Canadian (and some American) Alewife stock structure using microsatellites

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GOALS:

- Determine if alewife populations across the northern (primarily Canadian) portion of range are genetically distinguishable, and if so, on what spatial scales.
- Define conservation and management units.

METHODS:

- Sampled 34 alewife (+ 4 blueback) populations spanning 2500 km.
- N = 2517 river herring
- 14 microsatellite loci

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RESEARCH ARTICLE

Genetic diversity and structure of two hybridizing anadromous fishes (*Alosa pseudoharengus*, *Alosa aestivalis*) across the northern portion of their ranges

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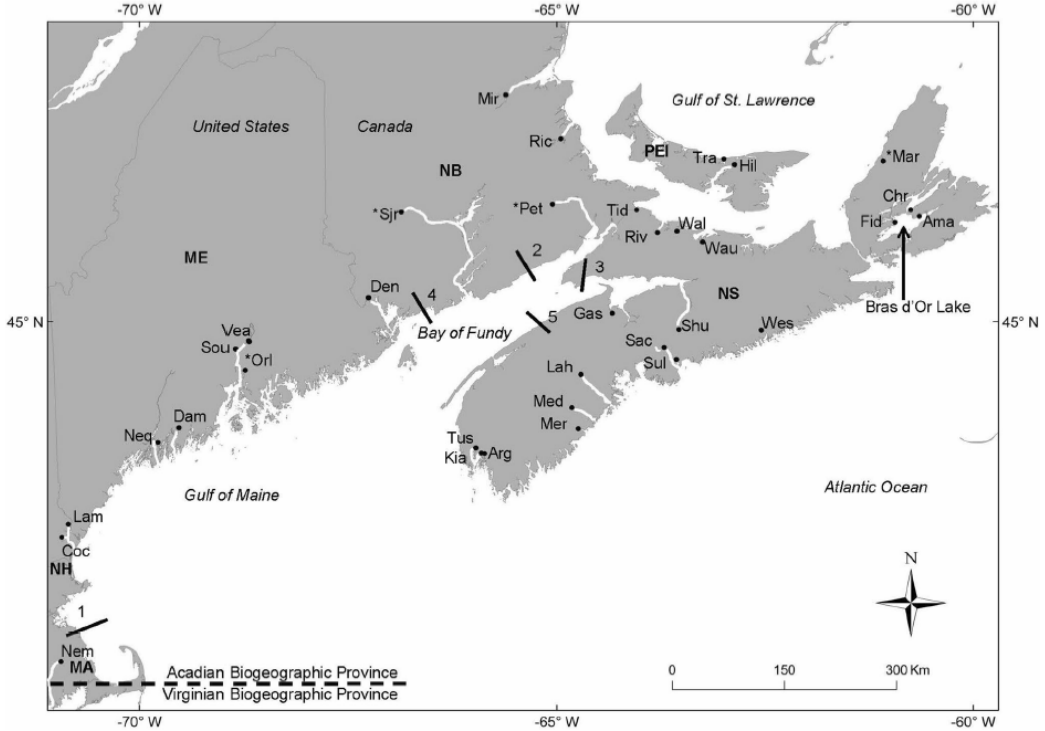


