

Incorporating sea-surface temperature to the light-based geolocation model TrackIt

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This supplement highlights the unique aspects of the TrackIt model and provides a complete listing of the parameter values used in the model

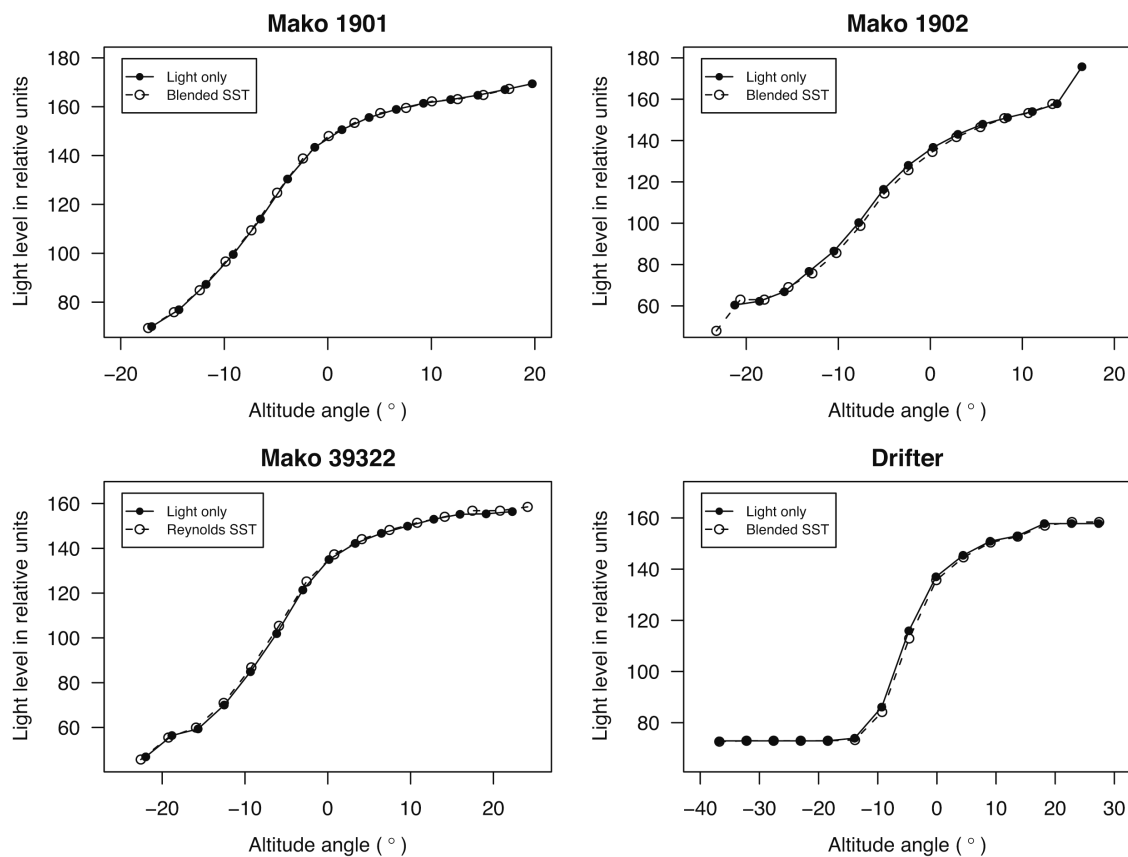


Fig. S1. The estimated function ϕ describing the relationship between solar altitude angle and the expected light measurements in the tag. The points correspond to the model parameters ϕ_1, \dots, ϕ_{15} . Only values for the light-only model (solid line, solid circles) and the sea-surface temperature matching model that most resembles the GPS/Argos track (broken line, open circles) are shown for clarity

