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National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southeast Fisheries Center
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ABSTRACT

This report summarizes observations of ulcerative mycosis (UM) infections of Atlantic menhaden (*Brevoortia tyrannus*) that were made ancillary to juvenile abundance sampling and tagging activities. Varying degrees of UM infection of the 1982-86 Atlantic menhaden year classes are noted. Geographic areas of primary infection are tentatively identified and distinguished from areas where immigration of diseased individuals hypothetically occurred. Problems associated with sampling for UM incidence levels and for determining the impact on the Atlantic menhaden population are discussed.

Introduction

During spring 1984, some of the Atlantic menhaden (*Brevoortia tyrannus*) collected from the Pamlico River, NC, by the North Carolina Division of Marine Fisheries were observed to have deep, crater-like lesions. The incidence of infected fish increased during the season, with a subsequent large fish kill during November 1984, was associated with this affliction (Noga and Dykstra 1986). Pathological investigations by Noga and Dykstra (1986) of the infected individuals revealed the consistent presence of aseptate fungal hyphae associated with the lesions. They identified the hyphae as Oomycetes of the genera *Saprolegnia* and *Aphanomyces*, and thus termed the disease ulcerative mycosis (UM) (Figures 1 and 2). Additional studies of these fungi are reported by Dykstra et al. (1986).

Field sampling from several studies conducted by the National Marine Fisheries Service, Southeast Fisheries Center Menhaden Program, documented infected Atlantic menhaden over much of their geographical range during 1984 and 1985, as well as for a more geographically restricted area during 1986 (Figure 3). Observations of lesions in the caudal peduncle area were noted in April 1984. The first crater-like abdominal lesions were noted in June 1984 on fish taken from North Carolina waters, but were discounted as wounds inflicted by predators. We encountered larger numbers of lesions later in the season on fish captured in Chesapeake Bay, and samples were taken to the Virginia Institute of Marine Science (VIMS), Gloucester Point, VA, for pathological investigation. Lesions which were apparently UM of the type noted in 1984 were subsequently noted on three juvenile menhaden retained as part of a reference sample taken during fall 1982 from the Peconic River, NY.

The primary objectives of this report are to: 1) present relative estimates of UM incidence; 2) identify the areas of major infection (epicenters); and 3) discuss problems encountered in sampling to estimate disease incidence, and subsequent quantitative projections to evaluate potential impacts at the population level.

Methods and Geographic Areas of Sampling

Juvenile Atlantic Menhaden Abundance Survey: Sampling was conducted from February 1984 to summer 1986 in two North Carolina streams: Bath Creek, tributary to the Pamlico River, and Hancock Creek, tributary to the Neuse River. Two Virginia streams, Machodoc Creek, tributary to the Potomac River, and Grays Creek, tributary to the James River, were sampled from March through July 1985. Some sampling was also conducted from December 1985 into June 1986 in Juniper Bay and Long Shoal River, tributaries to Pamlico Sound, North Carolina.

The primary sampling gear used was a 6.7 m wide x 6.1 m long x 0.9 m deep surface trawl, constructed from 6 mm bar length knotted multifilament netting. The trawl was pulled at a rate of approximately 1.7 m/sec between two outboard-powered aluminum boats. A smaller ichthyoplankton surface trawl (1.2 m wide x 5.2 m long x 0.6 m deep and constructed of 3 mm bar length woven multifilament netting) deployed in the same manner and pulled at a rate of 2.5 m/sec, was also used, but only half as frequently. Since absolute areal expansions were not made from these data, catch samples for both trawls were pooled for estimates of UM incidence. Trawling was conducted at predetermined, fixed sites in each estuarine area. Sampling sites were more or less systematically arranged from the head of the estuary to the mouth.

A 4.9 m diameter monofilament cast net was used solely for sampling diseased individuals during the latter part of the 1985-86 surveys. One or more cast-net samples were taken when surface schools of menhaden were sighted.

Southern Coastal Survey: Sampling was conducted in coastal estuarine systems from northern Florida to southern North Carolina during April and June 1985. The primary sampling gear used was the ichthyoplankton trawl described earlier. A series of tows were made from upstream portions of estuarine streams, down to or near the mouths. As with the abundance survey, when discrete schools of menhaden were seen, one or more cast-net samples were taken.

Juvenile Atlantic Menhaden Tagging: Juvenile Atlantic menhaden have been captured from estuaries along the Atlantic Coast and tagged with internal ferromagnetic tags annually since 1970. The tagging activity ranged from northern Florida to Massachusetts during 1984 and 1985, but was restricted to the southwestern portion of Chesapeake Bay and tributaries of Albemarle and Pamlico sounds during 1986. During recent years, cast nets were used for collecting individuals to be tagged.

Results

The site specific levels of infection observed in the three types of sampling are given in Tables 1-5. The samples from the abundance surveys (Table 1) represent pooled samples for an entire series of tows for each stream. Some bias may occur when subsamples were used, but this rarely occurred when infected fish were involved. Trawl samples from the southern coastal surveys (Table 2) were handled in a similar fashion. Samples from the tagging trips (Tables 3-5) probably represent the least biased sampling with respect to gear; but unless some disease or anomally was observed, the tagging proceeded rather rapidly and only one side of the fish was examined. When diseased fish were encountered, subsamples were more carefully scrutinized.

