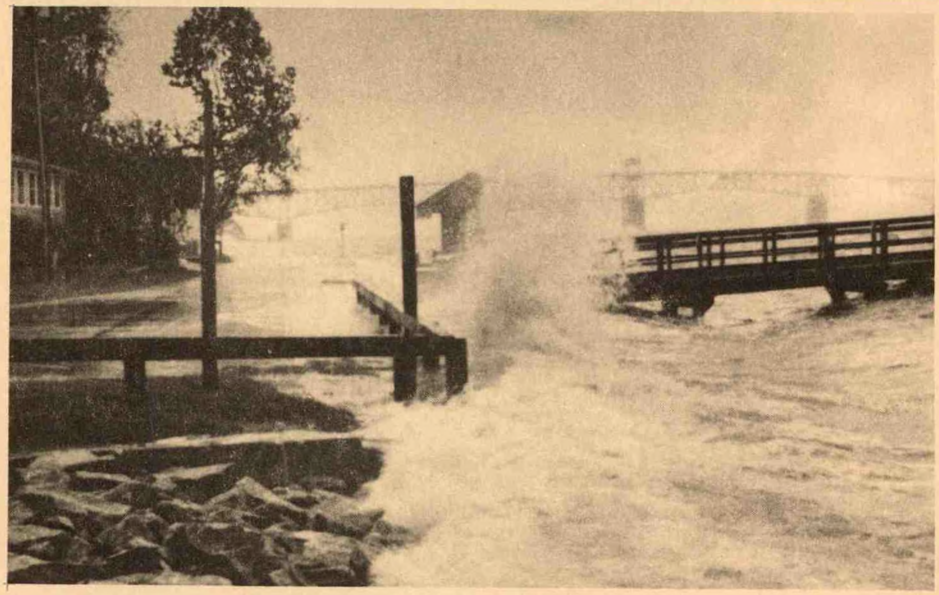
Chesapeake Bay

Marine Environmental Assessment

December 1985-February 1986



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CLIMATE IMPACT ASSESSMENT
UNITED STATES

In September 1981, the Marine Assessment Branch (MAB) of the National Oceanic and Atmospheric Administration 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. Support for the project is provided through the Virginia Sea Grant College Program.

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December 1985-February 1986

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Chesapeake Bay Marine Environment

1. Highlights - General Events and Impacts

Warmer-than-normal water temperatures during the 1985-86 winter quarter resulted in less than 10 percent ice cover on the Bay. Air temperatures and precipitation were below-normal for the winter quarter. Air temperatures were below-normal in December and February and slightly above-normal in January. Precipitation was extremely below-normal in December, below-normal in January and above-normal in February.

Watermen experienced no interruptions due to ice in the Bay mainstem in finfish and shellfish harvests. An increase in available fishing days, especially in Maryland waters where freezing is most prevalent, was possible due to lack of ice.

Streamflow was above-normal during December 1985 and February 1986 but below-normal in January 1986.

Warmer-than-normal water temperatures provided favorable conditions for juvenile finfish species such as croaker and flounder which overwinter in Chesapeake Bay.

Blue crab dredge fishery landings in December 1985 were lower than the 1984-85 landings. Higher December water temperatures may have contributed to the decline in landings of dredged crabs by increasing activity of females.

Maryland oyster landings increased over all three months of the 1985-86 winter quarter compared to 1984-85 winter quarter. On the other hand, Virginia reported decreases in December 1985 and February 1986 harvests compared to previous winter landings.

Variations in attendance at Virginia state parks closely followed fluctuations in air temperatures. There was decreased attendance in December 1985 and February 1986 in Virginia state parks compared to December 1984 and February 1985.

The lack of ice in the Bay mainstem during the winter quarter 1985-86 allowed for uninhibited water transportation in Chesapeake Bay.

Table 1 summarizes impacts of climate events by economic sector.

IMPACT SECTOR	Low precipitation	Below normal December and February air temp.	Absence of Ice	Low streamflow	Above normal December water temp.	January strong winds
FISHERIES						
Finfish Harvest Activities (General)			+			
Shellfish Harvest Activities (General)			+			
Blue Crab December Dredge Harvest					−	
Croaker 1984 year class					+	
Summer Flounder Population					+	
Oyster Population (Impact of MSX)	−					
RECREATION						
Park Usage	+	−				
Boating Activity	+	−	+			
Safety			+			
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, December 1985 - February 1986

2. Weather and Oceanography Summary

2.1 Weather

The winter quarter covering December 1985 through February 1986 was a period of below-normal precipitation and temperature for the Chesapeake Bay Region (Figure 1; Tables 2 and 3). Cold and warm frontal systems passing across the Region were most numerous in January. Coastal storms were most frequent in February.

December:

Total precipitation for December was extremely below-normal averaging 0.97 inches and ranging from 1.96 inches at Wilkes-Barre, PA to 0.56 inches at Patuxent, MD (Table 2). All 11 meteorological stations for the Chesapeake Bay Region reported an overall precipitation anomaly of -69 percent. Reporting stations within the Susquehanna River drainage received an average of 1.55 inches of precipitation as rain and/or snow, which was 46 percent below- normal for December. The Potomac River and James River basins stations also reported an average precipitation of 76 percent and 83 percent below-normal, respectively, and at stations immediately adjacent to the Chesapeake Bay their average precipitation was 77 percent below-normal.

Temperatures averaged 34.3 degrees F (2.2 degrees F below-normal) for the 11 meterological stations (Table 3). Ten of the eleven stations recorded below-normal temperatures, and only Aberdeen, MD reported an above-normal monthly temperature (35.1 degrees F; 0.1 degrees F above-normal). Temperatures ranged from a low of 26.7 degrees F at Wilkes-Barre, PA to a high of 41.2 degrees F at Norfolk, VA. The Susquehanna basin stations' average temperature was 28.5 degrees F (2.8 degrees below normal). The Potomac River and James River stations' temperatures averaged 34.8 degrees F and 37.8 degrees F (2.2 degrees F and 2.1 degrees F below normal), respectively. Temperatures of the five Bay stations averaged 36.9 degrees F (1.8 degrees F below-normal).

The lowest number of frontal passages for the winter quarter occurred in December. Six cold fronts and one warm front passed over the Chesapeake Bay. Three high pressure air mass centers crossed over the Bay; and two Atlantic coastal storms produced winds and precipitation.

Frozen ground cover (ice or snow) was absent from all 11 stations on December 1. In the Susquehanna drainage basin snow accumulated to a depth of 5 inches at Wilkes-Barre, PA during the second and third week; however, a warming trend reduced the accumulated snow depth to 2 inches by December 31. Stations surrounding the bay reported 0 to 1 inches of frozen ground cover.

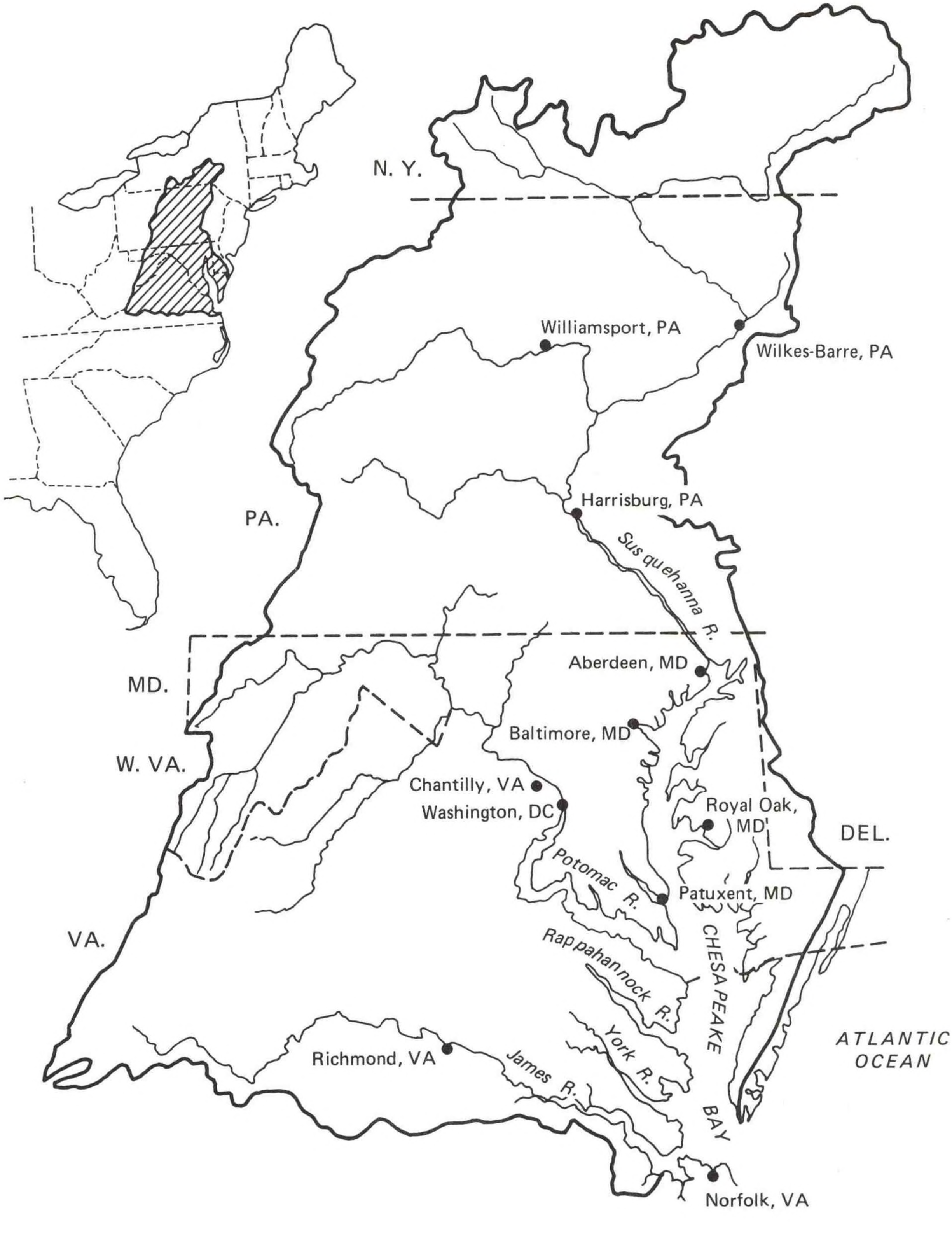


Figure 1--Selected meteorological stations, Chesapeake Bay watershed (modified EPA map)

Table 2 - Monthly precipitation and departures from normal for 11 stations, Chesapeake Bay watershed, December 1985-February 1986. Percentages rounded to nearest percentile.

