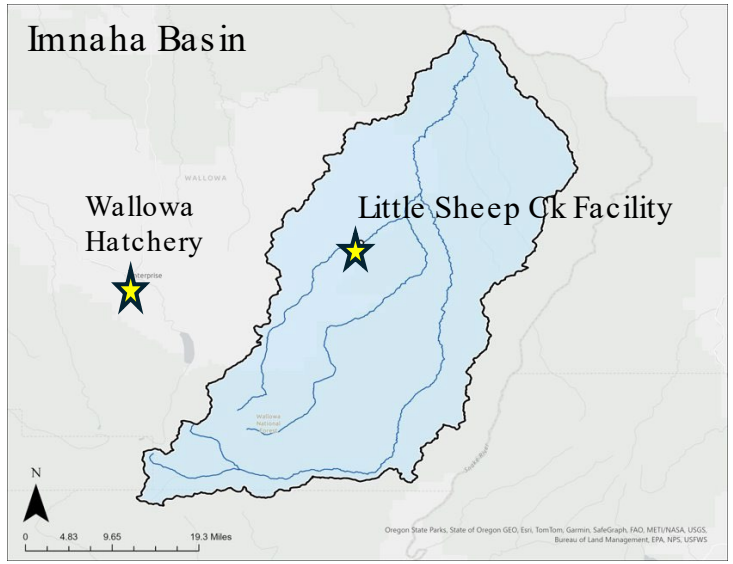
Imnaha and Grande Ronde Summer Steelhead Hatchery Program Review

January 21-23, 2025



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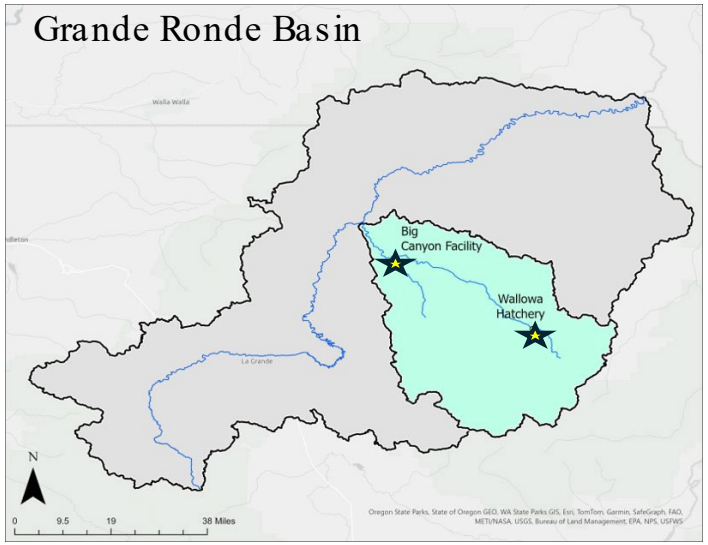

LOWER SNAKE RIVER COMPENSATION PLAN
Hatchery Program

CAYUSE - WALLA WALLA - UMATILLA
CONFEDERATED TRIBES OF THE UMATILLA INDIAN RESERVATION
Treaty of 1855

State of OREGON
Fish & Wildlife

NEZ PERCE TRIBE
TREATY OF 1855
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This project was funded by the United States Fish and Wildlife Service under the Lower Snake River Compensation Plan

Presentation Outline

- Management objectives &compensation/production goals
- Monitoring and evaluation objectives
- High level metrics comparing Imnaha vs Wallowa
  - Smolt releases
  - Juvenile Survival
  - Broodstock pre-spawn survival
  - Green egg-to-smolt
  - Total Returns vs Compensation Returns (SAS vs SAR)
  - Recruits/Spawner
  - Catch Distribution

Imnaha Basin (Little Sheep)

- Change in smolt releases
- Run-timing and returns at Little Sheep
- pHOS, pNOB, PNI
- Natural Recruits/Spawner

Wallowa Basin

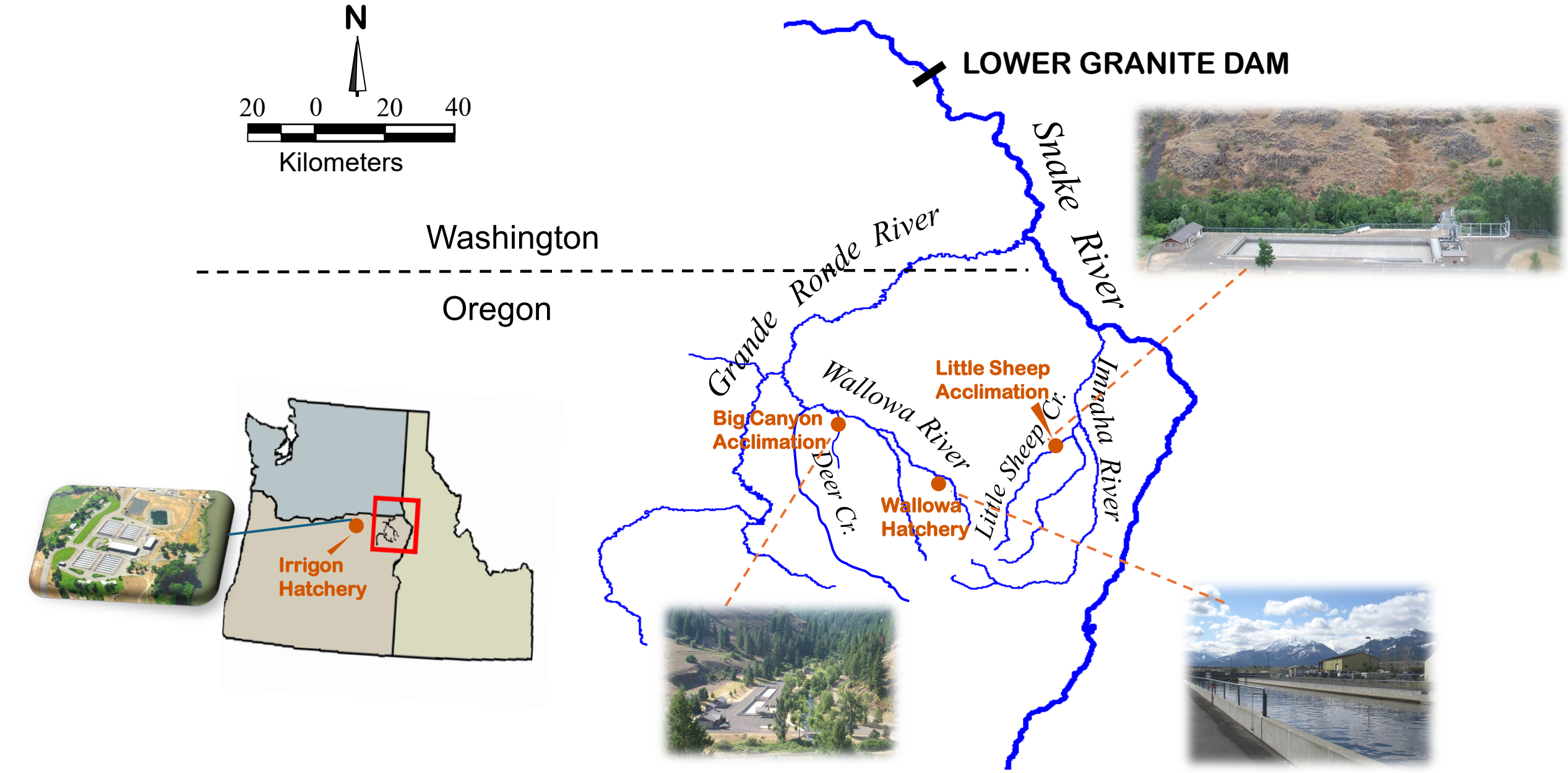
- Changes in smolt releases/transfer strategies
- Angler caught/Fallbrood program
- Run timing
- Age and size info

Adapting to E-creel

- App vs Paper tagging
- E-creel estimates vs Traditional estimates

Conclusions and Future Directions

The LSRCP Project Area:
Steelhead Facilities in the Grande Ronde and Imnaha River Basins



Five Primary Management Objectives

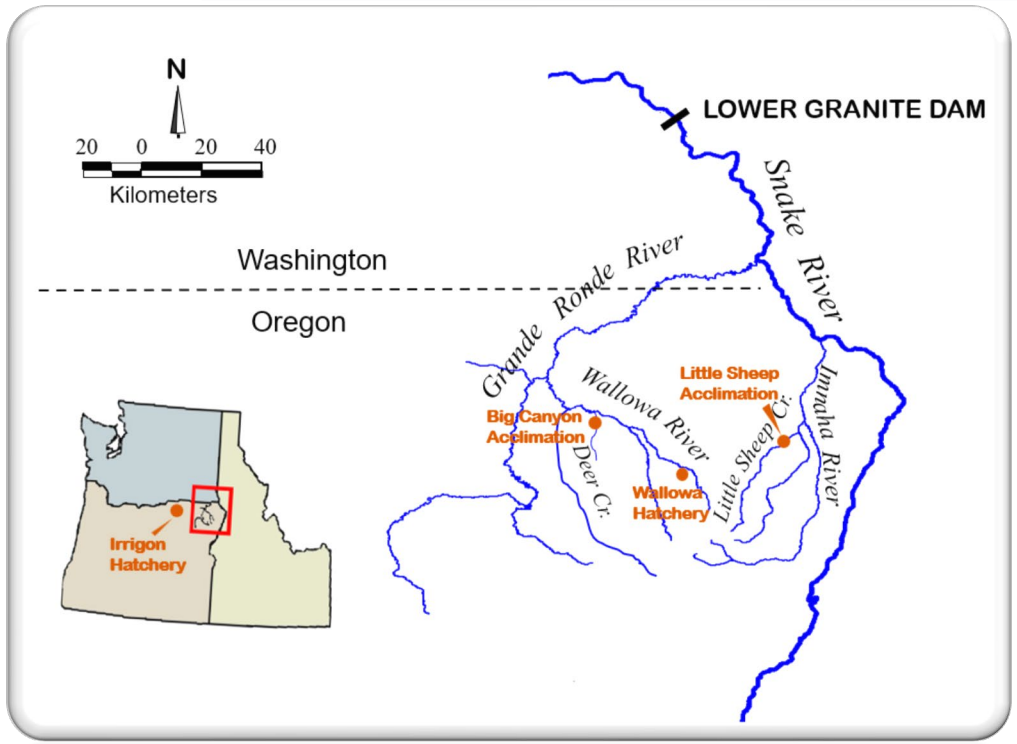
Objective	Imnaha (Integrated)	Wallowa (Segregated)
Establish an annual supply of broodstock capable of meeting production goals.	Yes	Yes
Maintain and enhance natural production while maintaining long term fitness of the natural population.	Yes	Yes[a]
Re-establish historic tribal and recreational fisheries.	Yes	Yes
Establish a total return number of summer steelhead that meets the LSRCP compensation goal.	Yes	Yes
Operate the hatchery program so we maintain the genetic and life history characteristics of the natural population and hatchery fish characteristics mimic those of the wild fish, while achieving management objectives.	Yes	Yes[b]

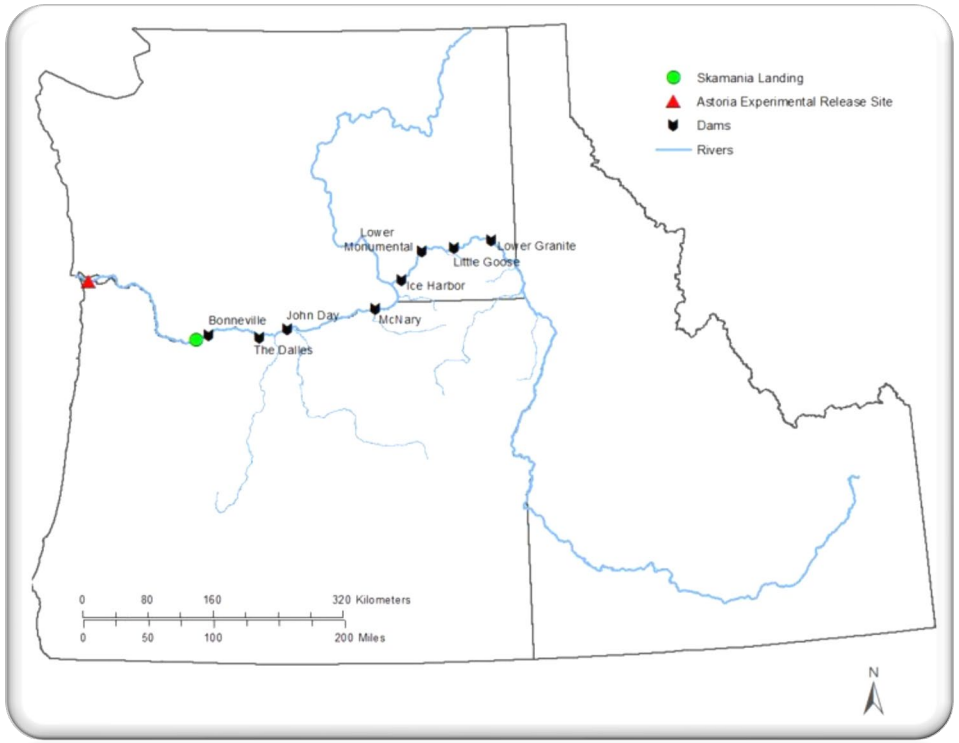
- *[a] For the Wallowa program, to "restore and maintain natural populations" was an original objective but it has never been a priority. The program has been operated as a harvest augmentation segregated program in terms of broodstock management and minimizing the number of hatchery fish spawning in nature.*
- *[b] Maintain Joseph Creek, Wenaha River, and Minam River as wild fish sanctuaries.*

Mitigation Goals:
compensation for annual loss of 48%

	Imnaha (Integrated)	Wallowa (Segregated)
Smolt Releases	330,000 (215,000 interim)	1,350,000 (800,000 interim)
Project Area Adult Returns	2,000	9,184
Smolt-to-Adult Return Rate	0.61%	0.68%
Total Adult Returns	6,000	27,552
Smolt-to-Adult Survival Rate	1.83%	2.04%
Broodstock needs listed in HGMPs	126	450

Assumed 2:1 catch to escapement





Monitoring and Evaluation Objectives

Objective	Imnaha (Integrated)	Wallowa (Segregated)
Document and assess fish culture and hatchery operation practices and performance.	Yes	Yes
Determine optimum rearing and release strategies that will produce maximum survival to adult.	Yes	Yes
Determine total catch and escapement, smolt survival to LGD, total smolt-to-adult survival (SAS), smolt-to-adult return rate to the compensation area (SAR), and assess if adult production meets mitigation goals.	Yes	Yes
Assess and compare recruits-per-spawner (R/S) of hatchery and natural origin fish.	R/S (H) & R/S (N)	R/S (H)
Assess response in natural population abundance and productivity (adult recruits-per-spawner, smolts-per-spawner) to supplementation.	Yes	Yes
Assess and compare life history characteristics (age structure, run timing, sex ratios, smolt migration, fecundity) of hatchery and natural fish.	Yes	Yes
Determine the magnitude and patterns of within and out of basin straying	Yes	Yes
Determine success in restoring fisheries.	Yes	Yes

Imnaha (Integrated)

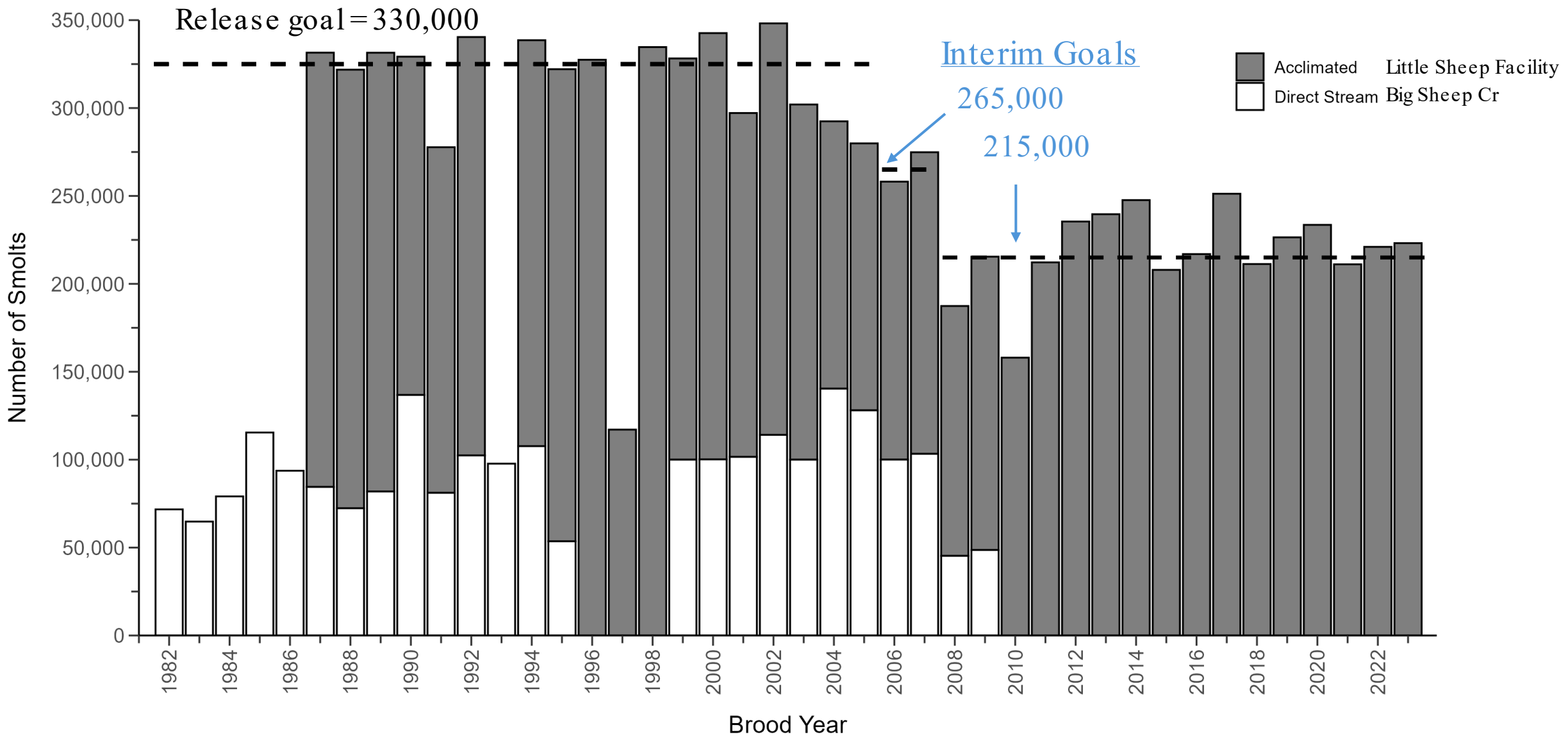
Little Sheep Sliding Scale Management Plan

Natural-Origin Fish Returning to Weir	Natural-Origin Fish Retained for Broodstock*	Percent Hatchery-Origin Fish Released Above Weir
≤100	10 (≤10%)	Any % hatchery to make 250 fish escapement goal
150	30 (20%)	52%
200	50 (25%)	40%
250	70 (28%)	32%
300	90 (30%)	16%

**When number of natural fish > 100, keep 10 plus 40% of natural run greater than 100 for brood.*

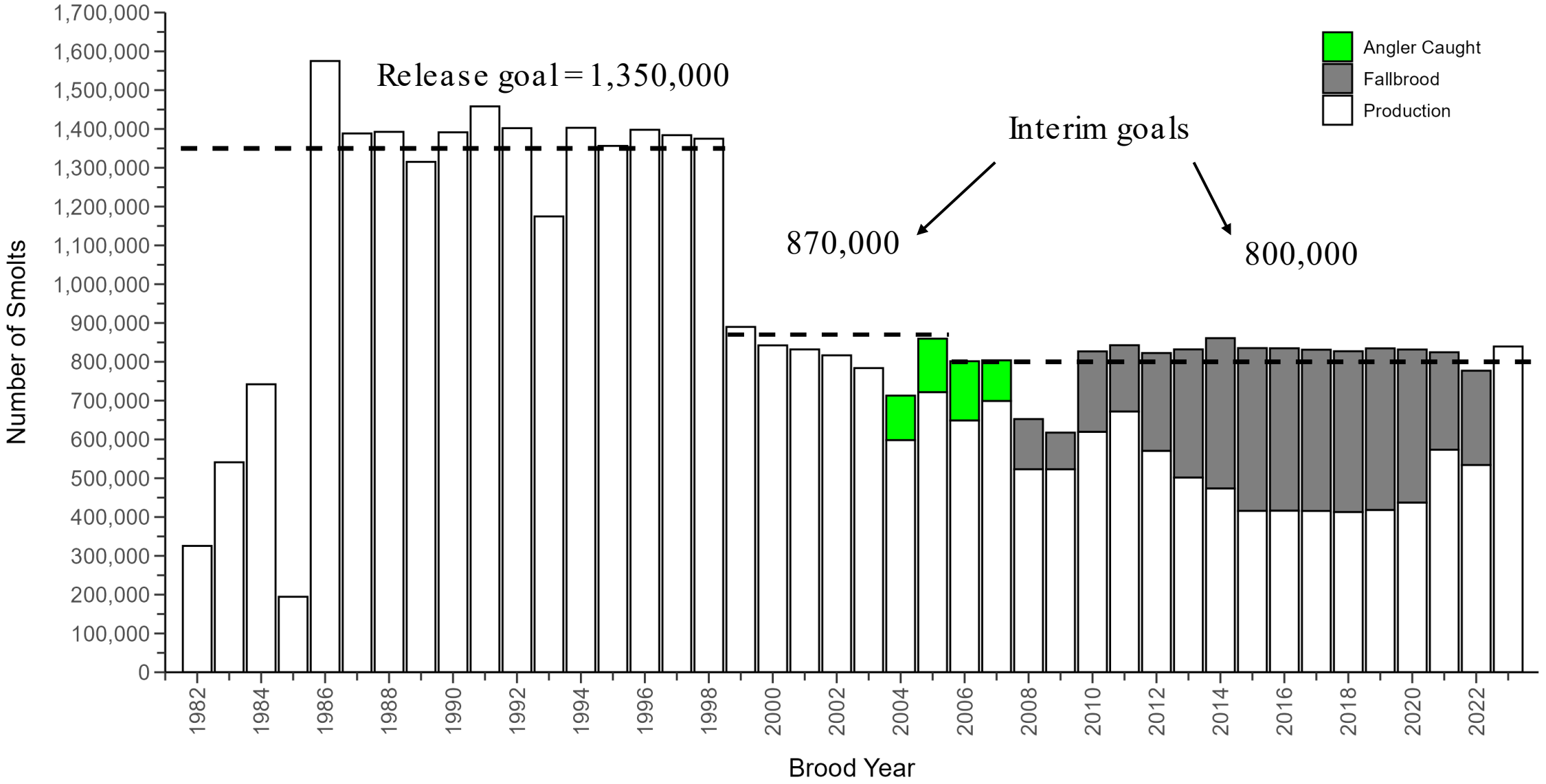
Wallowa (Segregated)

