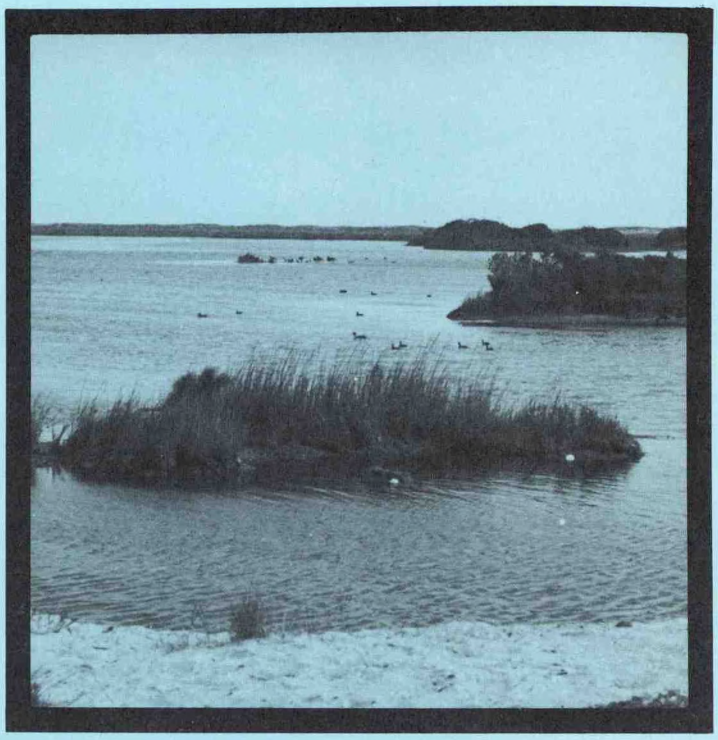
Marine Environmental Assessment

CHESAPEAKE BAY
ANNUAL SUMMARY 1981



U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Environmental Data and Information Service
Center for Environmental Assessment Services

CLIMATE IMPACT ASSESSMENT
UNITED STATES

The Center for Environmental Assessment Services (CEAS), Marine Environmental Assessment Division (MEAD), Marine Assessment Branch (MAB), produces periodic assessments of weather impacts on economic sectors of marine environmental activity. From September 1981 through March 1982, MAB issued monthly assessments of Chesapeake Bay in the economic sectors of fisheries, recreation, and transportation. The Chesapeake Bay region served as a prototype for assessment development. We now issue quarterly assessments in order to extend the service to other marine areas within existing resource limitations.

Please send any comments or questions regarding CEAS marine assessments to the Branch Chief, NOAA/EDIS/CEAS, Marine Environmental Assessment Division, 3300 Whitehaven Street, NW, Washington, DC 20235, or call (202) 634-7379.

Front Cover Photographs

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Beach Scene - EPA Documerica - Hope Alexander
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Catch on Fishing Boat - NOAA Photo by M. Dowgiallo

September 1982

Chesapeake Bay Marine Environment - 1981 Annual Summary

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1. Introduction

The Chesapeake Bay 1981 Annual Assessment, is a first attempt to present a synoptic view of several economic sectors and their direct and indirect relations to the physical and biological marine and atmospheric environment. The economic sectors are not independent, nor are the environmental processes.

Using research results of scientists in the fields of physical oceanography, marine biology, meteorology, political science, and economics, the Marine Assessment Branch (MAB), Marine Environmental Assessment Division of the Center for Environmental Assessment Services has attempted to give a multidisciplinary view of the Bay. Assessment is an integrative approach to a system. Data from several sectors are brought together for a single viewing. Data appear without bias. Only confirmable relationships are presented as correlations.

Relationships may appear between variables in one sector and those in another sector (e.g., climate and fisheries), but on the whole relationships between different sectors are not precise. Interactions among different sectors must exist since heavy multipurpose use of the Bay contributes to the cost of operation, maintenance, safety, and clean-up in each sector. Even where direct relationships are unclear, the presentation of data from several scientific and economic areas has value because it emphasizes the multiple use of the Bay system.

By presenting the collection of data here, we intend to stimulate further investigation by scientists and provide information to those persons responsible for usage regulations of the Bay.

1.1 Organization of the Report

The report comprises seven sections. In the introductory section we delineate the concept of marine environmental assessment embodied in this report, specify the coverage of the present report, and suggest extensions and future development for the assessment function.

In section 2 we present a summary of impacts identified for 1981. Only confirmed relationships appear as impacts.

In sections 3-7 we present in more detail the weather and oceanography, fisheries, recreation, transportation and safety sectors, and pollution events of the Chesapeake Bay marine environment for 1981. Discussions in these sections cover all information available to the Marine Assessment Branch at this time but are neither exhaustive nor definitive. The review gives a limited synoptic view of several sectors and their relationships for a single year.

1.2 Scope of the Report

The geographical area considered in the annual assessment includes the Chesapeake Bay and all tributaries in the entire drainage basin contributing to the Bay waters. We present a summary of weather and oceanographic events during 1981 over the region. Coverage is only for calendar year 1981, though regional environmental cycles in the Bay are from December through November. The calendar year serves the assessment function in tracking economic variables. Where discussion of environmental patterns or events requires reference to 1980 or to 1982 we extend coverage at those specific instances.

Four economic sectors appear in this report: fisheries, recreation, transportation, and industry. The fisheries section covers finfish, shellfish diseases, and predators. Distribution and abundance of species depends strongly on salinity and temperature regimes in the Bay which in turn relate to precipitation and air temperature and to general coastal conditions over a broader span of space and time. Harvest of the commercial species varies with climate conditions, fishing effort, and market conditions. Pollution and transportation sectors affect distribution of the fisheries species as well as harvest activity.

Recreation includes park usage, boating, Chesapeake Bay Bridge traffic, and recreational accident statistics. The recreational sector responds quickly to weather variations, but also correlates with pollution incidents and the presence of annoying or dangerous organisms in the water. The Bay is used heavily for recreation including swimming, boating, fishing, and tourism.

Transportation includes shipping, navigational aids, dredging, ice clearing and related shore activity. Through most months of the year shipping and related shore activities remain unaffected by climate or other activity. During winter, however, icebreaking requires resources to keep the Port of Baltimore operating.

Industry in this report appears only as specific events such as spills of oil and hazardous substances and sewage disposal discharge. The Bay and tributaries form a large resource for waste disposal for surrounding industry and populations. Heavy use of the Bay for transportation leads to a finite number of spills of cargo substances, some harmless, others potentially harmful.

1.3 Future Work

The Center for Environmental Assessment Services, Marine Environmental Assessment Division recognizes the need for extension of this assessment to other sectors and more detailed and rigorous analyses in those sectors already discussed. The industrial complex surrounding the Bay includes heavy manufacturing (steel, automobiles), food processing (spices, sugar), refining, shipbuilding, and chemicals. The use of water in each of these industries contributes to the quality of water entering the Bay system.

In fisheries the assessment may ultimately treat species specific problems. The analysis should treat species life stages sensitivity to environmental conditions.

Future work in the recreation sector will include assessment of sport fishing, marina usage, and sales of recreational equipment.

In transportation the detailed distribution of Search and Rescue (SAR) in categories of damage, injury, cost, and geography may enhance the usefulness of the assessment. The costs related to maintenance of navigational aids and icebreaking are of interest to port authorities.

The discharge of heated water from power generation loads the Bay system with waste energy. While local changes to the system can be measured at present, the cumulative impact of heat loading on the Bay ecosytem needs to be assessed.

Finally, the Chesapeake Bay assessment will increase in convenience to each user if sensitivity scales for impacts can be derived. For each sector or resource factor (e.g. streamflow, salinity change, temperature anomaly, wave height, number of rain days) the assessor needs to know not only if the impact is positive or negative, but the degree of impact.

Table 1. Climate impact summary, Chesapeake Bay, 1981.

	FISHERIES							RECREATION					TRANSPORTATION					
CLIMATE EVENT	Oyster Harvest	Blue Crab Harvest	Hard Clam Harvest	Finfish Harvest	Fishing Nets	Wooden Hull Boats	Docks	Boating	Bridge Traffic	State Park Attendance	Licenses and Revenues	Safety	Safety	Tug and Barge Traffic	Fuel Consumption, Vessel	Draft, Hull, HP Restrictions	Port Operations	Structural Aids to Navig.
Precipitation deficit	+	+		+				+	+	+	+	+	+				+	
Jan., Feb. icing	–			–	–	–	–	–				–	–	–	–	–	–	–
Low storm activity	+	+	+	+				+	+	+	+	+	+	+				+
Low streamflow, runoff	+	+	+	+				+				+						
High Salinities	+	+	+	+														
Moderate summer air temp.								+	+	+	+	+						

[+] Favorable

[–] Unfavorable

[ ] No abnormal effect, data unavailable, or not applicable

2. Impact Summary

Two major abnormal climatic events, icing and drought, occurred in the Chesapeake Bay region during 1981. Table 1 summarizes impacts of climate events by economic sector.

Low streamflow from an overall precipitation deficit contributed to higher than normal salinity, which affected distribution and abundance of sensitive finfish and shellfish species. High salinities favored populations of the commercially valuable oyster, blue crab, hard clam, and certain finfish species. Low precipitation and resultant low runoff provided favorable conditions for oyster habitat. Relatively low storm activity during warmer months allowed for normal finfish and shellfish harvest activities.

Extensive January and February icing restricted access by watermen to oysterbeds and damaged fishing nets, wooden hull boats and docks. Ice cover also affected Bay transportation by limiting tug and barge traffic and restricting vessel types.

Infrequent periods of high river flow following storm events were hazardous to recreation boaters in certain areas, but did not interrupt normal seasonal usage of rivers. Lower than normal precipitation favored all categories of recreation, especially during summer months of peak activity. Moderate summer air temperatures favored all categories of marine recreation.

3. Weather and Oceanography

During 1981 the Chesapeake region experienced extreme dryness. Low rainfall over regional river basins contributed to above normal salinities in the Bay proper, rivers, and tributary creeks.

Ice covered extensive portions of the Bay in January marking 1981 as one of the most severe since records began. With the exception of January, moderate temperatures prevailed throughout the year. Seasonally low storm activity characterized 1981.

3.1 Summary of Events

January was notable for intense cold, which resulted in 50% of the Bay being covered by ice for much of the month. The month was dry throughout the region.

February was marked by blustery cold fronts bringing heavy rain and flooding and warmer-than-normal temperatures. Both bridges over the Bay were closed at one time or another because of strong winds.

In March colder-than-normal weather and strong winds persisted, but little moisture.

Though April brought return of warmer, moister conditions, the drought persisted.

May returned colder-than-normal weather. Mid-month thunderstorms were accompanied by strong winds, heavy rain and local flooding.

June was slightly warmer and wetter than normal with local flooding and wind damage from thunderstorms. Tropical storm Bret touched the Virginia coast at the end of the month bringing rain and strong winds to the Southern Bay area.

July began with the last remnants of rain and wind from Bret. Later in the month a series of strong gusty squalls struck the Bay with 100 knot wind gusts recorded at South Island 21 July.

