Supporting Information for

Dramatic Improvements in Beach Water Quality Following Gull Removal

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Table S1: Water quality and visitation data collected during the study period.

Date	Time	Air Temp (C)	Water Temp (C)	Rainfall (cm)	UV ($\mu W/cm^2$)	% Cloud Cover	Wind Speed (km/h)	Wind Direction	pH	Total Dissolved Solids (ppm)	Bathers in Water	Bathers on Beach	Gulls along Transects	Geese
8/1/2011	0900	29.4	14	0	31.6	0-19	15.1	W	8.67	206	1-20	21-100	349	0
	1100												10	0
	1500	26.5	13.5	0	11.3	70-99	4.8	NW			21-100	101-200	0	0
	1700												57	0
8/2/2011	0900	28.8	18	0	8	70-99	16.5	SW	--	--	1-20	1-20	721	5
	1100												450	36
	1500	27.9	18.5	0	22	0-19	20.3	S			--	--	20	0
	1700												126	20
8/3/2011	0900	23.9	16	0.03	37.6	20-49	29	N	8.73	208	0	21-100	740	0
	1100												1360	13
	1500	24.2	17.6	0	37.3	0-19	9	NE			101-200	>201	0	0
	1700												10	0
8/4/2011	0900	22.4	21.5	0	12	100	12.2	E	8.72	212	1-20	21-100	1000	0
	1100												210	8
	1500	26.2	25.2	0	42.6	0-19	8.3	E			101-200	101-200	288	0
	1700												1035	0
8/5/2011	0900	24	22	0	18.3	70-99	3.8	E	8.75	210.3	1-20	21-100	950	18
	1100												270	13
	1500	24.9	26	0	41.3	0-19	9	E			101-200	101-200	17	0
	1700												80	0
8/6/2011	0900	24.9	24	0.51	27	70-99	0		8.77	212	1-20	1-20	1600	22
	1100												1760	0
	1500	26.6	27.3	0	38.6	0-19	7.9	E			101-200	>201	0	0
	1700												210	0
8/7/2011	0900	23.1	20	0	5.3	70-99	5.4	SW	8.78	207.3	0	0	2100	7
	1100												1560	16
	1500	28.8	21.8	0	8	50-69	33.3	NE			101-200	>201	0	0
	1700												935	0
8/8/2011	0900	23	22.6	0.05	36	20-50	12.2	NE	8.72	213	0	1-20	1400	0
	1100												1010	0
	1500	24.1	24	0	5.3	100	6.9	--			21-100	21-100	1040	0
	1700												1920	0
8/9/2011	0900	23.7	22.2	0.15	13.6	50-69	22.9	SW	8.76	210	0	1-20	1011	0
	1100												990	5
	1500	26.6	23.6	0	22.6	20-49	15.2	W			21-100	101-200	600	0
	1700												700	0
8/10/2011	0900	19.7	21	0	38	0-19	16.5	NE	8.74	211	1-20	21-100	1300	0
	1100												233	0
	1500	24.1	22.6	0	42.6	20-49	14.9	W			21-100	101-200	9	0
	1700												144	0
8/11/2011	0900	23	20.8	0	35	0-19	10.2	SW	8.76	212	0	1-20	1350	0
	1100												580	0
	1500	24.3	23.3	0	41.3	20-49	18.6	W			21-100	101-200	430	0
	1700												690	0
8/19/2012	0900	22	21.2	0.03	32.6	0-19	7.2	S	8.46	216	0	1-20	0	0

	1100												1	0
	1500	24.2	23.3	0	35.6	0-19	30.4	SE			101-200	101-200	2	0
	1700												6	0
8/20/2011	0900	21.8	21	0	1	71-99	12.3	NE	8.59	216	0	21-100	2	0
	1100												70	0
	1500	22.5	23	0	40	20-49	10.1	E			21-200	21-00	0	0
	1700												3	0
8/21/2011	0900	23.7	21.2	0.58	33	0-19	10.6	NW	8.62	217	1-20	1-20	0	1
	1100												3	0
	1500	24.3	24	0	37.6	20-49	12.6	NW			101-200	>201	2	0
	1700												7	0
8/22/2011	0900	23.1	21	0	35	0-19	4.2	N	8.63	217	1-20	1-20	3	0
	1100												2	0
	1500	23.1	23.6	0	40	0-19	15.2	SE			21-100	21-100	2	0
	1700												33	0
8/23/2011	0900	22.9	21	0	3	100	13.9	SE	8.64	215	0	1-20	47	0
	1100												45	0
	1500	22.6	22	0	38	20-49	24	SW			1-20	1-20	3	0
	1700												12	0
8/24/2011	0900	24.6	15.2	0.33	18	100	11.7	SW	8.57	215	1-20	1-20	13	0
	1100												0	0
	1500	32.6	19.6	0	22	50-69	13.4	W			101-200	>201	3	0
	1700												9	0
8/25/2011	0900	22.4	18.8	0	36	0-19	20.2	N	8.65	214	0	1-20	4	0
	1100												0	0
	1500	21.9	22	0	41	0-19	7.8	NW			21-100	21-100	0	0
	1700												20	0
8/26/2011	0900	23.2	20.2	0	36	0-19	2.2	E	8.68	215	1-20	1-20	2	0
	1100												2	0
	1500	23.2	22.5	0	38	20-49	16.2	SE			21-100	>201	26	0
	1700												9	0
8/27/2011	0900	22.2	21	0	34.6	0-19	18.6	NE	8.69	214	1-20	1-20	199	0
	1100												24	0
	1500	22.4	22.5	0	36	0-19	16.4	NE			21-100	101-200	5	0
	1700												35	0

Table S2: Primer and probe sequences, reagents, and assay conditions for qPCR assays used in the study.

