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# Assessment of the Modern Fish Assemblage in Mound Pond (Lonoke County) and Comparison with the Archeological Record

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# Assessment of the Modern Fish Assemblage in Mound Pond (Lonoke County) and Comparison with the Archeological Record

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Running title: Fish Assemblage of Mound Pond (Lonoke County)

## Abstract

Mound Pond is a 56-ha oxbow lake of the Arkansas River. The lake has been disconnected from the Arkansas River main channel for over 2,500 years. The lake lies adjacent to the Toltec Mounds Archeological State Park, which contains the Toltec Mound Complex (3LN42). In October 2012, a multiple-gear sampling of the fish assemblage in Mound Pond was conducted using boat-mounted electrofishing, mini-fyke nets, and experimental gill nets. Across all gears, 501 fish specimens were collected and identified to species. Percent Similarity Index (PSI) and Shannon-Weiner Diversity Index (H') values were calculated using data from this survey and a previous survey conducted in 2006. Mound Pond had a fish species richness of 11 in 2012 compared to 12 in 2006. PSI values indicated the 2006 and 2012 assemblages were 58% similar; H' values of 1.282 in 2012 and 1.465 in 2006 did not differ significantly ($p > 0.05$). Genus-level Jaccard coefficients (J) were calculated for pairwise comparisons of ichthyofaunal remains recovered from Toltec Mounds D and S, and the two modern fish surveys. Fish assemblages depicted from remains recovered at the two mounds were highly similar (J = 0.769), whereas the two modern surveys were only moderately similar (J = 0.545). Modern and ancient assemblages were generally dissimilar (J = 0.333 – 0.461). This observation suggested that fish resources used by the inhabitants of 3LN42 were likely not acquired from Mound Pond in spite of its close proximity.

## Introduction

Mound Pond (occasionally Mound Lake, or Lake Mound Pond) is a 56-ha oxbow lake of the Arkansas River located in Lonoke County (Adams et al. 2007). The lake is now permanently disconnected from the Arkansas River by a mainline levee system. As is common for many aquatic systems in central Arkansas, the surrounding watershed has shifted from a predominantly agricultural to suburban landscape. Only two houses are known to have stood near the lake up until the 1940s (Rolingson 2012). However, a gated subdivision now stands on the west bank of the lake, and another housing development lines the southeastern shoreline. Mound Pond is of particular interest because of the adjacent Toltec Mounds Archeological State Park, which protects and preserves the Toltec Mound Complex (3LN42) located within. This archeological site is composed of at least 18 mounds enclosed by an embankment, and represents the cultural center of the ancient Plum Bayou Culture. This Native American culture occupied the site from about 700-1050 A.D., during the Late Woodland-Early Mississippian transition (Rolingson 2012).

The present channel of the Arkansas River lies approximately 5 km to the west of Mound Pond (Figure 1). Old River Lake, an adjacent oxbow that lies between Mound Pond and the present-day Arkansas River channel was connected to the Arkansas River until the 1800s (Rolingson 2012). Mound Pond itself was formed by a previous channel of the Arkansas River prior to 500 B.C. (Saucier 1997). Mound Pond is located outside the stage 1 meander belt that represents the river's final natural course before construction of

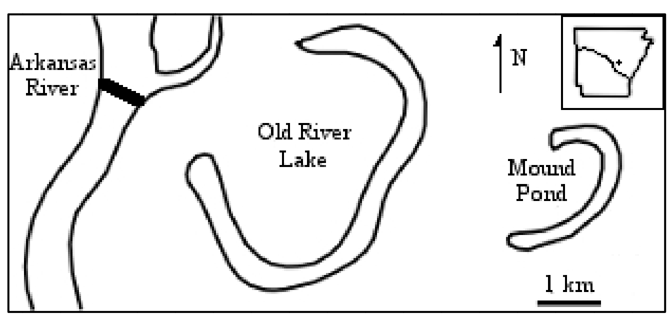


Figure 1: Map depicting present course of the Arkansas River, Old River Lake, and Mound Pond. The line traversing the Arkansas River main channel is the David Terry Lock and Dam No. 6 located at RKm 174 downstream of Little Rock.

the McClellan-Kerr Arkansas River Navigation System in the 1960s (Saucier 1997). It is unclear how often Mound Pond may have been connected with the Arkansas River after the channel shifted west about 2,500 years ago. Saucier (1997) indicated that Mound Pond was permanently disconnected from the Arkansas River by the time 3LN42 was first occupied 1,300 years before present. In more recent periods, it has been reported that the Knapp Farm, which included property on both sides of Mound Pond, did not flood during the extensive Arkansas River floods of 1844 and 1892 (Rolingson 2012). It is likely that after the Arkansas River channel shifted to its final meander belt, Mound Pond was intermittently connected to other adjacent water bodies, but not the main Arkansas River channel.

