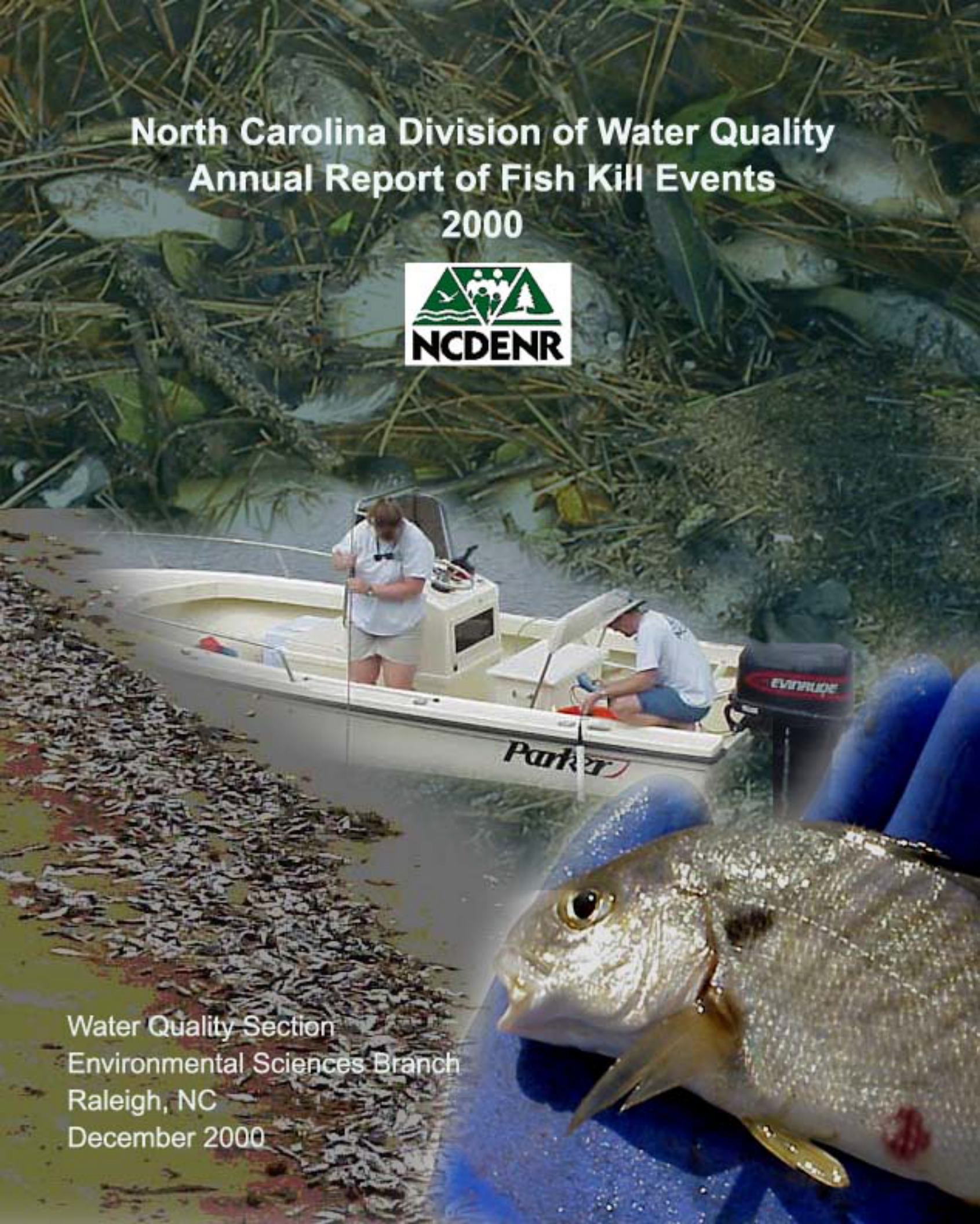
North Carolina Division of Water Quality
Annual Report of Fish Kill Events
2000



Water Quality Section
Environmental Sciences Branch
Raleigh, NC
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Introduction

The year 2000 marks the fifth year where fish kill investigation protocols established by the North Carolina Division of Water Quality (DWQ) have been used to investigate and report kill activity across the state. The protocols were developed with assistance from Regional Office staff, North Carolina Wildlife Resources Commission biologists, and Division of Marine Fisheries personnel as a means to improve the tracking and reporting of fish kill events in North Carolina. Fish kill and fish health investigations are recorded on a standardized form and sent to the Division's Environmental Sciences Branch (ESB) where the data are reviewed and compiled. Fish kill investigation forms and supplemental information sent to the ESB are entered into a central database where the data can be managed and retrieved for use in reports to concerned parties. The procedure also requires the notification of appropriate state officials and scientists associated with the investigation of such events. In addition, reported kill information is updated weekly on the ESB website at: www.esb.enr.state.nc.us/Fishkill/fishkill00.htm.

