SUMMER HABITAT SELECTION OF STRIPED BASS IN LAKE NORMAN

FINAL REPORT

PIEDMONT FISHERIES INVESTIGATIONS

Federal Aid in Fish Restoration Project F23-15

Project Type: Research

Period Covered: 1 April 1992 - 1 March 1994

NORTH CAROLINA WILDLIFE RESOURCES COMMISSION

DIVISION OF BOATING AND INLAND FISHERIES

Scott Van Horn

Jerome Finke

North Carolina Wildlife Resources Commission

Don Degan

Duke Power Company

1994

Abstract: Lake Norman is a 13,516 ha cooling pond for 2 Duke Power Company electric generating facilities and is stocked annually with striped bass (*Morone saxatilis*). Summer water temperatures and dissolved oxygen (DO) concentrations often are near or fail to meet levels reported in the literature as necessary to support large striped bass. The infrequency of summer temperature/DO related striped bass kills implies that the fish are using thermal refuges or are rarely subjected to lake wide lethal combinations of temperature/DO . The objective of this study was to determine the summer temperature and dissolved oxygen conditions used by the lake's striped bass. We tagged a total of 48 striped bass (2.2-7.8 kg) with temperature sensing radio tags (40-50 MHz) during spring 1992 and 1993. We found 25 of the tagged fish at least once during the 2 summer study periods. Tag frequency, tag temperature, location, and a water column temperature/DO profile were recorded with each tag encounter. Striped bass were not concentrated in specific locations and we did not find persistent thermal refugia during either summer. Tag temperatures (25.6 and 26.1 C) and associated DO concentrations (3.98 and 3.14 mg/l) were similar for large (≥4.5 kg) and small (<4.5 kg) striped bass in the warmest weeks of the summer of 1992. Habitat cooler than 28 C and containing ≥2.0 mg/l DO was always present in most of Lake Norman in both years. No significant striped bass mortalities attributed solely to heat stress were observed.

Striped bass have been stocked in southeastern reservoirs since the 1960s and early 1970s (Bailey 1974, Axon and Whitehurst 1985). Matthews' (1985) survey of 80 reservoirs in the United States containing striped bass populations revealed 27 impoundments had experienced some summer striped bass mortality, especially among fish >5 kg. Coutant (1985) argued warm water temperatures and a need for cooler water among striped bass >5 kg causes summer striped bass mortalities in many southeastern reservoirs.

Lake Norman is a 13,516 ha cooling reservoir on the lower Catawba River in south central North Carolina operated by Duke Power Company to serve 2 electric generating facilities. The lake has been stocked by the North Carolina Wildlife Resources Commission (NCWRC) with striped bass since the late 1960s (Bailey 1974). A stocking rate of 7.5 fingerlings per hectare has supported an important regional striped bass fishery in the reservoir. Baker (1983) reported striped bass fishing effort was 37 hours/ha in 1982 and the popularity of striped bass fishing on the lake remains high.

Few late summer striped bass mortalities (<30 fish annually) have been observed on Lake Norman in most years. However, a kill of 163 fish did occur in 1983. Duke Power Company subsequently initiated studies to help define the relationship between power production and striped bass habitat in Lake Norman (Lewis 1983). The Company adopted water temperature ≤ 26 C and DO ≥ 2 mg/l as a minimum habitat condition (critical habitat) to sustain striped bass >5 kg. Their studies (Duke Power Company, unpubl.)

demonstrate that often little or no critical habitat is present in Lake Norman in late summer. The few adult striped bass mortalities observed on Lake Norman concurrent with the apparent absence of 26 C water with ≥2.0 mg/l DO suggests either a better definition of striped bass critical habitat is needed or undetected thermal refuges (Coutant 1985) are present in Lake Norman.

Zale et al. (1990), studying striped bass summer mortality in Keystone Reservoir, Oklahoma, accepted the 2 mg/l DO criterion but reported adult striped bass can survive exposure to water temperatures between 27 and 28 C for about a month. They found more prolonged exposure resulted in striped bass deaths and exposure to water >28 C produced mortalities within a few weeks. They reported Keystone striped bass quit feeding at approximately 27 C and deaths at temperatures >28 C were probably related to starvation.

Expansion of striped bass production capacity by the NCWRC has allowed some flexibility in setting stocking rates for Lake Norman. If summer striped bass habitat in the lake is limited, increasing stocking rates or minimum size limits may increase the risk of summer striped bass mortalities. The objective of this study was to determine summer water temperature and dissolved oxygen concentrations used by Lake Norman striped bass >2 kg.

METHODS

We tagged striped bass with low frequency (40-50 MHz) temperature sensing radio transmitting tags. Temperature sensing for each tag was calibrated by recording changes in tag pulse intervals with changing tag temperatures (15-32 C) in a water bath. A regression equation using natural logarithmic transformed temperature and pulse count data was developed for each tag and used to determine tag temperatures from radio signals received from released fish.

