Bottom-up and invasive species mediated changes to Lake Michigan's food web

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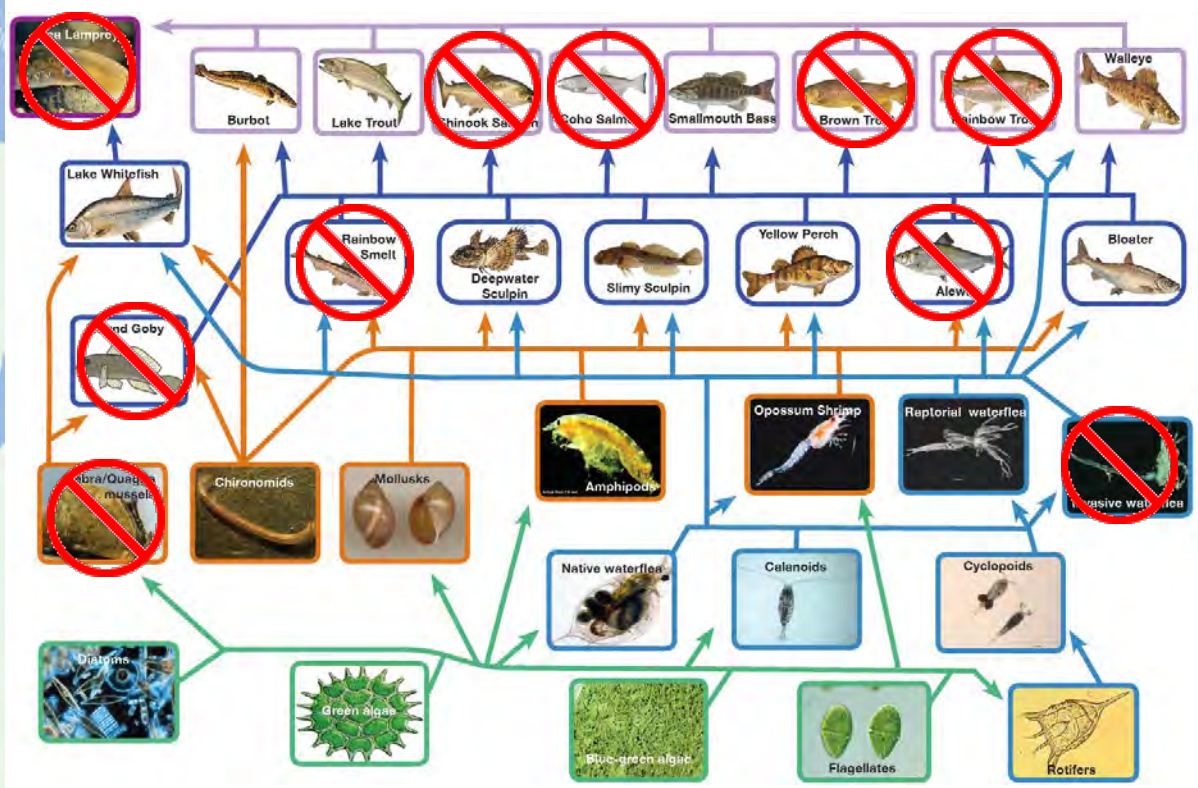


NOAA-GLERL

Non-native species

<u>Lake Michigan supports</u>:

-Multi-billion dollar recreational fishery

-Various culturally important commercial fisheries

These are dependent on nutrient inputs and lower foodweb dynamics.

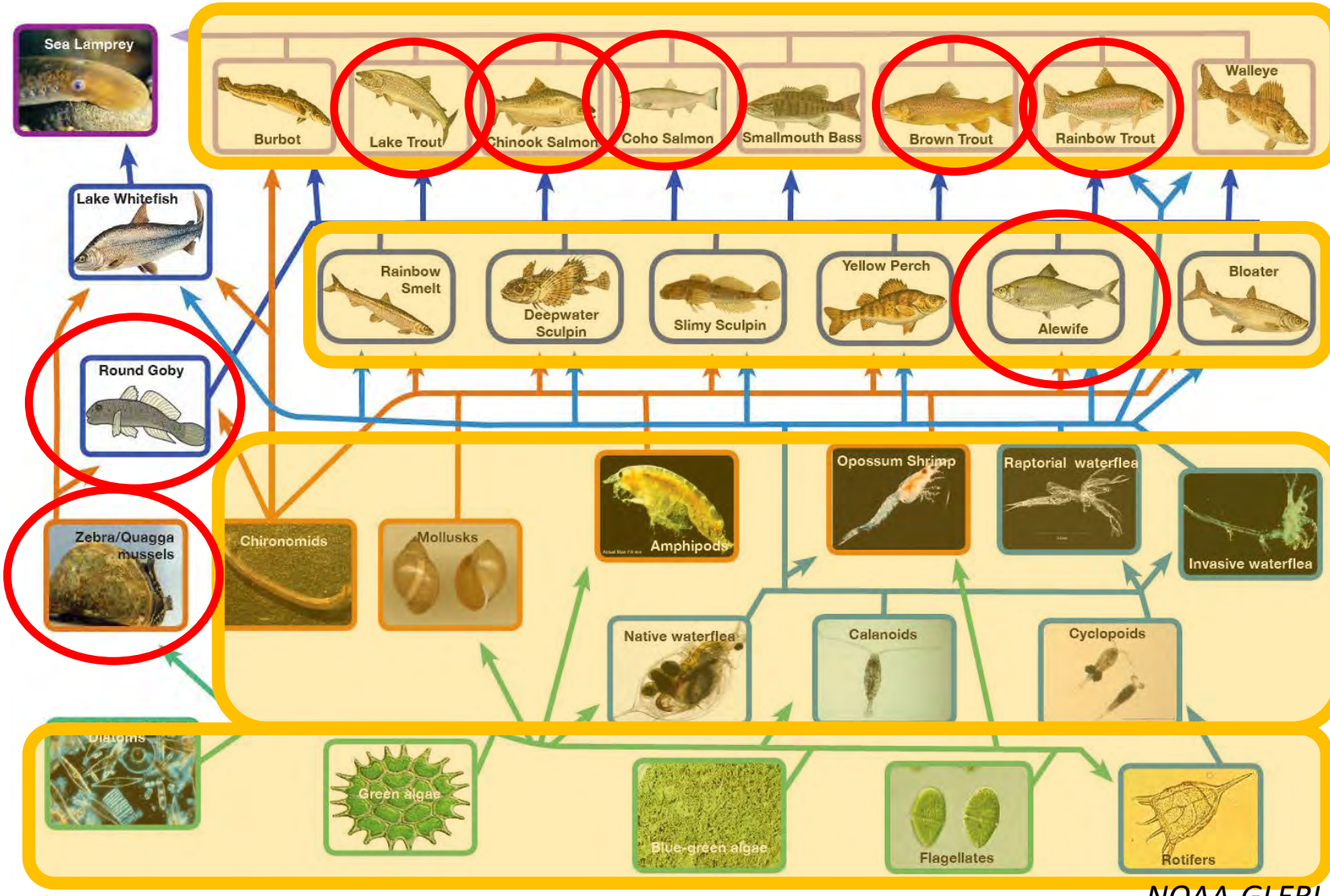
Tertiary consumers

Secondary consumers

Primary consumers

Primary producers

P



NOAA-GLERL

In freshwater, phosphorus tends to limit photosynthesis (e.g., David Schindler 1974)

