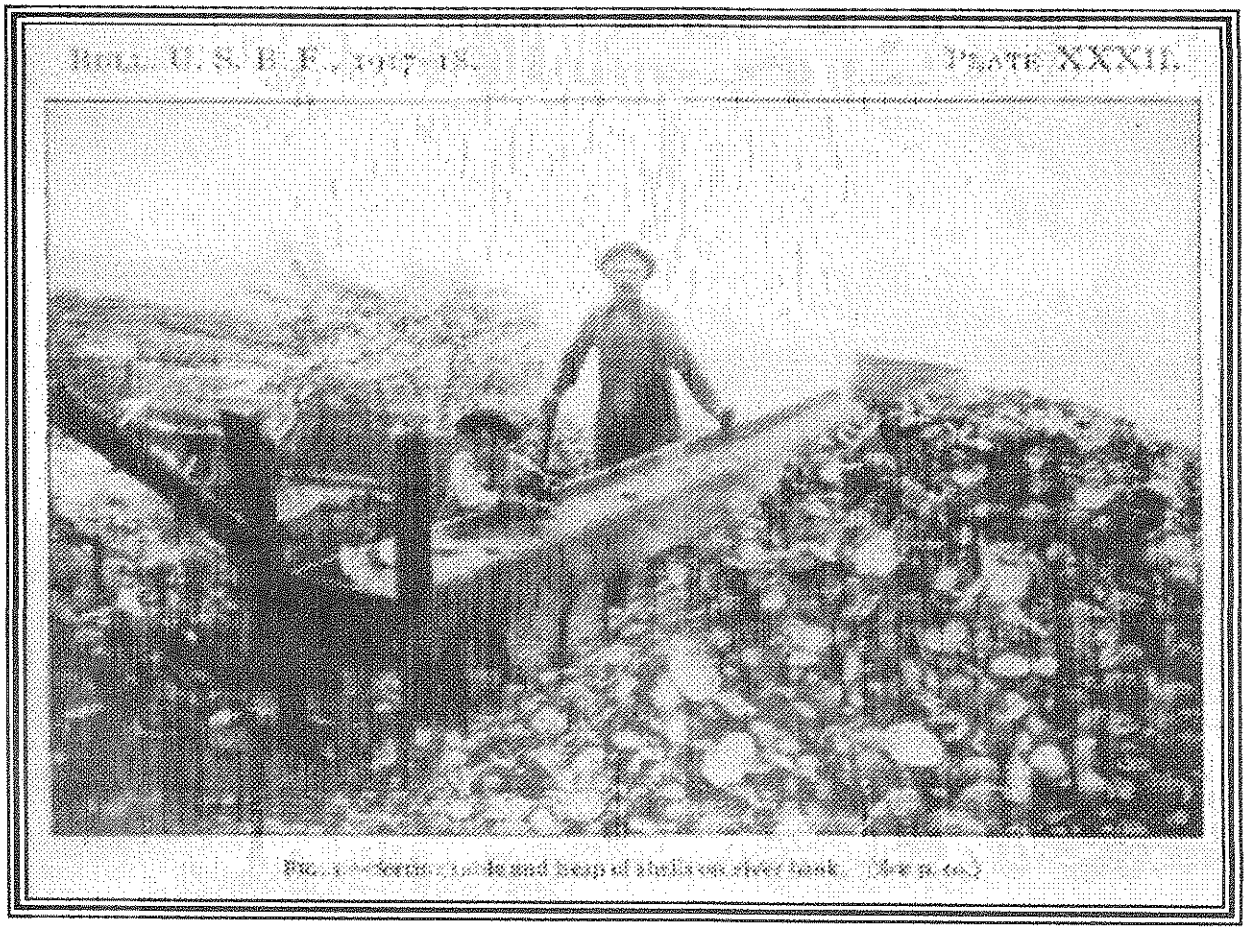
Hubbs
2000

2000
STATEWIDE COMMERCIAL MUSSEL REPORT



BY
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TENNESSEE WILDLIFE RESOURCES AGENCY
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INTRODUCTION

This report contains mussel population and commercial harvest data collected during 2000, and compares trend information regarding the commercial harvest for the period 1992-2000. Activities described in this report were partially funded by monies generated from the tax 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 mussels (shell with meat) purchased or obtained. During 2000, TWRA received the following revenues associated with the sale of commercial Musseling licenses and collection of the shell fee:

TYPE LICENSE	NUMBER	REVENUE
Resident Commercial Musseling	410	$ 51,250
Resident Commercial Musseling Helper	43	$ 5,375
Non-Resident Commercial Musseling	11	$ 8,250
Non-Resident Commercial Musseling Helper	0	$ 0
Wholesale Mussel Dealer	24	$ 6,000
Cultured Pearl	1	$ 1,000
Total License		**$ 71,875**
Shell Tax (accrued Jan. 1 to Dec. 31, 1999)		**$ 50,946**
TOTAL REVENUE		**$122,821**

Freshwater mussel shells harvested in Tennessee were shipped to Japan 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. Approximately 80% of the shells exported from the United States were harvested from Tennessee waters (Dobson 2000). During peak harvest years, the commercial mussel shell industry in Tennessee generates revenues approaching $50 million.

As recently as 1995, 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 have reduced the market for Tennessee's mussel shells. The decreased demand for mussel shells has caused a substantial decline in the number of mussel harvesters working in Tennessee. Reduced harvest pressure on the mussel resource has allowed populations to begin recovering from a decade of intense harvest activity. During the last century, the harvest of mussel shell has fluctuated according to market demands. Mussels were first harvested for the natural pearls they can produce, then as a source for buttons and mother of pearl inlay material, and finally for pearl nuclei. Each rise and fall in demand affects the quantity and quality of the resource.

Tennessee's quality commercial mussel stocks were primarily limited to Kentucky Reservoir (Hubbs 2001). Kentucky Reservoir streched184.3 miles from Pickwick Dam at Tennessee river mile (TRM) 206.7 in Hardin County, TN to Kentucky Dam at TRM 22.4 in 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 is reported from Kentucky Reservoir. No other Tennessee waters appeared to contain commercial mussel populations of sufficient quality, size and diversity to sustain a continuous harvest. Mussel shell values fluctuated in relation to market demand, generally increasing as the supply of legal sized shells declined.

METHODS and MATERIALS

The wholesale value of the mussel harvest was calculated by surveying two or three commercial mussel dealers monthly to collect data for each shell category. Total commercial harvest volume was calculated from the wholesale shell dealer's monthly purchase summaries. Mussel receipt data reports provided by TWRA's Data Management Division were used to calculate the species and size percent composition of the total harvest (Clouse 2001). Harvest value was derived by multiplying the average annual price per pound by the estimated number of pounds harvested and then summing the categories.

Commercial mussel population assessments were conducted exclusively on Kentucky Reservoir because it contains the most important commercial mussel beds. Several techniques were employed to collect mussels from a variety of habitat types. 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).

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 lake.

In deep water environments (reservoirs and mainstream rivers), SCUBA and brailling were used to conduct surveys and collect samples. Before sampling a given area, a depth finder was used to analyze bottom characteristics and detect underwater obstructions that might impair collection efforts. In shallow water where samples could be collected by surface supplied air compressor (Hookah system), snorkeling or hand

picking; the aerial extent of the mussel bed (shoal) was visually determined. Then a representative sample was collected from the bed.

Species composition was determined with timed collections. Searches consisted of free-swimming dives with 15 to 30 minutes of active collecting. Because a larger sample size can be attained during timed collections, this was the preferred method. Abundance was determined with 20m x 1m transects and 0.25m^2 quadrat samples. Mussels were placed in mesh bags and brought to the surface for examination.

