

Human-induced evolution and the restoration of diadromous fishes



Eric Palkovacs

University of California-Santa Cruz

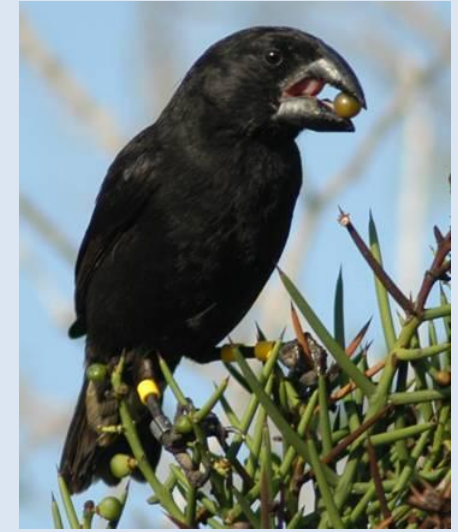
Species Interactions



The Puzzle Analogy



Contemporary Evolution



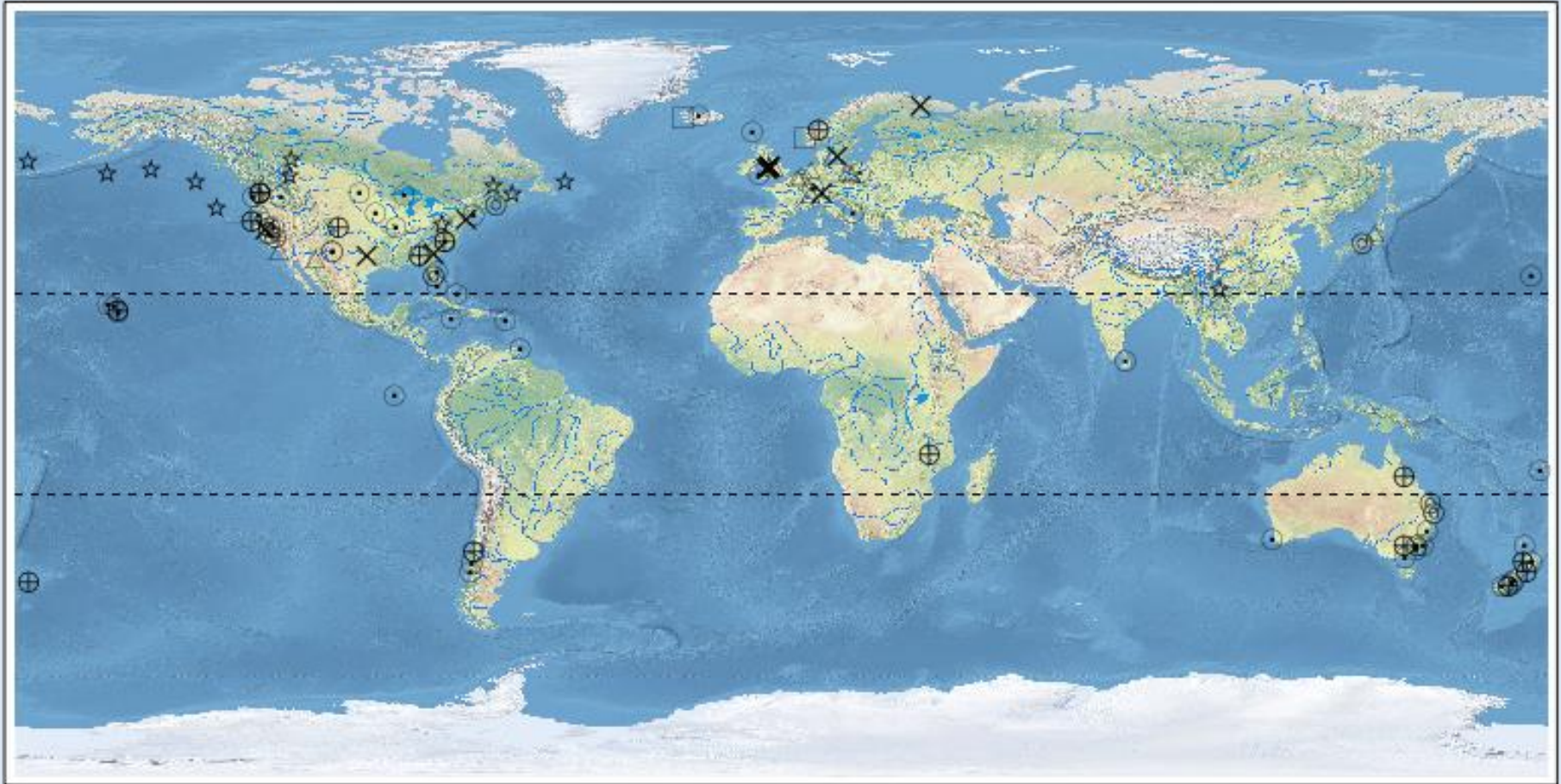
COURTESY CORNELL UNIVERSITY



J. K. Barnes



Human-induced Evolution



- △ Climate change
- ☆ Harvest
- × Pollution
- Landscape change

- ⊙ Introduction
- ⊕ Range expansion after introduction
- ⊗ Introduction of predator/prey/host/competitor

