Life cycle modeling and the potential effects of climate change in the management and restoration of Upper Willamette River Chinook salmon and steelhead

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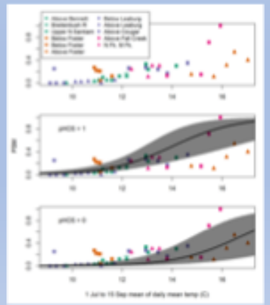
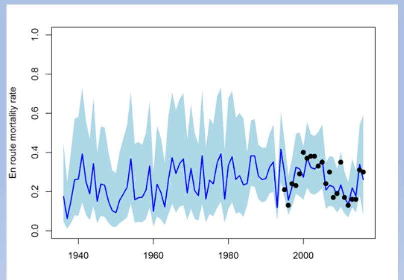
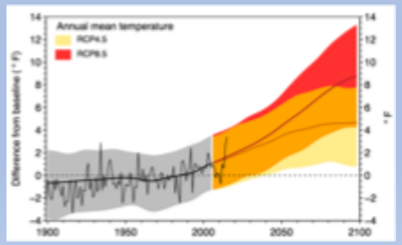
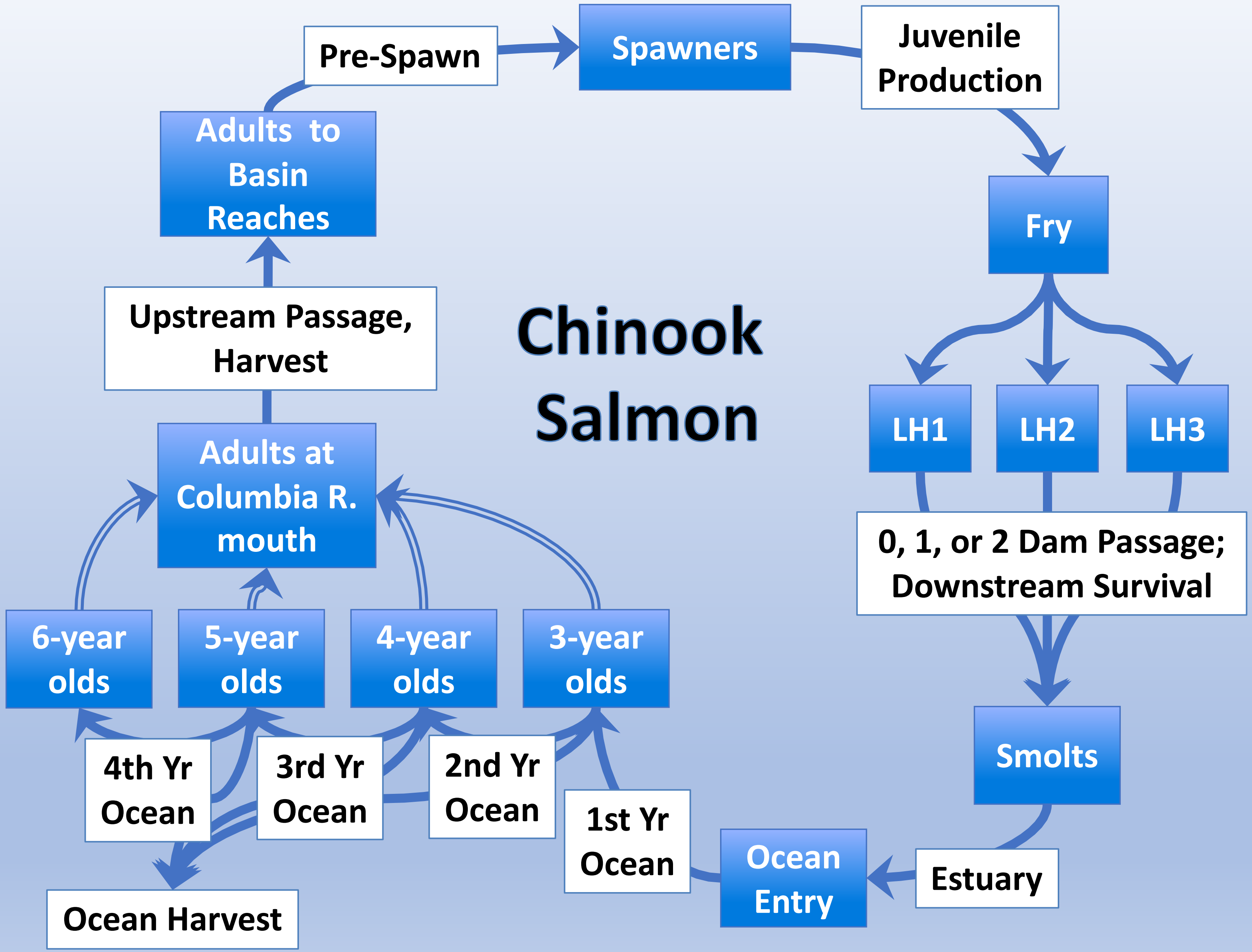
Refinements and climate change analyses

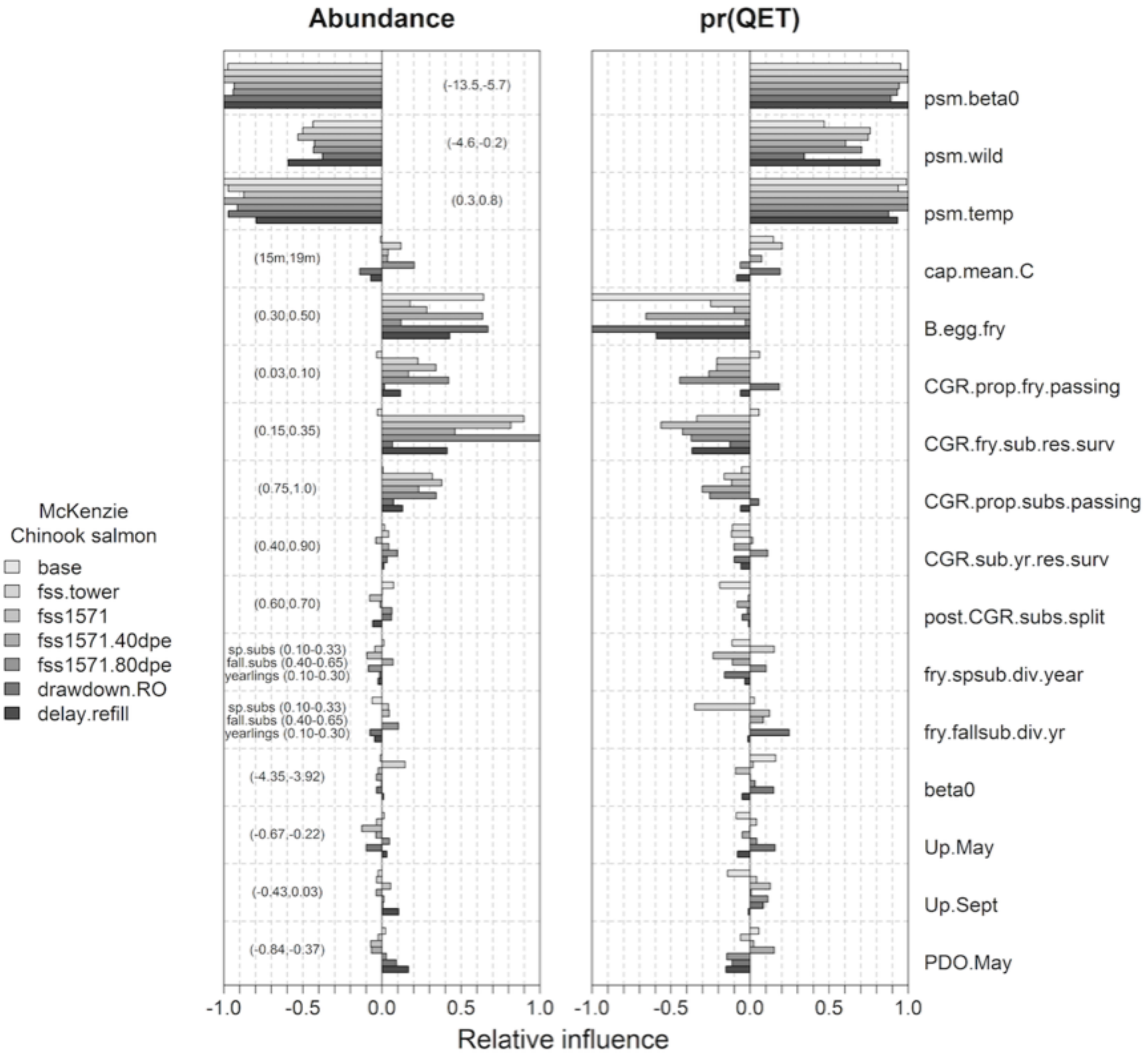
- Prespawn mortality
- *En route* mortality of adults
- Model calibrations
- Preliminary analyses of potential climate effects



