APPENDIX C: SENSITIVITY ANALYSIS OF POPCYCLE PARAMETER EFFECTS ON PREDICTED POPULATION SIZE

S.P. Cramer & Associates, Inc.
600 NW Fariss
Gresham, Oregon 97030
www.spcramer.com

Table of Contents

Table of Figures

List of Tables

Introduction and Methods

A sensitivity analysis was performed to identify how various model parameters affected the population numbers predicted by the PopCycle model. In actuality, with three species and three distinct lake systems, there are nine possible models that could be evaluated. However, because there is no spring Chinook salmon model for Lake Merwin, eight specific models were evaluated through the sensitivity analysis (Appendix Table C- 1).

Appendix Table C- 1. Specific PopCycle models developed for the Lewis River Basin.

	Lake System		
Species	Swift Reservoir	Yale Lake	Lake Merwin
Spring Chinook	Y	Y	N
Coho	Y	Y	Y
Steelhead	Y	Y	Y

The sensitivity analysis focused on those model parameters where specific values may not be in complete agreement among the Lewis River stakeholders. A range of values for each parameter was tested to gauge the effects of the parameter on the resulting predicted population. The ranges used in the sensitivity analysis are thought to cover the range of opinions of stakeholders. Specifies-specific default parameters were established for each model; the only difference in the default parameters was the assumed mortality rate as a result of incidental harvest. The specific default parameters are presented in Appendix Table C- 2 and the range of values for each tested parameter is presented in Appendix Table C- 3.

Appendix Table C- 2. Default parameters used in the sensitivity analysis.

	Parameter					
Species	Habitat Capacity[a] (%)	Productivity[a] (%)	Juvenile Passage Survival[b] (%)	Adult Passage Survival[b] (%)	Smolt Supplementation (years)	Harvest Mortality (%)
Spring Chinook	100	100	70	80	5	20
Coho	100	100	70	80	5	15
Steelhead	100	100	70	80	5	3

[a] Habitat capacity and productivity parameter values were derived from the EDT model (Mobrand Biometrics, Inc. 2002). The default parameters assume that habitat capacity and productivity is 100% of the values determined by the EDT model. Revised results of the EDT model were made available at the time of this publication, after the sensitivity analysis had been performed. The sensitivity analysis utilized the available preliminary EDT model values.
[b] Dam passage survival rates are literature-derived.

Appendix Table C- 3. Range of parameter values used in the sensitivity analysis.

	Parameter					
Species	**Habitat Capacity[a] (%)**	**Productivity[a] (%)**	**Juvenile Passage Survival[b] (%)**	**Adult Passage Survival[b] (%)**	**Smolt Supplementation (years)**	**Harvest Mortality (%)**
Spring Chinook	50, 100, 150	50, 100, 150	50, 60, 70, 80, 100	60, 70, 80, 90, 100	5, 10, 25	15, 20, 40
Coho	50, 100, 150, 200	50, 100, 150	50, 60, 70, 80, 100	60, 70, 80, 90, 100	5, 10, 25	10, 15, 40
Steelhead	50, 100, 150, 200	50, 100, 150	50, 60, 70, 80, 100	60, 70, 80, 90, 100	5, 10, 25	3

[a] Habitat capacity and productivity parameter values were derived from the EDT model (Mobrand Biometrics, Inc. 2002). The sensitivity analysis parameters assume that habitat capacity and productivity is some percentage of the values determined by the EDT model. Revised results of the EDT model were made available at the time of this publication, after the sensitivity analysis had been performed. The sensitivity analysis utilized the available preliminary EDT model values.
[b] Dam passage survival rates are expected to cover the range of values reported in the literature.

In the sensitivity analysis, various combinations of parameter values were used to investigate the effects each model parameter had on the predicted population size. Generally, most parameter values were held constant while a range of values for a specific parameter were tested to isolate the effects of that parameter. For each model run, the maximum predicted population, the predicted population size after 50 years, and the low run risk were derived. The low run risk is the percentage of years out of 50 that the model predicted the population size would be below the threshold number of 300 fish. For certain parameters, the predicted annual population sizes were compared to identify the parameter effects over time. For the sensitivity analysis, population size is analogous to the "natural spawners" output of the model. The following sections present the results and brief discussion of the model runs specified by location, parameter, and species.

New EDT model results were released after completion of the sensitivity analysis; these new results affect the habitat capacity and productivity model input values. Productivity values were calculated using the EDT model derived values for juvenile habitat capacity and juvenile abundance as described in the PopCycle model explanation. A comparison of the newly released habitat capacity and productivity values with those used in the sensitivity analysis is displayed in Appendix Table C-4. A new default model run with the updated habitat capacity and productivity values was performed and compared to the existing sensitivity analysis for the habitat capacity and productivity parameters.

Appendix Table C-4. Comparison of habitat capacity and productivity input values used in the sensitivity analysis and those calculated from newly released EDT model results.

		Values Used in Sensitivity Analysis		Updated Values Based on New EDT Model Results	
Location	**Species**	**Habitat Capacity**	**Productivity**	**Habitat Capacity**	**Productivity**
Swift Reservoir	Spring Chinook	205,009	0.054	68,172	0.068
	Coho	139,159	0.097	226,879	0.077
	Steelhead	24,924	0.068	29,920	0.036
Yale Lake	Spring Chinook	15,677	0.038	26,945	0.054
	Coho	61,251	0.043	80,842	0.057
	Steelhead	3,512	0.047	2,588	0.043
Merwin Lake	Coho	40,123	0.038	49,068	0.051
	Steelhead	2,970	0.03	2,965	0.046

Results

Swift Reservoir

Spring Chinook Salmon

The default model run for spring Chinook in Swift Reservoir resulted in a maximum population size of 1,137 fish, a population size after 50 years of 655 fish, and a low run risk of 6.3% (Appendix Table C- 5, runs 3, 7, 11, 18, 23, and 27). The default model run is included with model runs for each investigation of parameter effects for ease in comparison.

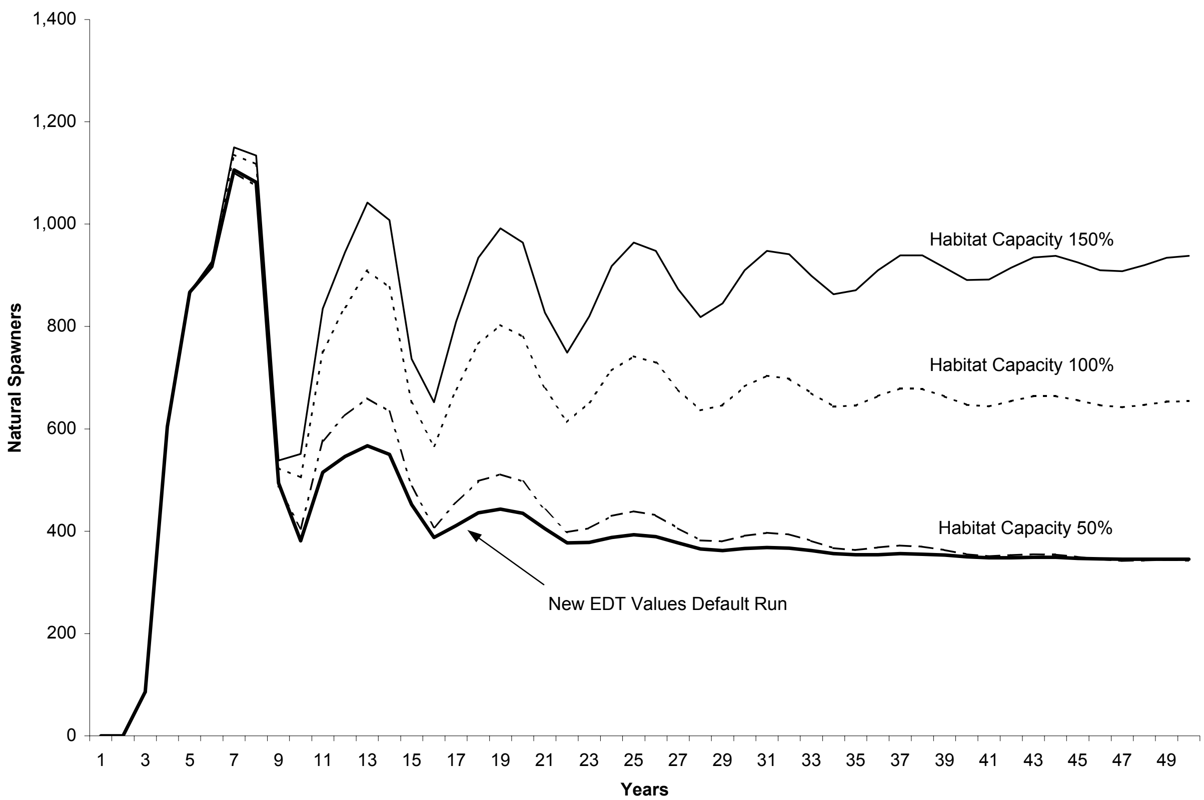
Appendix Table C- 5. Swift Reservoir spring Chinook sensitivity to changes in model parameters. Runs 3, 7, 11, 18, 23, and 27

Model Run	Model Input: Passage: Juvenile	Passage: Adult	Capacity	Productivity	Supplementation: Adults	Supplementation: Smolts	Harvest	Results: Population: Max	Population: 50 yr	Low Run Risk (< 300)
1	50%	80%	100%	100%	2 yrs	5 yrs	20	812	146	59.9%
2	60%	80%	100%	100%	2 yrs	5 yrs	20	974	359	19.5%
3	70%	80%	100%	100%	2 yrs	5 yrs	20	1,137	655	6.3%
4	80%	80%	100%	100%	2 yrs	5 yrs	20	1,299	993	5.5%
5	70%	60%	100%	100%	2 yrs	5 yrs	20	852	189	52.0%
6	70%	70%	100%	100%	2 yrs	5 yrs	20	994	393	16.1%
7	70%	80%	100%	100%	2 yrs	5 yrs	20	1,137	655	6.3%
8	70%	90%	100%	100%	2 yrs	5 yrs	20	1,279	950	5.6%
9	50%	60%	100%	100%	2 yrs	5 yrs	20	609	24	77.9%
10	60%	70%	100%	100%	2 yrs	5 yrs	20	852	189	53.3%
11	70%	80%	100%	100%	2 yrs	5 yrs	20	1,137	655	6.3%
12	80%	90%	100%	100%	2 yrs	5 yrs	20	1,462	1,349	5.4%
13	100%	100%	100%	100%	2 yrs	5 yrs	20	2,616	2,616	5.4%
14	70%	80%	50%	50%	2 yrs	5 yrs	20	1,000	20	71.7%
15	70%	80%	50%	100%	2 yrs	5 yrs	20	1,101	344	21.4%
16	70%	80%	50%	150%	2 yrs	5 yrs	20	1,179	634	6.0%
17	70%	80%	100%	50%	2 yrs	5 yrs	20	1,101	28	67.7%
18	70%	80%	100%	100%	2 yrs	5 yrs	20	1,137	655	6.3%
19	70%	80%	100%	150%	2 yrs	5 yrs	20	1,261	1,261	5.5%
20	70%	80%	150%	50%	2 yrs	5 yrs	20	1,015	33	66.3%
21	70%	80%	150%	100%	2 yrs	5 yrs	20	1,151	939	5.8%
22	70%	80%	150%	150%	2 yrs	5 yrs	20	1,883	1,883	5.4%
23	70%	80%	100%	100%	2 yrs	5 yrs	20	1,137	655	6.3%
24	70%	80%	100%	100%	2 yrs	10 yrs	20	1,703	699	5.6%
25	70%	80%	100%	100%	2 yrs	25 yrs	20	2,197	816	5.4%
26	70%	80%	100%	100%	2 yrs	5 yrs	15	1,208	800	5.8%
27	70%	80%	100%	100%	2 yrs	5 yrs	20	1,137	655	6.3%
28	70%	80%	100%	100%	2 yrs	5 yrs	40	852	189	52.1%
29	70%	80%	100%[a]	100%[a]	2 yrs	5 yrs	20	1,107	345	21.6%

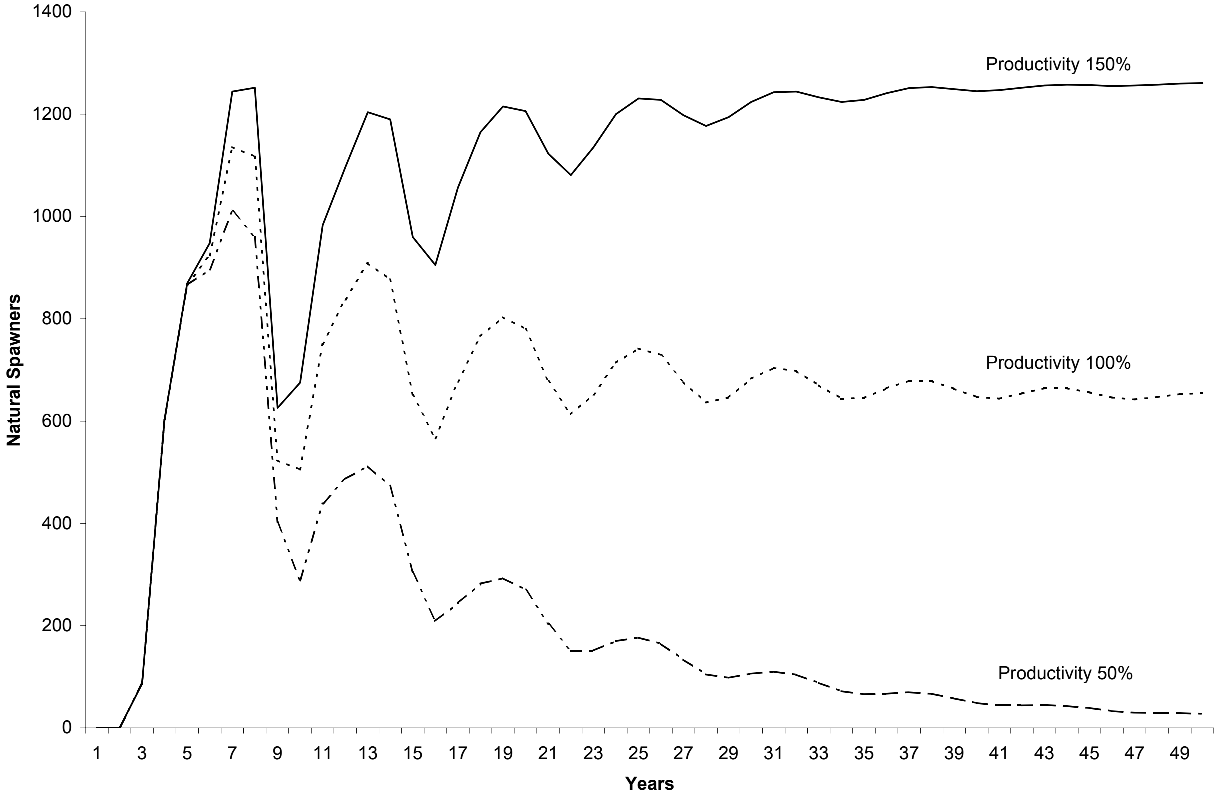
[a] Habitat capacity and productivity were assumed to equal the newly released EDT model results.

Habitat Capacity and Productivity

The three tested values for habitat capacity were paired with the three tested values for productivity, resulting in nine possible model runs (Appendix Table C- 5, runs 14 through 22). As expected, increases in habitat capacity and productivity result in predicted increases in population size after 50 years. Each incremental increase in habitat capacity results in approximately 300 more fish estimated in the population after 50 years (Appendix Table C- 5, runs 15, 18, and 21; Appendix Figure C- 1). In contrast, incremental increases in productivity result in approximately 600 more fish estimated in the population after 50 years (Appendix Table C- 5, runs 17, 18, and 19; Appendix Figure C- 2). This suggests, for spring Chinook in Swift Reservoir, that any improvements to productivity will produce greater results in future population size than improvements to habitat capacity.



Appendix Figure C- 1. Effect of habitat capacity on spawner number for a hypothetical spring Chinook population in Swift Reservoir. Productivity remained constant at 100%. Population was seeded with 100,000 smolts for 5 years and 500 adults for 2 years. The default model run with newly released EDT model values for habitat capacity and productivity is included for comparison.

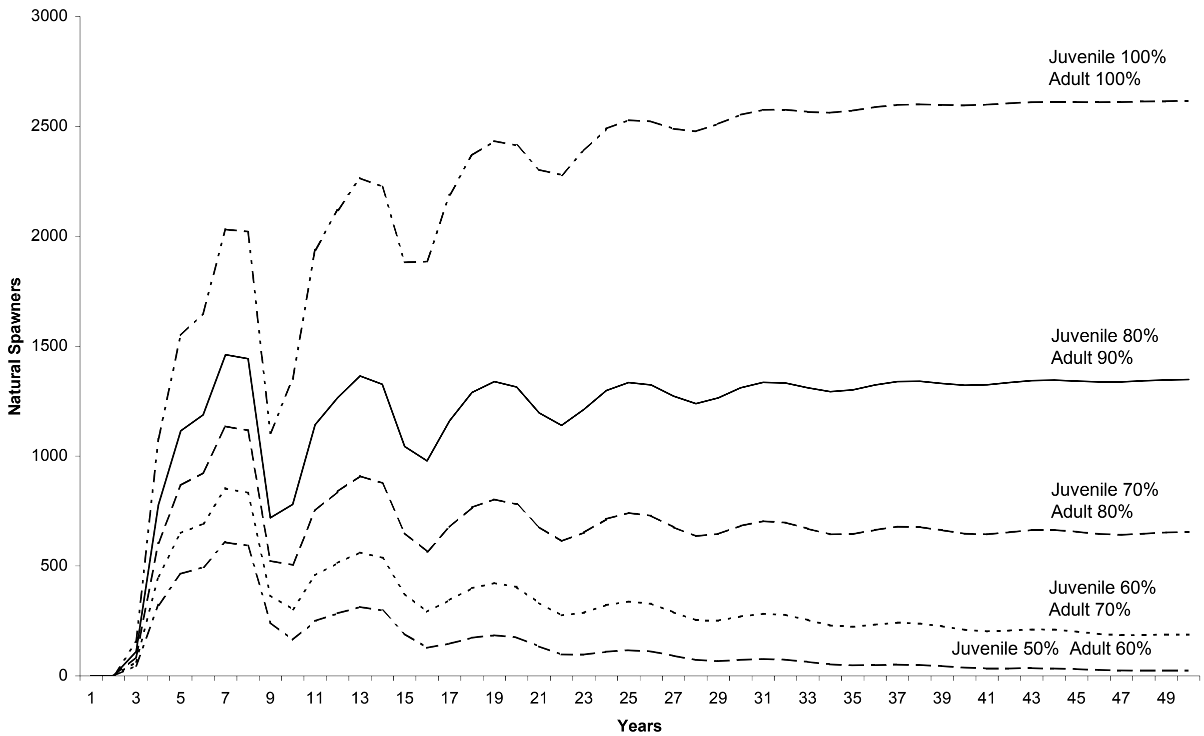


Appendix Figure C- 2. Effect of productivity on spawner number for a hypothetical spring Chinook population in Swift Reservoir. Habitat capacity remained constant at 100%. Population was seeded with 100,000 smolts for 5 years and 500 adults for 2 years.

The default model run that incorporates newly released EDT values for habitat capacity and productivity resulted in a maximum population size of 1,107 fish, a population size after 50 years of 345 fish, and a low run risk of 21.6% (Appendix Table C- 5, run 29). The recently released EDT model habitat capacity value is substantially lower than the habitat capacity value utilized in the sensitivity analysis and the productivity value is higher (Appendix Table C-4). The new predicted population curve is similar to the sensitivity analysis model run using a habitat capacity scaling factor of 50% (Appendix Figure C- 1). If the revised EDT model values become the accepted standard, the relative effects of habitat capacity and productivity on predicted spring Chinook populations in Swift Reservoir need to be reevaluated. It is possible that such a large decrease in habitat capacity will make this parameter more critical to population size than productivity.

