SMEA
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Memo

To: Santa Ana Sucker Conservation Team

From: Drs. Thomas Even, Jonathan Baskin, Thomas Haglund and David Moriarty

Date: March 7, 2011

Re: Santa Ana Sucker (*Catostomus santaanae*) Final Report Report: 2011 - 2012

Santa Ana Sucker Population Monitoring 2001-2011

2011 is the eleventh year San Marino Environmental Associates (SMEA) has monitored. *Catostomus santaanae* (Santa Ana sucker) populations in the Santa Ana River: Site 1, upstream of Mission Boulevard Bridge; Site 2, just downstream of Highway 60 Bridge; and Site 3, downstream of Riverside Avenue Bridge. A fourth site, MWD crossing, was added to the monitoring protocol in 2010 and it has been surveyed for the last two years. Fish densities within each 100-meter site were determined using maximum likelihood methods based on a multiple-pass depletion methodology. Fish captured per 100*m* were then converted to an estimate of fish population density per mile

Sucker Ana Sucker Population Data

Table 1. Santa Ana sucker, *Catostomus santaanae*, abundance expressed as fish/mile at the three monitoring sites over the 11-year period, 2001-2011; and 2 years of monitoring at MWD crossing.

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Mission Blvd	1,432	2,350	1,014	32	16	0	0	580	16	64	595
Highway 60	2,639	2,736	1,545	3,235	16	0	1,625	322	528	0	772
Riverside Ave	209	756	805	644	1,579	1,689	1,561	3,445	880	2,108	3,718
MWD Crossing										853	370
Average (w/MWD)	**1,427**	**1,947**	**1,121**	**1,304**	**537**	**563**	**1,062**	**1,449**	**475**	**724 (756)**	**1,695 (1,364)**

Over the first five sampling seasons (2001-2005), fish density decreased by a factor of almost 3 and then stabilized (2005-2006). By the next sampling season (2007) and through the 2008, fish density had increased but by 2009 it decreased precipitously to the lowest value recorded (475 fish/mile) since annual surveys began in 2001. Fish populations have since recovered (2010-2011) to densities similar to when monitoring first began in 2001. Long term monitoring indicates that there is substantial year-to-year variability in fish density within the Santa Ana River. A variety of statistical techniques including an autoregressive integrative moving average, autocorrelation using the Durbin-Watson statistic, spectral analysis and polynomial regression were used to try and detect periodicity or time related trends in average fish density. In no case was a pattern, periodicity, nor any pattern that would be expected if periodicity were present, detected in the data set.

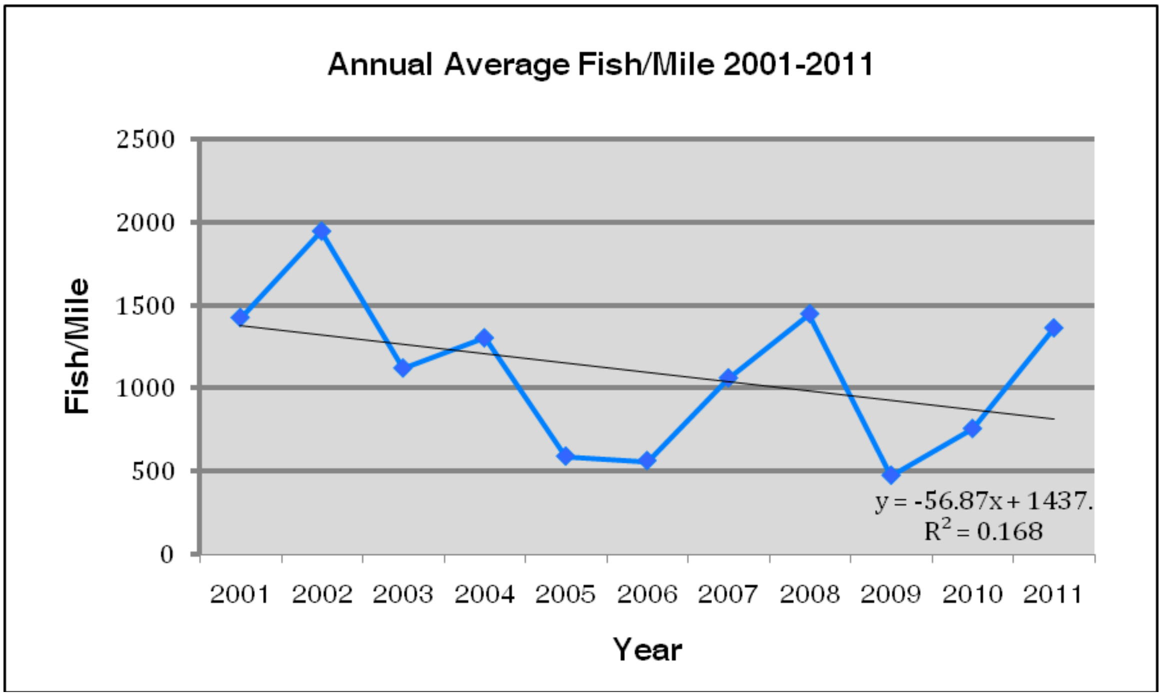

Figure 1. Annual average estimate of Santa Ana suckers, *Catostomus santaanae*, per mile of river based on the population estimates at the three long-term monitoring sites over the 11-year period from 2001-2011.

C. santaanae densities vary annually at each monitoring site. At the downstream site (Mission Boulevard) densities increased 2001 to 2001 but then declined from 2003-2005 to 16 fish per mile, and were absent between 2006 and 2007. Fish returned to the Mission Boulevard site in 2008, but density has since been low and highly variable (2009-2011). At the midstream site (Highway 60) fish densities have been highly variable year to year. Initial densities at the site from 2001-2001 were high, ranging from 1545 to 3235 fish per mile, dropped precipitously to 16 fish per mile in 2005 and declined to zero by 2006. Fish density recovered to 1625 fish per mile in 2007 but again declined through 2008 and 2009 to 322 and 528 fish per mile, respectively. In 2010 no fish were captured at the site but by 2011 fish densities had recovered to 772 fish per mile. Fish densities generally increased from 2001 to 2005 at the most upstream site (Riverside Drive), remained stable through the next two years 2006-2007 and then increased to 3445 fish per mile by 2008. Density has since fluctuated (2009-2010) but by 2011 had increased to 3718 fish per mile, the highest levels observed at any of the three monitoring sites during the eleven sampling seasons. In 2010 a fourth site, MWD crossing, was added to the monitoring protocol. Density in 2010 was 853 fish per mile and then dropped to 370 fish per mile by 2011.

