Conservation implications of anadromous sea lamprey population structure, status and evolutionary history

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Why is population genetics useful in conservation?

- Population structure - identifying management units
- Evolutionary trajectory – identifying & understanding demographic processes
- Effective population size (Ne) – assessing population status, identifying priority areas for conservation

- Population genetics - planning for a more localized approach to sea lamprey conservation & addressing local conservation concerns
- Genetic diversity - adaptation & resilience

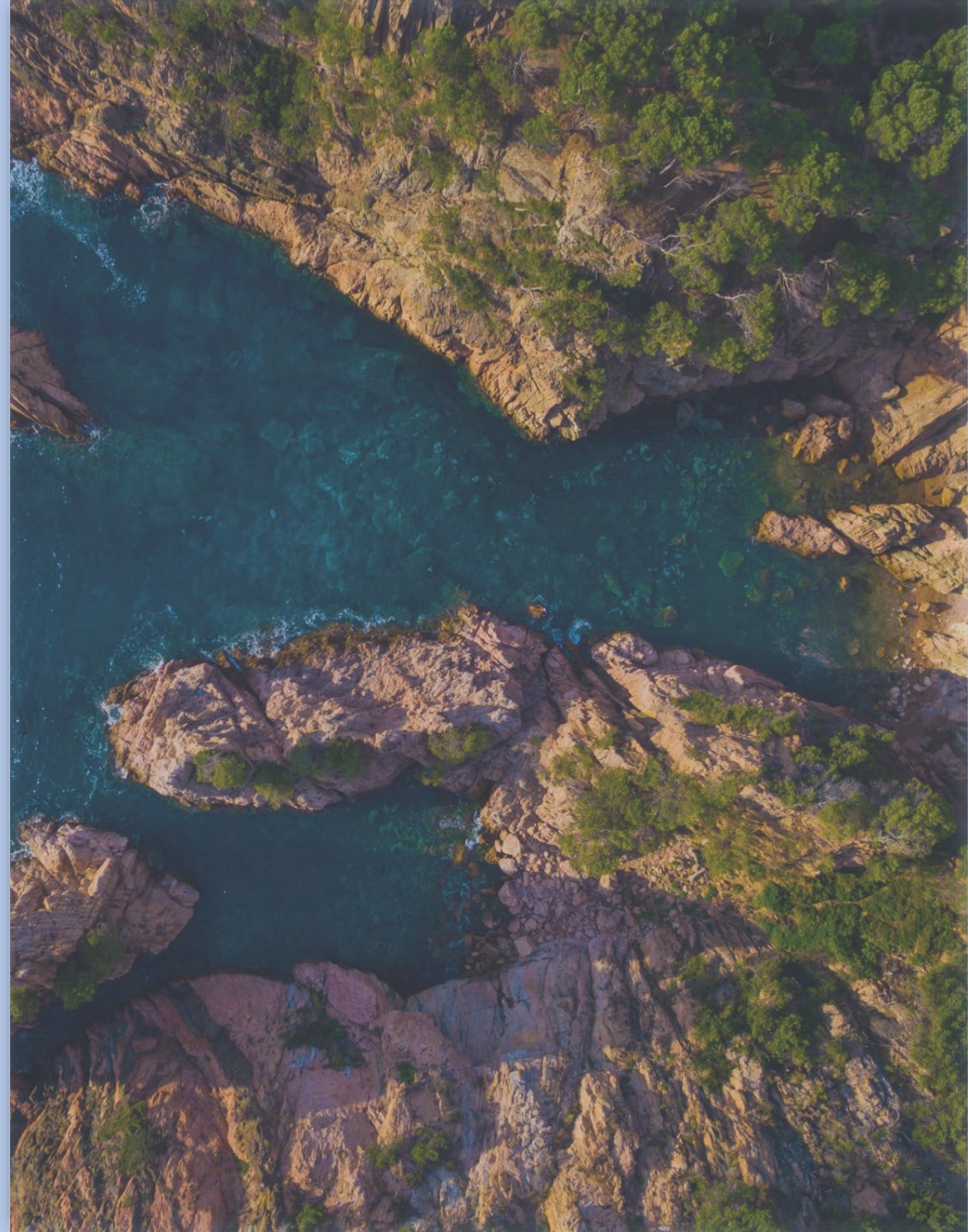
Literature to date

- Microsatellite & mitochondrial DNA markers - two genetically distinct East & West Atlantic sea lamprey populations [1,2,3]
- Microsatellite & mitochondrial DNA markers - No significant genetic structure found within either Atlantic coast [1,2,3,4,5,6]
- Whole genomes - geographically closer populations more genetically similar in the East Atlantic [9]

- Morphology and fatty acid signature analyses - evidence of distinct sea lamprey stocks in Portugal [7]
- Anadromous Pacific lamprey – geographically closer populations more genetically similar [8] and transoceanic movement [9]
- Existing literature – limited sampling sites, only one whole genome study focusing on East Atlantic

Objectives

- Detecting population structure and gene flow within and between East, West Atlantic coasts & Mediterranean Sea
- Account for contemporary effective population size
- Reconstruct recent evolutionary history
- Inform management & conservation planning



Materials & Methods


West Atlantic –
40 Individuals
East Atlantic –
109 Individuals
Sweden
Germany
Iceland
Ireland
France -
Atlantic
France - Mediterranean
New Brunswick
Massachusetts
Maryland
N. Carolina
Portugal
Mediterranean Sea –
6 Individuals

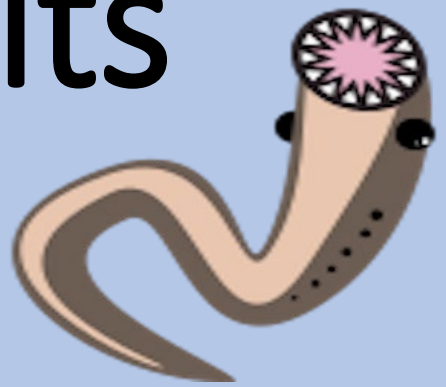
Sequencing

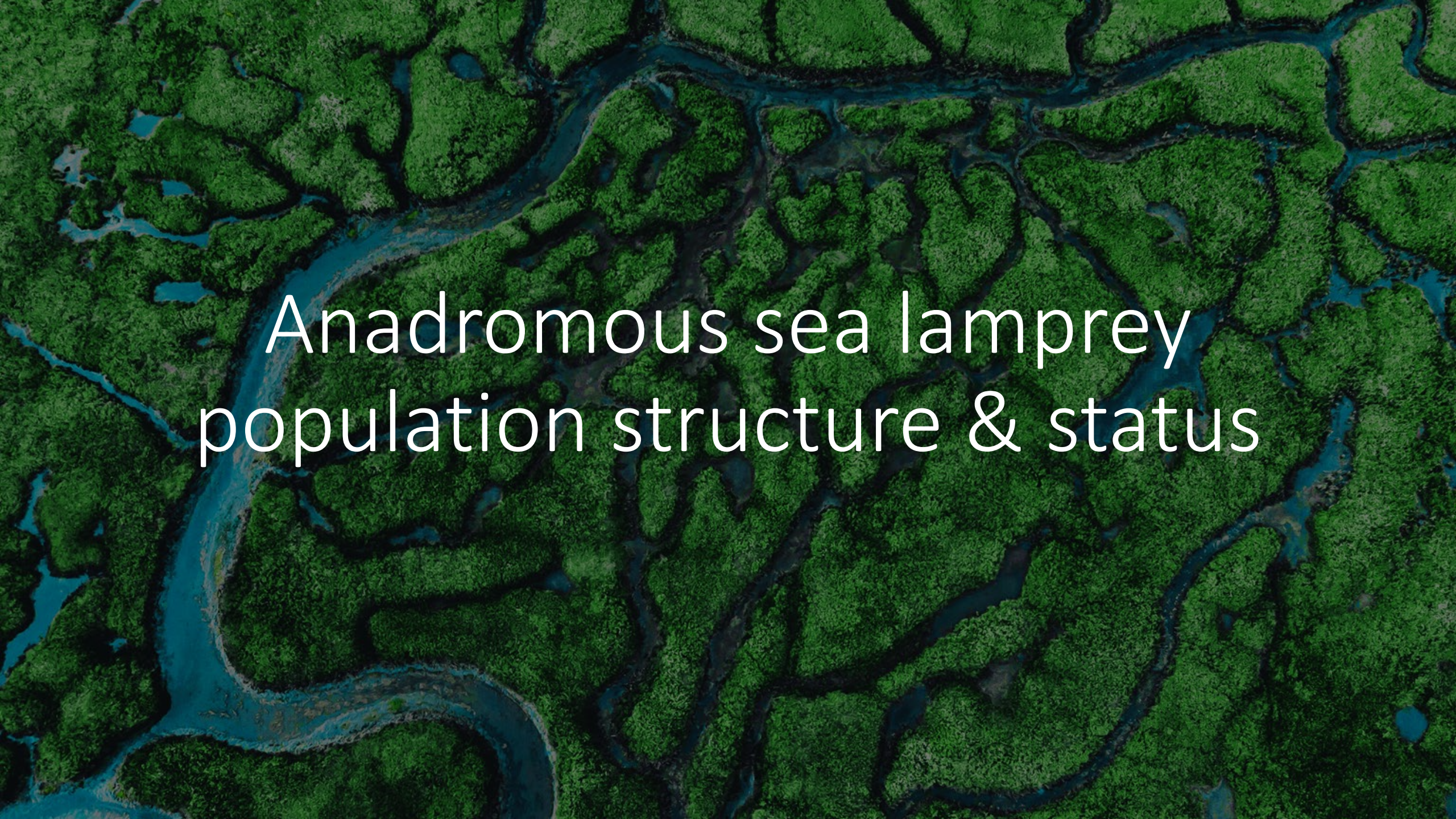
Whole-genome sequencing of ~ 8x read depth

