Alternative steelhead smolt rearing strategies for locally derived broodstocks

NOAA FISHERIES
Northwest Fisheries Science Center

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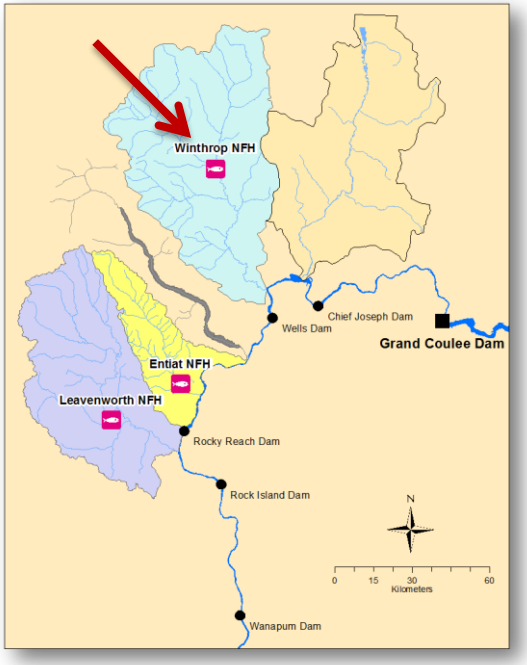
Steelhead program at WNFH

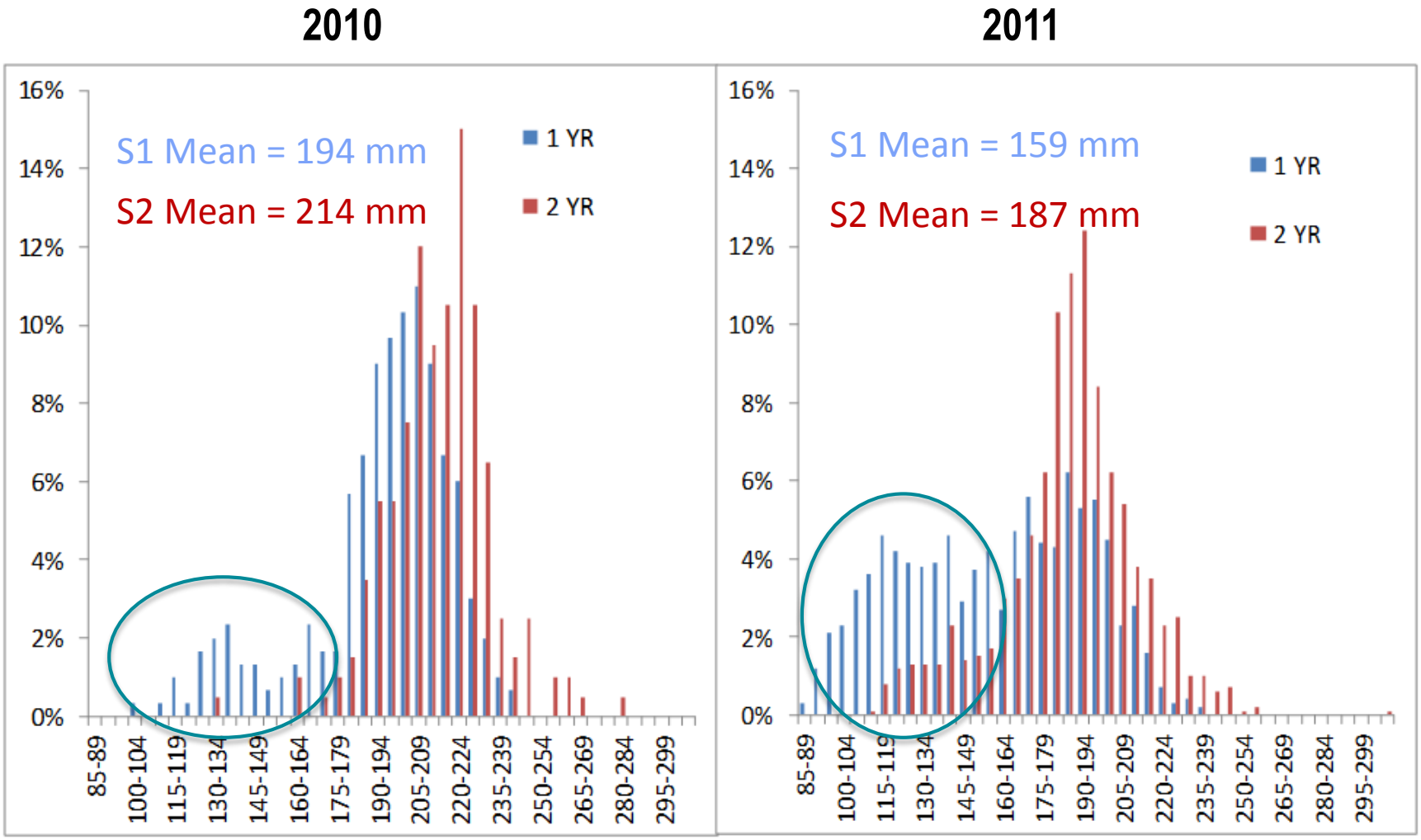
- Location: Winthrop, WA on Methow River
  - 54 miles from Columbia confluence
  - 524 miles from Pacific Ocean
  - Nine Columbia River dams
- Purpose
  - Mitigation for Grand Coulee Dam
  - Recover threatened upper Columbia River steelhead



Recovery actions for Upper Columbia steelhead

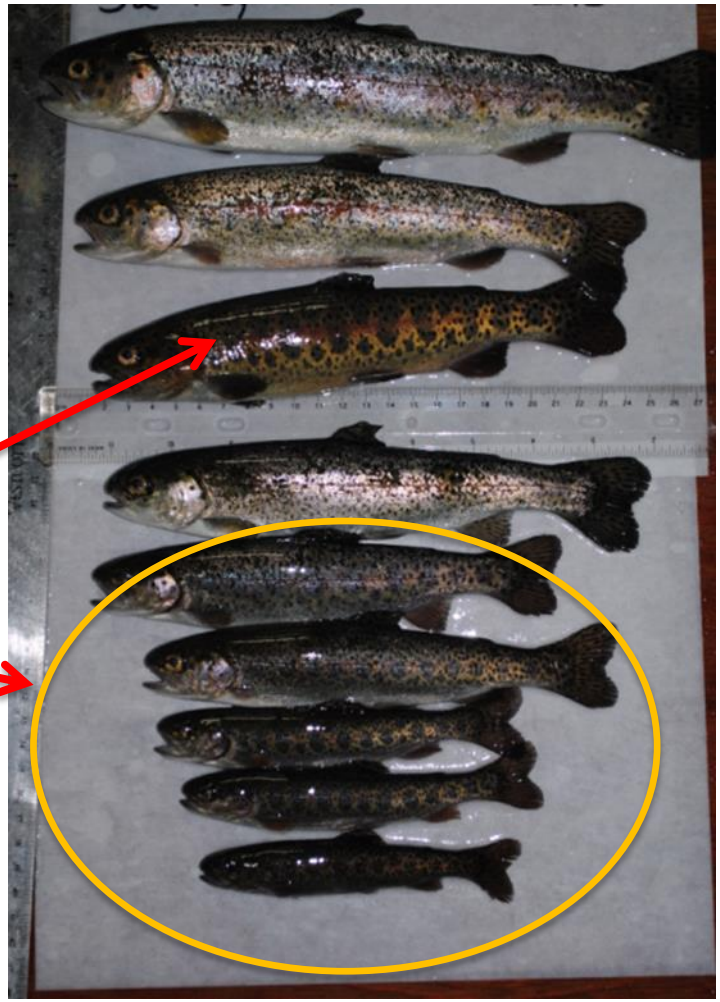
- Past program: Wells yearling smolts (S1)
- Switch to local Methow River broodstock
  - Requires change to the culture regime
    - Late spawn timing of Methow broodstock
      - Shortens growth window
    - Cold water temperatures at Winthrop NFH
      - Lower growth rates
    - **Two year smolt rearing (S2)**
- Compare S1 and S2 strategies to determine viability of switching exclusively to local broodstock.

