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Eliminating Bias in Survival Estimates due to the Effect of Tag Failure on Right-Skewed Travel Time Distributions: A Bayesian Approach

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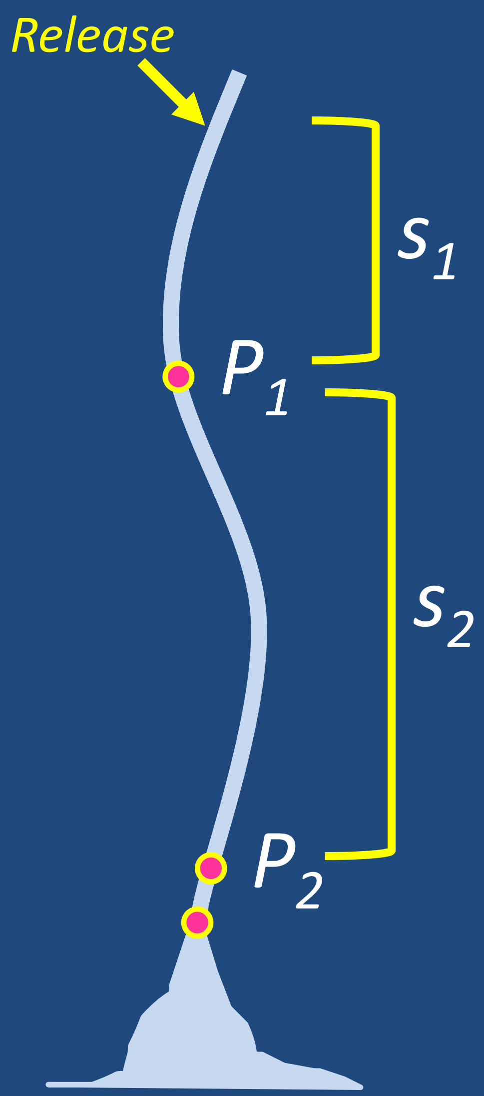
U.S. Geological Survey
Cook, WA

Estimating Survival



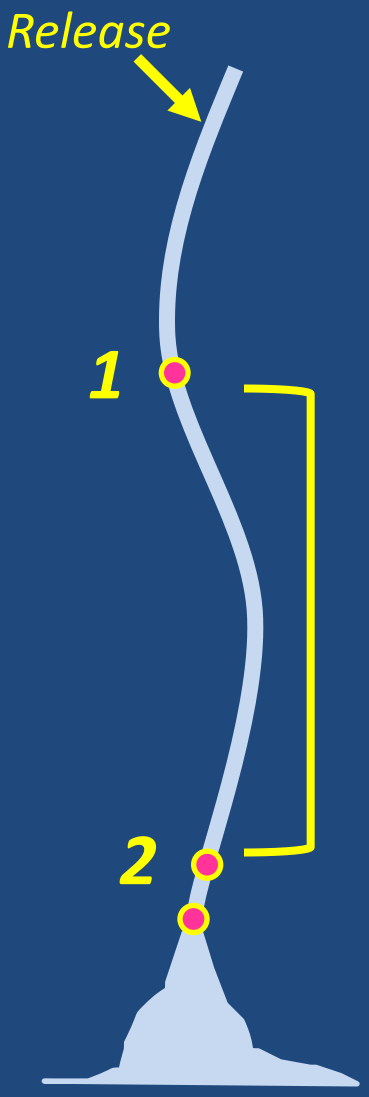
P = Detection probability

S = Fish survival probability

Assume:

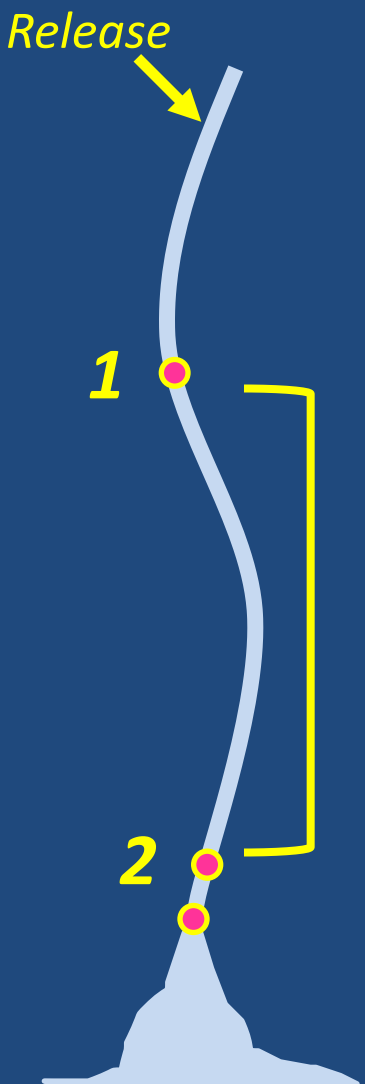
Tag does not fail

The Trouble with Tag Failure



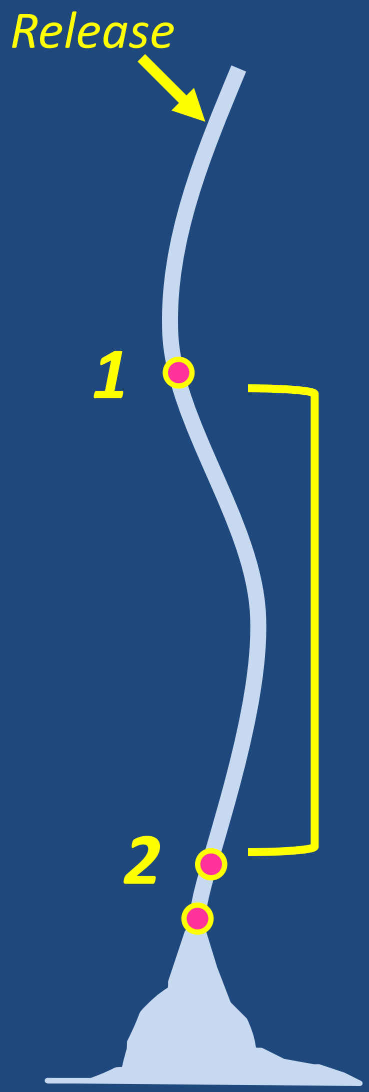
S_{fish}	x	S_{tag}	=	Apparent Survival
0.80	x	1.00	=	0.80

The Trouble with Tag Failure



S_{fish}	x	S_{tag}	=	*Apparent Survival*
0.80	x	1.00	=	0.80
0.80	x	0.50	=	0.40

The Trouble with Tag Failure



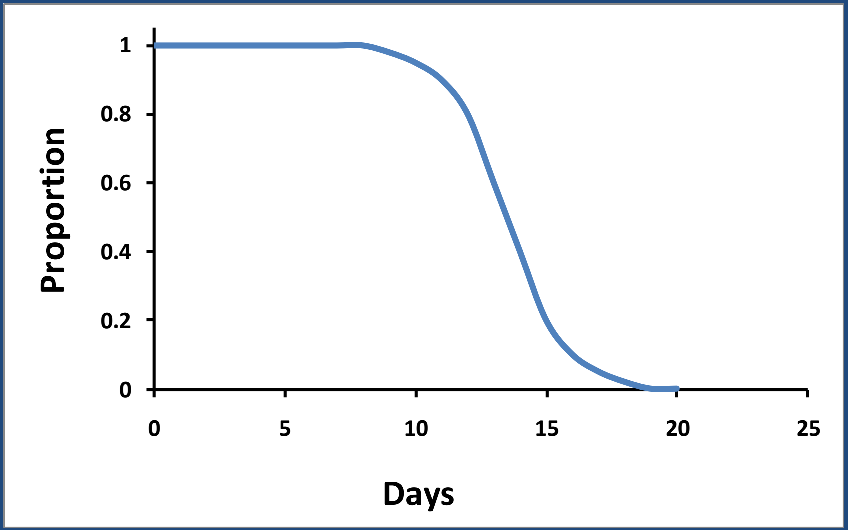
S_{fish}	x	S_{tag}	=	*Apparent Survival*
0.80	x	*1.00*	=	*0.80*
0.80	x	*0.50*	=	*0.40*

Estimate is BIASED LOW when tags fail.

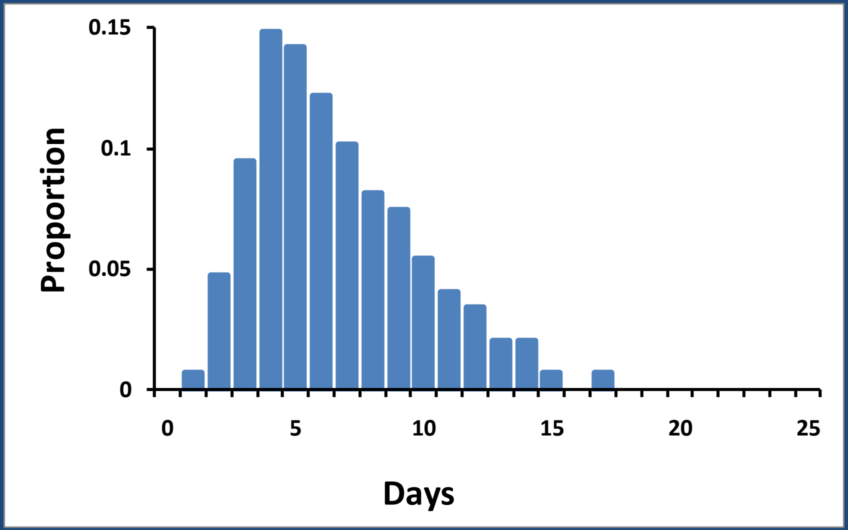
$$S_{fish} = \frac{\text{Apparent Survival}}{S_{tag}}$$