BASIN	STATION	Total Precipitation (in.) and Departure from Normal Observed/*Anomaly (% of Normal) DECEMBER	JANUARY	FEBRUARY	WINTER AVERAGE FOR STATION
Susquehanna	Williamsport PA	1.42/-56	2.18/-24	2.49/-12	2.03/-31
	Wilkes-Barre PA	1.96/-23	2.59/+14	2.58/+26	2.38/+06
	Harrisburg PA	1.28/-60	2.24/-24	4.50/+65	2.67/-06
Average		1.55/-46	2.34/-11	3.19/+26	2.36/+10
Potomac	Washington DC	0.68/-79	2.38/-14	3.49/+33	2.18/-20
	Chantilly VA	0.92/-72	1.58/-44	3.15/+19	1.88/-32
Average		0.80/-76	1.98/-29	3.32/+26	2.03/-26
James	Richmond VA	0.58/-83	2.69/-17	2.67/-15	1.98/-38
Chesapeake Bay	Aberdeen MD	0.72/-78	2.36/-20	3.60/-07	2.23/-35
	Baltimore MD	0.84/-75	2.16/-28	3.78/+27	2.26/-25
	Royal Oak MD	0.96/-74	4.47/+30	3.98/+24	3.14/-07
	Patuxent MD	0.56/-83	3.15/+08	2.67/-04	2.13/-26
	Norfolk VA	0.79/-75	2.52/-32	2.71/-17	2.01/-41
Average		0.77/-77	2.93/-08	3.35/+05	2.35/-27
All Station Average		0.97/-69	2.57/-14	3.13/+11	2.18/-25

* Anomaly=departure from 1951-1980 average.

Table 3 - Monthly mean air temperature and departures from normal for 11 stations, Chesapeake Bay watershed, December 1985-February 1986. Percentages rounded to nearest percentile.

		Air Temperature (F.) and Departure from Normal Observed/*Anomaly (% of Normal)			
BASIN	STATION	DECEMBER	JANUARY	FEBRUARY	WINTER AVERAGE FOR STATION
Susquehanna	Williamsport PA	27.9/-2.8	27.3/+1.1	27.6/-0.6	27.6/-0.8
	Wilkes-Barre PA	26.7/-3.0	27.2/+2.0	26.1/-0.7	26.7/-0.6
	Harrisburg PA	30.9/-2.5	31.3/+1.9	29.9/-1.6	30.7/-0.7
Average		28.5/-2.8	28.6/+1.7	27.9/-1.0	28.3/-0.7
Potomac	Washington DC	36.4/-2.5	35.4/+0.2	35.3/-2.2	35.7/-1.5
	Chantilly VA	33.2/-1.9	32.5/+1.1	32.1/-1.5	32.6/-0.8
Average		34.8/-2.2	34.0/+0.7	33.7/-1.9	34.2/-1.2
James	Richmond VA	37.8/-2.1	36.2/-0.4	39.3/+0.4	37.8/-0.7
Chesapeake Bay	Aberdeen MD	35.1/+0.1	34.2/+0.9	33.0/-1.7	34.1/-0.5
	Baltimore	33.8/-2.7	33.2/+0.5	33.4/-1.3	33.5/-1.2
	Royal Oak MD	36.8/-2.1	35.9/+0.9	35.9/-0.8	36.2/-0.6
	Patuxent MD	37.6/-2.0	34.8/-2.2	36.2/-1.8	36.2/-2.0
	Norfolk VA	41.2/-2.3	39.3/-0.6	42.1/+1.0	40.9/-0.6
Average		36.9/-1.8	35.5/-0.1	36.1/-0.9	36.2/-0.9
All Stations Average		34.3/-2.2	33.4/+0.5	33.7/-1.0	33.8/-0.9

* Anomaly = departure from 1951-1980 average

January:

Total precipitation for January averaged 2.57 inches and ranged from 1.58 inches at Chantilly, VA to 4.47 inches at Royal Oak, MD. Eleven stations reported an average precipitiation anomaly of -14 percent. The Susquehanna River stations received an average of 2.34 inches of precipitation as rain or snow, which was 11 percent below the monthly normal. The Potomac River and James River stations likewise reported below-average precipitation, -29 percent and -17 percent, respectively; and at stations surrounding the Bay, precipitation was 8 percent below-normal.

Temperatures averaged 33.4 degrees F for the 11 stations; 0.5 degrees F above normal. Eight of the eleven stations recorded warmer-than-normal-temperatures. The three southern most stations (Patuxent, MD; Richmond and Norfolk, VA) reported cooler-than-normal-temperatures. Temperature averages ranged from a low of 27.2 degrees F at Wilkes-Barre, PA to a high of 39.3 degrees F at Norfolk, VA. The Susquehanna River stations' average temperature was 28.6 degrees F (1.7 degrees above -normal). The Potomac River and James River stations' temperatures averaged 34.0 degrees F and 36.2 degrees F (0.7 degrees F above and 0.4 degrees F below normal), respectively. Temperatures at stations surrounding the Bay averaged 35.5 degrees F; 0.1 degrees F below-normal.

Unstable atmospheric conditions were most prevalent in January. Nine cold fronts and four warm fronts passed over the Chesapeake Bay. Three high pressure and two low pressure air mass centers passed over the Bay. One coastal storm produced winds and precipitation.

Frozen ground cover ranged from 0 inches to a trace between Williamsport and Harrisburg, PA and was absent at the other nine stations on January 1. During the month, snow cover accumulations at the Susquehanna River stations ranged from 8 inches at Wilkes-Barre to 3 inches at Harrisburg by January 31. Snow depths at stations surrounding the Bay ranged between 0 inches at Norfolk to a trace at Baltimore.

February:

Whereas January experienced below-normal precipitation and above-average temperatures; February conditions were reversed.

Total precipitation for February averaged 3.13 inches and ranged from 2.49 inches at Williamsport, PA to 4.50 inches at Harrisburg, PA. The average precipitation anomaly for the 11 stations was +11 percent. The Susquehanna River stations received an average of 3.19 inches as rain and/or snow, which was 26 percent above the monthly normal. The Potomac River stations received 3.32 inches (26 percent above-normal), whereas the James River station received 2.67 inches (15 percent below the normal). Stations adjacent to the Chesapeake Bay.received an average of 3.35 inches of precipitation (5 percent above normal).

Temperatures averaged 33.7 degrees F for the 11 stations; 1.0 degrees F below the monthly normal. Richmond and Norfolk, VA (the southern most stations) reported above-average temperatures, all other stations recorded below-average temperatures. Temperature averages ranged from a low of 26.1 degrees F at Wilkes-Barre, PA to a high of 42.1 degrees F at Norfolk, VA. The Susquehanna River stations' average temperature was 27.9 degrees F (1.0 degree F below the normal). The Potomac River stations' temperature average was 33.7 degrees F (1.9 degrees F below the normal) whereas the James River station's temperature average was 39.3 degrees F (0.4 degrees F above-normal). The temperature averaged 36.1 degrees F (0.9 degrees F below-normal) at stations immediately surrounding the Bay, .

There were fewer frontal passages in February; (seven cold fronts and four warm fronts passed over the bay), and coastal storms increased. Five storms formed off or passed along the Atlantic coast. Three high pressure and three low pressure centers moved over the Bay.

Frozen ground cover depths increased in the Susquehanna River drainage during the first two weeks of February. Both Williamsport and Wilkes-Barre reported maximum snow depth of 8 inches on the 12th and 13th. By February 28th, snow depths at the 11 stations ranged between 0 inches and a trace.

2.2 Bay Ice Cover

During the 1985-86 winter quarter, ice cover on the Chesapeake Bay was almost nonexistent (less than 10 percent) (Table 4). Ice cover during a normal winter is approximately 10 percent of the total Bay area including tributaries.

The winters of 1976-77 through 1981-82 were extremely cold. In four of the six years, Bay ice cover was 50 percent or greater. However, from 1982-83 to the present, maximum coverage has been closer to normal. Maximum freezing degree days at most stations for the 1985-86 winter quarter occured between January 21-31 (Table 5).

There was virtually zero ice cover in the Bay mainstem, but some ice formation may have occured in shallow tributary shoreline areas during colder periods. This was the first year since 1977-78 that no ice was reported in the Bay mainstem. Based on information available for this quarter, no interruptions were detected in finfish and shellfish harvest activities due to ice during the 1985-86 winter season.

Table 4--Maximum ice cover of Chesapeake Bay, 1977-1986

Winter	Estimated maximum ice cover extent (percent)	Estimated date of maximum ice cover extent
1976-77	85	February 10
1977-78	30	February 17
1978-79	60	February 20
1979-80	15	March 2
1980-81	50	January 18
1981-82	55	January 27
1982-83	<10	February 14
1983-84	30	January 23
1984-85	20	February 11
1985-86	<10	January 29

Data Source: 1976-1981 data courtesy of NASA. 1981-1982 data estimated from satellite imagery and Coast Guard reports.