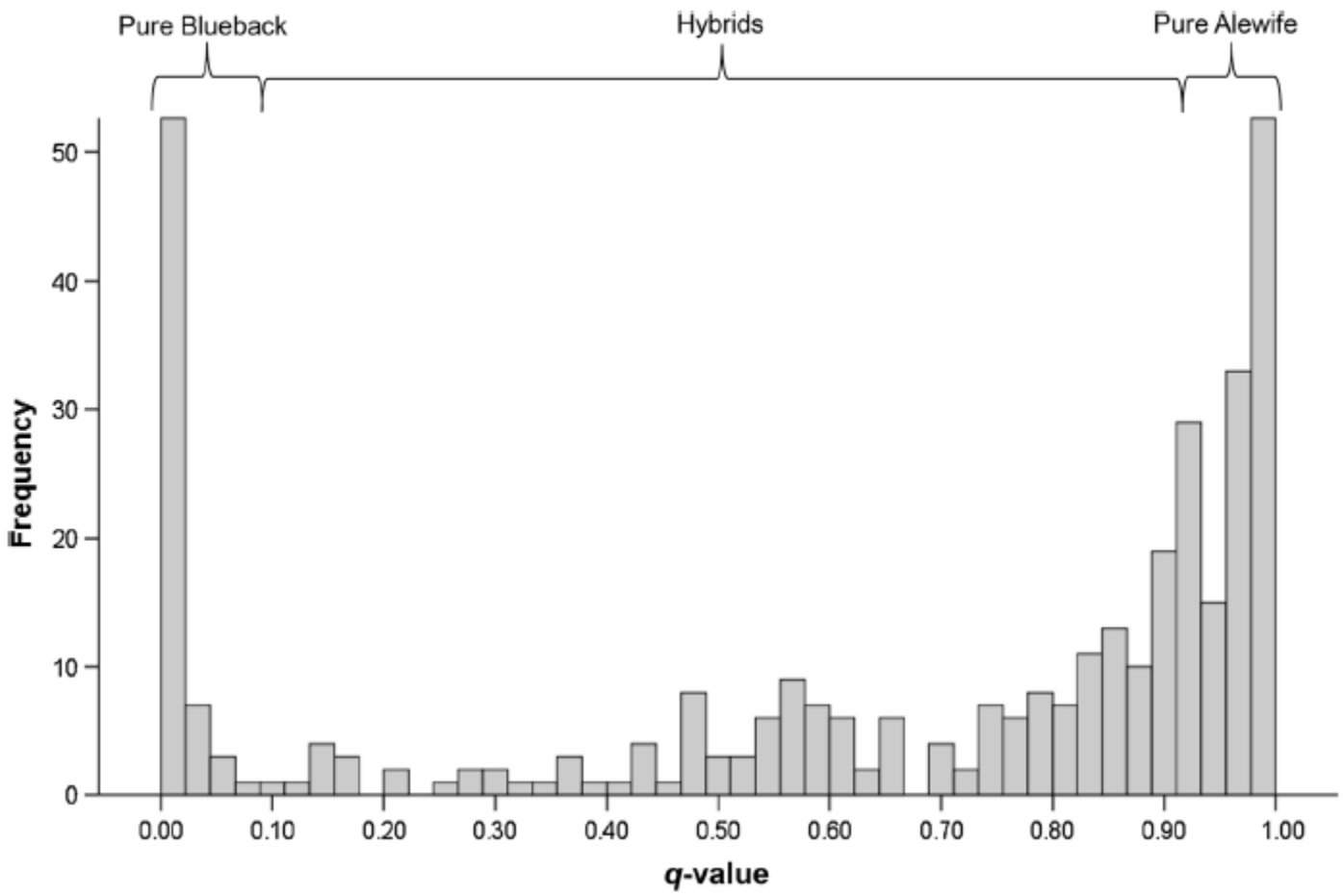
Fig. 1 Map showing collection sites for alewife and blueback (*), as well as discontinuities in gene flow (*1* most important; *5* least important) revealed using BARRIER

A basic result:
In pairwise comparisons, virtually all Canadian alewife populations show significant genetic differences (allele frequency differences).

- Consistent with fairly strong natal homing.
- → each river *ought to be* managed separately.

