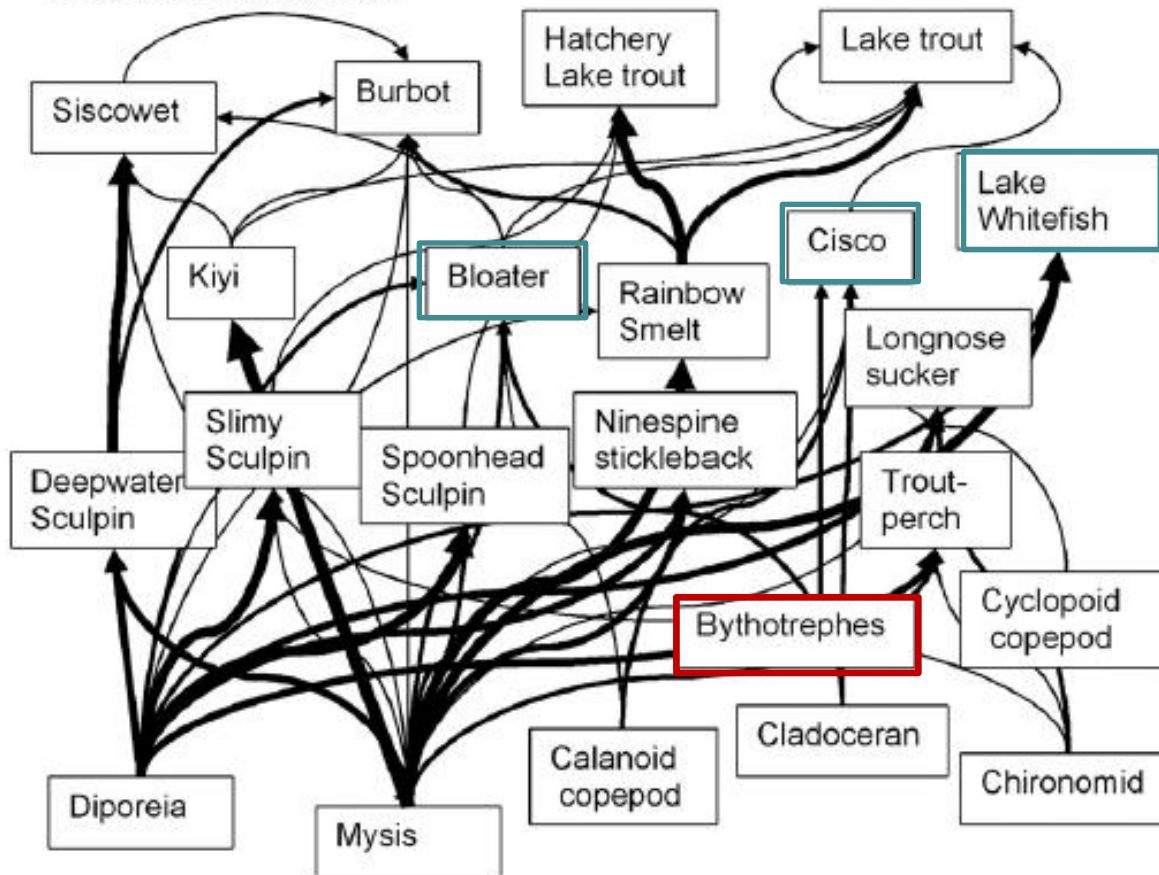
SPINY WATERFLEA

- *Bythotrephes* has been incorporated into the diet of Cisco, Lake Whitefish, Bloaters
- Cisco may act as a top-down control?
- Many factors influence dynamics: depth, temperature, prey resources
- LS food web configuration is similar to other large, stable, oligotrophic systems
 - Lower food web stability

Offshore food web

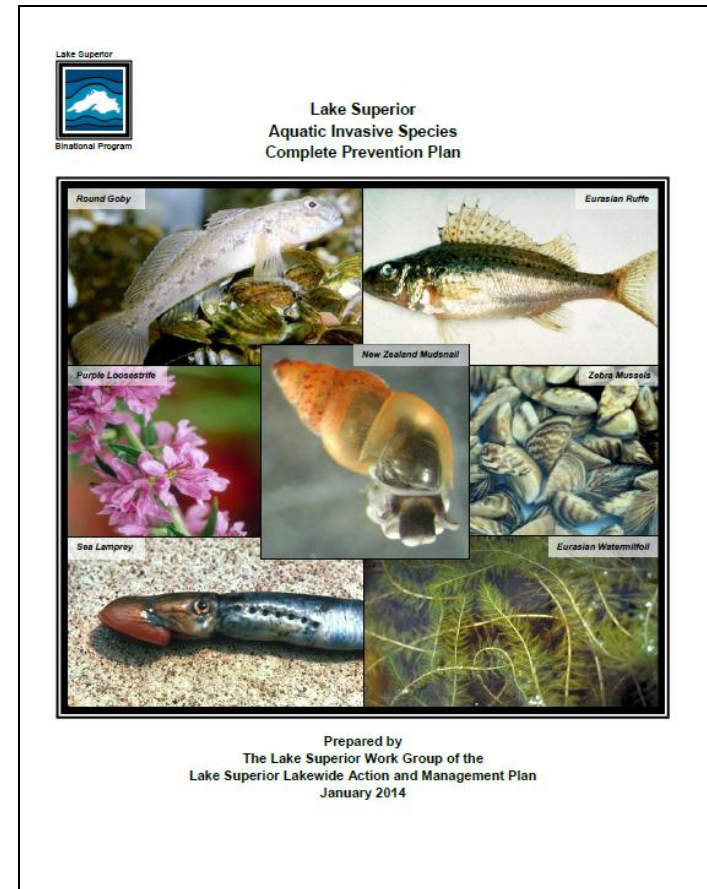


Nearshore food web



AIS PREVENTION AND MANAGEMENT

- Provincial, federal, and binational invasive species programs
- Lake Superior Aquatic Invasive Species Complete Prevention Plan, 2014



CONCLUSION

- Assessment of plankton populations is complex
- There is no consensus on how to assess plankton within the AOC/BUI model
- The Line of Evidence approach is useful in 2 ways:
 - Screening level assessment
 - Recognition of restoration and remediation
- Suggest that the “requires further assessment” status could be removed on the basis of existing information