Human-induced Evolution



Sockeye



Chinook



Chum



Steelhead

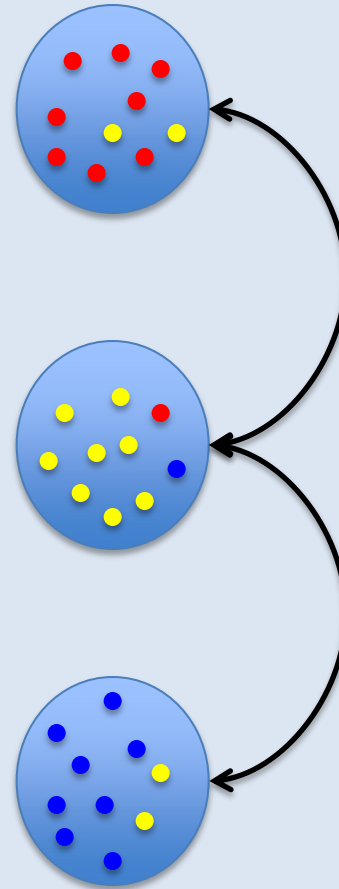


Alewife



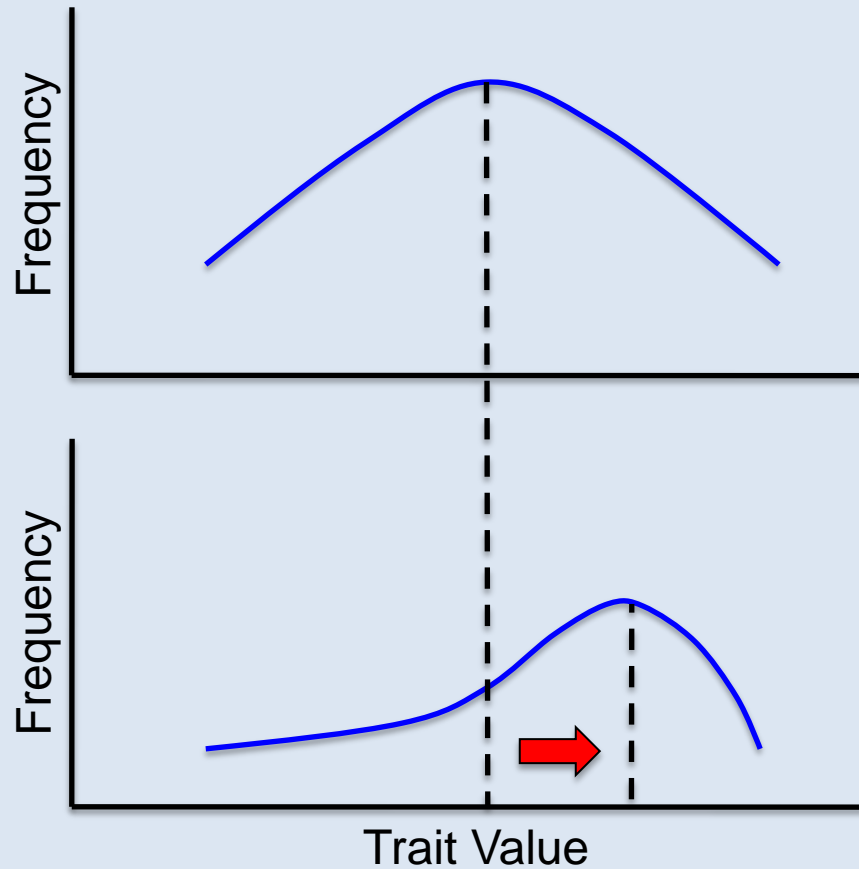
Atlantic Salmon

Human-induced Evolution



Modifications to Gene Flow

Human-induced Evolution



Modifications to Selection

Human-induced Evolution

1. **Stocking** – increased gene flow, hatchery selection
2. **Dam construction** – decreased gene flow, selection for freshwater residency
3. **Harvest** – harvest selection on age and size at maturation
4. **Aquaculture** – gene flow between wild and domestic fish
5. **Hydrology** – selection from altered environmental flows
6. **Climate Change** – altered gene flow and selection in freshwater and marine ecosystems

Human-induced Evolution

1. **Stocking** – increased gene flow, hatchery selection
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Steelhead



Alewife

Case 1: Stocking

1. Cross-basin stocking can increase gene flow among spawning runs (Alewife in Maine, McBride 2012 MS Thesis)
2. Hatchery selection can favor traits that are detrimental to fitness in the wild (Steelhead in Oregon, Araki et al. 2007 *Science*)
3. Hatchery stocking can homogenize population structure by introducing a common genetic source to many populations (Steelhead in California, Pearse et al. 2011 *Conservation Genetics*)

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Steelhead Stocking in California

