MMPA §120(b)(2)
Expected Benefits of Taking

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Marine Mammal Program

III. APPLICATION CONSIDERATIONS

(F). The expected benefits of the program (pg. 35)

1. Bioenergetic estimate of expected benefit (pg. 36)

Table 18 (pg. 36)
Table 19 (pg. 39)
Figure 10 (pg. 37)
Appendix 4 (pg. 93)

Outline

- Expected benefits estimated by…
  - Bioenergetic modeling of daily per capita prey requirements…
  - Applied to three management scenarios and two sea lion population sizes
  - Requirements $\neq$ consumption

- Presentation outline
  - Motivate model with familiar example
  - Explain model in detail
  - Explain management scenario calculations
  - Answer questions

Where do these number come from?

Table 18. Mean number of fish required* per day or per month to meet ~~resting~~ metabolic needs based on primary prey contributing 90% of the energetic density to overall daily requirement (n = 10,000 reps each):

	Chinook		Steelhead		White Sturgeon		Eulachon	
Sea-lion species	1 day	1 month	1 day	1 month	1 day	1 month	1 day	1 month
CSL	2.4	72	3.2	96			202	6048
SSL	3.5	105	4.8	144	2.4	63	339	10167

Calories provide a measure of how much energy you get from a serving of food.

100% salmon filet diet:

$$\frac{2000\ \text{cal/day}}{180\ \text{cal/filet}} =$$

11.1 filets/day

Nutrition Facts

Serving Size 1 Filet

Amount Per Serving	
Calories 180	Calories from Fat 70
	% Daily Value*
Total Fat 8g	**12%**
Saturated Fat 1g	**6%**
Cholesterol 60mg	**21%**
Sodium 190mg	**8%**
Total Carbohydrate 3g	**1%**
Dietary Fiber less than 1 gram	**2%**
Sugars 0g	
Protein 23g	

Vitamin A 2% • Vitamin C 2%

Calcium 2% • Iron 6%

*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:

		Calories: 2,000	2,500
Total Fat	Less than	65g	80g
Saturated Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

Calories per gram:
Fat 9 • Carbohydrate 4 • Protein 4

$$\frac{2500\ \text{cal/day}}{180\ \text{cal/filet}} =$$

13.9 filets/day

Requirements also depend on energy content of food

Nutrition Facts

Serving Size 1 Filet

Amount Per Serving	
Calories 180	Calories from Fat 70
	% Daily Value*
Total Fat 8g	**12%**
Saturated Fat 1g	**6%**
Cholesterol 60mg	**21%**
Sodium 190mg	**8%**
Total Carbohydrate 3g	**1%**
Dietary Fiber less than 1 gram	**2%**
Sugars 0g	
Protein 23g	
Vitamin A 2% •	Vitamin C 2%
Calcium 2% •	Iron 6%

*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:

	Calories:	2,000	2,500
Total Fat	Less than	65g	80g
Saturated Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

Calories per gram:
Fat 9 • Carbohydrate 4 • Protein 4

$$\frac{2000\ \text{cal/day}}{180\ \text{cal/filet}} =$$

11.1 filets/day

$$\frac{2000\ \text{cal/day}}{410\ \text{cal/filet}} =$$

4.9 filets/day

Model based on Winship et al. 2002 and Winship and Trites 2003

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A bioenergetic model for estimating the food requirements of Steller sea lions *Eumetopias jubatus* in Alaska, USA

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ABSTRACT: A generalized bioenergetic model was used to estimate the food requirements of Steller sea lions *Eumetopias jubatus* in Alaska, USA. Inputs included age- and sex-specific energy requirements by date, population size and composition, and diet composition and energy content. Error in model predictions was calculated using uncertainty in parameter values and Monte Carlo simulation methods. Our model suggests that energy requirements of individuals were generally lowest in the summer breeding season (June to August) and highest in the winter (December to February) and spring (March to May) mainly due to changes in activity budgets. Predicted relative daily food requirements were highest for young animals (12 ± 3% SD and 13 ± 3% of body mass for 1 yr old males and females respectively) and decreased with age (5 ± 1% and 6 ± 1% of body mass for 14 yr old males and 22 yr old females respectively). The mean daily food requirement of pregnant females predicted by the model was only marginally greater than the predicted mean daily food requirement of non-pregnant females of the same age. However, the model suggested that the mean daily food requirement of females nursing pups was about 70% greater than females of the same age without pups. Of the 3 sets of model parameters (diet, population, and bioenergetic), uncertainty in diet and bioenergetic parameters resulted in the largest variation in model predictions. The model provides a quantitative estimate of the Steller sea lion population's food requirements and also suggests directions for future research.

KEY WORDS: Bioenergetic model · *Eumetopias jubatus* · Food consumption · Steller sea lion · Sensitivity analysis

INTRODUCTION

Since the late 1970s, the Alaskan population of Steller sea lions *Eumetopias jubatus* has decreased by

tion estimates are also a prerequisite for assessing interactions between marine mammals and fisheries (Beverton 1985, Trites et al. 1997).

It is difficult to observe food consumption directly

Prey consumption of Steller sea lions (*Eumetopias jubatus*) off Alaska: How much prey do they require?

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Abstract—The effects of seasonal and regional differences in diet composition on the food requirements of Steller sea lions (*Eumetopias jubatus*) were estimated by using a bioenergetic model. The model considered differences in the energy density of the prey, and differences in digestive efficiency and the heat increment of feeding of different diets. The model predicted that Steller sea lions in southeast Alaska required 45–60% more food per day in early spring (March) than after the breeding season in late summer (August) because of seasonal changes in the energy density of the diets (along with seasonal changes in energy requirements). The southeast Alaska population, at 23,000 (±1660 SD) animals (all ages), consumed an estimated 140,000 (±27,800) t of prey in 1998. In contrast, we estimated that the 51,000 (±3680) animals making up the western Alaska population in the Gulf of Alaska and Aleutian Islands consumed just over twice this amount (303,000 [±57,500] t). In terms of biomass removed in 1998 from Alaskan waters, we estimated that Steller sea lions accounted for about 5% of the natural mortality of gadids (pollock and cod) and up to 75% of the natural mortality of hexagrammids (adult Atka mackerel). These two groups of species were consumed in higher amounts than any other. The predicted average daily food requirement per individual ranged from 16 (±2.8) to 20 (±3.6) kg (all ages combined). Per capita food requirements differed by as much as 24% between regions of Alaska depending on the relative amounts of low–energy-density prey (e.g. gadids) versus high–energy-density prey (e.g. forage fish and salmon) consumed. Estimated requirements were highest in regions where Steller sea lions consumed higher proportions of low–energy-density prey and experienced the highest rates of population decline.

Nutritional stress may account for the decline of Steller sea lions (*Eumetopias jubatus*) in Alaska (Alverson, 1992), which have declined by over 70% in the last 20–25 years (Loughlin et al., 1992; Trites and Larkin, 1996). Merrick et al. (1997) found a negative correlation between Steller sea lion diet diversity and the rate of population change among six regions of Alaska in the early 1990s. The greatest rates of population decline occurred in areas with low diet diversity, where Steller sea lions predominantly preyed on either walleye pollock or Atka mackerel. Steller sea lions from areas that did not experience a decline, or experienced a lower rate of decline, preyed on both walleye pollock and Atka mackerel along with several other groups of prey species.

