Chapter 7.2

Fish kill trends in the Maryland Coastal Bays

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Abstract
Fish are analogous to "canaries in coal mines". As such, fish kills are usually indications of unusual stress in the environment. Sporadic fish kills due to low oxygen are apparently increasing in frequency. There have been 77 reported fish kills and 71 confirmed or probable fish kills in the Maryland Coastal Bays since 1984. Collectively they represent approximately 4.5 million mortalities. The majority of fish kills occur in the summer months when there are abundant algal blooms, lower oxygen solubility, increased temperatures, increased oxygen demand from the breakdown of organic matter in the water, and larger fish stocks in the bays. Low dissolved oxygen is implicated in two thirds of all fish kills where the cause is known in the Coastal Bays. The vast majority (97.9%) of mortalities also occurred within dead-end canals.

Introduction
Fishkill investigations are the responsibility of the Maryland Department of the Environment (MDE) under Environmental Article Section 4-405C to investigate the occurrence of damage to aquatic resources, including, but not limited to, mortality of fish and other aquatic life. The investigations should determine the nature and extent of each occurrence and endeavor to establish the cause and sources of the occurrence. If appropriate, findings shall be acted upon to require the reparation of any damage done and the restoration of the water resources affected, to a degree necessary to protect the best interest of the state.

Since 1984 this program has received over 2,300 reports of fish kills and coordinated a statewide, multiagency cooperative response to those reports. Not all reports are investigated for a variety of reasons, including low numbers of dead fish, tardy reporting, or *a priori* information on the source of the dead fish. The Fish Kill Investigation Section maintains a database of all reports, investigation results, and other pertinent details from the last 30 years. This report is a summary of events reported in the Coastal Bays region from 1984-2013 with an emphasis on 2007-2013.

There have been 77 reported fish kills and 71 confirmed or probable fish kills in the Coastal Bays Region since 1984. Collectively they represent approximately 4,535,000 mortalities. During the same period, there were 1,922 fish kill reports, involving approximately 36,255,000 mortalities in the Chesapeake Bay and its tidal tributaries.

Management Objective: Decreasing fish kills that are not 'natural in origin'.

***Draft* Fishkill Indicators**: Number of fishkills due to low D.O. and pollution
Number of dead fish

Status of Fish Kills

Canals are confined spaces with characteristically low flushing where frequent algal blooms can lead to hypoxic or anoxic conditions. Fish often enter dead-end canals because of the deeper and cooler waters found there and become trapped when the conditions become intolerable. Within the Coastal Bays watershed, fish kills were reported in canals more often than in any other type of water body (Figure 7.2.1). Eighteen of the twenty-six reports involving canals were attributed to low dissolved oxygen. The majority (73.5%) of mortalities also occurred within canals (Figure 7.2.2). In addition to fish kills, citizen complaints about nuisance algae in canals were common in the summer time.

Several factors combine to explain reports in canal habitats. Excess nutrient runoff and poor circulation/flushing contribute to algal blooms, diurnal dissolved oxygen sags, and elevated biological oxygen demand (BOD). Additionally, dead end canals may act as traps for wind-blown floating macroalgae. Canals may also act as traps for schooling fish with poor maneuverability in shallow inshore environments. Concentrated fish that have been corralled into canals by predatory fish, or have simply wandered there, can become entrapped by low tides. This often results in the critical depletion of available oxygen due to a combination of fish respiration and natural diurnal oxygen depression.

Another explanation for the number of reports from canals depends on the fact that reports require an observer. With a large population living along canals, the probability of an observer seeing dead fish in a canal is high. There are fewer potential observers for dead fish in more remote areas.

The second most common habitat for fish kill reports is tidal creeks and rivers. Of the 18 reports from creeks and rivers, all but two occurred in smaller creeks near tidal headwaters. The most common cause of these events was low dissolved oxygen (seven of 10 events where cause was determined).

Trends of Fish Kills

<u>Temporal Patterns</u>
The majority of fish kills occur in the summer months in the Coastal Bays as they do throughout the state (Table 7.2.1). Algal blooms, lower oxygen solubility, increased temperatures, increased BOD from organic decomposition and larger fish stocks all occur in summer months. A small increase in the number of kills occurs in the Coastal Bays during the months of January and February. This is largely due to the fact that schools of 5-8" striped mullet (*Mugil cephalus*) have been found dead and dying of cold stress in past winters throughout the area. While most fisheries accounts of the Mid-Atlantic suggest that the species leaves the area in fall and moves south, apparently some attempted to over winter in the area.