Except for one trip in February to the two estuarine streams in Virginia, abundance sampling during 1984 was restricted to Hancock and Bath creeks (Table 1). Caudal peduncle lesions were noted on individuals of the 1983 year class in April 1984, from both Hancock and Bath creeks. The infections may well have been in an earlier phase in Hancock during March 1984, when discolorations in the caudal peduncle were noted. It is unclear whether or not the lesions noted on the caudal peduncle are manifestations of the same UM affliction. However, since the abdominal, anal and peduncle lesions were frequently observed together, and since the "primary stressor" for the disease has not been identified to date, we have treated the peduncle lesions as UM, but have denoted where only lesions on this anatomical site were encountered. The first abdominal ulcerations of UM were seen on 1983 year class individuals from Hancock Creek in June 1984.

During the tagging trip of late August and September 1984, UM infected individuals were found in Hancock Creek, NC, Felgate Creek, tributary to the York River, VA, and in the York River proper (Table 3). These observations were the first indications from the NMFS sampling of infection of the 1984 year class. Subsequently, infected individuals from this year class were encountered by NMFS port agents during November 1984 and January 1985[1], at the juvenile abundance sampling sites in Virginia and North Carolina during spring 1985 (Table 1), scattered along the southern U.S. Atlantic coastal estuaries in April 1985, and by June 1985 primarily in the Winyah Bay drainage of South Carolina (Table 2).

Only one infected individual of the 1985 year class was found during the juvenile abundance sampling in North Carolina in spring and early summer 1985. This individual, taken from Hancock Creek in June, was 58 mm in fork length and had a caudal peduncle lesion. An incidence of UM in the 1985 year class was found in Grays Creek, VA, in July 1985. During the tagging trip in late August-September 1985 no UM was found in North Carolina or Virginia waters, but sites of major infection were encountered in Delaware Bay (Stow Creek, NJ, and Leipsic River, DE) (Table 4).

In the abundance sampling in North Carolina waters from January into July 1986, UM infections were noted on 16 of 20 occasions when 1985 year class individuals were captured. These observations are noteworthy because no major outbreaks of UM on the 1985 year class in North Carolina waters were noted earlier, especially during the fall tagging trip. Additionally, no UM infected individuals were detected in the 1985 North Carolina fall fishery[1].

Except for two individuals taken in Bath Creek, NC, during May 1986, no UM infected individuals of the 1986 year class were encountered until the tagging trip in September 1986 (Table 5), when three infected individuals each were found in Bath and Hancock creeks. Subsequent abundance sampling in September and October 1986 in Hancock Creek found greater numbers of infected individuals from the 1986 year class.

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[1] Joseph Smith, SEFC, NMFS Beaufort Laboratory - Personal Communication.

Discussion

Sampling for UM to date has not been a statistically unbiased survey, nor been intensive enough to allow determination of absolute infection rates in menhaden. Thus, we are unable to estimate an absolute impact on the population. The major shortcomings stem from gear and geographical sampling area biases. These problems are aggravated by the distributional behavior characteristic of Atlantic menhaden.

The cast net is probably the least biased sampling gear relative to size and condition of fish captured. Since the menhaden population in a given geographic area must be viewed as composed of many separate schools, each cast-net catch represents a sample of an individual school, not the geographic population (hence a subsample within a two-stage sampling scheme).

Depending on the amount of area covered by a trawl sample, it might represent more than one school, but catches are generally biased towards fish in poor condition and/or of small size. The trawls used for the sampling reported here are not believed to be effective for unbiased sampling of menhaden greater than about 70 mm in fork length. It is common for trawl catches made in spring and summer to contain a few larger and generally debilitated individuals (Guthrie and Kroger 1974). Occasionally the trawl will have a herding and trapping effect resulting in catches of relatively large, apparently healthy fish.

It appears that a river (estuarine) system afflicted with UM may have a wide area of low incidence and pockets of relatively high incidence. Whether the high incidence areas were more environmentally suitable for manifestation of UM, or whether affected individuals tend to aggregate in those areas has not been determined. Seemingly, a behavioral modification could result from severe debilitation (Guthrie and Kroger 1974). Presence of areas of high incidence requires that a geographic-density component be introduced into any sampling scheme: sampling must include these high density areas, but cannot be restricted to them.

General conclusions regarding areas of major outbreaks can be drawn even though our sampling reported here has obvious geographical and temporal limitations. The occurrence of the disease affecting the 1984 year class of menhaden during fall 1984, probably represents sites of major primary infection. The subsequent occurrences of relatively large numbers of diseased individuals from the 1984 year class in the South Carolina area during spring 1985, on the other hand, probably represent diseased individuals that migrated from North Carolina and/or Virginia waters in winter 1984-85. This hypothesis is consistent with what is currently known about Atlantic menhaden migration and distribution (Kroger and Guthrie 1973). Additionally, no infected individuals of the 1984 year class were found in South Carolina waters during the tagging trips in September 1984 (Table 3). With the exception of one sampling site in Chesapeake Bay, the major geographic area of primary UM infection of the 1985 year class from our sampling was in the tributaries of Delaware Bay.

The occurrence of large numbers of diseased individuals of the 1985 year class captured in the Pamlico Sound system in the early half of 1986 is less easily explained. Lesions on these particular fish appeared to be too far advanced to be from a late 1985 season infection (should have progressed at least to the stage of detection in September 1985, when tagging activities were conducted in these waters). One possibility that cannot be discounted given our understanding of Atlantic menhaden biology, is that migratory schools of menhaden, probably from Delaware Bay (or an unsampled system with infection present), actually entered the Pamlico Sound system during the fall-winter migration southward. The presence of menhaden in the Pamlico Sound system of the noted size and age during the late winter - early spring time frame is normal.

Atlantic menhaden of year classes 1982-86 had some level of infection of UM. Estimates of relative incidence between these year classes and absolute incidence for each particular year class and cumulative impact on the Atlantic menhaden population as a whole are speculative. However, considering current estimates of the relative contributions from different geographic regions to the Atlantic menhaden stock and the levels of infection noted, the 1984 year class appears to be the most heavily impacted, followed by 1985, then 1983, with 1982 the least affected. It is too early to judge the relative impact on the 1986 year class.

