Chesapeake Bay

Marine Environmental Assessment

March 1986 - August 1986

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In September 1981, the Marine Assessment Branch (MAB) of the National Oceanic and Atmospheric Administration's Assessment and Information Services Center initiated production of a series of periodic assessments of weather impacts on economic sectors of marine environmental activity. Using the Chesapeake Bay region as a prototype, monthly assessments were issued from September 1981 through March 1982. From March 1982 until November 1985, quarterly assessments were issued, and annual summaries were provided through 1984.

In 1985, a decision was made to determine if regional organizations could assume, with the support of MAB, the production of ongoing regional assessments, thereby freeing the MAB staff to initiate assessments in other regions. The Chesapeake Bay assessment was chosen as the test case and the Chesapeake Research Consortium (CRC) was selected to prepare it. CRC is a regional organization made up of major research organizations located in Maryland and Virginia, the states which contain the estuarine portion of the Chesapeake Bay system.

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Chesapeake Bay

Marine Environmental Assessment

March 1986 - August 1986

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IMPACT SECTOR	EVENT: March through June low precipitation	March through July above-normal air temperature	High salinities	Low streamflow	Below - normal water temperature	High winds
FISHERIES						
Finfish Harvest Activities (General)	+	+				-
Shellfish Harvest Activities (General)	+	+				-
Bluefish Arrival					-	
Blue Crab Distribution (extent)	+		+	+		
Blue Crab Harvest	+	+				-
Occurrence of High Salinity Species	+		+	+		
Shellfish Diseases	+		+	+		
RECREATION						
Park Usage	+	+			-	
Boating Activity	+	+				-
Safety	-	-				-
Jellyfish	+		+	+		
TRANSPORTATION						
Port Operations						-
Cost to Shippers						-

KEY

+	Favorable
-	Unfavorable
	No identifiable effect, data unavailable, or not applicable

Table 1 -- Summary of meteorological events and probable environmental impacts, Chesapeake Bay March - August 1986

1. Highlights - General Events and Impacts

Unusually dry conditions developed in the southern United States in December 1985 and continued into July 1986 to produce the worst drought in at least 111 years. Because of above normal precipitation in the Susquehanna drainage basin, however, the Chesapeake Bay was not severely affected.

Below-normal rainfall conditions and above-normal air temperatures during the spring 1986 quarter provided favorable conditions for finfish and shellfish harvests. The blue crab harvest was so successful as a result of favorable working conditions that Virginia watermen requested a catch limitation (17 barrels/day of hard crabs), which was established by the Virginia Marine Resources Commission.

Following the 12°-15° C temperature band, bluefish arrived in Maryland waters during the last week of April. High salinities created conditions that affected the distribution of certain bay species of finfish during the summer of 1986. For example, black sea bass were reported in Maryland as far north as the Patuxent River. High salinities aided the spread and development of oyster diseases in the Chesapeake Bay mainstem and its tributaries.

Weather conditions were favorable for recreational activities during the warm spring and dry summer of 1986. Record spring attendance at Sandy Point State Park was attributed to warmer-than-normal air temperatures and below-normal precipitation during the spring quarter.

The 1986 jellyfish infestation appeared early, remained light, and subsided rapidly. Because of a warm spring, the strobilating season began before 1 May, and adult medusae died off earlier in the season.

Total crane down-time for the Port of Baltimore was 103 hours and 15 minutes, costing shippers over $412,000 in wind-related delays for the spring and summer quarters. The largest loss of time due to windy conditions occurred in March with a total loss of 39 hours and 38 minutes.

Table 1 summarizes impacts of climatic events by economic sector.

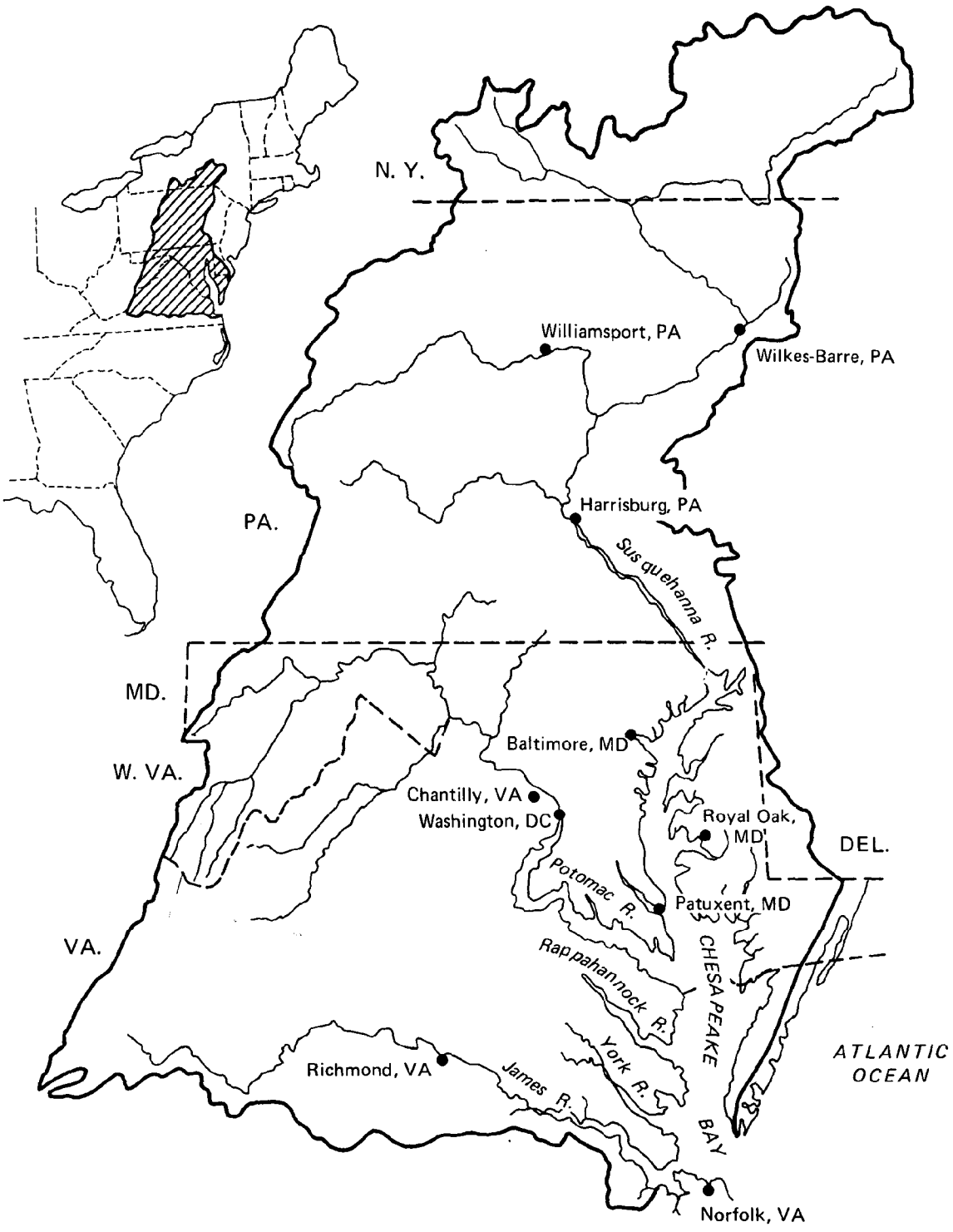

Figure 1 -- Selected meterological stations, Chesapeake Bay watershed (modified EPA map)

2. Meteorological and Oceanographic Summary

2.1 Precipitation and Temperature

2.1.a Spring Quarter

The spring quarter (March through May) of 1986 was a period of continued below-normal precipitation but above-normal temperatures for the Chesapeake Bay region (Figure 1). Precipitation during the preceding winter quarter averaged 25 % below normal and decreased further to 35 % below normal (Table 2) during the spring quarter. The spring quarter's average air temperature (Table 3) was 1.6° F above normal following the winter quarter's 0.9° F below-normal average temperature. Frozen ground cover had melted throughout the bay region by 9 March and did not recur in any appreciable amounts except during two days in mid-April at Wilkes-Barre, PA.

March:

Total precipitation for March was 17.26 inches (46 % below normal) for nine reporting stations (Figure 1). Patuxent, MD, monthly totals and averages are reported in Tables 2-5; however, Patuxent's totals are not included in the all-station totals or quarter totals, nor are anomalies reported because its 11-year data record does not permit long-term comparisons.

Above-normal precipitation (62 %) was reported at Wilkes-Barre, PA, and normal precipitation at Harrisburg, PA. All other stations reported below-normal precipitation in March. Negative departures from long-term averages (1951-1980 for all stations except Chantilly, VA [1964-1980]) ranged from 28 % at Williamsport, PA to 81 % at Norfolk, VA.

Reporting stations within the Susquehanna River drainage basin received a total of 10.40 inches of precipitation as rain or snow, which was 6 % above normal for March. The Potomac River and James River basins reported precipitation of 72 % and 68 % below normal, respectively, and precipitation for stations on the Chesapeake Bay was 67 % below normal. Even though one station reported well-above-normal rainfall and seven stations reported precipitation totals > 60 % below normal, none of the differences were significant (T-test; square root transformation for normality; $P<0.05$).

Temperatures averaged 45.0° F (1.9° F above normal) for the nine meteorological stations (Table 3). All stations reported above-normal temperature averages, except Harrisburg, PA, whose average monthly temperature was normal. March temperatures ranged from a high of 50.0° F (2.8° F above normal) at Richmond, VA, to a low of 39.8° F (3.7° F above normal) at Wilkes-Barre, PA. The Susquehanna basin stations' average temperature was 40.4° F (2.3° F above normal). The Potomac River and James River stations' temperatures averaged 45.9° F (1.4° F above normal) and 50.0° F (2.8° F above normal), respectively. Temperatures at the four stations on the bay averaged 47.4° F (1.0° F above normal). No stations showed significant temperature departures from normal (T-test; $P<0.05$).

Frozen ground cover (ice or snow) was absent from all Chesapeake Bay region meteorological stations by 9 March, except for a trace at Wilkes-Barre, PA, on 21 March.

April:

Precipitation at all stations in April totalled 25.19 inches. Although this was 7.93 inches more than reported in March, the total precipitation was still 10 % below normal. Four stations (Williamsport, PA; Harrisburg, PA; Chantilly, VA; and Norfolk, VA) reported above-normal precipitation, whereas the remaining stations reported below-normal

Table 2 -- Monthly precipitation (in) and departure from normal (%) for 9 stations*, Chesapeake Bay watershed, March-May 1986. Percentage rounded to nearest percentile.

Basin	Station	March Observed/Anomaly**	April Observed/Anomaly**	May Observed/Anomaly**	Spring Total Observed/Anomaly**
Susquehanna	Williamsport PA	2.65/ -28	4.25/ 20	3.93/ 7	10.83/ 0
	Wilkes-Barre PA	4.25/ 62	2.98/ -2	2.24/ -28	9.47/ 7
	Harrisburg PA	3.50/ 0	4.10/ 29	2.29/ -38	9.89/ -5
Total		10.40/ 6	11.33/ 16	8.46/ -19	30.19/ 4
Potomac	Washington DC	0.74/ -77	1.98/ -32	0.75/ -78	3.47/ -65
	Chantilly VA	1.12/ -65	3.01/ 5	1.19/ -69	5.32/ -46
Total		1.86/ -72	4.99/ -14	1.94/ -73	8.79/ -56
James	Richmond VA	1.16/ -68	1.16/ -60	3.15/ -13	5.47/ -45
Chesapeake Bay	Baltimore MD	0.96/ -74	2.64/ -21	0.37/ -89	3.97/ -62
	Patuxent MD	(0.92)/ --	(0.95)/ --	(1.94)/ --	(3.81)/ --
	Royal Oak MD	2.13/ -48	1.76/ -48	1.76/ -52	5.65/ -49
	Norfolk VA	0.75/ -81	3.31/ 15	1.41/ -62	5.47/ -48
Total		3.84*/ -67	7.71*/ -20	3.54*/ -67	15.09*/ -53
All Station Totals		17.26*/ -46	25.19*/ -10	17.09*/ -47	59.54*/ -35

*Patuxent's data not included in totals due to lack of long term averages. The Patuxent weather station has only been in existence since 1977.
**Anomaly = percent departure from 1951-1980 average, except for the Chantilly, VA weather station (1966-1980).

Data Source: National Weather Service

Table 3 -- Monthly mean air temperature (F°) and departure from normal (%) for 9 stations*, Chesapeake Bay watershed, March-May 1986.

Basin	Station	March Observed/Anomaly**		April Observed/Anomaly**		May Observed/Anomaly**		Spring Average for Station Observed/Anomaly**	
Susquehanna	Williamsport PA	40.7/	3.1	51.1/	1.5	63.7/	4.1	51.8/	2.9
	Wilkes-Barre PA	39.8/	3.7	49.3/	0.9	62.7/	4.0	50.6/	2.9
	Harrisburg PA	40.6/	0.0	53.5/	1.2	65.6/	3.6	53.2/	1.6
Average		40.4/	2.3	51.3/	1.2	64.0/	3.9	51.9/	2.5
Potomac	Washington DC	47.4/	1.5	56.2/	-0.5	68.1/	2.1	57.2/	1.0
	Chantilly VA	44.3/	1.2	53.6/	0.9	64.2/	2.1	54.0/	1.4
Average		45.9/	1.4	54.9/	0.2	66.2/	2.1	55.6/	1.2
James	Richmond VA	50.0/	2.8	59.2/	1.3	66.9/	0.8	58.7/	1.6
Chesapeake Bay	Baltimore MD	45.0/	1.8	53.5/	-0.5	66.7/	3.4	55.1/	1.6
	Patuxent MD	(46.5)/	--	(55.0)/	--	(68.0)/	--	(56.5)/	--
	Royal Oak MD	47.2/	2.0	55.0/	-0.8	67.3/	2.1	56.5/	1.1
	Norfolk VA	49.9/	1.3	57.3/	-1.0	67.6/	1.0	58.3/	0.4
Average		47.4/	1.7	55.3/	-0.8	67.2/	2.2	56.6/	1.0
All Station Averages		45.0*/	1.9	54.3*/	0.3	65.9*/	2.6	55.1*/	1.6

*Patuxent's data not included in averages due to lack of long term averages. The Patuxent weather station has only been in existence since 1977.
**Anomaly = departure from 1951-1980 average except for the Chantilly, VA weather station (1966-1980).
Data Source: National Weather Service

Table 4 -- Monthly precipitation (in) and departure from normal (%) for 9 stations*, Chesapeake Bay watershed, June-August 1986. Percentage rounded to nearest whole number.

Basin	Station	June Observed/Anomaly**	July Observed/Anomaly**	August Observed/Anomaly**	Summer Totals Observed/Anomaly**
Susquehanna	Williamsport PA	4.71/ 21	5.78/ 47	3.31/ 2	13.80/ 25
	Wilkes-Barre PA	6.77/ 94	7.25/ 116	3.94/ 14	17.96/ 74
	Harrisburg PA	1.48/ -50	5.17/ 56	6.26/ 90	12.91/ 26
Total		12.96/ 18	18.20/ 72	13.51/ 35	44.67/ 41
Potomac	Washington DC	1.29/ -61	3.79/ -2	5.33/ 21	10.41/ -10
	Chantilly VA	1.40/ -67	1.86/ -49	5.72/ 41	8.98/ -25
Total		2.69/ -64	5.65/ -25	11.05/ 31	19.39/ -18
James	Richmond VA	1.30/ -64	3.35/ -35	6.75/ 35	11.40/ -17
Chesapeake Bay	Baltimore MD	1.46/ -61	4.12/ 6	4.26/ -8	9.84/ -20
	Patuxent MD	(1.40)/ --	(1.69)/ --	(5.80)/ --	(8.89)/ --
	Royal Oak MD	1.56/ -55	3.35/ -24	6.63/ 30	11.54/ -11
	Norfolk VA	1.51/ -57	2.59/ -50	4.08/ -24	8.18/ -41
Total		4.53*/ -58	10.06*/ -25	14.97*/ -1	29.53*/ -25
All Station Totals		21.48*/ -35	37.26*/ 2	46.28*/ 20	105.02*/ -3

*Patuxent's data not included in totals due to lack of long term averages. The Patuxent weather station has only been in existence since 1977.
**Anomaly= percent departure from 1951-1980 average, except for the Chantilly weather station (1966-1980).

