Genetic variation and geographic structure of coastal cutthroat trout at the northern extent of their range, Prince William Sound, Alaska

Kitty E. Griswold
USGS/BRD Conte Anadromous Fisheries Research Center
Turners Falls, MA
University of Massachusetts, Amherst
Kenneth P. Currens
NWIFC, Olympia WA
Gordon H. Reeves
PNW Research Station, Corvallis, OR

Genetic structure at the local scale

Why use genetic tools?

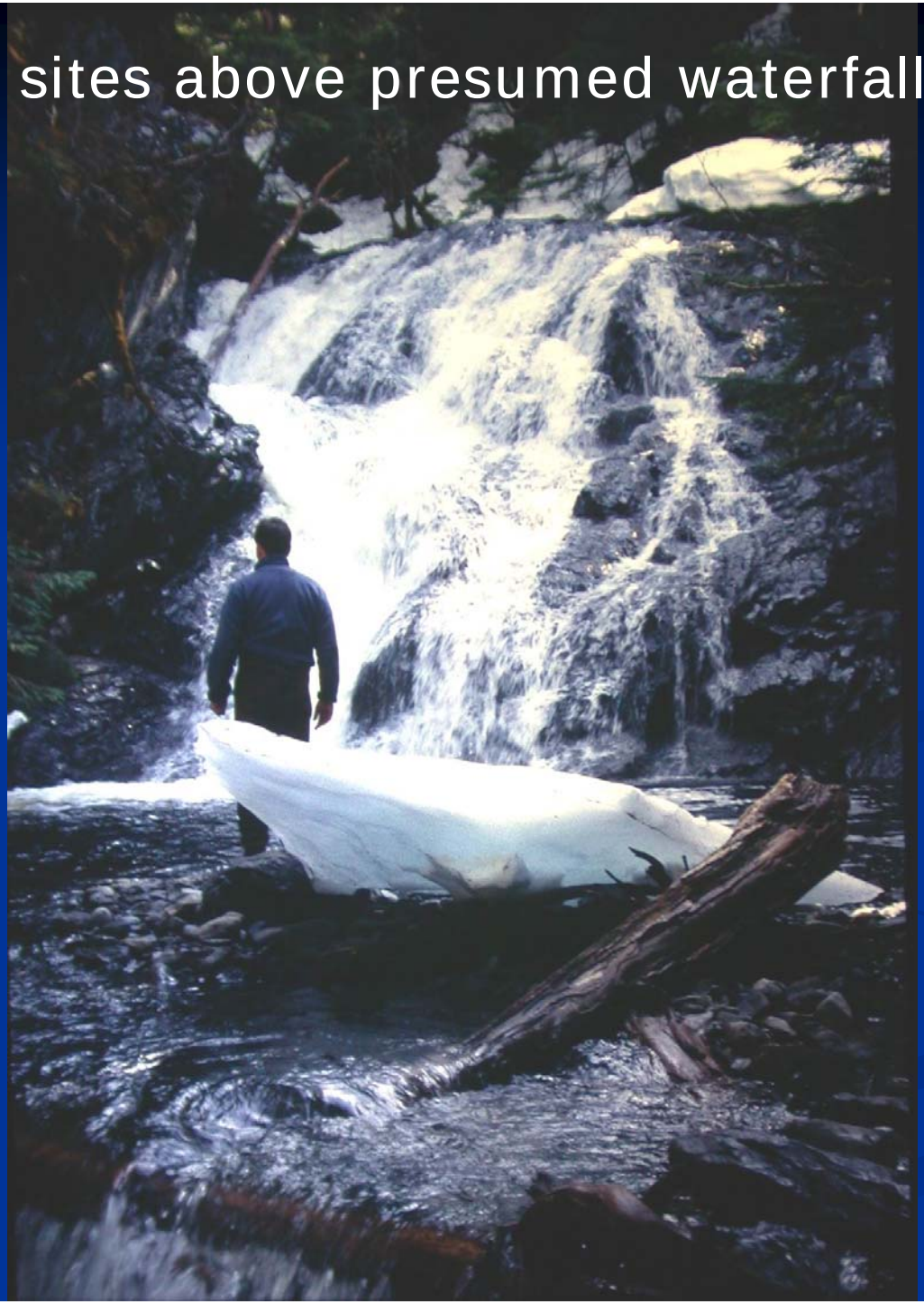
- Patterns tell us about species history
- Relative degree of isolation/gene flow
- Over space and time landscapes are dynamic

Distributional range of coastal cutthroat trout

Northern extent of range (8,000 ybp)

350 years
Unakwik Inlet
150 years
Columbia Bay
Milton Lake
Prince William Sound
Hawkins Creek:
below barrier
above barrier
18 Mile Creek
Gunboat Lake
Shelter Bay:
below barrier
above barrier
Makaka Creek
West Arm
Green Island
Stump Lake

Two sites above presumed waterfall barriers



Goals for this talk

- Genetic variation in Prince William Sound, AK with two genetic tools
- Correlation of genetic and geographic distance in coastal cutthroat trout in Prince William Sound, AK
- Otolith microchemistry analysis

Types of genetic variation and their applications

Mitochondrial DNA

- maternally inherited
- doesn't undergo recombination

Allozymes

Microsatellite DNA

- hypervariable
- tandem repeats (AGAGAGAG)

Ancestral Lineages

Kinship

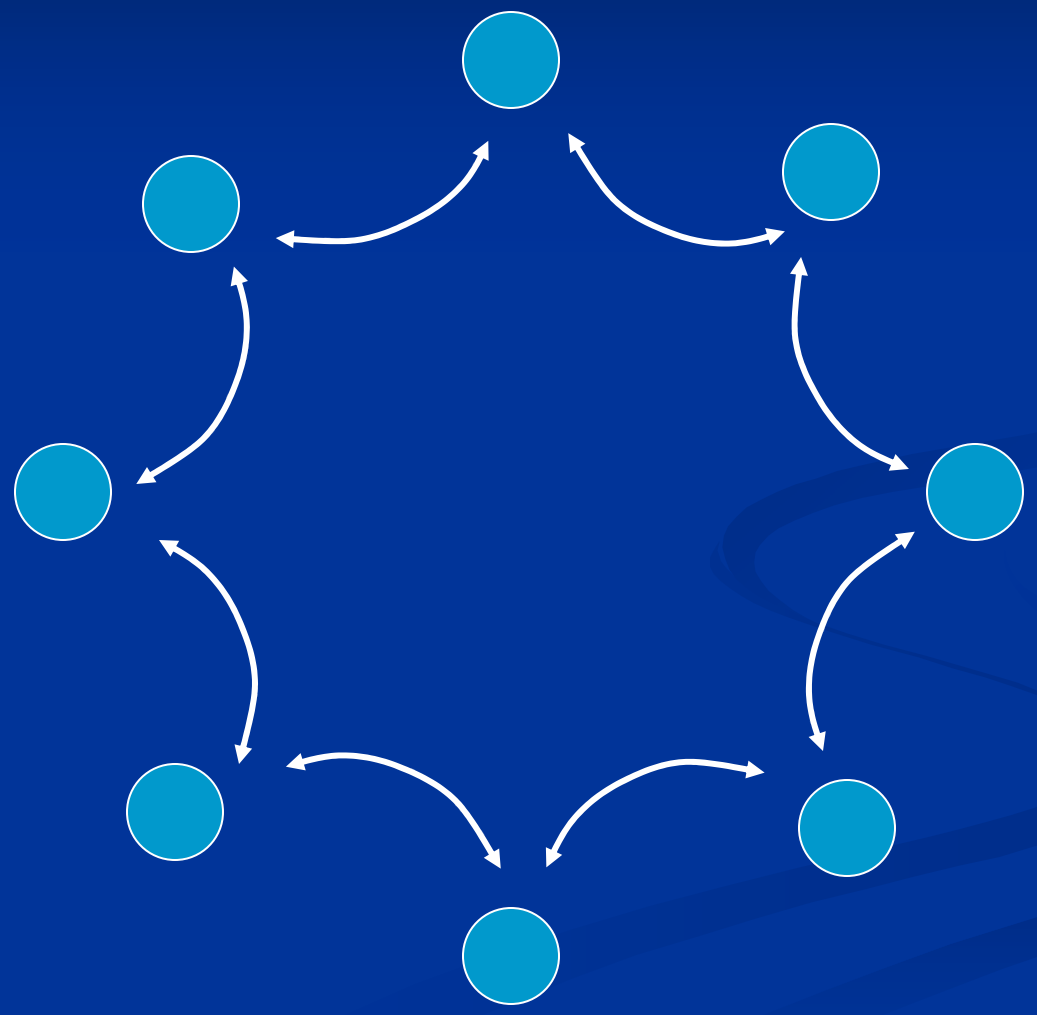
Data Analysis

- Haplotype diversity within Prince William Sound
- Genetic variation within sampling locations
  - Alleles per locus
  - Heterozygosity
- Genetic variation among sampling locations
  - Genetic distance
  - Test models of genetic structure

