Using Environmental DNA to Monitor Eulachon (*Thaleichthys pacificus*) Abundance Northern Southeast Alaska
(aka hooligan, Saak)

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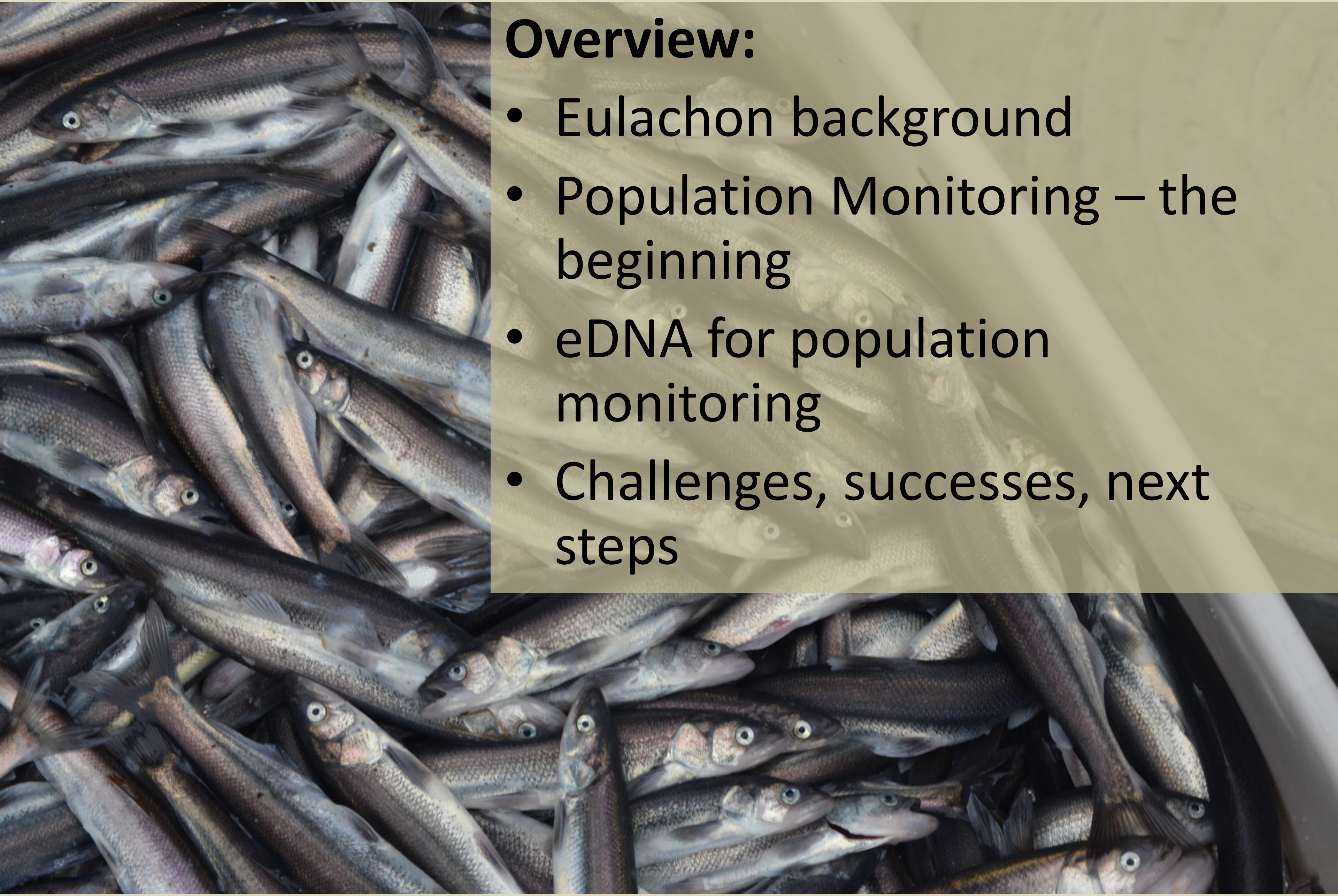
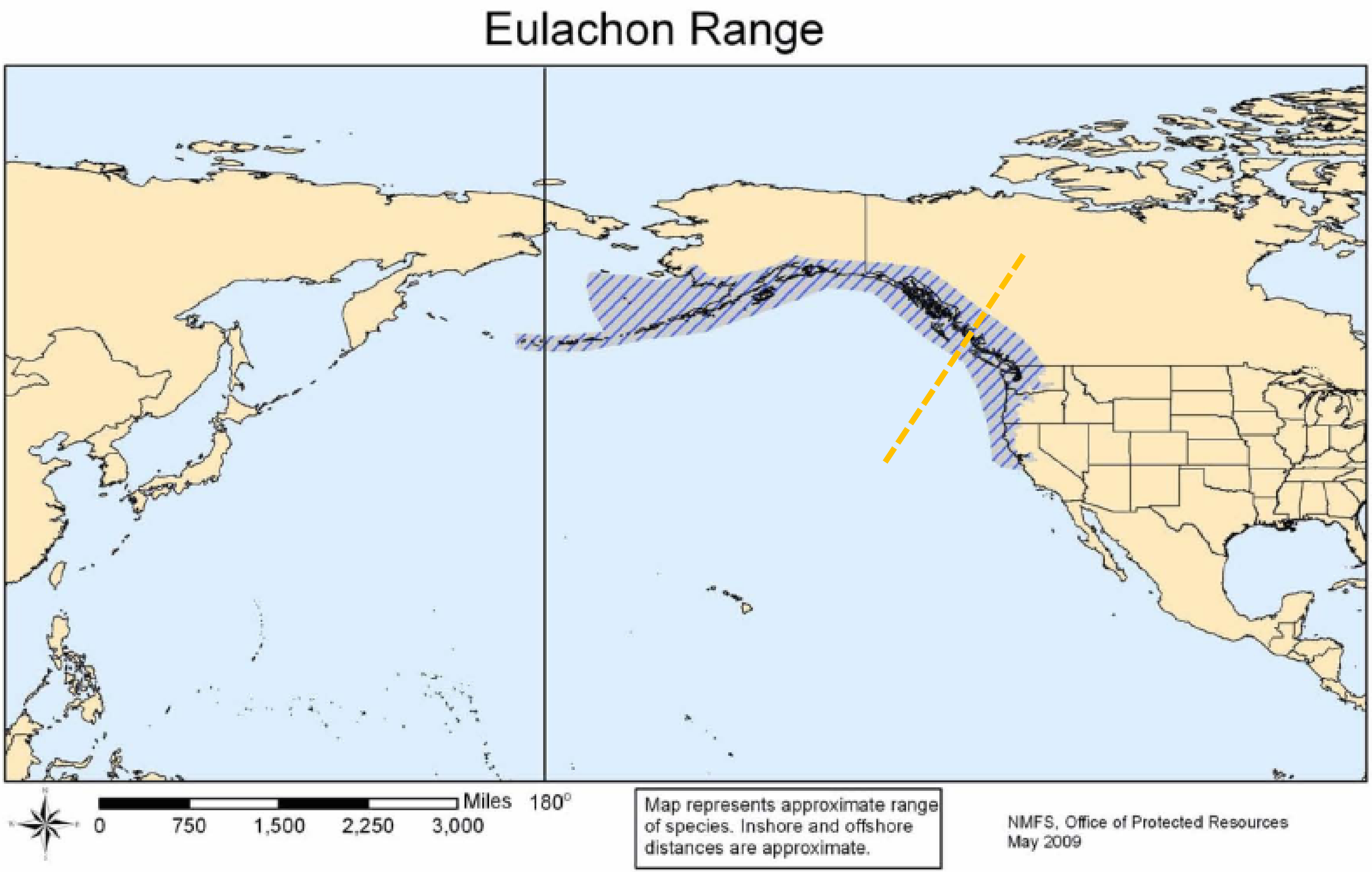
Takshanuk Watershed Council[1]
Chilkoot Indian Association[2]
Oregon State University [3]



Overview:

- Eulachon background
- Population Monitoring – the beginning
- eDNA for population monitoring
- Challenges, successes, next steps

Eulachon Background

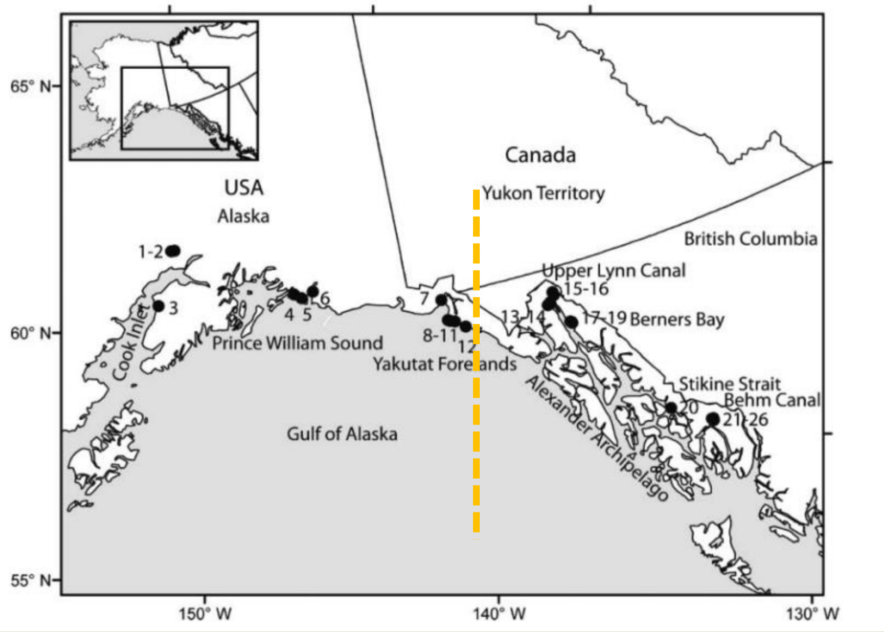


Endangered Species Act Recovery Plan for the Southern Distinct Population Segment of Eulachon (*Thaleichthys pacificus*)

Prepared by: National Marine Fisheries Service, West Coast Region

Life History

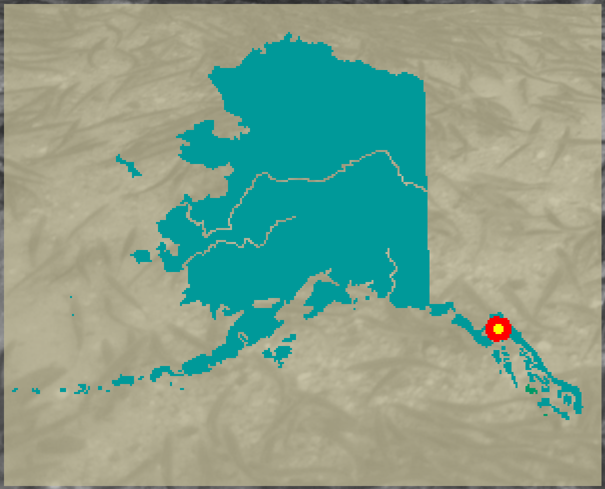
- Columbia River spawning – 2yrs.
- Alaska spawning – 4-5yrs.
  - Otolith & isotope
- Discrepancy in semelparous (Clark et al. 2007) vs. iteroparous (Patrick R. Biondo (WDFW), Personal communication & Barraclough, 1964)
  - Ovary & isotope
- Regional population structure



