

Pseudoscience, data fabrication and malarkey:

NMFS/NOAA's "analysis" of steelhead consumption by cormorants

Summary: A comparison of simulated juvenile steelhead survival during periods with few vs many double-crested cormorants (DCCO) was done by NMFS/NOAA to calculate permissible DCCOs populations at East Sand Island in the Columbia River Estuary. The "analysis" was included in an Environmental Impact Statement (EIS) as Appendix D and became a main focus of the EIS citing a 3.5-3.6% "survival gap" to be addressed by a control effort. Three data sets were involved: simulated consumption of juvenile steelhead, DCCO population estimates, and estimated populations of juvenile steelhead. From these a permissible DCCO population was calculated for acceptable consumption of 2.9% of steelhead. The analysis was done with little consideration to data quality and scientific integrity, although there was an attempt to correct a math error that has plagued almost 20 years of simulations of salmonid consumption. I show there was no relationship between DCCO population size and consumption of simulated steelhead using years with data. Ignoring this fact as the EIS did, I show the permissible population could be computed as a simple ratio. This makes the NMFS/NOAA "analysis" intelligible while reducing it to a 6th grade math problem. In error, a permissible range of 5,380-5,939 pairs from the Draft EIS was retained in the Final EIS despite corrections in Appendix D that I show increased this range to 3297-8399 pairs. However, corrections (e.g. using actual rather than adjusted random numbers, truncation of small proportions) that still need to be incorporated into the simulations of consumption could easily increase the permissible range of 0-11,000 pairs. Given the margin of error, the control effort had reached the goal before implementation.

Management Goals

(From page 3-4, Double-crested Cormorant Management Plan to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary, Final Environmental Impact Statement, USACE, 6 Feb 2015, <http://www.nwp.usace.army.mil/Missions/Current/CormorantEIS.aspx>)

"Management of the double-crested cormorant colony on East Sand Island was identified as reasonable and prudent alternative action 46 in the 2008 and associated 2010 and 2014 Supplements to the Federal Columbia River Power System Biological Opinion issued by NOAA Fisheries. In the 2014 Supplemental, NOAA Fisheries presented a "survival gap" analysis, which evaluated the difference in double-crested cormorant predation on juvenile steelhead between the "base period" of 1983–2002 and the "current period" of 2003–2009. Because steelhead are more susceptible to double-crested cormorant predation (compared to other salmonid species and in the context of the Biological Opinion), they were used to describe survival improvements that could be achieved through management of the double-crested cormorant colony on East Sand Island. NOAA Fisheries analysis determined that mortality of juvenile steelhead from double-crested cormorant predation was approximately 3.5* percent higher in the "current period" than the "base period."

*this is the corrected Gap to one decimal, which was 3.54%, but the original 3.6% or 3.64% was used most in calculations

Methodology & Overview: The validity of the "survival gap" was not assessed statistically or scientifically and I've done this in this commentary. Referenced are figures and tables in Fredricks and in this commentary. I added "below" to figures and tables specific to this commentary to minimize confusion.

Methods partially were explained in the Draft EIS, Final EIS (Fredricks 2014a, b; 2015a) and a Biological Opinion (BiOP) (Fredricks 2014a). The “survival gap” was simply the difference in average simulated steelhead survival for two arbitrarily designated periods, Base and Current (Fig. 1 & 2, below). In a memo (Fredricks 2015b), adjustments were made to simulated consumption estimates changing the “survival gap” to partially correct errors in OSU’s original calculations of simulated consumption (Fredricks 2015b, Shugart 2015, in prep). Since estimates of simulated consumption were simply midpoints of relatively huge CIs generated by a pseudorandom process, the midpoints change every time the simulation is run (see Shugart 2014, 2015; also see Fredricks 2015b). Therefore the differences in the “survival gap” (Fredricks 2015, Appendix D, p 22-23) variously stated as 3.65% originally or 3.54% corrected, or 3.6% or 3.5% contingent on formatting, represents noise generated by number generators. See Shugart (2015) for a simple more tractable alternative.

