Estimating Potential Spring Chinook Production Above Willamette River Dams

February 2016

Topics for Today

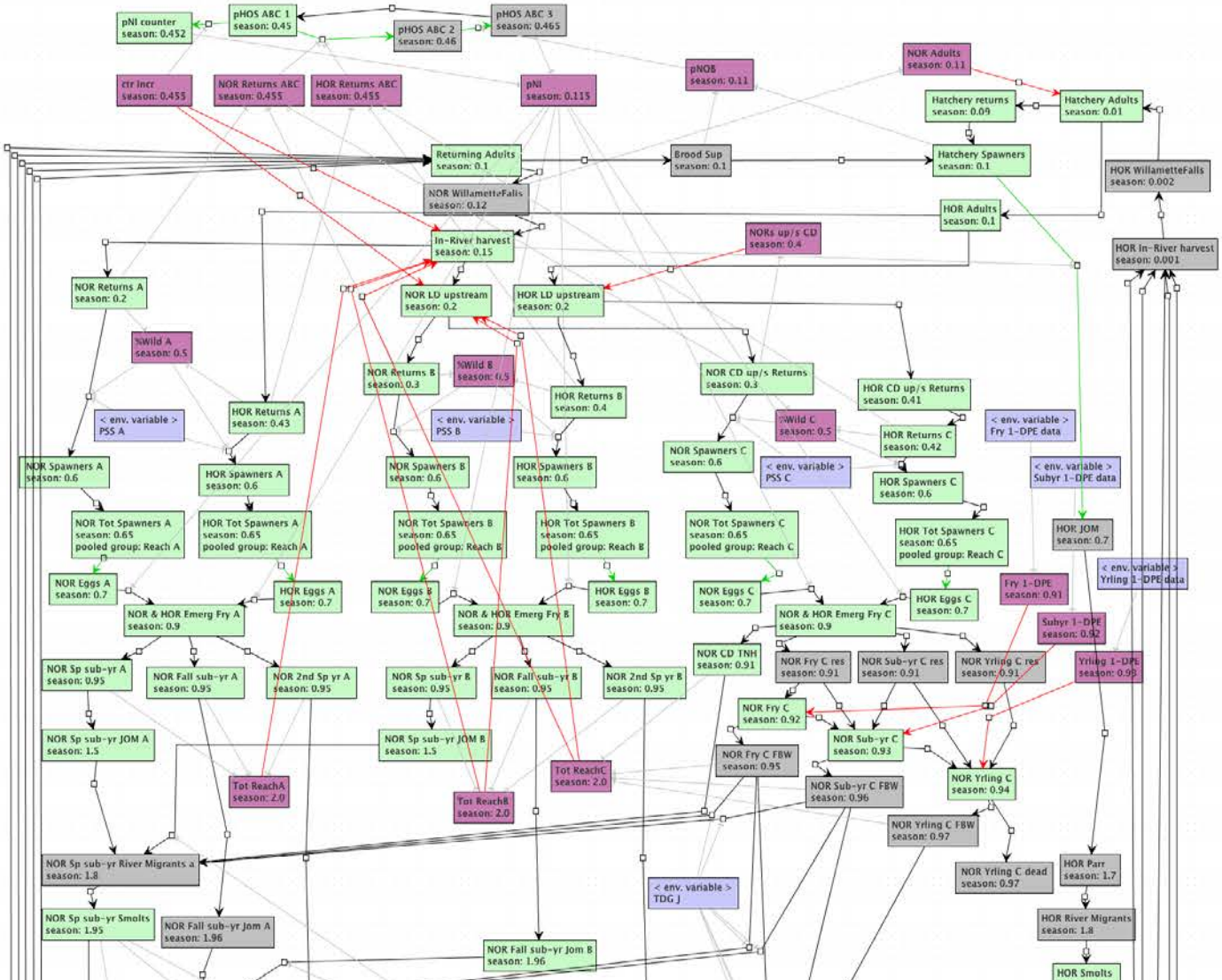
- SLAM Review and Development of the BPA Mini-Model
- Production Potential and effect of Capacity
  - Liermann et al. Watershed Area Analysis
  - EDT Analysis- Upstream of Cougar Dam

BONNEVILLE POWER ADMINISTRATION

DJWA
D.J. Warren & Associates, Inc.

