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Supplementary Materials for

Warm oceanographic anomalies and fishing pressure drive seabird nesting north

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This PDF file includes:

FIGURES

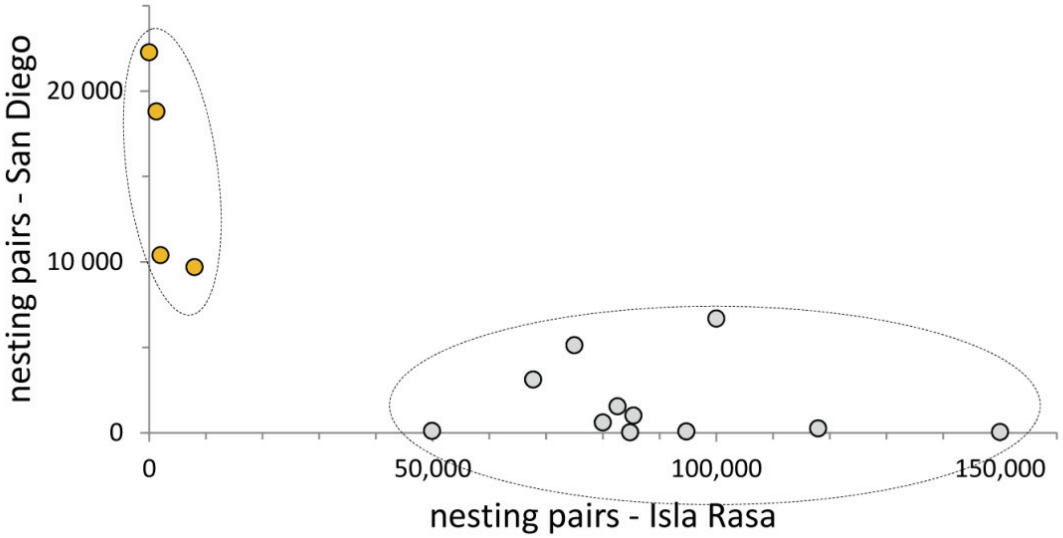

Figure S1. Demographic spillover from Isla Rasa into San Diego Bay. Phase-space plot showing nest numbers for all years after 2000. Yellow points indicate local years of anomalies, i.e., in which nesting collapsed in the Midriff but was successful in Southern California. Note the strongly bimodal distribution of the data points, where each population collapse in Rasa is accompanied by a surge in San Diego Bay. A significant negative correlation exists between the two data series (r = -0.78, p = 0.001).

