Sonar Estimation of Adult Steelhead: Various Methods to Account for Kelts in Determining Total Escapement

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Background

Why Sonar?

- Can be used where adult weirs can't.
  - Larger streams and rivers.
  - Can operate in higher flows than weirs.
  - Sonar more cost effective than weirs over time.
  - Doesn't back up fish.
- Unimpeded fish passage through the sonar beams.
  - Better for looking at run timing and daily migration patterns.

- The basic equation for sonar (Salmon Model)
  - Net Escapement = Upstream - Downstream
    - Works very well for salmon (semelparous): Die after spawning
    - Not so well for steelhead (iteroparous): Can return to ocean after spawning.

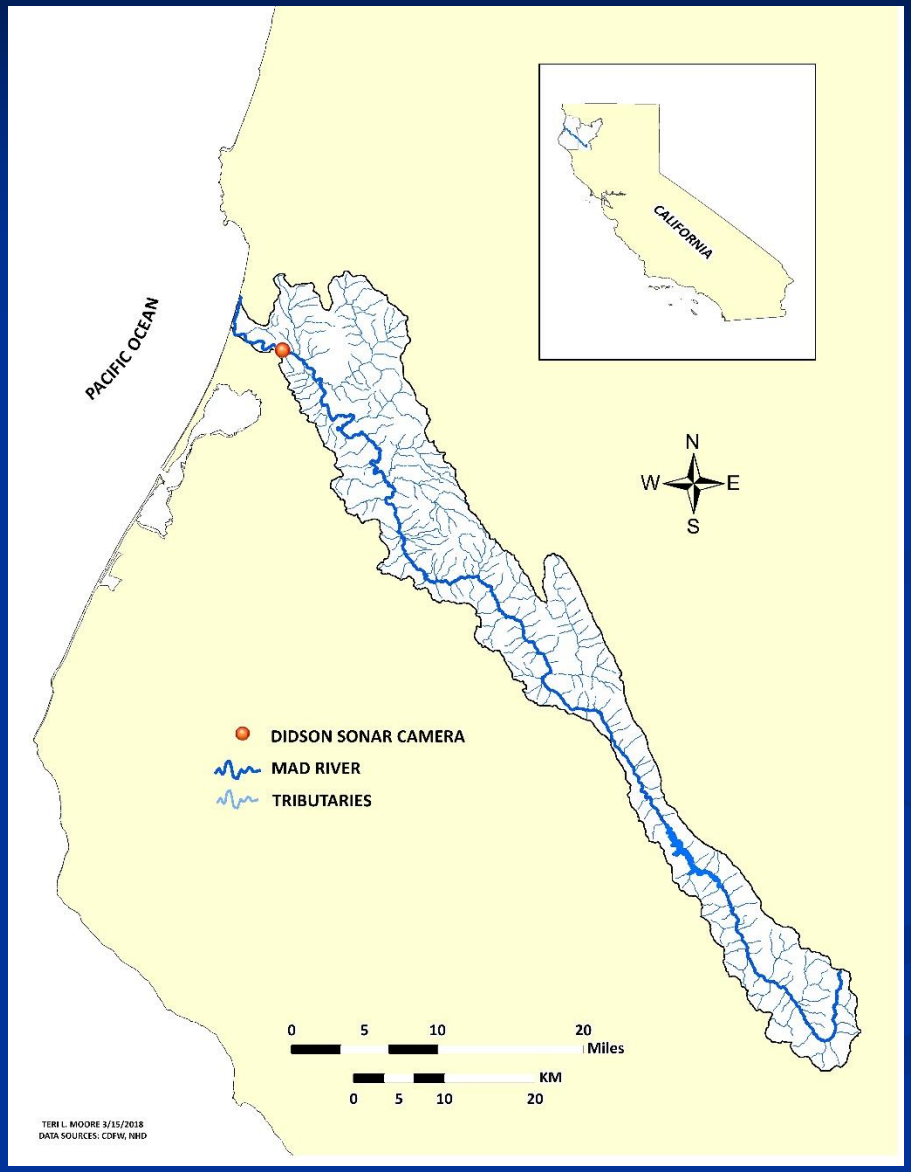
Steelhead Life History in Mad R

- Multiple Runs of Steelhead
  - Spring, summer, fall, winter
- Iteroparous
  - Degree depends upon many factors.
- Kelt Migrations
  - May vary over time due to different runs and time of adult spawning.

Focus

- Present methods which account for the downstream migration of kelts and milling fish.
  - Goal of consistency and repeatability.
- Compare methods with respect to total and monthly escapement.

