Supplementary Materials for

Temperature amplification and marine heatwave alteration in shallow coastal bays

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This PDF file includes:

Figs. S1 to S9
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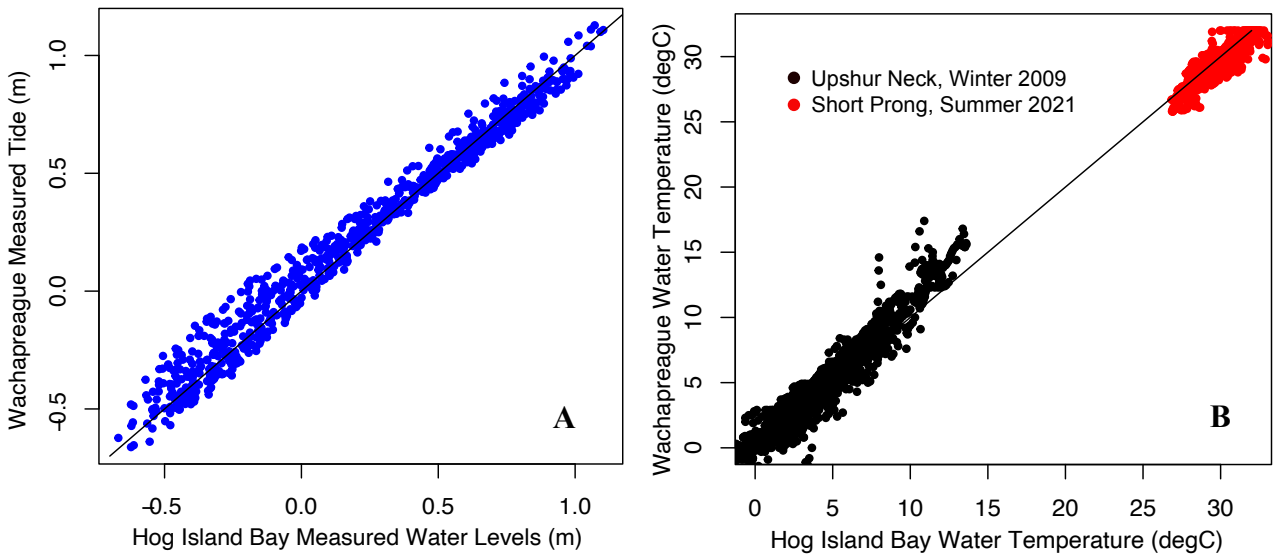

Fig. S1. Comparison of **A**) water levels and **B**) water temperatures at Wachapreague, VA and in Hog Island Bay (Fig. 1A). Water levels and temperature (red; summer) were measured near Short Prong on the southern side of the bay and temperature (black; winter) was also measured at Upshur Neck on the northern side of the bay. Wachapreague water temperatures averaged less than 0.5°C higher in summer and lower in winter than water temperatures in records from Hog Island Bay over the same time period.