Isolation by distance (IBD)

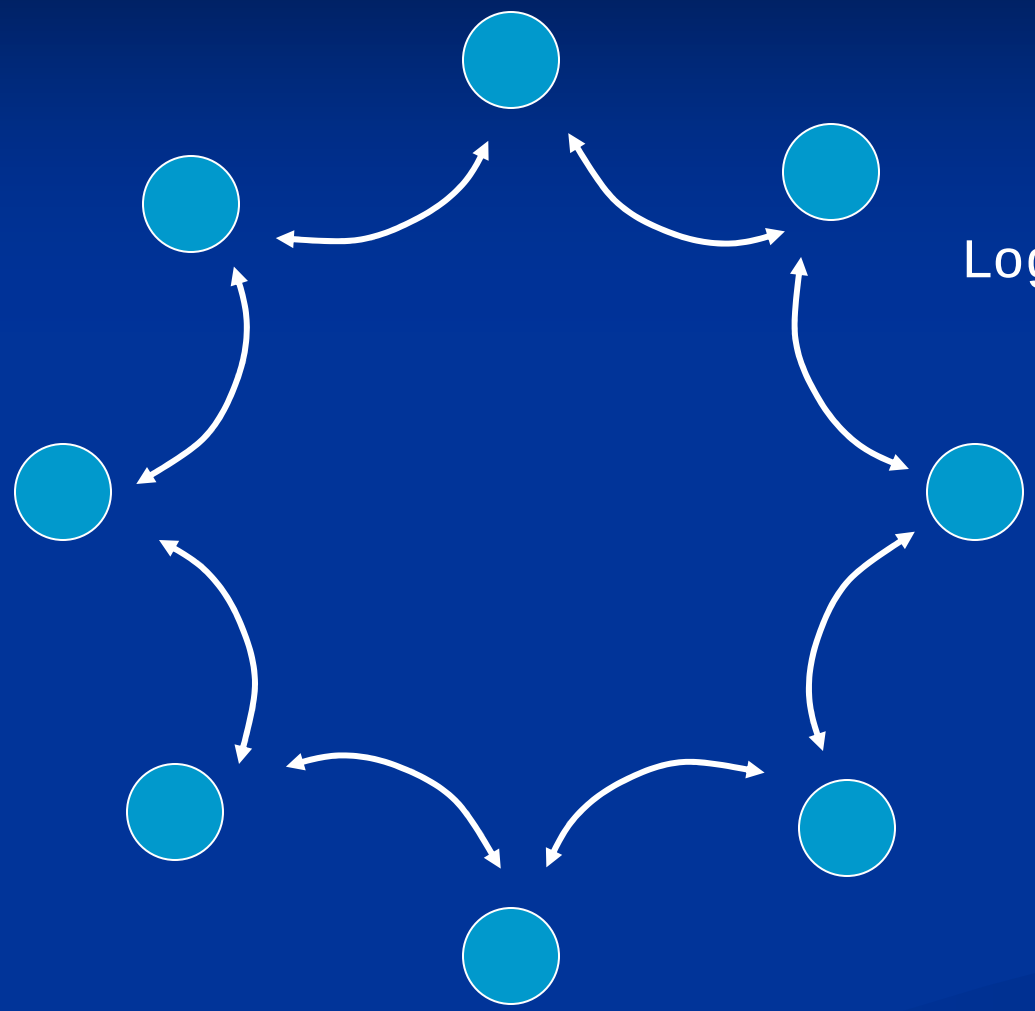
- Dispersal of organisms has limit which leads to a geographic pattern
- Isolation by distance
  - genetic differentiation increases with distance
- Migrants/generation (M) geographic distance (d)
  - Mantel test for significance
  - Regression
    - Slope of line describes model fit

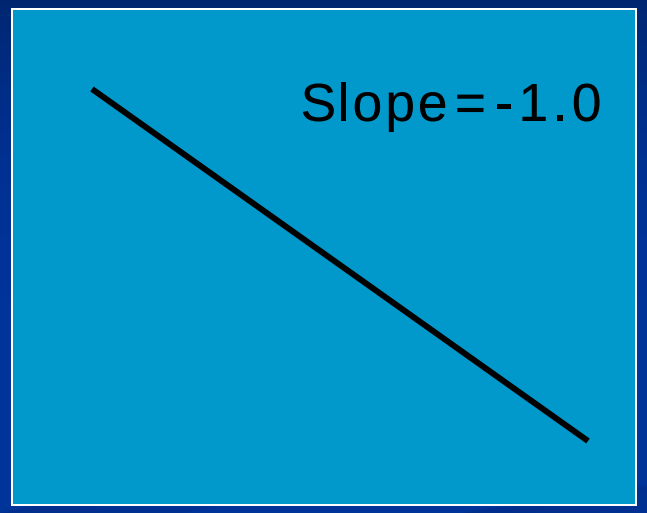
One dimensional stepping stone model



Slatkin (1993)

