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EXTREME SEA WATER TEMPERATURES AND DENSITIES ALONG THE NORTH ATLANTIC STATES DURING SUMMER 1955

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ABSTRACT

During the summer of 1955, record high sea water temperatures were observed in harbors and coastal waters of the North Atlantic States. Record air temperatures also occurred during this period. It is concluded that high sea water temperatures were due in large part to continued high air temperatures. The record low densities (or salinities) during the same summer corresponded with the periods of hurricanes Connie and Diane, hence the high runoff following these storms was doubtless responsible. The lag between rainfall and noticeable dilution and the delay in return to normalcy depend upon several factors including the amount of rain, type of estuary, and size of drainage basin.

The summer of 1955 was notable for the record high sea water temperatures and the extremely low densities observed in harbor and coastal waters of the North Atlantic States.

For many years and at many places along the Atlantic Coast, the Coast and Geodetic Survey has observed daily the temperature and density of the sea and has determined average monthly conditions from these records. Densities were observed by hydrometer, and the resulting data are given as density at 15° C (59° F) referred to the density of pure water at 4° C as unity. Temperatures are shown in degrees Fahrenheit. Air temperature and rainfall data were obtained from published reports of the U. S. Weather Bureau.

TABLE I. Highest Monthly Mean Water Temperatures (°F)

	1955 High		Previous High		Next Previous High		Number of monthly means that equaled or exceeded those of 1955	
	Temp.	Month	Temp.	Month, Year	Temp.	Month, Year		Series
Eastport, Me.	52.3	Aug.	55.2	Sept. '49	54.8	Sept. '47	21	1930–55
Bar Harbor, Me.	59.2	Aug.	59.1	Aug. '51	58.6	July '51	0	1948–55
Portsmouth, N. H.	64.6	Aug.	64.0	Aug. '47	63.5	Aug. '51	0	1944–55
Boston, Mass.	70.7	Aug.	69.5	July '49	69.2	Aug. '49	0	1921–55
Woods Hole, Mass.	73.2	Aug.	73.0	Aug. '52	72.5	Aug. '47 Aug. '49	0	1944–55
New London, Conn.	76.1	Aug.	74.1	Aug. '52	74.0	July '55	0	1947–55
Montauk, L. I., N. Y.	72.6	Aug.	71.8	Aug. '49	71.2	July '49 Aug. '52	0	1948–55
Willets Point, N. Y.	75.1	Aug.	74.9	Aug. '49	74.1	Aug. '41	0	1932–55
New York (The Battery), N. Y.	76.5	Aug.	77.2	Aug. '39	75.7	Aug. '49	1	1927–55
Sandy Hook, N. J.	78.0	Aug.	77.6	July '52 July '55	77.5	July '87	0	1887–93 & 1944–55
Atlantic City, N. J.	75.1	Aug.	76.1	Aug. '39	75.4	Aug. '49	2	1912–20 & 1923–55
Breakwater Harbor, Del.	77.5	Aug.	75.9	Aug. '53	75.8	July '48	0	1919–22, 1947–49 & 1952–55
Philadelphia, Pa.	84.1	July	82.4	July '34	82.0	Aug. '39	0	1922–46 & 1954–55
Baltimore, Md.	82.9	July	82.9	July '35	82.8	July '34	1	1914–55
Annapolis, Md.	82.8	July	82.3	July '53	82.2	July '52	0	1947–55
Washington, D. C.	85.3	July	85.1	July '44 Aug. '47	84.9	July '52 July '53	0	1944–55
Solomons, Md.	82.4	July	82.2	Aug. '38	81.9	July '53	0	1938–55
Richmond, Va.	84.5	July	84.8	July '53	84.2	July '52	1	1947–55
Gloucester Pt., Va.	83.4	Aug.	83.3	July '55	82.7	Aug. '51 July '52	0	1950–55

In examining the weather records for the possible cause of these extremes, we find that warm air over much of the United States, including the northeastern section of the country, set new records or approached old ones for highest average monthly air temperatures. Moreover, during August, heavy rains resulting from hurricanes Connie and Diane flooded drainage systems in the New England and Middle Atlantic States and greatly increased the fresh water discharge into the usually saline bays and estuaries.

