

**2009
STATEWIDE COMMERCIAL MUSSEL
REPORT**



**BY
Don Hubbs**

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TABLE OF CONTENTS

	<u>PAGE</u>
Title Page	i
Table of Contents	ii
List of Figures	iii
List of Tables	iii
List of Appendices	iv
INTRODUCTION	1
METHODS and MATERIALS	4
RESULTS and DISCUSSION	5
SUMMARY	12
RECOMMENDATIONS	13
LITERATURE CITED	15
FIGURES	16
TABLES	22
APPENDICES	38

LIST OF FIGURES

<u>FIGURE</u>	<u>PAGE</u>
1. Tennessee mussel shell harvest trends, 1999 - 2009	17
2. Tennessee wholesale shell price trends, 1999 - 2009	18
3. Legal sized mussel shell in Kentucky Reservoir population, 1999-2009	19
4. Zebra mussel CPUE at Kentucky Reservoir commercial mussel assessment sites during August.	20
5. Annual shell harvest weight distribution by species group (TWRA Receipt Data)	21

LIST OF TABLES

<u>TABLE</u>	
1. Harvest volume, value, license and shell fee revenue, 1992-2009	23
2. Average wholesale price paid for various categories of commercial shell during 2009	24
3. 2009 wholesale commercial shell harvest by size category, as estimated from Tennessee waters	25
4. Tennessee commercial mussel shell industry volume and value, 2005-2009	26
5. Tennessee's commercial mussel shell harvest size class distribution by weight, 2005-2009	27
6. Summary of commercial mussel species data, Kentucky Reservoir sections I, II, and III	28
7. Kentucky Reservoir percentage of legal-sized commercial mussels by category, 2009	32
8. Cumberland River Old Hickory and Cheatham Reservoirs, 2009	33

LIST OF APPENDICES

APPENDIX

I.	2009 Wholesale Mussel Dealer & Receipt Report Summary Data	39
II.	Freshwater Mussel Species Collected from Kentucky Reservoir during 2009 Sampling	42
III.	Zebra Mussel Distribution in Tennessee	44

INTRODUCTION

This report contains mussel population and commercial harvest data collected during 2009, and compares recent harvest trends. Activities described in this report were partially funded by the fee on commercial mussels and license sales associated with the commercial mussel program. Any person, firm or corporation who purchases or otherwise obtains freshwater mussels taken from Tennessee waters is required to pay the Tennessee Wildlife Resources Agency (TWRA) the amount equal to \$0.0145 per pound of mussel shells or \$0.0124 per pound of mussel (shell with meat) purchased or obtained. During 2009, TWRA received the following revenues associated with the sale of commercial musseling licenses and collection of the shell fee:

<u>TYPE LICENSE</u>	<u>NUMBER</u>	<u>REVENUE</u>
Resident Commercial Musseling	66	\$ 13,200
Non-Resident Commercial Musseling	0	\$ 0
Wholesale Mussel Dealer	5	\$ 2,500
Cultured Pearl	<u>2</u>	<u>\$ 2,000</u>
Total License -	71	\$ 17,700
Shell Fee (accrued Jan. 1, to Dec. 15, 2009)		<u>\$ 8,345</u>
TOTAL REVENUE		<u>\$ 26,045</u>

Adequate funding has been a problem for the commercial mussel program for more than a decade due to declining license sales and shell fee receipts. TWRA has experienced a drastic decline in the number of harvester licenses sold since the fee was levied (down from average of 1,440/year during 1990-95 to 221/year for last five years). Costs of annual harvester's licenses increased from \$125 to \$200 for residents and from \$250 to \$1,000 for non-residents in 2006, yet license revenue remains inadequate to fund the program. The current shell fee paid to TWRA by wholesale mussel dealers has not increased since it was levied in July 1991. While it was originally intended to provide a mechanism for tracking annual shell harvests, more recently, a fee increase appeared to be the logical method to fund the program. In order to balance the commercial mussel program's funding deficit, TWRA's Commercial Mussel strategic plans have recommended an increase in the shell fee for more than 10 years. However, not even a tenfold increase would provide sufficient revenue at the most recent harvest levels.

During the last century, the harvest of mussel shell has fluctuated according to market demand. Mussels were first harvested for the natural pearls they can produce, then as a source of raw material for buttons and mother of pearl inlay, and finally for the production of cultured pearl nuclei. The majority of freshwater mussel shells harvested in Tennessee were shipped to Japan, China and other countries where they were cut and polished into beads. These beads were inserted into marine oysters and freshwater mussels to form cultured pearls. According to Olson (2007), Tennessee leads the United States in pearl and mother of pearl shell production. Tennessee's commercial mussel shell industry accounted for 71% of the total shell harvest value and 21% of the total value of all natural gemstones produced in the United States during 2006 (latest figures available from USGS).

Through the early 1990's, commercial musseling employed as many as 3,000 people in Tennessee. However, biological problems affecting the survival and production of Japan's pearl producing oysters combined with other factors affecting the cultured pearl industry, Japanese and U.S. economies, reduced the market for Tennessee's mussel shells beginning in 1997. Some shell exporters chose to ship only their highest quality shells during this period creating a narrower market with a lower demand for standard quality shells, this contributed to lower domestic wholesale shell prices. The decreased demand and lower wholesale prices caused a substantial decline in the number of mussel harvesters working in Tennessee. During 2004-2007, Tennessee's shellfishery stabilized at a lower level where on average less than 300 harvesters were taking approximately 1,400 tons per year. Then competition from Chinese freshwater pearls and unfavorable economic conditions created an oversupply of nucleated cultured pearls and the U.S. shell market experienced a steep decline in 2008 that continued through 2009.

Recently, the estimated value of pearl production by market share was, White South Sea cultured pearls (Australia, Indonesia, the Philippines, Myanmar) 35% US\$ 220 million, Freshwater cultured pearls (China) 24% US\$ 150 million, Akoya cultured pearls (Japan, China) 22% US\$ 135 million, Tahitian cultured pearls (French Polynesia) 19% US\$ 120 million, total estimated pearl production US\$ 625 million (PEARL OYSTER 2006). China has rapidly grown its cultured pearl industry and is now the largest producer of cultured pearls, producing 95% of the cultured pearls as of 2008 (PEARL OYSTER 2008). Since 2004, China has increased its use of shell bead pearl nuclei resulting in US wholesale shell price increases until 2008 when competition from Chinese grown mussel shells began to negatively affect US shell prices. The Hong Kong Pearl Association (HKPA), a trade group composed of cultured pearl dealers, some of whom are also pearl farmers, estimates that China grew 1,654 tons of freshwater cultured pearls in 2006. Of that volume, an estimated 882 tons were suitable for use in jewelry. That jewelry-use tonnage is nearly 13 times the volume generated by all the other pearl-producing countries combined (Loupe Online 2008). Each rise and fall in cultured pearl demand has affected the quantity and quality of the mussel shell resource available for harvest and export.

Tennessee's quality commercial mussel stocks were primarily limited to Kentucky Reservoir (Hubbs 2009a). Kentucky Reservoir stretched 184.3 miles from Pickwick Dam at Tennessee River mile (TRM) 206.7 in Hardin County, TN to Kentucky Dam at TRM 22.4 near Gilbertsville, Kentucky. The Tennessee portion contained 1,971 shoreline miles and approximately 110,990 surface acres, ending at TRM 49.2 in Stewart County, TN. The main channel and over-bank widths varied from 0.25 to 2 miles. Information gathered from wholesale mussel dealers showed that most of the annual harvest was reported from Kentucky Reservoir. No other Tennessee waters appeared to contain mussel populations of sufficient quality, size and diversity to sustain a continuous commercial harvest.

Some wholesale mussel dealers have complained about the lower quality of shells being harvested from the mud and clay bars in the northern half of Kentucky Reservoir and the increase in "snout nosed mapleleaves" (*Quadrula apiculata*). They described the shells as having a "river grade" appearance, indicating that the periostracum in the umbonal area of the shell was damaged or missing, and the shells had a generally rougher exterior. The increased abundance of lower quality shells from this region could be attributed to the accumulation of Asian clam (*Corbicula fluminea*) shell shards, which are now part of the substrate layer on many of the clay

bars where mussels are harvested (personal observation). The periostracum of mussels growing in these shell shards is worn away as the mussel moves through the substrate exposing the shell to degradation through dissolution, erosion, and staining.

No mussel die-offs were reported from Kentucky Reservoir during 2009. Tennessee Valley Authority increased the frequency of generation cycles at Pickwick Dam during summer to improve water quality and reduce occurrence of zero flow through the reservoir. Drought conditions experienced during 2007 – 2008 were relieved by above average rainfall in 2009. Increased water elevations and turbidity reduced the acreage of aquatic vegetation growing in the reservoir, coontail and southern naiad continued to dominate aquatic vegetation in Kentucky Reservoir, while hydrilla sp. was identified in the middle portion of the reservoir (Broadbent 2009).

Old Hickory and Cheatham reservoirs were also sampled during 2009 to ascertain the status of mussel resources in relation to altered flows and water temperatures resulting from maintenance operations at Wolf Creek Dam and to collect mussels for a translocation project funded by the National Park Service. Cheatham Reservoir is located on the Cumberland River between Ashland City and Nashville, with a length of 67.5 river miles between Cheatham Dam (CRM 148.7) in Cheatham County and Old Hickory Dam (CRM 216.2) in Davidson County. Old Hickory Reservoir is located on the Cumberland River between Carthage and Nashville, running 97.3 river miles between Cordell Hull Dam (CRM 313.5), Smith County, TN and Old Hickory Dam (CRM 216.2), Davidson County, TN. Substrate ranged from silt to sand, gravel, cobble, and bedrock. Recently, these reservoirs have not produced significant quantities of commercial mussel shells due to inconsistency of shell quality and reduced recruitment from prolonged exposure to cold hypolimnetic releases from upstream reservoirs; impoundment altered habitats, and degraded water quality from industrial and municipal sewage discharges. Survey efforts were concentrated in the Rome Ferry sanctuary (CRM 292.5 to CRM 313.5) where historically mussel densities had been high with fewer sites surveyed downstream based on historic mussel bed locations.

During 2009, commercial musselers were restricted to harvesting only those individuals of the 10 freshwater mussel species listed below. Only individuals that will not pass through a ring with an inside diameter specified for that species as legal in Tennessee may be harvested. All other mussels were required to be returned immediately and unharmed to the bed from which they were taken.

<u>Mussel Species Listed for Harvest</u>	<u>Inside Ring Diameter in inches</u>
Pink heelsplitter (<i>Potamilus alatus</i>)	4.0
Washboard (<i>Megaloniaias nervosa</i>)	4.0
River pigtoe (<i>Pleurobema cordatum</i>)	2 5/8
Lake pigtoe (<i>Fusconaia flava</i>)	2 5/8
Mapleleaf (<i>Quadrula quadrula</i>)	2 5/8
Snoot nose Mapleleaf (<i>Quadrula apiculata</i>)	2 5/8
Three ridge (<i>Amblema plicata</i>)	2 5/8
Elephant Ear (<i>Elliptio crassidens</i>)	2 5/8
Monkeyface (<i>Quadrula metanevra</i>)	2 3/8

METHODS and MATERIALS

The wholesale value of the mussel harvest was calculated by surveying active commercial mussel dealers' monthly records, and reviewing TWRA mussel receipts to collect price data for each shell category. Monthly price data obtained from wholesale mussel dealers and TWRA mussel receipts were tabulated to compute average price paid for the major categories of shell. Wholesale mussel receipt reports provided by TWRA's Data Management Division were used to calculate the total commercial harvest volume, species distribution and percent size composition (Clouse 2010). In 2009, the commercial mussel shell category known as "lake mix" was composed of the following species: threeridge (*Amblema plicata*), snootnose mapleleaf (*Q. apiculata*), mapleleaf (*Q. quadrula*), and lake pigtoe (*Fusconaia flava*). Multiplying the average annual price per pound by the estimated number of pounds harvested and then summing the categories derived the annual harvest value.

