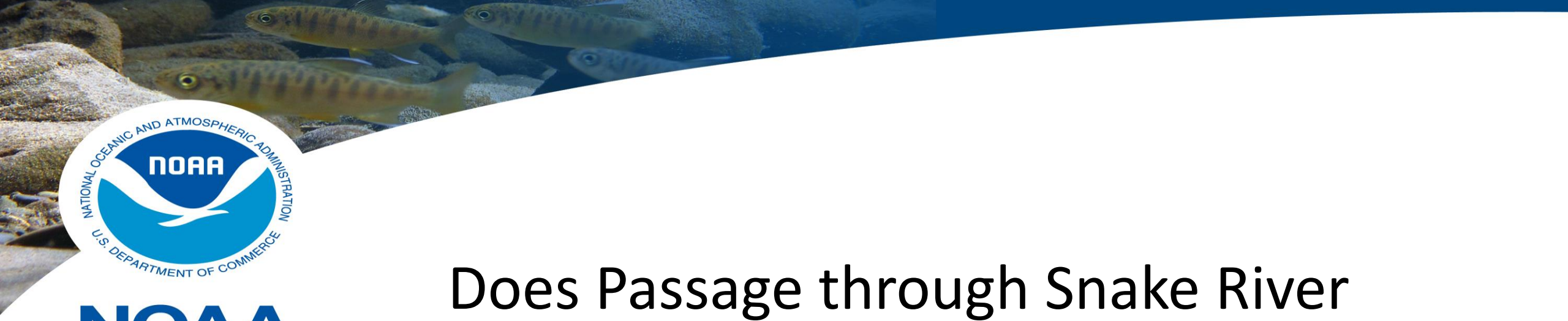

NOAA FISHERIES

- Northwest Fisheries Science Center

Does Passage through Snake River Dams Cause Latent Mortality?

Tiffani Marsh and Steven G. Smith

1 March 2021

What is “Latent Mortality”?

Mortality caused by passage through dams and reservoirs but not expressed until after hydrosystem passage is complete.


WASHINGTON
MONTANA
Chief Joseph
Columbia R.
Wells
Grand Coulee
Rocky Reach
Rock Island
Wanapum
Priest Rapids
Little Goose
Lower Monumental
Lower Granite
Clearwater R.
Dworshak
Snake River
Ice Harbor
Columbia River
McNary
Bonneville
The Dalles
John Day
Salmon R.
Hells Canyon
Oxbow
Brownlee
Snake River
IDAHO
OREGON
PACIFIC OCEAN
N
0
50
100 Km

Why might you think latent mortality is occurring?

1. Productivity differences between upriver and downriver stocks larger than explained by direct dam-passage mortality ("PATH" process).

2. Benefits of smolt transportation not as large as predicted from direct inriver survival.

3. Apparent "dose-response" relationship between smolt passage through bypass facilities and smolt-to-adult return rates.

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These are all circumstantial – how about an experiment?

