Survey of Lake Waccamaw and the Waccamaw Watershed with Emphasis on Imperiled Fishes

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Abstract

The rare and endemic fishes of Lake Waccamaw and surrounding waters were sampled during three extended collecting trips to the area. Five species were targeted during this survey. These were: the undescribed "broadtail madtom complex" (*Noturus* sp.); the Waccamaw killifish (*Fundulus waccamensis*); the Waccamaw silverside (*Menidia extensa*); the Carolina pygmy sunfish (*Elassoma boehlkei*); and the Waccamaw darter (*Etheostoma perlongum*). We have determined that, in general, the target fishes in the lake proper are all represented by healthy populations. However, the recent invasion of the brook silverside (*Labidesthes sicculus*) may represent a future threat to the security of the Waccamaw silverside, and should be monitored carefully. The status of the Carolina pygmy sunfish seems to be precarious, with one population in serious trouble. The broadtail madtom in Lake Waccamaw is apparently secure, but the status of the "riverine form" present in the Waccamaw River could not be determined due to poor collecting conditions.

Introduction

Lake Waccamaw and surrounding environs has long been known to support an interesting assemblage of rare and interesting plants and animals. Hubbs and Raney (1946) first addressed the existence of a unique fish fauna in their description of three new species endemic to the Lake, the Waccamaw killifish, *Fundulus waccamensis*, Waccamaw silverside, *Menidia extensa*, and Waccamaw darter, *Etheostoma perlongum*. Shute et al. (1981) conducted an extensive survey of the fishes of Lake Waccamaw and the Waccamaw River drainage and summarized other data from fish surveys in the watershed. They also provided an historical, geological, and zoogeographical summary of Lake Waccamaw and the Waccamaw drainage. In addition to fish surveys, water quality parameters were measured for stations throughout the lake and surrounding drainage (Lindquist and Yarbrough, 1982). These data serve as a baseline of information to which this and future studies can be compared.

The present study was initiated to ascertain the current status of Lake Waccamaw's endemic fishes and two other rare fishes known from the Waccamaw drainage. These are the Carolina pygmy sunfish, *Elassoma boehlkei* and the undescribed broadtail madtom, *Noturus sp.*. While a large-scale quantitative survey was not conducted, qualitative sampling was used to determine if changes had taken place over the past (roughly) twenty years since the survey by Shute et al. (1981). Lake Waccamaw and the surrounding Waccamaw drainage contain one of the richest aquatic faunal assemblages found along the Atlantic Coastal Plain (Shute et al 1981), an assemblage that may be used as a key indicator for the effects of land use practices in these aquatic habitats.

Methods and materials

Surveys were conducted during spring and fall of 1998 and again in spring of 1999. A total of 56 collections or observations were made during this period. Details about collecting localities and dates are provided in Appendix 1. Most collections were made using 1.25 to 3.0 m seines with a typical mesh size of approximately 4.8 mm. Dip

nets 0.5 m square with 4.8 mm fine mesh were also used extensively in swampy areas. A 50' (15 m) bag seine was used at several sites within the lake. When conditions allowed, underwater surveys were conducted using mask and snorkel in the lake proper.

Most specimens collected with nets were field identified, counted and released. Individuals identified during snorkel surveys were also mostly identified on sight, or collected with small hand nets, identified and released. Specimens of questionable identification were either preserved in 10% formalin or were returned to our facility alive for further observation.

Results

Collection sites for this study were chosen to compliment earlier surveys (Shute et al, 1981; Lindquist and Yarbrough 1982) and to maximize the potential to locate the targeted species. Since these earlier surveys, only one new fish species has been added to the known fishes of the Waccamaw drainage. The brook silverside, *Labidesthes sicculus* (see discussion below) was first reported from the Waccamaw system by Moser et al (1998).

Shute et al (1981) provided an extensive baseline of occurrence information for the fishes of the Waccamaw system downstream as far as Conway, SC. Using these records, we are able to qualitatively compare the present population status of many of the fish species found in the Waccamaw system. We concentrated our efforts on five target species.

Noturus sp. "Broadtail madtom"

This secretive little catfish is represented by two distinct "forms" in the Waccamaw system (Shute et al 1981). The taxonomy of this undescribed madtom (or complex of madtoms) is currently under study (F. C. Rohde, pers. comm.). The form found in Lake Waccamaw proper is more compressed, with a broader head. The river form is speckled with dark spots (Menhinick, 1997) and is more slender than the lake form. The lake form is relatively abundant. Shute et al (1981) speculated that the broadtail madtom might even

be more common in the lake than the tadpole madtom, *N. gyrinus*. This species commonly occupied artificial tiles placed in the lake to study nesting of the Waccamaw darter, and regularly used them for spawning cover (Lindquist et al 1984).

We collected broadtail madtoms ("lake form") from sites 6 and 19 (Appendix 1) during the current survey. Site 6 is a beach area a little east of the dam in Lake Waccamaw (Figure 1) and is only accessible from the water. This site was surveyed in April 1998 and again in April 1999. In 1998 two broadtail madtoms were observed while snorkeling (~2.5 person-hours of effort). Both madtoms were found inside glass drink bottles. In April 1999, the site was again visited and two additional specimens were observed while snorkeling (~1.5 person-hours effort). Again, both were found in submerged drink bottles. During this survey, four tadpole madtoms were observed in the same time period, and consisted of two pairs; all were found in drink bottles.

We also collected this madtom ("lake form") directly below the low dam on Lake Waccamaw (site 19, Appendix 1 and Figure 3a) This collection was made in October 1998. High water from a recent hurricane made surveying difficult at this time; however, two specimens were collected while seining over gravel substrate, below the dam. Three tadpole madtoms were also collected.

Shute et al (1981) reported the lake form from numerous localities throughout the lake. During this present survey, our efforts were hampered by strong winds on all three trips to the lake. Because of the prevailing wind direction, the southeastern shore of the lake was essentially the only shore where snorkeling was possible. Therefore, although we were not able to adequately survey other areas of the lake for the broadtail madtom, based on our recent observations on the southeastern shore, we have no reason to believe that the species is not also stable in other areas of the lake.

The river form of the broadtail madtom is much more difficult to collect. This more slender form is not known to occur in the river upstream of Old Dock (site 20, Appendix 1, Figure 3a). We found conditions at this site suitable for surveying only once in our three trips to the area (in October 1998). No madtoms were collected at this site at that time. In fact, we only collected six species of fish then. All except *Gambusia* were represented by a single specimen! Live mussels were relatively abundant at this site.