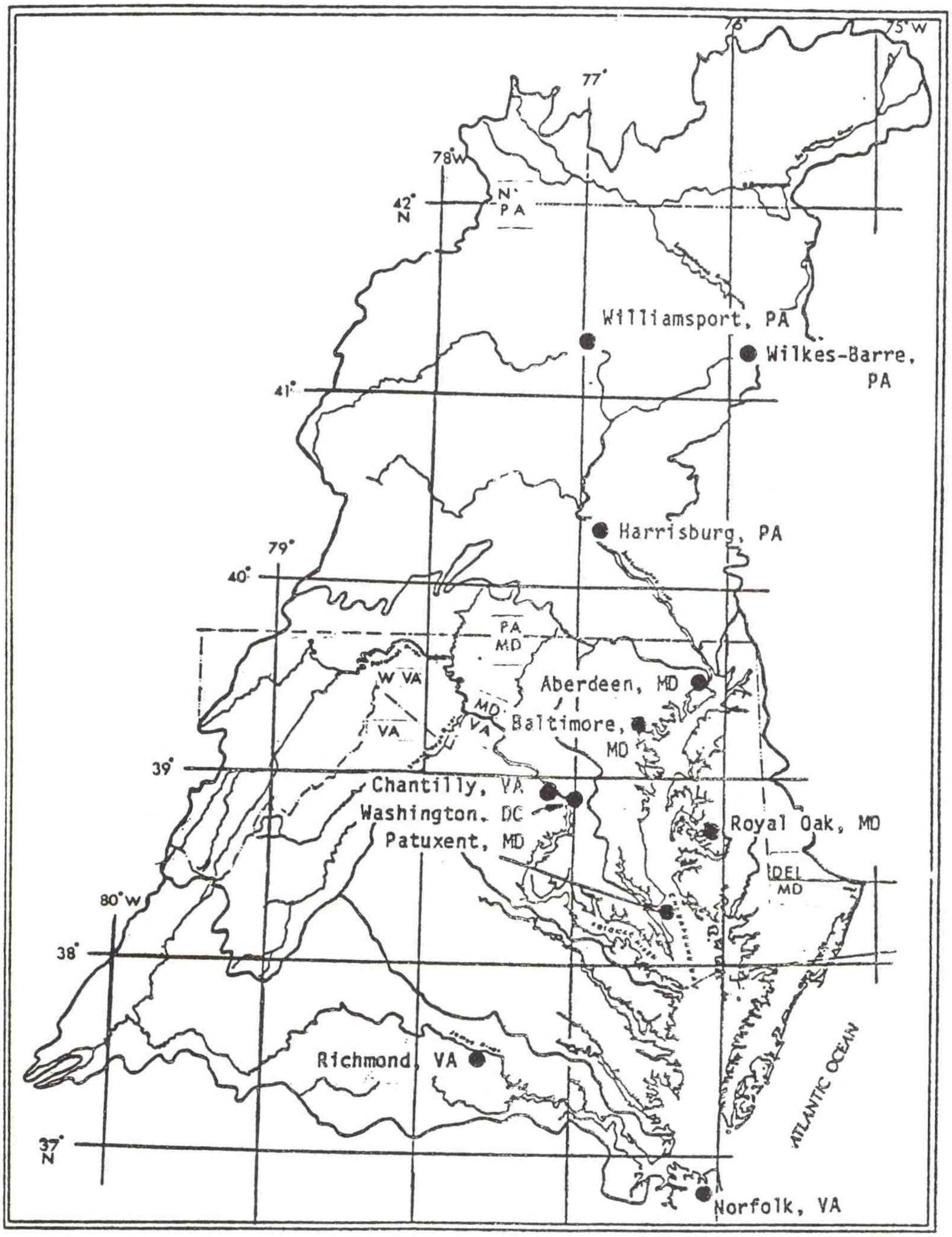

Figure 1. Selected meteorological stations, Chesapeake Bay watershed (Modified EPA map).

August was primarily cool and dry despite the effects of Hurricane Dennis just after mid-month.

September weather continued slightly cooler and dryer than normal. A tornado formed over water and struck near Crisfield 8 September, producing moderate damage.

October was windy in the first part of the month but normal in other respects.

November was slightly warmer than usual but broke records for dryness.

December brought recurrent cold fronts, colder-than-normal temperatures, and persistent northwest winds over the Bay. The Southern Bay received storm rains, but most areas continued to be drier than usual.

3.2 Precipitation and Streamflow

Precipitation data from the 11 selected stations in Figure 1 show 1981 was a dry year in the Chesapeake region. Table 2 shows January to have been an extremely dry month through the Bay area with the 11 stations more than 80% below normal for the month. The area-weighted rainfall for Maryland and Delaware was 19% below the previous record low established in 1955, and the combined December 1980 and January 1981 precipitation totals for the three stations, Baltimore, Washington, and Patuxent, were less than half previously established low amounts for the same two months.

February was wet except at Royal Oak, Richmond, and Norfolk. The three stations in Pennsylvania received more than twice normal rainfall.

March returned to very dry conditions; all stations except Norfolk fell below 50% of normal.

April through October precipitation varied over the region, but did not depart markedly from normal.

November was very dry again, the driest November on record at both Washington and Baltimore, and second driest at Royal Oak.

December showed normal precipitation for the region. The three southernmost stations recorded greater than normal precipitation.

The 1981 annual total precipitation for the 11 stations was 13% below normal. All stations of the group, except Wilkes-Barre, received less than normal precipitation for the year. Baltimore, Washington, Chantilly, and Royal Oak ended the year with less than 80% of the normal total annual precipitation.

Table 2. Monthly total precipitation and departure from normal, selected stations, Chesapeake Bay region, 1981.

A. Total precipitation

Station	Precipitation (inches)												
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Williamsport, PA	2.52	2.58	3.53	3.42	3.99	3.25	4.19	3.44	3.03	3.20	3.74	3.10	39.99
Wilkes-Barre, PA	2.04	1.96	2.50	3.06	3.50	3.40	4.09	3.21	2.82	2.71	3.01	2.51	34.81
Harrisburg, PA	2.57	2.42	3.22	2.98	3.76	3.11	3.70	3.22	2.66	2.57	3.19	3.07	36.47
Aberdeen, MD	2.94	2.81	3.82	3.29	3.75	3.55	4.22	3.91	3.30	2.77	3.56	3.34	41.26
Baltimore, MD	2.91	2.81	3.69	3.07	3.61	3.77	4.07	4.21	3.12	2.81	3.13	3.26	40.46
Washington, DC	2.62	2.45	3.33	2.86	3.68	3.48	4.12	4.67	3.08	2.66	2.90	3.04	38.89
Chantilly, VA	2.84	2.61	3.48	2.96	3.68	3.61	4.12	4.25	3.29	2.74	3.06	3.47	40.11
Royal Oak, MD	3.29	3.12	4.06	3.43	3.83	3.77	4.68	4.88	3.72	3.17	3.68	3.73	45.36
Patuxent, MD	2.92	2.77	3.40	2.80	3.69	3.48	4.15	4.35	3.21	2.85	3.07	3.29	39.98
Richmond, VA	2.86	3.01	3.38	2.77	3.42	3.52	5.63	5.06	3.58	2.94	3.20	3.22	42.59
Norfolk, VA	3.35	3.31	3.42	2.71	3.42	3.62	5.70	5.92	4.20	3.06	2.94	3.11	45.30

B. Departure from Normal

Station	Departure in Percent of Normal												
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Williamsport, PA	-73	+226	-76	-14	-48	70	-2	-70	-31	26	-61	-37	-12
Wilkes-Barre, PA	-69	311	-80	16	-14	1	4	-45	- 3	29	-39	-15	2
Harrisburg, PA	-83	145	-68	- 7	-51	50	26	27	-17	46	-70	-21	-5
Aberdeen, MD	-87	19	-64	61	-6	35	1	-28	50	28	-77	-10	-8
Baltimore, MD	-83	4	-69	-34	1	43	13	-54	-7	-9	-90	1	-23
Washington, DC	-85	15	-55	- 8	-7	-27	38	-35	-37	-37	-90	-8	-21
Chantilly, VA	-86	57	-72	3	18	7	-2	-16	-37	9	-92	-29	-20
Royal Oak, MD	-82	-5	-67	21	27	-30	13	-51	19	-1	-83	-4	-21
Patuxent, MD	-84	58	-59	63	33	19	37	-70	3	-16	-78	15	-8
Richmond, VA	-78	-8	-55	7	94	8	-29	-43	-25	-20	-79	57	-16
Norfolk, VA	-69	-32	-45	-17	-20	38	-11	16	-24	7	-39	86	-8
Total Region	-80	+61	-64	+8	+2	+19	+6	-33	-10	+12	-73	+3	-13

Table 3 shows monthly streamflow for 1980 and 1981 at 5 sections along the Bay. The low precipitation from late 1980 and much of 1981 affected streamflow values which are the lowest on record for those months. Only February, June, and July exceeded normal monthly streamflow (Figure 2). Abundant February rain over the Susquehanna Basin temporarily reversed a cumulative deficit trend lasting from late 1980, despite low runoff in tributaries of the southern Bay (Figure 3). Areawide deficits of streamflow in March and April brought the cumulative deficit close to 4 trillion gallons. Runoff between May and November remained slightly below normal. December was more than 40,000 cubic feet per second lower than normal, ending the year with a deficit of nearly 5.5 trillion gallons.

3.3 Air Temperatures

January was very cold throughout the Bay area, averaging nearly 6°F below normal among the 11 stations. (Table 4 and Table 5). Icing in Chesapeake Bay reached 50 percent by 18 January when warming through February arrested the icing. February temperatures were well above normal among most of the 11 stations.

March temperatures were cooler than normal and April returned to warmer than normal temperatures.

May through September exhibited nearly normal temperatures. June temperatures in the lower Bay area were more than 3°F above normal balancing slightly cooler than normal May and August temperatures for that region.

October averaged more than 3°F below normal.

November and December showed nearly normal temperatures for the entire region.

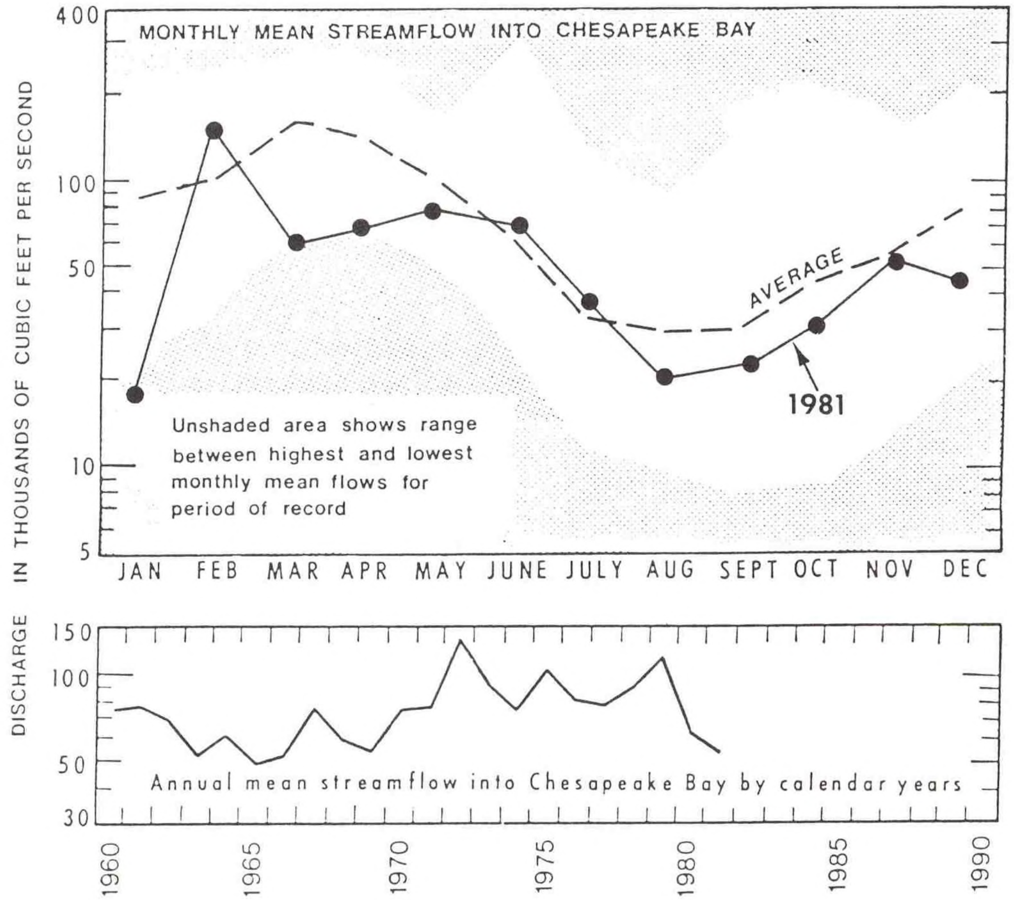

Figure 2. Monthly streamflow, Chesapeake Bay tributaries, 1981.

January and March 1981 streamflow values are lowest on record for those months. Combined with deficits from 1979 the low streamflow for 1981 contributed to higher than normal salinities in the Bay. Data from U.S. Geological Survey.

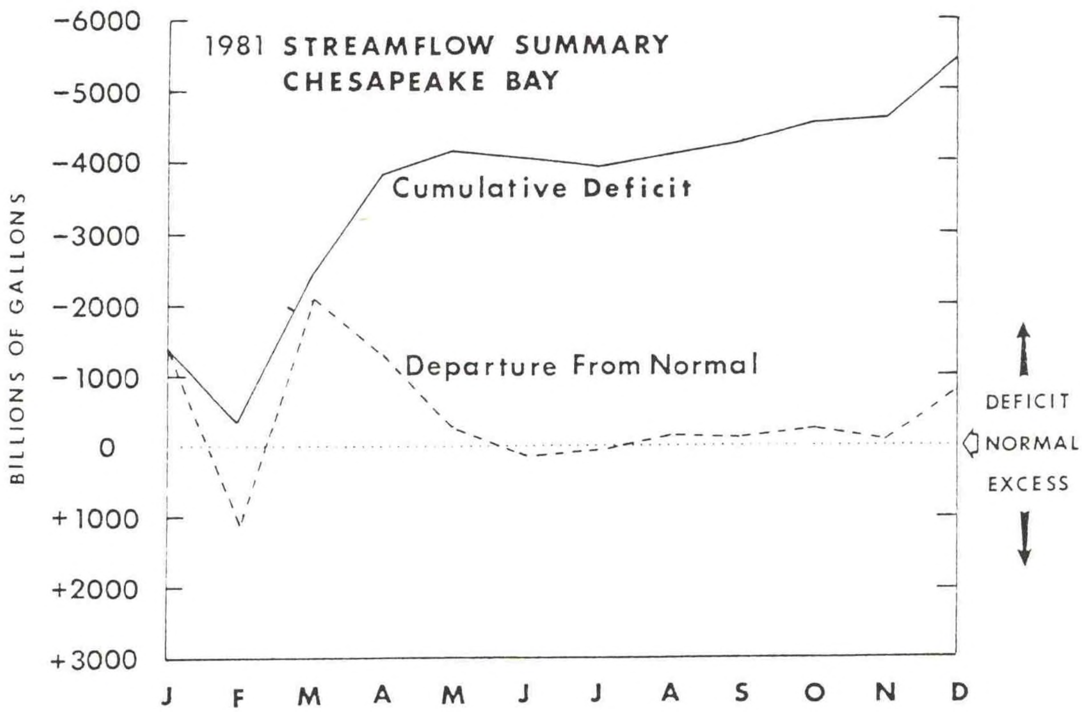

Figure 3. Cumulative streamflow, Chesapeake Bay tributaries, 1981.