Striped bass were captured by hook and line and electrofishing during April and May of 1992 and 1993. Length and weight were measured and fish >2 kg were fitted with temperature sensing radio transmitters. Transmitters were surgically implanted into the body cavity of each fish using methods described by Hart and Summerfelt (1975). All fish were released near the Cowan's Ford dam. Tag life was designed to be >6 months.

We tracked fish from 8 July to 9 September 1992 and 4 July to 29 August 1993. A boat equipped with a yagi antennae and ATS R2100™ receiver was used to search the reservoir for tagged striped bass. Location, tag pulse frequency, and tag radio frequency were recorded for each fish encountered. A Hydrolab™ was used to collect a water column temperature and DO profile at each tag encounter location. Measurements were taken at approximately 1-m intervals. Tag pulse frequencies were used to calculate tag temperatures. Tag temperatures were compared with their associated water profile data to estimate the DO available to each fish at each encounter.

Striped bass information from 1992 was analyzed for fish <4.5 kg and ≥4.5 kg. The data were further combined into a period of declining habitat (Period 1, 8-22 July), a period of maximum habitat stress (Period 2, 28 July - 15 August), and a habitat recovery period (Period 3, 17 August - 10 September). We compared mean temperatures and DOs between the 2 size groups of striped bass within periods using the Mann-Whitney independent 2 sample nonparametric statistical test ($\alpha = 0.05$)(Wilkinson 1990). The spatial distributions of radio tag encounters were plotted on maps of the reservoir.

Finally, the water temperature and DO conditions available to each fish at its encounter site were assigned to 1 of 4 categories based on the Zale et al. (1990) discussion of striped bass thermal tolerance. The categories included all habitat with ≥2.0 mg/l DO that were (1) cooler than 26 C, (2) 26-27 C, (3) 27.1-28 C, or (4) warmer than 28 C.

Tag malfunctions in 1993 restricted analysis to plotting the location of each tag encounter and describing the available habitat at each encounter site using the 4 habitat categories.

RESULTS

Twenty-nine striped bass tagged between 4 April and 21 May 1992 (Table 1) ranged in length from 596-810 mm and weighed 2.5-7.8 kg. All fish tagged and released on 21 May were from Gaston Reservoir near the North Carolina - Virginia state line. The Gaston fish were added to increase the number of large tagged fish in Lake Norman for the summer. We found 19 active fish, 5 immobile tags, and made 114 tag field measurements. Most fish were found in the lower two-thirds of the reservoir

(Figs. 1,2,3).

Mean temperature (Fig. 4) and associated DO (Fig. 5) were generally similar between large and small stripers in 1992. Mean temperature (20.0 C) of large striped bass was nearly 2 C cooler than the mean temperature (21.7 C) of smaller striped bass in Period 1 when water temperatures were rising rapidly but 26 C and 2 mg/l water was still universally available in the lake (Duke Power Co., unpubl.). The sample size of large fish was small and the difference was not statistically significant ($\underline{P}$ = 0.086). Mean DOs (2.5 and 2.3 mg/l)($\underline{P}$ = 0.432) for large and small fish were also similar in Period 1. During the stressful conditions of Period 2, tag temperatures of large and small fish remained similar (25.6 C and 26.1 C)($\underline{P}$ = 0.515) as did associated DO concentrations (4.0 and 3.1 mg/l)($\underline{P}$ = 0.292). Small but statistically significant differences ($\underline{P}$ = 0.002) between large and small fish mean tag temperature (25.1 and 26.0 C) were present following the rapid mid-August cooling in Period 3. Differences in DO concentrations associated with the large and small size groups were not statistically significant (3.7 and 4.7 mg/l)($\underline{P}$ = 0.353)

We observed 1 fish in water warmer than 28 C in 1992. The fish weighed 5.1 kg and was found 4 August. A 2.5 kg fish was observed 30 July and a 7.2 kg fish was observed 6 August at sites with no water cooler than 27 C. Fifteen fish were found with at least some water between 26 and 27 C in the water column. The remainder were found in sites with water available cooler than 26 C.

We tagged 17 striped bass in spring 1993 (Table 2). Fish lengths ranged from 568 to 801 mm. Weights ranged from 2.2 to 6.2 kg. Seven of the tags were not found. Six active fish and 4 immobile tags were encountered during the study period. Twenty-one encounters with active fish provided location and limnological observations. The fish were distributed from the main pool near the dam to the extreme upstream end of the reservoir (Fig. 6). Summer conditions were harsh in 1993 and reached their most critical level in late July (Duke Power Co., unpubl.). From 28 July through 1 September there were few days and locations on the lake where any oxygenated water cooler than 27 C was present.

Three of the 21 tag encounters in 1993 occurred where oxygenated water (≥2 mg/l) less than 26 C was present. All of these observations were made in the vicinity of the small tributary to the Catawba River in the upstream reaches of the impoundment mentioned earlier. An additional 6 encounters occurred in the presence of oxygenated water between 26 and 27 C in the

upper reservoir Catawba River channel. Seven fish encounters occurred at temperatures between 27 and 28 C. Five fish were observed in locales devoid of any water cooler than 28 C. The largest of these 5 fish was 3.2 kg.

