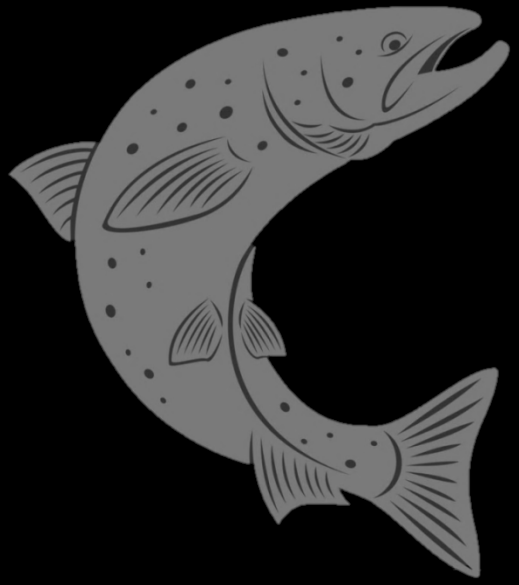
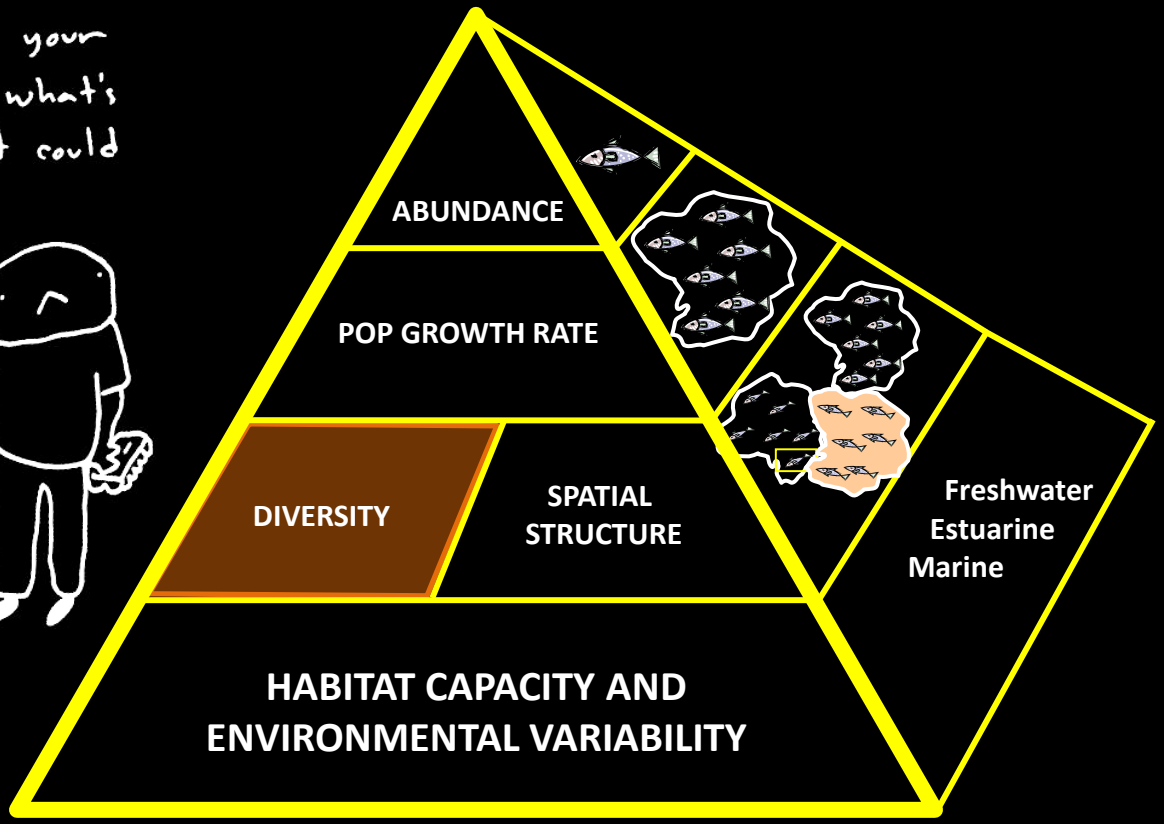
Using otolith strontium isotopes to reconstruct life history portfolios within salmon populations:

When do different phenotypes contribute?



Anna Sturrock, JD Wikert, Tim Heyne, Carl Mesick,
Alan Hubbard, Peter Weber, George Whitman, Justin Glessner,
Stephanie Carlson, Travis Hinkelman, Rachel Johnson

Salmon Population Viability

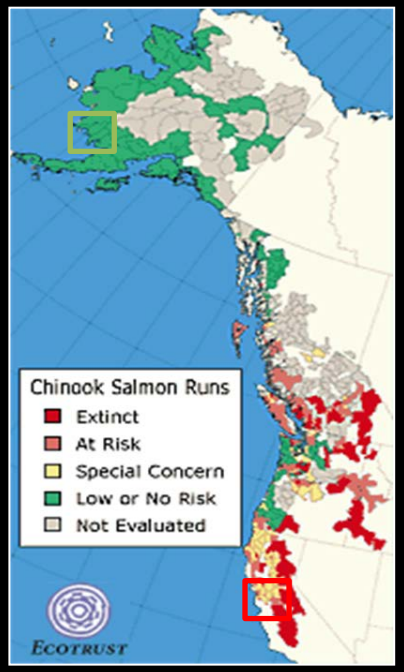


Graphic courtesy of S. Lindley and T. Williams

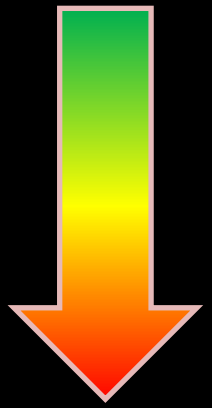
The Portfolio Effect

Population diversity and the portfolio effect in an exploited species

Daniel E. Schindler[1], Ray Hilborn[1], Brandon Chasco[1], Christopher P. Boatright[1], Thomas P. Quinn[1], Lauren A. Rogers[1] & Michael S. Webster[2]



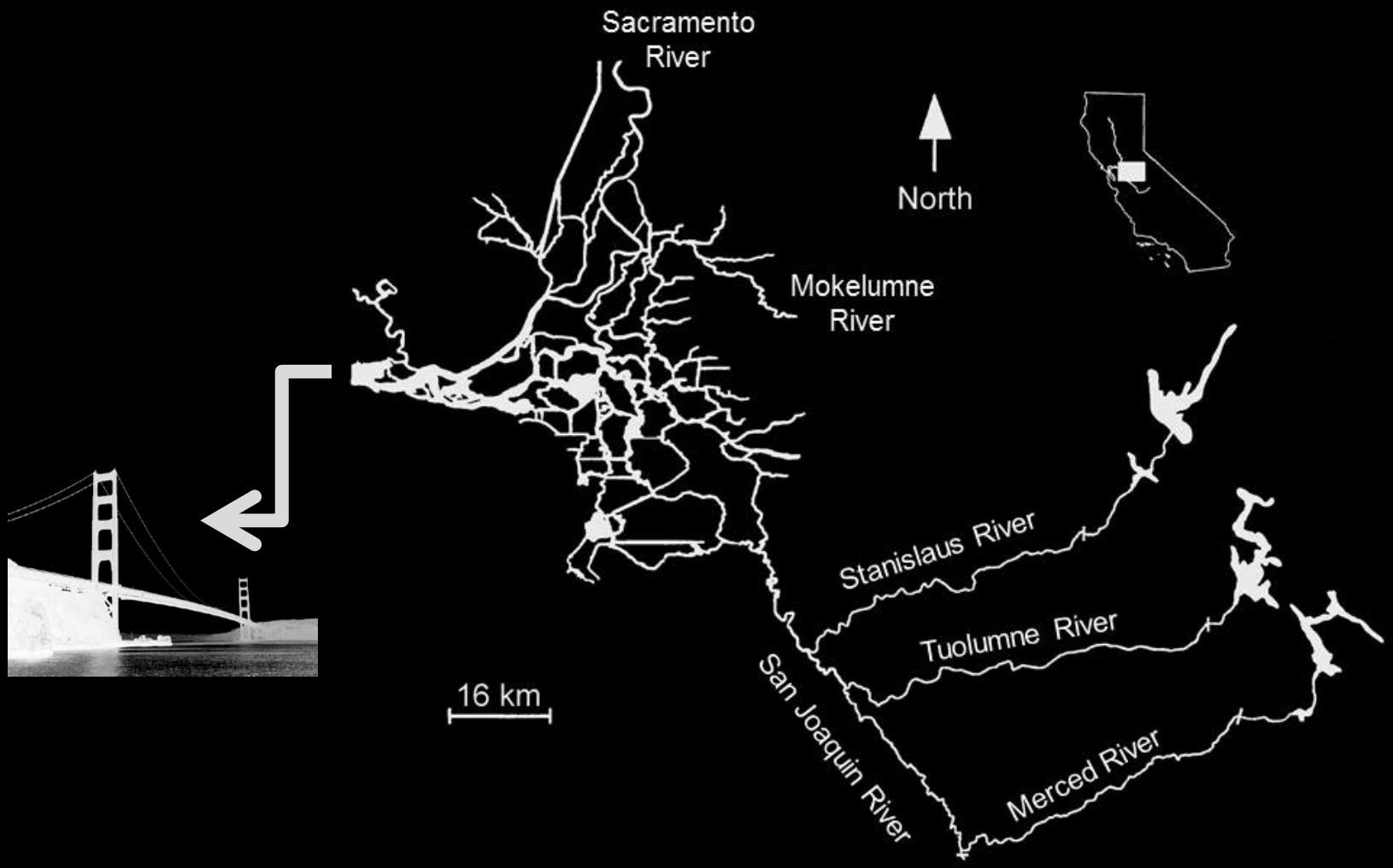
Returns 41-77% more stable than in individual stocks



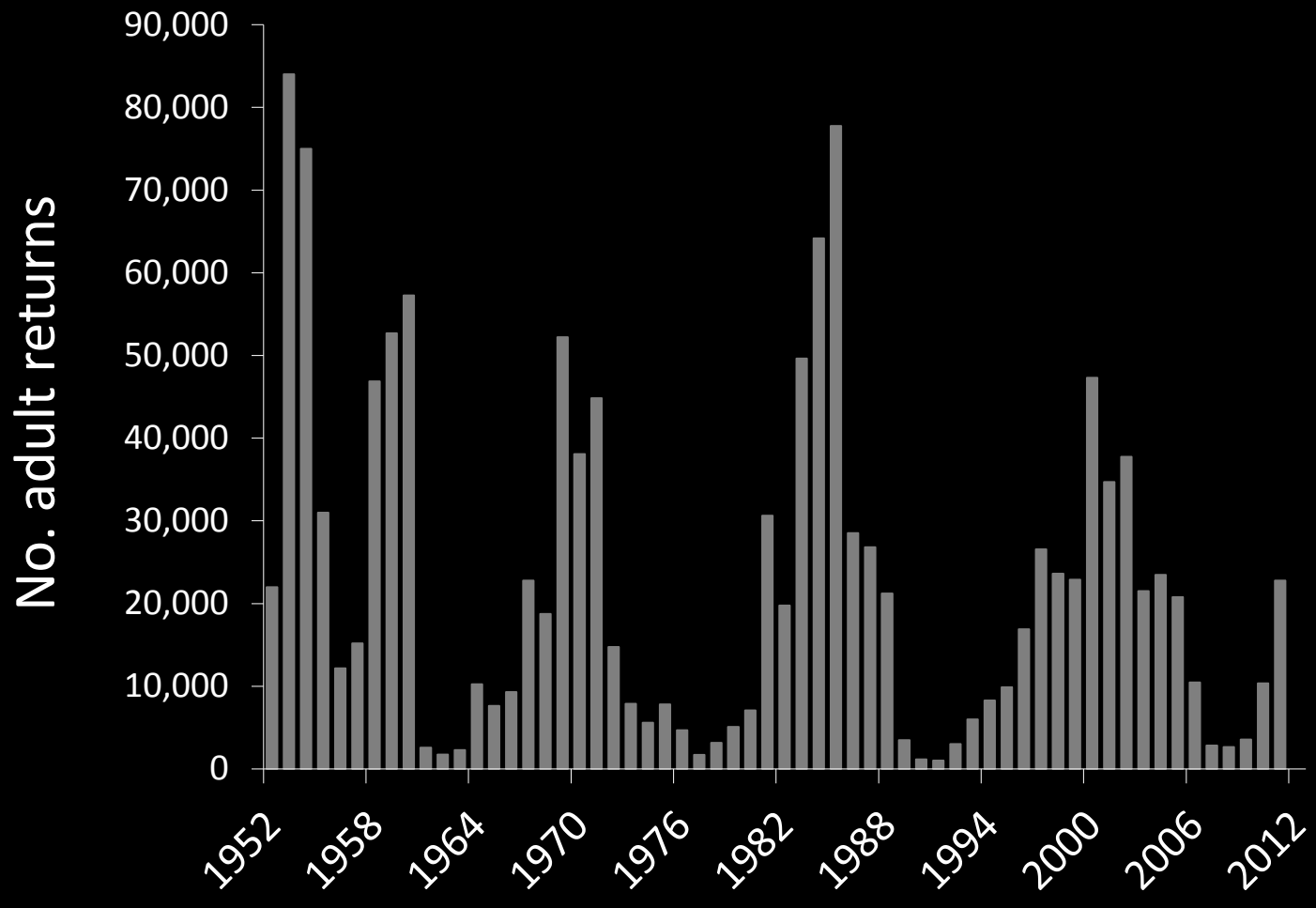
Weakened portfolio effect in a collapsed salmon population complex