Data Source: National Weather Service

Table 5 -- Monthly mean air temperature (F°) and departure from normal (%) for 9 stations*, Chesapeake Bay watershed, June-August 1986.

Basin	Station	June Observed/Anomaly**	July Observed/Anomaly**	August Observed/Anomaly**	Summer Average for Station Observed/Anomaly**
Susquehanna	Williamsport PA	67.5/ -0.8	72.6/ 0.1	68.3/ -2.9	69.5/ -1.2
	Wilkes-Barre PA	66.2/ -1.1	71.0/ -0.8	67.4/ -2.7	68.2/ -1.5
	Harrisburg PA	71.3/ 0.2	76.3/ 0.7	72.0/ -2.1	73.2/ -0.4
Average		68.3/ -0.6	73.3/ 0.0	69.2/ -2.6	70.3/ -1.0
Potomac	Washington DC	76.6/ 2.1	81.1/ 2.2	74.6/ -3.0	77.4/ 0.4
	Chantilly VA	73.4/ 2.9	79.0/ 3.7	72.5/ -1.8	75.0/ 1.6
Average		75.0/ 2.5	80.1/ 3.0	73.6/ -2.4	76.2/ 1.0
James	Richmond VA	76.1/ 2.6	80.9/ 3.1	74.2/ -2.6	77.1/ 1.1
Chesapeake Bay	Baltimore MD	74.3/ 2.2	79.4/ 2.6	73.1/ -2.5	75.6/ 0.8
	Patuxent MD	(75.0)/ --	(81.0)/ --	(75.0)/ --	(77.0)/ --
	Royal Oak MD	74.7/ 1.2	79.5/ 1.8	74.7/ -1.9	76.3/ 0.4
	Norfolk VA	76.1/ 1.7	82.1/ 3.6	76.6/ -1.2	78.3/ 1.4
Average		75.0*/ 1.7	80.3*/ 2.6	74.8*/ -1.9	76.7*/ 0.8
All Station Averages		72.9*/ 1.5	78.0*/ 2.2	72.6*/ -2.3	74.5*/ 0.5

*Patuxent's data not included in averages due to lack of long term averages. The Patuxent weather station has only been in existence since 1977.
**Anomaly = percent departure from 1951-1980 average except for the Chantilly weather station (1966-1980).

Data Source: National Weather Service

precipitation, indicating variable precipitation patterns throughout the bay region. The Susquehanna River stations received a total of 11.33 inches of precipitation as rain or snow, which was 16 % above normal. The Potomac River stations and the James River station received total precipitation of 4.99 inches (14 % below normal) and 1.16 inches (60 % below normal), respectively. Stations on the Chesapeake Bay received 7.17 inches of precipitation (20 % below normal).

Temperatures averaged 54.3° F for the nine stations; or 0.3° F above normal. The Susquehanna River stations' average temperature was 51.3° F (1.2° F above normal). The Potomac River stations and the James River station also reported above-normal average temperatures, 54.9° F (0.2° F above normal) and 59.2° F (1.3° F above normal), respectively. Only stations on the bay reported a below-average monthly temperature (55.3° F; 0.8° F below normal). During April, no station showed a significant temperature departure from normal (T-test; $P<0.05$).

Frozen ground cover remained absent at all stations until 22 April, when a storm moving up the Ohio Valley deposited 3 to 4 inches of snow on the ground at Wilkes-Barre, PA. Temperatures reaching the 60's and 70's on 23 and 24 April, caused a rapid melt, and by 25 April, frozen ground cover was again absent.

May:

Total precipitation in May at the nine meteorological stations was 17.09 inches (47 % below normal), making this the third consecutive month of below-normal precipitation for the Chesapeake Bay region. The Susquehanna River basin, which reported above-normal precipitation in March and April, showed a 19 % deficiency this month. Only Williamsport, PA, had above-normal rainfall (7 % above normal). For the spring quarter as a whole, the Susquehanna drainage had a 4 % positive precipitation anomaly. The Potomac River and James River basin stations reported total precipitation of 1.94 inches (73 % below normal), and 3.15 inches (13 % below normal), respectively, producing a total spring quarter deficit of 56 % for the Potomac and 45 % for the James. Meteorological stations on the bay reported 3.54 inches of precipitation (67 % below normal) and a total deficit of 53 % for the spring quarter. None of these differences, however, for the month of May or for the quarter, were statistically significant (T-test; square root transformation; $P<0.05$).

Warmer-than-normal temperatures continued in May throughout the bay region. The warmest region was the Susquehanna basin, which averaged 3.9° F above normal for the month. The Potomac River drainage basin stations reported an average temperature of 2.1° F above normal; and the James River station reported an average temperature of 0.8° F above normal. For the spring quarter, the Potomac and James River stations reported average temperatures of 1.2° F and 1.6° F above normal, respectively. Stations on the bay reported an average temperature for May of 2.2° F above normal, and a spring quarter average of 1.0° F above normal.

2.1.b Summer Quarter

The summer quarter (June through August) was a period of slightly below-normal precipitation (3 %) and slightly above-normal temperatures (0.5° F) for the Chesapeake Bay region. The summer quarter marked the third consecutive quarter of below-average precipitation for the region. In August, Hurricane Charlie's center passed near the bay mouth and moved northward along the Atlantic coast.

June:

Total precipitation amounts in June (Table 4) were below normal (35 %) for the Chesapeake Bay region, making this the sixth month in the past seven, of below-normal rainfall (only February's precipitation was above normal). The overall below-normal precipitation total was due to the lack of precipitation in the Maryland and Virginia.

The Susquehanna drainage basin, whose winter and spring quarter totals were above normal, also had above-normal precipitation totals (18 % above normal) for June. The Potomac and James River meteorological stations reported precipitation totals of 3.69 inches (64 % below normal) and 1.30 inches (64 % below normal), respectively. Stations on the Chesapeake Bay also reported below-normal rainfall (4.35 inches, 58 % below normal). No stations, however, reported significant departures from normal precipitation (T-test; square root transformation for normality; $P<0.05$).

Temperatures in June continued to be above average (1.5° F above normal) for the all-stations average (Table 5). The Susquehanna River basin was 0.6° F cooler than normal, while the remainder of the bay region was dryer and warmer than normal. The Potomac River drainage and the James River stations reported temperatures 2.5° F above normal and 2.6° F above normal, respectively, primarily because of very warm daytime readings. Stations on the bay also reported higher-than-normal average temperatures (1.7° F above normal). However no stations within the Chesapeake Bay region had temperatures which significantly departed from normal (T-test, $P<0.05$).

July:

Unusually dry conditions started developing in the southern United States during December 1985, and continued in the Chesapeake Bay region into July 1986. Figure 2 shows the percentage of normal precipitation for the period 30 March through 19 July 1986. The drought in the Southeast was considered the worst in at least 111 years by the Climate Analysis Center, NOAA (Figure 3).

Weather patterns in July produced above-normal precipitation in the northern portion of the Chesapeake Bay region while the drought continued in the southern portion of the bay. The Susquehanna River drainage basin stations totaled 18.20 inches (72 % above normal). Heavy thunderstorm activity produced 7.25 inches of rain (116 % above normal) at Wilkes-Barre, PA, during July. The Potomac and James River meteorological stations reported 25 % and 35 % below normal rainfall, respectively. Of the weather stations on the bay, only Baltimore, MD, had a positive rainfall anomaly (6 % above normal). The total precipitation for all stations on the bay was 25 % below normal.

Temperatures in the Susquehanna drainage basin were normal during July and above normal within the other bay drainage areas. The Potomac and James River stations reported temperature averages of 3.0° F and 3.1° F above normal, respectively. Stations on the bay had an average temperature of 2.6° F above normal. No station reported significant temperature departures from normal throughout the bay area (T-test; $p<0.05$).

August:

Hurricane Charlie, which moved up the Atlantic coast in mid-month, helped produce the first above-normal rainfall (20.0 %) for the Chesapeake Bay region since February 1986. August, after five months of above-normal average temperatures, was 2.3° F cooler than normal.

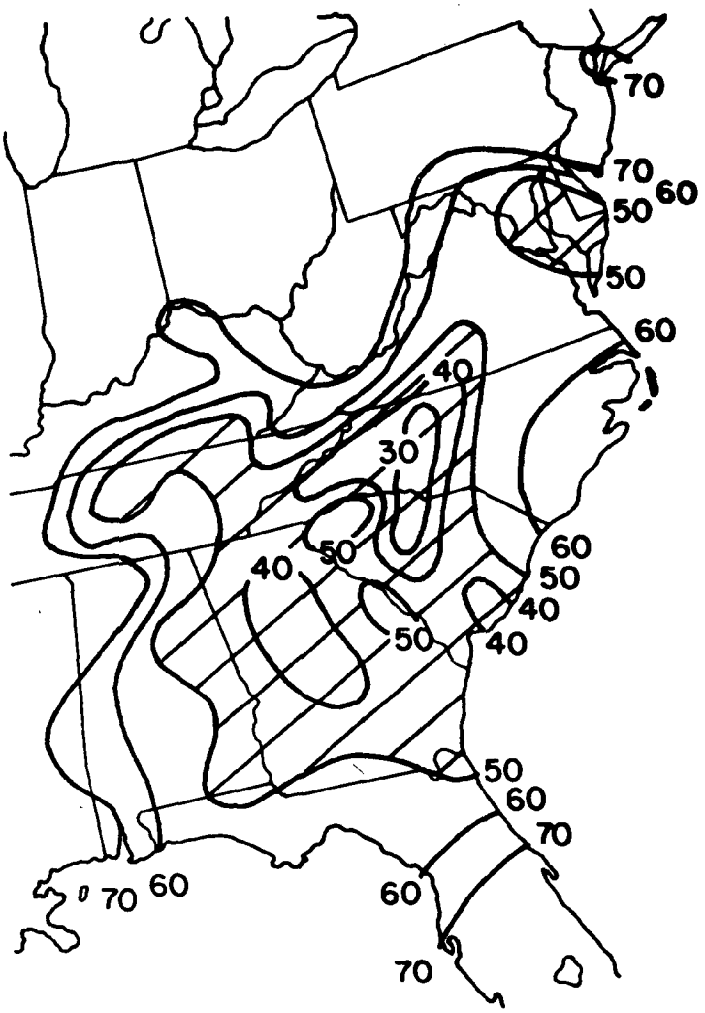

Figure 2 -- Percent of normal precipitation 30 March - 19 July, 1986 (Shaded areas are 50 percent or less)

Data Source: Climate Analysis Center, National Weather Service, NOAA - Preliminary Report

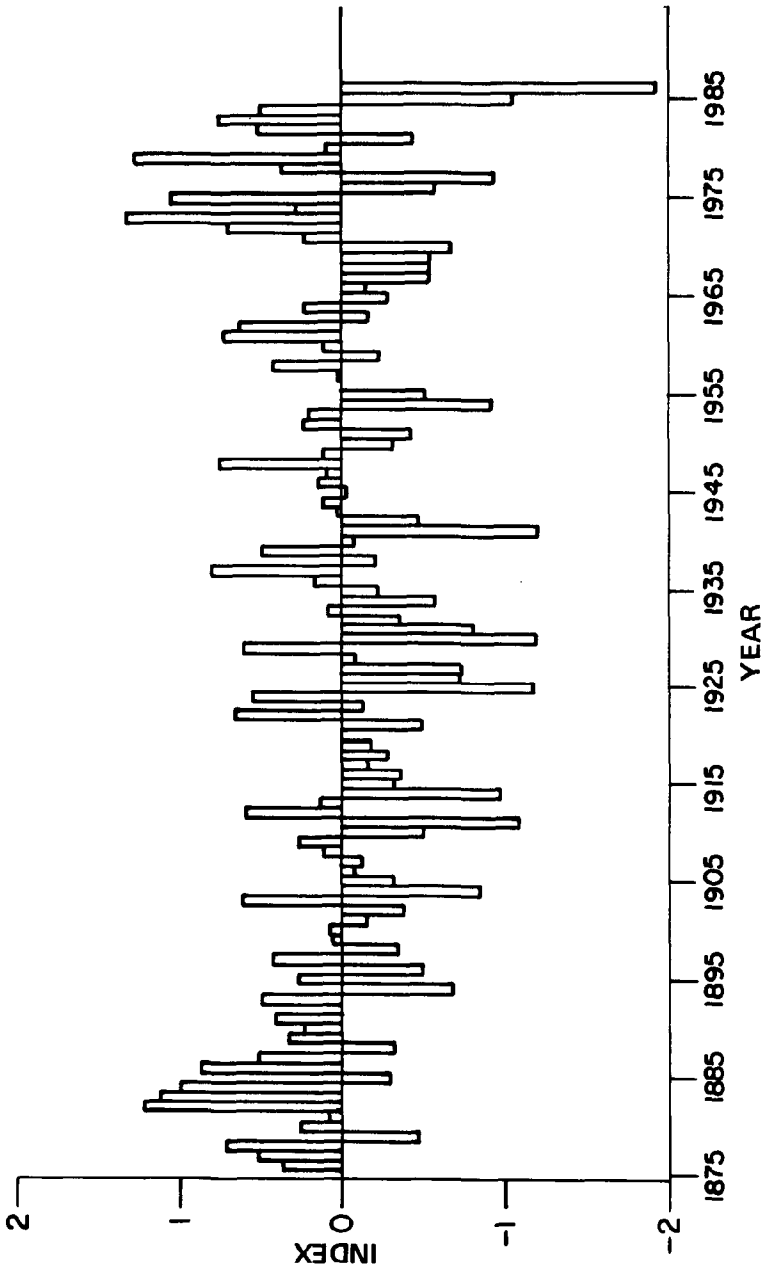

Figure 3 -- An index of arbitrary units of normalized precipitation for comparison plotted yearly in sequence for the January - June period since 1875.

Data Source: Climate Analysis Center, National Weather Service, NOAA

The Susquehanna River basin experienced its third straight month of above-normal precipitation (35 %). The Potomac and James River basins, on the other hand, had their first above-normal precipitation in almost six months. Rainfall at the two Potomac stations totaled 11.05 inches, or 31 % above normal and at the James River station 6.75 inches (35 %) of rain fell. Stations on the bay had near normal amounts of rain (1 %).

Below-normal temperatures were reported at all of the stations within the Chesapeake Bay region. Temperatures within the Susquehanna basin were 2.6° F below normal. The Potomac and James River stations reported temperatures of 2.4° F and 2.6° F below normal, respectively. Temperatures around the bay averaged 1.9° F below normal.

On 17 August, Hurricane Charlie moved up the Atlantic coast, producing high winds and heavy rains.

