Yee Method of Estimating Annual Fatality in September 2007 Analysis
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April 5, 2008

The purpose of this document is to explain the methods I used when analyzing the MTeam data in September 2007 (documents in the M16 series, specifically M16b). The purpose of that analysis had been to estimate and understand the effect of shutdown on fatality, while accounting for variation due to survey interval length, shutdown timing, scavenger removal, and seasonal variation. That analysis did not account for searcher detection error, under the presumption that the ability of an observer to detect a carcass is unaffected by whether the fatality occurred during a non-operational or an operational period. That analysis also produced estimates that could be used to derive rough estimates of annual fatality rates after adjusting for scavenger detection, which I did in my review of the February 2008 MTeam report (document P80). The methods I used have been mostly described in document P55 ("A Proposed Poisson model for operating vs. nonoperating effect on turbine-related fatalities"), but P55 stops short of describing how I used that model to calculate annual fatality estimates. In this document I present the model, describe how I calculated the annual estimate, and then briefly summarize what I see as the main differences between this estimation and the Smallwood and MTeam approaches.

To tie all this information together, I sometimes reference those earlier documents (P55, M16b, and P80), however I have repeated or copied the relevant contents so that the SRC and MTeam should be able to follow without having to revisit them.

Basic Model

From P55, the mean number of daily mortalities occurring at an analysis unit (string or turbine) is assumed to be $a \times nTurbs \times b^{\mathrm{ONO}}$

Here, *nTurbs* is a data covariate representing the number of turbines in the string, i.e. size of string, when string is the analysis unit. When turbine is the unit, then *nTurbs* is just 1. In my M16 analysis, I generalized this expression to allow size to be based on *MW* capacity so in my SAS code, *nTurbs* is replaced by *&size* which can be either *nTurbs* or *MW*.

ONO (Operating-Non-Operating) is an indicator variable representing whether this particular turbine or string was operating or non-operating. When operating, then *ONO* is 0 and the mean daily fatalities is $a \times nTurbs$. When non-operating, then *ONO* is 1 and the mean daily fatalities is $a \times nTurbs \times b$.

The parameters *a* and *b* are undetermined, but we are greatly interested in estimating their values. The parameter *b* represents the multiplicative effect on mortalities when the turbine is non-operating compared to operating. The parameter *a* represents the mean daily fatalities per turbine (or per MW) when the turbines are operating.

Ideally, the parameter *a* would be the mean of *actual* fatalities. However there are factors in the survey process that prevent the MTeam from observing data that represent *actual* daily fatalities. These factors include (but are not limited to) variable number of days between last survey, various mixtures of operating and non-operating days within the survey interval, scavenger removal, and seasonal variability. All of these factors are, in some way or another, the result of various timings of search interval. I adjusted the basic model to account for the effects of search interval and its resulting complications. But I did not account for searcher detection error. So, in order to derive an *adjusted* daily fatality, then I only need to adjust for searcher detection, i.e. calculate *a/p*. This differs from the Smallwood and MTeam approaches in which they calculated *unadjusted/(Rxp)*.

Basic Model Accounting for Timing of Search Interval

The length of search interval creates several problems in the basic model. Firstly, the presence of scavenging activity creates a discrepancy between counted fatalities and actual fatalities. Secondly, if the search interval varies, then the exposure to scavengers also varies and therefore the level of discrepancy varies. Thirdly, many search intervals spanned both a non-operational and an operational period, which leads to ambiguity in the definition *ONO*. Fourthly, it is well accepted that the daily mortality rate is not one value, but several different values that vary according to the season.

Expanding the basic model for mean daily fatalities, the number of carcasses at a turbine (or string) after an *ndays*-long interval has the following mean:

$$a \times size \times b^{ONO_1} \sum_{i=nday2+1}^{nDays1+nDays2} R_i \quad + \quad a \times size \times b^{ONO_2} \sum_{i=1}^{nDays2} R_i$$

The mean is partitioned into two sub-intervals in order to accommodate intervals that span both a non-operating and an operating period. The first sub-interval when turbines are in $ONO{=}ONO_1$ status is *nDays1* long. The left-hand side of the sum represents the mean number of carcasses from the first sub-interval. The summation factor (ΣR_i) is consistent with the scavenger removal adjustment used in Smallwood's and the MTeam's analyses, calculated from Smallwood 2007. Similarly, the second sub-interval when turbines are in the opposite *ONO* status (designated $ONO{=}ONO_2$) is *nDays2* long, and the right-hand side of the sum represents the mean number of carcasses from the second sub-interval. The sum *nDays1+nDays2* is the total interval length, *nDays.* When the search interval does not span two different *ONO* statuses, then *nDays1=nDays* and *nDays2*=0.

I accounted for seasonal variation by expanding the model further to estimate a different *a* parameter for each of four seasons. I defined seasons using Smallwood and Thelander (2004, p. 182) (document R2). The seasons are defined as follows: Spring = Mar 1 – May 31, Summer = Jun 1 – Sep 25, Autumn = Sep 26 – Nov 15, and Winter=Nov 16 – Feb 28. So, instead of just *a* and *b*, the model parameters are:
a = mean daily fatality per turbine (or string) in winter
b = shutdown effect
c = mean daily fatality per turbine (or string) in spring
d = mean daily fatality per turbine (or string) in summer
e = mean daily fatality per turbine (or string) in fall

To incorporate these parameters, the mean number of carcasses at a turbine (or string) is:

$$a^{winter} \times c^{spring} \times d^{summer} \times e^{fall} \times size \times b^{ONO_1} \sum_{i=nday2+1}^{nDays1+nDays2} R_i$$
$$+ a^{winter} \times c^{spring} \times d^{summer} e^{fall} \times size \times b^{ONO_2} \sum_{i=1}^{nDays2} R_i$$

where *winter, spring, summer*, and *fall* are indicator variables representing the season corresponding to the date of survey. For example, if the survey occurred in winter, then *winter*=1 and *spring*=*summer*=*fall*=0.