Commercial mussel population assessments were conducted on Kentucky Reservoir because it contains the most important commercial mussel beds. Major collection efforts were directed toward sampling areas frequented by commercial harvesters. Because mussels exist as clumped, contiguous aggregations, stratified sampling techniques were employed. The reservoir was divided into three sections based on major hydrological characteristics. Specific sample locations were selected based on presence of significant mussel resources (density, diversity, and harvest activity). All mussels collected were placed in mesh bags, brought to the surface for examination, and either retained for additional analyses or returned to the bed after enumeration. Mussels collected during population surveys were identified to species, enumerated, and recorded. Commercial species were measured (using rings of 2 3/8, 2 5/8 and 4.0 inches inside diameter according to current size limits for each species) to determine size distribution. Data were entered into a computer spreadsheet to tabulate species composition, size distribution, and relative abundance parameters. The legal-sized portion of the population was determined for all commercial species.

On Kentucky Reservoir, each commercial assessment site consisted of ten tethered dives with five minutes of active collecting per sample replicate. While not as quantitative as measured area sampling (i.e. quadrats), CPUE usually detects greater numbers of mussels and species richness, especially in situations where mussels occur in low abundance (Strayer and Smith 2003). Because a larger sample size could be attained during timed collections, this was the preferred method. However, on other reservoirs where low site density, depth, or swift current rendered this method impractical, timed dives of varied duration were employed to generate catch per unit effort data (CPUE).

Vessel to diver communications (Ocean Technology Systems) and surface supplied air were the preferred dive methods used to conduct surveys and collect samples in deep water environments (reservoirs and mainstream rivers). Before sampling a given area, a 16-channel WAAS enabled GPS side-scanning sonar (Hummingbird model 987c SI) was used to analyze bottom characteristics, detect underwater obstructions that might impair collection efforts, and mark sample locations. In shallow water where samples could be collected by snorkeling or hand picking, the aerial extent of the mussel bed (shoal) was visually determined before a

representative sample was collected from the bed. Species composition was determined from timed collections. Effort was directed toward the collection of commercial mussel species consistent with methods employed by commercial mussel harvesters utilizing surface-supplied air diving equipment.

The Cumberland River was sampled on both Cheatham and Old Hickory reservoirs during 2009. On Old Hickory Reservoir, sampling effort was concentrated around Lock 7 with less effort at Carter's Island and Lovell's Island. All three are within the Rome Ferry Landing sanctuary. Spot dives were conducted on Cheatham Reservoir between Ashland City and Nashville to determine the viability of historical mussel beds. Each collection site was characterized according to location, substrate composition, water depth and any other relevant characteristics. The specific location of each site was recorded by river mile, proximity (left, right descending side or center), and latitude and longitude (determined by a global position system). To aid data interpretation, population metrics were calculated with individual samples pooled for all collection methods and presented for each location.

RESULTS and DISCUSSION

Commercial Shell Market Assessment

The shell industry in Tennessee has harvested 28,614 tons (57,215,203 lb) of mussels with an estimated wholesale value of \$63,362,904 since 1992 (Table 1). The export value of this harvest is estimated to range from \$190,088,710 to \$443,540,330 (three to five times the wholesale value). During the same period, TWRA received \$2,242,940 in revenue (\$1,501,540 from license sales and \$741,400 from the fee on mussel shells) only 3.54 % of the wholesale value of the resource. These figures indicate sufficient value existed in the commercial shell industry to provide adequate funding for its management; however, due to recent changes in the economy and market this funding model is no longer sufficient.

While the shellfishery volume has declined since the 1990's, more recently shell prices have increased (average up \$0.42/lb during 2003-07), and recent annual harvests averaged 2.8 million pounds per year before the global recession and competition from Chinese mussel shells slowed demand in the third quarter of 2008 and continued through 2009. Increasing the shell fee appeared to be the most practical way to increase funding for the management of this unique resource. However, given current low harvest and license sales trends, even if the shell fee were raised to \$0.10 /lb the revenue could not fund the commercial mussel program.

During the late 1980's through 1995, intense harvest pressure on Kentucky Reservoir's mussel stocks resulted in mussels being taken almost immediately after attaining legal size. TWRA's concern for declining percentages in the adult portion of mussel populations led to recommendations to increase the legal size limit on washboards from 3 ¾" to 4", and increasing the size limit on lake mix shells from 2 5/8" to 2 ¾". In April 1999, the Tennessee Wildlife Resources Commission voted to increase the size limit on washboards from 3 ¾" to 4", staggering the increase in 1/16" increments over a four-year period beginning in 2000 and ending in 2003 when the size limit reached 4". The size limit on lake mix shells remains at 2 5/8", however reduced demand and lower harvest pressure has allowed some expansion of the 2 ¾" size class.

Tennessee's freshwater mussel shell market volume decreased significantly for the second year in a row in 2009 (Figure 1), lower prices were paid for all categories of shell (Figure 2). After harvest, shells are normally sized and grouped into the categories listed in Table 2. Shell values were only reported for green (live mussels) because the wholesale market for open (dead) mussel shell was limited.

Information from TWRA's wholesale mussel receipt system, wholesale mussel dealer summaries, and the wholesale price survey were used to compute the volume and value of the reported mussel harvest (Table 3). Tennessee wholesale mussel dealers reported purchasing 681,523 pounds (341 tons) of mussels from Tennessee waters during 2009. The harvest value was estimated at \$332,210 compared to \$1,387,187 paid for 1,583,626 pounds (792 tons) in 2008. The 2009 commercial shell market did not begin actively trading until May and opened with prices substantially lower than 2008. Reported prices remained steady throughout the rest of the year. Market decline resulted in fewer harvesters, decreasing from 194 in 2008 to 66 in 2009 (Table 4). The average income per harvester also declined from \$7,150 in 2008 to \$5,033 (Figure 1).

With a late start and little demand, price paid for all categories of shell was low. The average price of 2 3/8" ebony shells has declined precipitously from a high of \$0.61 in 2006 to \$0.15/lb in 2009. Even the larger 2 5/8" and 2 3/4" ebony shells decreased from \$0.99 to \$0.60 and from \$1.05 to \$0.60/lb respectively. Both the 2 5/8" and 2 3/4" lake mix shells declined from \$1.25/lb in 2008 to \$0.60/lb (Figure 2). Minimum sized 4.0" lake washboard (*Megaloniais nervosa*) prices also dropped from \$1.36 to \$0.60/lb.

The lower priced 2 3/8" and 2 1/2" (ebony and monkey-face *Q. metanevra*) categories combined, comprised 26.9% of the harvest weight but only 11.6% of the total value. Ebony shells in the 2 5/8" to 2 3/4" size comprised 16% by weight and 19.7% by value of the 2009 harvest. All size categories combined, the ebony shell produced 42.9% by weight and 31.3% by value of the harvest. Landings of lake mix categories (2 5/8" and 2 3/4") increased slightly from 40% by weight in 2008 to 41.7% in 2009; however the total value dropped from 55% to 51.4% (Table 2). Lake grade washboards 4.0" and larger increased slightly from 7.05% to 7.70% by weight but decreased in value from 10.95% to 9.48%. River grade washboard production remained low at 42 pounds. The market for colored shells (pinks), increased lead by elephantear (*Elliptio crassidens*), producing 7.69% by weight (Figure 7) and 7.88% by value. These shifts in species and sizes of commercial shell landings were attributed to a general economic decline and market fluctuations. Weighted average wholesale prices paid to harvesters declined (from \$0.88/lb in 2008 to \$0.49 in 2009), continuing a decline since 2007 (Table 4).

According to wholesale dealer receipts, 92% of the 2009 Tennessee mussel harvest occurred on Kentucky Reservoir (Appendix I). An analysis of Kentucky Reservoir's harvest data and size distribution by species group showed 62% by weight of the ebony shells were between 2 3/8" and 2 1/2", compared to 38% at 2 5/8" and larger. Harvest pressure on the lake mix group kept the weight of 2 3/4" shells (down from 37% in 2007) at 32%, while the 2 5/8" comprised 68%. Lake grade washboards accounted for 8.4% of the Kentucky Reservoir harvest weight, and were entirely made up of 4.0" grade shells with none reported as ≥ 5.0 ". The majority of the elephantear harvest (90%) came from Fort Loudon Reservoir. Only 1.6% of the reported harvest (11,375 pounds) was imported from other states.

Because of their longevity and relatively slow growth, commercial mussel populations subjected to intense harvest pressure are susceptible to being “cropped off” (very low percentage of legal-sized and larger individuals present in a population) (Figure 3). When this occurs, the shell industry has to fill orders with higher percentages of the more abundant, smaller categories of mussel shell. Conversely, when harvest pressure is reduced, viable commercial mussel populations will recuperate allowing increased recruitment into the larger size classes. Variation in the size distribution of the shells harvested can also be attributed to shifts in demand for different shell products. This is evident when comparing the distribution of the percent weight by size category data during 2005 to 2009. During this period, the combined percent weight of the 2 3/8” and 2 1/2” categories fluctuated from 42% to 32%. The shell industry has experienced difficulty meeting the market demand for the 2 3/4” lake mix (down to 13.4% in 2009) and legal sized washboard shells (≥ 4 ”) which remained $\leq 8\%$ of the total harvest weight (Table 5). The worldwide economic decline that commenced in the third quarter of 2008 has had a negative effect on the commercial shell industry as consumers reduced their expenditures on luxury items like cultured pearls. However, with a reduced shell industry, Kentucky Reservoir’s mussel populations will be afforded additional time to grow into larger size classes that could return increased value in future markets.

Mussel Population Assessments

The Tennessee portion of Kentucky Reservoir was sampled at thirteen commercial mussel sites (ten open water sites and three-closed harvest sites, one in the mussel management area and two sanctuaries) during 2009. One hundred five-minute timed dive grab samples were taken from open harvest waters and 30 from closed harvest waters a total of 650 minutes of effort collecting 4,118 mussels. Thirty-four freshwater mussel (Unionid) taxa were recorded during all 2009 survey activities on Kentucky Reservoir along with two exotic bivalve species (Asian clam, *Corbicula fluminea* and zebra mussel, *Dreissena polymorpha*) (Appendix II).

Section I – Tennessee River Mile 49.2 to 82.5. Paris Landing/White Oak Creek. This section is dominated by reservoir over-bank habitat with silt, sand, Asian Clam shells, and clay substrates, with gravel along the shorelines. During years of high commercial shell demand, mussel harvest pressure has reached ten harvesters per river mile. Harvest pressure is spread across the shallow (<10 - 15 ft) bars, shoreline habitats, old creek channels and river channel wall (depth >20 - 50 ft). Commercially valuable mussel species are found amongst the clay and gravel bars, scattered in the bays, along shorelines, and more concentrated near and along sloping channel walls. Densities rarely exceed ten mussels per square meter away from the main channel. Mussel recruitment is primarily limited to areas with well-established mussel populations. Mussels in this section of the lake exhibit the fastest shell growth rate, but overall densities are low. Few recent records of endangered mussel species are known from this section.

Three sites were sampled during 2009, producing 630 individuals representing seven of the ten commercial mussel species (Table 6). The five most abundant species are all commercially important: threeridge (*A. plicata*) 32%; ebony shell (*F. ebena*) 31%; washboard (*M. nervosa*) 18%; and mapleleaf 15% (*Q. quadrula* and *Q. apiculata* combined). Approximately 33% of the commercial species collected were legal-size or larger, down from 37% in 2008. Timed sampling resulted in an average collection rate of 4.20 mussels per minute

down slightly from 4.38 in 2008.

