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Systematic Review of JSATS Passage and Survival Data at Bonneville and The Dalles Dams during Alternate Turbine and Spillbay Operations from 2008-2012

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Introduction: BON

- Operation of Bonneville Dam to reduce fish injury
  - B2 operation at low to mid range of 1% peak efficiency
    - Improve conditions for guided fish in the gatewell
    - May result in unfavorable conditions for turbine passed fish
  - B1 increase flow to offset reduced discharge at B2
    - Compare survival within to above the 1% operating range
      - Best operating point (range) as identified by TSP
  - Spillway survival variability
    - Erosion of stilling basin or ogees in several spill bays and accumulation of rock

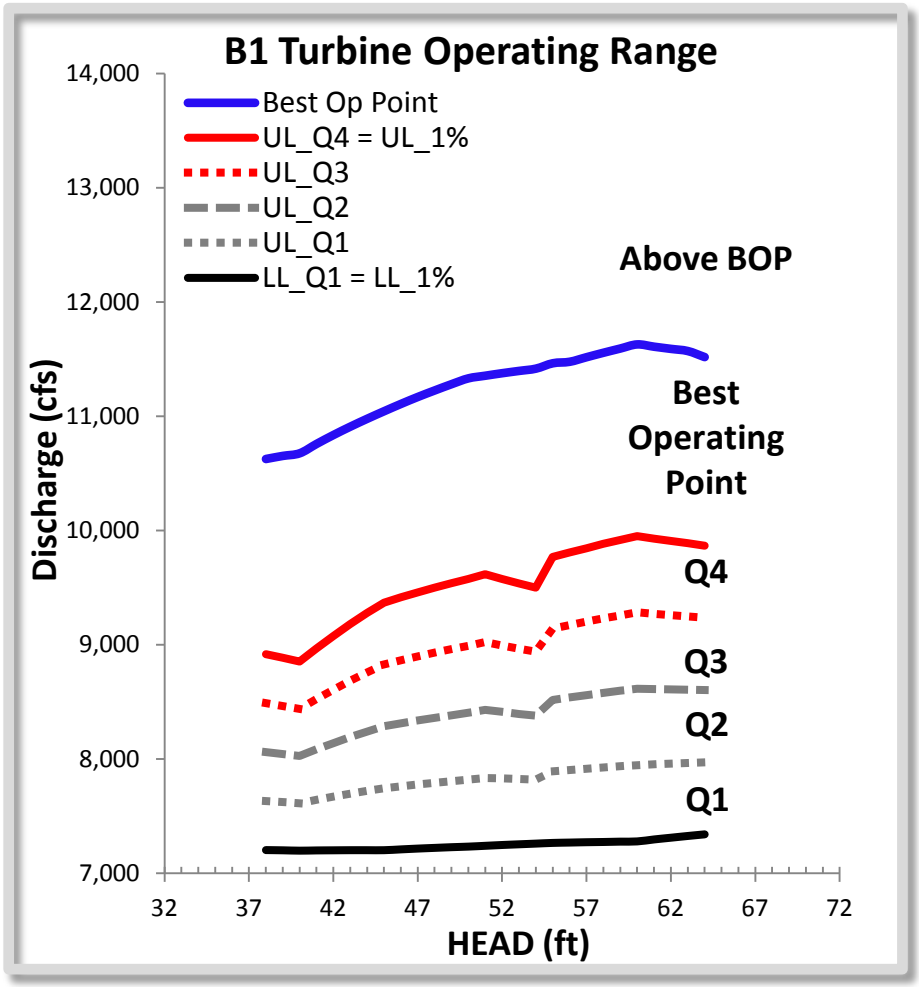
Objectives: BON

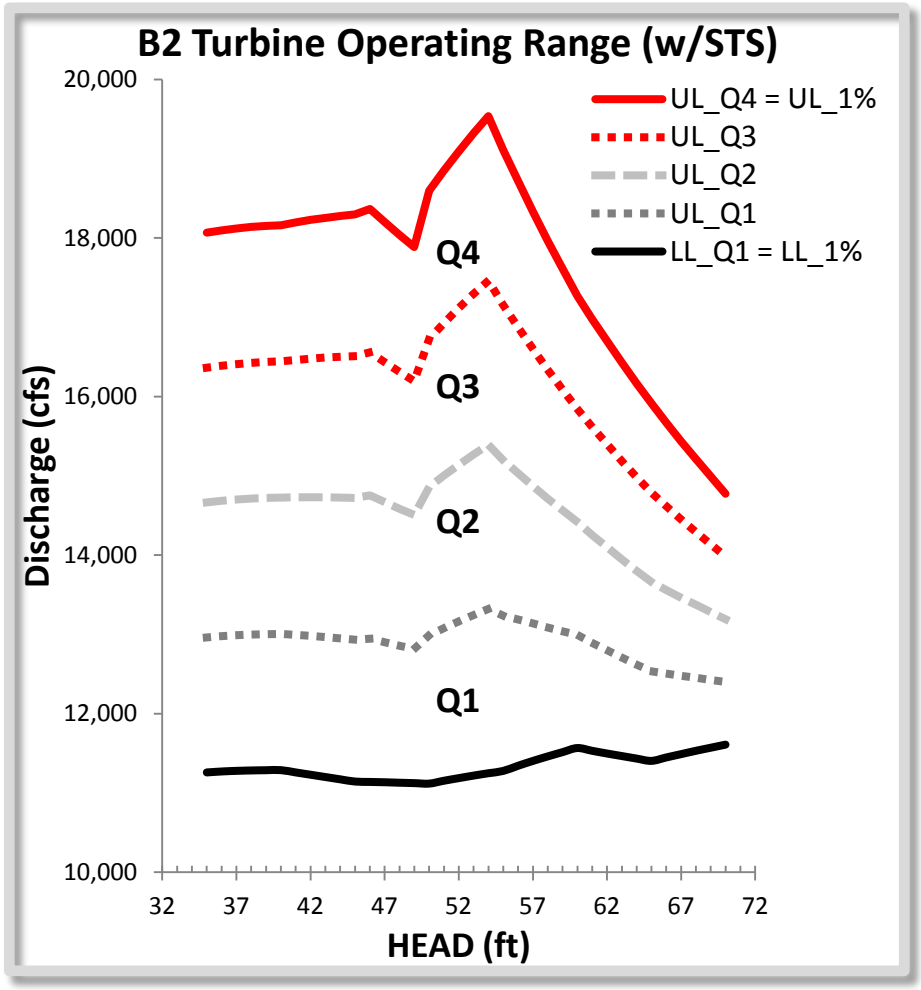
- Analyze 2008-2012 JSATS and operations data to examine survival rates for juvenile salmonids at BON
  - B2 Turbine Survival Comparison:
    - Examine survival for fish passing turbines operating across the 1% peak efficiency range
  - B1 Turbine Survival Comparison:
    - Examine survival for fish passing turbines operating within the 1% peak efficiency range and above the upper limit of the 1% operating range
  - Bonneville Spillway:
    - Examine spillway survival by spillbay with focus on those bays where erosion of the ogee or stilling basin immediately downstream had occurred

Methods: BON

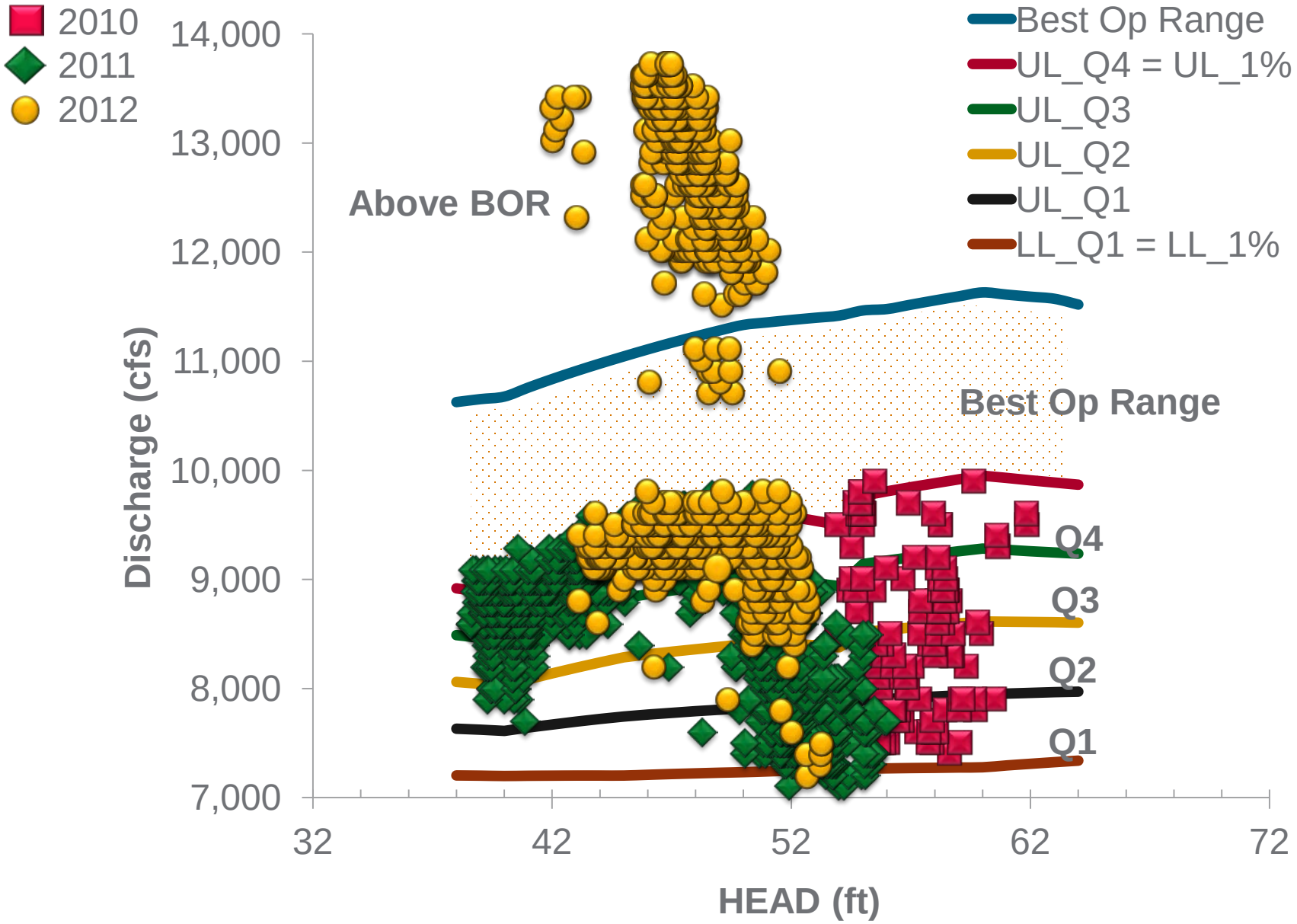
- B1 turbines
  - Lower quarter of 1% efficiency (Q1)
  - Lower middle quarter of 1% efficiency (Q2)
  - Upper middle quarter of 1% efficiency (Q3)
  - 1% of peak efficiency (Q4)
  - Best operating point/range (BOP)
  - Above best operating point to generator limit (ABOP)
- B2 turbines
  - Lower quarter of 1% efficiency (Q1)
  - Lower middle quarter of 1% efficiency (Q2)
  - Upper middle quarter of 1% efficiency (Q3)
  - 1% of peak efficiency (Q4)
- BON spillway
  - By bay
  - Group bays