SLAM Review and Development of the BPA Mini-Model

SLAM-Review


pNI counter season: 0.452
pHOS ABC 1 season: 0.45
pHOS ABC 2 season: 0.46
pHOS ABC 3 season: 0.465
ctr Incr season: 0.455
NOR Returns ABC season: 0.455
HOR Returns ABC season: 0.455
pNI season: 0.115
pNOB season: 0.11
NOR Adults season: 0.11
Hatchery returns season: 0.09
Hatchery Adults season: 0.01
Returning Adults season: 0.1
Brood Sup season: 0.1
Hatchery Spawners season: 0.1
HOR WillametteFalls season: 0.002
NOR WillametteFalls season: 0.12
HOR Adults season: 0.1
In-River harvest season: 0.15
NORs up/s CD season: 0.4
HOR In-River harvest season: 0.001
NOR Returns A season: 0.2
NOR LD upstream season: 0.2
HOR LD upstream season: 0.2
%Wild A season: 0.5
NOR Returns B season: 0.3
%Wild B season: 0.5
HOR Returns B season: 0.4
NOR CD up/s Returns season: 0.3
HOR CD up/s Returns season: 0.41
< env. variable > PSS A
HOR Returns A season: 0.43
< env. variable > PSS B
%Wild C season: 0.5
HOR Returns C season: 0.42
< env. variable > Fry 1-DPE data
NOR Spawners A season: 0.6
HOR Spawners A season: 0.6
NOR Spawners B season: 0.6
HOR Spawners B season: 0.6
NOR Spawners C season: 0.6
< env. variable > PSS C
HOR Spawners C season: 0.6
< env. variable > Subyr 1-DPE data
NOR Tot Spawners A season: 0.65 pooled group: Reach A
HOR Tot Spawners A season: 0.65 pooled group: Reach A
NOR Tot Spawners B season: 0.65 pooled group: Reach B
HOR Tot Spawners B season: 0.65 pooled group: Reach B
NOR Tot Spawners C season: 0.65 pooled group: Reach C
HOR Tot Spawners C season: 0.65 pooled group: Reach C
HOR JOM season: 0.7
< env. variable > Yrling 1-DPE data
NOR Eggs A season: 0.7
HOR Eggs A season: 0.7
NOR Eggs B season: 0.7
HOR Eggs B season: 0.7
NOR Eggs C season: 0.7
HOR Eggs C season: 0.7
Fry 1-DPE season: 0.91
NOR & HOR Emerg Fry A season: 0.9
NOR & HOR Emerg Fry B season: 0.9
NOR & HOR Emerg Fry C season: 0.9
Subyr 1-DPE season: 0.92
NOR Sp sub-yr A season: 0.95
NOR Fall sub-yr A season: 0.95
NOR 2nd Sp yr A season: 0.95
NOR Sp sub-yr B season: 0.95
NOR Fall sub-yr B season: 0.95
NOR 2nd Sp yr B season: 0.95
NOR CD TNH season: 0.91
NOR Fry C res season: 0.91
NOR Sub-yr C res season: 0.91
NOR Yrling C res season: 0.91
Yrling 1-DPE season: 0.95
NOR Fry C season: 0.92
NOR Sub-yr C season: 0.93
NOR Sp sub-yr JOM A season: 1.5
NOR Sp sub-yr JOM B season: 1.5
NOR Fry C FBW season: 0.95
NOR Sub-yr C FBW season: 0.96
NOR Yrling C season: 0.94
Tot ReachA season: 2.0
Tot ReachB season: 2.0
Tot ReachC season: 2.0
NOR Yrling C FBW season: 0.97
NOR Sp sub-yr River Migrants season: 1.8
NOR Yrling C dead season: 0.97
HOR Parr season: 1.7
< env. variable > TDG J
NOR Sp sub-yr Smolts season: 1.95
NOR Fall sub-yr Jom A season: 1.96
HOR River Migrants season: 1.8
NOR Fall sub-yr Jom B season: 1.96
HOR Smolts