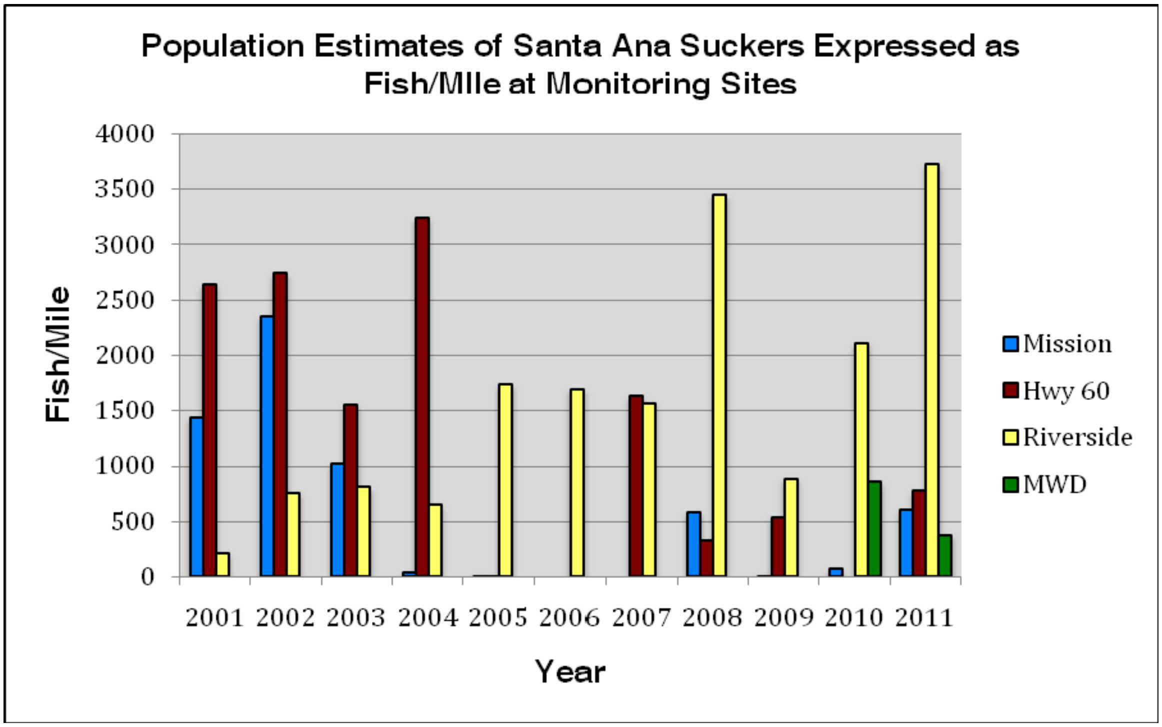

Figure 2. Population estimate of Santa Ana sucker, *Catostomus santaanae*, expressed as fish/mile at the three long-term monitoring sites over the 11 year period, 2001-2011.

Analysis of Covariance (ANCOVA) was used to examine trends in sucker density at monitoring sites over time. There is a highly significant site by time interaction, which indicates that the density (fish/mile) at a site (Mission, Hwy 60, Riverside and MWD) is dependent on time. The whole model regression plot (Figure 3) shows that site 1 (Mission), site 2 (Highway 60) and site 4 (MWD crossing) have declined in sucker density over time whereas site 3 (Riverside) has increased in density over time.

The Effects Test Table shows the level of confidence that we can assign to density patterns among sites over time. The individual effect of site (p=0.02) was significant but not the individual effect of time (p=0.60) on the mean density of fish. There was, however, a highly significant interaction between year of sampling and sampling location (Time * Site, p=0.0004), because the density of *C. santaanae* declined at Site 1 (Mission) and Site 2 (Highway 60) over 11 sampling seasons and at MWD crossing from 2010-2011, whereas the abundance of *C. santaanae* has increased at Site 3 (Riverside) over 11 sampling seasons.

