435-Molecular to Landscape, the integration of adverse outcome pathways into a regional scale pesticide driven risk assessment for Chinook salmon in Puget Sound Watersheds

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Cathy Laetz, NOAA Fisheries
Julann Spromberg, NOAA Fisheries/Ocean Associates

Contributing Agencies-Data on Sites and Exposure-Response
Northwest Fisheries Science Center, NOAA
USGS
WA Department of Agriculture
WA Department of Ecology
City of Bellingham
Noocksack Salmon Enhancement Association
King County DNR
King Conservation District
Skagit Conservation district
Yakima Tribal DNR
Samish Tribal DNR

Goal

Take molecular effects and write the equation to predict risks to populations in a defined landscape.

AOP Poster

Population Modeling

WE071 Stark et al. Population Models for Use in Bayesian Networks and Adverse Outcome Pathways

Introduction

Background to the Adverse Outcome Pathway (AOP) model

Construction of the Bayesian network to describe mixture toxicity, the AOP and changes in the population

Sensitivity analysis

Frustrations

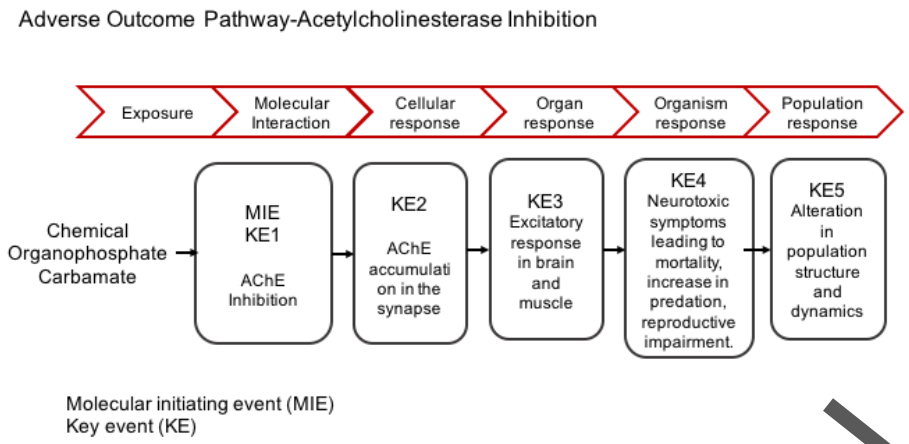
Conclusions

Adverse Outcome Pathway

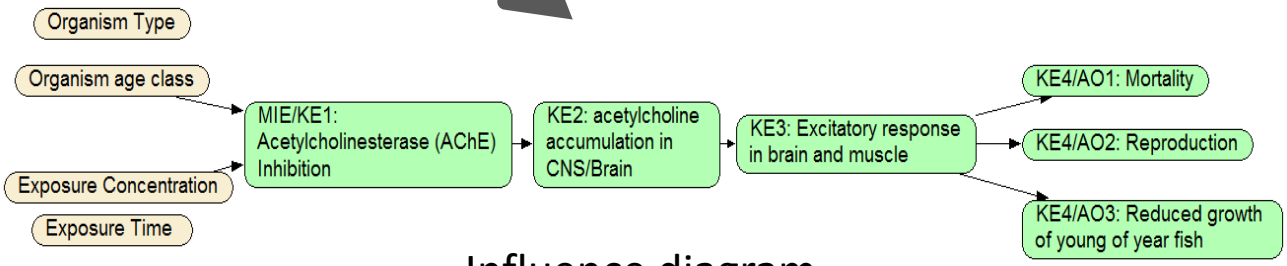
An AOP is a conceptual construct that portrays existing knowledge concerning the linkage between a direct molecular initiating event and an adverse outcome at a *biological level of organization* relevant to risk assessment.

I do not do levels of organization ---I prefer scale but that is another talk.

Adverse Outcome Pathway for OP (Russom et al 2014) is turned into an Influence diagram.

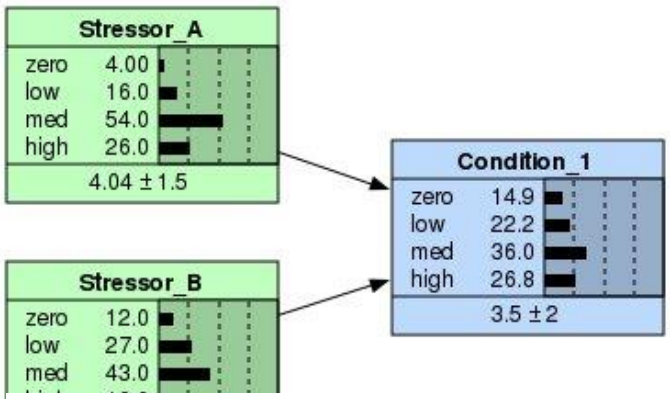


AOP is not sufficient to predict effects or risks to populations until scale, location, and environmental conditions are introduced.



Influence diagram

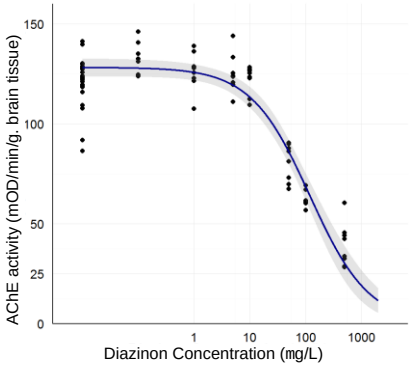
Bayesian Network Models-acyclic graphs

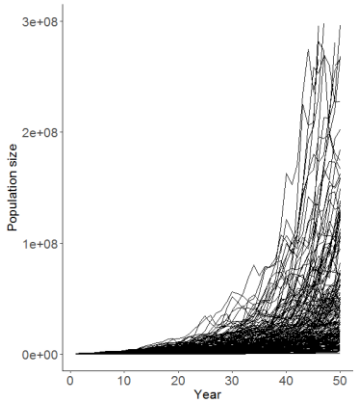


Stressor_A	Stressor_B	zero	low	med	high
zero	zero	100.00	0.000	0.000	0.000
zero	low	90.000	8.000	1.500	0.500
zero	med	75.000	20.000	4.000	1.000
zero	high	60.000	25.000	10.000	5.000
low	zero	75.000	20.000	4.000	1.000
low	low	50.000	35.000	10.000	5.000
low	med	25.000	35.000	30.000	10.000
low	high	10.000	30.000	45.000	15.000
med	zero	25.000	35.000	30.000	10.000
med	low	10.000	30.000	45.000	15.000
med	med	5.000	25.000	50.000	20.000
med	high	1.000	9.000	40.000	50.000
high	zero	15.000	25.000	40.000	20.000
high	low	10.000	15.000	35.000	40.000
high	med	5.000	10.000	30.000	55.000
high	high	1.000	4.000	20.000	75.000

The conditional probability tables are describe by exposure-response relationships whether they are organophosphates or ecological attributes.