2.2 Winds

2.2.a Spring Quarter

The National Weather Service posted 27 small craft advisories and 3 gale warnings (Figure 4 and Table 6) for the Chesapeake Bay area during the spring quarter. In comparison with the 1985 spring quarter, small craft advisories decreased by 7 and gale warnings decreased by 1.

March had the greatest number of small craft and gale warning hours posted throughout the bay (Figure 5) during the spring quarter. May had the fewest small craft warnings, and no gale warnings were posted.

The number of hours for which marine advisories and warnings were issued was significantly different (Chi-square = 49.9; df = 4; $P<0.001$) between forecast areas even though data were incomplete for the tidal Potomac and Windmill Point to the mouth of the bay for 19 March-31 March. The area of the bay from Windmill Point to the mouth of the bay had more advisory hours than the northern portion of the bay. According to Table 7, during the spring quarter, marine advisories and warnings were issued at least 15 % of the total hours (2208 hours) for the entire bay region.

2.2.b Summer Quarter

During the summer quarter the National Weather Service issued 13 small craft advisories, 2 gale warnings, and one hurricane warning (Table 7) for the Chesapeake Bay area. Compared to last year's summer quarter, small craft advisories and gale warnings increased by 2 each. July 1986 had the fewest advisories and warnings (Figure 6) issued of any month in 1986. A hurricane warning was posted in August for the area from Windmill Point to the mouth of the bay.

The number of hours marine advisories and warnings were issued was significantly different (Chi-square = 35.7; df = 4; $p<0.001$) between forecast areas during the summer quarter. The area from Windmill Point to the mouth of the bay had significantly more advisory hours than the area from Baltimore Harbor to the head of the bay. According to Table 8, during the summer quarter, marine advisories and warnings were issued at least 5 % of the total hours (2208 hours) for the bay area.

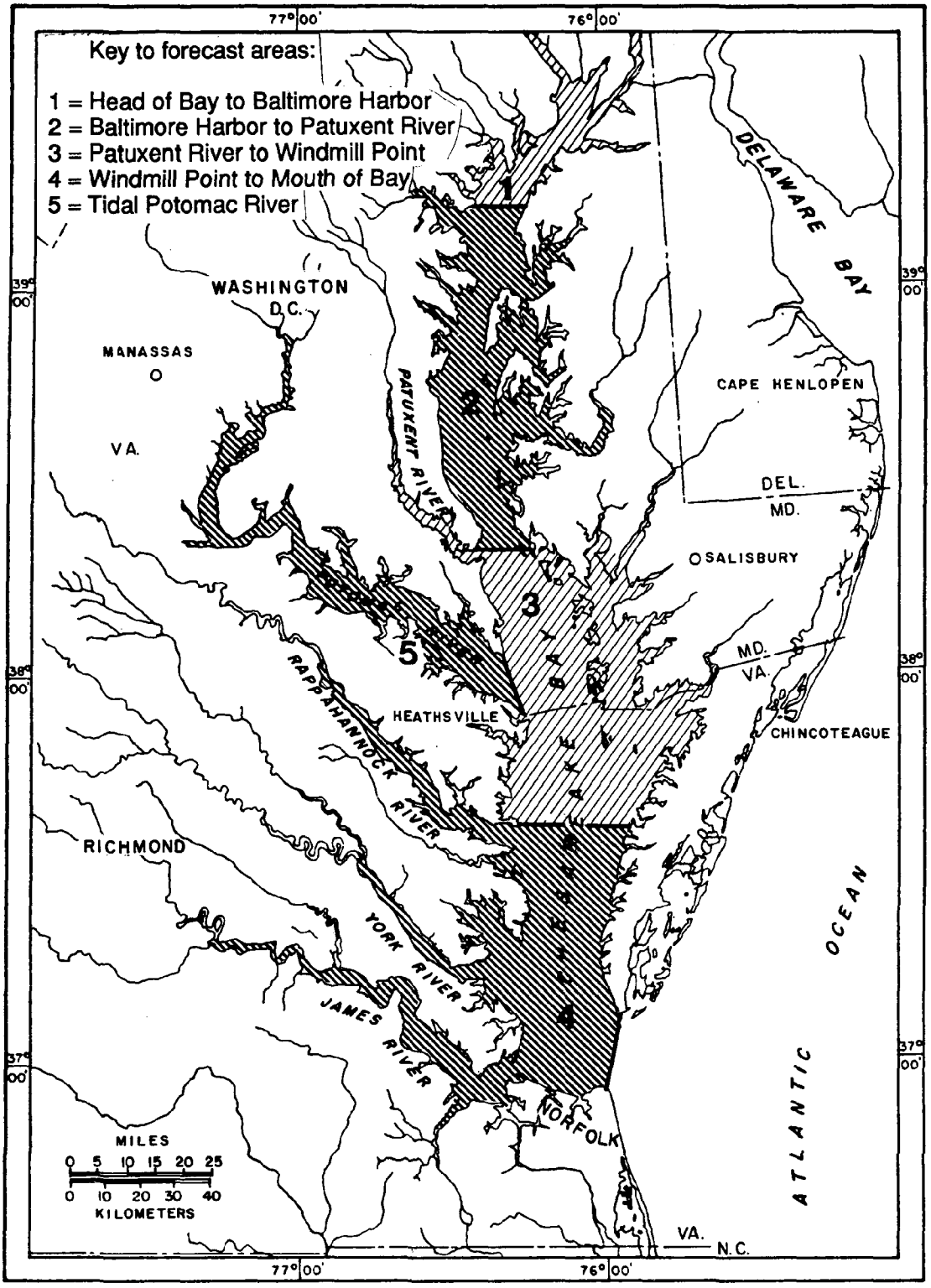

Figure 4 -- National Weather Service (NWS) forecast areas for Chesapeake Bay

Table 6 -- Marine advisories/warnings, Chesapeake Bay, March-August 1986.

Date		Condition Report[1]	Forecast Area
March	1	A	South of Windmill Pt.[2]
	2	A	South of Windmill Pt.
	6	A	Entire bay
	6	B	Entire bay
	8	A	Head of Bay to Windmill Pt. and tidal Potomac
	8	A	South of Windmill Pt.
	9	A	Entire bay
	10	A	Entire bay
	12	A	South of Windmill Pt.
	14	A	South of Windmill Pt.
	14	A	Head of bay to Windmill Pt. and tidal Potomac
	18	A	Head of bay to Windmill Pt.
	19	A	Tidal Potomac
	19	B	Head of bay to Windmill Pt.
	19	A	Head of bay to Windmill Pt.
	21	B	South of Windmill Pt.
April	5	A	South of Windmill Pt.
	8	A	Entire bay
	13	A	South of Windmill Pt.
	15	A	South of Windmill Pt.
	16	A	South of Windmill Pt.
	17	A	Entire bay
	20	A	Entire bay
	22	A	South of Windmill Pt.
	23	A	Entire bay
May	1	A	Entire bay
	5	A	Entire bay
	8	A	Entire bay
	10	A	South of Windmill Pt.
	20	A	South of Windmill Pt.
June	2	A	Entire bay
	3	A	Patuxent River to South of Windmill Pt.
	7	A	South of Windmill Pt.
	20	A	Baltimore Harbor to tidal Potomac
	27	A	Patuxent River to South of Windmill Pt.
July	14	A	Head of bay to Patuxent and tidal Potomac
August	11	A	Patuxent River to South of Windmill Pt.
	17	A	Entire bay
	17	B	South of Windmill Pt.
	17	C	South of Windmill Pt.
	17	B	Entire bay
	18	A	Entire bay
	20	A	Entire bay
	24	A	Entire bay
	27	A	Entire bay
	28	A	South of Windmill Pt.

[1] Key to Condition Reports:
A= SMALL CRAFT ADVISORY (WIND 25-34 KNOTS)
B= GALE WARNING (WIND 34-47 KNOTS)
C= STORM (WIND 47-64 KNOTS)
D= SPECIAL MARINE WARNING (UNUSUAL WEATHER PHENOMENA)

[2] Windmill Point = North side of Rappahannock River mouth

Data Source: National Weather Service

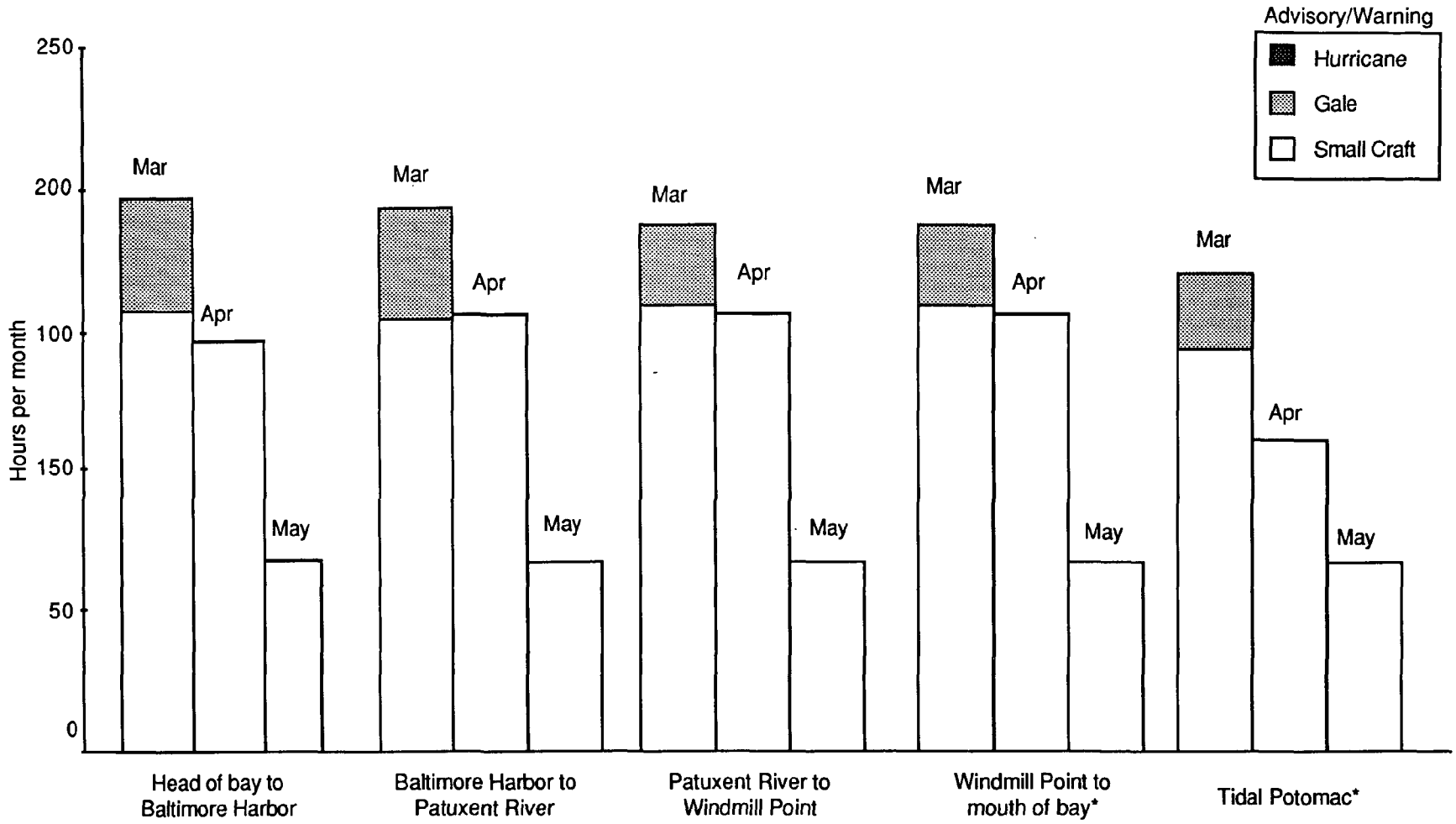

Figure 5 - - Hours per month for which National Weather Service Marine advisories/warnings were issued for locations within the Chesapeake Bay (March - May 1986).

* Data for the period 19-31 March 1986 for areas Windmill Point to mouth of bay and Tidal Potomac are unavailable; thus the values are minimums.

Data Source: National Weather Service

Table 7 -- Percent total time and hours [in brackets] during which marine advisories/warnings were issued for areas within Chesapeake Bay, March-May 1986 (total hours in the quarter = 2208)

Location	Small Craft % [Hours]	Gale % [Hours]	All Warnings % [Hours]
Head of bay to Baltimore Harbor	17.2 [379.9]	1.8 [40.6]	19.0 [420.5]
Baltimore Harbor to Patuxent River	19.6 [432.5]	1.8 [40.6]	21.4 [473.1]
Patuxent River to Windmill Point	18.0 [398.0]	1.8 [40.6]	19.8 [438.6]
Windmill Point to mouth of bay	≥22.2 [490.1]*	≥2.1 [47.3]*	≥24.3 [537.4]*
Tidal Potomac	≥13.8 [305.7]*	≥ 1.3 [29.3]*	≥15.1 [335.0]*

*Data for the period 19-31 March 1986 for areas Windmill Point to the mouth of bay and tidal Potomac are unavailable, thus these values are minimums.

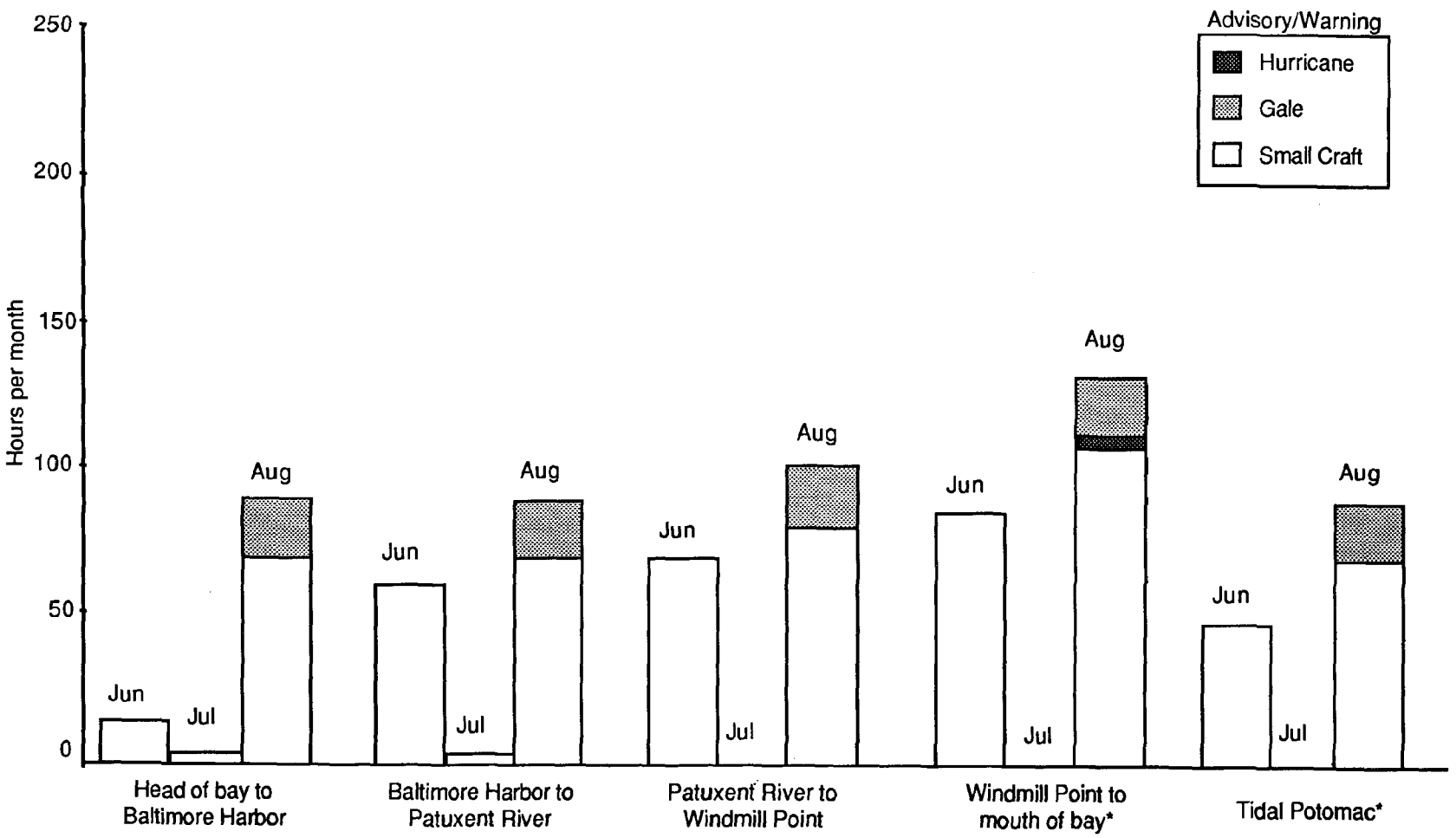

Figure 6 - - Hours per month for which National Weather Service Marine advisories/warnings were issued for locations within the Chesapeake Bay (June - August 1986).