Three bankclimbers (*Plectomerus dombeyanus*), a shell with purple nacre which has invaded the reservoir and may eventually warrant addition to the list of commercially harvested species, were collected during 2009. The zebra mussel collection rate remained low at 0.04 per minute (six individuals) compared to 0.02 per minute (three individuals) in 2008 (Figure 6). The Asian clam was abundant at all sites, with their dead shells comprising a majority of the top layer of substrate.

Section II - TRM 82.5 to 111.1. Harmons Creek/New Johnsonville/Duck River. This section is a transitional area with both lotic and lentic habitats. Mussel harvest pressure has reached ten harvesters per river mile. Harvest pressure is dispersed over the bays, submerged creek channels, over-bank bars, channel walls and old riverbeds at depths from one to > 50 ft. Mussel populations are dispersed throughout the varied habitats, and reach maximum densities (> 100 mussels per square meter) in the river channel. Population recruitment is high in and near the main river and creek channels resulting in colonies expanding from these habitats. Substrate composition varies from silt, sand, clay, to gravel, Asian Clam shells, cobble, and bedrock. Several recent endangered mussel species records (pink mucket, *Lampsilis abrupta*) exist for this section (Parmalee and Bogan 1998).

Four sites were sampled during 2009; three in waters open to commercial harvest and one from the closed waters of the management study area. Six of the ten commercial mussel species were collected from the open water sites totaling 697 individuals. The collection rate was 4.65 mussels per minute down from 7.95 in 2008. The closed harvest site yielded all ten commercial species totaling 305 individuals with a CPUE of 6.10 down from 7.17 in 2008 (Table 6). Two commercially important species composed 71% of the open water population (threeridge 19%, and ebony 52%), followed by washboard (13%), and mapleleafs (6%). Lower harvest pressure on the ebony shell contributed to an increase in the legal-sized portion from 40% in 2008 to 54% in 2009. Washboards collected were 18% legal-sized and comprised 13% of the sample from open waters compared to 21% legal-sized but only 8% abundance from closed waters. Approximately 41% of all commercial species collected from open waters were legal-sized or larger compared to 34% in 2008, and 59% from the closed water site. The open water zebra mussel collection rate decreased from 0.02 per minute (three individuals) in 2008 to 0.01 (one individual) in 2009 (Figure 6). No zebra mussels were collected at the closed water site. The Asian clam was abundant at all sites, with their dead shells comprising a portion of the top layer of substrate.

Section III - TRM 111.1 to 206.7. Located south of the mouth of the Duck River to Pickwick Dam. Lotic habitats dominate this section. Harvest pressure averages less than one harvester per river mile. However, harvest pressure can be intense around the shallow (10 - 25 ft deep) sand/gravel bars and around mainstream islands. Some harvest also occurs in the larger bays of this reach. Mussel populations are primarily found outside the navigation channel when depths are less than 40 feet, in and near the old river channel, and along the shorelines. Maximum densities (> 100 mussels per square meter) and recruitment levels are found outside the navigation channel in the shallow gravel deposits on the inside river bends and at the head and tail areas of mainstream islands. Many recent endangered mussel records for several different species exist for this section (Hubbs 2009).

Six commercial mussel population assessments were performed in this section during 2009, four in open harvest waters below Diamond Island (TRM 195), along the head of Swallow Bluff Island (~TRM 170.3), one in the back shoot of Eagle Nest Island (~TRM 164.0), and below Kelly's Island (TRM142.3). Two sanctuaries were sampled, one located at Cedar Creek (TRM 141.5), and the other below Pickwick Dam (TRM 202.7). Eight of the 10 commercial mussel species and 12 federal endangered pink mucketts (*L. abrupta*) were collected totaling 1,742 individuals from the four open water sites. A layer of young of the year Asian clams (length ~ 10-15mm) covered the bottom at TRM 195. The collection rate was 11.61 up from 8.47 mussels per minute in 2008, with 18% legal size or larger compared to 10% previously. Young ebony shell mussels dominated the sample population (81% abundance only 16% legal), followed by monkeyface (9 % abundance, 17% legal) and elephantear (7% abundance, 32% legal). The Asian clam was abundant at all sites, with their dead shells comprising a portion of the top layer of substrate. Only four zebra mussels were encountered during 300 minutes of sampling (0.013 per minute) compared to 18 in 250 minutes (0.07 per minute) during 2008. The sanctuary below Pickwick Landing Dam was sampled near TRM 202.7 on the gravel shoal extending out from the right descending bank. Eight commercial species and three federal endangered pink mucketts (*L. abrupta*) totaling 139 individuals were collected at this site netting a CPUE of 2.72 mussels per minute. Ebonys comprised 60% of the sample that was dominated by large older mussels of all species exemplified by the 68% legal-size distribution. Nine commercial species along with three federal endangered pink mucketts (*L. abrupta*) were collected totaling 605 individuals with a CPUE of 12.04 from the Cedar Creek sanctuary located near TRM141.5. This site was dominated by young ebonys that comprised 81% of the sample that only netted 7% legal size.

Section I, II, & III combined - Reservoir wide sampling of open waters resulted in the collection of 3,069 mussels representing nine commercial taxa at an average collection rate of 6.14 mussels per minute, similar to the 6.8 collected in 2008. Twenty-six percent of the commercial mussels collected were legal sized or larger down slightly from 27% in 2008. It was noted that legal sized washboards continued their recovery from one percent in 2007 (5 of 344), to six percent (18 of 297) in 2008, to nine percent (19 of 220) in 2009. While improved, the continued low percentage of legal-sized washboards was attributed to the impact of harvest pressure and previous years' (2001 to 2004) illegal harvest and sale of sub-legal sized washboards documented by TWRA and USFWS law enforcement investigations (F. Couch, personal communication). Commercial harvest of Tennessee's mussel shells did not exceeded 2,000 tons during 2005 to 2009, and lower overall demand has allowed mussel populations to recover somewhat from the previous decade of intense harvest activity. However, years of harvest pressure above 1,200 tons per year and high recruitment of young mussels into the population caused an overall decrease in the percentage of legal-sized ebonys in Kentucky Reservoir since 2006 (Figure 3).

Ebonys are the foundation species of Tennessee's commercial shell market. On average, they comprised 52% by weight and 39% by value of the harvest during the last five years (Figure 7). Under continuous harvest pressure, the legal-sized population has decreased from 61% in 2005 to 29% in 2008 and 28% in 2009. The legal-sized washboard population has remained very low during the last five years. It averaged 3% legal-sized shells during 2004-08, while averaging 6% by weight and 7% by value of the harvest. However, washboards responded positively to

lower harvest pressure since 2008, increasing to 9% legal-size or larger and comprising 7.7% of the harvest weight and 9.5% of the value in 2009. The 1/16" per year (2000 to 2003) incremental size limit increase, and illegal harvest of smaller than 4.0" washboards during 2001 to 2004, were contributing factors to its decline in the harvest. The lake mix group (threeridge, mapleleaf, and pigtoe) with legal sizes averaging 24% during 2005-09, was down slightly from 29% in 2008 to 28% in 2009, yet it has not been as sensitive to harvest pressure as the washboard. During the last five years, the lake mix group averaged 39% by weight and 48% by value of Tennessee's commercial shell market. However, it has fluctuated from 15% to 28% legal-sized during 2005 to 2009. The inverse relationship between the tons of shell harvested and the percent legal-sized shell remaining, suggests the washboard population remains overharvested while the ebony and lake mix groups are also affected by sustained moderate harvest pressure (Table 7). Because abundance of the adult portion of the population is negatively correlated with harvest pressure, some populations (washboard and lake mix) remain below the market's demand and the reservoir's carrying capacity. Current size limits appear adequate to protect reproduction; however, previous year's harvests may affect recruitment into the fishery.

Zebra mussels were encountered in notably fewer numbers than in previous years. In 2009, only 11 individuals were collected during 650 minutes of sampling at the 13 commercial sites compared to the 339 individuals collected during 400 minutes of sampling during the recent population peak of 2007 (Figure 6). The reservoir wide collection rate dropped from 0.03 to 0.017 per minute from 2008 to 2009, which was also less than the 27 individuals collected during 2006 (collection rate = 0.08 per minute).

Cumberland River - Old Hickory Reservoir – The Cumberland River was sampled on both Cheatham and Old Hickory reservoirs during 2009. Timed dives of varying duration were used to survey mussel populations in the Cumberland River because of the variety of habitats and mussel densities encountered. On Old Hickory Reservoir sampling effort was concentrated around Lock 7, with less effort at Carter's Island, Strawberry Patch (CRM 303.6), and Lovell's Island. All three are within the Rome Ferry sanctuary (CRM 292.5 to CRM 313.5) where mussel densities had historically been high. Spot dives were conducted around Hartsville (CRM 278-283) and on Cheatham Reservoir between Ashland City and Nashville (CRM 165 -180) to determine the viability of historical mussel beds in this reach. Sampling trips were made during July, August, and September, depth at sample locations ranged 10 to 30 feet.

The back chute near the downstream end of Carter's Island (CRM 304.3) was sampled for 3.0 person-hours. Ninety live mussels representing ten species were collected resulting in a CPUE of 0.50 mussels per minute (Table 8). Mussels were located in firmly packed sand and gravel and some areas covered in silt around submerged trees along the left descending side. Washboards dominated the sample composing 79% of the total of which 56% were legal-sized, followed by pimpleback (*Q. pustulosa*) at six percent. One endangered pink mucket was collected (0.33 per hour) (Table 8).

A mussel bed known as the Strawberry Patch located at CRM 303.6 was sampled for 2.0 person-hours. Dead relic shells were abundant at this site and live individuals were limited to 65 individuals of nine species including one endangered pink mucket. The washboard was the dominant species (75%) followed by pimpleback (11%) and monkeyface (7%). One endangered pink mucket was collected (0.50 per hour).

Lock 7 (CRM 299-300) was sampled for six man-hours netting 16 species totaling 269 individuals. Sixty-five percent of the commercial mussels were legal-size or larger and the washboard was the dominant species (67%) followed by pimpleback (6%). The CPUE was 0.84 mussels per minute with 43% of the commercial species legal-size or larger indicating the older age structure of the population. Five endangered pink muckets were collected (0.83 per hour).

The back chute of Lovell's Island (CRM298.5) was sampled for 1.0 person-hours collecting forty live mussels representing ten species. This area had been sampled in previous years and has substrate ranging from sand and gravel to silt and submerged trees along the sides. The CPUE of 0.67 mussels per minute included four endangered pink muckets at a rate of four per hour. Washboard (30%), pigtoe (20%), and monkeyface (15%) were the top three species and 58% of the commercial mussels were legal-size or larger.

The four sites sampled in the Rome Ferry sanctuary yielded 453 mussels representing 19 species with a CPUE of 0.63 mussels per minute netted during 12 hours of bottom time. No invasive zebra mussels were encountered during these survey efforts, while the Asian Clam was encountered in low to moderate densities. The washboard accounted for 69% of the sample population followed by the pimpleback (9%) and monkeyface (7%). Eleven endangered pink muckets were collected at a CPUE of 0.91 per hour. Gravid individuals of several species were noted, tactytictic species released glochidia in packets, and some of the bradytictic species (pink mucket and black sandshell *Ligumia recta*) exhibited mantle displays. Relic shells of washboard and pigtoes were abundant in depositional areas of the riverbed. Mussel recruitment in this reach of the Cumberland River has long been suppressed by cold water resulting from the hypolimnetic releases from upstream reservoirs (Wolf Creek, Dale Hollow, and Center Hill). However, warmer water temperatures observed during the two most recent summers (2007 and 2008) due to drought and flow alterations caused by renovations at Wolf Creek Dam has caused some species to become gravid and active spawning displays of others. Evidence of recruitment within the last ten to fifteen years was noted for the following species *Q. pustulosa*, *Q. metanevra*, *L. abrupta*, *Lasmigonia complanata*, *L. fragilis*, while the rest were represented by older specimens that continue to decline in abundance. All sites sampled had historically supported dense and diverse mussel assemblages, however years of habitat alteration via impoundment and navigation dredging along with cold-water releases from dams has reduced the mussel fauna significantly.