Estimating Annual Adjusted Fatality Rates

I used the NLMIXED procedure in SAS Software to fit the model using the mean structure described above, and assuming the data varied according to a Poisson distribution. The procedure finds the estimates of the parameters *a*, *b*, *c*, *d*, and *e* which best fit the data. I also programmed the procedure to take the daily fatality estimates (*a*, *c*, *d*, *e*) and extrapolate an annual fatality estimate. Since there are 105 days in winter, 92 days in spring, 117 days in summer, and 51 days in winter, then the annual estimate of mean fatality is 105*a* + 92*c* + 117*d* + 51*e*, assuming no shutdown. The annual estimate with a 2-month winter shutdown period requires splitting the winter period into a 60-day non-operating period with ONO=1 and a 45 day operating period where ONO=0: 60*ab* + 45*a* + 92*c* + 117*d* + 51*e*.

I performed the analysis on October 2005 – May 2007 data obtained by Wally Erickson on the MTeam in September 2007. The estimates are shown in document M16b (see end of this document for relevant pages from M16b with key estimates highlighted). In my review of the MTeam report (document P80), I applied the same searcher detection rates and Altamont-wide extrapolation used by the MTeam to derive an adjusted fatality estimate. Those estimates are reproduced here:

Table 1. Estimated annual fatalities in the Altamont (using extrapolation based on assumption/method 1 from comment #9 above) using fatality rates on a per turbine basis from document M16b and searcher detection factors consistent with MT report.

	fatalites/turbine/year			adjusted for searcher detection			extrapolated to 4489 turbin		
	estimate	lower	upper	estimate	lower	upper	estimate	lower	upper
.AMKE	0.06721	0.0496	0.08481	0.090824	0.067027	0.114608	408	301	514
BUOW	0.1193	0.09682	0.1417	0.161216	0.130838	0.191486	724	587	860
GOEA	0.009273	0.005989	0.01256	0.009273	0.005989	0.01256	42	27	56
RTHA	0.05777	0.05011	0.06543	0.05777	0.05011	0.06543	259	225	294

Table 2. Estimated annual fatalities in the Altamont (using extrapolation based on assumption/method 1 from comment #9 above) using fatality rates on a per MW basis from document M16b and searcher detection factors consistent with MT report.

	fatalites/MW/year			adjusted for searcher detection			extrapolated to 580 MW		
	estimate	lower	upper	estimate	lower	upper	estimate	lower	upper
.AMKE	0.65700	0.48430	0.82970	0.88784	0.65446	1.12122	515	380	650
BUOW	1.17760	0.95730	1.39790	1.59135	1.29365	1.88905	923	750	1096
GOEA	0.09034	0.05860	0.12210	0.09034	0.05860	0.12210	52	34	71
RTHA	0.56160	0.48780	0.63540	0.56160	0.48780	0.63540	326	283	369

Differences between my analysis and Smallwood or MTeam analyses

Among the several analyses performed to date,

1. JYee performed September 2007 using partial MT data (Nov 05 – May 07)
2. SSmallwood performed 2004 on CEC data
3. SSmallwood performed 2008 on CEC data using MT methods
4. MTeam performed 2008 on MT data (Nov 05 – Oct 07)

I see two main differences between my method of estimation and the methods used by Smallwood and the MTeam: 1) differences in the data, 2) the use of the Poisson model to characterize mean fatalities at the unit level vs. aggregating the data.

The data. Besides the differences in the survey period, the filtering of the data differed. Both Smallwood and the MTeam filtered out fatalities they believed to be unrelated to turbines. I did not filter out any fatalities, because my intent had been to examine the shutdown effect. So Smallwood and MTeam estimates strived to exclude background mortality while my estimates include it.

Poisson model vs. data aggregation. In other words, the use of the Poisson model to characterize mean fatalities at the unit level vs. aggregating the data. My approach assumes fatality counts at sampling units are Poisson-distributed with means which vary according to the unit's size (i.e. number of turbines or MW) or timing (i.e. number of days in operating or non-operating status, length of survey interval). Each of these means incorporates a different scavenging factor based on the length of interval corresponding to the count. Both Smallwood and the MTeam seem to aggregate the fatality counts prior to applying the scavenging adjustment. In effect, this is like applying a one-size-fits-all scavenging factor.

