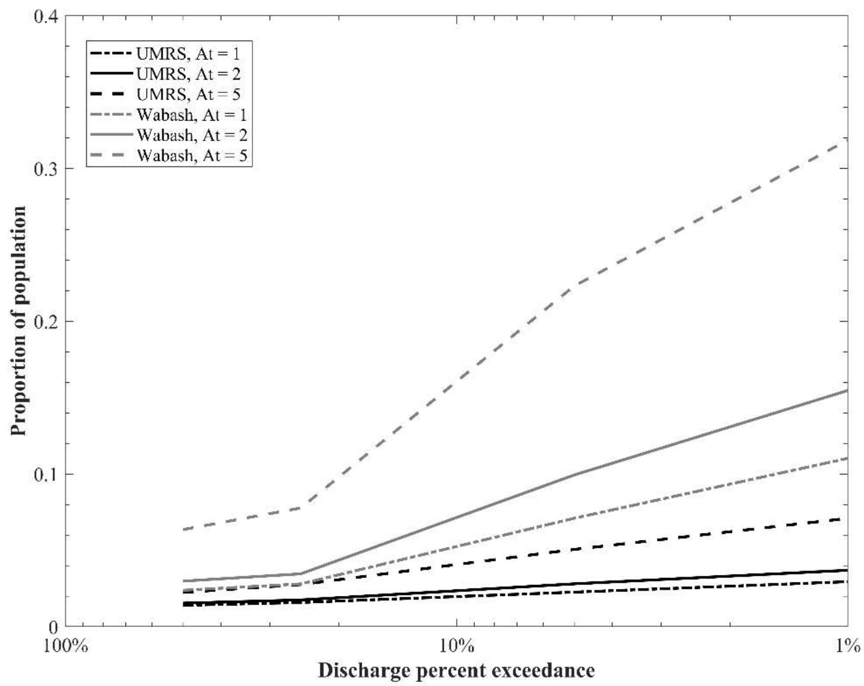

Figure S1. The effects of both silver carp size (UMR= smaller fish; Wabash River= gray lines) and challenge (attempts to pass LDs per month) rates on the proportion of silver carp passing consecutive LDs as calculated by the S-FPM. Dashed lines indicate the effects of changing the number of spillway passage attempts per month. These model runs assumed spillway gate operation were modified to limit carp passage. In summary, the S-FPM predicted the proportion of passage for a silver carp population similar to that seen in the Wabash River to be 68% higher at a single LD (A) and 225% higher at consecutive LDs (A+B) compared to a population similar to that seen in the UMR with a spillway passage attempts rate of 2 per month and modified spillway gate operation (no lock deterrence or removal). The proportion passing consecutive LDs also increased with increasing spillway passage attempt rate. At 5 spillway passage attempts per month, the passage rate of silver carp population with fish sizes similar to that in the UMR was 109% and 75% higher than a population with 1 and 2 passage attempts per month.

Table S1. Effects of exceedance on silver carp passage rates at LD(s) when gates are operated under base (historical) conditions as calculated by our S-FPM. Model results during base (historical) gate operation, 2 passage attempts, no deterrence or removal, and length distribution selected from the Upper Mississippi River [48]. The proportion passing Lock-and-Dam A is the total passage at one lock-and-dam (A) and the proportion passing Lock-and-Dam B is the total passage at two consecutive lock-and-dams (i.e., A and B together).

Exceedance Discharge	Attempt #	Deterrence	Removal	Lock-and-Dam	Proportion Passed
50%	2	0%	0%	A	**18.5%**
25%	2	0%	0%	A	**18.1%**
5%	2	0%	0%	A	**21.1%**
1%	2	0%	0%	A	**22.4%**
50%	2	0%	0%	B	**2.3%**
25%	2	0%	0%	B	**2.3%**
5%	2	0%	0%	B	**3.5%**
1%	2	0%	0%	B	**3.9%**

Table S2. Model runs (104 independent simulations using the S-FPM) of the effects of different levels of exceedance, adding deterrents with different efficacies and removing cap upstream of LD A on overall silver carp passage rates at LD(s) if operated with modified gate operation, 2 passage attempts, and a fish length distribution similar to presently found in the Upper Mississippi River [48]. Deterrence ranges between 0, 25, 50, 75, and 100% and removal ranges from 0, 5, 10, and 40%. The proportion passing Lock-and-Dam A is the total passage at one lock-and-dam and the proportion passing Lock-and-Dam B is the total passage at two consecutive lock-and-dams (A and B).