Release Fish at Different Locations and Compare Survival

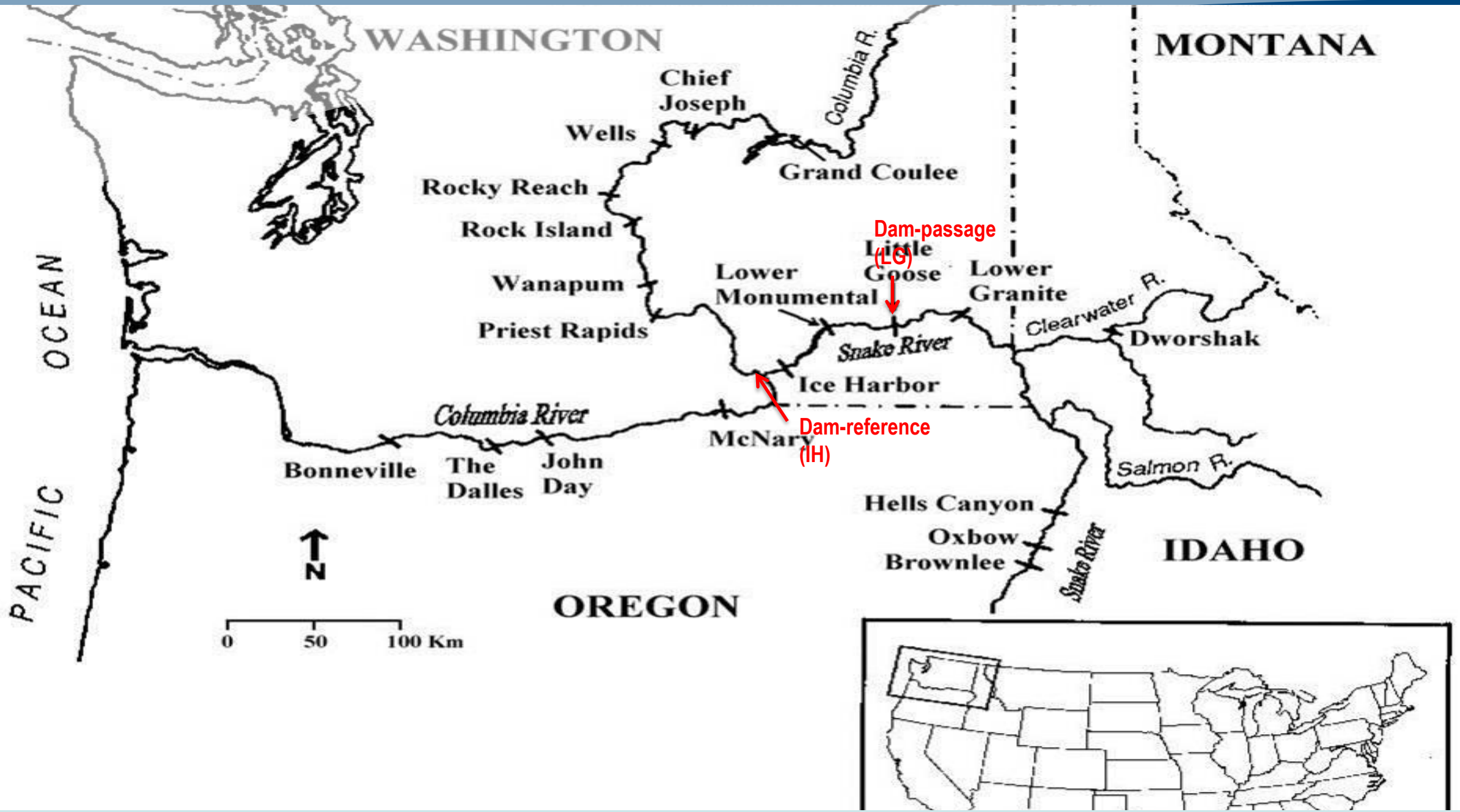
IH – “Dam-reference”: Tailrace of Ice Harbor Dam after truck transport

