Genetic relationship between alewife and blueback herring in midcoast Maine

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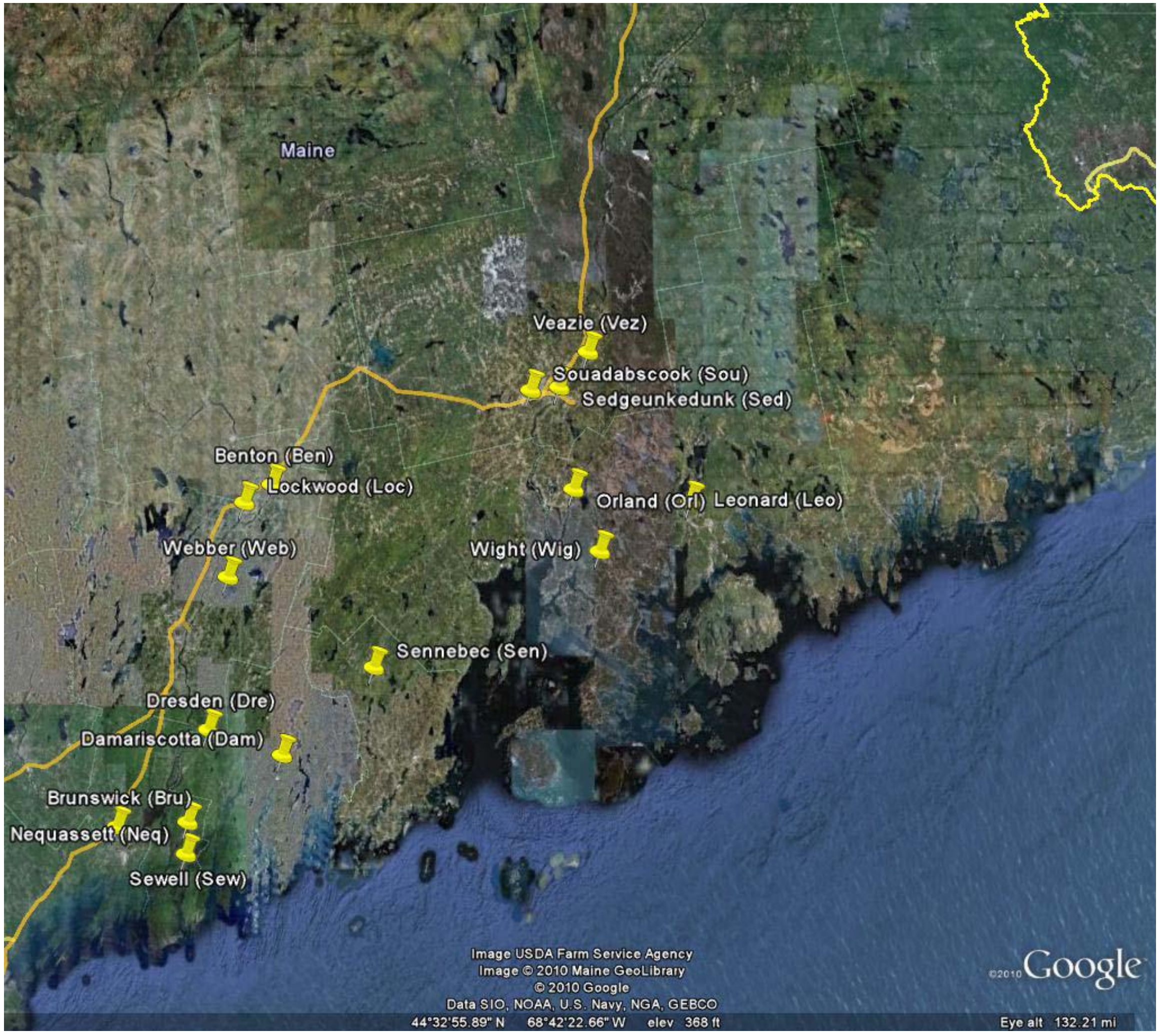
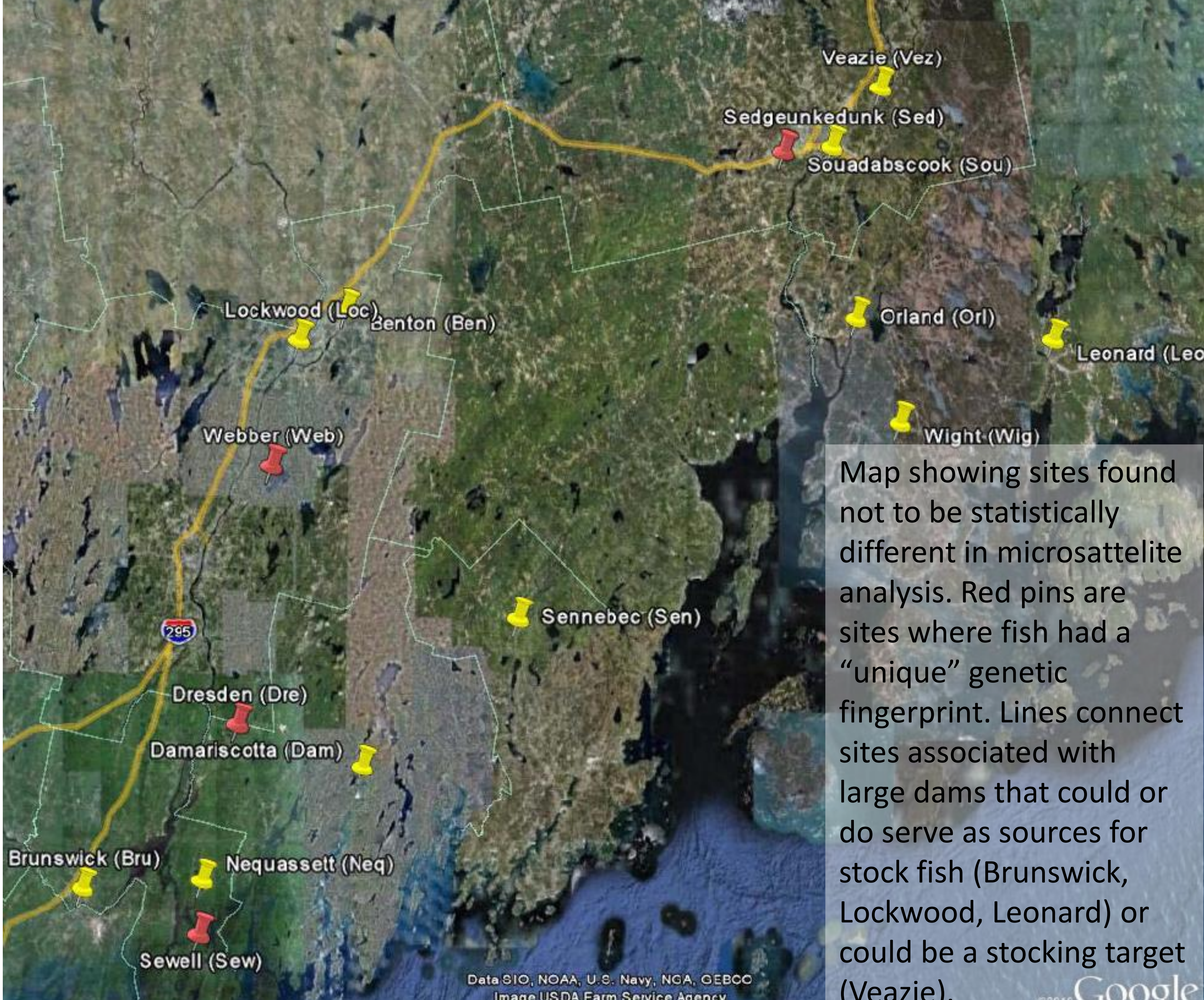
Funders:
USFWS – Coastal Program
NMFS