Winthrop NFH steelhead smolt size at release

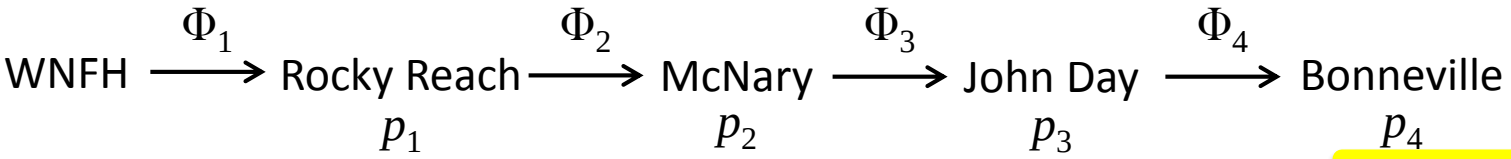


Evaluation of S1 and S2 steelhead smolts

- Outmigration (PIT tag detections)
  - Survival
  - Travel time
- Residualism
  - Precocious male maturation
  - Too small to smolt
- Prerelease subsampling
  - FL, WT, Sex, Smolt Index, tissues for physiological & genetic analyses



Outmigration Survival Data: SURPH

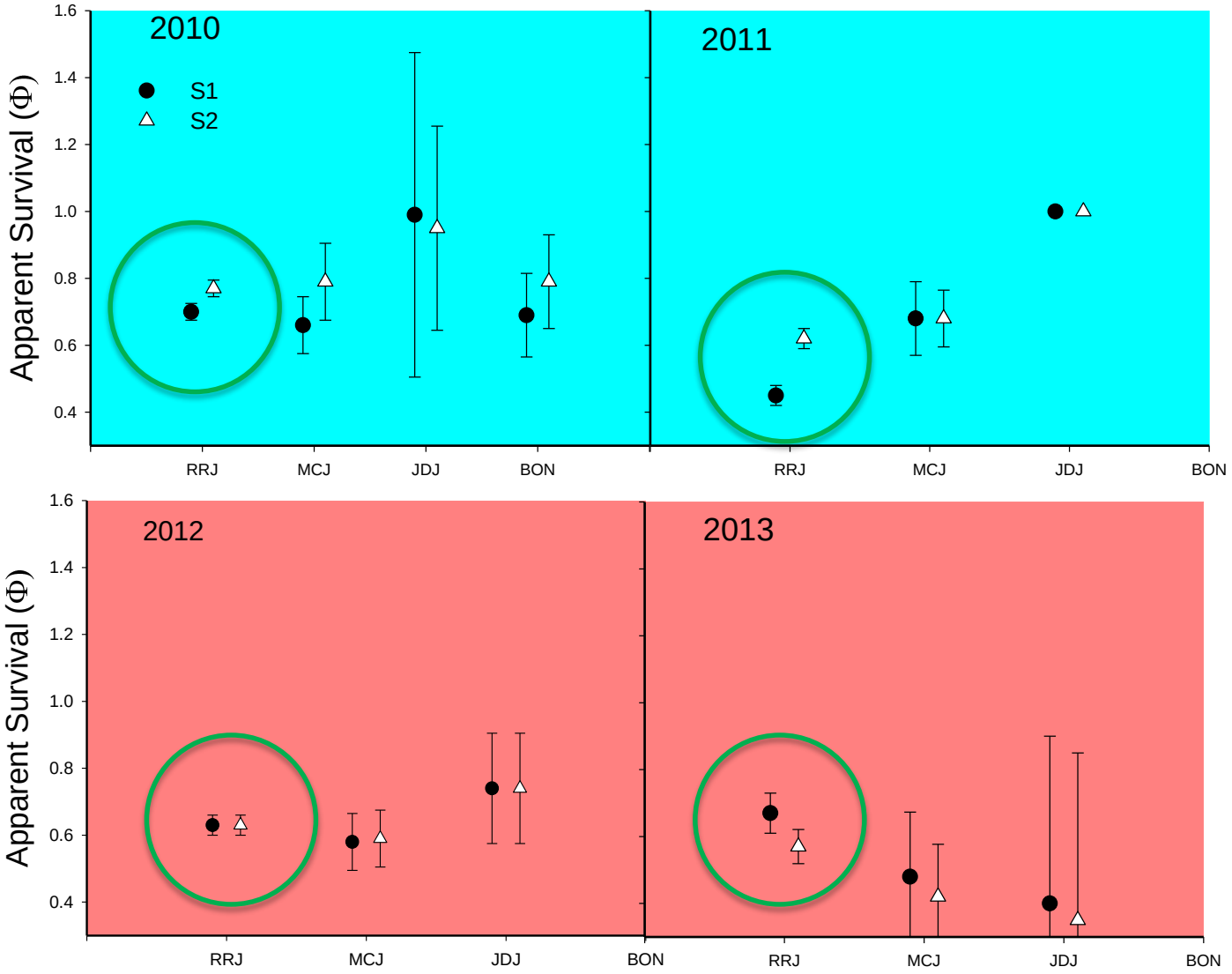


	RELEASE YEAR	GROUP	# PIT TAGS RELEASED	SURVIVAL RELEASE-RR	SURVIVAL RR-MCN	OVERALL (JOHN DAY)
Forced	2010	S1	14,841	73.7 (2.4)	55.4 (10.1)	40.8 (7.3)
		S2	14,756	81.5 (3.0)	64.9 (12.7)	52.9 (10.2)
	2011	S1	14,907	45.8 (1.8)	55.9 (5.3)	25.6 (2.2)
		S2	14,945	69.5 (2.1)	57.4 (4.3)	39.9 (2.7)
Volitional	2012	S1	14,917	64.5 (2.1)	55.5 (4.3)	28.5 (2.2)
		S2	14,892	62.2 (2.3)	56.8 (4.8)	28.0 (2.4)
	2013	S1	14,543	69.3 (2.2)	67.5 (10.1)	42.3 (5.9)
		S2	14,477	58.9 (1.7)	61.8 (6.9)	45.3 (5.6)

