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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

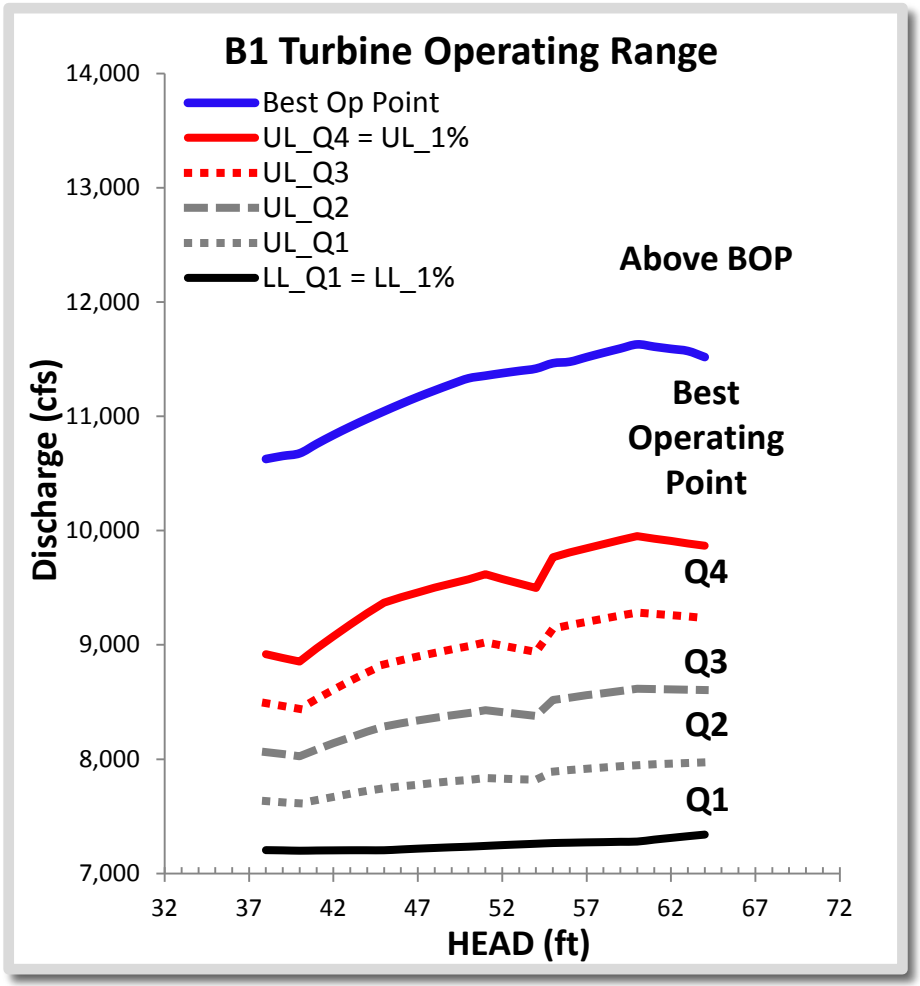
Objectives: BON

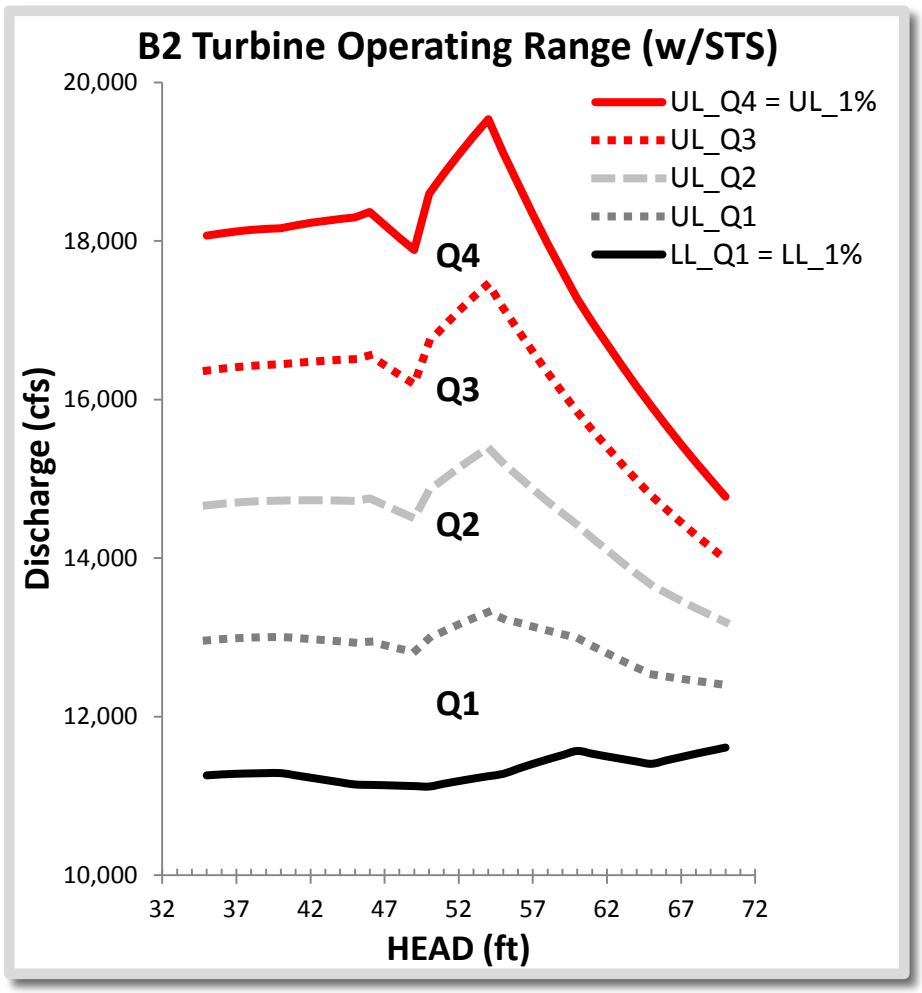
- Analyze 2008-2012 JSATS and operations data to examine survival rates for juvenile salmonids at BON
  - B2 Turbine Survival Comparison:
    - Examine survival for fish passing turbines operating across the 1% peak efficiency range
  - B1 Turbine Survival Comparison:
    - Examine survival for fish 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

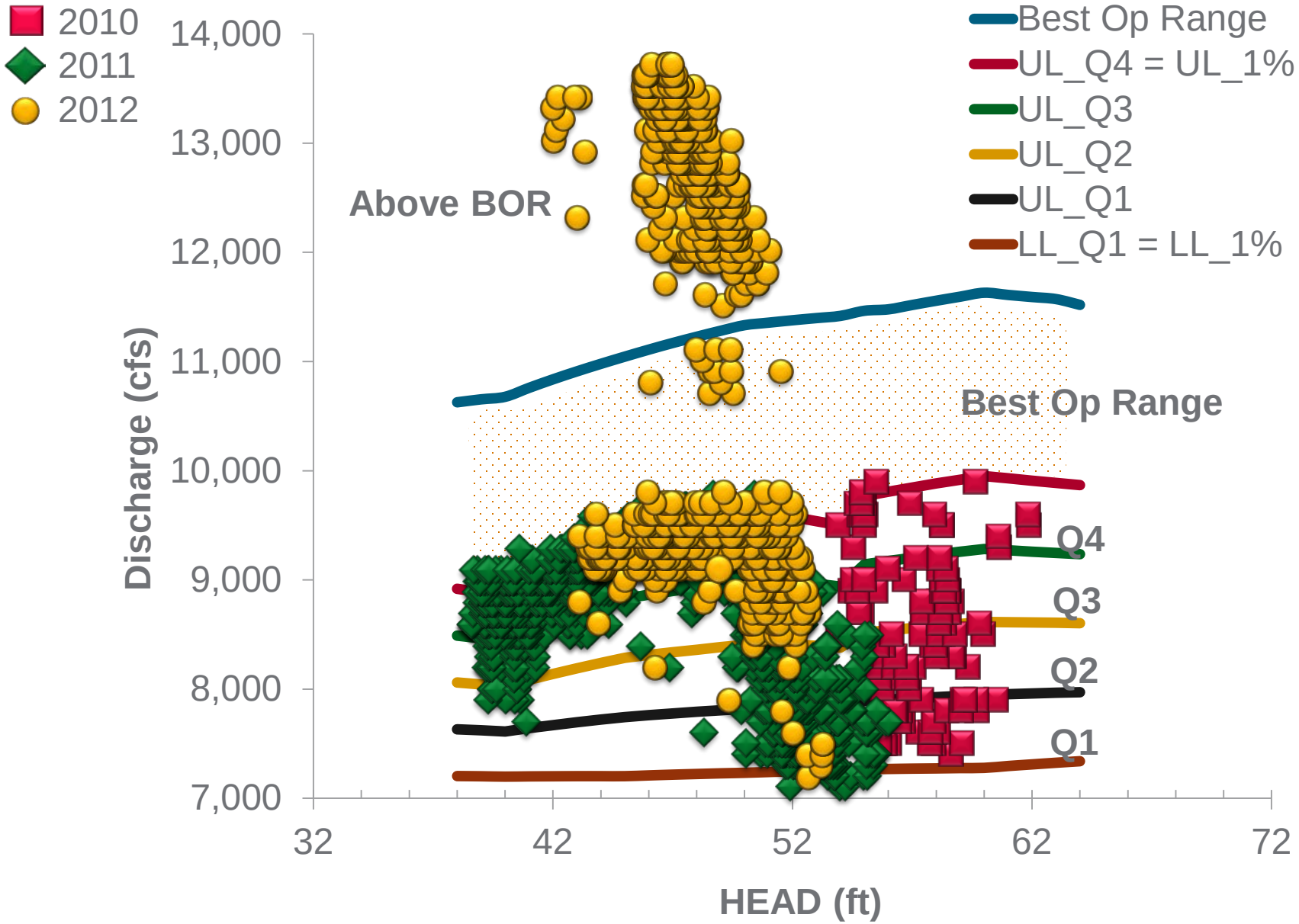
Methods: B1 and B2 Binned Operating Ranges



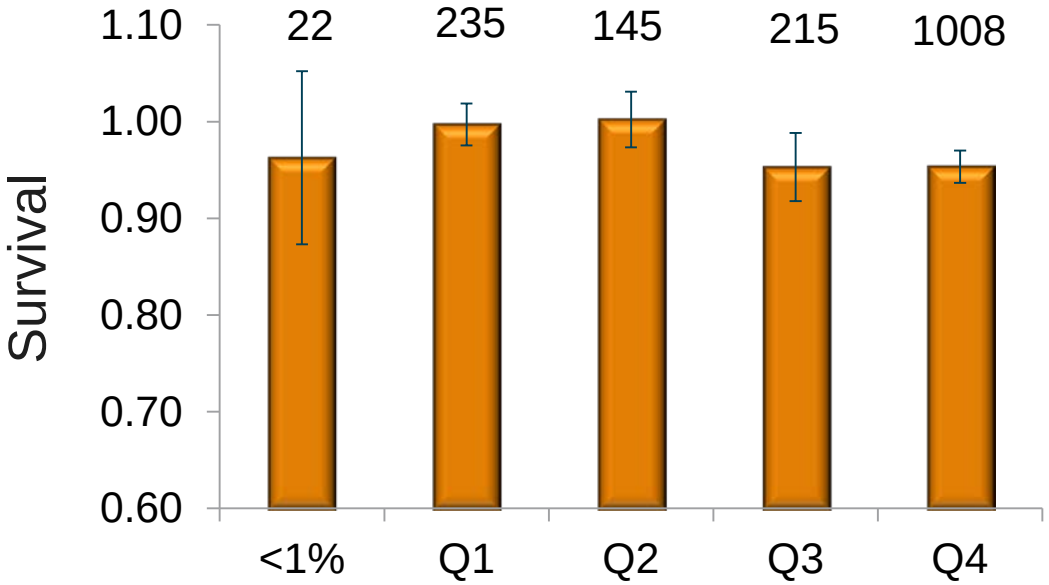


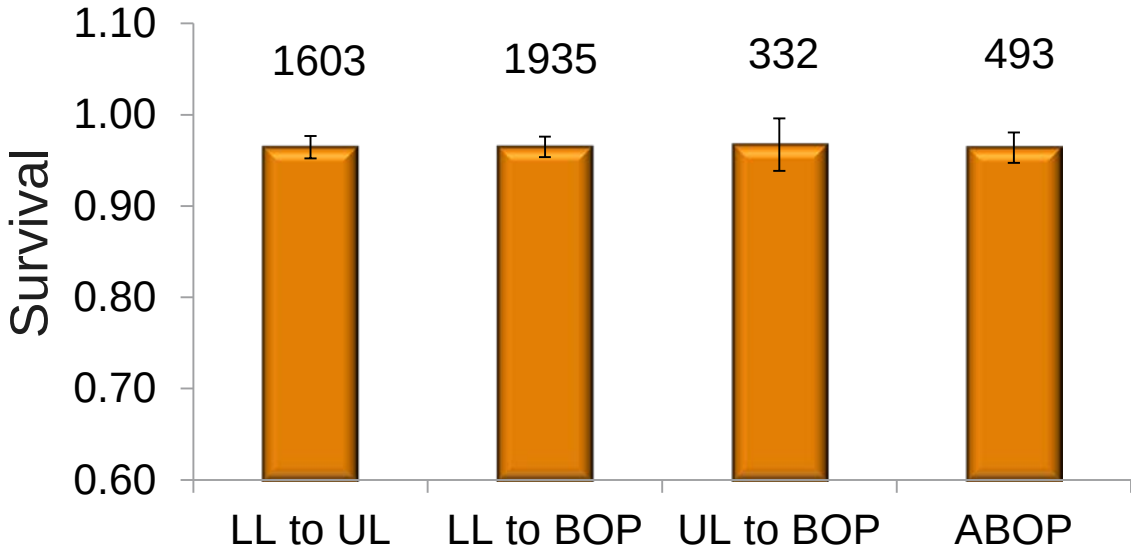
BON B1 Survival By Species and Operation

