Mussel Die-off Investigations and Mussel Distribution Surveys

Kentucky Lake Reservoir

June 2, 1989 - September 25, 1989

Tennessee Wildlife Resources Agency
Environmental Services Division
Habitat Protection Program

Introduction

Kentucky Lake Reservoir extends from Pickwick Dam, Tennessee River mile (TRM) 206.8, in southwest Tennessee to Kentucky Lake Dam (TRM 22.5), approximately 184 miles downstream into Southwest Kentucky. The reservoir essentially bisects the western portion of Tennessee. From Pickwick Dam to the mouth of the Duck River (TRM 110), the reservoir is more lotic in nature. From the Duck River downstream, the reservoir widens, current slows, larger embayments are found, and the reservoir becomes more lenthic.

Prior to impoundment, the Tennessee River supported a very rich and diverse molluscan fauna (Bates and Dennis, 1985). At present, Kentucky Lake Reservoir still maintains an overall diverse mussel fauna. However, due to the irratic lotic and lenthic conditions existing in different sections of the reservoir, a community level shift in mussel species composition is occurring (Bates and Dennis, 1985).

Management and protection of all mussel species in Kentucky Lake Reservoir is a major goal for TWRA (TWRA, 1990). The reservoir is home to seven Tennessee Heritage Program (THP), state and federally listed endangered mussels, as well as, one additional species THP lists as in

need of special concern. Kentucky Lake Reservoir provides a valuable mussel resource for the commercial pearl industry. In 1988, approximately 4,493 tons of mussels were harvested, resulting in an economic value of $9,122,854 (Todd, 1990). A mussel industry representative reported a 22 million dollar value to the local economy from the commercial mussel industry in statments made to the Tennessee State Legislature. However, four successive years of record drought has had known and unknown impacts on mussel fauna. Although reports of mussel die-offs were not infrequent during the drought period, reports of massive die-offs date to at least 1965.

During 1989, mussel die-off reports were investigated by the Environmental Services Division's, Habitat Protection Program. Obtaining basic background information on species composition and distribution throughout the reservoir was an inportant objective. This report summarizes these investigations, and is independant of mussel surveys conducted in conjunction with other ongoing mussel projects on Kentucky Lake Reservoir. Tennessee Wildlife Resources Agency projects to determine the occurence and significance of toxics in sediment and mussel flesh are in progress and will be reported seperately.

Methods

Sampling

In an effort to standardize mussel collecting efforts and to reduce diver bias associated with timed dives, the Environmental Services Division utilized a line transect for collecting mussels during most of the work reported here.

In conducting line transect dives, a 19.8 meter length of rope was used to establish a standard distance for all transects taken. This method also helped to maintain diver direction and to assist in making collections in strong current . The transect line was weighted at each end. One end was lowered from the boat to the lake bottom by a connecting line which was tied off to the boat. Scuba equipped divers then swam out with the other weighted end of the transect line, and submerged. Upon reaching the lake bottom, the transect line was pulled taut, and secured. With one diver holding to each side of the transect line, each worked their way along the line searching the area from the line to approximately one meter to the side of the line. Upon seeing or feeling a mussel shell, collection was made. Once the transect was completed, collected mussels and shells were sorted and counted by species. Single valves

that were collected were discarded. Each species group was then separated into three categories: (1) live mussels, (2) fresh dead mussels, and (3) relic shells.

For our purposes, a live mussel is defined as a mussel showing any characteristic of life (i.e., siphoning, closure upon disturbance, maintaining shell closure, etc.). A fresh dead mussel is a mussel not showing any characteristic of life. It may be a predominantly vacant shell with remnant tissue attached, a shell emitting the distinct odor of recently decayed tissue, or a shell in which a lustrous nacre is present. The fresh dead designation was extremely important for determining if a die-off was recent or in progress. A relic shell was described as not having a lustrous nacre, but a chalky nacre, as well as other indications of extended exposure of the nacre to the aquatic environment (i.e. compacted sediment inside the shell, algal growth, severe nacre erosion, etc.). Previous surveys on Kentucky Lake Reservoir have classified mussels as dead if the hinge ligament was intact, making it difficult to determine when a mussel die-off may have occurred relative to the investigation.

Once the species groups were categorized, the information was recorded on field data sheets , and mussels and shells were returned to the lake. If single diver transects were conducted, only one side of the transect was

searched, and this was appropriately noted on the data sheet.

In order to determine the density of mussels, the number of live mussels from a line transect was divided by the area searched. The result is given as mussels per square meter.

Data Analysis

Basic assumptions of sample bias included: (1) areas sampled are subject to commercial mussel harvest which may periodically remove both live and dead shells, (2) strong current may displace empty shells, and result in a concentration of dead and relic shells in a given area, and (3) healthy mussels move vertically in the substrate and may be unavailable for collection certain times of the year.

Results and Discussion

From June through September, 1989, TWRA surveyed 6 areas in response to 4 mussel die-off reports, and conducted 6 mussel distribution surveys (Table 1). The mussel die-off and survey data will be covered in separate sections.

Mussel Die-off Investigations

On July 12, 1989, the Environmental Services Division (ESD) investigated a report of a mussel die-off at the mouth of the Duck River and the downstream vicinity. The report suggested 90% of the mussels were dead. Because of recent high rainfall, flows prohibited diving directly at the mouth of the Duck River. However, transect sampling was conducted downstream of the Duck River in the McCallies Light area (TRM 109.3). At this site, no mussels were considered fresh dead (Fig. 1), with relics of two species, Obliquaria reflexa and Potamilus alatus, observed (Fig. 2). Transect sampling was also conducted in the Rockport Landing Light area, (TRM 107.3, 106.2, 106.0) Again, live mussels predominated the sample. No fresh dead shells were observed (Fig. 3), and a total of 9 relic shells from four commercial species was noted (Fig. 4). Additional transect sampling was conducted in the Birdsong Light area (TRM 104.9) with no fresh dead shells observed (Fig. 5). Amblema plicata was the dominant specie by number of the sample (Fig. 6).

On July 21, 1989, the ESD investigated a report of 100% mussel die-off in the Eva Beach area (TRM 98.5). Transect sampling was conducted at 4 sites in the overbank of the western side of the river, and extending out to the western edge of the main channel. One mussel, a small Q. quadrula (approximately 1" in length) was considered fresh dead.

Eleven species were represented in the sample (Fig. 7, 8). Commercial mussel divers working the channel and overbank area had not observed any increased mortality.

On September 24, 1989, the ESD investigated a report of 50% mussel die-off in the Shirley Light area. Sampling was conducted at TRM 90.5 and 90.9. Twenty-eight mussels out of a total of 363 were considered fresh dead, thirty-nine as relics, and the remaining 296 were live mussels (Fig. 9). Twenty-two of the twenty-eight mussels, 78.6%, considered fresh dead were five commercially harvested species, Q. quadrula. A. plicata, Tritogonia verrucosa, Fusconaia ebena, and F. flava (Fig. 10). These five species comprised 75.7% of the total live sample. Mussels in the fresh dead category comprised 8% of the sample. Fresh dead mussels and relic shells contributed 19% of the sample.

Sampling was also conducted downstream in the Greenbottom Light area (TRM 88.9) in September 1989 in response to a reported mussel die-off die-off. Of a total of 445 mussels and shells collected, 330 were live , 45 were fresh dead, and 70 were considered relics (Fig. 11). Fusconaia ebena was the dominant species by number in the total sample (Fig. 12). The five commercial species, Q. quadrula, A. plicata , T. verrucosa, F. ebena, and F. flava, comprised 80.9% of the live sample, and 71.4% of the dead sample. Fresh dead mussels comprised 10% of the sample.

Fresh dead mussels and relic shells combined contributed 26% of the sample.

Line transect and timed dive mussel sampling was conducted in the Harmon Creek area in September 1989. This was in response to a reported 50% mussel die-off. From line transect sampling, 384 mussels and shells representing twelve species were collected. Sixty-three mussel shells were relics, 71 were considered fresh dead, and 250 live mussels were collected (Fig. 13). Fusconaia ebena provided the largest number of live mussels, 68, as well as the largest number of dead shells with 48. Five species, Q. quadrula, Megalonaias nervosa, Arcidens confragosus, Anodonta grandis, and A. imbecillis, did not provide any dead shells (Fig. 14). Timed dives were conducted by an experienced commercial mussel diver in order to provide a comparison with line transect samples. From the two timed dives conducted, 575 mussels and shells representing twelve species were collected. Of those collected, 115 were relic shells, 183 were considered fresh dead, and 277 were live mussels (Fig. 15). Amblema plicata provided the largest number of live shells with 81. Fusconaia ebena provided the largest number of dead shells, 109, during the sampling (Fig. 16). Fresh dead mussels comprised 19% of the line transect sample; fresh dead and relic shells combined contributed 35%. Fresh dead mussels comprised 32% of the commercial harvester's timed dives; fresh dead and relic shells combined totaled 52% of the timed dive sample.

Summary of Results

September 1989 data from the Shirley Light area, Greenbottom Light area, and the Harmon Creek area indicate what might be considered an increased mortality in some species (Table 2). In the Shirley Light area, F. ebena, F. flava, and Q. nodulata provided the highest percentages of fresh dead mussels. At the Greenbottom Light area, again F. ebena and F. flava and Q. nodulata provided the highest percentages of fresh dead mussels. At the Harmon Creek location, F. ebena, F. flava Q. nodulata, Q. pustulosa, Obliquaria reflexa, M. nervosa, P. alatus, and Lasmigona complanta all reported mortalities greater than 5%. However, it must be noted that only one individual was found of L. complanata. Only six individuals of Q. pustulosa were found in the transect samples and only five individuals of Q. reflexa were found in the timed dives. Fusconaia ebena, F. flava, and Q. nodulata reported mortalities in both the transect and timed dive samples which would be considered high.

Disscussion

Fusconaia flava had not been collected in the Tennessee River prior to impoundment (Ecological Consultants, 1981). Those authors first reported collecting F. flava in 1967,

and reported steadily increasing numbers for the species in 1981. This species was considered one of three dominant overbank species in the New Johnsonville area (TRM 85-105), along with Q. quadrula and A. plicata. In 1985, Bates and Dennis reported five dominant species in Kentucky Lake, F. flava, F. ebena, Q. quadrula, A. plicata, and M. nervosa.

Goodrich (1939) did not report F. ebena from the New Johnsonville area prior to impoundment. Bates (1958) reported F. ebena from the channel at New Johnsonville, but did not report the species from the overbank. Yokely (1972, in Ecological Consultants, 1981) reports F. ebena comprising 32.5% of the sampling in the New Johnsonville area. Ecological Consultants (1987) later reported F. ebena representing 45% of the sample from the New Johnsonville area in 1986-87.

Quadrula nodulata was also not reported as a member of the overbank community in the New Johnsonville area until 1972 (Yokely, in Ecological Consultants, 1981). Yokely reported Q. nodulata representing 1.4% of the community. Ecological Consultants, Inc. (1981) reported Q. nodulata representing 5.8% and 9.2% of the community at TRM 89 and 91, respectively. In 1987 Ecological Consultants reports Q. nodulata representing 1.8% of the commercial mussel species from the New Johnsonville area.

Each of these species, F. ebena, F. flava, and Q. nodulata, are relatively new members to the overbank community in the New Johnsonville area and could be in varying stages of population stabilization. Charactoristically, population levels of colonizing species boom and bust until a relatively stable population is attained (Fig. 17). Nicholson (1954 in Odum, 1959) described this type of population curve as a 'density triggered' pattern. It is interesting to note that the three areas identified here yielded among the highest densities sampled (Table 3). Further, F. ebena, F. flava, and Q. nodulata are commercially harvested species, and harvest itself may have or had an inpact on stabilization. This population stabilization pattern is generally associated with a relatively stable environment; the extent to which this pattern may be reflective of an extremely dynamic system such as Kentucky Lake Reservoir is unknown.

Although, population stabilization may be a factor in periodic die-offs, instances of locally increased mortality in the lower Tennessee River and elsewhere in middle and eastern North America are largely unexplained. Confounding factors include: (1) relatively recent colonization of the overbank, (2) population and potential reproductive shifts resulting from commercial harvest and (3) seasonally dynamic flow, dissolved oxygen, and high temperture.

Mussel Surveys

On June 2, 1989, line transect sampling was conducted in the White's Lake Light area (TRM 209.6) of Pickwick Reservoir. A total of 57 mussels, representing ten species, were collected, with all but three being live (Fig. 18). Quadrula quadrula, Q. nodulata, and Ellipsaria lineolata each had one mussel considered fresh dead (Fig. 19). Fresh dead mussels comprised 5% of the sample and all three transects yielded a density of 1.34 mussels per square meter (Table 3).

Transect sampling was also conducted on June 2, 1989 in the Pickwick Dam tailwater area (TRM 200) . A total of 67 mussels were collected with three mussels considered fresh dead (Fig. 20). Fresh dead mussels comprised 5% of the sample. The commercially harvested species, Q. metanevra, comprised the largest number of individuals in the sample (Fig. 21). A density of 3.23 mussels per square meter was observed from the transect (Table 3).