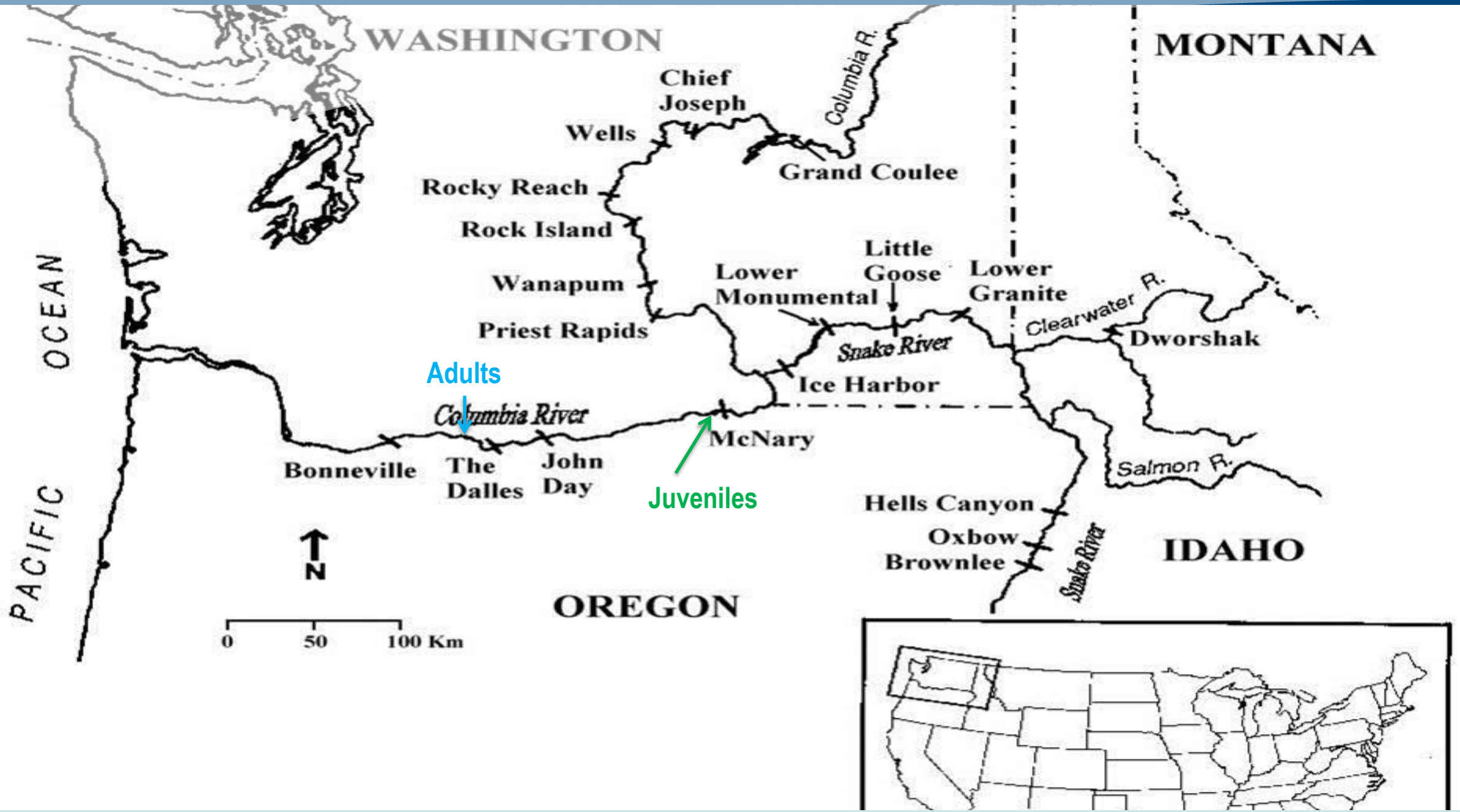
versus

LG – “Dam-passage”: Tailrace of Lower Granite Dam after equivalent truck transport

(Third site, not included today:
LN – “Truck-reference”: Tailrace of Lower Granite Dam without truck transport)

All collected and tagged at Lower Granite Dam.


WASHINGTON
MONTANA
Chief Joseph
Columbia R.
Wells
Grand Coulee
Rocky Reach
Rock Island
Dam-passage (LG)
Little Goose
Lower Monumental
Lower Granite
Wanapum
Priest Rapids
Clearwater R.
Dworshak
Snake River
Ice Harbor
Columbia River
Dam-reference (IH)
McNary
Bonneville
The Dalles
John Day
Salmon R.
Hells Canyon
Oxbow
Brownlee
Snake River
IDAHO
OREGON
PACIFIC OCEAN
N
0
50
100 Km


WASHINGTON
MONTANA
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Rock Island
Wanapum
Priest Rapids
Little Goose
Lower Monumental
Lower Granite
Clearwater R.
Dworshak
Snake River
Ice Harbor
Adults
Columbia River
McNary
Bonneville
The Dalles
John Day
Juveniles
Salmon R.
Hells Canyon
Oxbow
Brownlee
Snake River
IDAHO
OCEAN
PACIFIC
N
OREGON
0
50
100 Km

Latent Mortality

- $H_0: SAR_{LG} \geq SAR_{IH}$ vs. $H_A: SAR_{LG} < SAR_{IH}$

  (McNary-to-Bonneville SARs)

  - Rejection of Null Hypothesis Means:

    - There is evidence that ***after leaving McNary Dam*** survival was lower for dam-passage group (LG) than for dam-reference group (IH)

      LG group experienced passage at three of the four Lower Snake River dams after release

Study Design (2005-2011)

- Hatchery Spring/Summer Chinook Salmon
- Collect and Tag fish at Lower Granite Dam, 20-25 April – mid May
- Planned 10 replicates of (IH,LG,LN) within each year
  - Each replicates of 3 groups *released* same day
  - Expected to see within-season trend in SAR

