Evaluation of the sensitivity of recovery potential of spring chinook salmon in the Middle Fork to different sources of uncertainty

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UBC pφ Integrated Passage Assessment

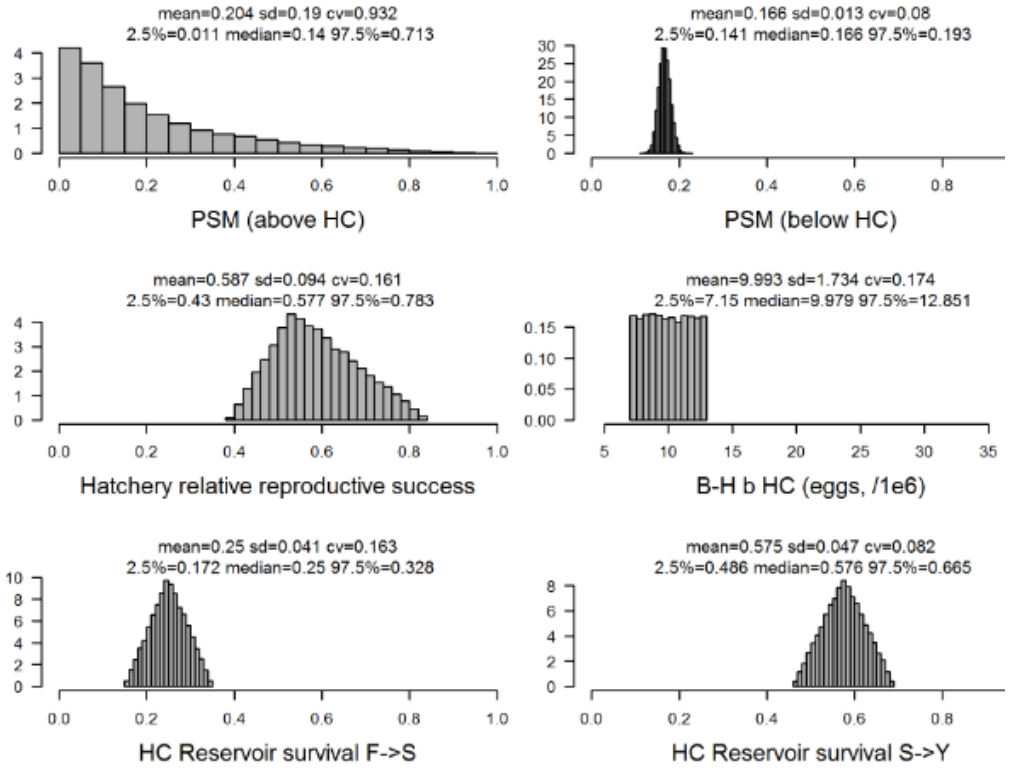
Background

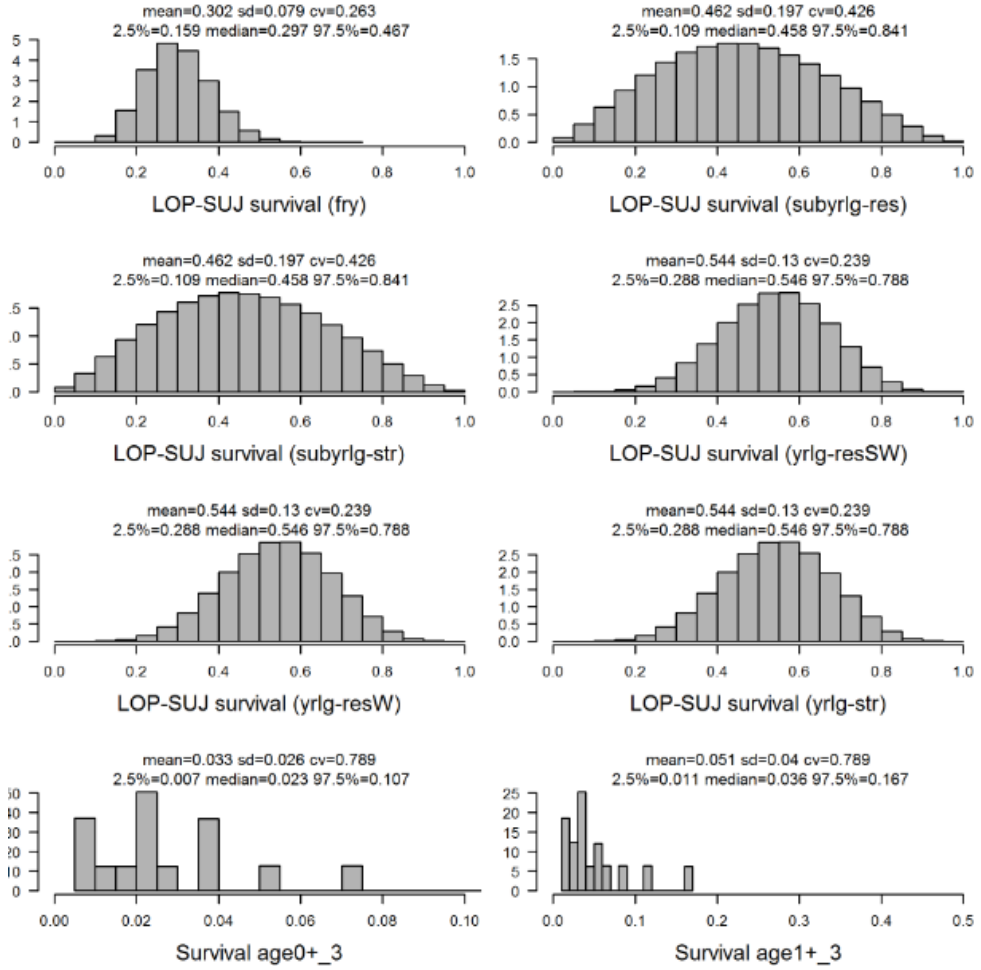
- A multi-stage life cycle model for Middle Fork (MF) spring Chinook salmon (*Oncorhynchus tshawytscha*)

