

Effects of sea lion predation on Willamette River winter steelhead viability



Matt Falcy
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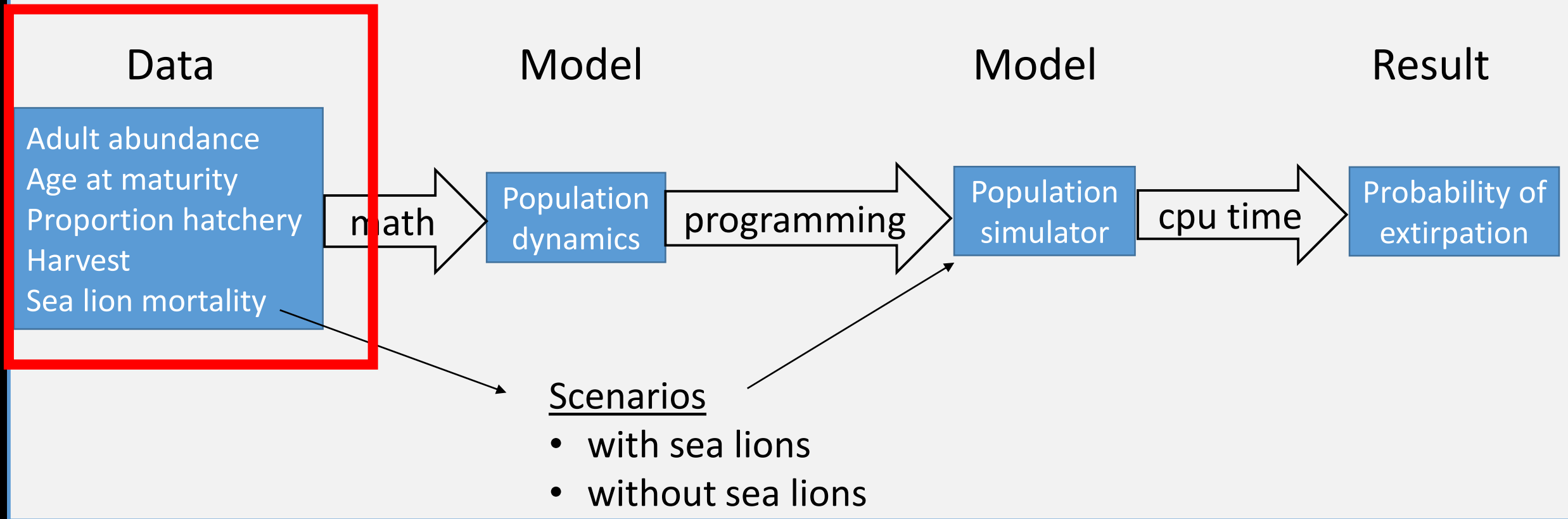


**Willamette
Falls**



Goal: Quantify threat of extirpation posed by sea lions

Method: Population Viability Analysis (PVA)



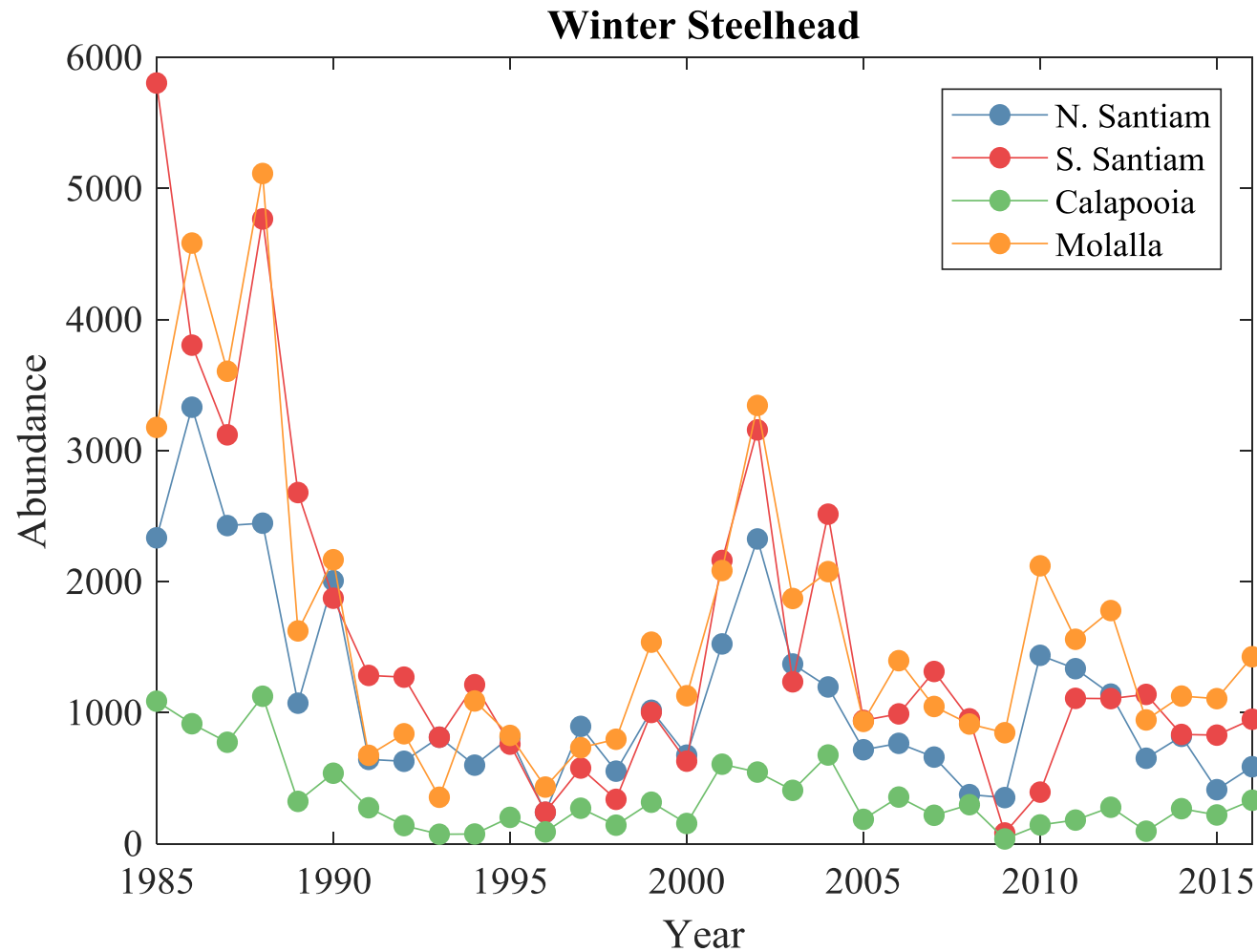
Steelhead Spawner Abundance

Base enumeration

- counted at Willamette Falls (WF)
- 62% at WF spawn in focal populations (U of I)