Methods: B1 and B2 Binned Operating Ranges

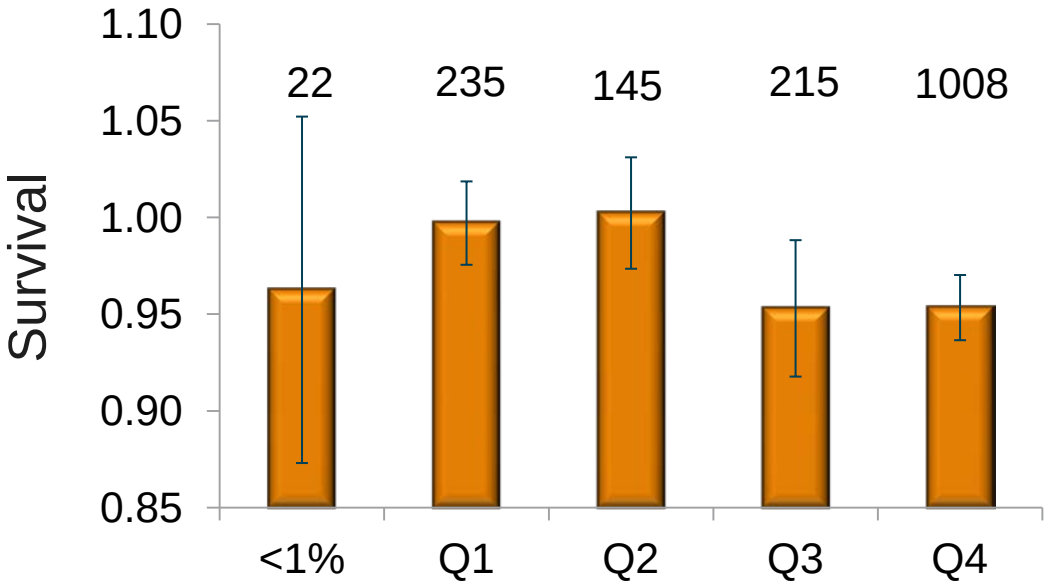


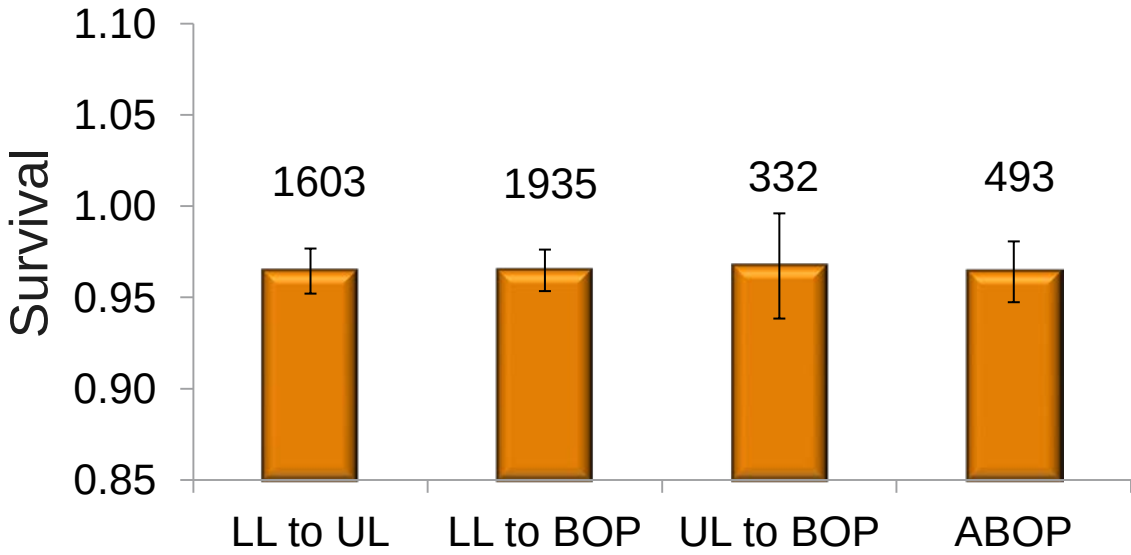


Analyses: BON
B1 CH1 Passage Distribution

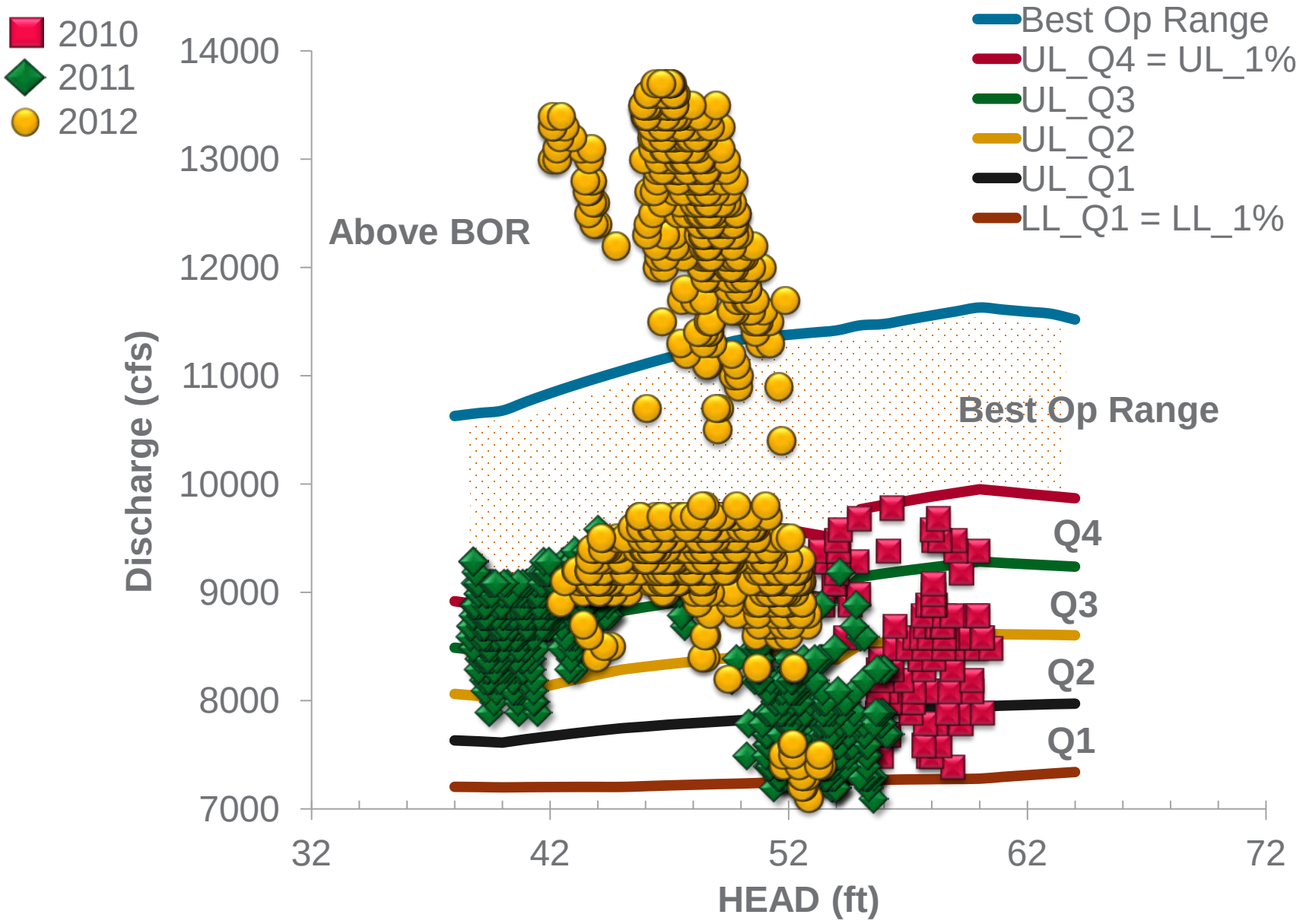


Analyses: BON
B1 CH1 Survival by Operating Condition

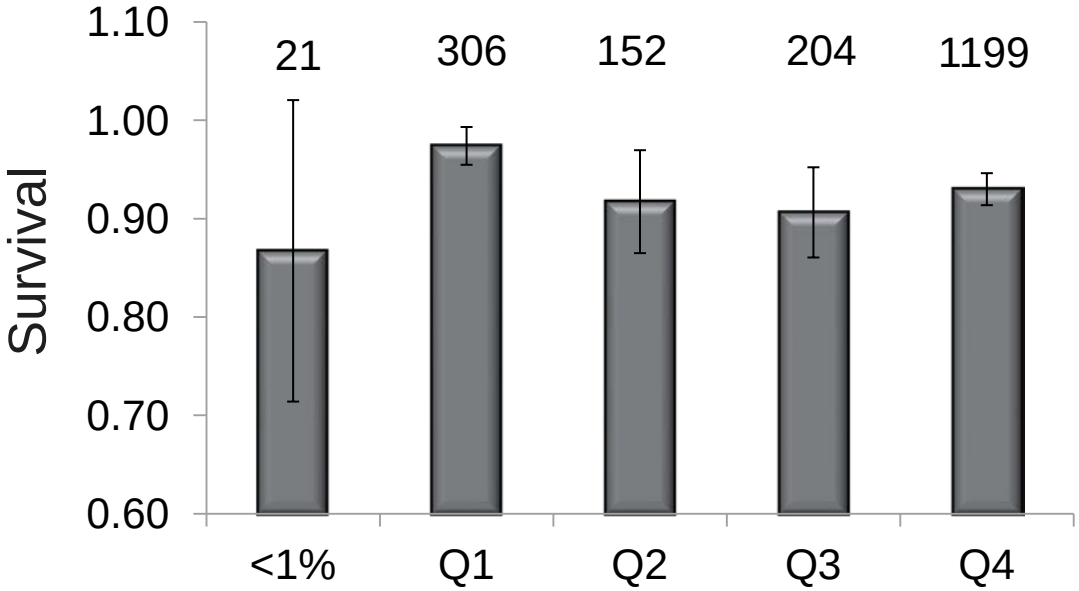


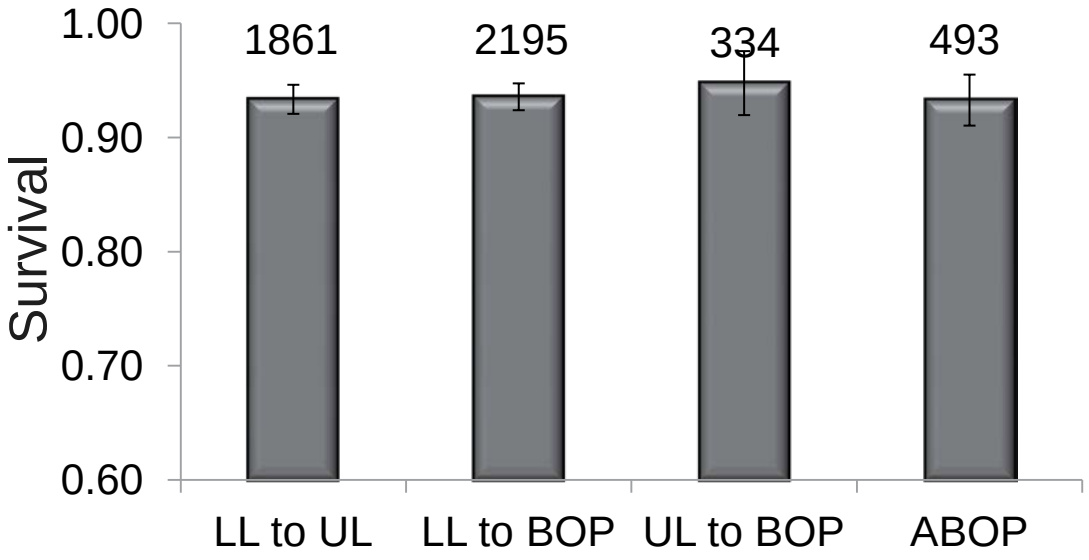


Analyses: BON
B1 STH Passage Distribution

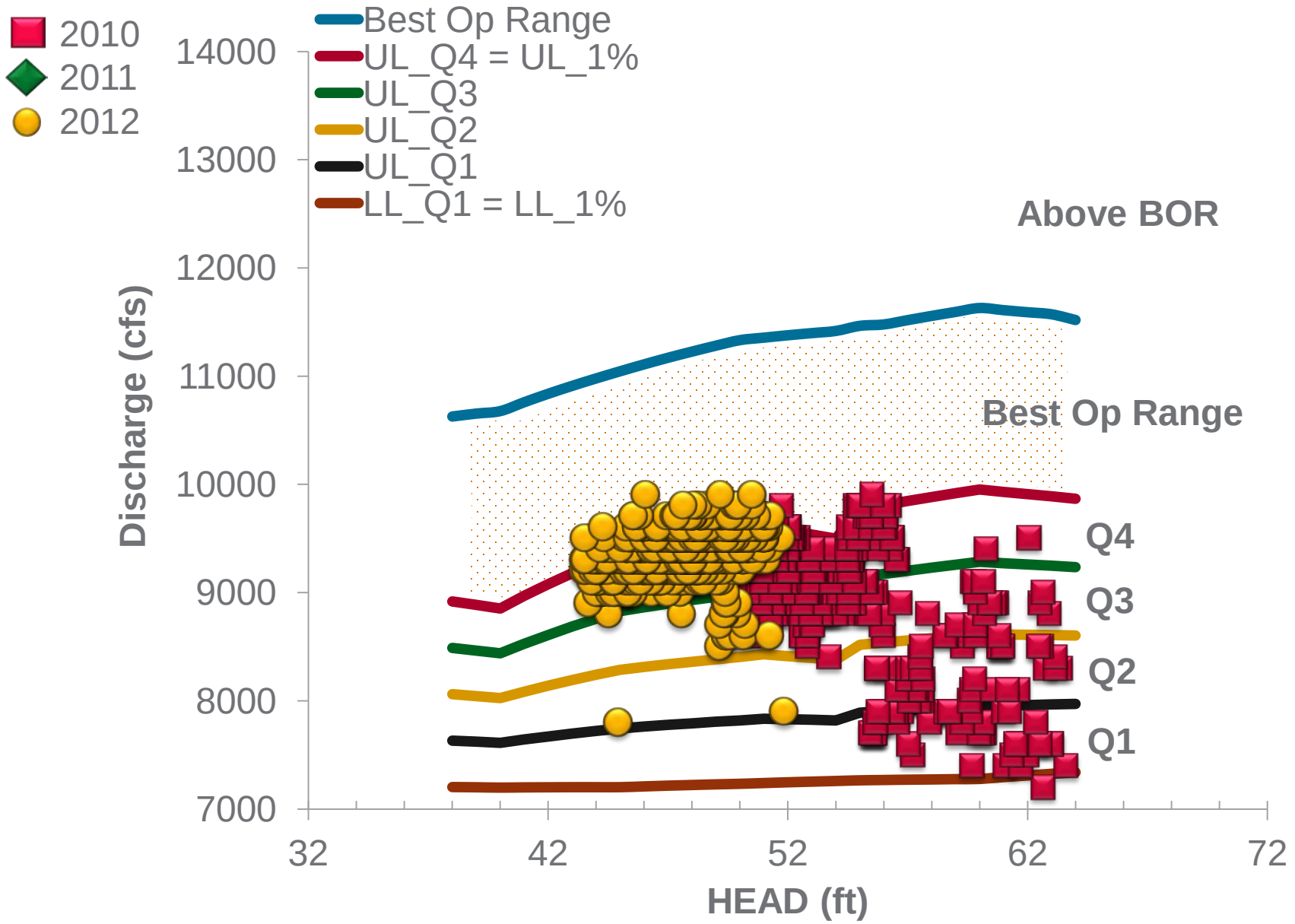


Analyses: BON
B1 STH Survival by Operating Condition

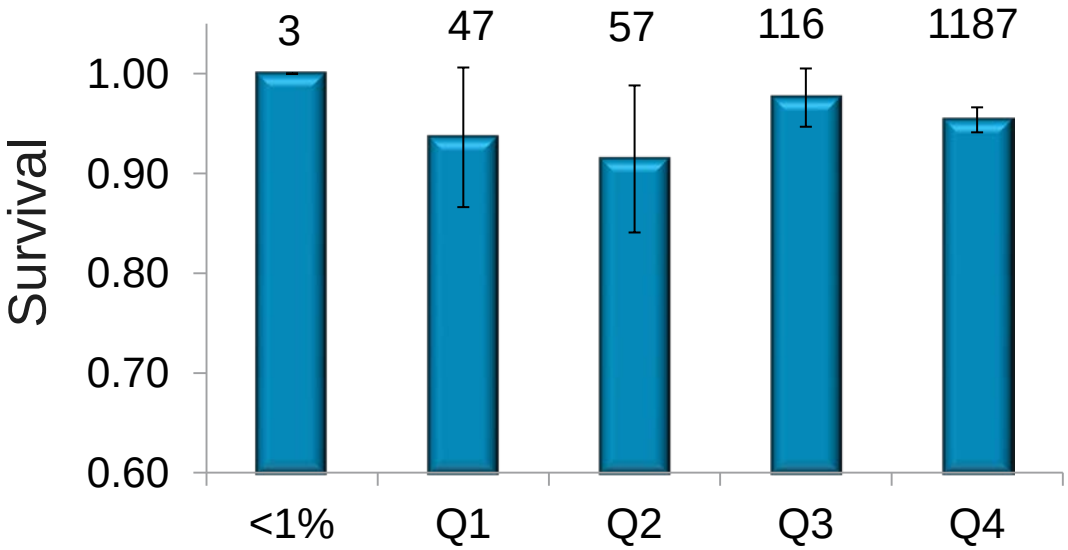


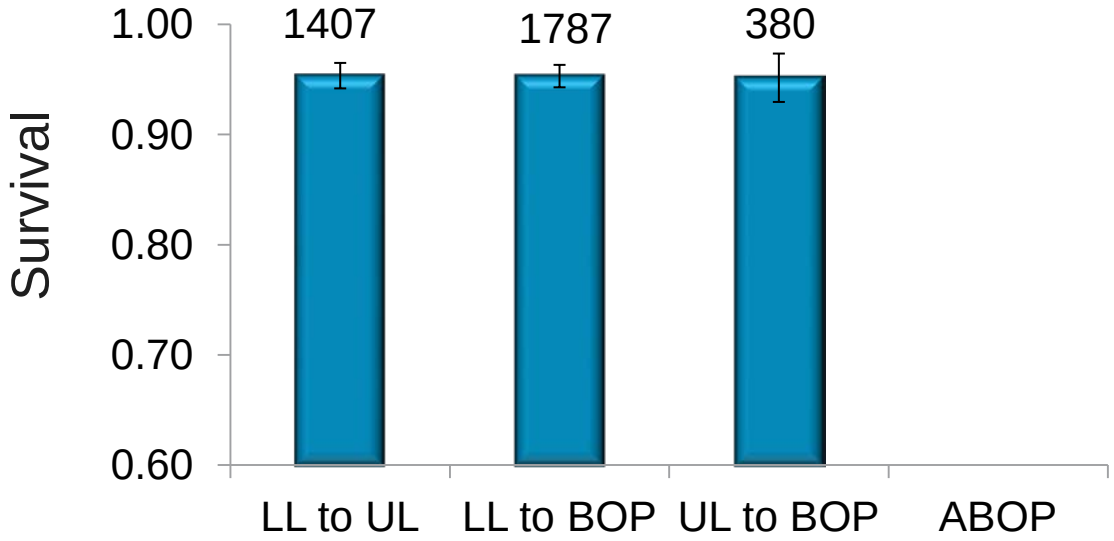


Analyses: BON
B1 CH0 Passage Distribution

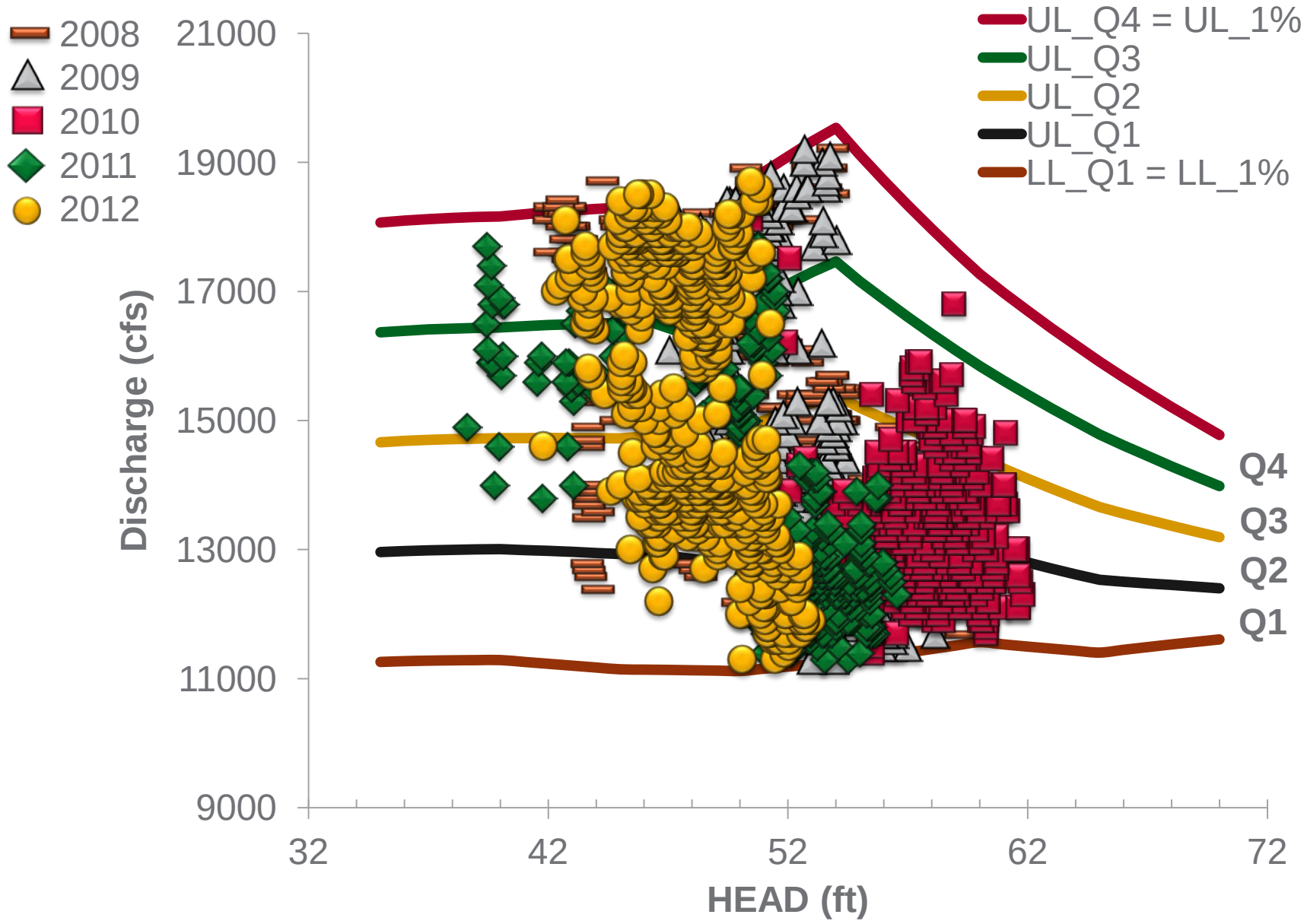


Analyses: BON
B1 CH0 Survival by Operating Condition

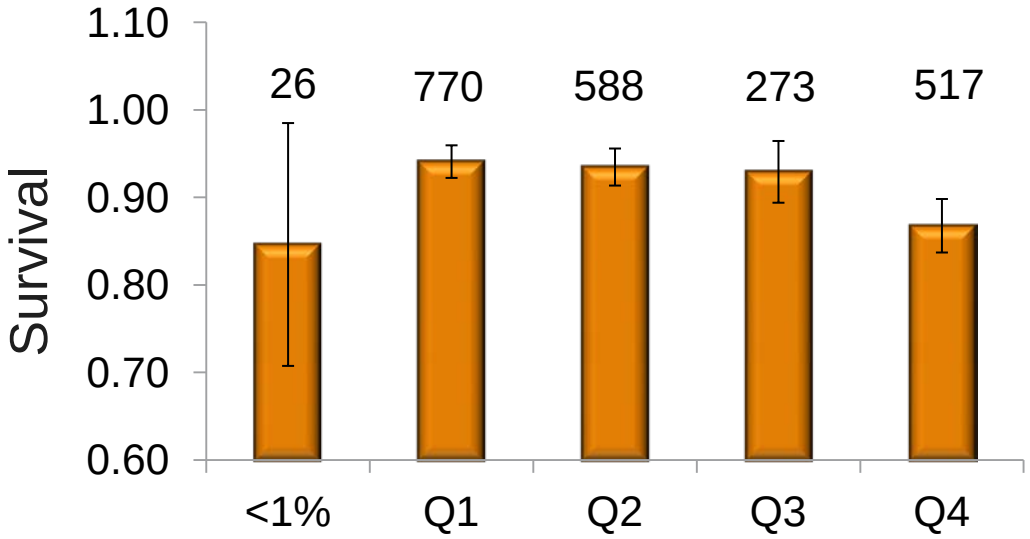




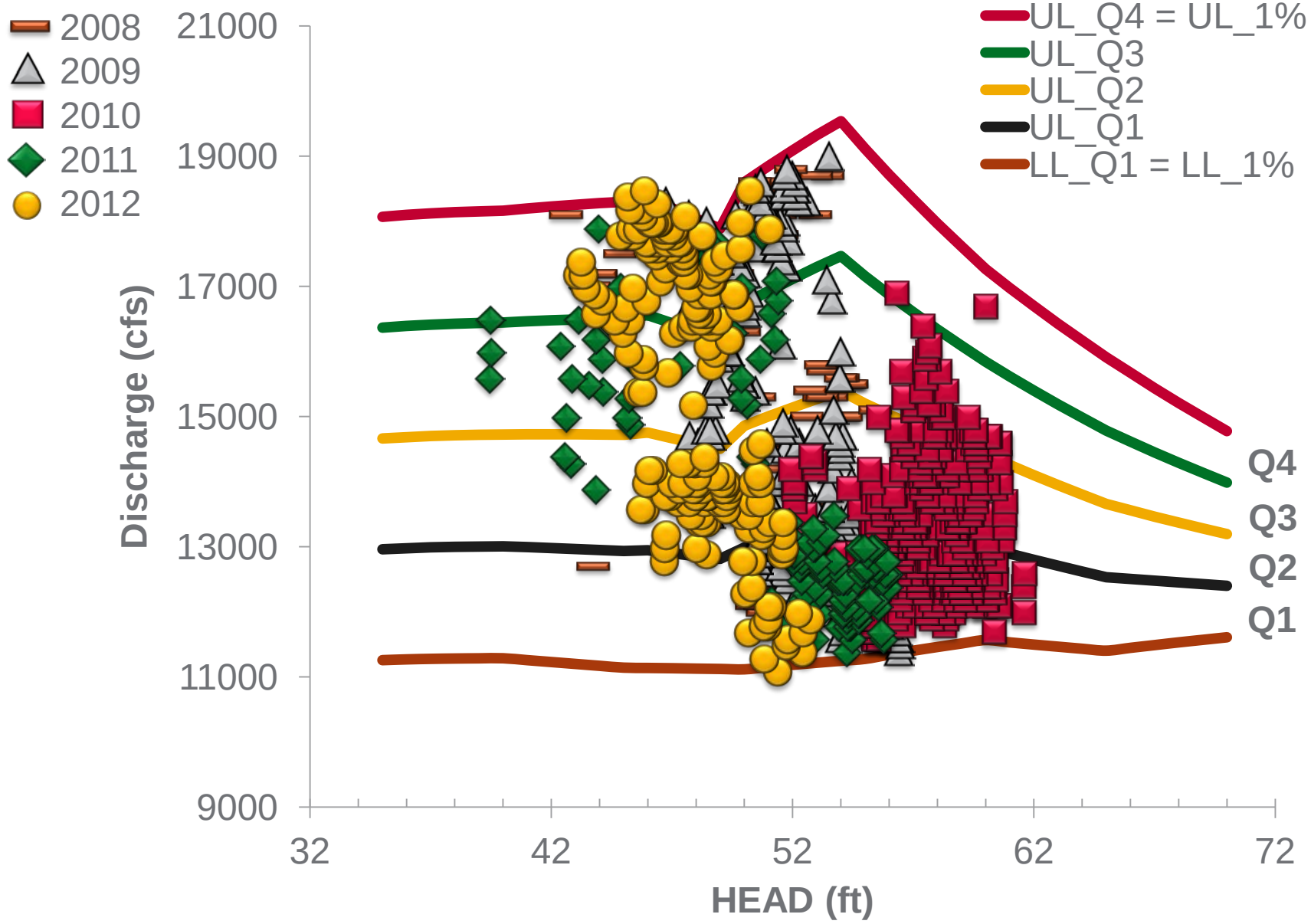
Analyses: BON
B2 CH1 Passage by Quartile