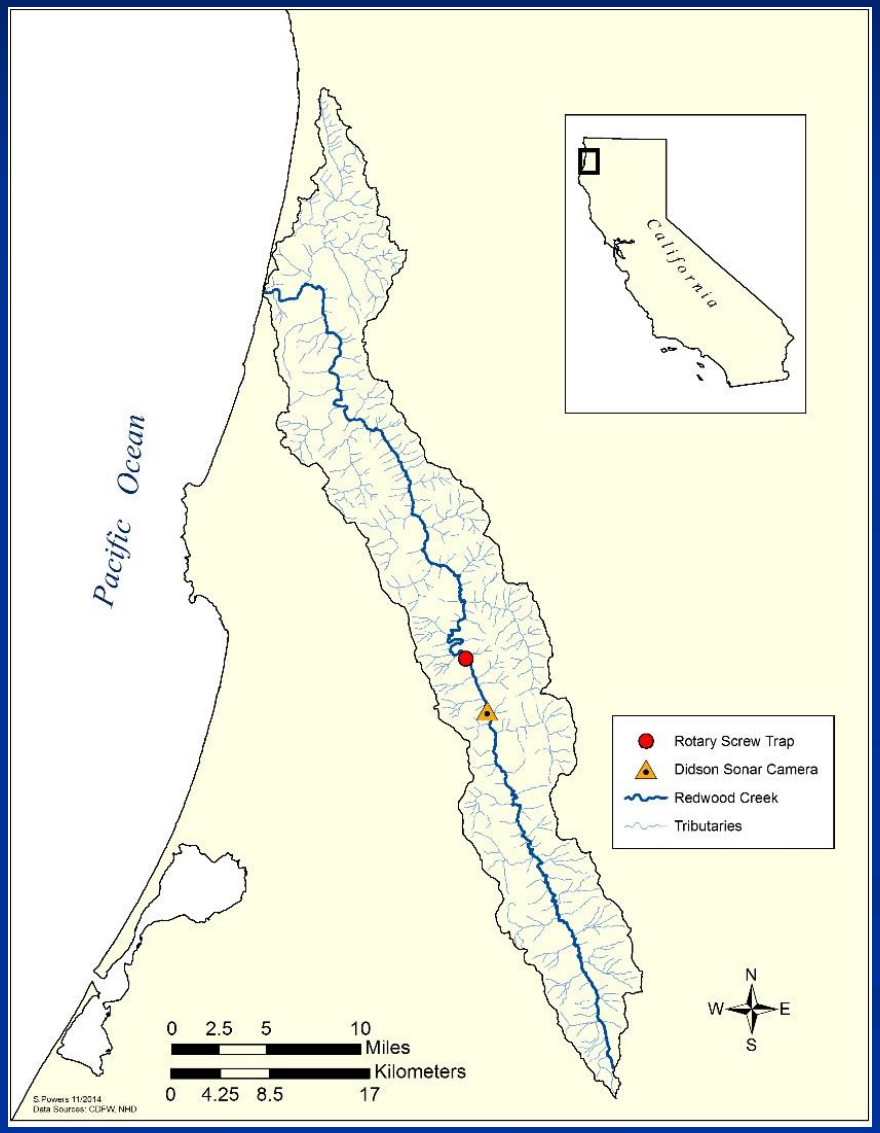
Site Description (Mad R)



Mad River

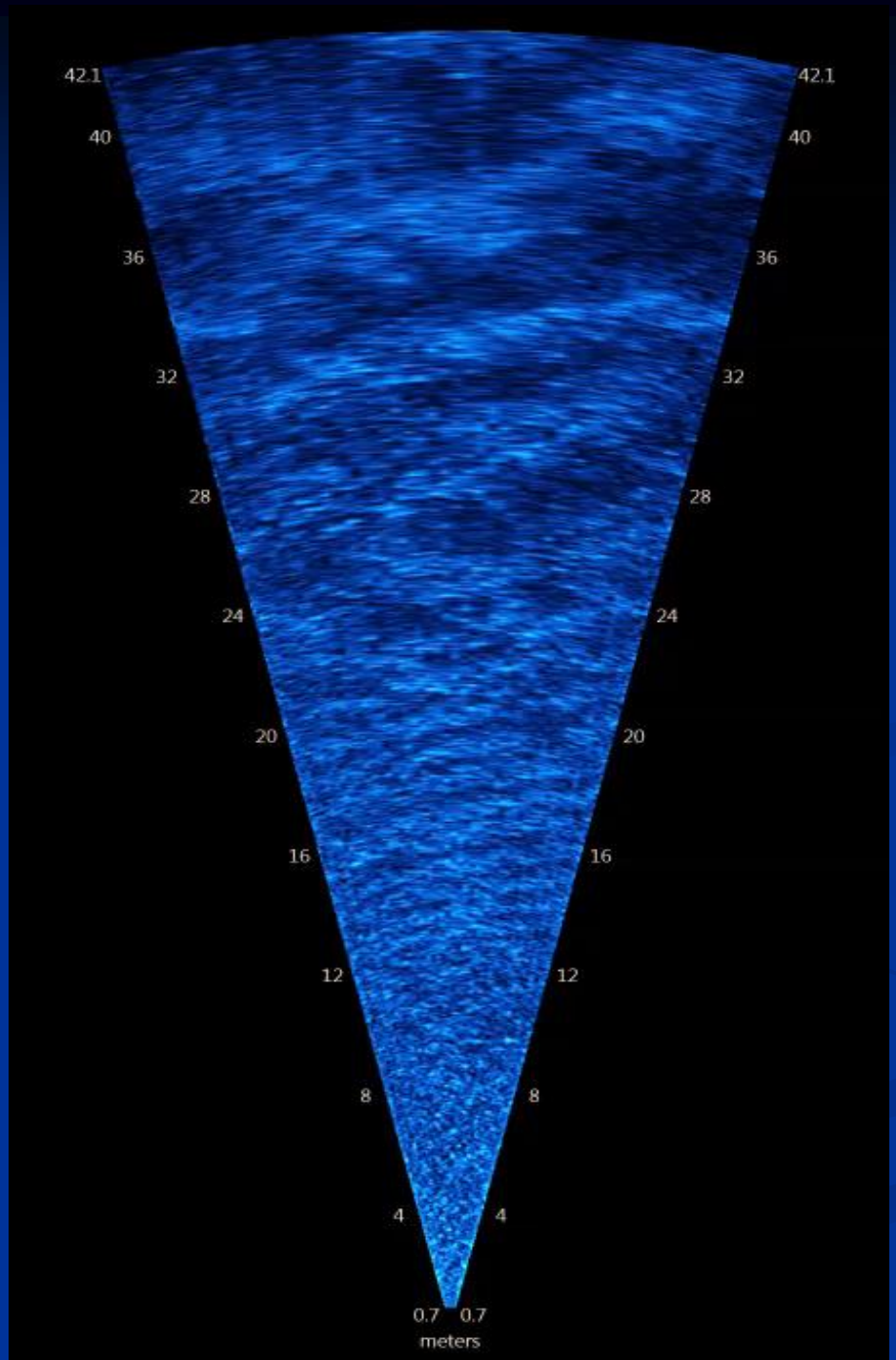
- Angler Creel Surveys (2000-2004)
- Angler Creel Surveys conducted near the Sonar (2013-present)
- Attempted to operate weirs.
- Radio Telemetry (2001-2003; 2018).
- Mad R Hatchery (1970 to present).