Imnaha Program

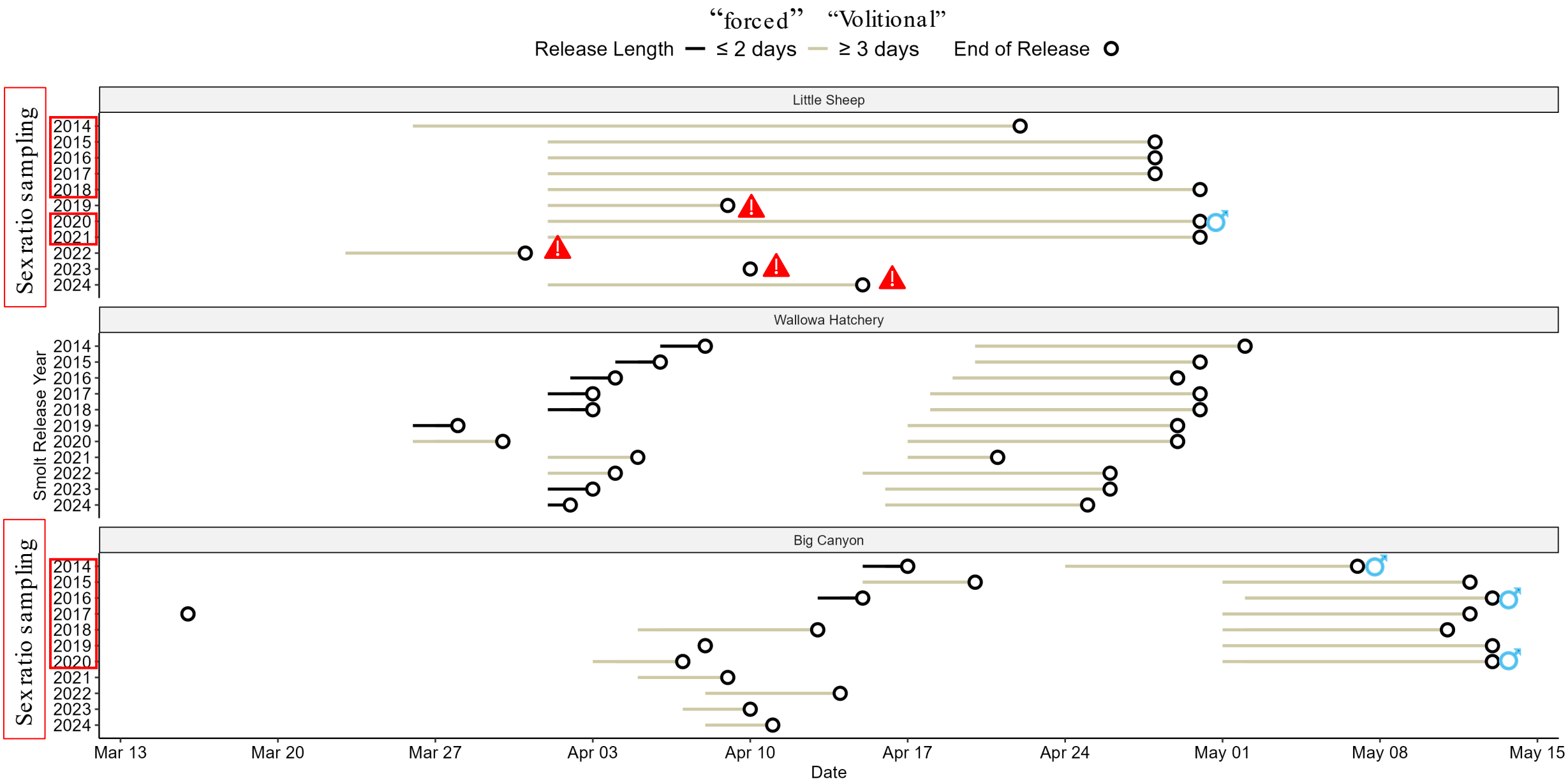


Wallowa Program

Acclimation Facilities
- ✓ Wallowa Hatchery
- ✓ Big Canyon

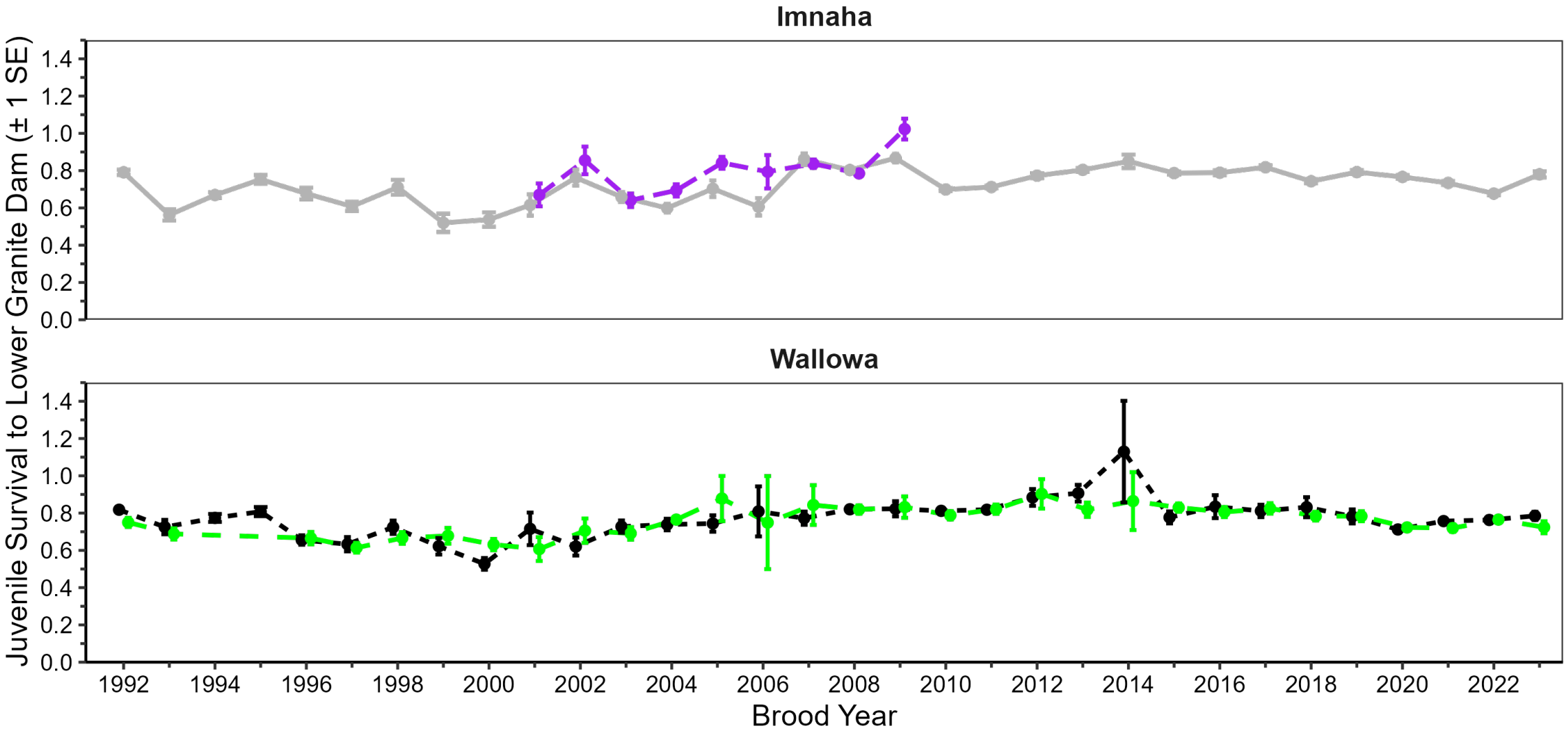


Release Strategies &Release Dates



Juvenile Survival

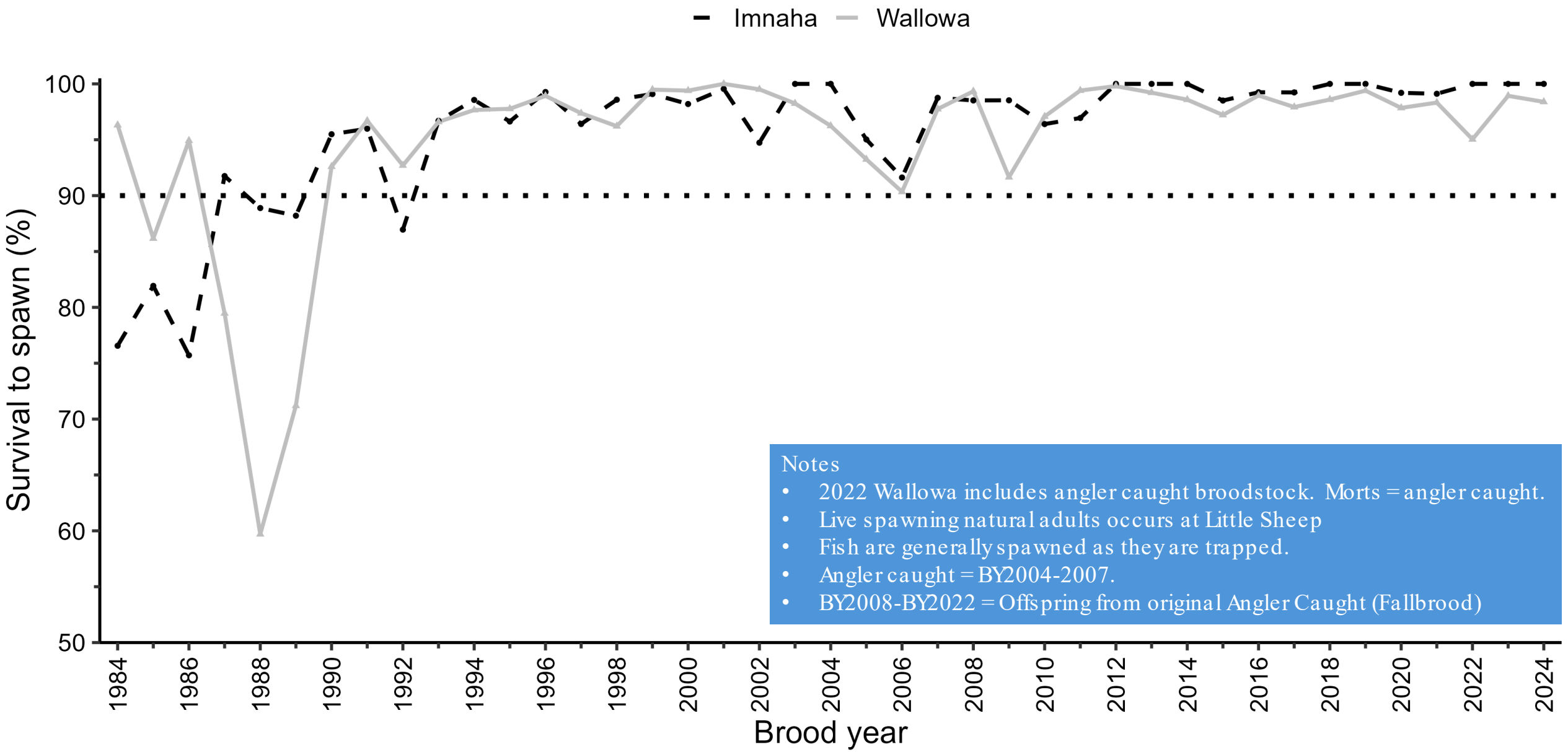
Release site to Lower Granite Dam



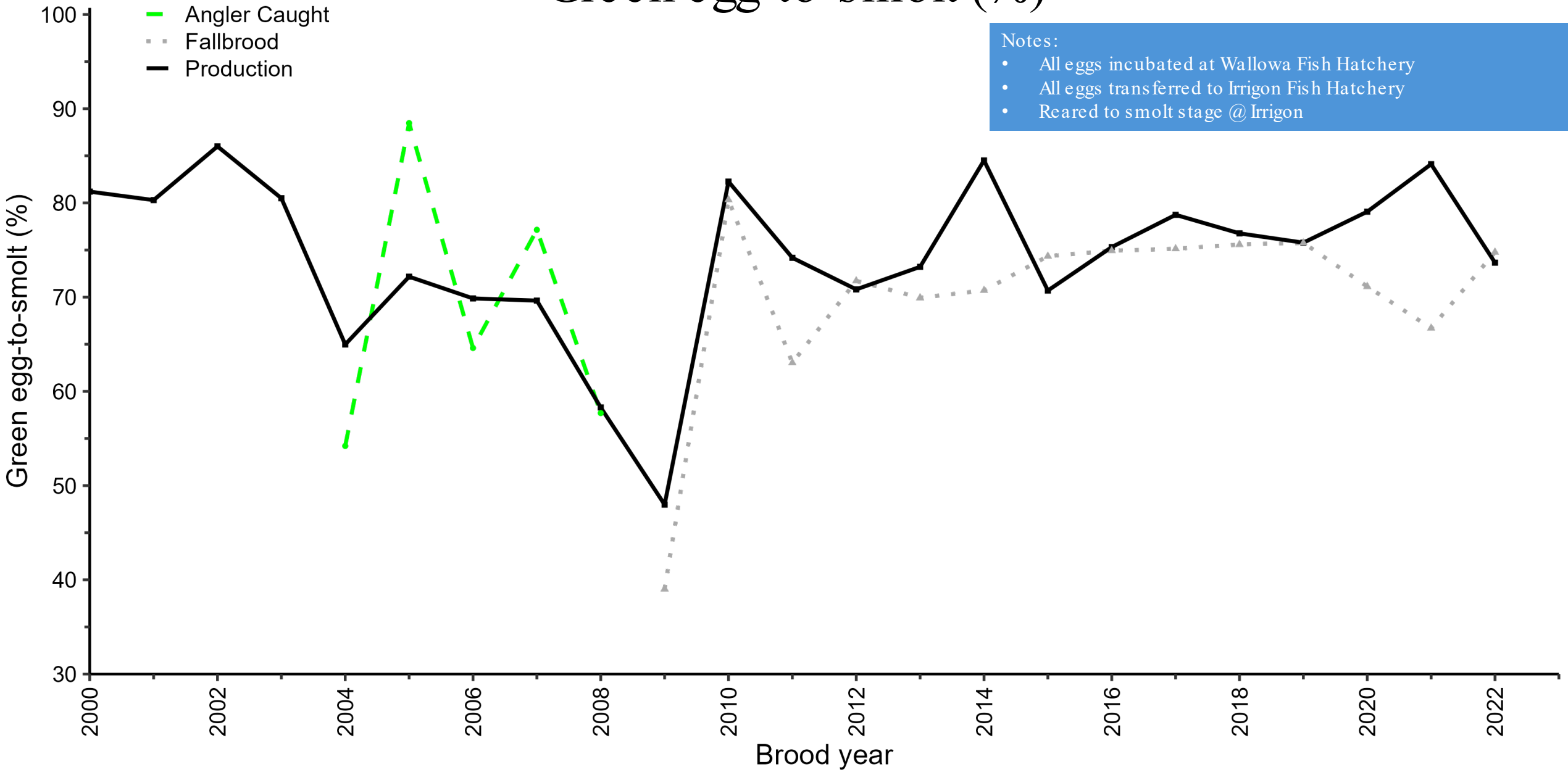
Spawning metrics

- Prespawn survival
- Green egg-to-smolt

Broodstock: Prespawn survival



Green egg-to-smolt (%)



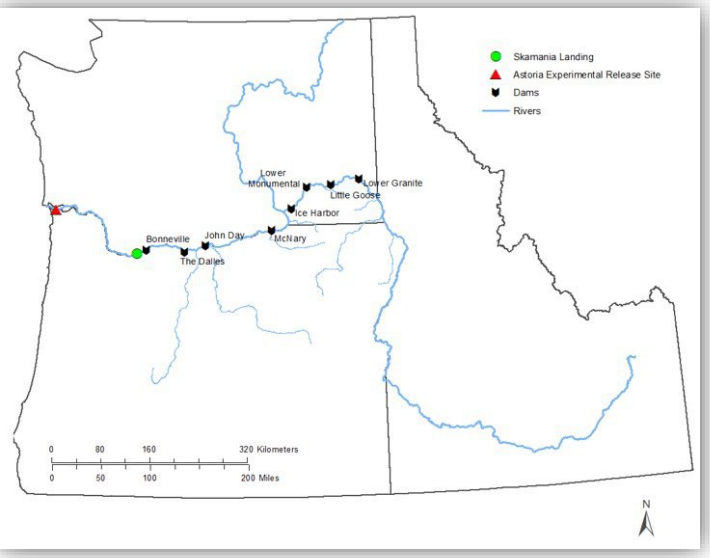
Notes:

- All eggs incubated at Wallowa Fish Hatchery
- All eggs transferred to Irrigon Fish Hatchery
- Reared to smolt stage @ Irrigon

Compensation returns

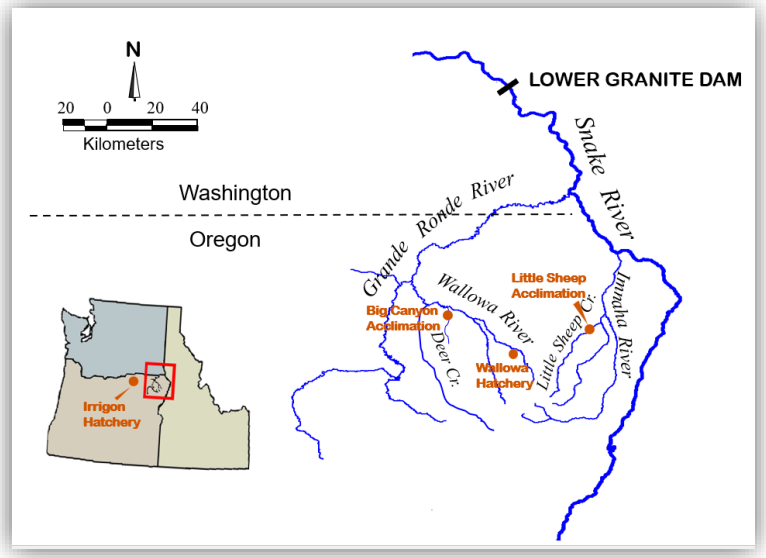
- Total returns
- SAS
- SAR

SAS and SAR calculations



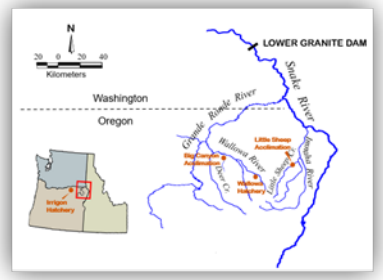
ODFW is currently using Method 1

- SAR calculations: Spawn Year 2013 we started incorporating PBT data from Snake River fisheries



	Smolt-to-Adult Survival (SAS)			Smolt-to-Adult Return (SAR)
Method Type	Method Description	Columbia R. Mouth to Bonneville Dam	Bonneville Dam to Project Area	Project Area Escapement
1	Traditional Run Reconstruction	Creel (CWT)	Creel (CWT) + Stray (CWT)	Hatchery Trap + Spawning Ground + Creel (CWT)
2	Parental Based Tagging	Creel (PBT or CWT)	PIT Tag Conversion Rate	Direct PBT Estimate at Lower Granite Dam
3	Hybrid-Parental Based	Creel (PBT or CWT) ODFW = CWT below Bon	PIT Tag Conversion Rate	Hatchery Trap + Spawning Ground + Creel (CWT & PBT)

Adult returns to the Compensation Area



Last review

Imnaha

LSRCP Method1
LSRCP Method2

Adult Goal= 2,000

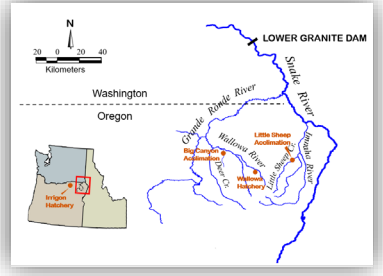
Wallowa

Adult Goal= 9,184

Total Adults

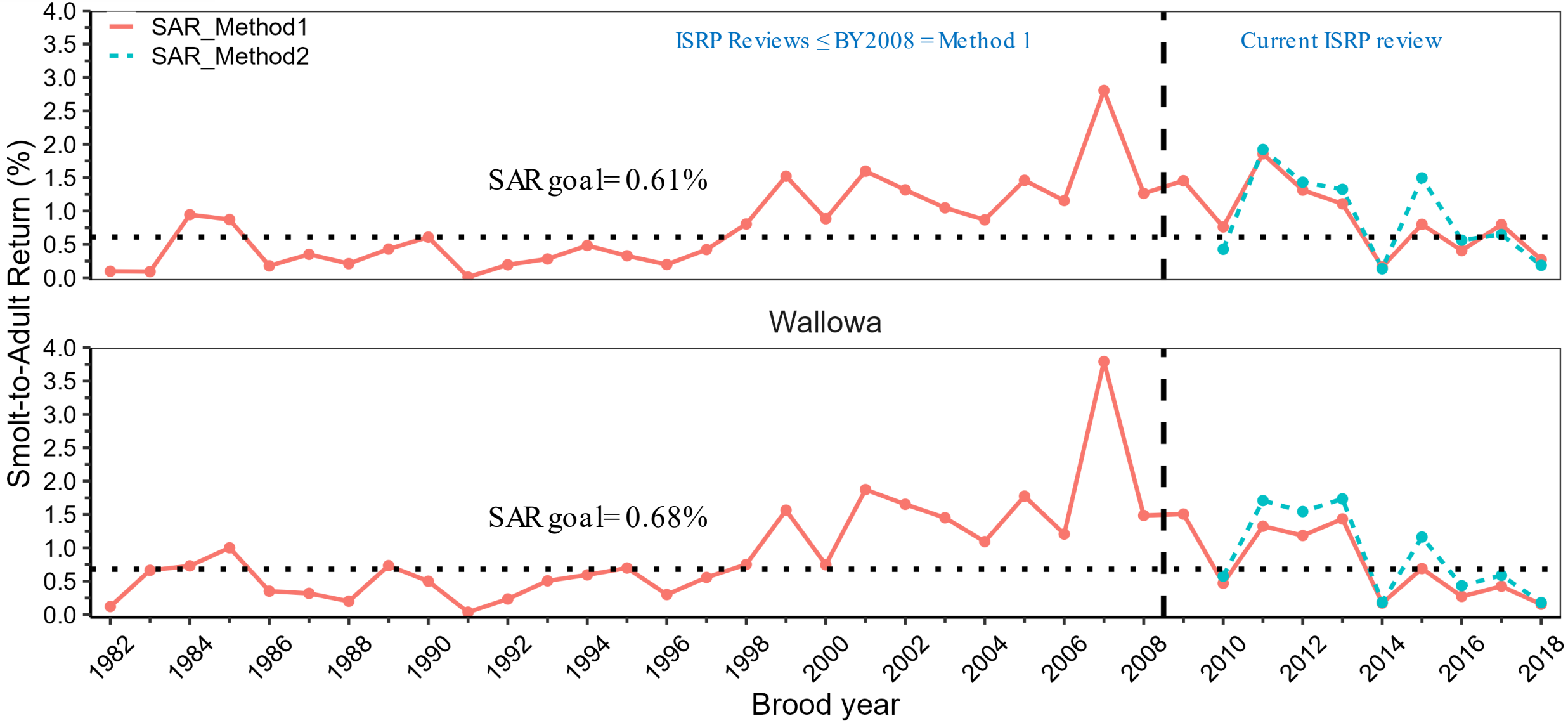
Bonneville Return Year

Smolt-to-Adult Returns: Amethods shift?



Method 1 < Method 2

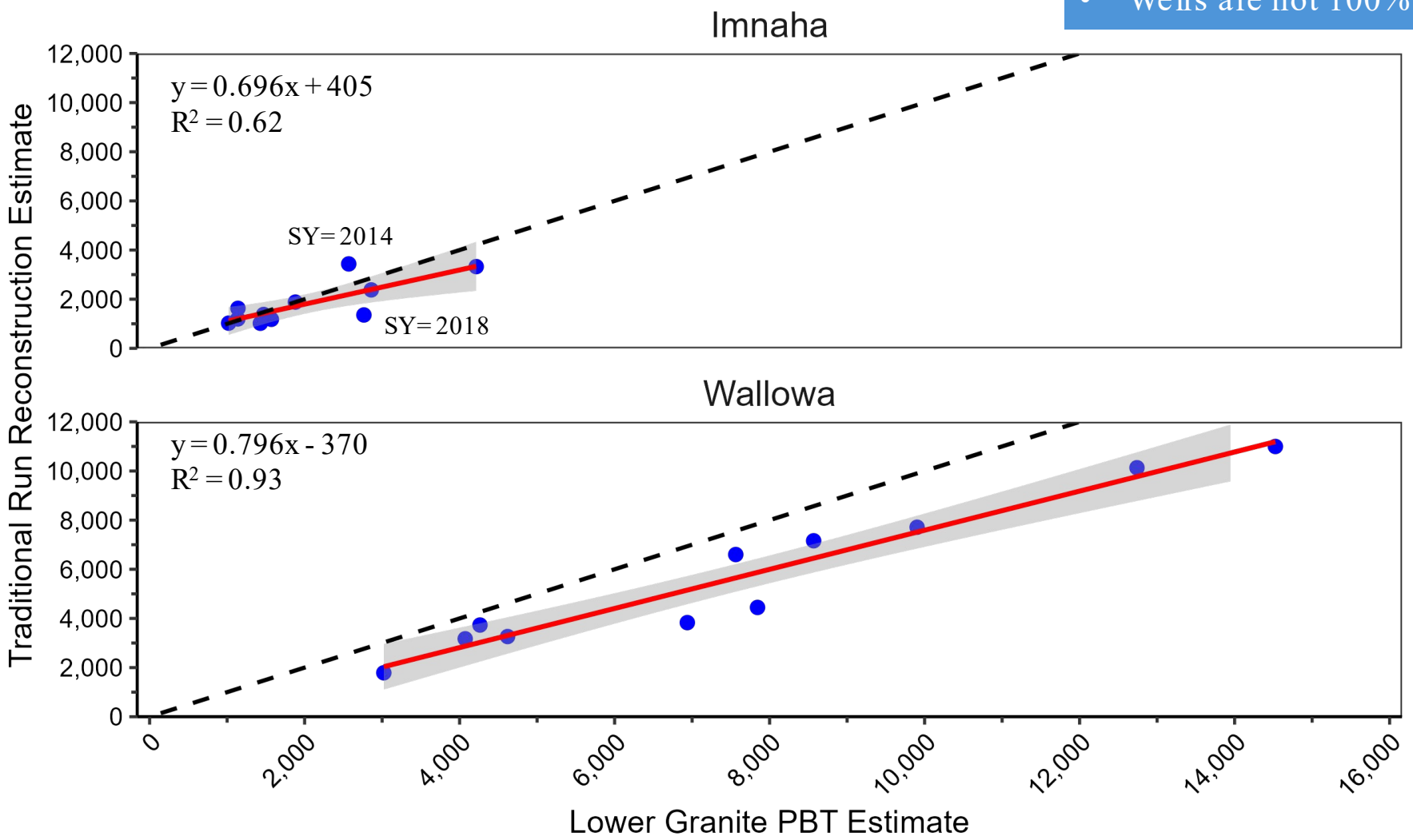
Imnaha



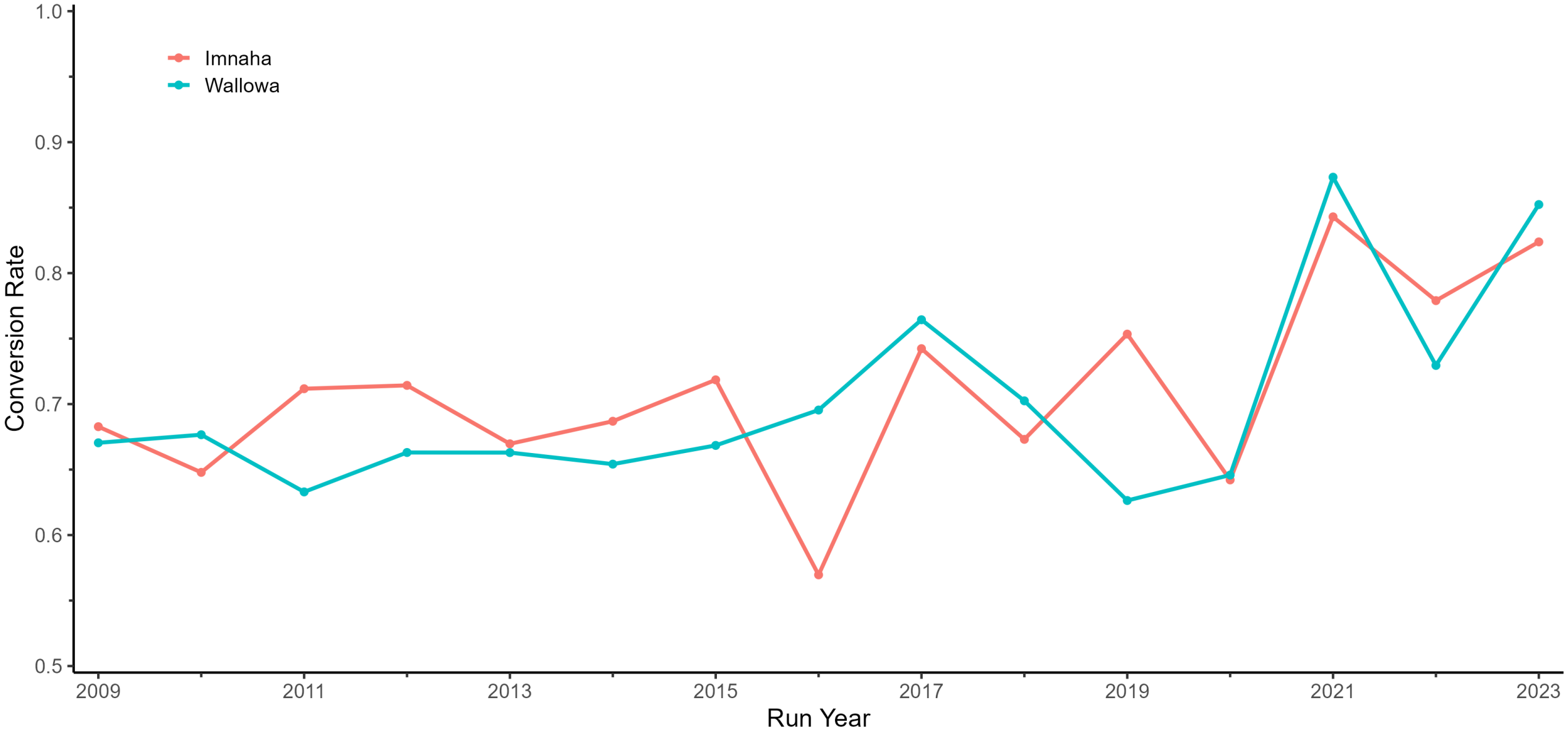
Spawn Years (2013-2023)
Method 1 vs Method 2

Method Type	Method Description	Smolt-to-Adult Return (SAR) Project Area Escapement
1	**Traditional Run Reconstruction**	**Hatchery Trap + Spawning Ground + Creel (CWT)**
2	Parental Based Tagging	Direct PBT Estimate at Lower Granite Dam
3	Hybrid-Parental Based	Hatchery Trap + Spawning Ground + Creel (CWT & PBT)