Exceedance Discharge	Attempt #	Deterrence	Removal	Lock-and-Dam	Proportion Passed
50%	2	0%	0%	A	**16.1%**
25%	2	0%	0%	A	**16.8%**
5%	2	0%	0%	A	**19.1%**
1%	2	0%	0%	A	**21.9%**
50%	2	0%	5%	A	**12.2%**
25%	2	0%	5%	A	**12.7%**
5%	2	0%	5%	A	**14.9%**
1%	2	0%	5%	A	**16.8%**
50%	2	0%	10%	A	**9.3%**
25%	2	0%	10%	A	**9.9%**
5%	2	0%	10%	A	**11.5%**
1%	2	0%	10%	A	**13.2%**
50%	2	0%	40%	A	**2.2%**
25%	2	0%	40%	A	**2.4%**
5%	2	0%	40%	A	**3.1%**
1%	2	0%	40%	A	**3.6%**
50%	2	25%	0%	A	**12.5%**
25%	2	25%	0%	A	**13.3%**
5%	2	25%	0%	A	**16.1%**
1%	2	25%	0%	A	**18.6%**
50%	2	25%	5%	A	**9.8%**
25%	2	25%	5%	A	**10.3%**
5%	2	25%	5%	A	**12.5%**
1%	2	25%	5%	A	**14.3%**
50%	2	25%	10%	A	**7.4%**
25%	2	25%	10%	A	**7.9%**
5%	2	25%	10%	A	**9.5%**
1%	2	25%	10%	A	**11.3%**
50%	2	25%	40%	A	**1.7%**
25%	2	25%	40%	A	**1.8%**
5%	2	25%	40%	A	**2.4%**
1%	2	25%	40%	A	**3.1%**
50%	2	50%	0%	A	**9.4%**
25%	2	50%	0%	A	**10.3%**
5%	2	50%	0%	A	**12.9%**
1%	2	50%	0%	A	**15.7%**
50%	2	50%	5%	A	**7.1%**

25%	2	50%	5%	A	**7.8%**
5%	2	50%	5%	A	**10.1%**
1%	2	50%	5%	A	**12.0%**
50%	2	50%	10%	A	**5.3%**
25%	2	50%	10%	A	**6.0%**
5%	2	50%	10%	A	**7.5%**
1%	2	50%	10%	A	**9.4%**
50%	2	50%	40%	A	**1.2%**
25%	2	50%	40%	A	**1.3%**
5%	2	50%	40%	A	**1.8%**
1%	2	50%	40%	A	**2.5%**
50%	2	75%	0%	A	**5.9%**
25%	2	75%	0%	A	**6.8%**
5%	2	75%	0%	A	**10.0%**
1%	2	75%	0%	A	**12.6%**
50%	2	75%	5%	A	**4.6%**
25%	2	75%	5%	A	**5.1%**
5%	2	75%	5%	A	**7.4%**
1%	2	75%	5%	A	**9.7%**
50%	2	75%	10%	A	**3.4%**
25%	2	75%	10%	A	**3.9%**
5%	2	75%	10%	A	**5.7%**
1%	2	75%	10%	A	**7.5%**
50%	2	75%	40%	A	**0.7%**
25%	2	75%	40%	A	**0.8%**
5%	2	75%	40%	A	**1.3%**
1%	2	75%	40%	A	**2.0%**
50%	2	100%	0%	A	**2.4%**
25%	2	100%	0%	A	**3.2%**
5%	2	100%	0%	A	**6.4%**
1%	2	100%	0%	A	**9.4%**
50%	2	100%	5%	A	**1.7%**
25%	2	100%	5%	A	**2.4%**
5%	2	100%	5%	A	**4.8%**
1%	2	100%	5%	A	**7.1%**
50%	2	100%	10%	A	**1.3%**
25%	2	100%	10%	A	**1.8%**
5%	2	100%	10%	A	**3.5%**
1%	2	100%	10%	A	**5.6%**
50%	2	100%	40%	A	**0.3%**
25%	2	100%	40%	A	**0.4%**
5%	2	100%	40%	A	**0.8%**
1%	2	100%	40%	A	**1.5%**
50%	2	0%	0%	B	**1.5%**
25%	2	0%	0%	B	**1.8%**
5%	2	0%	0%	B	**2.8%**