Mini-Model – Output

Model Results Based on 100-year outcomes from 32 model runs					
Reach Name (Fish Length)	Life Stage	50 Million Capacity Cougar Reservoir	5.0 Million Capacity Cougar Reservoir	2.5 Million Capacity Cougar Reservoir	1.25 Million Capacity Cougar Reservoir
	Adult Runsize	15,503	8,468	5,694	3,561
Reach C	Spawning Escapement	13,889	7,618	5,105	3,205
Reach C	Effective spawners	9,621	5,234	3,521	2,233
Reach C	Egg incubation	6,637,019	4,606,385	3,472,765	2,422,589
Reach C (35-59mm)	Fry colonization	4,988,614	3,463,189	2,610,059	1,821,339
Cougar Reservoir (60-80mm)	0-age resident rearing	1,085,925	595,642	402,859	243,526
Cougar Dam (100% Survival) (60-80mm)	0-age migrant	1,085,768	595,573	402,799	243,493
Below Willamette Falls (80-110mm)	0-age migrant	407,341	223,168	151,058	91,303
	END	-	-	-	-
	END	-	-	-	-
	END	-	-	-	-
	END	-	-	-	-
	Smolt to Adult Survival	3.90%	3.80%	3.79%	3.78%
	Cumulative Productivity	2.30	2.26	2.24	2.23
	Cumulative Capacity	33,489	23,224	17,410	11,650

Stockley 1961 -Mayfield

Chinook salmon were captured as emergent fry from mid-December until early September with the greatest number pass-

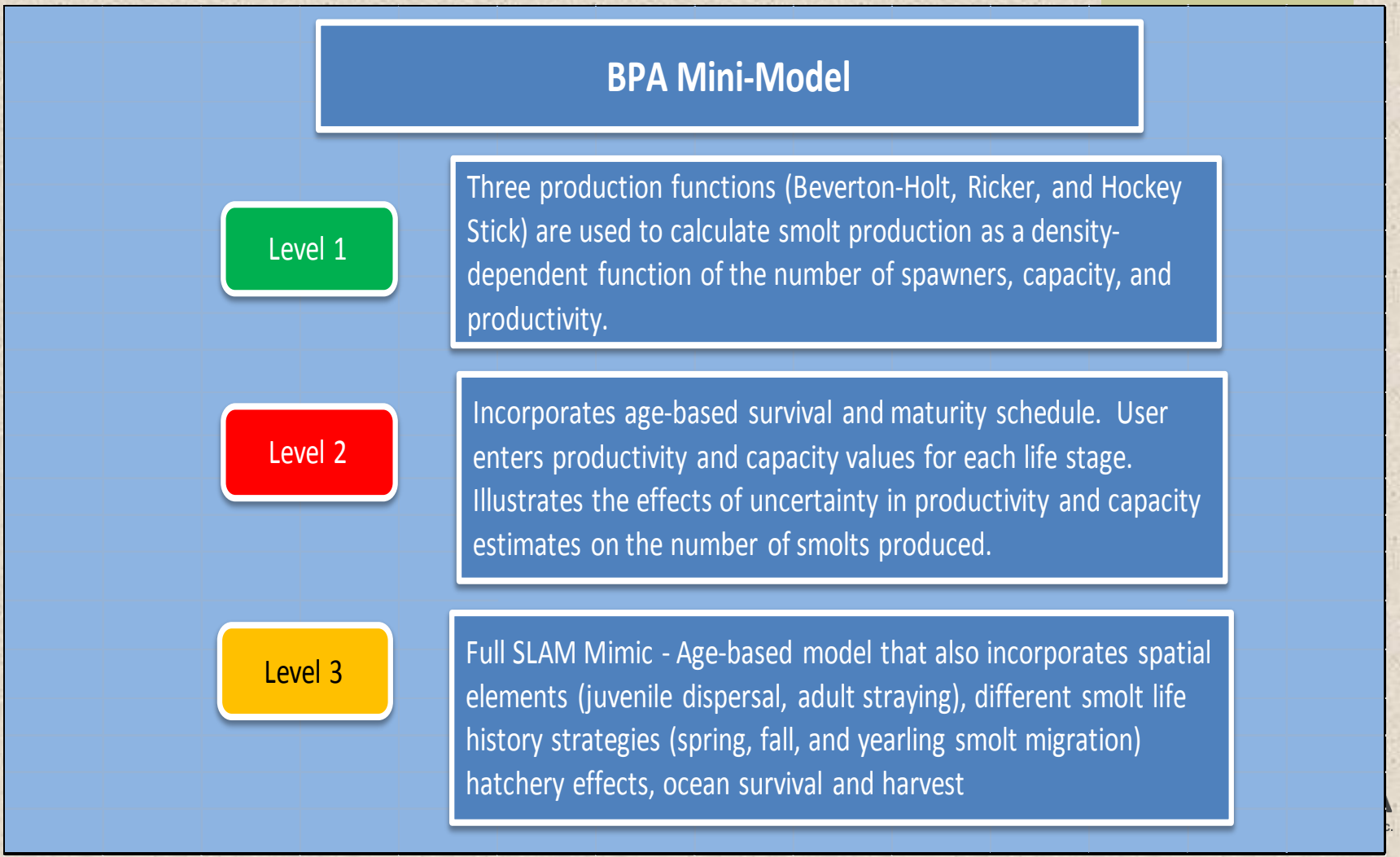
have passed the sampling site. These consisted of 1,283,133 fry and 207,667 others classified as yearlings based on a