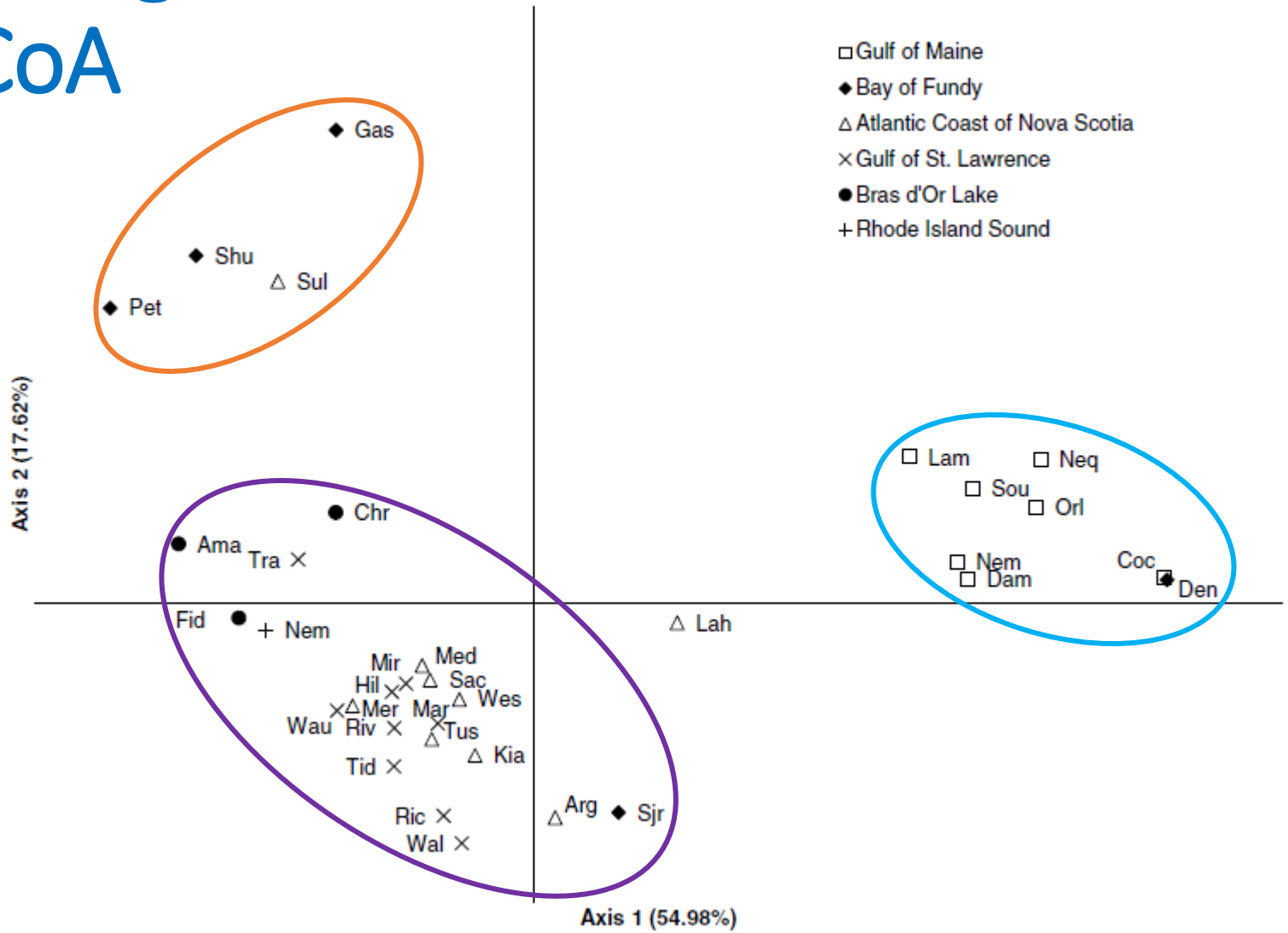
First: identify species & hybrids

- Most samples taken early in run to minimize chance of collecting bluebacks.
- All specimens ID'd to species in field using peritoneal color.
- Bayesian clustering of all river herring samples revealed 2 strongly differentiated genetic groups, alewife & blueback, but also presence of hybrids and individuals misidentified in field.
- Fish with admixture coefficients ('q') <0.1 or >0.9 regarded as pure blueback, and alewife, respectively.
- Working data set = 2,235 alewife, 170 blueback, 112 hybrids.



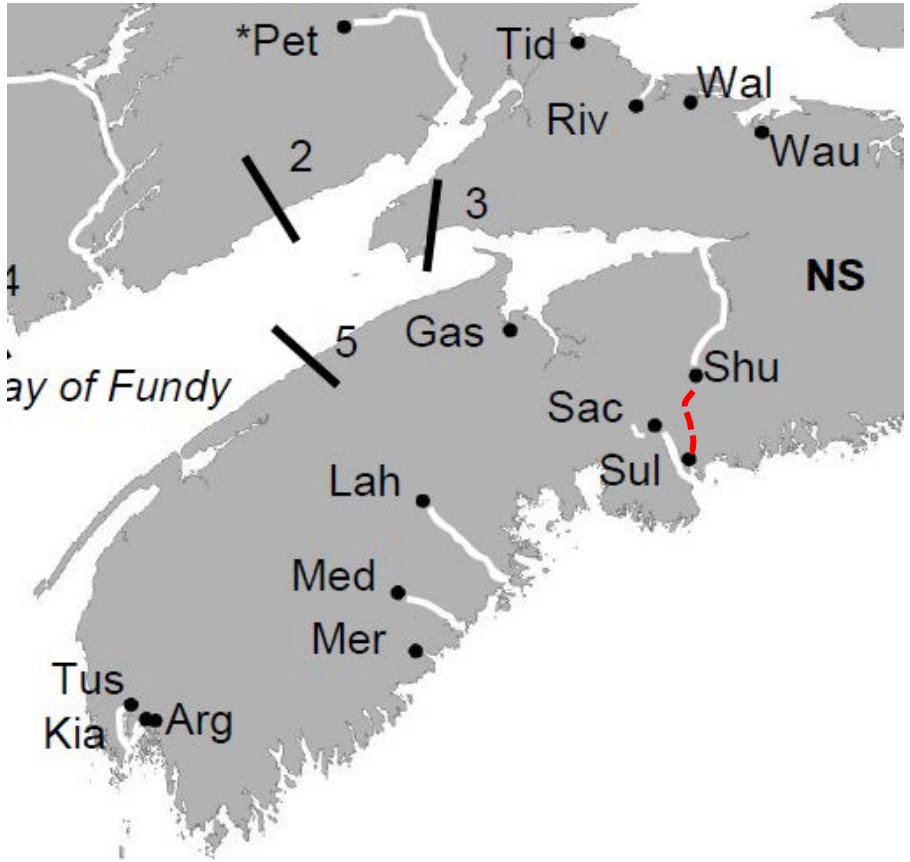
Geographic clustering also evident in PCoA

- Principle coordinates analysis based on F'_{ST} shows clear geographic clusters, and some outliers.
- Clusters: Gulf of Maine; Gulf of St. Lawrence + Atlantic coast NS; Bay of Fundy.
- Outliers: Saint John R., Lahave R., Nemasket, Sullivan's Pond Outlet.