Juvenile and Adult Dam Passage Survival

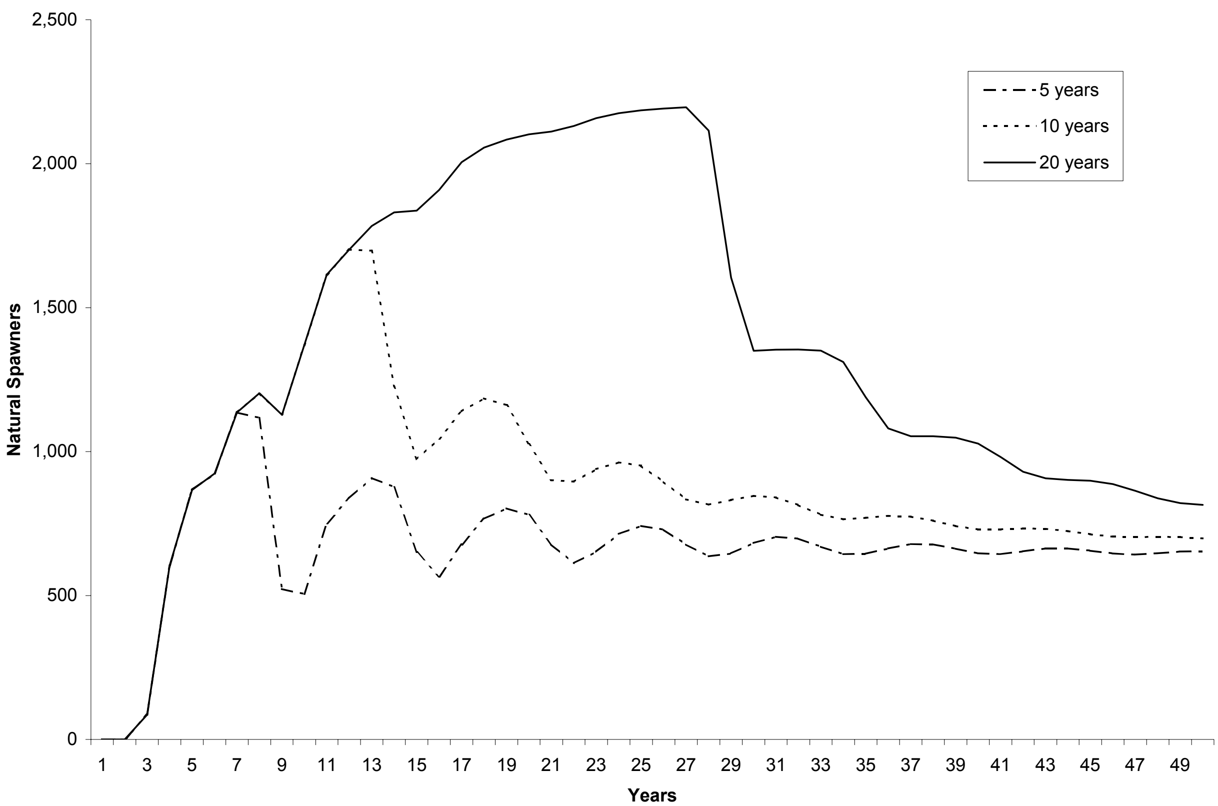
The various model runs for combinations of juvenile and adult dam passage survival are included in Appendix Table C- 5 (runs 1 through 13). As anticipated, higher dam passage survival rates translate to higher predicted population numbers (Appendix Figure C- 3). Incidentally, each 10% increase in dam passage survival rate results in a greater relative change in the predicted population size after 50 years (Appendix Figure C- 3). In order to obtain a predicted population size above the low run threshold, minimum juvenile dam passage survival needs to be maintained between 60-70% and minimum adult dam passage survival needs to be maintained between 70-80% (Appendix Table C- 5).



Appendix Figure C- 3. Effects of juvenile and adult dam passage survival rates on spawner number for a hypothetical spring Chinook population in Swift Reservoir. Population was seeded with 100,000 smolts for 5 years and 500 adults for 2 years.

Hatchery Supplementation Strategies

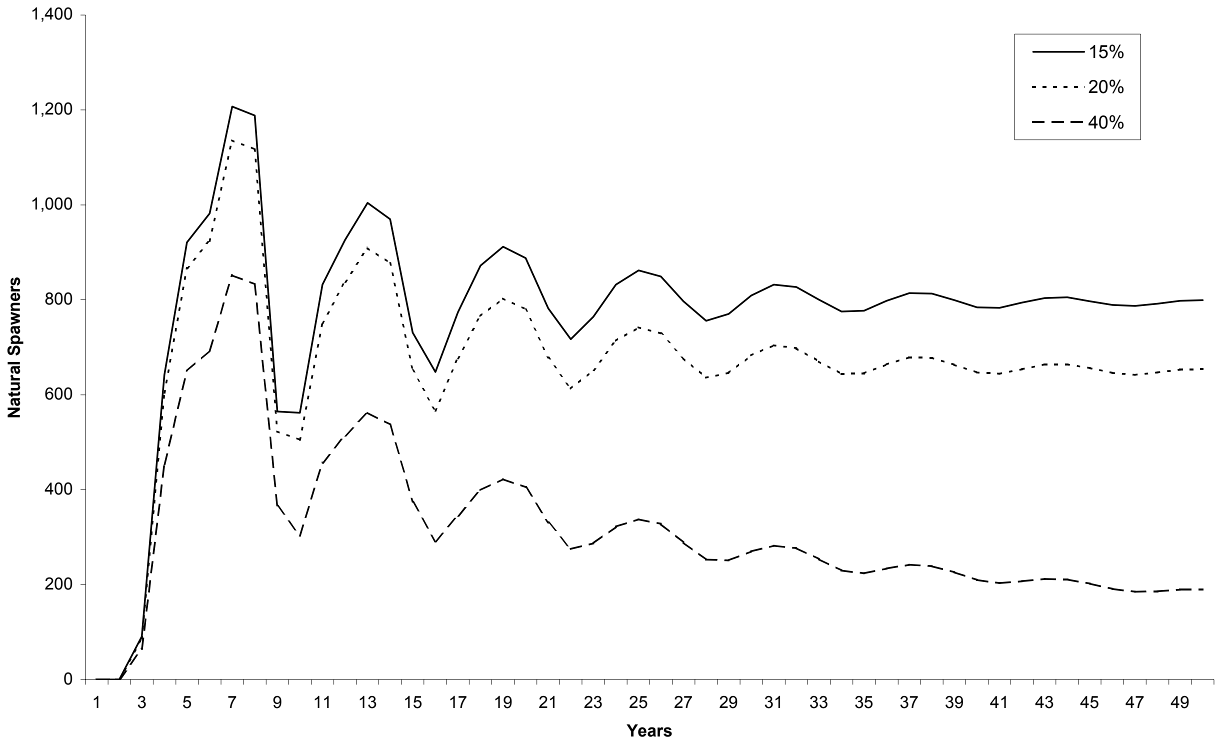
Based on the calculated habitat capacity and productivity values, appropriate spring Chinook supplementation numbers were estimated at 100,000 smolt and 500 adults annually. Duration of three smolt supplementation programs were investigated: 5, 10, and 25 years (Appendix Table C- 5, runs 23, 24, and 25). Smolt supplementation for longer periods of time results in initial spikes in the maximum population size, but over time results in the same population size as supplementation for shorter time periods (Appendix Figure C- 4). Although Appendix Figure C- 4 shows small differences in the population size at 50 years, the upper curves are declining and all three supplementation strategies would result in the same predicted population size given enough time.



Appendix Figure C- 4. Effect of different smolt supplementation strategies on spawner number for a hypothetical spring Chinook population in Swift Reservoir. Annual smolt supplementation was 100,000 fish. Adult supplementation remained constant at 500 fish for 2 years.

Harvest

Three incidental harvest mortality rates for spring Chinook were investigated: 15, 20, and 40% (Appendix Table C- 5, runs 26, 27, and 28). Doubling the harvest mortality from 20 to 40% results in a substantial decrease in the predicted population size and greatly increases the low run risk (Appendix Table C- 5, runs 27 and 28).



Appendix Figure C- 5. Effect of harvest rate on spawner number for a hypothetical spring Chinook population in Swift Reservoir. Population was seeded with 100,000 smolts for 5 years and 500 adults for 2 years.

Coho Salmon

The default model run for coho salmon in Swift Reservoir resulted in a maximum population size of 2,491 fish, a population size after 50 years of 1,407 fish, and a low run risk of 3.7% (Appendix Table C- 6, runs 3, 7, 11, 18, 24, and 28).

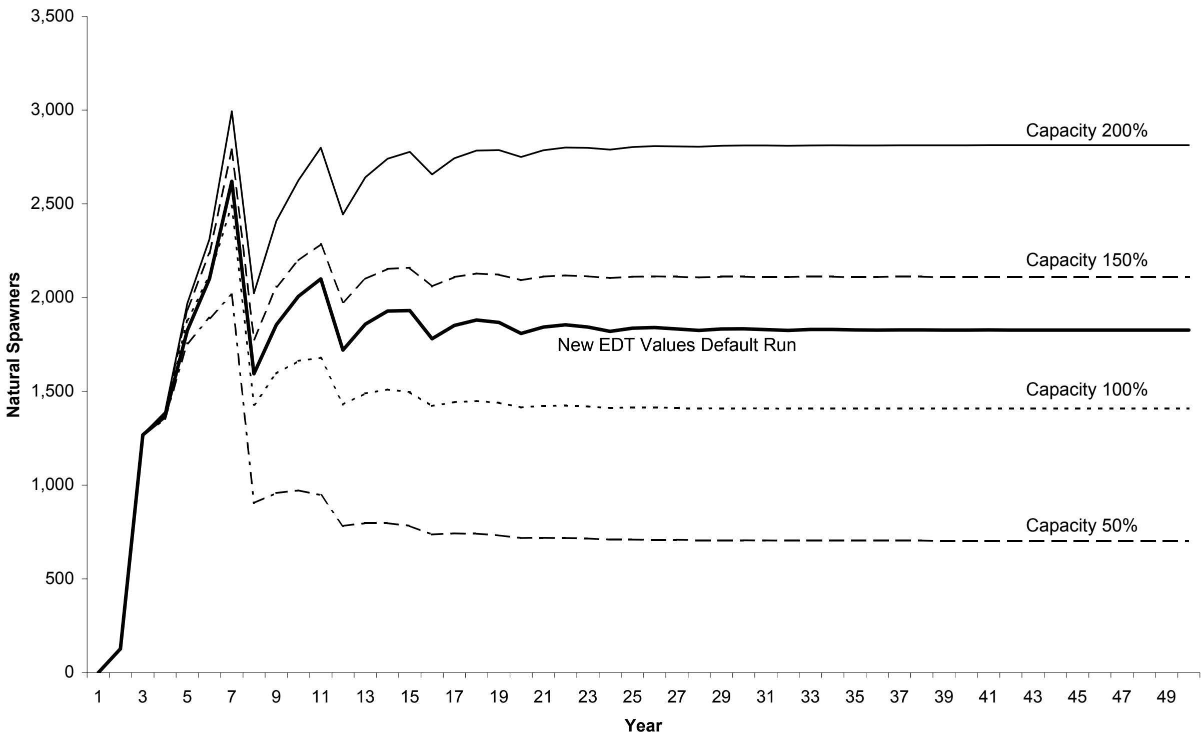
Appendix Table C- 6. Swift Reservoir coho sensitivity to changes in model parameters. Runs 3, 7, 11, 18, 24, and 28

	Model Input							Results		
	Passage				Supplementation			Population		Low Run Risk
Model Run	Juvenile	Adult	Capacity	Productivity	Adults	Smolt	Harvest	Max	50 yr	(< 300)
1	50%	80%	100%	100%	2 yrs	5 yrs	15	1,629	691	5.8%
2	60%	80%	100%	100%	2 yrs	5 yrs	15	2,052	1,049	4.0%
3	70%	80%	100%	100%	2 yrs	5 yrs	15	2,491	1,407	3.7%
4	80%	80%	100%	100%	2 yrs	5 yrs	15	2,941	1,766	3.7%
5	70%	60%	100%	100%	2 yrs	5 yrs	15	1,733	780	5.0%
6	70%	70%	100%	100%	2 yrs	5 yrs	15	2,106	1,094	3.9%
7	70%	80%	100%	100%	2 yrs	5 yrs	15	2,491	1,407	3.7%
8	70%	90%	100%	100%	2 yrs	5 yrs	15	2,884	1,721	3.6%
9	50%	60%	100%	100%	2 yrs	5 yrs	15	1,128	261	42.1%
10	60%	70%	100%	100%	2 yrs	5 yrs	15	1,733	780	5.1%
11	70%	80%	100%	100%	2 yrs	5 yrs	15	2,491	1,407	3.7%
12	80%	90%	100%	100%	2 yrs	5 yrs	15	3,401	2,125	3.7%
13	100%	100%	100%	100%	2 yrs	5 yrs	15	5,063	3,380	3.3%
14	70%	80%	50%	50%	2 yrs	5 yrs	15	1,810	190	51.0%
15	70%	80%	50%	100%	2 yrs	5 yrs	15	2,015	704	5.2%
16	70%	80%	50%	150%	2 yrs	5 yrs	15	2,114	888	4.2%
17	70%	80%	100%	50%	2 yrs	5 yrs	15	2,058	372	20.1%
18	70%	80%	100%	100%	2 yrs	5 yrs	15	2,491	1,407	3.7%
19	70%	80%	100%	150%	2 yrs	5 yrs	15	2,741	1,775	3.7%
20	70%	80%	150%	50%	2 yrs	5 yrs	15	2,187	546	9.8%
21	70%	80%	150%	100%	2 yrs	5 yrs	15	2,790	2,111	3.7%
22	70%	80%	150%	150%	2 yrs	5 yrs	15	3,178	2,663	3.6%
23	70%	80%	200%	100%	2 yrs	5 yrs	15	2,995	2,814	3.6%
24	70%	80%	100%	100%	2 yrs	5 yrs	15	2,491	1,407	3.7%
25	70%	80%	100%	100%	2 yrs	10 yrs	15	3,032	1,407	3.8%
26	70%	80%	100%	100%	2 yrs	25 yrs	15	3,117	1,412	3.7%
27	70%	80%	100%	100%	2 yrs	5 yrs	10	2,675	1,555	3.7%
28	70%	80%	100%	100%	2 yrs	5 yrs	15	2,491	1,407	3.7%
29	70%	80%	100%	100%	2 yrs	5 yrs	40	1,604	670	6.3%
30	70%	80%	100%[a]	100%[a]	2 yrs	5 yrs	15	2,621	1,827	3.7%

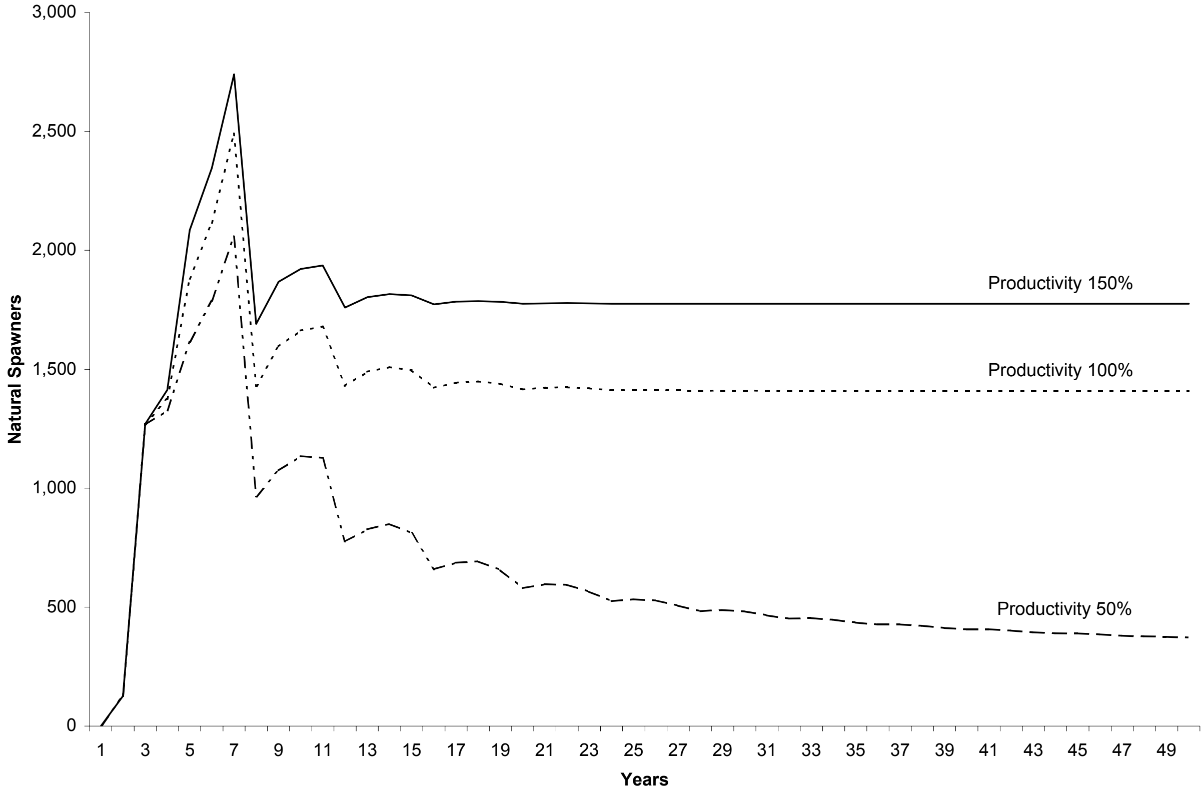
[a] Habitat capacity and productivity were assumed to equal the newly released EDT model results.

Habitat Capacity and Productivity

The nine model runs representing the possible combinations of habitat capacity and productivity are shown in Appendix Table C- 6 (runs 14 through 22). An additional model run (run 23) was performed using a habitat capacity scaling factor of 200% because the coho habitat capacity was thought to be underestimated in the preliminary EDT model. Each incremental increase in habitat capacity resulted in approximately 700 more coho in the predicted population (Appendix Table C- 6, runs 15, 18, 21, and 23; Appendix Figure C- 6). In comparison, the importance of productivity is relative to the productivity level; at low productivity, increases in productivity result in substantial increases to the predicted population size whereas, at higher levels of productivity, productivity increases have less effect (Appendix Table C- 6, runs 17, 18, and 19; Appendix Figure C- 7).



Appendix Figure C- 6. Effect of habitat capacity on spawner number for a hypothetical coho population in Swift Reservoir. Productivity remained constant at 100%. Population was seeded with 100,000 smolts for 5 years and 500 adults for 2 years. The default model run with newly released EDT model values for habitat capacity and productivity is included for comparison.

