Supplementary Material for:

Ocean warming alters the distributional range, migratory timing, and spatial protections of an apex predator, the tiger shark (*Galeocerdo cuvier*)

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Tables S1-S3

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Table S1. Metadata associated for pop-off archival satellite tagged female tiger sharks, including ID, tag type, tagging date and location, shark size, the number of recordings, temperature range, average (avg.) temperature and average depth, as well date and location of the last known location. Sampling frequency, data acquisition method, and transmission rate of satellite-linked data varied by tag type and deployment date (see text). TL = total length in cm; No. = number; Averages are in (mean +/- SD). Tags physically recovered are marked with an * under Tag ID.

		Tagging Location					Last Location				
Tag ID	Tag Type	Month	Day	Year	Latitude	Longitude	Month	Day	Year	Latitude	Longitude
112979*	Sea-Tag MOD	12	12	2011	26.86	-79.04	3	4	2012	27.00	-78.77
112981*	Sea-Tag MOD	12	14	2011	26.86	-79.04	2	27	2012	26.40	-80.17
112988*	Sea-Tag MOD	12	14	2011	26.86	-79.04	12	26	2012	26.71	-78.49
115915*	Sea-Tag MOD	9	4	2012	25.04	-77.24	9	22	2013	NA	NA
112982	Sea-Tag MOD	9	9	2012	25.04	-77.24	10	22	2012	24.95	-77.33
181740	miniPAT	5	21	2019	25.06	-77.23	7	5	2019	24.13	-75.10
181742	miniPAT	5	23	2019	24.96	-77.48	7	7	2019	24.93	-77.53
181741	miniPAT	5	24	2019	24.98	-77.50	7	8	2019	23.60	-79.38
183613	PSATLife	6	22	2019	25.07	-77.21	7	21	2019	25.48	-77.34
183614	PSATLife	6	22	2019	25.07	-77.21	7	5	2019	24.84	-77.03

Tag ID	Tag Type	TL	Total Tracking Days	No. of Recordings	Temperature Range (°C)	Avg. Temperature (°C, mean ± SD)	Avg. Depth (m, mean ± SD)
112979*	Sea-Tag MOD	245	86	30,266	17.9 - 26.5	24.7 ± 0.9	13.5 ± 27.4
112981*	Sea-Tag MOD	270	76	27,095	17.6 - 32.5	24.8 ± 0.9	11.8 ± 30.9
112988*	Sea-Tag MOD	223	379	120,618	7.0 - 28.5	23.8 ± 2.7	15.6 ± 43.6
115915*	Sea-Tag MOD	153	384	125,166	15.2 - 31.3	26.1 ± 2.4	0 ± 26.8
112982	Sea-Tag MOD	140	44	771	19.4 - 33.4	29.1 ± 1.5	21.0 ± 36.1
181740	miniPAT	267	46	18,870	11.8 - 30.8	27.7 ± 2.5	34.0 ± 73.3
181742	miniPAT	248	47	2,159	19.8 - 31.9	28.8 ± 1.8	22.7 ± 43.3
181741	miniPAT	304	47	17,873	10.8 - 31.6	27.2 ± 2.9	51.3 ± 82.6
183613	PSATLife	307	34	4,472	13.3 - 31.0	26.2 ± 3.6	84.0 ± 99.0
183614	PSATLife	177	14	1,648	13.0 - 34.0	29.4 ± 2.2	17.2 ± 44.3

Table S2. Metadata associated for SPOT-tagged tiger sharks, including shark ID, sex, size, and location of tagging. Tracking durations (i.e. days elapsed between tagging and last position date) and tracking days (number of regularized and filtered daily positions) for each shark are provided. TL = total length (cm).