Four sites around Hartsville (CRM 278-283) were sampled for 3.0 person-hours. No concentration of live mussels was located only relic shell beds. During this effort, only thirty-four individuals representing 10 species were collected including one endangered pink mucket. No invasive zebra mussels were encountered during these survey efforts. The washboard was the most abundant mussel (41%) followed by the pimpleback (21%) and river pigtoe (12%). All of the sites examined were dominated by relic shells including the endangered Dromedary Pearlymussel (*Dromus dromas*) indicating the historic presence of robust mussel populations.

Five sites historically documented to have supported commercially important mussel beds between Ashland City and Nashville (CRM 165-180) were sampled by timed dives of 15 minutes to one-hour duration for 2.5 person-hours. Substrate ranged from bedrock to sand, gravel, and silt. Only three of the five sites yielded live individuals, and relic shells dominated collections at these sites. Washboard and mapleleaf both accounted for 37% of the sample population, which totaled 19 live individuals representing four species. Three zebra mussels were collected from

this reach of the Cumberland River within Cheatham Reservoir at CRM 176.8. Additional sites warrant sampling downstream of Ashland City where commercial mussel harvesters worked during the 1990's.

SUMMARY

Work performed under TWRA Commercial Musseling project number 7363 addressed Strategic Plan Problem I. Strategies 1, 2 and 3. License sales and mussel fee revenue associated with the commercial mussel program garnered only \$26,045 during 2009. Tennessee's mussel shell market declined due to a global recession that began during 2008. Tennessee wholesale mussel dealers reported purchasing 681,523 pounds (341 tons) of mussels from Tennessee waters during 2009. The harvest value was estimated at \$332,210 compared to \$1,387,187 paid for 1,583,626 pounds (792 tons) in 2008. The economic recession continued to affect the mussel shell market in Tennessee during 2009. Wholesale mussel dealers did not begin actively advertising shell prices and recruiting harvesters until May. Lower average prices were paid for all shell categories, which substantially reduced the harvest volume and value. The market decline resulted in fewer harvesters, the number of licensed harvesters decreased from 194 in 2008 to 66 in 2009.

Decreased demand for all shells drove the average price of 2 3/8" ebony shells down from a high of \$0.61 in 2006 to \$0.15/lb by 2009. Even the larger 2 5/8" and 2 3/4" ebony shells decreased from \$0.99 to \$0.60 and from \$1.05 to \$0.60/lb respectively. Both the 2 5/8" and 2 3/4" lake mix shells declined from \$1.25/lb in 2008 to \$0.60/lb (Figure 2). Four-inch lake washboard prices dropped from \$1.36 to \$0.60/lb. The market for colored shells (pinks), increased lead by elephantear. These shifts in species and sizes of commercial shell landings were attributed to a general economic decline and market fluctuations. Weighted average wholesale prices paid to harvesters declined (from \$0.88 in 2008 to \$0.49/lb in 2009), continuing a two year decline.

According to wholesale dealer receipts, 92% of the 2009 Tennessee mussel harvest came from Kentucky Reservoir. An analysis of Kentucky Reservoir's harvest data and size distribution by species group showed 62% by weight of the ebony shells were between 2 3/8" and 2 1/2", compared to 38% at 2 5/8" and larger. Harvest pressure on the lake mix group kept the weight of 2 3/4" shells (down from 37% in 2007) at 32%, while the 2 5/8" comprised 68%. Lake grade washboards accounted for 8.4% of the Kentucky Reservoir harvest weight, and were entirely made up of 4.0" grade shells with none reported as ≥ 5.0 ". The majority of the elephantear harvest (90%) came from Fort Loudon Reservoir. Only 1.6% of the reported harvest (11,375 pounds) was imported from other states.

The Strategic Plan objective of increasing/maintaining commercial mussel populations to a level where $\geq 15\%$ are above legal-size limits was met for the ebony and lake mix categories.

Although, sustained harvest pressure caused a decline in the legal-sized ebony shell population (28% in 2009) compared to the five-year average (35%), while the legal-sized lake mix population increased (26% in 2009 compared to five-year average of 24%). Kentucky Lake washboards failed to reach the objective, however they did improve to 9.0% above legal-size compared to the five-year average of 3.8%. Strategic Plan Problem VII. Strategy 2 dealing with the introduced aquatic nuisance species *Dreissena polymorpha* (zebra mussel) was partially accomplished in Appendix III, via information exchange with the U.S. Army Corps of Engineers and Tennessee Valley Authority. Lack of personnel and funding restricted monitoring efforts to

only those that coincided with scheduled freshwater mussel investigations.

Even during periods of decreased harvest activity, law enforcement continues to play a critical role in the management and protection of Tennessee's valuable mussel resources. During 2009, three individuals were found guilty in federal court and received prison sentences of up to two years and were ordered to pay a total of \$75,000 in restitution for their roles in a conspiracy to harvest and export undersized washboard mussels in Tennessee and Alabama. Nine other individuals involved in this case either had their charges dropped or reduced for their cooperation in the investigation. Recent history of the commercial shell industry's buying practices indicates that market demand for a particular category of shell can trump any regulation against the harvesting of said shell. The viability of the commercial mussel populations can be assured only through adherence to adequate minimum size regulations and maintaining the integrity of closed waters for population comparisons and species protection. Minimum shell size regulations are based on conservative age and growth estimates, which allow brooding female mussels several years to spawn before reaching the species-specific legally harvestable size limit.

RECOMMENDATIONS

The commercial mussel program continues to be inadequately funded. In order to monitor and protect this valuable renewable resource, many person-hours of biological and law enforcement effort are required to guard against illegal take, overexploitation, and habitat degradation. Therefore, in order for this program to meet its fiduciary and resource management responsibilities, the following recommendations are offered:

1. Seek increased revenue to fund fully the existing commercial mussel program (Appendix IV). The current shell fee paid to TWRA by wholesale dealers has not increased since it was levied in July 1991 at \$0.0124/lb for live mussels (shells with meat) and \$0.0145/lb for open shells (shells without meat). In order to balance the commercial mussel program's deficit, TWRA's Commercial Mussel strategic plans have recommended an increase in the shell fee for more than 15 years. TWRA has experienced a drastic decline in the number of harvester licenses sold since the fee was levied (down from average of 1,440/year during 1990-95 to 221/year for last 5 years). The fee on commercial mussels and shells should be increased to a level sufficient to fund the commercial mussel program (approximately \$0.10 per pound at the current five-year average harvest level). However, given the current low level of license sales and harvest activity, this recommendation could not be expected to yield positive results. Therefore, personnel should be reassigned to perform nongame and endangered mussel work funded through state wildlife grants and endangered species recovery funds.
2. Extend the Cedar Creek Sanctuary to include Kelly's Island and Tennessee River Mile 145.0. Combined brail and dive samples indicate that the majority of the mussel stocks in this reach lie within a bed that extends from TRM 145 - 141.0. This extension would protect a population of the rare spectaclecase mussel (*Cumberlandia monodonta*) (Garner, 1991) and better protect the existing mussel bed which shown an increase in recent recruitment. By making this addition to the sanctuary system, not only would rare and endangered species be protected, but several commercial species would also be afforded a greater opportunity to reproduce without being

disturbed. This additional protection would enhance mussel recruitment that could help replenish populations adjacent to the protected zones through dispersion of juvenile mussels by their fish hosts.

3. Consider closing the Cumberland River to commercial mussel harvesting due to the low recruitment rate of the upper reservoirs (Old Hickory and Cordell Hull) and lack of viability of the fishery in the lower reservoirs (Barkley and Cheatham). The Cumberland River reservoirs have not produced significant shell harvests during the last five years (combined average of 0.69% of annual harvest weight). Water quality and flow alterations resulting from emergency repair operations to Wolf Creek Dam are scheduled to continue for the next five years. The warmer temperatures predicted for this period may negatively affect Barkley Reservoir mussel populations, but could allow for increased recruitment in the upper reservoirs that could enhance the future commercial shellfishery. Closing the commercial mussel harvest on the Cumberland River would afford the population the opportunity for expansion and create the possibility of a rejuvenated fishery in the future. **Note:** The low level of harvest activity especially on the Cumberland River reduces the priority for this recommendation at this time.

4. Continue to monitor the mussel resource through commercial industry, population surveys, and laboratory analysis. These surveys provide critical trend data on the species composition, condition, volume of the mussel harvest, and mussel population status.