Despite our earlier stated restrictions on data quantity and quality, the information in this report is the most geographically extensive, and apparently the least biased relative to sample collection that is available for the relatively heavily infected 1984 year class of Atlantic menhaden. Only three of 23 geographic sites visited in 1984 had signs of UM infection. The incidence level was relatively low (probably about 2%) at each site (Table 3), and two could be considered as one site. Subsequently, commercial purse-seine catches from migratory schools from the Pamlico Sound system contained UM infected fish at an incidence rate of less than 2% for a period of about two weeks during the North Carolina fall fishery in January 1985.[1]

Given other potential factors causing natural mortality and taking a population dynamics view, it is difficult to ascribe losses from the 1984 year class solely to UM even with a known incidence level of the disease. Since the UM disease apparently progresses over a relatively long time span, affected individuals are still subject to, and succumb to, the more normal sources of mortality. Young of the year menhaden of the size and age which have been found to be susceptible to UM, can be expected to sustain losses to natural mortality at a rate of 3-6% monthly (Ahrenholz et al. 1987). These losses are normally from disease (other), predation, and other factors such as low dissolved oxygen levels and can be viewed as acting more or less concurrently as competing sources of loss. For example, many individuals which may (or may not) have died from UM actually are consumed by predators. Additionally, the extensive fish kill of fall 1984 in the Pamlico Sound system (Noga and Dykstra 1986), was probably a situation of low dissolved oxygen levels (which chronically occur in this area) aggravated by the physiologically weakened condition of the UM infected individuals. There were survivors of this fish kill, as a number of UM infected individuals were subsequently taken by commercial fishing, as noted earlier.

One has to conclude that an actual fish kill would have to be extremely large to expect a noticeable level of impact to the population. For example, the number of Atlantic menhaden of a recruiting year class during late summer to early fall in the Pamlico Sound system could easily number 1-2 billion individuals. If 1% died over a period of several months, 10 to 20 million dead fish would result. This phenomenon would be very noticeable in an environmental sense, but have a much lesser impact on the population. Hence, it must be concluded that the level of UM observed in the 1984 year class in North Carolina and other areas along the coast would not likely have an appreciable impact relative to numbers of individuals at a year class recruitment level, and thus not at the population level.

This conclusion does not diminish our concern over the well-being of the Atlantic menhaden population (or other fish species) and subsequent numerical impacts resulting from UM infections, as the potential is certainly present. The inherent variability of year class size in Atlantic menhaden among years, means that a significant loss to a recruiting year class could occur and go undetected if the determination rests solely on statistical analysis from purse-seine landing statistics. Vaughan et al. (1986) suggest that only catastrophic losses (>70%) can be detected from subsequent catches of age-2 fish or virtual population analysis estimates of number of recruits at age 1. Hence, more direct sampling schemes are required to estimate losses.

A major concern is that the UM outbreaks may be symptomatic of severe environmental degradation. A number of estuarine species afficted with UM have been observed in many of the estuarine systems where infected Atlantic menhaden were observed (Noga and Dykstra 1986). This may be indicative of deteriorating environmental conditions caused by increasing levels of a variety of pollutants. Physiologically stressed individuals would then be more susceptible to disease infections and parasite infestations.

It is apparent that serious aesthetic and subsequent economic impacts will occur before the populations themselves are threatened. Due to the appearance of affected fish, a relatively low incidence and mortality rate can seriously affect the marketability of all fishes taken from affected waters, impacting both recreational and commercial interests.

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Table 1. Incidence of ulcerative mycosis from juvenile Atlantic menhaden abundance sampling. Percent of infection is in parentheses when number examined is less than 50. ST = surface trawl(s) and CN = cast net. Superscripts: a = caudal peduncle lesions only, and b = nonsevere and healing ulcers.

Location	Date	Gear	Number examined	Fork length range (mm)	Probable year class	Number lesioned	Percent	Observed salinity (o/oo)
Hancock, Ck.,	2/6/84	ST	2	71, 93	1983	0	-	8.0 - 10.0
NC		ST	3	30-32	1984	0	-	" - "
Bath Ck.,	2/10/84	ST	1	93	1983	0	-	0.0 - 7.0
NC		ST	25	25-33	1984	0	-	" - "
Hancock Ck.,	3/8/84	ST	38	64-142	1983	0	-	- 0.0 -
NC		ST	480	24-38	1984	0	-	"
Bath Ck.,	4/2/84	ST	23	73-94	1983	10[a]	(43.5)	- 0.0 -
NC		ST	864	27-41	1984	0	-	"
Hancock, Ck.,	4/18/84	ST	22	74-94	1983	1[a]	(4.5)	0.0 - 2.0
NC		ST	966	27-47	1984	0	-	" - "
Bath Ck.,	5/7/84	ST	2	87, 94	1983	1[a]	(50.0)	- 0.0 -
NC		ST	783	26-58	1984	0	-	"
Hancock Ck.,	6/4/84	ST	7	72-122	1983	5	(71.4)	0.0 - 3.0
NC		ST	177	27-54	1984	0	-	" - "
Bath Ck.,	6/5/84	ST	811	28-67	1984	0	-	- 0.0 -
NC								