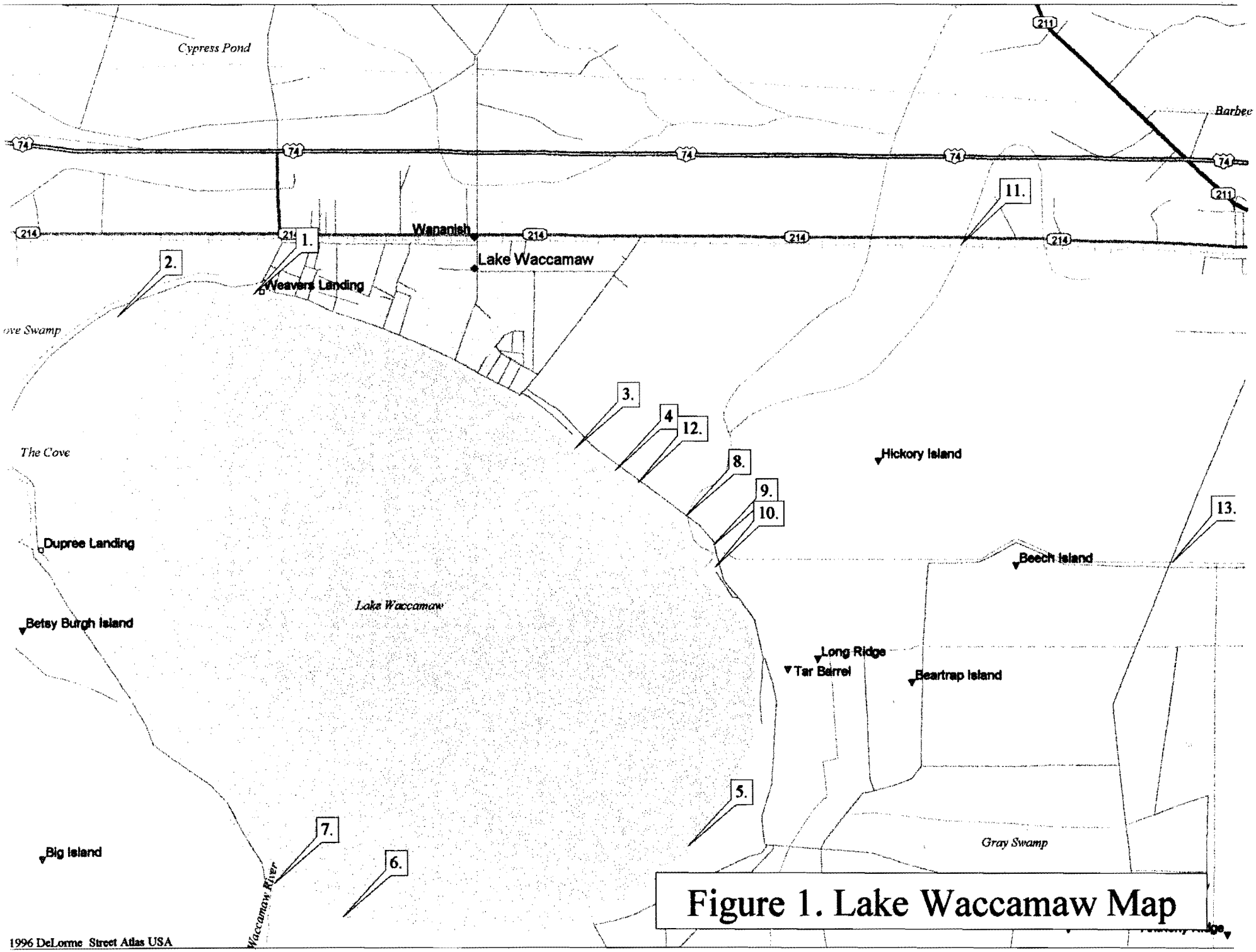

Figure 1. Lake Waccamaw Map

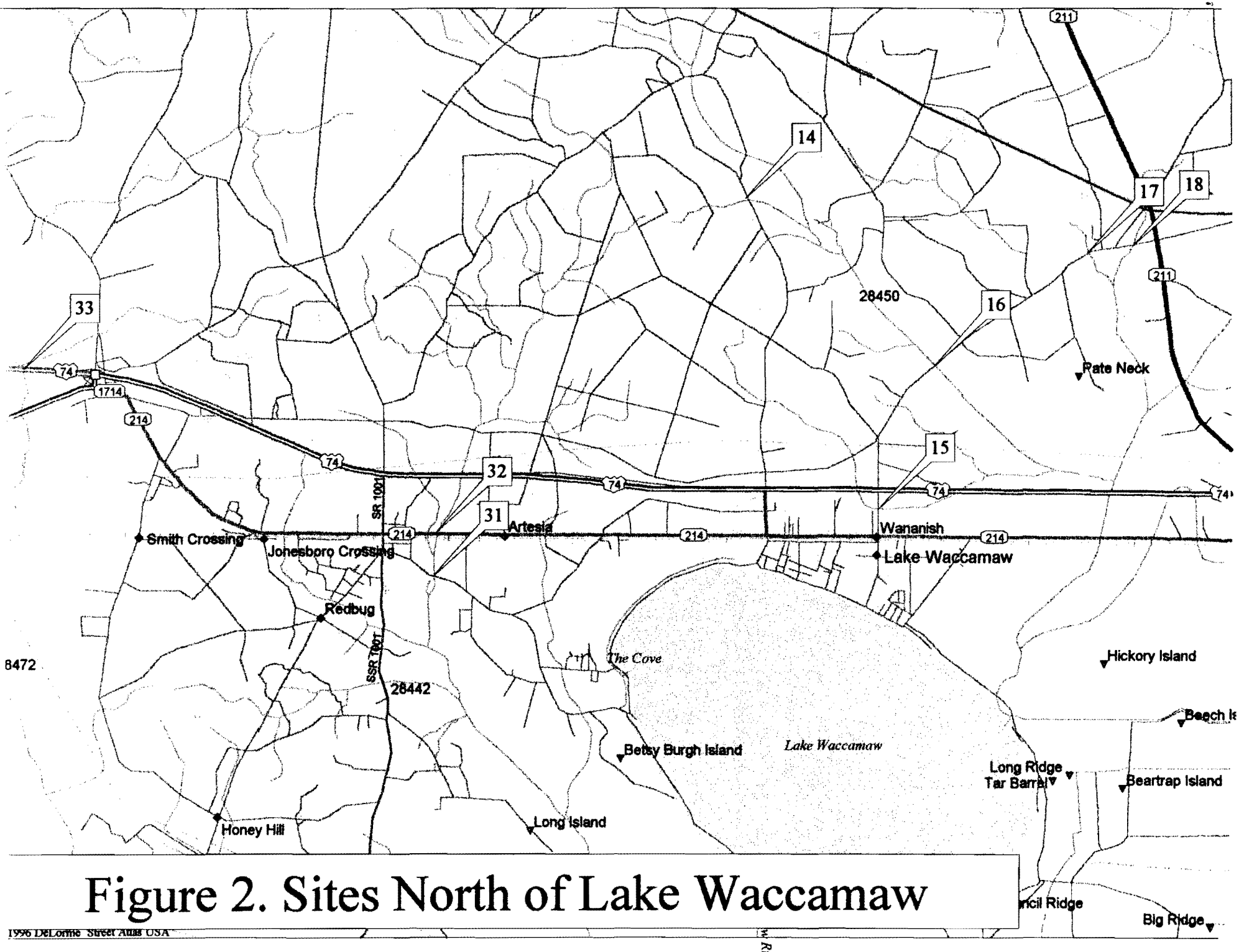

Figure 2. Sites North of Lake Waccamaw

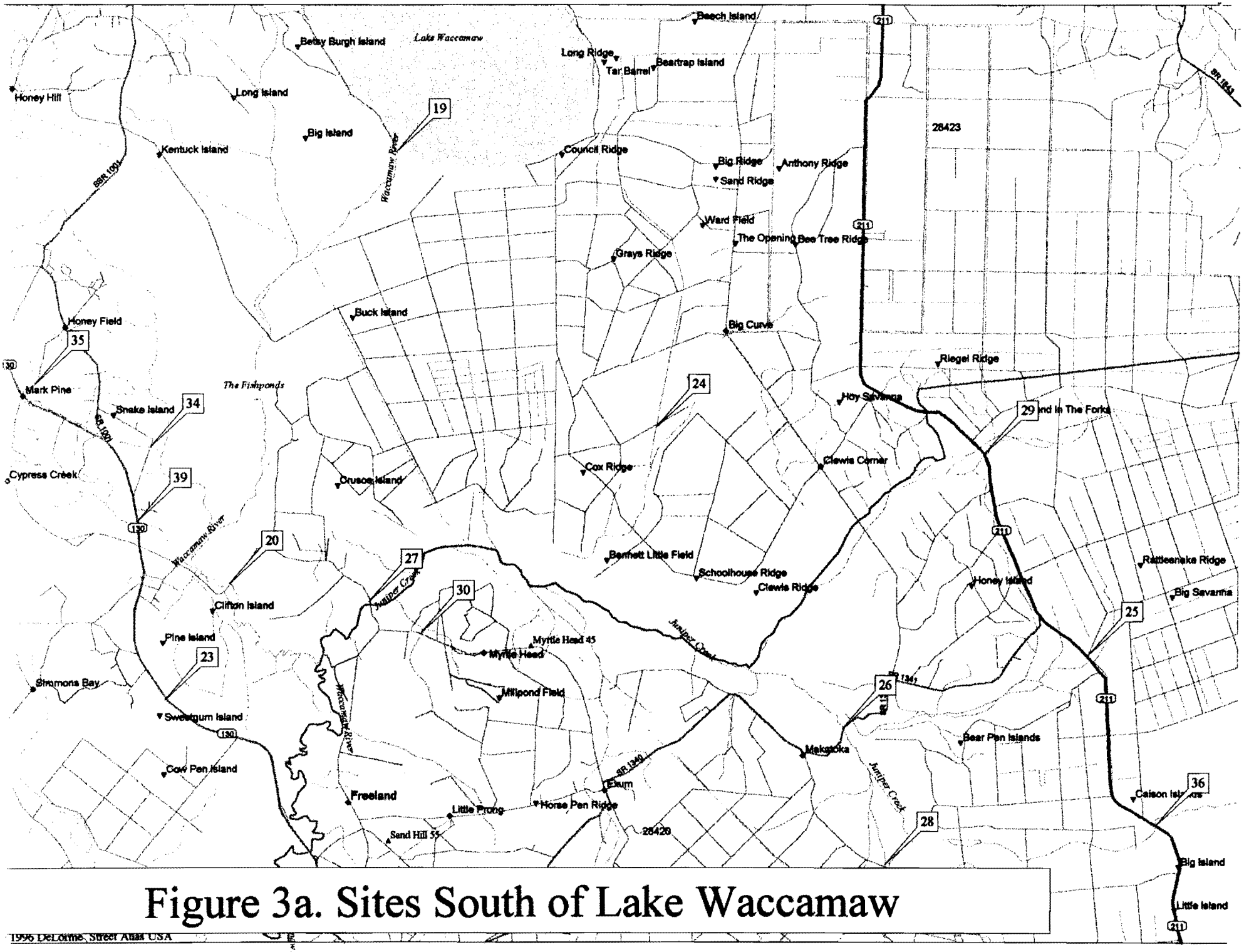

Figure 3a. Sites South of Lake Waccamaw

1996 DeLorme. Street Atlas USA

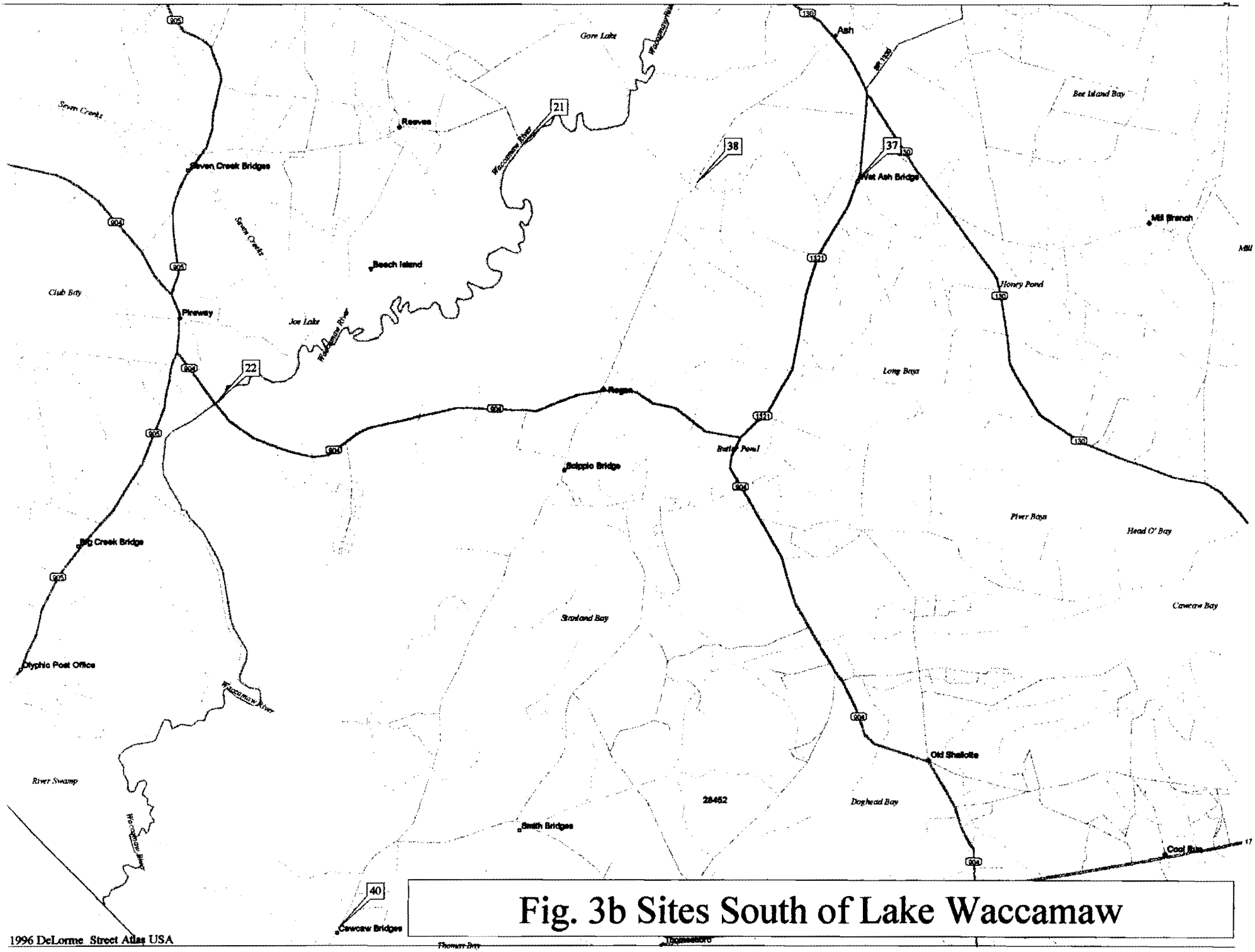

Fig. 3b Sites South of Lake Waccamaw

On our three attempts, we were never able to find the low water conditions necessary to effectively collect the Waccamaw River. As a result, no "river form" broadtail madtoms were collected. Shute et al (1981) collected the river form of broadtail madtom at several sites in the main channel of the Waccamaw River, and while it was never common at any locality, one site (north of NC Hwy. 130) yielded eight specimens in one collecting effort. F. C. Rohde (pers. comm.) has found them to be difficult to collect, not only in the Waccamaw River, but in other riverine situations as well.

With fishes as secretive as this one, population estimates are difficult to ascertain. Rohde (pers. comm.) collected one specimen from the Waccamaw River (just above our Site 20, Appendix 1, Figure 3a) as recently as July 1998. Although we do not have data to substantiate this assumption, because there have been no obvious changes in water or habitat quality in the Waccamaw River, it may be reasonable to assume that the species is still present in appropriate habitats in the Waccamaw River. However, like most madtoms, this species is believed to be extremely sensitive to poor water quality. We have seen changes in canals and other aquatic habitats in the area that may be related to extensive logging on paper company properties. Because of the amount of these holdings in the Waccamaw River watershed, we believe this madtom, and several other fishes found in the Waccamaw system are vulnerable to potentially deteriorating conditions. Numerous clear-cut areas already drain into the Waccamaw River.