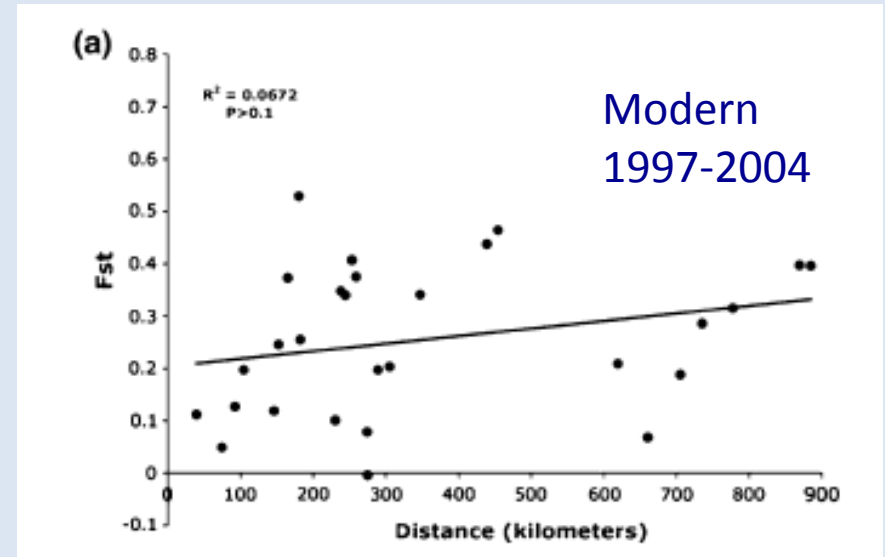
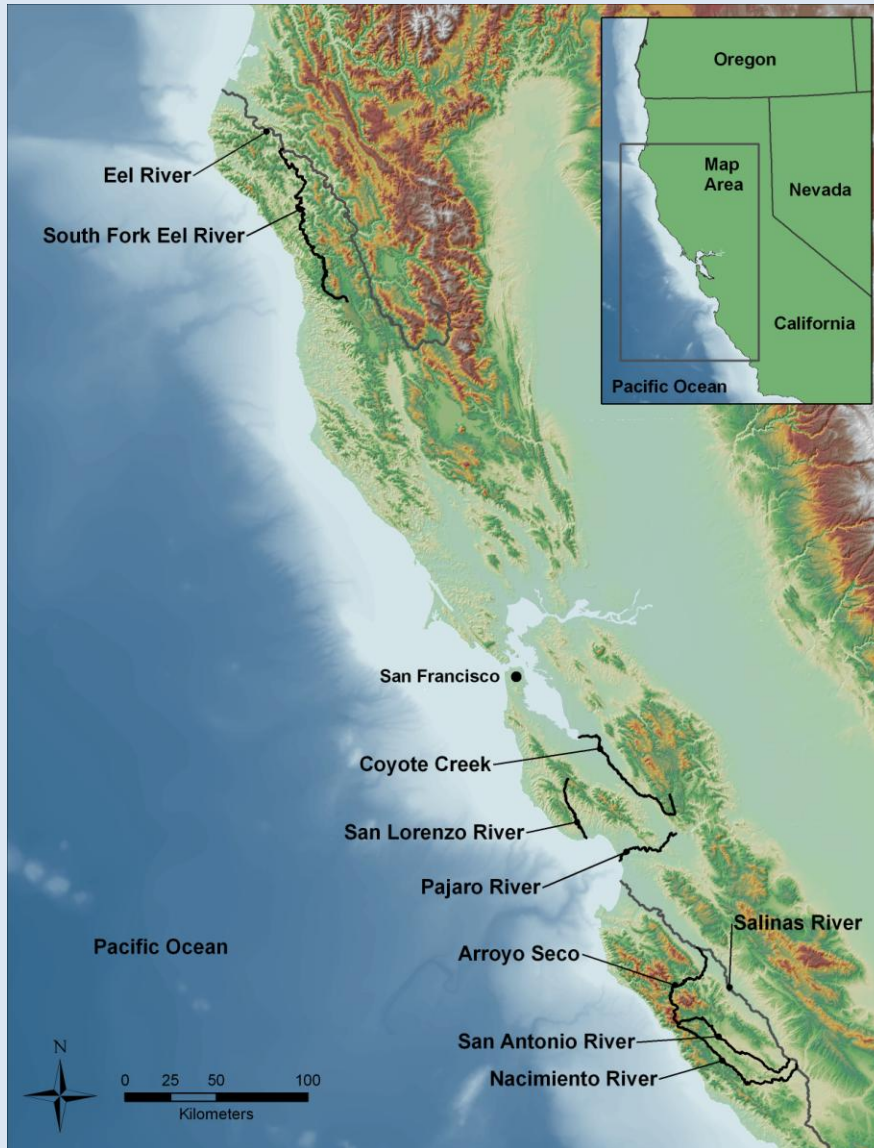


Historical
1897-1909

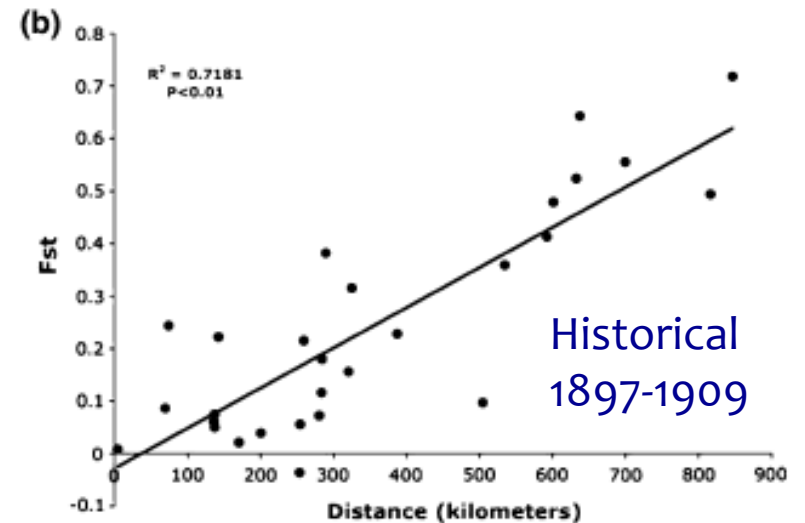
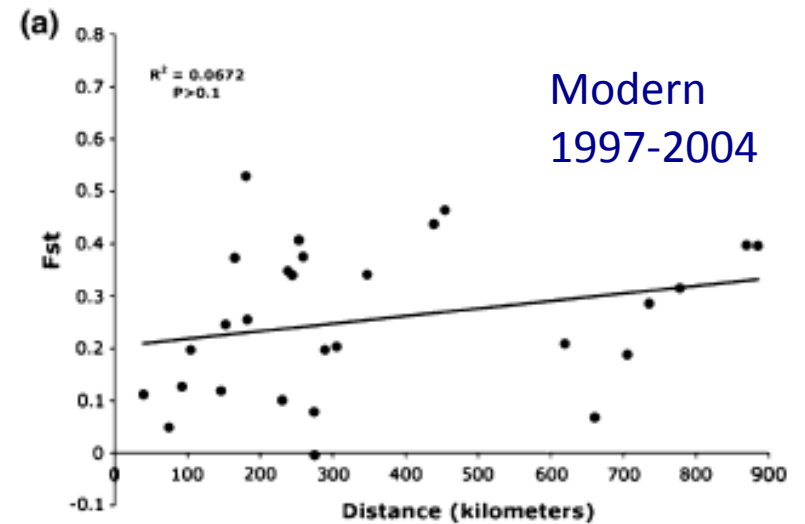