Stephanie Marie Carlson and William Hallowell Satterthwaite

The San Joaquin Basin

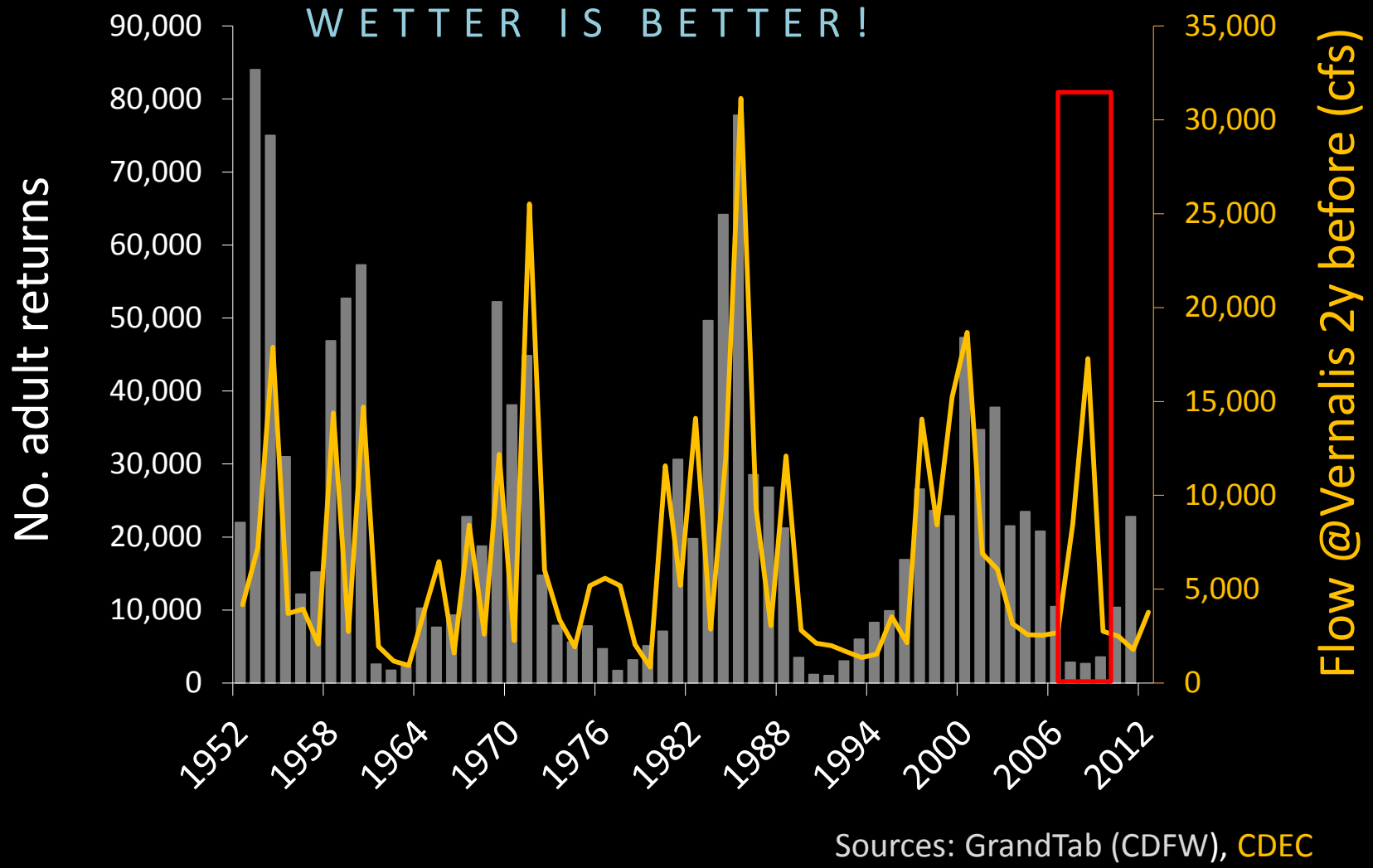


The San Joaquin Basin

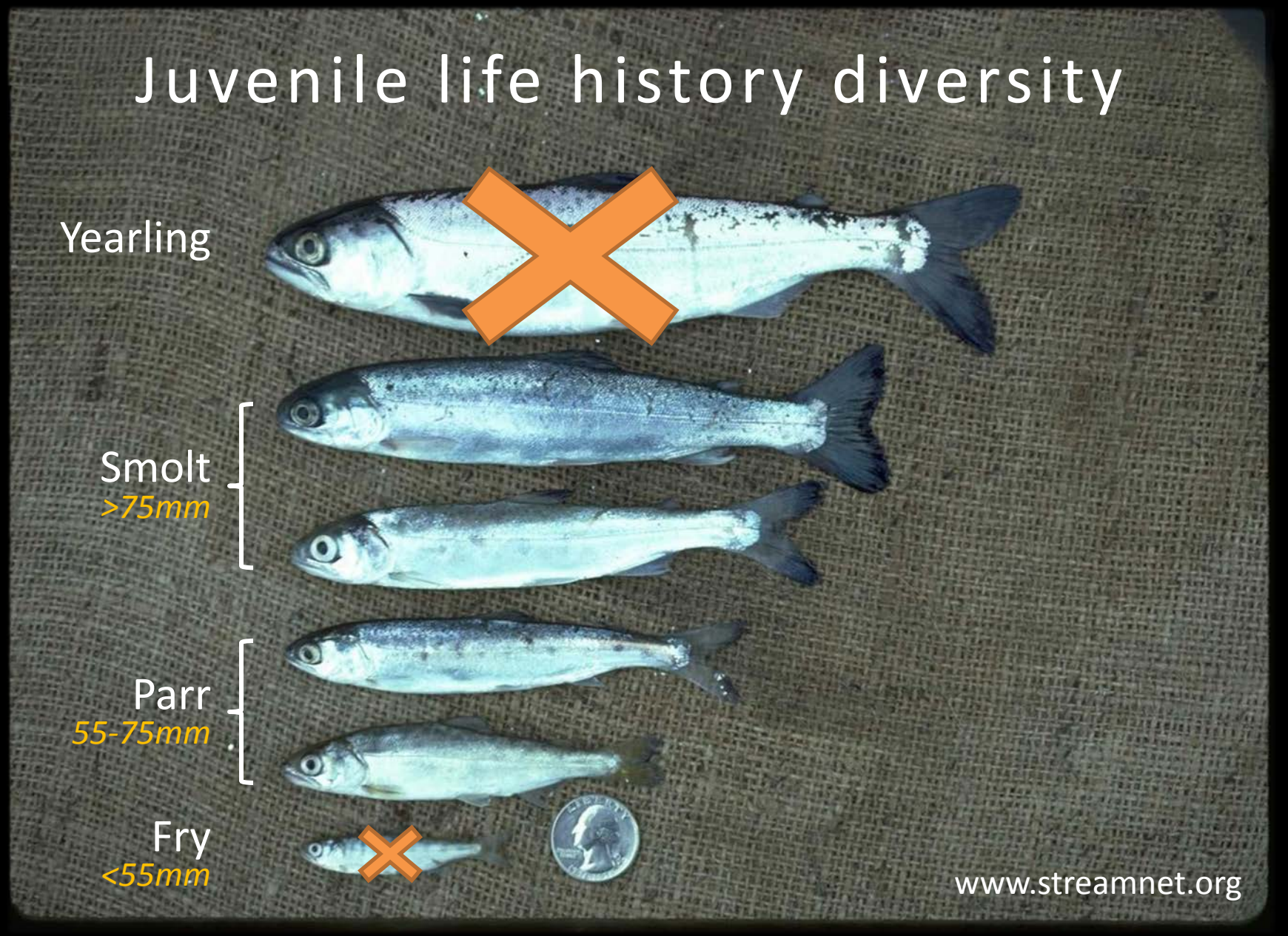


Sources: GrandTab (CDFW)

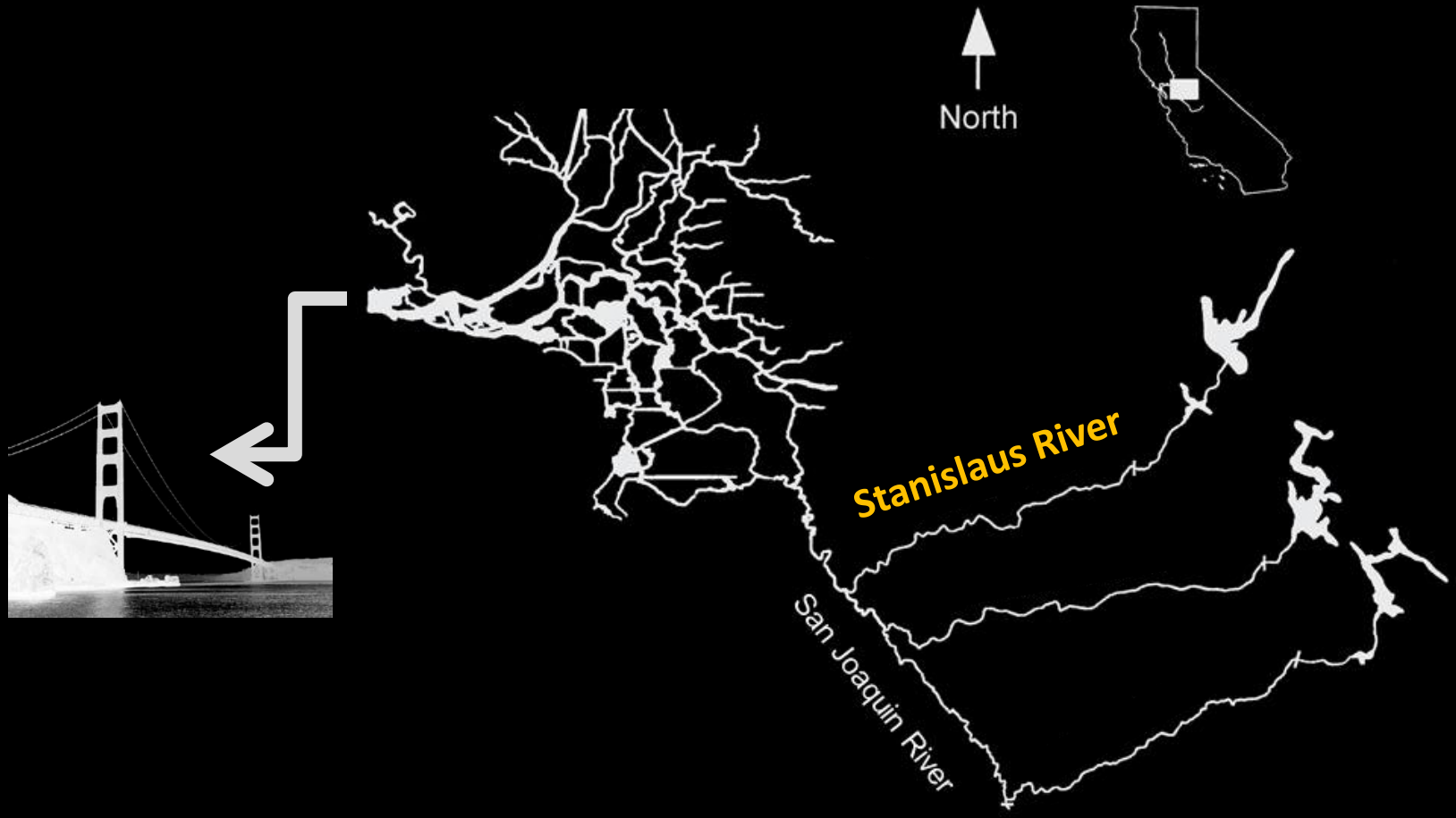
The San Joaquin Basin



Sources: GrandTab (CDFW), CDEC

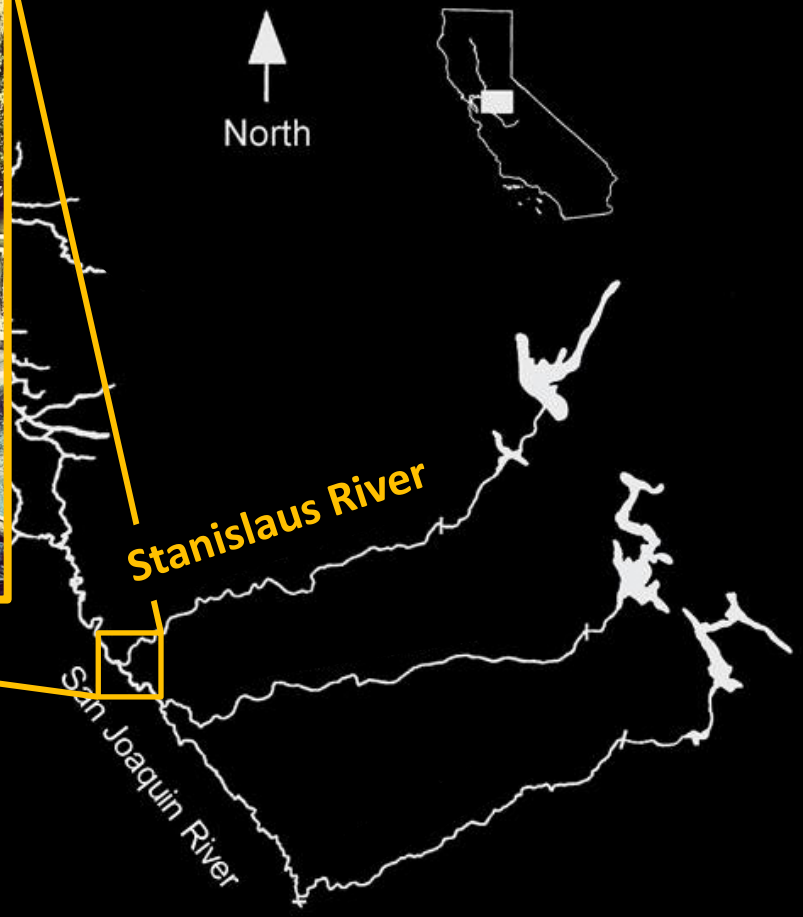

Juvenile life history diversity
Yearling
Smolt
>75mm
Parr
55-75mm
Fry
<55mm
www.streamnet.org

