

**Resource Equivalency Analysis for Storm-Petrels & Shearwaters  
New Carissa Spill, February 1999**

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**Resource Equivalency Analysis for Storm-Petrels & Shearwaters  
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The New Carissa oil spill killed approximately 36 Storm-Petrels and Shearwaters in February 1999. Resource equivalency analysis (REA) is used to evaluate the direct loss (birds killed) and indirect loss (two generations of lost reproduction) over time. Details on the method used are provided in the report for Marbled Murrelets in the Seabirds section. The scaling and results of restoration projects are provided in the Restoration Results section. Complete citations are provided in a separate References section. All figures are converted to 2004 values (present value, or PV) using a 3% discount rate. The injury results and REA inputs are provided in the tables below.

**Injury Results**

**Table 1  
Total Lost Bird-Years (Debit)**

Interim Losses	Lost Bird-Years in PV
<b>Direct Injury</b>	<b>322.05</b>
<b>1<sup>st</sup> Generation</b>	195.63
<b>+ 2<sup>nd</sup> Generation</b>	60.42
<b>= Total Indirect Injury</b>	<b>256.06</b>
<b>Total Direct &amp; Indirect Injury:</b>	<b>578.11</b>

**Table 2**  
**Direct Injury by Age Class\***

Year	Discount Factor	Bird-Years by Age Class												
		(0-1)	(1-2)	(2-3)	(3-4)	(4-5)	(5-6)	(6-7)	(7-8)	(8-9)	(9-10)	(10-11)	(11-12)	(12-13)
1999	1.16	8.640	2.232	2.232	2.232	2.232	2.232	8.910	4.010	1.804	0.812	0.365	0.164	0.074
2000	1.13	0.000	7.776	2.126	2.159	2.159	2.159	2.159	8.620	3.879	1.746	0.786	0.353	0.159
2001	1.09	0.000	0.000	7.037	1.988	2.019	2.019	2.019	2.019	8.060	3.627	1.632	0.734	0.331
2002	1.06	0.000	0.000	0.000	6.580	1.859	1.888	1.888	1.888	1.888	7.536	3.391	1.526	0.687
2003	1.03	0.000	0.000	0.000	0.000	6.152	1.738	1.765	1.765	1.765	1.765	7.046	3.171	1.427
2004	1.00	0.000	0.000	0.000	0.000	0.000	5.752	1.625	1.650	1.650	1.650	1.650	6.588	2.965
2005	0.97	0.000	0.000	0.000	0.000	0.000	0.000	5.378	1.519	1.543	1.543	1.543	1.543	6.160
2006	0.94	0.000	0.000	0.000	0.000	0.000	0.000	0.000	5.029	1.420	1.443	1.443	1.443	1.443
2007	0.92	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	4.702	1.328	1.349	1.349	1.349
2008	0.89	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	4.396	1.242	1.261	1.261
2009	0.86	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	4.111	1.161	1.179
2010	0.84	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	3.843	1.086
2011	0.81	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	3.594
2012	0.79	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2013	0.77	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2014	0.74	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2015	0.72	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2016	0.70	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2017	0.68	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2018	0.66	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2019	0.64	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
<b>Total</b>														

Year	Discount Factor										Total Lost	Total Lost
		(13-14)	(14-15)	(15-16)	(16-17)	(17-18)	(18-19)	(19-20)	(20-21)	Bird-Years	Bird-Years in PV	
1999	1.16	0.033	0.015	0.007	0.003	0.001	0.001	0.000	0.000	0.000	36.000	--
2000	1.13	0.072	0.032	0.014	0.007	0.003	0.001	0.001	0.001	0.000	34.213	38.507
2001	1.09	0.149	0.067	0.030	0.014	0.006	0.003	0.001	0.001	0.001	31.756	34.700
2002	1.06	0.309	0.139	0.063	0.028	0.013	0.006	0.003	0.001	0.001	29.691	31.499
2003	1.03	0.642	0.289	0.130	0.059	0.026	0.012	0.005	0.002	0.002	27.760	28.593
2004	1.00	1.334	0.600	0.270	0.122	0.055	0.025	0.011	0.005	0.005	25.954	25.954
2005	0.97	2.772	1.247	0.561	0.253	0.114	0.051	0.023	0.010	0.010	24.262	23.555
2006	0.94	5.760	2.592	1.166	0.525	0.236	0.106	0.048	0.022	0.022	22.675	21.374
2007	0.92	1.349	5.385	2.423	1.091	0.491	0.221	0.099	0.045	0.045	21.181	19.384
2008	0.89	1.261	1.261	5.035	2.266	1.020	0.459	0.206	0.093	0.093	19.763	17.559
2009	0.86	1.179	1.179	1.179	4.708	2.119	0.953	0.429	0.193	0.193	18.391	15.864
2010	0.84	1.103	1.103	1.103	1.103	4.402	1.981	0.891	0.401	0.401	17.015	14.250
2011	0.81	1.015	1.031	1.031	1.031	1.031	4.116	1.852	0.833	0.833	15.534	12.631
2012	0.79	3.360	0.949	0.964	0.964	0.964	0.964	3.848	1.732	1.732	13.745	10.851
2013	0.77	0.000	3.142	0.887	0.901	0.901	0.901	0.901	3.598	3.598	11.233	8.609
2014	0.74	0.000	0.000	2.937	0.830	0.843	0.843	0.843	0.843	0.843	7.138	5.311
2015	0.72	0.000	0.000	0.000	2.746	0.776	0.788	0.788	0.788	0.788	5.886	4.252
2016	0.70	0.000	0.000	0.000	0.000	2.568	0.725	0.737	0.737	0.737	4.767	3.343
2017	0.68	0.000	0.000	0.000	0.000	0.000	2.401	0.678	0.689	0.689	3.768	2.566
2018	0.66	0.000	0.000	0.000	0.000	0.000	0.000	2.245	0.634	0.634	2.879	1.903
2019	0.64	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.099	2.099	2.099	1.347
<b>Total</b>											<b>339.710</b>	<b>322.053</b>