***Fundulus waccamensis*, Waccamaw killifish**

Shute et al (1981) collected the Waccamaw killifish from all stations sampled within Lake Waccamaw proper. They also found this killifish to be relatively widespread in the canals immediately surrounding the lake and in lower Big Creek, especially during the winter. The Waccamaw killifish also occurs just below the dam in the headwaters of the Waccamaw River. There are no records of the Waccamaw killifish further than about 100m below the dam (Shute et al., 1981; F. C. Rohde pers. comm.).

During the present survey, we were able to collect the Waccamaw killifish at all stations sampled in the lake proper (sites 1-7, Appendix 1, Figure 1). We also found them in two of the Big Creek stations (sites 9 and 10) and just below the dam (site 19).

Waccamaw killifish were common to abundant at most sites sampled in Lake Waccamaw. Most collections were made using a 3.0 m seine. Several collections were made using a 50' (~15.0 m) bag seine. A few pulls of the seine usually yielded between 20 and 50 specimens. We usually observed several age classes. Juveniles and adults were both represented. Specimens were collected from Big Creek in April and October.

Presently, the population of Waccamaw killifish seems to be stable. All areas sampled within Lake Waccamaw with appropriate killifish habitat yielded specimens. A visual assessment of Lake Waccamaw suggests that there is still plenty of suitable habitat available for spawning and nursery areas for the killifish. The population of *Fundulus waccamensis* will probably remain secure so long as there are no significant changes in water quality within the lake or major shoreline modification.

***Menidia extensa*, Waccamaw silverside**

Waccamaw silversides are mostly pelagic and are almost never found outside of the confines of Lake Waccamaw proper. Specimens have occasionally been collected just below the dam in the Waccamaw River (site 19, Appendix 1, Figure 3a) but never more than a few dozen meters below the dam. Large schools of silversides are sometimes encountered near the shoreline, especially when the water is somewhat choppy. Shute et al (1981) suggested that the Waccamaw silverside was possibly the most abundant fish in the lake as a result of their surveys.

