Lake Superior’s Lower Trophic Levels

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Fisheries Management Goal

Maintain Balance Between Density of Predators and Prey
Components of Food Web

Physical Features
- Temperature
- Light

Phytoplankton

Nutrients
- Phosphorus

Predators
- Salmonids

Crustacean Zooplankton
- Cladocerans
- Copepods

Benthos
- Diporeia

Planktivorous Forage Fish
Limiting Factors in Lake Superior

- Cold Water temperatures
Spring Water Temperatures

Temperature (°C)

Superior
Spring Water Temperatures

Temperature (°C)

- Superior
- Michigan
- Huron

Summer Water Temperatures

Superior Offshore

Nearshore

Temperature (°C)

2001 2002 2003 2004 2005 2006
Limiting Factors in Lake Superior

- Cold water temperatures
- Low Levels of Nutrients
Effects on Food Web

Physical Features
- Temperature
- Light

Predators
- Salmonids

Phytoplankton

Crustacean Zooplankton
- Cladocerans
- Copepods

Planktivorous Forage Fish

Nutrients
- Phosphorus

Benthos
- Diporeia
Effects on Food Web

**Physical Features**
- Temperature
- Light

**Predators**
- Salmonids

**Phytoplankton**
- Cladocerans
- Copepods

**Planktivorous Forage Fish**

**Nutrients**
- Phosphorus

**Benthos**
- Diporeia
Limiting Factors

- Cold Water temperatures
- Low Levels of Nutrients
- Lead to lower primary productivity
Lake Superior Chlorophyll

Chlorophyll (ug/L)

2001 2002 2003 2004 2005 2006

summer spring
Phytoplankton Community Structure

- Chlorophyll concentrations don’t show complexity of phytoplankton communities
- Distinct differences in phytoplankton species composition and biomass in Great Lakes each year
Spring Phytoplankton Biomass from Integrated Samples

Biomass (µg/m³)

2001 2002 2003 2004

Superior

Centric Diatoms  Pennate Diatoms  Chlorophytes  Chrysophytes  Cryptophytes  Cyanophytes  Dinoflagellates  Others
Spring Phytoplankton Biomass

Total Biomass (ug/m³)

- Superior
- Michigan
- Huron

2001 2002 2003 2004
Summer Phytoplankton Biomass from Integrated Samples

- Centric Diatoms
- Pennate Diatoms
- Chlorophytes
- Chrysophytes
- Cryptophytes
- Cyanophytes
- Dinoflagellates
- Others
Zooplankton community

- Depends on phytoplankton abundance and species composition
- Certain types of zooplankton are important food for fish
Relative size of common zooplankton

Cladocerans

Cyclopoid Copepods

0.522 mm

0.982 mm

1.666 mm

1.295 mm

0.328 mm

Calanoid Copepods
Relative size of common zooplankton

Cladocerans

Cyclopoid Copepods

Diporeia

Calanoid Copepods
Mysis
Opossum shrimp

GLERL photo gallery
Community Composition

Spring Zooplankton Density

Density (#/m³)

- Daphnia
- Bosminids
- Other Cladocerans
- Immature Cyclopoids
- Adult Cyclopoids
- Immature Calanoids
- Adult Calanoids

Year:
- 2001
- 2002
- 2003
- 2004
- 2005
- 2006

Density Range:
- 0 to 1,400

Density Distribution over Years
Lake Superior - Summer 2001

Biomass (ug/m³) vs. Length (mm)

- Adult Calanoids
- Imm Calanoids
- Adult Cyclopoids
- Imm Cyclopoids
- Other Cladocerans
- Bosminids
- Daphnia
Lake Superior - Summer 2006

![Graph showing biomass ( ug/m^3 ) vs. length ( mm ) for different groups of zooplankton: Adult Calanoids, Imm Calanoids, Adult Cyclopoids, Imm Cyclopoids, Other Cladocerans, Bosminids, and Daphnia. The x-axis represents length in millimeters, and the y-axis represents biomass in micrograms per cubic meter.]
Lake Superior Crustacean Density
Summer 2005
Note: Stations SU06, SU08, and SU11 not sampled due to weather conditions.
Nearshore Zooplankton Summer 2005

Density (#/m³)

Ad Calanoids
imm cal
ad Cyc
imm cyc
bytho
daphnia
other cla
bosminid

SN97 SN17 SN33 SN101 SN81 SN145 SN13 SN135 SN102 SN109 SN29 SN99 SN11 SN35 SN159 SN147 SN107 SN103 SN143 SN127 SN95
Threats to Lower Food Web

- Introduction of non-native species
- Competitors
- Predators
Invertebrate Predators

- *Bythotrephes* and *Cercopagis*
- Invertebrate predators would select smaller or slower prey - cladocerans
Changes in Food Web

Physical Features
- Temperature
- Light

Phytoplankton
- Crustacean Zooplankton
  - Cladocerans
  - Copepods
    - Bythotrephes
    - Circopagis

Predators
- Salmonids

Forage Fish
- Coregonids

Nutrients
- Phosphorus

Benthos
- Diporeia
Dreissenid mussels

- Zebra and quagga mussels
- Filter algae and small zooplankton
- Change flow of nutrients to offshore regions of lakes
Changes in Food Web

- Phytoplankton
- Crustacean Zooplankton
  - Cladocerans
  - Copepods
- Forage Fish
  - Coregonids
- Nutrients
  - Phosphorus
- Benthos
  - Diporeia
  - Dreissenid mussels
Diporeia Abundance

Lake Superior Diporeia - Moderate depths

Density (#/m²)

97 98 99 00 01 02 03 04 05 06
Diporeia Abundance

Lake Superior Diporeia Density at Deep Stations

Year

# m^-2

0 200 400 600 800 1000 1200 1400 1600 1800 2000

97 98 99 00 01 02 03 04 05 06
Summary

- Lake Superior is an oligotrophic lake
- Cool temperatures and low nutrients limit primary production
- Chlorophyll and phytoplankton concentrations are lower than in other Great Lakes
- Lake Superior’s phytoplankton community is quite diverse
Offshore zooplankton density and biomass are lower than in other Great Lakes. Communities are dominated by large calanoid copepods which prefer cold water. A few cladocerans appear in summer. Near-shore zooplankton populations are more variable in density and composition.
Summary

- Offshore Diporeia density is low
- Abundance is greater at moderate depths
- These regions can serve as nursery areas for fish
Summary

- Low abundance of non-native predatory cladocerans
- Dreissenid mussels are not established in open lake
- Lake Superior’s lower food web is not showing the major changes in composition that are occurring in the other Great Lakes