Modern
1997-2004

Steelhead Stocking in California



Steelhead Stocking in California



Case 2: Dams

1. Dam construction can favor freshwater resident life histories (Alewife in Connecticut, Palkovacs et al. 2008 *Molecular Ecology*)
1. Freshwater residency can drive the evolution of trophic traits and modify species interactions (Alewife in Connecticut, Post et al. 2008 *Ecology*, Palkovacs & Post 2009 *Ecology*)
2. Modified species interactions may impact the restoration of anadromous runs (Alewife in Rogers Lake, Connecticut)

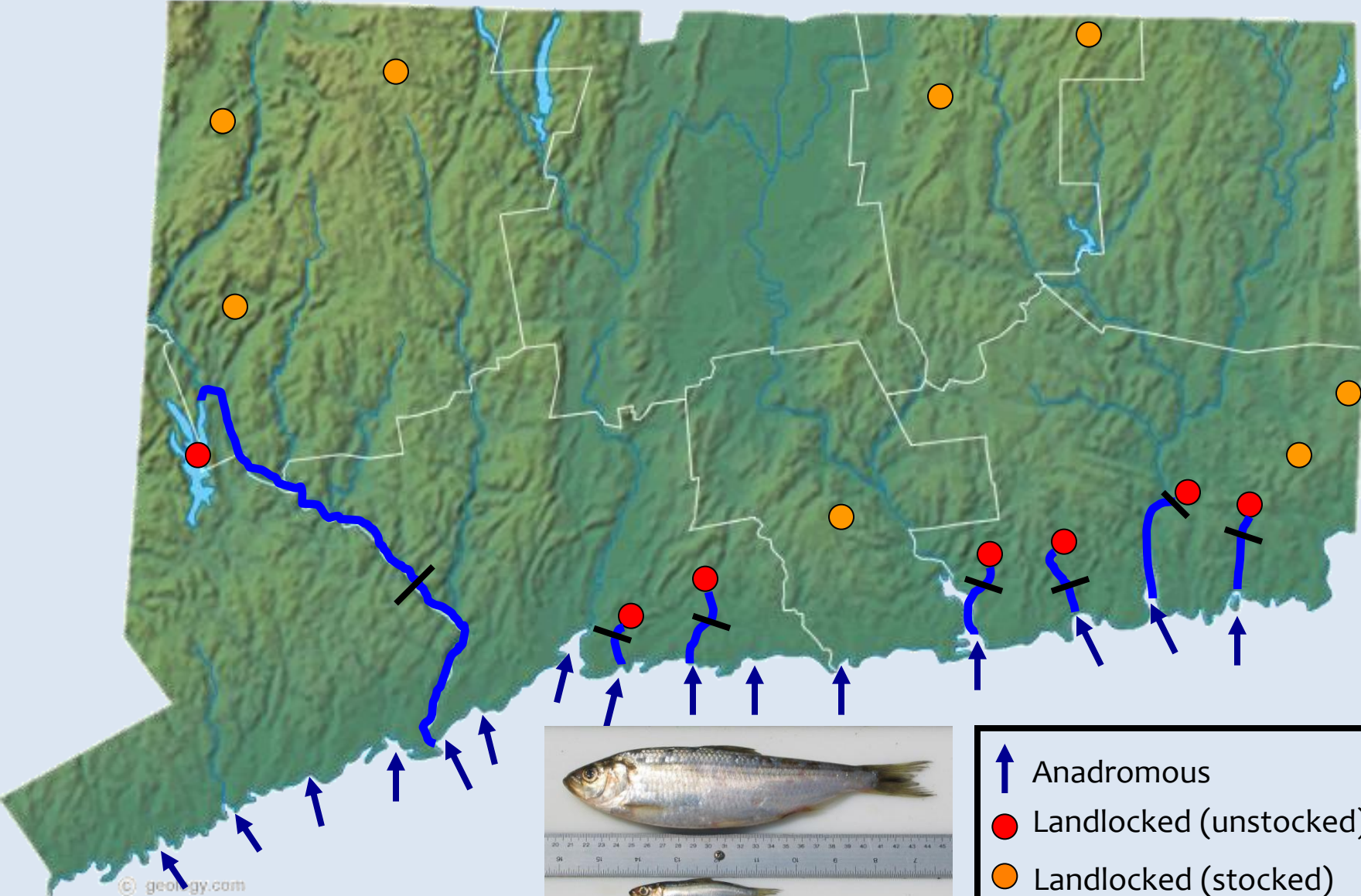
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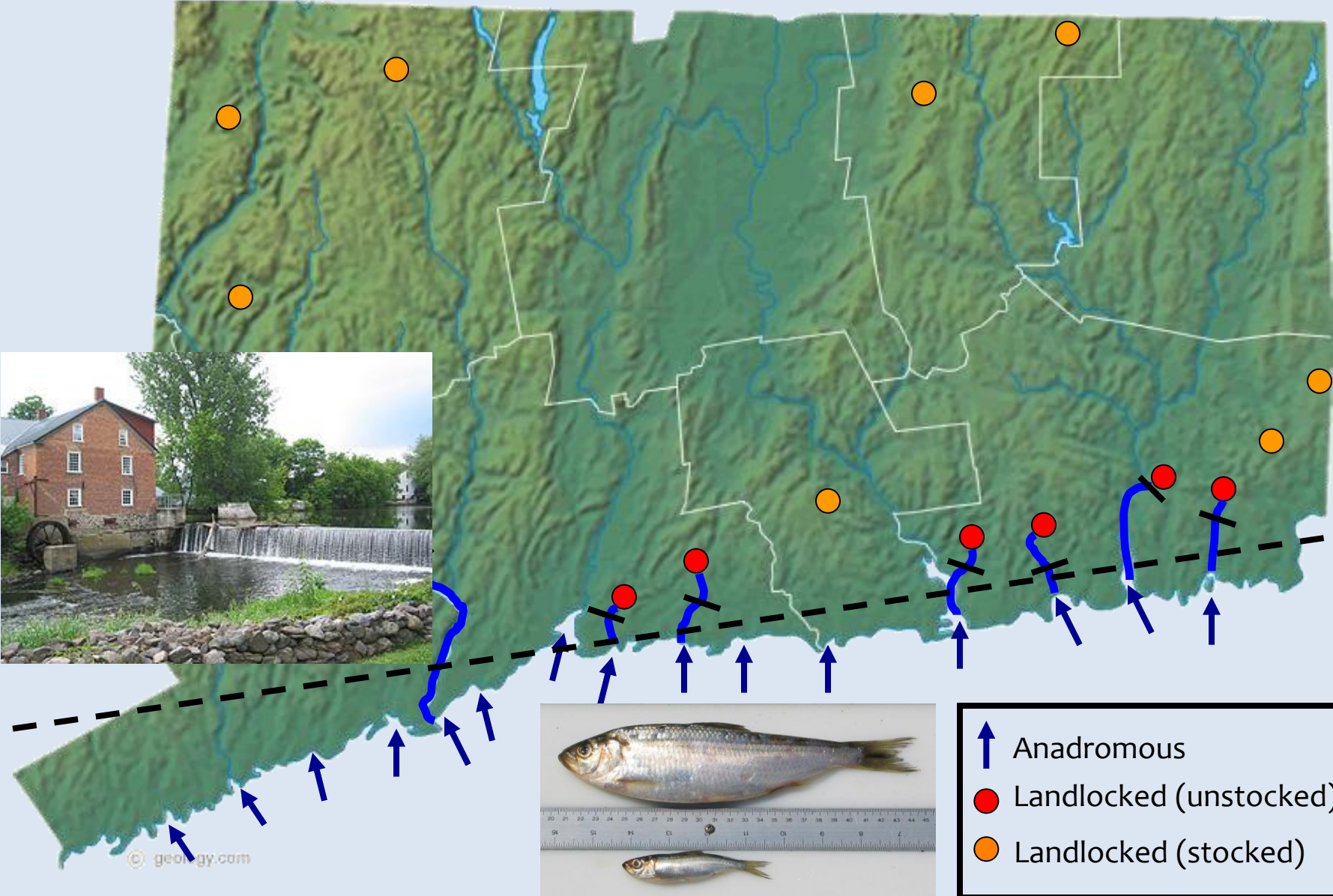
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Alewife and Dams in Connecticut