During the current survey, we were able to collect Waccamaw silversides at four of seven sites sampled within the lake and also immediately below the dam in the Waccamaw River, as described above. Waccamaw silversides were most abundant along the north and northeast shores of the lake. As stated earlier, this fish prefers open, choppy waters and this area of the lake is where those conditions are most often observed along the shoreline. Numerous individuals were collected with relatively little effort at sites 1, 2 and 4 (all north and northeast shore sites, Figure 1). Our surveys at one site (3) along the northeast shore did not result in any Waccamaw silversides. This site, lacking typical Waccamaw silverside habitat, is a shallow backwater, protected by an extensive cane bed with dense submergent and emergent aquatic vegetation and tannin-stained water. The fishes found at this site were also somewhat atypical for most habitats surveyed in the lake

proper. We collected: brown bullhead (*Ameiurus nebulosus*); tadpole madtom (*Noturus gyrinus*); chain pickerel (*Esox niger*); eastern mosquitofish (*Gambusia holbrooki*); Everglades pygmy sunfish (*Elassoma evergladei*); bluespotted sunfish (*Enneacanthus gloriosus*); banded sunfish (*E. obesus*); and swamp darter (*Etheostoma fusiforme*). All these fishes are usually associated with swamp habitats. Just beyond the cane beds at this site, we also collected Waccamaw killifish. Waccamaw silversides surely occur in the area beyond the cane bed, but conditions were unfavorable for seining (very windy with high waves) when we collected this site. Several specimens were taken directly below the dam on the south shore of the lake in October 1998. At least a few specimens were seen here regularly by Shute et al. (1981).

While the distribution of the Waccamaw silverside population appears to be the same as that reported by Shute et al (1981), and the population appears to be stable, a potential threat has recently been observed in the system. Another silverside, the brook silverside (*Labidesthes sicculus*), has recently invaded the Waccamaw drainage, including the lake proper.

The brook silverside was not recorded from the Waccamaw drainage by Shute et al (1981). It was first reported in the Waccamaw system by Moser et al (1998). They speculated, and we agree, that the species was most likely a natural invasion, and not introduced into the system by humans. However, their invasion has apparently been extremely rapid. We can say with relative confidence that brook silversides were not present in the Waccamaw system when our original surveys were conducted in the late 1970s. During that earlier survey, many sites within the lake and throughout the river system were surveyed on a monthly basis and no brook silversides were ever collected. Brook silversides were not known north of the Santee Drainage in South Carolina (Lee 1978) at that time. Since that time, however, brook silversides have apparently invaded the Waccamaw drainage essentially to the headwaters, as they've been collected at sites 2, 3, 4, 6, 7, 10, 11, and 19 (Appendix 1, Figure 1 and 3a).

The primary concern with this recent invasion is the uncertainty of its ecological relationship with the endemic Waccamaw silverside in habitats in the lake proper. We found brook silversides at nearly all stations sampled within the lake (see above). They were also taken at site 19, just below the dam and at two sites in Big Creek (Sites 10 and

11). In some cases, these were observed in the same habitats as Waccamaw silversides, but in most collections, we observed what may be habitat segregation between the two species. Brook silversides were most often found in areas with at least some aquatic vegetation present. They were often collected in, or adjacent to, the cane beds that borders much of the lake's shoreline. Waccamaw silversides are almost always collected in open areas, with little or no vegetation. Brook silversides are certainly well established in the lake. Removal does not appear to be an option.

Moser et al (1998) collected brook silversides below the dam at Lake Waccamaw and at several sites further south in the Waccamaw River and tributaries in 1995. They did not collect any specimens within the lake or in tributaries above the lake. They only collected 42 specimens throughout the Waccamaw drainage after what appears to have been rather extensive sampling using seines, electrofishing and ichthyocides (Moser et al 1998). We counted more than 40 specimens from six sites (all total) in the lake and just below the dam using only seines or direct observation. We listed them as "abundant" (50 or more) at two additional localities in Big Creek. This would suggest that the species is experiencing a rapid increase in the upper Waccamaw drainage.

***Elassoma boehlkei* Carolina pygmy sunfish**

The first collection records of the Carolina pygmy sunfish date to the 1950's but it wasn't recognized as a unique taxon until the late 1960's (Rohde and Arndt 1987). Shute et al (1981) collected this species (listed as *Elassoma* sp.) from two general areas within the Waccamaw drainage. Big Creek is the primary feeder to Lake Waccamaw (Figure 1). One site at a drainage canal connected to Big Creek (site 9) had consistently yielded specimens of the Carolina pygmy sunfish during collections in the 1970's (Shute et al 1981). Several specimens were collected there during this survey. However, a considerable effort was expended in order to collect these. Only a few specimens (four) could be collected, and these were only collected on one of the three visits to the area (April 1998).

Three specimens of the Carolina pygmy sunfish were reported by Shute et al (1981) from a drainage ditch (Mainline Canal, Figure 1) east of Lake Waccamaw and Big Creek. We made several attempts to collect more specimens from this site (site 13) , but

were unable to document the presence of Carolina pygmy sunfish at this locality during the current survey. Conditions at this site had deteriorated in the years since that first collection, primarily due to poor timber harvesting practices. It seems unlikely that the Carolina pygmy sunfish still occurs in that area.

A portion of the Juniper Creek watershed is the other area where Shute et al. (1981) reported this species. We visited five sites in the Juniper Creek watershed (sites 24, 25, 26, 27, 28) and found Carolina pygmy sunfish present at two of these (sites 26 and 27). At site 26 only a single reproductively spent female was collected in April 1998. However, during the October 1998 collection, the species was relatively abundant (at least 12 individuals were collected there). At site 27, 15 specimens were collected in April 1998 and seven in October 1998. In April 1999, five very large (old) individuals, numerous larvae and very young juveniles were collected. Three different habitat types were surveyed at this site (27): a borrow pit; the main channel of Juniper Creek; and a drainage canal across the road from the borrow pit. In past years (see Shute et al. 1981), the pygmy sunfish had been most abundant in the borrow pit. Specimens were almost never taken from the main channel of the stream and the canal across the road produced only a few individuals.

During the present sampling survey, specimens were taken in the borrow pit only once (April 1998) despite considerable effort on three occasions. Also during the April 1998 collection, several specimens were taken in the main channel of the creek and several more in the canal across the road. Males and females were all sexually mature and in high breeding condition, indicating that spawning was imminent.

In April 1999, a number of larval pygmy sunfish were collected from this same site. Since these individuals were too small to be identified to species, they were returned to CFI aquaria for rearing. They have been added to our captive population. At the time of this writing, all specimens are adult. Of the nine individuals reared to adulthood, five were Carolina pygmy sunfish and four were banded pygmy sunfish (*E. zonatum*). Although banded pygmy sunfish have been collected from other sites in Juniper Creek, this is the only time they have been reported from this locality. No adults were collected and Shute et al. (1981) did not report any from here.

We concentrated our search for additional populations of Carolina pygmy sunfish in swamps of the Juniper Creek watershed, Waccamaw River, tributaries and swamps feeding into Lake Waccamaw, and the upper Waccamaw drainage north of the lake. Larval pygmy sunfish were collected from two tributaries of the Waccamaw River in North Carolina, Wet Ash Swamp (site 37 Appendix 1, Figure 3b) and Caw Caw Branch (site 40). These were returned to the CFI facility to be reared for identification. These were later all identified as banded pygmy sunfish. Rohde (pers. comm.) has collected Carolina pygmy sunfish from the Wet Ash Swamp locality in the past. Shute et al. (1981) collected banded and Everglades pygmy sunfish (*E. zonatum* and *E. evergladi)* from this site, but no Carolina pygmy sunfish. At present, the significance of these observations is unknown, especially the potential results of ecological interactions between the three pygmy sunfishes on the distribution and abundance of Carolina pygmy sunfish.

***Etheostoma perlongum*, Waccamaw darter**

Shute (1984) studied the taxonomy of the Waccamaw darter and its relationship to the *Etheostoma olmstedi* complex. He determined that the Waccamaw darter, described as *E. perlongum,* was an ecomorph of the tessellated darter, *E. olmstedi,* and that morphological differences observed between the two probably resulted from environmental influences within Lake Waccamaw. Therefore, although we do not recognize the "Waccamaw darter" as a species, we will continue to refer to the Waccamaw darter as *E. perlongum* for the purposes of this report. However, we would like to re-emphasize (see Shute 1984) that the lake population is unique from other *E. olmstedi* in the Waccamaw River and elsewhere.

Shute et al. (1981) reported the Waccamaw darter from all stations sampled in the lake as well as immediately below the dam. We collected the Waccamaw darter from five of seven sites sampled in the lake during the present survey. They were also collected immediately below the dam. The two sites that did not produce Waccamaw darters in the lake were the two sites with swampy habitats along the northeast shore (sites 3 and 4). Numerous nests were seen during each of the April surveys, especially along the shore east of the dam (site 6) where more than a dozen nests were seen while snorkeling in April

1998. In October 1998 more than 50 individuals were seined in less than 30 minutes at site 2 along the north shore of the lake.

