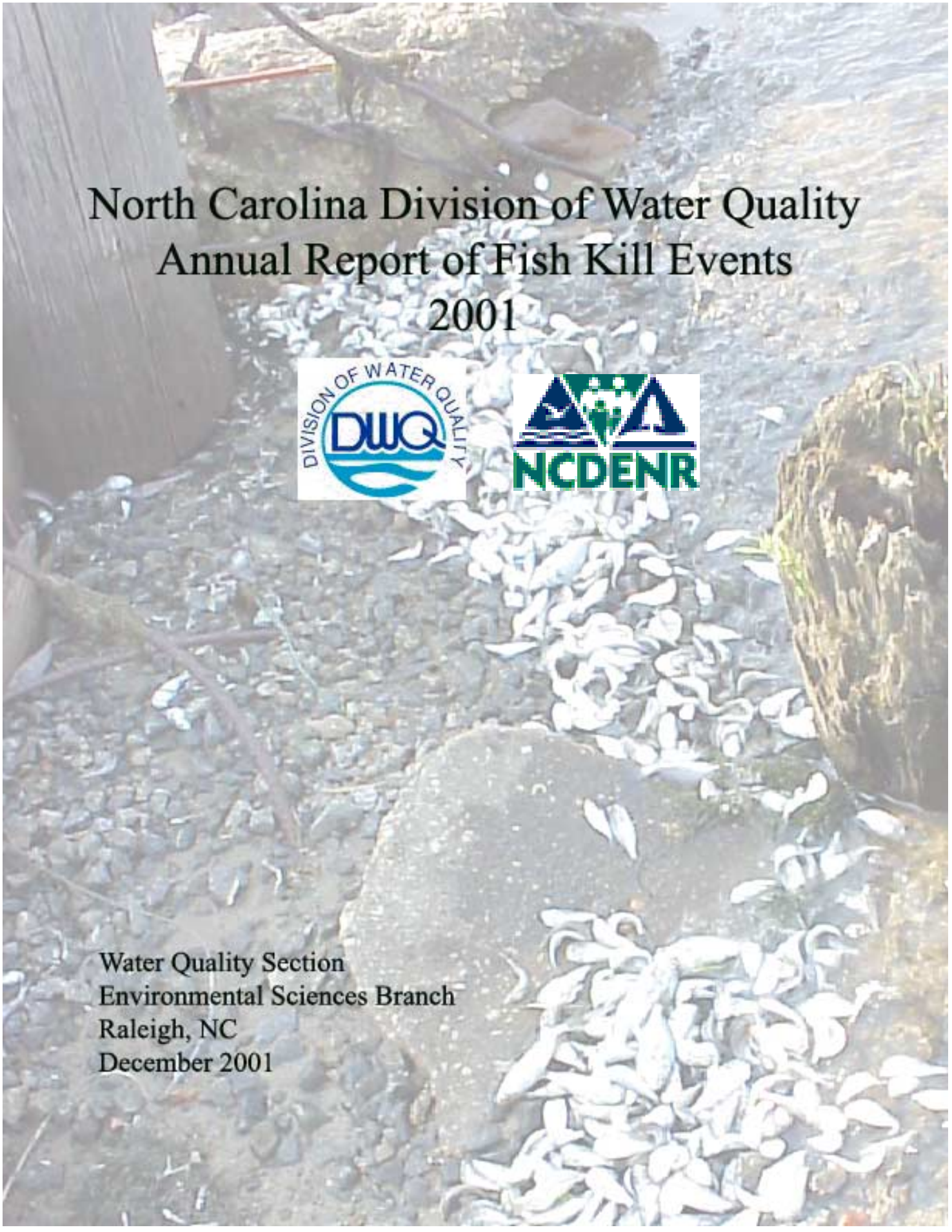


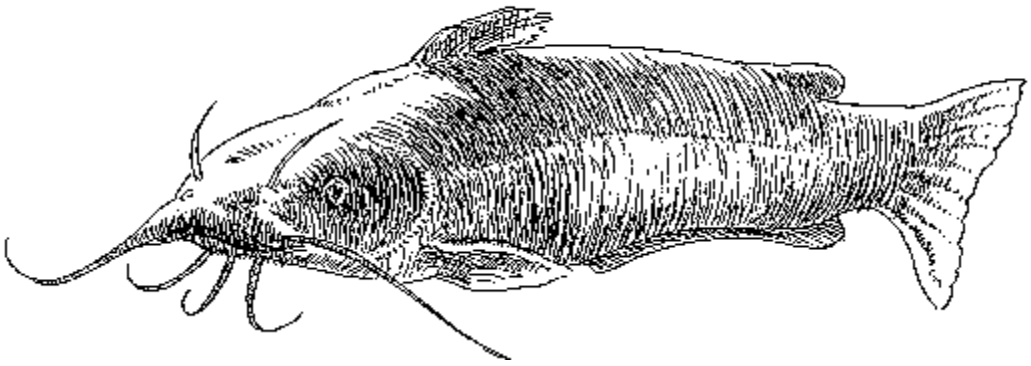
North Carolina Division of Water Quality
Annual Report of Fish Kill Events
2001

Water Quality Section
Environmental Sciences Branch
Raleigh, NC
December 2001

Introduction

The investigation of fish kill activity across the state currently involves protocols established by the North Carolina Division of Water Quality (DWQ) in 1996. 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. Data from 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/fishkillmain.htm.

This document is a summary of fish kill events reported to the DWQ from January to mid December, 2001. The report is mandated under Section 4 of Chapter 633 of the 1995 North Carolina General Assembly Session Laws.