Apportion to populations

- amount of spawning habitat
- redd-density surveys
- multiple imputation for missing observations



Sea Lion Predation

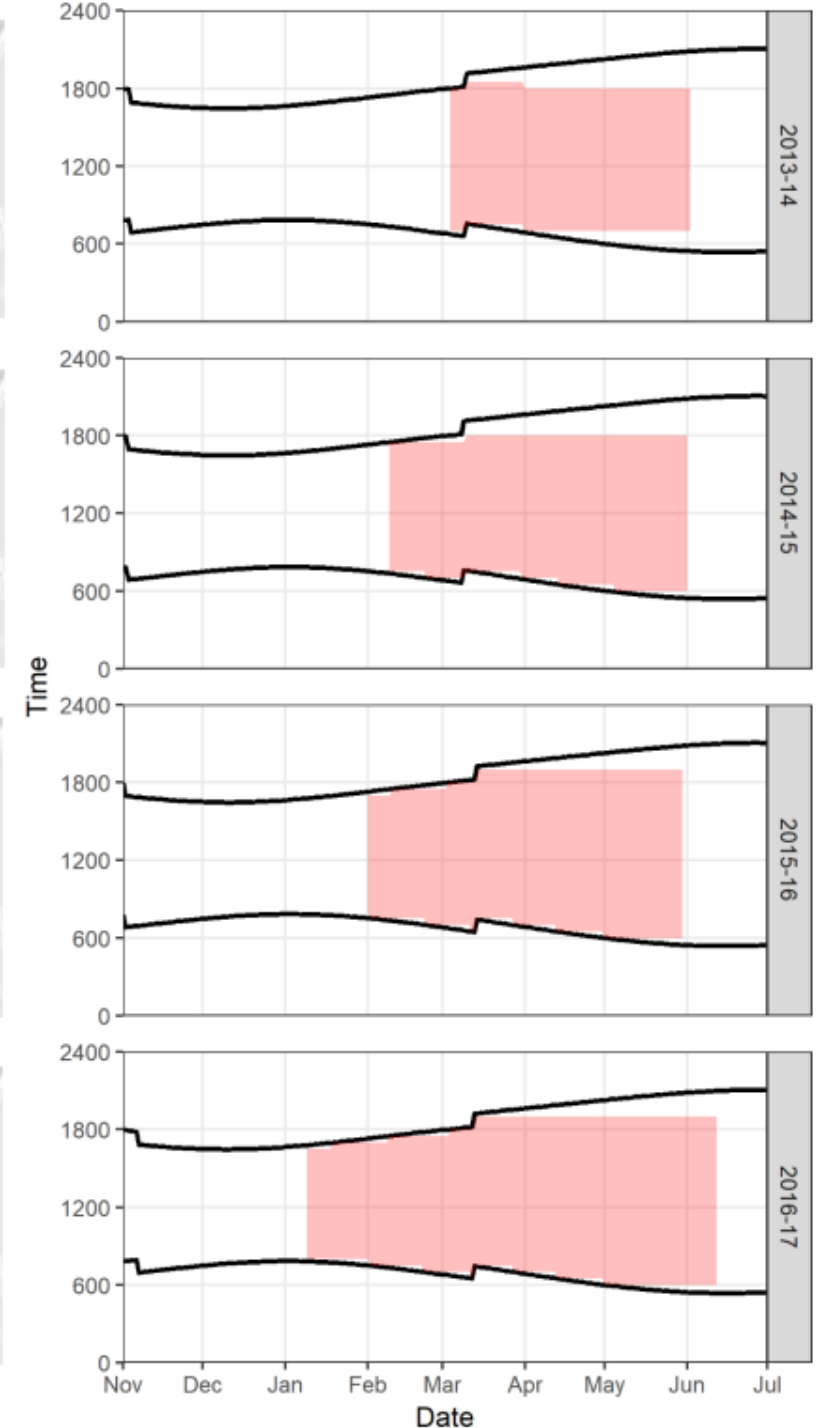
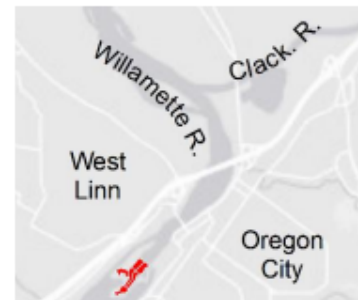
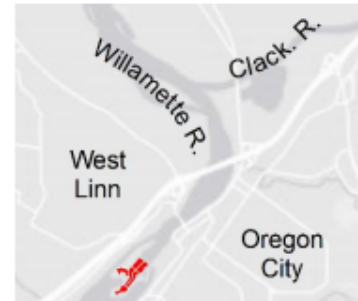
Observe (surface) feeding events

Stratified three-stage cluster sampling design

- days of week
- site-shift (block of hours at given site)
- 30-min observation bouts (3 of 4)