January departure from normal streamflow reflects the extremely low precipitation throughout the Chesapeake Bay drainage area during the month and dryness in late 1980. Abundant February rain over the Susquehanna basin temporarily reversed the cumulative deficit trend though drainage areas in the southern portion of the Bay showed low runoff. The 1981 streamflow deficit contributed to increased Bay salinity, affecting the abundance and distribution of commercially valuable fish and shellfish.

Table 3. Monthly streamflow, Chesapeake Bay sections, 1980-1981.

		Flow of Section* (thousand cfs)				
YEAR	MONTH	A	B	C	D	E
1980	January	27.3	32.4	55.5	67.9	88.8
	February	13.0	17.0	27.9	33.5	42.9
	March	72.2	83.0	110.7	125.6	151.0
	April	107.7	121.0	158.4	175.6	205.2
	May	47.0	53.4	85.6	92.9	104.8
	June	17.2	21.6	32.8	35.7	40.8
	July	11.9	15.7	22.4	24.7	28.8
	August	8.5	11.9	17.4	18.6	21.0
	September	5.0	7.0	11.0	12.4	15.0
	October	5.3	8.0	11.2	12.1	14.0
	November	10.8	14.4	20.6	21.8	24.2
	December	17.1	21.5	27.2	28.5	31.1
	Mean	28.6	34.0	48.4	54.1	64.0
1981	January	7.4	10.7	13.9	15.2	17.8
	February	110.6	124.2	141.3	145.2	151.9
	March	36.0	41.5	52.0	54.3	58.6
	April	37.6	43.0	60.7	63.9	69.6
	May	47.8	54.4	68.1	72.1	78.9
	June	30.9	36.3	53.4	59.2	68.9
	July	17.1	21.5	28.6	31.3	36.1
	August	9.0	12.5	16.0	17.6	20.6
	September	9.6	13.2	17.7	19.6	23.2
	October	15.7	20.1	24.2	26.7	31.1
	November	34.4	39.9	45.0	46.7	50.0
	December	23.8	28.6	34.9	8.3	42.2
	Mean	31.7	37.2	46.3	49.2	54.2

*Key to Sections:

A = Mouth of Susquehanna River
B = Above mouth of Potomac River
C = Below mouth of Potomac River
D = Above mouth of James River
E = Mouth of Chesapeake Bay

Table 4. Monthly mean air temperature selected stations, Chesapeake Bay region, 1981.

Station	Air Temperature (°F)											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Williamsport, PA	20.3	33.2	36.5	51.8	62.5	70.8	74.4	72.4	64.5	51.3	42.2	30.2
Wilkes-Barre, PA	19.5	34.9	36.2	51.0	59.8	68.5	72.2	70.1	62.1	49.1	41.1	29.1
Harrisburg, PA	27.3	34.6	38.7	53.7	61.9	71.6	75.7	72.2	63.8	50.7	44.6	31.8
Aberdeen, MD	27.5	39.7	42.5	57.7	63.0	74.1	76.8	73.7	67.7	53.9	46.5	34.2
Baltimore, MD	27.9	38.8	41.9	57.0	62.2	74.3	77.3	74.4	67.7	53.2	46.2	34.5
Washington, DC	33.0	43.7	47.6	62.1	66.2	78.7	80.2	77.0	71.0	58.3	51.4	38.5
Chantilly, VA	27.8	38.5	41.4	57.0	60.9	73.5	75.1	71.9	66.7	52.5	45.9	34.1
Royal Oak, MD	29.4	40.7	43.6	58.8	63.0	75.8	77.4	75.3	68.8	56.7	47.7	37.0
Patuxent, MD	30.1	39.4	44.2	58.9	63.4	76.3	78.5	75.5	69.3	57.1	49.4	37.6
Richmond, VA	31.2	42.2	44.6	60.6	64.1	77.9	79.6	75.1	69.4	56.4	49.1	38.0
Norfolk, VA	32.7	43.1	45.4	61.2	65.1	78.3	79.8	75.1	70.7	51.6	50.7	41.0

Table 5. Monthly mean air temperature anomaly selected stations, Chesapeake Bay region, 1981.

Station	Air Temperature Departure from Normal (°F)											
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Williamsport, PA	-6.9	+4.6	-1.0	+2.0	+2.4	+2.0	+1.5	+1.5	+0.5	-2.0	+0.7	0.0
Wilkes Barre, PA	-6.5	+7.6	+0.2	+2.5	+0.9	+0.6	0.0	+0.1	-0.8	-3.5	+0.3	0.0
Harrisburg, PA	-6.4	+2.3	-2.3	+0.9	-1.2	-0.4	-0.4	-1.7	-3.2	-5.1	+0.8	-0.8
Aberdeen, MD	-5.8	+5.0	0.0	+4.2	-0.3	+1.6	+0.4	-1.1	-0.7	-4.1	+0.2	-0.8
Baltimore, MD	-5.5	+4.0	-0.9	+3.2	-1.5	+1.9	+0.7	-0.5	-0.8	-4.2	+0.1	-0.8
Washington, DC	-2.6	+6.4	+2.5	+5.7	0.0	+4.1	+1.5	-0.1	+0.4	-1.5	+3.4	+1.1
Chantilly, VA	-4.3	+4.7	-0.4	+3.9	-1.7	+2.4	-0.2	-1.7	-0.2	-3.4	+1.2	+0.1
Royal Oak, MD	-6.7	+3.1	-1.2	+3.7	-1.9	+2.0	-0.6	-0.4	-0.9	-3.1	-1.4	-2.1
Patuxent, MD	-5.9	+1.4	-1.8	+3.9	-1.6	+3.3	+0.5	-1.5	-1.7	-3.2	+0.4	-2.0
Richmond, VA	-6.3	-2.8	-2.3	+2.8	-2.4	+3.7	+1.7	-1.2	-0.6	-2.9	+0.1	-1.0
Norfolk, VA	-7.8	+1.7	-2.7	+3.4	-1.6	+3.8	+1.5	-1.8	-1.1	-2.1	-0.9	-1.3

3.4 Surface Water Salinity and Temperature

Bay salinity and temperature vary together under the influence of freshwater inflow, sea water, air temperatures, and solar radiation. Bay salinities range from near oceanic (30.0 ppt) at the mouth to brackish at the head of the Bay. During 1981 salinities were overall higher and temperatures overall cooler than normal.

Salinity

The National Ocean Survey (NOS) maintains daily surface water salinity and temperature measurements at selected stations (Figure 4) along the U.S. Coast. Table 6 gives mean monthly values of salinity and temperature at five NOS stations on Chesapeake Bay, computed in accordance with NOS instructions.

All Bay stations except Kiptopeake Beach remained at higher than normal salinity throughout the year (Table 7). Kiptopeake shows a salinity anomaly of -0.4 parts per thousand (ppt) for July when all stations except Baltimore approached nearest to their respective normals (Figure 5). Surface salinities are 2-7 ppt above normal in early 1981 due to a precipitation deficit from mid-1980 and very dry January conditions in the Bay region. Although streamflow increased in February following higher than normal rainfall, only Baltimore and Annapolis anomalies reflect the situation. March anomalies decreased at all stations except Chesapeake Bay Bridge Tunnel.

March dryness appears to have driven April salinity anomalies higher in the upper Bay. From May through July all station salinity anomalies again declined following normal and above normal rainfall over the area. August, September, October and November show alternating slight increases and decreases in salinity anomalies around the Bay. December anomalies rise sharply to end 1981 with values as high as when the year began.

In addition to remaining consistently above normal, the seasonal cycle of salinity shows differences from an average year at some of the stations (Figure 6). Baltimore salinity is near the average pattern decreasing to a minimum salinity in June then increasing to a maximum in October. Annapolis salinity follows a near average pattern very similar to that of Baltimore, but shows an unusual rise in December.

Solomons salinity displays unusual secondary peaks in February, April, and December. The February peak may reflect the lingering drought of 1980, but the April peak is relatively distinct and must be related to more local phenomena since similar patterns do not appear at the other stations.

The Chesapeake Bay Bridge Tunnel salinity showed the largest departure from normal of the seasonal cycle of salinity of all the stations considered. The Chesapeake Bay Bridge Tunnel salinity normally exhibits a minimum in March or April of around 19.8 ppt and a maximum plateau near 24.1 ppt through the months of July through October. However, during 1981 the salinity at this station showed maxima in March and May followed by a minimum in July and a plateau from September to November.

Kiptopeake Beach exhibits strong oceanic influence due to location relative to the mouth of Chesapeake Bay. The cycle of salinity at Kiptopeake normally

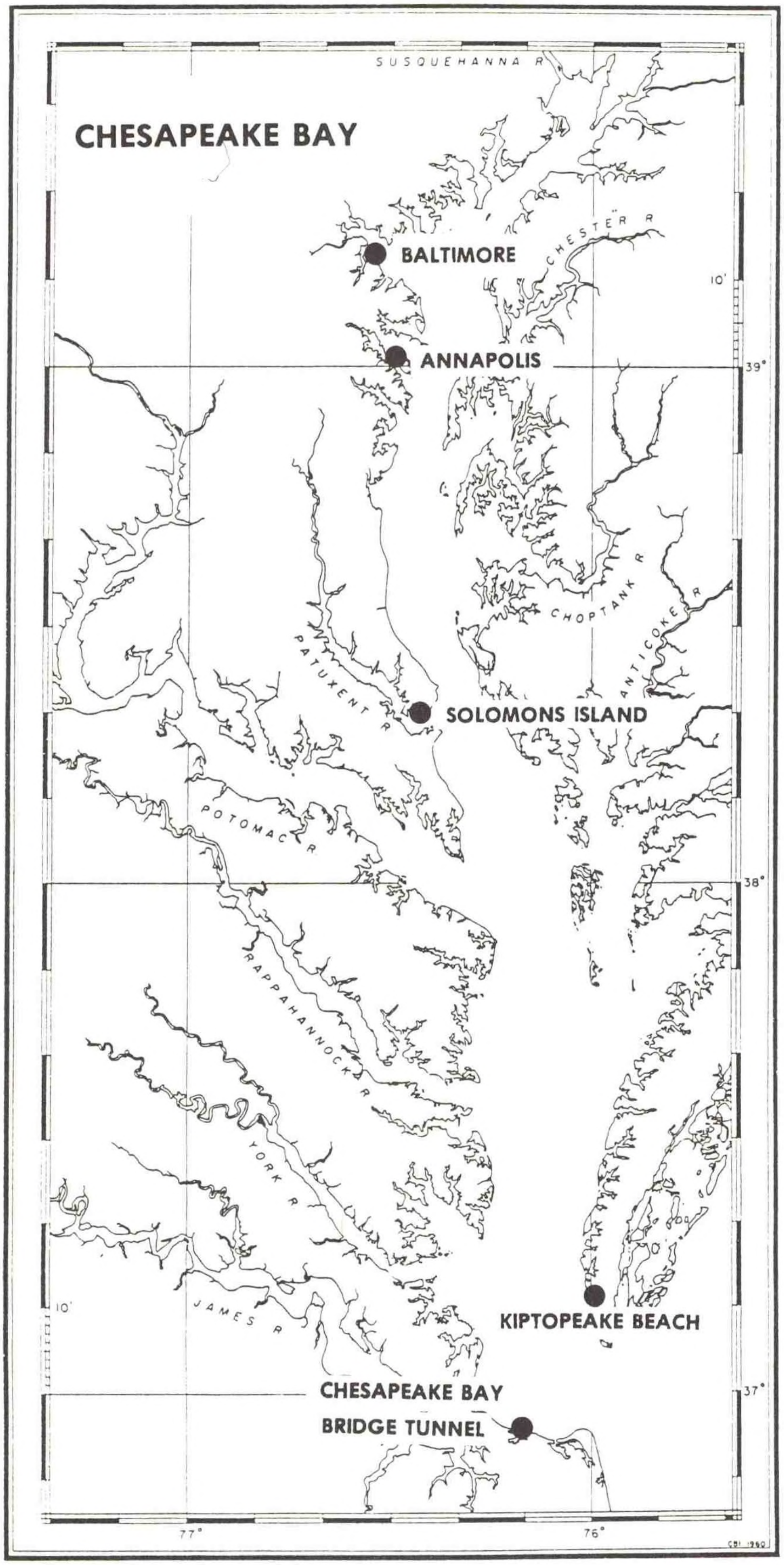

Figure 4. Locations of National Ocean Survey temperature and density stations, Chesapeake Bay.

