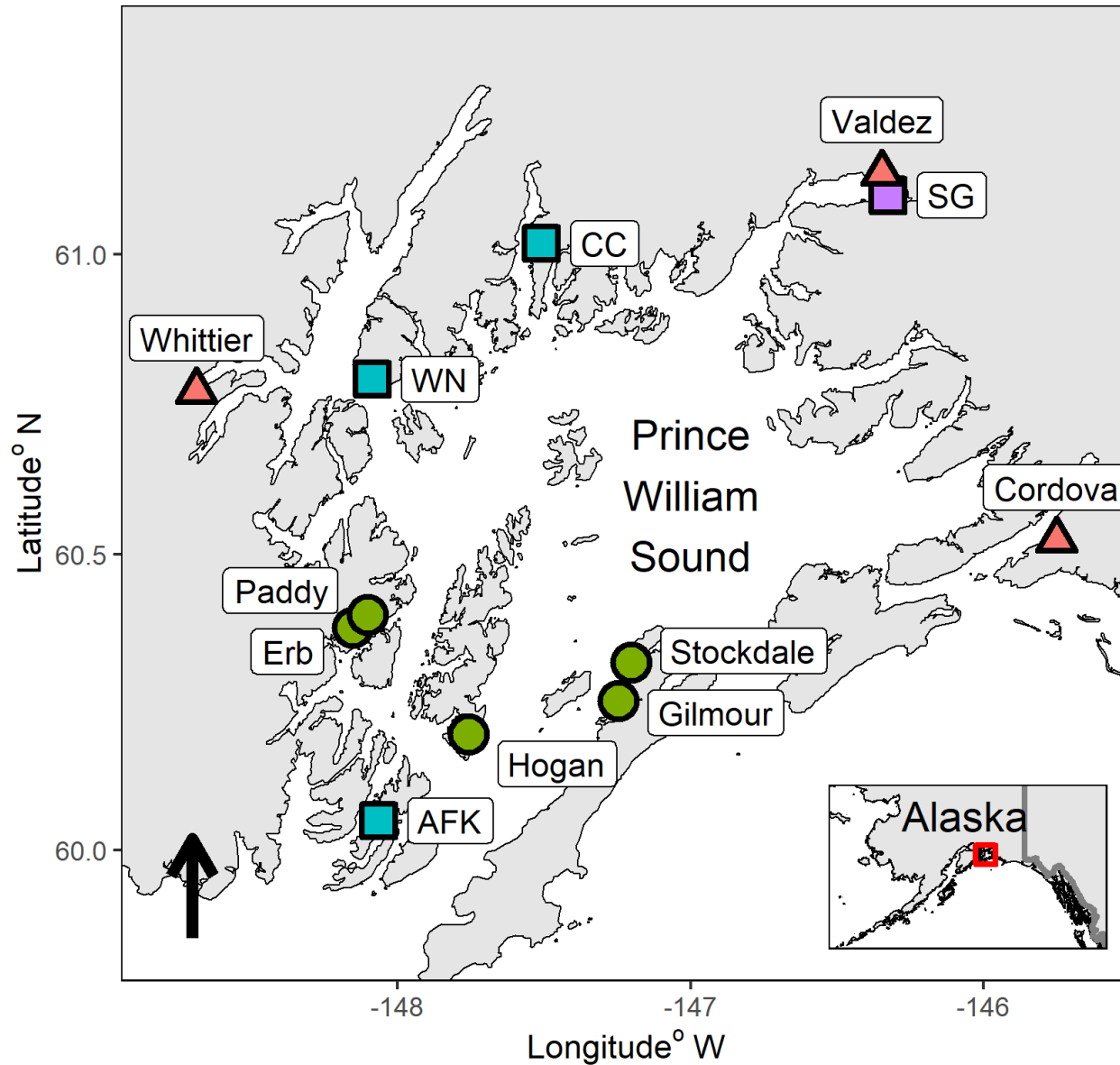


# Pink Salmon pedigree analyses results and remaining work



Kyle Shedd  
Gene Conservation Laboratory  
Alaska Department of Fish and Game  
AHRP Informational Meeting  
March 9, 2022

# AHRP Streams in PWS



## Legend

- City
- Fitness
- PWSAC
- VFDA

**VFDA** = Valdez Fisheries Development Association  
**PWSAC** = Prince William Sound Aquaculture Corporation

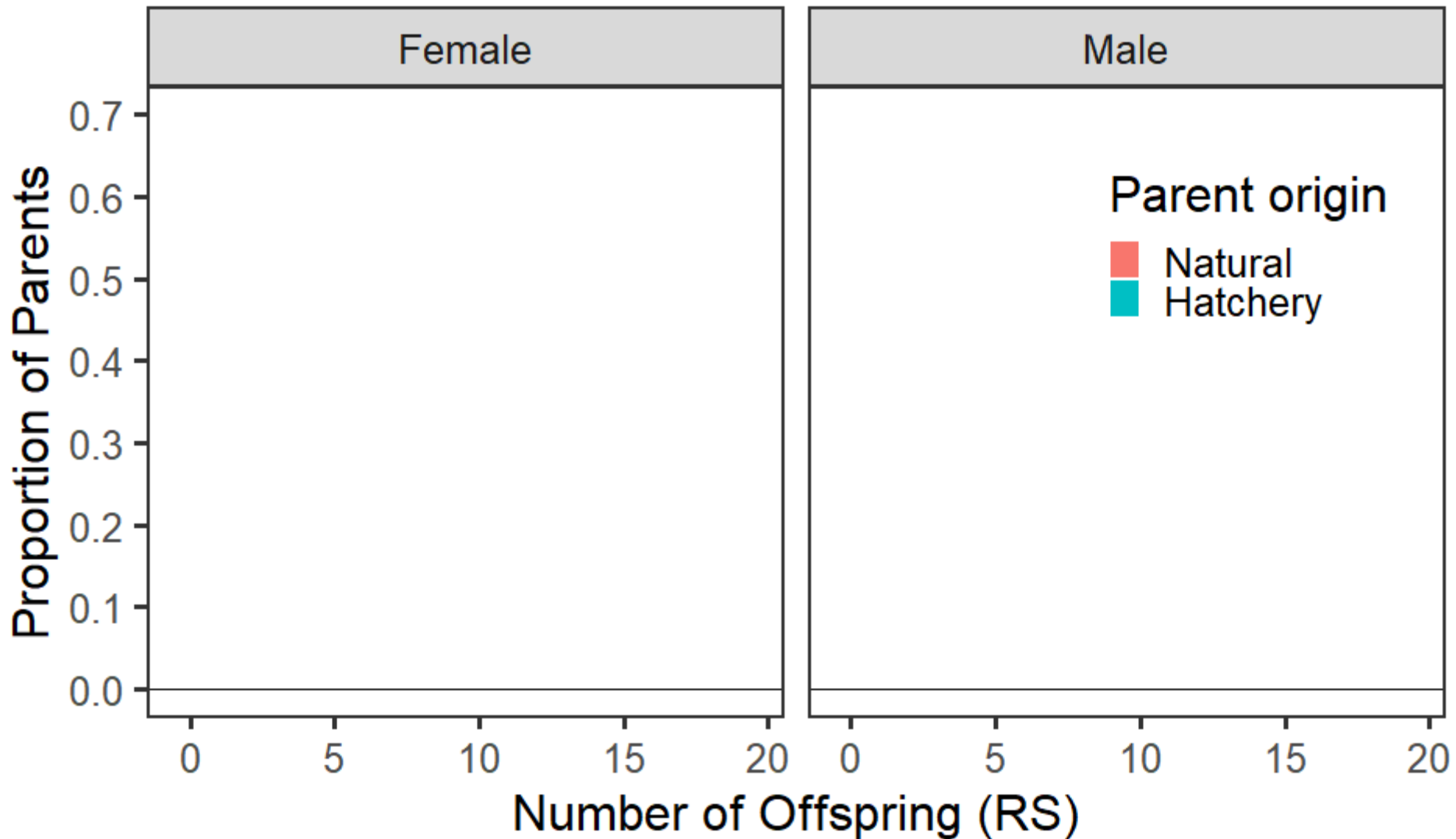
# Average Reproductive Success

Stockdale 2014/2016

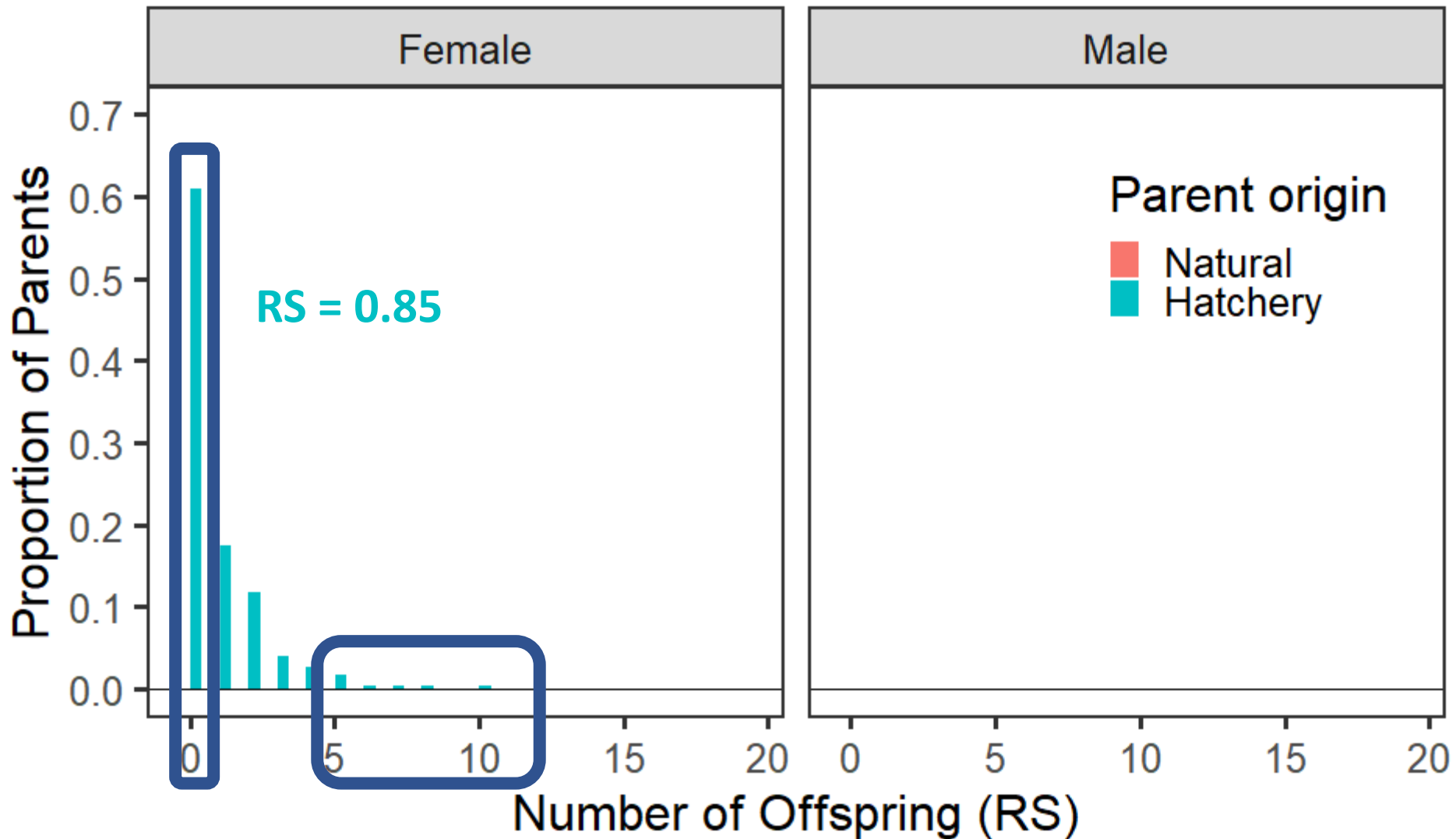
<b>Female</b>	2014 Parents	2016 Offspring	Average RS	<b>RRS</b>
<b>Hatchery</b>	<b>230</b>	<b>196</b>	<b>0.85</b>	<b>= 0.42</b>
<b>Natural</b>	<b>221</b>	<b>448</b>	<b>2.03</b>	

