To: Ritchie Graves, Blane Bellerud

cc: John Skidmore

From: Charlie Paulsen

Subj.: Hatchery mix of Snake Spring-summer Chinook and declining upstream survival rate

Date: 11/29/2013

As you know, following our 11/7 meeting with the harvest TAC, I agreed to investigate one suggestion by TAC members that might account for the decrease in apparent survival for Snake spring-summer Chinook adult survival, namely a change in the mix of hatchery fish arriving at Bonneville in recent years. The idea was that if one or more hatcheries had lower-than-average survival from Bonneville to Lower Granite, and the low-surviving group dominated recent returns, that might account for the survival decline.

To investigate this, I first applied transport on-off dates (supplied by Blane on 11/12) to the results we discussed with the TAC (SAS code attached, appendix B), resulting in a sample size of about 17K Snake yearling Chinook adults (no jacks) detected at Bonneville Dam from 2002-2012. They were tagged (and presumably reared) at five hatchery facilities: Clearwater, Dworshak, Looking Glass, McCall, and Rapid River. As can be seen from Table 1, transport proportions varied substantially, from 28.8% for Clearwater, to 51.8% for McCall.

In addition, from Table 2, one can see that the hatchery of origin varies over time. For example, in 2002, Clearwater-origin fish comprised only 0.33% of the upstream run, while in 2012 they made up over 22% of adults detected at Bonneville. Of particular interest, given the regression results discussed below, is Dworshak Hatchery. These have varied as well, but less so than Clearwater, from a low of about 3.5% in 2005, to a high of almost 14% in 2008.

To investigate the question raised by the TAC, I used a logistic regression of the form:

Logit (BON to LGR survival) = f (Hatchery of origin, transport status, upstream migration year).

Complete results, including regression diagnostics, appear in Appendix A; SAS code is at the very end of Appendix B.

The focus in the results is on the hatchery effects: if any hatchery has a significant, negative parameter and that hatchery also has an increase in its proportion of adult returns in recent years, that would support the TAC's hypothesis that differences in stock composition might be responsible for recent survival decreases.

As can be seen from Table 3, Dworshak fish have, on average, lower survival than the "reference" case, Rapid River. From the last column, one can see that Dworshak fish have a survival rate that is about 73% of Rapid River fish. However, looking back at Table 2, it is apparent that Dworshak fish do not account for an especially large proportion of the run in recent years, with more fish coming from Clearwater and Looking Glass in the last three years.

So, based on this result, it would appear that the stock composition/hatchery mix does not account for the recent decline in adult survival. Many other possibilities remain, of course, including size at return, run timing vs. harvest timing, and perhaps harvest accounting. If you would like my assistance in follow-up investigations, please let me know.

Table 1. Upstream survival by tagging site (Hatchery)

| **transported** | **Site of tagging** | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| **Frequency Percent Row Pct Col Pct** | **CLWH** | **DWOR** | **LOOH** | **MCCA** | **RAPH** | **Total** |
| **0 - Inriver** | 1077 6.22 11.04 71.23 | 1847 10.67 18.94 64.74 | 1781 10.29 18.26 59.91 | 1968 11.37 20.18 48.14 | 3081 17.80 31.59 52.34 | 9754 56.34 |
| **1 - Transported** | 435 2.51 5.75 28.77 | 1006 5.81 13.31 35.26 | 1192 6.88 15.77 40.09 | 2120 12.25 28.05 51.86 | 2806 16.21 37.12 47.66 | 7559 43.66 |
| **Total** | 1512 8.73 | 2853 16.48 | 2973 17.17 | 4088 23.61 | 5887 34.00 | 17313 100.00 |

Table 2. Site of tagging vs. adult (upstream migration) year.

