



Frequency and Magnitude Data on Coastal Storms

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ABSTRACT

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Waves generated by extratropical storms are responsible for much of the coastal erosion that occurs along the Atlantic coast. Between 1942 and 1984, 1,349 storms producing waves high enough to cause measurable shoreline erosion of an open coast beach were investigated. In this report we provide a tabulation of the 1,349 storms. Storms with winds of sufficient velocity to generate deep-water wave heights over 5' (1.6 m) occur on average every 10 days; a height of 11' (3.4 m), every 3 months; one of at least 17' (5.2 m), every three years; and a deep-water wave height greater than 21' (7 m), every 25 years. The months of December, January, February and March, each averaging 4 storms, comprise the period of maximum frequency; 51 percent of all storms occur during these four months.

ADDITIONAL INDEX WORDS: *Extratropical storms, wave height, coastal erosion.*

INTRODUCTION

There have been surprisingly few investigations of the climatology of Atlantic coast storms. MATHER *et al.* (1964) studied storm damage along the Atlantic coast for the years 1921 to 1964 and BOSSERMAN and DOLAN (1968) hindcasted deep-water wave heights for the years 1942-1967 in the vicinity of Cape Hatteras, North Carolina. This latter study was updated to 1974 by HAYDEN (1975) and to the present in this paper. RESIO and HAYDEN (1975) modelled and reconstructed a storm wave (breaker height) and a storm-surge history for the U.S. mid-Atlantic coast for the years 1899-1970, and, more recently, HAYDEN (1975) examined secular trends in annual cyclone frequencies along the Atlantic and Gulf coasts for the years 1885 to 1978, and WAYLAND and HAYDEN (1985) analyzed the climatology of Atlantic coast storm tracks. Each of these studies suggests some degree of secular variations in storminess along the Atlantic coast.

Over the past decade we have been collecting data on the extratropical storms that affect the mid-Atlantic coast. Our database now spans the period

July 1942 through June 1984. In another article (DOLAN *et al.*, 1987), we reported on the frequency and magnitude of these storms; the baseline statistical attributes of the monthly and yearly storm occurrences by magnitude; the cumulative monthly and annual average hourly duration of waves in each wave height interval; and we identified trends or recurrent patterns in storm frequency and magnitude. Our objective in this brief report is to provide a tabulation of the storm data (Table 1) in hopes that the information will be useful to other coastal scientists.

THE STORM DATA

We included in our study all extratropical storms generating wind fields that resulted in waves (storm waves) greater than 5' (1.6 m) because we have found that waves of this height or higher cause some degree of beach change along the mid-Atlantic coast barrier islands (BOSSERMAN and DOLAN, 1968; HAYDEN, 1975).

Although extratropical storms normally include only low pressure systems that form outside the tropics along cold or stationary fronts, wave generation is a function of wind fields, regardless of the

Table 1. Extratropical storm frequency by month, year and wave height category.