Several large storms (in 1998 and 1999) with accompanying high winds have apparently blown much woody debris into the lake. Over the next few years, this debris should provide additional spawning substrate for the Waccamaw darter. Lindquist et al (1981) demonstrated that the Waccamaw darter would readily accept nearly any cover provided as a spawning substrate, and suggested that shortage of spawning cover might be a limiting factor for the Waccamaw darter.

Discussion and Conclusions

Nearly twenty years ago the North Carolina Wildlife Resources Commission, with funding from the U. S. Fish and Wildlife Service, contracted biologists to survey the unique biota of Lake Waccamaw. The primary purpose of that study was to determine the status of the endemic fishes and mollusks of Lake Waccamaw with regards as to whether any, or all, should be listed under the Endangered Species Act of 1973. As a result of that study, only the Waccamaw silverside is presently federally protected (U. S. Fish and Wildlife Service. 1987). It is listed as "Threatened" with Lake Waccamaw and a small portion of Big Creek listed as "Critical Habitat".

In the report resulting from this study Lindquist and Yarbrough (1982) stated that the endemic fish populations seemed to be stable and their habitats appeared to be adequately healthy to continue to support their continued existence. They did caution, however, that nutrient loading rates and algal pollution indices indicated that Lake Waccamaw was in the "danger zone" and was "mildly eutrophic". They recognized two basic threats to the continued health of the Waccamaw system: habitat destruction and alteration; and further deterioration of water quality that might result in eutrophication of the lake (Lindquist and Yarbrough 1982).

We would like to re-emphasize these threats. Indiscriminate development, poor agricultural practices and unregulated logging of the surrounding wetlands could have a

significant effect on the health of the Waccamaw watershed. Run-off from the canals draining the land on the northern side of the lake has a direct effect on the water quality in the lake. This is evident every time there is a major rain event in the area. The color of the lake can change dramatically as a result of increased input from Big Creek and the surrounding swamps. Herbicide, pesticide and/or fertilizer run-off could drastically alter the planktonic component of the lake. This, in turn, could have a profound effect on the fish and mussel communities. These potential threats were also recognized in the recovery plan for the Waccamaw silverside (U. S. Fish and Wildlife Service 1993).

In Lake Waccamaw proper, with the exception of the Carolina pygmy sunfish (more discussion below) and the "riverine population" of broadtail madtom, noted below, the status of the endemic fish populations do not seem to have changed much over the past twenty years. During our brief visits, we found the endemic fishes readily collectable or observable in the lake. Because of poor collecting conditions, we were unable to make a determination on the "riverine population" of broadtail madtom. Following is a more detailed discussion of each of the target species.

***Noturus* sp. "Broadtail" madtom**

The Lake Waccamaw form of the broadtail madtom appears to be present in good numbers within the lake. Choppy water and higher than normal turbidity made snorkel observations nearly impossible during all three of our visits to the area. Despite these poor conditions, we were able to locate several specimens of this madtom, both in the lake and directly below the dam in the Waccamaw River. If there is no deterioration of habitat or water quality conditions within the lake, the broadtail madtom should continue to thrive.

Unfortunately, information regarding the "riverine form" of the broadtail madtom was essentially unobtainable, and we cannot assess the current status of this madtom. As described earlier, the water level in the Waccamaw River was high during all three visits we made to the area. However, on the one occasion, we were able to collect one site (site 20) reasonably well, no broadtail madtoms, and indeed very few fish, were collected. Shute et al. (1981) reported a total of 18 species taken at this site, including the broadtail madtom.

We reviewed field notes from the original (1979-81) surveys, and observed that the broadtail madtom was rather widespread in the Waccamaw River at that time. Specimens were collected from the site (20) mentioned above and as far down river as Horry Co., SC. It is also apparent from these notes that some of the best collecting sites were accessible only by boat (i.e., not at bridge crossings). In spite of several efforts, F. C. Rohde (pers. comm.) has only been able to collect the broadtail madtom once in recent years (just upstream of our site 20). This is certainly a fish that deserves careful monitoring. We suggest a series of float trips down the Waccamaw River when water levels are appropriate for efficient surveys to ascertain the current population status of the riverine form of the broadtail madtom. Like most other madtoms, the broadtail is almost certainly vulnerable to habitat and water quality alterations that may result from extensive logging operations. We observed several extensive, large clear cuts adjacent to the Waccamaw River which might be a threat to this species. When the taxonomy of the "broadtail madtom complex" is resolved, one or more of the resultant taxa should probably be considered as candidates for federal protection. It is currently considered as a species of Special Concern in North Carolina (Menhinick 1997).

***Fundulus waccamensis*, Waccamaw killifish**

Of all the endemic fishes of Lake Waccamaw, the Waccamaw killifish may be in the best shape in terms of distribution and abundance. The Waccamaw killifish occurs throughout the lake, below the dam, and during the colder months of the year, it regularly invades the surrounding canals and Big Creek. Most of our collections from the lake yielded 30-50 individuals, sometimes more. Aside from general deterioration of water conditions in the lake, the only foreseeable threat to the Waccamaw killifish would be shoreline alteration. This killifish requires shallow, lightly vegetated, sandy shorelines for spawning. Larvae and juveniles also require a similar habitat. At present, these habitats are abundant, and much of the shoreline containing these habitats are protected by State Park properties, and are unlikely to change in the near future.

***Menidia extensa*, Waccamaw silverside**

As stated previously, we believe the Waccamaw silverside population in the lake is reasonably healthy. The looming question about how (or if) the recent invasion of the brook silverside may affect Waccamaw silverside populations remains unanswered. For example, competition for resources between adults, juveniles or larvae of the two silverside species could be a threat to the Waccamaw silverside, or hybridization may be a concern.

The Waccamaw silverside recovery plan (U. S. Fish and Wildlife Service 1993) lists invasion or introduction of non-native species as one of the threats to the continued existence of the silverside population.

Our preliminary, purely qualitative, observations seem to demonstrate that there may be some differences in habitat preferences between the two silversides. Waccamaw silversides seem to prefer open water habitats. Brook silversides appear to be found more often in association with aquatic vegetation and in calmer, more sheltered areas. They were also found in Big Creek and some of the adjacent canals. Waccamaw silversides have never been found in Big Creek or these canals.

Since it is not feasible to remove the brook silverside from the system, we make several recommendations. A captive population of Waccamaw silversides should be established, in the remote possibility that brook silversides may hybridize with the resident Waccamaw silversides and pollute their gene pool or that brook silversides are at a competitive advantage and displace the Waccamaw silverside population. This recommendation was also presented in the Waccamaw silverside recovery plan (U. S. Fish and Wildlife Service 1993). At the very least, we feel like efforts should begin immediately to secure pure genetic stock and to develop captive propagation protocols for this highly restricted species. Status surveys monitoring the changes in population structures of the two silversides in Lake Waccamaw should be conducted regularly, as was also suggested in the recovery plan (U. S. Fish and Wildlife Service 1993).

***Elassoma boehlkei*, Carolina pygmy sunfish**

This beautiful little pygmy sunfish has a much more limited distribution than any of the other target fishes. Shute et al. (1981) reported the species from two areas within the

Waccamaw drainage. This was supported by the findings of Rohde and Arndt (1987). We were unable to locate any additional populations during the current survey, despite a concentrated effort to do so. Not only were we unable to locate additional populations, it appears that the Big Creek population has declined significantly, or may have been extirpated.

The site (site 9) on Big Creek that supported a relatively strong population in the late 1970's and early 1980's (pers. obs.) was sampled during each of our visits to Lake Waccamaw. In April 1998, only four specimens of Carolina pygmy sunfish were collected after approximately 30 minutes of effort. The second visit (October 1998) yielded no specimens after 30 minutes of effort. During the third visit 45 minutes were spent searching, but no Carolina pygmy sunfish were collected. We reviewed field notes from 1979-81 of collections from this site. Examples of data from these field notes include: 10/06/79, six *E. boehlkei* collected in 10 minutes; 10/19/79, seven *E. boehlkei* collected in 10 minutes; 03/14/80, four *E. boehlkei* collected in five minutes (15 dips of the net); 04/09/80, seven *E. boehlkei* collected in <15 minutes; 08/19/80, 25 *E. boehlkei* collected in 15 minutes; 12/10/80, five *E. boehlkei* collected in five minutes; 01/12/81, six *E. boehlkei* collected in 12 dips of the net; 02/20/81 11 *E. boehlkei* collected in 20 dips of the net.