2001 Fish Kill Summary

Field investigators reported 77 fish kill events from January to December, 2001. Kill events were reported from the coastal counties to as far west as Alexander County in 8 of the states 17 major river basins (Figure 1). The ESB tracks fish kill events when at least 25 fish are affected and when the event is confirmed by investigators.

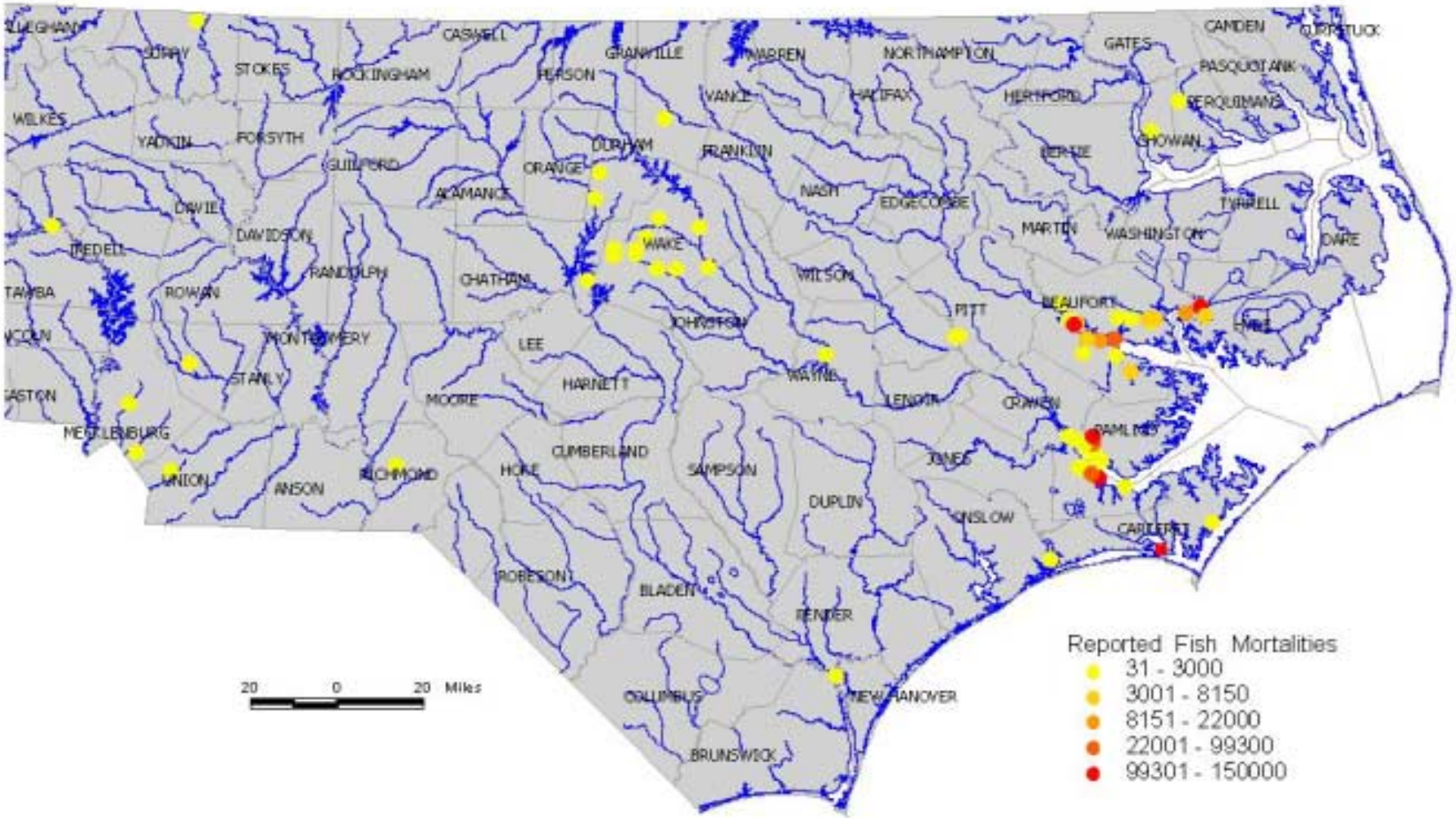
The total reported fish mortality for 2001 was just under 1.4 million. The 2001 figure is the highest mortality total since systematic fish kill reporting began in 1996. Mortality totals for individual events ranged from 31 to 162,000 with a median mortality of 1000.

