Alewives and Rogers Lake: What Ecological History Tells Us
Lily Twining – June 2011

Alewife Basics

- Alewife Ecology
  - Alosa pseudoharengus – closely related to American shad and blueback herring
  - Native to the East Coast from North Carolina to the St. Lawrence River
  - Anadromous – live most of life in ocean, but require freshwater habitat to spawn; alewife spawn primarily in coastal lakes and ponds off of small streams
  - Once an incredibly abundant fish – so abundant that early colonists described being almost able to walk across streams on their backs during spawning runs
  - Keystone species – influence lower food levels by preying upon them, influence higher food levels by serving as an important prey item; supply freshwater systems with nutrients for primary production (plant growth)
  - Other species – coastal breeding birds, such as osprey, night heron and cormorants, and sportfish, such as largemouth bass and striped bass, both thrive when alewife (especially anadromous alewife) are present in lakes
  - Species of Concern – listed as a federal species of concern by NOAA and NMFS due to decline since colonial times that has accelerated in past ~40 years; alewife fishery in Connecticut has been closed for several years
  - Size-selective Predator – go after the largest zooplankton and leave lakes with only smaller zooplankton species through their voracious predation
  - 3 Types of Lakes in Connecticut – lakes without any alewife have large zooplankton all year round that graze on algae intensely; lakes with anadromous alewife have large zooplankton when alewife are not around in the late fall-spring, but have only small zooplankton in the summer when alewife are present; lakes with landlocked alewife have only small zooplankton year-round because large zooplankton cannot survive with constant intense predation by alewife

- Landlocked v. Anadromous Alewife
  - Two Kinds of Alewife – south central Connecticut has two distinct types of alewife: anadromous alewife that migrate back and forth between the ocean and coastal lakes and ponds seasonally and landlocked alewife that live in lakes year-round because they cannot access the ocean
  - Genetics – several of the populations of landlocked alewife (including those in Rogers Lake) in the region diverged from anadromous alewife 300-400 years ago and all evolved to be genetically different from each other and from anadromous populations; some lakes in Connecticut were also stocked with these landlocked alewife in the 1950s-1960s as a forage fish to encourage sportfishing
  - Differences – anadromous alewife are larger, have a different body shape and spawn earlier than landlocked alewife; anadromous alewife create a seasonal cycle in the species composition of lakes whereas lakes with landlocked alewife have more constant species composition; anadromous alewife select the largest prey they can find whereas landlocked alewife consume anything they can get

Alewife Restoration

- Because of the alewife's decline and listing as a federal species of concern, environmental managers in Connecticut and throughout the Eastern seaboard are taking action to restore alewife populations
- Connecticut has closed the fishery for alewife for the past several years
- Fishways – many states, including Connecticut are building fishways to enable to anadromous alewife to access freshwater spawning habitat that is blocked by dams
  - In Connecticut, fishway construction is mandated by law when the state repairs an old dam standing in the way of anadromous fish habitat
  - Concerns – anadromous alewife may cause algae blooms by bringing in lots of nutrients from the ocean or may cause algae blooms by consuming all of the zooplankton that are keeping algae in check
  - Benefits – increased coastal breeding bird populations and sportfish populations

Research Questions

- How and why did alewife in Rogers Lake and throughout south central Connecticut become landlocked?
- How did the landscape of coastal New England change from the perspective of anadromous fish from pre-colonial to colonial/post-colonial times?
- What ecological changes occurred as alewife became landlocked?
- What can the answers to these questions tell us about the potential for current alewife restoration efforts in the area?

Historical Research

- Looked for evidence of dam and mill construction that would have blocked fish passage and landlocked alewife along Mill Brook (the stream leading out from Rogers Lake into the Lieutenant River) and Rogers Lake
- Found evidence of many dams along Mill Brook
  - Area settled in the mid-1600s
  - Earliest dam put on Lower Millpond by 1672 for a grist mill to grind town's corn
  - Next dam put on Upper Millpond for a sawmill
  - Later dam put on Rogers Lake around 1798
- Conclusion: many dams along watershed match up perfectly with dates of genetic divergence for landlocked alewife suggesting that the landlocked alewife in Rogers Lake did indeed become landlocked due to colonial dam construction

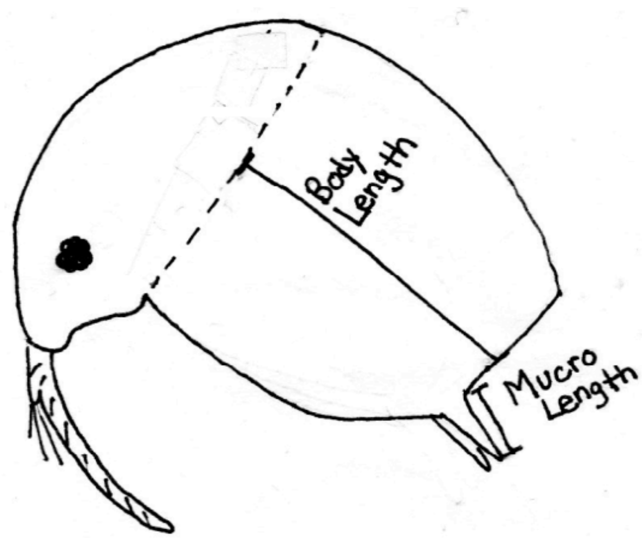
Ecological Research

- Lake Cores – cored Rogers Lake and several other lakes in the area in order to go back in time and examine the ecological changes the lakes went through as alewife became landlocked; lake sediment cores hold a record of lake biology/chemistry/geology because everything in the lake eventually sinks to the bottom and becomes part of the mud