Exposure-response can be determined by data or modeling.





Specific case study

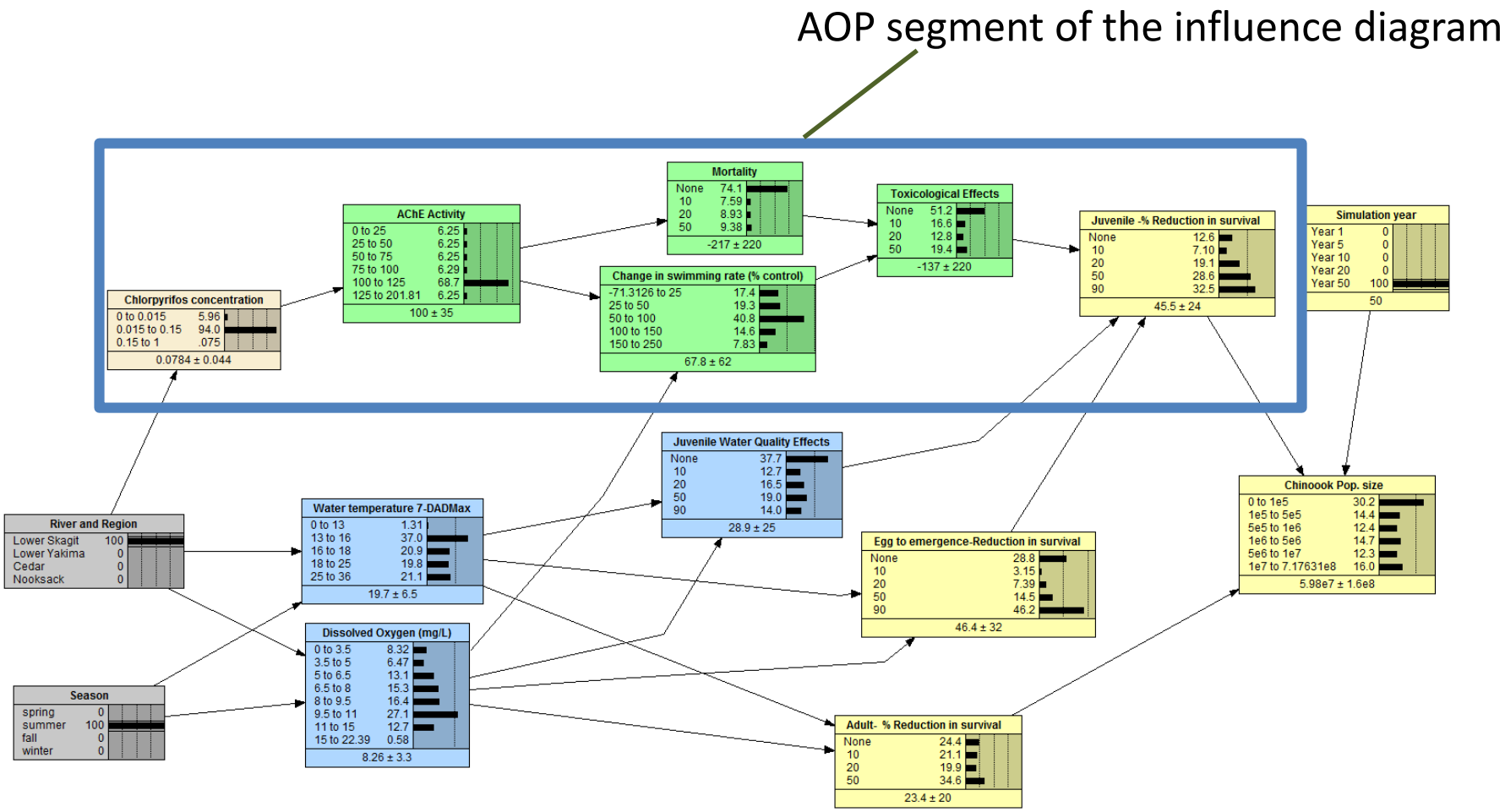
Pesticides in Washington State Rivers with the Skagit River as today's example

Acetylcholinesterase inhibitor-organophosphates

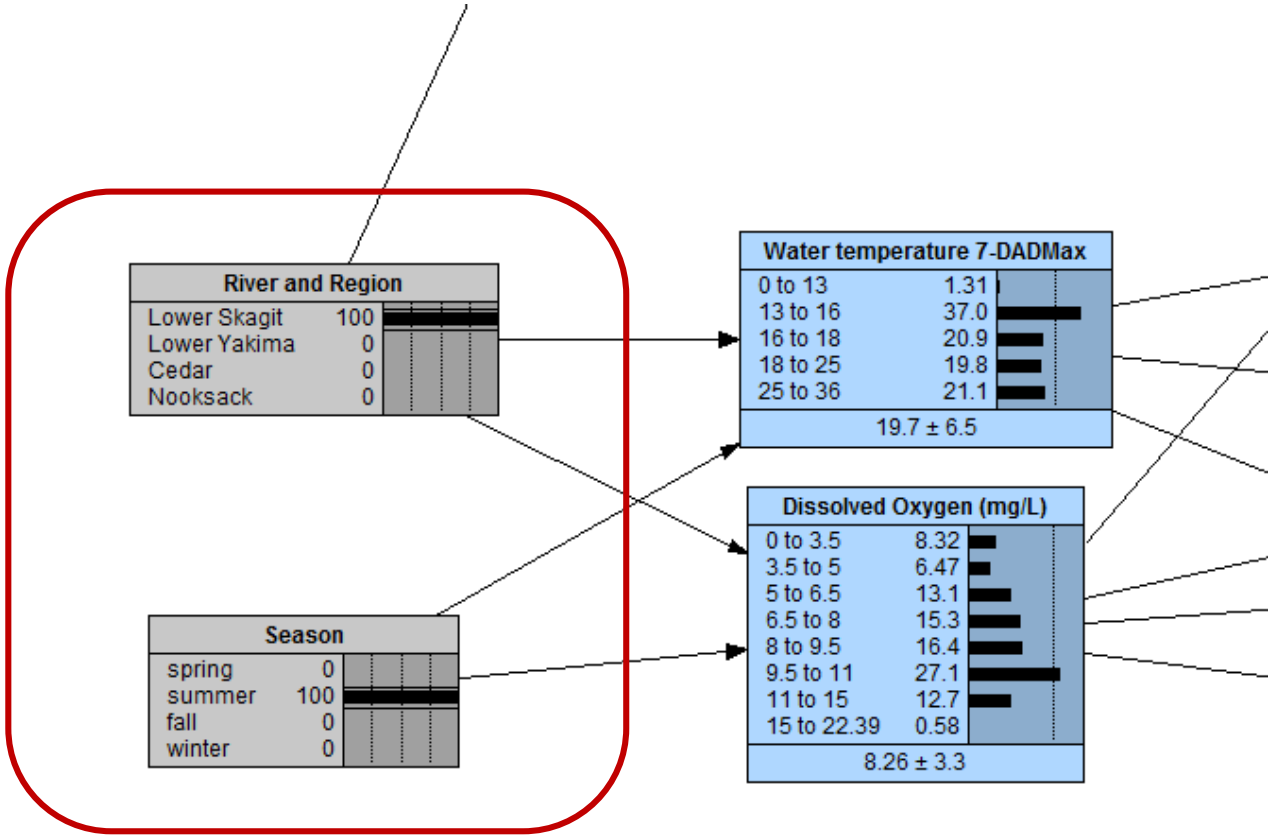
Chinook as species (listed as protected)