On July 10, 1989, transect sampling was conducted in the Shirley Light area (TRM 90.0, 91.0). Of 137 mussels

and shells collected, 9 were relics and 128 were live mussels (Fig. 22). No dead mussels were observed. Nine species comprised the sample, with Q. quadrula the dominant species by number (Fig. 23). The three transects conducted at each site revealed a density of 3.99 and 0.69 mussels per square meter, respectively (Table 3). The sample from TRM 90.0 yielded the highest density of all sites.

On August 9, 1989, timed dives and line transect were conducted in the Greenbottom Light area (TRM 88.9). One 15 minute timed dive yielded 158 mussels and shells, with eight mussels considered fresh dead. Line transect sampling yielded 102 mussels and shells, with eight mussels considered fresh dead. In the combined samples, 204 of the 260 mussels collected were live mussels (Fig. 24). The timed dive yielded twelve species, while in the line transect sample only eight species were found (Fig. 25). Fusconaia ebena was the dominant species by number in both samples. Only F. ebena and F. flava produced dead mussels. The line transect dive reported 2.7 mussels per square meter (Table 3). Because the amount of area sampled during a timed dive is unknown, density estimates cannot be ascertained. Fresh dead mussels contributed 6% of the combined sample. Fresh dead mussels and relic shells combined comprised 22% Of the total sample.

On August 15, 1989, line transect sampling was conducted in the Piney Campground area (TRM 65.0). Of the 122 mussels and shells collected, no fresh dead shells were found, and only 5 relics reported (Fig. 26). Of the 112 commercially sought mussels, only 14 individuals were of legal harvestable size. Nine mussel species were identified, and four individuals of an unidentified species were noted. A. plicata and Q. quadrula, were the dominant species by number from the sampling (Fig. 27). A density of 0.95 mussels per square meter was observed in the area sampled (Table 3).

The density of all sampling can be found in Table 2. The Shirley Light area, Greenbottom Light area, and the Harmon Creek area provided the highest density of all areas sampled.

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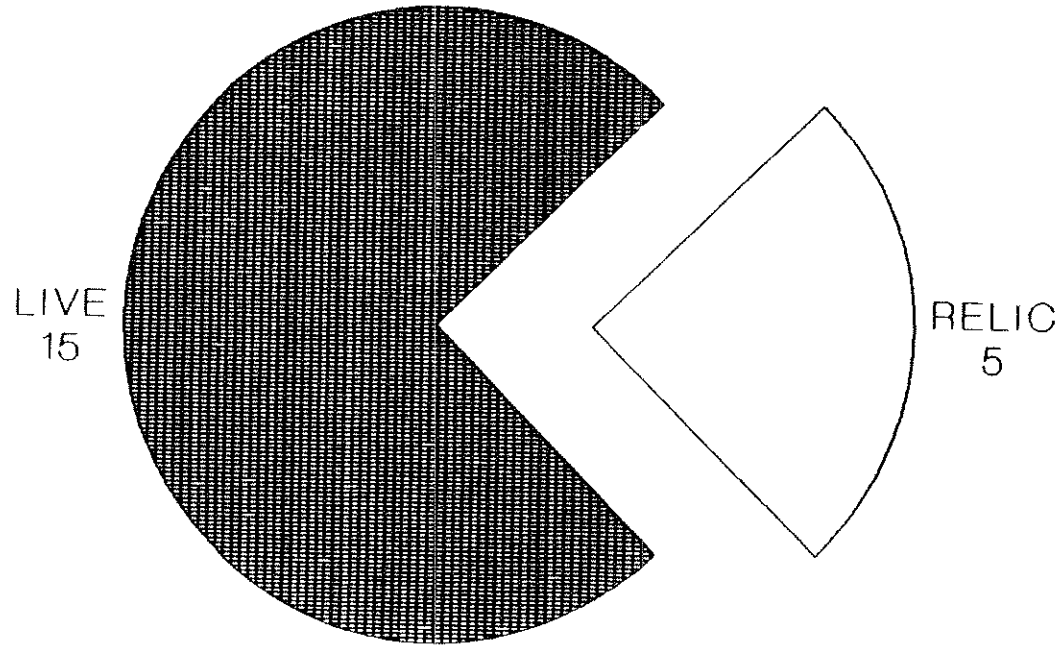
Table 1. Investigations Conducted during 1989

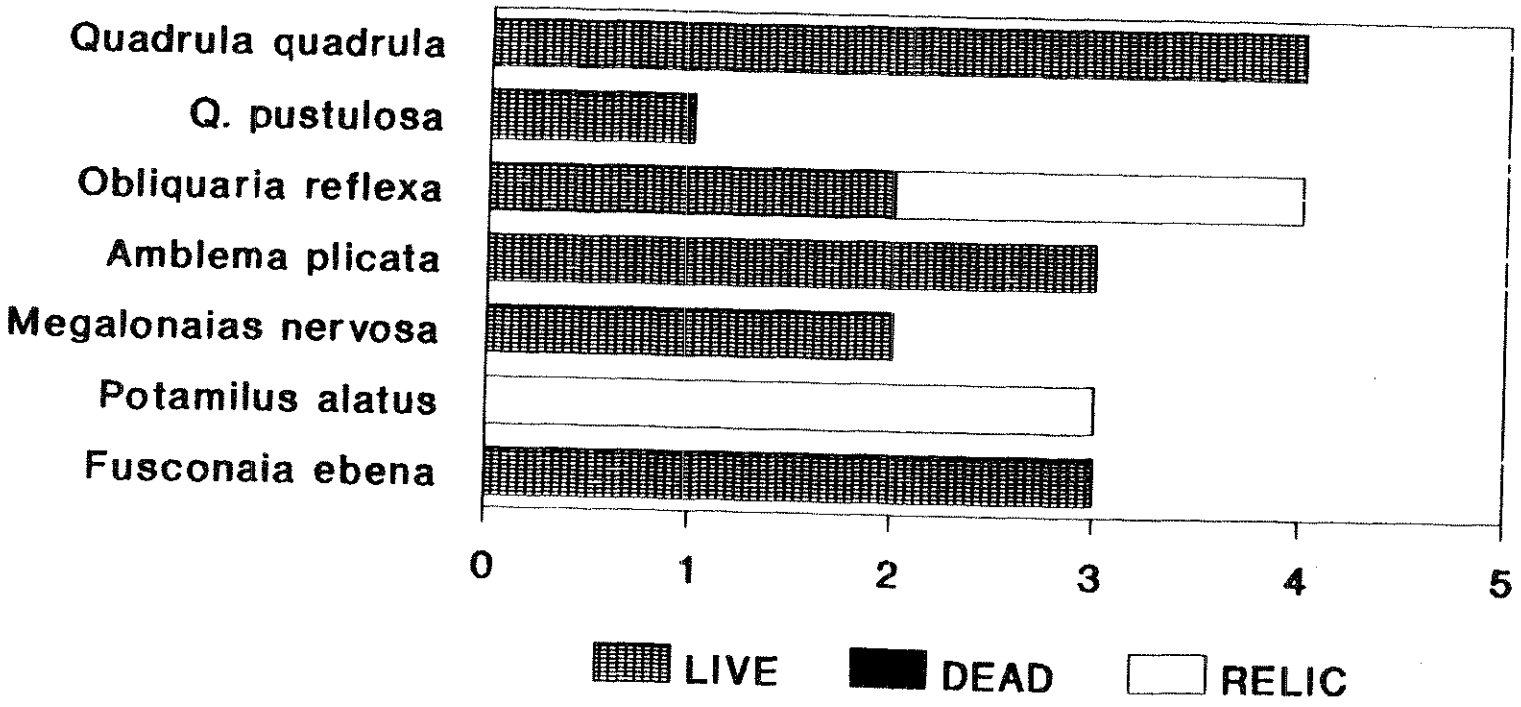
DATE	LOCATION	TRM
June 02, 1989	White's Lake Light	209.6
June 02, 1989	Pickwick Tailwater	200.0
July 10,1989	Shirley Light	90.0, 91.0
July 12, 1989	McCallie's Light	109.3
July 12, 1989	Rockport Landing	107.3, 106.2, 106.0
July 12, 1989	Birdsong	104.9
July 21, 1989	Eva Beach	98.5
August 09, 1989	Greenbottom Light	88.9
August 15, 1989	Piney Campground	65.0
September 24, 1989	Shirley Light	90.5, 90.9
September 24, 1989	Greenbottom Light	88.9
September 25, 1989	Harmon Creek	Left Bank

Fig. 1 Summary of Live, Dead and Relic Shells from the McCallies Light Area, TRM 109.3, Red Bank, July 1989



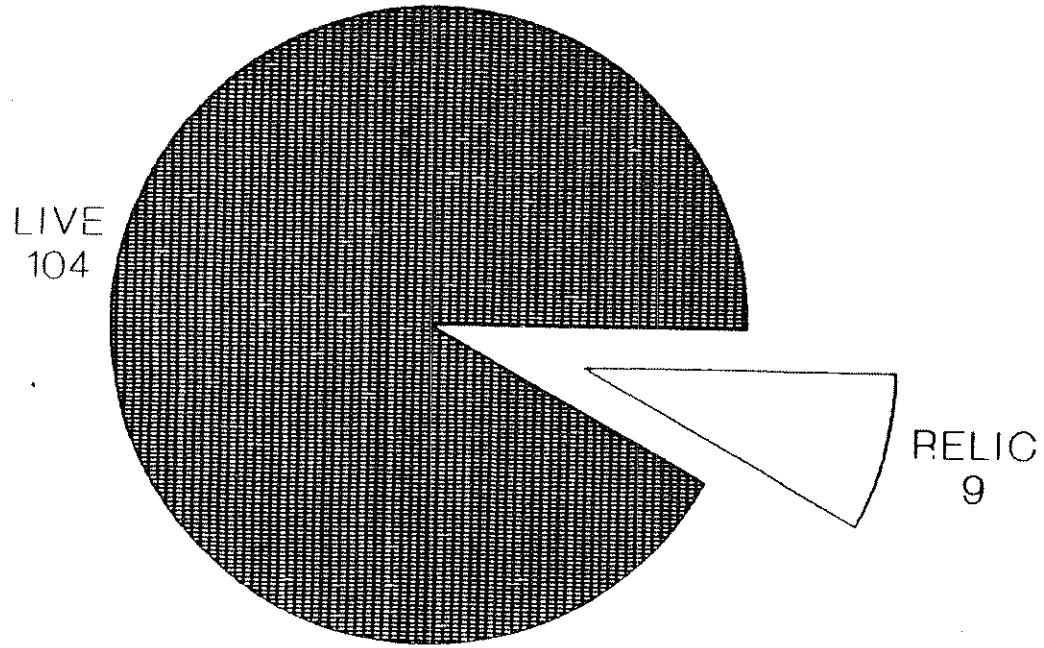
N = 20 7 Species Observed
(NO Fresh Dead Shells Observed)

Fig. 2. Mussel Status by Species from the McCallies Light Area, TRM 109.3, Red Bank, July 1989



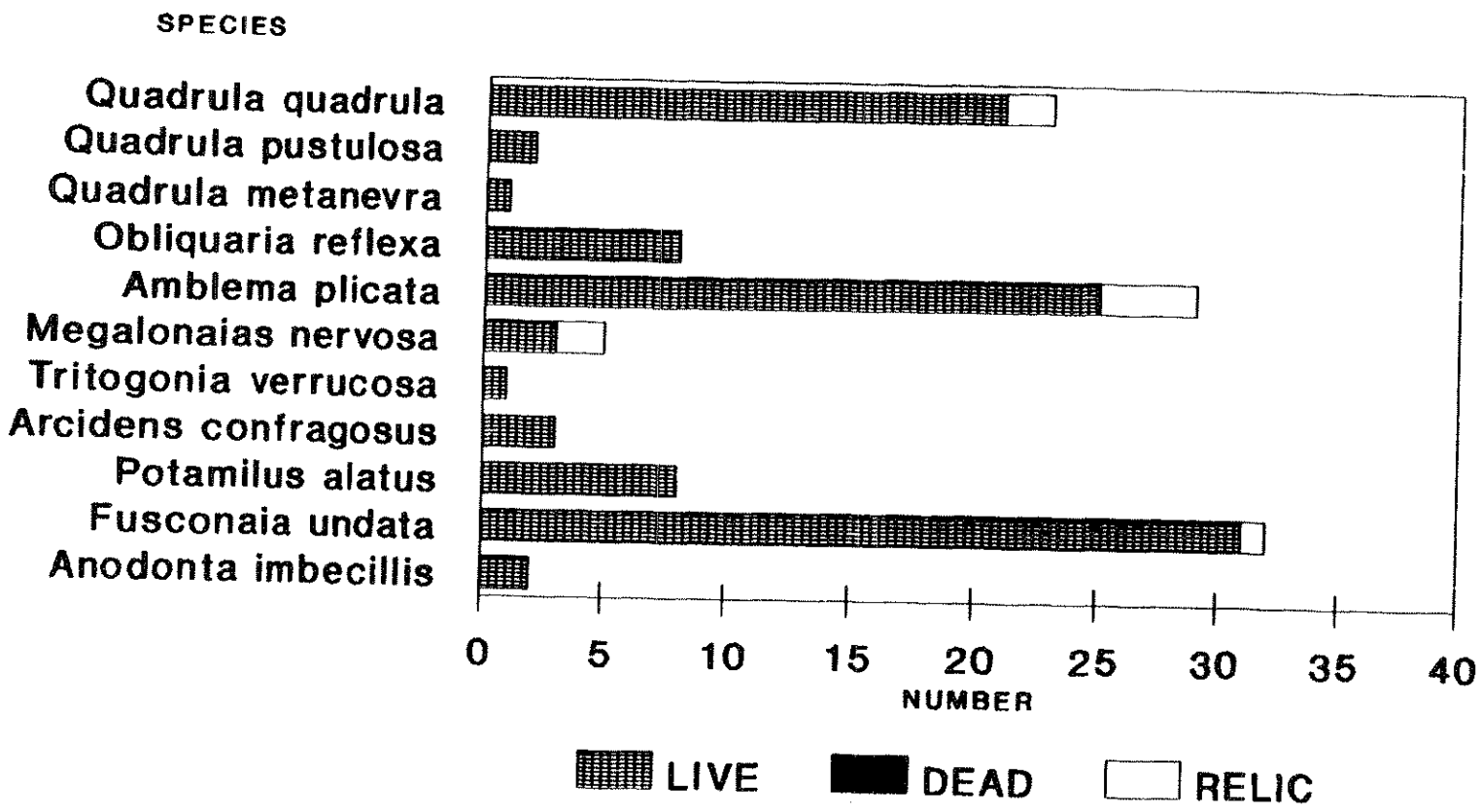
N = 20 7 Species Observed
(No Fresh Dead Shells Observed)