| **Site of tagging** | **Year of upstream migration** | | | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Frequency Percent Row Pct Col Pct** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **Total** |
| **CLWH** | 5 0.03 0.33 0.26 | 4 0.02 0.26 0.23 | 16 0.09 1.06 0.77 | 3 0.02 0.20 0.30 | 0 0.00 0.00 0.00 | 1 0.01 0.07 0.20 | 243 1.40 16.07 14.27 | 147 0.85 9.72 10.95 | 363 2.10 24.01 11.25 | 395 2.28 26.12 21.13 | 335 1.93 22.16 22.88 | 1512 8.73 |
| **DWOR** | 278 1.61 9.74 14.57 | 364 2.10 12.76 21.27 | 275 1.59 9.64 13.31 | 99 0.57 3.47 10.06 | 160 0.92 5.61 29.36 | 114 0.66 4.00 23.08 | 394 2.28 13.81 23.14 | 332 1.92 11.64 24.72 | 326 1.88 11.43 10.11 | 191 1.10 6.69 10.22 | 320 1.85 11.22 21.86 | 2853 16.48 |
| **LOOH** | 390 2.25 13.12 20.44 | 215 1.24 7.23 12.57 | 246 1.42 8.27 11.91 | 157 0.91 5.28 15.96 | 93 0.54 3.13 17.06 | 65 0.38 2.19 13.16 | 212 1.22 7.13 12.45 | 210 1.21 7.06 15.64 | 630 3.64 21.19 19.53 | 459 2.65 15.44 24.56 | 296 1.71 9.96 20.22 | 2973 17.17 |
| **MCCA** | 728 4.20 17.81 38.16 | 547 3.16 13.38 31.97 | 475 2.74 11.62 22.99 | 274 1.58 6.70 27.85 | 174 1.01 4.26 31.93 | 218 1.26 5.33 44.13 | 426 2.46 10.42 25.01 | 331 1.91 8.10 24.65 | 444 2.56 10.86 13.76 | 263 1.52 6.43 14.07 | 208 1.20 5.09 14.21 | 4088 23.61 |
| **RAPH** | 507 2.93 8.61 26.57 | 581 3.36 9.87 33.96 | 1054 6.09 17.90 51.02 | 451 2.60 7.66 45.83 | 118 0.68 2.00 21.65 | 96 0.55 1.63 19.43 | 428 2.47 7.27 25.13 | 323 1.87 5.49 24.05 | 1463 8.45 24.85 45.35 | 561 3.24 9.53 30.02 | 305 1.76 5.18 20.83 | 5887 34.00 |
| **Total** | 1908 11.02 | 1711 9.88 | 2066 11.93 | 984 5.68 | 545 3.15 | 494 2.85 | 1703 9.84 | 1343 7.76 | 3226 18.63 | 1869 10.80 | 1464 8.46 | 17313 100.00 |

Table 3. Logistic model parameter estimates.

| **Analysis of Maximum Likelihood Estimates** | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Parameter** |  | **DF** | **Estimate** | **Standard Error** | **Wald Chi-Square** | **Pr > ChiSq** | **Exp(Est.)** |
| **Intercept** |  | 1 | 1.0628 | 0.0223 | 2275.8495 | <.0001 | 2.894 |
| **Tag Site** | **CLWH** | 1 | -0.0694 | 0.0493 | 1.9802 | 0.1594 | 0.933 |
| **Tag Site** | **DWOR** | 1 | **-0.3165** | **0.0373** | **71.9044** | **<.0001** | **0.729** |
| **Tag Site** | **LOOH** | 1 | 0.1742 | 0.0390 | 19.9696 | <.0001 | 1.190 |
| **Tag Site** | **MCCA** | 1 | 0.2784 | 0.0369 | 57.0377 | <.0001 | 1.321 |
| **transported** | **0 - Inriver** | 1 | 0.1176 | 0.0188 | 38.9390 | <.0001 | 1.125 |
| **adult year** | **2002** | 1 | 0.2383 | 0.0559 | 18.1770 | <.0001 | 1.269 |
| **adult year** | **2003** | 1 | 0.2243 | 0.0575 | 15.1929 | <.0001 | 1.251 |
| **adult year** | **2004** | 1 | 0.3719 | 0.0567 | 43.0172 | <.0001 | 1.450 |
| **adult year** | **2005** | 1 | 0.4121 | 0.0782 | 27.7854 | <.0001 | 1.510 |
| **adult year** | **2006** | 1 | -0.2891 | 0.0866 | 11.1397 | 0.0008 | 0.749 |
| **adult year** | **2007** | 1 | 0.1315 | 0.0998 | 1.7352 | 0.1877 | 1.141 |
| **adult year** | **2008** | 1 | -0.2072 | 0.0526 | 15.4908 | <.0001 | 0.813 |
| **adult year** | **2009** | 1 | -0.0660 | 0.0609 | 1.1760 | 0.2782 | 0.936 |
| **adult year** | **2010** | 1 | -0.2171 | 0.0412 | 27.7458 | <.0001 | 0.805 |
| **adult year** | **2011** | 1 | -0.3716 | 0.0505 | 54.0938 | <.0001 | 0.690 |