Table 1. Continued

Location	Date	Gear	Number examined	Fork length range (mm)	Probable year class	Number lesioned	Percent	Observed salinity (o/oo)
Hancock Ck.,	3/11/85	ST	135	68-99	1984	0	-	0.0 - 2.0
NC		ST	292	27-59	1985	0	-	" - "
Bath Ck.,	3/13/85	ST	84	78-106	1984	10	11.9	4.0 - 8.0
NC		ST	444	28-53	1985	0	-	" - "
Grays Ck.,	3/19/85	ST	11	63-96	1984	1	(9.1)	- 0.0 -
VA		ST	810	27-47	1985	0	-	"
Machodoc Ck.,	3/20/85	ST	20	71-101	1984	0	-	0.0 - 5.0
VA		ST	95	27-34	1985	0	-	" - "
Hancock Ck.,	4/16/85	ST	810	28-53	1985	0	-	1.0 - 8.0
NC								
Bath Ck.,	4/22/85	ST	46	81-98	1984	0	-	5.0 - 8.0
NC		ST	828	26-71	1985	0	-	" - "
Grays Ck.,	4/17/85	ST	111	76-115	1984	2	1.8	0.0 - 1.5
VA		ST	667	25-50	1985	0	-	" - "
Machodoc Ck.,	4/18/85	ST	108	70-117	1984	3	2.8	0.2 - 6.0
VA		ST	900	27-58	1985	0	-	" - "

Table 1. Continued

Location	Date	Gear	Number examined	Fork length range (mm)	Probable year class	Number lesioned	Percent	Observed salinity (o/oo)
Hancock Ck., NC	5/23/85	ST	548	26-64	1985	0	-	2.0 - 12.0
Bath Ck., NC	5/24/85	ST	487	26-60	1985	0	-	0.0 - 10.0
Grays Ck., VA	5/21/85	ST	105	73-125	1984	0	-	2.0 - 3.8
		ST	866	27-70	1985	0	-	" "
Machodoc Ck., VA	5/22/85	ST	77	91-125	1984	0	-	2.0 - 8.0
		ST	1,058	29-70	1985	0	-	" "
Hancock Ck., NC	6/25/85	CN	550	77-116	1984	0	-	- 16.0 -
		CN	1,126	55-63	1985	1	0.1	- 16.0 -
		ST	3	103-112	1984	0	-	12.0 - 18.0
		ST	417	34-56	1985	0	-	" "
Bath Ck., NC	7/2/85	ST	200	38-50	1985	0	-	7.0 - 12.0
Grays Ck., VA	7/8/85	CN	348	55-84	1985	46	13.2	- 5.0 -
		ST	1,948	49-84	1985	116	6.0	2.0 - 5.0
Machodoc Ck., VA	7/9/85	ST	459	44-79	1985	0	-	6.0 - 10.0

Table 1. Continued

Location	Date	Gear	Number examined	Fork length range (mm)	Probable year class	Number lesioned	Percent	Observed salinity (o/oo)
Hancock Ck.,	12/5/85	ST	1	61	1985	0	-	0.0 - 7.0
NC		ST	1	32	1986	0	-	" "
Bath Ck.,	12/10/85	ST	286	50-76	1985	0	-	0.2 - 8.0
NC		ST	1	29	1986	0	-	" "
		CN	1,038	62-83	1985	0	-	- 6.2 -
Juniper Bay, NC	12/11/85	ST	40	25-35	1986	0	-	5.2 - 16.0
Hancock Ck.,	1/13/86	ST	5	60-90	1985	2	(40.0)	0.0 - 10.0
NC		ST	73	26-41	1986	0	-	" "
Bath Ck.,	1/14/86	ST	2	58-89	1985	1	(50.0)	6.0 - 8.0
NC		ST	50	26-38	1986	0	-	" "
Juniper Bay,	1/21/86	ST	9	79-155	1985	1	(11.1)	0.0 - 16.0
NC		ST	54	22-38	1986	0	-	" "
Long Shoal R.,	1/22/86	ST	1,022	59-115	1985	23	2.3	5.0 - 16.0
NC		ST	26	24-37	1986	0	-	" "

Table 1. Continued

Location	Date	Gear	Number examined	Fork length range (mm)	Probable year class	Number lesioned	Percent	Observed salinity (o/oo)
Hancock Ck.,	2/19/86	ST	395	56-112	1985	12	3.0	1.0 - 11.0
NC		ST	110	24-43	1986	0	-	" "
Bath Ck.,	2/24/86	ST	260	56-99	1985	4	1.5	1.0 - 10.0
NC		ST	610	22-46	1986	0	-	" "
Juniper Bay,	3/10/86	ST	296	61-118	1985	33	11.1	7.0 - 17.0
NC		ST	135	23-34	1986	0	-	" "
Long Shoal R.,	2/26/86	ST	98	58-95	1985	12	12.2	8.0 - 15.0
NC		ST	35	24-37	1986	0	-	" "
Hancock Ck.,	3/17/86	ST	27	68-112	1985	14	(51.9)	0.0 - 10.0
NC		ST	1,102	24-40	1986	0	-	" "
Bath Ck.,	3/25/86	ST	226	60-113	1985	18	8.0	2.0 - 8.0
NC		ST	675	24-40	1986	0	-	" "
Juniper Bay,	3/26/86	ST	5	75-96	1985	0	-	10.0 - 19.0
NC		ST	640	23-35	1986	0	-	" "
Long Shoal R., NC	3/31/86	ST	221	24-32	1986	0	-	8.0 - 18.0