Objectives

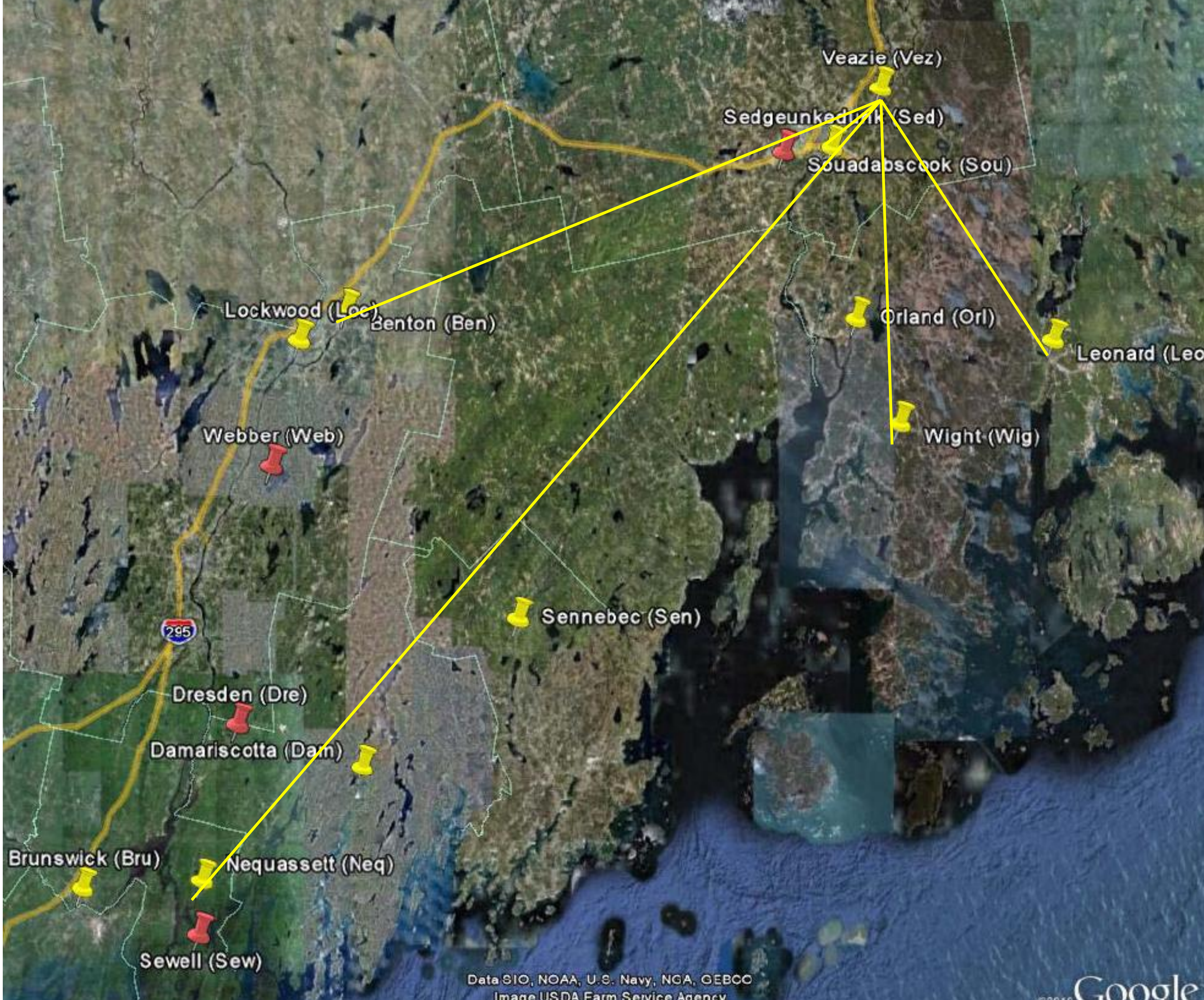
- **Is local adaptive pressure in individual watersheds sufficient to overcome outbreeding and inbreeding depression**
- **Are extant alewife runs in inner Penobscot Bay distinct enough from common donor populations to warrant preserving their genetic structure.**

