A molecular reinterpretation of the biodiversity of *Cottus* in western North America

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Dan Isaak, Sharon Parkes, and Michael Schwartz
U.S. Forest Service, Rocky Mountain Research Station
National Genomics Center for Wildlife and Fish Conservation

and the SculpinQwest Collaborative

9 April 2019 – WA-BC AFS annual meeting, Bremerton, WA

Outline

- Units of conservation
- The problem with *Cottus*
- Resolving that problem: crowds & genes
- Case studies: the species complexes

What is biodiversity?

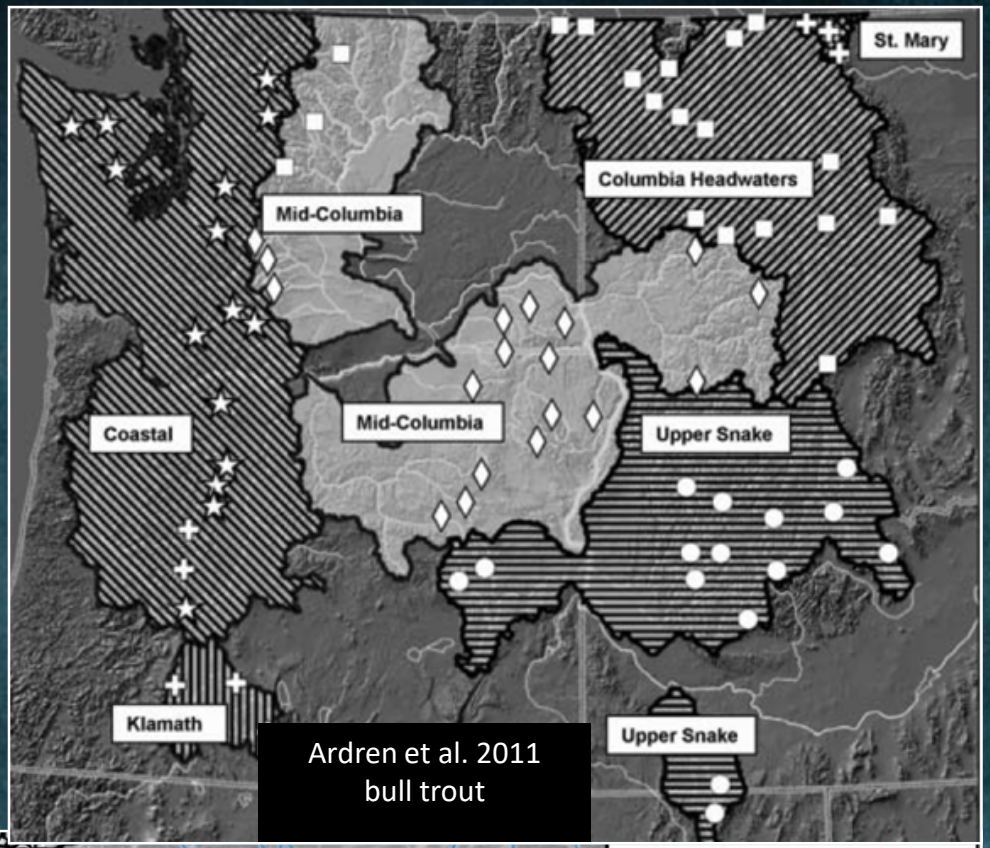
Conservation units: recognizable, substantive components of the evolutionary legacy of a taxon

- DPS
- ESU
- GMU
- Stock
- UCS
- Subspecies
- Species
- MOTU

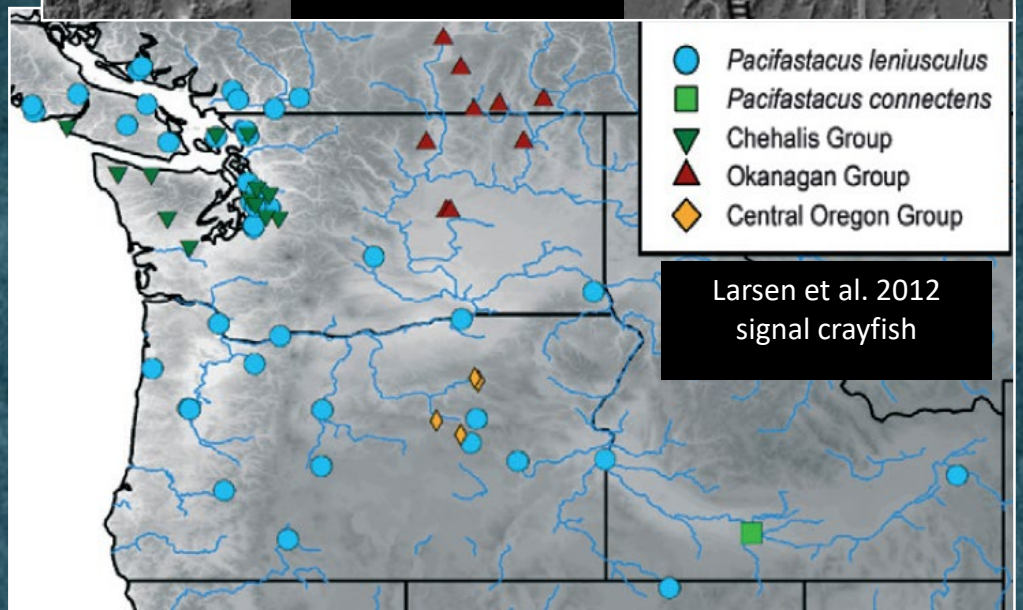
...all are lineages

Why is it relevant?

- ESA & SARA
- Tinkering: demographic manipulation via translocation
- Basis for understanding evolutionary histories