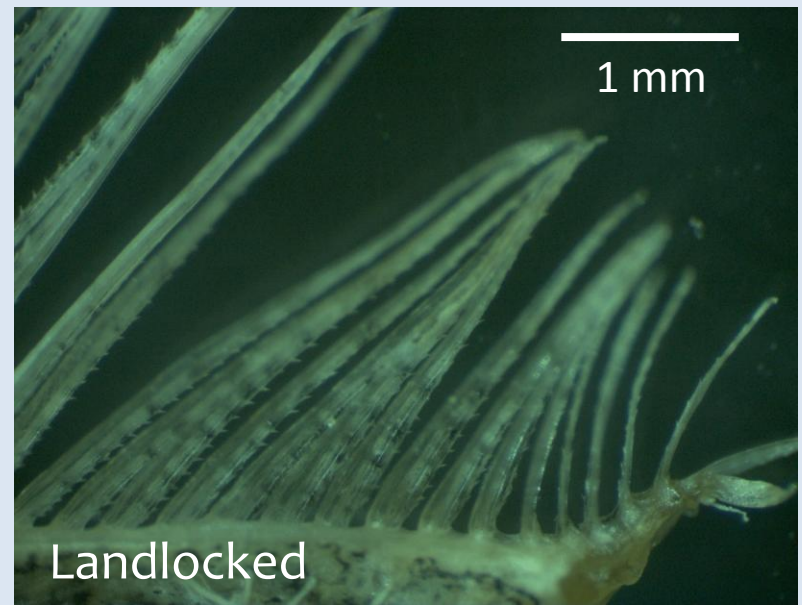
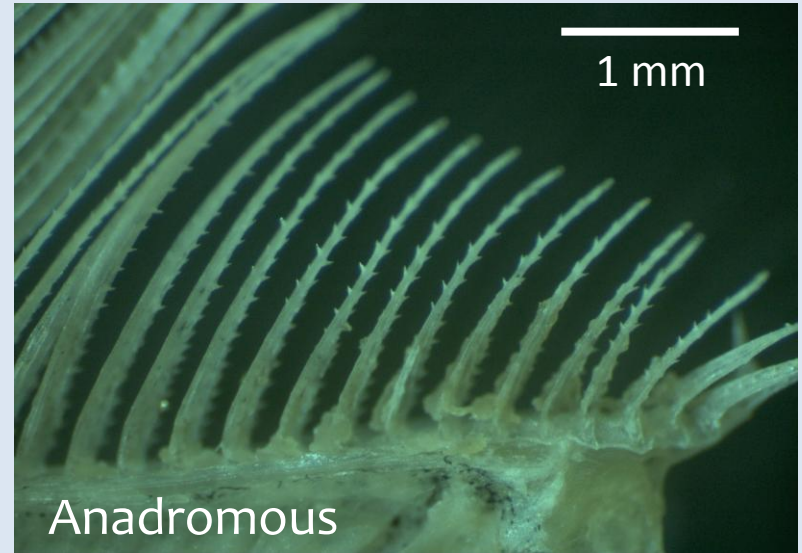


- ↑ Anadromous
- Landlocked (unstocked)
- Landlocked (stocked)