Merrick et al. (1997) suggested that the relationship between diet diversity and the rate of population decline reflected differences in the efficiency with which Steller sea lions could find, capture, and handle different numbers of prey categories. However, the energy content of the diet may also have a substantial effect on the foraging efficiency of Steller sea lions. Steller sea lions consuming a low diversity diet of primarily low–energy-density species than it would be for animals consuming prey of high-energy content.

The overall goal of our study was to estimate the amount of prey required by Steller sea lions in Alaska during the 1990s using a previously developed bioenergetic model (Winship et al., 2002). Our first objective was to examine how daily food biomass requirements were affected by seasonal differences in the energy density of the diet of Steller sea lions in southeast Alaska. Our second objective was to use the same model to compare the food requirements of Steller sea lions among seven regions of Alaska during the 1990s (regions based on Merrick et al., 1997, and Sease and Loughlin, 1999; Fig. 1). Our third objective was to use data from 1998 to compare estimates of Steller sea lion prey consumption with fisheries catches and estimates of prey stock sizes (and natural mortality rates).

Methods

Model structure

The bioenergetic model that we used is described in detail by Winship et al.

i = salmonid
j = CSL

Biomass requirement (BR) of prey i for predator j

i = sturgeon
j = SSL

$$BR_{ij}[kg\ d^{-1}] = \frac{GER[kJ\ d^{-1}] \times prey_i}{ED_{diet}[kJ\ g^{-1}]} \div 1000$$

$$\text{Gross Energy Requirement } (GER) = \frac{P + (A_j \times BM_j)}{E_u \times \sum_i (prey_i \times E_{f_i} \times E_{HIF_i})}$$

$$\text{Production } (P) = \text{energy invested in daily growth} = 0^*$$

$$\text{Basal Metabolism } (BM_j)\ [kJ\ d^{-1}] = 292.88 \times M_j^{0.75}, where\ M_j \sim N(\mu_j, \sigma_j)$$

$$\text{Energetic Cost of Activity } (A_j) = water_j * A_{water} + (1 - water_j) * A_{land}$$

$$\text{Proportion of time spent in the water } (water_j) \sim \text{triangle}(min_j, max_j, mode_j)$$

$$'\text{On land}'\text{multiplier of } BM\ (A_{land}) \sim \text{triangle}(1.0, 1.4, 1.2)$$

$$'\text{In water}'\text{multiplier of } BM\ (A_{water}) \sim \text{triangle}(2.5, 5.5, 4.0)$$

$i =$ salmonid
j = CSL

Biomass requirement (BR) of prey i for predator j

$i =$ sturgeon
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$$BR_{ij}[kg\ d^{-1}] = \frac{GER[kJ\ d^{-1}] \times prey_i}{ED_{diet}[kJ\ g^{-1}]} \div 1000$$

$$\text{Gross Energy Requirement } (GER) = \frac{P + (A_j \times BM_j)}{E_u \times \sum_i \left(prey_i \times E_{f_i} \times E_{HIF_i}\right)}$$

$$\text{Urinary digestive efficiency } (E_u) \sim uniform(0.90, 0.93)$$

$$\text{Proportion by wet mass of prey } i \text{ in diet } (prey_i) = \begin{cases} 0.9, i = 1 \\ 0.1, i = 2 \end{cases}$$

$$\text{Fecal digestive efficiency } \left(E_{f_i}\right) = \frac{\alpha}{1 + e^{-\theta(ED_i - \gamma)}}, where\ \alpha, \theta, \gamma \sim N$$

$$\text{Efficiency of utilizationof metabolizable energy } \left(E_{HIF_i}\right) =$$

$$1 - \left(\frac{\beta_0 + \beta_1 \times ED_i}{E_u \times E_{f_i}}\right), where\ \boldsymbol{\beta} \sim N$$

$i =$ salmonid
j = CSL

$i =$ sturgeon
j = SSL

Biomass requirement (BR) of prey i for predator j

$$BR_{ij}[kg\ d^{-1}] = \frac{GER[kJ\ d^{-1}] \times prey_i}{ED_{diet}[kJ\ g^{-1}]} \div 1000$$

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$$\text{Proportion by wet mass of prey } i \text{ in diet } (prey_i) = \begin{cases} 0.9, i = 1 \\ 0.1, i = 2 \end{cases}$$

$$\text{Energetic density of diet } (ED_{diet}) = \sum_i prey_i \times ED_i$$

i = salmonid
j = CSL

Number of fish of prey i for predator j

i = sturgeon
j = SSL

$$\#\ prey_i\ d^{-1} = k, where \frac{BR_{ij}[kg\ d^{-1}]}{\sum_k N(\mu_i, \sigma_i)} > 1\ for\ k-1$$

Example: $BR = 10\ kg\ d^{-1}$

$$\frac{10}{\sum_{k=1}^{1}(3.5)} > 1, \qquad \frac{10}{\sum_{k=1}^{2}(3.5+5)} > 1, \qquad \frac{10}{\sum_{k=1}^{3}(3.5+5+4.1)} \leq 1$$

$\therefore$ k = 3 fish/d

i = salmonid
j = CSL

Predator-prey inputs (Appendix 4)

i = sturgeon
j = SSL

j	M_j (lbs)	M_j (kgs)
CSL	~N(600, 100)	~N(272, 45)
SSL	~N(1200, 267)	~N(544, 121)

i	ED_i kJ g^{-1}	M_i (lbs)	M_i (kgs)
Chinook salmon	~uniform(5, 9)	~N(14.3, 2.6)	~N(6.5, 1.2)
Winter steelhead	~uniform(5, 9)	~N(10, 1.67)	~N(4.5, 0.8)
White Sturgeon	4.4	~N(4, 0.7) ft 34.9 lbs	~N(121.9, 20.3) cm 15.8 kgs
Eulachon	~N(9.7, 1.13)	0.09	0.041
Secondary prey (*i* = 2)	~uniform(3, 11)	NA	NA

$i =$ salmonid
j = CSL

Results

$i =$ sturgeon
j = SSL

- Monte Carlo simulation implemented in R
- Each combination of *j* and *i* run 10K times
- 1-day estimates in Table 18 are averages over the 10K runs

Table 18. Mean number of fish required* per day or per month to meet resting metabolic needs based on primary prey contributing 90% of the energetic density to overall daily requirement (n = 10,000 reps each):

	Chinook		Steelhead		White Sturgeon		Eulachon	
Sea-lion species	1 day	1 month	1 day	1 month	1 day	1 month	1 day	1 month
CSL	2.4	72	3.2	96			202	6048
SSL	3.5	105	4.8	144	2.4	63	339	10167