Estimating S_{tag}

Tag failure curve



Fish travel times to a given site



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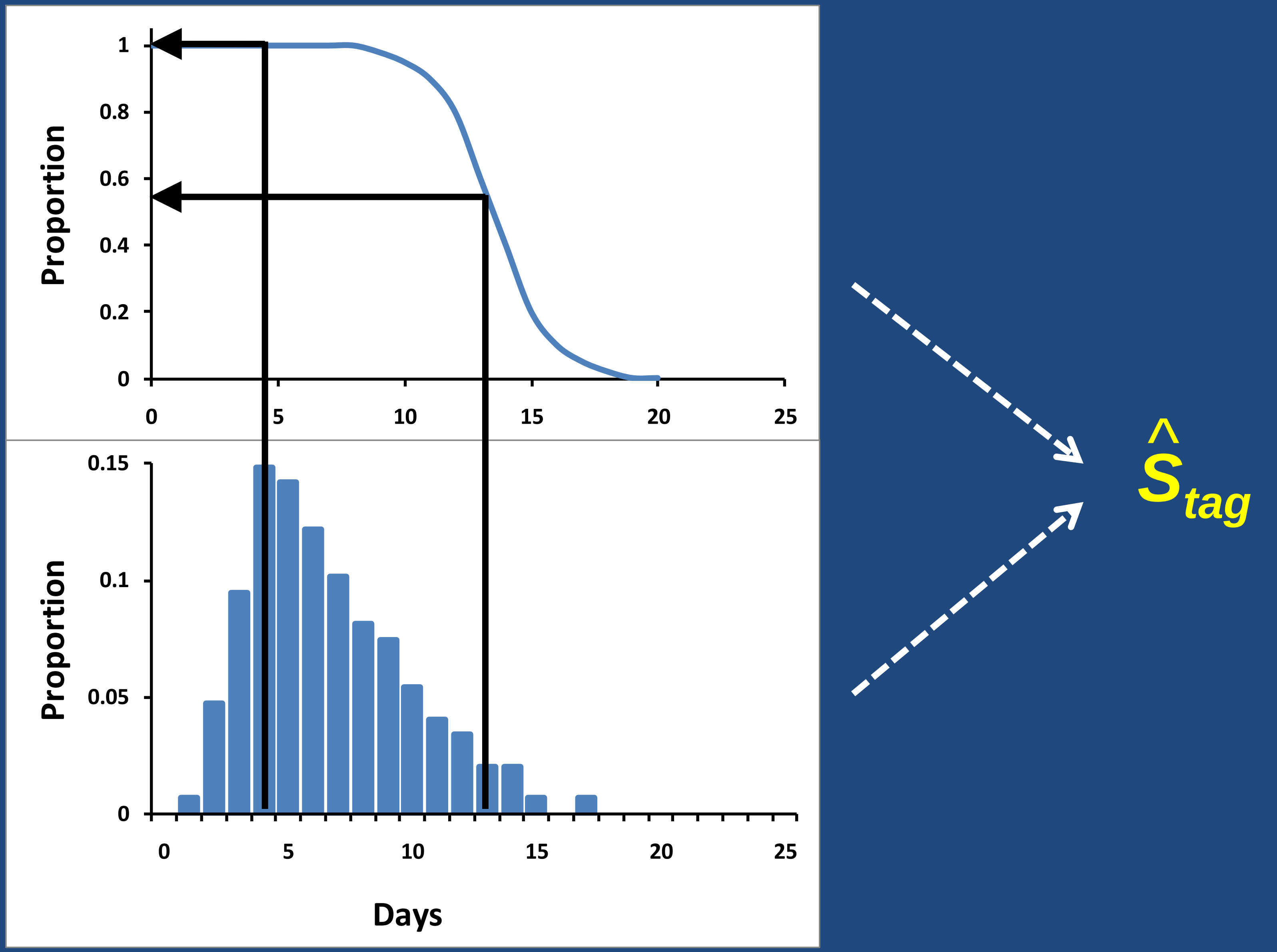
Estimating S_{tag}



Case Study Summary

- *Still biased after correction*
- *Appears unbiased with 90-d travel times*

Why?

-Travel time distribution is also biased

-Long travel times not observed

-S_{tag} estimate is too high

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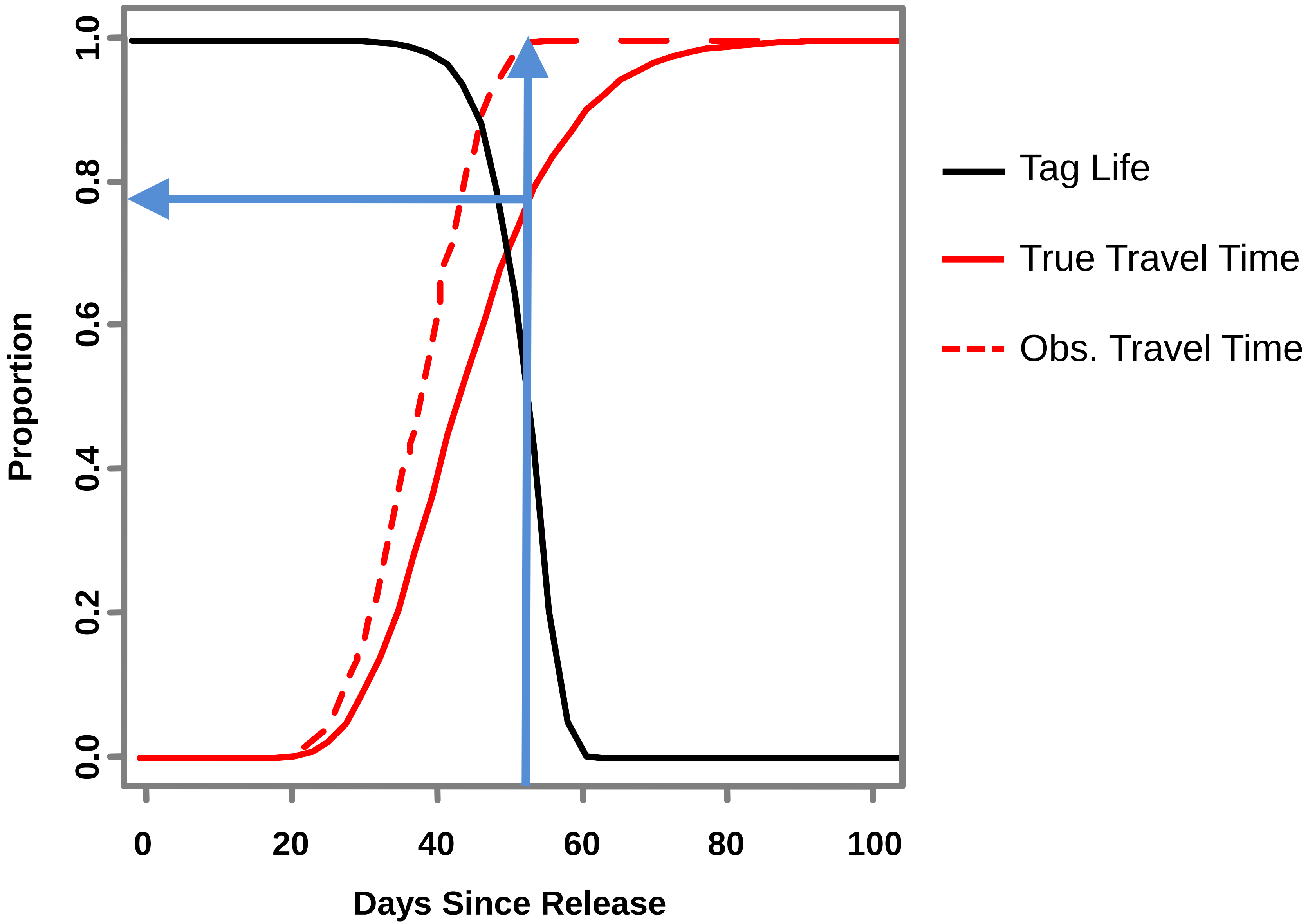
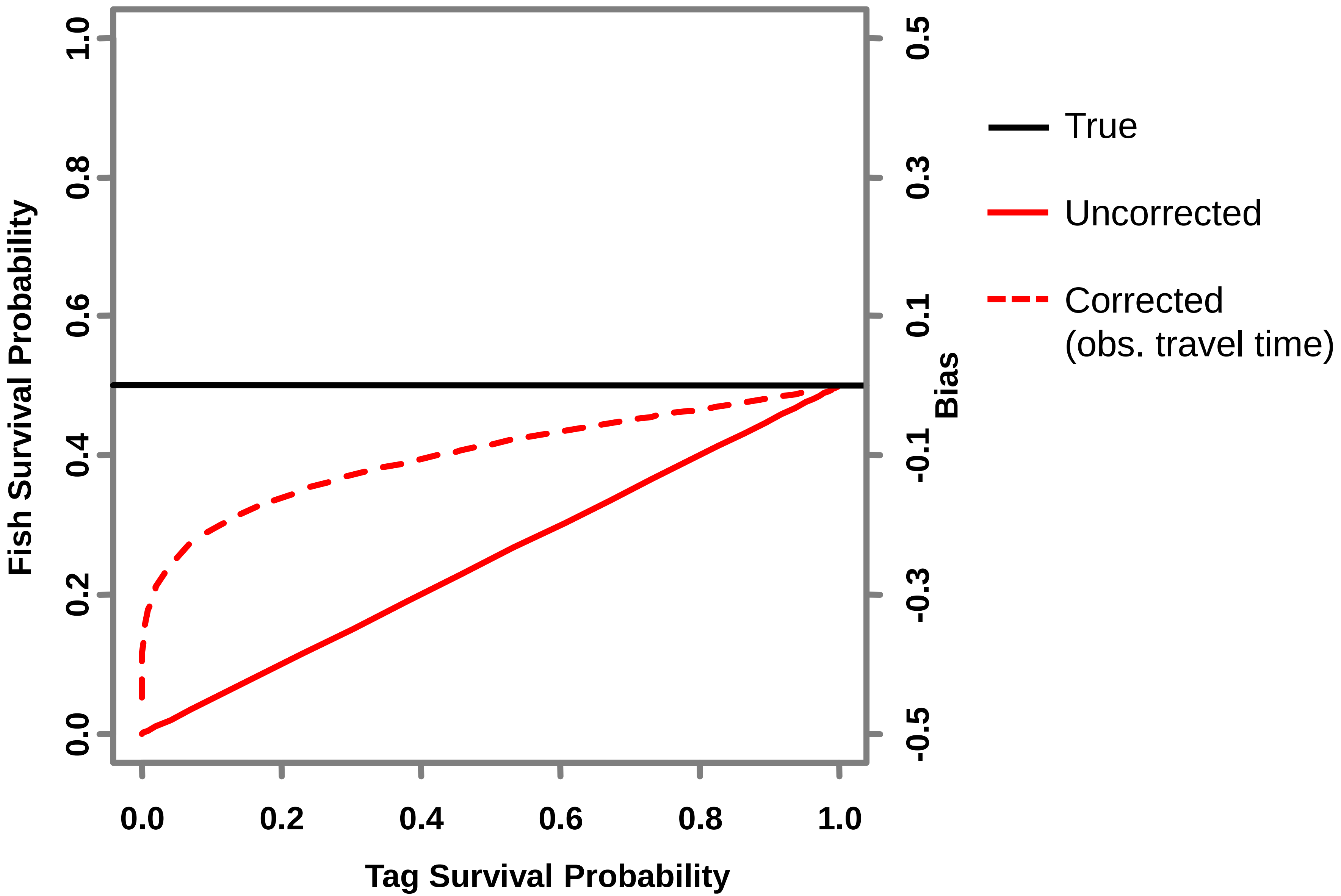
Simulation Results (S_{tag} = 0.67)