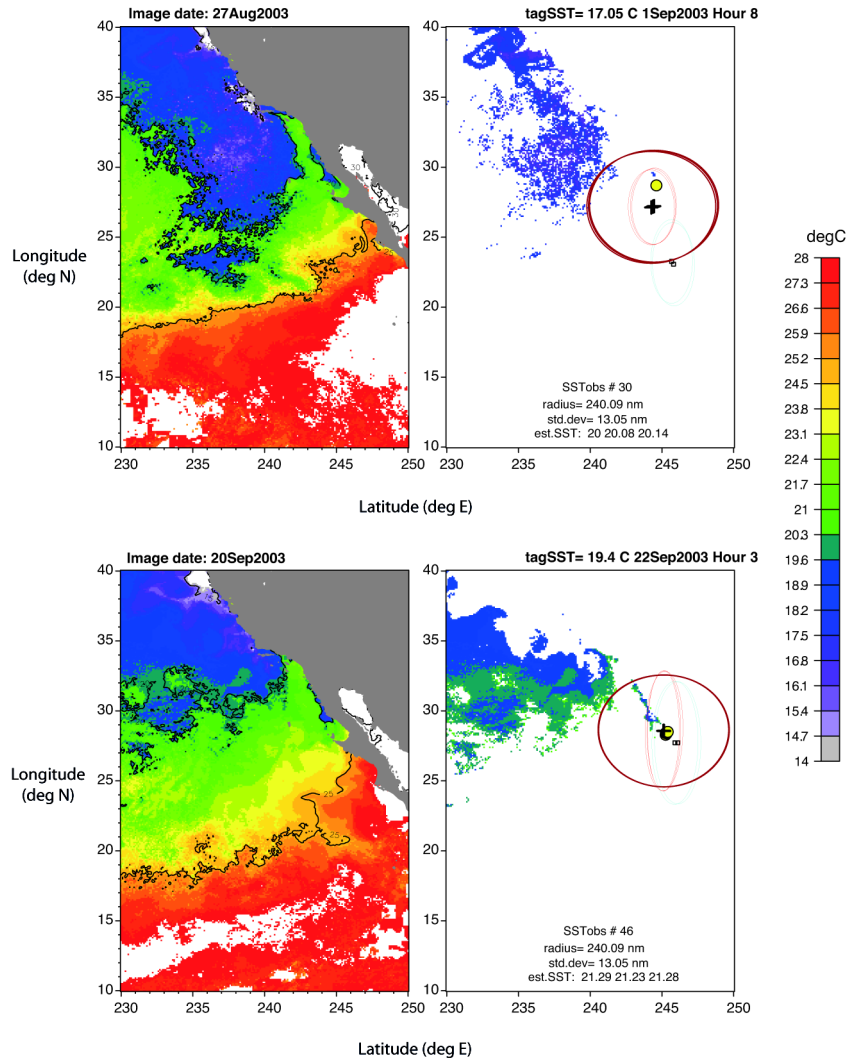


Fig. S2. Benefits of a holistic approach to geolocation. Sea-surface temperature (SST) matching is shown for 1 and 22 September 2003 for Mako 1902. The satellite SST images (CoastWatch blended SST) are shown in the left-hand panels, where colors are scaled to the range of SSTs recorded by the tag for the entire deployment period. The tag-recorded SSTs are shown at the top of the right-hand panels. Portions of the satellite SST image are shown where the satellite SST values are within $\pm 1^\circ\text{C}$ of the tag-recorded SST. The SPOT-Argos satellite positions are shown as filled yellow circles. Note the mismatch between tag-recorded and satellite remotely sensed SST values. TrackIt position estimates and confidence ellipses were plotted for the light-only model (open square; cyan ellipses) and the light with CoastWatch blended SST model (crosses; red ellipses). The smoothing radius (r) estimated by the light with SST model was used to construct a circumference bounded by the brown circle, with a position estimate at the center. The SST values estimated by the model for the corresponding date are shown, along with the estimated smoothing radius and its standard deviation