Over half of the year's kill events occurred in estuarine waters during 2001. A majority of the year's mortality was a result of large coastal events in the lower Neuse and Pamlico rivers. Reports noted 48 events affecting estuarine species and 29 involving freshwater fish. No events were reported in ocean waters.

2001 Fish Kill Summary

Total Kill Events for 2001	**77**
Total Mortality for 2001	**1,369,140**
Mortality Range	**31 to 162,000**
Median Mortality	**1000**
Basins with Activity	**8 (of 17)**
Freshwater Kills	**29**
Estuarine Kills	**48**

Figure 1: Fish Kill Events Reported to NCDWQ During 2001



Basin Activity

Investigators reported fish kill events in 8 of the state's 17 major river basins during 2001 (Figure 1). The Neuse River basin produced the most activity this year with 37 events, a majority of which occurred in the upper subbasins throughout Wake County and lower subbasins between New Bern and Minnesott Beach. Fish kill activity was also heavy within the Pamlico River basin where investigators reported 23 events. Nearly all reported kill activity in the Pamlico was located in the river and tributaries below Washington and around the Pungo River. Kill reports from the Cape Fear, Yadkin, and Catawba basins were sparse. The northeastern corner of the state was relatively quiet during 2001 with only two reports from the Chowan and Pasquotank basins. The remaining basins have generally experienced light fish kill activity since 1996 and this was also the case in 2001 (Table1).

Table 1: Fish kill reports by basin, 1996 -2001

	Year					
River Basin	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Broad	None	None	None	1	None	None
Cape Fear	21	16	23	14	12	5
Catawba	None	3	1	3	2	4
Chowan	2	2	1	1	None	1
French Broad	None	2	3	1	None	None
Neuse	14	12	8	16	23	37
Lumber	4	3	5	None	2	None
Pasquotank	10	2	8	2	None	1
Roanoke	2	None	1	None	None	None
Tar/Pamlico	3	6	5	11	14	23
Watauga	None	None	None	1	None	None
White Oak	3	3	1	3	3	3
Yadkin	1	10	2	1	2	3
Totals	**60**	**57**	**58**	**54**	**58**	**77**

Note: Since 1996 no reports have been received from the New, Little Tennessee, Hiawassee, or Savannah basins.

Most reports were received during the warmest months of the 2001 season – July and August (Figure 2). These months mark the period where fish stress (especially menhaden) is at a maximum from environmental factors such as low dissolved oxygen, high water temperatures, and fluctuating salinities.