\*Totals are rounded by the computer; hand calculations may not sum to those presented.

**Table 3**  
**Indirect Injury\***

Year	Discount Factor	Total # Birds-- Reproduction Age	1st Gen Lost				Total # Birds--				2nd Gen Lost
			# Reproducing Females	# 1st Gen Fledglings	Bird-Years/ Fledge in PV	Bird-Years Total in PV	1st Gen-- Reproduction Age	# Reproducing Females	# 2nd Gen Fledglings	Bird-Years/ Fledge in PV	Bird-Years Total in PV
1999	1.16	16.200	6.885	4.131	3.061	12.645	0.000	0.000	0.000	0.000	0.000
2000	1.13	17.833	7.579	4.547	2.969	13.502	0.000	0.000	0.000	0.000	0.000
2001	1.09	18.693	7.944	4.767	2.880	13.728	0.000	0.000	0.000	0.000	0.000
2002	1.06	19.365	8.230	4.938	2.794	13.795	0.000	0.000	0.000	0.000	0.000
2003	1.03	19.870	8.445	5.067	2.710	13.731	0.000	0.000	0.000	0.000	0.000
2004	1.00	20.201	8.586	5.151	2.629	13.541	0.000	0.000	0.000	0.000	0.000
2005	0.97	24.262	10.311	6.187	2.550	15.775	0.000	0.000	0.000	0.000	0.000
2006	0.94	22.675	9.637	5.782	2.473	14.301	0.777	0.330	0.198	2.473	0.490
2007	0.92	21.181	9.002	5.401	2.399	12.958	1.582	0.672	0.403	2.399	0.968
2008	0.89	19.763	8.399	5.039	2.327	11.727	2.376	1.010	0.606	2.327	1.410
2009	0.86	18.391	7.816	4.690	2.257	10.586	3.151	1.339	0.803	2.257	1.814
2010	0.84	17.015	7.231	4.339	2.190	9.500	3.899	1.657	0.994	2.190	2.177
2011	0.81	15.534	6.602	3.961	2.124	8.413	4.615	1.961	1.177	2.124	2.499
2012	0.79	13.745	5.842	3.505	2.060	7.221	5.479	2.328	1.397	2.060	2.878
2013	0.77	11.233	4.774	2.864	1.998	5.724	6.210	2.639	1.584	1.998	3.165
2014	0.74	7.138	3.034	1.820	1.938	3.528	6.823	2.900	1.740	1.938	3.372
2015	0.72	5.886	2.502	1.501	1.880	2.822	7.328	3.114	1.869	1.880	3.513
2016	0.70	9.534	4.052	2.431	1.824	4.434	7.734	3.287	1.972	1.824	3.597
2017	0.68	7.536	3.203	1.922	1.769	3.400	8.047	3.420	2.052	1.769	3.630
2018	0.66	5.758	2.447	1.468	1.716	2.520	8.269	3.514	2.109	1.716	3.619
2019	0.64	4.198	1.784	1.070	1.665	1.782	8.391	3.566	2.140	1.665	3.562
2020	0.62	0.000	0.000	0.000	0.000	0.000	8.081	3.435	2.061	1.615	3.327
2021	0.61	0.000	0.000	0.000	0.000	0.000	7.565	3.215	1.929	1.566	3.021
2022	0.59	0.000	0.000	0.000	0.000	0.000	7.005	2.977	1.786	1.519	2.714
2023	0.57	0.000	0.000	0.000	0.000	0.000	6.645	2.824	1.694	1.474	2.497
2024	0.55	0.000	0.000	0.000	0.000	0.000	6.202	2.636	1.582	1.429	2.261
2025	0.54	0.000	0.000	0.000	0.000	0.000	5.697	2.421	1.453	1.387	2.014
2026	0.52	0.000	0.000	0.000	0.000	0.000	5.074	2.156	1.294	1.345	1.740
2027	0.51	0.000	0.000	0.000	0.000	0.000	4.320	1.836	1.102	1.305	1.437
2028	0.49	0.000	0.000	0.000	0.000	0.000	3.642	1.548	0.929	1.265	1.175
2029	0.48	0.000	0.000	0.000	0.000	0.000	3.036	1.290	0.774	1.227	0.950
2030	0.46	0.000	0.000	0.000	0.000	0.000	2.494	1.060	0.636	1.191	0.757
2031	0.45	0.000	0.000	0.000	0.000	0.000	2.013	0.856	0.513	1.155	0.593
2032	0.44	0.000	0.000	0.000	0.000	0.000	1.592	0.676	0.406	1.120	0.455
2033	0.42	0.000	0.000	0.000	0.000	0.000	1.231	0.523	0.314	1.087	0.341
2034	0.41	0.000	0.000	0.000	0.000	0.000	0.940	0.400	0.240	1.054	0.253
2035	0.40	0.000	0.000	0.000	0.000	0.000	0.746	0.317	0.190	1.022	0.194
<b>Total</b>		<b>316.011</b>	<b>134.305</b>	<b>80.583</b>		<b>195.632</b>	<b>142.211</b>	<b>60.439</b>			<b>60.424</b>