Fishes found in disconnected oxbow lakes vary from the fishes found in periodically connected oxbows of the same river (Miranda 2005, Dembkowski and Miranda 2011). Miranda (2005) found similar fish assemblages in Lake Washington and Eagle Lake, MS. Both lakes are oxbows of the Mississippi River, and became disconnected from the main river channel c.a. 700 and 100 years before present, respectively. Research on these lakes suggested that a stable fish assemblage was reached relatively soon after permanent disconnection. Lubinski et al. (2008) detected significant negative correlations between lake connectivity (as reflected by degree of flooding) and species richness in floodplain lakes of the lower White River, AR. Alfermann and Miranda (2013) reported that some centrarchid (e.g., longear sunfish *Lepomis megalotis* and green sunfish *Lepomis cyanellus*) abundances were directly related to connectivity, while others (e.g., black crappie *Pomoxis nigromaculatus*) were found almost exclusively in lakes that were permanently disconnected from their rivers. Seasonal flooding in large river systems is purported to help maintain biological diversity by allowing re-mixing of lotic and lentic fish species and/or addition of new species to floodplain fish assemblages (Galat et al. 1998). This phenomenon cannot occur when lakes are permanently disconnected from their parent rivers.

The fish assemblage of Mound Pond was assessed during the summer of 2006 by Adams et al. (2007) as a portion of a larger study on fish assemblages in Arkansas River backwater lakes. In this survey of Mound Pond, three shoreline reach seines, five experimental gill nets, and five mini-fyke nets were employed (Adams et. al 2007). With all gears pooled, Adams et al. (2007) collected 962 fishes from 12 species. Mound Pond had the lowest species richness of all backwater lakes studied by Adams et al. (2007), though the assemblage was still typical of shallow disconnected oxbows reported by other studies in the region (Lubinski et al. 2008, Dembkowski and Miranda 2011). This observation of lower fish species richness also was consistent with Mound Pond being disconnected with the Arkansas River for a significant period of time.

The present study encompassed a multiple-gear survey of the fishes of Mound Pond conducted in October 2012. The primary objective of this study was to assess the modern fish assemblage of Mound Pond, specifically identifying short-term changes (if any) occurring between 2006 and 2012. This objective supported the Arkansas Department of Parks and Tourism – Division of State Parks' fisheries management planning for Mound Pond. The second objective was to compare the modern fish assemblage complex of Mound Pond to that depicted by the ichthyofaunal remains recovered from the Toltec Mound Complex. Completion of this objective will add insight into long-term changes of fish assemblages in Mound Pond, as well as aid understanding of the fishing habits of the enigmatic Plum Bayou Culture.

## Methods

### *Prehistoric Data Sources*

3LN42 has been studied for more than 30 years (Rolingson 2012). Analyses of faunal remains are available from excavations of middens found in Mound D (Hoffman 1982) and Mound S (Kelly 2012) (Table 1). These remains have been interpreted as being associated with community feasting events (Rolingson 2012). As is common at many archeological sites, many fish fragments recovered were only identifiable to genus.

### *Multiple-gear Survey*

Three fish sampling gears were used during this study. Electrofishing was conducted from a boat-mounted platform using a pulsed-DC 7.5 GPP Smith-Root electrofisher unit (Smith-Root, Inc., Vancouver, WA). Pulsed voltage and frequency were determined by an experienced electrofishing operator and based on ambient conductivity (measured on site as <100 µS/cm). Standard mini-fyke nets and experimental gill nets were deployed using protocols and sampling gears of the same specifications as described in Eggleton et al. (2010).