SAS Program used to generate document M16b (20Sep07 version)

```
%let path=e:\reviews\altamont\m\analyses\19sep07;

title "Analysis on Shutdown Effect                                                          M16b (20SEP07)";
title2 "by Julie Yee                                                                                                                      ";

libname perm "&path";
footnote "output from &path\analyze 19SEP07.sas";
ods pdf file="&path\M16b analyze shutdown effect 20SEP07.pdf";
options pageno=1 orientation=landscape;

data amkebywt;
       set perm.amkebywt;
       species='AMKE';
data buowbywt;
       set perm.buowbywt;
       species='BUOW';
data goeabywt;
       set perm.goeabywt;
       species='GOEA';
data rthabywt;
       set perm.rthabywt;
       species='RTHA';
       run;

data amkebystring;
       set perm.amkebystring;
       species='AMKE';
data buowbystring;
       set perm.buowbystring;
       species='BUOW';
data goeabystring;
       set perm.goeabystring;
       species='GOEA';
data rthabystring;
       set perm.rthabystring;
       species='RTHA';
       run;


data Alldatabywt;
       set amkebywt buowbywt goeabywt rthabywt;
       if datesearch in ('26SEP06'd,'27SEP06'd,'28SEP06'd) then autumn=1;         * for some reason, several autumn dates were not
classified as autumn ;
       run;
data Alldatabystring;
```

```
        set amkebystring buowbystring goeabystring rthabystring;
        if winter=0 and summer=0 and spring=0 and autumn=0 then autumn=1;          * for some reason, several autumn dates were not
classified as autumn – these were the ones where all season indicators were zero;
        run;

%macro modelparms(size=);;
                * initial values:
                a, c, d, e = mean mort/unit/day=0.0001369
                b = mean effect of shutdown, set at 1% reduction (almost no reduction) ;
                parms aAMKE 0.0001 aBUOW 0.0001 aGOEA 0.0001 aRTHA 0.0001
                        bAMKE 0.99 bBUOW 0.99 bGOEA 0.99 bRTHA 0.99
                        cAMKE 0.0001 cBUOW 0.0001 cGOEA 0.0001 cRTHA 0.0001
                        dAMKE 0.0001 dBUOW 0.0001 dGOEA 0.0001 dRTHA 0.0001
                        eAMKE 0.0001 eBUOW 0.0001 eGOEA 0.0001 eRTHA 0.0001;
                if species='AMKE' then do;
                        mu1 = (aAMKE**winter)*&size*RC1*(bAMKE**ono1)*(cAMKE**spring)*(dAMKE**summer)*(eAMKE**autumn);
                        mu2 = (aAMKE**winter)*&size*RC2*(bAMKE**ono2)*(cAMKE**spring)*(dAMKE**summer)*(eAMKE**autumn);
                        end;
                else if species='BUOW' then do;
                        mu1 = (aBUOW**winter)*&size*RC1*(bBUOW**ono1)*(cBUOW**spring)*(dBUOW**summer)*(eBUOW**autumn);
                        mu2 = (aBUOW**winter)*&size*RC2*(bBUOW**ono2)*(cBUOW**spring)*(dBUOW**summer)*(eBUOW**autumn);
                        end;
                else if species='GOEA' then do;
                        mu1 = (aGOEA**winter)*&size*RC1*(bGOEA**ono1)*(cGOEA**spring)*(dGOEA**summer)*(eGOEA**autumn);
                        mu2 = (aGOEA**winter)*&size*RC2*(bGOEA**ono2)*(cGOEA**spring)*(dGOEA**summer)*(eGOEA**autumn);
                        end;
                else if species='RTHA' then do;
                        mu1 = (aRTHA**winter)*&size*RC1*(bRTHA**ono1)*(cRTHA**spring)*(dRTHA**summer)*(eRTHA**autumn);
                        mu2 = (aRTHA**winter)*&size*RC2*(bRTHA**ono2)*(cRTHA**spring)*(dRTHA**summer)*(eRTHA**autumn);
                        end;
                mu = mu1+mu2;
                model count ~ poisson(mu);

                estimate "1) Mean AMKE/&size./Day (Winter)"         aAMKE alpha=0.10;
                estimate "2) Mean AMKE/&size./Day (Spring)"         cAMKE alpha=0.10;
                estimate "3) Mean AMKE/&size./Day (Summer)"         dAMKE alpha=0.10;
                estimate "4) Mean AMKE/&size./Day (Autumn)"         eAMKE alpha=0.10;
                estimate "5) Mean AMKE/&size./Yr w/o Shutdown"      105*aAMKE+92*cAMKE+117*dAMKE+51*eAMKE alpha=0.10;
                estimate "6) Shutdown Effect for AMKE"              bAMKE-1 alpha=0.10;
                estimate "7) MeanAMKE/&size./Yr w/ 2-mo Shut"       60*aAMKE*bAMKE+45*aAMKE+92*cAMKE+117*dAMKE+51*eAMKE alpha=0.10;
                estimate "8) 2-mo Shut.Effect on AMKE/&size./Yr"
        (60*aAMKE*bAMKE+45*aAMKE+92*cAMKE+117*dAMKE+51*eAMKE)/(105*aAMKE+92*cAMKE+117*dAMKE+51*eAMKE)-1   alpha=0.10;
                estimate "9) MeanAMKE/&size./Yr w/ 3-mo Shut"       90*aAMKE*bAMKE+15*aAMKE+92*cAMKE+117*dAMKE+51*eAMKE alpha=0.10;
                        estimate "10) 3-mo Shut.Effect on AMKE/&size./Yr"
        (90*aAMKE*bAMKE+15*aAMKE+92*cAMKE+117*dAMKE+51*eAMKE)/(105*aAMKE+92*cAMKE+117*dAMKE+51*eAMKE)-1 alpha=0.10;
                estimate "11) MeanAMKE/&size./Yr w/ 4-mo Shut"
        105*aAMKE*bAMKE+92*cAMKE+117*dAMKE+36*eAMKE+15*eAMKE*bAMKE alpha=0.10;