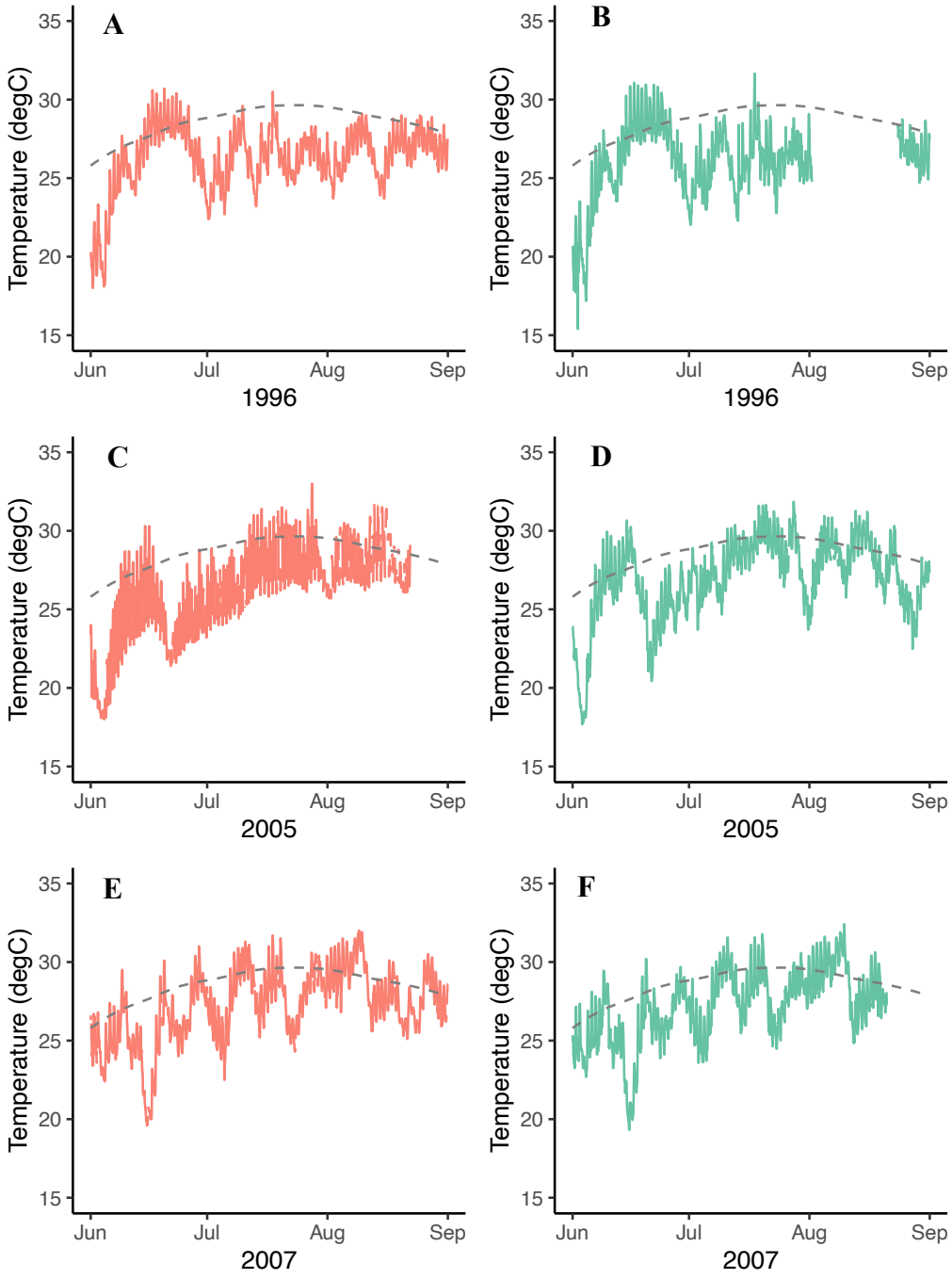

Fig. S2. Comparison of summer hourly water temperatures at Wachapreague, VA (left) and Redbank, VA (right) in **A, B**) 1996, **C, D**) 2005, and **E, F**) 2007 illustrating the apparent error in water temperatures recorded at Wachapreague between 1998-2005 (2005 shown for example in **C, D**) compared to prior and following years. Other than that period of time, the correlation between Wachapreague and Redbank hourly water temperatures was 0.95.

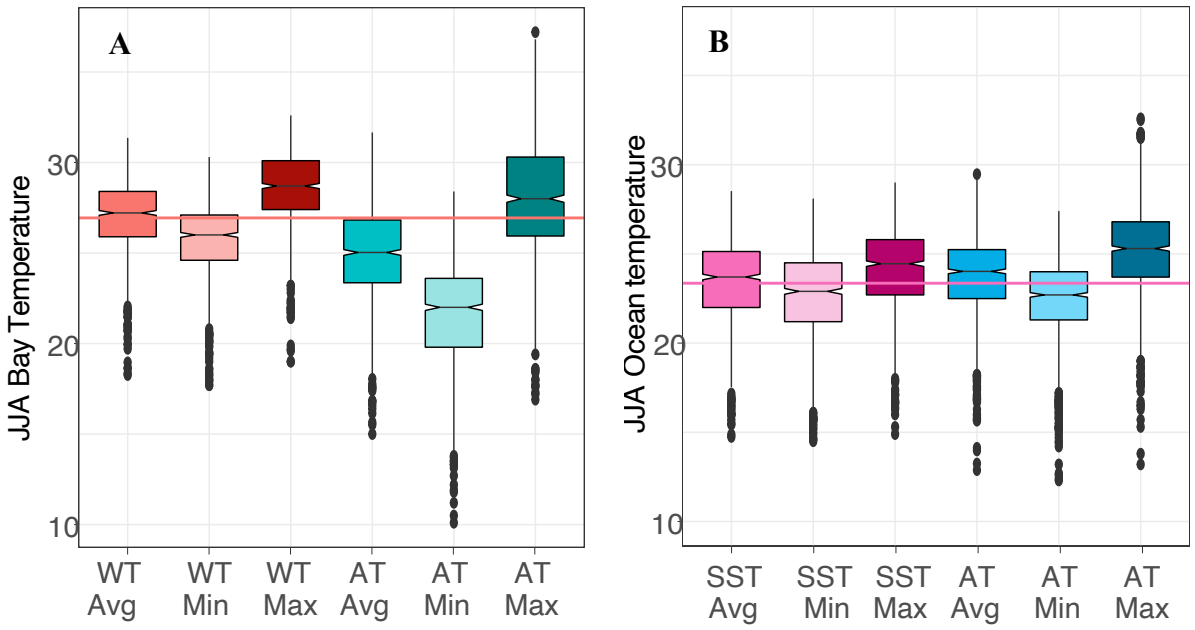

Fig. S3. Comparison of daily average, daily minimum, and daily maximum water (WT/SST) and air (AT) temperature at the **A**) coastal bay site and **B**) coastal ocean site during June, July, and August (JJA). Details of datasets are described in the Methods. The horizontal lines show the mean JJA water temperatures.