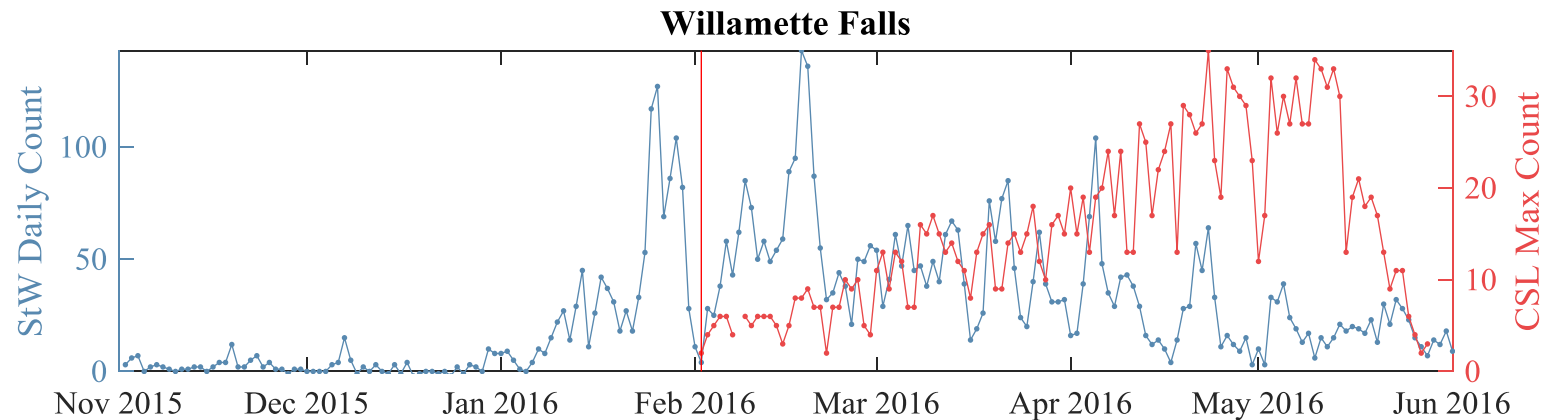
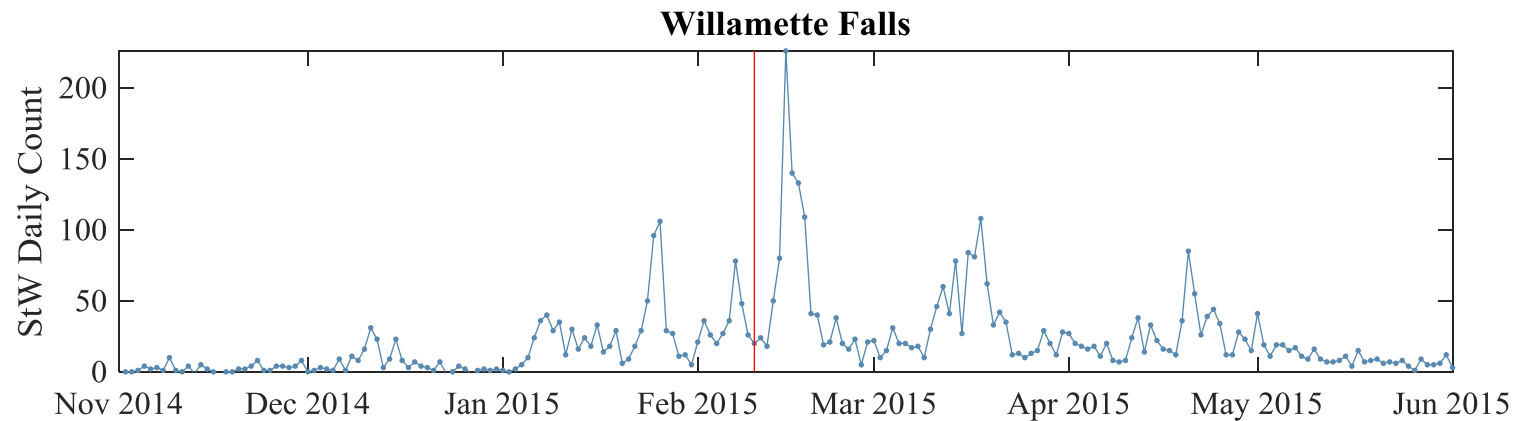
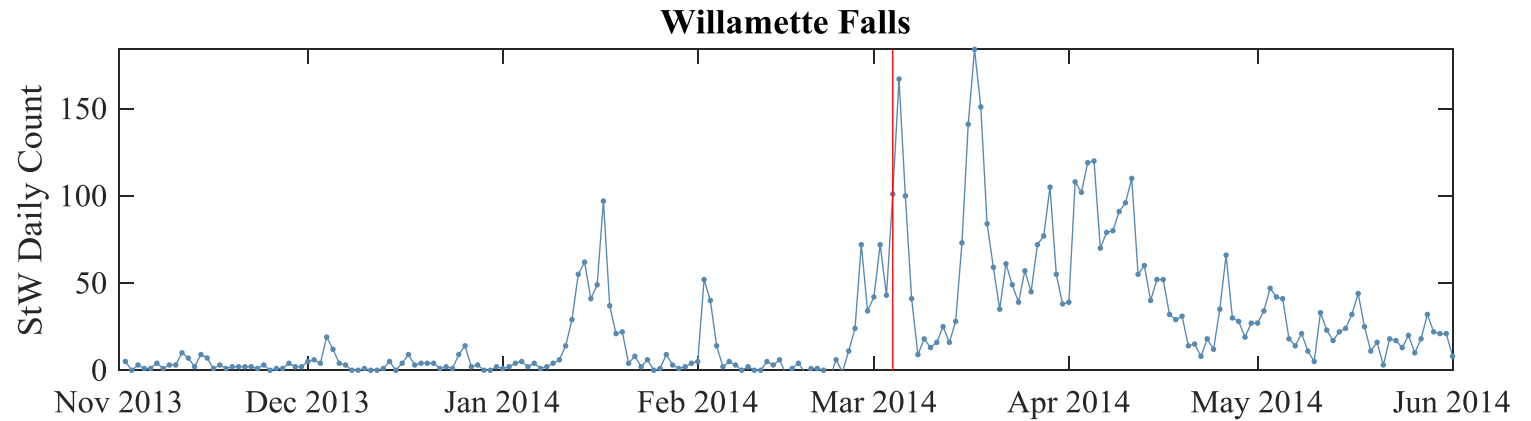
Predation events assigned to species