After designating a “survival gap”, simulated steelhead survival (or the complementary consumption) was assumed to be related to DCCO population size and then used to calculate the permissible DCCO population. The obvious approach here was to simply use a ratio:

$$\frac{12,280 \text{ pairs}}{6.5\% \text{ survival}} = \frac{\text{permissible pairs}}{2.9\% \text{ survival}}$$

where 12,280 DCCO pairs was the average estimated colony size for 2003-2009, 6.5% survival was the estimated steelhead survival for 2003-2009, 2.9% was the estimated survival from 1993-2002 which was the current desired survival, and permissible pairs is the number that would match a 2.9% survival. However, rather than using a simple and direct approach with ratios where “permissible pairs = $12,280 / .065 * .029$ ”, for those that don’t recall 6th grade math, data from 1998-2012 were subjected superfluous Excel manipulations by first calculating the average proportion of steelhead consumed by a DCCO pair (erroneously referred to as “Per Capita”) per year, which was then used to calculate the permissible DCCO population. Apparently Fredricks was unaware that a simple ratio could be used. To add to the puzzle, the permissible population appears without explanation at the bottom of Table 3 (Fredricks 2014a, b; 2015) and apparently were derived by dividing the permissible survival by “Per Capita” consumption. As done, this calculation is extremely sensitive to variation due to rounding, truncation or minor mistakes which pervade the presentation (see below). Although an undocumented effort was made to correct errors, methods still fail to consider uncertainty in the three main data sets related to the simulated consumption using minimally documented bioenergetics methods and huge errors (see FEIS Fig 1.7 and Shugart 2015), unknown validity of DCCO population counts (see BRNW website), plus uncertainty in juvenile fish populations (Fredricks 2015b).

Retrospective Data Analysis: The survival analysis started with Fredricks (2015a, Table 1 in Appendix 1 of Appendix D) where survival and consumption values were calculated. Reproduced below as Fig. 1, the 3.6% gap arises from subtracting the average Base Period (1983-2002) from Current Period (2003-2009) or $.971 - .935 = .036$ or 3.6 (or 3.65) as a percent. Notably this value results from the inclusion of fabricated or simulated “data” from 1983-1997 for fish consumption and guesses at population size. If only years with data were used for a comparison there was no significant difference in survival between the two periods (Mann-Whitney_{5,7}, $P = .75$) and thus no rationale for control. Including the 13 years (1983-1997) of fabricated data and the two periods were significantly different (Mann-Whitney_{20,7}, $P = .02$). Thus the Base Period survival is a sliding scale that increases or decreases depending on how many years of higher vs lower DCCOs years were included. As a demonstration, dropping the first four years (1983-1986) with .999 survival and significance is lost (Mann-Whitney_{16,7}, $P = .07$) indicating the that 3.6% gap exists simply because years were included when there were few DCCOs present. An opposite result could be achieved by including additional years when there were few DCCOs (1980-1982) or when no DCCOs were present when consumption would be assigned zero. The survival gap “analysis” then supports a conclusion regarding DCCO consumption of simulated steelhead: zero DCCOs eat zero fish, a few eat a few fish, and a lot eat a lot of fish; all of which are subsumed by the conclusion that DCCOs eat

fish (Shugart 2014). This was one of the fundamental conclusions from the FEIS and the basis for NOAA Fisheries survival gap analysis. Incredibly, NMFS personnel actually get paid to produce this stuff.

