

McNary Direct Fish Injury & Survival Studies with Split-Leaf Spill Operations

Keith van den Broek & Stine Griep
Hinchinbrook, Inc.



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Introduction

- Emergency Spill Operations Spring 2024
- Downgraded lifting capacity of spillway gates
- Split-leaf operation in upstream slot believed favorable to fish
- Not previously evaluated for direct injury and survival of salmon smolts
- Balloon tagging study recommended

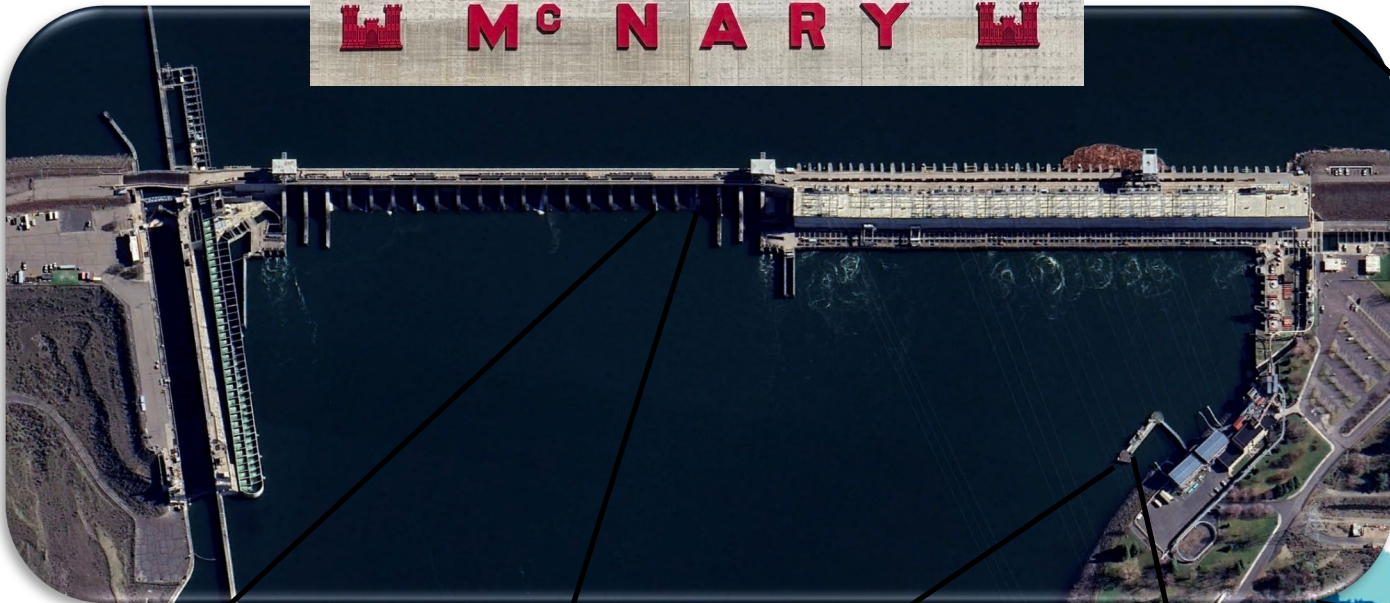


Objectives

- Estimate direct injury and survival of yearling Chinook salmon through McNary Dam spillways:
 - Split-Leaf Configuration, Upstream Slot (# 21)
 - Temporary Spillway Weir (TSW) Configuration, Downstream Slot (# 20)
- Two release depths per spillway
- Precision goal of $\pm 5\%$ @ 95% Confidence Interval