- observed
- species composition at window (1, 7, 14 d)
- Monte Carlo



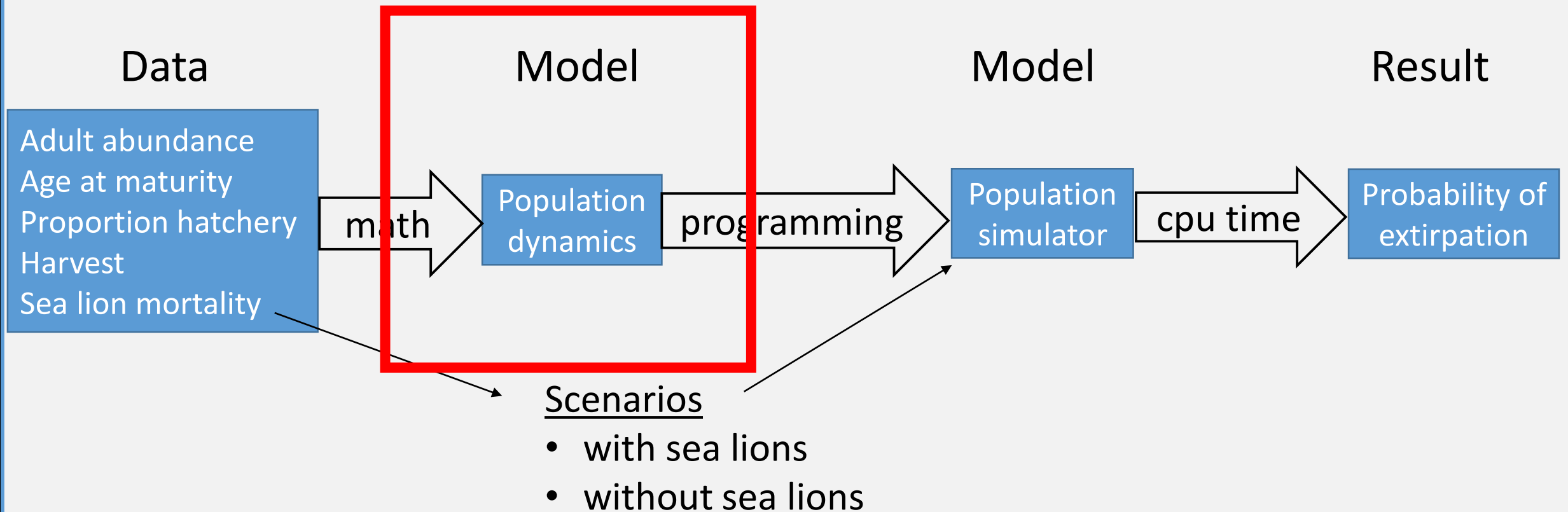
Sea Lion Predation

Expand estimated predation for steelhead run passing before predation monitoring.



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Population Dynamics

- Density-dependence
- Sea lion predation identical to fishing
- Multi-model inference

Bayesian analysis

- Yields probability-based inference for parameters.
- MCMC provides random draws of parameters that include covariance.

Three Ricker models

$R_{t,p} = \alpha_p S_{t,p} e^{-\beta_p S_{t,p} \varepsilon_{t,p}}$ Each pop separate, $k=12$, WAIC=224.8

$R_{t,p} = \alpha_p S_{t,p} e^{-\beta_p S_{t,p} \varepsilon_{t,p}}$ Shared error variance, $k=9$, WAIC=248.9

$R_{t,p} = \alpha S_{t,p} e^{-\beta_p S_{t,p} \varepsilon_{t,p}}$ Shared productivity, $k=9$, WAIC=217.6

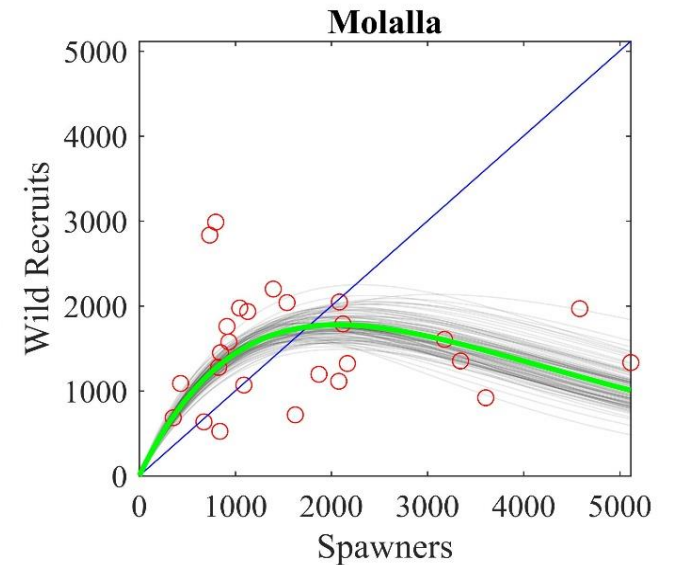
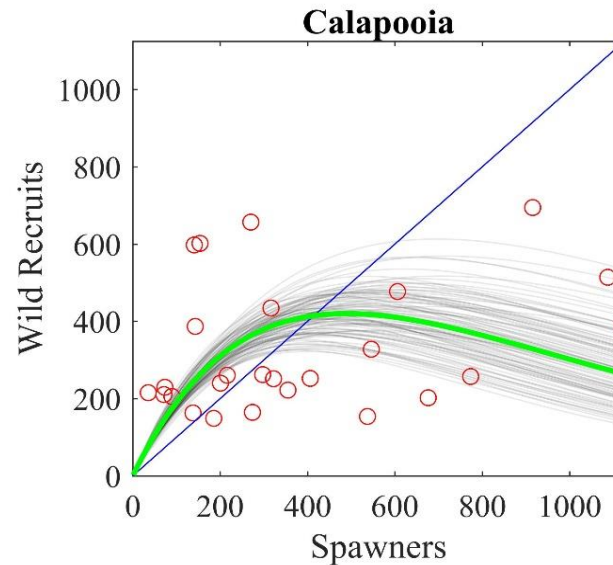
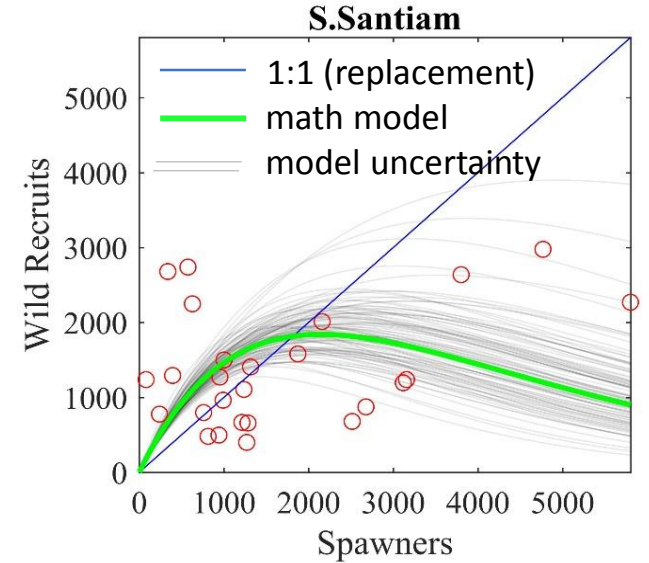
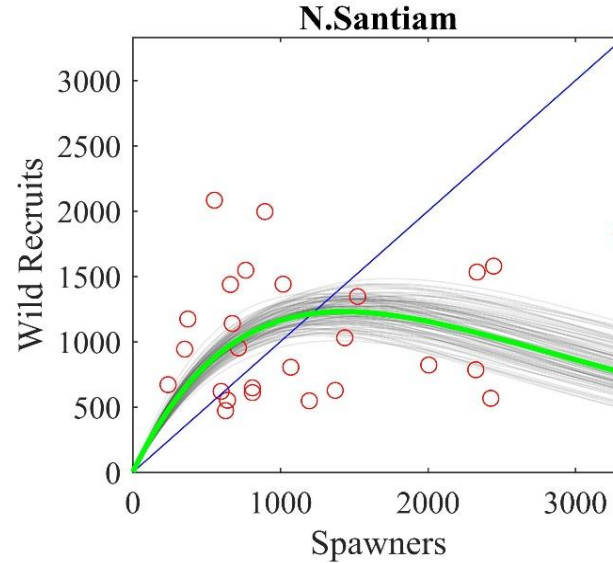