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       estimate "12) 4-mo Shut.Effect on AMKE/&size./Yr"
(105*aAMKE*bAMKE+92*cAMKE+117*dAMKE+36*eAMKE+15*eAMKE*bAMKE)/(105*aAMKE+92*cAMKE+117*dAMKE+51*eAMKE)-1 alpha=0.10;
       estimate "13) Mean BUOW/&size./Day (Winter)"         aBUOW alpha=0.10;
       estimate "14) Mean BUOW/&size./Day (Spring)"         cBUOW alpha=0.10;
       estimate "15) Mean BUOW/&size./Day (Summer)"         dBUOW alpha=0.10;
       estimate "16) Mean BUOW/&size./Day (Autumn)"         eBUOW alpha=0.10;
       estimate "17) Mean BUOW/&size./Yr w/o Shutdown"      105*aBUOW+92*cBUOW+117*dBUOW+51*eBUOW alpha=0.10;
       estimate "18) Shutdown Effect for BUOW"                             bBUOW-1 alpha=0.10;
       estimate "19) MeanBUOW/&size./Yr w/ 2-mo Shut"       60*aBUOW*bBUOW+45*aBUOW+92*cBUOW+117*dBUOW+51*eBUOW alpha=0.10;
       estimate "20) 2-mo Shut.Effect on BUOW/&size./Yr"
(60*aBUOW*bBUOW+45*aBUOW+92*cBUOW+117*dBUOW+51*eBUOW)/(105*aBUOW+92*cBUOW+117*dBUOW+51*eBUOW)-1  alpha=0.10;
       estimate "21) MeanBUOW/&size./Yr w/ 3-mo Shut"       90*aBUOW*bBUOW+15*aBUOW+92*cBUOW+117*dBUOW+51*eBUOW alpha=0.10;
       estimate "22) 3-mo Shut.Effect on BUOW/&size./Yr"
(90*aBUOW*bBUOW+15*aBUOW+92*cBUOW+117*dBUOW+51*eBUOW)/(105*aBUOW+92*cBUOW+117*dBUOW+51*eBUOW)-1 alpha=0.10;
       estimate "23) MeanBUOW/&size./Yr w/ 4-mo Shut"
105*aBUOW*bBUOW+92*cBUOW+117*dBUOW+36*eBUOW+15*eBUOW*bBUOW alpha=0.10;
       estimate "24) 4-mo Shut.Effect on BUOW/&size./Yr"
(105*aBUOW*bBUOW+92*cBUOW+117*dBUOW+36*eBUOW+15*eBUOW*bBUOW)/(105*aBUOW+92*cBUOW+117*dBUOW+51*eBUOW)-1 alpha=0.10;
       estimate "25) Mean GOEA/&size./Day (Winter)"         aGOEA alpha=0.10;
       estimate "26) Mean GOEA/&size./Day (Spring)"         cGOEA alpha=0.10;
       estimate "27) Mean GOEA/&size./Day (Summer)"         dGOEA alpha=0.10;
       estimate "28) Mean GOEA/&size./Day (Autumn)"         eGOEA alpha=0.10;
       estimate "29) Mean GOEA/&size./Yr w/o Shutdown"      105*aGOEA+92*cGOEA+117*dGOEA+51*eGOEA alpha=0.10;
       estimate "30) Shutdown Effect for GOEA"              bGOEA-1 alpha=0.10;
       estimate "31) MeanGOEA/&size./Yr w/ 2-mo Shut"       60*aGOEA*bGOEA+45*aGOEA+92*cGOEA+117*dGOEA+51*eGOEA alpha=0.10;
       estimate "32) 2-mo Shut.Effect on GOEA/&size./Yr"
(60*aGOEA*bGOEA+45*aGOEA+92*cGOEA+117*dGOEA+51*eGOEA)/(105*aGOEA+92*cGOEA+117*dGOEA+51*eGOEA)-1  alpha=0.10;
       estimate "33) MeanGOEA/&size./Yr w/ 3-mo Shut"       90*aGOEA*bGOEA+15*aGOEA+92*cGOEA+117*dGOEA+51*eGOEA alpha=0.10;
       estimate "34) 3-mo Shut.Effect on GOEA/&size./Yr"
(90*aGOEA*bGOEA+15*aGOEA+92*cGOEA+117*dGOEA+51*eGOEA)/(105*aGOEA+92*cGOEA+117*dGOEA+51*eGOEA)-1 alpha=0.10;
       estimate "35) MeanGOEA/&size./Yr w/ 4-mo Shut"
105*aGOEA*bGOEA+92*cGOEA+117*dGOEA+36*eGOEA+15*eGOEA*bGOEA alpha=0.10;
       estimate "36) 4-mo Shut.Effect on GOEA/&size./Yr"
(105*aGOEA*bGOEA+92*cGOEA+117*dGOEA+36*eGOEA+15*eGOEA*bGOEA)/(105*aGOEA+92*cGOEA+117*dGOEA+51*eGOEA)-1 alpha=0.10;
       estimate "37) Mean RTHA/&size./Day (Winter)"         aRTHA alpha=0.10;
       estimate "38) Mean RTHA/&size./Day (Spring)"         cRTHA alpha=0.10;
       estimate "39) Mean RTHA/&size./Day (Summer)"         dRTHA alpha=0.10;
       estimate "40) Mean RTHA/&size./Day (Autumn)"         eRTHA alpha=0.10;
       estimate "41) Mean RTHA/&size./Yr w/o Shutdown"      105*aRTHA+92*cRTHA+117*dRTHA+51*eRTHA alpha=0.10;
       estimate "42) Shutdown Effect for RTHA"              bRTHA-1 alpha=0.10;
       estimate "43) MeanRTHA/&size./Yr w/ 2-mo Shut"       60*aRTHA*bRTHA+45*aRTHA+92*cRTHA+117*dRTHA+51*eRTHA alpha=0.10;
       estimate "44) 2-mo Shut.Effect on RTHA/&size./Yr"
(60*aRTHA*bRTHA+45*aRTHA+92*cRTHA+117*dRTHA+51*eRTHA)/(105*aRTHA+92*cRTHA+117*dRTHA+51*eRTHA)-1  alpha=0.10;
       estimate "45) MeanRTHA/&size./Yr w/ 3-mo Shut"       90*aRTHA*bRTHA+15*aRTHA+92*cRTHA+117*dRTHA+51*eRTHA alpha=0.10;
       estimate "46) 3-mo Shut.Effect on RTHA/&size./Yr"
(90*aRTHA*bRTHA+15*aRTHA+92*cRTHA+117*dRTHA+51*eRTHA)/(105*aRTHA+92*cRTHA+117*dRTHA+51*eRTHA)-1 alpha=0.10;
       estimate "47) MeanRTHA/&size./Yr w/ 4-mo Shut"
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       105*aRTHA*bRTHA+92*cRTHA+117*dRTHA+36*eRTHA+15*eRTHA*bRTHA alpha=0.10;

               estimate "48) 4-mo Shut.Effect on RTHA/&size./Yr"
       (105*aRTHA*bRTHA+92*cRTHA+117*dRTHA+36*eRTHA+15*eRTHA*bRTHA)/(105*aRTHA+92*cRTHA+117*dRTHA+51*eRTHA)-1 alpha=0.10;

               estimate "49) Mean Subtotal(noBUOW)/&size./Yr w/o Shutdown"
105*aAMKE+92*cAMKE+117*dAMKE+51*eAMKE + 105*aGOEA+92*cGOEA+117*dGOEA+51*eGOEA + 105*aRTHA+92*cRTHA+117*dRTHA+51*eRTHA   alpha=0.10;

               estimate "50) Mean Subtotal(noBUOW)/&size./Yr w/ 2-mo Shut" 60*aAMKE*bAMKE+45*aAMKE+92*cAMKE+117*dAMKE+51*eAMKE
+ 60*aGOEA*bGOEA+45*aGOEA+92*cGOEA+117*dGOEA+51*eGOEA + 60*aRTHA*bRTHA+45*aRTHA+92*cRTHA+117*dRTHA+51*eRTHA      alpha=0.10;