<b>Male</b>	2014 Parents	2016 Offspring	Average RS	<b>RRS</b>
<b>Hatchery</b>	<b>206</b>	<b>177</b>	<b>0.86</b>	<b>= 0.28</b>
<b>Natural</b>	<b>137</b>	<b>417</b>	<b>3.04</b>	

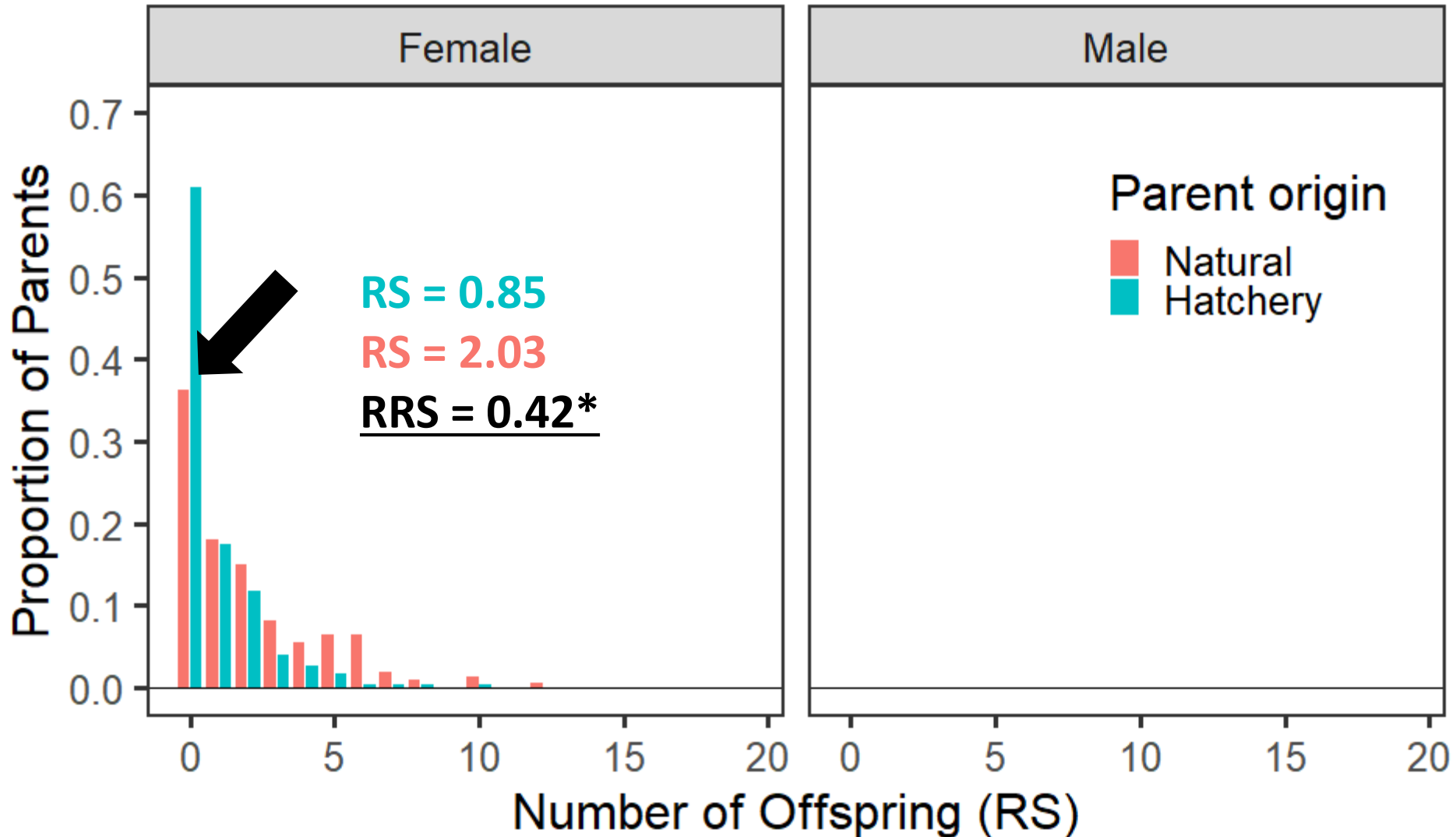
# RS Distribution: Stockdale 2014/2016



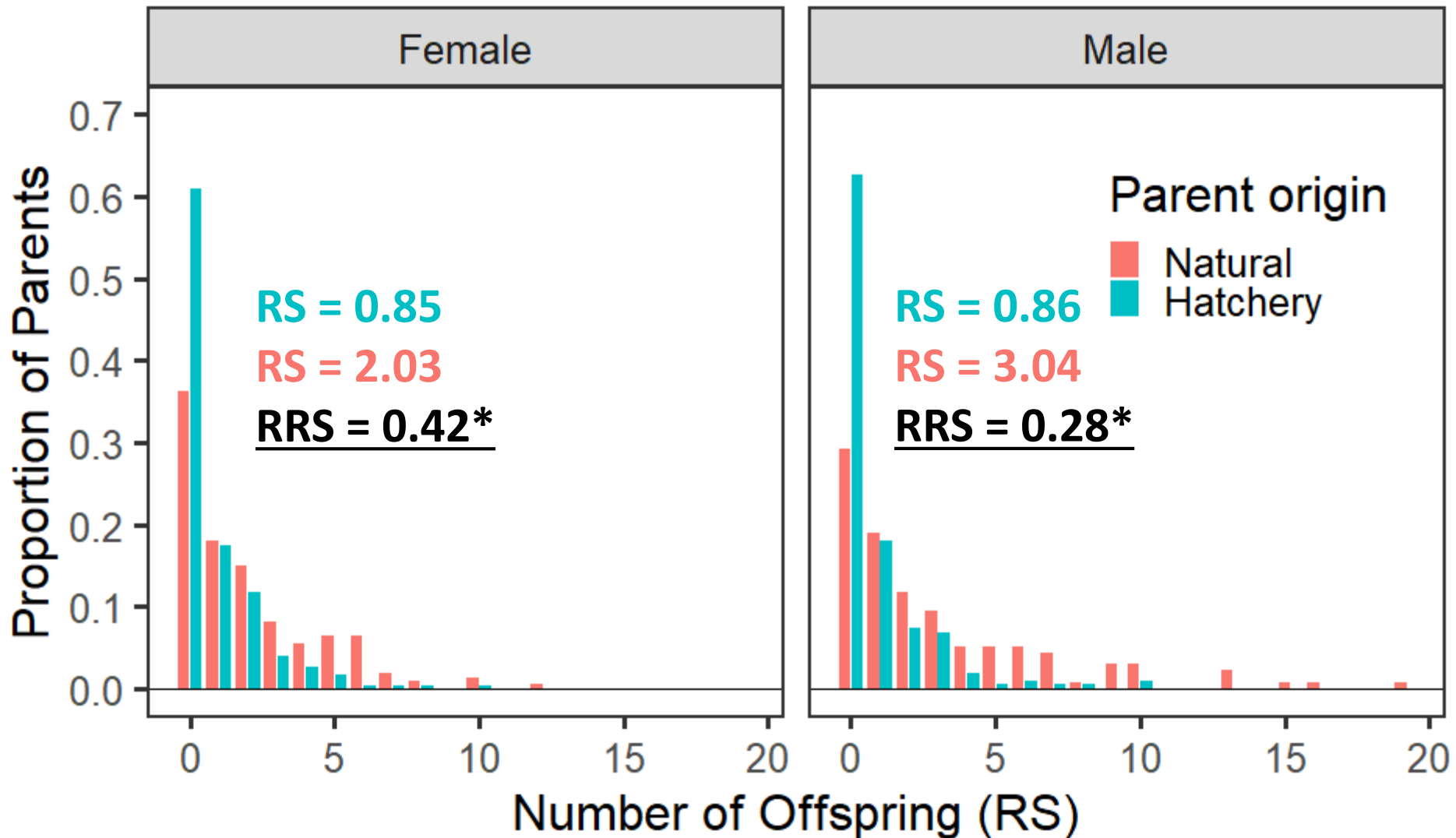
# RS Distribution: Stockdale 2014/2016



# RS Distribution: Stockdale 2014/2016



# RS Distribution: Stockdale 2014/2016



# AHRP Streams in PWS Presenting Now

Stream	2013	2014	2015	2016	2017	2018	2019	2020
Erb	P	P	P,O	P,O	O,G	P,O,G		O,G
Paddy	P	P	P,O	P,O	O,G	P,O,G		O,G
Hogan	P	P	P,O	P,O	P,O,G	O,G	O,G	
Gilmour		P	P	P,O	P,O	O,G	O,G	
Stockdale	P	P	P,O	P,O	P,O,G	O,G	O,G	