A tabulation of the highest monthly mean water temperature for each station along the North Atlantic for the year 1955 is given in Table I. Also given are the previous two highest values and the dates when they occurred. The last columns show the total number of times the highest 1955 mean was equaled or exceeded during previous years as well as the series duration for each station. From this tabulation, covering stations from Maine to Virginia, it is seen that 1955 monthly means equaled or exceeded the records set during previous years at 15 of the 19 stations for which data are available.

Let us examine the air temperatures for several stations in this area for which Weather Bureau data are available. These values together with sea water temperatures are given in Table II. This table reveals that sea water temperatures during July and August 1955 averaged 2.5° F above normal and air temperatures were 3.9° F above normal.

TABLE II. Mean Air and Water Temperatures for July-August (°F)

		Air (1921–1950)			*Water**		
Station		*1955*	*Av.*	*Diff.*	*1955*	*Av.*	*Diff.*
Boston	July	77.2	72.2	+5.0	68.7	64.5	+4.2
	Aug.	74.5	71.5	+3.0	70.7	65.6	+5.1
New York	July	79.7	74.6	+5.1	73.1	71.6	+1.5
	Aug.	77.2	73.2	+4.0	76.5	73.3	+3.2
Atlantic City	July	76.0	73.6	+2.4	70.2	69.5	+0.7
	Aug.	76.3	73.1	+3.2	75.1	71.7	+3.4
Philadelphia	July	81.8	77.2	+4.6	84.1	78.6	+5.5
	Aug.	78.5	75.2	+3.3	79.7	78.4	+1.3
Baltimore	July	83.5	78.5	+5.0	82.9	79.6	+3.3
	Aug.	79.2	76.4	+2.8	81.2	79.6	+1.6
Washington	July	82.9	77.8	+5.1	85.3	83.6	+1.7
	Aug.	79.1	75.8	+3.3	80.7	82.1	−1.4
		Av. Difference +3.9			Av. Difference +2.5		

* For length of series, see Table I.

Since air temperatures appear to have such an important effect on sea water temperatures, let us study the meteorological conditions for the stations shown in Table II. The Weather Bureau reports that the July mean temperature for Boston was within 0.3° of the all-time record for July (77.5°, set in 1952) and that August 1955 was the third warmest August since 1871. At New York the average monthly air temperature for July established a new record, the previous one being 78.9° in 1952; August was the second month in a row to set a heat record. The July mean at Philadelphia also was a new record for that month. The average monthly temperature for July in Baltimore broke the old record of 81.5° set in 1872. Washington continued this record breaking precedent by exceeding the highest July average temperature of 81.4° set in 1949. Thus, when it is seen how many air temperature records were set, it is easy to understand why the water temperatures also were high.

Whereas the extreme sea water temperatures can be explained in large part through a correlation with air temperatures, we need to study the precipitation data to explain the extremely low sea water densities. During August 1955 two tropical hurricanes, Connie and Diane, hit the northeastern section of the country, bringing heavy rains generally along the entire coast from North Carolina northward and eastward through southern New England. Sea water density data, and precipitation data for the same stations where available, are shown in Table III. Stations north of Boston were little affected and are not included in this table.

The daily densities of the monthly records fell naturally into the groupings shown in Table III. It is seen that they correspond with periods of light and heavy rainfall. Densities at stations located in harbors and estuaries were affected by the increased runoff. Upriver stations such as Washington and Richmond showed little effect, for their waters are practically fresh at all times. Normally saline coastal stations such as Woods Hole, Montauk, and Atlantic City showed no unusual density fluctuations.