Once a “survival gap” was designated, the next step was to equate this with DCCO population size, however an obvious question that was never addressed was: Are DCCO populations predictably related to consumption, or conversely, survival of steelhead? A regression using all years with data (1998-2012) indicates that there is absolutely no relationship ($r_{adj}^2=0.034$, $F=1.49$, $p=.24$). Although a trend line can be drawn (Fig. 3 below), there is no predictability as indicated by the small r^2 . To demonstrate this, populations associated with any population can be calculated using the regression equation $y = -4E-06x + 0.9795$ solved for x . The results show that predicted population vs actual deviates an average of 65% from the actual populations reinforcing a conclusion these data are useless for prediction and are not usable for management purposes (Table 1 below). Including fabricated data does little to improve the predictability (Fig. 4, below).

Without recognizing the lack of a relationship between DCCO population size and steelhead survival, Fredricks forges on with a “Per Capita” calculation which simplifies to a simple ratio (Table 2 below from Fredricks 2015a, Table 3). However, Fredricks Table 3 is reproduced (Fig. 5 below) as a screen shot to show the slipshod presentation with ill-formatted and truncated legends in both DEIS & FEIS, missing data for last two columns for averages showing 0.00000, and truncation, rather than rounding, and variability in decimal places for “Per Capita”. The presentation is cleaner in Fredricks (2014b) but the lack of attention to detail may in part explain discrepancies in his calculation versus numbers presented. Apparently Fredricks calculated values as “.029 consumption/Per Capita” to calculate the number of pairs at 5,661 pairs. Although in checking this result using the stated average rounded to six decimals (.000005), I get 5,479 pairs (Fig. 6, below). This was comparable to calculations using a ratios (Table 2, below), which probably just points to a sloppy presentation by Fredricks. Recomputing yearly averages using values in Fredricks’ table produces an average of .00000517 resulting in 5608 pairs. Notably, a deviation of a few .000001’s from mistakes or rounding in “Per Capita” results in a change in permissible pairs (Table 6 below). In any case, the “Per Capita” calculations suggest confusion by Fredricks, and NMFS/NOAA, and appears to be simply filler making the “analysis” seem detailed and complex. Only the cells shown in yellow in Fig. 5 (below) were needed to compute the permissible DCCO population size and the range.

After the “analysis” updated new values for error estimates resulting from corrected consumption numbers, which were shown in Fig 1.7 (FEIS) and summarized in Appendix D Fig. 1 of the FEIS (Fredricks 2015b), were ignored. Rather, the permissible DCCO uncorrected population of 5,380 to 5,939 pairs (FIES page 1-22) with a midpoint of 5661 pairs were presented as the permissible range (FEIS, Exec. Summary, page 4). With corrections, the range of permissible population size with an increased range of 3297-8399 pairs (Table 2 below) and was asymmetrical about a single point of 5530 pairs (lower -2233, upper +2869). The asymmetry in corrected results reflects manipulation of the simulated consumption estimates and attempts Don Lyons of OSU made at corrections. If done without manipulations (Shugart 2015), the permissible population range would be between ~0-11,000 pairs, which is useless for management. Zero is selected as the left tail end point simply to exclude negative values which commonly appear in the pseudorandom simulation (Shugart 2014). Despite many problems, Fredricks’ “analysis” suggesting 2.9%, or 2.8% corrected, consumption can be achieved by reducing the colony to a single point of 5,661 DCCO pairs despite corrections.

In ignoring corrections that dramatically increased variance and error, the FIES indicates “These changes increased variance of the estimates but had essentially no effect on the point estimates, or conclusions drawn from the original analyses, including the management goal for a reduced DCCO colony size. For steelhead, updated “base period” survival was 2.8 percent and “current period” survival was 6.3 percent, a base to current gap of 3.54 percent (Figure 1-7).” This is simply politics. First, “point estimates” have little meaning in statistics or biology. With corrections, variance and resulting CIs are so large as to render the consumption numbers biologically meaningless which cascades into every estimation in the FEIS that used the simulated consumption numbers. Secondly, the original 95% CI (\pm

280 pairs) based on population variation in the DEIS was 10x larger based on simulated consumption in the Final EIS (note ranges in Fig 1-7, FEIS; Fredricks 2015b). Recall that a CI indicates that if the study was done 100 times the mean value or the “point estimate” will fall within the CI 95% of the time. The CI does not mean the midpoint has a 95% chance of being correct, which means the point estimates are statistically and biologically meaningless.