Bottom-up **focus of presentation**

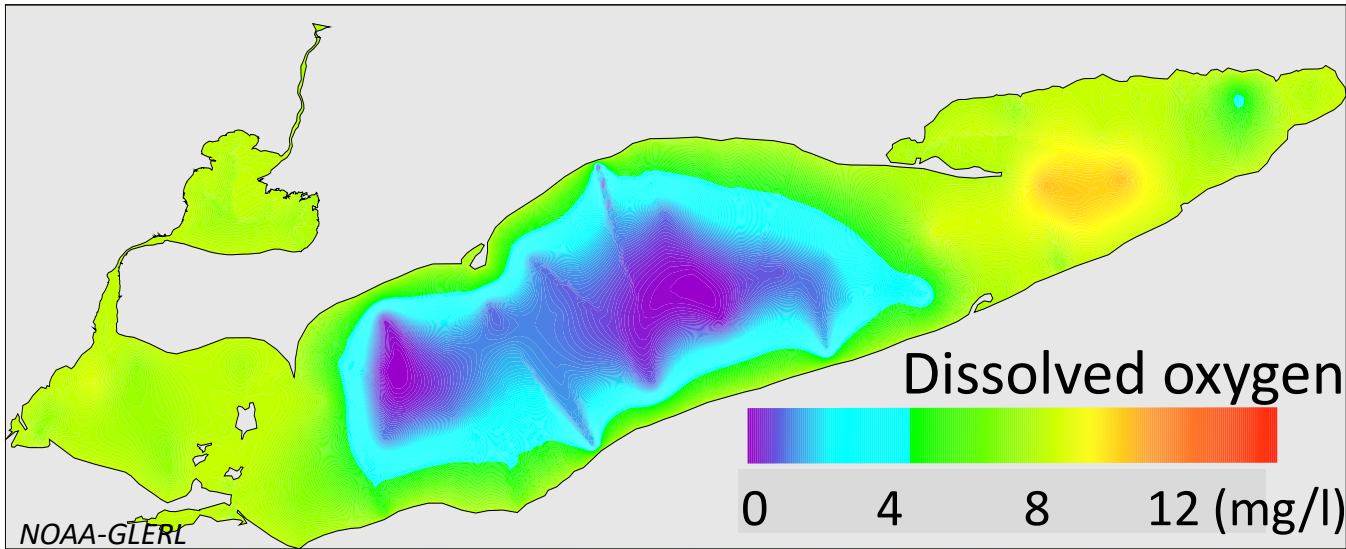
Top-down **processes also important**

Eutrophication

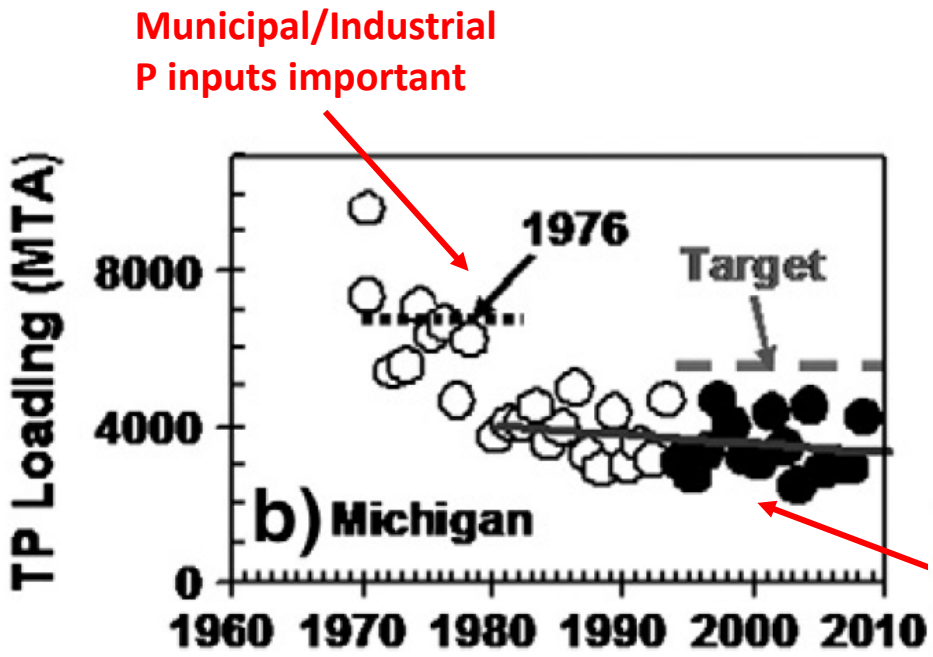
Algal blooms

Hypoxia

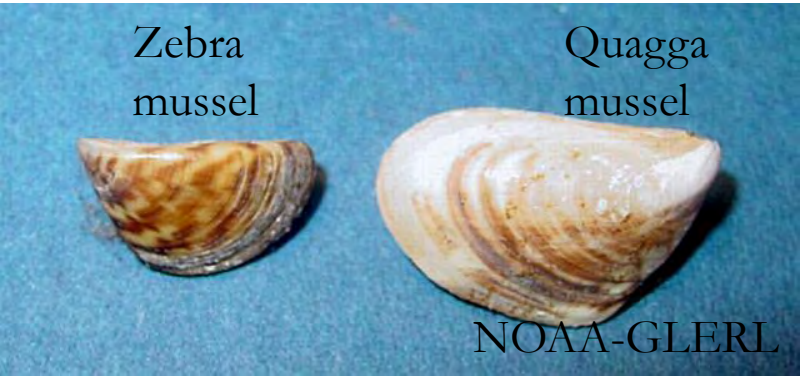
Lake Erie
September 2005

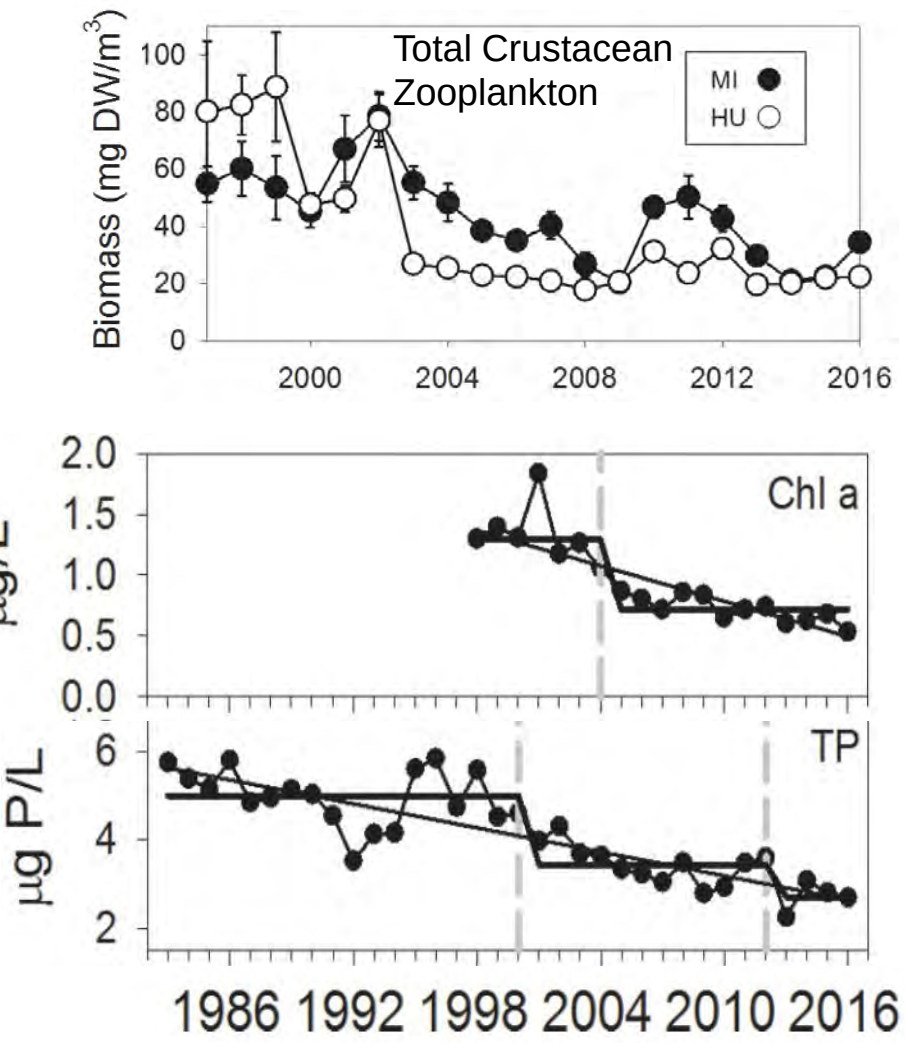


Oligotrophication



Dolan and Chapra 2012 JGLR

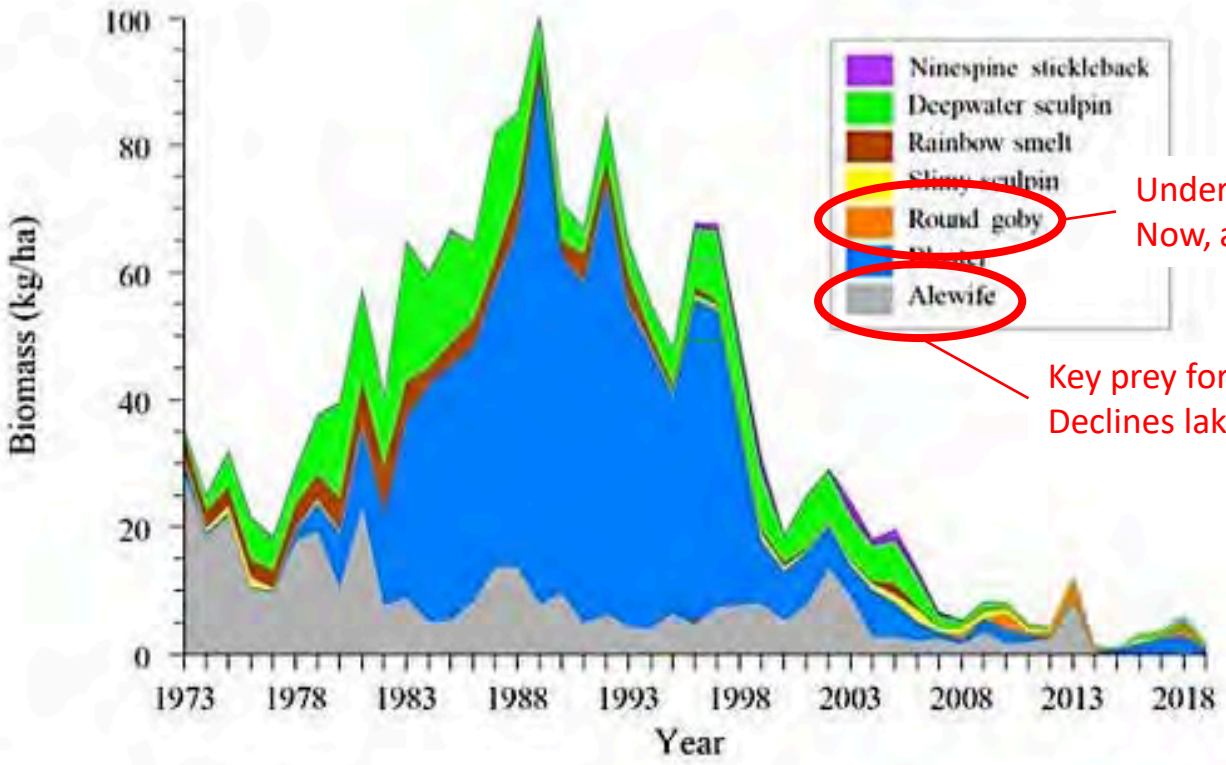




Barbiero et al. 2018 JGLR

Oligotrophication