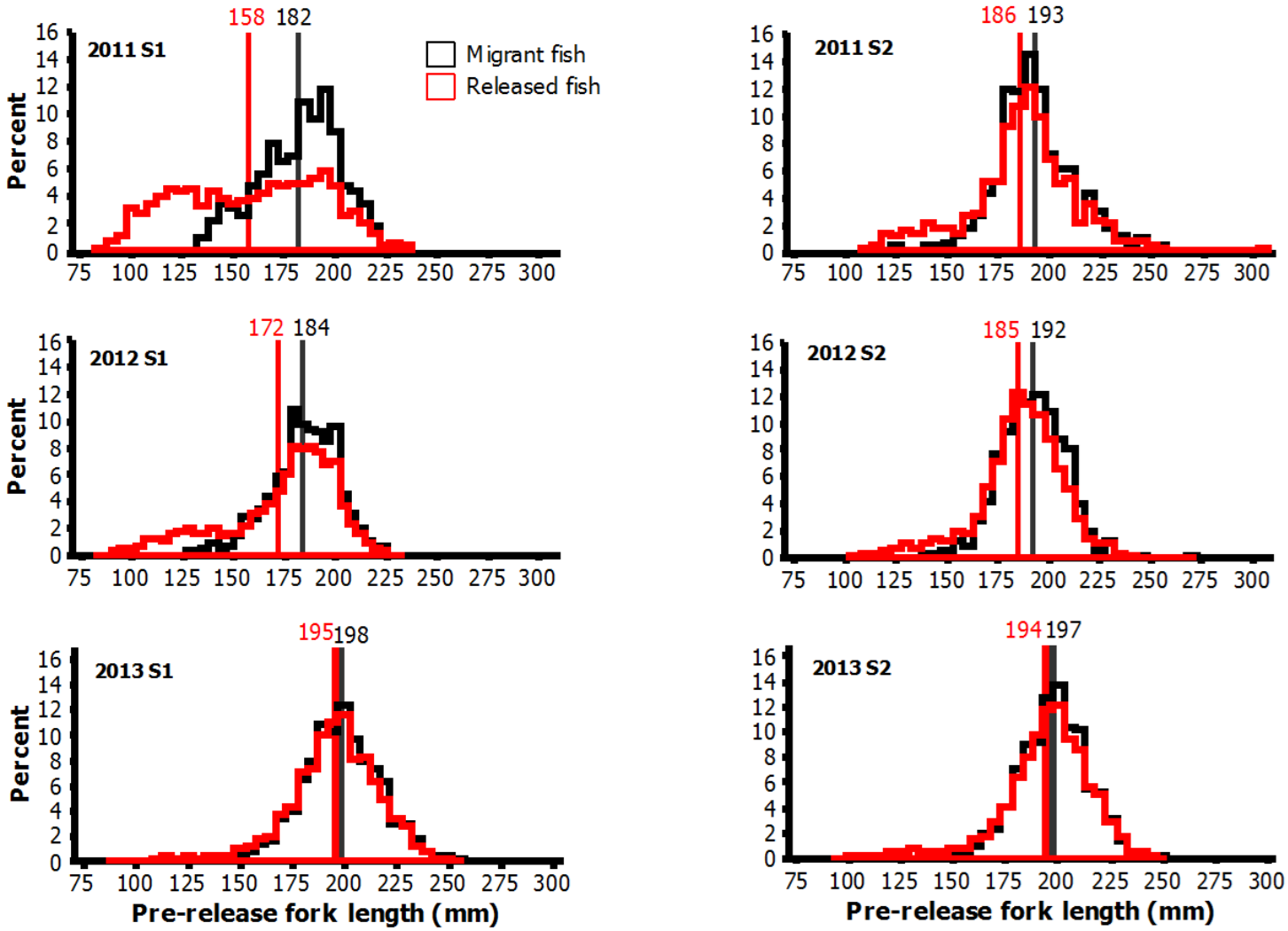
Outmigration Survival

Forced

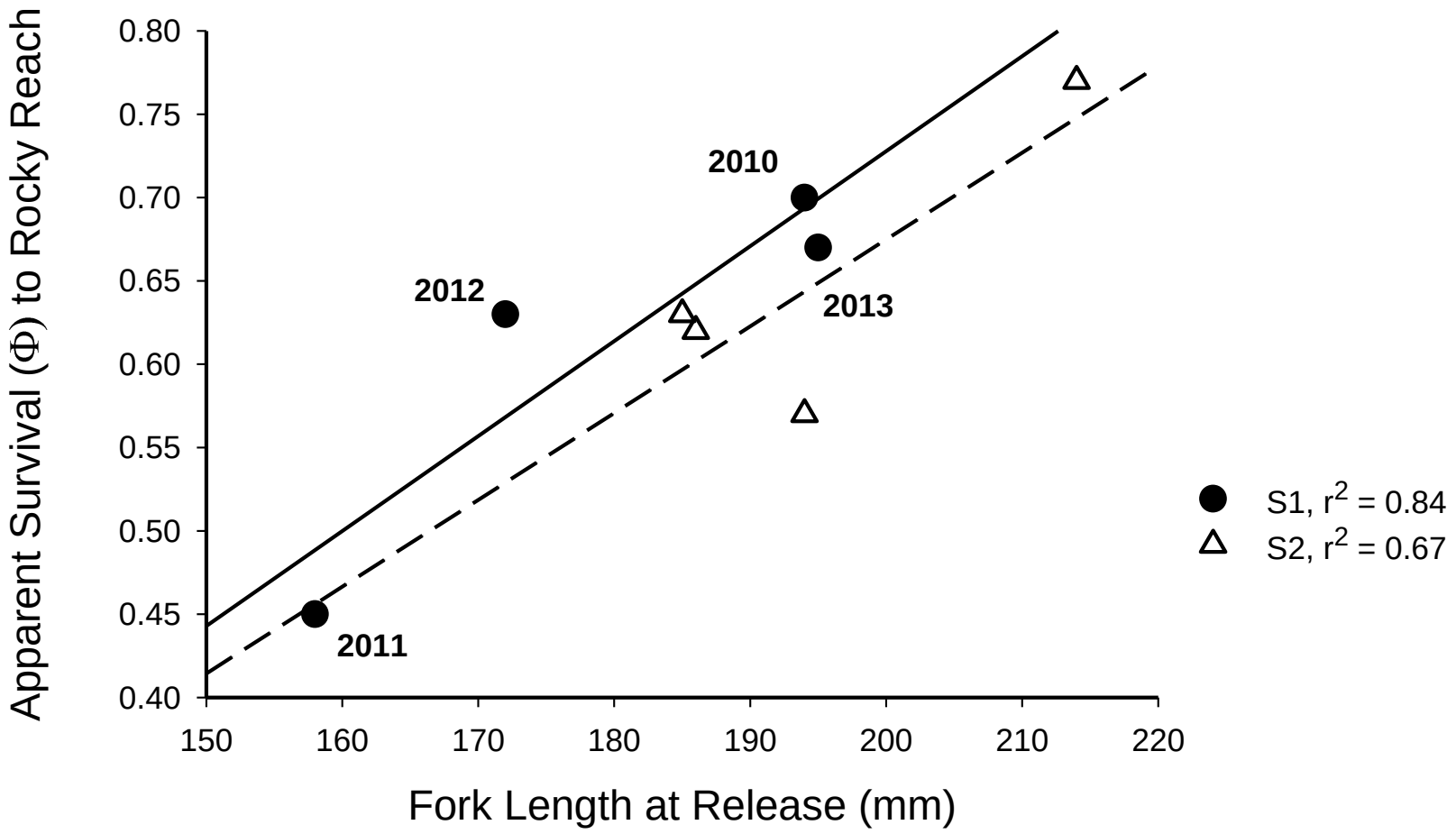
Volitional



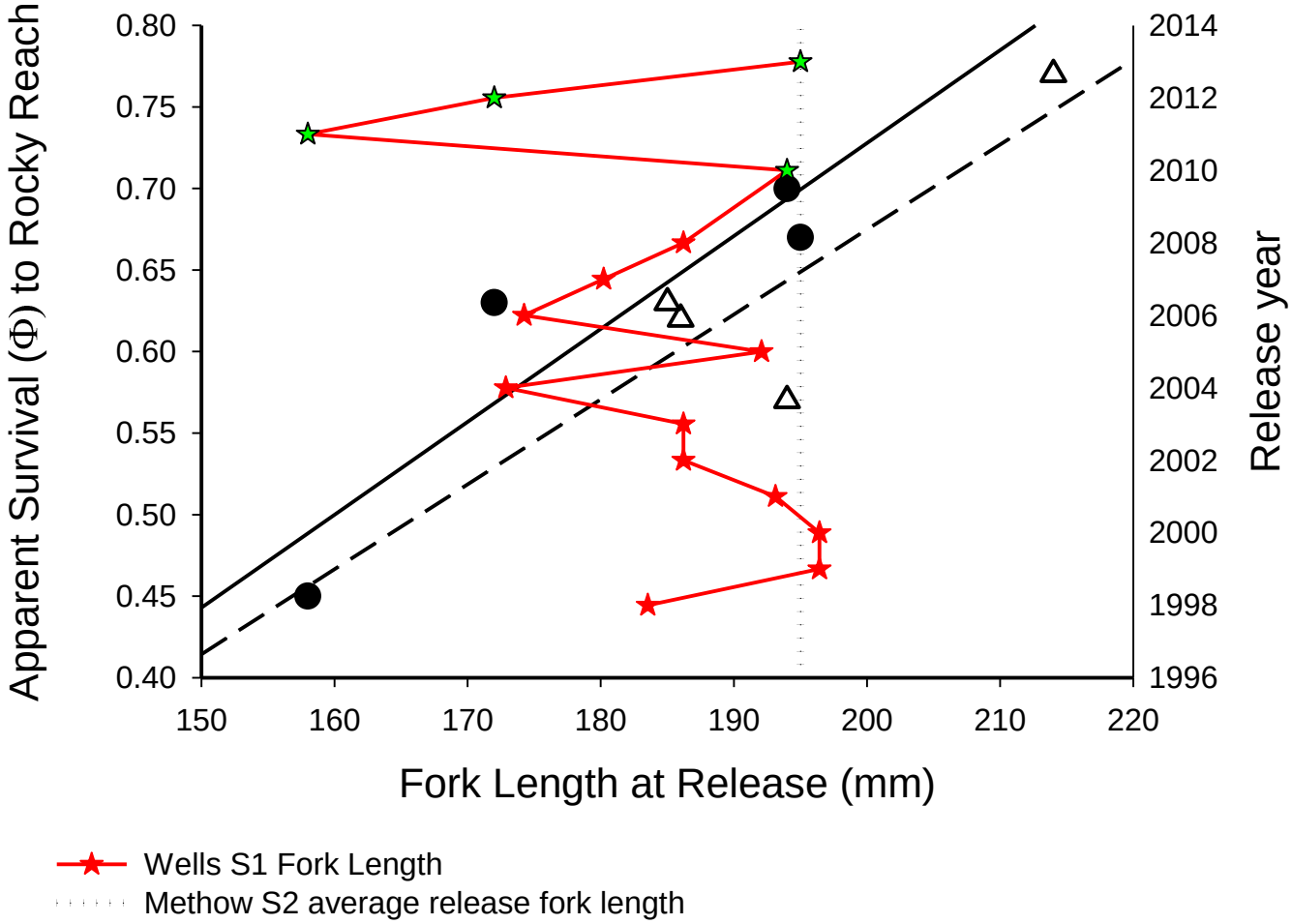
Selection on body size after release