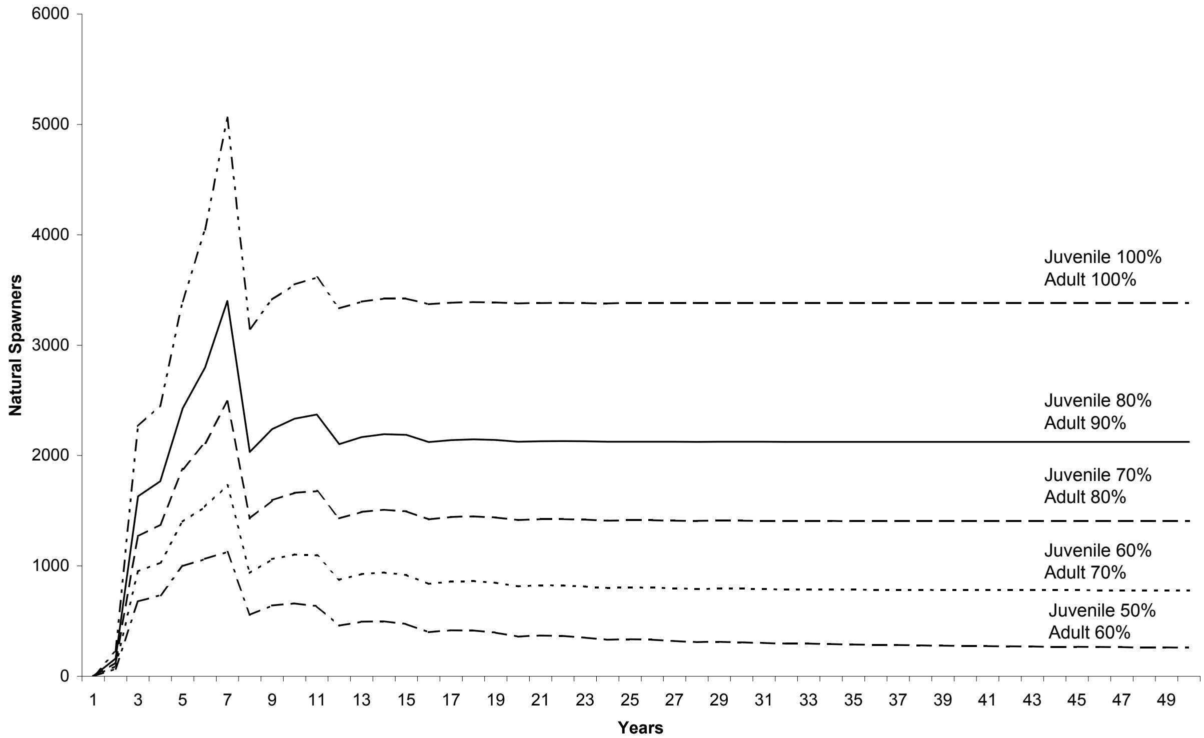


Appendix Figure C- 7. Effect of productivity on spawner number for a hypothetical coho salmon population in Swift Reservoir. Habitat capacity remained constant at 100%. Population was seeded with 100,000 smolts for 5 years and 500 adults for 2 years.

The default model run that incorporates newly released EDT values for habitat capacity and productivity resulted in a maximum population size of 2,261 fish, a population size after 50 years of 1,827 fish, and a low run risk of 3.7% (Appendix Table C- 6, run 30). The recently released EDT model habitat capacity value is substantially higher than the habitat capacity value utilized in the sensitivity analysis and the productivity value is considerably lower (Appendix Table C-4). Although the habitat capacity increased approximately 163%, the lower productivity value kept the predicted population curve below the sensitivity analysis model run using a habitat scaling factor of 150% (Appendix Figure C- 6). If the revised EDT model values become the accepted standard, the relative effects of habitat capacity and productivity on predicted coho salmon populations in Swift Reservoir need to be reevaluated.

Juvenile and Adult Dam Passage Survival

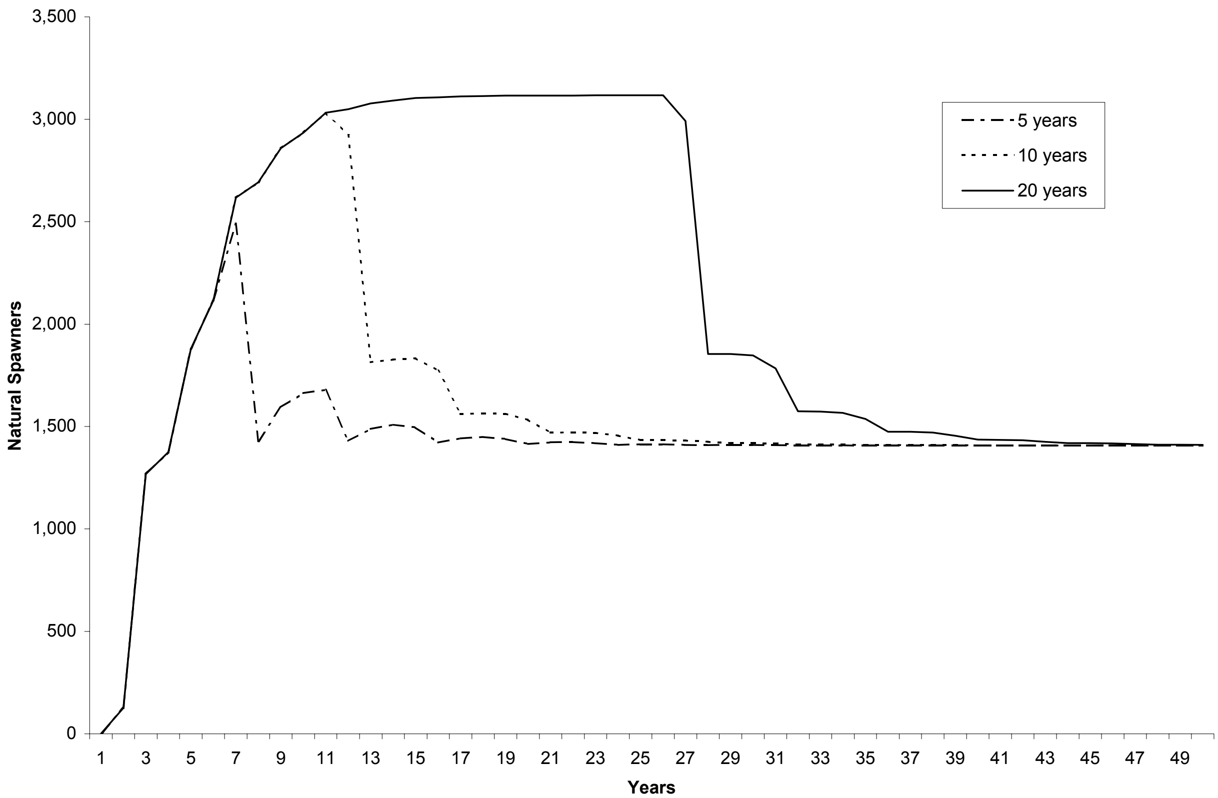
The various model runs for combinations of juvenile and adult dam passage survival are included in Appendix Table C- 6 (runs 1 through 13). As anticipated, higher dam passage survival rates translate to higher predicted population numbers (Appendix Figure C- 8). Incidentally, each 10% increase in dam passage survival rate results in a greater relative change in the predicted population size after 50 years (Appendix Figure C- 8). Juvenile dam passage survival at 50% and adult dam passage survival at 60% results in a predicted population size below the low run threshold (Appendix Table C- 6, run 9).



Appendix Figure C- 8. Effects of juvenile and adult dam passage survival rates on spawner number for a hypothetical coho salmon population in Swift Reservoir. Population was seeded with 100,000 smolts for 5 years and 500 adults for 2 years.

Hatchery Supplementation Strategies

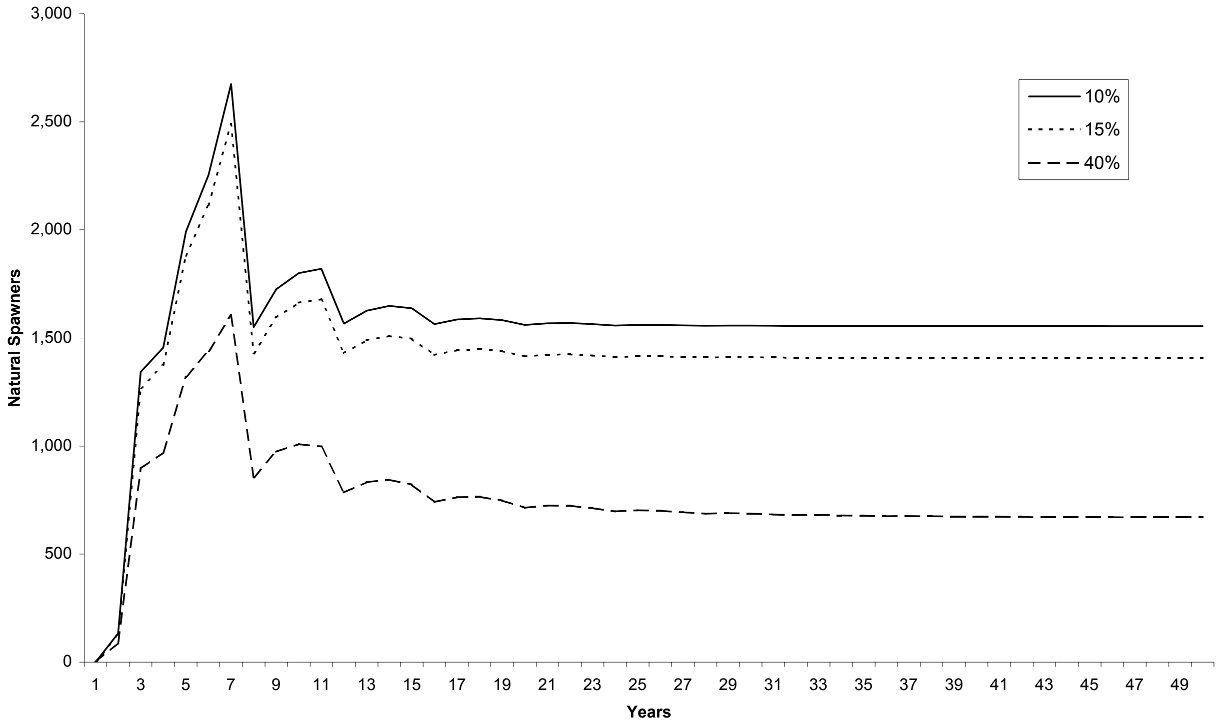
Based on the calculated habitat capacity and productivity values, appropriate coho salmon supplementation numbers were estimated at 100,000 smolt and 500 adults annually. Duration of three smolt supplementation programs were investigated: 5, 10, and 25 years (Appendix Table C- 6, runs 24, 25, and 26). Smolt supplementation for longer periods of time results in initial spikes in the maximum population size, but over time results in the same population size as supplementation for shorter time periods (Appendix Figure C- 9).



Appendix Figure C- 9. Effect of different smolt supplementation strategies on spawner number for a hypothetical coho population in Swift Reservoir. Annual smolt supplementation was 100,000 fish. Adult supplementation remained constant at 500 fish for 2 years.

Harvest

Three incidental harvest mortality rates for coho salmon were investigated: 10, 15, and 40% (Appendix Table C- 6, runs 27, 28, and 29). The model predicts that a coho population in Swift Reservoir could sustain high incidental harvest mortality and still maintain levels above the low run threshold (Appendix Table C- 6, run 29 and Appendix Figure C- 10).



Appendix Figure C- 10. Effect of harvest rate on spawner number for a hypothetical coho salmon population in Swift Reservoir. Population was seeded with 100,000 smolts for 5 years and 500 adults for 2 years.

Steelhead

The default model run for steelhead in Swift Reservoir resulted in a maximum population size of 1,197 fish, a population size after 50 years of 882 fish, and a low run risk of 2.7% (Appendix Table C- 7, runs 3, 7, 11, 18, and 24).

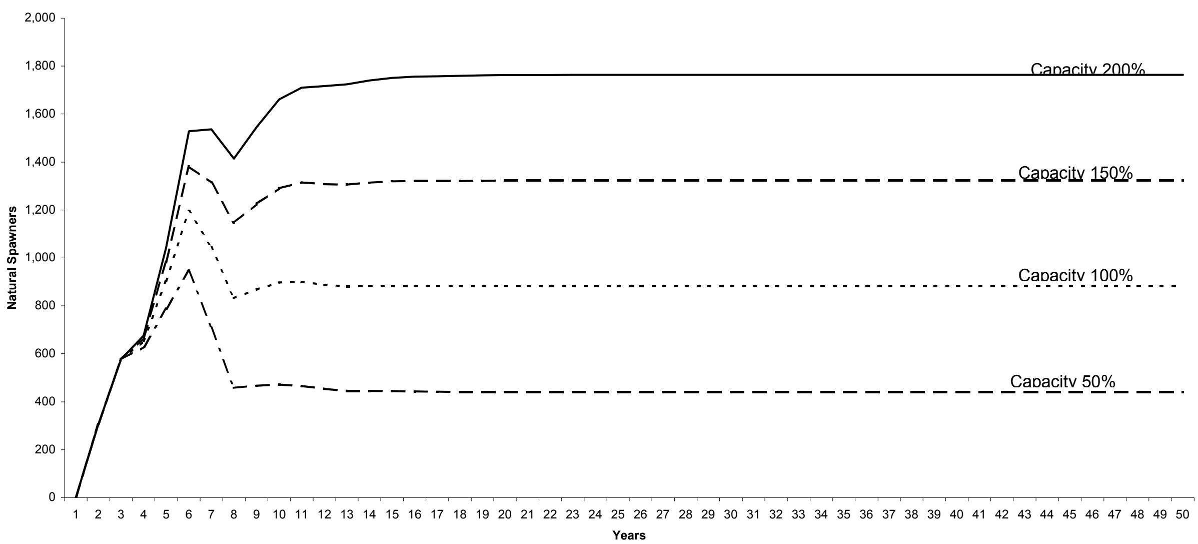
Appendix Table C- 7. Swift Reservoir steelhead sensitivity to changes in model parameters. Runs 3, 7, 11, 18, and 24 represent default parameters.

	Model Input							Results		
	Passage				Supplementation			Population		
Model Run	Juvenile	Adult	Capacity	Productivity	Adults	Smolt	Harvest	Max	50 yr	Low Run Risk (< 300)
1	50%	80%	100%	100%	2 yrs	5 yrs	3	834	588	4.8%
2	60%	80%	100%	100%	2 yrs	5 yrs	3	1,015	735	3.3%
3	70%	80%	100%	100%	2 yrs	5 yrs	3	1,197	882	2.7%
4	80%	80%	100%	100%	2 yrs	5 yrs	3	1,380	1,029	2.4%
5	70%	60%	100%	100%	2 yrs	5 yrs	3	879	625	4.1%
6	70%	70%	100%	100%	2 yrs	5 yrs	3	1,038	754	3.2%
7	70%	80%	100%	100%	2 yrs	5 yrs	3	1,197	882	2.7%
8	70%	90%	100%	100%	2 yrs	5 yrs	3	1,357	1,011	2.5%
9	50%	60%	100%	100%	2 yrs	5 yrs	3	612	405	14.7%
10	60%	70%	100%	100%	2 yrs	5 yrs	3	879	625	4.1%
11	70%	80%	100%	100%	2 yrs	5 yrs	3	1,197	882	2.7%
12	80%	90%	100%	100%	2 yrs	5 yrs	3	1,565	1,176	2.2%
13	100%	100%	100%	100%	2 yrs	5 yrs	3	2,217	1,691	1.9%
14	70%	80%	50%	50%	2 yrs	5 yrs	3	887	368	18.2%
15	70%	80%	50%	100%	2 yrs	5 yrs	3	947	441	7.6%
16	70%	80%	50%	150%	2 yrs	5 yrs	3	974	466	6.4%
17	70%	80%	100%	50%	2 yrs	5 yrs	3	1,054	736	2.9%
18	70%	80%	100%	100%	2 yrs	5 yrs	3	1,197	882	2.7%
19	70%	80%	100%	150%	2 yrs	5 yrs	3	1,271	931	2.7%
20	70%	80%	150%	50%	2 yrs	5 yrs	3	1,162	1,104	2.7%
21	70%	80%	150%	100%	2 yrs	5 yrs	3	1,383	1,323	2.6%
22	70%	80%	150%	150%	2 yrs	5 yrs	3	1,506	1,397	2.6%
23	70%	80%	200%	100%	2 yrs	5 yrs	3	1,765	1,765	2.8%
24	70%	80%	100%	100%	2 yrs	5 yrs	3	1,197	882	2.7%
25	70%	80%	100%	100%	2 yrs	10 yrs	3	1,499	882	2.7%
26	70%	80%	100%	100%	2 yrs	25 yrs	3	1,516	882	2.7%
27	70%	80%	100%[a]	100%[a]	2 yrs	5 yrs	3	1,117	903	2.7%

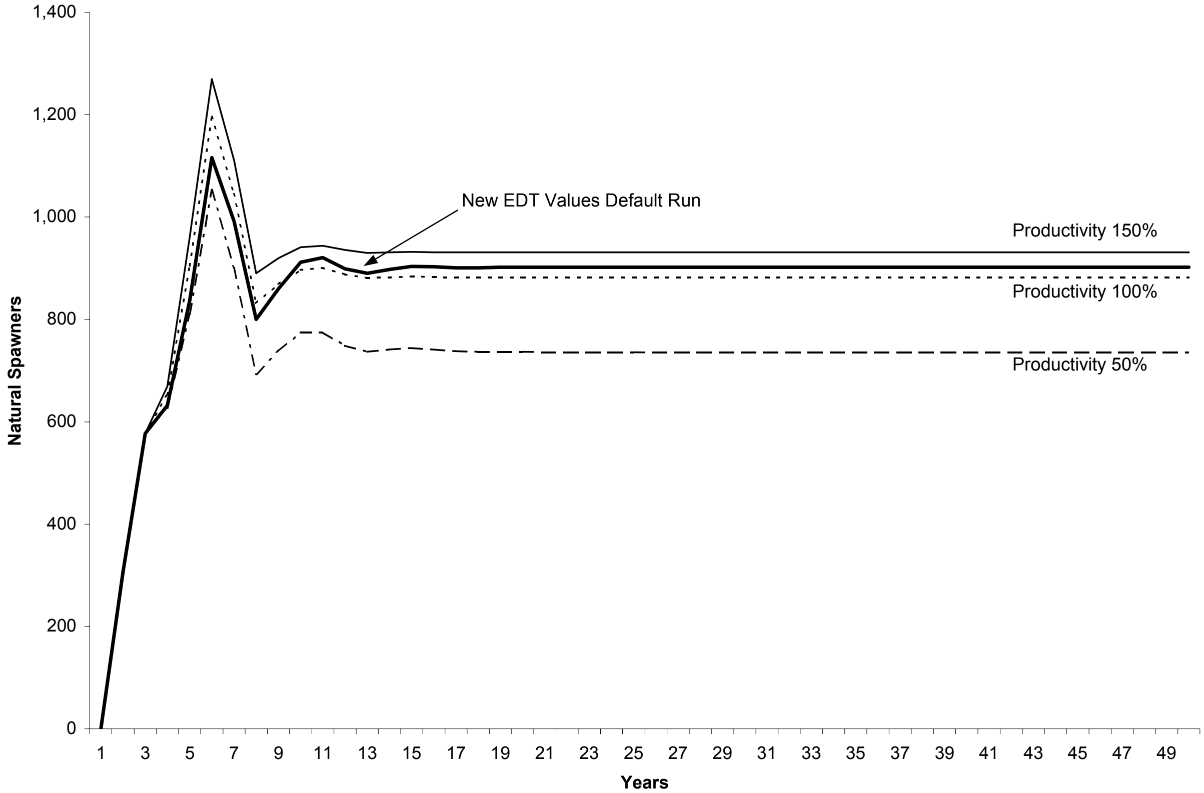
[a] Habitat capacity and productivity were assumed to equal the newly released EDT model results.

Habitat Capacity and Productivity

The nine model runs representing the possible combinations of habitat capacity and productivity are shown in Appendix Table C- 7 (runs 14 through 22). An additional model run (run 23) was performed using a habitat capacity scaling factor of 200% because the steelhead habitat capacity was thought to be underestimated in the preliminary EDT model. Each incremental increase in habitat capacity resulted in approximately 400 more steelhead in the predicted population (Appendix Table C- 7, runs 15, 18, 21, and 23; Appendix Figure C- 11). In comparison, the importance of productivity is relative to the productivity level; at low productivity, increases in productivity result in greater increases to the predicted population size than do increases at higher levels of productivity (Appendix Table C- 7, runs 17, 18, and 19; Appendix Figure C- 12). However, increases in productivity within the levels investigated during the sensitivity analysis do not result in substantial increases in the predicted population size (Appendix Figure C- 12).