Table 6. Monthly mean surface water temperature and salinity, selected stations, Chesapeake Bay, 1981.

A. Surface Salinity (ppt)

Station	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Baltimore, MD	9.9	9.8	8.4	6.2	5.8	6.0	6.9	8.0	9.7	10.8	11.1	10.6
Annapolis, MD	11.4	10.8	9.6	7.2	6.9	8.0	9.2	10.2	11.6	13.1	13.6	12.0
Solomon Is., MD	15.0	14.5	13.1	11.2	10.8	11.2	12.6	13.5	14.8	16.0	16.0	15.8
Kiptopeake Bch, VA	26.7	26.1	25.4	24.4	24.6	25.8	26.4	27.3	27.7	27.7	27.1	26.5
Chesapeake Bay Bridge Tunnel, VA	21.8	20.9	19.7	19.9	20.6	22.2	24.2	24.1	24.1	24.1	23.3	22.6

B. Surface Water Temperature (Deg. F)

Station	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Baltimore, MD	37.4	37.0	42.6	53.1	64.2	74.1	79.1	79.5	75.2	65.7	54.0	43.0
Annapolis, MD	36.9	36.7	42.6	53.2	64.8	74.5	80.2	79.7	74.8	64.9	52.9	41.7
Solomons Is., MD	37.8	37.4	42.6	52.5	64.6	74.5	80.1	80.1	65.7	65.7	54.7	43.3
Kiptopeake Bch, VA	38.7	38.8	42.6	53.1	63.1	72.1	77.2	77.2	73.8	64.6	53.8	44.1
Chesapeake Bay Bridge Tunnel, VA	39.6	41.2	46.9	55.2	65.7	74.1	79.0	79.9	75.4	65.8	55.2	45.1

Table 7. Monthly surface water temperature and salinity anomaly, selected stations, Chesapeake Bay, 1981.

A. Surface Salinity Anomaly (ppt)

Station	Month												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg
Baltimore, MD	+7.5	+5.2	+4.2	+4.7	+3.8	+2.8	+3.2	+4.8	+3.2	+4.6	+4.6	+7.7	+4.7
Annapolis, MD	+5.6	+4.2	+3.5	+5.9	+4.1	+2.8	+2.3	+3.5	+3.5	+3.5	+2.9	+5.4	+4.0
Solomon Is., MD	+4.8	+5.6	+3.1	+6.9	+5.9	+3.3	+2.3	+3.0	+2.8	+4.2	+3.3	+4.0	+4.1
Kiptopeake Bch, VA	+2.8	+4.0	+2.8	+3.3	+4.5	+1.1	-0.4	+ .6	+ .4	+ .9	+1.1	+2.1	+1.9
Chesapeake Bay Bridge Tunnel, VA	+4.9	+6.0	+9.3	+8.6	+8.3	+5.0	+ .9	+4.6	+4.2	+4.9	+5.6	+5.7	+5.7

B. Surface Temperature Anomaly (Deg. F)

Station	Month												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg
Baltimore, MD	-3.5	+2.3	-0.5	+3.4	-0.2	+0.5	-0.6	-0.6	-1.3	-3.7	-0.2	-1.4	-0.4
Annapolis, MD	-4.3	-0.5	-1.2	+0.8	-2.0	+0.4	+1.1	-2.0	-2.5	-4.4	-0.8	-1.2	-1.6
Solomons Is., MD	-5.4	-1.5	-0.4	0.0	-1.5	+1.6	+1.0	-0.3	-1.0	-2.9	-0.8	-0.6	-1.0
Kiptopeake Bch, VA	-3.4	+1.3	+1.4	+3.7	-0.1	+5.3	+4.2	+0.7	+0.8	-2.1	-0.5	+2.7	+1.2
Chesapeake Bay Bridge Tunnel, VA	-5.9	-2.6	-2.9	-0.2	-3.2	+0.3	-0.6	-3.4	-2.2	-3.1	-0.2	-1.5	-2.1

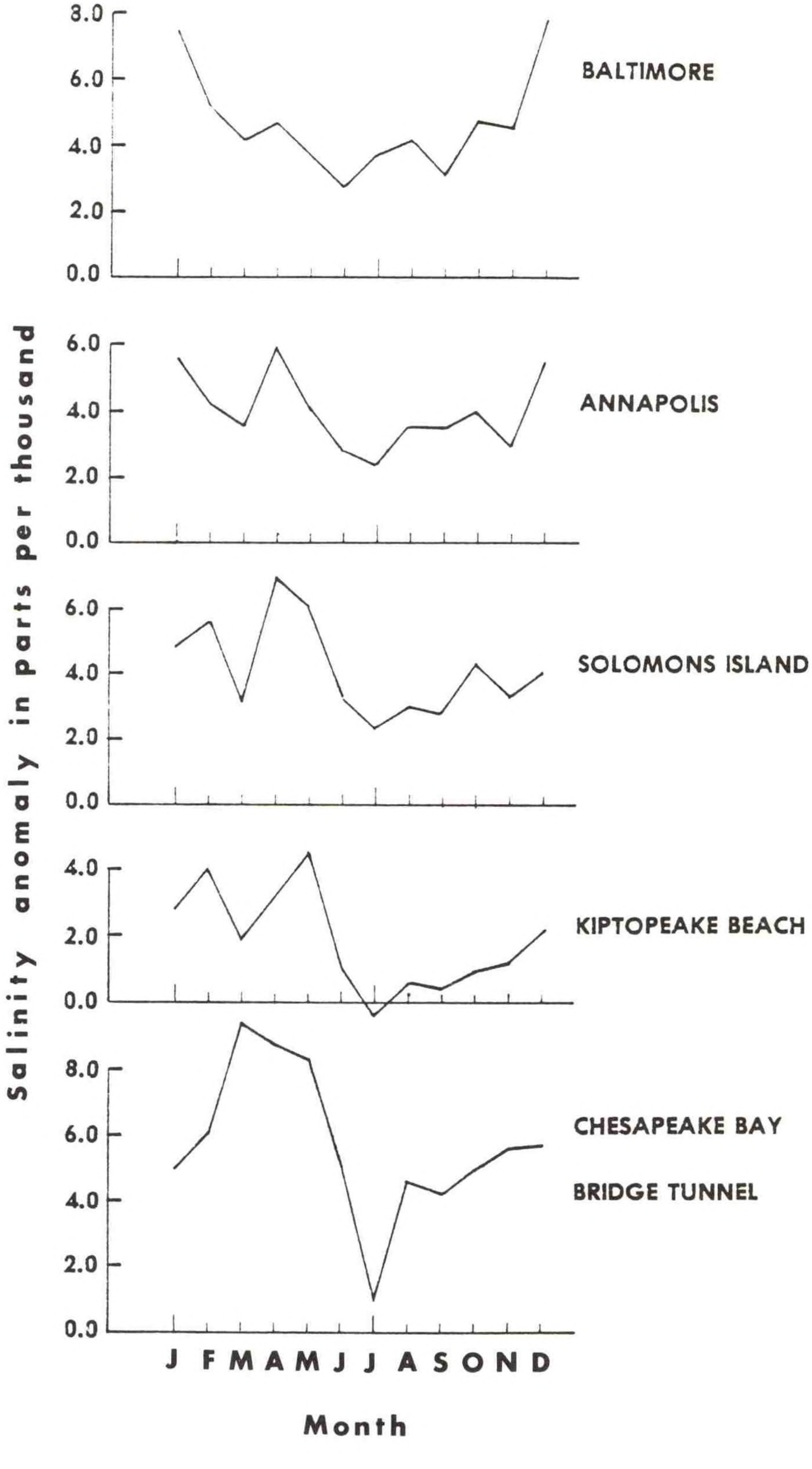

Figure 5. Monthly surface water salinity anomaly, selected stations Chesapeake Bay, 1981

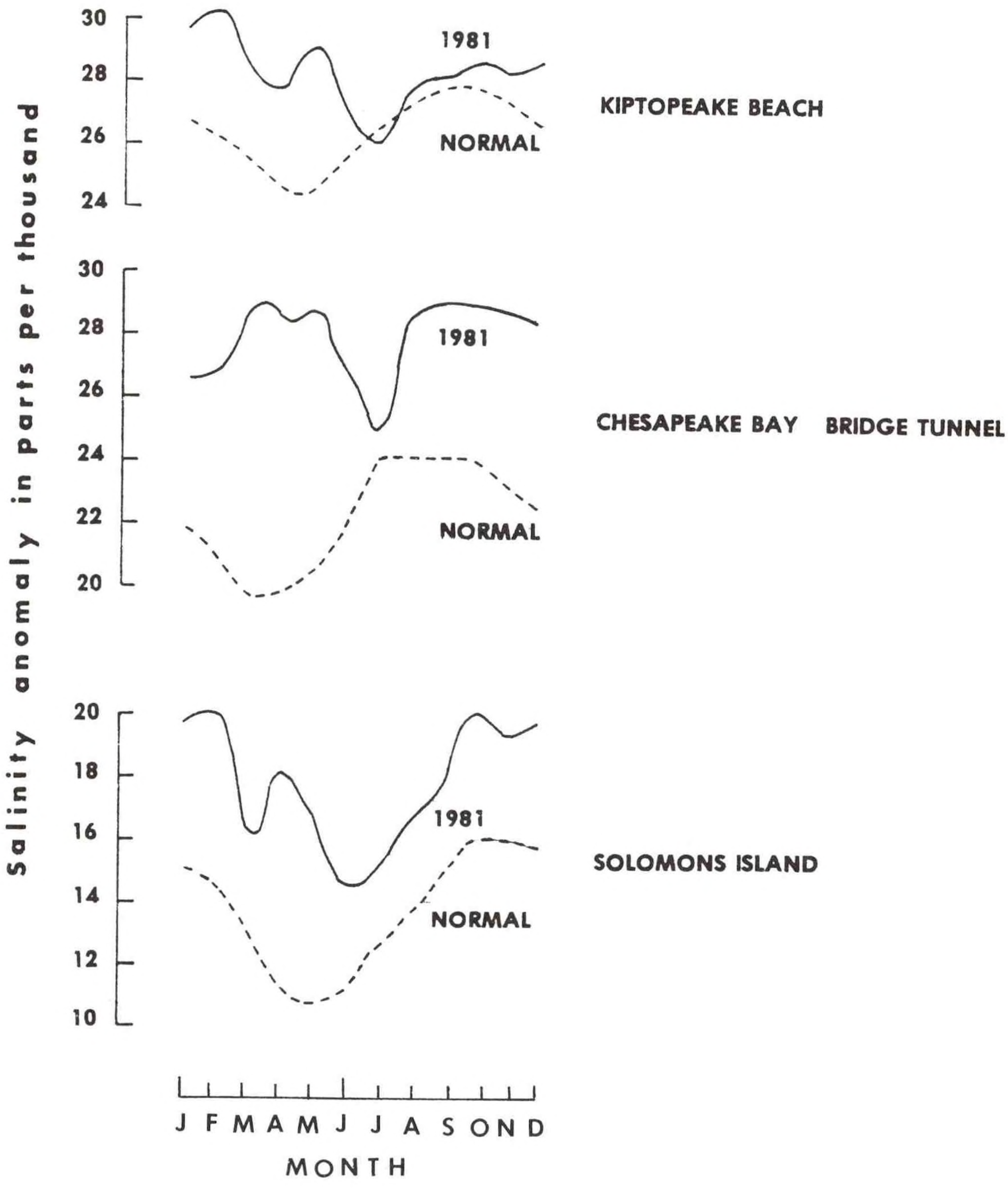

Figure 6. Seasonal cycle of salinity, selected stations, Chesapeake Bay, 1981.