Population effects-Chlorpyrifos example.

Simplified one pesticide model

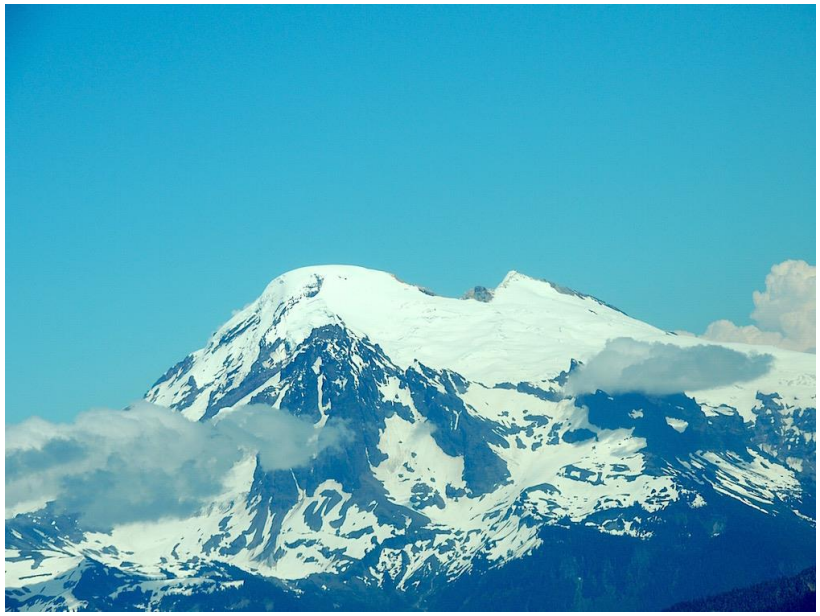


The Rivers: The nodes are set from site specific data for each of the 4 watersheds