Table 7.2.1 Fish kills reported by Month: 1984-2013.

Month	# Reported Kills Statewide	# Reported Kills Coastal Bays
January	74	4
February	88	4
March	133	1
April	273	4
May	580	5
June	631	11
July	577	11
August	463	24
September	325	5
October	90	5
November	38	3
December	26	0

The number of fish kills reported per year varies following trends in ease of reporting, public awareness about fish health and environmental concerns, disease outbreaks, and cyclical trends in weather (i.e. drought, cold winters, cool summers, wet years). The number of kills reported per year is not likely to be changing statewide (Table 7.2.2). However, there is a very recent downward trend in the number of fish kill reports received in the last three years, which may not be significant. In the early to mid 2000's there appeared to be an increase in the number of fish kills reported per year in the Coastal Bays. The average number of kills reported in the late 1980's through the 1990's was 1.5/year. That number has increased to more than six per year from 2000 to 2005. Since then the average is about two, about the same as the 30-year average.

Increased public awareness resulting from renewed interest in environmental initiatives in the Coastal Bays may explain the several year increase in fish kill reports.

Table 7.2.2 Fish Kills per Year: 1984-2013

Year	# Reports Statewide	# Reports Coastal Bays
1984	25	0
1985	90	3
1986	136	0
1987	148	1
1988	187	0
1989	122	1
1990	105	2
1991	120	0
1992	99	2
1993	103	3
1994	84	4
1995	105	2
1996	87	1
1997	87	3
1998	100	0
1999	132	1
2000	178	4
2001	129	5
2002	149	14
2003	126	5
2004	111	3
2005	90	6
2006	90	1
2007	141	2
2008	112	1
2009	98	2
2010	97	3
2011	70	4
2012	97	2
2013	65	2
TOTAL	**3297**	**77**

Cause

Approximately 12% of all fish kills statewide are "pollutional" in nature. Pollution induced fish kills are direct results of discharges of some kind (i.e. sewage spills, manure spills, pesticide misuse, chlorine discharges or chemical spills). Other kills like fishing discards arose directly from anthropogenic factors. "Natural" kills may be entirely natural occurrences such as spawning stress or arise in part from anthropogenic factors such as nutrient runoff.

Statewide, nearly half of all tidal fish kills where the cause was known were attributable to low dissolved oxygen (DO) (Table 7.2.3). These events may have been due to strandings of schooling fish in tidal headwaters, entrapment in commercial fishing nets or other man made structures, low DO that could be attributed to nightly oxygen sags resulting from algal blooms, inversions, or intrusions of deep anoxic water onto shorelines. Low DO was implicated in nearly two thirds of all fish kills where the cause is known in the Coastal Bays. While entrapment in man-made structures accounts for 14% of all low dissolved oxygen kills statewide, it accounts for 35% of all low DO kills in the Coastal Bays.

Table 7.2.3 Fish kills by cause: 1984-2013.

Cause of Fish Kills	**Statewide Cases (% where cause is known)**	**Coastal Bays Cases (% where cause is known)**
Low Dissolved Oxygen	**1003 (43.5 %)**	**35 (63.6%)**
General	335	9
Algal bloom	276	9
Entrapment	137	12
Intrusion/Inversion	91	1
Stranding	61	3
BOD	48	1
Winter Kill	55	0
Unknown	**766 (n/a)**	**16 (n/a)**
Discards	**468 (20.3 %)**	**10 (18.2 %)**
Thermal Stress	**52 (2.3 %)**	**5 (9.1 %)**
Disease	**236 (10.2 %)**	**1 (1.8 %)**
Seasonal/Spawning Stress	**158 (6.9 %)**	**1 (1.8 %)**
Pond Management	**71 (3.1 %)**	**1 (1.8 %)**
Misc. Natural	**16 (0.7 %)**	**0**
Storm Winds	**1 (0.04 %)**	**1 (1.8 %)**
Pollution	**266 (11.5 %)**	**1 (1.8%)**
Toxic Algae	**36 (1.6 %)**	**0**
TOTAL KILLS	**3073**	**71**

<u>Mortalities</u>

Of the estimated 42,128,000 fish mortalities statewide since 1984, 85% died in low DO events. Of the 4,535,460 fish mortalities in the Coastal Bays, approximately 74% died in low oxygen events (Table 7.2.4). Excepting one major event in 2004, the species most affected were schooling species, such as Atlantic silversides (*Menidia menidia*), Atlantic menhaden (*Brevoortia tyrannus*), and striped mullet (Table 7.2.5).