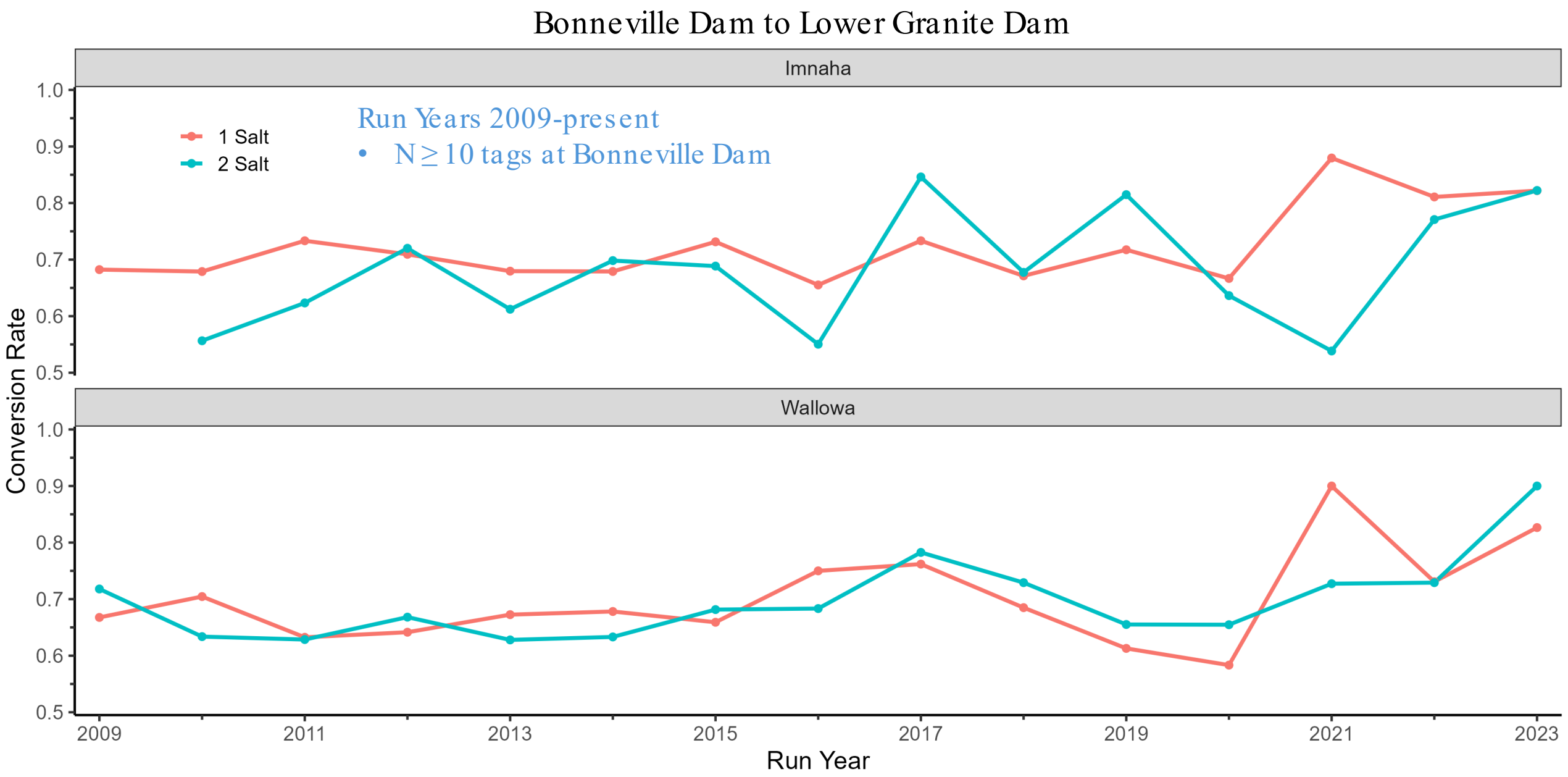
Notes
- Traditional run reconstruction < PBT@ Lower Granite
- Creel is underestimating harvest
- Weirs are not 100% efficient in all years (e.g. flooding)

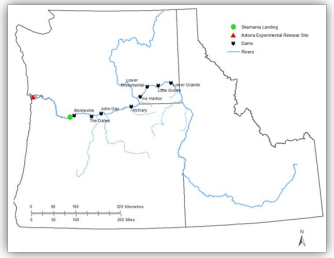


Bonneville to Lower Granite Dam: Conversion Rates

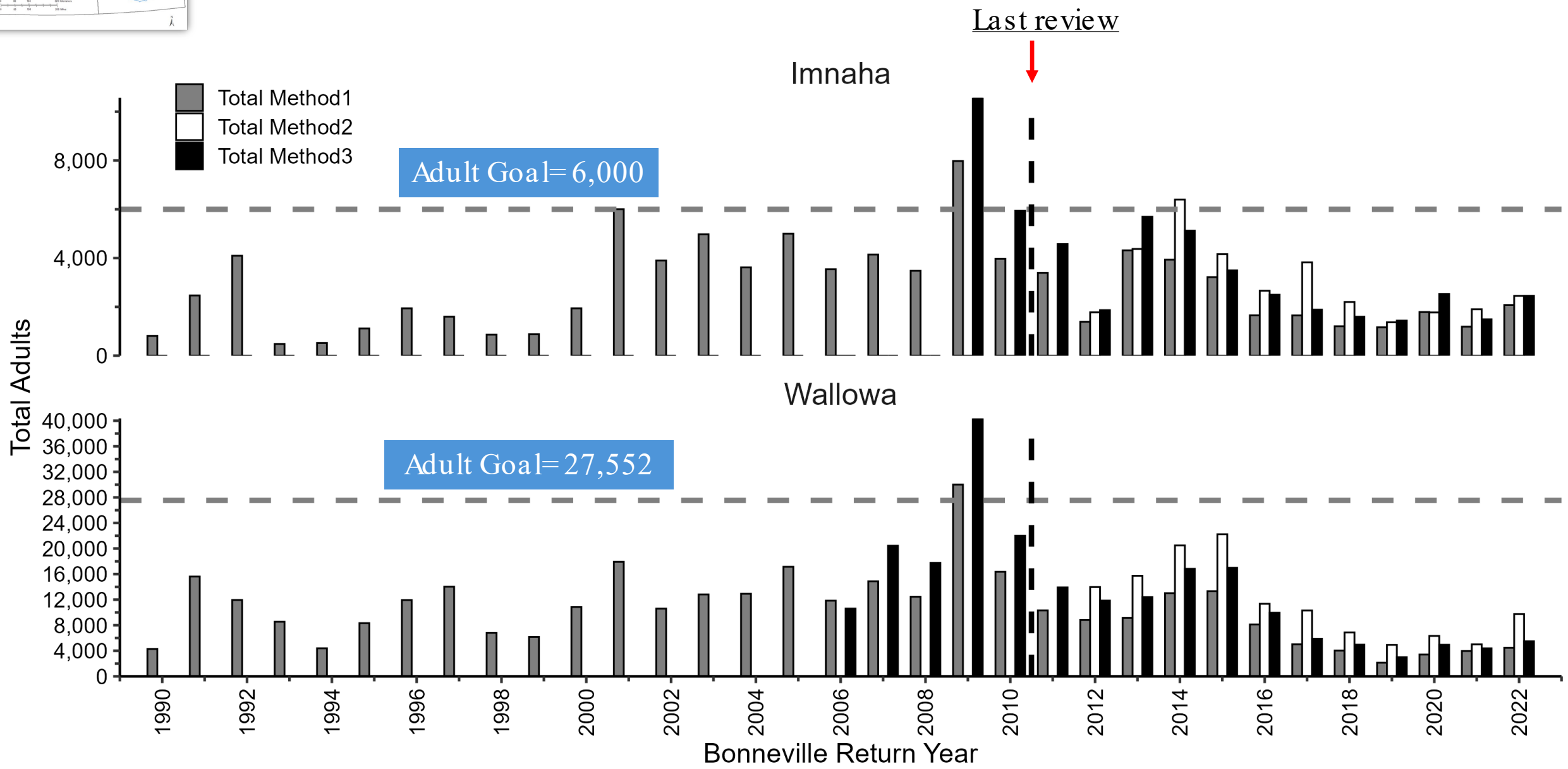


Using Stock and Age Specific PIT tag conversion rates to replicate Method 2

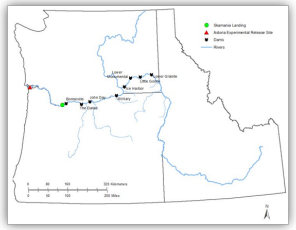




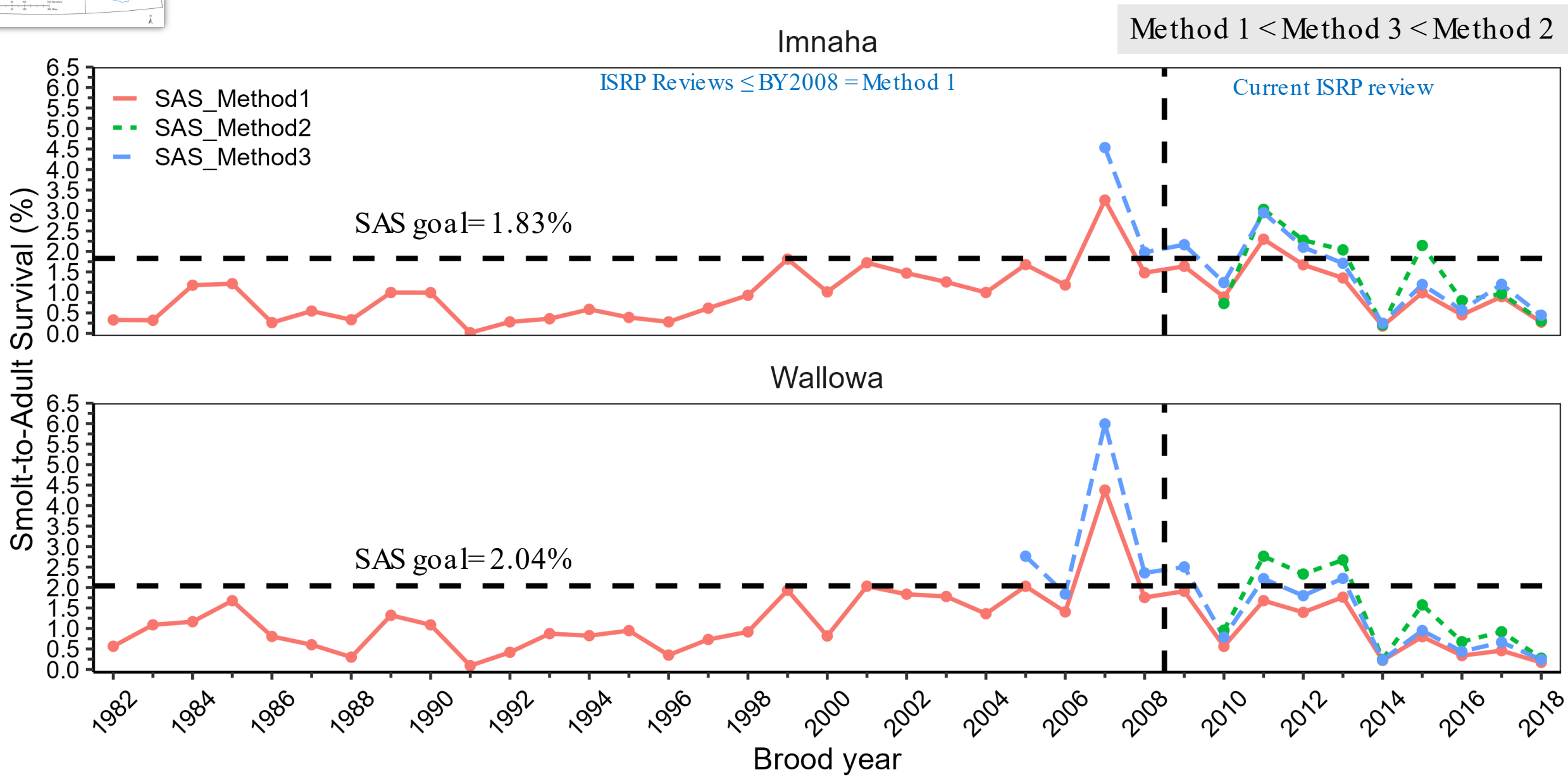
Total Production
2:1 catch to escapement ratio



Comparing Smolt-to-Adult Survival Methods



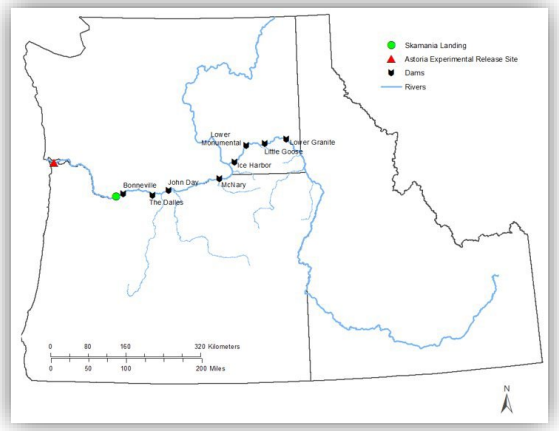
Method 1 < Method 3 < Method 2

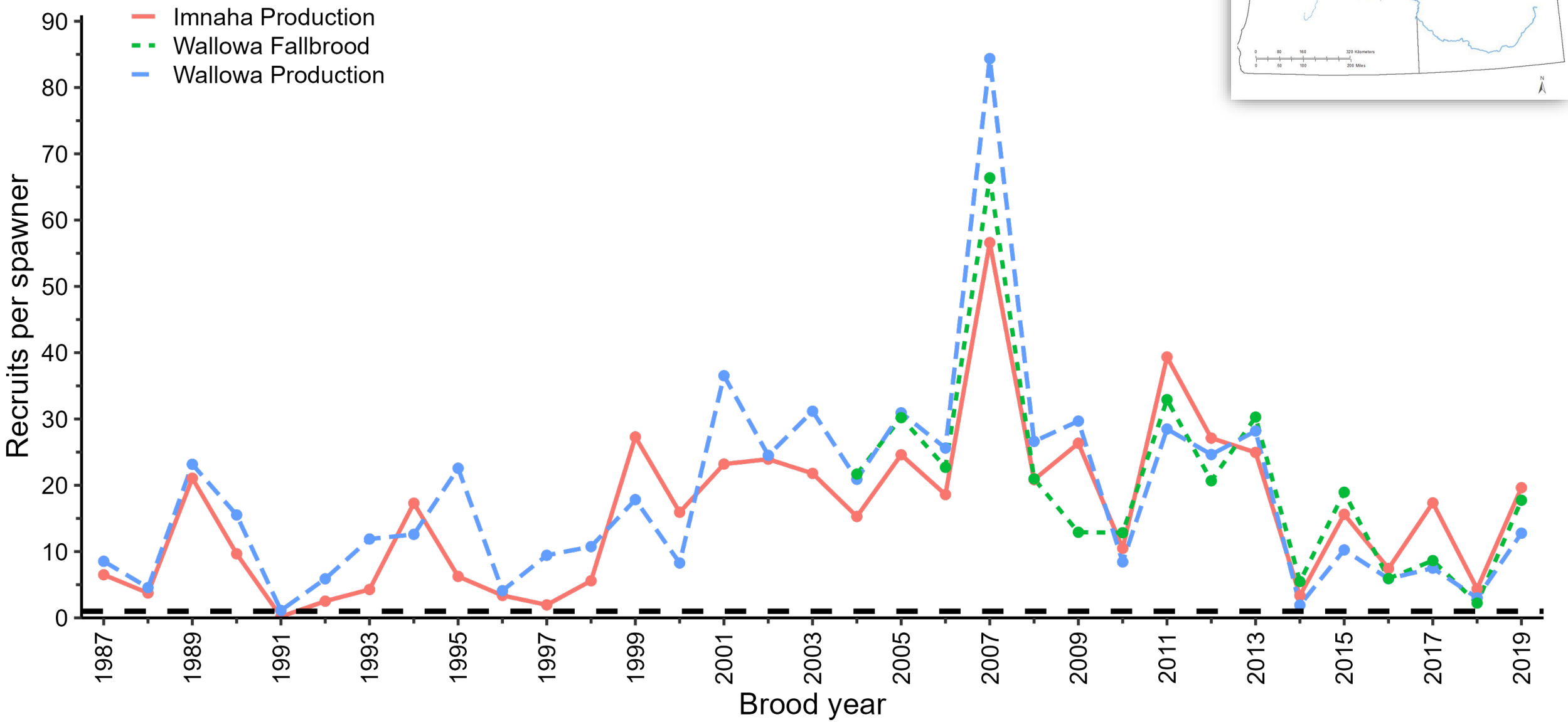


Total Return

Recruits/Spawner:

Method 1 (Traditional Run Reconstruction)





Percent Harvest and Escapement of Imnaha Stock Releases

	Brood Year				
	2015	2016	2017	2018	Mean
Ocean	0.0	0.0	0.0	0.0	0.0
Columbia River					
Sport	8.0	0.0	0.0	0.0	2.0
Tribal	9.3	6.4	11.3	0.0	6.8
Stray Harvest	0.8	1.8	0.0	1.4	1.0
Stray Rack	1.2	1.8	0.0	0.0	0.8
Snake River					
Stray below LGD	0.0	0.0	0.0	0.0	0.0
Stray above LGD Rack	0.0	0.0	0.0	0.0	0.0
Sport below LGD	0.0	0.0	0.0	0.0	0.0
Sport above LGD	28.0	24.6	57.3	56.9	41.7
Imnaha Sport	0.9	5.5	6.3	9.6	5.6
Escapement to Weir	51.8	59.8	25.1	32.1	42.2

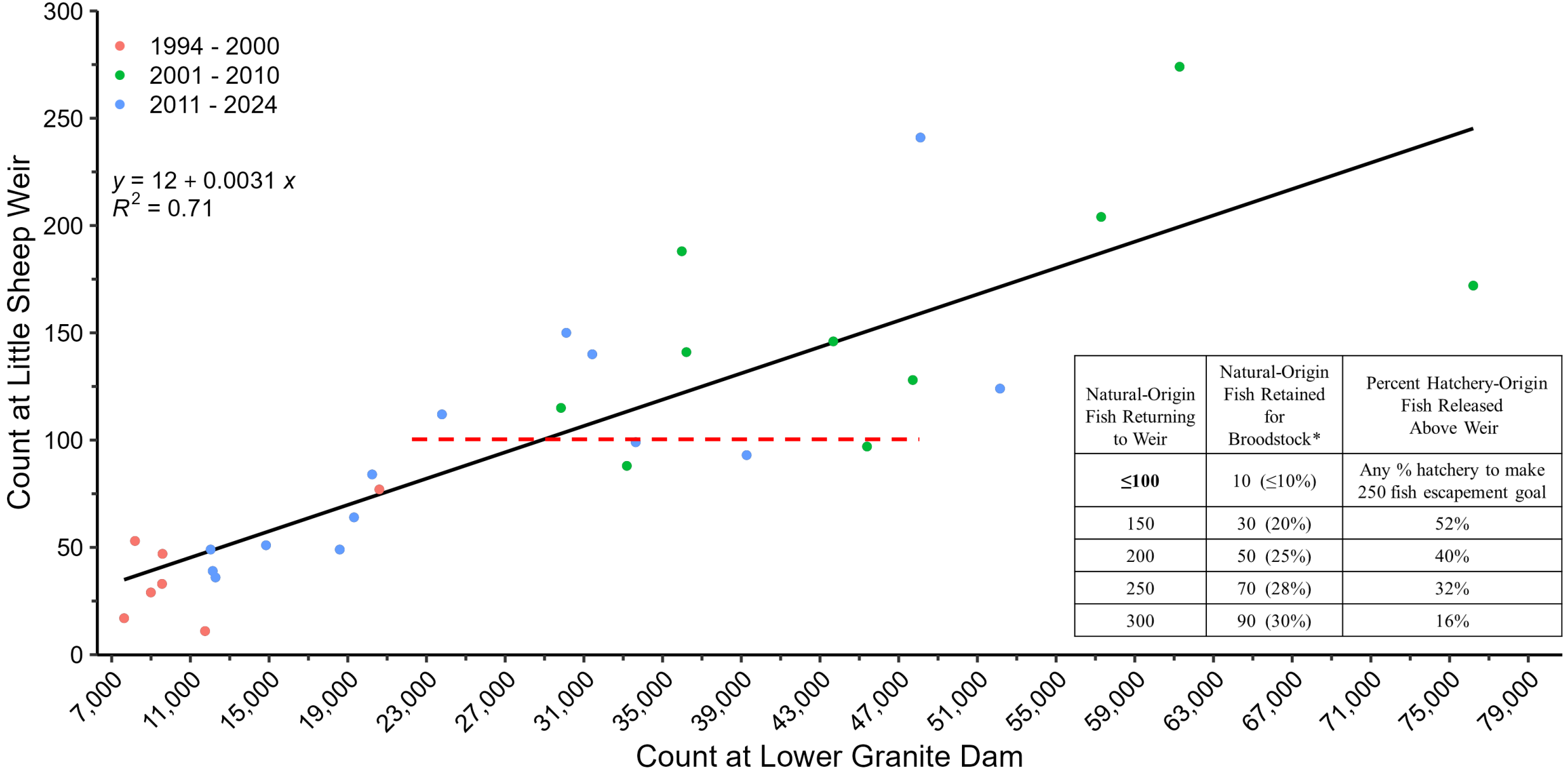
Percent Harvest and Escapement of Wallowa Stock Releases

	Brood Year				
	2015	2016	2017	2018	Mean
Ocean	0.0	0.0	0.6	0.2	0.2
Columbia River					
Sport	3.9	10.0	0.7	1.5	4.0
Tribal	6.3	10.0	0.7	1.5	5.1
Stray Harvest	2.5	5.2	0.0	0.0	1.9
Stray Rack	0.8	1.6	1.0	2.7	1.5
Snake River					
Stray below LGD	0.0	0.0	0.0	0.0	0.0
Stray above LGD Rack	0.1	0.0	0.0	0.0	0.0
Sport below LGD	0.5	0.0	0.1	0.2	0.2
Sport above LGD	21.2	23.9	25.5	31.6	25.5
Wallowa Sport	17.4	10.0	20.6	24.1	18.1
Escapement to Weir	47.3	46.4	46.2	33.8	43.4

Imnaha Program: Little Sheep Facility

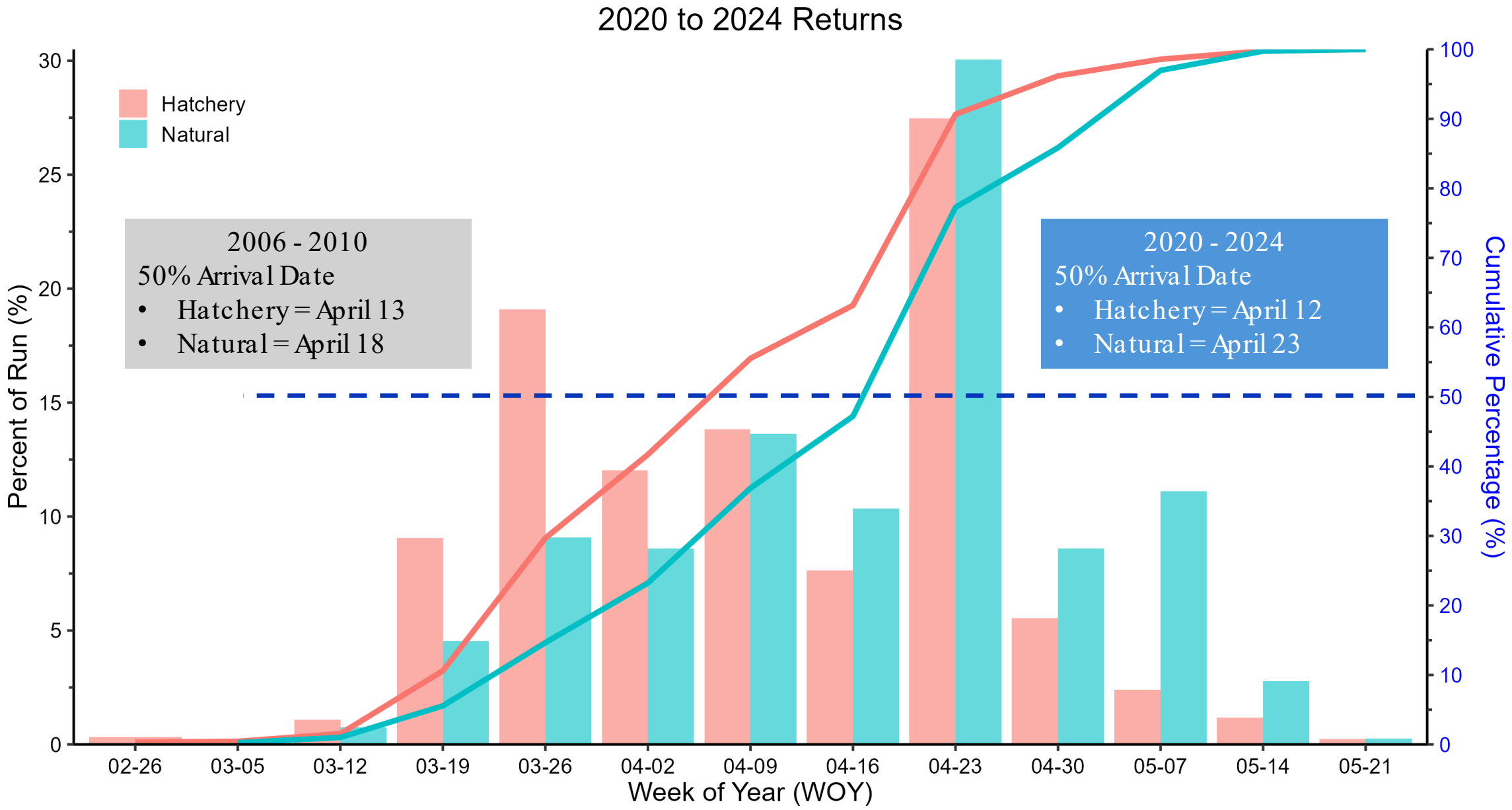
- May 2018 flooding
- Devils Gulch instability
- Emergency smolt releases
- End of sex ratio sampling

Wild Steelhead
Lower Granite Dam vs Returns to the Little Sheep Facility

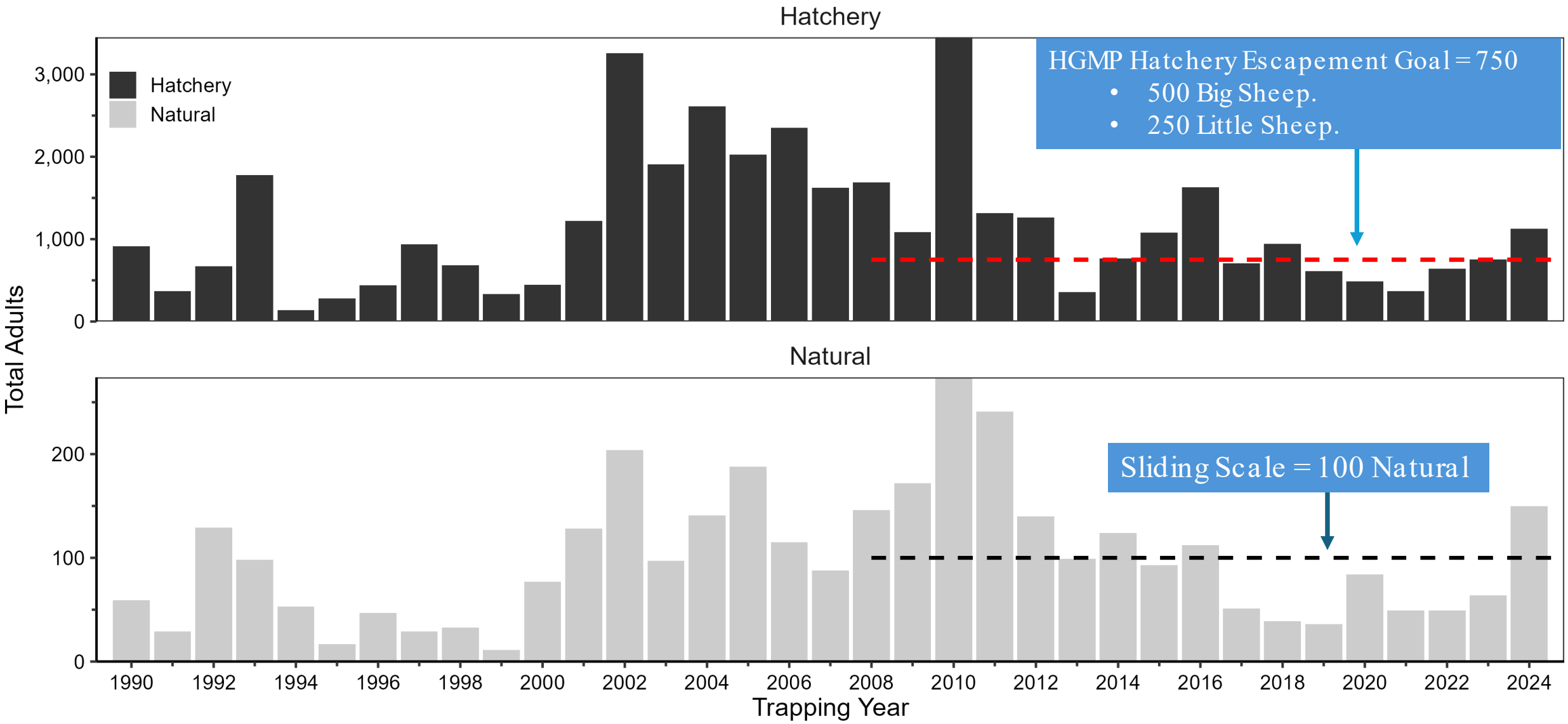


Natural-Origin Fish Returning to Weir	Natural-Origin Fish Retained for Broodstock*	Percent Hatchery-Origin Fish Released Above Weir
≤100	10 (≤10%)	Any % hatchery to make 250 fish escapement goal
150	30 (20%)	52%
200	50 (25%)	40%
250	70 (28%)	32%
300	90 (30%)	16%