Year	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	>1.6	>2.4	>3.4	>4.3 (meters)	>5.2	>6.1	>7.0
1983-1984	-	-	2	4	4	3	3	3	3	-	1	-	23	8	1	-	-	-	-
1982-1983	-	1	2	2	1	6	4	6	7	2	1	1	33	13	6	3	2	1	1
1981-1982	1	-	-	3	2	5	5	8	1	5	1	2	31	14	2	-	-	-	-
1980-1981	-	-	1	3	2	4	2	4	2	3	5	-	26	10	3	1	-	-	-
1979-1980	-	-	1	1	2	5	7	4	5	3	4	3	35	11	3	1	1	1	1
1978-1979	3	1	3	4	4	4	5	4	2	1	2	4	37	20	2	2	-	-	-
1977-1978	-	-	-	4	-	2	3	2	6	5	4	2	28	12	3	1	-	-	-
1976-1977	-	2	1	4	4	2	1	2	4	2	1	-	23	4	2	-	-	-	-
1975-1976	-	-	1	3	1	2	3	1	2	1	4	2	20	10	5	2	-	-	-
1974-1975	-	2	1	4	3	4	2	2	-	-	-	-	22	8	2	1	-	-	-
1973-1974	-	-	1	-	-	2	2	4	5	1	2	4	21	9	5	-	-	-	-
1972-1973	1	2	1	4	5	5	6	6	2	2	1	-	35	14	7	2	2	1	-
1971-1972	-	-	1	1	2	2	2	4	4	5	3	1	25	14	5	2	-	-	-
1970-1971	-	2	1	3	3	2	4	1	4	4	3	1	28	17	10	3	1	1	-
1969-1970	-	-	2	3	3	2	5	5	3	5	1	-	29	18	10	5	1	-	-
1968-1969	-	1	1	2	4	5	6	4	4	4	2	-	33	19	10	4	1	1	1
1967-1968	1	-	2	3	2	5	8	4	3	7	2	-	37	16	9	2	1	-	-
1966-1967	1	-	4	4	3	5	4	5	2	3	1	1	33	17	4	-	-	-	-
1965-1966	1	1	2	5	1	3	6	5	3	1	3	2	33	9	3	1	-	-	-
1964-1965	1	1	-	4	5	3	4	5	6	4	1	1	35	13	4	2	-	-	-
1963-1964	2	2	4	1	3	4	6	8	4	2	3	2	41	18	5	-	-	-	-
1962-1963	-	1	3	-	3	2	6	7	1	4	5	-	32	20	5	2	-	-	-
1961-1962	-	-	1	3	1	2	6	4	4	2	-	3	26	10	3	1	1	1	1
1960-1961	-	2	1	1	2	5	4	9	5	5	2	1	37	16	3	-	-	-	-
1959-1960	-	1	2	4	5	4	4	6	9	4	2	1	42	13	4	1	1	-	-
1958-1959	-	-	2	2	5	5	3	4	7	2	1	-	31	12	6	1	-	-	-
1957-1958	1	3	3	3	6	2	5	2	6	5	1	2	39	9	2	1	-	-	-
1956-1957	1	2	2	4	2	2	6	5	4	4	1	1	32	11	4	-	-	-	-
1955-1956	1	-	4	4	2	2	9	7	6	8	3	3	48	12	3	1	-	-	-
1954-1955	1	1	-	3	2	4	2	5	3	2	4	1	28	8	3	1	-	-	-
1953-1954	2	1	3	1	3	4	2	1	3	3	2	1	26	11	3	2	1	1	-
1952-1953	1	2	5	3	3	5	3	4	4	5	2	-	39	18	2	-	-	-	-
1951-1952	-	3	3	3	4	5	3	4	5	4	-	1	35	14	6	3	2	-	-
1950-1951	1	-	2	2	3	4	3	7	7	5	1	2	37	11	2	-	-	-	-
1949-1950	2	2	2	3	1	3	2	4	8	3	2	2	34	14	2	-	-	-	-
1948-1949	1	-	2	4	3	4	3	3	5	4	3	2	34	15	3	1	1	-	-
1947-1948	1	1	1	2	5	5	10	4	7	6	3	3	45	23	9	3	1	-	-
1946-1947	3	1	1	3	4	3	3	1	5	5	3	2	34	8	2	2	1	-	-
1945-1946	-	-	1	1	3	6	4	3	2	5	4	1	30	14	5	3	1	1	-
1944-1945	-	1	2	3	1	4	7	2	3	2	3	-	28	9	2	-	-	-	-
1943-1944	-	1	3	2	-	4	3	5	4	8	-	1	36	9	3	1	-	-	-
1942-1943	-	3	2	-	4	3	3	1	5	4	-	3	28	13	5	-	-	-	-
Total:	26	40	76	108	141	174	176	176	181	146	91	54	1,349	544	178	57	18	8	4
Average:	0.6	1.0	1.8	2.6	3.4	4.1	4.2	4.2	4.3	3.5	2.2	1.3	32.1	13.0	4.2	1.4	0.4	0.2	0.1

Table 2. Extratropical storm duration (hours) by month, year and wave height category.