*Data for the period 19-31 March 1986 for areas Windmill Point to mouth of bay and Tidal Potomac are unavailable; thus the values are minimums.

Data Source: National Weather Service

Table 8 -- Percent total time and hours [in brackets] during which marine advisories/warnings were issued for areas within Chesapeake Bay, June-August 1986 (Total hours in the quarter = 2208).

Location	Small Craft % [Hours]	Gale % [Hours]	Hurricane % [Hours]	All Warnings % [Hours]
Head of bay to Baltimore Harbor	4.4 [97.0]	1.0 [22.0]	0.0 [0.0]	5.4 [119.0]
Baltimore Harbor to Patuxent River	6.5 [144.0]	1.0 [22.0]	0.0 [0.0]	7.5 [166.0]
Patuxent River to Windmill Point	7.1 [157.8]	1.0 [22.0]	0.0 [0.0]	8.1 [179.8]
Windmill Point to mouth of bay	9.1 [200.5]	0.1 [2.0]	1.0 [22.0]	10.2 [224.5]
Tidal Potomac	5.9 [129.5]	1.0 [22.0]	0.0 [0.0]	6.9 [151.5]

2.3 Streamflow

Bay streamflow was 20.4 % below normal for the spring quarter, reflecting below-normal precipitation (35.0 %) throughout the bay drainage areas (Table 9).

In March, streamflow was 5.6 % above normal due to above-normal (6.0 %) precipitation in the Susquehanna drainage and the residual effects of February's above-normal streamflow. Of the March total streamflow, 60.1 %, or 101.5 thousand cubic feet per second (Figures 7 and 8), was contributed by the Susquehanna River drainage. In April, the Susquehanna's contribution increased to 62.9 %. This increase again reflected the above-normal precipitation in the Susquehanna drainage basin and below-normal rainfall throughout the remainder of the bay region. Overall streamflow was 32.9 % below normal in April. In May, the total streamflow fell to 45.4 % below normal, a reflection of the increasing drought conditions within the bay area.

Although the drought during the spring and summer of 1986 in the southeastern United States was the severest in 111 years, no new low Chesapeake Bay streamflow records were set (Figure 9). The above-normal precipitation in the Susquehanna drainage area helped to compensate for the drought in the southern region of the bay. Thus the overall effect was lower-than-normal, but not record-setting, streamflow.

In June, total streamflow was still below normal (Table 10), but had risen to 26.3 % below normal from 45.4 % below normal in May. Heavy rains in the Susquehanna River drainage basin (72 % above normal) decreased the total streamflow deficit to 11.3 % in July. Hurricane Charlie and numerous thunderstorms combined to bring the total streamflow to above normal (4.9 %) in August.

Calendar year 1985 ended with a cumulative streamflow deficit of 2.1 trillion gallons (Figure 10). The first eight months of 1986 continued to show deficit total streamflow.

Table 9 -- Chesapeake Bay drainage basin streamflow and precipitation anomalies, March-May 1986.

Month	Drainage	Precipitation Anomaly (%)*	% Contribution of total bay Streamflow	Total Streamflow Anomaly (%)**
March	Susquehanna	6.0	60.1	
	Potomac	-72.0	19.5	
	James	-68.0	8.3	
	Others***	-67.0	12.1	
	All Stations	-46.0		5.6
April	Susquehanna	16.0	62.9	
	Potomac	-14.0	17.3	
	James	-60.0	6.5	
	Others	-20.0	13.3	
	All Stations	-10.0		-32.9
May	Susquehanna	-19.0	52.1	
	Potomac	-73.0	19.3	
	James	-13.0	12.0	
	Others	-67.0	16.6	
	All Stations	-47.0		-45.4
Quarter Average		-35.0		-20.4

*Anomaly = departure from 1951-1980 average, except Chantilly VA within Potomac drainage, whose average is from 1966-1980

**Anomaly = departure from 1951-1980 average

***Others = West Chesapeake, Patuxent, Rappahannock and York drainages

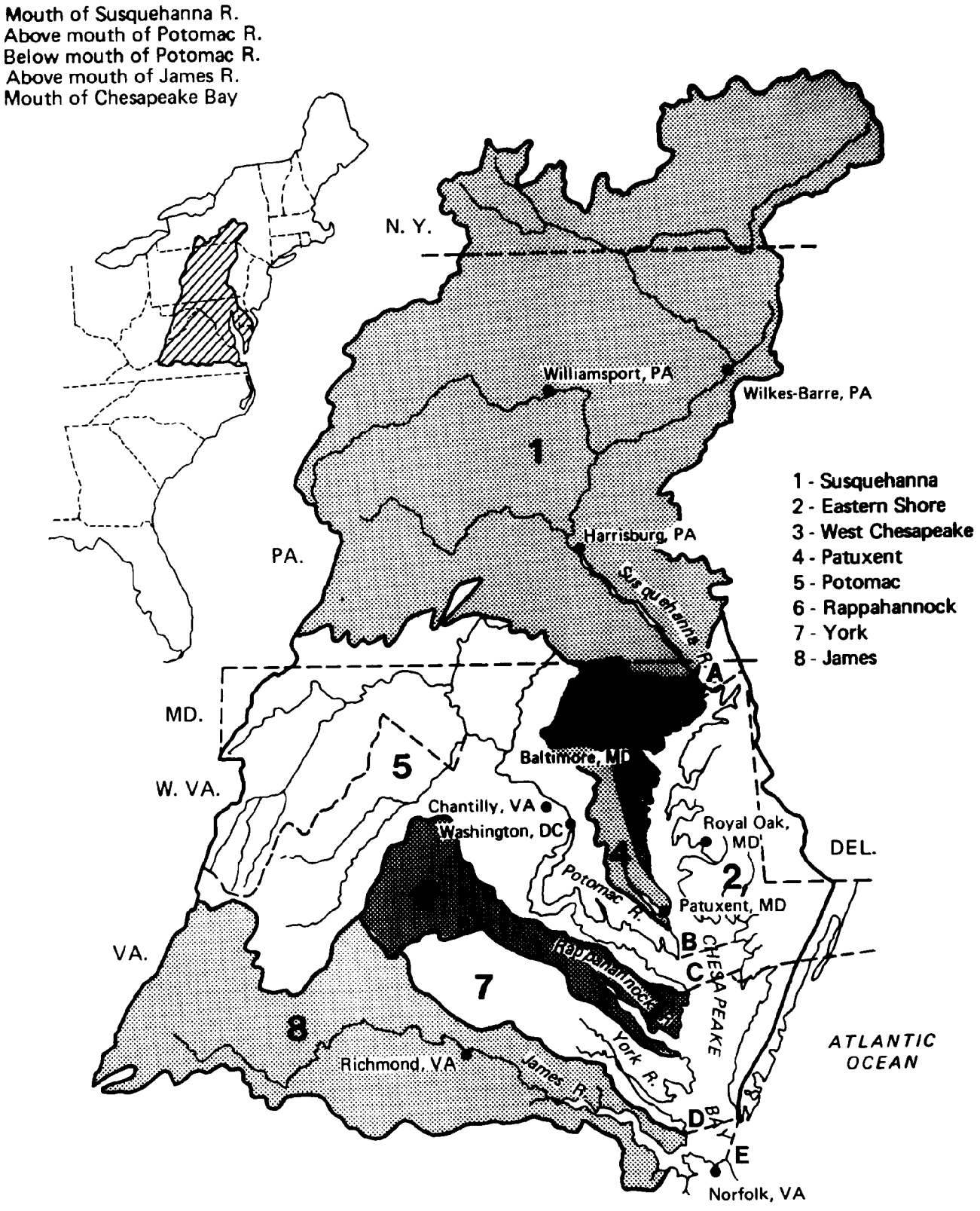

Figure 7 -- The major drainage basins of the Chesapeake Bay system

Figure from: U.S. Geological Survey

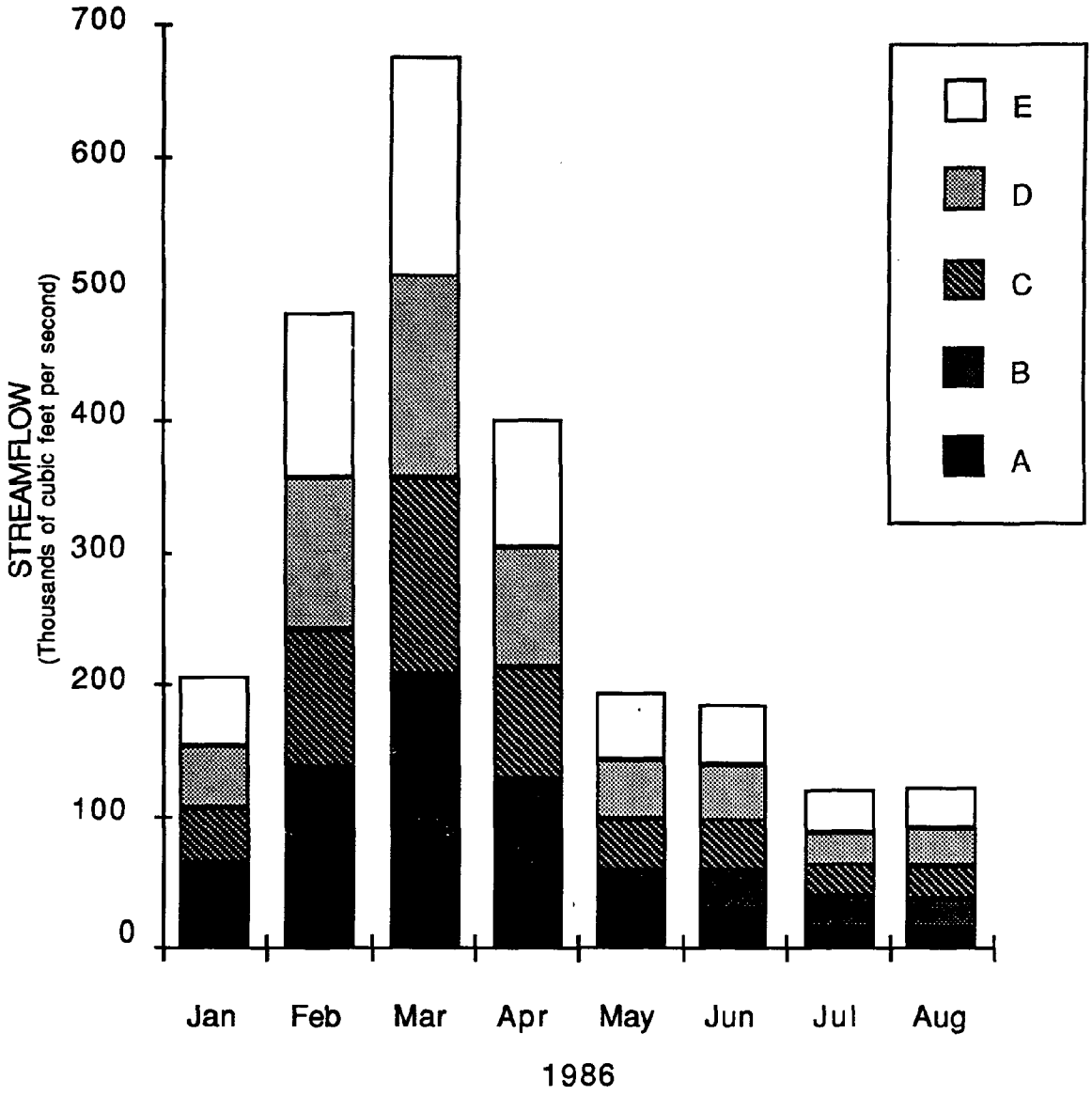

Figure 8 - - Estimated cumulative streamflow into Chesapeake Bay above dashed lines shown on Figure 7. A = mouth of Susquehanna River, B = above mouth of Potomac River, C = below mouth of Potomac River, D = above mouth of James River, and E = mouth of Chesapeake Bay.

Data Source: U.S. Geological Survey

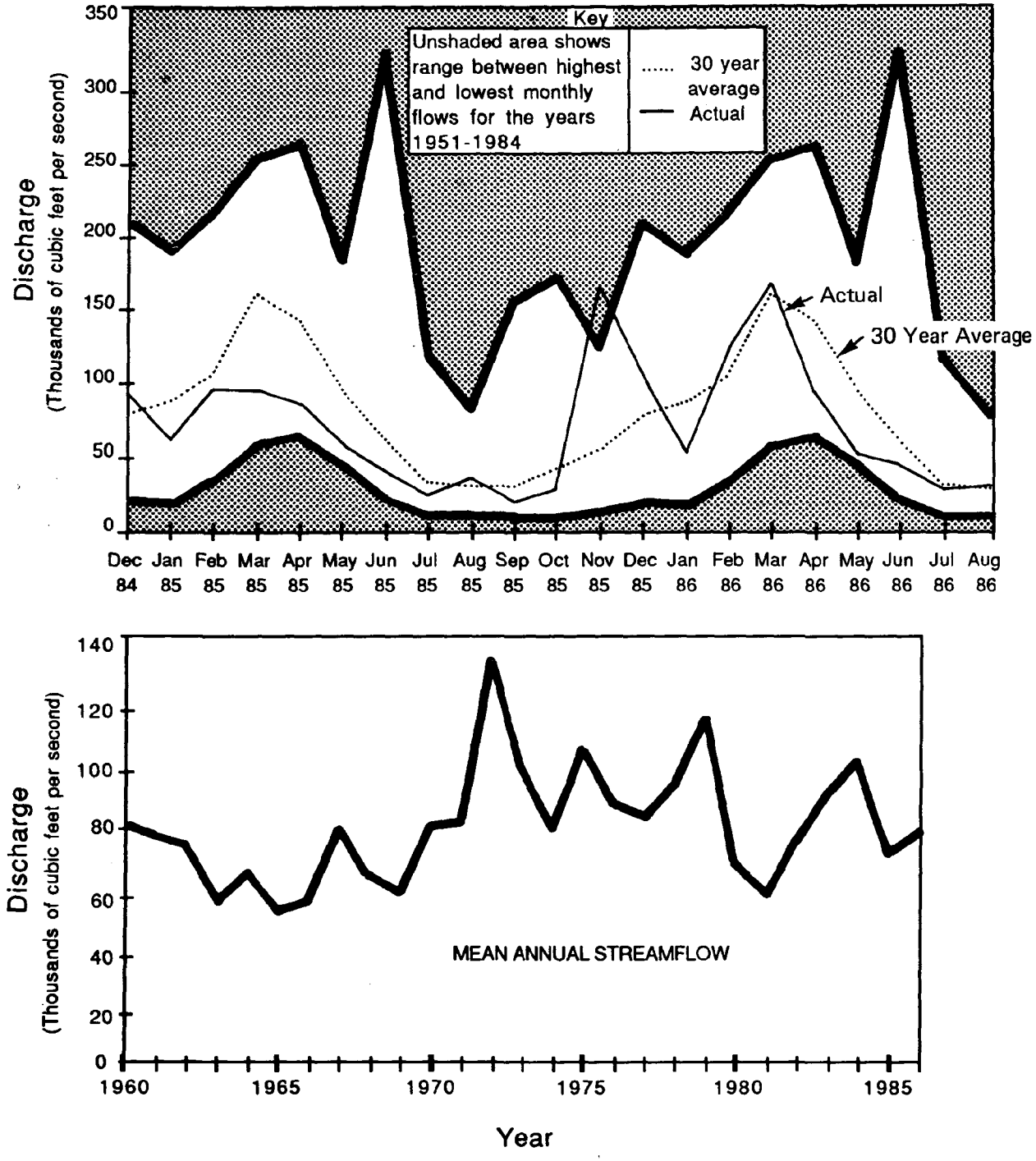

Figure 9 -- Monthly streamflow into Chesapeake Bay, December 1984 - August 1986, and annual mean streamflow since 1960.