Emerging chinook salmon fry made their appearance in December with a length mode of 35 millimeters (Figure 8). Their growth progressed slowly through the spring and summer reaching a modal length of 60 mm. in August, 70 mm. in September and

BONNEVILLE POWER ADMINISTRATION

DJWA
D.J. Warren & Associates, Inc.

BPA Mini-Model



Mini-Model – Level 3

Harvest Policy Inputs

Parameter	Baseline-Natural	Baseline-Hatchery	Scenario-Natural	Scenario-Hatchery
Harvest Policy	Harvest Rate	Harvest Rate Multiplier	Harvest Rate	Harvest Rate Multiplie
Harvest Rate	10%	2.00	10%	2.00
MSY Harvest Rate	-		-	
Escapement Goal	10,000		10,000	
MSY Escapement	-		-	

Fish Passage Survival

Juvenile Life Stage	Cougar Dam			
Juvenile Survival	80%	100%	80%	100%
Adult Passage Downstream of Terminal Fishery	100%	100%	100%	100%
Adult Passage Upstream of Terminal Fishery	100%	100%	100%	100%

Randomization Options

Randomization	PDO		PDO	
	Synchronize with Baseline		Both	

Run Mode

Return to Dashboard

Enter No
Model Ru
10

Life History Segment Inputs

AHA

Life History Segment	EDT Productivity	EDT Range (+ or -)	EDT Capacity
Spawning	1.000	0.0%	10,000
Incubation	0.516	0.0%	168,375,080
Cougar Reservoir	0.435	0.0%	1,719,881
Cougar Dam	1.000	0.0%	1,970,000
to Mck 30	0.701	0.0%	342,802
to Mck-26	0.969	0.0%	9,716,689
to Willamette	0.836	0.0%	1,353,799
END			
END			
END			
END			
Early Marine Survival	11.00%	4.64%	24.78%	1.00E+12

Baseline-Hatchery In Hatchery Survival		
Life Stage	Survival	
Prespawning	0.900	
Eggs/spawner	2,341	
Incubation	0.975	
Fry to Smolt	0.800	
Hatchery Program		Age at Release
Number of Smolts Released	150,000	Yearling
Broodstock Needed	91	
pNOB Target	15%	100% Max % N
Stray Rate of HOR Adults	5%	
Early Marine Survival for HORs	11.00%	4.64% 24.78%

Return to Dashboard

D.J. Warren & Associates, Inc.

Median Results After 100-years from 10 model runs

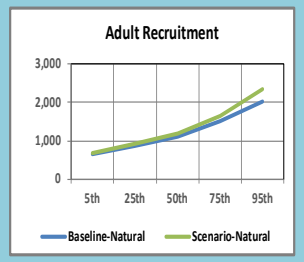
Life Stage	Baseline-	Baseline-	Scenario-	Scenario-
Smolt Production	71,417	150,000	77,424	50,000
Adult Recruitment	1,110	2,327	1,179	212
Pre-terminal Harvest	88	374	96	34
Return to Subbasin (escapement)	1,018	1,946	1,085	177
Terminal Harvest	22	94	24	9
NOR Spawners	881	14	935	30
HOR Spawners	75	78	0	0
pHOS or pNOB	6.90%	15%	0.00%	100%
PNI	68.5%		100.0%	
Fitness	87.7%		100.0%	
Life History Segment Survival				
Smolt to Adult Survival	1.51%	1.51%	1.51%	0.41%
Smolts per Spawner	75	1,643	83	1,643
Recruits per Spawner	1.16	25	1.26	7
Exploitation Rate	0.10	0.20	0.10	0.20