Hurricane Connie was active August 11–13 in eastern Virginia, Maryland, Delaware and Pennsylvania. Some rain fell in New England, but it was minor when compared with that produced by Hurricane Diane, which began moving inland in the vicinity of Wilmington, North Carolina early on the 17th of August. This storm continued on a more or less northerly path until it approached the Mason-Dixon Line, where it turned eastward on August 19 and passed almost directly over Philadelphia; from there it continued northeastward along the southern shores of New England. Prior to these two storms there had been a long dry spell in the New England

TABLE III. Rainfall and Sea Water Density Data for August 1955

	Rainfall		*Density*			
	Dates	*Total (inches)*	*Dates*	*Average*	*1955 Low*	*Previous Low*
Boston, Mass.	1–10	0.28	1–10	1.0222		
	11–13	1.47	11–15	1.0209		
	14–16	0.00	17	1.0226		
	17–19	12.47	18–31	1.0102		
	20–31	2.87	19		1.0029	1.0136
Woods Hole, Mass.	—	—	1–11	1.0236		
	—	—	12	1.0227		
	—	—	13–17	1.0235		
	—	—	18–31	1.0232		
New London, Conn.	—	—	1–13	1.0205		
	—	—	14–31	1.0065		
	—	—	28		1.0028	1.0083
Montauk, L. I., N. Y.	—	—	1–22	1.0224		
	—	—	23	1.0188		
	—	—	24–31	1.0220		
Willets Point, N. Y.	1–10	1.29	1–11	1.0195		
	11–14	12.50	12–14	1.0160		
	15–17	0.00	15–31	1.0179		
	18–19	1.73	12		1.0157	1.0164
	20–31	0.53				
New York (The Battery) N. Y.	1–6	0.00	1–12	1.0186		
	7	2.20	15–19	1.0162		
	8–10	0.07	22–26	1.0097		
	11–14	9.60	29–31	1.0141		
	15–17	0.00	23		1.0081	1.0095
	18–19	1.62				
	20–31	0.33				
Sandy Hook, N. J.	—	—	1–13	1.0207		
	—	—	15–31	1.0145		
	—	—	22		1.0103	1.0127
Atlantic City, N. J.	1–7	0.00	1–20	1.0235		
	8	1.36	22–29	1.0229		
	9–11	0.06				
	12–13	2.26				
	14–30	0.56				
	31	1.66				
Breakwater Harbor, Del.	—	—	1–19	1.0229		
	—	—	21–31	1.0191		
	—	—	29		1.0162	1.0199

TABLE III.—*Continued*

	—*Rainfall*—		—————*Density*—————			
	Dates	*Total (inches)*	*Dates*	*Average*	*1955 Low*	*Previous Low*
Philadelphia, Pa.	1–11	0.95	1–12	0.9996		
	12–13	3.90	15–19	0.9991		
	14–16	0.02	22–26	0.9994		
	17–19	3.51	29–31	0.9991		
	20–31	0.55				
Baltimore, Md.	1–5	0.01	1–12	1.0071		
	6–7	2.08	15–19	1.0034		
	8–11	0.16	22–31	1.0051		
	12–14	9.07				
	15–16	0.00				
	17–18	3.58				
	19–31	2.79				
Annapolis, Md.	—	—	1–12	1.0092		
	—	—	13–24	1.0085		
	—	—	25–30	1.0069		
Washington, D. C.	—	—	1–31	0.9992		
Solomons, Md.	—	—	1–13	1.0115		
	—	—	14–19	1.0106		
	—	—	22–31	1.0092		
Richmond, Va.	—	—	1–31	0.9993		
Gloucester Point, Va.	—	—	1–11	1.0169		
	—	—	13–18	1.0148		
	—	—	19–31	1.0090		

and Middle Atlantic States, making the land very dry. Rains from Connie, therefore, were absorbed by the soil. When Diane's rains hit the area less than one week later, the ground was too soaked to absorb the additional water. The result was flooding of all streams. This high runoff, continuing for several days, sharply reduced the density of sea water in harbors such as Boston, New London, and New York.