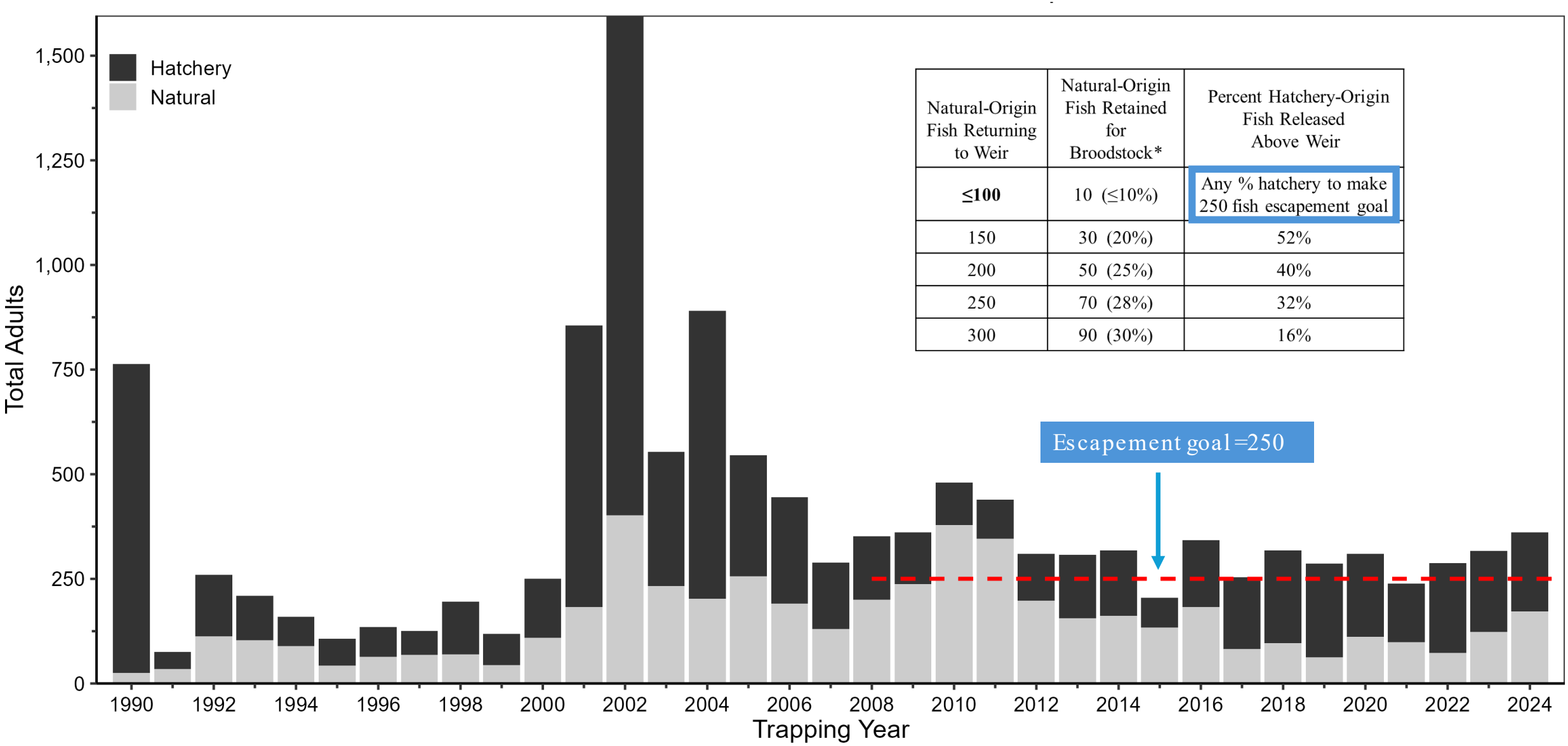
Run Timing to the Little Sheep Facility (2020 to 2024)



Trapped Adults at the Little Sheep Facility



Trapped Adults at the Little Sheep Facility



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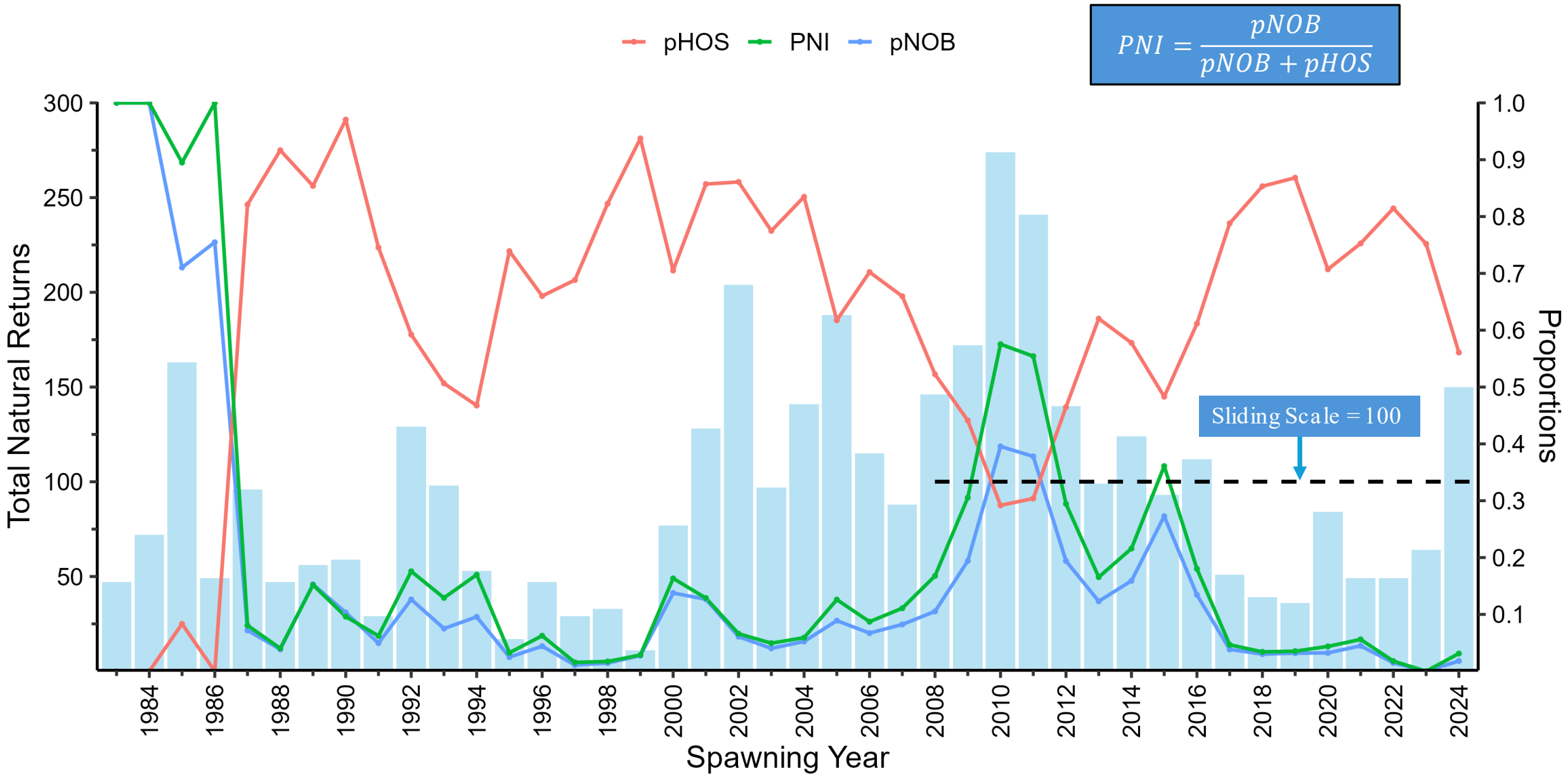
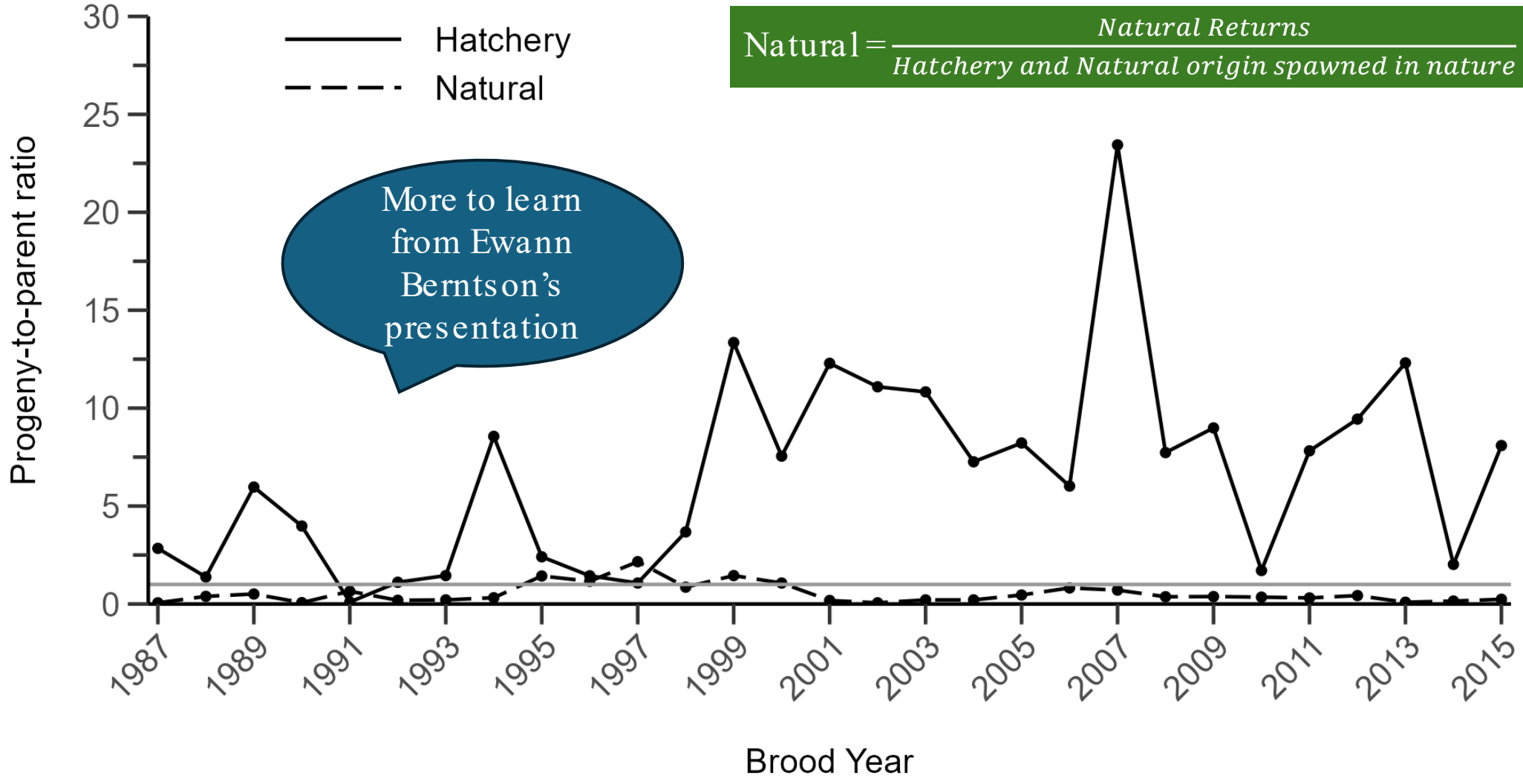
Broodstock Management & Natural Spawning



Return to Little Sheep Trap: Progeny-to-Parent

$$\text{Hatchery} = \frac{\textit{Hatchery Returns}}{\textit{Spawned Broodstock}}$$

$$\text{Natural} = \frac{\textit{Natural Returns}}{\textit{Hatchery and Natural origin spawned in nature}}$$



Wallowa Stock

- Angler caught -> Fallbrood
  - A return to Angler caught
- Reciprocal study with WDFW
- November transfer (BY20-present)
- Residual work
- Spring flooding (2017 Deer Cr)
- End of adult Steelhead Spawning ground surveys in GR basin.
- Changes to sex ratio sampling

DOI: 10.1111/fme.12221

ORIGINAL ARTICLE

WILEY Fisheries Management and Ecology

Increased harvest of anadromous hatchery steelhead, *Oncorhynchus mykiss* (Walbaum), through return timing manipulation

L. R. Clarke | M. W. Flesher | W. J. Knox† | R. W. Carmichael

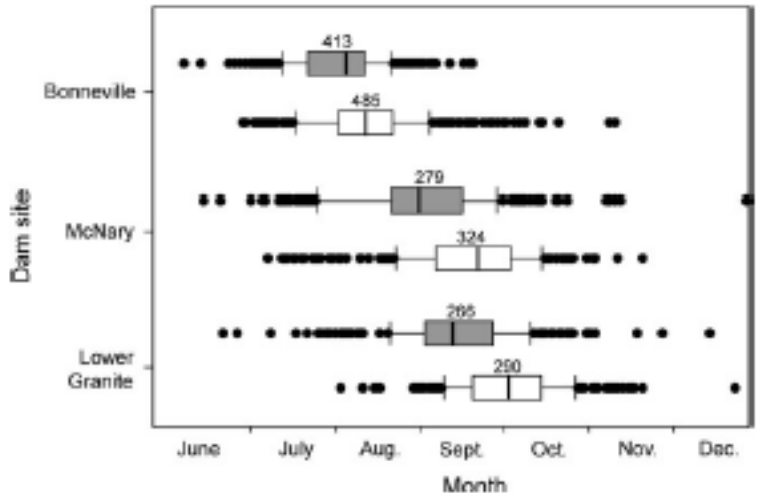


FIGURE 3 Adult return timing at Bonneville, McNary and Lower Granite dams based on PIT tag recoveries of the early arriving (grey) and standard strain (white) steelhead in return years 2006-2012. Boxes represent the interquartile range containing 50% of the detections, vertical lines within the boxes are the median, whiskers extend to the 10th and 90th percentiles and solid circles indicate outlier values. The number of PIT tag recoveries by dam location is above the boxes

Key findings for progeny from Angler Caught Broodstock

- ✓ Earlier Arrival Time
- ✓ Increased contribution to Lower Grande Ronde fishery

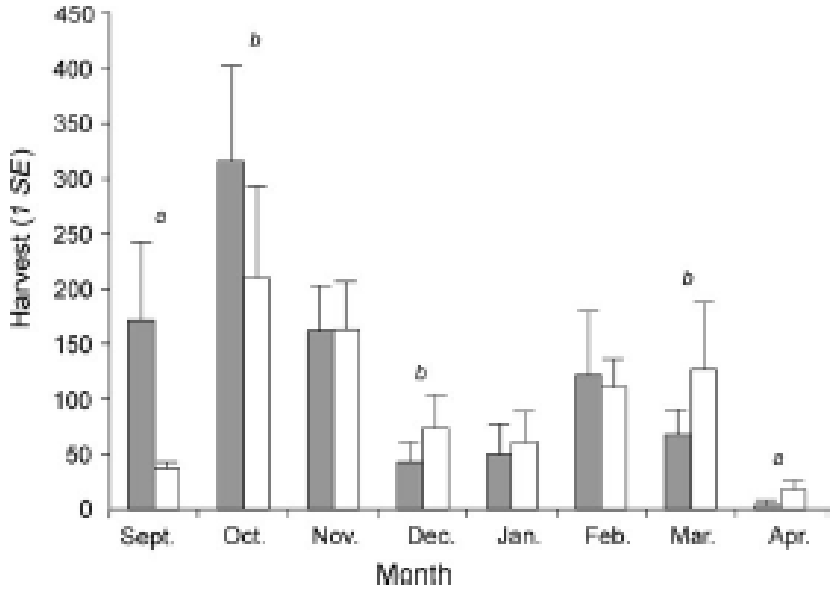
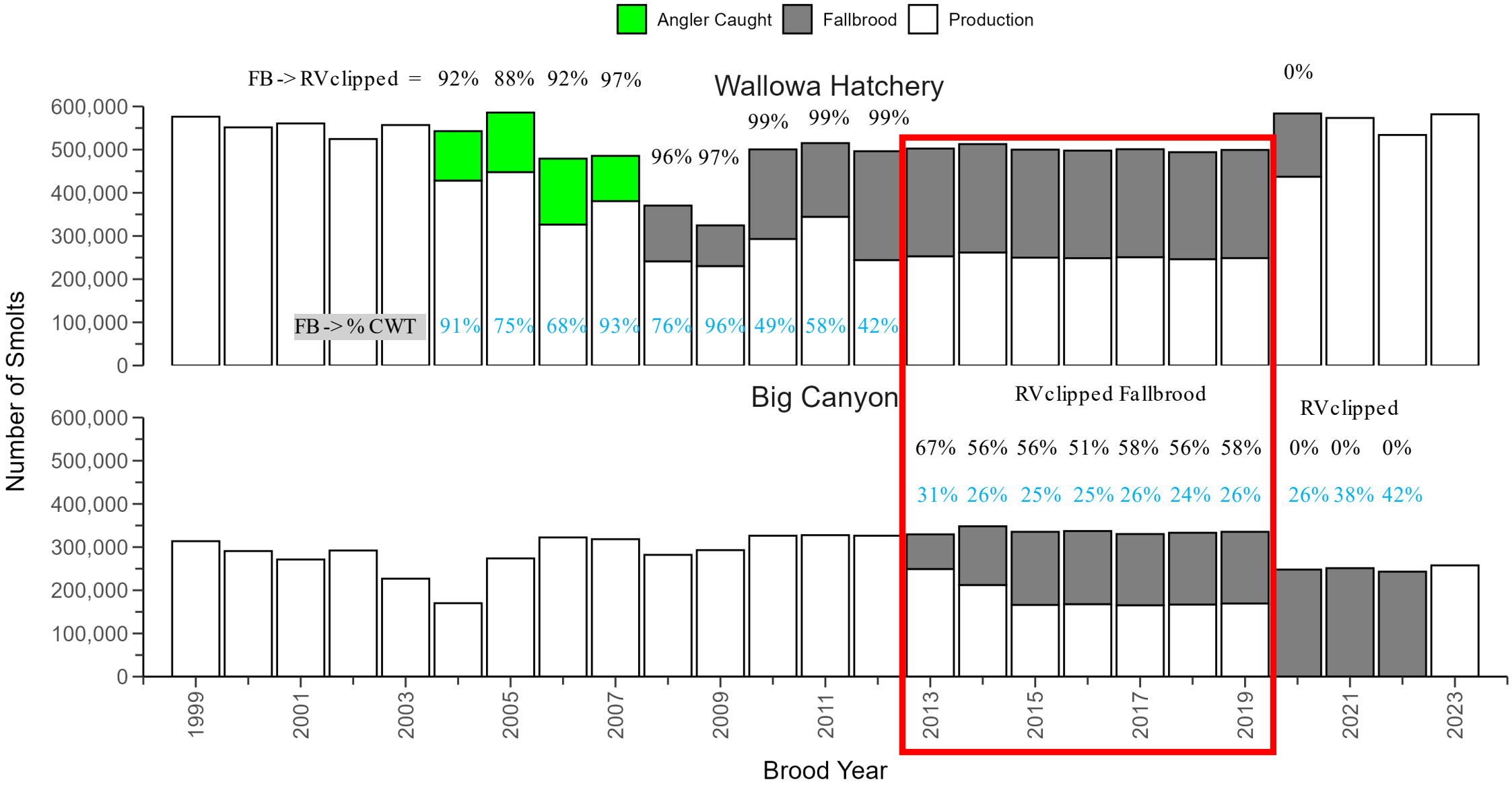


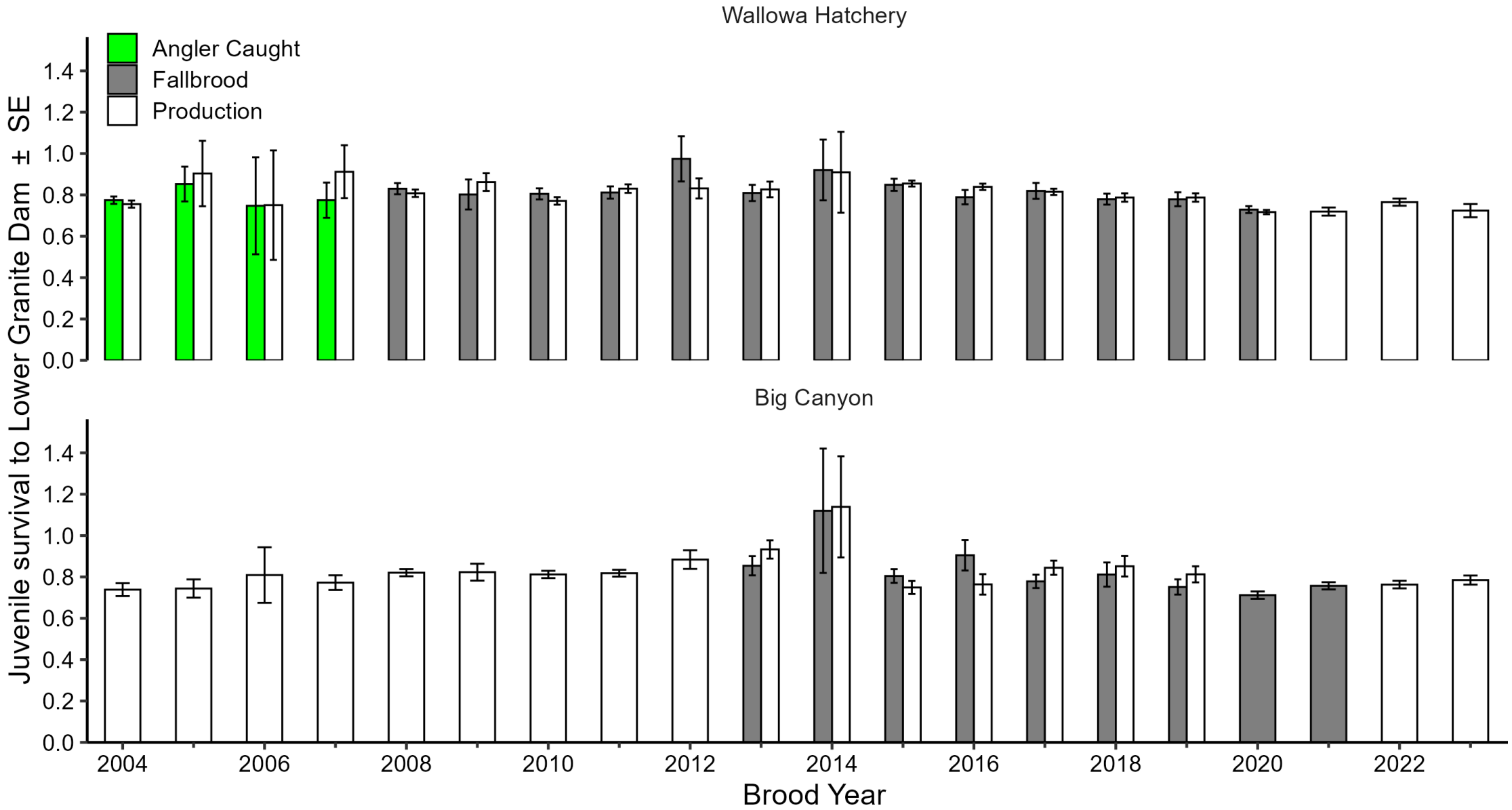
FIGURE 5 Estimated number of steelhead harvested monthly in the Grande Ronde River basin of the early arriving (grey) and standard strain (white), run years 2006-2007 to 2010-2011. Letters above the bars denote a large (*a*) and medium (*b*) effect size. Error bars = 1 SE

Wallowa Stock overall CWT tag rates for BYs 2004-2023 = 27-39%

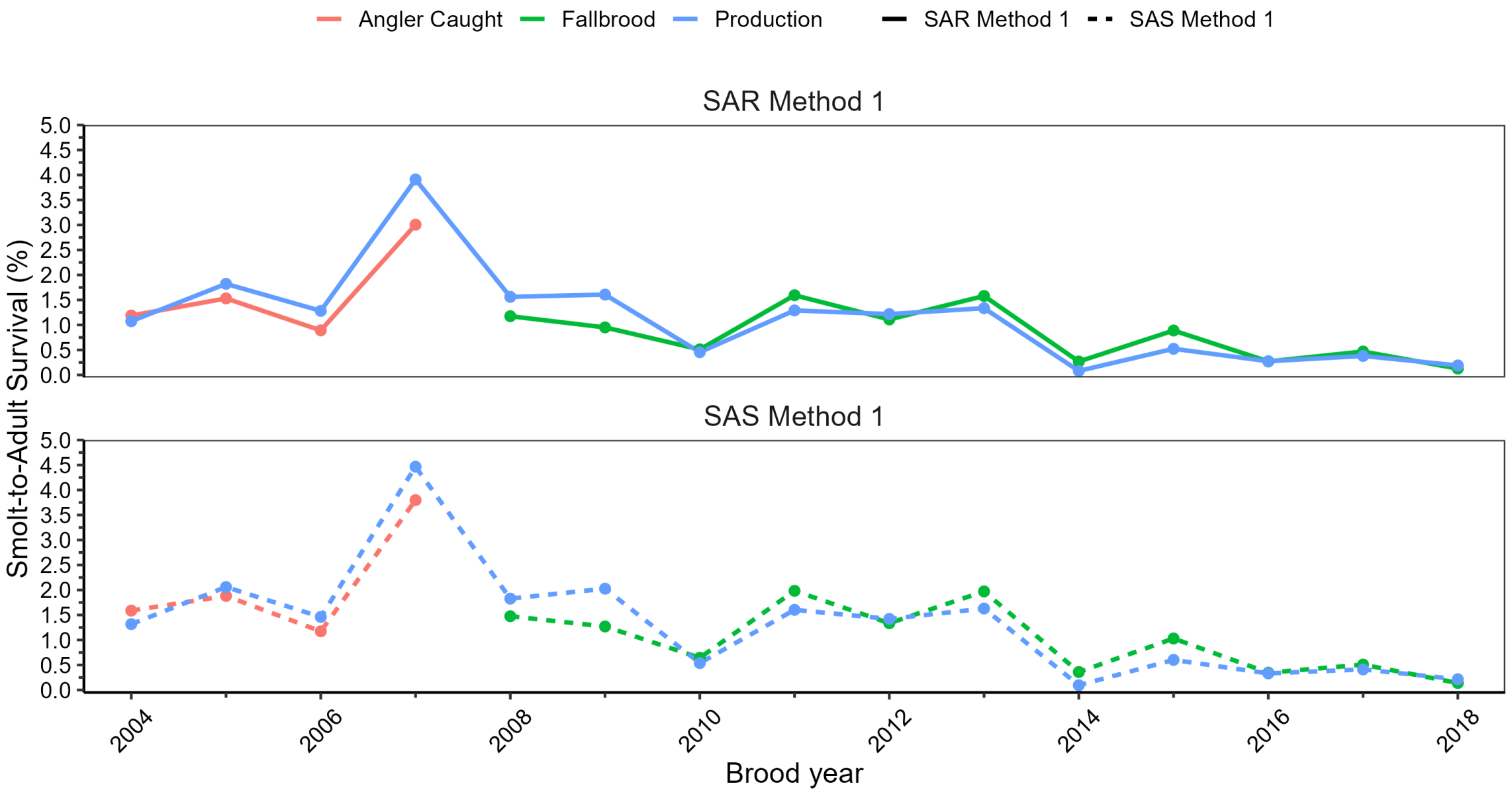
Smolt Releases by Facility



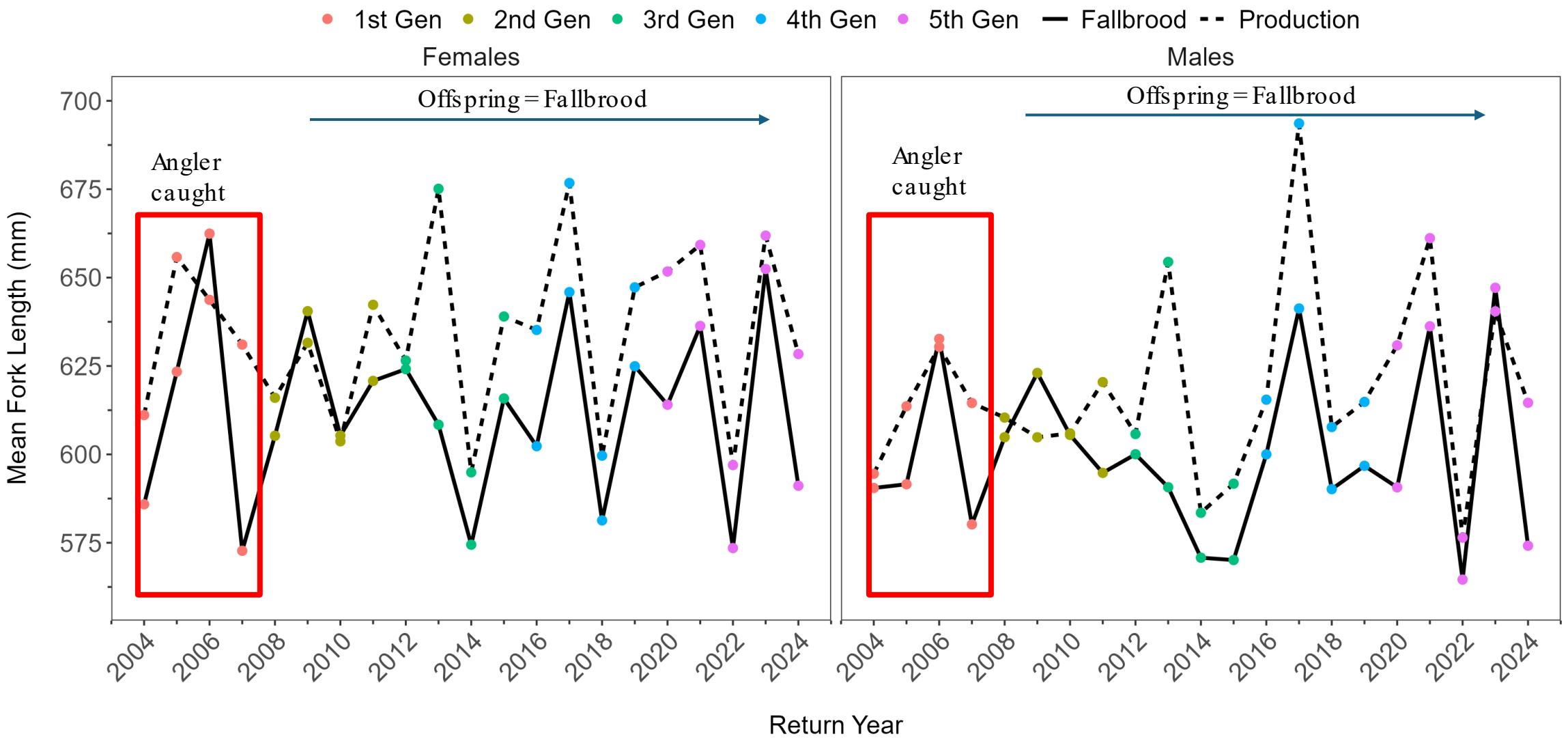
Juvenile Survival to Lower Granite Dam for Fallbrood and Production Smolts