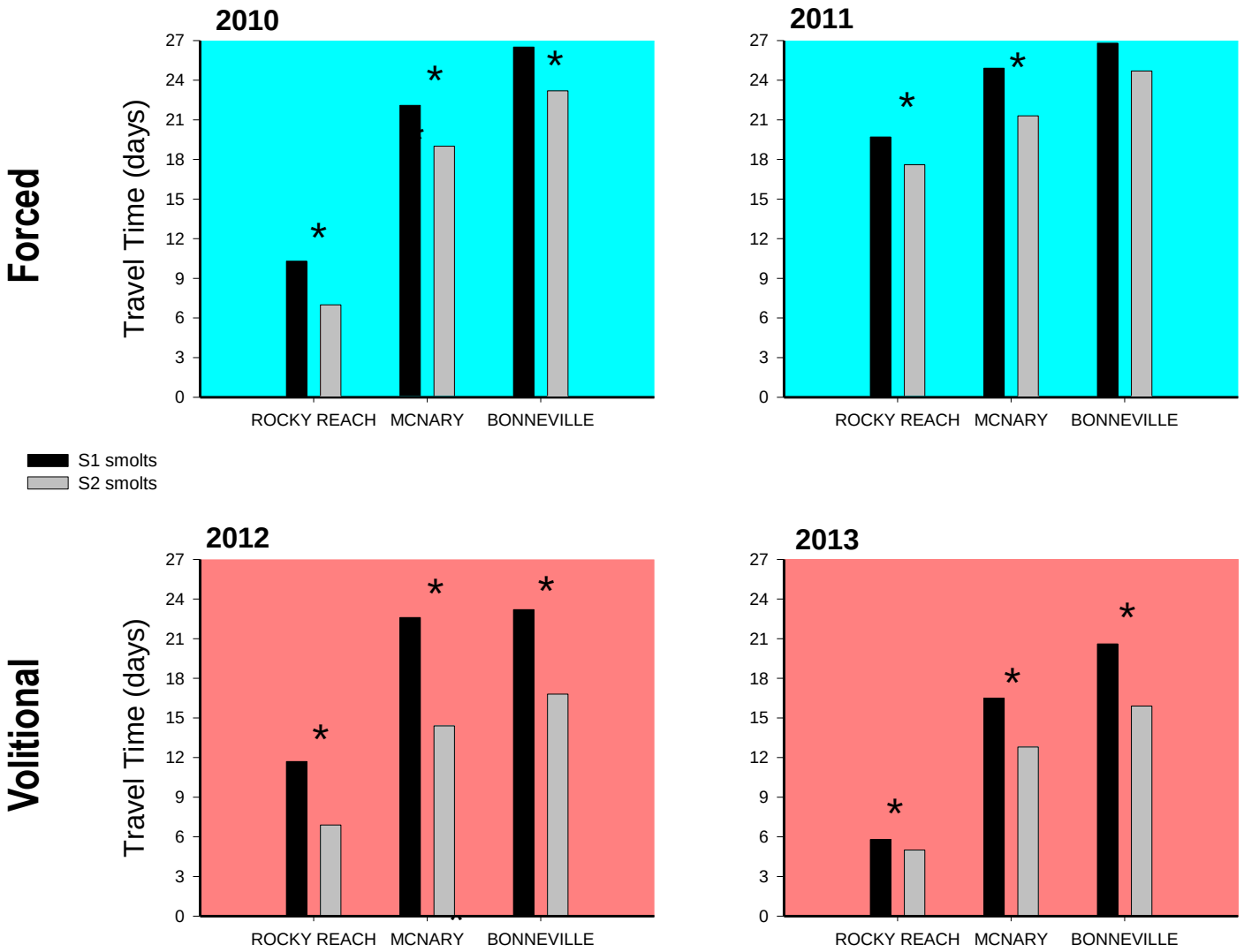
Final smolt size affects survival to Columbia



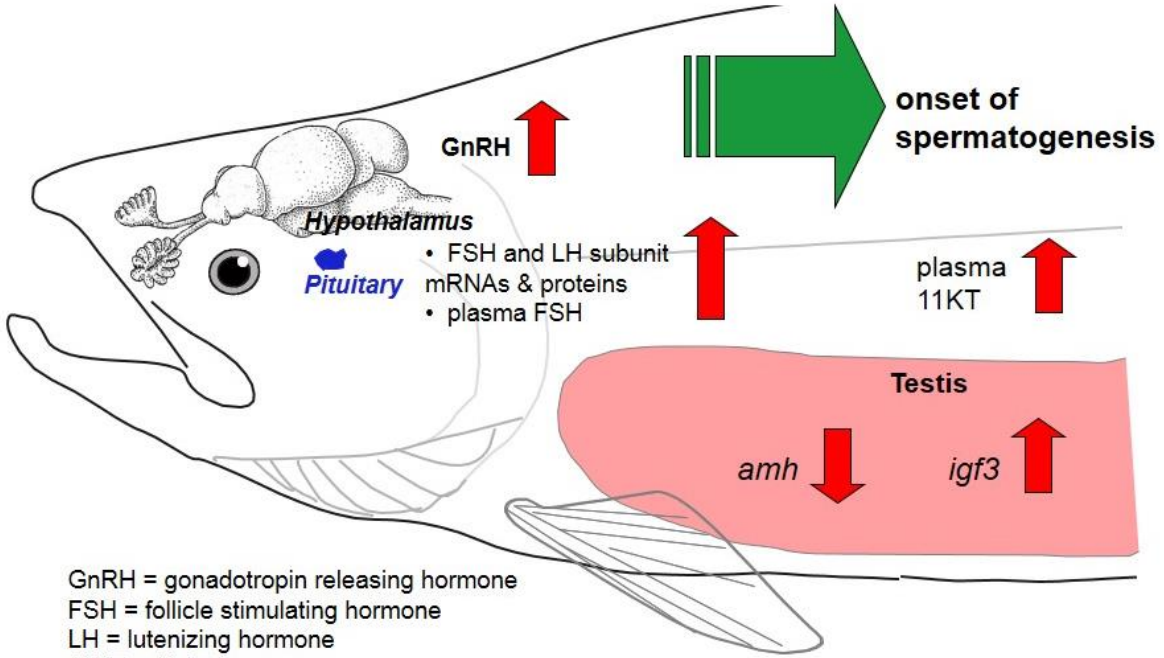
Inter-annual variability of S1 smolt size



