Determining the effects of landlocked alewives on anadromous alewife restoration

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Dams alter spatial connectivity

- Hydrology and geomorphology
  - Reduce variability in discharge
  - Alter thermal environments
  - Alter sediment and nutrient dynamics
- Movement of organisms
  - Impact fisheries and food webs
  - Facilitate invasive species
  - Restrict gene flow

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Spatially isolated ecosystems can be hotspots for evolution

Restoration of connectivity

- Dam removed
  - 1400 in the past century in USA
    - 50-100 per year in the past decade
- Fishways installed
  - Hundreds in the past decades

Restoration of connectivity

- Anadromous alewife (*Alosa pseudoharengus*)
- Species of conservation concern

Restoration of connectivity

- Anadromous alewife (*Alosa pseudoharengus*)

- Species of conservation concern
- Focus of considerable conservation and management
  - Harvest restrictions
  - Dam removal and fishway construction
    - Access to historical spawning habitat

Restoration of connectivity

- Anadromous alewife
- Fishway
  - What is above the restoration?

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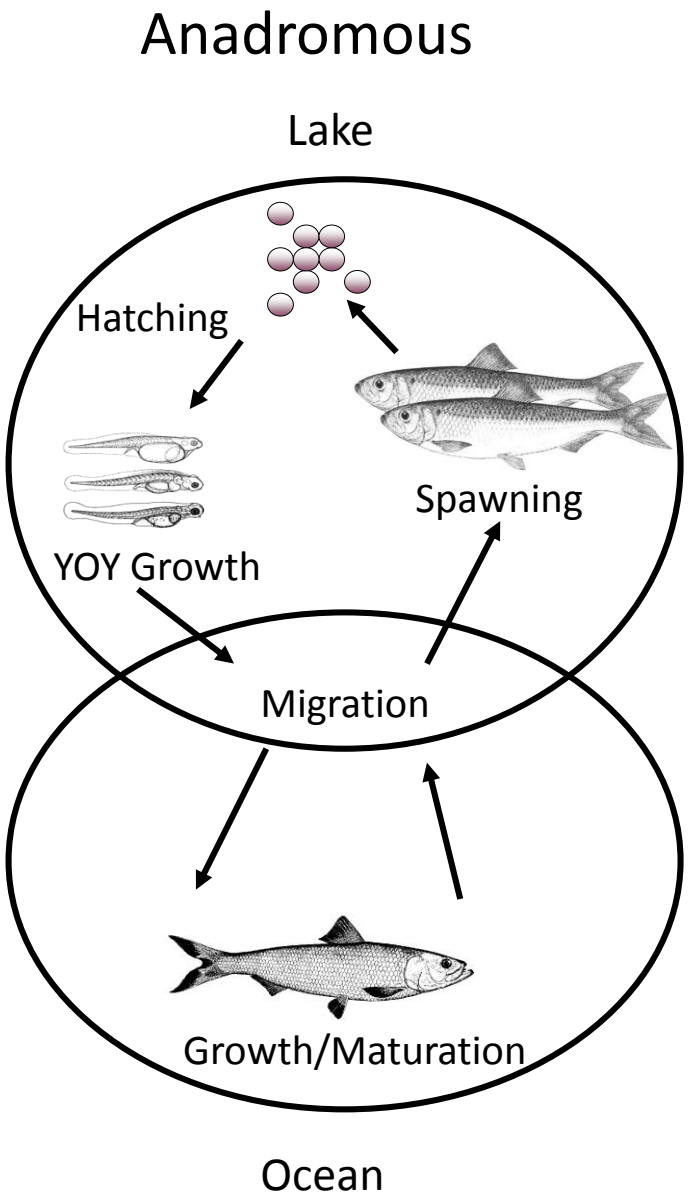
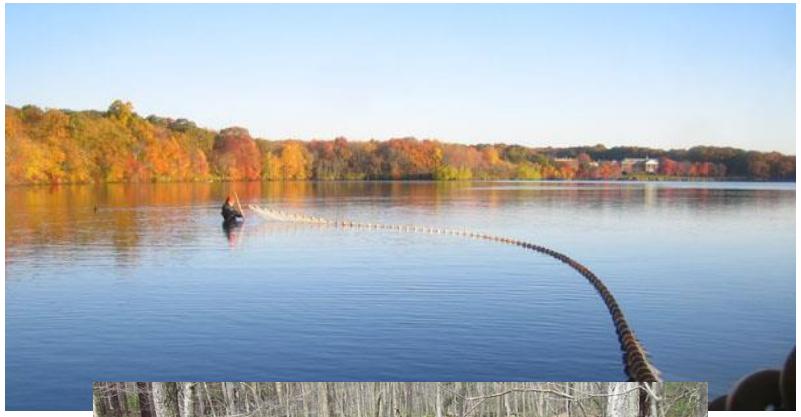
- Anadromous alewife
- Fishway
  - What is above the restoration?