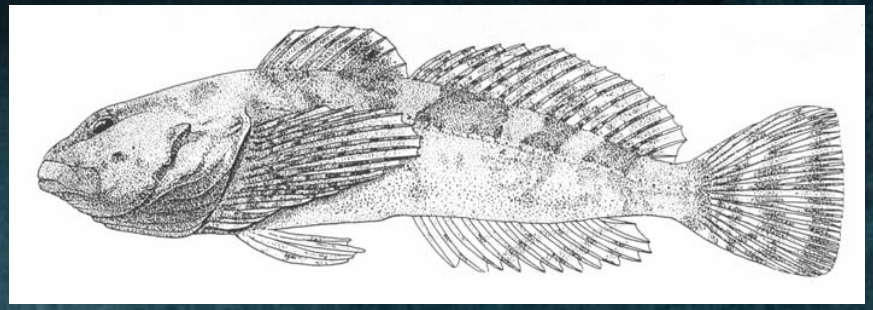
Ardren et al. 2011
bull trout

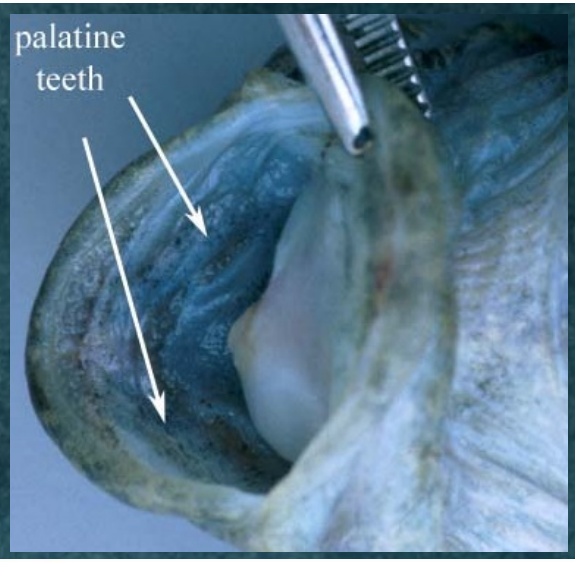


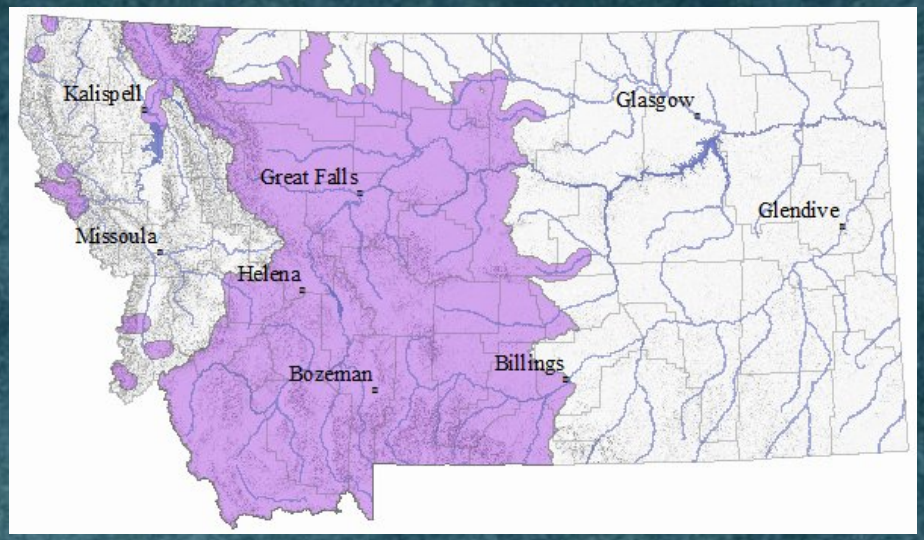
Larsen et al. 2012
signal crayfish

The problem with *Cottus*

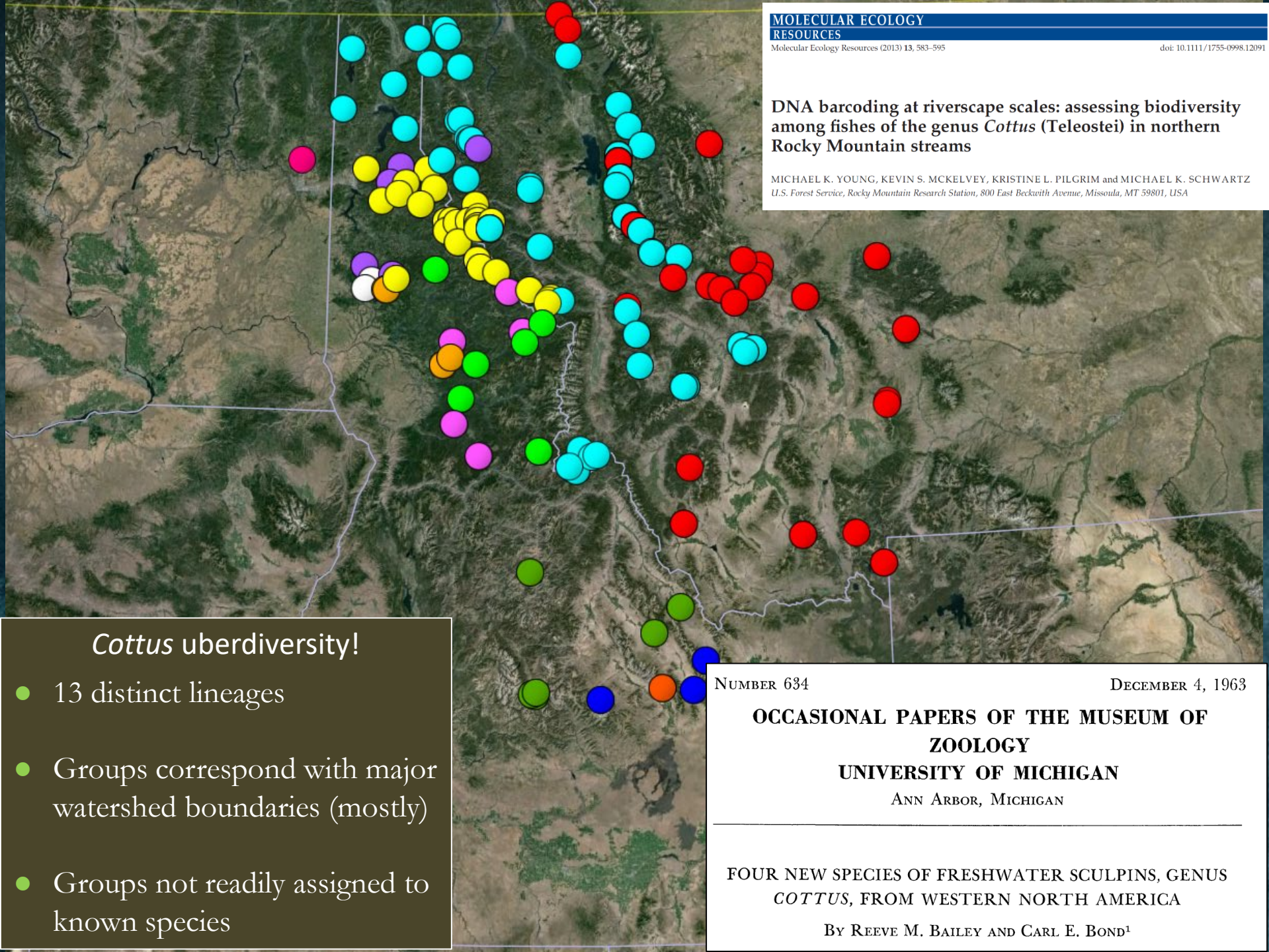
- Most challenging group to identify
- Morphology: difficult & "unstable"
- Hybridization ongoing & ancient
- Taxonomy unsatisfying
- Extraordinarily abundant







Images & drawing by D. Neely



MOLECULAR ECOLOGY RESOURCES
Molecular Ecology Resources (2013) **13**, 583–595 doi: 10.1111/1755-0998.12091

DNA barcoding at riverscape scales: assessing biodiversity among fishes of the genus *Cottus* (Teleostei) in northern Rocky Mountain streams

MICHAEL K. YOUNG, KEVIN S. MCKELVEY, KRISTINE L. PILGRIM and MICHAEL K. SCHWARTZ
U.S. Forest Service, Rocky Mountain Research Station, 800 East Beckwith Avenue, Missoula, MT 59801, USA

Cottus uberdiversity!

- 13 distinct lineages
- Groups correspond with major watershed boundaries (mostly)
- Groups not readily assigned to known species

NUMBER 634 DECEMBER 4, 1963

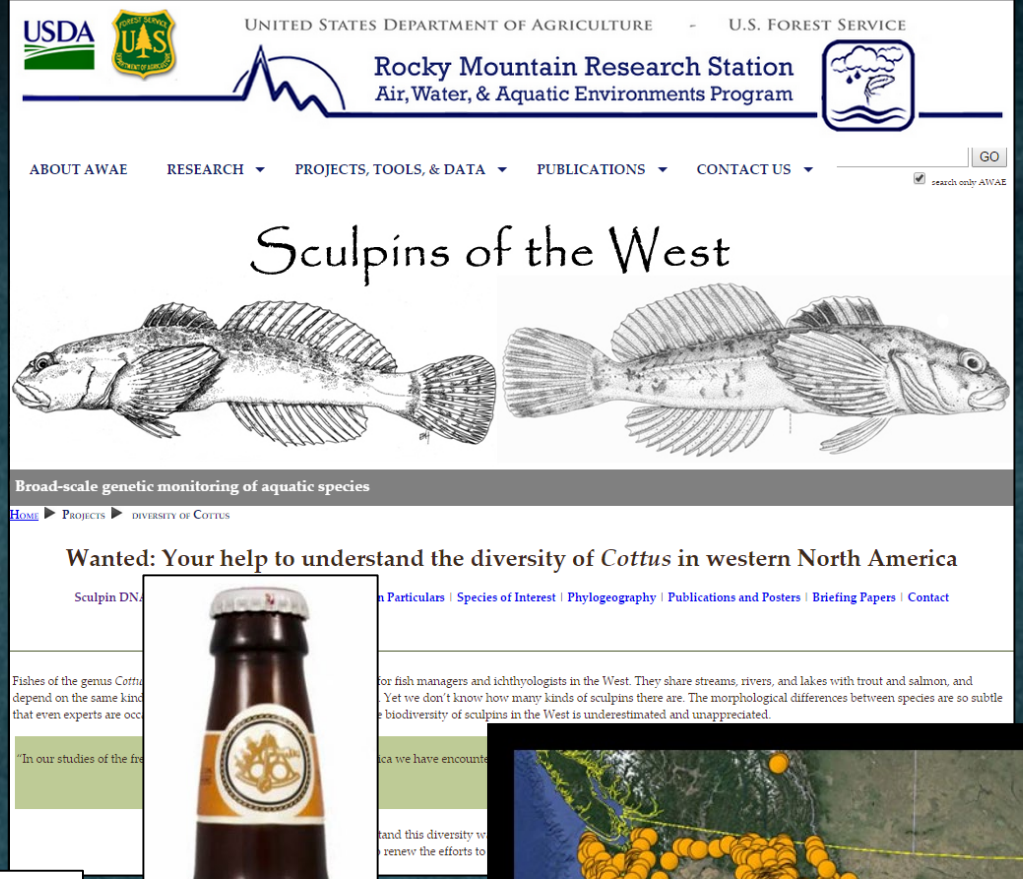
OCCASIONAL PAPERS OF THE MUSEUM OF ZOOLOGY
UNIVERSITY OF MICHIGAN
ANN ARBOR, MICHIGAN