Juvenile outmigration (Jan-Jun)



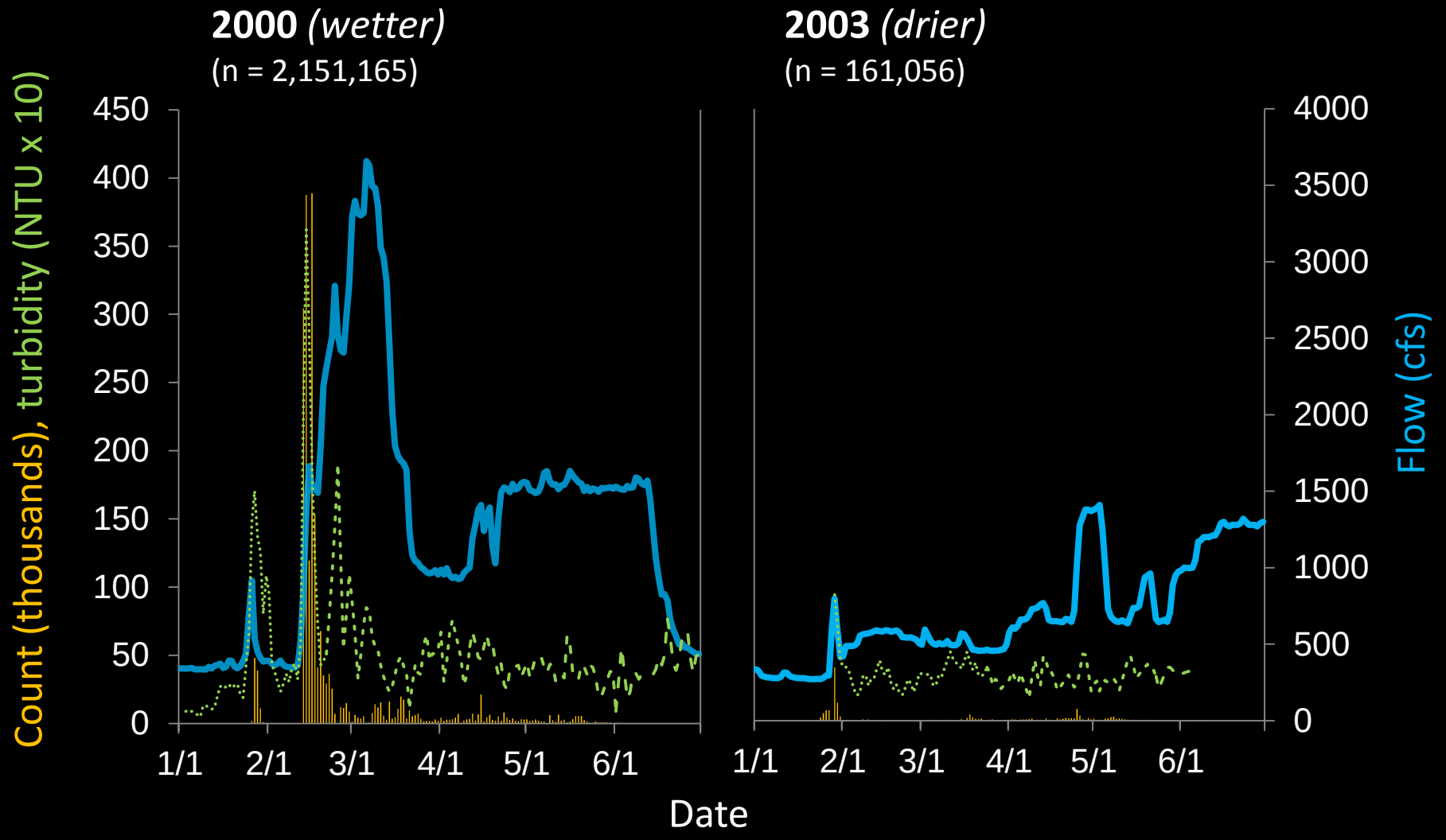
Juvenile outmigration (Jan-Jun)

RST
(N, timing, size)

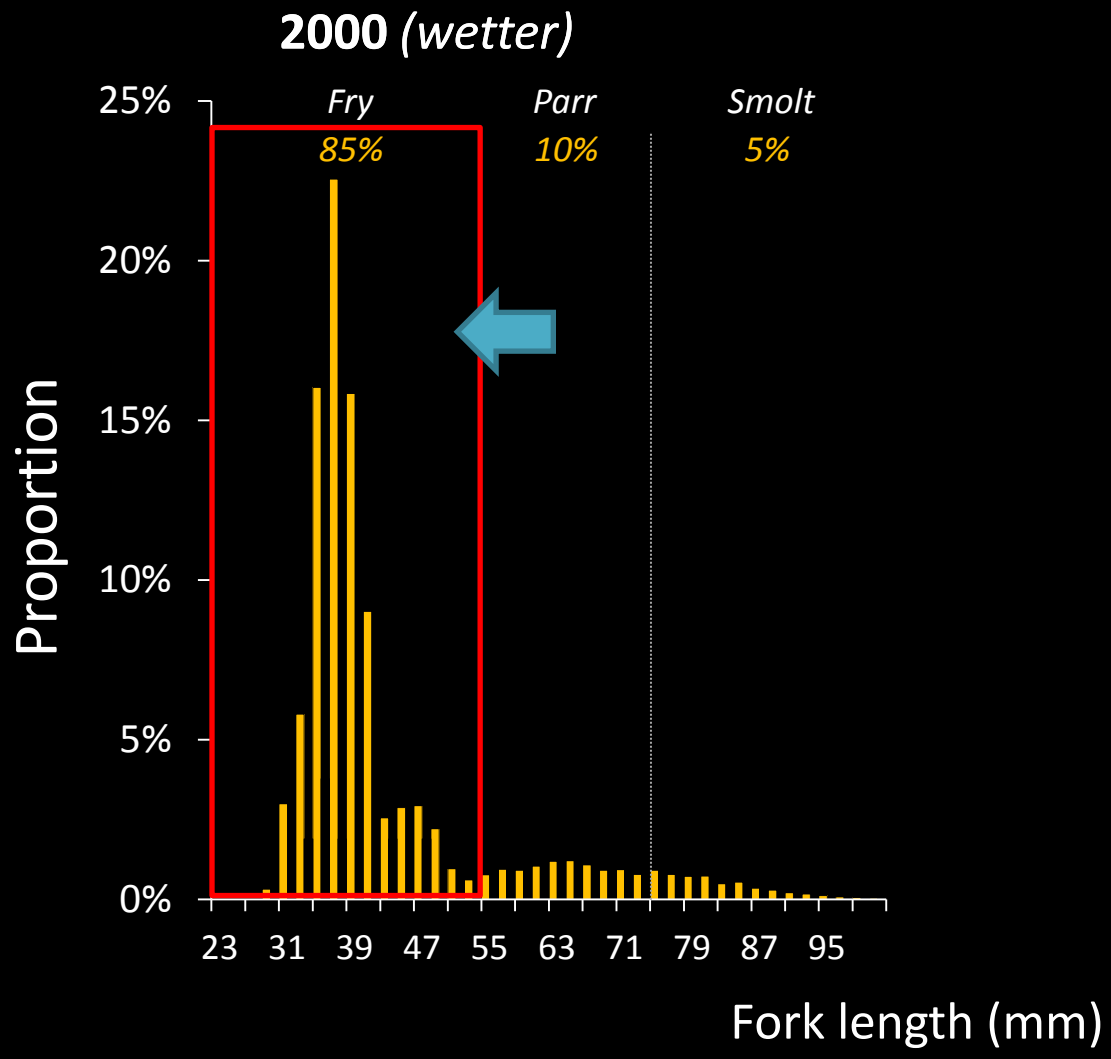


Zeug et al (2014) Response of juvenile Chinook salmon to managed flow: lessons learned from a population at the southern extent of their range in North America. *Fisheries Management and Ecology*

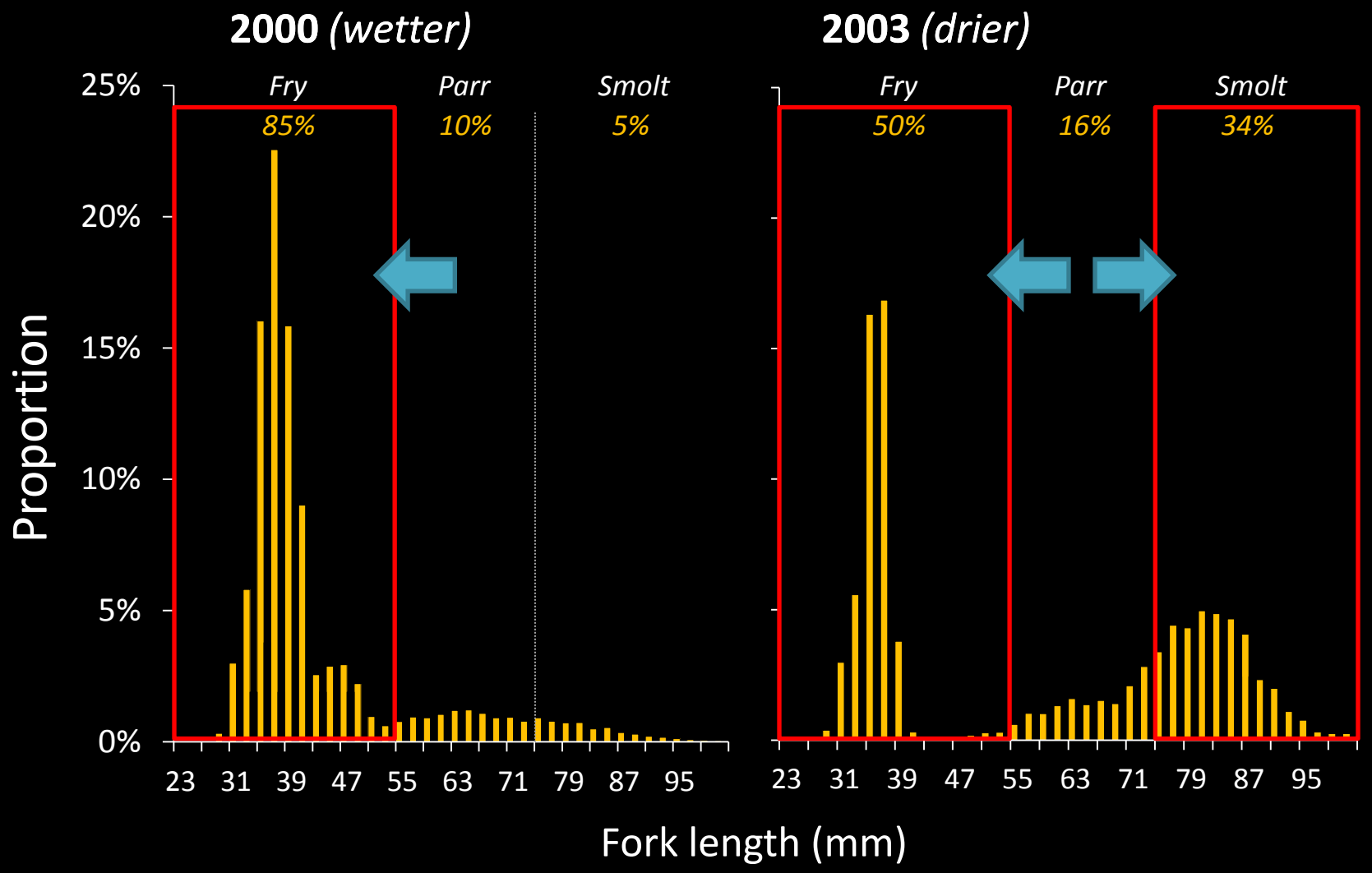
Juvenile outmigration (Jan-Jun)



