Effects of Sea Lion Predation on Willamette River Salmonid Viability

Presenter: Matt Falcy

Corresponding Summary Page(s):
18-21

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OREGON Fish & Wildlife
Matt Falcy

Population Viability of Willamette River Winter Steelhead

An assessment of the effect of sea lions at Willamette Falls

July 7, 2017

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Spring Chinook Status Assessment

McKenzie, Clackamas, and Sandy River Populations

A memorandum to

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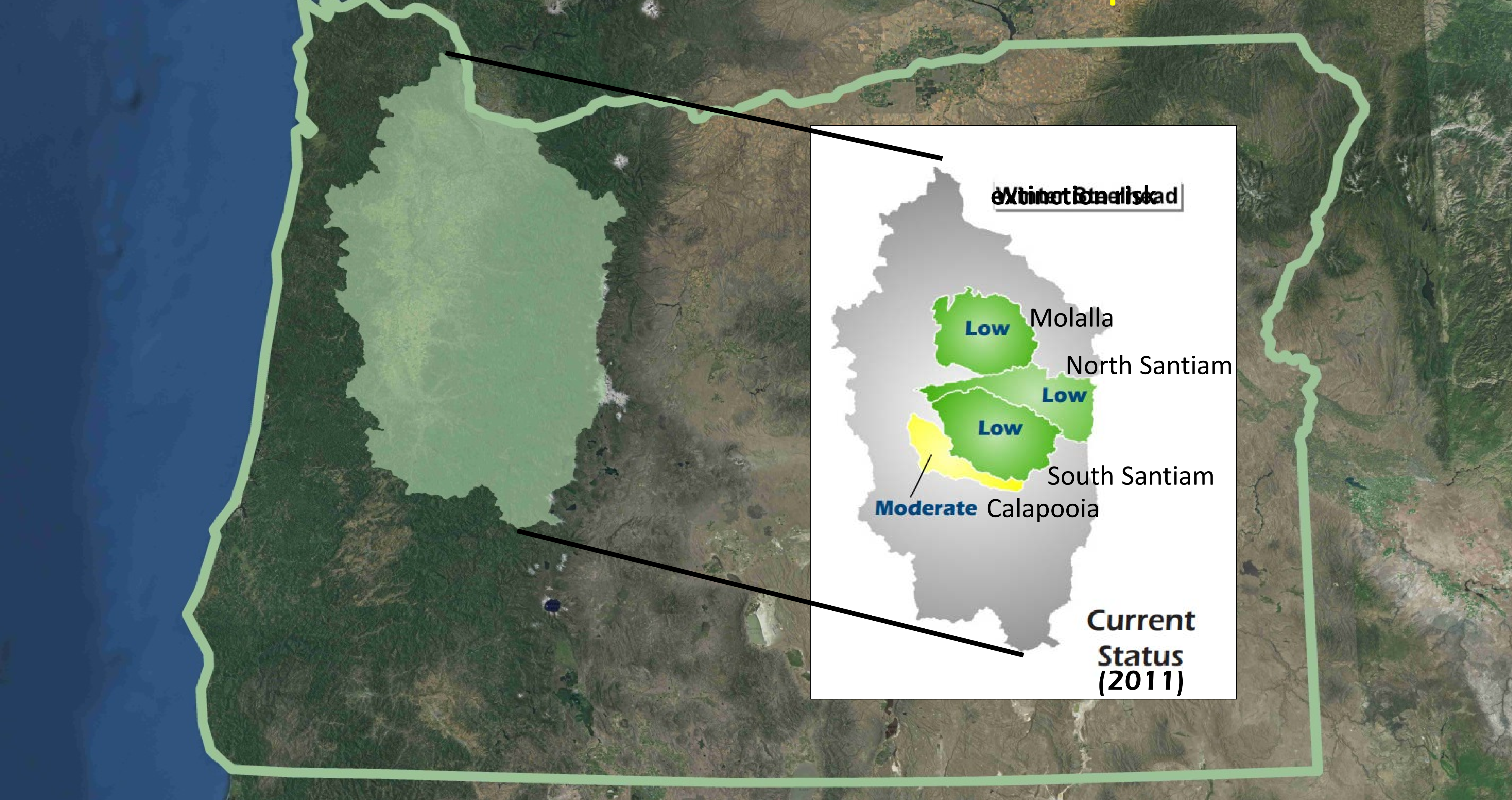
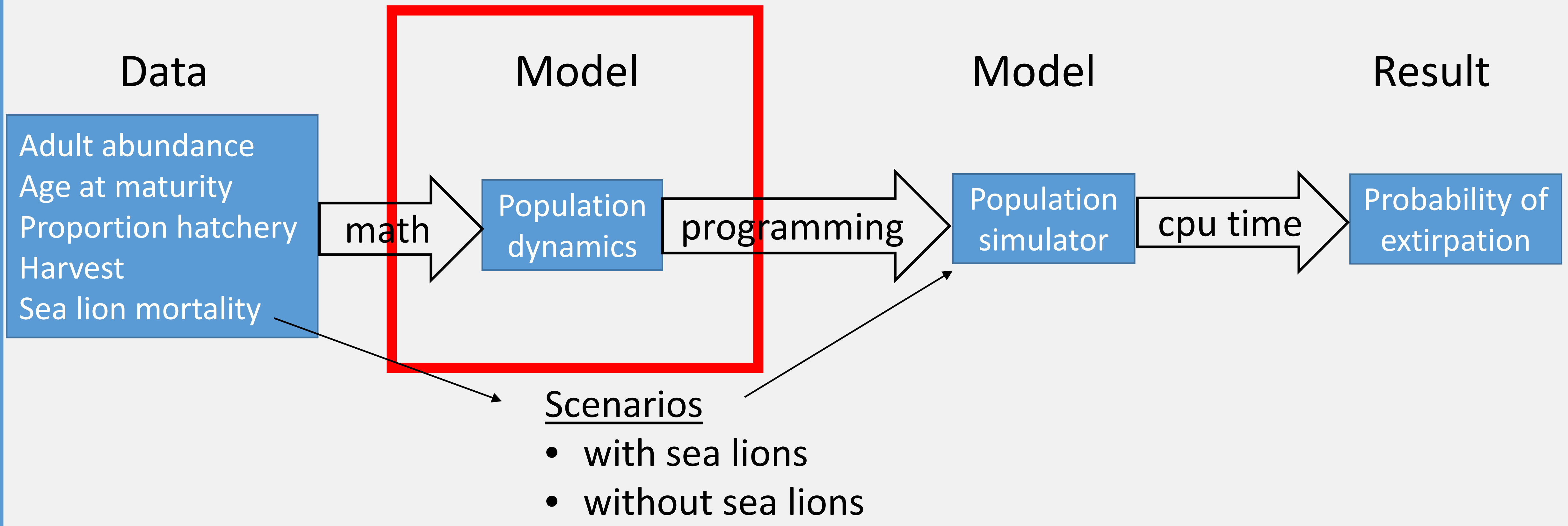
Willamette winter Steelhead Populations

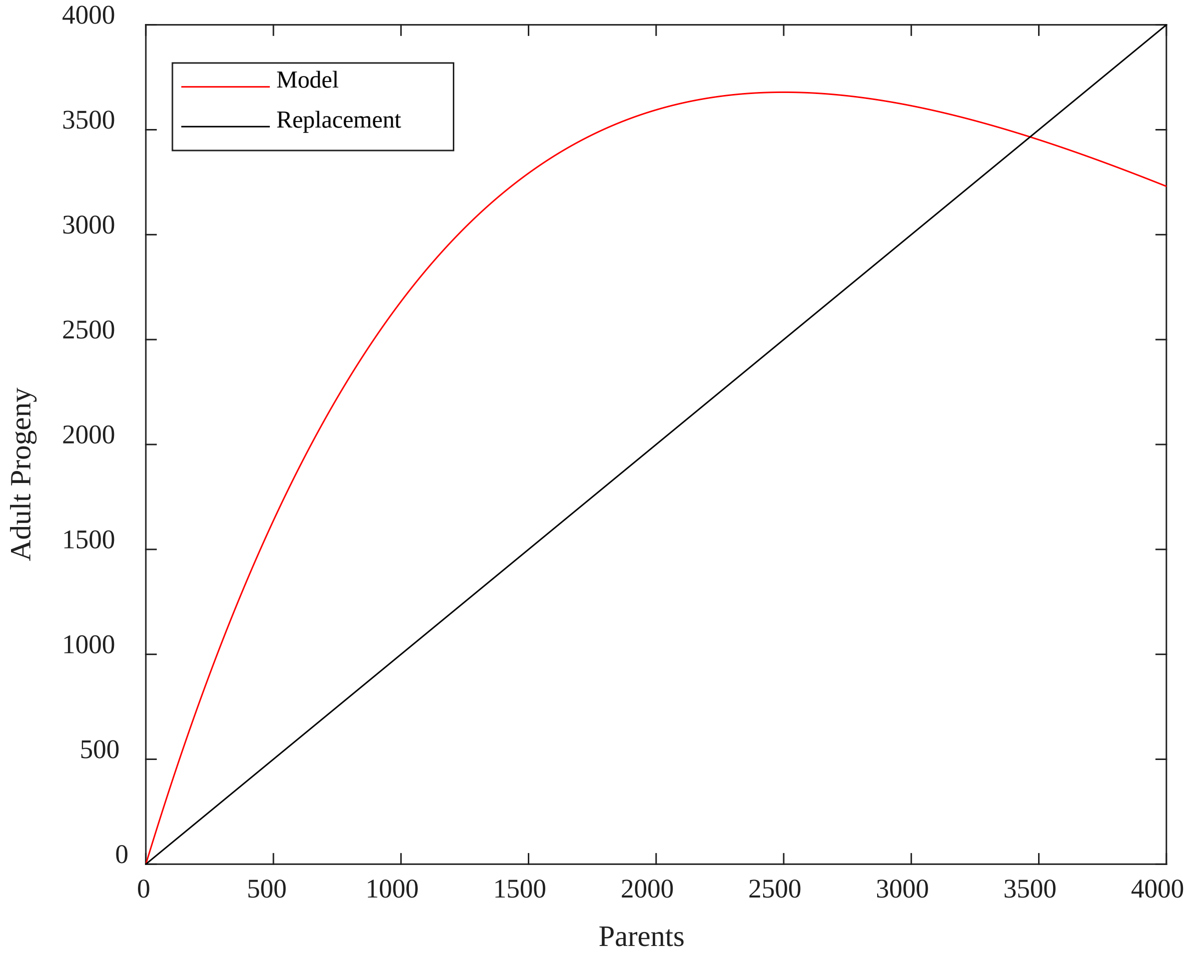


Goal: Quantify threat of extirpation posed by sea lions

Method: Population Viability Analysis (PVA)



A stock-recruitment model reveals density-dependent population dynamics



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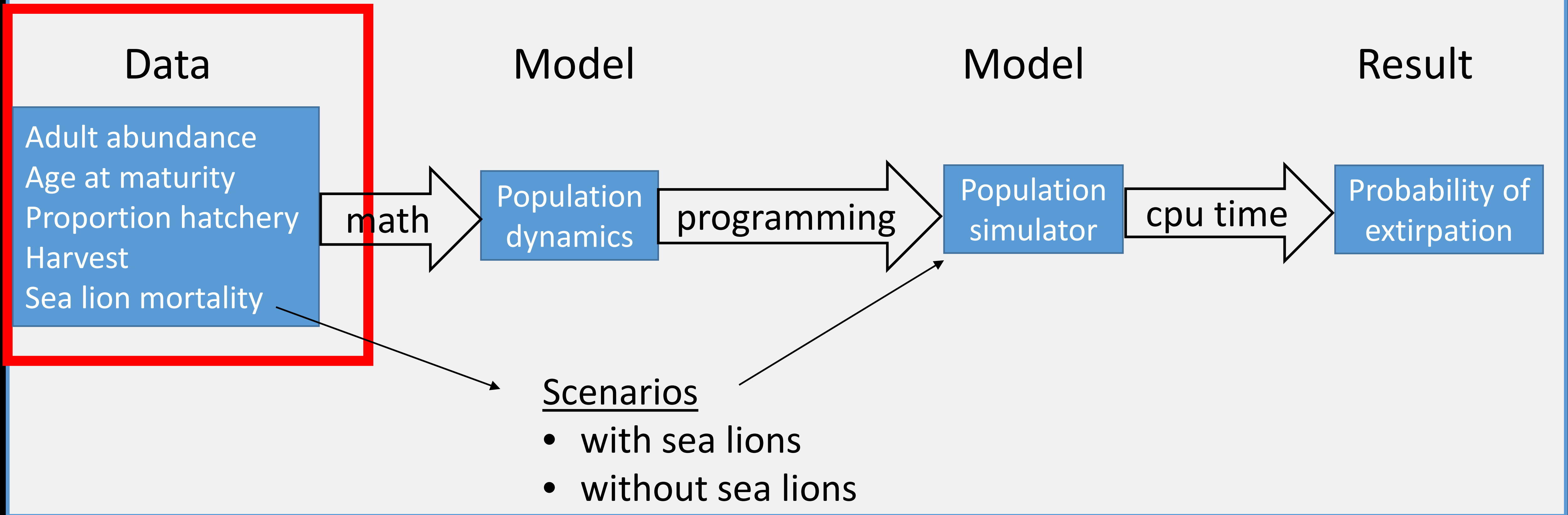