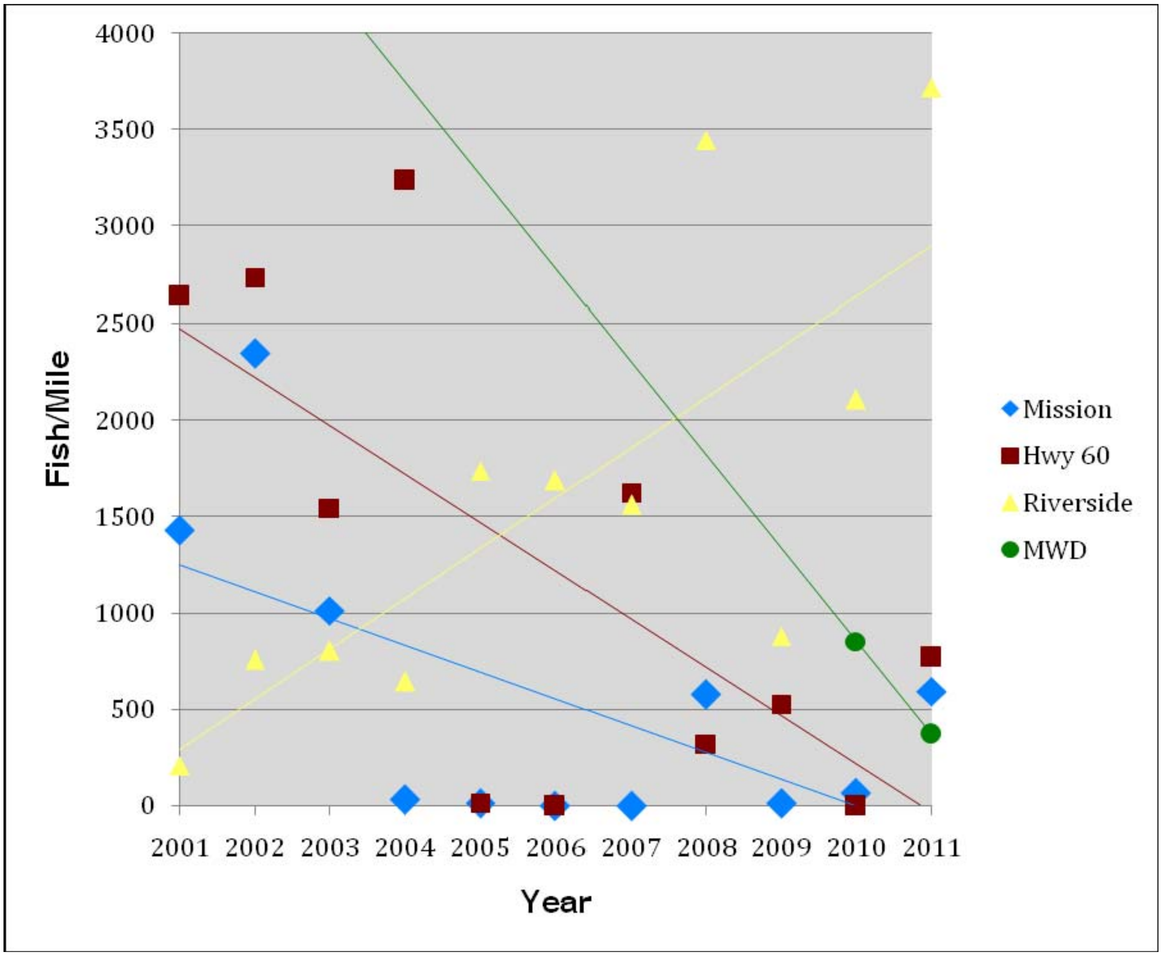

Figure 3. Analysis of covariance (ANCOVA). Response abundance, whole model regression plot (abundance of *Catostomus santaanae* is the estimate of fish per mile over the sampling years 2001-2011).

Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Site	3	3	7076499	3.79	0.02
Time	1	1	183885	0.30	0.60
Site*Time	3	3	16031815	8.59	0.0004

Conclusions are:

1. There is substantial year-to-year variability in the density of *C. santaanae* both among and within monitoring sites in the Santa Ana River.

2. The average annual density of *C. santaanae* measured in 2011 is near the highest levels reported since sampling began in 2001. This result, however, must be examined in the context of increasing and decreasing trends in population size among individual monitoring sites. Only one site (Riverside Ave) has consistently shown an increase in fish density from 2001-2011, whereas the Mission Blvd and Highway 60 sites have shown a long term decrease in fish density over this same time period.
3. A new monitoring site (MWD crossing) was established in 2010 and has been surveyed for the last two years. There has been a 57% decrease in *C. santaanae* density at the site from 2010-2011 but a longer time course is necessary to comment on trends in population size.
4. Absence of *C. santaanae* at a monitoring site in any one sampling year does not appear to signal long-term elimination of the species from that locality and often recovery at depauperate sites is significant in the following year. (see Highway 60, 2006-2007)

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Memo

To: Santa Ana Sucker Conservation Team

From: Drs. Jonathan N. Baskin and Thomas R. Haglund, Principal Senior Scientists

Date: January 18, 2012

Re: Draft Progress Report – Periodicity of Sucker Population Data

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We asked Dr. David Moriarty, Professor of Biological Sciences at Cal Poly University Pomona and an expert on Biometrics, to examine all 11 years of our population estimation data for an evidence of periodicity. As you may recall this question came up at our last team meeting. Below is his response.

November 18, 2011

Jon,

The “executive summary” for the Average variable in the fish data is that there is no evidence of periodicity or time related trends. I would emphasize that a sample size of n=11 is quite low for detecting periodicity.

Here’s more detail on what I did, and the output below.

Page 1
An attempt to identify relationships using an ARIMA (Autoregressive Integrative Moving Average) modeling approach. If there is a periodic relationship, you should be able to detect autocorrelation in the data, i.e. Average at a given time period should be predicted by previous time periods. However, there is very little autocorrelation in the data. The “white noise” test asks whether there is pattern in the data, or if it represents random fluctuations. There is no pattern detected.

Sample size is an issue here. I had the program do the time period lags up to 6 because that is the minimum to get the whitenoise test. However, as stated on the output, the lags generally should not exceed 25% of the series length, which would be a maximum lag of ~2 time periods.

The graphs indicate the autocorrelation is very low, even at lag=1, indicating the series is not stationary. This is consistent with the white noise conclusion.

Pages 2-3

Use an autoregression approach to try to detect autocorrelation with the Durbin-Watson statistic. I only went to time lag = 3 here, because you quickly run out of degrees of freedom. None of the time lags show anything even close to autocorrelation.

Pages 4-7

Uses spectral analysis to try to detect periodicity. The series is decomposed into a sum of sine and cosine waves using Fourier transforms. It’s sort of like regressing the series – not onto a straight line function – but rather a function involving the sines and cosines. This is done with very small increments to try to fit the series well. The graphs on page 6 and 7 indicate the lack of periodicity. If periodicity were present, the periodgram and spectral density would peak at the value of the period. The near monotonic increase in both graphs indicates lack of periodicity. The spectral analysis also includes tests for white noise: Fisher’s Kappa, and the Bartlett's Kolmogorov-Smirnov test. I do not have access to a table of significant values of Fisher’s Kappa, but a value of 1.774936 is quite low. It would have to be much higher (at least around 7) to begin to approach significance. The Bartlett's Kolmogorov-Smirnov has a p value of 0.5543. This would have to be ≤ 0.05 to conclude that periodicity was present. As above, the fluctuations appear to be random.

Pages 8-20

As a last resort, I attempted to fit a polynomial regression to the Average data. Polynomial regression would not establish periodicity, but could detect some nonlinear pattern to the change in Average over the years. I fit the polynomial up to degree 5, which is rather aggressive given the sample size of 11. However, no polynomial of any degree, linear through quintic, produced a significant relationship of any kind.