This document is a summary of fish kill events reported to the DWQ during 2000. The report is mandated under Section 4 of Chapter 633 of the 1995 North Carolina General Assembly Session Laws.

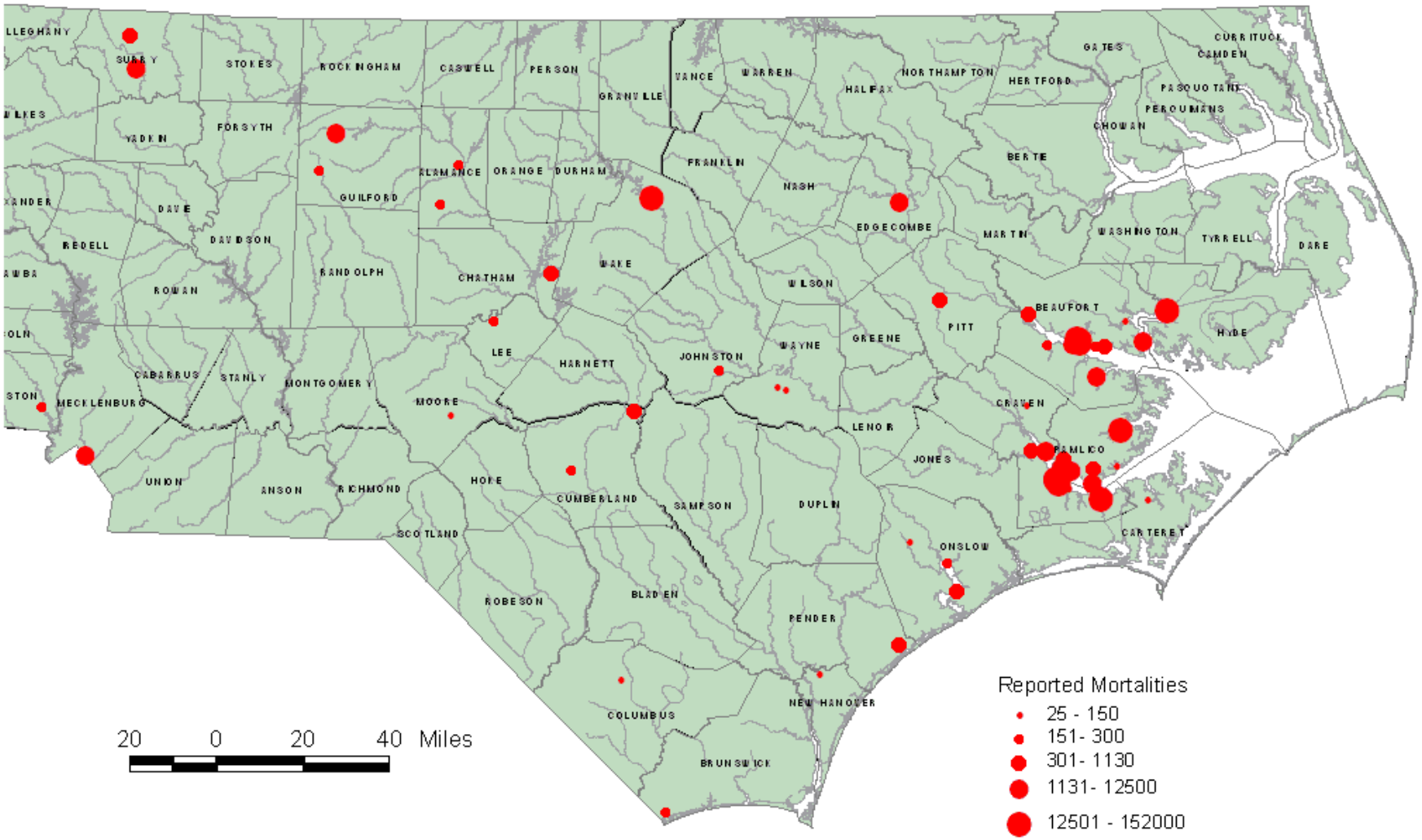
2000 Fish Kill Summary

Field investigators reported 58 fish kill events from January to November, 2000. Kill events were reported from the coastal counties to as far west as Gaston County in 7 of the states 17 major river basins (Figure 1). The ESB tracks fish kill events when at least 25 fish are affected and the event can be confirmed by investigators.