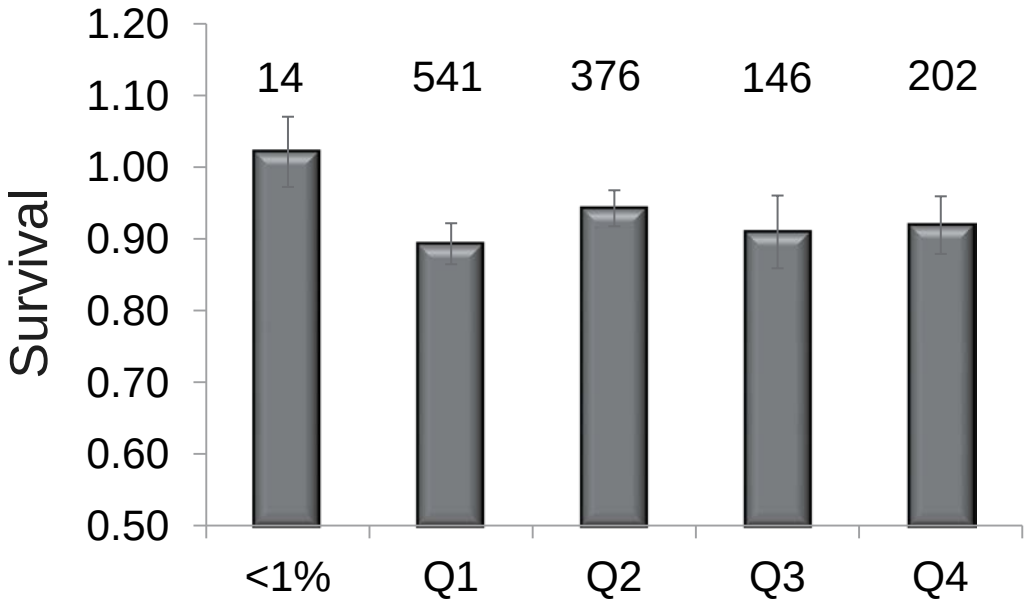
Analyses: BON
B2 CH1 Survival by Operating Condition



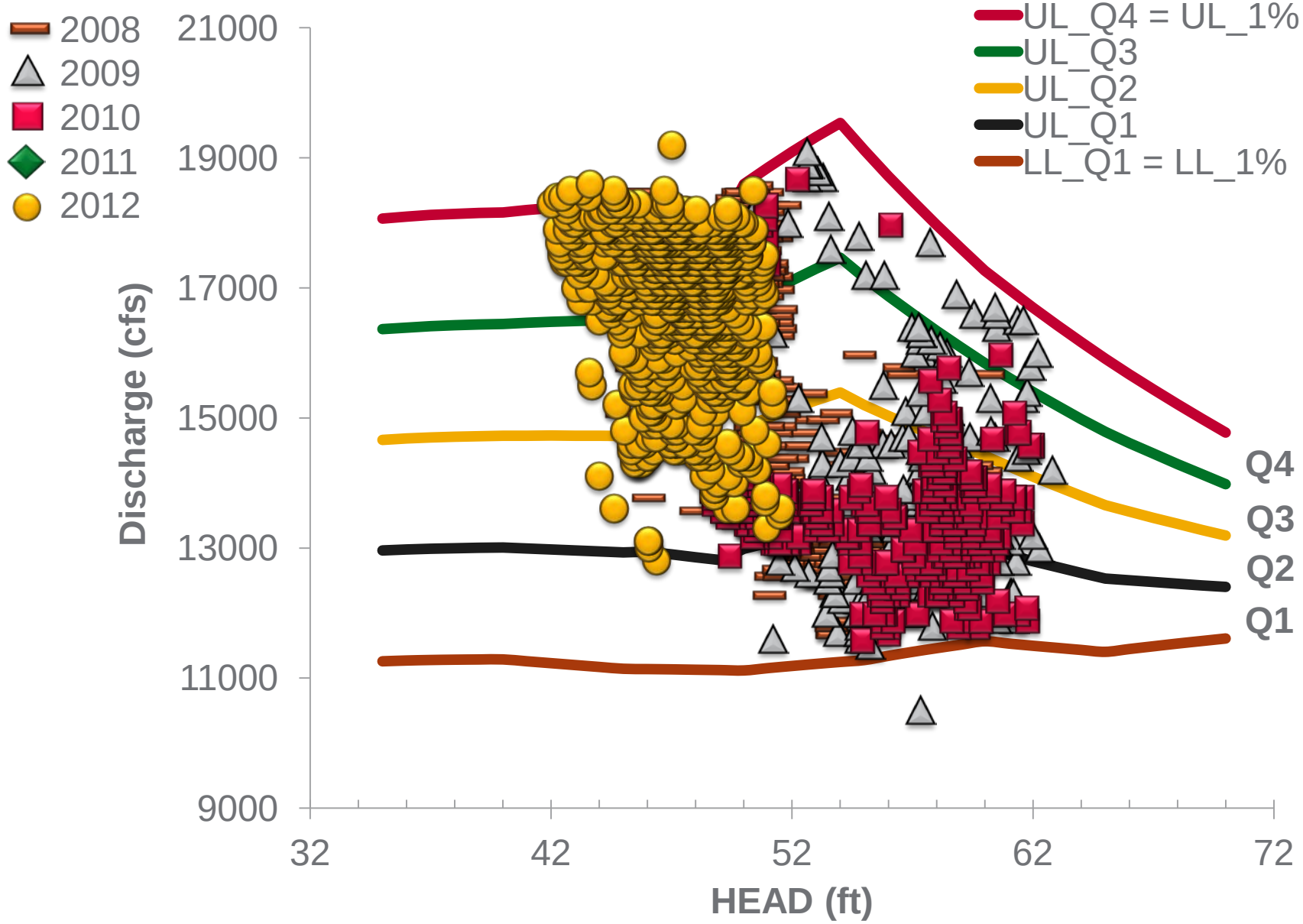
Analyses: BON
B2 STH Passage Distribution



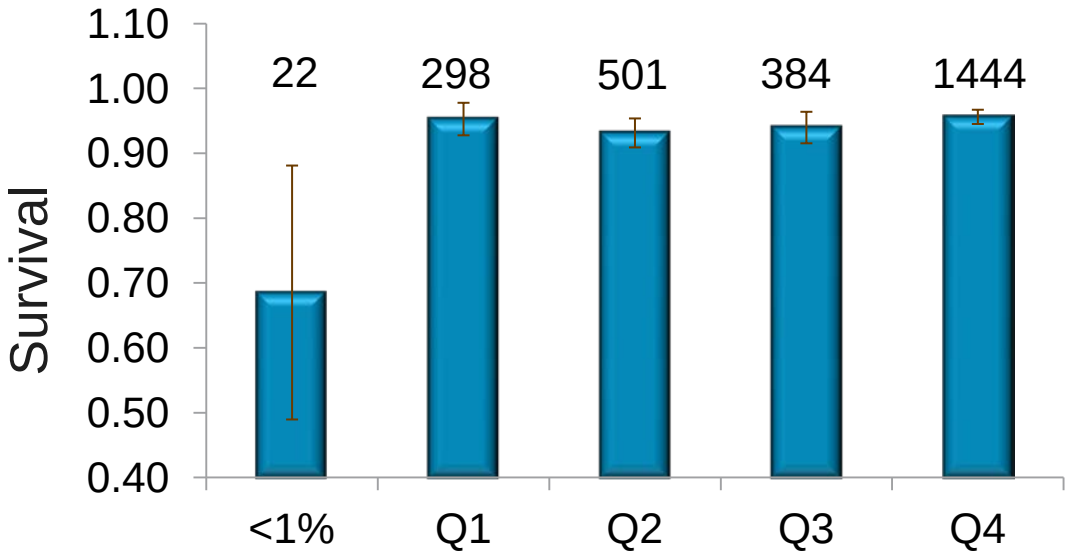
Analyses: BON
B2 STH Survival by Operating Condition



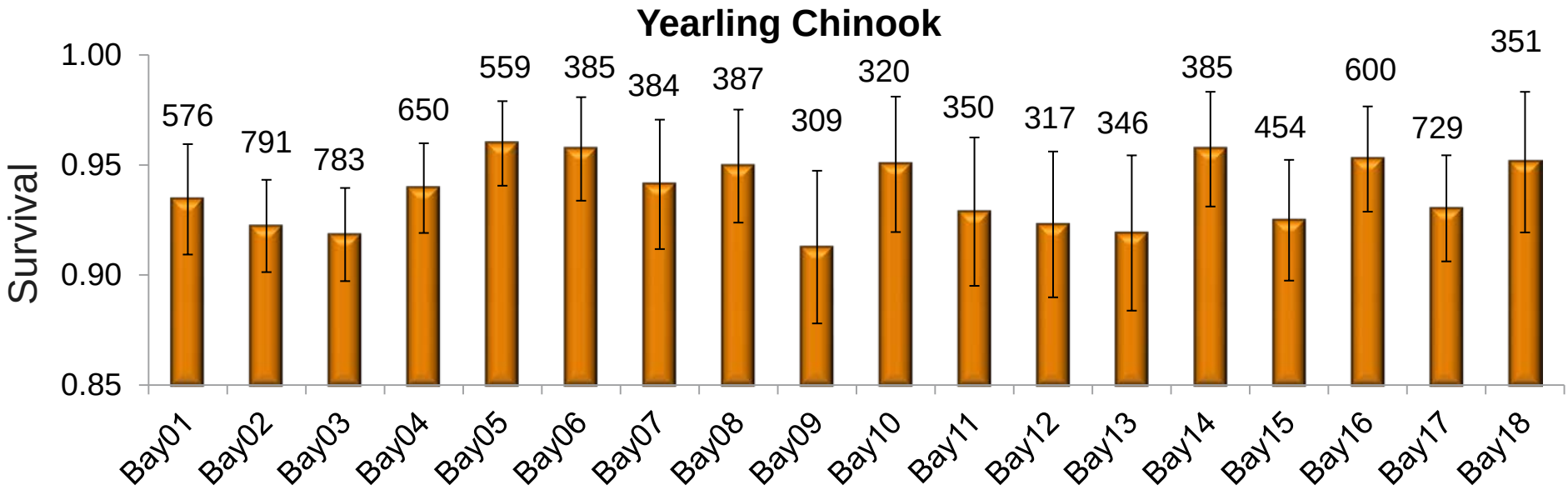
Analyses: BON
B2 CH0 Passage Distribution