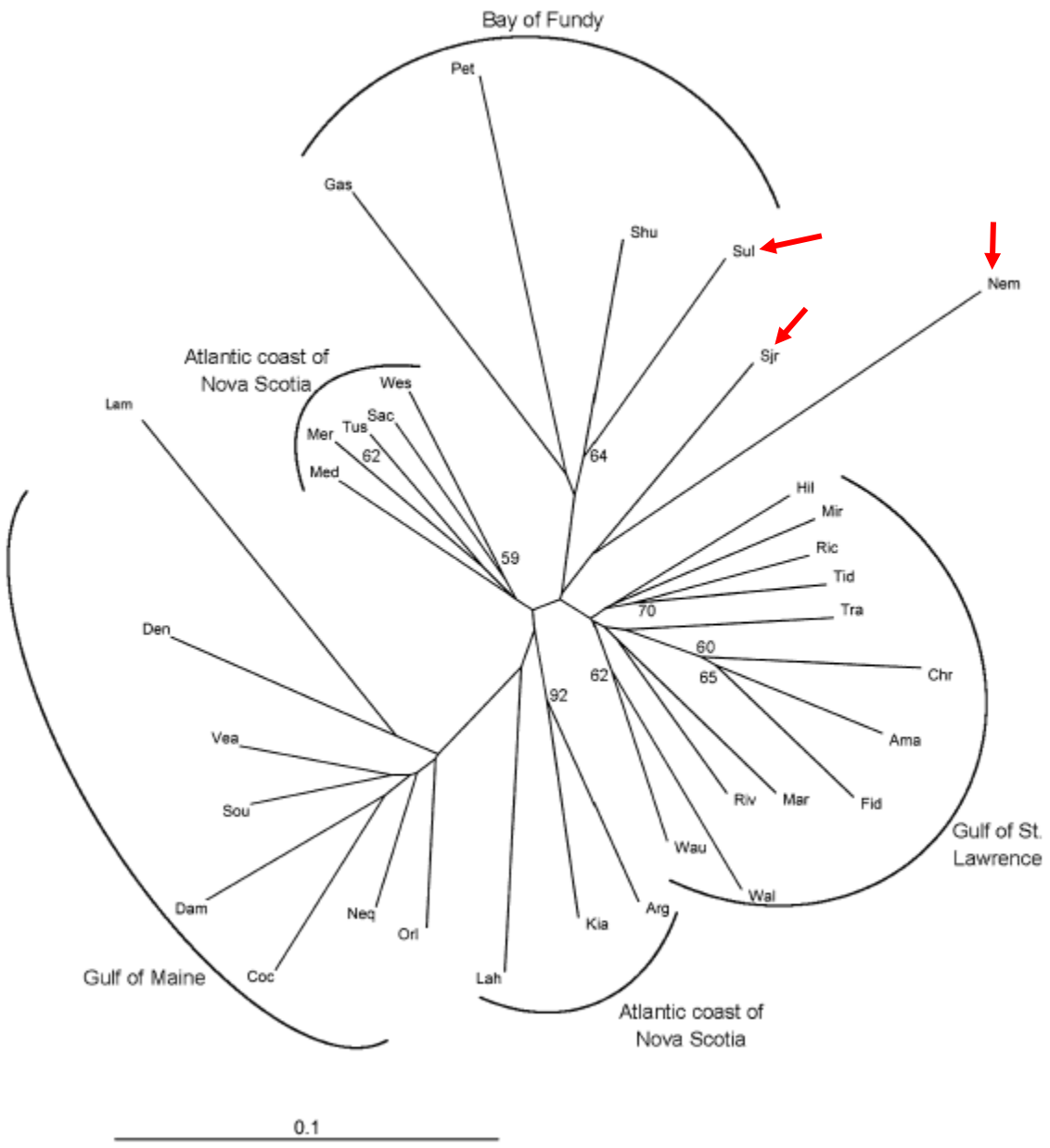
Sullivan's Pond outlet population likely a result of 19th century canal construction

- In 1800's, construction of Shubenacadie Canal linked Bay of Fundy to Atlantic coast, via the Shubenacadie River.
- Population of alewife in Atlantic coast outlet of Sullivan's Pond likely the result of colonization from the Shubenacadie River via the canal.
- Sullivan's Pond population remains genetically similar to other BoF populations, and genetically distinct from nearby Sackville River population.