McNARY

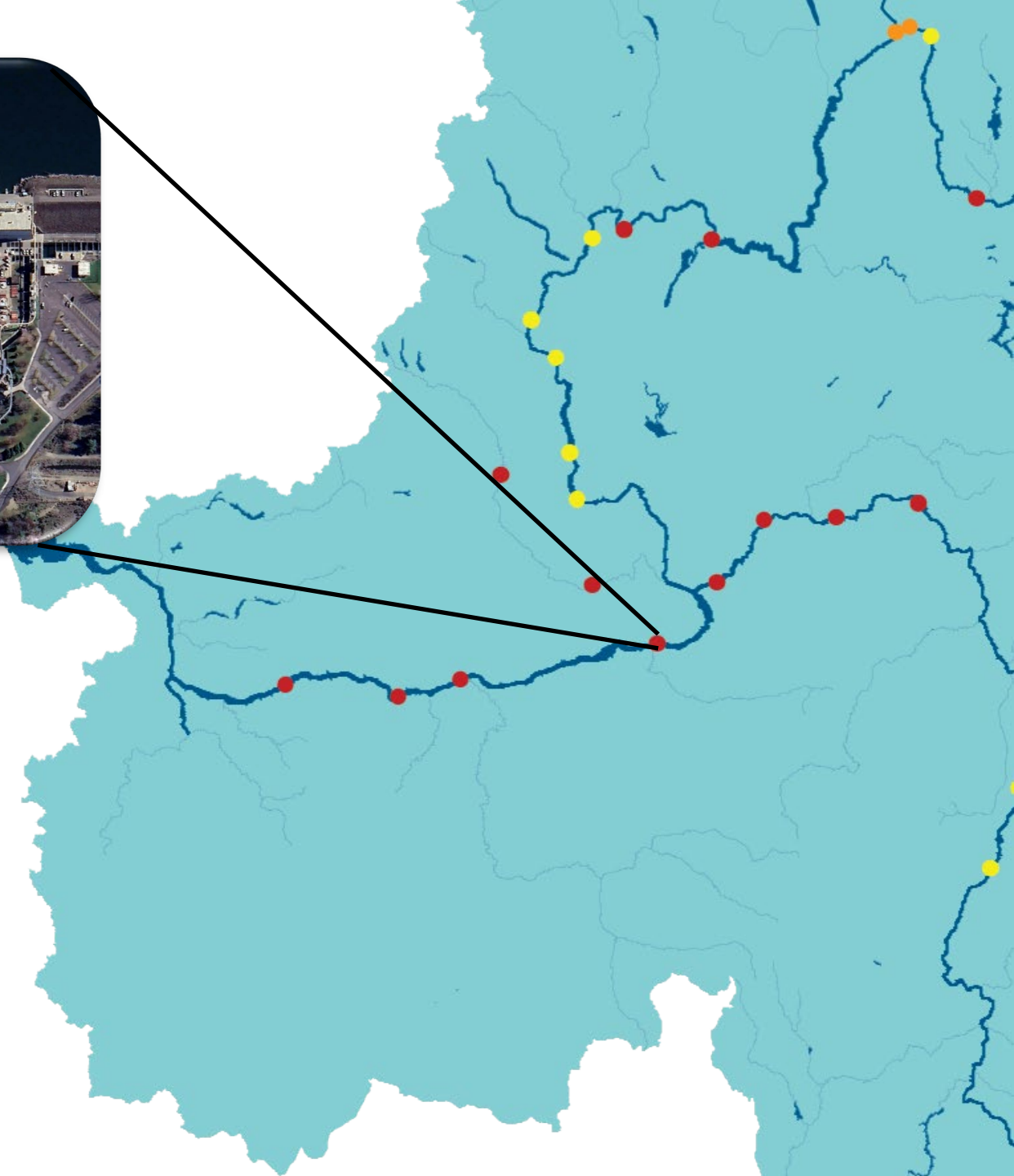


TSW
#20

Split-Leaf
#21

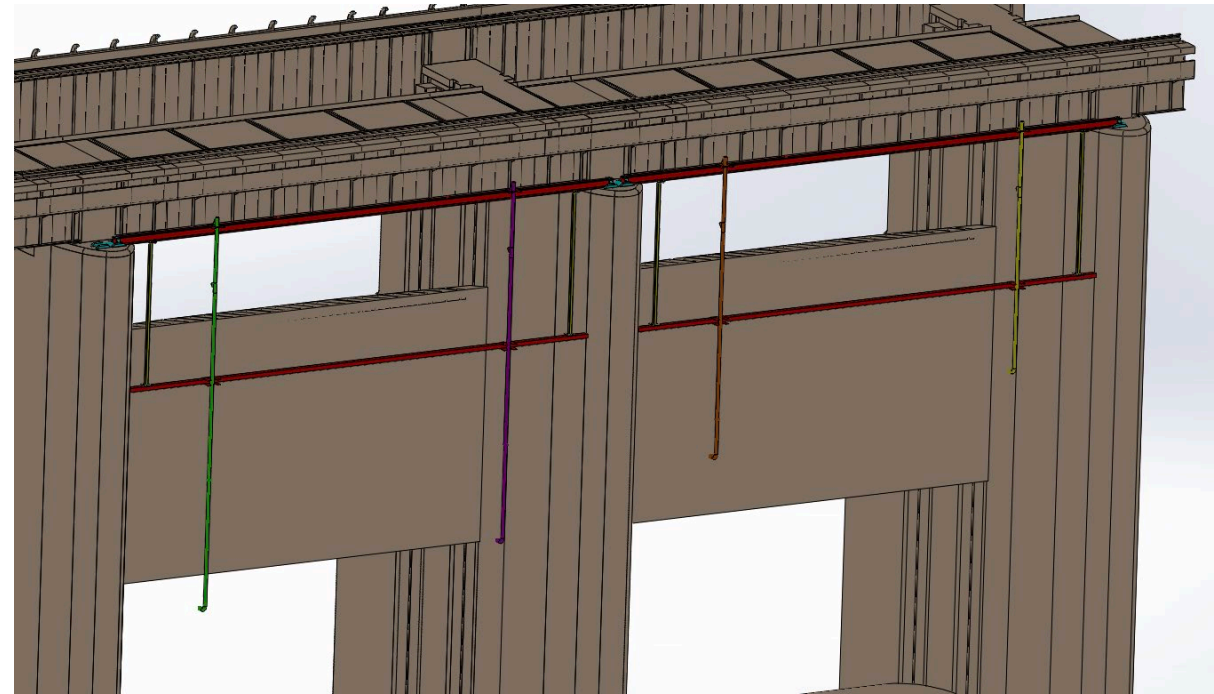
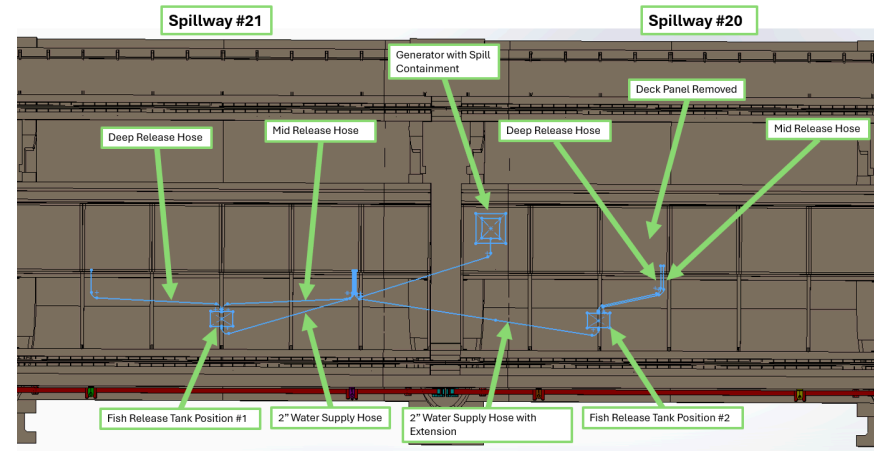


Control

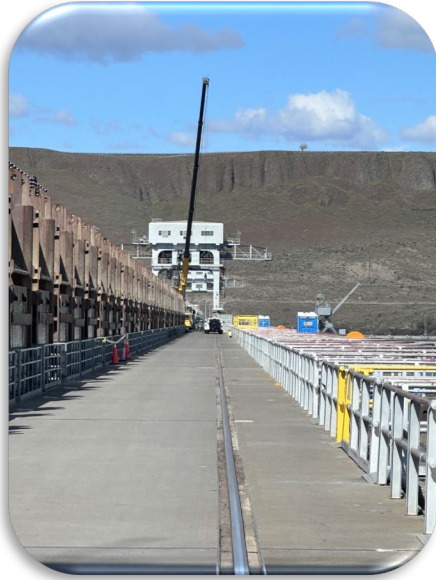


Release Pipes

- 2 release pipe elevations per spillway slot:
 - Dam deck ~22' from water surface
 - Split-leaf pipes extended ~40.5 and 44' down from dam deck
 - TSW pipes extended ~ 28.9' and 34.3' down from dam deck
- 4" diameter steel pipe fitted to 3" diameter plastic flex hose to basin
- Continuous flow of river water through hose/pipe system
- Control release basin fitted to 3" diameter plastic flex hose only