The only pollution case in the Coastal Bays took place on August 7, 1993 in Bishopville Pond. A sudden collapse of a storage tank at a plant in Selbyville, Delaware caused approximately

250,000 gallons of chicken processing waste to spill into the creek feeding Bishopville Pond. Fish mortalities occurred during the night, but were cleaned up by contractors before Maryland Department of the Environment biologists could accurately assess the damage. At least 150 fish died. No acute effects were visible below the pond in Bishopville Prong.

Table 7.2.4 Fish mortalities by cause: 1984-2014.

Cause of Fish Kills	**Coastal Bays Mortalities**	**Statewide Mortalities**
Low Dissolved Oxygen	**3,364,552 (74.2%)**	**35,704,570 (84.8 %)**
General	26,422	3,953,960
Algal bloom	25,362	13,732,120
Entrapment	3,200,743	3,572,950
Intrusion/Inversion	10,000	347,640
Stranding	102,000	13,709,250
BOD	25	337,790
Winter Kill	0	50,860
Unknown	**34,388 (0.8 %)**	**731,125 (1.7 %)**
Discards	**131,139 (2.9 %)**	**292,610 (0.7 %)**
Thermal Stress	**1,004,900 (22.2 %)**	**3,089,900 (7.3 %)**
Disease	**0**	**877,910 (2.1 %)**
Seasonal/Spawning Stress	**0**	**32,800 (0.1 %)**
Pond Management	**300**	**81,840 (0.2 %)**
Misc. Natural	**0**	**18,050 (0.0 %)**
Storm Winds	**25**	**25 (0.0 %)**
Pollution	**150**	**1,032,040 (2.5 %)**
Toxic Algae	**0**	**267,450 (0.6 %)**
TOTAL KILLED	**4,535,460**	**42,128,320**

Table 7.2.5 Mortalities of Fish by Species in the Coastal Bays Region: 1984-2014.

Fish species	**Number killed in Coastal Bays**
Atlantic silversides, *Menidia menidia*	3,000,000
Atlantic croaker, *Micropogonias undulatus*	1,000,045
Atlantic menhaden, *Brevoortia tyrannus*	520,137
Striped mullet, *Mugil cephalus*	5,050
Bluegill sunfish, *Lepomis macrochirus*	2,415
Gizzard shad, *Dorosoma cepedianum*	1,850
Golden shiner, *Notemigonus crysoleucas*	1,375
Minnow species	671
White perch, *Morone americana*	600
Black sea bass, *Centropristis straita*	500

Summary

Two of the top 10 fish kill events occurred during the 2007-2013 timeperiod. The first was a low DO event that occurred in 2010 in a canal off Greys Creek near Bishopville. Approximately 100,000 Atlantic menhaden died. The second occurred in 2011 as a result of commercial fishing discards offshore (Approximately 100,000 adult Atlantic menhaden began washing ashore on Maryland and Delaware beaches). The year 2011 had one of the highest number of reported fish kills (4). Low oxygen is still a major factor in fish kills in the Coastal Bays.