- Zooplankton Remains – examined the remains of bosmina, a small herbivorous zooplankton in order to reconstruct past lake food web structure
  - Bosmina morphology – bosmina are small and not very appealing to alewife; bosmina grow tail spines (called mucrones) as a defense against invertebrate

predators; when zooplankton-eating fish like alewife are abundant, bosmina don't need to defend themselves against invertebrate predators and their tail spines are shorter; without zooplankton-eating fishes bosmina need to grow long tail spines to defend themselves against their predators; bosmina preserve well in sediments

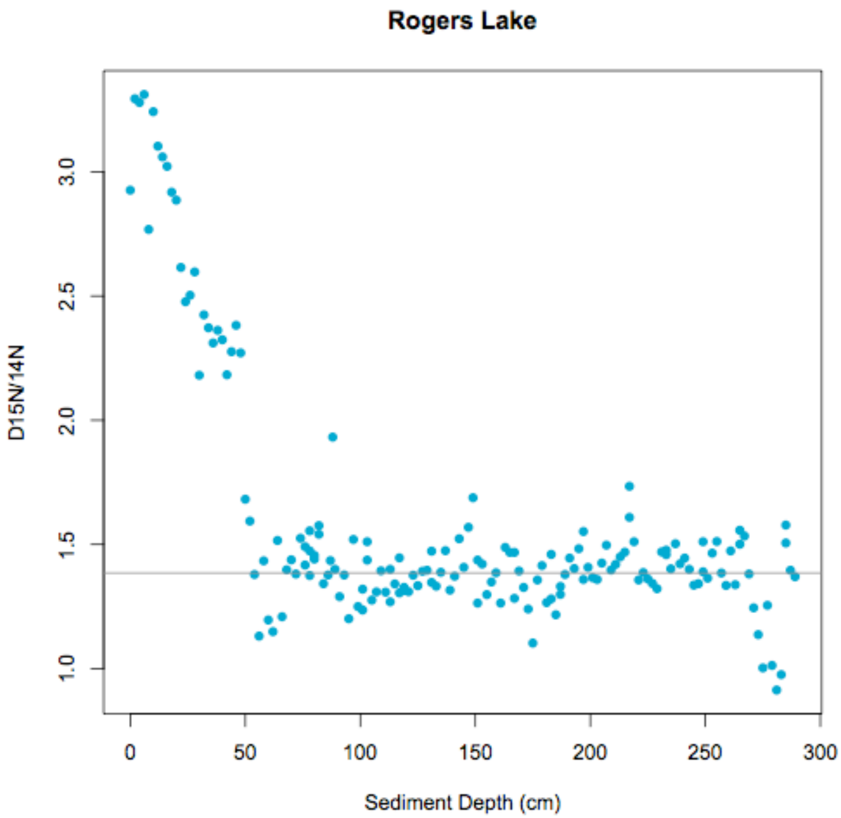
- First, examined recent zooplankton samples lakes with no alewife, anadromous alewife and landlocked alewife where the current food web structure is well-understood; found little difference in bosmina tail spine length between lakes with the two types of alewife, but found major difference between lakes without any alewife and lakes with alewife of any kind; this means we can look at bosmina remains to detect if alewife were present in a lake historically, but we can't tell what kind of alewife were in a lake based on bosmina tail spines alone
- Next, examined bosmina remains from sediment cores; the results of this matched up well with the results of recent samples suggesting that this method is reliable; we again can see major differences between lakes with and without alewife, but not between lakes with the two types of alewife; my estimates of alewife presence based on my historical study were confirmed by this



Bosmina morphology

- Nitrogen Stable Isotopes
  - Two Forms of Nitrogen – nitrogen has two main forms: N-14, a lighter form, and N-15, a heavier form with an extra neutron; different organisms have different amounts of these two forms depending on what environment they're from and where they sit along a food chain; can detect these differences by taking a tissue sample and analyzing it
  - Marine-Derived Nitrogen – organisms from the ocean have more of the heavy nitrogen than organisms from freshwater; we can use this to determine where an organism is from and to track how organisms move nitrogen back and forth between freshwater and saltwater ecosystems
  - What I hoped to find was a decrease in the isotopic weight of nitrogen in lake sediment as alewife became landlocked due to dam construction and stopped being able to bring isotopically heavier nitrogen from the ocean into lakes

- My Results – instead I saw the exact opposite: at the time around which alewife became landlocked, I saw an increase in nitrogen isotopic weight; saw this same pattern across lakes with both anadromous and landlocked alewife, so we know that it was not anything to do with the fish becoming landlocked
- Why – humans activities also contribute isotopically heavy nitrogen; land clearing, animal agriculture, human sewage and septic tanks, and inorganic fertilizers all can add isotopically heavy nutrients to freshwater systems
- Conclusions: we can see that humans were already having a major impact on the nutrient cycles of New England's coastal lakes as earlier as the 17th century!



Overall Conclusions

- Anadromous alewife historically native to Rogers Lake
- Humans have had a major direct influence on the Rogers Lake-Mill Brook watershed by altering nutrient loading and cycling since European colonization; have also had a major indirect influence on the Rogers Lake-Mill Brook watershed by blocking anadromous fish migration and preventing the fish from transporting nutrients to and from the ocean
- Nutrient loading from past anadromous fish runs was fairly minor compared to more recent (past 350 years) human inputs of nutrients