Mound Pond was spatially divided *a priori* into three approximately equal-sized segments, designated

Table 1: Fishes identified as present in communal feasting middens at 3LN42 (Hoffman 1982, Kelly 2012).

| Mound D | Mound S |
|---|---|
| *Amia calva* | *Amia calva* |
| *Ictiobus bubalus* | *Ictiobus bubalus* |
| *Ictiobus cyprinellus* | *Ictiobus cyprinellus* |
| *Micropterus dolomieu* | *Ictalurus furcatus* |
| *Micropterus salmoides* | *Ictalurus punctatus* |
| *Ameiurus melas* | *Pylodictis olivaris* |
| *Ameiurus natalis* | *Aplodinotus grunniens* |
| *Ictalurus furcatus* | |
| *Ictalurus punctatus* | *Ameiurus* spp. |
| *Pylodictis olivaris* | *Esox* spp. |
| *Atractosteus spatula* | *Ictalurus* spp. |
| *Lepisosteus osseus* | *Ictiobus* spp. |
| *Aplodinotus grunniens* | *Lepomis* spp. |
| | *Micropterus* spp. |
| *Ictiobus* spp. | *Morone* spp. |
| *Lepomis* spp. | |
| *Micropterus* spp. | |
| *Morone* spp. | |
| *Pomoxis* spp. | |

lower, middle, and upper. Each segment was subjected to three 10-minute daytime electrofishing transects for a total of 90 minutes of active sampling effort (i.e., pedal down time). In each lake segment, two of the 10-minute transects were conducted in the littoral zone, with the third transect conducted in the pelagic zone. Nine mini-fyke nets were fished overnight in littoral-zone habitats for 15-18 hours, with three nets deployed in each lake segment. Three experimental gill nets were deployed in pelagic habitats for 3-4 hours each while other sampling was conducted. Within each lake segment, one net was bottom-set in approximately 3-4 m of water.

Fishes were identified in the field. Voucher specimens of smaller-bodied species were retained and accessioned to the ichthyology teaching collection at the University of Arkansas at Pine Bluff (UAPB). Fishes not retained as voucher specimens were handled in accordance with the UAPB Aquaculture/Fisheries Center Animal Welfare Policy of 2005 in effect at the time of sampling, and released alive.

### *Data Analysis*

After collection and identification, fish assemblages were compared between lake segments using Percent Similarity Index (PSI) (Washington 1984). Species abundance data were pooled from all lake segments, with PSI and Shannon-Wiener Diversity Index (H') values (Magurran 2004) calculated for both the present study and previous survey conducted by Adams et al. (2007). Variance of H' was calculated using the method of Jayaraman (2000). This variance estimate was used to conduct a Student's *t*-test that compared H' values between 2006 and 2012. A two-sample *z*-test of the proportions of largemouth bass *Micropterus salmoides* also was conducted to assess potential changes that might have resulted from an isolated stocking event that occurred in 2007.

Both modern fish surveys were compared to the ichthyofaunal remains recovered from the archeological site. Assemblage comparisons were done using the Jaccard Similarity (J) coefficient (Magurran 2004). J uses presence/absence data to quantify the similarity of the different assemblages, but was calculated at the genus rather than species level because most fishes from the archeological remains could only be identified to genus. Statistical analyses were conducted using R 2.13.1 (The R Foundation for Statistical Computing, Vienna) and EstimateS 9.0 (Colwell 2013). In all cases, an alpha level of 0.05 was used for statistical interpretations.

## Results

Modern fish assemblages surveyed in 2006 and 2012 were mostly similar. A total of 501 fishes representing 11 species were collected during the 2012 survey (Table 2). The most abundant species was gizzard shad *Dorosoma cepedianum* (n=218, 44%), followed by bluegill *Lepomis macrochirus* (n=199, 40%) and white crappie *Pomoxis annularis* (n=14, 9%). All other species comprised less than 3% of the total catch. Between-segment PSI ranged from 77-87%, which indicated a relatively homogenous fish assemblage throughout the lake. PSI between the 2006 and 2012 surveys was 58%, which suggested moderate similarity in fish assemblages. The summer sampling conducted in 2006 collected 92% more fishes than the present study, which was conducted during fall. However, despite the seasonal difference in sampling periods, the species richness of 12 recorded in 2006 was not appreciably different from the 11 species collected in 2012 (Table 2). Three fish species were unique to the 2006 survey, while two species were found only in 2012. Gizzard shad were 137% more abundant in the present study, while bluegills were 194% more abundant in the 2006 survey (Table 2).