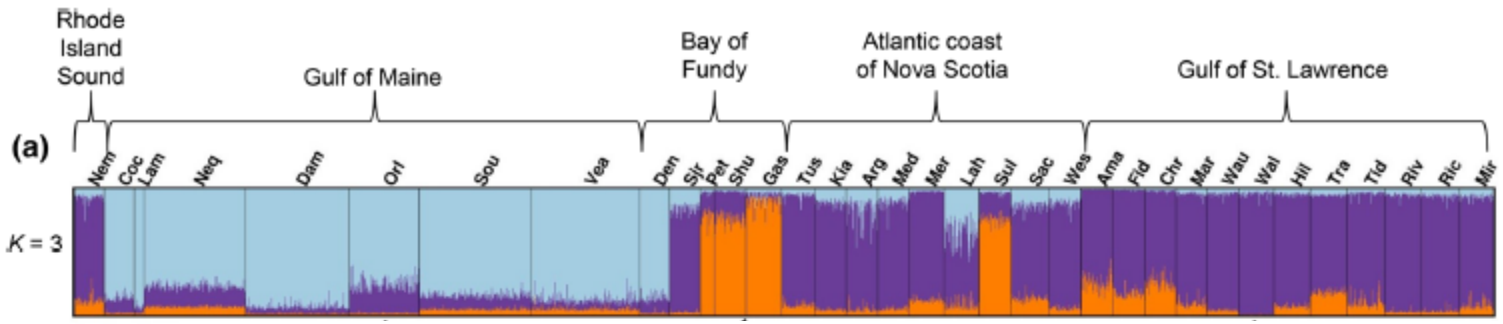
Dendrogram analysis shows alewife populations cluster by geographic region

- Neighbor-joining analysis based on chord distances.
- Nearly all alewife populations cluster according to geographic region. Sullivan's Pond clusters with BoF.
- Atlantic coast of Nova Scotia: 2 clusters.
- Nemasket (MA) and Saint John River (NB) appear relatively distinct from other populations.



Bayesian clustering initially reveals 3 genetic ‘clusters’ among alewife populations.

- 3 genetic clusters, each strongly associated with 1 geographic region.
- ‘Gulf of Maine’
- ‘Gulf of St. Lawrence/Atlantic Coast NS’
- ‘Bay of Fundy’



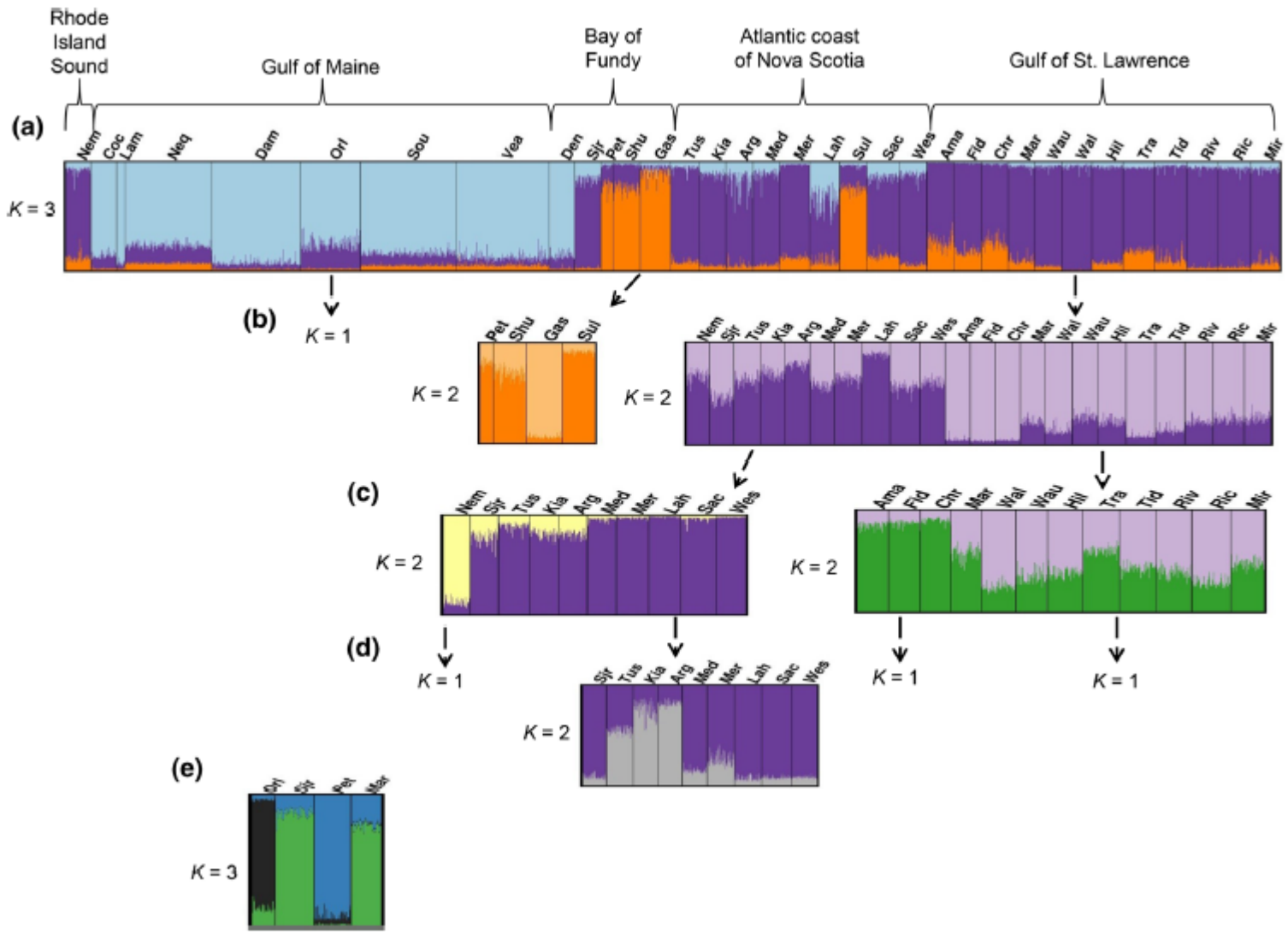
Subsequent rounds of Bayesian clustering initially reveal a total of 8 genetic clusters of alewife

