




Determining mechanisms of latent mortality & patterns of *D*

Jennifer L. Tran
James J. Anderson

AFEP, Portland, 8-11 December 2008



University of Washington
School of Aquatic & Fishery Sciences
Columbia Basin Research

Acknowledgments

- **NMFS BiOp Implementation grant**
- **Bonneville Power Administration**

- **Lauren R. Donaldson Scholarship**
- **Marsha Landolt and Robert Busch Scholarship**

- **NMFS (Montlake, Seattle WA)**
 - Lyle Gilbreath
 - Doug Marsh
 - John Williams
 - John Ferguson



- **US Army Corps of Engineers**
 - Mike Langeslay
 - Mike Halter
 - John Bailey
 - Jon Rerecich
 - Tammy Mackey
 - Miroslaw Zydol



US Army Corps
of Engineers
Portland District



US Army Corps
of Engineers®
Walla Walla District

- **Pacific States Marine Fisheries Commission**
 - Dean Ballinger
 - Dave Marvin



- **WDFW**
 - Shawn Rapp
 - Doug Ross



- **UC Davis/NOAA**
 - Frank Loge
 - Don Thompson
 - Kai Eder
 - Joe Dietrich
 - Jim Lathe



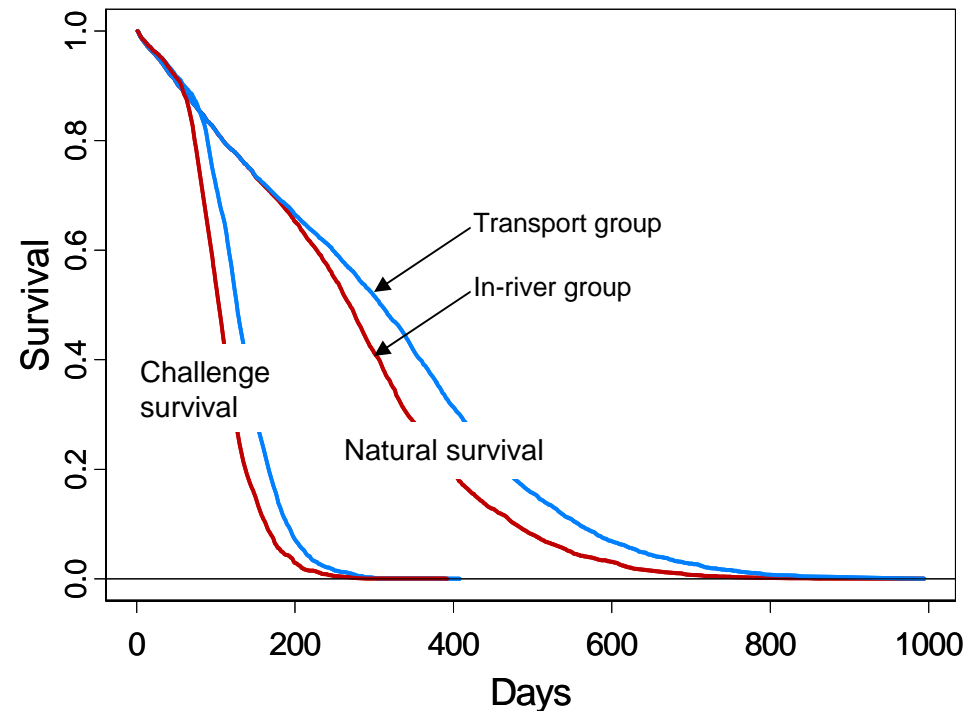
- **Bonneville Power Administration**
 - John Piccininni



Objectives

- Determine survival capacity patterns of
 - barged and in-river yearling chinook
 - throughout the migration season
 - by challenge trials

- Explore possible factors
 - Time of migration
 - Travel time
 - Water temperature
 - Migration route



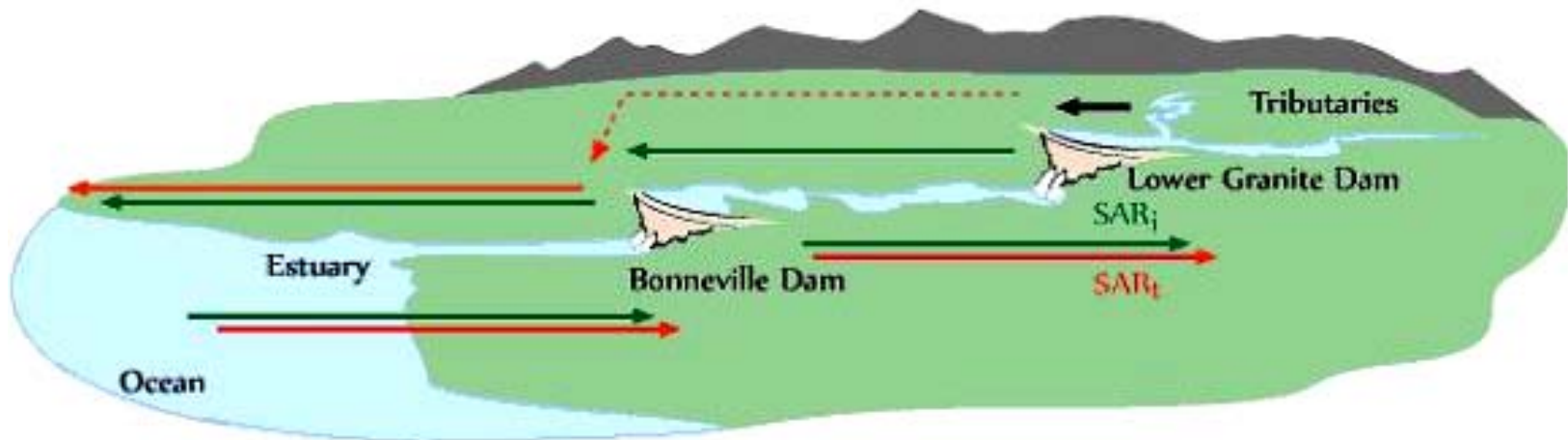
- Future goal is to compare these survival capacity measures to SARs