Appendix Figure C- 11. Effect of habitat capacity on spawner number for a hypothetical steelhead population in Swift Reservoir. Productivity remained constant at 100%. Population was seeded with 20,000 smolts for 5 years and 200 adults for 2 years.

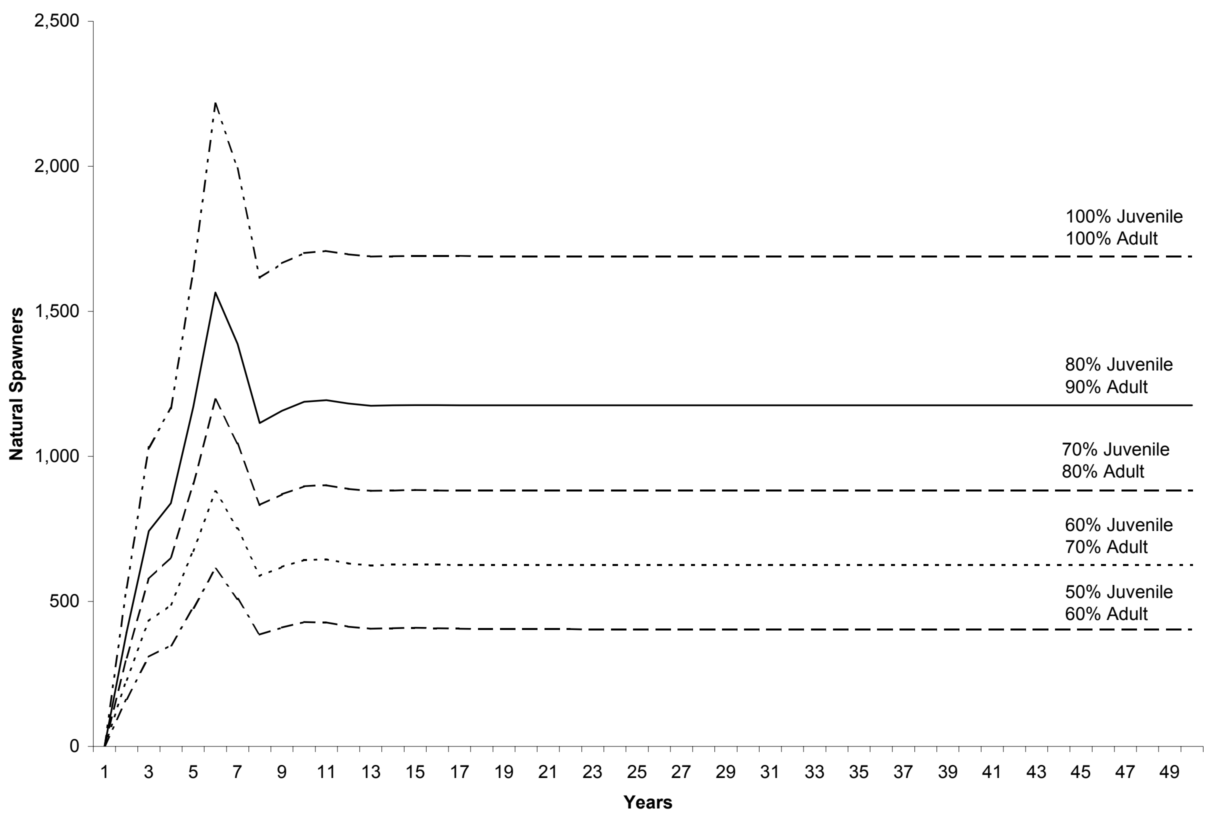


Appendix Figure C- 12. Effect of productivity on spawner number for a hypothetical steelhead population in Swift Reservoir. Habitat capacity remained constant at 100%. Population was seeded with 20,000 smolts for 5 years and 200 adults for 2 years. The default model run with newly released EDT model values for habitat capacity and productivity is included for comparison.

The default model run that incorporates newly released EDT values for habitat capacity and productivity resulted in a maximum population size of 1,117 fish, a population size after 50 years of 903 fish, and a low run risk of 2.7% (Appendix Table C-7, run 27). The recently released EDT model habitat capacity value is higher than the habitat capacity value utilized in the sensitivity analysis and the productivity value is substantially lower (Appendix Table C-4). Although the productivity decreased approximately 47%, the increased habitat capacity value kept the predicted population curve above the sensitivity analysis model run using a productivity scaling factor of 100% (Appendix Figure C- 12). If the revised EDT model values become the accepted standard, the relative effects of habitat capacity and productivity on predicted steelhead populations in Swift Reservoir need to be reevaluated.

Juvenile and Adult Dam Passage Survival

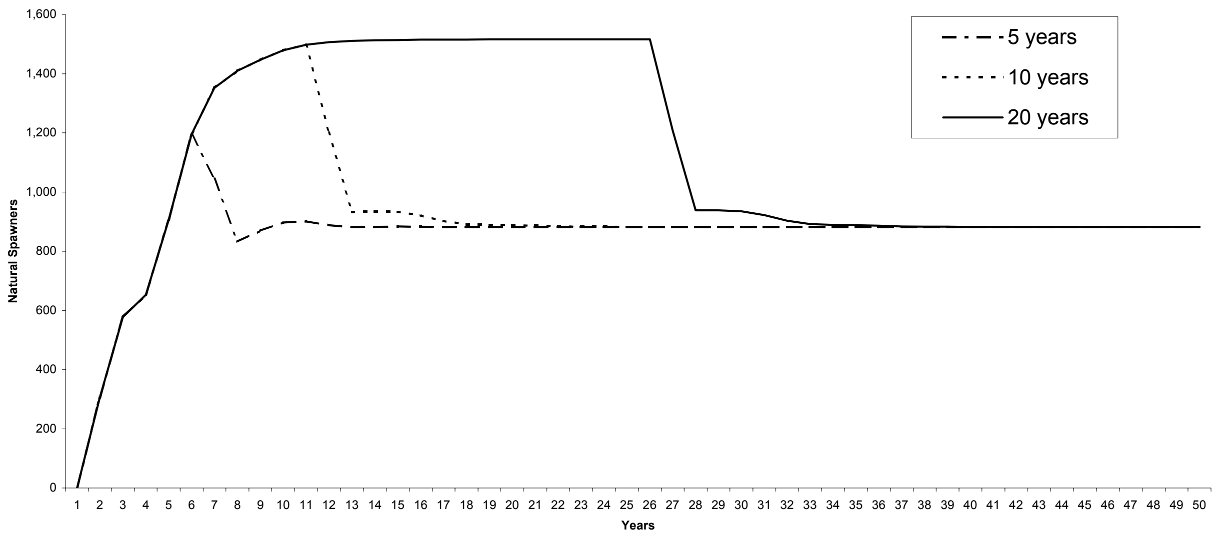
The various model runs for combinations of juvenile and adult dam passage survival are included in Appendix Table C- 7 (runs 1 through 13). As anticipated, higher dam passage survival rates translate to higher predicted population numbers (Appendix Figure C- 13). Incidentally, each 10% increase in dam passage survival rate results in a greater relative change in the predicted population size after 50 years (Appendix Figure C- 13). The model predicts that a steelhead population in Swift Reservoir can withstand low juvenile and adult dam passage survival rates and still maintain a population size above the low run threshold (Appendix Table C- 7, run 9). Regardless, minimizing dam passage survival rates is not recommended.



Appendix Figure C- 13. Effects of juvenile and adult dam passage survival rates on spawner number for a hypothetical steelhead population in Swift Reservoir. Population was seeded with 20,000 smolts for 5 years and 200 adults for 2 years.

Hatchery Supplementation Strategies

Based on the calculated habitat capacity and productivity values, appropriate steelhead supplementation numbers were estimated at 20,000 smolt and 200 adults annually. Duration of three smolt supplementation programs were investigated: 5, 10, and 25 years (Appendix Table C- 7, runs 24, 25, and 26). Smolt supplementation for longer periods of time results in initial spikes in the maximum population size, but over time results in the same population size as supplementation for shorter time periods (Appendix Figure C- 14).



Appendix Figure C- 14. Effect of different smolt supplementation strategies on spawner number for a hypothetical steelhead population in Swift Reservoir. Annual smolt supplementation was 20,000 fish. Adult supplementation remained constant at 200 fish for 2 years.

Yale Lake

Spring Chinook Salmon

The default model run for spring Chinook in Yale Lake resulted in a maximum population size of 184 fish, a population size after 50 years of 18 fish, and a low run risk of 89.3% (Appendix Table C- 8, runs 3, 7, 11, 18, 23, and 27).

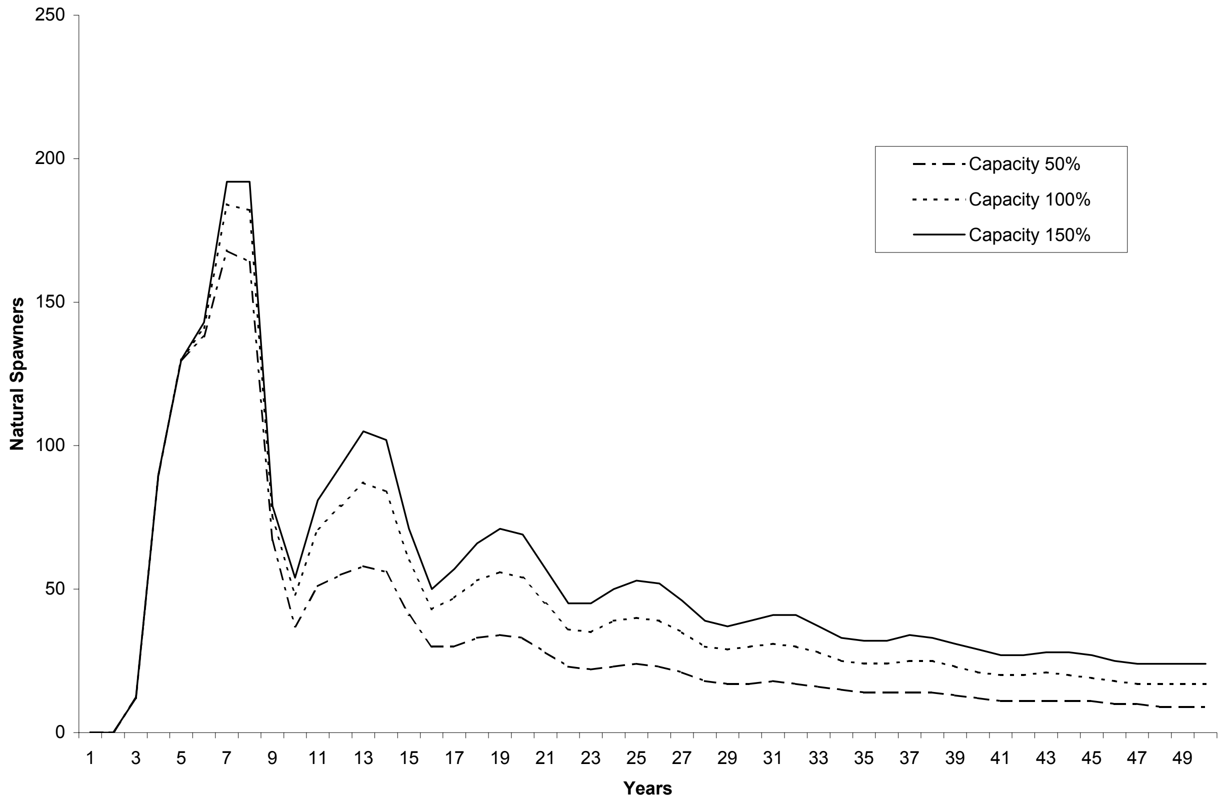
Appendix Table C- 8. Yale Lake spring Chinook sensitivity to changes in model parameters. Runs 3, 7, 11, 18, 23, and 27 represent default parameters.

	Model Input							Results		
	Passage				Supplementation			Population		
Model Run	Juvenile	Adult	Capacity	Productivity	Adults	Smolt	Harvest	Max	50 yr	Low Run Risk (< 300)
1	50%	80%	100%	100%	2 yrs	5 yrs	20	132	0	89.3%
2	60%	80%	100%	100%	2 yrs	5 yrs	20	158	8	89.3%
3	70%	80%	100%	100%	2 yrs	5 yrs	20	184	18	89.3%
4	80%	80%	100%	100%	2 yrs	5 yrs	20	211	33	89.2%
5	70%	60%	100%	100%	2 yrs	5 yrs	20	138	3	89.3%
6	70%	70%	100%	100%	2 yrs	5 yrs	20	161	9	89.3%
7	70%	80%	100%	100%	2 yrs	5 yrs	20	184	18	89.3%
8	70%	90%	100%	100%	2 yrs	5 yrs	20	207	31	89.2%
9	50%	60%	100%	100%	2 yrs	5 yrs	20	99	0	89.3%
10	60%	70%	100%	100%	2 yrs	5 yrs	20	138	3	89.3%
11	70%	80%	100%	100%	2 yrs	5 yrs	20	184	18	89.3%
12	80%	90%	100%	100%	2 yrs	5 yrs	20	237	53	88.9%
13	100%	100%	100%	100%	2 yrs	5 yrs	20	329	141	86.2%
14	70%	80%	50%	50%	2 yrs	5 yrs	20	157	0	89.3%
15	70%	80%	50%	100%	2 yrs	5 yrs	20	169	10	89.3%
16	70%	80%	50%	150%	2 yrs	5 yrs	20	176	30	89.3%
17	70%	80%	100%	50%	2 yrs	5 yrs	20	164	0	89.3%
18	70%	80%	100%	100%	2 yrs	5 yrs	20	184	18	89.3%
19	70%	80%	100%	150%	2 yrs	5 yrs	20	200	59	89.3%
20	70%	80%	150%	50%	2 yrs	5 yrs	20	167	0	89.3%
21	70%	80%	150%	100%	2 yrs	5 yrs	20	193	24	89.3%
22	70%	80%	150%	150%	2 yrs	5 yrs	20	216	87	89.2%
23	70%	80%	100%	100%	2 yrs	5 yrs	20	184	18	89.3%
24	70%	80%	100%	100%	2 yrs	10 yrs	20	209	22	89.2%
25	70%	80%	100%	100%	2 yrs	25 yrs	20	231	35	87.5%
26	70%	80%	100%	100%	2 yrs	5 yrs	15	196	24	89.3%
27	70%	80%	100%	100%	2 yrs	5 yrs	20	184	18	89.3%
28	70%	80%	100%	100%	2 yrs	5 yrs	40	138	3	89.3%
29	70%	80%	100%[a]	100%[a]	2 yrs	5 yrs	20	217	88	89.1%

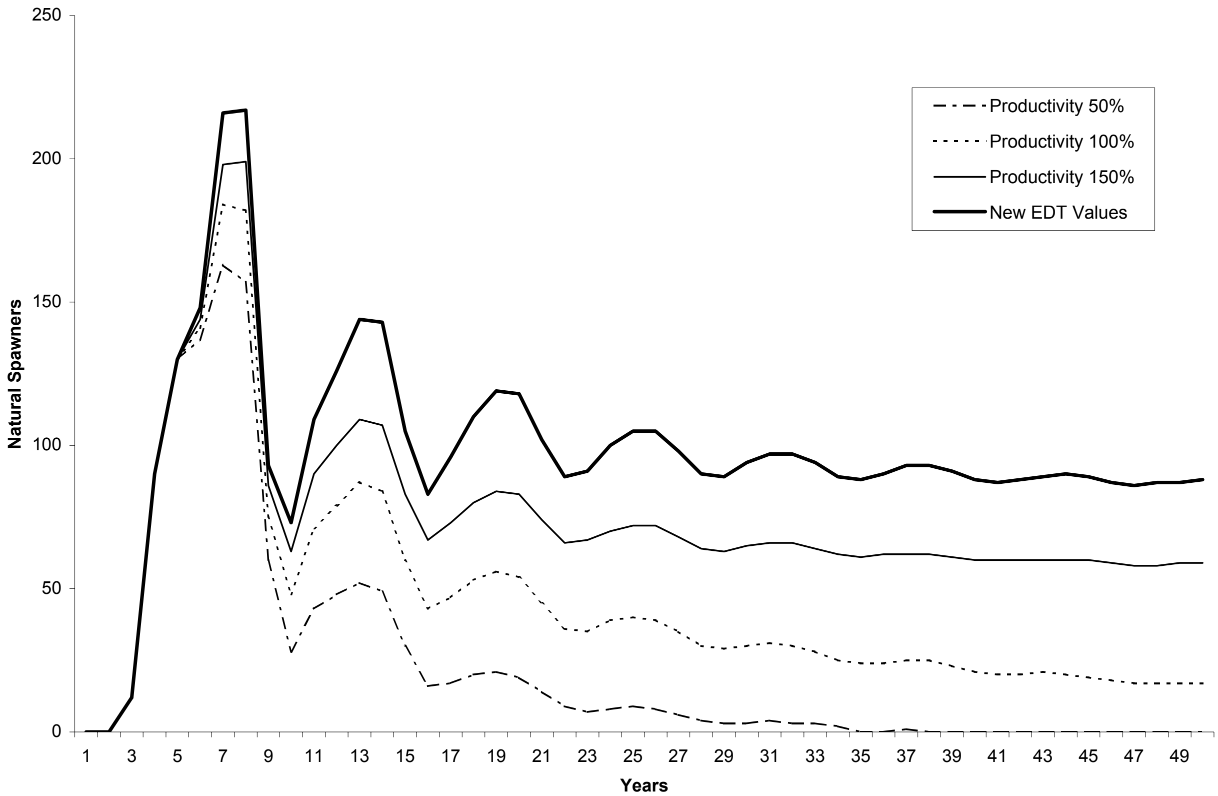
[a] Habitat capacity and productivity were assumed to equal the newly released EDT model results.

Habitat Capacity and Productivity

The three tested values for habitat capacity were paired with the three tested values for productivity, resulting in nine possible model runs (Appendix Table C- 8, runs 14 through 22). As expected, increases in habitat capacity and productivity result in predicted increases in population size after 50 years. However, the range of improvements in habitat capacity or productivity investigated through the sensitivity analysis did not produce appreciable increases in the predicted population size (Appendix Figure C- 15 and Appendix Figure C- 16).



Appendix Figure C- 15. Effect of habitat capacity on spawner number for a hypothetical spring Chinook population in Yale Lake. Productivity remained constant at 100%. Population was seeded with 15,000 smolts for 5 years and 200 adults for 2 years.