- The parameter distributions (i.e., from data or reports) range from wide to very narrow, but overall they remain pretty uncertain

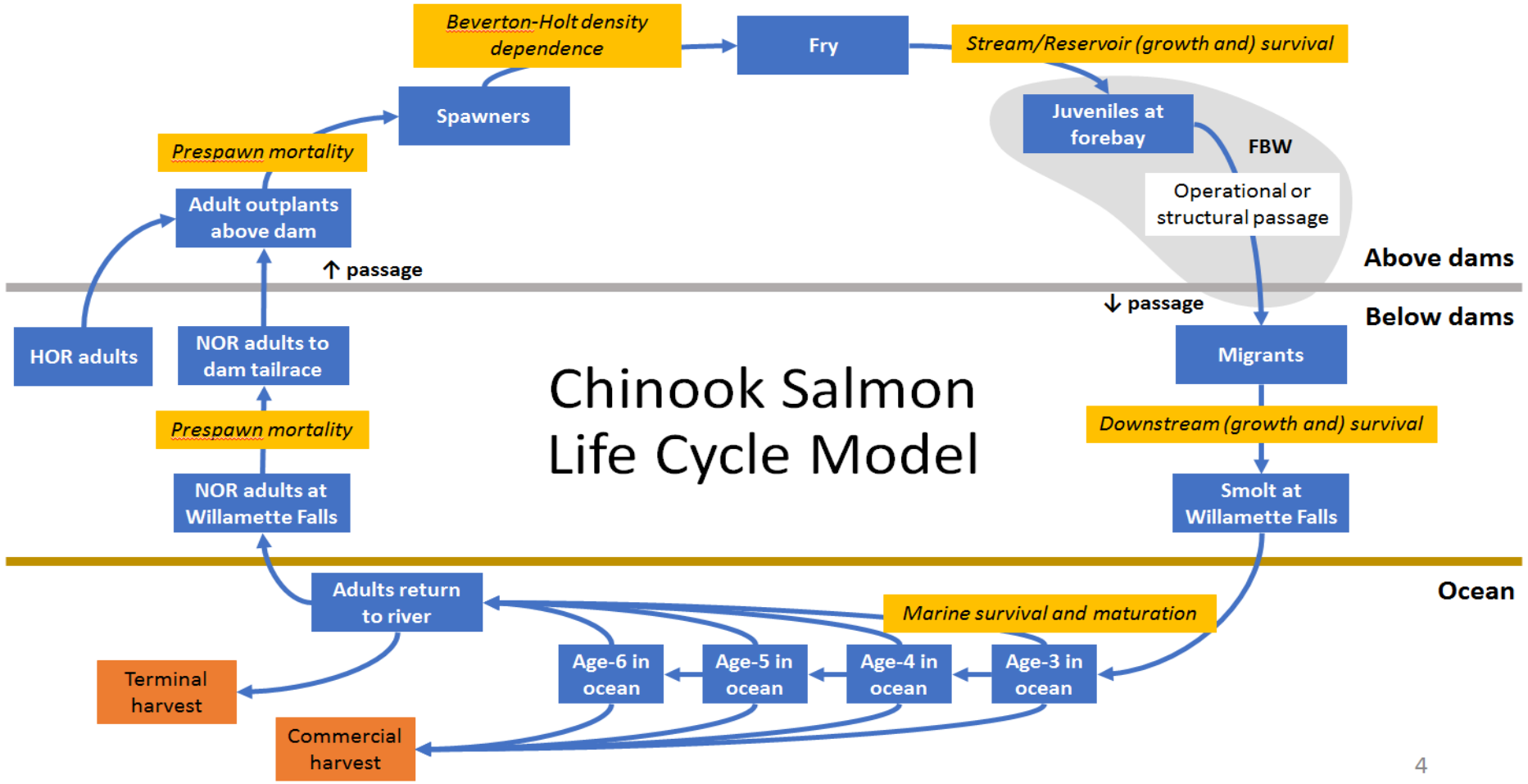
- To assess the stock recovery potential, it is important to perform sensitivity analysis; i.e., which parameter contribute more to population increase