Annual totals of statewide events have generally remained consistent since 1996. Kill reports received annually for North Carolina have numbered between 54 and 60 for the past five years, regardless of yearly environmental conditions and a series of severe hurricanes. Reports received in 2001, however, increased noticeably over totals for prior years to 77. Investigators cited increased recruitment and congregation of menhaden in

Figure 2: Fish kill reports to ESB by month.

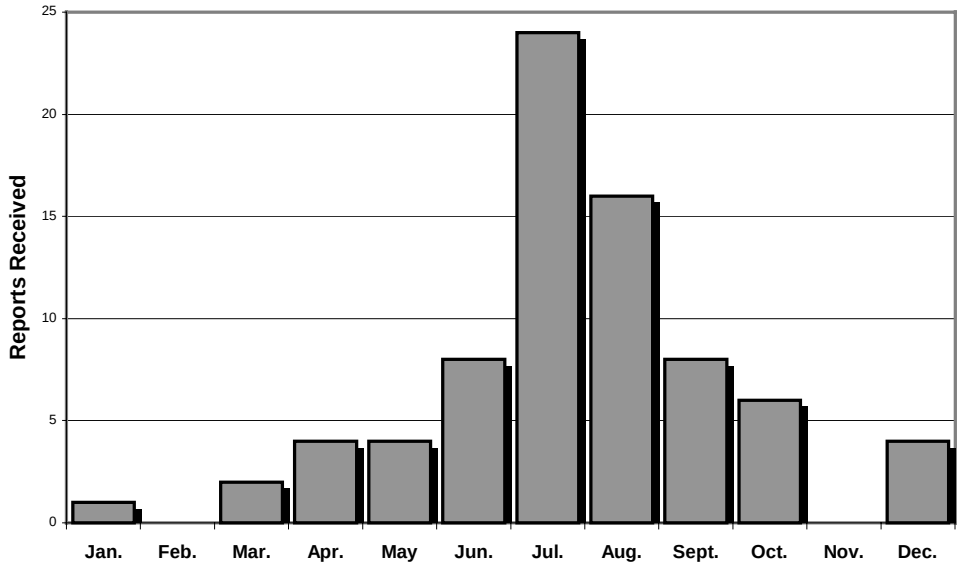
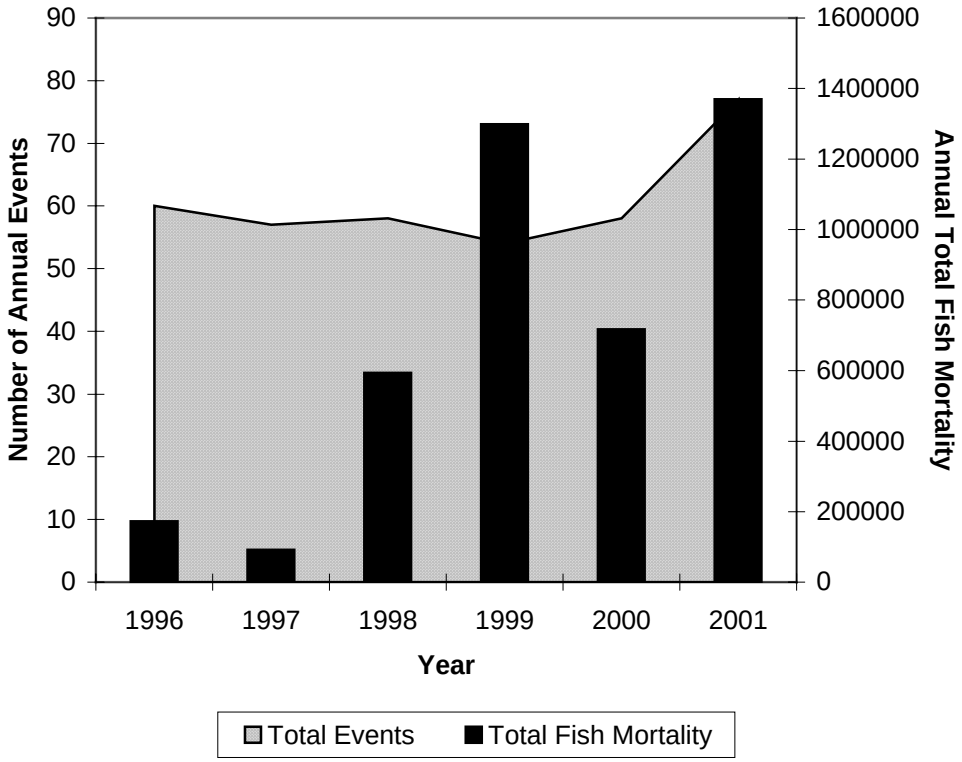


