Benefits analysis

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2022-01-12

Benefits analysis

- How many (future) fish were saved by sea lion removals?

Benefits analysis

- How many (future) fish were saved by sea lion removals?
- Depends on sea lion:
  - age
  - weight
  - annual site fidelity (recurrence)
  - daily site fidelity (residency)
  - prey
    - > composition
    - > energetic density
    - > weight

Methods

- Agent (Individual) Based Model
- *Computational model for simulating the actions and interactions of autonomous agents…in order to understand the behavior of a system and what governs its outcomes…Monte Carlo methods are used to understand the stochasticity of these models.* [Wikipedia]
- See Appendix 3 of MMPA §120(f) Sea Lion Management Annual Report (12/1/2021) for details
- Ongoing development

Ecological Modelling 351 (2017) 36–50

Contents lists available at ScienceDirect

Ecological Modelling

journal homepage: www.elsevier.com/locate/ecolmodel

An agent-based bioenergetics model for predicting impacts of environmental change on a top marine predator, the Weddell seal

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ARTICLE INFO

Article history:
Received 31 August 2016
Received in revised form 5 February 2017
Accepted 6 February 2017
Available online 6 March 2017

Keywords:
Bioenergetics
Pinnipeds
Agent-based model
Climate change
Fishing pressure

ABSTRACT

One of the crucial scientific challenges of this century is characterizing the vulnerability
climate change. Bioenergetics models can provide a theoretical construct for addressing
logical and ecological hypotheses about how individuals may respond; however, many n
energy deficiencies with reproductive consequences, and thus cannot be used to predict
impacts. Here, we present an agent-based, ecophysiological model that simulates the e
adult, female Weddell seals (*Leptonychotes weddellii*). The input parameters include phy
and population-wide ranges for the duration and phenology of life history events. Energ
on foraging effort and stochastic prey availability, whereas energy expenditure is calcu
and behavior-specific demands. The simulated seal selects an activity (forage, nurse pup,
on body condition and life history constraints. At the end of each timestep, the energy bu
and catabolism or anabolism occurs. Following model development and validation wit
simulations were run to study the responses of individuals to: (1) baseline conditions;
prey availability. As expected, the model replicated the known fluctuations in energet
associated with reproduction and molt. A 10% reduction in prey availability resulted
more and resting less. At the end of the year-long simulations, animals in the baseline
significantly higher body masses than animals in the perturbation simulation. The model
used to explore decision-based energy allocation strategies that occur under different en
and to elucidate how extrinsic conditions can impact individual fitness. Identifying the
tivities of Weddell seals to predicted anthropogenic changes is a valuable contributio
global change biology and can inform management decisions in polar regions.

1. Introduction

The rapid environmental change that is occurring in polar regions (Parkinson 2004; Stammerjohn et al., 2008; Forcada et al., 2012) has energetic implications for top predators (Fraser and Hofmann 2003; Forcada et al., 2008). For pinnipeds, loss of ice platforms increases the distance between predator haul-outs and prey concentrations (Jay et al., 2010) and reduces suitable habitat used for resting, breeding, and predator avoidance (Siniff et al., 2008; Costa et al., 2010; Kovacs et al., 2010). Further, the delayed for-

mation of sea ice in the fall and winter can alter
molting phenology of ice-obligate species that em
sea ice (Simpkins et al., 2003; MacIntyre et al., 2013
tions or changes in the timing of ice coverage can in
predators by interrupting typical primary productivi
decreasing prey availability (Durant et al., 2007; Kov
Reductions in the abundance or quality of pre
baseline energetic costs as animals are forced to inc
aging effort to obtain the same energetic return (Tri
Goundie et al., 2015). Overfishing of high-energy
lead to reduced prey availability or a dietary shift
prey items (Hückstädt et al., 2012). In the Antarct
competition between commercial fisheries and pin
and Siniff 2009) will likely worsen as demands fo
and sea ice reductions promote the expansion of co

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http://dx.doi.org/10.1016/j.ecolmodel.2017.02.002

Ecological Modelling 407 (2019) 108725

Contents lists available at ScienceDirect

Ecological Modelling

journal homepage: www.elsevier.com/locate/ecolmodel

Individual-based modelling of black bear (*Ursus americanus*) foraging in Whistler, BC: Reducing human-bear interactions

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ARTICLE INFO

Keywords:
Computational ecology
Individual-based modelling
Whistler
BC
Bear movement
Human-bear interactions
Wildlife management

ABSTRACT

Human-black bear interactions have a long standing history involving extermination of bears
property, and, in some cases, injury or loss of human life. Much work has been done in the
agement to reduce the number of human-black bear interactions, including aversive condi
resource management, etc. However, determining which strategies are most effective is challe
terms of both time and fiscal resources. We approached this problem using an individu
technique that allows for the examination of multiple different bear management strategies
tested several different types of bear management strategies (BMS) and bear management sp
(BMC) using the community of Whistler, BC as a case study. Our results indicate that the op
on the BMS used, however, all implementations of bear management resulted in a decre
conflict bears. Models of this type could be used to guide future conservation efforts in s
seeking to reduce conflicts between humans and bears.