Over half of the year's kill events occurred in estuarine waters during 2000. A majority of the year's mortality was a result of large coastal events in the lower Neuse and Pamlico rivers. Reports noted 32 events affecting estuarine species and 26 involving freshwater fish. No events were reported in ocean waters.

2000 Fish Kill Summary	
Total Kill Events for 2000	**58**
Total Mortality for 2000	**716,141**
Mortality Range	**25 to 152,000**
Median Mortality	**650**
Basins with Activity	**7 (of 17)**
Freshwater Kills	**26**
Estuarine Kills	**32**

Figure 1: Fish Kill Events Reported to NCDWQ During 2000



Basin Activity

Investigators reported fish kill events in 7 of the state's 17 major river basins during 2000 (Figure1). As was the case in 1999, the Neuse River basin produced the most activity this year with 23 events. Kill events reported in the Neuse during 2000 were nearly double the numbers reported for the basin in each of the previous four years. Fish kill activity was especially heavy within the Pamlico and lower Neuse basins during the warmer months of the year. In late June and early July a series of kills along the Pamlico River below Washington claimed over 150,000 fish. In mid September, kills claimed nearly 130,000 fish along the Neuse River below New Bern. Kill reports from the Cape Fear and Yadkin basins were light. The northeastern corner of the state remained completely quiet during 2000 with no reports of kill activity from Albemarle Sound or the Chowan/Pasquotank basins. The remaining basins have generally experienced light fish kill activity since 1996 and this was also the case in 2000 (Table1).

The total number of statewide events has remained quite consistent since 1996. Reported annual kill events for North Carolina have numbered between 54 and 60 for the past four years, regardless of yearly environmental conditions and a series of severe hurricanes. Detailed summaries of 2000 fish kills are presented in the Appendix C.

Table 1: Fish kill report numbers by basin

	Year				
River Basin *	1996	1997	1998	1999	**2000**
Broad	None	None	None	1	**None**
Cape Fear	21	16	23	14	**12**
Catawba	None	3	1	3	**2**
Chowan	2	2	1	1	**None**
French Broad	None		3	1	**None**
Neuse	14	12	8	16	**23**
Lumber	4	3	5	None	**2**
Pasquotank	10	2	8	2	**None**
Roanoke	2	None	1	None	**None**
Tar/Pamlico	3	6	5	11	**14**
Watauga	None	None	None	1	**None**
White Oak	3	3	1	3	**3**
Yadkin	1	10	2	1	**2**
Totals	**60**	**57**	**58**	**54**	**58**