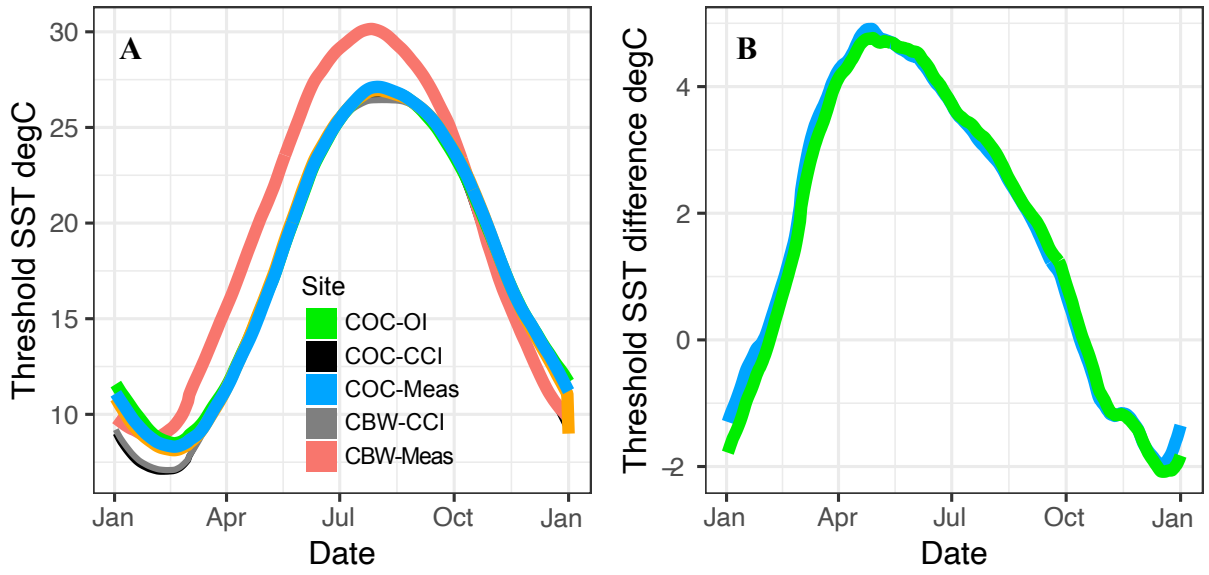

Fig. S4. A) Threshold climatology and **B**) bay-ocean threshold difference between CBW-Meas and COC-OI (green) and COC-Meas (blue).

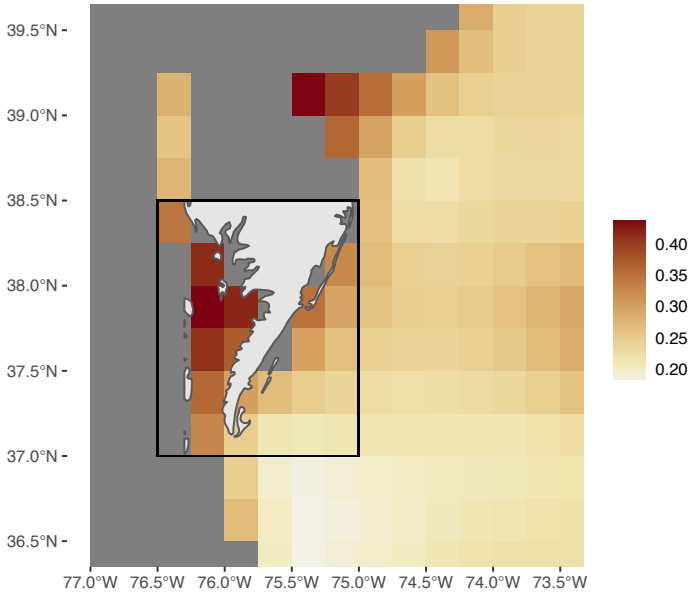

Fig. S5. Mean error index for OISST-V2 during the June 2015 MHW shown in Fig. 1.

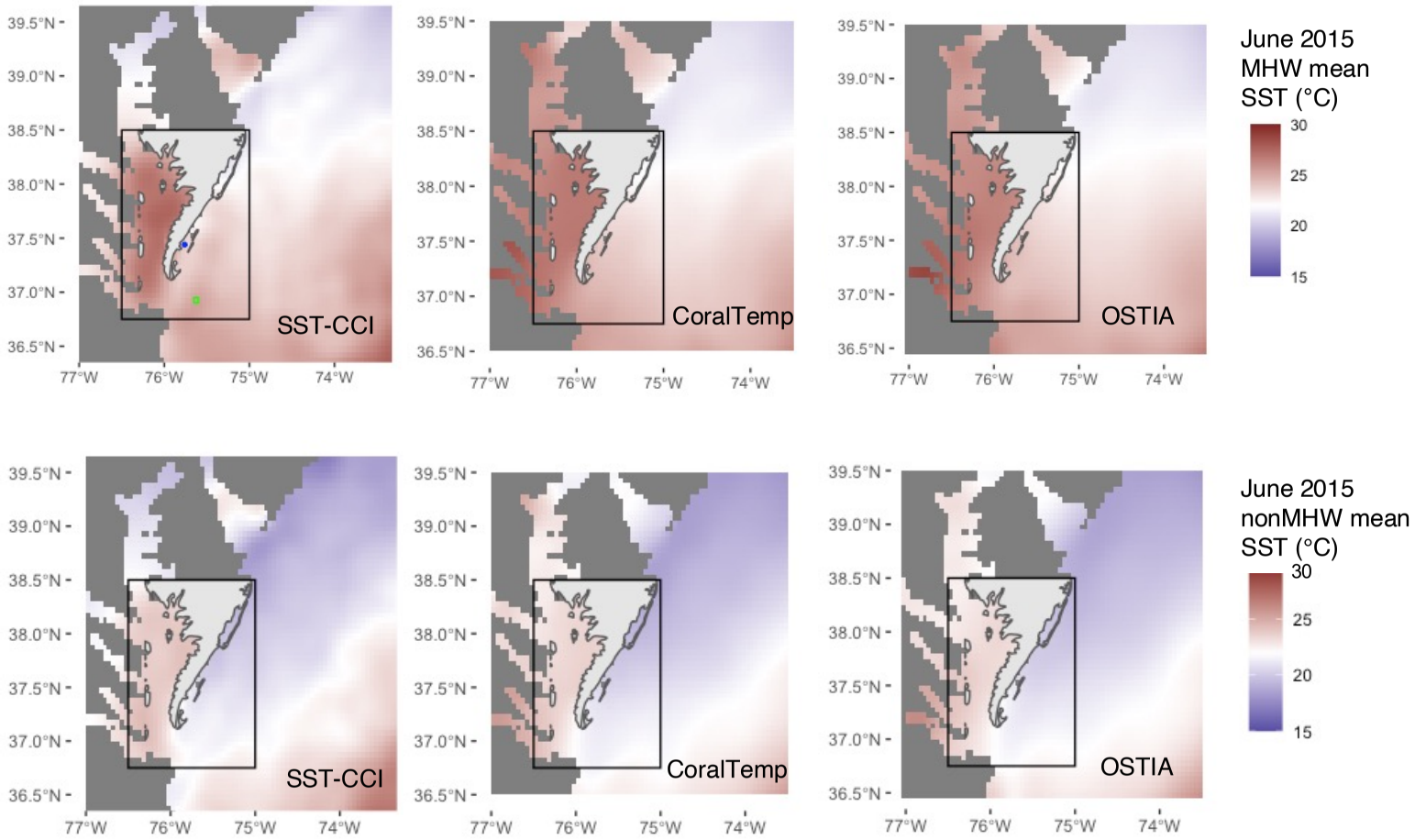

Fig. S6. Comparison of SST-CCI/CS3, CoralTemp, and OSTIA mean temperature fields during the June 2015 MHW (June 12-25; top row) and during the non-MHW days of June 2015 (June 1-11 & 26-30; bottom row).