1. Introduction

It has long been acknowledged that human-wildlife interactions are expected to increase with urban growth and development (Woodroffe et al., 2005; Hristienko and Mcdonald Jr, 2007). As we continue to expand into wildlife habitat it is reasonable to expect the number of conflicts with wildlife to increase, thus creating a demand for mitigation strategies (Hostetler et al., 2009). A prominent example of such conflicts is that between humans and American black bears (*Ursus americanus*). Black bears have experienced dramatic losses in habitat range (McLean and Pelton, 1990; Schoen, 1990) as well as increased involvement in human-bear conflicts (Beckmann and Berger, 2003; Gore et al., 2005; Zack et al., 2003).

Black bears are abundant throughout North America with an estimated total population of 750,235 to 917,650 individuals (Hristienko and Mcdonald Jr, 2007). A conflict bear is here defined as a bear that

acts on its learned behaviour to such an extent that it
to human safety and property when seeking human
bage. Conflict bears are a result of specific types of l
actions, in particular, overexposure of bears to an
sources, garbage, and other attractants. Conflict bears
anthropogenic food and resources, and sometimes da
order to gain access to these resources. Any bear
conditioned and habituated towards humans to varyin
which lead to higher likelihood of more conflicts
(Greenleaf et al., 2009; Mattson et al., 1992; Pein
quently, both the prevention and handling of conflict
focus of modern wildlife management (Gniadek an
Gunther, 1994; Herrero et al., 2005).

Historically, lethal control has been implemen
measure for human-black bear conflict, but this app
unsatisfactory as human-black bear conflicts conti

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https://doi.org/10.1016/j.ecolmodel.2019.108725
Received 3 October 2018; Received in revised form 12 June 2019; Accepted 17 June 2019
Available online 28 June 2019

1709

NRC Research Press

ARTICLE

Using an individual-based model to simulate the Gulf of Maine American lobster (*Homarus americanus*) fishery and evaluate the robustness of current management regulations

Mackenzie Mazur, Bai Li, Jui-Han Chang, and Yong Chen

Abstract: Individual-based models (IBMs) can capture complex processes with a flexible probabilistic approach, which makes them useful for studying organisms with complex life history and fishery processes such as the American lobster (*Homarus americanus*). This research aims to modify and parameterize an individual-based lobster simulator (IBLS) to simulate the American lobster fishery in the Gulf of Maine. To simulate the fishery, the IBLS was tuned to match the seasonal catch and size composition from the 2015 American lobster stock assessment by adjusting the values of coefficients for select parameters. With appropriate coefficients for the initial abundance, recruitment, and seasonal encounter probability levels, the tuned IBLS accurately simulated the historical landings. Given the uncertainty in future American lobster recruitment, the tuned IBLS was then used to evaluate the effectiveness of current management regulations under different levels of recruitment.

Résumé : Les modèles basés sur les individus (MBI) peuvent décrire des processus complexes par une approche probabiliste souple, ce qui les rend utiles pour l'étude d'organismes caractérisés par des processus biologiques et de pêche complexes comme le homard américain (*Homarus americanus*). L'étude vise à modifier et paramétrer un simulateur du homard basé sur les individus (SHBI) pour simuler la pêche au homard dans le golfe du Maine. Pour simuler cette pêche, le SHBI a été ajusté de manière à reproduire les prises et la composition des tailles saisonnières déterminées dans l'évaluation du stock de homards de 2015, en ajustant les valeurs des coefficients pour des paramètres sélectionnés. En utilisant des coefficients appropriés pour l'abondance initiale, le recrutement et les niveaux de probabilité de rencontre saisonniers, le SHBI ajusté a simulé avec exactitude les quantités débarquées passées. Au vu de l'incertitude associée au recrutement futur de homards, le SHBI ajusté a ensuite été utilisé pour évaluer l'efficacité des règlements de gestion actuels pour différents niveaux de recrutement. [Traduit par la Rédaction]

Introduction

Fishery failures have been common over time and space (Worm et al. 2009), and as a result, there has been a push for better fisheries management. Fisheries management must consider the effects of environmental variability (Hofmann and Powell 1998). In a changing environment, the effectiveness of current fishery management regulations may change. Management regulations may become detrimental to the resource if environmental change is not considered (Hofmann and Powell 1998). Identifying management regulations that are robust to environmental fluctuations is a critical need in fisheries management (Walters and Parma 1996). The distribution and seasonal cycles of marine species may change with changing water temperatures (Mills et al. 2013), which may affect life history parameters such as recruitment into a fishery.