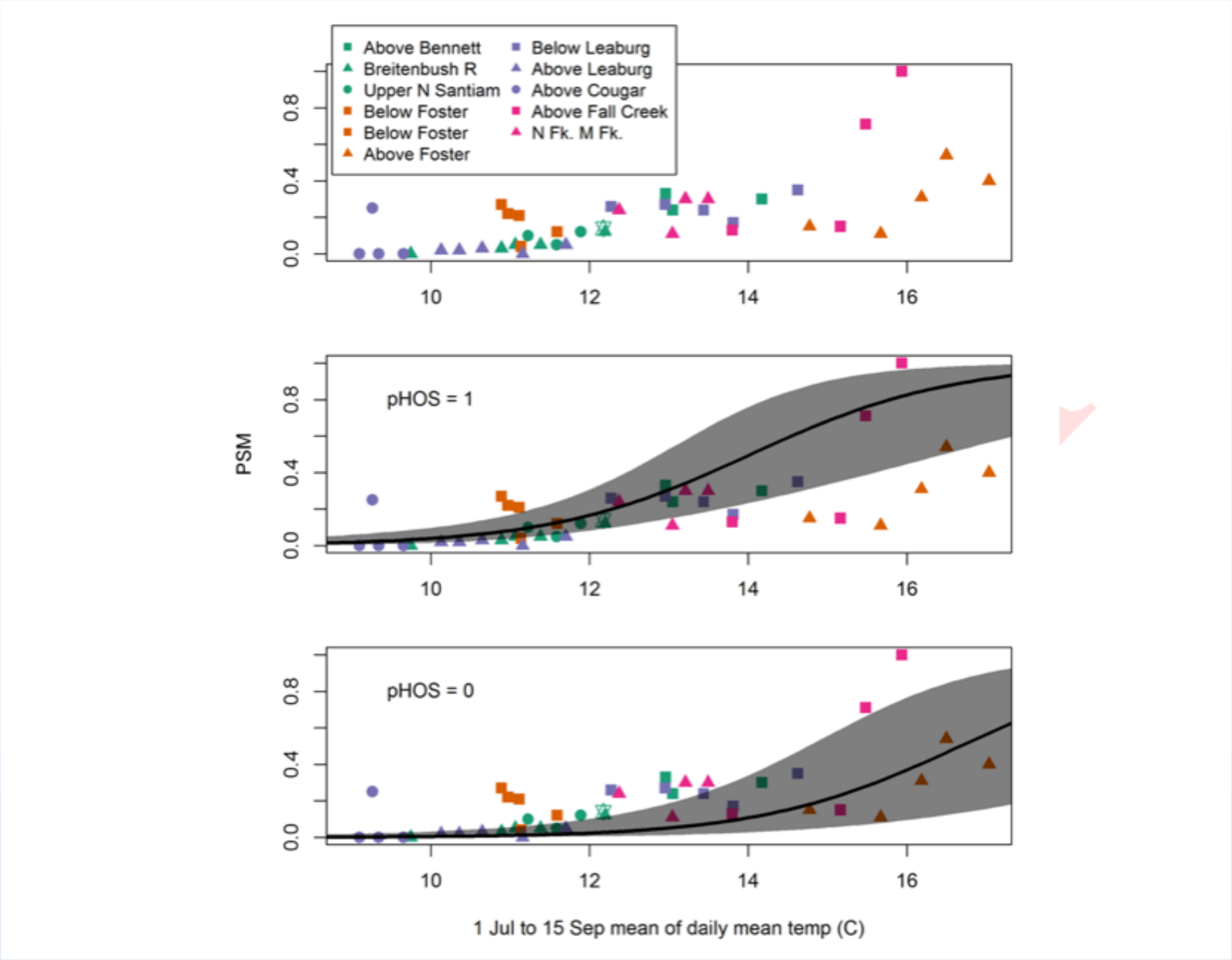





Chinook
Salmon
Pre-Spawn
Spawners
Juvenile Production
Fry
LH1
LH2
LH3
0, 1, or 2 Dam Passage; Downstream Survival
Smolts
Estuary
Ocean Entry
1st Yr Ocean
2nd Yr Ocean
3rd Yr Ocean
4th Yr Ocean
Ocean Harvest
3-year olds
4-year olds
5-year olds
6-year olds
Adults at Columbia R. mouth
Upstream Passage, Harvest
Adults to Basin Reaches

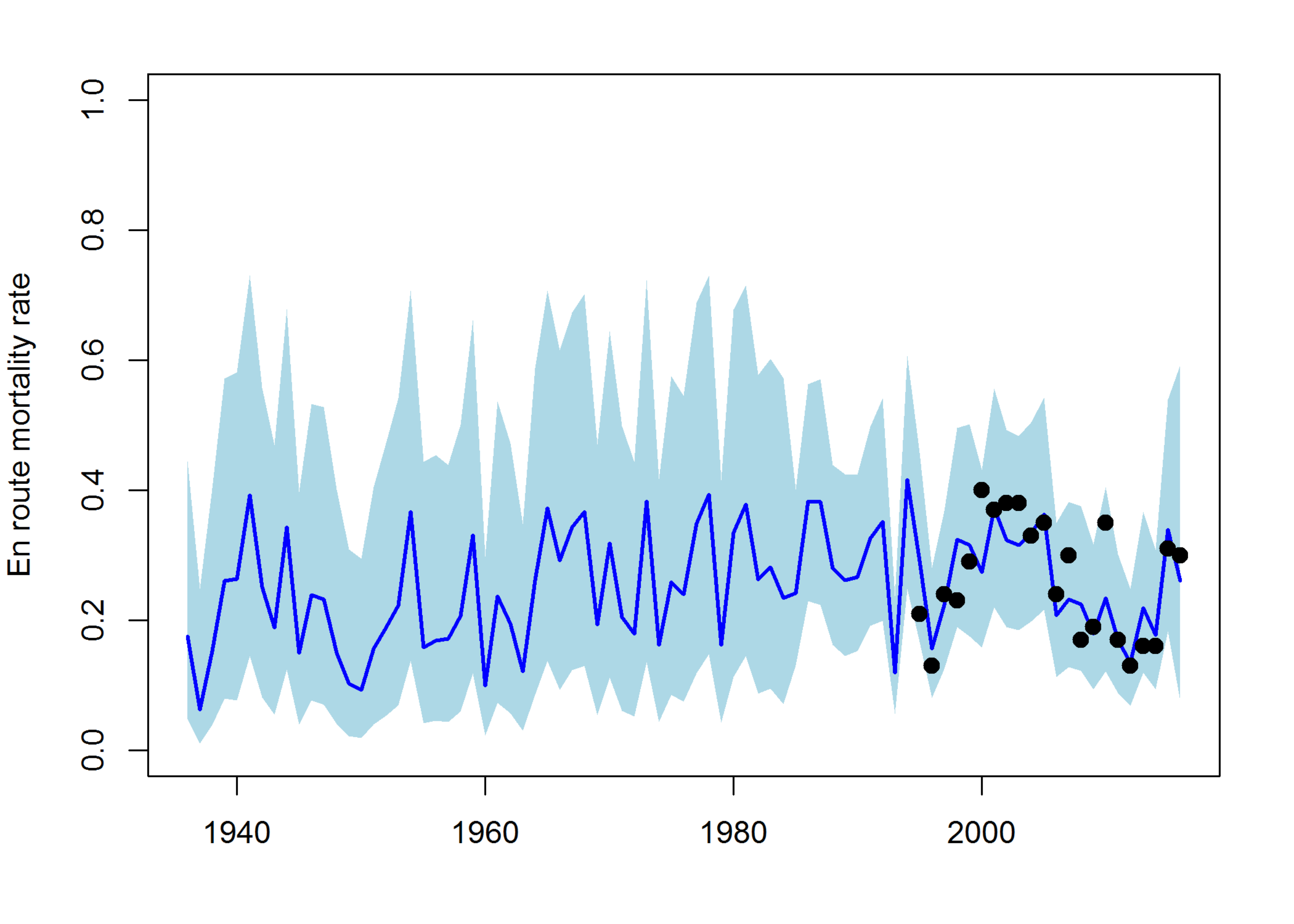


Zabel et al. 2015

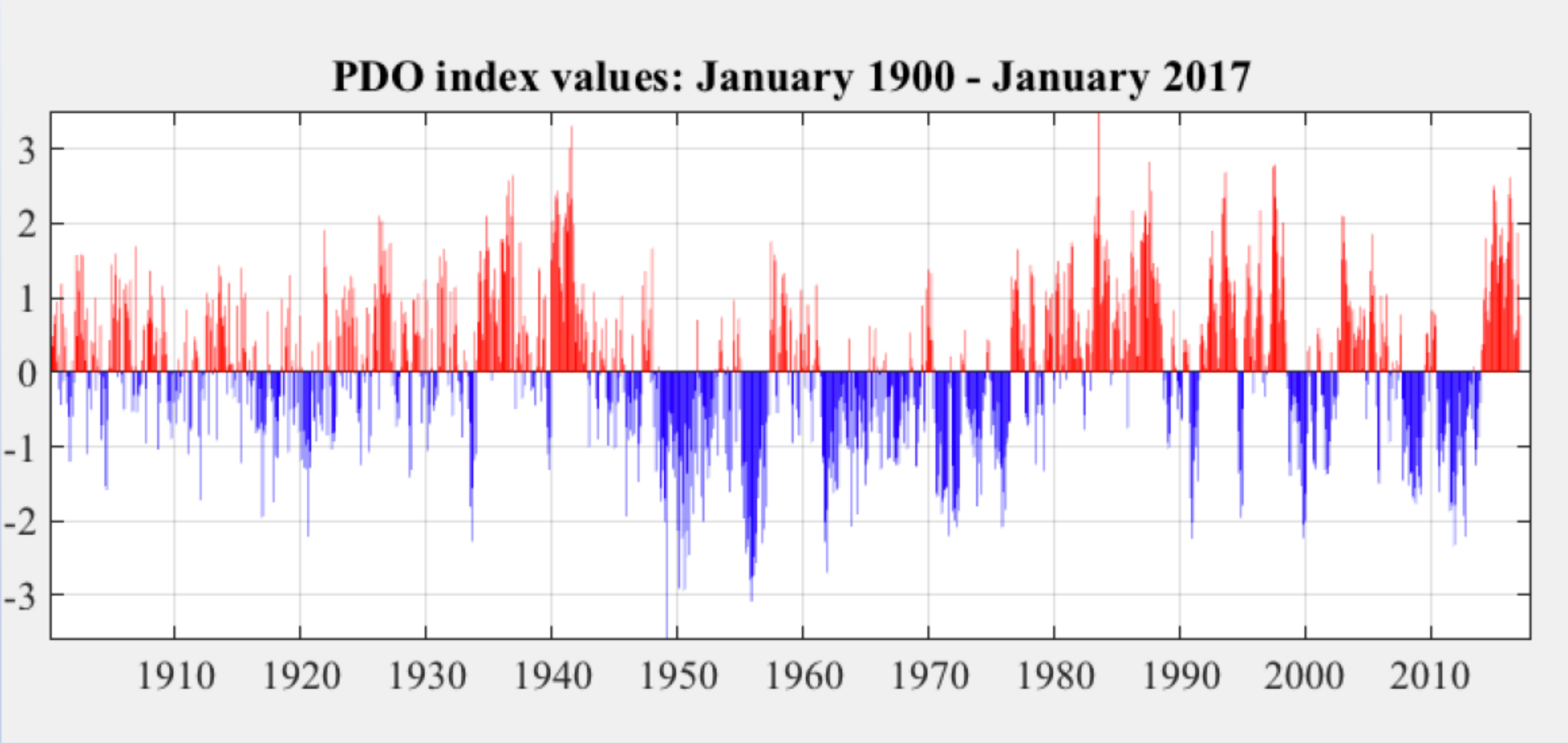


$$\text{Logit(PSM)} = -13.2061 + (\text{pHOS} * 2.0923) + (\text{Temp} * 0.7919)$$