Analyses: BON
B1 CH1 Passage Distribution

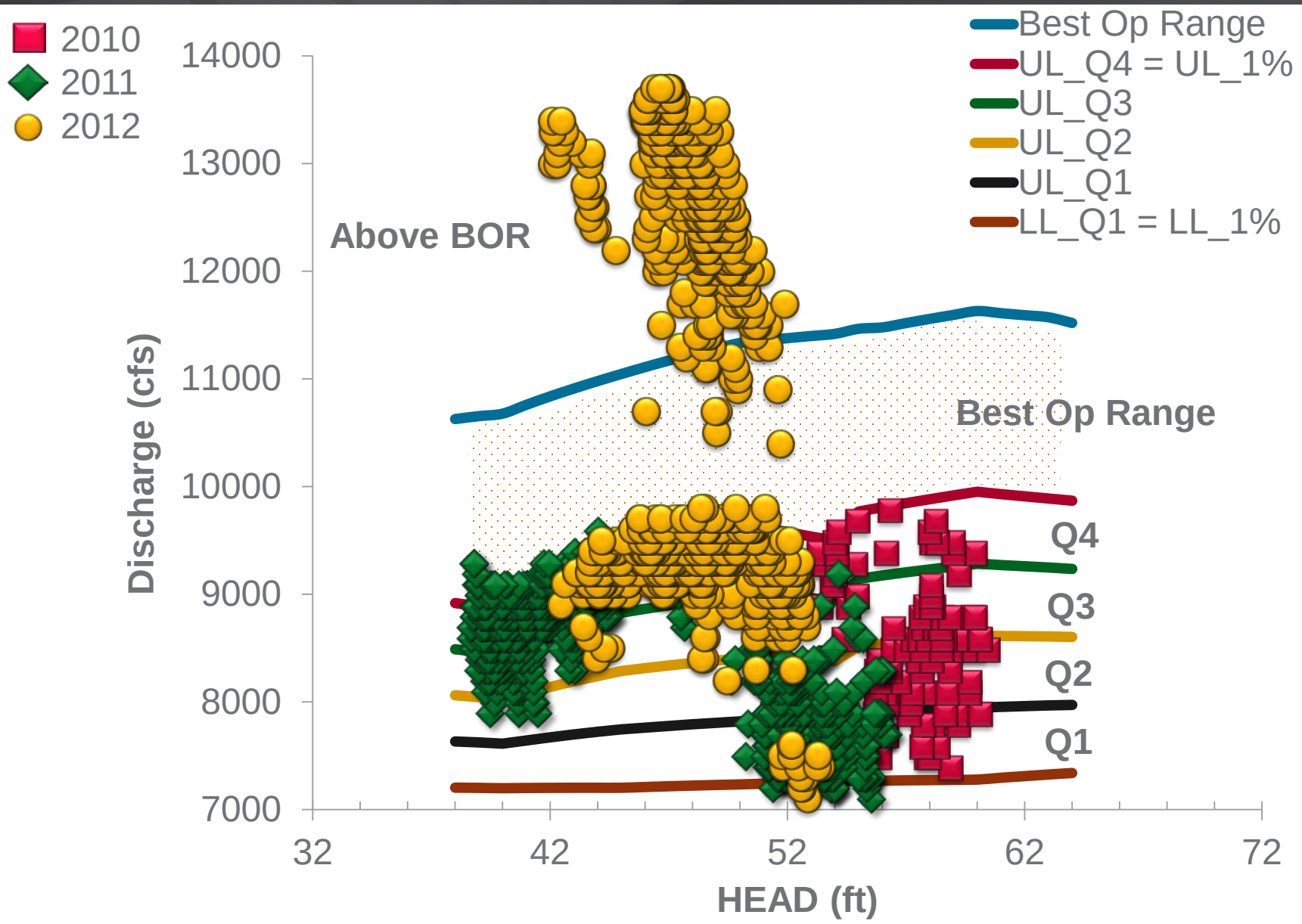


Analyses: BON
B1 CH1 Survival by Operating Condition

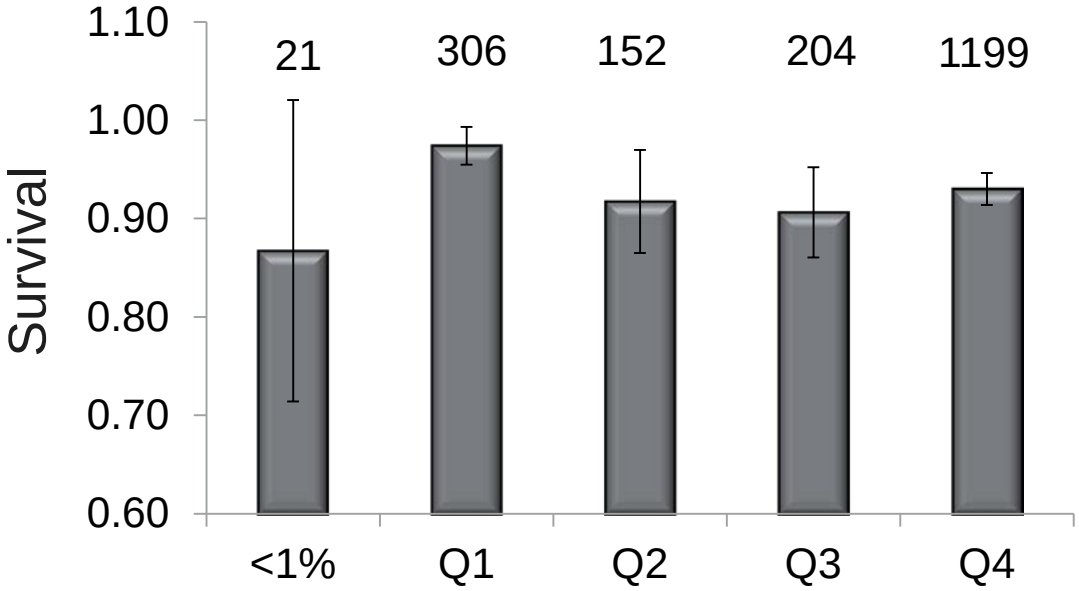


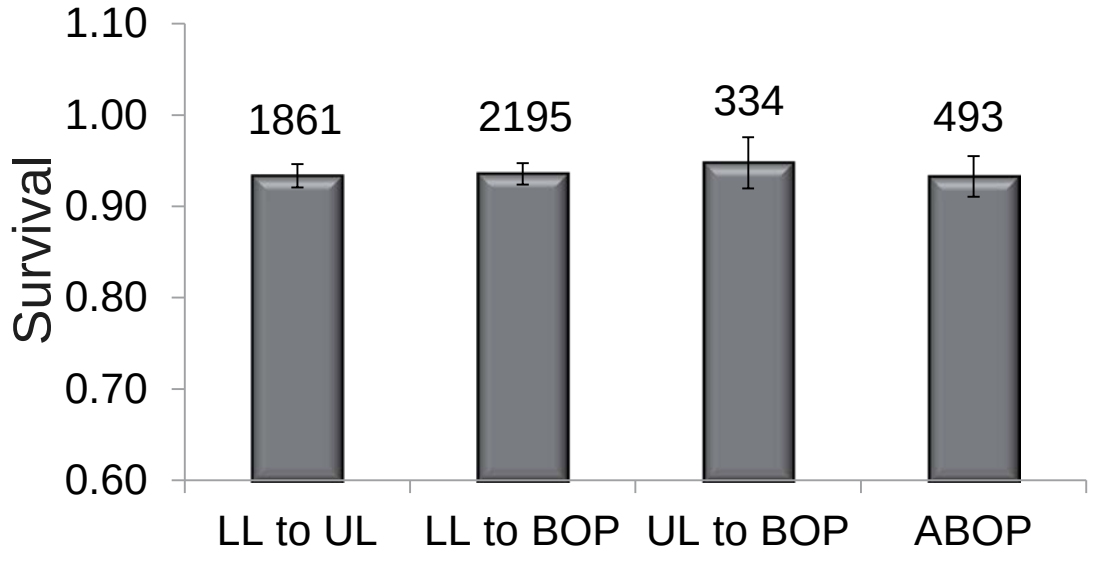


Analyses: BON
B1 STH Passage Distribution

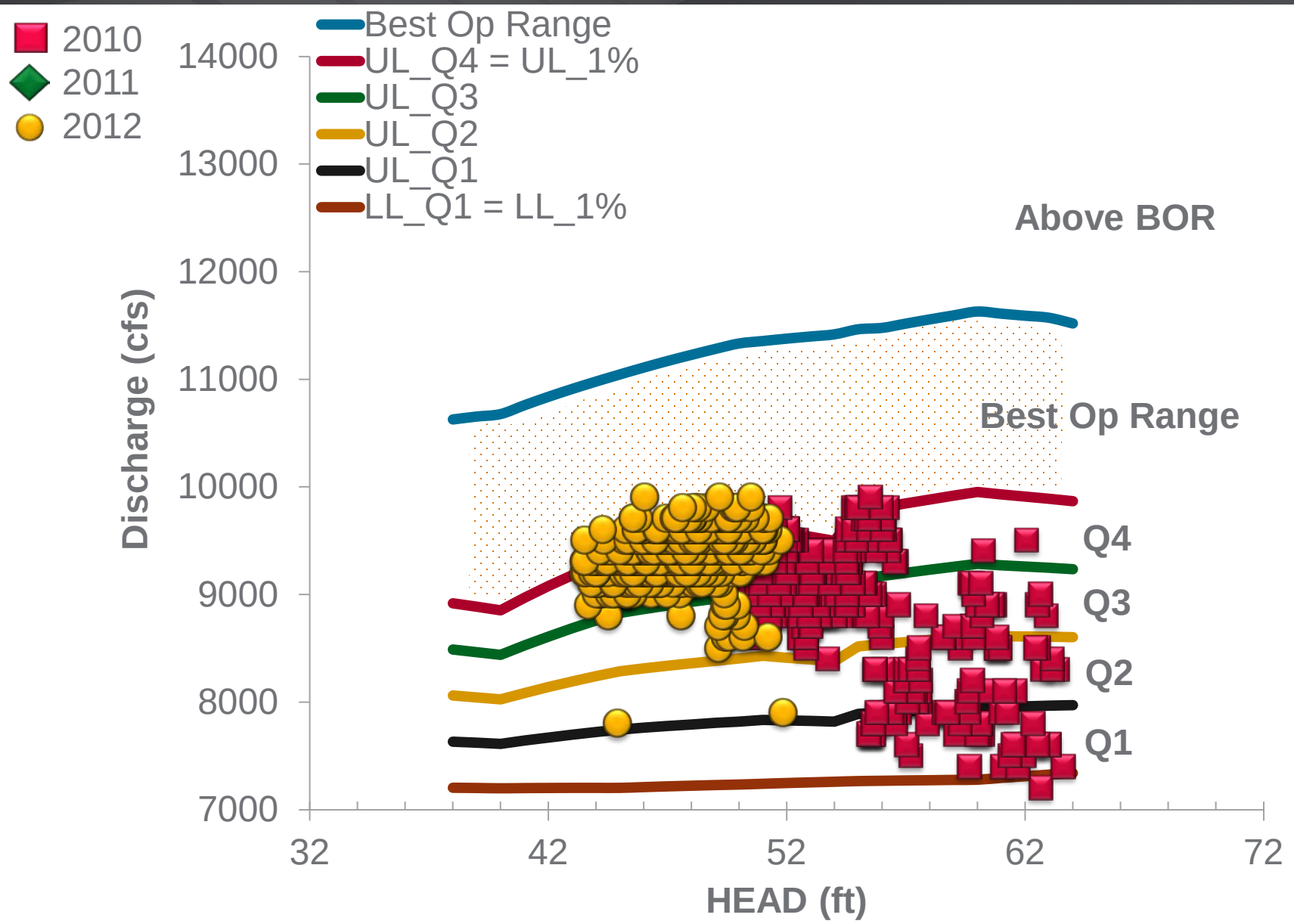


Analyses: BON
B1 STH Survival by Operating Condition

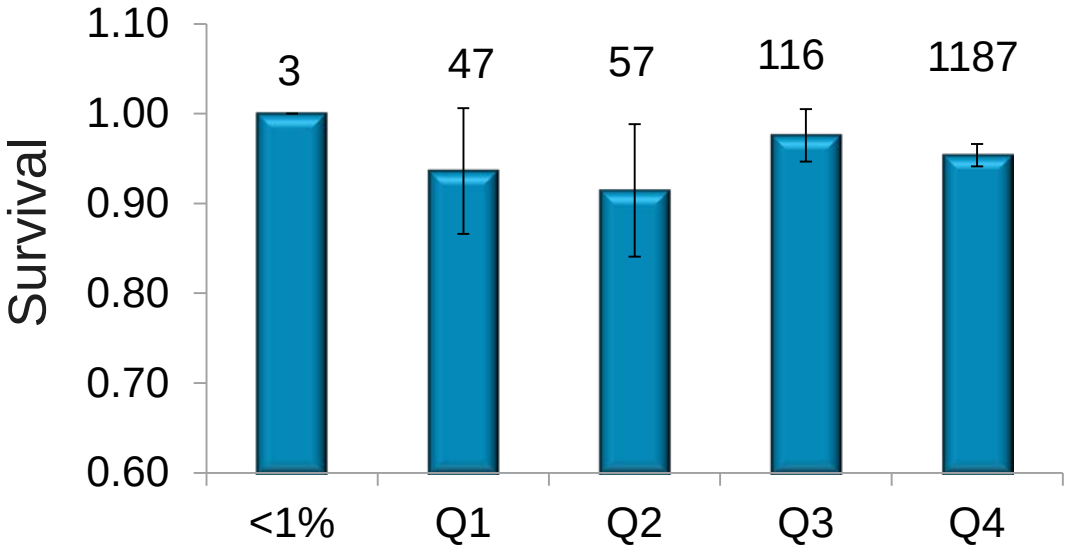


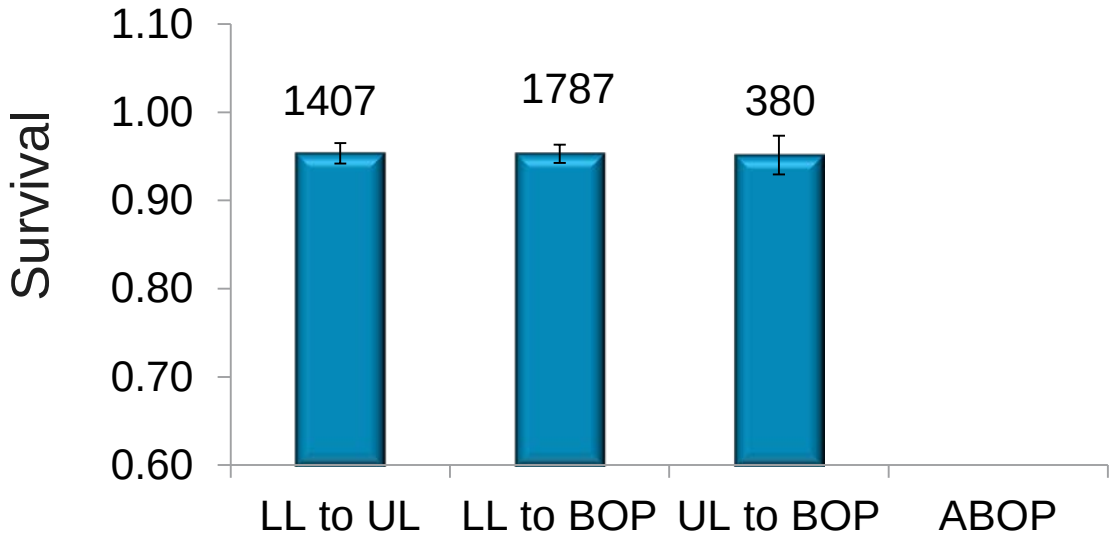


Analyses: BON
B1 CH0 Passage Distribution



Analyses: BON
B1 CH0 Survival by Operating Condition





BON B1 Survival at Lower & Upper BOP

Analyses: BON
B1 CH1 Survival within BOP

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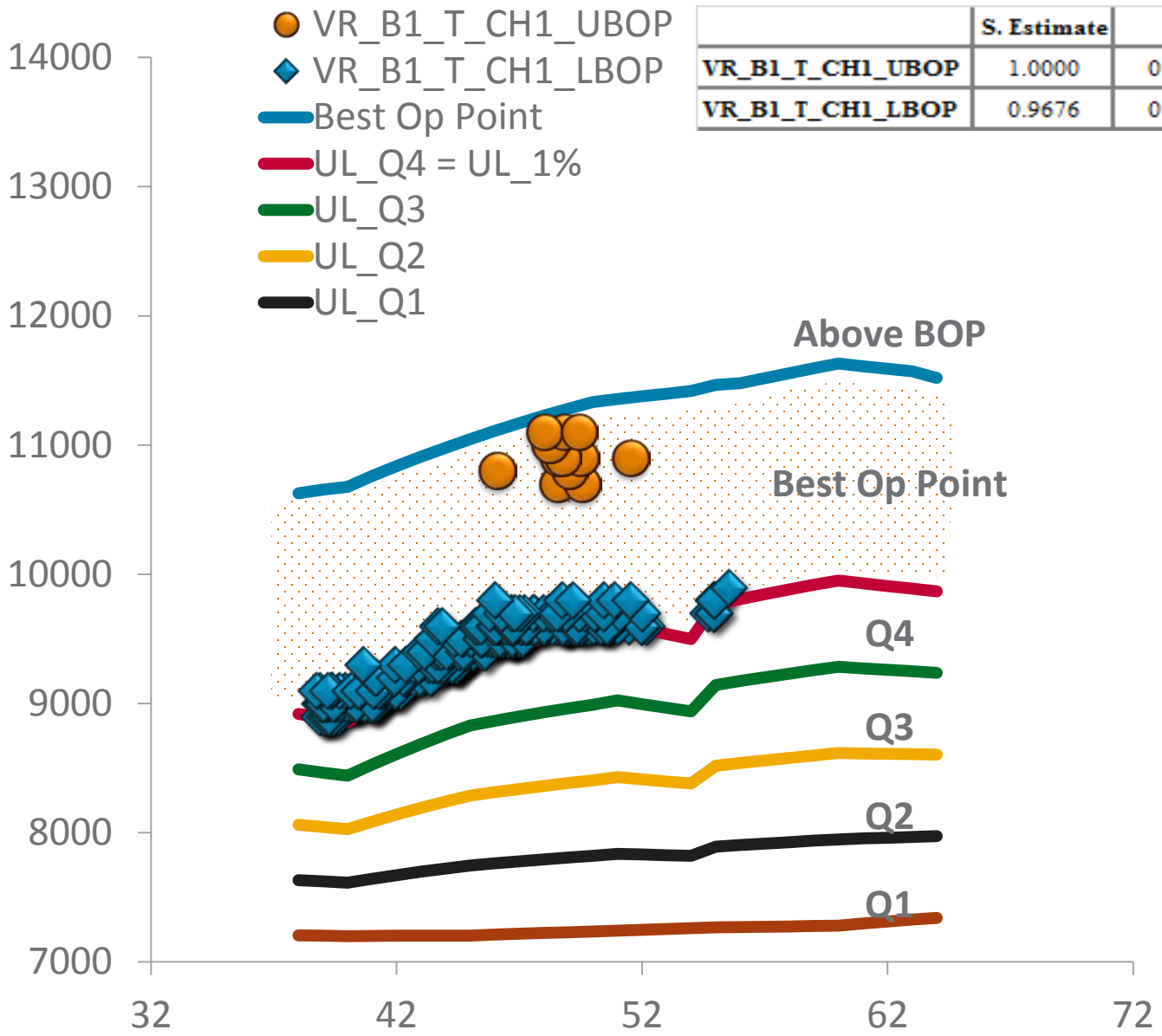
	S. Estimate	s.e.	N
VR_B1_T_CH1_UBOP	1.0000	0.0000	12
VR_B1_T_CH1_LBOP	0.9676	0.0155	320