1%	2	0%	0%	B	**3.7%**
50%	2	0%	5%	B	**1.4%**
25%	2	0%	5%	B	**1.6%**
5%	2	0%	5%	B	**2.5%**
1%	2	0%	5%	B	**3.3%**
50%	2	0%	10%	B	**1.3%**
25%	2	0%	10%	B	**1.4%**
5%	2	0%	10%	B	**2.4%**
1%	2	0%	10%	B	**3.1%**
50%	2	0%	40%	B	**0.8%**
25%	2	0%	40%	B	**0.9%**
5%	2	0%	40%	B	**1.5%**
1%	2	0%	40%	B	**2.2%**
50%	2	25%	0%	B	**1.0%**
25%	2	25%	0%	B	**1.2%**
5%	2	25%	0%	B	**2.1%**
1%	2	25%	0%	B	**2.9%**
50%	2	25%	5%	B	**0.9%**
25%	2	25%	5%	B	**1.1%**
5%	2	25%	5%	B	**2.0%**
1%	2	25%	5%	B	**2.6%**
50%	2	25%	10%	B	**0.9%**
25%	2	25%	10%	B	**1.0%**
5%	2	25%	10%	B	**1.7%**
1%	2	25%	10%	B	**2.5%**
50%	2	25%	40%	B	**0.5%**
25%	2	25%	40%	B	**0.6%**
5%	2	25%	40%	B	**1.3%**
1%	2	25%	40%	B	**1.7%**
50%	2	50%	0%	B	**0.6%**
25%	2	50%	0%	B	**0.7%**
5%	2	50%	0%	B	**1.5%**
1%	2	50%	0%	B	**2.3%**
50%	2	50%	5%	B	**0.5%**
25%	2	50%	5%	B	**0.7%**
5%	2	50%	5%	B	**1.4%**
1%	2	50%	5%	B	**2.1%**
50%	2	50%	10%	B	**0.4%**
25%	2	50%	10%	B	**0.6%**
5%	2	50%	10%	B	**1.3%**
1%	2	50%	10%	B	**1.9%**
50%	2	50%	40%	B	**0.3%**
25%	2	50%	40%	B	**0.3%**
5%	2	50%	40%	B	**0.9%**
1%	2	50%	40%	B	**1.4%**
50%	2	75%	0%	B	**0.2%**

25%	2	75%	0%	B	**0.4%**
5%	2	75%	0%	B	**1.1%**
1%	2	75%	0%	B	**1.8%**
50%	2	75%	5%	B	**0.2%**
25%	2	75%	5%	B	**0.3%**
5%	2	75%	5%	B	**1.0%**
1%	2	75%	5%	B	**1.7%**
50%	2	75%	10%	B	**0.2%**
25%	2	75%	10%	B	**0.3%**
5%	2	75%	10%	B	**1.0%**
1%	2	75%	10%	B	**1.6%**
50%	2	75%	40%	B	**0.1%**
25%	2	75%	40%	B	**0.2%**
5%	2	75%	40%	B	**0.7%**
1%	2	75%	40%	B	**1.2%**
50%	2	100%	0%	B	**0.1%**
25%	2	100%	0%	B	**0.1%**
5%	2	100%	0%	B	**0.8%**
1%	2	100%	0%	B	**1.4%**
50%	2	100%	5%	B	**0.1%**
25%	2	100%	5%	B	**0.1%**
5%	2	100%	5%	B	**0.7%**
1%	2	100%	5%	B	**1.4%**
50%	2	100%	10%	B	**0.1%**
25%	2	100%	10%	B	**0.1%**
5%	2	100%	10%	B	**0.7%**
1%	2	100%	10%	B	**1.3%**
50%	2	100%	40%	B	**0.0%**
25%	2	100%	40%	B	**0.1%**
5%	2	100%	40%	B	**0.6%**
1%	2	100%	40%	B	**0.9%**