Redwood Creek



Crux of Problem

- Milling fish vs Downstream Migrating Kelts
- Milling Fish: unspawned adults
  - Need to be subtracted from counts of upstream moving fish.
- Kelts: spawned adults
  - Can't be subtracted from counts of upstream moving fish.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Daily Steelhead Movement Patterns in 2002 (Radio Telemetry)

	Average Percent of Time Detected		
Steelhead	Upstream	Downstream	Same Place
Wild	31	30	39
Hatchery	25	32	43

Sparkman, M.D. 2002. Habitat utilization and migration movement patterns of wild and hatchery radio tagged adult winter-run steelhead in the Mad River, Humboldt County, CA. CDFW AFRAMP, Project 1e2, Arcata, CA. 33 p.

Past Methods to Deal with Down-Runners

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ARTICLE

Estimating Escapement for a Low-Abundance Steelhead Population Using Dual-Frequency Identification Sonar (DIDSON)

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Abstract

Estimating the escapement of small populations of steelhead *Oncorhynchus mykiss* (ocean-migrating rainbow trout) is challenging and requires innovative methods. Difficulties arise from rare and episodic occurrence of individuals, high turbidity levels during migration, and the need to minimize jeopardy to the fish, which have led to a lack of population estimates, especially in California. Here we show that dual-frequency identification sonar (DIDSON) can be used to produce escapement estimates for a small steelhead population in Scott Creek, Santa Cruz County, California, with virtually no impact on the fish. The DIDSON uses sound to form near-video quality images and passively monitors fish without the need to handle them or constrict passage. We deployed a DIDSON and recorded steelhead passage over three spawning seasons (2008–2010). We used a decision support tool to analyze DIDSON images and compared the resulting estimates (153, 57, and 84) with raw weir counts (50, 23, and 40), mark–recapture estimates (293 ± 9, 126 ± 12, and 109 ± 34) generated over the entire migration period, and adjusted mark–recapture estimates (201, 74, and 85), which coincided with the period of DIDSON deployment. The DIDSON and weir estimates were restricted to a smaller sampling window due to the installation of downstream migrant traps causing increased incidences of milling fish that interfered with the DIDSON results late in the migration season. The DIDSON estimates were two to three times higher than weir estimates and 23% to 55% less than the full-season mark–recapture estimates. The adjusted mark–recapture estimates followed the same trends as the full-season mark–recapture estimates and were correlated with the DIDSON estimates. We conclude that DIDSON is an effective tool to generate steelhead escapement estimates, but it is important to collect data over the entire migration season and to consider fish behavior and potential species identification issues during analysis.

Monitoring the status and trends of threatened or endangered populations is important to assess the effectiveness of conservation and management strategies (NRC 1995). Recovery plans for Pacific salmonid species listed under the U.S. Endangered Species Act (ESA) focus on the specific goal of increasing abundance of migratory adults, also known as escapement (Boughton et al. 2007; Lindley et al. 2007; Spence et al. 2008; Williams et al. 2008). However, estimating escapement may be difficult due to the patchy distribution of individuals, unfavorable environmental conditions, and the need to not further jeopardize the individuals being monitored. The suitability of methods to determine escapement varies by condition and location, and no single method is best for all circumstances (Parsons and Skalski 2010), especially in California, which exhibits highly diverse landscape and stream conditions. Monitoring populations of steelhead *Oncorhynchus mykiss* (ocean-migrating rainbow trout) in California exemplifies this dilemma. Steelhead occur in varied locations throughout California, from the smallest coastal tributaries to the larger inland systems of the Central Valley. Despite the listing of coastal steelhead populations in California (Southern California Steelhead Distinct Population Segment [DPS], endangered; South-Central California Coast

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Past Methods

- Pipal et al. (2012): measure each fish multiple times, decision tree diagram for deciding whether downstream moving fish is a miller or a kelt.
  - For small populations (< 400 adults per 3 years).
  - Requires Census or CSOT (Convolved Samples Over Threshold) of all data files.

USE OF DUAL FREQUENCY IDENTIFICATION SONAR TO ESTIMATE SALMONID ESCAPEMENT TO REDWOOD CREEK, HUMBOLDT COUNTY CALIFORNIA

By

Matthew D. Metheny

A Thesis Presented to

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Committee Membership

Walter G. Duffy, Committee Chair

Margaret A. Wilzbach, Committee Member

Darren M. Ward, Committee Member

Rob Van Kirk, Natural Resources Graduate Coordinator

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Past Methods

- Metheny (2012): used a salmon model with a simplified "Kelt Adjustment"
- Find point in time where % downstream movements exceed % upstream movements.
  - From that point onward, no subtraction of down-runners.
    - Assumes all down-runners are kelts.
- When you have lots of steelhead return in March, will over-estimate that portion of the run.