88 150

Adult Recruitment

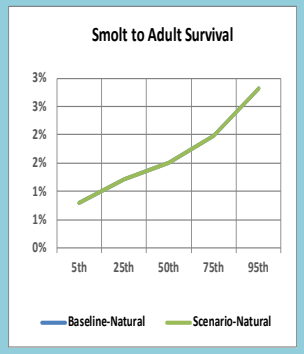
Metric	Baseline-Natural	Baseline-Hatchery	Scenario-Natural	Scenario-Hatchery
5th Percentile	640	1,413	688	128
25th Percentile	857	1,868	927	170
50th Percentile	1,110	2,327	1,179	212
75th Percentile	1,517	3,008	1,657	273
95th Percentile	2,023	3,998	2,337	363

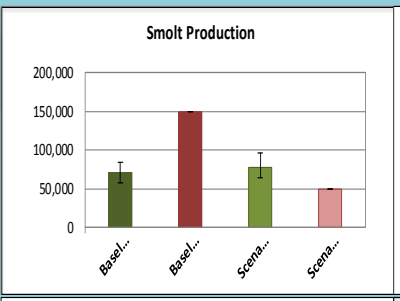
1.06223

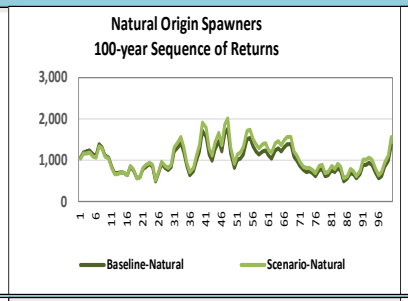


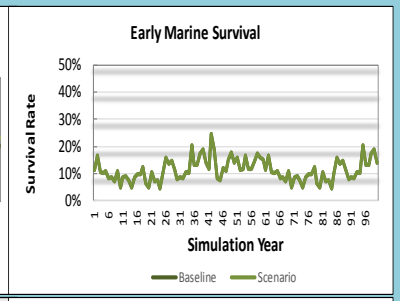
Smolt to Adult Survival

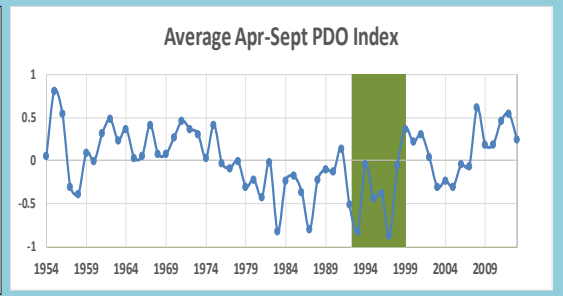
Metric	Baseline-Natural	Baseline-Hatchery	Scenario-Natural	Scenario-Hatchery
5th Percentile	0.79%	0.79%	0.79%	0.21%
25th Percentile	1.21%	1.21%	1.21%	0.33%
50th Percentile	1.51%	1.51%	1.51%	0.41%
75th Percentile	1.97%	1.97%	1.97%	0.54%
95th Percentile	2.83%	2.83%	2.83%	0.77%

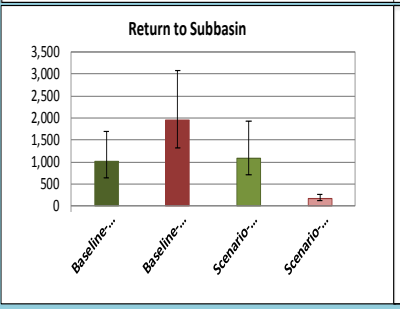


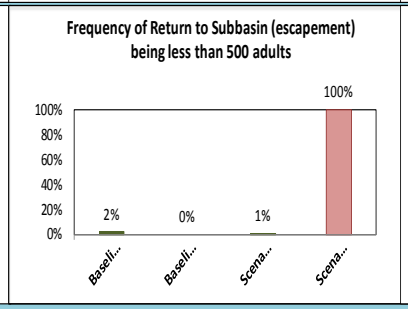


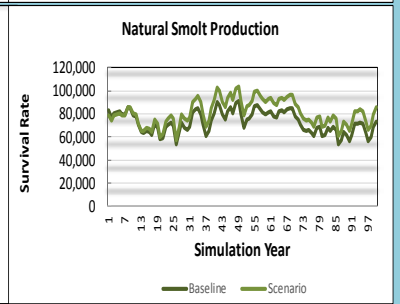












PDO Inputs

	Begin Year 1954-2013	Amplitude
Baseline	1974	40%
Scenario	1974	40%

Update Table (F9)

Return to Dashboard

* Median and range (10th-90th percentile).