Results

Annual Tagging Results

Study year	Replicates	Released			Total	
		Dam-reference	Dam-passage	Truck-reference	Goal	Released
2005	7	10,833	13,406	22,826	301,073	47,065
2006	10	38,468	56,939	94,024	301,073	189,431
2007	6	16,735	23,820	31,198	120,000	71,753
2008	10	28,790	42,386	50,542	120,000	121,718
2009	10	28,878	45,511	46,217	120,000	120,606
2010	10	29,001	45,487	47,825	120,000	122,313
2011	10	29,050	45,734	--	74,430	74,784
Total		181,755	273,283	292,632		747,670

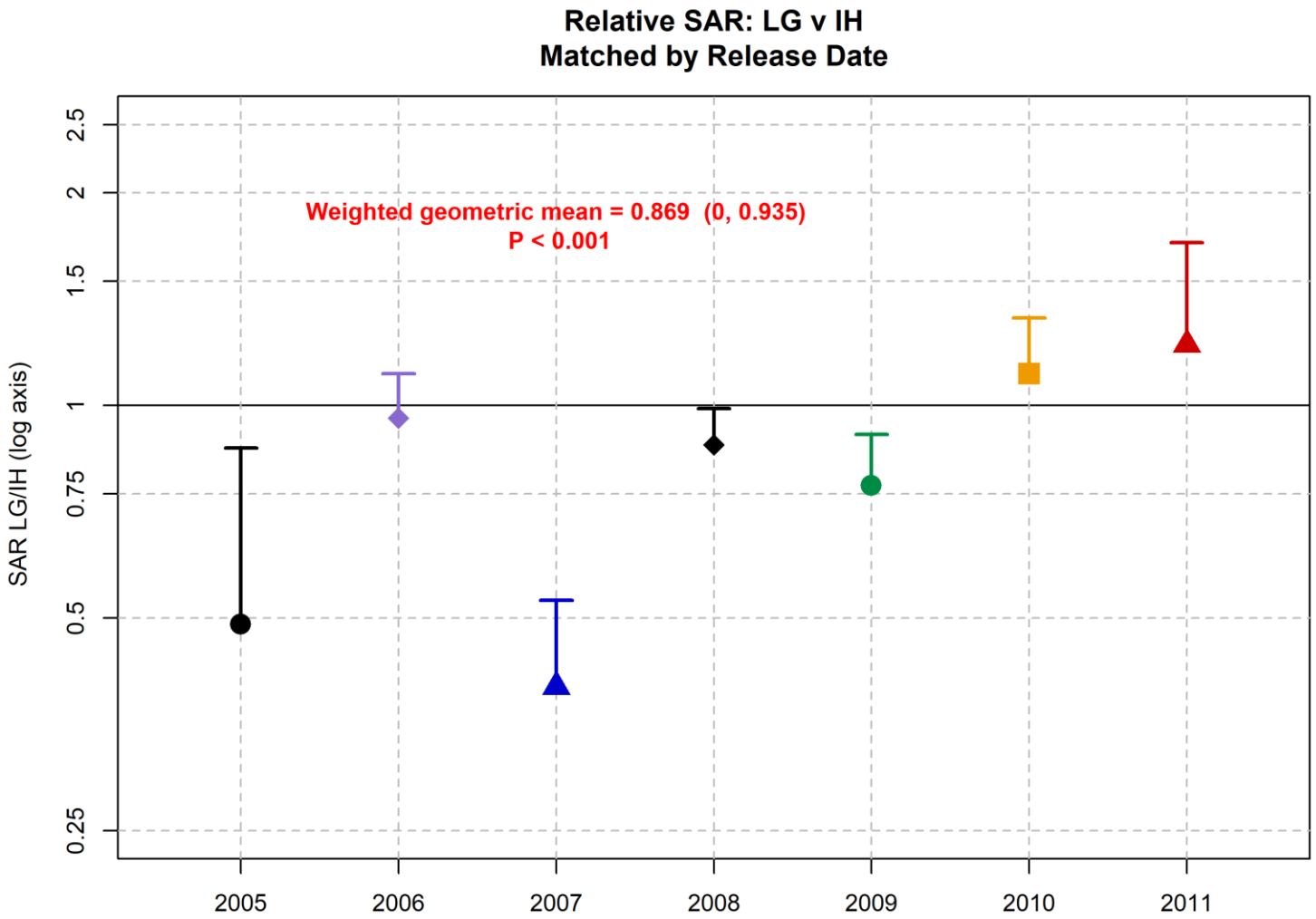
Bootstrap at Release Group level

	Trucked and Released in IH tailrace						Trucked and Released in LG tailrace				
Rep.	Rel.	Estimated MCN	Adults	SAR	CI		Rel.	Estimated MCN	Adults	SAR	CI