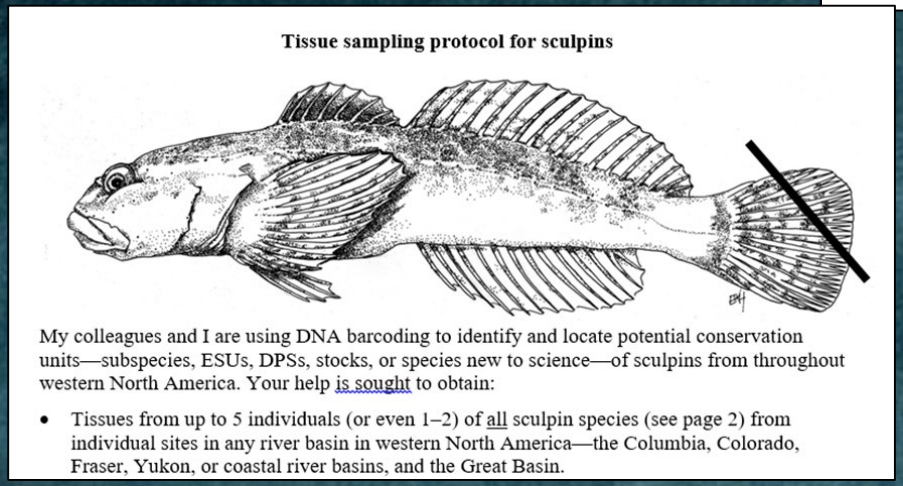
FOUR NEW SPECIES OF FRESHWATER SCULPINS, GENUS *COTTUS*, FROM WESTERN NORTH AMERICA

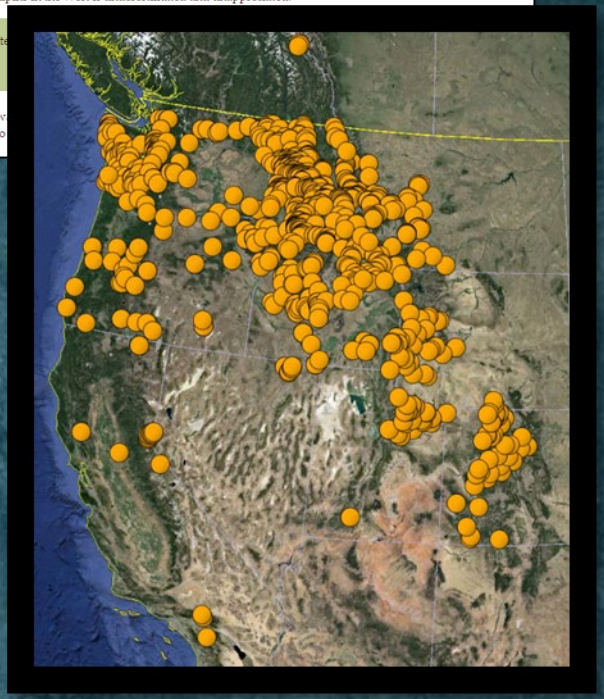
BY REEVE M. BAILEY AND CARL E. BOND[1]

SculpinQwest: the collection approach

- Sourcing the crowd: the SculpinQwest collaborative
  - 100s of biologists & citizen-scientists from every state and province in western NA
  - A simple collection protocol
  - ~8,000 specimens
- Rewarding the crowd: providing results to the stakeholders



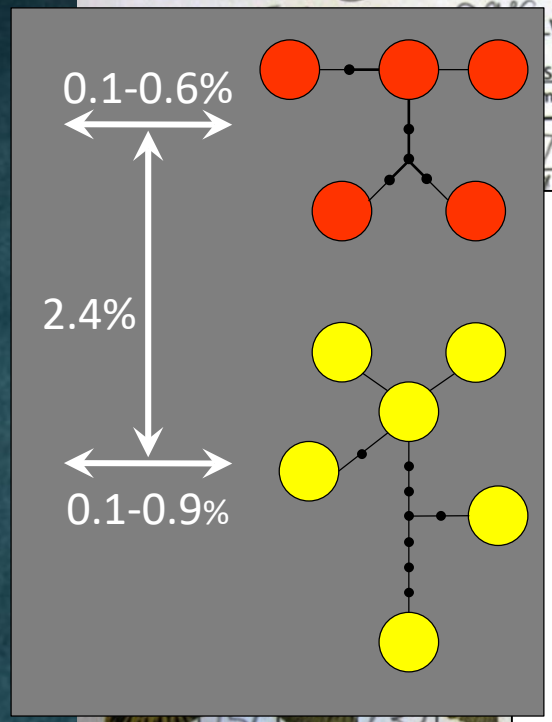


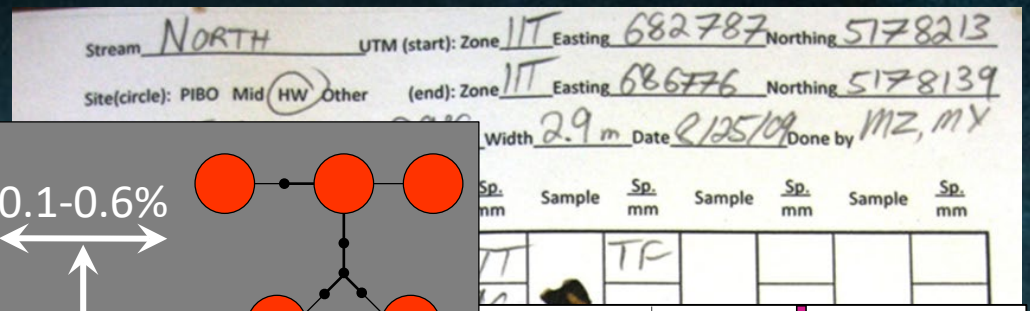


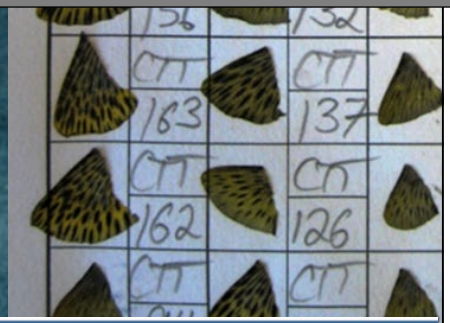
Google "Sculpin Qwest"

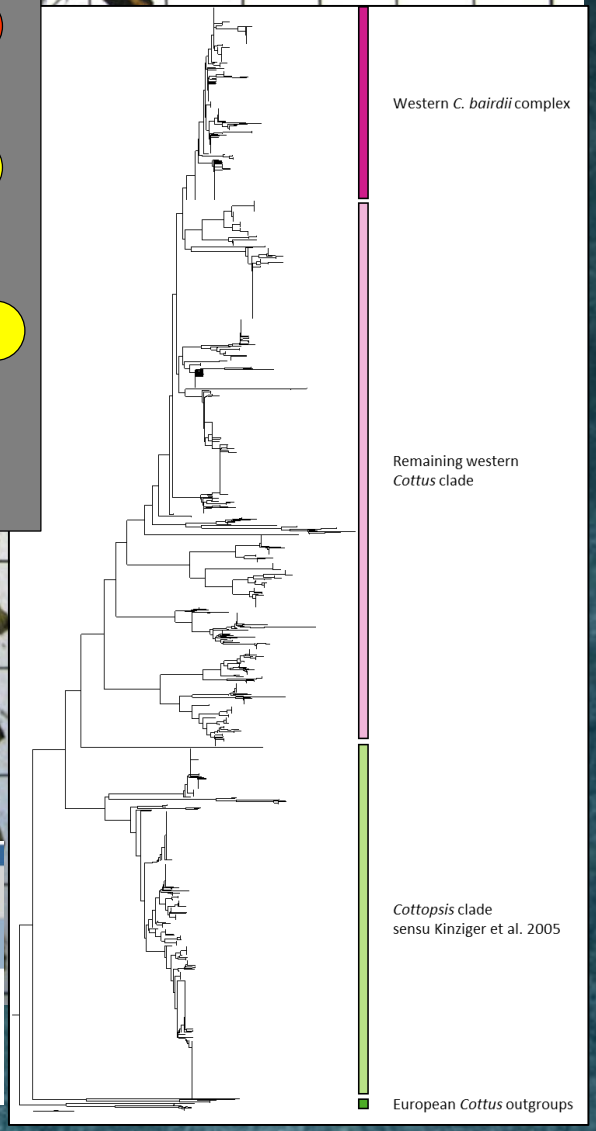
SculpinQwest: the molecular approach

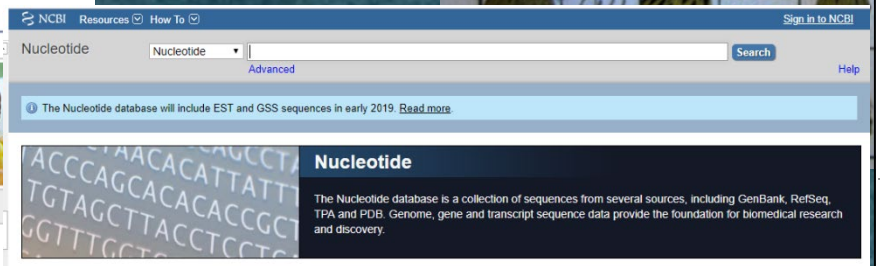
- COI (mtDNA)
  - The ~600 bp "barcode"
- cyt b (mtDNA)
  - The most commonly sequenced gene for fish
- S7 (nuDNA)
  - A non-coding intron with modest evolutionary rates
- Rhodopsin (nuDNA)
  - Highly conserved for detecting ancient divergence