Parameter uncertainty



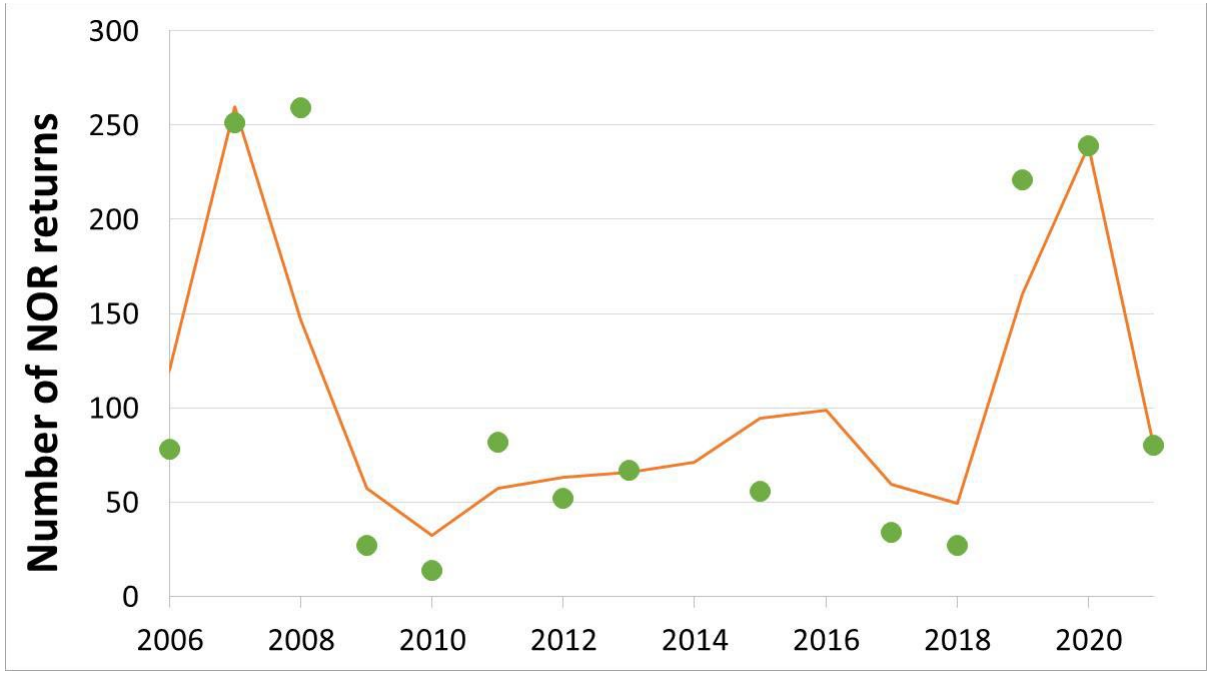


Life cycle model fitting



What limits the NOR increases/abundance?

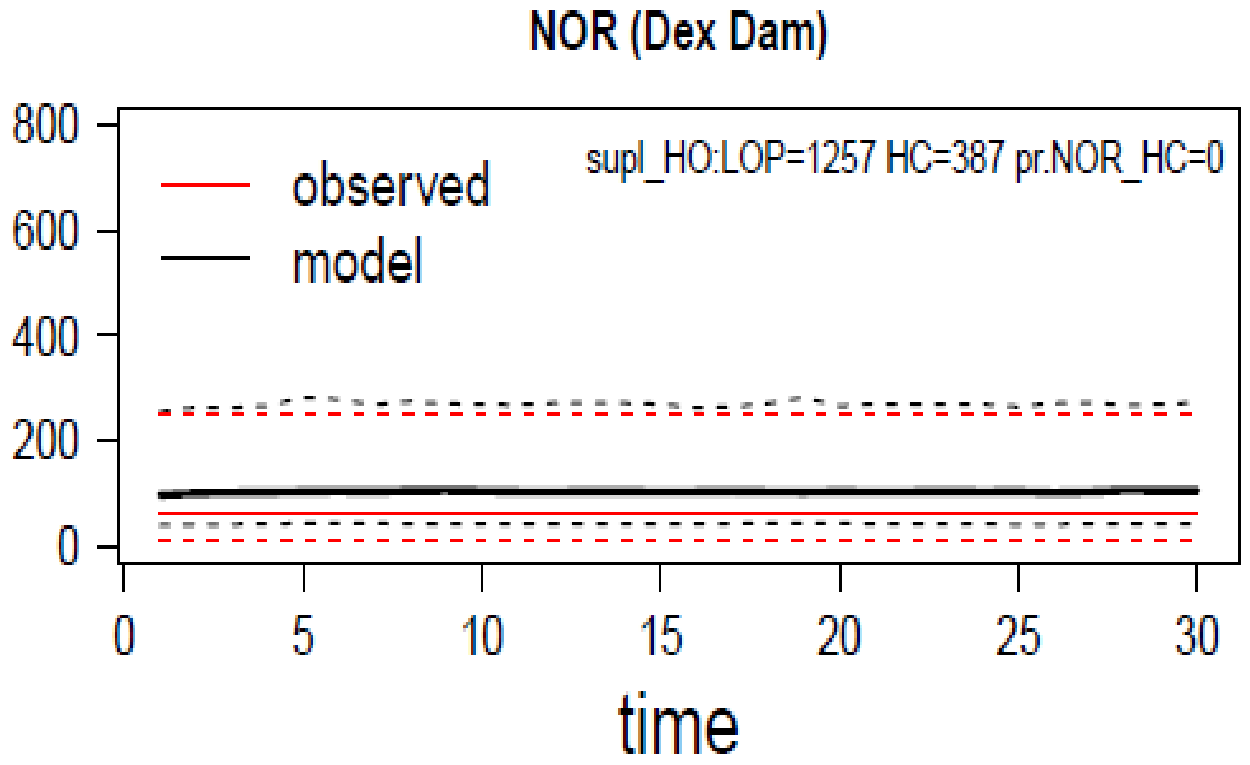
- Middle Fork shows very low abundances of adults over the last two decades (average 94, range 14-259).



- Marine survival
- Freshwater survival
- PSM (above and below dams)
- Reservoir survival
- Dam passage survival
- Etc.