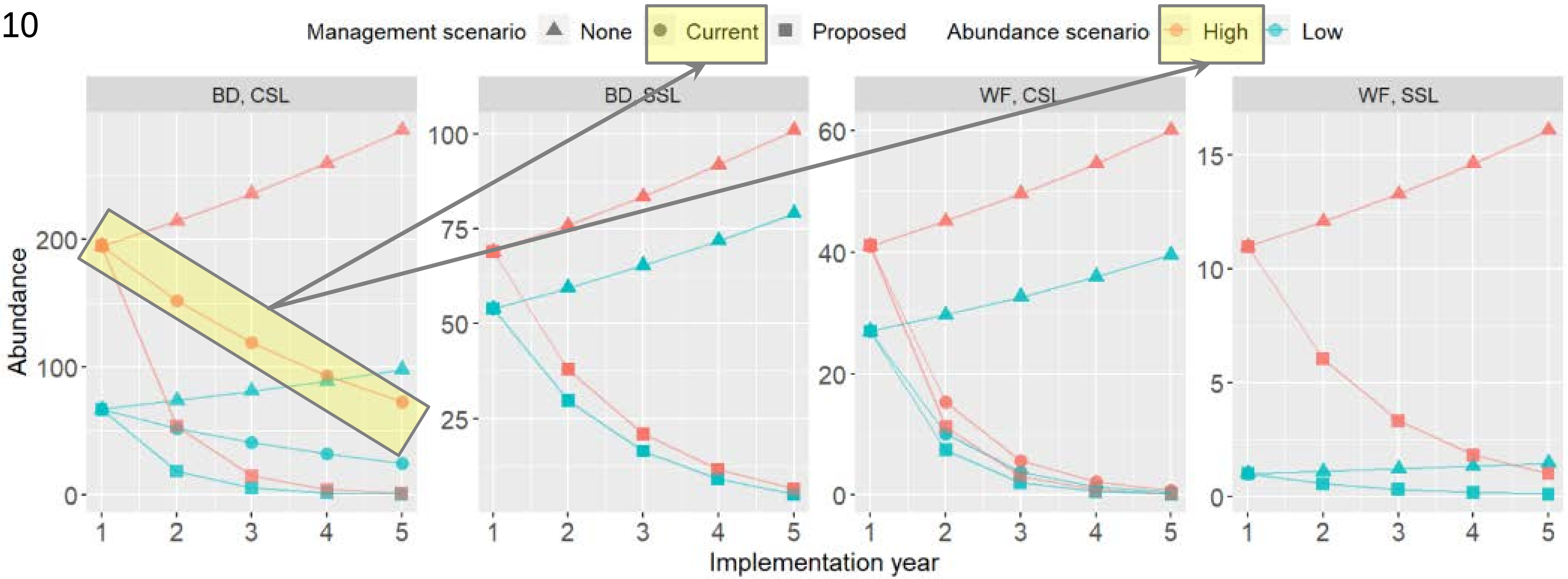
Model validation

Species*	Prey	kg d^{-1}	fish d^{-1}	Source	Method
CSL	Chinook salmon	11.6 (12.9 total)	2.4	Application	Bioenergetic model
	Mixed	11 (35 max)		Kastelein et al. 2000	Captive animal
	Chinook salmon		3.5-5.5	Lessard/CRITFC 2018	Functional response
SSL	Chinook salmon	19.4 (21.5 total)	3.5	Application	Bioenergetic model
	Mixed	18 (26 max)		Kastelein et al. 1991	Captive animal
	Mixed	33		Winship et al. 2002	Bioenergetic model
	Mixed	30		Allen 2009	Bioenergetic model

*Adult males

Next step: Scale up from individual to population

Figure 10



Species	Management scenario	Annual recruitment rate	Annual removal rate	
			Bonneville	Willamette
CSL	None	10%	0%	0%
	Current	10%	29%	66%
	Proposed	10%	75%	75%
SSL	None/Current	10%	0%	0%
	Proposed	10%	50%	50%

Table 19. Estimate of 5 year fish consumption under scenarios of "No Management", "Current Management", or "Proposed Management" at Bonneville Dam and Willamette falls and the number of fish potentially saved under the proposed management relative to no management or current management. Daily consumption requirements are based on a bioenergetics model. The estimates are for two different starting population abundances of CSL or SSL (see text for detail) and two different residence times for SSL or CSL (7 or 42 d).

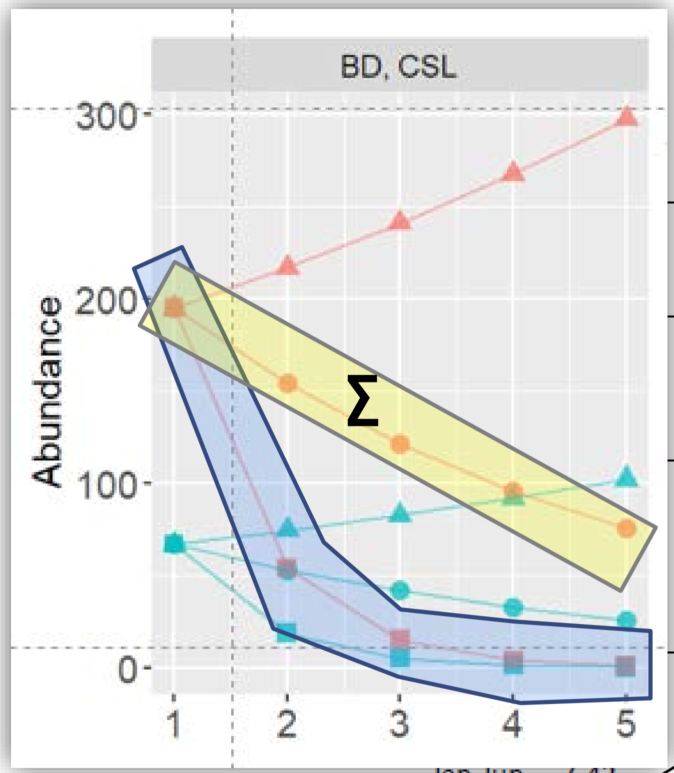
Population-level bioenergetics

Results (requirements)

"Savings"