USGS Annual Bottom Trawl Survey

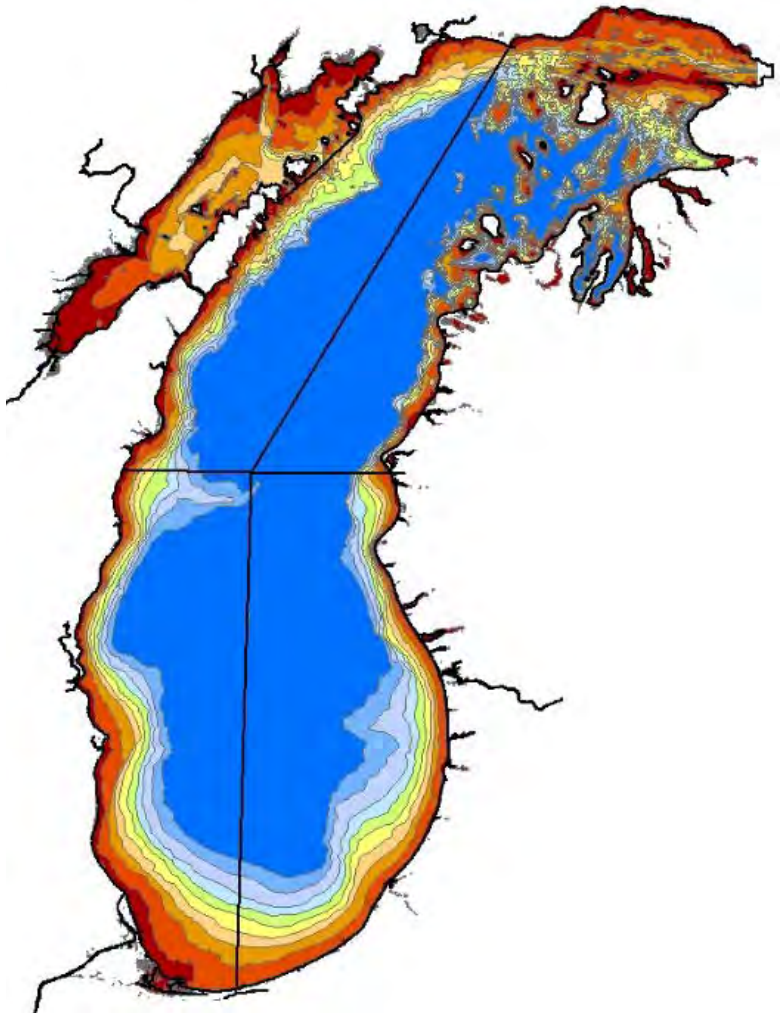


Effects of Oligotrophication of Lake Michigan

- Decreased primary production
  - Nutrient abatement and dressenid filtering
- Decreased secondary production
  - Offshore zooplankton and native benthic invertebrates reduced
- Decreased prey fish
  - Alewife abundance very low
  - Round goby abundant in nearshore
- Reductions in piscivores
  - Decreased stocking