Tag ID	Month	Day	Year	Latitude	Longitude	Sex	TL	Tracking Duration	Tracking Days
98332	11	12	2010	24.73	-80.85	F	184	33	32
34203	11	13	2010	24.73	-80.85	F	255	47	41
68485	2	19	2011	26.86	-79.04	F	355	95	94
68494	2	19	2011	26.86	-79.04	F	365	191	123
68529	2	19	2011	26.86	-79.04	F	325	558	246
68554	2	19	2011	26.86	-79.04	F	403	185	168
68555	2	19	2011	26.86	-79.04	F	286	157	155
68486	2	20	2011	26.86	-79.04	F	320	99	72
68488	2	20	2011	26.86	-79.04	F	295	253	225
68495	2	20	2011	26.86	-79.04	F	325	168	124
68496	2	20	2011	26.86	-79.04	F	280	217	197
68556	2	20	2011	26.86	-79.04	F	322	253	212
105600	2	20	2011	26.10	-79.10	F	310	48	47
105595	2	22	2011	26.10	-79.10	F	325	23	22
106660	4	10	2011	25.82	-77.93	M	206	53	52
106661	4	10	2011	25.82	-77.93	F	320	48	45
108064	12	9	2011	25.32	-80.23	F	175	53	38
113537	12	14	2011	26.86	-79.04	F	346	125	58
113536	12	15	2011	26.86	-79.04	F	305	52	52
115907	2	7	2012	25.35	-80.26	M	200	28	27
115906	5	27	2012	24.73	-80.85	M	299	24	23
119440	3	18	2013	25.60	-80.16	F	206	57	16
130582	5	24	2013	24.73	-80.85	F	220	15	14
130580	8	5	2013	24.73	-80.85	F	300	28	28
129952	10	19	2013	25.91	-79.06	F	360	25	24
130583	10	19	2013	25.91	-79.06	F	369	24	23
134992	3	21	2014	25.26	-80.06	F	199	151	148
137337	5	12	2014	26.91	-79.06	F	352	187	185
137736	5	13	2014	26.91	-79.06	F	383	378	318
137335	5	14	2014	26.91	-79.06	F	366	128	13
137738	6	29	2014	25.77	-80.09	F	296	33	28
144019	11	14	2014	27.02	-79.16	M	352	105	53
144020	11	14	2014	26.90	-79.09	F	356	475	372
146598	3	15	2015	25.75	-80.17	M	245	49	44
144397	4	26	2015	25.78	-80.08	F	270	308	96
146031	6	30	2015	25.60	-80.19	M	233	12	9
153288	1	5	2016	26.91	-79.06	F	324	283	199
153289	1	6	2016	26.91	-79.06	F	387	286	179
159313	4	3	2017	26.96	-80.01	F	240	435	166
159310	6	29	2017	25.70	-80.09	F	280	140	56
174032	4	28	2018	26.91	-79.07	F	258	283	281
175438	4	28	2018	26.91	-79.07	F	255	131	127
19687	10	25	2018	25.78	-80.09	F	339	10	4
175437	1	8	2019	26.91	-79.07	F	327	29	28
175439	1	8	2019	26.91	-79.07	F	334	297	295
176751	1	8	2019	26.91	-79.07	F	340	297	248
19802	1	13	2019	26.91	-79.07	F	328	232	220

Table S3. Description of spatial protections in the subtropical western North Atlantic that prohibit pelagic longlines (PLL), bottom longlines (BLL) or both annually or seasonally. See Fig. S1 for a spatial map of these zones. Information based on the U.S. National Oceanic and Atmospheric Association Highly Migratory Species Compliance Guide for Commercial Fishing downloaded from https://www.fisheries.noaa.gov/topic/atlantic-highly-migratory-species.

Location	Abbreviation	When Gear is Prohibited	Type of Longline Gear Restricted
Northeast Closed Area	NECA	June	PLL
Mid-Atlantic Shark Closed Area	MASA	Jan. 1 – July 31	BLL
Charleston Bump Closed Area	CBCA	Feb. 1 - April 30	PLL
South Atlantic Marine Protected Areas	SAMPAs	All Year	BLL
Gray's Reef National Marine Sanctuary	GRNMS	All Year	PLL & BLL
South Atlantic Deepwater Coral HAPCs	SAFMC	All Year	BLL
East Florida Coast Closed Area	EFCA	All Year	PLL
Florida Keys National Marine Sanctuary	FKNMS	All Year	PLL & BLL
The Dry Tortugas Marine Reserves	DRTO	All Year	PLL & BLL
Bahamas Exclusive Economic Zone	BAH	All Year	PLL & BLL