Sea lion Spp.	Location	Season	Days	Prey spp.	Prey /day	Proportion in diet	No Management Low	No Management High	Current Management Low	Current Management High	Proposed Management Low	Proposed Management High	Fish Saved (vs "No Mgmt.") Low	Fish Saved (vs "No Mgmt.") High	Fish Saved (vs "Proposed Mgmt.") Low	Fish Saved (vs "Proposed Mgmt.") High
SSL	BONN	Jul-Dec	7-42	Sturgeon	2.4	0.21	595	4,558			203	1,556	392	3,002		
		Jul-Dec	7-42	Chinook	3.5	0.35	1,445	11,079			493	3,782	952	7,297		
		Jul-Dec	7-42	Steelhead	4.8	0.11	623	4,775			213	1,630	410	3,145		
		Jul-Dec	7-42	Coho	3.5	0.33	1,363	10,446			465	3,566	897	6,880		
		Jan-Jun	7-42	Sturgeon	2.4	0.05	142	1,085			48	371	93	715		
		Jan-Jun	7-42	Chinook	3.5	0.90	3,716	28,489			1,269	9,726	2,447	18,762		
		Jan-Jun	7-42	Steelhead	4.8	0.05	283	2,171			97	741	186	1,430		
	WF	Jan-Jun	7-42	Sturgeon	2.4	0.75	79	5,190			27	1,772	52	3,418		
		Jan-Jun	7-42	Chinook	3.5	0.20	31	2,019			10	689	20	1,329		
		Jan-Jun	7-42	Steelhead	4.8	0.05	10	692			4	236	7	456		
CSL	BONN	Jan-Jun	7-42	Chinook	2.4	0.95	6,674	116,550	3,518	61,426	1,478	25,812	5,196	90,738	2,039	35,613
		Jan-Jun	7-42	Steelhead	3.2	0.05	468	8,179	247	4,311	104	1,811	365	6,368	143	2,499
	WF	Jul-Dec	7-42	Steelhead	3.2	1.00	377	3,439	96	879	84	762	294	2,678	13	117
		Jan-Jun	7-42	Chinook	2.4	0.73	1,860	16,947	475	4,330	412	3,753	1,448	13,194	63	577
		Jan-Jun	7-42	Steelhead	3.2	0.27	917	8,358	234	2,135	203	1,851	714	6,507	31	284

Table 19. Estimate of 5 year fish consumption under scenarios of “No Management”, “Current Management”, or “Proposed Management” at Bonneville Dam and Willamette falls and the number of fish potentially saved under the proposed management relative to no management or current management. Daily consumption requirements are based on a bioenergetics model. The estimates are for two different starting population abundances of CSL or SSL (see text for detail) and two different residence times for SSL or CSL (7 or 42 d).