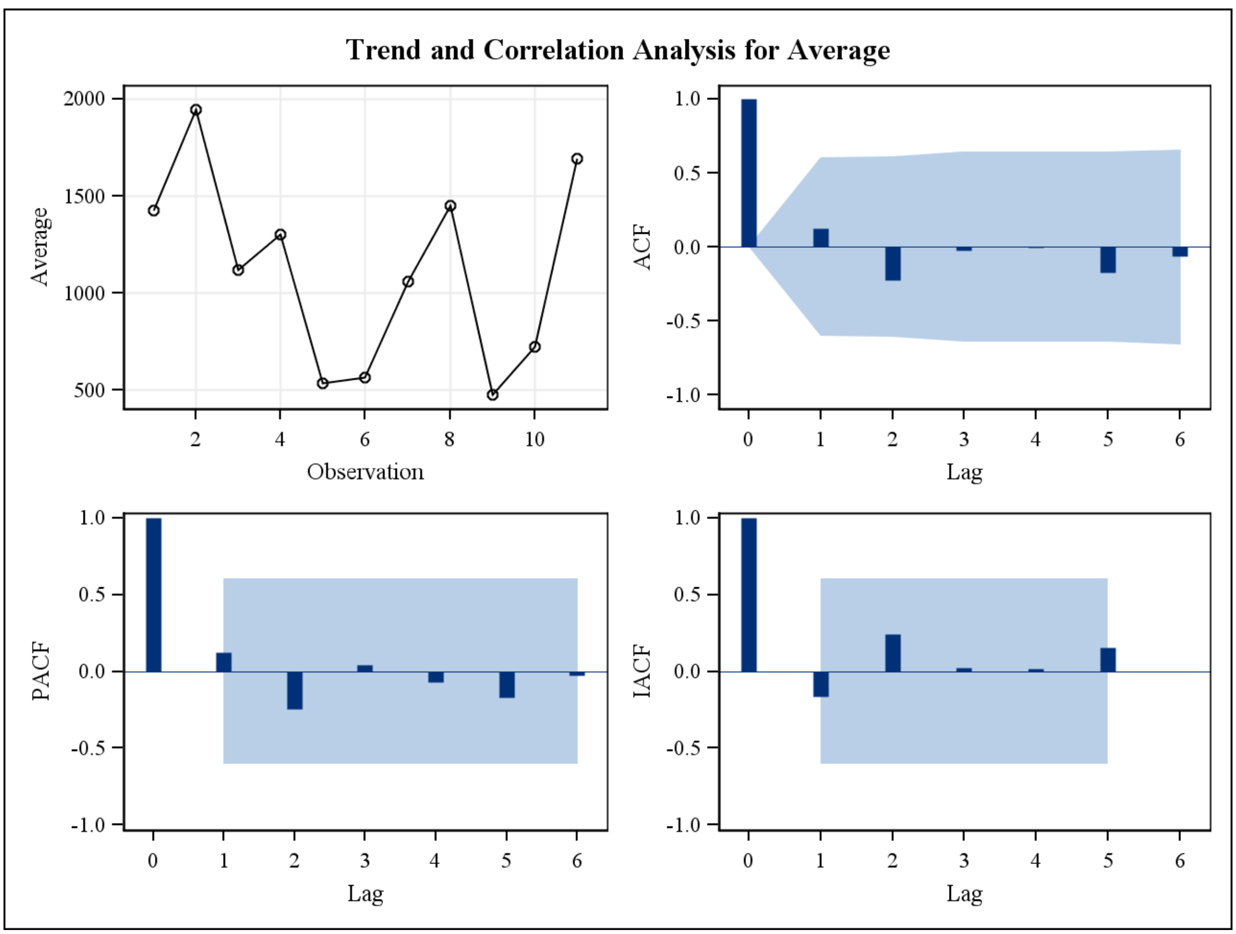
In conclusion, I did not detect any pattern in the data, certainly no periodicity, nor any pattern (e.g. autocorrelation) that would be expected if periodicity were present.

The ARIMA Procedure

Warning: The value of NLAG is larger than 25% of the series length. The asymptotic approximations used for correlation based statistics and confidence intervals may be poor.

Name of Variable = Average	
Mean of Working Series	1118.545
Standard Deviation	474.5544
Number of Observations	11

Autocorrelation Check for White Noise									
To Lag	**Chi-Square**	**DF**	**Pr > ChiSq**	**Autocorrelations**					
6	1.87	6	0.9313	0.121	-0.228	-0.024	-0.007	-0.173	-0.062



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The AUTOREG Procedure

Dependent Variable	Averag e

Ordinary Least Squares Estimates			
SSE	2477220.73	**DFE**	10
MSE	247722	**Root MSE**	497.71686
SBC	169.186821	**AIC**	168.788926
MAE	405.768595	**AICC**	169.23337
MAPE	48.8814305	**Regress R-Square**	0.0000
		Total R-Square	0.0000

Durbin-Watson Statistics			
Order	**DW**	**Pr < DW**	**Pr > DW**
1	1.5854	0.2357	0.7643
2	1.9443	0.6045	0.3955
3	1.3674	0.3473	0.6527

Note: Pr<DW is the p-value for testing positive autocorrelation, and Pr>DW is the p-value for testing negative autocorrelation.

Variable	**DF**	**Estimate**	**Standard Error**	**t Value**	**Approx Pr > |t|**
Intercept	1	1119	150.0673	7.45	<.0001

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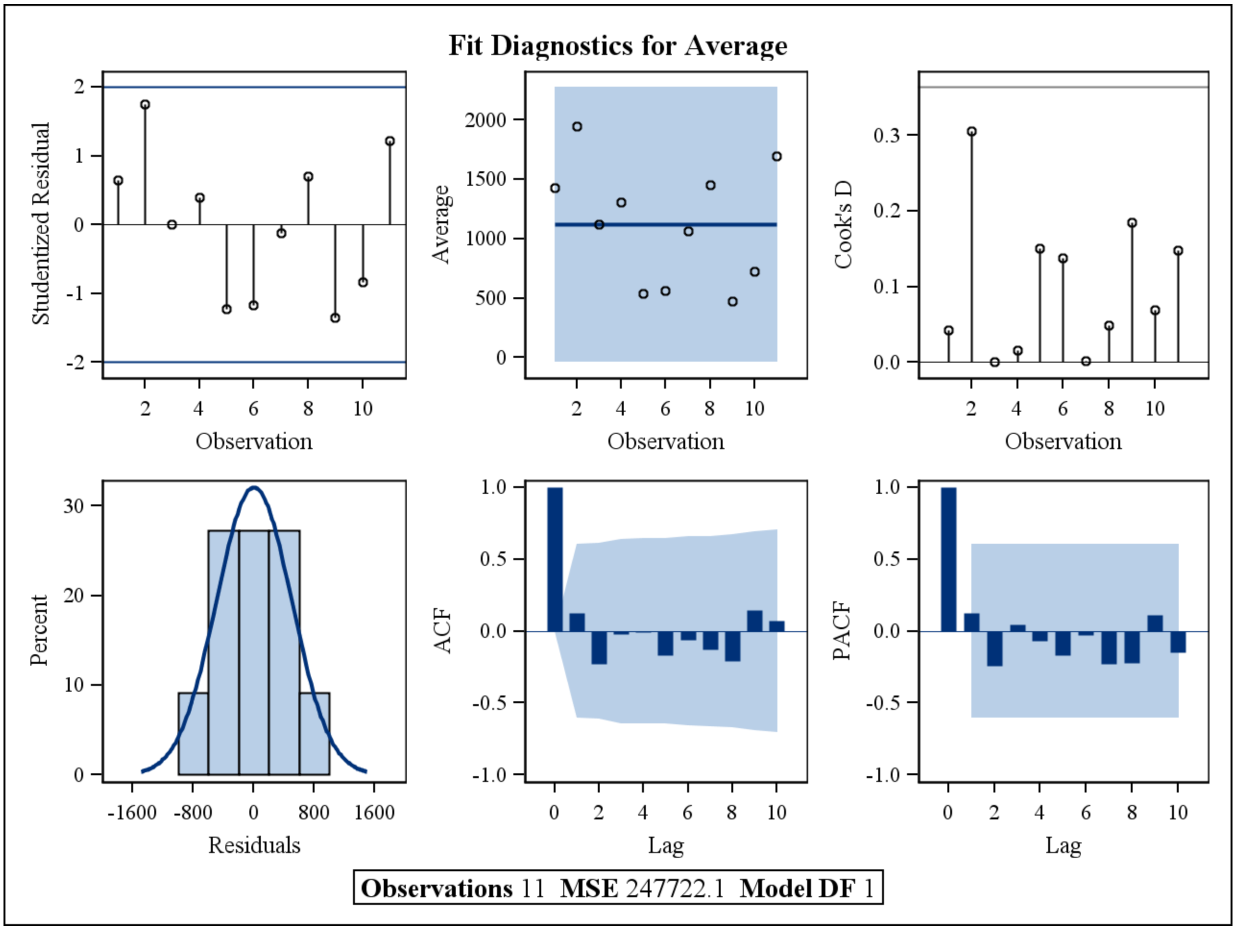
The AUTOREG Procedure