Myers et al. 2017

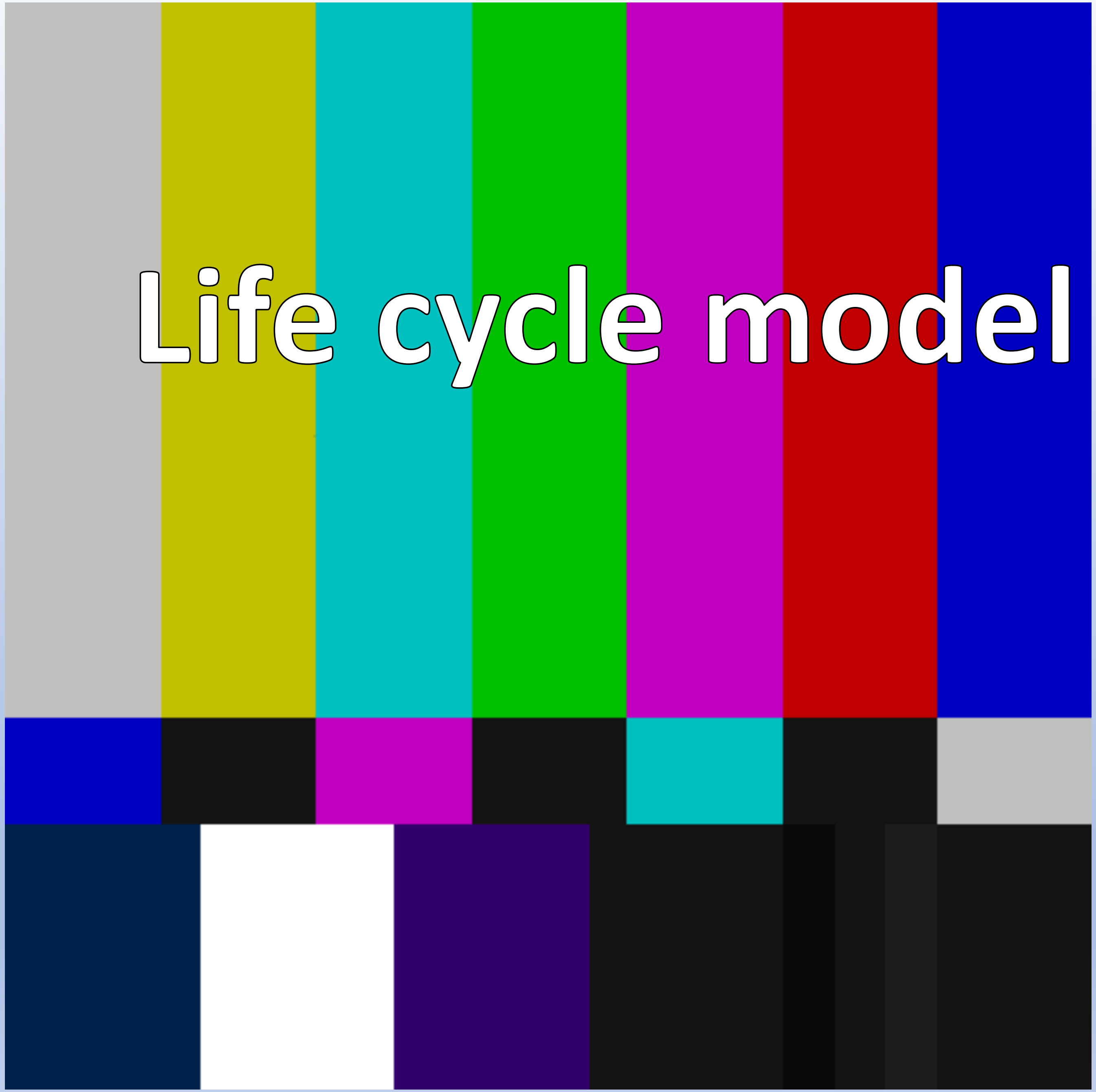


Myers et al. 2017

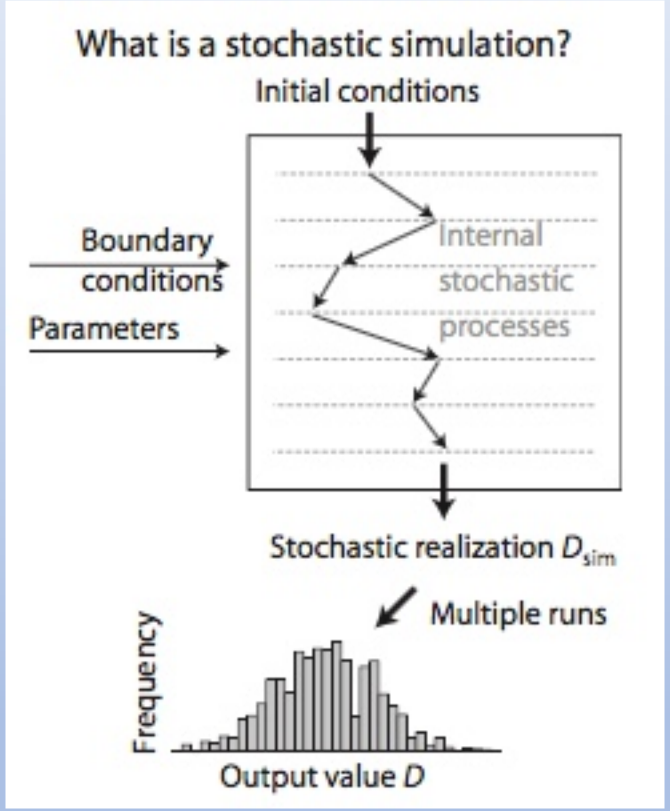


(UW JISAO:
http://research.jisao.washington.edu/pdo/)

Life cycle model calibration



<u>**ABC:**</u> <u>**A**</u>pproximate <u>**B**</u>ayes <u>**C**</u>omputation



Hartig et al. 2011. Ecology letters 14:816-827

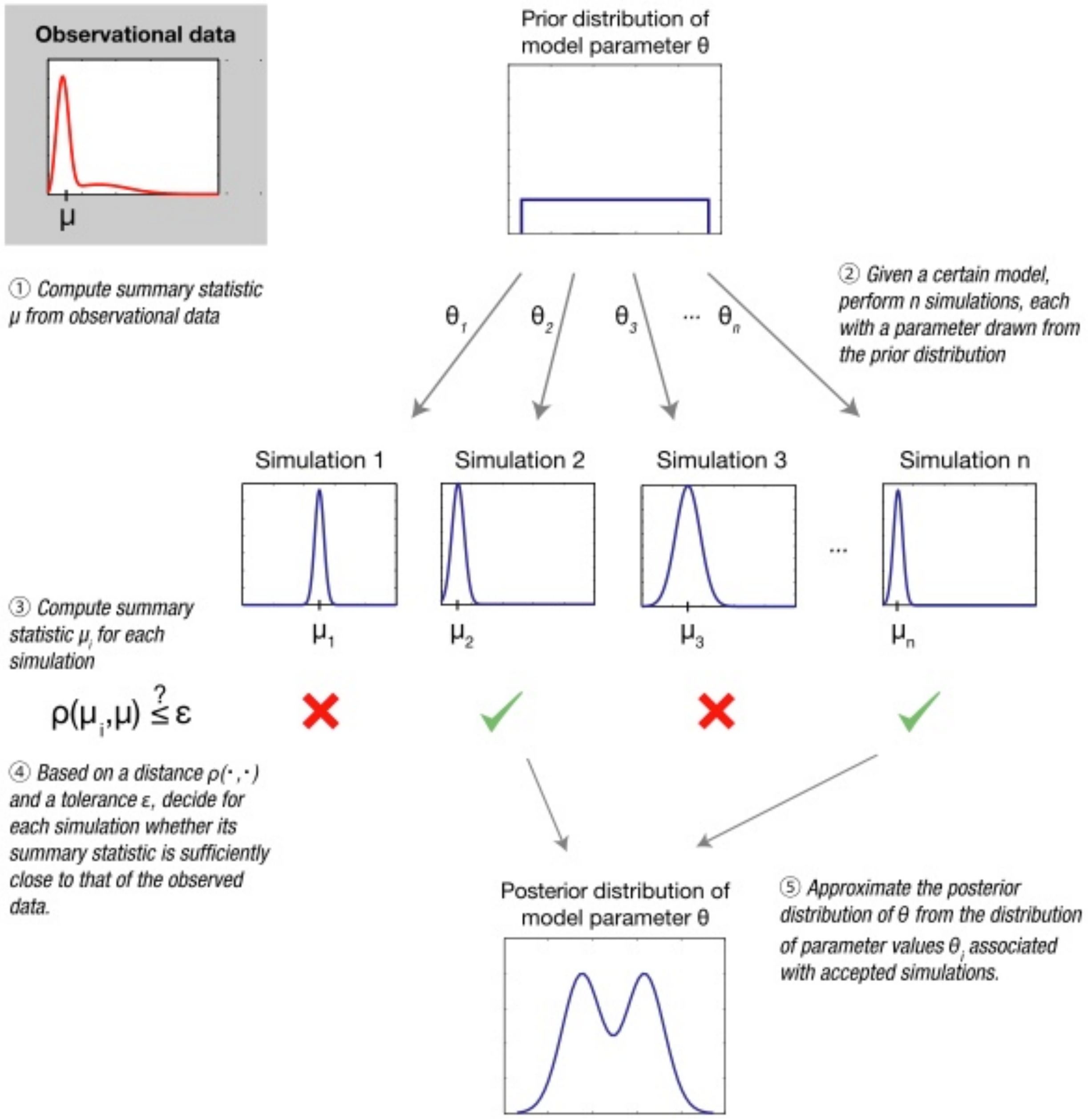
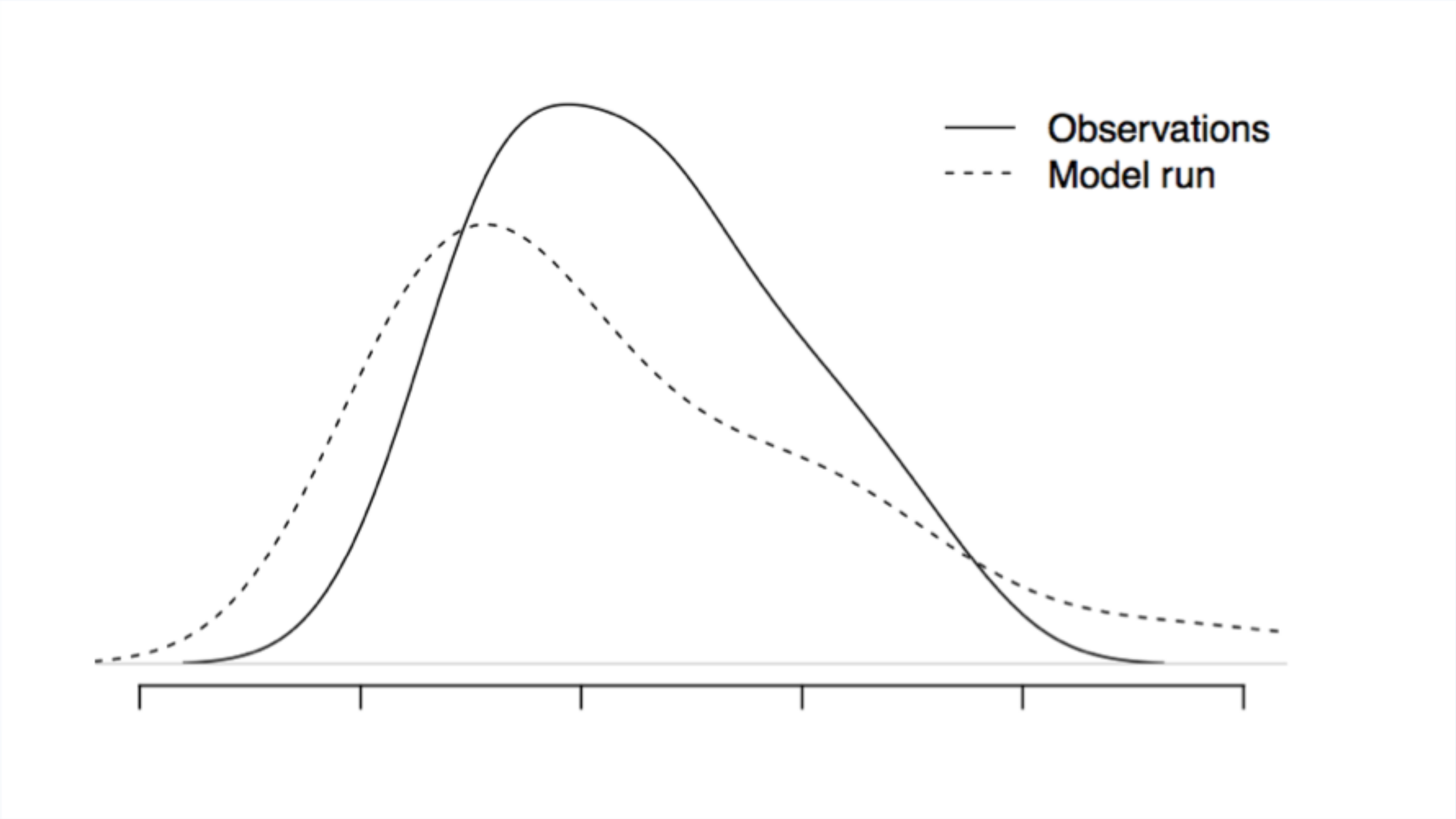