In conclusion, the relevant question isn't how many steelhead are eaten or how many DCCOs are allowed, but was there any science behind the “analysis”? The analysis appears to simply be an attempt to give the impression of science and could be categorized as pseudoscience or even voodoo science (Park 2000). The original Appendix in the BiOP and iterations in the DEIS and FEIS are based on misunderstanding of basic statistics and perhaps basic math, misrepresentation of underlying datasets, especially over-reliance on undocumented pseudorandom simulations of simulated consumption, and an overall shoddy presentation in the DEIS and FEIS. The original presentation from Jan 2014 BiOP apparently was incorporated into the DEIS and FEIS without question. Previously, legal action by Portland Audubon revealed that in preparing the “survival gap” “analysis”, Fredricks attended meetings where an alternative analysis based on PIT tags was discussed (see timeline link in <http://audubonportland.org/news/cormorant-update-august12-2015>). The PIT tag analysis demonstrated the compensatory nature of DCCO consumption, and although not specifically cited, the PIT analysis was discounted in Appendix D with a justification that the “survival gap” was thought to better. Compensatory mortality is also mentioned, but dismissed because DCCOs still eat salmon. In the end, Fredricks “survival gap” analysis” is simply an ill-conceived attempt to rationalize piscivore control.

References

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<http://www.pugetsound.edu/academics/academic-resources/slater-museum/research/pervasive-persecution-of-piscivores/>

Shugart, GW. 2015 & in prep. Page 16-17, Misrepresentation of Monte Carlo simulations in wildlife management: An example using piscivores (Double-crested Cormorants) (GWS comments on FEIS).

http://www.pugetsound.edu/files/resources/responsesdcco_feis-1.pdf

Table 1. Results from predicting DCCO population size based on survival, or conversely consumption, of steelhead by DCCOs. The % deviation of actual from predicted averaged 66% indicating that these estimates were not useful for predictions as it was used for those who don't understand the significance of a small r^2 .

	Proportion consumed	"Best" (population estimate)	Survival (1-consumed)	Predicted population, $x=(y-b)/m$	Deviation (predicted - actual)	% deviation from actual population
1998	0.063	6285	0.937	10625	4340	69.05%
1999	0.079	6561	0.921	14625	8064	122.91%
2000	0.069	7162	0.931	12125	4963	69.30%
2001	0.035	8120	0.965	3625	-4495	55.36%
2002	0.009	10230	0.991	-2875	-13105	128.10%
2003	0.048	10646	0.952	6875	-3771	35.42%
2004	0.044	12480	0.956	5875	-6605	52.92%
2005	0.012	12287	0.988	-2125	-14412	117.29%
2006	0.13	13738	0.87	27375	13637	99.26%
2007	0.094	13770	0.906	18375	4605	33.44%
2008	0.066	10950	0.934	11375	425	3.88%
2009	0.058	12087	0.942	9375	-2712	22.44%
2010	0.106	13596	0.894	21375	7779	57.22%
2011	0.076	13045	0.924	13875	830	6.36%
2012	0.119	12300	0.881	24625	12325	100.20%

Table 2. Permissible populations based on Current Period from Fredricks (2015, Appendix D, Table 3) for 12,280 pairs \times $.029/.065 = 5479$ pairs. Corrected, High and Low are from page 22 of the FEIS explaining the differences and adding alternative "95% CIs" based on attempts at correcting consumption error estimates of Lyons.