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The SPECTRA Procedure

Test for White Noise for Variable Average	
M =	5
Max(P(*))	879381.8
Sum(P(*))	2477221

Fisher's Kappa: M*MAX(P(*))/SUM(P(*))	
Kappa	1.774936

Bartlett's Kolmogorov-Smirnov Statistic: Maximum absolute difference of the standardized partial sums of the periodogram and the CDF of a uniform(0,1) random variable.	
Test Statistic	0.354987
Approximate P-Value	0.5543

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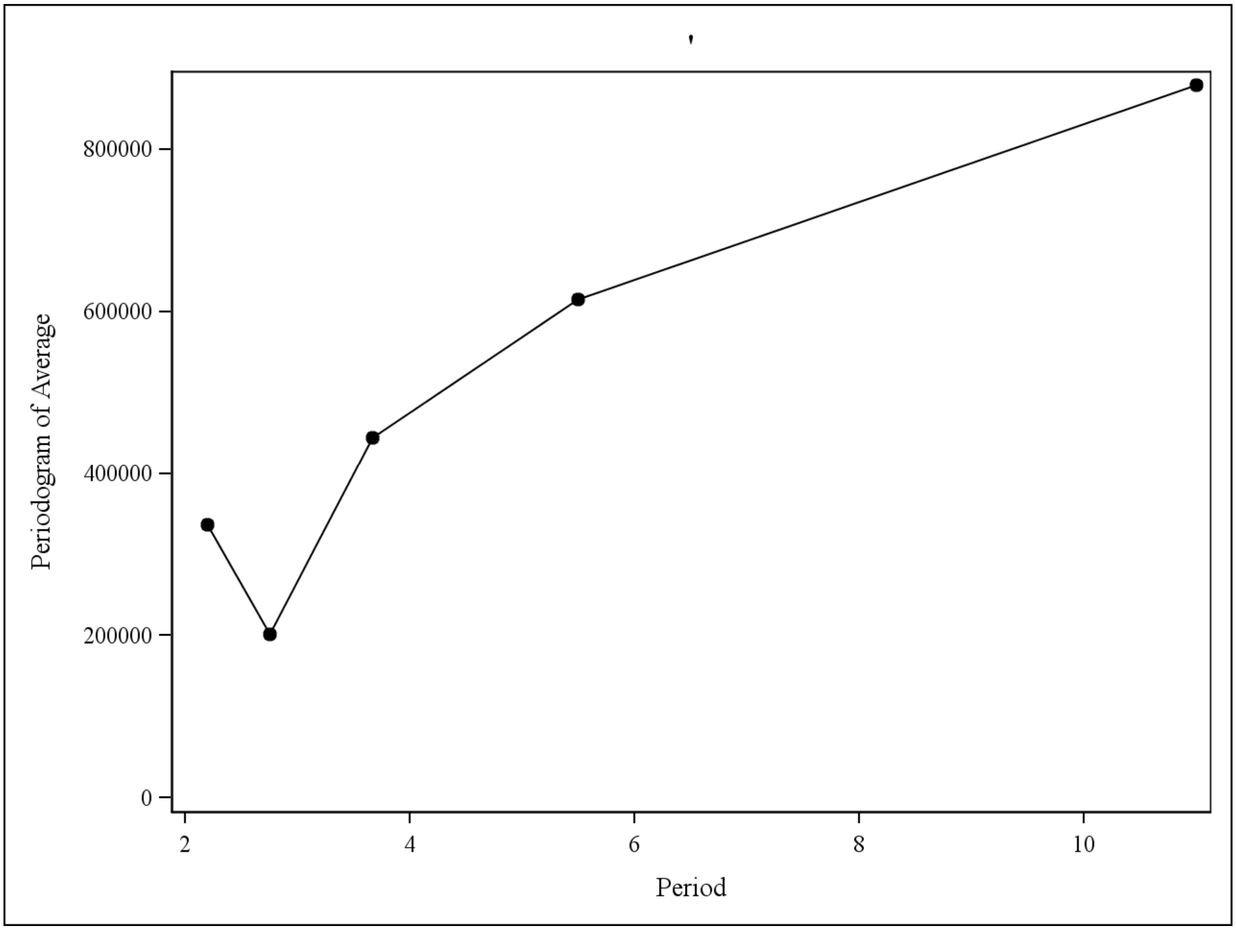
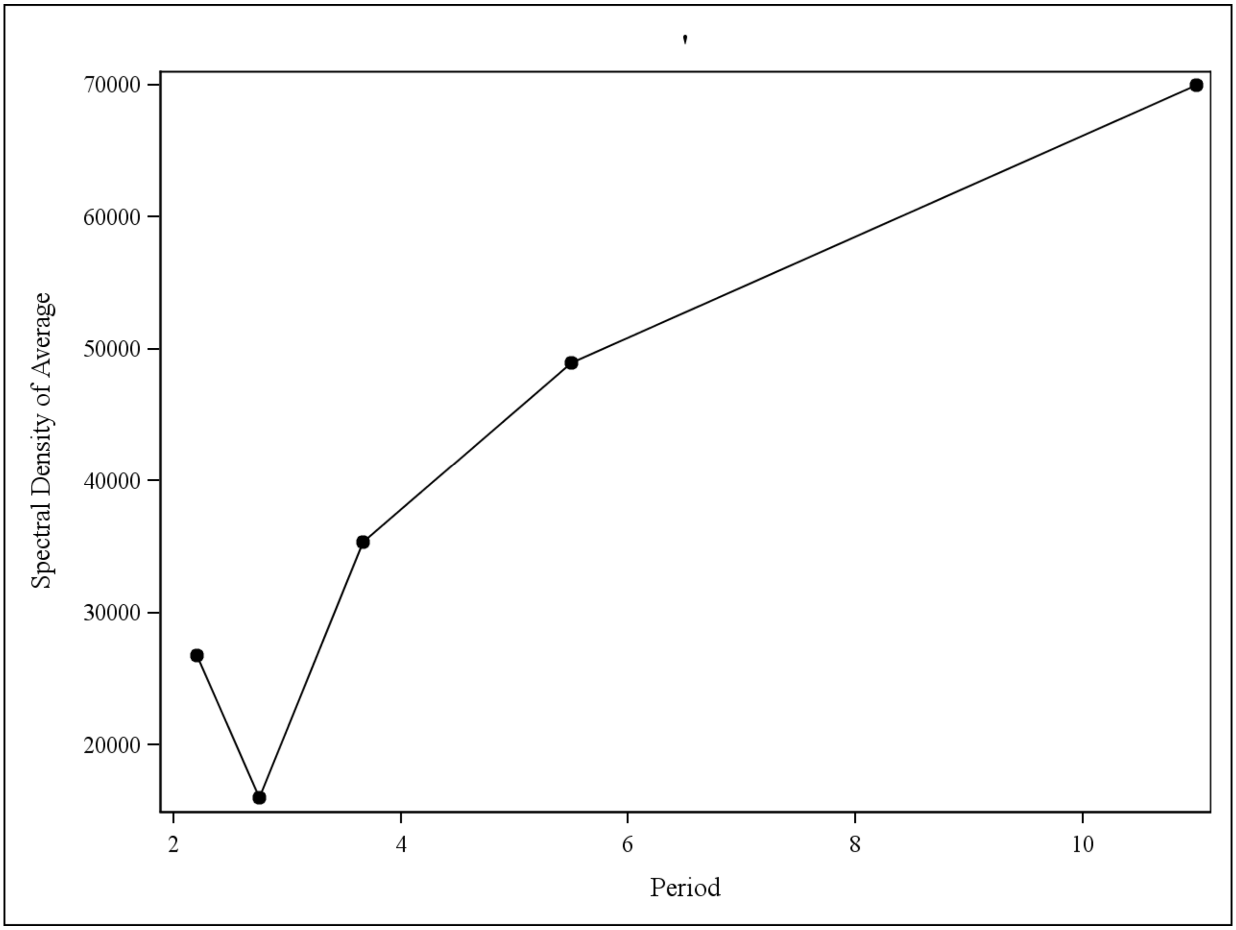
Obs	FREQ	PERIOD	P_01	S_01
1	0.00000	.	0.00	69978.98
2	0.57120	11.0000	879381.79	69978.98
3	1.14240	5.5000	615618.97	48989.40
4	1.71360	3.6667	444455.46	35368.64
5	2.28479	2.7500	201269.56	16016.52
6	2.85599	2.2000	336494.94	26777.42