Appendix A: Detailed Regression Results

|  |  |
| --- | --- |
| **Number of Observations Read** | 17313 |
| **Number of Observations Used** | 17313 |

| **Response Profile** | | |
| --- | --- | --- |
| **Ordered Value** | **lgracnt** | **Total Frequency** |
| **1** | 0 | 4497 |
| **2** | 1 | 12816 |

|  |
| --- |
| ***Probability modeled is lgracnt=1.*** |

| **Class Level Information** | | | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Class** | **Value** | **Design Variables** | | | | | | | | | |
| **tag\_site** | **CLWH** | 1 | 0 | 0 | 0 |  |  |  |  |  |  |
|  | **DWOR** | 0 | 1 | 0 | 0 |  |  |  |  |  |  |
|  | **LOOH** | 0 | 0 | 1 | 0 |  |  |  |  |  |  |
|  | **MCCA** | 0 | 0 | 0 | 1 |  |  |  |  |  |  |
|  | **RAPH** | -1 | -1 | -1 | -1 |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
| **transported** | **0 - Inriver** | 1 |  |  |  |  |  |  |  |  |  |
|  | **1 - Transported** | -1 |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |
| **adult\_year** | **2002** | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|  | **2003** | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|  | **2004** | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|  | **2005** | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
|  | **2006** | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
|  | **2007** | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
|  | **2008** | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
|  | **2009** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
|  | **2010** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
|  | **2011** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
|  | **2012** | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 |

| **Model Convergence Status** |
| --- |
| Convergence criterion (GCONV=1E-8) satisfied. |

| **Model Fit Statistics** | | |
| --- | --- | --- |
| **Criterion** | **Intercept Only** | **Intercept and Covariates** |
| **AIC** | 19835.500 | 19459.578 |
| **SC** | 19843.260 | 19583.725 |
| **-2 Log L** | 19833.500 | 19427.578 |

| **Testing Global Null Hypothesis: BETA=0** | | | |
| --- | --- | --- | --- |
| **Test** | **Chi-Square** | **DF** | **Pr > ChiSq** |
| **Likelihood Ratio** | 405.9228 | 15 | <.0001 |
| **Score** | 397.8408 | 15 | <.0001 |
| **Wald** | 388.5894 | 15 | <.0001 |

| **Type 3 Analysis of Effects** | | | |
| --- | --- | --- | --- |
| **Effect** | **DF** | **Wald Chi-Square** | **Pr > ChiSq** |
| **tag\_site** | 4 | 131.8949 | <.0001 |
| **transported** | 1 | 38.9390 | <.0001 |
| **adult\_year** | 10 | 206.2120 | <.0001 |