Comparing SAR and SAS rates: Method 1



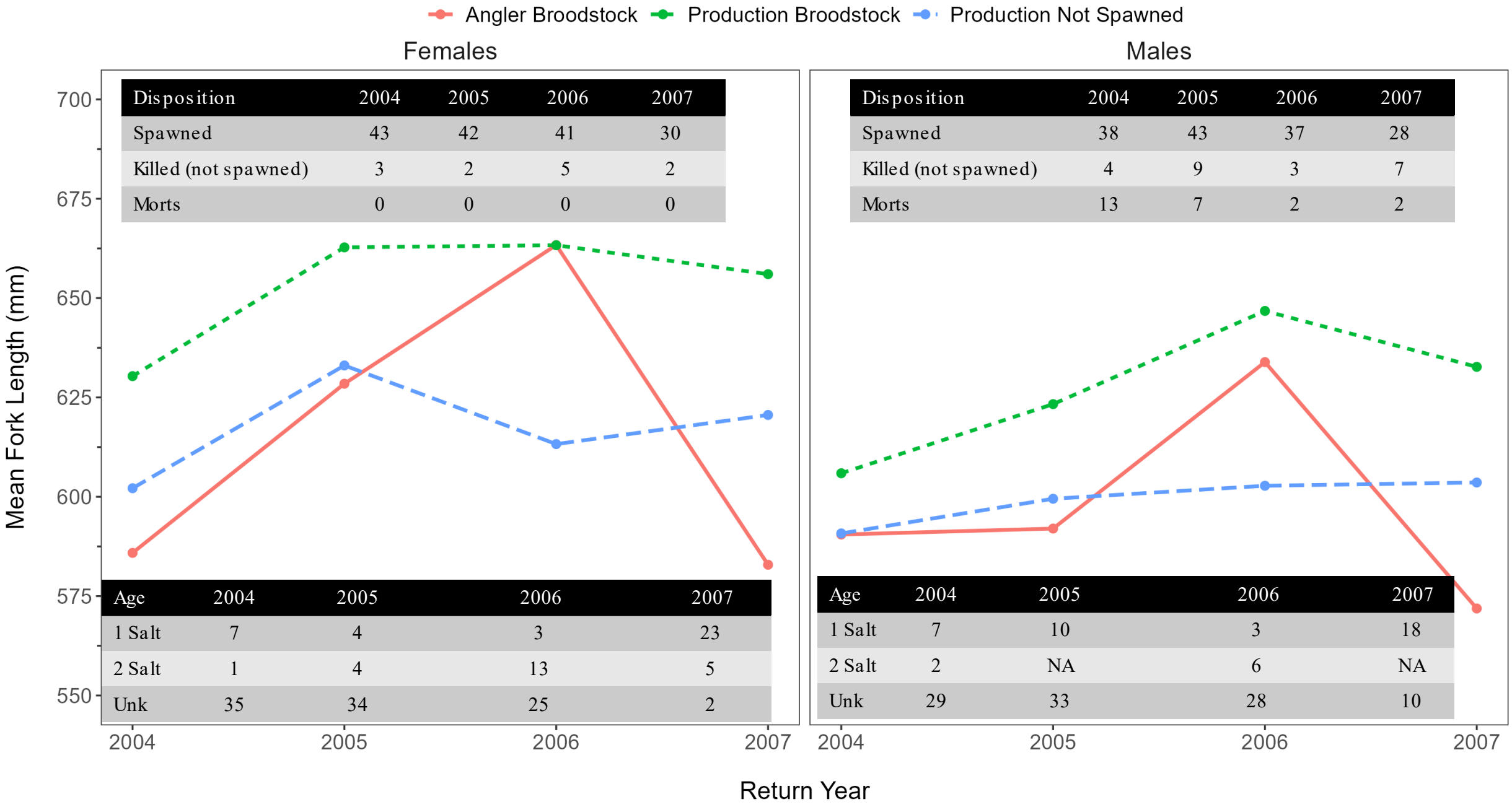
The talk around the Rack: “Those fallbrood fish look smaller…”



Total Known Age Returns

- ✓ Genetic Ages
- ✓ CWT Ages

Broodstock comparison: Back to the original evaluation



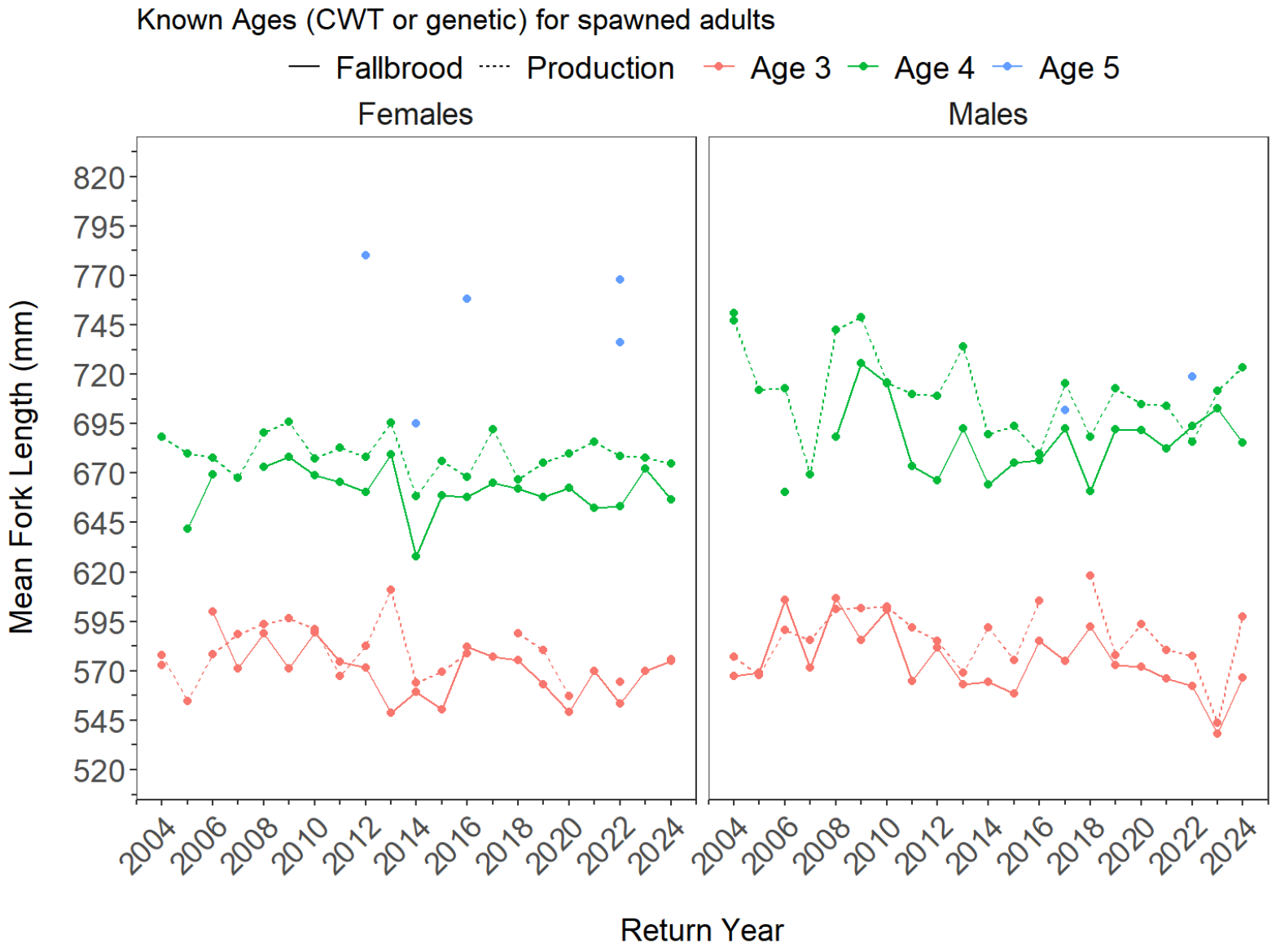
Disposition	2004	2005	2006	2007
Spawned	43	42	41	30
Killed (not spawned)	3	2	5	2
Morts	0	0	0	0

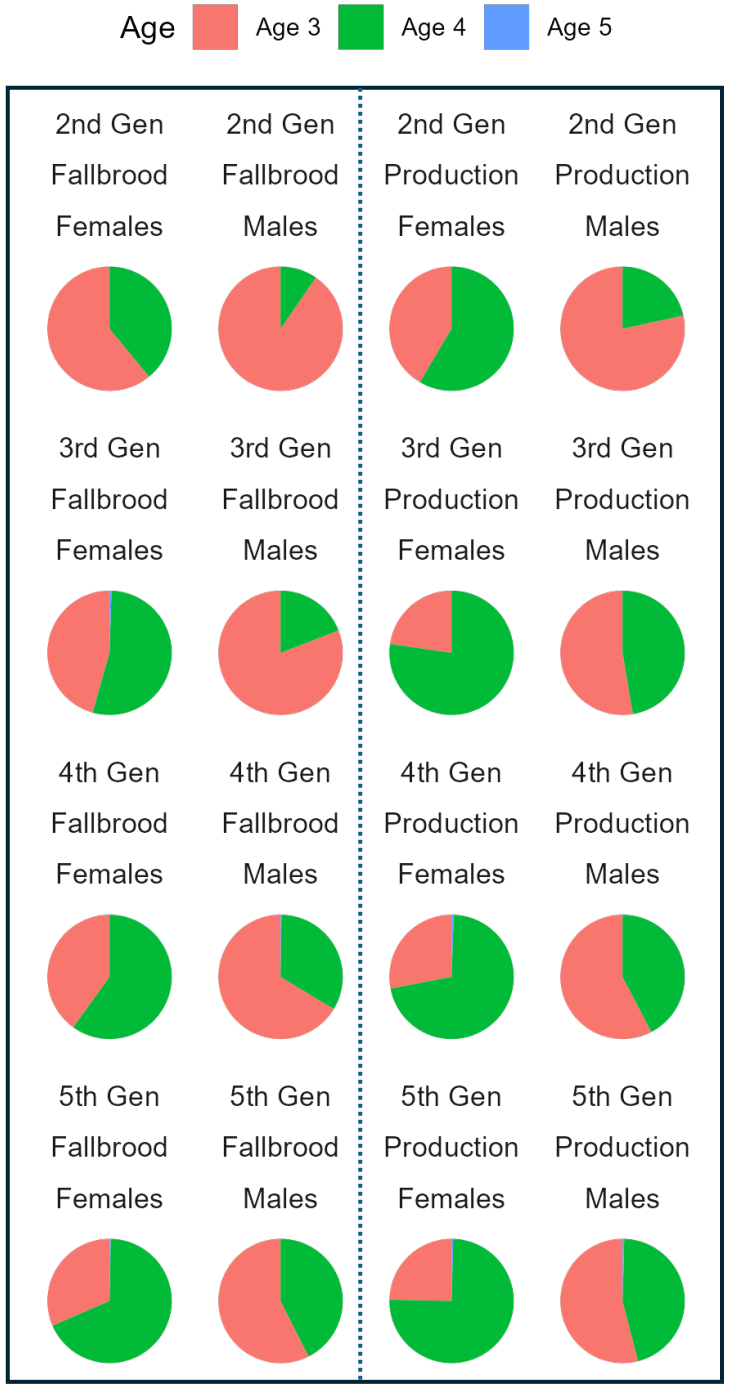
Age	2004	2005	2006	2007
1 Salt	7	4	3	23
2 Salt	1	4	13	5
Unk	35	34	25	2

Disposition	2004	2005	2006	2007
Spawned	38	43	37	28
Killed (not spawned)	4	9	3	7
Morts	13	7	2	2

Age	2004	2005	2006	2007
1 Salt	7	10	3	18
2 Salt	2	NA	6	NA
Unk	29	33	28	10

Broodstock: Mean Length and Known Age





Average total age for hatchery adult steelhead used for Broodstock from 2008 to 2024.

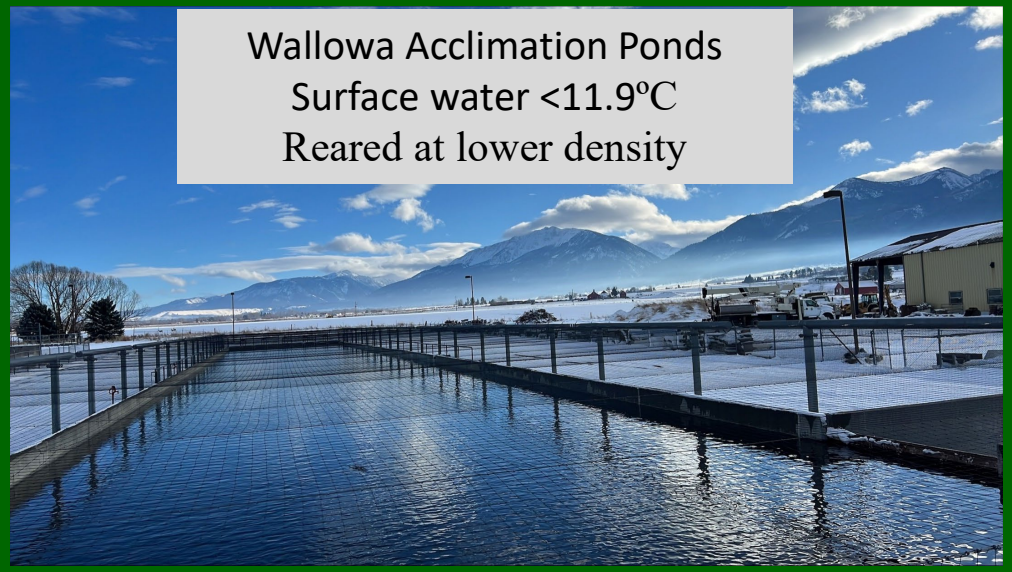
- Females spawned from production releases were older.
- Fallbrood spawned younger males.
- Age composition changed over time.

Conclusions to Fallbrood comparisions

- ✓ Similar juvenile survival to Lower Granite
- ✓ SAR/SAS similar -> slight edge to fallbrood
  - ❖ Not adjusted to a common age
- Fallbrood returned
  - Smaller size
  - Younger age
- Consider age structure of "founding" parents?

November Transfer: Evaluating tradeoffs

Irrigon Fish Hatchery
Well Water 10.5 to 13.9 ºC



Typical releases
Rearing on Well Water @ Irrigon (11 months)

Novel releases
Rearing on surface water @ Wallowa Acclimation (4.5 month)

ESA impacts: hatchery trout spawning in nature?

Popular adult steelhead fishery

Popular local trout fishery ± residuals

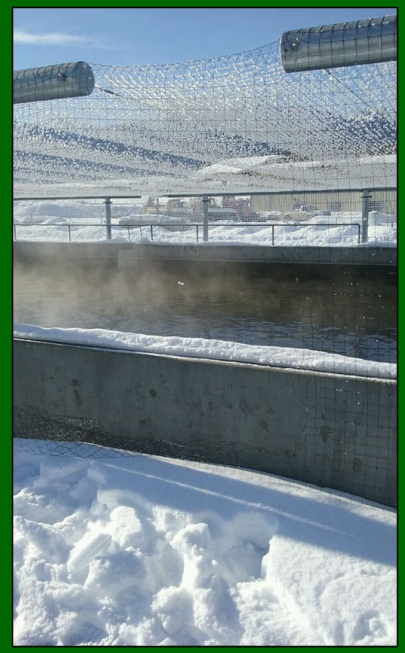
SAR rates regularly exceed 1%

± SAR rates?

Pre-Smolt growth rates and release size

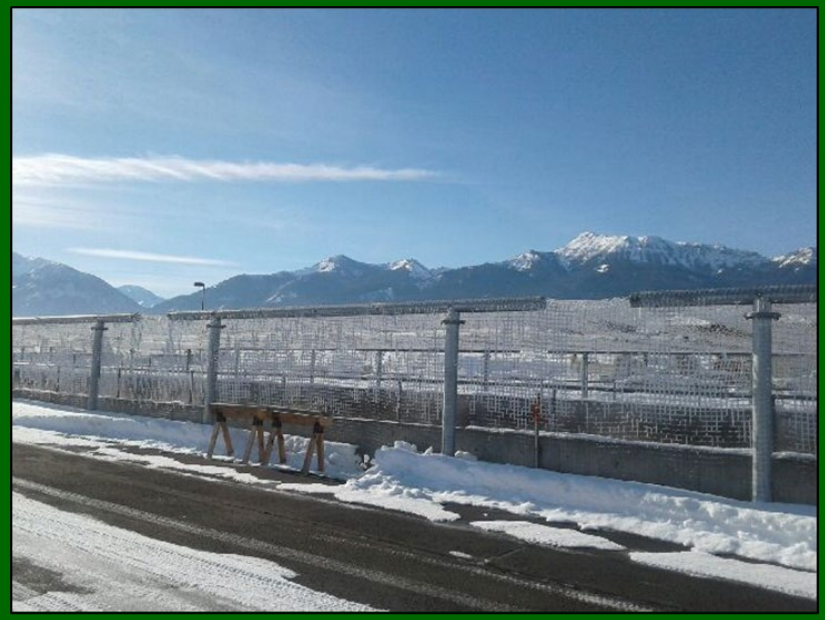
NOVEMBER TRANSFER TO WALLOWA: BY20-PRESENT

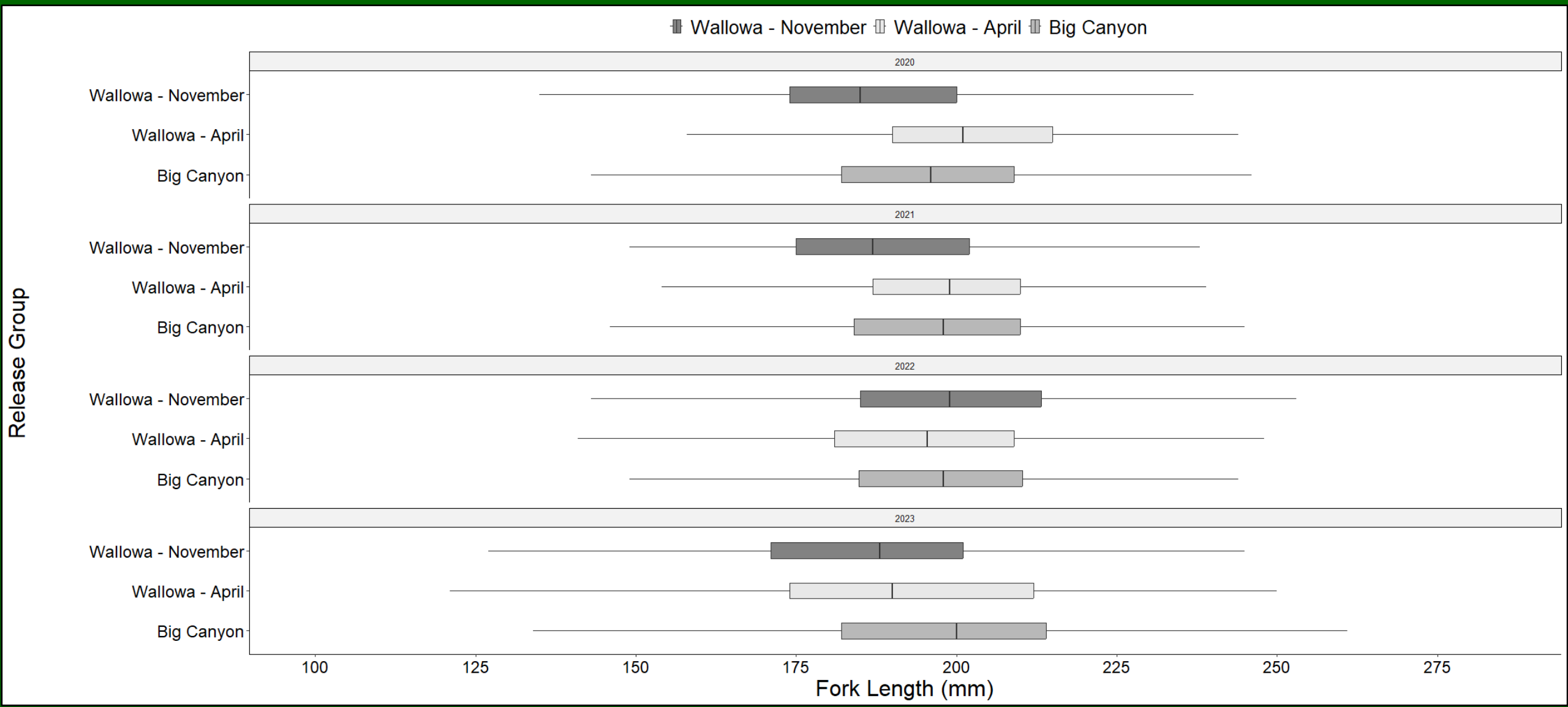
- ✓ Necessitated by space, shrinking aquafer at Irrigon Fish Hatchery & water issues @ Umatilla Hatchery (a hose length away)
- ✓ 3 months early