Sea lamprey germline assembly [10] used as mapping reference

10,658,258 are SNPs variants

Results





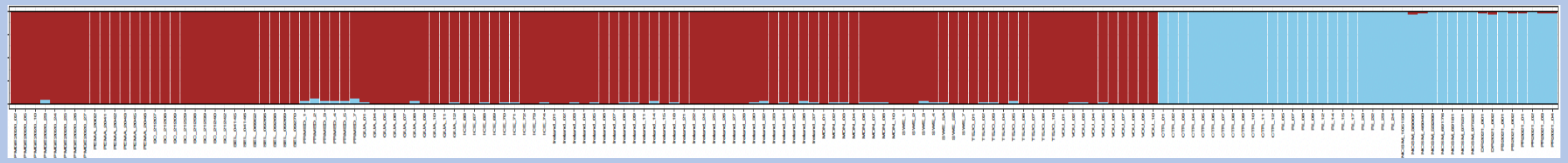
Anadromous sea lamprey population structure & status

Population structure: Entire Distribution Range

East Atlantic & Mediterranean

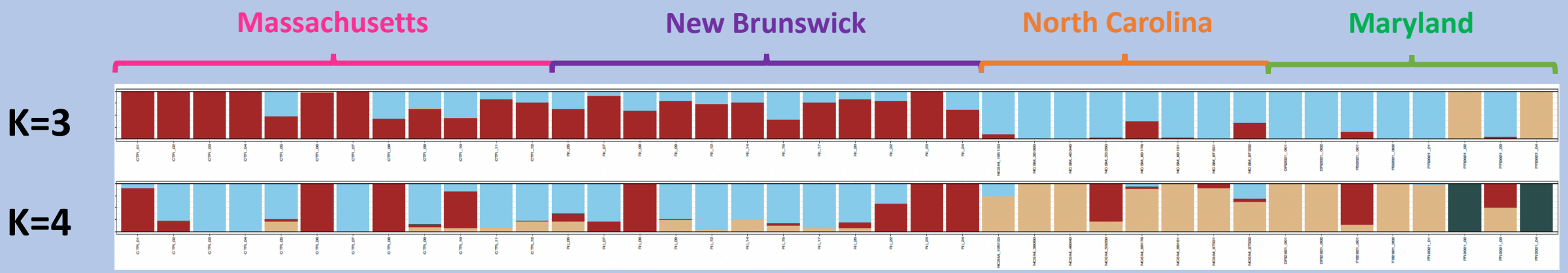
West Atlantic

K=2



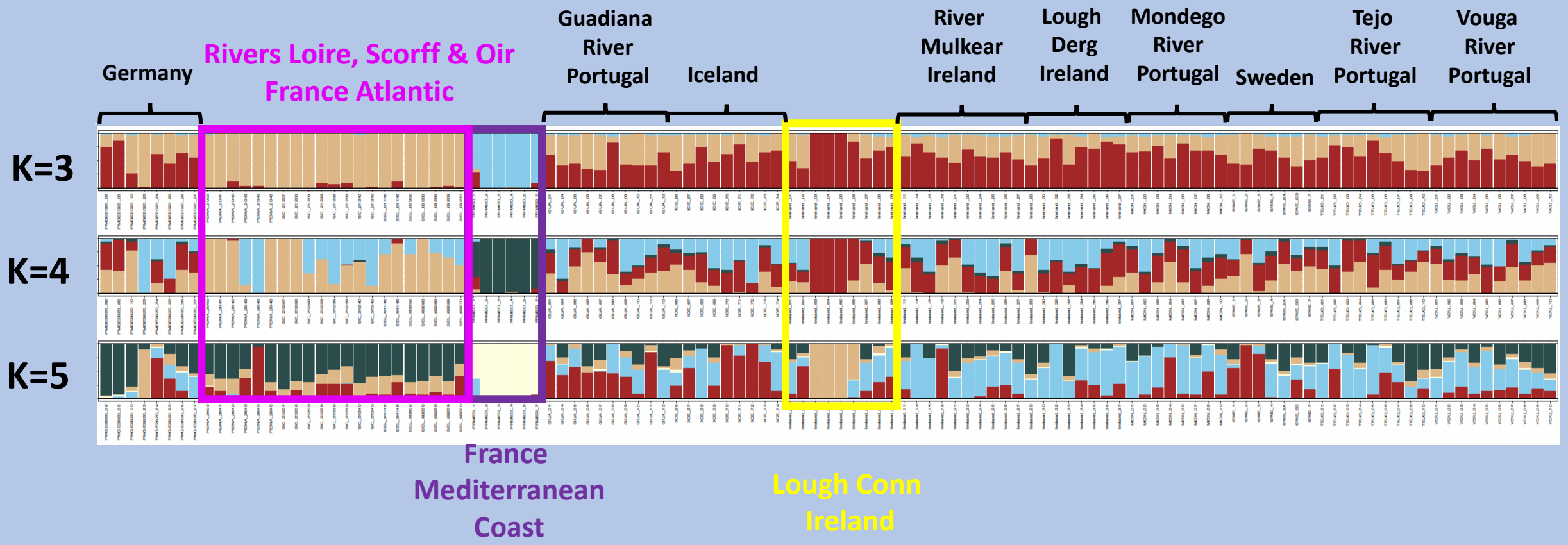
Analysis: snmf in LEA [11]

Population structure: West Atlantic coast



Analysis: snmf in LEA [11]