Sites sampled for alewives in Maine in 2009 to assess stock structure and genetic relationships between river sub-populations

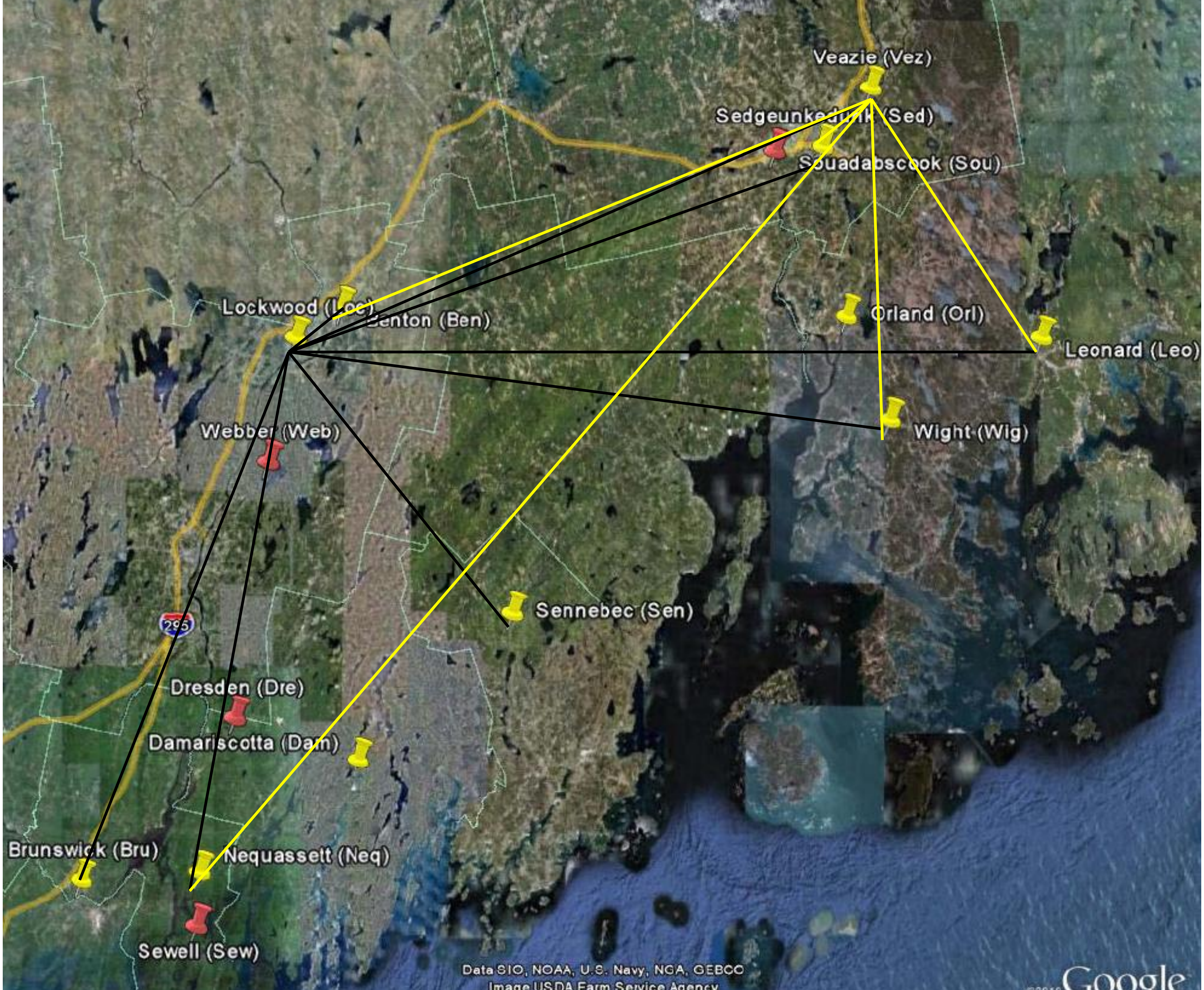




Map showing sites found not to be statistically different in microsattelite analysis. Red pins are sites where fish had a “unique” genetic fingerprint. Lines connect sites associated with large dams that could or do serve as sources for stock fish (Brunswick, Lockwood, Leonard) or could be a stocking target (Veazie).