How effective is correction?



A Bayesian Approach

- *Assume parametric form for travel time distribution*
- *Complete Data Likelihood (CDL) includes missing travel times greater than tag failure times*
- *Tag failure probability based on all travel times, both observed and missing*

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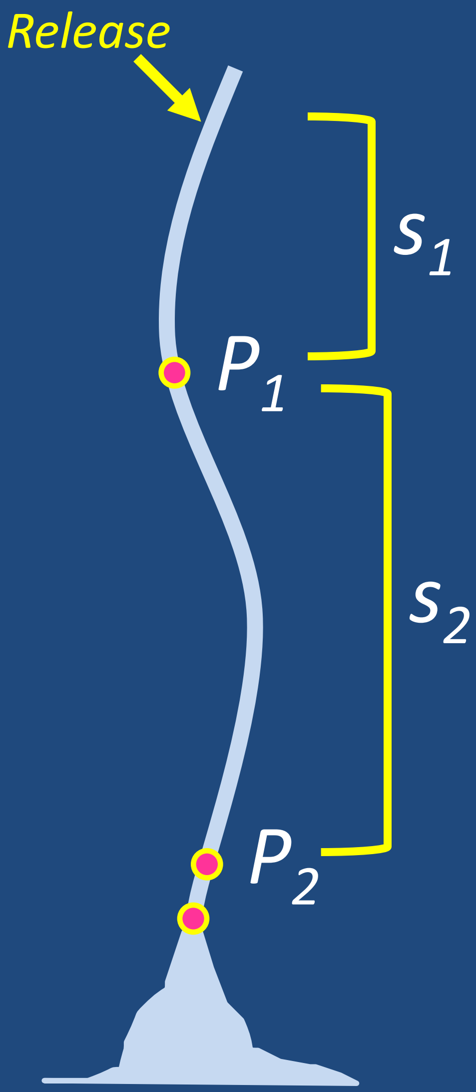
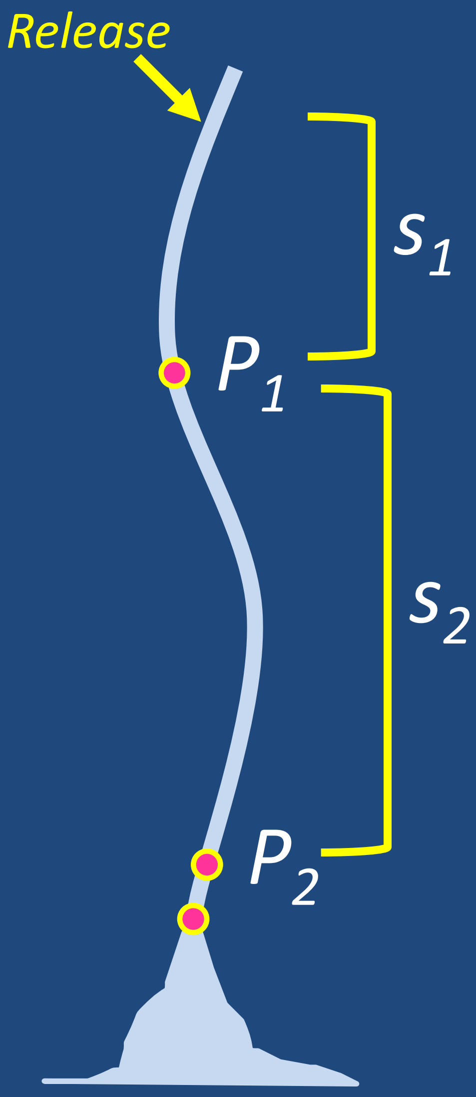
Data simulation



$P_1 = P_2 = 0.9$
$S_1 = 0.8$
$S_2 = 0.5$
$N_{rel} = 700$
IGRN travel time dist.
Mean travel time:
Reach 1 =6.5d, Reach 2 =13.9d
S_{tag} varies

Data simulation



$P_1 = P_2 = 0.9$

$S_1 = 0.8$ (0.82)

$S_2 = 0.5$ (0.46)

$N_{rel} = 700$

IGRN travel time dist.

Mean travel time:

Reach 1 =6.5d, Reach 2 =13.9d

S_{tag} varies

Data simulation

- *Assume parametric form for travel time distribution*
- *Complete Data Likelihood (CDL) includes missing travel times greater than tag failure times*
- *Tag failure probability based on all travel times, both observed and missing*