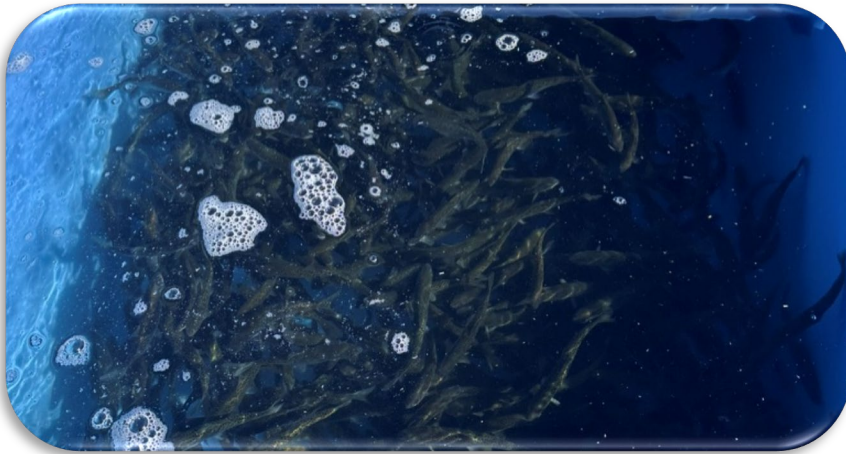
Release Pipe Installation



Release Pipe Operation



Test Fish



Entiat National Fish Hatchery

- 1+ summer-run Chinook salmon (non-listed)
- 20 fish/lb
- Average fork length 138mm



Fish Transport

- 270 gallon double walled insulated tank
- Recirculated & continuously aerated water from originating raceway
- Oxygen input as needed
- Tank Sensors
 - Oxygen >5mg/l
 - Temperature $\pm 2^{\circ}\text{C}$



Fish Holding

- Holding tanks 50-270 gallons
- Columbia River water
- Turnover rate >50% volume per hour
- Fish separated by pre- & post-release, injury quarantines, date, etc.





Tagging Operations

- Tagging trailer near release pipes
- PIT Tag for Individual Chain of Custody Identification
- Radio Tag for Post-Release Tracking
- Attachment loops for Balloon Tags
- Monitored for full recovery after tagging



Balloon Tags

- Two balloon tags/fish
- Oxalic acid and sodium bicarbonate capsules
- Acetic acid solution
- Activated and attached immediately prior to release
- 2-5 minutes for inflation



Fish Release

- Balloon tags activated and attached immediately prior to release
- Release basin connected to appropriate release pipe
- Release status communicated to recovery teams (radio & cloud app)
- Fish released for tracking and recovery



Recapture

- Radio tags used to pinpoint fish location
- Inflated balloon tags force fish to surface
- Visual relocation and recovery with dipnet
- Tags removed, evaluated & transferred by live wells to shore for further monitoring





Challenges

- Huge recovery area
- Hydraulic Turbulence
- Radio noise & backscatter
- Fast changing weather conditions
- Avian predation
- Dam operations

Evaluation Criteria

- Within 1h after recapture:
 1. Alive
 2. Alive with minor injuries
 3. Alive with severe injuries
 4. Dead
 5. Tags recaptures without fish
 6. Not recaptured

Injury Evaluation

- A. *No visible marks*
- B. *Flesh tear at tag site*
- C. *Minor scale loss, 3% to 20%*
- D. *Major scale loss, > 20%*
- E. *Laceration(s), tear(s) on body*
- F. *Severed body parts*
- G. *Hemorrhaging, bruised*
- H. *Stressed (lethargic)*
- I. *Spasmodic movement*
- J. *Infected tag site*
- K. *Bulging or missing eye*
- L. *Predator marks*
- M. *Fins damaged*
- N. *Alive but belly up*

- Within/after 48h or after mortality:
 - Detailed injury classification following Normandeau Associates et al., 2002
- After 48h monitoring period, all fish were released into Columbia River

Release Schedule

Release Location	Number Released Fish per Day							Release Total
	3/29	3/30	3/31	4/1	4/2	4/3	4/4	
Split-leaf deep	0	0	39	82	0	0	6	127
Split-leaf mid	0	18	0	11	60	0	20	109
TSW deep	0	0	20	21	0	63	4	108
TSW mid	2	16	20	0	0	58	18	114
Control	17	0	0	7	23	0	53	100
Release Total	19	34	79	121	83	121	101	558

Results



Recapture Counts

Release Fish Count per Condition					
Release Location	Alive (48h)	Dead (48h)	Tag recapture	No recapture	Total
Split-leaf deep	101	1	12	13	127
Split-leaf mid	90	5	4	10	109
TSW deep	96	3	4	5	108
TSW mid	93	7	8	6	114
Control	100	0	0	0	100

Data Homogeneity

Chi-square tests showed

- **No significant differences** between:
 - release batches per location
 - justifies data pooling for each release location
 - release heights (deep & mid)
 - treatment groups (split-leaf & TSW)
- **Significant differences** between:
 - treatment and control

Injury Evaluation

Within 1h after recapture:

- **Minor:**
 - Visible but not life threatening
 - Likely to disappear within 48h
- **Major:**
 - Aberrant behavior for >48h
 - Life threatening
 - Persistent for >48h
- No significant difference between treatment groups

Release Location	Injury Status Counts				Total Fish Count
	Minor	Major	Dead	None	
Split-leaf deep	0	3	1	98	102
Split-leaf mid	1	4	1	89	95
TSW deep	0	2	1	96	99
TSW mid	1	5	1	93	100
Control	1	0	0	99	100

Mortality Evaluation

- Number of fish that died within each observation period after recapture

- * Mortalities were removed from analysis:
 - No direct connection to dam passage
 - Died more than 48h after recapture

Release Location	Observation Period (hrs)	Mortality Count	Observed Fish Condition
Split-leaf deep	1	1	No external injuries
Split-leaf mid	1	1	Scale loss
Split-leaf mid	48	1	No external injuries
Split-leaf mid	48	2	Belly up
Split-leaf mid	48	1	Predation*
TSW deep	1	1	Scale loss/laceration
TSW deep	48	1	Belly up
TSW deep	48	1	Tagging injury*
TSW mid	1	1	Predation*
TSW mid	48	1	Belly up, bulging eye
TSW mid	48	1	Belly up, predation*
TSW mid	48	2	Belly up
TSW mid	48	1	Tagging injury*
TSW mid	>48*	1	Belly up

Survival Definitions

Recapture Survival: Probability of survival when considering all recaptured individuals, i.e., individuals of known fate