Fig. 3. Summary of Live, Dead, and Relic Shells from Rockport Landing Light Area, Kentucky Lake, TRM 106, 106.2, 107.3



N = 113
(No Fresh Dead Shells Observed)

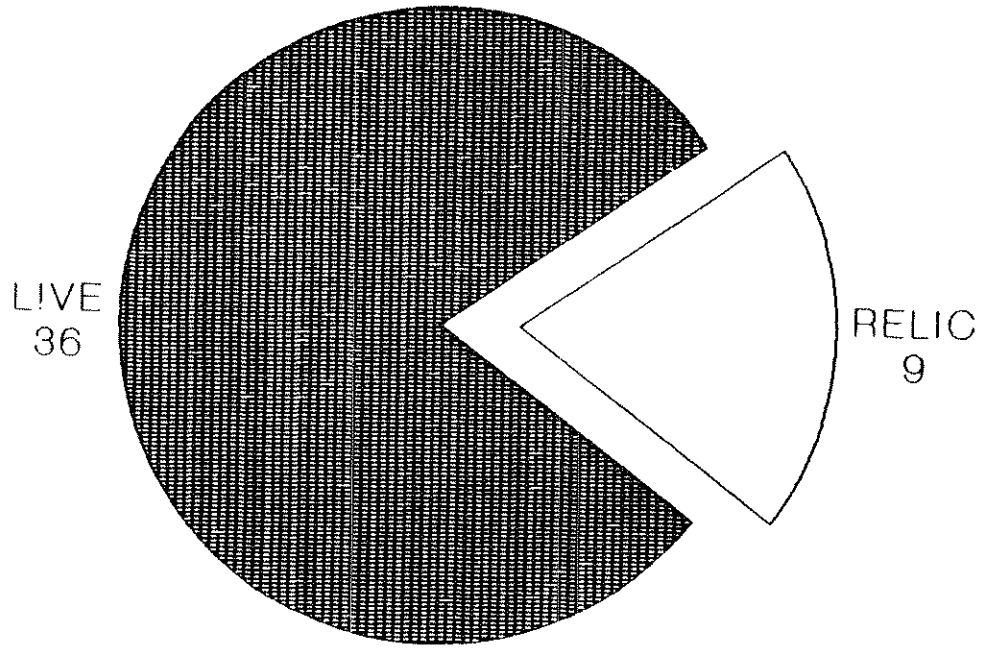
Fig 4. Mussel Status by Species from the Rockport Landing Light Area, Kentucky Lake, TRM 106, 106.2, 107.3



N = 113

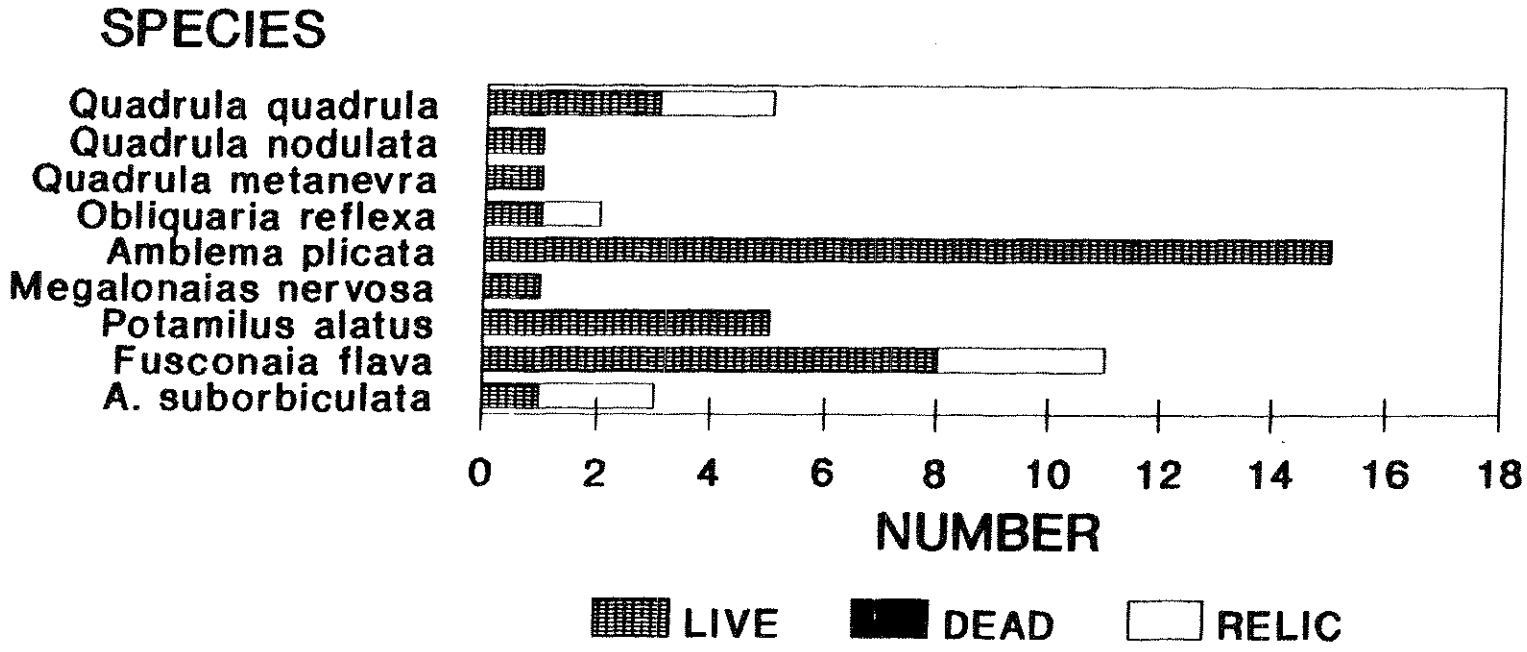
(No Fresh Dead Shells Observed)

Fig. 5. Summary of Live, Dead and Relic Shells from the Birdsong Light Area, Kentucky Lake, TRM 104.9 July 1989



N = 45
10 Species observed
(No Fresh Dead Shells Observed)

Fig. 6. Mussel Status by Species, from the Birdsong Light Area, Kentucky Lake, TRM 104.9, July 1989

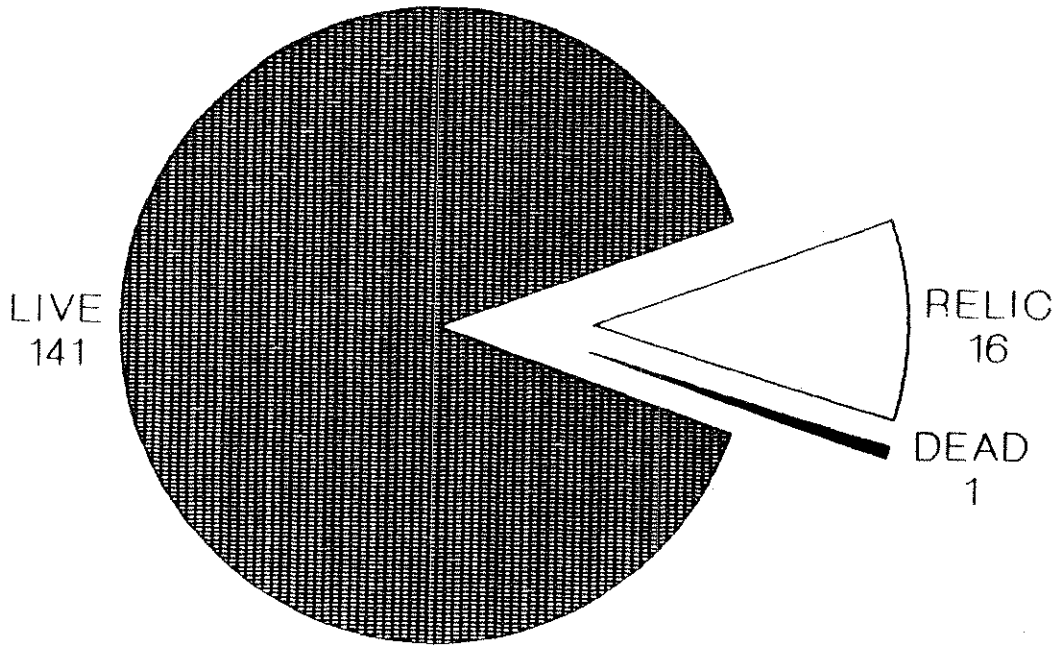


N = 45

10 Species Observed

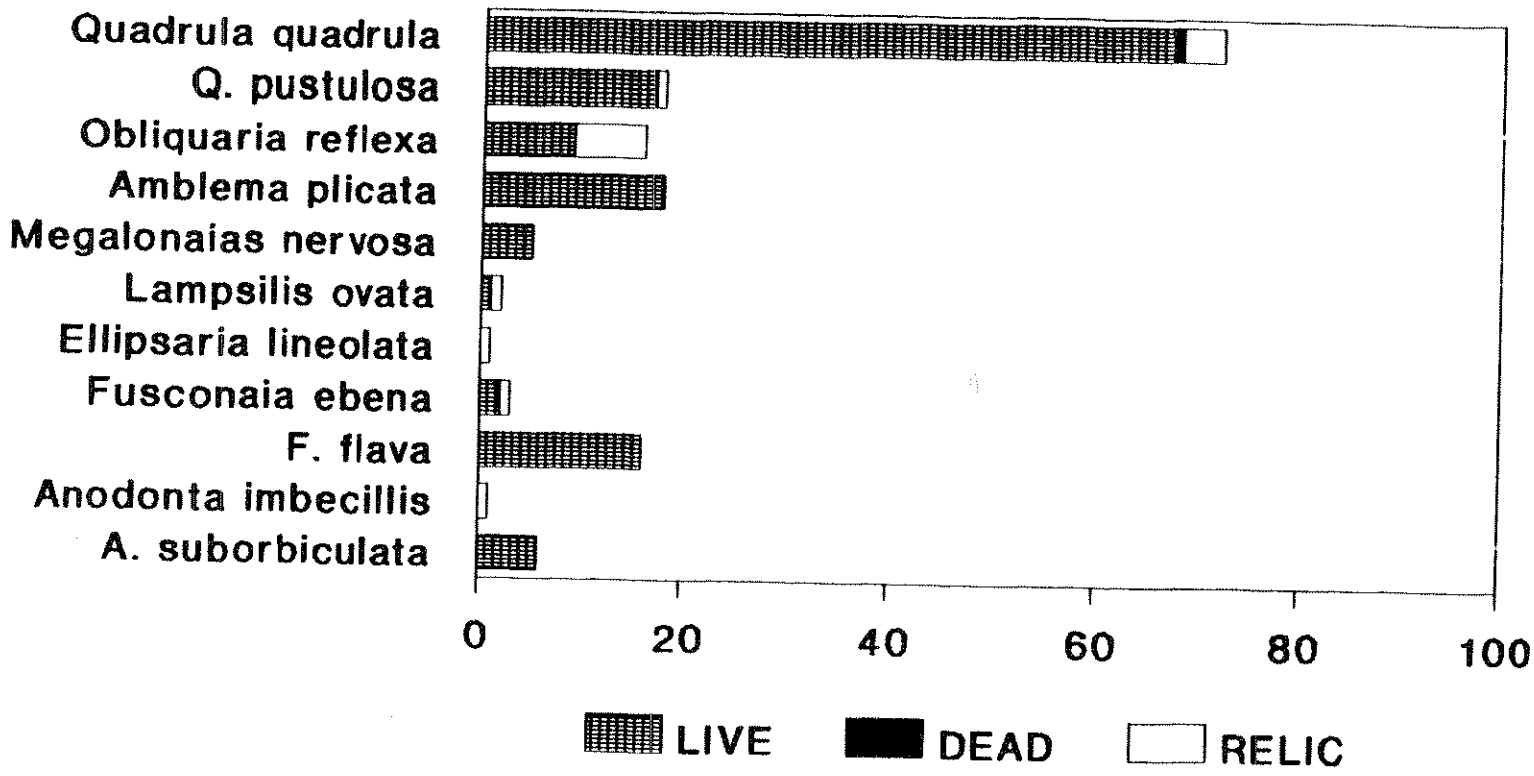
(No Fresh Dead Shells Observed)