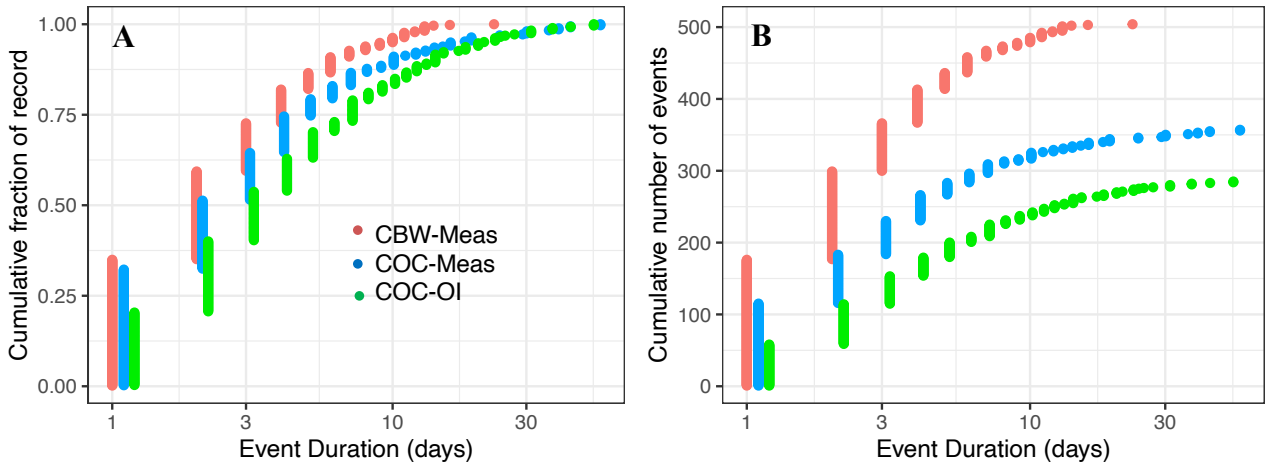

Fig. S7. A) Cumulative distribution of the durations of MHW threshold exceedance events for the gridded (COC-OI) and measured (COC-Meas) coastal ocean SST time series and the measured coastal bay (CBW-Meas) time series. Event durations are offset slightly to avoid overlap. **B**) Cumulative distribution of the total number of events of varying duration in the 1982-2020 records for each of the 3 records shown in **A**.

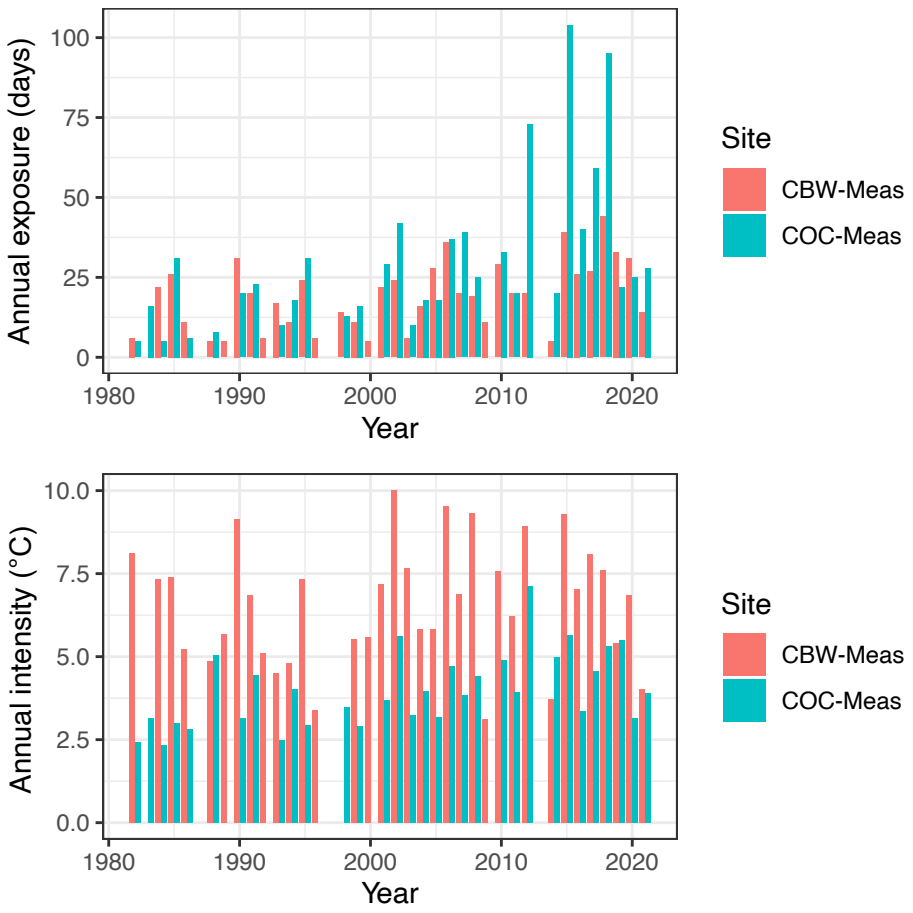

Fig. S8. A) Annual MHW exposure and **B**) MHW intensity for the measured records (1982-2021) at the coastal ocean (COC-Meas) and coastal bay (CBW-Meas) sites based on results in Table S5.