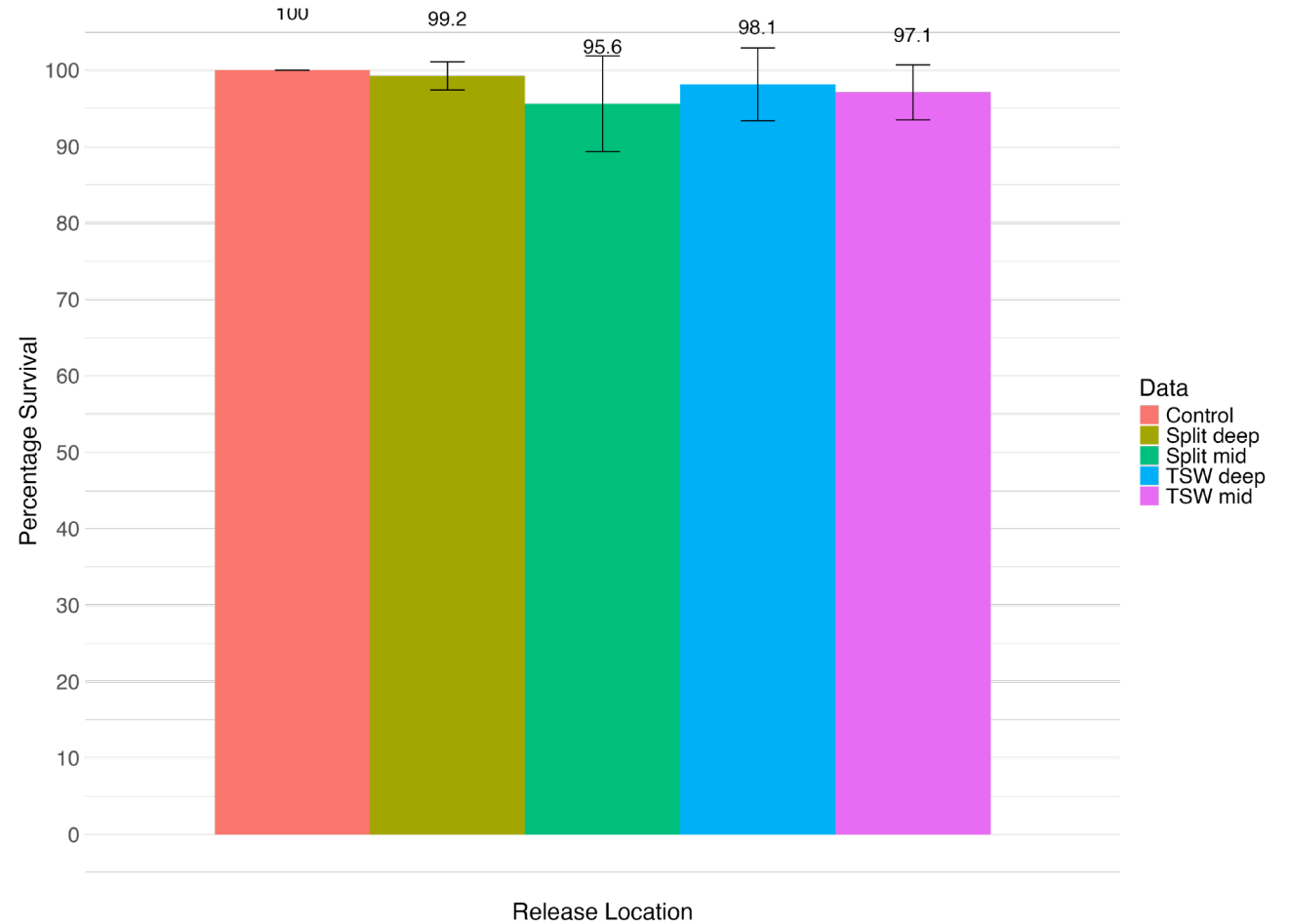
Release Survival: Probability of survival when considering all individuals released, including unknown fates

Worst-case survival: Probability of survival when considering all individuals with unknown fate dead

Best-case survival: Probability of survival when considering all individuals with unknown fate alive

Recapture Survival

- Mean survival > 95% at all release locations
 - highest at Control
 - lowest at Split-leaf mid
- wide 95% confidence intervals



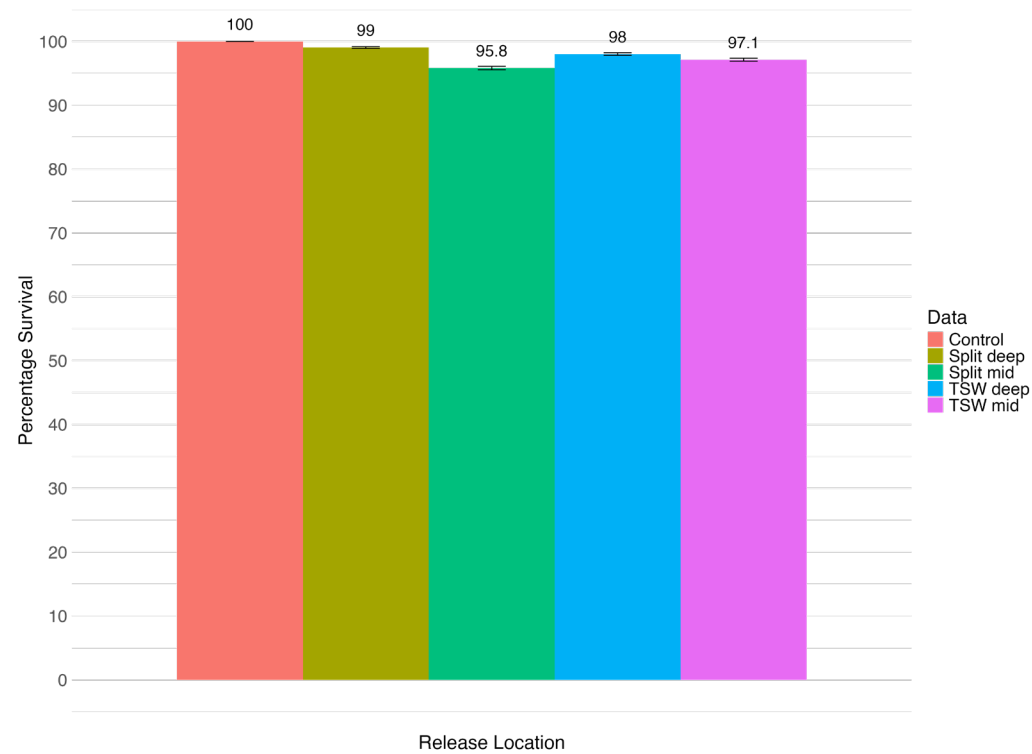
Increasing Precision

Model Random:

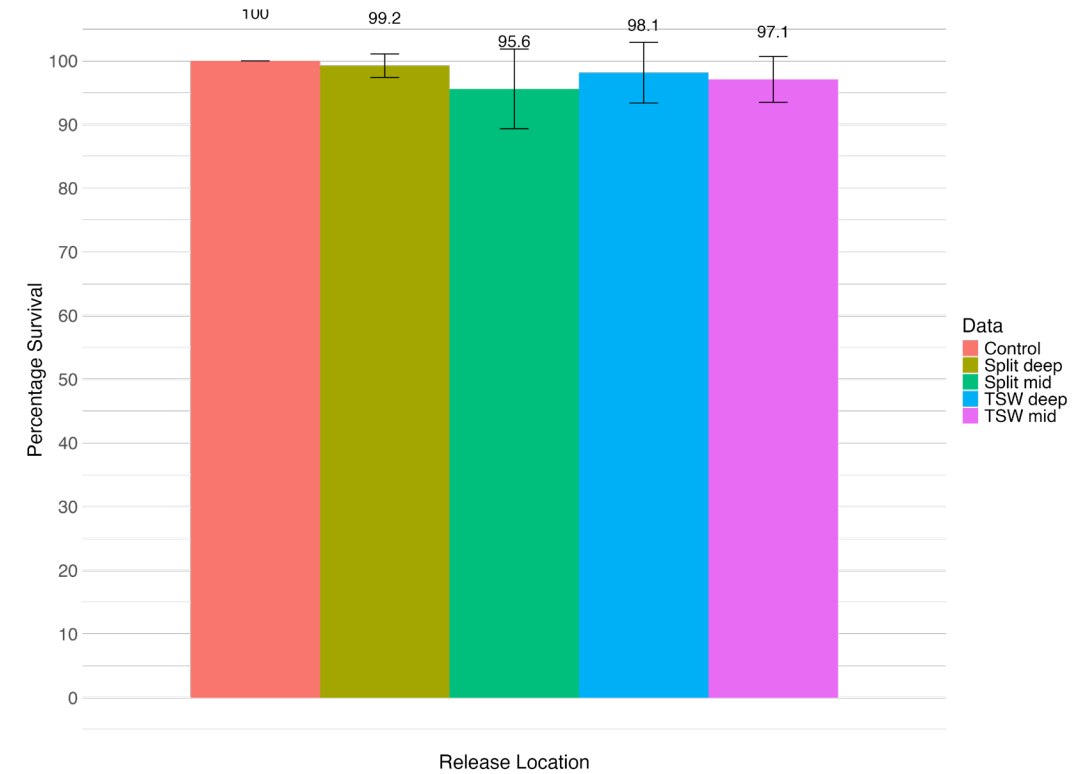
- Create larger simulated data set with same data distribution regarding survival and mortality as recaptured individuals by
 - Pooling recapture data sets per release location
 - Randomly picking 100 batches of 20 individuals with replacement
 - Calculating mean survival and mortality for each release location

Increased Precision

Model Random



Actual Data



Modeled Survival of Lost Individuals

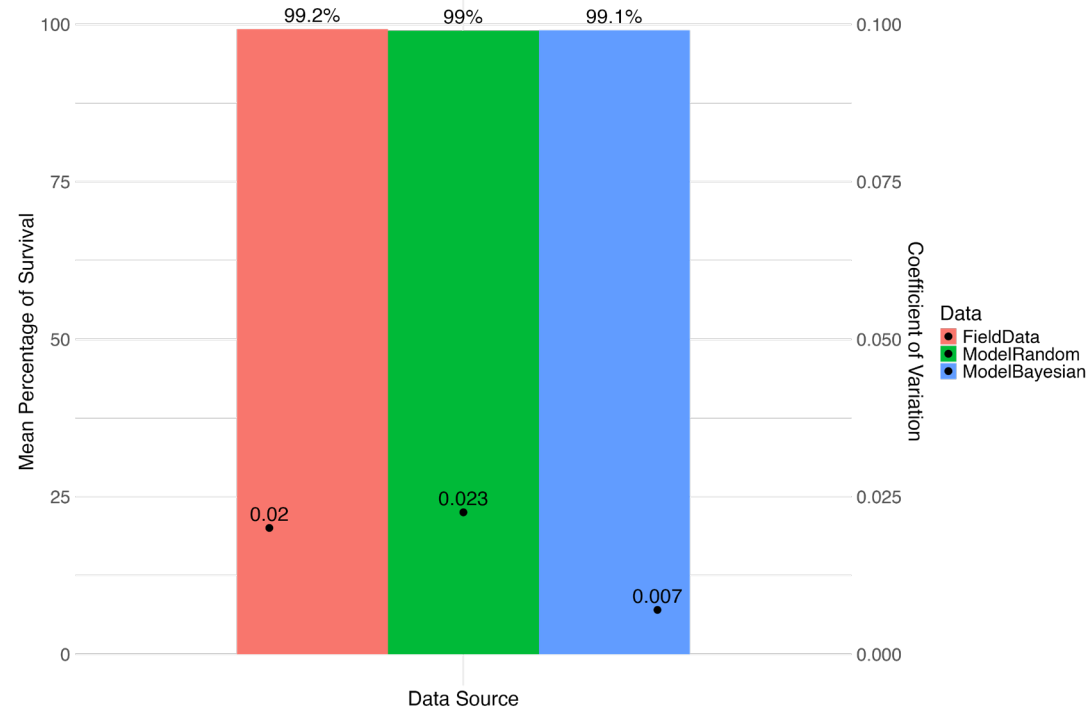
- Bayesian Models
 - Create 100 simulated data batches of 20 individuals drawn from pre-defined ("prior") distribution of survival and mortality from field data
 - Model uses a "likelihood function" to estimate survival and mortality for simulated data sets

Model validation:

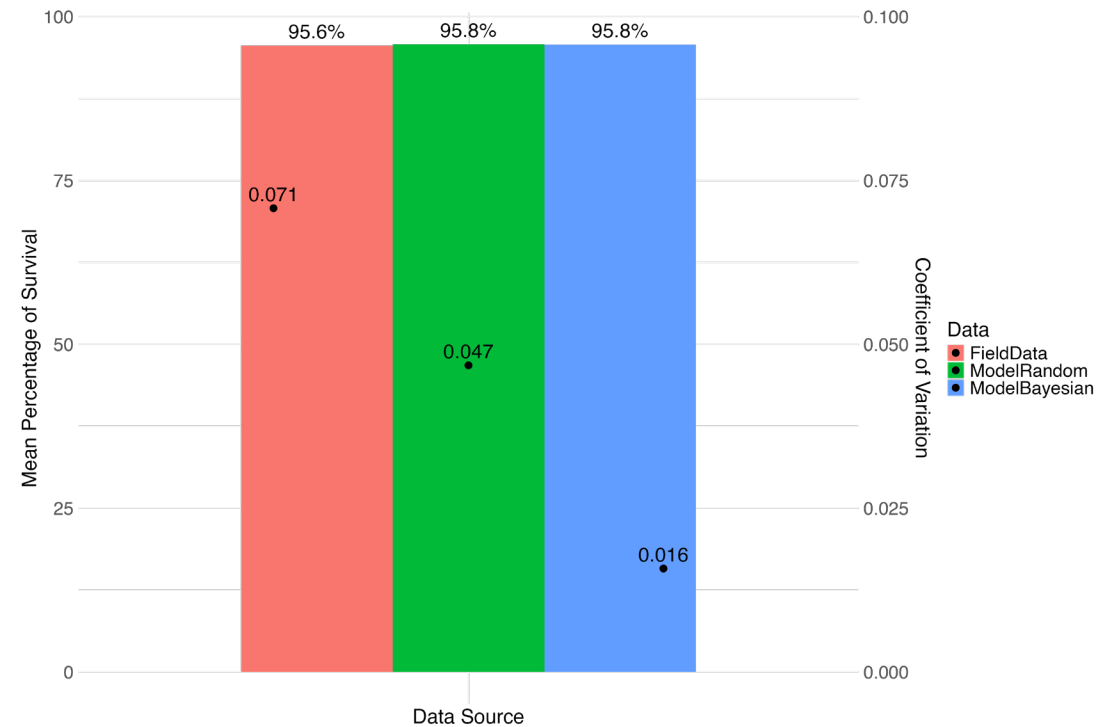
- Model output gives recapture survival with increased precision, i.e., low Coefficient of Variation (CV)
- Compare results to field data results and Model Random – expect lowest CV for Bayesian model