Projecting the population model for 30 years for the base case scenario (i.e., current conditions).

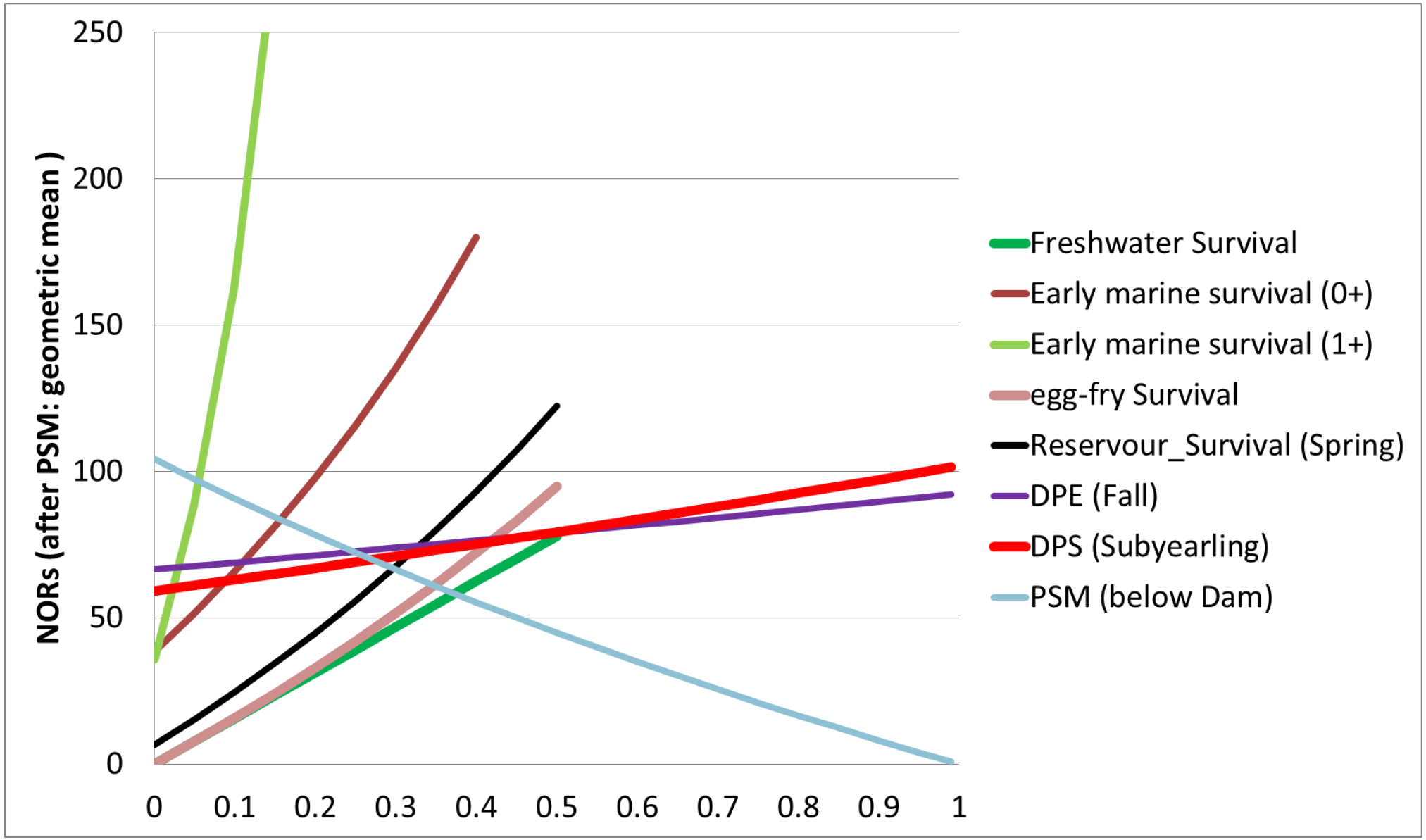
- Probabilistic model: Parameters have a parametric distribution (e.g., Marine survival, DPE, PSM, etc)
- Each year 1,257 and 387 hatchery adults are outplanted above LOP and HC, respectively
- The (probabilistic) model predicts the current conditions



Projecting the population model for 30 years for the base case scenario (i.e., current conditions).

