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Fluvial Transport of Human Remains in the Lower Mississippi River*

ABSTRACT: The Mississippi River has claimed many lives over the last several decades. A better understanding of the universal dynamics of its fluvial system can help direct the production of a predictive model regarding the transportation of human remains in the river. The model may then be applied to situations where the location and the identification of water victims are necessarily part of the recovery process. Results from the preliminary phase of a longitudinal project involving the transport of human remains in the Mississippi River are presented and represent the analyses of 233 case files of river victims.

A provisional model for fluvial transport of human remains in the Mississippi River is proposed and examined. This model indicates that time in the river and distance a body travels are related. Such a model may assist in pinpointing entry location for unidentified human remains found in the river or on its banks. Further, it has the potential to provide local and regional law enforcement agencies, the United States Coast Guard, and other search and rescue organizations with primary search areas when someone is missing in the river.

Other results from this study indicate that a relationship exists between the side of the river where victims enter the water and the side of the river where the remains are recovered. Finally, relationships are established between the length of time before recovery of the remains and state of preservation exhibited by those remains. A secondary benefit from this study is a database of river victims that can be used by a variety of different agencies.

KEYWORDS: forensic science, anthropology, human taphonomy, fluvial transport, Mississippi River, Louisiana

The Mississippi River is a vast and dangerous body of water, flowing more than 2,350 miles, through ten states, and reaching great depths of up to 225 feet in channel regions in Louisiana before it empties into the Gulf of Mexico. Baton Rouge, Louisiana, is at the heart of the Mississippi River. Industries surrounding the river in Baton Rouge play an important role in the local and national economy, and the river links the chemical industries in Louisiana to the rest of the world. The ports of New Orleans and Baton Rouge are, respectively, the second and fourth largest ports in the United States. The river supports other recreational activities as well, such as fishing, hunting, and swimming.

Industry-related deaths are often associated with the Mississippi's muddy waters. Boating accidents are also common in an environment where large oil tankers traverse the same waterway as small fishing and recreational boats. Additionally, people underestimate the power of the currents in the Mississippi. They can be misled by the tranquil water that laps up to the levees and can become victims of the fierce undertow if they try to swim in the river. Other people sometimes choose drowning as a means for a quick and seemingly painless death; thus, jumping from area river bridges is a common method of suicide. Congested traffic on this water highway and unfamiliarity with the power of the river have resulted in many deaths, all of which are a matter of concern for law enforcement agencies, private citizens, and industry.

An understanding of the universal dynamics of specific types of fluvial systems can help direct the production of predictive models regarding the transport of human remains. Identifying commonalities among water transport cases can contribute to the creation of such predictive models. These models may then be applied in real life situations where location and identification of water victims are necessarily part of the recovery process.

Various researchers who are interested in fluvial transport of human remains have published results on this topic regarding different regions of the United States. Dilen (1), Haglund (2), and Nawrocki et al. (3), among others, have contributed to the current state of the science. Their research includes individual case studies as well as controlled studies that look for commonalities in river transport victims. A river transport project on the Mississippi River has not been attempted previously. The objectives of the current study are threefold: (1) to build a database of river victims including cases which are resolved (found and identified) and those that are unresolved (persons known to be missing in the river but never found and persons whose remains are recovered but not identified); (2) to examine critical variables such as preservation of remains, river velocity, and water temperature for commonalities; and (3) to create a model of fluvial transport of human remains in the Mississippi River.

Methods

Data for this project were collected by contacting and meeting with coroners and other law enforcement personnel representing river parishes within the state of Louisiana. A total of 233 Mississippi River cases were collected from the following parishes: As-

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cension, East Baton Rouge, Iberville, Jefferson, Orleans, Plaquemines, St. Charles, West Baton Rouge, and West Feliciana. Other sources include the Louisiana State University forensic anthropology case files and Coahoma County Coroner's office in Mississippi (Fig. 1).

Variables for this study are divided into two categories. The first category includes demographic data about the river victims. Table 1 contains those 18 variables and a brief description of each.