Data Source: U.S. Geological Survey

Table 10 -- Chesapeake Bay drainage basin streamflow and precipitation anomalies, June-August 1986.

Month	Drainage	Precipitation Anomaly (%)*	% Contribution of the bay streamflow	Total streamflow Anomaly (%)**
June	Susquehanna	18.0	66.9	
	Potomac	64.0	11.3	
	James	64.0	6.5	
	Others***	-58.0	15.3	
	All Stations	-35.0		-26.3
July	Susquehanna	72.0	60.3	
	Potomac	-25.0	12.8	
	James	-35.0	7.7	
	Others	-25.0	19.2	
	All Stations	2.0		-11.3
August	Susquehanna	35.0	60.8	
	Potomac	31.0	10.3	
	James	35.0	9.7	
	Others	-1.0	19.1	
	All Stations	20.0		4.9
Quarter Average		-3.0		-14.8

*Anomaly = departure from 1951-1980 average, except Chantilly VA within Potomac drainage whose average is from 1964-1980

**Anomaly = departure from 1951-1980 average

***Others = West Chesapeake, Patuxent, Rappahannock and York drainages

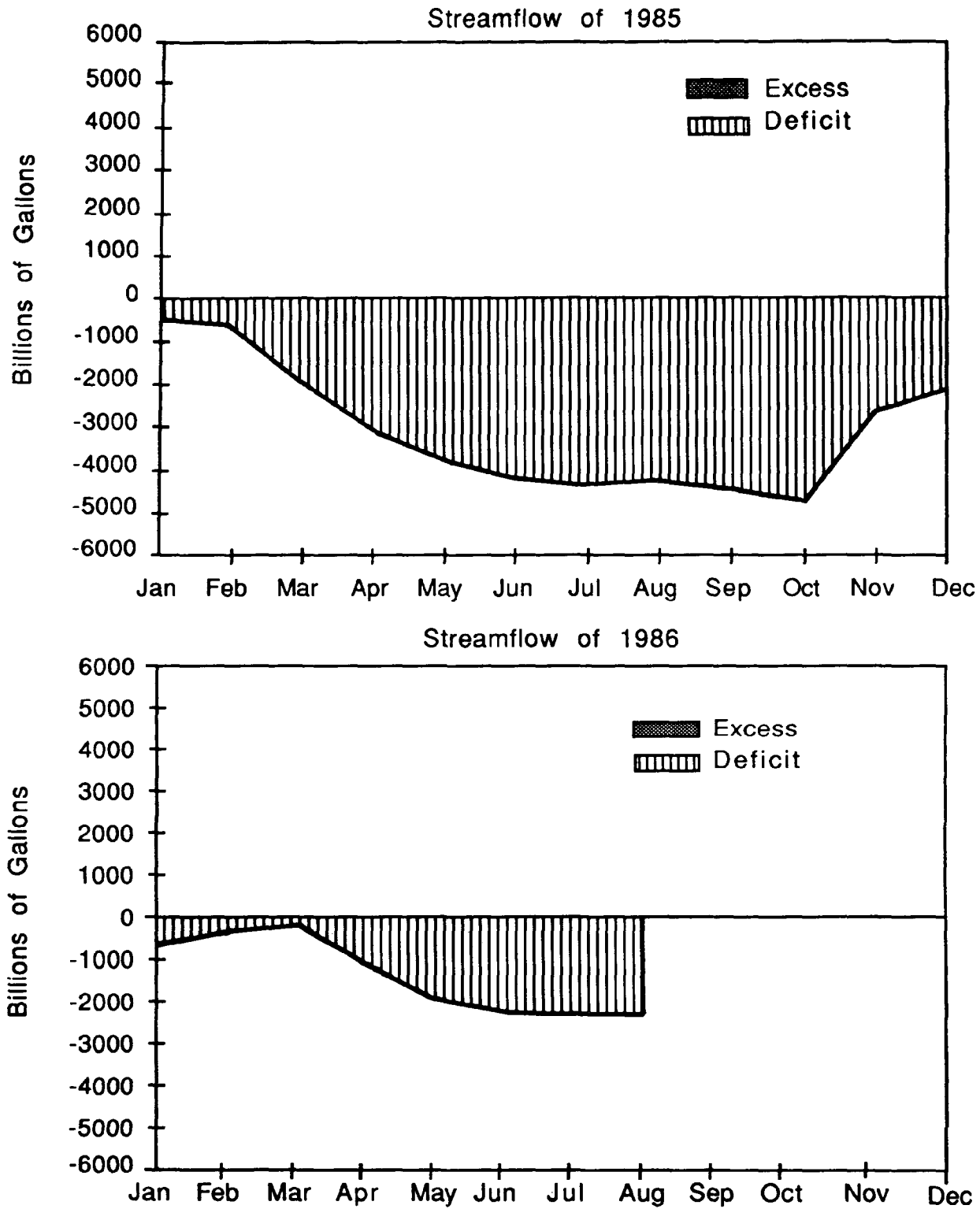

Figure 10 -- Cumulative monthly streamflow anomaly, Chesapeake Bay, 1985 and 1986

Data Source: U.S. Geological Survey

2.4 Oceanography

The five coastal stations around the bay for which a historical data base exists showed the average monthly bay surface salinities (Table 11) increasing from below normal to significantly above normal during in May (T-test; $P<0.001$). In the first two months of the summer quarter average bay surface salinities were still significantly above normal at nearly all reporting stations (Table 12).

Average surface water temperatures (Table 13) were mostly above average with two stations reporting significant departures from their monthly averages during part of the spring quarter. Above-average surface water temperatures continued at all five stations throughout most of the summer quarter (Table 14).

Salinity:

During the spring and summer quarters the bay displayed its normal salinity cycle, as it became less saline from March to April then progressively more saline as the summer passed (Figure 11 and 12). In May, the isohaline began to move northward. By August the 15 parts per thousand isohaline was north of the mouth of the Patuxent River (Figure 12).

March's below-normal salinities reflect above-normal (5.6 %) streamflow through the bay. Only the Bay Bridge Tunnel station showed significantly above-normal salinity for the month (T-test; $P<0.001$). In April, salinity within the bay started to increase, although it remained below normal in most parts of the bay. By the end of the spring quarter all stations except Kiptopeke, VA, had significantly ($P<0.001$) higher-than-normal average salinities due to below-normal precipitation and above-average temperatures.

Salinity continued to be significantly above normal during June at all stations except Kiptopeke, VA. In July, all stations reported significantly above-normal salinities. Hurricane Charlie and the numerous thunderstorms in August helped reduce the salinity in the bay, although two stations (Baltimore and Solomons) still had significantly above-average readings.

Temperature:

Surface water temperatures in March were above normal in the upper part of the bay, below normal at Kiptopeke, VA, and significantly ($P<0.001$) below normal at the Chesapeake Bay Bridge-Tunnel station. In April the Bay Bridge-Tunnel still had a significantly below-average water temperature, while the Solomon station reported a significantly above-average temperature. Other stations around the bay reported near normal temperatures. No significant departures from normal water temperatures was noted in May at any station.

In June, all stations recorded above-average surface water temperatures except the Bay Bridge-Tunnel station, which posted its sixth straight month of below-normal temperatures. No station, however, showed a significant departure from normal despite the above-normal air temperatures and below-normal precipitation. In July, the Bay Bridge-Tunnel still reported a below-average water temperature, as did the Baltimore station. Baltimore's below-normal temperature was probably due to the heavy streamflow from the Susquehanna River basin. Kiptopeke, VA, and Solomon, MD, were the only stations with water temperatures significantly above-normal in July. Hurricane Charlie, numerous thunderstorms, and cooler-than-normal air temperatures returned the Chesapeake Bay's water temperature to near normal in August. No station reported water temperatures that departed significantly from normal.

Table 11 -- Surface salinity (parts per thousand) and departure from normal (%), March-May 1986.

Station	March Observed/Anomaly*	April Observed/Anomaly*	May Observed/Anomaly*
Baltimore, MD	7.6/ -0.8	6.1/ -0.1	7.7/ 3.9**
Annapolis, MD	8.1/ -1.5	6.8/ -0.4	9.0/ 2.1**
Solomons, MD	12.7/ -0.4	11.0/ -0.2	13.1/ 2.3**
Kiptopeke, VA	24.5 / -0.9	25.6/ 1.2	25.9/ 1.3
Bay Bridge Tunnel, VA	22.1/ 2.4**	21.8/ 1.9**	24.4/ 3.8**

*Anomaly = departure from long-term averages
** = significance at P<0.001

Data Source: Calculated from National Ocean Service observed values and long-term (1951-1980) normals for Chesapeake Bay surface and water temperatures

Table 12 -- Surface salinity (parts per thousand) and departure from normal (%), June-August 1986.

Station	June Observed/Anomaly*	July Observed/Anomaly*	August Observed/Anomaly*
Baltimore, MD	8.5/ 2.5**	9.5/ 2.6**	9.4/ 1.4**
Annapolis, MD	9.5/ 1.5**	10.4/ 1.2**	10.9/ 0.7
Solomons, MD	14.6/ 3.4**	15.4/ 2.8**	16.3/ 2.8**
Kiptopeke, VA	26.6/ 0.8	28.2/ 1.8**	29.0/ 1.3
Bay Bridge Tunnel, VA	24.3/ 2.1**	26.0/ 1.9**	25.3/ 1.2

*Anomaly = departure from long-term averages
** = significance at P<0.001

Data Source: Calculated from National Ocean Service observed values and long-term (1951-1980) normals for Chesapeake Bay surface and water temperatures

Table 13 -- Average surface water temperature (F°) and departure from normal (%), March-May 1986.

Station	March Observed/Anomaly*	April Observed/Anomaly*	May Observed/Anomaly*
Baltimore, MD	44.8/ 2.6	52.9/ -0.2	65.5/ 1.3
Annapolis, MD	43.0/ 0.4	53.4/ 0.2	65.3/ 0.5
Solomons, MD	43.0/ 0.4	54.4/ 1.9**	64.5/ -0.1
Kiptopeke, VA	43.1/ -1.1	53.9/ 0.8	63.8/ 0.7
Bay Bridge Tunnel, VA	42.1/ -4.8**	53.5/ -1.7**	62.6/ -3.1

*Anomaly = departure from long-term averages
** = significance at P<0.001

Data Source: Calculated from National Ocean Service observed values and long-term (1951-1980) normals for Chesapeake Bay surface salinities and water temperatures

Table 14 -- Average surface water temperature (F°) and departure from normal (%), June-August 1986.

Station	June Observed/Anomaly*	July Observed/Anomaly*	August Observed/Anomaly*
Baltimore, MD	75.3/ 1.2	79.0/ -0.5	79.0 / -0.5
Annapolis, MD	75.4/ 0.9	80.5/ 0.3	79.1 / -0.6
Solomons, MD	76.2/ 1.7	84.4/ 2.3**	81.5 / 1.4
Kiptopeke, VA	73.8/ 1.7	80.1/ 2.9**	77.2 / 0.8
Bay Bridge Tunnel, VA	73.8/ -0.3	78.8/ -0.2	79.4 / -0.5

*Anomaly = departure from long-term averages
** = significance at P<0.0001

Data Source: Calculated from National Ocean Service observed values and long-term (1951-1980) normals for Chesapeake Bay surface salinities and water temperatures

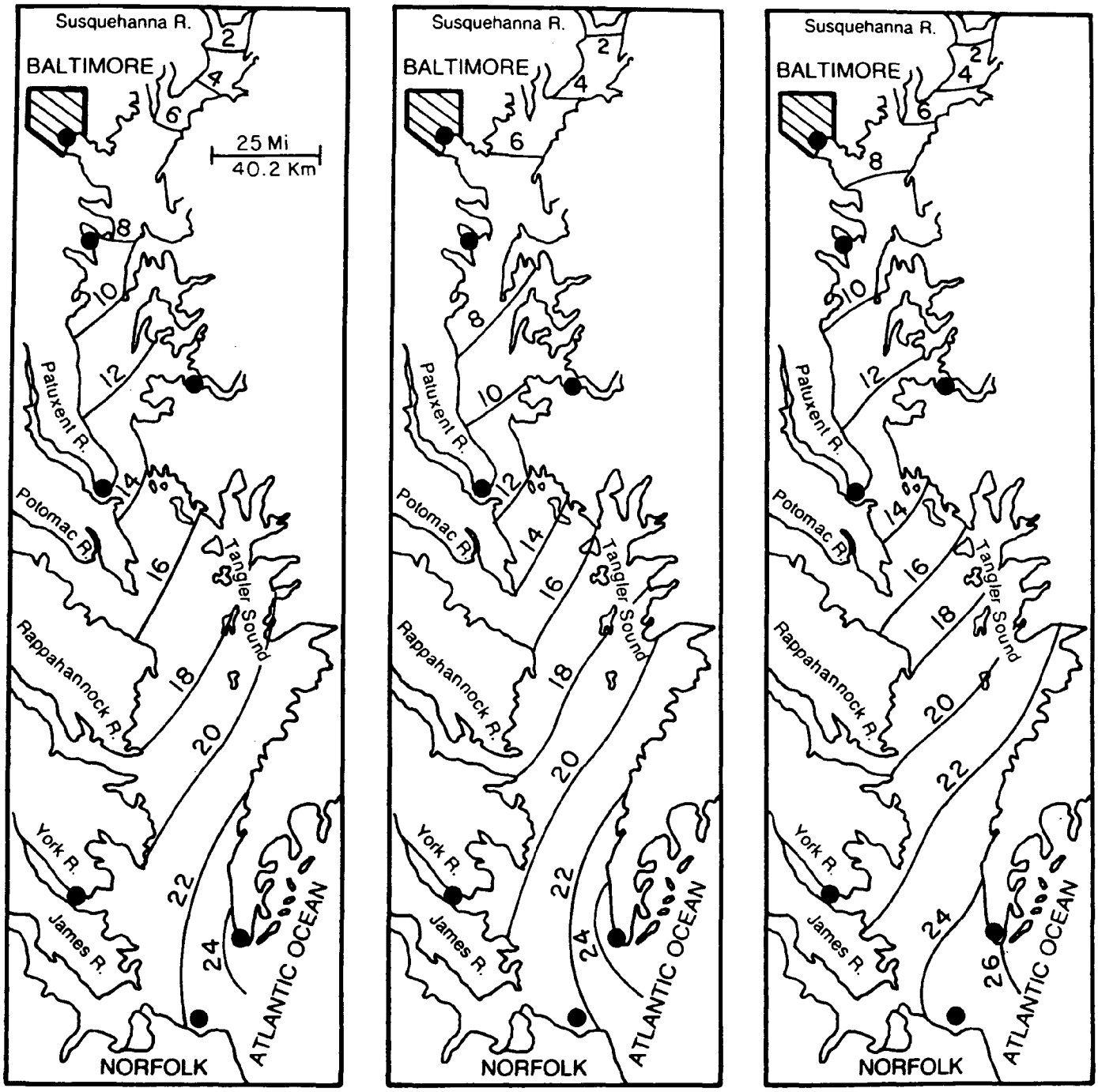

Figure 11 -- Mean surface salinity distribution, Chesapeake Bay, March - May 1986. Isohalines (parts per thousand) are linearly interpolated from designated stations.