               estimate "51) Mean Subtotal(noBUOW)/&size./Yr w/ 3-mo Shut" 90*aAMKE*bAMKE+15*aAMKE+92*cAMKE+117*dAMKE+51*eAMKE +
90*aGOEA*bGOEA+15*aGOEA+92*cGOEA+117*dGOEA+51*eGOEA + 90*aRTHA*bRTHA+15*aRTHA+92*cRTHA+117*dRTHA+51*eRTHA       alpha=0.10;

               estimate "52) Mean Subtotal(noBUOW)/&size./Yr w/ 4-mo Shut" 105*aAMKE*bAMKE+92*cAMKE+117*dAMKE+36*eAMKE+15*eAMKE*bAMKE
+ 105*aGOEA*bGOEA+92*cGOEA+117*dGOEA+36*eGOEA+15*eGOEA*bGOEA + 105*aRTHA*bRTHA+92*cRTHA+117*dRTHA+36*eRTHA+15*eRTHA*bRTHA alpha=0.10;

               estimate "53) 2-mo Shut.Effect on Subtotal(noBUOW)/&size./Yr"      (60*aAMKE*bAMKE+45*aAMKE+92*cAMKE+117*dAMKE+51*eAMKE
+ 60*aGOEA*bGOEA+45*aGOEA+92*cGOEA+117*dGOEA+51*eGOEA + 60*aRTHA*bRTHA+45*aRTHA+92*cRTHA+117*dRTHA+51*eRTHA)/
(105*aAMKE+92*cAMKE+117*dAMKE+51*eAMKE + 105*aGOEA+92*cGOEA+117*dGOEA+51*eGOEA + 105*aRTHA+92*cRTHA+117*dRTHA+51*eRTHA)-1 alpha=0.10;

               estimate "54) 3-mo Shut.Effect on Subtotal(noBUOW)/&size./Yr"      (90*aAMKE*bAMKE+15*aAMKE+92*cAMKE+117*dAMKE+51*eAMKE
+ 90*aGOEA*bGOEA+15*aGOEA+92*cGOEA+117*dGOEA+51*eGOEA + 90*aRTHA*bRTHA+15*aRTHA+92*cRTHA+117*dRTHA+51*eRTHA)/
(105*aAMKE+92*cAMKE+117*dAMKE+51*eAMKE + 105*aGOEA+92*cGOEA+117*dGOEA+51*eGOEA + 105*aRTHA+92*cRTHA+117*dRTHA+51*eRTHA)-1 alpha=0.10;

               estimate "55) 4-mo Shut.Effect on Subtotal(noBUOW)/&size./Yr"
(105*aAMKE*bAMKE+92*cAMKE+117*dAMKE+36*eAMKE+15*eAMKE*bAMKE +
105*aGOEA*bGOEA+92*cGOEA+117*dGOEA+36*eGOEA+15*eGOEA*bGOEA + 105*aRTHA*bRTHA+92*cRTHA+117*dRTHA+36*eRTHA+15*eRTHA*bRTHA)/
(105*aAMKE+92*cAMKE+117*dAMKE+51*eAMKE + 105*aGOEA+92*cGOEA+117*dGOEA+51*eGOEA + 105*aRTHA+92*cRTHA+117*dRTHA+51*eRTHA)-1 alpha=0.10;

               estimate "56) Mean Total4/&size./Yr w/o Shutdown"    105*aAMKE+92*cAMKE+117*dAMKE+51*eAMKE +
105*aBUOW+92*cBUOW+117*dBUOW+51*eBUOW + 105*aGOEA+92*cGOEA+117*dGOEA+51*eGOEA + 105*aRTHA+92*cRTHA+117*dRTHA+51*eRTHA   alpha=0.10;

               estimate "57) Mean Total4/&size./Yr w/ 2-mo Shut"
60*aAMKE*bAMKE+45*aAMKE+92*cAMKE+117*dAMKE+51*eAMKE + 60*aBUOW*bBUOW+45*aBUOW+92*cBUOW+117*dBUOW+51*eBUOW +
60*aGOEA*bGOEA+45*aGOEA+92*cGOEA+117*dGOEA+51*eGOEA + 60*aRTHA*bRTHA+45*aRTHA+92*cRTHA+117*dRTHA+51*eRTHA       alpha=0.10;

               estimate "58) Mean Total4/&size./Yr w/ 3-mo Shut"
90*aAMKE*bAMKE+15*aAMKE+92*cAMKE+117*dAMKE+51*eAMKE + 90*aBUOW*bBUOW+15*aBUOW+92*cBUOW+117*dBUOW+51*eBUOW +
90*aGOEA*bGOEA+15*aGOEA+92*cGOEA+117*dGOEA+51*eGOEA + 90*aRTHA*bRTHA+15*aRTHA+92*cRTHA+117*dRTHA+51*eRTHA       alpha=0.10;

               estimate "59) Mean Total4/&size./Yr w/ 4-mo Shut"
105*aAMKE*bAMKE+92*cAMKE+117*dAMKE+36*eAMKE+15*eAMKE*bAMKE + 105*aBUOW*bBUOW+92*cBUOW+117*dBUOW+36*eBUOW+15*eBUOW*bBUOW +
105*aGOEA*bGOEA+92*cGOEA+117*dGOEA+36*eGOEA+15*eGOEA*bGOEA + 105*aRTHA*bRTHA+92*cRTHA+117*dRTHA+36*eRTHA+15*eRTHA*bRTHA alpha=0.10;

               estimate "60) 2-mo Shut.Effect on Total4/&size./Yr"
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(60*aAMKE*bAMKE+45*aAMKE+92*cAMKE+117*dAMKE+51*eAMKE + 60*aBUOW*bBUOW+45*aBUOW+92*cBUOW+117*dBUOW+51*eBUOW +
60*aGOEA*bGOEA+45*aGOEA+92*cGOEA+117*dGOEA+51*eGOEA + 60*aRTHA*bRTHA+45*aRTHA+92*cRTHA+117*dRTHA+51*eRTHA)/
(105*aAMKE+92*cAMKE+117*dAMKE+51*eAMKE + 105*aBUOW+92*cBUOW+117*dBUOW+51*eBUOW +
105*aGOEA+92*cGOEA+117*dGOEA+51*eGOEA + 105*aRTHA+92*cRTHA+117*dRTHA+51*eRTHA)-1  alpha=0.10;

               estimate "61) 3-mo Shut.Effect on Total4/&size./Yr"
(90*aAMKE*bAMKE+15*aAMKE+92*cAMKE+117*dAMKE+51*eAMKE + 90*aBUOW*bBUOW+15*aBUOW+92*cBUOW+117*dBUOW+51*eBUOW +
90*aGOEA*bGOEA+15*aGOEA+92*cGOEA+117*dGOEA+51*eGOEA + 90*aRTHA*bRTHA+15*aRTHA+92*cRTHA+117*dRTHA+51*eRTHA)/
(105*aAMKE+92*cAMKE+117*dAMKE+51*eAMKE + 105*aBUOW+92*cBUOW+117*dBUOW+51*eBUOW +
105*aGOEA+92*cGOEA+117*dGOEA+51*eGOEA + 105*aRTHA+92*cRTHA+117*dRTHA+51*eRTHA)-1  alpha=0.10;

               estimate "62) 4-mo Shut.Effect on Total4/&size./Yr"
(105*aAMKE*bAMKE+92*cAMKE+117*dAMKE+36*eAMKE+15*eAMKE*bAMKE + 105*aBUOW*bBUOW+92*cBUOW+117*dBUOW+36*eBUOW+15*eBUOW*bBUOW +
105*aGOEA*bGOEA+92*cGOEA+117*dGOEA+36*eGOEA+15*eGOEA*bGOEA + 105*aRTHA*bRTHA+92*cRTHA+117*dRTHA+36*eRTHA+15*eRTHA*bRTHA)/
(105*aAMKE+92*cAMKE+117*dAMKE+51*eAMKE + 105*aBUOW+92*cBUOW+117*dBUOW+51*eBUOW +
105*aGOEA+92*cGOEA+117*dGOEA+51*eGOEA + 105*aRTHA+92*cRTHA+117*dRTHA+51*eRTHA)-1  alpha=0.10;

               ods exclude parameters iterhistory parameterestimates specifications dimensions convergencestatus fitstatistics;
               *ods output parameterestimates=parmests;
%mend;

%macro fitmodel0(data=, size=);
title5 "Estimates for mean fatalities PER &size";
title6 "Sampling unit is TURBINE";

proc nlmixed data=&data.bywt;
       %modelparms(size=&size);
       run;

title5 "Estimates for mean fatalities PER &size";
title6 "Sampling unit is STRING";

proc nlmixed data=&data.bystring;
       %modelparms(size=&size);
       run;
%mend;

%fitmodel0(data=Alldata, size=TURBINE);
%fitmodel0(data=Alldata, size=MW);

ods pdf close;
```