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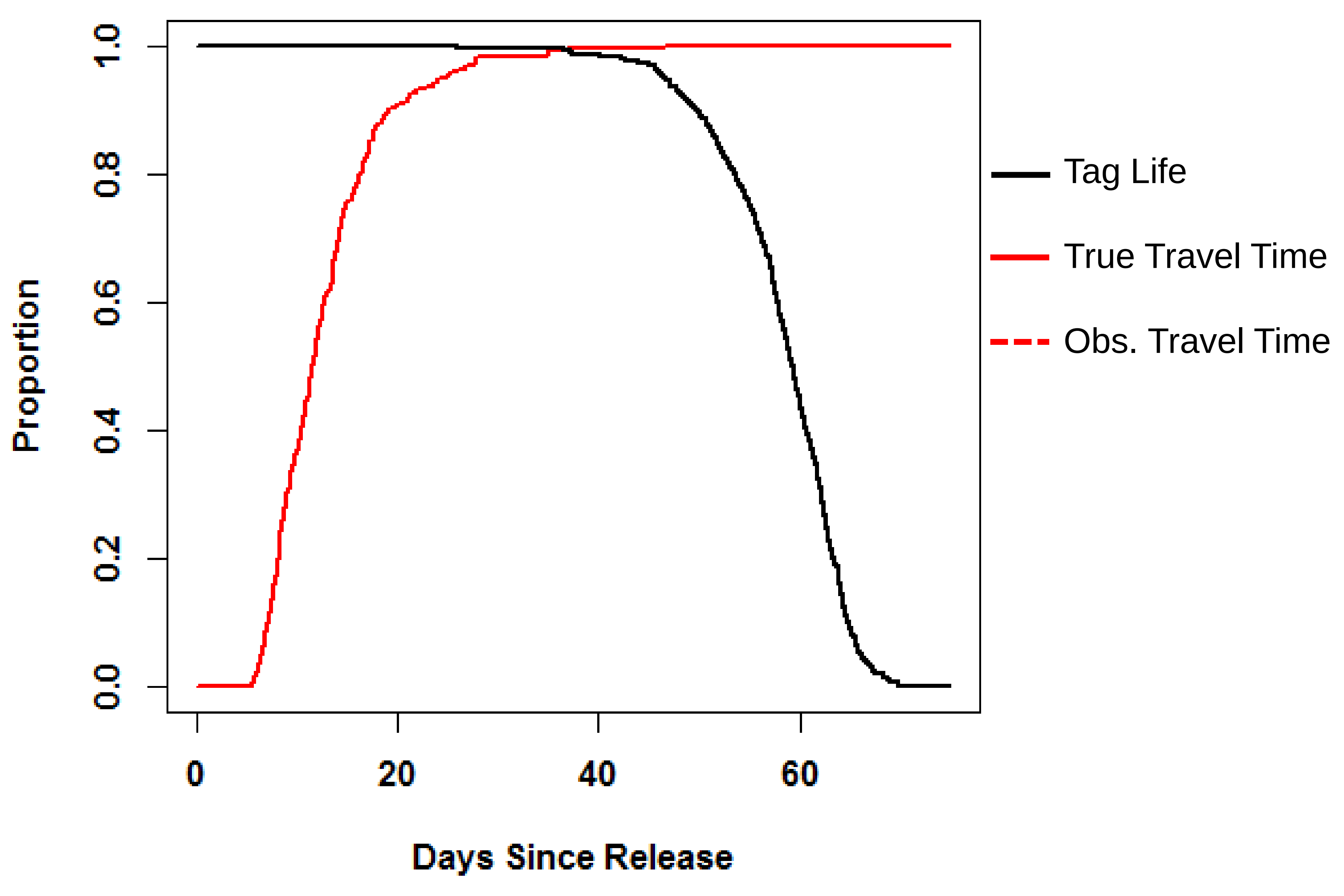
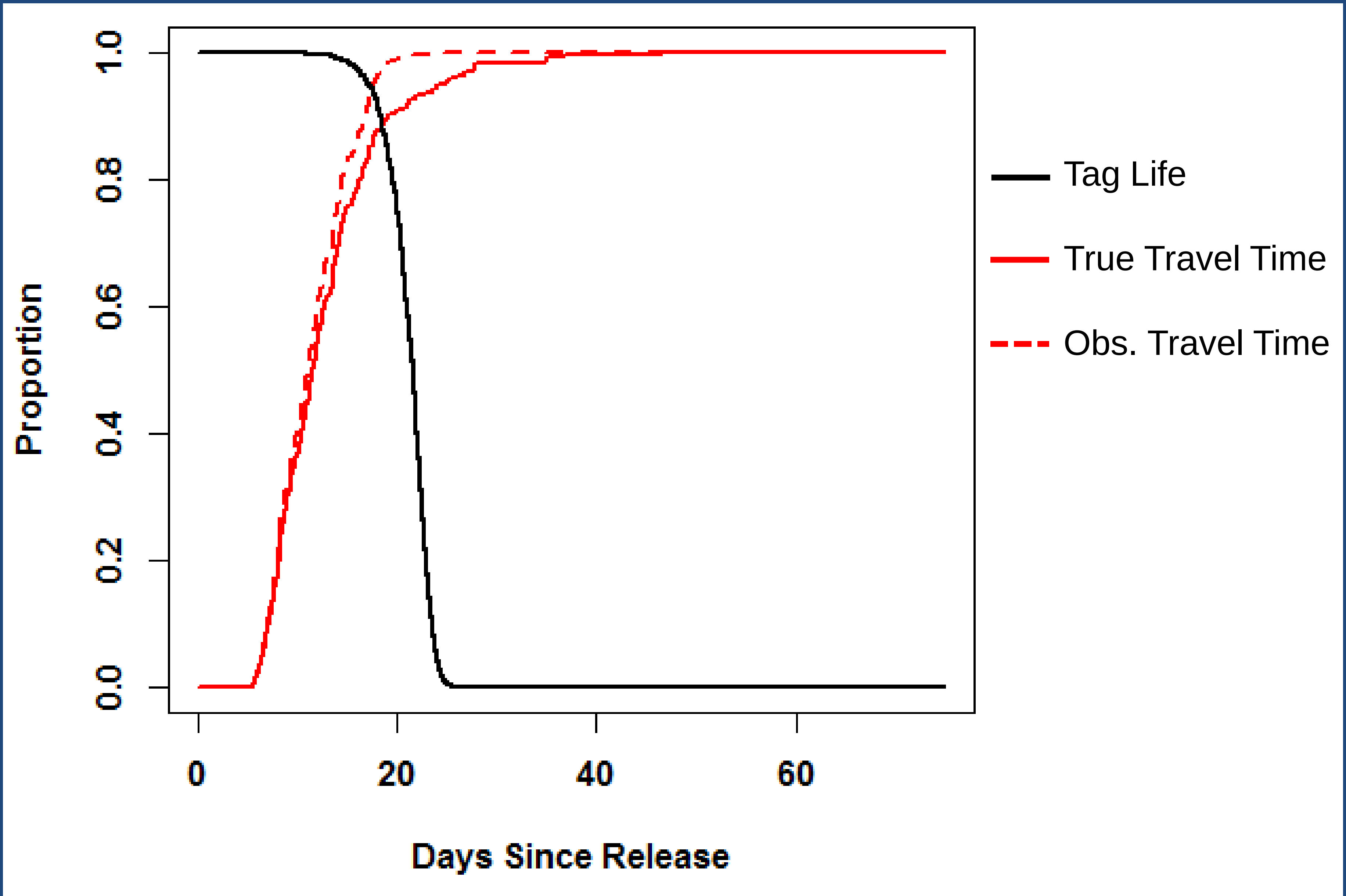
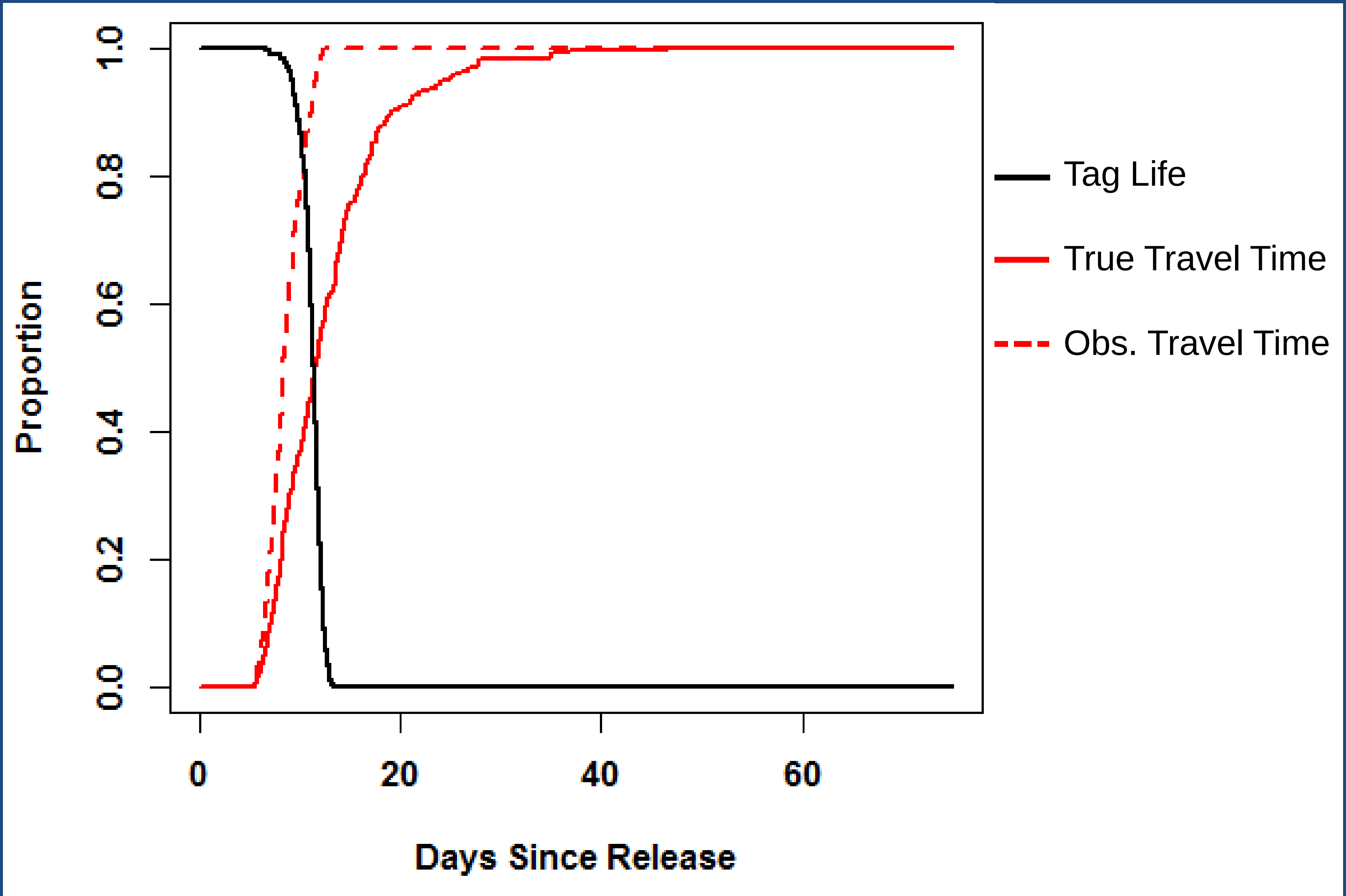
Simulation Results (S_{tag} = 0.996)



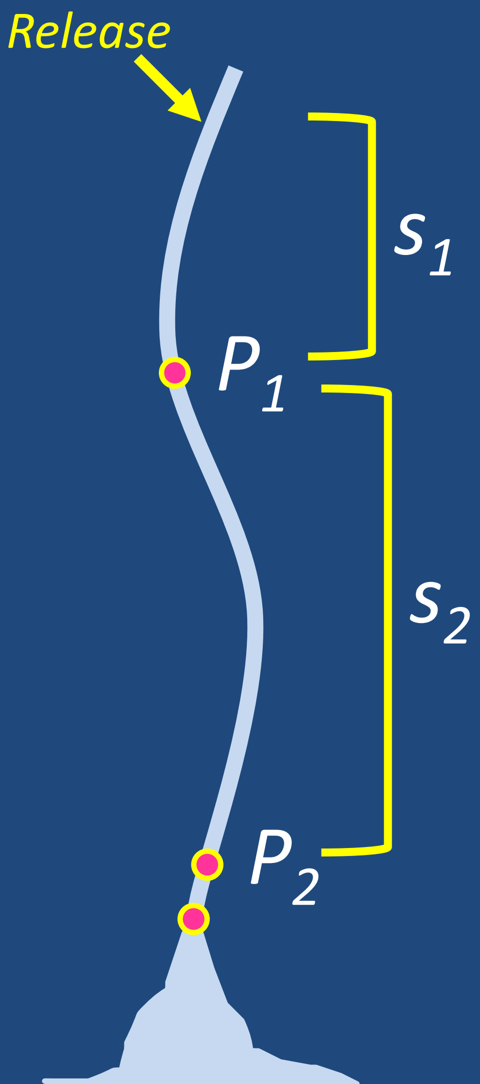
Simulation Results (S_{tag} = 0.90)



Simulation Results (S_{tag} = 0.45)