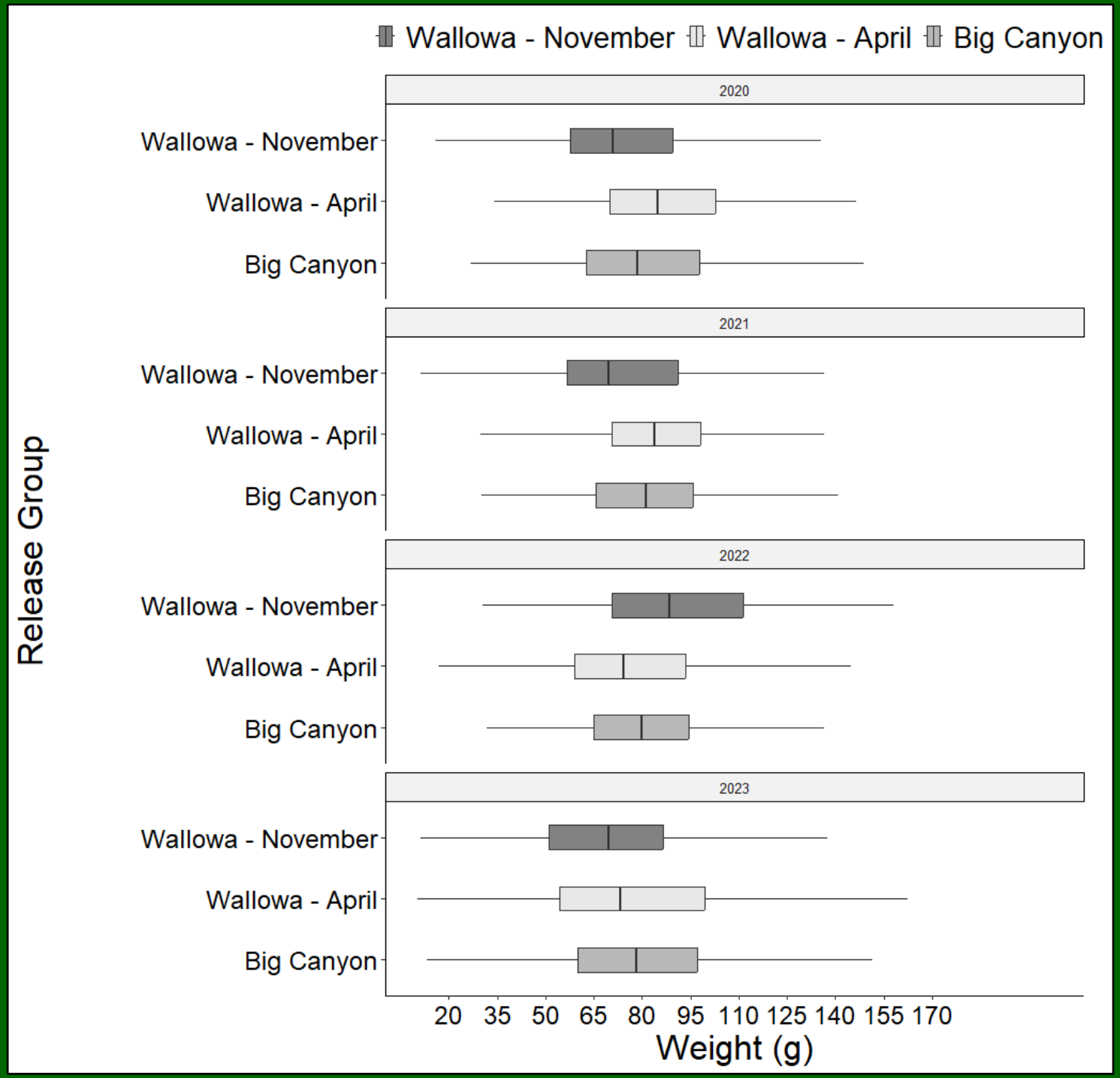


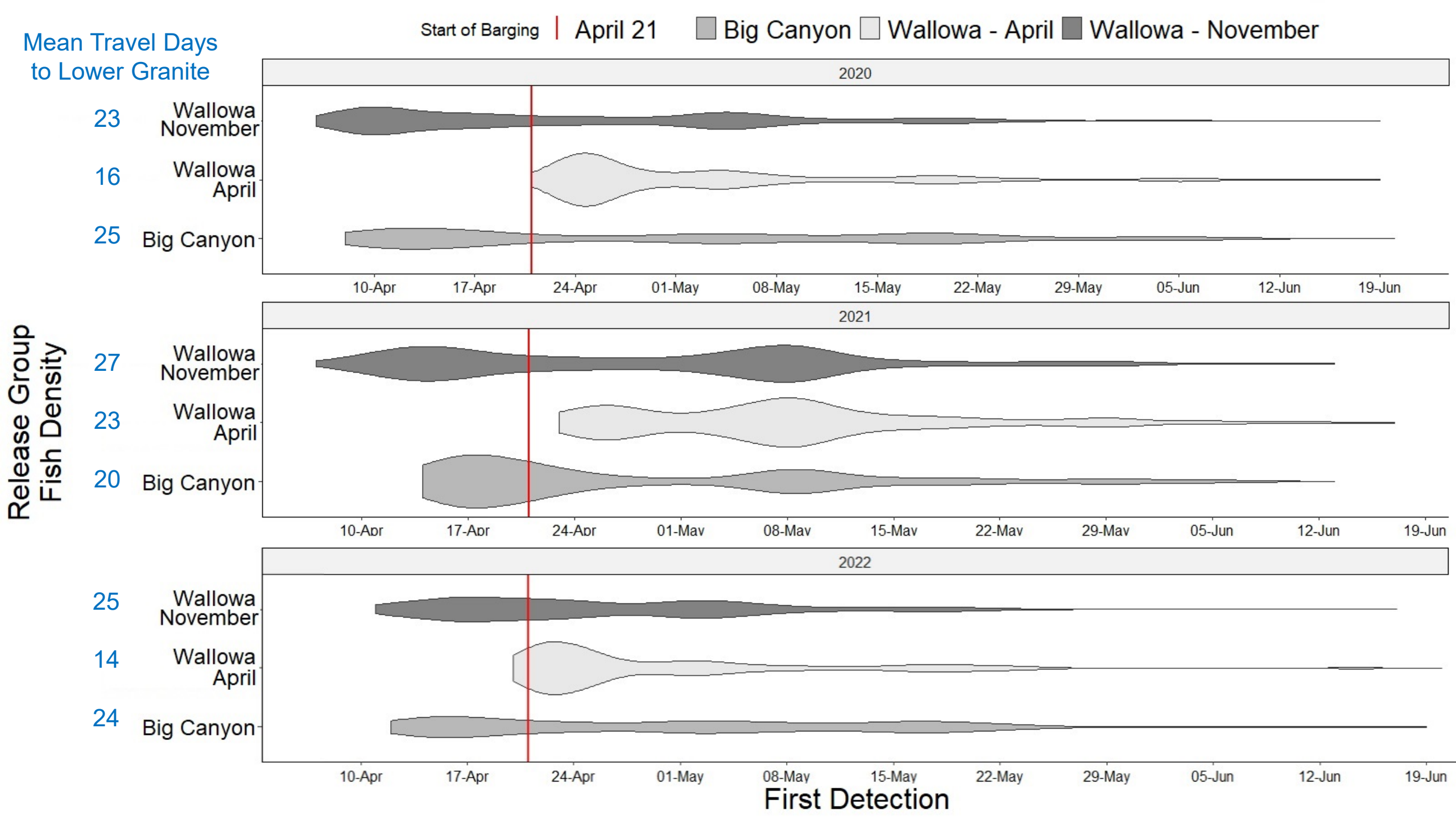
Release group	Transfer Date	Release Date	Time at Facility	# Smolts
Wallowa- early	15-17 Nov	1 April	4.5 months	400,000
Wallowa- late	5-6 April	16-26 April	2-3 weeks	160,000
Big Canyon	16-17 March	8-11 April	1 month	240,000

- Irrigon- well water 10.5-13.9 ˚C
- Wallowa- surface water 0-11.9 °C

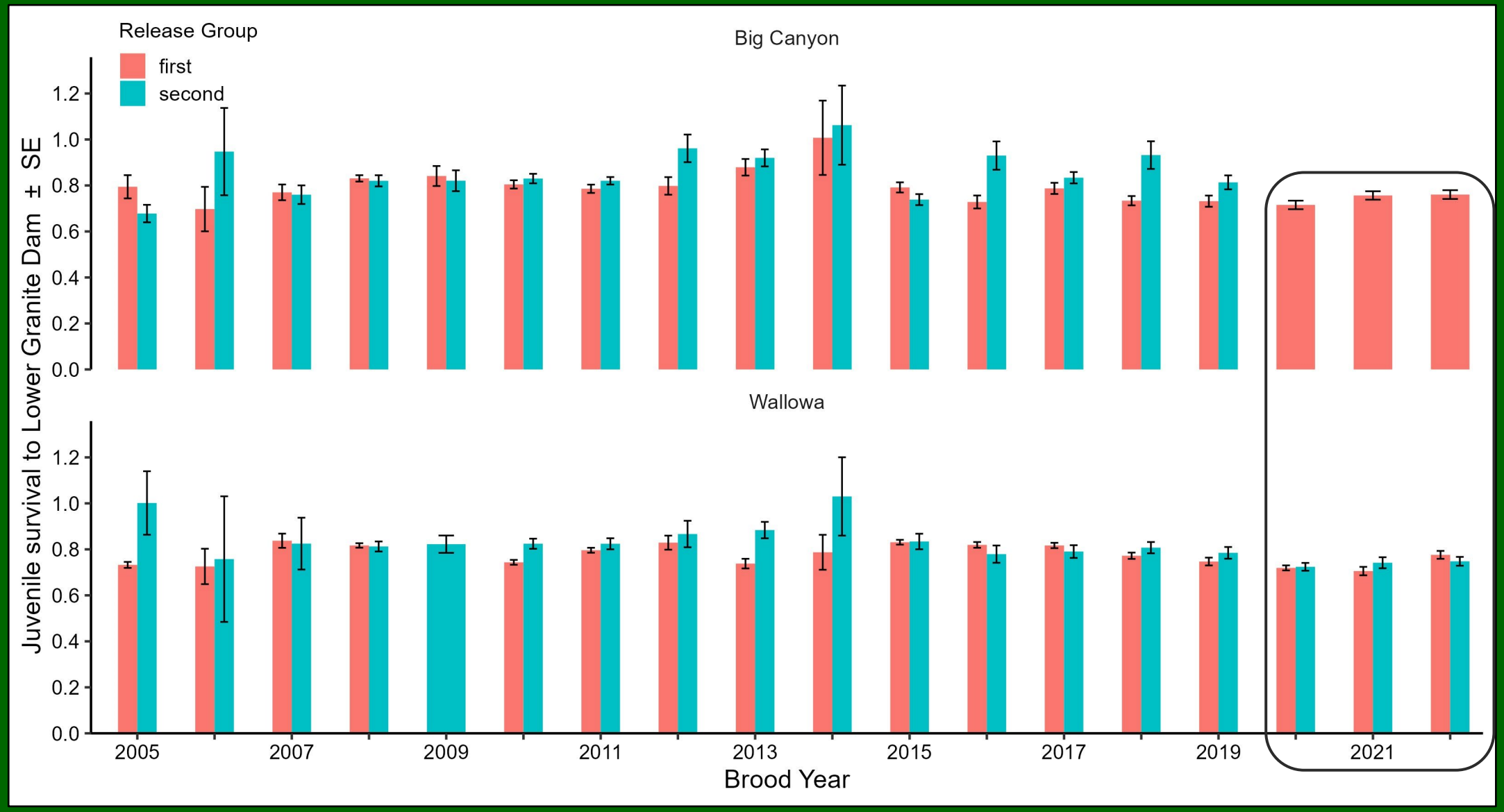



Wallowa - November
Wallowa - April
Big Canyon
2020
2021
2022
2023
Release Group
100
125
150
175
200
225
250
275
Fork Length (mm)

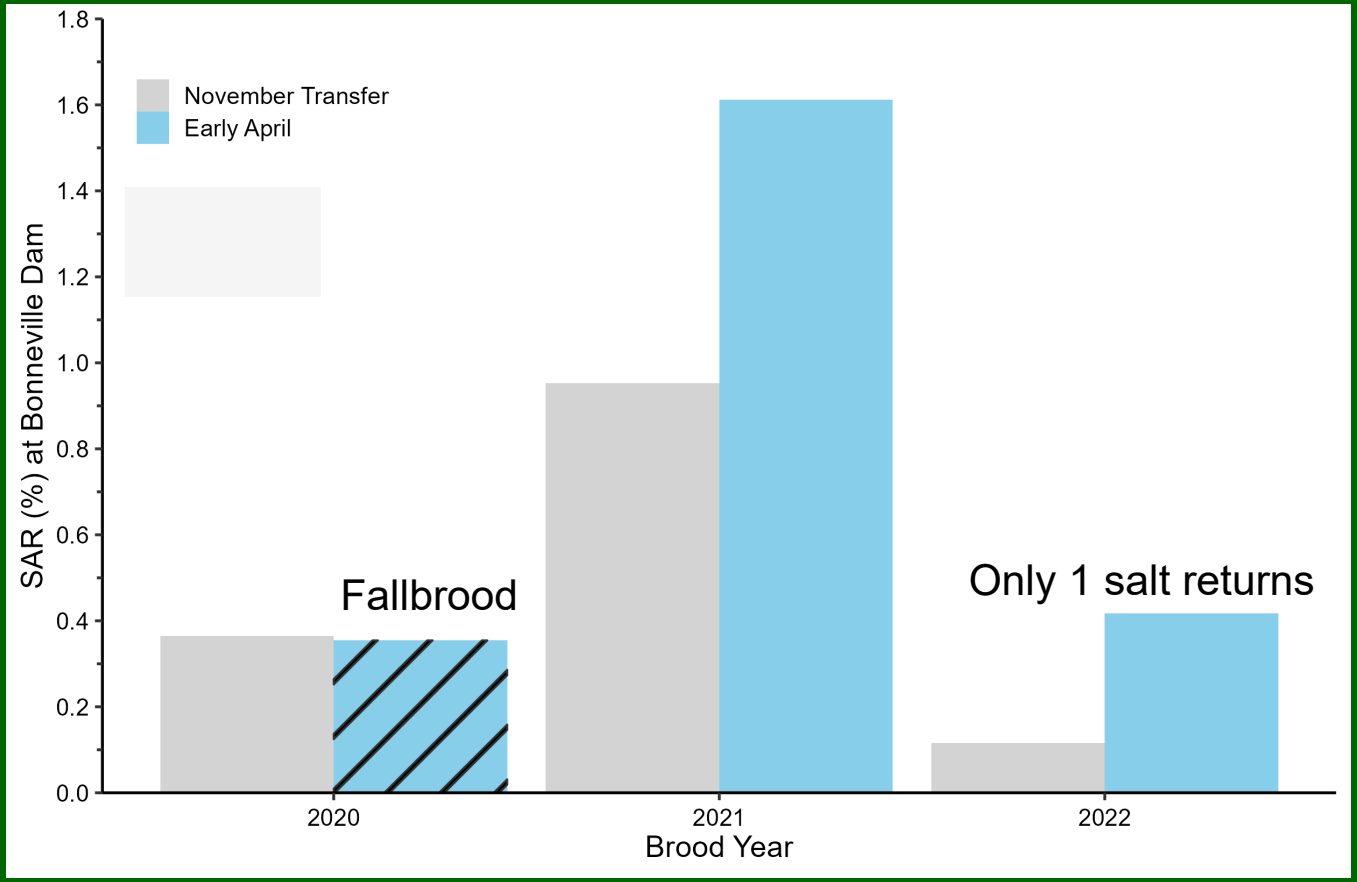

Wallowa - November
Wallowa - April
Big Canyon
2020
2021
2022
2023
Release Group
Wallowa - November
Wallowa - April
Big Canyon
20 35 50 65 80 95 110 125 140 155 170
Weight (g)


Mean Travel Days to Lower Granite
Start of Barging
April 21
Big Canyon
Wallowa - April
Wallowa - November
2020
23
Wallowa November
16
Wallowa April
25
Big Canyon
10-Apr
17-Apr
24-Apr
01-May
08-May
15-May
22-May
29-May
05-Jun
12-Jun
19-Jun
2021
27
Wallowa November
23
Wallowa April
20
Big Canyon
2022
25
Wallowa November
14
Wallowa April
24
Big Canyon
Release Group Fish Density
First Detection

JUVENILE SURVIVAL TO LOWER GRANITE DAM



EXPANDED PIT TAG-BASED SAR TO BONNEVILLE DAM

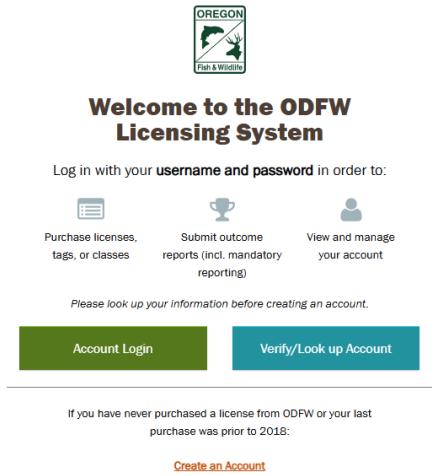


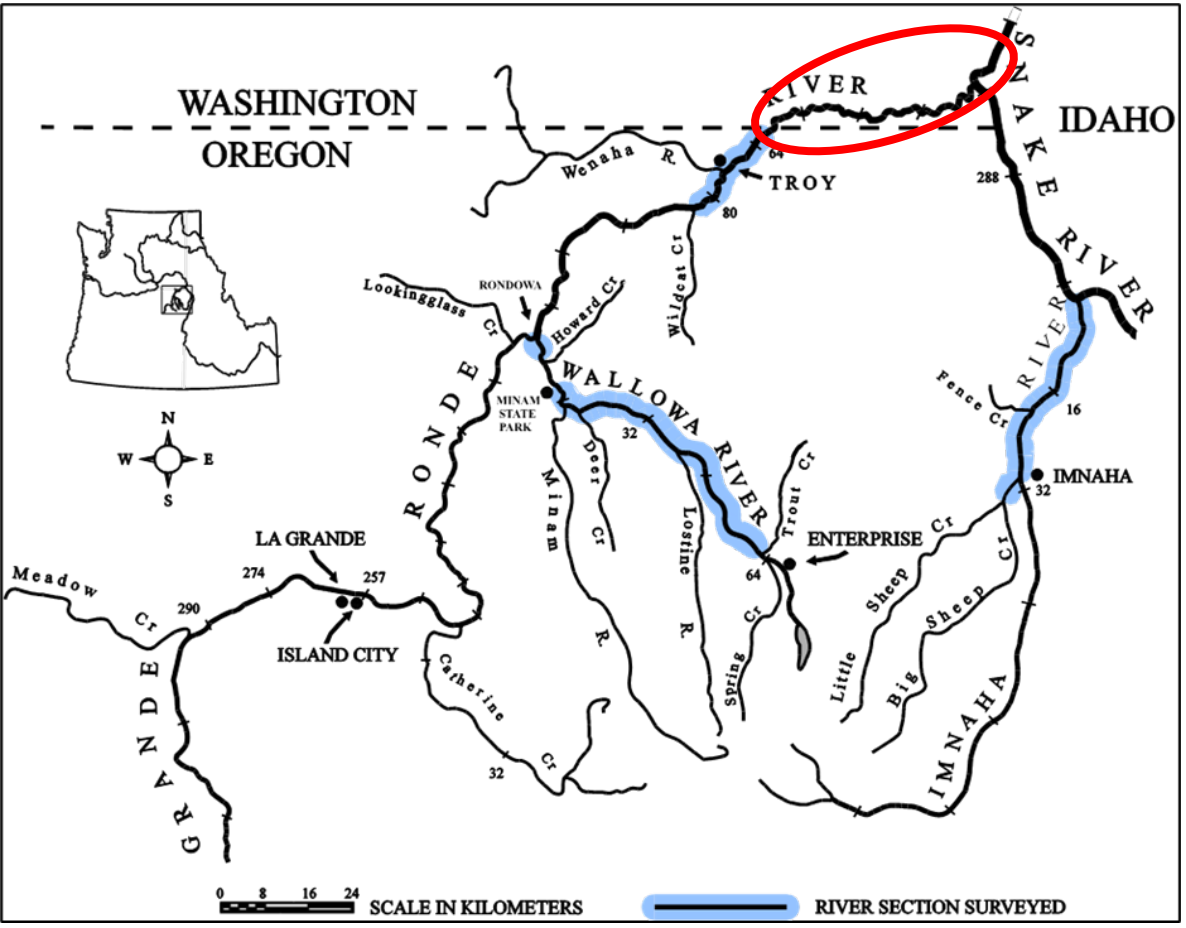
Key Takeaways

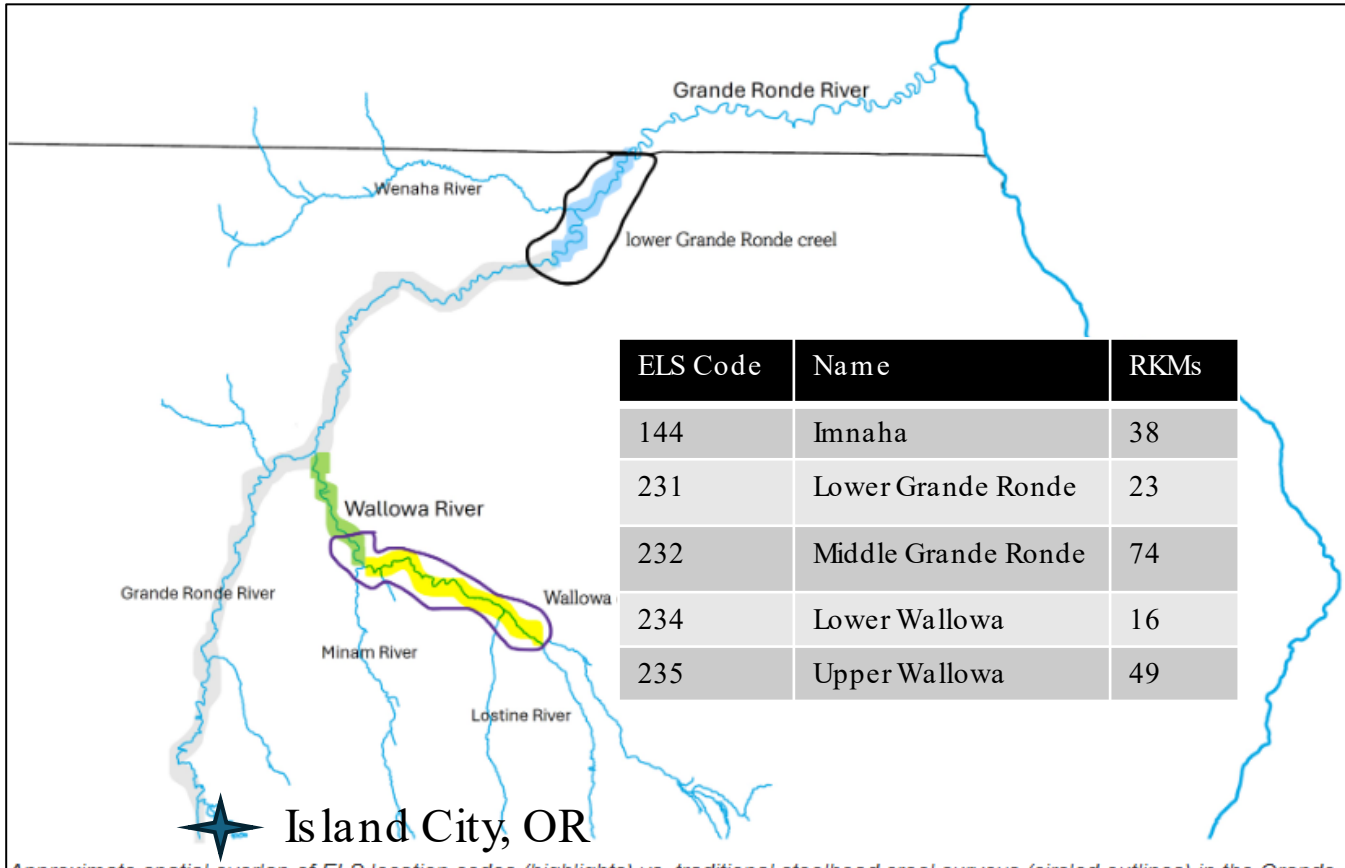
- Fallbrood ≠ Production
- November transfer is underperforming

Traditional Creel vs E-Creel

- ✓ Paper vs Smart phone
- ✓ Traditional driving surveys do not match well with all ELS codes







ELS Code	Name	RKMs
144	Imnaha	38
231	Lower Grande Ronde	23
232	Middle Grande Ronde	74
234	Lower Wallowa	16
235	Upper Wallowa	49

Approximate spatial overlap of ELS location codes (highlights) vs. traditional steelhead creel surveys (circled outlines) in the Grande Ronde basin.

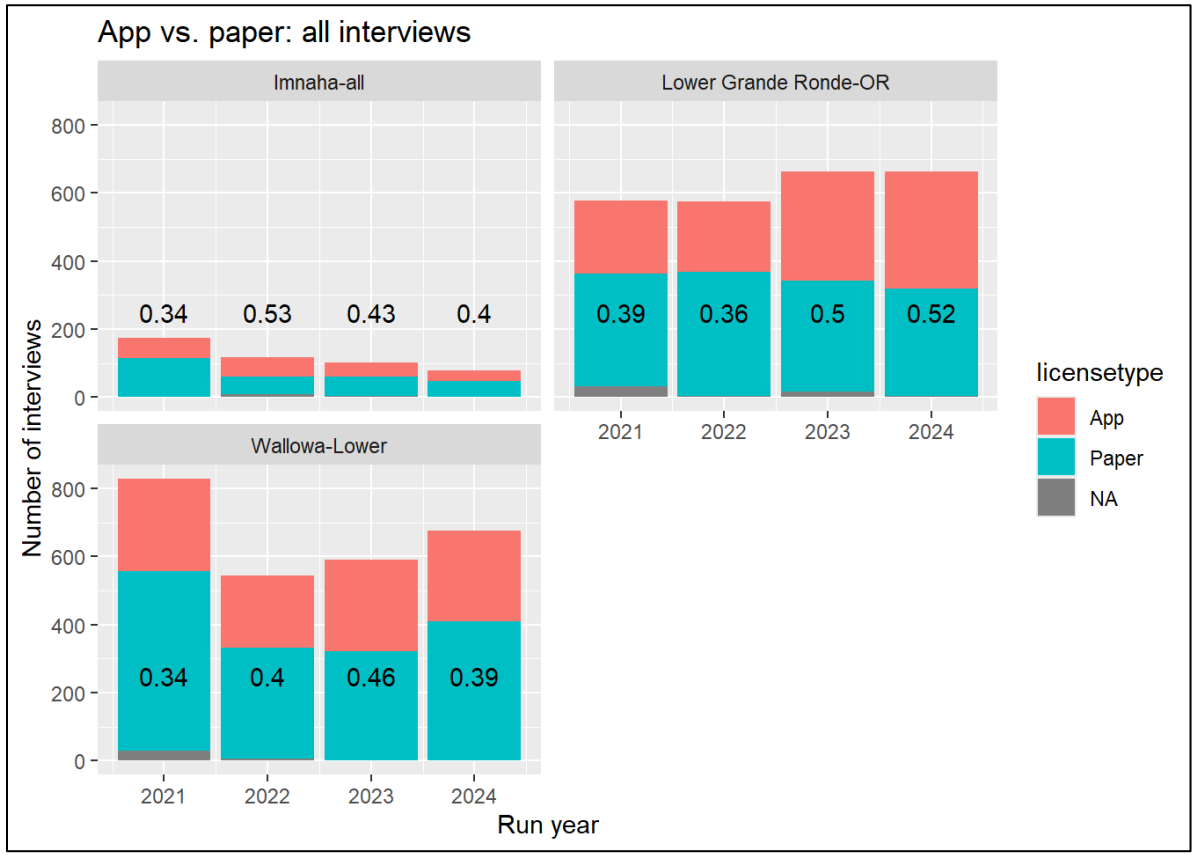
Are anglers recording harvest on the "App" or on Paper?

