State of California
Department of Fish and Game

Memorandum

Date: May 14, 2009

To: Chris Carr
State Water Resources Control Board
Division of Water Rights
P.O. Box 2000
Sacramento, CA 95812-2000

From: Carl Wilcox
Water Branch
Department of Fish and Game

Subject: Additional Comments on the Notice of Public Workshop Concerning Potential Amendments to the Bay-Delta Plan Relating to Southern Delta Salinity and San Joaquin River Flow Objectives

The Department of Fish and Game (Department) recently submitted comments for the April 22, 2009 workshop stating that we would be developing San Joaquin River (SJR) flow objectives recommendations using the updated SJR Salmon Escapement Model version 1.5. After further refinements to version 1.5, the Department feels that the changes were substantial enough to justify using that updated model and referencing it as version 1.6. Attachment 1, dated May 2009, describes the specific updates in version 1.6.

For your review and reference, the enclosed Compact Disc contains the SJR Fall-run Chinook Salmon Population Model version 1.6. The Department will continue to develop our recommendations, to be provided by July 2009, using version 1.6.

Should you have questions or require clarification regarding the information we have provided, please contact me at (916) 445-1231.

Attachment (1)

cc: Victoria Whitney, Deputy Director
Les Grober
Division of Water Rights
State Water Resources Control Board
1001 I Street, Floor 14
Sacramento, CA 95814

Attachment 1

Modifications to San Joaquin River Fall-run Chinook Salmon Population Model included in Version 1.6.

Dean Marston
California Department of Fish and Game
May 2009

Introduction

In late 2005, the California Department of Fish and Game (CDFG) submitted to the State Water Resources Control Board (SWRCB) its San Joaquin River fall-run Chinook salmon computer simulation population model (Model) and documentation (model version 1.0). Upon receiving, and responding to, peer review comments the CDFG provided to the SWRCB (September 2008) a revised preliminary model and documentation (version 1.5.); as well as, providing the structure for a model (version 2.0) that includes more resolution (spatial, temporal, and biological). Work continues on model version 2.0. In the interim, substantial changes have occurred to model version 1.5 that justify changing the version number from 1.5 to 1.6. Model version 1.6 changes are described herein. To acquire additional information regarding original model version 1.0 and refined model version 1.5, readers are referred to Marston 2005[1] and Marston et.al. 2008[2]. Both references are available on the California State Water Resources Control Board website[3].

Model Changes

1. Removal of Obsolete Information

Model version 1.5 contained obsolete information (data, spreadsheet pages, parameter functions, etc.) that were unused remnants remaining from model version 1.0. Removal of this information does not impair model processing and/or prediction.

2. Composite Delta Smolt Survival Relationship

Upon re-analysis of the South Delta salmon smolt survival vs. flow level survival relationships, Dr. Alan Hubbard recommends use of a composite smolt survival relationship. To understand why Dr. Hubbard arrived at this recommendation it is important to understand some of the nuances in the smolt survival data set. Figure 1 shows the smolt survival vs. flow range relationship for both Head of Old River Barrier (HORB) in and HORB-out data sets. It is clear from the existing data sets[4] that there is no substantive overlap in the data sets (range or replicates) therefore, it is not known if the difference in the slope between the two

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[1] Marston, Dean. 2005. *FINAL DRAFT 11-28-05* San Joaquin River Fall-run Chinook Salmon Population Model

[2] Marston, D. et. al. 2008. California Department of Fish and Game San Joaquin River Fall-run Chinook Salmon Population Model Peer Review: Response to Peer Review Comments-Initial Response.