Table S1. List of values for all the parameters in the TrackIt model. Radius is in nautical miles, D is in square nautical miles per day, b_{sst} , σ_{sst}^2 in degrees Celsius, and $\varphi_{1, \dots, 15}$, $\sigma_{1, \dots, 3}^2$, and ρ are unitless. The models are: light only, light with Reynolds 1° OI SST, light with NOAA 0.25° OI SST Version 1 AVHRR-only or NASA MODIS Aqua 0.05° 8 d composite SST, and light with CoastWatch blended 0.1° experimental SST. AVHRR: advanced very high resolution radiometer; MODIS: moderate resolution imaging spectroradiometer; NASA: National Aeronautics and Space Administration; NOAA: National Oceanic and Atmospheric Administration; OI: optimum interpolation; SST: sea-surface temperature; *: not estimated; NA: not applicable

	Estimates				Standard deviation				
	Light only	Reynolds	NOAA	Blended	Light only	Reynolds	NOAA	Blended	
Mako 1901									
b_{sst}	NA	-1.14	-1.01	-1.27	b_{sst}	NA	0.06	0.11	0.10
D	505.02	383.48	320.33	309.86	D	137.59	59.27	50.30	53.64
φ_1	75.68	74.54	74.65	75.10	φ_1	2.50	1.31	1.57	1.43
φ_2	3.43	9.28E-09	2.25E-08	2.23E-08	φ_2	2.39	1.29E-04	3.18E-04	3.16E-04
φ_3	11.32	8.11	7.37	7.08	φ_3	0.85	1.03	1.31	1.07
φ_4	12.16	11.74	11.55	12.28	φ_4	0.45	0.47	0.64	0.63
φ_5	14.82	12.50	12.33	12.27	φ_5	0.35	0.35	0.41	0.37
φ_6	15.84	15.26	15.00	15.50	φ_6	0.33	0.22	0.29	0.26
φ_7	11.66	14.32	14.74	14.52	φ_7	0.40	0.28	0.28	0.26
φ_8	6.50	10.05	10.31	9.99	φ_8	0.34	0.17	0.27	0.29
φ_9	4.68	6.00	6.22	6.01	φ_9	0.43	0.27	0.32	0.32
φ_{10}	3.06	3.99	3.97	4.09	φ_{10}	0.65	0.42	0.41	0.44
φ_{11}	2.41	3.31	3.18	2.87	φ_{11}	0.95	0.63	0.65	0.67
φ_{12}	1.37	1.00	1.83	1.61	φ_{12}	1.80	0.94	1.00	1.10
φ_{13}	1.88	2.66	2.26	1.87	φ_{13}	2.57	2.27	1.82	2.11
φ_{14}	2.21	0.05	0.70	1.51	φ_{14}	3.97	4.65	2.86	3.20
φ_{15}	2.93	3.80	3.32	2.52	φ_{15}	21.42	5.33	4.63	3.70
Radius	NA	88.37	74.79	92.84	Radius	NA	3.58	9.03	7.11
ρ	0.13	0.11	0.12	0.13	ρ	0.08	0.01	0.01	0.01
σ_1^2	0.96	3.08E-06	9.72E-07	5.14E-05	σ_1^2	69.02	0.02	0.01	0.64
σ_2^2	115.49	111.37	116.53	120.37	σ_2^2	69.19	7.91	8.53	9.45
σ_3^2	2.45	2.36	2.41	2.40	σ_3^2	0.22	0.20	0.21	0.21
σ_{sst}^2	NA	0.51	0.78	0.57	σ_{sst}^2	NA	0.06	0.12	0.08