The current management regulations of American lobster (*Homarus americanus*) in the Gulf of Maine (GOM) have not been evaluated for effectiveness with variability in recruitment. American lobster recruitment has increased dramatically in the past few decades (ASMFC 2015). However, settlement surveys may indicate a future decline in recruitment (Wahle et al. 2015), and the effects of warming water temperatures on the lobster population are not clear. Lobster landings and abundance in the GOM have increased dramatically and are at historic highs (ASMFC 2015). American lobster supports one of the most culturally and economically valuable fisheries in the United States, worth more than US$666 million in 2016 (ACCSP 2018). The importance of the lobster fishery and the uncertainty of its future call for an evaluation of the robustness of current management regulations with a simulation tool. Identifying a simulation tool for the complex American lobster fishery, in which fishery and life history processes vary among individuals, is necessary for such an evaluation.

The complexity of American lobster biological and fisheries processes makes the use of traditional mathematical-formulation-based models difficult (ASMFC 2000). Growth of the American lobster is not continuous, as lobsters grow by molting, which mainly occurs in summer and fall (Factor 1995). Molting frequency is dependent on the size and maturation status of the lobster (Factor 1995; Comeau and Savoie 2001). Additionally, conservation measures used in the GOM fishery, including minimum and maximum legal sizes, prohibition of the taking of egg-bearing lobsters, and protection of ovigerous females through a V-notching program, are difficult to consider as separate processes with traditional fishery models (ASMFC 2000). In the GOM lobster fishery, if an egg-bearing lobster is caught, the lobster fisher can choose to cut a "V"-shaped notch in the lobster's tail and release the lobster. It is illegal to catch lobsters with a V-notch because they are proven breeders. Consideration of all these fishery processes as separate from one another is important when evaluating changes

Received 26 March 2018. Accepted 25 November 2018.