Analyses: BON
B1 STH Survival within BOP

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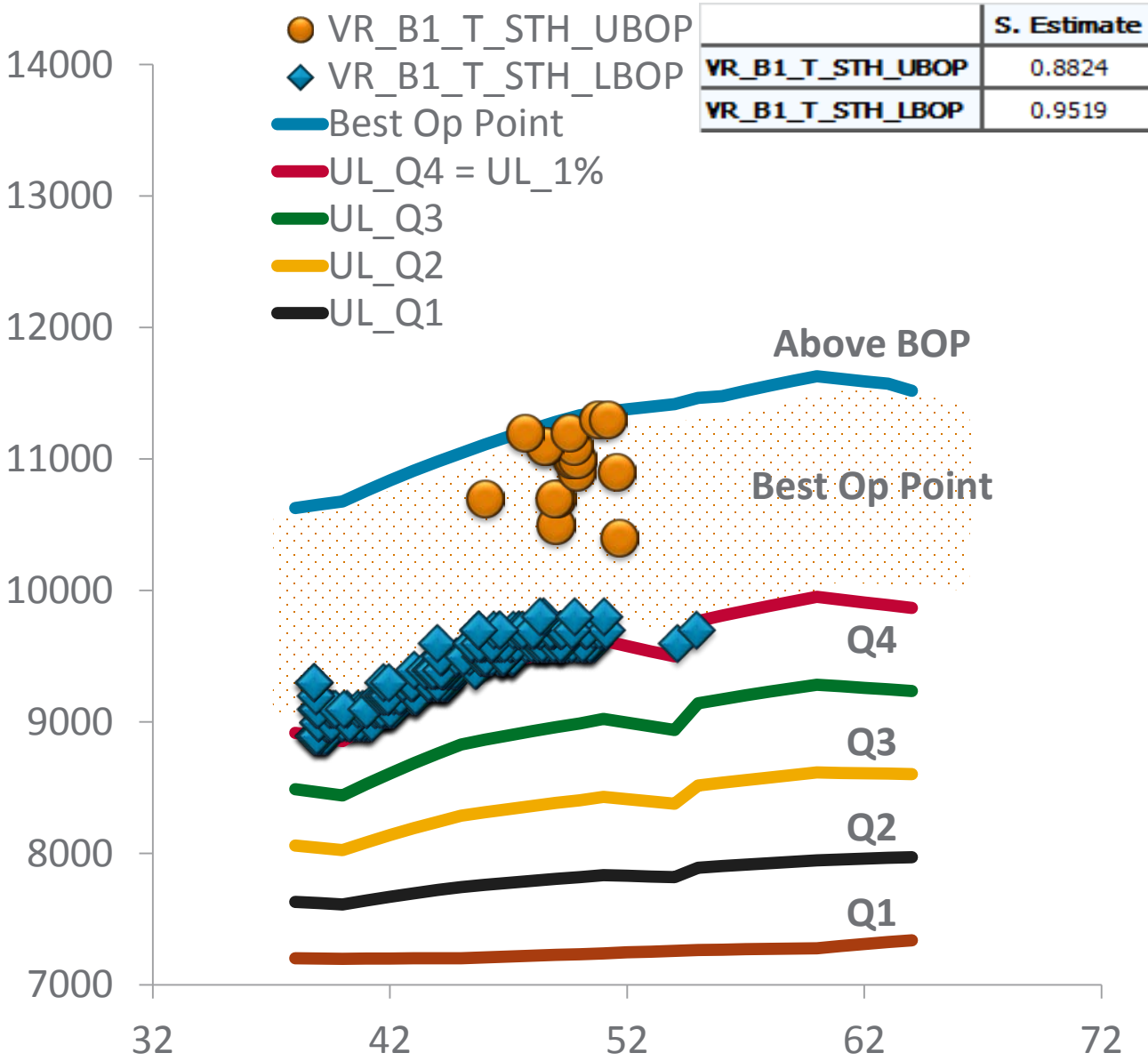
	S. Estimate	s.e.	N
VR_B1_T_STH_UBOP	0.8824	0.0781	17
VR_B1_T_STH_LBOP	0.9519	0.0145	317



Analyses: BON
B1 CH0 Survival within BOP

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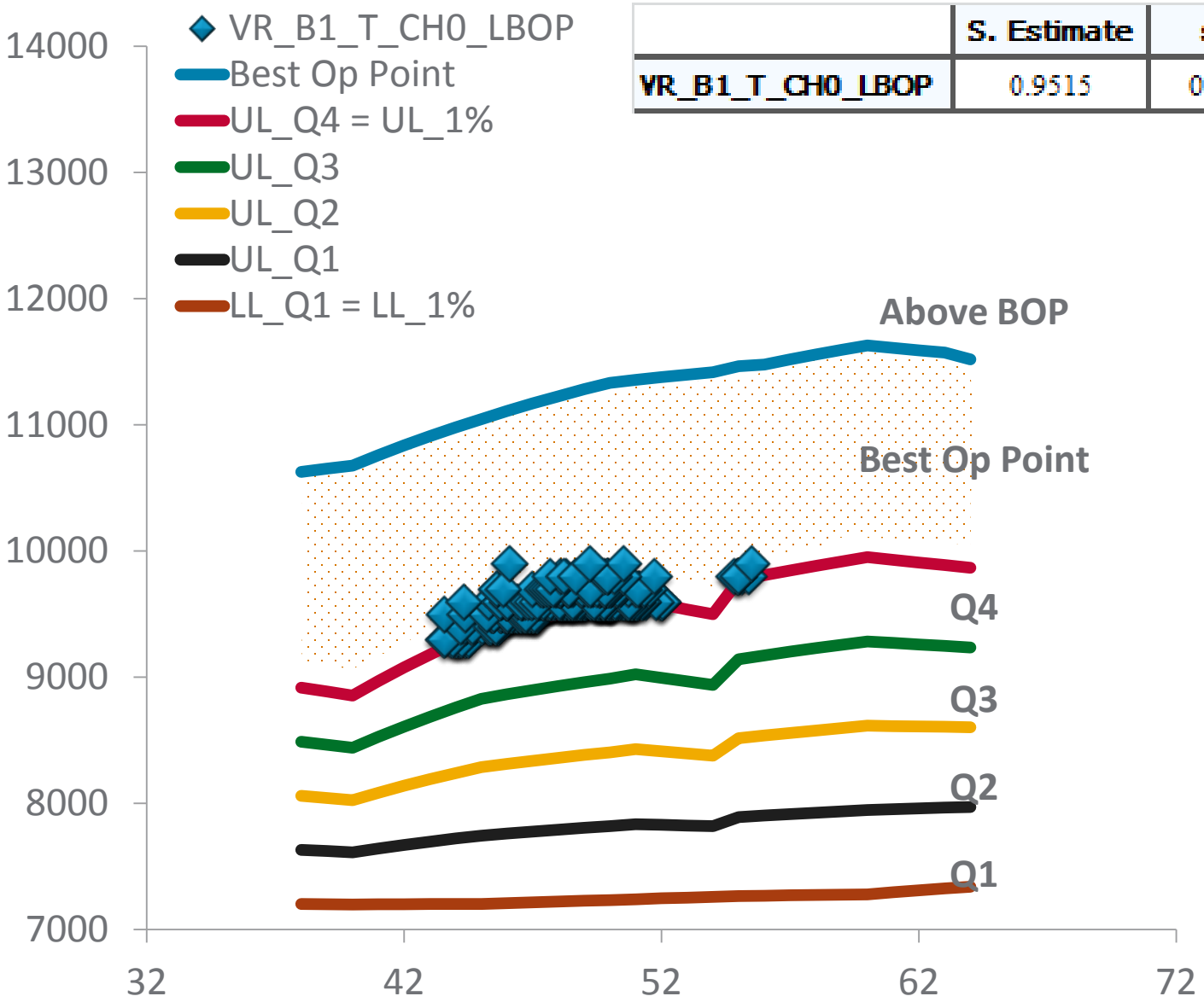
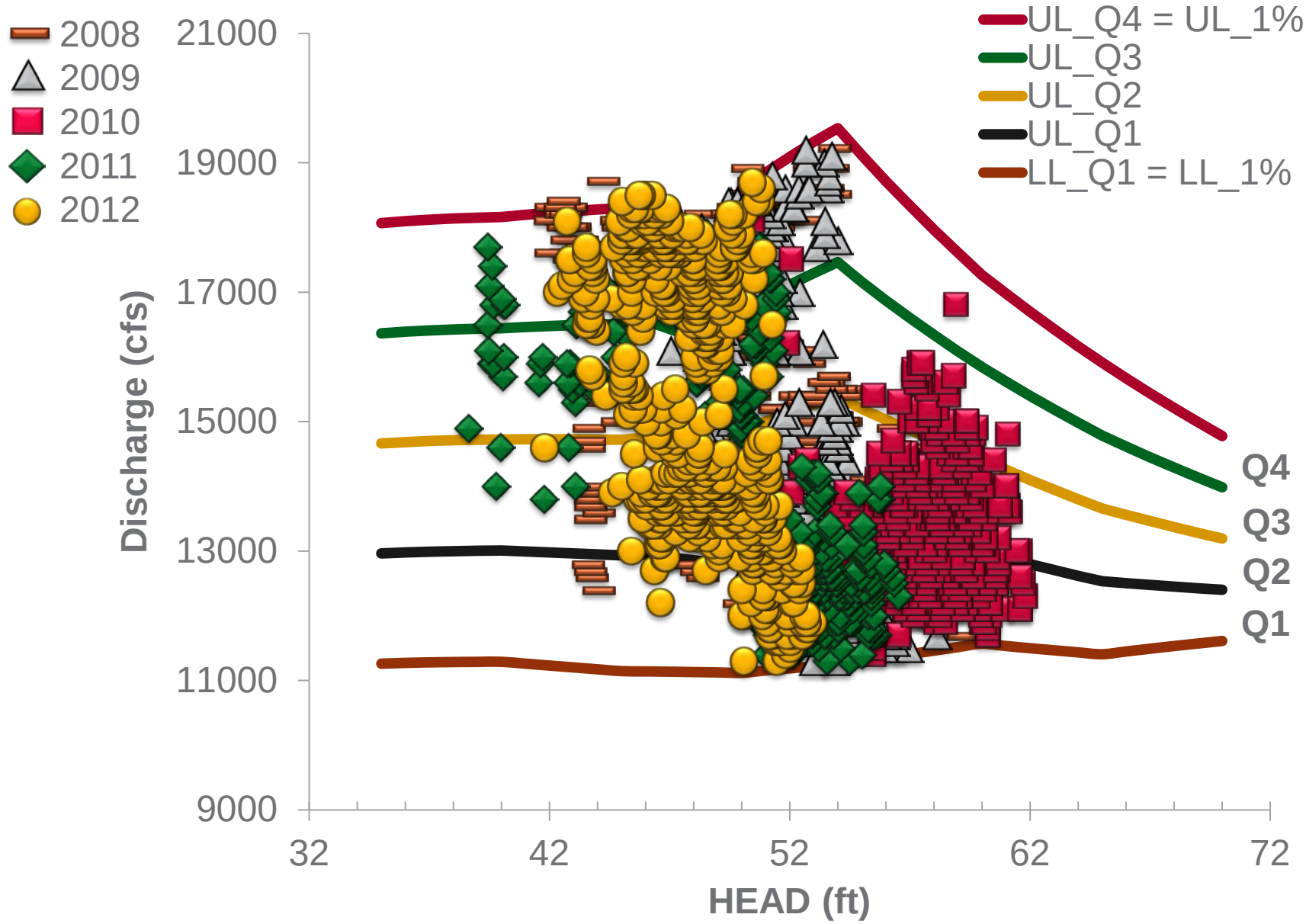
	S. Estimate	s.e.	N
VR_B1_T_CH0_LBOP	0.9515	0.0112	380

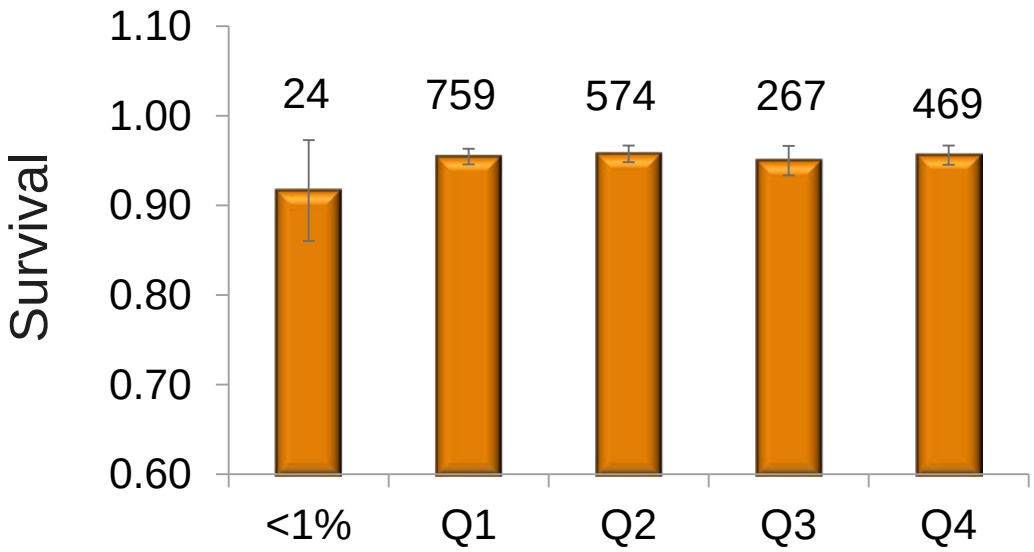


BON B2 Survival By Species and Operation

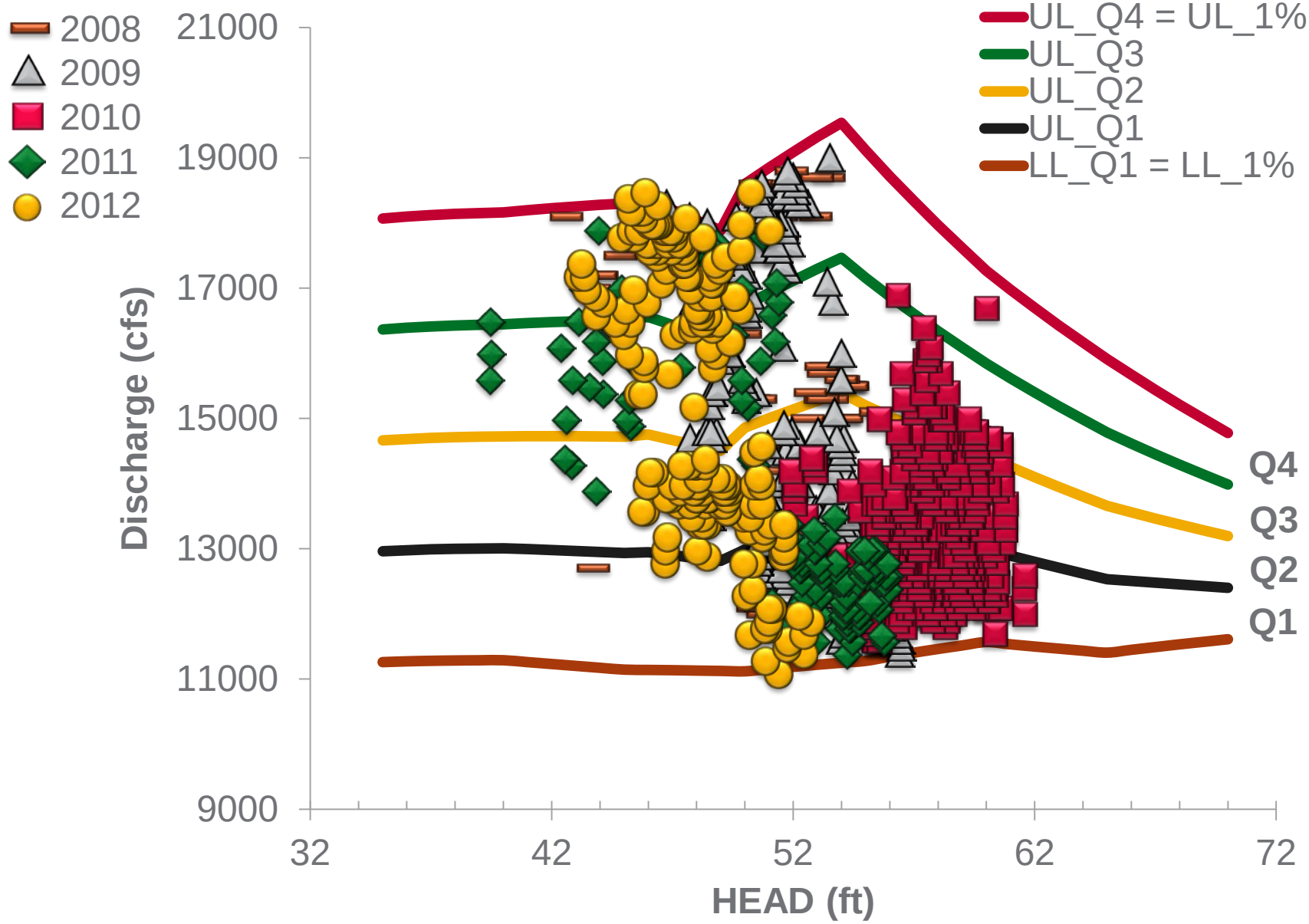
Analyses: BON
B2 CH1 Passage by Quartile



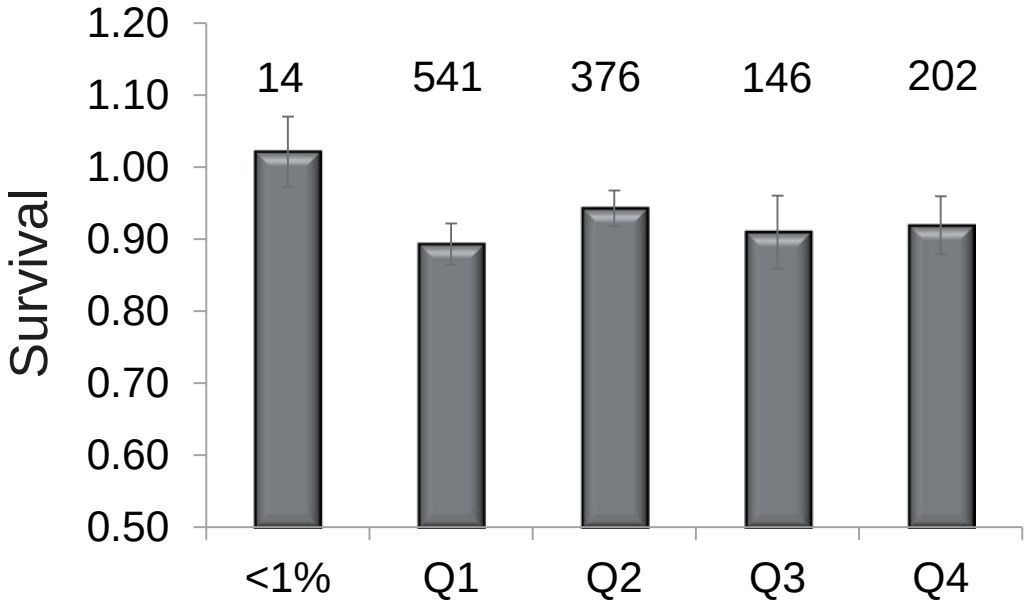
Analyses: BON
B2 CH1 Survival by Operating Condition