Landlocked populations of alewife

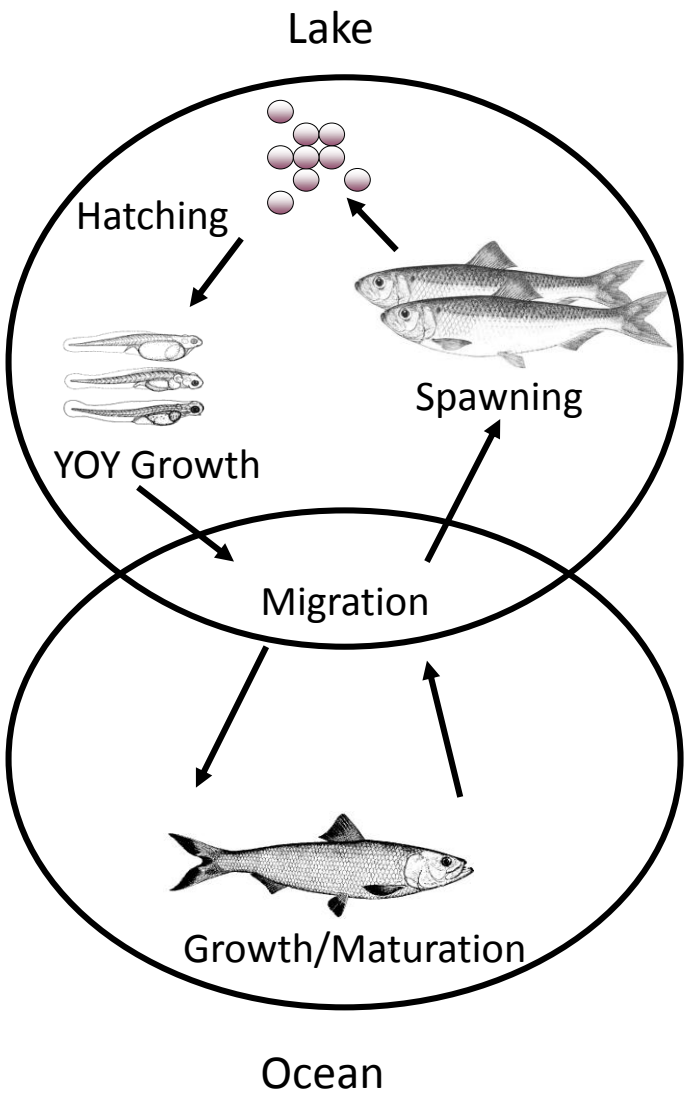
Alewife


Anadromous
Lake
Hatching
Spawning
YOY Growth
Migration
Growth/Maturation
Ocean

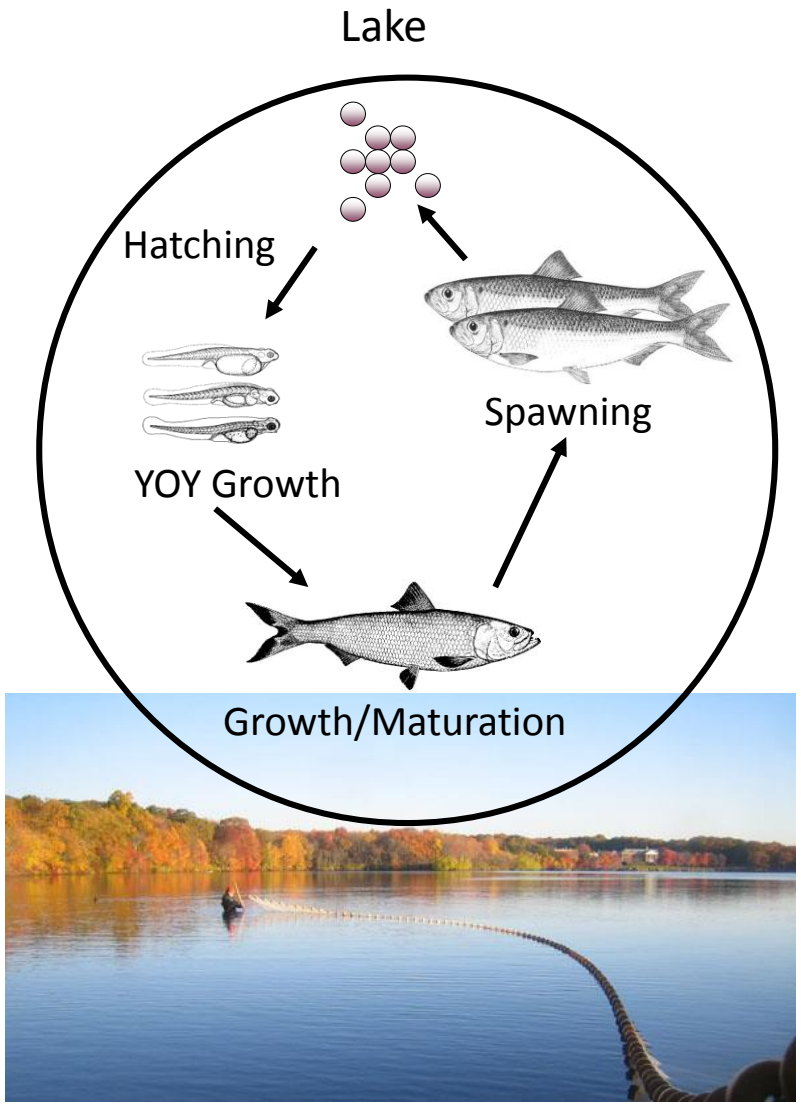


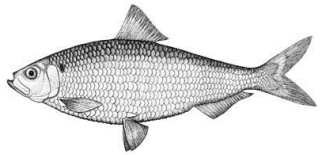
Alewife

Anadromous

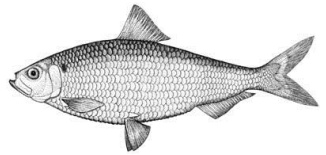


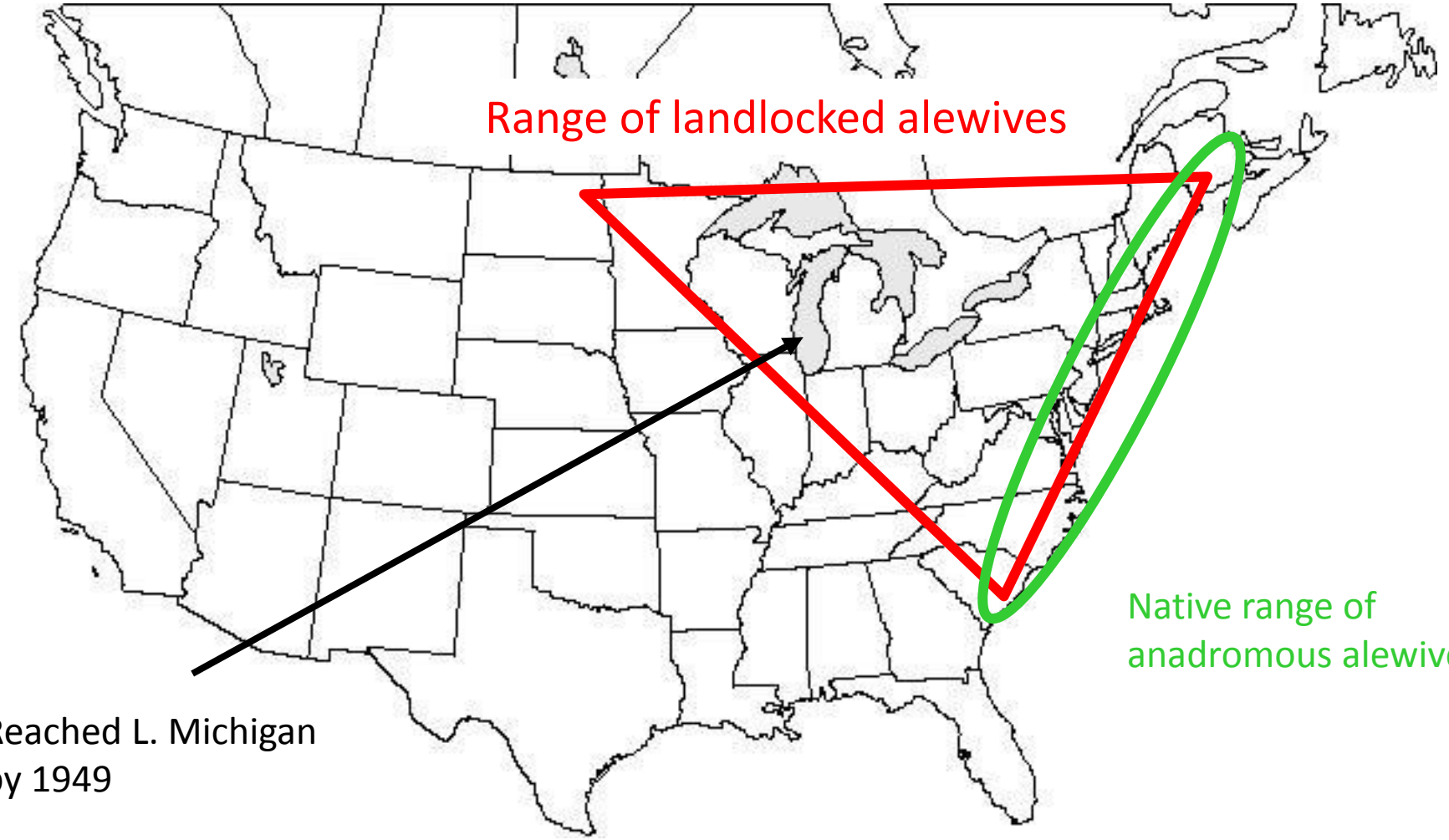
Landlocked





Alewife, *Alosa pseudoharengus*

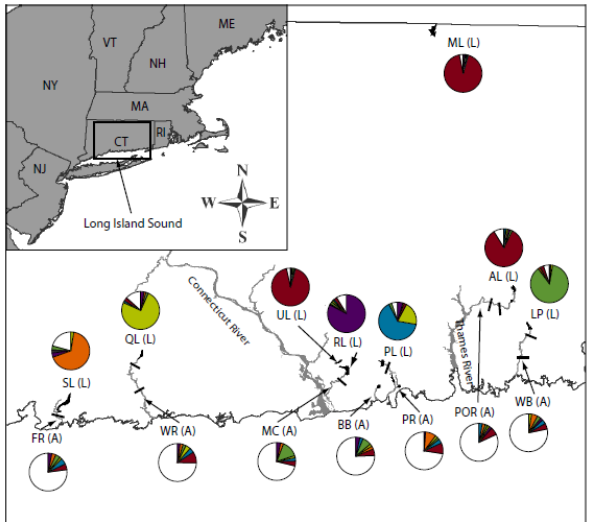




Reached L. Michigan
by 1949

Origin of landlocked alewife populations

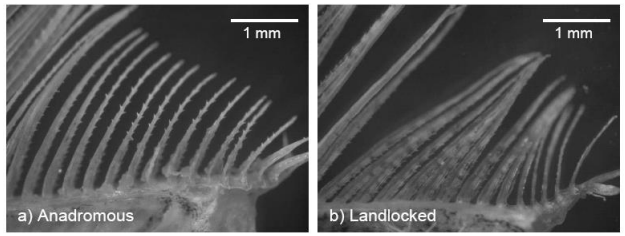
- Inland – stocked
- Coastal – many are naturally landlocked (independently derived)
  - Divergence time from genetic data: 270 – 522 YBP