P – parents

O – offspring

G – grand-offspring

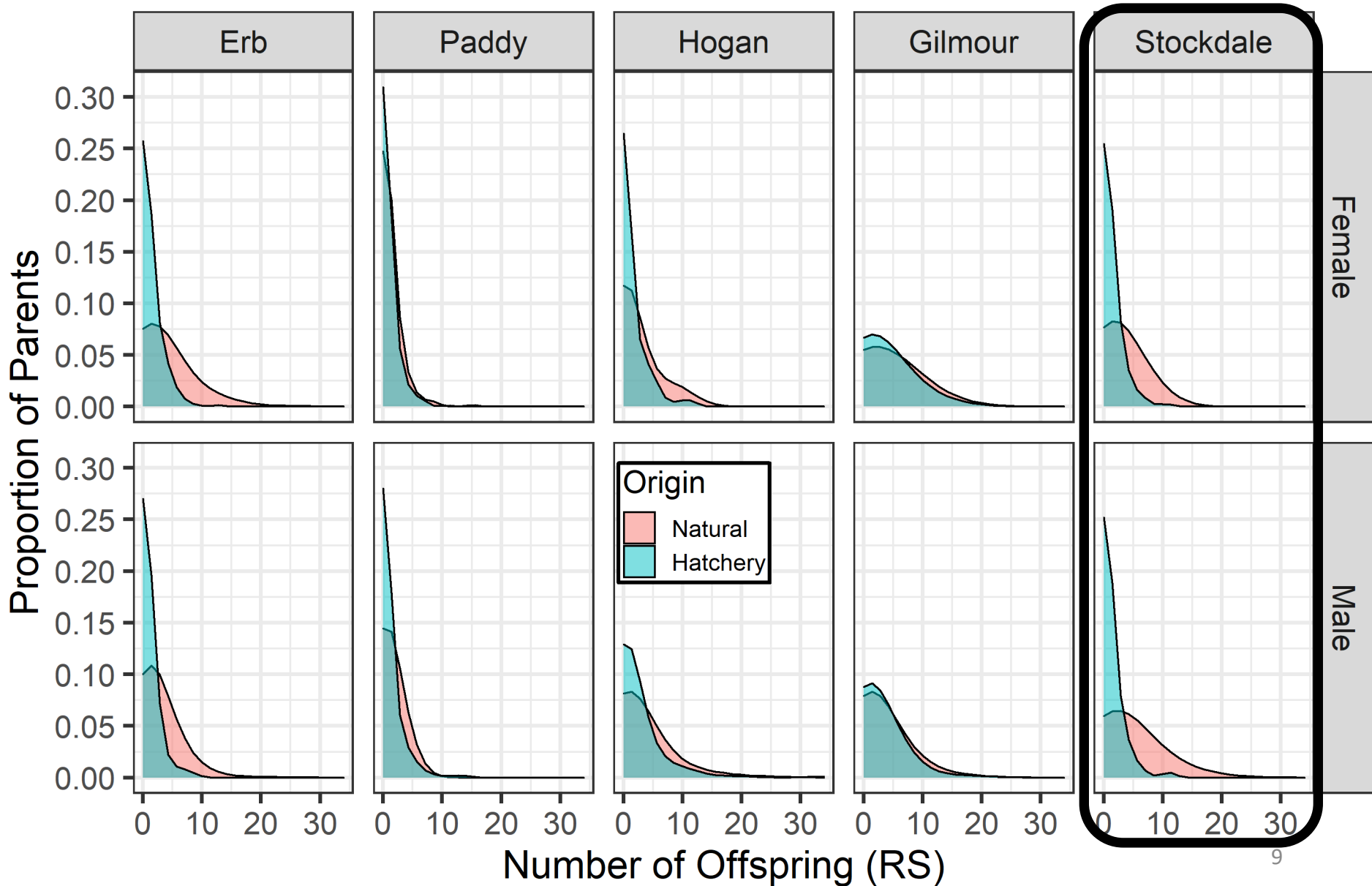
Odd-lineage

Even-lineage

>235K samples!