Flannery et al. 2013. Microsatellite Analysis of Population Structure in Alaska Eulachon with Application to Mixed-stock Analysis

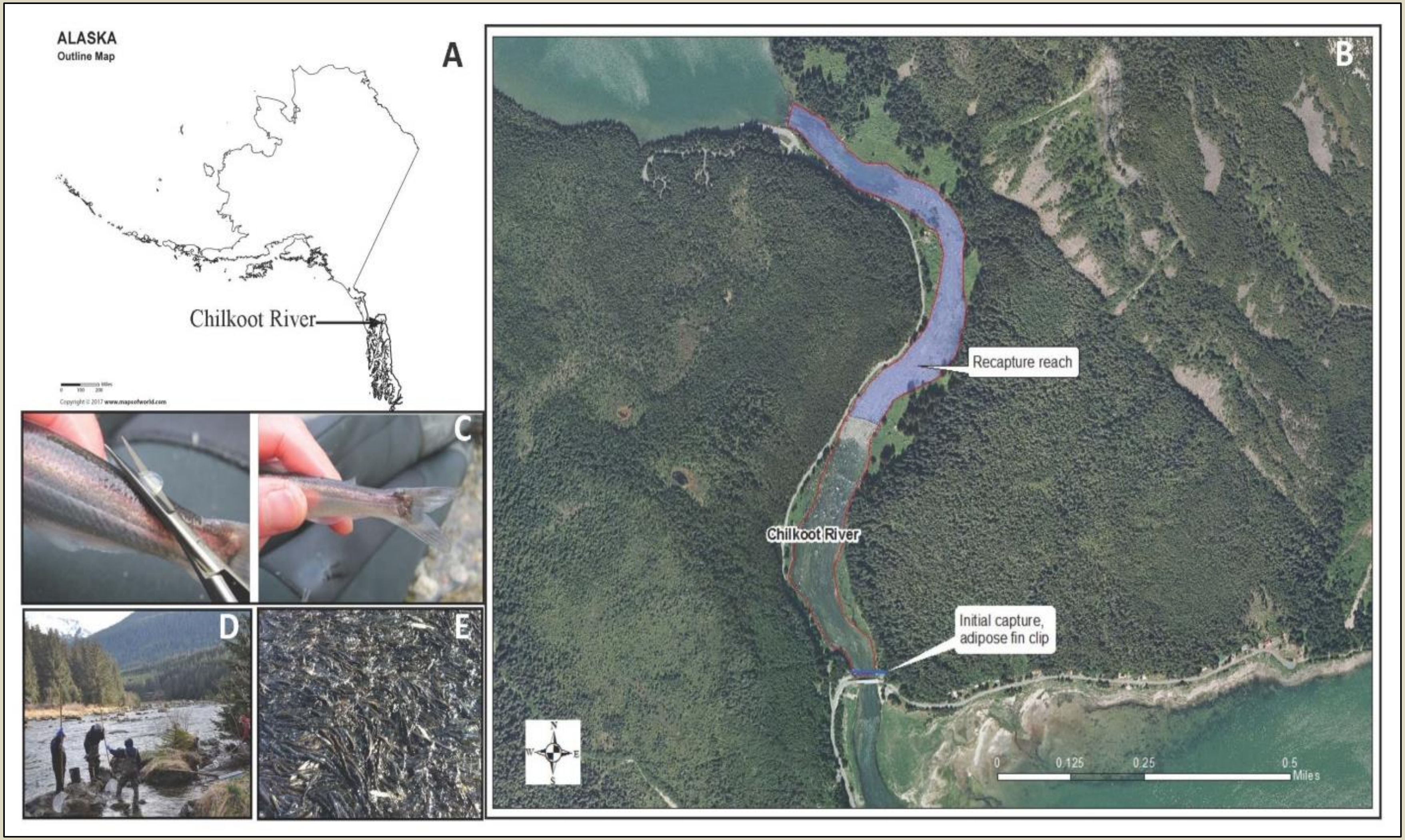
Indigenous-led Population Monitoring

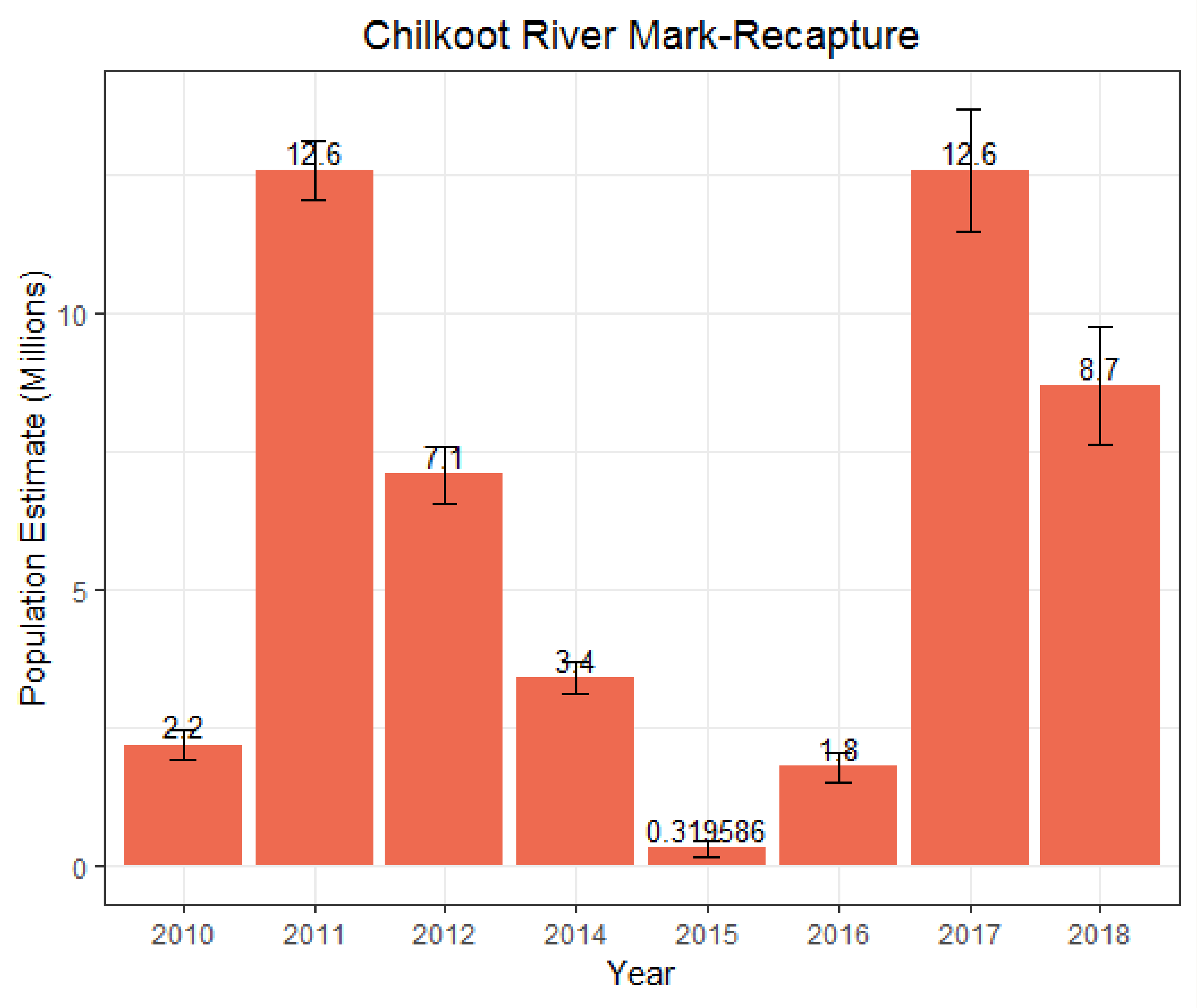
How does the spawning population vary on an annual basis – one river (Chilkoot) 2010-2018



Method 1:

Mark-Recapture

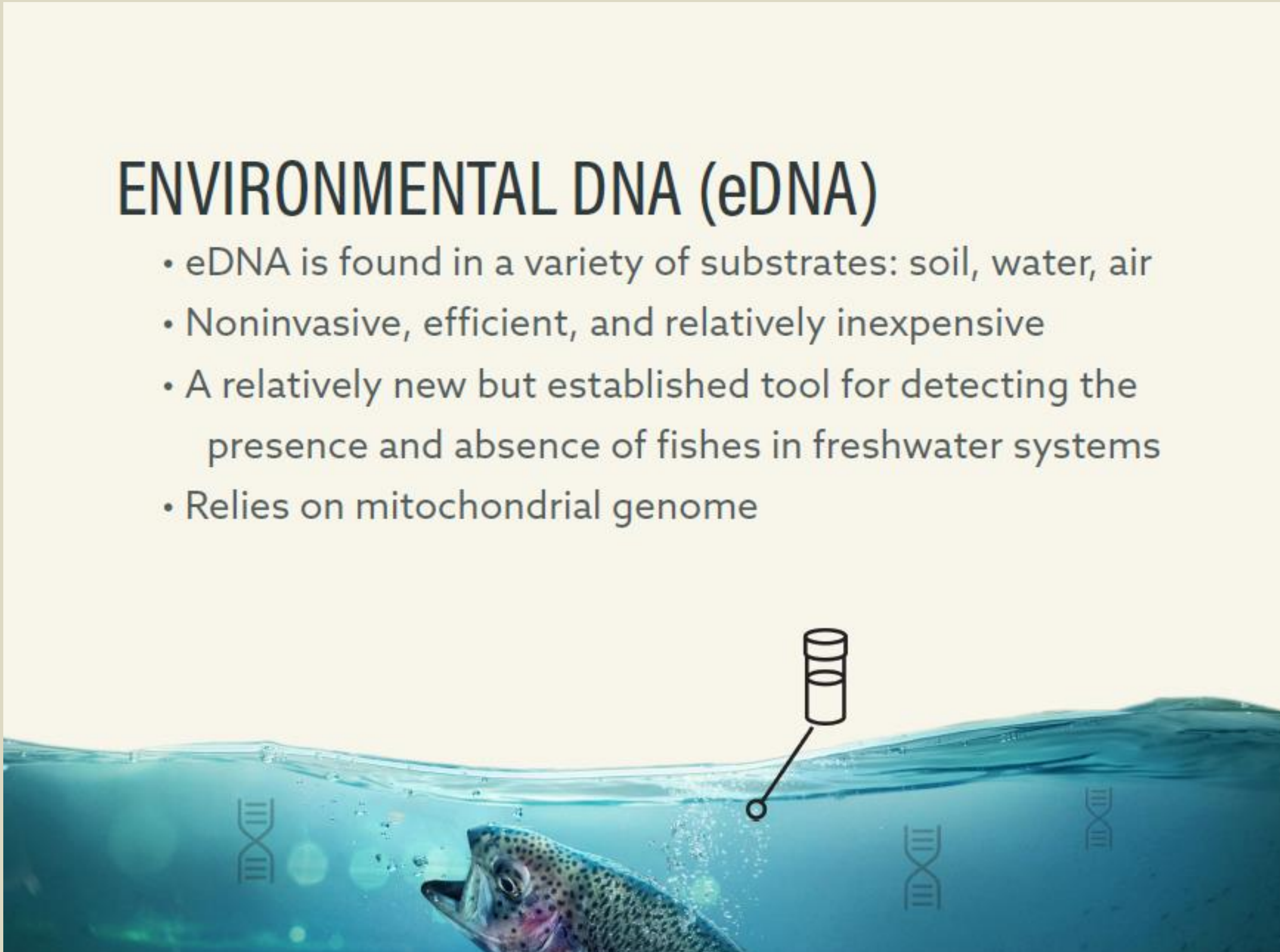



Chilkoot River Mark-Recapture
Population Estimate (Millions)
0
5
10
Year
2010
2011
2012
2014
2015
2016
2017
2018
2.2
12.6
7.1
3.4
0.319586
1.8
12.6
8.7