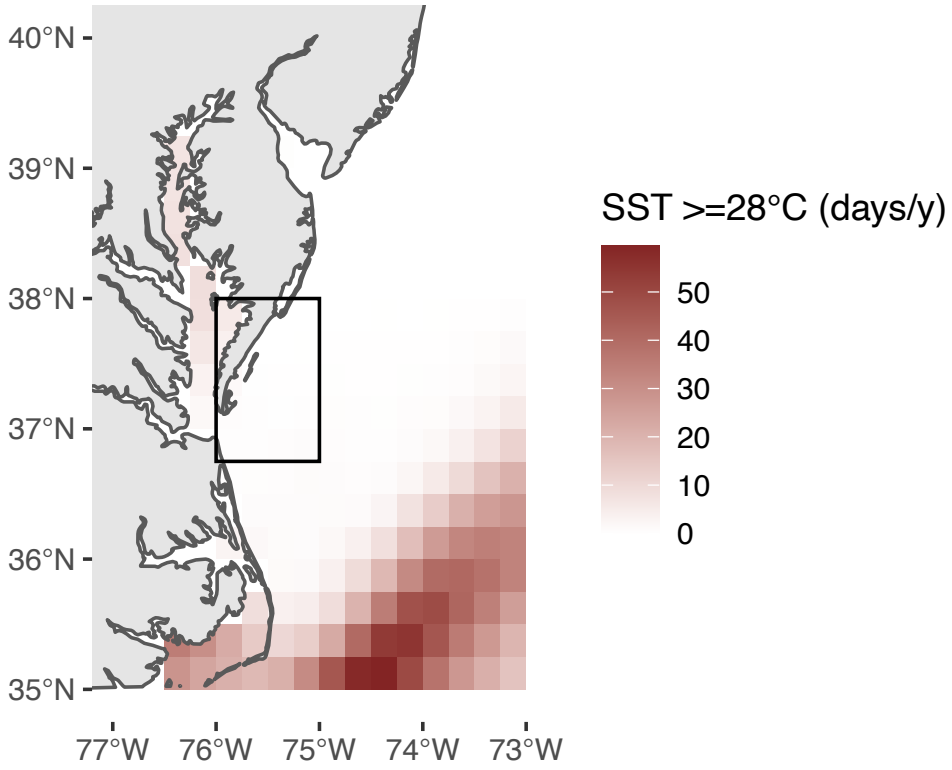

Fig. S9. Number of days/y with SST ≥ 28°C along the U.S. mid-Atlantic margin from 1982-2020. The black rectangle outlines the region that is the focus of this study.

Table S1. SST climatology and MHW threshold extremes

Site	Source	Max SST in climatology	Min SST in climatology	Max MHW threshold SST	Min MHW threshold SST
Coastal ocean site (36.91N, 75.71W)					
COC-Meas	NDBC	25.0 (14 Aug)	6.1 (17 Feb)	27.1 (30 Jul)	8.3 (17 Feb)
COC-OI	OISST-V2.1	25.4 (3 Aug)	6.4 (18 Feb)	27.0 (1 Aug)	8.5 (17 Feb)
COC-CCI	SST CCI/CS3	25.2 (6 Aug)	6.1 (16 Feb)	27.0 (31 Jul)	8.1 (17 Feb)
Coastal bay site (37.61N, 75.69W)					
CBW-Meas	NOAA/VCR-LTER	28.0 (23 Jul)	4.9 (30 Jan)	30.2 (25 Jul)	8.7 (31 Jan)
CBW-CCI	SST CCI/CS3	25.1 (16 Aug)	5.0 (8 Feb)	26.5 (12 Aug)	7.0 (7 Feb)

Table S2. Metrics for June 2015 MHW (12-26 June)

Site	MHW Duration (days)	MHW Peak SST (°C)	MHW Intensity* (°C)	CIRT† (°C-days)
COC-Meas	16	26.5	4.7	19.1
COC-OI	14	25.7	3.8	12.9
COC-CCI	6 (+4)	26.7	3.7	7.9
CBW-Meas	13	28.9	3.8	7.6
CBW-CCI	0 ‡	25.5	2.6	0

*MHW intensity = max SST anomaly during MHW
†CIRT = cumulative days above threshold, the difference between daily SST and threshold summed over the duration of the heat wave
‡5 nonconsecutive days above threshold. Peak SST and intensity are based on highest SST during the 5 days

Table S3. Correlation coefficients for SST anomaly time series 1982-2021 for the coastal ocean (COC) and coastal bay (CBW) sites

	COC-Meas	COC-OI	COC-CCI	CBW-Meas	CBW-CCI
COC-Meas	1				
COC-OI	0.86	1			
COC-CCI	0.80	0.78	1		
CBW-Meas	0.64	0.62	0.57	1	
CBW-CCI	0.67	0.66	0.76	0.55	1

Table S4. Correlation coefficients for SST anomaly time series 2007-2021* for the coastal ocean (COC) and coastal bay (CBW) sites

	COC-Meas	COC-OI	COC-CCI	COC-OSTIA*	CBW-Meas	CBW-CCI	CBW-OSTIA*
COC-Meas	1						
COC-OI	0.92	1					
COC-CCI	0.88	0.88	1				
COC-OSTIA*	0.90	0.89	0.89	1			
CBW-Meas	0.68	0.69	0.61	0.64	1		
CBW-CCI	0.73	0.74	0.76	0.71	0.61	1	
CBW-OSTIA*	0.71	0.76	0.70	0.75	0.60	0.73	1

* The anomaly time series for these correlations were determined using the seasonal climatology calculated over 2007-2021 for each record rather than the 1987-2016 seasonal climatologies used in Table 3 and all other calculations involving the 40-yr time series from 1982-2021.