Populations dominated by a single genetic cluster analyzed separately, until no further structure revealed.

8 alewife clusters (S-N):

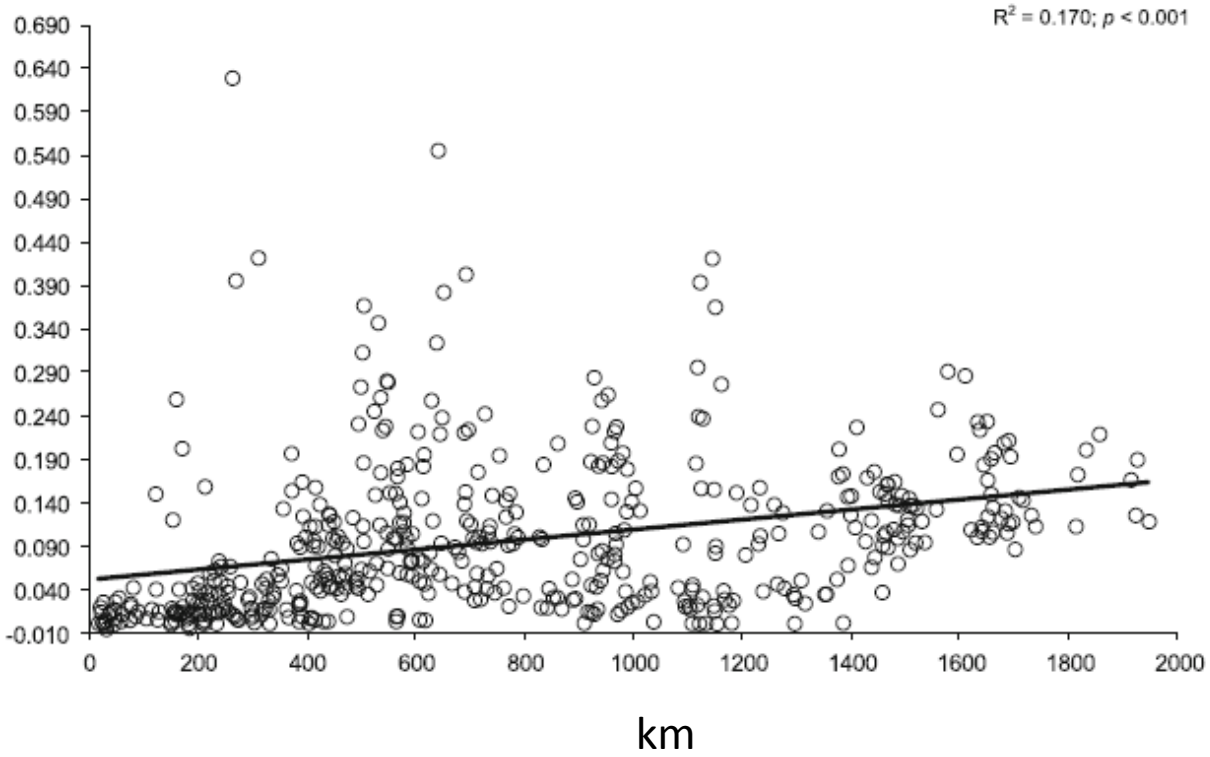
- Nemasket;
- GoM;
- BoF: [Pet,Shu,Sul][Gas];
- SW-NS[Tusk,Kia,Arg];
- Atlantic NS;
- Gulf of St. Lawrence,
- Bras d'Or Lake
- BoF has greatest genetic diversity (3 clusters)