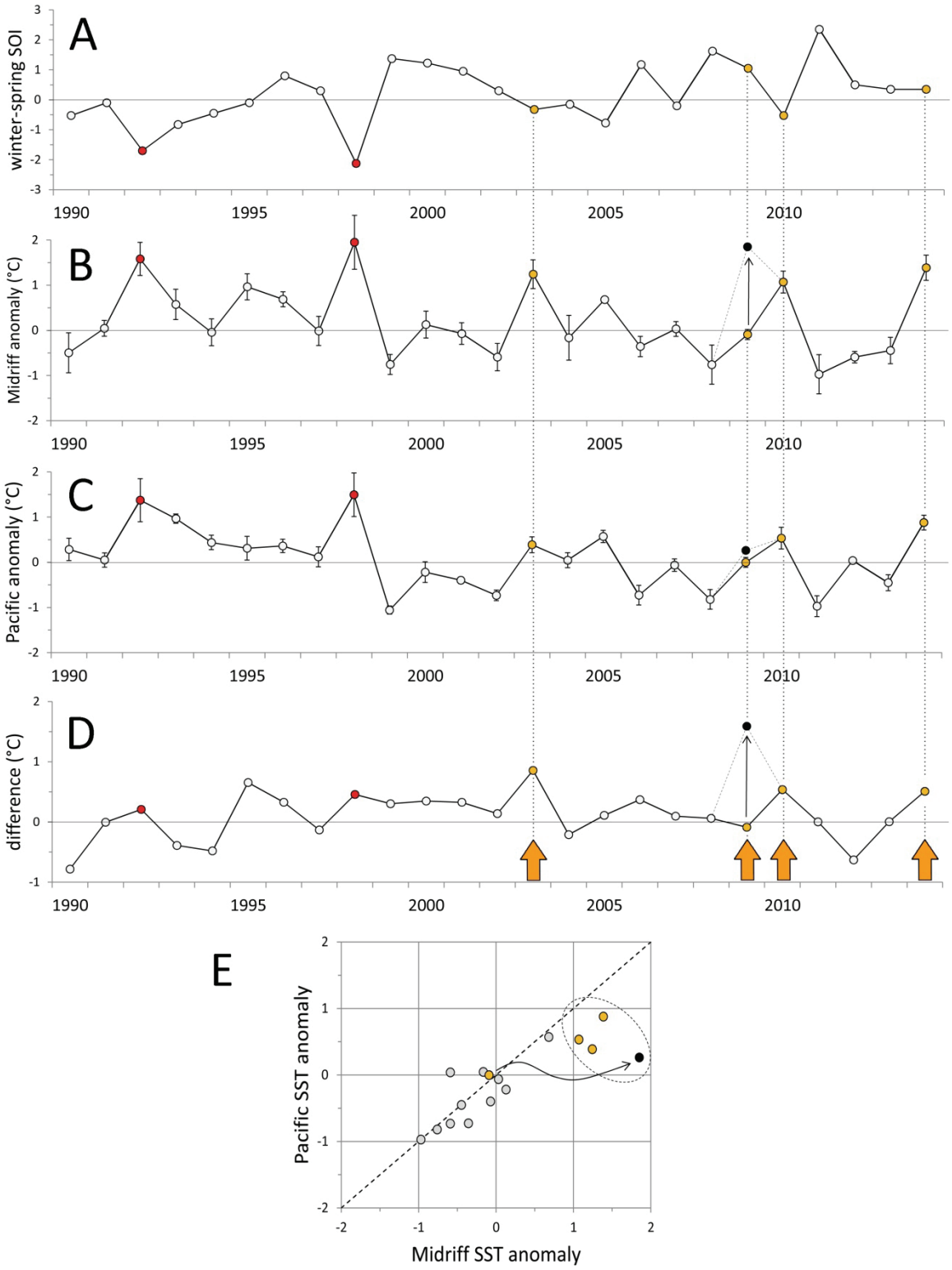

Figure S2. Local oceanographic anomalies in the Gulf of California. (**A**) Winter-spring SOI in the Pacific Ocean, (**B**) winter-spring SST anomaly values in the Gulf of California Midriff Island Region and (**C**) on the Pacific coast of Baja California; (**D**) differences in

SST anomalies between the Gulf of California and the Pacific, and (**E**) phase-space plot for all seasons after year 2000; the dotted diagonal shows the line of equal anomaly in the Midriff and in the Pacific. The cluster of three seasons in which nesting populations collapsed in the Midriff (yellow points enclosed in a dotted ellipse) corresponds to seasons in which SST was very high in the Midriff but less in the Pacific. Yellow points indicate local anomalies (i.e., years in which nesting collapsed in the Midriff but was successful in Southern California, and red dots show strong El Niño years, in which nesting collapsed throughout the Pacific coast and the Gulf of California. The black points in all graphs show the anomaly for May 2009, when the Midriff suddenly increased in surface temperature forcing terns to abandon the island. The arrow in plot **D** shows the SST change for year 2009, which started as a nesting season with average conditions but changed into an extreme SST anomaly in the Midriff during May.

TABLES

Table S1. Elegant Tern demography data. Total number of Elegant Tern nesting pairs on Isla Rasa and in Southern California between 1981 and 2014.

year	Isla Rasa	S.D. Salt-works	Bolsa Chica	LA Harbor	Total So. California
1981	16 658	-	-	-	-
1982	17 694	-	-	-	-
1983	19 862	-	-	-	-
1984	21 741	-	-	-	-
1985	24 897	-	-	-	-
1986	13 847	-	-	-	-
1987	26 895	-	-	-	-
1988	28 512	-	-	-	-
1989	29 713	-	-	-	-
1990	24 512	-	-	-	-
1991	29 829	250	0	0	250
1992	19 050	0	160	0	160
1993	21 826	318	1 614	0	1 932
1994	35 714	80	1 200	0	1 280
1995	34 987	1 870	4 000	0	5 870
1996	46 779	0	3 400	0	3 400
1997	68 562	2	4 000	0	4 002
1998	0	104	200	3 662	3 966
1999	64 049	3 100	1 940	1	5 041
2000	94 719	86	349	3 656	4 091
2001	49 867	107	4 592	166	732
2002	84 823	37	100	5 598	5 735
2003	2 000	10 400	475	1 516	12 391
2004	85 390	1 020	1 226	10 170	12 416
2005	67 688	3 125	9 300	2 700	15 125
2006	80 000	605	5 725	0	6 330
2007	75 000	5 121	5 500	0	10 621
2008	100 000	6 690	7 000	3 300	16 990
2009	8 000	9 700	7 500	3 500	20 700
2010	1 290	20 000	400	0	20 400
2011	82 605	1 550	10 646	0	12 196
2012	155 000	56	300	11 096	11 452
2013	117 924	264	600	18 783	19 647
2014	0	22 275	7 103	21 917	51 295