Size at outmigration

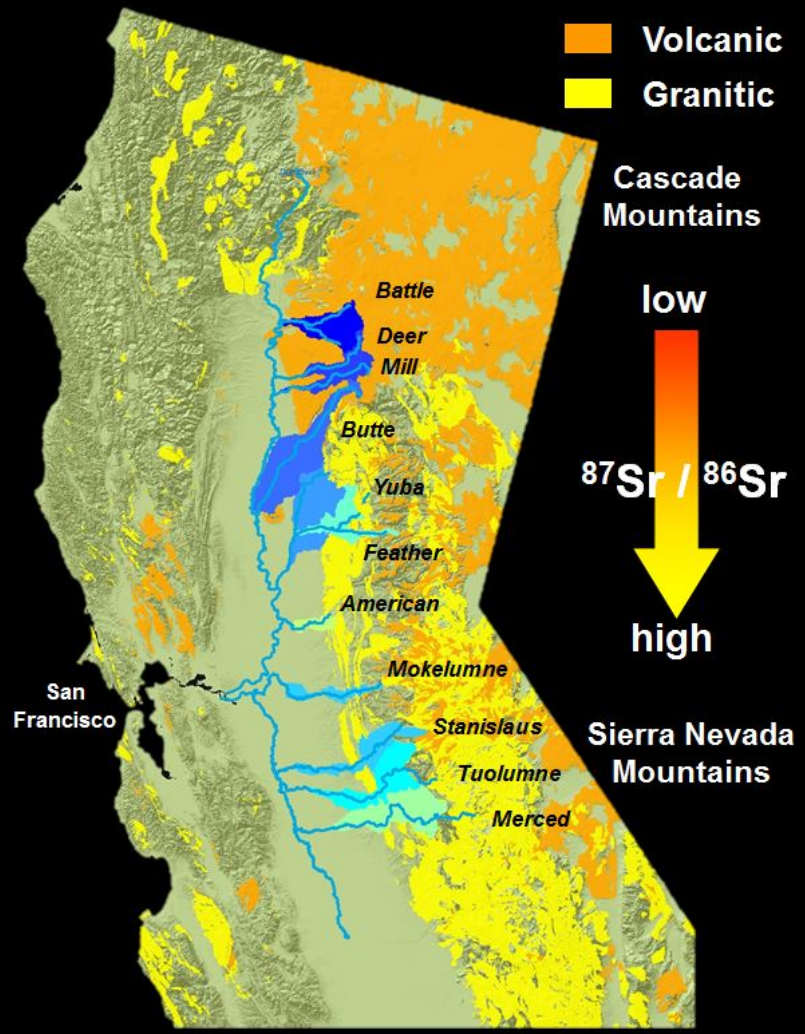


Size at outmigration



Otolith reconstructions

$^{87}Sr/^{86}Sr$ ISOSCAPE



Adult sampling (fall)

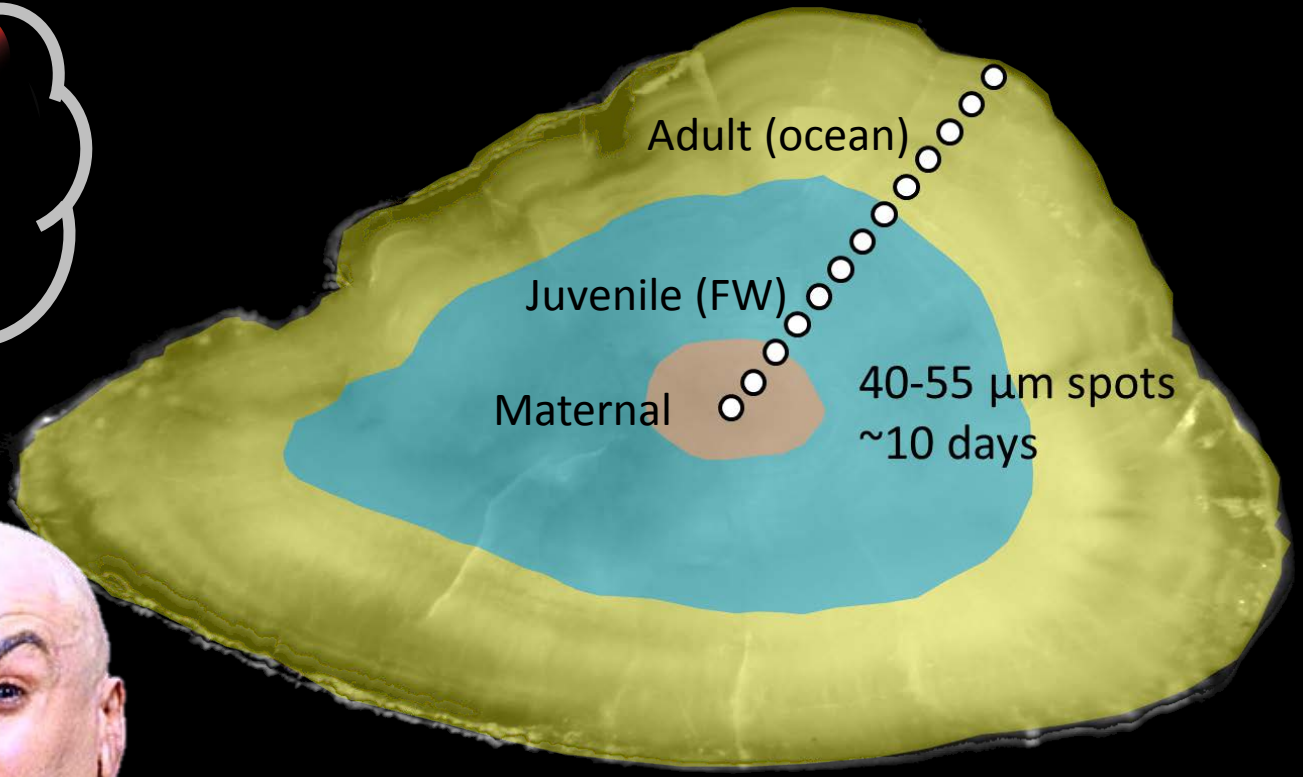
Carcass survey *(CDFW)*

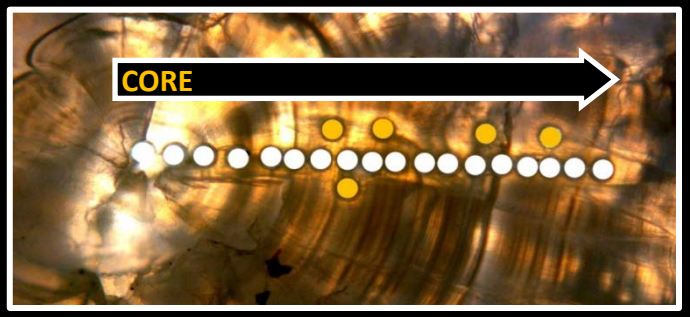
Scales *(age, cohort)*

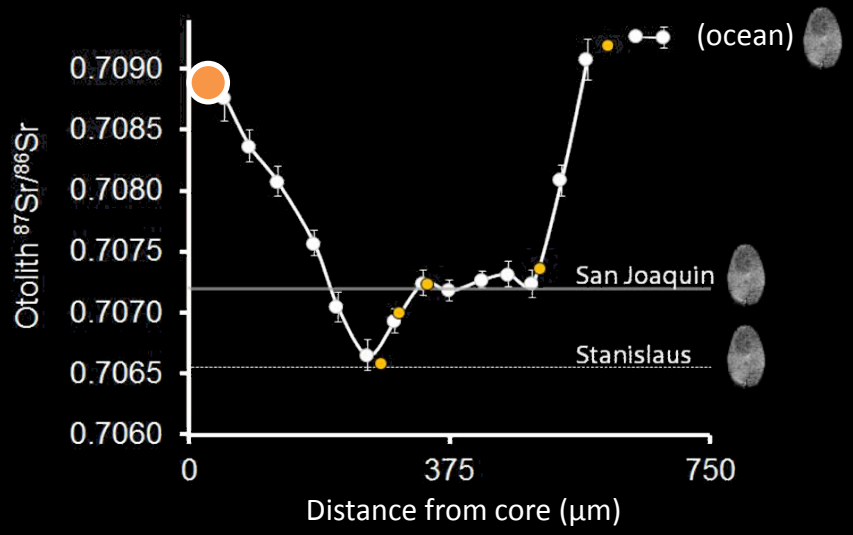
Otoliths *(origin, size)*

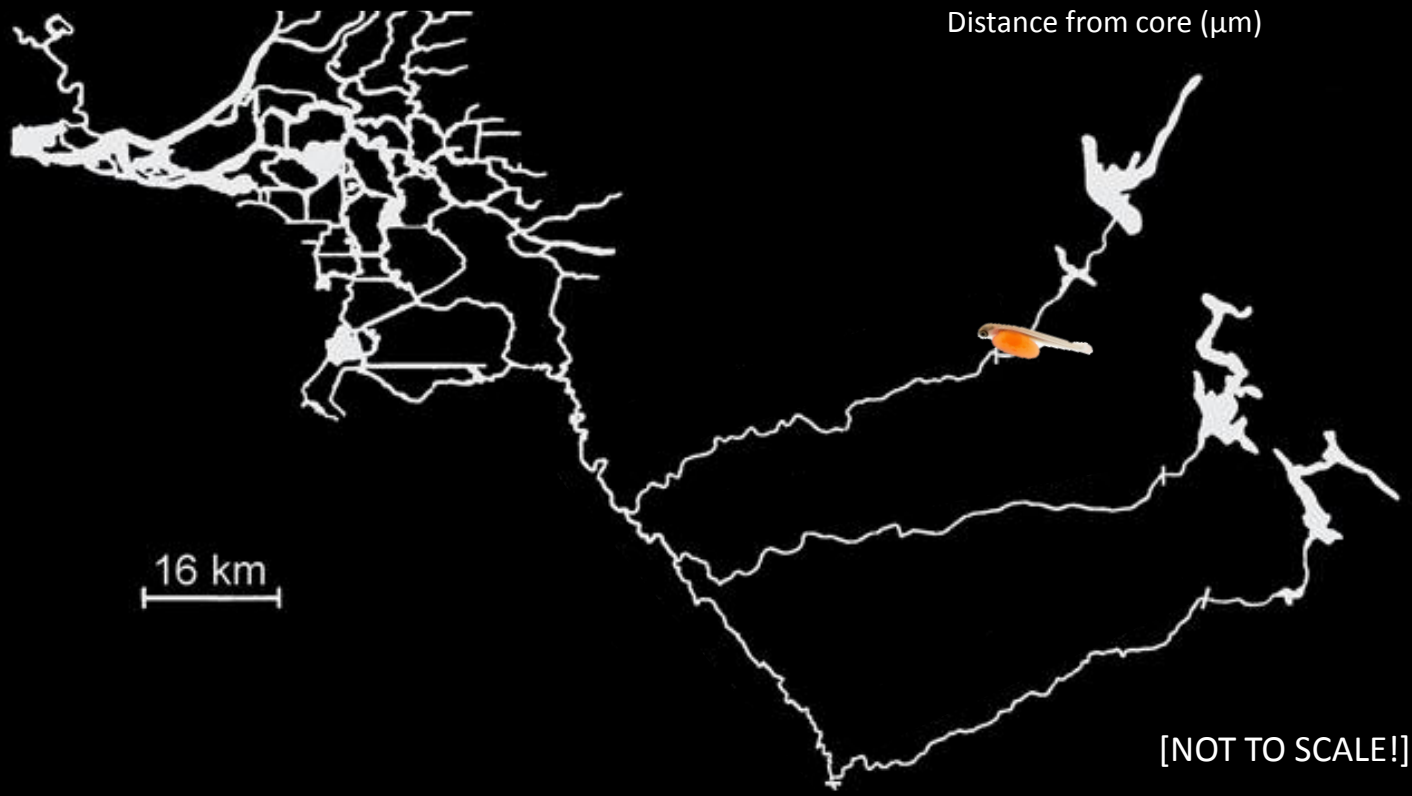
Mark-recapture *(abundance)*

Decoding the flight box recorder

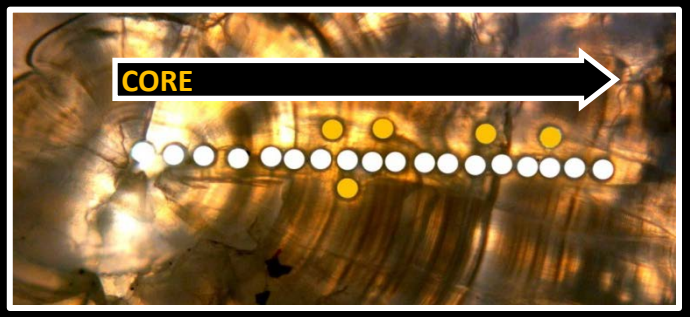


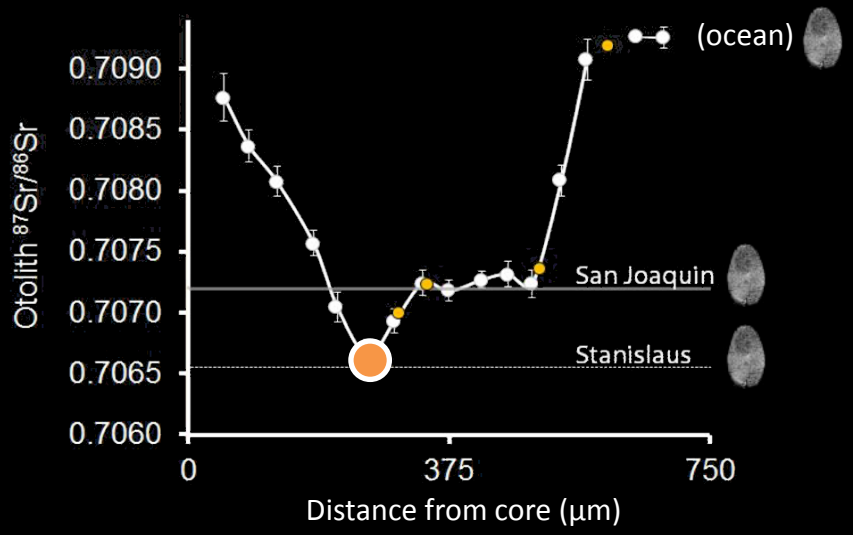

CORE


(ocean)
0.7090
0.7085
0.7080
0.7075
0.7070
0.7065
0.7060
Otolith $^{87}Sr/^{86}Sr$
San Joaquin
Stanislaus
0
375
750
Distance from core (µm)


16 km

[NOT TO SCALE!]