Table S5. MHWs from 1982-2021 [Gray shading indicates MHW conditions in all 3 records]

Ev#	BegDate	EndDate	CBW-MWT*			COC-MWT*			COC-OI*		
			Dur	CIRT	Tpk	Dur	CIRT	Tpk	Dur	CIRT	Tpk
1	7/24/82	7/28/82	0	-	29.4	**5**	0.9	27.3	**5**	1.3	27.3
2	12/2/82	12/7/82	**6**	13.0	16.8	3	0.9	14.5	3	0.8	14.5
3	7/14/83	7/19/83	2	0.8	30.3	**6**	3.5	27.8	**6**	3.8	27.8
4	9/4/83	9/14/83	4	4.3	29.1	**11**	6.8	27.1	**11**	8.3	27.1
5	8/13/84	8/17/84	2	0.3	29.6	**5**	1.8	27.3	**5**	1.8	27.3
6	10/20/84	11/4/84	**16**	33.1	22.7	3	0.4	19.8	**7**	3.6	20.6
7	12/29/84	1/3/85	**6**	8.7	11.8	4	0.3	11.5	0	-	11.5
8	9/4/85	9/11/85	8	17.5	30.4	7	4.9	26.9	7	2.1	26.2
9	10/13/85	10/29/85	3	2.8	23.2	3	0.1	19.9	**15**	5.6	22.8
10	11/11/85	12/5/85	12+ 6	19.5	18.5+ 13.5	24	15.7	17.7	18	10.8	17.8
11	12/21/85	12/27/85	0	-	4.7	1	1.5	13.4	**7**	5.5	13.6
12	9/26/86	10/6/86	11	11.3	26.3	6	4.6	24.5	6	3.8	24.3
13	3/31/88	4/8/88	5	5.4	18.1	8	11.3	14.9	6	53	13.3
14	1/31/89	2/4/89	**5**	3.6	10.6	1	<0.1	8.6	**7**	5.6	10.1
15	1/30/90	2/4/90	**6**	3.4	10.3	0	-	7.8	0	-	8.1
16	2/14/90	2/23/90	10	17.9	13.5	7	3.0	9.2	8	3.8	9.3
17	3/10/90	3/20/90	**8**	25.3	18.8	4	3.4	11.2	**10**	6.9	11.8
18	10/8/90	10/25/90	11	19.6	25	13	11.6	23.2	14	8.5	23.2
19	2/2/91	2/10/91	4	4.5	10.3	3	0.6	8.8	**9**	3.6	9.6
20	3/4/91	3/10/91	4	2.1	12.9	**5**	1.6	9.5	**7**	3.8	10.2
21	4/5/91	4/12/91	**5**	9.8	20.8	**5**	7.2	14.6	4	1.7	13.6
22	5/11/91	5/18/91	4	4.0	25	**7**	6.4	20.4	**7**	4.6	19.5
23	5/26/91	6/4/91	10	17.7	28.8	6	8.1	23.9	6	5.6	23.1
24	7/21/91	7/25/91	**5**	4.5	31.7	2	0.4	27.3	3	0.5	27.3
25	11/23/92	11/28/92	**6**	5.6	15.2	0	-	14.1	0	-	13.8
26	7/6/93	7/15/93	10	15.9	32.1	5	1.6	26.9	5	1.6	26.9
27	8/28/93	9/8/93	12	4.1	28.9	5	1.8	26.8	7	2.0	26.8
28	1/6/94	1/10/94	0	-	4.9	**5**	0.6	10.7	0	-	10.7
29	4/27/94	5/1/94	**5**	5.1	22.2	0	-	15.4	3	1.1	16.2
30	6/15/94	6/23/94	6	3.9	29.0	6	4.9	25.6	8	3.7	25.2
31	12/11/94	12/17/94	0	-	10.5	**7**	8.2	14.7	**7**	7.6	14.7
32	1/14/95	1/20/95	**7**	8.9	12.4	3	0.6	10.1	0	-	10.1
33	7/12/95	8/5/95	5+1 3	1.1 + 5.6	31.2	16	6.6	27.8	9	4.3	27.8
34	10/18/95	11/8/95	2	2.0	19	**16**	6.8	20.6	**21**	9.4	21.2
35	6/15/96	6/20/96	**6**	2.0	28.7	0	-	23.4	1	<0.1	24.4