Veazie (Vez)
Sedgeunkedunk (Sed)
Souadabscook (Sou)
Lockwood (Loc)
Benton (Ben)
Orland (Orl)
Leonard (Leo)
Wight (Wig)
Webber (Web)
295
Sennebec (Sen)
Dresden (Dre)
Damariscotta (Dam)
Brunswick (Bru)
Nequassett (Neq)
Sewell (Sew)
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google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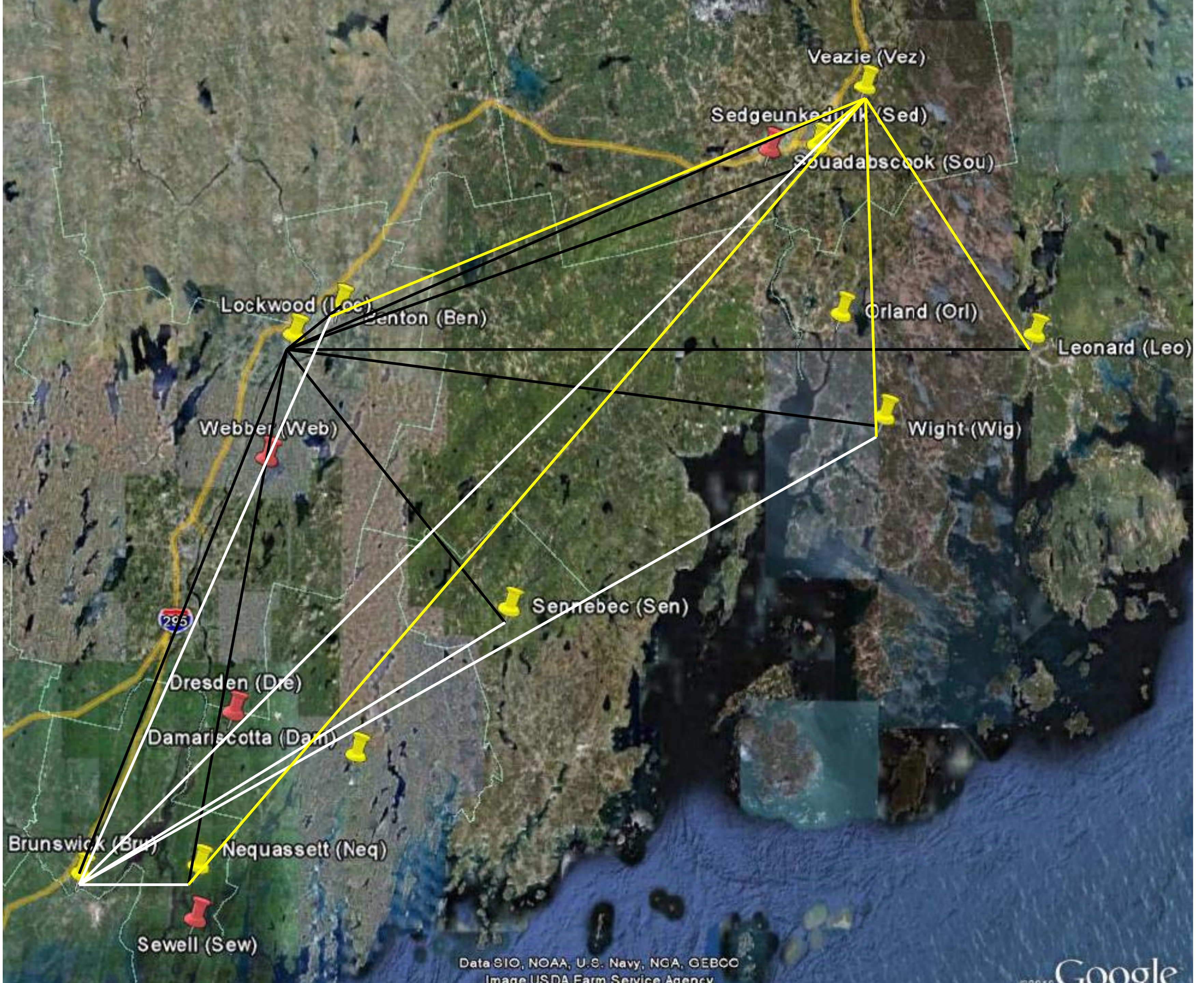
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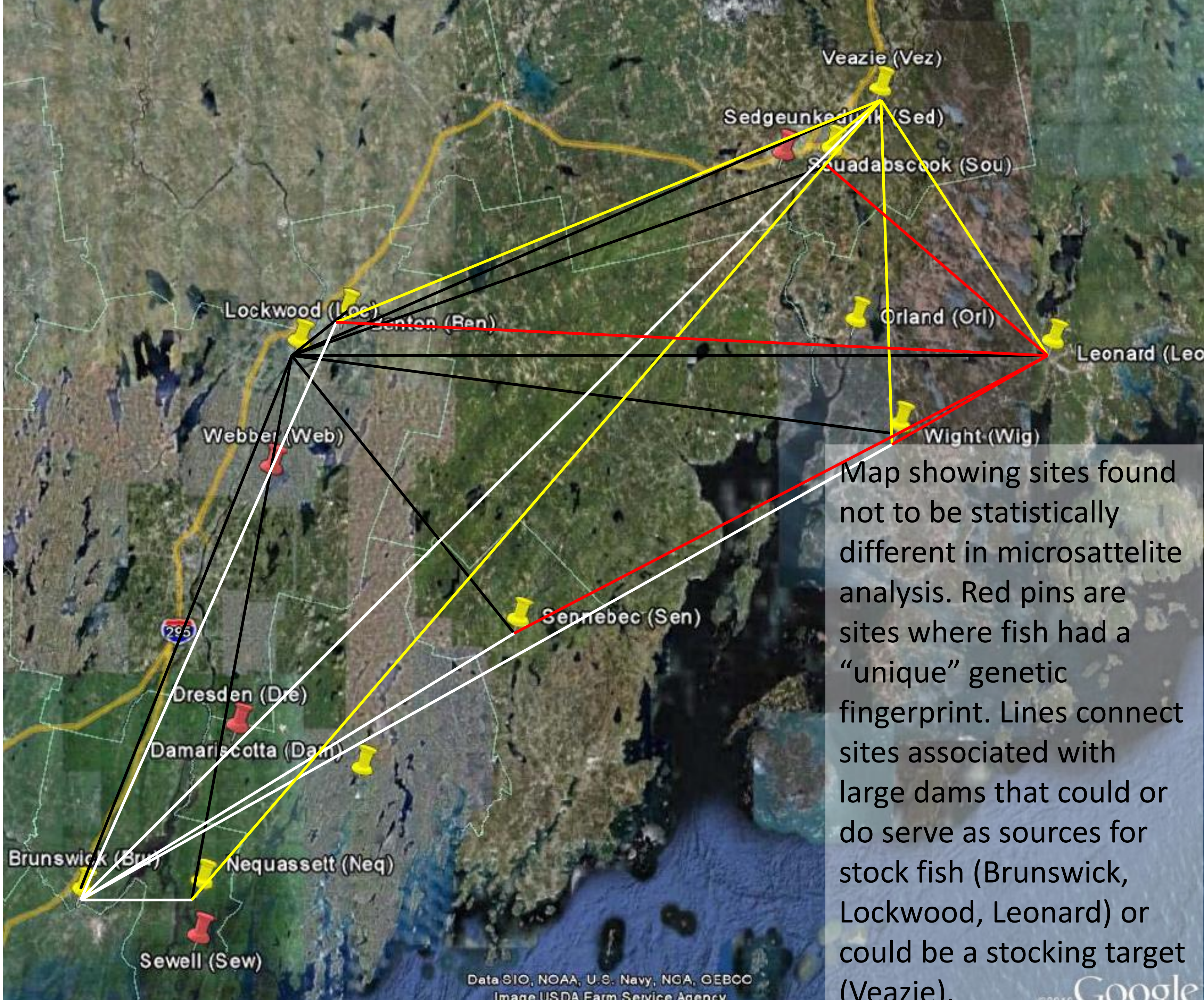