Simulation Results: $\hat{S}_2$

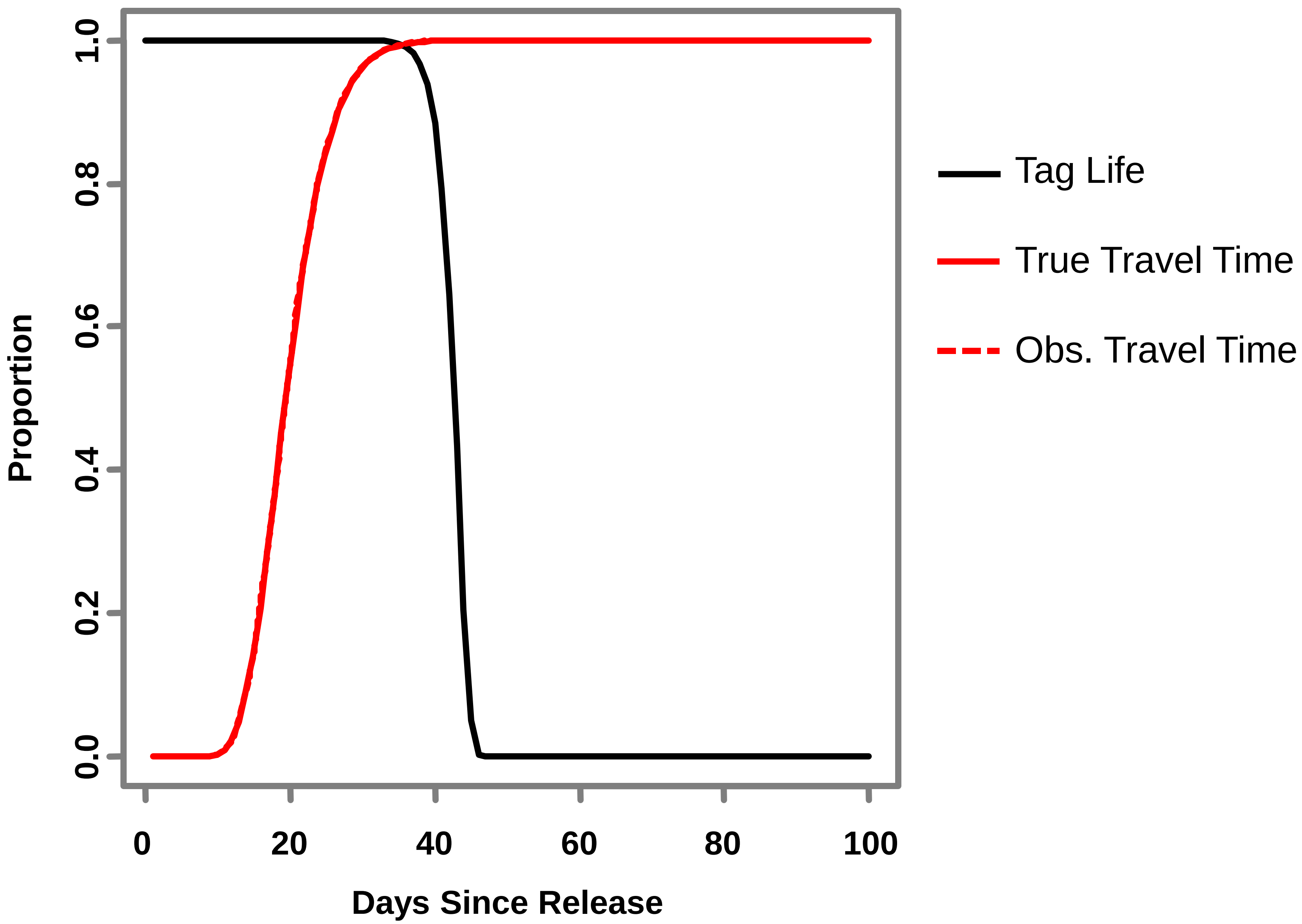


S_{tag}	CJS	Townsend	MCMC
0.996	0.46	0.46	0.46
(0.996)	0.42-0.50	0.42-0.50	0.42-0.50
0.90	0.43	0.43	0.47
(0.98)	0.38-0.47	0.38-0.47	0.42-0.52
0.45	0.24	0.27	0.44
(0.89)	0.20-0.28	0.22-0.31	0.32-0.68

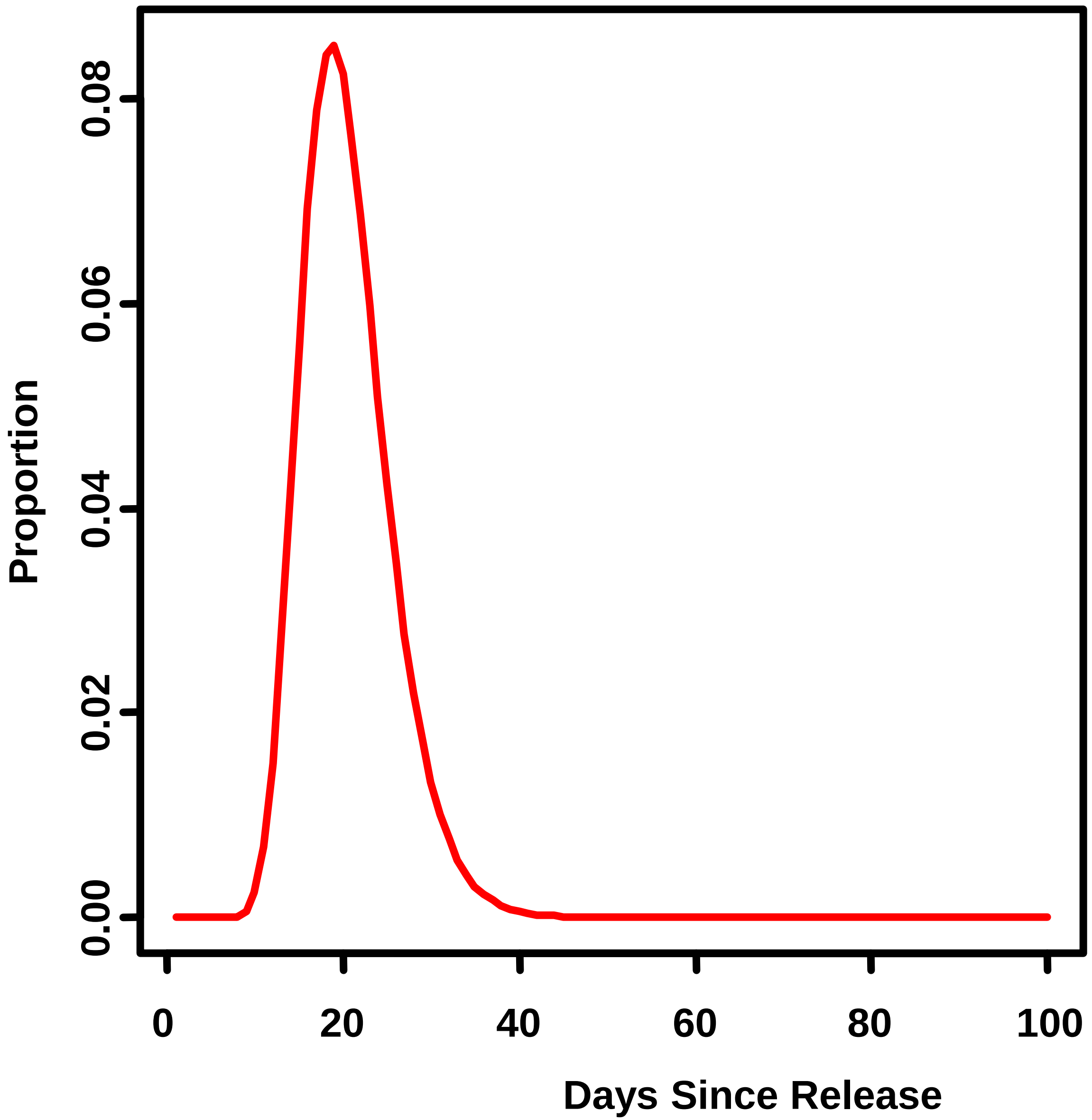
Acknowledgements

Questions?

No Premature Failure



Travel Time Distribution

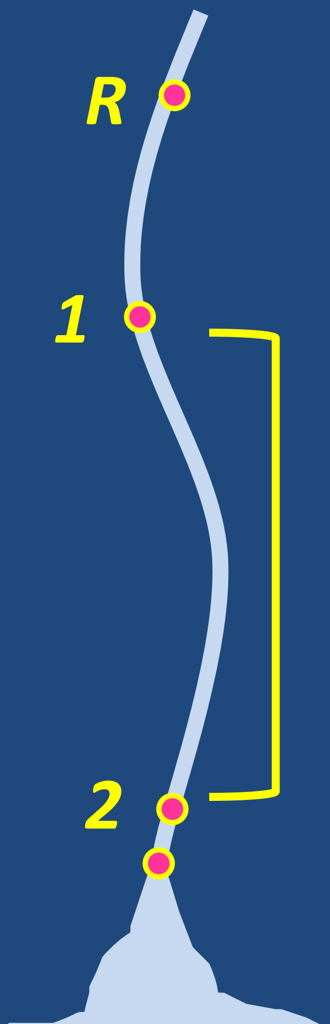


Case Study

Survival estimates: *(January Release)*

	S_{fish}
20-day tag:	
Uncorrected:	***0.22*** *(0.02 SE)*
Corrected (20-d travel time):	***0.22*** *(0.02 SE)*
Corrected (90-d travel time):	***0.30*** *(0.03 SE)*
90-day tag:	***0.30*** *(0.03 SE)*