Original	Average	Permissible
Pairs	12,280	5479
Consumption, proportion of total	0.065	0.029

Corrected consumption in FEIS*	Average	Permissible
Pairs	12,280	5530
Consumption, proportion of total*	0.0644	0.029

High, "95% CI"*	Average	Permissible
Pairs	12,280	8399
Consumption, proportion of total*	0.0424	0.029

Low, "95% CI"*	Average	Permissible
Pairs	12,280	3297
Consumption, proportion of total*	0.108	0.029

*from "Gaps" memo Fredricks 2015a

Figure 1. Self explanatory, from Fredricks, 2015, FEIS, Appendix D, p 10. Data copy/pasted to confirm calculations. Additions include notations on data fabrication and correcting the year 1084 to 1984. Also see Fredricks (2014b).

Appendix 1. Gap analysis tables. (Copy/pasted from Appendix, with comments)							
Table 1. Estuary Cormorant Consumption - Steelhead							
	Year	Cormorant Population (pairs)	Sthd Consumption (Millions)	Sthd Population (Millions)	Consumption Rate	Survival Rate	
	1980	150	no data	no data	0.001	0.999	red data = fabricated
	1981	150	no data	no data	0.001	0.999	"
	1982	150	no data	no data	0.001	0.999	"
Base	1983	150	no data	no data	0.001	0.999	"
Base	1984	150	no data	no data	0.001	0.999	"
Base	1985	150	no data	no data	0.001	0.999	"
Base	1986	150	no data	no data	0.001	0.999	"
Base	1987	150	no data	no data	0.001	0.999	"
Base	1988	1847	no data	no data	0.017	0.983	"
Base	1989	1847	no data	no data	0.017	0.983	"
Base	1990	3364	no data	no data	0.031	0.969	"
Base	1991	3364	no data	no data	0.031	0.969	"
Base	1992	3364	no data	no data	0.031	0.969	"
Base	1993	3364	no data	no data	0.031	0.969	"
Base	1994	3364	no data	no data	0.031	0.969	"
Base	1995	6104	no data	no data	0.045	0.955	"
Base	1996	6104	no data	no data	0.045	0.955	"
Base	1997	6104	no data	no data	0.045	0.955	"
Base	1998	6285	0.817	13	0.063	0.937	
Base	1999	6561	1.092	13.9	0.079	0.921	averages
Base	2000	7162	0.966	14	0.069	0.931	1983-2002
Base	2001	8120	0.516	14.9	0.035	0.965	1998-2002
Base	2002	10230	0.119	13.9	0.009	0.991	
Current	2003	10646	0.701	14.5	0.048	0.952	2003-2012
Current	2004	12480	0.605	13.7	0.044	0.956	2003-2009
Current	2005	12287	0.166	13.7	0.012	0.988	
Current	2006	13738	1.855	14.3	0.13	0.87	
Current	2007	13771	1.311	13.9	0.094	0.906	
Current	2008	10950	0.931	14.1	0.066	0.934	
Current	2009	12087	0.796	13.8	0.058	0.942	
	2010	13596	1.5	14.1	0.106	0.894	
	2011	13045	1.2	15.7	0.076	0.924	
	2012	12300	1.7	14.3	0.119	0.881	
From	Final Environmental Impact Statement Appendix D - Page 10						

Figure 2. Self-Explanatory-the 3.6% “Survival Gap” “Analysis” needed a separate Table in the FEIS.

Copy/pasted from Fredricks Appendix D (Chinook omitted)			
Table 1. Results of the gap analysis (MY= Migration Year).			
Steelhead	Survival	Consumption	
Ave Base Survival (MY1983-2002)	0.971	0.029	
Ave Current Survival(MY2003-2009)	0.935	0.065	
Current/Base (?? Purpose, GWS)	0.964		.971-.935
Base to Current Gap	0.036	<<<<	0.036

Figure 3. Plot showing the lack of a relationship between DCCOs populations and survival of steelhead. One unrecognized flaw in using the simulated number of steelhead consumed to compute the simulated proportion of salmon survival was that the simulation of the number consumed was a direct multiplier of the population size. So population size is being plotted or related to population size with the extrapolations of fish survival added as a factor. In addition, extrapolations of consumption may be as extreme as the detection of one (1) steelhead extrapolated to 1/4 to 1/3 million steelhead consumed (FEIS, page 885). The lack of a relationship further weakens any predictability between DCCO populations and fish survival.