The River and the season

Today we will talk about the Skagit River and Chinook salmon

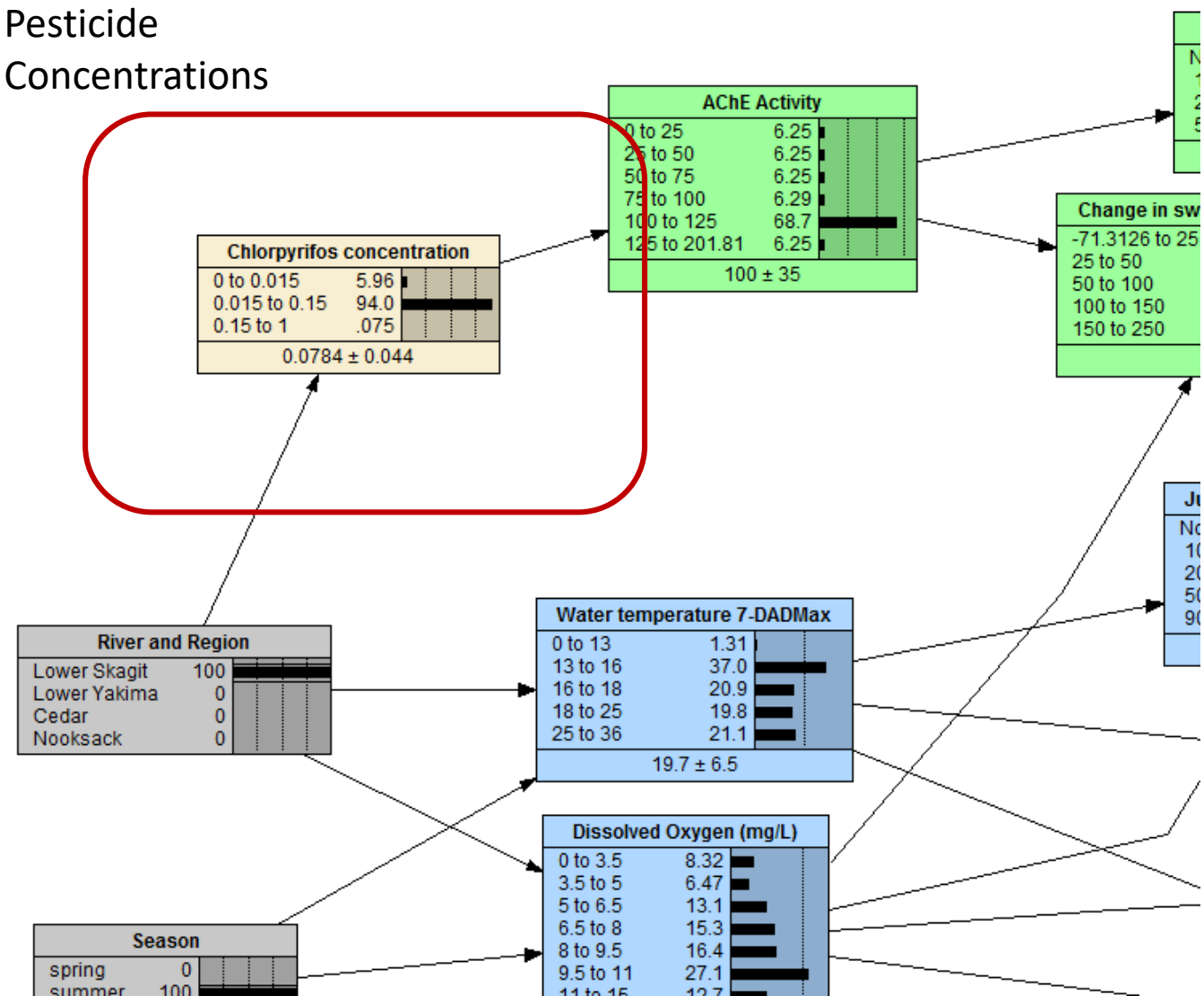


Mt. Baker

Skagit

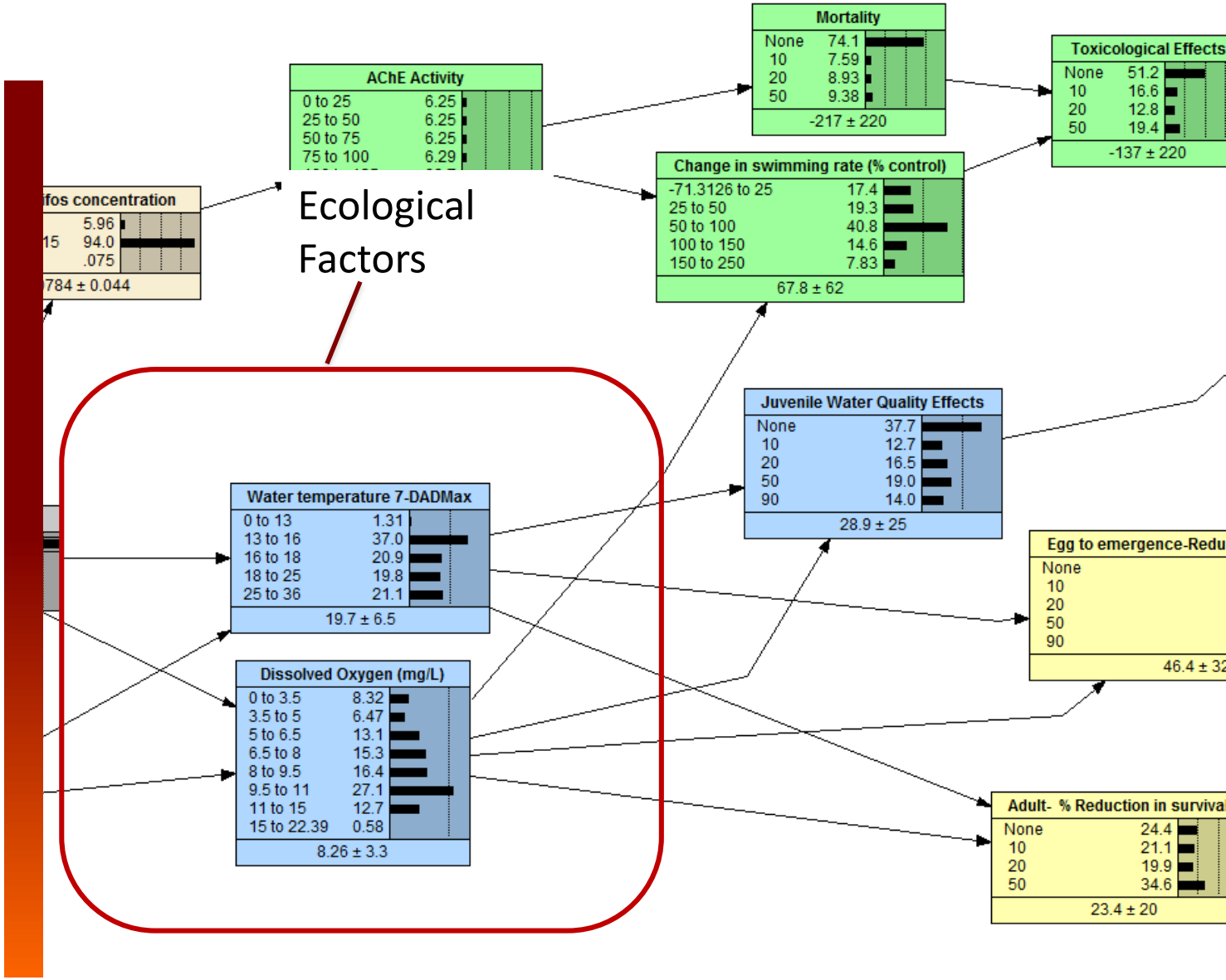
Pesticide concentrations are parent nodes and are specific to the river.