  - Paleolimnological data and historical records: late 1600s

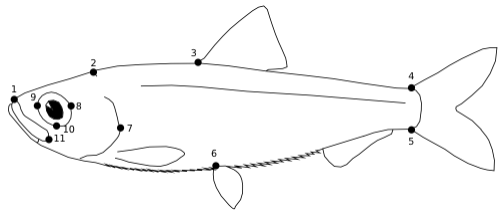


Palkovacs et al. 2008, Twining and Post 2013

Anadromous and Landlocked Alewife

	Anadromous	Landlocked
Duration of residence in FW	Summer-fall	Year round
Morphology		
Gape		Smaller
Gill raker spacing		Narrower
Body shape		More fusiform
		Smaller head
Prey size selectivity	Positive	Neutral
Habitat/resource use	Pelagic and littoral	Pelagic only

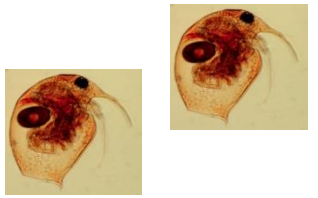




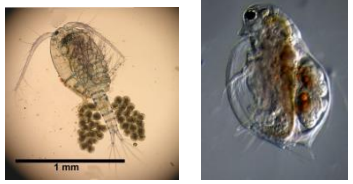
Post et al. 2008; Palkovacs and Post 2008; Schielke et al. 2011, Jones et al. 2013

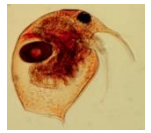
Anadromous and Landlocked Alewife

- Lakes with landlocked alewife