							No Management		Current Management		Proposed Management		Fish Saved (vs “No Mgmt.”)		Fish Saved (vs “Proposed Mgmt.”)	
				Prey spp.	Prey /day	Proportion in diet	Low	High	Low	High	Low	High	Low	High	Low	High
				Sturgeon	2.4	0.21	595	4,558			203	1,556	392	3,002		
				Chinook	3.5	0.35	1,445	11,079			493	3,782	952	7,297		
				Steelhead	4.8	0.11	623	4,775			213	1,630	410	3,145		
				Coho	3.5	0.33	1,363	10,446			465	3,566	897	6,880		
				Sturgeon	2.4	0.05	142	1,085			48	371	93	715		
				Chinook	3.5	0.90	3,716	28,489			1,269	9,726	2,447	18,762		
				Steelhead	4.8	0.05	283	2,171			97	741	186	1,430		
				Sturgeon	2.4	0.75	79	5,190			27	1,772	52	3,418		
				Chinook	3.5	0.20	31	2,019			10	689	20	1,329		
		Jan-Jun	7-42	Steelhead	4.8	0.05	10	692			4	236	7	456		
	BONN	Jan-Jun	7-42	Chinook	2.4	0.95	6,674	116,550	3,513	61,426	1,478	25,812	5,196	[illegible]	2,039	35,613
		Jan-Jun	7-42	Steelhead	3.2	0.05	468	8,179	247	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CSL		Jul-Dec	7-42	Steelhead	3.2	1.00	377	3,439	96	879	84	762	294	2,678	13	117
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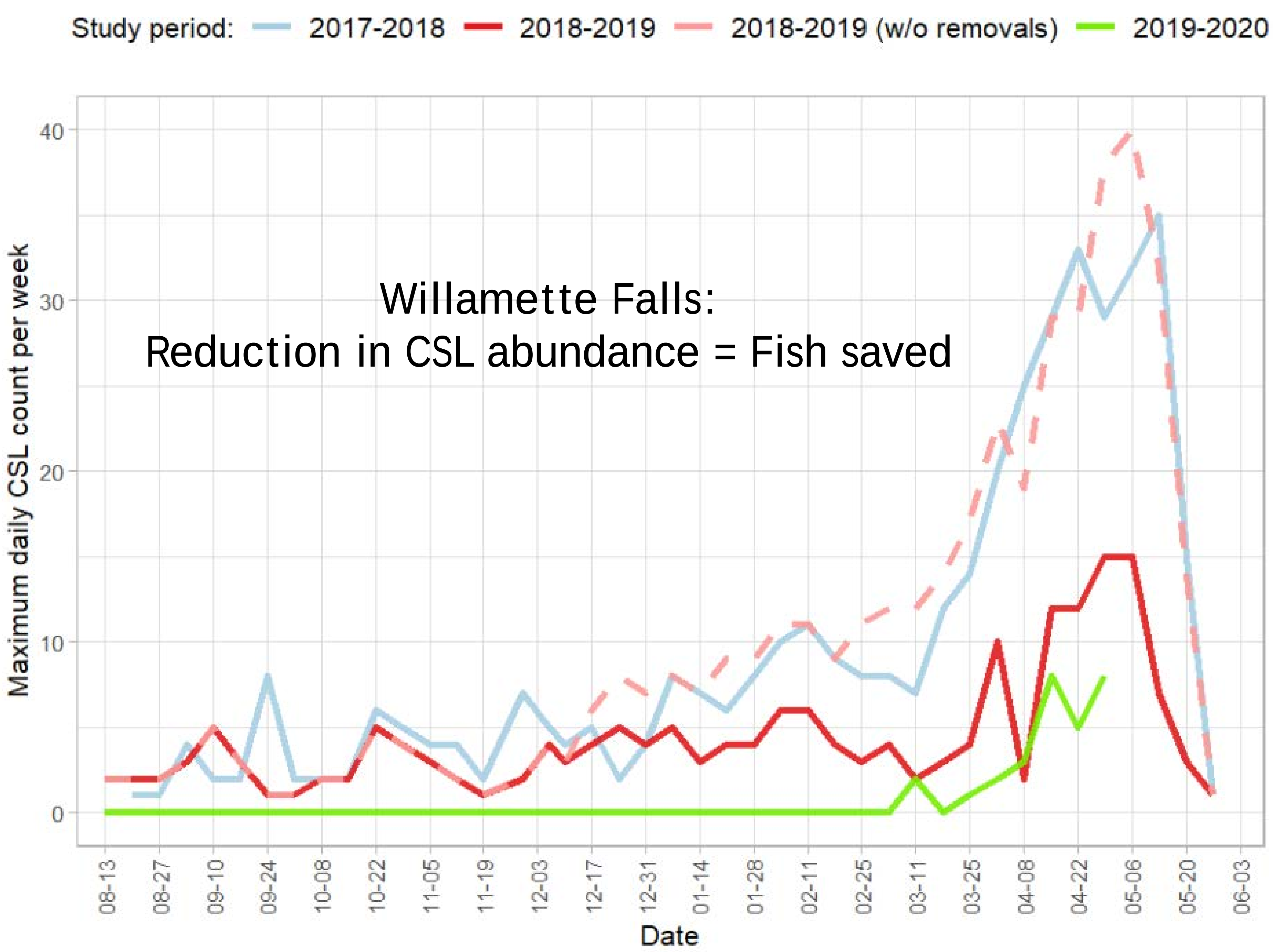
Study period: 2017-2018 2018-2019 2018-2019 (w/o removals) 2019-2020
Willamette Falls:
Reduction in CSL abundance = Fish saved
Maximum daily CSL count per week
0
10
20
30
40
08-13
08-27
09-10
09-24
10-08
10-22
11-05
11-19
12-03
12-17
12-31
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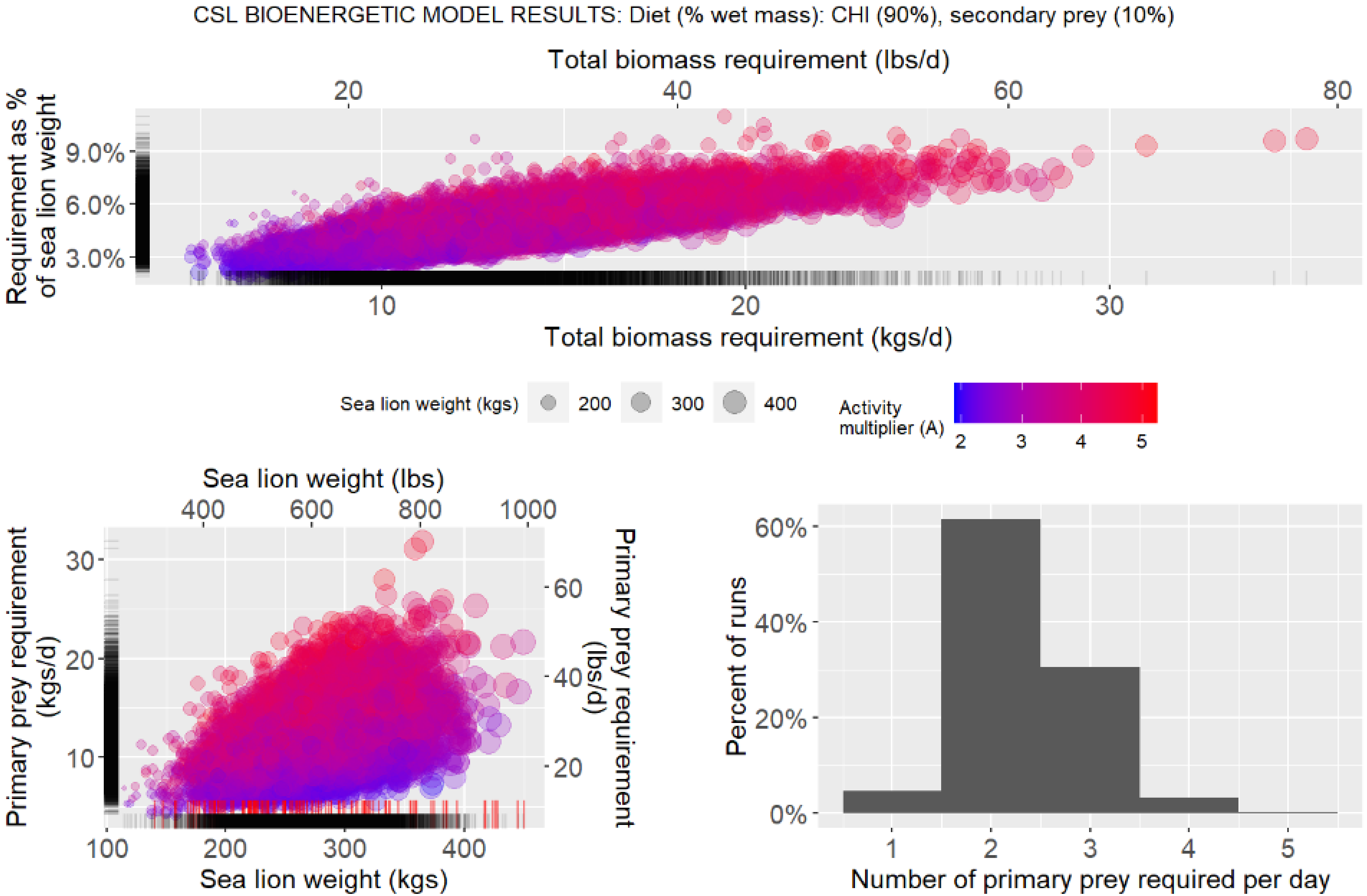
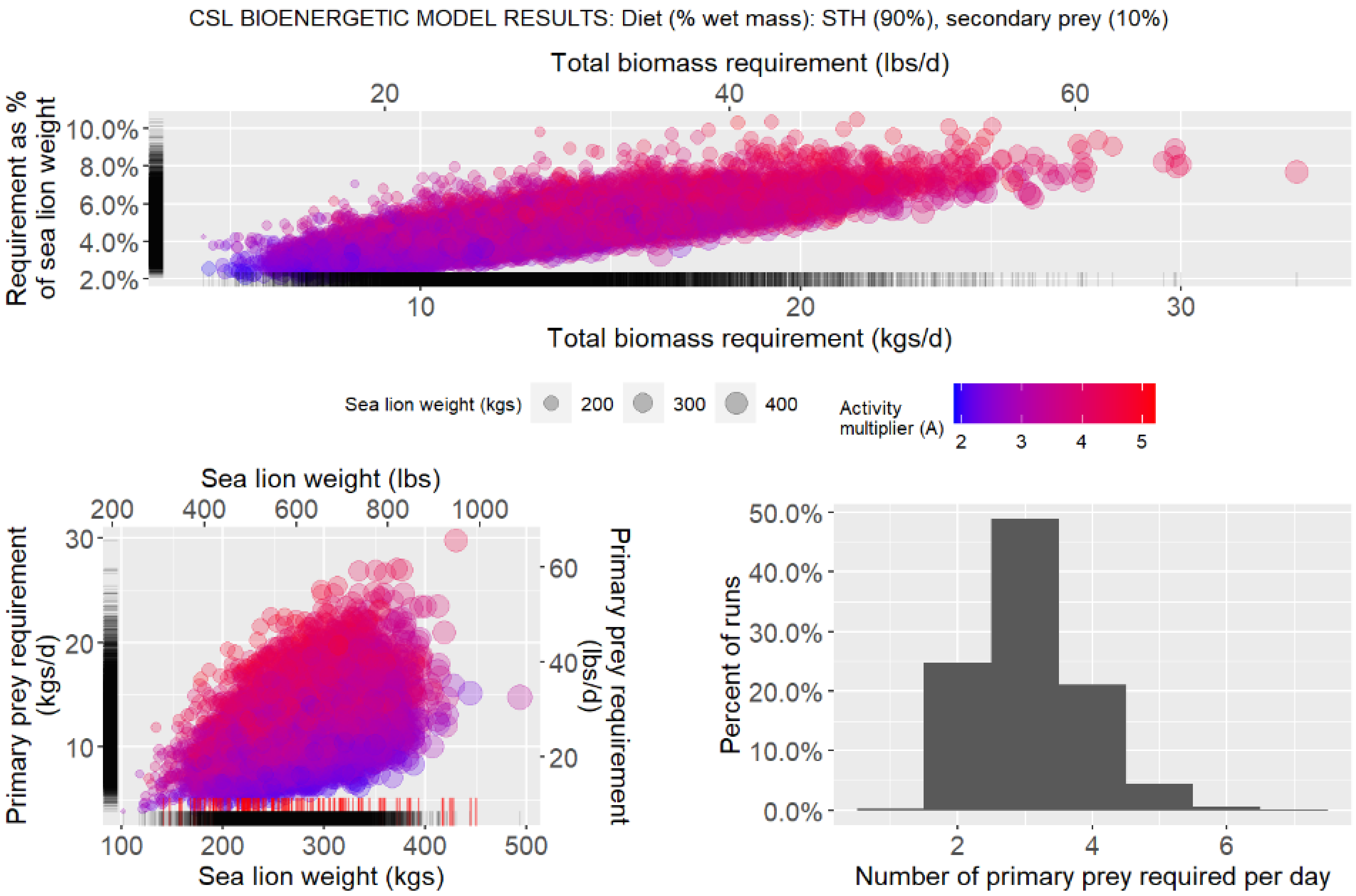
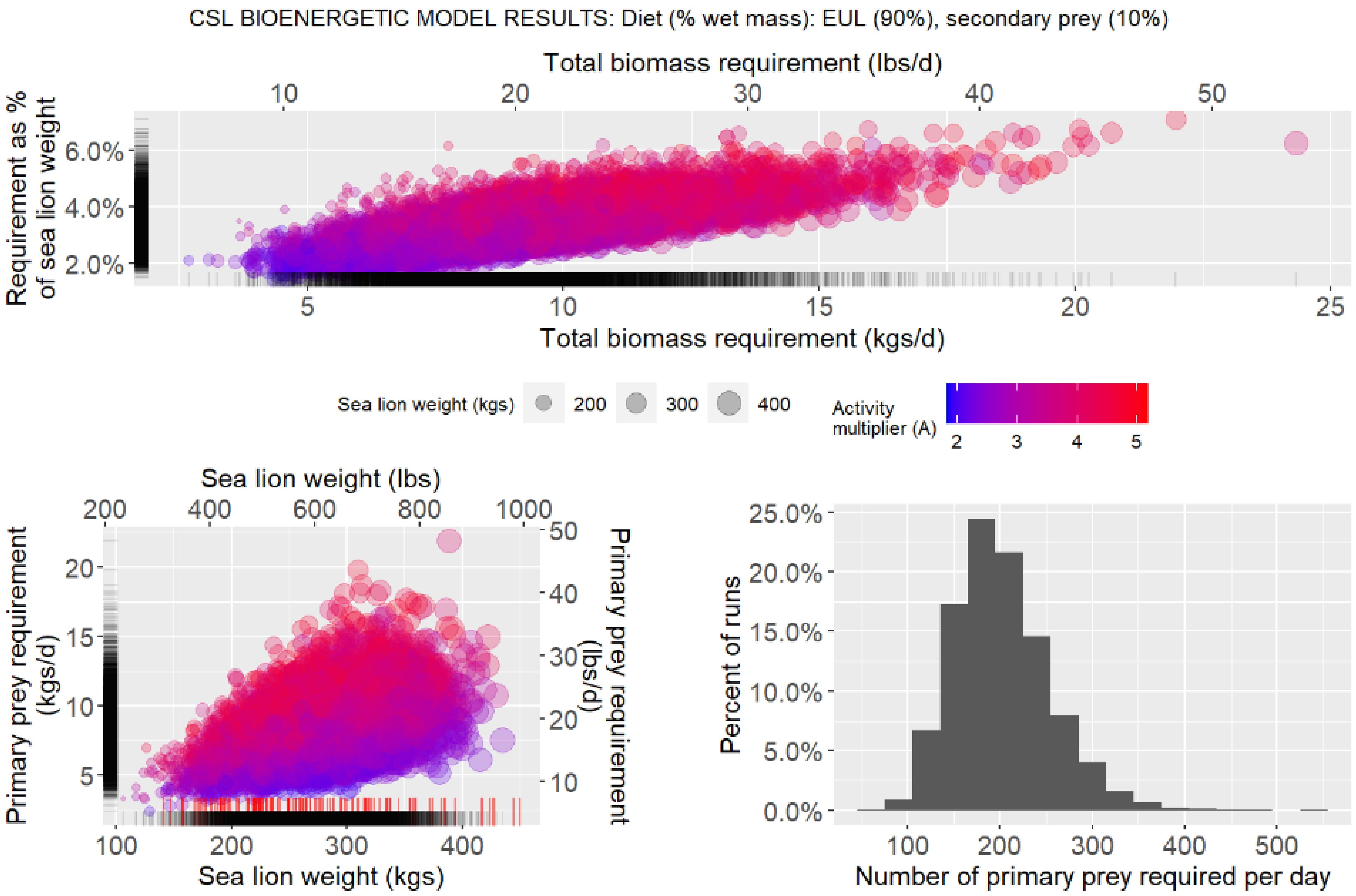
Date

