

Evaluation of Paddlefish Populations and Sport Fish Bycatch in Five Tennessee Reservoirs

INTRODUCTION

Paddlefish are found throughout the Mississippi drainage including all the major rivers of Tennessee. Paddlefish are commercially harvested for their roe (eggs) and flesh, but it is the value of the roe that generates most of the current demand for paddlefish. Commercial fishing for paddlefish in Tennessee is allowed in approximately 400,000 acres of reservoirs and large rivers statewide. Most of the harvest occurs at five fisheries that represent 70% of the total surface area currently open to commercial paddlefish harvest. Kentucky Lake's paddlefish average harvest represents > 50 % of Tennessee's total harvest each year followed by the Mississippi River and Lake Barkley. The estimated domestic (US) retail value for paddlefish (flesh and roe) harvest from Tennessee waters was approximately \$3.6 million for the 2009 harvest season, down from \$9.3 million in 2006. In 2011, 70 commercial fishers purchased permits to participate in the roe fishery.

In May 2011, the General Assembly of the State of Tennessee directed the Tennessee Wildlife Resources Agency (TWRA) to develop a plan to study the sustainability of commercial paddlefish roe fishing on waters that are currently closed to commercial fishing (TCA 70-2-303). The law (TCA 70-2-304) also provided for the formation of a Commercial Fisheries Advisory Committee (CFAC). On August 31, 2011, CFAC gave TWRA a list of closed waters where commercial fishers desire to fish for paddlefish using gillnets. Those locations are: Norris, Watts Bar, Cordell Hull, and Melton Hill lakes, and a currently restricted reach of Old Hickory Lake. TCA 70-2-303 also states that this study should be conducted with the help of commercial fishers who would be allowed to harvest the paddlefish during the study.

Paddlefish population studies are warranted because little is known about the current population dynamics of paddlefish in the named waters. The most recent study was conducted on Norris Lake in 1980, when Alexander and Peterson (1982) estimated a harvestable population of 8,772 fish and recommended a one-year fishery that would allow 15% of the population to be harvested. Scholten and Bettoli (2005) evaluated Tennessee's largest paddlefish fishery on Kentucky Lake, where they also used samples provided by commercial fishers. They concluded that inter-annual variation in river discharge provided some protection of this population, and

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that the current regulations did little to protect this fishery from overharvest. Many of the methods used by Scholten and Bettoli (2005) will be used in this study.

The Tennessee Department of Environment and Conservation (TDEC) has issued consumption advisories for some fish species in Norris, Melton Hill, and Watts Bar lakes, due to the presence of contaminants, primarily mercury and polychlorinated biphenyls (PCBs). Although paddlefish are not listed among the current advisories, it is necessary to confirm the safety of paddlefish flesh and eggs before opening these populations to commercial harvest. Contaminant data from flesh and roe will be obtained from Norris, Watts Bar, and Melton Hill lakes. Additional surveys to assess the feasibility of a paddlefish fishery will only be conducted pending the outcome of the contaminant study.

Another management consideration is bycatch of species that are intensively stocked by TWRA and highly prized by sport anglers. For example, an assessment of the TWRA's statewide stocking program revealed that in 2001 TWRA's striped bass stocking program costs \$328,000 a year and yields \$2.5 million in economic value to anglers (Fiss et al. 2004). Striped bass are present in all the proposed reservoirs, and TWRA manages Watts Barr, Cordell Hull, Melton Hill, and Norris lakes with special regulations to promote survival of large striped bass. Other species that may be vulnerable to large-mesh entanglement gear include muskellunge, sauger, walleye, blue catfish, flathead catfish, and the endangered lake sturgeon. Commercial fishers can reduce bycatch of most fish by using large-mesh gillnets (i.e. 6 inch and greater) and by avoiding locations where non-target species are known to inhabit. However large fish, such as 30-50 pound striped bass, could be caught by large-mesh gillnets.