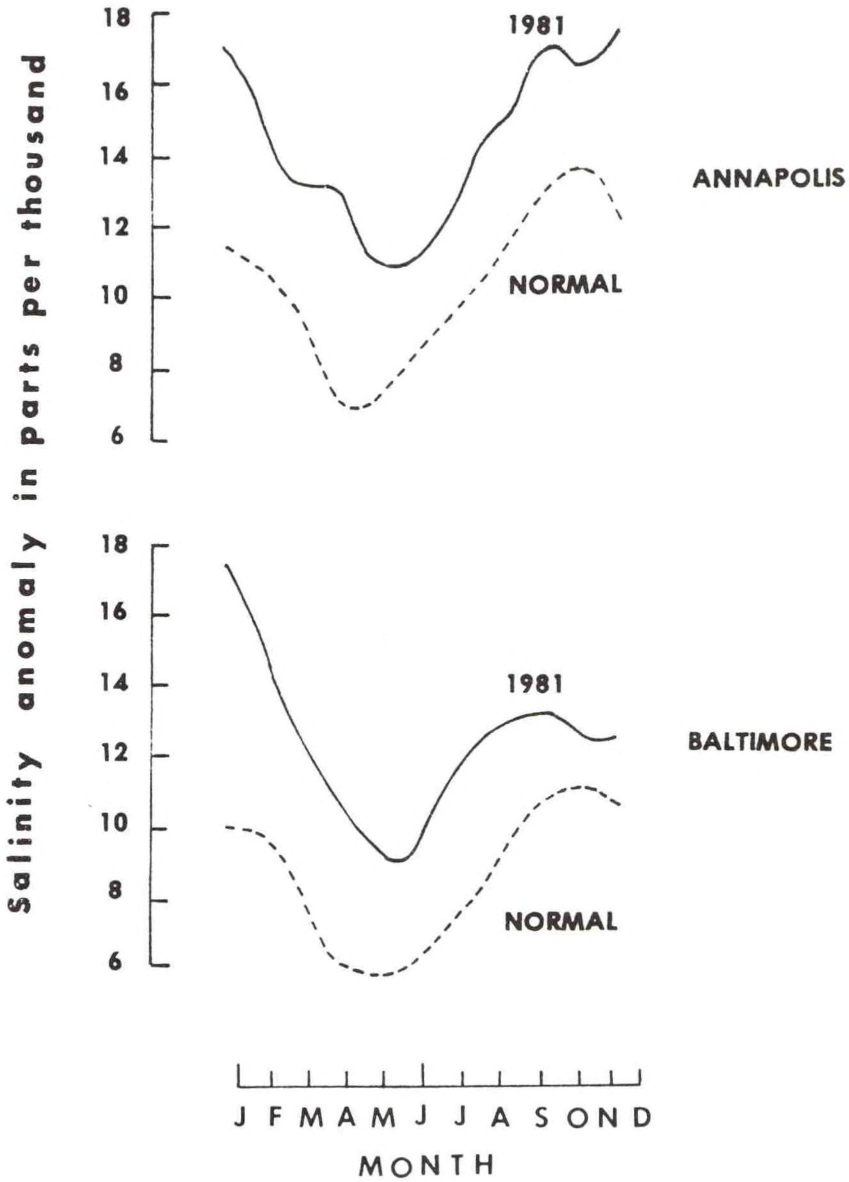

Figure 6. Seasonal cycle of salinity, selected stations, Chesapeake Bay, 1981 (Continued).

has a maximum of 27.8 ppt in September-October and a minimum near 24.5 ppt in April-May. The normal curve shows a very slight secondary maximum in January. During 1981 the salinity showed maxima in February (30.0 ppt), May (29.2 ppt), and October (28.6 ppt) with minima in April (27.8 ppt) and July (26.0 ppt). The double maxima in late winter and spring are probably related more to ocean water intrusion than to direct effect of precipitation.

Water Temperatures

Surface temperatures around the Bay remained overall cooler than normal during 1981 (Table 7) although the seasonal cycle followed a nearly average pattern at all stations. The temperature anomaly moved closer to normal over the year, so that the mean temperature anomaly for December 1981 was -0.4°C compared to -4.5°C for January 1981 (Figure 7).

The greatest impact of water temperature during 1981 was icing in January and February. NASA studies suggest 1981 icing in Chesapeake Bay is one of the more extensive since records began. Historical data show 15 percent of the Bay freezes in a normal year. The five-year period 1977-1981 experienced extreme ice conditions with 50 percent coverage in 1981 (Table 8).

Table 8. Maximum Ice Cover of Chesapeake Bay 1977-1981

	1977	1978	1979	1980	1981
Estimated maximum ice cover extent (%)	85	30	60	15	50
Estimated date of maximum ice cover extent	Feb 10	Feb 17	Feb 20	Mar 2	Jan 18

Data courtesy of NASA, estimated from Landsat imagery and Coast Guard reports.

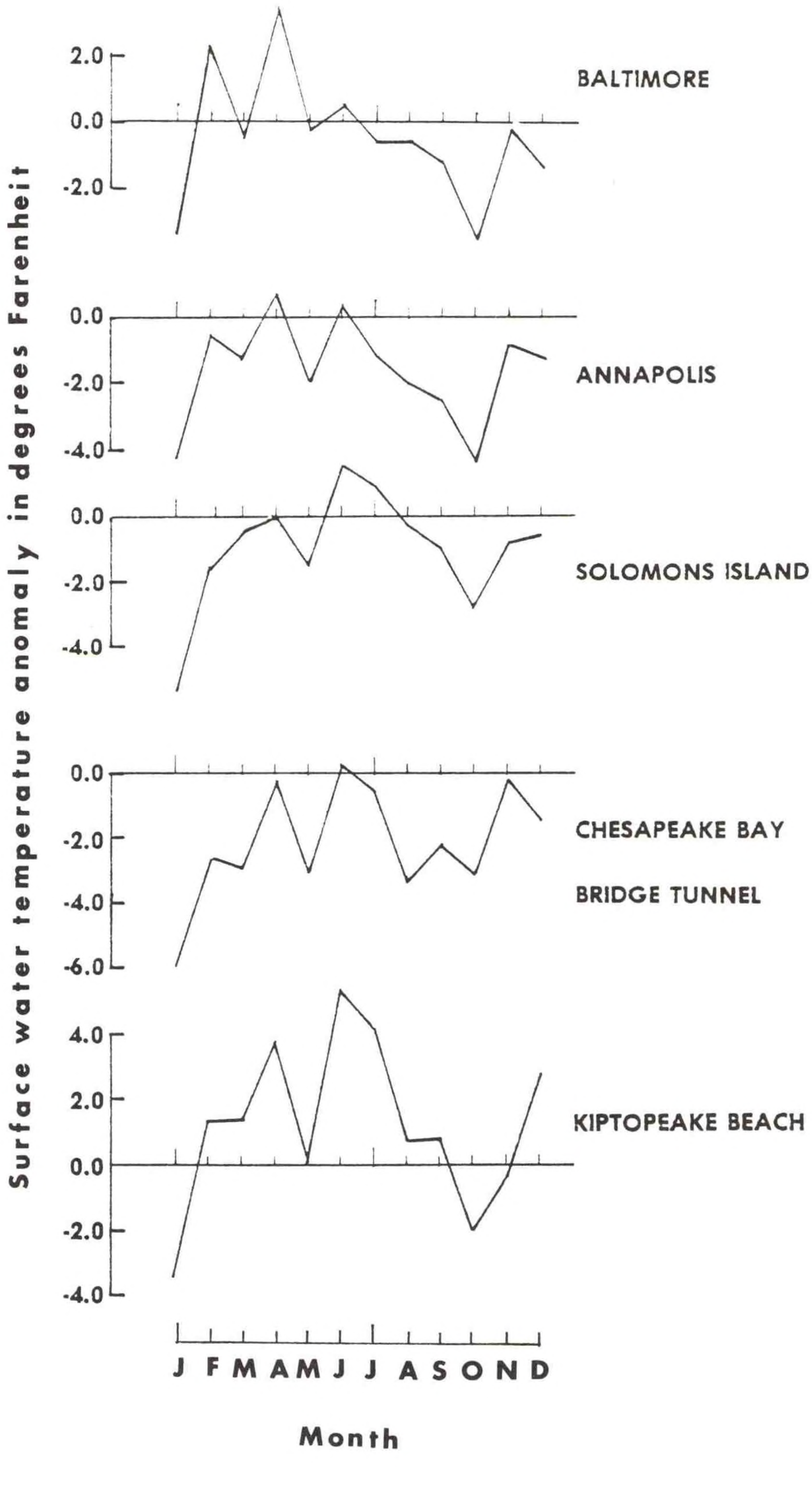

Figure 7. Monthly surface water temperature anomaly, selected stations, Chesapeake Bay, 1981.

4. Fisheries

Chesapeake Bay is the largest estuary on the East Coast of the United States and one of the largest in the world. The Bay provides extensive and valuable resources. Oyster and blue crab production rank among the highest in the United States and the Bay serves as the spawning and nursery area for the Atlantic coast striped bass and the nursery area for many other commercially important marine fishes such as menhaden and bluefish. Many marine fishes use the bay as a summer feeding ground, moving upstream as far as Baltimore to prey on the abundant estuarine forage species.

4.1 Summary of Commercial Fishing

Chesapeake Bay commercial fisheries composed ten percent of total landings in the United States in 1981, generating over 73 million dollars in the overall economy (Table 9), $46 million in Maryland and $27 million in Virginia.

Combined landings including ocean catches for Maryland and Virginia are over 600 million pounds for 1981, 114 million pounds lower than 1980. Catch value declined approximately four million dollars in the two States. While total U.S. poundage decreased over 500 million pounds, value increased slightly. The record high for Maryland landings is 141,607,000 pounds, set in 1890. The Virginia record is 666,180,000 pounds set in 1972.

Lack of rainfall in 1981 affected the abundance and distribution of some commercially valuable Bay species. The precipitation deficit which began in mid-1980 contributed to higher than normal salinities in 1981, extending the range of salinity sensitive finfish and shellfish species. The upstream salinity shift in normally low salinity areas of the Bay allowed some coastal ocean species to move into areas where they normally do not occur. Catches of coastal ocean finfish and squid occurred in upper portions of rivers and in the upper Bay during summer.

Table 9. Commercial landings, finfish and shellfish, 1980 and 1981.

	1980		1981	
	Thousand pounds	Thousand dollars	Thousand pounds	Thousand dollars
Bay Landing (1)				
Chesapeake Bay total	160,074	58,943	179,862	73,811
Maryland Bay only	57,724	34,846	91,780	46,159
Virginia Bay only	102,350	24,097	88,082	27,652
State Landings (2)				
Combined States	717,086	129,651	603,034	125,764
Maryland	79,571	44,658	115,115	56,640
Virginia	637,515	84,993	487,919	69,124
Total for U.S.	6,482,354	2,237,202	5,977,069	2,387,739

All data are preliminary from National Marine Fisheries Service. Landings are reported in live weight for all items except univalve and bivalve mollusks, such as clams, oysters, and scallops, which are reported in weight of meats (excluding the shell). Bay landings (1) include less than 1% ocean landings. Confidential data are not included for Virginia. State landings (2) include all State landings and confidential data.

Table 10. Commercial finfish landings by State and species, 1981, and total landings, 1975 - 1981.

Species	Maryland		Virginia	
	Thousand pounds	Thousand dollars	Thousand pounds	Thousand dollars
Alewives	82	8	520	42
Bluefish	371	45	2,058	293
Bonito	1	-	1	-
Butterfish	-	-	51	14
Croaker	-	-	407	118
Flounder, Black	-	-	6	3
Flounder, Fluke	7	5	434	130
Flounder, Atlantic	5	2	2	1
Ling Cod	-	-	14	3
Mackeral, King	-	-	2	1
Mackeral, Spanish	-	-	3	1
Menhaden	10,611	627	-	-
Mullet	-	-	7	1
Sea Trout, Gray	218	92	2,161	995
Sea Trout, Spot	-	-	4	2
Shark, Dogfish	1	-	31	6
Sharks, Unc.	-	-	2	-
Striped Bass	1,437	1,468	379	441
Whiting	-	-	17	5
Fish, other	2,103	854	5,440	1,201
All species, 1981	14,836	3,101	11,539	3,257
All species, 1980	14,131	3,224	21,437	5,072
All species, 1979	8,840	1,776	31,101	5,430
All species, 1978	10,917	2,086	37,989	5,067
All species, 1977	12,402	1,735	533,879	3,646
All species, 1976	9,057	1,504	423,719	14,829
All species, 1975	11,291	1,549	306,733	10,173

Data are preliminary from National Marine Fisheries Service. Landings are reported in live weight. Data includes less than 1% ocean landings. Potomac River landings are included in Maryland data. Confidential data are not included for Virginia.