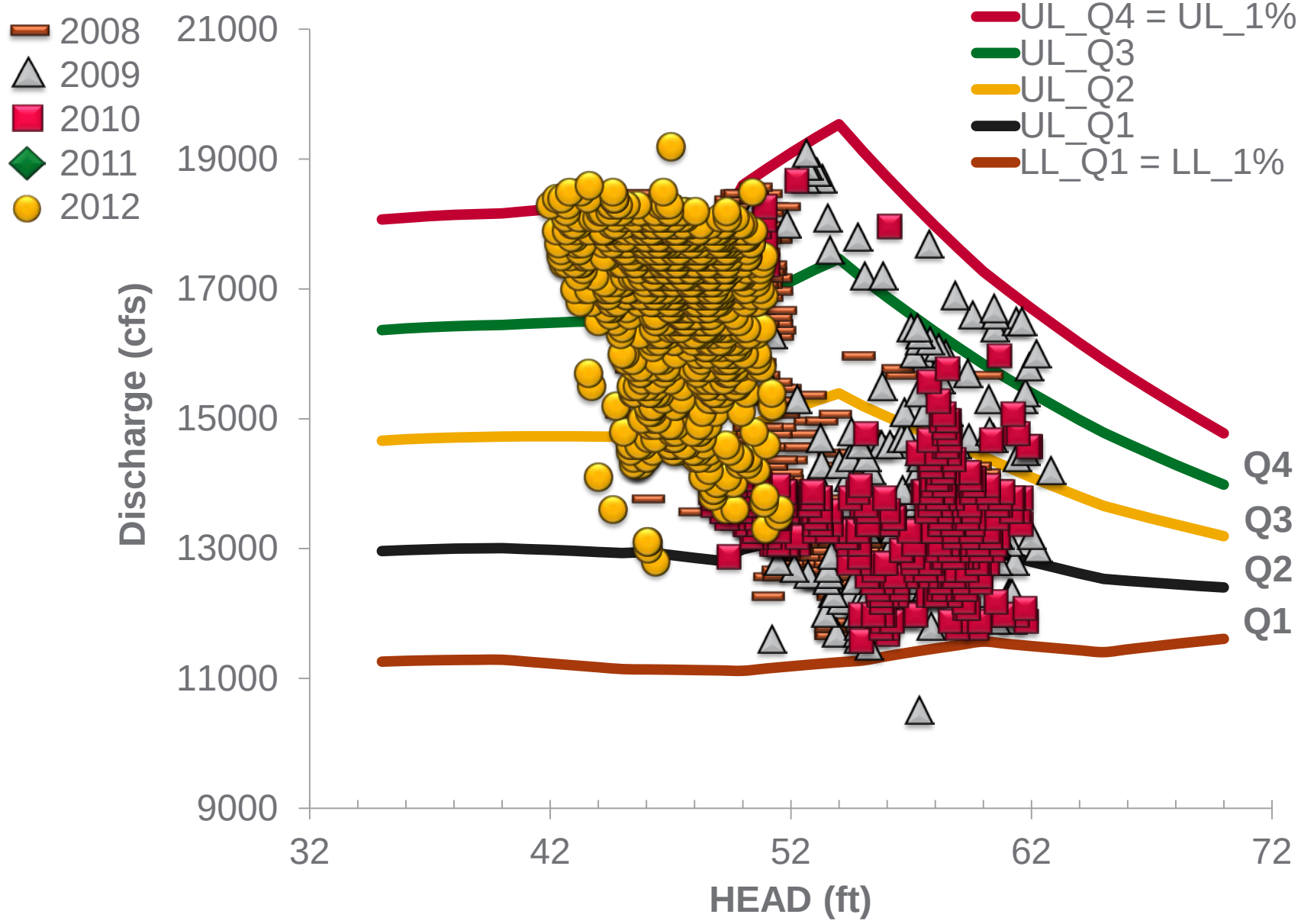
Analyses: BON
B2 STH Passage Distribution



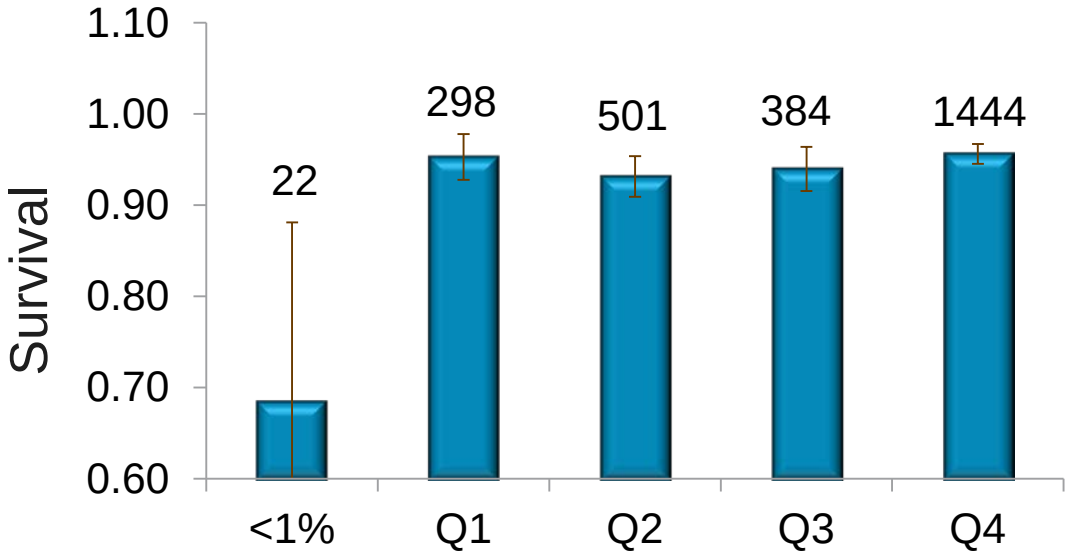
Analyses: BON
B2 STH Survival by Operating Condition



Analyses: BON
B2 CH0 Passage Distribution



Analyses: BON
B2 CH0 Survival by Operating Condition



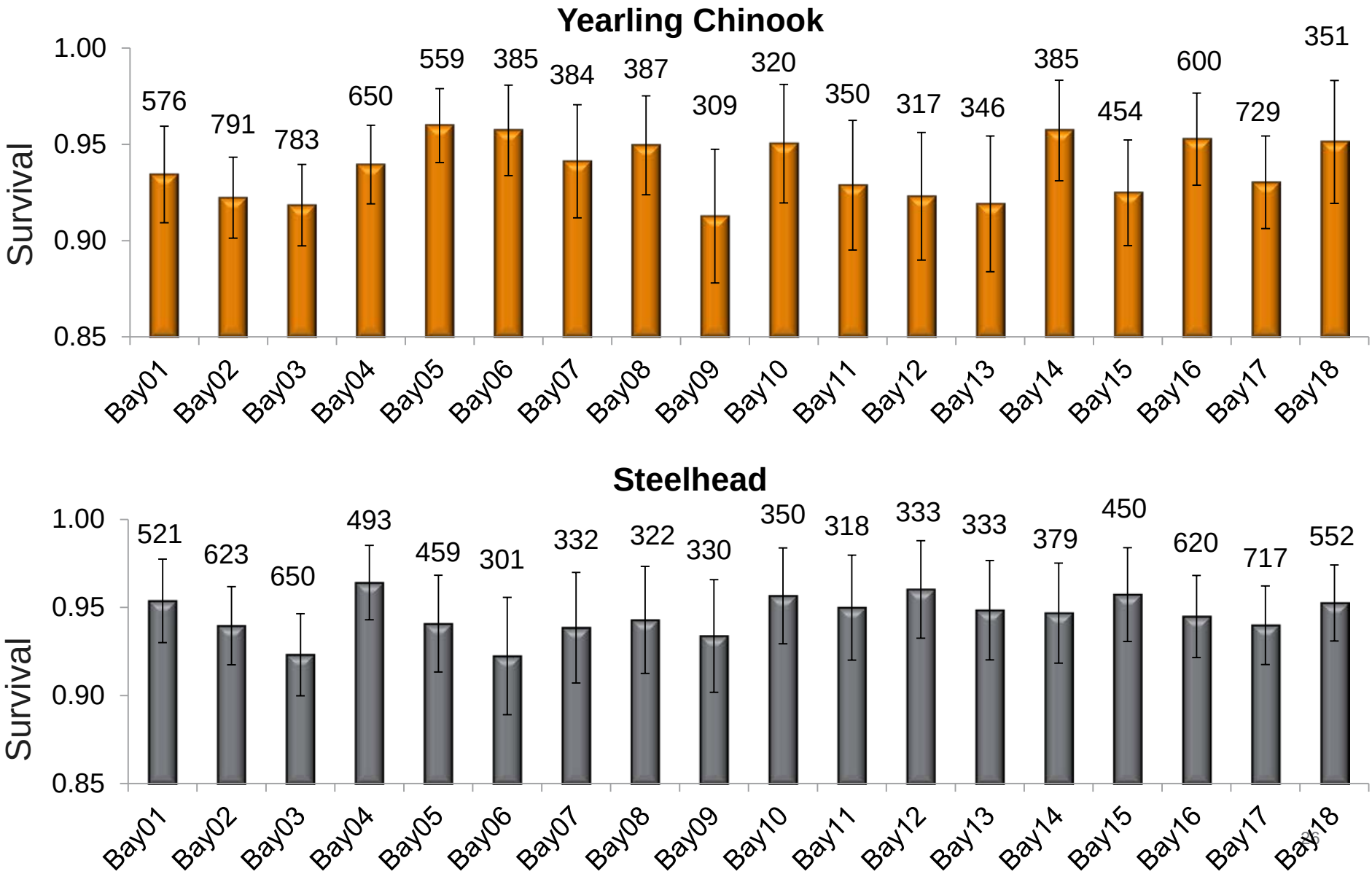
B2: STS vs No STS, 2008 & 2011

CH1		Estimate	s.e.	Count
2008	With STS_Q4	0.9320	0.0414	69
	Without STS_Q4	0.8299	0.0617	61
2011	With STS_Q4	0.9414	0.0495	50
	Without STS_Q4	0.9369	0.0601	37
	With STS_Q3_Q4	0.9511	0.0338	125
	Without STS_Q3_Q4	0.9771	0.0494	50

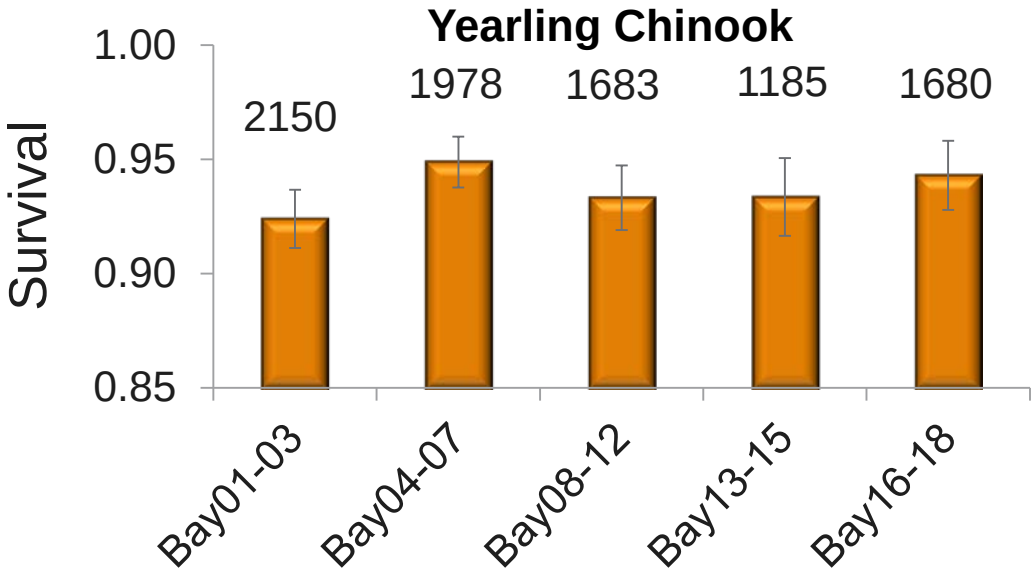
STH		Estimate	s.e.	Count
2008	With STS_Q4	0.9339	0.071	29
	Without STS_Q4	1.0417	0.2039	24
2011	With STS_Q4	0.9000	0.0987	15
	Without STS_Q4	0.9231	0.0739	13
	With STS_Q3_Q4	0.8907	0.0553	45
	Without STS_Q3_Q4	0.9790	0.0527	22

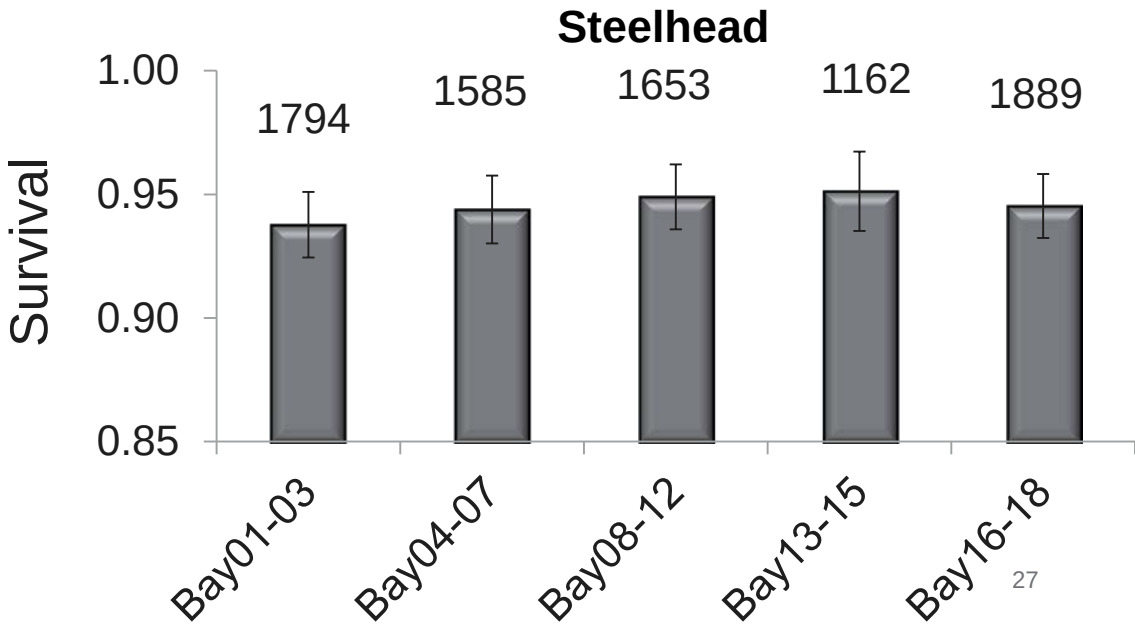
BON Spillway Surival

Analyses: BON
Spillway CH1 and STH Survival by Bay

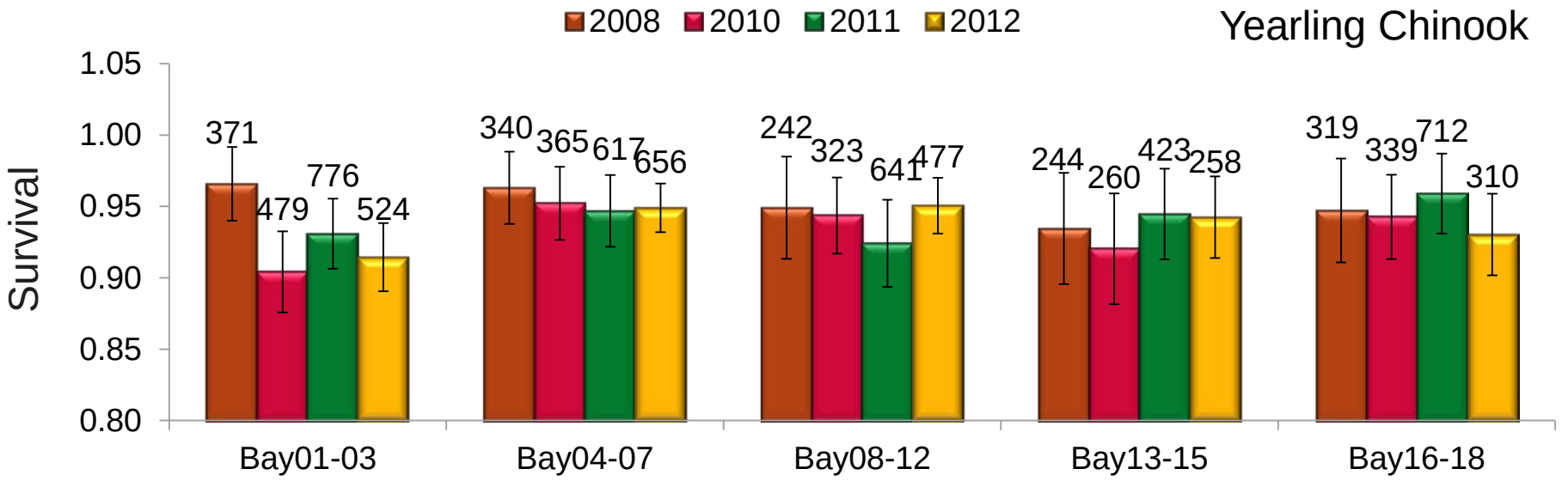


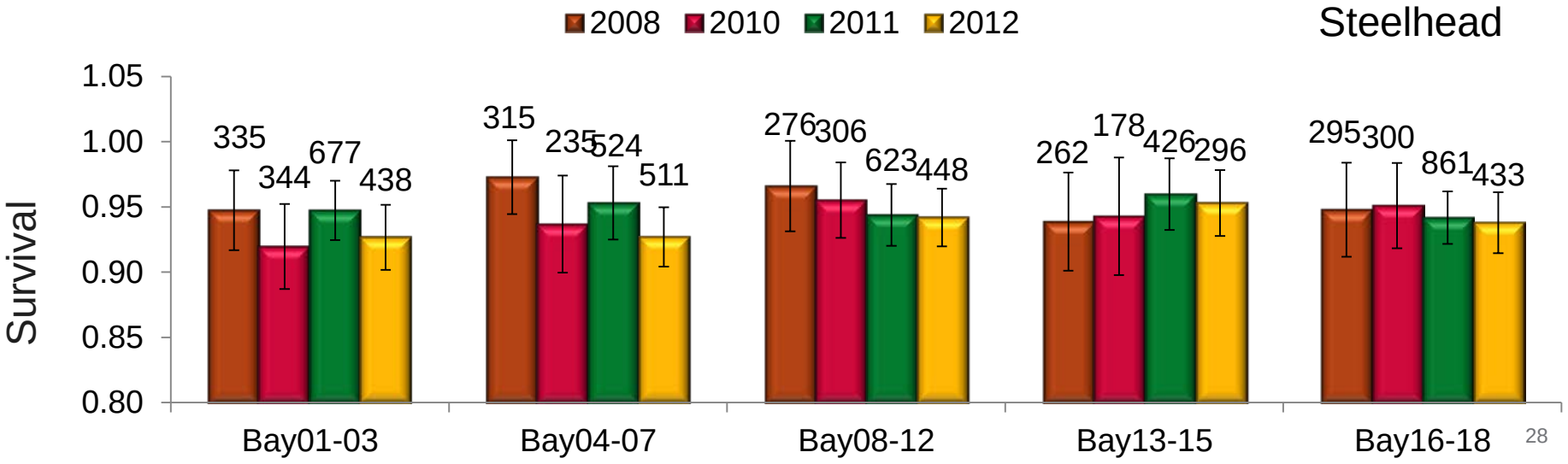
Analyses: BON
Spillway CH1 and STH Survival, Grouped Bays