The overall goal of this study is to recommend commercial fishing regulations that promote sustainable paddlefish fisheries where possible. Components of sustainability include the protection of consumers from contaminants and limiting bycatch of sport fish. Specifically, this study will address the following objectives at Norris, Watts Bar, Melton Hill, Old Hickory and Cordell Hull lakes:

- 1) Gather contaminant data for paddlefish flesh and eggs from Norris, Watts Bar, and Melton Hill lakes;
- 2) describe the size and age structure of paddlefish that are recruited to typical commercial gear on Old Hickory and Cordell Hull lakes ;

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- 3) describe mortality, growth, recruitment and stock density (CPUE) of paddlefish in Old Hickory and Cordell Hull lakes;
- 4) document bycatch of non-target species; and
- 5) complete objectives 2 through 4 for Norris, Watts Bar and Melton Hill lakes pending the results of the contaminant studies.

By TWRA standards this is a fairly large study, involving three administrative regions and requiring coordination with the commercial fishing community. TWRA does not have available manpower to conduct research on all the proposed waters concurrently. TWRA work crews intend to share manpower and boats to accomplish the objectives. Each lake will be considered a separate study unit and each lake will follow its own timeline such that field sampling is staggered over several years (Table 1). This staggered approach will reduce annual costs and limit loss of other critical activities performed by TWRA staff. We are prepared to take an adaptive approach to the study design and implementation should unforeseeable circumstances arise. Excessive bycatch, contaminants, or user conflicts that are considered detrimental to a fish population or fishery could call for a deviation from the initial design or result in termination of part of this study.

STUDY AREAS

Cordell Hull Lake: Cordell Hull Lake is a mainstream reservoir of the Cumberland River, located at the base of the Highland Rim within Smith, Jackson, and Clay Counties (Figure 1). The reservoir was impounded by the U.S. Army Corps of Engineers (USACOE) in March 1973, and the dam is located about 5 miles upstream from Carthage, Tennessee at river mile 313.5. There are 72 river miles in Tennessee and another 75 river miles between the Tennessee state line and Wolf Creek Dam in Kentucky. The reservoir is multi-purpose and serves for flood control, power generation, navigation, and recreation. At normal pool (elevation 504 feet), the reservoir covers 11,960 acres with a shoreline of 381 miles, draining an area of 1,372 square miles. The reservoir has a normal winter drawdown of four vertical feet. Flow is largely controlled by Wolf Creek Dam located in Kentucky, and to a lesser extent by Dale Hollow Dam on the Obey River in Tennessee. There are numerous other tributaries which have minor influence on reservoir flows. The reservoir generally has cooler year-round water temperatures due to cold water inputs from Wolf Creek and Dale Hollow, and its water retention time is short

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due to its riverine nature. These conditions provide excellent habitat for cool water species such as striped bass, sauger, and walleye.

Old Hickory Lake: Old Hickory Lake, completed in 1954, is a mainstream impoundment of the Cumberland River operated by the USACOE (Figure 2). The primary functions of this impoundment are flood control, hydroelectric power, navigation, and recreation. The dam is located in Davidson County at river mile 216. Old Hickory Lake is 22,500 acres at elevation full pool (445 feet above sea level), extends 97 river miles, has 440 miles of shoreline, and drains 11,674 square miles. Residential shoreline development is extensive and water level fluctuations are minimal. Cold water from Center Hill and Cordell Hull dams provide cool water temperatures and adequate dissolved oxygen concentrations in the channel and most embayments during summer. These conditions provide excellent cool water habitat supporting striped bass and other notable fisheries such as sauger and walleye. There are also numerous major tributaries (e.g. Bledsoe and Drakes creeks) that provide warm water habitat for largemouth bass, crappie, catfish, and sunfish.

Unlike the other reservoirs in this study, commercial fishing is currently permitted in the lower section of the reservoir. Commercially harvested fishes include buffalo, paddlefish, catfish, and common carp. It is open to all commercial fishing downstream of Highway 109 (Figure 2). Between Highway 109 and Highway 231 commercial fishing is restricted to a contract fishery that is limited to the use of entanglement gear set by the trammeling method (or whip set). Commercial fishing with entanglement gear is not permitted upstream of Highway 231. The proposed study will be limited to waters between Highway 109 and Highway 231, and no nets will be set within 300 yards of the outfall of Gallatin Steam Plant.