4.2 Finfish

Seven species of finfish dominate Chesapeake landings for 1981: alewives, bluefish, croaker, flounder (fluke variety), menhaden, gray sea trout, and striped bass (Table 10). Menhaden compose 42 percent by weight of total commercial landings in the United States. Striped bass is the most valuable finfish species, contributing $1.9 million to the economies of Maryland and Virginia. Table 10 shows landings 1975-81 for Maryland and Virginia for Chesapeake Bay only. The Maryland Tidewater Administration reports the relative abundance index for striped bass spawning success (Table 11) for 1981 in Chesapeake Bay is the lowest in the 28-year history of the survey. The relative abundance index is based on sampling of inch-long fry in Bay tributaries.

Table 11. Relative abundance index for young-of-the-year striped bass Chesapeake Bay, 1954-1981

Year	Index	Year	Index	Year	Index	Year	Index
1954	5.2	1961	16.9	1968	7.2	1975	6.7
1955	5.5	1962	12.2	1969	10.2	1976	4.9
1956	15.2	1963	4.0	1970	30.4	1977	4.9
1957	3.2	1964	23.5	1971	11.8	1978	8.4
1958	19.2	1965	7.4	1972	8.5	1979	4.2
1959	1.6	1966	22.1	1973	9.0	1980	1.9
1960	7.1	1967	7.8	1974	10.1	1981	1.2

Data from Maryland Tidewater Administration

Virginia 1981 finfish landings in the Bay are down in poundage and dollar value compared to 1980 figures. Market conditions and drought contributed to the decline. Higher than normal salinities extended ranges for highly mobile finfish species such as bluefish beyond the ability of commercial fishermen to capitalize on the upstream shift of habitat. Other species which declined from 1980 in Virginia landings include alewives, shad, flounder, spot, croaker, menhaden, and striped bass.

Maryland 1981 finfish landings in the Bay remain close to 1980 figures. Alewives, bluefish, flounder, gray sea trout and striped bass all declined in poundage, although prices per pound increased. Preliminary NMFS statistics show menhaden landings for Maryland are higher in 1981 than in 1980, contributing to the stability of total Maryland Bay landings for both years.

Fish Kills in Virginia

Virginia State Water Control Board identified and investigated 52 fish kills in Virginia waters during 1981 (Table 12). Estimates of loss range from $16 for a small kill in Nero Creek in March to $13,889 at a spill of toxic wastes in the Piney and Tye Rivers in June. Cost estimates are not available for the large kill in August in Cockrell Creek. Causes of many kills are unknown. Oil spills, temperature, low oxygen, toxic wastes, effluents, pH, and net dumping are agents of the identified kills. The most common agent for Virginia fish kills this year appears to be dissolved oxygen depletion. The dollar cost of the fish kills is approximately $30,000 including $8,700 for investigations.

4.3 Shellfish

The upstream intrusion of higher than normal salinity in 1981 extended the habitat range available to various Bay species, especially the commercially important blue crab and oyster. Landings figures reflect the increased abundance of shellfish to watermen.

Shellfish landings in Maryland for 1981 are 77 million pounds and 43 million dollars (Table 13). All categories increased over 1980 except soft clams, which are down 358,000 pounds. All categories of Virginia shellfish show increases in 1981 over 1980. Maryland and Virginia 1981 shellfish landings in dollars and pounds are highest for the period 1975-1981. New reporting procedures for blue crab landings in Maryland account for a portion of the high Maryland 1981 figures.

Monitoring agencies in Maryland and Virginia reported unusually high seasonal counts of oyster spat. Studies by the Virginia Institute of Marine Science (VIMS) show sections of the James and Rappahannock rivers received exceptionally good spatset. Other Virginia rivers experienced above average spatfall. Recently unproductive natural beds in the upper Bay also received good spatset indicating good harvest in 2-3 years if survival is high.

Traditional oyster grounds may shift upstream following the intrusion of higher than normal salinity in tributaries and upper Bay. Former habitats reduced in area or eliminated due to the 1972 influx of fresh water from Hurricane Agnes may be reestablished due to high salinities in 1980 and 1981, possibly increasing the abundance and distribution of oysters for the next several years.

Blooms

During summer 1981, field observers reported scattered local kills of shellfish, possibly associated with algal blooms. Bloom events occurred in June and July in the upper Bay (Table 14). The green alga, *Chlorella*, was reported in Eastern Shore oysters during summer months. Poor condition of oysters delayed harvest activities in affected areas up to three weeks.

Table 12. Virginia fish kill events, 1981.

Month	Location	Probable Cause	Estimated Fish Loss (in dollars)
January	James River	Cold water temperature, icing	--
January	Bennett Creek	Icing, stress	--
January	West Neck Creek	Cold water temperature, icing	--
February	Lewis Creek	Unknown	--
March	Nero Creek	Nutrients, oxygen, stress	16
April	Indian Creek	Algal bloom, low DO	--
April	Moore's Creek	Sewage overflow	--
April	Moore's Creek	Sewage effluent, low DO	--
April	Tye River	Unknown	--
April	Opequon Creek	Toxic wastes	571
April	Ni River (Reservoir)	Unknown	--
May	Piankatank River	Net kill (menhaden)	--
May	Rappahannock River	Net dumping	--
May	Dutchman Creek (private pond)	Algae, low DO	--
May	Town Run/Abrams	Unknown	--
May	Mountain Run Lake	Unknown	--
May	Piney and Tye Rivers	Toxic wastes	13,889
June	Piney and Tye Rivers	Toxic wastes	311
June	Labrel Run	Unknown	--
June	Lynnhaven River	Classic menhaden kill	--
June	S. Branch,		--
	Elizabeth River	Unknown	--
June	Potomac River	Low DO	--
June	Tributary to Appomattox River	Unknown	--
June	Tributary to Massaponax River	Low DO	--
June	Swift Creek	Spawning stress	--
June	Slate River	Toxic wastes	--
July	Morey Creek (private pond)	Oil spill	--
July	Chickahominy River	Low DO, stress	--
July	Jones Creek	Unknown	--
July	Deep Creek	Temperature, DO, red tide	--
July	Lake off Lynnhaven River	Algal bloom, DO	--
July	E. Branch Elizabeth River	Unknown	--

Table 12. Virginia fish kill events, 1981 (continued).

Month	Location	Probable Cause	Estimated Fish Loss (in dollars)
July	Swift Creek	Unknown	--
July	Dogue Creek	DO depletion	--
August	Yeocomico River	Net dumping	--
August	Scopus marsh	DO	--
August	Cockrell Creek	Unknown	(large kill)
August	Yeocomico River	Unknown	--
August	Four Mile Run	Unknown	--
August	Chesapeake Bay	Unknown	--
September	Little Bay (unnamed tributary)	Unknown	--
September	Chisman Creek	Temperature, stress	--
September	Shenandoah River	Low pH from $H_2 SO_4$	3,963
September	Kanawka Canal	Canal lock problem	--
September	Stutt's Creek	Classic menhaden kill	--
September	Little Bay (unnamed tributary)	Unknown	--
September	Parrot Creek	Classic menhaden kill	--
October	Mulberry Creek	Unknown	--
November	Powhite Creek	Fish drained out pond	--
November	Jackson River	Toxic wastes	2,484
December	York River	Unknown	--
December	Peirce Creek	Unknown	--
		Estimated dollar-loss to State	$21,234

Data from Virginia State Water Control Board summarized from individual field reports. Data are preliminary and subject to revision. (DO = Dissolved Oxygen)

Table 13. Commercial shellfish landings by State and species, 1981, and total landings, 1975-1981.

Species	Maryland		Virginia	
	Thousand pounds	Thousand dollars	Thousand pounds	Thousand dollars
Crabs, Blue	56,293	$ 15,362	38,447	$ 7,549
Crab, Other	2,338	2,823	410	625
Clam, Hard	65	148	5,061	8,495
Clam, Soft	1,568	3,188	--	--
Oyster Meat	16,546	2,823	5,607	6,897
Shellfish, Other	134	28	252	121
All species, 1981	76,944	43,058	49,777	23,687
All species, 1980	43,593	31,622	45,640	17,765
All species, 1979	39,555	27,147	50,226	19,390
All species, 1978	33,855	24,352	46,524	19,887
All species, 1977	35,039	22,791	44,104	14,243
All species, 1976	36,612	23,554	33,031	12,229
All species, 1975	42,372	18,706	38,680	10,191

Data are preliminary from National Marine Fisheries Service.

Landings are reported in live weight except univalve and bivalve mollusks, such as clams and oysters, which are reported in weight of meats (excluding the shell). Data includes less than 1% ocean landings. Potomac River landings are included in Maryland data.

Table 14. Maryland Bloom Events, 1981

Month	Location of Event	Description of Event
May	Manokin River	Massive breeding swarms of clam worms (*Nereis succinea*) (an estuarine polychaete worm). Observed in bright red patches occupying about 100 sq. ft. of surface area. An estuarine event not often witnessed.
June	Western Bay shore Dundalk to Bodkin Creek	Dark brown water from plankton bloom.
July	Upper Bay, scattered	Plankton blooms.

Data extracted from monthly technical briefs issued by Maryland Office of Environmental Programs

Icing

Ice conditions on Chesapeake Bay during the winter of 1981 reduced oyster harvest activities and damaged fishing gear and wooden hulled boats. Observers at NASA estimate that on 18 January approximately 50 percent of the Bay showed ice cover. NASA studies suggest 1981 icing in Chesapeake Bay is one of the more extensive since records began. See discussion of icing in Section 3.4 and Table 8.

4.4 Diseases

During previous droughts higher than normal salinity favored the survival and estuarine distribution of predatory oyster drills, *Urosalpinx cinera* and *Eupleura caudata*, and disease organisms MSX, *Minchinia nelsoni*, and Dermo, *Perkinsus marinas*. Occurrence of diseases and predators in oysters in 1981 was local and sporadic and did not influence the harvest or spatset.

5. Recreation

Climate and water quality in the Bay determine much of the recreational use of the Bay area, including boating, fishing, swimming, and camping. Licenses indicate potential demand for boating. Bay Bridge traffic indicates indirectly the use of ocean beaches and Eastern Shore recreational facilities. State park attendance and revenue are direct indicators for recreation.

5.1 Boating Licenses and Revenues

Boating related revenues bring in excess of $600,000 to the State of Maryland each year, about 70 percent of these fees in the Bay counties of Anne Arundel, Baltimore, Calvert, Caroline, Cecil, Charles, Dorchester, Harford, Kent, Prince Georges, Queen Anne, St. Mary, Somerset, Wicomico, and Worchester, and the city of Baltimore. While the total fee revenue is small, the figures (Table 15) reflect an increase year-by-year of more than 100,000 persons joining the recreational load to the Bay system. Figures are not presently available to determine the specific impact of weather on the boating sector of the Bay economy.

Table 15. Maryland boating licenses and fees, 1977-1981

License Type	Total Number of Licenses and Fees (thousands)										Average Percent of Total From Bay Counties
	1981		1980		1979		1978		1977		
Boat Dealer	.6	$14.2	.6	$14.3	-----		-----		-----		---
Original Cost Boat Registration	124.1	$517.4	111.9	$510.0	113.0	$513.5	125.4	$510.7	112.9	$518.1	65%
Original Boat Title	25.5	$50.9	24.9	$49.6	26.9	$53.5	28.1	$55.7	30.5	$60.8	74%
Security Interest Filing Fee	3.4	$51.0	4.0	$56.0	5.2	$77.7	5.4	$81.7	5.7	$85.1	72%
Total All Boat Related Fees		$640.3		$636.3		$650.9		$709.3		$670.1	---

Data from Maryland Department of Natural Resources. Data for 1981 are fiscal year; data for 1977-1980 are calendar year.

5.2 Bridge Traffic Statistics

Autombile and light commercial traffic on the Bay Bridge has increased every year since 1952 (Figure 8) except 1957 and 1963. Heavy commercial travel has increased at a slower rate. The two types of traffic have remained in approximately equal proportions of the total volume over Bay Bridge since 1952.

Automobile and light commercial traffic over the Chesapeake Bay Bridge was greater for all quarters of 1981 than for 1980 (Table 16). Traffic was maximum in the third quarter and least in the first quarter. Heavy commercial traffic was maximum in the third quarter and minimum in the first quarter. Toll revenue overall declined from 1980 to 1981.

Bay Bridge tolls provide $14.7 million revenue to the State of Maryland each year. Sixty per cent of the traffic occurs during the months of April through September. Warm summer weather strongly influences toll revenue of Chesapeake Bay Bridge.

Table 16. Traffic volume and toll revenue 1980 and 1981

	1981 Auto & Light Commercial	1981 Heavy Commercial	1981 Toll Revenue	1980 Auto & Light Commercial	1980 Heavy Commercial	1980 Toll Revenue
First Quarter	1,631,717	246,530	$ 2,614,966	1,496,226	255,722	$ 2,501,481
Second Quarter	2,660,080	279,248	$ 4,053,749	2,579,849	275,745	$ 3,982,544
Third Quarter	3,412,484	283,286	$ 4,979,326	3,273,084	276,145	$ 4,803,294
Fourth Quarter	2,075,509	251,622	$ 3,140,649	2,015,266	267,469	$ 3,152,756
Total	9,779,790	1,060,686	$14,788,690	9,364,425	1,075,081	$14,440,075

Data from Maryland Transportation Authority Quarterly Financial Reports March 31, 1981, June 30, 1981, September 30, 1981, and December 31, 1981.