Figs. 1 and 2 show graphically the daily record of density and rainfall for Boston Harbor and New York Harbor. Where daily density observations are missing, dashed lines have been used to connect the observed portions of the curve. It will be seen that there was a lack of rain in early August so that densities in the harbors were high. Then the rains came and the density was lowered due to runoff. Rains from Connie were heavier at New York whereas Diane dumped more water on the Boston area. From the graph it is seen that at New York there was considerable lag between the rainfall and the resulting decrease in harbor density, whereas at

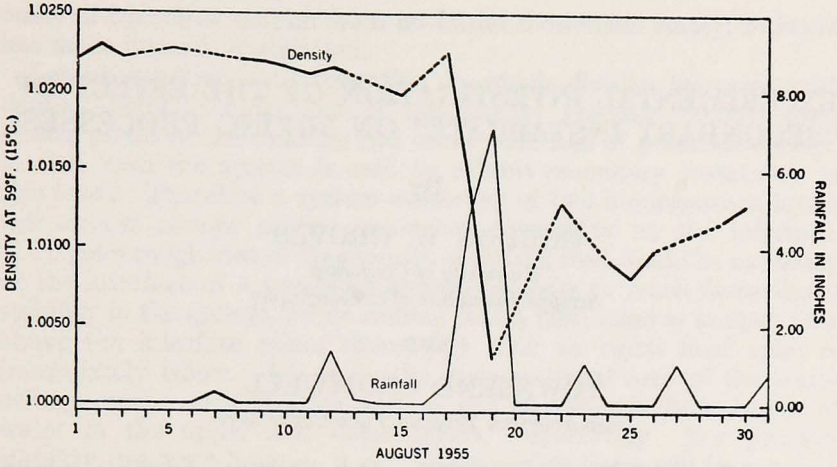

Figure 1. Daily sea water density and rainfall for Boston; August 1955.

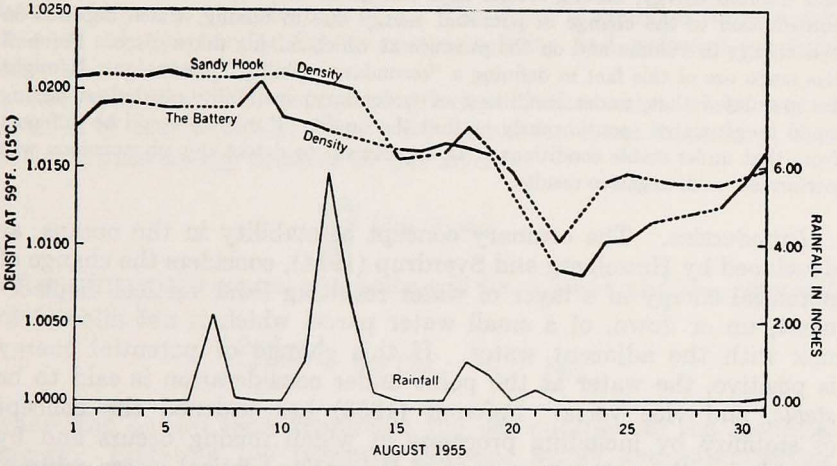

Figure 2. Daily sea water density and rainfall for New York Harbor; August 1955.

Boston there was practically no lag at all. This time difference reflects the different types and sizes of drainage basins. Waters in New York Harbor are the accumulation of many rivers emptying into the Hudson River over a drainage area of many square miles. At Boston the watershed is small and runoff is emptied almost immediately into the Harbor, resulting in quickly lowered density. There are similar lags between the end of the rain and the beginning of increasing density. Though the increase in density is rather rapid for a while, it shows some delay, possibly due to continuing runoff and to mixing with the saline waters entering from the sea.