Watts Bar Lake: Watts Bar Lake is a mainstream reservoir of the Tennessee River (Figure 3). Watts Bar Dam was completed in 1942 by the Tennessee Valley Authority (TVA) at river mile 529.9. The upper ends of the reservoir are impounded by Melton Hill Dam on the Clinch River and Ft. Loudoun Dam on the Tennessee River. The reservoir serves for flood control, power generation, navigation and recreation. Watts Bar Lake has approximately 39,000 acres of surface area water at full pool (741 feet above sea level) and has 722 miles of shoreline. It is 72.4 miles long and has a total drainage area of 17,310 square miles. The reservoir has an annual fluctuation of six vertical feet from summer pool to winter pool. Watts Bar Lake is thermally stratified during the summer months. Inflow and retention time depends on power

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generation schedules and flood control releases from upstream dams. Watts Bar Lake has important sport fisheries for black basses (largemouth and smallmouth), crappie, sauger, white bass and striped bass. Watts Bar Lake has several fish consumption warnings due to contaminants from the Oak Ridge Reservation and other sources. Contaminant testing is ongoing since TVA's coal ash spill in December 2008.

Norris Lake: Norris Lake is a tributary reservoir created in 1936 by the completion of Norris Dam (Figure 4). The reservoir is approximately 30 miles north of Knoxville, Tennessee and contains 33,804 acres at full pool. The impoundment provides hydroelectric power, flood control, and supports a variety of recreational activities. The Powell and Clinch Rivers are the primary tributaries of the reservoir and form its headwaters. The Clinch River arm extends from Norris Dam at Clinch River Mile (CRM) 80.0 upstream to CRM 152.0. The Clinch River arm is contaminated with mercury, and has a consumption advisory for black bass (*Micropterus spp.*) and sauger. The Powell River arm extends from the confluence of the Clinch River at Powell River Mile (PRM) 0.0, to PRM 56.0. The study will gather contaminant data and, if warranted, evaluate the paddlefish fishery in each of these arms.

Several creeks provide major embayments around the reservoir. Full pool elevation is 1,020 feet above sea level and minimum pool elevation is 961 feet, allowing potential water level fluctuations of 59 feet. The average hydraulic retention time is 245 days and there are approximately 800 miles of shoreline at full pool. The lower section of Norris Lake is classified as oligotrophic; whereas upper reaches are more fertile and considered mesotrophic. Of all the study lakes, Norris Lake has the longest retention time and greatest degree of thermal stratification. This allows wide distribution of both warm and cool water fish species throughout the impoundment. The principal sportfish are bluegill, black bass, striped bass, walleye, and crappie.

Melton Hill Lake: Melton Hill Lake is a mainstream TVA impoundment, found on the Clinch River near Oak Ridge, Tennessee (Figure 5). This 5,691 acre reservoir was created in 1963 by the completion of Melton Hill Dam at CRM 23.2 and extends 44 miles upstream to CRM 67.1. There are 170 miles of shoreline. Annual water level fluctuation is approximately 5 feet (between 790 and 795 feet above sea level), and the average hydraulic retention time is 12 days. The impoundment is largely bordered on its northwest bank by United States Department of Energy property, but much of the opposing bank is privately owned, resulting in limited

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access. Most of Melton Hill Lake is narrow and riverine; however, a few small coves are found adjacent to the main navigation channel. The water entering the lake is comprised of the cold deep water from Norris Lake and as a result Melton Hill Lake supports cold and cool water fish species like trout, striped bass, and muskellunge in addition to black bass and crappie fisheries. There are several fish consumption warnings for Melton Hill Lake as it is downstream from the Oak Ridge Reservation.

METHODS

Tissue and Egg Samples for Contaminant Analysis – TWRA will use gillnets or electrofishing gear to collect paddlefish for flesh and egg samples between January 1 and April 30. Samples will be collected from Norris, Watts Bar, and Melton Hill lakes. TWRA will collect 10 legal-size, gravid, female paddlefish at each site on each reservoir. There will be two sites on Norris Lake: the Clinch River arm and the Powell River arm (Figure 4). Watts Bar Lake will have three sites (Figure 3): Emory River arm, Clinch River arm between Emory River confluence and Melton Hill Dam, and Tennessee River between Clinch River confluence and Fort Loudoun Dam. All of Melton Hill Lake (i.e., the Clinch River between Melton Hill and Norris dams) will be considered one site.

