



United States Department of the Interior

FISH AND WILDLIFE SERVICE

Division of Economics
4401 N. Fairfax Drive, Room 570
Arlington, VA 22203

TO: KEVIN FOSTER Fax: 808-541-3470

From: DREW LAUGHLAND

Date: 5/17/99

Number of pages including cover sheet 9

Message SHEARWATERS ESTIMATES.

**US Fish and Wildlife Service
Division of Economics**

**Office: (703) 358-2082
FAX: (703) 358-2319**



To: Beth Flint, Kevin Foster, and Roger Helm
From: Drew Laughland
Date: May 17, 1999

Subject: Tesoro SPM Hose Oil Spill - Calculation of Shearwater Damage and Credit

The calculation of the damage to Newell's Shearwaters and Wedge-tailed Shearwaters from the Tesoro oil spill is analogous to the method used for the Red-footed Booby. The *Kauai Endangered Seabird Study, Volume 2: The Ecology of Dark-Rumped Petrels and Newell's Shearwaters on Kauai, Hawaii*, (1995) prepared by the Point Reyes Bird Observatory (PRBO) provides estimates of survival rates (page 38), age at first breeding, maximum age, breeding probability, and reproductive success. The PRBO estimates for existing conditions are the basis for Table 1. The PRBO survival estimates failed to eliminate all of the population by age 36, the stated maximum life span, so survival rates for ages 35 and 36 were reduced.

Beth Flint estimated that 3,150 Newell's and 7,700 Wedge-tailed Shearwaters were oiled. I assumed that all of the oiled birds were breeders. The age of first breeding for Shearwaters is 6 years so the life table indicates the average age of breeders is about 13 years. The second column of Table 2 shows the number of natural deaths expected for the year of the spill and each year thereafter for a population of 3,150 13 year-old Newell's Shearwaters. Table 3 shows the same information for Wedge-tailed Shearwaters. Column 3 shows the excess lost bird years as a result of direct oiling from the spill.

It is also appropriate to consider the first generation progeny lost as a result of the spill. PRBO found that Shearwaters natural reproductive success rate was 0.70 fledglings produced per breeding pair but that conditions on Kauai reduced this rate to 0.66 (page 39). The 0.70 rate was used for this estimate. PRBO estimated that breeding probability was 0.547 for breeding-aged individuals. This resulted in an estimated fledging rate of 0.1915 ($= (0.70 * 0.547) / 2$). In column 4 of Table 2 each year's excess lost adults are multiplied by this factor to derive the estimated number of progeny lost. Column 5 shows the lost bird-years as a result of lost progeny as in the Red-footed Booby estimate. The last column shows these losses discounted at 3 percent assuming compensation is agreed to in year 1. The total discounted lost bird-years due is 46,932.3 for Newell's Shearwaters and 114,723.3 for Wedge-tailed Shearwaters.

Table 1. Shearwater Life Table

Age	Survivorship	Number Surviving to age:	Proportion Surviving to age:	Survival Probability Distribution	Life Expectancy at age	Remaining Years of life at age:
Fledged		100	1.000	0.148	7.57	7.87
1	0.654	65.4	0.654	0.097	9.24	8.24
2	0.780	51	0.510	0.075	10.29	8.29
3	0.890	45	0.454	0.067	11.21	8.21
4	0.905	41	0.411	0.061	12.11	8.11
5	0.905	37	0.372	0.055	13.01	8.01
6	0.905	34	0.337	0.050	13.89	7.89
7	0.905	30	0.305	0.045	14.77	7.77
8	0.905	28	0.276	0.041	15.64	7.64
9	0.905	25	0.249	0.037	16.51	7.51
10	0.905	23	0.226	0.033	17.36	7.36
11	0.905	20	0.204	0.030	18.21	7.21
12	0.905	18	0.185	0.027	19.05	7.05
13	0.905	17	0.167	0.025	19.87	6.87
14	0.905	15	0.151	0.022	20.69	6.69
15	0.905	14	0.137	0.020	21.49	6.49
16	0.905	12	0.124	0.018	22.29	6.29
17	0.905	11	0.112	0.017	23.07	6.07
18	0.905	10	0.102	0.015	23.84	5.84
19	0.905	9	0.092	0.014	24.60	5.60
20	0.905	8	0.083	0.012	25.35	5.35
21	0.905	8	0.075	0.011	26.08	5.08
22	0.905	7	0.068	0.010	26.80	4.80
23	0.905	6	0.062	0.009	27.51	4.51
24	0.905	6	0.056	0.008	28.20	4.20
25	0.905	5	0.051	0.007	28.88	3.88
26	0.905	5	0.046	0.007	29.54	3.54
27	0.905	4	0.041	0.006	30.19	3.19
28	0.905	4	0.037	0.006	30.82	2.82
29	0.905	3	0.034	0.005	31.44	2.44
30	0.905	3	0.031	0.005	32.04	2.04
31	0.905	3	0.028	0.004	32.63	1.63
32	0.905	3	0.025	0.004	33.20	1.20
33	0.905	2	0.023	0.003	33.77	0.77
34	0.905	2	0.021	0.003	34.33	0.33
35	0.500	1	0.010	0.002	35.00	0.00
36	0.000	0	0.000	0.000	36.00	0.00