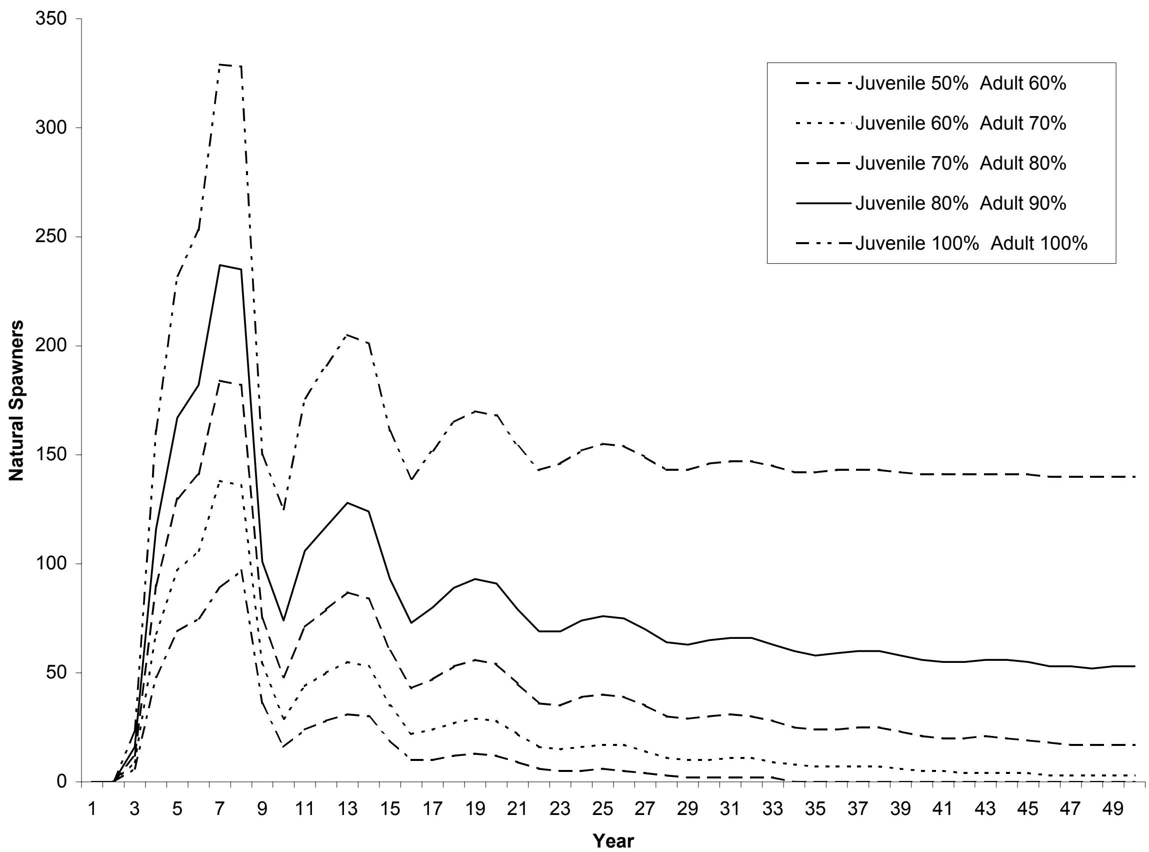


Appendix Figure C- 16. Effect of productivity on spawner number for a hypothetical spring Chinook population in Yale Lake. Habitat capacity remained constant at 100%. Population was seeded with 15,000 smolts for 5 years and 200 adults for 2 years. The default model run with newly released EDT model values for habitat capacity and productivity is included for comparison.

The default model run that incorporates newly released EDT values for habitat capacity and productivity resulted in a maximum population size of 217 fish, a population size after 50 years of 88 fish, and a low run risk of 89.1% (Appendix Table C-8, run 29). Values for habitat capacity and productivity increased as a result of the recently released EDT model results (Appendix Table C-4). These increases in habitat and productivity did not result in substantial increases to the predicted population size.

<u>*Juvenile and Adult Dam Passage Survival*</u>

The various model runs for combinations of juvenile and adult dam passage survival are included in Appendix Table C- 8 (runs 1 through 13). As anticipated, higher dam passage survival rates translate to higher predicted population numbers (Appendix Figure C- 17). Each 10% increase in dam passage survival rate results in a greater relative change in the predicted population size after 50 years (Appendix Figure C- 17). However, if juvenile and adult dam passage survival is assumed to be 100%, the predicted population size is 141 and the low risk is 86.2% (Appendix Table C- 8). Therefore, maximizing juvenile and adult dam passage survival rates for spring Chinook in Yale Lake produces marginal increases in the predicted population size.



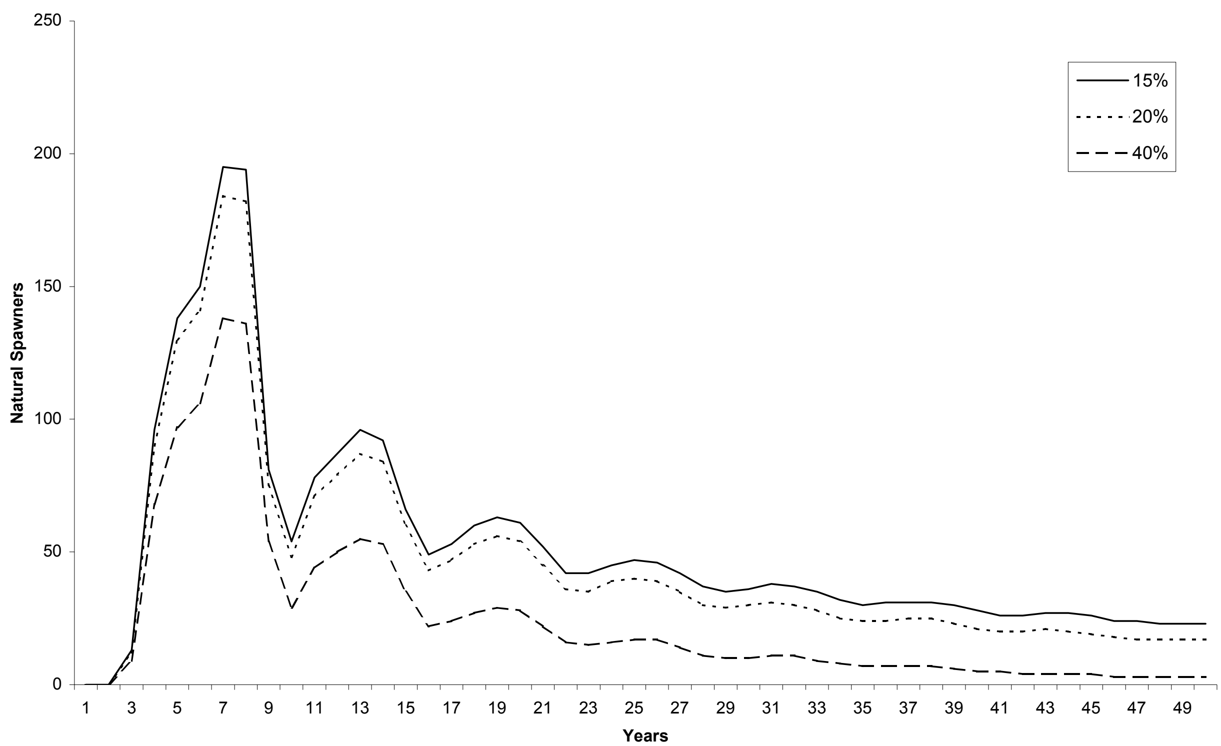
Appendix Figure C- 17. Effects of juvenile and adult dam passage survival rates on spawner number for a hypothetical spring Chinook population in Yale Lake. Population was seeded with 15,000 smolts for 5 years and 200 adults for 2 years.

Hatchery Supplementation Strategies

Based on the calculated habitat capacity and productivity values, appropriate spring Chinook supplementation numbers were estimated at 15,000 smolt and 200 adults annually. Duration of three smolt supplementation programs were investigated: 5, 10, and 25 years (Appendix Table C- 8, runs 23, 24, and 25). Smolt supplementation for longer periods of time results in initial spikes in the maximum population size, but over time results in the same population size as supplementation for shorter time periods.

Harvest

Three incidental harvest mortality rates for spring Chinook were investigated: 15, 20, and 40% (Appendix Table C- 8, runs 26, 27, and 28). Decreasing the spring Chinook harvest mortality does not result in a substantial increase in the predicted population size (Appendix Table C- 8, run 26 and Appendix Figure C- 18).



Appendix Figure C- 18. Effect of harvest rate on spawner number for a hypothetical spring Chinook population in Yale Lake. Population was seeded with 15,000 smolts for 5 years and 200 adults for 2 years.

Coho Salmon

The default model run for coho salmon in Yale Lake resulted in a maximum population size of 1,138 fish, a population size after 50 years of 91 fish, and a low run risk of 65.8% (Appendix Table C- 9, runs 3, 7, 11, 18, 24, and 28).

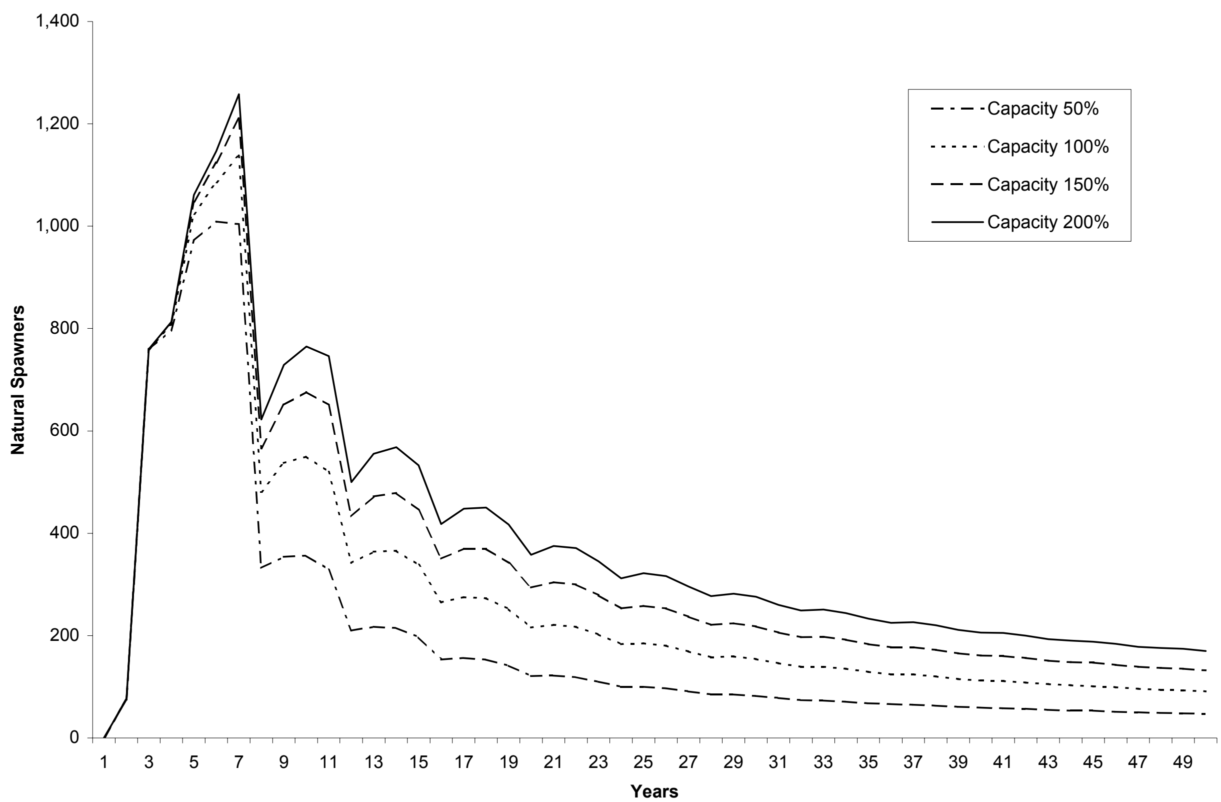
Appendix Table C- 9. Yale Lake coho sensitivity to changes in model parameters. Runs 3, 7, 11, 18, 24, and 28 represent default parameters.

	Model Input							Results		
	Passage				Supplementation			Population		
Model Run	Juvenile	Adult	Capacity	Productivity	Adults	Smolt	Harvest	Max	50 yr	Low Run Risk (< 300)
1	50%	80%	100%	100%	2 yrs	5 yrs	15	758	5	77.0%
2	60%	80%	100%	100%	2 yrs	5 yrs	15	941	28	73.1%
3	70%	80%	100%	100%	2 yrs	5 yrs	15	1,138	91	65.8%
4	80%	80%	100%	100%	2 yrs	5 yrs	15	1,342	200	51.7%
5	70%	60%	100%	100%	2 yrs	5 yrs	15	798	8	76.2%
6	70%	70%	100%	100%	2 yrs	5 yrs	15	965	33	72.3%
7	70%	80%	100%	100%	2 yrs	5 yrs	15	1,138	91	65.8%
8	70%	90%	100%	100%	2 yrs	5 yrs	15	1,317	185	54.1%
9	50%	60%	100%	100%	2 yrs	5 yrs	15	558	0	81.0%
10	60%	70%	100%	100%	2 yrs	5 yrs	15	798	8	76.1%
11	70%	80%	100%	100%	2 yrs	5 yrs	15	1,138	91	65.8%
12	80%	90%	100%	100%	2 yrs	5 yrs	15	1,552	338	27.5%
13	100%	100%	100%	100%	2 yrs	5 yrs	15	2,317	878	4.4%
14	70%	80%	50%	50%	2 yrs	5 yrs	15	922	0	79.2%
15	70%	80%	50%	100%	2 yrs	5 yrs	15	1,010	47	75.4%
16	70%	80%	50%	150%	2 yrs	5 yrs	15	1,065	189	68.8%
17	70%	80%	100%	50%	2 yrs	5 yrs	15	968	0	76.6%
18	70%	80%	100%	100%	2 yrs	5 yrs	15	1,138	91	65.8%
19	70%	80%	100%	150%	2 yrs	5 yrs	15	1,251	377	23.5%
20	70%	80%	150%	50%	2 yrs	5 yrs	15	995	0	75.7%
21	70%	80%	150%	100%	2 yrs	5 yrs	15	1,212	132	57.1%
22	70%	80%	150%	150%	2 yrs	5 yrs	15	1,370	564	8.7%
23	70%	80%	200%	100%	2 yrs	5 yrs	15	1,258	170	49.2%
24	70%	80%	100%	100%	2 yrs	5 yrs	15	1,138	91	65.8%
25	70%	80%	100%	100%	2 yrs	10 yrs	15	1,340	104	55.5%
26	70%	80%	100%	100%	2 yrs	25 yrs	15	1,372	160	29.0%
27	70%	80%	100%	100%	2 yrs	5 yrs	10	1,222	131	61.8%
28	70%	80%	100%	100%	2 yrs	5 yrs	15	1,138	91	65.8%
29	70%	80%	100%	100%	2 yrs	5 yrs	40	748	4	77.2%
30	70%	80%	100%[a]	100%[a]	2 yrs	5 yrs	15	1,288	376	23.5%

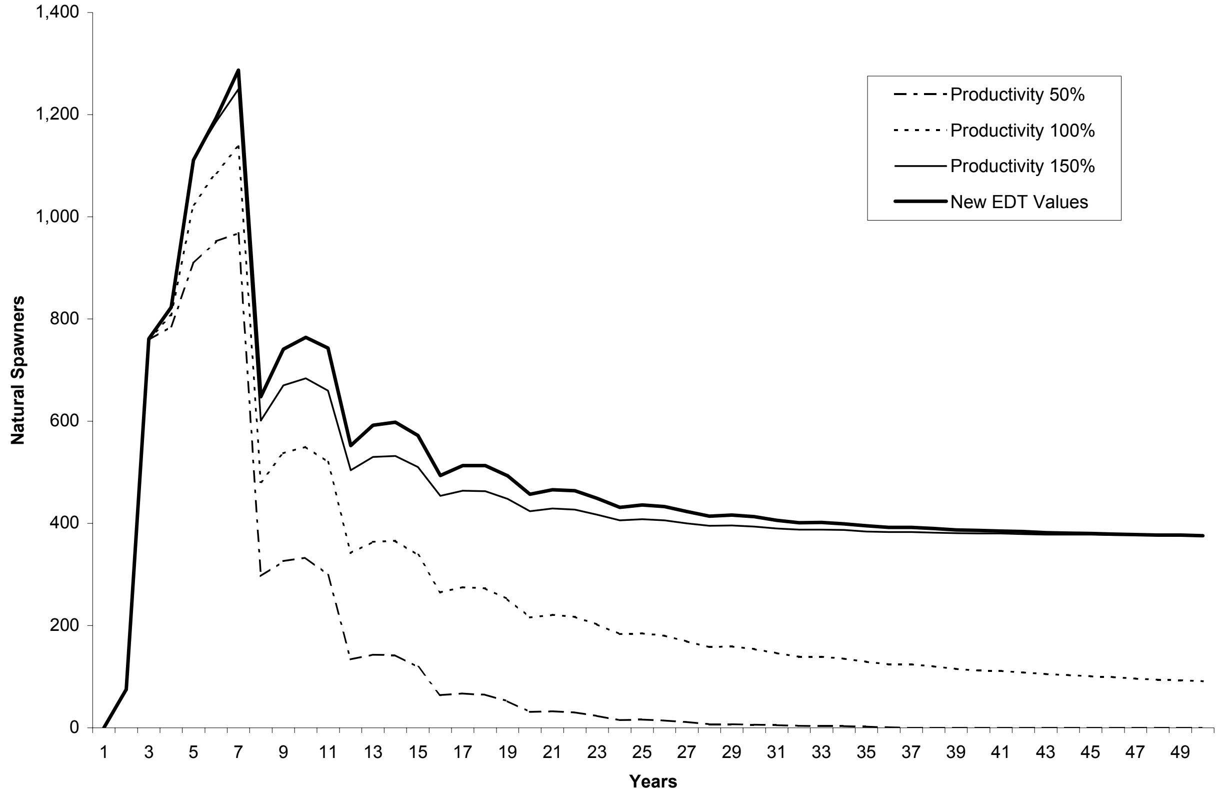
[a] Habitat capacity and productivity were assumed to equal the newly released EDT model results.

Habitat Capacity and Productivity

The nine model runs representing the possible combinations of habitat capacity and productivity are shown in Appendix Table C- 9 (runs 14 through 22). An additional model run (run 23) was performed using a habitat capacity scaling factor of 200% because the coho habitat capacity was thought to be underestimated in the preliminary EDT model. Each incremental increase in habitat capacity resulted in approximately 40 more coho in the predicted population; increases in habitat capacity did not result in predicted population sizes above the low run threshold (Appendix Table C- 9, runs 15, 18, 21, and 23;Appendix Figure C- 19). The importance of productivity is relative to the productivity level; at higher productivity levels, increases in productivity result in greater increases to the predicted population size compared to productivity increases at lower levels (Appendix Table C- 9, runs 17, 18, and 19; Appendix Figure C- 20). This suggests that the predicted population size may be productivity limited at the current productivity level. It is likely that if productivity were continually increased, the relative benefit to the predicted population size may eventually decrease. Improvements to productivity coupled with habitat capacity improvements result in a predicted population above the low run threshold and the low run risk is greatly reduced (Appendix Table C-9, run 22).



Appendix Figure C- 19. Effect of habitat capacity on spawner number for a hypothetical coho salmon population in Yale Lake. Productivity remained constant at 100%. Population was seeded with 60,000 smolts for 5 years and 500 adults for 2 years.