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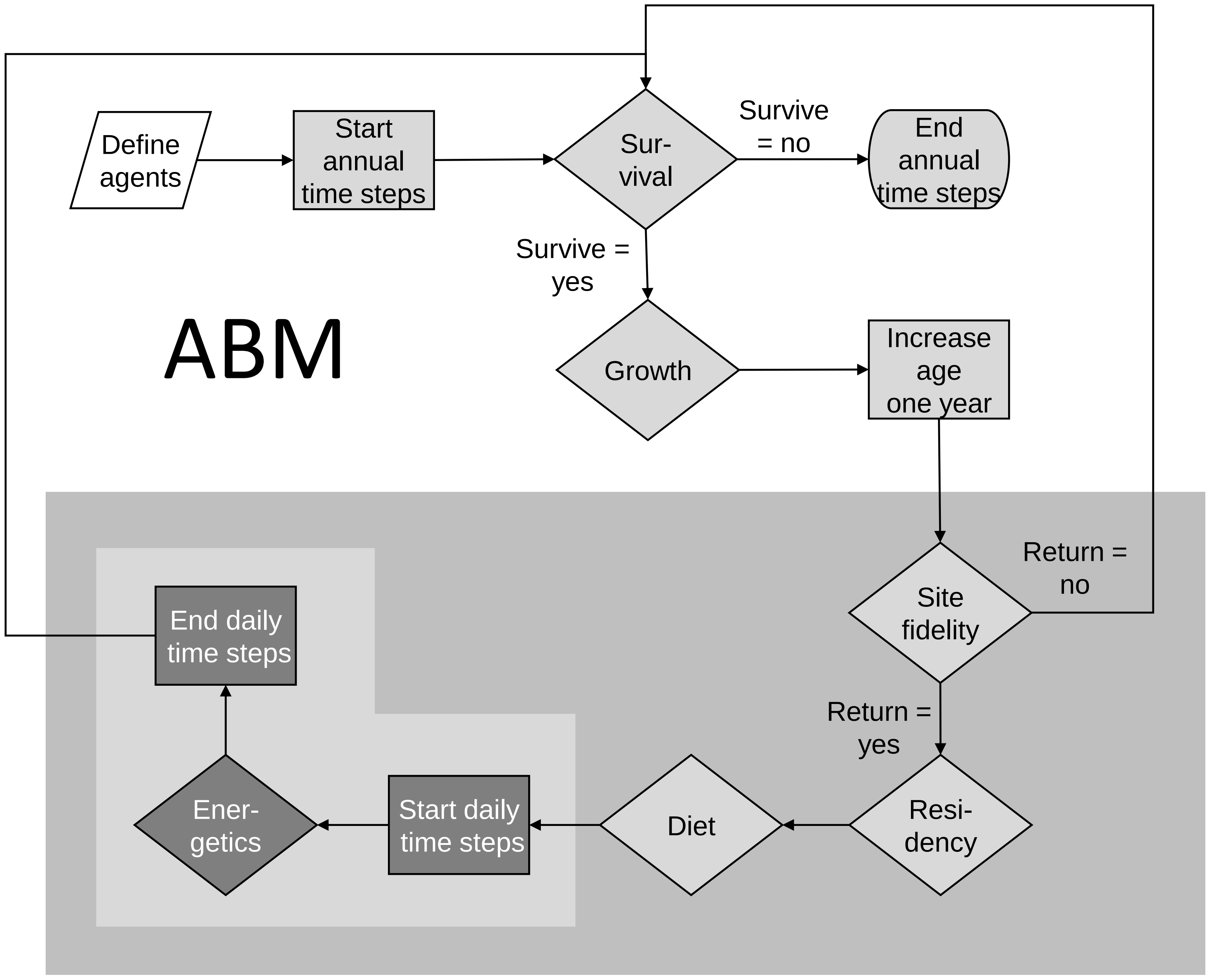
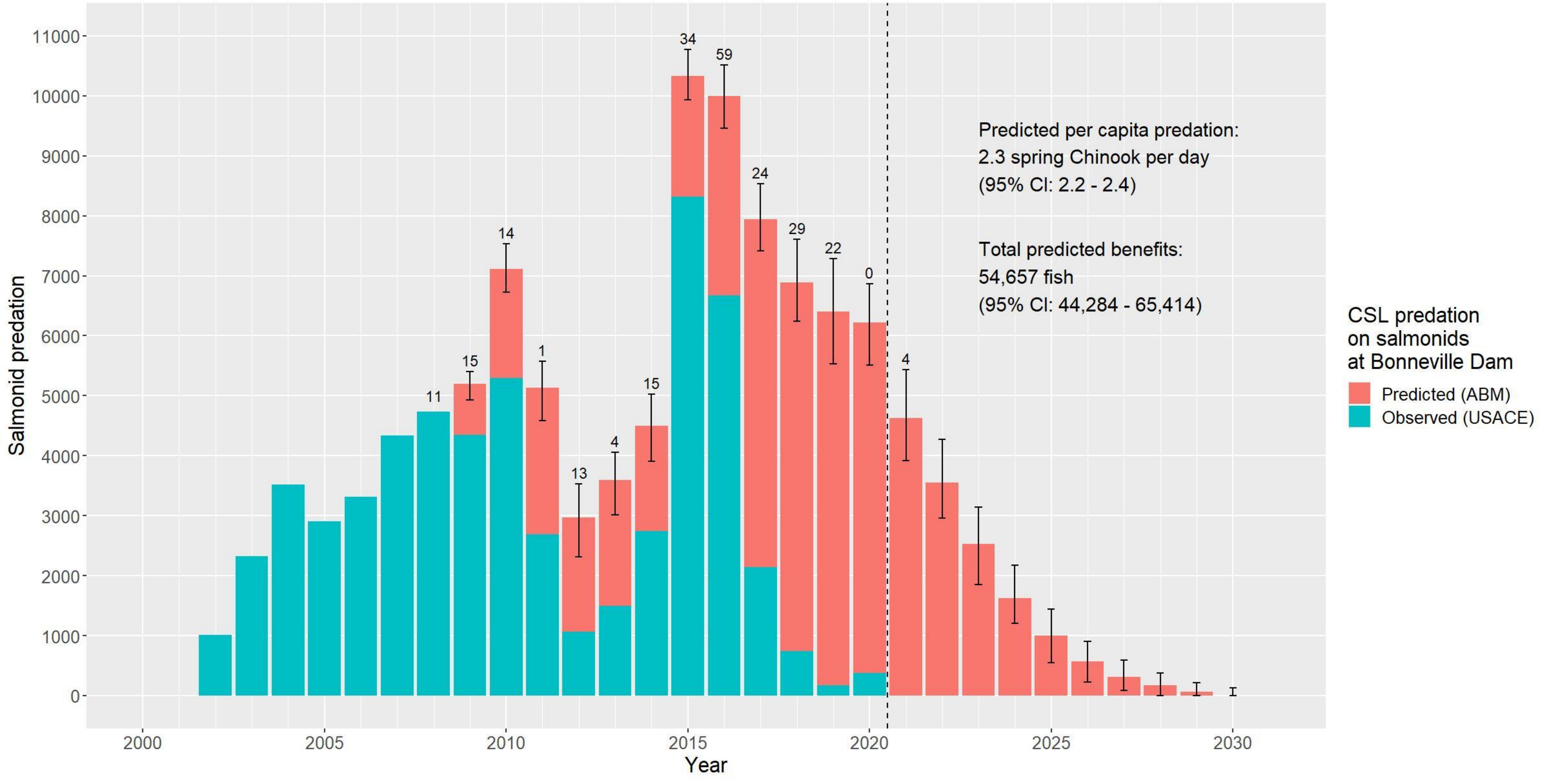
Can. J. Fish. Aquat. Sci. 76: 1709–1718 (2019) dx.doi.org/10.1139/cjfas-2018-0122 Published at www.nrcresearchpress.com/cjfas on 3 December 2018.