Table 2. Tesoro Spill Injuries - Newell's Shearwaters
Birds oiled 3,150

Year from Spill	Expected Natural Deaths	Excess Lost Bird-Years	Number of Progeny Lost	Lost Progeny Bird-Years	Total Lost Bird-Years	Discounted Lost Bird-Years
0	299	2,951	546	546	3,397	3,498.4
1	271	2,580	494	851	3,431	3,430.8
2	245	2,335	447	1,048	3,383	3,284.7
3	222	2,113	405	1,197	3,310	3,119.7
4	201	1,912	366	1,307	3,219	2,946.3
5	182	1,731	331	1,386	3,117	2,769.0
6	164	1,566	300	1,438	3,004	2,591.4
7	149	1,417	271	1,468	2,885	2,416.1
8	135	1,283	246	1,479	2,761	2,245.2
9	122	1,161	222	1,474	2,635	2,080.2
10	110	1,051	201	1,457	2,508	1,922.2
11	100	951	182	1,430	2,381	1,771.9
12	90	860	165	1,395	2,256	1,629.7
13	82	779	149	1,354	2,133	1,496.0
14	74	705	135	1,308	2,013	1,370.7
15	67	638	122	1,259	1,897	1,253.8
16	61	577	111	1,207	1,784	1,145.1
17	55	522	100	1,153	1,676	1,044.3
18	50	473	91	1,099	1,572	951.1
19	45	428	82	1,045	1,473	865.2
20	41	387	74	991	1,378	786.1
21	37	350	67	938	1,289	713.4
22	175	175	34	859	1,034	555.9
23	175	0	0	763	763	398.2
24				687	687	348.2
25				622	622	305.8
26				563	563	268.7
27				509	509	236.1
28				461	461	207.4
29				417	417	182.3
30				377	377	160.1
31				342	342	140.7
32				309	309	123.6
33				280	280	108.6
34				253	253	95.4
35				225	225	82.2
36				195	195	69.2
37				168	168	57.9
38				144	144	48.3
39				124	124	40.3
40				106	106	33.4
41				90	90	27.7
42				77	77	22.8
43				65	65	18.7
44				54	54	15.3
45				46	46	12.4
46				38	38	10.0
47				31	31	8.0

Table 2. Tesoro Spill Injuries - Newell's Shearwaters
Birds oiled 3,150

Year from Spill	Expected Natural Deaths	Excess Lost Bird-Years	Number of Progeny Lost	Lost Progeny Bird-Years	Total Lost Bird-Years	Discounted Lost Bird-Years
48				25	25	6.3
49				21	21	5.0
50				16	16	3.8
51				13	13	2.9
52				10	10	2.1
53				7	7	1.5
54				5	5	1.0
55				3	3	0.6
56				1	1	0.3
	3,150	26,845	5,139	34,735	61,580	46,932.3

Table 3. Tesoro Spill Injuries - Wedge-tailed Shearwaters
Birds oiled 7,700

Year from Spill	Expected Natural Deaths	Excess Lost Bird-Years	Number of Progeny Lost	Lost Progeny Bird-Years	Total Lost Bird-Years	Discounted Lost Bird-Years
0	731	6,969	1,334	1,334	8,303	8,551.7
1	662	6,306	1,207	2,080	8,386	8,386.4
2	599	5,707	1,093	2,563	8,270	8,029.4
3	542	5,165	989	2,925	8,090	7,625.9
4	491	4,674	895	3,195	7,870	7,202.0
5	444	4,230	810	3,388	7,618	6,768.8
6	402	3,829	733	3,515	7,344	6,334.6
7	364	3,465	663	3,587	7,052	5,906.1
8	329	3,136	607	3,614	6,750	5,488.3
9	298	2,838	549	3,604	6,441	5,085.0
10	270	2,568	492	3,563	6,131	4,698.7
11	244	2,324	445	3,497	5,821	4,331.2
12	221	2,103	403	3,411	5,514	3,983.8
13	200	1,904	364	3,310	5,214	3,656.9
14	181	1,723	330	3,198	4,921	3,350.7
15	164	1,559	298	3,077	4,636	3,064.9
16	148	1,411	270	2,950	4,361	2,799.1
17	134	1,277	244	2,819	4,096	2,552.8
18	121	1,156	221	2,687	3,843	2,324.9
19	110	1,046	200	2,555	3,600	2,114.8
20	99	946	181	2,423	3,369	1,921.5
21	90	857	164	2,293	3,150	1,743.9
22	428	4	82	2,100	2,528	1,358.9
23	428	0	0	1,865	1,865	973.3
24				1,680	1,680	851.1
25				1,520	1,520	747.5
26				1,375	1,375	656.8
27				1,245	1,245	577.1
28				1,126	1,126	507.1
29				1,019	1,019	445.5
30				922	922	391.5
31				835	835	344.0
32				756	756	302.2
33				684	684	265.5
34				619	619	233.3
35				549	549	200.9
36				476	476	169.0
37				410	410	141.5
38				353	353	118.2
39				303	303	98.4
40				259	259	81.7
41				221	221	67.6
42				187	187	55.7
43				158	158	45.7
44				133	133	37.4