CORE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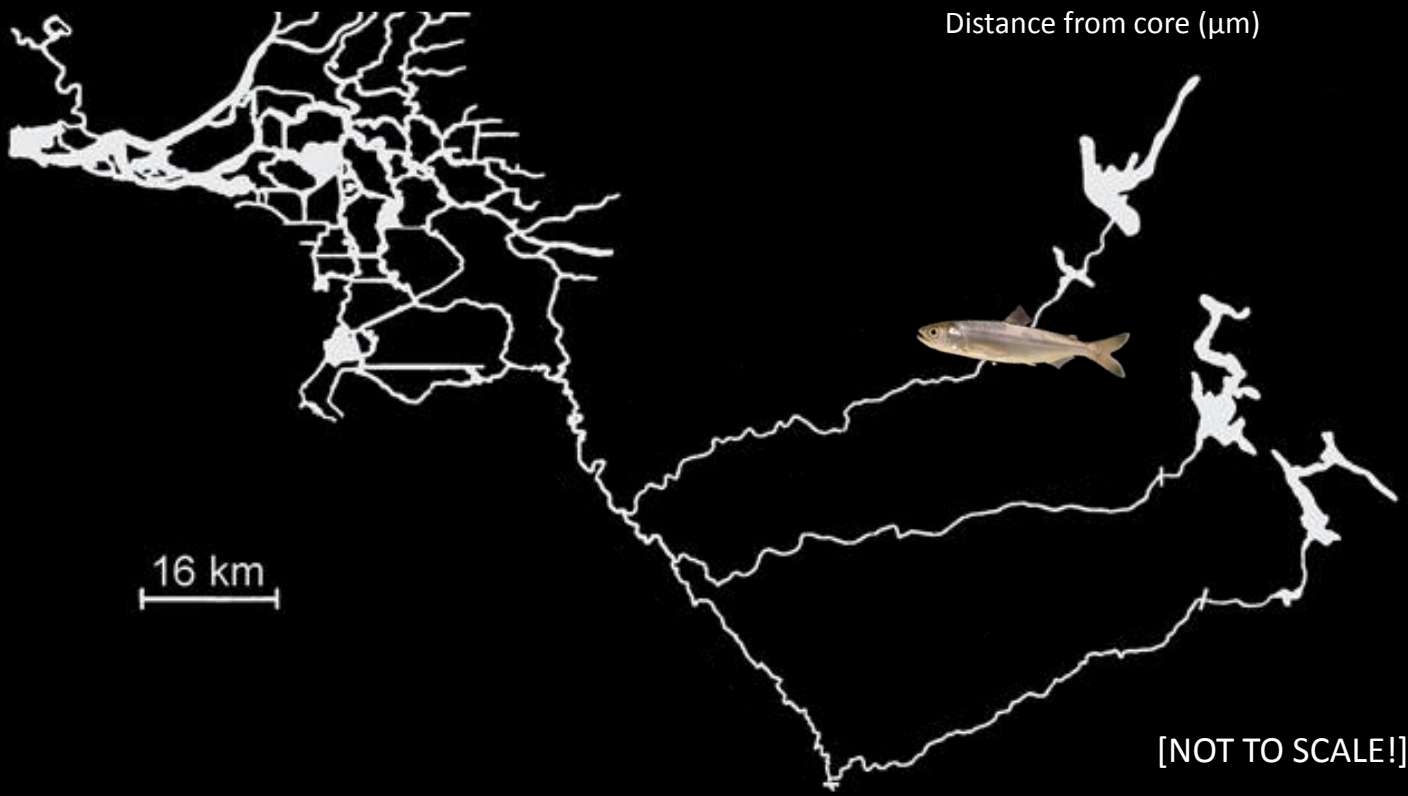
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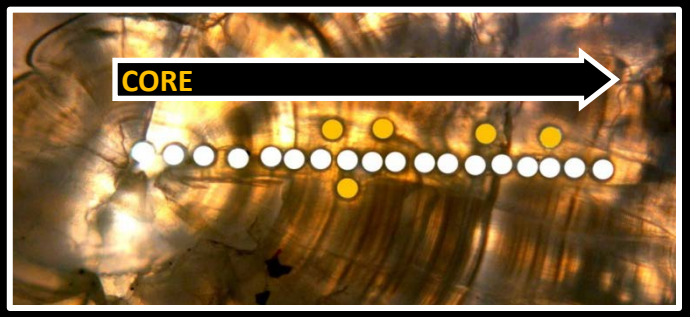
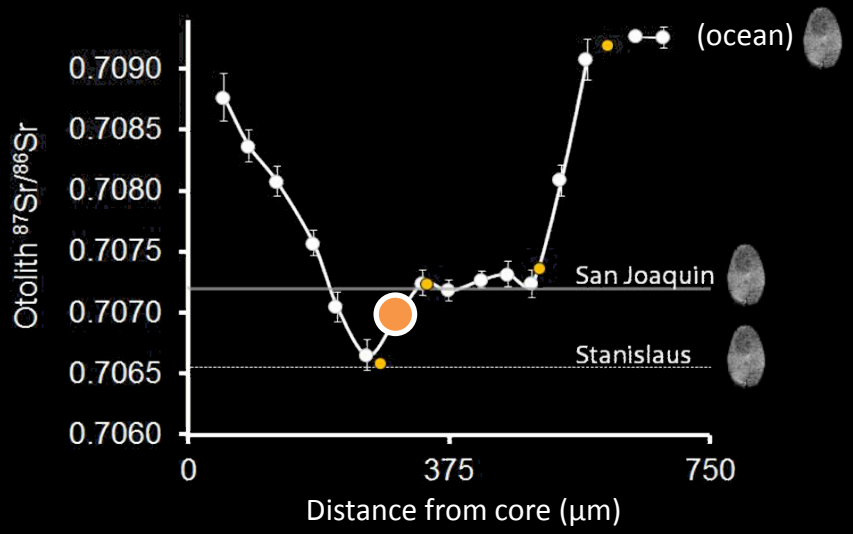

CORE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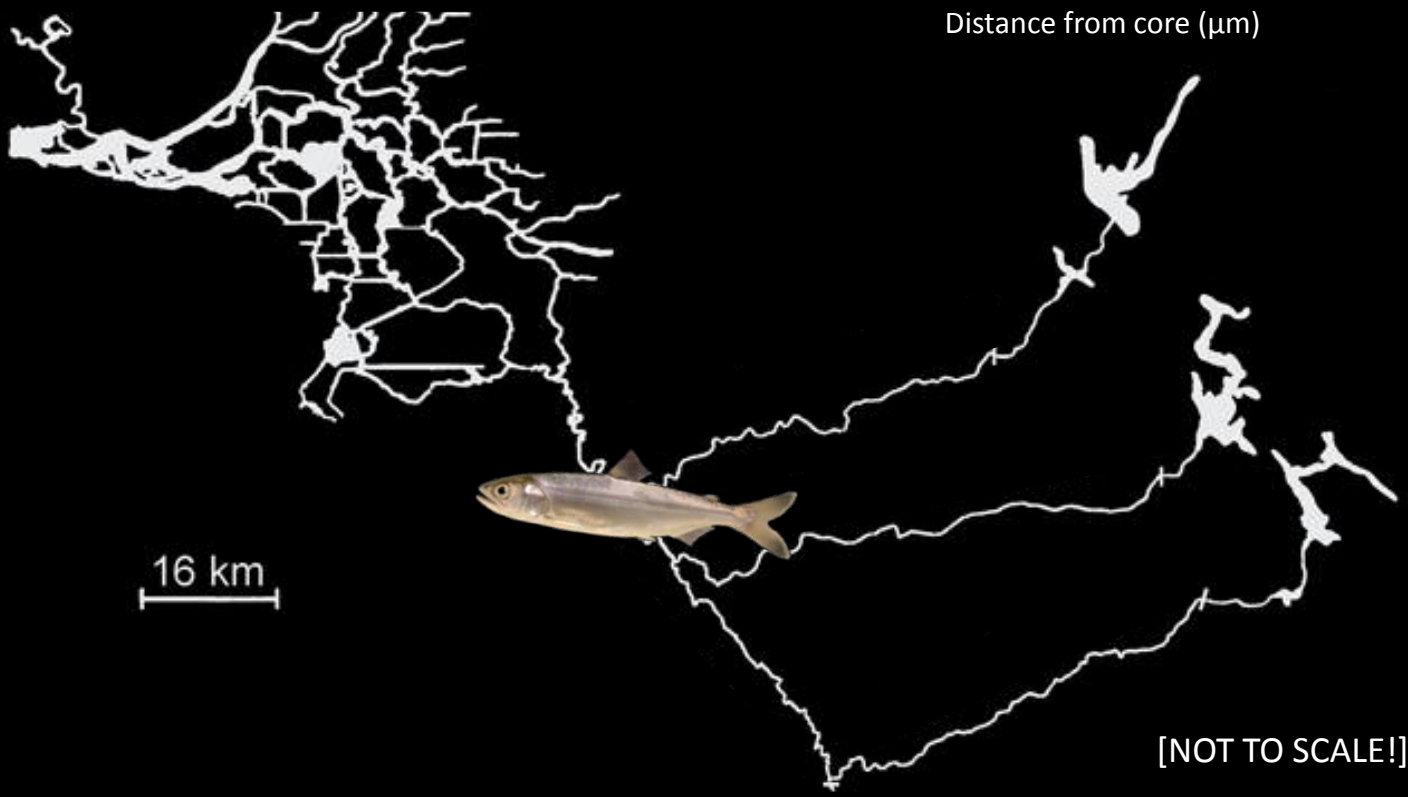
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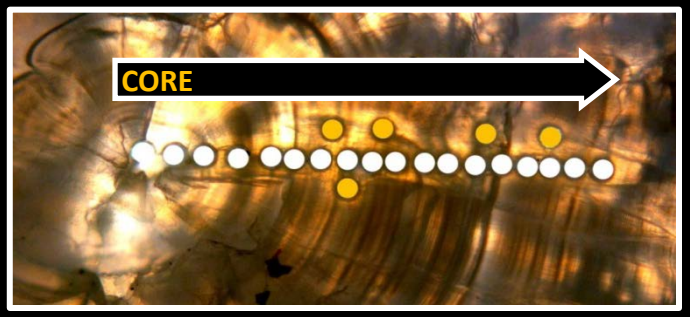
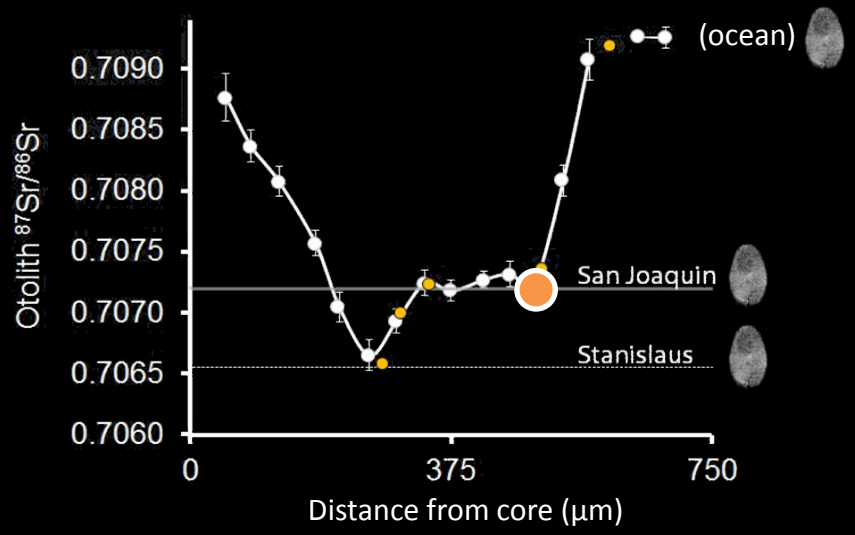