Estimates for mean fatalities PER TURBINE
Sampling unit is STRING

The NLMIXED Procedure

Additional Estimates								
Label	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**	**Alpha**	**Lower**	**Upper**
1) Mean AMKE/TURBINE/Day (Winter)	0.000282	0.000078	14E3	3.63	0.0003	0.1	0.000154	0.000411
2) Mean AMKE/TURBINE/Day (Spring)	0.000191	0.000051	14E3	3.73	0.0002	0.1	0.000107	0.000275
3) Mean AMKE/TURBINE/Day (Summer)	0.000138	0.000052	14E3	2.64	0.0083	0.1	0.000052	0.000223
4) Mean AMKE/TURBINE/Day (Autumn)	0.000349	0.000123	14E3	2.82	0.0048	0.1	0.000146	0.000552
5) Mean AMKE/TURBINE/Yr w/o Shutdown	0.08107	0.01306	14E3	6.21	<.0001	0.1	0.05960	0.1025
6) Shutdown Effect for AMKE	-0.8183	0.1198	14E3	-6.83	<.0001	0.1	-1.0154	-0.6212
7) MeanAMKE/TURBINE/Yr w/ 2-mo Shut	0.06721	0.01070	14E3	6.28	<.0001	0.1	0.04960	0.08481
8) 2-mo Shut.Effect on AMKE/TURBINE/Yr	-0.1710	0.04994	14E3	-3.43	0.0006	0.1	-0.2532	-0.08890
9) MeanAMKE/TURBINE/Yr w/ 3-mo Shut	0.06027	0.01027	14E3	5.87	<.0001	0.1	0.04337	0.07717
10) 3-mo Shut.Effect on AMKE/TURBINE/Yr	-0.2566	0.07490	14E3	-3.43	0.0006	0.1	-0.3798	-0.1333
11) MeanAMKE/TURBINE/Yr w/ 4-mo Shut	0.05253	0.009628	14E3	5.46	<.0001	0.1	0.03669	0.06837
12) 4-mo Shut.Effect on AMKE/TURBINE/Yr	-0.3521	0.08847	14E3	-3.98	<.0001	0.1	-0.4976	-0.2066
13) Mean BUOW/TURBINE/Day (Winter)	0.000415	0.000091	14E3	4.57	<.0001	0.1	0.000265	0.000564
14) Mean BUOW/TURBINE/Day (Spring)	0.000207	0.000051	14E3	4.07	<.0001	0.1	0.000124	0.000291
15) Mean BUOW/TURBINE/Day (Summer)	0.000245	0.000068	14E3	3.60	0.0003	0.1	0.000133	0.000357
16) Mean BUOW/TURBINE/Day (Autumn)	0.000508	0.000142	14E3	3.58	0.0004	0.1	0.000274	0.000742