Table 2: Fishes collected by 2006 (Adams et al. 2007) and 2012 surveys of Mound Pond.

| Family | Scientific Name | Common Name | 2006 | 2012 |
|---|---|---|---|---|
| Amiidae | *Amia calva* | bowfin[b] | 0 | 1 |
| Centrarchidae | *Lepomis gulosus* | warmouth | 31 | 10 |
| | *L. humilis* | orangespotted sunfish | 108 | 4 |
| | *L. macrochirus* | bluegill | 586 | 199 |
| | *Micropterus salmoides* | largemouth bass | 25 | 14 |
| | *Pomoxis annularis* | white crappie | 14 | 43 |
| | *P. nigromaculatus* | black crappie | 10 | 8 |
| Clupeidae | *Dorosoma cepedianum* | gizzard shad | 92 | 218 |
| Cyprinidae | *Cyprinus carpio* | common carp[b] | 0 | 1 |
| | *Notemigonus crysoleucas* | golden shiner[a] | 33 | 0 |
| Ictaluridae | *Ameiurus natalis* | yellow bullhead[a] | 6 | 0 |
| | *Ictalurus punctatus* | channel catfish | 14 | 2 |
| Lepisosteidae | *Lepisosteus oculatus* | spotted gar | 19 | 1 |
| Poeciliidae | *Gambusia affinis* | western mosquitofish[a] | 24 | 0 |

Superscript letters signify: a – species collected only in 2006, b – species collected only in 2012.

Table 3: Jaccard Coefficients from pairwise comparisons between and among modern fish surveys in Mound Pond and ichthyofaunal remains recovered from 3LN42 (Hoffman 1982, Adams et al. 2007, Kelly 2012, and present study).

| | 2012 | Mound D | Mound S |
|---|---|---|---|
| 2006 | 0.545 | 0.428 | 0.400 |
| 2012 | - | 0.461 | 0.333 |
| Mound D | - | - | 0.769 |

The calculated H' value from 2006 was 1.465 ($H_{max}$ = 6.869), which compared to 1.282 ($H_{max}$ = 6.217) in 2012. A *t*-test detected no significant difference between H' values in 2006 and 2012 ($t$ = 1.817, df = 925, $p > 0.05$). The genus-level J also indicated that the 2006 and 2012 assemblages were moderately similar (J = 0.545, Table 3), which was consistent with the species-level PSI value (58%).

The fish assemblages depicted by ichthyofaunal remains from Mound D and Mound S were highly similar (J=0.769) (Table 3). Fish assemblages characterized from both modern surveys were moderately dissimilar compared to those depicted by the ichthyofaunal remains from both mounds (J = 0.333 – 0.461) (Table 3). However, it is important to note that ichthyofaunal remains recovered from both mounds reflected ancient fish exploitation patterns of the Plum Bayou Culture, and not necessarily the fish assemblage structure of Mound Pond at that time.

## Discussion

### *Modern Fish Assemblage*

The fish assemblage composition of Mound Pond from both 2006 and 2012 was typical of those found in disconnected oxbow lakes and man-made impoundments (Adams et al. 2007, Lubinski et al. 2008). Two unique species were collected during the 2012 survey that had not been collected by Adams et al. (2007): bowfin *Amia calva* and common carp *Cyprinus carpio*. Three species collected in 2006 were not recorded from the 2012 survey: yellow bullhead *Ameiurus natalis*, western mosquitofish *Gambusia affinis*, and golden shiner *Notemigonus chrysoleucas*. These minor differences between the two modern surveys were likely attributable to differences in gear selectivity, time of year, or both. For example, gizzard shad and common carp have been demonstrated as being more susceptible to electrofishing than the gears used during the 2006 survey (Eggleton et al. 2010). Similarly, the greater abundance of bluegills from the 2006 survey may have been related to the Adams et al. (2007) survey being conducted during the bluegill spawning season. In addition, although not collected with mini-fyke nets, western mosquitofish were observed during 2012 sampling. Western mosquitofish would likely have been collected in 2012 had seining been employed as an additional sampling gear.