Population Dynamics

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- Sea lion predation identical to fishing
- Multi-model inference

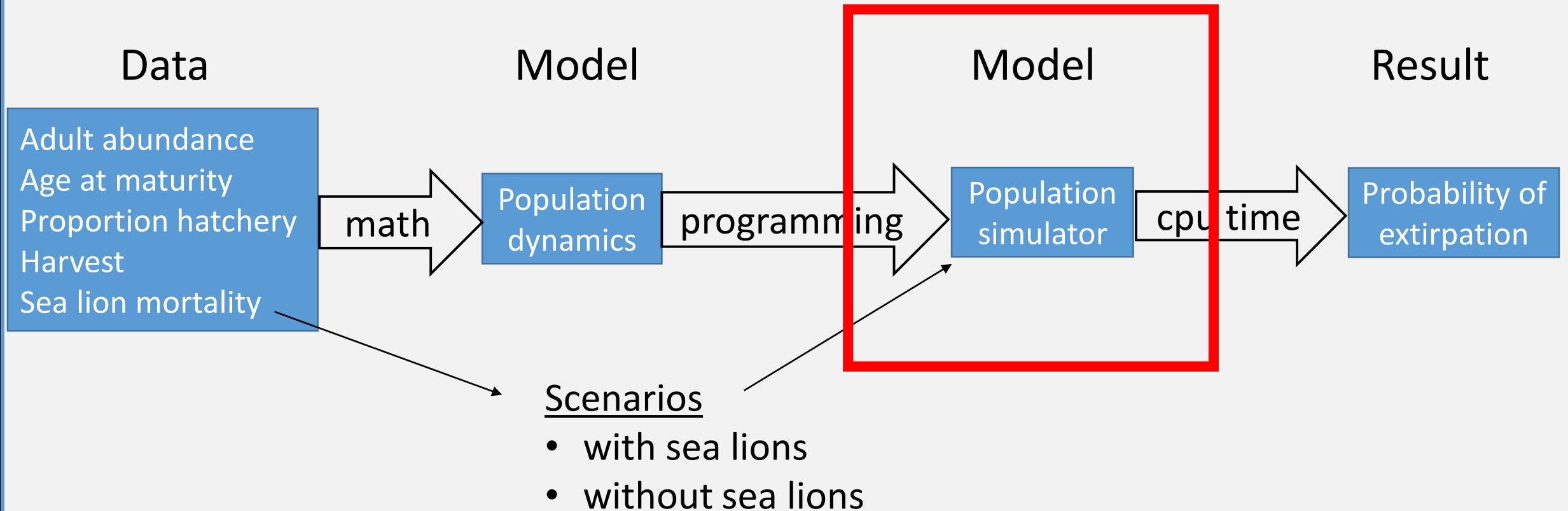
Bayesian analysis

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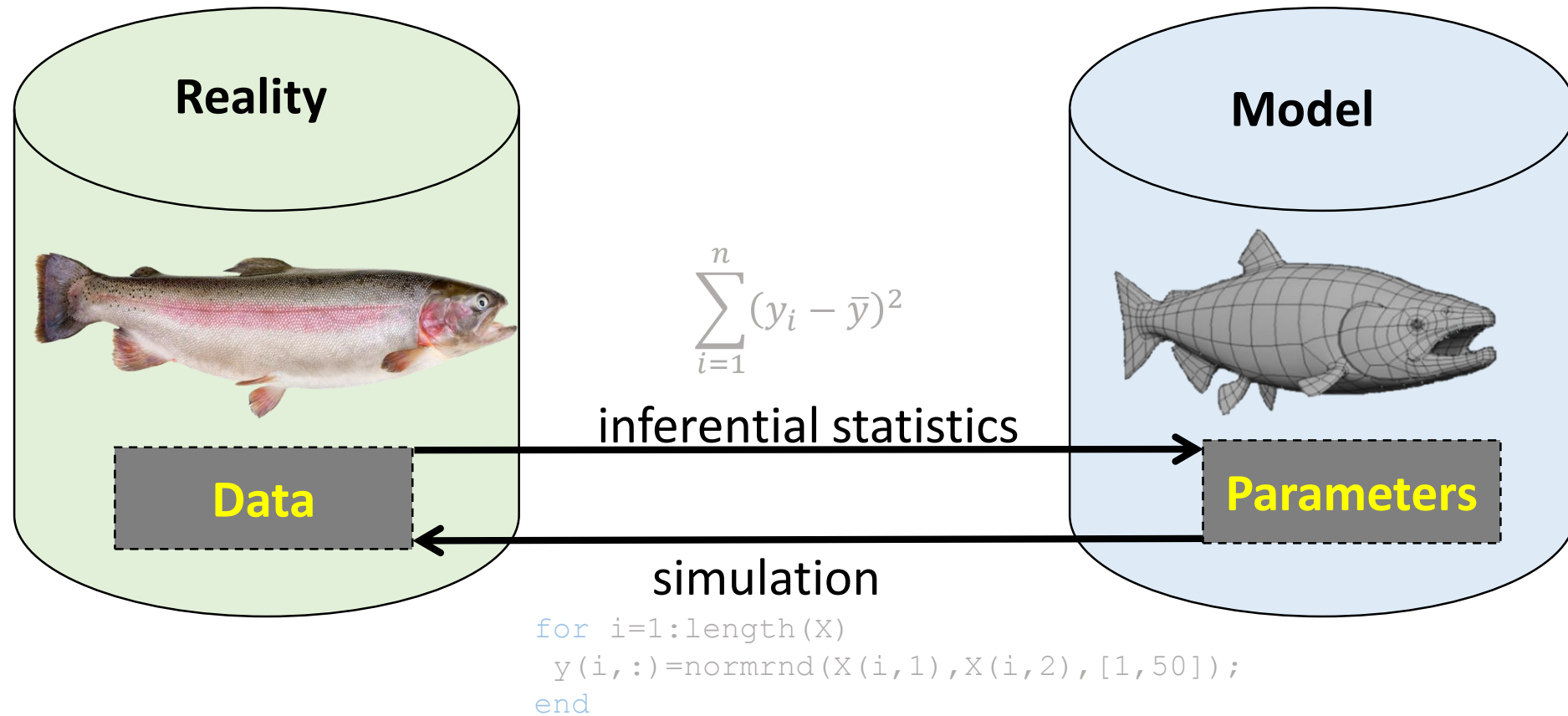