Define agents
Start annual time steps
Sur-vival
Survive = no
End annual time steps
Survive = yes
ABM
Growth
Increase age one year
Return = no
Site fidelity
Return = yes
End daily time steps
Resi-dency
Diet
Start daily time steps
Ener-getics

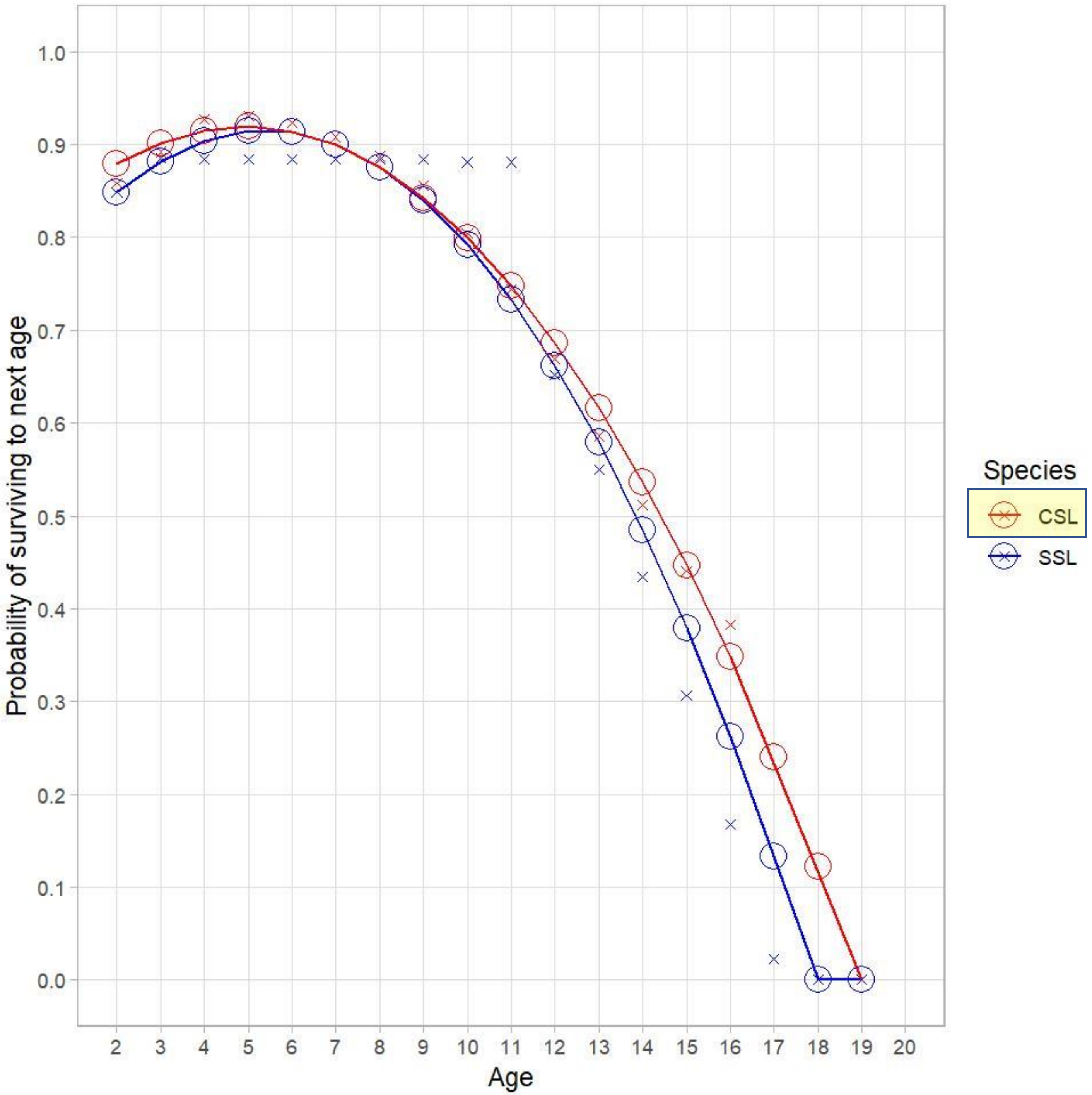
Predicted benefits from 245 CSL removals at Bonneville Dam under MMPA Section 120