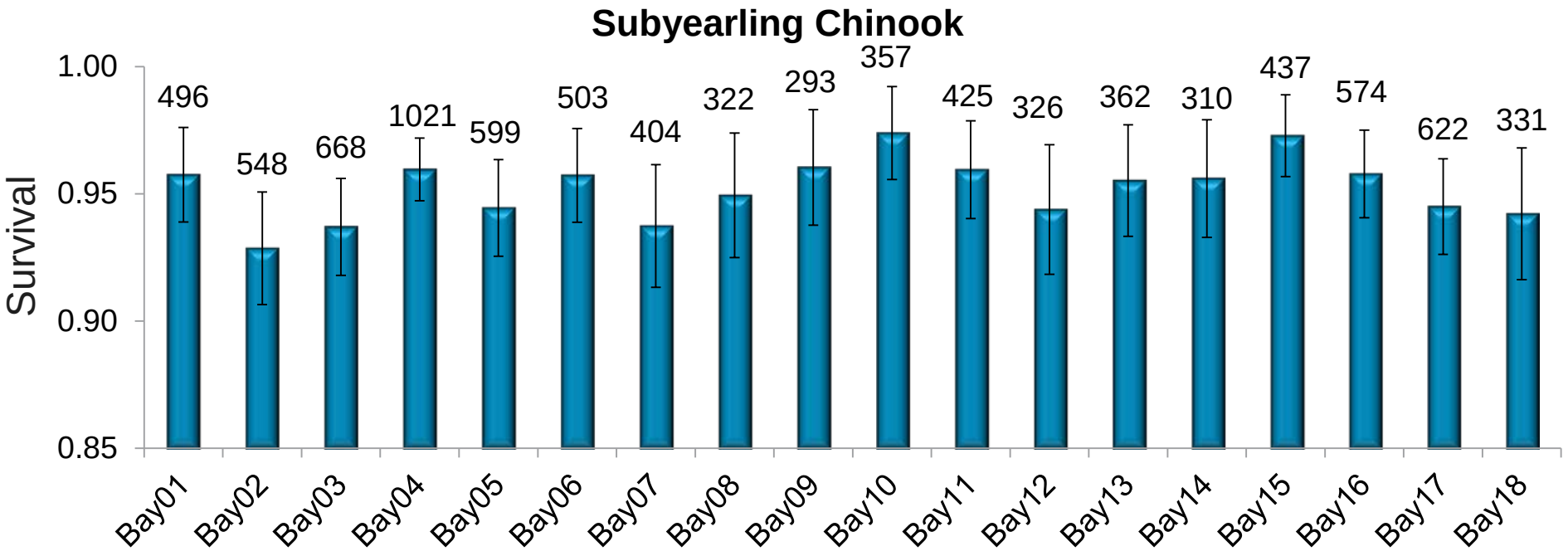


Analyses: BON
Spillway Survival by Grouped Bays

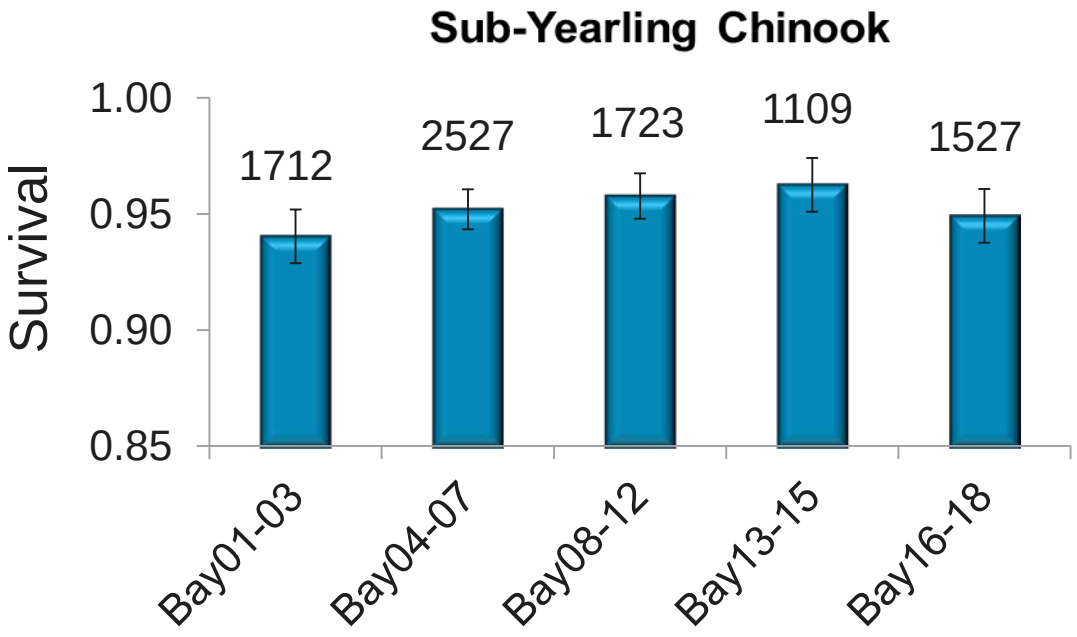




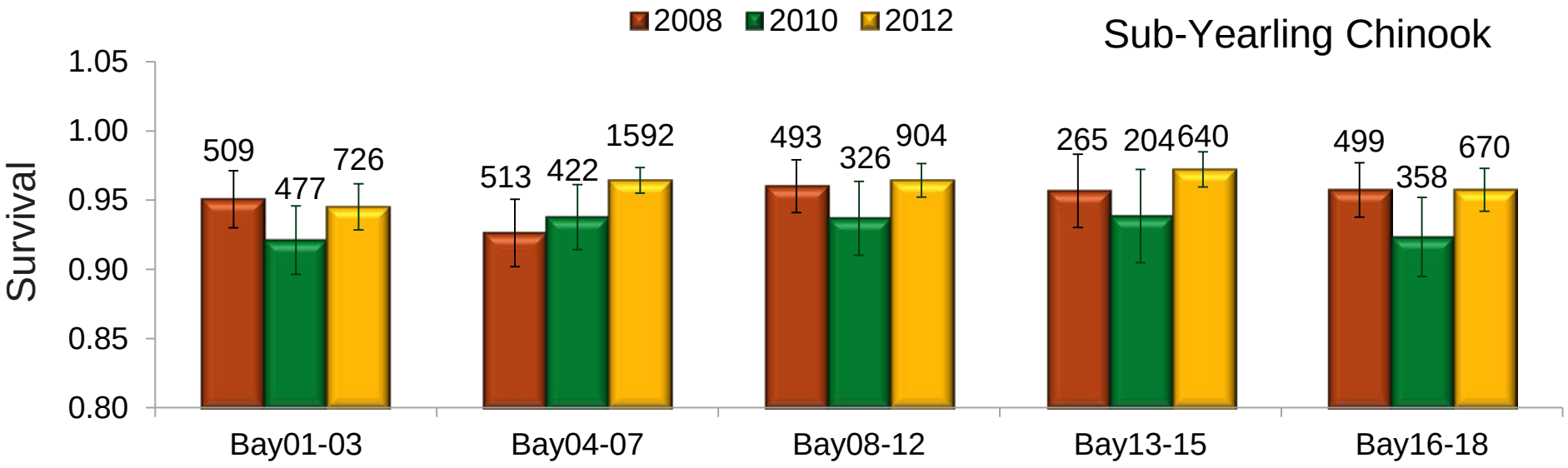
Analyses: BON
Spillway CH0 Survival by Bay



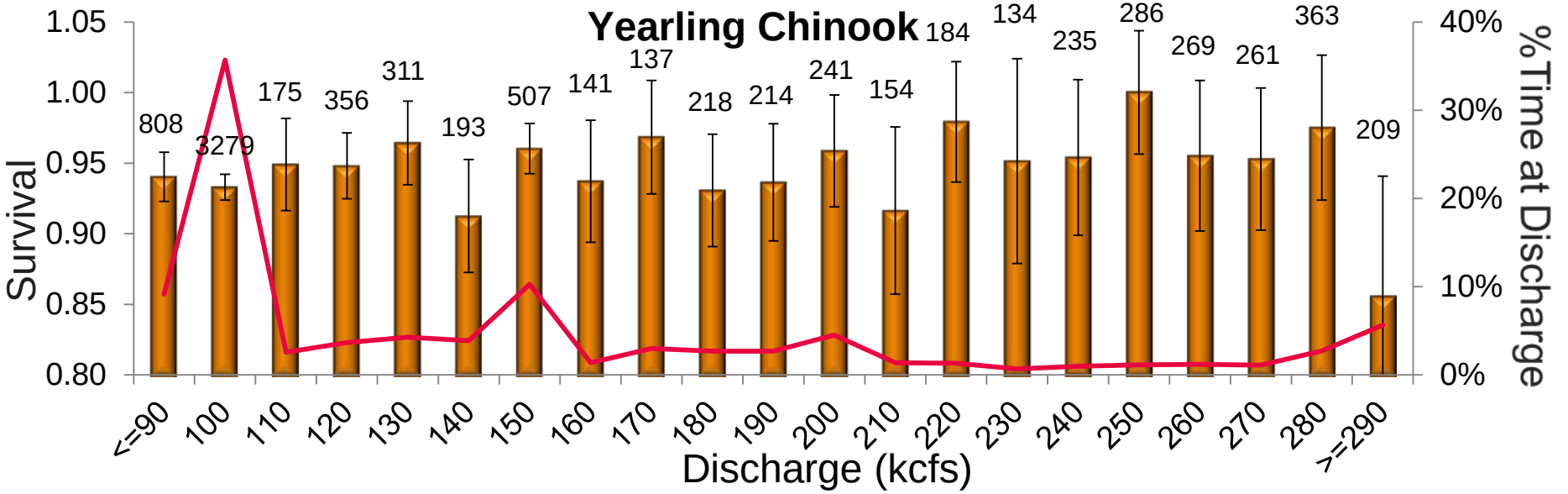
Analyses: BON
Spillway CH0 Survival, Grouped Bays

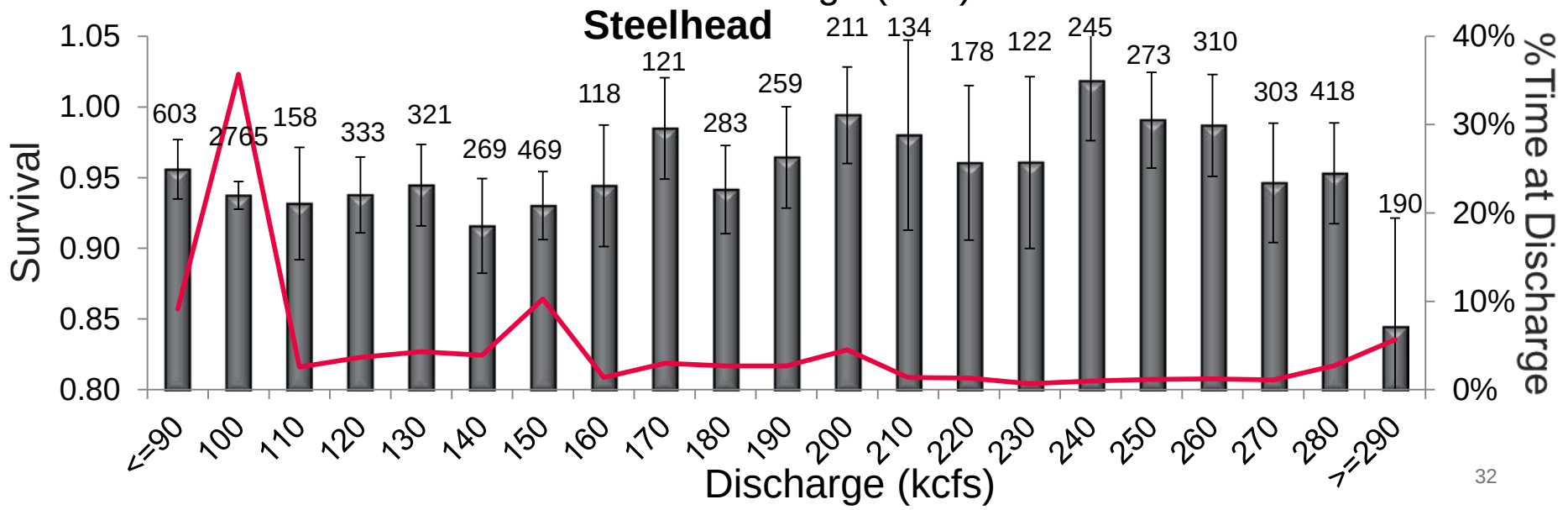


Analyses: BON
Spillway Survival by Bays, CH0

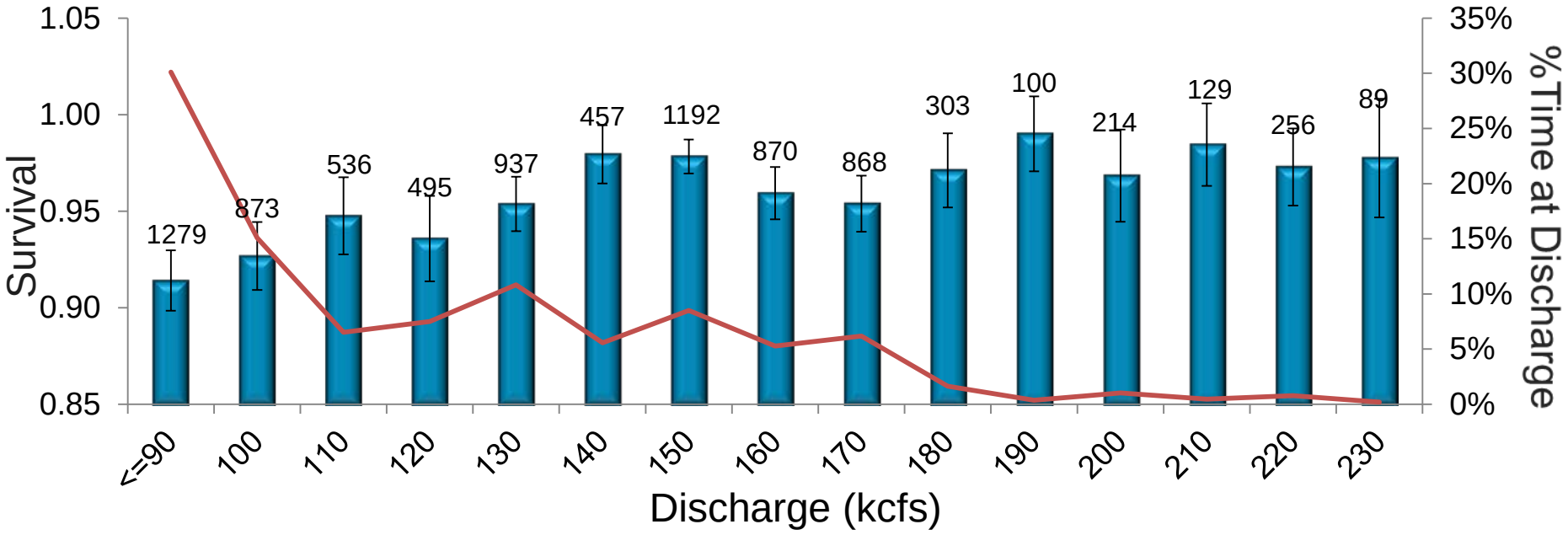


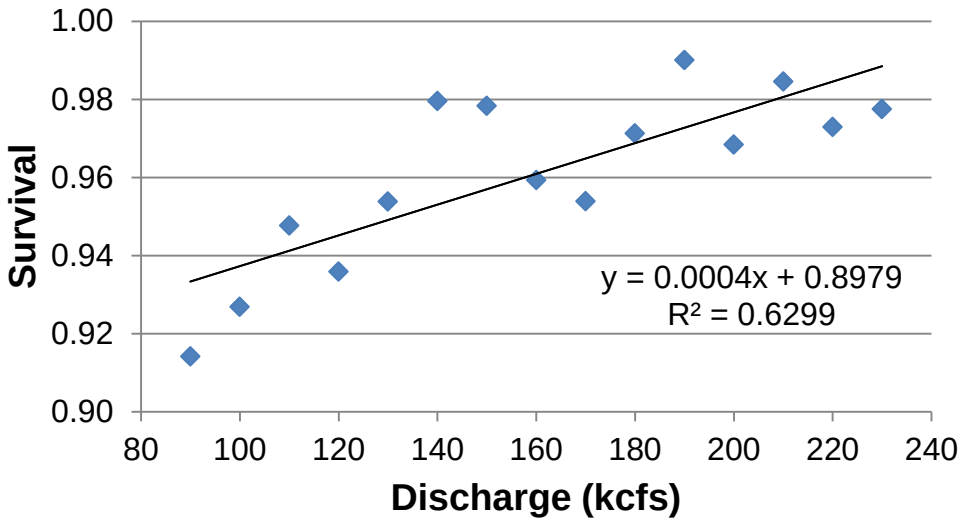
Analyses: BON
Spillway CH1 and STH Survival by Discharge