USE OF DUAL FREQUENCY IDENTIFICATION SONAR TO MONITOR STEELHEAD ESCAPEMENT IN THE SMITH RIVER, CALIFORNIA, 2012-2013

Prepared for the County of Del Norte by,

Zachary S. Larson

JUNE 2013

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Past Methods

- Larson (2013):
  - N = summation of all upstream movements.
    - Did not subtract any down-runners.
  - Assumes all down-runners are kelts.
  - If assumption is not met, then can double count fish as move back upstream.
  - Positive bias to estimate.

Best Method

- Periodically sample (capture) the down-runners and express kelts as a proportion, apply to total downstream counts each day.
  - Much like species apportionment for net escapement.

- Streams we work in are too large to capture down-runners.
- Costly to sample.

New Proposed Methods

- Salmon Model with Specific Kelt Adjustments
  - Perhaps better when sonar is lower in basin.
  - General knowledge of Steelhead life history in a given watershed is required.
    - How many runs of steelhead there are (fall, winter, spring, summer).
    - General timing of kelt migrations.

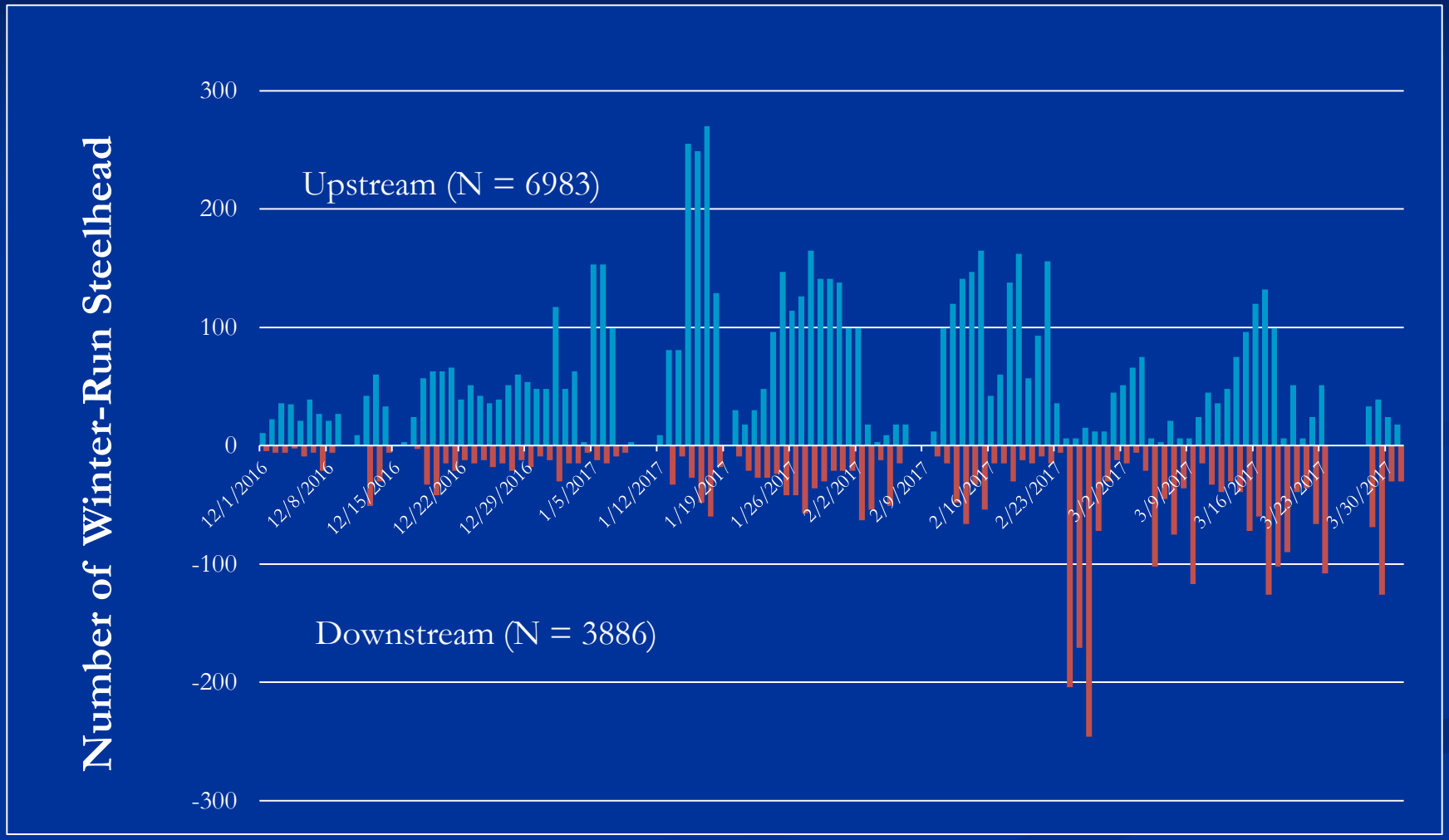
New Proposed Method

- Midpoint Index of Abundance (M.I.A)
  - When sonar is located in middle of basin.
  - When on any given day a down-runner could be a milling fish or a kelt.
  - When difficult to determine an average milling rate.

Minimize Milling!