Variables that relate to river dynamics involve 13 characteristics of the Mississippi River. These variables are shown in Table 2. A brief explanation of river variables follows. "River miles" represent the form of measurement used to determine location and distance traveled in the Mississippi River. The river mile of entry and recovery of each victim was determined by consulting a flood control and navigation map of the river. This map pinpoints cities and industrial locations, listing the corresponding river miles (4). River miles were assigned in descending order from northerly points along the river to Head of Passes (Head of Passes is the official beginning of the navigational miles on the Mississippi River; all miles were counted in ascending order from this point). The river victim's locations of entry and recovery in the river were found on this map and river miles were assigned. The distance the victim traveled was determined by subtracting the river mile of recovery from the river mile of entry.

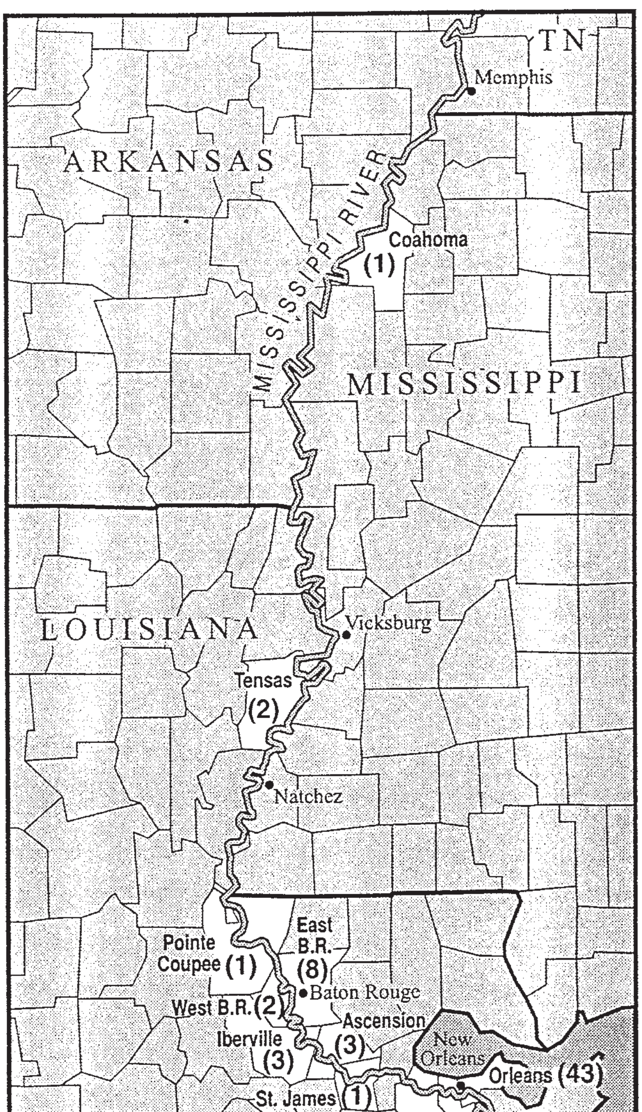

FIG. 1—*Mississippi River transport cases by parish/county.*

TABLE 1—*Demographic variables used for analyses.*

Variable	Definition
Source	Parish or County where the river victim was found
Case Number	Each case was assigned a new case number by the authors
Name	Name of the river victim
Date missing	Date that the person was missing in the river
Date found	Date that the remains were recovered
Time of year missing	Month that the river victim became missing
Time of year recovered	Month that the remains were recovered
Location missing	Location where the person entered the river
Location found	Location where the remains were recovered
Side of entry	Side of the river where the person entered the river
Side of recovery	Side of the river where the remains were recovered
Preservation condition	Scale of decomposition; each case categorized into one off our categories: 1) Fresh—no outward signs of decomposition 2) Bloat—expansion of the skin because of increased gases from bacterial activity 3) 25% or more decomposed—some appearance of skeletal elements, but the majority of the soft tissue remained 4) Skeletal - completely skeletonized remains
Sex	The sex of the river victim
Race	The race of the river victim
Age	The age of the river victim
Identified	The identification status of the human remains
Manner of death	Four categories: accidental, suicide, homicide, or unknown
Notes	Additional information about the case

Water temperature and discharge were determined by examining the Water Quality Records published by the United States Geological Survey (USGS). These records exist in yearly publications of various forms for Louisiana waterways from 1964 to present (5–16).