Model Validation

Split-leaf deep

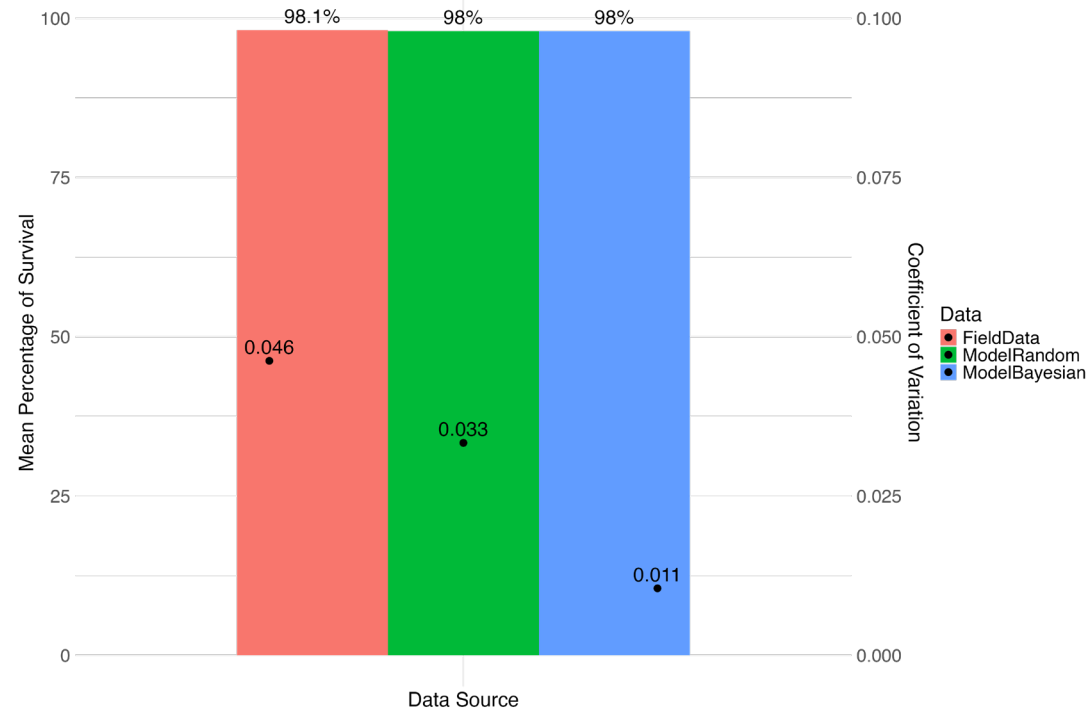


Split-leaf mid

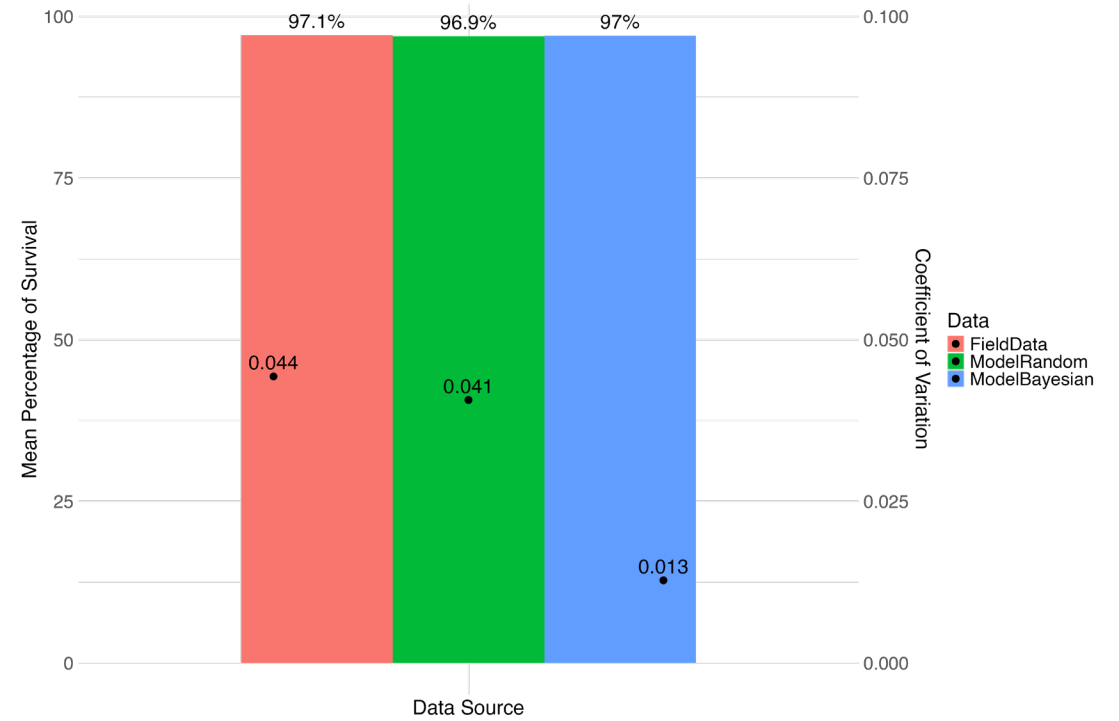


Model Validation

TSW deep



TSW mid

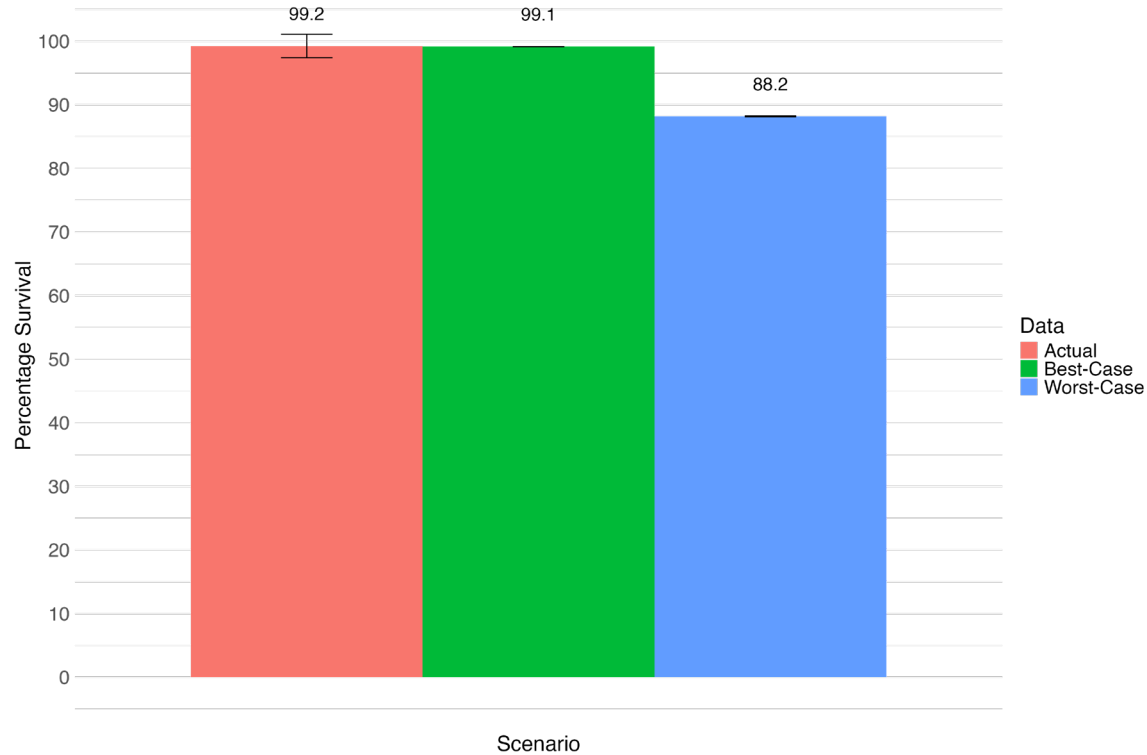


Expected Survival of Lost Individuals

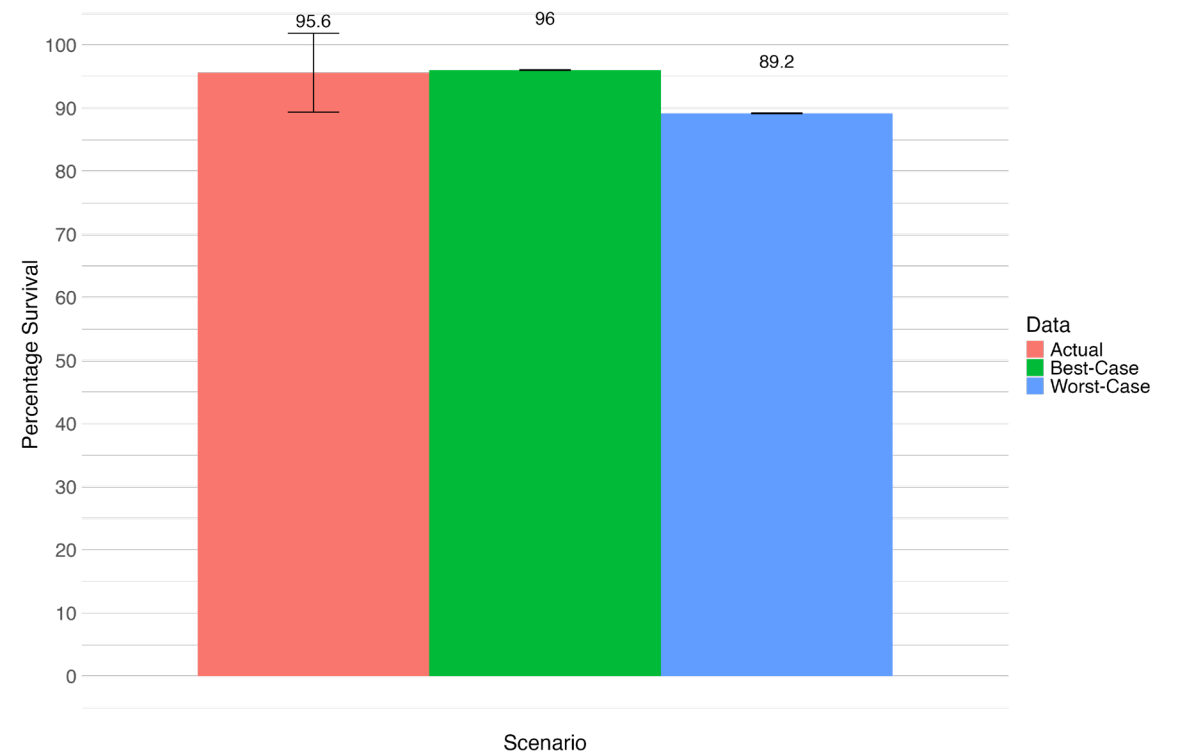
- Bayesian Models
 - Create 100 simulated data batches of 20 individuals drawn from pre-defined ("prior") distribution of survival and mortality from field data
 - Model uses a "likelihood function" to estimate survival and mortality for simulated data sets with varying sample size and comparing:
 - **worst case survival**
 - **best case survival**
 - Model output gives the range of survivorship values under the best- and worst-case circumstances.