- Sonar Site Selection
  - Lower in watershed.
  - Upstream of tidally influenced areas.
  - Stay away from confluence areas and pools.
  - Place upstream of riffles / rapids that are downstream of runs or glides.

Mad R Steelhead Movements (2016/17)

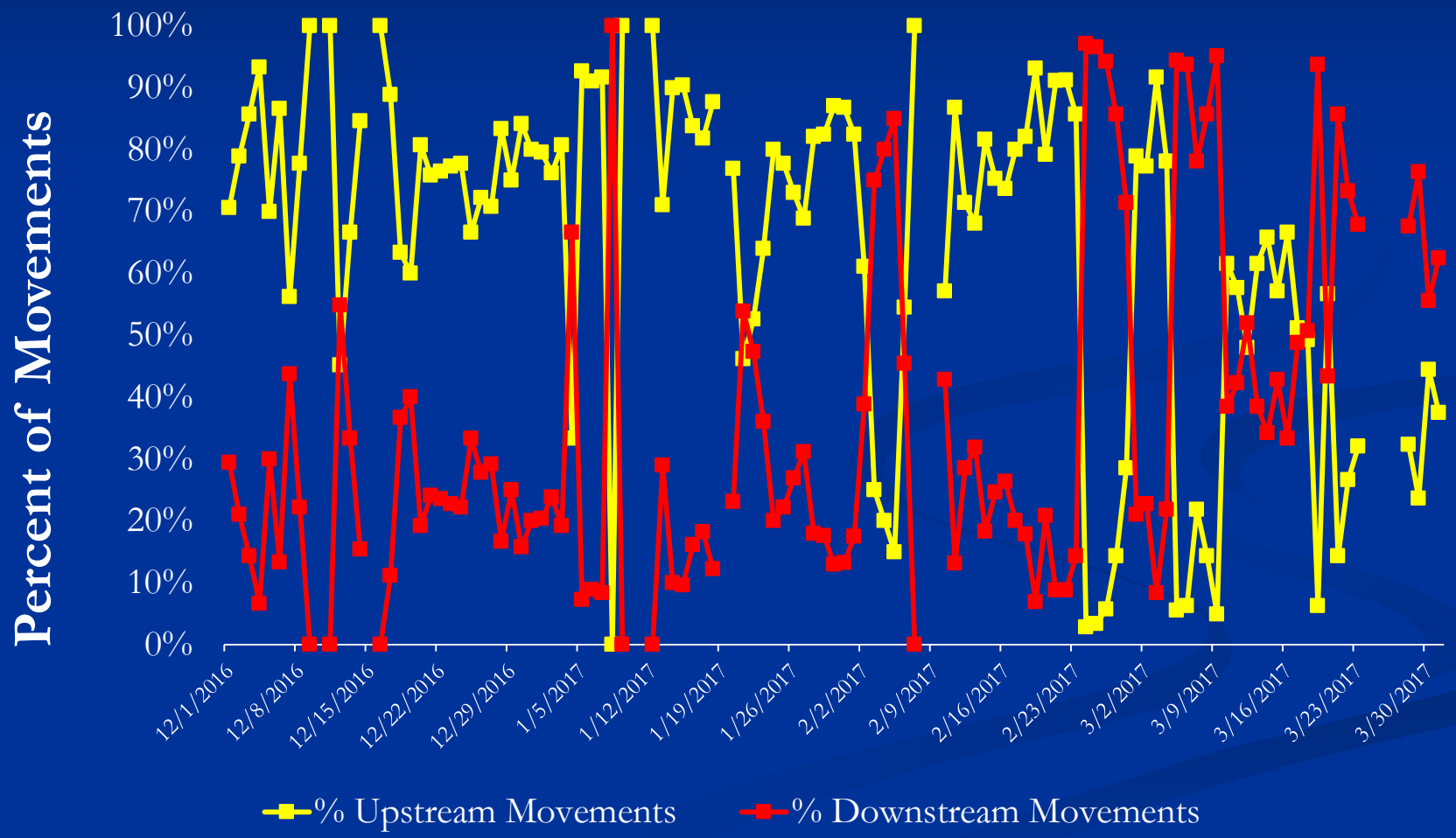


Mad R 2016/17 Net Passage (Salmon Model, Subtracts Downstream Fish)

Salmon Model By Month (2016/17 data)

Month	Number of Steelhead
December	721
January	2247
February	462
March	- 333
Total:	**3097**