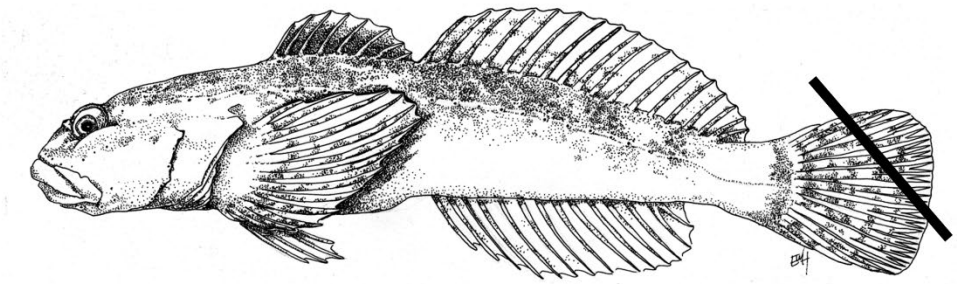


Lineage delineation

- Species concept: evolutionary
- Criteria: standard phylogenetic analyses
  - Distances (%)—barcode gap
  - Diagnosable—monophyletic
  - Allopatry with respect to close relatives
- Null hypothesis: existing taxonomy is correct
  - Ingroup defined by specimen nearest type location
  - Applied to each species complex
- Provisional: ~90% complete
- Four case histories

WANTED:

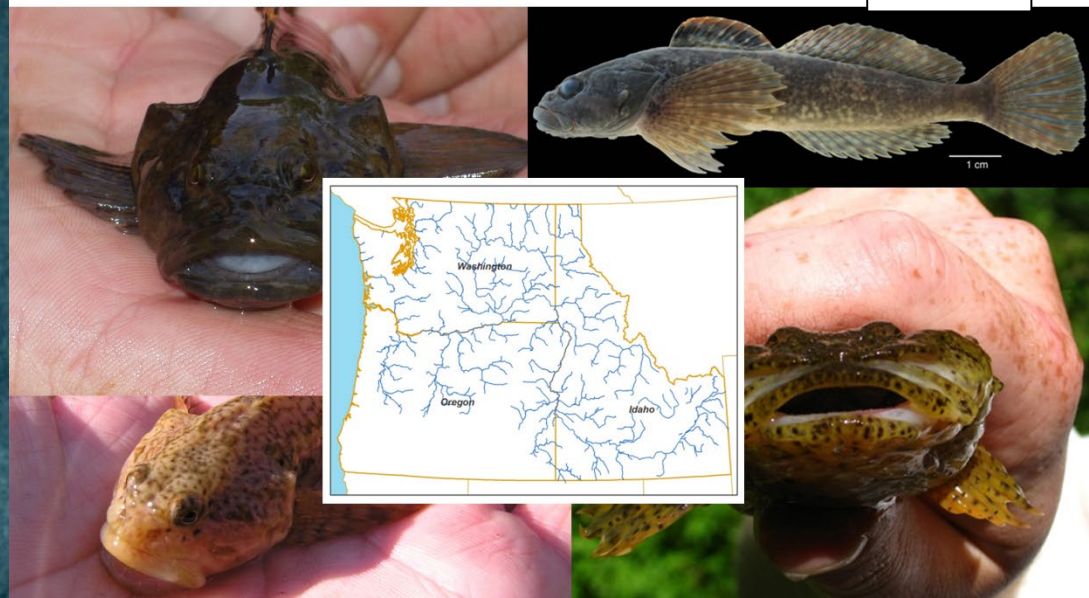
Upper caudal clips from Cottidae



As part of a one-year evaluation of the use of DNA barcodes for identifying sculpins from the Columbia River basin, I would appreciate receiving a few (2-5) fin clips from **all** species from as many waters as possible in Idaho, Oregon, Washington, and Wyoming.

Data wanted: fin clips (in ethyl alcohol, on chromatography paper, or in coin envelopes), GPS data, date, your name.

For more information, contact Michael Young at the Rocky Mountain Research Station in Missoula, MT (mkyoung@fs.fed.us; 406 542-3254



Torrent sculpin complex

C. rhotheus

Species of interest

Geographic distribution of clades

cytb NJ tree

cyt b distance matrix

	Gp_1	Gp_2	Gp_3
Gp_1			
Gp_2	1.04		
Gp_3	2.34	2.22	
Gp_4	3.01	3.12	2.87

Data SIO, NOAA, U.S. Navy, NGA, GEBCO
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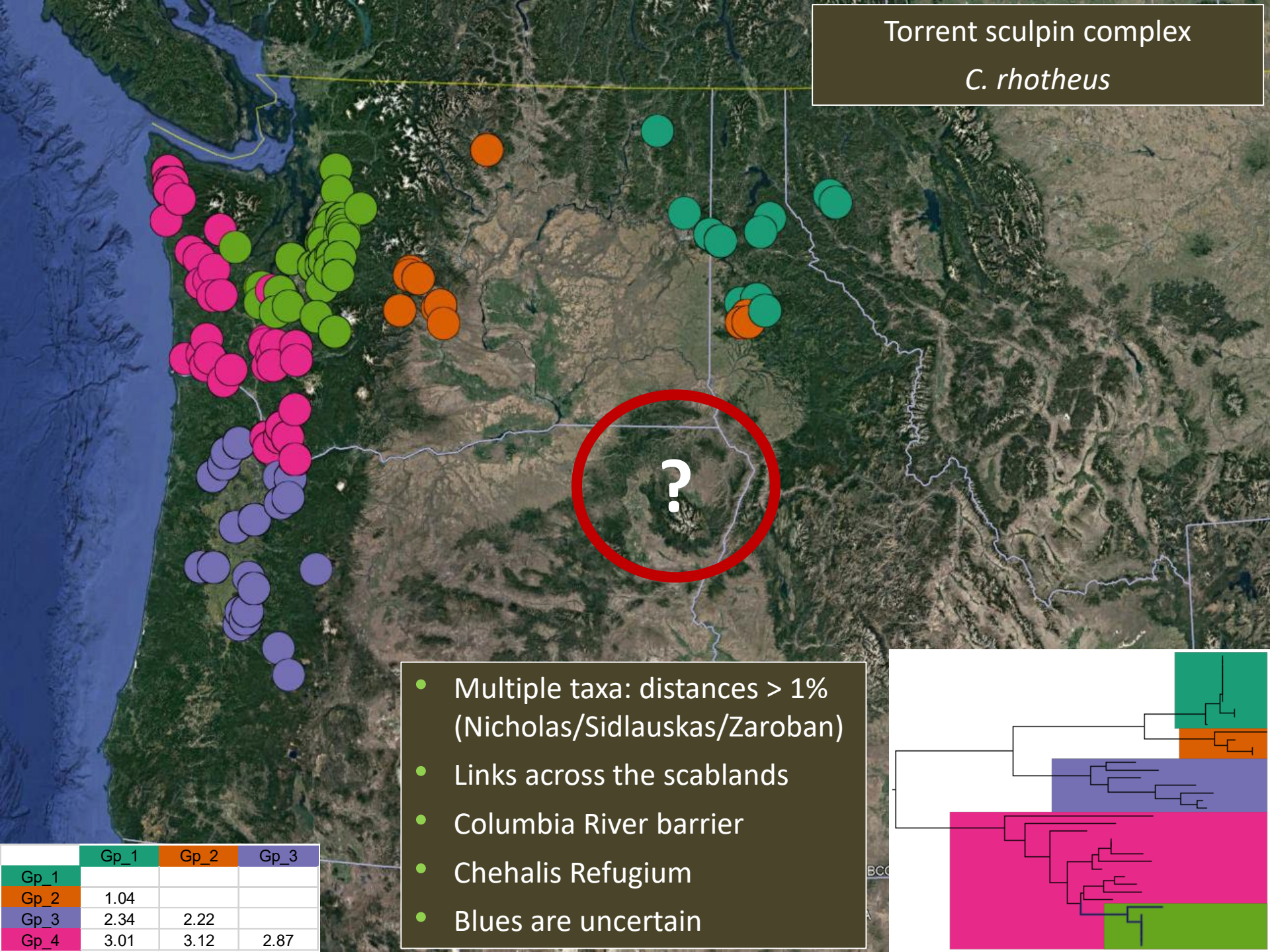
Image Landsat / Copernicus
Data LDEO-Columbia, NSF, NOAA