The Trouble with Tag Failure



S_{fish} x S_{tag} = ***Apparent Survival***

0.80 x *1.00* = *0.80*

0.80 x *0.50* = *0.40*

= σ = *"Joint Fish-Tag Survival"*

Tag Failure Prevented Unbiased Estimates of Fish Survival

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Prepared in cooperation with the
Technical Committee of the Vernalis Adaptive Management Plan and the
San Joaquin River Group Authority

Distribution and Joint Fish-Tag Survival of Juvenile Chinook Salmon Migrating through the Sacramento-San Joaquin River Delta, California, 2008

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Estimating S_{tag}

Traditional Mark-Recapture Model (known fate example)

Capture History	Likelihood
11	S
10	$(1-S)$

Include Tag Failure Probabilities (Townsend et al. 2006)

Capture History	Likelihood
11	$S_{fish} * S_{tag}$
10	$(1-S_{fish}) + (S_{fish} * (1-S_{tag}))$

REQUIRES AN ESTIMATE OF TAG SURVIVAL

Correcting S_{fish} with CWT Travel Times

	S_{fish}
Uncorrected:	***0.068*** *(0.015 SE)*
Corrected (obs. travel time):	***0.076*** *(0.016 SE)*
Corrected (2002 travel time):	***0.088*** *(0.019 SE)*
Corrected (2001 travel time):	***0.078*** *(0.017 SE)*
Corrected (1995 travel time):	***0.128****(0.028 SE)*

N=54; similar SJR flow (~3200 cfs)

Correcting S_{fish} with CWT Travel Times

	S_{fish}
Uncorrected:	***0.068*** *(0.015 SE)*
Corrected (obs. travel time):	***0.076*** *(0.016 SE)*
Corrected (2002 travel time):	***0.088*** *(0.019 SE)*
Corrected (2001 travel time):	***0.078*** *(0.017 SE)*
Corrected (1995 travel time):	***0.128****(0.028 SE)*

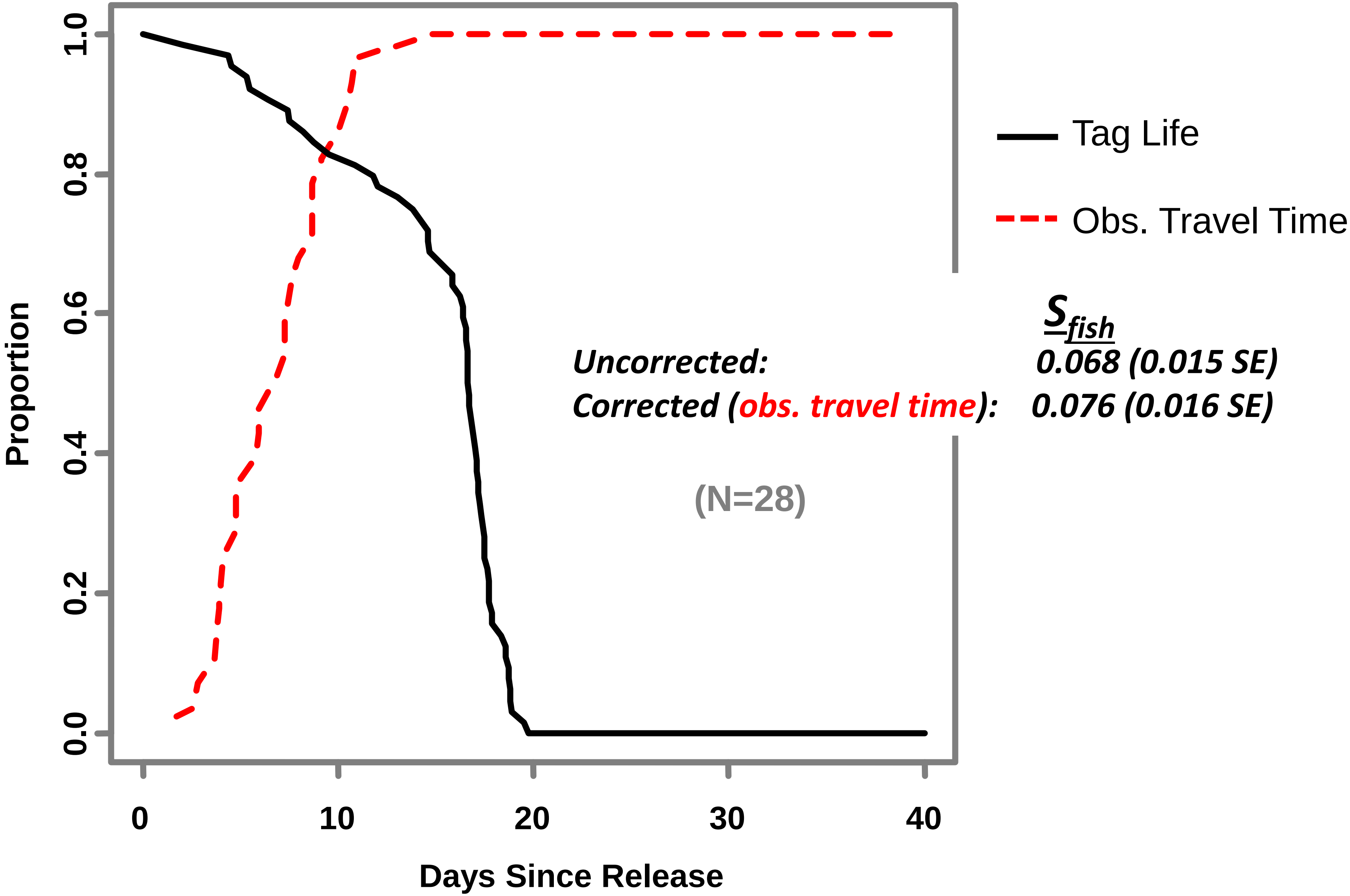
N=101; higher SJR flow (~4200 cfs)

Correcting S_{fish} with CWT Travel Times

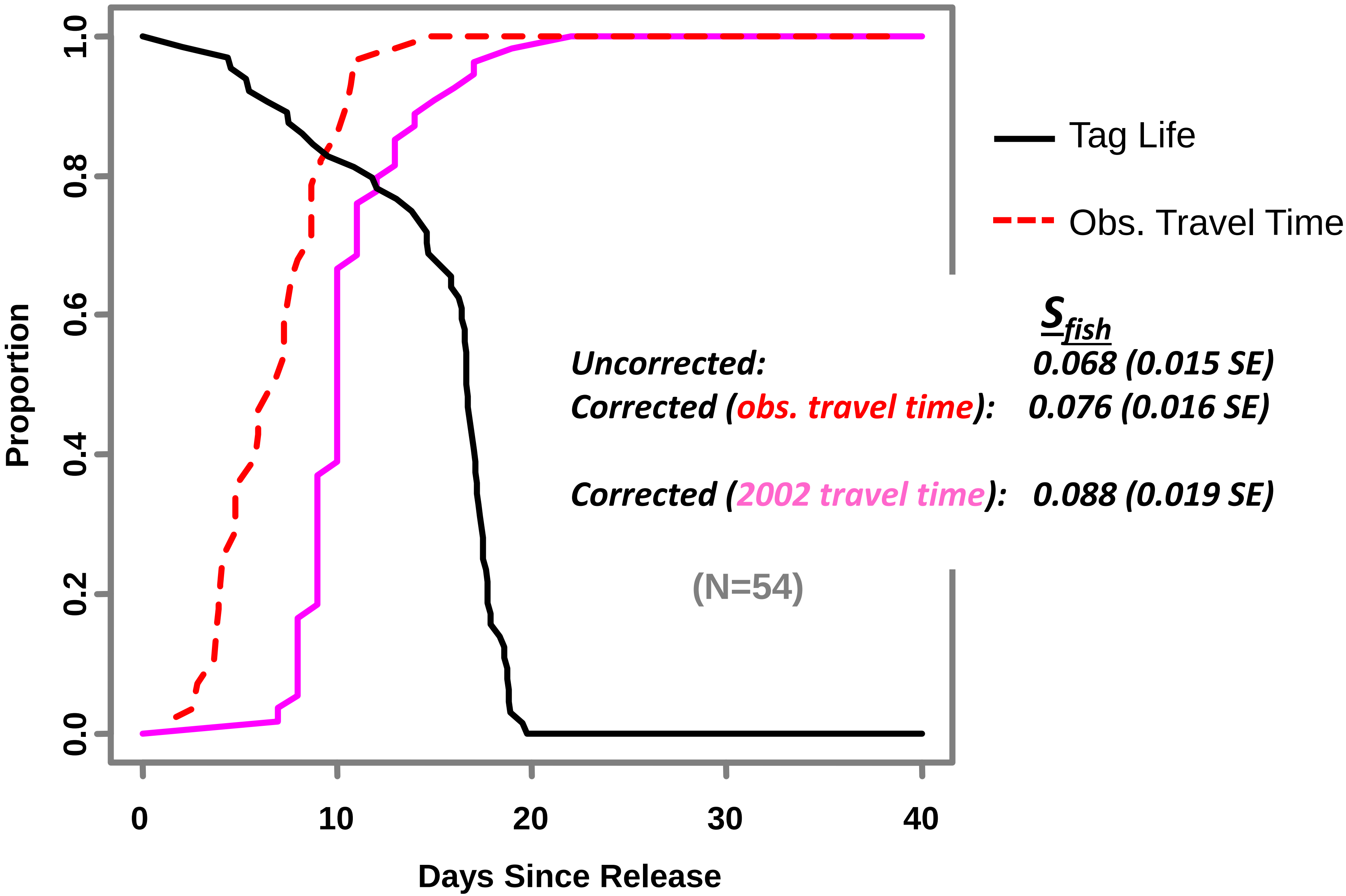
	S_{fish}
Uncorrected:	***0.068*** *(0.015 SE)*
Corrected (obs. travel time):	***0.076*** *(0.016 SE)*
Corrected (2002 travel time):	***0.088*** *(0.019 SE)*
Corrected (2001 travel time):	***0.078*** *(0.017 SE)*
Corrected (1995 travel time):	***0.128*** *(0.028 SE)*

N=41; much higher SJR flow (17-23 kcfs)

Sensitivity to CWT Travel Times?