Collection and processing of tissue samples will follow EPA's standard operating procedures for fish flesh with analysis by the TDEC's environmental laboratory. Each sample of 10 fish will be divided into two composite samples representing five fish each. Composite samples will use the same individuals for both flesh and roe. Composites will be tested for metals and organic compounds.

Samples from Watts Bar and Melton Hill lakes will be sampled twice, two years apart. Multiple collections over time are warranted at Melton Hill and Watts Bar for the initial screening because these reservoirs are relatively open systems compared to Norris Lake, which is a headwater impoundment without a lock. These initial contaminant surveys may need to be repeated on a timeline that will be dictated by the results of initial screenings.

Selection of Commercial Fishers: Commercial fishers will conduct the gillnetting for the paddlefish population surveys. Commercial fishers who held a roe permit on November 15, 2011 will be invited to participate in a random drawing for each reservoir. These invitations will be mailed to the address listed on their commercial fishing license. The invitation will include minimum gear and boat requirements to ensure that the fisher can fish according to the study

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guidelines. Three commercial fishers will be randomly selected for each reservoir with the exception of Norris Lake where four will be selected. Those selected fishers may have up to two licensed commercial fishers assisting them in their boat.

Population Survey – Paddlefish will be collected by selected commercial fishers during the two-year study at each reservoir. Three commercial fishing boats will be used at each reservoir, except Norris Lake where four boats will be used, two in each of the two major arms of the reservoir (Figure 4). Fishing locations will be determined by commercial fishers within each study area. The special season will allow 16 nights of fishing between February and March. Fishers will only set nets on Monday and Tuesday afternoons. To limit release mortality of paddlefish and other species, the study will cease if water temperature exceeds 57 °F. TWRA staff may cancel any study date for any reason, but the most likely reasons would be dangerous flows or winter road conditions. Likewise commercial fishers may use their discretion about which days they will participate. However, any scheduled commercial fisher that misses two sample days will be replaced by an alternate commercial fisher.

Each boat will be limited to setting 12 nets. Commercial fishers will set and pull their own multifilament gillnets. Nets will be deployed within 3 hours prior to sunset on each sample day and net retrieval will begin between sunrise and 8:00 AM the following day. All nets will be removed from the water until the next evening set. All nets will be sinking gillnets composed of 6-inch mesh (bar measure) netting that is 30 feet high, tied down to 20 feet. Net length may vary from 150 feet to 300 feet. Nets will be set perpendicular to the shore and the float lines will not be within 3 feet of the water's surface. Pickup floats will be used to identify all gillnets. Gillnets will be checked each morning in the presence of TWRA data recorders.

All fish collected in each net will be counted and identified to species, and dead specimens will be noted. TWRA biologists will measure total length (TL in mm) of all fish and eye-to-fork length (EFL in mm) of all paddlefish. Roe from paddlefish over 40 inches EFL will be eligible for harvest by commercial fishers. In theory, a 40-inch EFL minimum length should protect more mature fish in the population, compared to the commonly used 36-inch minimum length limit. TWRA biologists intend to be cautious as these populations are being evaluated for the first time in decades, yet still provide some harvest for commercial fishers.

The first ten paddlefish captured in each 25-mm EFL group in each reservoir will be sacrificed to determine sex and remove dentary bones (jaw bones) for age analysis. Roe from

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these fish will also be available for harvest by commercial fishers. Paddlefish not harvested or sacrificed for dentary bones will be marked by clipping the right pelvic fin, and then released.

All unmarked paddlefish will be weighed to the nearest 0.25 kg (unblocked weight), and examined to determine if eggs are present using a 12-gauge needle. Ovaries of up to 30 gravid paddlefish in each reservoir will be removed and weighed to the nearest 1gram. An aggregate subsample of eggs will be collected from at least six locations along the length and at various depths of each ovary. The sample from each site on the ovary will be approximately 10 g resulting in an aggregate sample of approximately 60 grams. This sample of eggs will be weighed (1 g) and preserved in 5% unbuffered formalin solution (Markle 1984). The preserved sample of eggs will be subsampled to estimate the number of eggs in that sample. Fecundity will be estimated as the number of eggs per kilogram of fish (Reed et al. 1992; Hoxmeier and DeVries 1997).