DISCUSSION

The early concentration of fish in the lower reservoir in 1992 (Fig. 1) may have been a function of the release site near the dam. Water quality did not influence the distribution as habitat was plentiful throughout the lake in Period 1. As the quantity of cool oxygenated water in the lake reached a minimum, it appeared fish moved closer to the deeper channels and away from the extreme lower end of the reservoir (Fig. 2). The hot water discharge from McGuire Nuclear Station enters the first large tributary on the lower east side of the reservoir. We did not see any apparent concentration of fish in a thermal refugia. When habitat was again plentiful, a few tagged striped bass returned to the lower reservoir area and tagged fish also became common in mid-reservoir (Fig. 3).

It is unclear how the presence of Gaston Lake fish may have influenced this distribution. The fish had several months to adjust to their new surroundings before we began tracking. The 2 fish which immediately moved uplake upon release and stayed there were both small striped bass native to the lake.

So few fish were observed in 1993 that it is not possible to make inferences about movement during that summer, other than to notice fish distribution was wider, earlier. We did observe 1 large fish using a very small thermal refuge in a small tributary at the upstream end of Lake Norman for several weeks. This fish was in water less than 1-m deep while in the tributary. The fish repeatedly moved from within the tributary out into the Catawba channel near the same side bank and then returned to the tributary. It appeared the fish was traveling in the mixing zone of the tributary outfall and the Catawba River. This site also was lost to warming water.

Although small and statistically nonsignificant, the observed temperature selection differences between small and large fish in 1992 were consistent with the literature (Coutant 1985). The lack of corresponding differences in associated DO concentrations may be a function of our methodology for determining temperature associated DOs. Fish of both sizes were commonly located near the thermocline where rapid changes in DO were associated with small changes in temperature. DO data for both sizes cover nearly the range of existing conditions in the lake for Periods 1 and 2. It is unclear why striped bass encountered in Period 1 were found at such low DO conditions when better habitat was present in the lake.

The large majority of fish encountered had access to water which was cooler than 27 C and oxygenated at >2 mg/l within the water column, particularly in 1992. Zale et al. (1990) described this as suitable temperature/DO conditions for striped bass.

In 1993, about half the striped bass observed only had access to water warmer than 27 C. Zale suggested that larger stripers should cease feeding and may starve to death if habitat deprivation continues for more than a month. Lake Norman fish are often difficult for anglers to capture during late summer (Baker, pers. commun.) suggesting that warm water may reduce feeding. This is further substantiated by unusually poor body condition of striped bass of all sizes observed in fall when the fish begin feeding again (Duke Power Company, unpubl.).

Overall, most fish in Lake Norman had access to oxygenated water cooler than 28 C (Duke Power Co., unpubl.), the temperature where Zale predicted increased short term mortalities. The few striped bass carcasses we observed (approximately 20) were small fish which we suspect died when high water temperatures exacerbated hooking mortality.

The mean temperature and dissolved oxygen concentrations we observed generally support using 26 C and 2 mg/l to define acceptable summer habitat conditions for large striped bass. However, our 1992 Period 2 information demonstrates that large striped bass will use 27 C water and at least briefly tolerate DO concentrations below 2 mg/l. The number of large fish observed in these poorer habitat conditions when better habitat was present suggests that 26 C and 2 mg/l does not represent a critical short term barrier to survival in Lake Norman. Our results support Zale's contention that water temperatures must exceed 27 C before striped bass experience any significant negative physiological responses to temperature/DO stress and must exceed 28 C to cause short term mortalities.

In summary, striped bass were not concentrated in specific locations and we did not find persistent thermal refugia during either summer at Lake Norman. The fish appear to disperse and may cease feeding at water temperatures >27 C. The availability of at least marginal habitat conditions throughout the lake suggests that stocking rates need not be restricted by habitat availability. Even under the extreme heat of 1993, water cooler than 28 C containing ≥2.0 mg/l DO was present in most of Lake Norman. However, the marginal summer habitat and resulting poor growth may limit the number of striped bass ≥4.5 kg produced in

Lake Norman. The practical implications of this consequence may be minimal if sport fishing harvest already limits the number of striped bass surviving to this large size.

RECOMMENDATIONS

1.) Recognize 27 C and 2 mg/l as the suitable habitat threshold for striped bass ≥ 4.5 kg.

2.) Reduce the frequency of monitoring striped bass habitat required of Duke Power Company and expand the reporting to include 26, 27, and 28 C isopleths on the reservoir temperature/DO plot.

3.) Striped bass stocking rates should not be limited by concerns for temperature/DO limitations in Lake Norman.

LITERATURE CITED

Axon, J. R. and D. K. Whitehurst. 1985. Striped bass management on lakes with emphasis on management problems. Trans. Am. Fish. Soc. 114:8-11.

Bailey, N. M. 1974. An evaluation of striped bass introductions in the southeastern United States. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 28:54-68.

Baker, K. B. 1983. 1981-82 creel survey of Lake Norman, North Carolina. Res. rep. PES/83-33. Duke Power Company, Huntersville, NC. 49 pp.