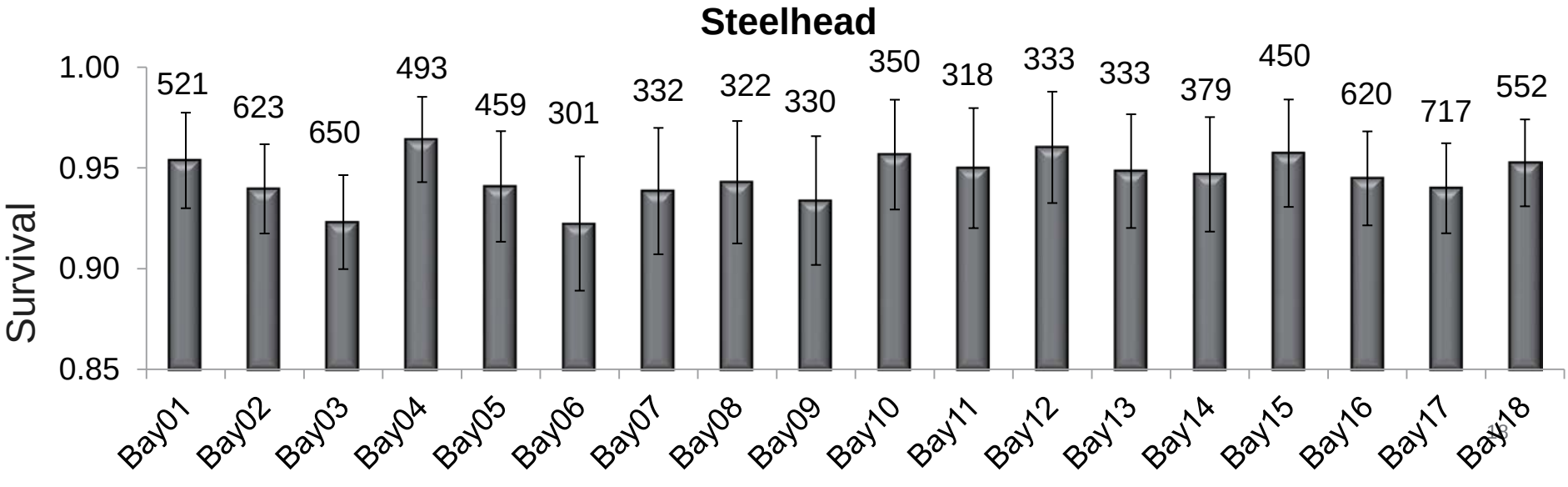


Analyses: BON
B2 CH0 Survival by Operating Condition

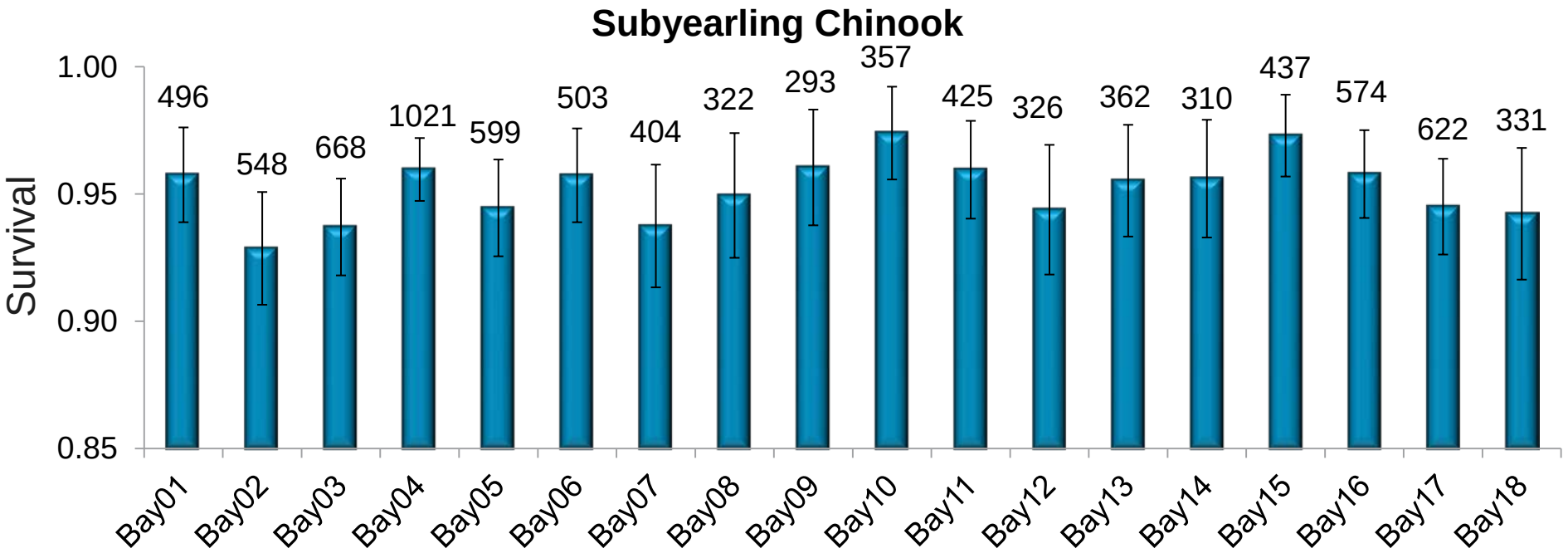


Analyses: BON
Spillway CH1 and STH Survival by Bay

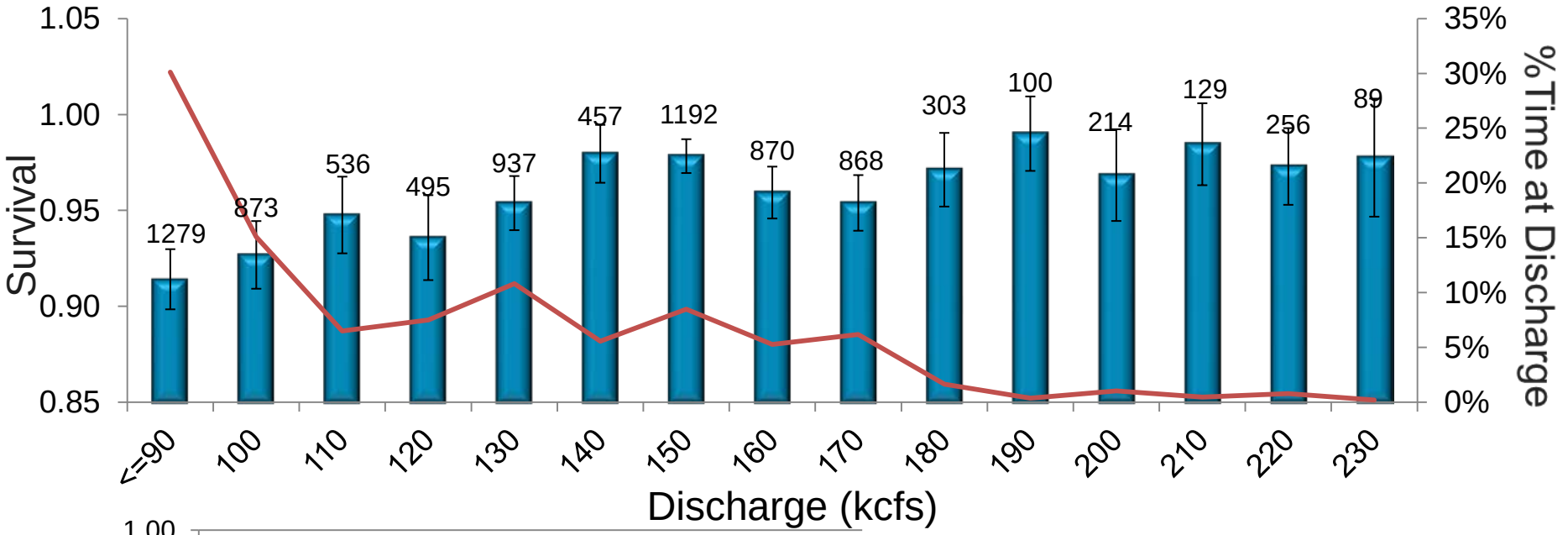


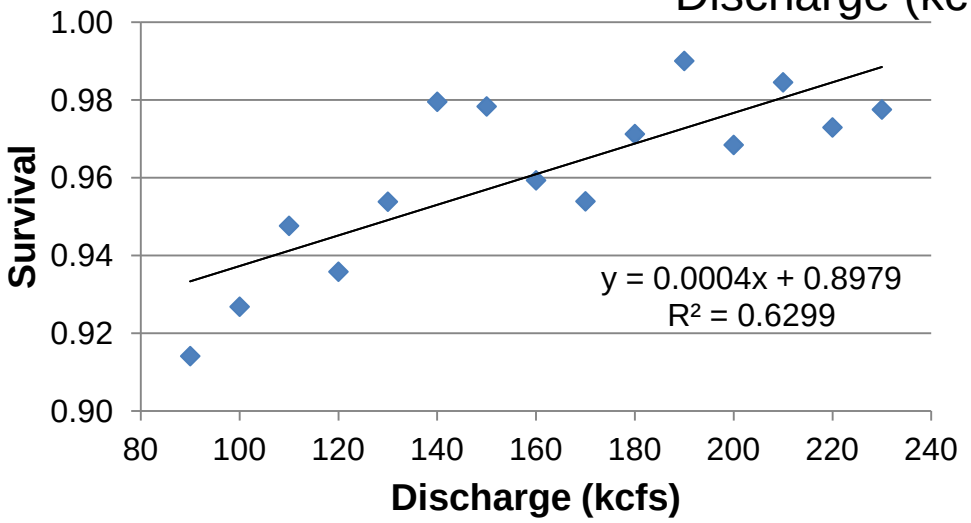


Analyses: BON
Spillway CH0 Survival by Bay



Analyses: BON
Spillway CH1 and STH Survival by Discharge

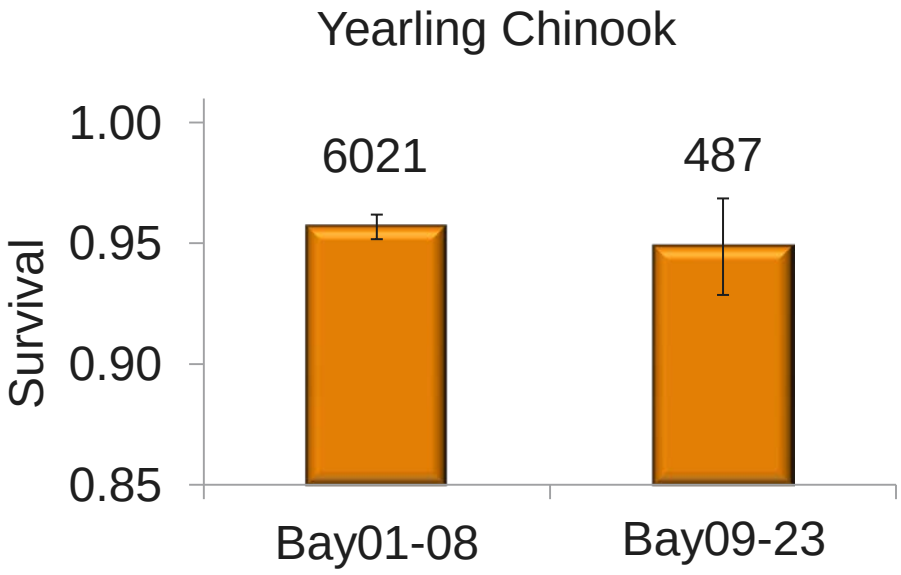


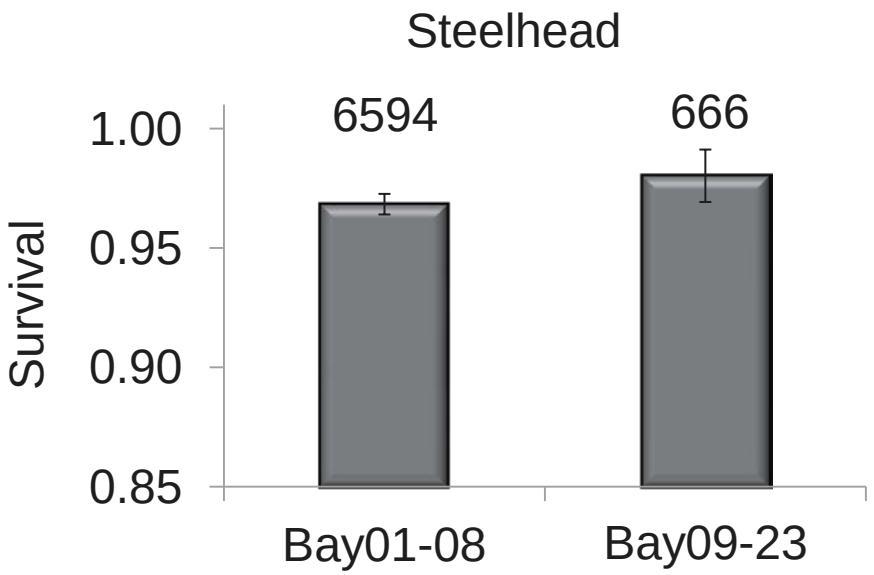


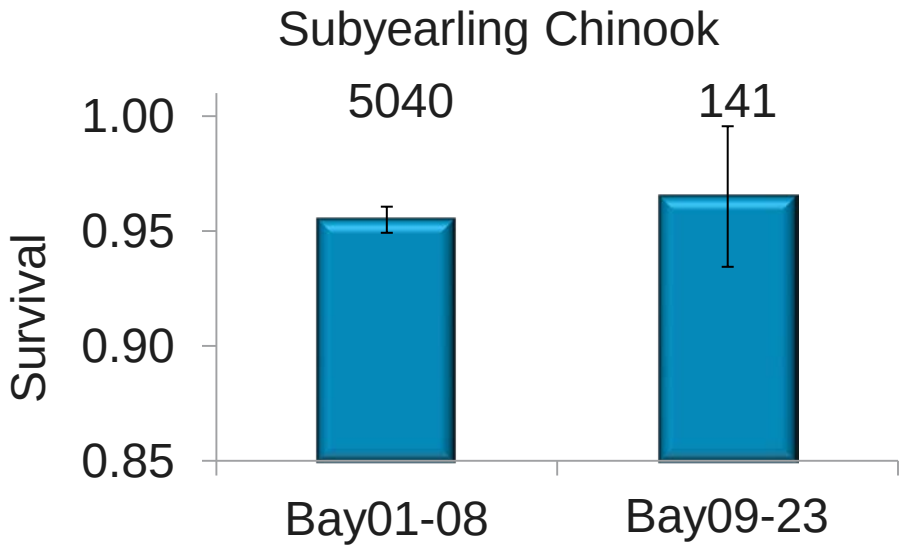
Introduction: TDA

- Introduction
  - High flows forced spill discharge at bays outside the new tailrace spillway wall. Concern of lower survival due to predation
- Objective
  - Examined spillway passage survival for juvenile salmonids passing on the north (spillbays 1-8) and south (spillbays 9-23) of the new spill wall at TDA
  - 2010-2012 JSATS datasets

Analyses: TDA
Survival Within and Outside of Spill Wall







Analyses: TDA
Survival Outside of Spill Wall, Grouped Bays

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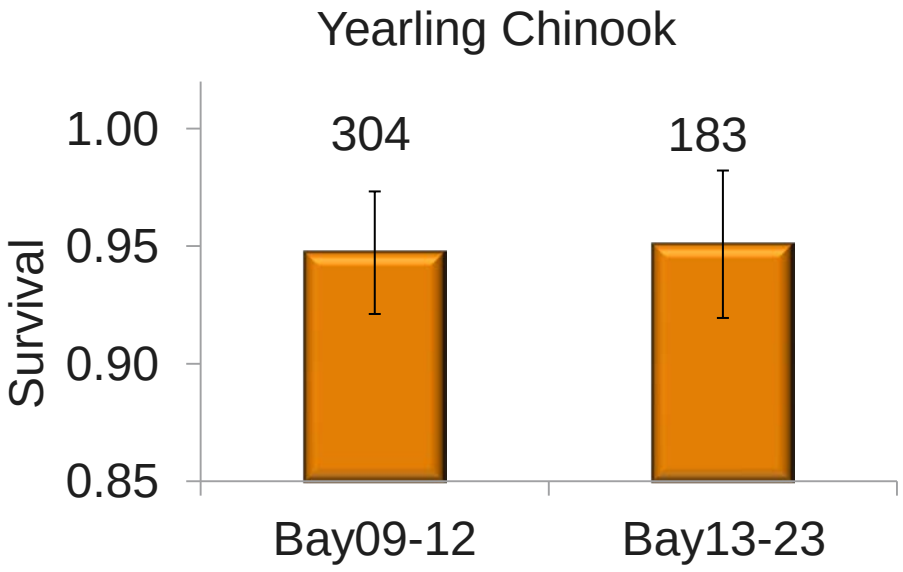
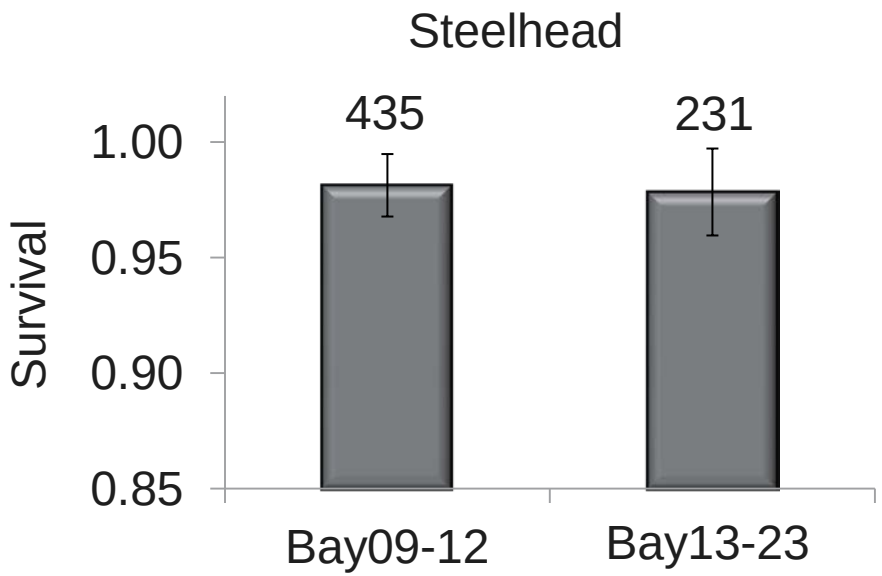
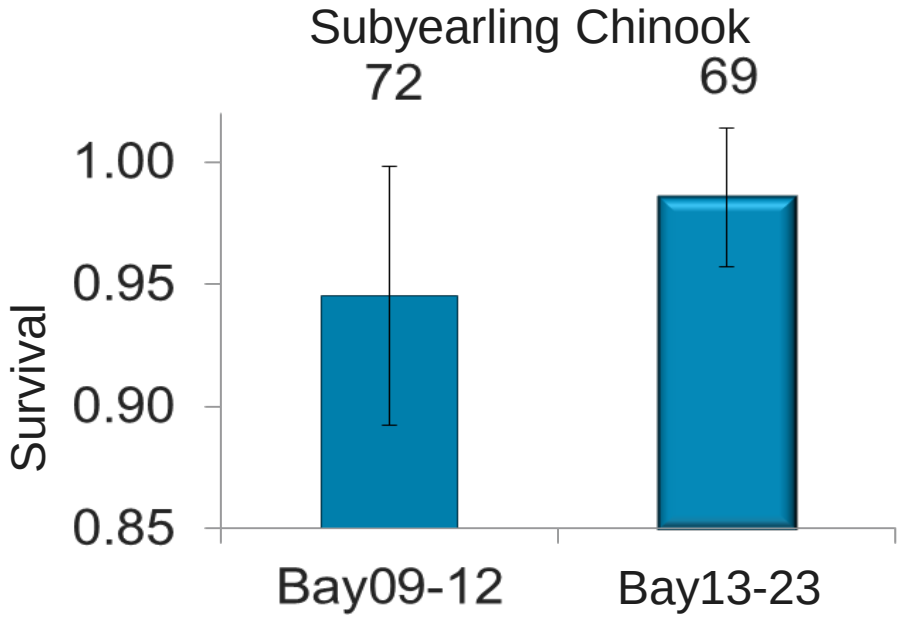
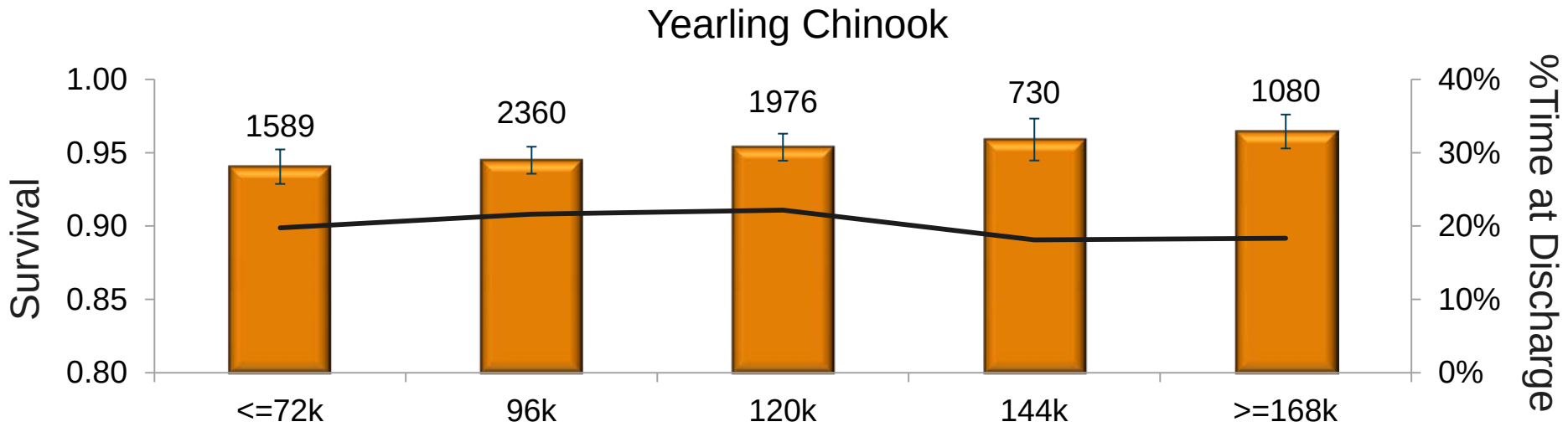
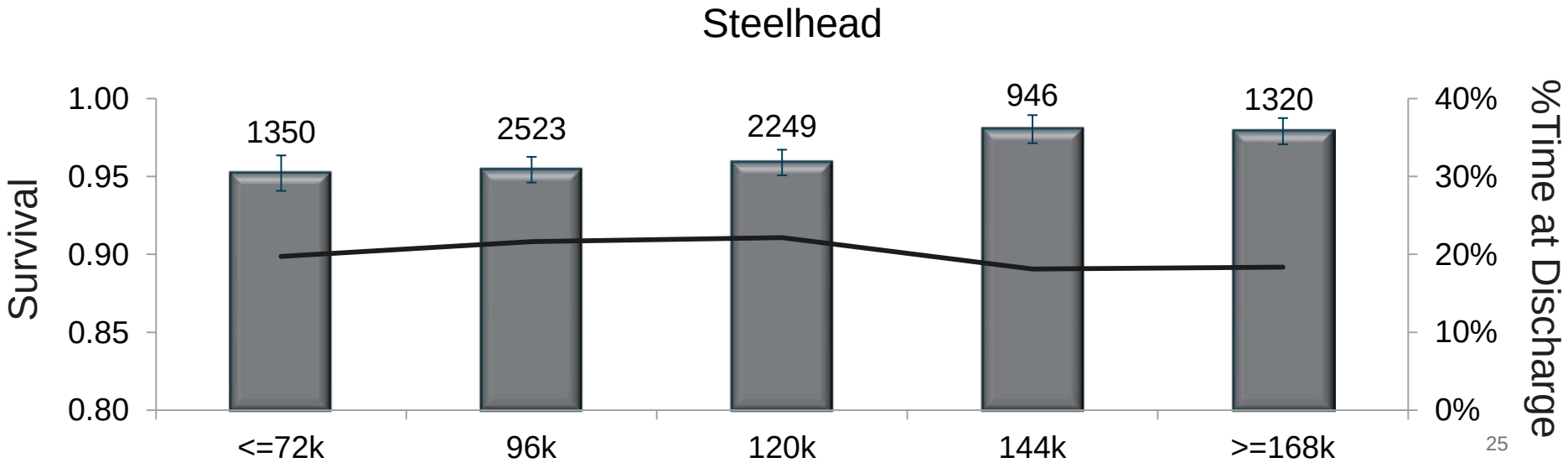




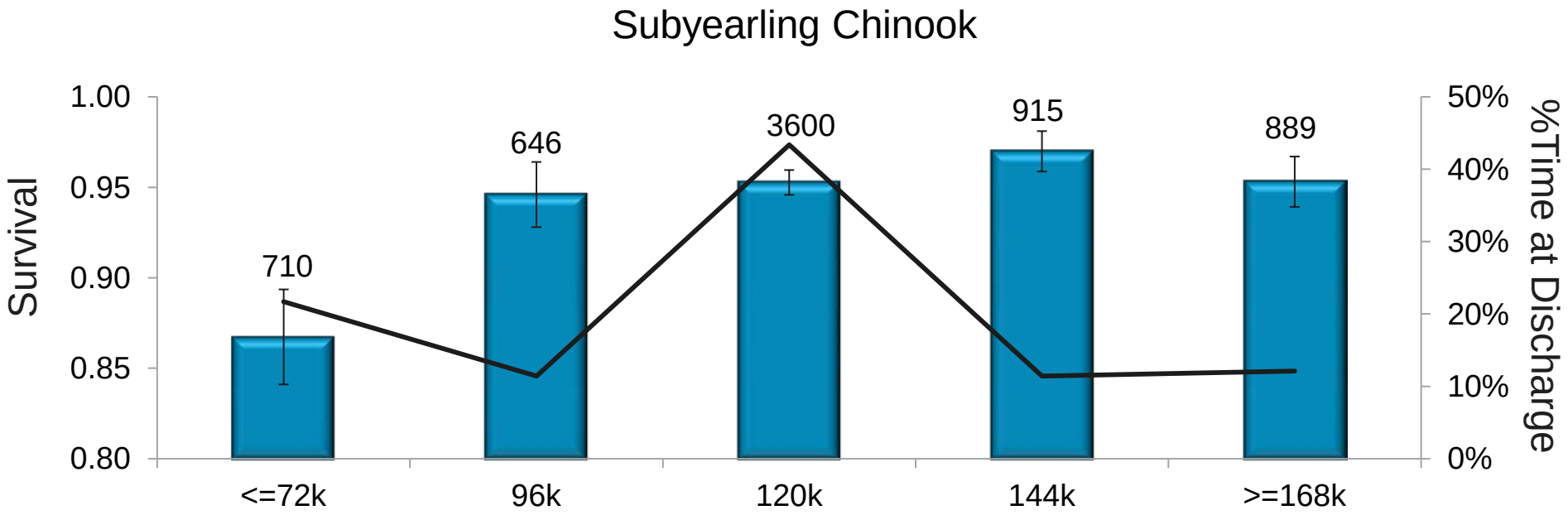


Analyses: TDA
Survival Grouped by Flow





Analyses: TDA
Survival Grouped by Flow



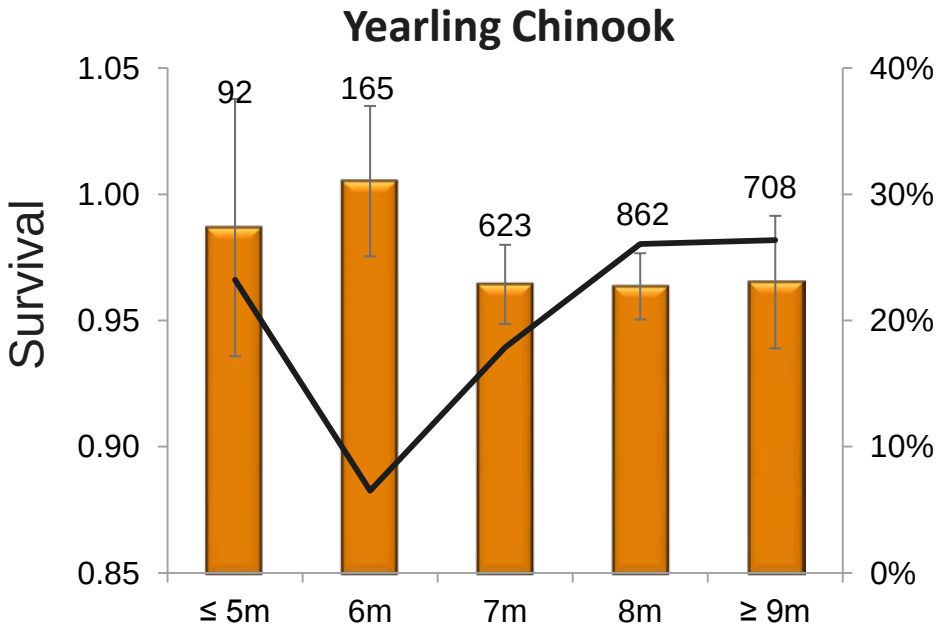
Conclusions: BON

- B1
  - There was not a difference in survival for salmonids passing within the 1% of peak operating efficiency and salmonids passing at operations above the upper 1% operating efficiency
- B2
  - Lower survival for CH1 in Q4 range
  - No difference in survival for STH across operating range
  - No difference in survival for CH0 across operating range
- Spillway
  - No obvious bay affect
  - Lower survival of CH1 and STH above 290 kcfs discharge
  - Trend of lower survival for CH0 at low discharge levels