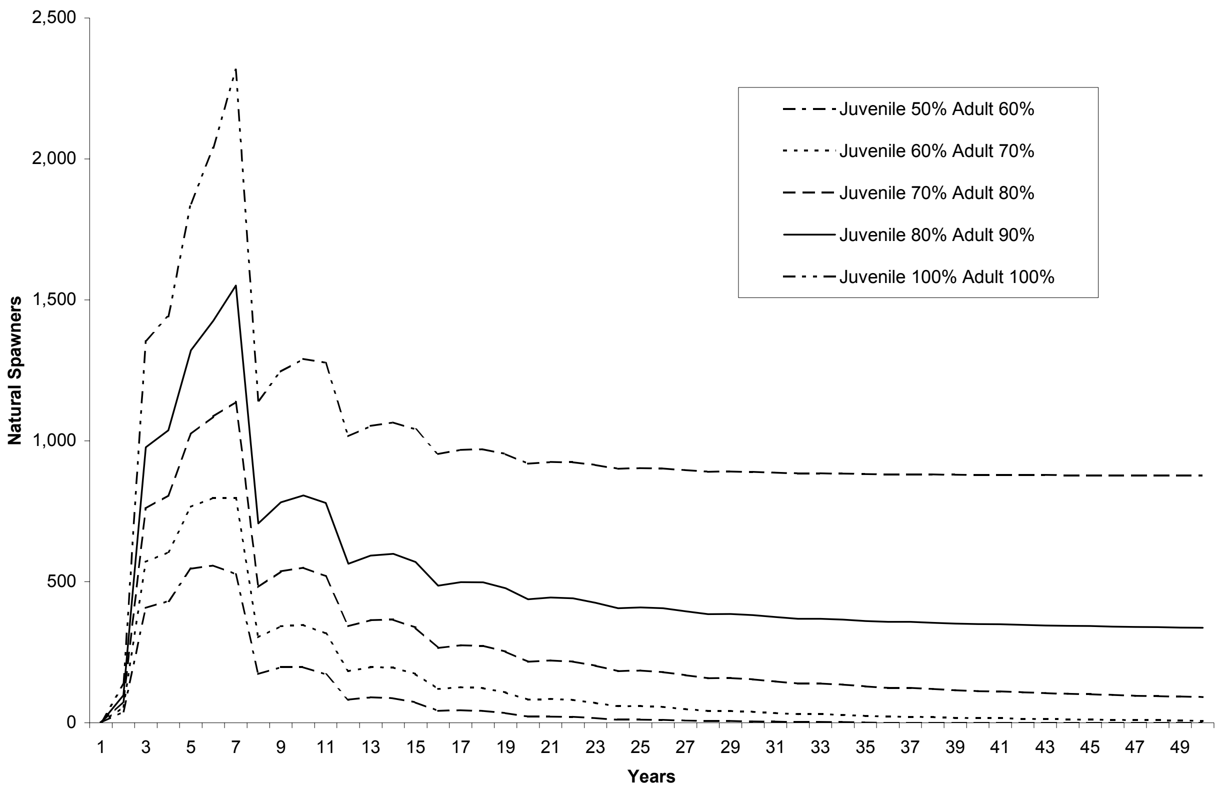


Appendix Figure C- 20. Effect of productivity on spawner number for a hypothetical coho salmon population in Yale Lake. Habitat capacity remained constant at 100%. Population was seeded with 60,000 smolts for 5 years and 500 adults for 2 years. The default model run with newly released EDT model values for habitat capacity and productivity is included for comparison.

The default model run that incorporates newly released EDT values for habitat capacity and productivity resulted in a maximum population size of 1,288 fish, a population size after 50 years of 376 fish, and a low run risk of 23.5% (Appendix Table C- 9, run 30). Values for habitat capacity and productivity increased as a result of the recently released EDT model results (Appendix Table C-4).

Juvenile and Adult Dam Passage Survival

The various model runs for combinations of juvenile and adult dam passage survival are included in Appendix Table C- 9 (runs 1 through 13). As anticipated, higher dam passage survival rates translate to higher predicted population numbers (Appendix Figure C- 21). Each 10% increase in dam passage survival rate results in a greater relative change in the predicted population size after 50 years (Appendix Figure C- 21). Minimum juvenile dam passage survival at 80% and adult dam passage survival at 90% is necessary to produce a predicted population size above the low run threshold (Appendix Table C- 9, run 12).



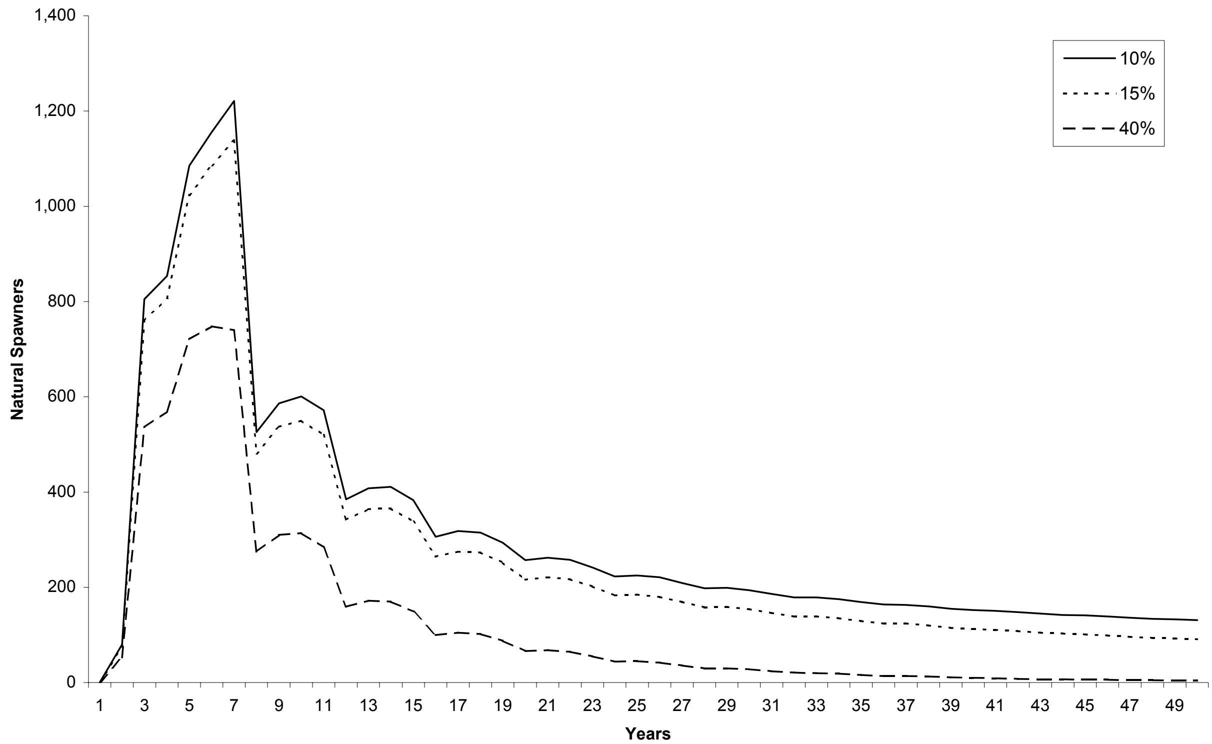
Appendix Figure C- 21. Effects of juvenile and adult dam passage survival rates on spawner number for a hypothetical coho salmon population in Yale Lake. Population was seeded with 60,000 smolts for 5 years and 500 adults for 2 years.

Hatchery Supplementation Strategies

Based on the calculated habitat capacity and productivity values, appropriate coho salmon supplementation numbers were estimated at 60,000 smolt and 500 adults annually. Duration of three smolt supplementation programs were investigated: 5, 10, and 25 years (Appendix Table C- 9, runs 24, 25, and 26). Smolt supplementation for longer periods of time results in initial spikes in the maximum population size, but over time results in the same population size as supplementation for shorter time periods. Although Table 9 shows small differences in the population size at 50 years, all three supplementation strategies would result in the same predicted population size given enough time.

Harvest

Three incidental harvest mortality rates for coho salmon were investigated: 10, 15, and 40 % (Appendix Table C- 9, runs 27, 28, and 29). Decreasing the coho salmon harvest mortality does not result in a substantial increase in the predicted population size (Appendix Table C- 9, run 27 and Appendix Figure C- 22).



Appendix Figure C- 22. Effect of harvest rate on spawner number for a hypothetical coho salmon population in Yale Lake. Population was seeded with 60,000 smolts for 5 years and 500 adults for 2 years.

Steelhead

The default model run for steelhead in Yale Lake resulted in a maximum population size of 248 fish, a population size after 50 years of 115 fish, and a low run risk of 89.0% (Appendix Table C- 10, runs 3, 7, 11, 18, and 24).

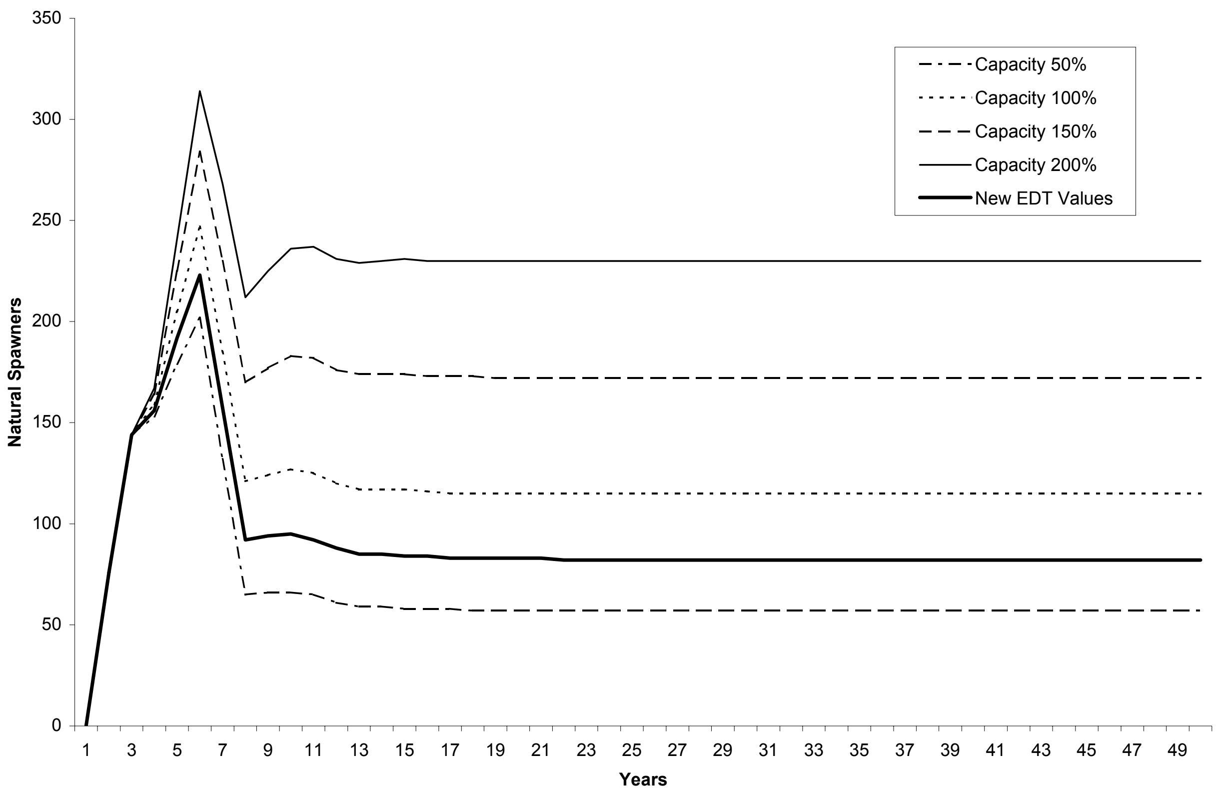
Appendix Table C- 10. Yale Lake steelhead sensitivity to changes in model parameters. Runs 3, 7, 11, 18, and 24 represent default parameters.

	Model Input							Results		
	Passage				Supplementation			Population		
Model Run	Juvenile	Adult	Capacity	Productivity	Adults	Smolt	Harvest	Max	50 yr	Low Run Risk (< 300)
1	50%	80%	100%	100%	2 yrs	5 yrs	3	175	74	89.3%
2	60%	80%	100%	100%	2 yrs	5 yrs	3	211	94	89.3%
3	70%	80%	100%	100%	2 yrs	5 yrs	3	248	115	89.0%
4	80%	80%	100%	100%	2 yrs	5 yrs	3	284	136	88.3%
5	70%	60%	100%	100%	2 yrs	5 yrs	3	184	79	89.3%
6	70%	70%	100%	100%	2 yrs	5 yrs	3	216	97	89.2%
7	70%	80%	100%	100%	2 yrs	5 yrs	3	248	115	89.0%
8	70%	90%	100%	100%	2 yrs	5 yrs	3	280	133	88.6%
9	50%	60%	100%	100%	2 yrs	5 yrs	3	130	48	89.3%
10	60%	70%	100%	100%	2 yrs	5 yrs	3	184	79	89.3%
11	70%	80%	100%	100%	2 yrs	5 yrs	3	248	115	89.0%
12	80%	90%	100%	100%	2 yrs	5 yrs	3	321	157	87.5%
13	100%	100%	100%	100%	2 yrs	5 yrs	3	450	229	78.0%
14	70%	80%	50%	50%	2 yrs	5 yrs	3	196	43	89.3%
15	70%	80%	50%	100%	2 yrs	5 yrs	3	202	58	89.3%
16	70%	80%	50%	150%	2 yrs	5 yrs	3	205	63	89.3%
17	70%	80%	100%	50%	2 yrs	5 yrs	3	229	85	89.1%
18	70%	80%	100%	100%	2 yrs	5 yrs	3	248	115	89.0%
19	70%	80%	100%	150%	2 yrs	5 yrs	3	256	125	88.8%
20	70%	80%	150%	50%	2 yrs	5 yrs	3	253	128	88.9%
21	70%	80%	150%	100%	2 yrs	5 yrs	3	284	173	88.3%
22	70%	80%	150%	150%	2 yrs	5 yrs	3	299	188	87.8%
23	70%	80%	200%	100%	2 yrs	5 yrs	3	314	230	82.3%
24	70%	80%	100%	100%	2 yrs	5 yrs	3	248	115	89.0%
25	70%	80%	100%	100%	2 yrs	10 yrs	3	274	115	86.4%
26	70%	80%	100%	100%	2 yrs	25 yrs	3	275	115	77.8%
27	70%	80%	100%[a]	100%[a]	2 yrs	5 yrs	3	224	83	89.2%

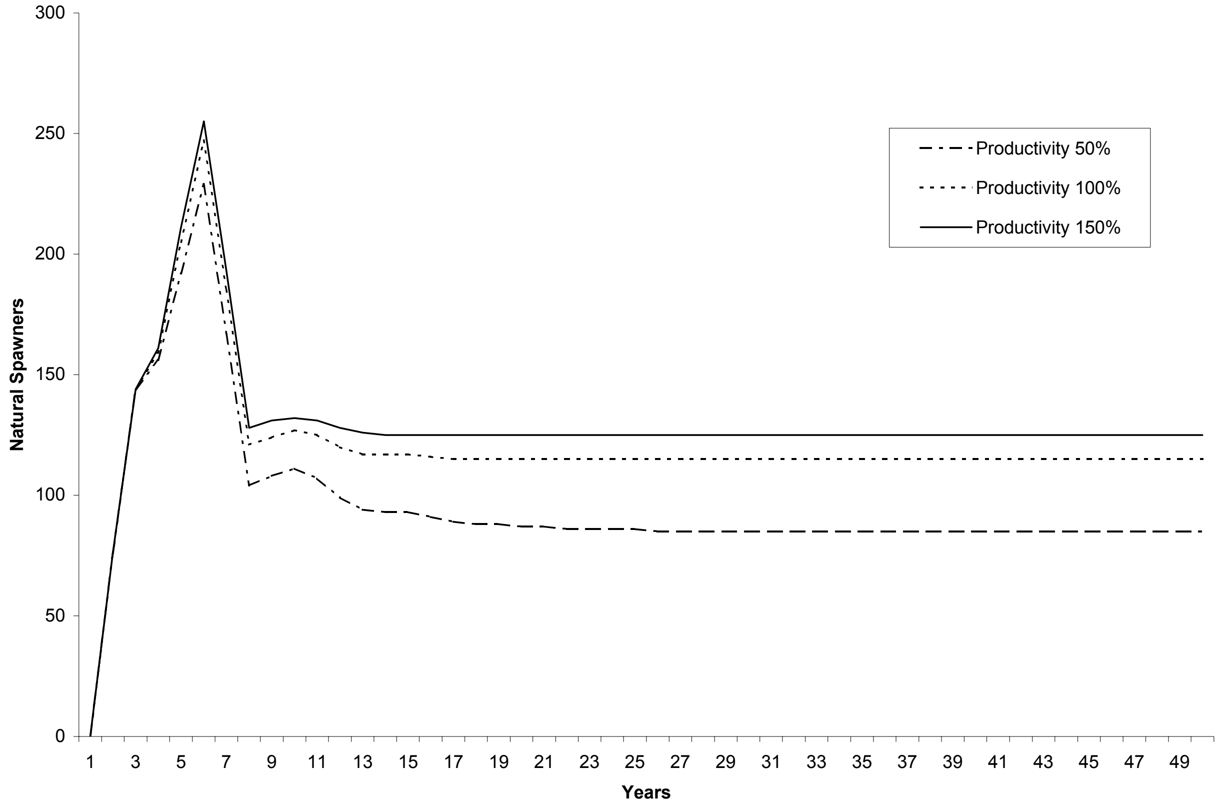
[a] Habitat capacity and productivity were assumed to equal the newly released EDT model results.

Habitat Capacity and Productivity

The nine model runs representing the possible combinations of habitat capacity and productivity are shown in Appendix Table C- 10 (runs 14 through 22). An additional model run (run 23) was performed using a habitat capacity scaling factor of 200% because the steelhead habitat capacity was thought to be underestimated in the preliminary EDT model. Each incremental increase in habitat capacity resulted in approximately 60 more steelhead in the predicted population (Table 10, runs 15, 18, 21, and 23;Appendix Figure C- 23). In comparison, the importance of productivity is relative to the productivity level; at low productivity, increases in productivity result in greater increases to the predicted population size than do increases at higher levels of productivity (Appendix Table C- 10, runs 17, 18, and 19; Appendix Figure C- 24). However, no combination of habitat capacity and productivity investigated during the sensitivity analysis was able to produce a predicted population size above the low run threshold (Appendix Table C- 10).



Appendix Figure C- 23. Effect of habitat capacity on spawner number for a hypothetical steelhead population in Yale Lake. Productivity remained constant at 100%. Population was seeded with 5,000 smolts for 5 years and 100 adults for 2 years. The default model run with newly released EDT model values for habitat capacity and productivity is included for comparison.

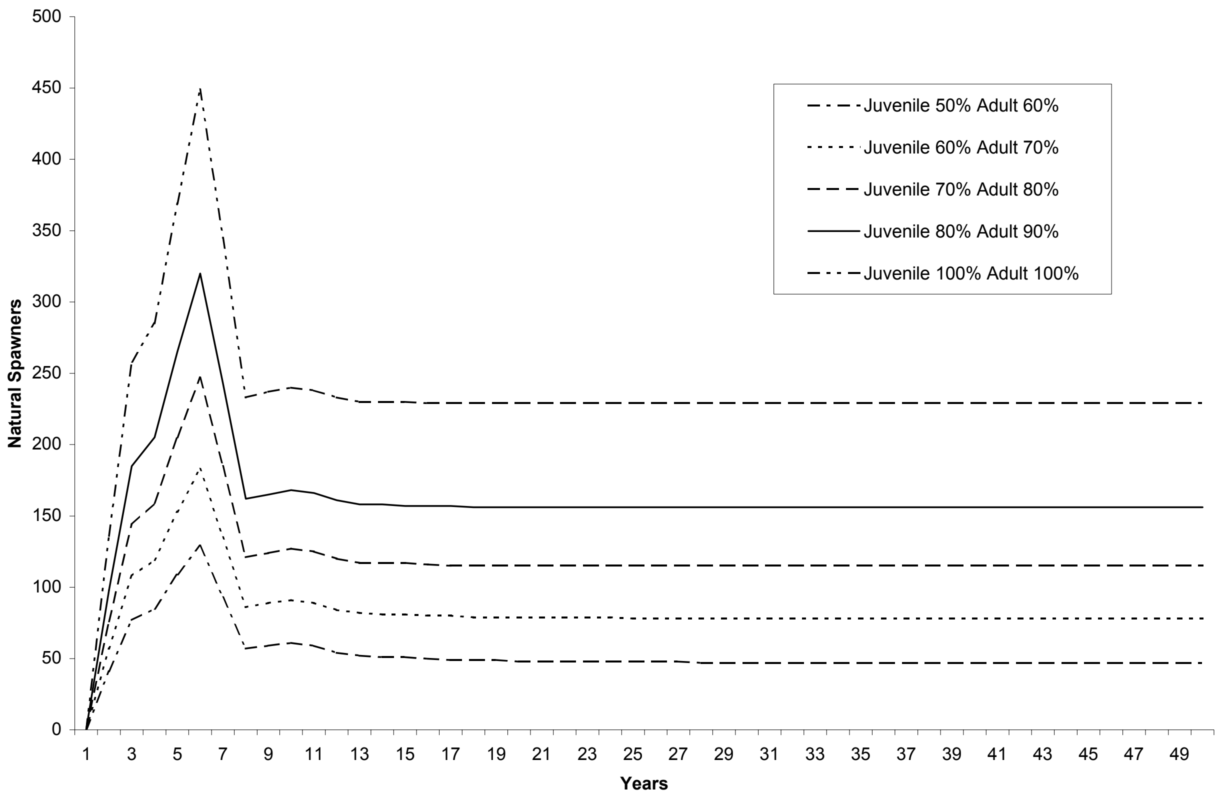


Appendix Figure C- 24. Effect of productivity on spawner number for a hypothetical steelhead population in Yale Lake. Habitat capacity remained constant at 100%. Population was seeded with 5,000 smolts for 5 years and 100 adults for 2 years.