Sensitivity to CWT Travel Times?



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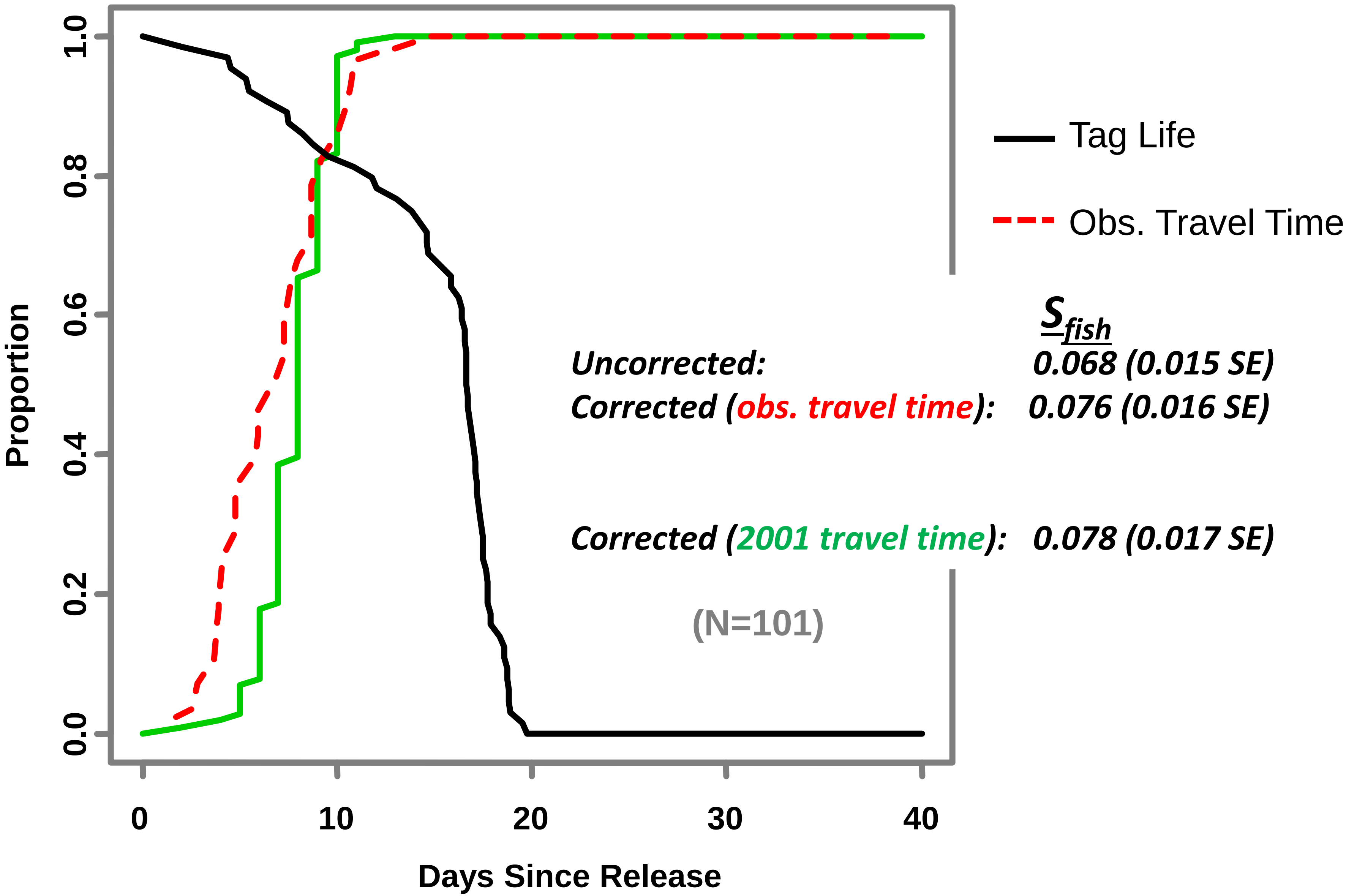
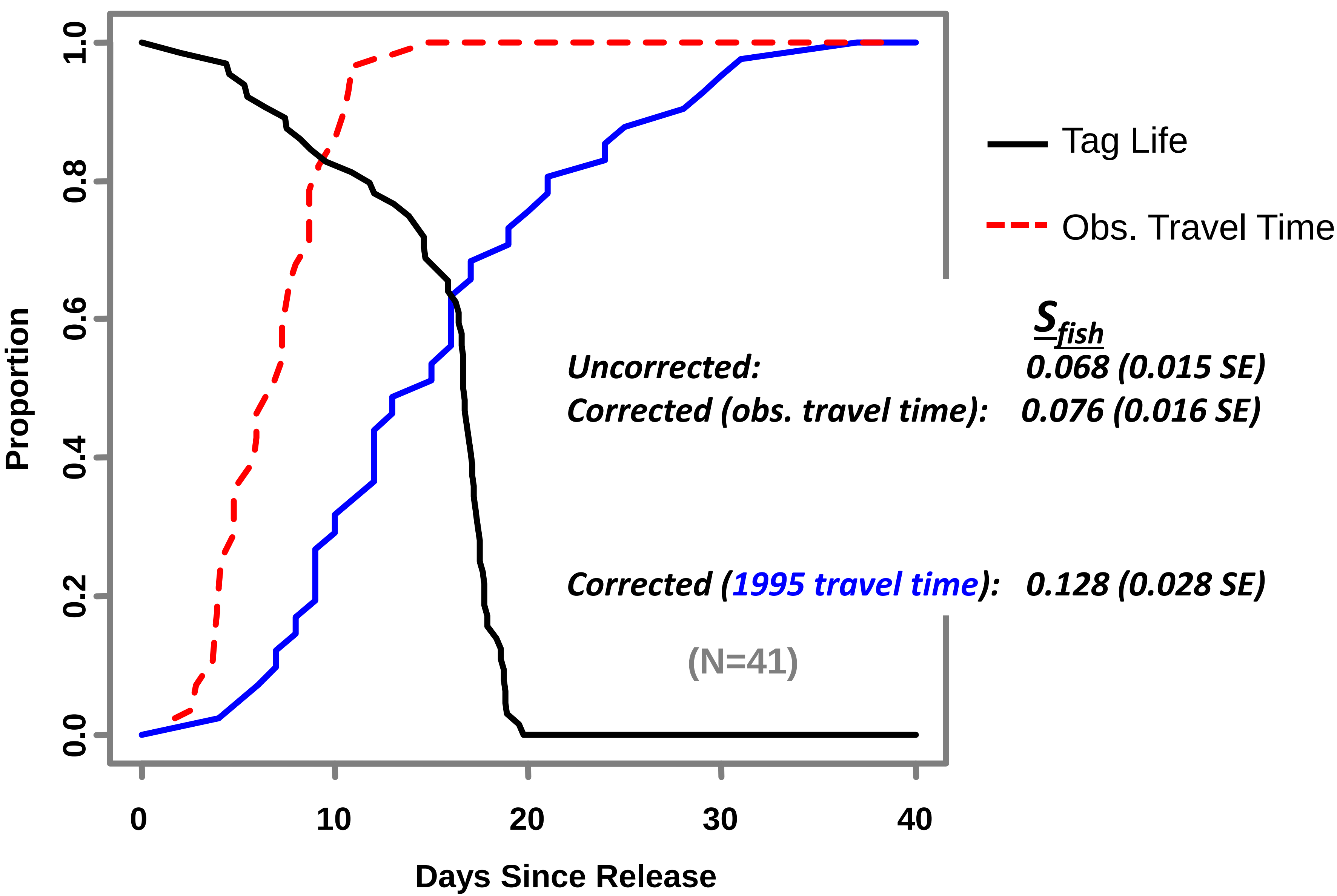


Sensitivity to CWT Travel Times?