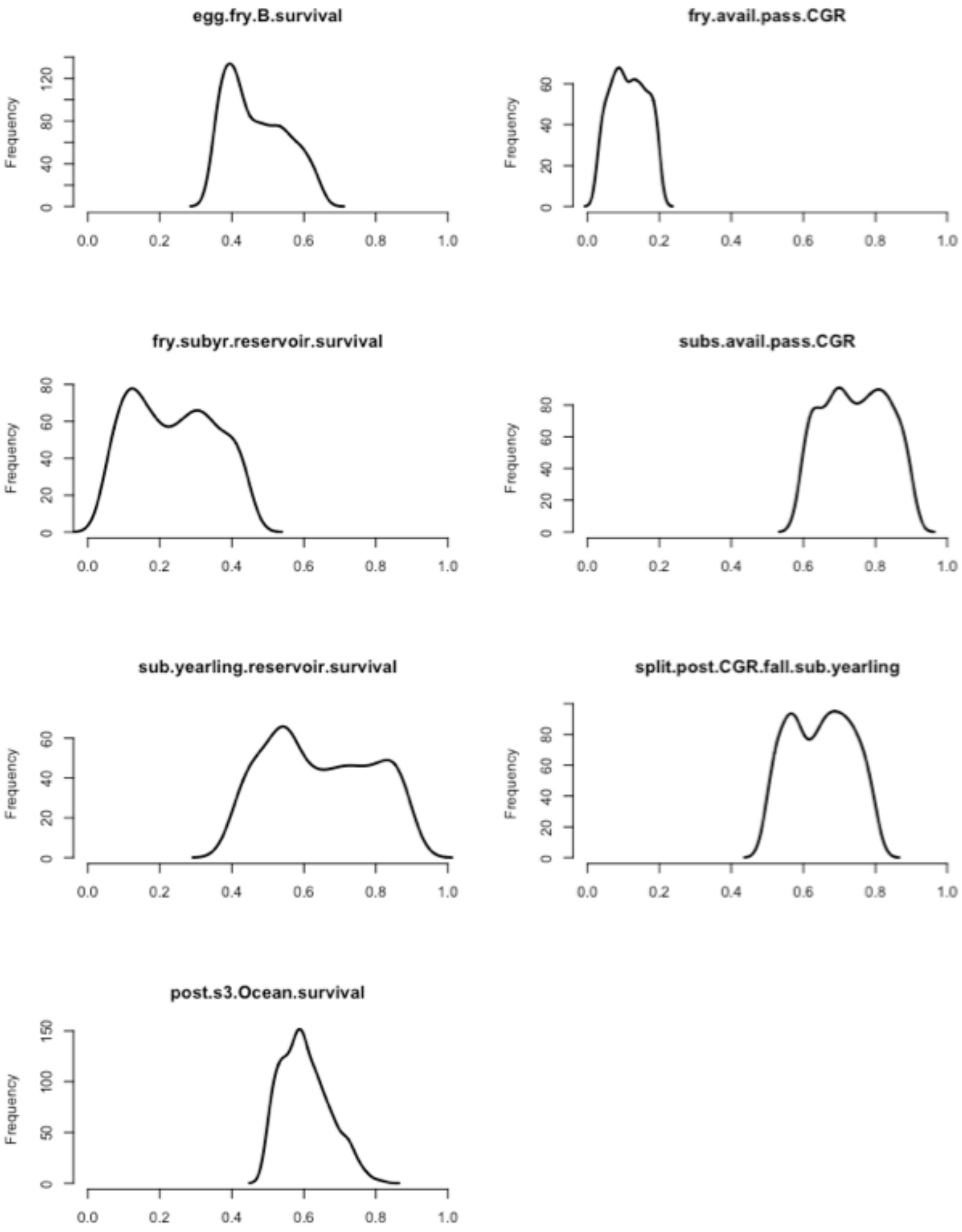
Figure 1. Parameter Estimation by Approximate Bayesian Computation: a conceptual overview

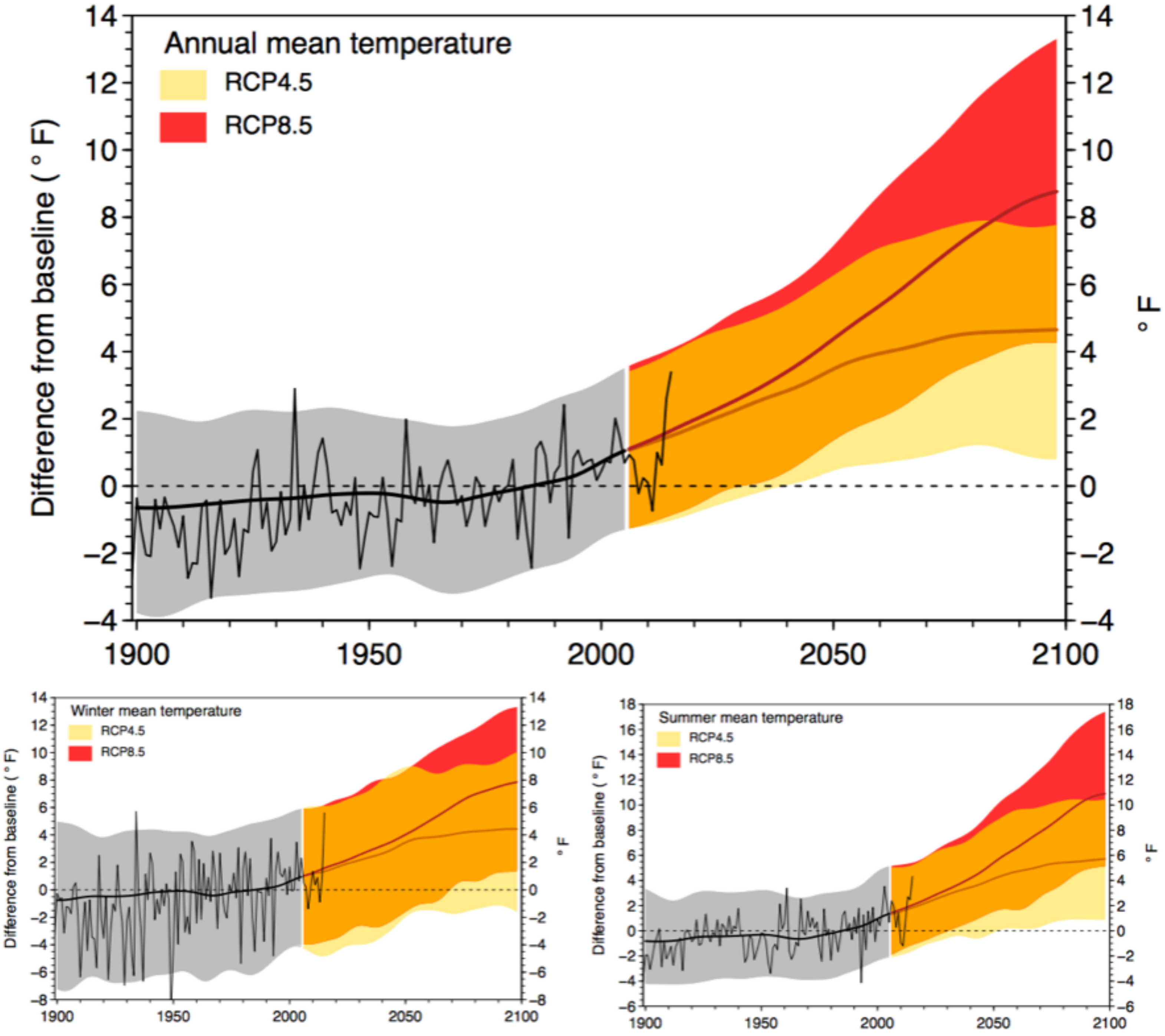
Sunnåker et al. 2013. PLoS Computational Biology 9(1), p.e1002803

der Vaart et al. 2015. Ecological Modelling 312:182-190.