One dimensional stepping stone model





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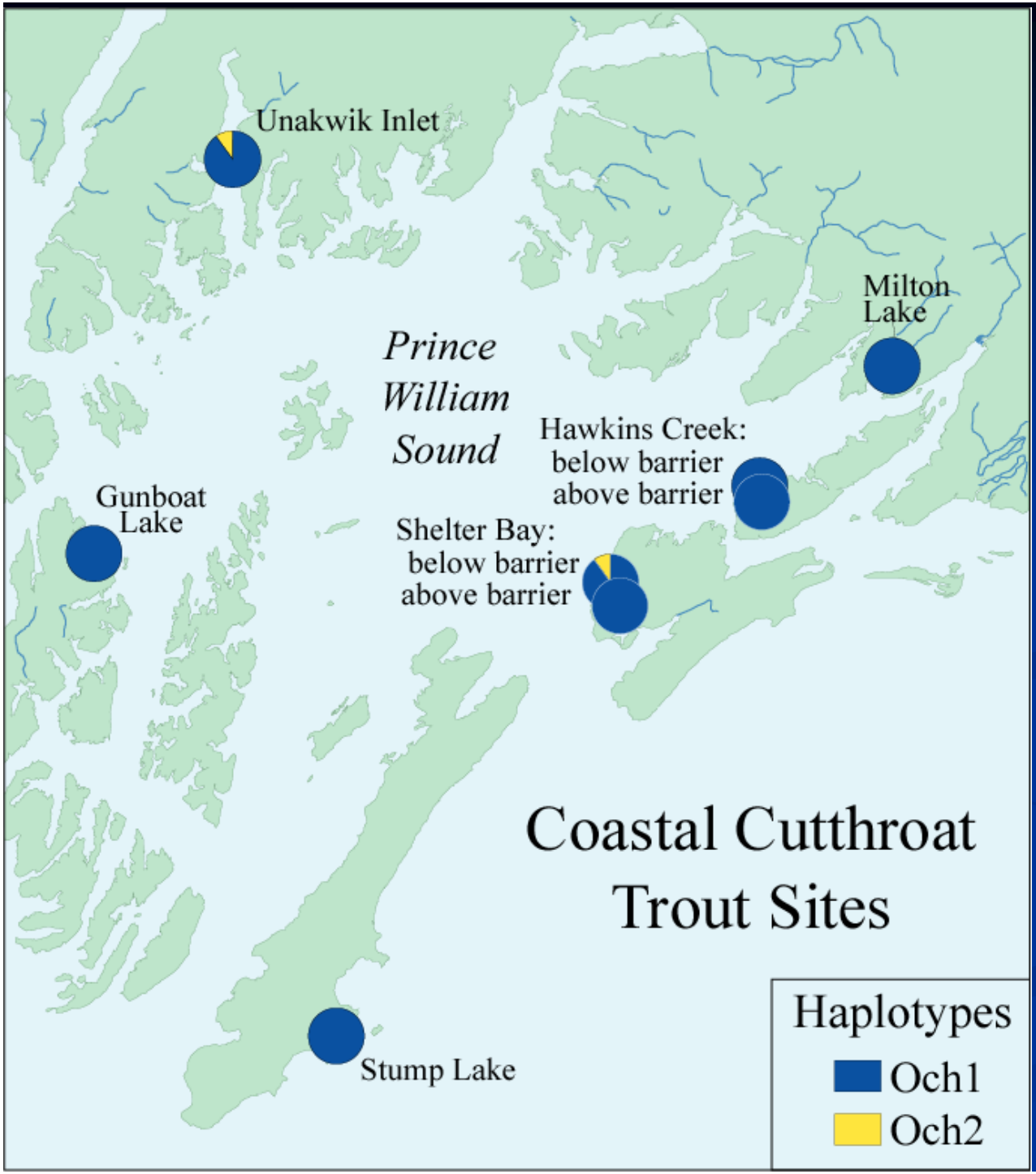
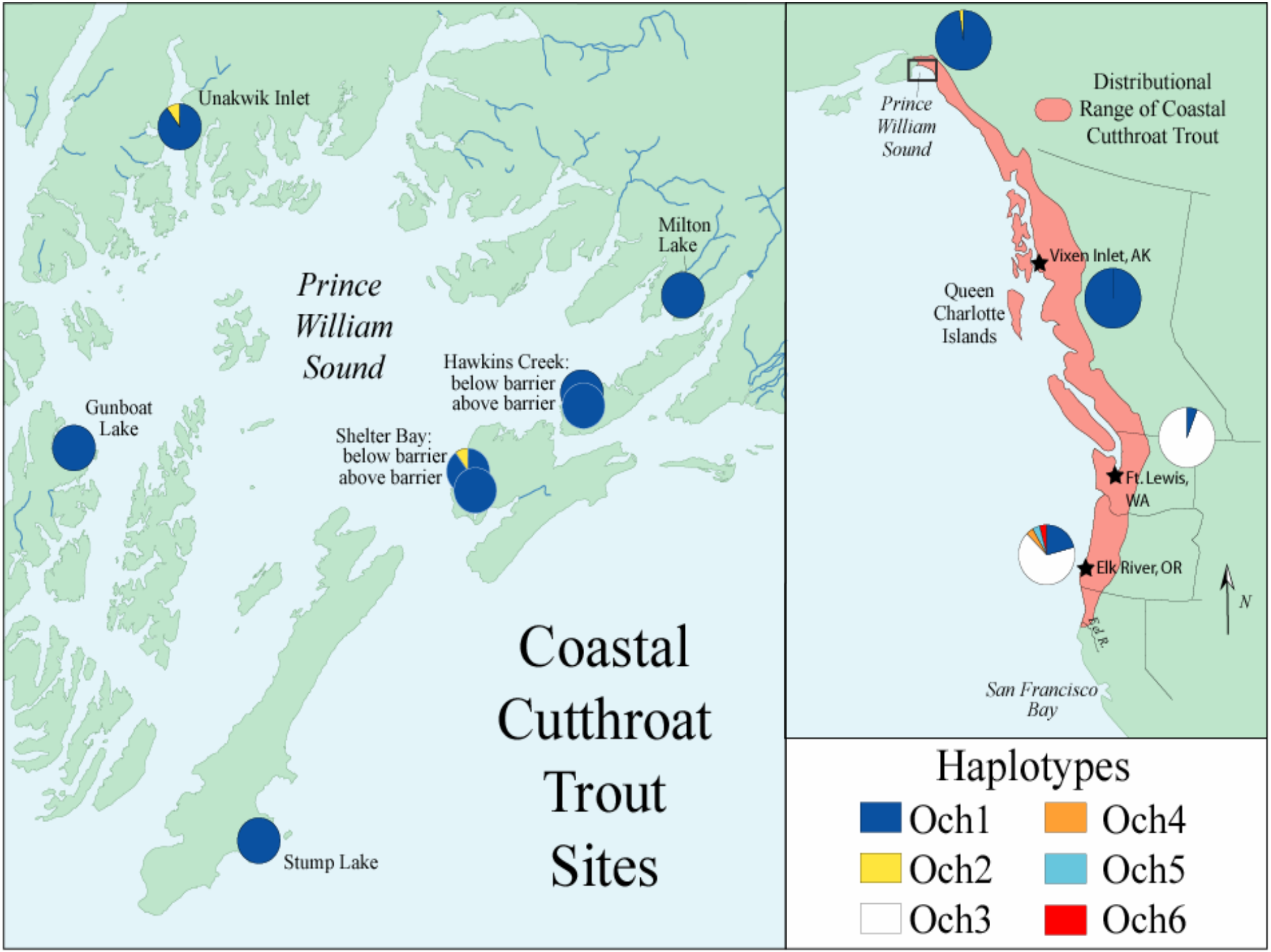


MtDNA Results

ND-1
ND 5-6
D-Loop
(N=79)