  - Low density of small-bodied zooplankton year-round



- Lakes with anadromous alewife
  - High densities of large-bodied zooplankton in the spring
  - Low densities of small-bodied zooplankton in the late summer and fall





  - Anadromous alewife migrate late summer and fall
    - Large-bodied zooplankton in the ocean

Post et al. 2008

Rogers Lake Restoration

- Rogers Lake
  - Eastern CT
  - 106 ha in area
  - 20 m deep
  - Dams date to late 1600s
  - Contains landlocked alewife population

Rogers Lake Restoration

- Fishway constructed winter of 2013
- Opened spring 2014

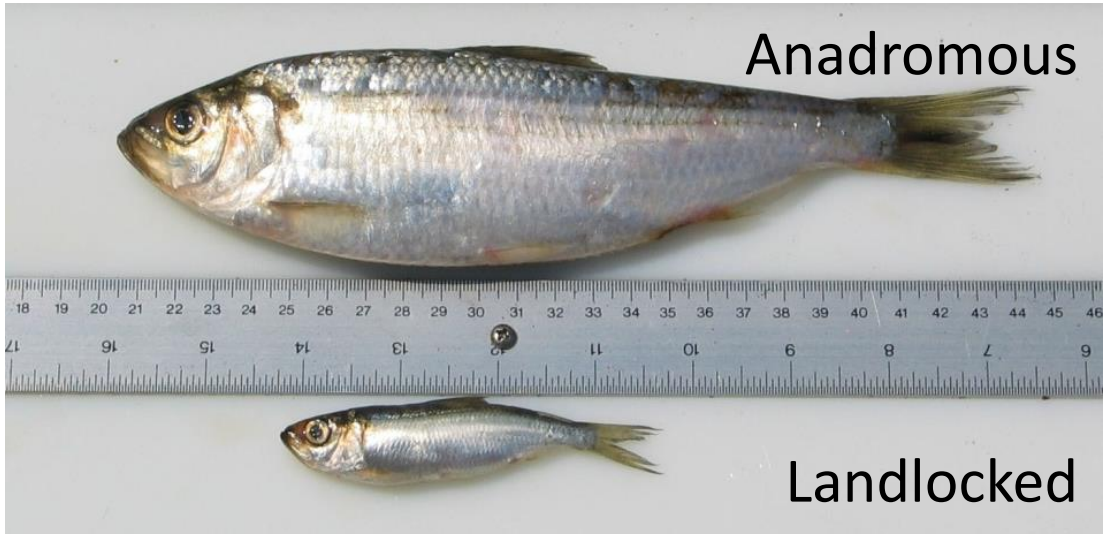
- Adult alewife stocked
  - 2015 – 134
  - 2016 – 1144
  - 2017 – 1024 to date