Challenges

- Active subsistence fishing & foraging – does not meet closed population assumptions
- Single river
- Costly: ~ $20,000 annually

Method 2:



E. Dziedzic, 2018

Origin of eDNA for monitoring aquatic vertebrates

biology
letters

Biol. Lett.
doi:10.1098/rsbl.2008.0118
Published online

Population genetics

Species detection using environmental DNA from water samples

Gentile Francesco Ficetola[1,2,*], Claude Miaud[2], François Pompanon[1] and Pierre Taberlet[1]

First Paper in 2008

eDNA research started slow

2011

LETTER

"Sight-unseen" detection of rare aquatic species using environmental DNA

Christopher L. Jerde[1], Andrew R. Mahon[1], W. Lindsay Chadderton[2], & David M. Lodge[1]

2011

OPEN ACCESS Freely available online PLoS one

Molecular Detection of Vertebrates in Stream Water: A Demonstration Using Rocky Mountain Tailed Frogs and Idaho Giant Salamanders

Caren S. Goldberg[1]*, David S. Pilliod[2], Robert S. Arkle[2], Lisette P. Waits[1]

2012

MOLECULAR ECOLOGY

Molecular Ecology (2011) doi: 10.1111/j.1365-294X.2011.05418.x

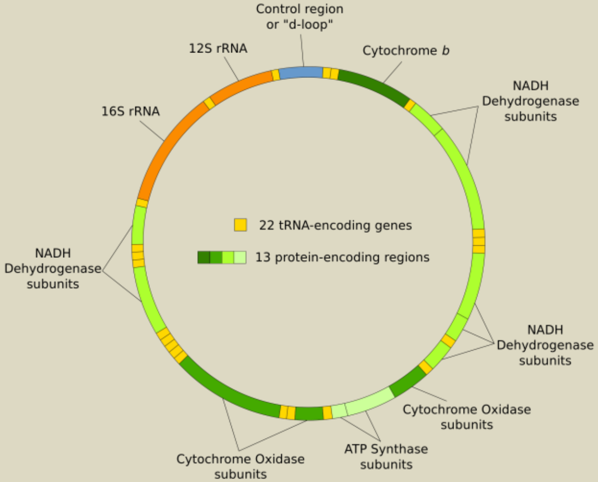
FROM THE COVER

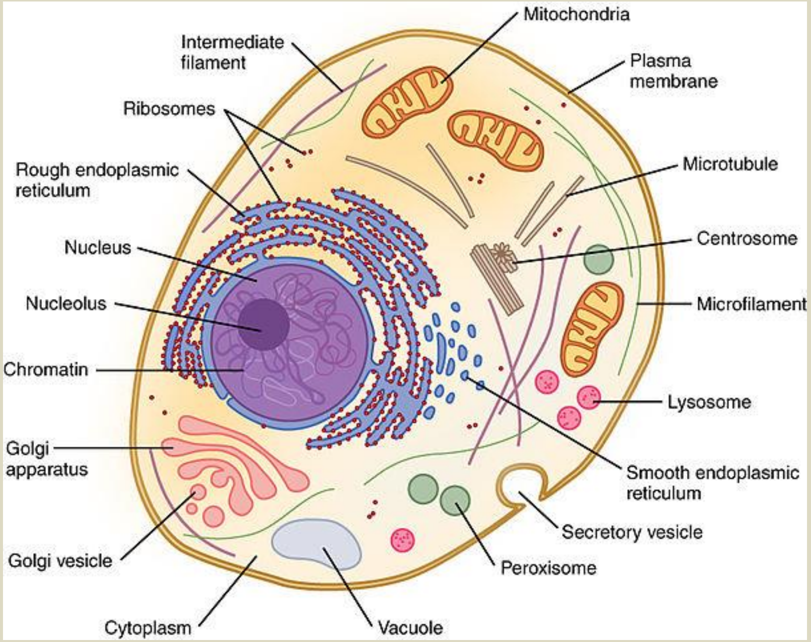
Monitoring endangered freshwater biodiversity using environmental DNA

PHILIP FRANCIS THOMSEN,[1]* JOS KIELGAST,[1]* LARS L. IVERSEN,† CARSTEN WIUF,‡ MORTEN RASMUSSEN,* M. THOMAS P. GILBERT,* LUDOVIC ORLANDO* and ESKE WILLERSLEV*

Now many hundreds of papers
Primary focus on technical aspects

Mitochondrial Genome

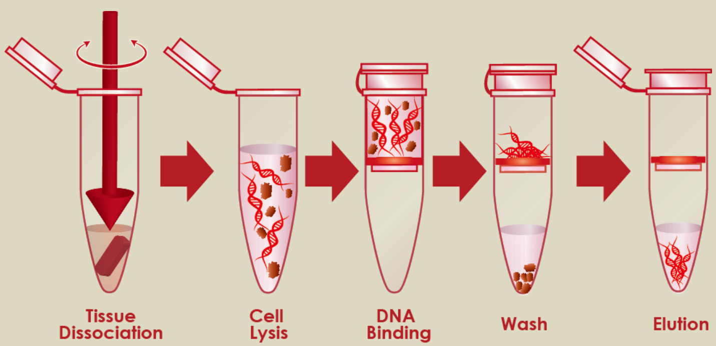




- More copies of mtDNA in each cell
- Shorter sequence
  - Genome mapped for more species