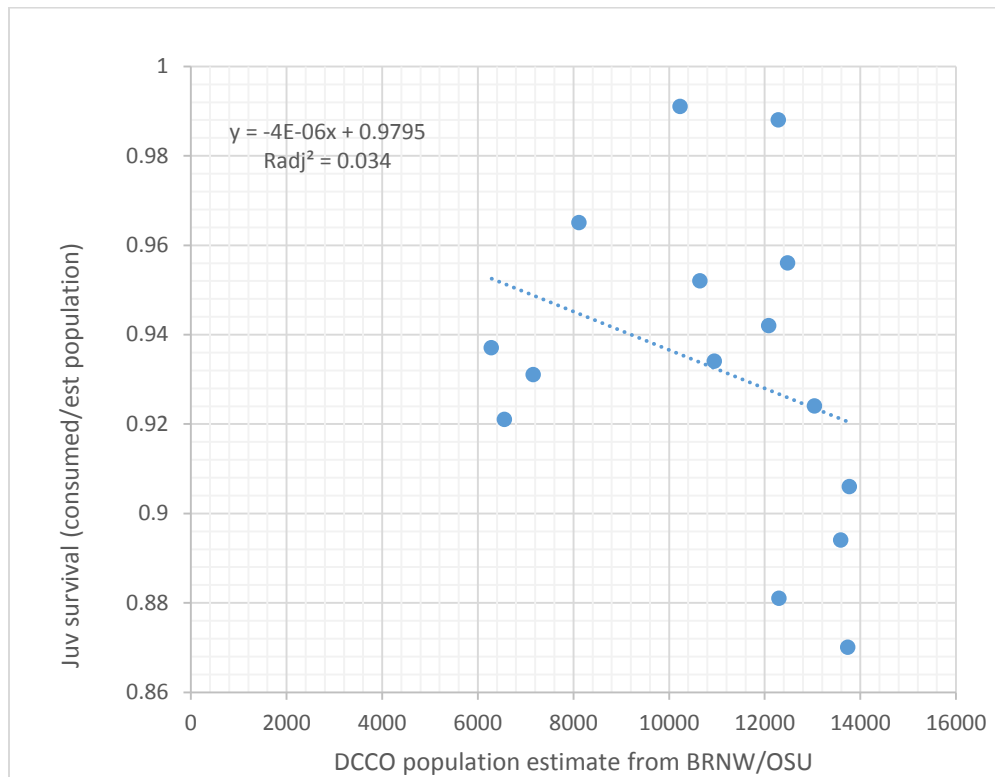


Figure 4. Including fabricated data from 1983-1997 and deviation from predicted values was 53%.