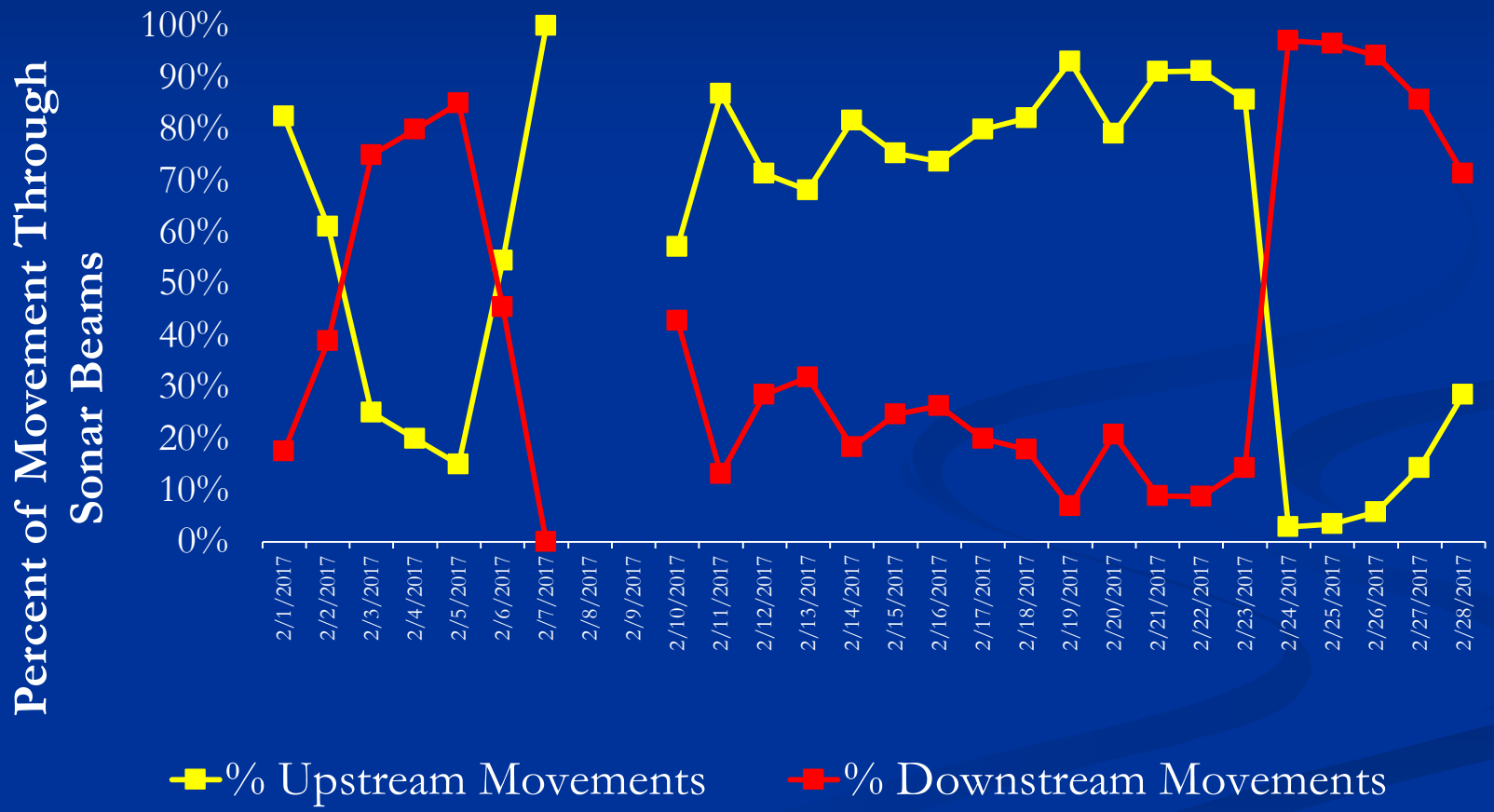
Daily Steelhead Movements (through sonar beams)



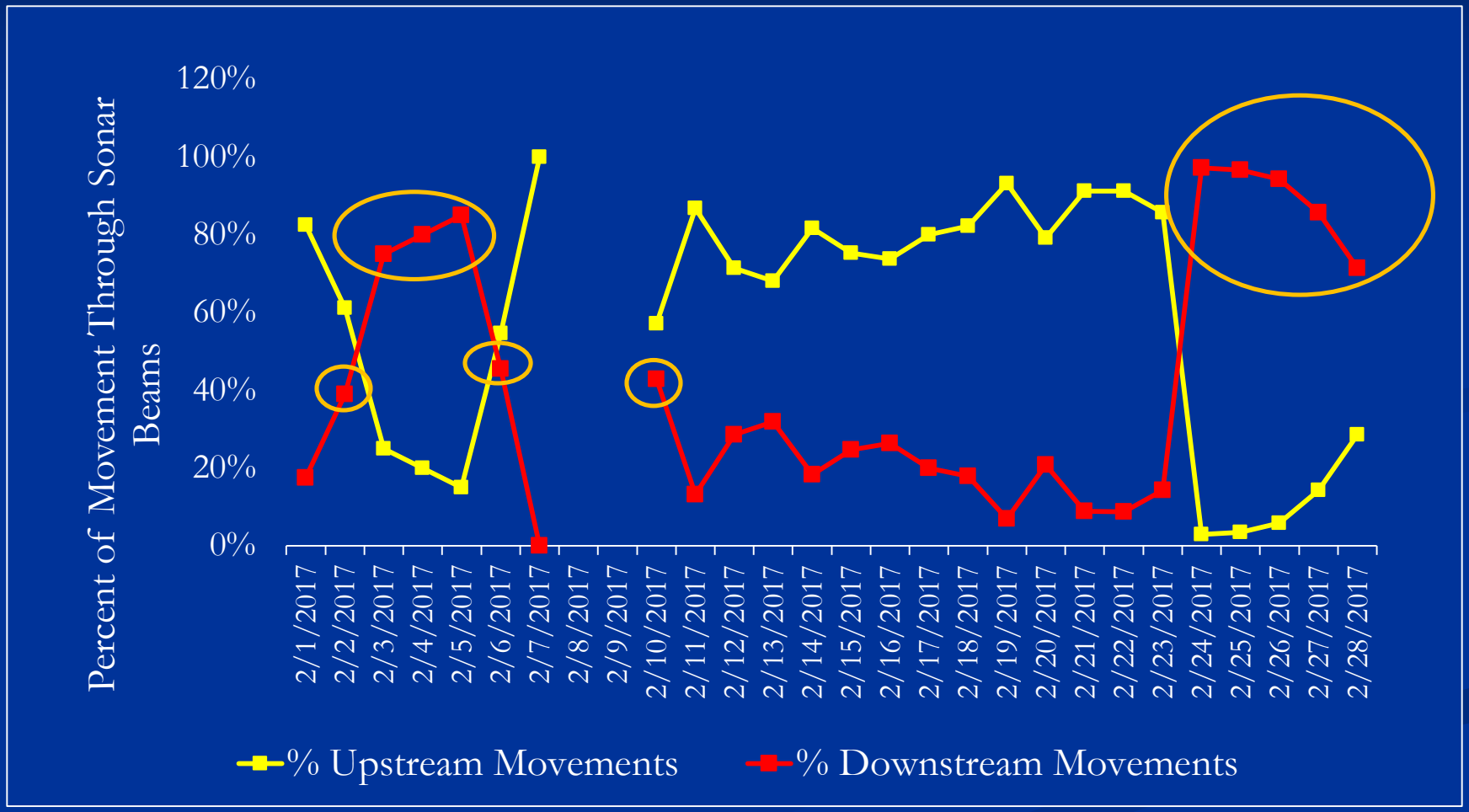
Salmon Method with Selective Kelt Adjustments