Collect sample

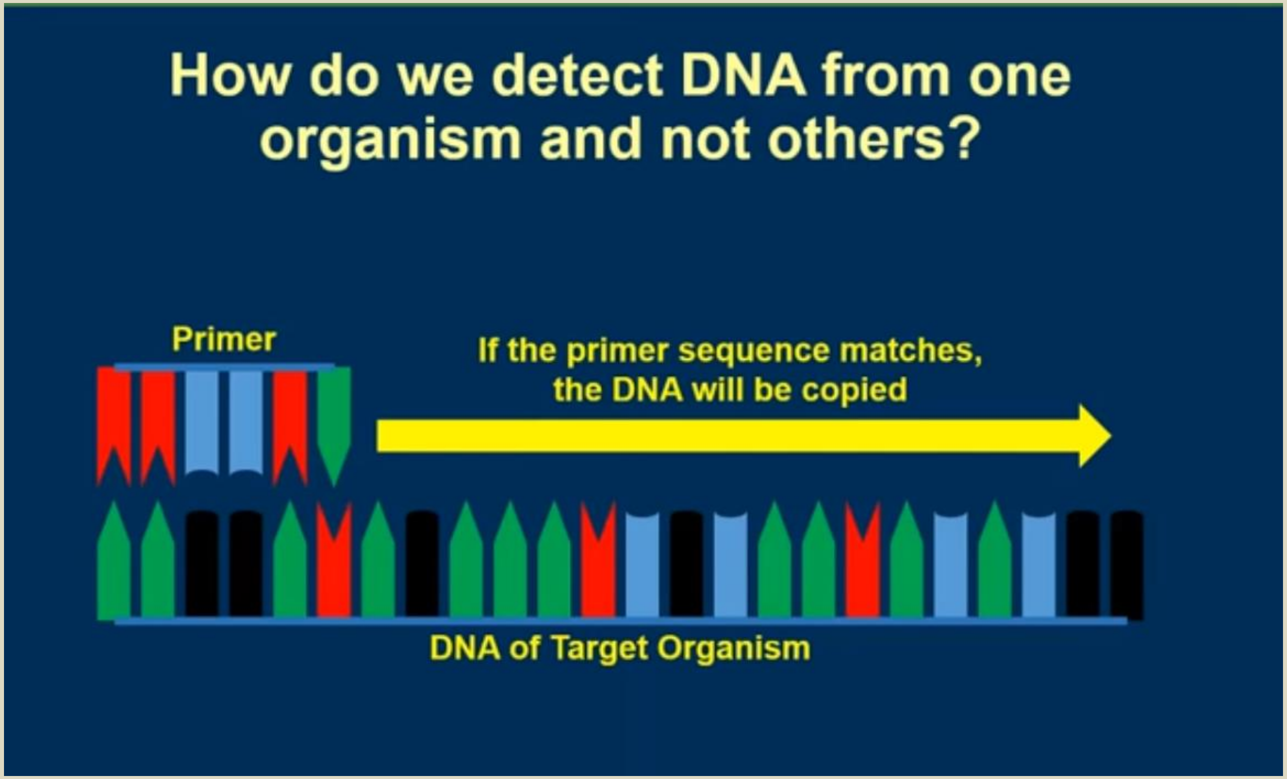
Concentrate all cells via filtering



Extract all DNA

How an eDNA assay works

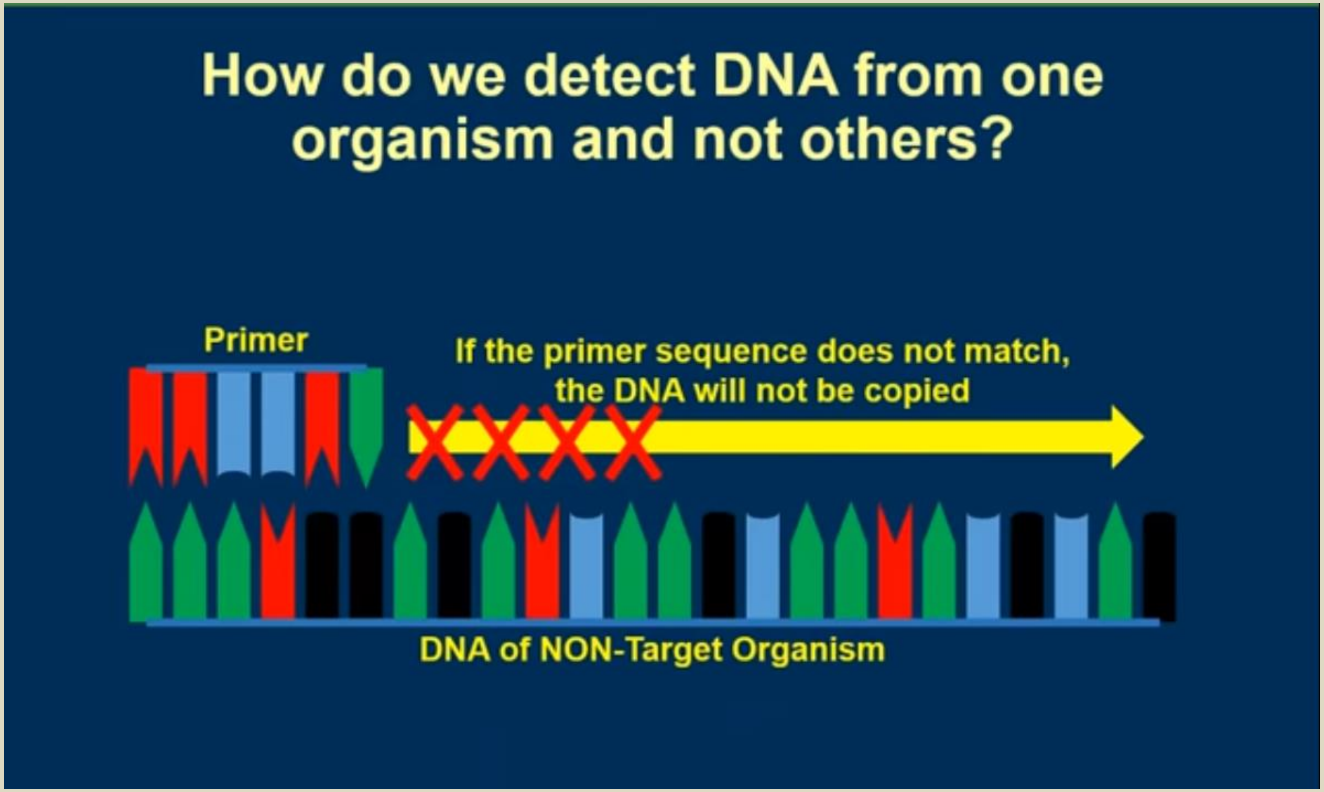
Isolate eulachon specific DNA



Merkes, C. (2017) USGS National Water Quality Monitoring Program

How an eDNA assay works

Isolate eulachon specific DNA



Merkes, C. (2017) USGS National Water Quality Monitoring Program

How an eDNA assay works

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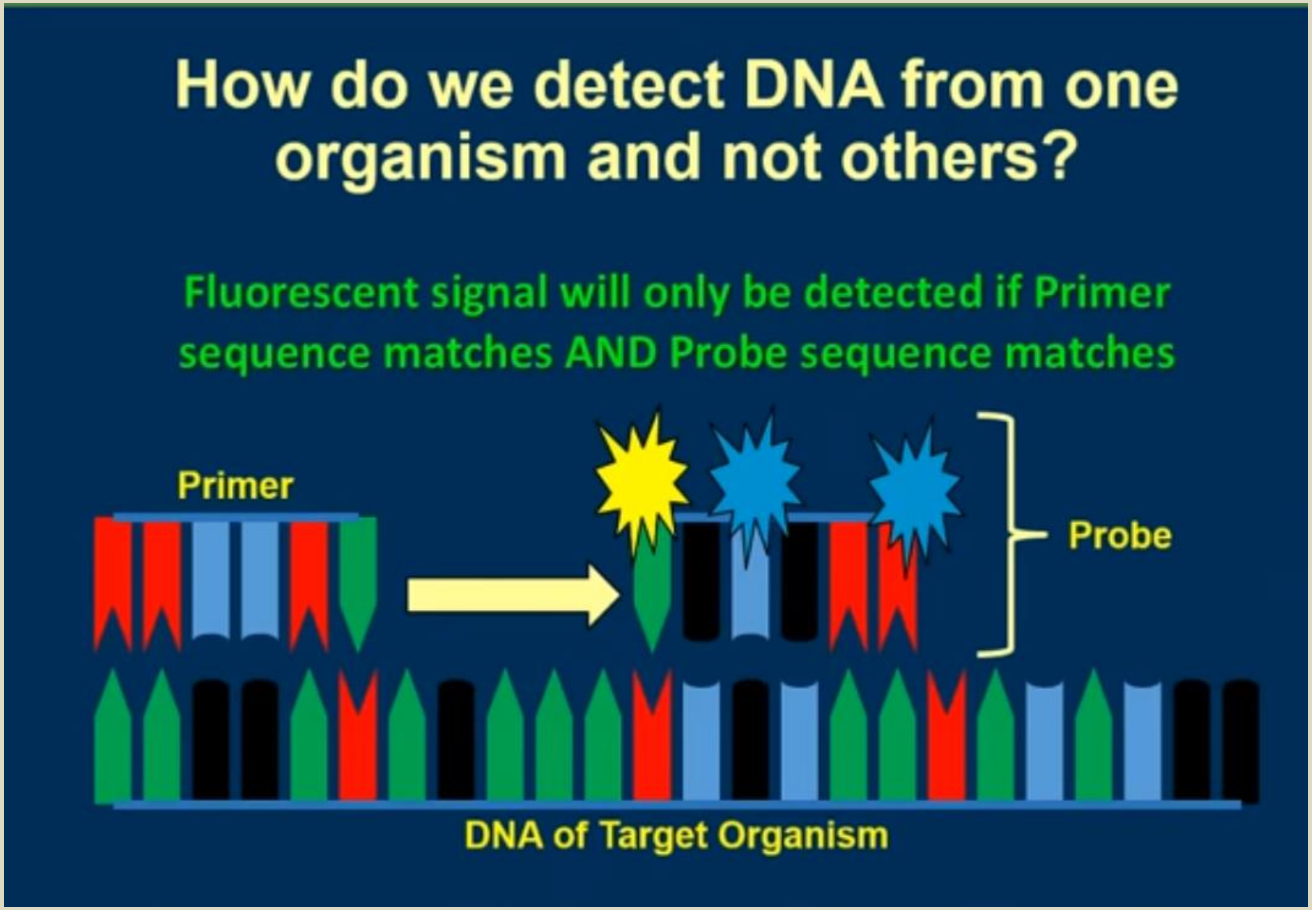
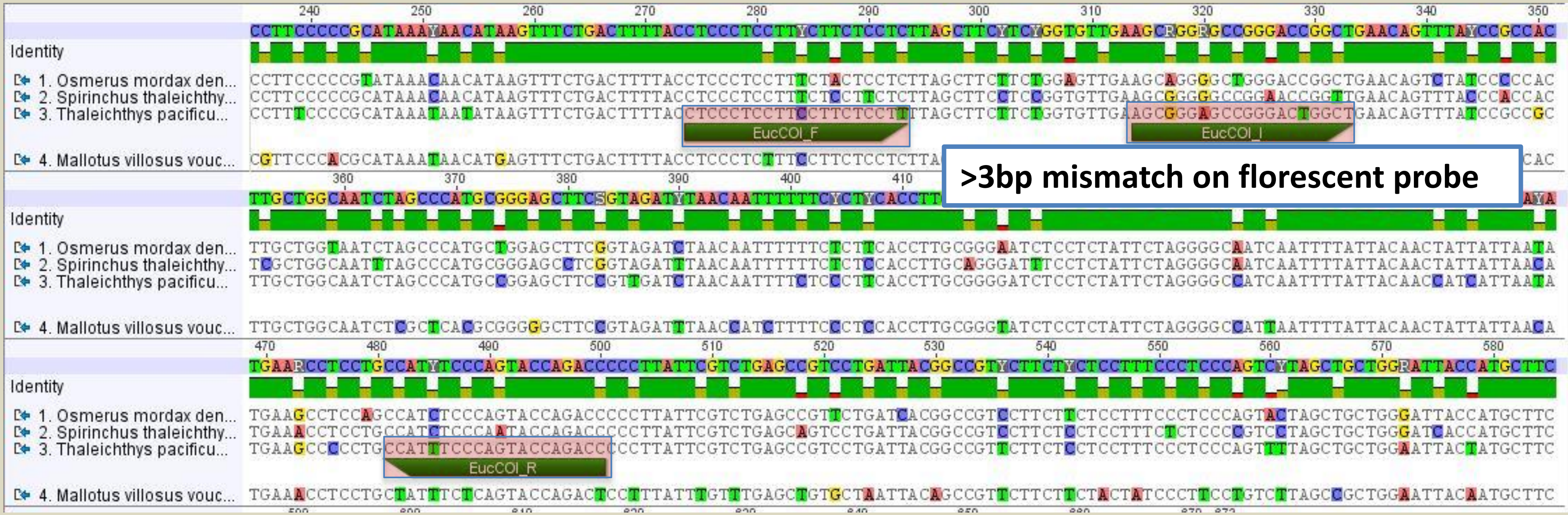