Fig. 7. Summary of Live, Dead, and Relic Shells from the Eva Beach Area, Kentucky Lake, TRM 98.5, July 1989



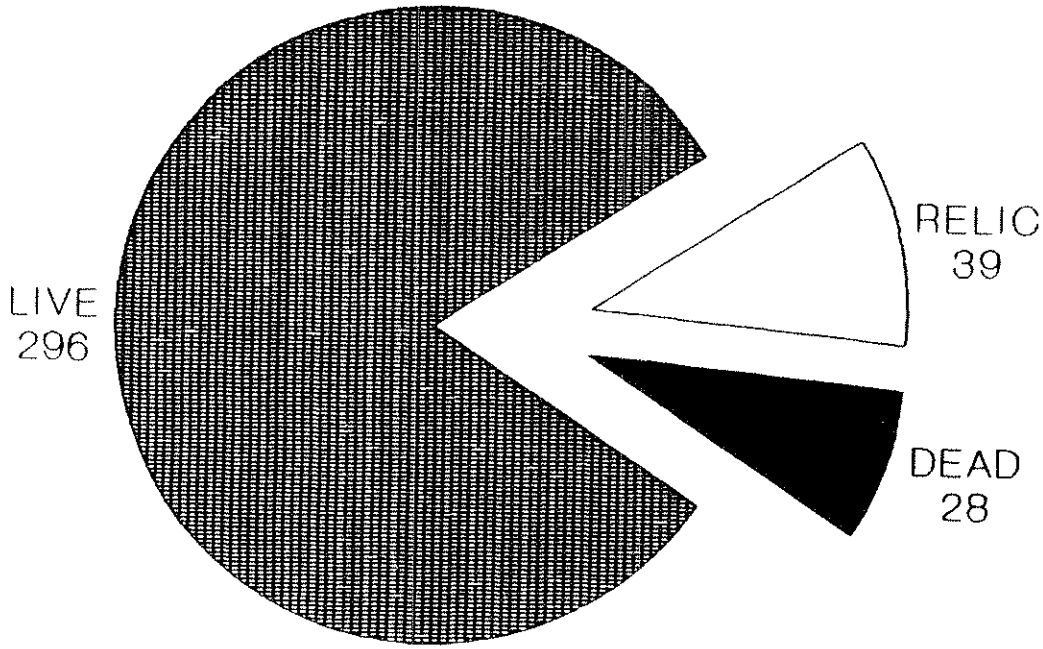
N = 158 11 Species Observed

Fig. 8. Mussel Status By Species from the Eva Beach Area, Kentucky Lake, TRM 98.5, July 1989



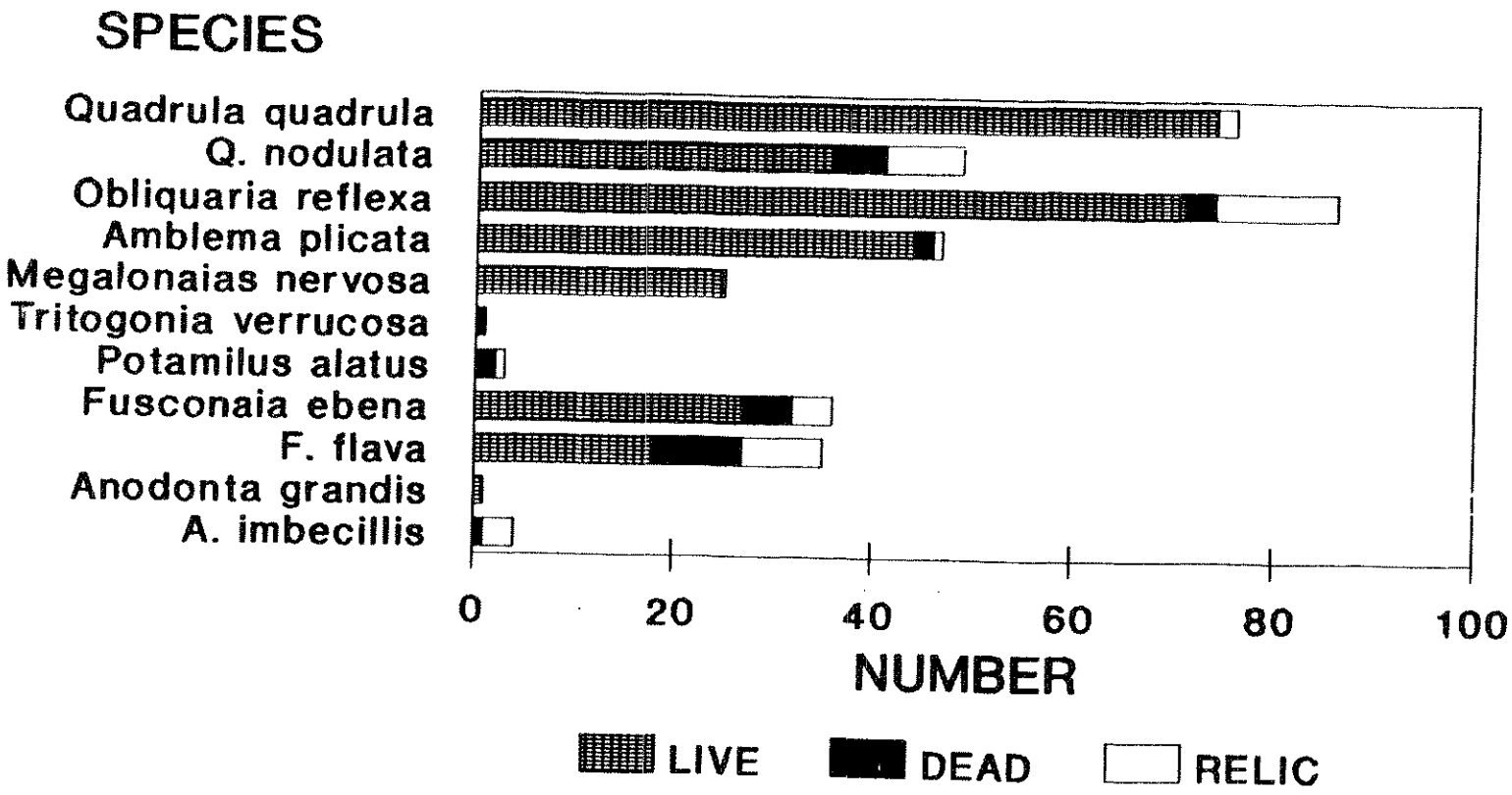
N = 158 11 Species Observed

Fig. 9. Summary of Live, Dead and Relic Shells from Shirley Light Area, Kentucky Lake, TRM 90.5, 90.9 September 1989



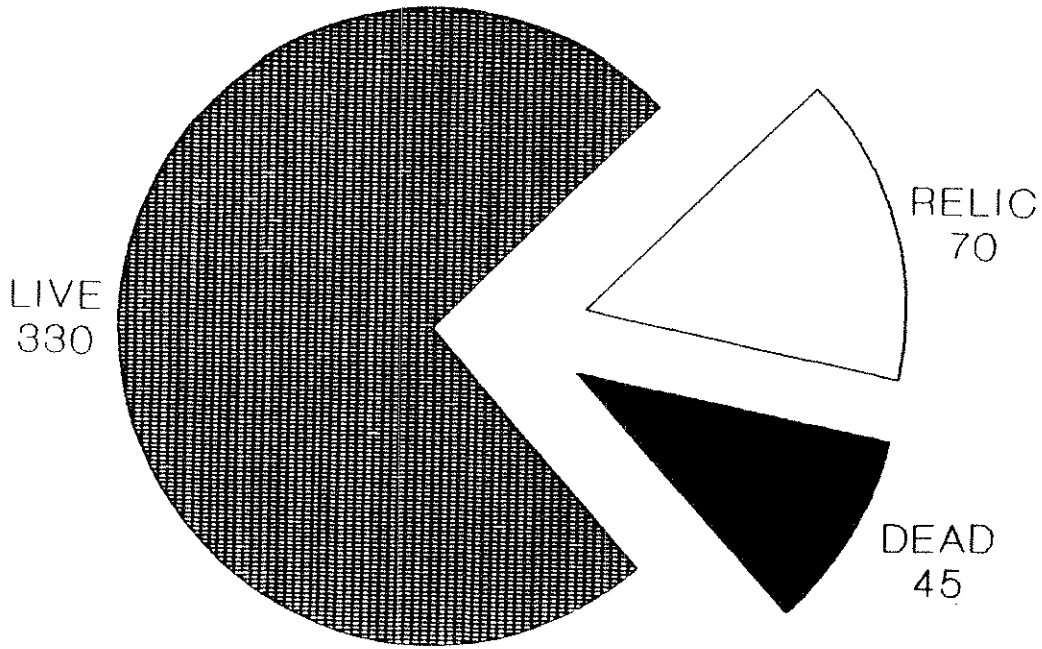
N = 363
11 Species Observed

Fig. 10. Mussel Status by Species from the Shirley Light Area, Kentucky Lake, TRM 90.5, 90.9, September 1989



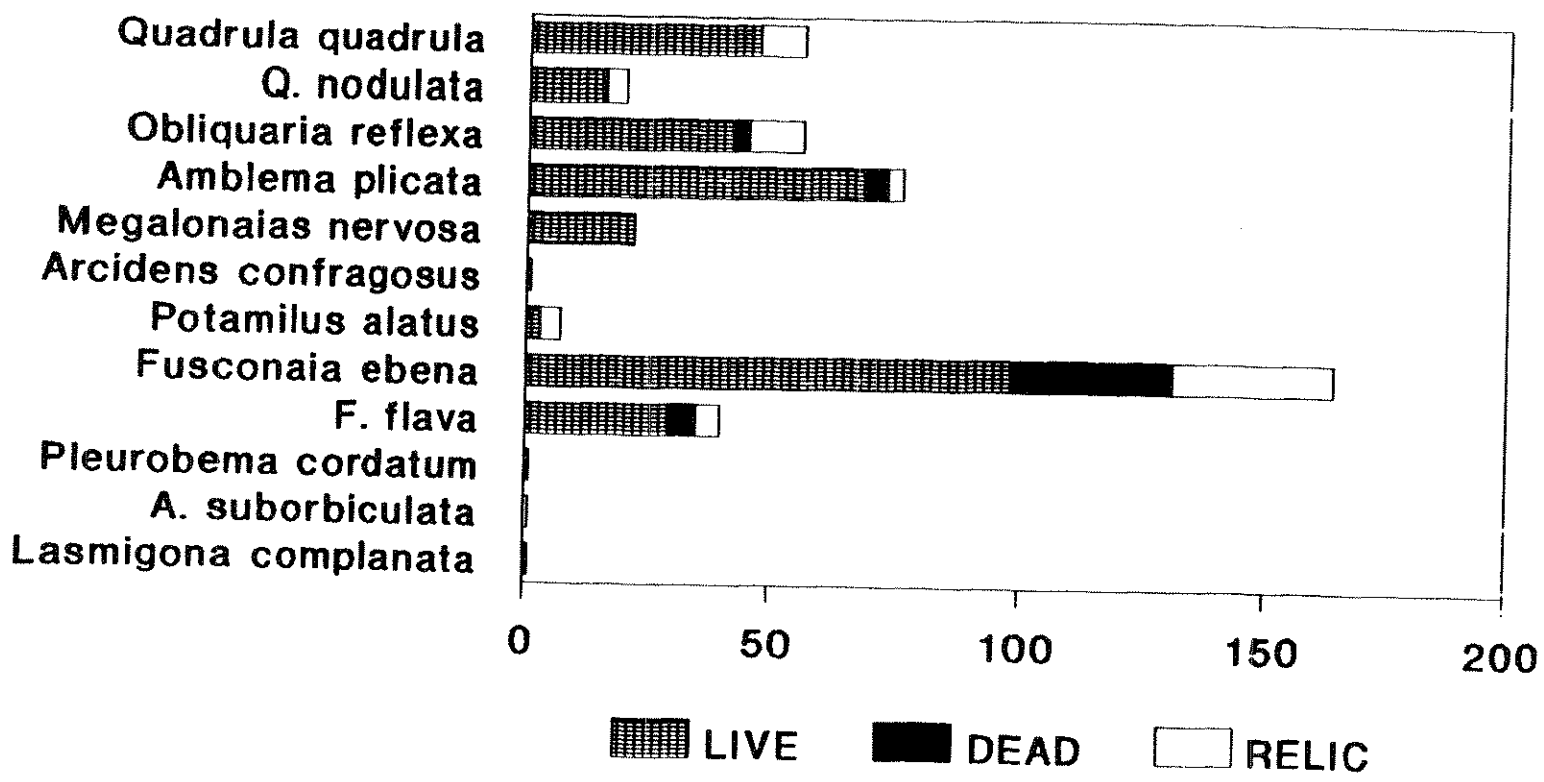
N = 363
11 Species Observed

Fig. 11. Summary of Live, Dead and Relic Shells from the Greenbottom Light Area, Kentucky Lake, TRM 88.9, September 1989