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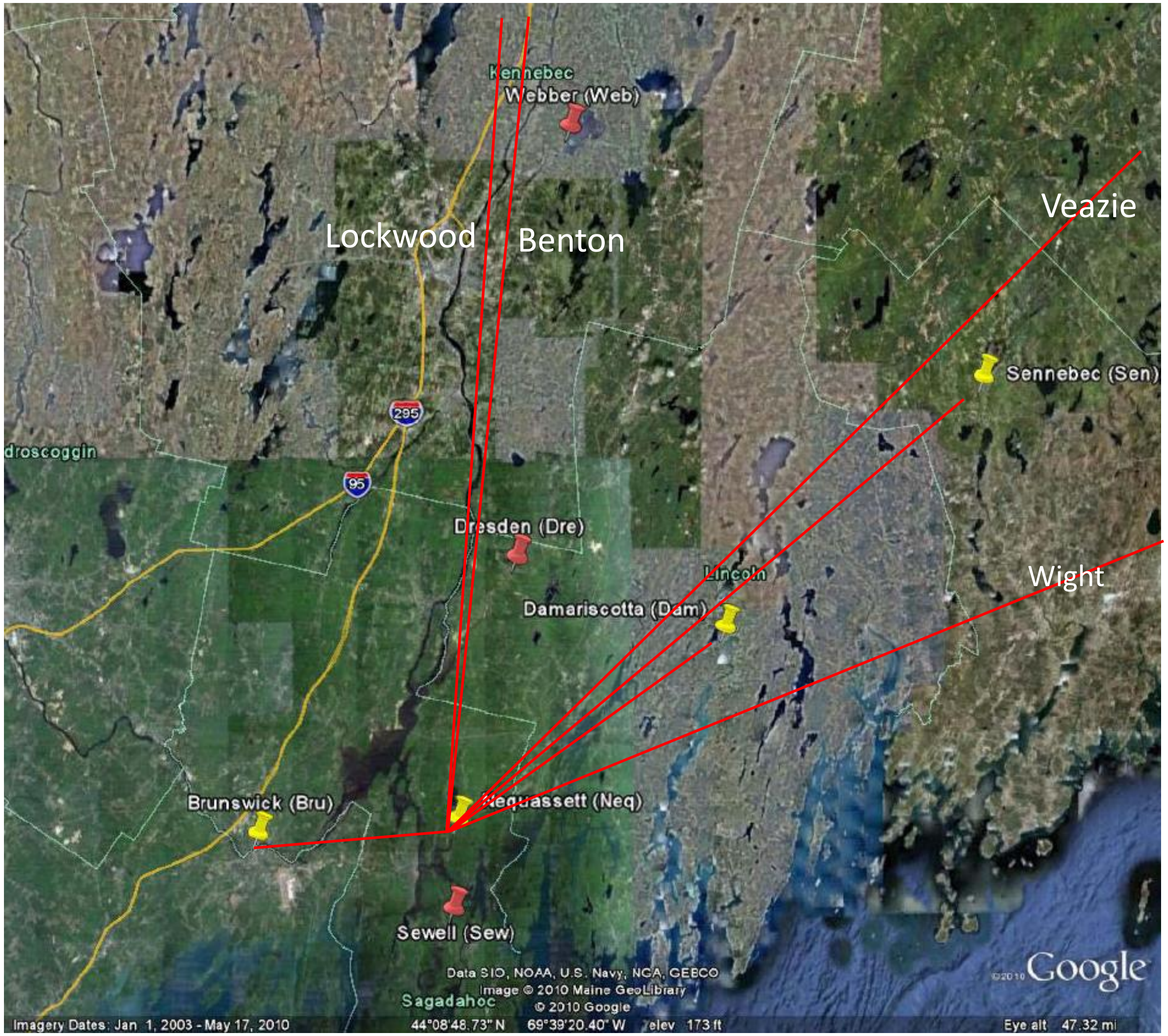
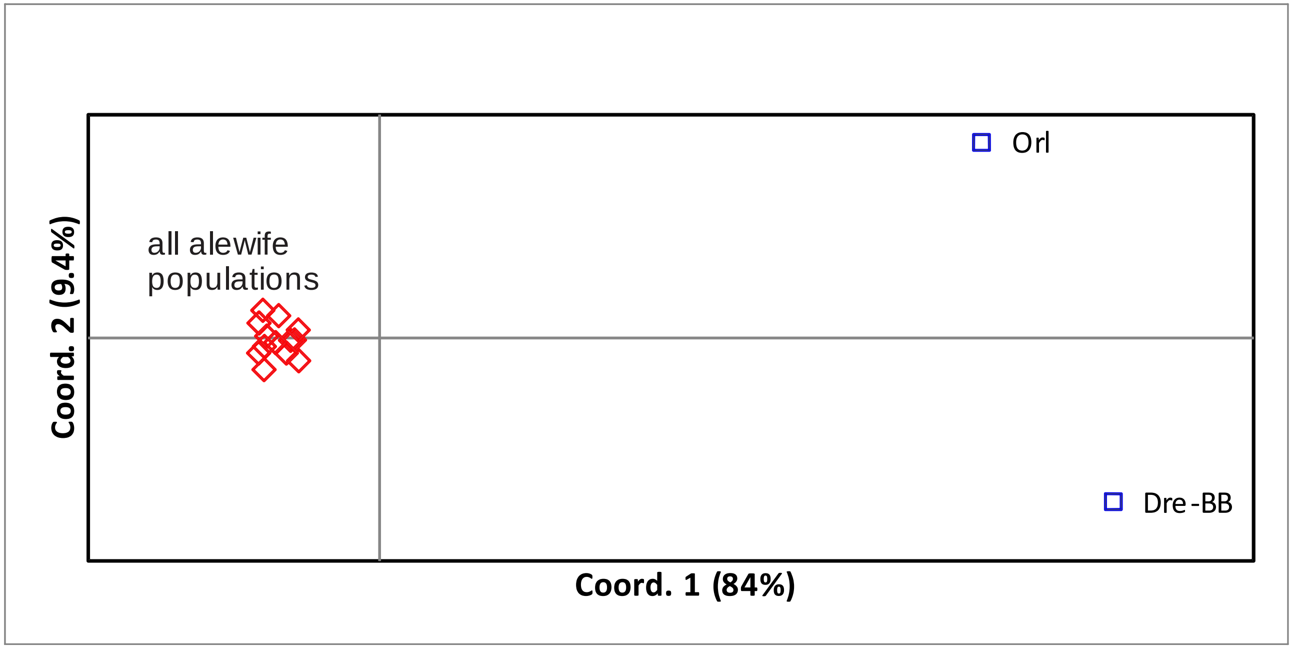
Perspectives on Genetically distinct populations