Table 1. Continued

Location	Date	Gear	Number examined	Fork length range (mm)	Probable year class	Number lesioned	Percent	Observed salinity (o/oo)
Hancock Ck.,	4/4/86	ST	33	65-124	1985	3	(9.1)	0.0 - 10.0
NC		ST	937	22-39	1986	0	-	" "
Bath Ck.,	4/16/86	ST	149	75-100	1985	0	-	5.0 - 8.0
NC		ST	847	25-61	1986	0	-	" "
Juniper Bay	4/28/86	ST	59	21-36	1986	0	-	18.0 - 20.0
NC								
Long Shoal R.,	4/29/86	ST	123	22-32	1986	0	-	18.0 - 22.0
NC								
Hancock Ck.,	5/1/86	ST	45	86-112	1985	10	(22.2)	6.0 - 12.0
NC		ST	603	26-48	1986	0	-	" "
Bath Ck.,	5/5/86	ST	110	80-105	1985	103	93.6	8.0 - 13.0
NC		ST	1,123	25-74	1986	2	0.2	" "
Juniper Bay,	5/14/86	ST	2	34, 38	1986	0	-	18.2 - 19.0
NC								
Long Shoal R.,	5/15/86	ST	24	17-31	1986	0	-	20.0 - 22.0
NC								

Table 1. Continued

Location	Date	Gear	Number examined	Fork length range (mm)	Probable year class	Number lesioned	Percent	Observed salinity (o/oo)
Hancock Ck., NC	5/19/86	ST	3	86-115	1985	2	(66.7)	9.0 - 17.0
		ST	523	26-64	1986	0	-	" - "
Bath Ck., NC	5/27/86	ST	12	91-120	1985	11	(91.7)	8.0 - 12.0
		ST	522	23-61	1986	0	-	" - "
Juniper Bay, NC	5/29/86	CN	426	75-132	1985	0	-	20.0 - 21.0
		ST	1	38	1986	0	-	19.0 - 23.0
Long Shoal R., NC	6/9/86	ST	61	34-56	1986	0	-	18.0 - 22.0
Pungo R., NC	5/29/86	CN	214	89-125	1985	21	9.8	- 11.0 -
Hancock Ck., NC	7/21/86	ST	9	107-152	1985	0	-	12.0 - 18.0
		ST	339	42-83	1986	0	-	" - "
Hancock Ck., NC	9/17/86	CN	322	61-113	1986	23	7.1	- 4.0 -
		ST	143	66-114	1986	17	11.9	4.0 - 10.0
Hancock Ck., NC	10/29/86	CN	226	82-105	1986	17[b]	7.5	- 6.0 -

Table 2. Incidence of ulcerative mycosis from juvenile Atlantic menhaden abundance sampling in southern coastal survey, April and June 1985. Percent of infection is in parentheses when number examined is less than 50. ST = surface trawl, CN = cast net, and NR = not recorded. Superscript: a = mostly caudal peduncle lesions. Young of the year (1985) captured are not reported on this table (none were infected).

Location	Date	Gear	Number examined	Fork length range (mm)	Probable year class	Number lesioned	Percent	Observed salinity (o/oo)
Lanceford Ck., FL	4/9/85	CN	109	73-113	1984	1	0.9	- 35.0 -
		ST	162	73-79	1984	0	-	32.0 - 35.0
White Chimney Ck., GA	4/10/85	ST	2	101, 108	1984	1	(50.0)	23.0 - 26.0
Store Ck., SC	4/11/85	ST	182	100-115	1984	1	0.5	- 34.0 -
South Edisto R., SC	4/11/85	CN	408	100-114	1984	4	1.0	- NR -
Ashepoo R., SC	4/11/85	CN	241	100-114	1984	0	-	- NR -
Turkey Ck., SC	4/12/85	ST	17	73-111	1984	9	(52.9)	4.0 - 6.5
Little Pee Dee R., SC	4/12/85	ST	8	79-126	1984	6	(75.0)	2.0 - 4.0
Winyah Bay, SC	4/12/85	ST	11	82-98	1984	0	-	4.0 - 18.0
		CN	1,113	81-126	1984	23	2.1	- NR -
Calabash Ck., NC	4/13/85	ST	70	66-113	1984	24[a]	34.3	8.0 - 35.0

Table 2. Continued.

Location	Date	Gear	Number examined	Fork length range (mm)	Probable year class	Number lesioned	Percent	Observed salinity (o/oo)
Lanceford Ck., FL	6/18/85	CN	434	95-172	1983-84	0	-	31.0 - 34.0
White Chimney Ck., GA	6/19/85	CN	404	89-115	1984	0	-	- NR -
Sapelo R., GA	6/19/85	CN	1,183	91-117	1984	0	-	- NR -
Store Ck., SC	6/20/85	CN	1,171	89-122	1984	0	-	- 31.0 -
Ashepoo R., SC	6/20/85	CN	1,077	89-119	1984	0	-	- NR -
Turkey Ck., SC	6/21/85	CN	607	88-169	1983-84	49	8.1	- 8.0 -
		ST	24	85-127	1984	24	(100.0)	6.0 - 10.0
Pee Dee R., SC	6/21/85	CN	483	94-169	1983-84	39	8.1	- 5.0 -
		ST	3	107-118	1984	3	(100.0)	1.0 - 5.0
Calabash Ck., NC	6/22/85	CN	659	78-140	1984	0	-	- 35.0 -

Table 3. Observations of ulcerative mycosis during Atlantic menhaden tagging - 1984. The number examined following the symbol > represents the number tagged, but a greater number of individuals are normally captured and handled. When diseases were seen and close examination ocurred without tagging, the > symbol is omitted. CN = cast net, NR = not recorded, and ? = present at low levels but number not recorded.