Fig. S1 Spatial protections in the subtropical western North Atlantic. These spatial management zones prohibit the use of pelagic longline (PLL), bottom longline (BLL) or both PLL and BLL fishing gear seasonally or year-round. NECA = Northeast Closed Area; MASA = Mid-Atlantic Shark Closed Area; CBCA = Charleston Bump Closed Area; SAMPAs = South Atlantic Marine Protected Areas; GRNMS = Gray's Reef National Marine Sanctuary; SAFMC = South Atlantic Deepwater Coral HAPCs; EFCA = East Florida Coast Closed Area; FKNMS = Florida Keys National Marine Sanctuary; DRTO = The Dry Tortugas Marine Reserves; BAH = Bahamas Exclusive Economic Zone. See Table S3 for details for details related to each spatial protection. Provided for spatial reference, two letter abbreviations for US states are FL = Florida, SC = South Carolina, NC = North Carolina, VA = Virginia, and PA = Pennsylvania.

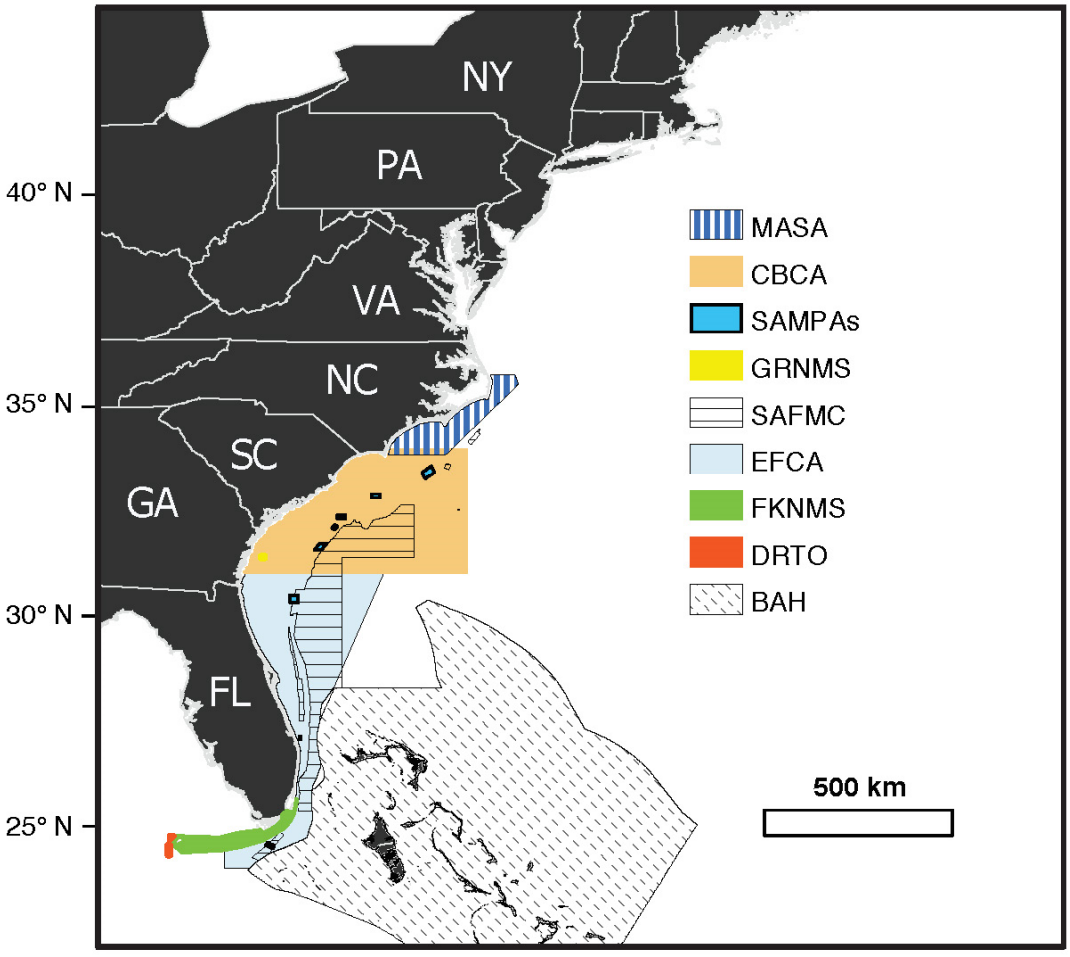

Fig. S2. Composite map of averaged sea-surface temperature (SST) anomalies during all days where at least one individual tiger shark was tracked (A) south of 30°N (N=2,967 positions) versus (B) north of 35°N (N=998 positions) versus (C) north of 40°N (N=290 positions). Here, SST anomalies were based on deviations from the SST averaged between 1971 and 2000. Scale bar represents the numbers of °C deviation in in SST from the 1971-2000 average. Note that white pixels overwater in the top-right corner of the plots are the Azores.