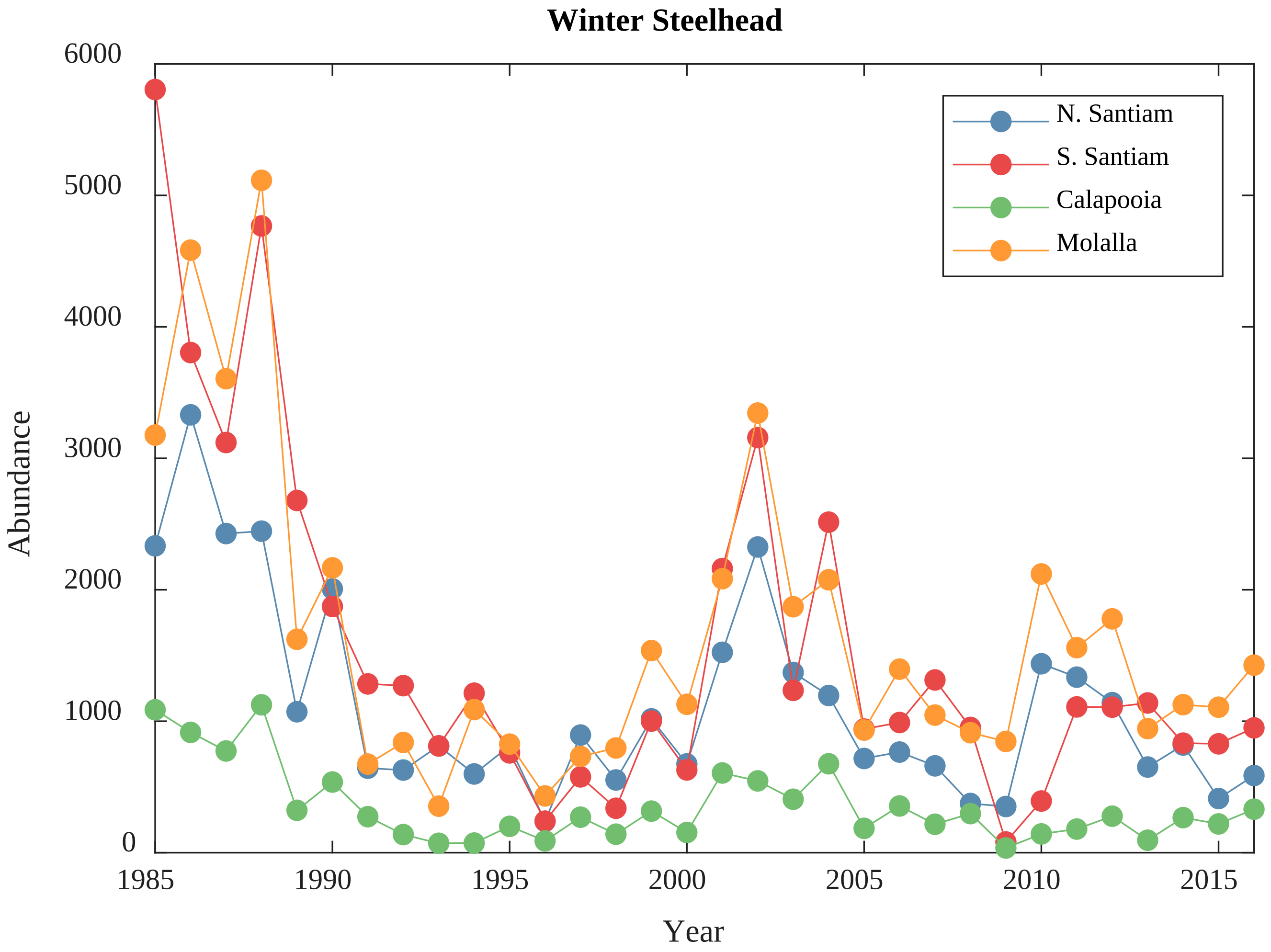
Steelhead Spawner Abundance

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

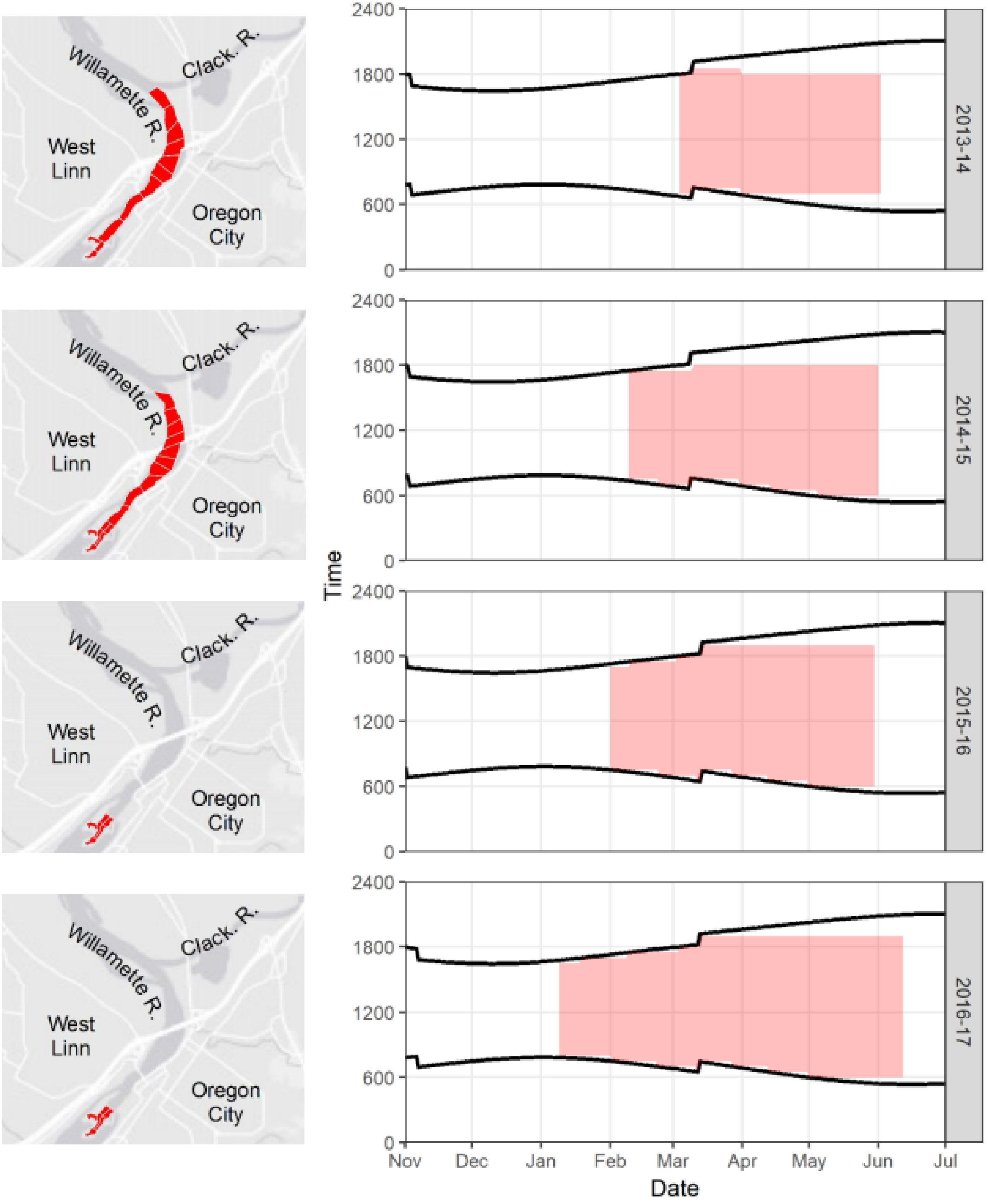
Observe (surface) feeding events

Stratified three-stage cluster sampling design

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

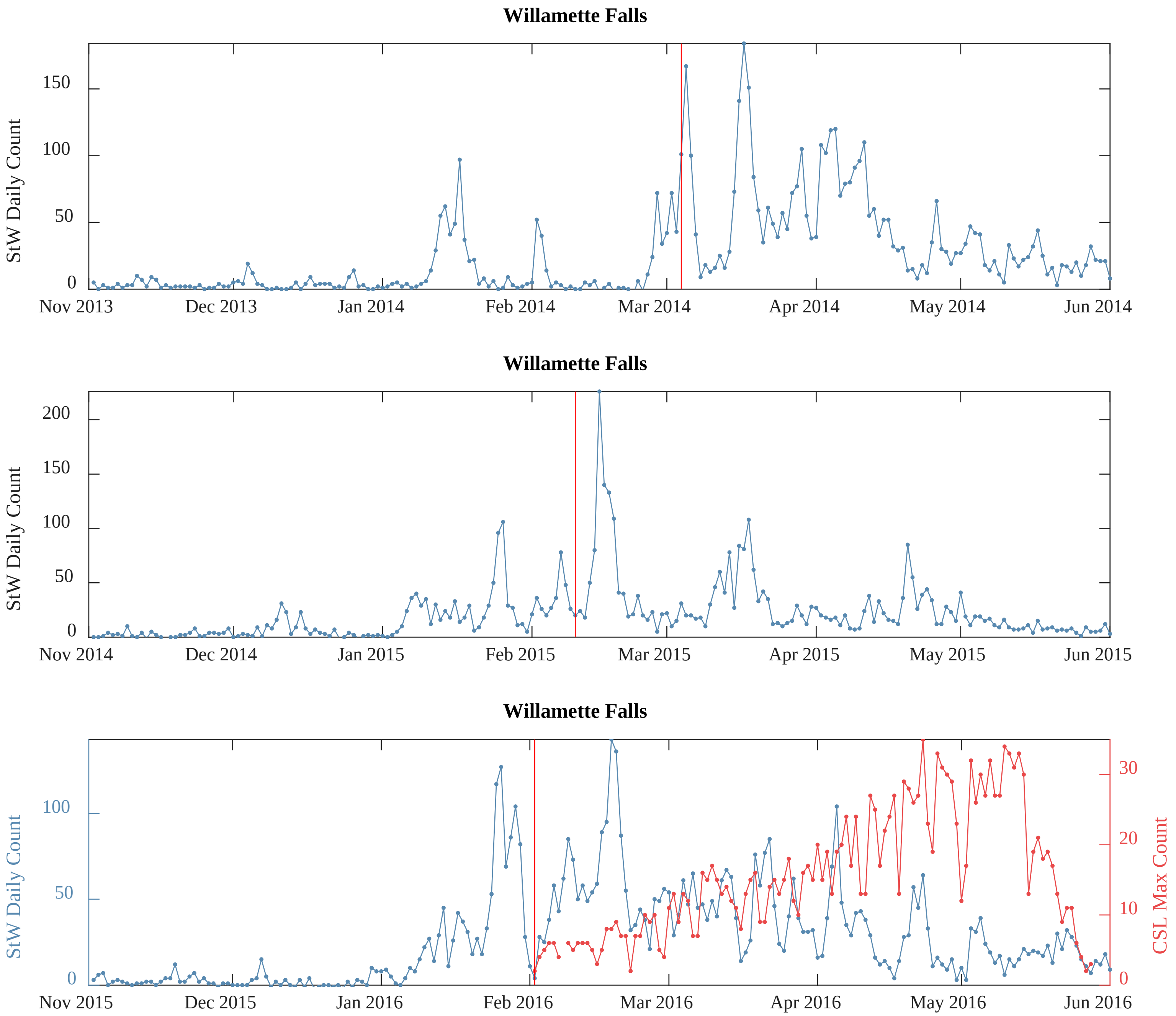
Predation events assigned to species

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



Sea Lion Predation

Expand estimated predation for steelhead run passing before predation monitoring.



Calculate Recruits associated with Spawners at time t, $R_{s(t)}$

Year	Spawn
1	1000
2	2000
3	1500
4	800
5	3000
6	2500
7	3000

Calculate Recruits associated with Spawners at time t, $R_{s(t)}$

Plus age composition

Year	Spawn	Age1	Age2	Age2	Age4	Age5	Age6
1		0	100	200	400	200	100
2	2000	0	200	400	800	400	200
3	1500	0	150	300	600	300	150
4	800	0	80	160	320	160	80
5	3000	0	300	600	1200	600	300
6	2500	0	250	500	1000	500	250
7	3000	0	300	600	1200	600	300

Proportion of hatchery fish on spawning grounds
(hatchery fish not progeny of “spawners”)

Spawner abundance

$$R_{S(t)} = \sum_{a=1}^{6} A_{t+a,a}\left(\frac{S_{t+a} * (1 - pHOS_{t+a})}{(1 - HR_{t+a})} + M_{t+a}\right).$$

Age composition

Harvest rate
(some fish get caught before returning).

Mortality from pinnipeds

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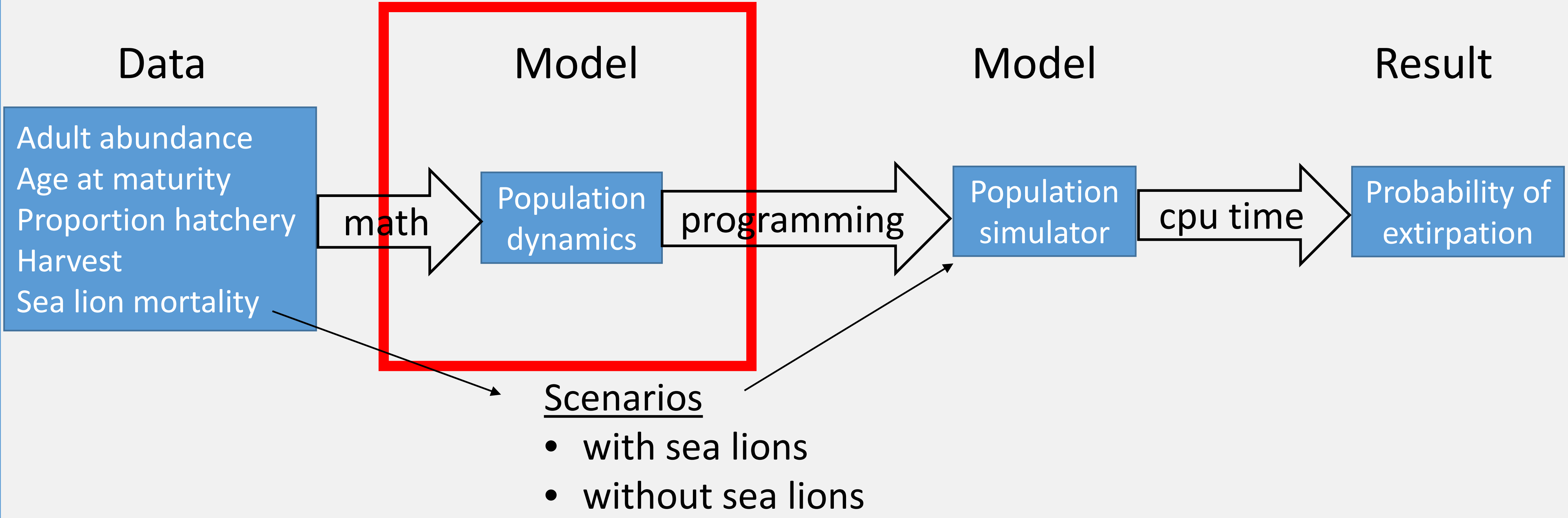


Population Dynamics

- Density-dependence
- Sea lion predation and fishing mort are additive
- Multi-model inference

Bayesian analysis

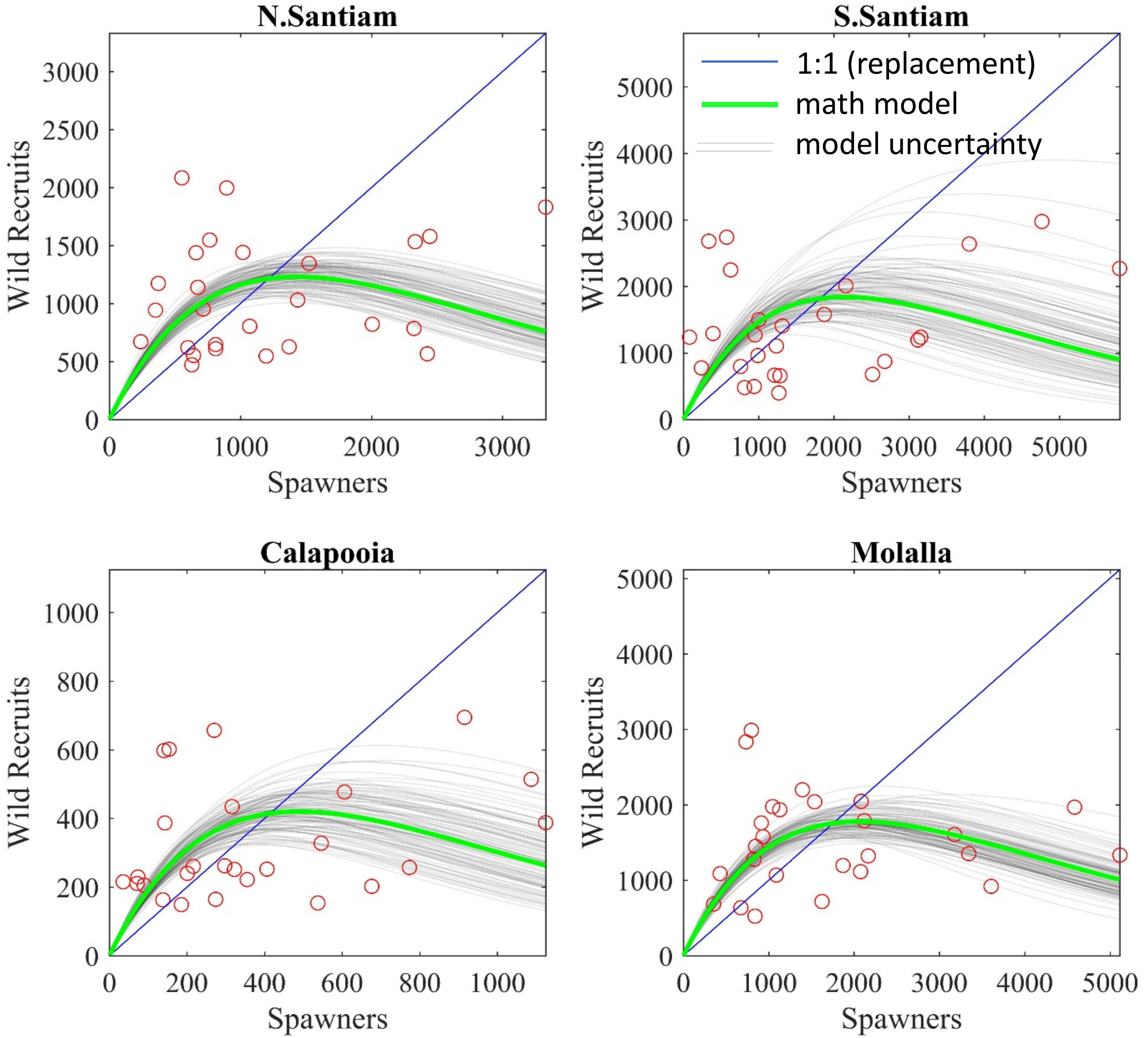
- Yields probability-based inference for parameters.
- MCMC provides random draws of parameters that include covariance.
- WAIC has cross-validation properties:
  get density at each datum within the MCMC, then compute over MCMC instead of conditioning on a point estimate (AIC, DIC).

<u>Ricker Models</u>

Model	<u>WAIC</u>
Model 1: Each pop separate $R_{t,p} = \alpha_p S_{t,p} e^{-\beta_p S_{t,p} + \varepsilon_{t,p}}$,where $\varepsilon \sim N(0, \sigma_p)$	225
Model 2: Shared error variance $R_{t,p} = \alpha_p S_{t,p} e^{-\beta_p S_{t,p} + \varepsilon_{t,p}}$,where $\varepsilon \sim N(0, \sigma)$	249
Model 3: Shared productivity $R_{t,p} = \alpha S_{t,p} e^{-\beta_p S_{t,p} + \varepsilon_{t,p}}$,where $\varepsilon \sim N(0, \sigma_p)$	218

Population Dynamics

- Density-dependence
- Sea lion predation and fishing mort are ad
- Multi-model inference



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- Yields probability-based inference for parameters.
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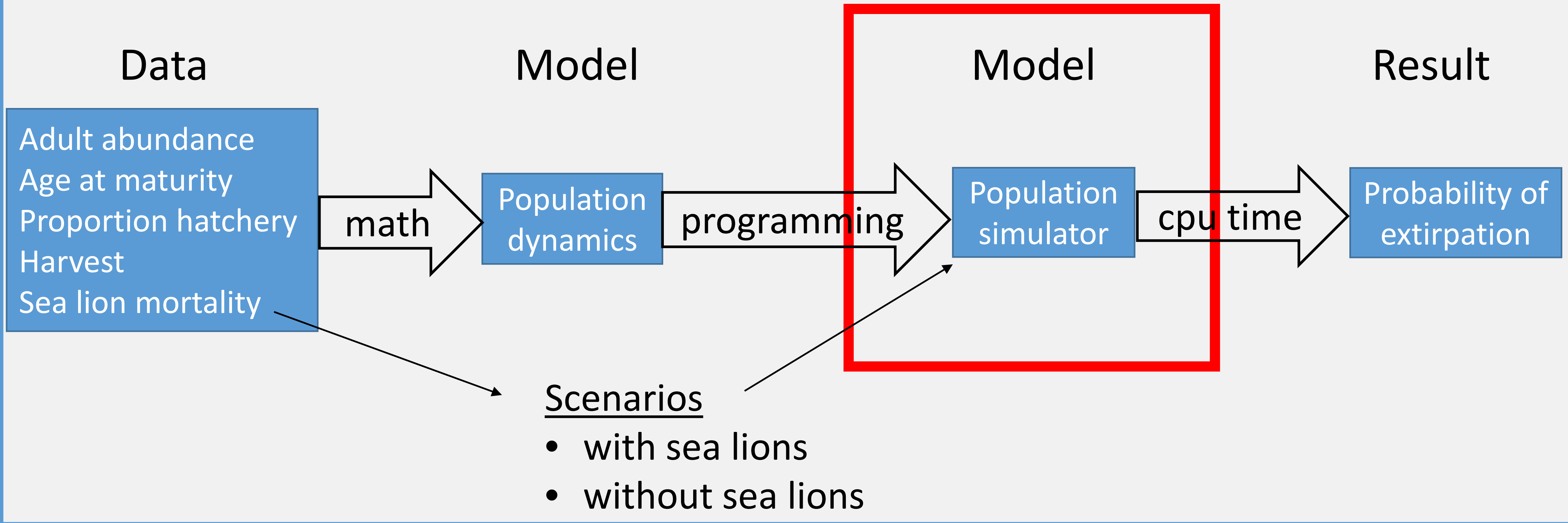
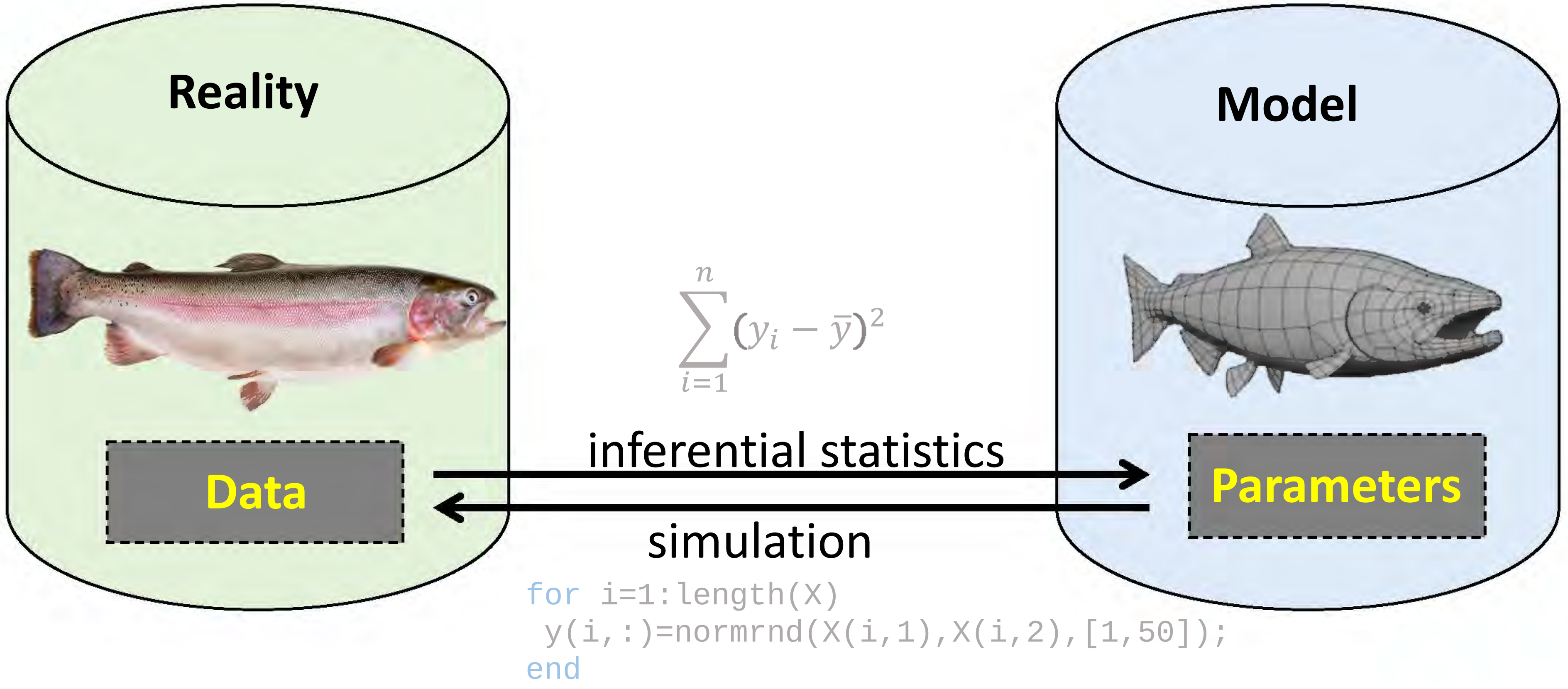


Population Simulator



Population Simulator

Replication

1000 random draws of parameters per population.