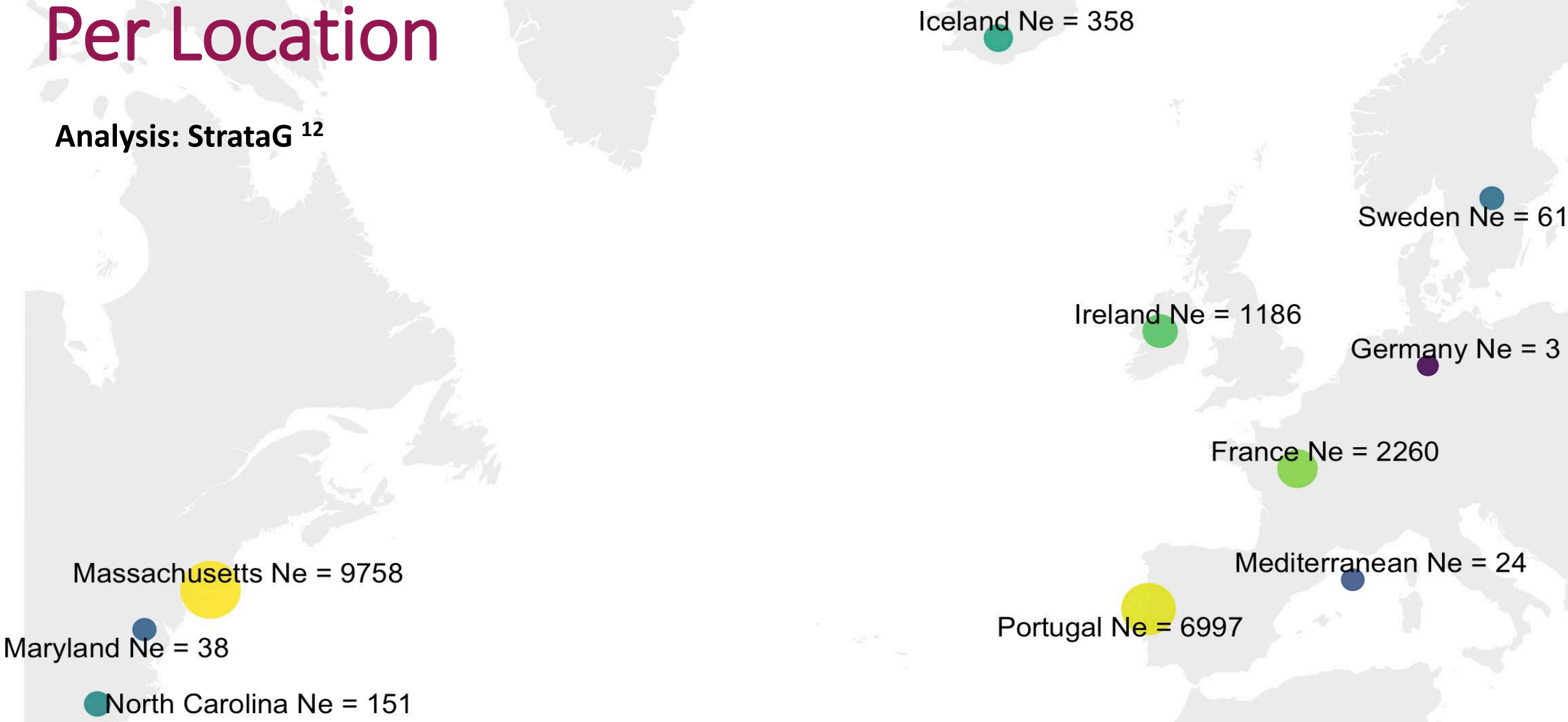
Population structure: East Atlantic coast & Mediterranean sea



Analysis: snmf in LEA [11]

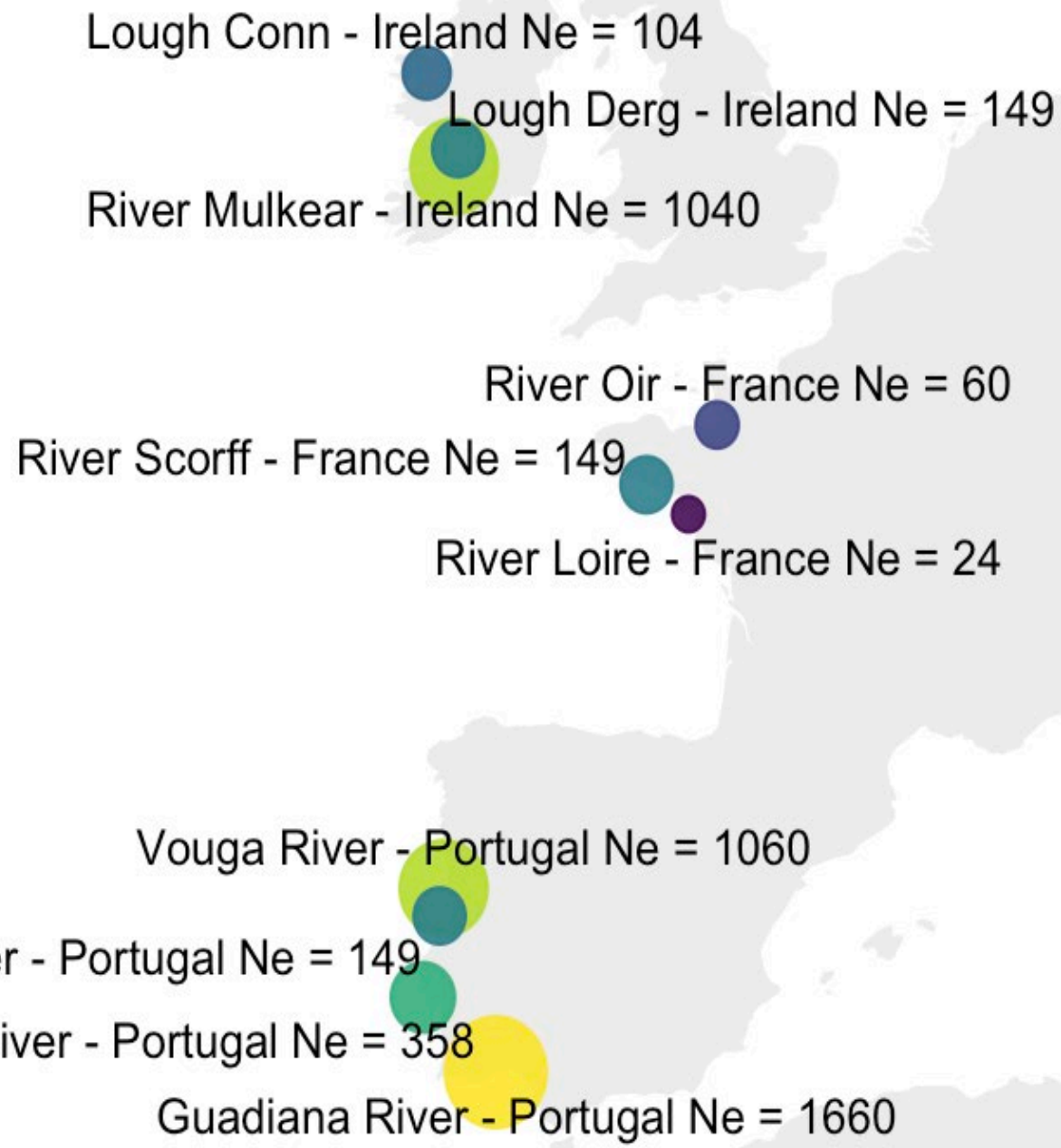
Contemporary Ne Per Location

Analysis: StrataG [12]