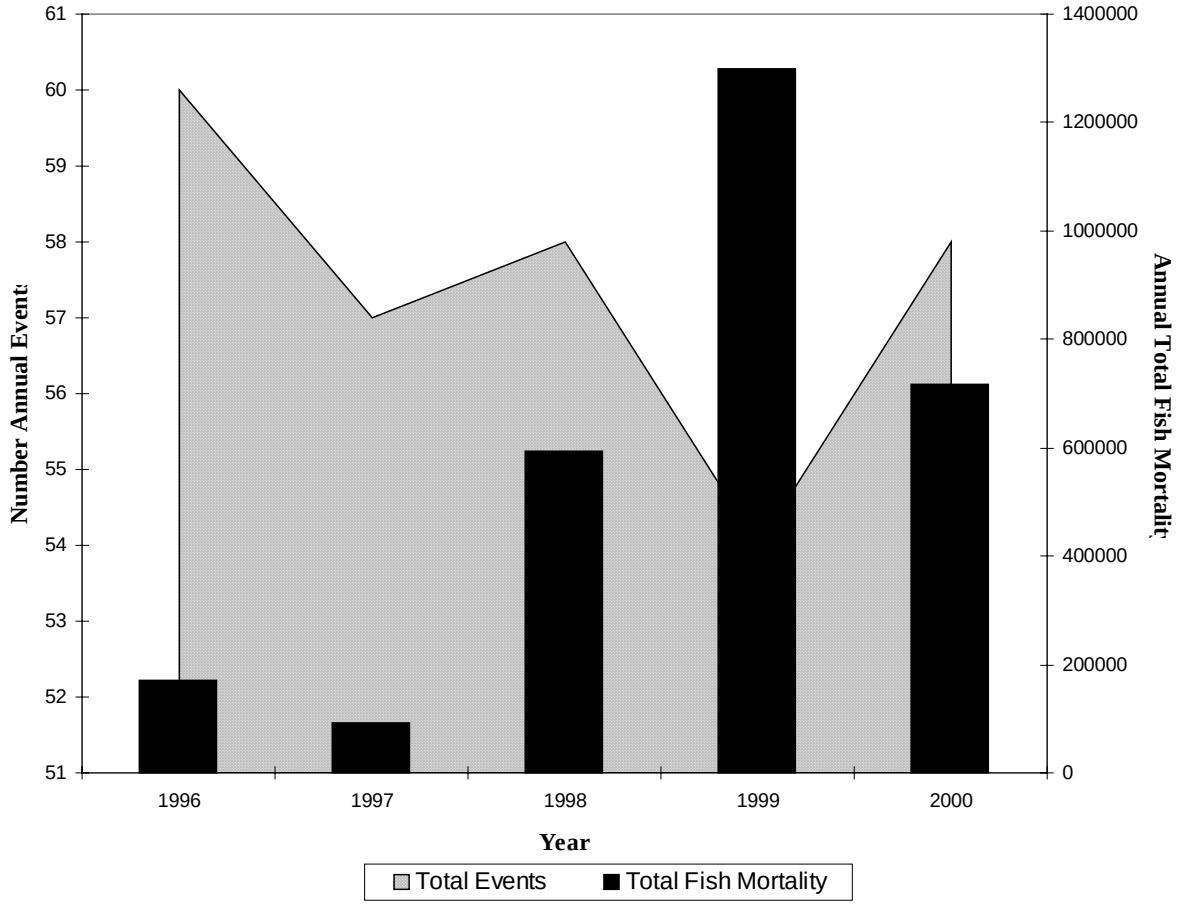
** Note: Since 1996 no fish kill reports have been received from the New, Little Tennesee, Hiwassee, and Savannah basins.*

Fish Mortality

Field investigators reported a total of 716,141 fish killed during the 58 events of 2000. Reported fish mortality figures ranged from 25 to 152,000, with a median mortality of 650. About one quarter (14 of 58) of the reported events had mortality totals exceeding 5000 – a count used by ESB to designate a large event. A majority of the large events reported during 2000 occurred in the Pamlico and Neuse estuaries from June to September. A detailed summary of the large kill events is shown in Appendix A.

ESB reports show a greater fluctuation in annual fish mortality totals than in total annual events (Figure 2). Since 1996, total annual mortality figures have ranged from about 92,000 (1997) to almost 1.3 million (1999). Mortality totals have not closely correlated with annual event totals due to the fact that a relatively consistent number of events has resulted in the loss of a varying number of fish from year to year (i.e., few events can affect large numbers of fish and vice versa).

Figure2: Reported annual fish kill event and mortality totals, 1996 to 2000

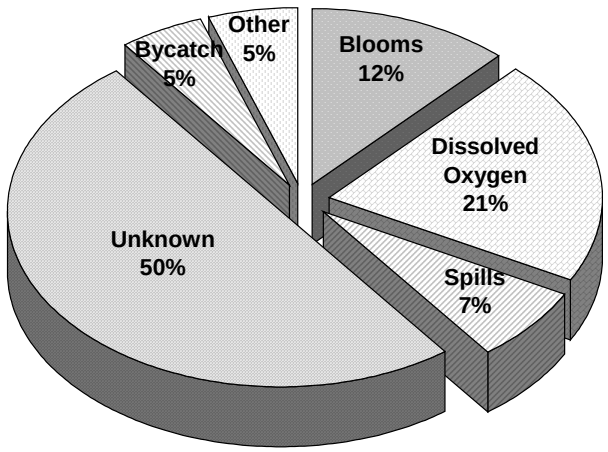


Suspected Causes of 2000 Fish Kill Events

Specific causes of fish kill events may or may not be obvious to investigators depending on a host of factors. Many causes may quickly be defined, but others remain unconfirmed or unclear due to an investigation occurring after the fact. Kill events often result from many environmental conditions, and sorting out the major reason(s) why fish die is frequently a difficult and often subjective task. The NCDWQ reviews and tracks suspected causes of fish kills reported by field investigators. Suspected cause reports aid in evaluating potential water quality trends and problems, and assist scientists and decision-makers with formulating future courses of action. Suspected cause reports should not be viewed as a definitive label for a particular event.