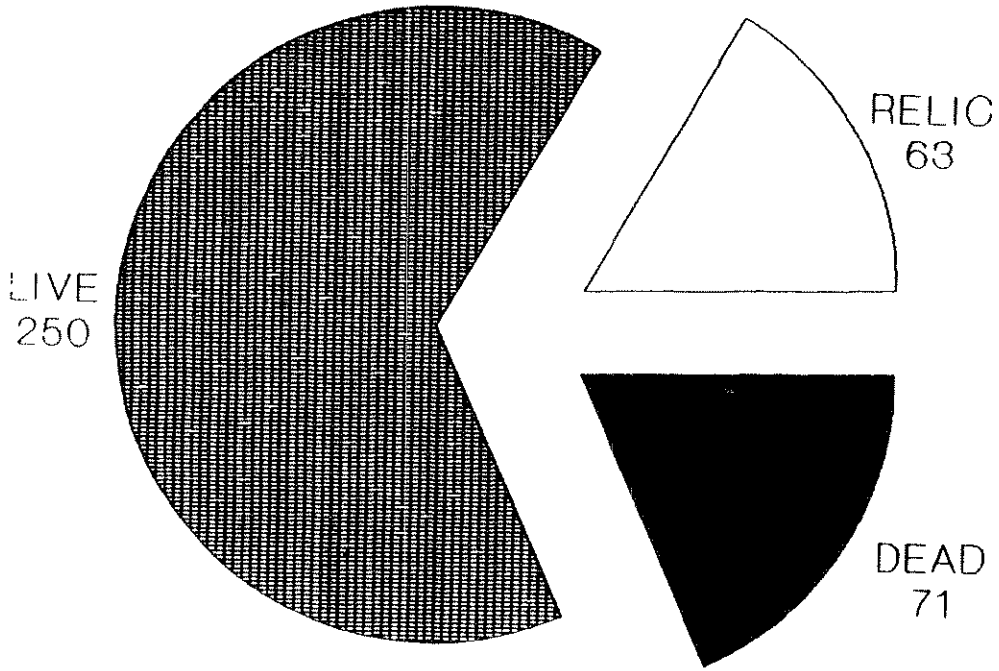
N = 445 12 Species Observed

Fig. 12. Mussel Status by Species from the Greenbottom Light Area, Kentucky Lake TRM 88.9, September 1989



N = 445 12 Species Observed

Fig. 13. Summary of Live, Dead and Relic Shells from the Harmon Creek area, as Reflected by Transects, September 1989



N = 384
12 Species Observed

Fig. 14. Mussel Status by Species from the Harmon Creek area, as Reflected by Transects, September 1989

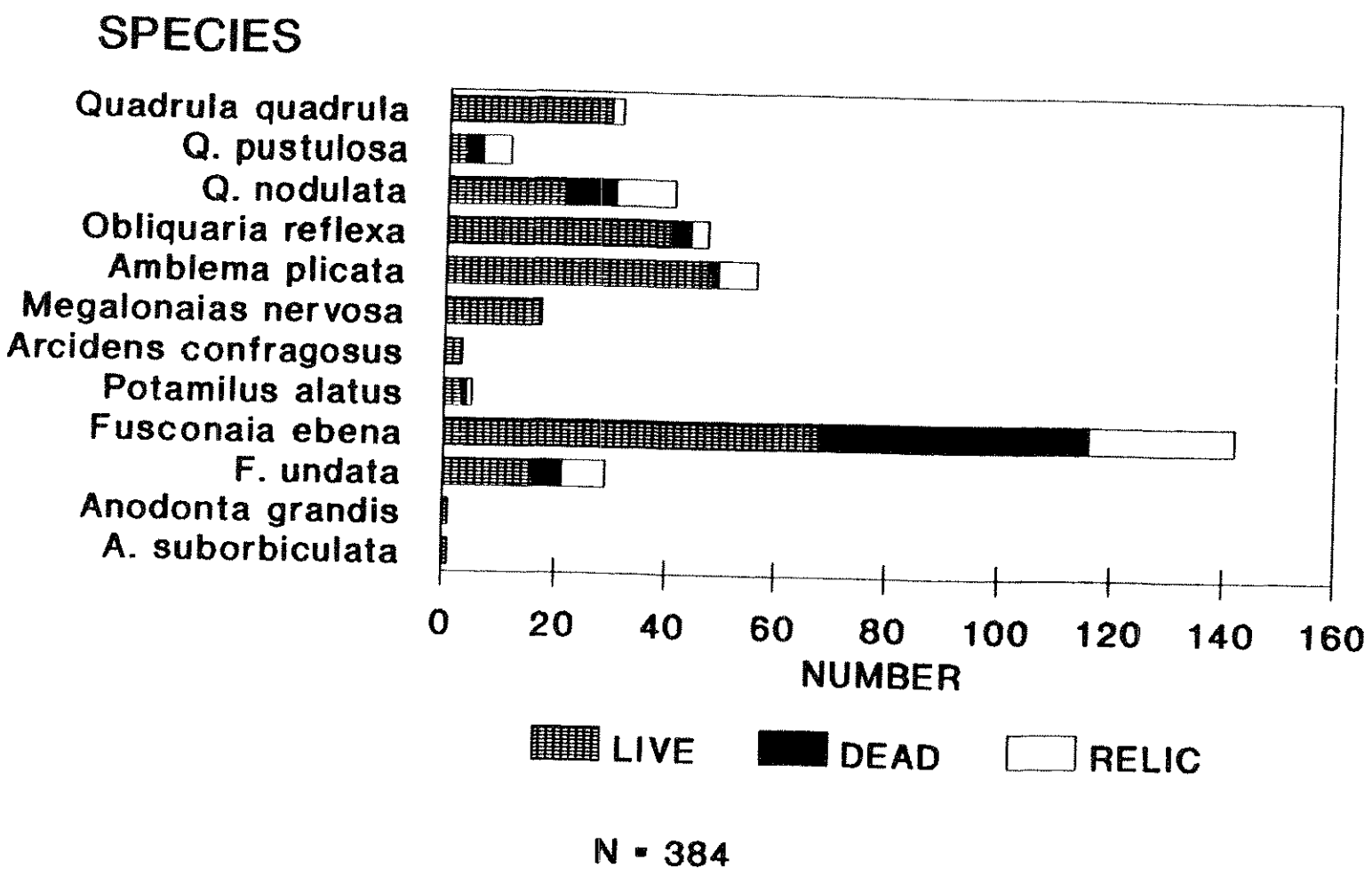
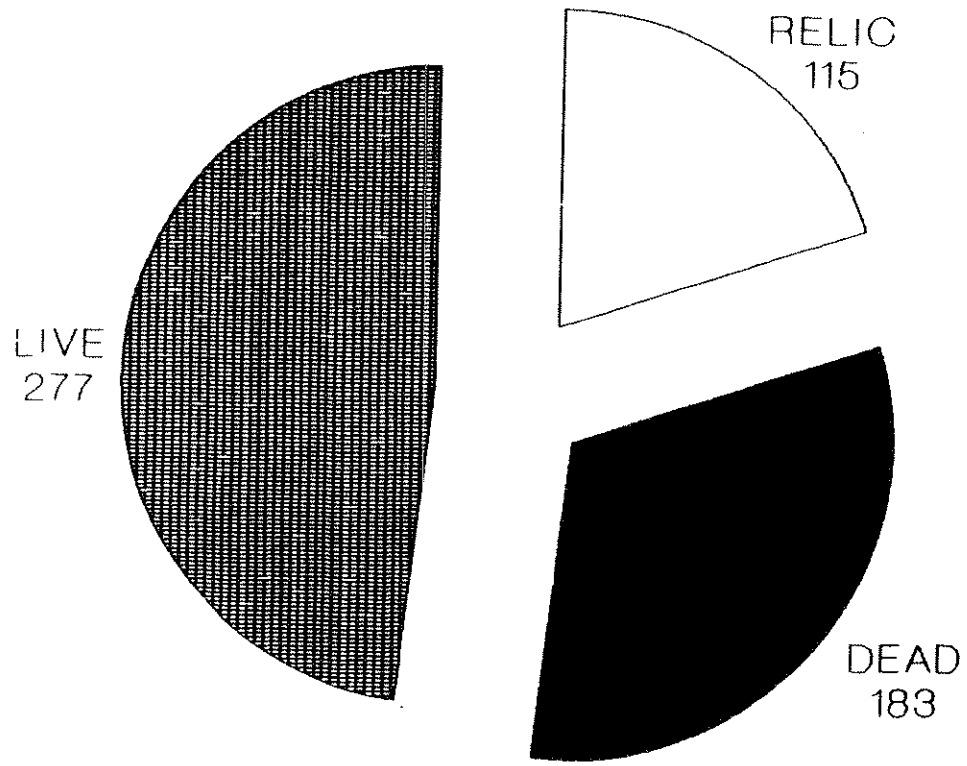


Fig. 15. Summary of Live, Dead and Relic Shells from the Harmon Creek Area as Reflected by 15 Minute Time Dives, 9/89



N = 575
12 Species Observed

Fig. 16. Mussel Status by Species from the Harmon Creek Area, as Reflected by 15 Minute Time Dives, September 1989

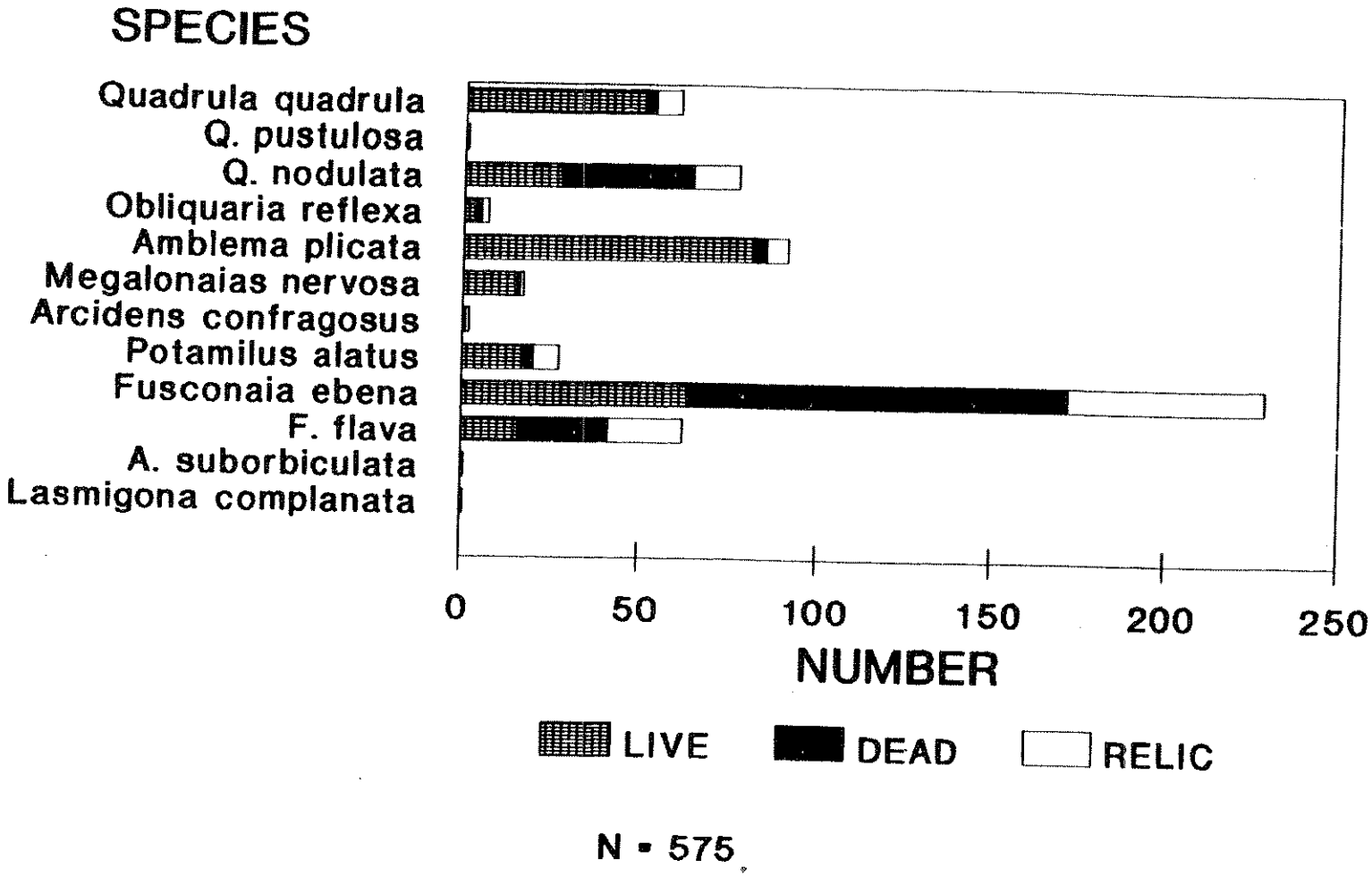


Table 2. Species composition and condition of mussels from three locations in Kentucky Lake Reservoir.