Dentary bones will be submersed in a 10:90 solution of liquid laundry detergent and water and heated to 43° C for 14 hours to loosen flesh adhering to the bones. After cleaning, the dentary bones will be soaked in a 50:50 solution of ammonia and water for five hours and then a 50:50 solution of ethanol and water for 24 hours. After drying, five sections (~0.5 mm thick) will be obtained from the left dentary bone 10 mm posterior to the mesial bend with a Buehler Isomet® low-speed saw (Scarnecchia et al. 1996; Lein and DeVries 1998). Age will be estimated for each set of sections in two independent readings. Annuli will be counted (Adams 1942) without knowledge of fish size or sex using a microprojector at 40X magnification. If discrepancies occur between first and second readings, then those sections will be read a third time. We will also ask other paddlefish aging experts (outside of TWRA) to review a sample of our prepared sections to confirm our estimates. Upon agreement, ages will then be assigned to un-aged fish using an age-length key.

Paddlefish Data Analysis: A net night will be defined as one overnight gillnet set; Therefore, actual soak time will vary by a few hours per net. Catch-per-unit-effort (CPUE) of paddlefish will be calculated as number caught per net night and standardized for net length. Length-frequency histograms will be reported for paddlefish based on 25-mm EFL groups.

Exploratory analyses of our data will determine the appropriate statistical methods for analysis and allow us to evaluate whether or not we have sufficient data to address all objectives. Again, our goal is to evaluate mortality, growth, recruitment, and stock density of paddlefish at

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these reservoirs and use those data to predict sustainable levels of harvest for future fisheries.

Given sufficient data, we intend to:

- 1) estimate mean length-at-age;
- 2) estimate parameters of the von Bertalanffy growth model;
- 3) estimate annual mortality (Z) of paddlefish that recruited to our gear;
- 4) evaluate recruitment (reproduction) variability by examining age frequency data;
- 5) index female paddlefish maturity using the gonadosomatic index (GSI; Snyder 1983);
- 6) calculate relationships between fecundity, EFL and age;
- 7) use Fishery Analysis Software Tools (FAST; Slipke and Maceina 2001) to calculate spawning potential ratios (Goodyear 1993),
- 8) use FAST software and the Beverton-Holt yield-per-recruit model to estimate flesh yield under a range of exploitation rates and minimum length limits; and
- 9) calculate mortality caps (Miranda 2002) to predict the maximum mortality rate that these populations can experience and still maintain a desired mean length of harvested fish.

Bycatch Data Analysis: CPUE will be calculated for all bycatch species (number/net night). Length-frequency histograms (10-mm length groups) will be reported for all fishes collected. We will also calculate the number of days each commercial boat (fishing a maximum of 12 nets daily) exceeded the typical creel limit for each species of sport fish. For example, the daily creel limit for striped bass is typically 2 fish per day. We will use the daily creel limit for each sport fish as a benchmark to evaluate bycatch levels that would trigger a management concern.

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Table 1. Schedule of study activities by reservoir.

Water	Activity	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Cordell Hull	Population Survey with Limited Harvest	X	X				
Old Hickory	Population Survey with Limited Harvest	X	X				
Norris	Contaminant Sample (2 sites)	X					
Norris	Population Survey with Limited Harvest *			X	X		
Watts Bar	Contaminant Sample (3 sites)	X		X			
Watts Bar	Population Survey with Limited Harvest *				X	X	
Melton Hill	Contaminant Sample (1 site)	X		X			
Melton Hill	Population Survey with Limited Harvest *					X	X

*Pending the results of the contaminants study

Population Survey: Count all fish caught in each net and measure length and weight of all paddlefish and length of all sport fish. TWRA will sacrifice 10 paddlefish per 25-mm size group to collect dentary bones to establish a length-age key for each population.

Limited Harvest: Roe taken by selected commercial fishers. This will include roe from fish sacrificed for dentary bones and any paddlefish over 40 inches (EFL) during the duration of the survey.