While these data are not directly applicable to the data resulting from our efforts, it is clear that, between 1979 and 1981, *E. boehlkei* could be collected from this site with very little effort during the fall, winter and spring. Because this fish is presumably short-lived (one year), our collecting efforts were planned to coincide with times that adult Carolina pygmy sunfish would be large and in spawning colors (spring), or that the juveniles would have grown large enough to be readily identifiable (fall). Personal observations and a review of the earlier field notes demonstrate that adults of the species disappear (presumably, they die after spawning) after the spring spawning season. In these earlier field notes, no adults were collected between May and July. Maturing juveniles were noted in some collections made after June.

We attempted to collect larval specimens during April 1999, in the event that spawning had been early that year, and the adults had all died. No larval or juvenile pygmy sunfish were collected at this site. We were, however, able to collect larval and

juvenile pygmy sunfish at other sites in April 1999. Therefore, we believe if the species had been present at this site, we would likely have collected some.

In Juniper Creek, the species appears to be relatively abundant still. We were able to collect specimens at several localities during each of our three trips to the area. We collected three sites in Juniper Creek proper (sites 26, 26 and 27). *Elassoma boehlkei* was taken in the two lower sites (26 and 27) during this survey. Carolina pygmy sunfish have also been taken at the most upstream site (25) in the past (Shute et al., 1981).

The banded and Everglades pygmy sunfish, (*E. evergladei* and *E. zonatum)* have been taken at several Juniper Creek localities either during the current survey or by Shute et al. (1981). We have no record of all three species being taken at the same site, at the same time. A study of spatial as well as temporal distribution of these three species is suggested as a valuable addition to the life histories of pygmy sunfish. In addition to describing the interactions between the three species, this might be important in assessing potential impacts to the extremely vulnerable populations of the Carolina pygmy sunfish.

Presently, the Juniper Creek watershed appears to be relatively healthy. While some portions of the creek are bordered by lands owned by The Nature Conservancy, most of the watershed is privately owned and therefore at risk of being affected by the extensive timber harvesting that is taking place in the watershed (briefly discussed above). A complete survey of Juniper Creek proper is recommended to identify the range and abundance of *Elassoma boehlkei* within this watershed. Maintaining the Juniper Creek population may be the best chance for this species' continued existence. The Big Creek population appears to have been impacted by the effects of poor timber harvest practices. The small population in the Mainline canal (see Shute et al., 1981) seems to have been eliminated. Our recent observations of the area revealed extensive clear-cutting and the apparent use of herbicides. This has completely changed the character of the swamp draining into Big Creek and ultimately, Lake Waccamaw. The character of the aquatic vegetation in Big Creek and especially the drainage canals has changed dramatically over the past twenty years (pers. obs.).

We attempted to collect Carolina pygmy sunfish from the Big Creek watershed (April 1999) in order that a breeding population could be established for future reintroduction into the system. We were unable to locate any individuals. We do,

however, have a small breeding colony from adults collected in Juniper Creek. Individuals reared from this captive population could be used to reestablish the species in the Big Creek area. However, this should only be done following an exhaustive search for the species in the watershed. Small, isolated populations of this and any restricted species might prove to be genetically divergent. Rohde et al. (pers. comm.) are currently examining the genetics of this rare pygmy sunfish.

Rohde and Arndt (1987) stated that no known populations of this species are now threatened. Shute et al. (1981) found the species to be abundant in Big Creek and Juniper Creek between 1979-1981. Rohde and Arndt (1987) did emphasize that the species occurred mostly along roadside habitats and was, therefore, vulnerable. They recommended that the species should be given a "large measure of protection by the appropriate state governments as well as by the Federal Government". We concur, especially given the apparent decline of the Big Creek population. The Carolina pygmy sunfish is currently considered a "Threatened" species in North Carolina (Rohde 1997).

Another important observation was made while searching for pygmy sunfish in the swamps of Big Creek and Juniper Creek. We were unable to locate any specimens of the blackbanded sunfish, *Enneacanthus chaetodon*, or sawcheek darter, *Etheostoma serriferum*. Both of these fish species were regularly taken in the earlier surveys in these areas (see Shute et al., 1981). Both species are usually associated with particular types of aquatic vegetation (pers. obs.). The absence of these species in our recent surveys could be a warning that conditions in these fragile swamps are declining!

***Etheostoma perlongum*, Waccamaw darter**

Waccamaw darters (see comment earlier about taxonomic status of this darter) appear to be stable in the lake. However, because this is apparently is an annual population (Shute et al 1982), it is subject to decline in the face of a single poor reproductive season. Lindquist and Yarbrough (1982) listed under their recommendations that artificial spawning structures should be added to the lake in strategic locations, and suggested that spawning cover was probably a factor limiting the lake's darter population. We agree with Lindquist and Yarbrough's recommendation. This population could easily be managed by augmenting spawning cover. This would also benefit the broadtail

madtom population in the lake, since madtoms also spawn beneath cover objects. On many occasions during the 1979-82 surveys, madtoms were observed using artificial tiles that had been placed in the lake for the darters. Since madtoms usually spawn later in the season than the darters, competition between the species for these nesting sites is unlikely.

Shute (1984) saw no evidence of large-scale gene flow from Waccamaw River tessellated darters (*E. olmstedi*) into Lake Waccamaw. It therefore seems unlikely that there is much risk of this unique population being genetically swamped by the river form. Aside from extensive shoreline disturbance, or a general deterioration of water quality within the lake, no other risks are identified that would influence the continued health of the Waccamaw darter population.

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Appendix 1. Sampling stations. Numbers in {brackets} correspond to site numbers used in Shute et al (1981).

Lake Waccamaw Sites:

1. NC: Columbus Co.; Lake Waccamaw, North Shore at public beach {1a}.

Collected 04/18/99 (PLR 99-19).

Choppy water, white caps on waves.

Species Collected: *Fundulus waccamensis*; *Menidia extensa*; *Lepomis macrochirus*; *Etheostoma perlongum*.

2. NC: Columbus Co.; Lake Waccamaw, North Shore at John A. McNeill Sr. property.

Collected 04/08/99 (PLR 98-10), 10/25/98 (PLR 98-63), 04/16/99 (PLR 99-4), 04/18/99 (PLR 99-22).

Water choppy on both earlier occasions. Too turbid to snorkel. On 04/18 water was low in turbidity, though darkly stained, and was snorkelable at night.

Species collected: *Anguilla rostrata*; *Notropis petersoni*; *Noturus gyrinus*; *Fundulus waccamensis*; *Menidia extensa*; *Labidesthes sicculus*; *Morone americana*; *Lepomis gibbosus*; *L. macrochirus*; *Etheostoma perlongum*; *Perca flavescens*.

3. NC: Columbus Co.; Lake Waccamaw, Northeast Shore just beyond last house at end of Bella Coola Rd.

Collected 04/18/99 (PLR 99-21).

Water choppy, but relatively clear with tannin stain. Abundant vegetation in backwater off lake proper.

Species collected: *Ameiurus nebulosus*; *Noturus gyrinus*; *Esox niger*; *Fundulus waccamensis*; *Gambusia holbrooki*; *Labidesthes sicculus*; *Elassoma evergladi*; *Enneacanthus gloriosus*; *E. obesus*; *Lepomis macrochirus*; *Etheostoma fusiforme*.

4. NC: Columbus Co.; Lake Waccamaw, shoreline along north side of lake west of Big Cr., (just west of outflow from pond.)
Collected 04/09/98 (PLR 98-14).
Water dark, tannin stained. Choppy from windy weather.
Species collected: *Fundulus waccamensis*; *Labidesthes sicculus*; *Menidia extensa*; *Enneacanthus gloriosus*; *Lepomis gulosus*; L. *macrochirus*.

5. NC: Columbus Co.; Lake Waccamaw, Southeast Shore at State Park pier {1d}.
Collected 10/23/98 (PLR 99-55). Wong PLR 98-55
Observed only. Water somewhat clear, less choppy than rest of lake.
Species observed: *Fundulus waccamensis*; *Lepomis macrochirus*; *Etheostoma fusiforme*; *Etheostoma perlongum*.

6. NC: Columbus Co.; Lake Waccamaw, beach approximately ½ mi. east of dam {1f}.
Collected 04/07/98 (PLR98-8), 04/08/98 (PLR98-10), 04/16/99 (PLR 99-5).
Both snorkeled and seined. Water relatively clear, mostly calm. Vegetation (cane beds) along shore.
Species collected/observed: *Notropis petersoni*; *Fundulus waccamensis*; *Labidesthes sicculus*; *Menidia extensa*; *Noturus gyrinus*; *Noturus sp.* (broadtail madtom); *Etheostoma perlongum* (numerous nests); *E. fusiforme*; *Perca flavescens*.