16 RFLP's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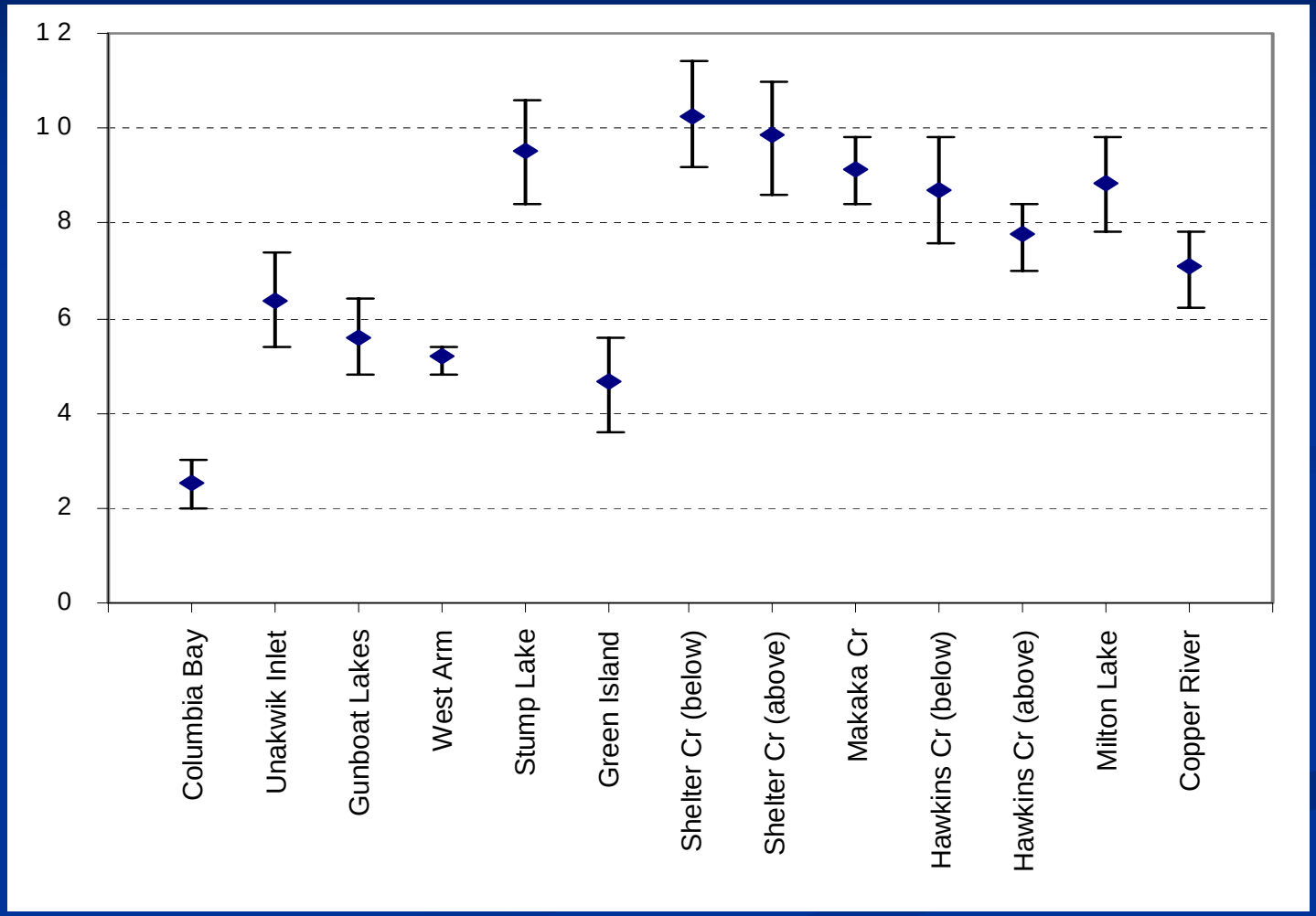
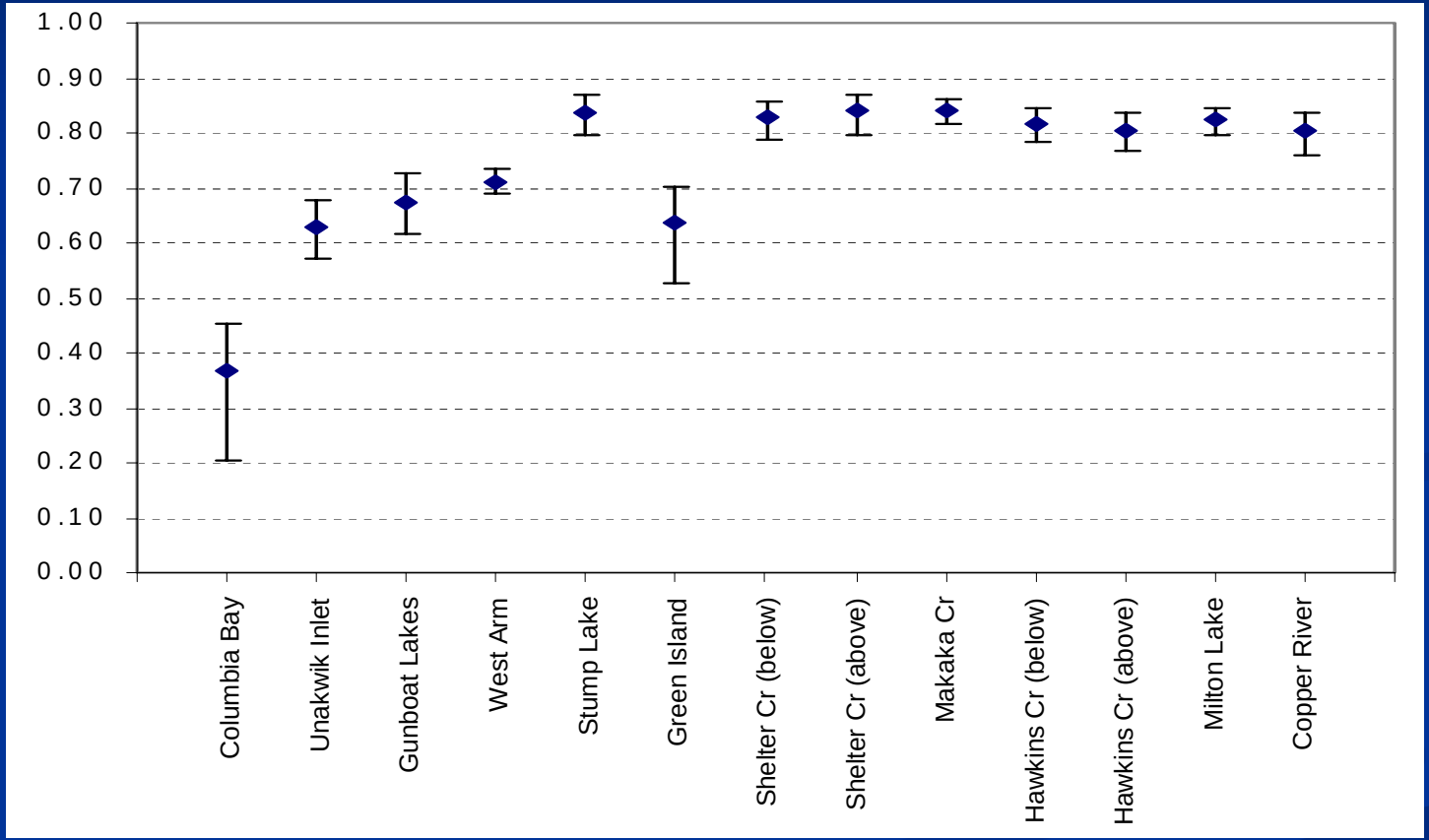
Milton Lake
Prince William Sound
Hawkins Creek:
below barrier
above barrier
Gunboat Lake
Shelter Bay:
below barrier
above barrier
Stump Lake
Coastal Cutthroat Trout Sites
Prince William Sound
Distributional Range of Coastal Cutthroat Trout
Vixen Inlet, AK
Queen Charlotte Islands
Ft. Lewis, WA
Elk River, OR
N
San Francisco Bay
Haplotypes
Och1
Och2
Och3
Och4
Och5
Och6