The temperatures for the present database were recorded in Celsius and represent the average for the particular month at Luling, Louisiana (which is a designated site for river measurements in southern Louisiana).

"Discharge," expressed in 1000's of cubic feet per second, indicates the volume of water that is moving in the river per unit of time. Discharge was reported consistently in one location only, Vicksburg, Mississippi. Therefore, the mean discharges for the months of entry and recovery are from that location.

Maximum depth of the Mississippi River at the locations of entry and recovery was recorded in feet and was determined by locating the river mile of entry and recovery, respectively, on a hy-

TABLE 2—*List of variables that relate to Mississippi river dynamics.*

Variable	Definition
River mile missing above HOP*	Location in the river where the person went missing
River mile found above HOP*	Location in the river where the remains were recovered
Distance traveled	Distance that the remains moved in river miles
Temperature missing	Mean temperature for the month of entry, Celsius
Temperature found	Mean temperature for the month of recovery, Celsius
Discharge missing	Volume of water moving in the river during the time of loss, 1000's of cubic feet per second, measured in Vicksburg, MS
Discharge found	Volume of water moving in the river during the time of recovery, 1000's of cubic feet per second, measured in Vicksburg, MS
Depth missing	Maximum depth of the river where the person was missing, feet (at low water)
Depth found	Maximum depth of the river where the remains were found, feet (at low water)
Bed load missing	Mean diameter of particle size in millimeters, where the person was missing
Bed load found	Mean diameter of particle size in millimeters, where the remains were recovered
Days	Number of days the remains were in the river
Category of days	Number of days in the river represented categorically

* HOP = Head of Passes.

drographic survey map that shows the depth of the river taken at various points along the thalweg. The thalweg is the deepest point along the stream channel. Because the deepest points are sometimes close to the sides, such as in the case of cut banks or erosion areas, the thalweg is not always in the center of the river. All recorded depths are based on the depth measurements taken during low water season by the hydrographic survey (17).

The final variable involving river dynamics is "bed load," which indicates the mean diameter of the particle size of the sediment. The variable "bed load" was chosen because it indicates the size of the particles in the substrate of the Mississippi River. The varying size of particles potentially affects the transport of human remains in the fluvial system. The size could determine whether the remains were trapped in the sediment or permitted to move along the surface of the river bottom. This measurement is given in millimeters (18).

The final two variables to be discussed are "number of days" and "category of days." "Number of days" represents the actual length of time that the human remains were in the water before recovery. The "category of days" is a categorical variable that ranks each case into one of six classifications based on the length of time the person was in the river.

Results

The 233 cases in this study span 42 years, ranging from 1957 to May, 2001. A breakdown of the cases in ten-year increments, including the identification status and sex, is shown in Table 3. Table 3 reflects a notable increase in the number of river cases in recent years. This increase may be explained by improved accuracy of records due to the use of computers by law enforcement agencies. The increase may also be explained by memory recall of those assisting with the data collection.

Additional results from Table 3 indicate an increase in the number of unidentified river victims in recent years. This increase is affected by the subset of data from the Louisiana State University (LSU) forensic anthropology case files. The cases contributed by the LSU laboratory represent human remains from many different parishes bordering the river throughout Louisiana.

When evaluating the demographic results of the database by sex, the majority of the river cases (89.6%) are male. Only 24 of the 233 river cases are female. The identified and unidentified human remains were placed into the following six categories based on race: white (116), black (101), Hispanic (5), Asian (4), East Indian (1) and those of unknown race (6).