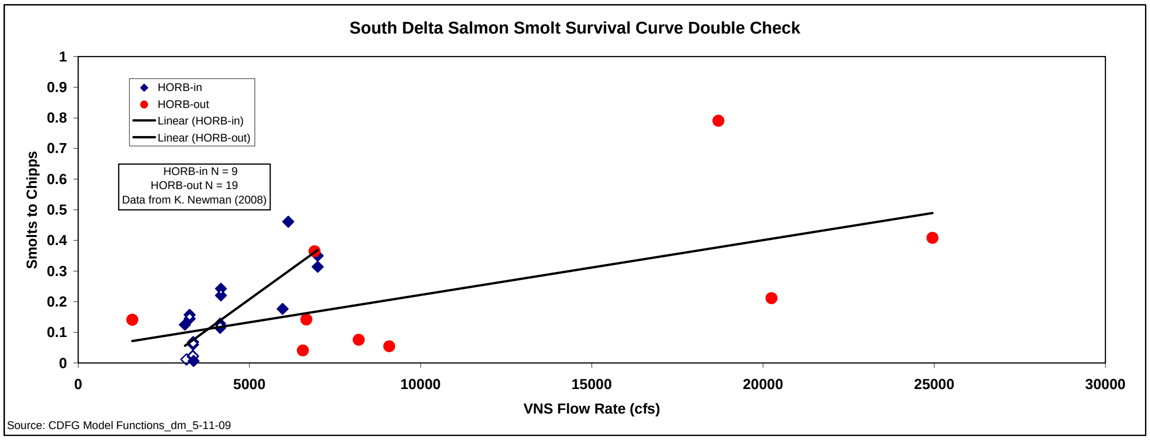
[3] SWRCB website where model documentation can be downloaded is: http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/sds_srjf/sjr/index.shtmlCite website reference.

[4] Data from: Newman, K. 2008. An Evaluation of Four Sacramento-San Joaquin River Delta Juvenile Salmon Survival Studies. The data set analyzed includes both Feather River and Merced River hatchery sources.

data sets is due to an actual difference in smolt survival as a function of the HORB being in or out, or due to variance within the data sets.

Dr. Hubbard's summary of the analysis of the slopes of the HORB-in and HORB-out data sets in provided in Appendix 1. The difference in the slopes of the HORB-in and HORB-out regression lines are not statistically significant inferring that there is not enough information to conclude they are different. Therefore, a composite smolt vs. flow survival relationship was chosen. It is important to note that when using a composite smolt survival (HORB-in and HORB-out) vs. flow rate relationship, the resulting relationship between smolt survival and flow rate is not statistically significant. However, it should also be noted that the trend between smolt survival and flow level indicates that higher flow implies higher estimated survival and the power to detect a relationship given this available data is limited. A diagram of the composite of the South Delta smolt survival vs. flow relationship is provided below in Figure 4.

Figure 1. South Delta Salmon Smolt vs. Survival Data Set.



3. Empirical Bounding of Parameter Functions

Model version 1.6 has parameter functions that are bounded by the ranges within the underlying empirical data sets upon which the parameter functions were developed. The following parameter function bounding is included in version 1.6:

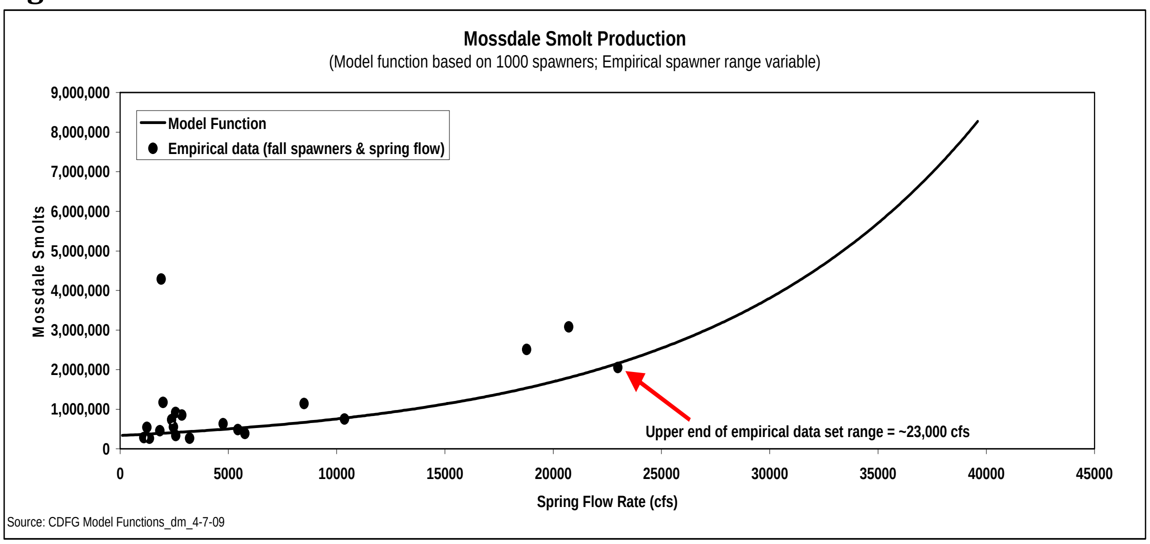
a. Fall spawners are limited to a minimum of 590 adult fish (does not affect any years due to this being the lowest spawner total observed within model time period);
b. Average spring Vernalis flow (3/15-6/15) in Mossdale smolt calculation limited to a minimum of 1,101 cubic feet per second (cfs) (affects two years: 1972 & 1977);
c. Mossdale smolt production estimate has a maximum value of 3,723,756 juvenile fish (affects a couple of wet years smolt production estimates);

d. Delta smolt survival rates limited to a low of 10% (at flows < 1,580 cfs) and a high of 56% (at flows > 25,000 cfs) (affects both critically dry and extra wet years);

e. Chipps smolts limited to a maximum of 1,058,351 juvenile fish (affects a couple of wet years)

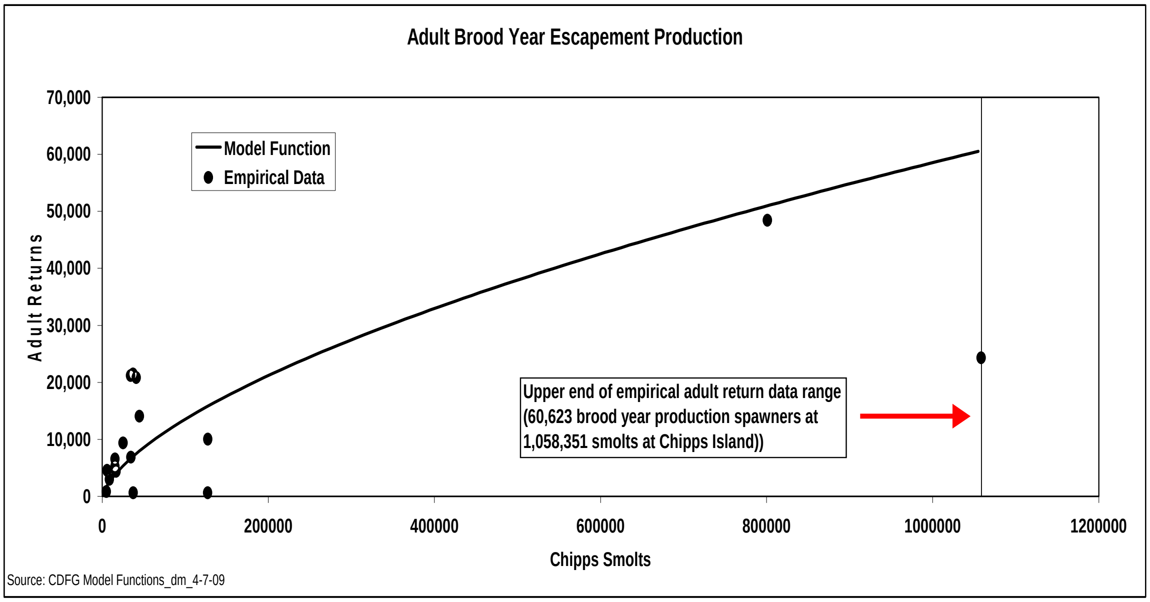
To visualize the bounds of the model version 1.6's parameter functions, Figures 2 through 4 are provided. Figure 2 shows the empirical bounds for the Mossdale smolt estimate parameter function. Figure 3 shows the Adult Brood Year Escapement Production Parameter Bounds. Figure 4 shows the empirically bound delta survival vs. flow relationship.