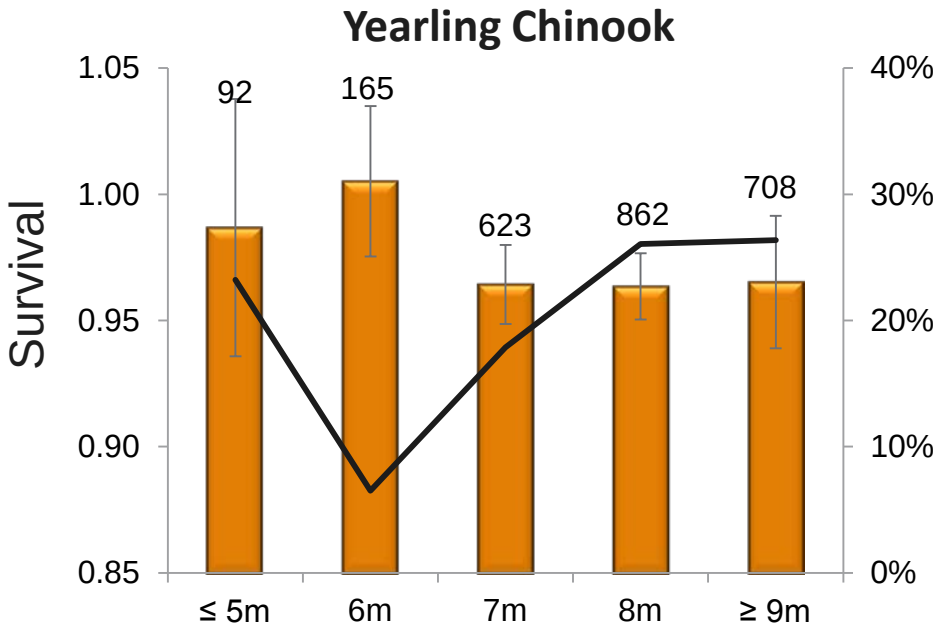
Analyses: BON
Spillway CH0 Survival by Discharge





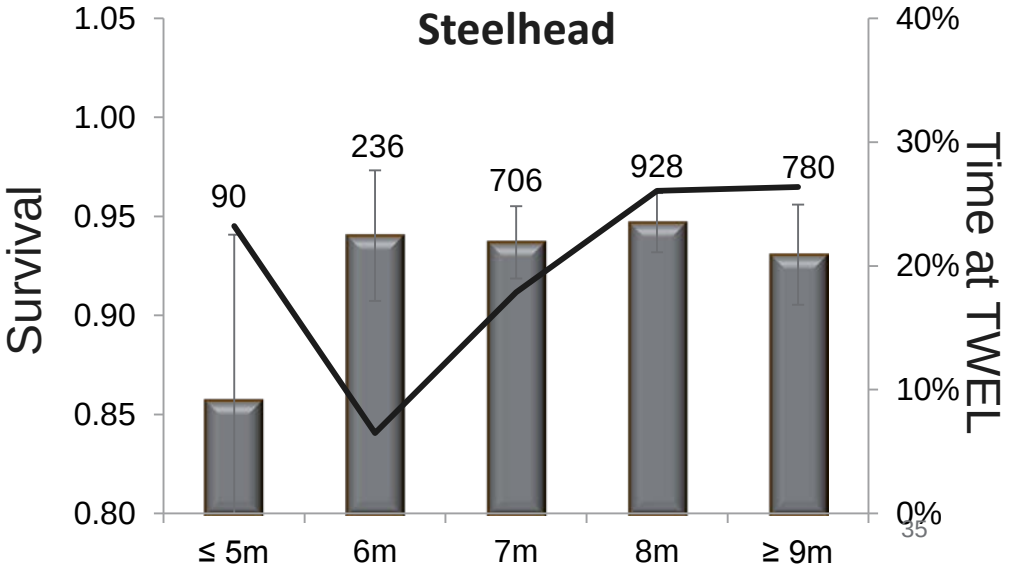
BON Survival by Tailwater Elevation

Analyses: BON
B1 Survival by Tailwater Level

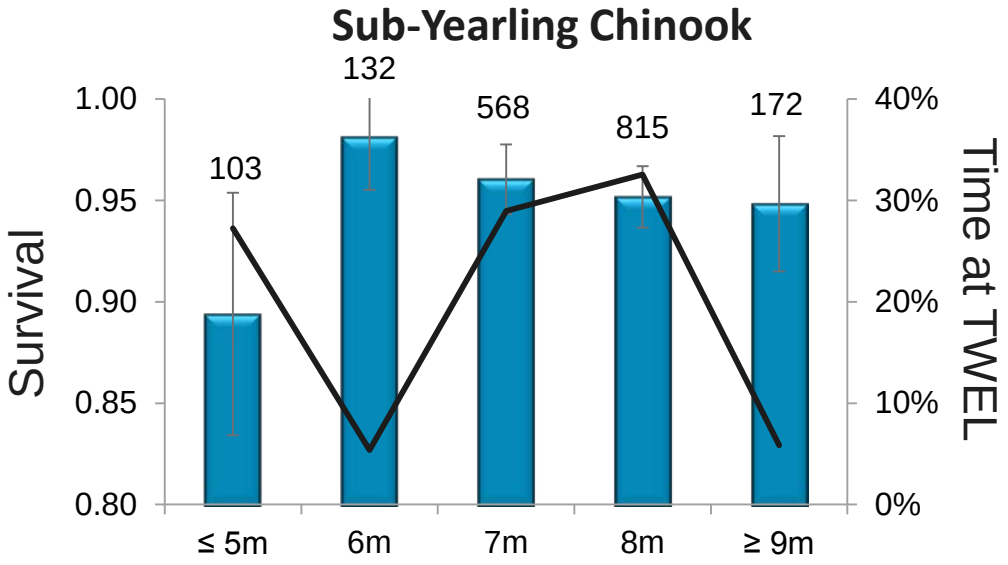


Bin	S. Estimate	+95 CI	-95 CI
≤ 5m	0.9868	1.0378	0.9358
6m	1.0052	1.0350	0.9754
7m	0.9643	0.9800	0.9486
8m	0.9635	0.9766	0.9504
≥ 9m	0.9652	0.9915	0.9389

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

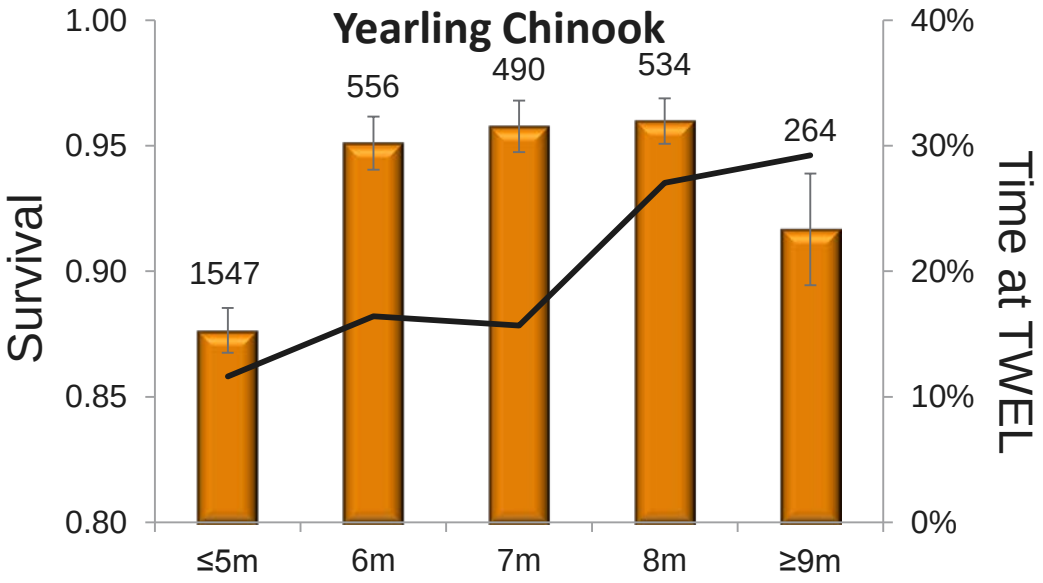


Analyses: BON
B1 Survival by Tailwater Level



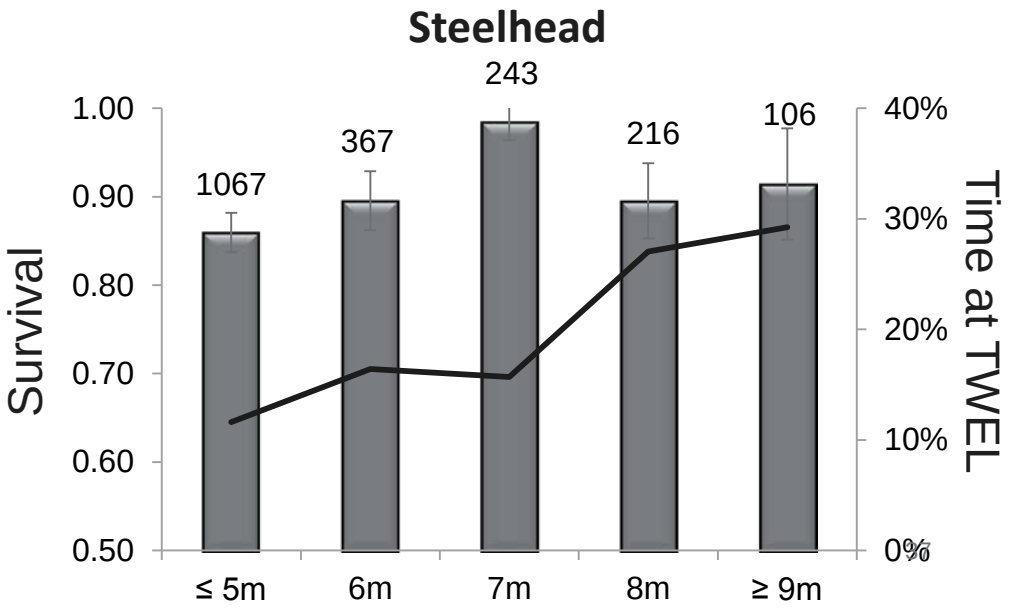
Bin	S. Estimate	+95 CI	-95 CI
≤ 5m	0.8939	0.9537	0.8341
6m	0.9811	1.0070	0.9552
7m	0.9604	0.9776	0.9432
8m	0.9517	0.9668	0.9366
≥ 9m	0.9483	0.9816	0.9150

Analyses: BON
B2 Survival by Tailwater Level

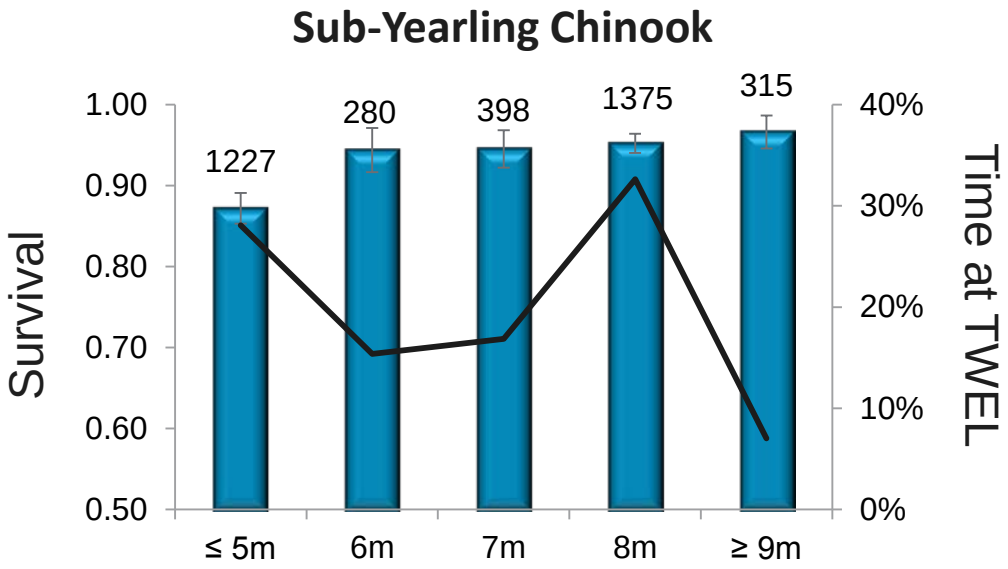


Bin	S. Estimate	+95 CI	-95 CI
≤ 5m	0.877	0.0089	1547
6m	0.951	0.0106	556
7m	0.958	0.0102	490
8m	0.960	0.0091	534
≥ 9m	0.917	0.0222	264

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

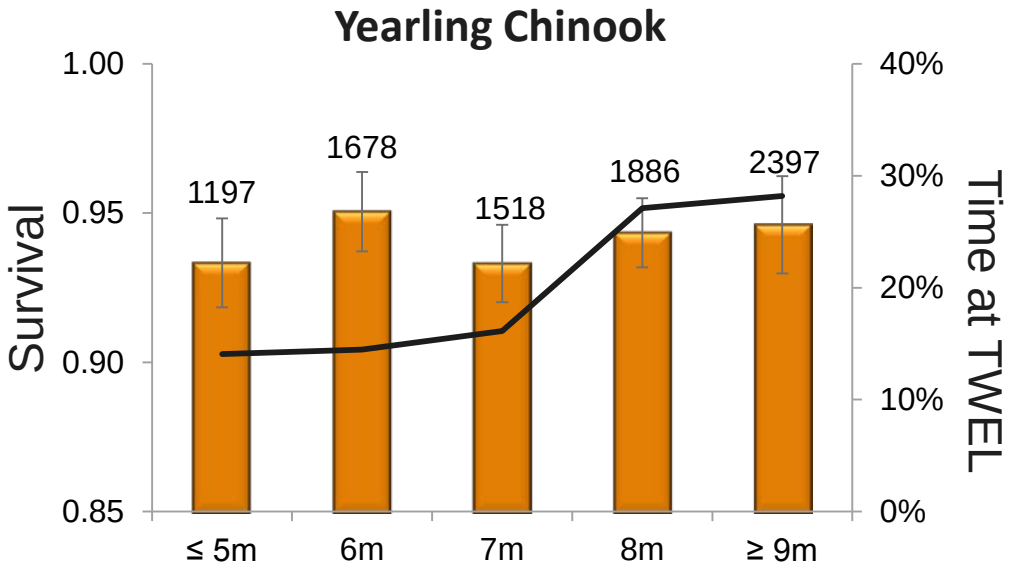


Analyses: BON
B2 Survival by Tailwater Level



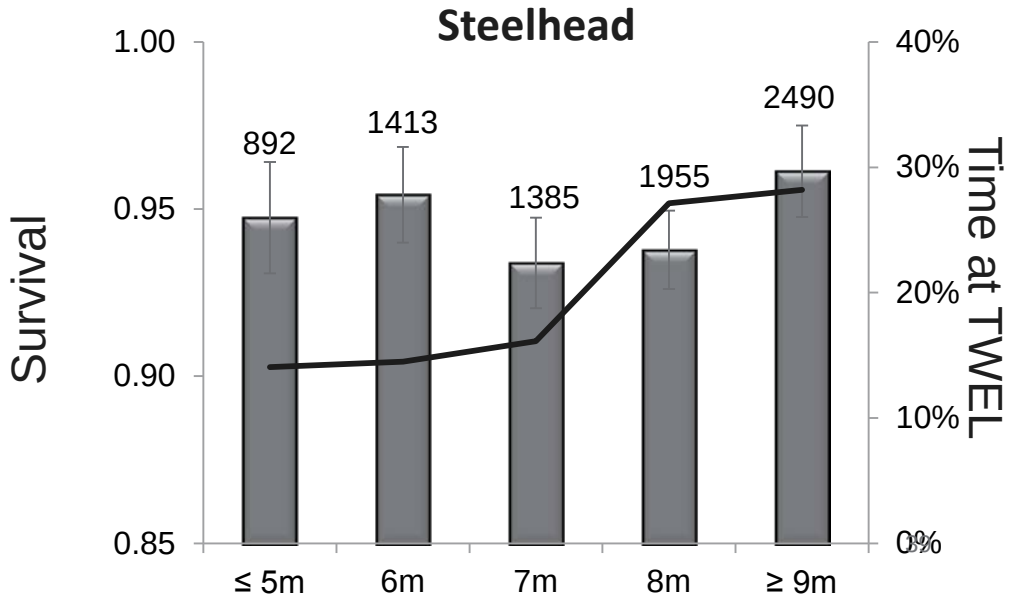
Bin	S. Estimate	+95 CI	-95 CI
≤ 5m	0.8720	0.8910	0.8530
6m	0.9440	0.9712	0.9168
7m	0.9454	0.9685	0.9223
8m	0.9522	0.9640	0.9404
≥ 9m	0.9663	0.9867	0.9459