- For each draw, magnitude of error (variance of residuals) and autocorrelation are recomputed.
- Each draw used to simulate 100 years.

\+ 100 replications of the process described above.

= 100,000 simulations of 100 years per population

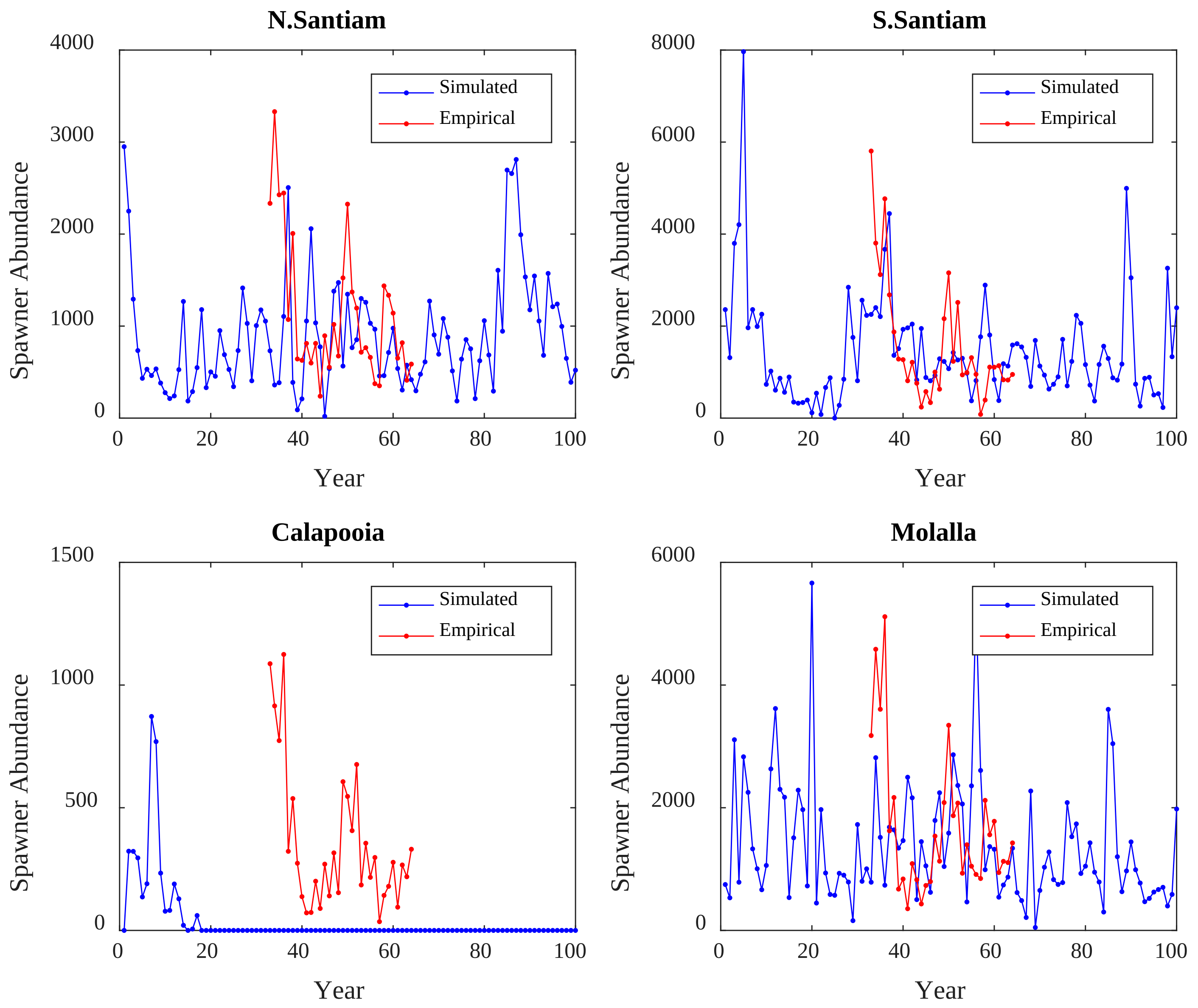
Allee effects (negative density dependence)

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

Pr[extirpation] = #extirpations/100,000

Population Simulator

Example output



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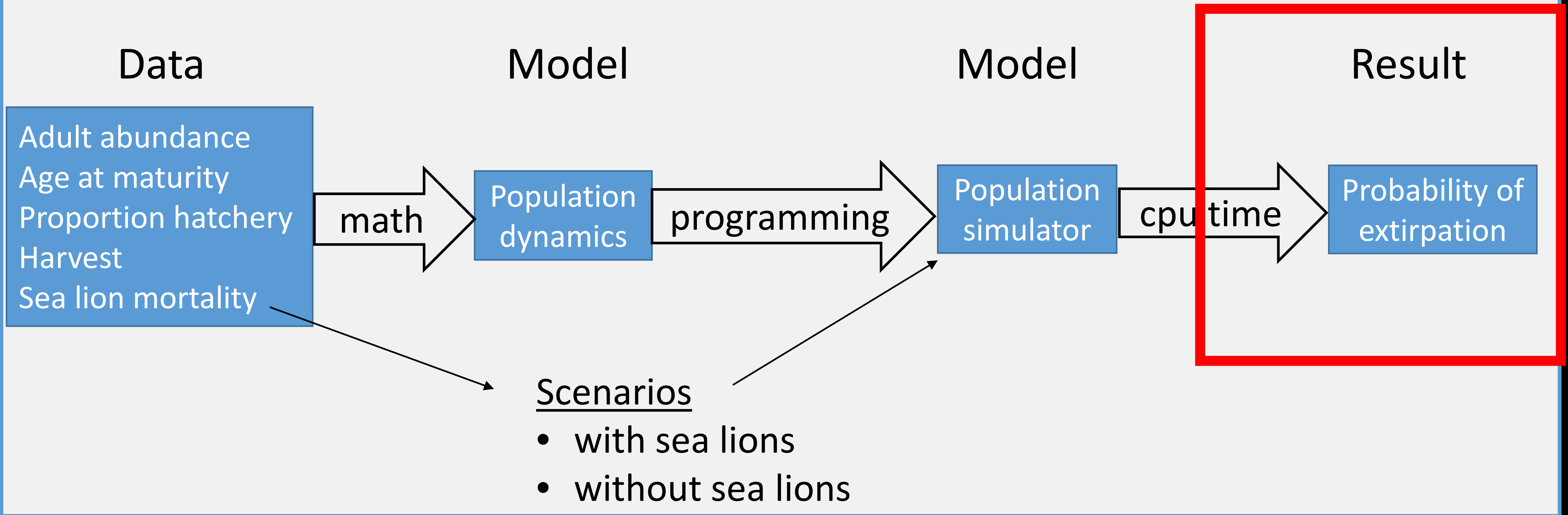

Probability of Extirpation

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%

Population Viability of Willamette River Winter Steelhead

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Spring Chinook Assessment

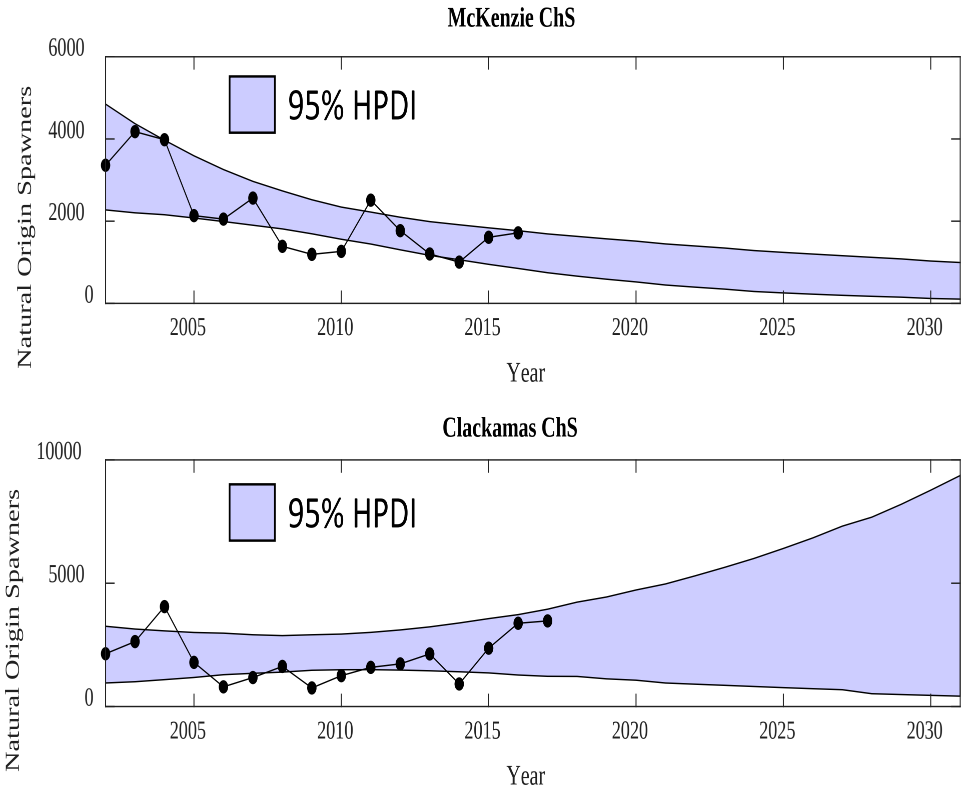
- Uses same PVA method as steelhead.

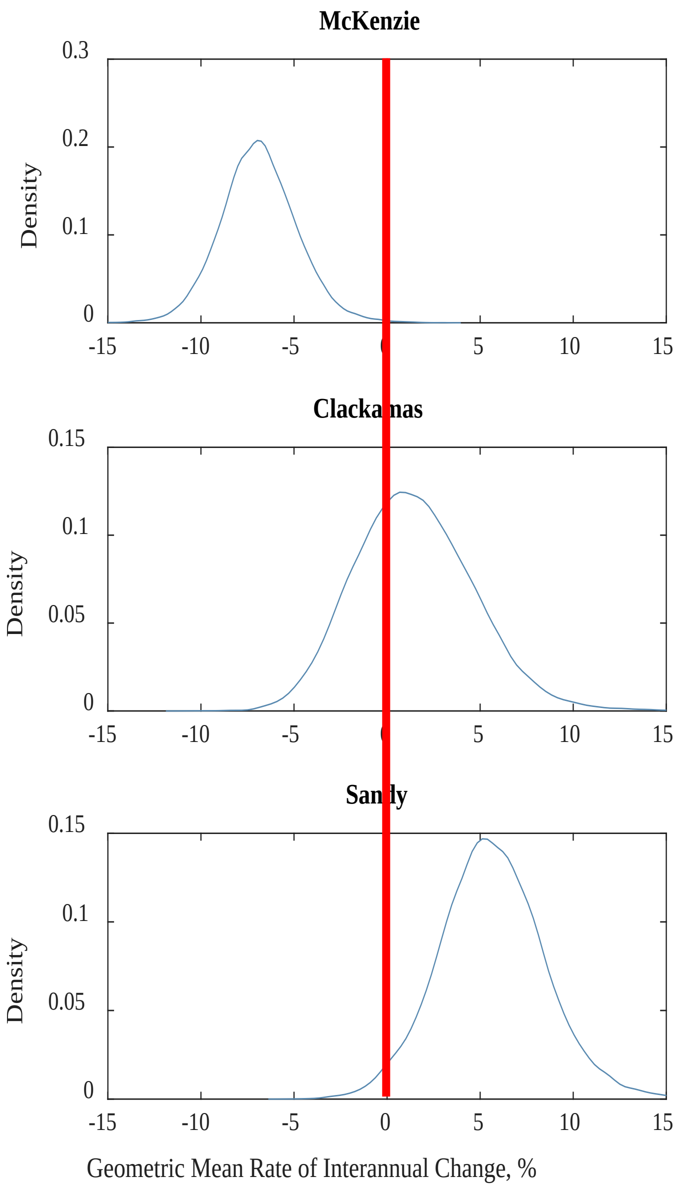
- However, abundance time series begins in 2002 because the proportion of hatchery-origin spawners in the McKenzie is unknown prior to 2002.

- Short time series complicates assessment.

- Comparison among three populations of spring Chinook:
  - McKenzie (exposed to pinnipeds at Willamette Falls)
  - Clackamas (not exposed to pinnipeds at Willamette Falls)
  - Sandy (not exposed to pinnipeds at Willamette Falls)

Trends in abundance





Recruits per Spawner

	Population								
	McKenzie			Clackamas			Sandy		
	RRS=1	RRS=0.5	RRS=0	RRS=1	RRS=0.5	RRS=0	RRS=1	RRS=0.5	RRS=0
Median	0.51	0.65	0.89	0.94	0.97	1.01	0.81	1.04	1.36
SD	0.25	0.29	0.35	0.55	0.58	0.63	0.50	0.50	0.59

RRS: Relative Reproductive Success of hatchery-origin fish.
If low, then recruits are progeny of natural-origin fish.

Probability of Extirpation

Population

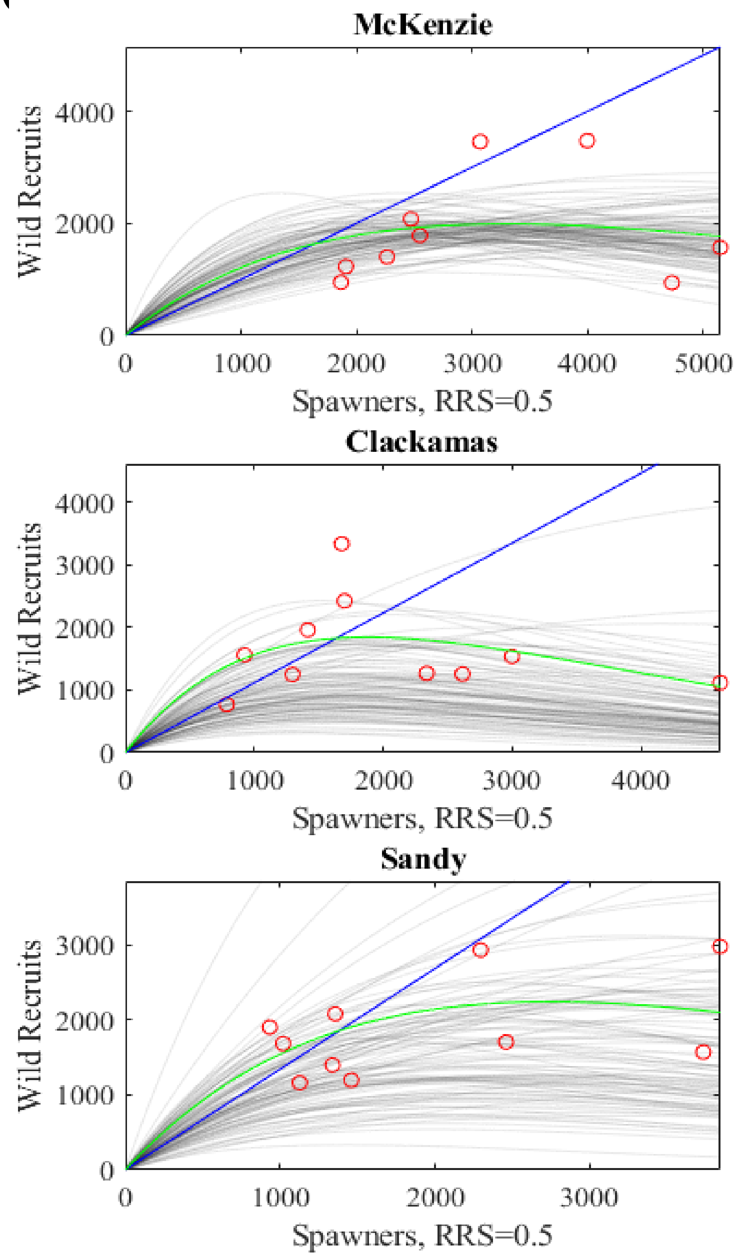
	McKenzie				Clackamas		Sandy	
	RRS=1		RRS=0.5		RRS=1	RRS=0.5	RRS=1	RRS=0.5
	Max CSL	No CSL	Max CSL	No CSL				
Model 1	0.35	0.23	0.28	0.22	0.007	0.006	0.010	0.004
Model 2	0.45	0.30	0.33	0.20	0.006	0.002	0.009	0.001

RRS: Relative Reproductive Success of hatchery-origin fish.
If low, then recruits are progeny of natural-origin fish.