Figure 2. Mossdale Smolt Production Parameter Bounds



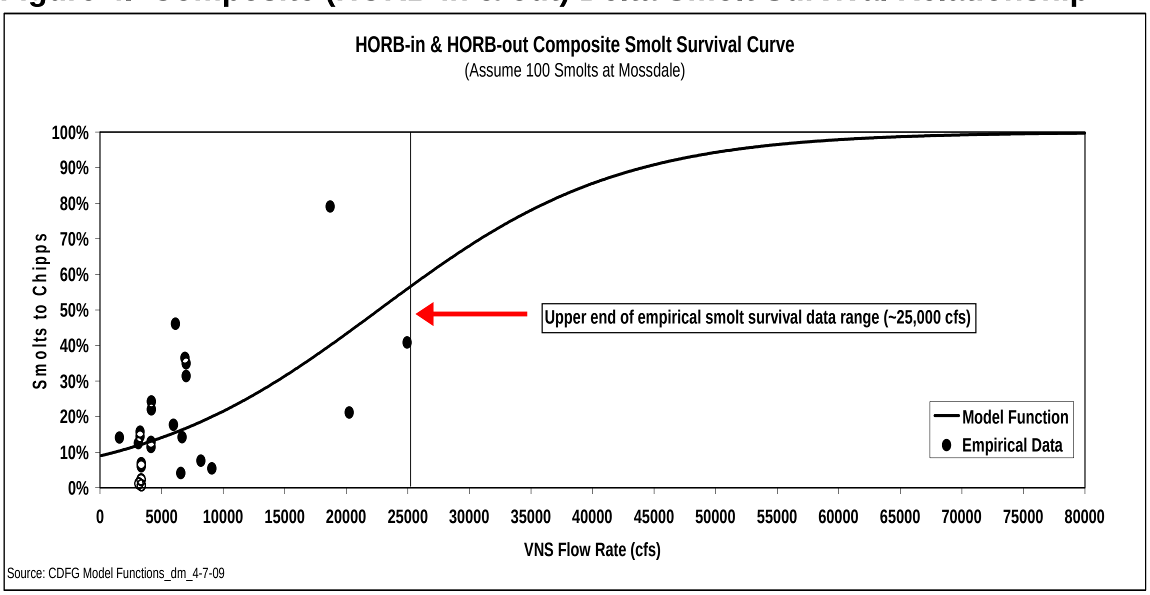
Note: The empirical adult escapement spawner range includes 590 to 39,447 adult spawners. Adding substantially more spawners (say 10,000) would change the y-axis range. Average Spring flow (March 15 to June 15) ranged from 1,101 to 22,984 cfs. Mossdale smolt abundance ranged from 267,898 to 3,723,756 juvenile fish. From the empirical data, and resulting parameter function, the number of Mossdale smolts ranges from a minimum 340,676 juvenile fish (at 590 spawners and 1,101 cfs spring flow) to a maximum of 3,723,756 juvenile fish (at 39,447 spawners and 22,984 cfs spring flow).

Figure 3. Adult Brood Year Escapement Production Parameter Bounds.



Note: The Chipps Island smolt production estimate ranged from 5,035 to 1,058,351 juvenile fish. The estimated adult return, based upon Chipps Island smolt production, ranged from 610 to 48,416 fish. The model is bounded by the maximum adult return rate possible, given the parameter function, when Chipps Island smolt production is at 1,058,351 juvenile fish the maximum adult brood year escapement is 60,623. Minimum brood year adult escapement return is 1,718 fish (when Chipps Island smolt production is at 5,035).