Table 4 reports age ranges. The youngest victim is five years of age; the oldest is 78 years of age. The large span of age ranges can be explained by the variety of activities, which occur in or near the Mississippi River. The cases involving children are likely related to swimming in the river, whereas elderly river victims are often fishermen or suicides.

The most common age range for river victims is from 15 to 34. Two categories, 15 to 24 and 25 to 34, account for over half of the cases in which the age of the river victims is known. These high numbers are closely linked to manner of death of river victims and, in turn, help to explain the higher number of male versus female victims.

The most common manner of death is accidental (155). Industry-related accidents or swimming and fishing tragedies comprise the greatest number of river victims. In fact, the highest number of accidental deaths is due to industry-related accidents. Only one doc-

TABLE 3—*Breakdown of Mississippi river cases in ten-year intervals.*

Years	Number	Identified	Unidentified
1957–1966	35	Male = 27 Female = 3	Male = 4 Female = 1
1967–1976	49	Male = 41 Female = 4	Male = 4 Female = 0
1977–1986	49	Male = 35 Female = 9	Male = 4 Female = 1
1987–1996	85	Male = 61 Female = 7	Male = 17 Female = 0
1997–2001	15	Male = 12 Female = 0	Male = 3 Female = 0
Totals	233	199	34

TABLE 4—*Number of Mississippi river victims in each age range.*

Age Range in Years	Number of Cases
5–14	22
15–24	53
25–34	52
35–44	28
45–54	25
55–64	10
65–78	14
Unknown	29
Total	233

umented case of a female industrial worker dying in the Mississippi River was reported. Therefore, occupation alone accounts for the large number of male victims.

The second most common manner of death is suicide (52). More likely than not, suicide victims jump from bridges which span the river in large metropolitan areas, i.e., Baton Rouge and New Orleans.

Finally, only four known homicides were documented in the Mississippi River database. However, the cause of death for 22 other individuals is unknown.

In an effort to evaluate various physical aspects of the Mississippi River system and their impact on the transport of human remains, several statistical analyses were performed.

"Side of the river missing" and "side of the river recovered" are two categorical variables that aid in the understanding of the transportation processes that the human remains undergo. Information is available for both variables for 160 cases (Table 5). Chi-square analysis was performed to determine if a person is likely to be found on the side of the Mississippi River where he/she entered the water. The test statistic is significant ($\chi^2 = 70.68$; degrees of freedom are 4; $p \leq 0.01$). These results indicate that when a person is missing in the Mississippi River, search areas should concentrate on the side where the person entered the river.

Chi-square analyses were performed separately on the variables "time of year missing" and "time of year found." Time of year variables were defined for each case based on the month of entry and exit, respectively. The results were significant for both "time of year missing" ($\chi^2 = 39.89$; degrees of freedom = 11; $p \leq 0.01$) and "time of year found" ($\chi^2 = 65.07$; degrees of freedom = 11; $p \leq 0.01$). For both variables the analysis shows that there are more cases missing and found during spring and summer months.

The identification of human remains found within fluvial environments is naturally problematic. After the majority of decomposition has occurred and the remains are somewhat disarticulated, the task becomes more difficult. Further investigation into the condition of preservation of the Mississippi River cases involved a chi-square analysis to determine if the condition of the remains is related to the identification status. Data were available for both variables for 206 cases (Table 6). The relationship between the two variables is significant ($\chi^2 = 32.51$; degrees of freedom = 3; $p \leq 0.01$). As expected, this result (also see Table 6) suggests that as the state of preservation deteriorates, the person is less likely to be identified. River victims who remain unidentified are those found in advanced stages of decomposition.

The final chi-square analysis performed involves length of time in the water and the condition of preservation of the remains. The expectation is that human remains exposed to fluvial conditions for extended periods of time exhibit advanced stages of decomposition. Therefore, "condition of preservation" was compared to the variable "category of days" (Table 7). The results were significant ($\chi^2 = 101.02$; degrees of freedom = 10; $p \leq 0.01$). Table 7 demonstrates that human remains subjected to fluvial conditions for longer periods of time exhibited more advanced stages of decomposition.