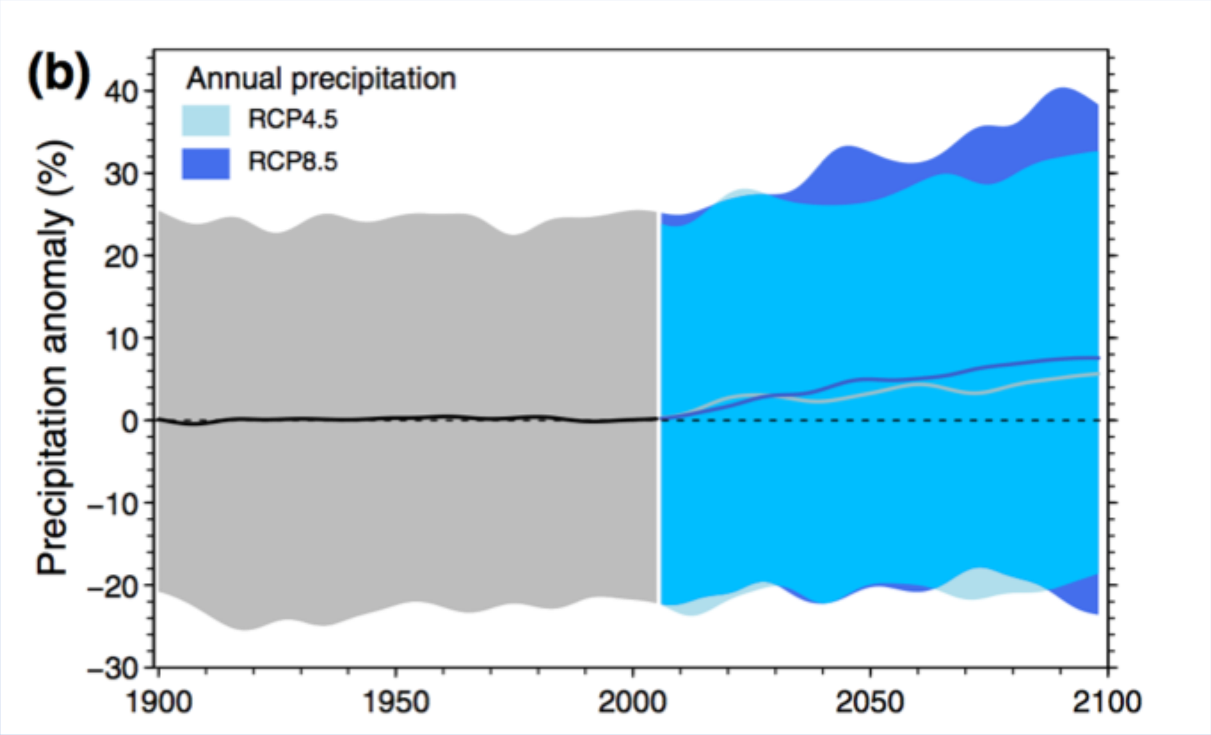


Top 1% of the
Kolmogorov-Smirnov *D*-statistic

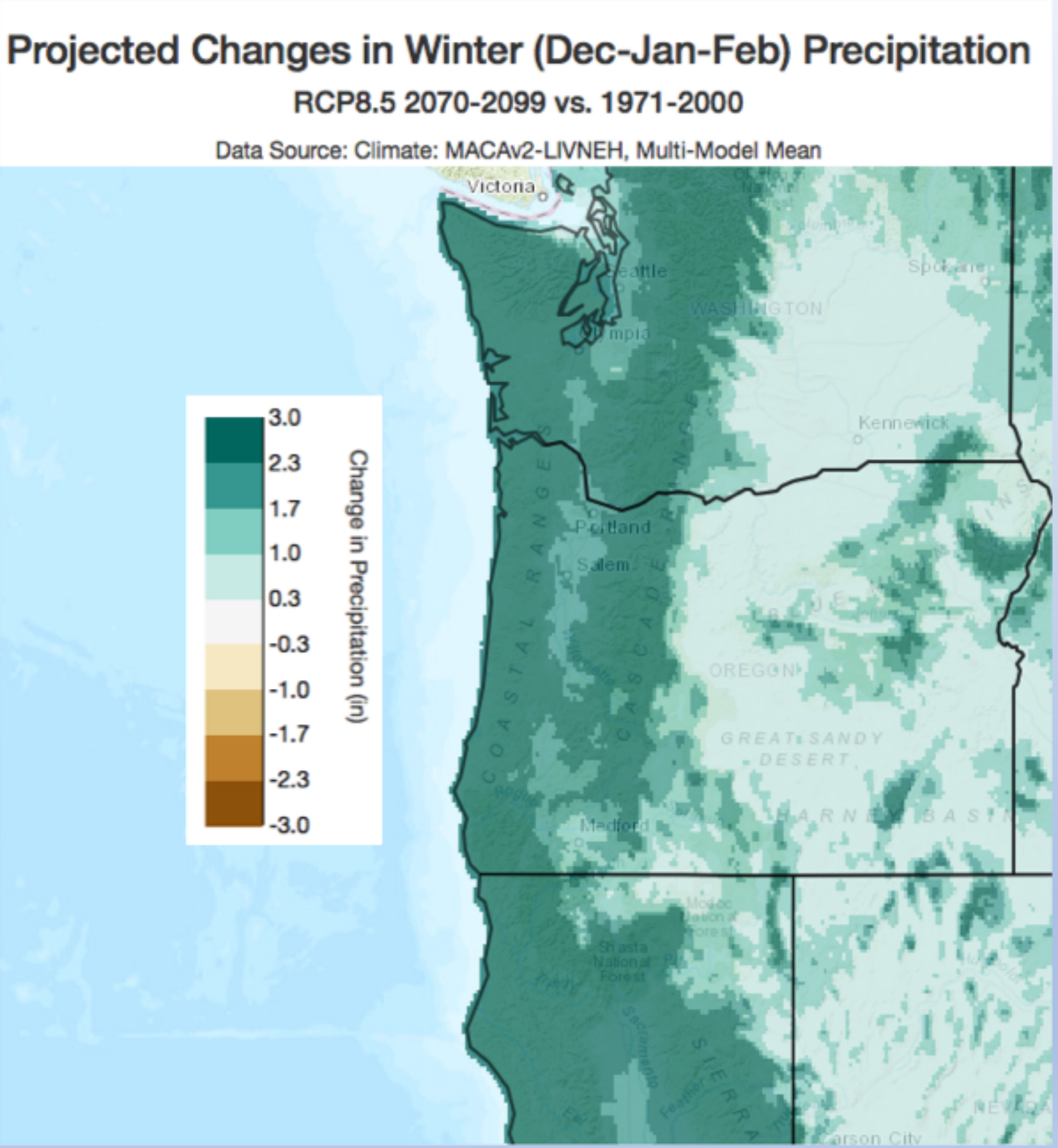

egg.fry.B.survival
Frequency
0 40 80 120
0.0 0.2 0.4 0.6 0.8 1.0
fry.avail.pass.CGR
Frequency
0 20 40 60
0.0 0.2 0.4 0.6 0.8 1.0
fry.subyr.reservoir.survival
Frequency
0 20 40 60 80
0.0 0.2 0.4 0.6 0.8 1.0
subs.avail.pass.CGR
Frequency
0 20 40 60 80
0.0 0.2 0.4 0.6 0.8 1.0
sub.yearling.reservoir.survival
Frequency
0 20 40 60
0.0 0.2 0.4 0.6 0.8 1.0
split.post.CGR.fall.sub.yearling
Frequency
0 20 40 60 80
0.0 0.2 0.4 0.6 0.8 1.0
post.s3.Ocean.survival
Frequency
0 50 100 150
0.0 0.2 0.4 0.6 0.8 1.0



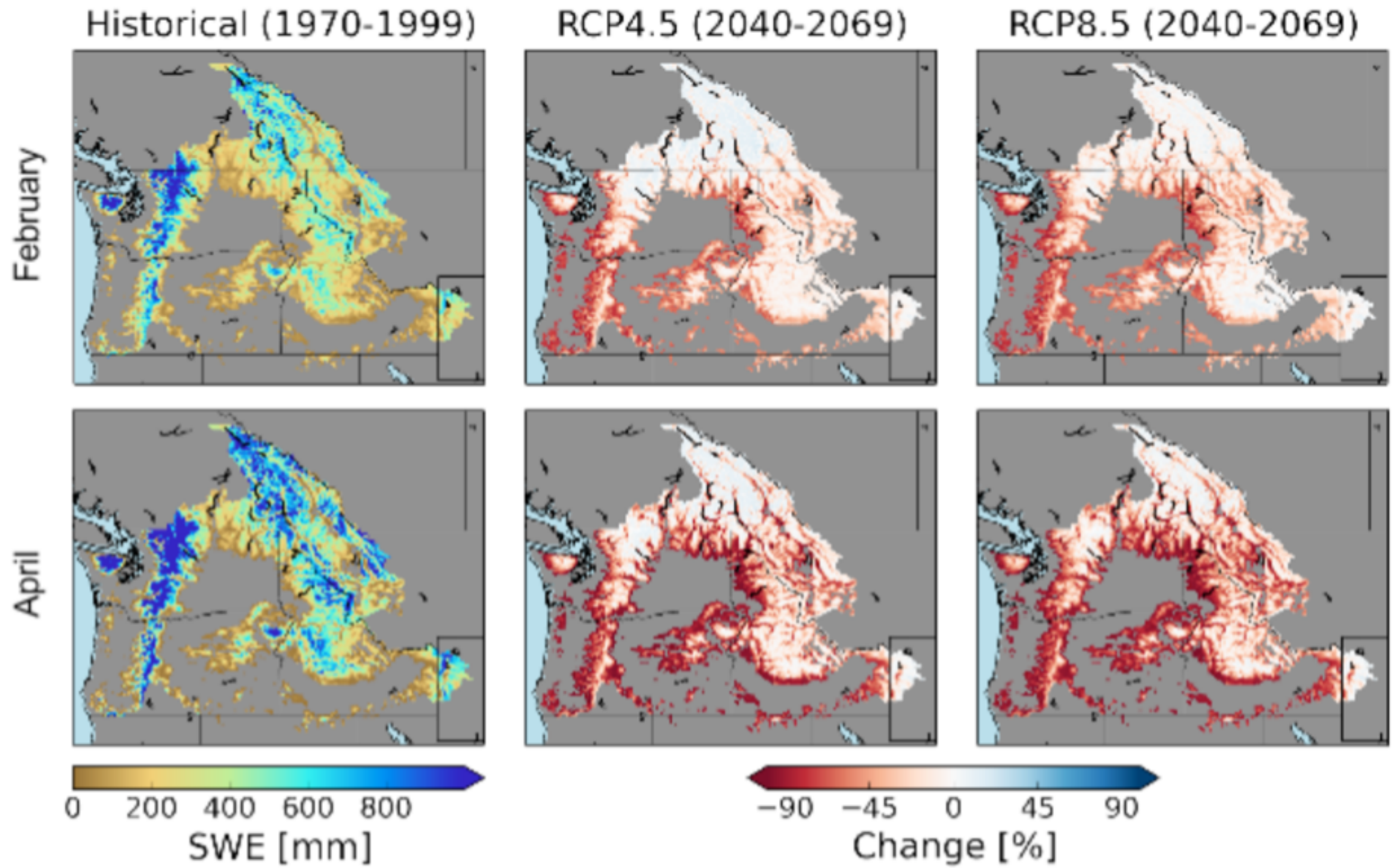
Dalton et al. 2017. The third Oregon climate assessment report. OCCRI.



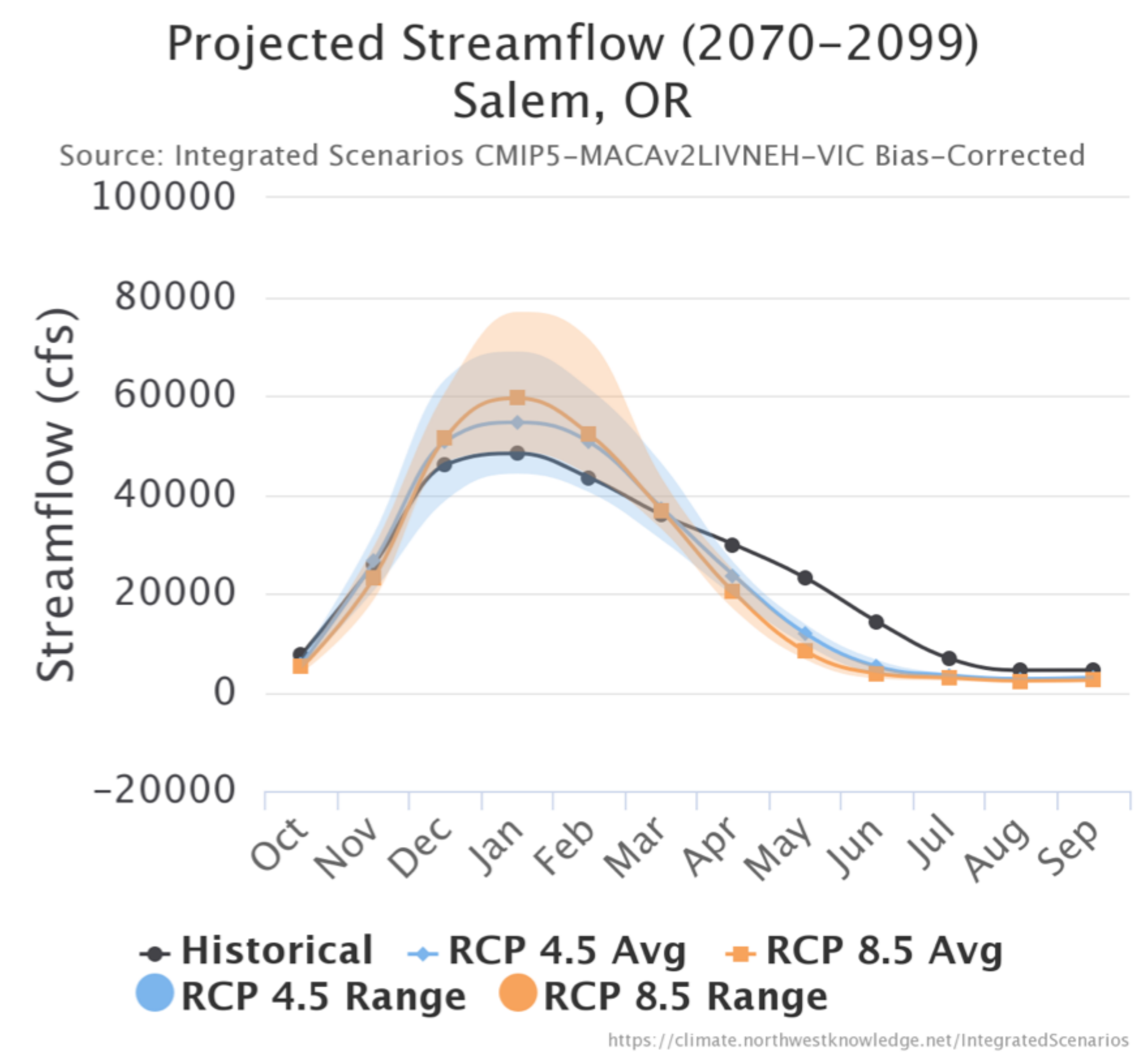
Rupp et al. 2016. Climate Dynamics 49:1783-1799.