Caveat: no sign of density-dependen

- A density-independent model would have produced more pessimistic results.

- Regardless of PVA mechanics, the McKenzie is clearly performing worse.



Effects of Sea Lion Predation on Willamette River Salmonid Viability

Matt Falcy

California sea lion and Steller sea lion population status, life history & ecology, behavior, distribution, etc.

Presenter: Bob DeLong

Corresponding Summary Page(s): 21-22

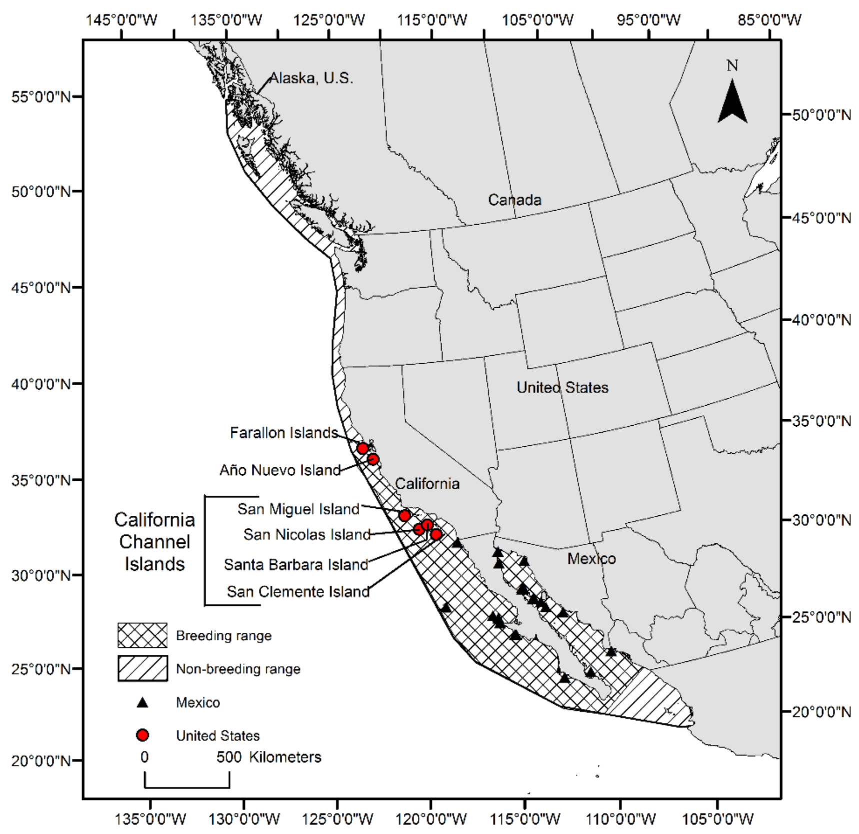
California sea lion Population Growth and Status*

Achieving the goals of the Marine Mammal Protection Act

*Laake, J.L., M.S. Lowry, R.L. DeLong, S.R. Melin and J.V. Carretta 2018.

Journal of Wildlife Management
DOI:10.1002/jwmg.21405

Distribution of California Sea Lion



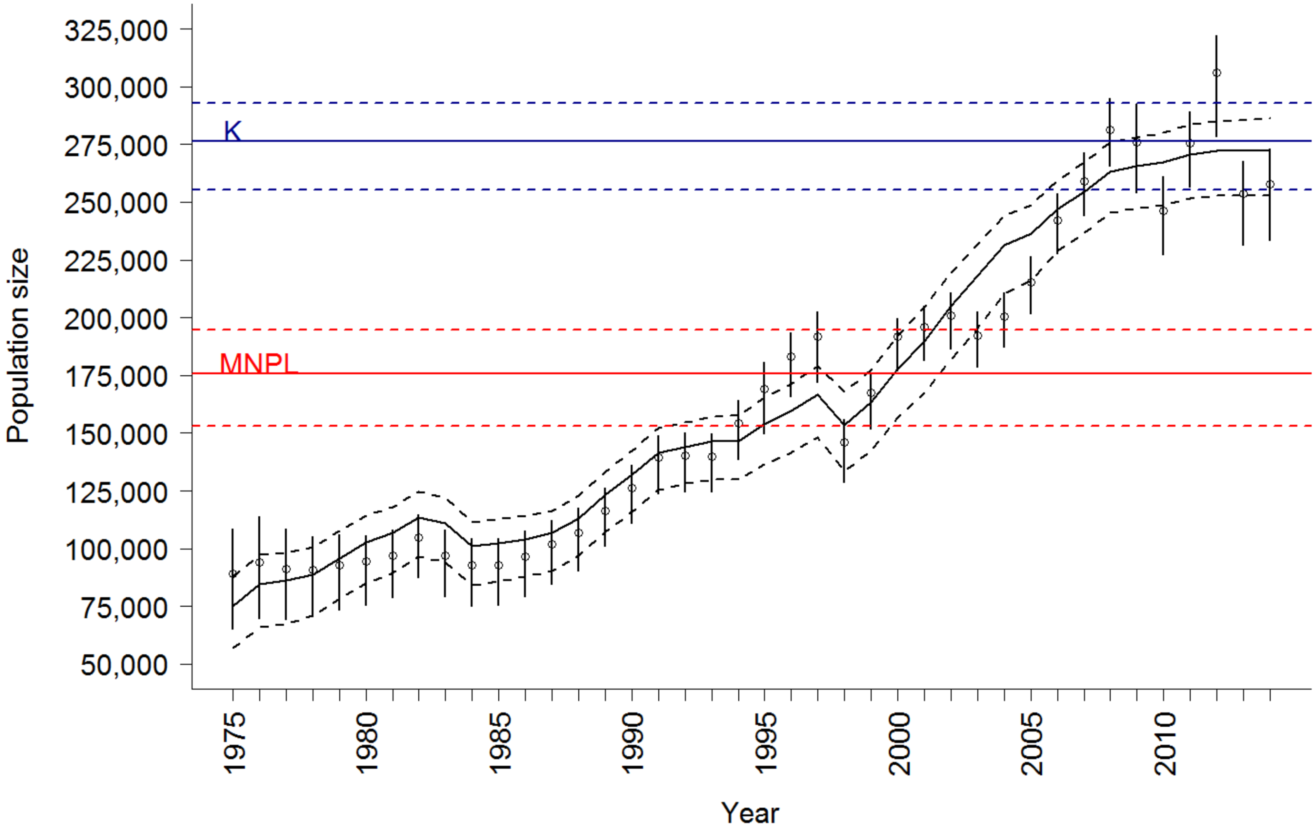
A novel method to assess population growth and status

- Conceptually simple but requires extensive population data
- Time series of 39 years of pup counts for all rookeries (6) in California waters 1975 – 2014 (Lowry et al 2017)
- Sex and age- Specific Survival Rates (28 years) 1975 to 2013 (DeLong et al 2017. MM Sci.)
- Use annual pup counts and survival estimates to reconstruct abundance of all age and sex components of population for each year
- Fit generalized logistic growth curve to time series of population size at each year to estimate MNPL ,K and population status

California sea lion Population Structure

			Population estimate		
Year	Pup count		F	M	Total
1975	12,499		49,136	39,788	88,924
1976	14,749		51,944	42,226	94,170
1977	11,712		50,784	40,415	91,199
1978[a]	13,449		50,942	39,971	90,913
1979[a]	14,145		52,151	40,661	92,812
1980[a]	14,878		53,180	41,153	94,333
1981	16,701		54,748	42,249	96,997
1982	20,540		58,881	45,899	104,780
1983	11,595		55,342	41,465	96,807
1984	13,550		53,657	39,354	93,011
1985	15,224		53,753	39,259	93,012
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
2004	43,490		114,985	85,342	200,327
2005	48,331		122,423	92,825	215,248
2006	56,144		135,829	106,364	242,193
2007	54,088		144,443	114,561	259,004
2008	59,774		156,091	125,359	281,450
2009	35,914		154,229	121,926	276,155
2010	33,873		139,983	106,348	246,331
2011	62,109		155,174	120,315	275,489
2012	67,396		171,149	135,071	306,220
2013	42,913		146,010	107,652	253,662
2014	47,691		148,499	109,107	257,606

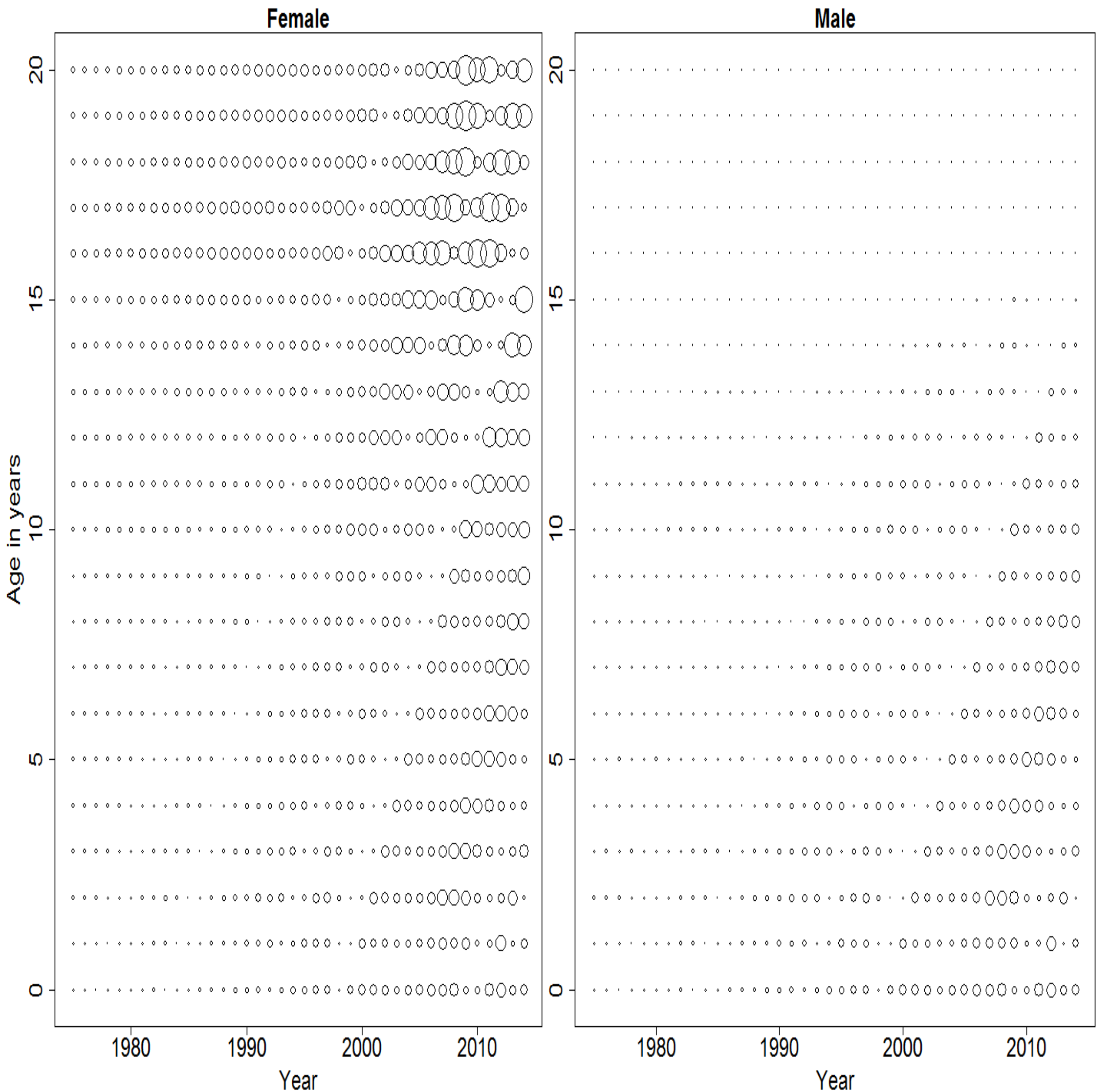
California sea lion Population Growth



Result

- MNPL (183,481), K (275,631) and population status N_{2014}/MNPL
- Annual Growth rate = 0.07, N_{2014}/MNPL = 1.2 , N_{2014}/K = 0. 94
- Increase of 1° C SST results in 7% decline in annual growth rate, bringing it to zero; 2° C SST > 14% decline in growth rate and a population decline of 7 %

Relative Abundance of Females and Males in the U.S. California sea Lion population 1975 to 2014



Model Estimates:
Males 4-7 yr ~ 29,000
Males ≥ 8 yr ~ 38,500
Potential Migrant Males in 2014 was ~67,500 animals; its fewer today.

Potential Biological Removals (PBR)

MMPA definition "the maximum number of animals, not including natural mortality, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population."

PBR is product of 3 elements: the minimum population estimate (Nmin); half the maximum net productivity rate (0.5 Rmax); a recovery factor (Fr)

Current PBR: (Nmin) 153,337 X 0.06 (1/2 Rmax) X 1.0 Fr = 9,200

Pacific Scientific Review Group (SRG) Recommended PBR (Draft): 7,823

Task Force should consider male only PBR for Section 120 removals in Columbia River as all removals are from male component of the population

PBR calculated for males > 4 years is Nmin (52,311) X ½ of Rmax of 0.12 and recovery factor of 1.0: 52,311 X 0.06 X 1 = 3,139.

PBR for males 8 years and older: Nmin is (27,451) X ½ of Rmax (0.12) and recovery factor of 1.0: 27,451 X 0.06 X 1.0 = 1,647

Steller Sea Lions in Oregon and Washington

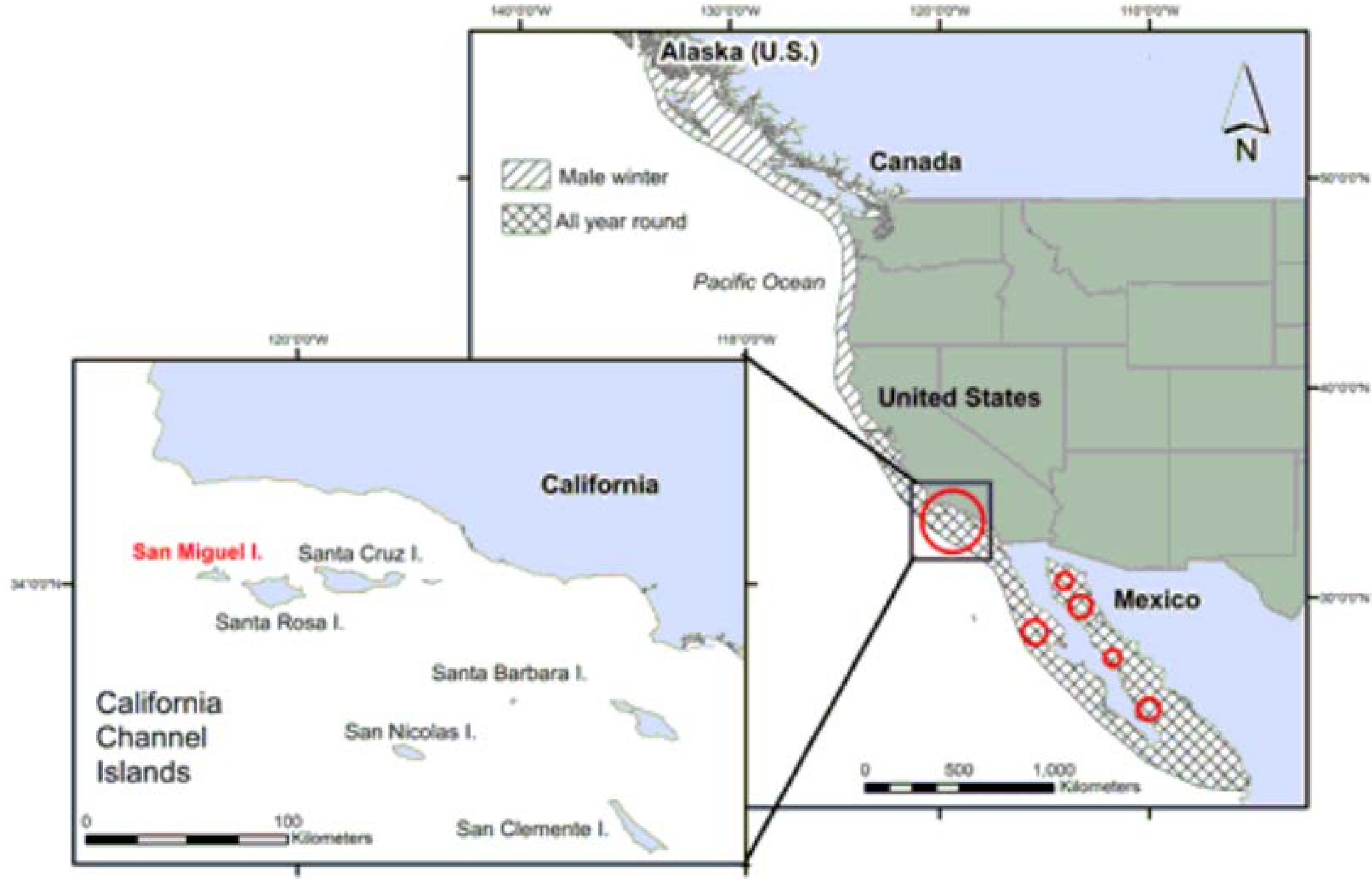
- Population of ~8,000 breed on 1 Washington and 2 Oregon locations
- Adult and Subadult males occur in the Columbia River and have become major salmon predators at Bonneville Dam

MMPA §120(d) Considerations and Benefits Analysis

Presenter: Bryan Wright

Corresponding Summary Page(s): 22-23

Day 2



Alaska (U.S.)
Canada
Male winter
All year round
Pacific Ocean
United States
Mexico
N
0 500 1,000 Kilometers
California
San Miguel I.
Santa Cruz I.
Santa Rosa I.
Santa Barbara I.
San Nicolas I.
San Clemente I.
California Channel Islands
0 100 Kilometers