Variables involving the Mississippi River and dynamics of fluvial transport are crucial to the understanding of fluvial transport of human remains. The information contained within the database includes cases of fluvial transport beginning as far north as Memphis, Tennessee, river mile 735. There are also cases in the database from as far south as the Gulf of Mexico. However, most cases involve southern Louisiana.

The distance traveled is an important parameter for each Mississippi River case. The case of human remains traveling the longest distance involves a barge worker who fell into the river at Westwego, Louisiana, and traveled approximately 104 miles down river into the Gulf of Mexico in six days. This case, though interesting, is not the norm. In 97 cases the distance traveled was zero, meaning that the remains were found within one mile of the location where they entered the river. This result alone suggests that pri-

TABLE 5—*Side of entry and recovery of Mississippi river victims.*

	Side of River Found				
Side of the River Missing	West Bank	East Bank	Middle	Unknown	Totals
West Bank	25	5	5		35
East Bank	7	21	4		32
Middle	24	11	58		93
Unknown					73
Totals	56	37	67	73	233

TABLE 6—*Condition of preservation and identification status.*

	Identification Status			
Condition of Preservation	Identified	Unidentified	Unknown	Totals
1—fresh	52	0		52
2—bloat	93	12		105
3—25% or more decomposed	33	9		42
4—skeletal	2	5		7
Unknown				27
Totals	180	26	27	233

TABLE 7—*Condition of preservation and length of time in the Mississippi river.*

	Condition of Preservation					
Category of Days	Fresh	Bloated	25% or More Decomposed	Skeletal	Unknown	Totals
1—0–9 days	48	65	8	0		121
2—10–19 days	2	16	2	0		20
3—20–29 days	1	5	0	0		6
4—30–39 days	0	1	4	0		5
5—40–49 days	0	1	2	0		3
6—50–176 days	0	0	13	0		13
Unknown						65
Totals	51	88	29	0	65	233

mary searches for Mississippi River victims should focus on the location where the person entered the river. Of the remaining 137 cases, 69 traveled distances of one mile or greater. The distance traveled cannot be determined for some cases because of unknown origin. Additionally, there are five cases of people known to be missing in the river but never found. Further, some human remains were found up river from where they were missing. These cases exhibit a negative distance traveled. One possible explanation for the negative distance traveled is that river traffic, such as barges, snagged those remains, carrying them up river.

Frequencies involving length of time in the water are also necessary to the understanding of the fluvial transport of human remains. Information on the length of time spent in the water is available for 186 of the 233 cases. Out of the 233 cases in the database, 163 were resolved within a month of the incident. The longest period of time that human remains were subject to the dynamics of the Mississippi River is approximately five years.

The final analyses included a stepwise multivariate regression and a Pearson's correlation that were performed to establish a preliminary model for the fluvial transport of human remains in the Mississippi River. Variables that were considered for the model include the following: distance traveled, days in the water, load missing, load found, depth missing, depth found, discharge missing, and discharge found. The cases chosen for this analysis included those with a "distance traveled" of greater than one mile and less than 40 miles. The cases for the evaluation had to possess data for all of the variables considered. After these qualifications were met, the data subset consisted of 38 cases.

The stepwise multivariate regression evaluated "distance traveled" as the dependent variable. All of the other variables in the previous list were considered independent variables. The results show that the only significant variable was the number of days in the water. The regression equation is: distance traveled $= 5.64 + 0.10$(days). The adjusted R^2 is 18%, indicating that 18% of the variation in the distance traveled is associated with the number of days in the water. Therefore, the preliminary model for the fluvial transport of human remains on the Mississippi River indicates that the length of time in the river affects the distance that remains will travel (based on the subset of cases that traveled at least one mile).

To further evaluate the relationship, a Pearson's correlation was performed on distance traveled and days in the water. The analysis was done to take advantage of a larger sample size ($n = 48$) than that available for the multivariate regression ($n = 38$). The correlation was significant ($r = 0.336$; $p \leq 0.05$). The R^2 for this correlation is 11.29%.