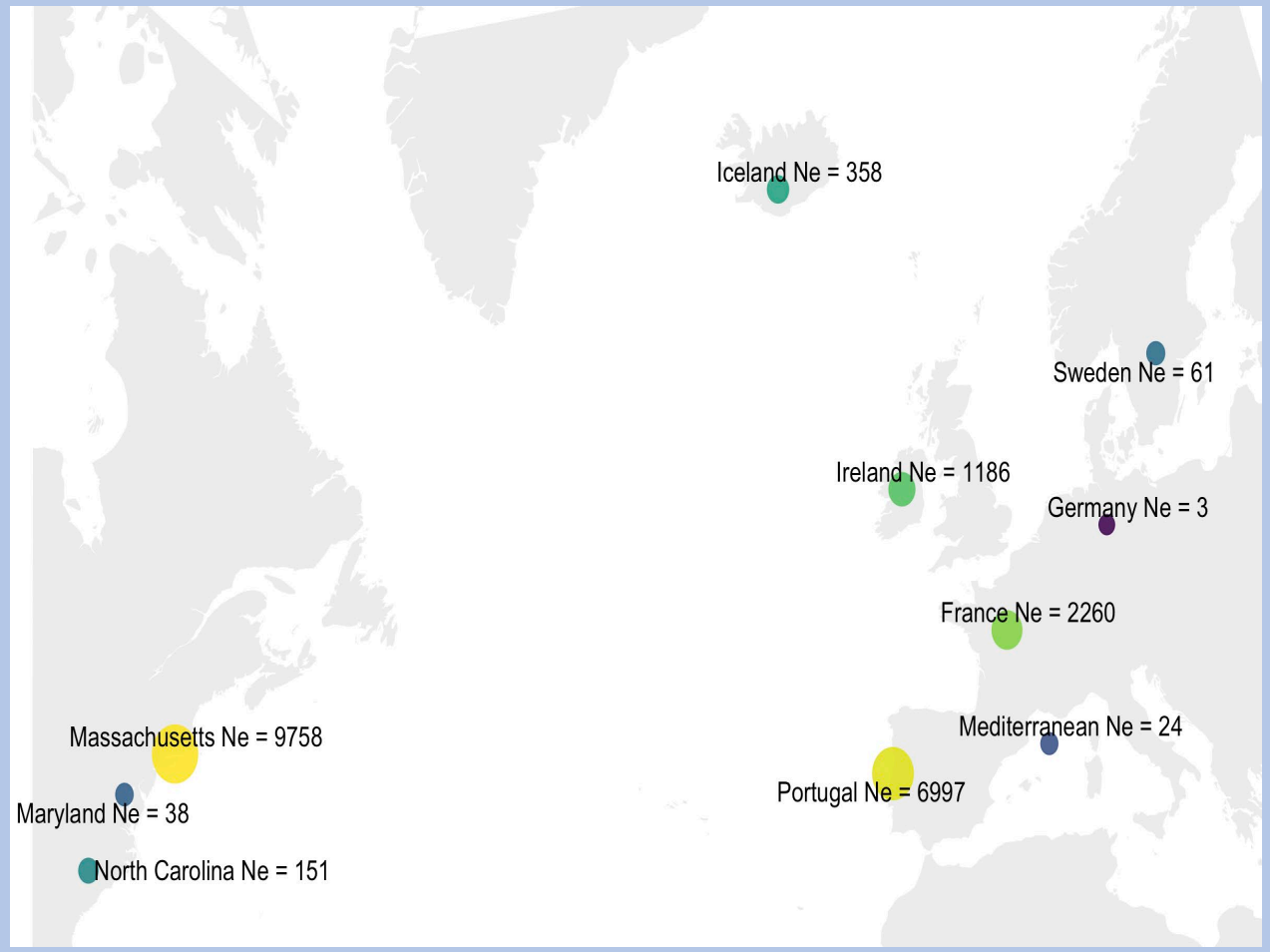
Contemporary Ne Within Locations

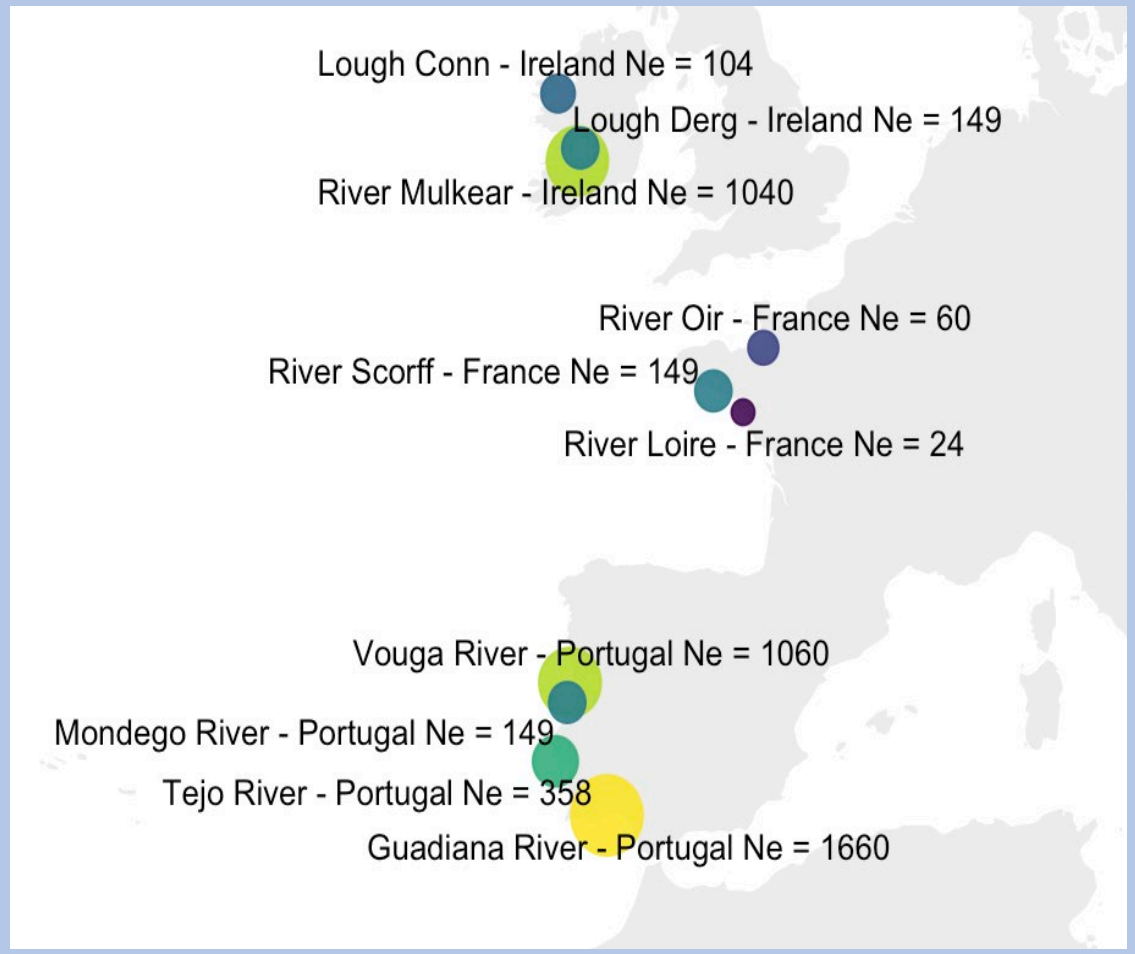
Analysis: StrataG [12]



Conservation implications

- West & East Atlantic – distinct management units
- Conservation of Mediterranean population – extinct on French coast but known spawning population exists in Italy. Further research needed
- Knowledge on population structure – advising potential restocking efforts
- Irish individuals observed feeding in fresh water are genetically distinct – invasive potential as new habitat becomes available due to climate change driven range shifts

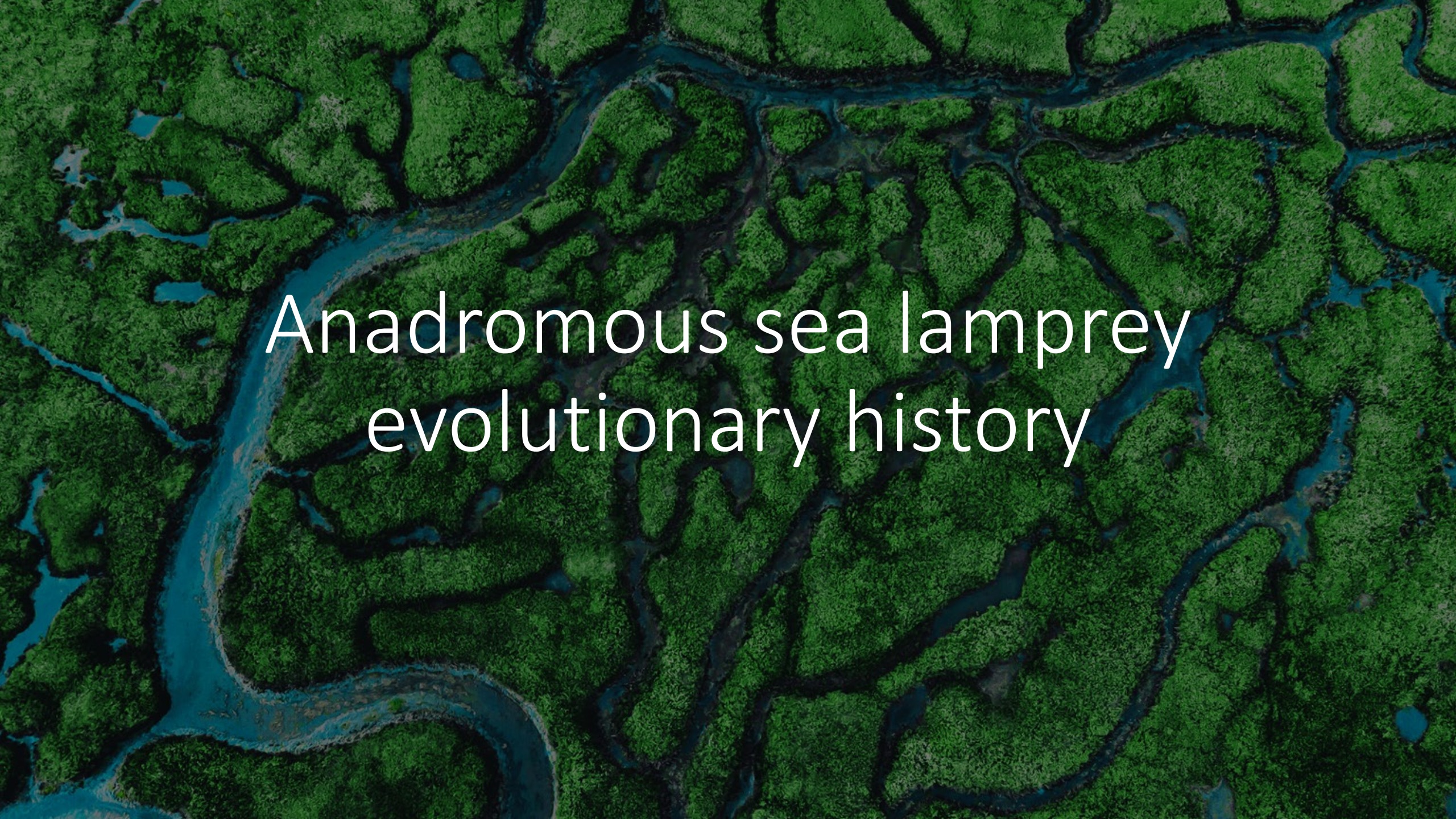




Vulnerability predictions:

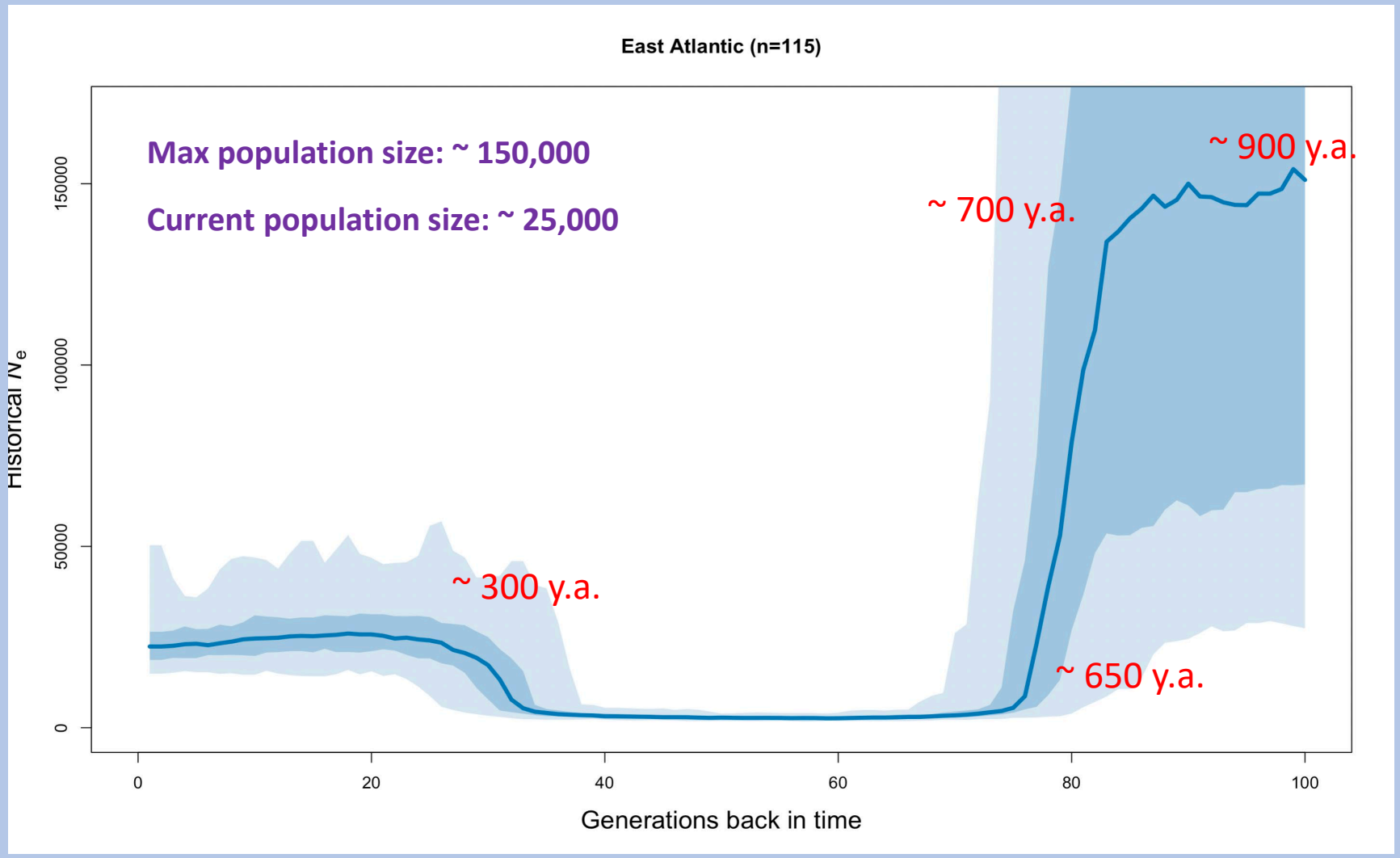
Ne prior to local extinction estimated at ~24 individuals in the Mediterranean

Kunming-Montreal Global Biodiversity Framework: Ne > 500 threshold


Anadromous sea lamprey
evolutionary history

Analysis: GONE[13]

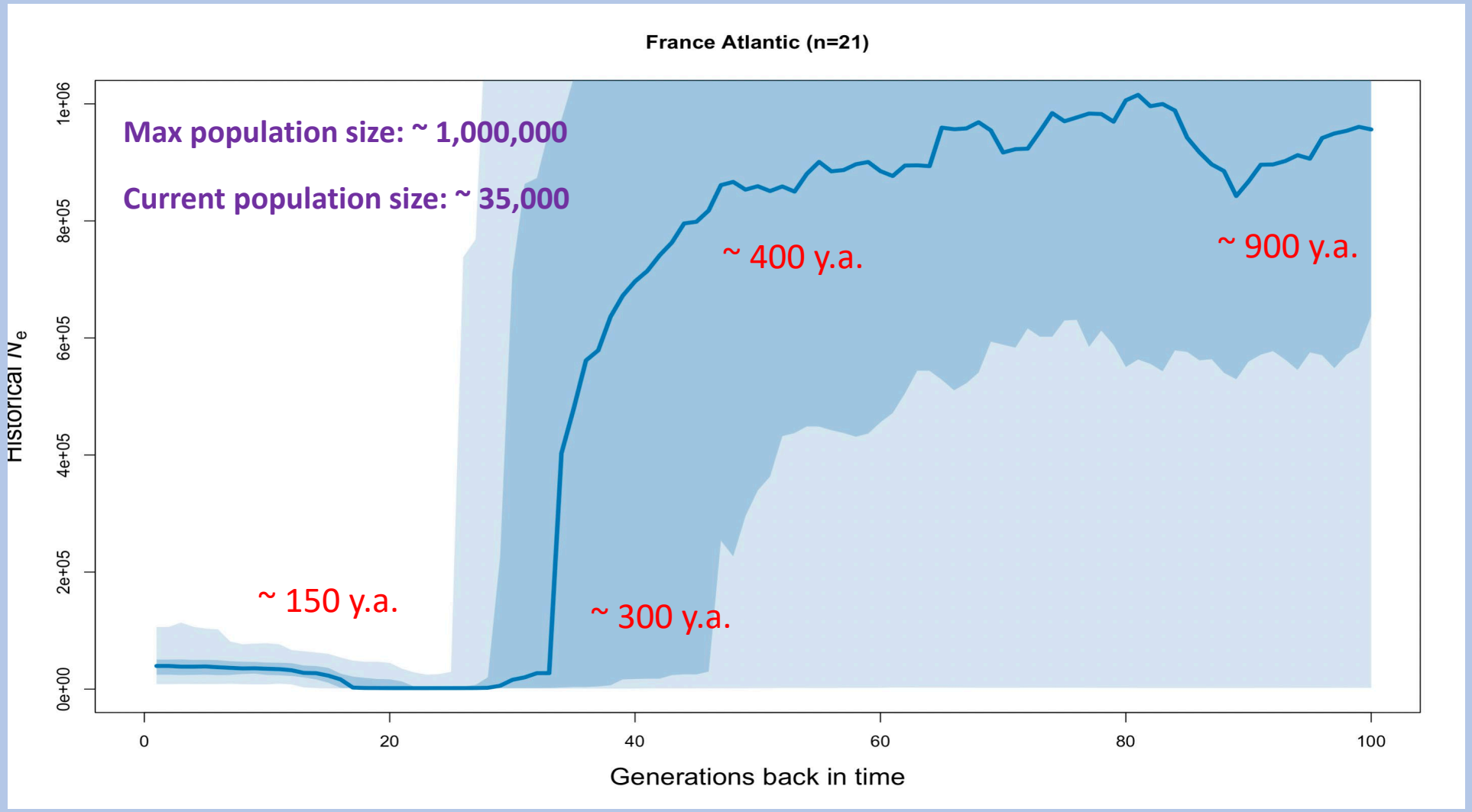
Recent evolutionary history - East Atlantic