Figure 4. Composite (HORB-in & out) Delta Smolt Survival Relationship



Note: The composite smolt survival relationship resulting from use of both HORB-in and HORB-out data sets has a minimum survival rate of 10% (at flow rates less than 1,580 cfs) and a maximum rate of 56% (at flow rates more than 24,950 cfs). The survival rates are combined differential recovery rates using recovery of coded-wire-tagged juvenile salmon at various locations[5].

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[5] Combined differential recovery rates per methods described in Vernalis Adaptive Management Program Annual Reports available online at http://www.sjrg.org/default.html

4. Addition of Hatchery Augmentation

The ability to add hatchery production at two locations, Mossdale and/or Chipps Island, has been added to the model. If the Mossdale site is chosen than the model adds the additional number of juvenile salmon identified to the predicted number of juvenile salmon estimated for Mossdale per the previous year's fall spawner abundance and the current spring year flow level. If the Chipps Island site is chosen, then the model adds the additional number of hatchery juvenile salmon to that amount of juveniles estimated to have survived migration from Mossdale, through the South Delta, to Chipps Island. It is noted that hatchery augmentation can occur at either Mossdale or Chipps Island separately or jointly. Table 1 provides a picture of the hatchery augmentation control setting in model version 1.6.

By providing the ability to add hatchery augmentation at both Mossdale and Chipps Island, the question arose, "does adding fish at either Mossdale or Chipps Island invalidate the confidence interval computation?" The confidence interval computation is predicated upon the variance in the underlying data sets used in each of the parameter functions, none of which directly account for hatchery augmentation in their derivation. Dr. Hubbard advises that the answer to the question is no, as long as the additions are just seen as deterministic. That is, the simple addition of fish without adding a statistical relationship generating a random number of fish does not alter the confidence interval computation. Simply adding fish, that use the same survival functions as provided in the parameter functions in the model, does not add uncertainty to the model, therefore no change to the confidence interval computation is needed. It is noted that the CDFG SJR Salmon Population Model is a deterministic[6] model in that the parameter function coefficients defined in the model are constant. That is, they do not vary randomly (or unpredictably) over the time period covered in the model (which occurs in stochastic models).

For reference, the average annual Merced River Hatchery (MRH) juvenile salmon production is approximately 750,000 per year. Most of this production goes into the Merced River to conduct scientific studies and to boost natural production (over time) in the Merced River. On average, 27% of MRH production is planted in the San Joaquin River[7]. On average MRH production is 84 times the number of fall spawners for the SJR basin (total Stanislaus, Tuolumne, and Merced River combined annual escapements)[8]. So, using MRH production as an example and point of historical reference for how many hatchery juveniles to add, if combined SJR adult salmon escapement is 10,000, then using the MRH production to spawner ratio, MRH production would be 840,000 juvenile fish. Applying the 27% value, of percent MRH production to the SJR, a rough estimate of the maximum number of hatchery fish to add at Mossdale and/or Chipps

[6] Haddon, Malcolm. 2001. Modelling and Quantitative Methods in Fisheries. Chapman and Hall./CRC.

[7] Reference time span for this metric is brood year 1997 through 2006.

[8] Reference time span for this metric is brood year 1997 through 2006.

Island would be about 227,000 juvenile fish. As a final note, the maximum egg take at the MRH is 2,000,000. It takes about 500 females, producing on average 4,000 eggs, to meet the maximum egg take level. The maximum smolt production from a 2,000,000 egg take is expected to be about 1.5 million fish. Thus, the maximum amount of hatchery production that might occur, for planting at Mossdale and/or Chipps Island, would be limited to a maximum of about 400,000 juvenile fish.