Reported causes of 2000 kill events fell into five major categories. Those events where no specific causes could be determined were assigned to a sixth "unknown" category (Figure 3).

Figure 3: Major suspected causes for fish kills during 2000



***Unknown Causes**:* Causes for kill events are listed as unknown when investigators fail to report specific reasons for an event. Investigations may not provide definitive causes when they are conducted too long after an event and no clear factors are determined, or when causes are suspected but not confirmed. Investigators failed to cite specific causes for an event in 50% of the year's reports. Reports with unknown causes were received mainly from estuarine waters. Investigators often reported dead or distressed fish when water quality measurements and water samples failed to suggest a problem. A number of kills were also associated with lesion events with underlying factors that could not be determined (see Pathology Results below).

Dissolved Oxygen Depletion: DO depletion prior to kill events often occurs as a result of heavy rain or following periods of drought and low flow. Anoxic conditions also occur in estuaries as nutrient and organic loading coupled with water column stratification deplete DO levels during the summer months. DO depletion was cited as a factor in 21% of the

kill events during 2000. The majority of DO related kills were reported in estuarine waters during the warmest months of the year (June to September).

Many scientists expected an increase in reports of estuarine DO related fish kills due to possible lingering effects of the 1999 hurricanes. Severe runoff, flooding of agricultural and urban areas, and flushing of swamps and backwaters resulted in high inputs of oxygen demanding organic material and chemicals into the states waterways. Exactly how flood materials were deposited into the estuaries and their role on fish health is still being assessed; however, such effects may have been a factor in certain areas of the coast this year, especially in the Pamlico and lower Neuse estuaries. Reports documented the heaviest fish kill activity in the lower Pamlico and Neuse basins since 1996 (Table 1). Reports also showed the highest fish mortality figures for the two basins since 1996 (Appendix A). Investigators also cited DO as a factor in largest kill of the year (Neuse River near Clubfoot Creek, see Appendix B) that affected over 152,000 fish.

Harmful Algal Blooms: Nutrient enrichment of waterbodies throughout North Carolina has resulted in eutrophication, frequent algal blooms, and a subsequent increase in fish kill events. Algal blooms cause dissolved oxygen (DO) and pH fluctuations as well as DO depletion through diurnal cycles and algal decomposition. These elements often precede fish kills events. Certain types of algae also release toxins during the course of a bloom that are detrimental to aquatic life. Algal blooms were suspected in 12% of the fish kill events for 2000. Bloom related kills occurred mainly in smaller freshwater lakes and ponds as a result of enrichment or runoff. Investigators also observed several algal blooms along the Pungo River in July that were suspected as a cause for kills around channel marker 19 and 21. The algal blooms at these two stations were probably caused by a large, nontoxic, photosynthetic dinoflagellate known as *Gyrodinium uncatenum*.

During 2000, the ESB staff routinely examined water samples associated with estuarine fish kills for of *Pfiesteria and Pfiesteria*-like organisms. ESB examinations were performed using light and epiflourescent microscopy. Suspect samples warranting further confirmation for toxic *Pfiesteria* species were also forwarded to UNC-Greensboro and the NCSU Center for Applied Aquatic Ecology for further tests. These tests included fish bioassays, scanning electron microscopy, and an RNA probe that can discern the presence of actual *Pfiesteria* cells.

Most *Pfiesteria*-like cells examined by ESB staff during 2000 appeared as nontoxic obligate autotrophs and not forms historically associated with fish health events. Two samples, however, were suspected of containing toxic *Pfiesteria* forms. In samples collected from a fish kill at Greens Creek off the Neuse River on September 28, the UNC-Greensboro RNA probe detected the presence of *Pfiesteria shumwayae*. A sample collected on June 21 from Flanners Beach on the Neuse River also contained a questionable *Pfiesteria* cell under epifluorescent microscopy. At the time of this report, all involved laboratories have not reported toxic *Pfiesteria* as a causal factor in any of the associated fish kills.