Torrent sculpin complex

C. rhotheus

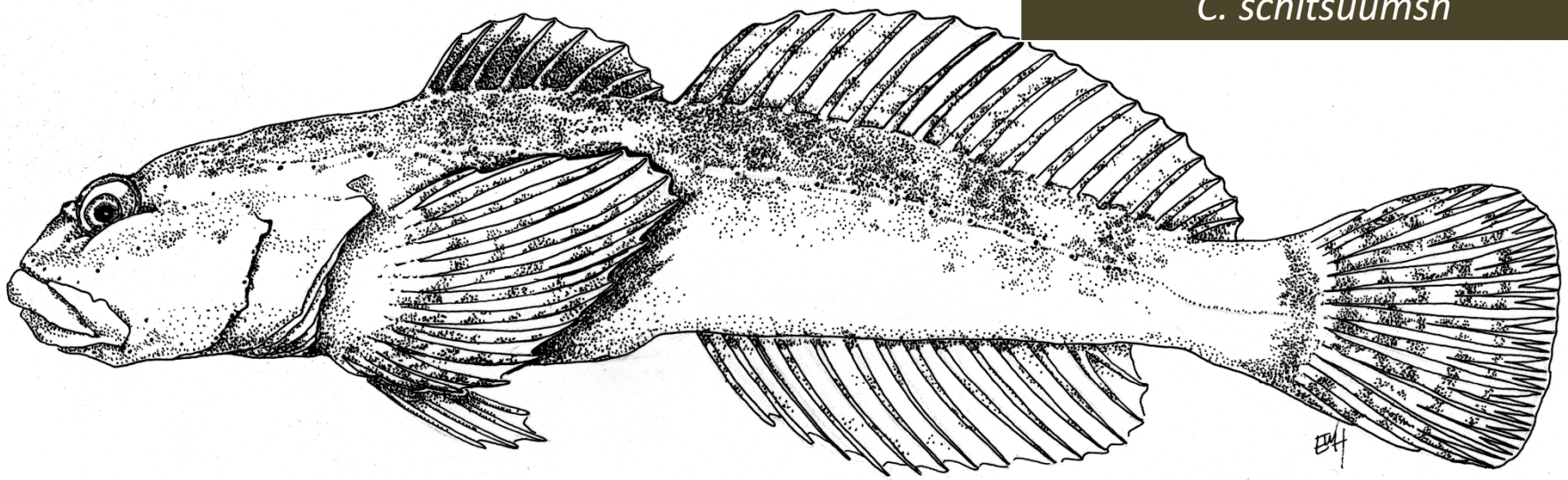


- Multiple taxa: distances > 1% (Nicholas/Sidlauskas/Zaroban)
- Links across the scablands
- Columbia River barrier
- Chehalis Refugium
- Blues are uncertain

	Gp_1	Gp_2	Gp_3
Gp_1			
Gp_2	1.04		
Gp_3	2.34	2.22	
Gp_4	3.01	3.12	2.87

Cedar sculpin

C. schitsuumsh



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Article

ISSN 1175-5326 (print edition)
ZOOTAXA
ISSN 1175-5334 (online edition)

http://dx.doi.org/10.11646/zootaxa.0000.0.0
http://zoobank.org/urn:lsid:zoobank.org:pub:00000000-0000-0000-0000-00000000000

Cottus schitsuumsh, a new species of sculpin (Scorpaeniformes: Cottidae) in the Columbia River basin, Idaho-Montana, USA

MICHAEL LEMOINE[1,3], MICHAEL K. YOUNG[2], KEVIN S. MCKELVEY[2], LISA EBY[1], KRISTINE L. PILGRIM[2] & MICHAEL K. SCHWARTZ[2]

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[3] *Corresponding author. E-mail: michael1.lemoine@umconnect.umt.edu*

Cedar sculpin

C. schitsuumsh

- Cohesive “taxon”
- Introduced in MT
- Native to central WA
- Links across the scablands

	Gp_1	Gp_2	Gp_3	Gp_4	Gp_5
Gp_1					
Gp_2	0.55				
Gp_3	0.84	0.82			
Gp_4	0.84	0.86	1.06		
Gp_5	0.58	0.60	0.77	0.70	
Gp_6	0.55	0.58	0.67	0.77	0.60

Data SIO, NOAA, U.S. Navy, NGA, GEBCO
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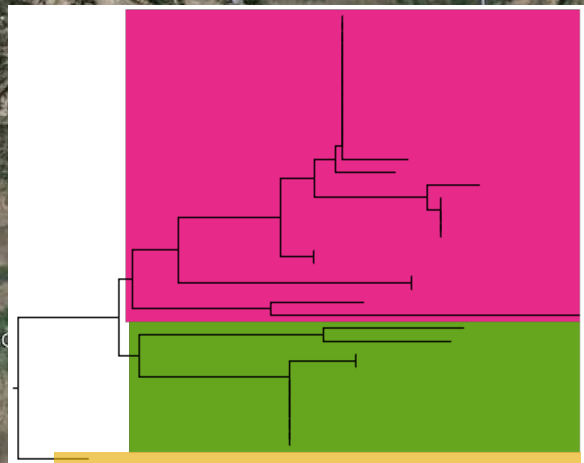
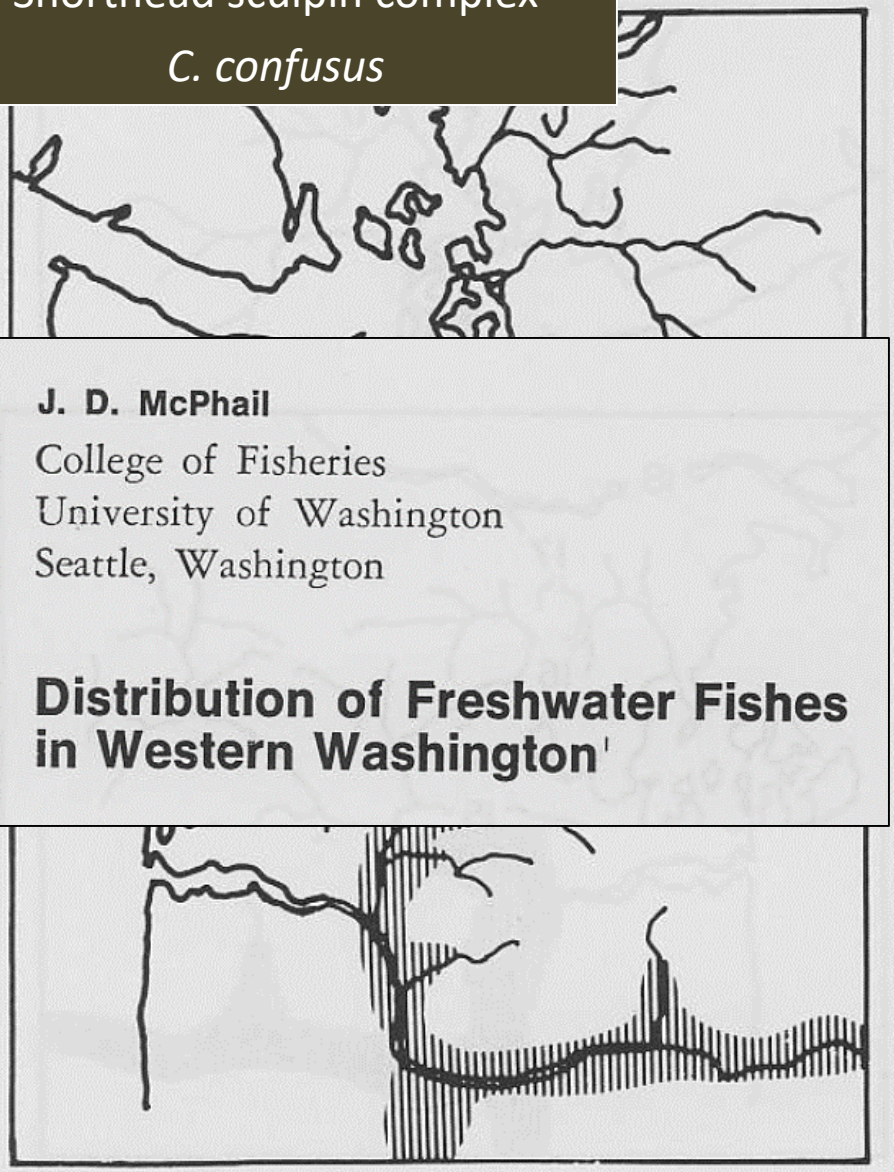
Image Landsat / Copernicus
Data LDEO-Columbia, NSF, NOAA