The nodes are set from site specific data for each of the 4 watersheds



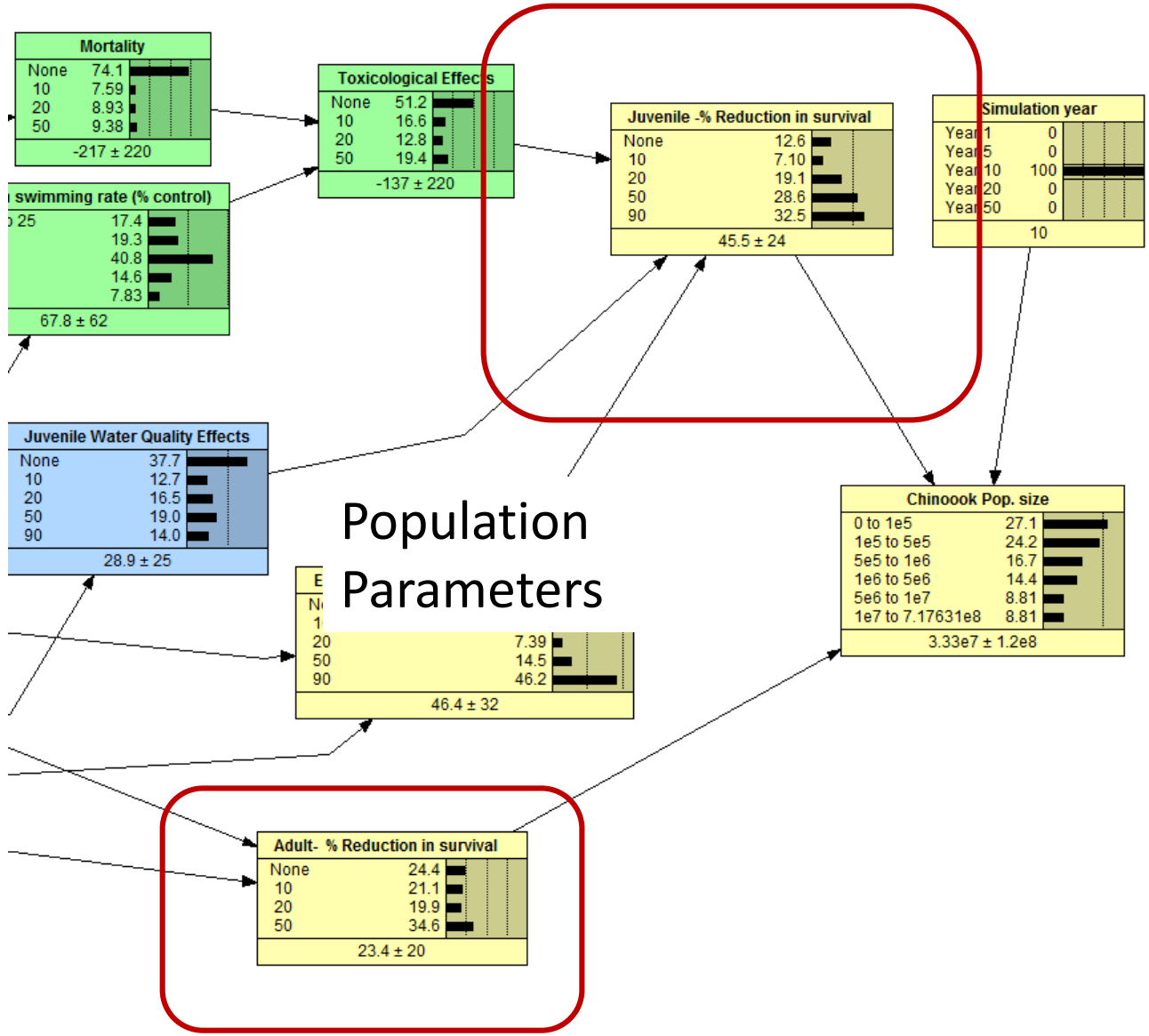
Part of the model describes water quality parameters.

These nodes are set from site specific data for each of the 4 watersheds



Now for the Population part of the calculation….

These nodes set up the input for the population simulations



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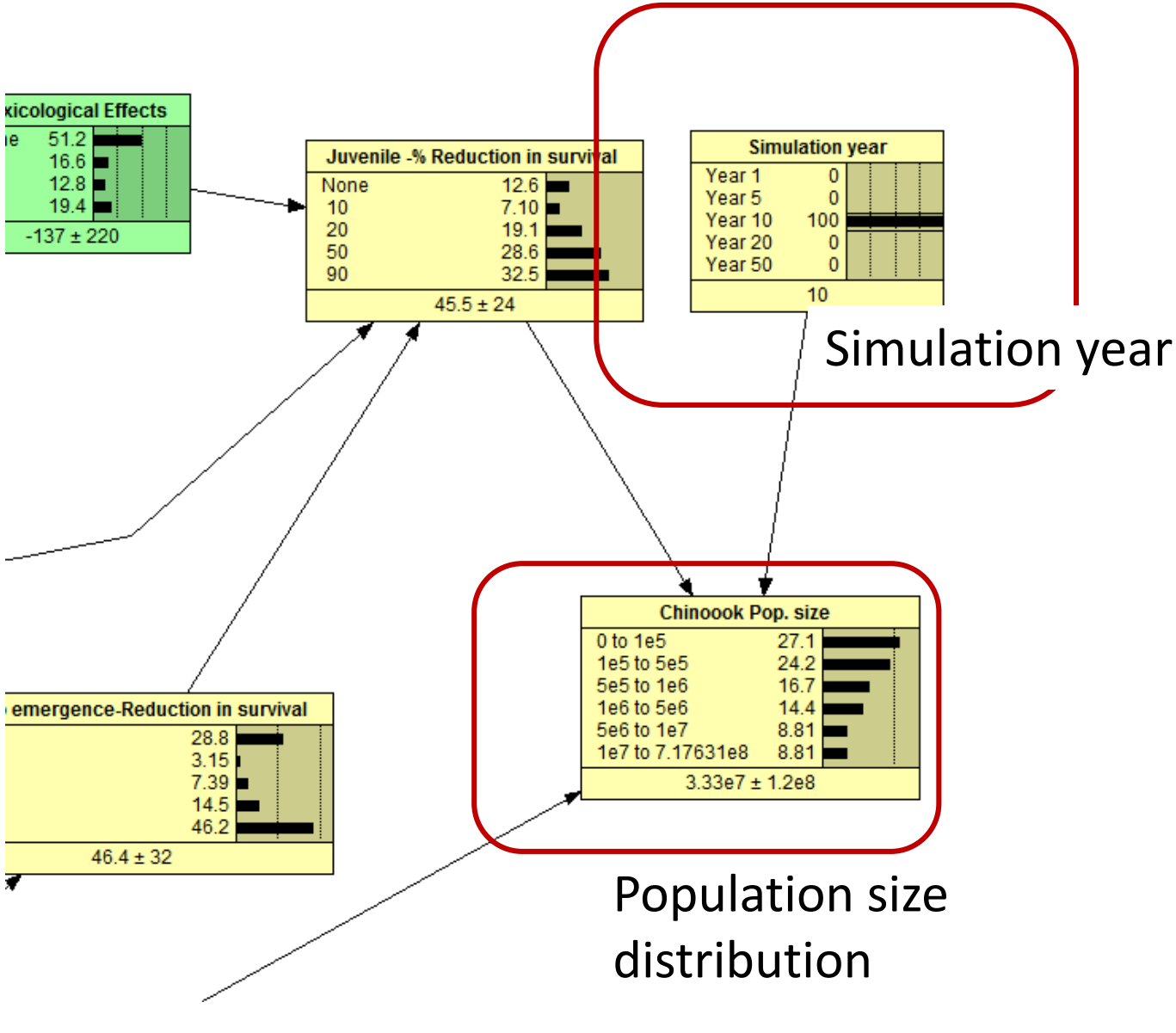