Contaminant Sample: Collection of 10 legal-size gravid females per site. Collection and processing to follow EPA/SOP for fish flesh with analysis by the TDEC's environmental laboratory.

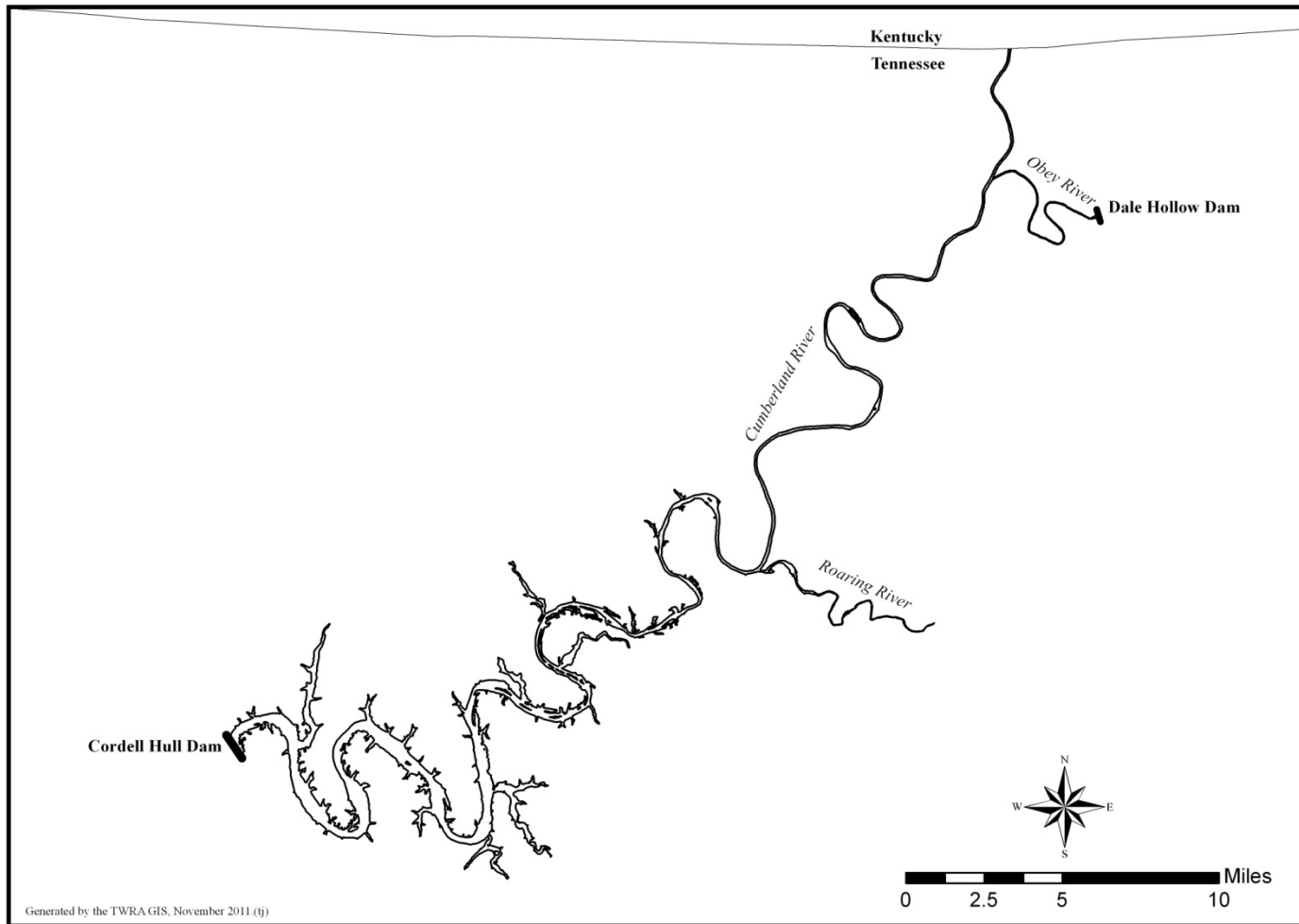


Figure 1. Map of Cordell Hull Lake to Tennessee state line.