Table 5--Number of freezing degree-days at selected Chesapeake Bay stations; winters of 1976-77, 1982-83, 1984-85, and 1985-86.

Date	Aberdeen 1976-77	Aberdeen 1982-83	Aberdeen 1984-85	Aberdeen 1985-86	Baltimore 1976-77	Baltimore 1982-83	Baltimore 1984-85	Baltimore 1985-86
December 01-10	27.0	7.5	1.0	1.5	31.5	5.5	7.0	2.0
December 11-20	9.0	17.0	0.0	23.5	5.5	30.0	0.0	36.0
December 21-31	42.0	0.0	0.0	32.0	53.0	0.0	0.0	45.0
January 01-10	56.5	0.0	12.0	10.5	73.0	1.0	18.0	21.0
January 11-20	143.0	39.0	51.5	31.0	137.0	42.0	52.5	38.0
January 21-31	75.0	3.0	76.0	42.5	77.5	3.0	81.0	50.0
February 01-10	58.5	8.0	32.5	6.0	48.0	15.0	37.5	8.0
February 11-20	25.5	19.5	0.5	45.7	24.0	44.5	2.0	47.0
February 21-28	1.5	0.0	0.0	11.0	1.5	1.0	0.0	18.0
TOTALS	438.0	94.0	173.5	203.7	451.0	142.0	198.0	265.0

Date	Royal Oak 1976-77	Royal Oak 1982-83	Royal Oak 1984-85	Royal Oak 1985-86	Patuxent 1976-77	Patuxent 1982-83	Patuxent 1984-85	Patuxent 1985-86
December 01-10	19.0	5.0	2.0	0.0	12.5	0.0	5.0	0.0
December 11-20	4.5	15.5	0.0	23.0	0.0	10.0	0.0	18.0
December 21-31	25.5	0.0	0.0	28.5	13.0	0.0	0.0	28.0
January 01-10	54.5	0.0	12.0	10.0	53.0	0.0	12.0	13.0
January 11-20	112.5	25.0	31.5	18.0	140.0	23.0	36.5	16.0
January 21-31	65.0	1.5	60.0	36.5	63.0	0.0	59.5	43.0
February 01-10	42.5	7.5	37.0	1.5	41.5	2.0	30.0	1.0
February 11-20	19.5	17.0	4.0	27.0	17.5	13.0	5.5	30.0
February 21-28	0.0	0.0	0.0	5.5	0.5	0.0	0.0	4.0
TOTALS	343.0	71.5	146.5	150.0	341.5	48.0	148.5	153.0

The number of freezing degree-days (FDD) is the difference between the mean daily air temperature (°F) and 32°. For example, a mean daily air temperature of 21°F yields 11 FDDs. Freezing degree-days accumulated over periods of continuously freezing temperatures provides a measure of ice thickness through the expression: Ice Thickness (Inches) = $0.7\sqrt{\text{Accumulated FDDs}}$ (°F). The values displayed above may be used to estimate the possible ice generation, but alternating periods of above-freezing temperatures have not been subtracted from the accumulations. Melting, rafting, and snowcover also alter the accuracy of ice thickness computed by this method.

2.3 Streamflow

Bay streamflow was slightly above-normal (+11.0 percent) although precipitation throughout the Bay drainage area was 27.3 percent below-normal (Figure 2; Table 6). This quarter's above-normal streamflow was due to residual effects from the November record high streamflow (Figure 3). Measured at the mouth of the Chesapeake Bay, November's streamflow was 200 percent above-normal (Figure 4).

In December, streamflow was 33 percent above-normal. Of the total streamflow, 50.3 percent was contributed by the Susquehanna River drainage. In January, the Susquehanna's contribution increased to 58.5 percent, whereas the Potomac's drainage decreased from 20.6 percent in December to 14.9 percent in January. Overall streamflow was 39 percent below-normal in January reflecting the below-normal December and January precipitation and the precipitation locked in frozen ground cover. February streamflow was 17 percent above-normal reflecting an above average precipitation (26 percent) in the Potomac drainage and snow-melt in the Susquehanna drainage. The Susquehanna drainage streamflow decreased to 51.4 percent of total streamflow, and drainage from the Potomac increased from 14.9 percent in January to 24.8 percent in February.

Calendar year 1985 ended with a streamflow deficit of 2.1 trillion gallons (Figure 5). The first two months of 1986 continued to show a total deficit streamflow.

Table 6--Chesapeake Bay drainage streamflow and precipitation anomalies (December 1985 - February 1986).

Month	Drainage	Precipitation Anomaly* (%)	% Contribution of Total Bay Streamflow	Total Streamflow Anomaly* (%)
	Susquehanna	-46.3	50.3	
DEC	Potomac	-75.5	20.6	
	James	-83.0	13.6	
	Others**	-77.0	15.5	
				+33.0
	Susquehanna	-11.3	58.5	
JAN	Potomac	-29.0	14.9	
	James	-17.0	10.4	
	Others	-8.4	16.2	
				-39.0
	Susquehanna	+4.7	51.4	
FEB	Potomac	+26.0	24.8	
	James	-15.0	9.6	
	Others	+4.6	14.2	
				+17.0
	Quarter Average	-27.3%		+11.0

* Anomaly=departure from 1951-1980 average
** West Chesapeake, Patuxent, Rappahannock and York drainages

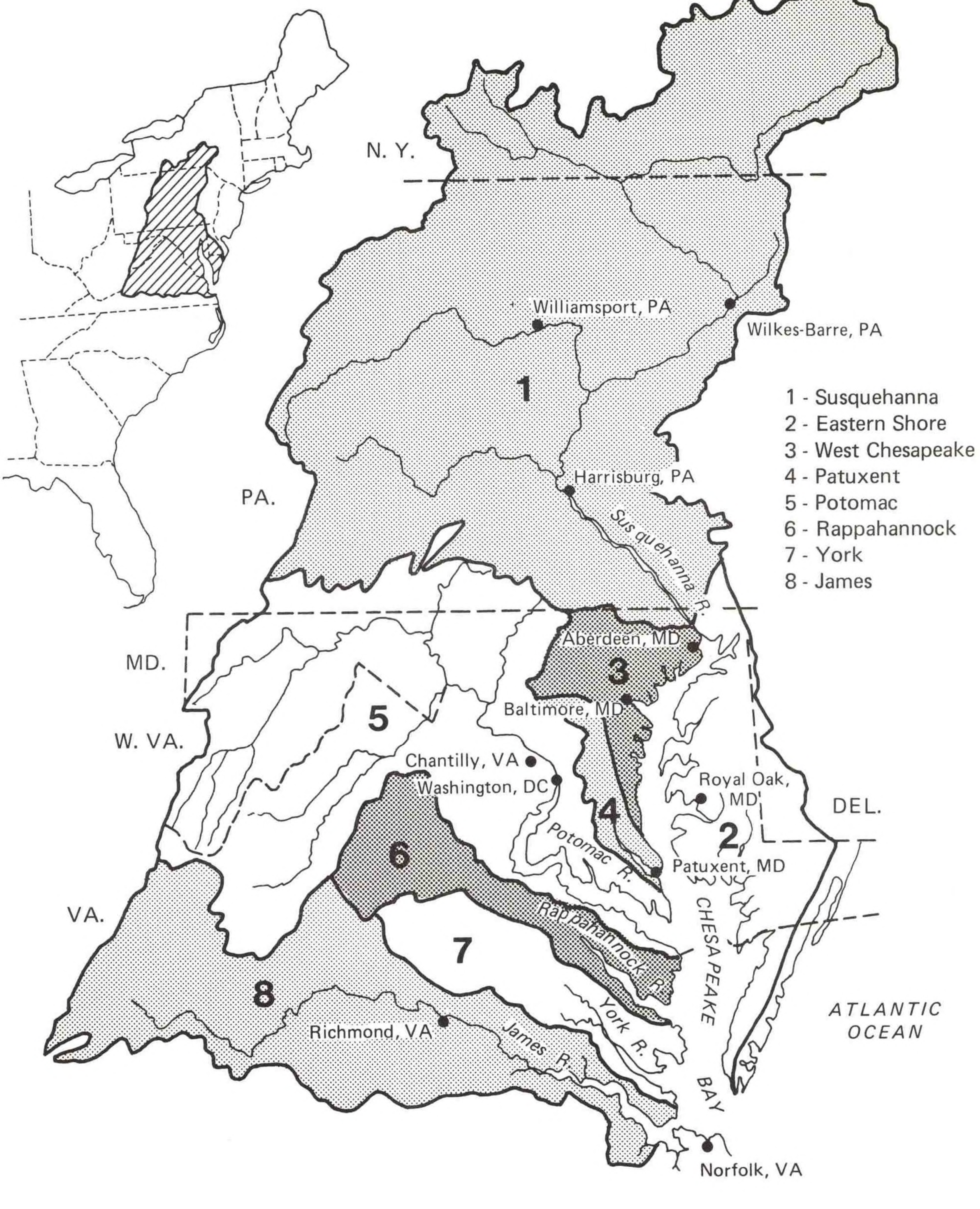


Figure 2--The major drainage basins of the Chesapeake Bay system.