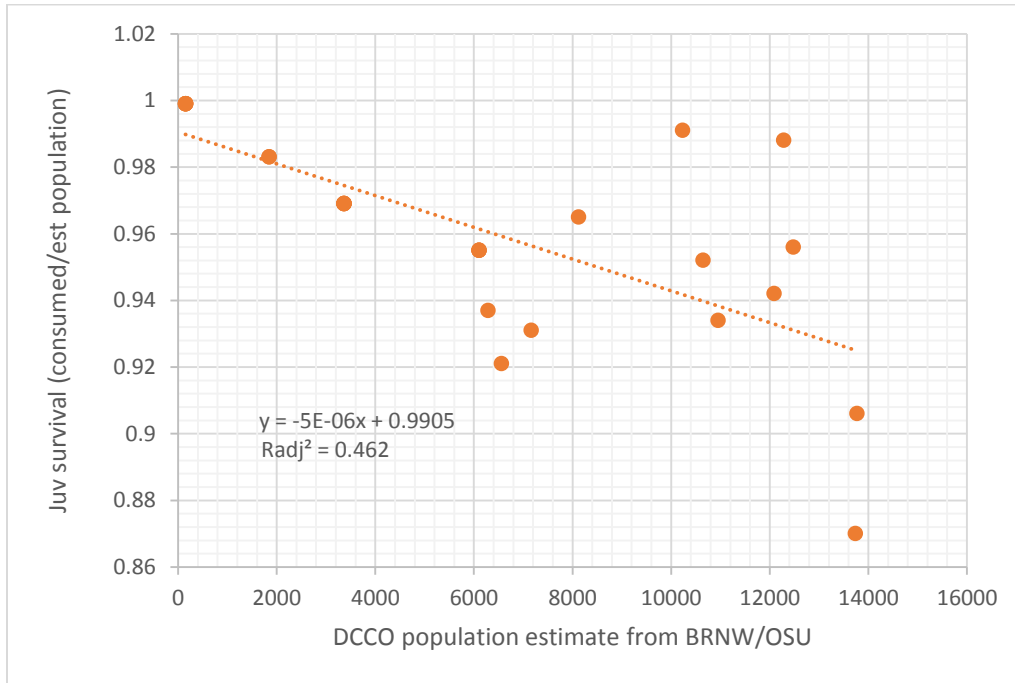


Figure 5. Self-explanatory, however the Table is reproduced below as a screen shot showing the slipshod presentation with formatting and truncated legend in both DEIS & FEIS, missing data for last two columns under averages showing 0.00000, variation in six or seven decimal places result from truncation, and variability in decimal places for Per Capita. Note that Per Capita is Per Pair

Table 3. Per capita analysis for steelhead

Steelhead							
Per Capita consumption analysis to estimate a cormorant colony size (pairs) that would close the							
Year	% Consumption	DCCO Population (pairs)				Per Capita	
		<95%CI	Best	>95%CI	<95%CI	Best	>95%CI
1998	6.3%	5908	6285	6662	0.0000106	0.000010	0.000009
1999	7.9%	6167	6561	6955	0.0000128	0.000012	0.000011
2000	6.9%	6732	7162	7592	0.0000103	0.000009	0.000009
2001	3.5%	7633	8120	8607	0.0000045	0.000004	0.000004
2002	0.9%	9616	10230	10844	0.0000009	0.000000	0.000000
2003	4.8%	10007	10646	11285	0.0000048	0.000004	0.000004
2004	4.4%	11731	12480	13229	0.0000038	0.000003	0.000003
2005	1.2%	11550	12287	13024	0.0000011	0.000001	0.000000
2006	13.0%	12914	13738	14562	0.0000101	0.000009	0.000008
2007	9.4%	12945	13770	14597	0.0000073	0.000006	0.000006
2008	6.6%	10585	10950	11315	0.0000063	0.000006	0.000005
2009	5.8%	11929	12087	12245	0.0000048	0.000004	0.000004
2010	10.6%	13130	13596	14062	0.0000081	0.000007	0.000007
2011	7.6%	12781	13045	13309	0.0000060	0.000005	0.000005
2012	11.9%	12035	12300	12567	0.0000099	0.000009	0.000009
Average	6.7%	10378	10884	11390	0.000007	0.000000	0.000000
Ave "Current" (03-09)	6.5%	11666	12280	12894	0.000005	0.000000	0.000000
An average colony size (pairs) of:					5380	5661	5939
Would achieve the Base Period consumption rate of:						2.9%	

Figure 6. Table used for data confirmation. Data needed to compute ratios are in yellow, the rest is superfluous data rumination. Grey row is the original estimates from Fredricks.