Coutant, C. C. 1985. Striped bass, temperature, and dissolved oxygen: a speculative hypothesis for environmental risk. Trans. Am. Fish. Soc. 114:31-61.

Hart, L. G. and R. C. Summerfelt. 1975. Surgical procedures for implanting ultrasonic transmitters into flathead catfish. Trans. Am. Fish. Soc. 104:56-59.

Lewis, R. E. 1983. Temperature selection and vertical distribution of striped bass during lake stratification. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies. 37:276-286.

Wilkinson, Leland. 1990. SYSTAT: The system for statistics. Evanston, IL:SYSTAT, Inc.

Matthews, W. J. 1985. Summer mortality of striped bass in reservoirs of the United States. Trans. Am. Fish. Soc. 114:62-66t.

Zale, A.V., A.D. Wiechman, R.L. Lochmiller, and J. Burroughs. 1990. Limnological conditions associated with summer mortality of striped bass in Keystone Reservoir, Oklahoma. Trans. Am. Fish. Soc. 119:72-76.

Table 1. Length (mm), weight (kg), date tagged, and disposition of striped bass tagged at Lake Norman in 1992.

Length (mm)	Weight (kg)	Date
596	2.4	4/06 **
600	2.5	4/04
605	2.5	4/04
605	2.5	4/08
612	2.6	4/07
616	2.5	4/06
620	2.5	4/08
651	3.0	4/07
661	3.0	4/08
680	2.8	4/07
680	3.4	4/08 **
680	4.1	5/21
688	4.0	4/14 **
690	3.6	4/08
695	2.3	4/07 **
705	4.5	5/21 *
710	4.1	4/04
730	5.1	5/21 *
732	5.0	5/21
735	5.1	5/21
736	4.4	4/07
740	4.6	4/04 **
740	5.6	5/21 *
753	5.1	5/21
760	4.9	4/14 *
810	6.9	5/21
810	7.2	5/21
812	6.9	5/21 *
850	7.8	5/21

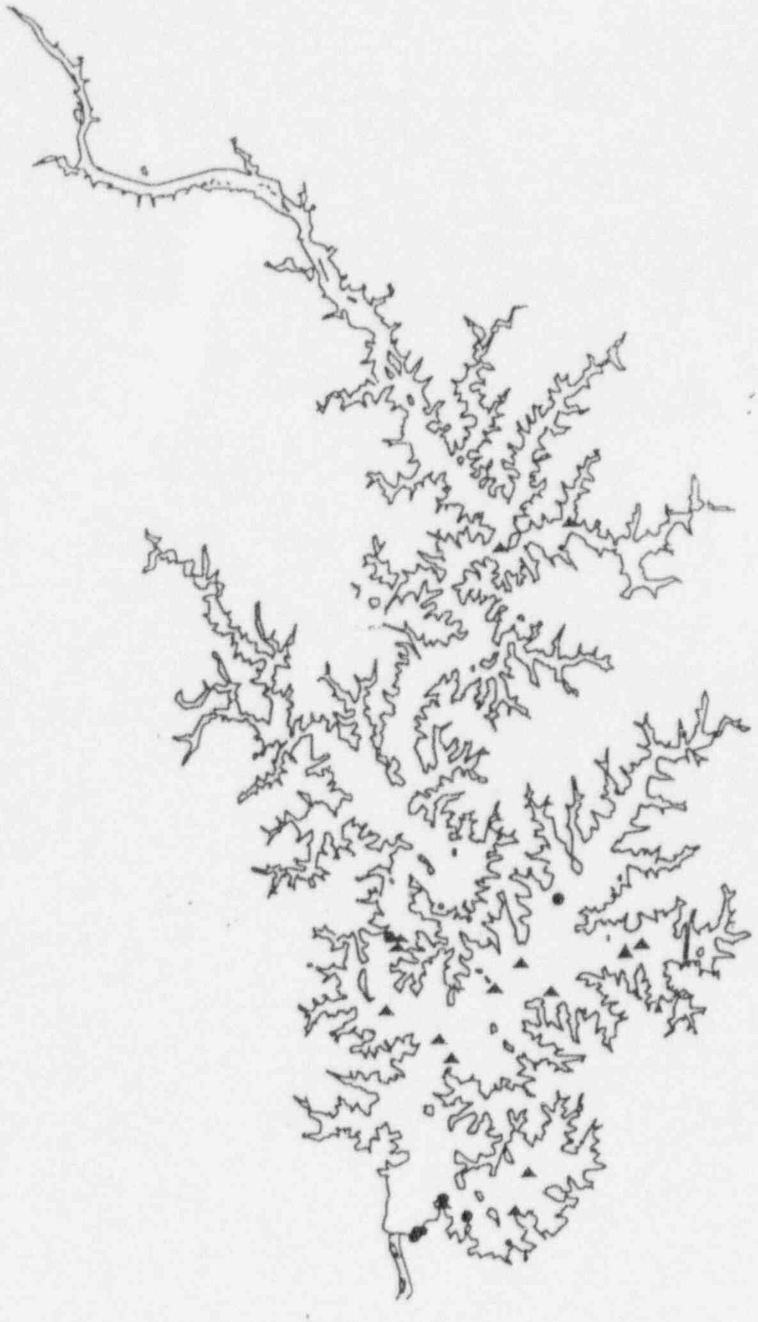
* Inactive tags
** Tags not encountered

Table 2. Length (mm), weight (kg), date tagged, and disposition of striped bass tagged at Lake Norman in 1993.