Figure 3: Reported annual fish kill events and mortality totals, 1996 to 2001



many coastal tributaries as one reason for the increase in kill reports to ESB during 2001. Menhaden were observed in large schools late in the season. Investigators suspect menhaden may have remained together upstream in many tidal creeks during the fall months due to drought conditions and subsequent high salinities. These schools were often the subject of kill reports received in September and October where investigators cited depleted oxygen levels and high incidences of disease.

Investigators also attribute increased kill reporting to better coverage of coastal events through improved cooperation with citizens and environmental groups. Investigators described a heightened awareness regarding fish kill events that translated into more timely notification of DWQ staff members and quicker responses. Detailed summaries of 2001 fish kills are presented in the Appendix.

Fish Mortality

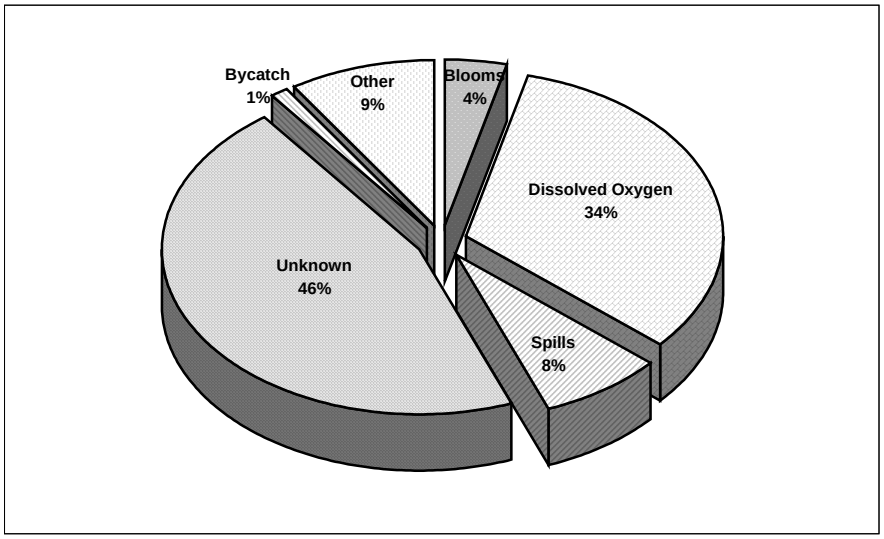
Field investigators reported a total of nearly 1.4 million fish killed during the 77 events of 2001. Reported fish mortality figures ranged from 31 to 162,000 with a median mortality of 1,000 fish. About 22% of the reported events had mortality totals exceeding 5,000 – a count used by ESB to designate a large event. Most large events reported during 2001 occurred in the Pamlico and Neuse estuaries or associated tributaries from June to October. Large fish kill events usually involved menhaden in the shoals and tidal creeks of these two estuaries. Total annual mortality figures have ranged from about 92,000 (1997) to over 1.3 million (2001) and ESB reports show an increase in annual fish mortality totals since 1999 (Figure 3).

Suspected Causes of 2001 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 2001 kill events fell into five major categories. Those events where no specific causes could be determined were assigned to a sixth “unknown” category (Figure 4).

Figure 4: Major suspected causes for fish kills during 2001



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 46% 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: Dissolved oxygen (DO) depletion was cited as a factor in 34% of the kill events during 2001. The majority of DO related kills were reported in estuarine waters during the warmest months of the year (June to September). As has been the case in prior years, the Pamlico and Neuse estuaries experienced the severest DO depletion in 2001. DO depletion prior to kill events often occurred as a result of heavy rain or following periods of drought and elevated water temperatures. Anoxic conditions also occurred in the estuaries as water column stratification depleted DO levels during the summer months. United Stated Geological Survey river monitoring stations often showed DO declining to lethal levels for fish days prior to to a kill event. Freshwater DO fish kills most often occurred following hot and dry conditions that resulted in low water levels and elevated water temperatures.