The mussel brail was used to find mussel populations, collect specimens for species composition, age and growth, reproductive activity and relative abundance. The crowfoot brail is often used by commercial operations to explore potential harvest sites. Stansbery and Cooney (1985) found that SCUBA and brailling showed similar distribution patterns of both abundance (number of individuals) and diversity (number of species). A brail rig consisting of a 14 ft. brail bar holding 54 lines with six sets of four pronged hooks per line (1296 total hooks), 75 ft. tow rope, 3.5 horsepower gasoline engine powered winch, and angle iron holding racks with a pulley were mounted to an aluminum boat. The boat was propelled by placing the outboard motor in reverse and slowly dragging the brail secured by the tow line from the bow. Areas surveyed were covered by a series of timed tows. Number and distribution of tows were determined by the size of the study area. Timed samples were taken by towing the brail along the bottom for 10 minutes. During the tow, the approximate location of the sample was recorded from the respective river chart to provide locality data. At the end of each sample the brail was hauled to the surface, the mussels removed. This method was repeated until the study reach had been sufficiently covered. Pertinent data were then collected from each sample before the mussels were released. Brailling allowed a large reach to be sampled in a short period. Under normal conditions, three to five river miles could be covered daily.

All mussels collected during population surveys were identified to species enumerated and recorded. The data were entered in a computer spreadsheet to tabulate species composition and relative abundance parameters. Commercial species were measured for size class distribution according to current size limits. The legal sized portion of the population was determined for all commercial species.

RESULTS and DISCUSSION

Freshwater mussel shell market results were mixed during 2000. Increased quantities of small to medium sized categories of shell were processed because of orders placed by Japan and China. Total shell harvest increased for the second consecutive year. While the shell industry experienced a 29% increase in shell tonnage, the wholesale value declined 15% due to the increased allotment of 2 3/8" size ebony shells in the harvest. Monthly price data obtained from wholesale mussel dealers were tabulated to compute average price paid for the major categories of shell (Table 1). After harvest, shells are normally sized and grouped into the categories listed. Shell values

were only reported for green (live mussels), because the market for open (dead) mussel shell was very limited. The commercial mussel shell category known as "Lake Mix" was composed of the following species: threeridge *(Amblema plicata)*, southern mapleleaf *(Quadrula apiculata)*, mapleleaf (*Q. quadrula)*, and lake pigtoe *(Fusconaia flava)*.

Information from TWRA's mussel receipt system, wholesale mussel dealer summaries, and wholesale price survey were used to compute the volume and value of the reported mussel harvest (Table 2). Tennessee wholesale mussel dealers reported purchasing 3,434,087 pounds (1,717 tons) of mussels from Tennessee waters during 2000 valued at $2,412,133. Lower average pries paid for various categories of mussels contributed to the decreased harvest value (Figure 1). However, lower prices did not hinder recruitment of additional harvesters. The number of licensed musselers increased to the highest level since 1997 (up by 58%)(Table 3). With more harvesters participating, the average income decreased dramatically, from $10,770 to approximately $5,883 per harvester (Figure 2).

Average price of all lake mix and ebony *(F. ebena)* size categories remained within $0.05 of 1999 values. However, washboard prices *(Megalonaias nervosa)* fell as much as 30% during 2000. The 2 3/8" (ebony and monkey-face *Q. metanevra*) category comprised 49% of the harvest weight, but only 19% of the total value. Lake mix categories (2 5/8" and 2 3/4") made up 28% of the shell harvest by weight and 35% by value (Table 2). The volume of 2 5/8" shells exceeded the 2 3/4" by 4%, but the 2 3/4" shell value exceeded the 2 5/8" by 9%. Take of all washboards 3 13/16" and larger, composed only 23% of the total weight, but contributed 47% of the total harvest value. River grade washboards produced 9% by weight and 19% by value, followed by 4" lake grade washboards at 8% weight and 15 % value. These two categories combined produced 21% by weight and 34% by value of the 1999 shell market. Weighted average wholesale price paid to harvesters has fluctuated dramatically with market shifts. It increased 80% during 1992-95, declined 69% during 1996-98, rebounded 78% for 1999, then declined 34% in 2000 (Figure 1).

According to wholesale dealer receipts, 90% of the 2000 Tennessee mussel harvest came from Kentucky Reservoir (Appendix A). An analysis of Kentucky Reservoirs harvest data size distribution by species group showed 86% of the ebonys were between 2 3/8" and 2 ½". The lake mix group was almost equally divided with 51% being 2 5/8" and 49% 2 3/4". Lake grade washboards were split 40% 3 13/16" and 60 % equal to or greater than 4". Statewide, washboards were graded 27% lake, 43% Cumberland River, and 29% Tennessee River. Cheatham Reservoir led the Cumberland River reservoirs, producing 5.5% of the total harvest, followed by Barkley reservoir at 3.57%. Mussel shells imported from other states totaled 252,016 pounds, approximately 7% of the total Tennessee market.

Because of their slow growth, commercial mussel populations subjected to intense harvest pressure are susceptible to being "cropped off" (very low percentage of legal-sized individuals). 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, mussel populations recoup 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 between the 1994-00 shell harvest receipt data. During this period, the 2 3/8" to 2 ½" categories' percent weight of the total harvest fluctuated from 22.8% to19% to 49.0%. Changing market demands along with increased availability of larger-sized shells have allowed more of the harvest to be composed of the 4" and larger shells during recent years. Seventeen percent or more of the harvest weight has been composed of shells from the 4" or greater size category since 1999 (Table 4). Smaller lake washboards (3 3/4", 3 13/16") comprised less than 10% the last two years. Changes incorporated into TWRA's mussel receipt allowed the 2 ½", 2 3/4", 3" and 4.0" data to be captured as distinct size categories.

Since the late 1980's, increasing harvest pressure on Kentucky Reservoir's mussel stocks has 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 *(Megalonaias nervosa)* from 3 3/4 inches to 4 inches, and increasing the size limit on lake mix shells from 2 5/8 inches to 2 3/4 inches. During the April 1999 Tennessee Wildlife Resources Commission meeting the Commission decided to increase the size limit on washboards from 3 3/4" 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 would reach 4". The size limit on lake mix shells remains at 2 5/8".

The washboard age and growth data collected from Kentucky Reservoir suggested that the 3 3/4 inch size limits did not adequately protect faster growing mussels (Figure 3). Some individuals became vulnerable to harvest at 3 3/4 inches by age five to seven. This allowed mussels to be harvested one to three years before reaching sexual maturity. A four-inch size limit will permit the faster growing washboards to reach age nine, allowing them one to two years of reproductive opportunity before becoming vulnerable to harvest.

The threeridge age and growth curve showed a similar vulnerability to harvest before reaching reproductive age (Figure 4). Faster growing threeridge mussels can reach the current 2 5/8 inch size limits by age four. Whereas a 2 3/4 inch size limit would protect them until at least age six. Trend analysis shows that the average individual would reach 2 5/8 inches by age seven, and 2 3/4 inches by age nine.

The Tennessee portion of Kentucky Reservoir was sampled at sixteen commercial and fifteen endangered mussel sites during 2000. A total of 5,746 individuals representing twenty-six freshwater mussel taxa were collected during reservoir wide

sampling efforts. Addition taxa remain extant, but were not represented in this year's samples.

Section I - TRM 49.2 to 82.5. Paris Landing/Whiteoak Creek. This section is dominated by reservoir over-bank habitat with silt, sand, 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 concentrated on the shallow (<10 - 15 ft) bars, shoreline habitats, old creek channels and river channel wall (depth >20 - 50 ft). Commercially valuable mussel species are spread out over the clay and gravel bars, scattered in the bays, and appear 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 densities are low. Few recent records of endangered mussel species are known from this section. Four sites were sampled during 2000, producing 609 individuals representing 12 species (Table 5). The five most abundant species are all commercially important (ebony shell 38.8%, threeridge 25.6%, southern mapleleaf 10.3%, mapleleaf 6.6% and washboard 4.1%). Approximately fifteen percent of the commercial species collected were legal-size or larger. Timed sampling resulted in an average collection rate of 10.2 mussels per minute. No zebra mussels were encountered during 60 minutes of sampling during 2000.