Shorthead sculpin complex

C. confusus



J. D. McPhail
College of Fisheries
University of Washington
Seattle, Washington

Distribution of Freshwater Fishes in Western Washington[1]

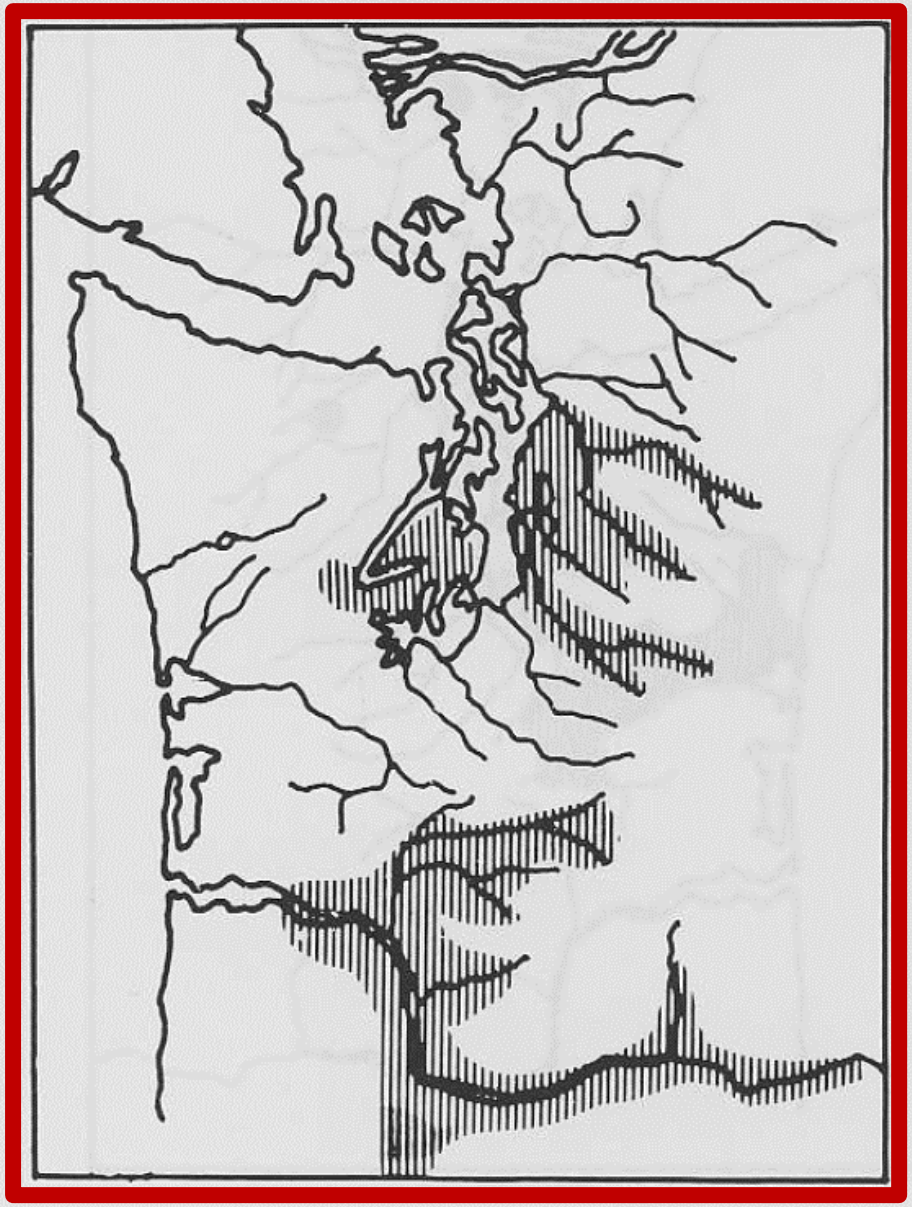
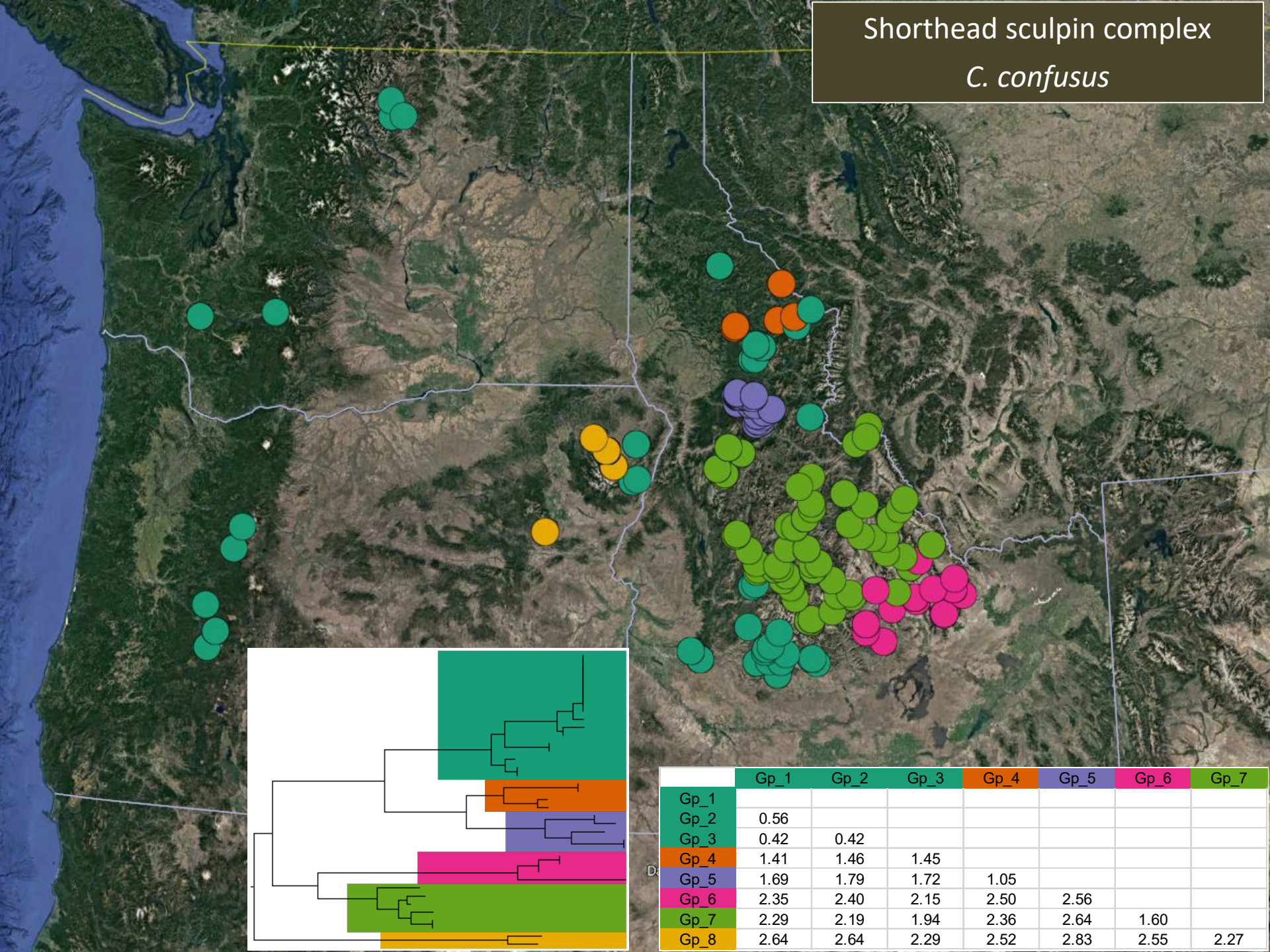