Within sample genetic variation Alleles/Locus

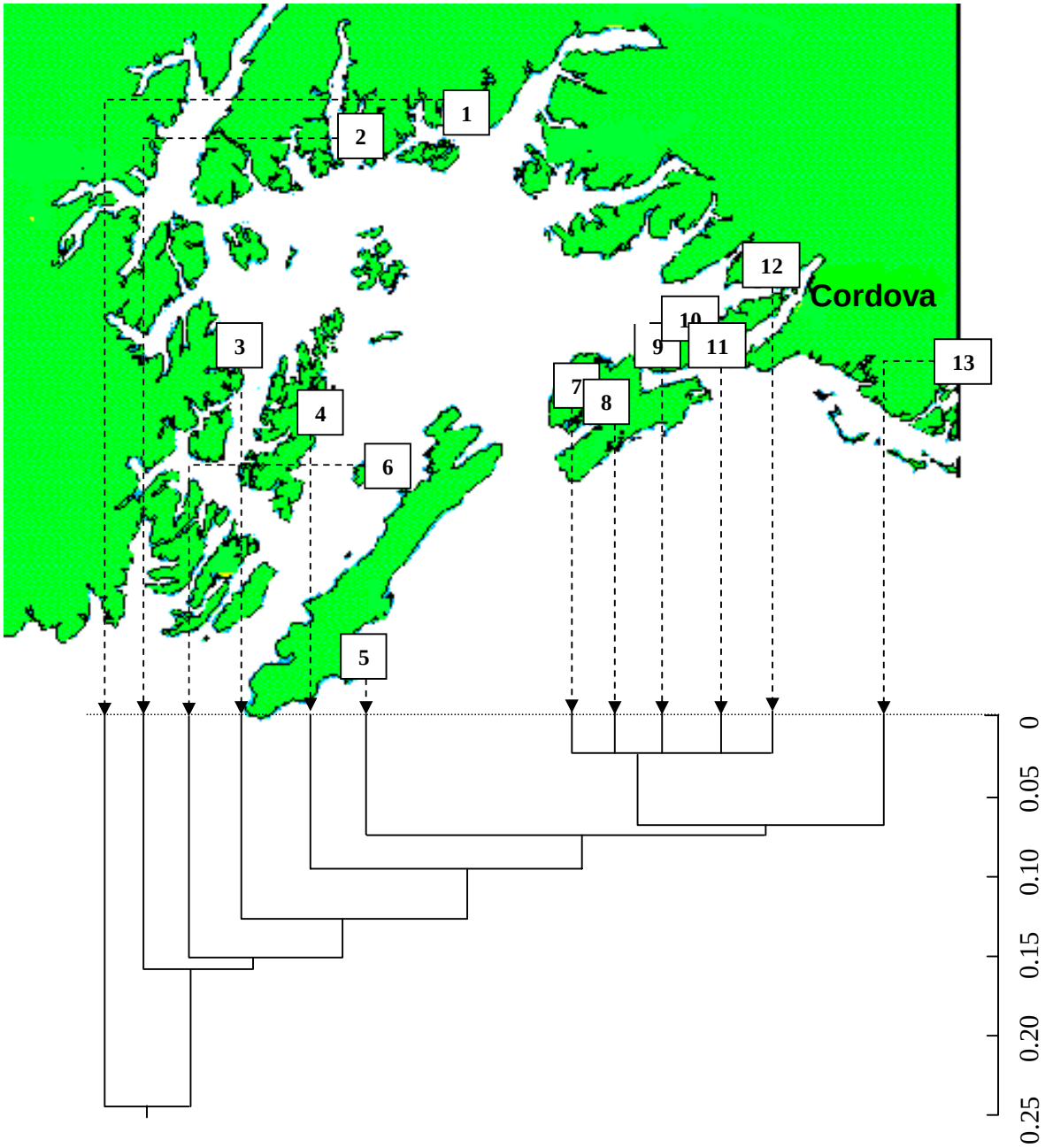


Within sample genetic variation average heterozygosity

He



Sampling location


1
2
3
4
5
6
7
8
9
10
11
12
13
Cordova
0.25
0.20
0.15
0.10
0.05
0

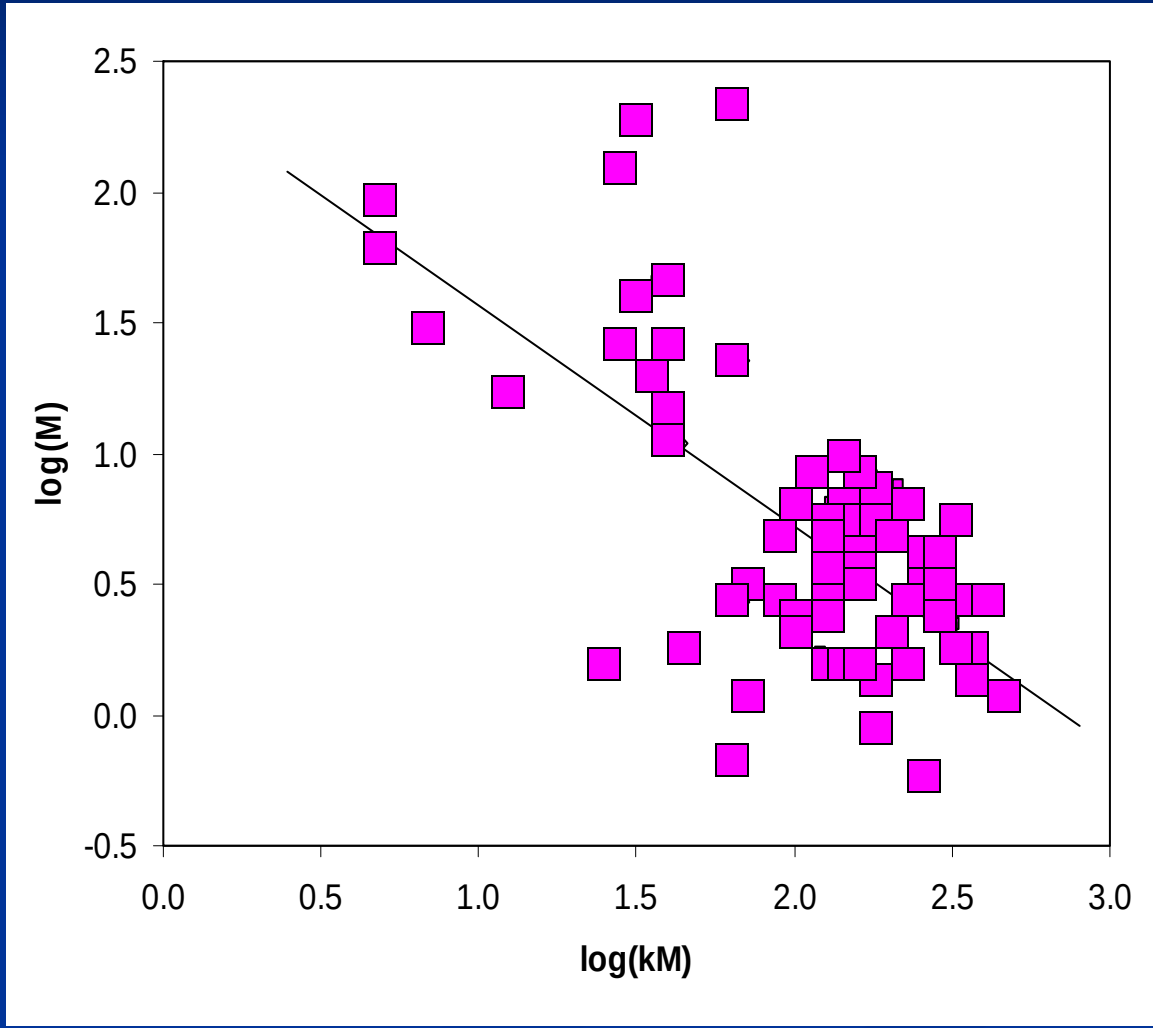
Models of IBD

- Post-glacial colonization route
- Shoreline migration route (5-10 km)
- Shortest distance between sites (open water)

Results IBD Mantel tests

- Post-glacial colonization route ($p<0.009$)
- Shoreline migration route (5-10 km open water) ($p=0.015$)
- Shortest distance between sites (open water) ($p>0.05$)