Figure 2. Map of Old Hickory Lake and Highways 109 and 231. The contract fishery for this study will take place between Highways 109 and 231, except within 300 yards of the Gallatin Steam Plant discharge.

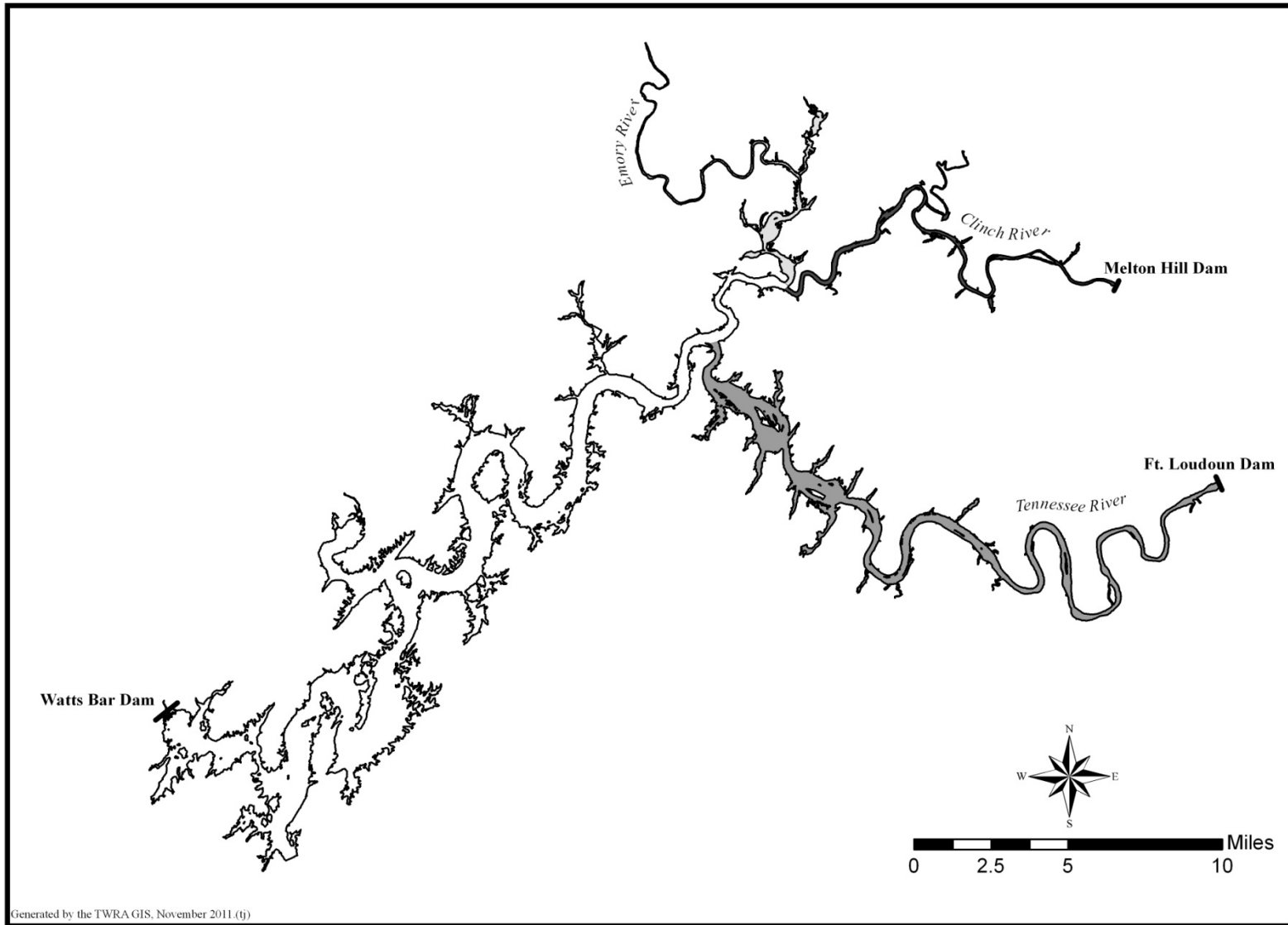


Figure 3. Map of Watts Bar Lake showing arms to be surveyed for contaminants: Emory, Clinch and Tennessee river arms.