The conditional probability table constructed using population modeling for all states of juvenile and Adult percent reduction

total_pop Table (in Bayes net Chlorpyrifos__3_23_2017_VRC)

Node: total_pop

Apply | OK | Reset | Close

Chance | % Probability

Simulation y...	Juvenile -% ...	Adult- % Re...	0 to 1e5	1e5 to 5e5	5e5 to 1e6	1e6 to 5e6	5e6 to 1e7	1e7 to 7.1...
Year 1	None	None	0.485	23.301	74.757	0.485	0.485	0.485
Year 1	None	10	0.485	18.447	79.612	0.485	0.485	0.485
Year 1	None	20	0.485	26.214	71.845	0.485	0.485	0.485
Year 1	None	50	0.485	23.301	74.757	0.485	0.485	0.485
Year 1	10	None	0.485	25.243	72.815	0.485	0.485	0.485
Year 1	10	10	0.485	23.301	74.757	0.485	0.485	0.485
Year 1	10	20	16.667	16.667	16.667	16.667	16.667	16.667
Year 1	10	50	16.667	16.667	16.667	16.667	16.667	16.667
Year 1	20	None	0.165	22.607	76.733	0.165	0.165	0.165
Year 1	20	10	16.667	16.667	16.667	16.667	16.667	16.667
Year 1	20	20	0.485	29.612	68.447	0.485	0.485	0.485
Year 1	20	50	16.667	16.667	16.667	16.667	16.667	16.667
Year 1	50	None	0.485	27.67	70.388	0.485	0.485	0.485
Year 1	50	10	16.667	16.667	16.667	16.667	16.667	16.667
Year 1	50	20	16.667	16.667	16.667	16.667	16.667	16.667
Year 1	50	50	0.485	20.388	77.67	0.485	0.485	0.485
Year 1	90	None	0.124	25.31	74.194	0.124	0.124	0.124
[illegible]	90	10	16.667	16.667	16.667	16.667	16.667	16.667
[illegible]	[illegible]	20	16.667	16.667	16.667	16.667	16.667	16.667
[illegible]	[illegible]	50	16.667	16.667	16.667	16.667	16.667	16.667
[illegible]	[illegible]	None	0.485	15.534	63.107	19.903	0.485	0.485
[illegible]	[illegible]	10	0.485	31.553	57.767	9.223	0.485	0.485
[illegible]	[illegible]	20	0.485	57.282	38.835	2.427	0.485	0.485
[illegible]	[illegible]	50	19.903	73.301	5.34	0.485	0.485	0.485
[illegible]	[illegible]	None	0.485	21.845	62.621	14.078	0.485	0.485
Year 5	10	10	0.485	40.291	50.971	7.282	0.485	0.485
Year 5	10	20	16.667	16.667	16.667	16.667	16.667	16.667
Year 5	10	50	16.667	16.667	16.667	16.667	16.667	16.667
Year 5	20	None	0.33	48.515	44.059	6.766	0.165	0.165

The table is 9 X 200 or 1800 cells.

The conditional probability table is based on RAMAS population modeling—see C. Mitchell et al poster

Population model based on Baldwin et al (2009) and Spromberg and Scholz (2011) to estimate changes in population and patches.


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Estimating the Future Decline of Wild Coho Salmon Populations Resulting from Early Spawner Die-Offs in Urbanizing Watersheds of the Pacific Northwest, USA

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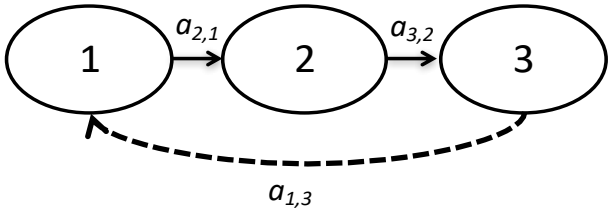
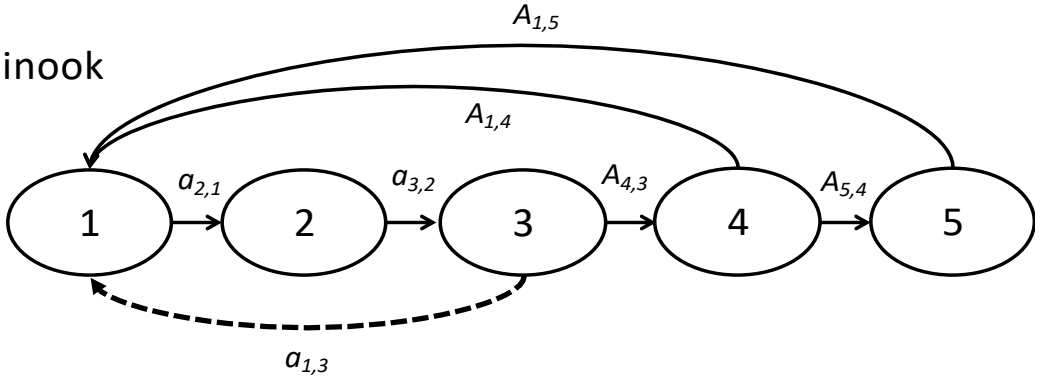
(Submitted 19 January 2011; Returned for Revision 28 February 2011; Accepted 20 April 2011)