Length (mm)	Weight (km)	Date
568	2.2	3/26 *
585	2.4	3/26 *
591	2.5	3/24
610	2.5	3/24 *
610	2.7	3/24
612	2.7	3/26 **
634	2.7	3/26
637	2.8	3/24 **
649	3.2	3/26
672	3.4	3/31 **
675	3.6	3/24
685	3.5	3/26 **
697	3.7	4/05 **
711	4.5	4/14 **
718	4.8	3/31 *
792	3.4	4/26 **
801	6.2	3/26

* Inactive tags
** Tags not encountered

Figure 1. The distribution of tagged striped bass encounters at Lake Norman in Period 1, 1992.



● = Striped bass ≥ 4.5 kg

▲ = Striped bass < 4.5 kg

Figure 2. The distribution of tagged striped bass encounters at Lake Norman in Period 2, 1992.

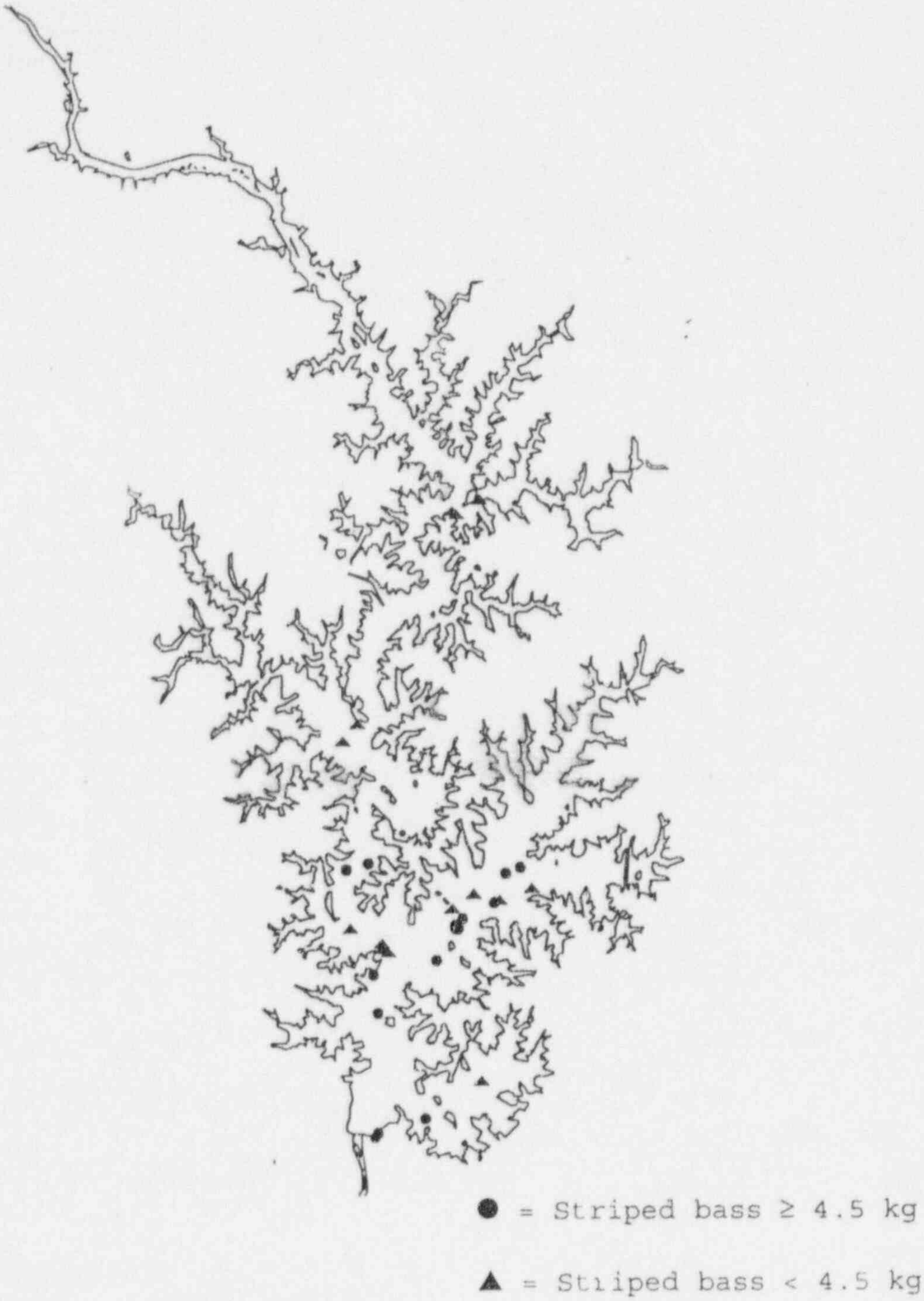
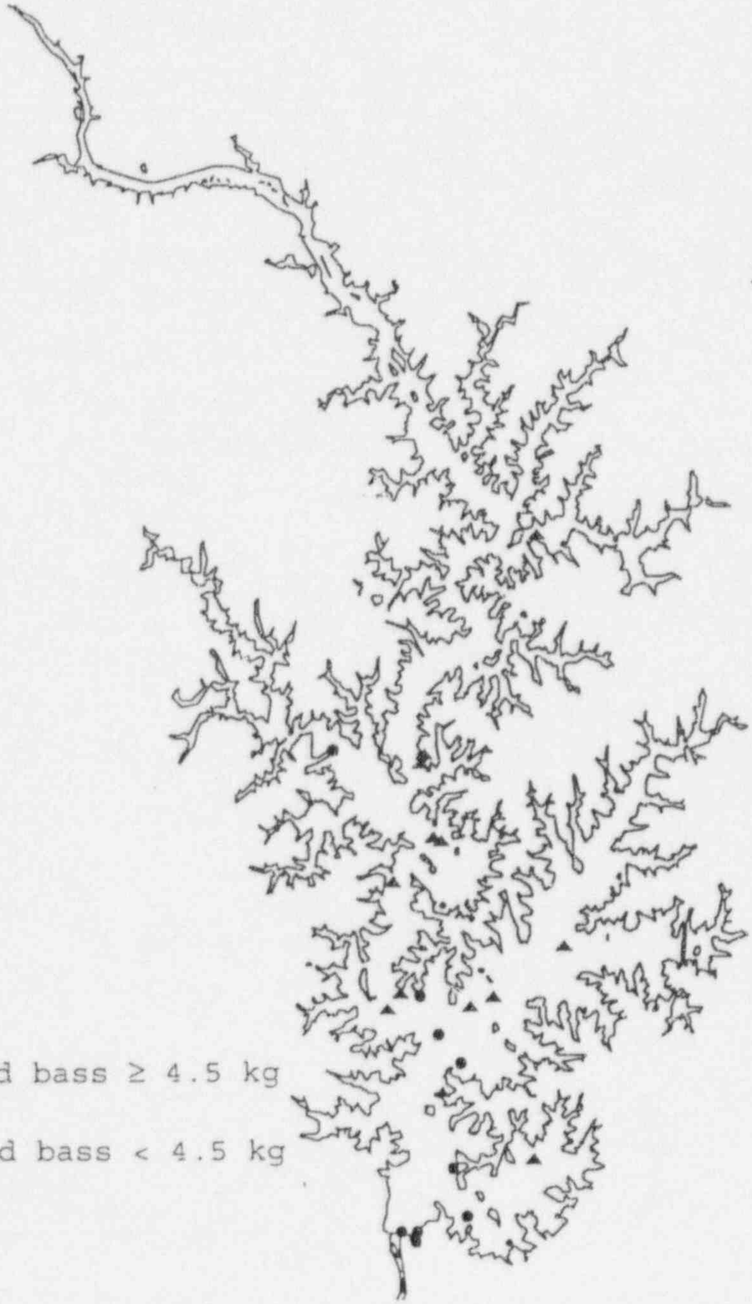