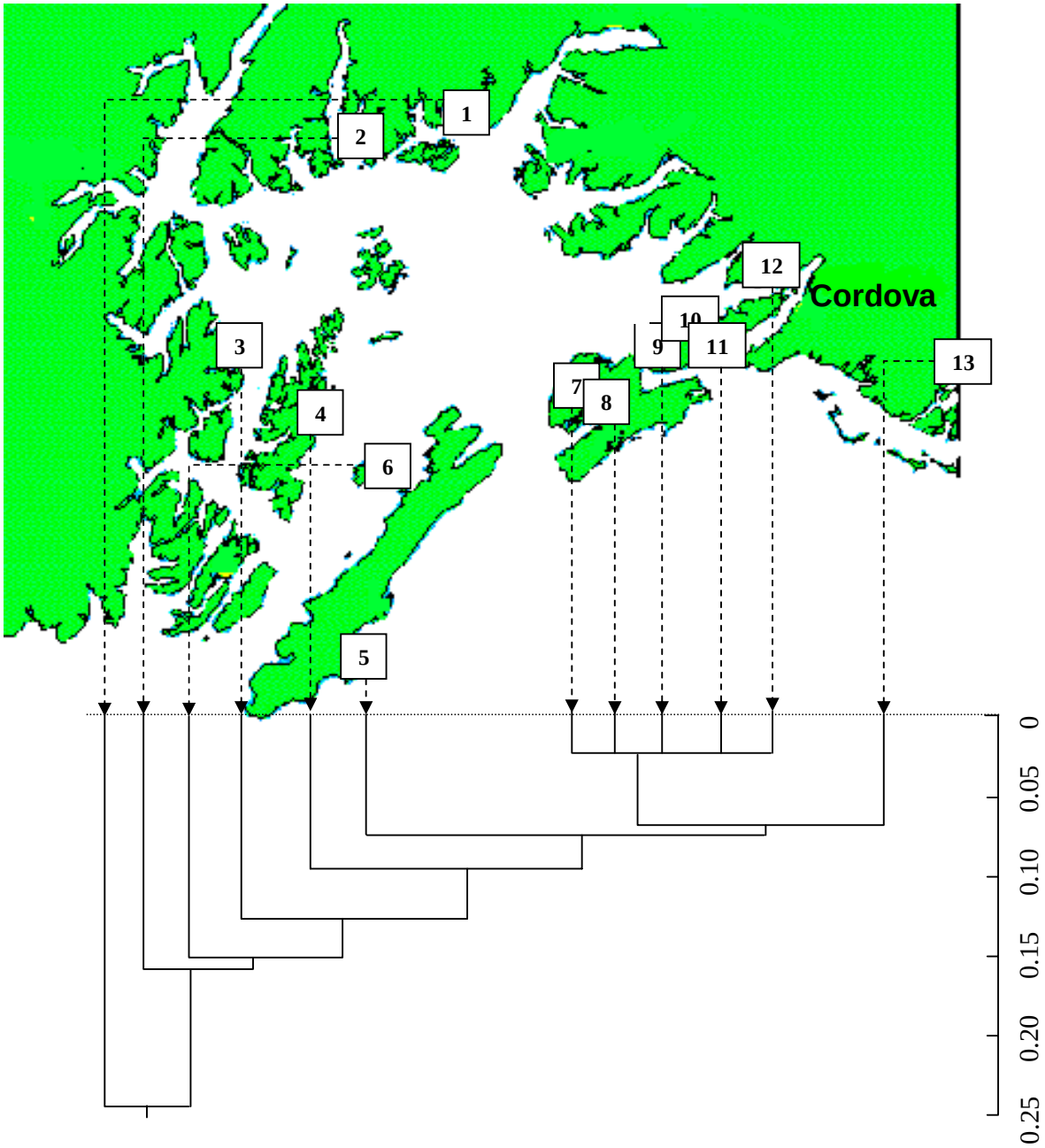
IBD slope



Slope= -0.836

Conclusions

- Geographic pattern of genetic variation
  - Northwest PWS sites significantly lower numbers of alleles and average heterozygosity
- Genetic distance appeared to be correlated to geographic distance
  - Support for IBD
  - East west dispersal following shorelines
- Above barrier sites unresolved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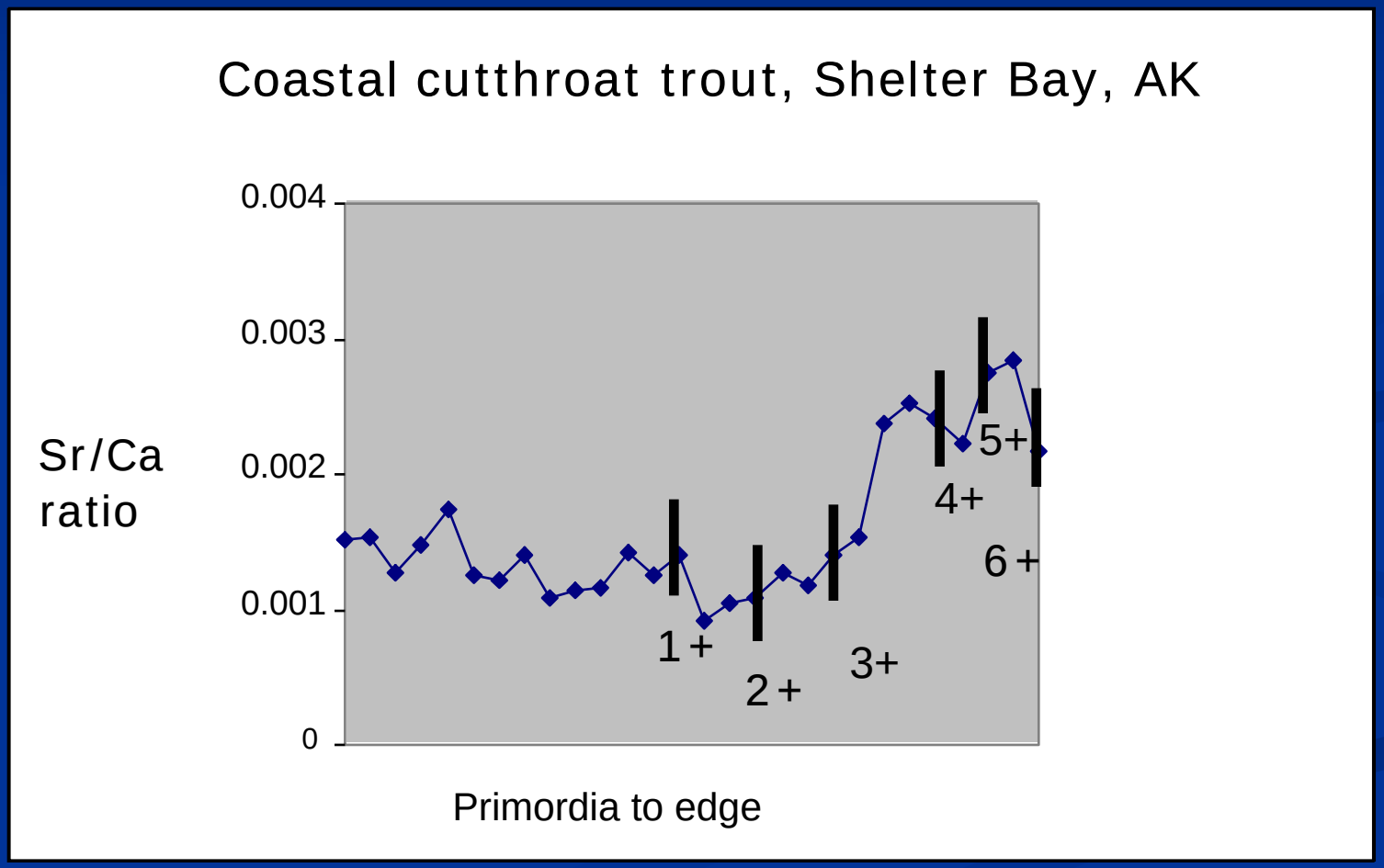
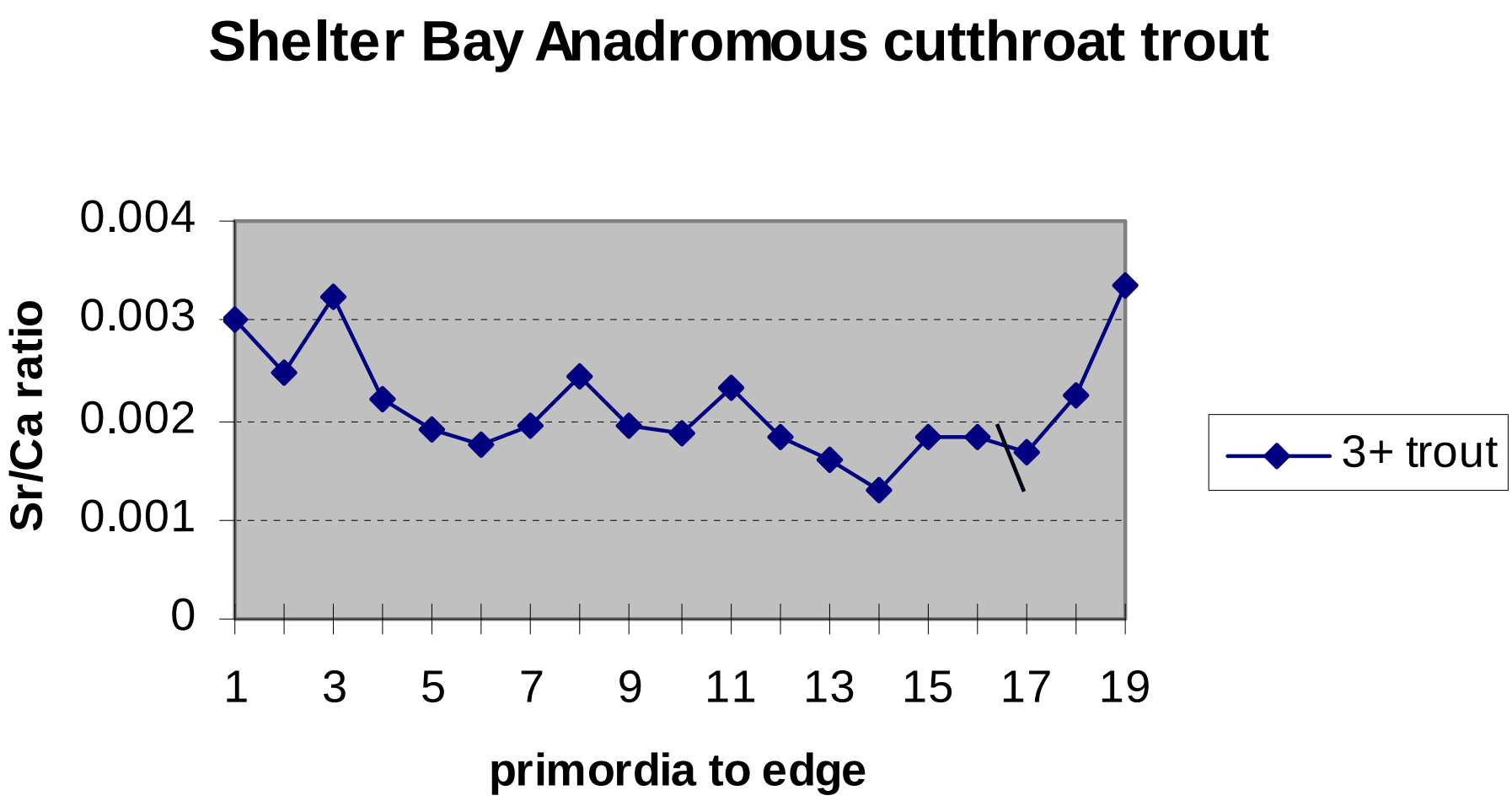
Otolith Microchemistry