Year from Spill	Expected Natural Deaths	Excess Lost Bird-Years	Number of Progeny Lost	Lost Progeny Bird-Years	Total Lost Bird-Years	Discounted Lost Bird-Years
45				111	111	30.3
46				92	92	24.5
47				76	76	19.6
48				62	62	15.5
49				50	50	12.1
50				40	40	9.4
51				31	31	7.1
52				24	24	5.2
53				17	17	3.7
54				12	12	2.5
55				7	7	1.5
56				4	4	0.7
57				1	1	0.2
	7,700	65,621	12,563	84,908	150,529	114,723.3

Credit

The credit calculation parallels the injury calculation. One restoration proposal is to remove non-indigenous predators (rats, cats, owls, etc.) from Shearwater nesting colonies. PRBO estimates that 2.5 percent of mortality is attributable to such predation. They found that owl/cat predation was most destructive to 4 and 5 year-olds. Column 2 of Table 4 shows the rate of extra survival by age. Table 4 works out the number of discounted bird years saved by one year of a predator control program directed at a colony of 100 birds. Column 3 shows the number of birds that do not become prey; Column 4 shows the number of bird-years expected from their survival by multiplying by their expected lifetime. Column 5 estimates the number of progeny saved by multiplying the expected breeding years of each age class times the number surviving and the expected fledging rate. Column 6 converts the added progeny surviving to bird-years by multiplying by the discounted expected life time of new fledglings. Keep in mind this table shows one year's population by age (unlike Table 3 in the Red-footed Booby credit estimates which showed one year class through time). As fledglings will provide bird services far into the future their bird years must be discounted by dividing age by a discount factor.

The final column shows the number of bird-years saved by age-class. The total, 218 credit bird-years, may be compared to the 46,932 or 114,723 bird-years lost. The credit may be scaled up directly by size of colony for a single year program but future years would need to be discounted for a multi-year program. That is, protection of a 500 bird colony for one year would generate a credit of 1,090 bird-years but a 5 year program of a 100 bird colony would generate only 997 bird-years. A 10 year program at a 2,500 bird colony would approximately equal 46,900 bird-years due.

Table 4. Tesoro Compensation from Predator Control Measures
Per 100 birds in project population for one year

Age	Excess					
	Mortality from Predation	Added Survival	Bird-years from 1yr class	Number of Progeny Saved	Saved Progeny Bird-Years	Saved Bird-Years
1	0.00	0.00	0	0.00	0	0
2	0.05	2.55	21	2.10	11	32
3	0.05	2.27	19	2.26	12	30
4	0.10	4.11	33	4.81	25	58
5	0.10	3.72	30	4.99	25	55
6	0.01	0.34	3	0.51	3	5
7	0.01	0.30	2	0.45	2	5
8	0.01	0.28	2	0.40	2	4
9	0.01	0.25	2	0.36	2	4
10	0.01	0.23	2	0.32	2	3
11	0.01	0.20	1	0.28	1	3
12	0.01	0.18	1	0.25	1	3
13	0.01	0.17	1	0.22	1	2
14	0.01	0.15	1	0.19	1	2
15	0.01	0.14	1	0.17	1	2
16	0.01	0.12	1	0.15	1	2
17	0.01	0.11	1	0.13	1	1
18	0.01	0.10	1	0.11	1	1
19	0.01	0.09	1	0.10	1	1
20	0.01	0.08	0	0.09	0	1
21	0.01	0.08	0	0.07	0	1
22	0.01	0.07	0	0.06	0	1
23	0.01	0.06	0	0.05	0	1
24	0.01	0.06	0	0.04	0	0
25	0.01	0.05	0	0.04	0	0
26	0.01	0.05	0	0.03	0	0
27	0.01	0.04	0	0.03	0	0
28	0.01	0.04	0	0.02	0	0
29	0.01	0.03	0	0.02	0	0
30	0.01	0.03	0	0.01	0	0
31	0.01	0.03	0	0.01	0	0
32	0.01	0.03	0	0.01	0	0
33	0.01	0.02	0	0.00	0	0
34	0.01	0.02	0	0.00	0	0
35	0.01	0.01	0	0.00	0	0
36	0.01	0.00	0	0.00	0	0
		16	124	18	93	218