It was not likely that Mound Pond has been affected by Arkansas Game and Fish Commission (AGFC) fish stockings. Mound Pond was stocked with 6,400 largemouth bass fingerlings in 2007 (AGFC –

largemouth bass stocking records, *unpublished data*). Largemouth bass comprised 2.6% of the fishes collected during the 2006 survey (Adams et al. 2007), compared to 2.8% of the fishes collected in 2012. A two sample *z*-test indicated this change to be not significant ($z$ = 0.22, $p$ = 0.83). Thus, this stocking event that occurred over 5 years ago appears to have had no detectable effect on the current abundance of largemouth bass or fish assemblage structure in Mound Pond. Although we were not able to assess size structure effects from our data, records indicated that this stocking event appears to have been isolated. Such information will be useful for any fisheries management conducted on Mound Pond.

### *Comparison with Ichthyofaunal Remains*

Because H' and PSI metrics can be strongly influenced by gear selectivity, we did not employ these metrics to compare modern assemblages to those depicted by the archeological remains. Emphasis was instead placed on J values, which are calculated from presence-absence data (Kwak and Peterson 2007). This should be an acceptable approach given that at least one gear employed in each modern survey was capable of capturing at least one individual of every species identified from the archeological remains (Eggleton et al. 2010). This approach allowed comparison of presence-absence data of the fish assemblages between and within the two eras.

Modern fish assemblages and assemblages depicted by the ichthyofaunal remains recovered at the mounds were more similar within than between. The greatest genus-level J coefficient was found between the assemblages reflected by the ichthyofaunal remains recovered from the two mounds (J=0.769). The next most similar assemblages were those depicted by the two modern surveys that used multiple sampling gears (J=0.545). The remaining four pairwise comparisons between modern assemblages and the ichthyofaunal remains indicated much lower similarity (J=0.333 – 0.461). Calculating J at the genus level was necessary in this comparison due to the limitations of the archeological ichthyofaunal remains data. However, it also may have artificially inflated the similarity for comparison of the mound remains and modern surveys. For example, the channel catfish *Ictalurus punctatus* is equivalent to the blue catfish *I. furcatus* in computations of J because they are congenerics. Although channel catfish is common in many waters throughout Arkansas, blue catfish are generally restricted to larger Arkansas rivers and unlikely in smaller disconnected oxbow lakes such as Mound Pond (Robison and Buchanan 1988). A similar situation occurs with gars. The genus *Lepisosteus* is represented in the mound ichthyofaunal remains by the longnose gar *Lepisosteus osseus*, while the modern surveys contains only spotted gar *L. oculatus*. Longnose gar is more typical of large riverine systems, while spotted gar is a smaller-bodied species more prevalent in oxbow lakes and backwater habitats (Lubinski et al. 2008). In all cases, calculating at the genus level would bias similarity metrics upward. Thus, it is likely that the actual similarity between the modern fish assemblage and ancient assemblages depicted by the ichthyofaunal remains was 10-20% lower than that calculated in the present study.

Fish assemblage structures in oxbow lakes begin shifting away from the parent river's assemblage structure at the time of permanent disconnection (Miranda 2005). Therefore, it is likely that the fish assemblage of Mound Pond developed its current structure long before the Plum Bayou Culture began building their mounds on the lake. The modern fish assemblage in Mound Pond appears similar to other permanently disconnected oxbow lakes (Miranda 2005), or large-river backwater lakes with low connectivity (Lubinski et al. 2008). These oxbow lakes typically have some riverine species, but have shifted over time towards more lacustrine assemblages. The assemblage shift results from the long-term disconnection from the parent river, which prevents species mixing or additions, leading to a proliferation of backwater or otherwise lentic species (e.g., bluegill, largemouth bass, crappies) (Galat et al. 1998). However, if this is true, why did ichthyofaunal remains recovered at the mound sites vary so much with modern surveys?