Numbers of *interview* records with App vs. Paper data, by run year:

	2021	2022	2023	2024
Imnaha	175	118	102	77
Lower Grande Ronde	577	576	662	663
Wallowa	828	545	592	676

Numbers in bars = proportion using the App

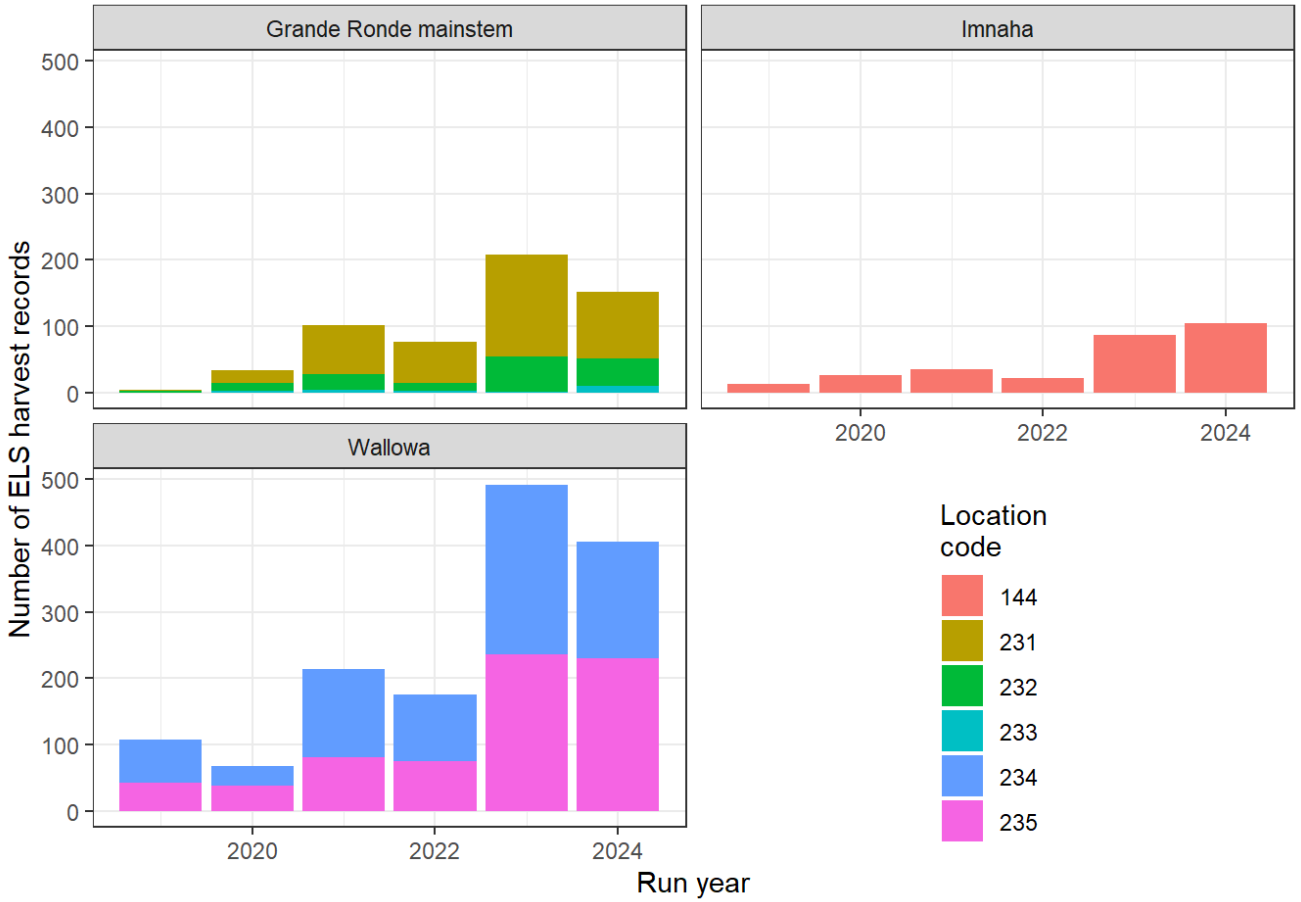
- ✓ App use varies annually & by location
- ✓ App use ≤ 50%



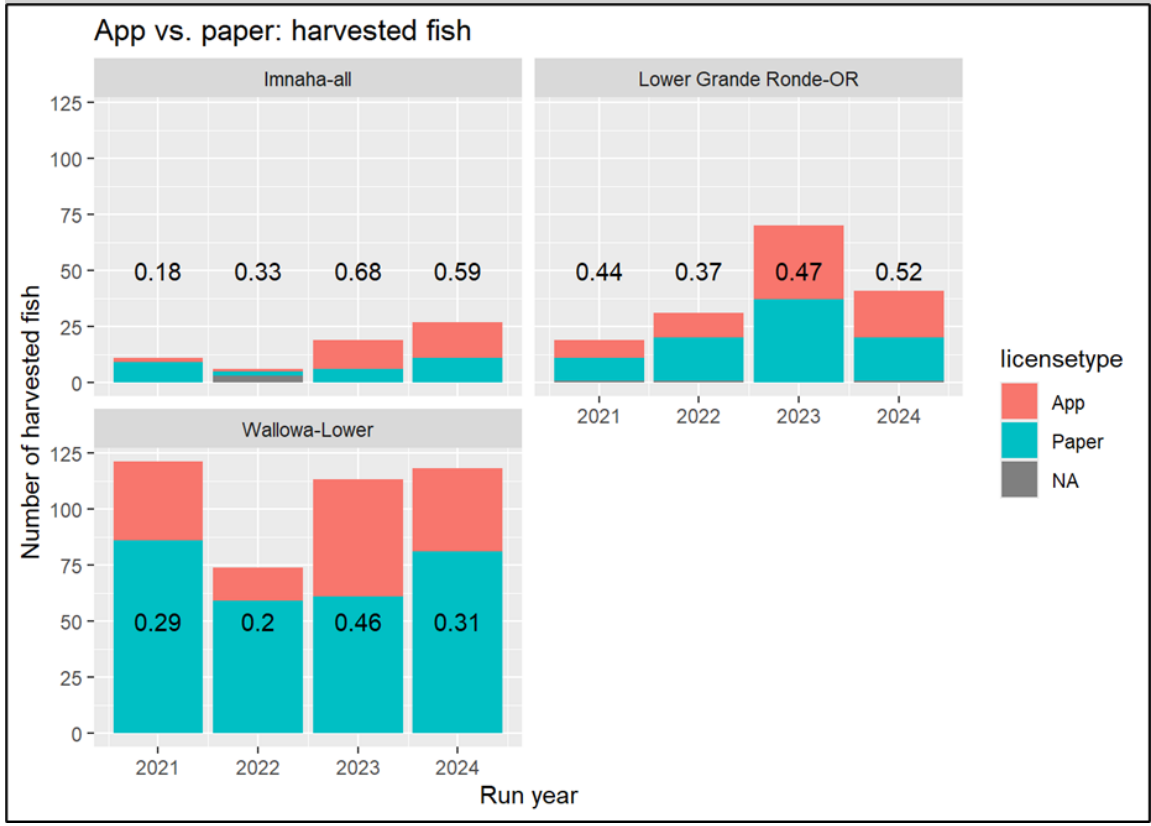
How many fish are recorded using the App?

A primary assumption of the e-creel method for estimating harvest is that "[t]he e-tag harvest ratios do not differ significantly in time and space within a basin" (Riggers and Jones 2022).

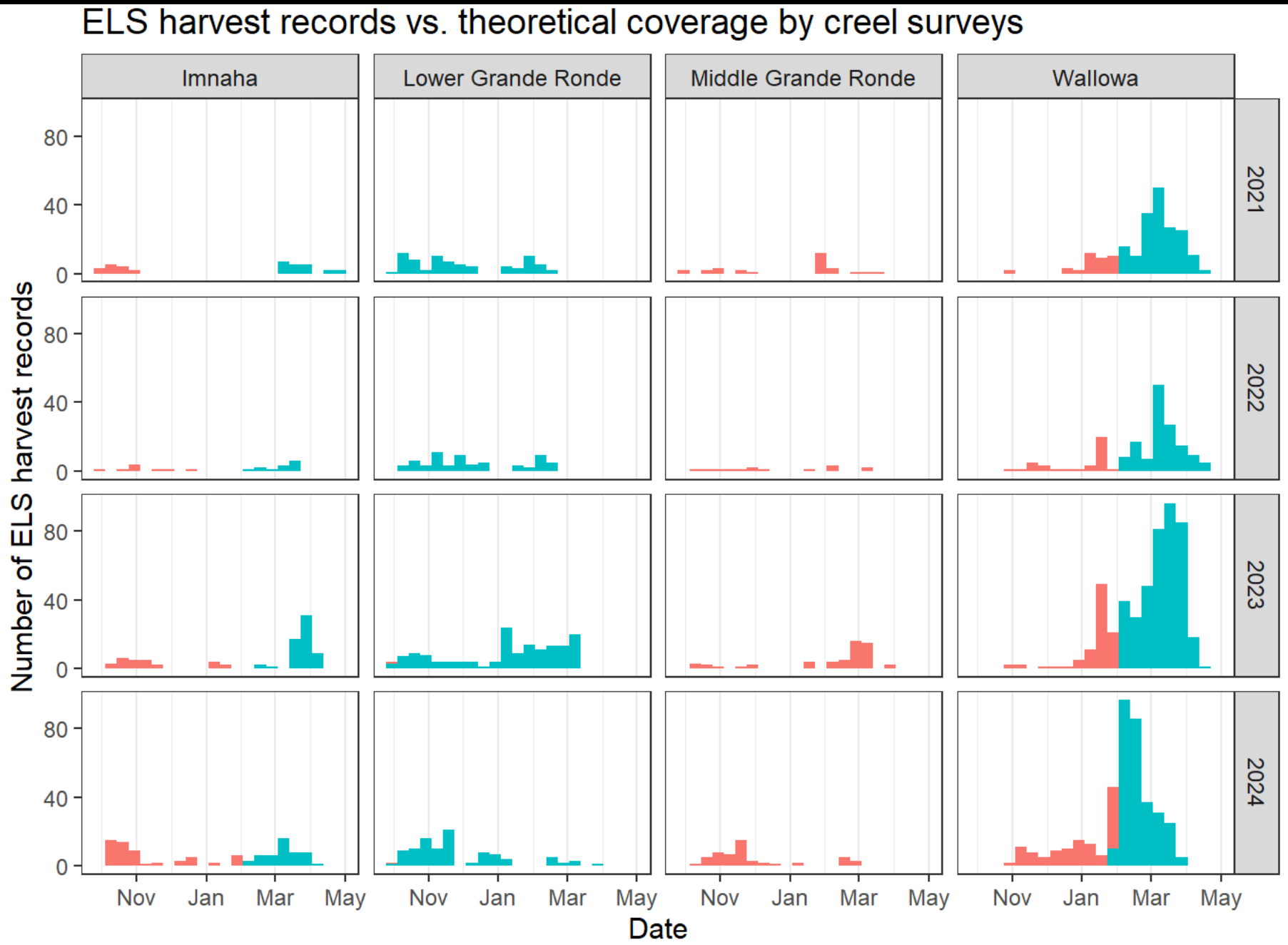
Key Results
- ELS harvest records have increased over time.
- Harvest proportions recorded with the App varies over time and by basin.
- Wallowa River fishery has the most harvest reported with the App.



Numbers in bars = harvest proportion recorded with the App.



Is our creel coverage adequate?



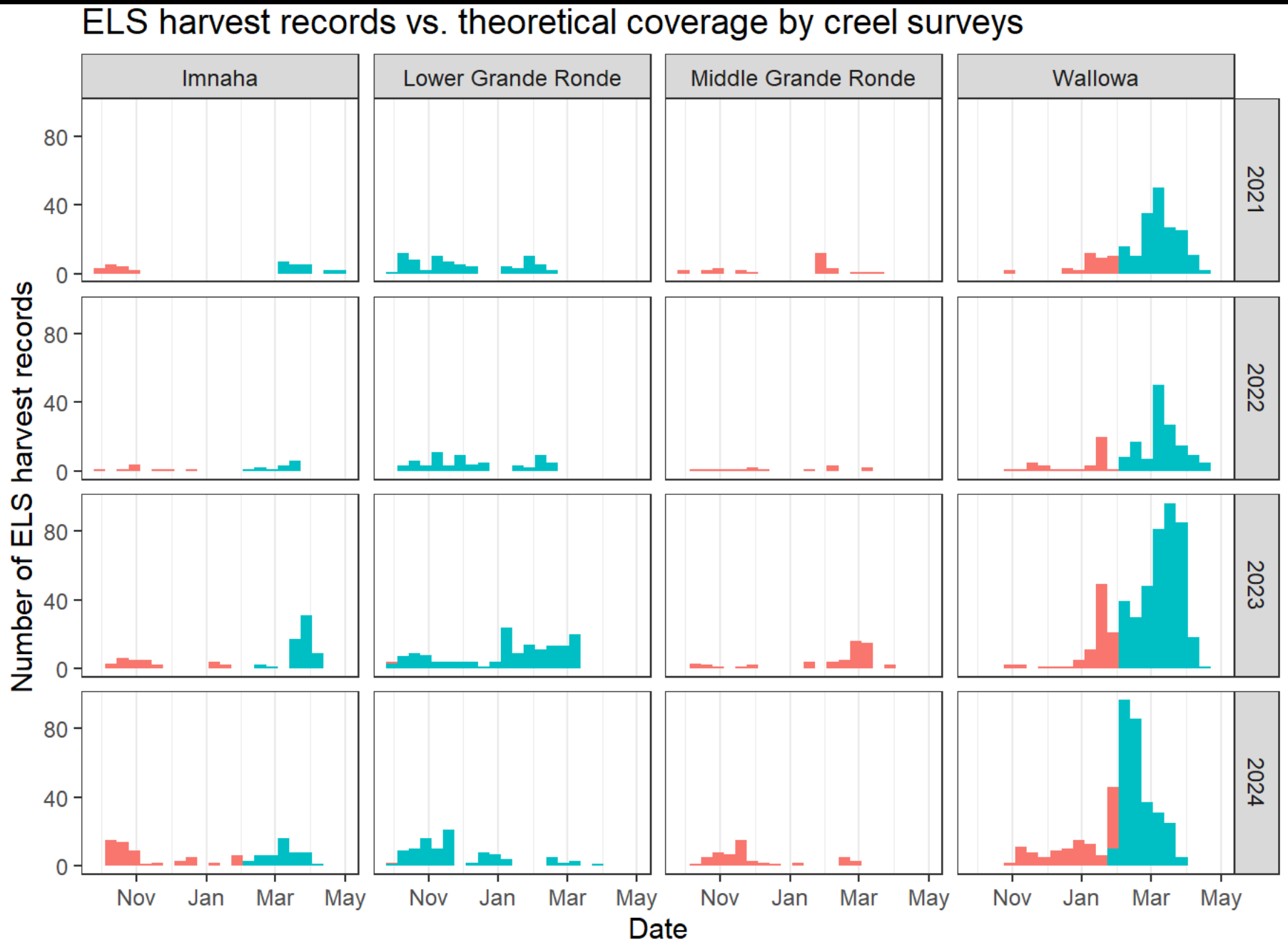
Imnaha

- ✓ ELS Code 144
- ✓ Current Creel is missing ~50% of the fishery.

Lower Grande Ronde

- ✓ ELS Code 231
- ✓ App only works for anglers in Oregon
- ✓ Current creel covers entire Lower Grande Ronde fishery

Is our creel coverage adequate?



"Middle" Grande Ronde

- ✓ ELS Code 232.
- ✓ "Wildcat bridge" to Island City, OR (~ 74 RKM).
- ✓ Currently, no traditional creel.

Wallowa Fishery

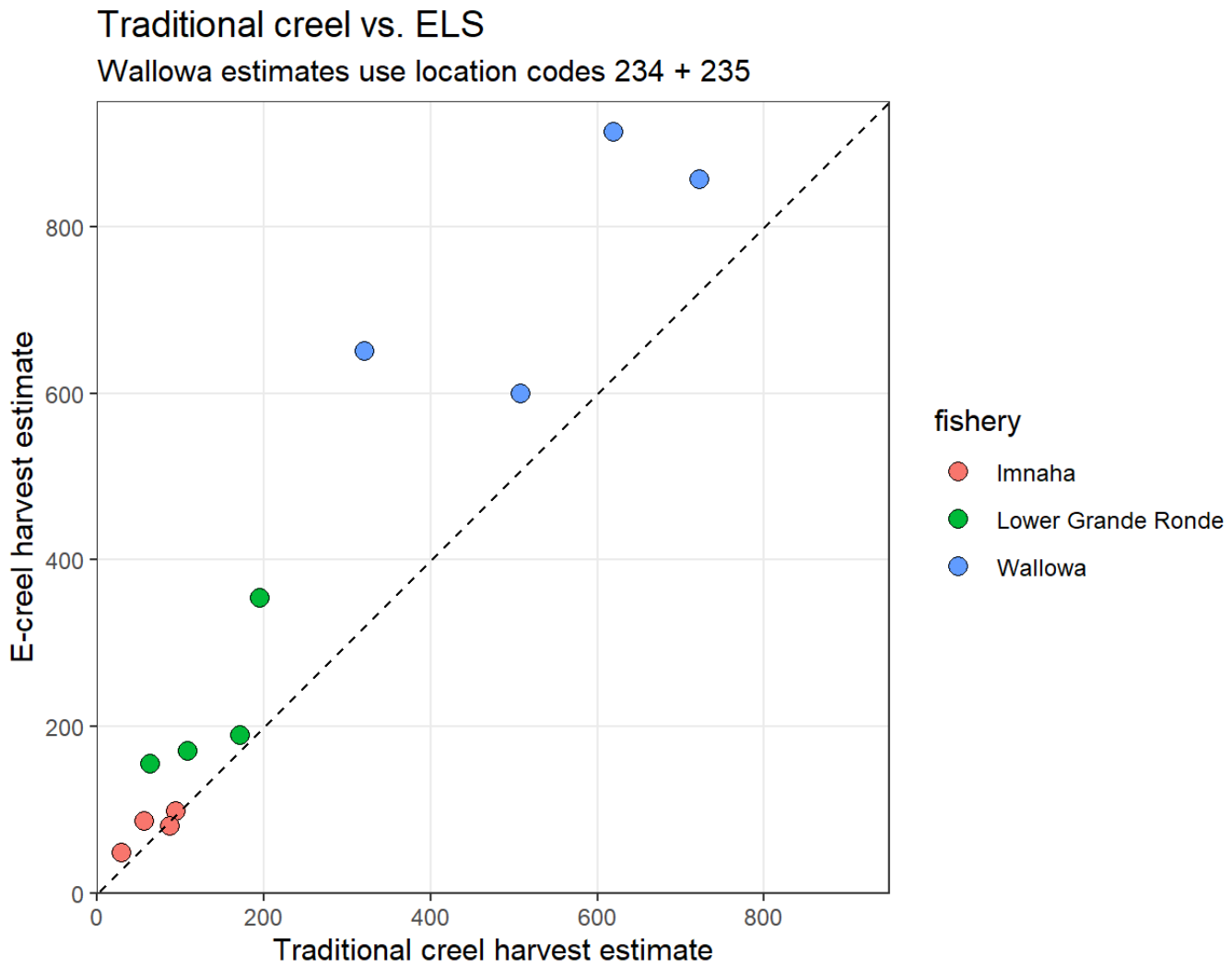
- ✓ ELS codes 234 + 235
- ✓ Poor match with ground surveys.
- ✓ Harvest in November-January before February creel starts.

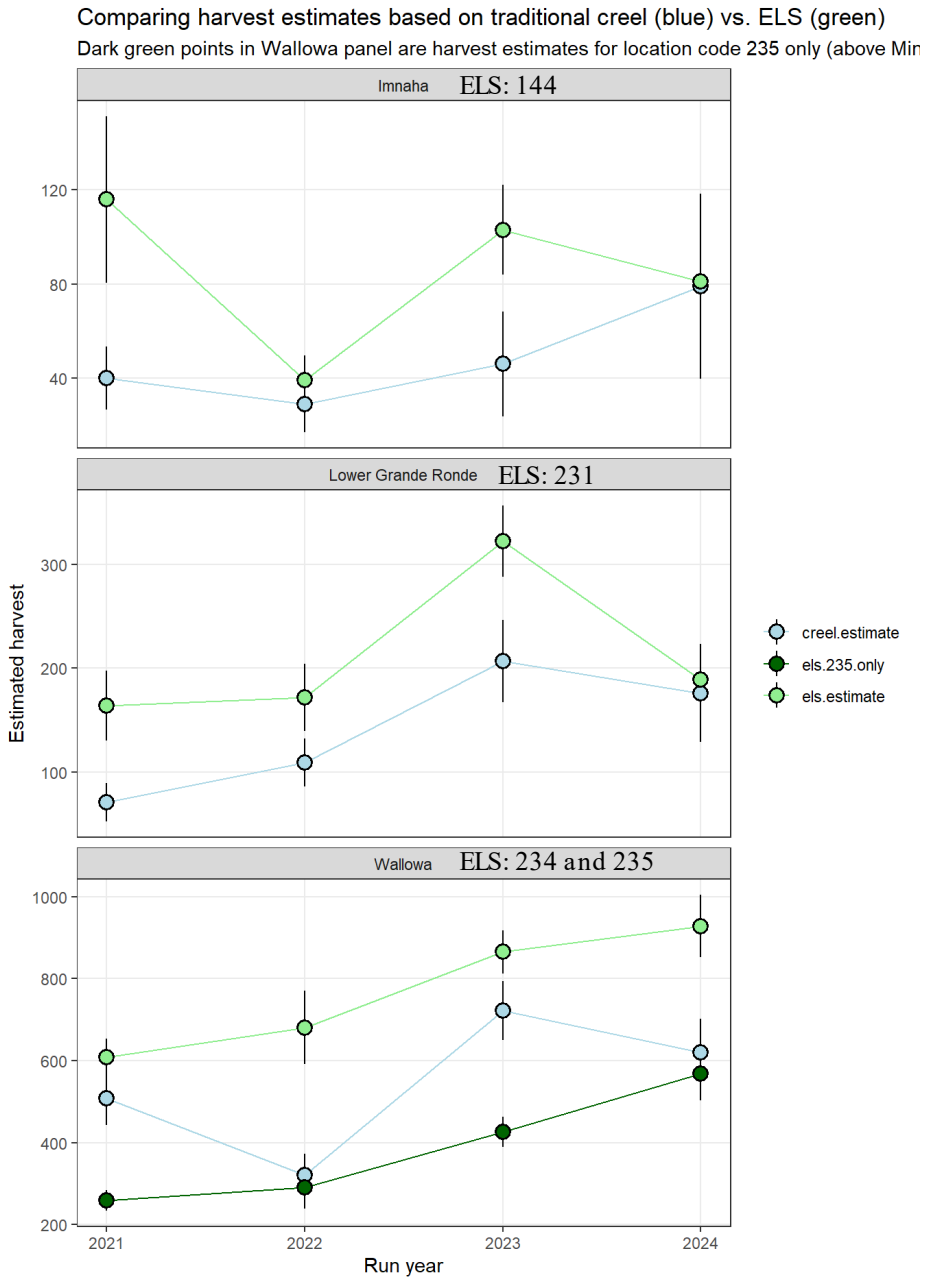
Current adjustments

- ✓ Expanded temporal ground creels on Wallowa & Imnaha.
- ✓ Standardized ground survey reach breaks with ELS codes.

Comparing ELS estimates with Traditional Creel

Result:
✓ Traditional creel underestimates harvest

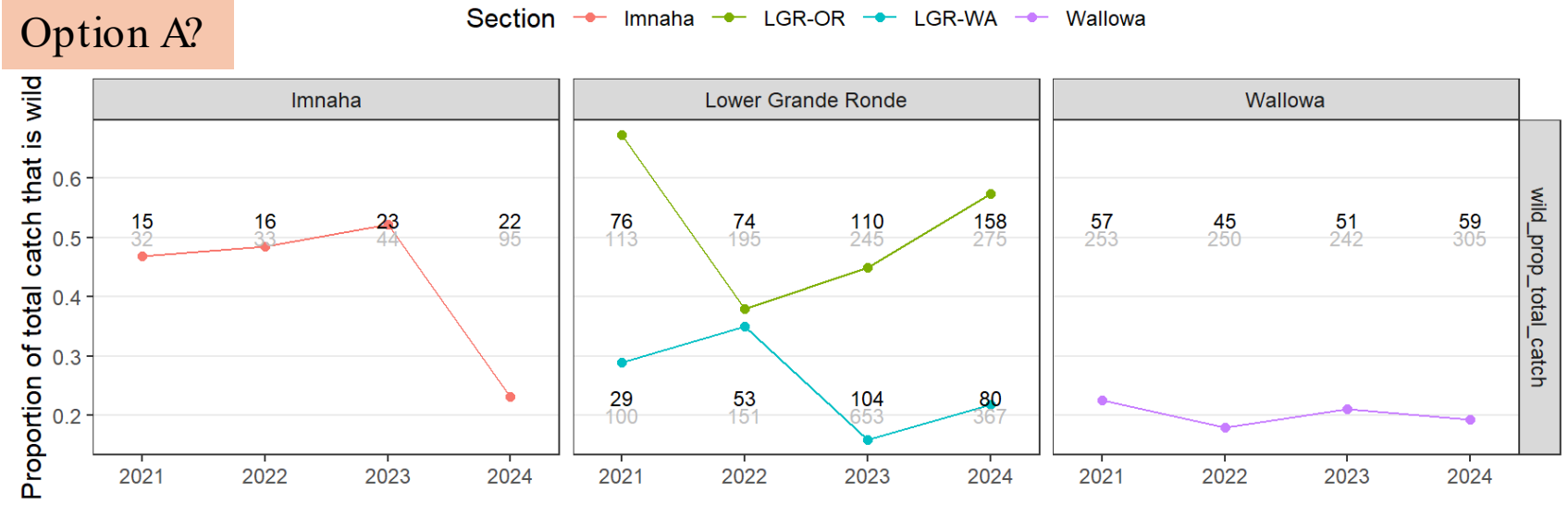




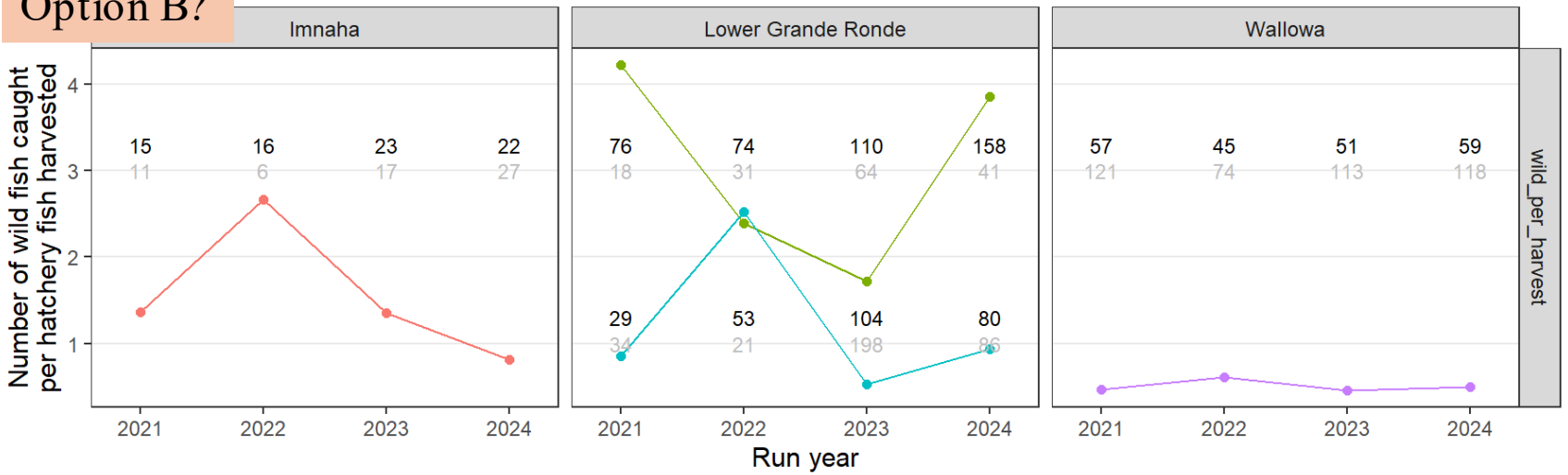
ELS limitations: Caution! The App does not record fish released.

- How do you estimate wild fish impacts using ELS data?
- Wild summer steelhead must be released unharmed by anglers!

Option A?



Option B?



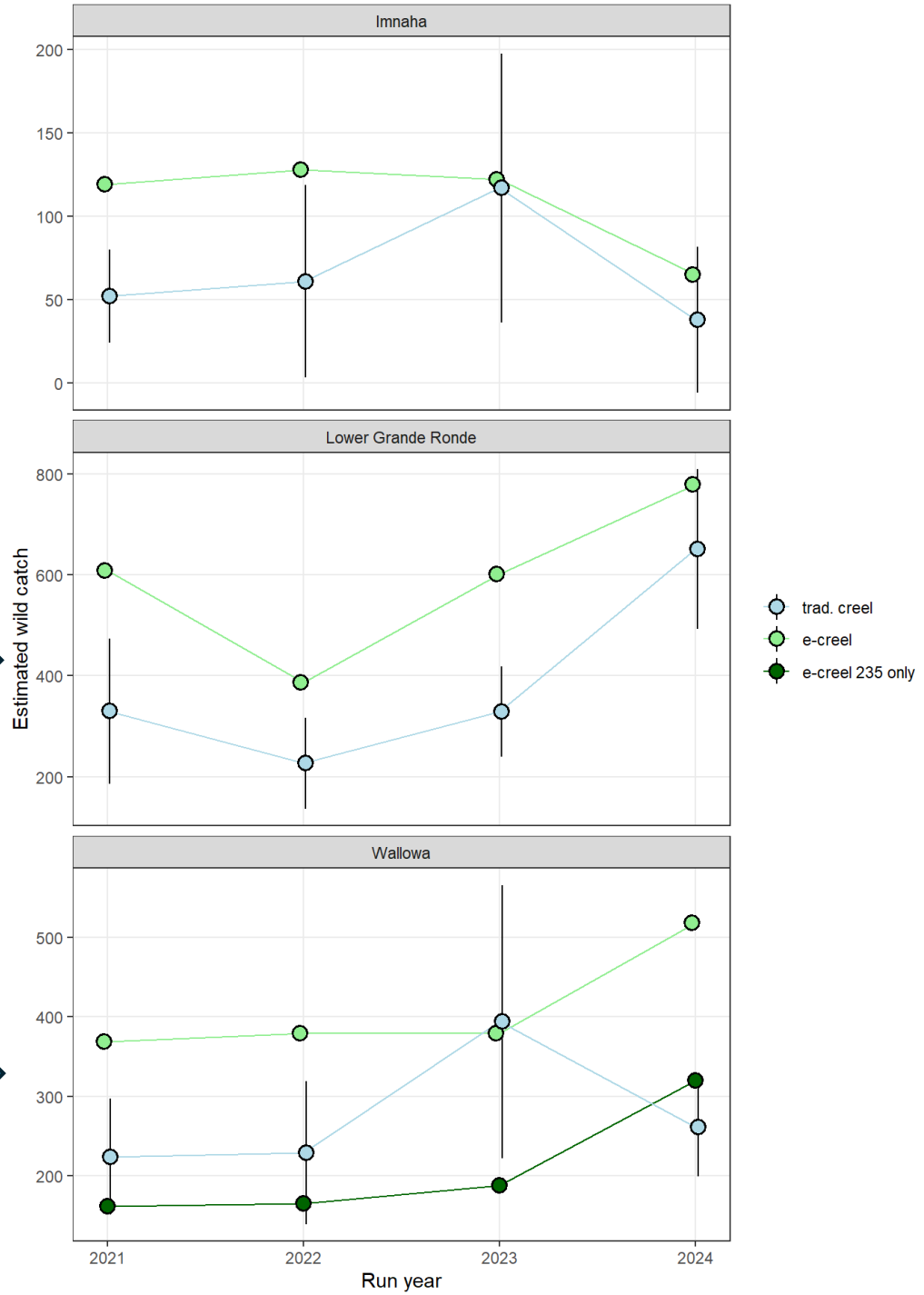
- Not all hatchery fish caught by anglers are harvested.
- More wild fish are caught (per harvested fish) in the LGR than in Wallowa.
- On the LGR, the WA section has more hatchery fish caught relative to wild fish caught, with the opposite pattern on the OR section (more wild fish caught relative to hatchery fish caught).
- More hatchery fish return to the Cottonwood Acclimation Facility (WDFW) just downstream of the state line.