Survival related to the FCRPS

- Smolt-to-adult return rates (*SAR*)
- Transported (T) vs. In-river (I) migrants
- Differential mortality (*D*)
- Post-Bonneville Dam survival (*O*)
- Latent mortality

$$\frac{T}{I} = \frac{SAR_T}{SAR_I} = \frac{O_T}{O_I} \cdot \frac{S_T}{S_I}$$

$$D = \frac{O_T}{O_I} = \frac{x_T}{x_I}$$



Methods

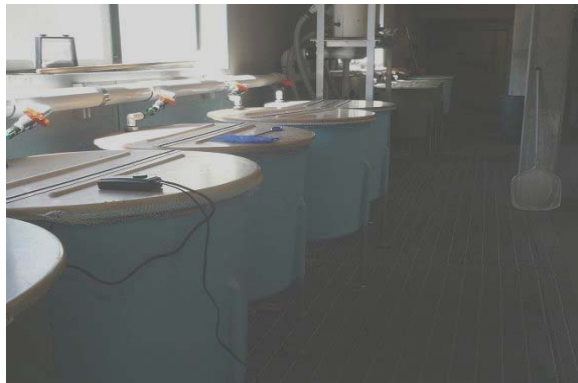
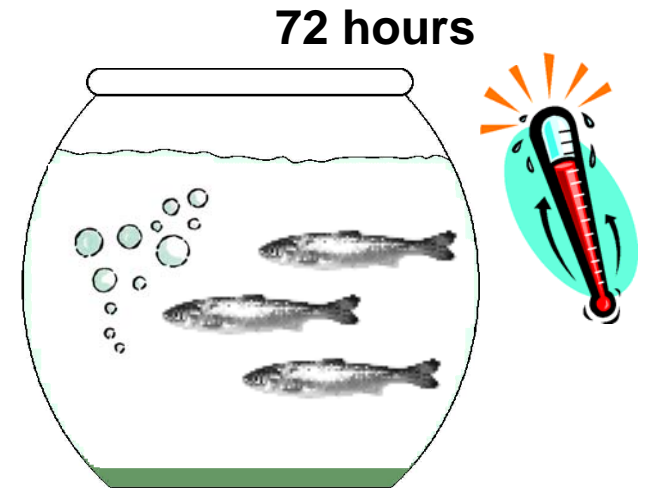
Sampling

- Hatchery yearling Chinook
- Barged (LGR→BON) vs. Run-of-river
- One group PIT-tagged at LGR
- Weekly throughout migration season



Challenge trials

- Acclimation period
- Temperature increased to 24.5°C (72 hours)
- Water aerated
- Fish unfed
- Observe for mortality and LOE



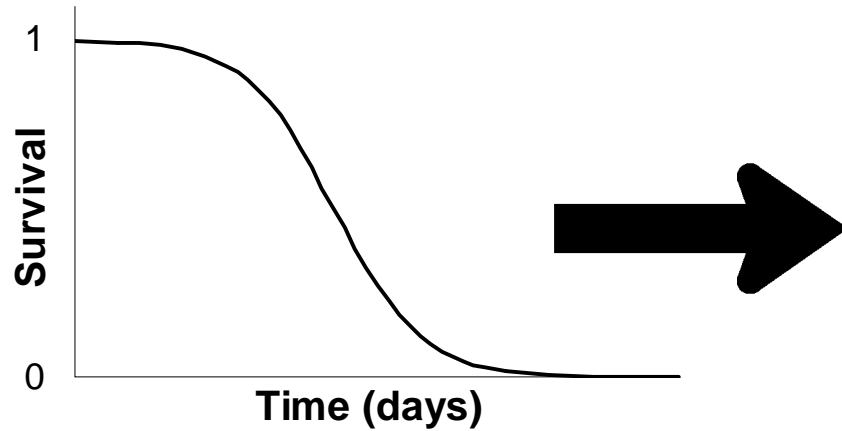
50 gallon flow-through tanks



Submersible heaters

Statistical Analysis

Survival capacity measures:

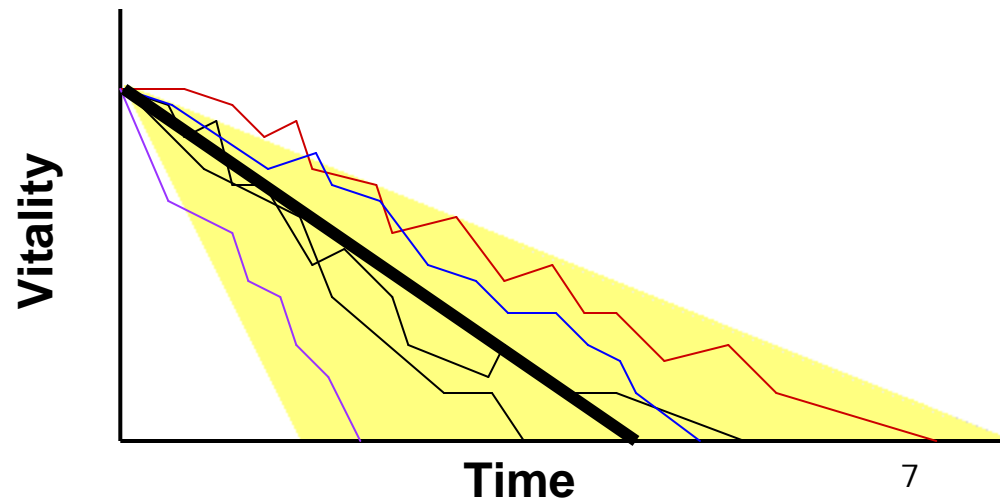


1. Reciprocal of average time to mortality ($1/m$, units of days)

2. Vitality parameters

- drift rate (r , units of t^{-1})
- spread rate (s , units of $t^{-1/2}$)
- accidental rate (k , units of t^{-1})

One curve per sample per treatment
(transported vs. in-river migration)



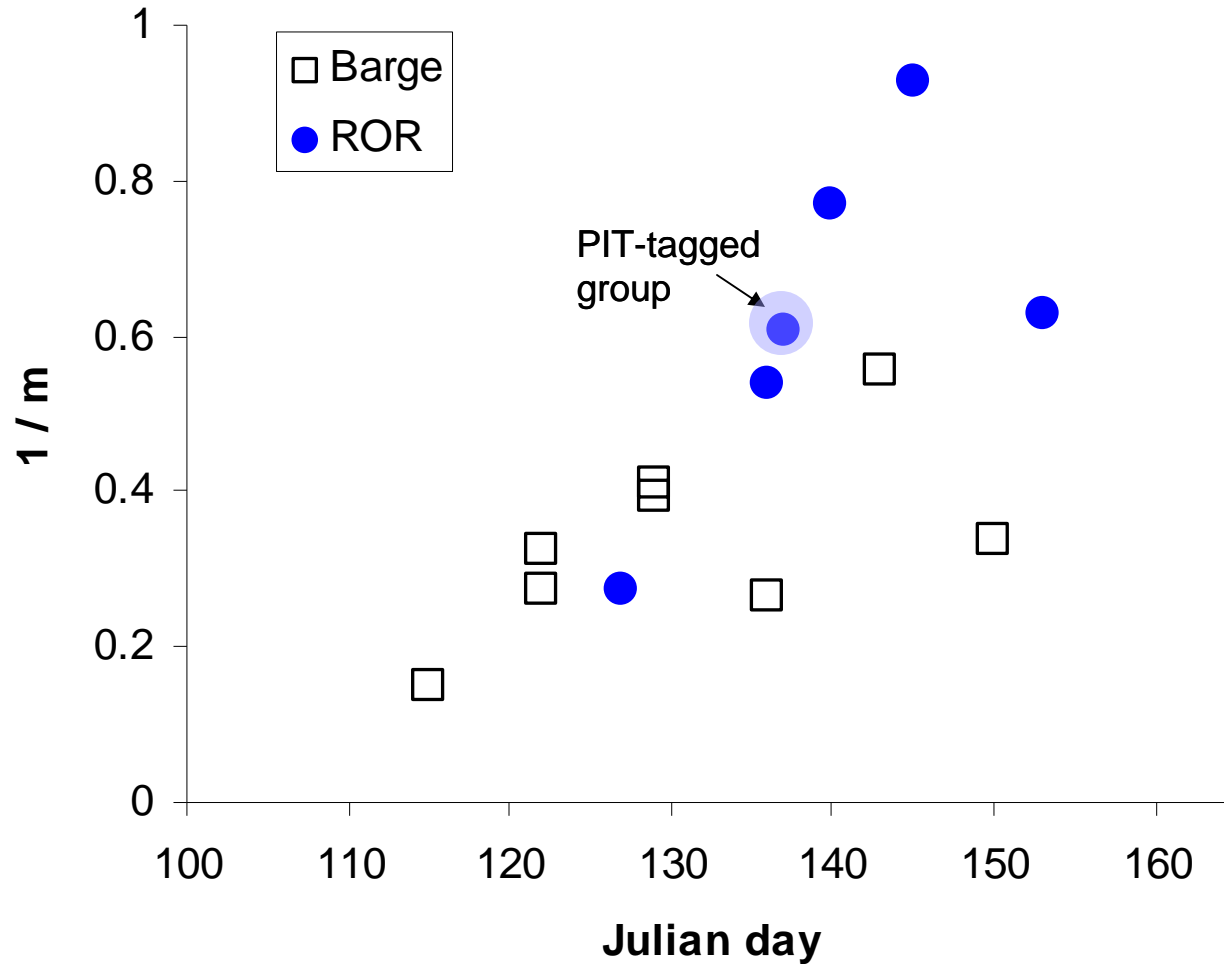
Statistical Analysis

■ **Linear model:** relate survival capacity measures to possible factors:

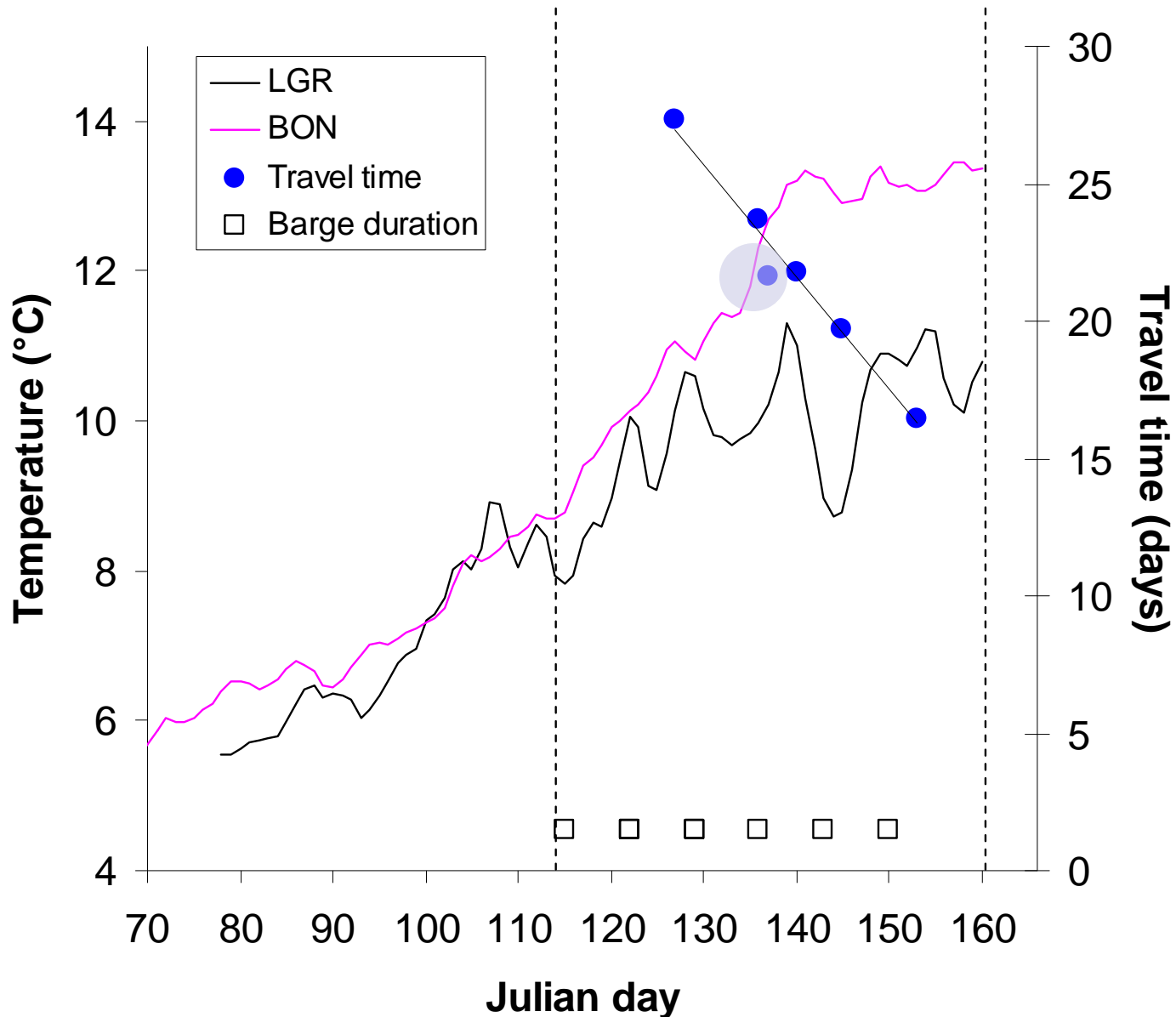
- | | |
|---------------------------------|--------------------------|
| ■ Barged vs. In-river migration | B vs I |
| ■ Time of year at BON | Day_{BON} |
| ■ Travel time (LGR to BON) | TT |
| ■ Degree days | q |
| ■ Cumulative percent spill | Spill |