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Population Simulator



Population Simulator

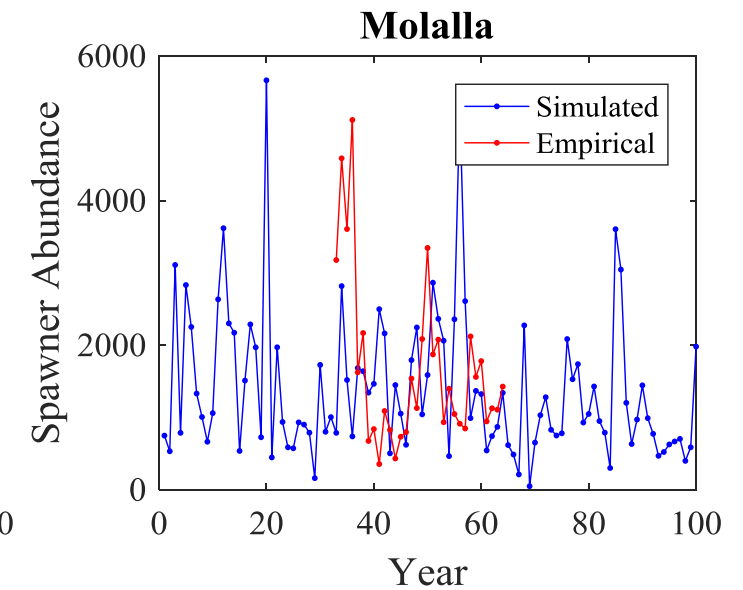
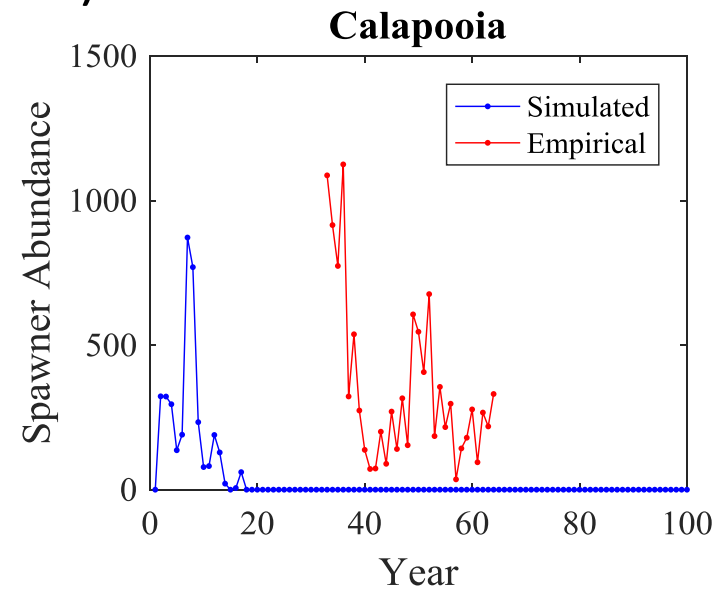
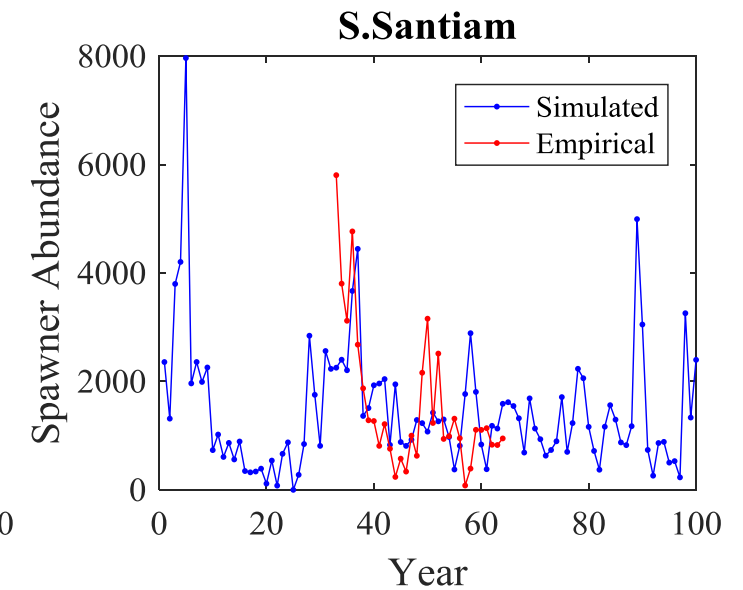
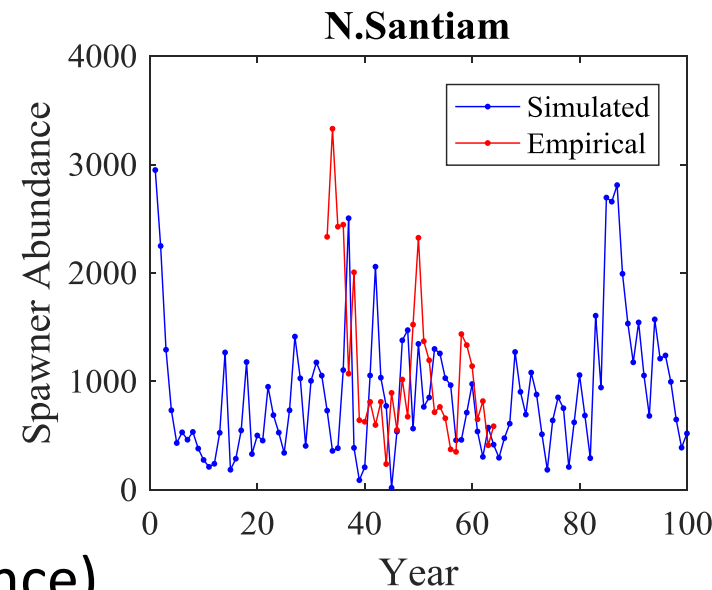
Replication