Questions?

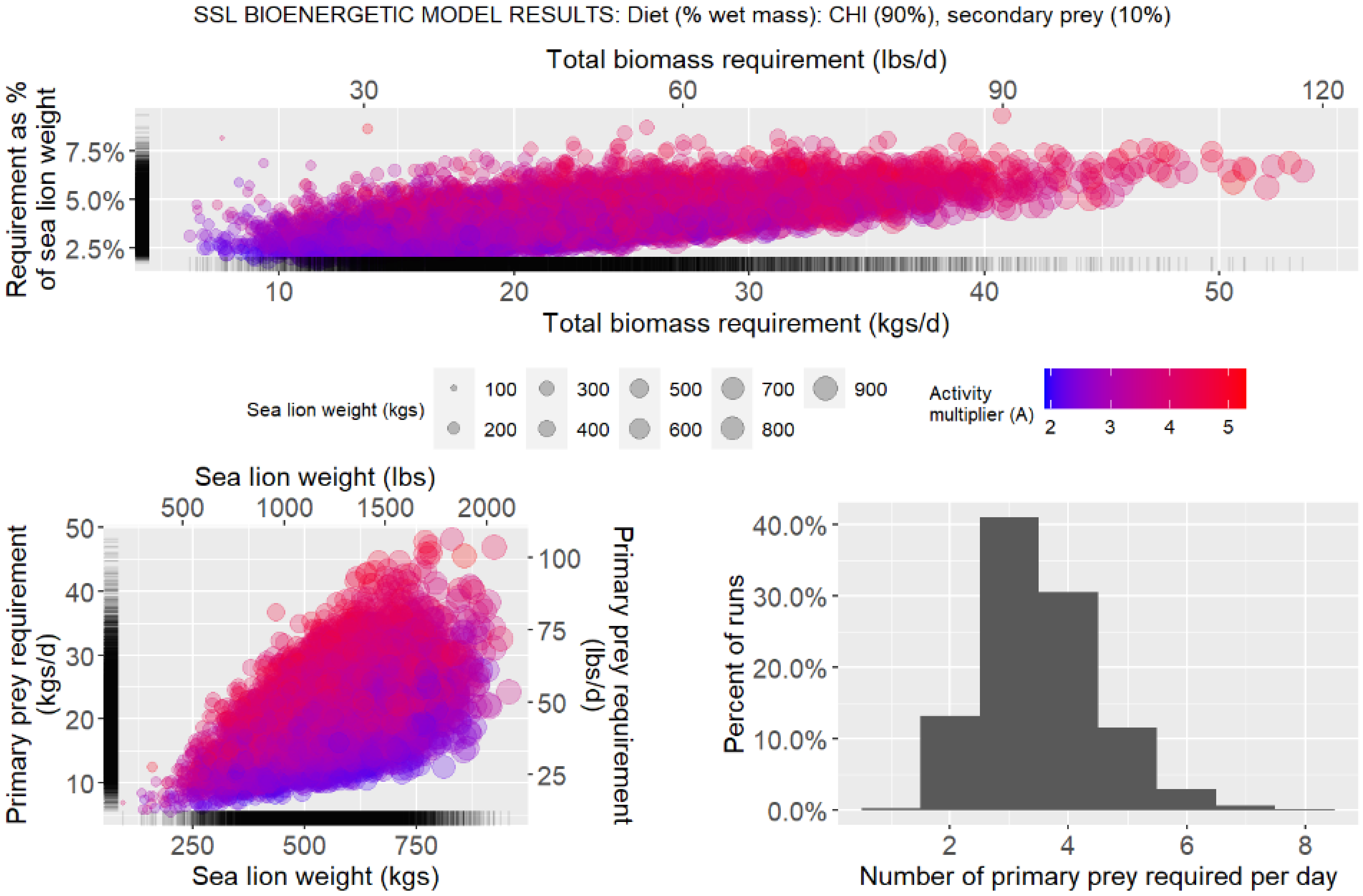

CSL BIOENERGETIC MODEL RESULTS: Diet (% wet mass): CHI (90%), secondary prey (10%)
Total biomass requirement (lbs/d)
20
40
60
80
Requirement as % of sea lion weight
9.0%
6.0%
3.0%
10
20
30
Total biomass requirement (kgs/d)
Sea lion weight (kgs)
200
300
400
Activity multiplier (A)
2
3
4
5
Sea lion weight (lbs)
400
600
800
1000
Primary prey requirement (kgs/d)
30
20
10
Primary prey requirement (lbs/d)
60
40
20
100
200
300
400
Sea lion weight (kgs)
Percent of runs
60%
40%
20%
0%
1
2
3
4
5
Number of primary prey required per day



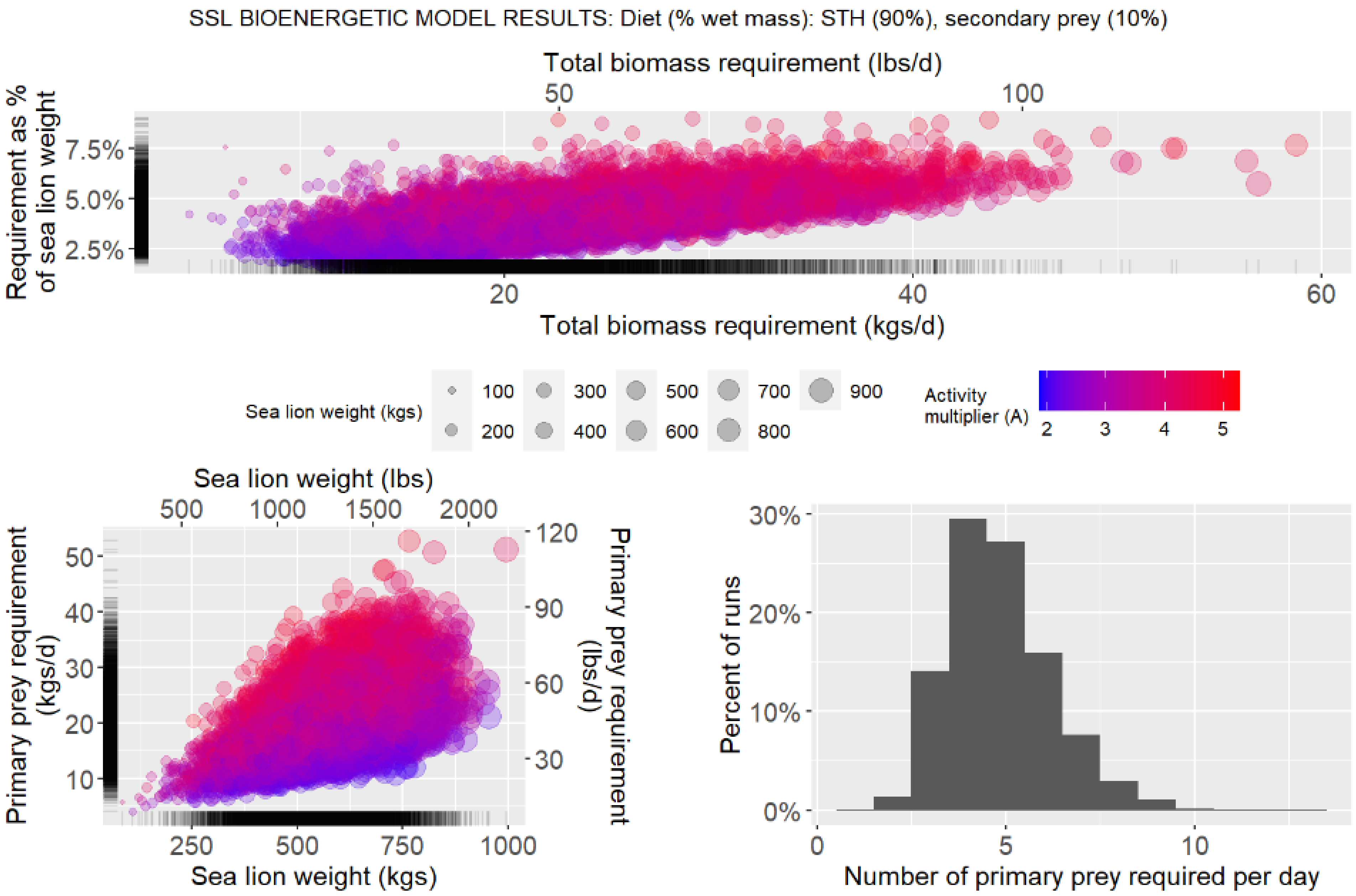
CSL BIOENERGETIC MODEL RESULTS: Diet (% wet mass): STH (90%), secondary prey (10%)
Total biomass requirement (lbs/d)
20
40
60
Requirement as % of sea lion weight
10.0%
8.0%
6.0%
4.0%
2.0%
10
20
30
Total biomass requirement (kgs/d)
Sea lion weight (kgs)
200
300
400
Activity multiplier (A)
2
3
4
5
Sea lion weight (lbs)
200
400
600
800
1000
Primary prey requirement (kgs/d)
30
20
10
Primary prey requirement (lbs/d)
60
40
20
100
200
300
400
500
Sea lion weight (kgs)
Percent of runs
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
2
4
6
Number of primary prey required per day