Location	Date	Gear	Number examined	Fork length range (mm)	Probable year class	Number lesioned	Percent	Observed salinity (o/oo)
Childs R., MA	9/21	CN	> 898	121-162	1983-84	0	-	10.0
Peconic R., NY	9/24	CN	>1,199	112-156	1983-84	0	-	2.0
West Ck., NJ	9/26	CN	> 800	81-147	1983-84	0	-	10.0
Stow Ck., NJ	9/27	CN	>1,997	87-103	1984	0	-	10.0
White Ck., DE	9/29	CN	> 368	86-111	1984	0	-	26.0
Leipsic R., DE	9/30	CN	>1,997	65-93	1984	0	-	1.0
Chester R., MD	9/30	CN	>1,589	67-115	1984	0	-	3.0
Beards Ck., MD	10/2	CN	>2,483	70-115	1984	0	-	6.0
Choptank R., MD	10/1	CN	>1,500	89-126	1984	0	-	7.0
Onancock Ck., VA	9/28	CN	>2,195	57-75	1984	0	-	14.0
Machodoc Ck., VA	10/3	CN	>2,400	65-131	1984	0	-	5.0
Felgate Ck., VA	10/4	CN	>1,997	65-91	1984	?	?	14.0

Table 3. Continued.

Location	Date	Gear	Number examined	Fork length range (mm)	Probable year class	Number lesioned	Percent	Observed salinity (o/oo)
York R., VA	10/4	CN	1,118	60-90	1984	13	1.2	- NR -
Perquimans R., NC	10/5	CN	> 518	58-71	1984	0	-	0.0
Hancock Ck., NC	9/17	CN	>1,995	68-111	1984	?	?	4.0
New River, NC	9/6	CN	>2,500	72-95	1984	0	-	26.0
Cape Fear R., NC	9/5	CN	>2,200	87-141	1984	0	-	1.0
Calabash Ck., NC	9/4	CN	> 399	57-83	1984	0	-	18.0
Sampit R., SC	9/3	CN	> 600	80-137	1984	0	-	5.0
Cooper R., SC	9/2	CN	>1,639	71-109	1984	0	-	12.0
Dawho R., SC	9/1	CN	> 999	67-131	1984	0	-	5.0
Savannah R., GA	8/31	CN	>2,000	78-139	1984	0	-	19.0
Lanceford Ck., FL	8/28	CN	>2,799	64-107	1984	0	-	- NR -

Table 4. Observations of ulcerative mycosis during Atlantic menhaden tagging - 1985. Percent of infection in parentheses when number examined is less than 50. The number examined following the symbol > represents the number tagged, but a greater number of individuals are normally captured and handled. When diseases were seen and close examination occurred without tagging, the > symbol is omitted.

Location	Date	Gear	Number examined	Fork length range (mm)	Probable year class	Number lesioned	Percent	Observed salinity (o/oo)
Peconic R., NY	9/11	CN	>3,000	87-126	1985	0	-	5.0
West Ck., NJ	9/12	CN	>1,000	80-113	1985	0	-	18.0
Stow Ck., NJ	9/13	CN	871	95-121	1985	446	51.2	6.0
Leipsic R., DE								
(river head)	9/15	CN	>1,260	80-113	1985	35	2.8	- NR -
(near Leipsic)	9/15	CN	17	80-100	1985	8	(47.1)	- NR -
Chester R., MD	9/14	CN	>2,400	78-99	1985	0	-	6.0
Beards Ck., MD	9/18	CN	>1,999	66-97	1985	0	-	- NR -
Little Choptank R., MD	9/17	CN	>2,000	73-94	1985	0	-	14.5
Onancock Ck., VA	9/17	CN	>2,199	72-95	1985	0	-	20.0
Machodoc Ck., VA	9/18	CN	>1,499	63-76	1985	0	-	- NR -
Felgate Ck., VA	9/19	CN	>2,500	66-90	1985	0	-	22.0
Pasquotank R., NC	9/20	CN	>1,998	54-80	1985	0	-	4.0

Table 4. Continued.

Location	Date	Gear	Number examined	Fork length range (mm)	Probable year class	Number lesioned	Percent	Observed salinity (o/oo)
Bath Ck., NC	9/5	CN	>2,600	83-119	1985	0	-	15.0
Hancock Ck., NC	9/4	CN	>1,998	53-87	1985	0	-	18.0
New River, NC	9/3	CN	> 347	91-129	1985	0	-	28.0
Cape Fear R., NC	9/3	CN	>2,000	81-119	1985	0	-	7.5
Calabash Ck., NC	9/2	CN	>2,996	61-81	1985	0	-	12.0
Cooper R., SC	8/31	CN	> 795	74-105	1985	0	-	10.0
Dawho R., SC	8/30	CN	>1,057	67-99	1985	0	-	15.0
Savannah R., GA	8/29	CN	>1,061	94-113	1985	0	-	18.0
Lanceford Ck., FL	8/27	CN	>2,000	64-102	1985	0	-	- NR -

Table 5. Observations of ulcerative mycosis during Atlantic menhaden tagging - 1986. The number examined following the symbol > represents the number tagged, but a greater number of individuals are normally captured and handled. When diseases were seen and close examination occurred without tagging, the > symbol is omitted.