Data Source: U.S. Geological Survey

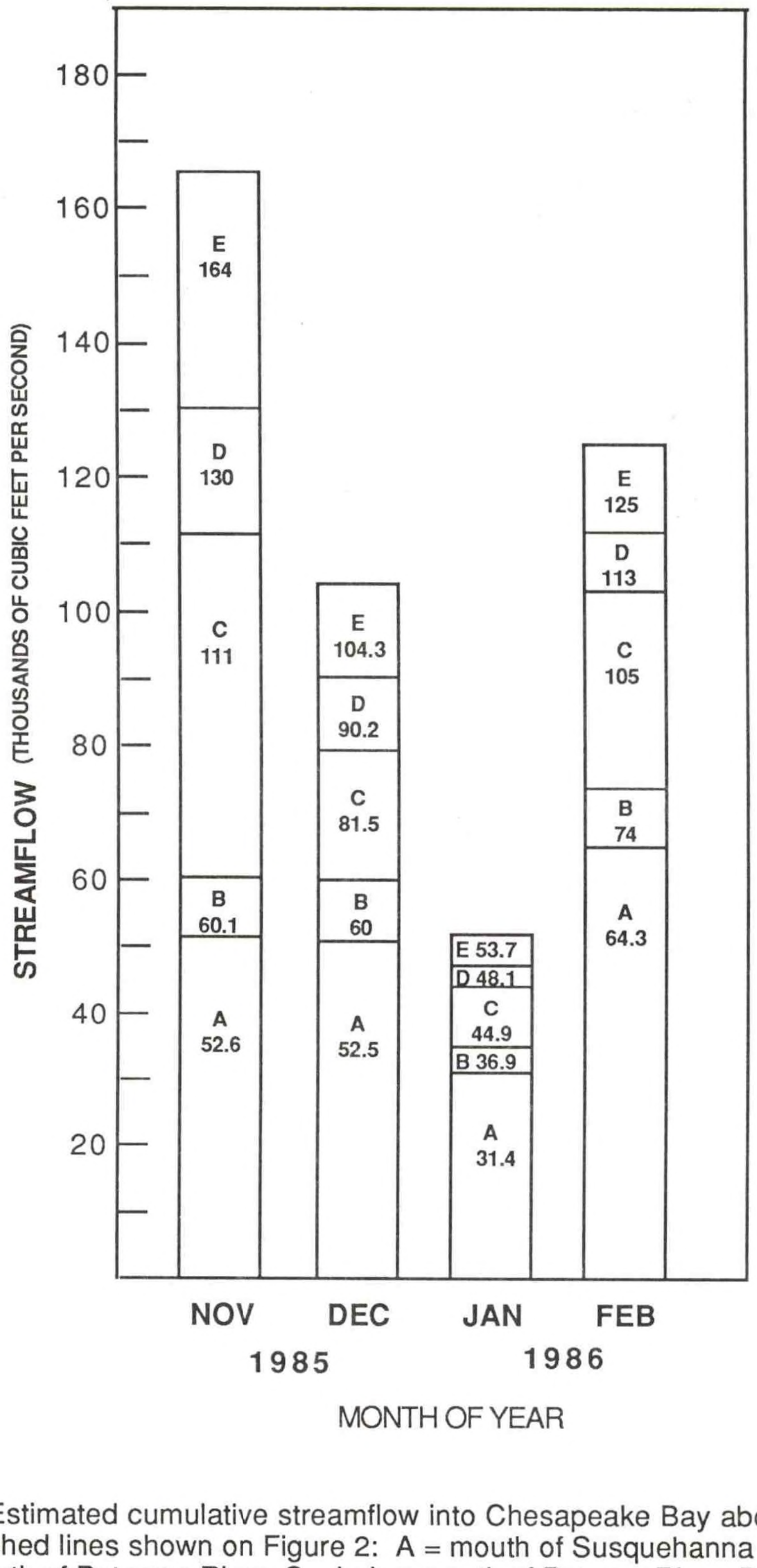
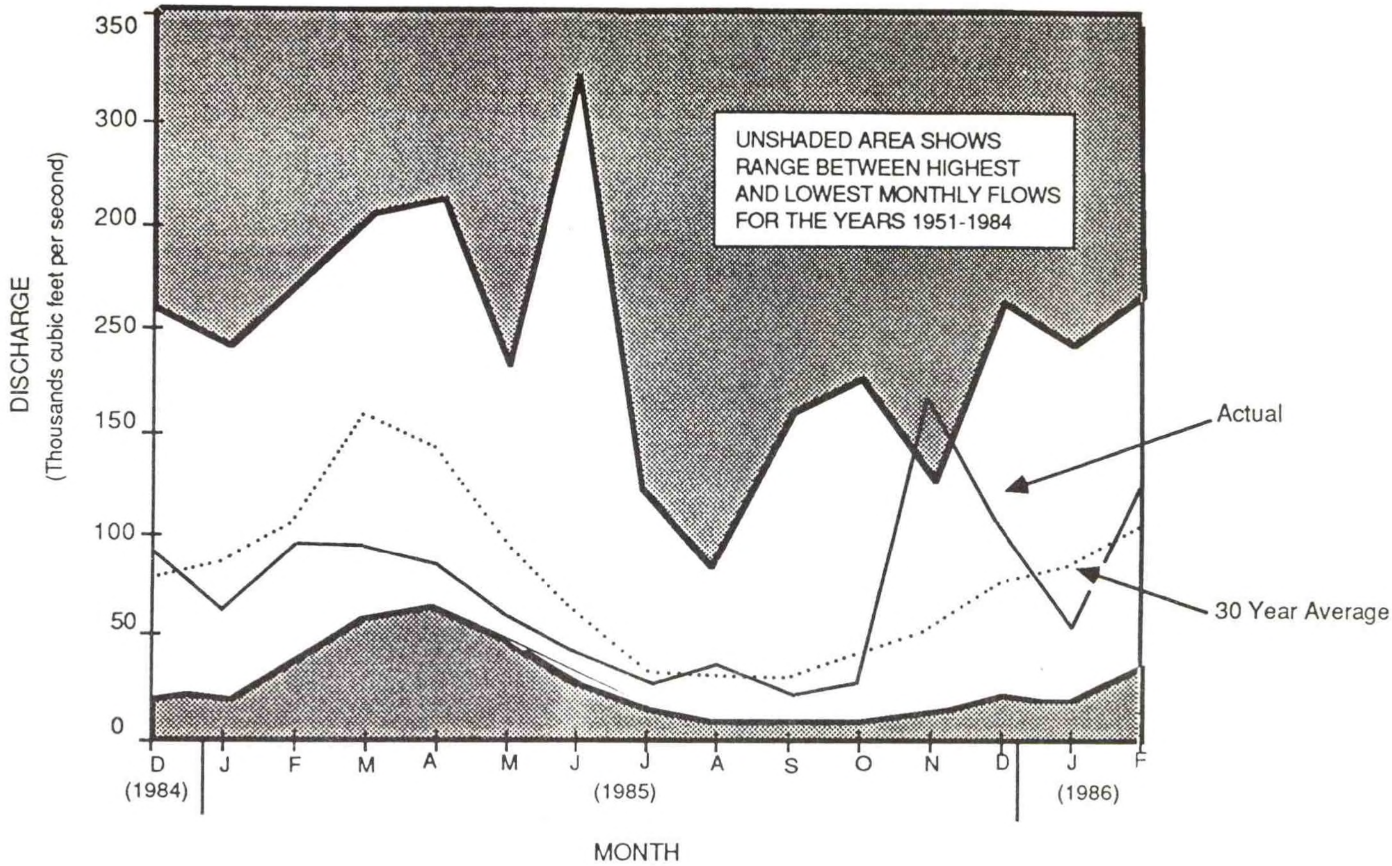


Figure 3--Estimated cumulative streamflow into Chesapeake Bay above indicated dashed lines shown on Figure 2: A = mouth of Susquehanna River. B = above mouth of Potomac River, C = below mouth of PotomacRiver, D = abovemouth of James River, and E = mouth of Chesapeake Bay.
Data Source: U.S. Geological Survey



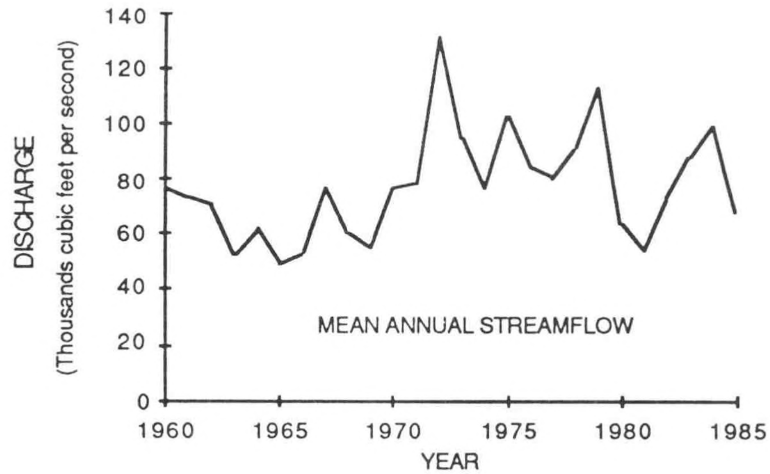
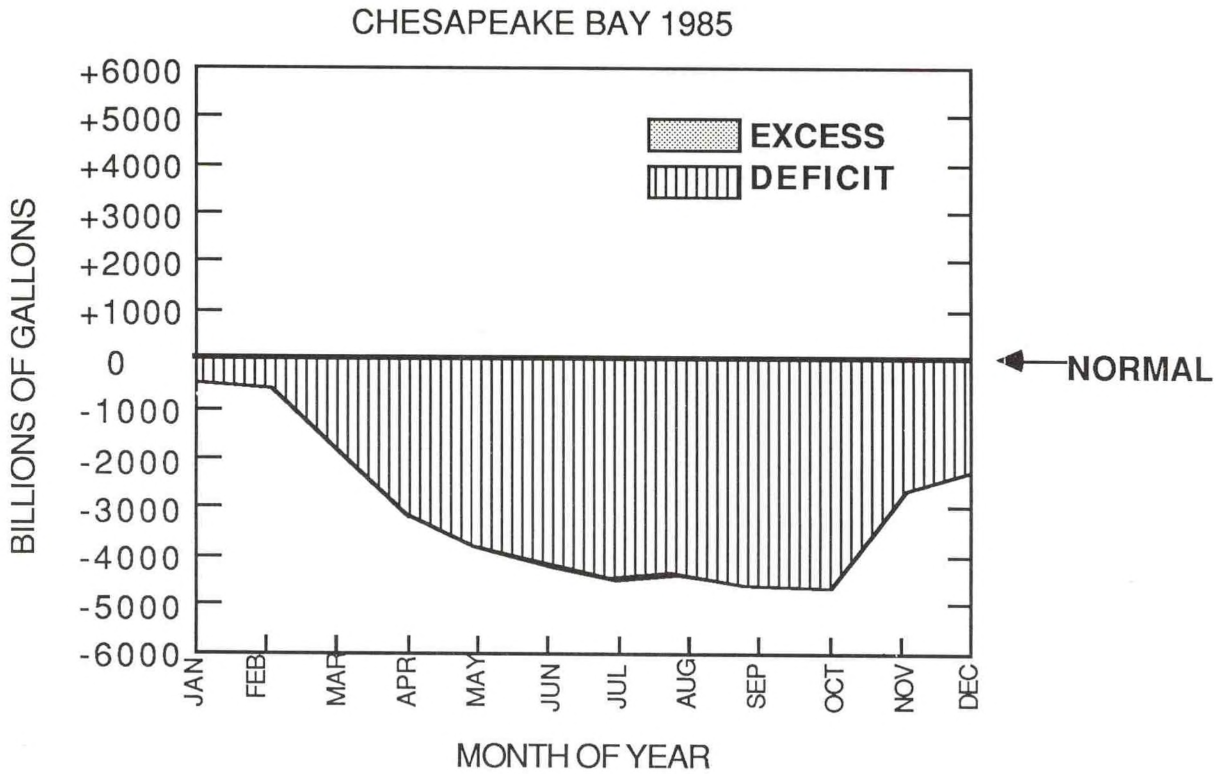