Travel time by reach



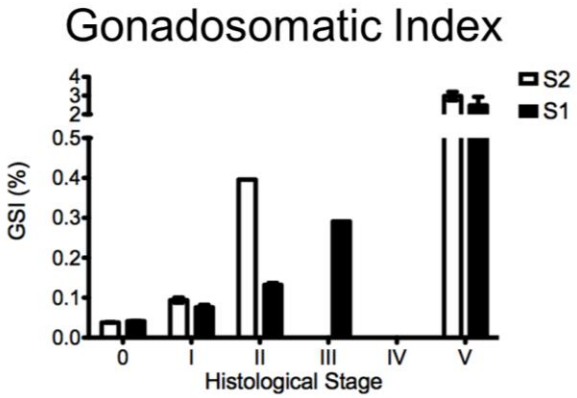
Puberty in male steelhead

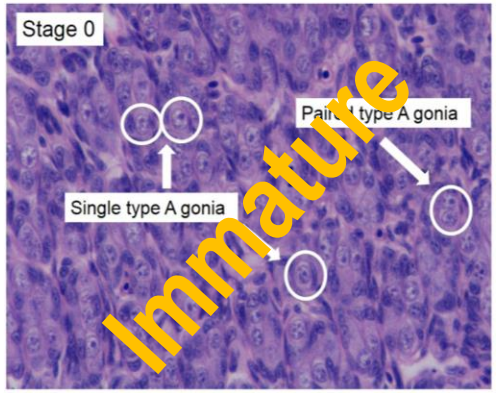


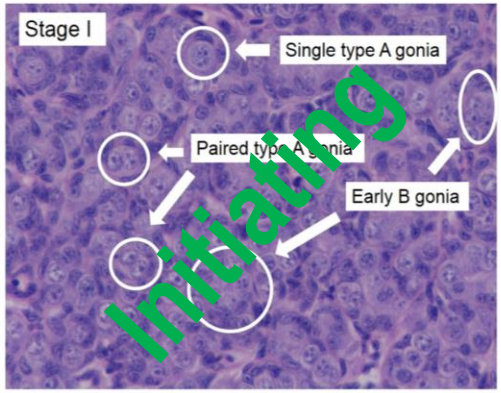
GnRH = gonadotropin releasing hormone
FSH = follicle stimulating hormone
LH = lutenizing hormone
11KT = 11-ketotestosterone
amh = anti mullerian hormone (in sertoli cells)
igf3 = insulin like growth factor 3 – a gonad specific IGF found in sertoli cells of teleost fish

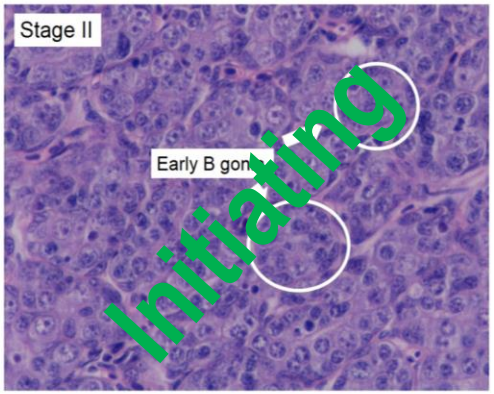
- Initiation of maturation occurs 1 year before maturation
- Before development of secondary sexual characteristics
- Small differences in GSI between initiating males and immature males
- Large differences in GSI for between mature and immature males
- Develop indicators and verify with histology of testis