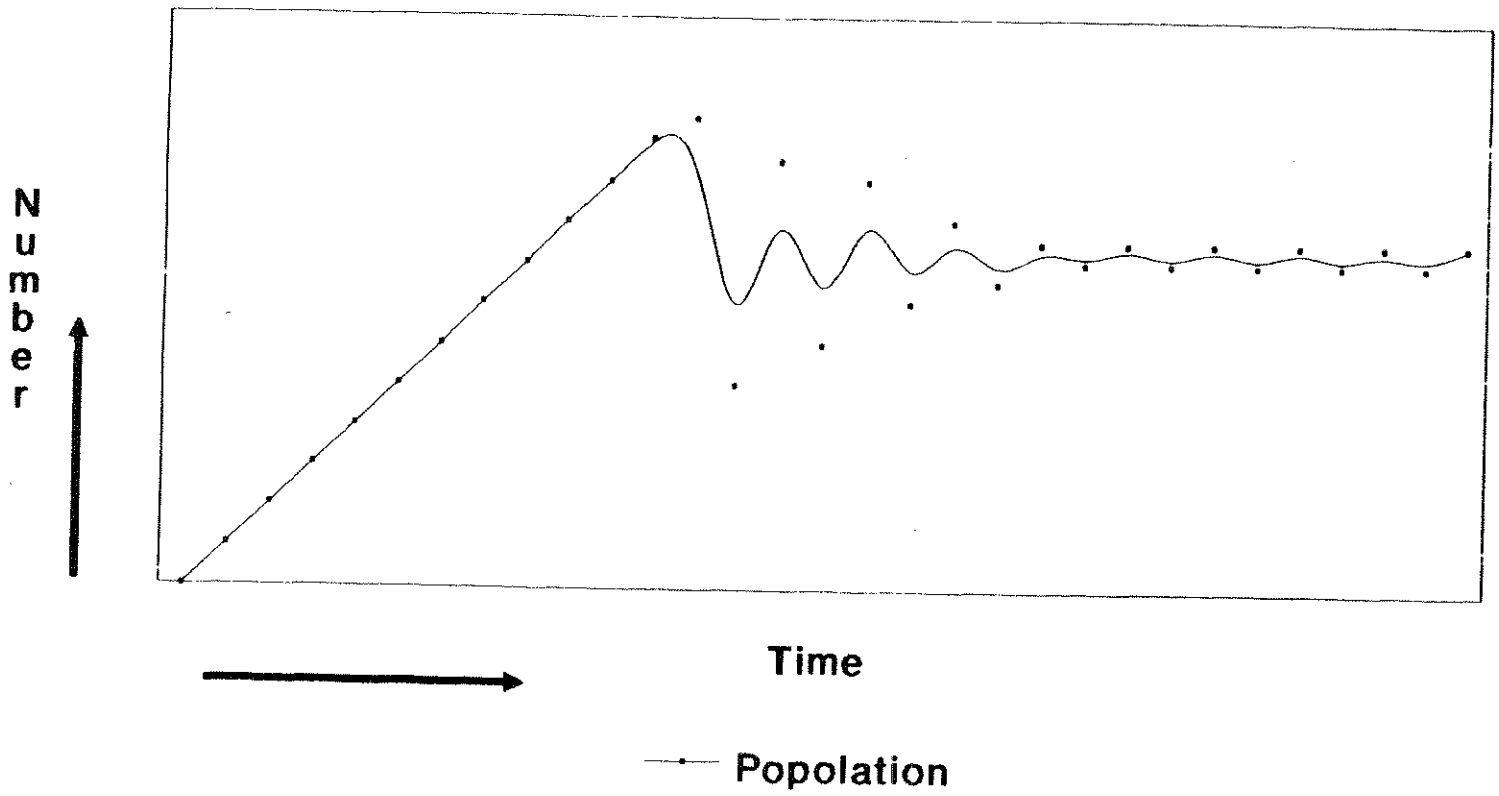
Location River Mile Date	Greenbottom Light TRM 88.9 September 24, 1989			Shirley Light TRM 90.5, 90.9 September 24, 1989			Harmon Creek Left Bank September 25, 1989 (Transect)			Harmon Creek Left Bank September 25, 1989 (Time Dive)		
SPECIES	n(%N)	LIVE(%n)	DEAD(%n)	n(%N)	LIVE(%n)	DEAD(%n)	n(%N)	LIVE(%n)	DEAD(%n)	n(%N)	LIVE(%n)	DEAD(%n)
Quadrula quadrula	47(13.4)	47(100)	-	74(22.8)	74(100)	-	29(9.0)	29(100)	-	53(11.5)	51(96.2)	2(3.8)
Q.pustulosa	-	-	-	-	-	-	6(0.9)	3(50)	3(50)	1(0.2)	1(100)	-
Q.nodulata	16(4.2)	15(93.8)	1(6.2)	41(12.7)	36(87.8)	5(12.2)	30(9.3)	21(70)	9(30)	64(13.9)	27(42.2)	37(57.8)
Obliquaria reflexa	43(12.3)	42(97.7)	1(2.3)	74(22.8)	71(95.9)	3(2.3)	45(14)	41(91.1)	9(8.9)	5(1.1)	3(60)	2(40)
Fusconaia plicata	71(20.3)	69(97.7)	2(2.8)	46(14.2)	44(95.7)	2(4.2)	49(15.2)	48(98)	1(2)	85(18.5)	81(95.3)	4(4.7)
Megalonaias nervosa	22(6.3)	22(100)	-	25(7.7)	25(100)	-	17(5.3)	17(100)	-	16(3.5)	15(93.8)	1(6.2)
Tritogonia verrucosa	-	-	-	1(0.3)	-	1(100)	-	-	-	-	-	-
Acidens confragosus	1(0.3)	1(100)	-	-	-	-	3(0.9)	3(100)	-	1(0.2)	1(100)	-
Lapsilis ovata	-	-	-	-	-	-	-	-	-	-	-	-
Obamilus alta	3(100)	3(100)	-	2(0.6)	-	2(100)	4(1.2)	3(75)	1(25)	20(4.3)	18(90)	2(10)
Fusconaia ebena	113(32.3)	99(87.6)	14(12.4)	32(9.9)	27(84.9)	5(15.6)	116(36)	68(58.6)	48(41.4)	172(37.4)	63(36.7)	109(63.3)
F.flava	32(9.1)	30(93.8)	2(6.2)	27(8.3)	18(66.6)	9(33.4)	21(6.6)	16(76.6)	5(23.8)	41(8.9)	16(39)	25(61)
Anodonta grandis	-	-	-	1(0.3)	1(100)	-	1(0.3)	1(100)	-	-	-	-
A.imbecillis	-	-	-	1(0.3)	-	1(100)	-	-	-	-	-	-
A.suborbiculata	-	-	-	-	-	-	1(0.3)	1(100)	-	1(0.2)	1(100)	-
Lamigona complanata	-	-	-	-	-	-	-	-	-	1(0.2)	-	1(100)
N(%N)	349	331(94.8)	18(5.2)	324	296(91.4)	28(8.6)	322	251(78)	71(22)	460	277(60.2)	183(39.8)

Table 3. Density of Mussels at all Sites Sampled During 1989

Location	(TRM) DENSITY*
White's Lake Light area	(209.6) 1.34
Pickwick Tailwater	(200.0) 3.23
Shirley Light area	(90.5) 2.06 (90.9) 0.43
	(90.0) 3.99 (91.0) 0.69
McCallies Light area	(109.3) 0.38
Birdsong Light area	(104.9) 0.29
Rockport Landing Light	(106.2) 0.76
Eva Beach	(98.5) 0.76
Piney Campground area	(62.2) .95
Greenbottom Light area	(88.9) 3.6 (88.9) 2.7
Harmon Creek	Left Bank 2.11

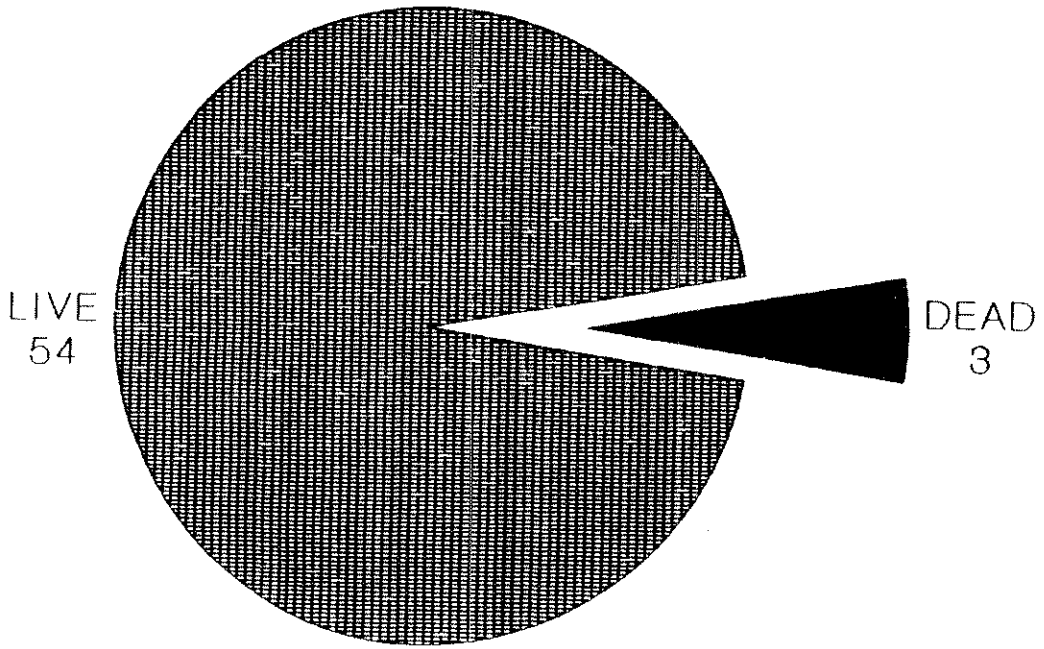
*Density given as mussels per square meter

Fig. 17. Population Fluxuations Associated with Colonization of New Areas



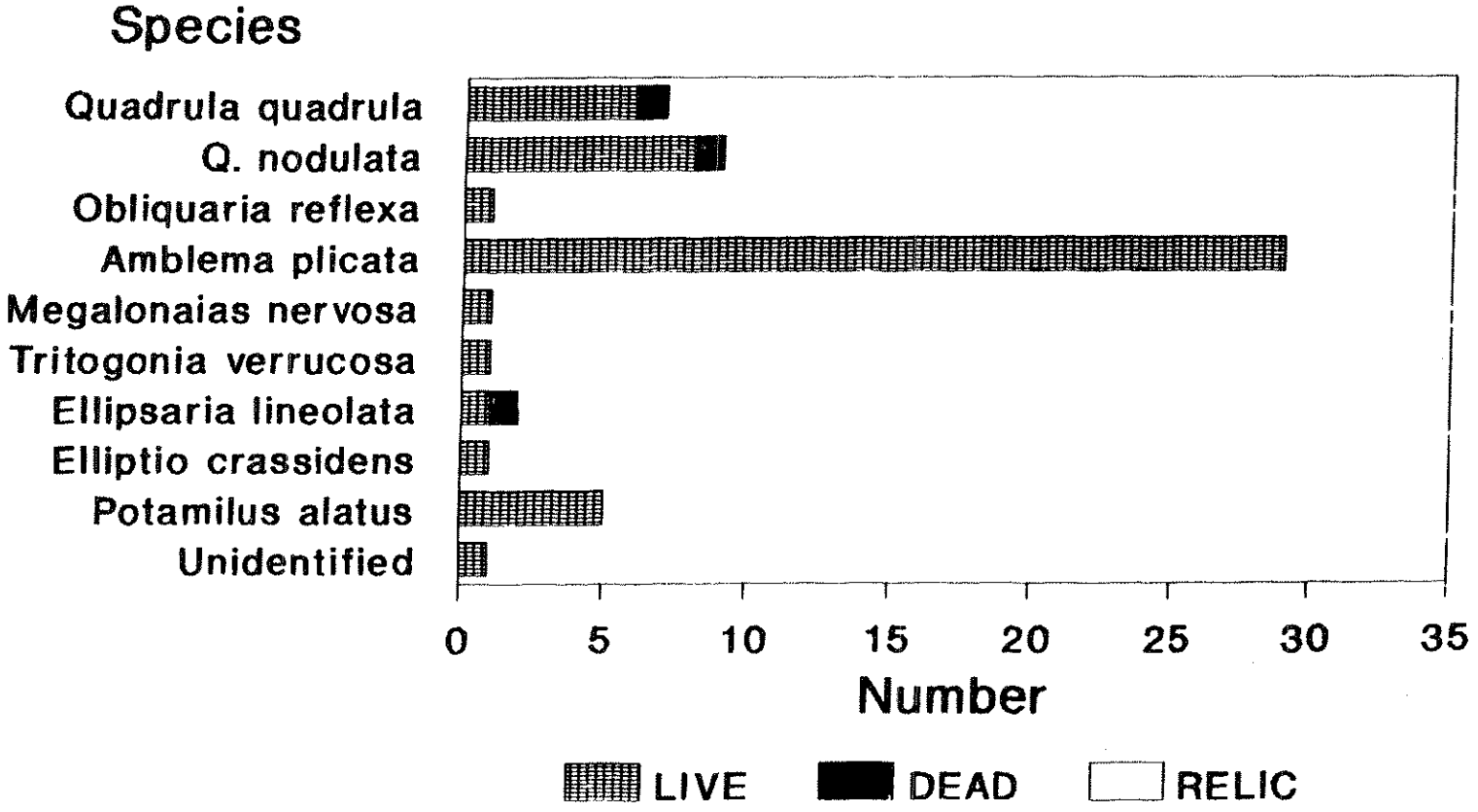
(Adapted from Nicholson, 1954 in Odum, 1959)