Estimates for mean fatalities PER TURBINE
Sampling unit is STRING

The NLMIXED Procedure

Additional Estimates								
Label	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**	**Alpha**	**Lower**	**Upper**
17) Mean BUOW/TURBINE/Yr w/o Shutdown	0.1172	0.01609	14E3	7.28	<.0001	0.1	0.09074	0.1437
18) Shutdown Effect for BUOW	0.08320	0.3068	14E3	0.27	0.7862	0.1	-0.4214	0.5878
19) MeanBUOW/TURBINE/Yr w/ 2-mo Shut	0.1193	0.01365	14E3	8.74	<.0001	0.1	0.09682	0.1417
20) 2-mo Shut.Effect on BUOW/TURBINE/Yr	0.01767	0.06374	14E3	0.28	0.7816	0.1	-0.08717	0.1225
21) MeanBUOW/TURBINE/Yr w/ 3-mo Shut	0.1203	0.01379	14E3	8.72	<.0001	0.1	0.09763	0.1430
22) 3-mo Shut.Effect on BUOW/TURBINE/Yr	0.02651	0.09560	14E3	0.28	0.7816	0.1	-0.1308	0.1838
23) MeanBUOW/TURBINE/Yr w/ 4-mo Shut	0.1215	0.01510	14E3	8.04	<.0001	0.1	0.09663	0.1463
24) 4-mo Shut.Effect on BUOW/TURBINE/Yr	0.03633	0.1317	14E3	0.28	0.7826	0.1	-0.1803	0.2530
25) Mean GOEA/TURBINE/Day (Winter)	0.000016	9.468E-6	14E3	1.68	0.0923	0.1	3.656E-7	0.000032
26) Mean GOEA/TURBINE/Day (Spring)	0.000011	6.766E-6	14E3	1.68	0.0933	0.1	2.26E-7	0.000022
27) Mean GOEA/TURBINE/Day (Summer)	0.000037	0.000012	14E3	3.14	0.0017	0.1	0.000017	0.000056
28) Mean GOEA/TURBINE/Day (Autumn)	0.000057	0.000024	14E3	2.43	0.0151	0.1	0.000018	0.000096
29) Mean GOEA/TURBINE/Yr w/o Shutdown	0.009919	0.002235	14E3	4.44	<.0001	0.1	0.006243	0.01359
30) Shutdown Effect for GOEA	-0.6750	0.3810	14E3	-1.77	0.0765	0.1	-1.3018	-0.04826
31) MeanGOEA/TURBINE/Yr w/ 2-mo Shut	0.009273	0.001996	14E3	4.65	<.0001	0.1	0.005989	0.01256
32) 2-mo Shut.Effect on GOEA/TURBINE/Yr	-0.06508	0.05990	14E3	-1.09	0.2772	0.1	-0.1636	0.03345

Estimates for mean fatalities PER TURBINE
Sampling unit is STRING

The NLMIXED Procedure

Additional Estimates								
Label	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**	**Alpha**	**Lower**	**Upper**
33) MeanGOEA/TURBINE/Yr w/ 3-mo Shut	0.008950	0.001949	14E3	4.59	<.0001	0.1	0.005744	0.01216
34) 3-mo Shut.Effect on GOEA/TURBINE/Yr	-0.09763	0.08985	14E3	-1.09	0.2772	0.1	-0.2454	0.05017
35) MeanGOEA/TURBINE/Yr w/ 4-mo Shut	0.008209	0.001882	14E3	4.36	<.0001	0.1	0.005114	0.01131
36) 4-mo Shut.Effect on GOEA/TURBINE/Yr	-0.1723	0.1312	14E3	-1.31	0.1889	0.1	-0.3881	0.04342
37) Mean RTHA/TURBINE/Day (Winter)	0.000199	0.000035	14E3	5.71	<.0001	0.1	0.000142	0.000256
38) Mean RTHA/TURBINE/Day (Spring)	0.000144	0.000023	14E3	6.18	<.0001	0.1	0.000105	0.000182
39) Mean RTHA/TURBINE/Day (Summer)	0.000094	0.000018	14E3	5.08	<.0001	0.1	0.000064	0.000124
40) Mean RTHA/TURBINE/Day (Autumn)	0.000323	0.000055	14E3	5.88	<.0001	0.1	0.000232	0.000413
41) Mean RTHA/TURBINE/Yr w/o Shutdown	0.06153	0.005970	14E3	10.31	<.0001	0.1	0.05171	0.07135
42) Shutdown Effect for RTHA	-0.3154	0.1989	14E3	-1.59	0.1128	0.1	-0.6426	0.01172
43) MeanRTHA/TURBINE/Yr w/ 2-mo Shut	0.05777	0.004658	14E3	12.40	<.0001	0.1	0.05011	0.06543
44) 2-mo Shut.Effect on RTHA/TURBINE/Yr	-0.06113	0.04305	14E3	-1.42	0.1557	0.1	-0.1320	0.009690
45) MeanRTHA/TURBINE/Yr w/ 3-mo Shut	0.05589	0.004572	14E3	12.22	<.0001	0.1	0.04837	0.06341
46) 3-mo Shut.Effect on RTHA/TURBINE/Yr	-0.09170	0.06458	14E3	-1.42	0.1557	0.1	-0.1979	0.01453
47) MeanRTHA/TURBINE/Yr w/ 4-mo Shut	0.05342	0.004958	14E3	10.77	<.0001	0.1	0.04526	0.06158
48) 4-mo Shut.Effect on RTHA/TURBINE/Yr	-0.1318	0.08978	14E3	-1.47	0.1421	0.1	-0.2795	0.01588

Estimates for mean fatalities PER MW
Sampling unit is STRING

The NLMIXED Procedure

Additional Estimates								
Label	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**	**Alpha**	**Lower**	**Upper**
1) Mean AMKE/MW/Day (Winter)	0.002550	0.000697	14E3	3.66	0.0003	0.1	0.001403	0.003697
2) Mean AMKE/MW/Day (Spring)	0.001908	0.000511	14E3	3.73	0.0002	0.1	0.001067	0.002748
3) Mean AMKE/MW/Day (Summer)	0.001368	0.000517	14E3	2.64	0.0082	0.1	0.000517	0.002219
4) Mean AMKE/MW/Day (Autumn)	0.003418	0.001210	14E3	2.82	0.0047	0.1	0.001427	0.005409
5) Mean AMKE/MW/Yr w/o Shutdown	0.7777	0.1246	14E3	6.24	<.0001	0.1	0.5728	0.9826
6) Shutdown Effect for AMKE	-0.7890	0.1365	14E3	-5.78	<.0001	0.1	-1.0135	-0.5644
7) MeanAMKE/MW/Yr w/ 2-mo Shut	0.6570	0.1050	14E3	6.26	<.0001	0.1	0.4843	0.8297
8) 2-mo Shut.Effect on AMKE/MW/Yr	-0.1552	0.04874	14E3	-3.18	0.0015	0.1	-0.2354	-0.07505
9) MeanAMKE/MW/Yr w/ 3-mo Shut	0.5966	0.1017	14E3	5.87	<.0001	0.1	0.4294	0.7639
10) 3-mo Shut.Effect on AMKE/MW/Yr	-0.2328	0.07311	14E3	-3.18	0.0015	0.1	-0.3531	-0.1126
11) MeanAMKE/MW/Yr w/ 4-mo Shut	0.5260	0.09615	14E3	5.47	<.0001	0.1	0.3678	0.6842
12) 4-mo Shut.Effect on AMKE/MW/Yr	-0.3237	0.08834	14E3	-3.66	0.0002	0.1	-0.4690	-0.1783
13) Mean BUOW/MW/Day (Winter)	0.003873	0.000818	14E3	4.74	<.0001	0.1	0.002528	0.005218
14) Mean BUOW/MW/Day (Spring)	0.002053	0.000504	14E3	4.07	<.0001	0.1	0.001224	0.002881
15) Mean BUOW/MW/Day (Summer)	0.002426	0.000674	14E3	3.60	0.0003	0.1	0.001317	0.003534
16) Mean BUOW/MW/Day (Autumn)	0.004887	0.001369	14E3	3.57	0.0004	0.1	0.002635	0.007140
17) Mean BUOW/MW/Yr w/o Shutdown	1.1286	0.1531	14E3	7.37	<.0001	0.1	0.8766	1.3805