Rogers Lake Restoration

- Pattagansett Lake
  - Fishway planned for next 5-10 years

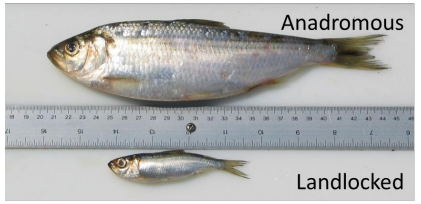
Rogers Lake Restoration

- Is there potential for gene flow?
  - Is there overlap in spawning time?
  - Genomic tools to detect gene flow



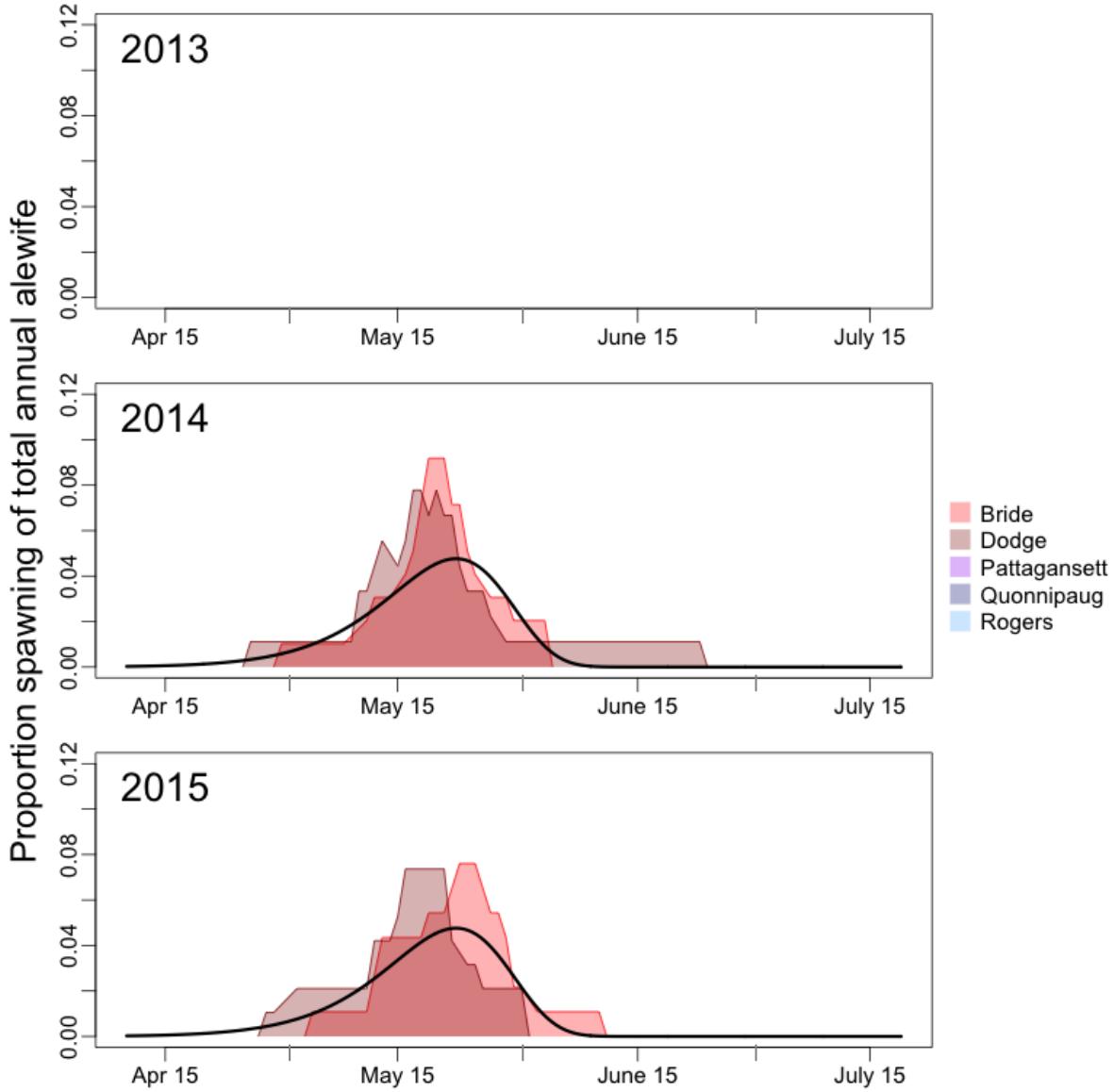
Rogers Lake Restoration

- Spawning time
  - Anadromous
    - Run time data from CT DEEP index stations
    - Back calculated from otoliths – Bride and Dodge lakes
  - Landlocked
    - Back calculated from otoliths – Rogers, Pattagansett, Quonnipaug lakes
  - Used local temperature to adjust for development to estimate spawning date