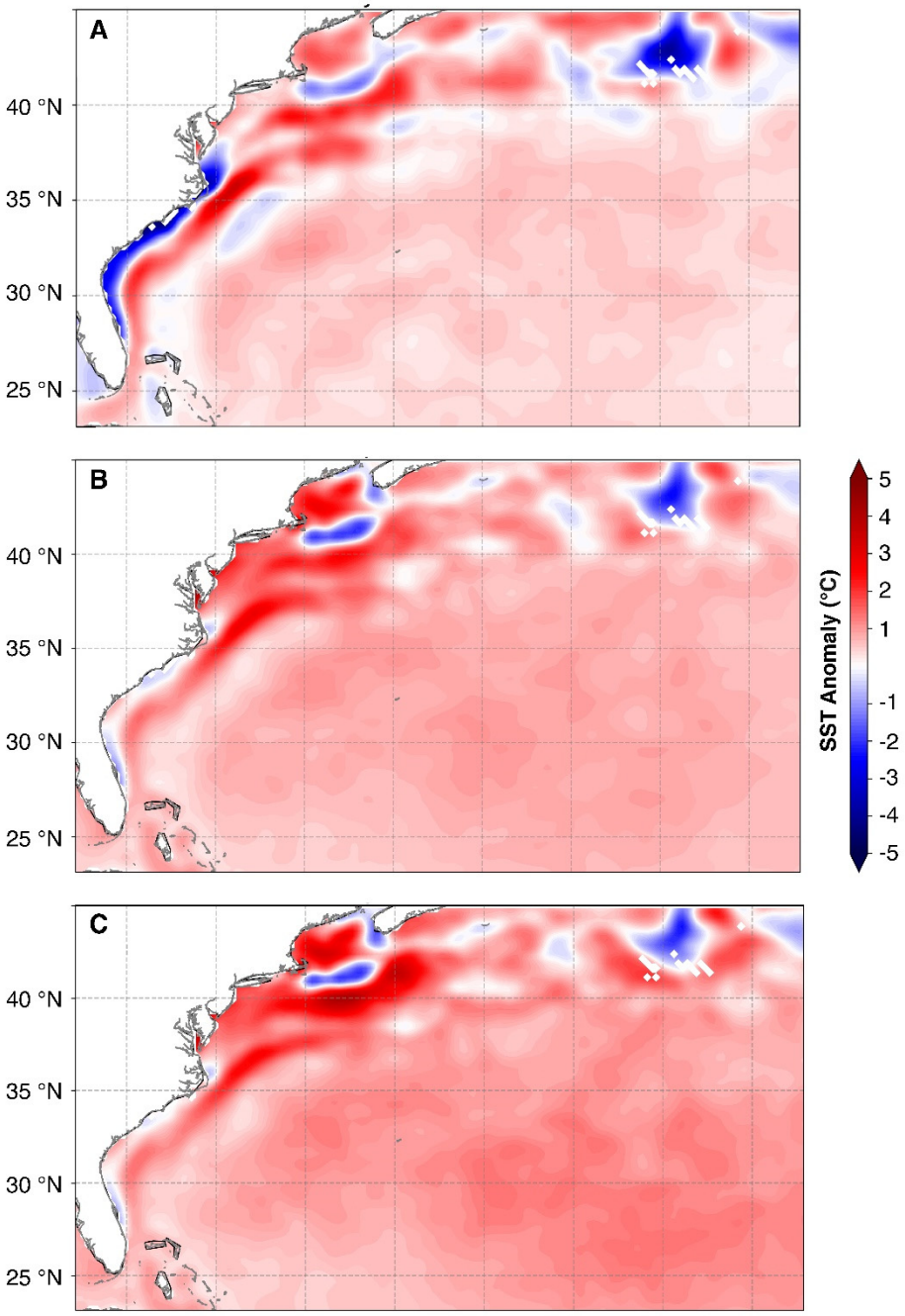

Fig. S3. Location of tiger shark captures (N=8,764) between 1980-2018 reported to the National Marine Fisheries Service Cooperative Shark Tagging Program. Data are raw tag-recapture locations by decade during the cold season (November-April; top row) and the warm season (May-October; bottom row). See Fig. 7 of main text for plots of high catch density areas by decade.