Figure 4--Monthly streamflow into Chesapeake Bay, December 1984 - February 1986; and annual mean streamflow since 1960. Streamflow was well above-average in December 1985, below-average in January 1986, and above-average in February 1986. November's streamflow was 200 percent above-average.
Data Source: U.S. Geological Survey



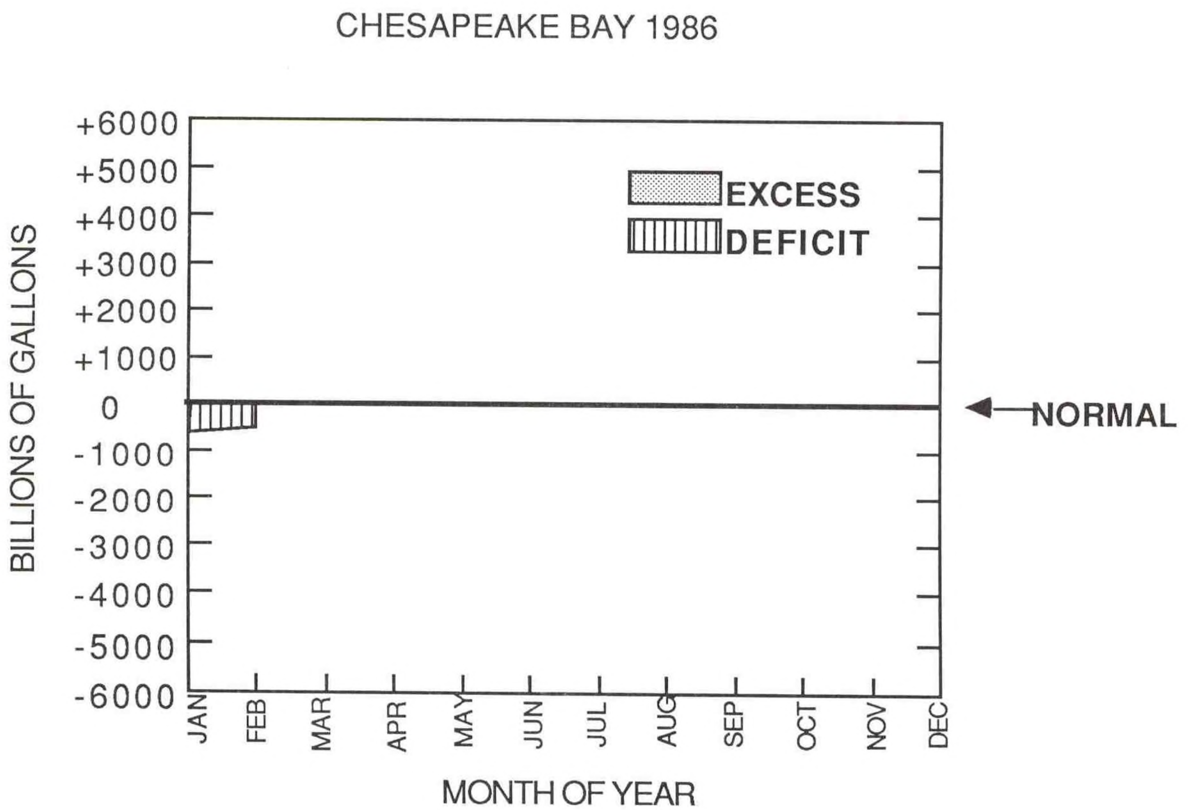


Figure 5--Cumulative monthly streamflow anomaly, Chesapeake Bay, 1985 and 1986.

2.4 Oceanography

Four of five coastal stations around the bay for which an historical data base exists showed slightly below-normal salinities in December (Table 7), and four of the five stations reported normal or above-normal salinities in January. Bay surface salinity could not be calculated at Baltimore for February due to malfunction of a salinity gauge. Water temperatures were above-average in December and slightly below average in January and February (Table 8).

Salinity:

December's below-normal salinities reflected above normal (+33 percent, Table 6) streamflow through the bay. The Bay Bridge-Tunnel Station showed a positive anomaly (+1.4 parts per thousand) whereas nearby Kiptopeke, VA station reported the lowest negative anomaly (-2.6 ppt).

All stations reported normal to above-normal salinities in January except Kiptopeke which recorded a below-average anomaly (-2.5 ppt). At Baltimore, salinity rose from 0.5 parts per thousand below-normal in December to 0.2 parts per thousand above-normal in January. Fresh water discharge from the Susquehanna River increased from 50.3 percent of total streamflow in December to 58.5 percent in January, however, the total streamflow discharge in January was still below normal which may explain why the isohalines did not change significantly in the upper Bay between December and January (Figure 6).

In February, salinities fell below normal at Annapolis and Solomon's Island, MD, and rose above normal at Kiptopeke and the Bay Bridge-Tunnel, VA. The 10, 12, and 14 parts per thousand isohalines shifted 20 - 30 miles (32.2 - 48.3 km) south during this month.

Temperature:

Surface water temperatures averaged above normal (+2.8 degrees F) within the Bay during December which may have reflected the warmer than normal November air temperatures (See Chesapeake Marine Assessment, September-November 1985). All stations reported above normal surface water temperatures. Solomon's Island station reported the highest departure (+4.1 degrees F) from normal. The average surface water temperatures dropped from 46.2 degrees F in December to 37.5 degrees F in January. The coldest water temperatures were recorded at the Chesapeake Bay Bridge Tunnel Station (2.2 degrees F below-normal) and at Annapolis, MD (1.2 degrees F below-normal).

February's average surface water temperature was not significantly different from January's average surface water temperature. Annapolis, MD and the Chesapeake Bay Bridge Tunnel Station again reported below-normal temperatures; 1.2 degrees F and 2.8 degrees F below-normal respectively, while the other stations reported normal or slightly above-normal temperatures.

Table 7--Bay surface salinities, December 1985 - February 1986.

	Surface Salinity and Departure from Normal Observed/*Anomaly (ppt)		
Station	December	January	February
Baltimore, MD	10.1/-0.5	10.1/+0.2	no report**
Annapolis, MD	10.2/-1.8	11.4/ 0.0	8.9/-1.9
Solomons, MD	15.3/-0.5	15.3/+0.3	13.4/-1.1
Kiptopeke, VA	23.9/-2.6	24.2/-2.5	26.6/+0.5
Bay Bridge-Tunnel, VA	23.9/+1.4	23.7/+1.9	23.6/+2.7

All salinity data are provisional. Salinities are based on water densities normalized to 15 degrees C.