* Frequency of observing <500 adult returns during 100 years.

Major Concerns on Initial SLAM Runs

- Large adult abundance
- Modeling of capacity was of concern
  - Capacity of reservoirs for rearing
  - Impact on fish passage effectiveness

BONNEVILLE POWER ADMINISTRATION

DJWA
D.J. Warren & Associates, Inc.

Production Potential: Liermann and EDT

Based on Far Side Cartoon

Liermann Watershed Analysis

Using accessible watershed size to predict management parameters for Chinook salmon, *Oncorhynchus tshawytscha*, populations with little or no spawner-recruit data: a Bayesian hierarchical modelling approach

M. C. LIERMANN

Northwest Fisheries Science Center, NOAA Fisheries, Seattle, WA, USA

R. SHARMA

Columbia River Inter-Tribal Fish Commission, Portland, OR, USA

C. K. PARKEN

Pacific Biological Station, Fisheries and Oceans, Nanaimo, BC, Canada

BONNEVILLE POWER ADMINISTRATION

DJWA
D.J. Warren & Associates, Inc.

Liermann: Watershed Analysis

Ocean-type Productivity = 6.81 Stream-type Productivity = 4.31

	Ocean-Type		Stream_Type	
Reach	Capacity	Abundance	Capacity	Abundance
Below Cougar	29,975	22,914	10,306	9,515
Above Lookout	20,692	18,529	8,897	8,214
Above Detroit	18,285	13,977	7,319	6,757
Below Foster	17,618	13,467	7,133	6,586
Above Green Peter	10,841	8,287	5,096	4,705
Below Big Cliff	10,074	7,701	4,844	4,472
Above Hills Creek	9,830	7,514	4,763	4,397
Above Foster	8,939	6,833	4,763	4,117
Below Dexter and Fall Creek	8,027	6,136	4,139	3,821
Above Cougar	**6,032**	**4,611**	**3,396**	**3,135**
Above Fall Creek	5,979	4,570	3,375	3,116
Total	146,292	114,539	64,031	58,835

- Upper North Fork Clackamas
  - Liermann Ocean Type – 3,754
  - Liermann Stream Type – 2,719
  - Observed - ~2,000 (Adult Returns)

BONNEVILLE POWER ADMINISTRATION

DJWA D.J. Warren & Associates, Inc.

Liermann: Watershed Analysis, EDT

Above Cougar

Model Results Based on 100-year Outcomes from 32 Model Runs			
Parameter	Initial SLAM	Liermann	EDT
Juvenile Production (Location)	1 million+ (Cougar)	747,000 (Basin)	~250,000 (Cougar)
Spawning Escapement	~10,000	~4,600	~1,300

- 80 Percent Juvenile Passage Survival
- 90 Percent Adult Passage Survival
- 10 Percent Harvest

BONNEVILLE POWER ADMINISTRATION

DJWA
D.J. Warren & Associates, Inc.

One Major Difference – Reservoir Rearing Capacity

- Liermann
  - -Juveniles have access to entire watershed
- SLAM –Capacity set at Egg Incubation
- EDT – Capacity estimate for all life stages and reaches (reservoir ~1.7 million)

BONNEVILLE POWER ADMINISTRATION

DJWA
D.J. Warren & Associates, Inc.

Does it make a difference?

Natural Spawners			
Juvenile Fish Pasage Survival Rate	**Capacity Only at Egg Stage**	**Capacity Only at Reservoir Rearing**	**Capacity at Egg Stage + Rearing Reservoir**
100%	14,378	7,273	4,830
90%	11,672	5,911	3,926
80%	8,965	4,535	3,007
70%	6,272	3,171	2,106
60%	3,641	1,842	1,223
50%	1,485	743	302
SAR 3.5% _Willamette Falls to Spawning (100% Juvenile Passage)			

EDT Reservoir Capacity -1.7 Million

BONNEVILLE POWER ADMINISTRATION

DJWA
D.J. Warren & Associates, Inc.

How About For Fish Passage?