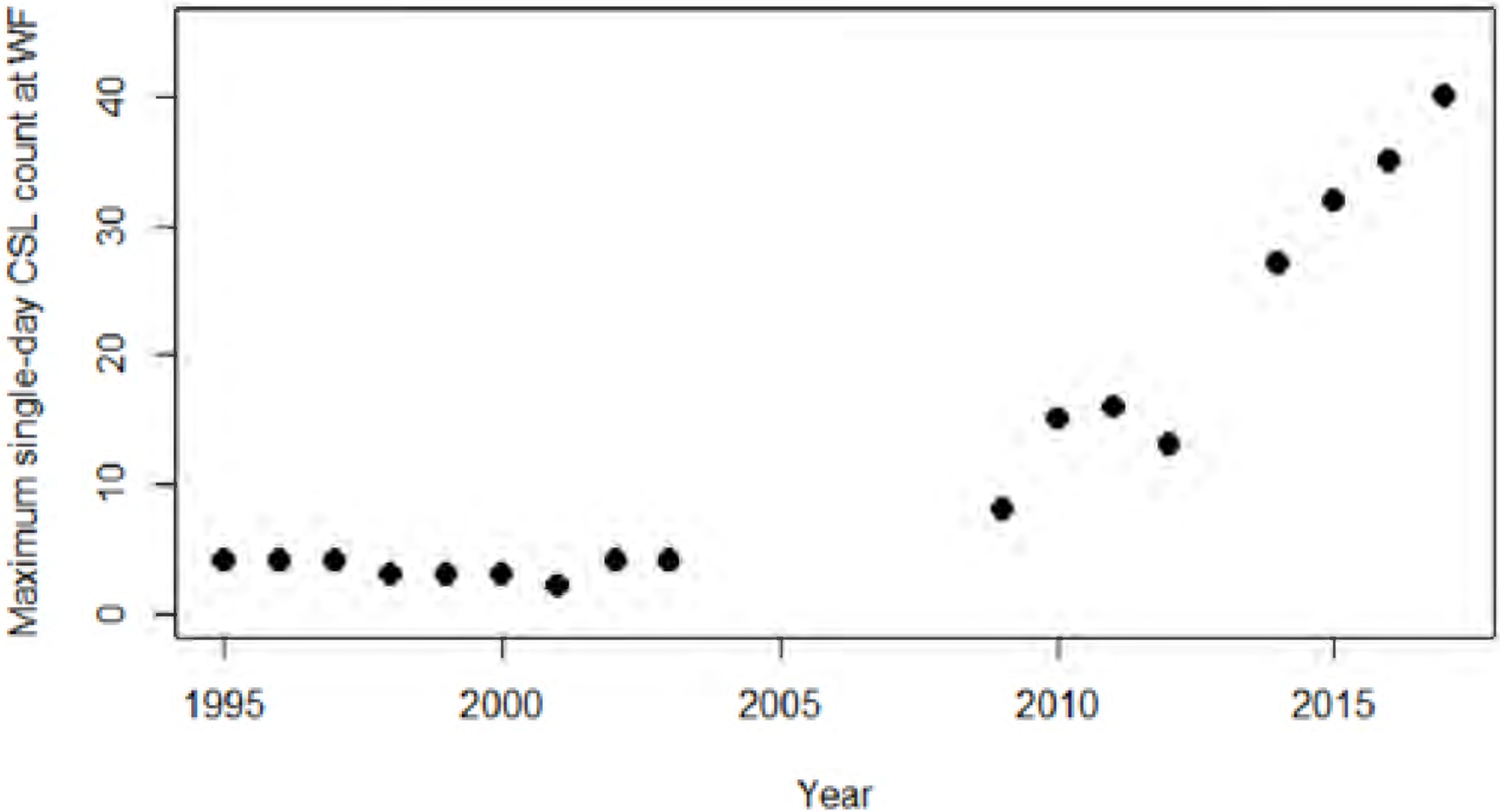


Figure 1. Maximum single-day CSL count at Willamette Falls by year. Monitoring from 1995-2003 and 2014-2017 was conducted by ODFW; monitoring from 2009-2012 was conducted by PSU.

Table 1. Observed predation by California sea lions at Willamette Falls, 2014-2017.

	Observed predation					% of observations				
Prey	2014	2015	2016	2017	Total	2014	2015	2016	2017	Total
Salmonids	959	1139	1001	753	3852	86.7%	85.2%	83.8%	82.7%	84.7%
Lamprey	126	175	182	145	628	11.4%	13.1%	15.2%	15.9%	13.8%
Other/unk.	18	21	11	12	62	1.6%	1.6%	0.9%	1.3%	1.4%
Sturgeon	3	2	0	0	5	0.3%	0.1%	0.0%	0.0%	0.1%
Total	1,106	1,337	1,194	910	4547	100%	100%	100%	100%	100%

Figure 1. Illustration of the spatial component of the sampling frame for 2017. Sites 1-6 ("Falls" stratum) were each approximately 0.9-ha in area.

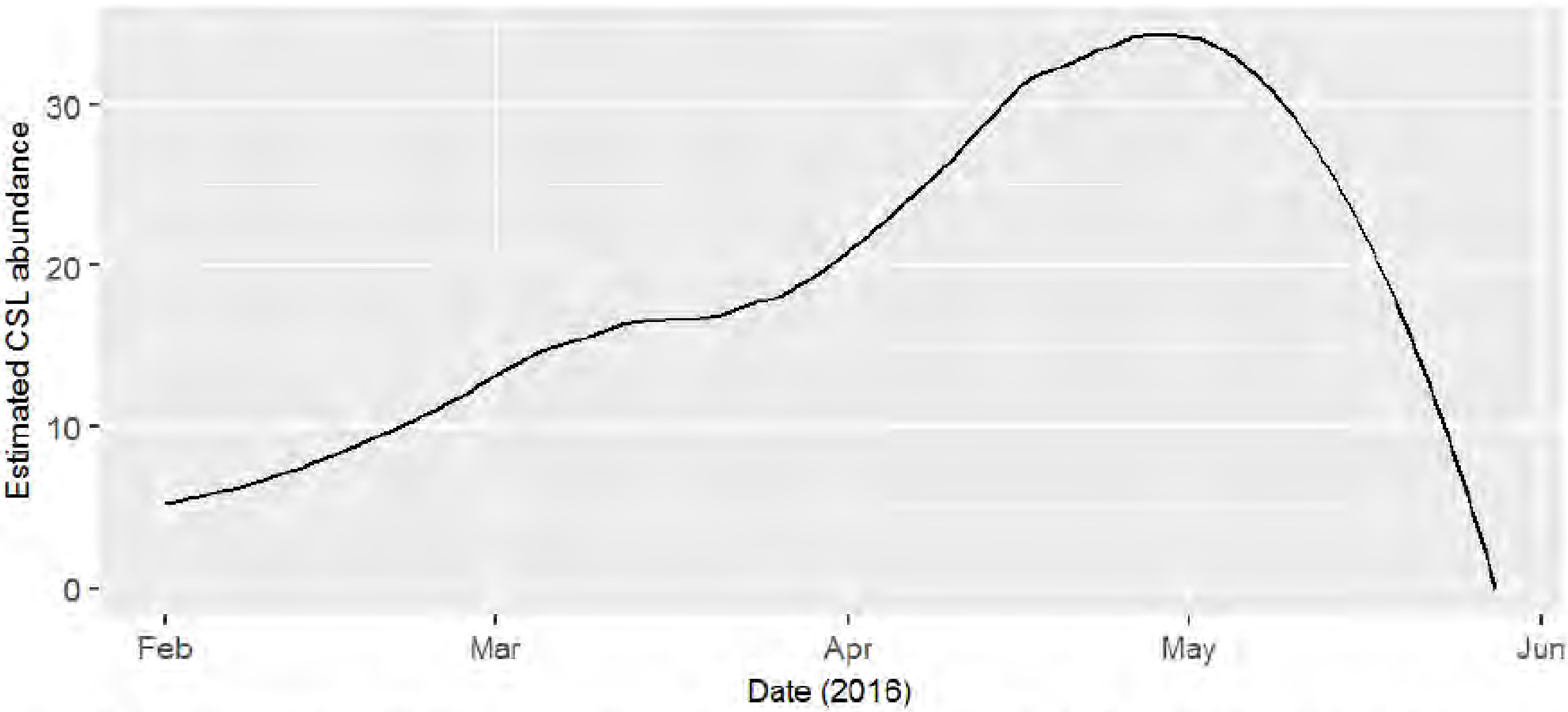


Figure 4. Estimated daily California sea lion abundance at Willamette Falls in 2016 based on loess model fit to weekly maximum count data (Wright et al. 2016).

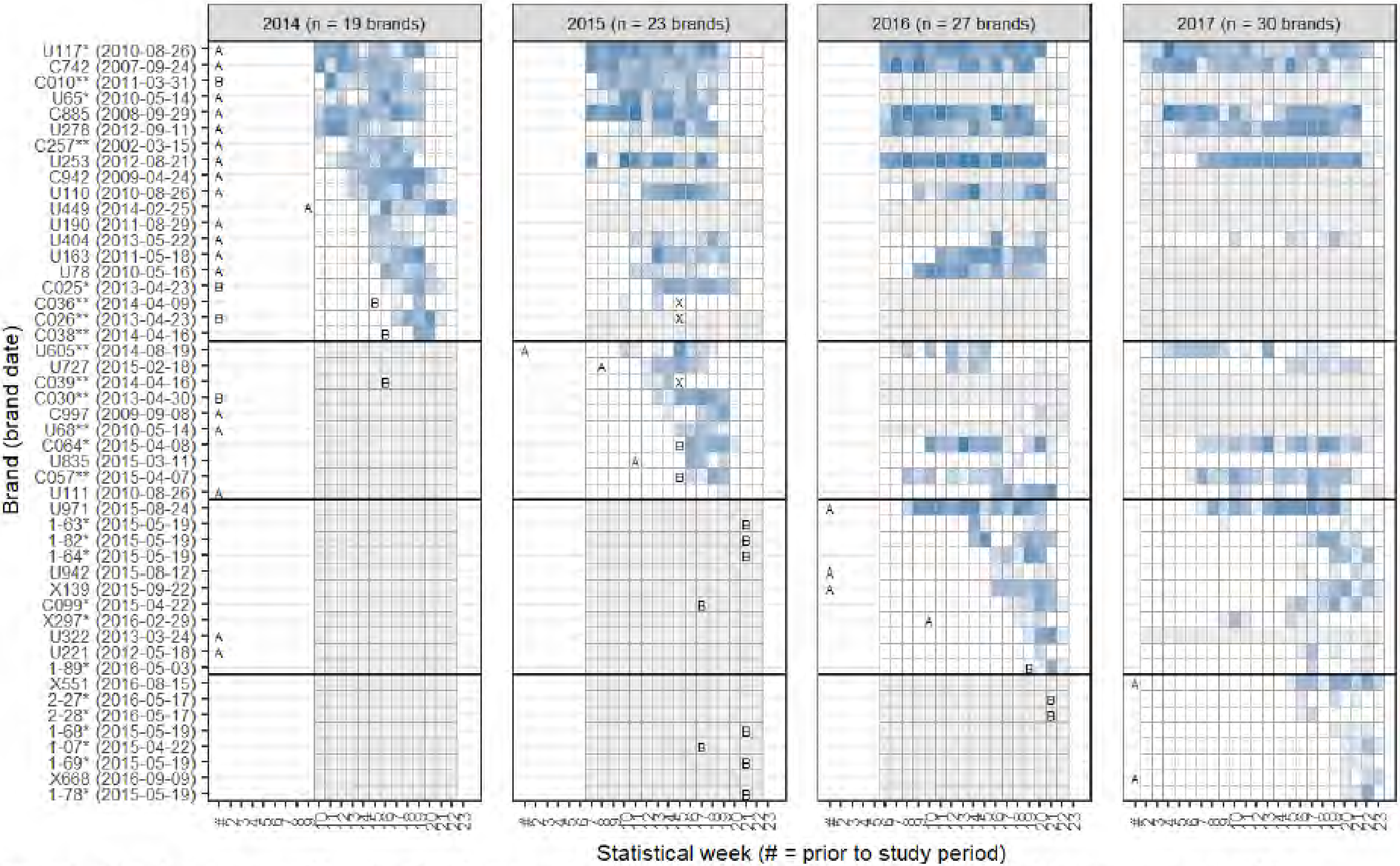


Figure 6. Weekly residency of branded California sea lions (n = 48 total) at Willamette Falls sorted by year and week of first detection (darker hue = more days detected). Capture location at branding denoted by 'A' (Astoria) or 'B' (Bonneville Dam); X denotes animal was removed under MMPA Section 120; * indicates animal documented at Bonneville Dam; ** indicates animal on MMPA Section 120 list for removal. Brands recorded less than three days per year were considered unconfirmed and are not included unless photographed. [Note that this graphic will be updated once image processing from automated cameras is competed.]

Hazing / non-lethal detternts

Table 4. Summary of ODFW hazing efforts at Willamette Falls from 2010-2013.

	Effort			Deterrents			Animals Exposed to Hazing	
Year	Start	End	Days	Shell Crackers	Rubber projectiles	Seal bombs	CSLs	SSLs
2010	3/26	4/30	8	~800	~30	~400	NA	0
2011	2/7	4/26	49	6,863	135	2,771	860	0
2013	2/4	4/29	81	10,976	601	8,042	1,871	45

Table 5. Estimated salmonid predation by California sea lions at Willamette Falls, 2014-2017.

	Estimated predation				% of potential escapement			
Run*	2014	2015	2016	2017	2014	2015	2016	2017
wSTH	780	557	915	270	13%	11%	14%	25%
nmCH	496	899	650	399	7%	9%	9%	6%
sSTH	712	172	768	181	3%	4%	3%	8%**
mCH	1,703	4,149	2,252	1,824	7%	9%	9%	6%

*wSTH = winter steelhead; nmCH = spring Chinook salmon (not marked); sSTH = summer steelhead; mCH = spring Chinook salmon (marked)

**As of 8/15/2017

Expected benefits

Expected benefits

Probabilities of extirpation (100 year PVA)

Scenario	Winter steelhead population				
Sea lion predation	N. Santiam	S. Santiam	Molalla	Calapooia	At least one extirpated*
None	2%	5%	0%	99%	6%
Low (2015)	8%	16%	0%	99%	23%
Average (2016)	27%	34%	2%	99%	53%
High (2017)	64%	60%	21%	99%	89%

* Excluding Calapooia and assuming independence

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

Expected benefits

CSLs removed	Winter steelhead	Summer steelhead	Spring Chinook-unmarked	Spring Chinook-marked	Total
46	431-913	496-1052	495-1049	2204-4672	3626-7686
92	1000-1665	1152-1918	1148-1913	5114-8518	8414-14014

Monte Carlo simulation assumptions

- Predation rate: 2 salmonids/d (conservative)
- CSL Residency: 1-21 weeks
- Salmonid run proportions: 60.8% hatchery Chinook, 13.6% wild Chinook, 13.7% summer steelhead, 11.9% winter steelhead

Table 5. Summary of California sea lion predation on salmonids extrapolated to river strata in 2017 based on relative amounts of predation observed between the two strata in 2014-2015. Note, however, that the 2014-2015 estimates themselves represent less temporal coverage than 2016-2017 (see Figures 1-3 and Appendix A).

Year	Stratum	Estimated California sea lion salmonid take	% California sea lion salmonid take	Site-adjusted % California sea lion salmonid take
2014	Falls	1,842	50%	60%
	River	1,848	50%	40%
		3,690	100%	100%
2015	Falls	3,620	63%	
	River	2,156	37%	
		5,775	100%	
2016	Falls	4,585		
	River	*2,870**		
		*7,455**		
2017	Falls	2,673		
	River	*1,615**		
		*4,288**		

*Extrapolations based on 2014 and 2015 estimates.

Compensatory Pinniped Immigration

Presenter: Bryan Wright

Corresponding Summary Page(s): 23-25

Replacement critique

Compensatory immigration?

“Attempts to control predator numbers through spatially restricted culling typically faces a compensation process via immigration from surrounding source populations.”