Table 1. SLR Salmon Model Hatchery Augmentation Control Settings

2. Hatchery	
Location	0 = No; 1 = Yes
Mossdale	0
Chipps Island	0

If Yes here add # below

3. Smolts Added	
Location	Add #
Mossdale	0
Chipps Island	0

Note: In some cases adding hatchery fish will not increase number of juvenile fish surviving through Delta nor adults returning from ocean for, if adding hatchery fish increases juvenile production to be at levels above empirical data bounds the added hatchery fish will not result in greater adult returns. For example, adding hatchery smolts at either Mossdale or Chipps Island in spring year 1983 does not increase adult returns due to smolt production being maxed out without hatchery production.

5. East-side Tributary Contribution

The ability to estimate the fraction of water coming from individual east-side tributaries, when using non-historical Vernalis spring flow levels, has been added to model version 1.6. Using the time period of 1967 to 2004, the model time period, the amount of east-side tributary flow to Vernalis flow was correlated (linear regression). A multiple linear regression was developed to identify the amount of water each east-side tributary contributed to the total east-side tributary flow level. For example, if the average spring Vernalis flow level (say in spring 2004) was changed from 2,598 cfs to 3,879, using the historical east-side tributary to Vernalis flow relationship, the additional east-side spring tributary flow would be 210, 342, and 180 cfs, respectively, for the Stanislaus, Tuolumne, and Merced Rivers.

Appendix 1

Vernalis Adaptive Management Program
Smolt Survival vs. Flow Level Data Analysis Summary

Dr. Alan Hubbard
March 2009

We first do a logistic regression of survival vs. flow data[9] that allows for a different relationship for the HORB in vs. HORB out in a logistic regression of the form:

$$\log\left(\frac{surv}{1-surv}\right) = b_0 + b_1\,flow + b_2 HORB + b_3\,flow * HORB$$

where HORB = 1 if HORB is in and 0 if out. In this case, the null hypothesis that survival curves are not different is equivalent to *H0:*b_3*=0*. When we do this regression over the whole data range, the results are as follows:

```
Call:
glm(formula = Mossdale ~ Vernalis.Q + horb + horbxflow, family = binomial,
   data = delta.surv, na.action = na.omit)

Deviance Residuals:
    Min        1Q    Median        3Q       Max
-0.40583  -0.28318  -0.07955   0.20640   0.86466

Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept) -2.301e+00  1.672e+00  -1.376    0.169
Vernalis.Q   9.403e-05  1.062e-04   0.886    0.376
horb        -2.016e+00  2.848e+00  -0.708    0.479
horbxflow    4.601e-04  4.652e-04   0.989    0.323
```

The results suggest, no statistically significant difference by HORB status. Thus, we refit the model taking out the interaction term. With the results being:

```
Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept) -2.6428746  1.7490804  -1.511    0.131
Vernalis.Q   0.0001184  0.0001077   1.100    0.271
horb         0.3208124  1.5141895   0.212    0.832


Coefficients:
             Estimate Std. Error z value Pr(>|z|)
(Intercept) -2.320e+00  8.109e-01  -2.861  0.00422 **
Vernalis.Q   1.025e-04  7.585e-05   1.351  0.17666
```

Given that the baseline survival rate is also not significantly different by HORB status, we remove that term as well resulting in a model of flow alone (however, even that relationship is not statistically significant, *p=0.18*). We now base our predictions on this final model, which is

$$\log\left(\frac{surv}{1-surv}\right) = b_0 + b_1\,flow$$

Below are the plots of the raw data and model versus flow over all data.