- For the sensitivity analysis, we used the deterministic model; i.e., the model parameters are fixed to their mean estimated value
- We vary one (or two) parameter(s) (e.g., survival rates) over a range of values (e.g., 0,…,1) while fixing the others to their mean estimated/calculated value.
- The performance metric was Natural Origin Returns (NOR) after PSM and after 30 year

Sensitivity analysis: Middle Fork



Sensitivity analysis: Middle Fork

Adults (after PSM: geometric mean)

Early marine survival (1+) \ Early marine survival (0+)	83	0.001	0.05	0.1	0.15	0.2	0.25	0.3	0.35	0.4
1E-04	0	11	22	34	47	60	75	91	108	
0.05	43	57	71	87	104	123	143	165	189	
0.1	101	119	139	161	186	213	243	277	315	
0.15	182	209	239	273	312	357	410	473	549	
0.2	310	355	408	472	550	647	772	939	1170	
0.25	553	651	781	956	1195	1460	1805	2224	2718	
0.3	1224	1499	1862	2300	2813	3400	4049	4355	4355	
0.35	2922	3517	4145	4355	4355	4355	4355	4355	4355	
0.4	4355	4355	4355	4355	4355	4355	4355	4355	4355	

Sensitivity analysis: Middle Fork

Adults (after PSM: geometric mean)

PSM ABOVE DAM (BASED ON TEMP)

PSM BELOW DAM	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1E-04	982	870	767	672	586	506	434	369	310	258	211	169	133	102	75	53	35	21	10	4	0
0.05	898	797	704	618	539	467	401	342	288	239	196	158	124	95	70	50	33	19	10	4	0
0.1	820	729	645	567	496	430	370	316	266	222	182	147	116	89	66	46	31	18	9	3	0
0.15	747	665	590	520	455	395	341	291	246	205	169	136	107	82	61	43	29	17	9	3	0
0.2	679	606	538	475	416	362	313	268	226	189	156	126	99	76	57	40	27	16	8	3	0
0.25	616	551	490	433	380	331	286	245	208	174	143	116	92	71	52	37	25	15	7	3	0
0.3	557	499	444	393	345	301	261	224	190	159	131	106	84	65	48	34	23	14	7	2	0
0.35	502	449	401	355	313	273	237	203	173	145	120	97	77	59	44	31	21	13	6	2	0
0.4	449	403	360	319	282	246	214	184	156	131	108	88	70	54	40	29	19	11	6	2	0
0.45	400	360	321	285	252	221	192	165	140	118	98	79	63	49	36	26	17	10	5	2	0
0.5	354	318	285	253	224	196	171	147	125	105	87	71	57	44	33	23	16	9	5	2	0
0.55	310	279	250	222	197	173	150	130	111	93	77	63	50	39	29	21	14	8	4	2	0
0.6	268	242	217	193	171	150	131	113	97	81	68	55	44	34	26	18	12	7	4	1	0
0.65	229	207	185	165	146	129	112	97	83	70	58	47	38	29	22	16	11	6	3	1	0
0.7	191	173	155	139	123	108	94	82	70	59	49	40	32	25	19	13	9	5	3	1	0
0.75	156	141	126	113	100	88	77	67	57	48	40	33	26	20	15	11	7	4	2	1	0
0.8	122	110	99	89	79	69	61	53	45	38	32	26	21	16	12	9	6	4	2	1	0
0.85	89	81	73	65	58	51	45	39	33	28	23	19	15	12	9	6	4	3	1	0	0
0.9	58	53	47	42	38	33	29	25	22	18	15	13	10	8	6	4	3	2	1	0	0
0.95	28	26	23	21	19	16	14	12	11	9	8	6	5	4	3	2	1	1	0	0	0
0.99	6	5	5	4	4	3	3	2	2	2	2	1	1	1	1	0	0	0	0	0	0

Sensitivity analysis: Middle Fork

DAM PASSAGE SURVIVAL (Fall)