- **Sewell, Dresden and Webber** are recently managed sites, all with at least 5 years of stocking
  - Webber stocked from Brunswick, Edwards Dam, Fort Halifax and Lockwood
  - 64,000 fish between 1989 & 2005
- **Nequasset**:
  - to our knowledge, has never been stocked
  - Not differentiated from 7 sites, 4 of which are out of basin
- **Damariscotta**:
  - Stocked in 1807 from either the St. George River or the Medomak River
  - Similar genomic characteristics to St. George, Bagaduce, Sebasticook, Nequasset



Principle coordinates analysis of alewife and blueback herring populations.



Results and Future Directions

- Sub-populations do not appear to conform to the hypothesis of less distinction at stocked-sites
  - Appear to have the opposite pattern

- 2011: Repeat analysis of 2009 sites with 2010 data (except Sewall)
  - Develop additional markers appropriate for BBH or both species
- 2012: Year 3 repeat sampling all 14 sites

Summary table of similar and dissimilar sites

Site	Dre	Sew	Web	Sou	Dam	Sed	Bru	Leo	Neq	Vea	*Sen*	Wig	Loc	Ben
Watershed	Kennebec	Kennebec	Kennebec	Penobscot	Damariscotta	Penobscot	Kennebec/ Androscoggin	Union	Kennebec	Penobscot	St. George	Bagaduce	Kennebec	Kennebec
Significantly different from:	13	13	13	13	9	9	7	7	6	6	6	5	5	4
Not dissimilar to:	distinct	distinct	distinct	distinct	Wight	Lockwood	Wight	Wight	Brunswick	Brunswick	Brunswick	Damariscotta	Brunswick	Brunswick
					Nequasset	Veazie	Lockwood	Lockwood	Wight	Wight	Wight	Lockwood	Wight	Wight
					Benton	Benton	Nequasset	Sedge	Damariscotta	Lockwood	Damariscotta	Nequasset	Nequasset	Damariscotta
					Sennebec	Leonard	Veazie	Veazie	Veazie	Nequasset	Lockwood	Veazie	Sedge	Lockwood
							Benton	Benton	Benton	Sedge	Nequasset	Benton	Veazie	Nequasset
							Sennebec	Sennebec	Sennebec	Benton	Benton	Sennebec	Benton	Sedge
									Lockwood	Leonard	Leonard	Leonard	Sennebec	Veazie
												Brunswick	Leonard	Sennebec
														Leonard

Results (5): Principle coordinates analysis of alewife populations

- Principle coordinates analysis of alewife populations suggests some populations relatively more similar than others (Figure 4).
- Sed, Web and Sew relatively distinct on PCA1, Sed, Web and Dam somewhat distinct on PCA2.
- Web and Dre most distinct on PCA 3 (panel B).
- No obvious associations of stocked vs. unstock populations, or by major drainage.
- Could indicate varying effects of genetic drift in relatively small populations?