| **Analysis of Maximum Likelihood Estimates** | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Parameter** |  | **DF** | **Estimate** | **Standard Error** | **Wald Chi-Square** | **Pr > ChiSq** | **Exp(Est)** |
| **Intercept** |  | 1 | 1.0628 | 0.0223 | 2275.8495 | <.0001 | 2.894 |
| **tag\_site** | **CLWH** | 1 | -0.0694 | 0.0493 | 1.9802 | 0.1594 | 0.933 |
| **tag\_site** | **DWOR** | 1 | -0.3165 | 0.0373 | 71.9044 | <.0001 | 0.729 |
| **tag\_site** | **LOOH** | 1 | 0.1742 | 0.0390 | 19.9696 | <.0001 | 1.190 |
| **tag\_site** | **MCCA** | 1 | 0.2784 | 0.0369 | 57.0377 | <.0001 | 1.321 |
| **transported** | **0 - Inriver** | 1 | 0.1176 | 0.0188 | 38.9390 | <.0001 | 1.125 |
| **adult\_year** | **2002** | 1 | 0.2383 | 0.0559 | 18.1770 | <.0001 | 1.269 |
| **adult\_year** | **2003** | 1 | 0.2243 | 0.0575 | 15.1929 | <.0001 | 1.251 |
| **adult\_year** | **2004** | 1 | 0.3719 | 0.0567 | 43.0172 | <.0001 | 1.450 |
| **adult\_year** | **2005** | 1 | 0.4121 | 0.0782 | 27.7854 | <.0001 | 1.510 |
| **adult\_year** | **2006** | 1 | -0.2891 | 0.0866 | 11.1397 | 0.0008 | 0.749 |
| **adult\_year** | **2007** | 1 | 0.1315 | 0.0998 | 1.7352 | 0.1877 | 1.141 |
| **adult\_year** | **2008** | 1 | -0.2072 | 0.0526 | 15.4908 | <.0001 | 0.813 |
| **adult\_year** | **2009** | 1 | -0.0660 | 0.0609 | 1.1760 | 0.2782 | 0.936 |
| **adult\_year** | **2010** | 1 | -0.2171 | 0.0412 | 27.7458 | <.0001 | 0.805 |
| **adult\_year** | **2011** | 1 | -0.3716 | 0.0505 | 54.0938 | <.0001 | 0.690 |

| **Odds Ratio Estimates** | | | |
| --- | --- | --- | --- |
| **Effect** | **Point Estimate** | **95% Wald Confidence Limits** | |
| **tag\_site CLWH vs RAPH** | 0.997 | 0.876 | 1.135 |
| **tag\_site DWOR vs RAPH** | 0.779 | 0.704 | 0.862 |
| **tag\_site LOOH vs RAPH** | 1.272 | 1.146 | 1.413 |
| **tag\_site MCCA vs RAPH** | 1.412 | 1.280 | 1.558 |
| **transported 0 - Inriver vs 1 - Transported** | 1.265 | 1.175 | 1.362 |
| **adult\_year 2002 vs 2012** | 1.592 | 1.351 | 1.877 |
| **adult\_year 2003 vs 2012** | 1.570 | 1.328 | 1.858 |
| **adult\_year 2004 vs 2012** | 1.820 | 1.547 | 2.141 |
| **adult\_year 2005 vs 2012** | 1.895 | 1.548 | 2.319 |
| **adult\_year 2006 vs 2012** | 0.940 | 0.756 | 1.169 |
| **adult\_year 2007 vs 2012** | 1.431 | 1.122 | 1.826 |
| **adult\_year 2008 vs 2012** | 1.020 | 0.873 | 1.192 |
| **adult\_year 2009 vs 2012** | 1.175 | 0.994 | 1.389 |
| **adult\_year 2010 vs 2012** | 1.010 | 0.878 | 1.162 |
| **adult\_year 2011 vs 2012** | 0.865 | 0.745 | 1.006 |



| **Association of Predicted Probabilities and Observed Responses** | | | |
| --- | --- | --- | --- |
| **Percent Concordant** | 59.2 | **Somers' D** | 0.201 |
| **Percent Discordant** | 39.1 | **Gamma** | 0.204 |
| **Percent Tied** | 1.7 | **Tau-a** | 0.077 |
| **Pairs** | 57633552 | **c** | 0.600 |