The default model run that incorporates newly released EDT values for habitat capacity and productivity resulted in a maximum population size of 224 fish, a population size after 50 years of 83 fish, and a low run risk of 89.2% (Appendix Table C-10, run 27). The recently released EDT model habitat capacity value is substantially lower than the habitat capacity value utilized in the sensitivity analysis and the productivity value is slightly lower (Appendix Table C-4). The new habitat capacity value was approximately 74% of the previous value and the predicted population curve fell between the sensitivity analysis model runs using the 50 and 100% habitat capacity scaling factors (Appendix Figure C- 23). The decreases in habitat capacity and productivity further limit the possibility of producing a viable steelhead population in Yale Lake.

Juvenile and Adult Dam Passage Survival

The various model runs for combinations of juvenile and adult dam passage survival are included in Appendix Table C- 10(runs 1 through 13). As anticipated, higher dam passage survival rates translate to higher predicted population numbers (Appendix Figure C- 25). Each 10% increase in dam passage survival rate results in a greater relative change in the predicted population size after 50 years (Appendix Figure C- 25). Even if dam passage survival rates for juveniles and adults is maintained at 100%, the model predicts that the steelhead population size in Yale Lake would be below the low run threshold (Appendix Table C- 10, run 13).



Appendix Figure C- 25. Effects of juvenile and adult dam passage survival rates on spawner number for a hypothetical steelhead population in Yale Lake. Population was seeded with 5,000 smolts for 5 years and 100 adults for 2 years.

Hatchery Supplementation Strategies

Based on the calculated habitat capacity and productivity values, appropriate steelhead supplementation numbers were estimated at 5,000 smolt and 100 adults annually. Duration of three smolt supplementation programs were investigated: 5, 10, and 25 years (Appendix Table C- 10, runs 24, 25, and 26). Smolt supplementation for longer periods of time results in initial spikes in the maximum population size, but over time results in the same population size as supplementation for shorter time periods (Appendix Table C- 10).

Lake Merwin

Coho Salmon

The default model run for coho salmon in Lake Merwin resulted in a maximum population size of 746 fish, a population size after 50 years of 27 fish, and a low run risk of 76.1% (Appendix Table C- 11, runs 3, 7, 11, 18, 24, and 28).

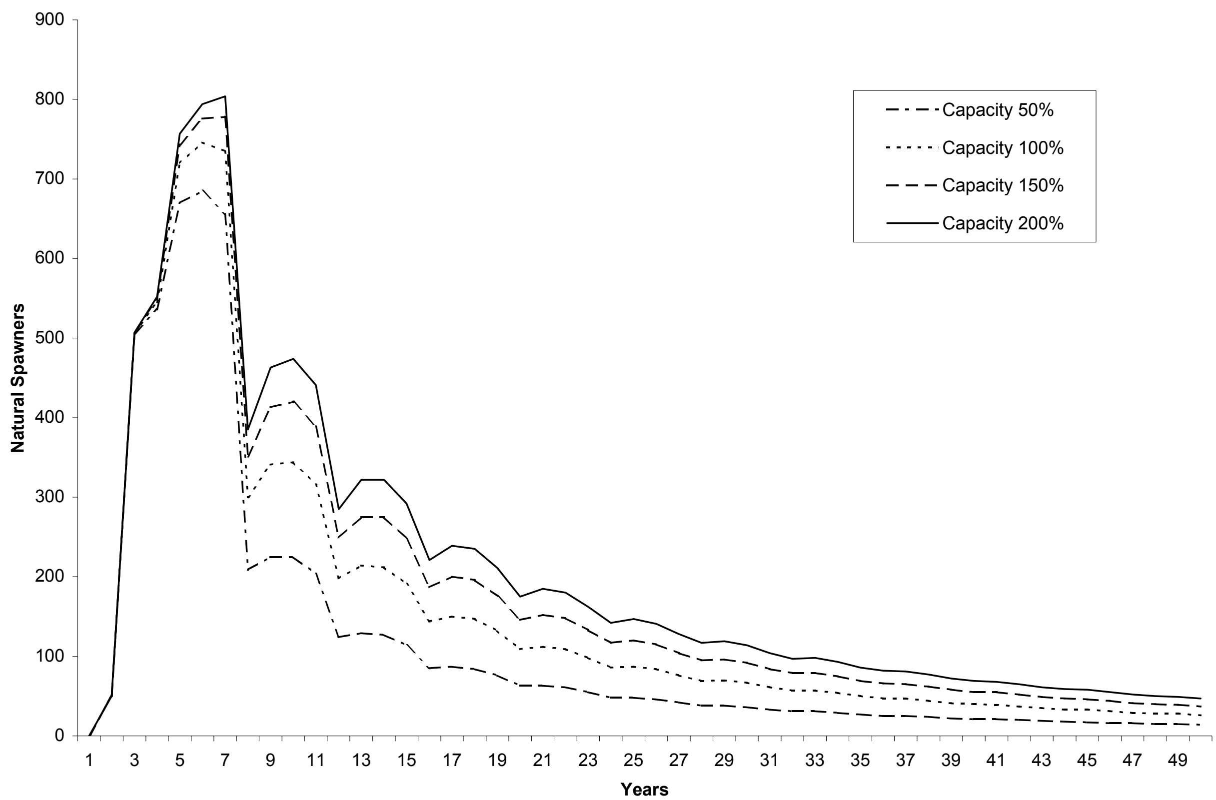
Appendix Table C- 11. Lake Merwin coho sensitivity to changes in model parameters. Runs 3, 7, 11, 18, 24, and 28 represent default parameters.

	Model Input							Results		
	Passage				Supplementation			Population		
Model Run	Juvenile	Adult	Capacity	Productivity	Adults	Smolt	Harvest	Max	50 yr	Low Run Risk (< 300)
1	50%	80%	100%	100%	2 yrs	5 yrs	15	522	0	81.4%
2	60%	80%	100%	100%	2 yrs	5 yrs	15	633	7	79.1%
3	70%	80%	100%	100%	2 yrs	5 yrs	15	746	27	76.1%
4	80%	80%	100%	100%	2 yrs	5 yrs	15	868	73	71.7%
5	70%	60%	100%	100%	2 yrs	5 yrs	15	550	0	80.9%
6	70%	70%	100%	100%	2 yrs	5 yrs	15	647	8	79.0%
7	70%	80%	100%	100%	2 yrs	5 yrs	15	746	27	76.1%
8	70%	90%	100%	100%	2 yrs	5 yrs	15	851	65	72.6%
9	50%	60%	100%	100%	2 yrs	5 yrs	15	386	0	83.9%
10	60%	70%	100%	100%	2 yrs	5 yrs	15	550	0	80.9%
11	70%	80%	100%	100%	2 yrs	5 yrs	15	746	27	76.1%
12	80%	90%	100%	100%	2 yrs	5 yrs	15	1,003	144	65.0%
13	100%	100%	100%	100%	2 yrs	5 yrs	15	1,499	482	12.5%
14	70%	80%	50%	50%	2 yrs	5 yrs	15	626	0	80.8%
15	70%	80%	50%	100%	2 yrs	5 yrs	15	686	14	80.0%
16	70%	80%	50%	150%	2 yrs	5 yrs	15	722	94	78.8%
17	70%	80%	100%	50%	2 yrs	5 yrs	15	650	0	80.4%
18	70%	80%	100%	100%	2 yrs	5 yrs	15	746	27	76.1%
19	70%	80%	100%	150%	2 yrs	5 yrs	15	815	187	65.5%
20	70%	80%	150%	50%	2 yrs	5 yrs	15	660	0	79.8%
21	70%	80%	150%	100%	2 yrs	5 yrs	15	778	38	72.7%
22	70%	80%	150%	150%	2 yrs	5 yrs	15	879	280	42.2%
23	70%	80%	200%	100%	2 yrs	5 yrs	15	805	47	70.0%
24	70%	80%	100%	100%	2 yrs	5 yrs	15	746	27	76.1%
25	70%	80%	100%	100%	2 yrs	10 yrs	15	862	34	65.9%
26	70%	80%	100%	100%	2 yrs	25 yrs	15	882	69	39.4%
27	70%	80%	100%	100%	2 yrs	5 yrs	10	793	42	74.6%
28	70%	80%	100%	100%	2 yrs	5 yrs	15	746	27	76.1%
29	70%	80%	100%	100%	2 yrs	5 yrs	40	516	0	81.4%
30	70%	80%	100%[a]	100%[a]	2 yrs	5 yrs	15	820	161	65.6%

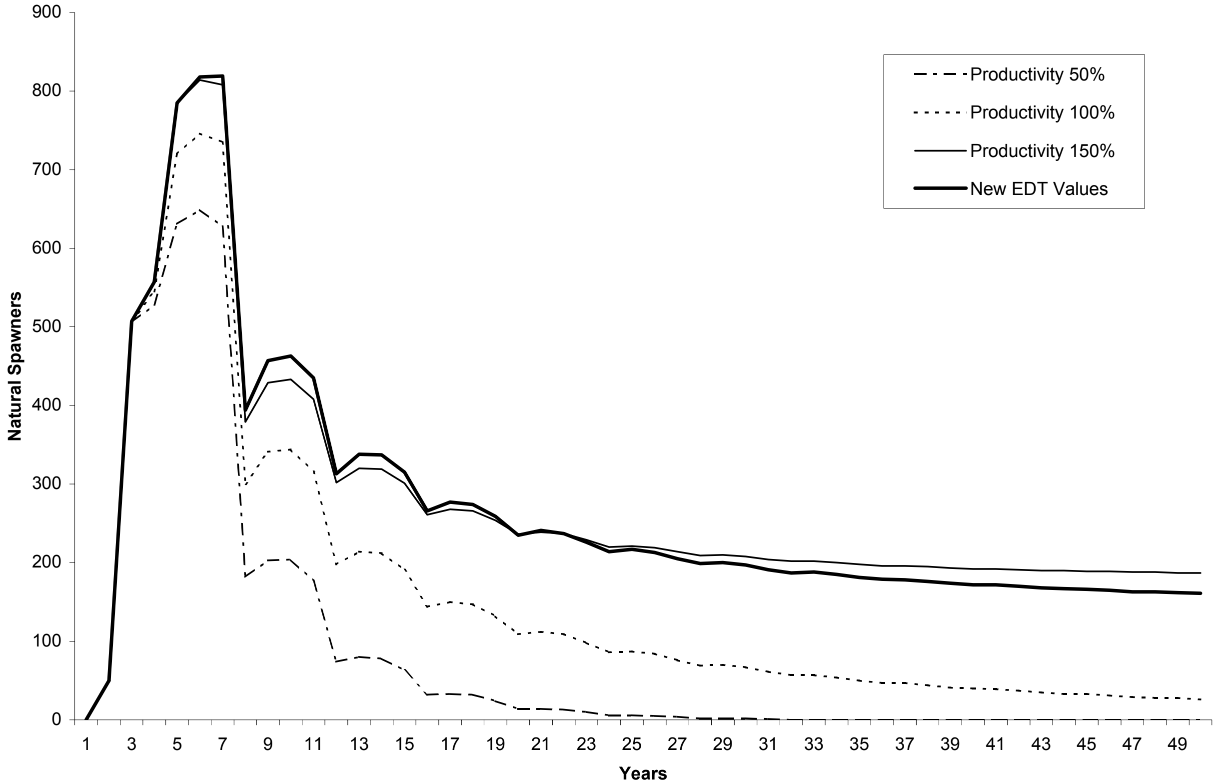
[a] Habitat capacity and productivity were assumed to equal the newly released EDT model results.

Habitat Capacity and Productivity

The nine model runs representing the possible combinations of habitat capacity and productivity are shown in Appendix Table C- 11 (runs 14 through 22). An additional model run (run 23) was performed using a habitat capacity scaling factor of 200% because the coho habitat capacity was thought to be underestimated in the preliminary EDT model. Incremental increases in habitat capacity resulted in negligible increases in the predicted population; predicted population sizes were below the low run threshold (Appendix Table C- 11, runs 15, 18, 21, and 23; Appendix Figure C-26). The importance of productivity is relative to the productivity level; at higher productivity levels, increases in productivity result in greater increases to the predicted population size compared to productivity increases at lower levels (Appendix Table C- 11, runs 17, 18, and 19; Appendix Figure C- 27). This suggests that the predicted population size may be productivity limited at the current productivity level; however, sensitivity analysis indicates that extreme increases in productivity are necessary to produce a predicted population size above the low run threshold. Improvements to productivity coupled with habitat capacity improvements still result in a predicted population below the low run threshold (Appendix Table C- 11, run 22).



Appendix Figure C-26. Effect of habitat capacity on spawner number for a hypothetical coho salmon population in Lake Merwin. Productivity remained constant at 100%. Population was seeded with 40,000 smolts for 5 years and 500 adults for 2 years.

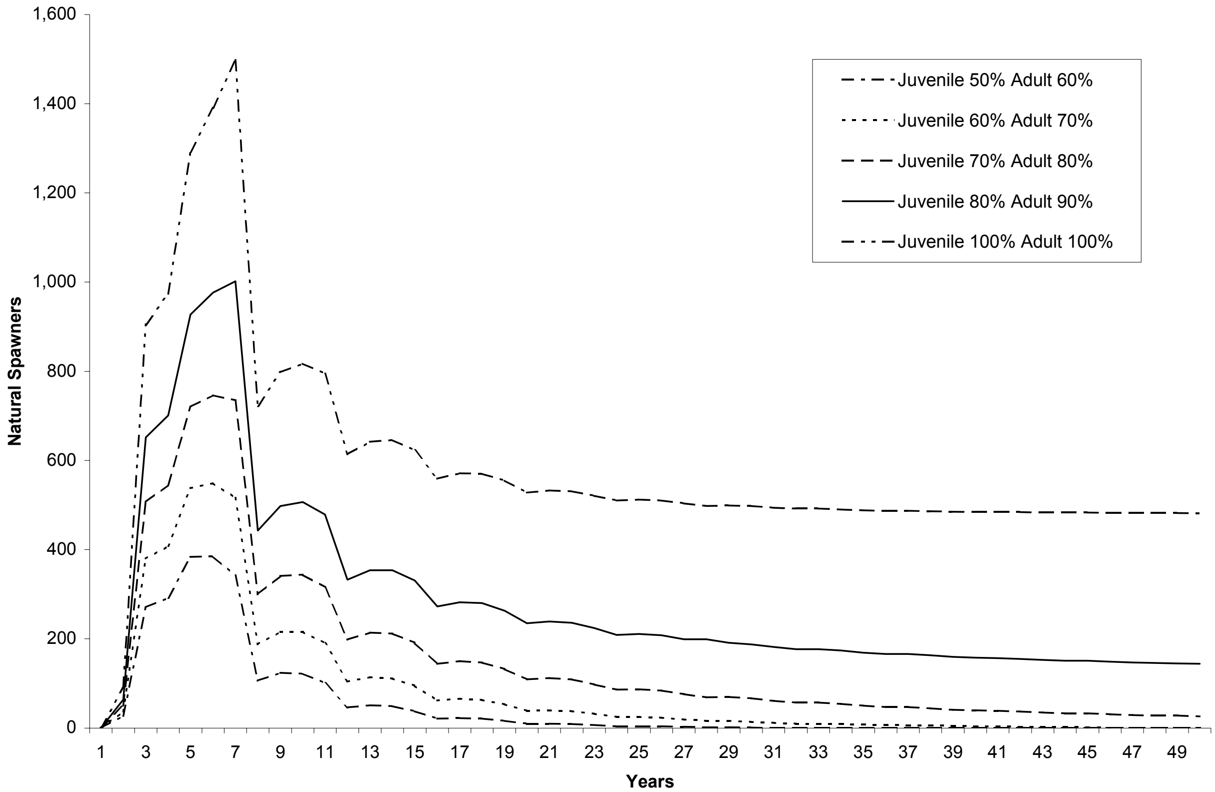


Appendix Figure C- 27. Effect of productivity on spawner number for a hypothetical coho salmon population in Lake Merwin. Habitat capacity remained constant at 100%. Population was seeded with 40,000 smolts for 5 years and 500 adults for 2 years. The default model run with newly released EDT model values for habitat capacity and productivity is included for comparison.

The default model run that incorporates newly released EDT values for habitat capacity and productivity resulted in a maximum population size of 820 fish, a population size after 50 years of 161 fish, and a low run risk of 65.6% (Appendix Table C- 11, run 30). Although the values for habitat capacity and productivity increased as a result of the recently released EDT model results (Appendix Table C-4), these increases were not significant enough to produce a predicted population size above the low run threshold (Appendix Figure C- 27).

Juvenile and Adult Dam Passage Survival

The various model runs for combinations of juvenile and adult dam passage survival are included in Appendix Table C- 11 (runs 1 through 13). As anticipated, higher dam passage survival rates translate to higher predicted population numbers (Appendix Figure C- 28). Each 10% increase in dam passage survival rate results in a greater relative change in the predicted population size after 50 years (Appendix Figure C- 21). In order to produce a predicted population size above the low run threshold, juvenile dam passage survival must be greater than 80% and adult dam passage survival must be greater than 90% (Appendix Table C- 11, runs 12 and 13).



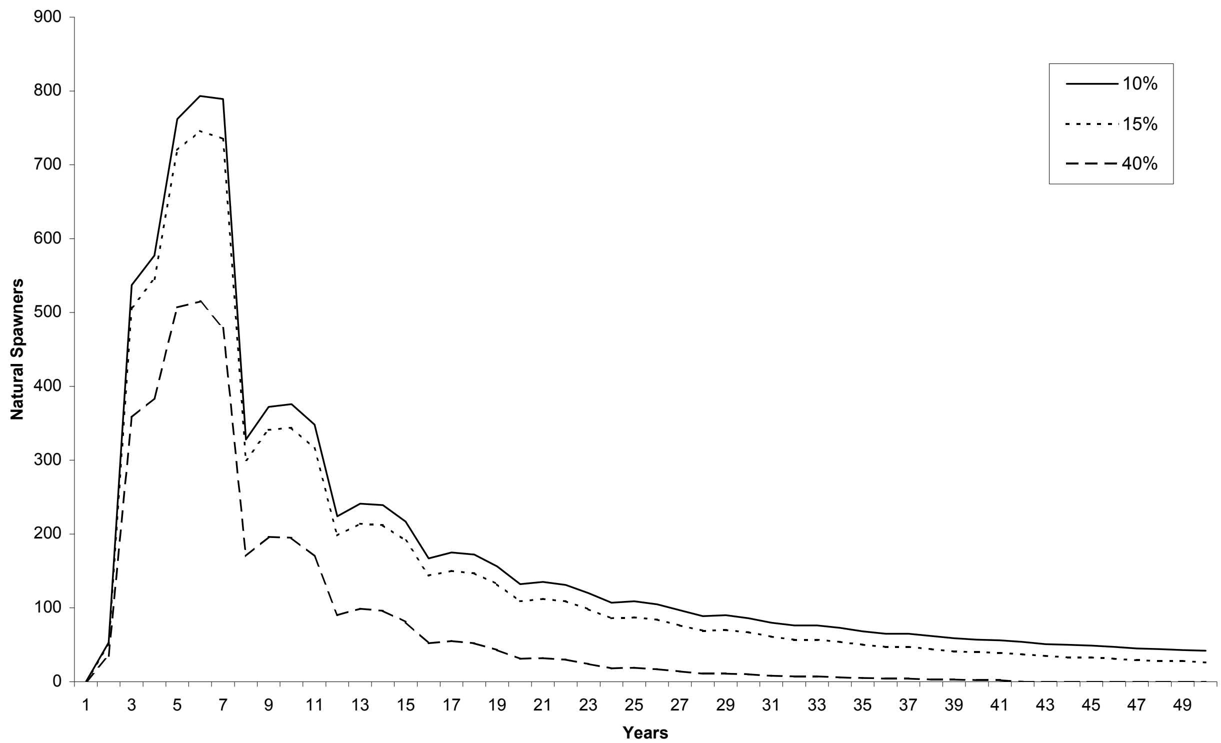
Appendix Figure C- 28. Effects of juvenile and adult dam passage survival rates on spawner number for a hypothetical coho salmon population in Lake Merwin. Population was seeded with 40,000 smolts for 5 years and 500 adults for 2 years.