Effective Population Size

Analysis: GONE[13]

Recent evolutionary history - France

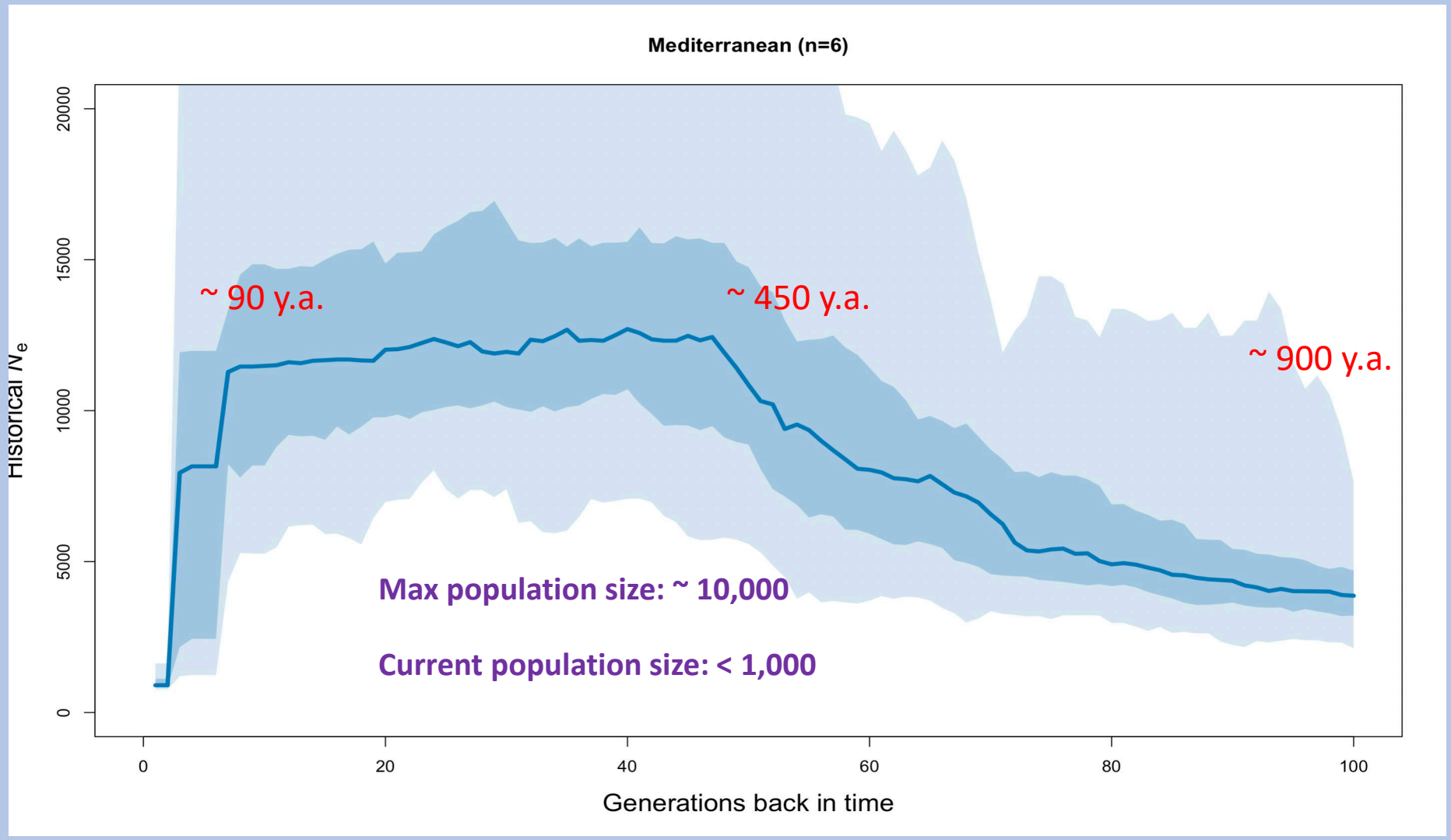


Effective Population Size

Analysis: GONE[13]

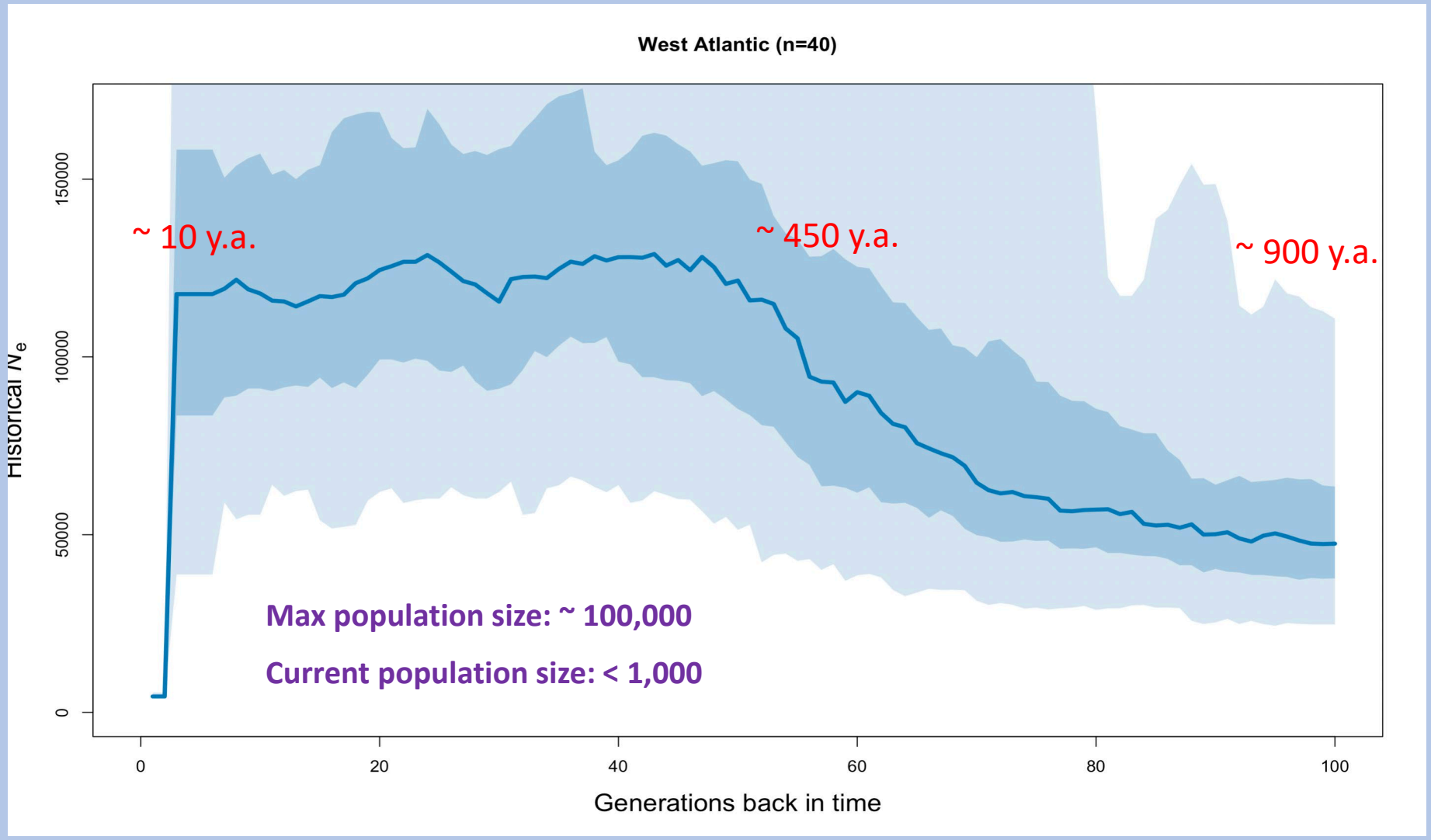
Recent evolutionary history - Mediterranean