Year	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	>1.6	>2.4	>3.4	>4.3 (meters)	>5.2	>6.1	>7.0
1983-1984	-	-	45	108	23	24	67	33	18	15	13	-	331	113	4	-	-	-	-
1982-1983	-	3	17	81	25	91	44	88	122	15	1	9	496	218	86	47	27	12	6
1981-1982	11	-	-	165	89	124	81	166	6	53	8	-	703	252	40	-	-	-	-
1980-1981	-	-	35	82	41	130	41	86	35	34	155	-	639	185	48	21	-	-	-
1979-1980	-	-	56	18	34	93	111	38	95	30	48	55	579	148	45	18	14	9	4
1978-1979	35	11	97	106	46	51	65	85	11	20	23	97	647	228	58	8	-	-	-
1977-1978	-	-	-	68	-	24	15	41	64	78	30	20	340	103	30	11	-	-	-
1976-1977	-	49	5	59	19	21	8	13	25	9	12	-	220	51	13	-	-	-	-
1975-1976	-	-	16	36	45	21	34	5	30	28	51	41	317	146	65	6	-	-	-
1974-1975	-	33	19	73	24	42	54	11	18	-	-	-	274	79	10	2	-	-	-
1973-1974	-	-	10	-	-	53	8	71	66	13	37	26	284	108	32	-	-	-	-
1972-1973	27	30	22	75	89	86	91	149	98	14	9	-	692	268	122	66	32	16	-
1971-1972	-	-	26	110	32	82	51	124	66	96	102	1	698	378	151	42	-	-	-
1970-1971	-	54	31	114	65	27	78	18	76	48	51	5	568	338	168	75	14	4	-
1969-1970	-	-	117	214	38	16	71	132	30	32	20	-	714	396	148	30	9	-	-
1968-1969	-	44	16	31	40	90	144	190	66	107	38	-	792	419	254	129	69	44	18
1967-1968	11	-	29	21	39	88	214	80	51	99	22	-	654	306	111	45	24	-	-
1966-1967	26	-	47	134	140	145	44	64	17	25	69	8	726	277	42	-	-	-	-
1965-1966	26	34	49	44	6	26	110	50	56	11	41	18	458	90	29	4	-	-	-
1964-1965	2	7	-	140	68	40	132	84	46	53	6	19	598	224	40	12	-	-	-
1963-1964	21	3	131	25	48	56	88	82	50	34	124	40	702	292	44	-	-	-	-
1962-1963	-	4	76	-	40	14	76	186	26	40	157	-	618	246	52	10	-	-	-
1961-1962	-	-	50	34	6	8	74	51	106	24	-	-	90	442	216	56	38	18	12
1960-1961	-	80	124	19	10	88	44	89	98	54	34	45	684	190	16	-	-	-	-
1959-1960	-	18	48	24	158	79	117	39	130	87	46	72	819	252	83	38	1	-	-
1958-1959	-	-	17	90	56	98	40	30	86	81	27	-	518	216	78	30	-	-	-
1957-1958	24	66	95	91	55	85	77	15	81	86	9	18	702	103	19	2	-	-	-
1956-1957	12	26	12	242	-	9	108	128	40	31	25	32	666	232	38	-	-	-	-
1955-1956	1	-	66	80	7	35	40	98	124	105	122	73	750	182	30	3	-	-	-
1954-1955	19	15	-	44	7	48	18	72	45	19	52	10	350	104	37	22	-	-	-
1953-1954	62	28	77	8	82	39	35	9	54	55	28	9	477	148	43	2	6	2	-
1952-1953	1	57	93	53	32	58	37	54	56	90	28	40	610	178	23	2	-	-	-
1951-1952	-	33	28	192	57	74	63	59	62	14	-	-	26	608	208	96	46	22	-
1950-1951	-	-	65	34	49	60	54	112	97	39	8	13	531	114	16	-	-	-	-
1949-1950	4	26	91	34	10	94	34	44	108	38	22	8	522	156	32	5	-	-	-
1948-1949	13	-	59	46	28	44	41	31	101	66	48	88	602	218	67	32	23	-	-
1947-1948	16	13	62	26	98	52	178	169	124	102	-	-	22	862	364	24	16	10	-
1946-1947	34	2	22	128	95	61	29	17	78	62	31	28	587	129	24	16	10	-	-
1945-1946	-	-	26	16	47	50	108	61	48	7	118	20	3	504	194	48	-	-	-
1944-1945	-	30	66	71	72	114	84	62	117	46	15	678	174	60	16	-	-	-	-
1943-1944	-	-	79	77	-	52	72	69	24	121	37	52	-	584	225				

type of weather system. Both cyclones and anticyclones were therefore considered in our study. We excluded tropical disturbances since information about their occurrence along the mid-Atlantic is already well-documented.

Using a variation of the Bretschneider method now known as the Sverdrup, Munk and Bretschneider (SMB) method (C.E.R.C., 1984), we calculated (hindcasted) significant wave heights, which are an index of storm magnitude, and made frequency counts of the number of disturbances occurring in each of seven deep-water wave height categories for the mid-Atlantic coast. The seven wave height intervals are 5' to 8' (1.6 m to 2.4 m); 8' to 11' (2.5 m to 3.4 m); 11' to 14' (3.4 m to 4.3 m); 14' to 17' (4.4 m to 5.2 m); 17' to 20' (5.3 m to 6.1 m); 20' to 23' (6.2 m to 7.0 m); and higher than 23' (7.1 m).

Fetch length was estimated from U.S. Weather Bureau 12- and 24-hour synoptic weather charts. We obtained wind speed over the fetch areas from records of the Cape Hatteras Weather Station, from published logs of ships at sea, and by estimating wind speed from isobaric spacings on weather charts. For the 42-year period of record, 1,349 storms were analyzed and found to produce waves in deep water off the mid-Atlantic coast of 5' (1.6 m) in height or higher.

Table 2 summarizes the raw data on the frequency, magnitude and duration of the 1,349 storms. The tables show the number of storms occurring each month during the 42-year period and the number of storms in each wave height category occurring during each storm year (July-June) and the duration (storm hours) in hours of the storm wave conditions for each category.

Of the 1,349 storms generating deep-water waves over 5' (1.6 m), 326, or 24 percent, were caused by anticyclones; however, 26 percent of the anticyclones had wind fields of sufficient speed and duration to generate waves greater than 8' (2.5 m). Cyclones of local origin rarely deepened rapidly enough to result in high waves, so only 13 percent of these storms of local origin generated waves greater than 11' (3.4 m). Cyclones that tracked eastward from the continent, especially those crossing the coast to the south of Cape Hatteras, generated the largest waves.

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