**Research Question:** How have seasonal changes in prey availability influenced diet composition and what is the effect on predator energy densities among spatial regions?

**Titles:**

1. Intraseasonal change in energy density of Emerald Shiner, *Notropis atherinoides*, and their prey in Lake Erie
2. Influence of intraseasonal change in zooplankton density on diet composition and energy density of Emerald Shiner, *Notropis atherinoides*,in Lake Erie
3. **Spatio-temporal and interindividual variation of Emerald Shiner, *Notropis atherinoides*, diets and energy density in Lake Erie**

Planktivorous fishes function both as food for piscivores and as a predator that can influence the composition, abundance, and size structure of zooplankton communities (Brooks 1968, Hartman and Margraf 1992, Johannsson et al. 1999). Most of the numerous studies published on the food of western Lake Erie fishes emphasized the feeding ecology of adult fish that are representative of high trophic levels of the food web (Griswold and Tubb 1977, Burr 1982, Knight et al. 1984). However, the food of forage fish and competition among them are usually not studied. This lack of information creates a barrier for understanding energy flow through the food web, as well as the importance of intratrophic level dynamics of forage fishes that might influence the production of piscivorous species. Despite the dramatic ecological and food web changes that have taken place in Lake Erie over past decades (Ryan et al. 1999, Ludsin et al. 2001), little historical or recent data exists on feeding ecology of Lake Erie’s major planktivorous fishes, particularly for the central and eastern basins.

A native planktivore that has persisted in Lake Erie and remains a dominant component of the fish community is Emerald Shiner, *Notropis atherinoides*, which serves as an important prey for abundant top predators such as Walleye, *Sander vitreus*, and Yellow Perch, *Perca flavescens* (Knight et al. 1984, Knight and Vondracek 1993). Piscivorous predators can experience multi-fold differences in energy intake rates based solely on the types of fishes consumed. As prey vary in resource value, optimally foraging predators must integrate this variability in simultaneously balancing costs and benefits to optimize survival and reproductive fitness (Stephens and Krebs, 1986). Predators rely on prey availability to satisfy nutritional and energy requirements (Murphy 1994), but can compensate to some extant through adjustments in selection for prey quality (Ricklefs 1979). To better understand the food web components that ultimately support valuable commercial and recreational fisheries for piscivores, we need to determine the energy density of Emerald Shiner in the western, central, and eastern basins of Lake Erie. Specifically, we can quantify how diets changed with seasonal changes in prey availability as well as energy densities among spatial regions.

Bioenergetics models are commonly used to estimate growth and consumption dynamics of planktivorous fishes. Despite the widespread use of bioenergetics models, information on one key input variable, energy density (J/g wet basis) of predators and prey, has been limited. If the results obtained from the use of bioenergetics models are to be accurate, estimates of energy density of predators and prey are required for specific seasons, fish ages, and ecosystems. Because biological systems, including fish, conform to the principles of thermodynamics, all energy consumed through the diets is used hierarchically for metabolism, excretion, or growth (Brett and Groves 1979). Feeding studies can be used to compare the types and amount of energy available to fish for growth, either somatic or gonadal. Whole-body energy density can be used as an index of fish condition. This condition metric is used because energy density is related to lipid content (Rottiers and Tucker 1982), which is reflective of the quantity and quality of food availability to a fish. (Phillips and Brockway 1959, Flath and Diana 1985, Madenjian and O’Connor 1999). Bomb calorimetry is an accurate method for measuring the energy content of aquatic organisms (Cummins and Wuycheck 1971).

Emerald Shiners appear to influence zooplankton community structure and abundance in Lake Erie, given their relatively high mass-specific consumption rates and a diet consisting mainly of cladoceran zooplankton. Given the feeding patterns and consumption rates for Emerald Shiners, combined with their high relative abundance in Lake Erie, it is clear that this species needs to be accounted for in food web analyses of planktivory (Pothoven et al. 2009). Ongoing ecological changes occurring in Lake Erie basins, including oligotrophication (Ludsin et al. 2001), the proliferation of invasive species that may ultimately reduce zooplankton abundance and community structure (Johannsson et al. 1999), and increasing hypoxia (Hawley et al. 2006) will likely affect this species. Such changes then could influence the potential capacity of the system to support forage fish production and ultimately piscivore production through bottom-up processes.

Subsampling Procedure:

* 5 fish of each sex per 10-mm length interval

Lab Methods:

* Fish Processing
  + Assign fish id
  + Record TL, wet weight, sex
  + Remove gut
* Diet Composition
  + Identify and numerate all large prey (e.g. Chironomidae, Bythotrephes, Leptodora)
  + Identify, numerate, and measure prey to family
  + Dry @ 60 C for 72 hrs
  + Measure dry weight
* Energy Analysis
  + Dry @ 60 C for 72 hrs
  + Measure dry weight (allows for percent water content calculations)
  + Grind
  + Place ground contents into a clean, dry scintillation vial for storage
  + Use approximately 1 g of each homogenized sample for determination
  + Duplicate determination for each sample
  + Average energy density

Energy Density Wet Weight Equation:

* Report all energy density values in J/g wet weight
* (J/g wet basis) = (J/g dry basis)\* (1 – (W/100))
  + W/100: percent moisture content

Analyses:

1. Physical Conditions and Prey Availability
   1. Depth, water temperatures, and DO
   2. Zooplankton and benthos availability by basin and season
2. Diet Composition
   1. Percent occurrence of prey items by basin and season
   2. Mean diet composition (% dry weight) of prey taxa by basin and season
3. Energy Density
   1. Simple Linear Regression
      1. Energy density against fish weight to determine the effects of biomass on energy density
   2. Analysis of Covariance
      1. Fish weight as the covariate to examine differences in energy density between basins, seasons, and sex

Journals:

Ecology of Freshwater Fish

Fisheries Management and Ecology

Journal of Great Lakes Research

New Outline (3-2-16):

1. Physical Conditions
   1. Water temp and DO
2. Feeding Ecology
   1. Diet Analysis
      1. Percent dry weight
      2. NMDS - Cut
   2. Prey Selectivity
      1. Chesson’s alpha
   3. Diet Overlap? (may be redundant to NMDS) - Cut
3. Energy Density
   1. Analysis of Covariance

I have scripts written for energy density, prey selectivity, and dry weight composition. The only script that is in “finished” condition is prey selectivity. I can scrap together old scripts for the physical conditions.

Sample Sizes:

1. Calorimetry



1. Non-empty diets



Obstacles:

1. Sample sizes are the biggest obstacles I see. The energy density data has proved to be difficult to fit, especially in September. I currently abandoned the regression.
2. I think the focus of this paper should change to feeding ecology. It’ll be good to report EMS energy data, but I don’t think it should be the focus anymore.