Data Source: National Ocean Service, NOAA

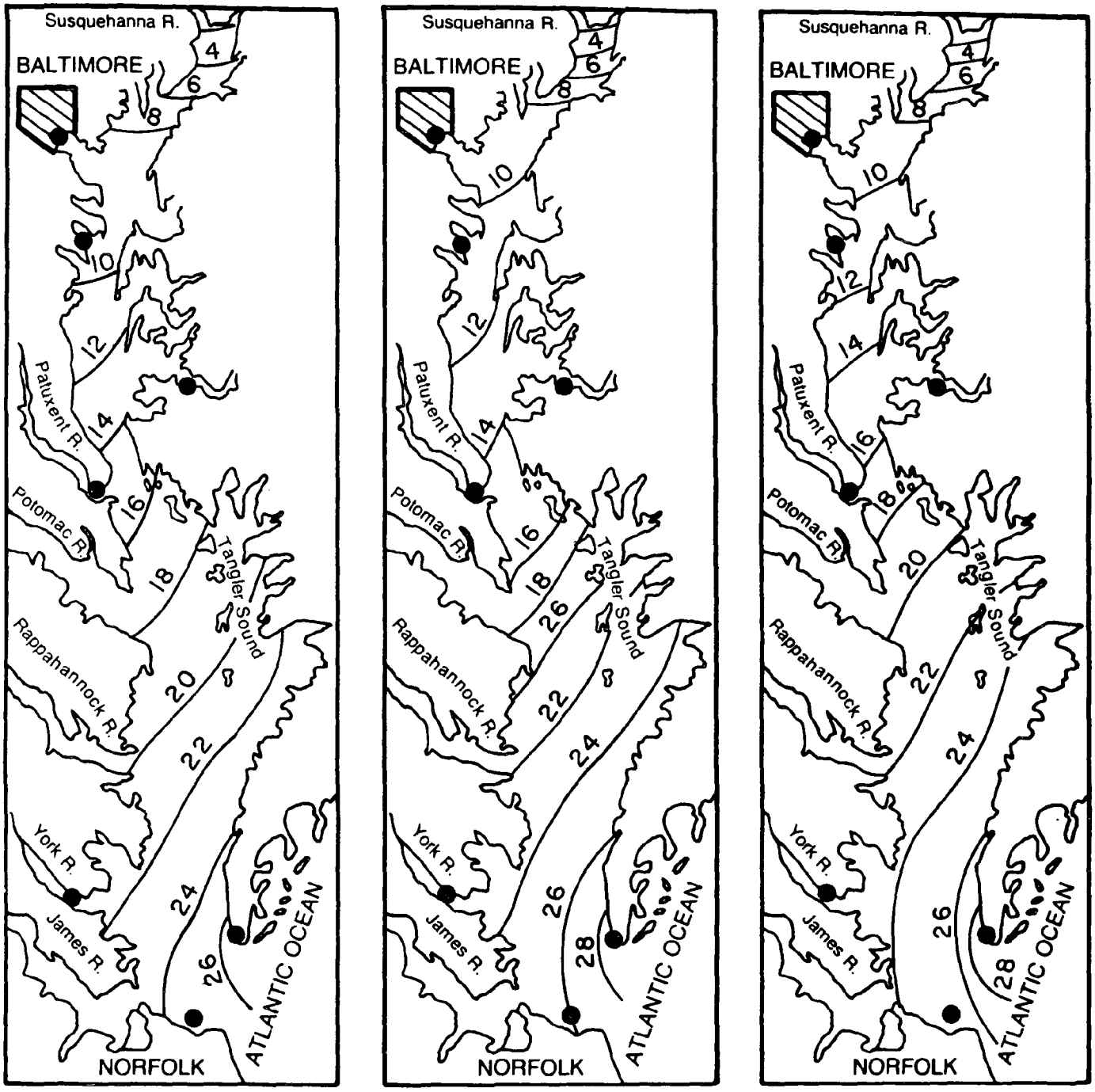

Figure 12 -- Mean surface salinity distribution, Chesapeake Bay, June - August 1986. Isohalines (parts per thousand) are linearly interpolated from designated stations.

Data Source: National Ocean Service, NOAA

3. Impact of Climate/Weather

3.1 Fisheries

Watermen experienced a good blue crab catch in the Virginia segment of the Chesapeake Bay during the spring of 1986 because of favorable conditions for harvest. Bluefish following the movement of the 15° C isotherm arrived in the Maryland portion of Chesapeake Bay during the last week of April. High salinities provided favorable conditions for oyster diseases: an 85 % loss of oysters due to disease was reported.

Shellfish:

In Virginia, March 1986 landings of blue crabs *(Callinectes sapidus)* were 203 % higher than 1985 landings, and the value increased 211 % over the 1985 value, with an average price of $ .38 per pound (Table 15). Prices remained high until August, when they dropped to an average of $ .18 per pound. Warmer-than-normal air temperatures and reduced precipitation during the spring provided favorable fishing conditions for watermen. However, so many hard blue crabs were being harvested in Virginia during favorable weather conditions in the spring that a catch limitation was requested by the Virginia Working Watermen's Association and the Tangier Island Watermen's Association. The Virginia Marine Resources Commission established a daily catch limit of 51 bushels or 17 barrels of crabs from 24 April to 24 May. A ruling passed on 12 January 1987 will establish the same limitations on crab harvest for the 1987 season from 15 March through 31 May. In Maryland, landings at the start of the season were 16 % lower than 1985, but they steadily increased during the season until a rapid decline in August. Average price per pound in Maryland was $ .77 in April and $1.03 in May. By August, however, the average price dropped to $ .37 per pound.

Because of the higher-than-normal salinities during the summer, the range of blue crab habitats was extended into the upper bay and into normally freshwater channels and tributaries. Warm water during the spring and summer of 1986 favored the growth of juvenile crabs of the 1985 year class.

The harvest of soft and peeler blue crabs began well in Maryland and Virginia, hit a low in July, but improved in August (Table 16). Price per pound for soft shell crabs increased overall in 1986 with an average total price per pound of $1.08 in Virginia and $2.06 in Maryland for March through August.

Finfish:

The literature suggests that changes in thermal gradients during the spring and summer may act as barriers to species such as bluefish (*Pomatomus saltatrix*). Within frontal systems off the Middle Atlantic coast, bluefish are found at temperatures ranging from about 12° to 15° C or 53° to 59° F (Figure 13). In addition to other ecological factors such as food availability, it is hypothesized that the majority of bluefish follow the 15° C (59° F) isotherm as it moves in early spring. Satellite derived sea surface temperature analyses show the positions of the 15° isotherm at the mouth of Chesapeake Bay in April 1983 - 1986 (Figures 14a-d).

Bluefish were reported outside Rudy Inlet in Virginia Beach during the second week of April 1986, which is approximately a normal time of arrival for bluefish there. The Maryland Department of Natural Resources reported that by the last week of April, a few large "pioneer" fish were caught in Maryland waters. By early May, groups of medium-size fish (5-6 lbs) were seen, and by mid-May most of the smaller-sized fish (over 2 pounds) entered Maryland waters.

Table 15 -- Maryland and Virginia hard shell blue crabs landings March-August 1985, March-August 1986.

	Maryland		Virginia	
	Pounds	Dollars	Pounds	Dollars
March				
1985	n/a	n/a	426,580	$157,446
1986	n/a	n/a	1,295,842	$491,430
% Change			203%	211%
April				
1985	763,469	$497,449	3,255,624	$1,038,638
1986	642,013	$493,512	4,320,056	$1,285,498
% Change	-16%	-1%	33%	24%
May				
1985	2,694,404	$2,875,264	4,175,848	$1,057,474
1986	2,715,720	$2,801,561	4,184,032	$1,136,381
% Change	1%	-3%	0%	7%
June				
1985	7,805,000	$3,485,000	4,857,886	$979,639
1986	8,424,968	$4,389,612	5,539,396	$1,230,072
% Change	8%	26%	14%	26%
July				
1985	10,573,000	$3,815,000	6,441,949	$1,026,570
1986	11,935,420	$5,081,352	5,645,416	$1,178,488
% Change	13%	33%	-12%	15%
August				
1985	12,608,000	$4,069,000	4,630,091	$764,172
1986	9,013,430	$3,293,658	4,075,471	$753,415
% Change	-29%	-19%	-12%	-1%

Data Source: Virginia Marine Resources Commission

Table 16 -- Blue crab landings, soft and peeler, Maryland and Virginia, March-August 1986.

Month	Maryland		Virginia	
	Pounds	Dollars	Pounds	Dollars
March	0	0	0	0
April	0	0	8,723	$8,026
May	673,773	$1,462,087	483,618	$579,050
June	223,778	$539,305	130,320	$143,689
July	444,045	$723,793	75,251	$79,611
August	324,497	$668,464	119,925	$135,394
Total	1,666,093	$3,393,649	817,837	$945,770

Data Source: Mike Oesterling, Virginia Institute of Marine Science, personal communication

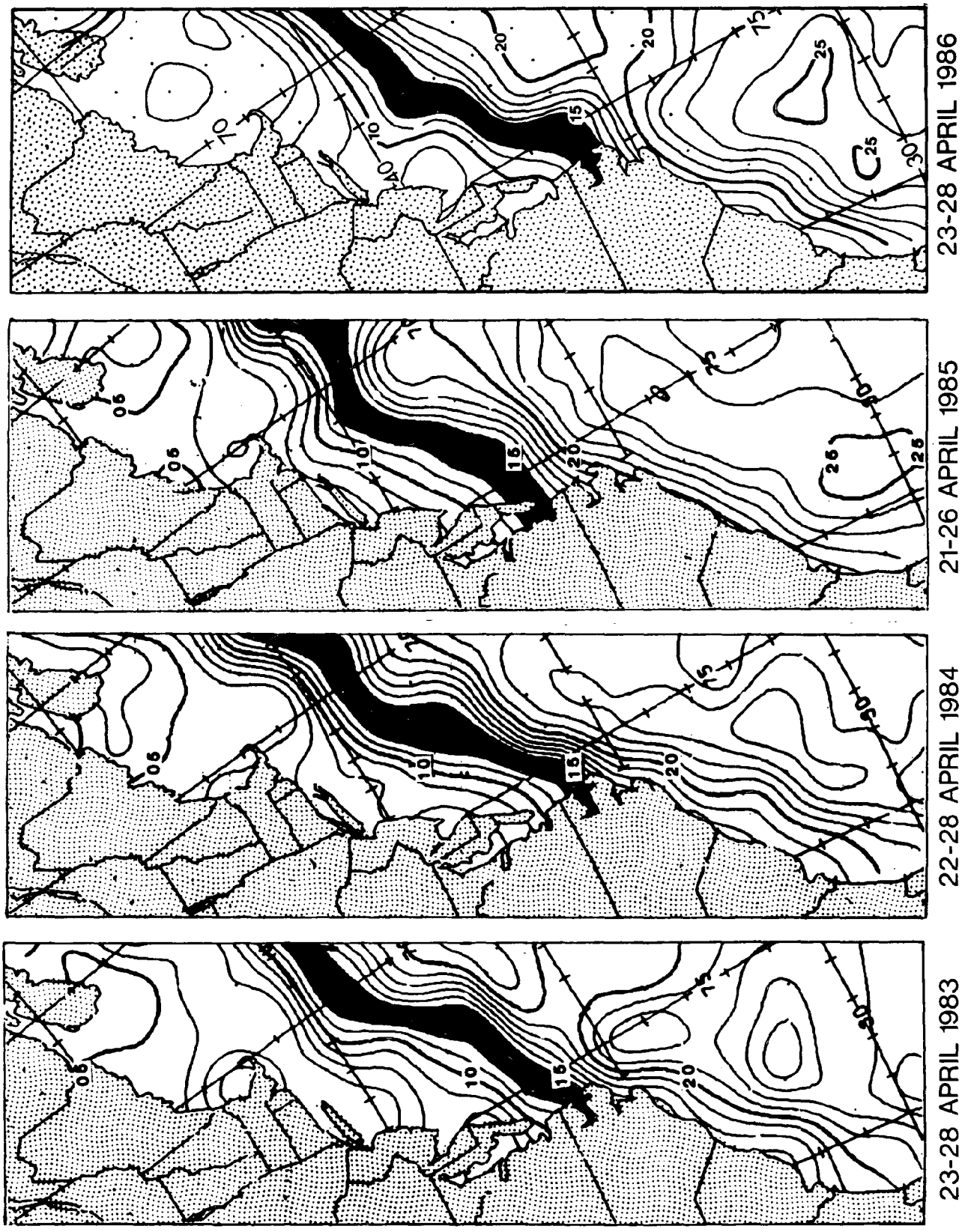

Figure 13 -- Sea surface isotherms along the Atlantic coast, late April, 1983-1984-1985-1986. The darkened bands in the panels of satellite derived sea surface isotherms cover the temperature region from 12° - 15°C preferred by migrating bluefish.