Merkes, C. (2017) USGS National Water Quality Monitoring Program

How an eDNA assay works

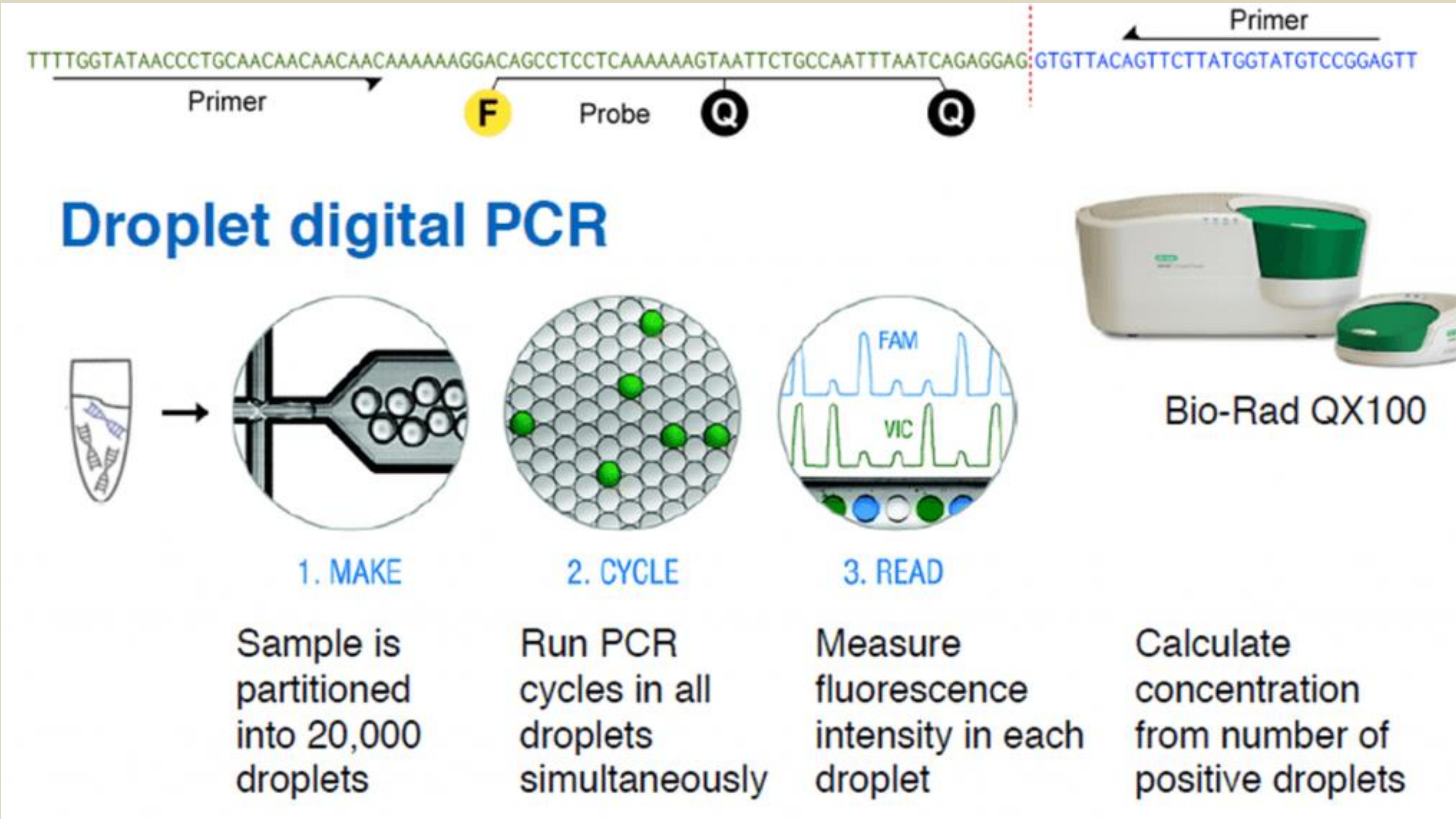
Osmeridae Alignment

Eulachon forward primer has at least 2bp mismatch to other Osmeridae



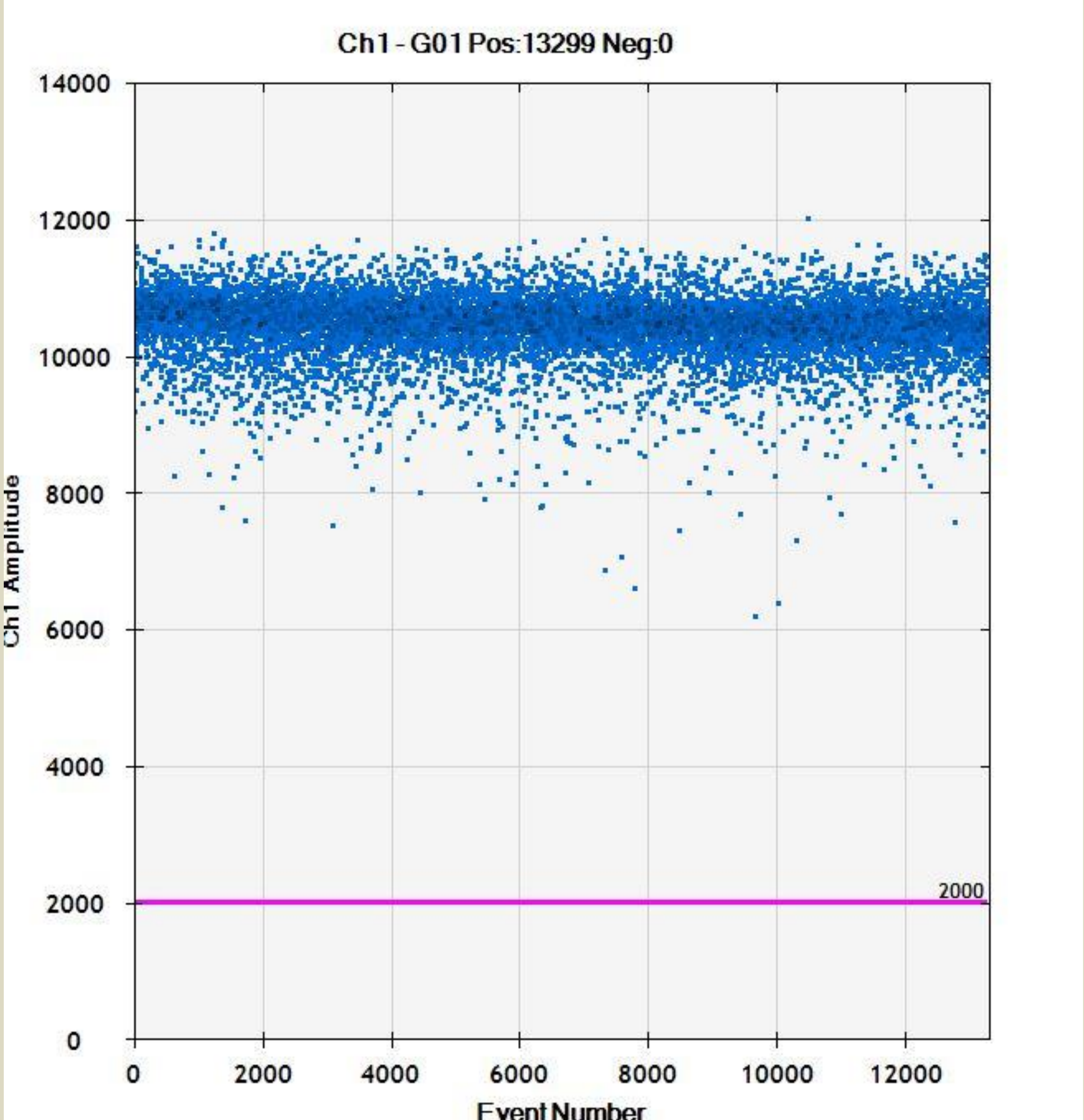
Eulachon reverse primer has 2bp mismatch to longfin smelt and at least 1bp mismatch to other Osmeridae