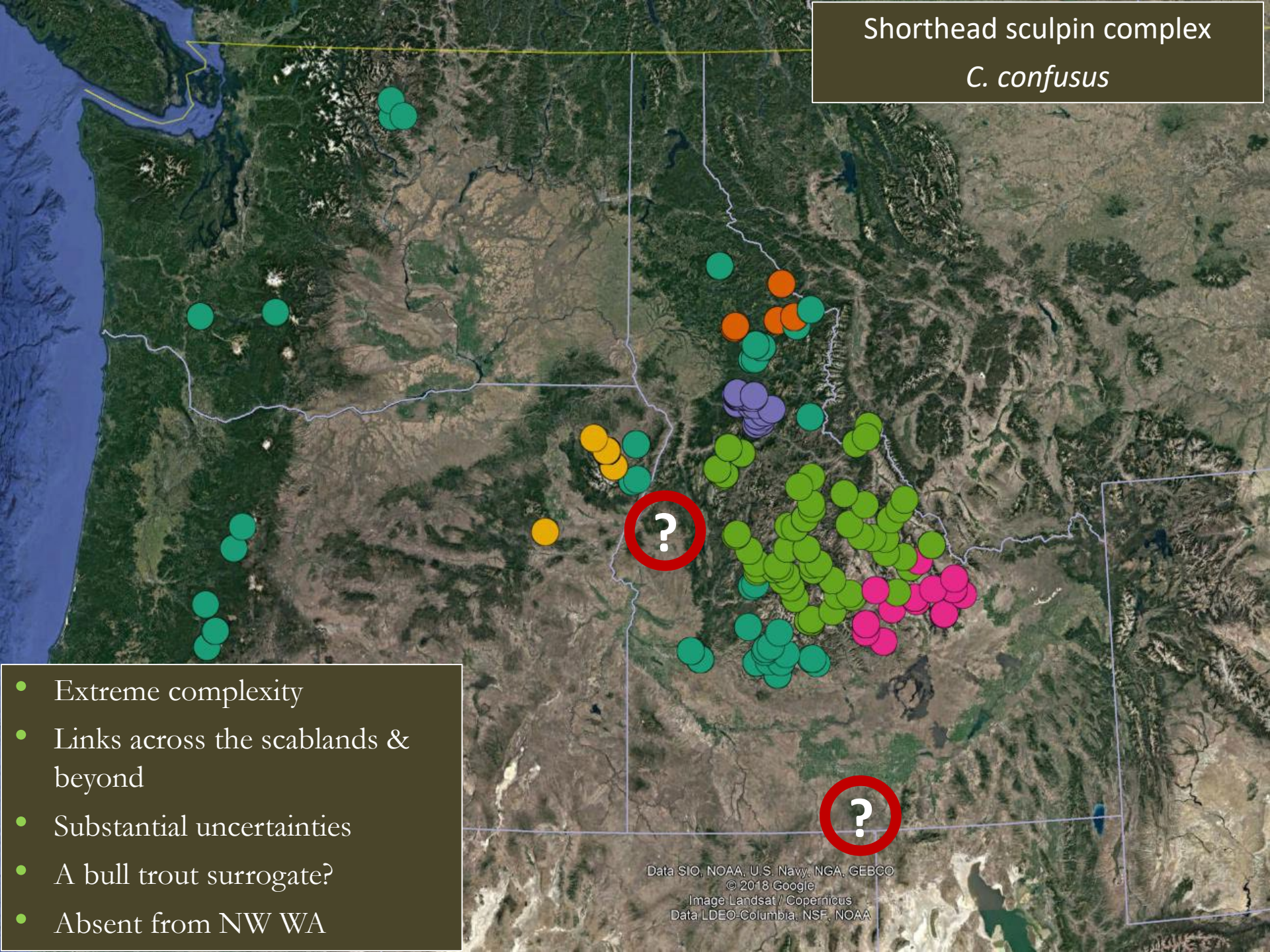
Figure 8. Left. Western Washington distribution of the leopard dace, *R. falcatus*.
Figure 9. Right. Western Washington distribution of the shorthead sculpin, *C. confusus*.

Shorthead sculpin complex

C. confusus



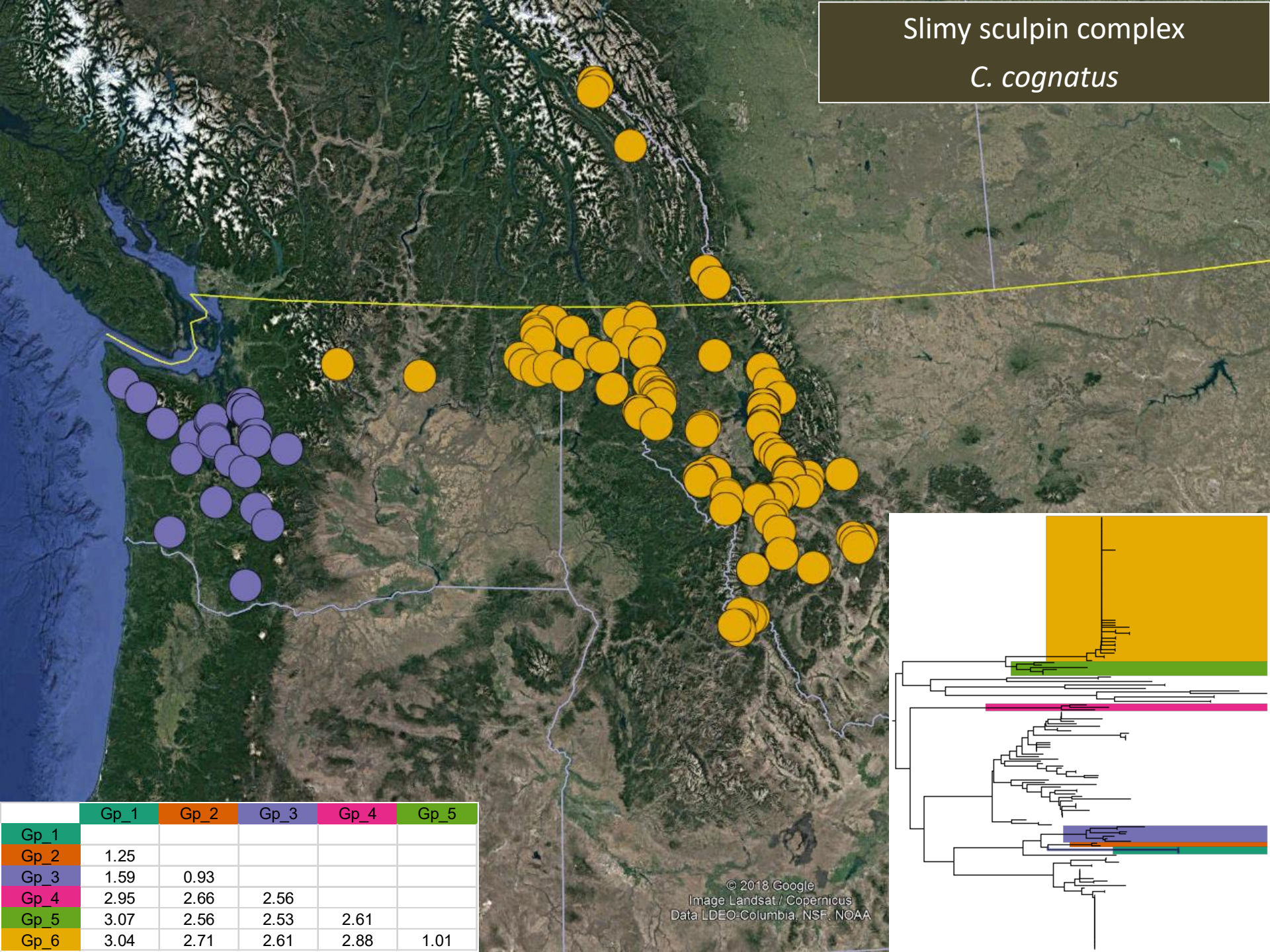
	Gp_1	Gp_2	Gp_3	Gp_4	Gp_5	Gp_6	Gp_7
Gp_1							
Gp_2	0.56						
Gp_3	0.42	0.42					
Gp_4	1.41	1.46	1.45				
Gp_5	1.69	1.79	1.72	1.05			
Gp_6	2.35	2.40	2.15	2.50	2.56		
Gp_7	2.29	2.19	1.94	2.36	2.64	1.60	
Gp_8	2.64	2.64	2.29	2.52	2.83	2.55	2.27



- Extreme complexity
- Links across the scablands & beyond
- Substantial uncertainties
- A bull trout surrogate?
- Absent from NW WA