36	3/27/98	4/3/98	**8**	21.2	20.0	4	1.3	11.9	3	0.9	11.8
37	12/1/98	12/16/98	6	14.3	16.3	13	8.4	15.3	12	9.2	15.7
38	2/10/99	2/15/99	1	<0.1	9.15	**6**	1.3	8.8	0	-	6.6
39	7/30/99	8/3/99	1	0.2	30.2	**5**	1.9	27.9	0	-	26.8
40	11/18/99	11/29/99	6	5.2	15.8	5	1.3	15.5	12	8.0	16.7
41	12/10/99	12/23/99	2	1.3	11.7	2	0.5	13.9	**14**	3.5	13.9
42	12/31/99	1/4/00	**5**	3.4	10.7	0	-	11.4	1	<0.1	11.4
43	2/8/00	2/28/00	**5**	7.6	12.7	4	3.8	9.4	**12**	13.9	10.7
44	3/9/00	3/14/00	3	4.8	14.8	3	2.2	10.4	**6**	4.2	10.4
45	5/6/00	5/11/00	4	8.9	25.0	1	<0.1	17.7	**5**	2.7	17.8
46	11/24/01	12/27/01	23	32.6	16.8	29	26.8	15.5	24	16.4	15.5
47	1/24/02	2/10/02	10	20.8	12.7	7	7.3	12.2	18	29.6	12.2
48	3/14/02	3/19/02	0	-	13.1	4	1.7	10.8	**6**	3.2	10.8
49	4/14/02	4/22/02	8	30.7	25.3	9	14.8	16.7	9	22.2	17.4
50	7/29/02	8/6/02	4	1.2	30.5	**8**	6.4	28.5	**7**	2.3	27.5
51	9/21/02	10/9/02	6	8.8	26.1	19	12.8	25.0	11	7.5	24.8
52	10/31/03	11/9/03	6	15.7	21.4	10	8.5	19.9	10	8.9	19.9
53	5/10/04	5/19/04	10+ 6	10.0 + 9.3	27.5	14	9.2	21.8	14	10.4	21.8
54	7/12/04	7/16/04	0	-	29.0	**5**	2.6	27.2	**5**	2.8	27.2
55	1/4/05	1/8/05	**5**	4.5	11.7	0	-	9.5	0	-	9.5
56	8/2/05	8/23/05	13	8.5	31.1	6+7	2.8 + 4.9	28.1	6+7	3.0 + 4.9	28.1
57	8/29/05	9/2/05	1	0.7	29.1	**5**	1.2	26.8	**5**	1.3	26.8
58	9/17/05	9/23/05	**7**	5.4	27.6	1	0.2	25.0	2	0.4	24.6
59	10/5/05	10/9/05	**5**	6.5	25.5	2	0.3	23.3	2	0.6	23.3
60	1/20/06	1/25/06	**6**	3.0	9.6	1	0.1	9.2	0	-	9.2
61	3/11/06	3/13/06	**5**	12.3	18.8	4	3.6	11.1	3	2.7	11.1
62	7/31/06	8/7/06	7	10.5	32.7	7	2.8	28.1	7	3.0	28.1
63	11/12/06	11/18/06	**7**	4.7	17.1	0	-	16	**7**	4.7	16
64	12/26/06	1/24/07	11	17.0	14.1	30	41.7	12.9	25	28.7	12.9
65	8/1/07	8/13/07	4	3.7	31.3	**10**	5.0	28.6	**13**	5.3	28.6
66	9/3/07	9/12/07	4	3.5	28.2	4	1.4	26.8	**9**	2.5	26.8
67	10/3/07	11/2/07	9+1 1	22.0+ 24.0	26.5	30	29.1	24.5	31	33.3	24.5
68	1/9/08	1/18/08	**5**	4.3	10.8	**8**	1.8	10.5	0	-	10.46
69	2/4/08	2/10/08	**7**	17.5	14.5	1	<0.1	8.5	0	-	8.5
70	3/4/08	3/15/08	2	2.9	13.5	**12**	3.9	10.2	2	0.21	9.4
71	6/8/08	6/12/08	7	11.6	30.3	5	5.4	25.0	5	5.70	25.0
72	8/18/09	8/30/09	**13**	6.0	29.9	1	0.1	26.5	0	-	26.3

73	3/31/10	4/9/10	**5**	13.8	21.2	**9**	13.8	14.7	3	2.6	13.4
74	5/1/10	5/7/10	6	12.0	24.0	7	6.5	18.3	5	3.5	17.8
75	5/30/10	6/8/10	8	10.5	29.4	10	9.1	24.7	5	5.9	24.4
76	6/16/10	6/28/10	10	11.4	30.6	7	8.5	26.5	13	21.7	27.8
77	8/19/10	8/23/10	4	0.4	26.8	4	0.4	26.8	**5**	2.2	27.2
78	4/23/11	4/30/11	**6**	10.4	23.0	3	2.8	16.4	4	4.5	16.6
79	5/23/11	6/14/11	9	15.7	28.9	7	4.3	24.5	23	25.7	24.7
80	7/23/11	8/12/11	5	2.4	30.9	15	8.1	28.2	15	8.6	28.2
81	2/2/12	2/10/12	1	0.4	9.1	**9**	4.1	9.2	**5**	0.5	8.9
82	2/22/12	4/5/12	14	43.7	19.8	36	55.6	15.3	43	52.6	15.1
83	4/14/12	4/18/12	2	2.6	20.3	4	5.9	16.0	**5**	4.4	15.3
84	5/1/12	5/5/12	1	0.6	22.0	4	4.3	18.4	**5**	3.8	17.8
85	5/23/12	6/1/12	4	2.4	26.3	**10**	11.0	22.9	**9**	7.1	22.5
86	6/30/12	7/19/12	6	4.8	31.0	8+5	8.1+ 3.4	27.7	20	12.1	27.8
87	8/31/12	9/7/12	2	1.0	28.3	**7**	3.2	26.6	**8**	3.4	26.8
88	5/8/14	5/15/14	3	2.9	24.6	**7**	9.1	20.7	**7**	10.3	20.5
89	6/16/14	6/20/14	2	1.5	29.1	**6**	3.5	25.7	**5**	3.8	25.3
90	9/1/14	9/7/14	5	5.3	29.1	7	4.7	27.1	7	6.8	27.3
91	10/14/14	10/18/14	2	0.7	21.9	2	0.3	22.0	**5**	1.2	21.9
92	5/9/15	5/13/15	**5**	3.9	23.9	1	0.8	18.3	0	-	16.9
93	6/11/15	6/26/15	13	7.6	29.8	16	19.1	26.5	14	12.9	26.0
94	7/25/15	8/3/15	0	-	29.4	**10**	2.6	27.5	**7**	1.9	27.4
95	8/31/15	9/13/15	5	3.5	28.8	14	8.3	26.9	14	7.3	26.8
96	9/18/15	9/22/15	2	0.6	26.4	**5**	2.7	25.5	4	1.7	25.3
97	11/5/15	11/23/15	3	5.1	19.3	**19**	10.7	18.6	**5+5**	1.5+ 1.1	18.6
98	11/28/15	1/11/16	7+1 1	15.3+ 40.5	15.0	43	57.4	15.5	5+31	1.3+ 38.7	15.2
99	3/10/16	3/18/16	**9**	13.3	15.9	2	1.0	10.1	2	0.5	10.0
100	7/6/16	7/29/16	6	4.8	31.2	6	3.5	28.1	10	3.6	27.6
101	8/10/16	8/22/16	11	9.5	31.1	10	10.1	28.4	11	8.2	28.1
102	8/27/16	9/2/16	2	0.2	28.4	**6**	3.1	26.9	**6**	2.9	26.9
103	9/18/16	10/5/16	3	1.0	24.6	**18**	8.0	25.3	**17**	9.9	25.3
104	2/20/17	3/3/17	10	25.7	15.5	12	11.2	10.2	11	8.7	10.7
105	4/27/17	5/4/17	6	12.8	24.6	5	8.8	18.1	8	11.7	18.9
106	8/18/17	8/25/17	1	0.2	29.0	3	1.0	27.2	**8**	3.0	27.4
107	10/5/17	11/14/17	6+5	8.7+5. 7	25.5	39	27.6	24.1	37	27.2	24.0
108	12/2/17	12/8/17	0	-	12.2	**6**	1.0	14.7	**7**	1.2	14.8