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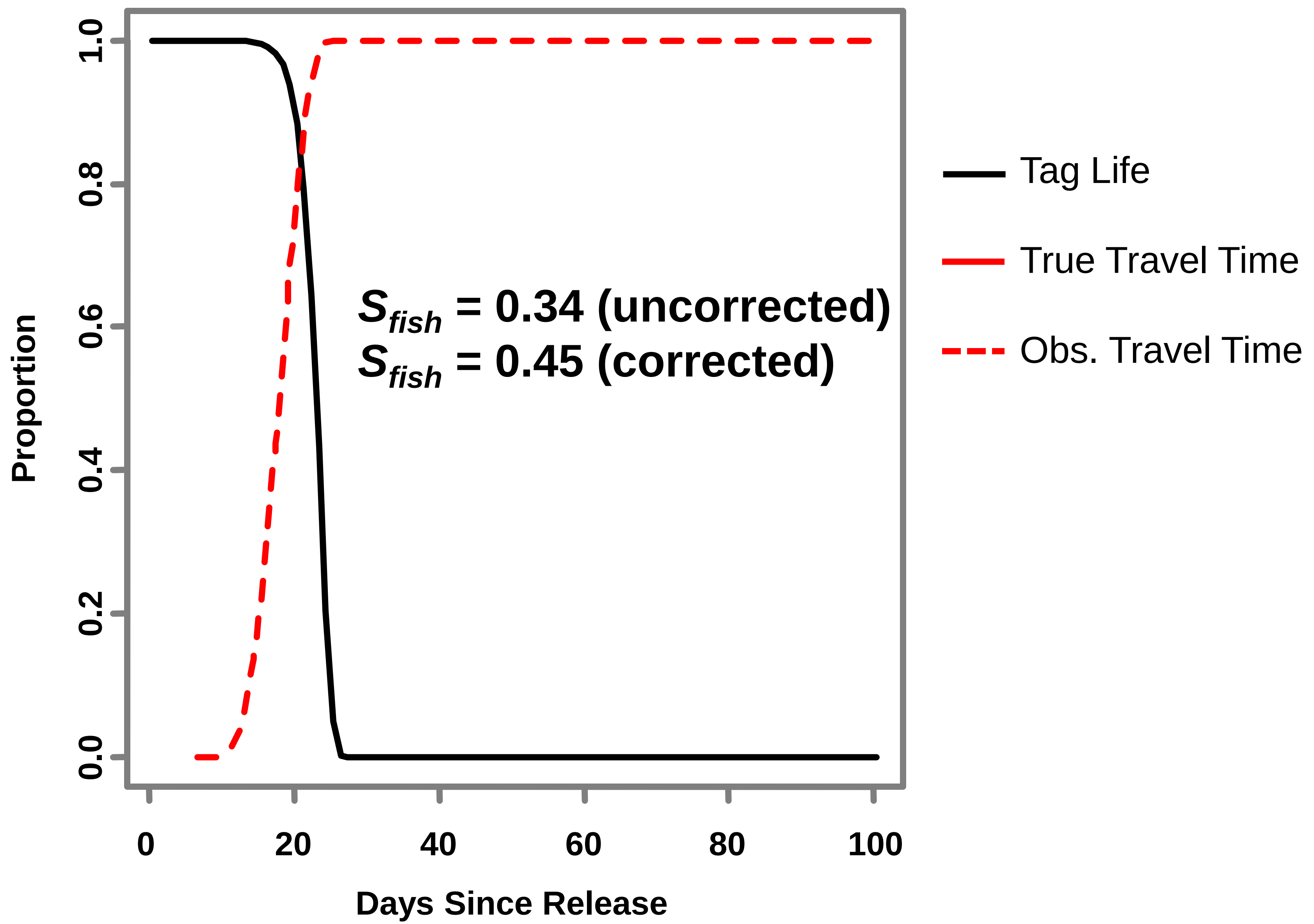
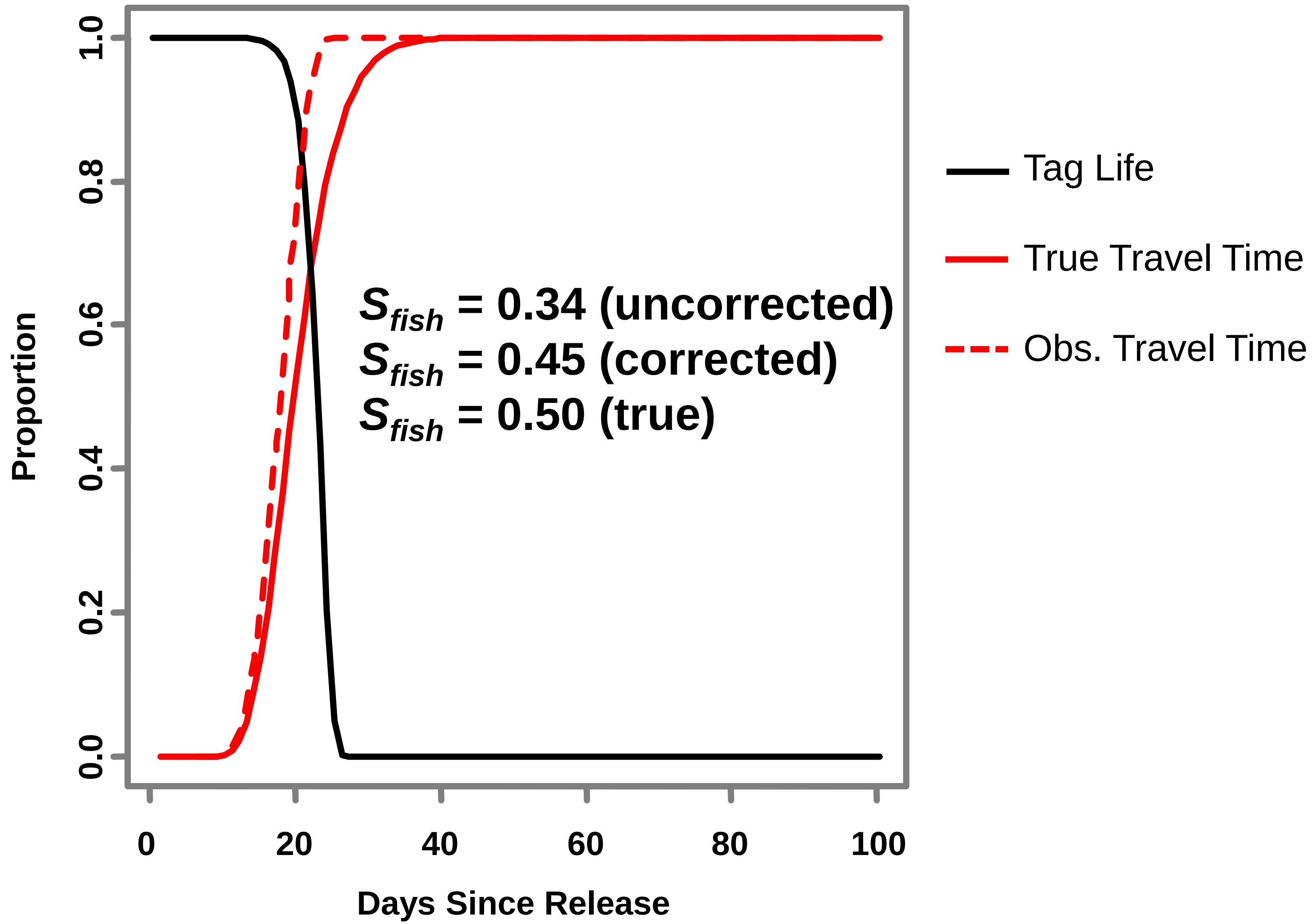
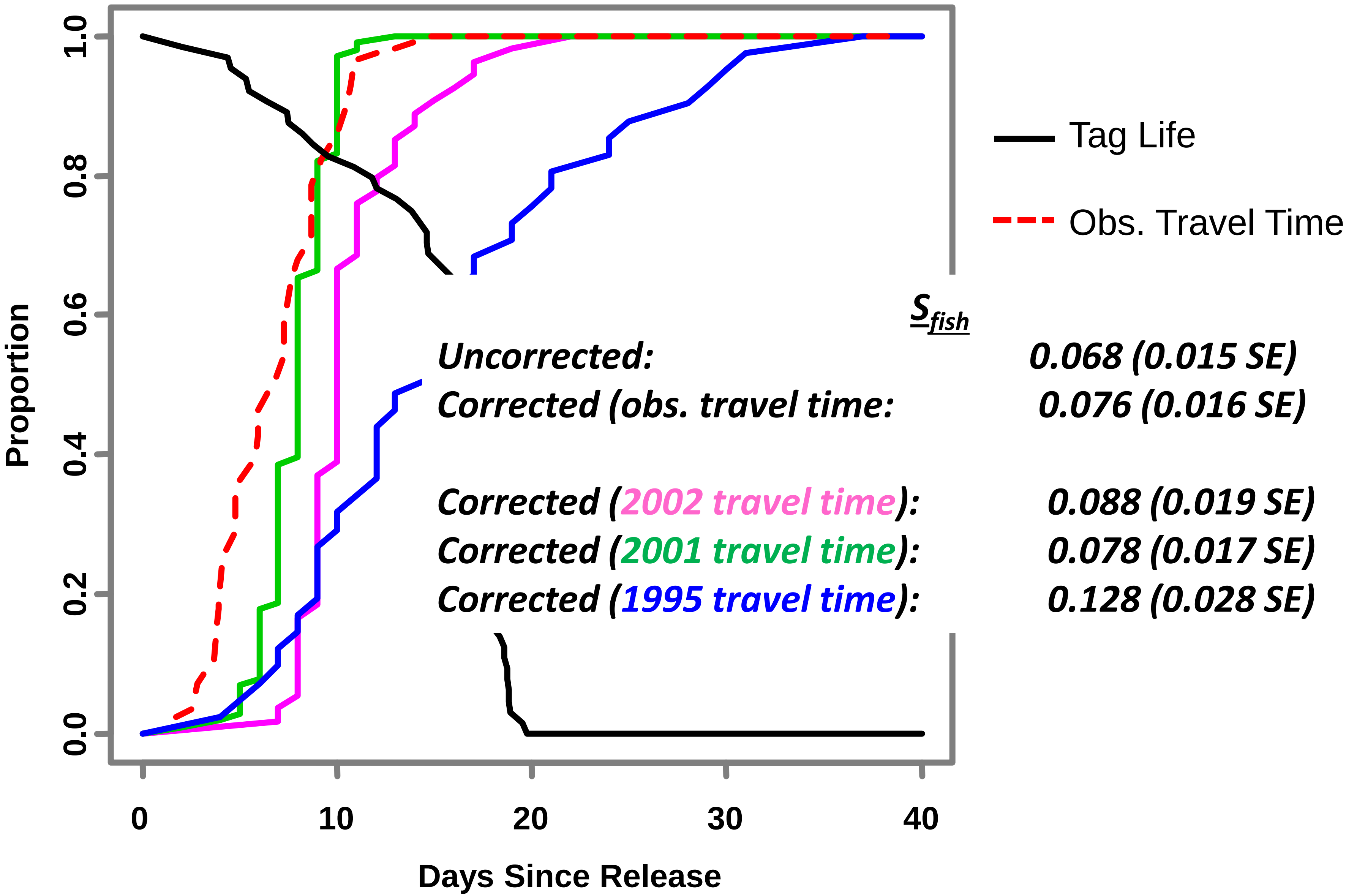
Premature Failure (S_{tag} = 0.67)



Premature Failure (S_{tag} = 0.67)



Sensitivity Analysis?



	S_{fish}
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