Location	Date	Gear	Number examined	Fork length range (mm)	Probable year class	Number lesioned	Percent	Observed salinity (o/oo)
Machodoc Ck., VA	9/3	CN	>3,400	72-87	1986	0	-	10.0
Felgate Ck., Va	9/4	CN	>2,000	68-98	1986	0	-	22.0
Pasquotank R., NC	9/5	CN	>2,600	62-80	1986	0	-	2.0
Bath Ck., NC	9/8	CN	>2,000	84-98	1986	3	<0.2	8.0
Hancock Ck., NC	9/10	CN	>2,000	99-109	1986	3	<0.2	6.0

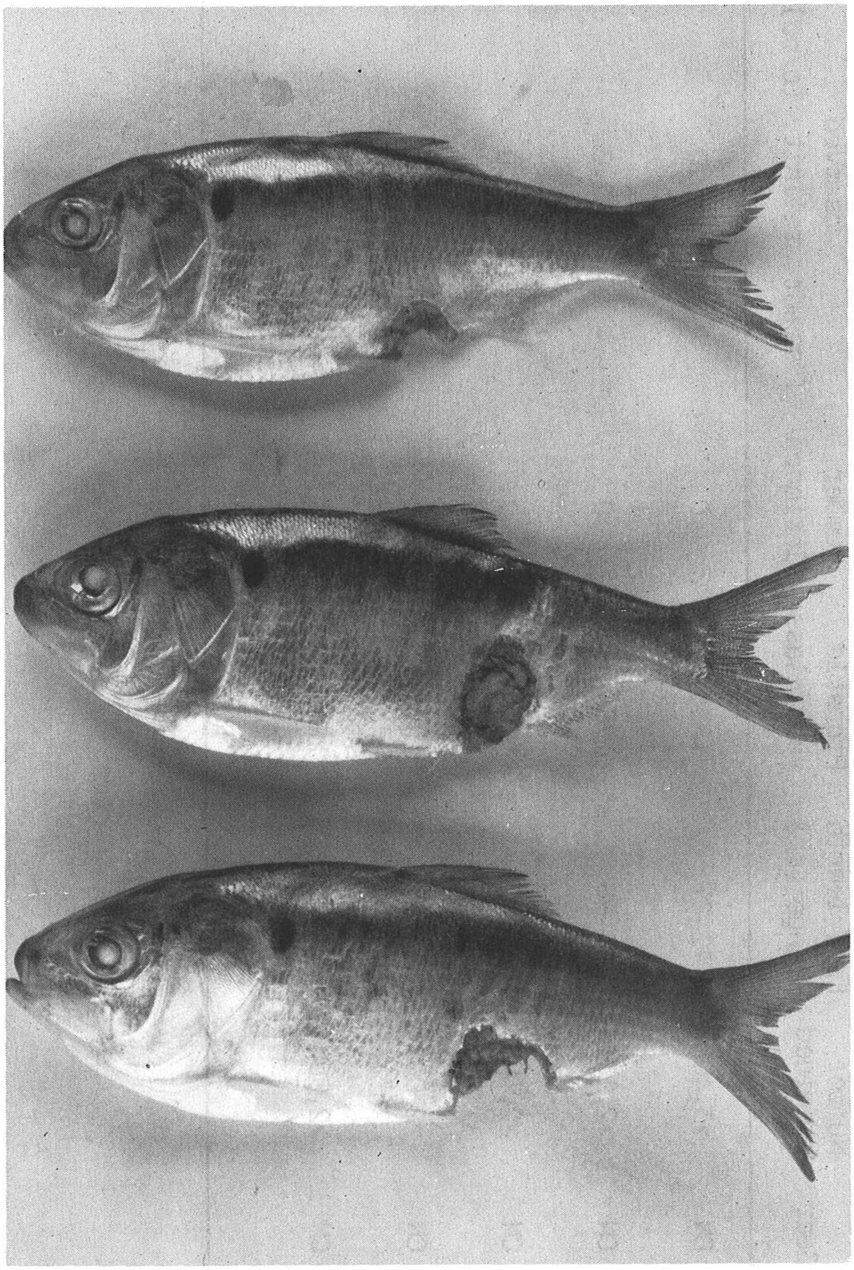

Figure 1. Ulcerative mycosis lesions on juvenile Atlantic menhaden (samples from Hancock Creek on 9/17/86).