■ AIC model selection

Survival capacity measure across the season



Water temperature & Travel time



Degree days

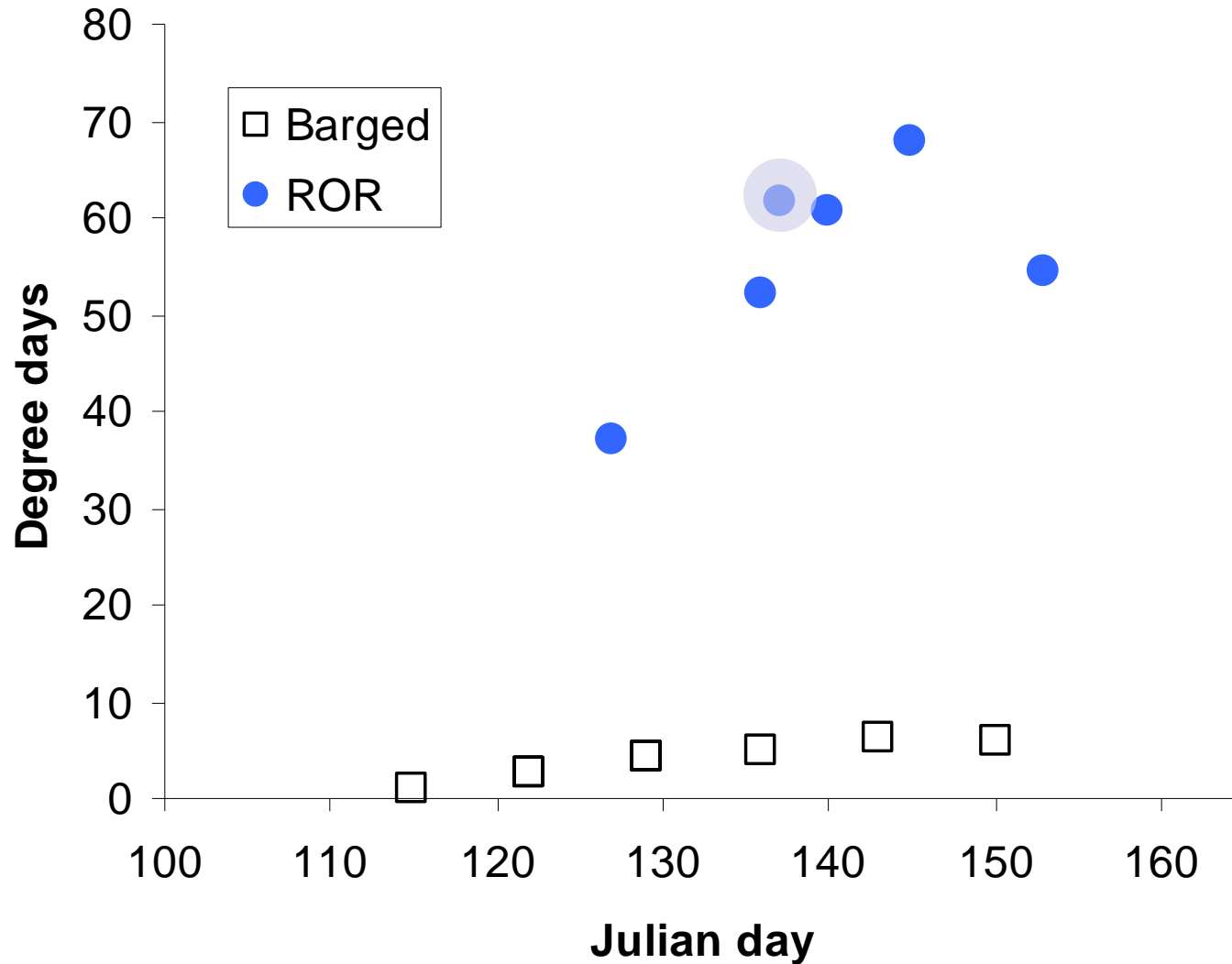




Table 1a.

Linear models with reciprocal of average time to mortality as dependent variable.

Model	Parameter Values									r ²	F _{1,12}	p-value	No. of variables	AIC score
	Intercept	B vs I	Day BON	q	TT	Spill	Route X Day	Route X q	Day X TT					
1	0.624	-0.285								0.448	9.724	0.009**	1	-6.194
2	-1.280		0.013							0.435	9.255	0.010**	1	-5.888
3	0.294			0.006						0.648	22.079	0.001***	1	-12.497
4	0.344				0.012					0.316	5.552	0.036*	1	-3.208
5	0.344					0.001				0.413	8.459	0.013*	1	-5.354
6	-0.644	-0.204	0.009							0.626	9.205	0.004**	2	-9.652
7	-0.519	0.778		0.021						0.851	31.363	<0.001***	2	-22.519
8	1.508	-1.107			-0.041					0.628	9.276	0.004*	2	-9.720
9	-1.048		0.011		0.008					0.582	7.671	0.008**	2	-8.110
10	-1.724	1.286	0.017				-0.011			0.678	7.029	0.008**	3	-9.764
11	-0.458	0.611		0.019				0.028		0.879	24.254	<0.001***	3	-23.472
12	-0.109		0.003		-0.125				0.001	0.736	9.289	0.003**	3	-12.525

Table 1b.

p-values of variables of linear models with 1/m.

Model	Intercept	B vs I	Day BON	q	TT	Spill	Route X Day	Route X q	Day X TT
1	<0.001***	0.009***							
2	0.046*		0.010*						
3	<0.001***			0.001*					
4	<0.001***				0.036*				
5	<0.001***					0.013*			
6	0.272	0.037*	0.043*						
7	0.033	0.003**		<0.001***					
8	0.003**	0.011*			0.041*				
9	0.073		0.023*		0.023*				
10	0.117	0.298	0.041*				0.231		
11	0.050*	0.019*		<0.001***				0.156	
12	0.857		0.472		0.048*				0.037

Observed vs. predicted reciprocal of average time to mortality ($1/m$) as determined by the model with route and degree days.