Conclusions: TDA

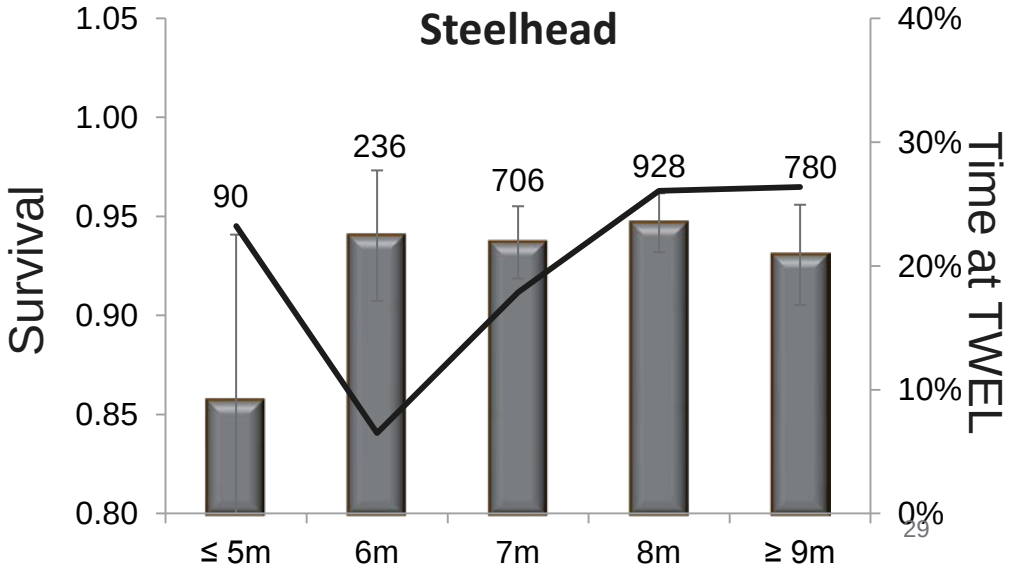
- There was not a difference in survival of juvenile salmonids passing at spillbays 1-8 and spillbays 9-23
- There was lower survival of CH0 at discharge below 72 kcfs

Analyses: BON
B1 Survival by Tailwater Level

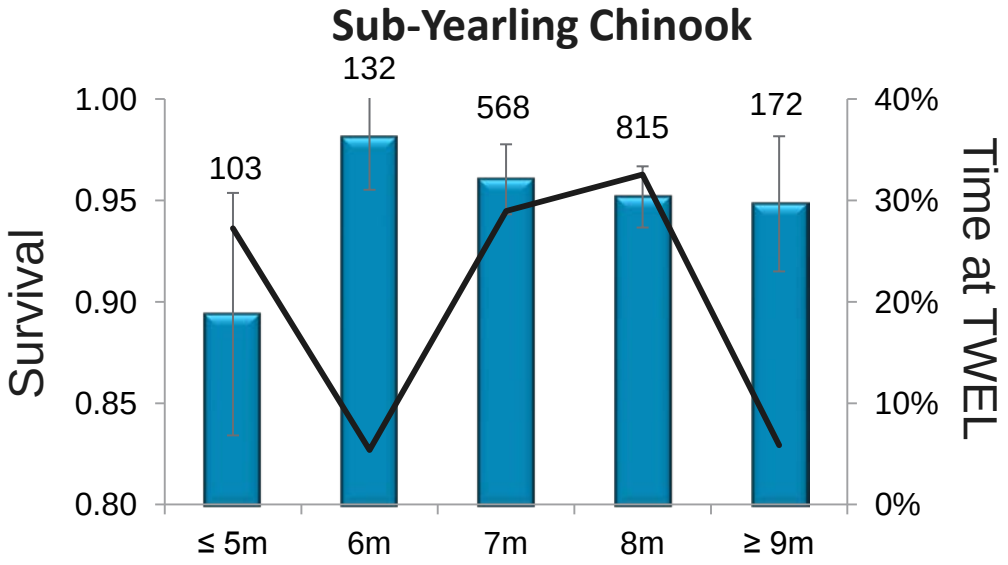


Bin	S. Estimate	+95 CI	-95 CI
≤ 5m	0.9868	1.0378	0.9358
6m	1.0052	1.0350	0.9754
7m	0.9643	0.9800	0.9486
8m	0.9635	0.9766	0.9504
≥ 9m	0.9652	0.9915	0.9389

Bin	S. Estimate	+95 CI	-95 CI
≤ 5m	0.8575	0.9408	0.7742
6m	0.9403	0.9732	0.9074
7m	0.9369	0.9551	0.9187
8m	0.9468	0.9617	0.9319
≥ 9m	0.9306	0.9559	0.9053

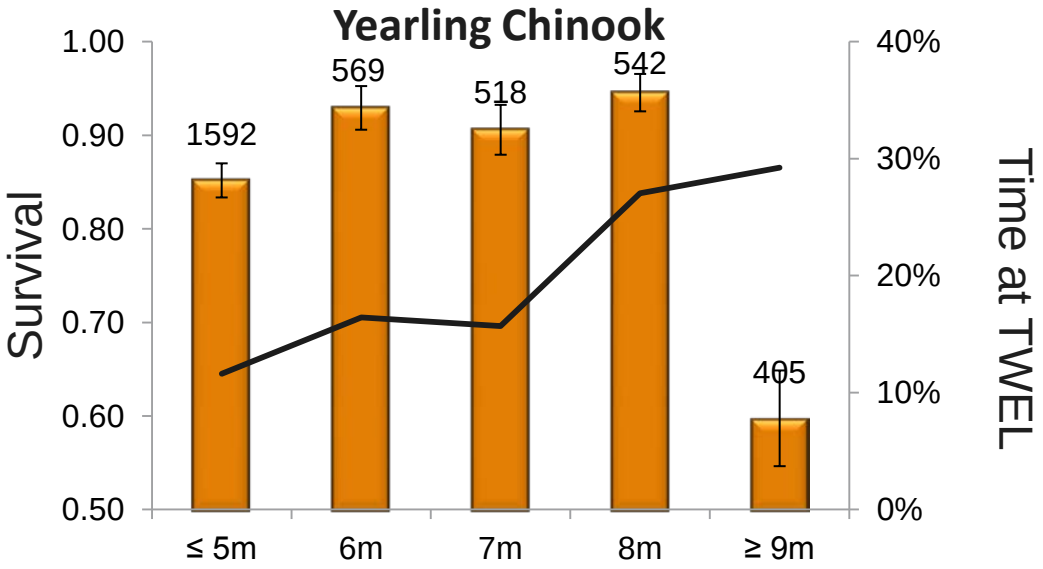


Analyses: BON
B1 Survival by Tailwater Level



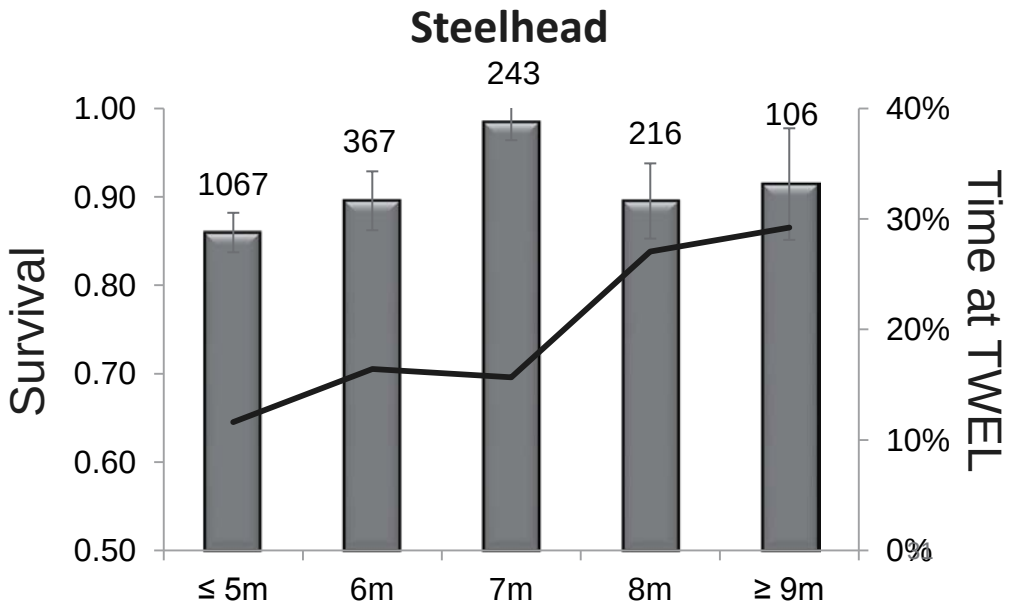
Bin	S. Estimate	+95 CI	-95 CI
≤ 5m	0.8939	0.9537	0.8341
6m	0.9811	1.0070	0.9552
7m	0.9604	0.9776	0.9432
8m	0.9517	0.9668	0.9366
≥ 9m	0.9483	0.9816	0.9150

Analyses: BON
B2 Survival by Tailwater Level

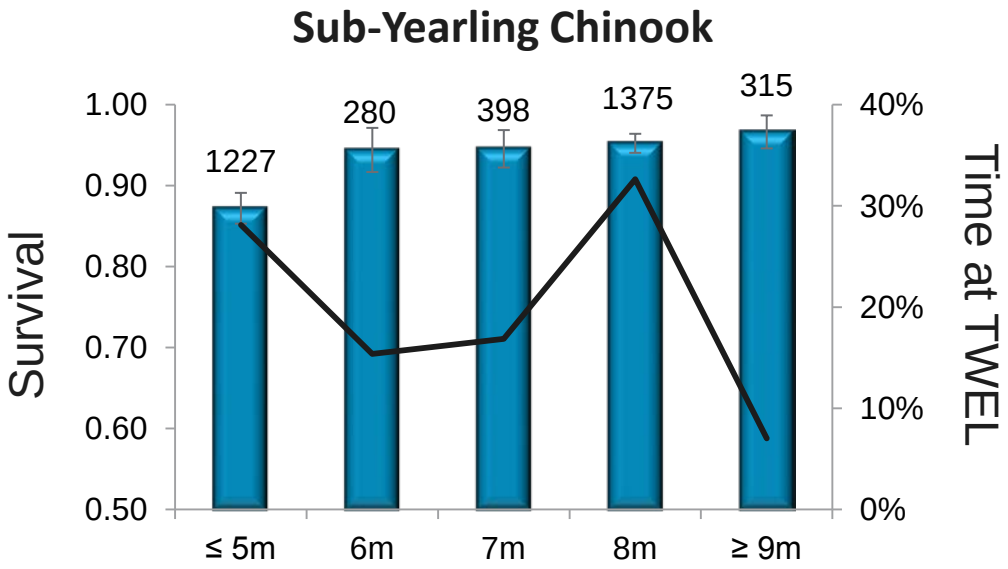


Bin	S. Estimate	+95 CI	-95 CI
≤ 5m	0.8518	0.8700	0.8336
6m	0.9293	0.9526	0.9060
7m	0.9059	0.9326	0.8792
8m	0.9456	0.9656	0.9256
≥ 9m	0.5975	0.6487	0.5463

Bin	S. Estimate	+95 CI	-95 CI
≤ 5m	0.8596	0.8819	0.8373
6m	0.8955	0.9288	0.8622
7m	0.9846	1.0052	0.9640
8m	0.8953	0.9378	0.8528
≥ 9m	0.9144	0.9775	0.8513



Analyses: BON
B2 Survival by Tailwater Level



Bin	S. Estimate	+95 CI	-95 CI
≤ 5m	0.8720	0.8910	0.8530
6m	0.9440	0.9712	0.9168
7m	0.9454	0.9685	0.9223
8m	0.9522	0.9640	0.9404
≥ 9m	0.9663	0.9867	0.9459

Analyses: BON
Spillway Survival by Tailwater Level

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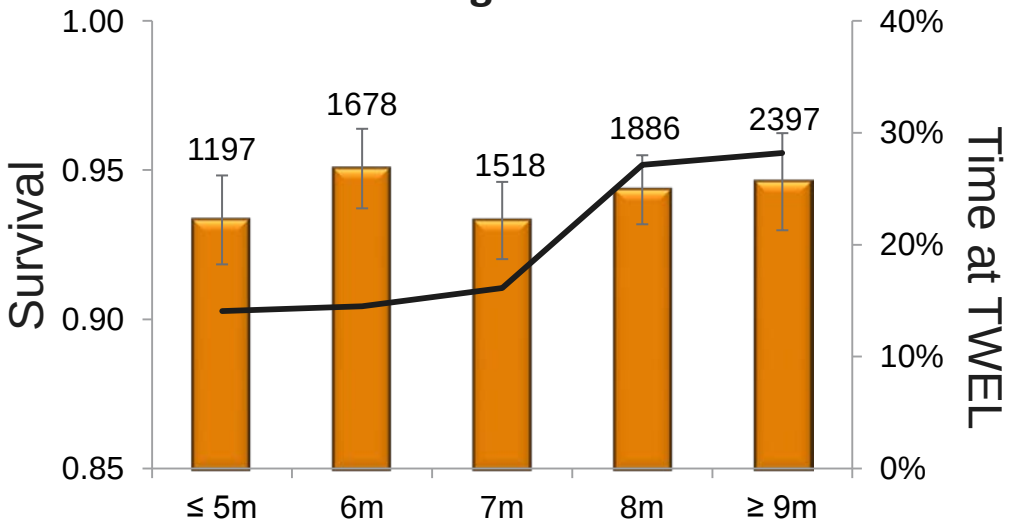
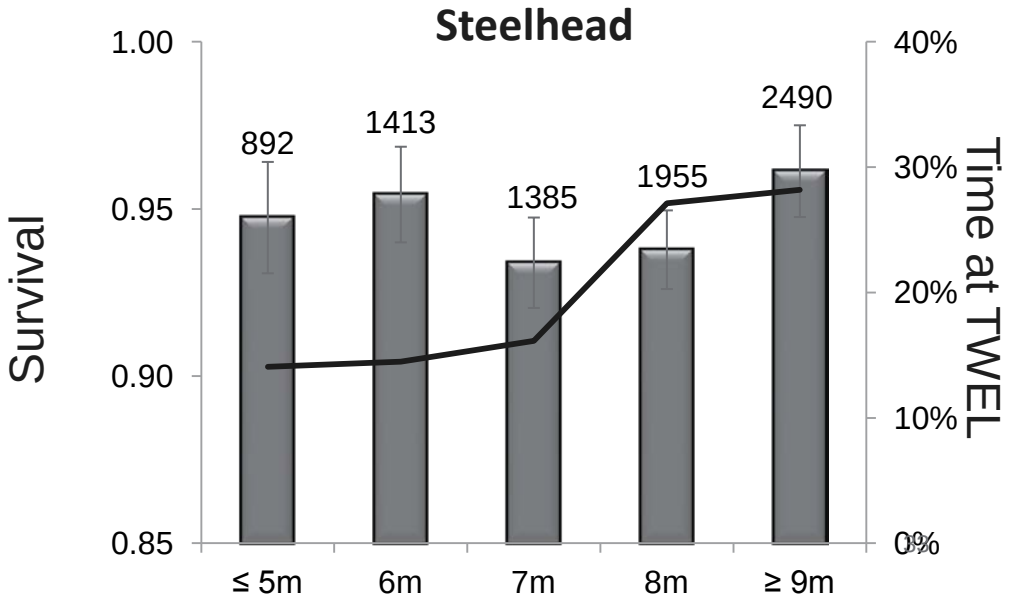
Yearling Chinook



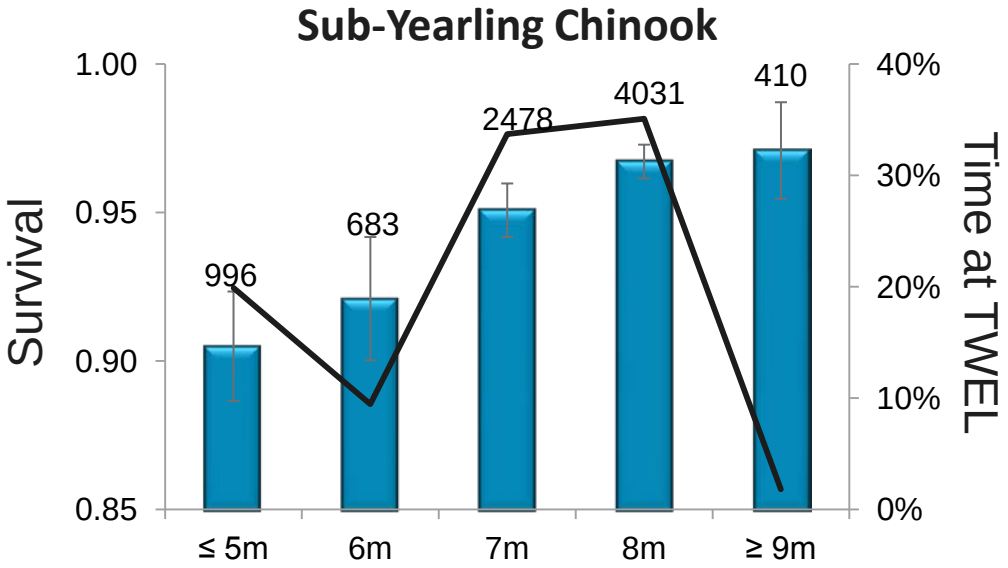
Bin	S. Estimate	+ 95 CI	-95 CI
≤ 5m	0.9333	0.9482	0.9184
6m	0.9505	0.9638	0.9372
7m	0.9331	0.9460	0.9202
8m	0.9434	0.9550	0.9318
≥ 9m	0.9461	0.9624	0.9298

Bin	S. Estimate	+ 95 CI	-95 CI
≤ 5m	0.9474	0.9641	0.9307
6m	0.9543	0.9686	0.9400
7m	0.9339	0.9474	0.9204
8m	0.9378	0.9496	0.9260
≥ 9m	0.9613	0.9750	0.9476