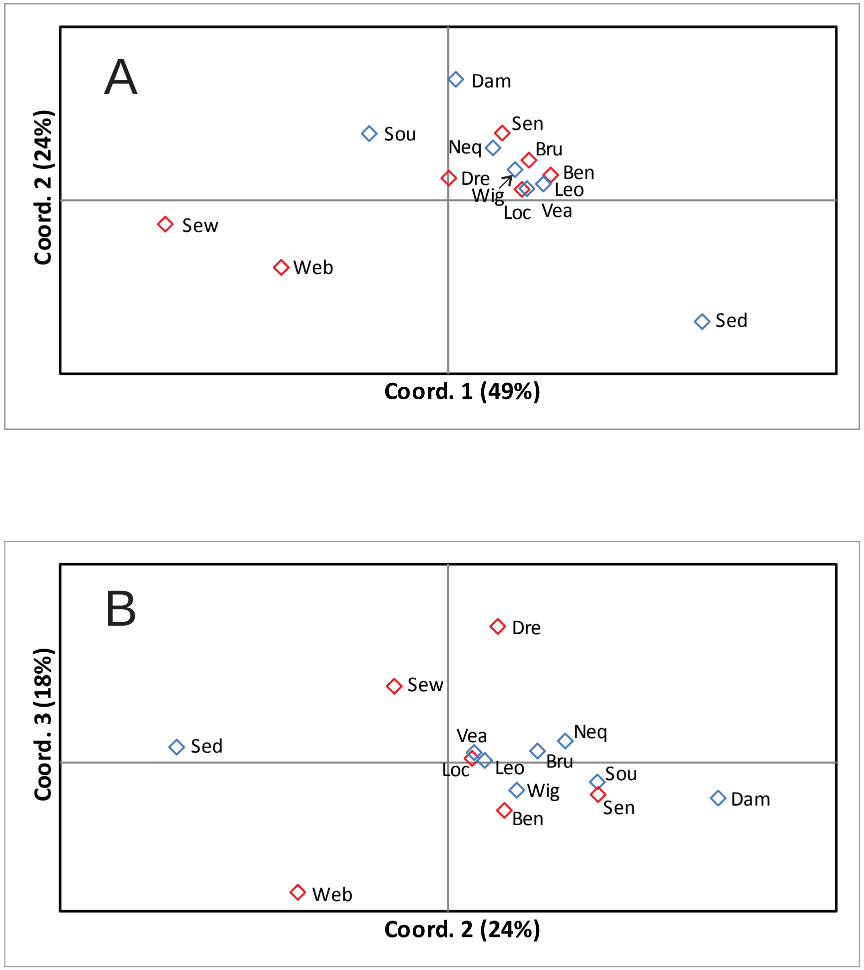
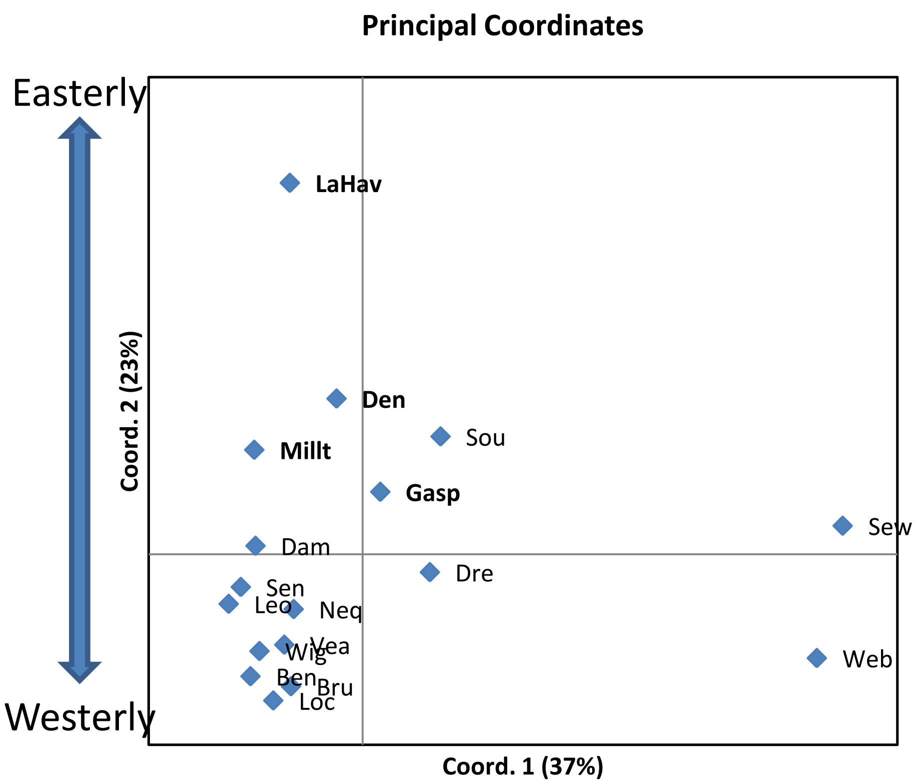