- Determine “normal” downstream movement percentages by month, based upon days.
  - Generate an average
- Adjust high daily downstream percentages to this average by pulling down-runners out.
- Difference in fish numbers with and w/o adjustments will equal estimate of kelts.

What is Normal?



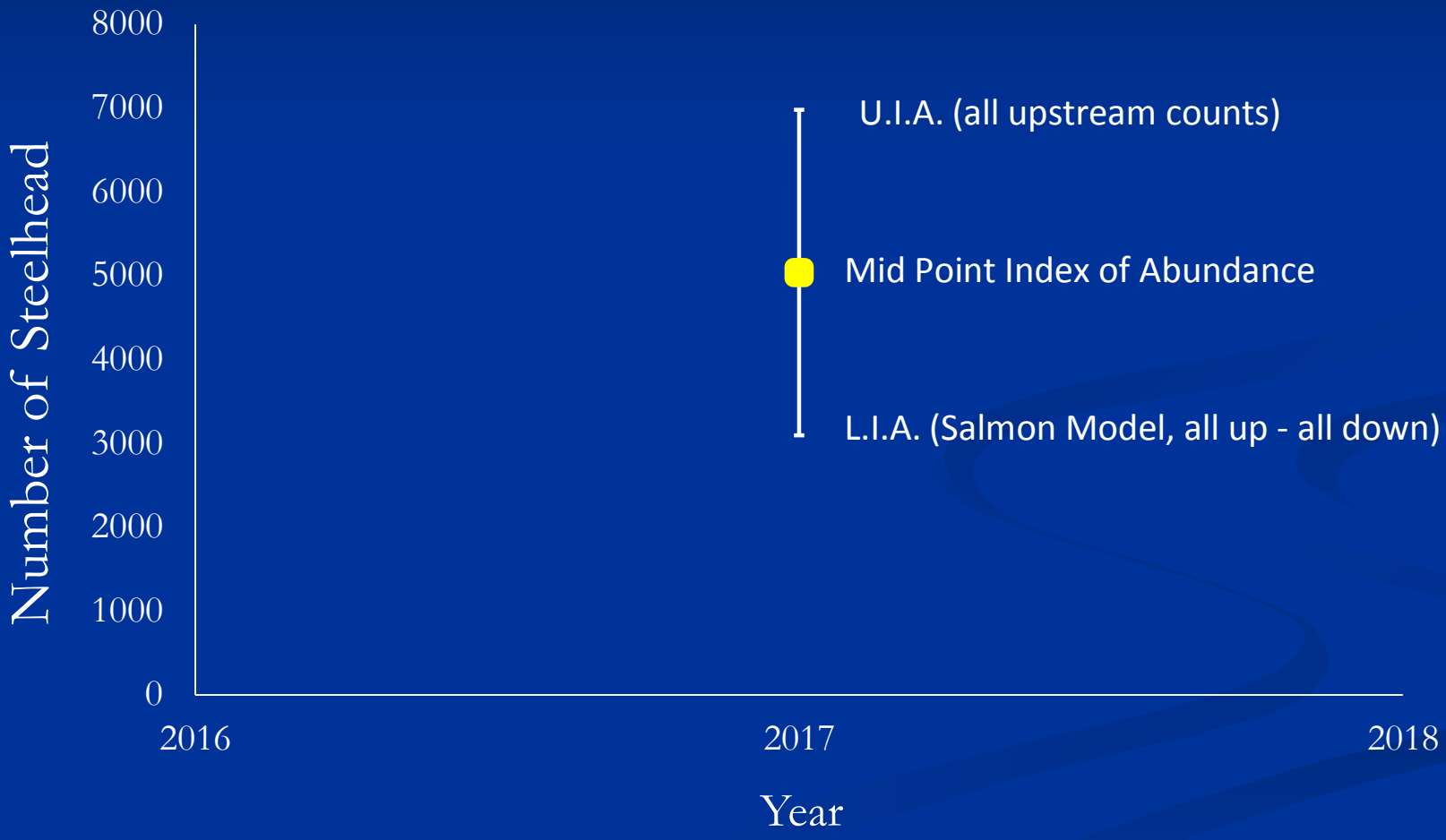
Specific Kelt Adjustments



Midpoint Index of Abundance (M.I.A.)