'
800000
600000
400000
200000
0
Periodogram of Average
2
4
6
8
10
Period


Spectral Density of Average
70000
60000
50000
40000
30000
20000
2
4
6
8
10
Period

Polynomial Regression

Obs	Year	Mission	Hwy_60	Riverside	Average	Y2	Y3	Y4	Y5
1	1	1432	2639	209	1427	1	1	1	1
2	2	2350	2736	756	1947	4	8	16	32
3	3	1014	1545	805	1121	9	27	81	243
4	4	32	3235	644	1304	16	64	256	1024
5	5	16	16	1579	537	25	125	625	3125
6	6	0	0	1689	563	36	216	1296	7776
7	7	0	1625	1561	1062	49	343	2401	16807
8	8	580	322	3445	1449	64	512	4096	32768
9	9	16	528	880	475	81	729	6561	59049
10	10	64	0	2108	724	100	1000	10000	100000
11	11	595	772	3718	1695	121	1331	14641	161051

Polynomial Regression

The GLM Procedure

Number of Observations Read	11
Number of Observations Used	11

Polynomial Regression

The GLM Procedure

Dependent Variable: Average

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	198687.500	198687.500	0.78	0.3987
Error	9	2278533.227	253170.359		
Corrected Total	10	2477220.727			

R-Square	Coeff Var	Root MSE	Average Mean
0.080206	44.98345	503.1604	1118.545

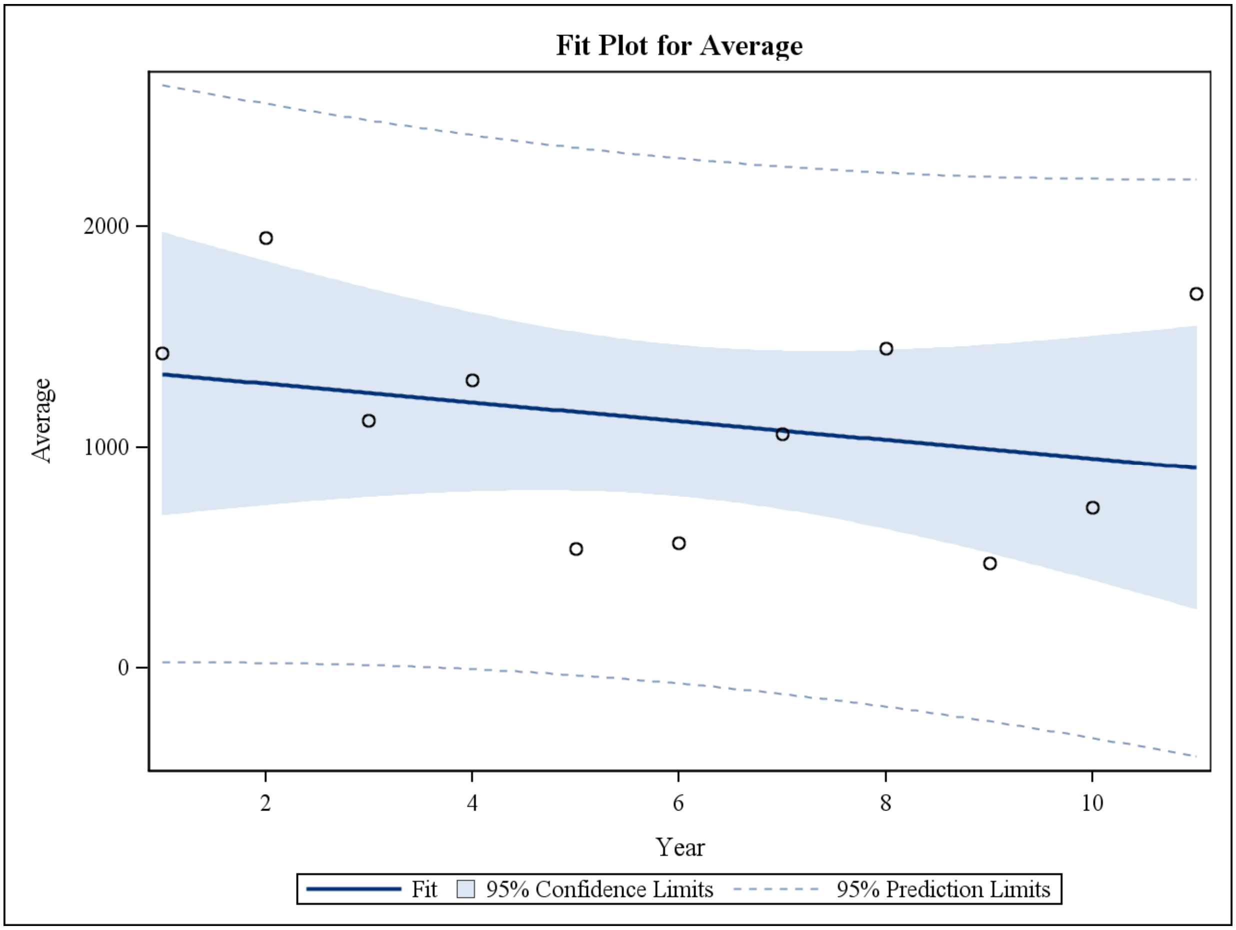
Source	DF	Type I SS	Mean Square	F Value	Pr > F
Year	1	198687.5000	198687.5000	0.78	0.3987

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	1373.545455	325.3786116	4.22	0.0022
Year	-42.500000	47.9744590	-0.89	0.3987

Polynomial Regression

The GLM Procedure

Dependent Variable: Average