109	2/20/18	3/1/18	**8**	14.2	14.0	0	-	8.3	1	0.2	9.1
110	5/12/18	6/3/18	5	2.5	26.4	5+12	1.1+16.8	24.6	23	22.3	24.8
111	6/17/18	7/6/18	7	7.0	30.8	19	26.5	28.8	20	27.1	28.7
112	8/4/18	8/10/18	1	0.2	30.0	3	0.9	27.4	**7**	2.1	27.6
113	8/27/18	10/22/18	13+11	22.8+26.0	30.5	55	82.8	28.5	52	74.8	28.0
114	11/5/18	11/10/18	3	1.1	17.5	**6**	2.7	18.5	4	1.6	18.6
115	4/29/19	5/12/19	4	8.2	24.1	**6**	6.5	19.2	**14**	14.9	19.9
116	5/23/19	6/3/19	7	9.1	28.1	10	13.9	24.0	12	21.1	24.3
117	6/26/19	7/7/19	**5**	2.2	30.2	3	1.6	26.1	**11**	4.4	26.6
118	7/12/19	7/22/19	9	4.4	31.3	6	1.7	27.1	10	5.6	27.6
119	8/18/19	8/23/19	**6**	3.7	30.1	0		26.6	1	0.02	26.9
120	9/23/19	10/4/19	3	2.9	25.2	3	1.3	24.1	**12**	8.4	25.0
121	10/27/19	11/1/19	**6**	3.3	19.9	2	0.2	19.3	**5**	0.8	19.7
122	1/12/20	1/16/20	**5**	11.6	12.1	4	2.3	10.4	2	0.4	10.6
123	3/10/20	3/15/20	2	1.8	13.9	4	2.5	10.4	**5**	2.4	10.4
124	7/2/20	7/30/20	13	7.4	31.3	10	5.2	27.9	27	17.3	28.2
125	9/1/20	9/5/20	3	3.2	29.4	3	1.5	26.8	**5**	5.1	27.3
126	10/21/20	10/31/20	**5**	5.1	21.2	4	0.9	19.8	**8**	2.2	20.8
127	11/8/20	11/19/20	9	12.7	19.5	10	8.0	18.6	10	5.1	18.5
128	11/25/20	12/1/20	2	1.3	14.1	**5**	1.7	15.5	3	0.9	15.7
129	8/11/21	9/1/21	9	12.5	30.4	17	21.4	28.6	21	22.0	28.3
130	9/15/21	9/19/21	**5**	1.7	27.0	2	0.45	25.3	1	0.13	24.9
131	10/3/21	10/10/21	2	1.4	34.1	**6**	1.3	23.4	**8**	2.4	23.5
132	10/21/21	10/27/21	2	1.2	27.3	**5**	1.3	20.6	**7**	3.4	21

*Dur=duration; only durations ≥ 5 days are counted as MHWs. Smaller values correspond to the largest number of consecutive days over the site threshold during an interval defined as a MHW in one of the other records. CIRT = cumulative days above threshold, the difference between daily SST and threshold summed over the duration of the heat wave. Tpk = peak SST during the indicated MHW event regardless of whether temperatures in a given record qualify as a MHW.

Table S6. MHW metrics from the 1982-2100 simulations

Site	CBW-Meas	COC-Meas	COC-OI
Annual exposure			
Mean value in 2100 (days)	111 ± 3	217 ± 4	156 ± 4
Trend (days/decade)	8.5 ± 0.3	21.1 ± 0.7	13.6 ± 0.4
Annual intensity			
Mean value in 2100 (°C)	9.0 ± 0.1	6.9 ± 0.1	5.2 ± 0.1
Trend (°C/decade)	0.31 ± 0.01	0.34 ± 0.01	0.24 ± 0.01
Annual number of MHW events			
Mean value in 2100	9.1 ± 0.2	8.8 ± 0.2	7.4 ± 0.2
Trend (#/decade)	0.66 ± 0.01	0.87 ± 0.04	0.58 ± 0.01
Annual MHW duration			
Mean value in 2100	12.5 ± 0.3	27 ± 1	23 ± 1
Trend (#/decade)	0.45 ± 0.01	1.6 ± 0.1	1.3 ± 0.3
Days > 28°C			
Mean value in 2100	71 ± 1	37 ± 2	18 ± 1
Trend (#/decade)	3.9 ± 0.04	1.8 ± 0.2	1.3 ± 0.1