Hatchery Supplementation Strategies

Based on the calculated habitat capacity and productivity values, appropriate coho salmon supplementation numbers were estimated at 40,000 smolt and 500 adults annually. Duration of three smolt supplementation programs were investigated: 5, 10, and 25 years (Appendix Table C- 11, runs 24, 25, and 26). Smolt supplementation for longer periods of time results in initial spikes in the maximum population size, but over time results in the same population size as supplementation for shorter time periods. Although Table 11 shows small differences in the population size at 50 years, all three supplementation strategies would result in the same predicted population size given enough time.

Harvest

Three incidental harvest mortality rates for coho salmon were investigated: 10, 15, and 40 % (Appendix Table C- 11, runs 27, 28, and 29). Decreasing the coho salmon harvest mortality does not result in a substantial increase in the predicted population size (Appendix Table C- 11, run 27 and Appendix Figure C- 29).



Appendix Figure C- 29. Effect of harvest rate on spawner number for a hypothetical coho salmon population in Lake Merwin. Population was seeded with 40,000 smolts for 5 years and 500 adults for 2 years.

Steelhead

The default model run for steelhead in Lake Merwin resulted in a maximum population size of 226 fish, a population size after 50 years of 83 fish, and a low run risk of 89.2% (Appendix Table C- 12, runs 3, 7, 11, 18, and 24).

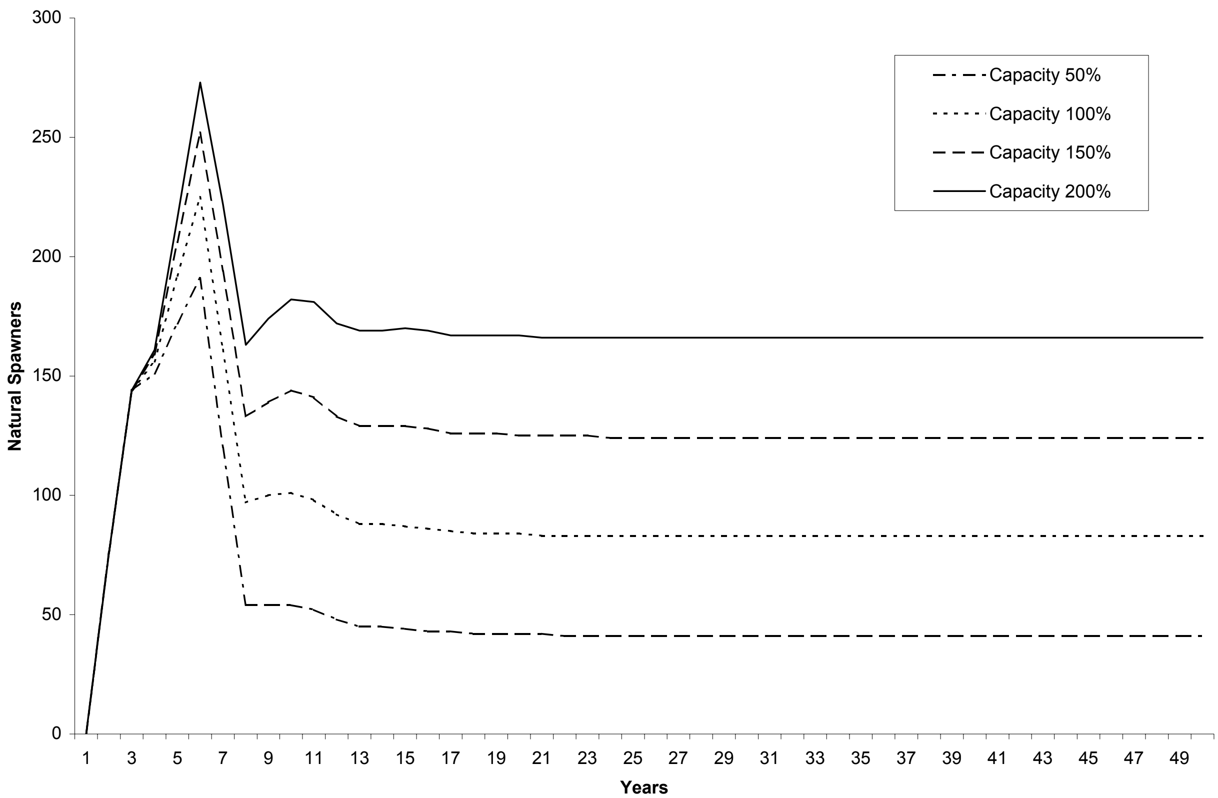
Appendix Table C- 12. Lake Merwin steelhead sensitivity to changes in model parameters. Runs 3, 7, 11, 18, and 24 represent default parameters.

	Model Input							Results		
	Passage				Supplementation			Population		
Model Run	Juvenile	Adult	Capacity	Productivity	Adults	Smolt	Harvest	Max	50 yr	Low Run Risk (< 300)
1	50%	80%	100%	100%	2 yrs	5 yrs	3	159	48	89.3%
2	60%	80%	100%	100%	2 yrs	5 yrs	3	193	65	89.3%
3	70%	80%	100%	100%	2 yrs	5 yrs	3	226	83	89.2%
4	80%	80%	100%	100%	2 yrs	5 yrs	3	259	101	88.8%
5	70%	60%	100%	100%	2 yrs	5 yrs	3	168	52	89.3%
6	70%	70%	100%	100%	2 yrs	5 yrs	3	197	68	89.3%
7	70%	80%	100%	100%	2 yrs	5 yrs	3	226	83	89.2%
8	70%	90%	100%	100%	2 yrs	5 yrs	3	255	98	88.8%
9	50%	60%	100%	100%	2 yrs	5 yrs	3	118	26	89.3%
10	60%	70%	100%	100%	2 yrs	5 yrs	3	168	52	89.3%
11	70%	80%	100%	100%	2 yrs	5 yrs	3	226	83	89.2%
12	80%	90%	100%	100%	2 yrs	5 yrs	3	293	118	88.1%
13	100%	100%	100%	100%	2 yrs	5 yrs	3	411	179	84.4%
14	70%	80%	50%	50%	2 yrs	5 yrs	3	185	22	89.3%
15	70%	80%	50%	100%	2 yrs	5 yrs	3	192	42	89.3%
16	70%	80%	50%	150%	2 yrs	5 yrs	3	194	48	89.3%
17	70%	80%	100%	50%	2 yrs	5 yrs	3	209	44	89.3%
18	70%	80%	100%	100%	2 yrs	5 yrs	3	226	83	89.2%
19	70%	80%	100%	150%	2 yrs	5 yrs	3	234	96	89.2%
20	70%	80%	150%	50%	2 yrs	5 yrs	3	225	66	89.2%
21	70%	80%	150%	100%	2 yrs	5 yrs	3	252	125	88.9%
22	70%	80%	150%	150%	2 yrs	5 yrs	3	267	144	88.6%
23	70%	80%	200%	100%	2 yrs	5 yrs	3	274	166	88.5%
24	70%	80%	100%	100%	2 yrs	5 yrs	3	226	83	89.2%
25	70%	80%	100%	100%	2 yrs	10 yrs	3	249	83	87.4%
26	70%	80%	100%	100%	2 yrs	25 yrs	3	250	83	83.6%
27	70%	80%	100%[a]	100%[a]	2 yrs	5 yrs	3	234	97	89.1%

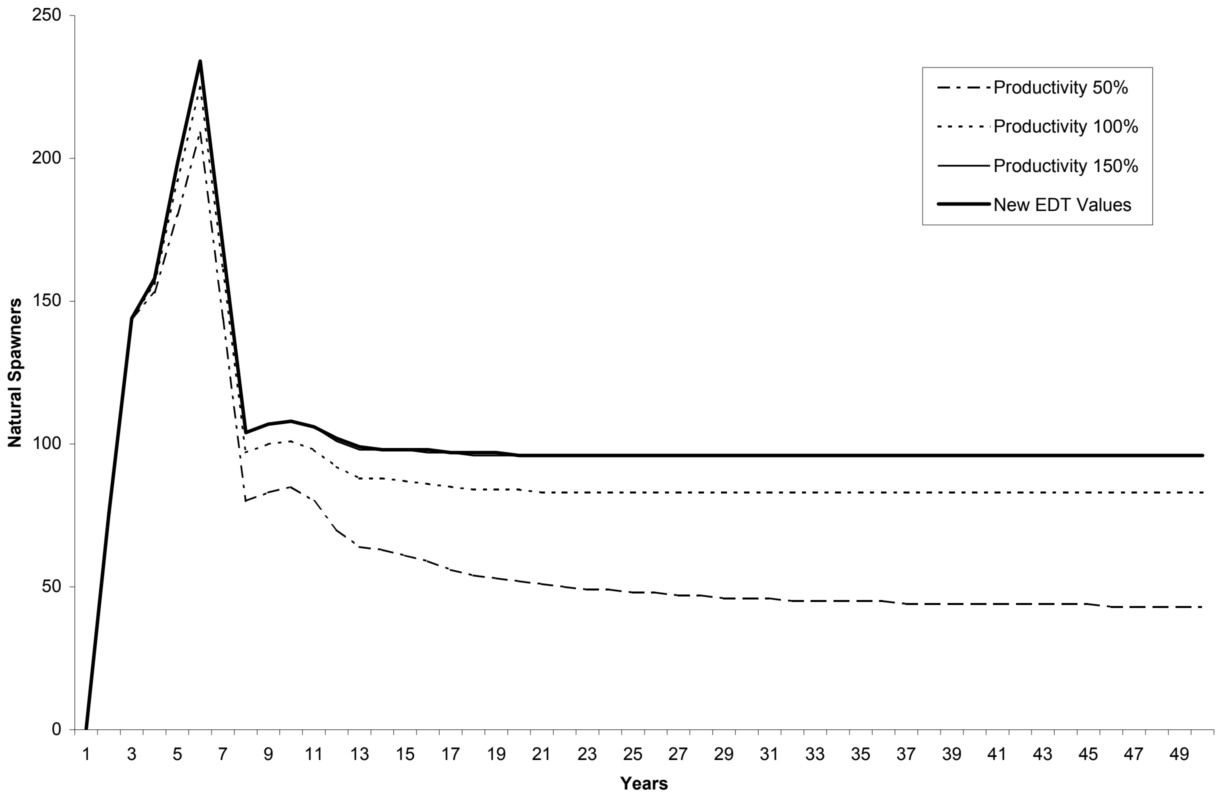
[a] Habitat capacity and productivity were assumed to equal the newly released EDT model results.

Habitat Capacity and Productivity

The nine model runs representing the possible combinations of habitat capacity and productivity are shown in Appendix Table C- 12 (runs 14 through 22). An additional model run (run 23) was performed using a habitat capacity scaling factor of 200% because the steelhead habitat capacity was thought to be underestimated in the preliminary EDT model. Each incremental increase in habitat capacity resulted in approximately 40 more steelhead in the predicted population (Appendix Table C- 12, runs 15, 18, 21, and 23; Appendix Figure C- 30). In comparison, the importance of productivity is relative to the productivity level; at low productivity, increases in productivity result in greater increases to the predicted population size than do increases at higher levels of productivity (Appendix Table C- 12, runs 17, 18, and 19; Appendix Figure C- 31). Regardless, no combination of habitat capacity and productivity investigated during the sensitivity analysis was able to produce a predicted population size above the low run threshold (Appendix Table C- 12).



Appendix Figure C- 30. Effect of habitat capacity on spawner number for a hypothetical steelhead population in Lake Merwin. Productivity remained constant at 100%. Population was seeded with 5,000 smolts for 5 years and 100 adults for 2 years.

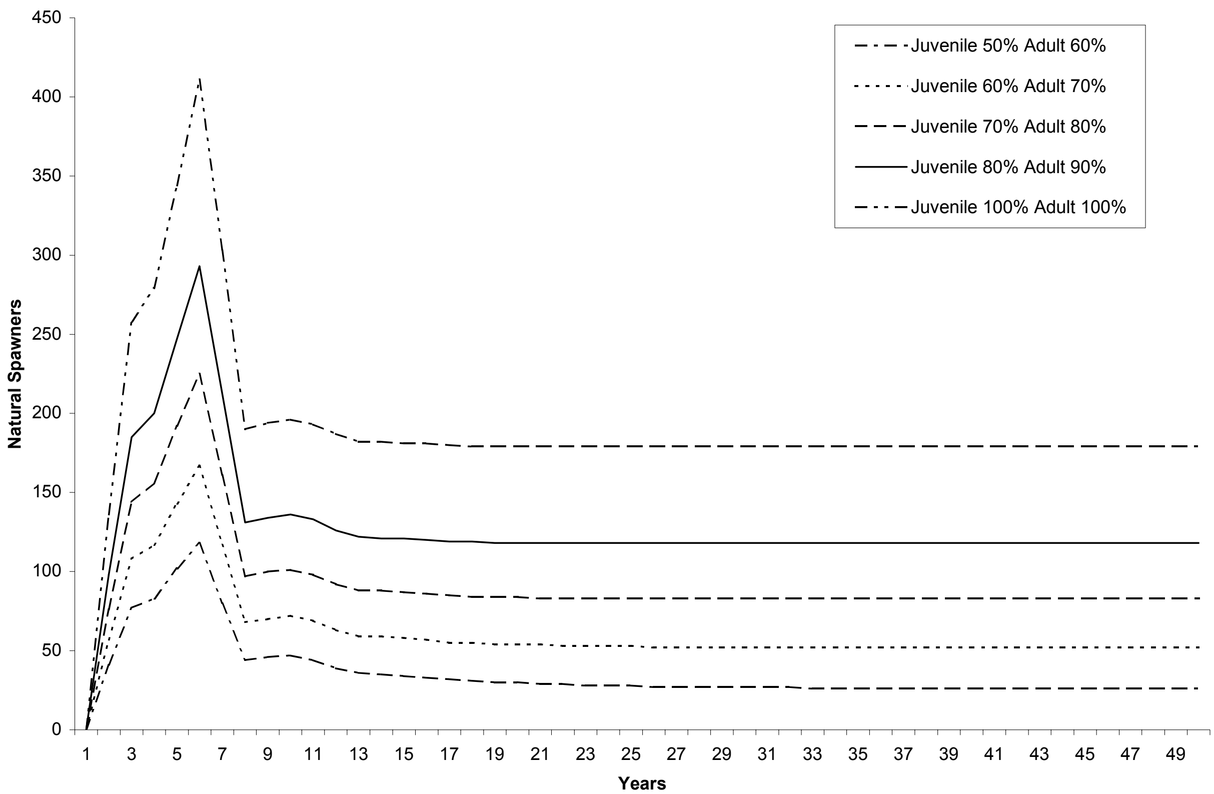


Appendix Figure C- 31. Effect of productivity on spawner number for a hypothetical steelhead population in Lake Merwin. Habitat capacity remained constant at 100%. Population was seeded with 5,000 smolts for 5 years and 100 adults for 2 years. The default model run with newly released EDT model values for habitat capacity and productivity is included for comparison.

The default model run that incorporates newly released EDT values for habitat capacity and productivity resulted in a maximum population size of 234 fish, a population size after 50 years of 97 fish, and a low run risk of 89.1% (Appendix Table C-12, run 27). The recently released EDT model habitat capacity value is relatively unchanged and the productivity value is approximately 150% of the previous productivity (Appendix Table C-4). Therefore, the resulting predicted population curve was almost identical to the sensitivity analysis model run using the 150% productivity scaling factor (Appendix Figure C- 31). The increased productivity does not result in a predicted steelhead population above the low run threshold.

Juvenile and Adult Dam Passage Survival

The various model runs for combinations of juvenile and adult dam passage survival are included in Appendix Table C- 12 (runs 1 through 13). As anticipated, higher dam passage survival rates translate to higher predicted population numbers (Appendix Figure C- 32). Each 10% increase in dam passage survival rate results in a greater relative change in the predicted population size after 50 years (Appendix Figure C- 32). Even if dam passage survival rates for juveniles and adults is maintained at 100%, the model predicts that the steelhead population size in Lake Merwin would be below the low run threshold (Appendix Table C- 12, run 13).



Appendix Figure C- 32. Effects of juvenile and adult passage rates on spawner number for a hypothetical steelhead population in Lake Merwin. Population was seeded with 5,000 smolts for 5 years and 100 adults for 2 years.

Hatchery Supplementation Strategies

Based on the calculated habitat capacity and productivity values, appropriate steelhead supplementation numbers were estimated at 5,000 smolt and 100 adults annually. Duration of three smolt supplementation programs were investigated: 5, 10, and 25 years (Appendix Table C- 12, runs 24, 25, and 26). Smolt supplementation for longer periods of time results in initial spikes in the maximum population size, but over time results in the same population size as supplementation for shorter time periods (Appendix Table C- 12).

Discussion

Sensitivity analysis simplifies the evaluation of possible spring Chinook, coho salmon, and steelhead reintroduction to the upper Lewis River by isolating the effect different PopCycle model parameters have on the predicted population size. In reality, all the various parameters collectively affect the predicted populations derived by the PopCycle model. However, the sensitivity analysis prioritizes the importance of each parameter and identifies which parameters will have the greatest effect on the success or failure of each species' potential reintroduction to the three distinct lake systems. Also, in some cases, the sensitivity analysis indicated that realistic improvements to different parameters would be unlikely to result in predicted population sizes above the low run threshold. For example, steelhead and spring chinook outcomes are so highly driven by habitat productivity and capacity derived from the EDT analysis, that other parameter changes have minimal effect on the outcome. However, coho in the lower reservoir can be affected by a combination of parameters since their outcome is not principally driven by a particular parameter. Therefore, insight gained through the sensitivity analysis can assist the in determining where time and effort should be focused, and needed performance criteria, to achieve the greatest likelihood of success in the Lewis River fish reintroduction experiment.

The revised EDT model results potentially affect the inferences that can be made from the sensitivity analysis. In most cases, the revised EDT model results were already incorporated in the range of parameter values tested in the sensitivity analysis; thus, the sensitivity analysis results remain valid. In Swift Reservoir, the revised EDT model created substantial changes to the habitat capacity and productivity parameters for each species. For spring Chinook, the habitat capacity value was reduced significantly and the resulting default model run predicted a population size close to the low run threshold. For coho salmon, the substantial increase to the habitat capacity value resulted in a default model run predicted population size approximately 400 fish greater than the previous default model run. For steelhead, the EDT model results decreased productivity appreciably, however, the resulting model run predicted a population size higher than the previous default model run likely because of the slight increase in steelhead habitat capacity. In any case, the revised EDT model results need to be evaluated in order to derive an accepted standard for the habitat capacity and productivity parameters for each species in Swift Reservoir. As suggested by the sensitivity analysis, an accepted range of habitat capacity and productivity values may be adequate for planning purposes rather than all stakeholders needing to agree on a specific value.

(This page blank)