(Benefits represented as medians and 95% percentile confidence intervals from 100 repeititions of agent based model; number of CSL removed per year under this authority noted at top of bars)

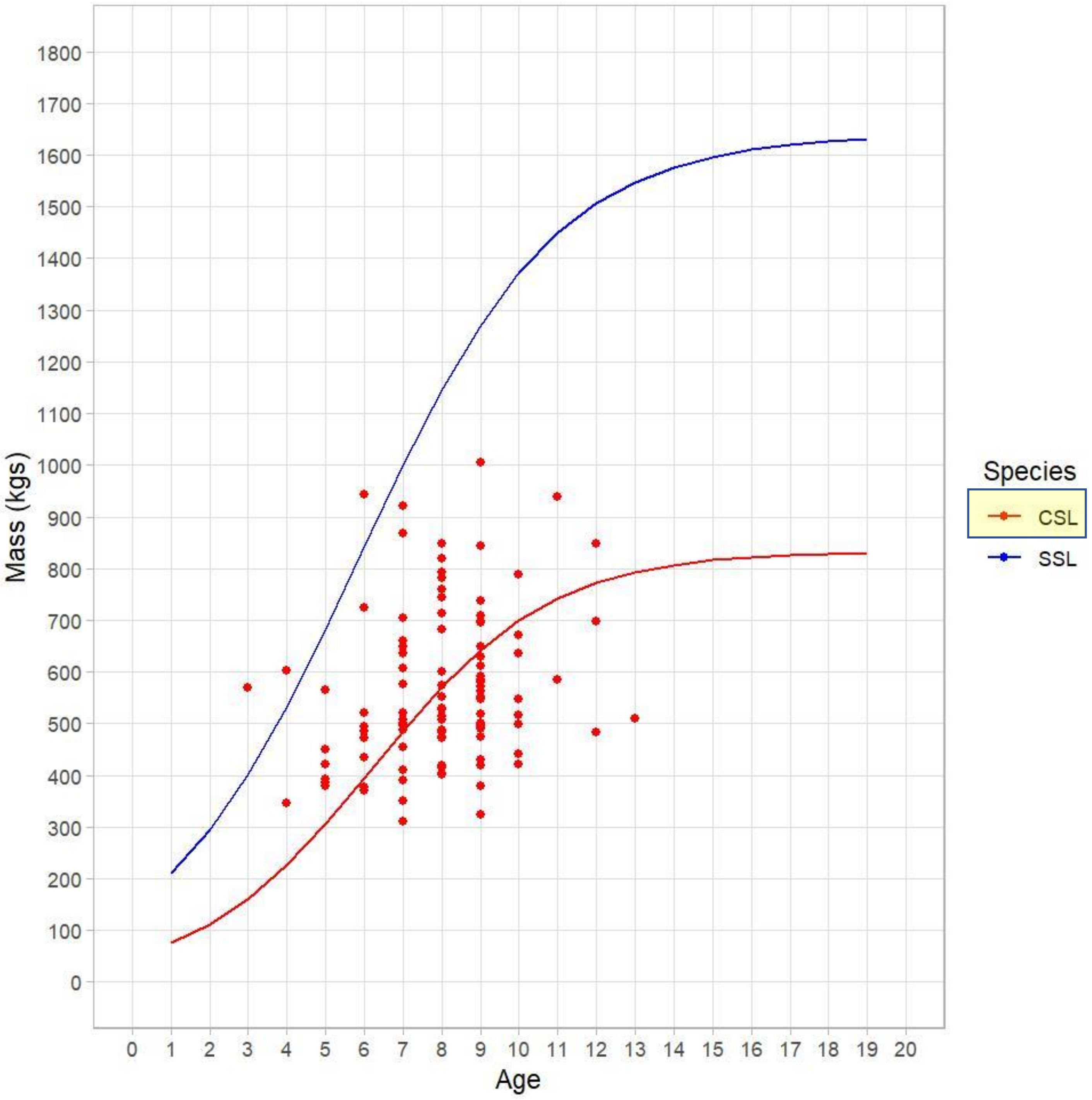