| **Partition for the Hosmer and Lemeshow Test** | | | | | |
| --- | --- | --- | --- | --- | --- |
| **Group** | **Total** | **lgracnt = 1** | | **lgracnt = 0** | |
| **Observed** | **Expected** | **Observed** | **Expected** |
| **1** | 1674 | 1096 | 1053.77 | 578 | 620.23 |
| **2** | 1626 | 1059 | 1072.68 | 567 | 553.32 |
| **3** | 1687 | 1159 | 1158.14 | 528 | 528.86 |
| **4** | 1812 | 1261 | 1284.82 | 551 | 527.18 |
| **5** | 1690 | 1206 | 1227.14 | 484 | 462.86 |
| **6** | 1731 | 1247 | 1297.47 | 484 | 433.53 |
| **7** | 1736 | 1382 | 1335.70 | 354 | 400.30 |
| **8** | 1866 | 1484 | 1484.93 | 382 | 381.07 |
| **9** | 1770 | 1464 | 1444.35 | 306 | 325.65 |
| **10** | 1721 | 1458 | 1457.01 | 263 | 263.99 |

| **Hosmer and Lemeshow Goodness-of-Fit Test** | | |
| --- | --- | --- |
| **Chi-Square** | **DF** | **Pr > ChiSq** |
| 24.1902 | 8 | 0.0021 |



Appendix B: Sas code to select tags and generate logistic regression results

\*\*\*adults at any ladder 1 2013-11-20.sas;

libname sasdata "D:\userfile\ptagis\sasdata\Upstream 2013 Fall";

libname mergdata "d:\userfile\ptagis\sasdata\PTAGIS SAS\Merged" ;

data sasdata.upstream\_at\_BON\_v1(label = "BON, MCN, etc adult detects 2013-11 BON Only");

set mergdata.all\_to\_2013\_10(where = (bonacnt = 1 or mcnacnt = 1 or lgracnt = 1 or WELLSACNT = 1));

by tag\_id;

if first.tag\_id;

adult\_year = year (datepart( obsdat8 ) );

if adult\_year < 2000 then delete;

age\_at\_return = adult\_year - migr\_yr;

if age\_at\_return >= 1 and age\_at\_return <= 7 ;

run;

data sasdata.upstream\_at\_BON\_v2(label = "BON MCN WELLS LGR ETC");

set sasdata.upstream\_at\_BON\_v1;

length region $20. life\_stage $10. ;

if species = "1" or species = "3" or species = "4" ;

if run = "1" or run= "2" or run = "3" or run = "5" ;

if adult\_year > 1999 ;

if adult\_year <= 2013;

if bonacnt > 0 ;

tag\_km\_1 = substr(tag\_km, 1, 3);

if tag\_km\_1 = "522" then region = "Snake";

if tag\_km\_1 = "539" and region = " " then region = "Yakima";

if tag\_km\_1 > "539" and region = " " then region = "Upper Col";

if region = " " then delete;

drop tag\_km\_1 ;

if age\_at\_return < 1 then delete;

if age\_at\_return > 6 then delete;

if age\_at\_return = 1 then life\_stage = "Jack" ;

else life\_stage = "Adult";

run;

proc sort;

by region species run life\_stage ;

run;

data upstream\_at\_receways(label = "Raceway fish, last detected into raceway");

set sasdata.upstream\_at\_BON\_v2;

if adult\_year >= 2002 ;

if adult\_year <= 2012 ;

if lgbypasd = 1 or gsbypasd = 1 or lmbypasd = 1 or (mcbypasd = 1 and region = "Upper Col" ) ;

if lgbypasd = 1 then do;

if gojcnt = 1 or lmjcnt = 1 or mcjcnt = 1 or jdjcnt = 1 or bvjcnt = 1 then delete;

lgr\_trans = 1;

lgr\_trans\_date = datepart (obsdat1) ;

end;

if gsbypasd = 1 then do;

if lmjcnt = 1 or mcjcnt = 1 or jdjcnt = 1 or bvjcnt = 1 then delete;

lgs\_trans = 1;

lgs\_trans\_date = datepart (obsdat2) ;

end;

if lmbypasd = 1 then do;

if mcjcnt = 1 or jdjcnt = 1 or bvjcnt = 1 then delete;