Data Source: Marine Products Branch, National Meterological Center, National Weather Service, NOAA

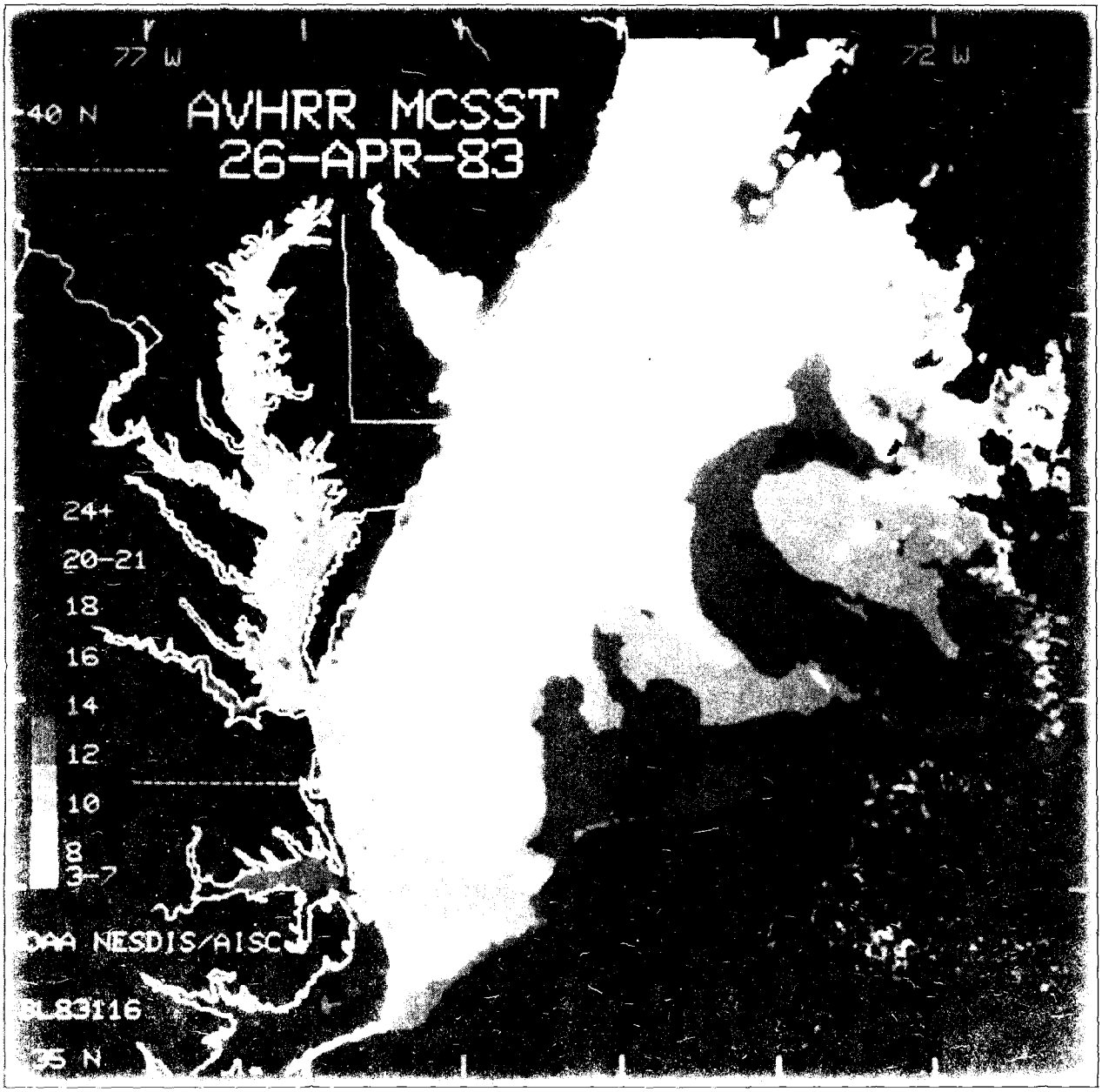

Figure 14a -- Satellite image of the Atlantic coast showing surface water temperatures on 26 April, 1983. Temperatures in late April 1983 were unusually cold on the northern Atlantic coast and bluefish arrived at the Chesapeake Bay area about two weeks later than normal.

Data Source: Figures 14a-14d from NOAA AISC/MEAD

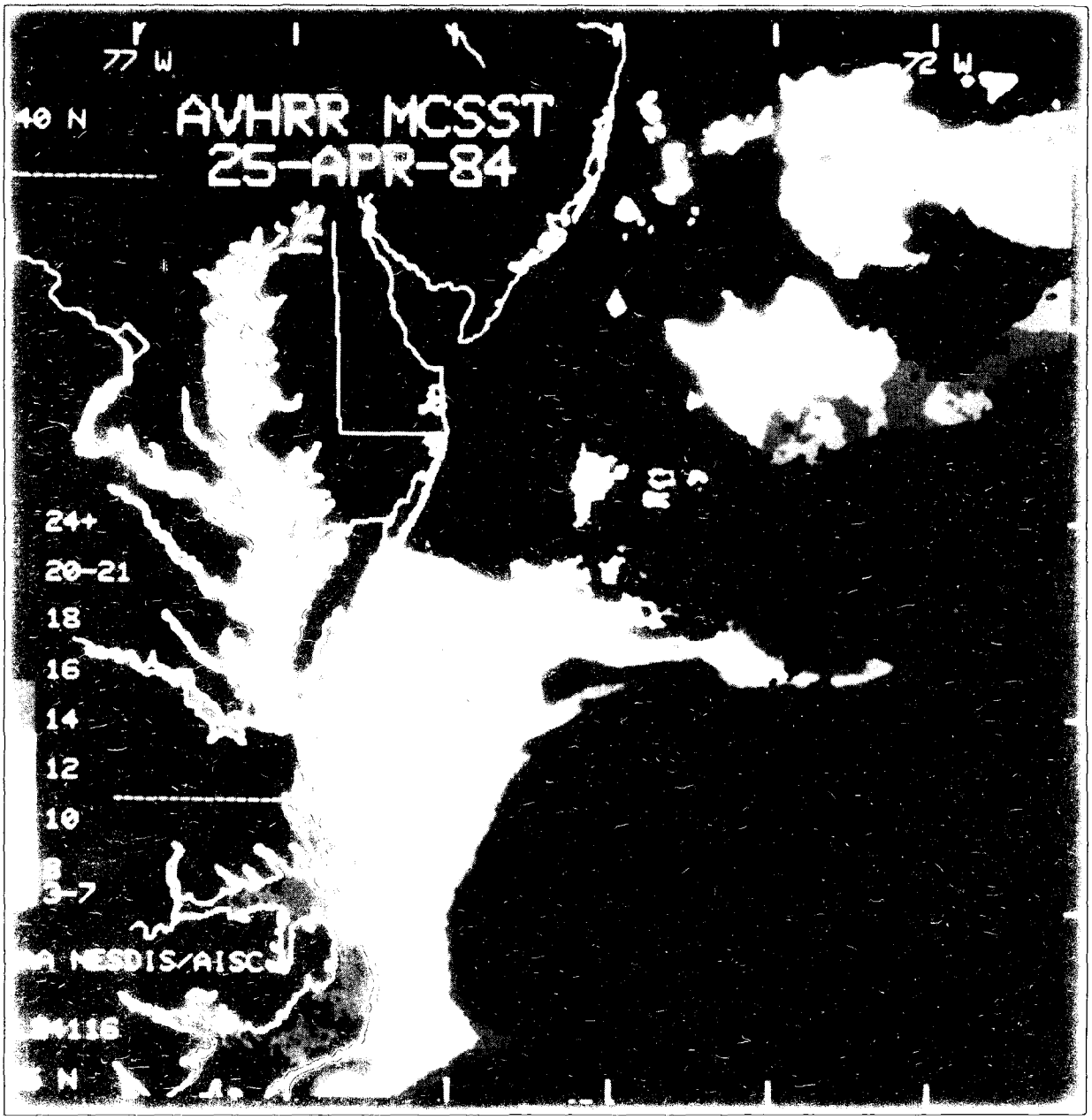

Figure 14b -- Satellite image of the Atlantic coast showing surface water temperatures on 25 April, 1984. The spring 1984 quarter was predominantly cooler than normal, though water temperatures were closer to normal than in spring 1983.

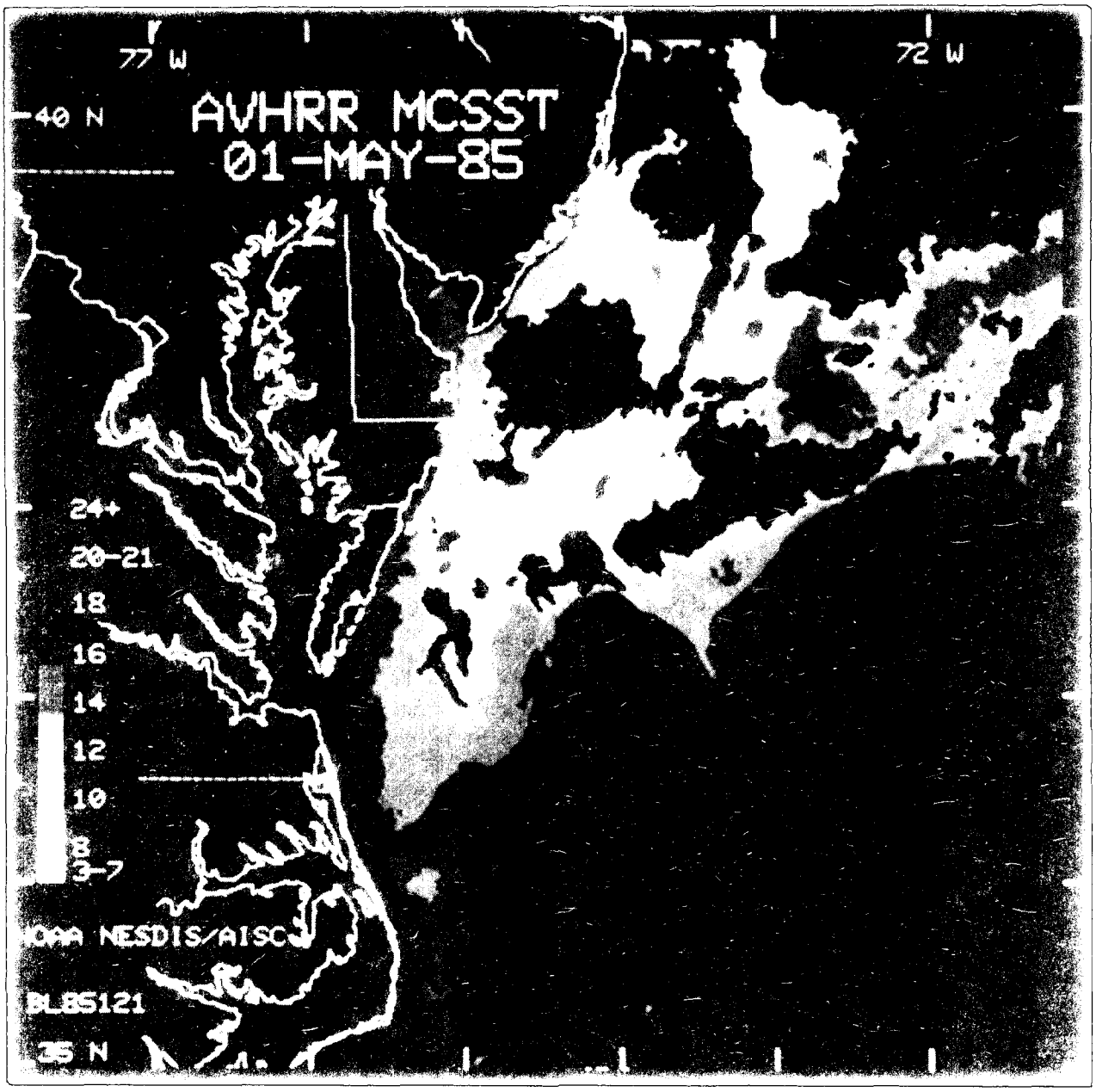

Figure 14c -- Satellite image of the Atlantic coast showing surface water temperatures on 1 May, 1985. Water temperatures were above normal during the entire spring 1985 quarter. By the end of April, the 12°-15°C temperature range had extended north of Delaware Bay. Larger-sized bluefish arrived at Chesapeake Bay about two weeks earlier than normal in 1985.

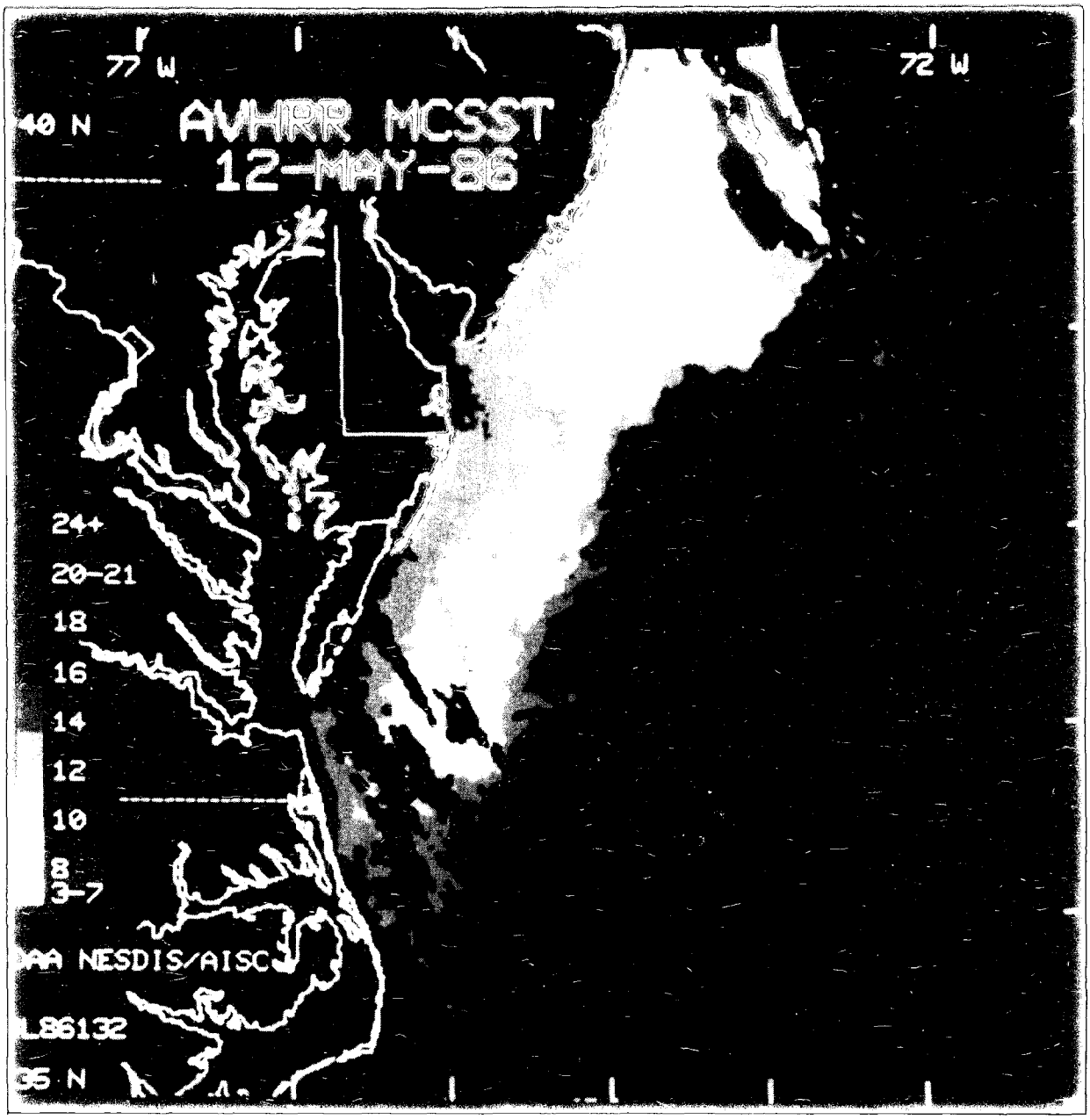

Figure 14d -- Satellite image of the Atlantic coast showing surface water temperatures on 12 May, 1986. Water temperatures were slightly above normal during the spring of 1986. By late April to early May, the 12°-15°C temperature range had extended into Chesapeake Bay.

High salinities permitted oceanic fish to travel further up the bay. Spotted sea trout *(Cynoscion nebulosus)* were caught in the Nanticoke River, and small black drum *(Pogonias cromis)* were landed in the upper reaches of the bay. The crevalle jack*(Caranx hippos)*, a high-salinity fish species, was reported in the Chesapeake and Delaware Canal. Black sea bass (*Centropristis striata)* were noted as far north as the Patuxent River but many of the fishermen in Maryland were surprised by the appearance of the higher-salinity species that are usually not found as far north as Maryland.