Coho



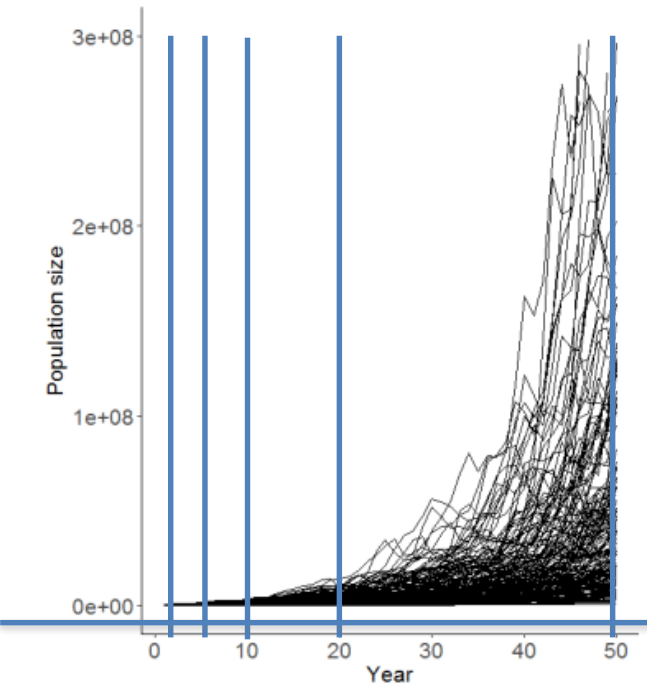
Chinook



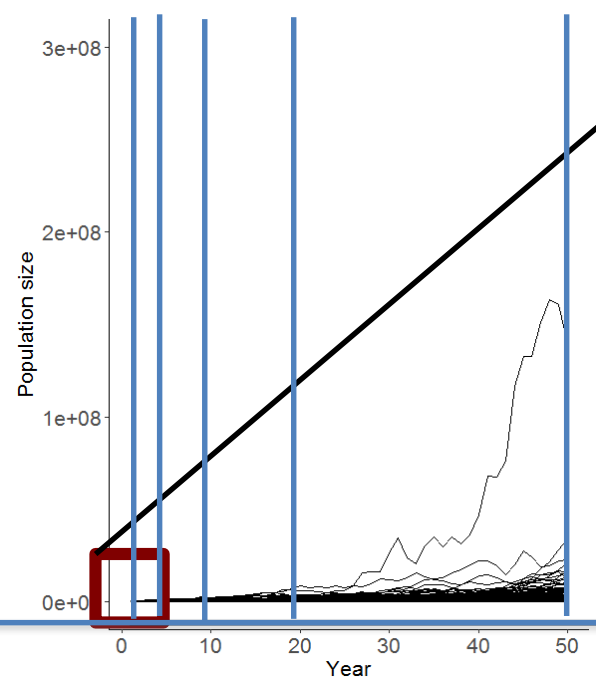
Baldwin et al 2009

RAMAS modeling and the output predicts exposure-response relationships-C. Mitchell modeling

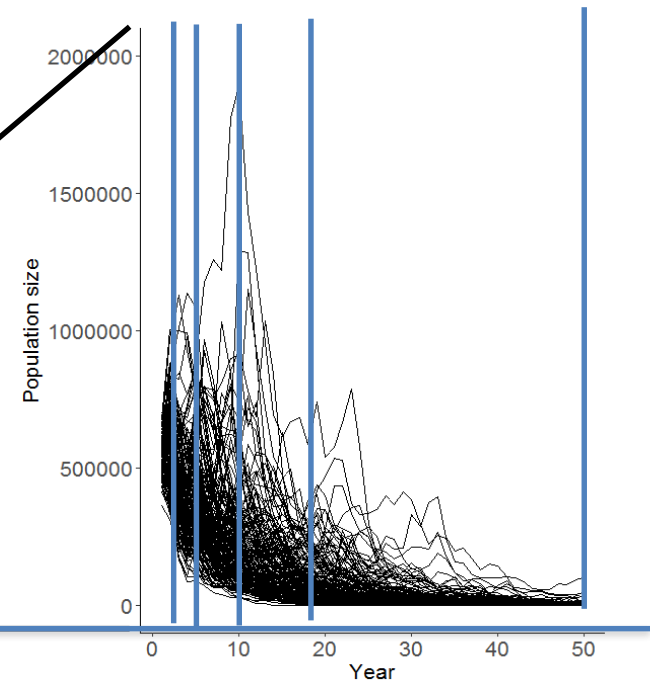
Baseline model



20 percent reduction



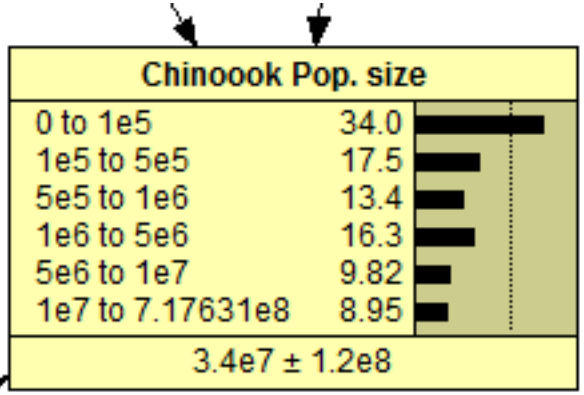
50 percent reduction



Changes in the Chlorpyrifos Case study-Typical Skagit Conditions

High risk

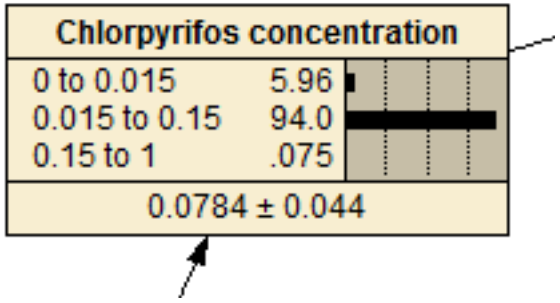
Low risk



Low population

High population

Skagit-spring-20 years
Chlorpyrifos measured

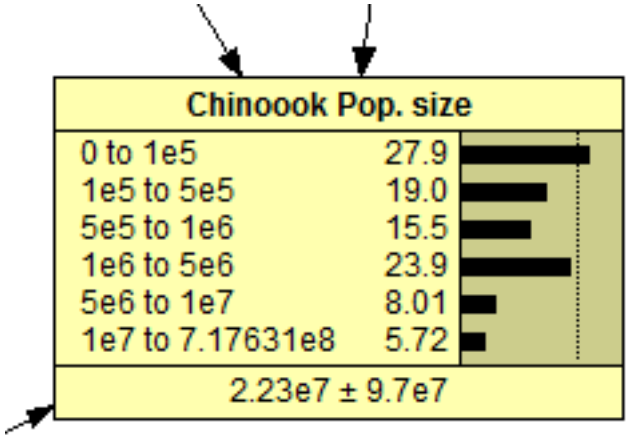


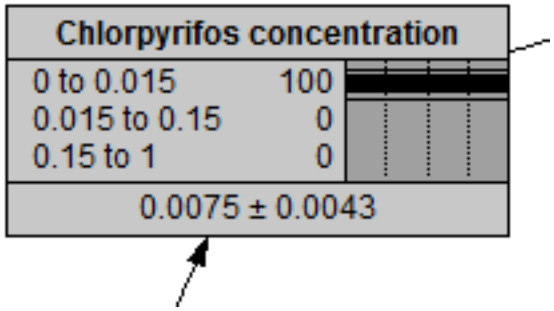
Spring is typical for some of the runs and the subsequent spawning.