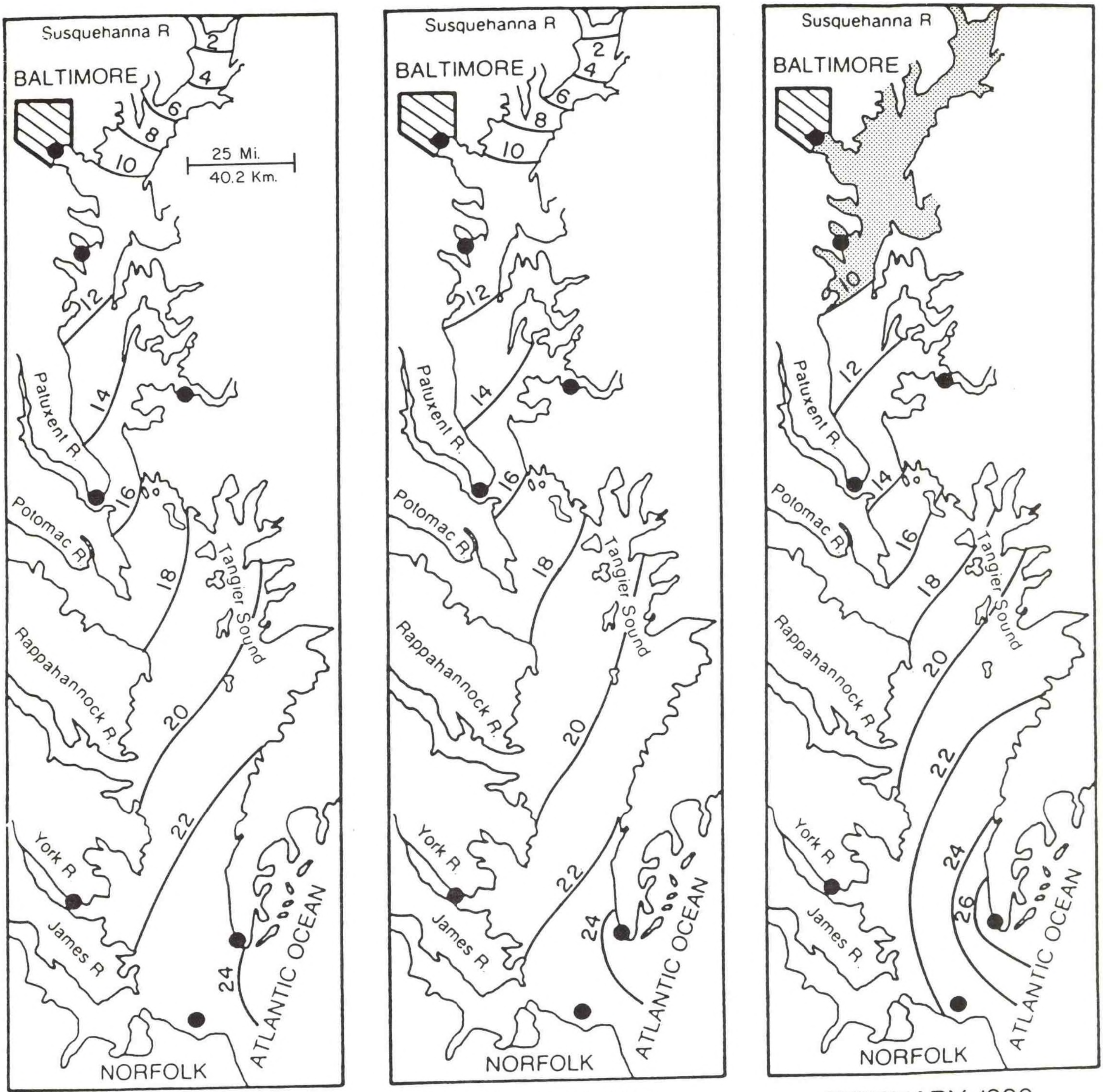
* Anomaly=departure from long-term (1951-1980) monthly averages.
** No Data reported from Baltimore in February due to equipment failure.

Table 8--Bay surface water temperatures, December 1985 - February 1986

	Surface Water Temperature and Departure from Normal Observed/*Anomaly(Deg.F)		
Station	December	January	February
Baltimore, MD	46.0/+3.0	37.6/+0.2	37.8/+0.8
Annapolis, MD	44.7/+3.0	35.7/-1.2	35.5/-1.2
Solomons, MD	47.4/+4.1	37.5/-0.3	37.4/ 0.0
Kiptopeke, VA	46.0/+1.9	39.5/+0.8	39.5/+0.7
Bay Bridge-Tunnel, VA	47.0/+1.9	37.4/-2.2	38.4/-2.8
Average	46.2/+2.8	37.5/-0.5	37.7/-0.5

Data Source: Calculated from National Ocean Service observed values and normals for Chesapeake Bay surface salinities and water temperatures.

* Anomaly = departure from long-term monthly averages.



DECEMBER 1985 JANUARY 1986 FEBRUARY 1986

Figure 6--Mean surface salinity distribution, Chesapeake Bay, December 1985 - February 1986. Isohalines (parts per thousands) are linearly interpolated from designated station data from the National Ocean Service, NOAA. Salinities in shaded area could not be interpolated for February due to lack of data (equipment malfuction) at Baltimore.

3. Impact of Climate/Weather on Bay Fisheries, Recreation and Transportation

3.1 Fisheries

Finfish:

Croaker stocks may have benefited from the mild winter of 1985-86. Warmer-than-normal winter water temperatures have been known to increase juvenile survivability[1]. The winters of 1982-83 through 1984-85 have been warmer than average, and associated with high year class survival of croaker.

In addition to the warmer water temperatures, favorable wind-driven transport of larvae to suitable nursery grounds is necessary for increased juvenile recruitment. Wind and temperature models constructed by scientists at the Virginia Institute of Marine Science (VIMS) predict low mortality for the young-of-the-year croaker indicating a strong year class throughout the Bay during the summer of 1986.

The warm winter also provided favorable conditions for survival of flounder, a species known to be affected adversely by cold water temperatures. Cold winter water temperatures have been known to increase the risk of parasitic infections while the flounder are overwintering in the Bay during their second year due to increased temperature stress.

In contrast, striped bass juvenile survivability is not enhanced by warm winter temperatures since nutrients received from scouring of the land by snow and ice in warm winter temperatures may inhibit the striped bass food supply. On the other hand, no estimates have been made regarding the effect temperature may have on the stock as a whole.

Blue Crabs:

As water temperatures begin to drop during the winter, female blue crabs travel south toward the mouth of Chesapeake Bay. When the water temperature drops to 47 degrees F (8.3 degrees C), the female burrows into the mud in a concentrated area at the mouth of the Bay and becomes accessible to the dredge crab fishermen. Males also burrow into the mud but remain spread throughout the channels and are less accessible than females.

The December 1985 dredge fishery in Virginia (Table 9) experienced reduced harvests. One factor in reduced landings, warm water temperatures, may have affected females so that they remained active on the surface and did not travel as far south as in normal winters. In addition, stock size may have been lower altogether or watermen may have turned to a product with higher market value when warmer winter water temperatures indicated a slower season for the dredge fishery. Landings for mature hard crabs decreased from 4.140 million pounds in December 1984 to 2.041 million pounds in 1985. However, the overall blue crab commercial harvest for the southeast did not decline since the pot season remained open longer in North and South

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[1] Norcross, Brenda L. 1983. Climate Scale Environmental Factors Affecting Year-Class Fluctuations of Atlantic Croaker (Micropogonias Undulatus) in the Chesapeake Bay, Virginia Institute of Marine Science PhD. dissertation, p.388.

Table 9--Virginia December commercial hard blue crab landings (millions of pounds) 1960-1985, and date when water temperature dropped to 47°F or lower.

Year	Date when water temperature dropped to 47°F or lower	Virginia December blue crab landings, millions of pounds
1960	December 9	4.448
1961	December 9	4.464
1962	December 7	4.626
1963	December 10	4.969
1964	December 16	4.746
1965	December 5	5.389
1966	December 4	6.028
1967	November 29	3.650
1968	December 6	3.358
1969	December 2	3.878
1970	December 8	3.769
1971	December 2, 20	6.056
1972	December 17	4.338
1973	December 17	3.301
1974	December 10	3.580
1975	December 19	1.885
1976	November 13	3.023
1977	December 8	4.085
1978	December 18	2.510
1979	December 18	4.161
1980	November 30	4.186
1981	December 5	3.771
1982	December 19	1.837
1983	December 21	4.269
1984	January 9 (1985)	4.140
1985	December 17	2.041

Data Source: Landings data from National Marine Fisheries Service, Current Fisheries Statistics, Annual Summaries, 1960-1979; Virginia Marine Resources Commission, 1980-84. Pier water temperatures from the Virginia Institute of Marine Science at Gloucester Point, Virginia. Data compiled by Virginia Institute of Marine Science. Landings primarily reflect year class strength, but other factors such as water temperatures may have some influence on landings in different years.

Carolina. Pot-caught crabs are preferred by the packers because these crabs are obtained with less internal mud and debris.

In Virginia waters, many small and large crabs were reported, but there were fewer mid-size crabs due to a reduced megalopal (juvenile) population last falll[2] However, warmer water temperatures allowed more time for juvenile crabs to mature before colder winter temperatures caused them to burrow.

Oysters:

During the 1985-86 winter, Virginia experienced a decrease in oyster production in December and February but an overall increase for the season (Table 10). However, the quality of oyster meat declined during the 1985-86 season. Poor quality meat is the result of oysters spawning into early winter. Oysters remain flaccid for a period of time after spawning and will exhibit a watery characteristic if harvested near this time.

Maryland oyster landings increased 38 percent over last season. This increase may have been related to more ice free days available for the watermen to dredge or tong. Watermen reported no interruptions in harvesting due to ice during the 1985-86 season. Tables 10 and 11 show oyster landings for Maryland and Virginia during maximum Chesapeake Bay ice cover for the winter quarters over the past 10 years. Maryland landings increased over the 1984-85 winter quarter while Virginia reported decreases in December and February harvests.

The total oyster population is expected to decrease during the 1986-87 season because of poor spat set from the 1983-84 season.

[2]Oesterling, Michael, Virginia Institute of Marine Science....Personal Communication.

Table 10--Virginia oyster landings and total Chesapeake Bay ice cover by winter quarter for years 1976-1986.

Year	Ice Cover[1]		Virginia Oyster Landings[2]					
			Month					
			December		January		February	
Winter of	Maximum ice cover	Date of maximum ice cover	Bushels	Dollars	Bushels	Dollars	Bushels	Dollars
1976-77	85%	Feb 10	138,698	625,590	43,796	5,890	31,078	206,780
1977-78	30%	Feb 17	163,775	927,368	84,028	499,581	66,090	453,727
1978-79	60%	Feb 20	183,999	972,161	120,188	780,498	38,508	240,067
1979-80	15%	Mar 02	168,983	1,199,439	125,515	946,845	69,865	378,620
1980-81	50%	Jan 18	173,933	1,159,837	51,414	606,959	62,956	454,632
1981-82	55%	Jan 27	128,368	1,189,551	52,257	416,708	93,119	736,986
1982-83	<10%	Feb 14	78,130	864,971	46,799	440,687	41,118	357,329
1983-84	30%	Jan 23	44,507	565,395	41,108	526,660	33,640	437,634
1984-85	20%	Feb 11	84,903	1,188,965	42,948	583,173	54,058	718,783
1985-86	<10%	Jan 29	78,348	952,103	59,546	652,924	46,310	473,892

Data Sources: [1] NASA - Goddard Space Flight Center and U. S. Coast Guard.