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FIGURES

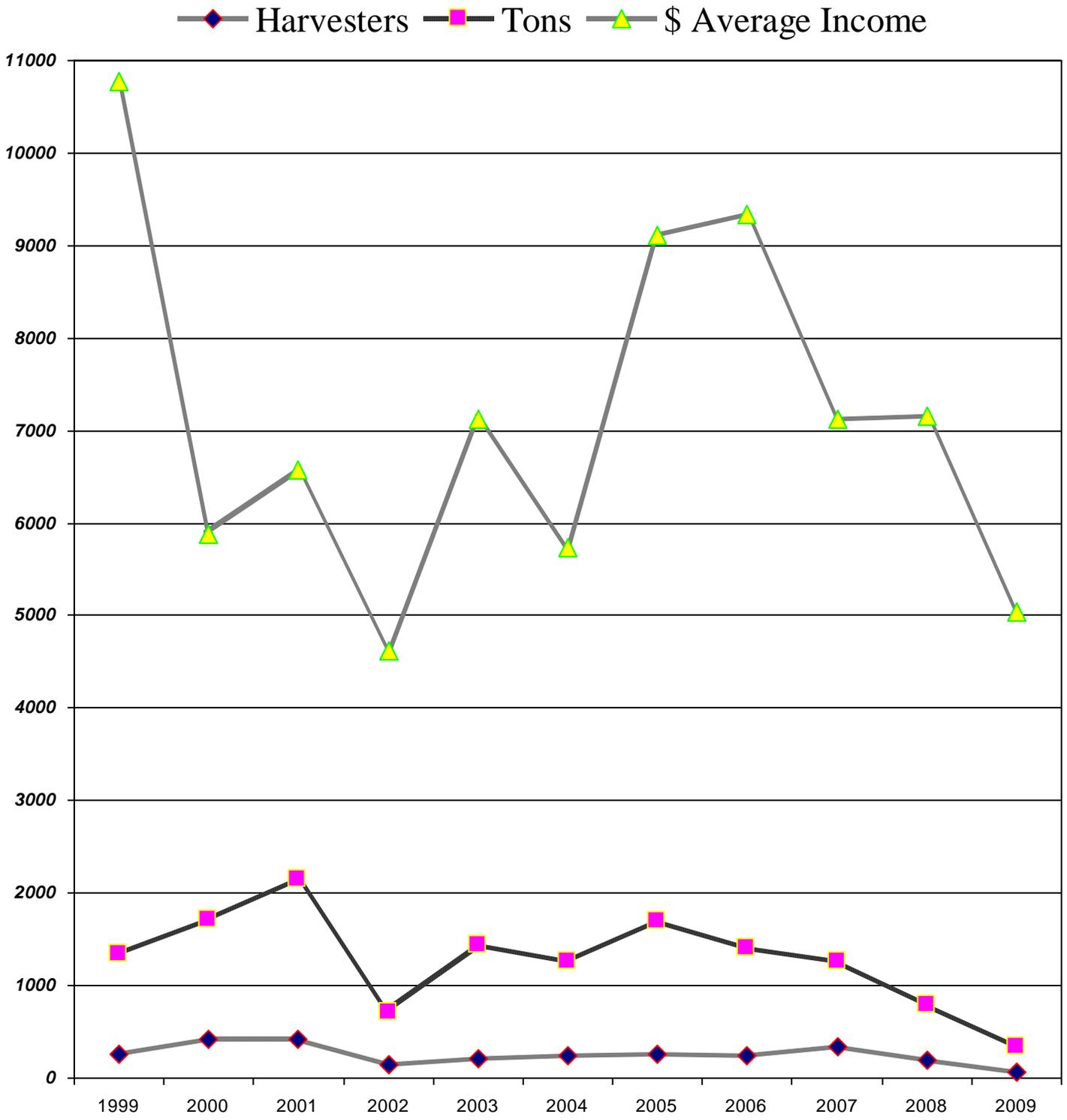
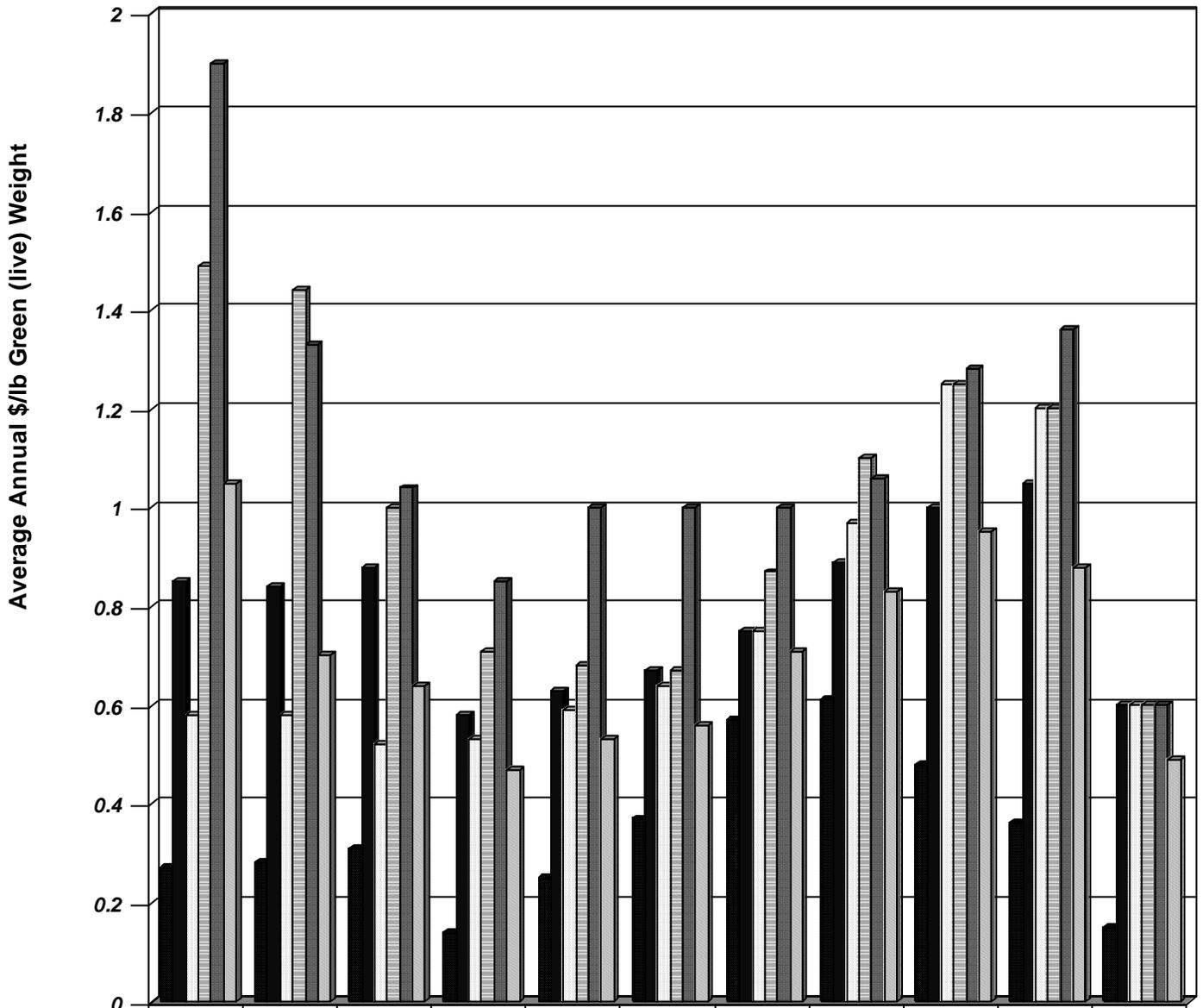


Figure 1. Tennessee mussel shell harvest trends, 1999 - 2009.



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
■ 2 3/8" Ebony	0.27	0.28	0.31	0.14	0.25	0.37	0.57	0.61	0.48	0.36	0.15
■ 2 3/4" Ebony	0.85	0.84	0.88	0.58	0.63	0.67	0.75	0.89	1	1.05	0.6
□ 2 5/8" Lake Mix	0.58	0.58	0.52	0.53	0.59	0.64	0.75	0.97	1.25	1.2	0.6
■ 2 3/4" Lake Mix	1.49	1.44	1	0.71	0.68	0.67	0.87	1.1	1.25	1.2	0.6
■ 4" Washboards	1.9	1.33	1.04	0.85	1	1	1	1.06	1.28	1.36	0.6
□ Weighted Average	1.05	0.7	0.64	0.47	0.53	0.56	0.71	0.83	0.95	0.88	0.49

Figure 2. Tennessee wholesale shell price trends, 1999 - 2009.

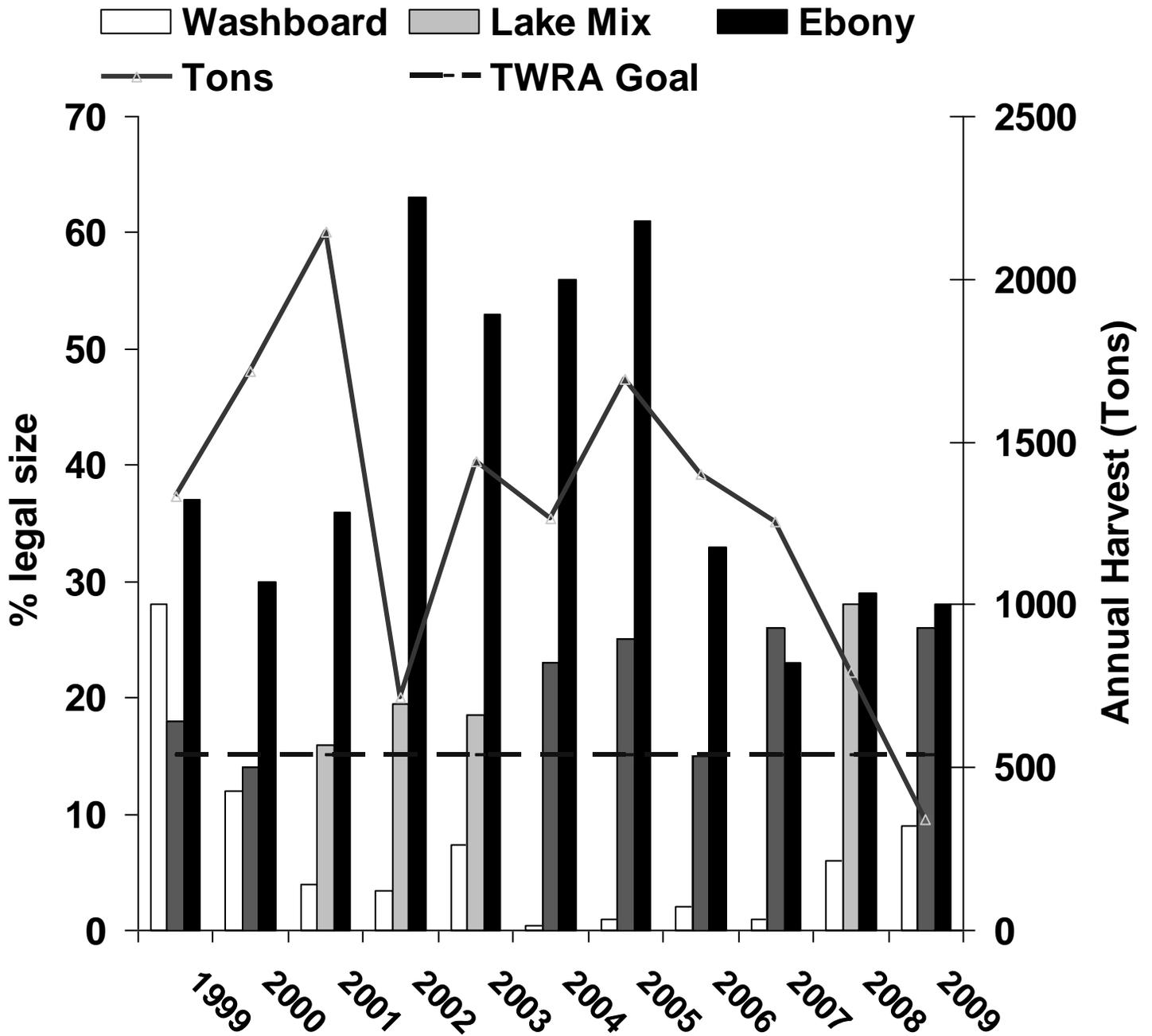


Figure 3. Legal sized mussel shell in Kentucky Reservoir population, 1999 - 2009.