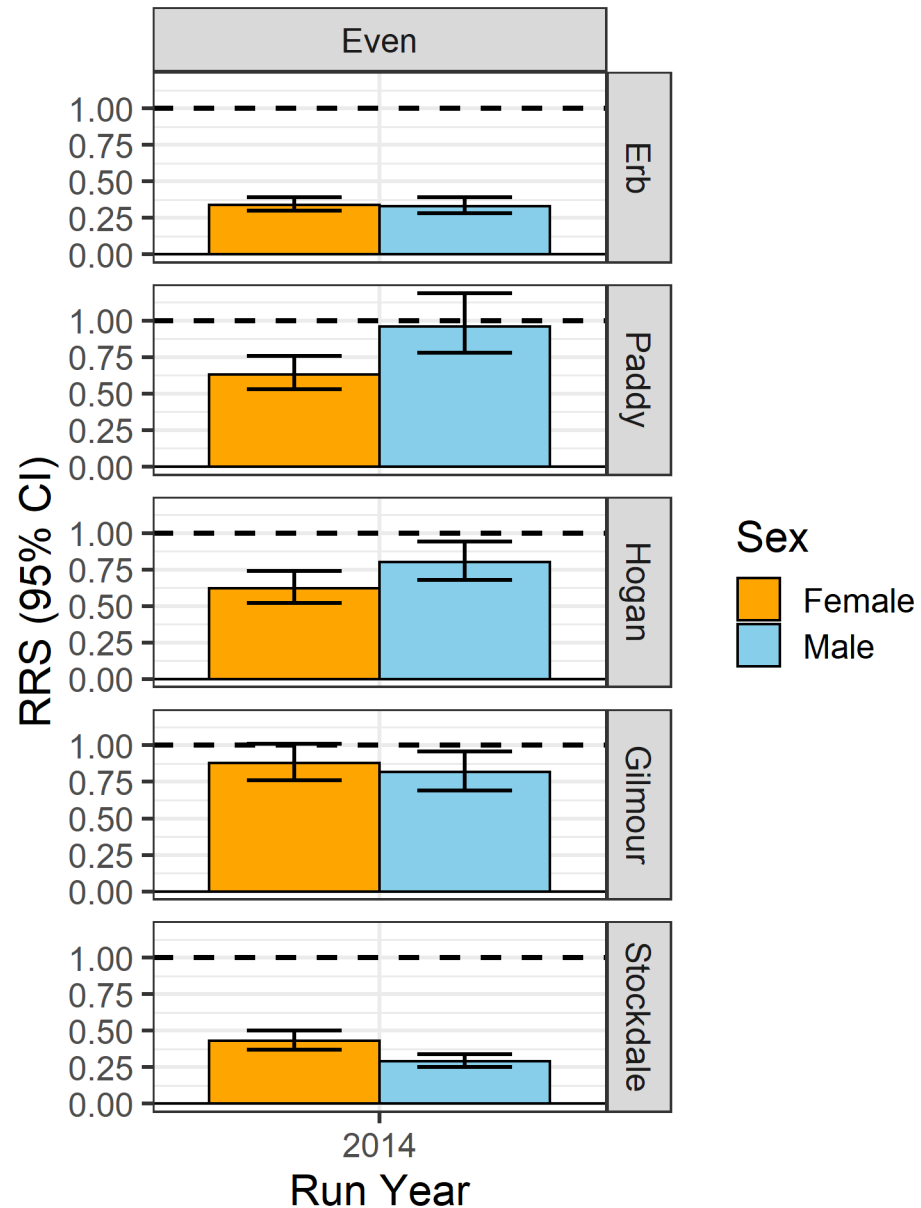


# RS Distribution – All Streams 2014

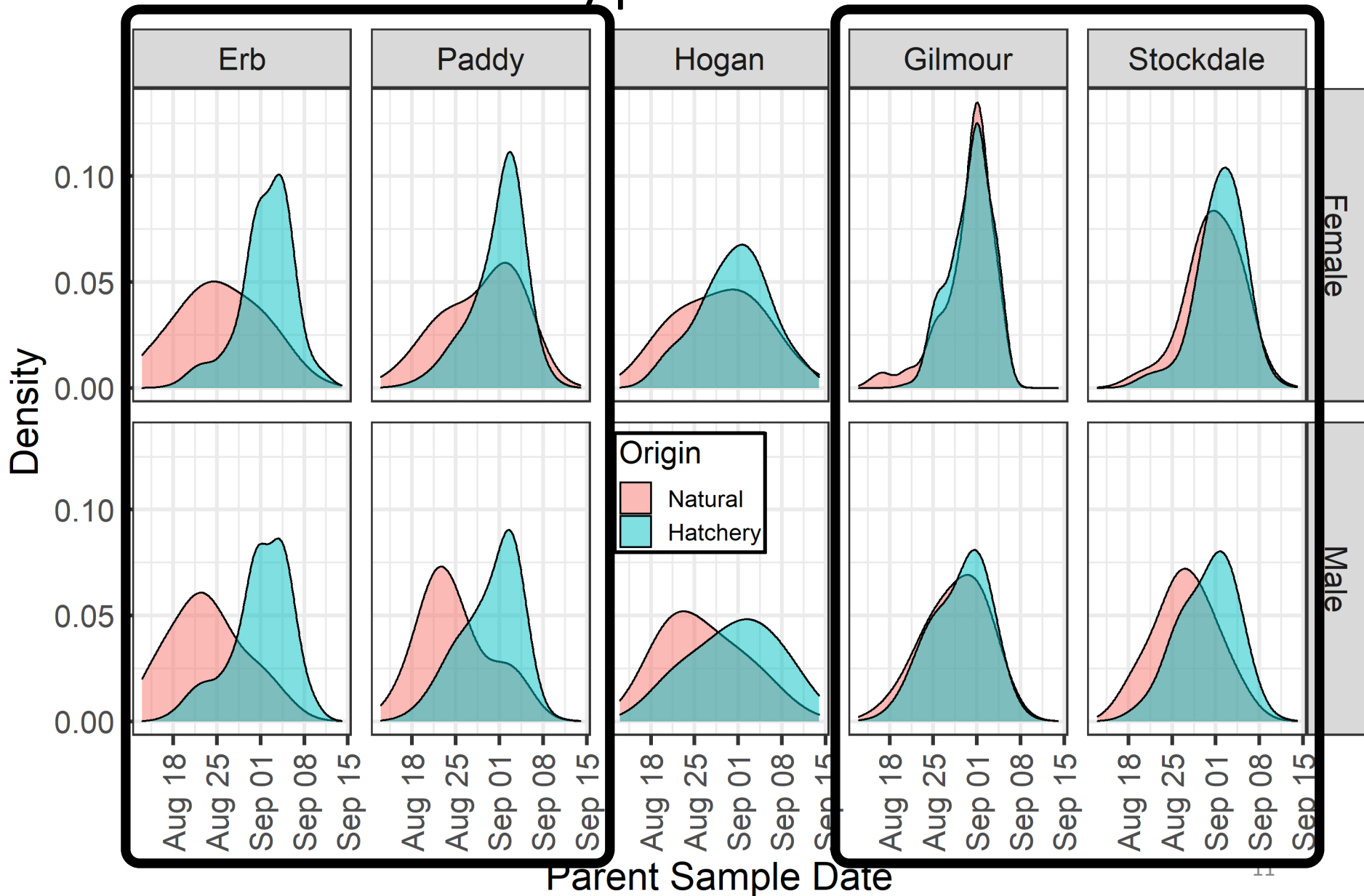


# Results: RRS by Sex 2014

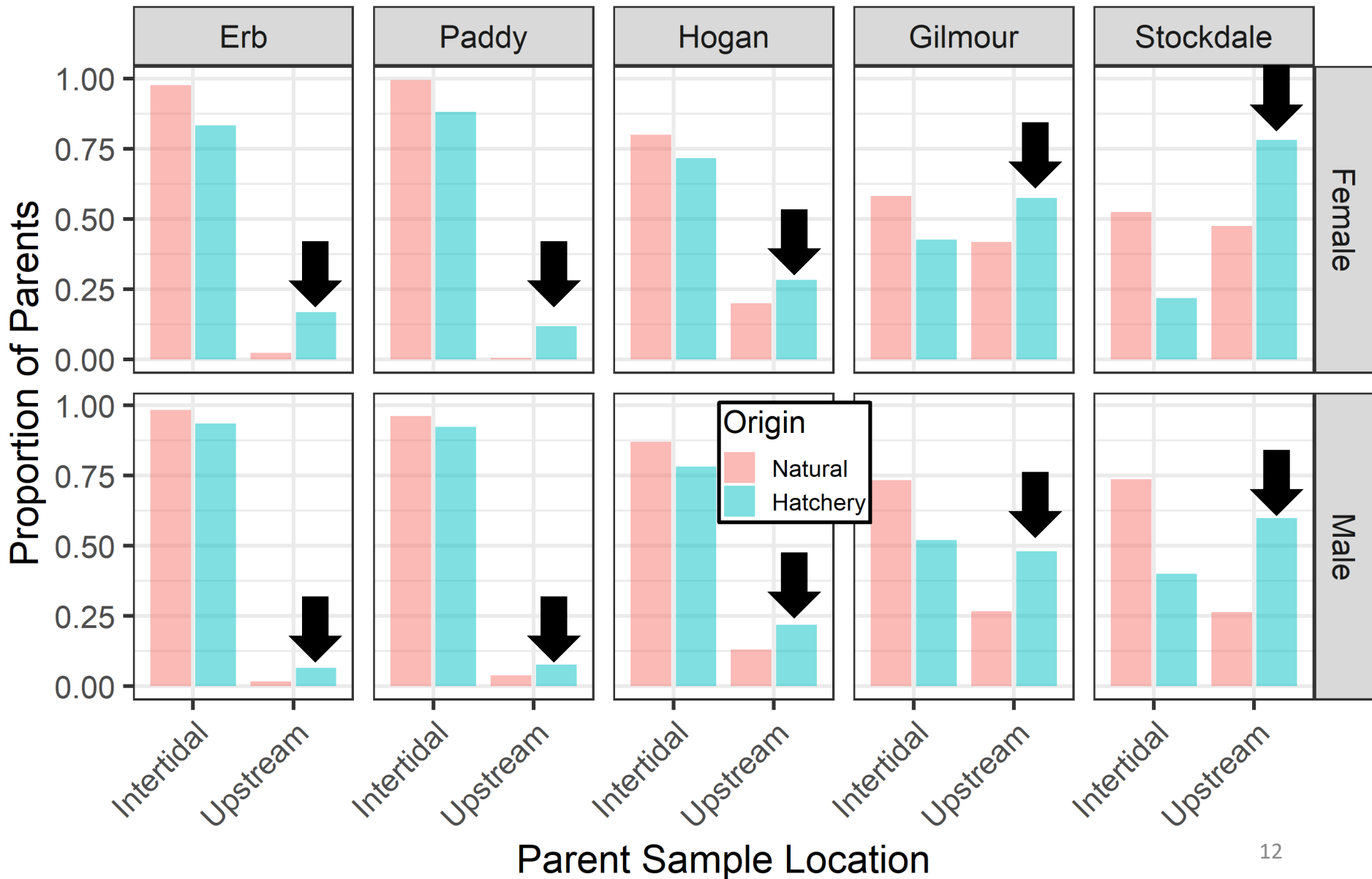
$$RRS = \frac{\overline{RS}_{\text{Hatchery}}}{\overline{RS}_{\text{Natural}}}$$