Figure 3. The distribution of tagged striped bass encounters at Lake Norman in Period 3, 1992.



● = Striped bass ≥ 4.5 kg

▲ = Striped bass < 4.5 kg

Figure 4. Striped bass temperature selection (mean and range) by period and size (small < 4.5 kg ≤ large) from Lake Norman, 1992.

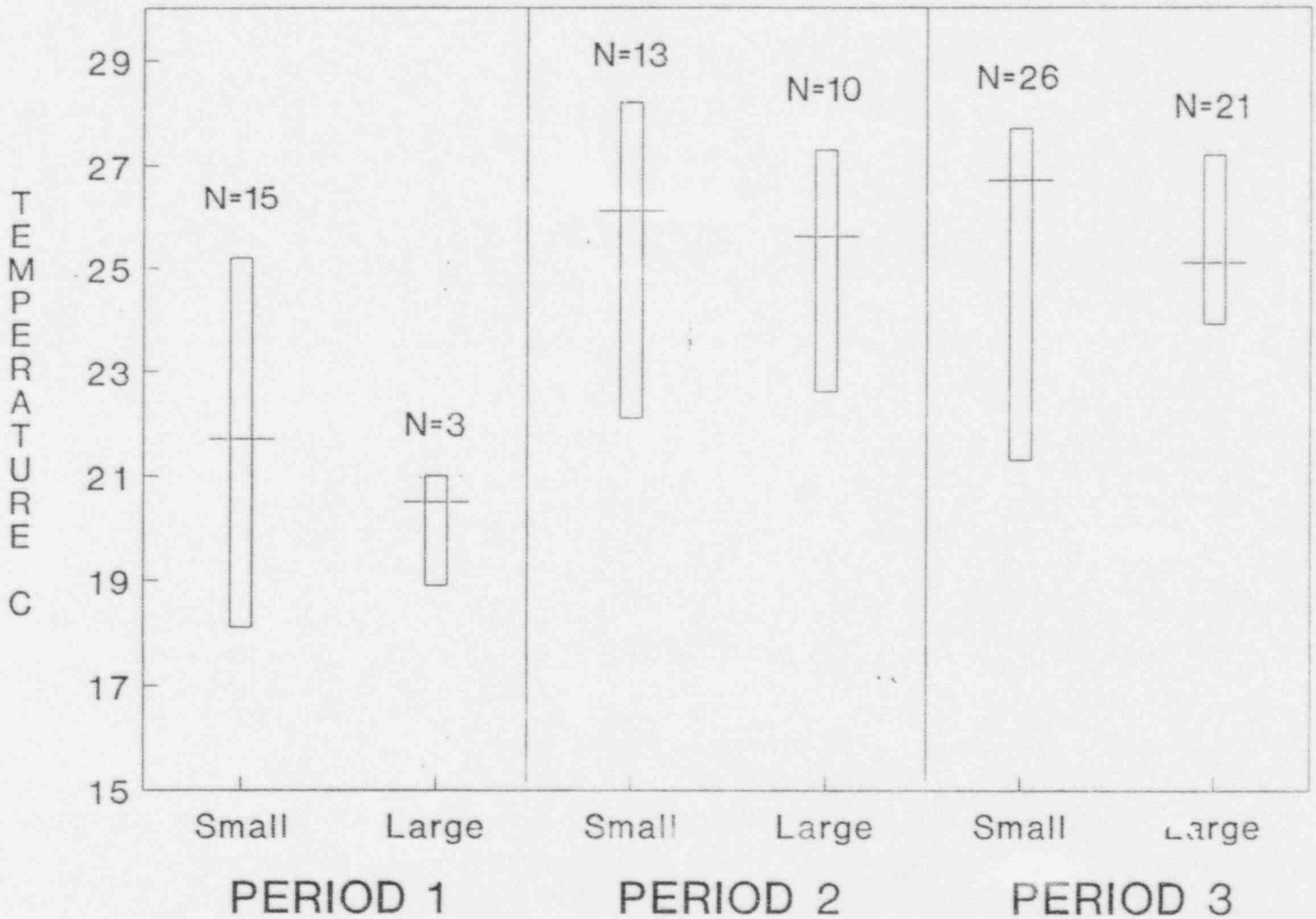


Figure 5. Striped bass dissolved oxygen selection (mean and range) by period and size (small < 4.5 kg ≤ large) from Lake Norman, 1992.