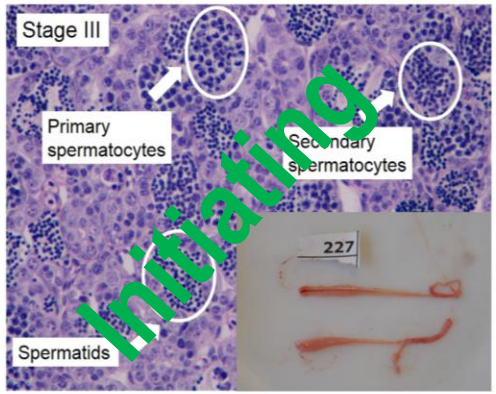
Reproductive Stages based on Histology







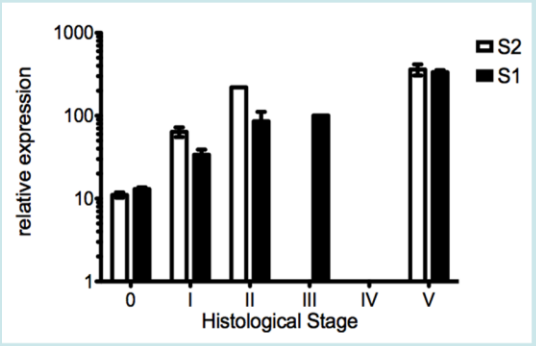




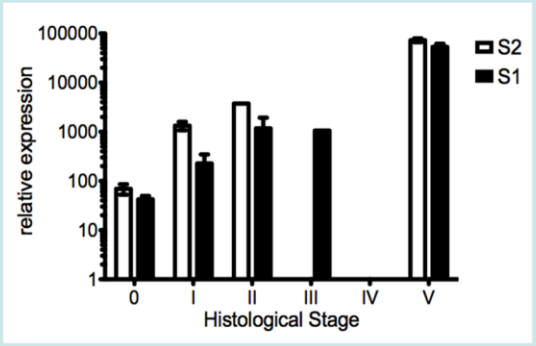
Indicators of male maturation status

Pituitary & Testis mRNAs

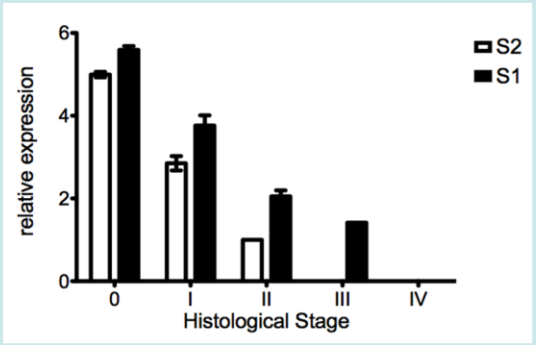
Pituitary *FSH*



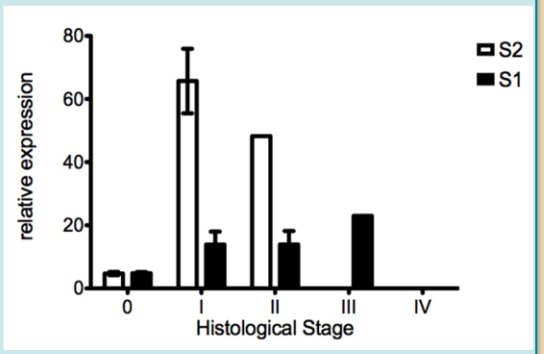
Pituitary *LH*



Testis *AMH*

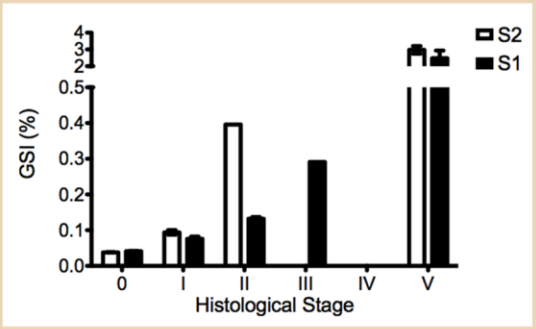


Testis *IGF-3*

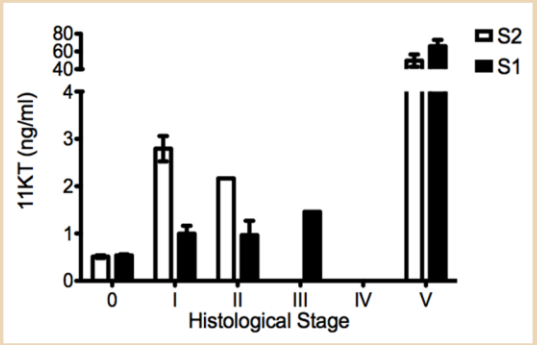


Testis size and hormones

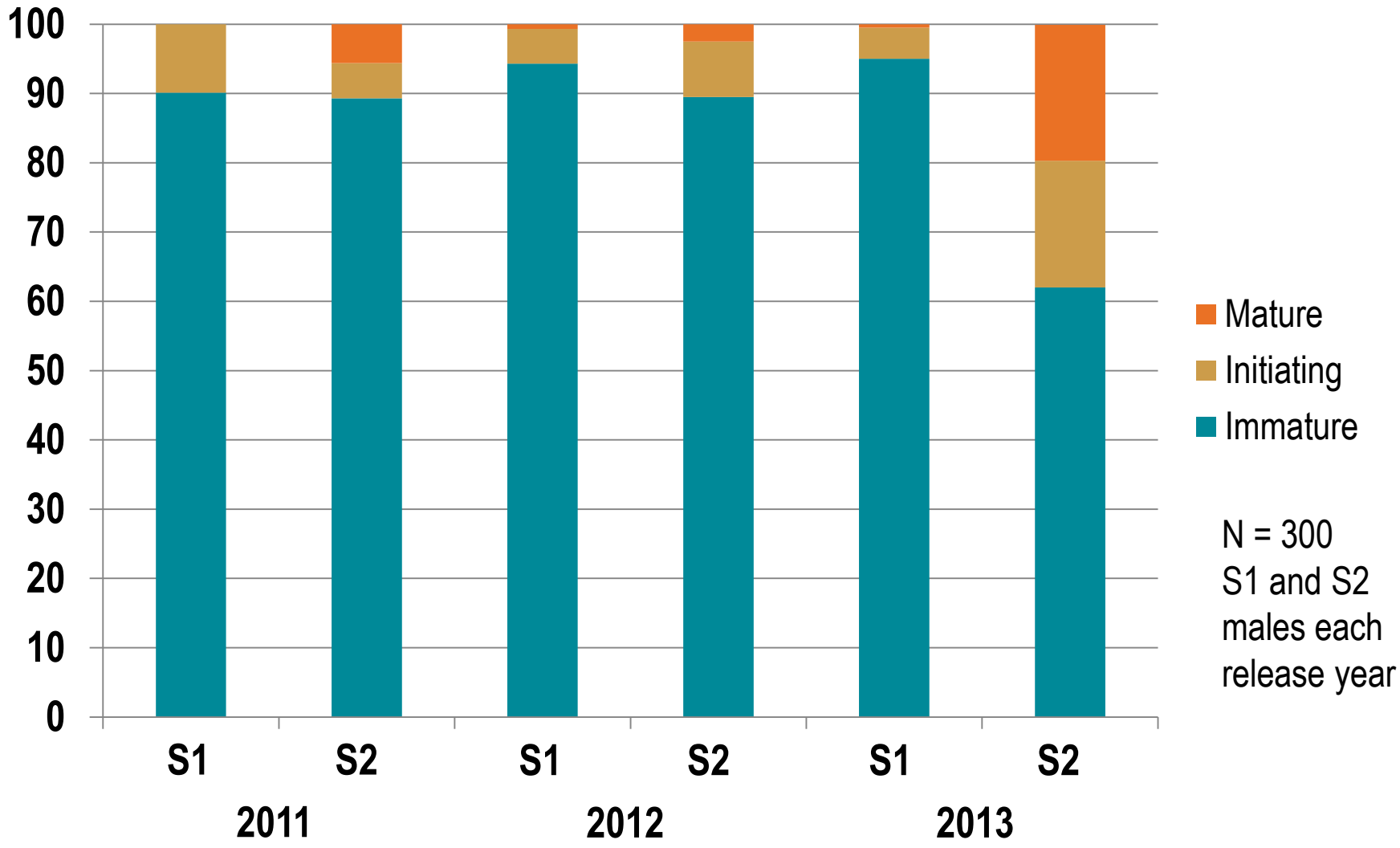