Fish kill events in order of severity were:

1. **August 30, 2001** in a canal off Isle of Wight Bay in West Ocean City. A school of 3,000,000 Atlantic silversides entered the canal, which had a sand bar partially blocking its mouth, and apparently became entrapped during low tide overnight. The fish became concentrated by low water, exhausted all available oxygen, and died. DO at the time of investigation varied between 0.05-2.1 mg/l.
2. **July 31, 2004** in the Atlantic Ocean. At least 1,000,000 Atlantic croaker (a warm water species) died suddenly and began washing ashore in Maryland, Virginia, and Delaware. Investigations by many State, Federal, and University researchers revealed that an event occurred July 31st in the Atlantic Ocean off Ocean City. Researchers showed that a so called "cold pool" of water had been moving southward from off New Jersey and that water temperatures in the Coastal Bays Region dropped prior to onset of the kill. Although the Maryland event was short-lived, croakers reportedly continued to die for several more weeks as migration progressed south along the coast. It is most probable that the initial intrusion of "cold pool" water, timed with mass seasonal migration, initiated both acute and latent stress factors that sustained die-off of the susceptible portion of the population. Independent investigations continued as the kill eventually moved south into Florida waters.
3. **September 22, 1997** in a canal off Assawoman Bay in Ocean City. Approximately 200,000 Atlantic menhaden apparently became entrapped in the canal and died of low oxygen. Dissolved oxgyen at the time of investigation was 0.77 mg/l.
4. **June 4, 2011** in the Atlantic Ocean. Approximately 100,000 adult Atlantic menhaden began washing ashore on Maryland and Delaware beaches. Investigation by various state and federal agencies revealed that the fish apparently were discarded by commercial fishermen offshore near the mouth of Delaware Bay.
5. **October 3, 2010** in a canal off Greys Creek near Bishopville. Approximately 100,000 Atlantic menhaden died. Investigation revealed that wind and tide combined to largely dewater the canal, stranding the fish. A continuous monitor in the canal measured oxygen at lethally low levels.
6. **August 17, 2002** in Massey Branch, a tidal tributary of Marshall Creek. Approximately 30,000 Atlantic menhaden died. Investigation revealed that the creek was extremely shallow and the fish were likely stranded. Most of the dead fish were found in less than eight inches of water. Algal samples revealed a bloom of the potentially toxic alga, *Chattonella sp.* in the area. Other species of fish were unaffected.
7. **July 8, 1993** in the Atlantic Ocean off Assateague Island. Approximately 30,000 adult Atlantic menhaden were discarded by commercial fishing operations.

8. **September 20, 2008** in Bishopville Prong, from Bishopville to the public landing. Approximately 20,000 Atlantic menhaden died throughout the creek due to low DO.
9. **June 7, 2002** in a canal off Isle of Wight Bay in West Ocean City. Approximately 15,000 Atlantic menhaden died due to low oxygen.
10. **September 12, 1985** in a canal off the St. Martin River in Ocean Pines. Approximately 10,000 Atlantic menhaden died due to a storm induced anoxic inversion.
11. **September 4, 2005** in Sinepuxent Bay at Great Egging Island. 700 Atlantic menhaden, Atlantic croaker, and seatrout died due to low dissolved oxgyen.
12. **January 17, 2001** in a canal off Isle of Wight Bay in Ocean Pines. Approximately 3,500 striped mullet died of cold stress under ice.

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References
Maryland Department of the Environment. 2015 2014 Fish Kill Summary Science Services Administration Fish Kill Investigation Section. 17 pages