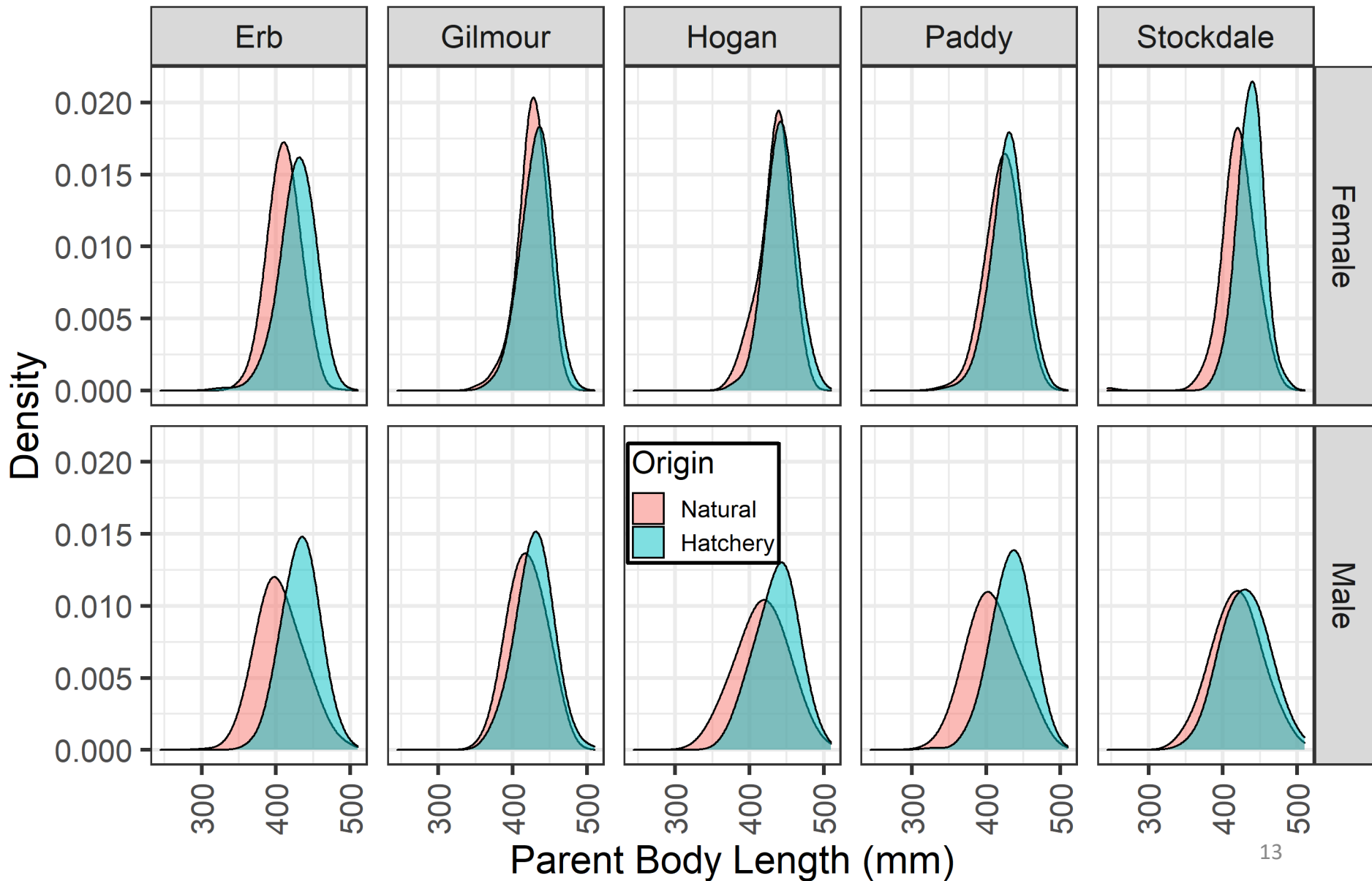
# Results: Phenotypic Differences 2014



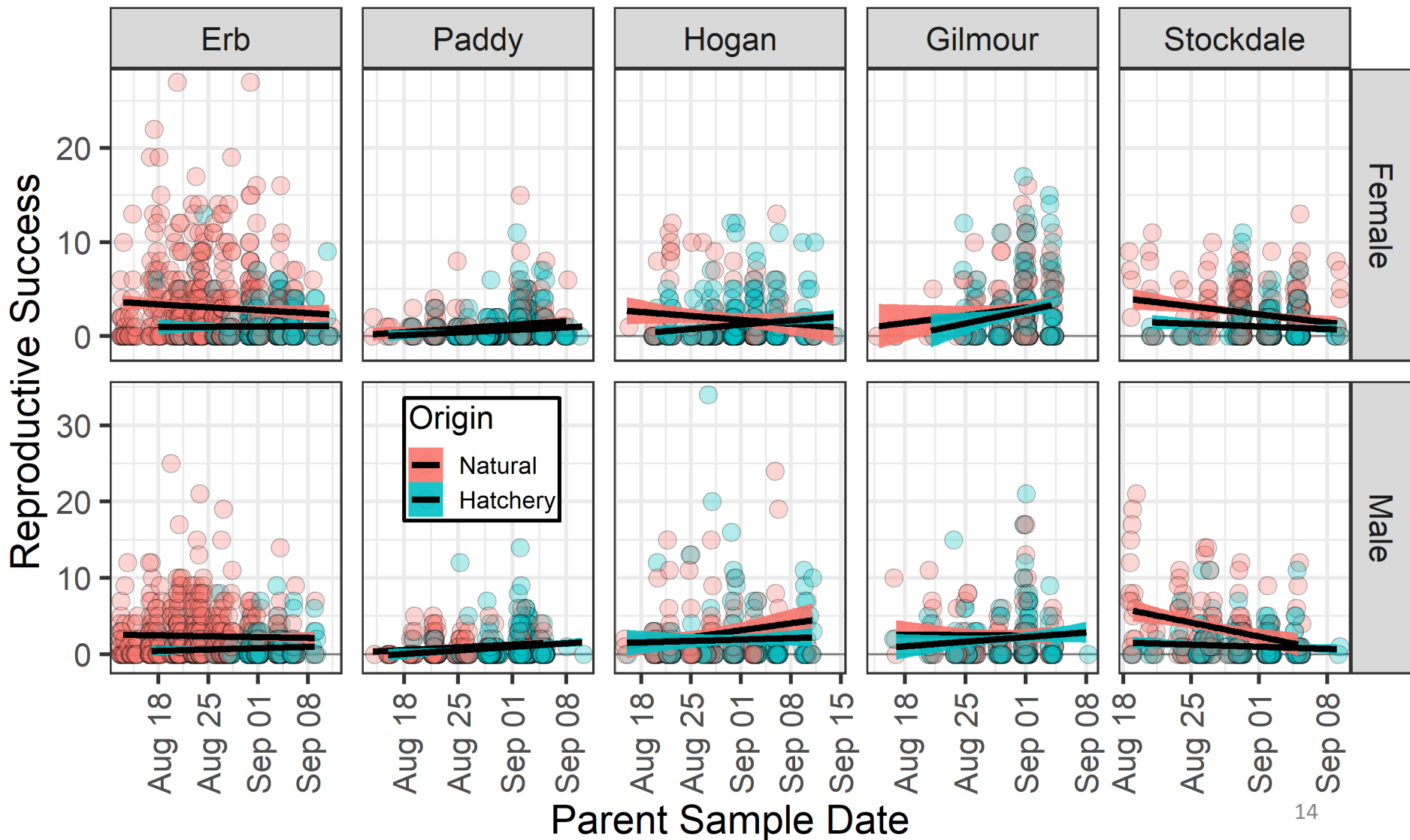
# Results: Phenotypic Differences 2014



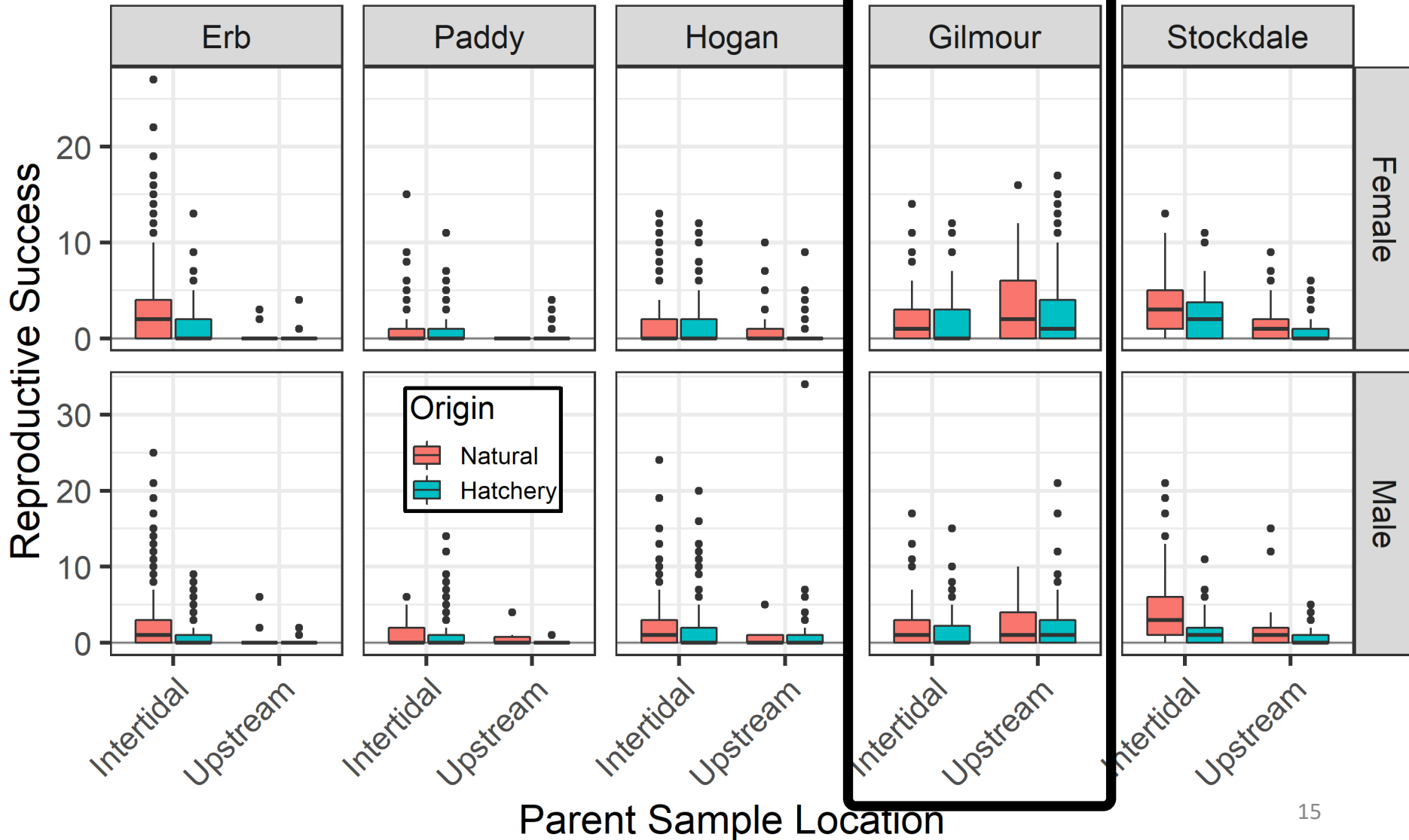
# Results: Phenotypic Differences 2014



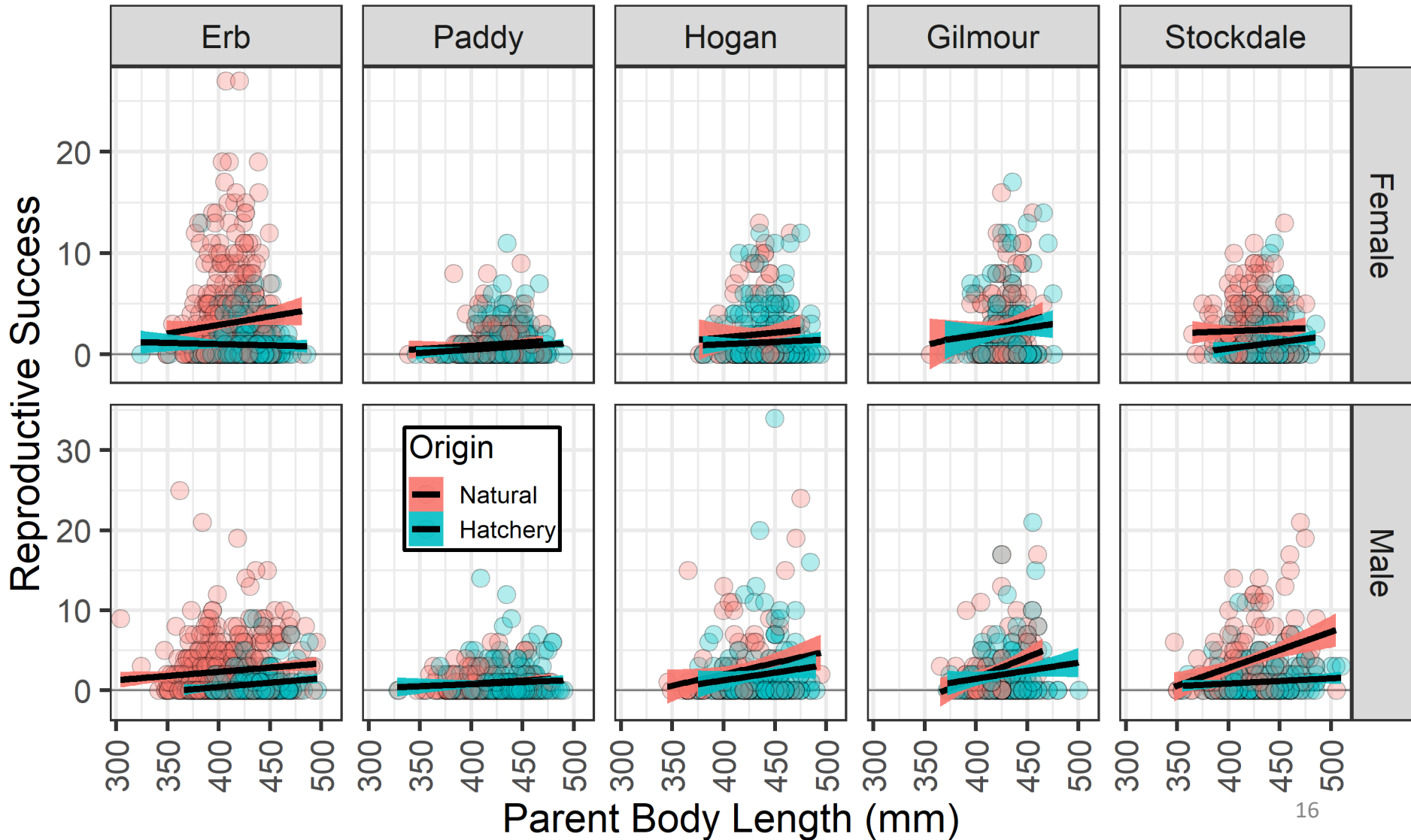
# Results: RS vs. Covariates 2014



# Results: RS vs. Covariates 2014



# Results: RS vs. Covariates 2014



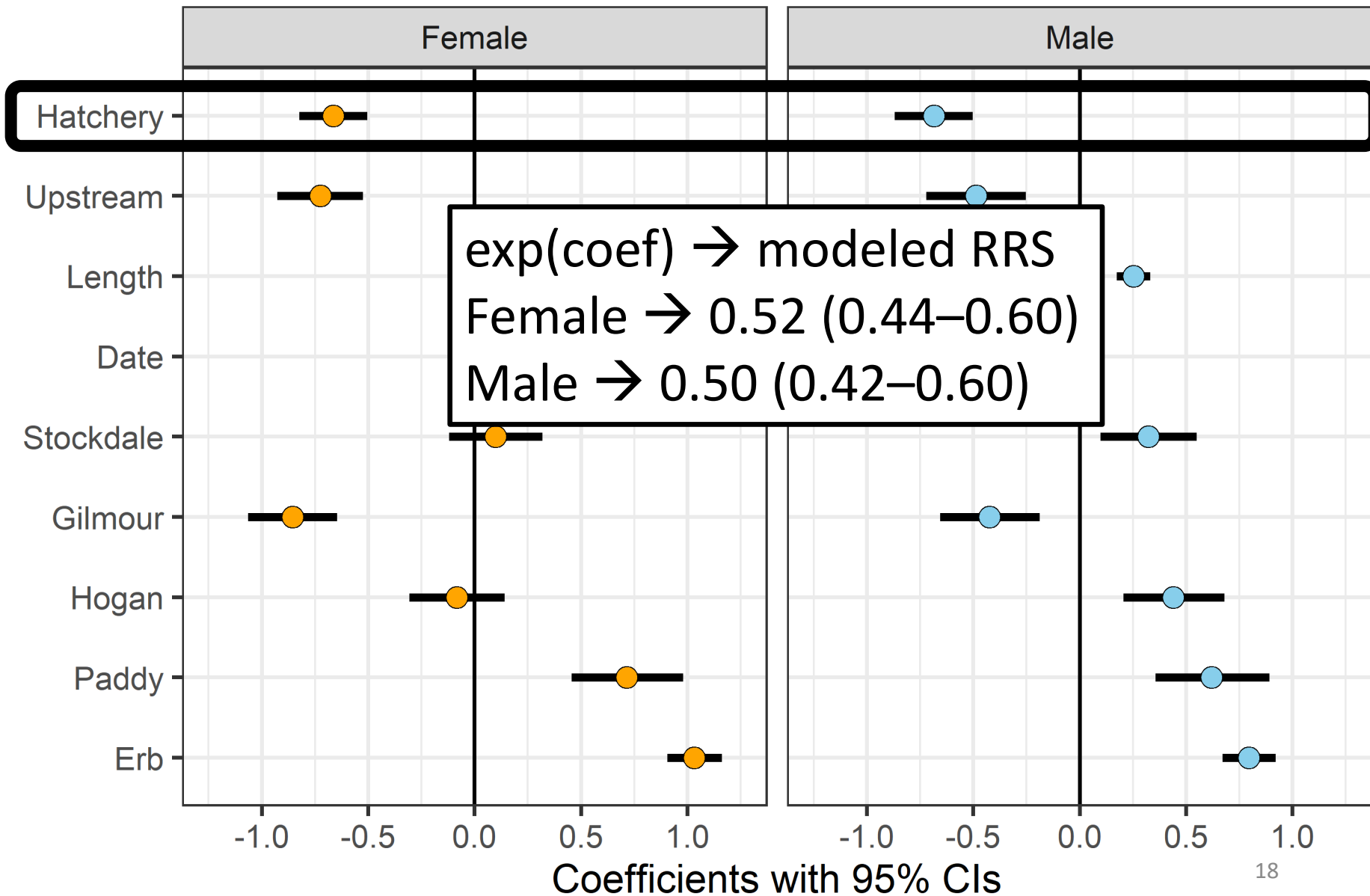


# Generalized Linear Modeling 2014

- Negative binomial GLM w/ logit link
- Separate models for males and females
- Scaled and centered covariates by stream/sex
  - Date and length
- No interaction terms (overly simplistic)
- Only linear effects (overly simplistic)

$RS \sim stream + date + length + intertidal + origin$

# Results: GLM Coefficients 2014



# Takeaways 2014

- Explored pedigree data for run year 2014
  - Very limited commercial fishing in 2016
- Hatchery-origin strays have lower RRS in all streams
  - Variation in RRS by stream and sex (range 0.29–0.96)
- Phenotypic differences between hatchery/natural
- RS correlated with date, location, body length
- GLMs indicate strong effect of hatchery-origin
  - Female RRS = 0.52 (0.44–0.60)
  - Male RRS = 0.50 (0.42–0.60)

# Next Steps - GLMs

- Explore stream location data in more detail
  - Distance from stream mouth
  - Stream reach effects
- Explore stream:covariate interactions
- Explore non-linear covariate relationships
- AIC model-selection
- Odd-lineage data