Effective Population Size



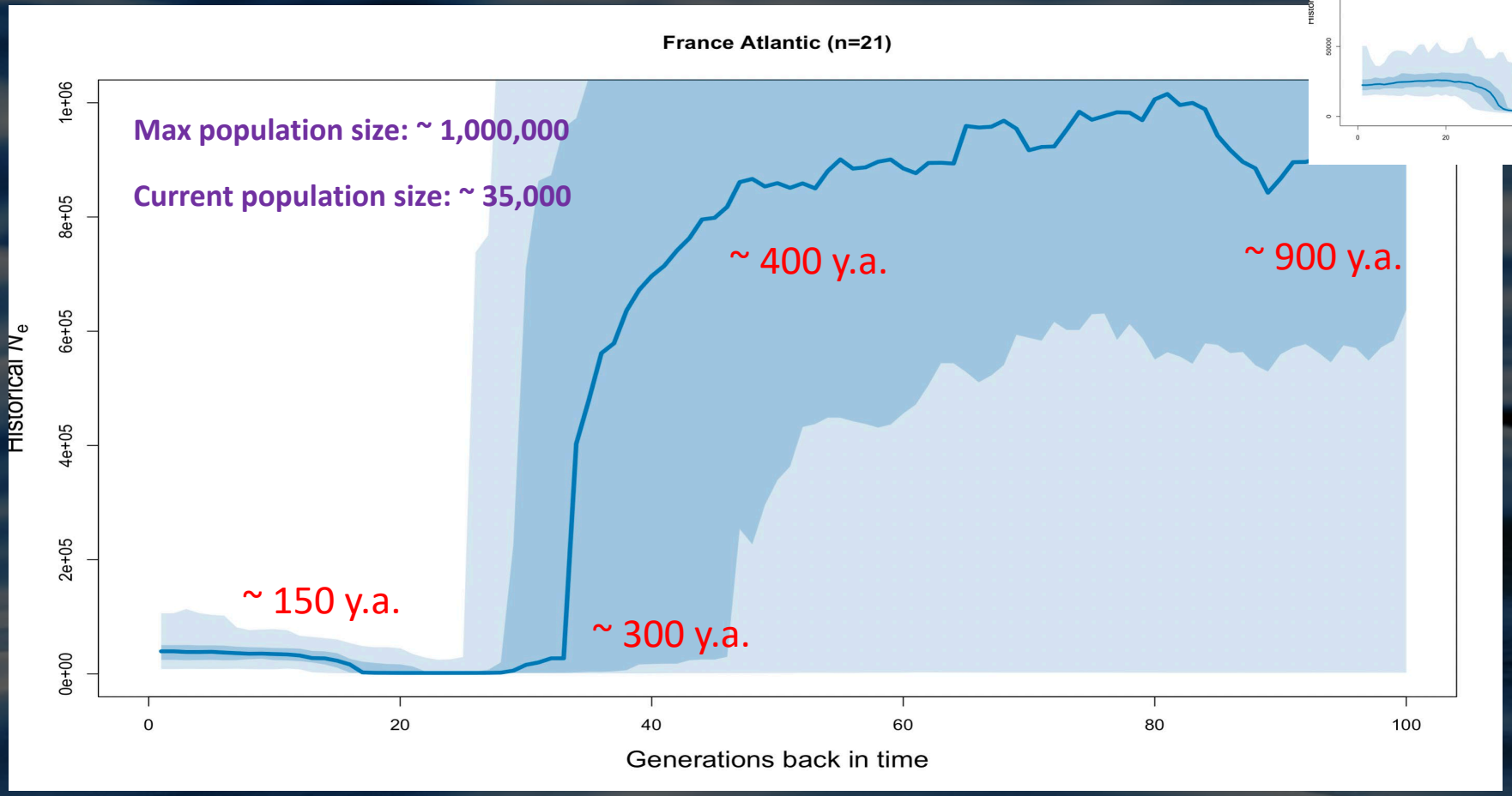
Analysis: GONE[13]

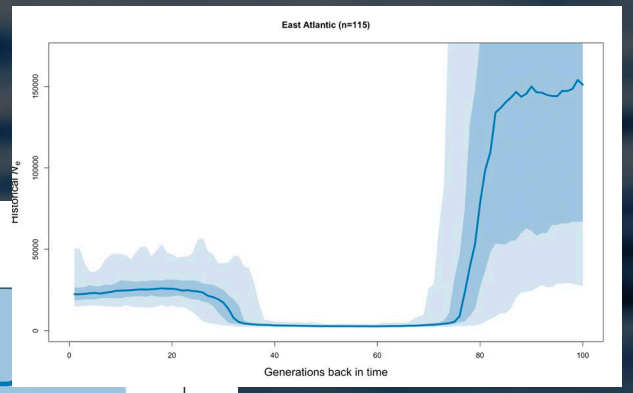
Recent evolutionary history - West Atlantic