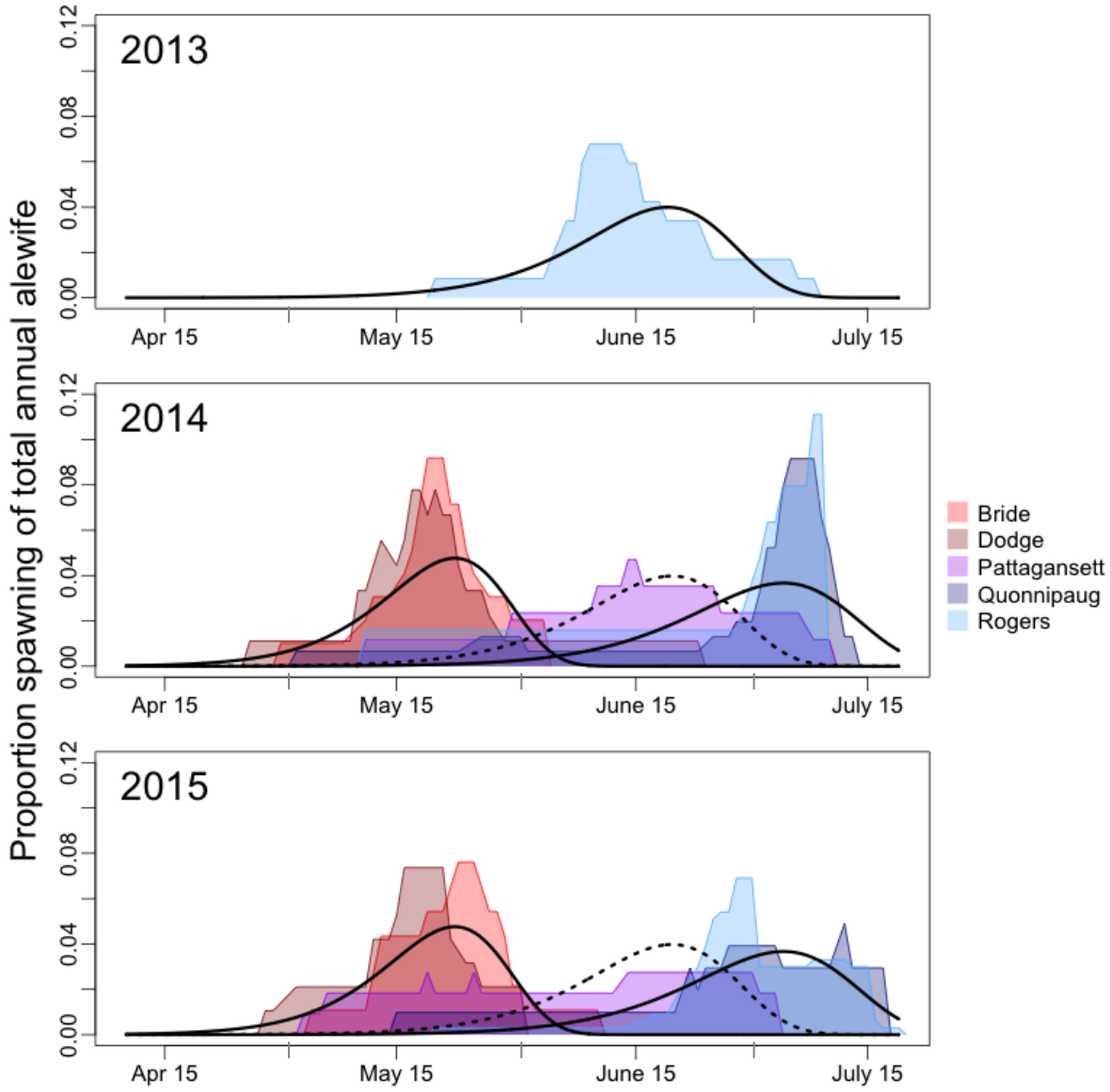
Rogers Lake Restoration – spawning time

- Anadromous populations
  - Runs start early April
  - Spawning begins late April
  - Peak spawning in May
    - 18°C
  - No significant difference among populations or years