lmn\_trans = 1;

lmn\_trans\_date = datepart (obsdat3) ;

end;

if mcbypasd = 1 then do;

if jdjcnt = 1 or bvjcnt = 1 then delete;

mcn\_trans = 1;

mcn\_trans\_date = datepart (obsdat4) ;

end;

format lgr\_trans\_date

lgs\_trans\_date

lmn\_trans\_date

mcn\_trans\_date date10. ;

keep tag\_id migr\_yr

lgr\_trans lgr\_trans\_date

lgs\_trans lgs\_trans\_date

lmn\_trans lmn\_trans\_date

mcn\_trans mcn\_trans\_date ;

run;

proc sort;

by migr\_yr ;

run;

data sas\_trans\_dates;

set sasdata.sas\_trans\_dates\_2013\_11\_20;

run;

proc sort;

by migr\_yr ;

run;

data sasdata.upstream\_at\_receways;

length transported $32. ;

merge upstream\_at\_receways sas\_trans\_dates ;

by migr\_yr ;

if tag\_id ne " " ;

transported = "0 - Inriver";

if lgr\_trans = 1 then do;

if lgr\_trans\_date >= LGR\_Start and lgr\_trans\_date <= LGR\_End then transported = "1 - Transported";

else transported = "0 - Inriver";

end;

if lgs\_trans = 1 then do;

if lgs\_trans\_date >= LGS\_Start and lgs\_trans\_date <= LGS\_End then transported = "1 - Transported";

else transported = "0 - Inriver";

end;

if lmn\_trans = 1 then do;

if lmn\_trans\_date >= LMO\_Start and lmn\_trans\_date <= LMO\_End then transported = "1 - Transported";

else transported = "0 - Inriver";

end;

if mcn\_trans = 1 then do;

transported = "1 - Transported" ;

end;

run;

proc sort;

by tag\_id;

run;

data upstream\_v2;

set sasdata.upstream\_at\_BON\_v2 ;

run;

proc sort;

by tag\_id;

run;

data trans\_inriver\_bypassed;

set sasdata.upstream\_at\_receways;

keep tag\_id transported;

run;

proc sort;

by tag\_id;

run;

data sasdata.upstream\_v3\_w\_trans;

merge upstream\_v2 trans\_inriver\_bypassed;

by tag\_id;

if rel\_site = "LGRRBR" then transported = "1 - Transported" ;

if rel\_site = "LGRRRR" then transported = "0 - Inriver";

if transported = " " then transported = "0 - Inriver";

run;

data upstream\_at\_BON\_v3(label = "BON MCN WELLS LGR ETC V3 - SNAKE");

set sasdata.upstream\_v3\_w\_trans;

if adult\_year >= 2002 ;

if adult\_year <= 2012 ;

if region = "Snake" ;

label tag\_site = "Site of tagging" ;

label adult\_year = "Year of upstream (adult) migration" ;

\*\* Just H yearling Chinook here \*\*;

if rear\_type = "H" ;

if species = "1" and (run = "1" or run = "2" ) ;

\*\*no trans needed ;

if lgracnt = 1 and mcnacnt = 0 then delete; \*\* No fish missed at MCN for MCN-LGR ;

if tag\_site = "CLWH" or tag\_site = "DWOR" or tag\_site = "LOOH" or tag\_site = "MCCA" or tag\_site = "RAPH" ;

adult\_age = adult\_year - migr\_yr ;

label adult\_age = "# Years at sea";

if adult\_age > 1 then life\_stage = "Adult" ;

if adult\_age <= 1 then delete; \*\*\* NO JACKS 11-21 \*\*;

if adult\_age > 3 then delete; \*\*\* just a handfull \*\*;

run;

Proc freq;

tables adult\_age transported \* lgracnt transported \* tag\_site adult\_year \* lgracnt tag\_site \* lgracnt tag\_site \* adult\_year ;

run;

proc logistic plots = all;

class tag\_site transported adult\_year ;

model lgracnt (event = '1') =

tag\_site transported adult\_year /expb lackfit;

run;