Use elevated levels of Sr/Ca ratios in otoliths to infer entry to seawater

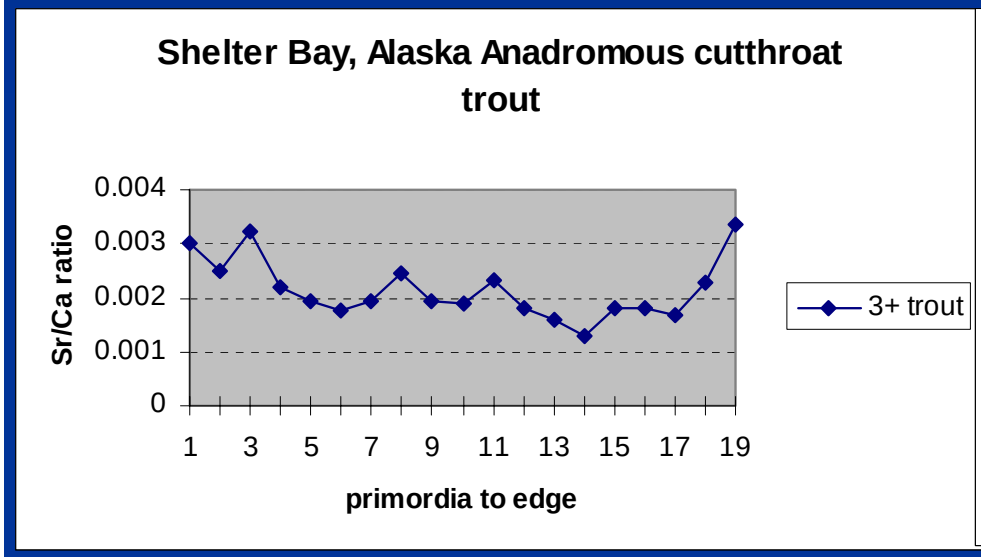
Otolith microchemistry

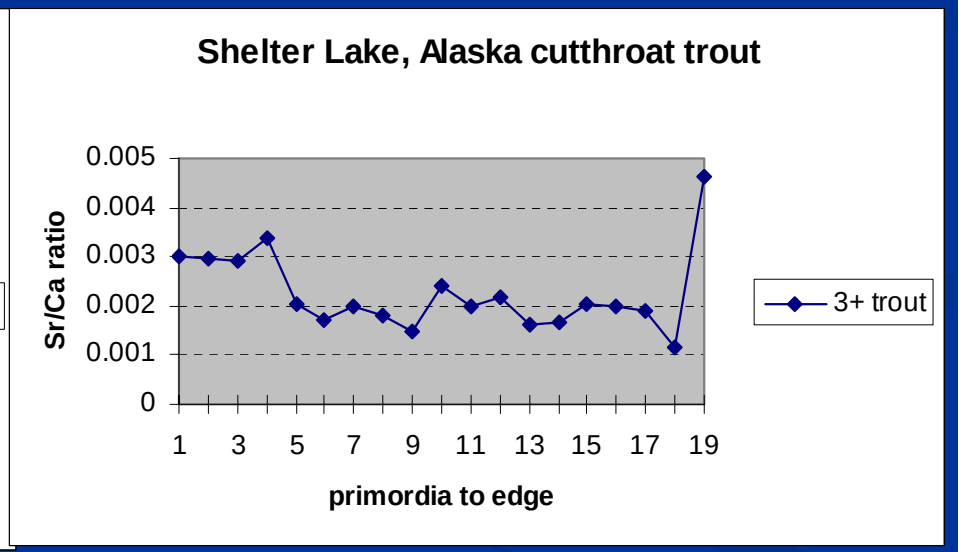


Otolith microchemistry



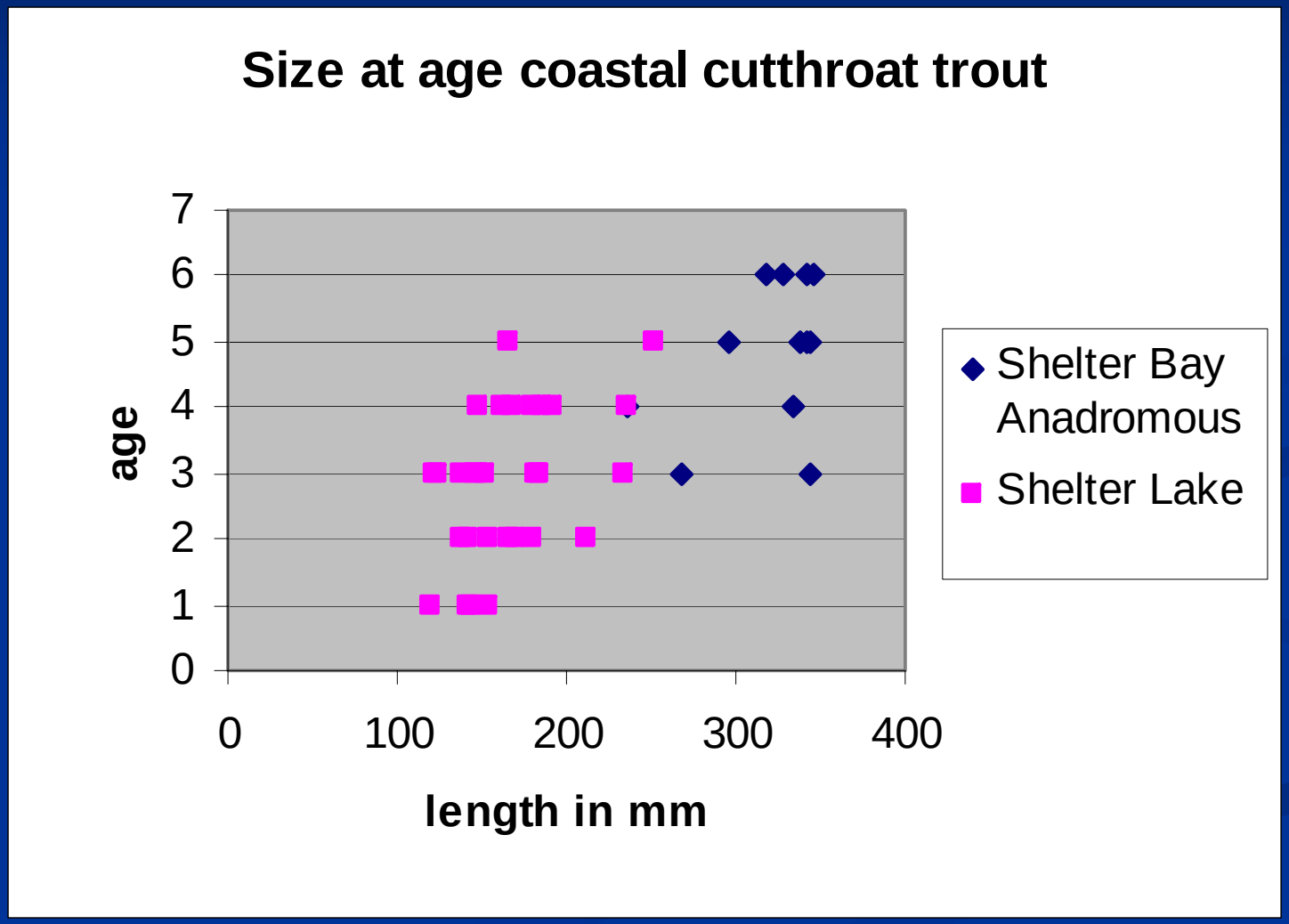
Primordia values of above and below barrier coastal cutthroat trout