Polynomial Regression

The GLM Procedure

Number of Observations Read	11
Number of Observations Used	11

Polynomial Regression

The GLM Procedure

Dependent Variable: Average

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	910957.711	455478.855	2.33	0.1598
Error	8	1566263.016	195782.877		
Corrected Total	10	2477220.727			

R-Square	Coeff Var	Root MSE	Average Mean
0.367734	39.55794	442.4736	1118.545

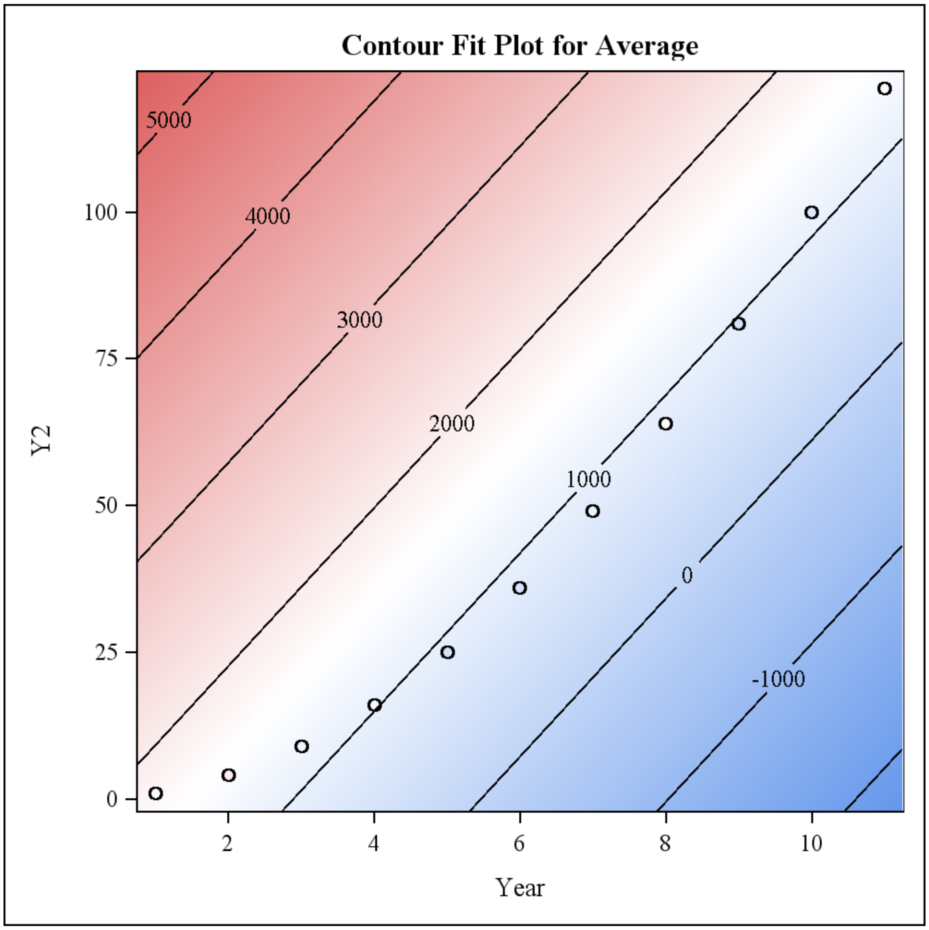
Source	DF	Type I SS	Mean Square	F Value	Pr > F
Year	1	198687.5000	198687.5000	1.01	0.3432
Y2	1	712270.2110	712270.2110	3.64	0.0929

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	2122.666667	485.9279940	4.37	0.0024
Year	-388.248252	186.1142365	-2.09	0.0704
Y2	28.812354	15.1057993	1.91	0.0929

Polynomial Regression

The GLM Procedure

Dependent Variable: Average



Polynomial Regression

The GLM Procedure

Number of Observations Read	11
Number of Observations Used	11

Polynomial Regression

The GLM Procedure

Dependent Variable: Average

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	994267.507	331422.502	1.56	0.2812
Error	7	1482953.220	211850.460		
Corrected Total	10	2477220.727			

R-Square	Coeff Var	Root MSE	Average Mean
0.401364	41.14917	460.2722	1118.545

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Year	1	198687.5000	198687.5000	0.94	0.3651
Y2	1	712270.2110	712270.2110	3.36	0.1094
Y3	1	83309.7960	83309.7960	0.39	0.5505