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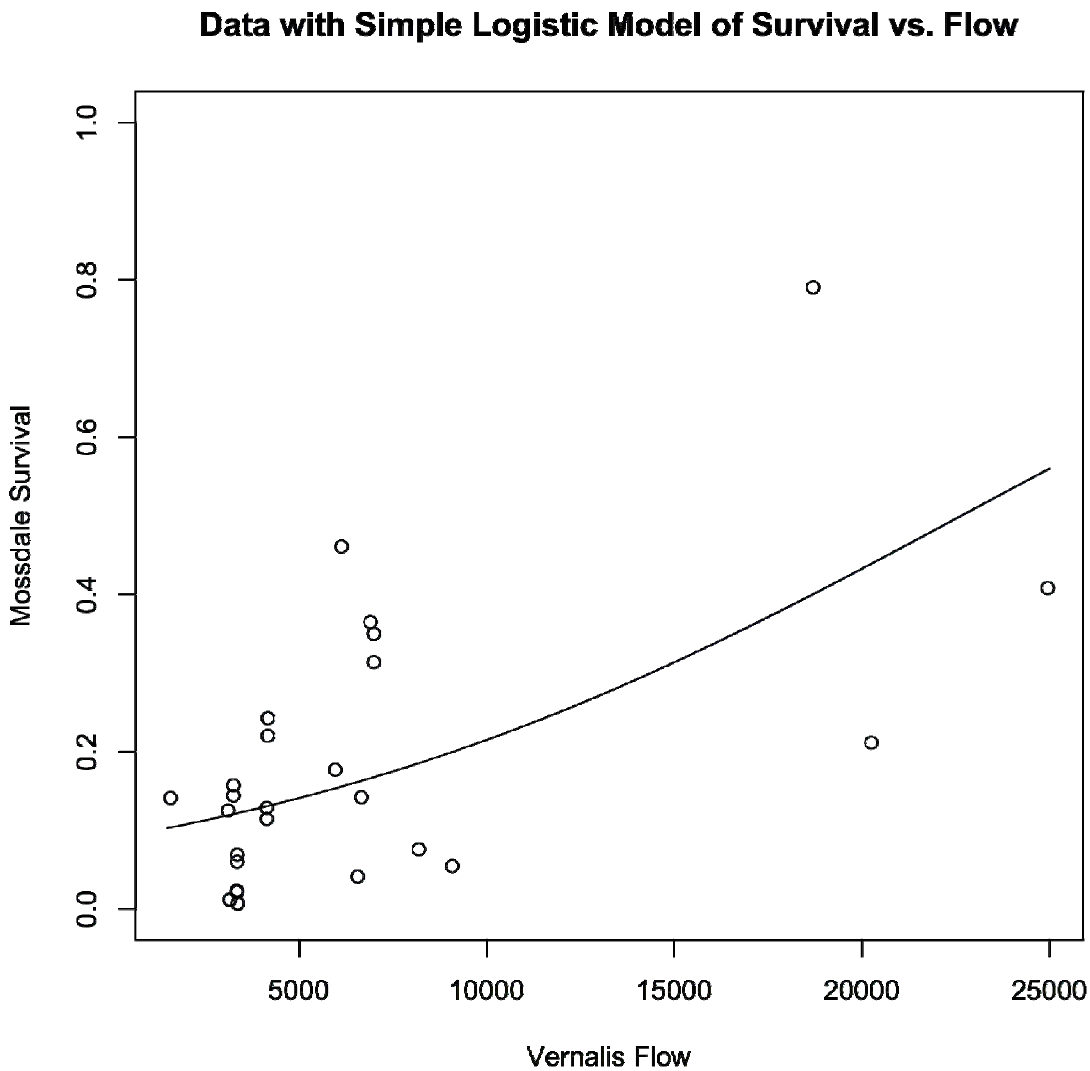
[9] Data from: Newman, K. 2008. An Evaluation of Four Sacramento-San Joaquin River Delta Juvenile Salmon Survival Studies. The data set analyzed includes both Feather River and Merced River hatchery sources.


Data with Simple Logistic Model of Survival vs. Flow
Mossdale Survival
0.0
0.2
0.4
0.6
0.8
1.0
5000
10000
15000
20000
25000
Vernalis Flow