- Also 3 blueback clusters (e)



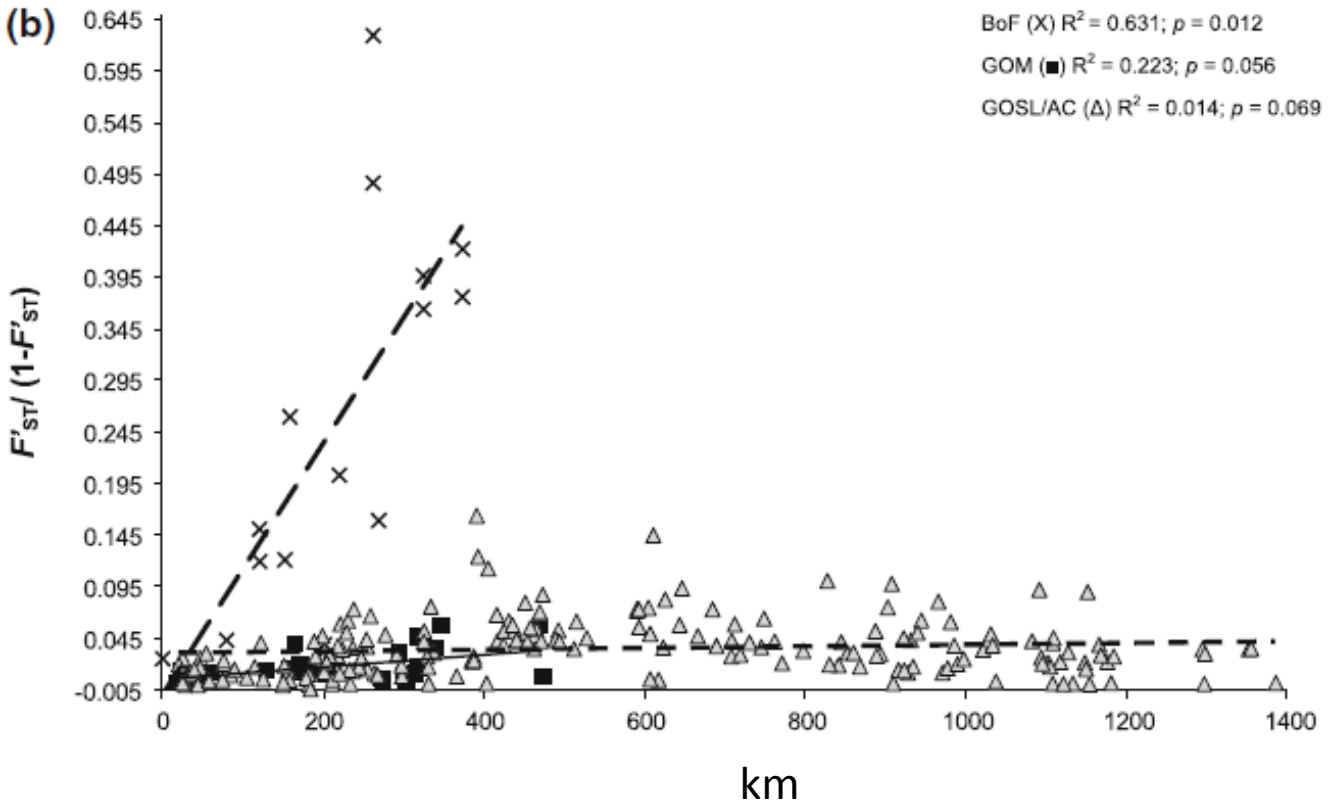
Isolation by Distance (IBD) highly significant across northern portion of alewife range

- Genetic distance ($F'_{ST}/(1- F'_{ST})$) is positively correlated with geographic distance (km) between rivers.
- But, relationship is very noisy.