  - Increased natural reproduction

Spatial aspects of oligotrophication

- Increased reliance on nearshore/benthic production
- Regional differences

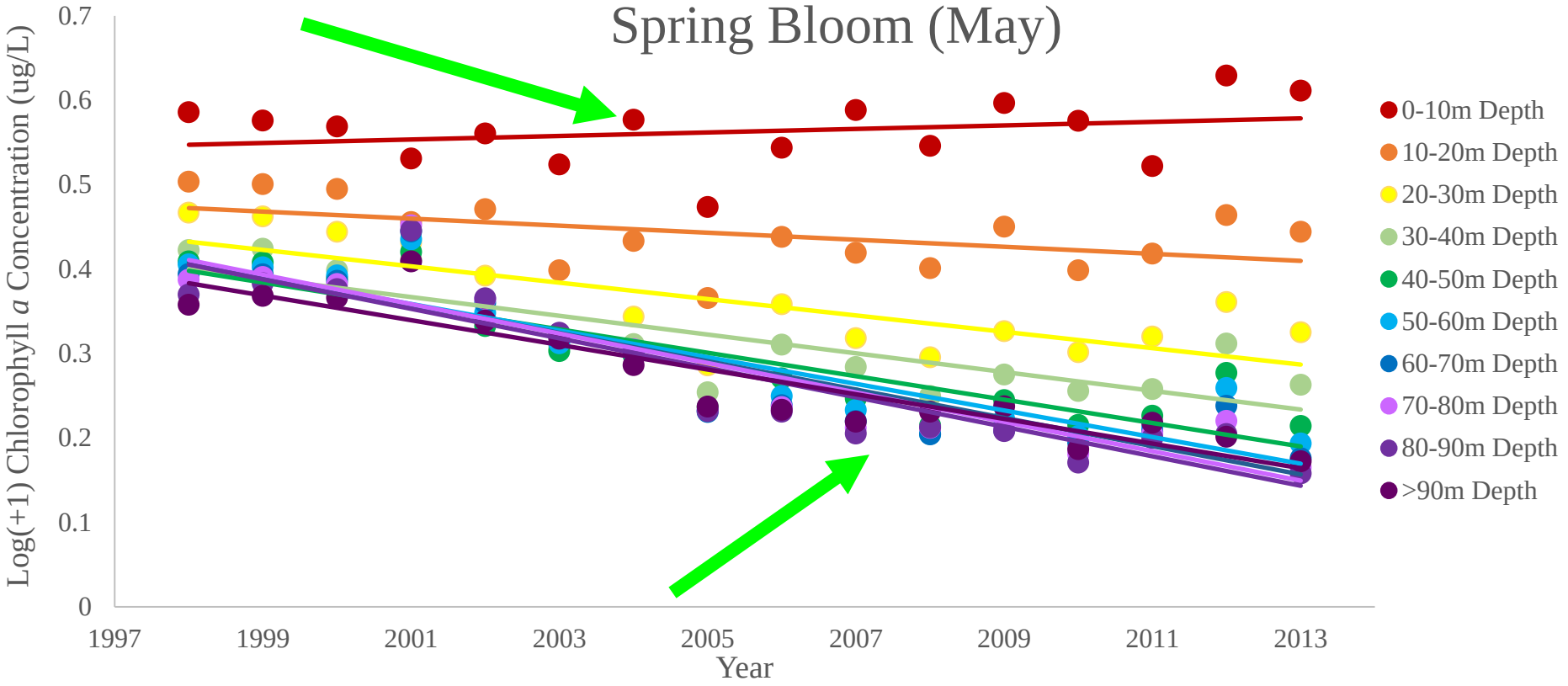


Trends in Chlorophyll *a*

- SeaWiFS and MODIS satellite imagery summarized and interpolated using published algorithm (Lesht et al. 2013)
- Summarized by
  - 10 m Depth Bins (and by distance from shore)
  - Monthly from 1998-2013
  - Whole Lake (excluding Green Bay)