Section II - TRM 82.5 to 111.1. Harmons Creek/New Johnsonville/Duck River. This section is a transitional area with both lotic and reservoir habitats. Peak 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 river bed at depths = 0 to 50 ft. The mussel population is dispersed throughout the varied habitat types, and reaches maximum densities (> 100 mussels per square meter) in the river channel. Population recruitment is abundant in and near the main river and creek channels resulting in colonies expanding out from these habitats. Substrate composition varies from silt, sand, clay, to gravel, cobble, and bedrock. Several recent endangered mussel species records exist for this section. Four sites were sampled during 2000, producing 726 individuals representing 17 species (Table 5). Two commercially important species composed 64% of the population (ebonys 38.2%, and threeridge 25.5%), followed by washboards (8.5%) and mapleleafs (7.4%). Approximately 33% of the commercial species collected were legal-size or larger. Timed sampling resulted in an average collection rate of 12.1 mussels per minute. One zebra mussel was collected during 60 minutes of sampling during 2000.

Section III - TRM 111.1 to 206.7. South of the mouth of the Duck River to Pickwick Dam. Lotic habitats dominate this section. Peak mussel 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 section. The mussel population of this

section is found primarily in and near the old river channel, and to a lesser extent, along the shorelines. Maximum densities (> 100 mussels per square meter) are found in the shallow gravel deposits on the inside river bends and at the head and tail areas of mainstream islands. Recruitment is abundant along 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. Eight sites were sampled for commercial mussels during 2000, producing 1,436 individuals representing 20 species (Table 5). Ebony shell dominates this section (73% of population) and is the most important commercial species. Approximately 23% of the commercial species collected from waters open to harvest were legal size or larger. Three sites sampled using timed collections resulted in an average collection rate of only 1.7 mussels per minute. However, these sites were in poor habitat. Five sites in good habitat were sampled quantitatively resulting in an average density of 17.5 mussels per square meter. Twenty-one zebra mussels were encountered during 2000.

Section III has several mainstream island complexes that provide the large river riffle habitat required by several endangered mussel species (Hubbs 1999). In 2000, the United States Fish and Wildlife Service provided Section 6 (endangered species) funding to TWRA for the monitoring and collection of endangered mussel species. On the lower Tennessee River, 14.9 days were expended surveying for endangered mussel species. Five sites were quantitatively surveyed in the tail-water section of Kentucky Reservoir immediately downstream from Pickwick Dam. A total of 150 ($0.25m^2$) quad samples were collected from 15 sub-sites, resulting in the collection of 2,975 unionid mussels and two zebra mussels (*Dreissena polymorpha*). The Asian Clam (*Corbicula fluminea*) was abundant throughout the study reach (Table 6). Twenty-three mussel species were collected, including three endangered mussels (all *Lampsilis abrupta)* during 23.5 man-hours of bottom time. The catch-per-unit-of-effort (CPUE) for endangered mussels equaled 0.13 per hour. Mean density ranged from 2 to 266.8 mussels per square meter. *Fusconaia ebena* was the dominant species, composing 69.1% of the population, followed by *Quadrula pustulosa* (13.8%), and *Obliquaria reflexa* (5.4%), *Cyclonaias tuberculata* (3.5%), and *Elipsaria lineolata* (2.8%).

Commercial demand for shells has remained below 2,000 tons per year since 1996. This has allowed mussel populations to recover some what from over a decade of intense harvest activity. Reduced harvest pressure on the mussel resource has caused a substantial increase in the percentage of legal-sized mussels in the Kentucky Reservoir population (Figure 5). The ebony shell is an example of a species with an adequate size limit. During increasing harvest pressure, the ebony population continued above 10% legal-sized, but after three harvests below 2,000 tons, it is currently estimated to be 30% legal sized or above. The washboard population averaged only 7% during 1992-98, before reduced harvest pressure brought the size distribution of the population to 12% legal sized. The lake mix group (threeridge, mapleleaf, pigtoe) has not been as sensitive as the washboards to harvest pressure with legal sizes representing less than 10% during 1994-

96, averaging 12% for the period 1992-98, and is currently at 14%. The inverse relationship between the tons of shell harvested and the percent legal sized mussels suggests an unbalanced, over harvested population of some commercial species (Table 7). Because the adult portion of the population is negatively correlated with harvest pressure, the population is not deemed to be at or above carrying capacity.

SUMMARY

Work performed under TWRA Commercial Musseling project number 7363 addressed Strategic Plan Problem I. Strategies 1, 2 and 4. License sales and mussel tax revenue associated with the commercial mussel program garnered $122,821 during 2000.

The shell industry experienced a 29% increase in shell tonnage, but the wholesale value declined 15% due to the increased allotment of 2 3/8" size ebony shells in the harvest. Lower average prices paid for various categories of mussels also contributed to the decreased harvest value. Average price of all lake mix and ebony *(F. ebena)* size categories remained within $0.05 of 1999 values. However, washboards prices fell as much as 30% during 2000. Lower prices did not hinder recruitment of additional harvesters. The number of licensed musselers increased to the highest level since 1997. With more harvesters participating, the musselers average income decreased dramatically.

The 2000 mussel harvest was valued at $2,412,133 for 3,434,087 pounds. The weighted average price equaled $0.70 per pound. The Strategic Plan objective of increasing/maintaining commercial mussel populations to a level where $\geq$ 15% are above legal size limits was met on a sectional basis for all three sections of Kentucky Reservoir. However, on a reservoir wide species basis, only the ebony shell met the objective.

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. The viability of the commercial mussel populations can be assured only through adherence to adequate size regulations and maintaining the integrity of closed waters for population comparisons and species protection. Size regulations should be based on conservative age and growth estimates, and should allow brooding female mussels several years to spawn before reaching legal harvestable size.

RECOMMENDATIONS

The commercial mussel program continues to be inadequately funded. In order to monitor and protect this valuable resource, many man-hours of biological and law enforcement effort are required to guard against illegal take, over exploitation, and habitat degradation. Therefore in order to make this program meet its fiduciary responsibilities, it is necessary to:

1. Increased revenue should be sought to fully fund the existing commercial mussel program. Increase the fee on commercial mussels and shells to a level sufficient to fund the commercial mussel program (approximately $0.05 per pound). At the 2000 harvest level, this would provide approximately $171,704 in direct revenue for the

management of mussels, compared to $50,946 received. Increase the wholesale mussel dealers license fee to at least $1,000 and resident harvester license fee to $250.

2. Remove from the list of Mussel Species for Harvest: the River Pigtoe *(Pleurobema cordatum)*. This species has not adapted to impoundment and has very limited recruitment, mainly in the lower Tennessee River. It constitutes less than 1% of the annual shell harvest and closely resembles the Federally listed endangered rough pigtoe (*P. Plenum*). The River Pigtoe itself is listed as threatened in the 1998 edition of "The Freshwater Mussels of Tennessee" (Parmalee and Bogan 1998).

3. Add the area around Diamond Island (TRM 195.2 to 197.5) to the TWRA mussel sanctuary system. This area supports a relatively diverse population of reproducing mussels of several endangered species, including the pink mucket (*Lampsilis abrupta*), orangefoot pimpleback (*Plethobasus cooperianus*), and fanshell (*Cyprogenia stegaria*).

4. 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. By making these two additions to the sanctuary system, not only would rare and endangered species be protected, but commercial species would be afforded a greater opportunity to reproduce without being disturbed. This additional protection would enhance mussel recruitment which could help replenish populations adjacent to the protected zones through dispersion of juvenile mussels by their fish hosts.