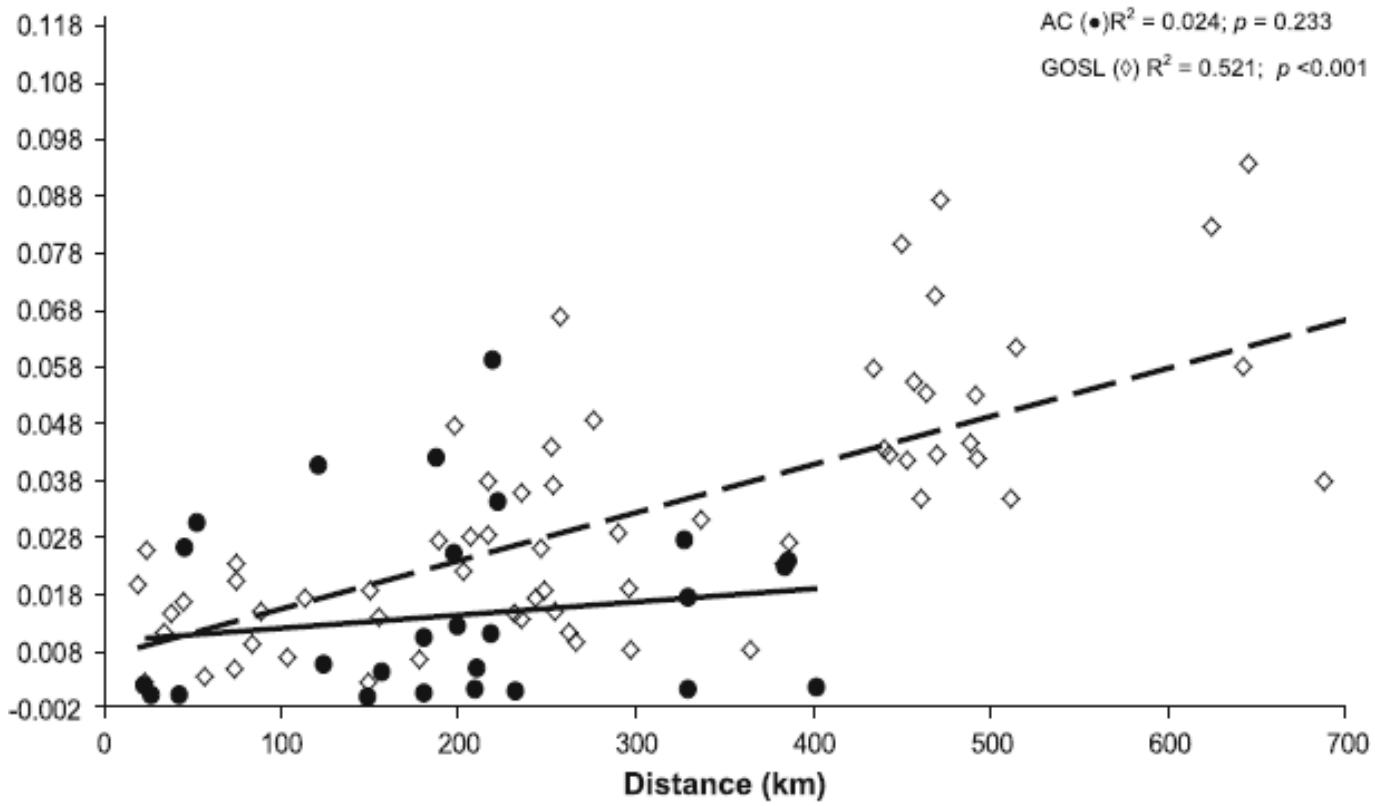
Patterns of IBD very different in different geographic regions

- Very steep IBD slope explains 63% of genetic variance in BoF.
- Conversely, slope of IBD much lower in other regions, and relationships are marginally (in)significant.
- At any given spatial scale (>~50km) alewife in BoF are much more genetically differentiated.
- Weak differentiation, low slope in GoM and Atlantic coast NS could reflect anthropogenic influences (dams, stocking), but not in Gulf of St. Lawrence.



Different patterns of IBD in Atlantic NS and Gulf of St. Lawrence

- IBD among Atlantic coast populations in NS is non-significant.
- By contrast, IBD in Gulf of St. Lawrence populations is highly significant. R^2 = 52%.
- Comparison confounded by different spatial scales, but suggests possibility that old mill dams on Atlantic coast may have disrupted IBD.



CONCLUSIONS/BOTTOM LINE:

- In Canadian portion of range, alewife populations are structured at level of river (*i.e.*, nearly all river populations are genetically distinguishable from nearest neighbor).
- Overall, genetic structure stronger in Canadian portion of range (6 of 8 genetic clusters detected in Bayesian clustering occur in Canada).
- Prevalence of IBD suggests that most (genetically meaningful) dispersal occurs on small spatial scales.
- Variation in strength of genetic structure, IBD, likely due to landscape, hydrographic features, but also human activities (dams, stocking).