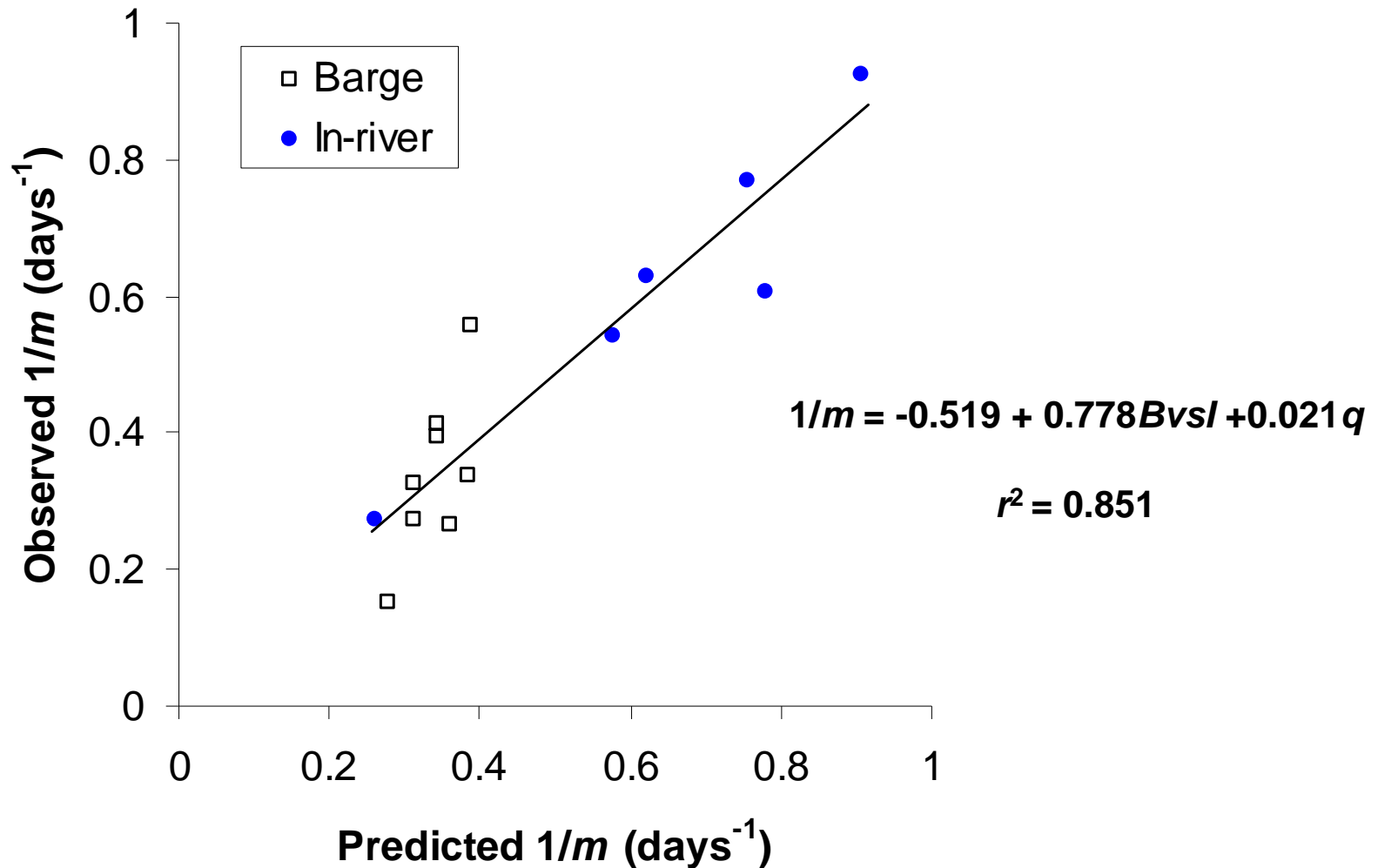


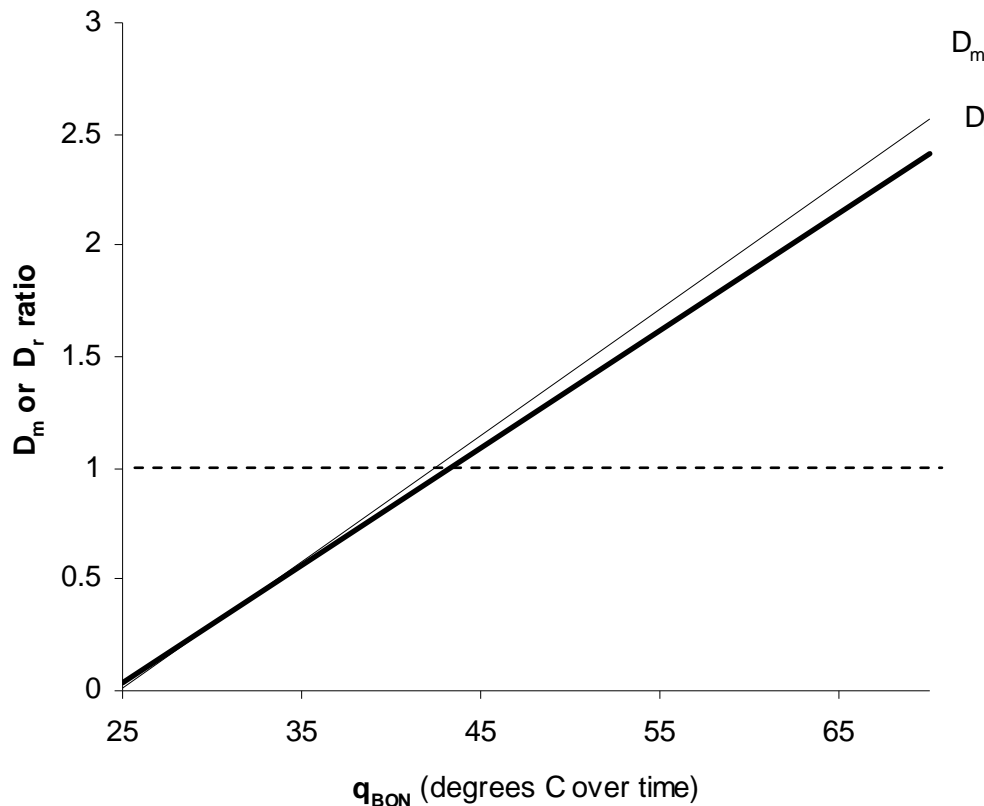
Table 2a. Linear models with r vitality parameter as dependent variable