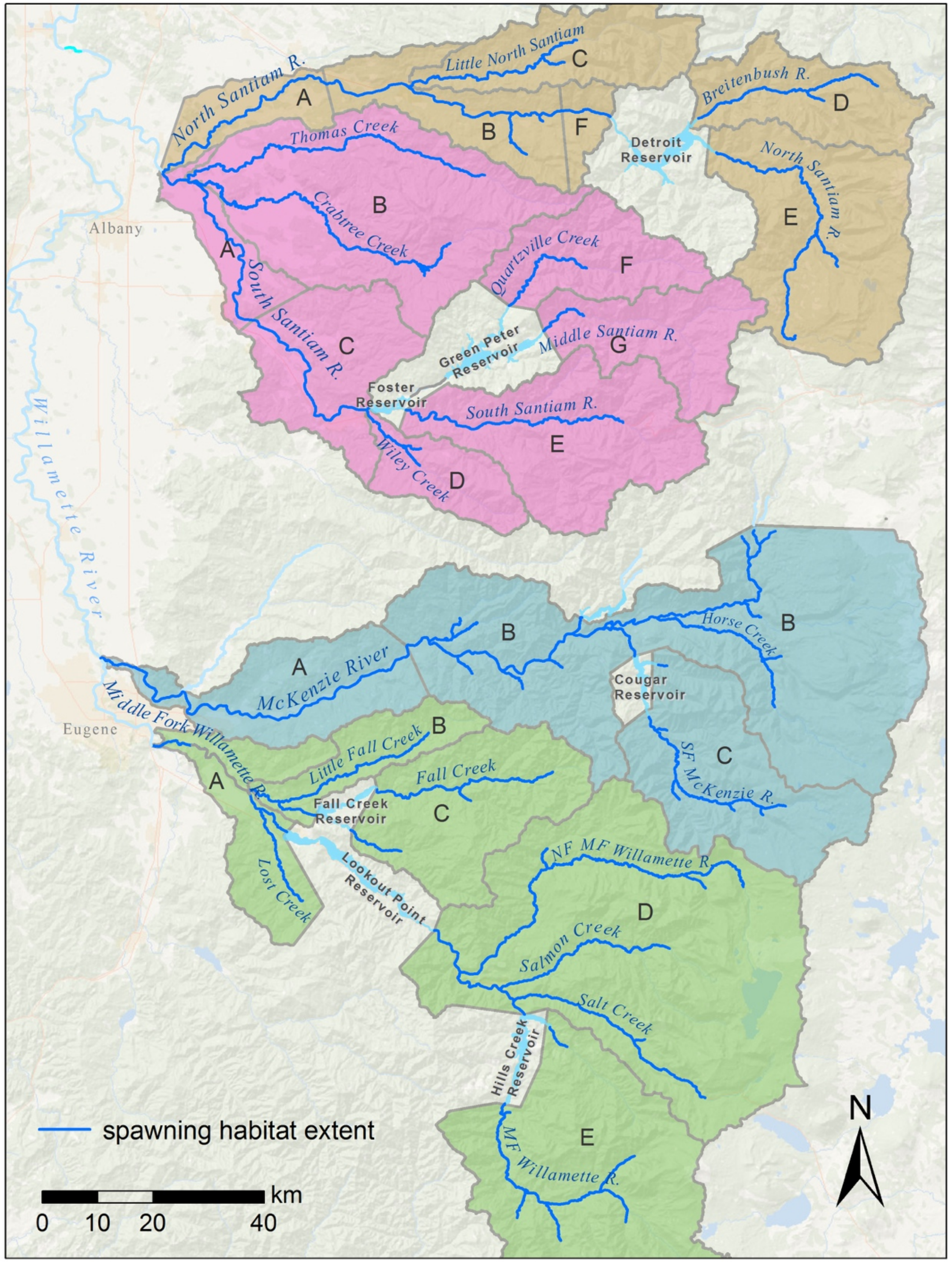
https://climate.northwestknowledge.net/IntegratedScenarios



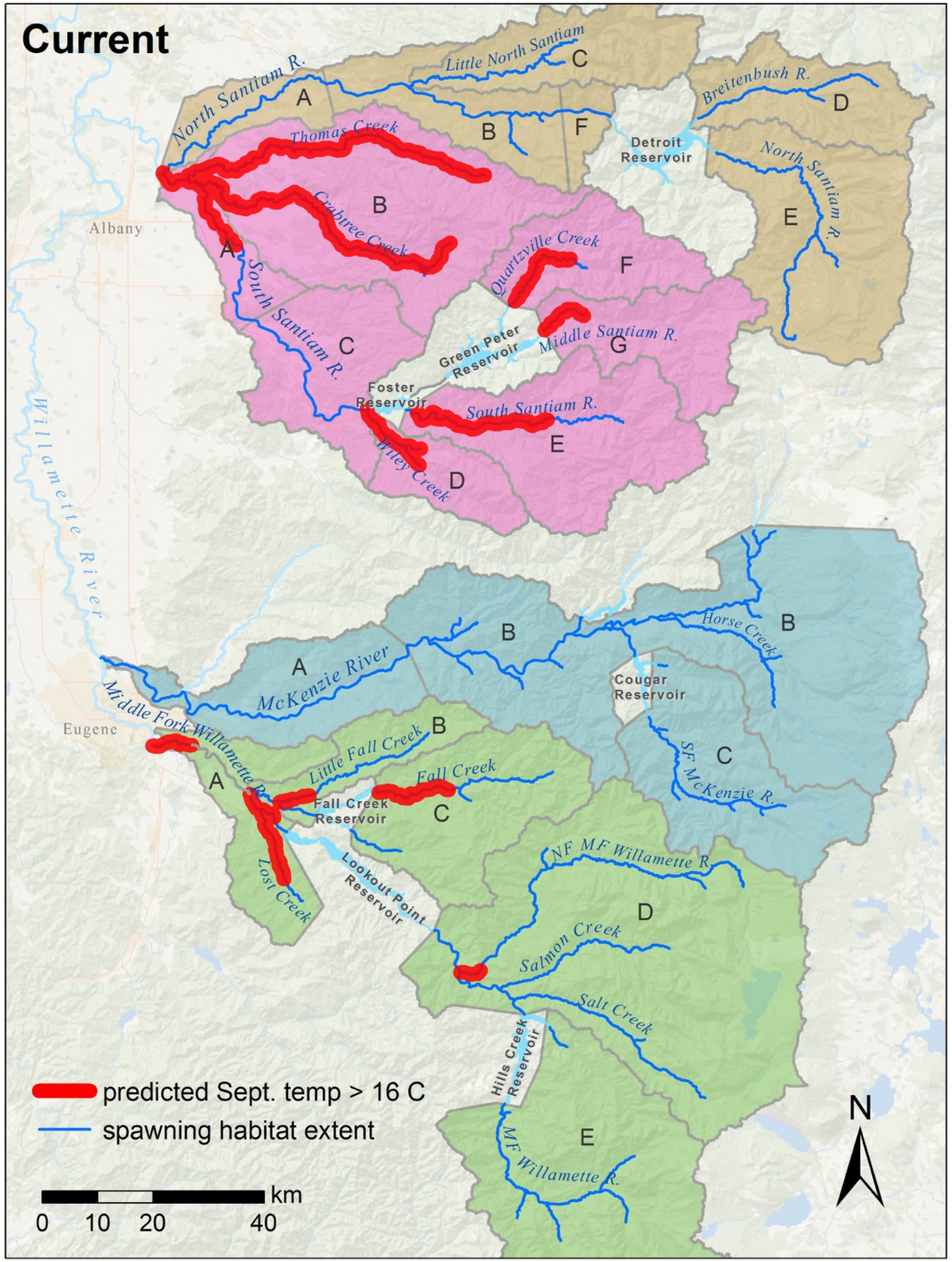
Integrated scenarios of climate, hydrology, and vegetation for the Northwest. Final report. 2014
https://climate.northwestknowledge.net/IntegratedScenarios