Spills: Waste spills either deplete DO levels in receiving streams or induce kills outright through physical or chemical toxicity. Spills were reported as a cause in 7% of the kill events during 2000. Spilled substances included sewage, chlorine, bleach, and unknown chemicals. The largest spill event occurred in April as a result of the discharge of sodium hydroxide from the Sugar Creek wastewater treatment plant near Charlotte killing 7500 fish including bass, sunfish and minnow species. Turtles were also reported killed.

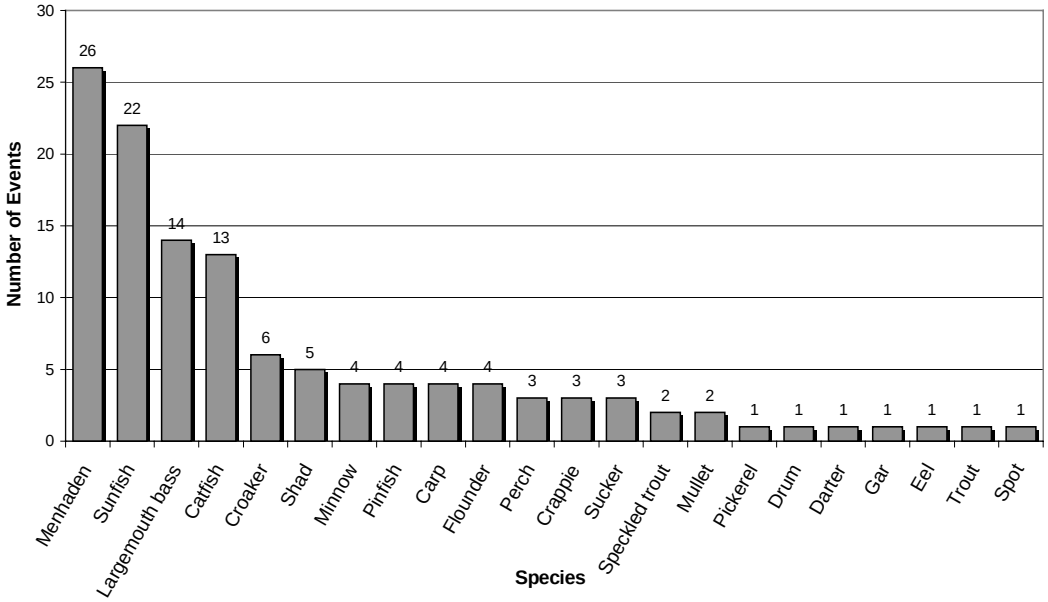
Bycatch: Discarded fish from nearby fishing operations were reported as a cause or possible factor in 5% of the kill events during 2000. Bycatch was cited as a possible factor for more events this year than in each of the previous four years. A large kill of flounder, spot, croaker and menhaden was reported on the Bay River near Vandemere (Pamlico Co.) following heavy trawling activity. The kill involved over 109,000 fish and was one of the year's largest.

Other: Three events that occurred in January and February were apparently the result of extreme cold or "winter kill". The largest of these occurred below Falls Lake Dam (Neuse River)following a two-week period of significant snow cover. The event claimed 40,000 shad when water temperatures dropped to fatal levels for the species. Historical "winter kill" events in North Carolina involving shad have been well documented.

Fish Species

Fish kills in 2000 involved at least 22 different species of fish across the state (see Figure 3). Freshwater species most commonly identified during investigations included largemouth bass, sunfishes, and catfishes. Estuarine species most commonly reported included menhaden and croaker. Menhaden, which have historically been the subject of large fish kills along the coast, were cited in nearly half of the kill events during 2000. Menhaden also composed the bulk of the year's total mortality figure.

Figure 4: Species reported during 2000 fish kill investigations (n=22)



Additional animals were observed at about 14% of the year's kill events. These included blue crab, crayfish, salamanders, and turtles. Only blue crab were noted in significant numbers at a kill on the Neuse River near Flanner's Beach during August (see Appendix C).

NCSU College of Veterinary Medicine Pathology Results

During 2000, Dr. Mac Law along with NCSU College of Veterinary Medicine staff and veterinary students, assisted DWQ investigators by performing gross and microscopic evaluations of fish found dead and fish found stressed and/or diseased. Dr. Mac Law is an American College of Veterinary Pathology (ACVP) board certified veterinary pathologist at the North Carolina State University College of Veterinary Medicine. The pathology team examined 69 fish from various disease events and/or fish kills in the Pamlico and Albemarle systems. Fish species examined included Atlantic menhaden, several shad species, white perch, striped bass, flounder, sunfish, pinfish, and speckled trout.