Stream	2013	2014	2015	2016	2017	2018	2019	2020
Erb	P	P	P,O	P,O	O,G	P,O,G		O,G
Paddy	P	P	P,O	P,O	O,G	P,O,G		O,G
Hogan	P	P	P,O	P,O	P,O,G	O,G	O,G	
Gilmour		P	P	P,O	P,O	O,G	O,G	
Stockdale	P	P	P,O	P,O	P,O,G	O,G	O,G	

# AHRP Streams in PWS

Presenting 2022

Stream	2013	2014	2015	2016	2017	2018	2019	2020
Hogan	P	P	P,O	P,O	P,O,G	O,G	O,G	
Stockdale	P	P	P,O	P,O	P,O,G	O,G	O,G	
Gilmour		P	P	P,O	P,O	O,G	O,G	
Paddy	P	P	P,O	P,O	O,G	P,O,G		O,G
Erb	P	P	P,O	P,O	O,G	P,O,G		O,G

P – parents  
 O – offspring  
 G – grand-offspring

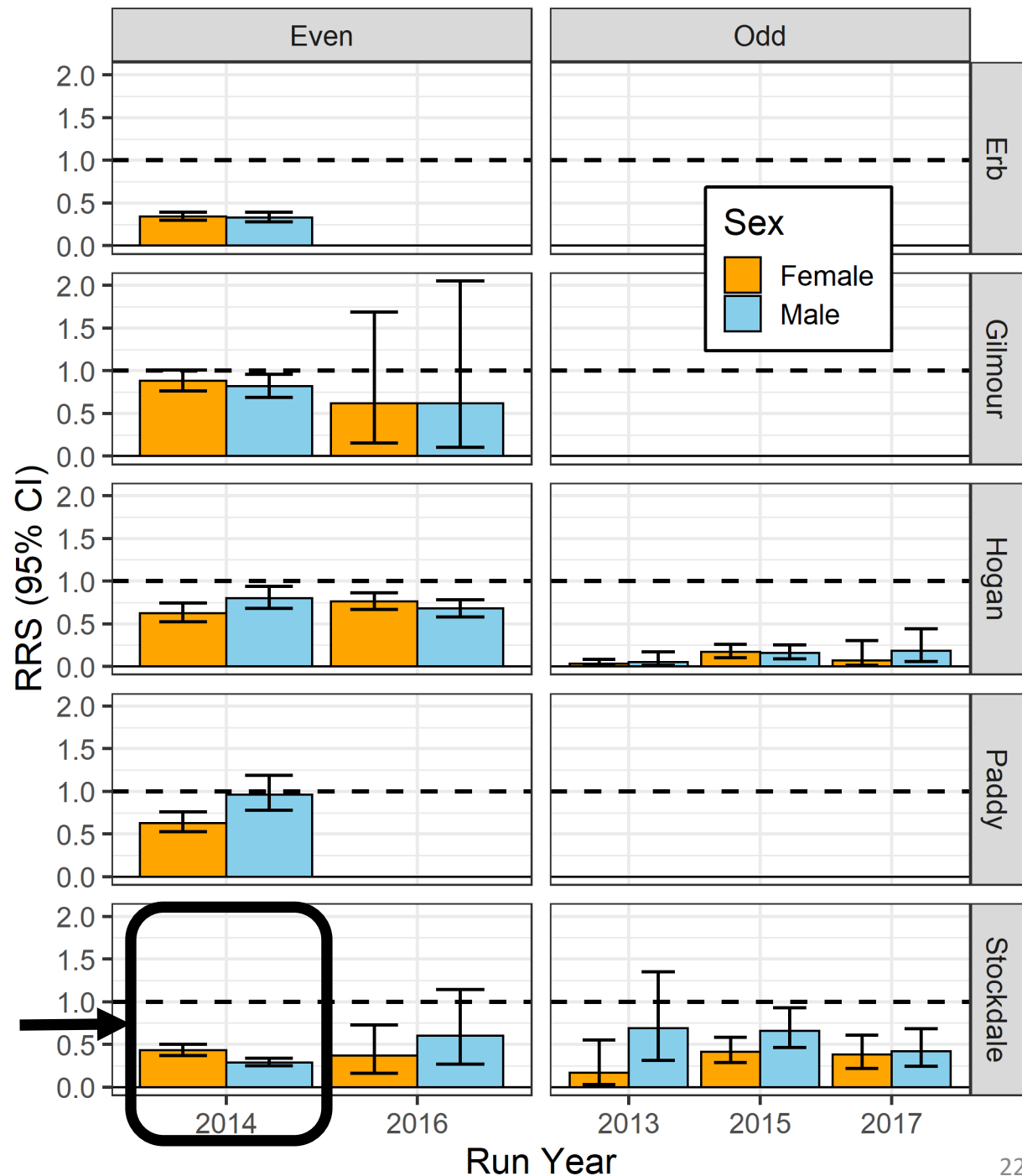
Odd-lineage  
 Even-lineage

>235K samples!

# Summary of RRS to Date

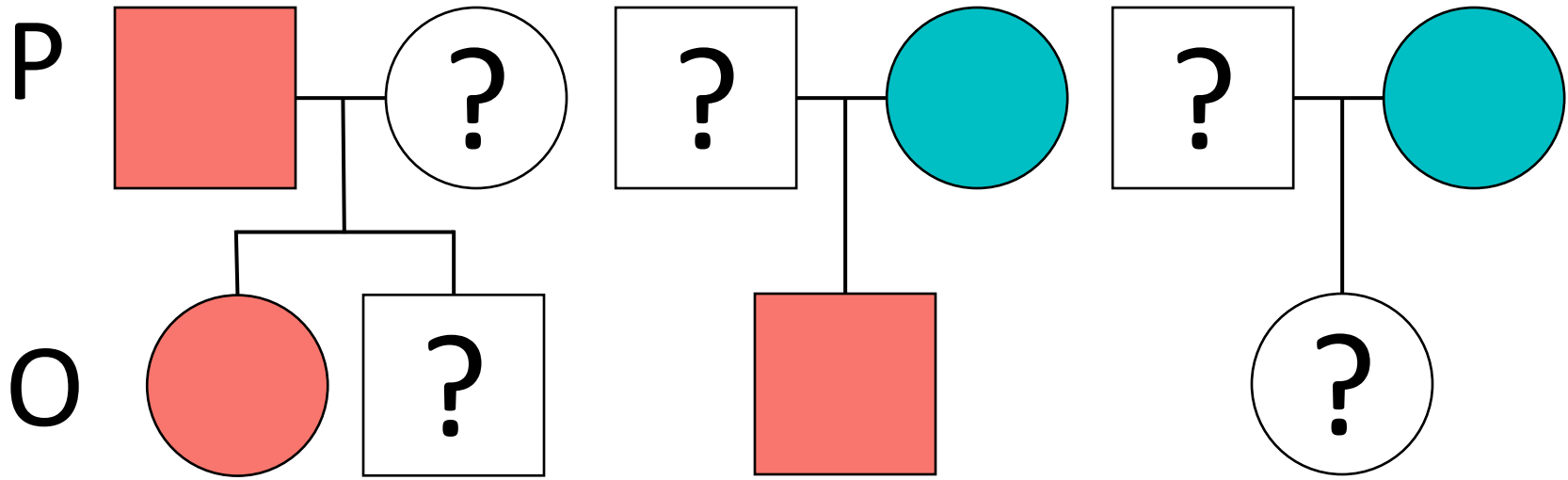
128K samples analyzed

$$RRS = \frac{\overline{RS}_{\text{Hatchery}}}{\overline{RS}_{\text{Natural}}}$$

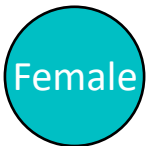
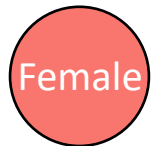
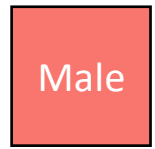


Results show in detail on previous slides

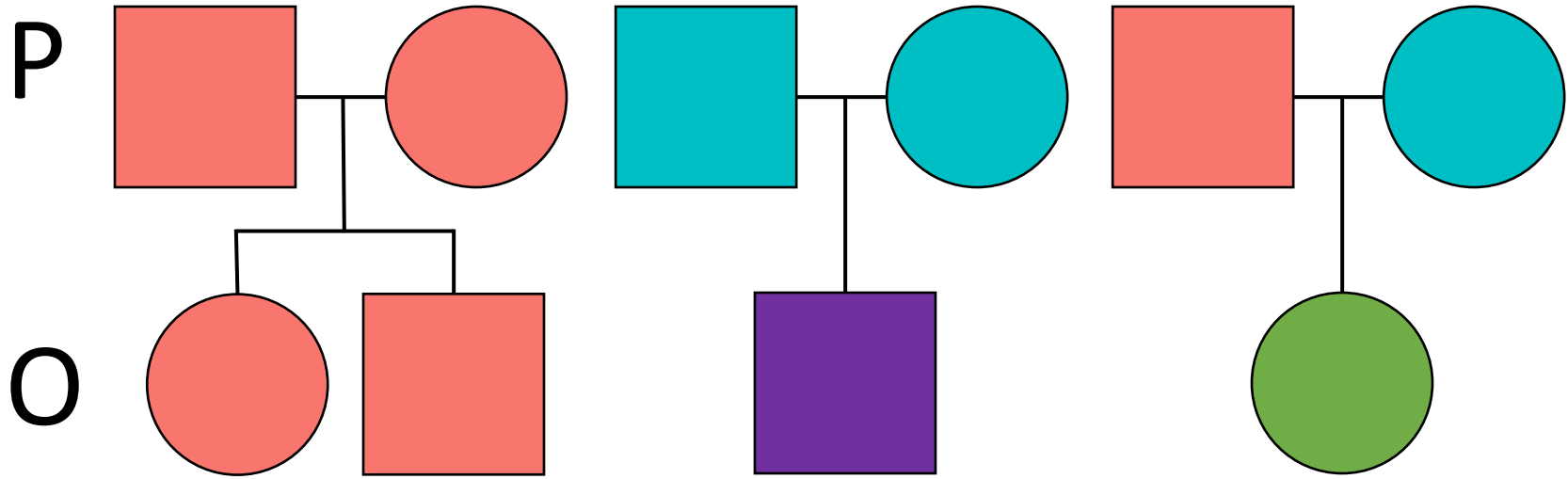
# Parent-Offspring Duos



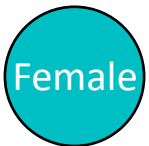
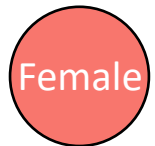
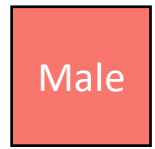
Natural Hatchery