Hutton-Stadig et al. 2020 Freshwater Biology

Lake Michigan Seasonal Depth Contour



Similar patterns for other months and when summarized by distance

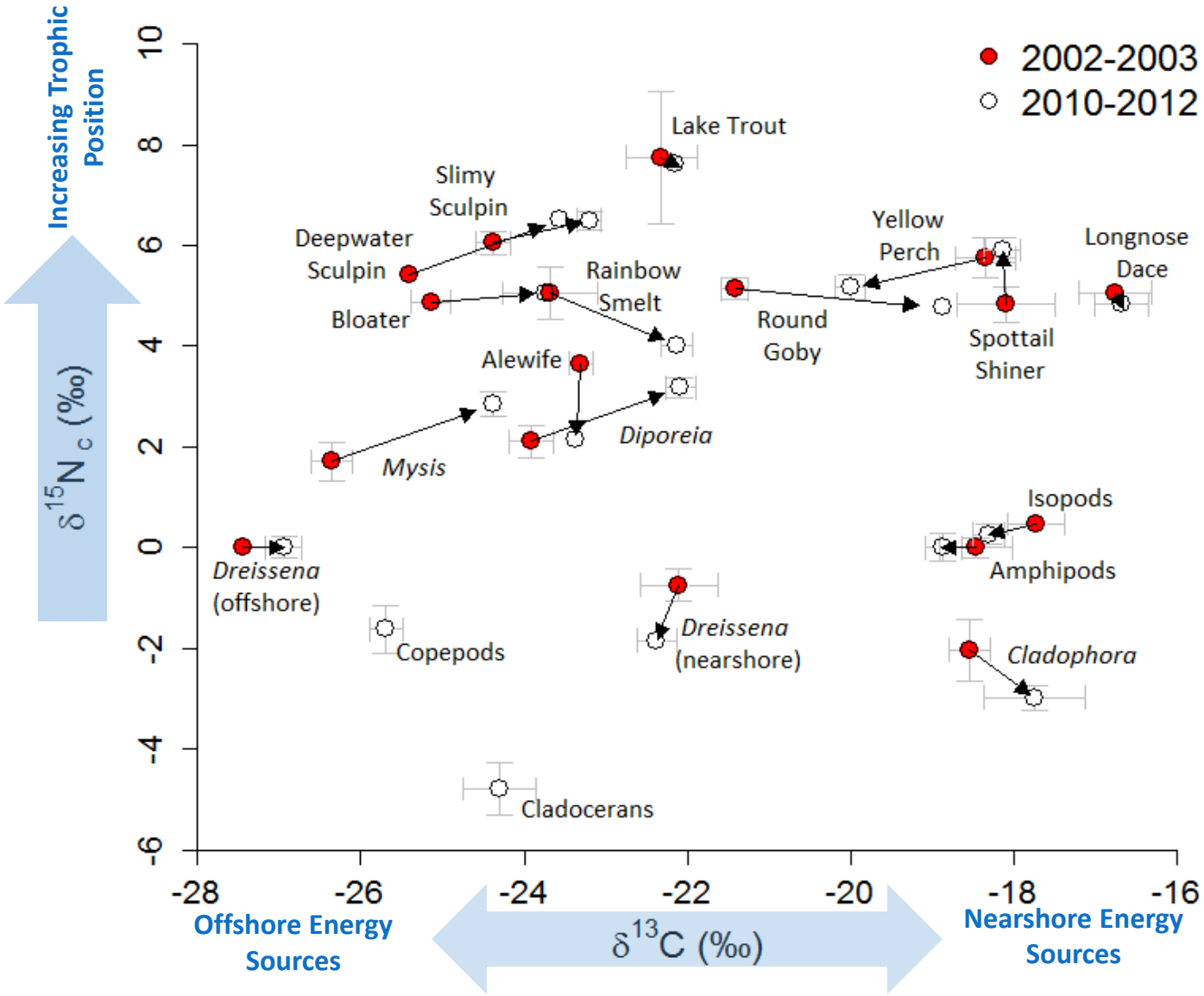
Hutton-Stadig et al. 2020 Freshwater Biology

Nearshore vs. Offshore Production: Consequences for consumers?

- Methods for examining trophic reliance
  - Stomach contents
  - Macromolecules (e.g., fatty acids)
  - Stable isotopes
    - Isotopes in consumer tissues reflect environment and food consumed
    - Common in trophic studies to examine ratios of:
      - Nitrogen isotopes $\delta^{15}N$
      - Carbon isotopes $\delta^{13}C$
        - $\delta^{13}C$ values reflect the primary production pathway supporting consumers and can help differentiate offshore pelagic reliance vs. nearshore benthic reliance