Analyses: BON
Spillway Survival by Tailwater Level

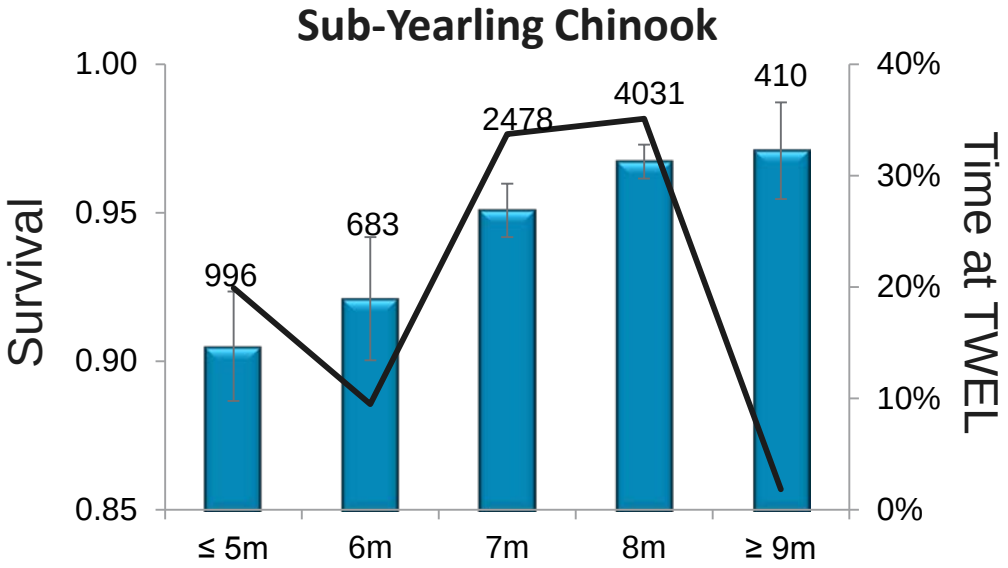


Bin	S. Estimate	+ 95 CI	-95 CI
≤ 5m	0.9333	0.9482	0.9184
6m	0.9505	0.9638	0.9372
7m	0.9331	0.9460	0.9202
8m	0.9434	0.9550	0.9318
≥ 9m	0.9461	0.9624	0.9298

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



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

BON Egress

BON: CH1 Tailrace Egress B1 and B2

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BON ROUTE	Treatment	Mean	StdErr	Min	Max	Median	N
B1	ABO	4.23	0.70	0.21	200.41	**0.30**	485
	BOP	5.90	1.67	0.24	281.36	**0.37**	286
	Q4	3.55	0.57	0.24	273.35	**0.37**	860
	Q3	2.43	0.82	0.23	110.46	**0.38**	189
	Q2	3.36	1.15	0.28	102.24	**0.44**	136
	Q1	6.40	2.10	0.27	280.27	**0.46**	234
	<1%	15.43	14.73	0.25	310.11	**0.53**	21
B2	Q4	5.92	0.29	0.25	42.82	**6.79**	340
	Q3	3.85	0.35	0.29	14.63	**0.75**	166
	Q2	3.52	0.26	0.25	33.28	**0.71**	452
	Q1	4.29	0.27	0.28	61.72	**0.71**	685
	<1%	8.92	0.79	0.58	18.77	**8.45**	26

BON: STH Tailrace Egress B1 and B2

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

BON: CH0 Tailrace Egress B1 and B2

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

BON: CH1 Tailrace Egress Spillway

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

BON: STH Tailrace Egress Spillway

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

BON: CH0 Tailrace Egress Spillway

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

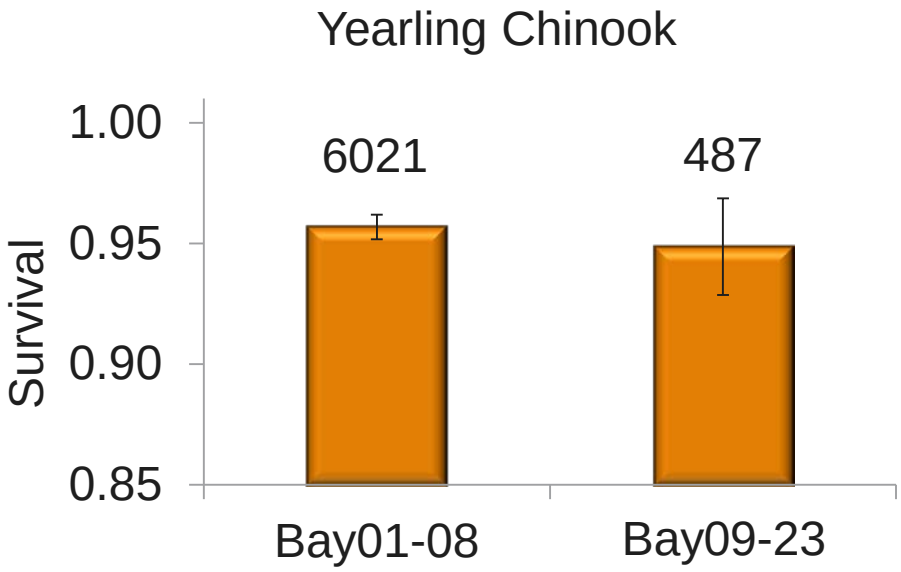
Conclusions: BON

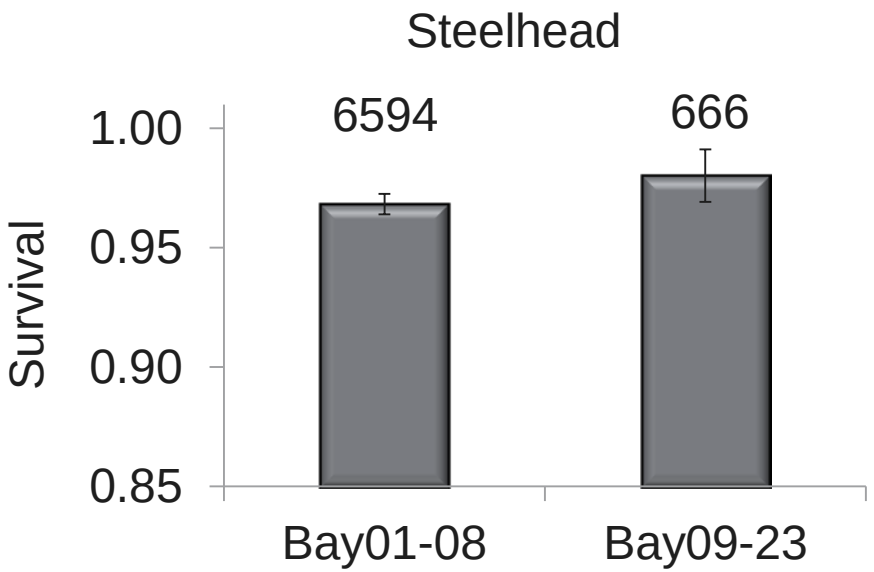
- B1
  - There was not a difference in survival for salmonids passing within the 1% of peak operating efficiency and salmonids passing at operations above the upper 1% operating efficiency
- B2
  - Lower survival for CH1 in Q4 range
  - No difference in survival for STH across operating range
  - No 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

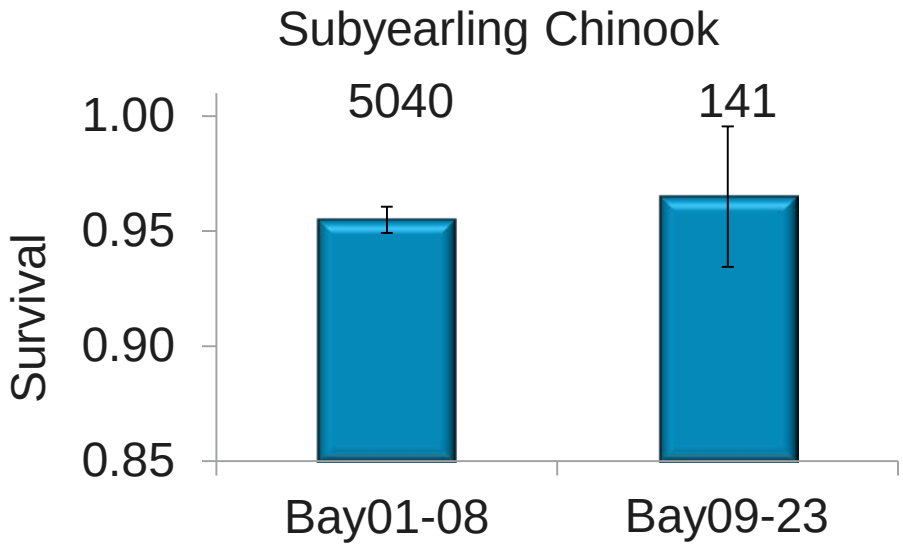
Introduction: TDA

- 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

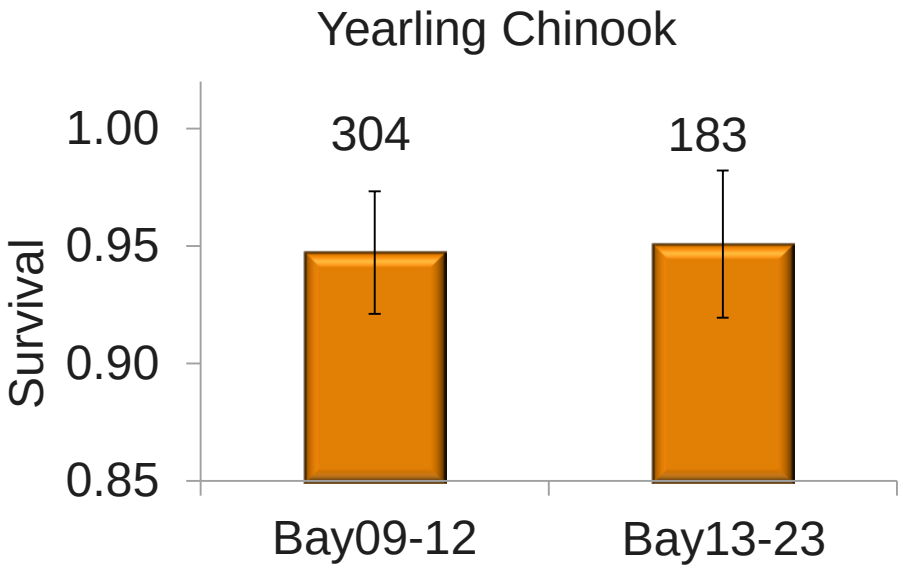
Analyses: TDA
Survival Within and Outside of Spill Wall

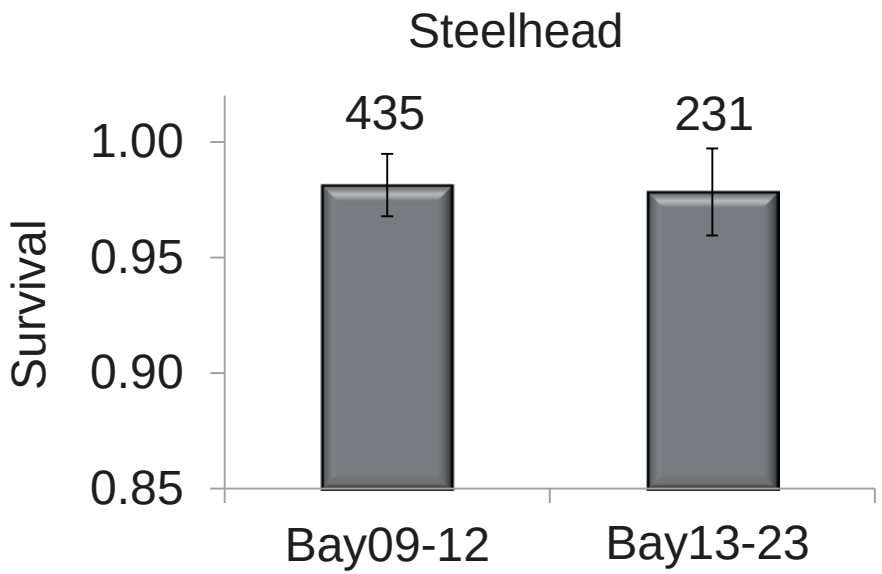


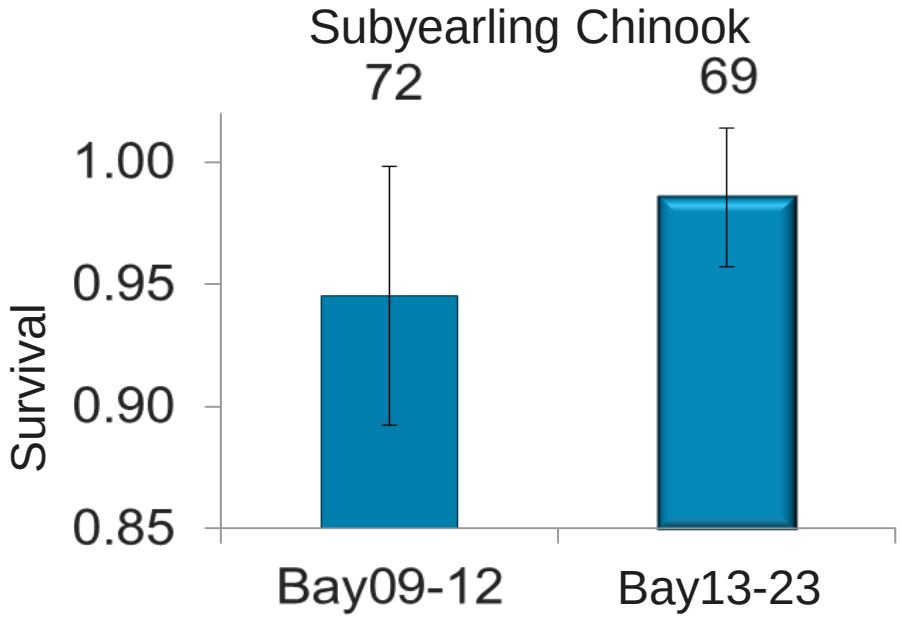




Analyses: TDA
Survival Outside of Spill Wall, Grouped Bays







Analyses: TDA
Survival Grouped by Flow

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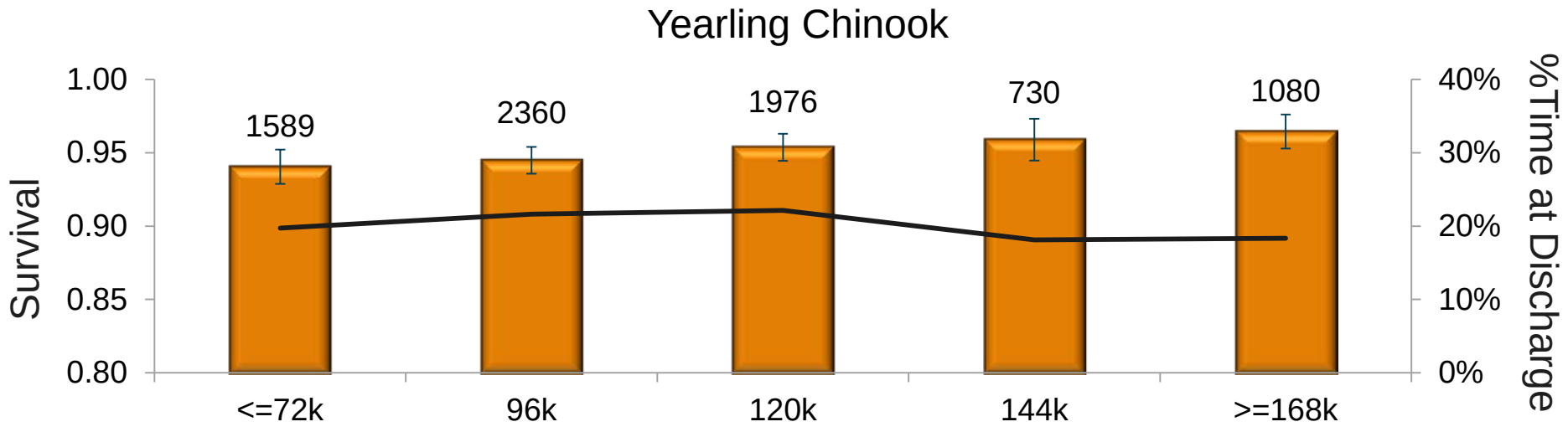
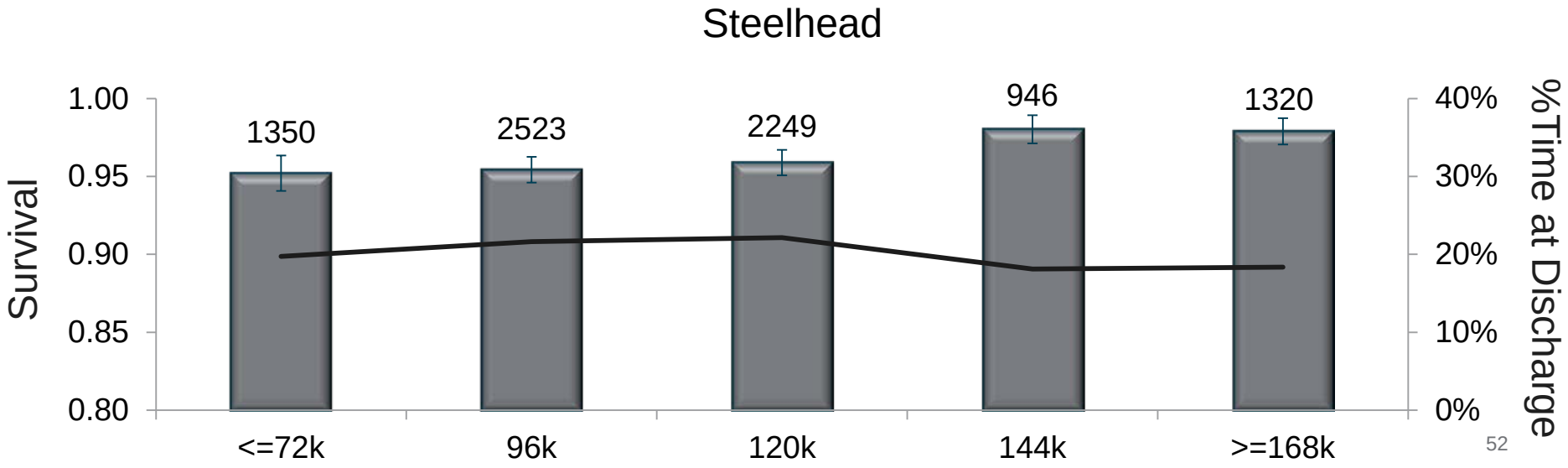
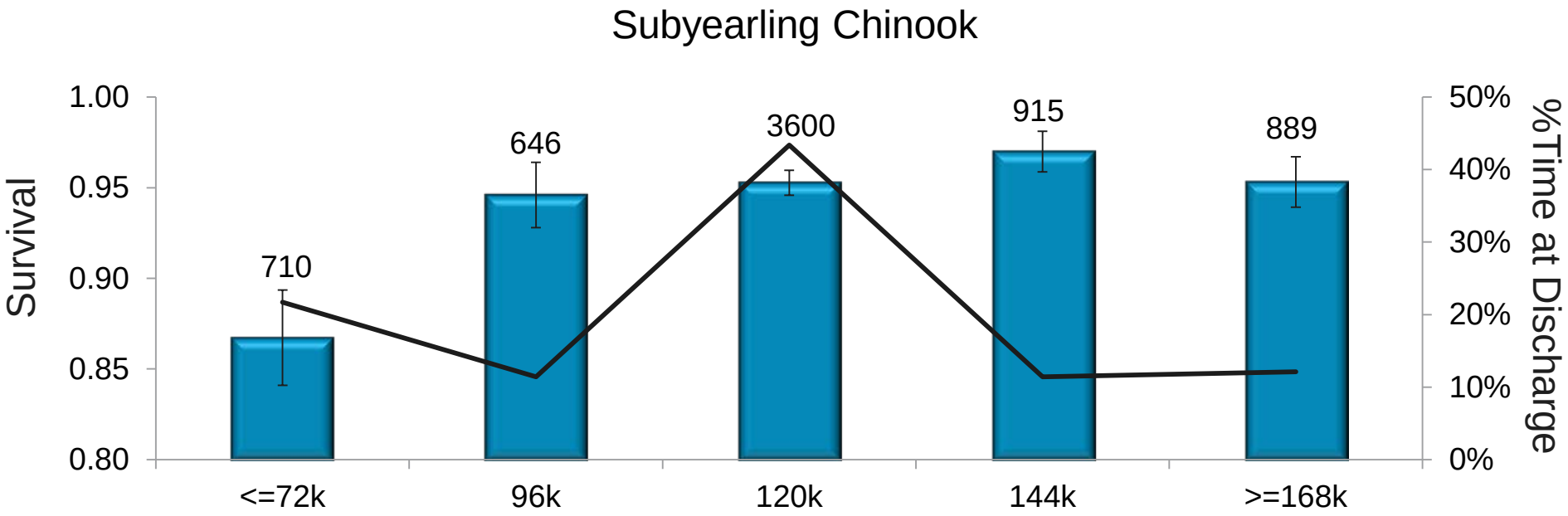