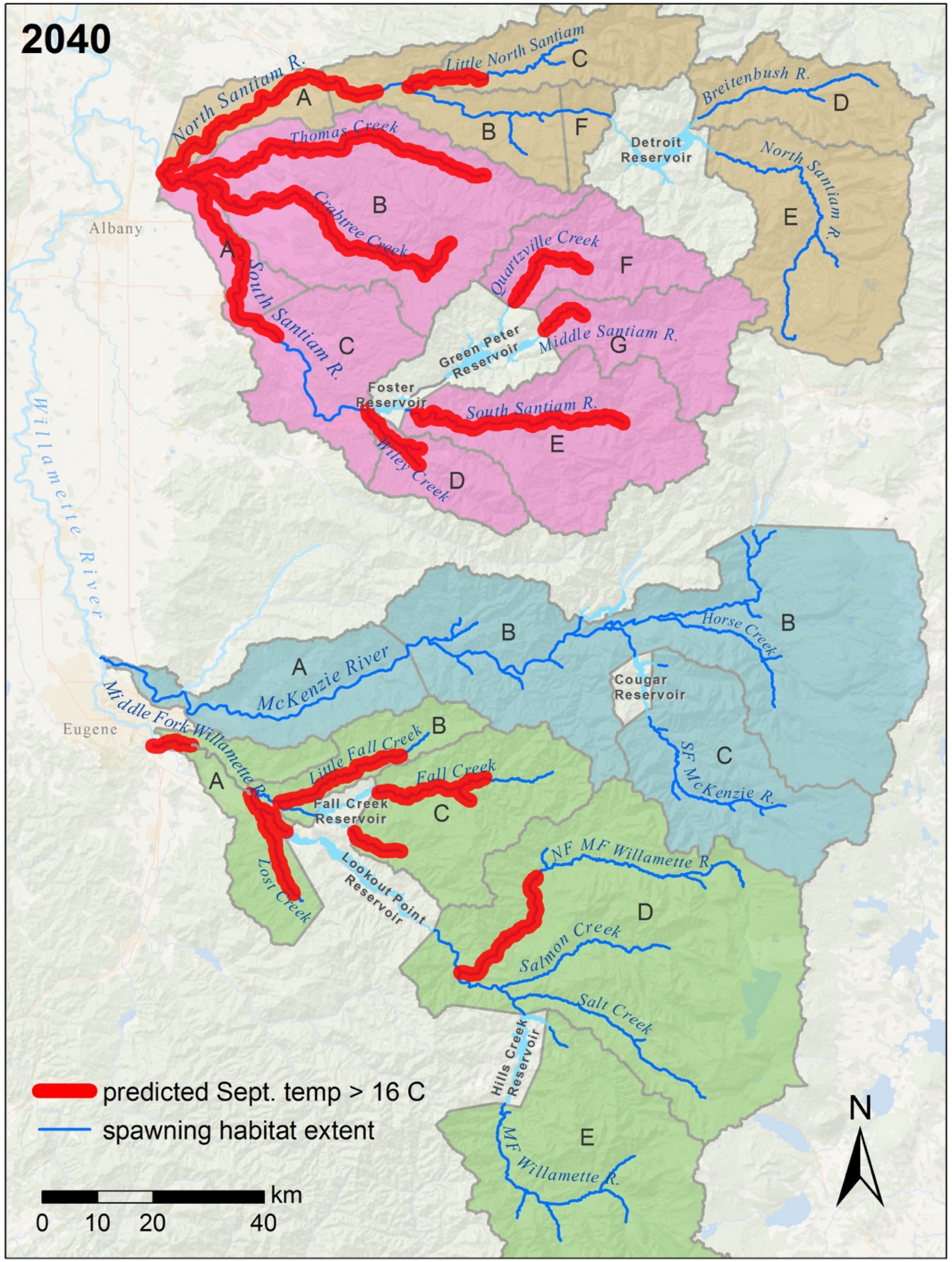
Projected Streamflow (2070–2099)
Salem, OR
Source: Integrated Scenarios CMIP5-MACAv2LIVNEH-VIC Bias-Corrected
100000
80000
60000
40000
20000
0
-20000
Streamflow (cfs)
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Historical
RCP 4.5 Avg
RCP 8.5 Avg
RCP 4.5 Range
RCP 8.5 Range
https://climate.northwestknowledge.net/IntegratedScenarios



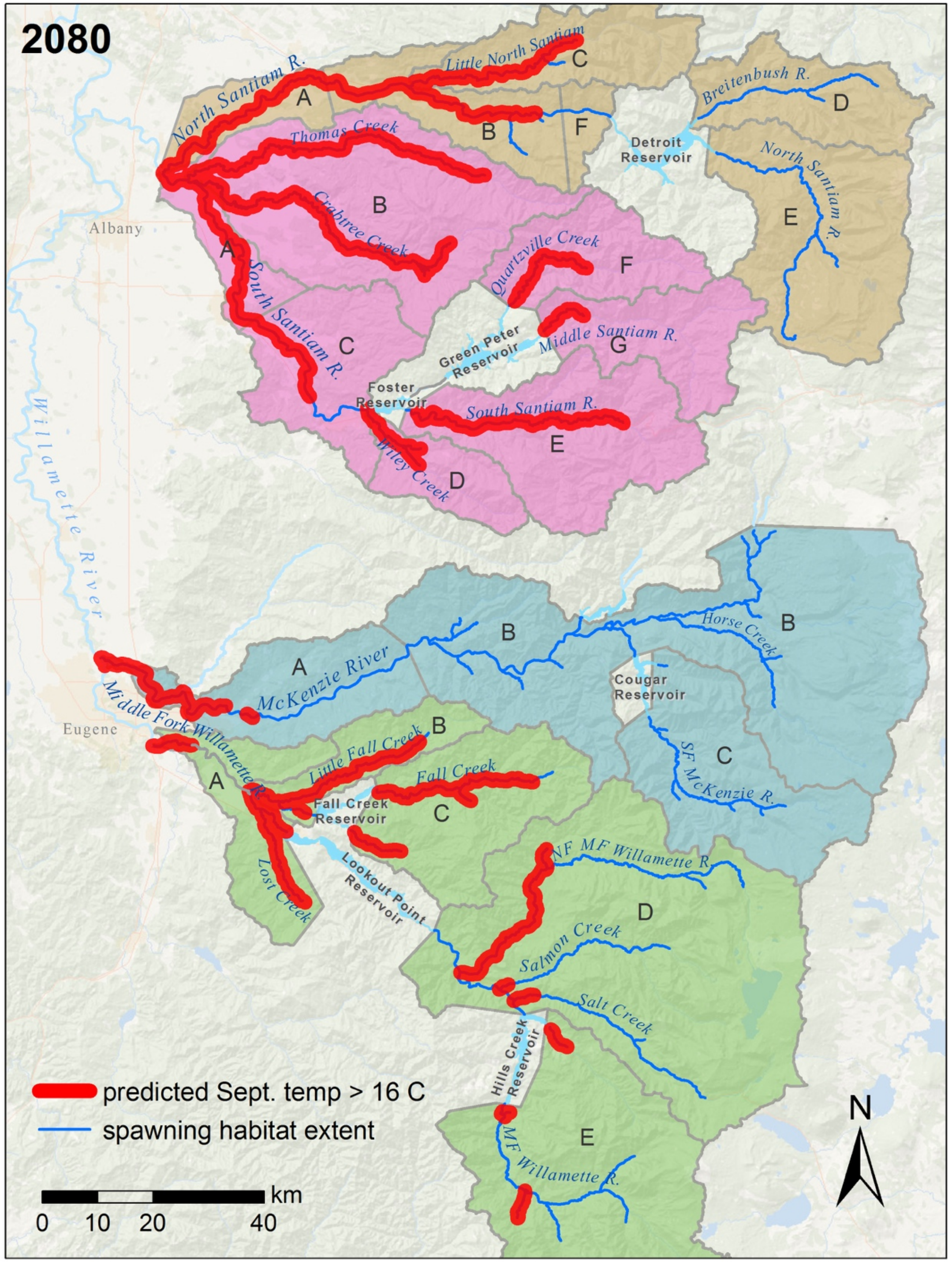
North Santiam R.
Little North Santiam
A
B
C
D
E
F
Breitenbush R.
Detroit Reservoir
North Santiam R.
Thomas Creek
Crabtree Creek
South Santiam R.
Quartzville Creek
Green Peter Reservoir
Middle Santiam R.
G
Foster Reservoir
South Santiam R.
Wiley Creek
Albany
Willamette River
McKenzie River
Horse Creek
Cougar Reservoir
SF McKenzie R.
Eugene
Middle Fork Willamette R.
Little Fall Creek
Fall Creek
Fall Creek Reservoir
Lost Creek
Lookout Point Reservoir
NF MF Willamette R.
Salmon Creek
Salt Creek
Hills Creek Reservoir
MF Willamette R.
spawning habitat extent
km
0
10
20
40
N



Current
North Santiam R.
Little North Santiam
Breitenbush R.
Detroit Reservoir
North Santiam R.
Thomas Creek
Crabtree Creek
Quartzville Creek
South Santiam R.
Green Peter Reservoir
Middle Santiam R.
Foster Reservoir
South Santiam R.
Wiley Creek
Albany
Willamette River
McKenzie River
Horse Creek
Cougar Reservoir
SF McKenzie R.
Middle Fork Willamette R.
Eugene
Little Fall Creek
Fall Creek
Fall Creek Reservoir
Lost Creek
Lookout Point Reservoir
NF MF Willamette R.
Salmon Creek
Salt Creek
Hills Creek Reservoir
MF Willamette R.
A
B
C
D
E
F
G
predicted Sept. temp > 16 C
spawning habitat extent
N
0
10
20
40
km



2040
North Santiam R.
Little North Santiam
Breitenbush R.
Thomas Creek
Detroit Reservoir
North Santiam R.
Albany
Crabtree Creek
South Santiam R.
Quartzville Creek
Green Peter Reservoir
Middle Santiam R.
Foster Reservoir
South Santiam R.
Wiley Creek
Willamette River
McKenzie River
Horse Creek
Cougar Reservoir
Middle Fork Willamette R.
Eugene
Little Fall Creek
Fall Creek
Fall Creek Reservoir
SF McKenzie R.
NF MF Willamette R.
Lookout Point Reservoir
Lost Creek
Salmon Creek
Salt Creek
Hills Creek Reservoir
MF Willamette R.
predicted Sept. temp > 16 C
spawning habitat extent
km
0 10 20 40
N



2080
North Santiam R.
Little North Santiam
Thomas Creek
Crabtree Creek
South Santiam R.
Quartzville Creek
Middle Santiam R.
Green Peter Reservoir
Foster Reservoir
South Santiam R.
Wiley Creek
Detroit Reservoir
Breitenbush R.
North Santiam R.
Albany
Willamette River
McKenzie River
Horse Creek
Cougar Reservoir
SF McKenzie R.
Middle Fork Willamette R.
Eugene
Little Fall Creek
Fall Creek
Fall Creek Reservoir
Lost Creek
Lookout Point Reservoir
NF MF Willamette R.
Salmon Creek
Salt Creek
Hills Creek Reservoir
MF Willamette R.
predicted Sept. temp > 16 C
spawning habitat extent
km
0 10 20 40
N