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 reported as a minor factor in the list of causes for fish kills during 2001. Blooms were suspected in just 4% of the

fish kill events for the year. Bloom related kills occurred in two small freshwater lakes as a result of enrichment or runoff. Investigators also observed an algal bloom along the Pungo River in August near a kill of menhaden. The bloom was composed mainly of nontoxic diatoms and chrysophytes.

During 2001, 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 2001 appeared as nontoxic obligate autotrophs and not forms historically associated with fish health events. Two samples, however, were suspected of containing toxic *Pfiesteria* forms. *Pfiesteria shumwayae* were detected via the UNC-Greensboro RNA probe in samples collected from a fish kill on the Pamlico River at Blounts Bay on September 28 and at Broad Creek off the Neuse River on October 5th. A sample collected on September 24 from Pamlico River near Whichard's Beach also contained questionable cells. At the time of this report, all confirmatory tests results have been reported as negative and all involved laboratories have not reported toxic *Pfiesteria* as a causal factor in any 2001 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 8% of the kill events during 2001. Spilled substances included sewage, chlorinated water, bleach, and chlorpyrifos (a pesticide). The largest spill induced kill occurred near Beaufort (Carteret Co.) during December. The release of fish wastes from a processing plant caused a kill of 162,000 pinfish in Taylors Creek.

Bycatch: Discarded fish from nearby fishing operations was reported as a cause in only one kill event during 2001. A kill of 175 striped bass was reported on the Neuse River near New Bern (Craven Co.). The fish had gill net markings near the head. No responsible party was identified.

Other: Miscellaneous causes were reported for 9% of the fish kills during 2001. These included three events caused by extremely high or low water temperature. Several coastal fish kills late in the year were attributed to drought conditions. After minimal rainfall in October and November saline water reportedly entered a number of tributaries and overwhelmed freshwater fish. Another event occurred when a lake in Cary (Wake Co.) was drained for maintenance.

Fish Species

Fish kills in 2001 involved at least 25 different species of fish across the state (see Figure 4). Freshwater species most commonly identified during investigations included sunfishes, catfishes, and largemouth bass. Estuarine species most commonly reported included menhaden and flounder. Menhaden, which have historically been the subject of large fish kills along the coast, were cited in almost half of the kill events during 2001. Menhaden also composed the bulk of the year's total mortality figure.

Additional animals were observed at about 12% 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).

NCSU College of Veterinary Medicine Pathology Results

During 2001, 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 45 fish from various sites of fish disease events and/or fish kills in the Pamlico and Albemarle systems. Fish species examined included Atlantic menhaden, croaker, sunfish, striped bass, and flounder.

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. Several fish also had hemorrhages in and around the eyes, most likely due to bacterial infection. Lesions were most common in Atlantic menhaden, although lesions seen in croaker caught in November, 2001 off a pier at Cape Hatteras were also significant. It is not known how widespread the lesion problem in croakers is at this time.

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 diseased 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.