Analyses: TDA
Survival Grouped by Flow



TDA Spillway

Analyses: TDA
Survival by Bay for All Years

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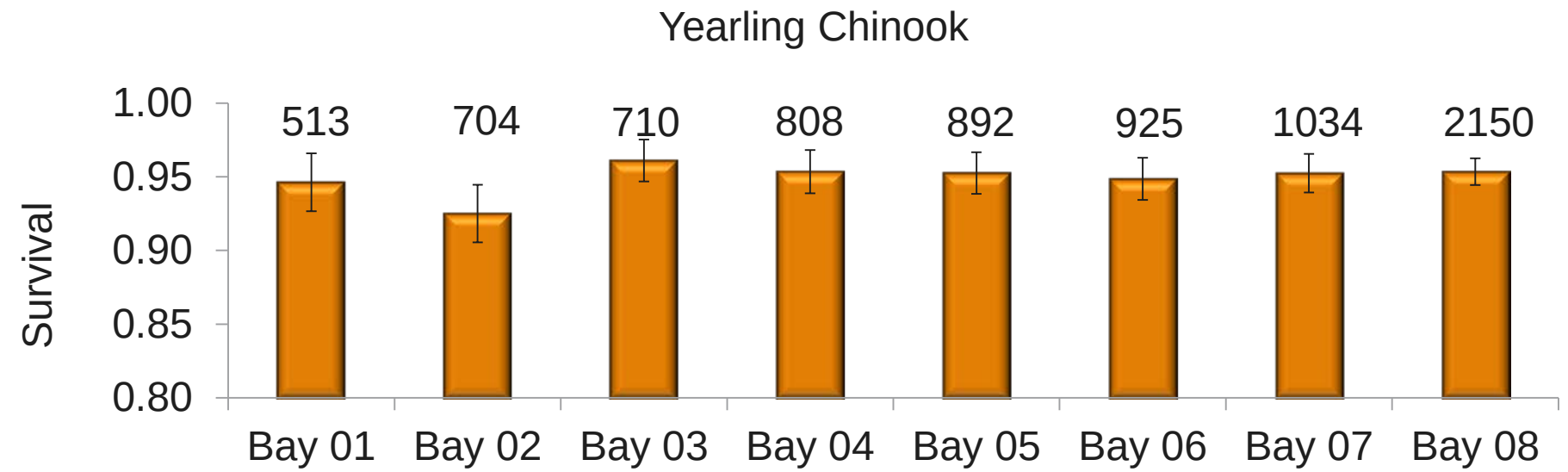
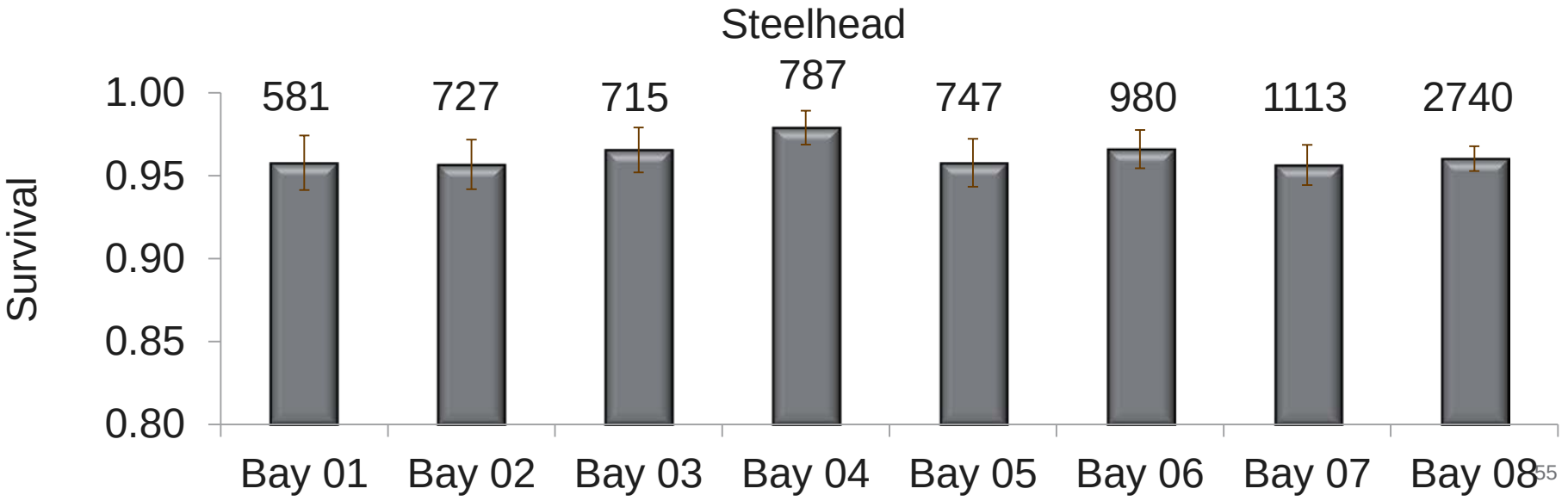
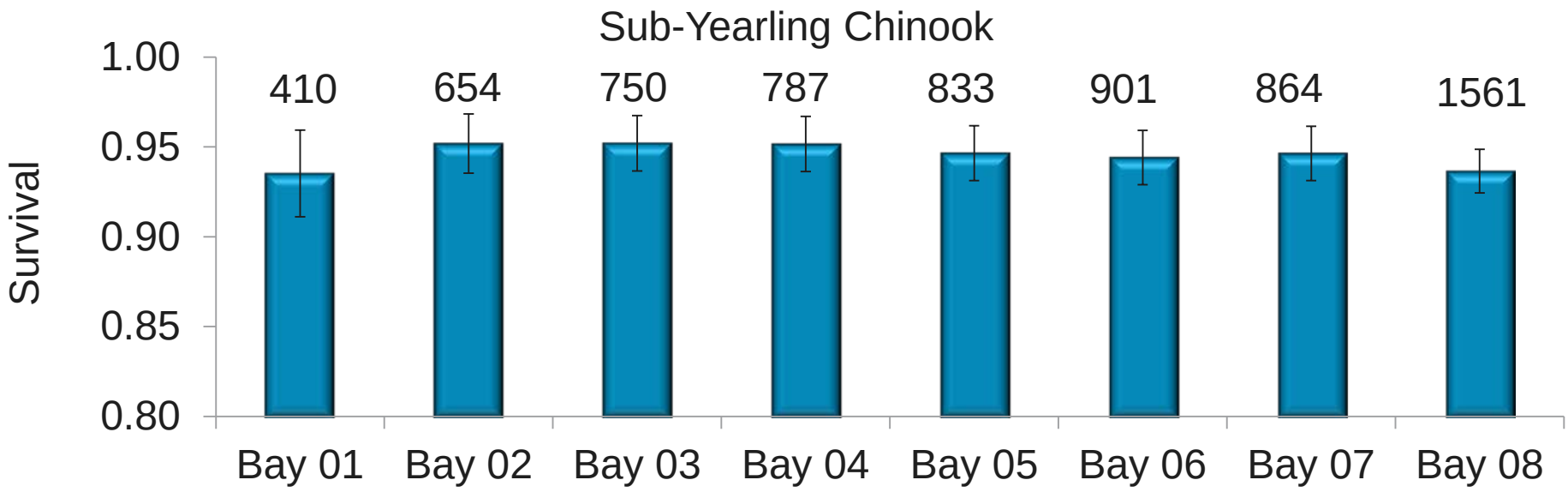




Analyses: TDA
Survival by Bay for All Years



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

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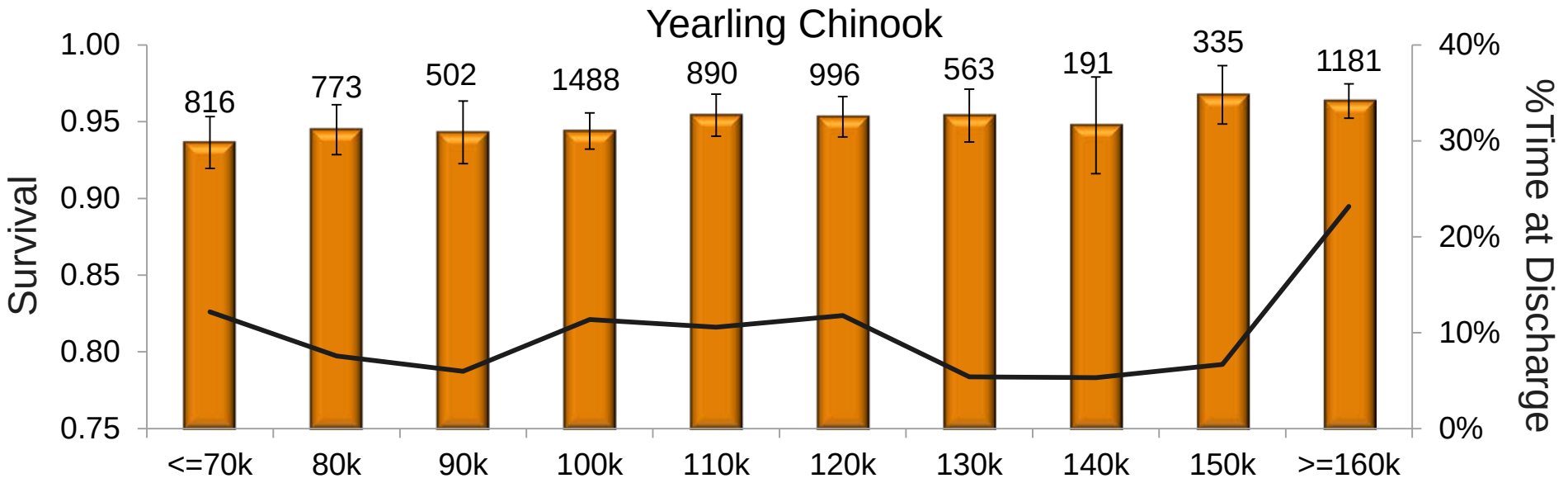
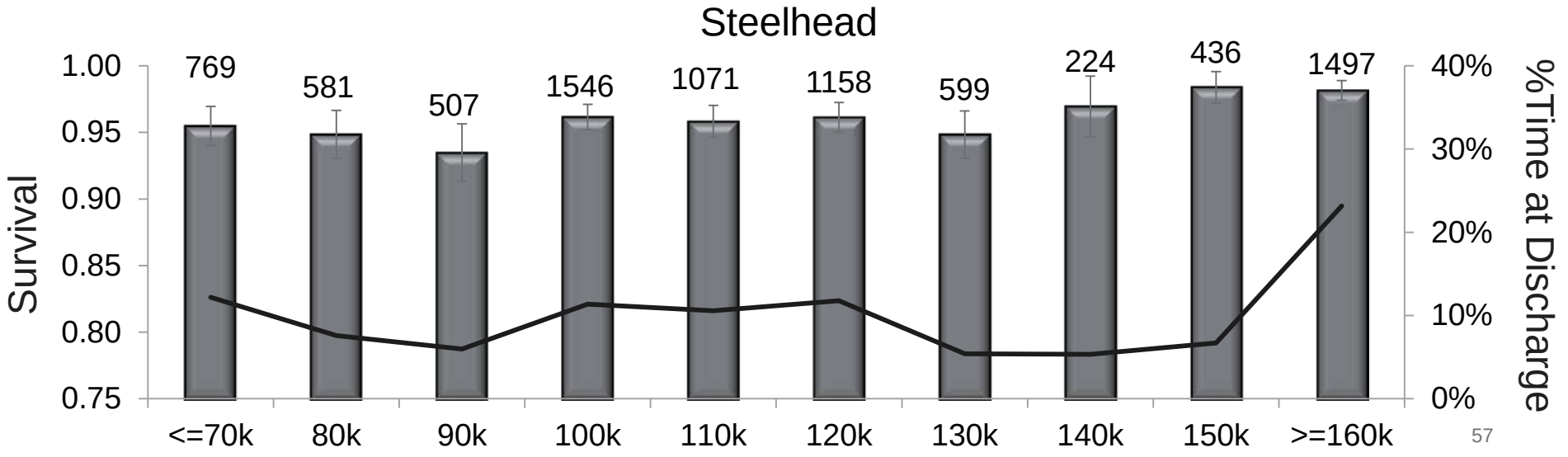
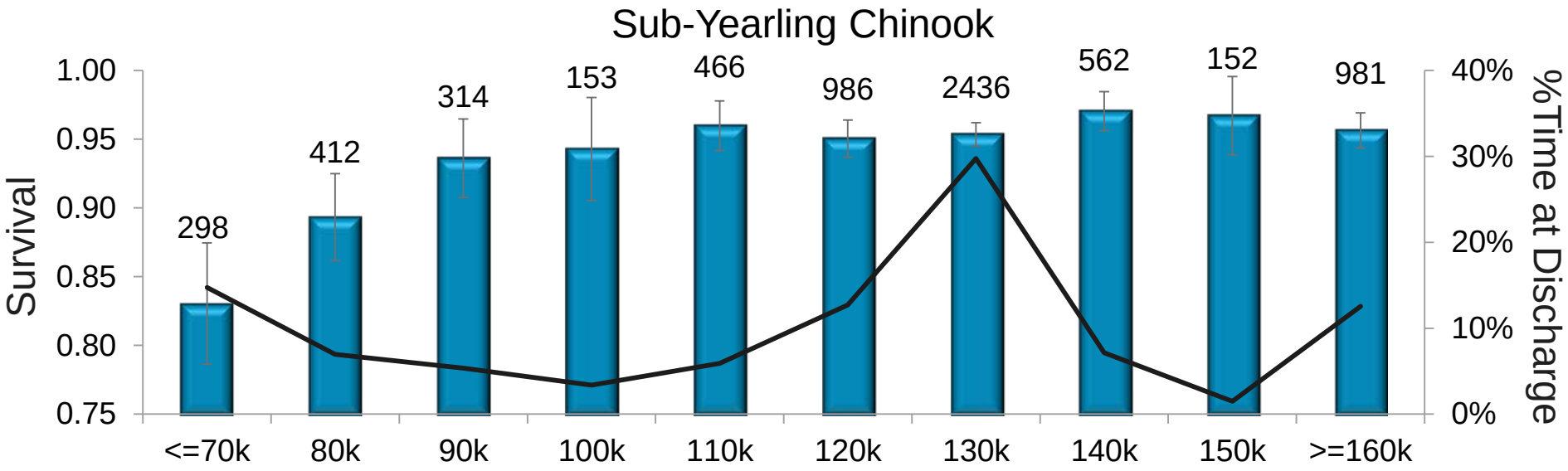




Analyses: TDA
Survival by Flow, 2010, 2011, 2012



TDA Egress

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

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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

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

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