CORE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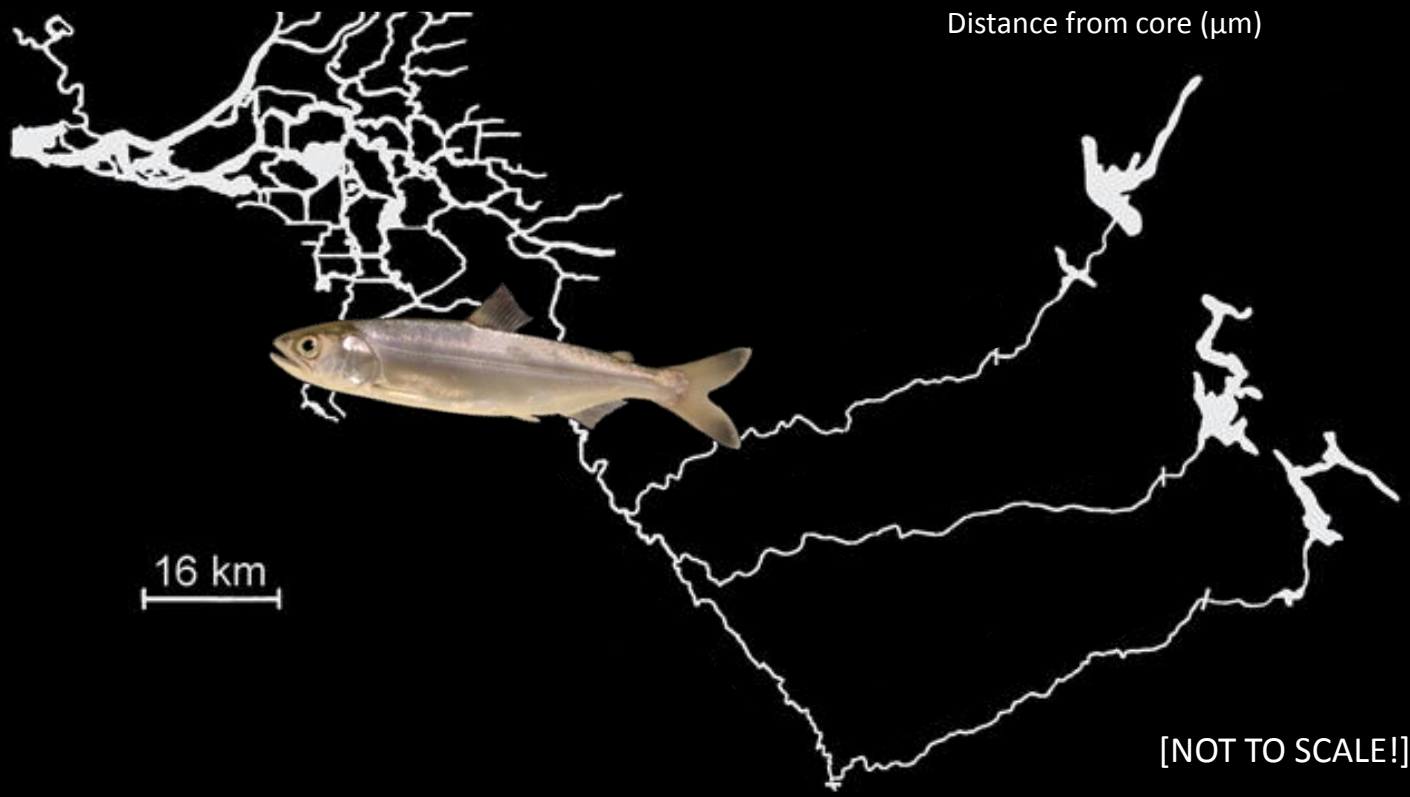
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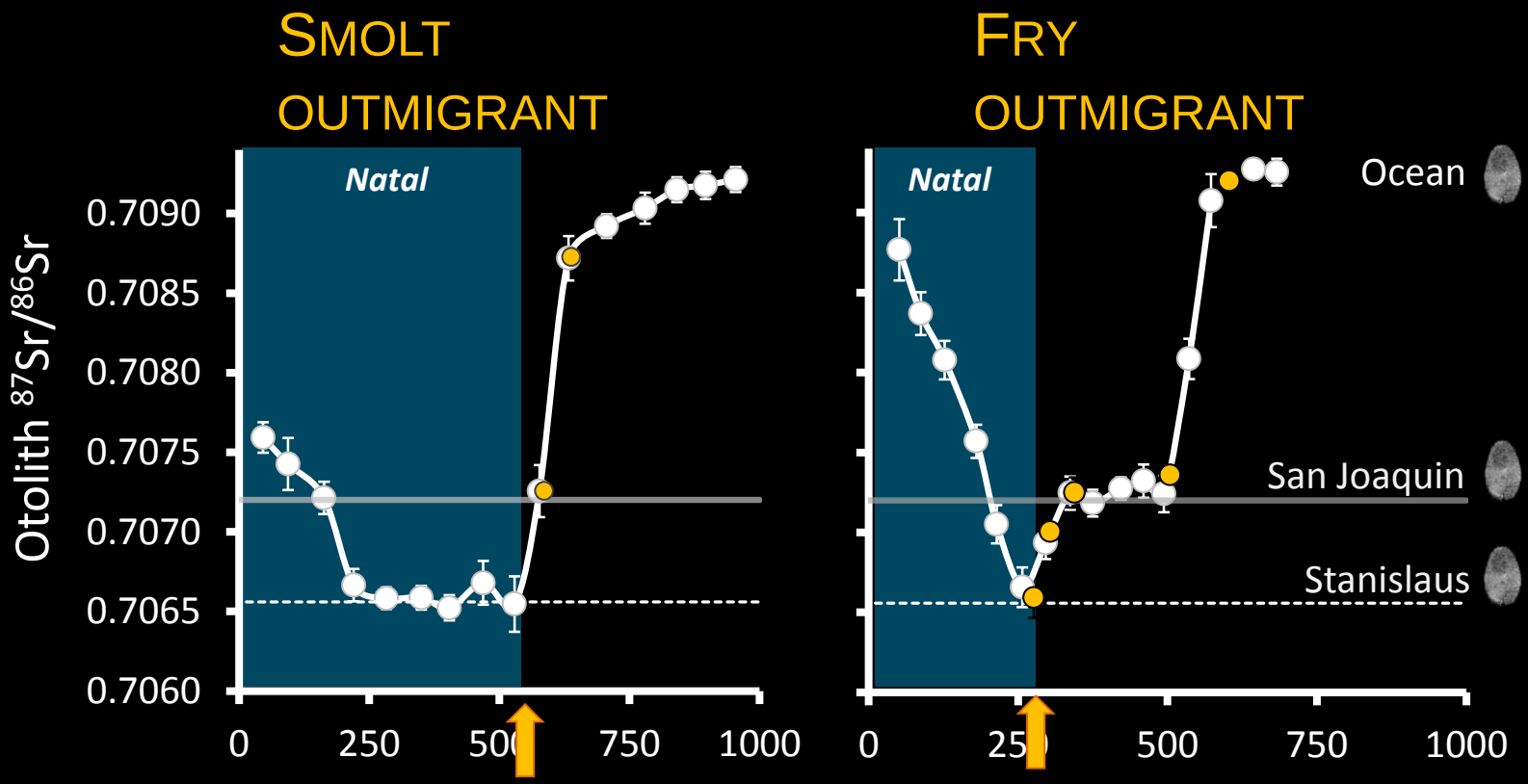
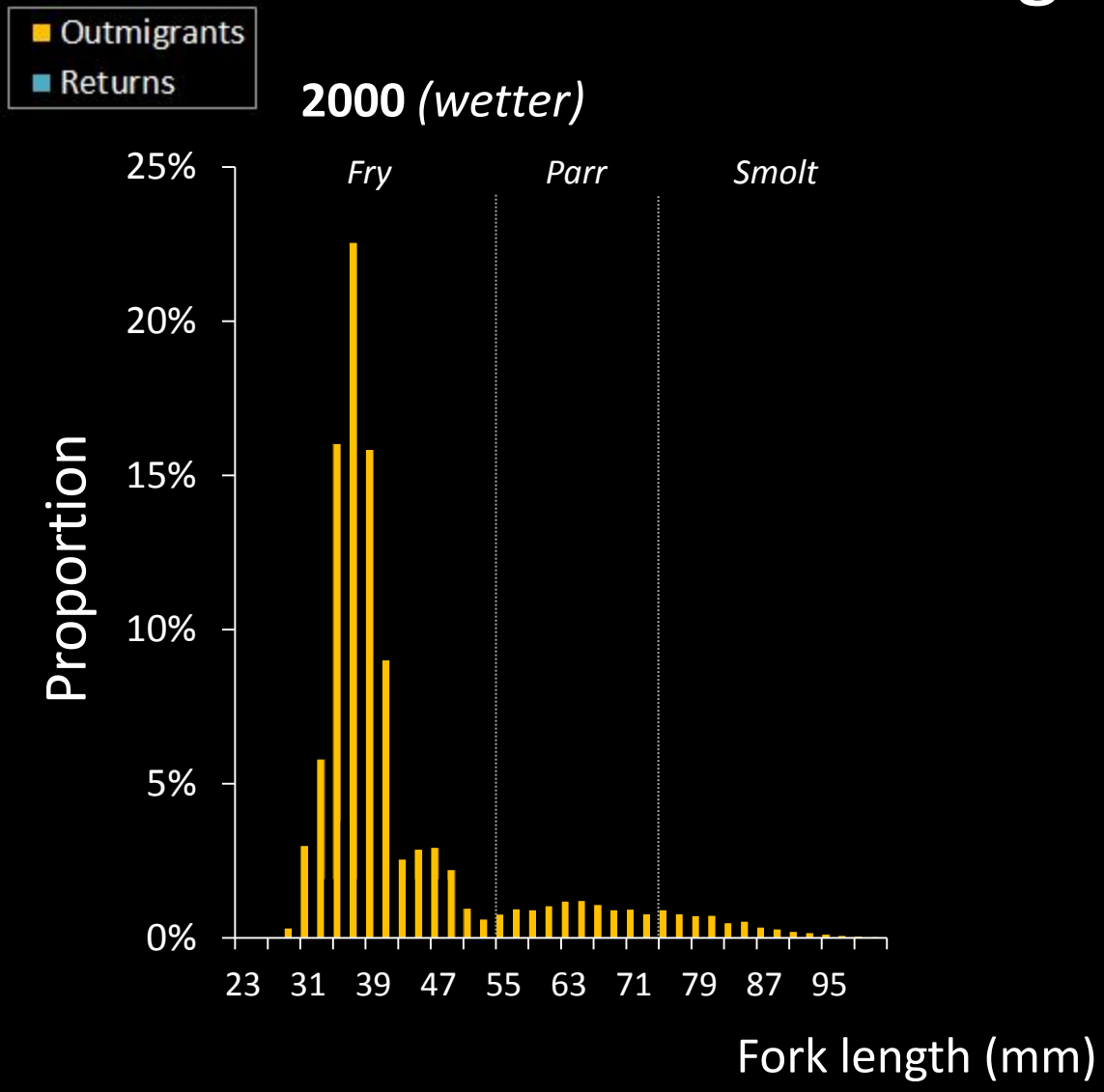
[NOT TO SCALE!]