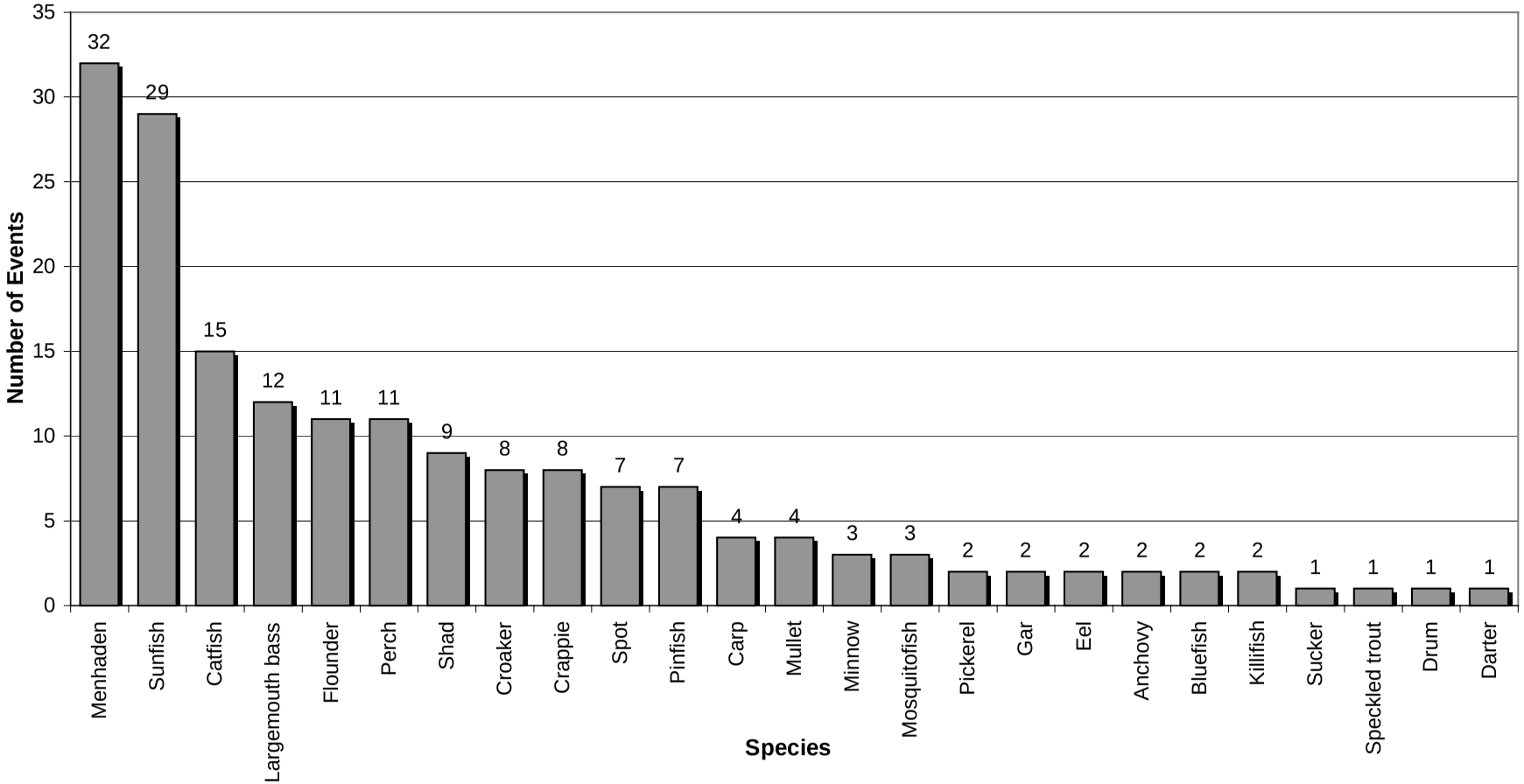
Summary

The number of fish kills reported across North Carolina during 2001 reached 77, the highest number since ESB began systematic tracking and reporting in 1996. Reported fish mortalities were also significant, totaling over 1.3 million fish, the highest total since 1996. Although events during 2001 were observed throughout the state, the majority of reports were received from coastal waters. Most kill activity was reported from the Neuse and lower Pamlico river basins. As in previous years, Atlantic menhaden were most often associated with the estuarine kill events. A cluster of events was also observed throughout Wake County in the upper subbasins of the Neuse River. 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.

Reports to ESB show a notable increase in the number of kill events and fish mortality in the Neuse and Tar/Pamlico basins during the last three years. These basins continued to experience eutrophication, stratification, and associated hypoxia, especially along shallow, poorly flushed shoals and tributaries. Coastal investigators also pointed to several factors that may account for an increase in kill reports. Anecdotal reports by investigators suggested greater recruitment and schooling of menhaden late in the year in the lower Neuse and Pamlico. Water quality measurements by investigators indicated that the dense menhaden schools seemed to deplete surrounding dissolved oxygen levels. Reports also describe higher percentages of lesioned fish associated with the schools. Secondly, better communication between ESB fish kill response teams, citizens, and environmental organizations resulted in increased coverage of estuarine events. The Neuse and Pamlico Response Teams were able to receive information on many events that they would have otherwise missed. An increase in fish kill reports to ESB may therefore have resulted from more numerous investigations of menhaden kills throughout the Neuse and Pamlico estuaries.