Estimates for mean fatalities PER MW
Sampling unit is STRING

The NLMIXED Procedure

Additional Estimates								
Label	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**	**Alpha**	**Lower**	**Upper**
18) Shutdown Effect for BUOW	0.2111	0.3300	14E3	0.64	0.5225	0.1	-0.3319	0.7540
19) MeanBUOW/MW/Yr w/ 2-mo Shut	1.1776	0.1339	14E3	8.79	<.0001	0.1	0.9573	1.3979
20) 2-mo Shut.Effect on BUOW/MW/Yr	0.04346	0.06496	14E3	0.67	0.5035	0.1	-0.06339	0.1503
21) MeanBUOW/MW/Yr w/ 3-mo Shut	1.2021	0.1372	14E3	8.76	<.0001	0.1	0.9764	1.4279
22) 3-mo Shut.Effect on BUOW/MW/Yr	0.06519	0.09743	14E3	0.67	0.5035	0.1	-0.09508	0.2255
23) MeanBUOW/MW/Yr w/ 4-mo Shut	1.2299	0.1525	14E3	8.06	<.0001	0.1	0.9790	1.4808
24) 4-mo Shut.Effect on BUOW/MW/Yr	0.08977	0.1354	14E3	0.66	0.5074	0.1	-0.1330	0.3125
25) Mean GOEA/MW/Day (Winter)	0.000141	0.000083	14E3	1.69	0.0917	0.1	3.457E-6	0.000278
26) Mean GOEA/MW/Day (Spring)	0.000109	0.000064	14E3	1.71	0.0881	0.1	3.852E-6	0.000213
27) Mean GOEA/MW/Day (Summer)	0.000366	0.000116	14E3	3.15	0.0016	0.1	0.000175	0.000556
28) Mean GOEA/MW/Day (Autumn)	0.000539	0.000221	14E3	2.43	0.0150	0.1	0.000174	0.000903
29) Mean GOEA/MW/Yr w/o Shutdown	0.09502	0.02138	14E3	4.44	<.0001	0.1	0.05985	0.1302
30) Shutdown Effect for GOEA	-0.5537	0.4943	14E3	-1.12	0.2627	0.1	-1.3668	0.2594
31) MeanGOEA/MW/Yr w/ 2-mo Shut	0.09034	0.01930	14E3	4.68	<.0001	0.1	0.05860	0.1221
32) 2-mo Shut.Effect on GOEA/MW/Yr	-0.04923	0.06012	14E3	-0.82	0.4129	0.1	-0.1481	0.04966
33) MeanGOEA/MW/Yr w/ 3-mo Shut	0.08800	0.01893	14E3	4.65	<.0001	0.1	0.05687	0.1191

Estimates for mean fatalities PER MW
Sampling unit is STRING

The NLMIXED Procedure

Additional Estimates								
Label	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**	**Alpha**	**Lower**	**Upper**
34) 3-mo Shut.Effect on GOEA/MW/Yr	-0.07385	0.09018	14E3	-0.82	0.4129	0.1	-0.2222	0.07449
35) MeanGOEA/MW/Yr w/ 4-mo Shut	0.08236	0.01888	14E3	4.36	<.0001	0.1	0.05130	0.1134
36) 4-mo Shut.Effect on GOEA/MW/Yr	-0.1332	0.1431	14E3	-0.93	0.3517	0.1	-0.3686	0.1021
37) Mean RTHA/MW/Day (Winter)	0.001761	0.000305	14E3	5.78	<.0001	0.1	0.001260	0.002263
38) Mean RTHA/MW/Day (Spring)	0.001370	0.000222	14E3	6.18	<.0001	0.1	0.001005	0.001735
39) Mean RTHA/MW/Day (Summer)	0.000935	0.000184	14E3	5.09	<.0001	0.1	0.000633	0.001237
40) Mean RTHA/MW/Day (Autumn)	0.003017	0.000514	14E3	5.87	<.0001	0.1	0.002171	0.003863
41) Mean RTHA/MW/Yr w/o Shutdown	0.5743	0.05540	14E3	10.37	<.0001	0.1	0.4832	0.6654
42) Shutdown Effect for RTHA	-0.1200	0.2389	14E3	-0.50	0.6156	0.1	-0.5129	0.2730
43) MeanRTHA/MW/Yr w/ 2-mo Shut	0.5616	0.04488	14E3	12.51	<.0001	0.1	0.4878	0.6354
44) 2-mo Shut.Effect on RTHA/MW/Yr	-0.02208	0.04545	14E3	-0.49	0.6272	0.1	-0.09683	0.05268
45) MeanRTHA/MW/Yr w/ 3-mo Shut	0.5553	0.04500	14E3	12.34	<.0001	0.1	0.4812	0.6293
46) 3-mo Shut.Effect on RTHA/MW/Yr	-0.03311	0.06817	14E3	-0.49	0.6272	0.1	-0.1452	0.07902
47) MeanRTHA/MW/Yr w/ 4-mo Shut	0.5467	0.05067	14E3	10.79	<.0001	0.1	0.4633	0.6300
48) 4-mo Shut.Effect on RTHA/MW/Yr	-0.04808	0.09801	14E3	-0.49	0.6237	0.1	-0.2093	0.1131
49) Mean Subtotal(noBUOW)/MW/Yr w/o Shutdown	1.4470	0.1380	14E3	10.49	<.0001	0.1	1.2200	1.6740