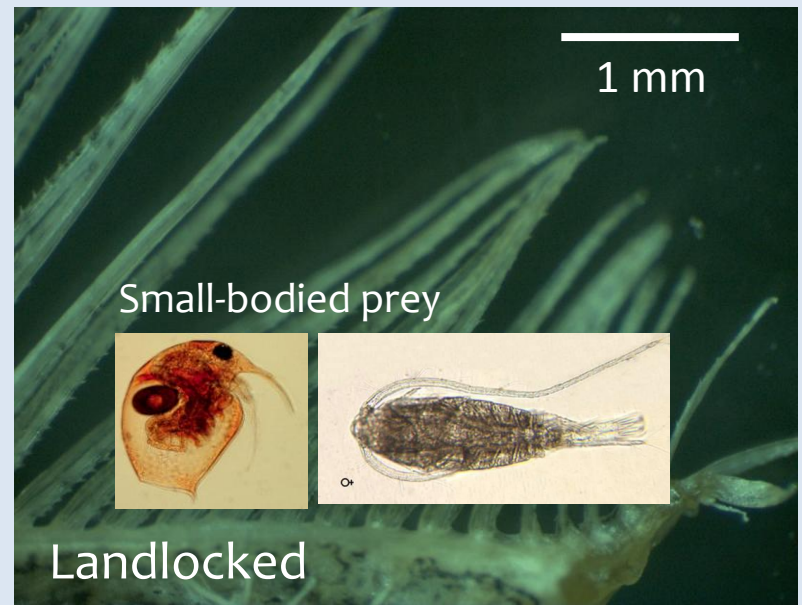
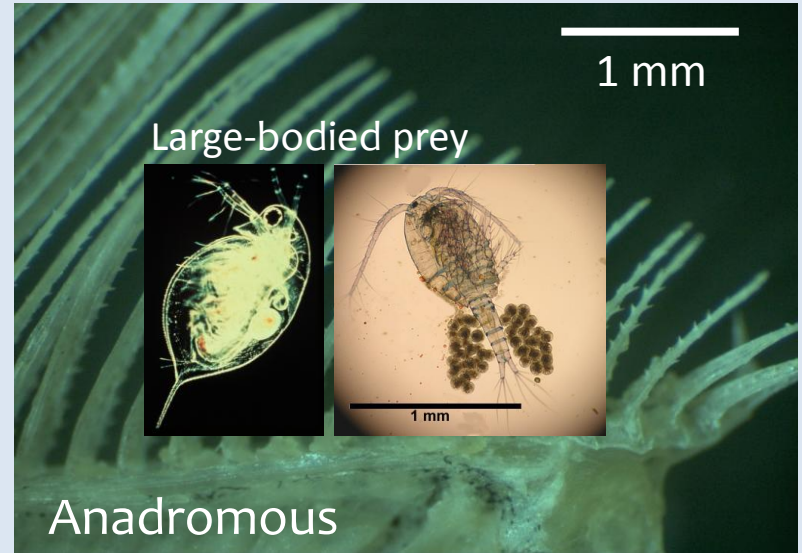
Alewife and Dams in Connecticut