Model	Parameter Values									r^2	$F_{1,12}$	p-value	No. of variables	AIC score
	Intercept	B vs I	Day BON	q	TT	Spill	Route X Day	Route X q	Day X TT					
13	0.491	-0.226								0.256	4.134	0.065	1	-0.727
14	-1.294		0.012							0.359	6.719	0.024*	1	-2.808
15	0.231			0.005						0.363	6.834	0.023*	1	-2.894
16	0.273				0.009					0.165	2.378	0.149	1	0.886
17	0.268					0.001				0.247	3.931	0.071	1	-0.550
18	-0.859	-0.139	0.010							0.440	4.327	0.041*	2	-2.709
19	-0.364	0.569		0.015						0.462	4.722	0.033*	2	-3.261
20	1.383	-1.056			-0.041					0.423	4.040	0.048*	2	-2.294
21	-1.142		0.011		0.005					0.416	3.920	0.052	2	-2.117
22	-2.156	1.651	0.019				-0.013			0.509	3.459	0.059	3	-2.549
23	-0.320	0.451		0.015				0.020		0.475	3.016	0.081	3	-1.604
24	-0.294		0.004		-0.115				0.001	0.530	3.761	0.048*	3	-3.157

Table 2b. p-values of variables of linear models with vitality parameter r .

Model	Intercept	B vs I	Day BON	q	TT	Spill	Route X Day	Route X q	Day X TT
14	0.066		0.024*						
15	0.007**			0.023*					
18	0.254	0.232	0.084						
19	0.409	0.182		0.065					
20	0.019*	0.048*			0.102				
24	0.728		0.514		0.168				0.150

D predicted from survival capacity measures $1/m$ and r based on migration route and degree days



$$D_m = 1 \text{ when } q_{BON} = 42.4$$

$$D_r = 1 \text{ when } q_{BON} = 43.2$$

$$D = \frac{O_T}{O_I} \sim \frac{m_T}{m_I} = \frac{-0.519 + 0.778BvsI + 0.021q_I}{-0.519 + 0.778BvsI + 0.21q_T}$$

$$D_m = \frac{-0.519 + 0.778(0) + 0.021q_I}{-0.519 + 0.778(1) + 0.021(1.5)}$$

$$D_m = -1.787 + 0.0723q_I$$

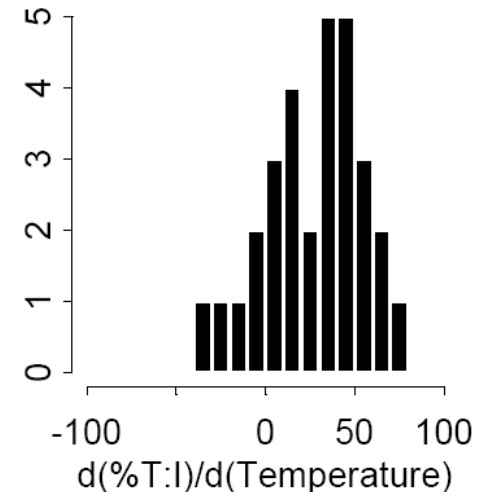
$$D = \frac{O_T}{O_I} \sim \frac{r_I}{r_T} = \frac{-0.364 + 0.569BvsI + 0.015q_I}{-0.364 + 0.569BvsI + 0.015q_T}$$

$$D_r = \frac{-0.364 + 0.569(0) + 0.015q_I}{-0.364 + 0.569(1) + 0.015q(1.5)}$$

$$D_r = -1.6 + 0.0659q_I$$

Discussion

- Barge vs. In-river migration
- Degree days
 - Water temperature
 - Zabel et al. (2008)
 - T:I~temperature (Anderson et al. 2005)
 - Travel time
 - Raymond (1979)
 - Williams et al. (2005)
 - Metabolism and energy reserves
 - Declining lipid reserves (Congleton et al. 2004)