One explanation pertains to how the ichthyofaunal remains data are interpreted. Ichthyofaunal remains recovered from the mounds actually reflect ancient fish exploitation by the Plum Bayou Culture. These data may or may not be reflective of the actual fish assemblage of Mound Lake at the time, as is depicted by the two modern fish surveys. Wheeler and Jones (1989) suggested that modern fisheries data could be used to make inferences regarding prehistoric fishing efforts. Yerkes (1981) cautioned against this approach, suggesting that changes in water quality and quantity related to agricultural and industrial development throughout North America would confound interpretations. Anthropogenic changes from agricultural land clearance during the 1800s and urbanization during the late 1900s have undoubtedly influenced the fish assemblage of Mound Pond during the past millennium. However, we feel it unlikely that Mound Pond would have had a drastically different fish assemblage during the time it was occupied by the Plum Bayou Culture. In particular, fluvial fishes (e.g., blue catfish, flathead catfish *Pylodictis olivaris*, and freshwater drum *Aplodinotus grunniens*) found in the remains were most likely already absent in Mound Pond by the time the site was occupied and the mounds built. So where did these fish species come from?

The Plum Bayou Culture falls into the Late Woodland period of Native American occupation of Arkansas. Although the specific use of aquatic resources within this culture varies from site to site, the general trend has been that Late Woodland cultures used fewer aquatic resources than their Mississippian descendants (Compton 2009). Kelly (2012) noted that fish remains comprised only 1.7% of the total sample from Mound S, which was surprisingly low considering the proximity of Mound Pond and other nearby water bodies. Although Kelly (2012) concluded that most of the fishes found could have been obtained from Mound Pond, it was suggested that the larger-bodied fishes (e.g., flathead and blue catfishes, longnose gar, and buffalofishes *Ictiobus* spp.) may have been harvested from other waters, such as the Arkansas River, and transported to the site. This suggestion would be consistent with the mismatch of fish species found in the mound remains compared to what was suspected to have existed in Mound Pond at the time the site was occupied. Such transporting of fishes from other waters might also explain the smallmouth bass *M. dolomieu* recorded from the mound remains (Hoffman 1982). At present, the closest significant smallmouth bass populations are located in the Little Red River, which is north of Mound Pond in the White River basin, and the Saline River, which is southwest in the Ouachita River basin. Communal feasting at the Toltec Mound site may have been an important cultural ceremony, justifying the transport of exotic food items from other parts of Arkansas (Lindauer and Blitz 1997).

Despite the ichthyofaunal remains recovered from the Toltec Mound Complex, the fishing habits of the Plum Bayou Culture are essentially unknown. Gorge-type fishhooks were considered to be the most primitive type of angling gear. Rostlund (1952) noted that these types of hooks were indistinguishable from other small pointed artifacts, and thus, not identifiable as fishhooks without ethnographic data. Carved fishhooks suitable for trotlines have been found in Arkansas in association with Late Mississippian (1350-1500 A.D.) sites, but have not been found at Plum Bayou sites (Morse and Morse 2009). During Baytown occupation (400-700 A.D) of the Meador Site (3SF414) in northwestern Arkansas, Compton (2009) inferred that the inhabitants had some form of mass fish capture technology such as nets or weirs on the basis of large numbers of small fishes. It is possible that the Plum Bayou people also had nets of some form. In contrast, Limp and Reidhead (1979) demonstrated that it was possible to capture large numbers of fishes by hand from isolated pools created by receding flood waters. Many of the fishes represented in the mound remains are floodplain-obligate fishes (e.g., buffalofishes, gars, bowfin *Amia calva*, bullheads *Ameiurus* spp., and various Centrarchidae). These species would have been common in such pools, a possibility also mentioned by Morse and Morse (2009).

Having now compared the modern fish assemblage in Mound Pond to the ichthyofaunal remains from the Toltec Mound Complex, we believe that only limited exploitation of the lake's fishery occurred by the Plum Bayou Culture that occupied the site a millennium ago. Of the 14 different fish species identified from ichthyofaunal remains from both mounds (Hoffman 1982, Kelly 2012), only four of these species (bowfin, largemouth bass, black bullhead *Ameiurus melas*, and channel catfish) are habitat generalists that remain present today in both Mound Pond and the adjacent Arkansas River (Robison and Buchanan 1988). Further explanation of this apparently odd behavior of the Plum Bayou people may lie in a cost-benefit analysis of fishing in the adjacent oxbow lake versus other means of meat capture. In addition, it might have been related to the cultural norms and taboos of the time that we are unable to assess today, or due to a lack of appropriate fish-capture technology. Continued excavations at 3LN42 may shed further light on this subject, and perhaps yield identifiable fishing artifacts in the future.

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