Turschak, et al. *Ecology* 2014

Food Web Shift

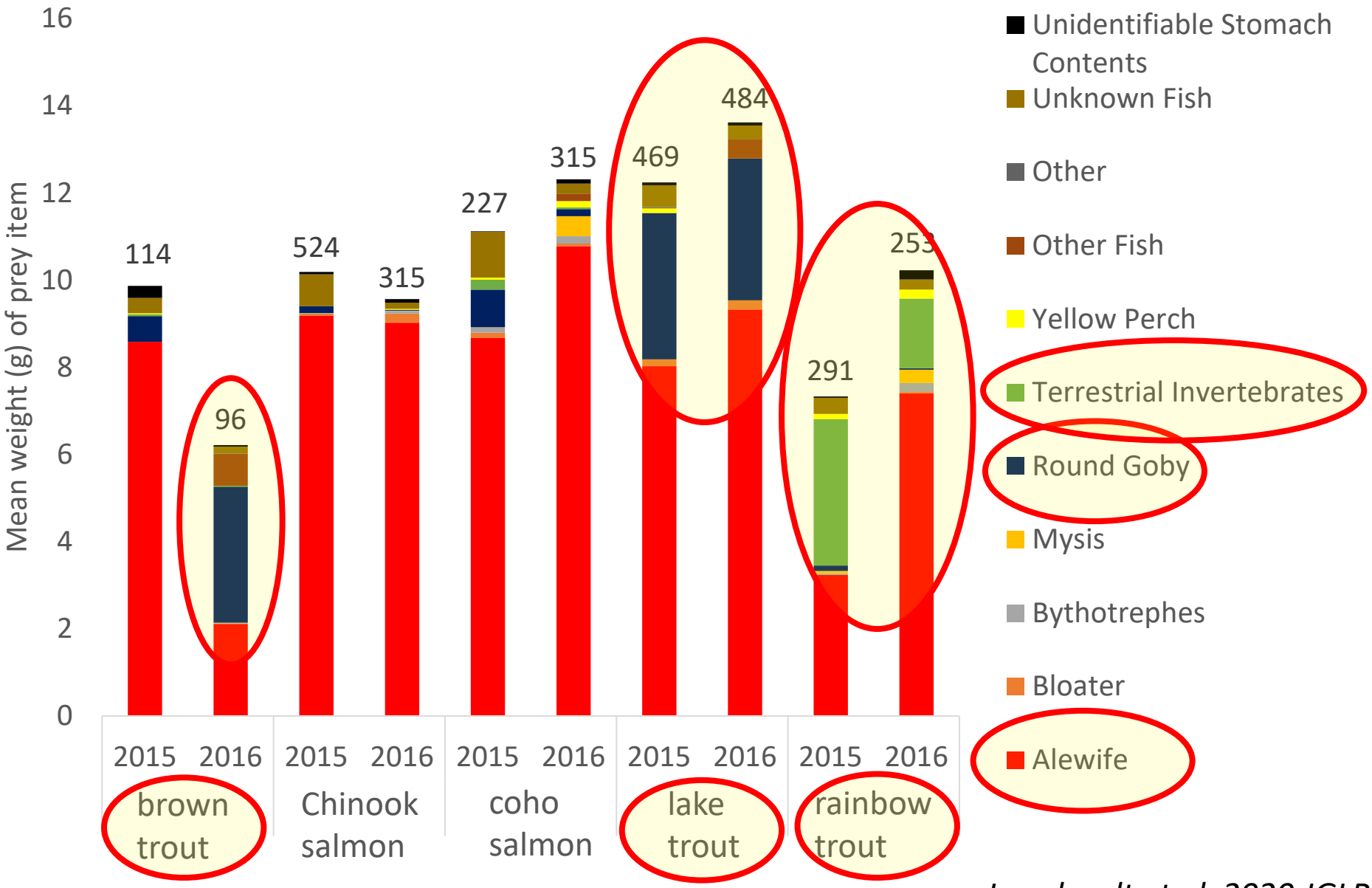


What are the five main salmon and trout species eating in the new Lake Michigan food web?

Examined stomachs of >3,000 salmon and trout (primarily angler caught fish from 2015 and 2016).

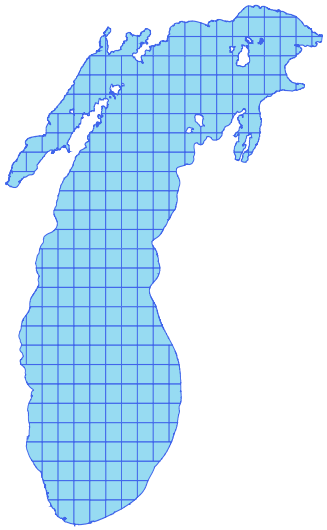
Leonhardt et al. 2020 JGLR

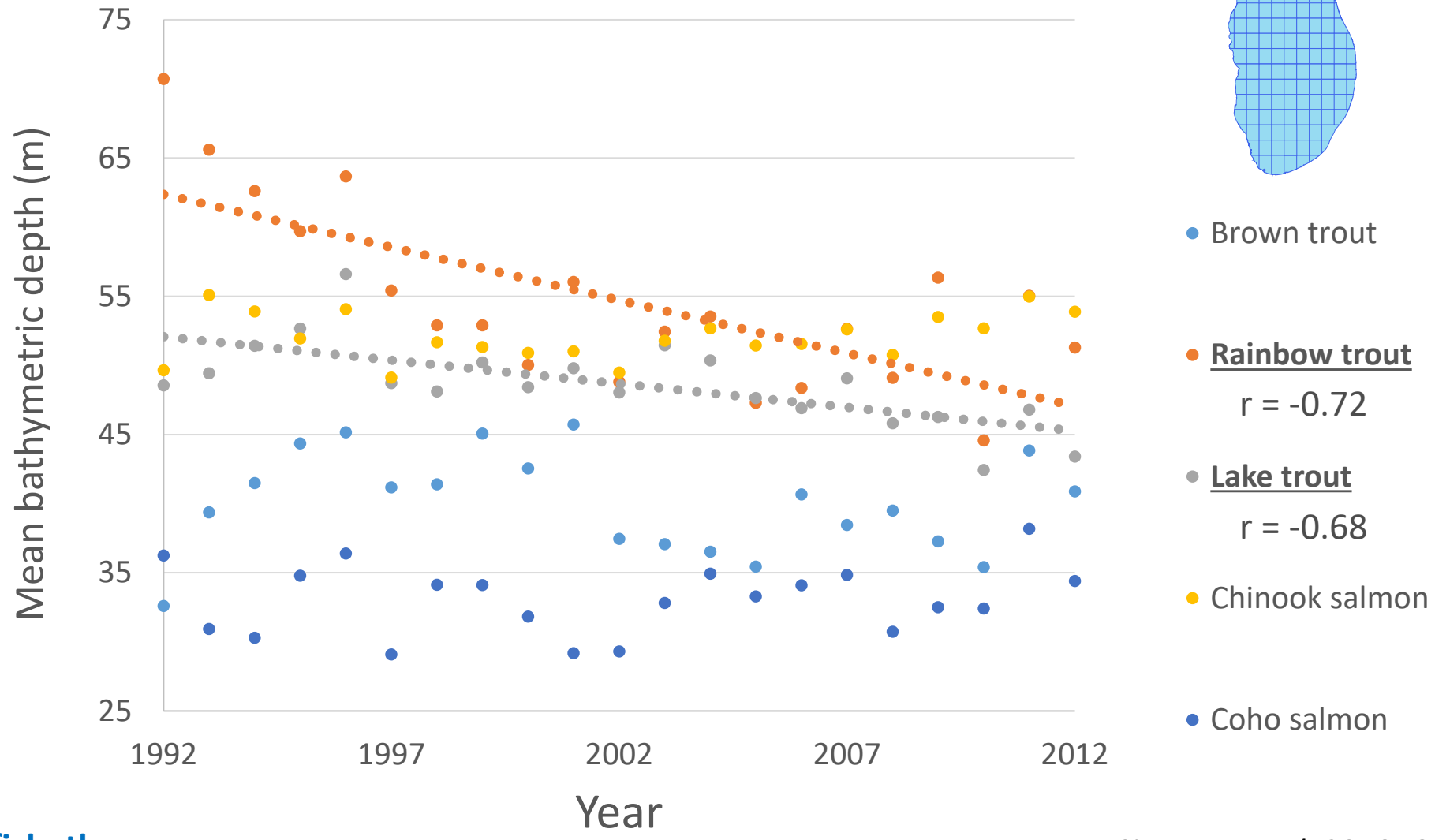
Alewife still dominant prey



Leonhardt et al. 2020 JGLR

Lake trout and rainbow trout harvest trends in charter boat fishery: IL, MI and WI waters (Lake Michigan, 1992-2012; N=~500K fishing trips)