The Journal of Wildlife Management 79(3):425–434; 2015; DOI: 10.1002/jwmg.850

Research Article

Compensatory Immigration Challenges Predator Control: An Experimental Evidence-Based Approach Improves Management

NICOLAS LIEURY, *Institut Mé*
Avignon Université, Technopôle
SANDRINE RUETTE,[1] *Office N*
France
SEBASTIEN DEVILLARD, *La*
UMR5558, Villeurbanne F-696
MICHEL ALBARET, *Office Na*
France
FRANCK DROUYER, *Fédératio*
BRUNO BAUDOUX, *Fédération*
10440, France
ALEXANDRE MILLON, *Instit*
IRD, Avignon Université, Techn

ABSTRACT Attempts t
compensation process vi
avoid this issue is in most

ORIGINAL PAPER

The compensatory potential of increased immigration following intensive American mink population control is diluted by male-biased dispersal

M. K. Oliver · S. B. Piertney · A. Zalewsk
Y. Melero · X. Lambin

Received: 15 December 2015 / Accepted: 21 June 20

Abstract Attempts to mitigate the impact
sive species on native ecosystems increasing
large land masses where control, rather than
tion, is the management objective. Depressi
bers of invasive species to a level where thei

Biological Conservation 191 (2015) 632–639

Contents lists available at ScienceDirect

Biological Conservation

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Compensatory immigration counteracts contrasting conservation strategies of wolverines (*Gulo gulo*) within Scandinavia

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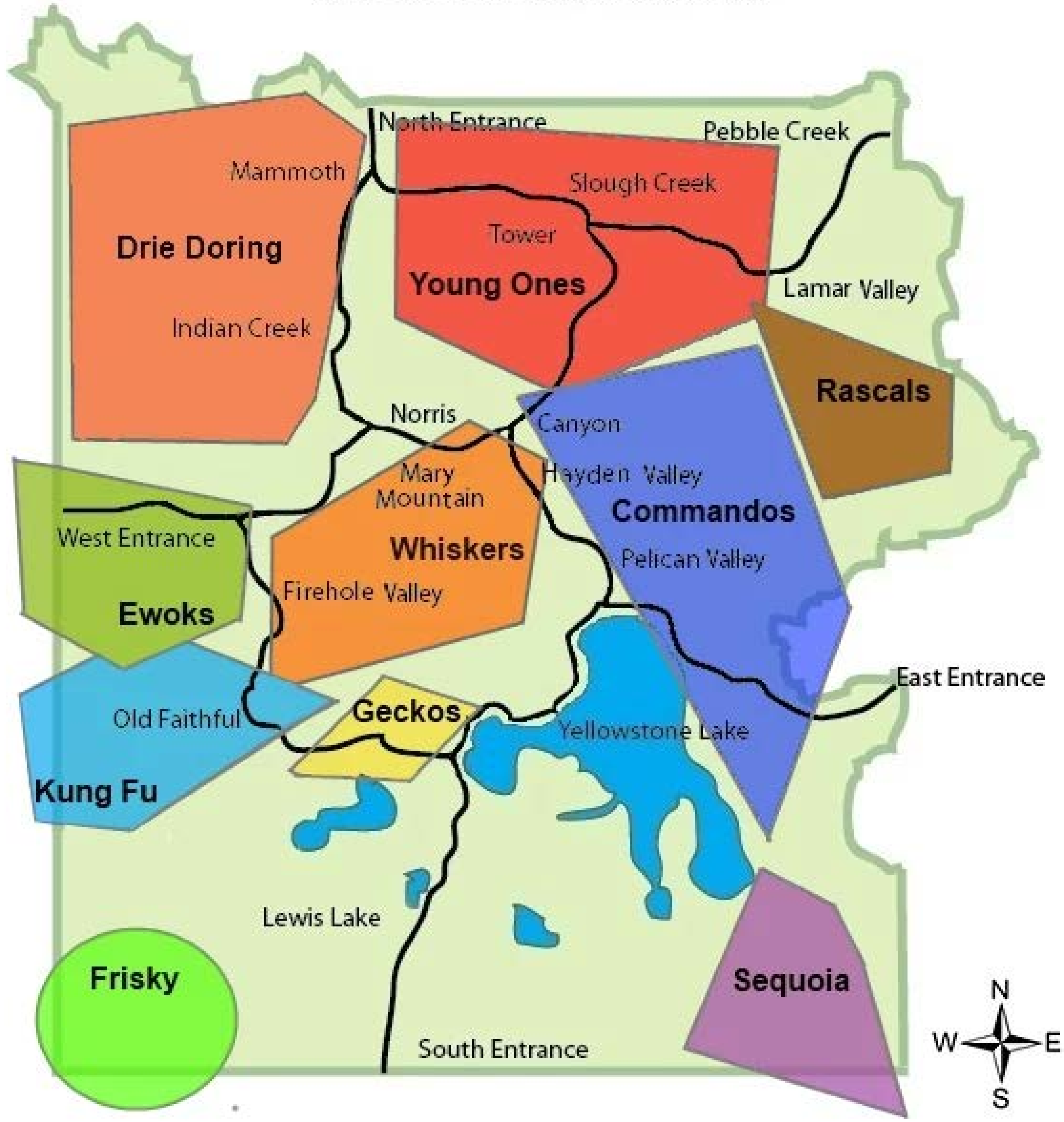
ABSTRACT

In wide ranging species, portions of the same population often fall within different administrative jurisdictions; where different regulations apply. The same species can be fully protected or heavily harvested on different sides of a border. This can generate a source–sink dynamic from the areas with lower to those with higher mortality, a process known as compensatory immigration. We tested this hypothesis on the wolverine (*Gulo gulo*) population of southern Scandinavia, which is shared between two countries: Sweden and Norway. Wolverines are fully protected in Sweden, but subject to intensive population regulation in Norway. Using non-invasive genetic sampling and capture–recapture modeling, we analyzed the dynamics of wolverine survival and emigration patterns between 2002 and 2013. Wolverines in Norway experienced a lower survival than in Sweden. Migration across the national border was directed towards movements from Sweden to Norway. There was a functional relationship between harvest rate in Norway and emigration rates across the national border, both at the individual and population level, thus confirming the compensatory immigration hypothesis. Contrasting management regimes within the same population can generate undesired demographic and spatial dynamics, jeopardize conservation goals on the two sides of a border, and reduce the efficiency of management actions. This calls for the adoption of

Yellowstone National Park



California sea lions ≠ terrestrial carnivore (e.g., fox, coyote, wolf)

- Seasonal, migratory males—not breeding pairs such as wolf pack
- Not territorially (outside rookeries)
- Little or no evidence carrying capacity reached at WF or BD (sea lions not queued up waiting to get in)
- Nearest "source" population over 100 miles away
- Ecologically valid concept does not apply in this situation

PROCEEDINGS B

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Research

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Epidemiological models to control the spread of information in marine mammals

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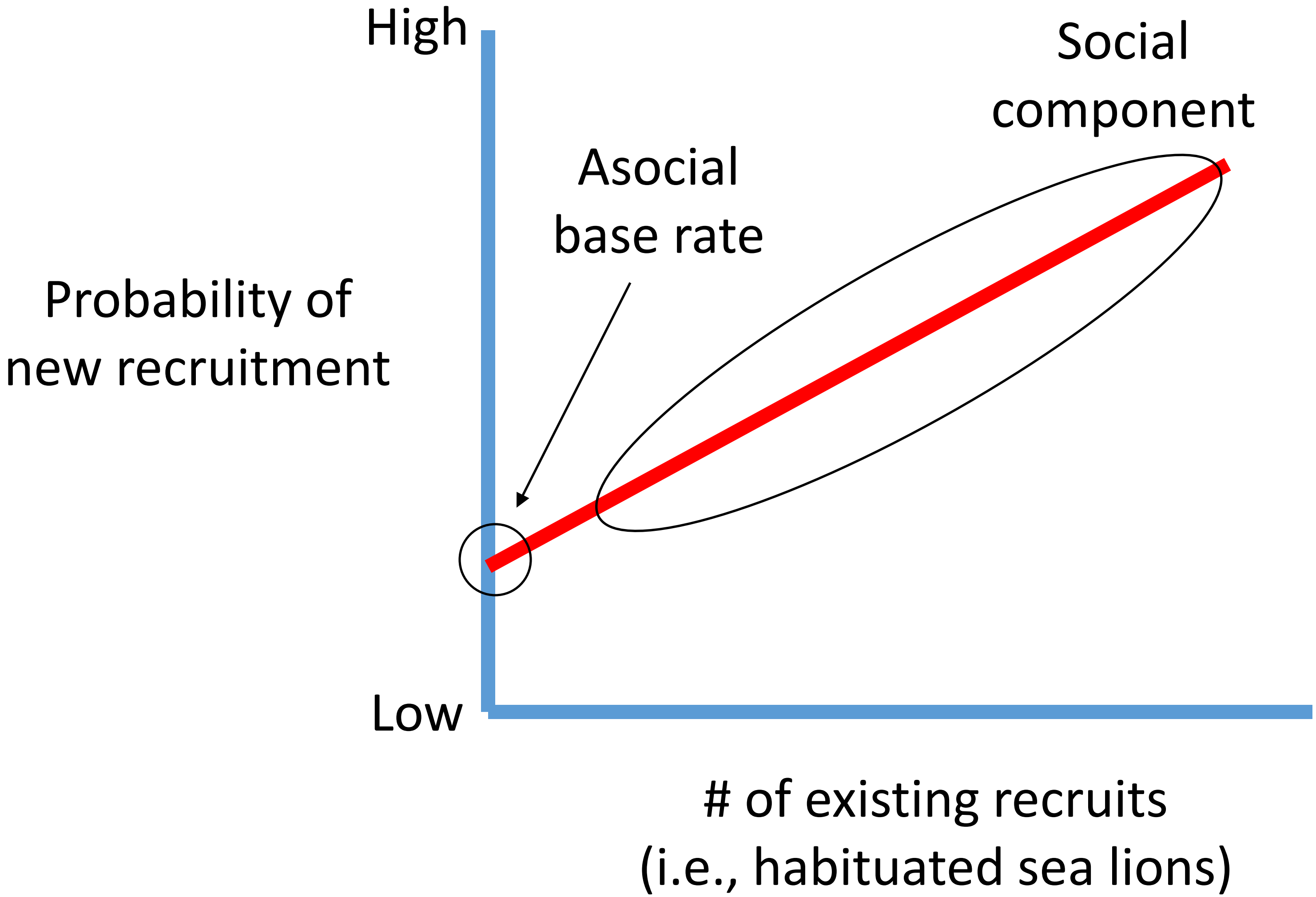
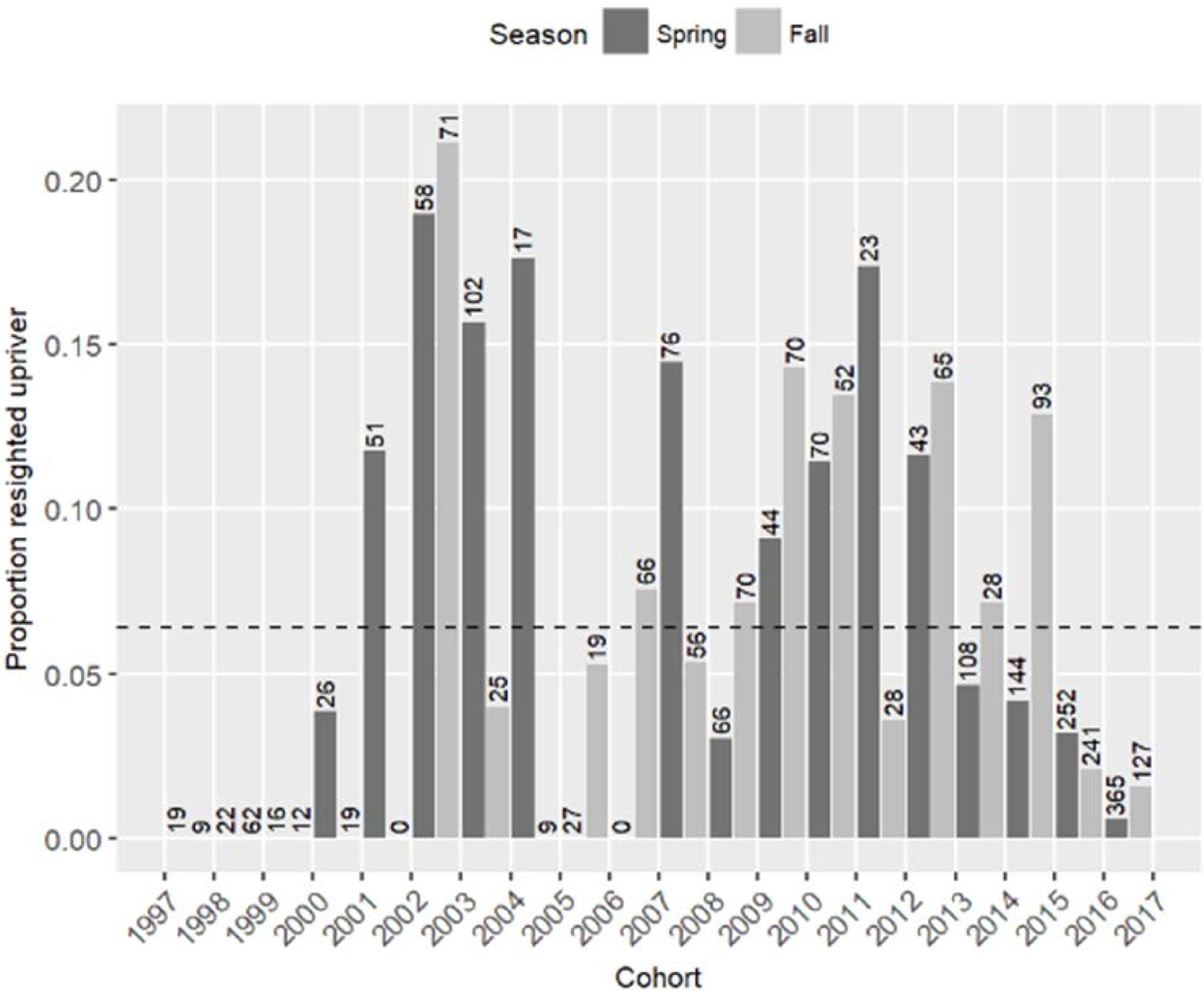
Socially transmitted wildlife behaviours that create human–wildlife conflict are an emerging problem for conservation efforts, but also provide a unique opportunity to apply principles of infectious disease control to wildlife management. As an example, California sea lions (*Zalophus californianus*) have learned to exploit concentrations of migratory adult salmonids below the fish ladders at Bonneville Dam, impeding endangered salmonid recovery. Proliferation of this foraging behaviour in the sea lion population has resulted in a controversial culling programme of individual sea lions at the dam, but the impact of such culling remains unclear. To evaluate the effectiveness of current and alternative culling strategies, we used network-based diffusion analysis on a long-term dataset to demonstrate that social transmission is implicated in the increase in dam-foraging behaviour and then studied different culling strategies within an epidemiological model of the behavioural transmission data. We show that current levels of lethal control have substantially reduced the rate of social transmission, but failed to effectively reduce overall sea lion recruitment. Earlier implementation of culling could have substantially reduced the extent of behavioural transmission and, ultimately, resulted in fewer animals being culled. Epidemiological analyses offer a promising tool to understand and control socially transmissible behaviours.


High
Social
component
Asocial
base rate
Probability of
new recruitment
Low
# of existing recruits
(i.e., habituated sea lions)



Season
Spring
Fall
Proportion resighted upriver
0.00
0.05
0.10
0.15
0.20
19
9
22
62
16
12
26
19
51
0
58
71
102
25
17
9
27
19
0
66
76
56
66
70
44
70
70
52
23
28
43
65
108
28
144
93
252
241
365
127
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
Cohort

- P(travel from EMB to Bonneville and/or WF) = ~0.07
- Recruitment = function of social and/or asocial process (i.e., follow others, follow fish, explore)
- P(stay upon first arrival) = f(# sea lions, # fish, age, haul-out space?, hazing/disturbance?,…)
- P(return next year) = f(previous experience, age,…)
- Within-year new recruitment likely independent of removals (i.e., no compensatory immigration)
- Next-year recruitment likely reduced due to reduced opportunity for social transmission

U253

- Branded in Astoria 8/21/2012
- First seen at Willamette Falls 2013 and seen every year since
- Relocated to coast March 13, 2018—returned 5 days later
- Returned last week—earliest return on record
- 2019 will be 7^{th} year (C742 headed into 11^{th} year)
- Behavior has been growing over time
- Removing U253 next week would not result in a “replacement” the following week and probably not for several years, if ever

Expected benefits

Probabilities of extirpation (100 year PVA)

Scenario	Winter steelhead population				
Sea lion predation	N. Santiam	S. Santiam	Molalla	Calapooia	At least one extirpated*
None	2%	5%	0%	99%	6%
Low (2015)	8%	16%	0%	99%	23%
Average (2016)	27%	34%	2%	99%	53%
High (2017)	64%	60%	21%	99%	89%