5	3,276	2,888 (2,758 - 3,032)	26	0.91	0.58-1.27		4,287	3,642 (3,431 - 3,886)	18	0.50	0.29-0.76
6	2,523	2,356 (2,223 - 2,500)	22	0.94	0.57-1.34		3,976	2,946 (2,790 - 3,132)	10	0.35	0.14-0.58
7	2,137	1,897 (1,777 - 2,036)	14	0.75	0.38-1.17		2,417	1,846 (1,686 - 2,017)	10	0.55	0.23-0.91
8	2,812	2,550 (2,417 - 2,699)	15	0.59	0.32-0.94		4,117	2,957 (2,788 - 3,134)	7	0.24	0.07-0.41
9	3,582	3,258 (3,080 - 3,465)	19	0.59	0.34-0.86		5,713	4,191 (4,010 - 4,393)	4	0.10	0.03-0.20
10	2,405	2,087 (1,966 - 2,224)	10	0.49	0.20-0.80		3,310	2,463 (2,305 - 2,649)	2	0.09	0.01-0.22
Total	16,735	15,036 (14,722-15,425)	106	0.71	0.57-0.84		23,820	18,045 (17,607-18,527)	51	0.28	0.21-0.36

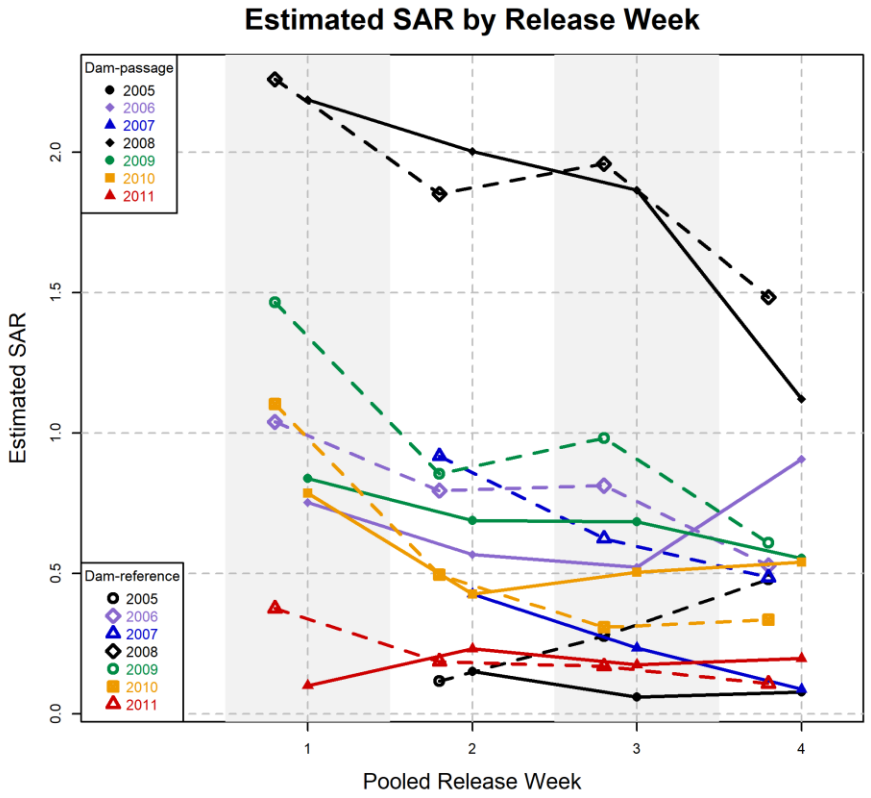
Relative SAR: 0.28/0.71 = 0.40 (0.00-0.53)