# Parent-Offspring Trios

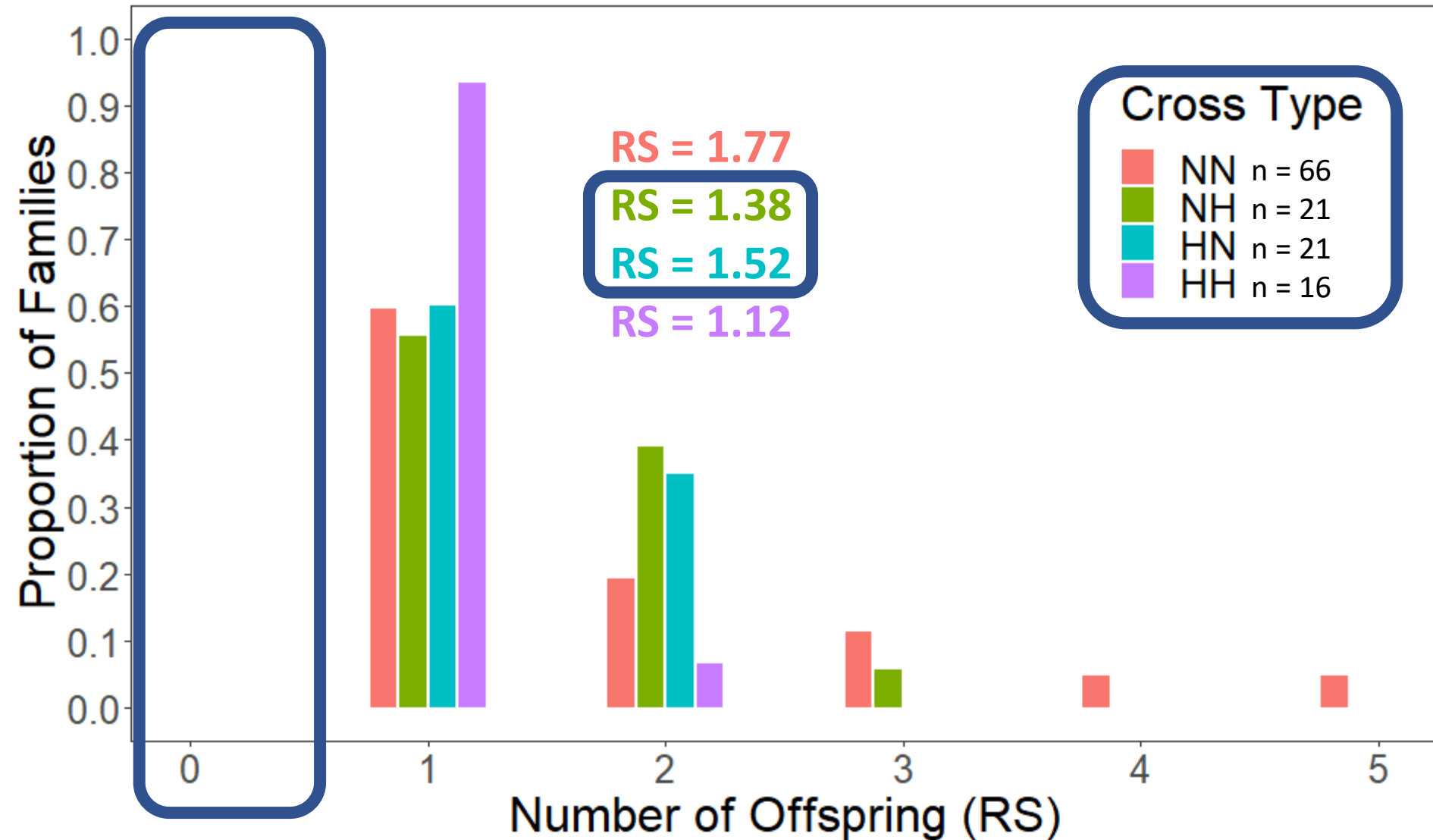


**Natural**   **Hatchery**





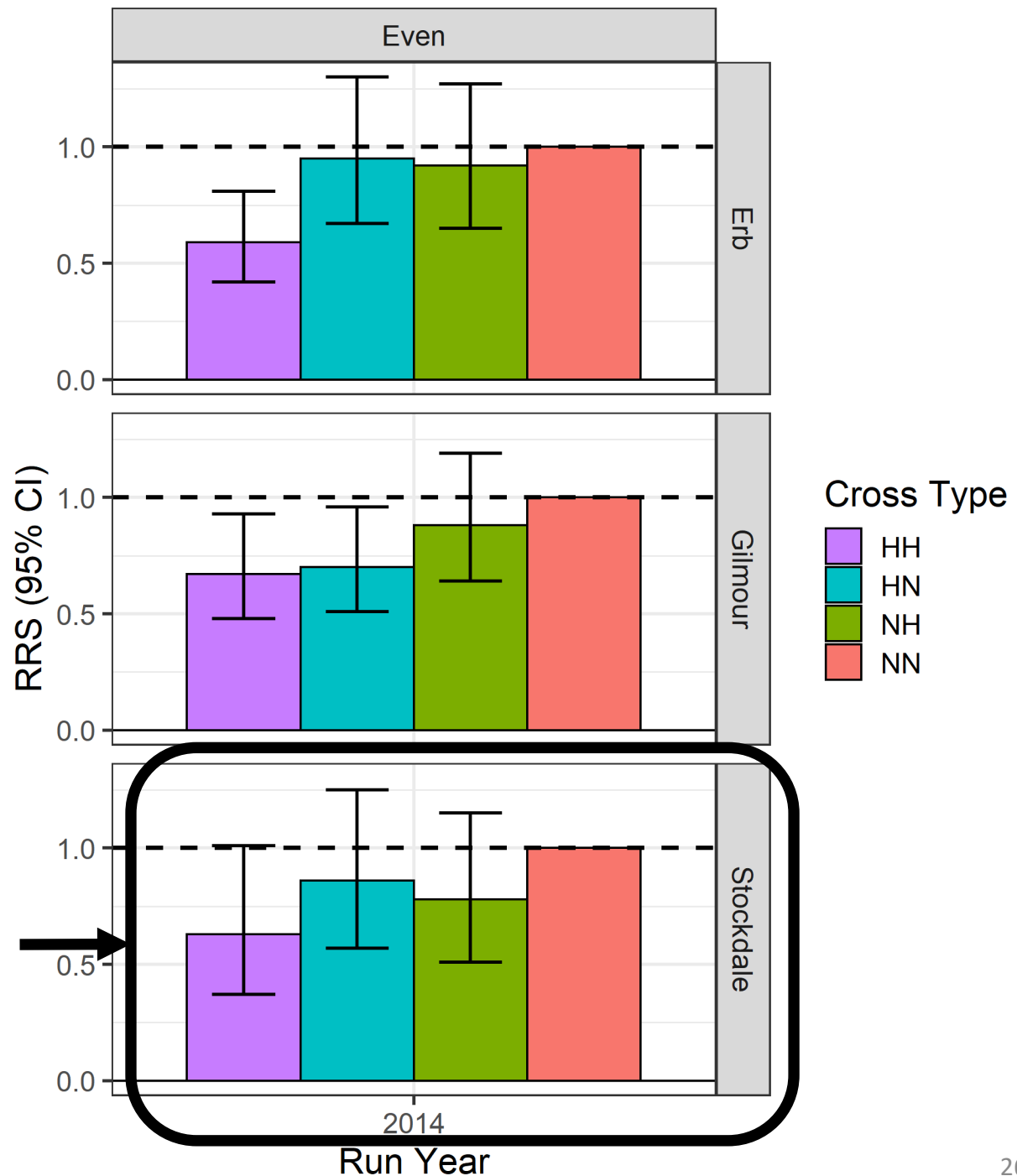
# RS Distribution: Stockdale 2014/2016



# Summary of RRS to Date

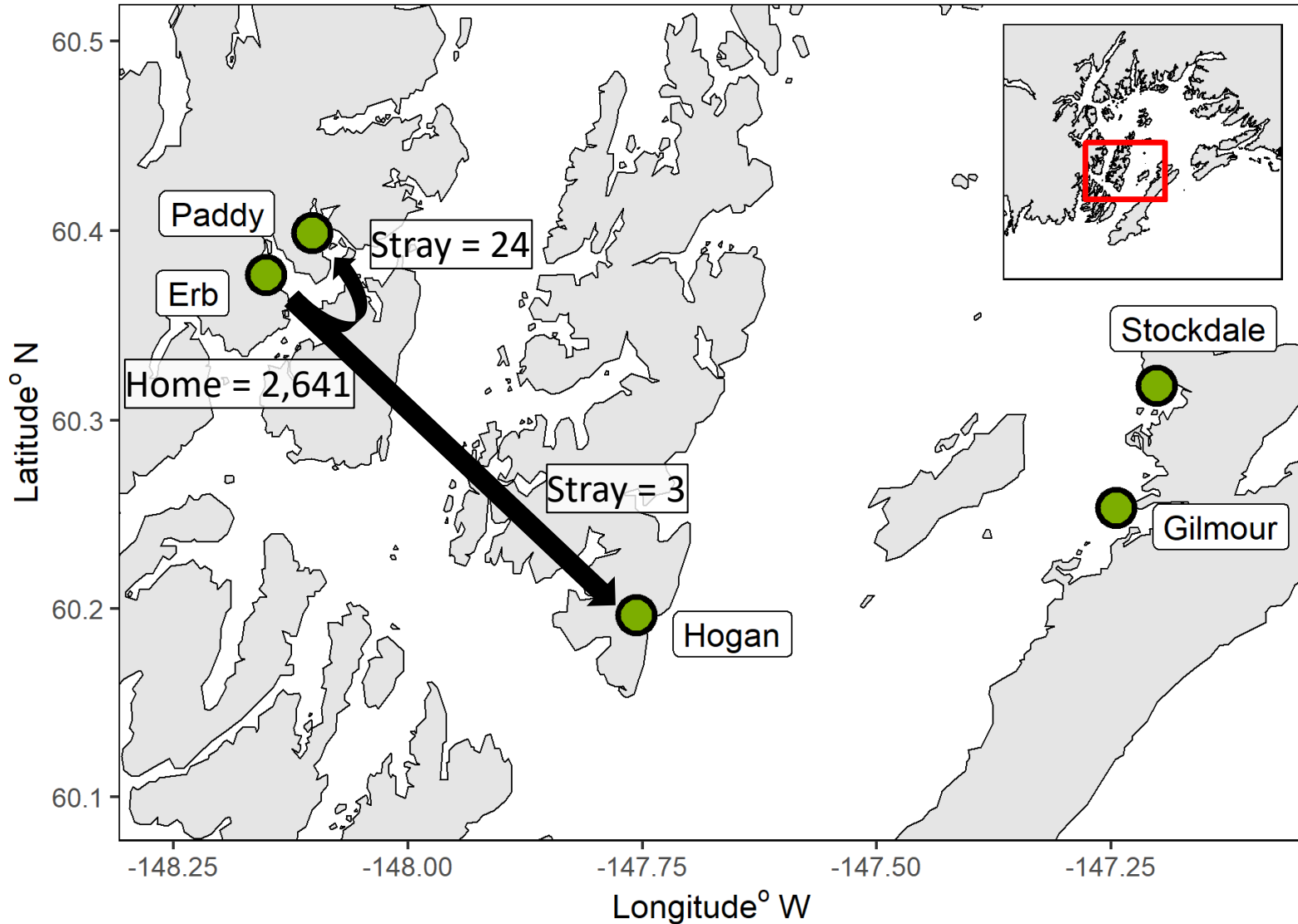
Limited to  $n_{\text{family}} > 15$

$$\text{RRS} = \frac{RS_{XX}}{RS_{NN}}$$

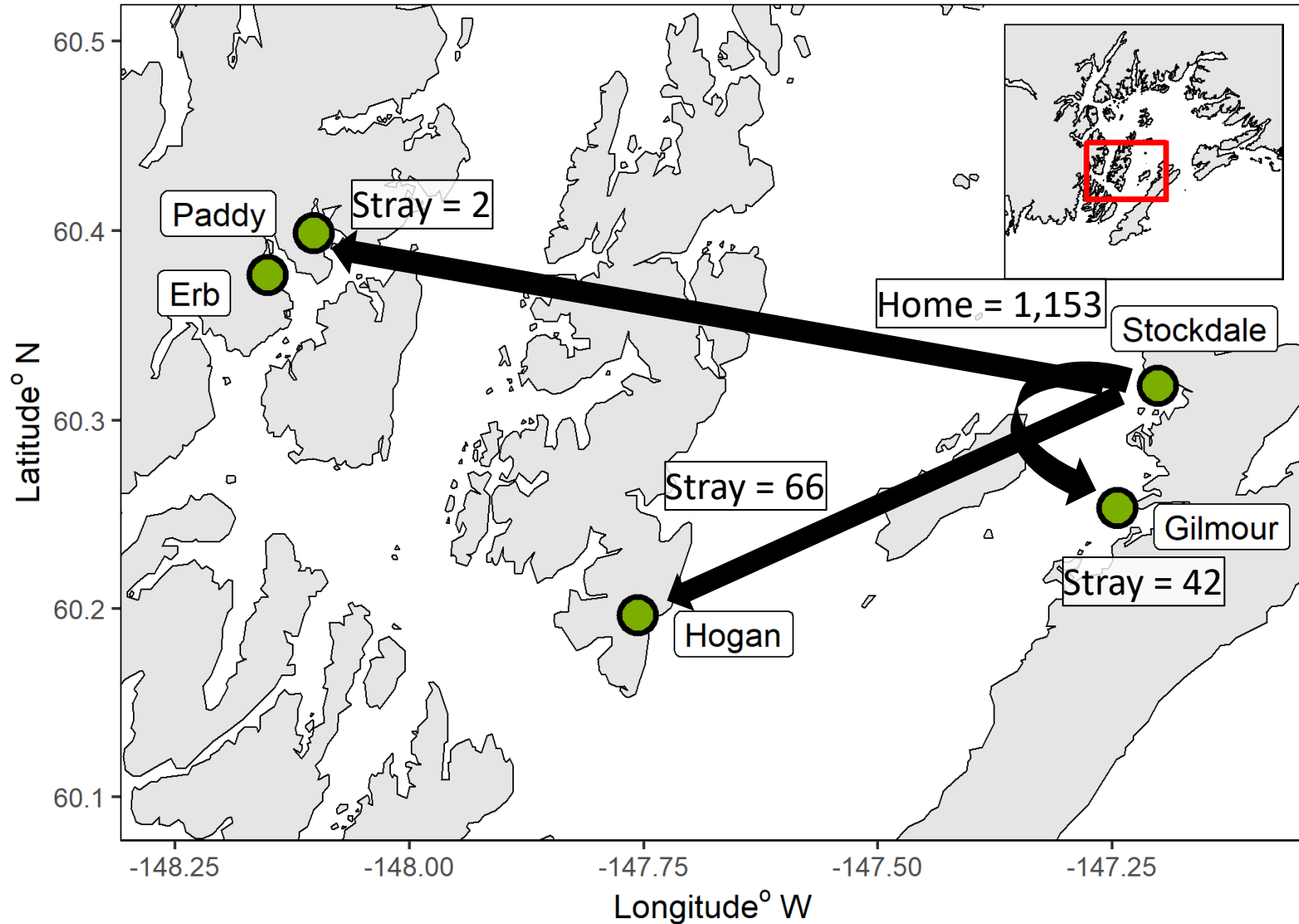


Results show in detail on previous slides

# Natural-straying: 2014 Pedigrees

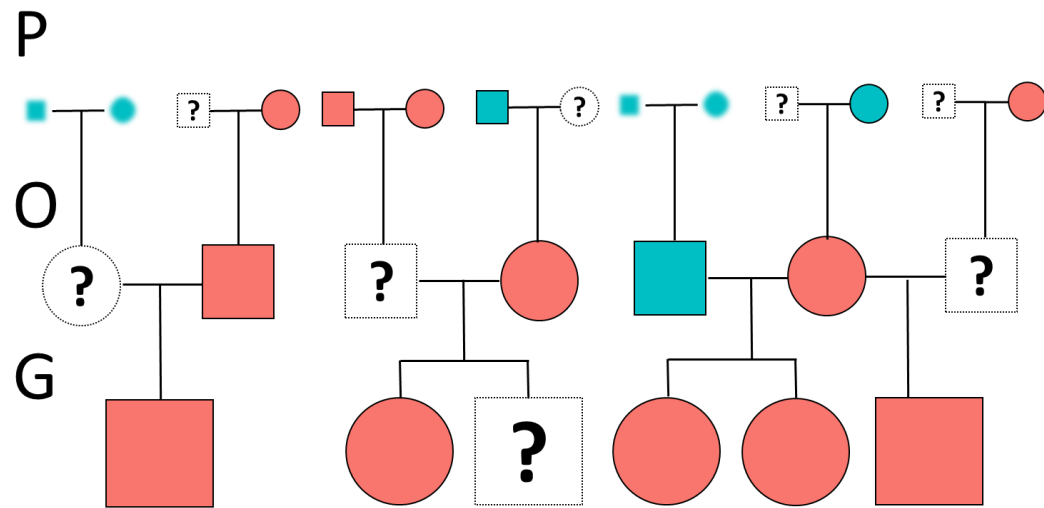


# Natural-straying: 2014 Pedigrees



# Grandparentage and F<sub>2</sub> analyses

- RRS of the offspring of hatchery strays
- Challenging given incomplete sampling
- Missing parents and missing grandparents



# Parent RRS (P → O)

Gilmour	hatchery	natural	RRS
2014	311	238	0.82 (0.73-0.91)
2016	645	604	

Numbers =  $\sum$  parent-offspring relationships

# Offspring RRS (O → G)

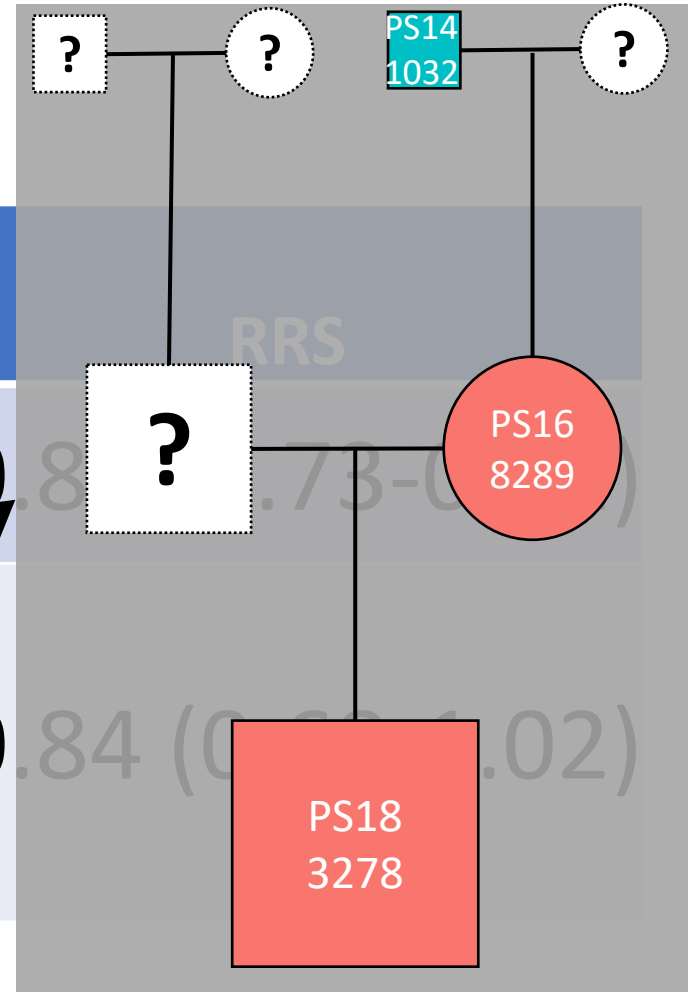
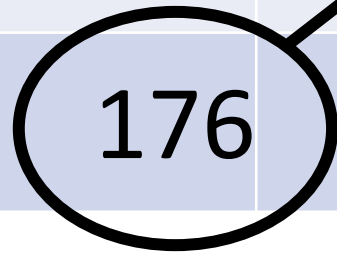
Gilmour	hatchery	natural	RRS
2014	311	238	0.82 (0.73-0.91)
2016	645	604	0.84 (0.68-1.02)
2018	176	197	

Numbers =  $\sum$  parent-offspring relationships

# Offspring RRS (O → G)

Gilmour (14/16/18)	
# Grandparents	# Grandoffspring
1	175
2	84
3	10

Gilmour	hatchery	natural	
2014	311	238	0
2016	645	604	0
2018	176	197	0



Numbers =  $\sum$  parent-offspring relationships



# Offspring RRS (O → G)

Gilmour	hatchery	natural	RRS
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2018	176	197	

Stockdale	hatchery	natural	RRS
2014	436	358	0.35 (0.31-0.40)
2016	373	865	0.94 (0.61-1.42)
2018	30	74	

Hogan	hatchery	natural	RRS
2015	4,383	3,775	0.16 (0.11-0.22)
2017	41	221	0.35 (0.11-0.84)
2019	4	62	

Stockdale	hatchery	natural	RRS
2015	1,487	6,064	0.52 (0.40-0.66)
2017	71	561	1.17 (0.59-2.12)
2019	11	74	

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2019	11	74	