Expected Survival

Split-leaf deep

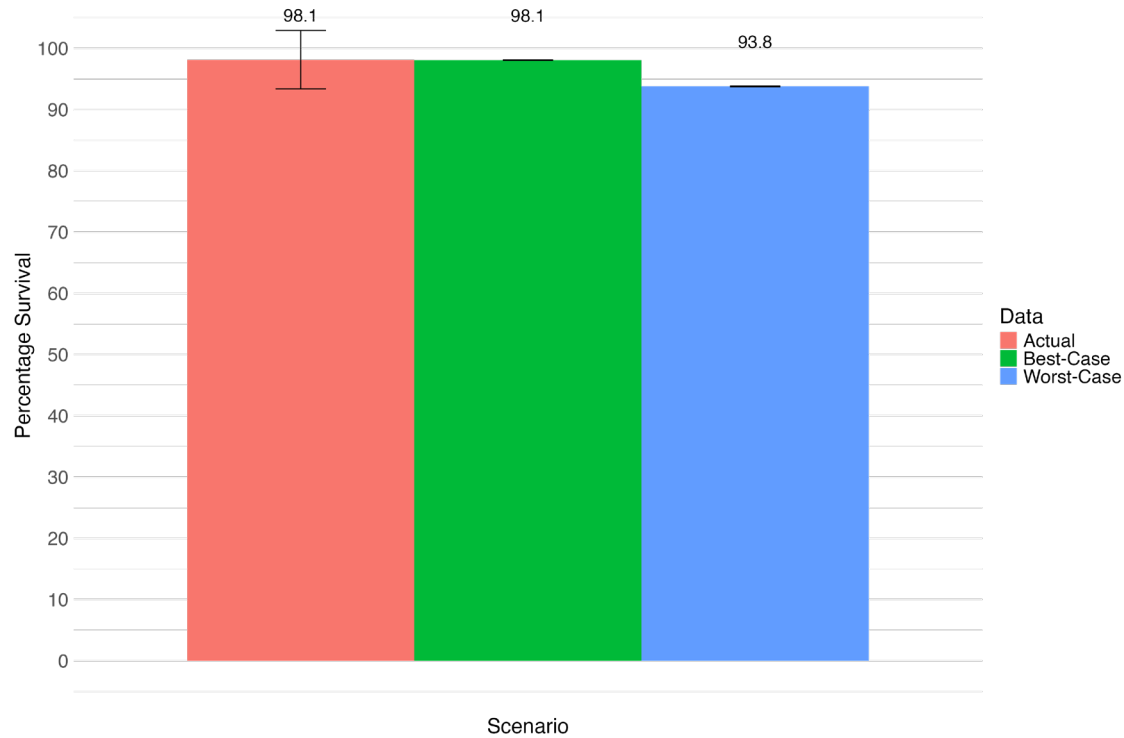


Split-leaf mid

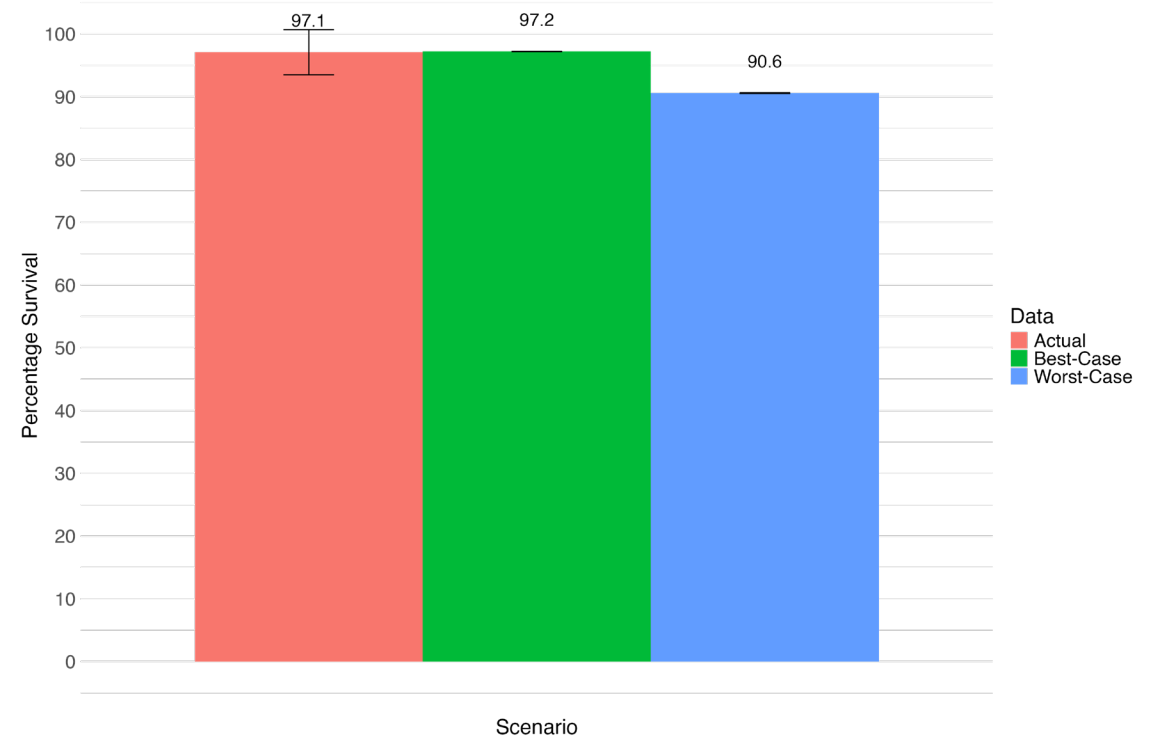


Expected Survival

TSW deep



TSW mid



Conclusions

- Under short-term conditions survival rates were comparably high at split-leaf and TSW release locations
- Release depths appear to effect survival
- Survival of other species, life stages, individuals in other conditions or from different sources remains unknown
- Study did not account for temporal variability
- Tagging effects need better evaluation

Future Work

- Repeat study with greater lead time for planning that includes
 - Additional release depths
 - Additional species and life stages
 - Comparative tagging and tracking methods
 - Additional control release locations and approaches
 - Increased sample size
 - Larger temporal scale

Acknowledgements

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- Charles Barnes, Bobby Johnson, and all McNary Project staff
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- Hinchinbrook Team



Questions?

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