ddPCR

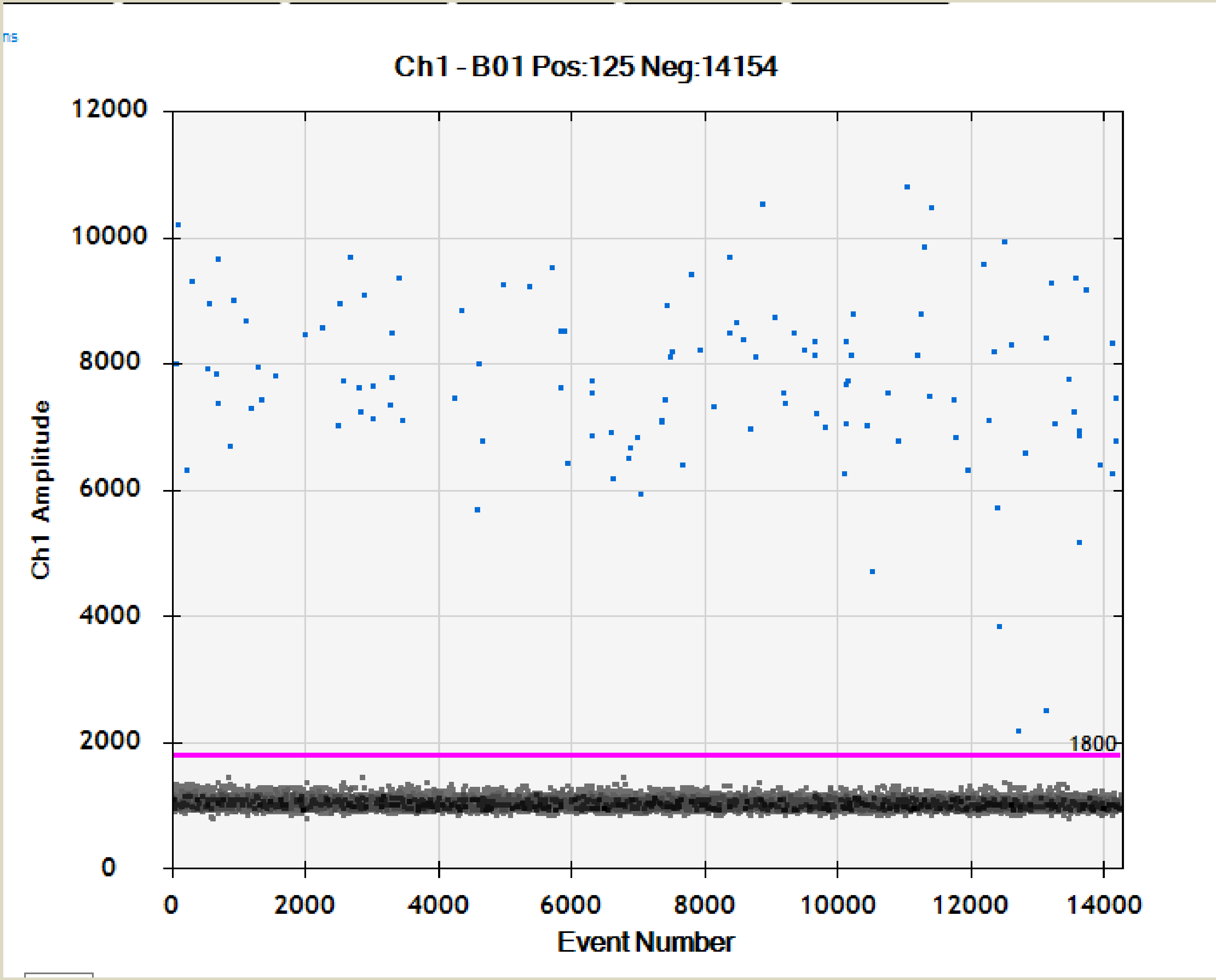


www.labcritics.com

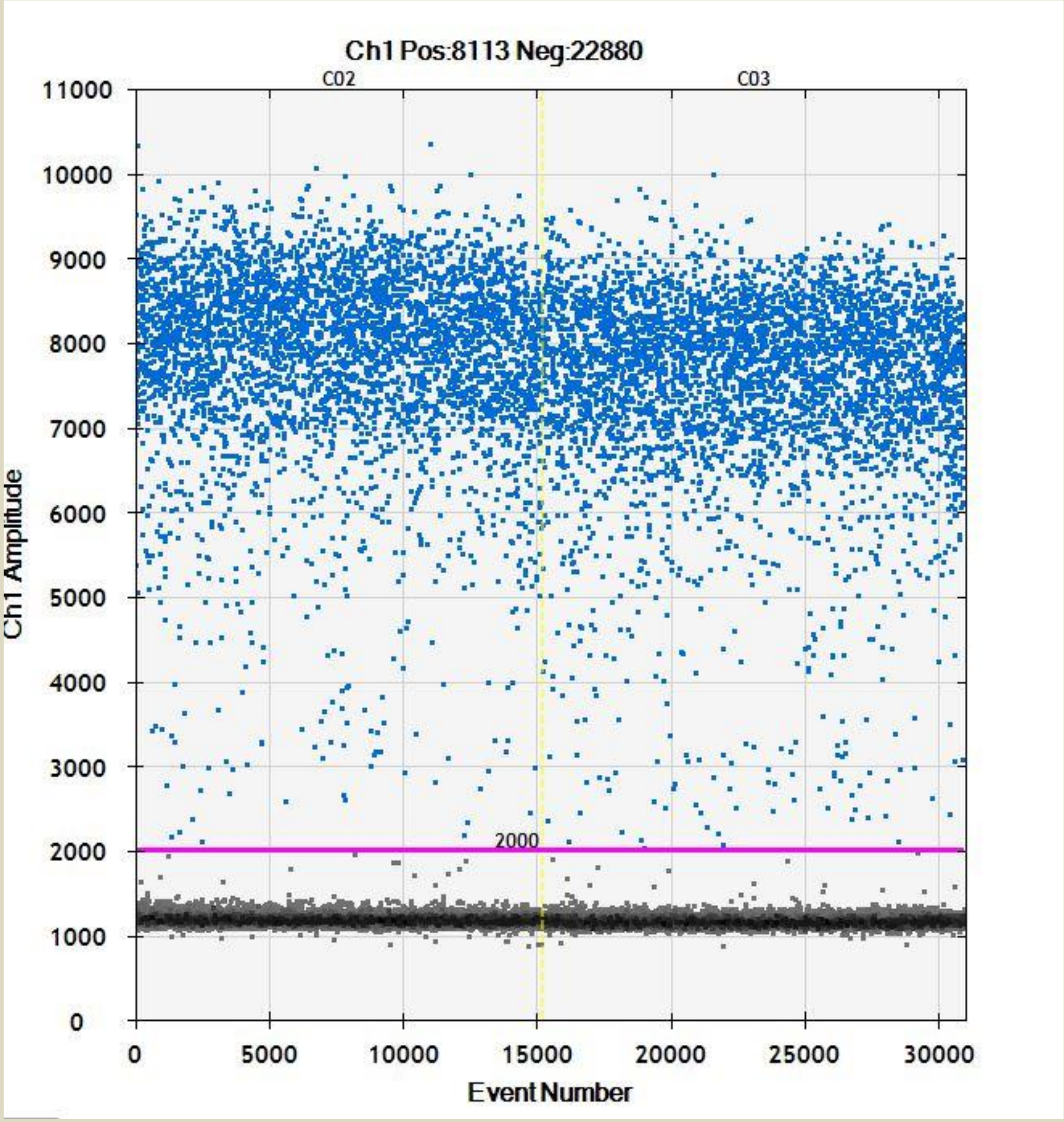
Eulachon Tissue



Eulachon Rare



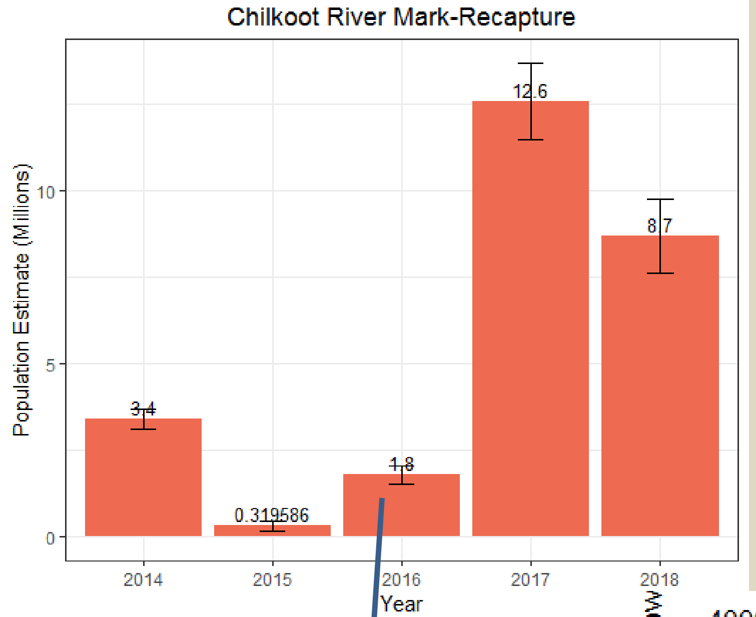
Eulachon Abundant



DNA concentration and species detection is affected by:

- Variance in production among individuals through time (Pilliod et al. 2014, Klymus et al. 2015, Spear et al. 2015)
- Degradations rate – UV, temp. (Barnes et al. 2014, Strickler et al. 2015)
- Transport downstream, dilution, diffusion (Wilcox et al. 2016, Deiner and Altematt 2014, Eichmiller et al. 2014)
  - Flow-corrected concentration: DNA Concentraion (copies/µl) * Discharge (cfs)