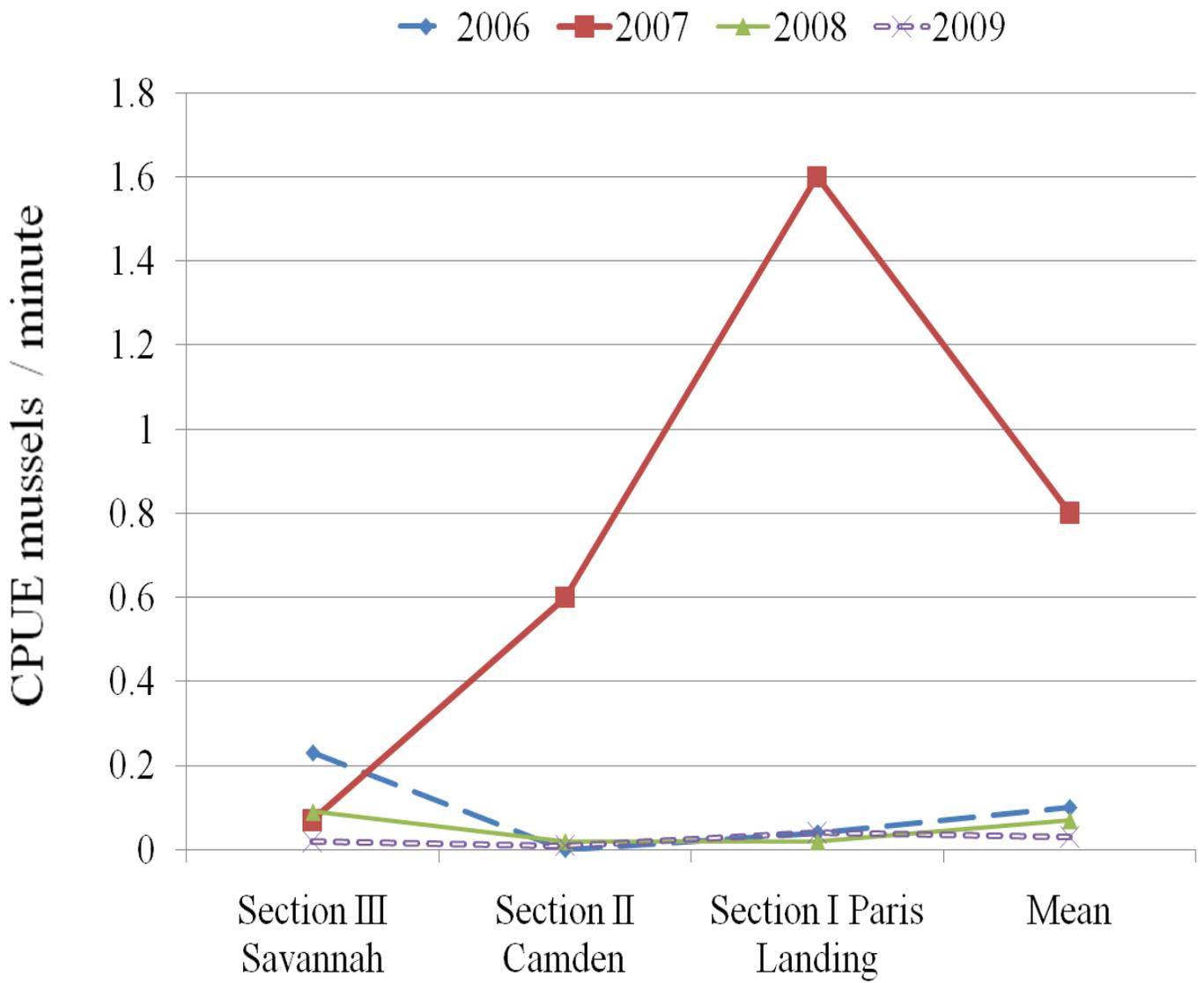


Figure 4. Zebra mussel CPUE at Kentucky Reservoir commercial mussel assessment sites during August.

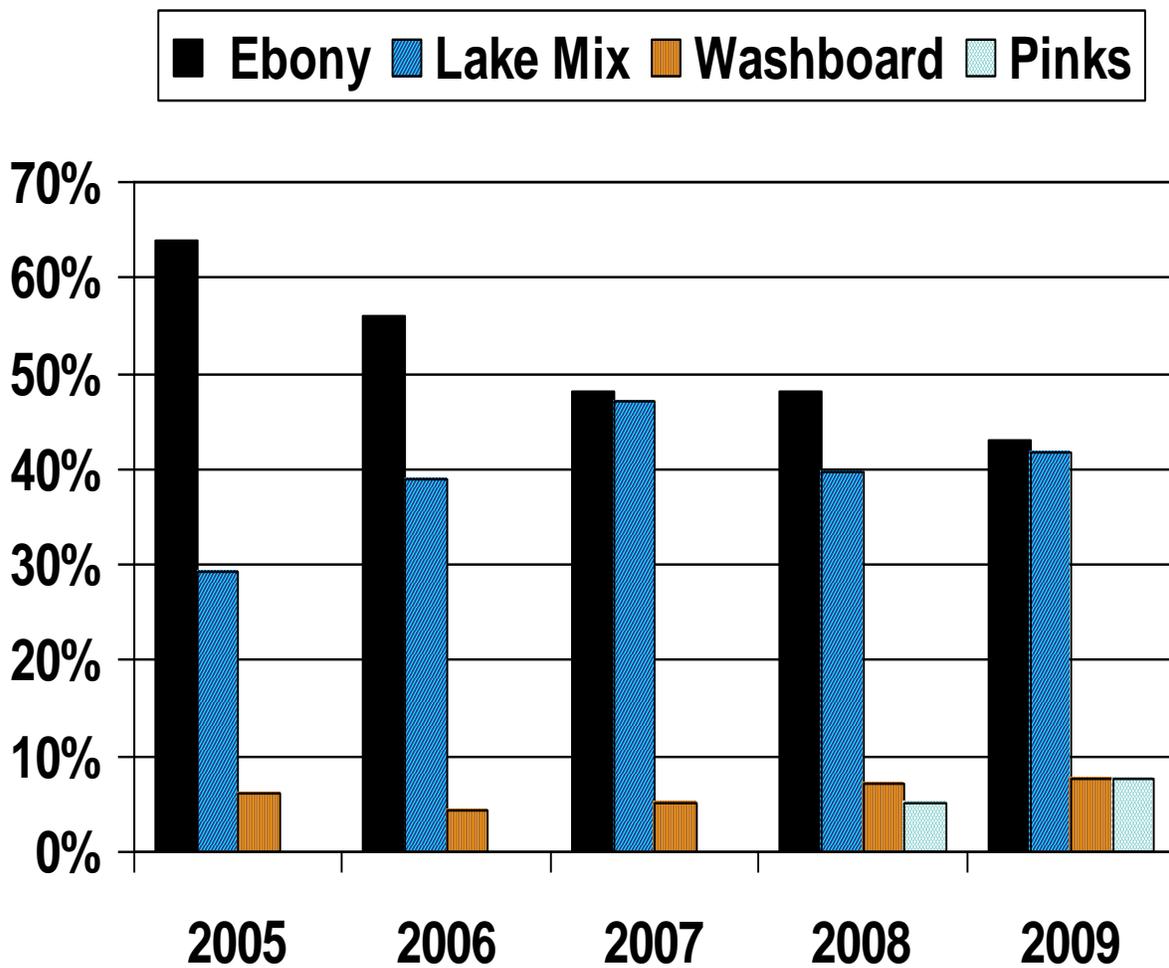


Figure 5. Annual Shell Harvest Weight Distribution by Species Group (TWRA Receipt Data).

TABLES

Table 1. Harvest volume, value, license and shell fee revenue, 1992-2009.

Year	Tons of Mussels	Pounds of Mussels	Wholesale Value	License Revenue FY	Shell Fee CY	Total Revenue	Revenue % of Wholesale Value
1992	2,258	4,516,416	\$4,613,120	\$75,330	\$56,533	\$131,863	2.86%
1993	1,643	3,286,373	\$4,572,810	\$113,165	\$41,382	\$154,547	3.38%
1994	2,707	5,414,238	\$8,492,090	\$135,850	\$67,773	\$203,623	2.40%
1995	3,881	7,761,235	\$14,731,777	\$223,625	\$103,666	\$327,291	2.22%
1996	2,362	4,723,088	\$6,820,139	\$189,195	\$65,731	\$254,926	3.74%
1997	1,061	2,121,907	\$3,024,779	\$101,875	\$33,140	\$135,015	4.46%
1998	601	1,201,514	\$709,133	\$57,000	\$15,185	\$72,185	10.18%
1999	1,335	2,669,716	\$2,800,239	\$39,125	\$38,187	\$77,312	2.76%
2000	1,717	3,434,087	\$2,412,133	\$71,875	\$50,946	\$122,821	5.09%
2001	2,144	4,287,072	\$2,734,081	\$62,625	\$53,625	\$116,250	4.25%
2002	714	1,429,293	\$665,326	\$25,625	\$15,759	\$41,384	6.22%
2003	1,439	2,878,808	\$1,531,327	\$33,375	\$35,049	\$68,424	4.47%
2004	1,267	2,533,947	\$1,417,753	\$48,375	\$31,786	\$80,161	5.65%
2005	1,693	3,386,254	\$2,404,375	\$69,500	\$32,985	\$102,485	4.26%
2006	1,400	2,800,901	\$2,336,027	\$60,900	\$31,174	\$92,074	3.94%
2007	1,253	2,505,205	\$2,378,398	\$96,900	\$33,924	\$130,824	5.50%
2008	792	1,583,626	\$1,387,187	\$79,500	\$26,210	\$105,710	7.62%
2009	347	681,523	\$332,210	\$17,700	\$8,345	\$26,045	7.84%
TOTAL	28,614	57,215,203	\$63,362,904	\$1,501,540	\$741,400	\$2,242,940	3.54%

FY = fiscal year

CY = calander year

Table 2. Average wholesale price paid for various categories of commercial shell during 2009.

CATEGORY	CONDITION	AVERAGE PRICE (\$/LB)	SPECIES
LAKE MIX 2 5/8"	GREEN	\$0.60	<i>A. plicata, F. flava, Q. quadrula Q. apiculata</i>
LAKE MIX 2 3/4"	GREEN	\$0.60	<i>A. plicata, F. flava, Q. quadrula Q. apiculata</i>
ELEPHANT EAR	GREEN	\$0.50	<i>E. crassidens</i>
EBONY 2 3/8"	GREEN	\$0.15	<i>F. ebena</i>
EBONY 2 1/2"	GREEN	\$0.25	<i>F. ebena</i>
EBONY 2 5/8"	GREEN	\$0.60	<i>F. ebena</i>
EBONY 2 3/4"	GREEN	\$0.60	<i>F. ebena</i>
LAKE WASHBOARD 4.0"	GREEN	\$0.60	<i>M. nervosa</i>
LAKE WASHBOARD 5.0"	GREEN	\$0.60	<i>M. nervosa</i>
RIVER WASHBOARD 4.0" & Larger	GREEN	\$0.60	<i>M. nervosa</i>
PINK HEELSPLITTER 4.0" & Larger, Grade #1	OPEN	\$0.80	<i>P. alatus</i>

GREEN = Shell with meat

OPEN = Shell without meat

Table 3. 2009 wholesale commercial shell harvest by size category, as estimated from Tennessee waters.

	WEIGHT LBS	PERCENT WEIGHT	ESTIMATED VALUE	PERCENT VALUE
CATEGORY				
Lake Grade Washboards 4.0" to 4.5"	52,500	7.70%	\$31,500	9.48%
Lake Grade Washboards 5.0"	0	0.00%	\$0	0.0%
River Grade Washboards ≥4.0"	42	0.01%	\$25	0.01%
Pink Heelsplitter ≥4.0"	39	0.01%	\$31	0.01%
Ebony 2 3/8"	73,111	10.73%	\$10,967	3.30%
Ebony 2 1/2"	110,208	16.17%	\$27,552	8.29%
Ebony 2 5/8"	91,332	13.40%	\$54,799	16.50%
Ebony ≥2 3/4"	17,600	2.58%	\$10,560	3.18%
Lake Mix 2 5/8"	192,830	28.29%	\$115,698	34.83%
Lake Mix ≥ 2 3/4"	91,472	13.42%	\$54,883	16.52%
Total	681,523	100%	\$332,210	100%
Tons	341			

Table 4. Tennessee commercial mussel shell industry volume and value, 2005-2009.

Year	2005	2006	2007	2008	2009
Harvesters	264	250	334	194	66
Dealers	15	15	15	13	5
Tons	1,693	1,400	1,253	792	341
Millions \$	\$2.4	\$2.33	\$2.38	\$1.3	\$0.33
Shell Fee	\$32,985	\$31,174	\$33,924	\$26,210	\$8,345
Average Wholesale price/lb	\$0.71	\$0.83	\$0.95	\$0.88	\$0.49

Table 5. Tennessee's commercial mussel shell harvest size class distribution by weight, 2005-2008.

	YEAR				
SIZE CLASS	2005	2006	2007	2008	2009
2 3/8"	21.1%	18.4%	23.5%	23.1%	10.7%
2 1/2"	21.2%	22.6%	9.3%	8.7%	16.2
2 5/8"	32.4%	27.4%	41.5%	47%	49.4%
2 3/4"	18.4%	26.7%	20.7%	13.9	16%
=>4"	6.8%	4.9%	5.0%	7.3%	7.7%

Table 6. Summary of commercial mussel species data, Kentucky Reservoir sections I, II, and III.