Questions?

Survival sub-model



Growth sub-model

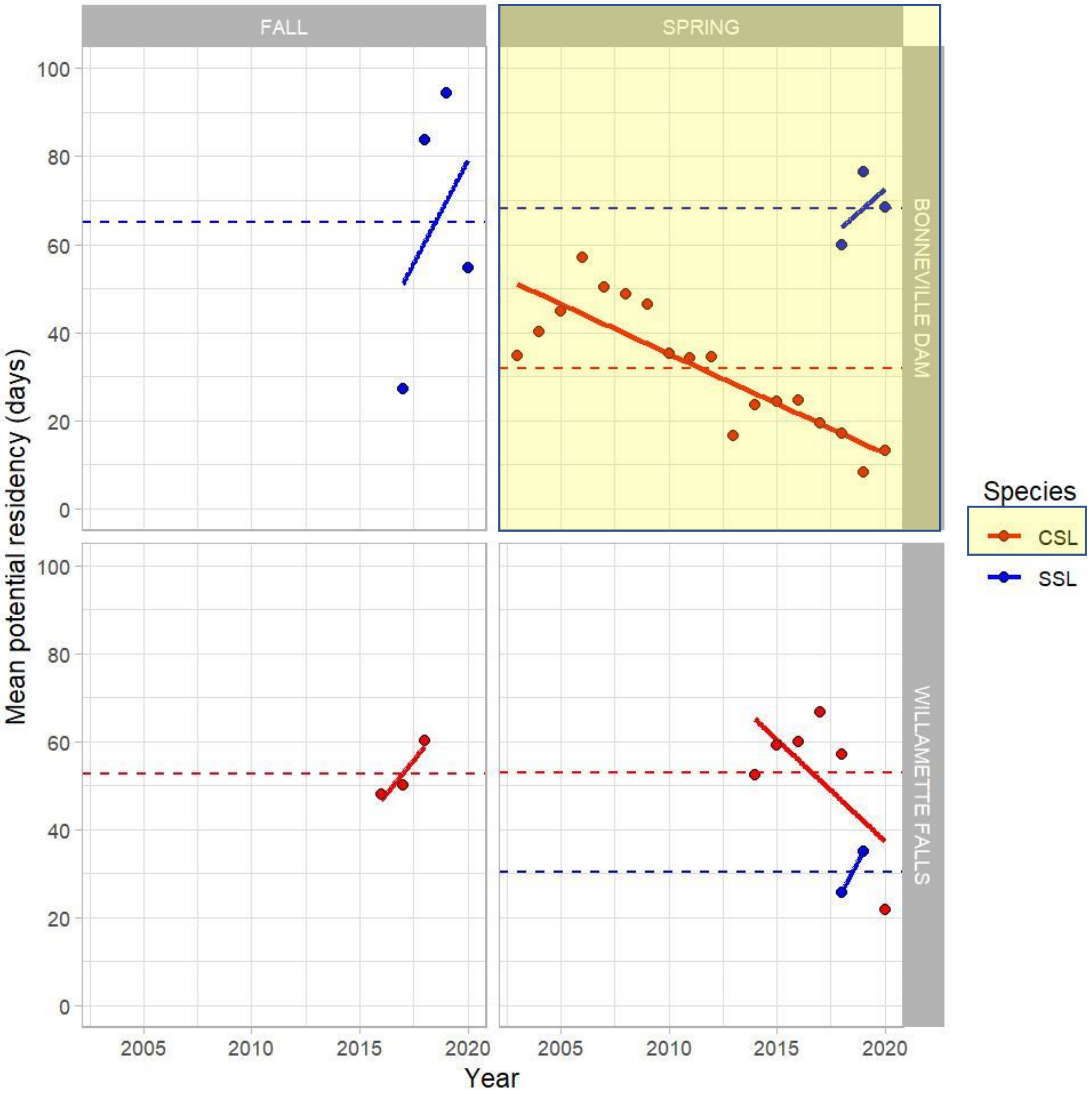


Fidelity and residency sub-models

Table 2. Average fidelity and residency sub-model parameters based on mark resight data of upriver animals.