Assay	Target	Primer/Probe Sequences (5' to 3')	Reagents	Cycling Conditions	Reference
Sketa22	Salmon testes DNA (SPC)	Forward: GGTTTCCGCAGCTGGG Reverse: CCGAGCCGTCCTGGTC Probe: Cal Red-AGTCGCAGGCGGCCACCGT-BHQ	Cepheid OmniMix	95°C for 2 min; 45 cycles of 94°C for 15 s and 60°C for 30 s	US EPA 2010
Entero	*Enterococcus* spp.	Forward: AGAAATTCCAAACGAACTTG Reverse: CAGTGCTCTACCTCCATCATT Probe: FAM-TGGTTCTCTCCGAAATAGCTTTAGGGCTA-BHQ	Cepheid OmniMix	95°C for 2 min; 45 cycles of 95°C for 15 s and 60°C for 1 min	Haugland et al. 2005
E. coli	*E. coli*	Proprietary *E. coli* SmartBeads (BioGX)	Cepheid OmniMix	94°C for 2 min; 45 cycles of 94°C for 5 s and 62°C for 43 s	Noble et al. 2010
HF183	Human-associated *Bacteroidales* spp.	Forward: ATCATGAGTTCACATGTCCG Reverse: TACCCCGCCTACTATCTAATG	Eurogentec qPCRTM core kit for SYBR Green 1	50°C for 2 min; 95°C for 10 min; 40 cycles of 95°C for 30 s, 53°C for 1 min, and 60°C for 1 min; melting curve with increase from 60°C to 95°C at 0.4°C per minute	Seurinck et al. 2005
CowM2	Bovine-associated marker	Forward: CGGCCAAATACTCCTGATCGT Reverse: GCTTGTTGCGTTCCTTGAGATAAT Probe: FAM-AGGCACCTATGTCCTTTACCTCATCAACTACAGACA-TAMRA	Applied Biosystems 1X TaqMan Universal Master Mix	50°C for 2 min; 95°C for 10 min; 40 cycles of 95°C for 15 s and 60°C for 1 min	Shanks et al. 2008
CowM3	Bovine-associated marker	Forward: CCTCTAATGGAAAATGGATGGTATCT Reverse: CCATACTTCGCCTGCTAATACCTT Probe: FAM-TTATGCATTGAGCATCGAGGCC-TAMRA	Applied Biosystems 1X TaqMan Universal Master Mix	50°C for 2 min; 95°C for 10 min; 40 cycles of 95°C for 15 s and 60°C for 1 min	Shanks et al. 2008
Gull2	*C. marimammalium*	Forward: TGCATCGACCTAAAGTTTTGAG Reverse: GTCAAAGAGCGAGCAGTTACTA	Takara Bio 2X SYBR Premix Ex Taq	50°C for 2 min; 95°C for 2 min; 40 cycles of 95°C for 5 s, 64°C for 15s, and 72°C for 10 s; disassociation at 60°C for 15 s	Lu et al. 2008
Campy	*C. jejuni, C. lari, C. coli*	Forward: CTGCTTAACACAAGTTGAGTAGG Reverse:TTCCTTAGGTACCGTCAGAA Probe: FAM-CGCTCCGAAAAGTGTCATCCTCC-BHQ	Cepheid OmniMix	95°C for 2 min; 50 cycles of 94°C for 15 s, 60°C for 60 s, and 72°C for 30 s	Van Dyke et al. 2010

Table S3: Gull counts and log_{10} transformed FIB concentrations collected during regular beach monitoring. Note that gulls were counted using the same protocol but at different and fewer intervals during regular beach monitoring. We present counts from a single time point (1130) in this table. MF results were assigned a value of 0.1 CFU/ 100 mL (or -1, when data are log_{10} transformed) when below the limit of detection (<10 CFU/100mL).

Period with Respect to Intervention	Date	Log_{10} *Enterococcus* spp. by MF (CFU/100 mL)	Log_{10} *E. coli* by MF (CFU/100 mL)	Log_{10} *Enterococcus* spp. by qPCR (CCE/100 mL)	Log_{10} *E. coli* by qPCR (CCE/100 mL)	Gulls
Pre	8/1/2011	1.23	0.48	2.89	0.70	575
	8/2/2011	1.45	1.08	2.78	1.29	950
	8/3/2011	2.34	2.38	3.33	2.21	1570
	8/4/2011	1.75	2.32	3.83	2.14	2850
	8/5/2011	1.90	1.70	4.72	1.57	2600
	8/8/2011	1.70	1.70	3.43	2.22	2415
	8/9/2011	0.90	1	3.51	1.52	2400
	8/10/2011	1.36	1	3.60	1.28	2500
	8/11/2011	0.90	0.70	2.33	0.70	2650
During (First Week)	8/12/2011	1	1	2.39	1.78	0
	8/15/2011	1.48	1.85	2.95	inhibited	0
	8/16/2011	-1	1.30	1.78	0.70	0
	8/17/2011	-1	-1	0.70	0.70	0
	8/18/2011	-1	-1	2.39	1.53	0
During (Second Week)	8/19/2011	0.60	0.30	3.05	0.70	1
	8/22/2011	0.48	0.30	2.14	0.70	0
	8/23/2011	0.48	0.78	2.26	0.70	6
	8/24/2011	0	0.70	3.45	0.70	0
	8/25/2011	0	0.78	2.13	0.70	3
	8/26/2011	0	0.70	2.73	1.71	2
Post	8/30/2011	1.30	1.70	2.43	1.46	1000
	8/31/2011	1	1.34	3.49	1.34	1000
	9/1/2011	1.50	1.30	2.65	1.33	850
	9/2/2011	0	1.30	2.52	0.70	1000