Fig.18. Summary of Live, Dead, and Relic Shells From the White's Lake Light Area Pickwick Reservoir, TRM 209.6, June 1989



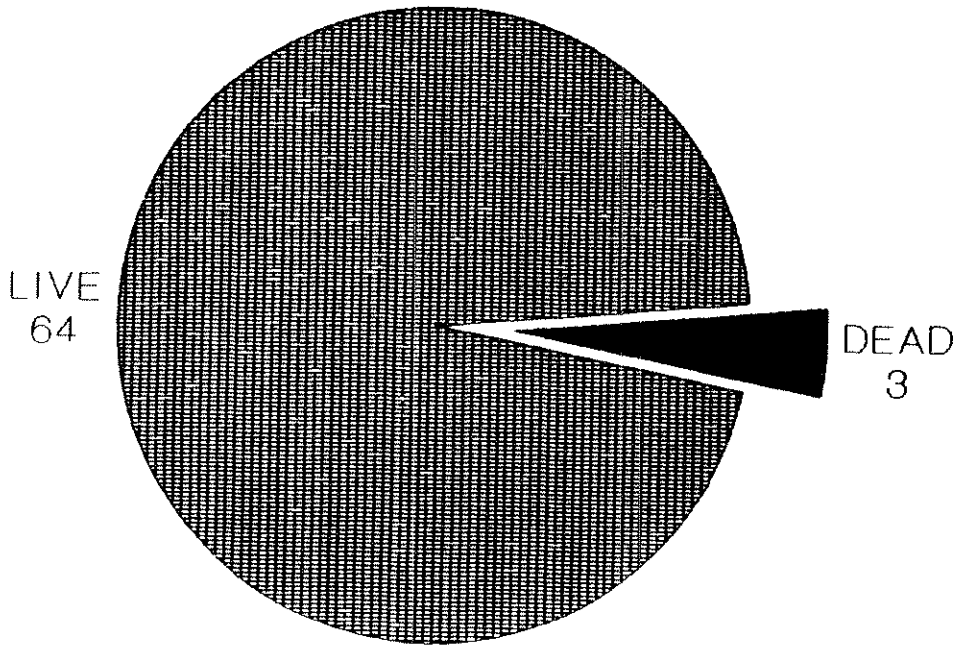
N = 57
10 Species Observed

Fig. 19. Mussel Status by Species from the White's Lake Light Area, Pickwick Reservoir, TRM 209.6, June 1989



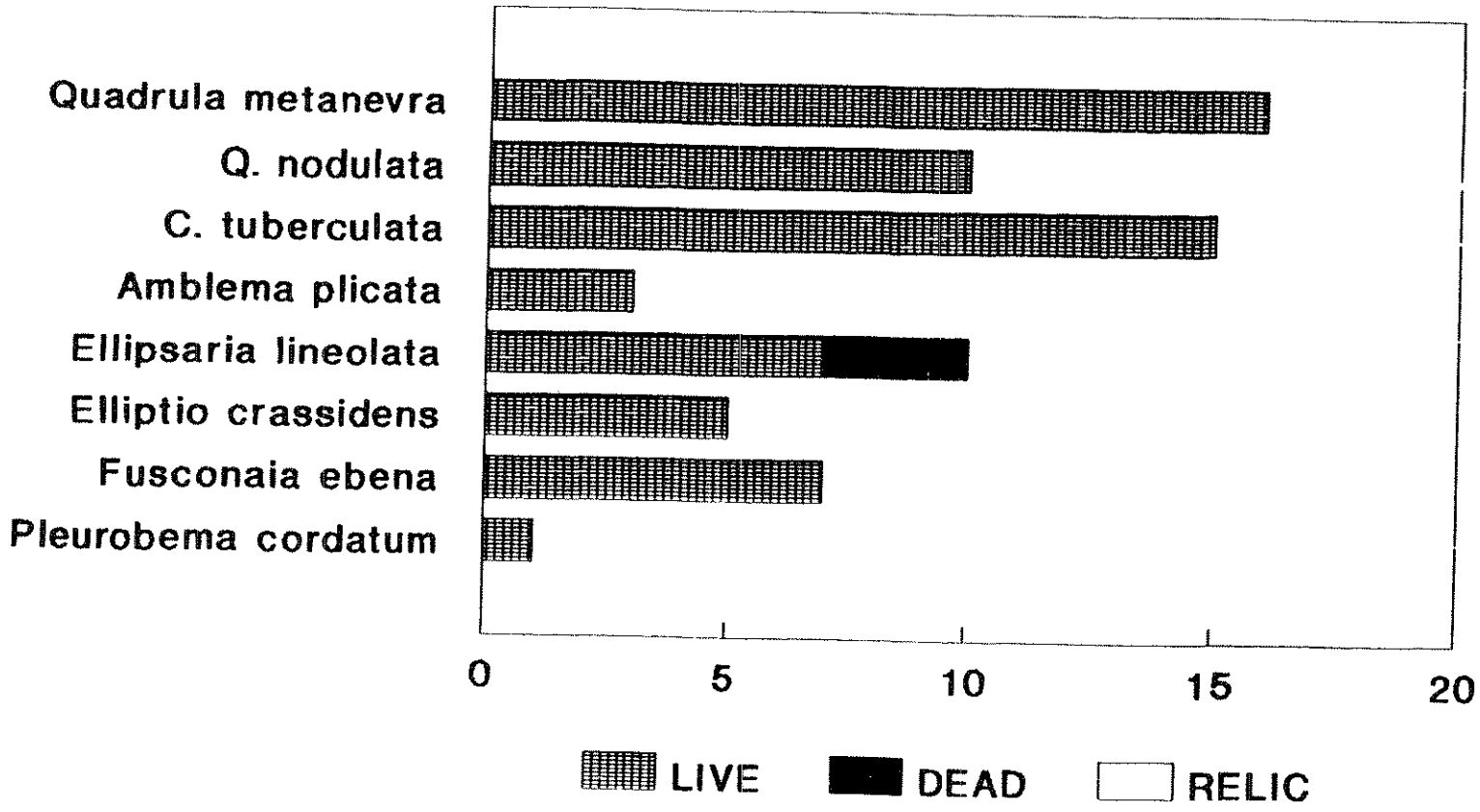
N = 57 10 Species Observed

Fig. 20. Summary of Live, Dead and Relic Shells from the Pickwick Tailwater Area, TRM 200, June 1989



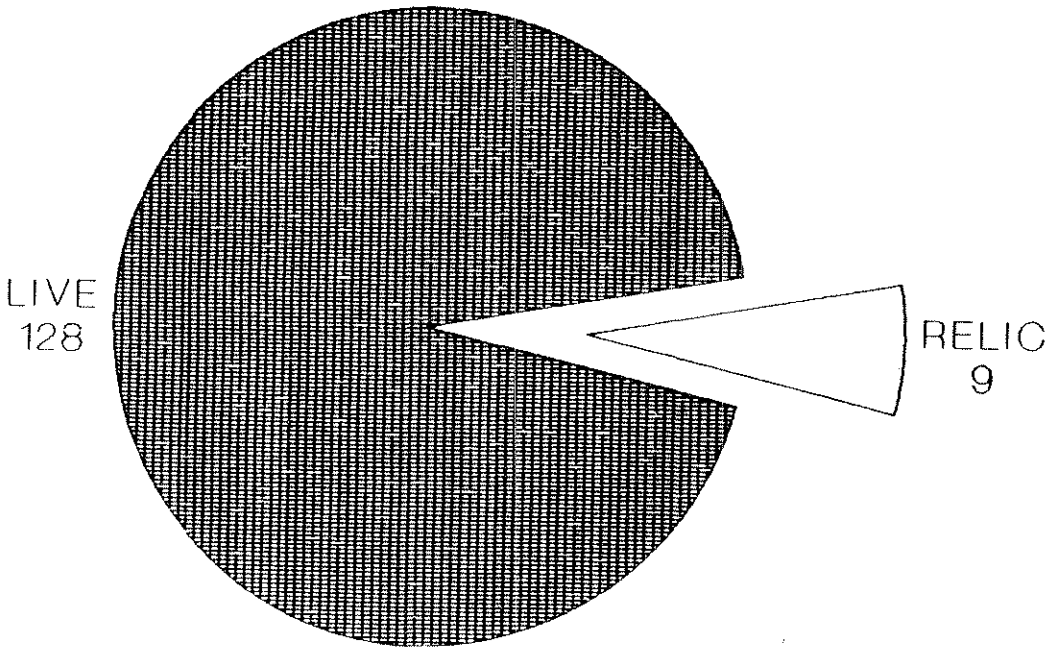
N = 67
8 Species Observed

Fig. 21. Mussel Status by Species from the Pickwick Tailwater Area, TRM 200, June 1989



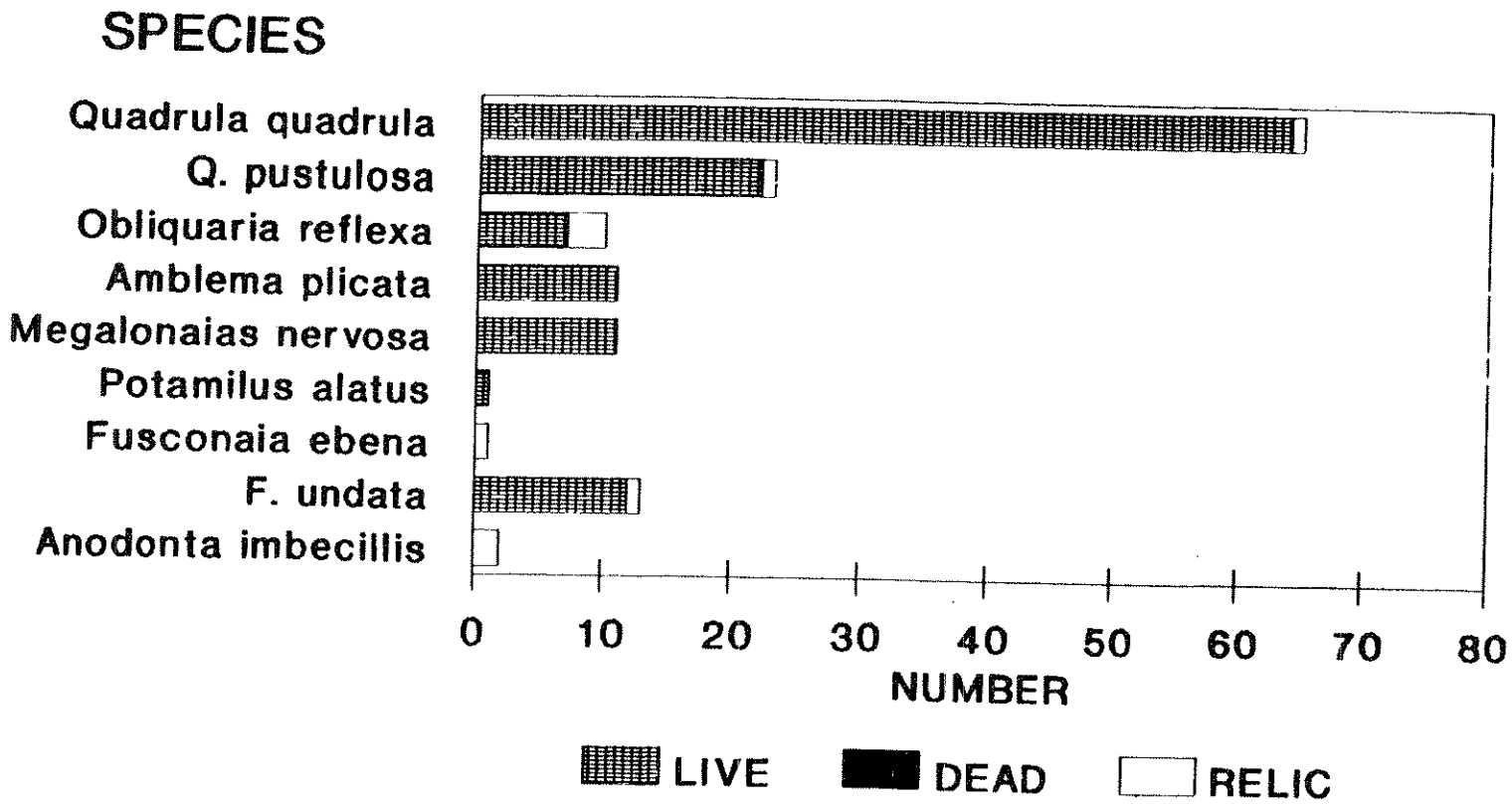
N = 67 8 Species Observed

Fig. 22. Summary of Live, Dead and Relic Shells from Shirley Light area, Kentucky Lake, TRM 90.0, 91.0 July 1989