Higher-than-normal numbers of Spanish mackerel *(Scomberomorus maculatus)* were caught in pound nets near St. George Island in the Potomac River. The Virginia Marine Resources Commission reported that more Spanish mackerel were caught in one month in 1986 than in the previous year in Virginia. However, fewer king mackerel *(Scomberomorus cavalla)* were caught, and it is thought that they were not as prevalent.

Some anadromous species that require lower salinity waters for spawning, such as herring (*Clupea harengus)*, shad (*Alosa sapidissima)*, striped bass (*Morone saxatilis),* and white perch (*Morone americana)* had a reduction in area for nursery grounds because of the higher salinities permeating further up the bay than usual.

Oyster Diseases:

As salinity increases in the bay during the warm summer months, MSX (caused by *Haplosporidium nelsoni*) may spread to areas with historically low salinity levels (< 15 parts per thousand). Areas of the bay traditionally low in MSX activity could become infested if there were reduced rainfall and no river flushing action during the spring to decrease salinity levels.

Oysters (*Crassostrea virginica*), infected with Dermo, (*Perkinsus marinus*) usually do not die until the third summer after infection. However, in transplanted seed oysters taken from the *Perkinsus* - infested Thomas Rock area of the James River, high mortalities have been reported in the York River and tributaries of the Potomac. Mortalities occur in late summer and fall when water temperatures are > 68° F. If infected oysters are transplanted to other grounds, accelerated mortalities could result from *Perkinsus* during the second summer after transplanting. However, if uninfected oysters are planted in areas observed to have *Perkinsus*, low mortalities (10% - 20%) could occur the second summer after planting, and high (> 50 %) mortalities the third summer. *Perkinsus marinus* is a more persistent organism and is not eliminated from oysters by river flushing action as readily as MSX.

Both Virginia and Maryland reported losses in oyster populations due to both diseases during the summer of 1986. Experimental trays of oysters studied at the Virginia Institute of Marine Science showed approximately 85 % mortality caused by *Perkinsus marinus*, and this summer was reported to be one of the worst summers for this disease on record. Of the two oyster diseases, *Perkinsus* had more impact in transplanted James River seed oysters taken from Thomas Rock. Reduced rainfall during the summer of 1986 and subsequent decreased stream discharge caused unusually high salinities throughout the bay. Expansion of disease territories can be directly related to salinity increases. As a compounding factor, warm fall 1985 temperatures were favorable for development and spread of both diseases.

3.2 Recreation

Weather around the bay region was favorable for recreational activities during the spring of 1986. Warmer air temperatures in April and May most likely contributed to increased attendance and revenue at Maryland and Virginia state parks (Tables 17 & 18). The Coast Guard conducted more search and rescue missions during the spring and summer of 1986 (Table 19). Sea nettle infestation in the Chesapeake Bay was light, and rapidly subsided.

Attendance figures for selected bay region parks are listed in Tables 17 and 18. Sandy Point State Park had a higher increase in attendance during the spring of 1986 than any other state park in the bay region. Tom Haines of Sandy Point State Park attributed the record attendance to the warmer spring air temperatures. The unseasonably warm weather from March to June 1986 provided favorable conditions for increased park usage. As the summer progressed, however, attendance levels dropped slightly in most Virginia parks, as they normally do.

As boating activity increases during summer months, so do boating accidents. The Coast Guard conducted a total of 2,348 Search and Rescue (SAR) missions in the bay area during the spring and summer of 1986 (Table 19). During the same period in 1985, 2,124 missions were conducted. Tables 20 and 21 list boating accident statistics for Maryland and Virginia. Boating accidents in Maryland increased over the past spring and summer from 168 in 1985 to 174 in 1986. A total of 54 accidents occurred during March - August in the Virginia segment of the Chesapeake Bay and its tributaries.

Because of a combination of meteorological events during the past winter and spring, sea nettle (*Chrysaora quinquecirrha*) infestation was light and rapidly subsided in the late summer of 1986. David Cargo, an associate researcher from the University of Maryland Chesapeake Biological Laboratory, stated that a very wet winter caused lower salinity levels in April, resulting in a reduced population of medusae. But, since late spring water temperatures were considerably warmer, the budding of immature medusae (strobilation) (Figure 15), began earlier than usual (before 1 May), accelerating the entire adult medusal life cycle so that by 15 August, no sea nettles were observed in the upper Chesapeake Bay. Nettles also subsided early in Virginia, but they reproduce rapidly in higher-salinity waters; therefore, a normal recruitment of newly-settled polyps will be the adult medusae of the 1987 season.

Table 17 -- State Park attendance and revenue at selected Maryland and Virginia facilities, March-May 1985 and March-May 1986.

Facility	March Revenue 1985	March Revenue 1986	March Attendance 1985	March Attendance 1986	April Revenue 1985	April Revenue 1986	April Attendance 1985	April Attendance 1986	May Revenue 1985	May Revenue 1986	May Attendance 1985	May Attendance 1986
Maryland												
Sandy Point	$0	$500	7,470	36,000	$0	$2,469	5,068	69,000	$0	$75,837	9,585	91,000
Pt. Lookout	$519	$83	11,634	16,587	$4,868	$794	25,316	24,625	$14,355	$7,672	33,352	43,364
Virginia												
Westmoreland	$25	$25	2,486	1,174	$3,472	$3,924	3,460	4,172	$9,873	$13,755	30,966	17,994
Chippokes	$50	$9	1,314	1,157	$394	$400	6,519	1,931	$1,079	$1,037	9,301	14,139
York River	$0	$0	5,517	3,677	$229	$216	5,985	6,395	$970	$1,379	8,524	8,990
Seashore	$10	$0	57,324	41,744	$16,837	$12,053	119,496	74,406	$37,860	$37,523	127,233	127,435
Totals	$604	$617	85,745	100,339	$25,800	$19,856	165,844	180,529	$64,137	$137,203	218,961	302,922

Total Revenue 1985: $90,541 Total Attendance 1985: 470,550

Total Revenue 1986: $157,676 Total Attendance 1986: 583,780

Data Source: Maryland Department of Natural Resources, Forest, Park, and Wildlife Service, amd Virginia Department of Conservation and Economic Development, Division of State Parks

Table 18 -- State Park attendance and revenue at selected Maryland and Virginia facilities, June-August 1985 and June-August 1986.

Facility	June Revenue 1985	June Revenue 1986	June Attendance 1985	June Attendance 1986	July Revenue 1985	July Revenue 1986	July Attendance 1985	July Attendance 1986	August Revenue 1985	August Revenue 1986	August Attendance 1985	August Attendance 1986
Maryland												
Sandy Point	$76,015	$91,277	94,507	111,000	$106,715	$101,026	96,548	103,000	$59,127	$68,226	63,746	67,000
Pt. Lookout	$25,956	$37,155	43,326	50,715	$23,176	$29,701	44,086	55,403	$25,718	$23,011	40,890	51,203
Virginia												
Westmoreland	$12,922	$22,477	27,664	20,017	$15,918	$28,275	36,681	35,744	$16,520	$18,125	26,327	19,678
Chippokes	$1,800	$1,841	11,400	14,292	$2,611	$3,376	8,488	20,224	$2,390	$2,932	10,292	16,058
York River	$919	$1,284	10,466	9,361	$943	$1,408	10,307	9,735	$846	$908	7,688	6,580
Seashore	$32,891	$35,908	104,713	131,467	$29,253	$25,032	125,125	206,906	$32,542	$25,225	96,754	84,502
Totals	$150,503	$189,942	292,076	336,852	$178,616	$188,818	321,235	431,012	$137,143	$138,427	245,697	245,021

Total Revenue 1985: $466,262 **Total Attendance 1985: 859,008**

Total Revenue 1986: $517,187 **Total Attendance 1986: 1,012,885**

Data Source: Maryland Department of Natural Resources, Forest, Park, and Wildlife Service, and Virginia Department of Conservation and Economic Development, Division of State Parks

Table 19 -- U. S. Coast Guard Search and Rescue (SAR) caseload, March-August 1986.

Month	Group Baltimore		Group Eastern Shore		Group Hampton Roads	
	1985	1986	1985	1986	1985	1986
March	36	51	6	6	36	43
April	100	88	7	5	88	58
May	215	208	17	11	144	164
June	167	299	30	34	210	273
July	286	220	35	32	239	262
August	312	232	36	42	160	320
Totals	1,116	1,098	131	130	877	1,120

Total Cases 1985: 2,124
Total Cases 1986: 2,348

Group Baltimore - most of upper bay
Group Eastern Shore - lower central portion of Eastern Shore
Group Hampton Roads - most of lower bay

Table 20 -- Maryland marine accident statistics, March-August 1986.

Month	No. of Boating Accidents		No. of Injuries		No. of Deaths		Property Damage	
	1985	1986	1985	1986	1985	1986	1985	1986
March	2	3	0	0	1	0	$10,050	$14,590
April	10	4	6	2	0	2	$41,250	$32,000
May	37	23	20	5	1	2	$27,756	$24,165
June	32	51	7	18	4	2	$30,631	$69,816
July	52	43	26	15	4	4	$179,854	$48,980
August	35	50	10	11	3	1	$78,646	$76,621
Total	168	174	69	51	13	11	$368,187	$266,172

Data Source: Maryland Department of Natural Resources Marine Police. All categories are for recreational boating. Includes Potomac River to Virgina shoreline.

Table 21 -- Virginia marine accident statistics, March-August 1986.

Month	No. of Boating Accidents
March	7
April	4
May	11
June	19
July	5
August	8
Total	54

Data Source: Virginia Game & Inland Fisheries

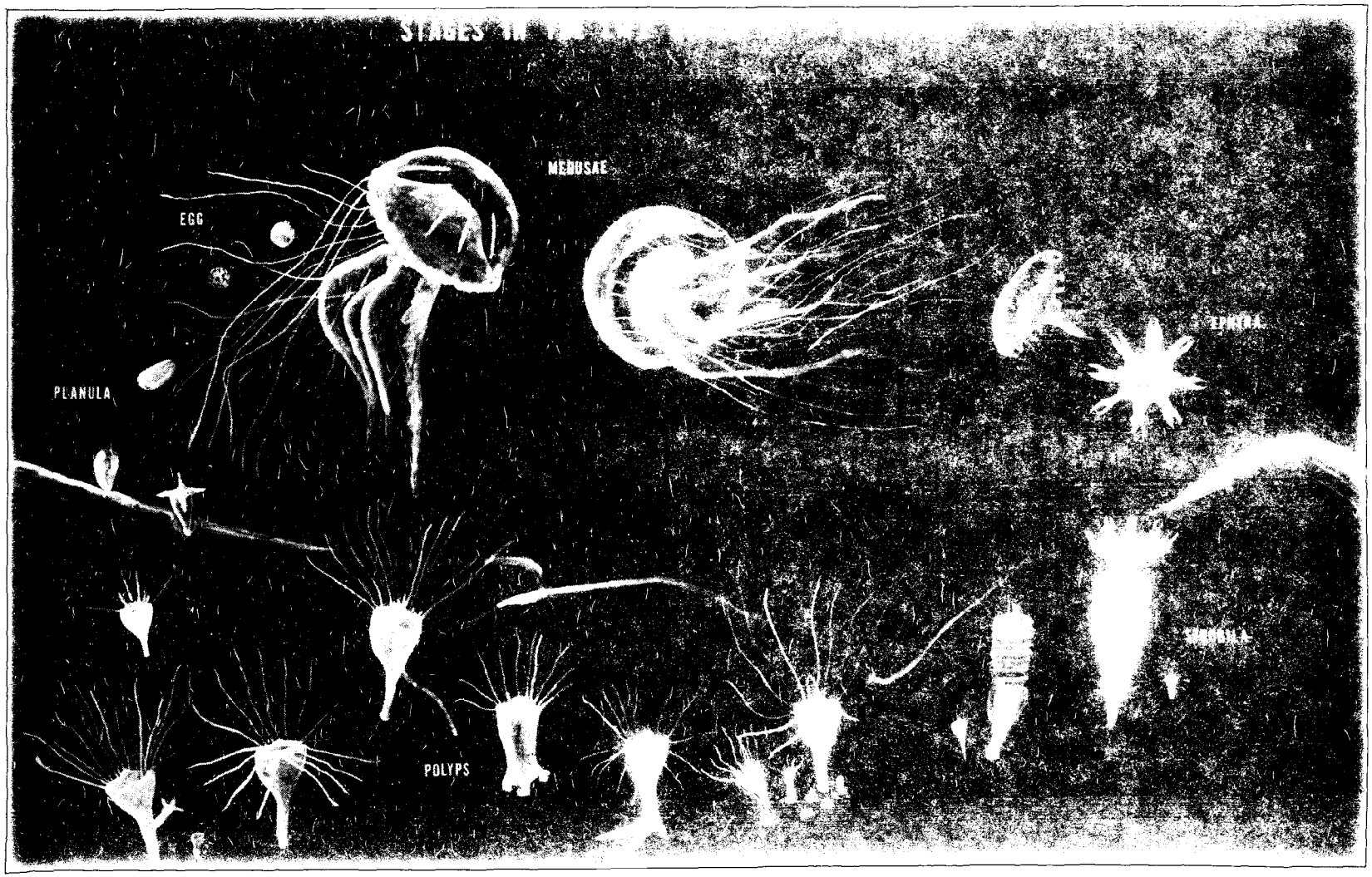

Figure 15 -- Stages in the life cycle of a jellyfish (*Chrysaora quinquecirrha*)

3.3 Transportation

The Port of Baltimore experienced extended delays (over 7 hours) in 1986 caused by high winds during the first and third week of March, the first week in May, the second week in June, and the first week in August (Table 22). It is unusual that no crane delays were reported for the entire month of April.

Shutdowns of 103 hours and 15 minutes occurred from March to August 1986. During the same time period in 1985, a total of 141 hours and 18 minutes of shutdown was reported. March winds caused the most delays during the spring and summer quarters of both 1985 and 1986.

The total down-time of 103 hours and 15 minutes may have caused shippers a loss of over $412,000 in wind-related crane delays at the Port of Baltimore during the 1986 spring and summer quarters.

Table 22 -- Number of crane shutdowns and productive time lost due to wind at Port of Baltimore, March-August 1986.

Date	Number of Shutdowns	Productive Time Lost (Hours: Minutes)
Mar-7	2	16:55
Mar-8	1	2:30
Mar-11	1	6:32
Mar-15	1	4:40
Mar-19	1	9:01
April	none	
May-1	1	2:55
May-2	2	7:07
May-20	1	4:45
May-21	1	2:58
May-22	1	1:48
Jun-12	1	8:01
Jun-20	2	1:23
Jul-2	1	1:05
Jul-12	1	:50
Jul-13	1	4:28
Jul-14	1	4:25
Jul-18	2	2:59
Jul-20	2	3:21
Jul-27	1	:47
Jul-29	1	3:19
Aug-2	1	7:30
Aug-6	1	1:28
Aug-8	1	2:50
Aug-17	1	1:38
Total	29	103:15

Data Source: Maryland Port Administration

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United States Geological Survey

State

Maryland Department of Natural Resources
- Natural Resources Marine Police
- Forest, Park, and Wildlife Service

Maryland Port Administration
Virginia Department of Conservation and Economic Development
- Division of State Parks

Virginia Marine Resources Commission

Private

Private seafood processors in Maryland and Virginia
Other independent individuals contributing data

Educational Institutions

University of Maryland
- Center for Environmental and Estuarine Studies
- Chesapeake Biological Laboratory
- Coastal Ecology Research Laboratory

Virginia Institute of Marine Science

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