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Reconstructing patterns of coastal risk in space and time along the US Atlantic coast, 1970–2016

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Supplemental Figures

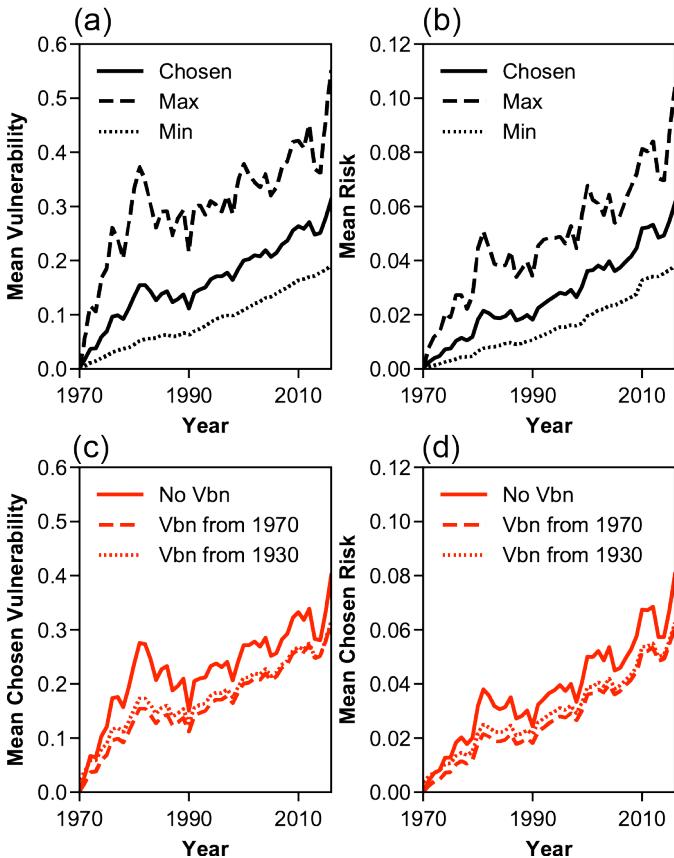


Figure S1. Sensitivity analysis. **(a)** Spread of mean vulnerability and **(b)** mean risk, for chosen vulnerability parameters (solid black), and parameters that create the maximum (dashed black) and minimum (dotted black) mean vulnerability. **(c)** Spread of mean vulnerability and **(d)** mean risk, using chosen vulnerability parameters without V_{bn} (solid red), with V_{bn} calculated from 1970 (dashed red), and V_{bn} calculated from 1930 (dotted red).

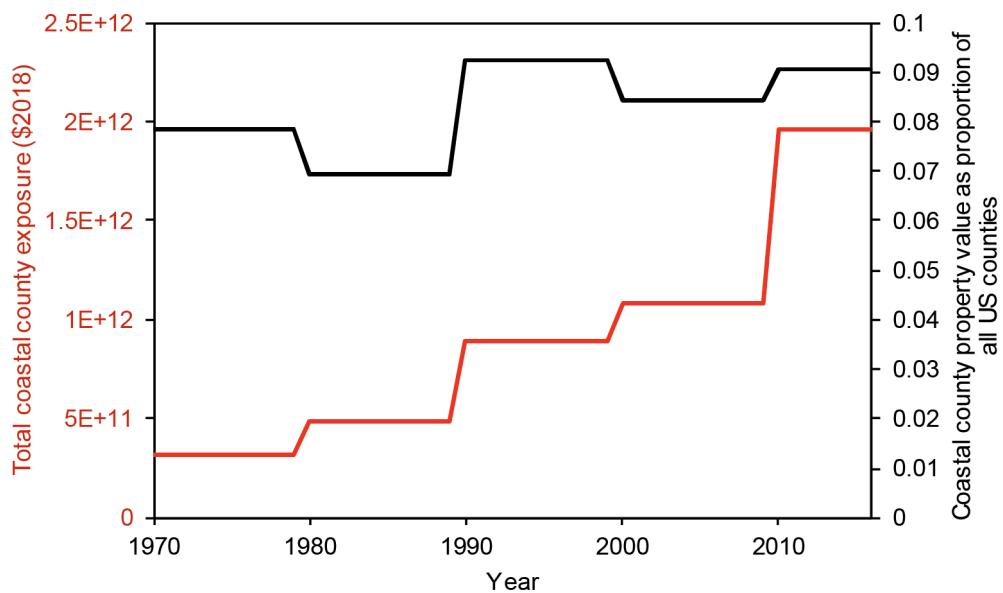


Figure S2 – Total exposure over time for 51 coastal counties in \$USD2018 (red, left axis), as a proportion of all US counties (black dashed, right axis).