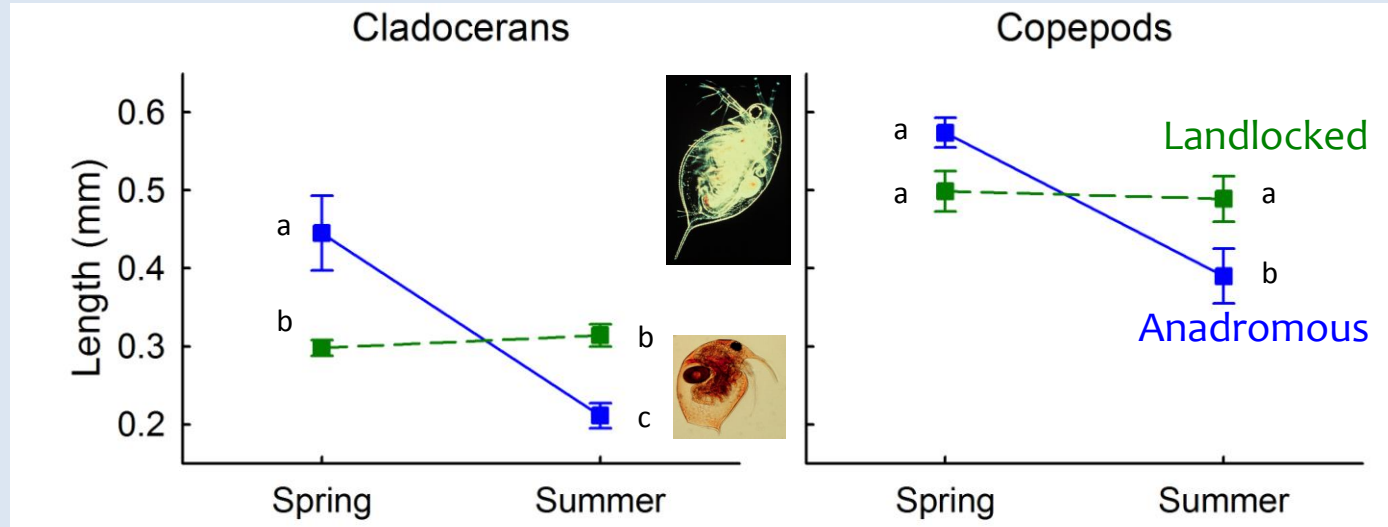
Alewife and Dams in Connecticut



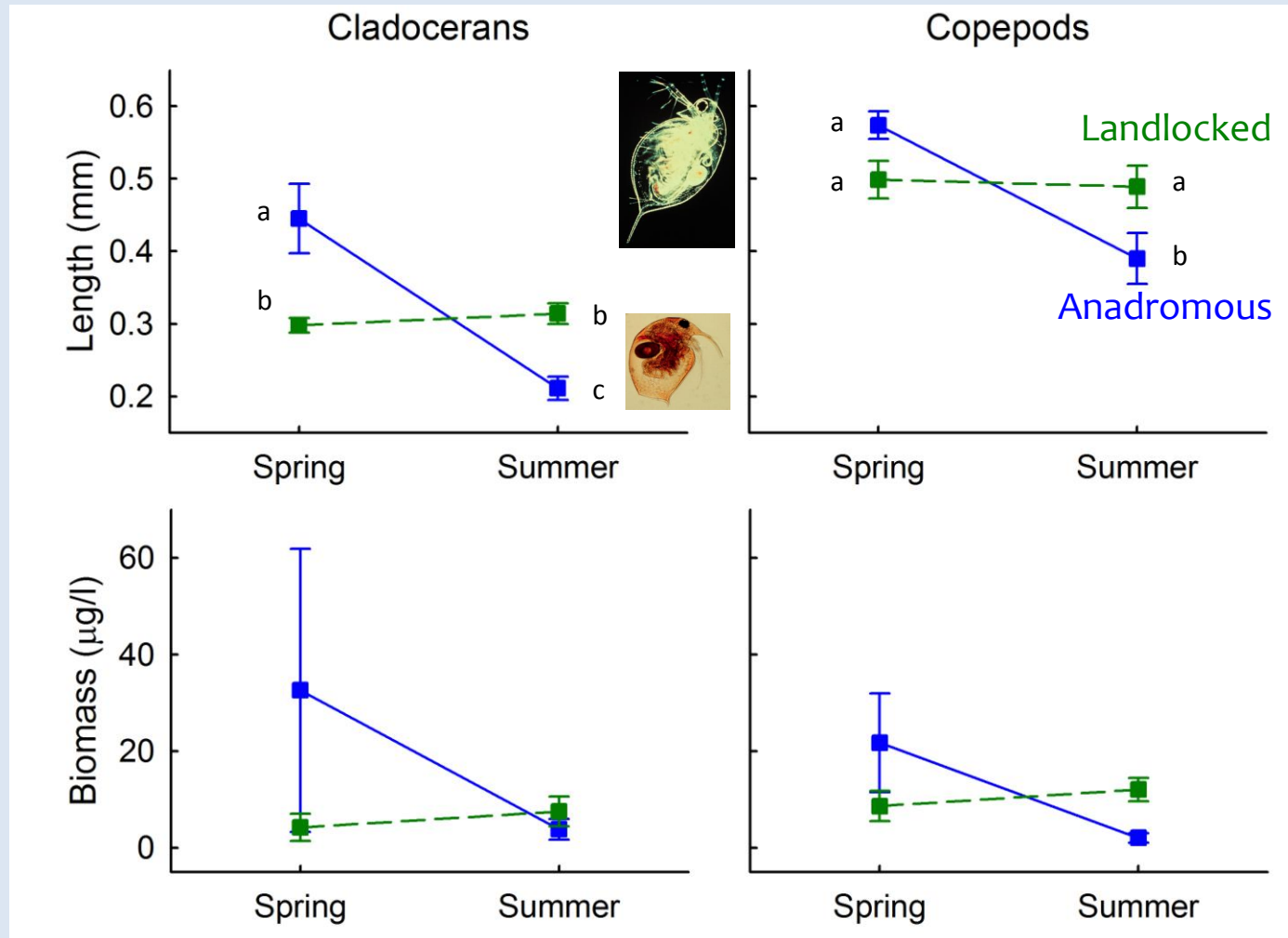
Alewife and Dams in Connecticut



Alewife and Dams in Connecticut



Alewife and Dams in Connecticut



Alewife and Dams in Connecticut



Rogers Lake Restoration Project, Old Lyme, Connecticut

Conclusions

1. Human-induced evolution is occurring in diadromous fish populations
1. This evolution has the potential to impact ecological processes such as species interactions
2. The ecological consequences of human-induced evolution may impact restoration efforts
3. Recovering native diadromous fishes requires the restoration of evolutionary as well as ecological processes

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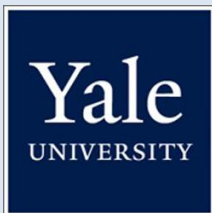
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Thank You



UCSC



Modifications to Selection

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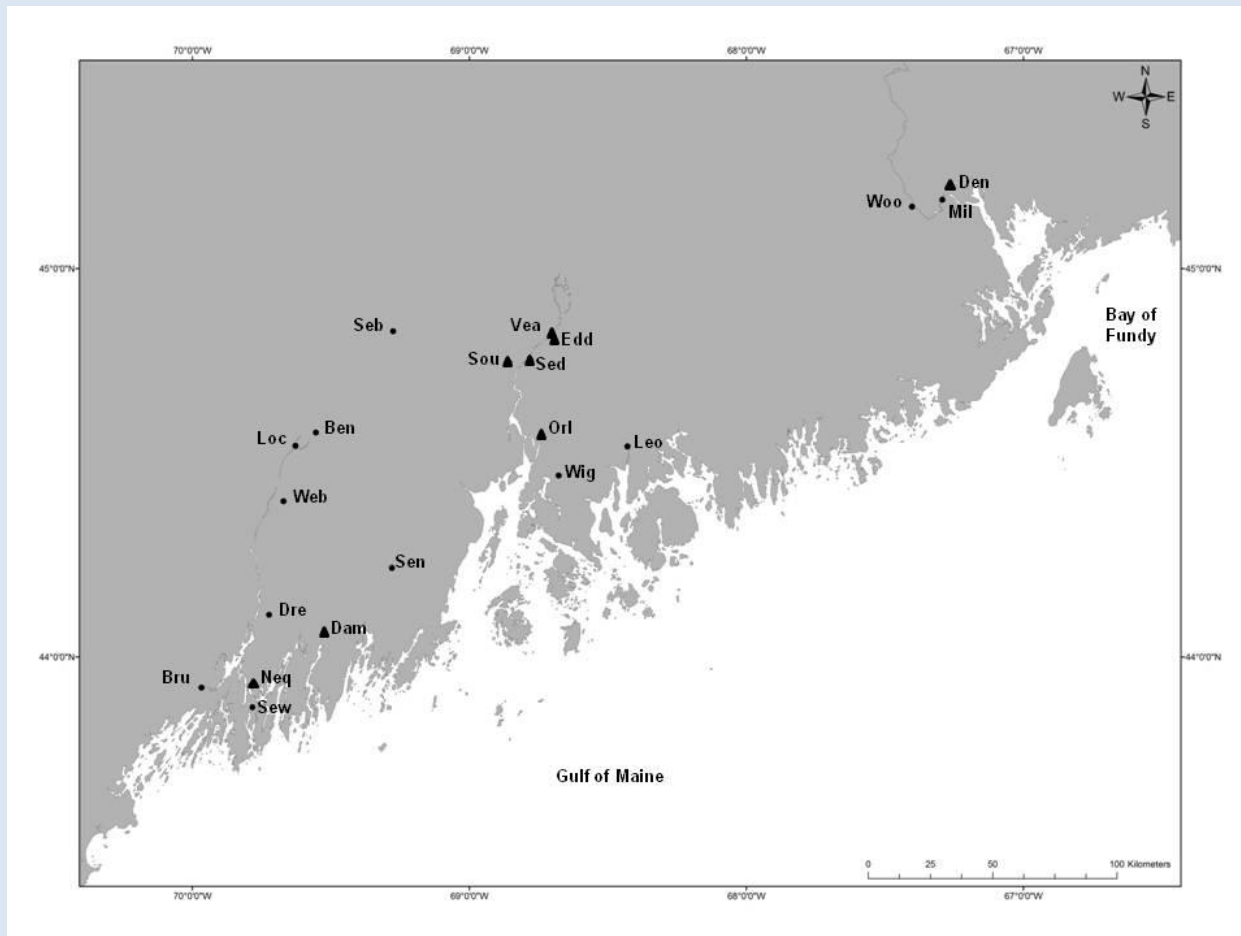
Modifications to Gene Flow