Section I - Paris Landing	Legal	Sub-Legal	Total	%Legal	%Abundance
<i>Amblema plicata</i>	65	136	201	32%	32%
<i>Fusconaia ebena</i>	128	67	195	66%	31%
<i>Fusconaia flava</i>	2	15	17	12%	3%
<i>Megaloniaias nervosa</i>	2	112	114	2%	18%
<i>Potamilus alatus</i>		6	6	0%	1%
<i>Quadrula apiculata</i>	11	86	97	11%	15%
Sites Sampled			3		
CPUE = mussels per minute	1.39	2.81	4.20		
Total	208	422	630	33%	100%
<i>Plectomerus dombeyanus</i>			3		
CPUE = P. dombeyanus / hour			1.20		
<i>Dreissena polymorpha</i>			6		
CPUE D. polymorpha / minute			0.04		

Section II - Camden	Legal	Sub-Legal	Total	%Legal	%Abundance
<i>Amblema plicata</i>	43	90	133	32%	19%
<i>Fusconaia ebena</i>	195	166	361	54%	52%
<i>Fusconaia flava</i>	10	16	26	38%	4%
<i>Megaloniaias nervosa</i>	17	77	94	18%	13%
<i>Potamilus alatus</i>	10	32	42	24%	6%
<i>Quadrula apiculata</i>	9	32	41	22%	6%
Sites Sampled			3		
CPUE = mussels per minute	1.89	2.75	4.65		
Total	284	413	697	41%	100%
<i>Plectomerus dombeyanus</i>			5		
CPUE = P. dombeyanus / hour			2.00		
<i>Dreissena polymorpha</i>			1		
CPUE D. polymorpha / minute			0.01		

Table 6. Continued.

Section III - Savannah	Legal	Sub- Legal	Total	%Legal	%Abundance
<i>Amblema plicata</i>	1	11	12	8%	1%
<i>Elliptio crassidens</i>	37	79	116	32%	7%
<i>Fusconaia ebena</i>	230	1178	1408	16%	81%
<i>Megalonaias nervosa</i>		12	12	0%	1%
<i>Potamilus alatus</i>		2	2	0%	0%
<i>Pleurobema cordatum</i>	17	10	27	63%	2%
<i>Quadrula apiculata</i>		9	9	0%	1%
<i>Quadrula metanevra</i>	27	129	156	17%	9%
Sites Sampled			4		
CPUE = mussels per minute	2.08	9.53	11.61		
Total	312	1430	1742	18%	100%
<i>Lampsilis abrupta*</i>			12		
CPUE <i>L. abrupta</i> / hour			3.60		
<i>Plethobasus cooperianus*</i>			1		
<i>Dreissena polymorpha</i>			3		
CPUE <i>D. polymorpha</i> / minute			0.02		

* Federal Endangered Species

Section I, II, & III combined	Legal	Sub- Legal	Total	%Legal	%Abundance
<i>Amblema plicata</i>	109	237	346	32%	11%
<i>Elliptio crassidens</i>	37	79	116	32%	4%
<i>Fusconaia ebena</i>	553	1411	1964	28%	64%
<i>Fusconaia flava</i>	12	31	43	28%	1%
<i>Megalonaias nervosa</i>	19	201	220	9%	7%
<i>Potamilus alatus</i>	10	40	50	20%	2%
<i>Pleurobema cordatum</i>	17	10	27	63%	1%
<i>Quadrula apiculata</i>	20	127	147	14%	5%
<i>Quadrula metanevra</i>	27	129	156	17%	5%
Sites Sampled			10		
CPUE = mussels per minute	1.61	4.53	6.14		
Total	804	2265	3069	26%	100%
<i>Dreissena polymorpha</i>			10		
CPUE <i>D. polymorpha</i> / minute			0.02		

Table 6. Continued.
Closed Mussel Mgmt Area,
Section II

	Legal	Sub- Legal	Total	%Legal	%Abundance
<i>Amblema plicata</i>	36	31	67	54%	22%
<i>Elliptio crassidens</i>	1		1	100%	0%
<i>Fusconaia ebena</i>	131	53	184	71%	60%
<i>Fusconaia flava</i>	3	3	6	50%	2%
<i>Megaloniaias nervosa</i>	5	19	24	21%	8%
<i>Potamilus alatus</i>	1	6	7	14%	2%
<i>Pleurobema cordatum</i>	1		1		
<i>Quadrula quadrula</i>		1	1	0%	0%
<i>Quadrula apiculata</i>		13	13	0%	4%
<i>Quadrula metanevra</i>	1		1	100%	0%
Sites Sampled			1		
CPUE = mussels per minute	3.58	2.52	6.10		
Total	179	126	305	59%	100%
<i>Plectomerus dombeyanus</i>			0		
<i>Dreissena polymorpha</i>			0		

Section III - Sanctuary TRM
202.7R

	Legal	Sub- Legal	Total	%Legal	%Abundance
<i>Amblema plicata</i>	2	3	5	40%	4%
<i>Elliptio crassidens</i>	15	2	17	88%	13%
<i>Fusconaia ebena</i>	58	24	82	71%	60%
<i>Megaloniaias nervosa</i>	1	3	4	25%	3%
<i>Potamilus alatus</i>	5	3	8	63%	6%
<i>Pleurobema cordatum</i>	3	1	4	75%	3%
<i>Quadrula apiculata</i>	2	4	6	33%	4%
<i>Quadrula metanevra</i>	7	3	10	70%	7%
Sites Sampled			1		
CPUE = mussels per minute	1.86	0.86	2.72		
Total	93	43	136	68%	100%
<i>Lampsilis abrupta*</i>			3		
CPUE <i>L. abrupta</i> / hour			3.60		
<i>Dreissena polymorpha</i>			1		
CPUE <i>D. polymorpha</i> / minute			0.01		

* Federal Endangered Species

Table 6. Continued.
Section III - Sanctuary TRM
141.5

	Legal	Sub- Legal	Total	%Legal	%Abundance
<i>Amblema plicata</i>	5	19	24	21%	4%
<i>Elliptio crassidens</i>	2	44	46	4%	8%
<i>Fusconaia ebena</i>	37	450	487	8%	81%
<i>Fusconaia flava</i>		1	1	8%	0%
<i>Megaloniaias nervosa</i>		22	22	0%	4%
<i>Potamilus alatus</i>		3	3	0%	
<i>Pleurobema cordatum</i>	1	6	7	14%	1%
<i>Quadrula apiculata</i>		5	5	0%	1%
<i>Quadrula metanevra</i>		7	7	0%	1%
Sites Sampled			1		
CPUE = mussels per minute	0.90	11.14	12.04		
Total	45	557	602	7%	100%
<i>Lampsilis abrupta</i> *			3		
CPUE <i>L. abrupta</i> / hour			3.60		
<i>Dreissena polymorpha</i>			0		

* Federal Endangered Species

Table 7. Kentucky Reservoir percentage of legal-sized commercial mussels by category, 2009.

	TWRA Population Samples, Sections I, II and III combined			
	N	Open Waters Legal-Sized	N	Closed waters Legal-Sized
Ebony $\geq 2 \frac{3}{8}$"	1964	28%	753	30%
Lake Mix $\geq 2 \frac{5}{8}$"	536	26%	128	38%
Washboards ≥ 4"	220	9%	50	12%

Table 8. Cumberland River Old Hickory and Cheatham Reservoirs, 2009.

Lovells Island back chute CRM 298.5, 08/27/2009, 1.0 man-hours, D. Hubbs.

Rome Landing Sanctuary	Non-Commercial	Legal	Sub-Legal	Total	%Legal	%Abundance
<i>Actinonaias ligmentina</i>	2			2		5%
<i>Amblema plicata</i>		1		1	100%	3%
<i>Lampsilis abrupta</i> *	4			4		10%
<i>Lasmigonia complanata</i>	1			1		3%
<i>Ligumia recta</i>	1			1		3%
<i>Megalonaias nervosa</i>		10	2	12	83%	30%
<i>Pleurobema cordatum</i>		8		8	100%	20%
<i>Ptychobranchus fasciolaris</i>	2			2		5%
<i>Quadrula pustulosa</i>	3			3		8%
<i>Quadrula metanevra</i>		4	2	6	67%	15%
Species	10					
CPUE = mussels per minute		0.38	0.07	0.67		
Total	13	23	4	40	58%	100%
<i>Dreissena polymorpha</i>	0					

* Federal Endangered species

Carter's Island CRM 304.3, 08/28/2009, 3.0 man-hours, D. Hubbs, G. Moates, A Pyburn et al.

Rome Landing Sanctuary	Non-Commercial	Legal	Sub-Legal	Total	%Legal	%Abundance
<i>Actinonaias ligmentina</i>	4			4		4%
<i>Elliptio crassidens</i>		1		1	100%	1%
<i>Elliptio dilatata</i>	1			1		1%
<i>Lampsilis abrupta</i> *	1			1		1%
<i>Leptodea fragilis</i>	1			1		1%
<i>Megalonaias nervosa</i>		40	31	71	56%	79%
<i>Obliquaria reflexa</i>	2			2		2%
<i>Pleurobema cordatum</i>		1		1	100%	1%
<i>Quadrula pustulosa</i>	5			5		6%
<i>Quadrula metanevra</i>		3		3	100%	3%
Species	10					
CPUE = mussels per minute		0.25	0.17	0.50		
Total	14	45	31	90	50%	100%
<i>Dreissena polymorpha</i>	0					

* Federal Endangered Species

Table 8. Cumberland River continued.

Strawberry Patch CRM 303.6R, 09/09/2009, 2.0 man-hours, D. Hubbs, D. Sims.

Rome Landing Sanctuary	Non-Commercial	Legal	Sub-Legal	Total	%Legal	%Abundance
<i>Actinonaias ligmentina</i>	3			3		5%
<i>Cyclonaias tuberculata</i>						
<i>Fusconaia flava</i>			1	1	0%	2%
<i>Lampsilis abrupta</i> *	1			1		2%
<i>Lasmigonia complanata</i>	3			3		5%
<i>Leptodea fragilis</i>						
<i>Ligumia recta</i>						
<i>Megalonaias nervosa</i>		39	10	49	80%	75%
<i>Obliquaria reflexa</i>						
<i>Potamilus alatus</i>		1		1		2%
<i>Pleurobema cordatum</i>		1		1	100%	2%
<i>Quadrula pustulosa</i>	4			4		6%
<i>Quadrula metanevra</i>		1	1	2	50%	3%
Species	9					
CPUE = mussels per minute		0.35	0.10	0.54		
Total	11	42	12	65	65%	100%
<i>Dreissena polymorpha</i>	0					

*** Federal Endangered Species**

Table 8. Cumberland River continued.

Lock 7 CRM 299-300, 07/21 & 8/27/2009, 6.0 man-hours, D. Hubbs, D. Sims et al.

Rome Landing Sanctuary	Non-Commercial	Legal	Sub-Legal	Total	%Legal	%Abundance
<i>Actinonaias ligmentina</i>	6			6		2%
<i>Elliptio crassidens</i>		1		1	100%	0%
<i>Ellipsaria lineolata</i>	1			1		0%
<i>Fusconaia ebena</i>		2		2	100%	1%
<i>Fusconaia flava</i>			1	1	0%	0%
<i>Lampsilis abrupta</i> *	5			5		2%
<i>Lasmigonia complanata</i>	4			4		1%
<i>Leptodea fragilis</i>	2			2		1%
<i>Ligumia recta</i>	1			1		0%
<i>Megalonaias nervosa</i>		83	96	179	46%	67%
<i>Obliquaria reflexa</i>	1			1		0%
<i>Potamilus alatus</i>		4		4	100%	1%
<i>Pleurobema cordatum</i>		8	1	9	89%	3%
<i>Pleurobema sintoxia</i>	4			4		1%
<i>Ptychobranhus fasciolaris</i>	1			1		0%
<i>Quadrula pustulosa</i>	29			29		11%
<i>Quadrula metanevra</i>		18	1	19	95%	7%
Species	17					
CPUE = mussels per minute		0.36	0.31	0.84		
Total	54	116	99	269	43%	100%
<i>Dreissena polymorpha</i>	0					

* Federal Endangered species

Table 8. Cumberland River continued.