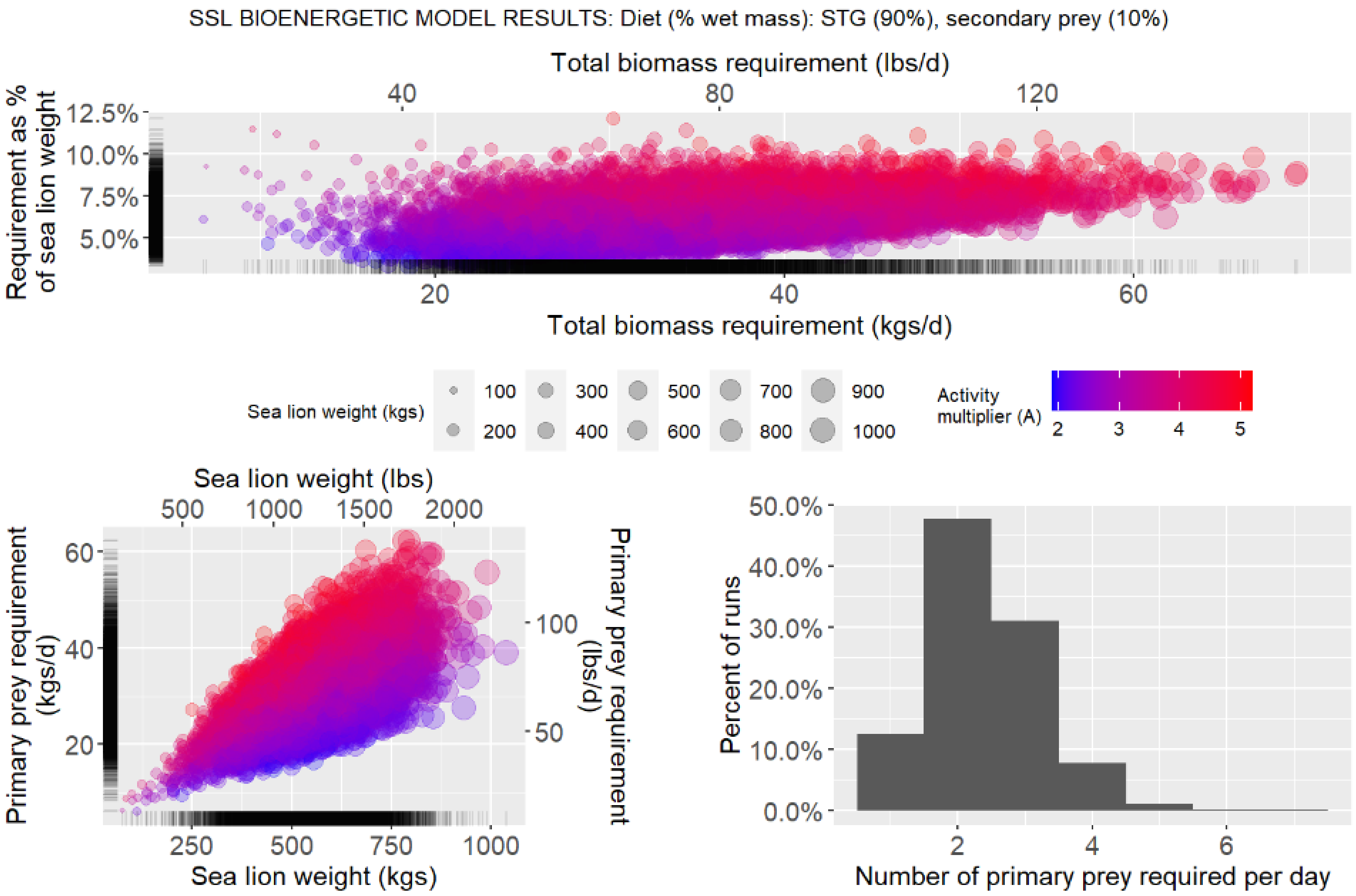


CSL BIOENERGETIC MODEL RESULTS: Diet (% wet mass): EUL (90%), secondary prey (10%)
Total biomass requirement (lbs/d)
10
20
30
40
50
Requirement as % of sea lion weight
6.0%
4.0%
2.0%
5
10
15
20
25
Total biomass requirement (kgs/d)
Sea lion weight (kgs)
200
300
400
Activity multiplier (A)
2
3
4
5
Sea lion weight (lbs)
200
400
600
800
1000
Primary prey requirement (kgs/d)
20
15
10
5
100
200
300
400
Sea lion weight (kgs)
Primary prey requirement (lbs/d)
50
40
30
20
10
Percent of runs
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
100
200
300
400
500
Number of primary prey required per day



SSL BIOENERGETIC MODEL RESULTS: Diet (% wet mass): CHI (90%), secondary prey (10%)
Total biomass requirement (lbs/d)
30
60
90
120
Requirement as % of sea lion weight
7.5%
5.0%
2.5%
10
20
30
40
50
Total biomass requirement (kgs/d)
Sea lion weight (kgs)
100
200
300
400
500
600
700
800
900
Activity multiplier (A)
2
3
4
5
Sea lion weight (lbs)
500
1000
1500
2000
Primary prey requirement (kgs/d)
50
40
30
20
10
100
75
50
25
Primary prey requirement (lbs/d)
250
500
750
Sea lion weight (kgs)
Percent of runs
40.0%
30.0%
20.0%
10.0%
0.0%
2
4
6
8
Number of primary prey required per day


SSL BIOENERGETIC MODEL RESULTS: Diet (% wet mass): STH (90%), secondary prey (10%)
Total biomass requirement (lbs/d)
50
100
Requirement as % of sea lion weight
7.5%
5.0%
2.5%
20
40
60
Total biomass requirement (kgs/d)
Sea lion weight (kgs)
100
200
300
400
500
600
700
800
900
Activity multiplier (A)
2
3
4
5
Sea lion weight (lbs)
500
1000
1500
2000
Primary prey requirement (kgs/d)
50
40
30
20
10
120
90
60
30
Primary prey requirement (lbs/d)
250
500
750
1000
Sea lion weight (kgs)
Percent of runs
30%
20%
10%
0%
0
5
10
Number of primary prey required per day



SSL BIOENERGETIC MODEL RESULTS: Diet (% wet mass): STG (90%), secondary prey (10%)
Total biomass requirement (lbs/d)
40
80
120
Requirement as % of sea lion weight
12.5%
10.0%
7.5%
5.0%
20
40
60
Total biomass requirement (kgs/d)
Sea lion weight (kgs)
100
200
300
400
500
600
700
800
900
1000
Activity multiplier (A)
2
3
4
5
Sea lion weight (lbs)
500
1000
1500
2000
Primary prey requirement (kgs/d)
60
40
20
Primary prey requirement (lbs/d)
100
50
250
500
750
1000
Sea lion weight (kgs)
Percent of runs
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
2
4
6
Number of primary prey required per day

SSL BIOENERGETIC MODEL RESULTS: Diet (% wet mass): EUL (90%), secondary prey (10%)