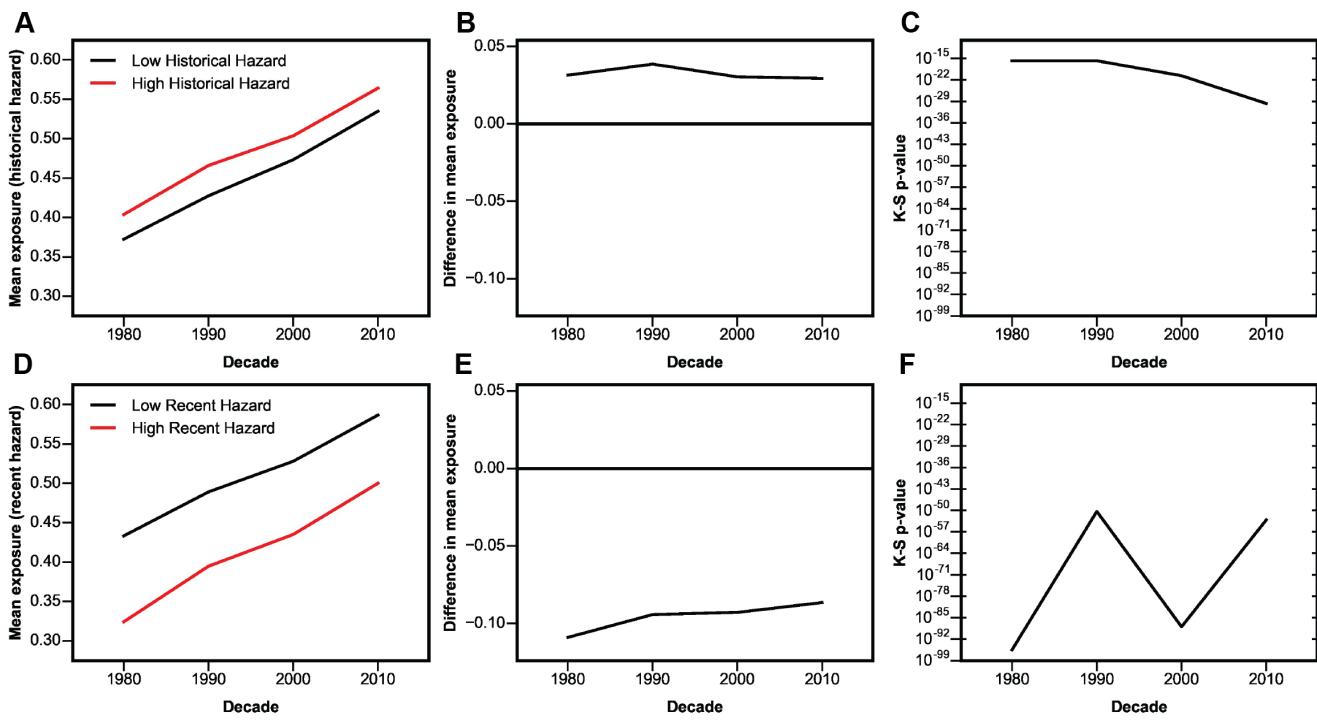


Figure S3 – Comparisons of property exposed to high and low (**a–c**) historical and (**d–f**) recent shoreline-change hazard, from Figure 7 (main text). Columns show mean exposure each decade, the relative difference between mean exposure to high and low hazard each decade, and the Kolmogorov-Smirnov *p*-value for the difference in distributions each decade. All *p*-values indicate that the distributions are statistically distinct (i.e., a rejection of the null hypothesis that the distributions are sampled from the same parent distribution).