\*Totals are rounded by the computer; hand calculations may not sum to those presented.

**REA Inputs**

**Table 4**  
**Injury, Life History & Demographic Parameters**

<b>Parameter</b>	<b>REA Value</b>	<b>Reference</b>
Species	Fork-tailed Storm-petrel Leach's Storm-petrel Short-tailed Shearwater Sooty Shearwater Wedge-tailed Shearwater	Field Surveys
# shorebirds killed (carcasses in hand)	21	Morgue database
# injured (rehabbed birds)	0	Rehab records
Estimated direct mortality (includes injured birds)	36	Field Surveys; Ford <i>et al.</i> 2001
Confidence in mortality estimate	High	Ford <i>et al.</i> 2001
Age Distribution of Birds Killed (estimate)	24% 0-1 year 31% 1-6 year 45% 6+ years	OSPR General Bird REA 2002
Average life span	21 years	Calculated based on adult survival rate of 0.935
Age of first breeding	6 years	Many sources
Expected years of breeding	15 years	Average lifespan – Age of first breeding
% of adult females that breed	85%	Russell 1999; Lee & Haney 1996
# eggs/nest	1	Lee & Haney 1996, Huntington <i>et al.</i> 1996
Nesting success (% of nests that successfully fledge a chick)	60% 0.60 fledglings/pair	Whittow 1997; Lee & Haney 1996; Ainley <i>et al.</i> 1990; McIver <i>et al.</i> 2001; Huntington <i>et al.</i> 1996
Year 0-1 survival	0.34	Russell 1999; Lee & Haney 1996
Annual survival years 1-2	0.80	Estimate
Annual survival years 2-3	0.90	Estimate
Annual survival years 3+	0.935	Russell 1999; Lee & Haney 1996; Huntington <i>et al.</i> 1996; Warham 1995
Threatened or Endangered?	No	
Locally overpopulated?	No	
Additional factors affecting recovery	None	

**Source:** Research and data were provided by Mike Szumski, Natural Resource Damage Assessment/Spill Response, US Fish & Wildlife Service, US Department of the Interior, 2600 SE 98th Ave., Suite 100, Portland, OR, 97266-1398, November 18, 2004, and finalized on May 7, 2005.

**Table 5**  
**Population Information**

<b>% of Total Population</b>	<b>Age</b>	<b>Age Distribution of 36 Birds*</b>	<b>Annual Survival Rate</b>
24%	0-1	8.6400	0.74
31%	1-2	2.2320	
	2-3	2.2320	
	3-4	2.2320	0.825
	4-5	2.2320	
	5-6	2.2320	
45%	6-7	8.9101	0.91
	7-8	4.0095	
	8-9	1.8043	
	9-10	0.8119	
	10-11	0.3654	
	11-12	0.1644	
	12-13	0.0740	
	13-14	0.0333	
	14-15	0.0150	
	15-16	0.0067	
	16-17	0.0030	
	17-18	0.0014	
	18-19	0.0006	
	19-20	0.0003	
20-21	0.0001		
<b>Total:</b>		<b>36</b>	

\*Totals are rounded by the computer; hand calculations may not sum to those presented.