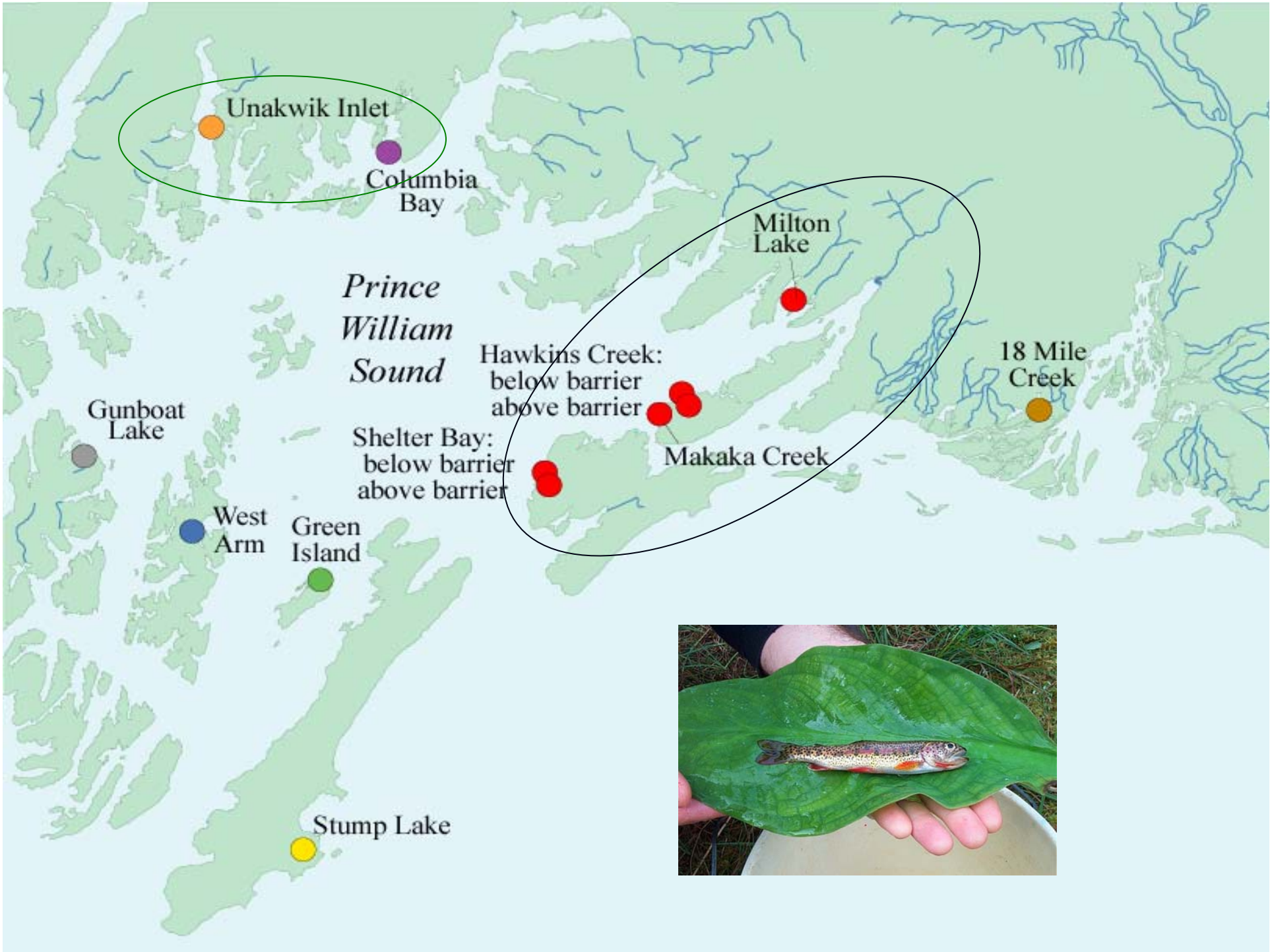
Primordia samples of above and below populations not significantly different ($p > 0.05$)

Size at age


Size at age coastal cutthroat trout
age
7
6
5
4
3
2
1
0
0
100
200
300
400
length in mm
Shelter Bay Anadromous
Shelter Lake

Bottom line

- Genetic tools useful for describing geographic variation in coastal cutthroat trout
- Scale the tool to the question
- Genetic tools used in combination with ecological measures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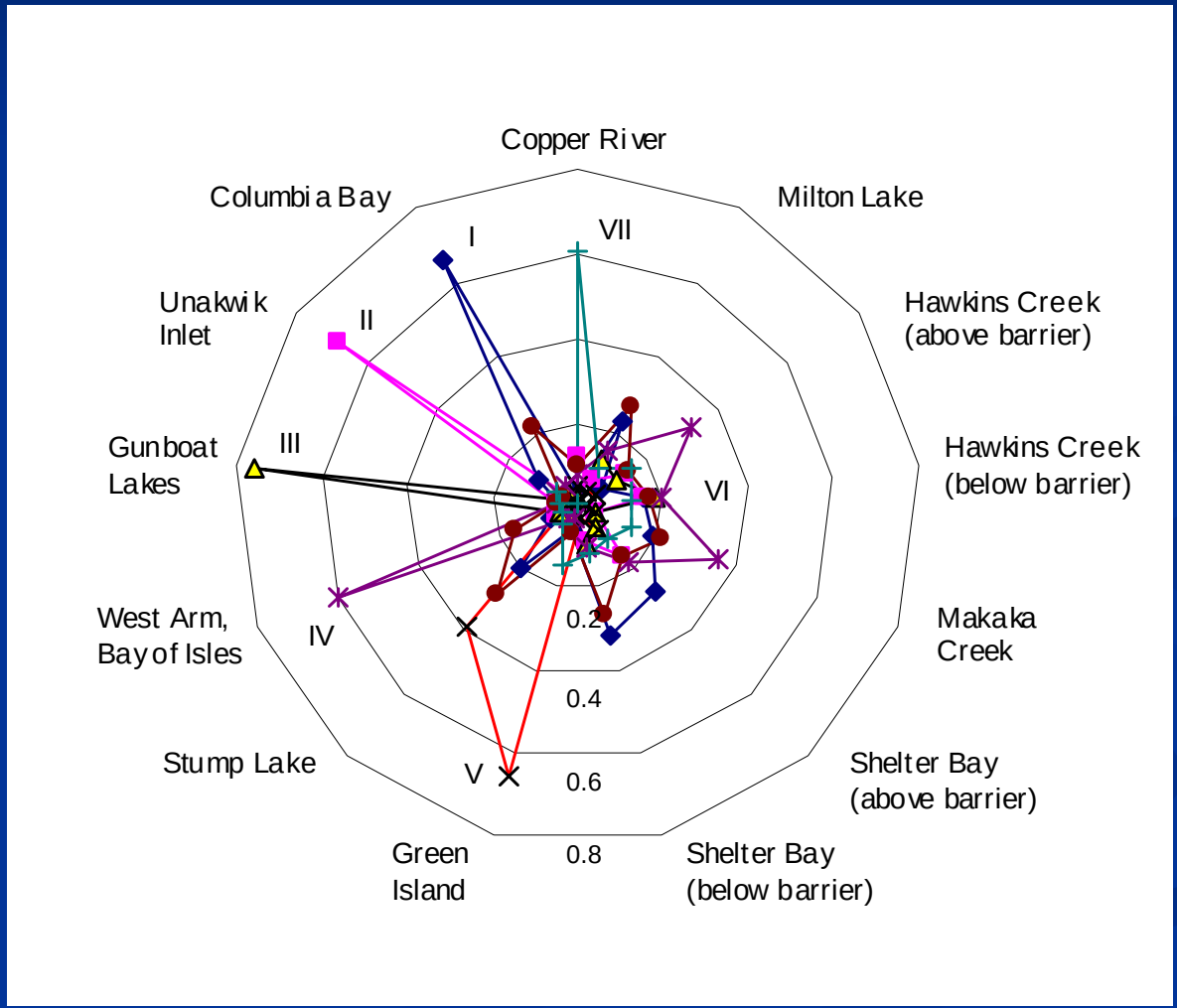
Bayesian Structure of Populations



(Pritchard et al. 2000)