Steelhead

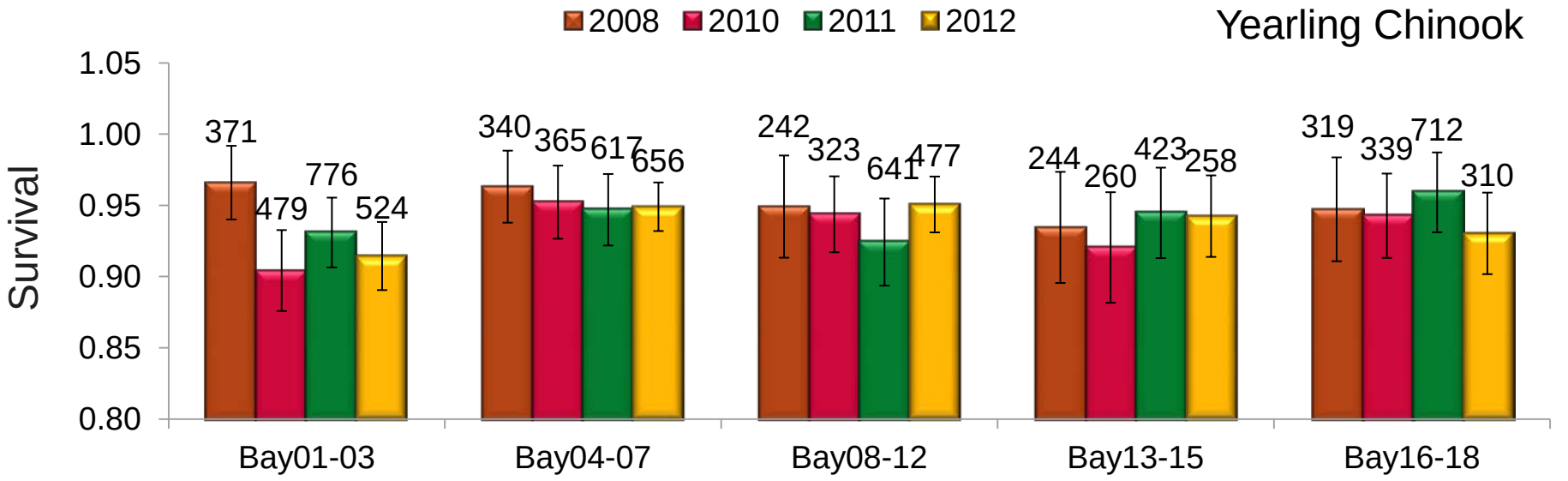


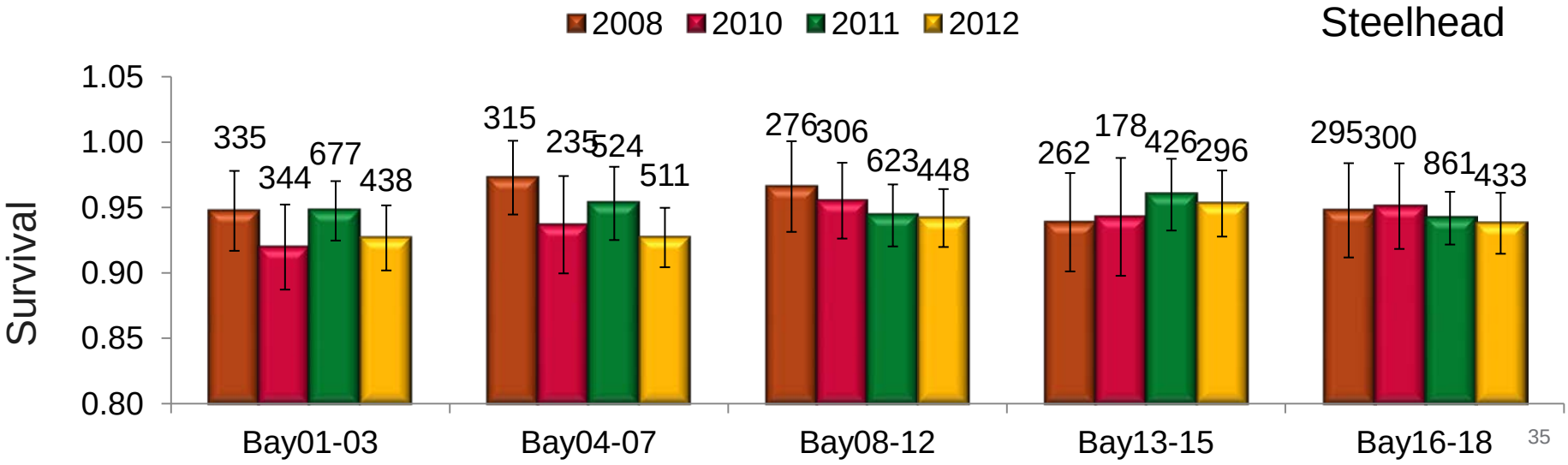
Analyses: BON
Spillway Survival by Tailwater Level



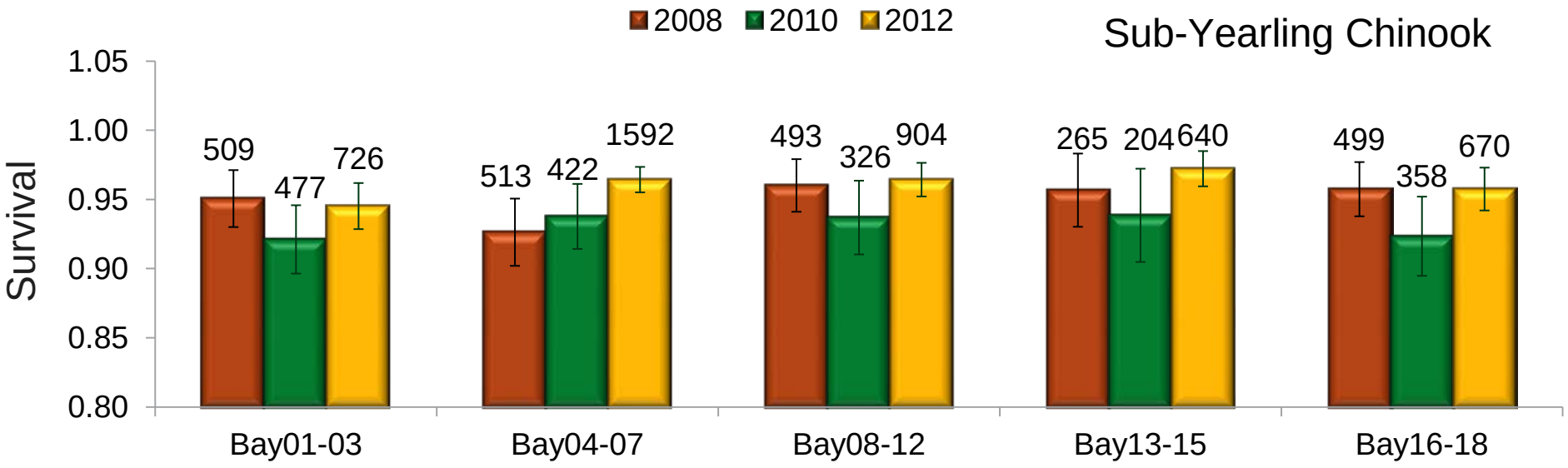
Bin	S. Estimate	+ 95 CI	-95 CI
≤ 5m	0.9050	0.9234	0.8866
6m	0.9210	0.9418	0.9002
7m	0.9508	0.9598	0.9418
8m	0.9672	0.9729	0.9615
≥ 9m	0.9709	0.9872	0.9546

Analyses: BON
Spillway Survival by Grouped Bays

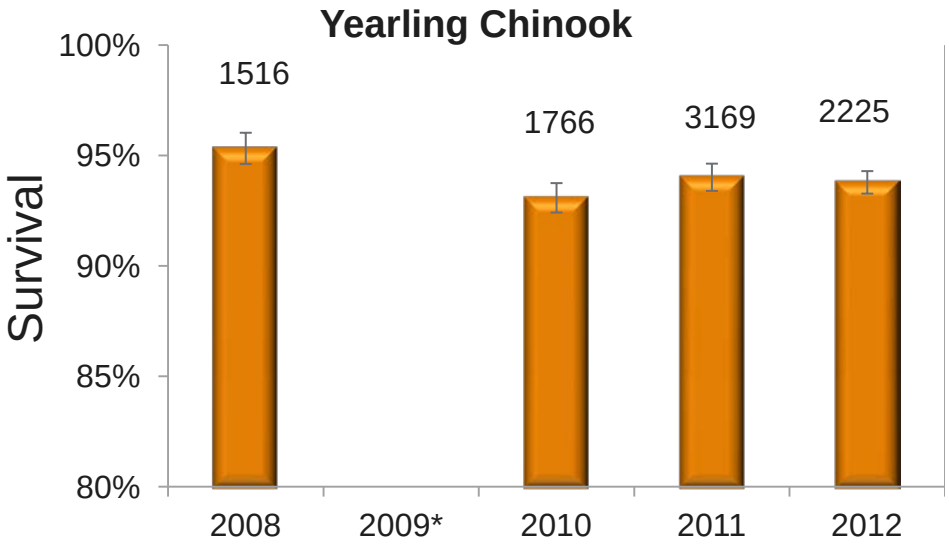




Analyses: BON
Spillway Survival by Bays, CH0

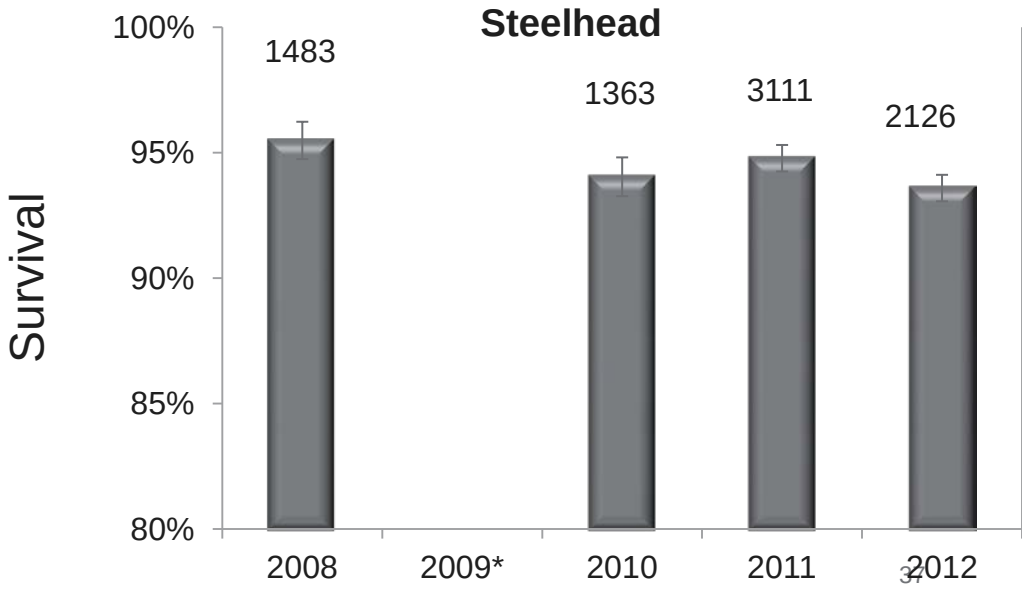


Analyses: BON
Spillway Survival 2008, ‘09, ‘10, ‘11, ‘12

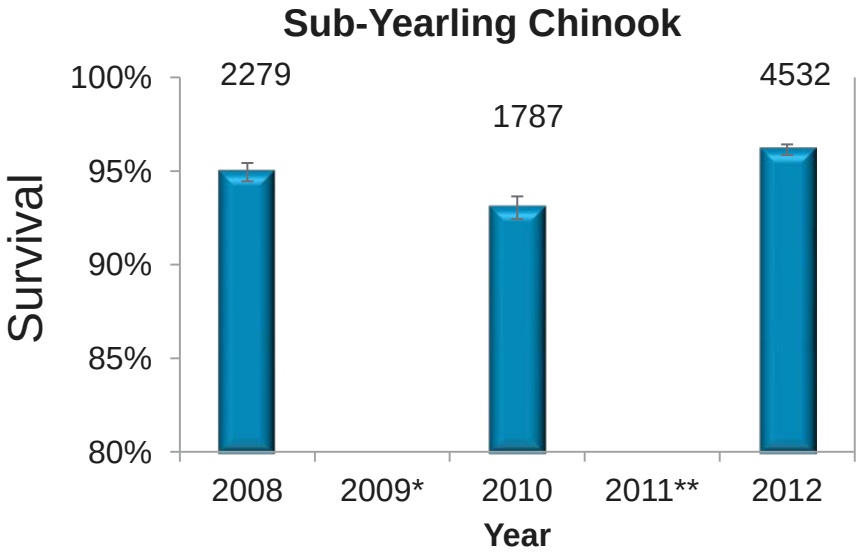


Year	S. Estimate	+95% CI	-95% CI
2008	0.9532	0.9673	0.9391
2009			
2010	0.9308	0.9441	0.9175
2011	0.9401	0.9542	0.9278
2012	0.9378	0.9480	0.9276

Year	S. Estimate	+ 95 CI	-95 CI
2008	0.9549	0.9698	0.9400
2009			
2010	0.9404	0.9559	0.9429
2011	0.9478	0.9584	0.9372
2012	0.9359	0.9465	0.9253

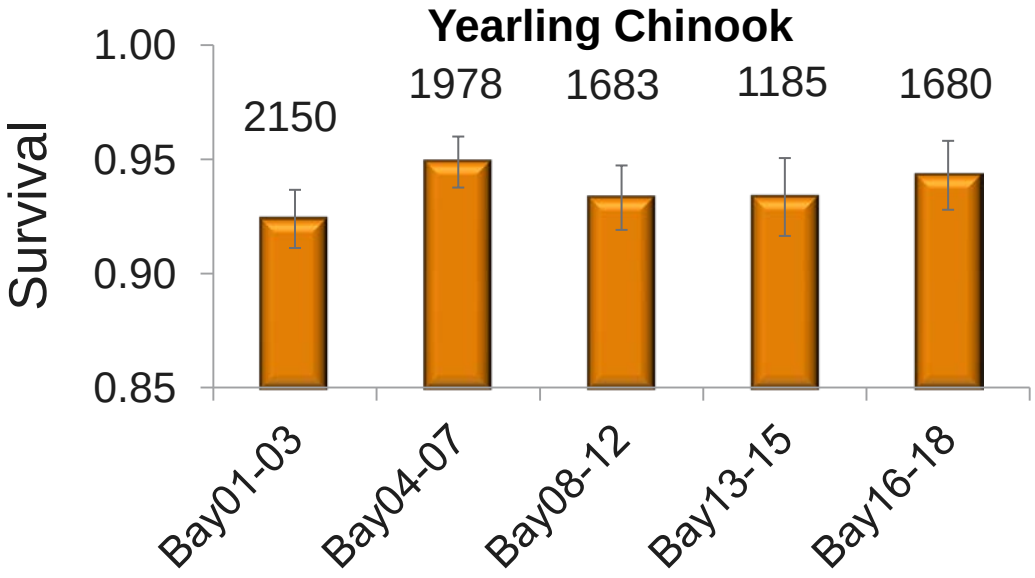


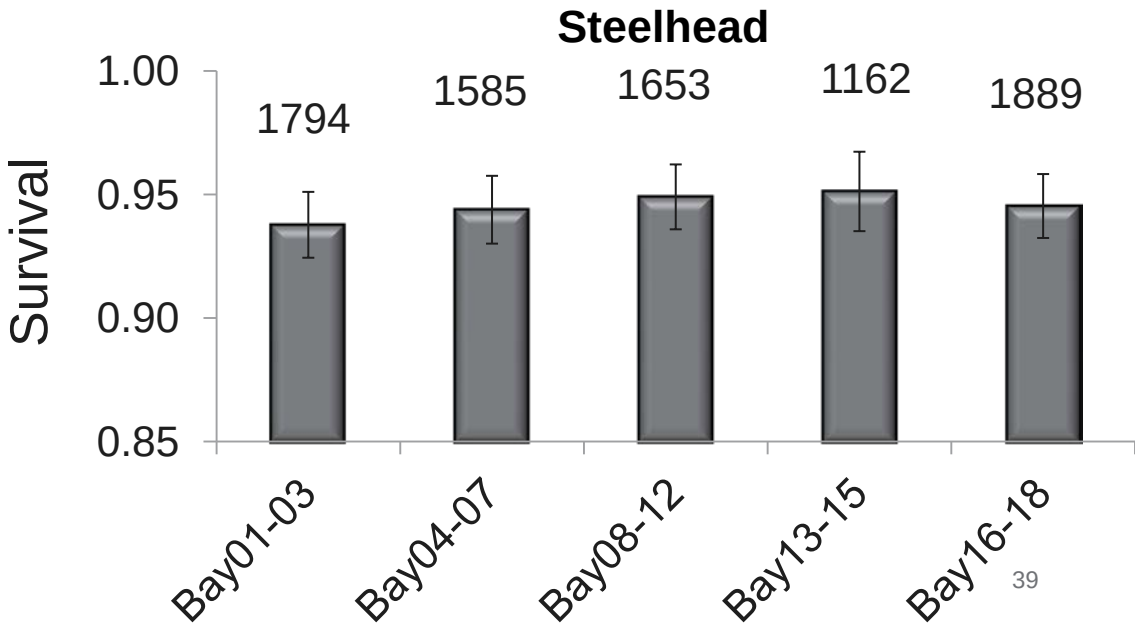
Analyses: BON
Spillway Survival by 2008, ‘09, ‘10, ‘ 11, ‘12



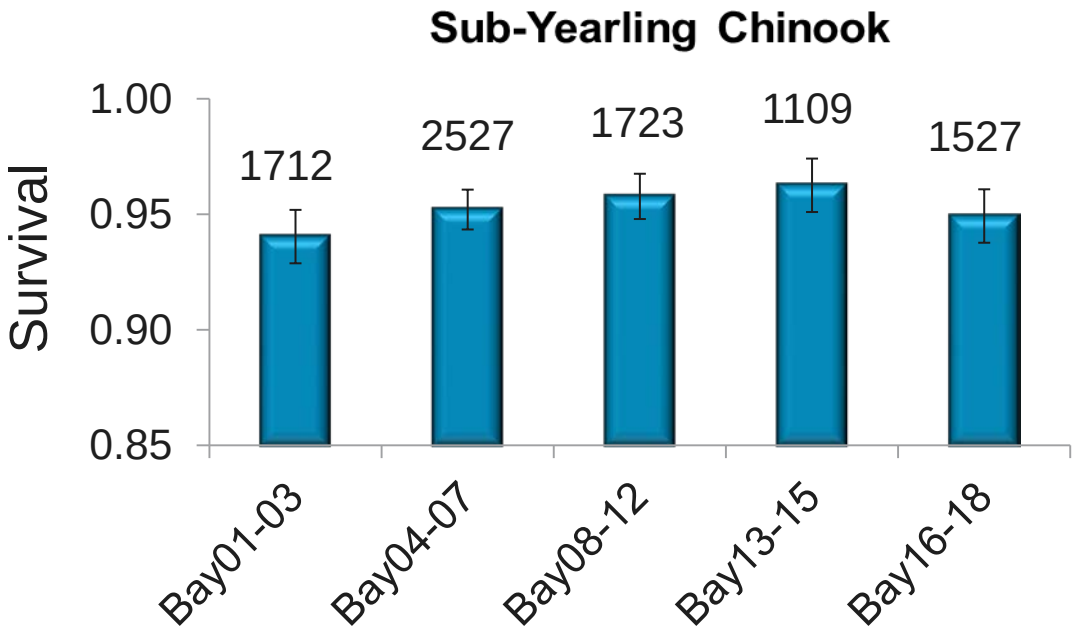
Years	S. Estimate	+ 95 CI	-95 CI
2008	0.9494	0.9543	0.9445
2009			
2010	0.9304	0.9365	0.9243
2011			
2012	0.9614	0.9642	0.9586