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	1721.651515	815.1319398	2.11	0.0726
Year	-57.006799	562.5772121	-0.10	0.9221
Y2	-37.289044	106.5736838	-0.35	0.7367
Y3	3.672300	5.8560505	0.63	0.5505

Polynomial Regression

The GLM Procedure

Number of Observations Read	11
Number of Observations Used	11

Polynomial Regression

The GLM Procedure

Dependent Variable: Average

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	994347.231	248586.808	1.01	0.4728
Error	6	1482873.497	247145.583		
Corrected Total	10	2477220.727			

R-Square	Coeff Var	Root MSE	Average Mean
0.401396	44.44499	497.1374	1118.545

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Year	1	198687.5000	198687.5000	0.80	0.4045
Y2	1	712270.2110	712270.2110	2.88	0.1405
Y3	1	83309.7960	83309.7960	0.34	0.5826
Y4	1	79.7238	79.7238	0.00	0.9863

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	1742.242424	1445.511523	1.21	0.2735
Year	-81.821484	1509.343996	-0.05	0.9585
Y2	-28.885490	481.843402	-0.06	0.9541
Y3	2.616356	59.131957	0.04	0.9661
Y4	0.043998	2.449696	0.02	0.9863

Polynomial Regression

The GLM Procedure

Number of Observations Read	1 1
Number of Observations Used	1 1

Polynomial Regression

The GLM Procedure

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	1837392.256	367478.451	2.87	0.1359
Error	5	639828.471	127965.694		
Corrected Total	10	2477220.727			

R-Square	Coeff Var	Root MSE	Average Mean
0.741715	31.98108	357.7229	1118.545

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Year	1	198687.5000	198687.5000	1.55	0.2679
Y2	1	712270.2110	712270.2110	5.57	0.0648
Y3	1	83309.7960	83309.7960	0.65	0.4564
Y4	1	79.7238	79.7238	0.00	0.9811
Y5	1	843045.0255	843045.0255	6.59	0.0502

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	-2080.424242	1816.580252	-1.15	0.3040
Year	5892.320395	2568.460431	2.29	0.0703
Y2	-2951.020104	1190.095531	-2.48	0.0559

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Y3	606.034091	238.912334	2.54	0.0521
Y4	-55.090618	21.552771	-2.56	0.0509
Y5	1.837821	0.716019	2.57	0.0502

March 18, 2012

To: Jon Baskin

From: Dave Moriarty

Re: Santa Ana Sucker data

As a follow-up to discussion and suggestions at the March 15, 2012 meeting of the conservation team, I conducted further analysis on the data. I did not include the MWD site because there are only n = 2 observations from that site.

Distribution and Homoscedasticity

In the context of the ANCOVA prepared by Tom Even, the question of data assumptions and transformations was raised. No simple data transformation will normalize the data. However, I used the Box-Cox procedure to identify a transformation ($\lambda = 0.4099$) which was able to normalize the data for all three sites (Shapiro-Wilk Test, all $P > 0.05$). This transformation also produced a normal distribution for eight of the 11 years. The years not normal were 2005, 2006, 2007. I would emphasize that these tests for the years were all based on n = 3. The transformed data were also homoscedastic for all sites and years (Levene's Test – Brown and Forsythe method, $P > 0.05$).

ANCOVA on Transformed Data

I ran the ANCOVA model on the transformed data, with the following results:

```
Source                   DF     Type III SS     Mean Square    F Value    Pr > F

Site                      2     3628.770072     1814.385036       6.92    0.0037
Year                      1      379.334708      379.334708       1.45    0.2395
Year*Site                 2     3636.198663     1818.099332       6.93    0.0037
```

Notice that the significance of all sources is the same as the ANCOVA provided by Tom that appeared in the original report. That is, there is a significant site and year x site interaction, but the pooled regression (year) is not significant. The transformed data do not cause any difference in the ANCOVA or in the interpretations provided in the original report.

Repeated Measures; Multiple Comparisons

The meeting produced a suggestion that a repeated measures approach be taken with the data. To implement this, I treated both site and year as factors in a two-factor model II ANOVA without replication performed on transformed data. The results were:

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Site	2	2777.406176	1388.703088	3.64	0.0448
Year	10	3466.323902	346.632390	0.91	0.5434

This indicates there is significant variance explained by site, but not by year. Since the notion of multiple comparison tests (specifically LSD and the Tukey HSD) was discussed, I performed those tests as well as nine additional multiple comparison tests. All eleven tests produced the same result, which is that the Riverside and Mission sites were significantly different, with Highway 60 being intermediate and not significantly different from either Riverside or Mission. The site means are provided below for your convenience. I would repeat the point that Tom made in the original report, namely that variation is extremely high. Notice that in the table below, the coefficients of variation are 71.7%, 98.9%, and 138.7%.

Site	N Obs	Mean	Std Dev	Std Error	Coeff of Variation
Riverside	11	1581.3	1134.3	342.0	71.7
Hwy_60	11	1219.8	1206.4	363.7	98.9
Mission	11	554.5	769.1	231.9	138.7

I would be happy to respond to any questions you may have.

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Memo

To: Santa Ana Sucker Conservation Team

From: Drs. Jonathan N. Baskin and Thomas R. Haglund, Principal Senior Scientist

Date: January 19, 2012

Re: Draft Progress Report – Sucker Survey in Sunnyslope Creek

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On January 18, 2012 four of us, Brett Mills, Cary Galst, Kerwin Russell and Jonathan Baskin, explored the entire length of Sunnyslope Creek, from the confluence with the Santa Ana River main stem to Rubidoux Nature Center, for suckers (*Catostomus santaanae*). We used a common sense seine and a dip net, no electroshocking. Several suckers were found in the lower portion of the creek, within the first 200 meters upstream from the confluence, but no other suckers were seen or captured. The creek in the nature center area was seined especially intensely in several quite good habitat sites. Some particularly good sites there could not be sampled due to excessively deep water, so we could not rule out the possibility that suckers are present in the creek at the Nature Center.

The suckers captured were juveniles and not tuberculated (see Table 1). One larger sucker was seen but not captured. Suckers were last captured in Sunnyslope Creek at the Nature Center on February 12, 2010 by SMEA by electrofishing. These suckers were tuberculated.

Chubs, *Gila orcutti*, were found throughout the creek.

Table 1. Standard length of the Santa Ana suckers captured and the degree of tuberculation on the anal fin. Data by Brett Mills.

Standard Length (mm)	Tuberculation	Weight (grams)
81	none	6
76	none	7
71	none	7