Mako 1902

b_{sst}	NA	-2.95	-2.94	-2.80	b_{sst}	NA	0.16	0.18	0.15
D	726.02	952.07	835.88	967.95	D	141.00	145.39	163.20	110.99
φ_1	60.42	62.15	63.15	47.94	φ_1	5.55	6.06	4.93	31.68
φ_2	1.83	1.03E-06	5.52E-07	15.10	φ_2	4.36	0.01	0.01	32.38
φ_3	4.62	1.49	2.57	4.53E-07	φ_3	3.78	4.61	3.52	0.01
φ_4	9.83	6.91	5.68	6.05	φ_4	1.82	2.55	2.19	3.35
φ_5	9.81	7.79	9.70	6.66	φ_5	0.91	1.21	1.15	1.42
φ_6	13.78	9.97	10.20	9.85	φ_6	0.60	0.67	0.64	0.78
φ_7	16.12	14.51	15.59	13.12	φ_7	0.43	0.47	0.46	0.49
φ_8	11.62	14.62	13.45	15.66	φ_8	0.35	0.37	0.36	0.36
φ_9	8.66	10.29	10.12	11.28	φ_9	0.50	0.32	0.32	0.21
φ_{10}	6.27	8.61	7.96	8.84	φ_{10}	0.36	0.29	0.35	0.28
φ_{11}	4.92	6.72	5.93	7.21	φ_{11}	0.56	0.34	0.38	0.32
φ_{12}	3.21	4.47	4.27	4.75	φ_{12}	0.77	0.48	0.55	0.44
φ_{13}	2.89	3.98	3.42	4.31	φ_{13}	1.40	0.75	0.88	0.69
φ_{14}	3.78	2.59	2.72	2.52	φ_{14}	3.34	1.28	1.49	1.16
φ_{15}	17.92	4.53	5.34	4.46	φ_{15}	14.02	2.69	3.87	2.12
Radius	NA	370.77	860.81	240.09	Radius	NA	25.12	120.64	13.05
ρ	0.03	0.04	0.03	0.03	ρ	4.95E-03	0.01	0.01	0.01
σ_1^2	48.76	35.92	34.70	43.30	σ_1^2	8.33	9.39	8.27	8.59
σ_2^2	35.61	46.98	42.84	42.94	σ_2^2	5.32	8.46	7.12	7.14
σ_3^2	0.62	0.59	0.58	0.60	σ_3^2	0.16	0.15	0.15	0.15
σ_{sst}^2	NA	0.64	1.42	0.67	σ_{sst}^2	NA	0.14	0.30	0.16

Mako 39322

b_{sst}	NA	-0.80	-0.98	0*	b_{sst}	NA	0.12	0.21	NA
D	519.84	326.78	630.66	289.53	D	190.72	42.68	208.59	31.67
φ_1	46.90	45.70	47.63	45.51	φ_1	5.47	5.91	6.44	5.96
φ_2	9.51	9.81	6.66	10.25	φ_2	6.97	7.53	7.61	7.31
φ_3	2.97	4.45	7.86	4.21	φ_3	6.90	6.34	4.57	5.57
φ_4	10.66	11.02	11.65	11.83	φ_4	2.22	2.02	1.85	1.84
φ_5	14.87	15.87	15.38	16.30	φ_5	0.89	0.74	0.62	0.67
φ_6	17.03	18.54	18.62	18.68	φ_6	0.39	0.35	0.36	0.33
φ_7	19.43	19.78	18.84	19.52	φ_7	0.27	0.25	0.28	0.25
φ_8	13.58	12.14	11.28	11.59	φ_8	0.42	0.25	0.35	0.28
φ_9	7.24	6.79	6.27	6.56	φ_9	0.30	0.30	0.31	0.30
φ_{10}	4.54	4.11	3.92	3.96	φ_{10}	0.37	0.43	0.42	0.43