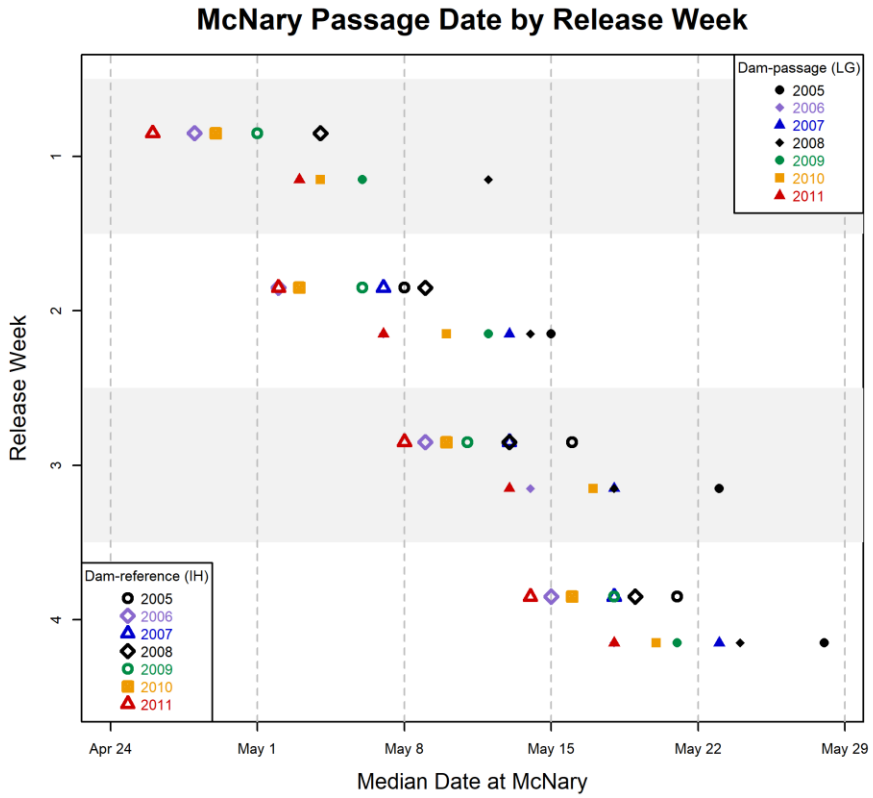
	Trucked and Released in IH tailrace						Trucked and Released in LG tailrace				
Rep.	Rel.	Detected MCN	Adults	SAR	CI		Rel.	Detected MCN	Adults	SAR	CI
5	3,276	1,081	9	0.85	0.38-1.46		4,287	1,063	5	0.49	0.11-0.96
6	2,523	768	8	1.06	0.41-1.88		3,976	1,029	2	0.21	0.03-0.51
7	2,137	701	3	0.45	0.05-0.99		2,417	595	1	0.20	0.06-0.54
8	2,812	912	7	0.78	0.24-1.42		4,117	1,117	1	0.11	0.03-0.29
9	3,582	1,060	7	0.68	0.21-1.21		5,713	1,537	1	0.08	0.02-0.21
10	2,405	789	3	0.40	0.04-0.91		3,310	922	0	0.04	0.00-0.33
Total	16,735	5,311	37	0.70	0.49-0.93		23,820	6,263	10	0.16	0.07-0.27

Relative SAR: 0.16/0.70 = 0.23 (0.00-0.41)


Relative SAR: LG v IH
Matched by Release Date
Weighted geometric mean = 0.869 (0, 0.935)
P < 0.001
SAR LG/IH (log axis)
2.5
2
1.5
1
0.75
0.5
0.25
2005
2006
2007
2008
2009
2010
2011