All Sites CRM 298-304,2009, 12.0 man-hours.

Rome Landing Sanctuary	Non-Commercial	Legal	Sub-Legal	Total	%Legal	%Abundance
<i>Actinonaias ligmentina</i>	5			5		1%
<i>Amblema plicata</i>		1		1	100%	0%
<i>Elliptio crassidens</i>		1		1	100%	0%
<i>Elliptio dilatata</i>	1			1	0%	0%
<i>Ellipsaria lineolata</i>	1			1		0%
<i>Fusconaia ebena</i>		2		2	100%	0%
<i>Fusconaia flava</i>			2	2	0%	0%
<i>Lampsilis abrupta</i> *	11			11		2%
<i>Lasmigonia complanata</i>	8			8		2%
<i>Leptodea fragilis</i>	3			3		1%
<i>Ligumia recta</i>	2			2		0%
<i>Megalonaias nervosa</i>		172	139	311	55%	69%
<i>Obliquaria reflexa</i>	3			3		1%
<i>Potamilus alatus</i>		5		5	100%	1%
<i>Pleurobema cordatum</i>		18	1	19	95%	4%
<i>Pleurobema sintoxia</i>	4			4		1%
<i>Ptychobranhus fasciolaris</i>	3			3		1%
<i>Quadrula pustulosa</i>	41			41		9%
<i>Quadrula metanevra</i>		26	4	30	87%	7%
Species	19					
CPUE = mussels per minute		0.31	0.20	0.63		
Total	82	225	146	453	50%	100%
<i>Dreissena polymorpha</i>	0					

* Federal Endangered Species

Table 8. Cumberland River continued.

Hartsville CRM 278-283, 9/08/2009, 3.0 man-hours, D. Hubbs, D. Sims.

	Non-Commercial	Legal	Sub- Legal	Total	%Legal	%Abundance
<i>Cyclonaias tuberculata</i>	1			1		3%
<i>Ellipsaria lineolata</i>	1			1		3%
<i>Lampsilis abrupta</i> *	1			1		3%
<i>Lasmigonia complanata</i>	1			1		3%
<i>Megalonaias nervosa</i>		12	2	14	86%	41%
<i>Pleurobema cordatum</i>		2	2	4	50%	12%
<i>Ptychobranchus fasciolaris</i>	1			1		3%
<i>Quadrula pustulosa</i>	7			7		21%
<i>Quadrula metanevra</i>		3		3	100%	9%
<i>Quadrula quadrula</i>		1		1	100%	3%
Species	10					
CPUE = mussels per minute		0.10	0.02	0.19		
Total	12	18	4	34	53%	100%
<i>Dreissena polymorpha</i>	0					

Upstream of Ashland City CRM 165-180, 7/17/2009, 2.5 man-hours, A. Pyburn, D. Hubbs, D. Sims.

	Non-Commercial	Legal	Sub- Legal	Total	%Legal	%Abundance
<i>Amblema plicata</i>		2		2	100%	11%
<i>Megalonaias nervosa</i>		5	2	7	71%	37%
<i>Obliquaria reflexa</i>	3			3		16%
<i>Quadrula quadrula</i>			7	7	0%	37%
Species	4					
CPUE = mussels per minute		0.05	0.06	0.13		
Total	3	7	9	19	37%	100%
<i>Dreissena polymorpha</i>	3					

APPENDICES

**APPENDIX
I
2009 Wholesale Mussel Dealer
& Receipt Report Summary Data**

Mussel Harvest by Lake

1/1/2009 through 12/31/2009

BARKLEY RESERVOIR												
Lake	shl	mea	g500	g450	g400	g375	g300	g275	g268	g250	g238	Shell Total
MEP	O		0	0	0	0	0	0	3712	0	0	3712
Totals			0	0	0	0	0	0	3712	0	0	3712

FORT LOUDOUN RESERVOIR												
Lake	shl	mea	g500	g450	g400	g375	g300	g275	g268	g250	g238	Shell Total
EER	G		0	0	0	0	0	0	2398	0	0	2398
EER	O		0	0	0	0	0	0	2764	0	0	2764
MEP	G		0	0	0	0	0	0	7636	643	0	8279
MEP	O		0	0	0	0	0	0	11191	1817	0	13008
ZZZ	G		0	0	0	0	0	0	23223	0	0	23223
Totals			0	0	0	0	0	0	47212	2460	0	49672

KENTUCKY RESERVOIR												
Lake	shl	mea	g500	g450	g400	g375	g300	g275	g268	g250	g238	Shell Total
DEB	G		0	0	0	0	0	0	96	237	9	342
LEB	G		0	0	0	0	0	17600	89370	104800	60748	272518
LEB	O		0	0	0	0	0	0	1866	2452	12335	16653
LML	G		0	0	57	0	0	91382	191148	211	0	282798
LML	O		0	0	0	0	0	90	1586	0	0	1676
LWB	G		0	198	52225	0	0	0	1	11	19	52454
LWB	O		0	0	20	0	0	0	0	0	0	20
MEP	G		0	0	0	0	0	0	1465	0	0	1465
PHS	O		0	0	39	0	0	0	0	0	0	39
RW	G		0	0	6	0	0	0	0	0	0	6
RWB	G		0	0	36	0	0	0	0	0	0	36
ZZZ	G		0	0	0	0	0	0	95	37	0	132
Totals			0	198	52383	0	0	109072	285627	107748	73111	628139

Lake		OUT-OF-STATE									
shl	mea	g500	g450	g400	g375	g300	g275	g268	g250	g238	Shell Total
BFB	O	0	0	1550	0	0	0	0	0	0	1550
BFF	O	0	0	283	0	0	0	0	0	0	283
LEB	G	0	0	0	0	0	0	96	6740	0	6836
LML	G	0	0	0	0	0	0	401	0	0	401
LML	O	0	0	0	0	0	64	0	0	0	64
LWB	G	0	0	135	0	0	0	0	0	0	135
PBP	O	0	0	68	0	0	0	0	0	0	68
REB	G	0	0	0	0	0	0	0	1375	0	1375
ZZZ	O	0	0	0	0	0	663	0	0	0	663
Totals		0	0	2036	0	0	727	497	8115	0	11375
Report		0	198	54419	0	0	109799	337048	118323	73111	692898

**APPENDIX
II
Freshwater Mussel Species
Collected From Kentucky Reservoir
During 2009 Sampling and Observations**

2009 Mussel species collected from Kentucky Reservoir all sites and supplemental sampling, 1 = collected live.

Species

1	<i>Anadonta suborbiculata</i>	1
2	<i>Pyganodon grandis</i>	1
3	<i>Utterbackei imbecillis</i>	1
4	<i>Amblema plicata</i>	1
5	<i>Arcidens confragosa</i>	1
6	<i>Cumberlandia monodonta</i>	
7	<i>Cyclonaias tuberculata</i>	1
8	<i>Cyprogenia stegaria*</i>	1
9	<i>Elliptio crassidens</i>	1
10	<i>Ellipsaria lineolata</i>	1
11	<i>Fusconaia ebena</i>	1
12	<i>Fusconaia flava</i>	1
13	<i>Lampsilis abrupta *</i>	1
14	<i>Lampsilis cardium</i>	
15	<i>Lampsilis ovata</i>	1
16	<i>Lampsilis teres</i>	1
17	<i>Lasmigonia complanata</i>	
18	<i>Leptodea fragilis</i>	1
19	<i>Ligumia recta</i>	1
20	<i>Megalonaias nervosa</i>	1
21	<i>Obliquaria reflexa</i>	1
22	<i>Plectomerus dombevanus</i>	1
23	<i>Plethobasus cooperianus*</i>	1
24	<i>Plethobasus cyphus</i>	
25	<i>Pleurobema rubrum</i>	1
26	<i>Pleurobema cordatum</i>	1
27	<i>Pleurobema sintoxia</i>	
28	<i>Potamilus alatus</i>	1
29	<i>Potamilus ohioensis</i>	1
30	<i>Ouadrula apiculata</i>	1
31	<i>Ouadrula c. cylindrica</i>	1
32	<i>Ouadrula metanevra</i>	1
33	<i>Ouadrula nodulata</i>	1
34	<i>Ouadrula pustulosa</i>	1
35	<i>Ouadrula ouadrula</i>	1
36	<i>Toxolasmus parvus</i>	1
37	<i>Toxolasmus lividus</i>	
38	<i>Truncilla donaciformis</i>	1
39	<i>Truncilla truncata</i>	1
40	<i>Tritogonia verrucosa</i>	1
	TOTAL	34
	EXOTIC SPECIES	
	<i>Dreissena polymorpha</i>	1
	<i>Corbicula fluminea</i>	1

***Federal Endangered species**

**APPENDIX
III
Zebra Mussel Distribution
In Tennessee**



Since the first documented collection of the zebra mussel in Tennessee occurred on the Tennessee River at Savannah, Hardin Co., Tennessee during February 1992, reports of one to several individuals have become more numerous. Clusters of zebra mussels have been discovered on the lock walls of most TVA and Army Corps of Engineer facilities open to commercial navigation traffic on the Tennessee River up to Knoxville and the Cumberland River above Nashville on Old Hickory Dam. Barge and boat traffic are believed to be the primary vectors of dispersion of this exotic species. Summer water temperature extremes, fish predation and water chemistry characteristics may be limiting the expansion of the zebra mussel population in some areas, particularly the lower Tennessee River.

Zebra mussel sightings continue to be reported by commercial musselers working the Kentucky Reservoir portion of the Tennessee River system. While it has yet to develop densities that endanger the native mussel fauna, frequency of occurrence and number of individuals increased in 2007 at TWRA's annual commercial mussel assessment sites on Kentucky Reservoir to 0.8 individuals per minute. However, 2008 and 2009 samples showed a decline to 0.07 and 0.03 individuals per minute respectively.

Zebra mussel densities in the upper Tennessee River system increased during the late 1990's through 2001. An established colony of zebra mussels below Watts Bar Dam, at TRM527.1, increased from 600 to just over 5,000 per square meter in late 2001. At TRM558.2, zebra mussels reached an even higher density of 23,166 per square meter. A large population was also noted below Chickamauga Dam, at TRM 470.0. Density at this site was estimated at 11,613 per square meter (Tennessee Valley Authority, 2002). However, unknown factors caused the population to dramatically decline, possibly the hot and dry summers of 2004, 2005 and 2007 significantly limited these populations. Only two live zebra mussels were encountered at nine TWRA freshwater mussel assessment sites below Watts Bar Dam during sampling conducted in 2005, resulting in a CPUE of 0.45 zebra mussels per hour. Zebra mussels were encountered in increasing numbers during 2008 to 2009 maintenance of submerged ultrasonic receiver fish movement stations located below Watts Bar Dam. Although density estimates were not recorded.

Zebra mussels have colonized the Mississippi River along the western border of Tennessee. They are abundant and attached to surfaces of concrete and rock bank stabilization structures below the water line. Some native mussels collected from the Mississippi River have been covered with zebra mussels.

TWRA personnel will continue to monitor zebra mussel populations through cooperation with commercial harvesters, and other government agencies. While accurately predicting what ultimate effect this exotic species will have on native mussel stocks and other aquatic species is difficult, the potential for devastation does exist. For more on zebra mussels and their current distribution in the United States go to <http://nas.er.usgs.gov/taxgroup/mollusks/zebramussel/>.