7. NC: Columbus Co.; Lake Waccamaw just above dam on south shore of lake {1g}.
Collected 04/07/98 (PLR 98-9).
Snorkeled at night on 04/07. Water relatively clear, low turbidity.
Species observed/collected: Amia calva; *Anguilla rostrata*; *Notropis petersoni*; *Fundulus waccamensis*; *Labidesthes sicculus*; *Lepomis macrochirus*; *Etheostoma perlongum* (one nest seen); *Perca flavescens*.

Big Creek, tributaries North of Lake Waccamaw, and Waccamaw canal Sites:

8. NC: Columbus Co.; Big Cr., First bridge going east on SR 1947, and canal across road {2c}.

Collected 04/8/98 (PLR 98-13), 04/14/99 (PLR 99-1).

Blackwater, submerged vegetation present. Some emergent vegetation.

Species collected: *Esox americanus*; *E. niger*; *Umbra pygmaea*; *Aphredoderus sayanus*; *Gambusia holbrooki*; *Enneacanthus gloriosus*; *E. obesus*; *Lepomis gulosus*; L. *macrochirus.*

9. NC: Columbus Co.; Big Cr. At second bridge going east on SR 1947, and canal across road{2b}.

Collected 04/06/98 (PWS 98-2), 10/23/98 (PLR 98-52), 04/14/99 (PLR 99-1).

Blackwater, submergent and emergent vegetation. Bridge crossing and canal on both sides of the road.

Species collected: *Esox americanus*; *E. niger*; *Umbra pygmaea*; *Aphredoderus sayanus*; *Fundulus lineolatus*; *Gambusia holbrooki*; *Noturus gyrinus*; *Fundulus waccamensis*; *Elassoma boehlkei*; *Enneacanthus gloriosus*; *E. obesus*; *Lepomis gulosus*; *L. macrochirus*.

10. NC: Columbus Co.; Big Cr. ,Wildlife Access Area on SR 1947, and canal across road {2a}.

Collected 04/08/98 (PLR 98-10), 10/23/98 (PLR 98-53), 04/14/99 (PLR 99-1), 04/17/99 (PLR 99-14).

Blackwater, relatively clear. Submergent and emergent vegetation. Fine sandy substrate at boat launch.

Species collected: *Notropis maculatus* (Full breeding color 04/08/98); *N. petersoni*; *Ameiurus nebulosus*; *Noturus gyrinus*; *Esox americanus*; *E. niger*; *Umbra pygmaea*; *Fundulus lineolatus*; *F. waccamensis* (10/23/98 and 04/17/99); *Gambusia holbrooki*; *Labidesthes sicculus*; *Enneacanthus gloriosus*; *Lepomis gulosus*; *L. gibbosus*; L. *macrochirus*; *Micropterus salmoides*; *Perca flavescens*.

11. NC: Columbus Co.; Big Cr., NC 214 (old US 74/76) crossing. {9}.

Collected 04/07/98 (PLR 98-5).

Flowing blackwater with abundant submergent and emergent vegetation. Beaver dam with rip rap incorporated into the structure.
Species collected: *Esox americanus*; *Aphredoderus sayanus*; *Gambusia holbrooki*; *Labidesthes sicculus* (first specimens seen above the lake); Elassoma zonatum; *Enneacanthus gloriosus*; *E. obesus*; *Lepomis gulosus*.

12. NC: Columbus Co.; Canal and pond on cr. rd. 1947, NE side of Lake Waccamaw {3}.
Collected 04/17/99 (PLR 99-13).
Borrow pond that connects to Lake and canal across street. Abundant submergent vegetation. Dark, somewhat turbid water.
Species collected: *Umbra pygmaea* (abundant); *Gambusia holbrooki*. No other species collected or observed.

13. NC: Columbus Co.; Main Line Canal at Tram Rd. Crossing northeast of Lake Waccamaw.
Collected 04/06/98 (PWS 98-3), 10/23/98 (PLR 98-54).
Water tannin stained, cool and flowing in canal. Abundant submergent vegetation and filamentous algae. Water low, stagnate and much warmer on 10/23/98.
Species collected: Large blue amphipods were abundant; *Ameiurus nebulosus*; *Esox americanus*; *Umbra pygmaea*; *Aphredoderus sayanus*; *Gambusia holbrooki*; *Enneacanthus gloriosus*; *E. obesus*.

14. NC: Columbus Co.; Unnamed tributary to Slap Swamp (part of Friar Swamp) at Chancy Rd., approx. 1 mi. S of St. James.
Collected 04/16/99 (PLR 99-6).
Drainage canal, some submergent vegetation, mud bottom.
Species collected: *Esox americanus*; *Gambusia holbrooki*; *Lepomis* sp. juvs. (not *macrochirus*).

15. NC: Columbus Co.; Creek Branch at Old Lake Road at Lake Waccamaw city limit sign just North of Lake Waccamaw.

Collected 04/16/99 (PLR 99-7).

Swamp. Relatively clear. Abundant submergent vegetation.

Species collected: *Esox americanus*; *Aphredoderus sayanus*; *Gambusia holbrooki.*

16. NC: Columbus Co.; Slap Swamp on Old Lake Rd., approx. 2 mi. North of Lake Waccamaw.

Collected 04/16/99 (PLR 99-8).

Swampy, with relatively clear water. Some submergent vegetation around margins.

Species collected: *Notemigonus crysoleucas*; *Esox americanus*; *Umbra pygmaea*; *Aphredoderus sayanus*; *Gambusia holbrooki*; *Enneacanthus gloriosus.*

17. NC: Columbus Co.; Friar Swamp North of Lake Waccamaw on Old Lake Rd. < 1 mi. from Hwy. 211.

Collected 04/16/99 (PLR 99-9).

Swampy creek with abundant submergent and emergent vegetation. Water relatively clear.

Species collected: *Ameiurus* sp. juv.; *Esox americanus*; *E. niger*; *Umbra pygmaea*; *Aphredoderus sayanus*; *Gambusia holbrooki*; *Enneacanthus gloriosus*; *E. obesus.*

18. NC: Columbus Co.; Tributary to Friar Swamp approx. 200 m West of Hwy. 211.

Collected 04/16/99 (PLR 99-9).

Swamp, "impounded" by beavers. Dark stained, relatively clear water. Vegetation sparse.

Species collected: *Esox americanus*; *Gambusia holbrooki*; *Enneacanthus obesus.*

Waccamaw River and tributaries.

19. NC: Columbus Co.; Waccamaw River, just below dam at south shore of Lake Waccamaw {7}.

Collected 10/24~~/99~~(PLR 98-56), 04/11/99 (PLR 99-5).

Water flowing over dam. Barely workable (10/24/98). Water high on 04/11/99.

Species collected: *Anguilla rostrata*; *Notropis petersoni*; *Fundulus waccamensis*; *Gambusia holbrooki*; *Labidesthes sicculus*; *Menidia extensa*; *Noturus gyrinus*; *Noturus*

sp. (broadtail madtom); *Lepomis gibbosus*; L. *macrochirus*; *Etheostoma perlongum*; *E. fusiforme*; *Perca flavescens*.

20. NC: Columbus Co.; Waccamaw River at co. rd. 1928 bridge {19}.
Collected 10/24/98 (PLR 98-57).
Water very dark stained, but relatively low turbidity. Water much higher than normal for this time of year, but relatively easily collected. Vegetation sparse. Sandy substrate with some fine gravel and limited limestone slabs and bedrock.
Species collected: *Anguilla rostrata*; *Ameiurus natalis*; *Chologaster cornuta*; *Gambusia holbrooki*; *Enneacanthus gloriosus*; *Perca flavescens*. Live mussels were relatively common here.

21. NC: Columbus Co.; Waccamaw River, 7.2 air km NE Pireway, "Reeve's Ferry" {31}.
Collected 10/25/98 (PLR 98-60).
High water and limestone outcrops made seining nearly impossible.
Species collected: *Gambusia holbrooki*; *Enneacanthus gloriosus*. No other fish were observed or collected.

22. NC: Columbus/Brunswick Co. line; Waccamaw R. at NC 904 crossing, 1.6 air km SE Pireway {37}.
Collected 10/25/98 (PLR 98-60).
River was not collectable at this locality due to high water.