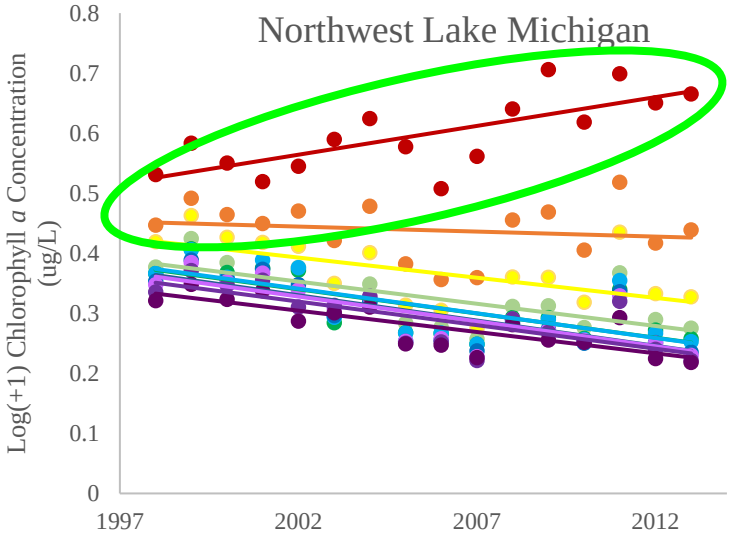


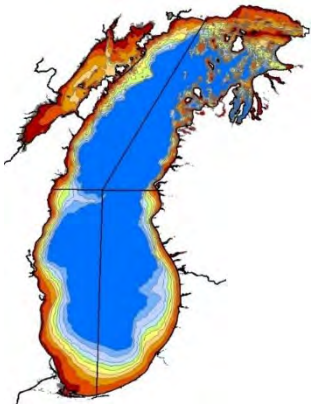
fishatlas.org

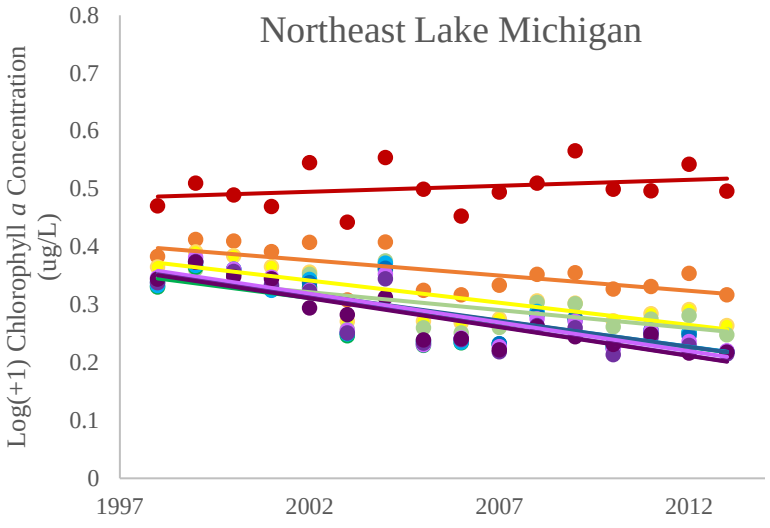
Simpson, et al. 2016 JGLR.

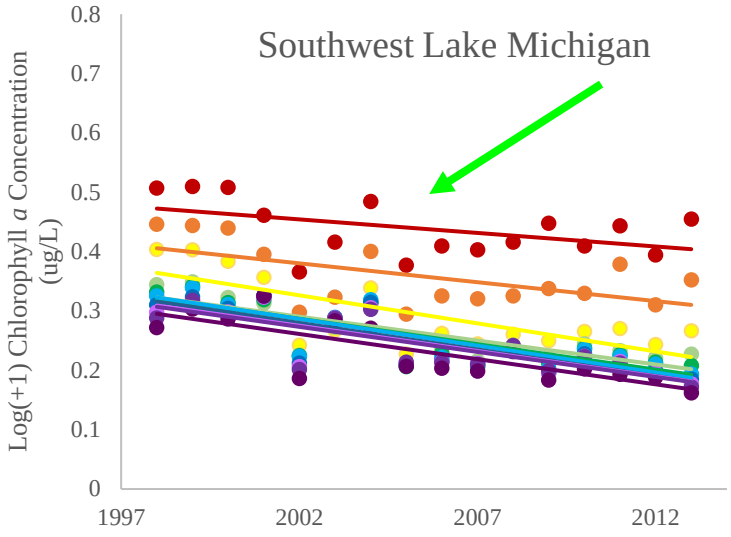
Nearshore patterns may not be homogeneous throughout the Lake

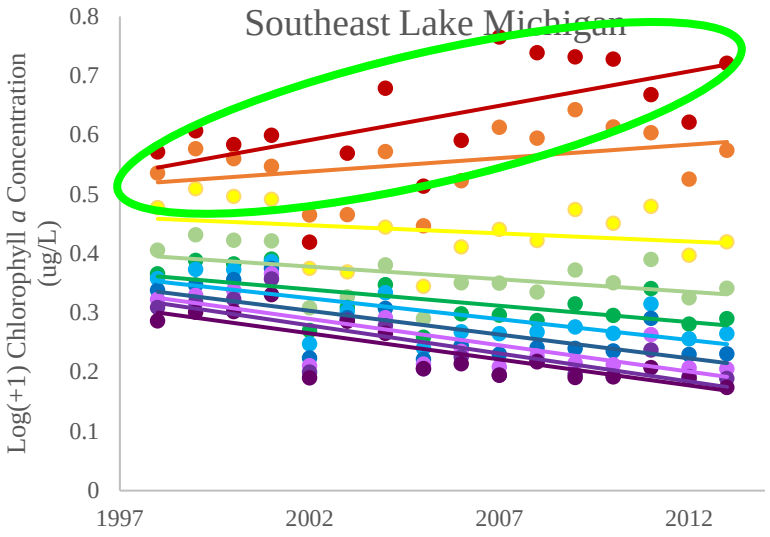
- **Physical processes vary throughout the lake and may structure foodweb dynamics**
  - **Tributary inputs**
  - **Limited tributary inputs in SW**