1000 random draws of parameters per population
each draw used to simulate 100 years
+ process above replicated 100 times
= 100,000 simulations of 100 years per population

Allee effects (negative density dependence)

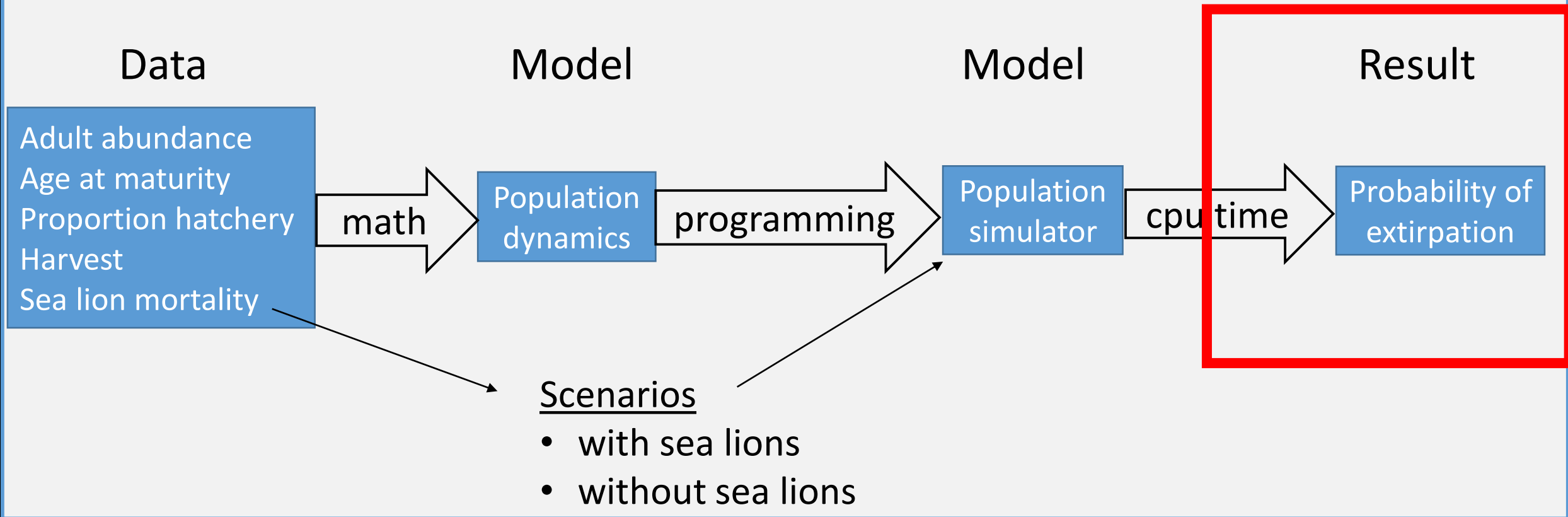
- If $N_t < 100$, then no reproduction
- If $N_{t:t+3} < 100$ (4 consecutive years), then functionally extirpated

$$\text{Pr}[\text{extirpation}] = \# \text{extirpations} / 100,000$$



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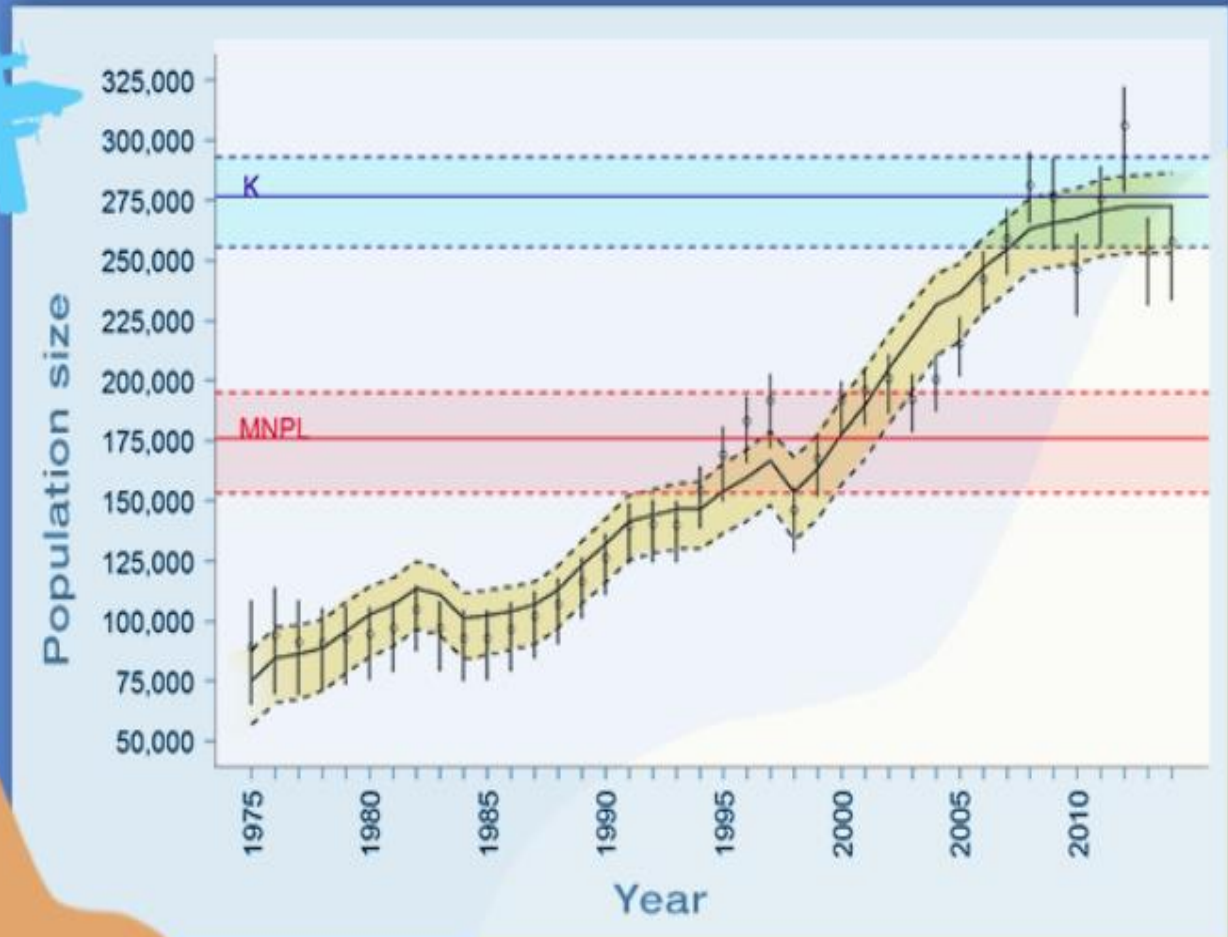