Table S2. Fisheries data. Total landings of the small pelagic fish fleet in the Gulf of California by species, in metric tons per year, number of boats, and fishing effort (in boat-trips) between 1969 and 2014. Species are as follows: Pacific Sardine (*Sardinops sagax*), Threadfin Herring (*Opisthonema libertate*), Pacific Jack Mackerel (*Scomber japonicus*), Round Herring (*Etrumeus teres*), Northern Anchovy (*Engraulis mordax*), Pacific Anchoveta (*Cetengraulis mysticetus*), and Shortjaw leatherjack (*Oligoplites* spp.). The column labelled "other" lumps all other small pelagic fish (source: www.sardinagolfodecalifornia.org).

season	Pacific Sardine	P. Thread Herring	Chub Mack.	Round Herring	Northern Anchovy	Pacific Anchov.	Shortj. Leathe.	other	boats	effort
1969/70	11 287	4 705	-	-	-	-	-	-	23	846
1970/71	19 558	3 617	19	-	-	-	-	-	30	1 172
1971/72	32 617	4 166	226	36	-	-	-	118	32	1 545
1972/73	9 924	27 291	150	1 240	-	-	-	-	32	1 482
1973/74	16 180	10 812	2 721	1 526	-	-	-	-	26	1 449
1974/75	36 648	15 193	1 326	2 183	-	-	-	-	36	1 885
1975/76	51 263	8 357	2 893	581	-	-	-	-	38	2 312
1976/77	8 802	26 016	1 442	2 092	-	-	-	-	38	1 625
1977/78	32 600	22 224	1 508	1 837	-	-	-	522	46	2 002
1978/79	24 627	22 650	3 320	1 862	-	-	-	1 988	48	1 617
1979/80	77 566	28 856	5 704	371	-	-	-	140	55	2 306
1980/81	93 989	27 652	1 642	2 833	-	-	-	5	59	2 888
1981/82	71 425	51 626	5 645	6 304	-	-	-	2 813	68	2 452
1982/83	111 526	98 966	766	3 380	-	-	-	11 666	77	3 213
1983/84	146 467	33 999	2 381	2 437	-	-	-	4 234	69	2 379
1984/85	160 391	13 276	12 110	4 038	-	-	-	7 988	72	2 693
1985/86	240 226	25 997	5 918	10 364	2 081	-	-	2 771	69	3 773
1986/87	272 574	16 967	6 975	2 919	39	-	-	5 398	72	3 953
1987/88	261 363	15 851	3 421	673	777	-	-	2 849	69	3 595
1988/89	294 095	13 255	2 074	366	7 706	-	-	4 303	76	4 132
1989/90	109 942	63 784	12 935	2 243	18 493	490	-	4 970	77	3 156
1990/91	113 631	92 935	8 014	1 790	12 768	4 035	-	1 871	65	3 171
1991/92	6 858	62 867	12 058	1 750	5 168	16 864	803	237	48	1 538
1992/93	7 549	23 728	6 951	2 868	1 606	11 624	682	919	32	782
1993/94	127 486	7 219	3 538	156	-	55	-	-	32	1 331
1994/95	174 951	9 454	17 057	2 085	1 039	936	123	130	29	1 936
1995/96	200 870	16 895	1 768	242	4 217	856	-	1 011	30	2 135
1996/97	214 609	22 084	2 845	555	-	2 141	406	298	27	1 990
1997/98	58 690	61 982	1 668	263	-	11 296	159	357	30	1 333
1998/99	51 266	39 103	40 535	7 623	846	16 071	3 523	152	31	1 580
1999/00	65 593	38 510	34 240	5 006	4 493	25 229	4 741	1 091	28	1 603