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

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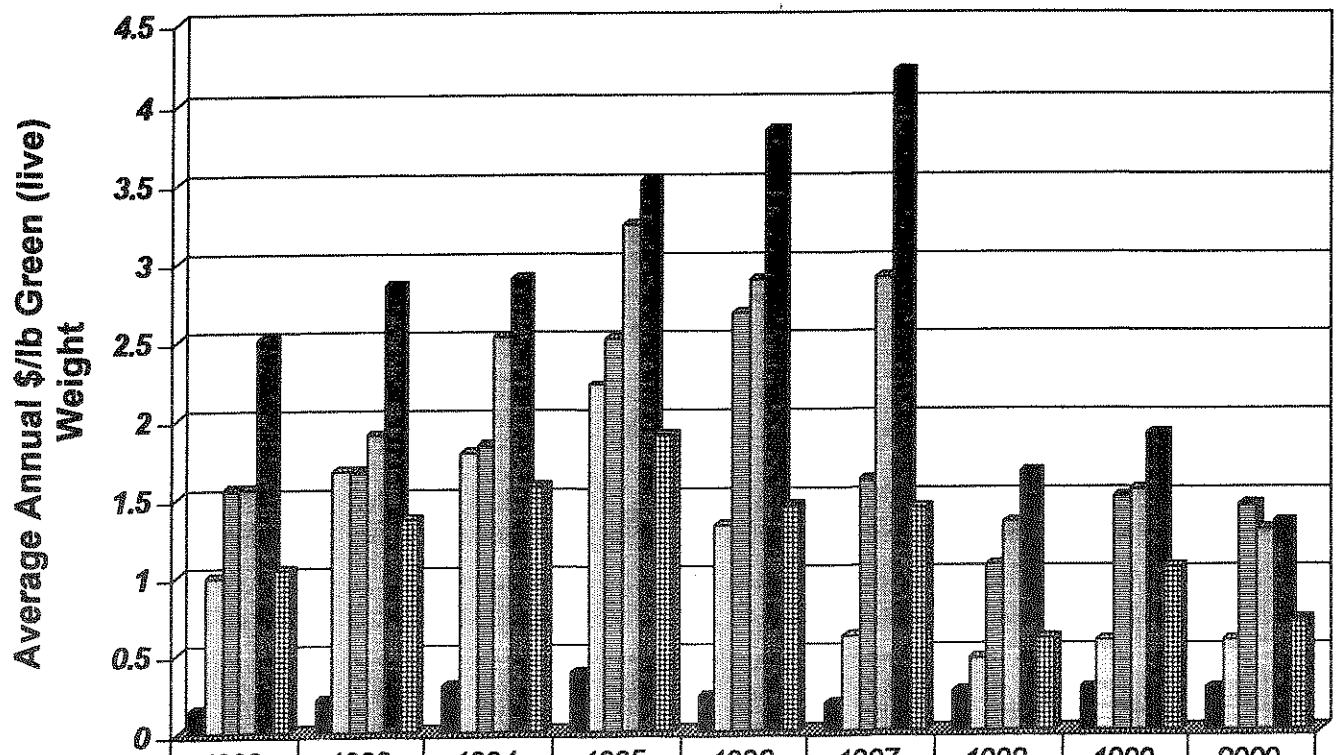
FIGURES



	1992	1993	1994	1995	1996	1997	1998	1999	2000
2 3/8" Ebony	0.15	0.21	0.31	0.38	0.22	0.17	0.25	0.27	0.28
2 5/8" Lake Mx	1	1.67	1.79	2.21	1.32	0.61	0.46	0.58	0.58
2 3/4" Lake Mx	1.56	1.67	1.84	2.5	2.66	1.61	1.06	1.49	1.44
3 3/4" Washboards	1.56	1.9	2.53	3.23	2.88	2.89	1.33	1.54	1.28
4" Washboards	2.5	2.85	2.9	3.5	3.83	4.2	1.66	1.9	1.33
Weighted Average	1.05	1.36	1.57	1.89	1.44	1.43	0.59	1.05	0.7

Figure 1. 1992 - 2000 Tennessee wholesale shell price trends by size category.

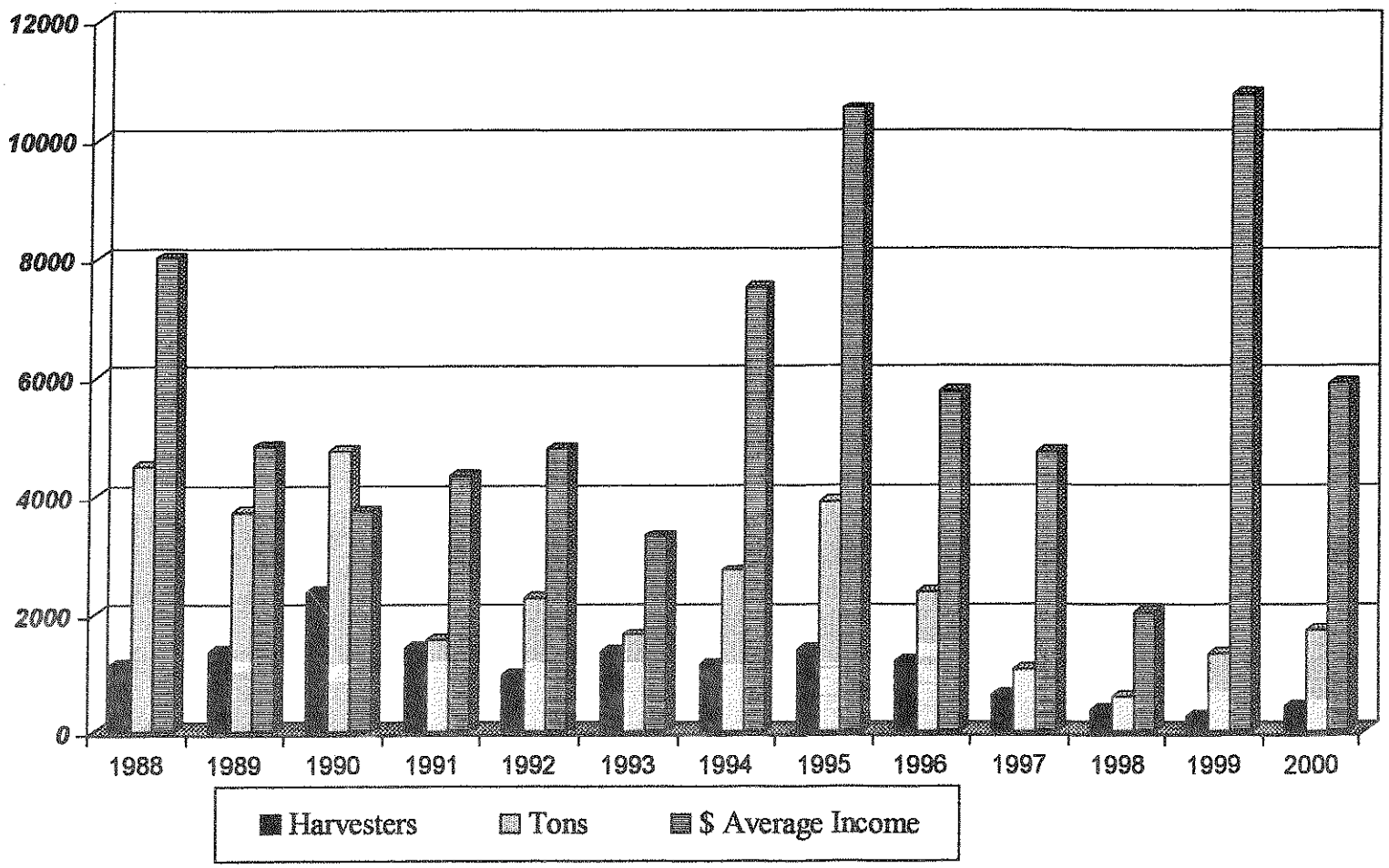


Figure 2. Tennessee mussel shell harvest trends 1988 - 2000.