Probability of Extirpation

Scenario		Population			
		North Santiam	South Santiam	Molalla	Calapooia
Without Sea Lions:		2%	5%	0%	99%
With Sea Lions:	lowest observed predation (2015)	8%	16%	0%	99%
	average predation (2016)	27%	34%	2%	99%
	highest observed predation (2017)	64%	60%	21%	99%

Management

- Sea lions functionally extirpated steelhead at Ballard Locks, Seattle
- Non-lethal deterrence is ineffective (20+ years)
- “Take” under Marine Mammal Protection Act is a long process



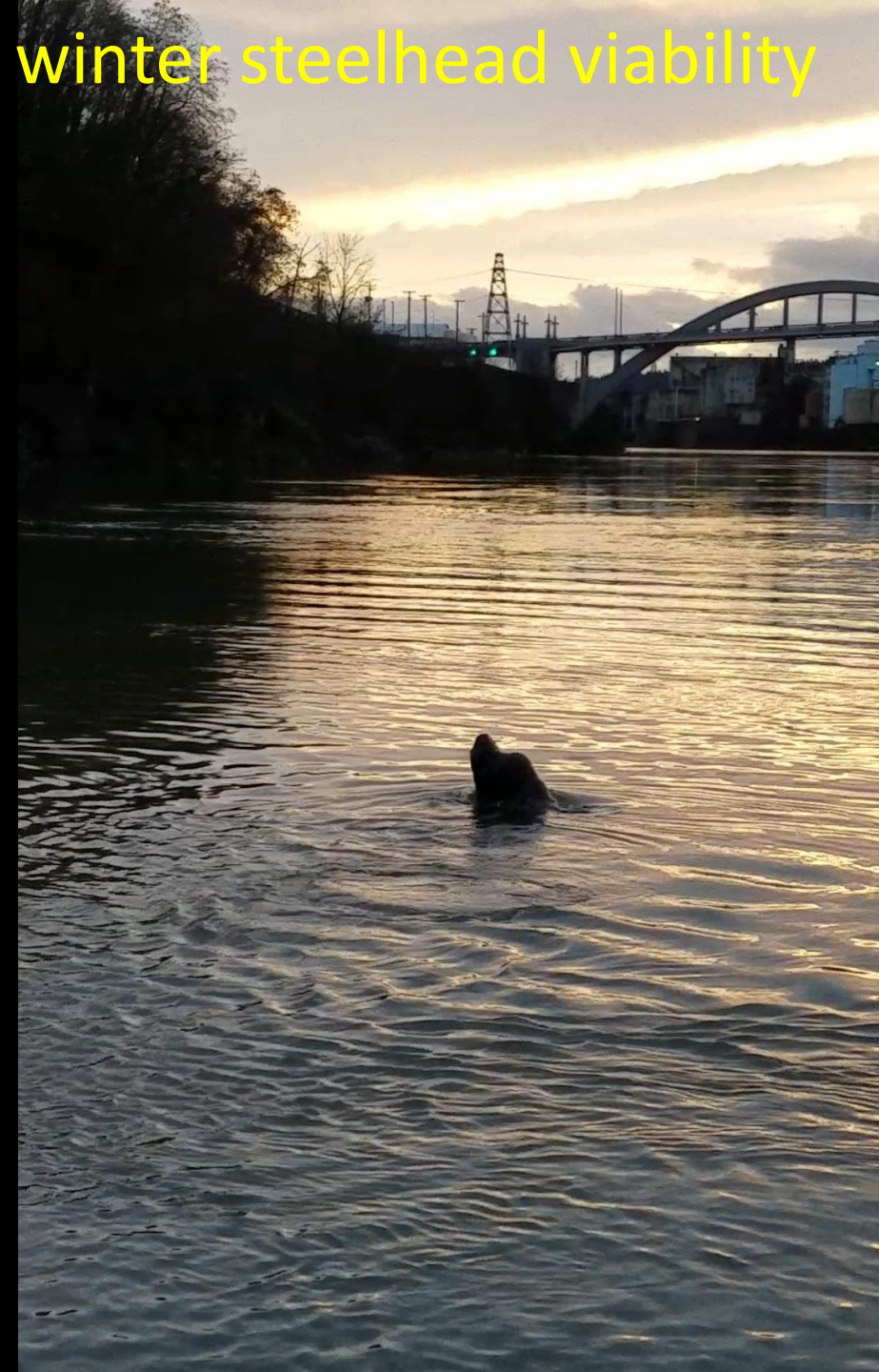
California sea lion population, 1975-2014

Source: NOAA Fisheries

California sea lion numbers have grown steadily since the 1970s, the new study shows. The yellow band reflects the approximate population size, while K represents carrying capacity and MNPL is maximum net productivity level (the population level for maximum growth). The range above MNPL and below K is the optimum sustainable population, which the Marine Mammal Protection Act sets as the goal for protected species.

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Reproducible results: www.falcy.weebly.com/pva
(data and code)



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