- Upper Index of Abundance (U.I.A)
  - Equals summation of all upstream counts.
  - Abundance estimate can be no greater than this value.
- Lower Index of Abundance (L.I.A)
  - The Salmon Method (U – D).
  - Abundance estimate can be no lower than this estimate.

Midpoint Index of Abundance (M.I.A.)



M.I.A.

- Accounts for the fact that some of the down-runners will be milling fish, and some will be kelts on any given day.

COMPARISONS (2016/17 DATA)

Model	Estimated Abundance	Bias Relative to Salmon Model with Specific Kelt Adj.
Salmon (U-D)	3,097	- 46%
Salmon (Upstream only)	6,983	+ 25%
Salmon with Simple Kelt Adj.	5,359	- 4%
Mid-point of Abundance Index	5,040	- 10%
Salmon with Specific Kelt Adj.	5,589	

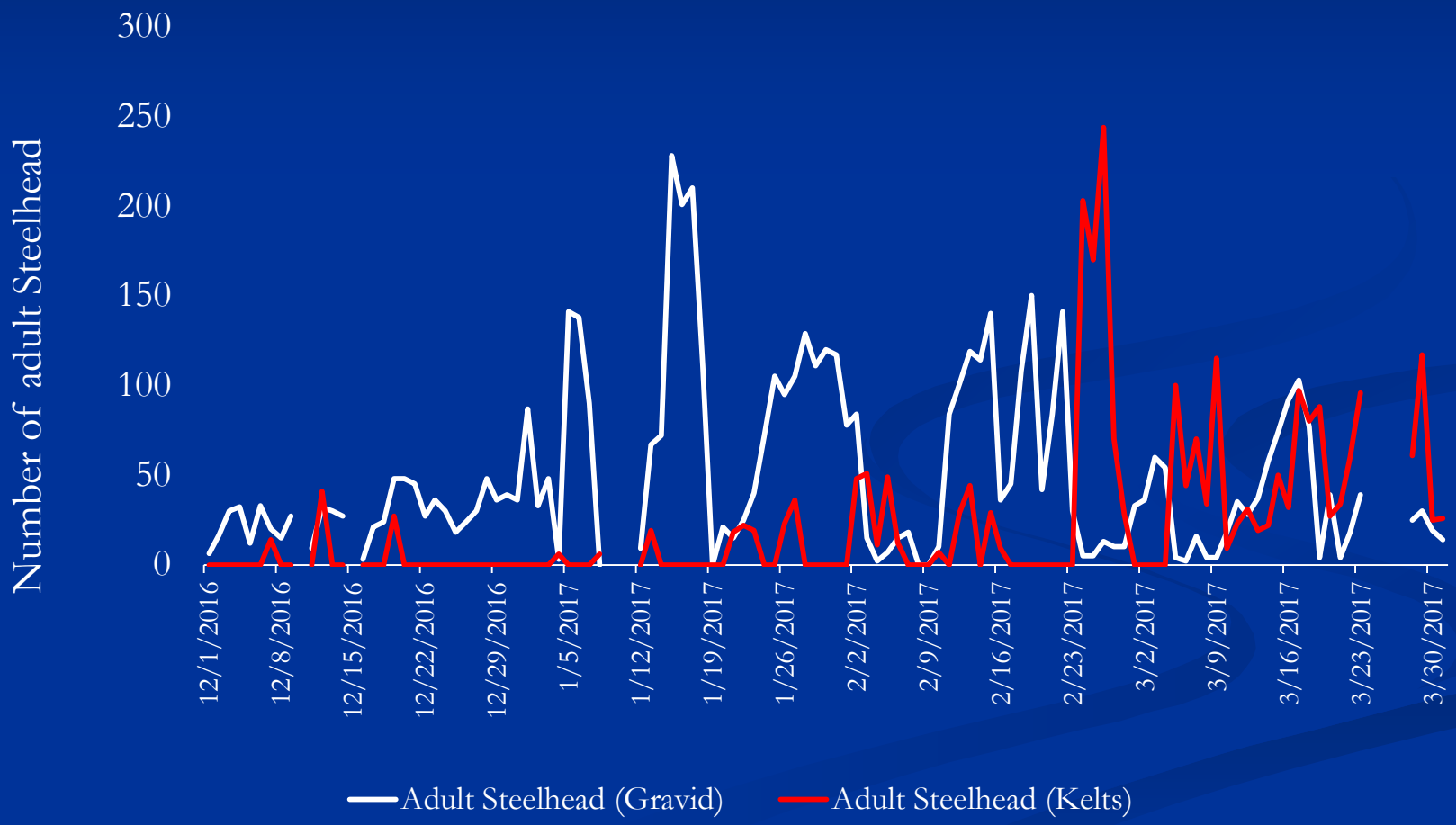
Monthly Winter-Run Steelhead Abundance

	Salmon Model with Simplified Kelt Adjustment	Salmon Model with Specific Kelt Adjustments	Midpoint Index of Abundance (no Kelt Adj.)
December	721	803	924
January	2247	2393	2577
February	1185	1466	1103
March	1206	927	436
Total:	5359	5589	5040

End Result of the Winter-Run Steelhead Abundance Estimate

Adult Steelhead Run 2016/17

(Salmon Model with Specific Kelt Adjustments)



Conclusions

- We provided several approaches, knowing that a given method may or may not work in the stream of study.

- These methods could make it more feasible to track adult numbers in more rivers and create consistent, long term datasets.

Conclusions

- The datasets can then be used for comparing steelhead numbers to fishery management, land management and ocean conditions.

- And result in better management and conservation of Steelhead.

What's Next?

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