[2] Virginia Marine Resources Commission.
Data are for total Virginia public ground oyster harvest.
For the Virginia section of the Potomac River, landings include only tributaries to the river on the Virginia side.
Data for 1984-85 are preliminary.

Table 11--Maryland oyster landings and total Chesapeake Bay ice cover by winter quarter for years 1976-1986.

Year	Ice Cover [1]		Maryland Oyster Landings[2]					
			Month					
			December		January		February	
Winter of	Maximum ice cover	Date of Maximum ice cover	Bushels	Dollars	Bushels	Dollars	Bushels	Dollars
1976-77	85%	Feb 10	374,954	2,982,744	68,690	657,112	127,320	1,238,809
1977-78	30%	Feb 17	411,283	2,880,563	219,352	1,616,819	198,180	1,509,357
1978-79	60%	Feb 20	419,384	2,846,756	271,639	1,897,385	75,006	603,108
1979-80	15%	Mar 02	363,076	3,181,805	302,390	2,554,738	194,377	1,595,119
1980-81	50%	Jan 18	442,172	3,662,949	217,632	2,023,641	253,868	2,056,193
1981-82	55%	Jan 27	402,127	3,898,151	123,401	1,228,415	251,778	2,319,330
1982-83	<10%	Feb 14	264,779	2,866,463	171,704	1,699,835	134,405	1,276,832
1983-84	30%	Jan 23	158,962	2,392,771	103,334	1,658,239	112,890	1,565,141
1984-85	20%	Feb 11	219,963	3,480,070	96,190	1,388,986	92,642	1,329,709
1985-86	<10%	Jan 29	244,531	2,820,702	170,782	2,032,080	148,845	1,682,861

Data Sources:

1 NASA - Goddard Space Flight Center and U.S. Coast Guard.

2 Maryland Department of Natural Resources, Tidewater Administration. Data are for total Maryland public and private ground oyster harvest. For the Potomac River, landings include the main portion and tributaries to the river on the Maryland side. Data for 1984-85 are preliminary.

3.2 Recreation

The National Weather Service posted 42 small craft advisories and six gale warnings (Figure 7 and Table 12) for the Chesapeake Bay area during the winter quarter. Compared to the 1984-85 winter quarter, small craft advisories increased by 13 warnings. December had the greatest number of gale warning hours posted throughout the Bay (Figure 8), but had fewer hours of small craft advisories compared to January. February had the lowest number of small craft advisory hours throughout the bay and no gale warnings were posted.

The number of hours of marine advisories/warnings issued was significantly[3] different between forecast areas. Windmill Point to the mouth of the Bay had a significantly greater number of advisory hours compared to the area from Baltimore Harbor to the Head of the Bay. According to Table 13, during the winter quarter, marine advisories/warnings were issued greater than 25 percent of the time for the entire Bay region.

Maryland parks showed increases in attendance for December 1985 and January 1986 over December 1984 and January 1985. This higher attendance was most influenced by the period of below normal precipitation. Overall, attendance at selected Maryland and Virginia state parks during the winter of 1985-86 showed large increases compared to the winter quarter two years ago, however overall attendance for 1985-86 decreased compared to the 1984-85 attendance values (Table 14). The months of December 1985 and February 1986 showed decreases in attendance for all Virginia parks listed, except York River, which increased in December and Chippokes which increased in January. Maryland facilities, except Sandy Point in February, showed increased attendance for the winter quarter. Fluctuations in attendance may reflect monthly weather conditions, or simply the weather conditions on weekends. In addition, special athletic events or inoperative census equipment may account for attendance figure differences.

The Maryland Department of Natural Resources Marine Police reported 3 boating accidents, 0 injuries, 0 deaths, and $151,500 in property damage related to recreational boating (Table 15). Property damage in the 85-86 quarter exceeded the figures for 1984-1985 by $34,650 with $140,000 lost in a boat fire. The U.S. Coast Guard conducted 218 Search and Rescue (SAR) operations during the quarter (Table 16).

[3]Significance determined by chi-square analysis (chi-square statistic = 95.08, $P<0.001$, df=4).

Table 12--Marine advisories/warnings, Chesapeake Bay, December 1985 - February 1986. (National Weather Service data)

Date	Condition Report[1]	Forecast Area
DEC 1	A	Baltimore Harbor to Mouth of Bay
	B	Entire Bay
3	A	Entire Bay
6	A	Entire Bay
11	A	Entire Bay except Tidal Potomac
12	A	Patuxent River to Mouth of Bay
13	A	Head of Bay to Windmill Pt.[2]
17	A	Entire Bay
18	B	Entire Bay
18	A	Entire Bay
20	A	Entire Bay
23	A	Entire Bay
24	B	Entire Bay
27	A	Entire Bay
31	A	Entire Bay
JAN 1	A	Windmill Pt. to Mouth of Bay
3	A	Entire Bay
4	A	Entire Bay
6	A	Entire Bay
7	A	Head of Bay to Windmill Pt. and Tidal Potomac
7	B	Windmill Pt. to Mouth of Bay
8	A	Windmill Pt to Mouth of Bay
10	A	Entire Bay
11	A	Windmill Pt. to Mouth of Bay
12	A	Head of Bay to Tidal Potomac
12	B	Windmill Pt. to Mouth of Bay
14	A	Head of Bay to Tidal Potomac
19	A	Windmill Pt. to Mouth of Bay
JAN 20	A	Head of Bay to Tidal Potomac
20	B	Windmill Pt. to Mouth of Bay
22	A	Entire Bay
26	A	Entire Bay
29	A	Entire Bay
FEB 2	A	Entire Bay
5	A	Windmill Pt. to Mouth of Bay
6	A	Windmill Pt. to Mouth of Bay
7	A	Head of Bay to Tidal Potomac
11	A	Windmill Pt. to Mouth of Bay
11	A	Patuxent River to Mouth of Bay
13	A	Windmill Pt. to Mouth of Bay
14	A	Entire Bay
17	A	Windmill Pt. to Mouth of Bay
20	A	Windmill Pt. to Mouth of Bay
21	A	Entire Bay
24	A	Windmill Pt. to Mouth of Bay
25	A	Head of Bay to Tidal Potomac
25	A	Head of Bay to Baltimore Harbor and Tidal Potomac
27	A	Patuxent River to Mouth of Bay
TOTAL:	A: 42 B: 6	

[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

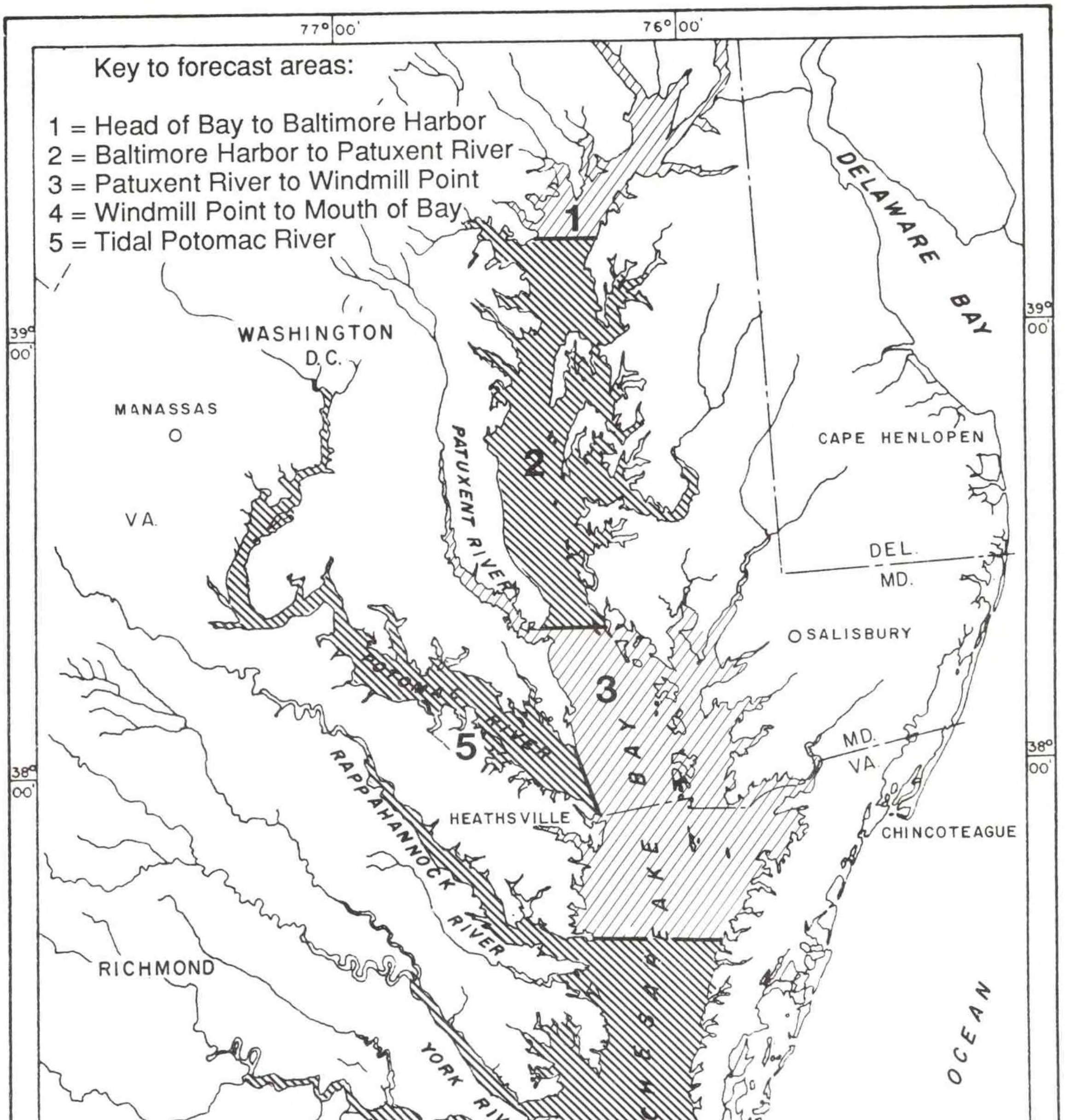

Figure 7--National Weather Service (NWS) forecast areas for Chesapeake Bay.