GSI



Plasma 11-KT



Male steelhead reproductive state at release

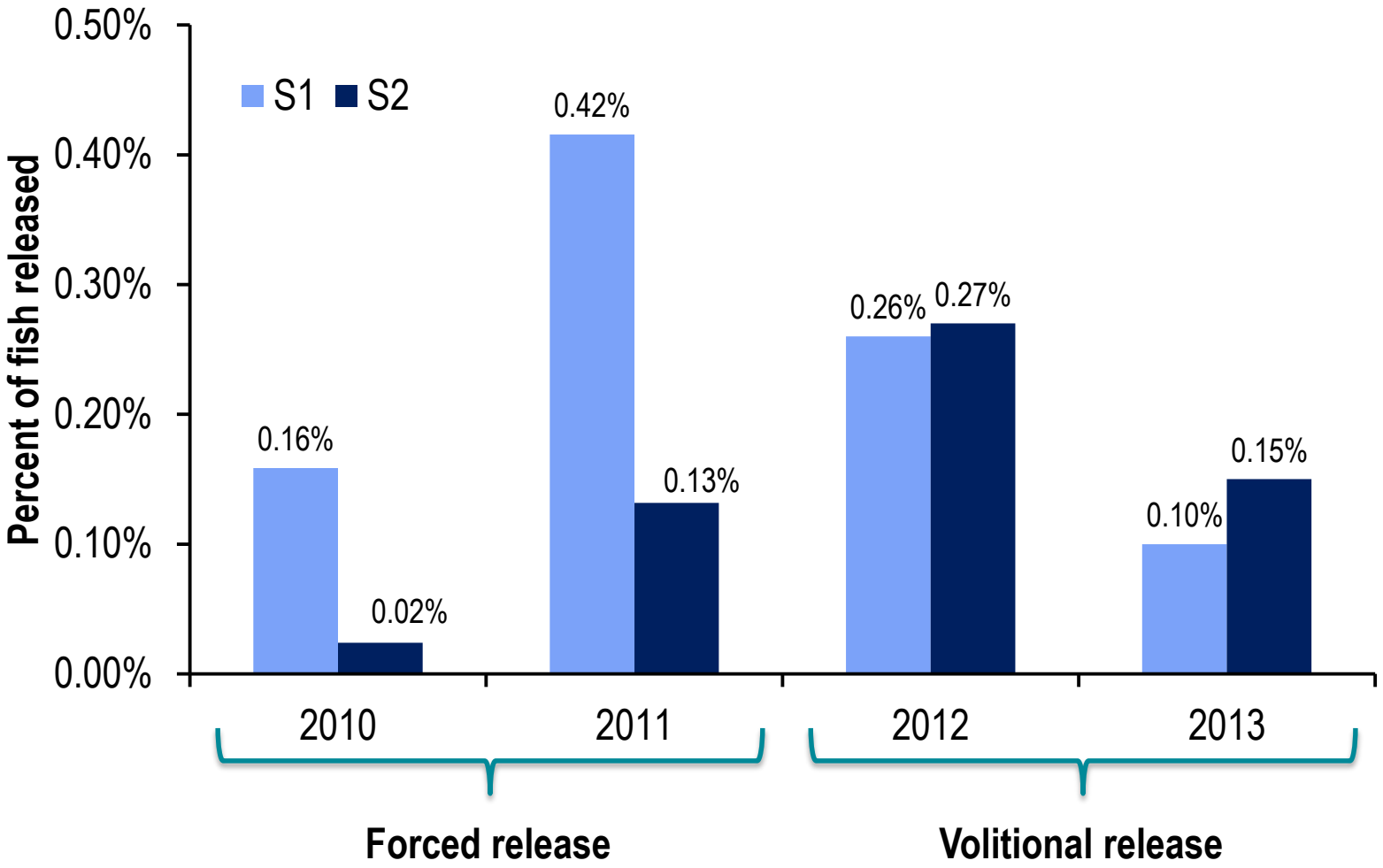


Residualism

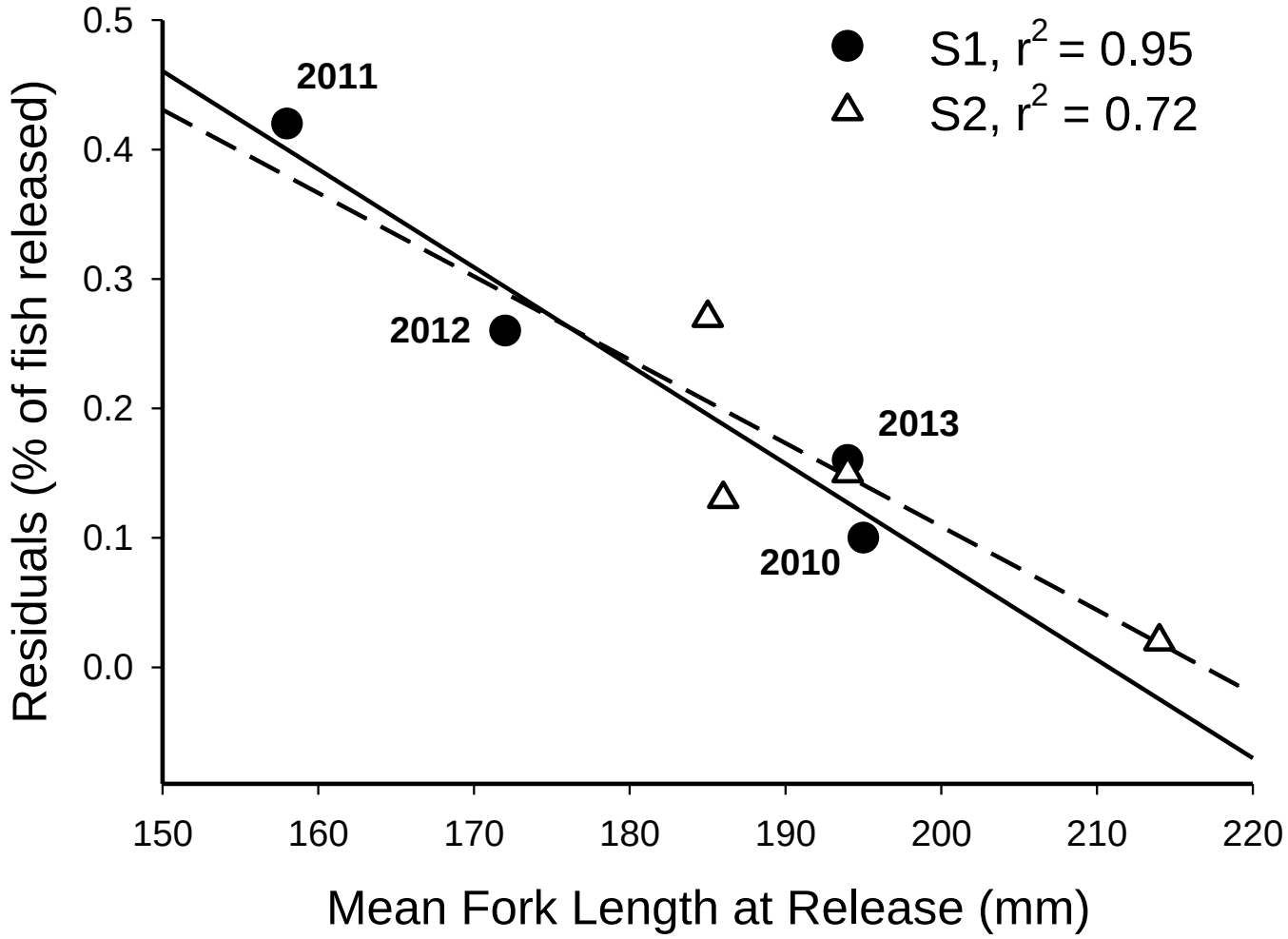
- PIT tag data
  - Compare size of released and detected S1 & S2 populations

- Annual field sampling (August and September)
  - Electrofishing, seining, angling
  - Spring Creek outfall of WNFH
  - Downstream reference reach of Methow River

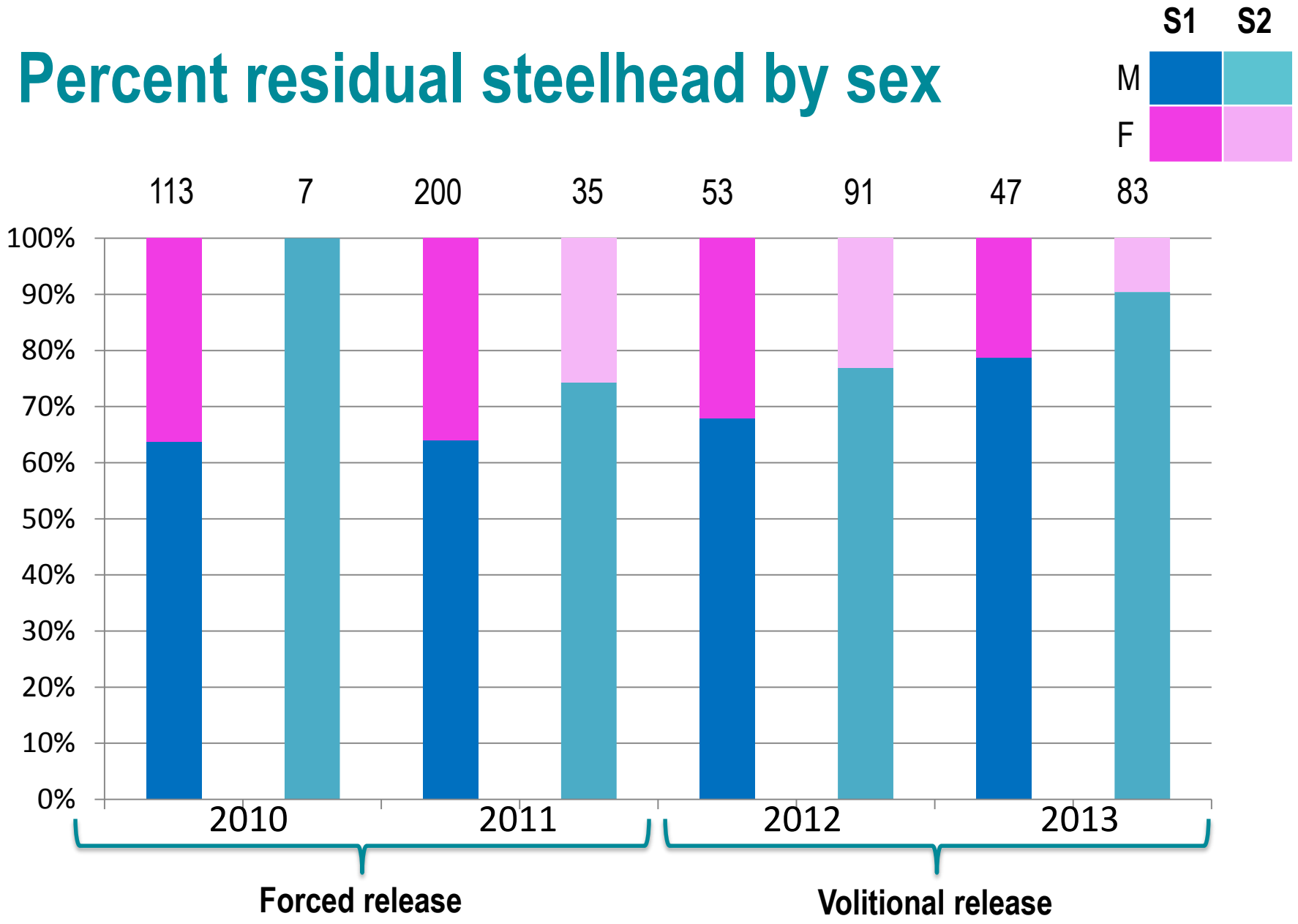
Proportional representation of S1 & S2 residuals