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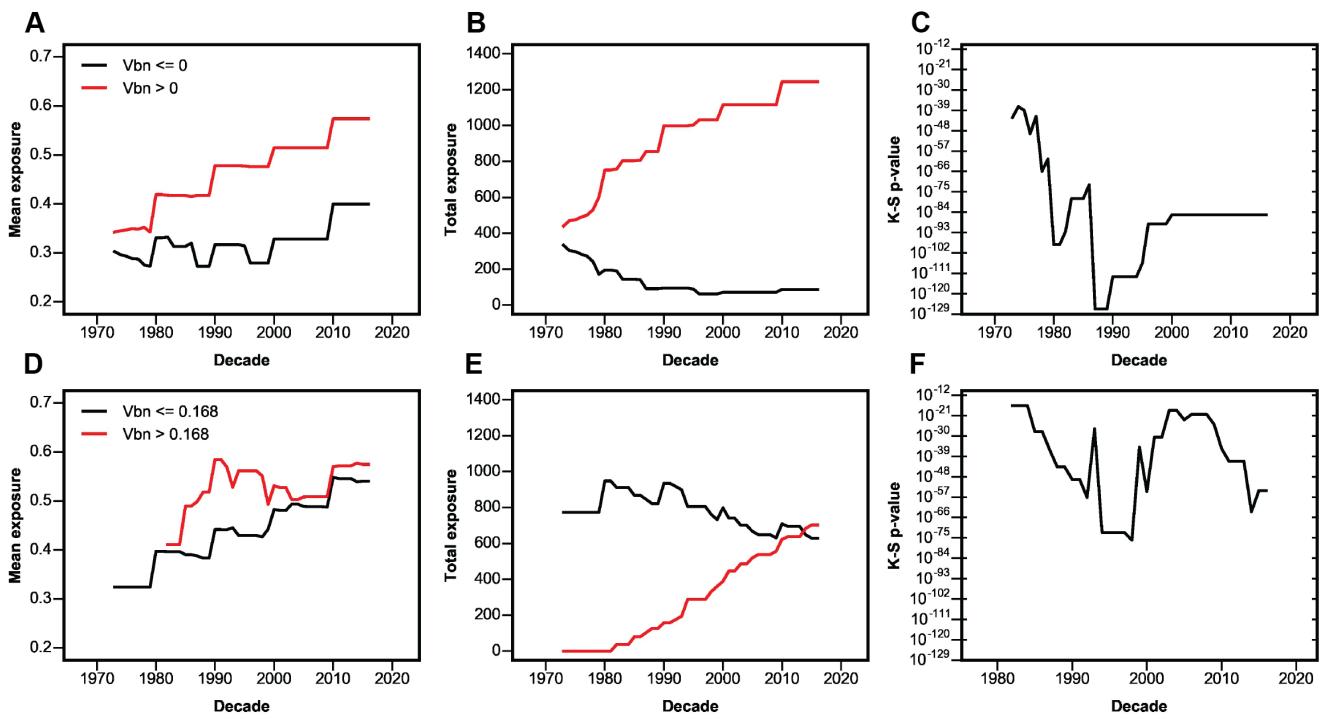


Figure S4 – Comparisons of property exposed (a–c) in counties that have and have not nourished, and (d–f) counties that have nourished more or less than the 2016 median V_{bn} . Columns show mean exposure each decade, total exposure each decade, and the Kolmogorov-Smirnov *p*-value indicating the relative difference in exposure distributions each decade for each condition (nourished versus non-nourished; above versus below median V_{bn}). All *p*-values indicate that the distributions are statistically distinct (i.e., a rejection of the null hypothesis that the distributions are sampled from the same parent distribution).

Supplemental Tables

Table S1. Tide gauges used to calculate sea-level change rates.

<i>Tide Gauge</i>	<i>Latitude</i>	<i>Longitude</i>
Bar Harbor, Frenchman Bay, ME	44.3917	-68.205
Boston, MA	42.3533	-71.0533
Woods Hole (Ocean. Inst.), MA	41.5233	-70.6717
Newport, RI	41.505	-71.3267
Montauk, NY	41.0483	-71.96
New York (The Battery), NY	40.7	-74.0133
Sandy Hook, NJ	40.4667	-74.0083
Atlantic City, NJ	39.355	-74.4183
Lewes (Breakwater Harbor), DE	38.7817	-75.12
Kiptopeke Beach, VA	37.165	-75.9883
Wilmington, NC	34.2267	-77.9533
Charleston I, SC	32.7817	-79.925
Fort Pulaski, GA	32.0333	-80.9017
Fernandina, FL	30.6717	-81.465
Key West, FL	24.555	-81.8067

All tide gauge data from Permanent Service for Mean Sea Level (PSMSL, 2018)

5 **Table S2.** LiDAR files used to calculate beach slope.