* Excluding Calapooia and assuming independence

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

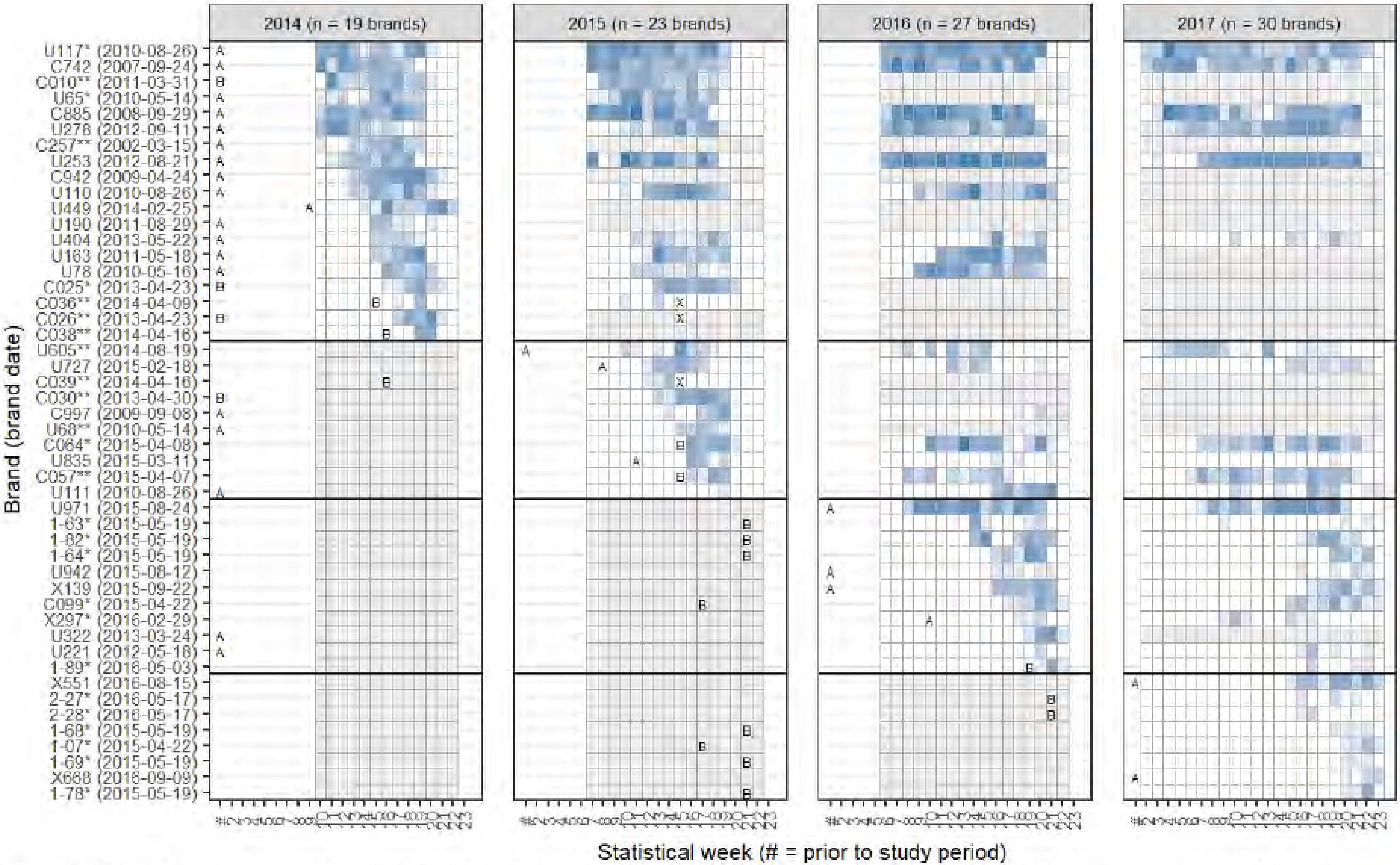
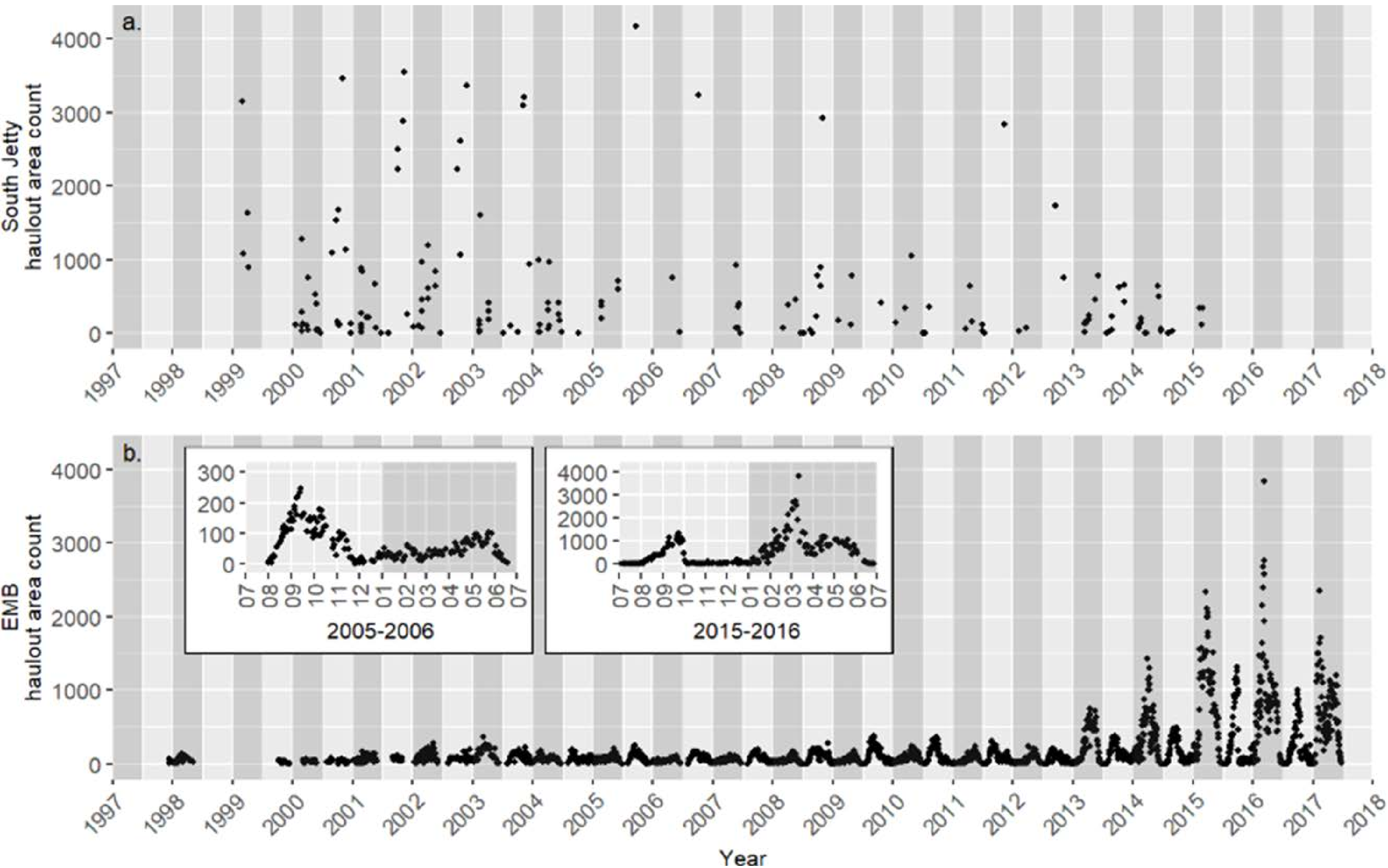
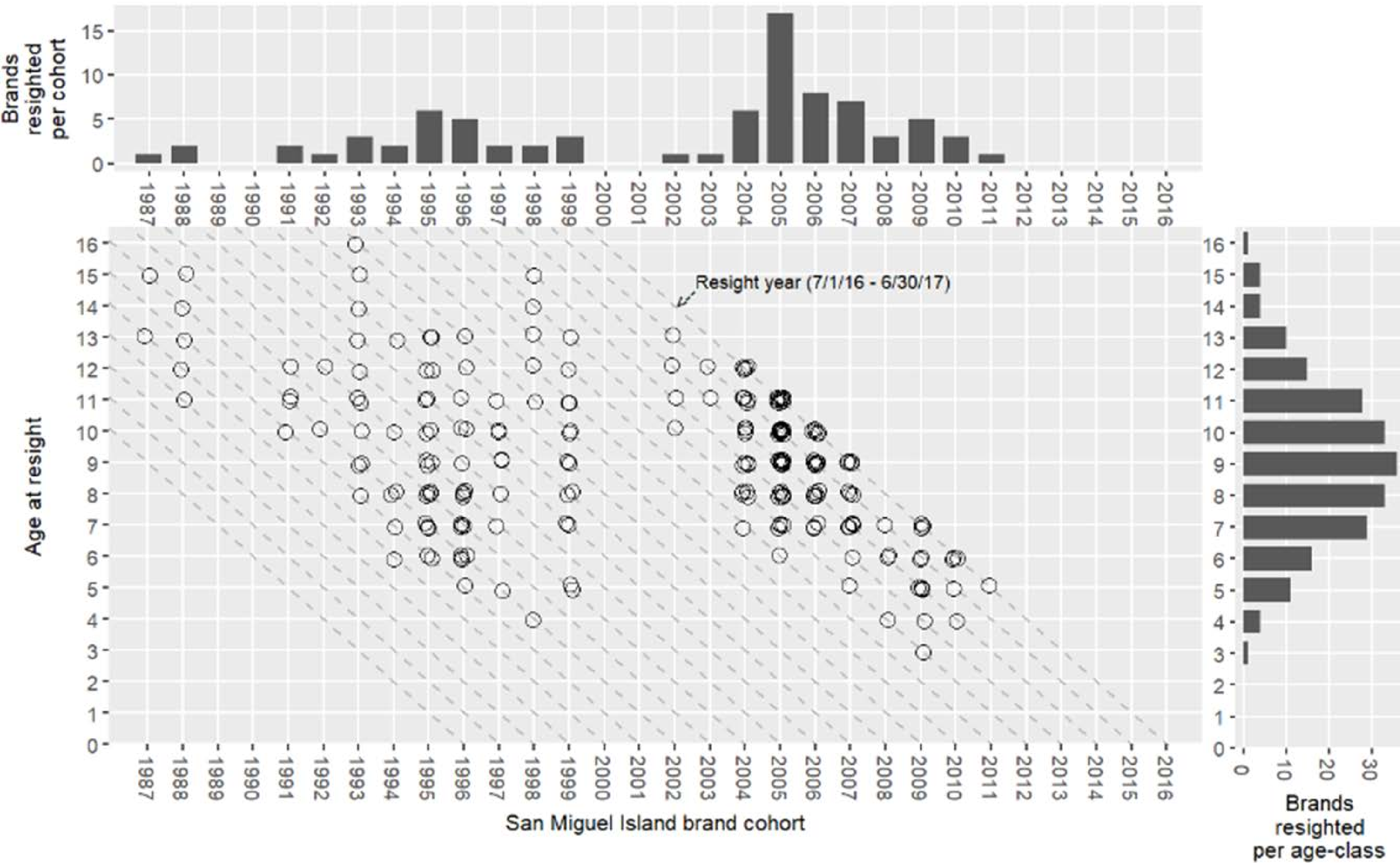


Figure 6. Weekly residency of branded California sea lions (n = 48 total) at Willamette Falls sorted by year and week of first detection (darker hue = more days detected). Capture location at branding denoted by 'A' (Astoria) or 'B' (Bonneville Dam); X denotes animal was removed under MMPA Section 120; * indicates animal documented at Bonneville Dam; ** indicates animal on MMPA Section 120 list for removal. Brands recorded less than three days per year were considered unconfirmed and are not included unless photographed. [Note that this graphic will be updated once image processing from automated cameras is competed.]

Columbia River estuary



a.
South Jetty haulout area count
b.
EMB haulout area count
2005-2006
2015-2016
Year
0
1000
2000
3000
4000
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018



Brands resighted per cohort
Resight year (7/1/16 - 6/30/17)
Age at resight
San Miguel Island brand cohort
Brands resighted per age-class

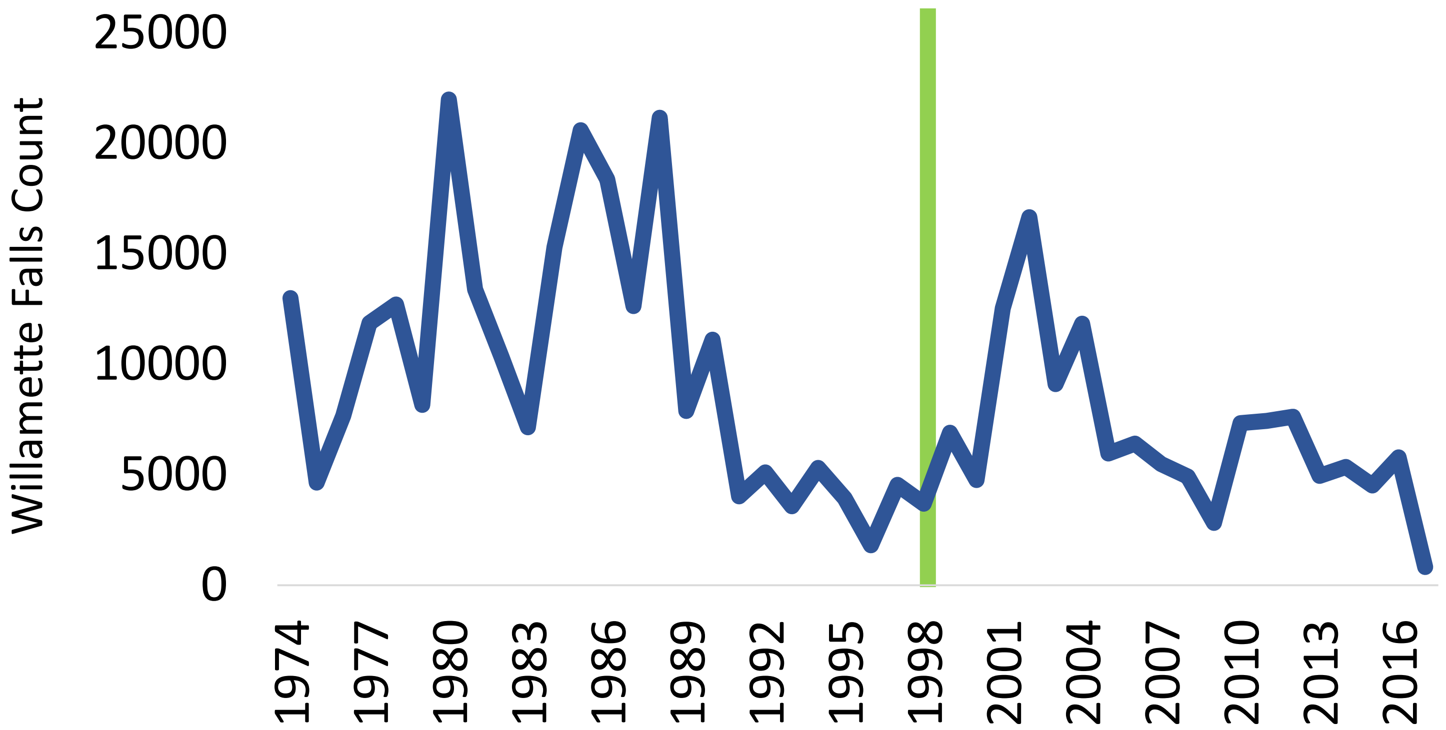
Are California Sea Lions Causing Undue Injury to Salmonids or Humans?

Presenter: Shaun Clements

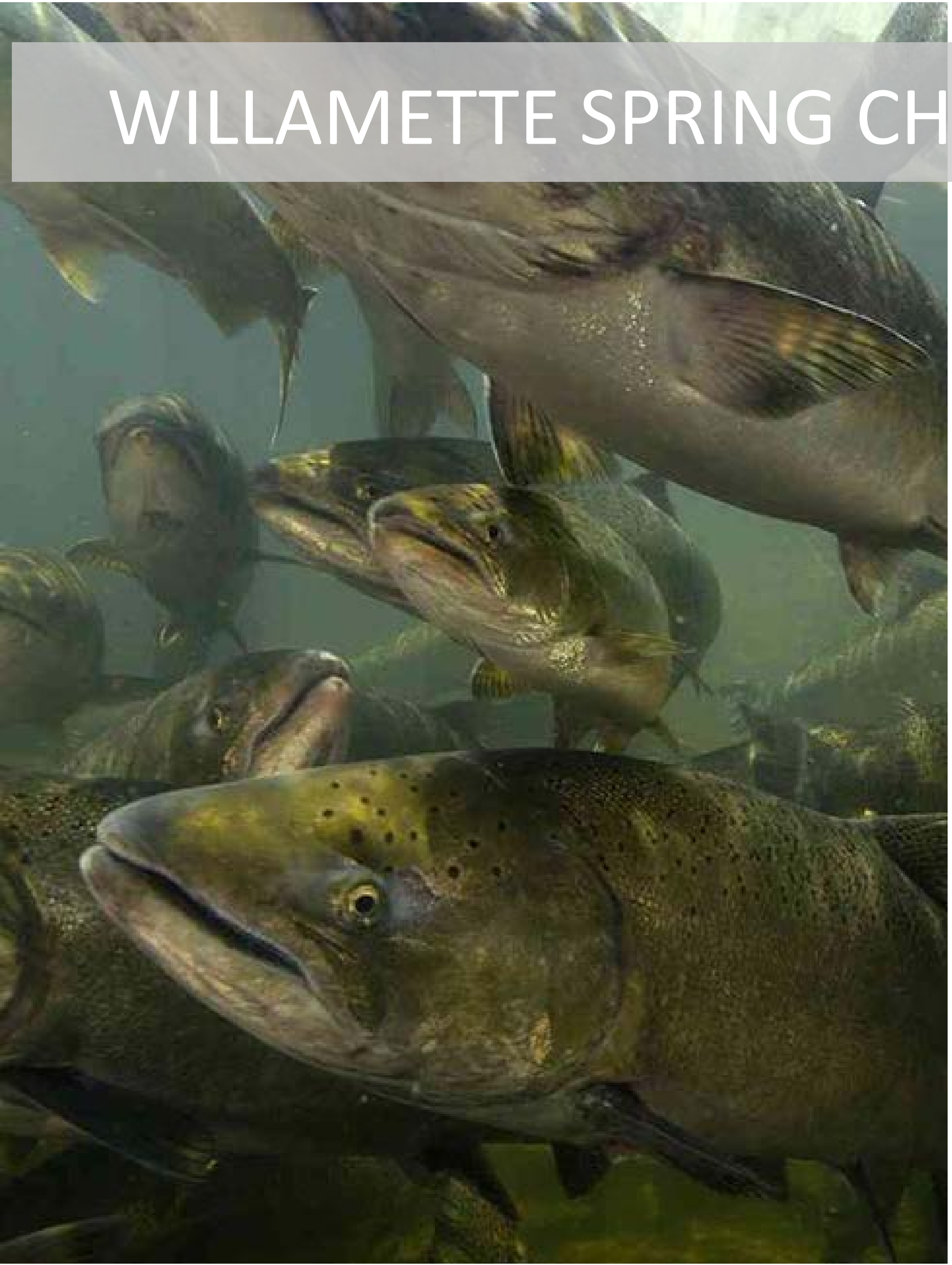
Corresponding Summary Page(s): 25-27

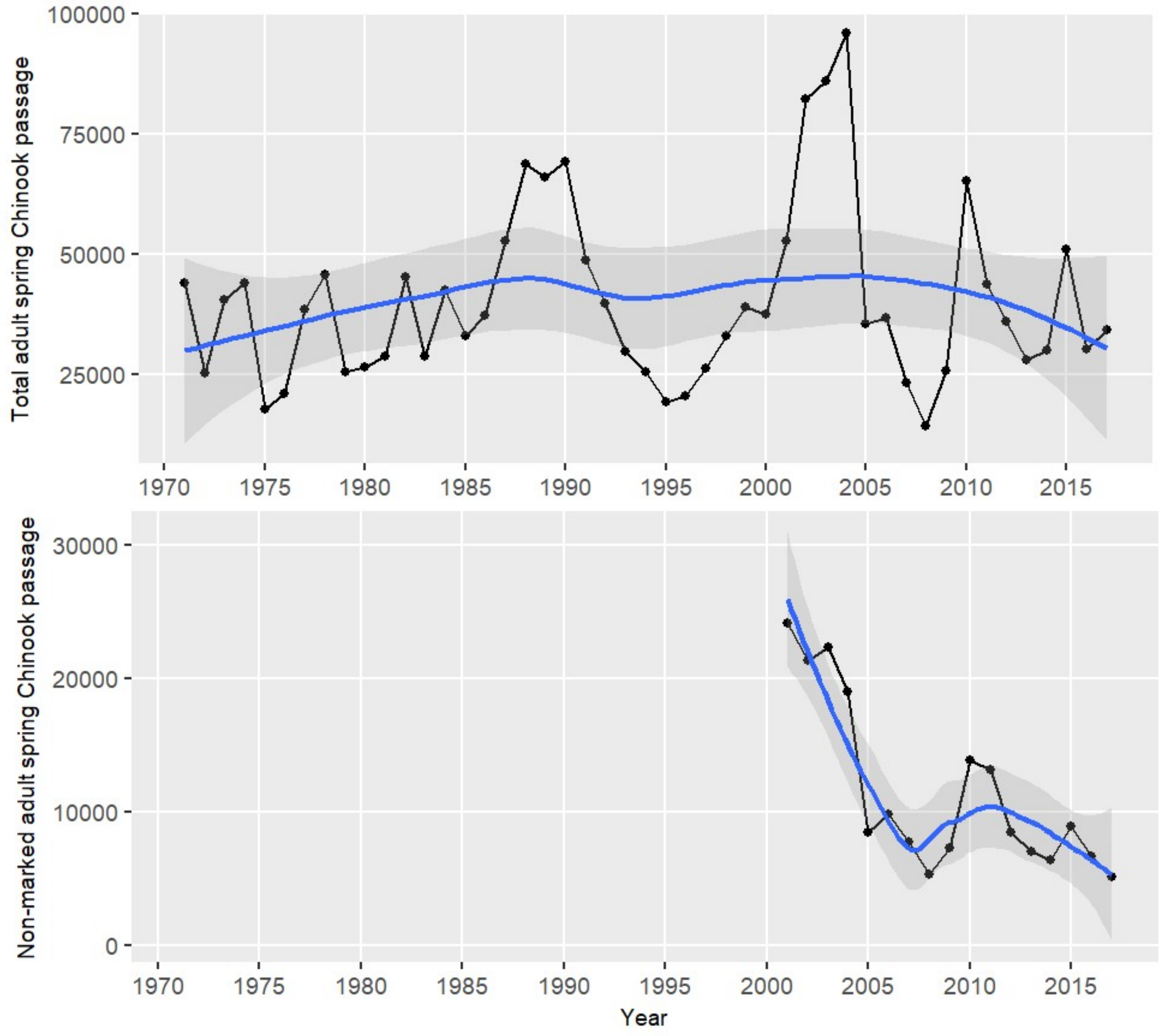
Are CSL causing undue injury to UWR steelhead and Chinook?