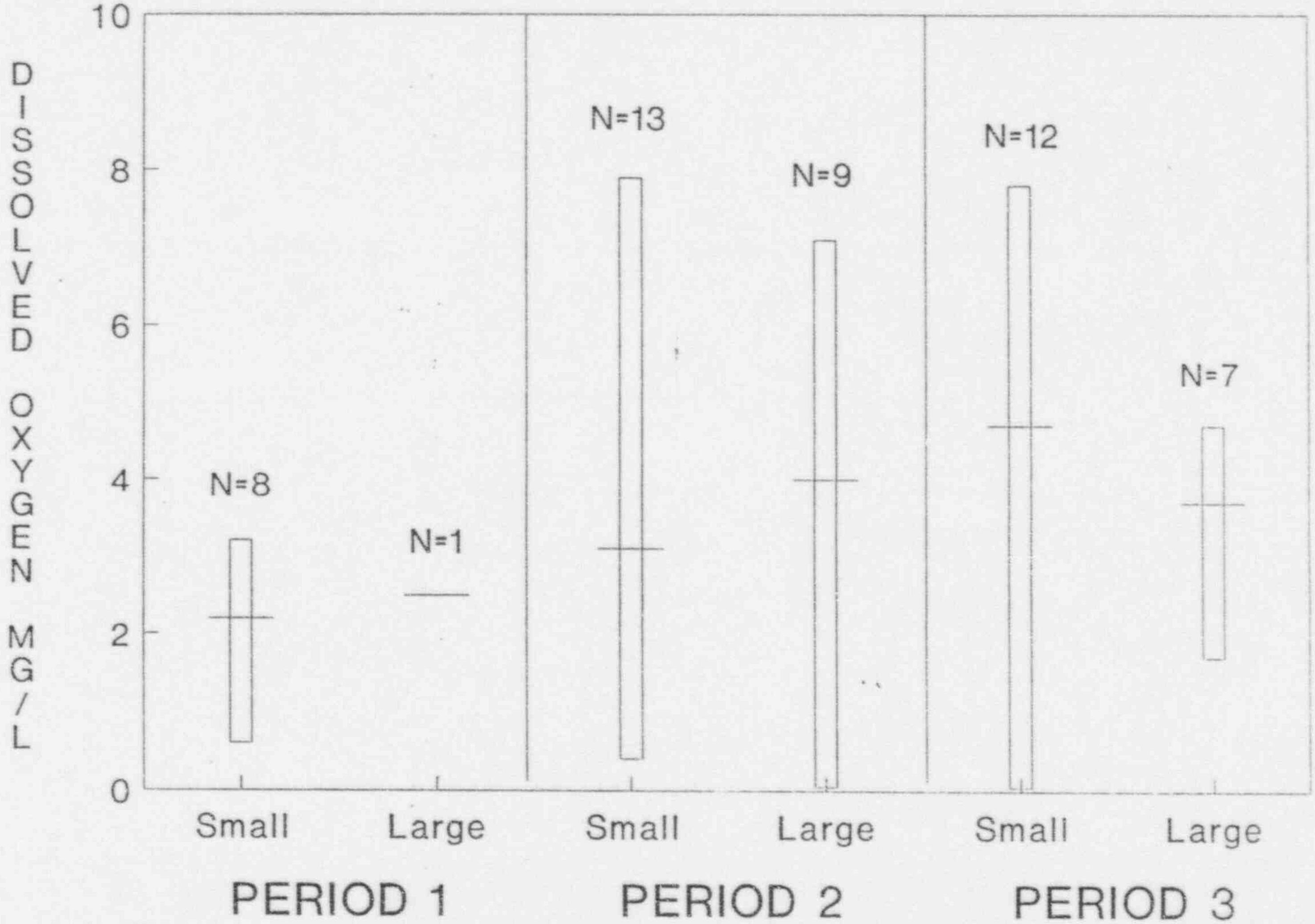
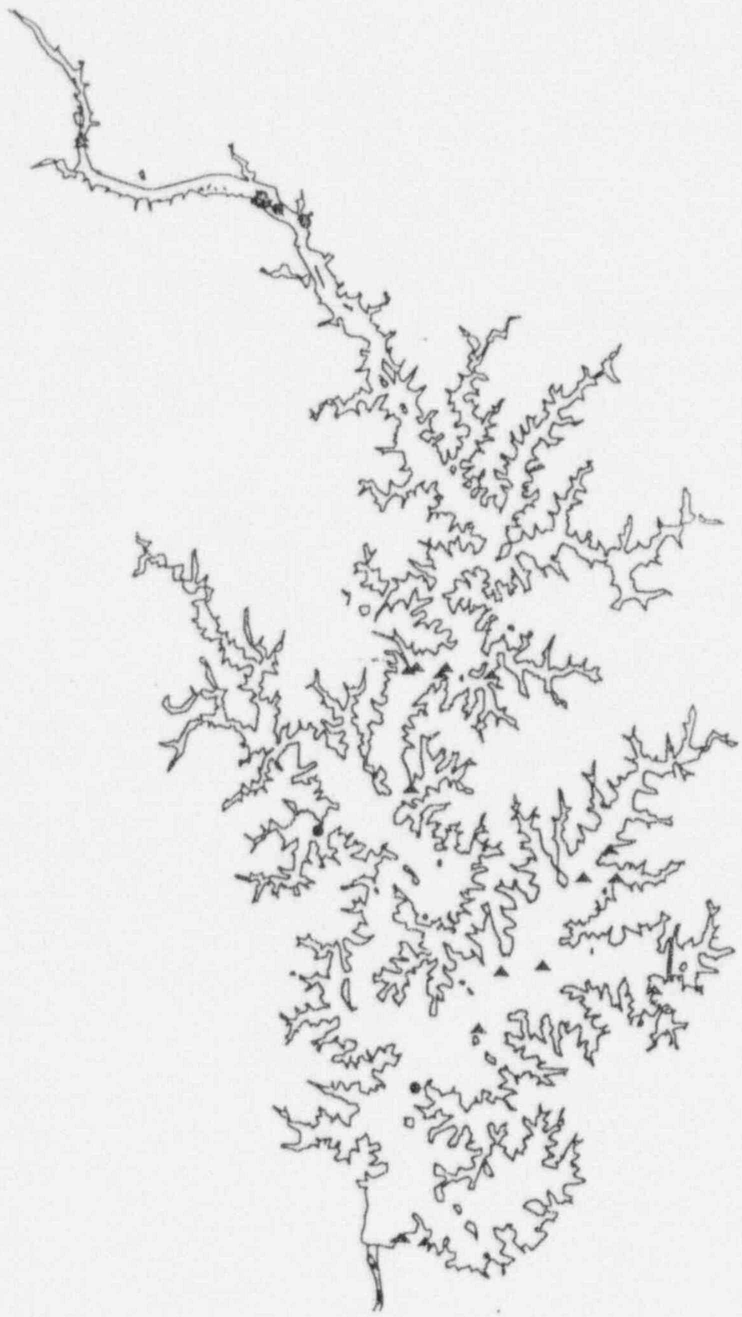


Figure 6. The distribution of tagged striped bass encounters at Lake Norman in summer, 1993.



● = Striped bass ≥ 4.5 kg

▲ = Striped bass < 4.5 kg