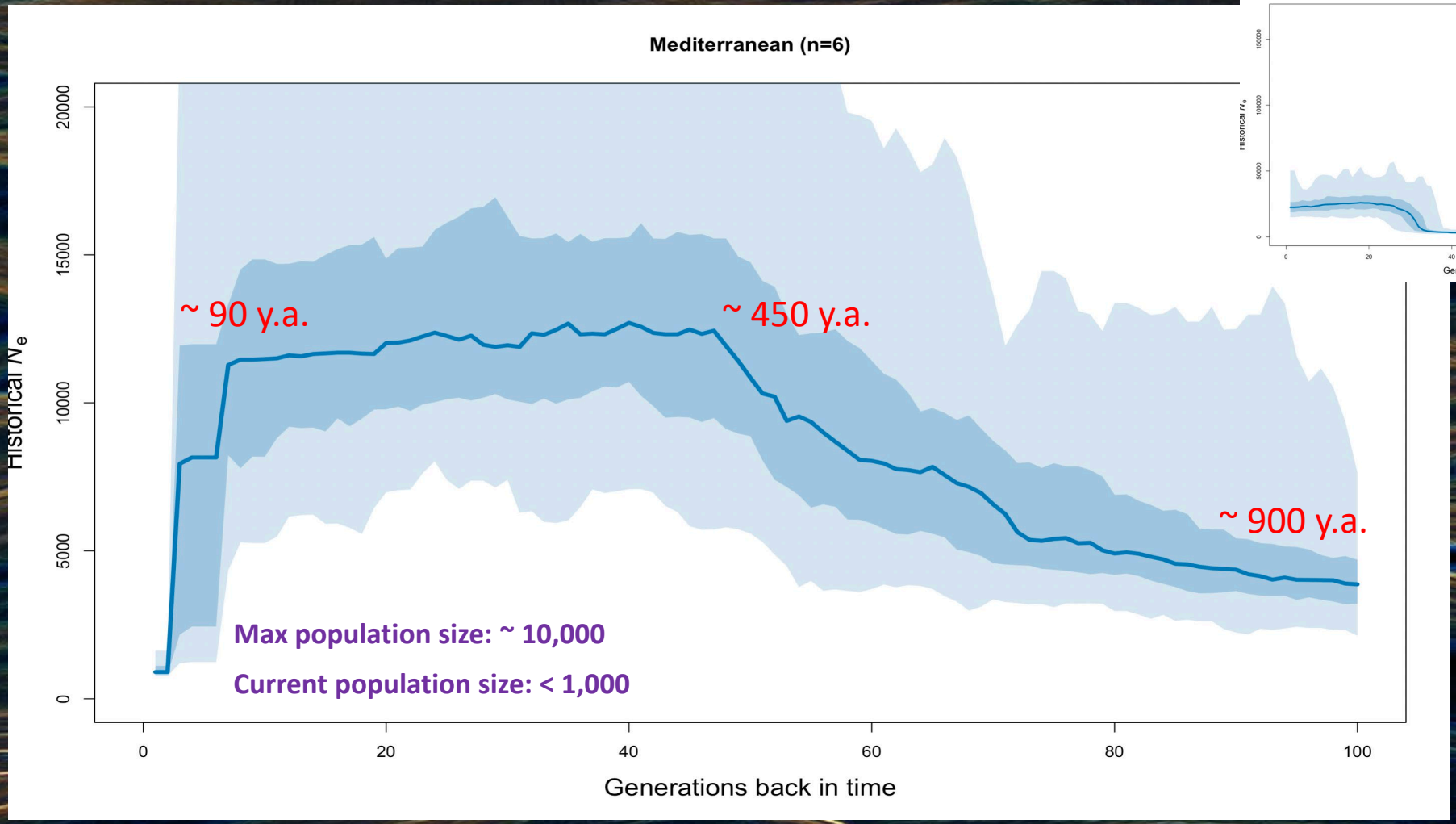
Effective Population Size

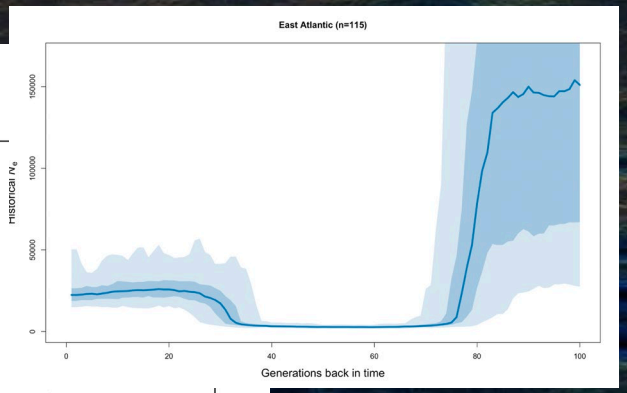
Conservation implications





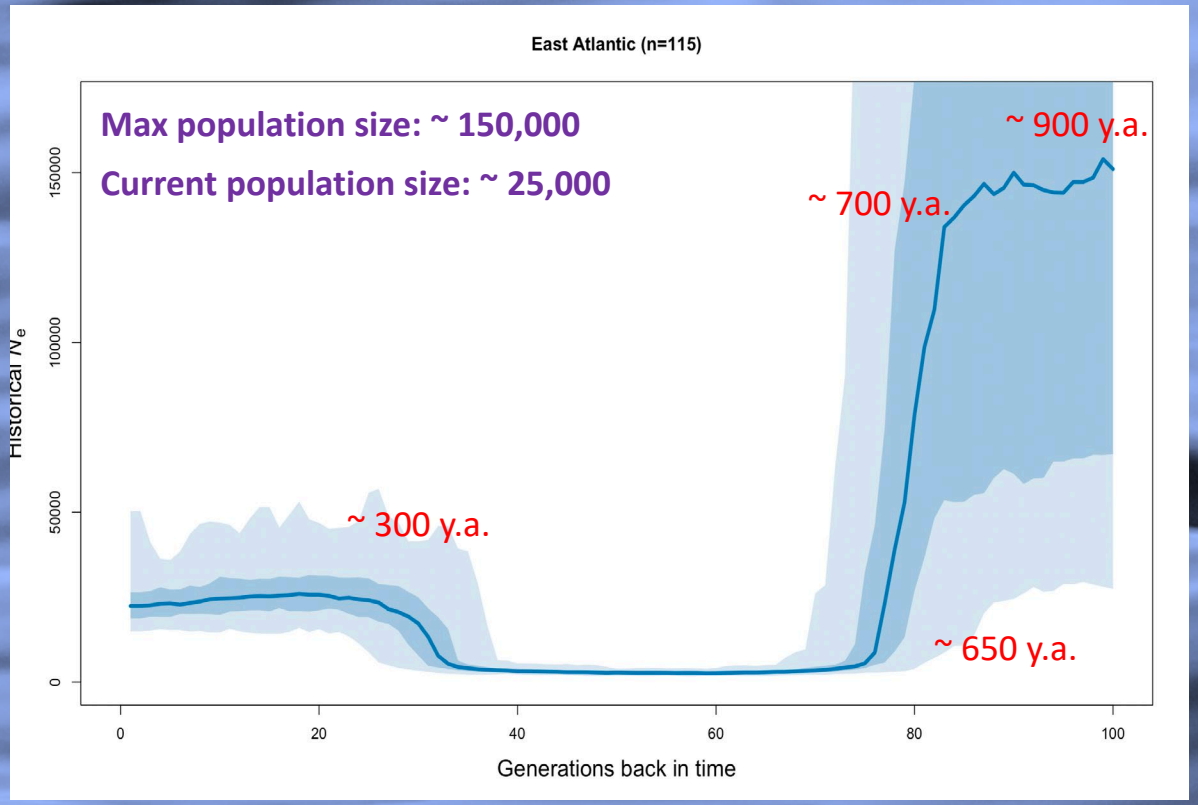
Sea lamprey in France share similar evolutionary history with the rest of the East Atlantic. Despite being genetically different they can not be considered a distinct population.

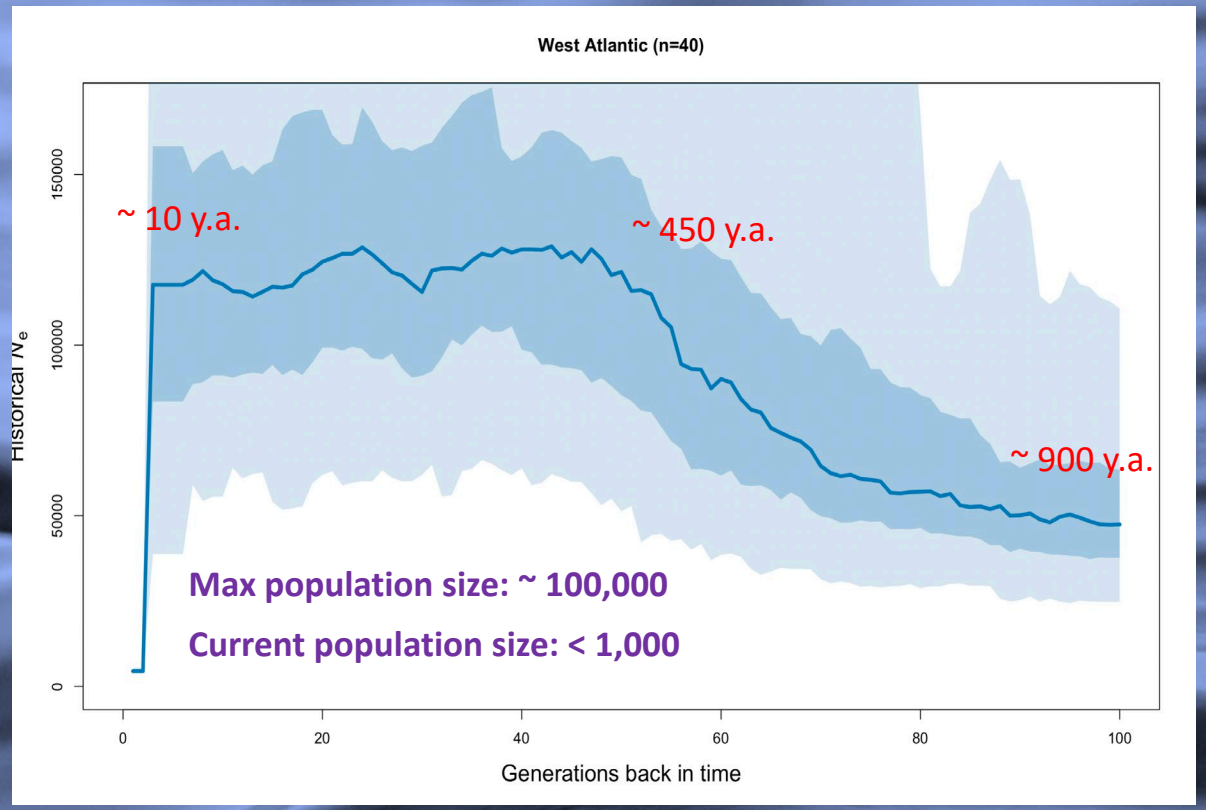




The Mediterranean displays a different recent evolutionary path, supporting that it is a distinct population. Despite undergoing an expansion in the past it has declined substantially in recent years. It has always been the smaller population.

(East Atlantic max population size ~ 150,000 & West Atlantic max population size ~ 100,000)





Over the last ~ 900 years, sea lamprey in the East Atlantic have declined substantially, but have shown signs of recent recovery.

Over the last ~ 900 years, sea lamprey in the West Atlantic have undergone a steady expansion, followed by a decline in recent times.

Future Research

Do anadromous sea lamprey display signs of selection and adaptation?

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Questions?