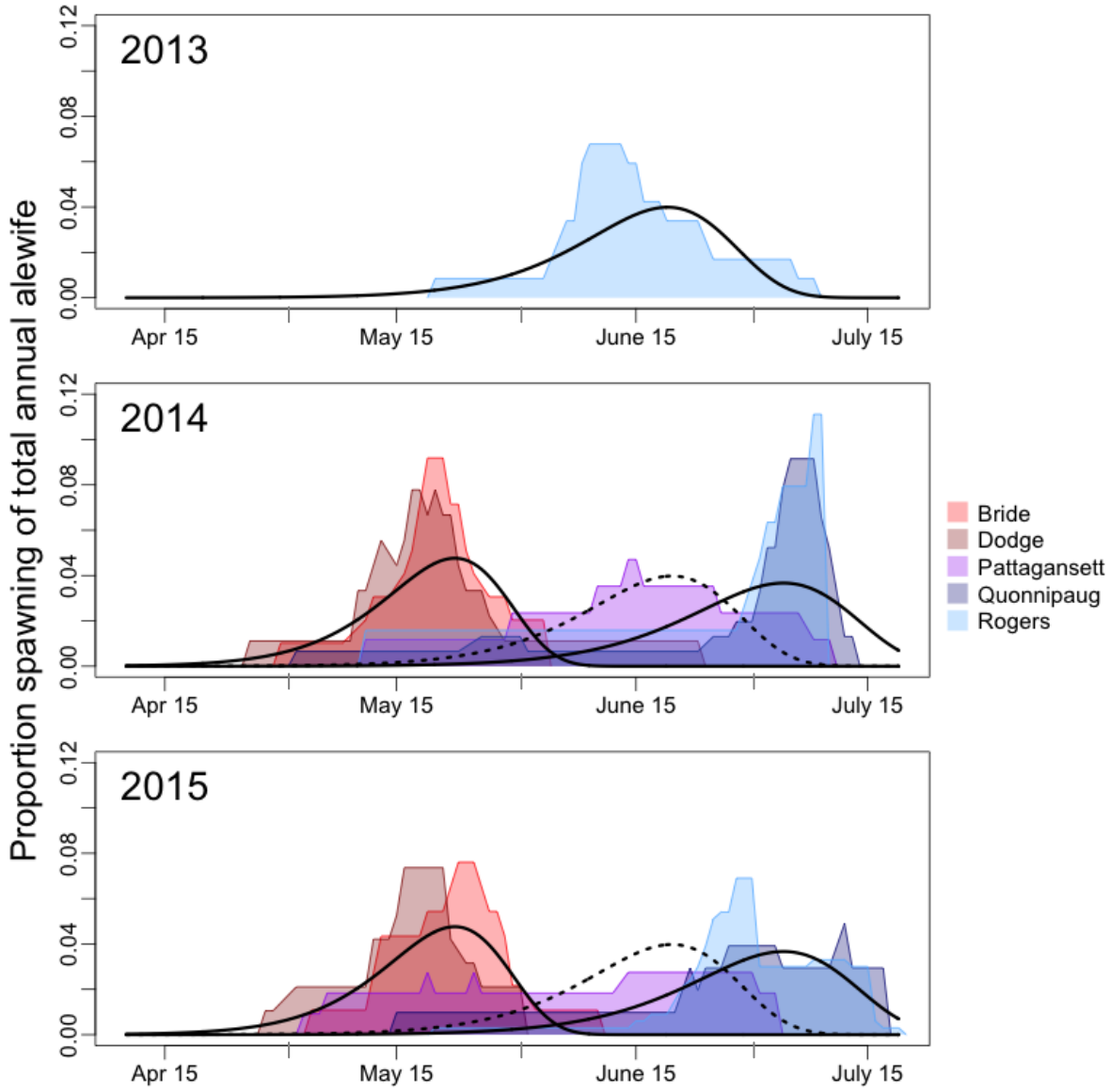
Rogers Lake Restoration – spawning time

- Landlocked populations
  - Spawning begins in May
  - Peaks in June and July
    - 22-26 °C
  - Longer spawning period
  - Significant differences among lakes and years



Rogers Lake Restoration – spawning time

- Rage of overlap
  - Rogers Lake: 0% - 10%
    - Some years of overlap
    - Some years of no overlap
  - Pattagansett: 20-30%
    - Likely to be greater overlap



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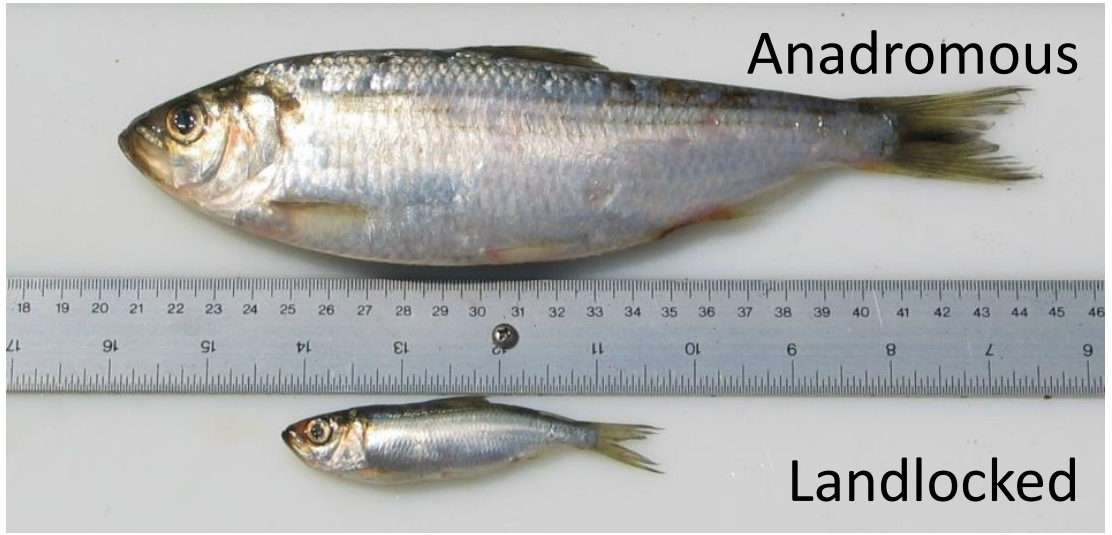
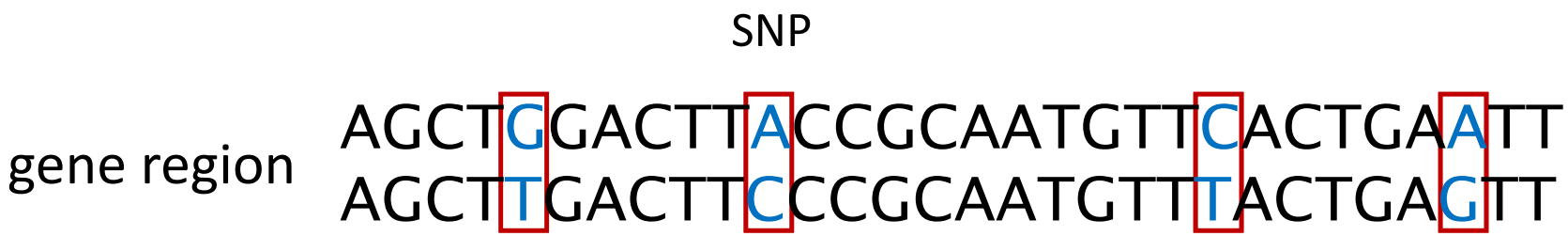