Table 3, recreated for confirmation Year % Consumption DCCO Population (pairs) Per Capita								
Year	% consumption	DCCO population (pairs)			Per Capita (actually per pair)			Original "best" showing truncation and zeros
		<95%CI	Best	>95%CI	<95%CI	Best, (proportion consumption/pairs)	>95%CI	
1998	6.30%	5,908	6,285	6,662	0.0000106	0.0000100	0.000009	0.00001
1999	7.90%	6,167	6,561	6,955	0.0000128	0.0000120	0.000011	0.000012
2000	6.90%	6,732	7,162	7,592	0.0000103	0.0000096	0.000009	0.000009
2001	3.50%	7,633	8,120	8,607	0.0000045	0.0000043	0.000004	0.000004
2002	0.90%	9,616	10,230	10,844	0.0000009	0.0000009	0	0
2003	4.80%	10,007	10,646	11,285	0.0000048	0.0000045	0.000004	0.000004
2004	4.40%	11,731	12,480	13,229	0.0000038	0.0000035	0.000003	0.000003
2005	1.20%	11,550	12,287	13,024	0.0000011	0.0000010	0.000001	
2006	13.00%	12,914	13,738	14,562	0.0000101	0.0000095	0.000008	0.000009
2007	9.40%	12,945	13,770	14,597	0.0000073	0.0000068	0.000006	0.000006
2008	6.60%	10,585	10,950	11,315	0.0000063	0.0000060	0.000005	0.000006
2009	5.80%	11,929	12,087	12,245	0.0000048	0.0000048	0.000004	0.000004
2010	10.60%	13,130	13,596	14,062	0.0000081	0.0000078	0.000007	0.000007
2011	7.60%	12,781	13,045	13,309	0.000006	0.0000058	0.000005	0.000005
2012	11.90%	12,035	12,300	12,567	0.0000099	0.0000097	0.000009	0.000009
Average (1998-2012)	6.70%	10,378	10,884	11,390	0.000007	0.0000062	0.0000059	0 in original
Ave Currentv(03-09)	6.50%	11,666	12,280	12,894	0.0000056	0.0000053	0.0000050	0 in original
Inserted (.029/Per Capita), see text for discrepancy					5205	5479	5753	
changing Per Capita by -.000001 or -.000002					5370	5686	5918	
An average colony size (pairs) of using Ave Current (2003-2009):					5380	5661	5939	
Would achieve the Base Period consumption "rate" (actually %)						2.9%*		
*97.1% survival is 2.9% total consumption								

Yet another Appendix showing showing mistakes highlighted from Fredricks (2015a, page 493) "explaining" 5,661 nests with the 95% CIs (page 5 Appendix D).

"The results of the per capita analysis indicated a fifteen year average annual total consumption rate of 6.7 percent and 2.7 percent for steelhead and yearling Chinook, respectively, for a fifteen year average annual cormorant population of 10,378 pairs (**mistake, this was the lower limit, should be 10,884 from Table 3**). These respective values for the current period were 6.5 percent and 2.5 percent for an average current period (for steelhead) cormorant population of 12,024 pairs (**another mistake, should be 12,280 pairs from his Table 3**). The base period consumption rate (**mistake, is not a rate**) values were 2.9 percent and 1.2 percent for steelhead and Chinook, respectively. Since steelhead consumption rates are higher, a larger number of birds will need to be removed to achieve elimination of the negative multiplier or gap*. **Because of this, the steelhead portion of the analysis will likely drive the management actions. The per capita consumption rates for steelhead translate to a needed reduction of the cormorant colony size to a range of between 5,380 and 5,939** pairs in order to achieve the base (2.9 percent) consumption rate value. The range in the colony size reflects the average 95 percent confidence interval for the East Sand Island cormorant population estimates.**"

* aka, there was no significant impact on other species

**this is the range from the DEIS, the corrected range should be 3297-8399 pairs based on values from Fredricks