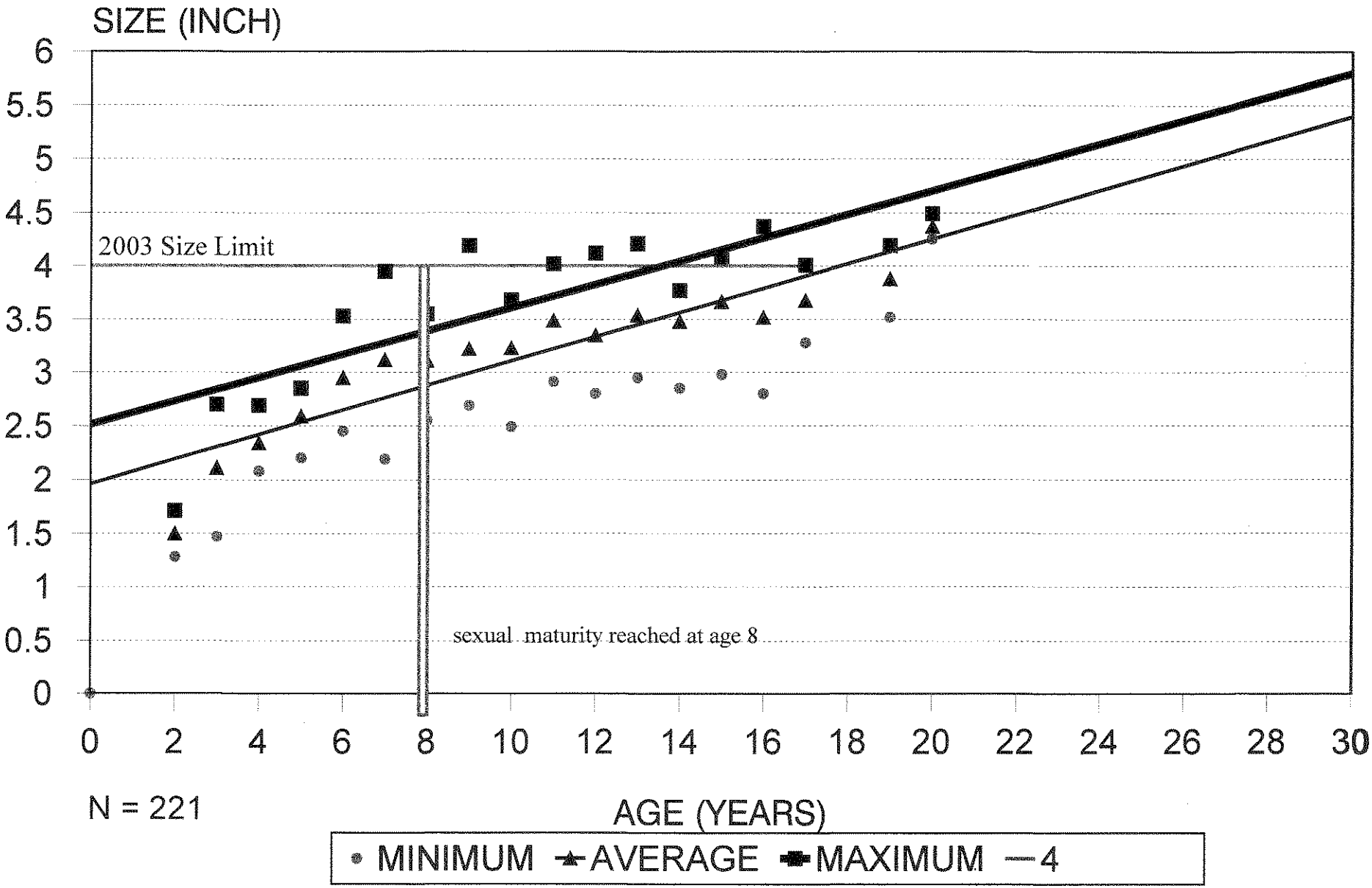


Figure 3. Growth curve for Kentucky Reservoir washboard mussels sampled during 1999.

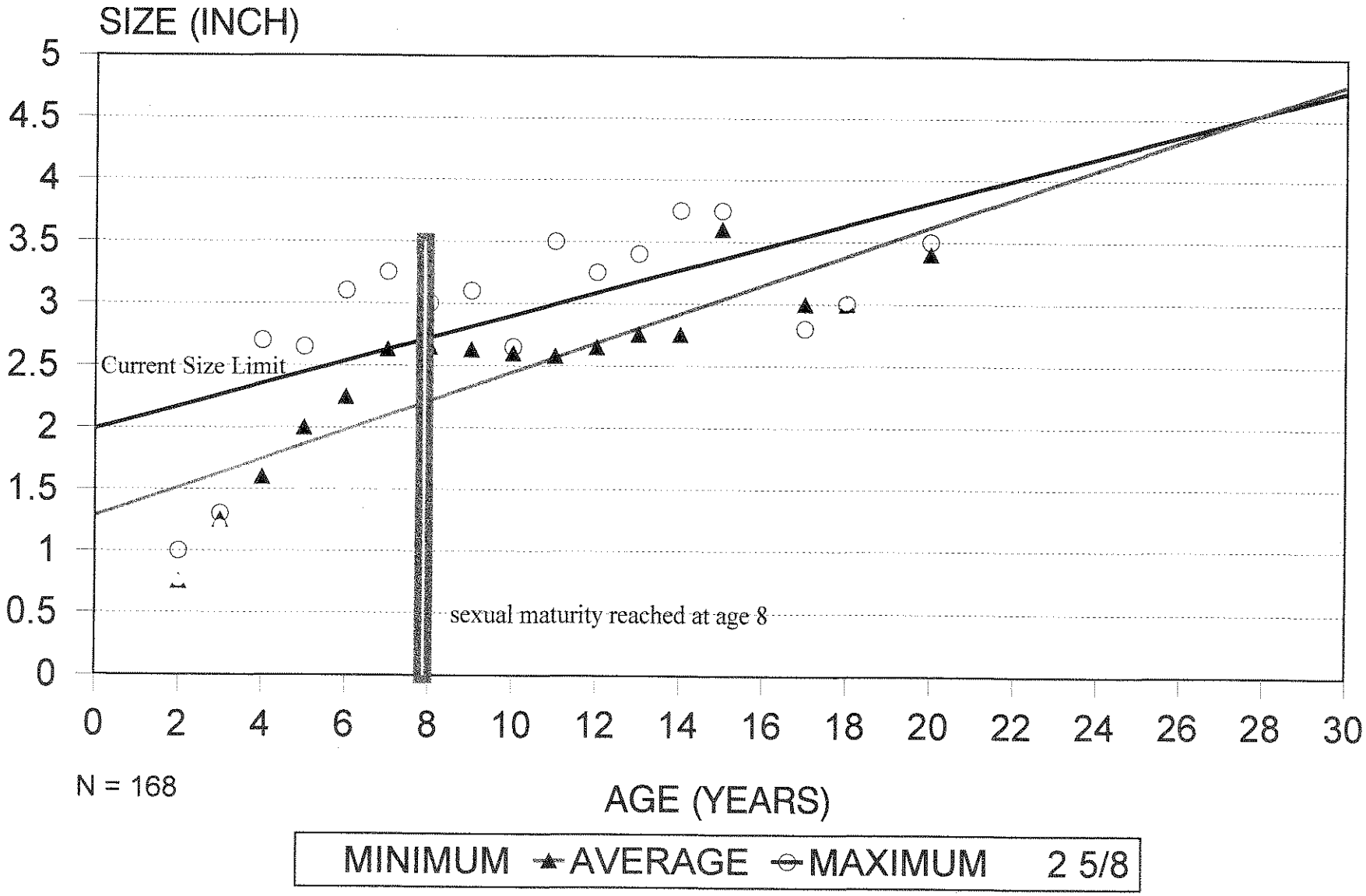


Figure 4. Growth curve for Kentucky Reservoir threeridge mussels.