Hutton-Stadig et al. 2020 Freshwater Biology

Lake Michigan
Spatial food web variation

Foley et al 2017;
Happel et al. 2016a & 2016b;
Turschak et al. 2016 & 2019;
Feiner 2018 & 2019

Western sites:
Benthic pathways more important for fish production

Eastern sites:
Pelagic pathways and tributary inputs important for fish production

-Stomach contents
-Fatty acids
-Stable isotopes

$\delta^{13}C, \delta^{15}N, \delta^{2}H, \delta^{18}O$

Collaboration with: *Bootsma, Bowen, Bronte, Czesny, Feiner, Foley, Happel, Henebry, Höök, Janssen, Kornis, Leonhardt, Rinchard, Turschak*

Regional differences in nearshore fish condition

Examined length-adjusted proportional dry mass for ~2,500 individual fish.

alewife, bloater, rainbow smelt, round goby, spottail shiner, & yellow perch

Foley, Feiner and Höök in prep

Southwestern sites:
Lower proportional dry weight than rest of lake

Piscivore Stomach Contents (Angler-caught & netted fish)

Chinook Salmon

Lake Trout

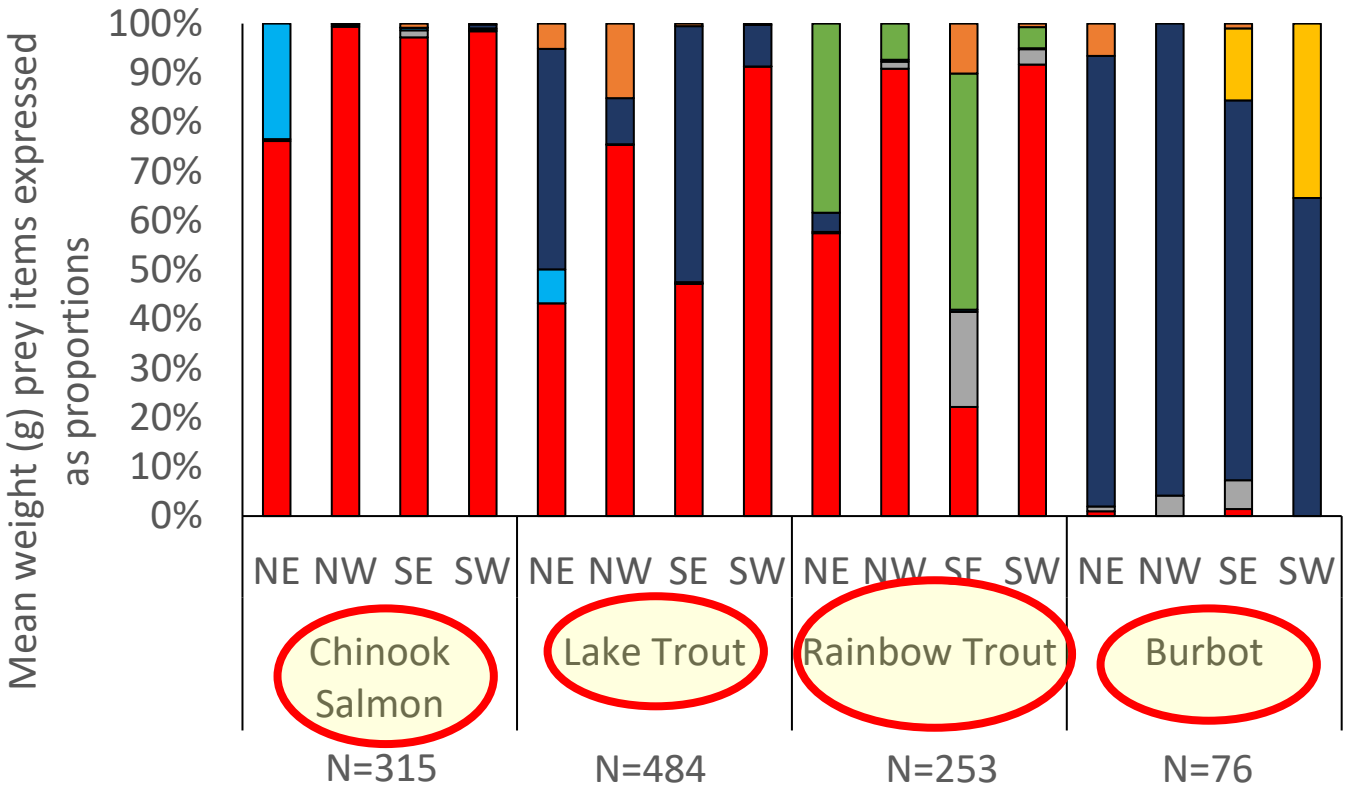
Rainbow Trout

Burbot

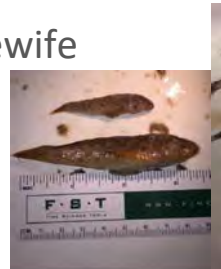
http://www.miseagrant.umich.edu/explore/native-and-invasive-species/species/fish-species-in-michigan-and-the-great-lakes/brown-trout/

http://www.michigan.gov/dnr/0,4570,7-153-10364_18958---,00.html

2016 Lake Michigan Piscivore Stomach Contents



- Other Fish
- Sculpin
- Terrestrial Invertebrates
- Round Goby
- Bloater
- Aquatic Inverts
- Alewife



Conclusion:
Spatial aspects of oligotrophication of Lake Michigan

- Increased reliance on nearshore/benthic production
  - Decreased production offshore
  - Shift to rely more on nearshore, benthic resources
  - Many top predators continue to rely on pelagic resources (e.g., Chinook target alewife)
- Regional differences
  - Importance of production pathways and prey consumption patterns vary regionally
  - Strongest decrease in productivity in southwest Lake Michigan
  - Implications for performance of consumers incl. fish

- These patterns may have implications for the future success of different species.

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