Temporal Trends within Year



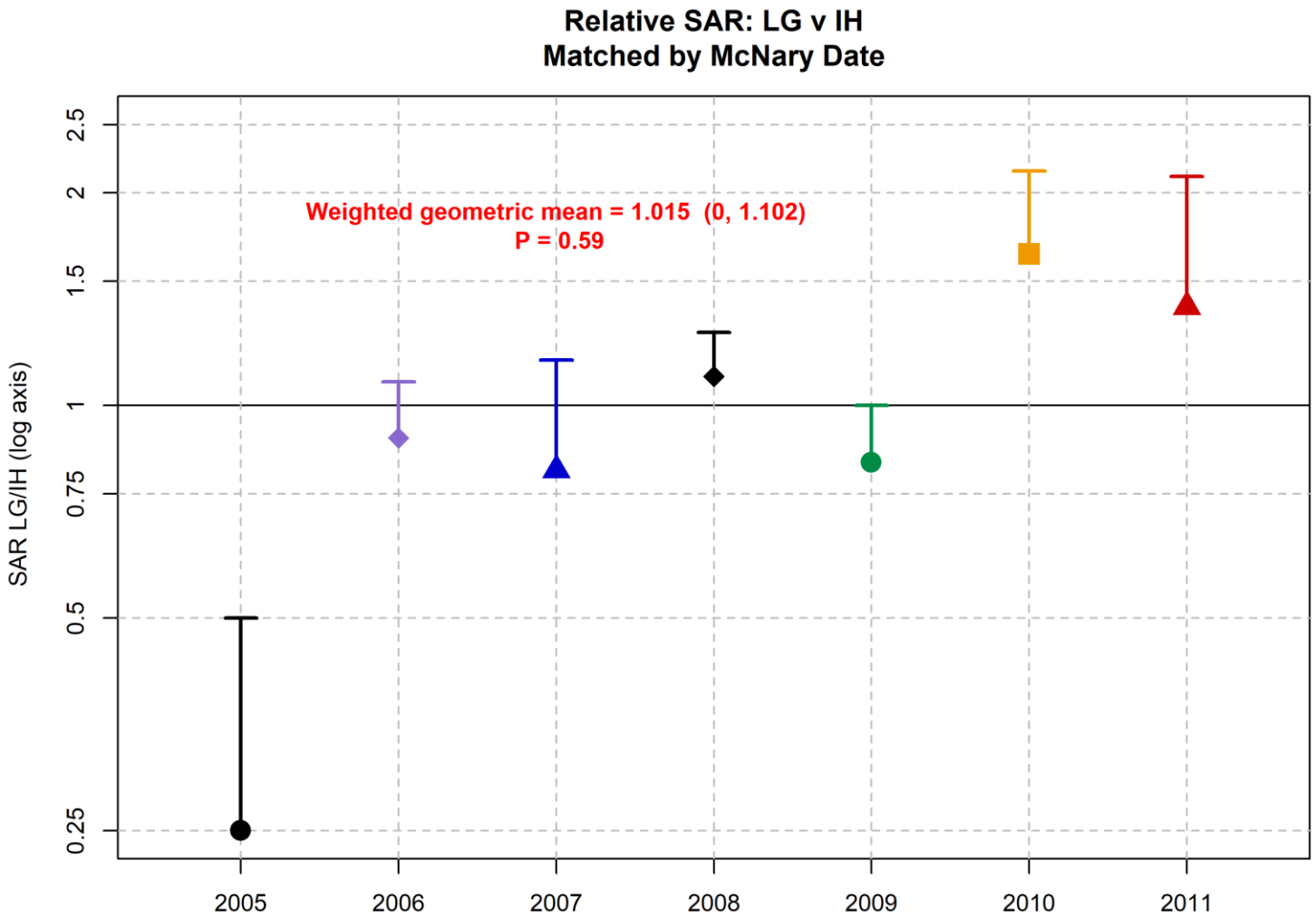


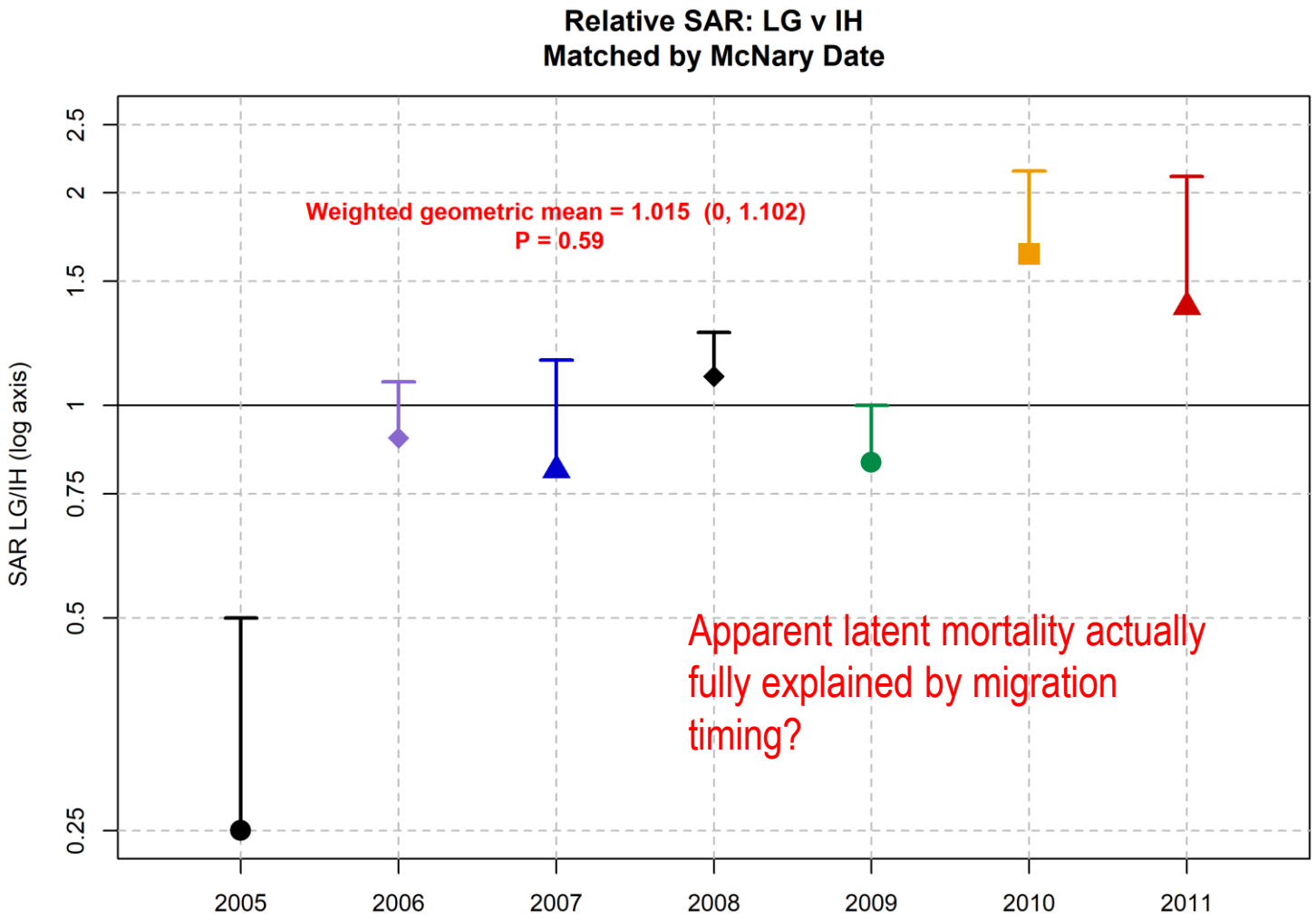
SAR generally decreases for later migrants as expected

In migration timing, dam-reference groups match better with dam-passage groups released 5-7 days earlier

Control for Migration Timing (date at McNary)

- Drop 3 latest dam-passage (LGR tailrace) and 3 earliest dam-reference (IHR tailrace) groups
  - McNary timing of resulting groups much more similar


Relative SAR: LG v IH
Matched by McNary Date
Weighted geometric mean = 1.015 (0, 1.102)
P = 0.59
SAR LG/IH (log axis)
0.25
0.5
0.75
1
1.5
2
2.5
2005
2006
2007
2008
2009
2010
2011


Relative SAR: LG v IH
Matched by McNary Date
SAR LG/IH (log axis)
0.25
0.5
0.75
1
1.5
2
2.5
Weighted geometric mean = 1.015 (0, 1.102)
P = 0.59
Apparent latent mortality actually fully explained by migration timing?
2005
2006
2007
2008
2009
2010
2011

Logistic Regression for Prob(return as adult)

- Use only individuals detected at McNary
  (McNary date known)

  - Candidate predictors for Adult return:
    - Release location (LG or IH)
    - Release date
    - McNary date
    - Length at time of tagging
    - Number of times detected at LGO, LMN, IHR

Logistic Regression

- Results
  - Significant variation among years
  - McNary date a better predictor than release date
  - Larger at tagging = more likely to return

Logistic Regression

- Results
  - Adjusting for McNary date and length:
    - Release location not significant overall
    - However, suggestion of dose-response based on number of times detected.

      (careful: length and #detections are correlated)

Conclusions

- Migration timing and smolt size are best predictors of adult return

- Evidence of a small amount of “latent mortality,” which might be associated with passage through juvenile bypass systems