Changes in the Chlorpyrifos Case study-Best case and Worst case scenarios-Influence analysis

Best Case

Skagit-winter-20 years
Chlorpyrifos low

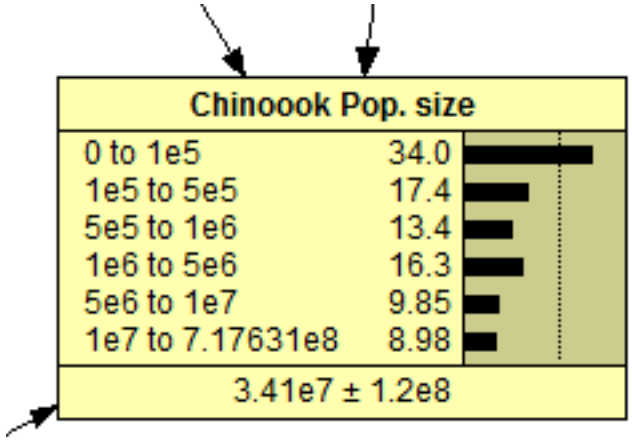


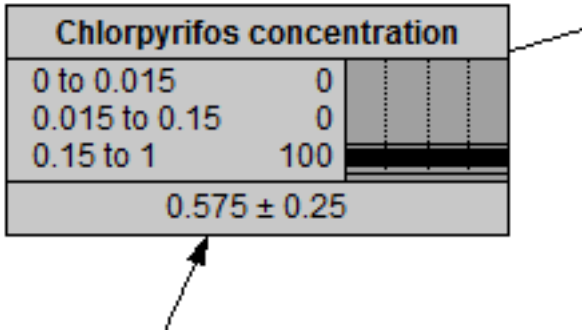


Shift in distribution

Worst Case

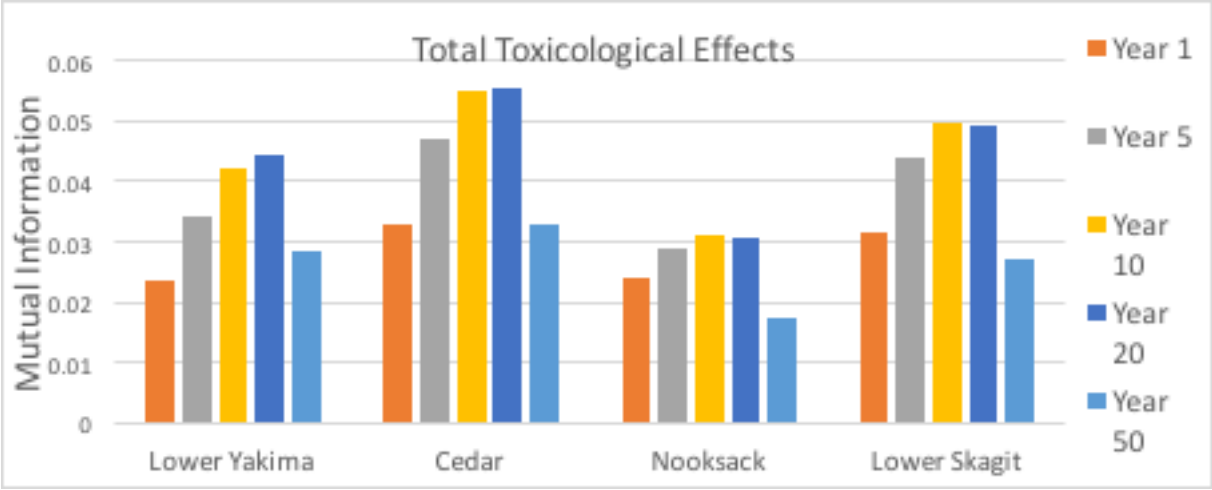
Skagit-summer-20 years
Chlorpyrifos maximum

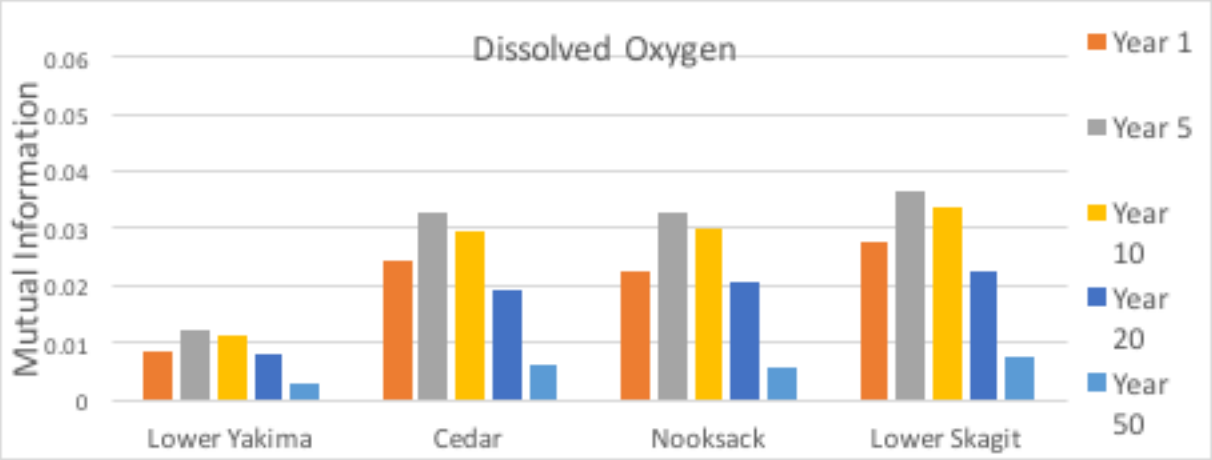




Sensitivity Analysis via Entropy analysis measured by mutual Information

Toxicity equivalent to **Dissolved Oxygen** and **Temperature** in information contribution





Limitations and Frustrations

Additional dose-response information needed to describe effects upon migration and other endpoints in an exposure-response manner

The interactions between ecology and toxicology are not clear.

River and run specific life-history data are not available, although Chinook are the iconic species of the region.

Conclusions

AOPs can be incorporated into models that include ecological parameters to predict population dynamics and risk to those populations.

So now we can incorporate an AOP into a probabilistic risk assessment.

Toxicology and the Environment are important variables the rank of importance changes with location, season and the time into the future.