φ_{11}	3.15	3.21	3.30	3.44	φ_{11}	0.56	0.74	0.72	0.78
φ_{12}	3.07	2.71	2.60	2.33	φ_{12}	1.07	1.39	1.36	1.39
φ_{13}	2.23	2.66	2.16	2.97	φ_{13}	1.88	2.25	2.22	2.38
φ_{14}	0.23	1.43E-07	0.07	3.80E-07	φ_{14}	2.40	2.02E-03	3.28	0.01
φ_{15}	0.96	1.71	2.10	1.58	φ_{15}	3.95	4.90	5.87	4.16
Radius	NA	162.12	649.31	200*	Radius	NA	11.00	125.30	NA
ρ	0.26	0.26	0.26	0.26	ρ	0.03	0.03	0.03	0.03
σ^2_1	7.36E-07	8.36E-07	8.13E-07	7.94E-07	σ^2_1	2.47E-03	2.93E-03	2.87E-03	2.78E-03
σ^2_2	127.86	137.13	130.75	138.27	σ^2_2	11.43	11.72	11.63	11.76
σ^2_3	0.94	0.91	0.95	0.90	σ^2_3	0.09	0.09	0.09	0.09
σ^2_{sst}	NA	0.41	1.41	0.70	σ^2_{sst}	NA	0.08	0.23	0.12

Drifter

b_{sst}	n/a	1.90	0.60*	0.61	b_{sst}	n/a	0.08	n/a	0.08
D	472.90	276.57	200*	202.84	D	83.80	52.72	n/a	42.69
φ_1	72.91	72.75	72.52	72.59	φ_1	0.57	1.68	1.80	1.66
φ_2	1.28E-07	0.33	0.52	0.35	φ_2	1.81E-03	1.59	1.77	1.57
φ_3	3.41E-09	4.52E-09	5.14E-09	4.52E-09	φ_3	4.74E-05	6.33E-05	7.19E-05	6.33E-05
φ_4	1.63E-09	1.81E-09	1.87E-09	1.83E-09	φ_4	2.25E-05	2.50E-05	2.59E-05	2.53E-05
φ_5	7.11E-10	9.80E-10	1.08E-09	9.34E-10	φ_5	9.53E-06	1.33E-05	1.48E-05	1.27E-05
φ_6	1.04	0.10	6.68E-09	0.30	φ_6	0.49	0.50	9.36E-05	0.50
φ_7	12.15	10.74	10.14	10.96	φ_7	0.31	0.29	0.28	0.28
φ_8	29.81	28.71	27.88	28.72	φ_8	0.18	0.19	0.17	0.17
φ_9	21.07	23.06	23.79	22.84	φ_9	0.25	0.21	0.17	0.19
φ_{10}	8.46	8.91	9.29	8.87	φ_{10}	0.16	0.16	0.15	0.15
φ_{11}	5.50	5.89	6.01	5.84	φ_{11}	0.21	0.20	0.20	0.21
φ_{12}	2.10	2.19	2.42	2.25	φ_{12}	0.37	0.35	0.34	0.36
φ_{13}	4.81	4.30	3.91	4.37	φ_{13}	0.68	0.69	0.66	0.70
φ_{14}	1.86E-08	1.84	1.97	1.24	φ_{14}	2.64E-04	1.28	1.12	1.32
φ_{15}	7.09E-09	6.06E-09	6.19E-09	6.78E-09	φ_{15}	9.94E-05	8.49E-05	8.64E-05	9.49E-05
Radius	n/a	1200	80*	80*	Radius	n/a	8.24E-04	n/a	n/a
ρ	0.13	0.12	0.12	0.12	ρ	0.01	0.01	0.01	0.01
σ^2_1	3.34E-07	3.34E-07	3.40E-07	3.35E-07	σ^2_1	1.72E-04	1.77E-04	2.14E-04	1.83E-04
σ^2_2	18.88	20.48	21.86	21.24	σ^2_2	1.39	1.51	1.53	1.54
σ^2_3	1.78	1.80	1.79	1.79	σ^2_3	0.06	0.06	0.06	0.06
σ^2_{sst}	n/a	0.50	0.38*	0.38	σ^2_{sst}	n/a	0.08	n/a	0.06