<i>Data files used</i>	<i>USGS LiDAR files</i>
<i>USGS LiDAR files</i>	10CNT07_morphology (FL-NC)
	13CNT05_morphology (NY-NH)
	14CNT01_morphology (SC-NY)
	2016-368-DD_morphology (FL)

Lidar data from Doran et al., (2017).

Table S3. Census data files used to calculate exposure.

<i>Decade</i>	<i>Data File</i>	<i>Source Code</i>	<i>NHGIS code</i>
1970	ds94_1970_county	NT14A	CBH
		NT40 and	
1980	ds104_1980_county	NT42	C8K and C8M
1990	ds120_1990_county	NH24	ESV
2000	ds151_2000_county	NH078A	GB9
2010*	ds201_20135_2013_county	B25082	UMR

* use 2009-2013 5-year community survey in place of 2010 for coverage

Data source: Minnesota Population Center. 2011. National Geographic Information

System: Version 2.0. <http://www.nhgis.org>. Accessed 12/03/2019.

Table S4. Sensitivity testing of the effect of changing variables in Eq. (5) on the vulnerability due to beach width (V_{bw}). Factors are: maximum beach width (x_0), fraction of beach width affected by the nonlinear rate (μ), and the nonlinear rate (θ). Highlighted rows indicate the maximum and minimum mean V_{bw} , and the chosen set of variables, all of which are plotted on Figure S1.

x_0	μ	θ	V_{bw} max mean	V_{bw} max median	V_{bw} max variance	Figure S1
25	0.75	0.75	0.879921486		1	0.238276168 Max
25	0.66	0.75	0.837619876	0.973178273		0.228515365
25	0.75	0.5	0.812977086		1	0.229546306
25	0.66	0.5	0.764614503	0.896672321		0.219268978
50	0.75	0.75	0.757426568	0.812667632		0.20000084
25	0.5	0.75	0.724148105	0.766012983		0.195911534
50	0.66	0.75	0.694330452	0.71098647		0.179730302
50	0.75	0.5	0.684253691	0.689489093		0.191766161
100	0.75	0.75	0.669695312	0.667161775		0.16489023
25	0.75	0.25	0.663239488	0.741045746		0.200831919
25	0.5	0.5	0.659276382	0.651402958		0.187095246
50	0.66	0.5	0.62860932	0.61837553		0.174063671
25	0.66	0.25	0.623883198	0.661900729		0.19273165
100	0.66	0.75	0.604522644	0.600846261		0.141685799
100	0.75	0.5	0.603277433	0.557908844		0.158263847
50	0.5	0.75	0.572033801	0.5462328		0.144798312
25	0.33	0.75	0.567529465	0.545899862		0.157351573
50	0.75	0.25	0.551923387	0.465753575		0.176237297
100	0.66	0.5	0.54607491	0.506611107		0.137084567
25	0.5	0.25	0.54562914	0.495041802		0.177123537
25	0.33	0.5	0.523770133	0.466287757		0.156396001
50	0.5	0.5	0.522220392	0.472430072		0.142790918
50	0.66	0.25	0.510965068	0.421488275		0.162509334
25	0.75	0.1	0.490515605	0.405481161		0.178020267
25	0.25	0.75	0.487472406	0.426503224		0.14579159
100	0.5	0.75	0.486469537	0.474650386		0.105978907
100	0.75	0.25	0.483897448	0.370947148		0.144004668
25	0.66	0.1	0.466774318	0.366603894		0.174628282
25	0.25	0.5	0.454519147	0.379043029		0.146138187
25	0.33	0.25	0.446413944	0.335029587		0.154193301
100	0.5	0.5	0.44219094	0.394234119		0.104064359
100	0.66	0.25	0.441020523	0.331600214		0.127097143
50	0.33	0.75	0.433541881	0.364941853		0.115762651
50	0.5	0.25	0.432685403	0.342794407		0.138001607
25	0.5	0.1	0.42061617	0.269679155		0.164919202