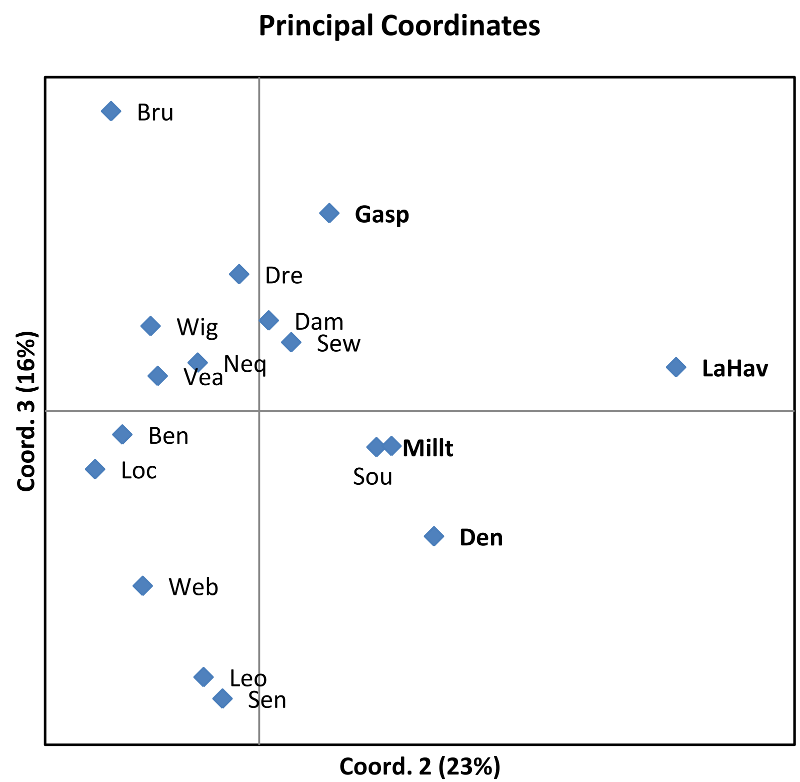
Figure 4. Principle coordinates plots showing genetic relationships among alewife populations. A, Coordinates 1 & 2. B, Coordinates 2 & 3. The percentage of the genetic variation explained by each axis is shown in parentheses. Population labels are as given in Table 1. Stocked and unstocked locations are indicated with red and blue symbols, respectively.

PCA based on Nei's unbiased D , combining data from current study with data from previous study of St. Croix R. & 2 Nova Scotia populations of alewife.

Principle coordinates 1 & 2



Principle coordinates 2 & 3



- Sew & Web differentiation drive PCA results
- Northeast vs. southwest gradient in PCA driven by addition of Atlantic Provinces sites (bold)
- Overall, clustering of populations in PCA with Maine only sites is not uncharacteristic of alewives sampled from a wider geographic area

Results (3): Differentiation among populations

- Pairwise Fst values calculated with Genetix showed substantial divergence between the two blueback herring populations, Dresden Mills and Orland, and all alewife samples (mean pairwise Fst = 0.283).
- Pairwise Fst between the two blueback herring samples, Dresden Mills and Orland, was less but still substantial (Fst = 0.11). This value is greater than the differentiation seen between any two alewife populations, and suggests the possibility of greater structuring in this species. However, relatively small sample size for the Dresden Mills sample, and the generally poorer amplification results obtained with blueback herring (an average of only 5.7 loci were scored per fish in this species) suggests the need for caution in interpreting these results.
- Pairwise Fst values were lower for comparisons between alewife samples (mean Fst = 0.014), but were significantly greater than zero in most cases (Table 2).

N	56	44	48	69	62	58	62	36	14	50	63	62	36	59
Watershed	Androscoggin	Bagaduce	Damariscotta	Eastern	Kennebec	Kennebec	Kennebec	Kennebec	Penobscot	Penobscot	Penobscot	Sebasticook	St. George	Union
Location	Bru	Wig	Dam	Dre	Loc	Neq	Sew	Web	Sed	Sou	Vea	Ben	*Sen*	Leo
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Bru		0.002	*0.007*	***0.011***	0.002	0.004	***0.025***	***0.024***	*0.017*	***0.017***	0.001	0.001	0.010	*0.012*
Wig	0.276		0.000	***0.013***	-0.001	0.001	***0.026***	***0.017***	***0.013***	***0.015***	0.003	0.000	0.006	0.007
Dam	0.030	0.435		***0.017***	*0.007*	0.003	***0.027***	***0.024***	***0.028***	***0.010***	*0.008*	0.003	0.006	***0.010***
Dre	<0.001	<0.001	<0.001		***0.010***	***0.011***	***0.016***	***0.032***	***0.027***	***0.024***	***0.015***	***0.018***	***0.016***	***0.019***
Loc	0.229	0.501	0.019	0.001		-0.001	***0.021***	***0.019***	0.006	***0.014***	0.001	0.000	-0.003	0.001
Neq	0.089	0.351	0.190	<0.001	0.575		***0.020***	***0.023***	*0.016*	***0.009***	0.004	0.002	0.004	***0.008***
Sew	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		***0.017***	***0.043***	***0.015***	***0.022***	***0.027***	***0.027***	***0.025***
Web	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001		***0.033***	***0.023***	***0.021***	***0.019***	***0.020***	***0.025***
Sed	0.026	0.045	0.003	0.001	0.171	0.028	<0.001	<0.001		***0.033***	-0.001	0.006	*0.018*	0.008
Sou	<0.001	0.001	0.009	<0.001	0.002	0.004	0.001	<0.001	<0.001		***0.009***	***0.011***	***0.013***	***0.008***
Vea	0.331	0.178	0.016	<0.001	0.285	0.084	<0.001	<0.001	0.483	0.006		0.001	*0.008*	0.002
Ben	0.297	0.451	0.143	<0.001	0.396	0.205	<0.001	<0.001	0.152	0.002	0.349		0.004	0.004
Sen	0.016	0.089	0.051	<0.001	0.833	0.120	<0.001	<0.001	0.029	0.006	0.021	0.138		0.001
Leo	0.001	0.018	0.002	<0.001	0.330	0.007	<0.001	<0.001	0.112	0.008	0.251	0.069	0.285	