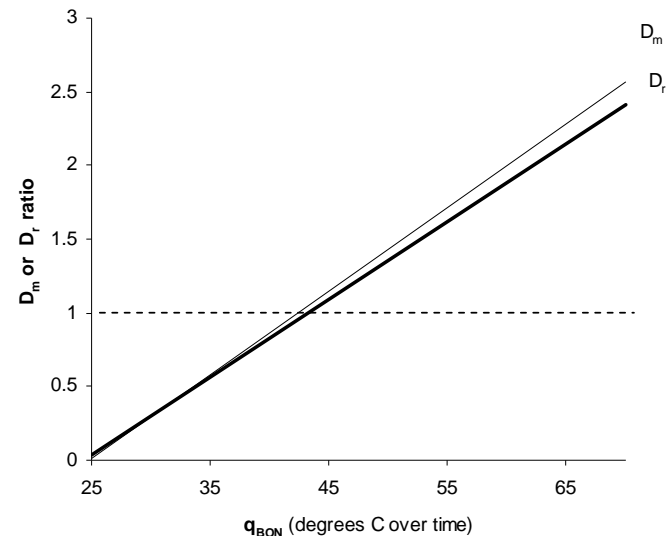
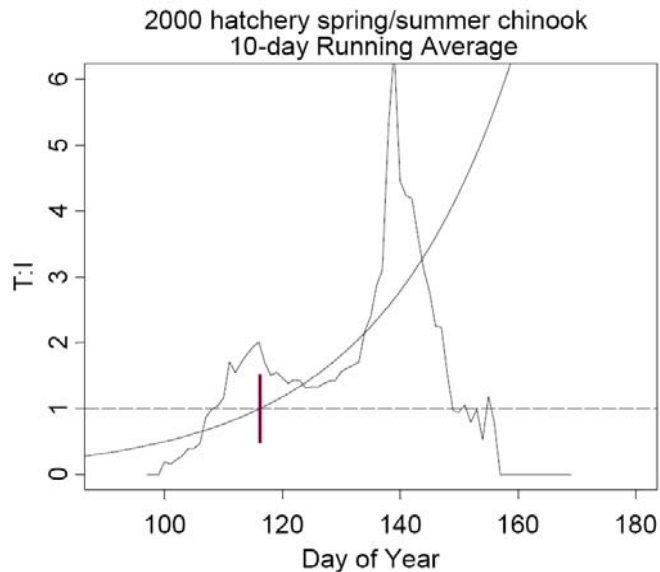


Discussion

■ Patterns of D

Anderson, J.J., R.A. Hinrichsen, C. Van Holmes, and K.D. Ham. 2005. Historical Analysis of PIT Tag Data for Transportation of Fish at Lower Granite, Little Goose, Lower Monumental and McNary Dams. Task 1: Analysis of In-River Environmental Conditions. U.S. Army Corps of Engineers (Walla Walla District) Report.

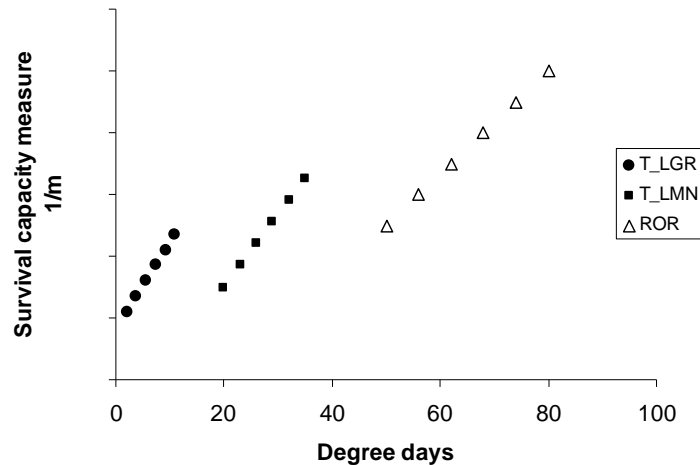
Throughout season, $T:I$ and D change from below 1 to



SAR and $T:I$ vs. Day_{LGR}

2009 Field Season

- Additional collection of yearling Chinook transported from Lower Monumental Dam



- Test proxies for vitality
 - Biological impedance analysis (BIA): water, lipid, protein content
- Test surrogate endpoints
 - Loss of equilibrium
 - Timed avoidance behaviors (freshwater, saltwater, light)

Summary

Goals

Determining survival capacity of barged and in-river migrants throughout season

Estimate D

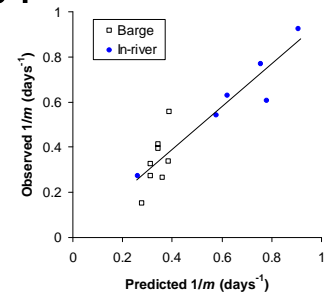


Results

Barge vs. In-river type of migration

Degree days

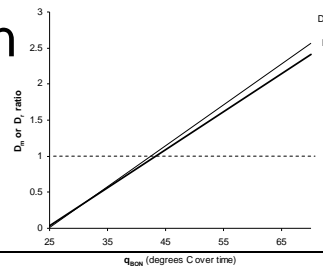
$r^2 = 0.851$



Discussion

D is below 1 and increases throughout season

Metabolism/Energy



Future

Samples transported from LMN

Proxies for vitality

Surrogate endpoints

Relate to SARs