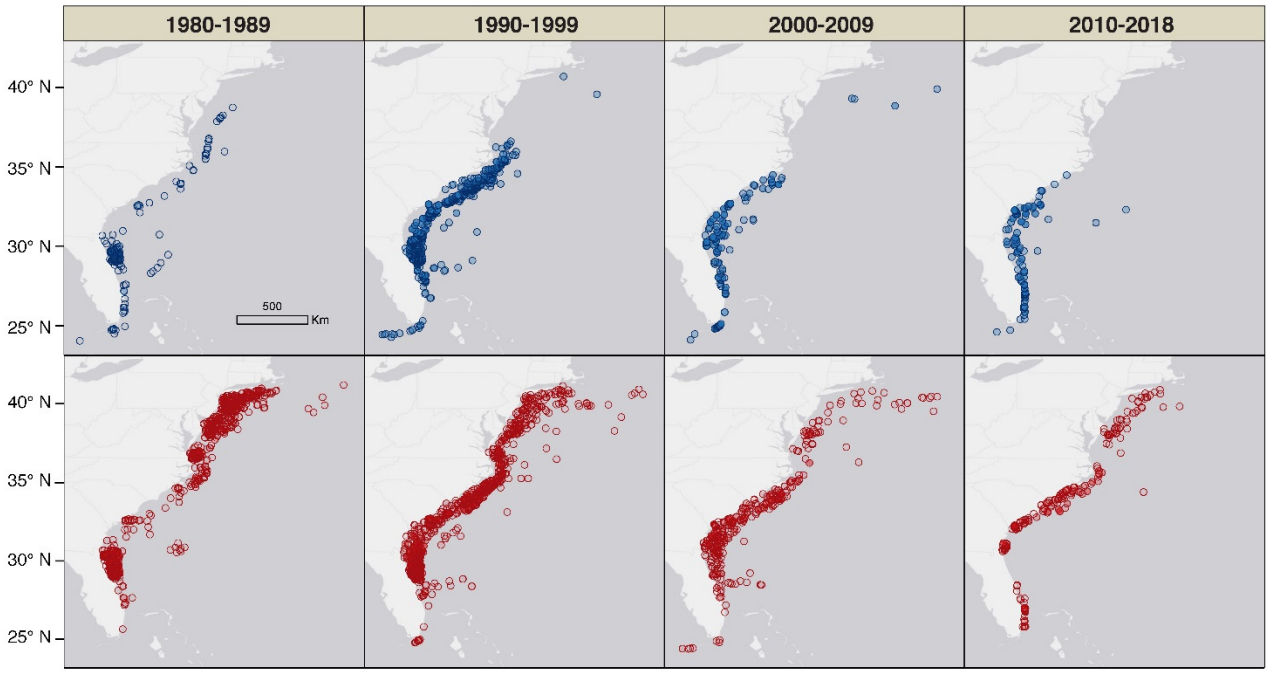

Fig. S4 Composite map of sea-surface temperature (SST) anomalies averaged by decade in the cold months (top row) and warm months (bottom row). Here, SST anomalies were based on deviations from the SST averaged between 1805-1979. Scale bar represents the numbers of °C deviation in in SST from the 1850-1979 historical average.