Although beyond the scope of this report, further analyses of fish health, water quality, and environmental (weather) data is required to explain an increase in kill reports from coastal regions across North Carolina. A better understanding of menhaden life cycles, recruitment, migration, and diseases may also help confirm observations expressed by coastal fish kill investigators.

Figure 5: Fish species observed during 2001 fish kill events



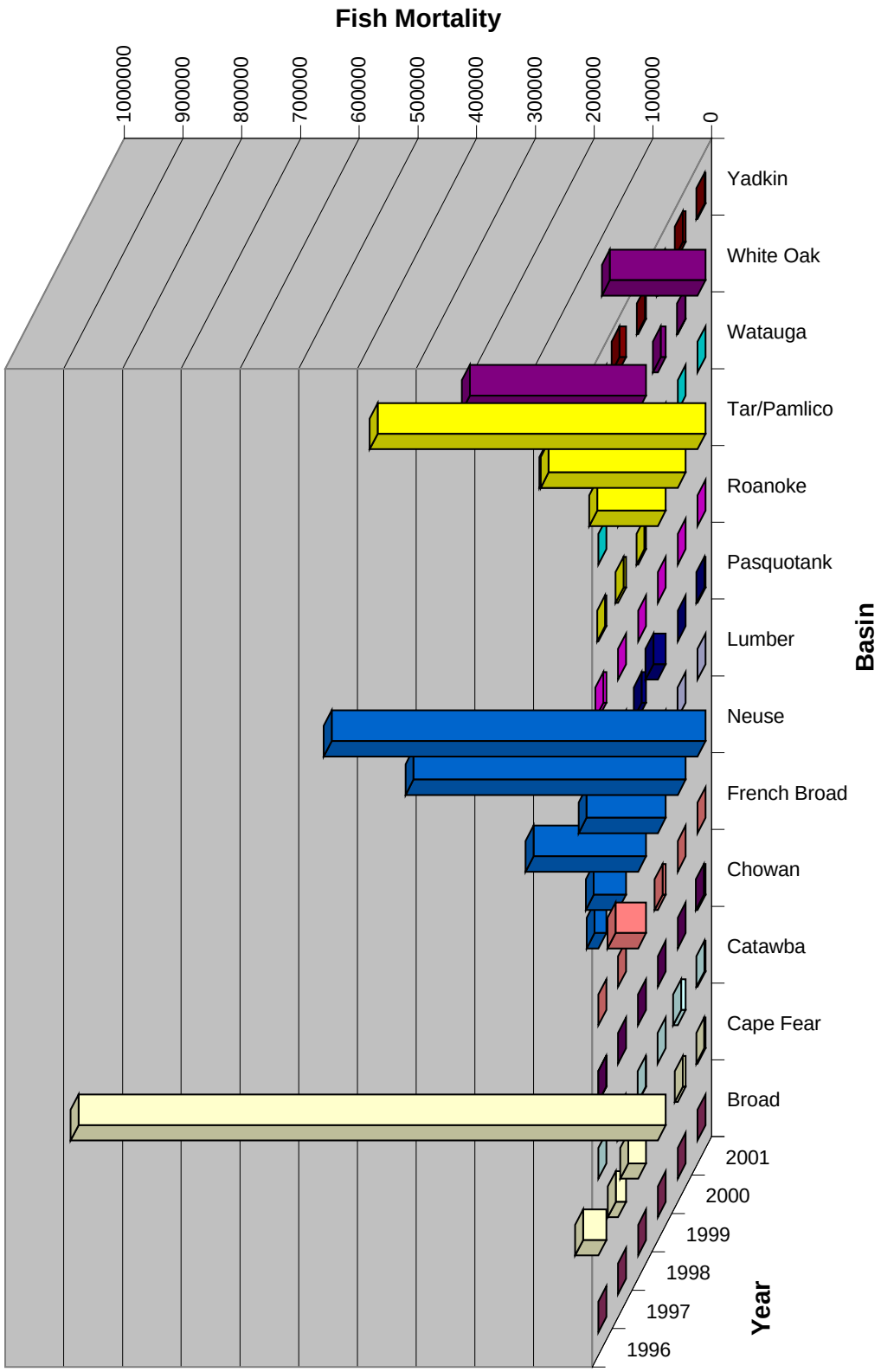


Figure 6: Fish mortality totals by basin, 1996-2001