DAM PASSAGE SURVIVAL (SPRING)	0	0.05	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1
0.0001	12	17	22	27	32	37	42	48	54	60	66	73	79	86	93	101	109	117	125	134	143
0.05	13	18	23	28	33	39	44	50	56	62	68	75	81	88	96	103	111	119	128	137	146
0.1	15	20	25	30	35	40	46	52	58	64	70	77	84	91	98	106	114	122	131	140	149
0.15	16	21	26	31	37	42	48	53	59	66	72	79	86	93	100	108	116	125	134	143	152
0.2	18	23	28	33	38	44	49	55	61	68	74	81	88	95	103	111	119	127	136	146	155
0.25	19	24	29	35	40	46	51	57	63	70	76	83	90	98	105	113	122	130	139	149	159
0.3	21	26	31	36	42	47	53	59	65	72	78	85	93	100	108	116	124	133	142	152	162
0.35	22	27	33	38	43	49	55	61	67	74	81	88	95	102	110	118	127	136	145	155	165
0.4	24	29	34	40	45	51	57	63	69	76	83	90	97	105	113	121	130	139	148	158	168
0.45	26	31	36	41	47	53	59	65	71	78	85	92	100	107	115	124	132	142	151	161	172
0.5	27	32	38	43	49	55	61	67	73	80	87	94	102	110	118	126	135	144	154	164	175
0.55	29	34	39	45	51	56	63	69	75	82	89	97	104	112	120	129	138	147	157	168	178
0.6	30	36	41	47	52	58	65	71	78	84	92	99	107	115	123	132	141	151	160	171	182
0.65	32	37	43	48	54	60	67	73	80	87	94	101	109	117	126	135	144	154	164	174	185
0.7	34	39	44	50	56	62	69	75	82	89	96	104	112	120	129	138	147	157	167	178	189
0.75	35	41	46	52	58	64	71	77	84	91	99	106	114	123	131	140	150	160	170	181	193
0.8	37	42	48	54	60	66	73	79	86	93	101	109	117	125	134	143	153	163	174	185	196
0.85	39	44	50	56	62	68	75	81	88	96	103	111	119	128	137	146	156	166	177	188	200
0.9	40	46	52	58	64	70	77	84	91	98	106	114	122	131	140	149	159	170	181	192	204
0.95	42	48	54	60	66	72	79	86	93	100	108	116	125	134	143	152	162	173	184	196	208
1	44	49	55	61	68	74	81	88	95	103	111	119	127	136	146	155	166	176	188	199	212

Sensitivity analysis: Middle Fork

Adults (after PSM: geometric mean)

Reservoir survival at LOP (spring)

Reservoir survival at LOP (fall)	0	0.05	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5
0	6	11	17	22	27	33	39	45	52	58	65
0.05	6	12	18	24	30	37	44	51	58	66	74
0.1	6	13	19	26	33	40	48	56	65	73	83
0.15	6	13	21	28	36	44	53	62	71	81	92
0.2	6	14	22	30	39	48	58	68	78	90	102
0.25	6	15	23	32	42	52	62	74	86	98	112
0.3	6	15	25	34	45	56	67	80	93	107	123
0.35	6	16	26	37	48	60	73	86	101	117	134
0.4	6	17	27	39	51	64	78	93	109	127	146
0.45	6	17	29	41	54	68	83	100	117	137	158
0.5	6	18	30	43	57	72	89	107	126	148	171

Conclusions

- The results show that early marine survivals are the most influential parameter affecting the predicted/future adults abundance
- Many recent peer-review papers agree that early stages marine survivals are key for increasing salmon abundance (e.g., Beamish 2020, Welch et al 2021). The early stages marine survivals also have high variability (Brenden et al 2012)
- Reservoir survivals (for fish remaining in spring and fall at LOP) and PSM were also important.
- Model runs show that low adults abundance at MF could be explained by marine survival. I might the case for spring Chinook salmon in other Willamette sub-basins.
- More studies to reduce uncertainty. Some parameters were estimated from data, taken from reports or assumed. Overall model parameters have a lot of uncertainty

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