# Conclusions

- Hatchery-origin strays spawn in streams
- Stray hatchery-origin RRS  $< 1$
- Variability in RRS (streams, years, sexes)
- Body size, sample date, sample location matter...
- But stray hatchery-origin RRS still  $< 1$
- Hybrids had intermediate RRS
- Grandparentage/ $F_2$   $\rightarrow$  low sample size

# Remaining Questions

- Are observed reductions in hatchery-origin RRS an artifact of the study design?
  - Returning adults that are harvested?
  - Returning adults that stray to other streams?
  - Sampling proportion through time?
  - All possible, but unlikely to fully explain our results
- Are results consistent in other streams and years?
  - Yes, RRS consistently < 1, but lots of variation
- Do hatchery/natural hybrids consistently produce fewer offspring than two natural-origin pink salmon?
  - Yes, on average
- Are reductions in fitness persistent across generations (grand-offspring and beyond)?
  - We do not know yet

# Acknowledgements

- Alaska Hatchery Research Program
  - State of Alaska
  - Seafood industry
  - Private non-profit hatcheries
- North Pacific Research Board (Project #1619)
  - Funding for Hogan Bay analyses (2013-2016)
- Saltonstall-Kennedy (NA16NMF4270251)
  - Funding for Stockdale analyses (2014/2016)
- Prince William Sound Science Center
  - Field collection
- ADF&G Cordova Otolith Lab
- University of Washington - Seeb Lab
- ADF&G Gene Conservation Laboratory



A large group of salmon are captured in mid-air, jumping out of the water onto a rocky shore. The fish are in various stages of their jump, with some fully extended and others just beginning to leave the water. The water is a deep blue-green color, and the rocks on the shore are dark and wet. The overall scene is dynamic and energetic.

# Questions?