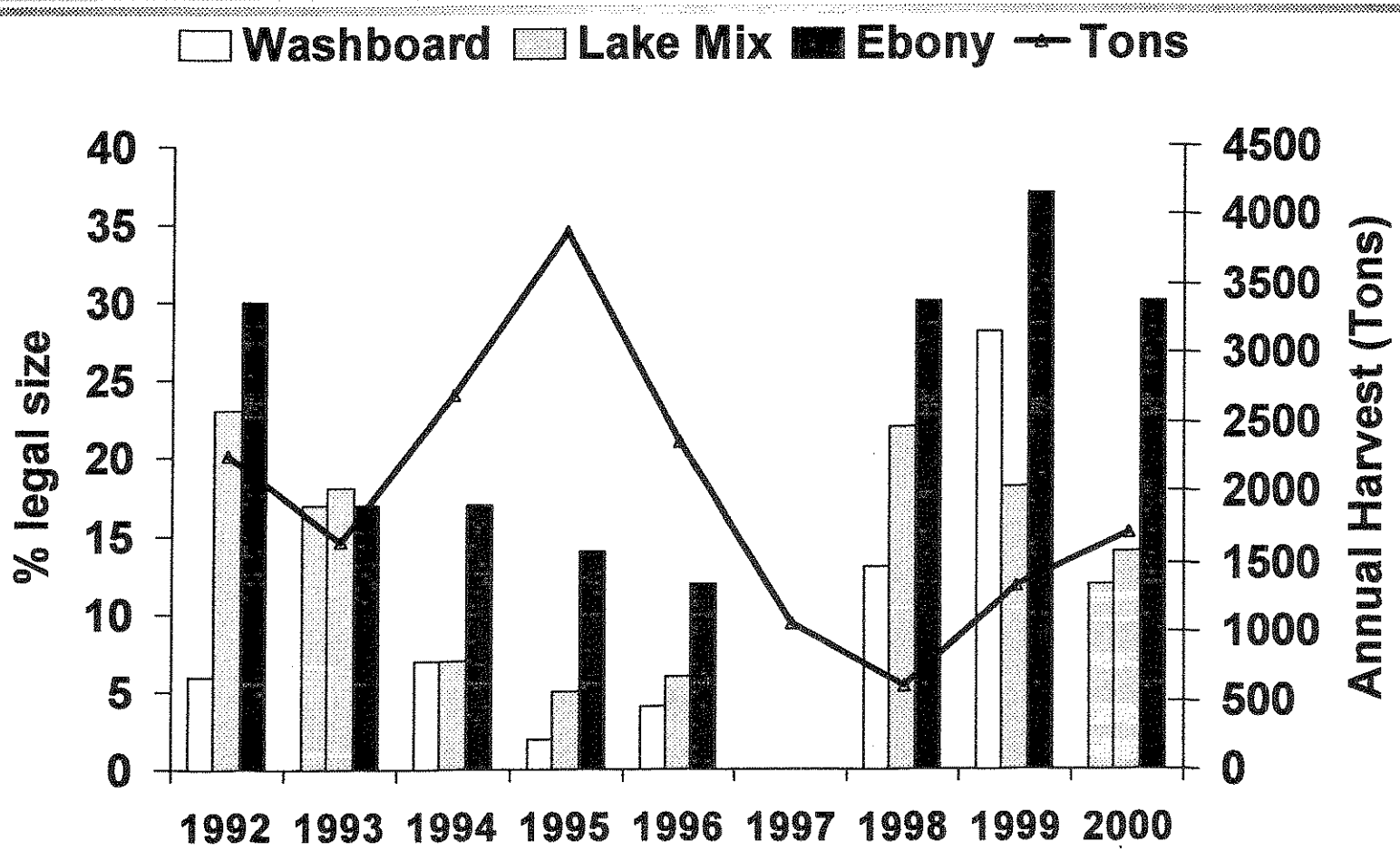


Figure 5. Legal sized mussel shell in Kentucky Reservoir population, 1992 - 00.

TABLES

Table 1. Average wholesale price paid for various categories of commercial shell during 2000.

CATEGORY	CONDITION	AVERAGE PRICE ($/LB)	SPECIES
LAKE MIX 2 5/8"	GREEN	$0.58	*A. plicata, Q. quadrula,*
LAKE MIX 2 3/4"	GREEN	$1.44	*Q. apicualta, F. flava*
EBONY 2 3/8"	GREEN	$0.28	*F. ebena*
EBONY 2 5/8"	GREEN	$0.53	*F. ebena*
EBONY 2 3/4"	GREEN	$0.84	*F. ebena*
LAKE WASHBOARD 3 3/4"	GREEN	$1.28	*M. nervosa*
LAKE WASHBOARD 4.0"	GREEN	$1.33	*M. nervosa*
LAKE WASHBOARD 5.0"	GREEN	$5.50	*M. nervosa*
RIVER WASHBOARD 3 13/16" & UP	GREEN OPEN	$1.38 $0.25 to $2.00	*M. nervosa*

GREEN = Shell with meat
OPEN = Shell without meat

Table 2. 2000 wholesale commercial shell harvest by size category, as estimated from Tennessee waters.

	WEIGHT LBS	PERCENT WEIGHT	ESTIMATED VALUE	PERCENT VALUE
CATEGORY				
Lake Grade Mussels 3 13/16 in.	184,208	5%	$235,786	10%
Lake Grade Mussels 4.0 to 4 ½ in.	272,846	8%	$362,885	15%
River Grade Mussels 3 13/16 to 4.5 in.	325,810	9%	$449,618	19%
Lake Grade Mussels 5.0 in.	10,174	1%	$55,957	3%
mussels 2 3/8 to 2 ½ in.	1,668,349	49%	$467,138	19%
mussels 2 5/8 in.	553,635	16%	$321,108	13%
mussels 2 3/4 to 3 in.	419,065	12%	$519,641	22%
Total	**3,434,087**		**$2,412,133**	
Tons	1717			

Table 3. Tennessee commercial mussel shell industry volume and value, 1994-00.

Year	1994	1995	1996	1997	1998	1999	2000
Harvesters	1,133	1,397	1,188	641	351	260	410
Dealers	34	32	23	25	19	15	24
Tons	2,707	3,881	2,362	1,061	601	1,335	1,717
millions $	$8.5	$14.7	$6.8	$3.0	$0.7	$2.8	$2.4
Shell Fee	$68,285	$98,713	$65,731	$33,140	$15,185	$38,187	$50,946
Average Wholesale price/lb	$1.57	$1.95	$1.44	$1.42	$0.59	$1.05	$0.70

Table 4. Size class distribution of Tennessee's commercial mussel shell harvest, 1994-00.

PERCENT OF HARVEST WEIGHT BY SHELL SIZE CATEGORY							
YEAR	1994	1995	1996	1997	1998	1999	2000
2 3/8"	22.8%	24.3%	24.0%	25.0%	42.0%	19.0%	29.0%
2 1/2"							20.0%
2 5/8"	61.2%	44.7%	60.0%	55.0%	27.0%	28.0%	16.0%
2 3/4"					19.0%	22.0%	11.0%
3"							1.0%
3 3/4"	15.9%	31.0%	16.0%	20.0%	6.0%	9.0%	
3 13/16"							6.0%
=>4"					4.0%	20.0%	17.0%

Table 5. Mussel species collected from the Kentucky Reservoir portion of the Tennessee River, 2000 (all methods).

SECTION 1 TRM49.2 TO TRM 82.5												
LATITUDE	36 22 .54			36 21 .32			36 20 .01			36 15 .90												
LONGITUDE	88 00 .46			87 59 .61			87 57 .80			87 56 .59			TOTAL									
RIVER MILE	72.2L			74.2L			76.0R			81.2R			4									
DEPTH (ft.)	13 to 16			5 to 10			14			15												
SUBSTRATE	clay			clay			silt,clay,gravel			silt,clay,corbicula												
METHOD	15 minutes			15 minutes			15 minutes			15 minutes			60									
SIZE	NC	LG	SL	NC	LG	SL	NC	LG	SL	NC	LG	SL		PERCENT ABUNDANCE		PERCENT LEGAL						
Species																						
Pyganodon grandis																						
Utterbackei imbecillis																						
Anadonta suborbiculata																						
Amblema plicata	1		22		5	16		6	44		7	55	156	25.6		12.2						
Arcidens confragosa										2			2	0.3								
Cumberlandia monodonta																						
Cyclonaias tuberculata																						
*Cyprogenia stegaria**																						
Elliptio crassidens																						
Elliptio dilatata																						
Ellipsaria lineolata										5			5	0.8								
Fusconaia ebena		72	53			2		9	6		24	70	236	38.8		44.5						
Fusconaia flava			6			2			20			6	34	5.6		0.0						
*Lampsilis abrupta**																						
Lampsilis ovata																						
Lampsilis teres																						
Leptodea fragilis																						
Ligumia recta																						
Ligumia subrostrata																						
Megalonaias nervosa			12						1			12	25	4.1		0.0						
Obliquaria reflexa	1						2			3			6	1.0								
Plectomerus dombeyanus																						
Plethobasus cooperianus *																						
Plethobasus cyphus																						
Pleurobema cordatum																						
Pleurobema coccineum																						
Pleurobema oviforme																						
Potamilus alatus					1	1		3	1			3	9	1.5		44.4						
Potamilus ohiensis																						
Quadrula apiculata			12			5		1	3			42	63	10.3		1.6						
Quadrula c. cylindrica																						
Quadrula metanevra																						
Quadrula nodulata			7	2			10						19	3.1								
Quadrula pustulosa				3			3			8			14	2.3								
Quadrula quadrula						5			9			26	40	6.6		0.0						
Toxolasmus parvus																						
Truncilla donaciformis																						
Truncilla truncata																						
Tritogonia verrucosa																						
Dreissena polymorpha																						
TOTAL	1	73	112	5	6	31	15	19	84	18	31	214	609									
% LEGAL SIZE		39			16			18			13		22			14.7						
TOTAL UNIONID SPECIES	7			8			10			11			12									