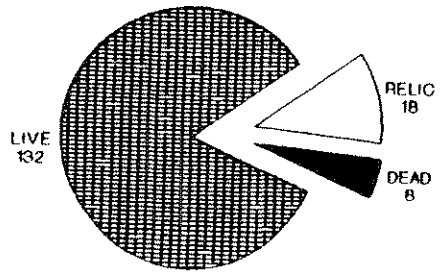
N = 137
(No Fresh Dead Shells Observed)

Fig. 23. Mussel Status by Species from the Shirley Light Area, Kentucky Lake TRM 90.0, 91.0 July 1989



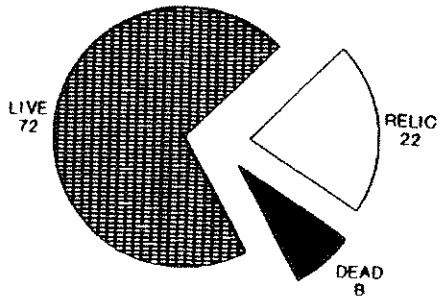
N = 137
(No Fresh Dead Shells Observed)

Fig. 24. Mussel Status from the Greenbottom Light Area, Kentucky Lake, TRM 88.9 August 1989



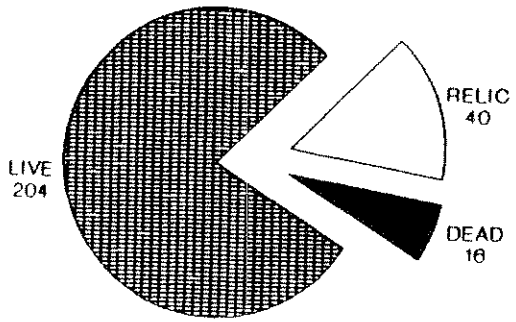
One "15 minute" Timed Dive

N = 158
12 Species Observed



One Transect

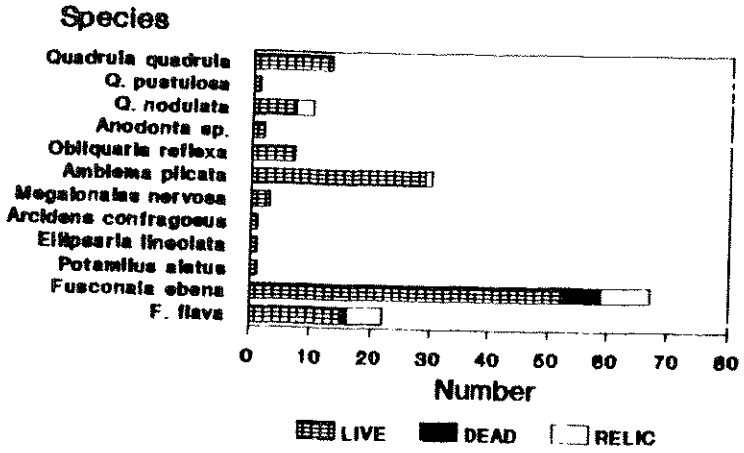
N = 102
8 Species Observed



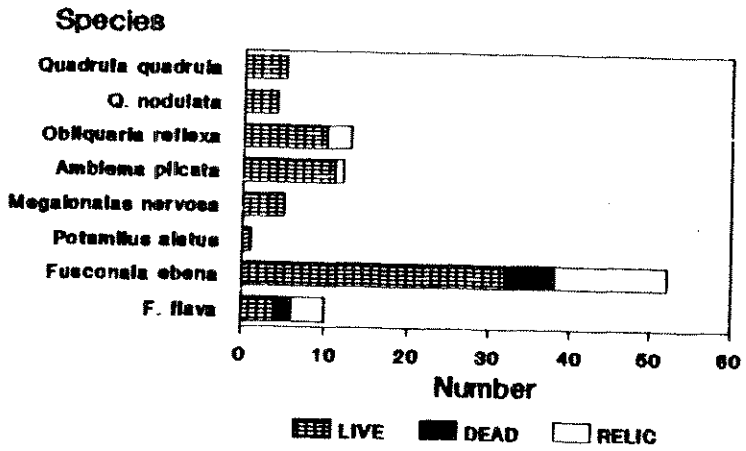
One "15 minute" Timed Dive and
One Transect Combined

N = 260
12 Species Observed

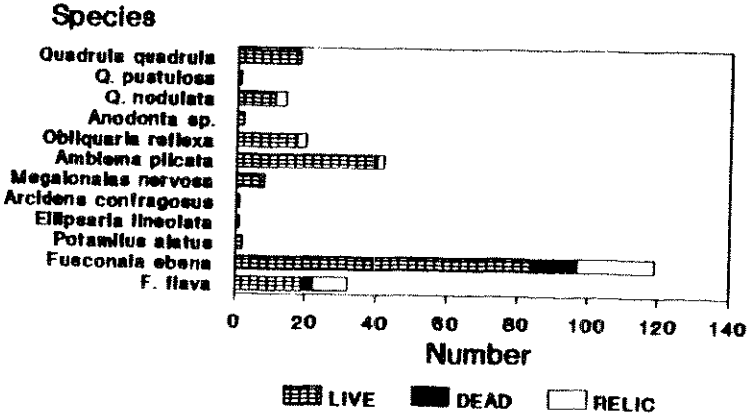
Fig. 25. Mussel Status from the Greenbottom Light Area, Kentucky Lake, TRM 88.9, August 1989



One "15 minute" Timed Dive
N = 158 12 Species Observed

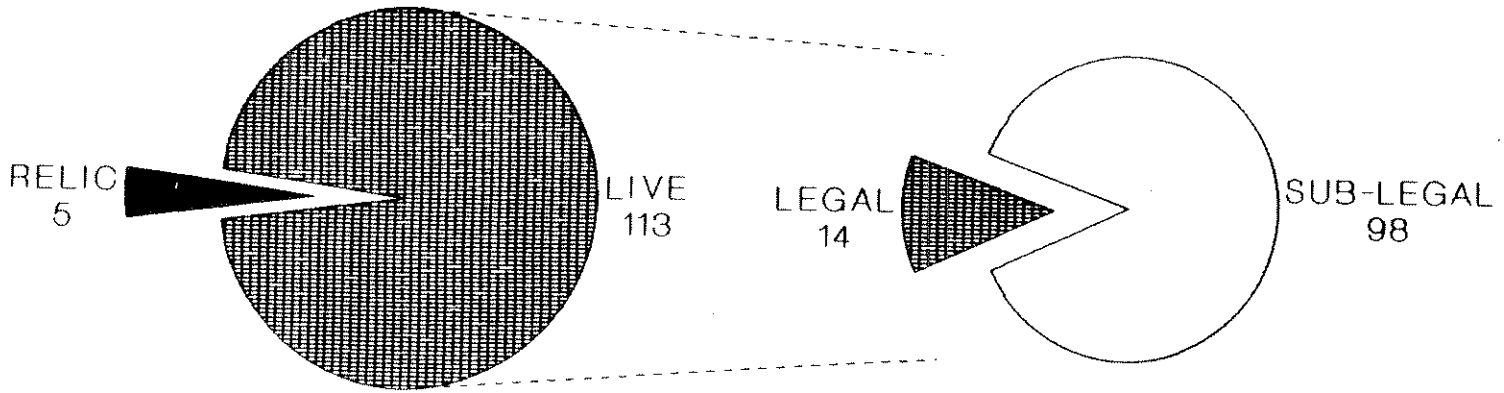


One Transect
N = 102 8 Species Observed



One "15 minute" Timed Dive and
One Transect
N = 260 12 Species Observed

Fig. 26. Summary of Mussels Observed from the Piney Creek Campground Area of Kentucky Lake, TRM 62.5, August 1989



Live, Dead, Relic

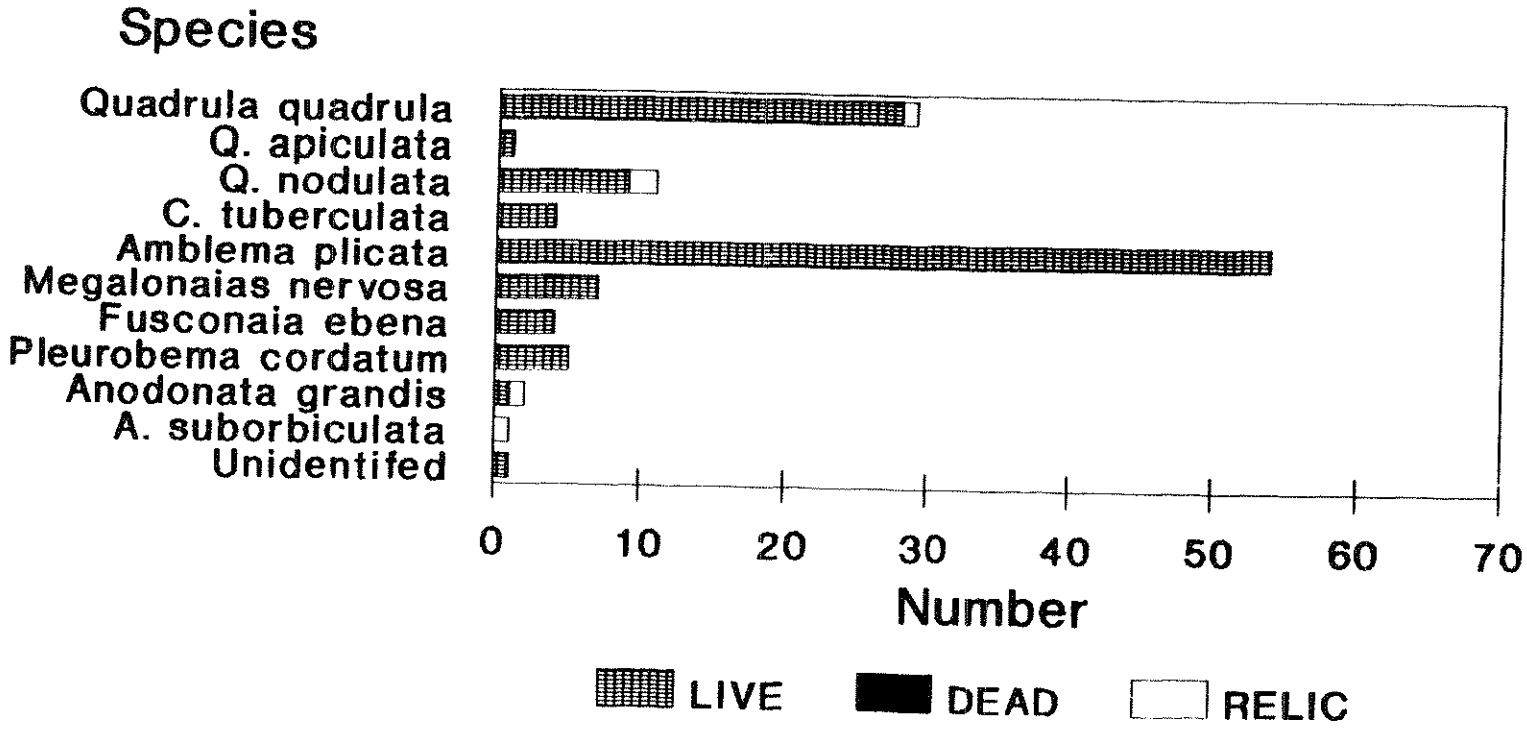
Legal, Sub-legal

N = 118
All Species

N = 112
Commercial Species

(No Fresh Dead Shells Observed)

Fig. 27. Mussel Status by Species from the Piney Creek Campground Area, Kentucky Lake, TRM 62.5, August 1989



N = 122
11 Species Observed
(No Fresh Dead Shells Observed)

TENNESSEE WILDLIFE RESOURCES AGENCY

ELLINGTON AGRICULTURAL CENTER
P. O. BOX 40747
NASHVILLE, TENNESSEE 37204

September 26, 1990

Dr. Richard Neves
Virginia Polytechnic Institute
and State University
Blacksburg, Virginia 24061-0321

Dear Dr. Neves:

I want to thank you for the comments and suggestions you made on the draft report I sent you back in the spring. I sent the draft to several people for comments, but you were the only one who gave me the serious critique I was looking for.

I appreciate your candor.

Sincerely,

Richard Kirk
Environmental Services Division

RK:mjc