x_0	μ	δ	V_{bw} max mean	V_{bw} max median	V_{bw} max variance	Figure S1
50	0.75	0.1	0.40339037	0.266815988	0.154000228	
50	0.33	0.5	0.400665031	0.33625212	0.115907988	Chosen
25	0.75	0.05	0.400298363	0.237574677	0.167206633	
25	0.25	0.25	0.396462905	0.280872694	0.14662032	
25	0.66	0.05	0.38414404	0.22330029	0.162659349	
50	0.66	0.1	0.378487693	0.244388944	0.144360101	
50	0.25	0.75	0.368369213	0.287254869	0.107933547	
100	0.5	0.25	0.362592829	0.261650109	0.099731286	
25	0.33	0.1	0.360064439	0.198813102	0.150159303	
100	0.33	0.75	0.355942308	0.315993987	0.075004785	
25	0.5	0.05	0.35076797	0.171423949	0.154207676	
100	0.75	0.1	0.343996607	0.194113736	0.11732885	
50	0.25	0.5	0.343462508	0.244276109	0.108567792	
50	0.33	0.25	0.341571938	0.248212773	0.115807823	
25	0.25	0.1	0.331168061	0.16333967	0.146465666	
50	0.5	0.1	0.327759773	0.20353052	0.125771424	
100	0.33	0.5	0.32671843	0.274833569	0.074748399	
100	0.66	0.1	0.317907784	0.175986812	0.107855831	
50	0.75	0.05	0.317203403	0.164986448	0.130849361	
25	0.33	0.05	0.315338453	0.131957875	0.147441761	
25	0.25	0.05	0.301263407	0.113385606	0.144976684	
50	0.66	0.05	0.299083839	0.145479896	0.12448709	
50	0.25	0.25	0.298695014	0.185640676	0.109583098	
100	0.25	0.75	0.294285612	0.242770133	0.065338968	
100	0.33	0.25	0.27417866	0.187328122	0.07399774	
50	0.33	0.1	0.272757927	0.13747646	0.112796148	
100	0.25	0.5	0.272146311	0.209968921	0.065503813	
100	0.5	0.1	0.268476398	0.143761168	0.088324508	
50	0.5	0.05	0.266871281	0.117621491	0.115576825	
100	0.75	0.05	0.261384038	0.122358182	0.0960952	
50	0.25	0.1	0.246927408	0.101129683	0.109105535	
100	0.66	0.05	0.243437051	0.112841924	0.088826496	
50	0.33	0.05	0.232655666	0.083737609	0.109476288	
100	0.25	0.25	0.232343454	0.15235307	0.065687065	
50	0.25	0.05	0.216655523	0.064283981	0.106150414	
100	0.33	0.1	0.211741291	0.108617309	0.070288879	
100	0.5	0.05	0.209512152	0.095924132	0.075461562	

x_0	μ	δ	V_{bw} max mean	V_{bw} max median	V_{bw} max variance	Figure S1
100	0.25	0.1	0.185042417	0.090458009	0.064239038	
100	0.33	0.05	0.17299541	0.064657731	0.064948939	
100	0.25	0.05	0.155851353	0.052276218	0.061316482	Min

Table S5. Distribution statistics (mean, median, skewness) for Figures 7 & 8 in the main text.

Fig. 7	Exposure with...	1980			1990			2000			2010		
		Mean	Median	Skewness									
	High historical hazard (Fig. 7 a-d)	0.404	0.410	-0.018	0.466	0.478	-0.046	0.504	0.518	-0.180	0.564	0.572	-0.241
	Low historical hazard (Fig. 7 e-h)	0.372	0.404	0.906	0.427	0.457	1.061	0.473	0.490	1.000	0.535	0.568	0.986
	High recent hazard (Fig. 7 i-l)	0.324	0.351	0.124	0.395	0.387	0.323	0.435	0.429	0.171	0.500	0.500	-0.006
	Low recent hazard (Fig. 7 m-p)	0.433	0.439	0.160	0.489	0.478	0.116	0.528	0.521	-0.027	0.587	0.586	-0.044

Fig. 8	Exposure with...	1980			1990			2000			2010		
		Mean	Median	Skewness									
	Nourishment (Fig. 9 a-d)	0.419	0.424	-0.065	0.478	0.478	0.022	0.514	0.518	0.014	0.574	0.572	-0.039
	No nourishment (Fig. 9 e-h)	0.331	0.321	0.735	0.317	0.297	2.668	0.328	0.289	0.586	0.399	0.358	0.590
	High cumulative nourishment (Fig. 9 i-l)	nan	nan	nan	0.585	0.621	0.005	0.531	0.545	-0.416	0.570	0.581	-0.160
	Low cumulative nourishment (Fig. 9 m-p)	0.397	0.409	0.170	0.442	0.459	0.320	0.482	0.501	0.266	0.548	0.568	0.165

Skewness = 0 is normally distributed; > 0 indicates a heavier left tail; < 0 indicates a heavier right tail.