* = FEDERALLY LISTED ENDANGERED SPECIES

LG = LEGAL SIZE, SL = SUBLEGAL SIZE, NC = NONCOMERCIAL SPECIES

Table 5 (continued). Mussel species collected from the Kentucky Reservoir portion of the Tennessee River, 2000 (all methods).

SECTION II TRM82.5 TO TRM111.1											
LATITUDE	36 09 .72	36 08 .97	35 06 .51	35 58 .82							
LONGITUDE	87 55 .32	87 54 .63	87 56 .01	88 00 .09	TOTAL						
RIVER MILE	88.7L	90.2R	92.7R	103.0R	4						
DEPTH (ft.)	10 to 15	8 to 12	10 to 45	7 to 10							
SUBSTRATE	silt,sand,clay	silt,clay	clay,sand, grave	clay, silt, stumps							
METHOD	15 minutes	15 minutes	15 minutes	15 minutes	60	PERCENT	PERCENT				
SIZE	NC LG SL	NC LG SL	NC LG SL	NC LG SL		ABUNDANCE	LEGAL				
Species											
Pyganodon grandis											
Utterbackei imbecillis											
Anadonta suborbiculata											
Amblema plicata	8 66	11 24	2 4	28 42	185	25.5	26.5				
Arcidens confragosa	1			2	3	0.4					
Cumberlandia monodonta											
Cyclonaias tuberculata				1	1	0.1					
*Cyprogenia stegaria**											
Elliptio crassidens											
Elliptio dilatata											
Ellipsaria lineolata	5			6	11	1.5					
Fusconaia ebena	66 43	37 12	14 65	21 19	277	38.2	49.8				
Fusconaia flava	7	2		3 13	25	3.4	12.0				
*Lampsilis abrupta**											
Lampsilis ovata											
Lampsilis teres											
Leptodea fragilis				1	1	0.1					
Ligumia recta											
Ligumia subrostrata											
Megalonaias nervosa	6	1 4	6 10	3 32	62	8.5	16.1				
Obliquaria reflexa	12	4		9	25	3.4					
Plectomerus dombeyanus											
Plethobasus cooperianus *											
Plethobasus cyphus											
Pleurobema cordatum			1		1	0.1	100.0				
Pleurobema coccineum											
Pleurobema oviforme											
Potamilus alatus	1 1	1 3	1 5	5 6	23	3.2	34.8				
Potamilus ohiensis											
Quadrula apiculata	4	5	2 2	3	16	2.2	12.5				
Quadrula c. cylindrica											
Quadrula metanevra											
Quadrula nodulata	3	2	3	4	12	1.7					
Quadrula pustulosa	4	6	1	16	27	3.7					
Quadrula quadrula	21	4	2	5 22	54	7.4	13.0				
Toxolasmus parvus											
Truncilla donaciformis				1	1	0.1					
Truncilla truncata											
Tritogonia verrucosa		1		1	2	0.3					
Dreissena polymorpha				1	1						
TOTAL	25 75 148	13 50 54	4 28 86	41 65 137	726						
% LEGAL SIZE	34	48	25	32	35		33.1				
TOTAL UNIONID SPECIES	12	11	9	16	17						

* = FEDERALLY LISTED ENDANGERED SPECIES LG = LEGAL SIZE, SL = SUBLEGAL SIZE, NC = NONCOMERCIAL SPECIES MMA = MUSSEL MANAGEMENT AREA, CLOSED HARVEST

Table 5 (continued). Mussel species collected from the Kentucky Reservoir portion of the Tennessee River, 2000 (all methods).

SECTION III TRM111.1 TO TRM206.7											
LATITUDE	35 56 06"	35 55 49"	35 42 .25	35 24 .53	35 23 .41	35 23 .46	35 23 .46	35 23 .49			
LONGITUDE	87 55 33"	87 55 28"	88 01 .83	88 05 .21	88 09 .34	88 09 .47	88 09 .48	88 09 .91	**TOTAL**		
RIVER MILE	111.5R, trench	111.7R	129.3R	164.6 head Isl.	169.2C below Isl.	169.4, 50m off Isl.	169.4, 25m off Isl	169.8, 30 to 100m off I	8		
DEPTH (ft.)	65	40 to 45	30	12	45	35 to 40	25 to 30	20 to 35			
SUBSTRATE	silt, cobble	silt,sand, gravel	gravel, sand	gravel, sand	cobble, gravel, silt	gravel, sand	sand, gravel,silt	silt, sand, gravel			
METHOD	20 minutes	20 minutes	15 minutes	20 (0.25m2)	20m2 transect	20m2 transect	20m2 transect	20 (0.25m2)	**70M2**	**PERCENT**	**PERCENT**
SIZE	NC LG SL	NC LG SL	NC LG SL	NC LG SL	NC LG SL	NC LG SL	NC LG SL	NC LG SL	**75 MINUTES**	**ABUNDANCE**	**LEGAL**
Species											
Pyganodon grandis											
Utterbackei imbecillis											
Anadonta suborbiculata							1		1	0.1	
Amblema plicata	1 1			1					3	0.2	33.3
Arcidens confragosa					1				1	0.1	
Cumberlandia monodonta											
Cyclonaias tuberculata		1		5				14	20	1.4	
*Cyprogenia stegaria**									0	0	
Elliptio crassidens		3 1	1	3 3		1 3		5	20	1.4	20.0
Elliptio dilatata											
Ellipsaria lineolata		2		30		3	1	19	55	3.8	
Fusconaia ebena	3	17 1	4	206 465	5	8	7	4 334	1054	73	21.9
Fusconaia flava											
*Lampsilis abrupta**											
Lampsilis ovata											
Lampsilis teres											
Leptodea fragilis				1				2	3	0.2	
Ligumia recta				1	1		1	1	4	0.3	
Ligumia subrostrata											
Megalonaias nervosa	2	2 2		2		1		1	10	0.7	20.0
Obliquaria reflexa				16	1		1	11	31	2.2	
Plectomerus dombeyanus											
Plethobasus cooperianus *											
Plethobasus cyphus											
Pleurobema cordatum		8 1		1 1	1	1		2	15	1	60.0
Pleurobema rubrum											
Pleurobema oviforme											
Potamilus alatus	6	1 9	3	1			3	2	25	1.7	4.0
Potamilus ohiensis											
Quadrula apiculata	8	3			1		1		13	0.9	0.0
Quadrula c. cylindrica											
Quadrula metanevra				6 8		1		3 5	23	1.6	39.1
Quadrula nodulata											
Quadrula pustulosa		7	4	46	4	2	4	41	108	7.5	
Quadrula quadrula	3	4	1	1 4	1	2		1	17	1.2	5.9
Toxolasmus parvus											
Truncilla donaciformis				6				5	11	0.8	
Truncilla truncata				17	1			4	22	1.5	
Tritogonia verrucosa											
Dreissena polymorpha	1	1		2	10	3	2	2	21		
TOTAL	1 23	10 31 21	4 5 4	15 217 485	8 1 7.0	5.0 1.0 16.0	7 0 12	97 7 350	1436	100	
% LEGAL SIZE	4.2	60	56	31	13	5.9	0	2	21		22.696
Density Mussels/meter2				143	0.8	1.1	0.95	90.8	17.5		
TOTAL UNIONID SPECIES		10	5	16	9	8.0	8	15	20		

* = FEDERALLY LISTED ENDANGERED SPECIES LG = LEGAL SIZE, SL = SUBLEGAL SIZE, NC = NONCOMERCIAL SPECIES SANT. = SANCTUARY (CLOSED TO HARVEST)

Table 6. Mussel species collected during endangered mussel monitoring, lower Tennessee River, 2000.