Otolith reconstructions



Size at outmigration



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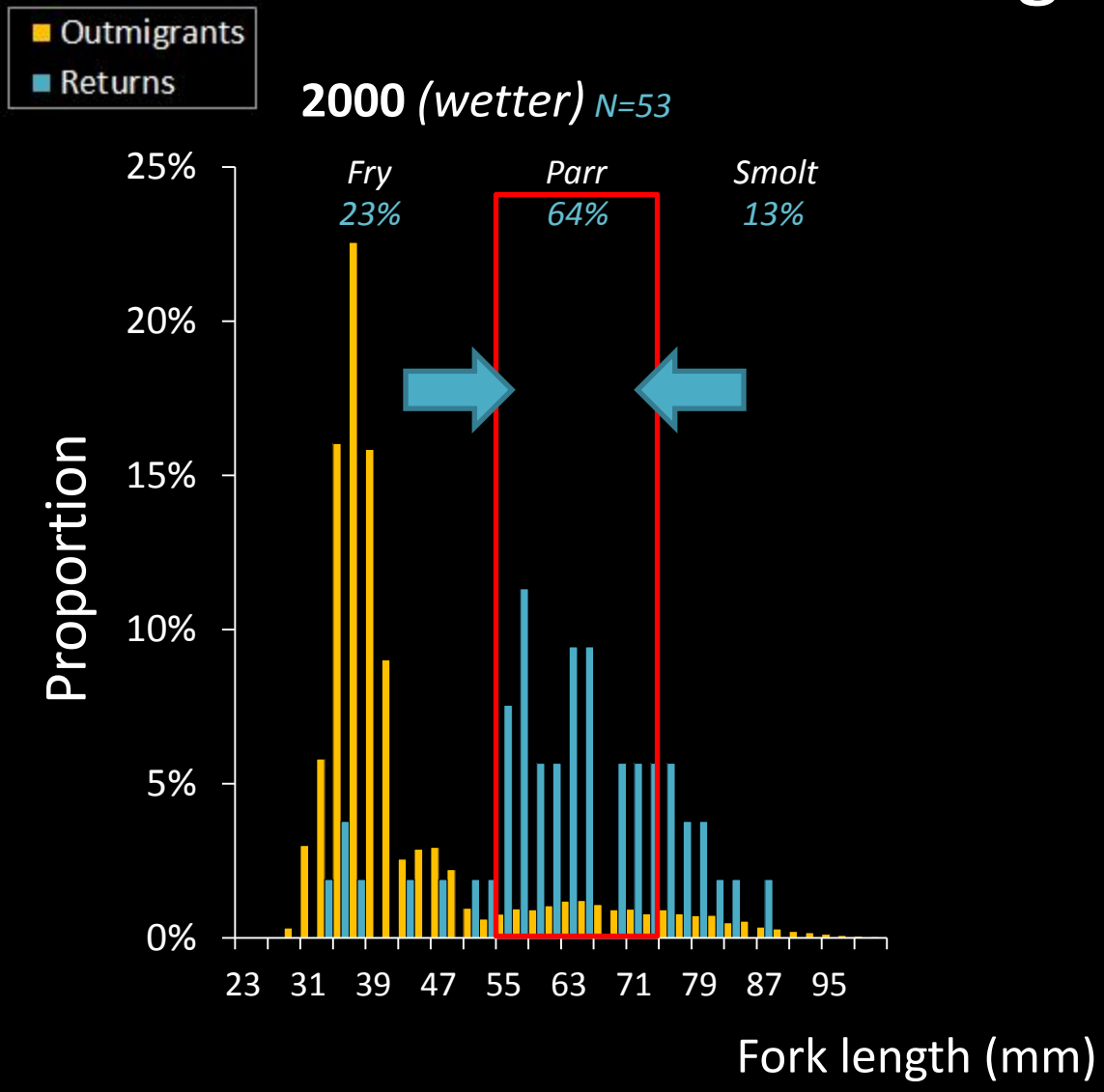

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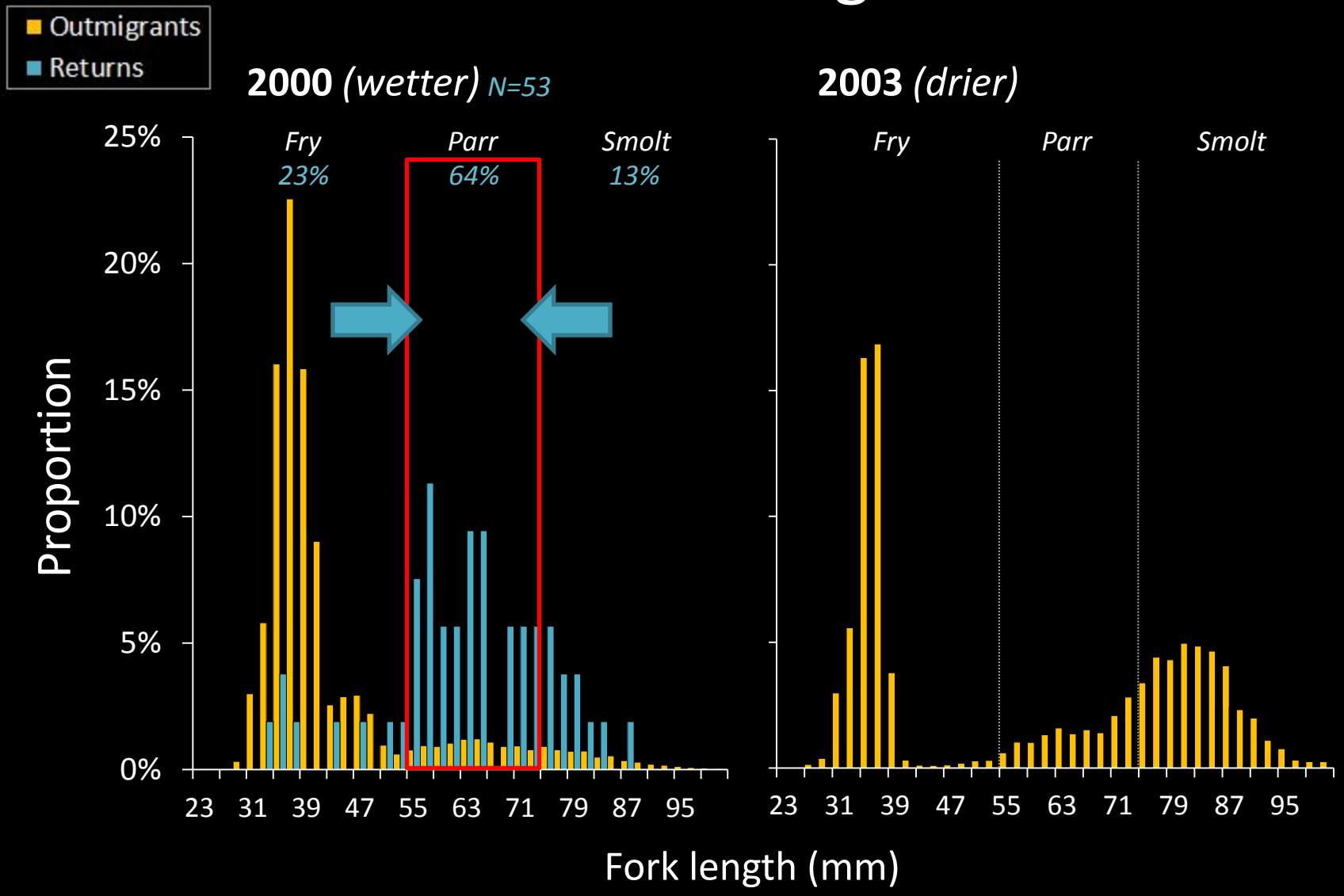

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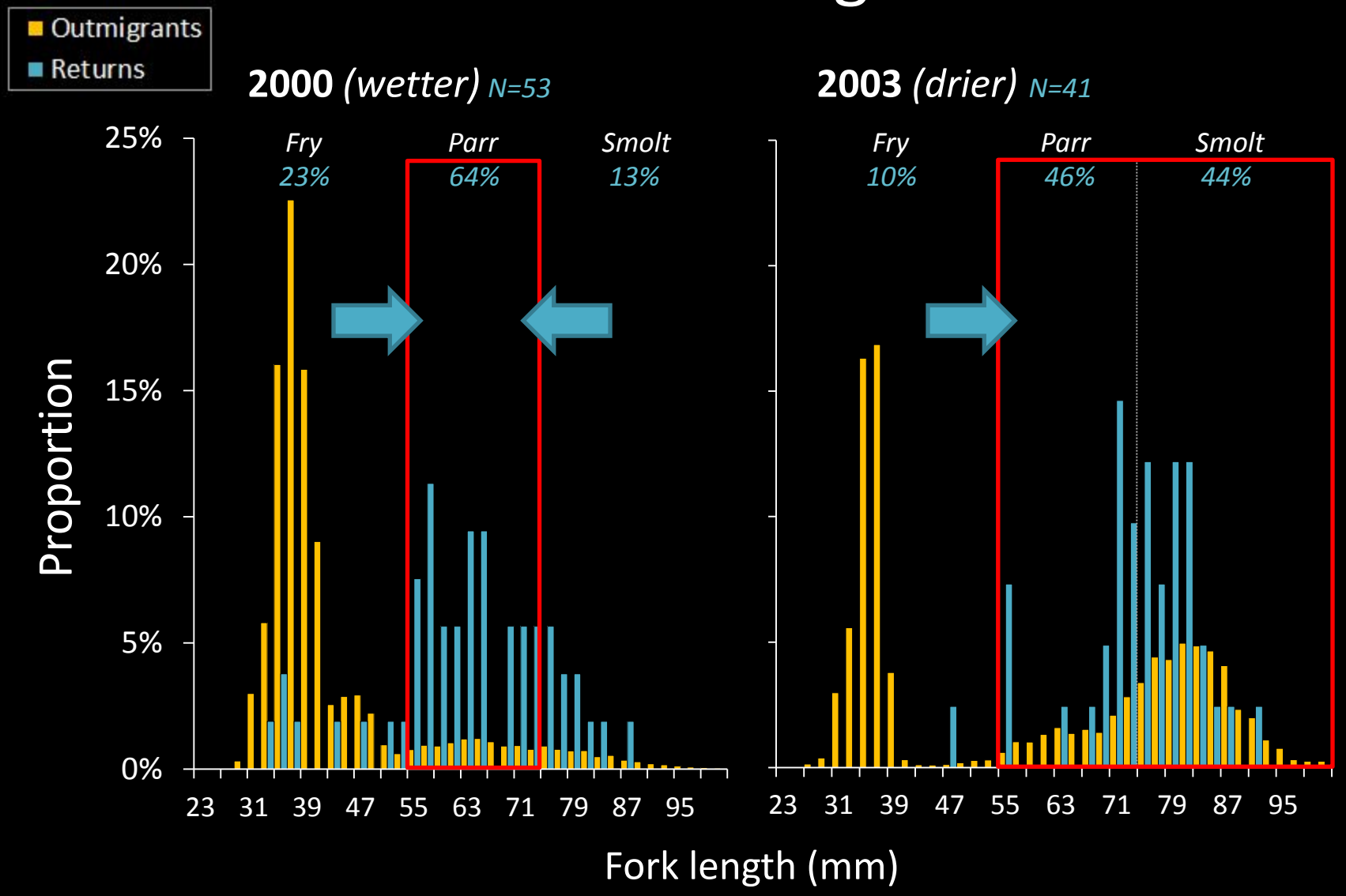

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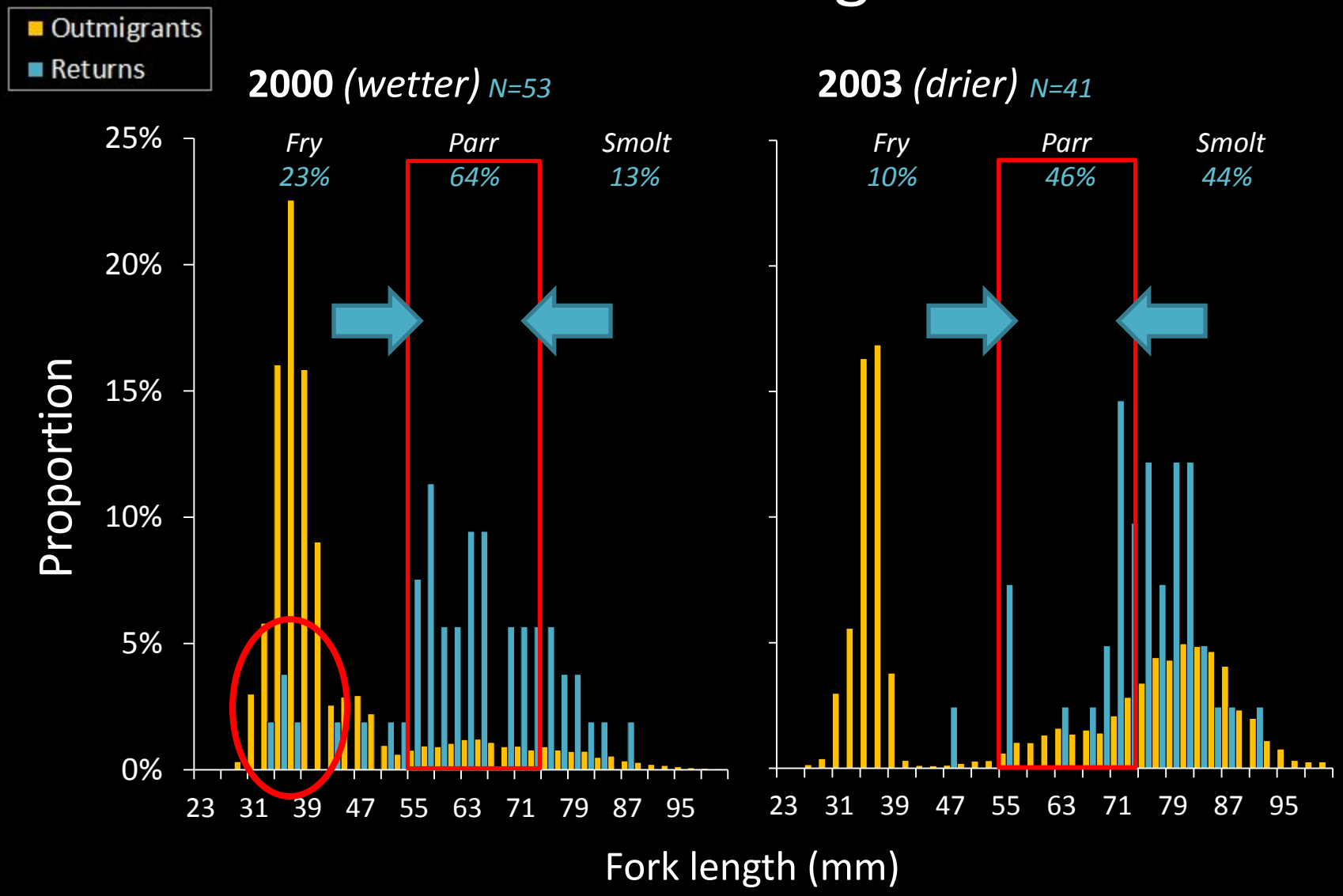