WILLAMETTE WINTER STEELHEAD |

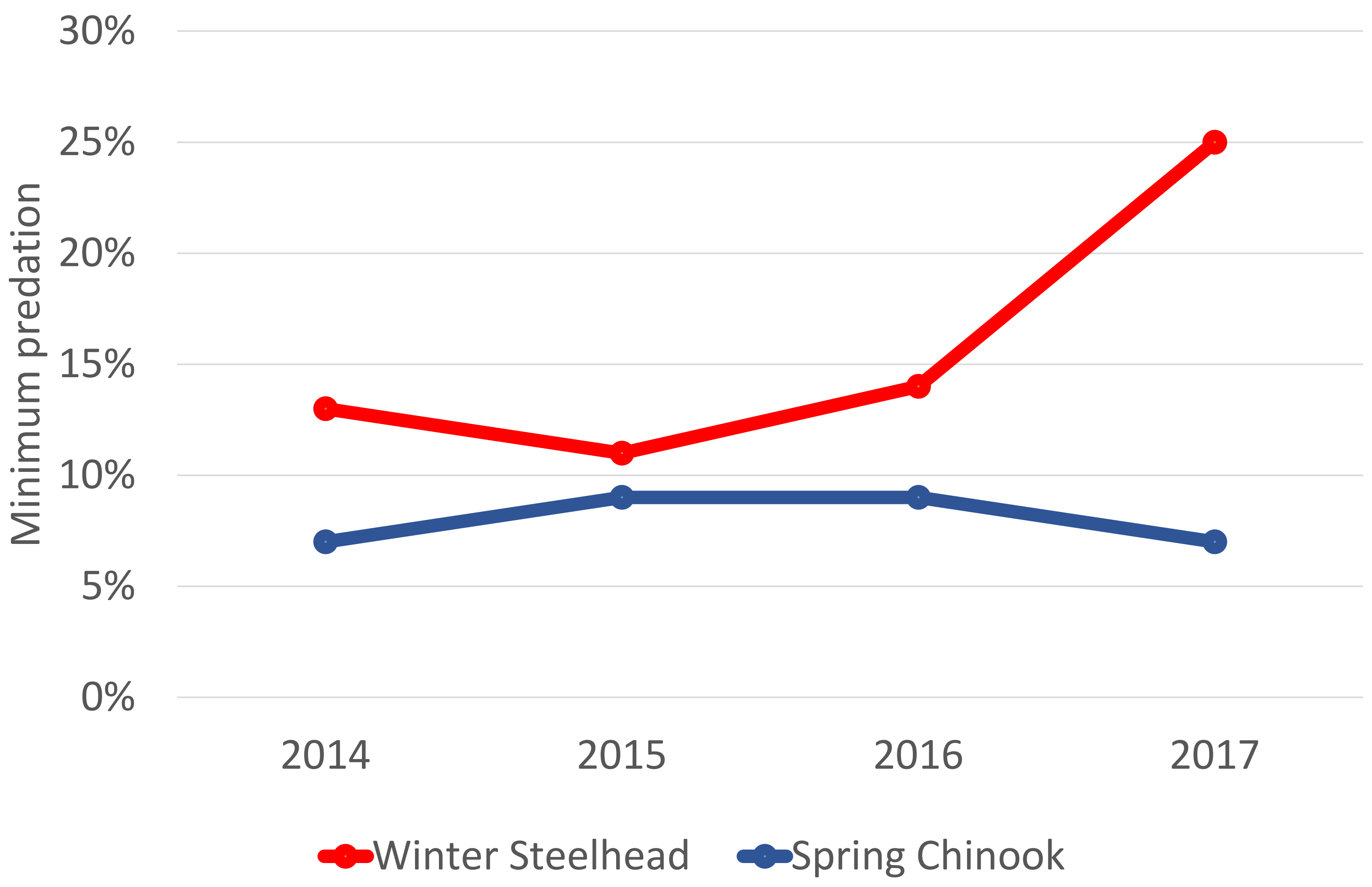


WILLAMETTE SPRING CHINOOK





WILLAMETTE SPRING CHINOOK   PREDATION RATE



WILLAMETTE WINTER STEELHEAD | EXTINCTION RISK

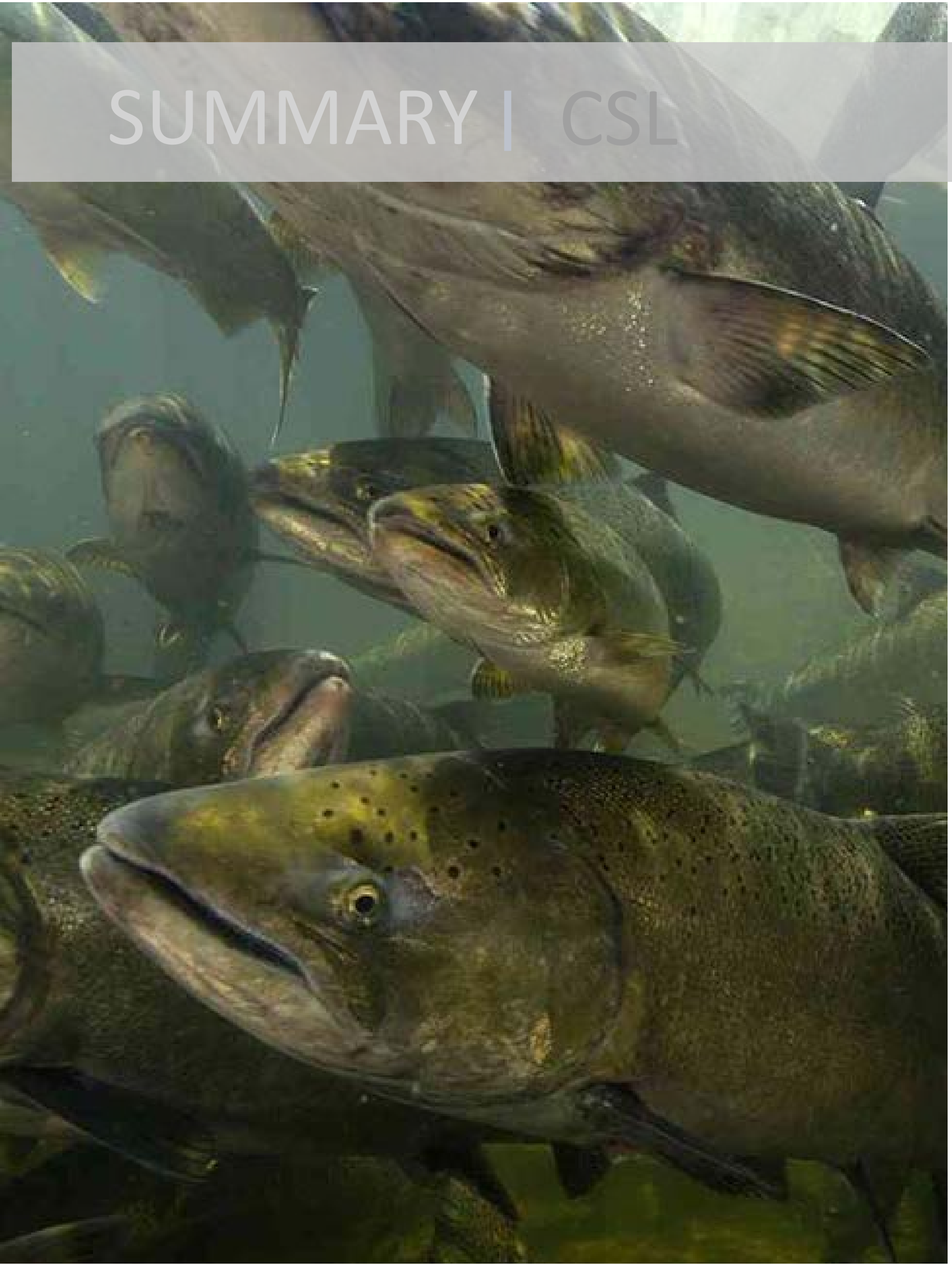
Scenario		Single Population		
		North Santiam	South Santiam	Molalla
Without Sea Lions		2%	5%	0%
With Sea lions	lowest observed predation (2015)	8%	16%	0%
	average predation (2016)	27%	34%	2%
	highest observed predation (2017)	64%	60%	21%

MCKENZIE SPRING CHINOOK | EXTINCTION RISK

Scenario		Single Population
		McKenzie
Without Sea Lions		20-30%
With Sea lions		
	highest observed predation (2015/16)	33-45%

Do CSL pose a risk to human safety?

SUMMARY | CSL



Sea lions
250-300,000
Population abundance

Sea lions
40+
At Willamette Falls

Months Present
3
Per Year

→

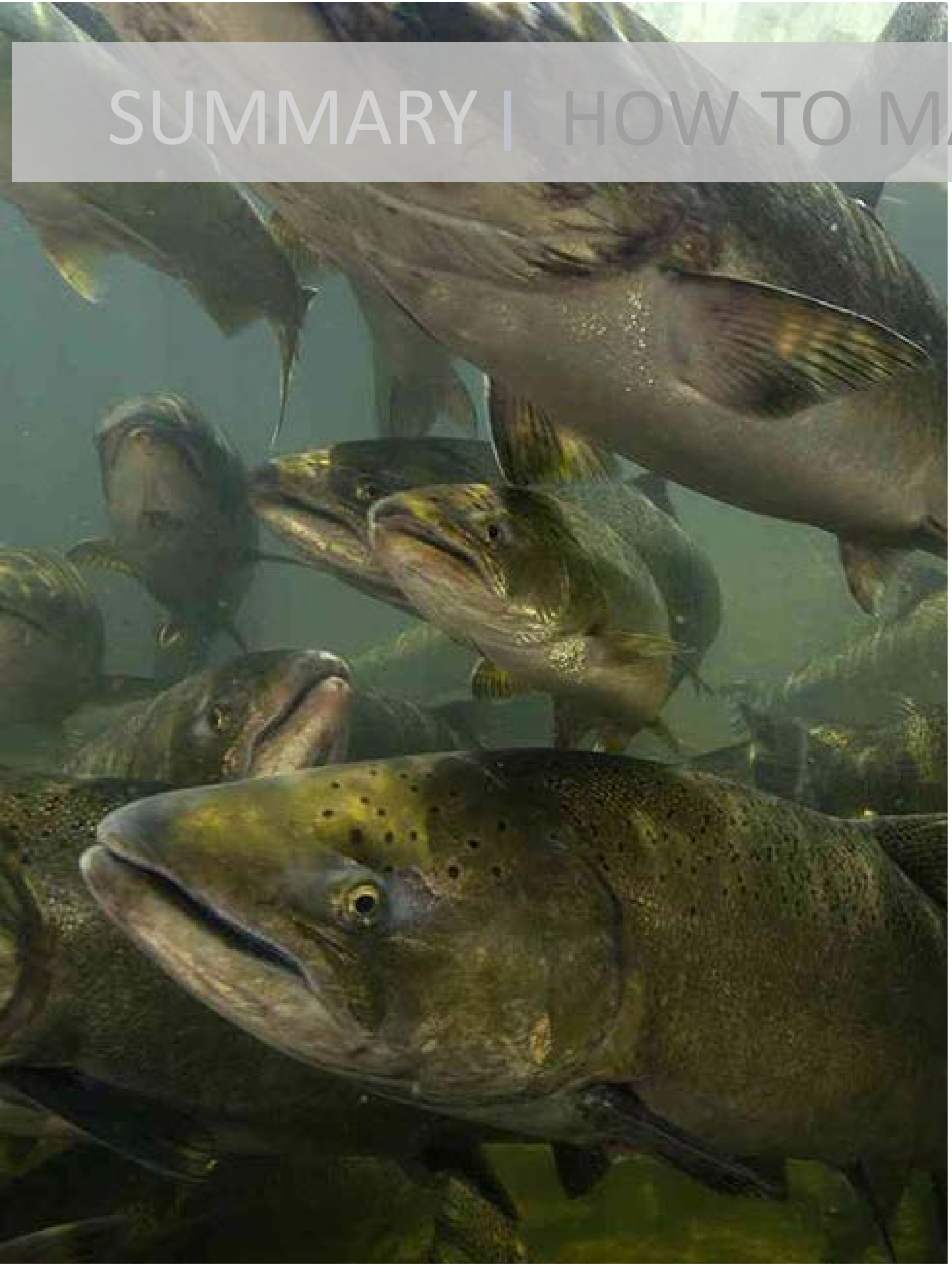
Months Present
10
Per Year

Salmonid
~85%
Of diet

SUMMARY | IMPACT TO FISH

Winter Steelhead	Spring Chinook
4H's **0-5%** Probability of Extinction	4H's **20-30%** Probability of Extinction
↓	↓
Predation **11-25%** Rate	Predation **7-9%** Rate
↓	↓
Increase in **0-62%** Probability of Extinction	Increase in **13-15%*** Probability of Extinction

SUMMARY | HOW TO MANAGE THREAT



Non lethal?

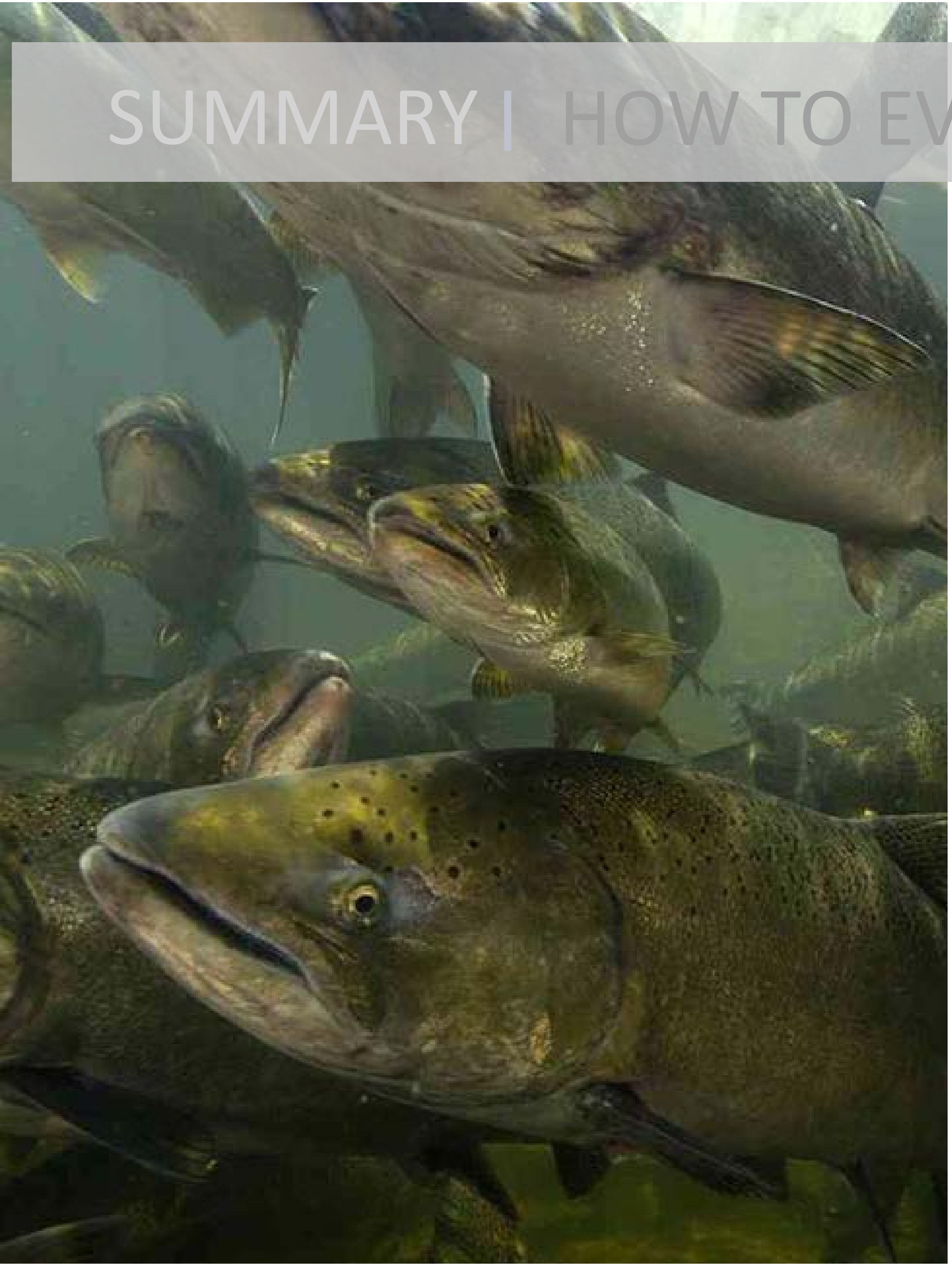
Lethal?

- Replacement?
  - Are we at carrying capacity?
    - Early arriving animals (Aug-Mar)
    - Peak period (Apr-May)
      - 7% of animals exhibit behavior
      - Animal behavior/transmission
- What we don't know?
  - Replacement rate at low occupancy

Non lethal as part of mgmt. portfolio?

- Naïve animals?
  - Evidence
  - Practicability

SUMMARY | HOW TO EVALUATE EFFECTIVENESS?



Nov-Mar

1) Have we reduced predator presence prior to April (metric: number of sea lions present or predator days)

Apr-May

1) Have we reduced the single day maximum count (metric: single day maximum)
2) Have we reduced predation rate @ falls (stratified sampling)

↓

PVA-reduce extinction risk