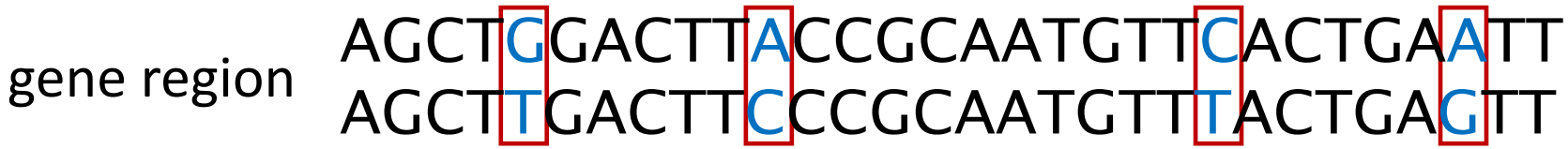
Rogers Lake Restoration

- Genetic markers to detect gene flow (introgression) between populations
  - Single Nucleotide Polymorphisms (SNPs)
  - Next Generation Sequencing (NGS) we can use all of the variation within a gene region
  - Targeting regions with multiple SNPs



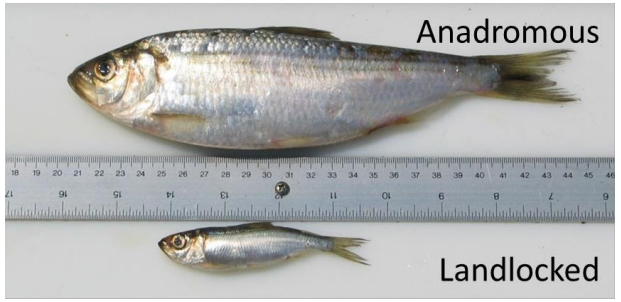
Rogers Lake Restoration

- Genetic markers to detect gene flow (introgression) between populations
  - We have developed 96 variable regions for alewife
  - NGS allows us to sequence hundreds of individuals at the same time
  - Benefits
    - Improve the detection of introgression
    - Utilize pedigree based approaches



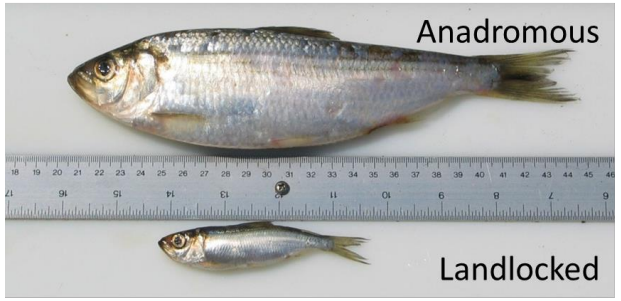
Rogers Lake Restoration

- Rogers and Pattagansett landlocked populations
  - Genetically distinct from Anadromous populations
  - Genetically distinct from each other
  - Genetic drift and population bottlenecks have played a large role in shaping landlocked genetic diversity



Rogers Lake Restoration

- Genetic data
  - Baseline samples from 2013 & 2014
  - All adult anadromous alewife entering the lake
  - 1000 YOY collected in August of each year starting in 2015
    - Spawning success of anadromous
    - Production of hybrids (introgression)
    - Pedigree of hybrids
    - Phenotype of hybrids



Anadromous Alewife Restoration

- Landlocked populations across Eastern North America
- Rogers (and Pattagansett) in Connecticut
- St. Croix River in Maine
  - Local landlocked populations

Anadromous Alewife Restoration

- Fundamental questions about the ecology and evolution of secondary contact
  - Ecological impact
    - Competition
    - Nutrient loading and water quality
    - Game fish growth and survival
    - Coastal breeding birds

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- The Nature Conservancy
- Pew Charitable Trust
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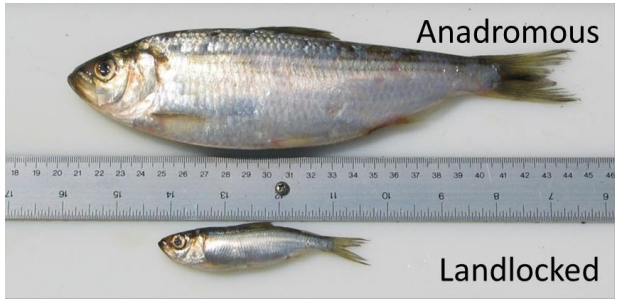


Thank you!