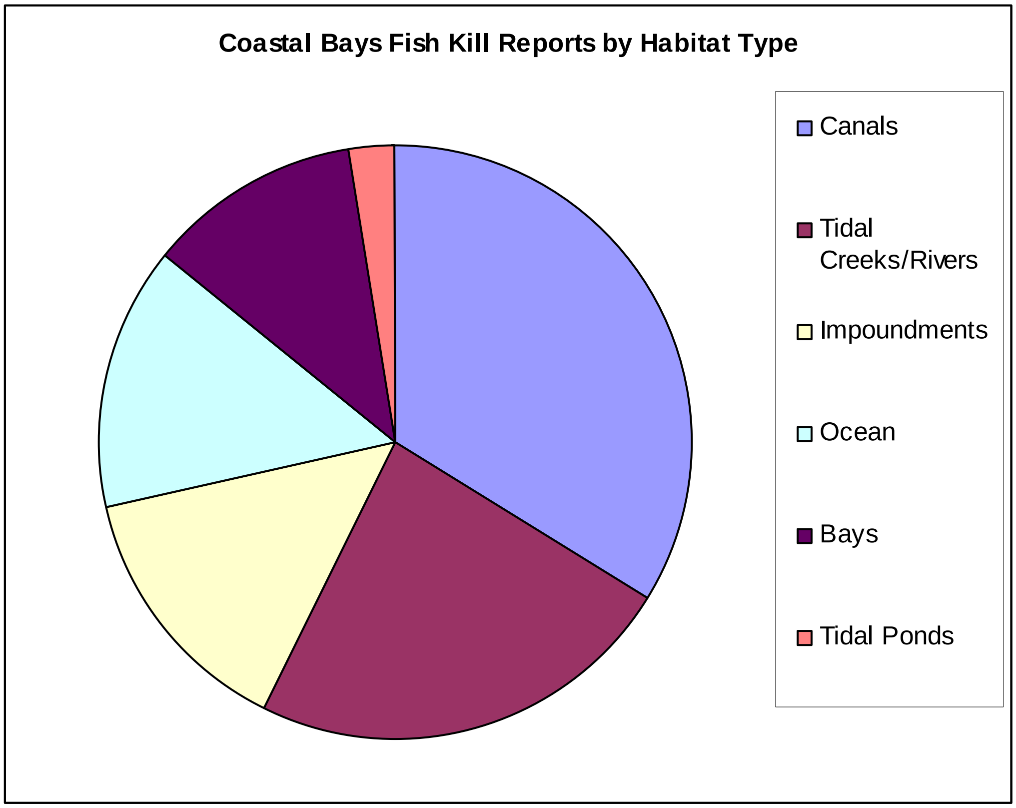

Figure 7.2.1 Number of fish kills per habitat type, 1984-2013.

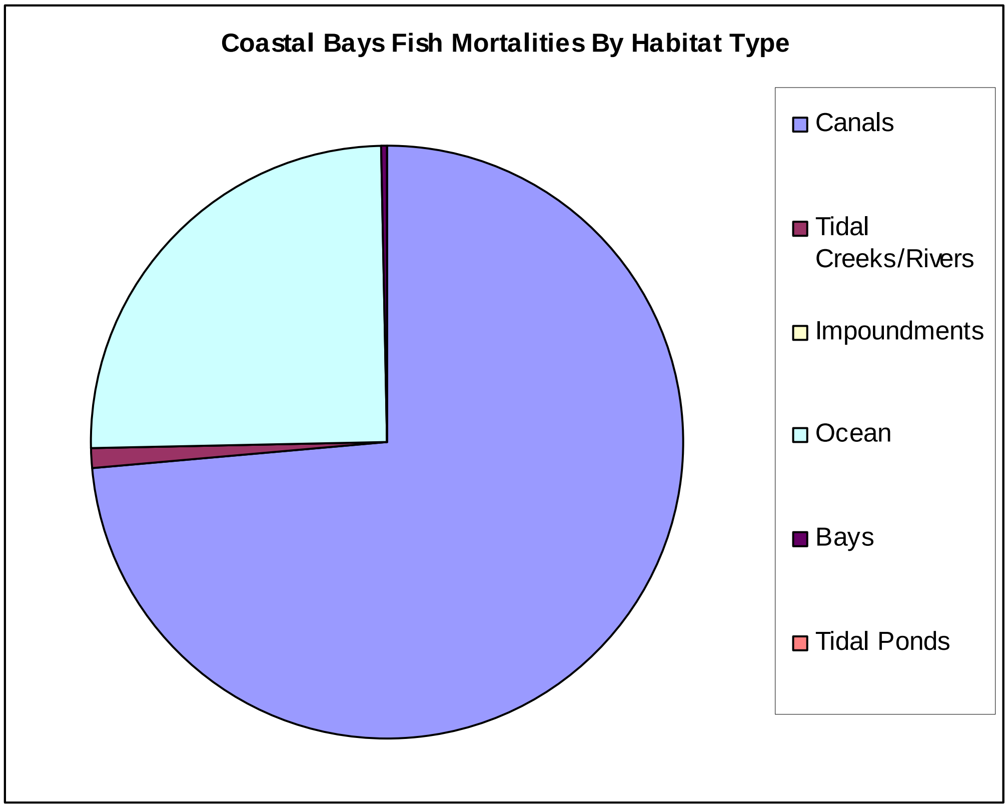

Figure 7.2.2 Numbers of fish killed during fish kill events per habitat type, 1984-2013.