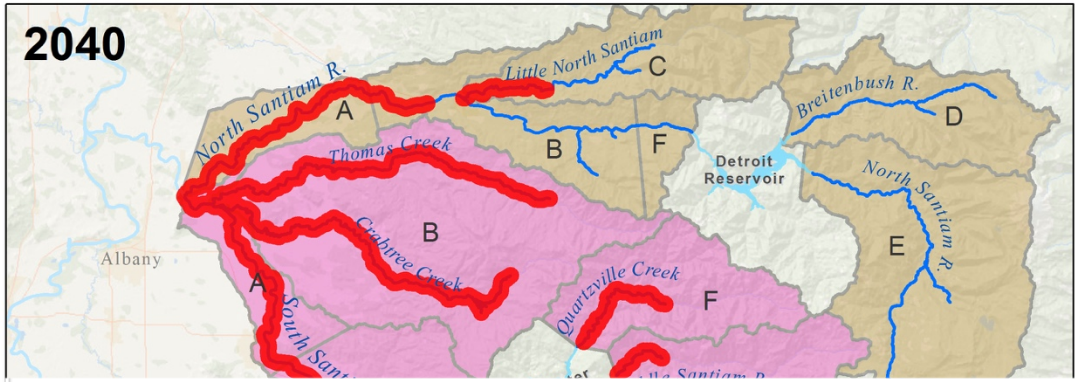
Predicted Change in Capacity

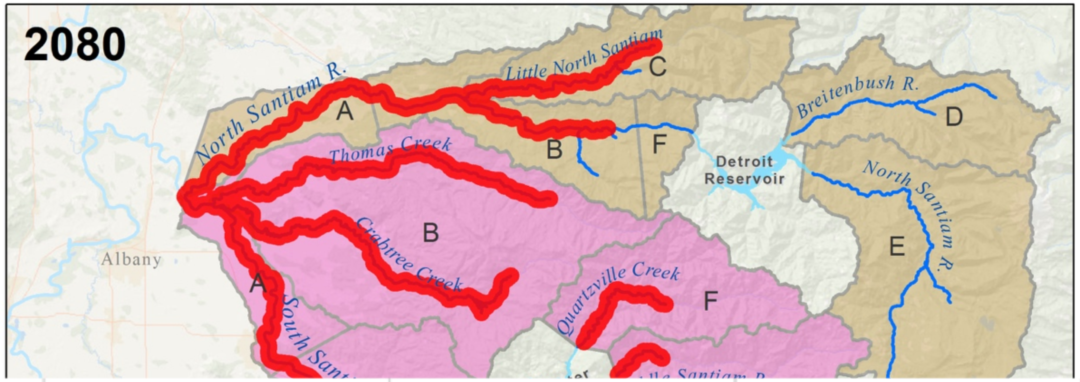
Tributary	Model Reach	1993-2011 average temp.	2040 projected temperature	2080 projected temperature	1993-2011 average temp.	2040 projected temperature	2080 projected temperature
		Redds			Adults (redds x 2.5)		
North Santiam River	A	6,427	3,336	217	16,068	8,340	543
	B	10,212	10,212	8,749	25,530	25,530	21,873
	C	3,988	3,774	1,680	9,970	9,435	4,200
	D	4,185	4,185	4,185	10,463	10,463	10,463
	E	11,417	11,417	11,417	28,543	28,543	28,543
	F	2,066	2,066	2,066	5,165	5,165	5,165
	Total	38,295	34,990	28,314	95,738	87,475	70,785

A: Below Bennett Dam
B: N. S. below Minto
C: Little N. Santiam
D: Breitenbush
E: Above Detroit
F: Minto to Big Cliff

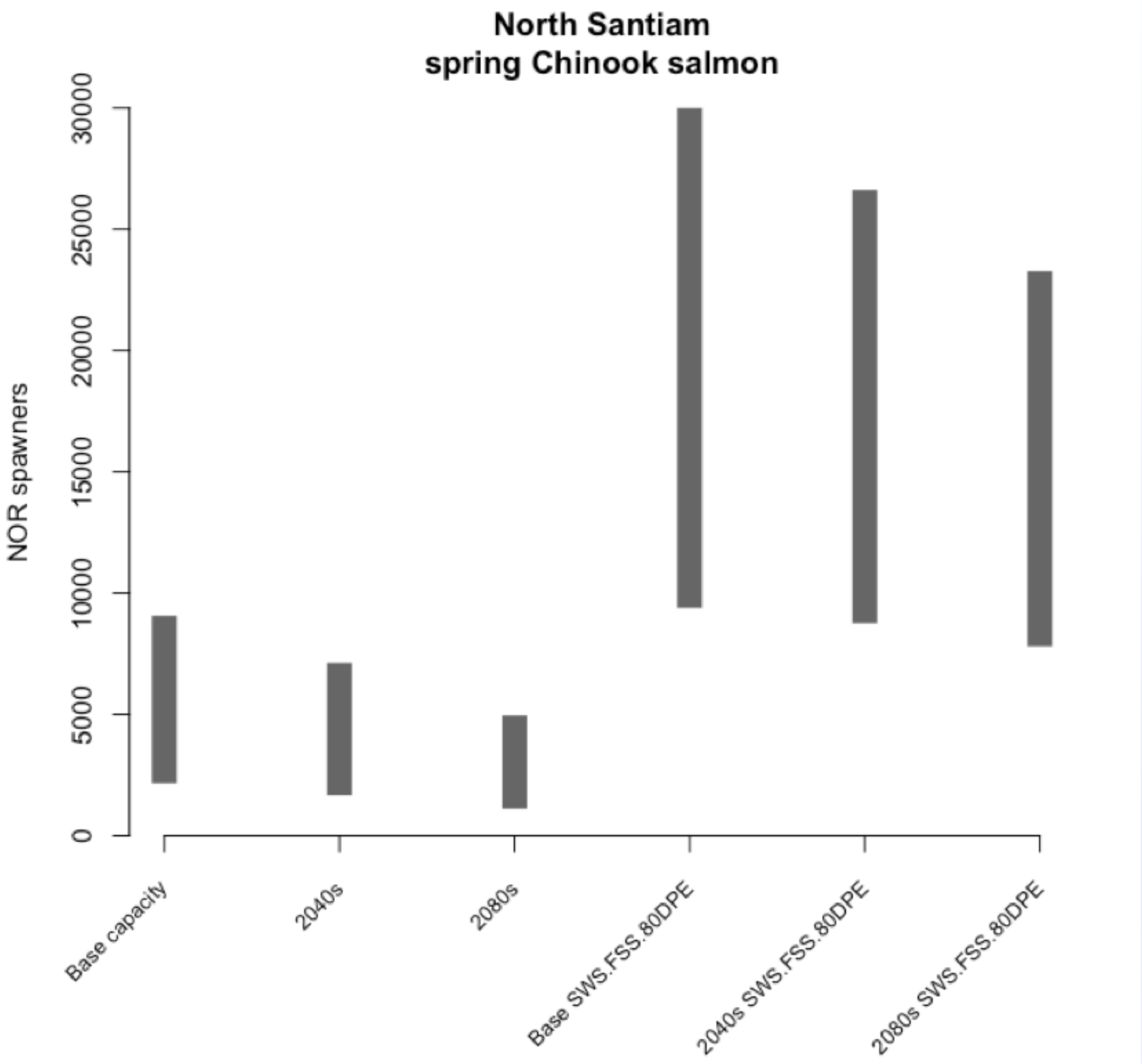
Bond et al. 2017

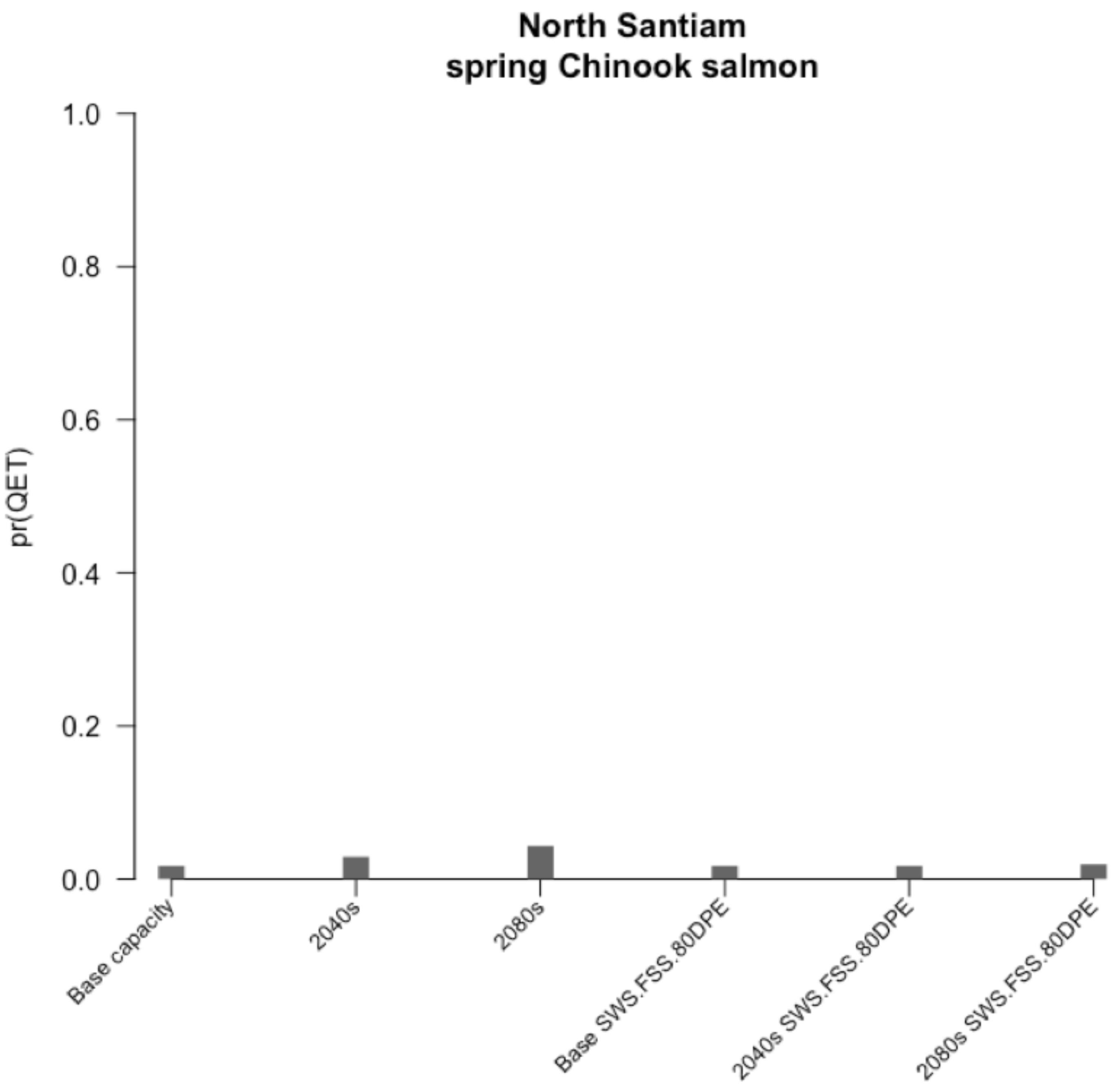
Predicted Change in Capacity





	Percent of current estimated capacity	
Reach	**2040s**	**2080s**
A: Below Bennett Dam	52%	3%
B: North Santiam below Minto	100%	86%
C: Little North Santiam	95%	42%
D: Breitenbush	100%	100%
E: Above Detroit to Marion Forks Hatchery	100%	100%
F: Minto to Big Cliff	100%	100%


North Santiam
spring Chinook salmon
NOR spawners
0
5000
10000
15000
20000
25000
30000
Base capacity
2040s
2080s
Base SWS.FSS.80DPE
2040s SWS.FSS.80DPE
2080s SWS.FSS.80DPE


North Santiam
spring Chinook salmon
pr(QET)
1.0
0.8
0.6
0.4
0.2
0.0
Base capacity
2040s
2080s
Base SWS.FSS.80DPE
2040s SWS.FSS.80DPE
2080s SWS.FSS.80DPE

Considerations

Coarse-scale temperatures	?
> 16 deg C threshold cutoff	?
Threshold cutoff vs. functional relationship	?
Higher winter flows/scouring events	(-)
Lower summer flows (reduced snowpack, lower summer precip)	(-)
Increase in summer water temperatures	(+) (-)
Changes in dam operations	?
Cool water available in late summer?	?
Ocean conditions	?
Capacity declines in lower elevation below-dam reaches were largest	(-)
Lower abundances, increased extirpation risks	(-)

Acknowledgements

Stefan Talke (PSU)

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NWS

Morgan Bond, Tyler Nodine, Paul Chittaro (NWFSC)

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