Baseline Passage Survival Rate	Modeled Passage Survival Rate	Juvenile Capacity Limitation Upstream of Dam	Juvenile Capacity Limitation Downstream of Dam
50%	60%	108%	95%
50%	70%	223%	184%
50%	80%	340%	265%
50%	90%	456%	336%
50%	100%	573%	401%

Reservoir Capacity at 1.7 million -EDT

BONNEVILLE POWER ADMINISTRATION

DJWA
D.J. Warren & Associates, Inc.

Reservoir Issues

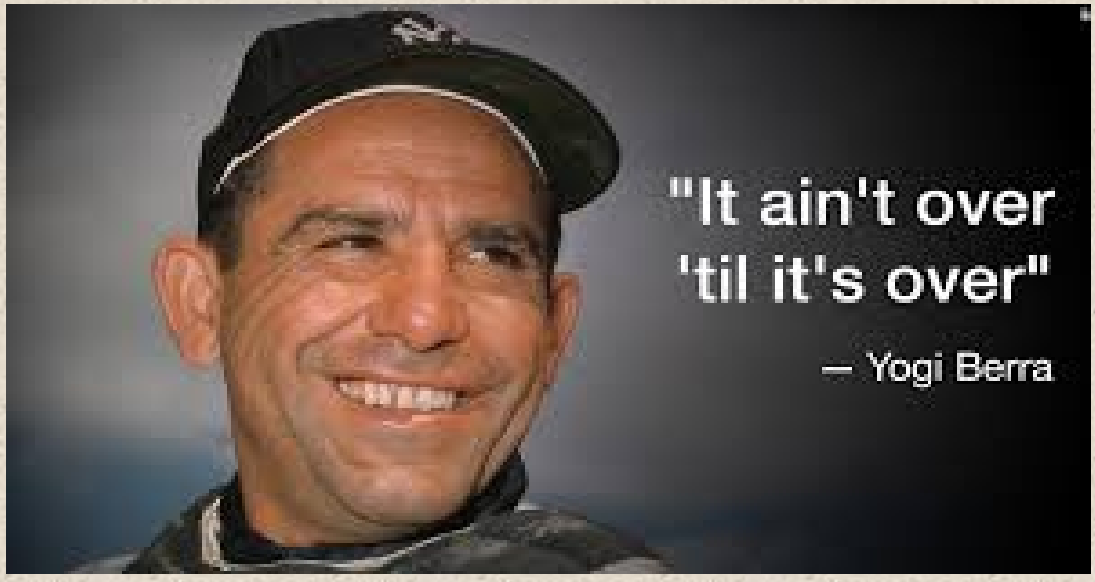
- Predation (stocking of non-native)
- Migration (fry do poorly)
- Disease +/-
- Eutrophication
  - Growth rates

DJWA
D.J. Warren & Associates, Inc.

Working Hypothesis

Model Results Based on 100-year outcomes from 32 model runs					
Reach Name (Fish Length)	Life Stage	50 Million Capacity Cougar Reservoir	5.0 Million Capacity Cougar Reservoir	2.5 Million Capacity Cougar Reservoir	1.25 Million Capacity Cougar Reservoir
	Adult Runsize	15,503	8,468	5,694	3,561
Reach C	Spawning Escapement	13,889	7,618	5,105	3,205
Reach C	Effective spawners	9,621	5,234	3,521	2,233
Reach C	Egg incubation	6,637,019	4,606,385	3,472,765	2,422,589
Reach C (35-59mm)	Fry colonization	4,988,614	3,463,189	2,610,059	1,821,339
Cougar Reservoir (60-80mm)	0-age resident rearing	1,085,925	595,642	402,859	243,526
Cougar Dam (100% Survival) (60-80mm)	0-age migrant	1,085,768	595,573	402,799	243,493
Below Willamette Falls (80-110mm)	0-age migrant	407,341	223,168	151,058	91,303
	END	-	-	-	-
	END	-	-	-	-
	END	-	-	-	-
	END	-	-	-	-
	Smolt to Adult Survival	3.90%	3.80%	3.79%	3.78%
	Cumulative Productivity	2.30	2.26	2.24	2.23
	Cumulative Capacity	33,489	23,224	17,410	11,650

It’s Over!



BONNEVILLE POWER ADMINISTRATION

DJWA
D.J. Warren & Associates, Inc.