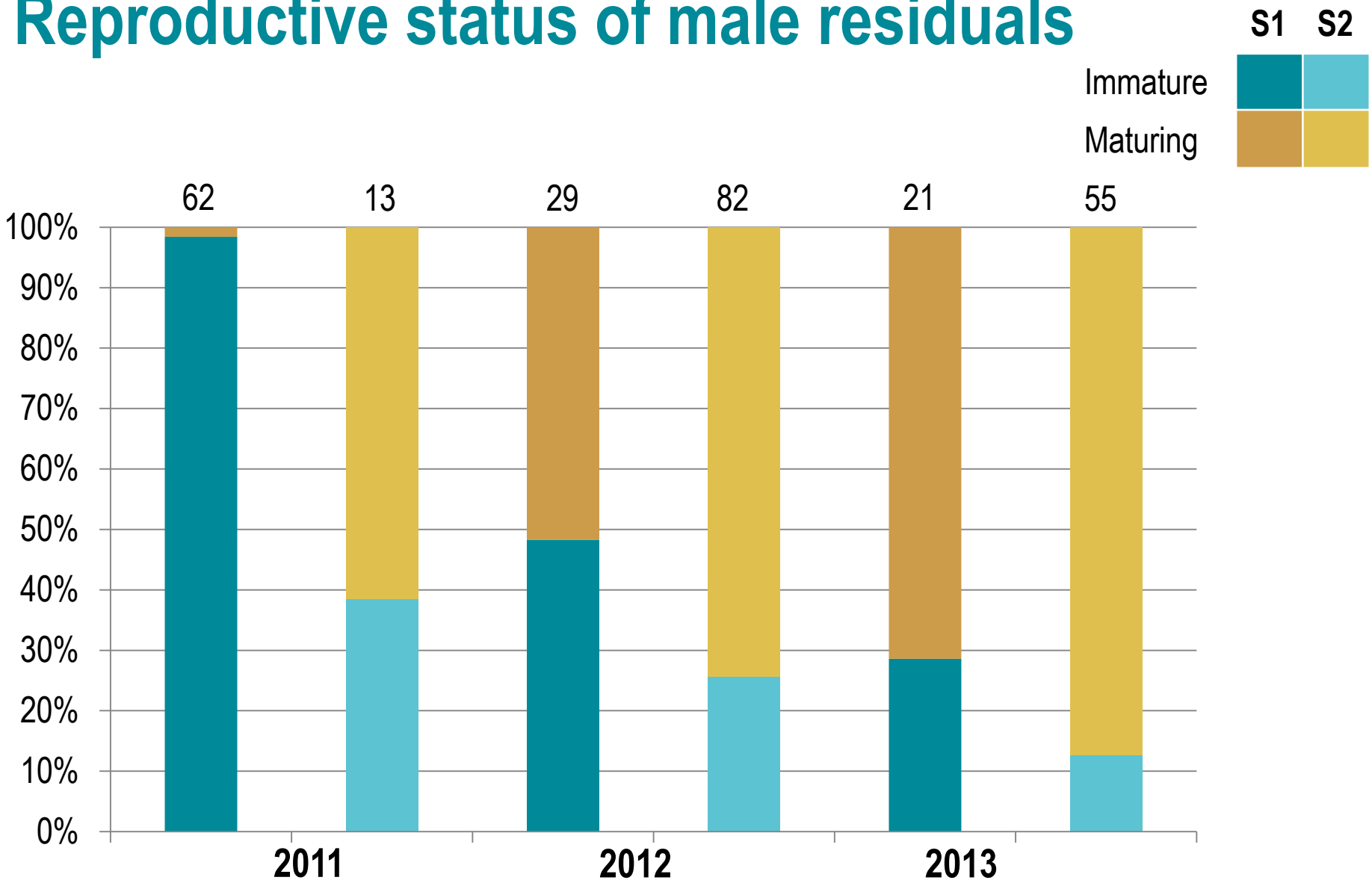
Size at release and residualism



Percent residual steelhead by sex



Reproductive status of male residuals



Conclusions: Survival and Travel Time

- WNFH can raise steelhead from a locally-sourced broodstock (S2)
  - Survival: S2 ≥ S1
  - Travel time: S2 < S1
- Survival of S1 (co-mingled Wells stock) is
  - More variable than S2s and is contingent on rearing practices that maximize size at release
- Detections of migrating steelhead are inversely related to residualism

Conclusions: Residualism

- S1 & S2 residual populations are male biased
  - Regardless of release strategy
  - Most male residuals are maturing
- Residualism rates appear to be inversely related to size at release for S1 and S2 steelhead
- S1 residualism is likely due to growth rates insufficient to induce smoltification in 1 year
- S2 residualism is likely due to increased rates of precocial maturation

Costs? Benefits? Appropriateness?

- **Costs?**
  - Maybe 1 year production (S1→S2)
  - Natural broodstock collection – angling
  - ↑ risk in culture (hold fish for 2 years)
  - Slight increase in feed and labor
- **Benefits?**
  - Preserve life history variation
  - Larger smolts and fewer residuals
  - Natural age of smoltification
  - Reduce size selection
  - Higher SAR?
  - Reduce hatchery/ wild ecological interactions
- **When to use?**
  - Transition to locally-derived broodstock
  - Late spawn timing
  - Cold hatchery water sources
  - Short hatchery culture season
  - Recovery of ESA listed populations

Acknowledgements

- Collaborators
  - USFWS – staff of WNFH and Mid Columbia FRO
  - NOAA/NWFSC - Manchester and Montlake
  - UW
  - USGS
  - WDFW
- Funding: BPA (project 1993-056-00), BOR, USFWS, NOAA

Two more reasons to care about residuals

S1 residual collected in
Methow River 14 Sept. 2011

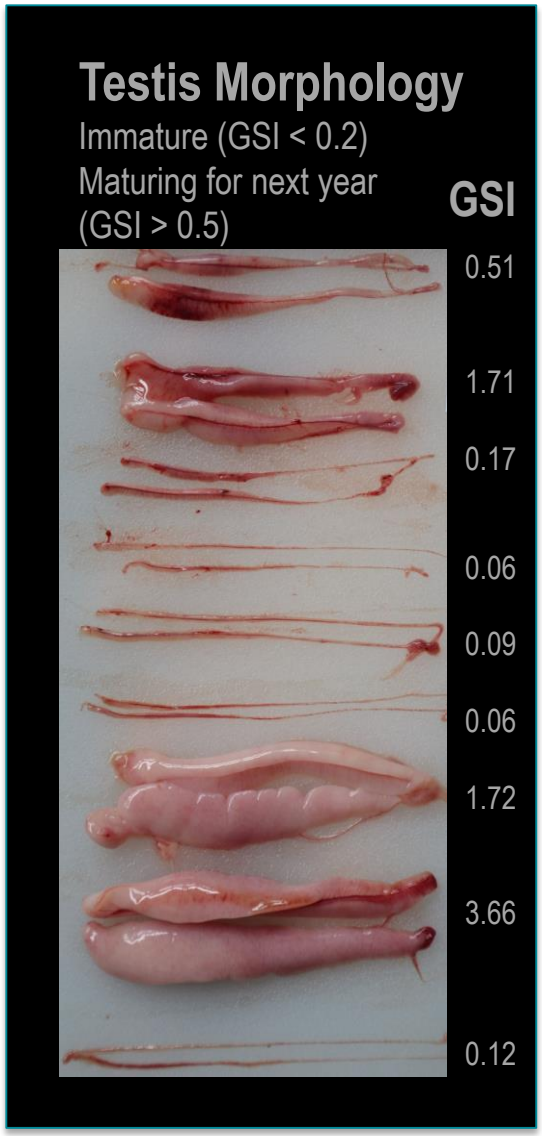
Maturing Testes - Bad

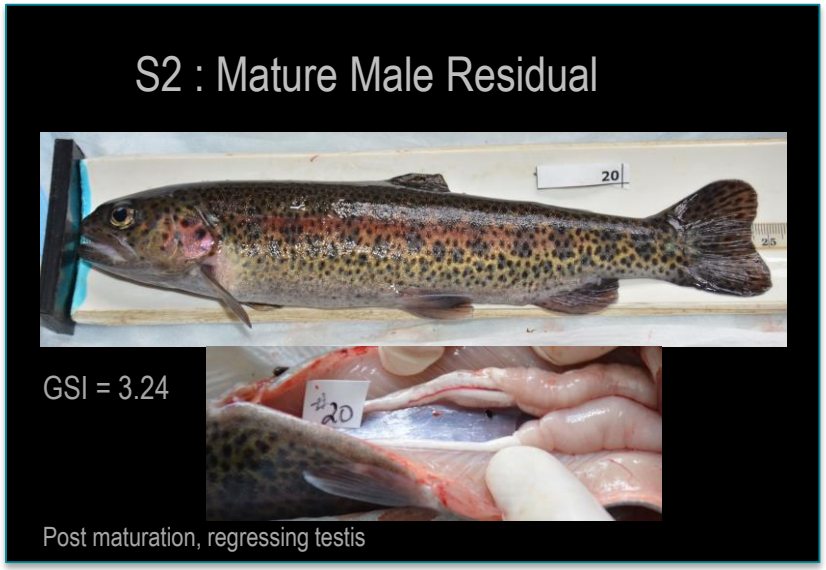
Yellow Jackets - Good

Chinook eggs - Bad

Residual Male Maturation Phenotypes

August 2013





Males with high GSI were a mixture of males that had matured the previous spring, or were maturing for the following spring