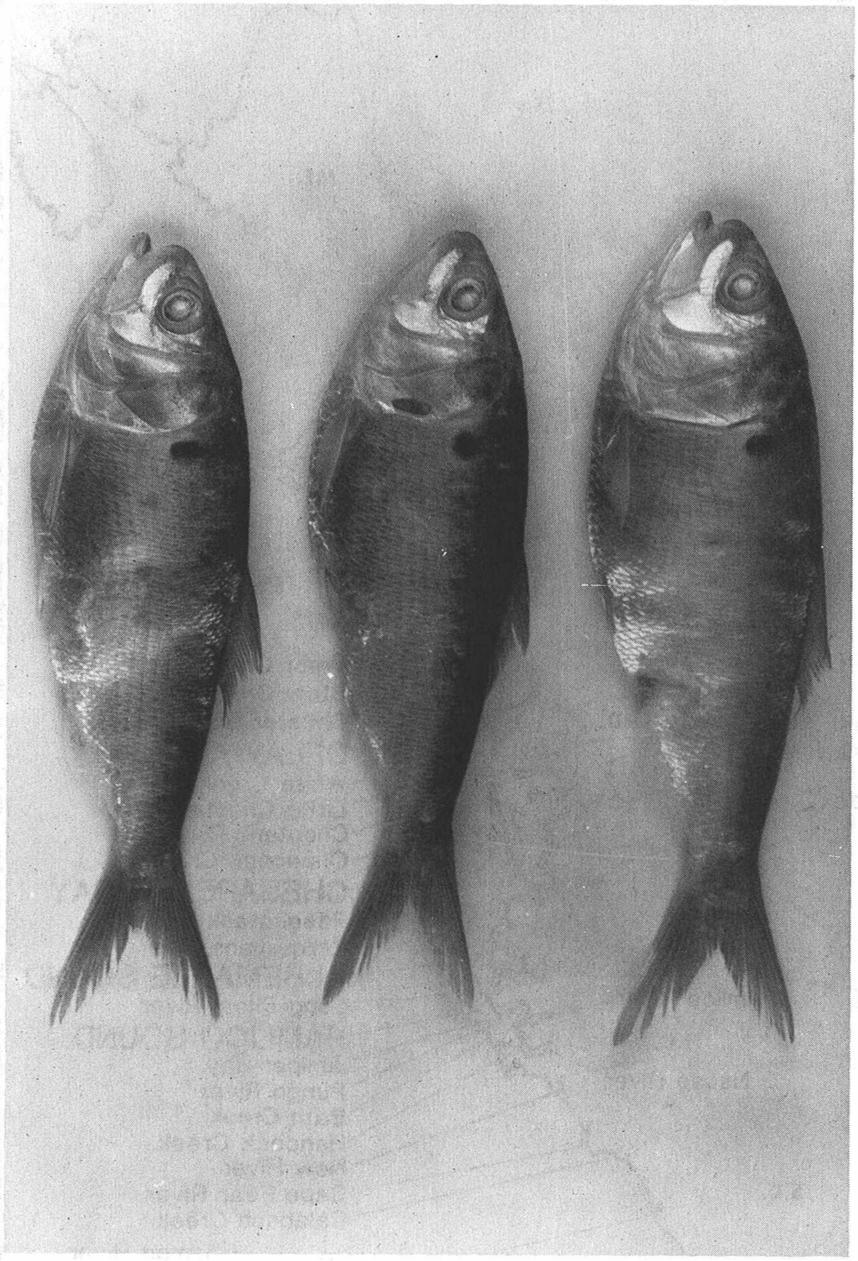

Figure 2. Juvenile Atlantic menhaden with apparent tissue regrowth at sites where ulcerative mycosis lesions normally occur (samples from Hancock Creek on 9/17/86). (Photograph is of the right side of the fish.)

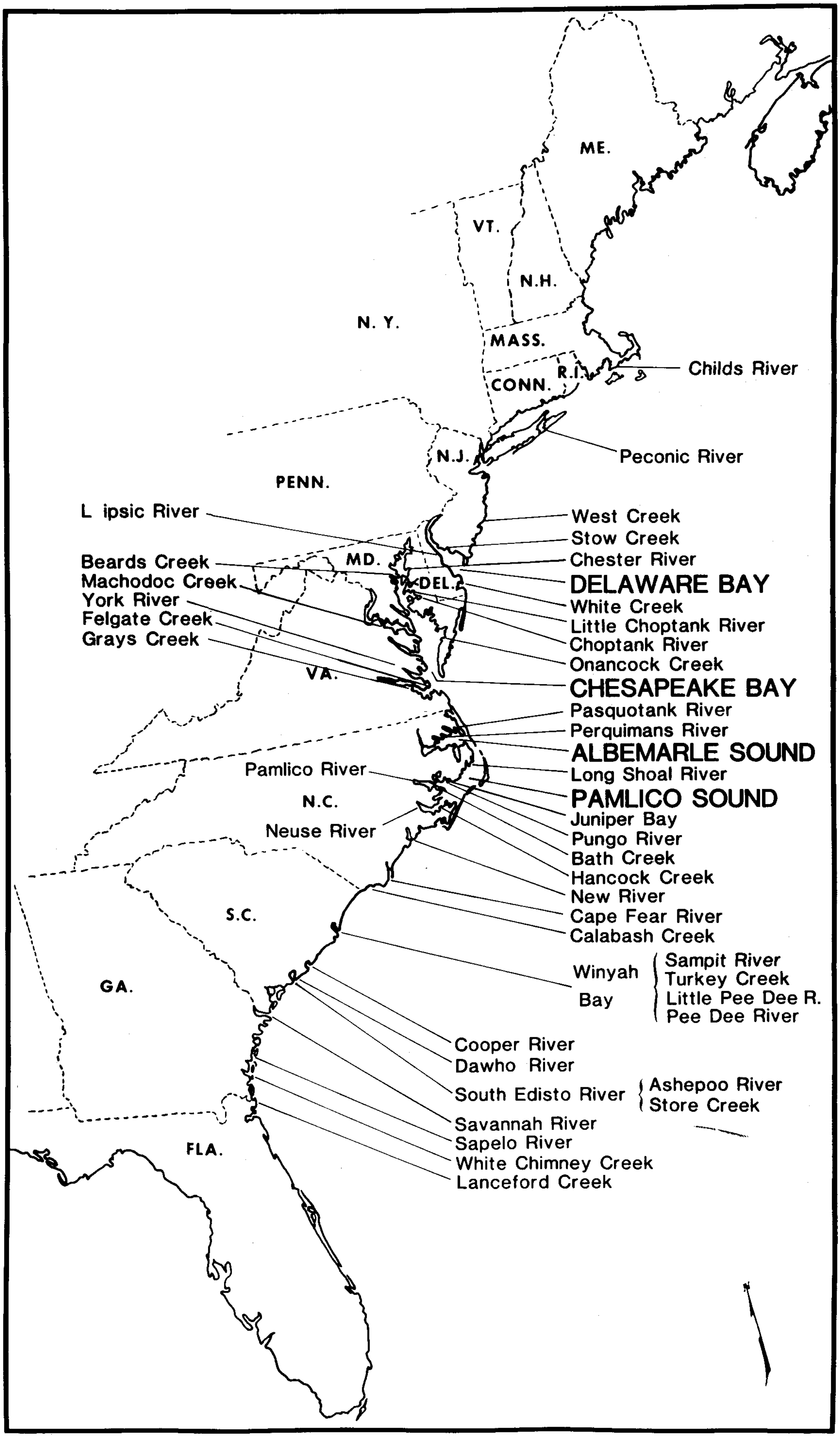

Figure 3. Juvenile Atlantic menhaden sampling sites where fish were examined for ulcerative mycosis infections.