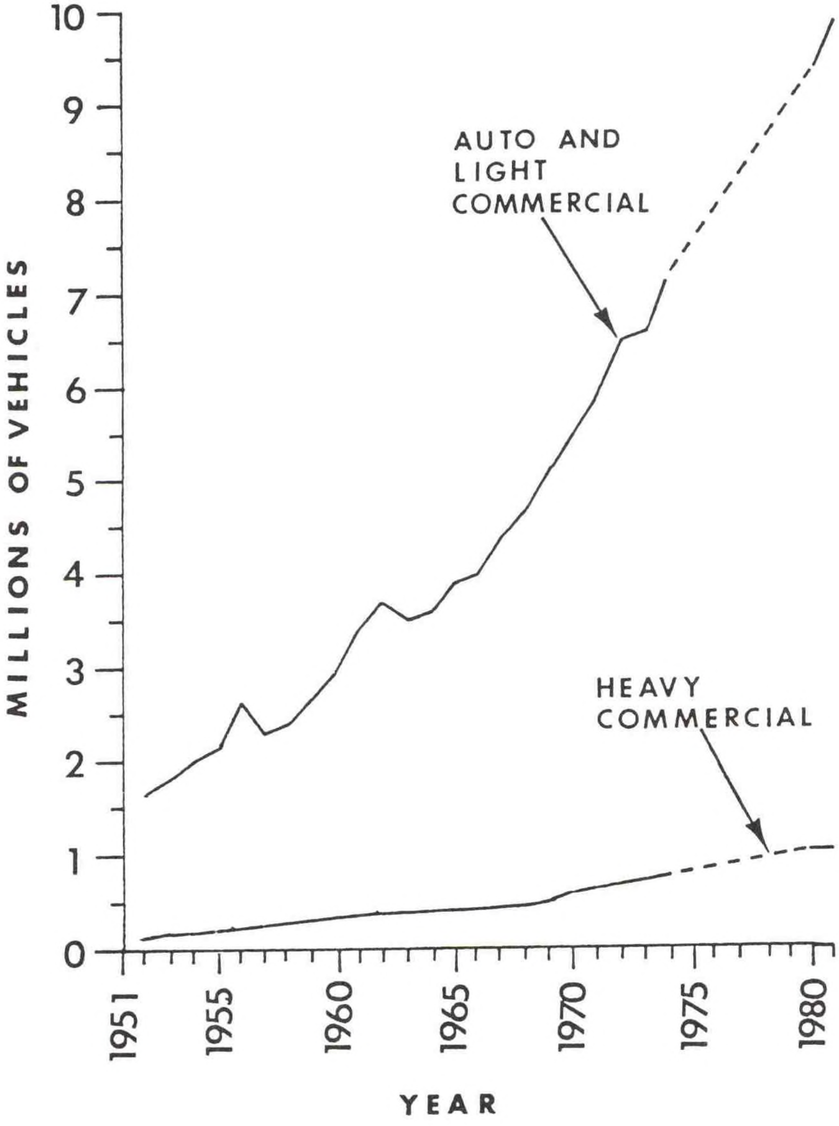

Figure 8. Chesapeake Bay Bridge vehicle traffic, 1951-1981. (Dashed line indicates data not available for years 1975-1979.)

5.3 State Park Activity Levels

The 37 Maryland State parks provide recreation facilities to more than 5 million persons each year. These parks provide useful information about weather effects on recreational activity. Day usage peaks during June and July while camper use peaks July and August (Table 17). Since a majority of the revenue derives from day use, and weather may determine day usage of the parks, the weather directly affects revenue from the parks. With summer 1981 being close to normal for the region the park revenue likely is near average. Using fiscal year attendance data, the second half of calendar 1981 showed lower attendance than the same period of 1980. Parks around the Bay proper account for 36 per cent of all Maryland State parks attendance.

Table 17. Attendence and Revenue, Selected Maryland State Parks, 1981

	Sandy Point State Park			Point Lookout State Park		
Month	Day Use	Camper Use	Total Revenue	Day Use	Camper Use	Total Revenue
January	5455	-----	$ 409	2563	0	$ 800
February	6051	-----	330	3509	11	918
March	10441	-----	776	6915	60	1063
April	24113	-----	2586	9069	522	2205
May	73444	-----	31579	29297	5157	3590
June	78947	-----	67953	31337	8975	28238
July	76959	-----	54768	28315	13277	20653
August	62828	-----	45933	24266	10779	16970
September	99800	-----	13473	21505	5436	13393
October	11500	-----	624	11728	1988	6353
November	7670	-----	577	3920	157	551
December	2736	-----	366	2367	6	876
Totals	459944	-----	$219374	174771	46368	$95610

Data from Maryland Department of Natural Resources, Parks and Recreation.

5.4 Marine Accident Statistics

Accidents in the marine environment relate both to number of boats on the water and the weather. During 1981, 27 persons died and 74 were injured in 224 boating accidents in Maryland Bay waters (Table 18). Figures are not available for Virginia portions of the Bay. The Coast Guard additionally recorded 2800 search and rescue operations (SARs) for 1981. (Table 19).

Coast Guard search and rescue operations peak in July when recreational boating is maximum. Eighty-eight percent of SARs in the upper Bay are between May and September. SAR data includes any type of call to the Coast Guard including disabled boats and overdue vessels regardless of whether any damage or casualty results.

Maryland Department of Natural Resources (DNR) keeps figures for boating accidents where property damage or injury does occur. Table 18 shows DNR Marine Police data 1970-1981. Proportional to the number of boating accidents the property damage for 1981 is near average. Injuries and deaths associated with recreational boating depend strongly on individual safety practices for which no data exist.

Table 18. Maryland accident statistics recreational boating, 1970 - 1981.

Year	No. of boating accidents	No. of injuries	No. of deaths	Property damage (thousands)
1970	188	26	54	$ 258
1971	198	26	58	763
1972	189	40	40	295
1973	210	62	42	503
1974	211	69	47	440
1975	177	55	17	631
1976	223	27	31	528
1977	218	30	19	626
1978	195	44	33	398
1979	224	84	38	781
1980	234	79	27	830
1981	224	74	27	427
Totals	2491	616	433	$ 6,480

All data from Maryland Department of Natural Resources Marine Police and apply to recreational boating. Includes Potomac River to Virginia shoreline.

TABLE 19. Search and rescue operations U.S. Coast Guard, 1981.

Month	Group Baltimore	Group Eastern Shore	Group Hampton Roads
January	11	3	34
February	15	4	26
March	30	0	43
April	95	5	115
May	135	11	255
June	178	18	280
July	206	28	312
August	163	19	231
September	124	6	165
October	79	7	129
November	42	3	68
December	28	3	36
Totals	1106	107	1694

Group Baltimore handles all the Bay North of Smith Point including Potomac River. Group Hampton Roads handles all of the Bay South of Smith Point. Group Eastern Shore covers the eastern portion of the Bay but rescue vessels use some of the same port facilities as the other two Groups.

6. Transportation

The Chesapeake Bay serves as an important resource for transportation both foreign and coastwise in the eastern United States. Heavy usage of an estuary such as the Chesapeake by shipping to Norfolk, Hampton Roads and Baltimore places unusual stress on the Bay. Pollution incidents are more probable with frequent shipping. Dredging of key channels for development and maintenance is a requisite operational expense. Icing in the upper Bay requires clearing during extremely cold winters. Except for the icing situations and extreme events such as hurricanes, shipping and Bay transportation continue uninterrupted by weather patterns.

6.1 Shipping and Shore Related Activity

The ports of Hampton Roads and Baltimore account for 80 per cent of export tonnage and 24 per cent import tonnage for all Atlantic ports. Each port handles more than 10 ships per day on the average. Principal cargos include coal (export), iron ore (import), petroleum (import), and grain (export). Trade through the port of Baltimore reportedly generated more than $1 billion in revenue, $52 million in State local taxes and employment for 79,000 workers in port related jobs during 1980 according to a Booz-Allen & Hamilton, Inc., study. Hampton Roads provides similar stimulus to the economy of Virginia.

Shipments for 1981 contributed $155.9 million in customs receipts in Virginia and $247.0 million in Baltimore from a total volume of 105.0 million tons of material worth $17.65 billion for the two ports.

Vessel arrivals for 1981 totaled 3,776 for Baltimore and 3,703 for Hampton Roads, a decrease from 1980 of 5.3 and 8.6 per cent, respectively. Table 20 shows total export and import tonnages for the two ports for recent years.

Table 20. Export and import tonnages
Baltimore and Hampton Roads, 1976-1981

	1981	1980	1979	1978	1977	1976
Export (Millions of Tons)						
Hampton Roads	55.4	58.2	42.0	22.5	31.8	40.0
Baltimore	21.5	21.6	18.1	14.2	14.0	14.9
Import (Millions of Tons)						
Hampton Roads	7.2	9.4	10.4	11.3	12.3	11.9
Baltimore	12.9	15.3	20.3	14.5	15.9	9.7

6.2 Dredging

U.S. Army Corps of Engineers dredging operations in Chesapeake Bay navigable waters normally follow 5, 6, and 7 year cycles due to scheduling. Dredging in Ocean City, MD is every eight months and is included here because of its economic importance and proximity.

A dredging operation summary for 1980-present appears in Table 21. During 1980 completed projects removed 1.6 million cubic yards of sediment at a cost of $5.2 million. Projects completed in 1981 removed 2.7 million cubic yards at a price of $9.6 million. Projects underway or completed in the Baltimore Harbor area account for the largest portion of material removed and dollar cost, 3.4 million cubic yards and 11.5 million dollars, respectively. Dredging in 1980 and 1981 focused on tributaries and harbors in the Bay region with no operations in the Bay proper.

Although rainfall and sediment distribution are related, scheduling normally eliminates any direct correlation between weather patterns and volumes or dollar values for dredging operations.

Table 21. Summary of dredging operations Chesapeake Bay region, U.S. Army Corps of Engineers 1980 - present.

Project Location	Completion date or Scheduled dates of Operation	Estimated quantity of material removed (cubic yards)	Estimated cost (in dollars)
Ocean City Inlet	March 1980	40,000	$320,000
Knapps Narrows and Tilghman Island	April 1980	88,000	$640,000
Baltimore Harbor (Swann Point and Tolchester Channels)	April 1980	872,000	$2,400,000
Baltimore Harbor and Craig Hill	1981 (month undetermined)	535,000	$1,000,000
Washington Harbor	April 1980	4,000	$17,000
St. Catherine Sound (Island Creek)	December 1979	44,000	$335,000
Anacostia River	February 1980	61,000	$450,000
Ocean City	March 1981	70,000	$350,000
Chester River	May 1981	43,000	$250,000
Baltimore Harbor	December-April 1981	545,000	$2,800,000
Wicomico River	July-October 1981	160,000	N/A
Baltimore Harbor	October 1981-June 1982	1,500,000	$5,300,000
Black Walnut Harbor	May 1982	35,000	$270,000
Dutch Point Cove	May 1982	40,000	$250,000
Herring Bay and Rock Hold Creek	December 1981	38,000	$240,000
Honga River and Tar Bay	October-December 1981	250,000	$480,000

Table 21. Summary of dredging operations Chesapeake Bay region, U.S. Army Corps of Engineers 1980 - present (continued).

Project Location	Completion date or Scheduled dates of Operation	Estimated quantity of material removed (cubic yards)	Estimated cost (in dollars)
Knapps Narrows	November 1981-January 1982	50,000	$250,000
Neale Sound	October-December 1981	38,000	$143,000
Ocean City	March 1982	40,000	N/A
Slaughter Creek	November-December 1981	48,000	$181,000
St. Jerome Creek	May-June 1982	55,000	N/A
Twitch Cove and Big Thoroughfare	January-March 1982	130,000	N/A

Summary of Operations by Fiscal Year
(October 1 - October 1)

Year	No. of Projects	Materials removed	Dollar cost
1980	7	1,644,000	$5,200,000
1981	7	2,700,000	$9,600,000

7. Pollution Events Summary

The Chesapeake Bay system is heavily used for conflicting purposes. Oil and hazardous materials enter the Bay waterways only accidentally, but are related to the use of the Bay for transportation and industrial cooling. Manufacturers must dump some waste products into the Bay, and municipal sewage treatment and power generation all require water from the Bay. Only accidental spills and sewage outfall volume appear in this report.