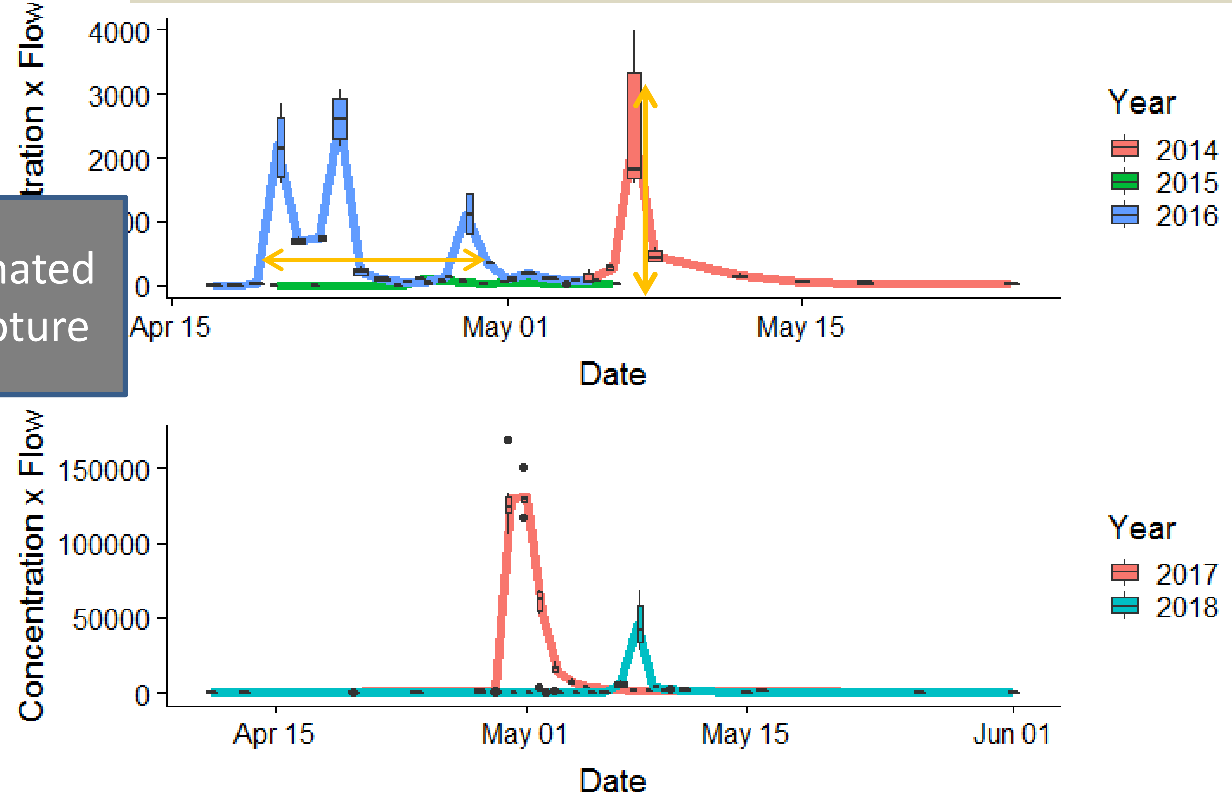
Photo: Felipe Pedrosa



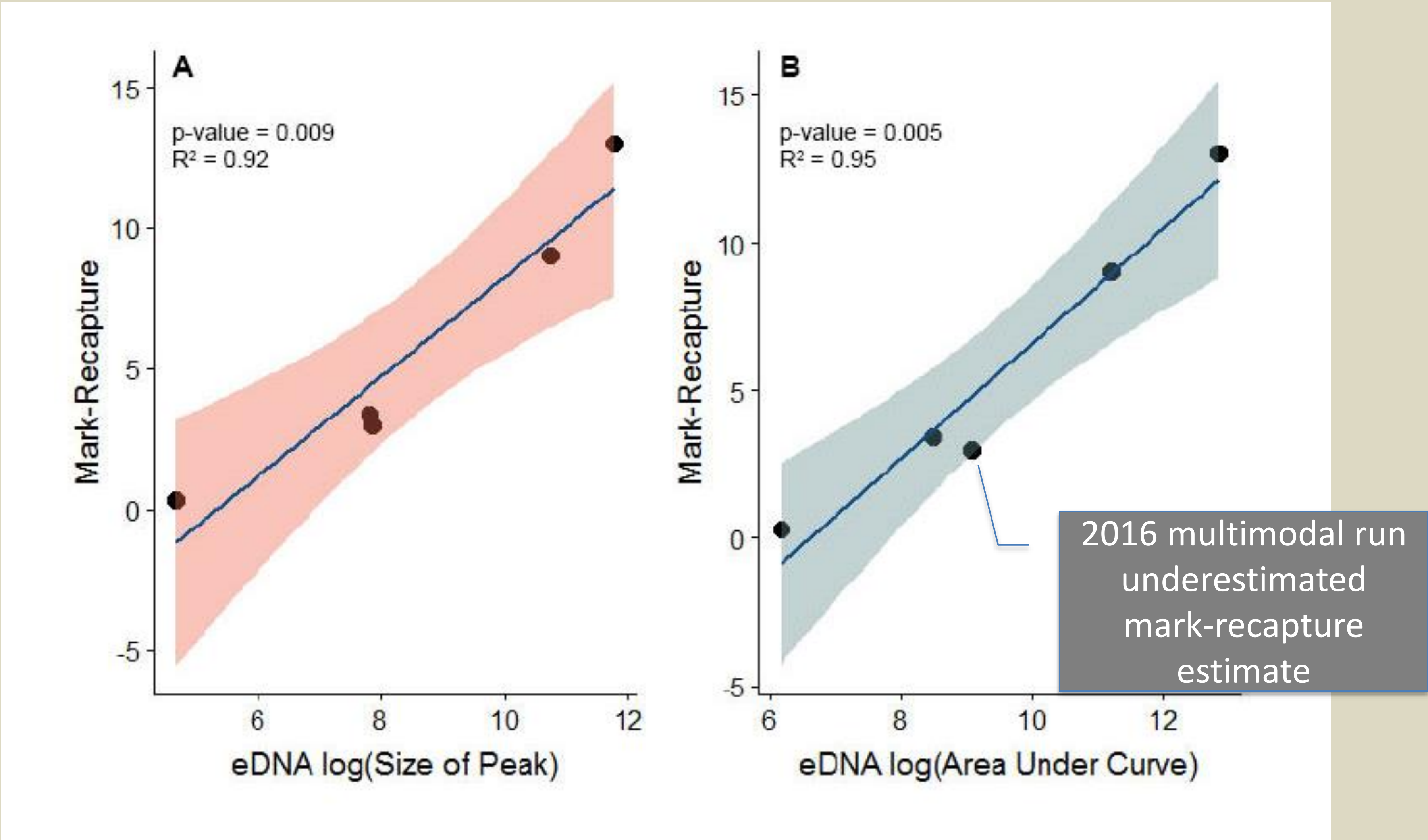
Results

- 2 metrics
  - Size of Peak
  - Area under the curve

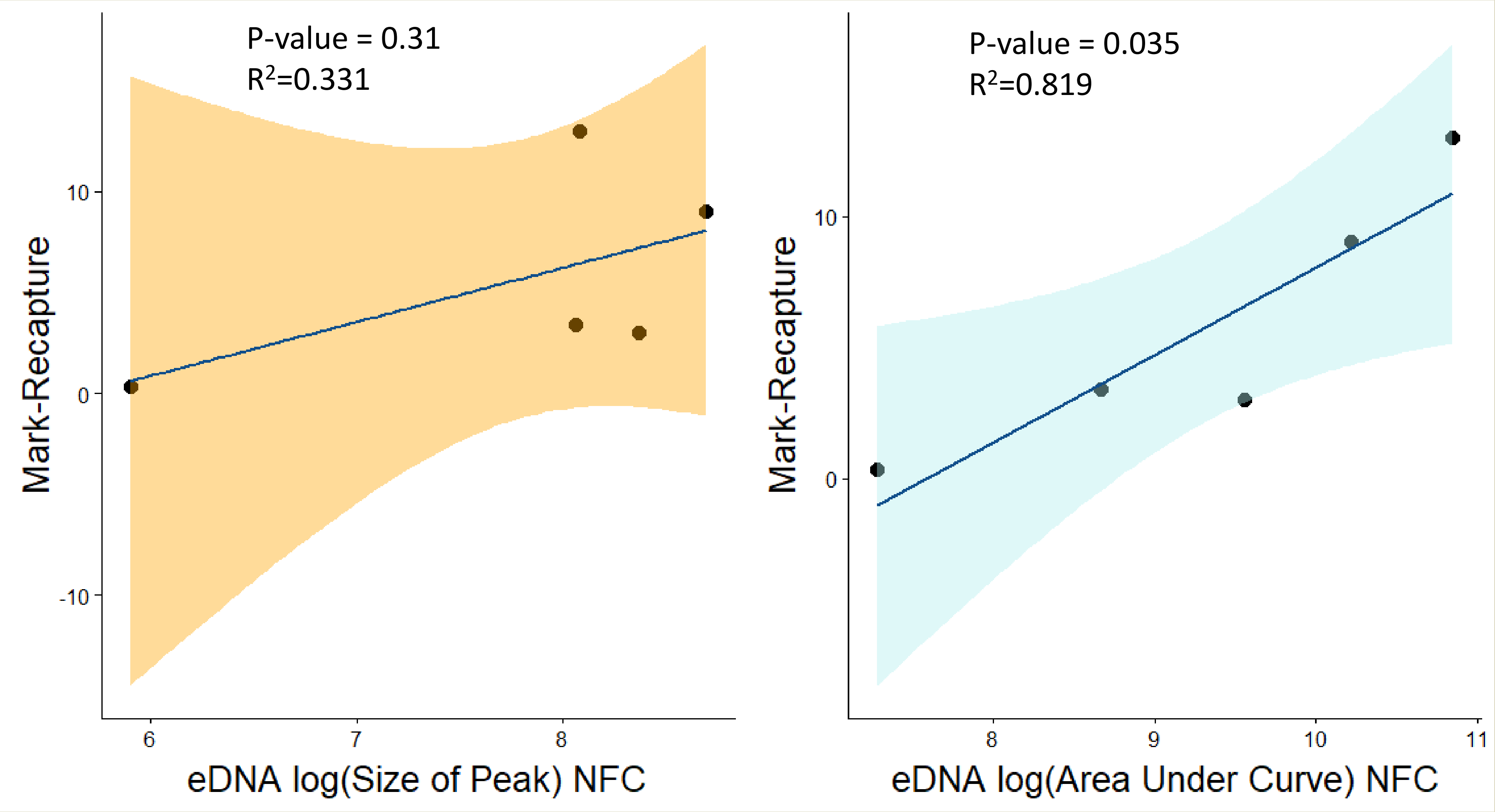
Underestimated mark-recapture



Comparing eDNA & M-R

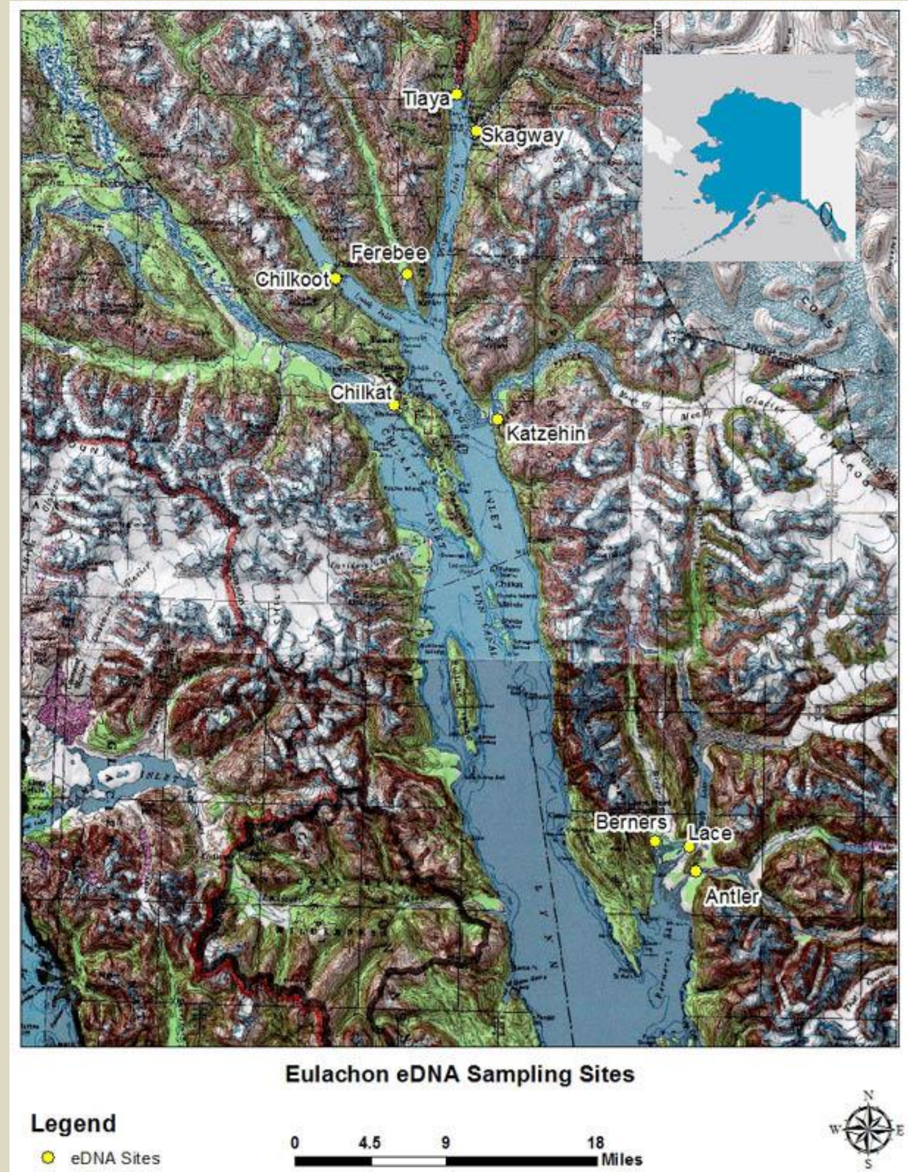


Does Flow-Correcting Matter?

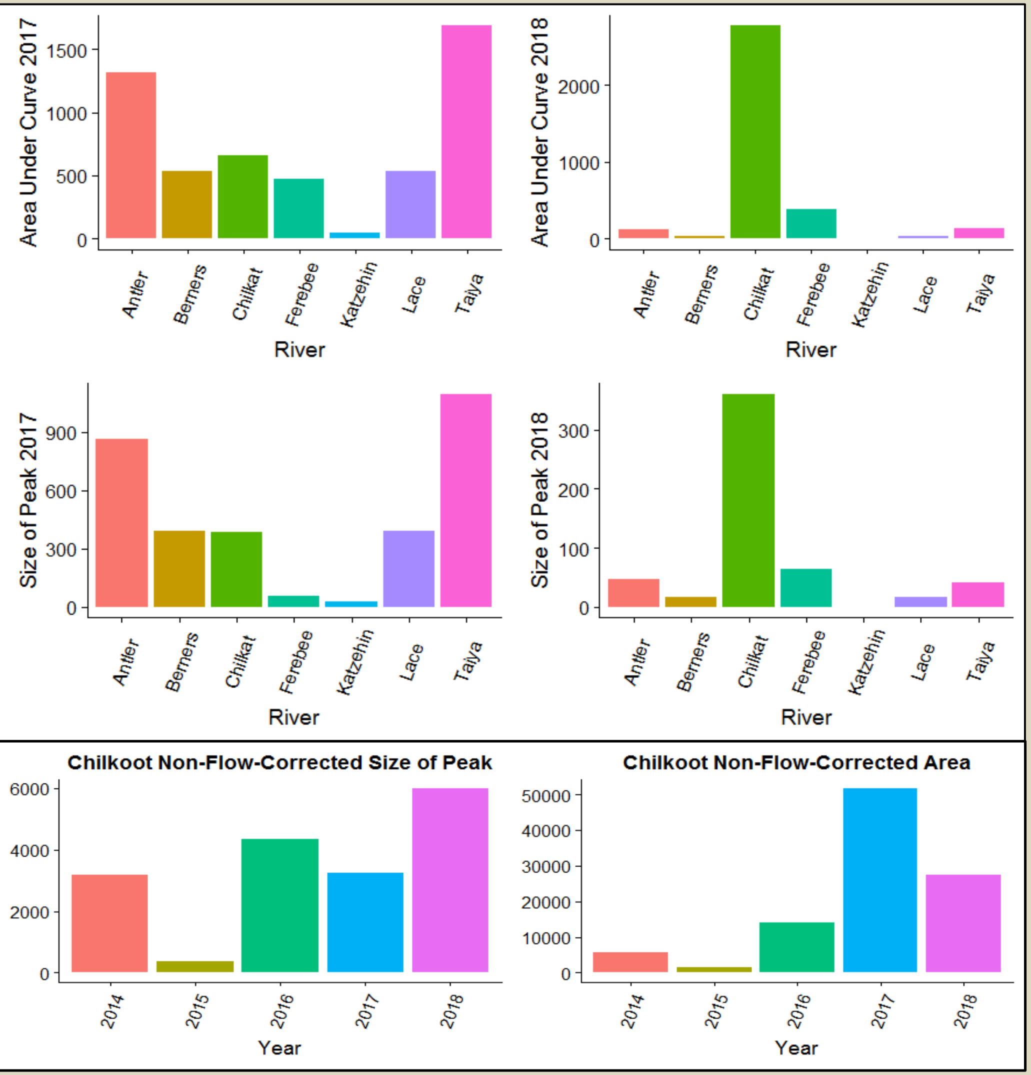


eDNA for Regional Spatial and Temporal Monitoring

- eDNA peak and AUC
  - Flow-correction limitations
- Peak vs. river latitude
- Run timing – environmental covariates (Chilkoot)