Discussion

Mississippi River victims include persons of varying ages, both sexes, and various races. By far the greatest numbers have died from accidents, both recreational and industrial in nature. However, a considerable number of those victims have also been suicides. Variables involving the Mississippi River and characteristics of fluvial transport are crucial to the understanding of fluvial transport of human remains.

The analysis of side of entry and recovery from the river indicates that when a person is lost in the Mississippi River, primary search areas should be on the side of the river where the loss occurred. This result supports the research of Dilen (1) who concluded that human remains are unlikely to cross currents during fluvial transport.

Another notable aspect to the chi-square analysis of side of entry and recovery from the river (see Table 5) is that 24 of the 93 cases that were missing in the middle of the river were recovered on the west bank side. Only 11 of the 93 cases missing in the middle of the river were recovered from the east bank. This result suggests that if someone is missing from a barge or other apparatus located in the middle of the river, he/she would more likely be recovered from the west bank. This result is potentially linked to the specific cases analyzed in the current database. Different areas of the river, depending on the physical geography in a particular area, may have different outcomes. If the loss of a river victim occurred in a meandering area of the river versus a straight channel, the outcome of his/her fluvial transport may be different.

Though one might expect an even distribution in the time of year that river cases occurred, the results of the chi-square analysis of "time of year missing" and "time of year found" show that cases of river victims occur more frequently in the spring and summer months. These results can be explained by the increase in recreational activities in the Mississippi River during spring and summer months.

A significant relationship was established between the "state of preservation" and the "identification status." This result indicates that the amount of decomposition exhibited in the remains affected the ability to assign positive identification to those remains. This is a logical result because the recovery of skeletal remains is often incomplete due to disarticulation. Partial recovery of remains, in turn, can hinder the identification process. An additional comparison proves a significant relationship between the "category of days" and the "decomposition condition." This result indicates that longer amounts of time in the Mississippi River lead to more advanced stages of decomposition.

In the examination of distance traveled by the victim, the most frequent result is that the remains did not travel at all. This suggests that immediately after human remains are lost in the Mississippi River the best area to begin the search is the location where the person entered the river.

The results of the stepwise multivariate regression indicate that distance traveled by the human remains in the Mississippi River can be partially explained by the length of time the remains are in the water. Only one of the proposed nine variables was important to the prediction of distance traveled during the fluvial transport of human remains. The variables describing river dynamics were included to maximize the understanding of the effects that physical aspects of the river have on fluvial transport. These variables were inconsequential to the explanation of the distance that human remains traveled in the Mississippi River.

Additionally, a Pearson's correlation was performed between the variables "distance traveled" and "days." Because only those two variables were considered, the sample size increased to 48. The correlation also indicated a significant relationship between the length of time in the river and the distance that the remains traveled (Table 8). This final set of analyses demonstrates that the length of

TABLE 8—*Distance traveled and length of time in the Mississippi river (cases of distance traveled in miles >1 and <40).*

Length of Time in Days	Range (in Miles) of Distances Traveled
0 to 5 ($N = 20$)	1.1 to 15.4
6 to 10 ($N = 10$)	1.1 to 34.8
11 to 15 ($N = 3$)	8.0 to 20.1
16 to 20 ($N = 5$)	5.3 to 14.7
>20 ($N = 10$)	2.1 to 37.1

time that the human remains have been in the Mississippi River affects the distance that those remains have traveled.

Conclusions

The value of this ongoing project lies in the possible uses of the predictive model and the database. The model might be used not only to suggest the location of river victims who have not been found but also to predict the point of origin of human remains that are recovered from the Mississippi River but remain unidentified. Finally, the database serves as a link among all unresolved river cases that could lead to connections between people known to be missing and human remains that are not yet identified.

In conclusion, the continuous addition of Mississippi River cases to the database will aid in the improvement and future evaluations of the data. Thus far, the majority of the cases have been from southern Louisiana. As additional information becomes available, the preliminary model will improve, leading to a better understanding of the fluvial transport of human remains in the Mississippi River.

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