	DATE:						Comments: SUMMARY OF ALL SITES												
	Collectors: D. Hubbs, A. Jones, S. Seymore, D. Sims, A. Pyburn																		
RIVER MILE: 203 to 195	Bottom Time: 1,190 MINUTES = 19.83 HOURS for 150 quadrats, 225 minutes Qualitative																		
DEPTH (ft.):	Water Temp.: Averaged 8 minutes per quadrat																		
SUBSTRATE:	Collection Method: Hookah, SCUBA																		
QUADRAT #, size: (0.25m2)	Samples collected from right, center and left portions of the river channel at each river mile																		
SITE	195R	195C	195L	197R	197C	197L	199R	199C	199L	201R	201C	201L	203L	203C	203R	TOTAL	#/m2	%	QUAL.
Species																			
Anadonta suborbiculata																			
Pyganodon grandis																			
Utterbackel imbecillis							1									1	0.03	0.0	X
Actinonaias ligamentina																			
Amblema plicata				1	1			2	1	1	1		3		2	12	0.32	0.4	X
Arcidens confragosa																			X
Cumberlandia monodonta																			
Cyclonaias tuberculata	1	4	16	10		2	7	9		23	1	4	11	3	14	105	2.80	3.5	X
Cyprogenia stegaria*																			
Elliptio crassidens	2		3	1			1	3	2	4	1	3	7		1	28	0.75	0.9	X
Elliptio dilatata																			
Ellipsaria lineolata	3	3	8	15	3	2	4	10	1	12		5	12		4	82	2.19	2.8	X
Fusconaia ebena	203	52	332	67	31	30	578	238	52	306	1	62	70		33	2055	54.80	69.1	X
Fusconaia barnesiana																			
Fusconaia flava																			
Lampsilis abrupta *		1				2										3	0.08	0.1	X
Lampsilis ovata																			X
Lampsilis teres																			X
Lasmigona complanata																			
Lasmigona costata																			
Leptodea fragilis	4	1						1				1			1	8	0.21	0.3	X
Ligumia recta	2		1	2			1		2							8	0.21	0.3	X
Lexingtonia dolabelloides																			
Megalonaias nervosa	2						1	1	2							6	0.16	0.2	X
Obliquaria reflexa	11	5	12	7	10	13	15	29	3	19		8	8		21	161	4.29	5.4	X
Plectomerus dombeyanus																			
Plethobasus cooperianus*																			
Pleurobema oviforme																			
Pleurobema plenum *																			
Pleurobema rubrum																			
Pleurobema cordatum			2	1						2						5	0.13	0.2	X
Pleurobema sintoxia																			
Potamilus alatus			2					3	1						2	8	0.21	0.3	X
Potamilus ohiensis																			
Quadrula apiculata			1			1							1	1		4	0.11	0.1	X
Quadrula c. cylindrica																			
Quadrula metanevra	2	5	4	6	3	1	3	5		2		1	1			33	0.88	1.1	X
Quadrula nodulata																			
Quadrula pustulosa	25	13	53	17	8	14	53	34	7	94	1	21	34		37	411	10.96	13.8	X
Quadrula quadrula	1	1	5			1	3	4	3	3					1	22	0.59	0.7	X
Toxolasmus parvus																			
Truncilla donaciformis	7		2					2				1				12	0.32	0.4	X
Truncilla truncata	2		1		1	2		2		1						9	0.24	0.3	X
Tritogonia verrucosa											1			1		2	0.05	0.1	X
Strophitus undulatus																			
TOTAL UNIOINDS	265	86	442	127	57	68	687	343	74	467	6	106	147	5	116	2975			
DENSITY (m2)	106	34	176.8	50.8	22.8	27.2	266.8	137.2	29.6	186.8	2.4	42.4	58.8	2	46.4	79.3			
TOTAL SPECIES	13	9	14	10	7	10	11	14	10	11	6	9	9	3	10	20			23
Dreissena polymorpha	1		1													2	0.05		
Corbicula fluminea	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			

* = FEDERALLY LISTED ENDANGERED SPECIES, X = PRESENT R = relic

Table 7. Kentucky Reservoir % legal-sized commercial mussels by category, 2000.

	TWRA Population Samples, Sections I, II and III.		
	N	Open Waters Legal-Sized	Closed waters Legal-Sized
Ebony	1,567	30%	not sampled
Lake Mix	607	14%	"
Washboards	97	12%	"

APPENDICES

APPENDIX
A
2000 Wholesale Mussel Dealer & Receipt Report Summary Data

Wholesale Commercial Shell Harvest Receipt Report Summary (green& open bs. combined) by Location, for 2000.

	Size Class										
	2 3/8	**2 1/2**	**2 5/8**	**2 3/4**	**3**	**3 13/16**	**4**	**4 1/2**	**5**	**Total**	**Percent**
KY RSV	989292	678927	552195	387150	28417	184117	182085	79779	9857	3091819	90.03
PW RSV	52	12	871	204		68	328			1535	0.04
NJ RSV			51				30			81	
DK RV										0	0.00
BK RSV			252	1549	601	4413	77966	37908	72	122761	3.57
CH RSV	66		25	1144		1910	114076	72371		189592	5.52
OH RSV						17	14258	2861	245	17381	0.51
No Code			241			23	4706	5948		10918	0.32
Total	989410	678939	553635	390047	29018	190548	393449	198867	10174	3434087	100
Percent	29	20	16	11	1	6	11	6	0		
Out of State	21656	14322	14687	26982	608	1519	91535	77312	3395	252016	
	1011066	693261	568322	417029	29626	192067	484984	276179	13569	3686103	

Wholesale Commercial Shell Harvest Receipt Report Summary (green& open lbs. combined), by % weight by species class for 2000.

	Ebony/ MF	LAKE MIX	Wash-board	Total
LBS.	1977332	712020	744735	3434087
Percent	58	21	22	100

State-wide WASHBOARDS

	LWB	CRWB	TRWB	No Code	Total
LBS.	203251	317438	213392	10654	744735
Percent	27	43	29	1	100

Wholesale Commercial Shell Harvest Receipt Report Summary (green& open lbs. combined), by % weight by species class for 2000.

Ky. Lake Washboard % Weight By Size Class, 2000.

	3 13/16	=>4	Total
LBS.	184117	271721	455838
Percent	40	60	100

Ky. Lake, Lake Mix % Weight By Size Class, 2000.

	2 5/8	2 3/4	Total
LBS.	338013	326884	664897
Percent	51	49	100

Ky. Lake Ebony Shell % Weight By Size Class, 2000.

	2 3/8	2 1/2	=> 2 5/8	Total
LBS.	989410	678939	284831	1953180
Percent	51	35	15	100

APPENDIX
B
Zebra Mussel Distribution in Tennessee

Since the first documented collection of the zebra mussel in Tennessee occurred 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 in Tennessee. Barge and boat traffic are believed to be the primary vector 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.

The zebra mussel continues to be reported by commercial musselers working the Kentucky Reservoir portion of the Tennessee River system and Barkley, Cheatham, and Old Hickory reservoirs of the Cumberland River system. It has yet to develop densities that endanger the native mussel fauna of these reservoirs. However, zebra mussel densities in the upper Tennessee River system continue to increase from 248/m^2 to 2,795/m^2 in the Watts Bar tail-water (Kerley 2000).

Zebra mussels have colonized the Mississippi River along the western border of Tennessee. They are abundant and attached to the 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 investigate and document zebra mussel sightings. 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.