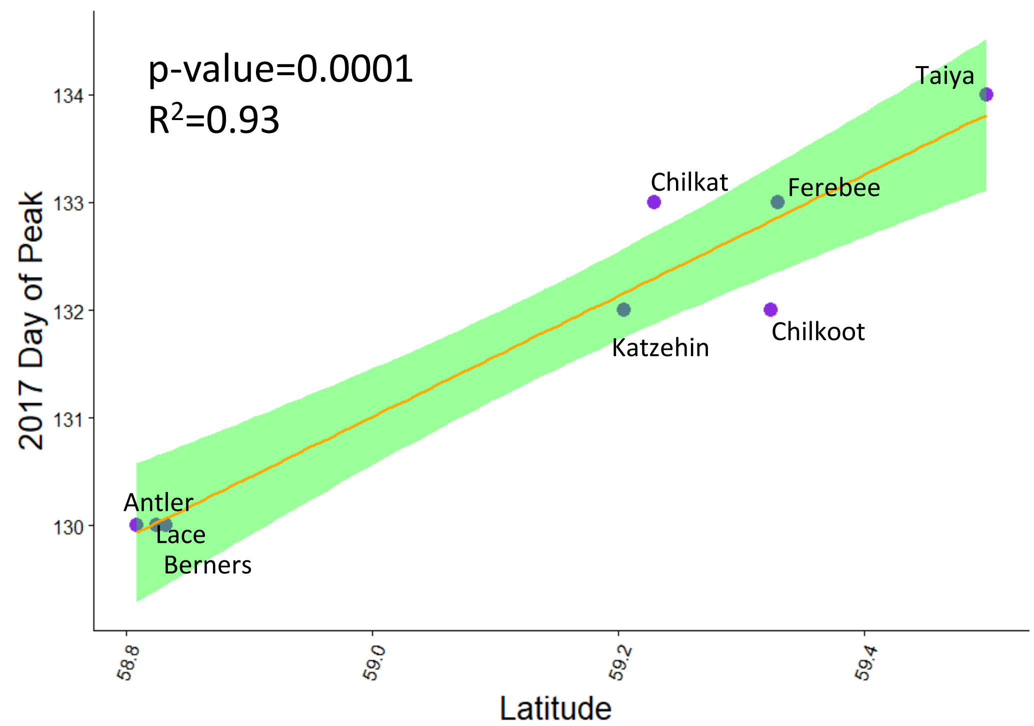


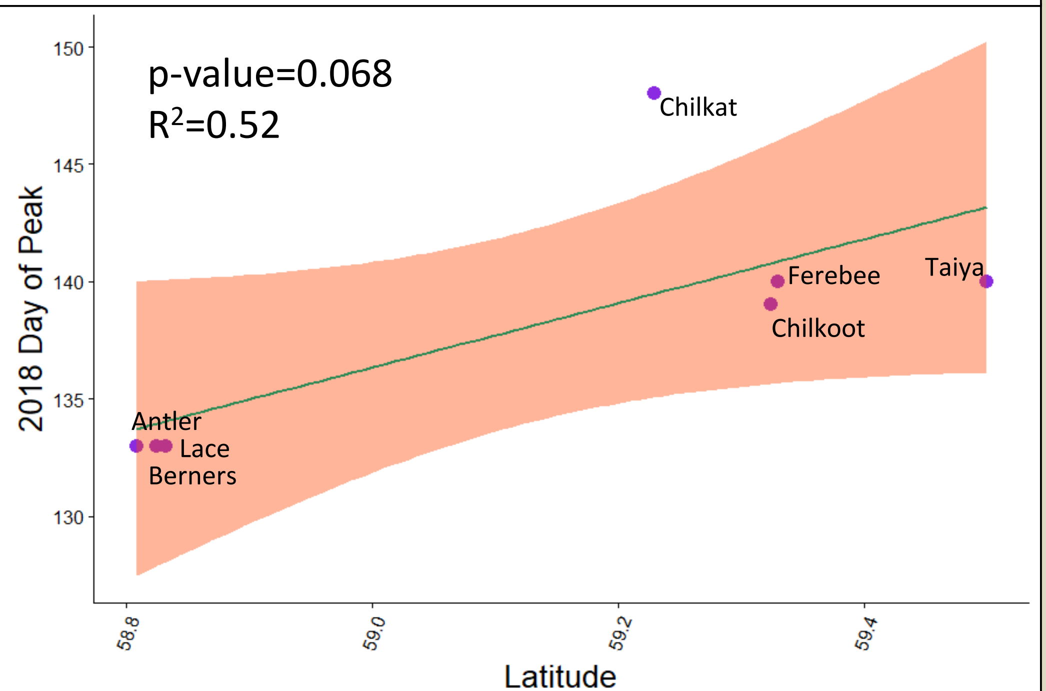
Results



- Chilkoot had highest NFC eDNA in 2017 & 2018
  - Not always typical
- Taiya was 2nd in 2017
- Chilkat 2nd in 2018
- All rivers showed a decline from 2017 to 2018

Latitudinal Migration – "Grease Wave"





Schindler et al., (2013), Armstrong et al. (2016)

Conclusion

- eDNA – cost effective monitoring tool for data-poor species
  - Approx. $50/sample; $3,500 per river
- Regional approach for regional populations
- Flow-correction improves abundance estimates

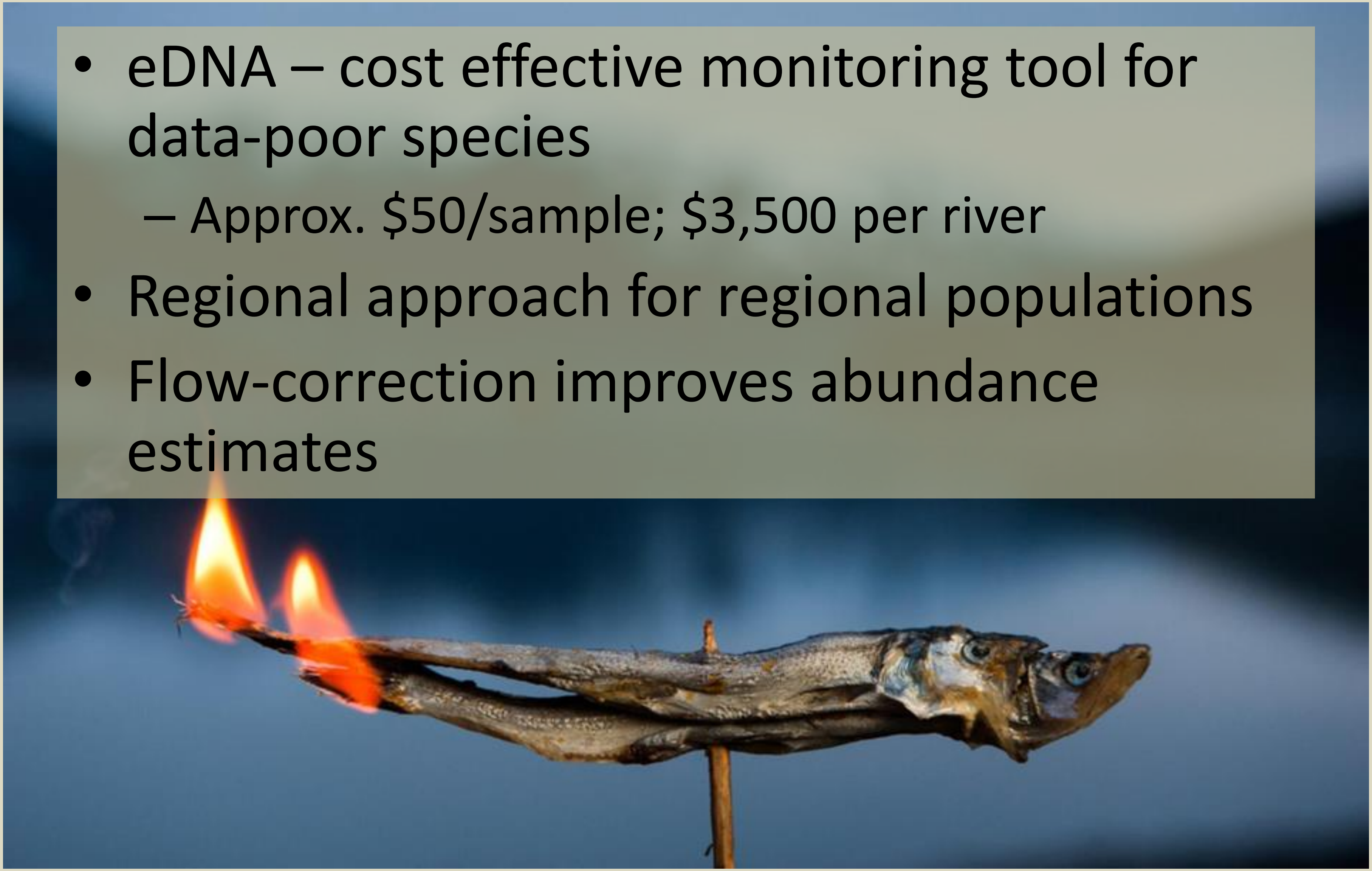


Photo: National Geographic

Future Research

- Auto-sampler, *OSU OPENS Lab*
- Southeast regional tribal eulachon monitoring network
  - Expanding to new areas that are unmonitored
- Regional flow-correction
  - Inter-river comparison
  - Discharge model and/or surrogate flow (Hill et al. 2015)
- Life history investigation
  - Age at spawning, size, reproduction

Thanks to the Partners!

Chilkoot Indian Association

Takshanuk Watershed Council
Haines, Alaska

OSU
Oregon State
UNIVERSITY

Taiya Inlet
Watershed Council

NATIONAL
PARK
SERVICE

And our Funding Organizations!

NORTH PACIFIC LANDSCAPE
CONSERVATION COOPERATIVE

AK CSC
Alaska Climate Science Center

U.S. DEPARTMENT OF THE INTERIOR
1824
BUREAU OF INDIAN AFFAIRS

U.S.
FISH & WILDLIFE
SERVICE
DEPARTMENT OF THE INTERIOR

Questions

Chilkoot River packed with eulachon in 2011!