Estimating wild fish impacts using a "hybrid" creel (ELS + creel surveys)

Year	Hatchery Harvest Estimate using e-creel	Wild Catch/ Harvest (talking to anglers)	Estimated Wild Catch
2021	144	4.2	608
2022	162	2.39	387
2023	350	1.72	602
2024	202	3.85	779

Hatchery Harvest X Wild Catch/Harvest = Estimated Wild Catch

2021	784	0.47	369
2022	623	0.61	379
2023	840	0.45	379
2024	1037	0.45	518



Leveraging e-creel to improve harvest estimates & allocate creel effort

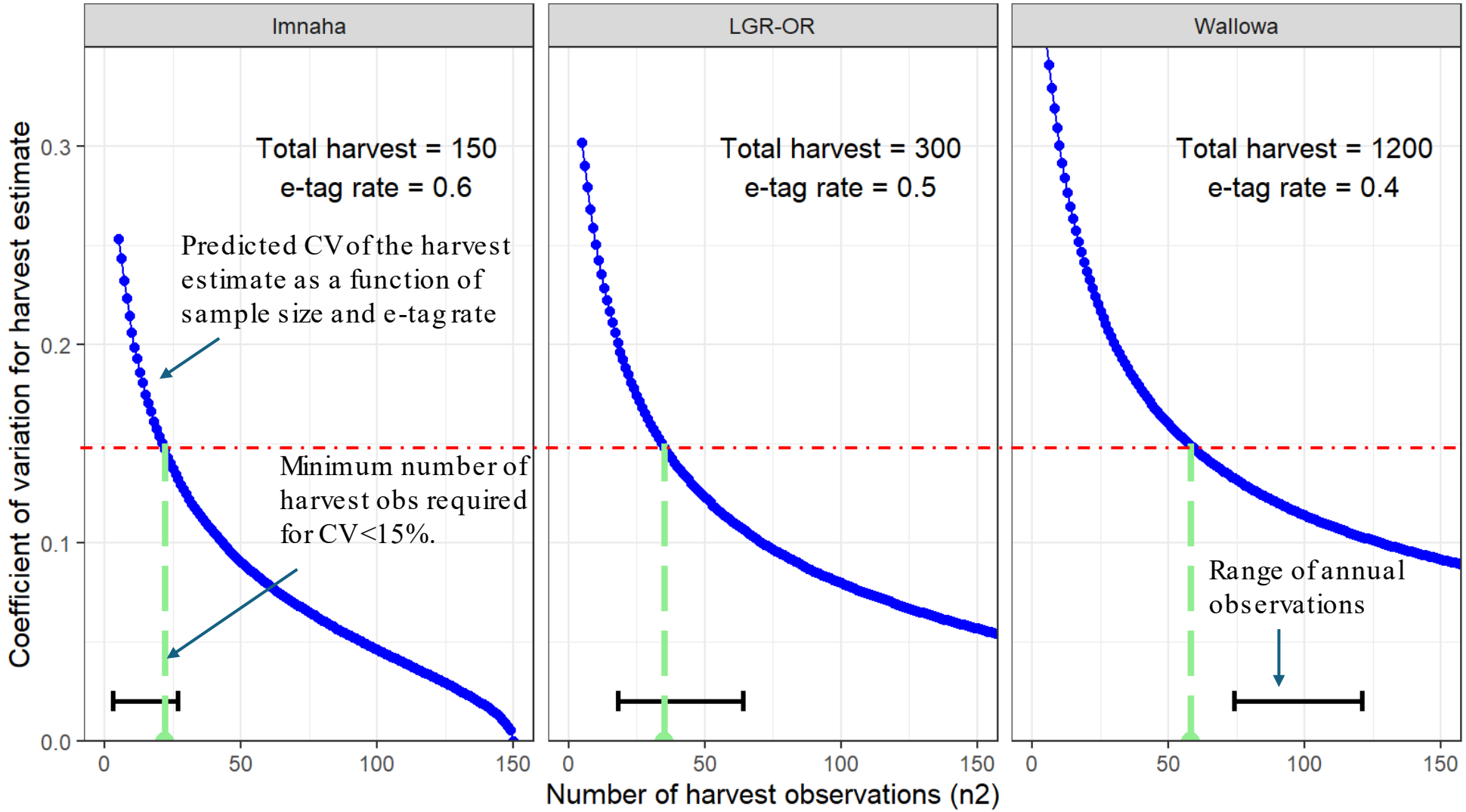
Chapman modification of the Petersen estimator

$$\hat{N} = \frac{(n_1+1)(n_2+1)}{(m+1)}$$

Variance Estimate

$$\hat{Var}(\hat{N}) = \frac{(n1+1)*(n2+1)*(n1-m)*(n2-m)}{(m+1)^2*(m+2)}$$

Rigger and Jones (2022) cite the Pacific Salmon Commission Chinook Technical Committee standard of a coefficient of variation (CV) <15% for nonbiased estimates.



Conclusions and Future Directions

Manager's summary

- Meeting broodstock and smolt release goals
- Consistent juvenile survival
- High site fidelity (low levels of straying)
- Harvest is occurring in the mitigation area
  - ✓ Steelhead fisheries occur every year in the Imnaha and Grande Ronde basins.
- Wild fish impact limits are < limits allowed in the Fisheries Management and Evaluation Plan.
- A return to angler caught broodstock.
  - ✓ fantastic outreach
  - ✓ AOP = 30% of total Wallowa stock may be from angler-caught broodstock.
  - ✓ Tracking = PBT based
- Creels are adapting to utilize ELS records

M&E Challenges

- Data management for long term datasets
  - ✓ Multiple file formats (Excel, Access, R)
  - ✓ Multiple internal data storage options: local servers vs cloud storage (e.g., one-drive)
  - ✓ Multiple websites for data repositories (PTAGIS, RMIS, FINS)
  - ✓ Staff turnover (e.g., retirements, new job opportunities).
- New methods (e.g., PBT vs CWT for SARs) = extra levels of data tracking
- Disseminating results in publications.

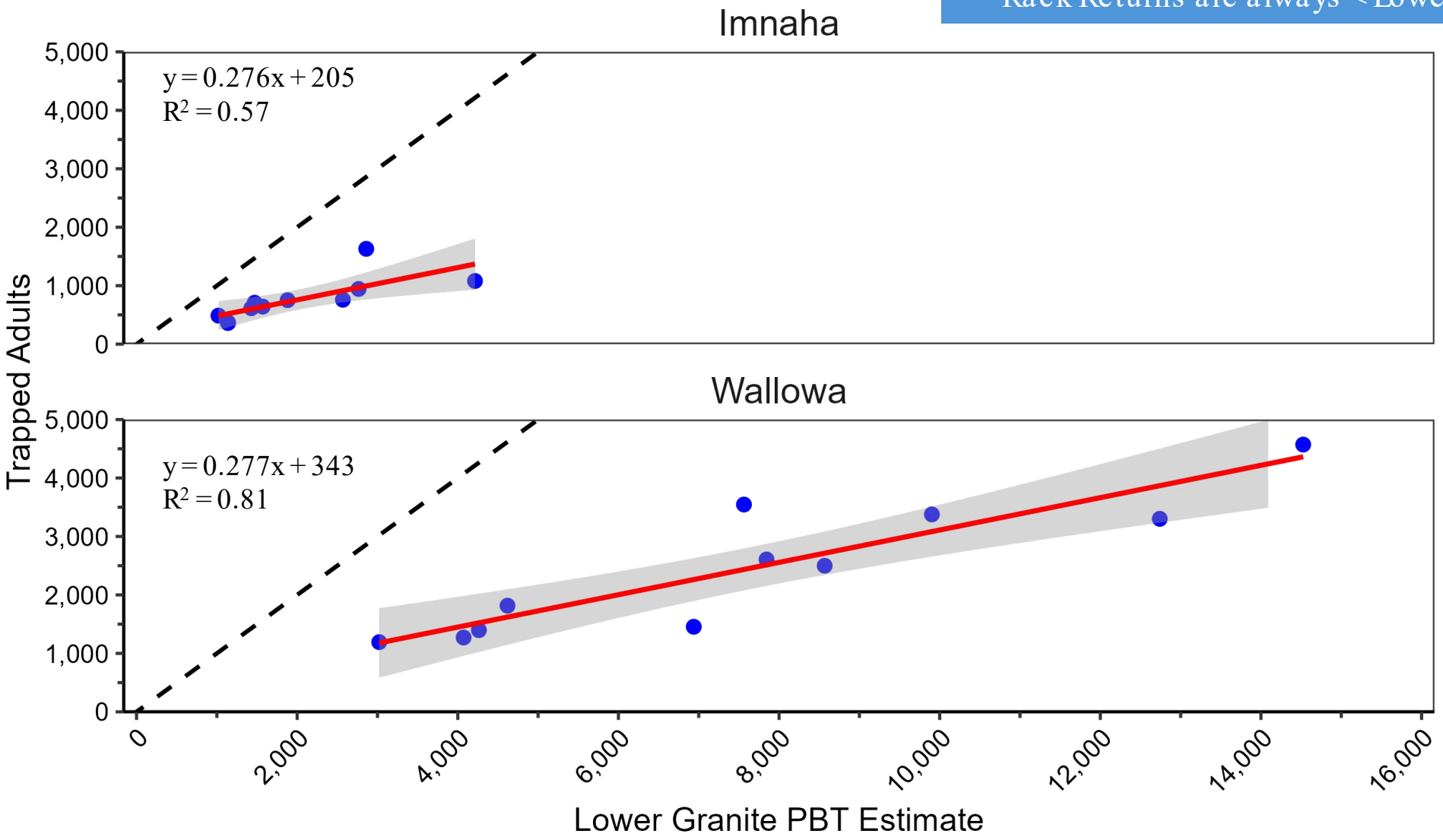
The End!

Spawn Years (2013-2023)

Lower Granite PBTestimates vs Rack Returns

Key Finding:

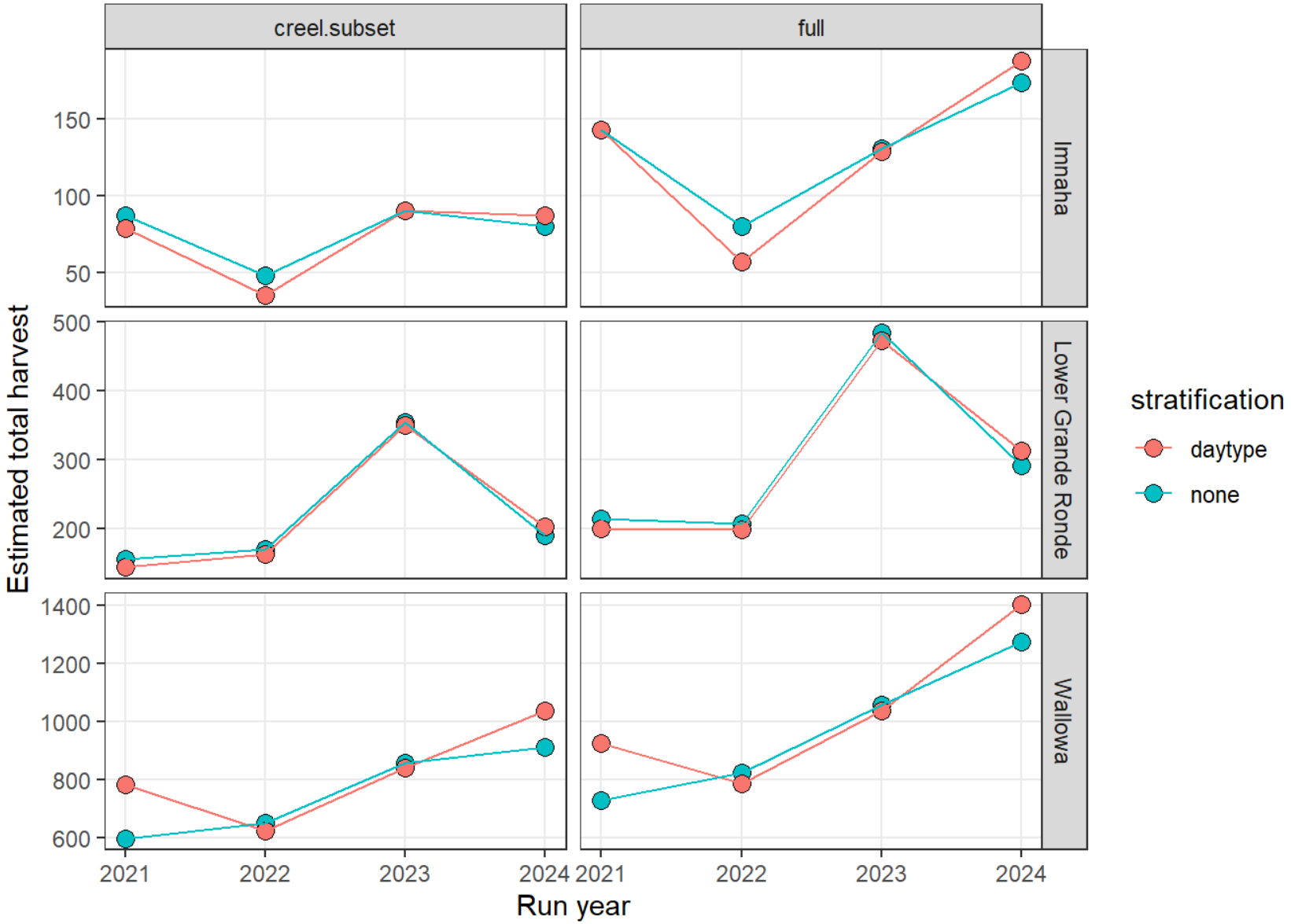
- Rack Returns are always < Lower Granite PBTestimates



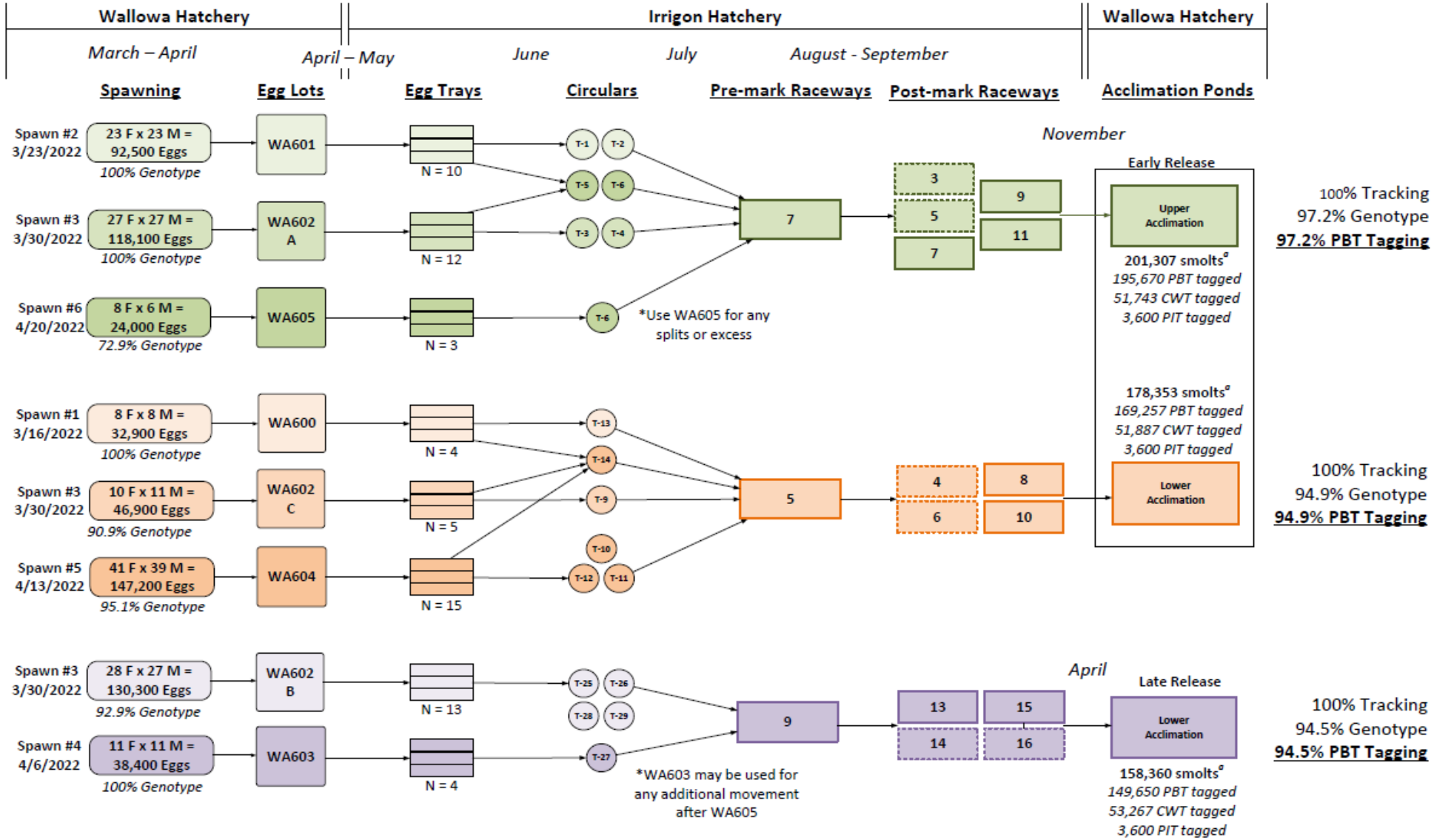
LGD TRAVEL DAYS

BY	Release Group	N	mean	sd	median	min	max
2020	Big Canyon	1916	25.28	18.05	22.38	3.56	93.53
2020	Wallowa-April	1850	16.13	11.98	11.12	4.39	83.51
2020	Wallowa-November	5173	22.93	14.38	18.44	4.90	81.39
2021	Big Canyon	3120	20.33	14.08	13.39	5.07	88.66
2021	Wallowa-April	1581	23.34	11.12	22.93	7.83	75.07
2021	Wallowa-November	3028	27.44	13.50	28.16	5.93	72.77
2022	Big Canyon	2256	23.61	14.82	23.07	3.79	98.12
2022	Wallowa-April	1579	14.29	11.10	9.17	4.22	77.08
2022	Wallowa-November	2789	24.62	10.41	22.27	9.16	76.89

Estimates stratified by daytype (weekday & weekend) vs no stratification



WALLOWA HATCHERY STEELHEAD PRODUCTION RELEASES
BROOD YEAR 2022



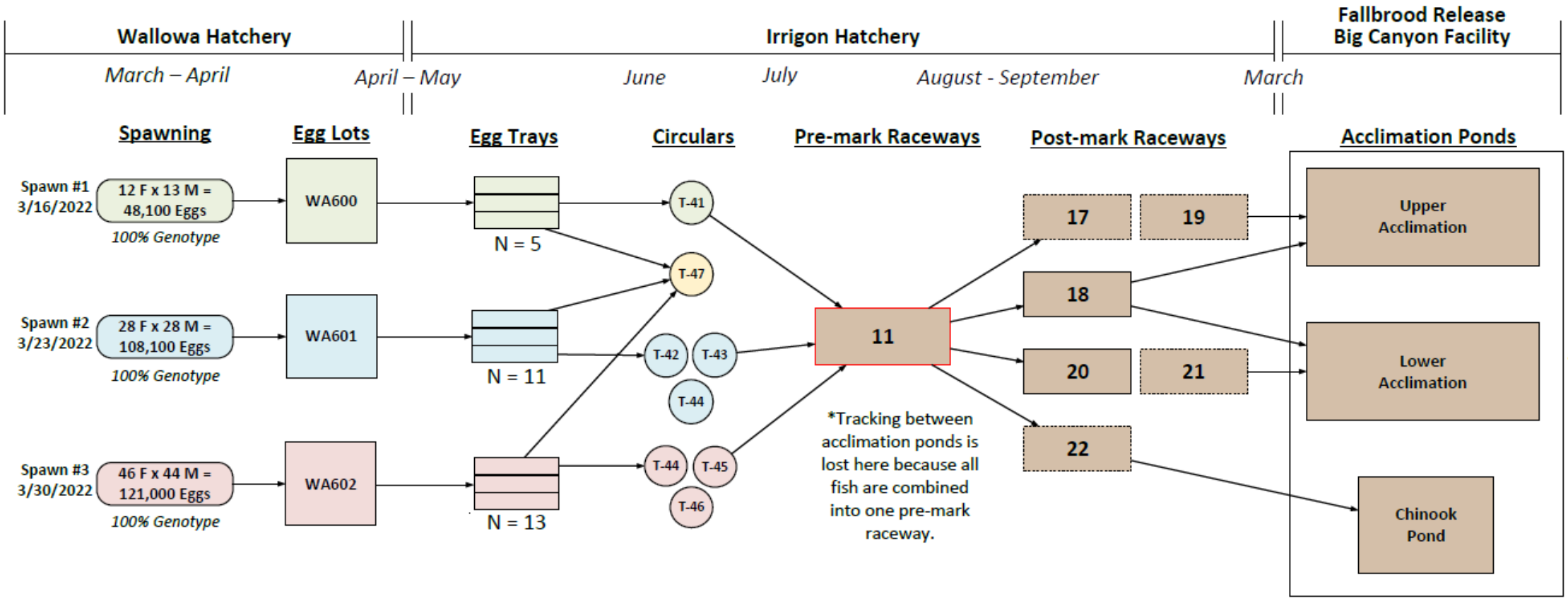
* Individual spawners are not tracked during spawning, meaning that genetic tracking can only be achieved by spawn event. Finer scale tracking would require some element of separation during spawning and in egg handling.

Estimated CWT = 29%

---------- Represents CWT (25,000) and PIT (1,800) tagged raceways.

° *Calculations do not take mortality or program excess into account, as final release numbers have yet to be determined.*

BIG CANYON FACILITY STEELHEAD FALLBROOD RELEASE
Brood Year 2022



100% Tracking
100% Genotype
100% PBT Tagging
**No PBT tagging between acclimation ponds*

245,632 smolts[a]
245,632 PBT tagged
104,403 CWT tagged
6,800 PIT tagged

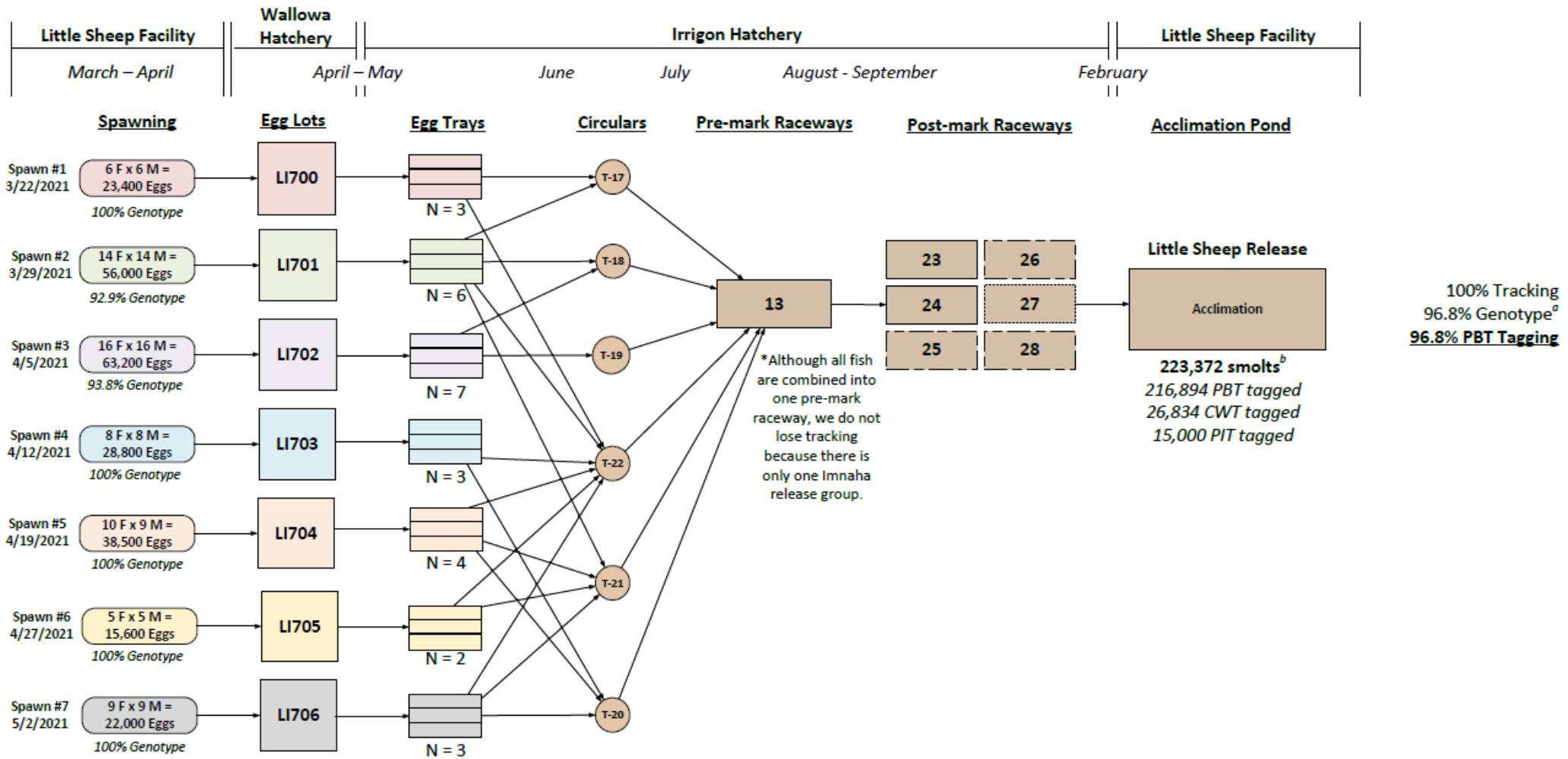
[a] *Calculations do not take mortality or program excess into account, as final release numbers have yet to be determined.*

* Individual spawners are not tracked during spawning, meaning that genetic tracking can only be achieved by spawn event. Finer scale tracking would require some element of separation during spawning and in egg handling.

Estimated CWT = 43%

Represents CWT (25,000) and PIT (1,700) tagged raceways.

IMNAHA STOCK LITTLE SHEEP STEELHEAD RELEASE
Brood Year 2022



* Individual spawners are not tracked during spawning, meaning that genetic tracking can only be achieved by spawn event. Finer scale tracking would require some element of separation during spawning and in egg handling.

Estimated CWT = 12%

..... Represents CWT (25,000) and PIT (3,800) tagged raceway.

— – — Represents PIT (3,700 – 3,800) tagged raceways.

[a] ((1*23,400)+(0.929*56,000)+(0.938*63,200)+(1*28,800)+(1*38,500)+(1*15,600)+(1*22,000) / 223,372

[b] *Calculations do not take mortality or program excess into account, as final release numbers have yet to be determined.*