Slimy sculpin complex

C. cognatus

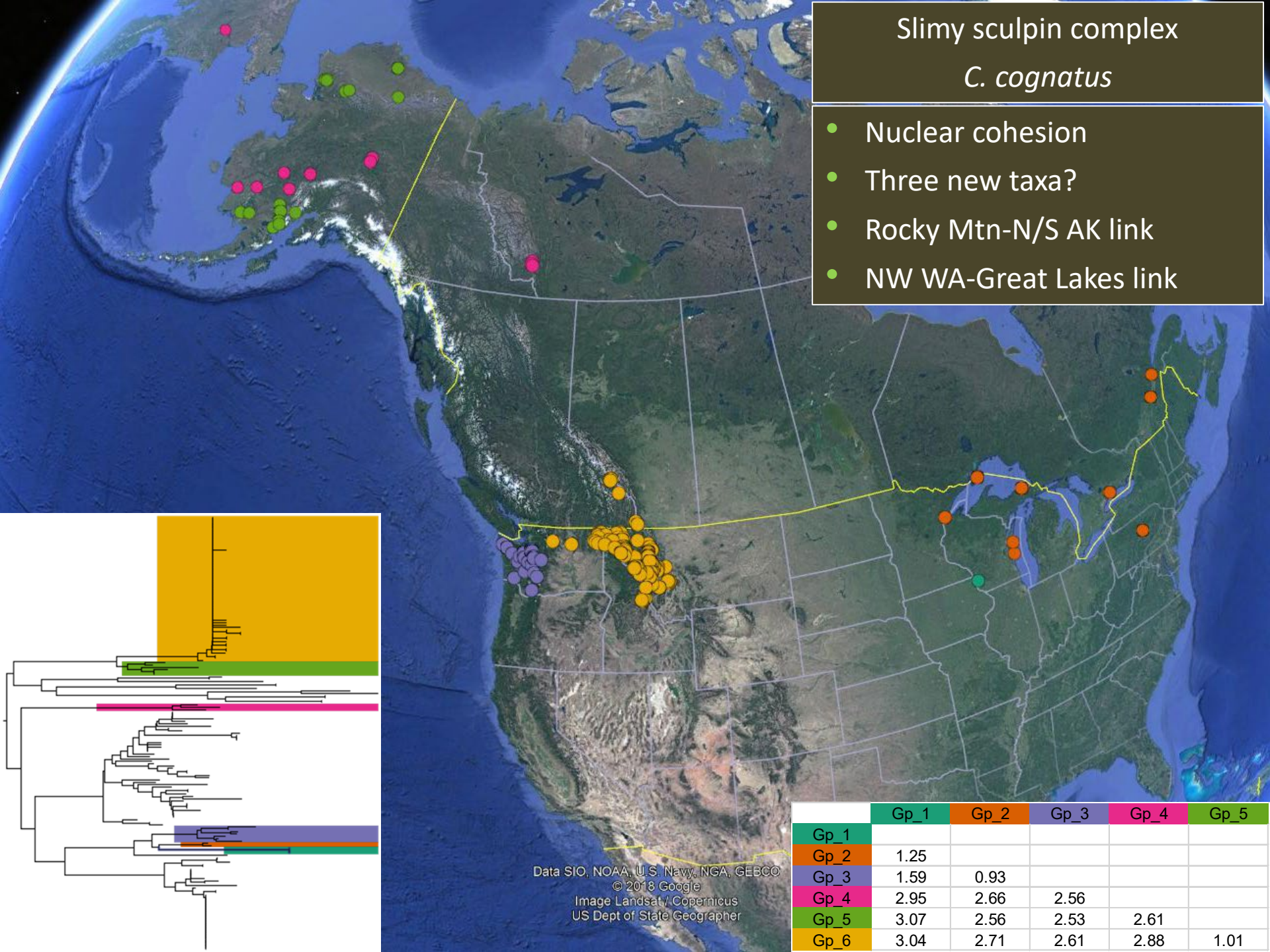


	Gp_1	Gp_2	Gp_3	Gp_4	Gp_5
Gp_1					
Gp_2	1.25				
Gp_3	1.59	0.93			
Gp_4	2.95	2.66	2.56		
Gp_5	3.07	2.56	2.53	2.61	
Gp_6	3.04	2.71	2.61	2.88	1.01

Slimy sculpin complex

C. cognatus

- Nuclear cohesion
- Three new taxa?
- Rocky Mtn-N/S AK link
- NW WA-Great Lakes link



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Gp_1					
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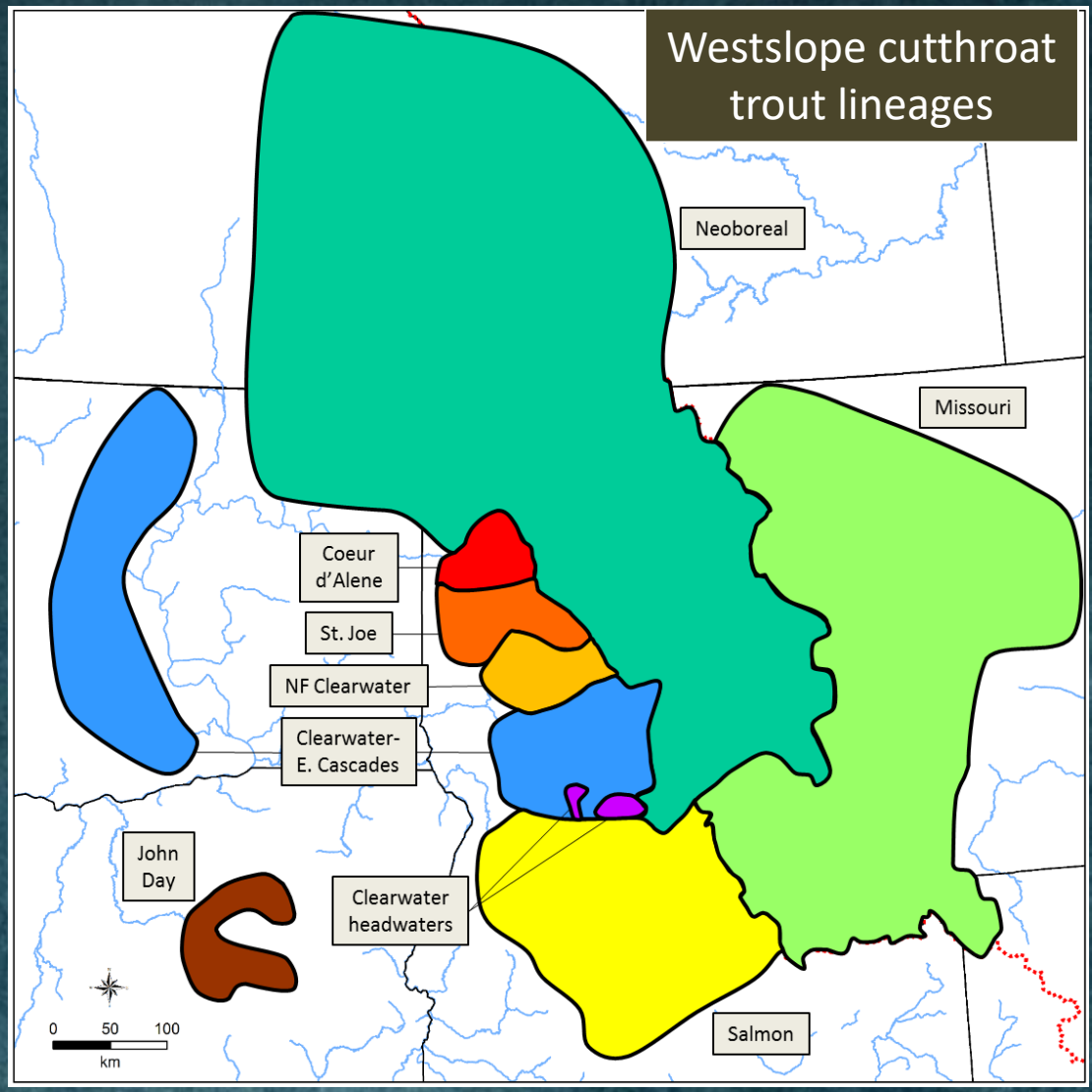
Gp_5	3.07	2.56	2.53	2.61	
Gp_6	3.04	2.71	2.61	2.88	1.01

Briefly...

- Additonal results
  - *C. gulosus* is not found in WA
  - *C. beldingii* isn't either...but *C. tubulatus* is
  - *C. bendirei* is real...just not here
- Biodiversity hotspots & "gray" zones
  - The Blues
  - E. Cascades
  - Columbia Gorge tributaries (Klickitat R. downstream)
- Corroboration from comparative phylogeography

Young et al. (2018). The phylogeography of westslope cutthroat trout. Pages 261-301 in Trotter P, Bisson P, Schultz L, Roper B (editors). Cutthroat Trout: Evolutionary Biology and Taxonomy. Special Publication 36, American Fisheries Society, Bethesda, Maryland.



https://www.fs.usda.gov/treesearch/pubs/57473