23. NC: Columbus Co.; Gum Swamp canal adjacent to NC Hwy 130, approx. 2 mi. N of Waccamaw R. at New Brittan.
Collected 04/17/99 (PLR 99-15).
Relatively clear, cool canals with abundant submergent vegetation.
Species collected: *Amia calva* (juvs. common); *Umbra pygmaea*; *Aphredoderus sayanus*; *Gambusia holbrooki*; *Enneacanthus gloriosus*.

24. Little Swamp (headwaters of Juniper Cr.) Approx. 6 mi. SE of Lake Waccamaw at 34 11 39N/78 27 07W.

Collected 04/07/98 (PLR 98-7).

Flowing swampy stream. Little vegetation.

Species collected: *Ameiurus sp.* (juv.); *Esox americanus*; *Gambusia holbrooki*; *Lepomis gibbosus*; L. *macrochirus.*

25. NC: Brunswick Co.; Juniper Cr., at Hwy 211 crossing, 29.8 km S of Bolton {23}.

Collected 04/16/99 (PLR 99-10).

Clear, flowing cool, headwater stream. Some emergent vegetation and filamentous algae.

Species collected: *Umbra pygmaea*; *Fundulus lineolatus*; *Enneacanthus obesus*; *Elassoma evergladi* (both males and females in high reproductive condition).

26. NC: Brunswick Co.; Juniper Cr. 1.6 air km E of Makatoka on co.rd. 1340 {24}.

Collected 04/06/98 (PLR 98-3), 10/24/98 (PLR 98-58).

Water level in creek high. Abundant filamentous algae in adjacent canal.

Species collected: *Umbra pygmaea*; *Aphredoderus sayanus*; *Chologaster cornuta*; *Fundulus lineolatus*; *Gambusia holbrooki*; *Elassoma boehlkei* (One spent female found at margin of creek on 04/06/98. On 10/24/98, Carolina Pygmies were abundant in creek proper); E. evergladi; *Enneacanthus gloriosus*; *Lepomis gulosus*; L. *macrochirus.*

27. NC: Columbus/Brunswick Co. line; Juniper Cr. At overflow pond on co. rd.1928 and canal across road{21}.

Collected 04/06/98 (PLR 98-1), 10/24/98 (PLR-98-58), 04/17/99 (PLR-99-16).

Juniper Cr. very high (04/06/98) sandy substrate, very little vegetation in stream. Canal and borrow pit heavily vegetated.

Species collected: *Esox americanus*; *E. niger*; *Umbra pygmaea*; *Aphredoderus sayanus*; *Chologaster cornuta*; *Fundulus lineolatus*; *Gambusia holbrooki*; *Elassoma boehlkei* (Males and females all in high reproductive condition 04/06/98. All males and several females collected in creek proper. Several females collected in overflow pond. On 10/24/98, water lower in Juniper Cr. All *Elassoma* collected in canal, none in overflow

pond or creek proper. On 04/17/99, five very large adult Carolina pygmies and numerous larvae collected from canal across road from the overflow pond. None collected in pond or creek proper.); *E. zonatum* (four of the larvae mentioned above were later identified as *E. zonatum*); *Centrarchus macropterus* (larvae collected from overflow pond); *Enneacanthus gloriosus*; *E. obesus.*

28. NC: Brunswick Co.; Muddy Branch (headwaters of Juniper Cr.) at co. rd. 1342.
Collected 10/24/98 (PLR 98-58).
Small swampy headwaters.
Species collected: *Chologaster cornuta*; *Gambusia holbrooki* no other species collected.

29. NC: Brunswick Co.; Honey Is. Swamp, at NC Hwy. 211.
Collected 04/06/98 (PLR 98-7).
Small, shallow, relatively clear swamp. Some emergent vegetation.
Species collected: *Esox* juveniles; *Aphredoderus sayanus*; *Enneacanthus obesus.*

30. NC: Brunswick Co.; Ready Branch at co. rd. 1335. ***(get better locality)***
Collected 04/06/98 (PLR 98-6).
Some submergent vegetation.
Species collected: *Esox* juveniles; *Umbra pygmaea*; *Aphredoderus sayanus*; *Gambusia holbrooki*; *Enneacanthus obesus.*

31. NC: Columbus Co.; Bogue Swamp, co. rd. 1736 crossing, 1.6 km. SE of Hallsboro {10}.
Collected 10/25/98 (PLR 98-59).
Heavily vegetated swamp. Water tannin stained, but clear.
Species collected: *Umbra pygmaea*; *Gambusia holbrooki*; *Elassoma zonatum*; *Centrarchus macropterus*; *Enneacanthus gloriosus*; *E. obesus*; *Lepomis gulosus.*

32. NC: Columbus Co.; Bogue Swamp, at NC 214 (formerly US Hwy 74-76) crossing, 1.2 km E of Hallsboro {11}.

Collected 04/14/99 (PLR 99-2).

Swamp with steep banks. Some submergent vegetation.

Species collected: *Esox americanus*; *E. niger*; *Umbra pygmaea*; *Aphredoderus sayanus*; *Gambusia holbrooki*; *Enneacanthus obesus*.

33. NC: Columbus Co.; White Marsh, at US Hwy 74-76 crossing, 3.2 km E of Whiteville {14}.

Collected 04/14/99 (PLR 99-3).

Shallow swamp with abundant submergent and emergent vegetation.

Species collected: *Esox americanus*; *Umbra pygmaea*; *Aphredoderus sayanus*; *Gambusia holbrooki*; *Enneacanthus gloriosus*; *E. obesus*.

34. NC: Columbus Co.; Trib, to White Marsh on Snake Is. Rd., Approx. 3 mi. N. of Old Dock.

Collected 10/25/98)PLR 98-62).

Ditch under road with abundant submergent vegetation.

Species collected: *Noturus gyrinus*; *Aphredoderus sayanus*; *Gambusia holbrooki*; *Elassoma evergladi* ***check ID***; *E. zonatum*; *Lepomis macrochirus*.

35. NC: Columbus Co.; Simmons Bay Cr., Mark Pine Rd. Co. rd. 1932 at Simmons Bay Bridge.

Collected 10/25/98 (98-61).

Swamp....No other site description given.

Species collected: *Ameiurus natalis*; *A. nebulosus*; *Aphredoderus sayanus*; *Fundulus lineolatus*; *Gambusia holbrooki*; *Elassoma evergladi*; *E. zonatum*; *Enneacanthus gloriosus*; *E. obesus*; *Lepomis gulosus*.

36. NC: Brunswick Co.; Driving Cr. (Green Swamp), adjacent to the Nature Conservancy Preserve on NC Hwy 211.

Collected 04/16/99 (PLR 99-11).

Very brown, almost orange stained water with filamentous algae.
Species collected: *Aphredoderus sayanus*; *Chologaster cornuta*; *Elassoma evergladi* (In high reproductive condition, relatively abundant).

37. NC: Brunswick Co.; Wet Ash Swamp 5.3 air km NE Longwood at NC Hwy 130 crossing {30}.
Collected 04/16/99 (PLR 99-12)
Swamp with rip-rap cover under bridge. Filamentous algae and other submergent vegetation abundant. Dark stained water.
Species collected: *Esox americanus*; *Umbra pygmaea*; *Aphredoderus sayanus*; *Gambusia holbrooki*; *Elassoma zonatum*.

38. NC: Brunswick Co.; Wet Ash Swamp, at lowermost bridge crossing (Boundary House Rd, co. rd. 1300), approx. 2 mi. S of Ash.
Collected 04/17/99 (PLR 99-17).
Canal alongside road adjacent to swamp.
Species collected: *Esox americanus*; *Umbra pygmaea*; *Aphredoderus sayanus*; *Gambusia holbrooki*; *Elassoma zonatum*.

39. NC: Brunswick Co.; Bear Branch, 1 mi. S of New Brittan at NC Hwy 130 crossing.
Collected 04/16/99 (PLR 99-12A). No site description.
Species collected: *Gambusia holbrooki*; *Lepomis gulosus*; *Lepomis macrochirus.*

40. NC: Brunswick Co.; Caw-Caw Branch, at Boundary House Rd. (or Little River-Ash Rd.), approx. 1 mi. N of Hickman's Cross Roads.
Collected 04/17/99 (PLR 99-18).
Murky brown, channalized swamp with abundant emergent vegetation.
Species collected: Amia calva; *Esox americanus*; *E. niger*; *Aphredoderus sayanus*; *Fundulus lineolatus*; *Gambusia holbrooki*; Heterandria formosa; *Elassoma zonatum*; *Enneacanthus gloriosus*; *E. obesus*; *Etheostoma serriferum* (collected as larvae and raised at CFI).