Figure 8--Hours per month which National Weather Service marine advisories/warnings were issued for locations within the Chesapeake Bay (December 1985 - February 1986).

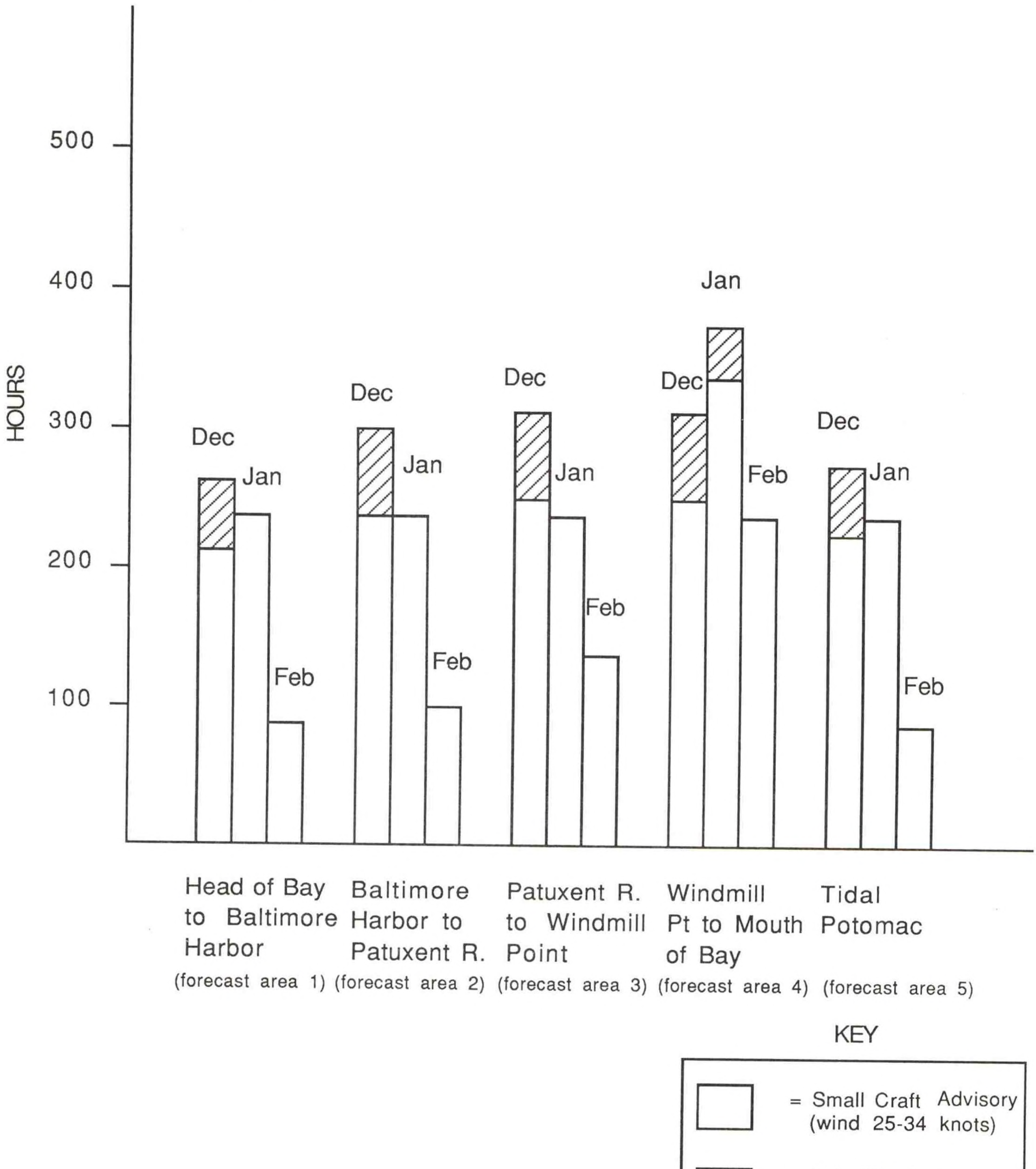

Table 13--Percent total time and hours [in brackets] during which small craft and/or gale advisories/warnings were issued for locations within Chesapeake Bay for the quarter December 1985 - February 1986 (Total hours in the quarter= 2160 hours).

Location	Small Craft % [HOURS]		Gale % [HOURS]		All Warnings % [HOURS]	
Head of Bay to Baltimore Harbor	25.0	[540.4]	2.5	[55.0]	27.5	[595.4]
Baltimore Harbor to Patuxent River	27.0	[583.1]	2.5	[55.0]	29.5	[638.1]
Patuxent River to Windmill Point	29.2	[631.8]	2.5	[55.0]	31.7	[686.8]
Windmill Point to Mouth of Bay	38.3	[827.1]	3.7	[80.5]	42.0	[907.6]
Tidal Potomac	27.5	[555.0]	2.5	[55.0]	30.0	[610.0]

Table 14--State parks attendances at selected Maryland and Virginia facilities, December 1985 - February 1986 and December 1984 - February 1985.

	Month					
	December		January		February	
Facility	1985-86	1984-85	1985-86	1984-85	1985-86	1984-85
Maryland						
Sandy Pt.	11,000	7,470	9,804	5,068	8,126	9,585
Pt. Lookout	3,885	3,158	4,185	3,835	5,114	4,891
Virginia						
Westmoreland	527	575	845	882	651	1,630
Chippokes	2,162	2,316	1,163	978	939	1,354
York River	2,259	1,050	3,163	2,728	2,324	3,395
Seashore	22,000	42,897	40,767	34,348	32,698	44,750
TOTALS	41,833	57,466	59,927	47,839	49,852	65,605

GRAND TOTAL	
1985/86	1984/85
151,612	170,910

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 15--Maryland marine accident statistics, December 1985 - February 1986 and December 1984 - February 1985.

MONTH	No. of Boating Accidents		No of Injuries		No. of Deaths		Property Damage	
	1984-85	1985-86	1984-85	1985-86	1984-85	1985-86	1984-85	1985-86
Dec	4	1	0	0	0	0	$81,500	$140,000
Jan	2	1	1	0	1	0	$30,000	$1,000
Feb	4	1	0	0	0	0	$5,350	$10,500
TOTALS	10	3	1	0	1	0	$116,850	$151,500

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

Table 16--U.S. Coast Guard Search and Rescue (SAR) Caseload, December 1985 - February 1986

Month	Number of Search and Rescues					
	Group Baltimore		Group Eastern Shore		Group Hampton Roads	
	1985-86	1984-85	1985-86	1984-85	1985-86	1984-85
December	41	28	17	4	39	32
January	18	16	27	3	30	23
February	12	18	13	6	21	27
Totals	71	62	57	13	90	82

Group Baltimore - most of Upper Bay
Group Eastern Shore - lower central portion of Eastern Shore
Group Norfolk - most of Lower Bay

GRAND TOTAL	
1985-86	1984-85
218	157

3.3 Transportation

Shipping and related transportation activities at Maryland and Virginia ports proceeded normally during the winter quarter. Lack of ice kept ports and tributaries accessible throughout the Bay.

The Port of Baltimore experienced extended delays due to high winds during the first week in December (Table 17). Shutdown time during December 2nd and 3rd totaled 25 hours and 43 minutes. A second extended shutdown was experienced during the last week in January with a delay of 23 hours 11 minutes on the 27th and 28th. A total of 83 hours 05 minutes of shutdown time occurred during the winter quarter of 1985-86 compared to 99 hours 24 minutes during the same period in the 84-85 season.

Of all commercial vessels using crane facilities at the Port of Baltimore, including American and foreign flag ships, individual container-line shippers could expect losses of between $2,300 - $2,500 per hour from crane delays caused by excessive winds. Increased dollar value losses from winds includes delays of stevedore crew time at $1,200 - $1,500 per hour (as of the winter of 1985-86), crew overtime, extra steam necessary for increased engine speed and expenses from delayed tug boats[4]. Based on the total down-time (Table 17), shippers may have experienced costs close to $332,000 related to excessive wind, and crane delays at the Port of Baltimore during the Winter 1985-86 quarter.

[4] Ted Sanderson, Port of Baltimore....Personal Communication.

Table 17--Number of crane shutdowns and productive time lost due to wind at Port of Baltimore, December 1985 - February 1986.

Date		Number of Shutdowns	Productive Time Lost (Hours:Minutes)
Dec.	2	1	15:20
	3	2	10:23
	14	1	5:16
	18	1	6:45
	27	1	3:50
Jan.	3	1	1:37
	5	1	4:25
	6	2	2:00
	13	1	2:38
	20	1	3:19
	22	1	3:20
	27	1	15:34
	28	3	7:37
Feb.	9	1	1:01
Totals		18	83:05

Data Source: Maryland Port Administration

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    National Weather Service
United States Coast Guard: Chesapeake Bay Groups
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

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Virginia Institute of Marine Science

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