7.1 Accidental Spills of Oil and Hazardous Substances

The U.S. Coast Guard, Department of Transportation, maintains records of spills of all hazardous substances which ultimately may enter navigable waters. Tables 22-25 give information on spills in the Chesapeake Bay Region for 1981 from the Pollution Incident Reporting System (PIRS) database managed by the Coast Guard. During 1981 a total of 364 spills put 184,000 gallons of various pollutants into the Bay and its tributary waters. The spills represent 3.6% of the spill incidents nationwide but only 0.9% of the total volume.

Eighty-one percent of the spills are oil spills, the largest being 35,000 gallons of diesel fuel on 28 November into Baltimore Harbor. Chlordane, coal dust, chlorosulphonic acid, and asphalt spilled into the Bay system during 1981. Table 25 and Figure 9 show those spills which occurred in the Bay proper.

Table 22. Spills of oil and hazardous substances by month, Chesapeake Bay region, 1981.

Month	No. of Spills	Quantity (gallons)
January	33	25,958
February	39	11,377
March	25	4,453
April	26	20,248
May	17	10,164
June	20	3,486
July	26	8,313
August	34	9,009
September	36	3,521
October	35	42,721
November	35	42,725
December	38	4,790
Total Chesapeake Bay region spills	364	186,765
Total Spills, all U.S. waters	10,072	19,637,913
Chesapeake Bay region spills as percentage of all U.S. spills	3.61%	0.95%

Data from U.S. Coast Guard Pollution Incident Reporting System (PIRS) database. Data are preliminary and subject to revision. All spills listed here are within latitudes 39°36'N and 36°46'N, longitudes 077°22'W and 075°38'E.

Table 23. Spills (>5000 gallons) of hazardous substances and oil, Chesapeake Bay region, 1981.

Material	(Gallons)	Date	Location	Source
Oils				
Diesel	35,000	November 28	Baltimore Harbor	Rail Vehicle General Cargo
Diesel	17,750	January 26	Patapsco River	Rail Vehicle dry bulk
Other Oil	8,300	April 5	Lower Potomac	Offshore Bulk Cargo Transfer
Diesel	7,000	July 25	Unavailable	Unavailable
Residual Fuel Oil	6,500	May 13	North of Baltimore	Rail Vehicle General Cargo
Diesel	5,500	November 30	Patapsco River	Rail Vehicle General Cargo
Diesel	5,500	August 11	Lower Potomac	Offshore Bulk Cargo Transfer
Other Hazardous Substances				
Chlorosulphonic	38,000	October 16	York River	Deep Water Port Transfer
Chlordane	15	June 11	Unavailable	Unavailable

Data from U.S. Coast Guard Pollution Incident Reporting System (PIRS) database.

Table 24. Number of spills by material type, Chesapeake Bay region, 1981.

Material	No. of Spills
Diesel Oil	136
Other Oil	75
Residual Fuel Oil	49
Other Distillate Fuel Oil	12
Unknown	25
Waste Oil	31
Gasoline	17
Other Pollutant	4
Other Material	2
Crude Oil	5
Natural Substance	3
Asphalt or Other Residual	1
Hazardous Substance	2
Other	2

Data preliminary from U.S. Coast Guard Pollution Incident Reporting System (PIRS)

Table 25. Accidental spills of oil and hazardous substances, Chesapeake Bay, 1981.

Type of spill Material	Date	Quantity	Source	Cause
1. No. 6 Fuel Oil	January 5	2000 Gallons	Unknown	Unknown
2. Waste Oil	January 19	2000 Gallons	Dry cargo ship	Improper equipment
3. Unknown	January 27	Sheen	Unknown	Unknown
4. Light Diesel Oil	January 29	5 Gallons	Unknown	Unknown
5. Light Diesel Oil	February 24	Unknown	Unknown	Unknown
6. Light Diesel Oil	April 19	50 Gallons	Other vessels	Structural failure, rupture or leak
7. Mixture of two or more Petroleum Products	April 20	2050 Gallons	Tug or Tow Boat	Flanges improperly secured
8. Unknown	June 6	20 Gallons	Unknown	Unknown
9. Unknown	June 15	2 Gallons	Unknown	Unknown
10. Unknown	June 20	Sheen	Unknown	Unknown
11. Heavy Crude Oil	July 10	500 Gallons	Other vessels	Structural failure, rupture or leak
12. Heavy Diesel oil	August 11	Unknown	Unknown	Unknown
13. Heavy Diesel Oil	August 19	100 Gallons	Other vessels	Unknown
14. Waste Oil	September 10	350 Gallons	Unknown	Unknown
15. No. 6 Fuel Oil	October 9	50 Gallons	Unknown	Unknown
16. Light Diesel Oil	October 16	1 Gallon	Onshore bulk cargo transfer	Rupture or leak
17. Coal dust	October 20	Sheen	Unknown	Unknown

Data preliminary from U.S. Coast Guard Pollution Incident Reporting System (PIRS)

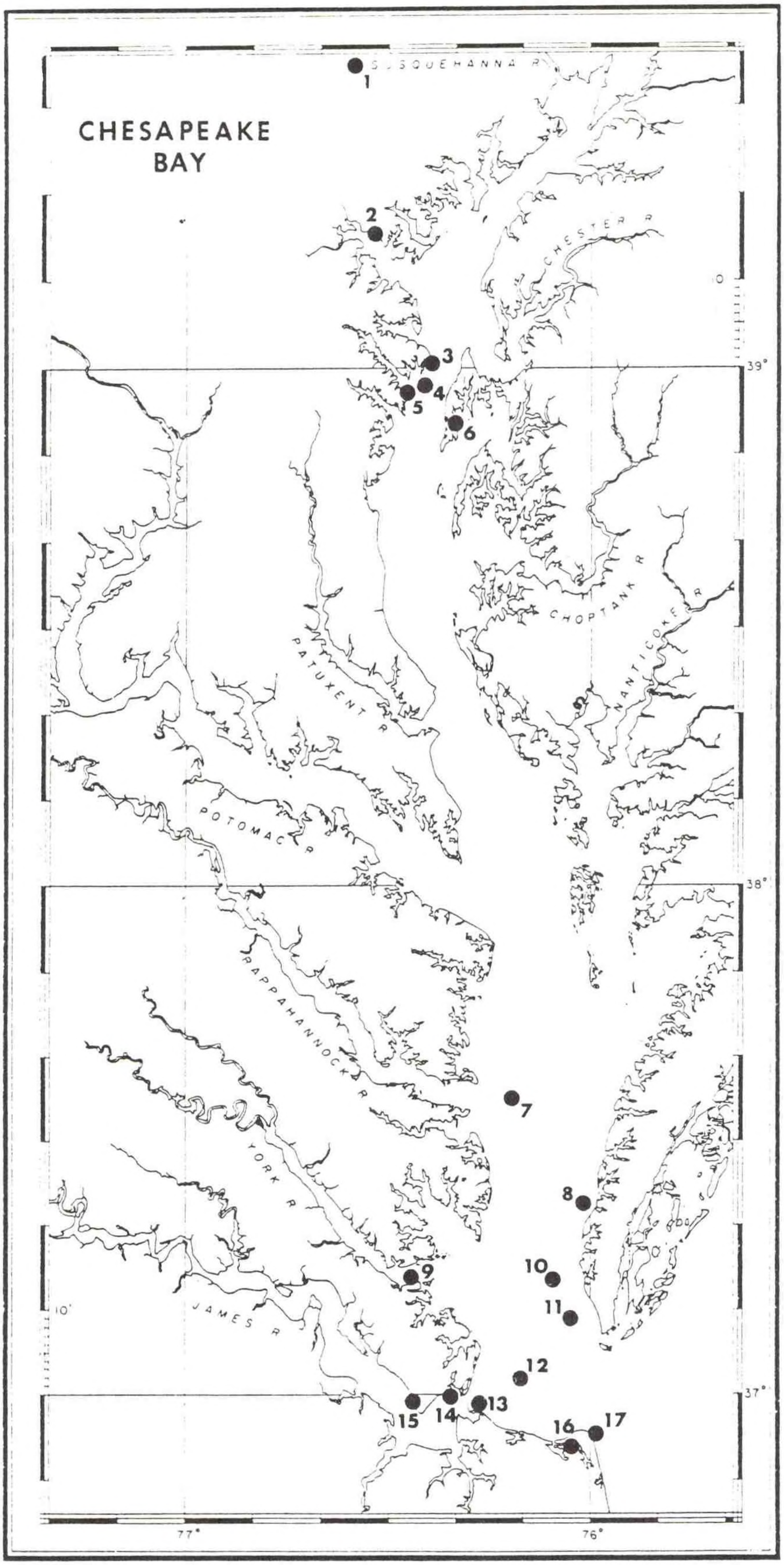

Figure 9. Locations of spills of oil and hazardous substances, Chesapeake Bay region, 1981. (Modified Chesapeake Bay Institute map)

7.2 Sewage Disposal Discharge

Environmental Protection Agency (EPA) studies estimate the Chesapeake Bay drainage basin at 64,000 square miles in six states; Pennsylvania, New York, Maryland, Virginia, Delaware, and West Virginia. Five hundred eighty-four sewage treatment plants discharge greater than 0.5 million gallons per day (MGD) into the Bay system. Although many smaller plants are operational throughout the Bay region (approximately 400 in Maryland alone), plants with discharge rates in excess of .5 MGD represent approximately 96 per cent of all plants.

Total average daily flows in MGD are listed in Table 26 for selected treatment plants in the Bay region for the years 1980 and 1981. Twenty-two plants with discharge rates in excess of 10 MGD are ranked according to discharge rate.

Thirteen plants showed decreases in flow from 1980 to 1981. The flow decreases ranged to 45 per cent below the 1980 values with an average decrease of 13.2 per cent.

Six plants showed increases in flow from 1980 to 1981. Flow increases ranged to 7 per cent with an average increase of 3.1 per cent.

Table 26. Average daily discharge of selected sewage treatment facilities, Chesapeake Bay region, 1980-1981.

Sewage Treatment Plant	Rank	Drainage Basin	Flow (MGD) 1980	1981	% Change of 1980 Flow
Blue Plains	1	Potomac	317.00	324.00	+2.0
Back River	2	Upper Chesapeake Bay Delmarva	80.60	64.00	-20.6
Richmond	3	James	61.03	63.00	+3.2
Wyoming Valley Sanitary Authority	4	Susquehanna	40.00	31.5	-21.2
Hopewell	5	James	33.63	31.85	-5.3
Patapsco	6	Upper Chesapeake Bay Delmarva	30.00	24.90	-17.0
Blue Plains Bypass	7	Potomac	27.60	15.30	-44.6
Alexandria	8	Potomac	26.96	28.93	+7.3
UPRC Waste water treatment plant	9	Potomac	22.40	21.50	-4.0
Arlington Co.	10	Potomac	22.27	22.20	-0.3
Lower Potomac	11	Potomac	22.20	22.36	+0.7
Scranton Sewer Authority	12	Susquehanna	21.20	20.20	-4.7
Lamberts Point	13	James	20.63	21.30	+3.2
Harrisburg	14	Susquehanna	20.45	19.60	-4.1
Bing John City	15	Susquehanna	19.99	14.00	-30.0
Chesapeake-Elizabeth	16	James	19.70	19.99	+1.4
Boat Harbor	17	James	17.60	17.55	-0.2
York Water Pollution Control Center	18	Susquehanna	16.25	16.00	-1.5
Piscataway	19	Potomac	15.00	13.90	-7.3
Western Branch	20	Upper Chesapeake Bay Delmarva	13.90	9.91	-28.7
James River	21	James	13.70	13.90	+1.4
Army Base	22	James	12.38	11.53	-6.9

1980 Data from EPA Chesapeake Bay Program database

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- Maryland Department of Natural Resources
  - Natural Resources Marine Police
  - Parks and Recreation
  - Tidal Fisheries
- Maryland Highway Toll Administration
- Maryland Pilots Association
- Maryland Port Administration
- Maryland State Climatologist - Mr. J. Moyer
- Maryland State Police
- Maryland Steamship Trade Association
- NASA/Goddard Space Flight Center
- NOAA/National Earth Satellite Service
- NOAA/NAVY Joint Ice Center
- NOAA/National Marine Fisheries Service
  - Resource Statistics Division
- NOAA/National Ocean Survey
  - Tidal Datums Branch
- NOAA/National Weather Service
  - Baltimore Weather Service Field Office
  - Washington Weather Service Field Office
  - Norfolk Weather Service Field Office
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- U.S. Coast Guard
  - Group Baltimore
  - Group Eastern Shore
  - Group Hampton Roads
  - Pollution Information Reporting System
  - Baltimore Safety Office
  - Public Affairs Office
  - District Office - Hampton Roads

U.S. Geological Survey
Virginia Polytechnic Institute
Virginia Water Control Board
Virginia Institute of Marine Sciences
Virginia Marine resources Commission
Weather Observers
    Aberdeen Airport
    Capitol City Airport