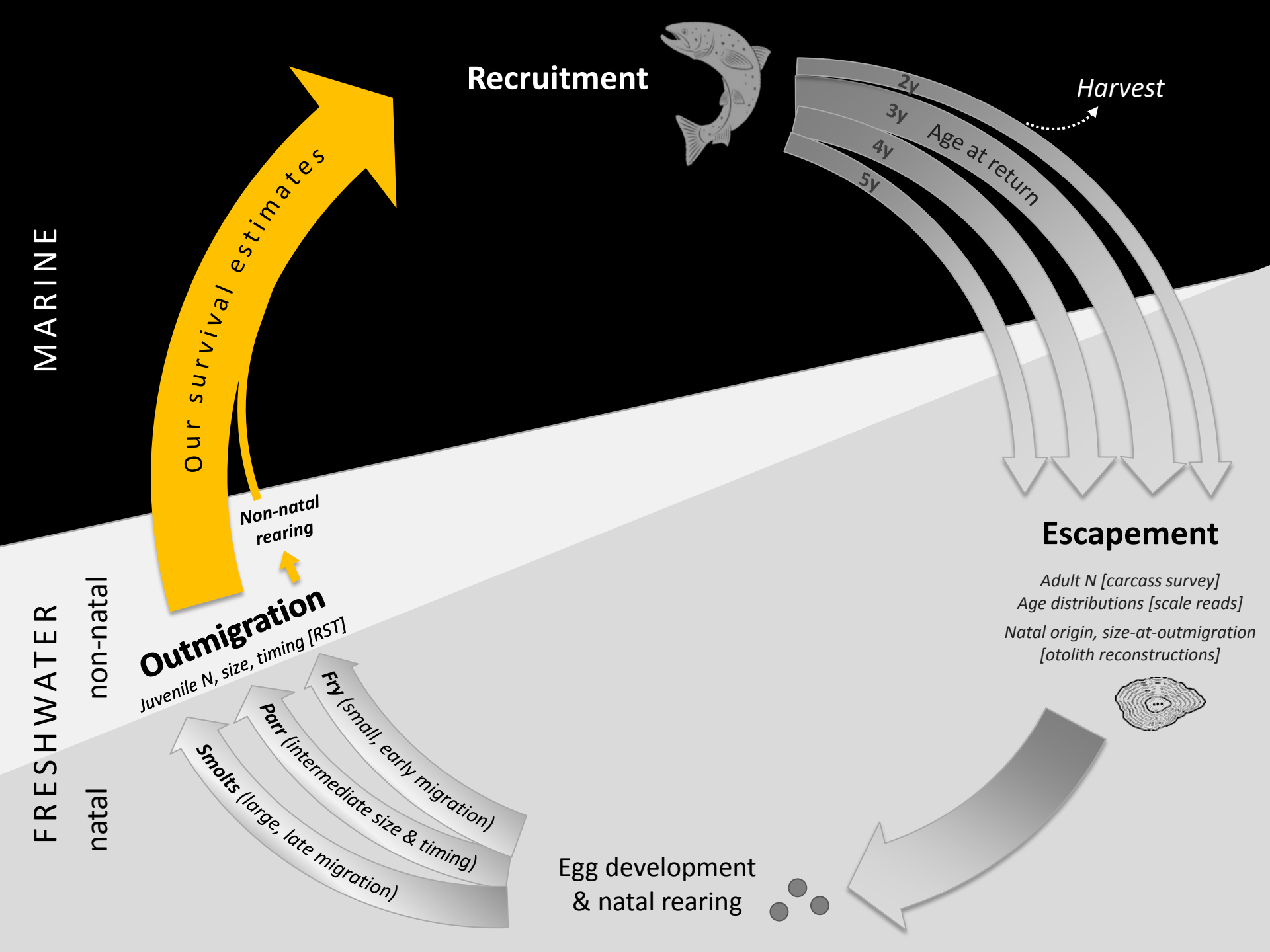
MARINE
FRESHWATER
non-natal
natal
Recruitment
Our survival estimates
Non-natal rearing
Outmigration
Juvenile N, size, timing [RST]
Fry (small, early migration)
Parr (intermediate size & timing)
Smolts (large, late migration)
Egg development & natal rearing
2y
3y
4y
5y
Age at return
Harvest
Escapement
Adult N [carcass survey]
Age distributions [scale reads]
Natal origin, size-at-outmigration [otolith reconstructions]

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FRESHWATER

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natal

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2y

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5y

Age at return

Harvest

Our survival estimates

Non-natal rearing

Outmigration

Juvenile N, size, timing [RST]

***Fry** (small, early migration)*

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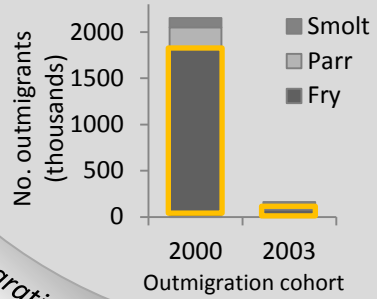
Juvenile outmigrants



Escapement

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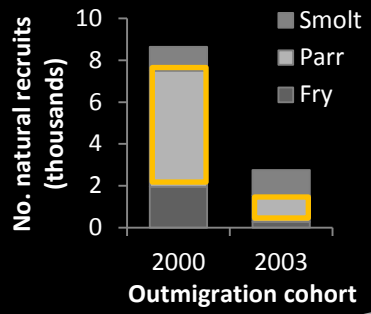
Surviving adults



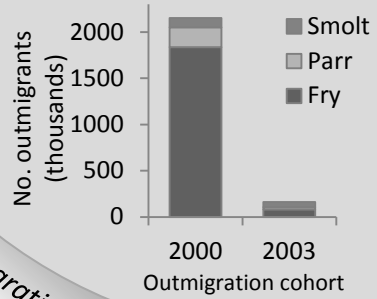
Our survival estimates

Non-natal rearing

Outmigration

Juvenile N, size, timing [RST]

Juvenile outmigrants



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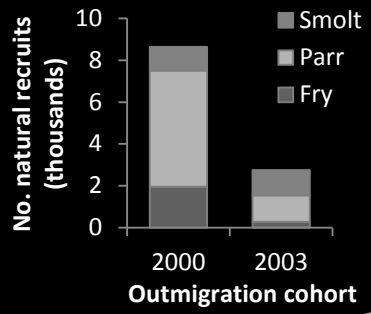

Non-natal rearing

Outmigration

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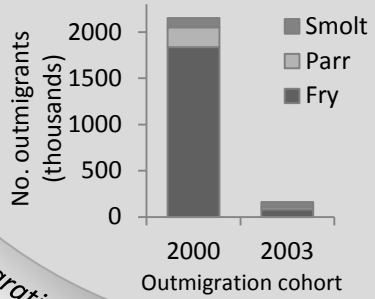
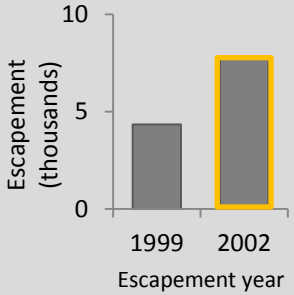
Juvenile outmigrants



Parental spawners



Escapement

Adult N [carcass survey]

Age distributions [scale reads]

Natal origin, size-at-outmigration [otolith reconstructions]

Egg development & natal rearing

?

Conclusions

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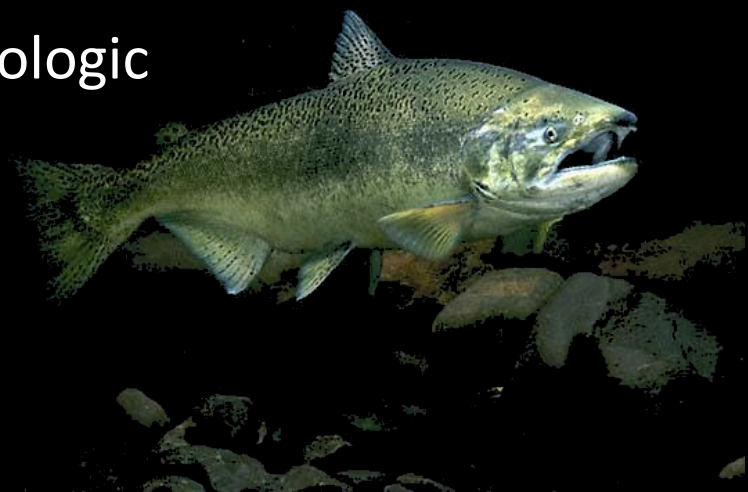
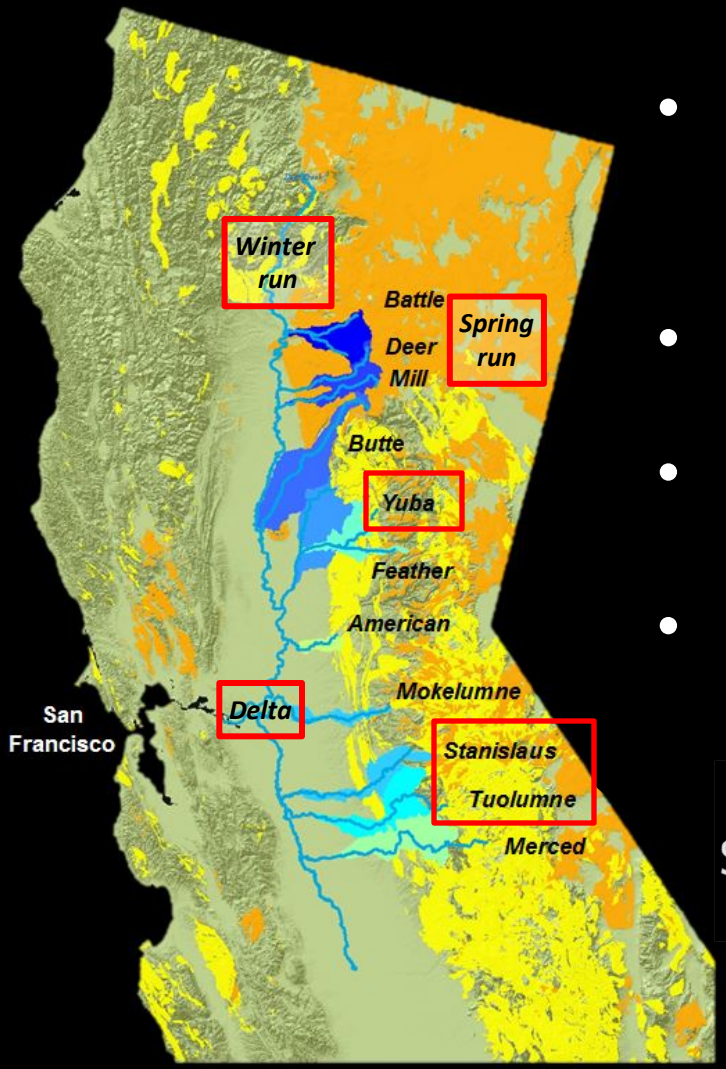
Conclusions

- All 3 phenotypes contributed to the adult population
  i.e. Life history diversity is key.
- While fry survival is often assumed negligible, they can represent >20% of the returns!
- Parr consistently exhibited the greatest survival
  i.e. BIG is not always better.
- In these southernmost populations, hydrologic regime plays a critical role.

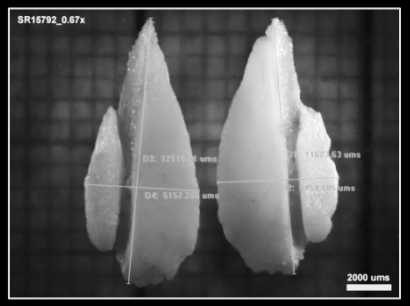


What next? *Scaling of the portfolio effect*



- Expression of different portfolios (across space & time)?
- Mechanisms and scale(s) of selection?
- Role of hydroclimatic regime?
- Management actions?

DELTA STEWARDSHIP COUNCIL



Acknowledgements

Rachel Johnson, George Whitman, Justin Glessner, Mike Miller (**UC Davis**)

Stephanie Carlson, Alan Hubbard (**UC Berkeley**)

Peter Weber (**Lawrence Livermore National Laboratory**)

JD Wikert, Carl Mesick, Eric Hopson, Doug Threloff (**USFWS**)

Tim Heyne, Gretchen Murphy, Crystal Sinclair, Shelly Schubert and all the scale readers and carcass survey teams at **CDFW**

Travis Hinkleman, Clark Watry, Steve Zeug, Joe Merz

and all the RST operators at **Cramer Fish Sciences**.

Jason Wyman (**14 Black Poppies**) for his wonderful salmon graphic.

And thank **you** for listening!

a.sturrock@berkeley.edu