season	Pacific Sardine	P. Thread Herring	Chub Mack.	Round Herring	Northern Anchovy	Pacific Anchov.	Shortj. Leathe.	other	boats	effort
2000/01	190 862	15 834	13 003	345		112 954	277	75	28	2 533
2001/02	220 360	46 666	4 493	270	2 853	78 261	890	110	32	2 827
2002/03	198 757	94 956	6 992	4 889	1 100	7 682	3 309	693	31	2 745
2003/04	102 034	59 685	25 507	8 858	5 717	63 253	5 494	1 090	28	2 121
2004/05	94 559	76 183	32 943	4 683	7 354	38 031	4 233	2 874	30	2 074
2005/06	133 567	60 560	13 191	7 178	41 820	106 062	945	1 841	36	2 922
2006/07	178 205	87 172	6 616	3 088	1 271	16 491	2 530	2 495	38	2 499
2007/08	488 639	25 726	3 988	698	5 885	12 303	238	1 190	40	3 861
2008/09	528 094	21 564	963	422	2 620	9 537	212	885	47	3 757
2009/10	256 409	85 116	3 527	5 545	481	8 315	520	1 039	43	2 761
2010/11	138 068	73 507	38 762	3 040	76 849	74 067	2 382	441	49	3 306
2011/12	86 470	51 780	47 600	2 560	73 124	197 354	666	1 503	50	3 358
2012/13	72 802	101 814	20 557	12 587	118 833	129 296	3 947	5 649	48	3 601
2013/14	3 571	102 836	40 465	6 645	33 772	64 135	10 869	564	47	2 331

Table S3. Oceanographic data. Mean winter-spring (Jan–Apr) values for (a) the SST anomaly in the Midriff of the Gulf of California, (b) the SST anomaly in Baja California's Pacific coast at the same latitude, (c) the Southern Oscillation Index (SOI; www.cpc.ncep.noaa.gov/ data/indices/soi) and (d) the Multivariate ENSO Index (MEI; www.esrl.noaa.gov/psd/ enso/mei/table.html). Local anomalies for May 2009 in both the Midriff and the Pacific coast of Baja California are shown in an additional line below the mean winter-spring values for 2009.

year	Midriff		Pacific		SOI	MEI
	mean	st.error	mean	st.error		
1983	0.23	0.37	1.36	0.30	-2.600	2.877
1984	0.90	0.08	0.50	0.05	0.300	-0.111
1985	-0.37	0.29	-0.71	0.16	0.725	-0.596
1986	0.69	0.17	0.45	0.02	0.200	-0.159
1987	0.26	0.15	-0.13	0.29	-1.150	1.502
1988	0.26	0.25	-0.18	0.53	0.050	0.629
1989	-0.62	0.73	-0.78	0.54	1.350	-1.094
1990	-0.50	0.44	0.29	0.25	-0.525	0.519
1991	0.05	0.17	0.05	0.16	-0.100	0.363
1992	1.58	0.37	1.37	0.48	-1.700	1.972
1993	0.58	0.33	0.96	0.10	-0.825	1.017
1994	-0.04	0.30	0.44	0.16	-0.450	0.278
1995	0.97	0.29	0.31	0.26	-0.100	0.860
1996	0.69	0.17	0.36	0.15	0.800	-0.503
1997	-0.01	0.32	0.12	0.22	0.300	-0.215
1998	1.95	0.60	1.49	0.48	-2.125	2.670
1999	-0.75	0.22	-1.06	0.09	1.375	-1.120
2000	0.13	0.30	-0.22	0.23	1.225	-1.026
2001	-0.07	0.24	-0.40	0.07	0.950	-0.503
2002	-0.59	0.30	-0.73	0.12	0.300	-0.031
2003	1.24	0.32	0.39	0.17	-0.325	0.809
2004	-0.16	0.50	0.05	0.17	-0.150	0.182
2005	0.68	0.07	0.57	0.14	-0.775	0.668
2006	-0.36	0.23	-0.73	0.22	1.175	-0.552
2007	0.03	0.16	-0.06	0.14	-0.200	0.377
2008	-0.76	0.43	-0.82	0.22	1.625	-1.248
2009	-0.09	0.11	0.00	0.11	1.050	-0.588
(May 2009)	1.85	–	0.26	–	–	–
2010	1.07	0.24	0.53	0.24	-0.525	1.230
2011	-0.97	0.43	-0.97	0.23	2.350	-1.574
2012	-0.59	0.13	0.04	0.05	0.500	-0.528
2013	-0.45	0.29	-0.45	0.18	0.350	-0.072
2014	1.39	0.28	0.88	0.16	0.350	-0.113