Analyses: BON
Spillway CH1 and STH Survival, Grouped Bays

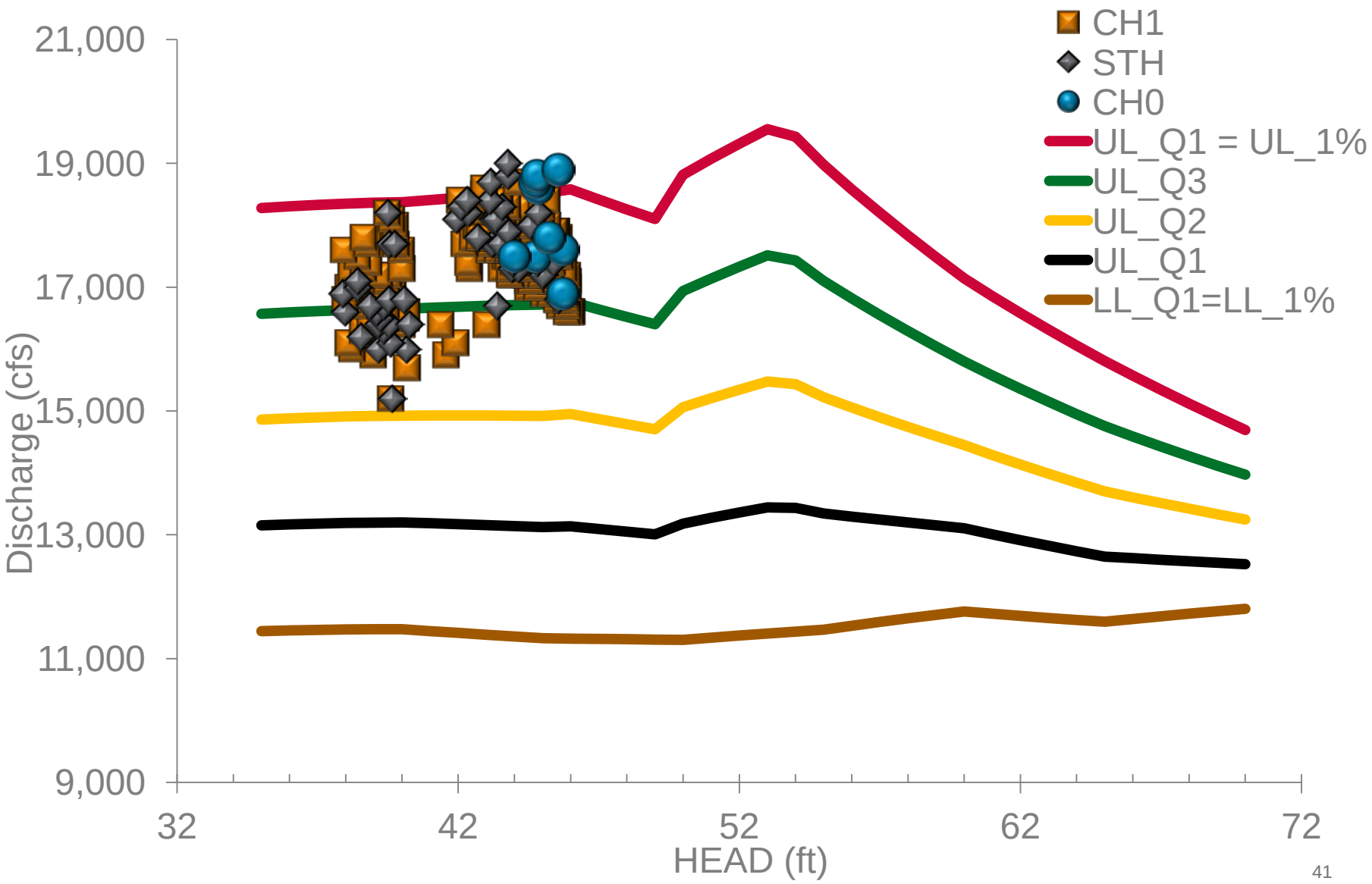




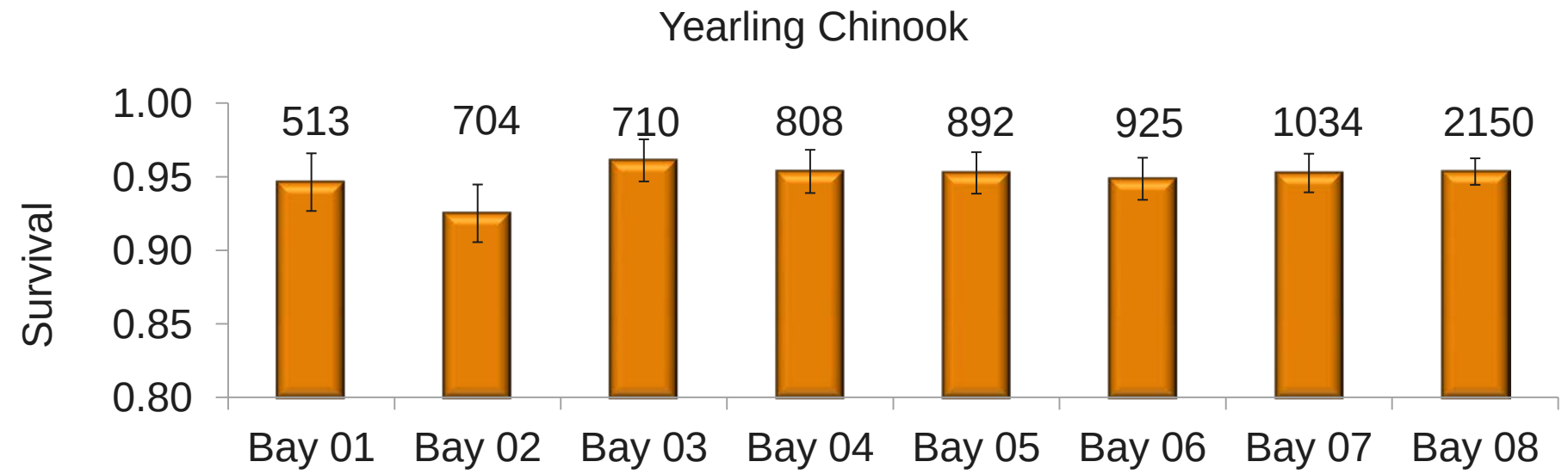
Analyses: BON
Spillway CH0 Survival, Grouped Bays

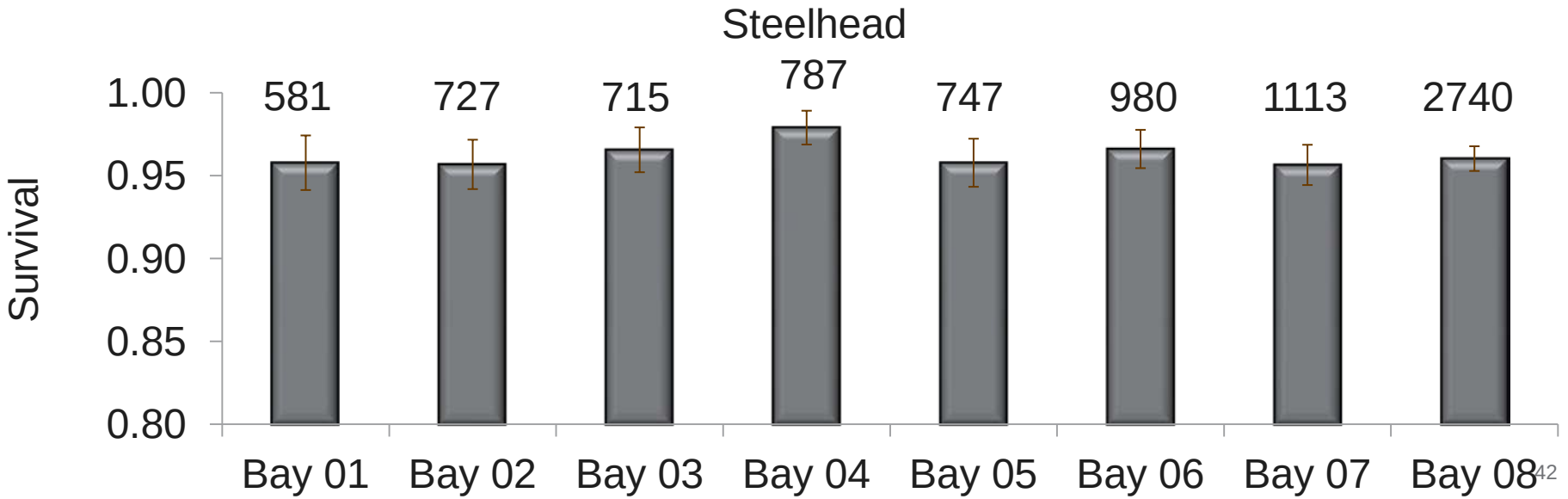


Analyses: BON
B2 Passage without STS

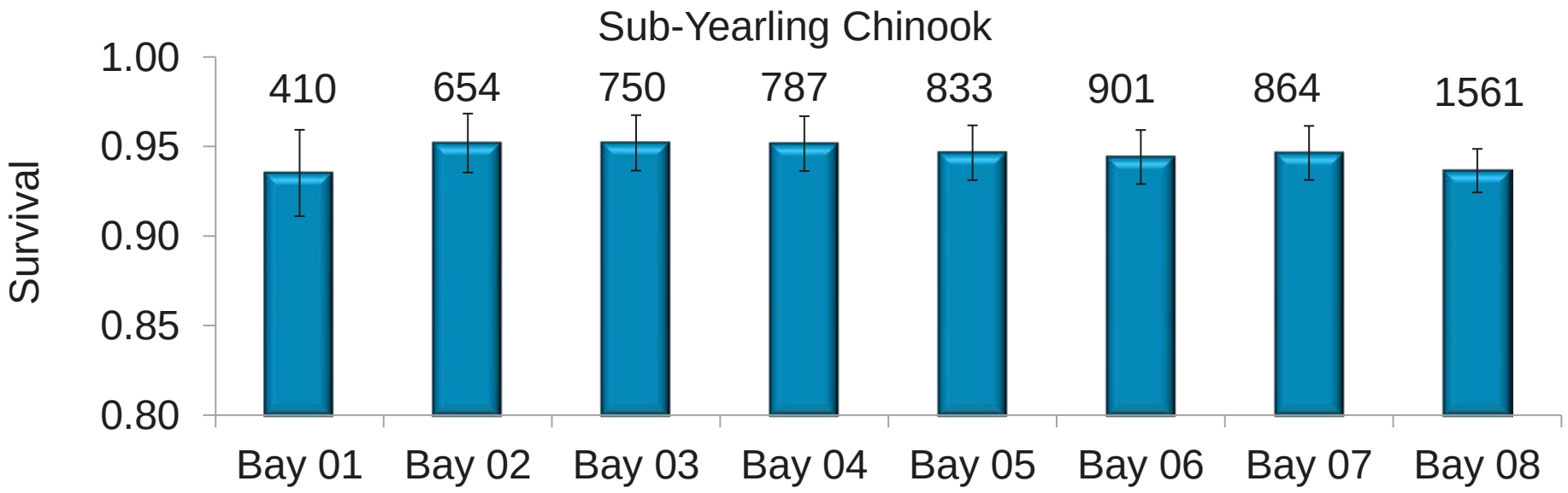


Analyses: TDA
Survival by Bay for All Years





Analyses: TDA
Survival by Bay for All Years



Analyses: TDA
Survival by Flow, 2010, 2011, 2012

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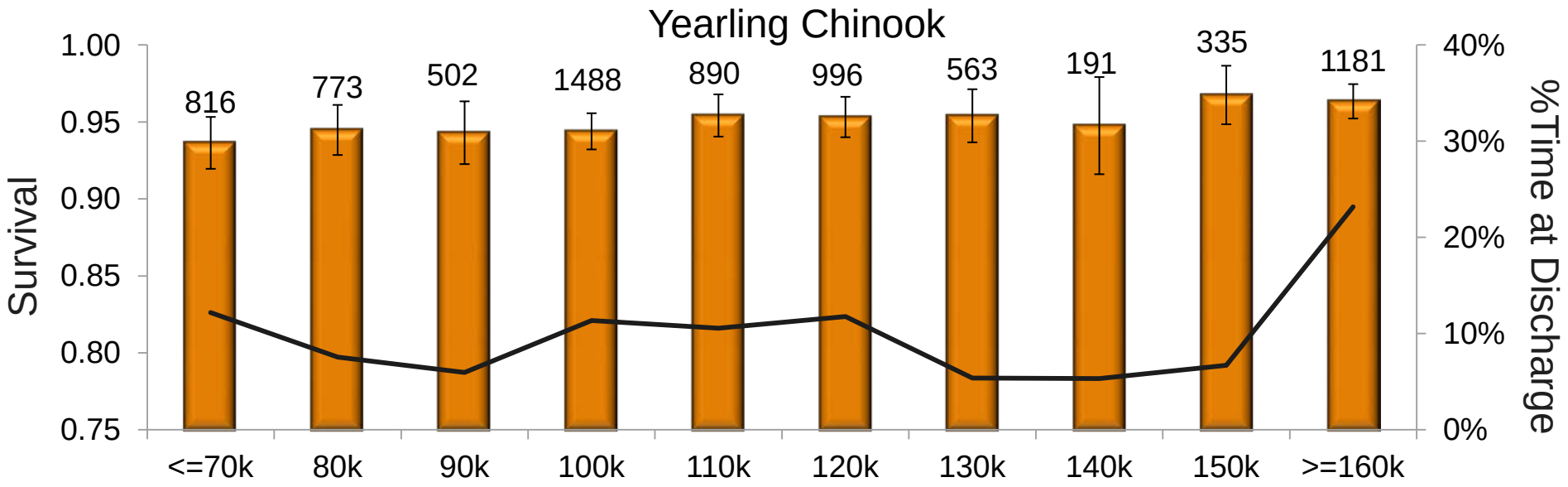
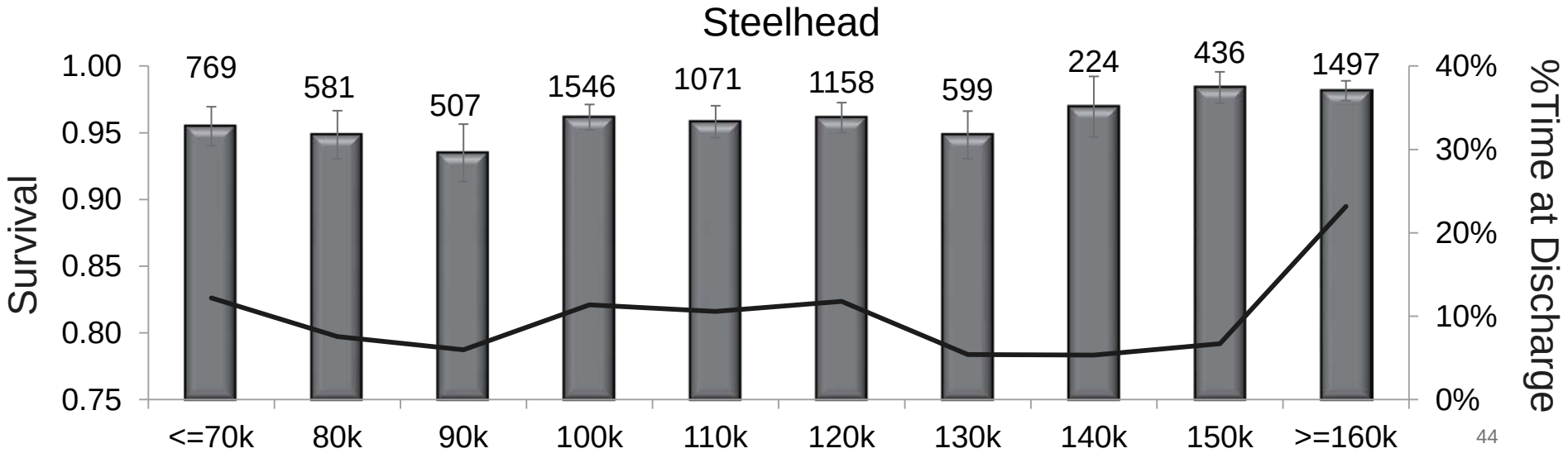
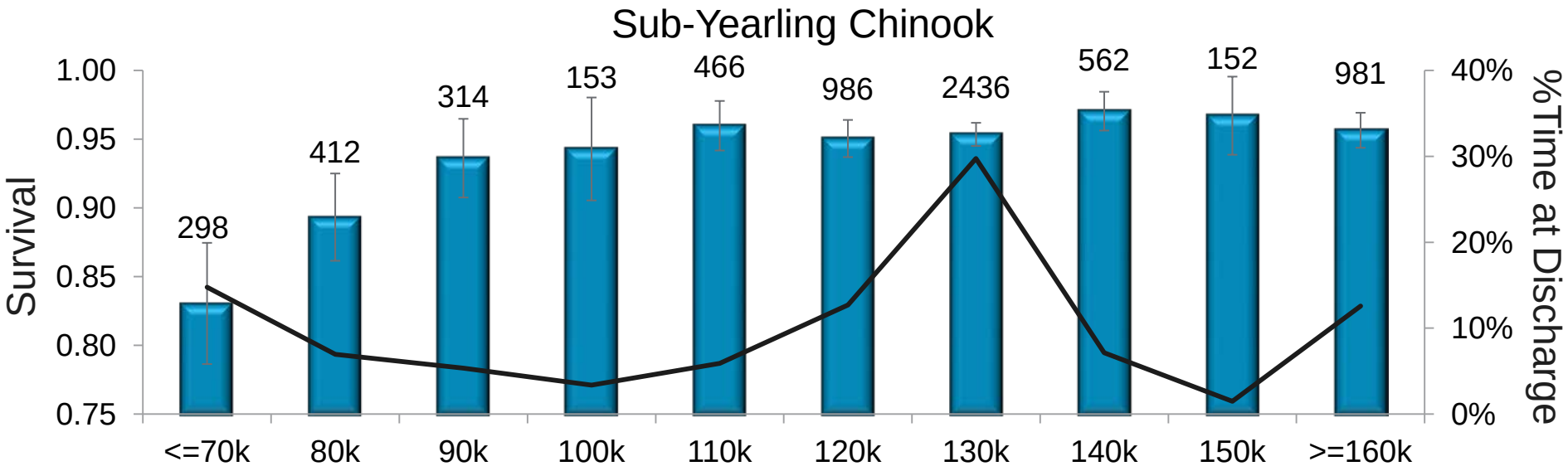
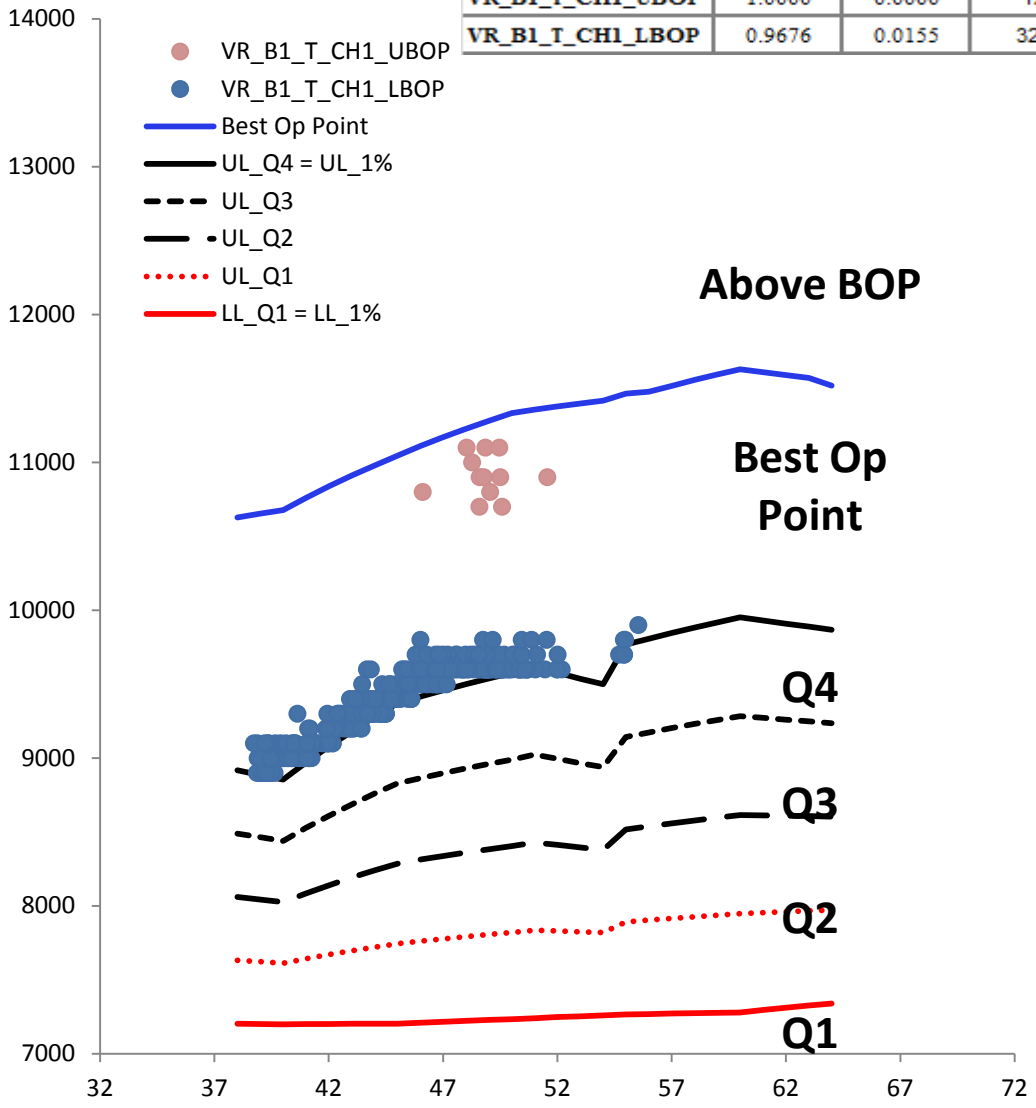