			Fidelity			Residency (d)		
Location	Species	Season	Mean	*n* (unique) animals		Mean	*n* years	*n* (non-unique) animals
Bonn. Dam	CSL	Spring	0.98	190		32	18	435
Bonn. Dam	SSL	Spring	0.79	7		68	3	44
Bonn. Dam	SSL	Fall	0.95	7		65	4	49
Will. Falls	CSL	Spring	1	21		53	6	131
Will. Falls	CSL	Fall	0.48	9		53	3	21
Will. Falls	SSL	Spring	0.79*	0		30	2	8

Residency sub-model



Diet sub-model

Table 3. Diet sub-model parameters.

			Diet component #1				Diet component #2			Diet component #3		
Location	Species	Season	Prey	%	ED* (kJ/g)	Weight** (kg)	Prey	%	ED* (kJ/g)	Prey	%	ED* (kJ/g)
Bonn. Dam	CSL	Spring	Spr. Chi. salmon	90	7.2	5.7	NA	0	NA	Other	10	~*U*(3, 7.2)
Bonn. Dam	SSL	Spring	Spr. Chi. salmon	45	7.2	5.7	W. sturgeon	45	4.4	Other	10	~*U*(3, 7.2)
Bonn. Dam	SSL	Fall	Salmonid	30	5.9	5.4	W. sturgeon	60	4.4	Other	10	~*U*(3, 7.2)
Will. Falls	CSL	Spring	Salmonid	90	5.9	5.4	P. lamprey	5	25.65	Other	5	~*U*(3, 7.2)
Will. Falls	CSL	Fall	Salmonid	70	5.9	5.4	NA	0	NA	Other	30	~*U*(3, 7.2)
Will. Falls	SSL	Spring	Salmonid	30	5.9	5.4	W. sturgeon	60	4.4	Other	10	~*U*(3, 7.2)

*Energetic density (ED) sources: salmonids (O'Neil et al 2014), sturgeon (pers. com. P. Stevens, ODFW), lamprey (Clemens et al. 2019), other (Winship and Trites 2003).

**Mean weight sources: salmonids (predation-weighted mean of salmon and steelhead at Willamette Falls, Jepson et al. 2015); spring Chinook salmon (CRTIFC, 2004-2007).

Bioenergetics sub-model

$$BR_{ij}[kg\ d^{-1}] = \frac{GER[kJ\ d^{-1}] \times prey_i}{ED_i[kJ\ g^{-1}]} \div 1000, \qquad GER = \frac{P + (A_j \times BM_j)}{E_{HIF} \times E_{f+u}}, \qquad A_j = water_j * A_{water} + (1 - water_j) * A_{land}$$

Table 4. Bioenergetics sub-model parameters.

Symbol	Description	Value	Units	Source
P	Production (energy invested in growth)	0	kJ d^{-1}	See methods
A_{water}	Water metabolic rate multiplier	~triangle(2.5, 4.0, 5.5)	Unitless	Winship et al. (2002)
A_{land}	Land metabolic rate multiplier	~triangle(1.0, 1.2, 1.4)	Unitless	Winship et al. (2002)
$water_{j=CSL}$	Percent of time spent in the water	~triangle(0.08, 0.78, 1)	%	Unpublished data, ODFW & WDFW
$water_{j=SSL}$	Percent of time spent in the water	~triangle(0, 0.68, 1)	%	Unpublished data, ODFW & WDFW
BM_j	Basal metabolism	$292.88 \times M_j^{0.75}$	kJ d^{-1}	Winship et al. (2002); adults
M_j	Body mass	f_j(mass, age)	kgs	Growth sub-model
E_{f+u}	Fecal and urinary digestive efficiency	~U(0.81, 0.89)	%	Winship et al. (2002)
E_{HIF}	Energy utilization efficiency	~U(0.85, 0.90))	%	Winship et al. (2002); maintenance
$prey_i$	% of total diet biomass comprised of prey *i*	0-100	%	Diet sub-model
ED_i	Energetic density of prey *i*	3-25.65	kJ g^{-1}	Diet sub-model