Figure 4. Map of Norris Lake showing Clinch River and Powell River arms.

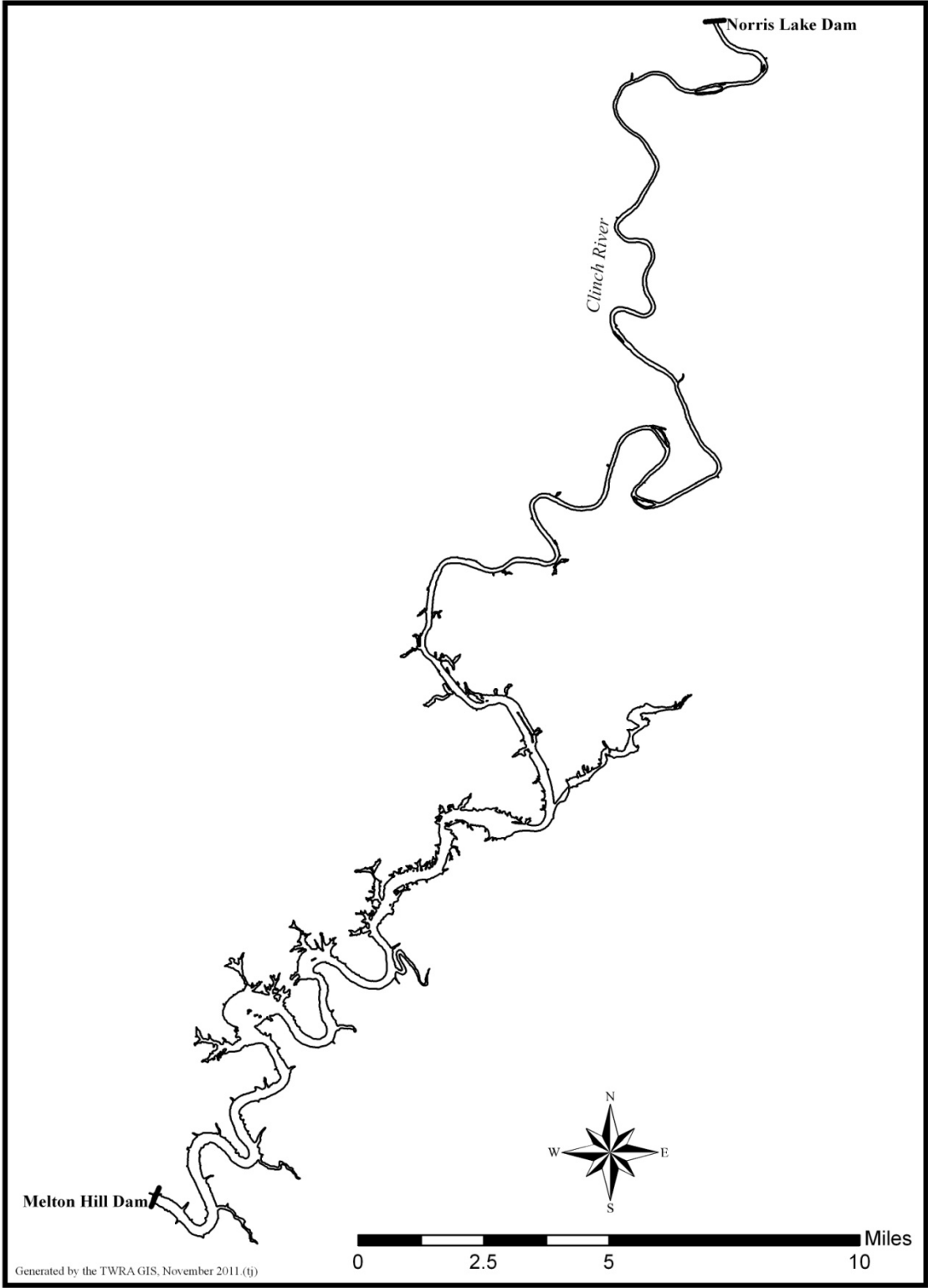


Figure 5. Map of Melton Hill Lake upstream to the tailwater of Norris dam.