1. Stocking can increase gene flow and homogenize population structure
2. Dam construction can reduce gene flow and isolate populations

Species Interactions

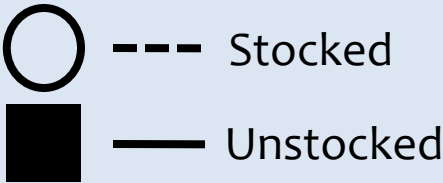
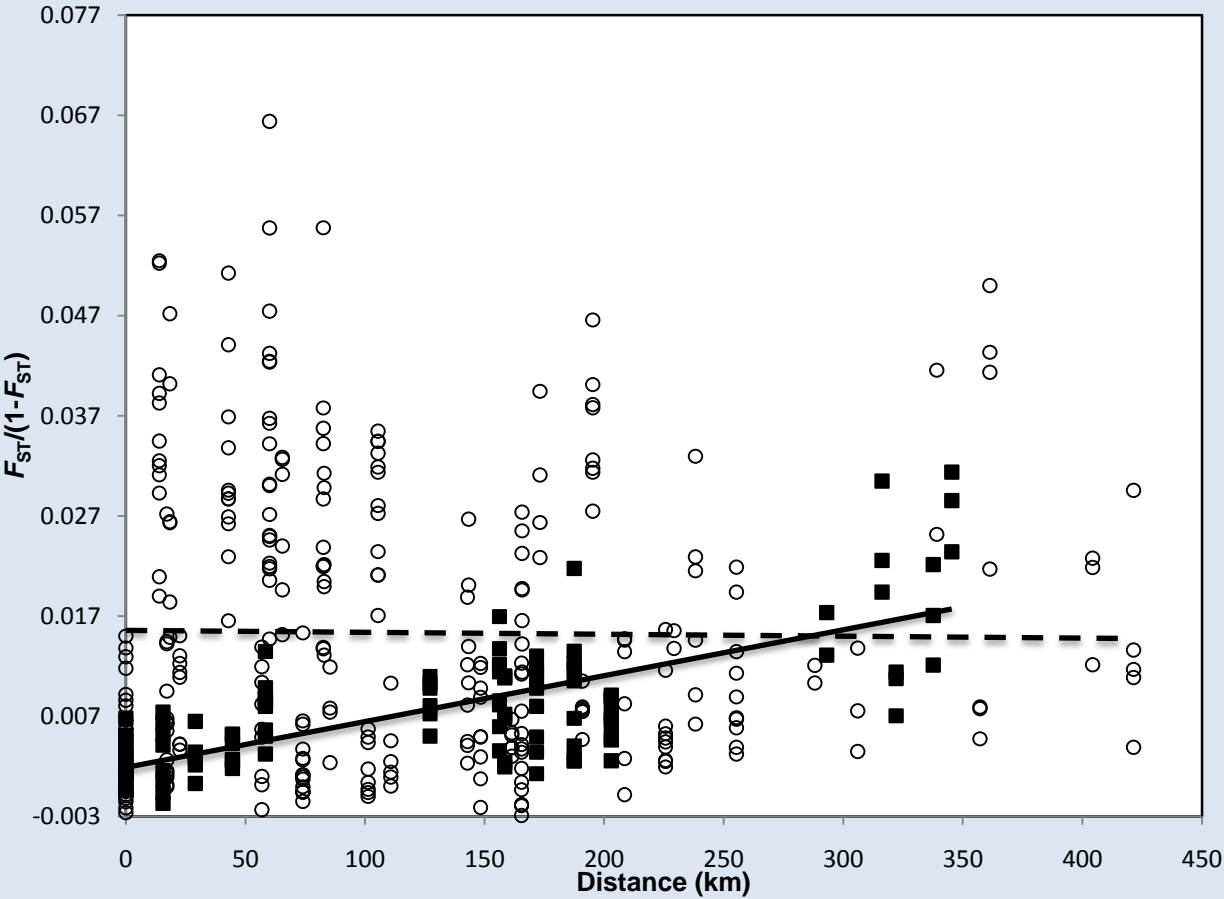
1. **Populations** – individual species recovery impacted by species interactions
2. **Communities** – species diversity and food web dynamics are shaped by species interactions
3. **Ecosystems** – ecosystem function and ecosystem services supported and maintained by species interactions

Case 1: Stocking



- Stocked
- ▲ Unstocked

Case 1: Stocking



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Stocking: Consequences of Evolution

Human-induced Evolution