***Dr. Law's Findings**:* Many fish had one to several ulcerative lesions of the skin and underlying muscle tissue which were often circular and centered near the anus. These lesions ranged from 4 mm to >3 cm in diameter, were of variable depth, and occasionally penetrated through the body wall of the fish. Lesions were most common in the Atlantic menhaden, although several flounder from the Currituck Sound area had similar ulcers.

Some fish samples were characterized by extensive necrosis of skin and underlying muscle tissue. Within the injured areas, special stains revealed abundant bacteria and fungal infections. Most of the ulcerative lesions associated with the fish samples contained mature forms of inflammation. This type of inflammatory process takes at least a week to develop to the point observed by the NCSU veterinary staff. In general, most of the ulcerative lesions in these fish were compatible with the "ulcerative mycosis" lesions of menhaden reported by Noga *et al* in 1986 (Journal of Fish Diseases 9:47-53). The significance of the fungi in the initiation and development of these lesions is uncertain at this time. It is likely that some primary stressor such as a toxin, low dissolved oxygen, trauma, parasitism, etc. causes an initial breach in the fish's skin, allowing secondary invasion of fungi and other organisms.

Several striped bass from the Chowan River were received which had bubbly, pale tan skin lesions of a pudding-like consistency. These lesions were determined to be due to lymphocystis disease, a chronic (many weeks) disease affecting many marine and freshwater fish. It is caused by an iridovirus (DNA virus) and causes low mortality, but can be very disfiguring. Transmission of the disease probably occurs by rupture of lesions followed by infection of abraded skin. Many fish probably carry a latent infection that may be activated when the animal is stressed. Since these female striped bass were likely experiencing multiple forms of stress at this time of year (1. spawning = tremendous hormonal changes; 2. physiological changes of converting from salt to fresh water), they were probably more susceptible to this disease.

Summary

Total numbers of reported fish kills across North Carolina during 2000 closely matched the those seen annually since 1996. Although events during 2000 were observed throughout the state, the majority of reports were received from coastal waters. Kill events were especially prevalent in the Pamlico and lower Neuse waterways during the warm months of the year. Events remained light in basins toward the inner coastal plain and piedmont regions. No reports of significant activity were received from the northeastern corner of North Carolina, including the Chowan/Pasquotank and Albemarle Sound waters nor the western mountain region.

Investigators failed to establish a definitive cause for half of the kill events reported in 2000. Most of these "unknown" kills occurred in estuarine waters and were associated with chronic lesion events, especially in menhaden. Those kills that could be associated with a cause were generally the result of harmful algal blooms or DO depletion. The presence of *Pfiesteria*-like organisms was observed in conjunction with two events, however, further investigation has not resulted in reports of toxic forms of *Pfiesteria* as a causal factor.

The pathology of fish samples evaluated in conjunction with 2000 fish kills was similar to results from the previous several years. Most of the observed lesions contained extensive secondary fungal and bacterial infections along with mature forms of inflammation that may suggest the presence of chronic stressors. The cause(s) for lesions on coastal North Carolina fish is still uncertain, however, researchers are focusing on such factors as hypoxia (low DO), invasive fungal infections, algal toxins, and species immune susceptibility.

The state experienced a reprieve from hurricane activity during 2000. Although there was notable storm activity in the Atlantic, not a single storm made landfall along the North Carolina coast. Regardless of the inactivity, many researchers anticipated an increase in fish kill activity, especially in the state's estuarine waters, as a result of extreme flooding during 1999. Hurricanes Dennis, Floyd and Irene produced record rainfall and flooding that washed large amounts of chemicals, waste, and organic matter into the estuaries. These substances were expected to produce conditions for extensive kill activity during the 2000 season. The 1999 hurricane effects may have played a role in the intense kill activity seen in the Neuse and Pamlico rivers during 2000. During the warm months of the season, investigators reported clusters of events in both waters where DO depletion and severe lesion development were common. Investigators observed more kill events and total fish mortality in the Pamlico and Neuse basins during 2000 than in any year since 1996 (Table 1). Researchers continue to investigate how past hurricane effects have contributed to fish disease and mortality.

Appendix A: Fish mortality totals by basin, 1996-2000