Table S3. Model results showing the effects of different (1-5) attempt rates on silver carp passage at either one or two LDs during modified gate operation and no deterrence or removal using fish the size of those presently in the UMR [48]. The proportion passing Lock-and-Dam A is the total passage at one lock-and-dam and the proportion passing Lock-and-Dam B is the total passage at two consecutive lock-and-dams.

Exceedance Discharge	Attempt #	Deterrence	Removal	Lock-and-Dam	Proportion Passed
50%	1	0%	0%	A	**15.5%**
25%	1	0%	0%	A	**15.7%**
5%	1	0%	0%	A	**18.0%**
1%	1	0%	0%	A	**20.0%**
50%	2	0%	0%	A	**16.1%**
25%	2	0%	0%	A	**16.8%**
5%	2	0%	0%	A	**19.1%**
1%	2	0%	0%	A	**21.9%**
50%	5	0%	0%	A	**18.2%**
25%	5	0%	0%	A	**20.3%**
5%	5	0%	0%	A	**25.2%**
1%	5	0%	0%	A	**29.9%**
50%	1	0%	0%	B	**1.4%**
25%	1	0%	0%	B	**1.6%**
5%	1	0%	0%	B	**2.3%**
1%	1	0%	0%	B	**3.0%**
50%	2	0%	0%	B	**1.5%**
25%	2	0%	0%	B	**1.8%**
5%	2	0%	0%	B	**2.8%**
1%	2	0%	0%	B	**3.7%**
50%	5	0%	0%	B	**2.2%**
25%	5	0%	0%	B	**2.8%**
5%	5	0%	0%	B	**5.1%**
1%	5	0%	0%	B	**7.1%**

Table S4. Model results showing the effects of different (1-5) attempt rates on silver carp passage at either one or two LDs during modified gate operation and no deterrence or removal using fish the size of those in Wabash River [48]. Passage attempts ranged between 1, 2, and 5. The proportion passing Lock-and-Dam A is the total passage at one lock-and-dam and the proportion passing Lock-and-Dam B is the total passage at two consecutive lock-and-dams.

Exceedance Discharge	Attempt #	Deterrence	Removal	Lock-and-Dam	Proportion Passed
50%	1	0%	0%	A	**19.4%**
25%	1	0%	0%	A	**20.6%**
5%	1	0%	0%	A	**30.6%**
1%	1	0%	0%	A	**37.8%**
50%	2	0%	0%	A	**21.7%**
25%	2	0%	0%	A	**23.1%**
5%	2	0%	0%	A	**35.5%**
1%	2	0%	0%	A	**43.7%**
50%	5	0%	0%	A	**30.8%**
25%	5	0%	0%	A	**32.8%**
5%	5	0%	0%	A	**51.3%**
1%	5	0%	0%	A	**60.6%**
50%	1	0%	0%	B	**2.4%**
25%	1	0%	0%	B	**2.8%**
5%	1	0%	0%	B	**7.1%**
1%	1	0%	0%	B	**11.0%**
50%	2	0%	0%	B	**3.0%**
25%	2	0%	0%	B	**3.5%**
5%	2	0%	0%	B	**9.9%**
1%	2	0%	0%	B	**15.5%**
50%	5	0%	0%	B	**6.4%**
25%	5	0%	0%	B	**7.8%**
5%	5	0%	0%	B	**22.3%**
1%	5	0%	0%	B	**31.8%**