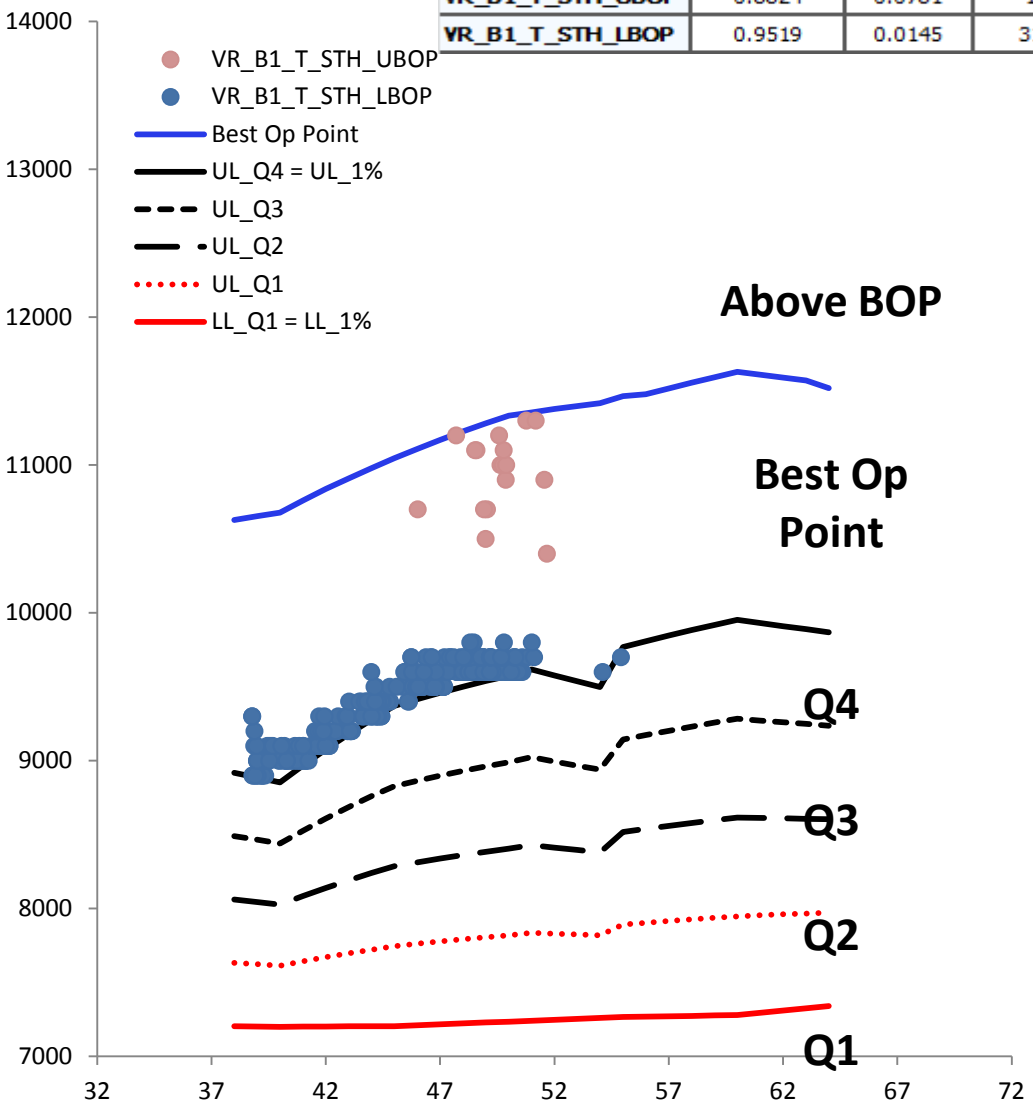
Analyses: TDA
Survival by Flow, 2010, 2011, 2012



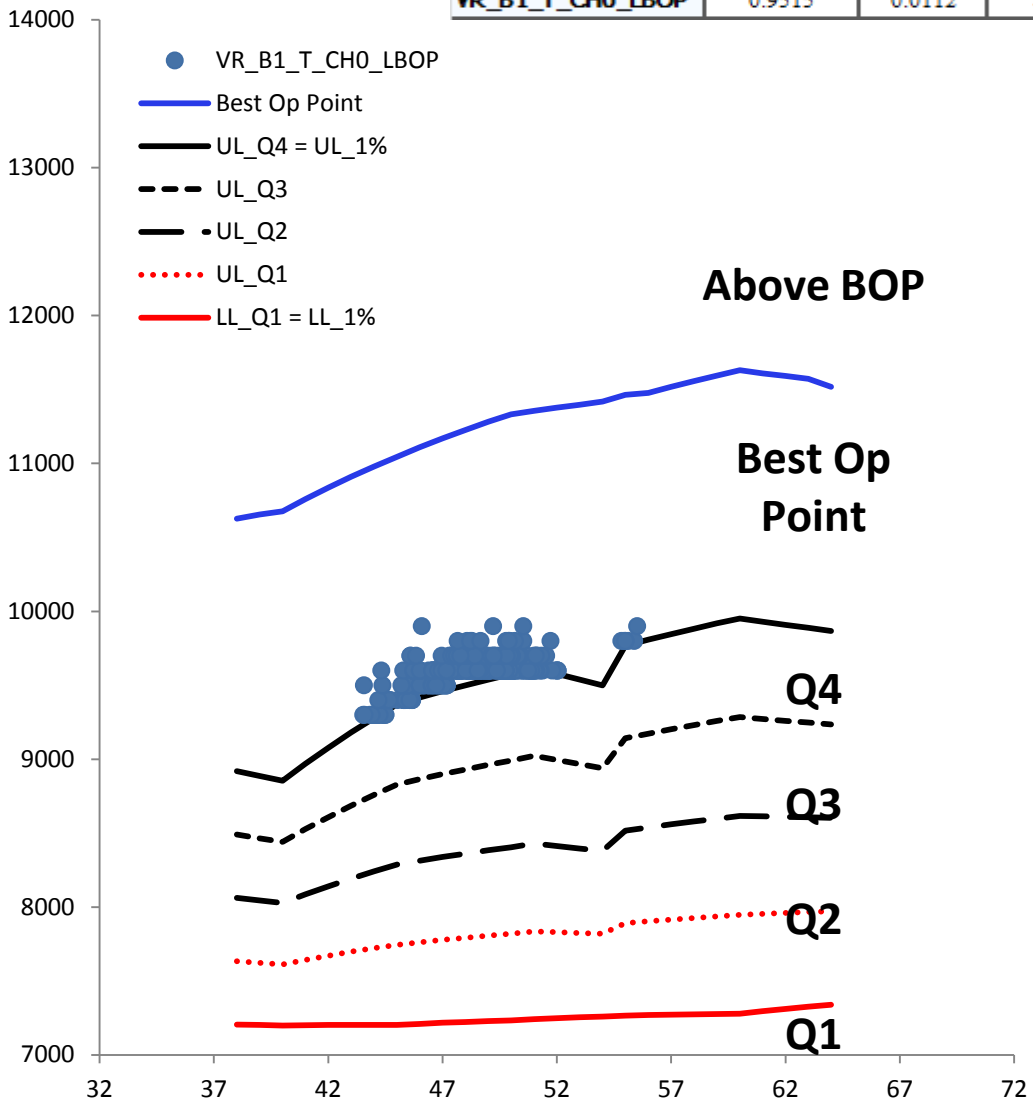
	S. Estimate	s.e.	N
VR_B1_T_CH1_UBOP	1.0000	0.0000	12
VR_B1_T_CH1_LBOP	0.9676	0.0155	320



	S. Estimate	s.e.	N
VR_B1_T_STH_UBOP	0.8824	0.0781	17
VR_B1_T_STH_LBOP	0.9519	0.0145	317



	S. Estimate	s.e.	N
VR_B1_T_CH0_LBOP	0.9515	0.0112	380



BON: CH1 Tailrace Egress B1 and B2

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	BON_ROUTE	TTRT	Min	Max	Mean	StdErr	Median	N
TR_EGR_TIME	B1	ABO	0.21	200.41	4.23	0.70	0.30	485
		BOP	0.24	281.36	5.90	1.67	0.37	286
		Q4	0.24	273.35	3.55	0.57	0.37	860
		Q3	0.23	110.46	2.43	0.82	0.38	189
		Q2	0.28	102.24	3.36	1.15	0.44	136
		Q1	0.27	280.27	6.40	2.10	0.46	234
		<1%	0.25	310.11	15.43	14.73	0.53	21
	B2	OG	0.45	12.23	5.76	0.75	6.44	27
		Q4	0.25	42.82	6.29	0.22	6.87	455
		Q3	0.29	14.63	3.98	0.34	0.78	172
		Q2	0.25	33.28	3.65	0.25	0.72	465
		Q1	0.28	61.72	4.34	0.27	0.71	695
		<1%	0.58	18.77	8.82	0.74	8.45	28

BON: STH Tailrace Egress B1 and B2

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	BON_ROUTE	TTRT	Min	Max	Mean	StdErr	Median	N
TR_EGR_TIME	B1	ABO	0.20	415.51	15.11	2.21	0.42	476
		BOP	0.25	404.61	23.96	3.49	0.58	282
		Q4	0.24	419.08	17.14	1.39	0.52	1013
		Q3	0.26	225.21	7.75	2.10	0.63	146
		Q2	0.25	589.93	9.84	4.57	0.57	146
		Q1	0.25	254.90	8.51	1.69	0.60	301
		<1%	0.31	87.32	6.61	4.55	0.77	19
	B2	OG	0.70	10.27	6.15	1.43	6.28	6
		Q4	0.22	21.13	5.95	0.33	6.95	165
		Q3	0.21	105.44	5.08	1.13	0.83	116
		Q2	0.22	138.40	3.68	0.48	0.82	333
		Q1	0.26	48.20	3.40	0.24	0.79	492
		<1%	0.25	10.24	5.98	0.86	6.74	14

BON: CH0 Tailrace Egress B1 and B2

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	BON_ROUTE	TTRT	Min	Max	Mean	StdErr	Median	N
TR_EGR_TIME	B1	BOP	0.27	127.56	4.33	0.68	0.40	363
		Q4	0.24	622.50	3.81	0.68	0.40	1148
		Q3	0.25	44.93	1.67	0.53	0.39	116
		Q2	0.32	31.24	1.22	0.56	0.44	56
		Q1	0.29	68.26	2.17	1.45	0.46	47
		<1%	0.56	0.97	0.81	0.13	0.90	3
	B2	OG	0.27	19.84	3.99	0.68	0.80	48
		Q4	0.19	32.29	3.62	0.13	0.72	1320
		Q3	0.21	530.52	4.98	1.47	0.74	364
		Q2	0.22	18.89	4.07	0.24	0.79	411
		Q1	0.29	26.43	6.39	0.32	7.45	266
		<1%	1.03	27.60	11.35	1.64	11.01	14

BON: CH1 Tailrace Egress Spillway

Pacific Northwest NATIONAL LABORATORY
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	SP10	Min	Max	Mean	StdErr	Median	N
TR_EGR_TIME	70	0.38	3.07	0.83	0.16	0.53	18
	80	0.33	306.51	1.76	1.13	0.51	271
	90	0.32	16.68	1.54	0.13	0.48	472
	100	0.19	157.14	1.88	0.09	0.43	2992
	110	0.29	26.45	0.86	0.21	0.39	146
	120	0.26	38.92	1.14	0.18	0.38	288
	130	0.26	6.73	0.39	0.03	0.35	251
	140	0.26	12.85	0.53	0.12	0.34	126
	150	0.23	18.30	1.69	0.16	0.33	352
	160	0.24	0.51	0.32	0.00	0.31	113
	170	0.25	68.85	3.84	0.86	0.35	84
	180	0.23	17.49	2.59	0.26	0.33	176
	190	0.22	42.81	6.35	0.31	6.41	175
	200	0.20	16.78	4.32	0.29	5.25	199
	210	0.13	16.17	5.15	0.30	6.03	119
	220	0.22	20.18	6.02	0.18	6.05	154
	230	0.01	12.29	3.62	0.37	5.11	89
	240	0.01	12.26	2.84	0.33	0.40	105
	250	0.02	11.04	0.56	0.13	0.28	125
	260	0.01	0.94	0.29	0.01	0.27	136
	270	0.02	2.11	0.29	0.02	0.27	110
	280	0.01	1.14	0.29	0.01	0.28	129
	290	0.01	0.61	0.26	0.02	0.26	39
	300	0.01	0.70	0.27	0.04	0.28	16

BON: STH Tailrace Egress Spillway

	SP10	Min	Max	Mean	StdErr	Median	N
TR_EGR_TIME	70	0.39	0.65	0.50	0.08	0.47	3
	80	0.35	7.76	0.66	0.05	0.47	163
	90	0.31	91.65	2.21	0.34	0.45	411
	100	0.28	614.65	1.97	0.28	0.42	2537
	110	0.29	6.62	0.64	0.10	0.38	123
	120	0.27	11.14	1.95	0.17	0.38	292
	130	0.26	7.17	0.57	0.07	0.35	252
	140	0.25	11.92	0.53	0.09	0.32	175
	150	0.23	12.13	1.40	0.13	0.33	321
	160	0.25	5.74	0.46	0.07	0.31	105
	170	0.22	13.22	3.18	0.34	3.05	73
	180	0.11	10.49	2.57	0.20	0.38	213
	190	0.22	70.37	5.17	0.37	5.14	205
	200	0.05	14.68	3.41	0.22	4.46	167
	210	0.19	11.32	4.38	0.25	4.94	95
	220	0.19	9.19	5.10	0.13	5.13	132
	230	0.10	16.41	3.85	0.34	4.89	75
	240	0.11	7.43	2.04	0.24	0.42	90
	250	0.01	13.65	0.57	0.14	0.30	116
	260	0.02	2.15	0.33	0.02	0.29	133
	270	0.03	22.94	0.55	0.22	0.31	103
	280	0.01	1.73	0.31	0.02	0.29	142
	290	0.03	0.70	0.32	0.03	0.29	39
	300	0.01	0.53	0.30	0.05	0.33	8

BON: CH0 Tailrace Egress Spillway

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	SP10	Min	Max	Mean	StdErr	Median	N
TR_EGR_TIME	80	0.40	18.00	6.72	0.29	6.88	130
	90	0.34	40.68	6.34	0.15	7.15	985
	100	0.31	21.46	1.67	0.11	0.47	814
	110	0.31	47.89	5.75	0.22	6.91	474
	120	0.27	11.91	1.08	0.10	0.38	471
	130	0.26	26.07	2.69	0.16	0.37	860
	140	0.26	24.85	2.85	0.22	0.36	408
	150	0.23	50.35	0.99	0.08	0.33	1130
	160	0.23	23.80	1.38	0.11	0.31	801
	170	0.23	23.51	1.71	0.13	0.31	744
	180	0.22	217.95	1.26	0.80	0.30	275
	190	0.23	10.71	0.44	0.11	0.28	99
	200	0.21	22.72	3.36	0.40	0.29	205
	210	0.21	4.13	0.35	0.04	0.28	126
	220	0.19	4.40	0.29	0.02	0.26	242
	230	0.19	1.06	0.29	0.02	0.25	78

TDA: CH1 Tailrace Egress Spillway

CH1	SP24	Min	Max	Mean	StdErr	Median	N
TR_EGR_TIME	**48**	0.28	153.02	1.69	0.83	0.47	210
	72	0	367.24	1.14	0.35	0.36	1233
	96	0	475.07	2.14	0.69	0.27	858
	120	0.01	156.4	0.9	0.34	0.21	663
	144	0.1	120.33	0.49	0.26	0.16	464
	168	0.11	0.44	0.16	0	0.14	227
	312	0.14	0.14	0.14	0	0.14	2

TDA: STH Tailrace Egress Spillway

STH	SP24	Min	Max	Mean	StdErr	Median	N
TR_EGR_TIME	48	0.27	201.79	1.63	1.05	0.42	192
	72	0	24.1	0.44	0.03	0.33	1060
	96	0	52.84	0.43	0.08	0.25	1006
	120	0	55.83	0.31	0.07	0.2	838
	144	0.1	3.81	0.21	0.01	0.15	610
	168	0.1	0.78	0.16	0	0.14	338
	312	0.14	0.14	0.14	0	0.14	2

TDA: CH0 Tailrace Egress Spillway

Pacific Northwest NATIONAL LABORATORY
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CH0	SP24	Min	Max	Mean	StdErr	Median	N
TR_EGR_TIME	**48**	0.26	194.7	5.98	5.39	0.42	36
	72	0.16	65.88	0.73	0.15	0.35	560
	96	0.11	145.41	0.8	0.29	0.3	586
	120	0.12	324.61	0.57	0.13	0.22	3436
	144	0.11	324.19	0.84	0.42	0.19	870
	168	0.11	449.89	1.82	0.98	0.17	648
	216	0.17	324.49	18.26	12.55	0.24	36
	240	0.15	0.48	0.24	0.01	0.23	84
	312	0.12	0.54	0.18	0	0.16	168