The Isthmus of Plenty

Faunal Analysis for the Site of Santa Isabel "A", Rivas, Nicaragua

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Introduction

The site of Santa Isabel "A" (*11° 28.5' north, 86° 12.5' west*) is located in the southwest corner of Nicaragua along the western coast of Lake Nicaragua (Figure 1). Previous archaeological work at the site is limited but the most extensive excavations were carried out by the Harvard University – Peabody Museum Nicaragua Project in 1959 and 1961. Results of these excavations were published in *Archaeology of the Rivas Region, Nicaragua* (Healy 1980). At the time of these excavations, very little was known about the archaeology of the Rivas region but previous work has been summarized by Healy (1980). Ceramic chronologies were used to date the 1959 and 1961 excavations to the Apompua, La Virgen, and Las Lajas phases, which correspond to the Postclassic period of Mesoamerica, and have led to suggestions that the indigenous inhabitants of Santa Isabel were the Nicarao mentioned by the Spanish Chroniclers. Since then, Carbon-14 dating techniques have been employed to more accurately date the site, suggesting that the site of Santa Isabel was in fact occupied prior to the Postclassic period form AD 900-1250 (McCafferty and Steinbrenner 2005).

A preliminary analysis of the faunal remains excavated during the 1959 and 1961 field seasons at the site of Santa Isabel was begun by Norweb in 1963, but was not completed until 1973 by Pohl and Healy (Healy 1980). Results of this analysis indicated that mammalian remains constituted the vast majority of faunal remains; white-tailed deer were the primary species recovered, constituting 78 % of the total vertebrate remains from the Las Lajas phase and 67 % from the La Virgen phase. Reptiles were the next most common vertebrates with four different species of turtle being recovered. Healy also noted a surprising lack of fish remains at the site (n = 1) despite the close proximity to Lake Nicaragua.

The conclusions reached by Pohl and Healy indicated that the early inhabitants of the area consumed meat on a regular basis and traded game with neighbours, likely for marine resources, which were also found at the site. Based on excerpts from the Spanish chronicles (Stone 1966) it was concluded that the distribution of meat was not egalitarian at the site and that distribution was controlled by an elite class, which presumably controlled the hunting of deer as well.

In light of the new evidence for the dating of the site, it is likely that the site of Santa Isabel was not constructed by the Nicarao but by an earlier group. The previous faunal analysis conducted by the Harvard University – Peabody Museum Nicaragua Project was based heavily on the ethnohistorical data available for the Nicarao, and is therefore unlikely to provide as much insight into the economy of this earlier group. Further investigation into the types of faunal remains, as well as there distribution throughout the site would provide a more accurate estimation of their economy, and the objective of this study was to determine the types of animal resources that were exploited as food at the site of Santa Isabel and the possible implications of these choices. A more thorough comparison of frequencies between classes of animals exploited can determine food preferences. Distribution analysis of exploited species, as well as specific cuts of meat can also help to identify class differences within the site.

Recently, the importance of food practices as indicators of social status has gained more attention (Jackson and Scott 2003). Distinctions between classes within a society can be determined by assessing the relative access to specific types and cuts of meat. The nutritional quality of the meat, along with culturally derived proscriptions and perceptions of quality are leading causes of this differential access (Jackson and Scott 2003). While the distribution of faunal remains within a site may be influenced by a variety of factors – such as differential preservation, discrete processing centres, individual household preference, or culturally distinct groups – it still stands that lower quality cuts of meat and less desirable taxa will be found in higher frequencies in lower status areas than in areas of high status. Research at other sites where elite and commoner middens have been identified according to other independent lines of evidence have supported this claim of class differentiation (Jackson and Scott 2003). At the site of Santa Isabel where areas of high and low status have not yet been identified, it can be assumed that the spatial distribution of faunal remains can act as an adequate correlate of the spatial distribution of social classes.

Natural History of the Isthmus of Rivas

The Isthmus of Rivas is a narrow stretch of land, approximately 30 km across at Rivas (Financial Times 2004), bounded by the Pacific Ocean to the west and Lake Nicaragua to the east (Figure 1). The elevation of the isthmus does not exceed 450 metres above sea level at any point, despite the chain of volcanoes that run parallel to the Pacific Coast (Healy 1980) (Figure 2). Presented here is a brief overview of the natural history of the Isthmus of Rivas, the area of Nicaragua where the site of Santa Isabel is located. This overview will be limited to the immediate region surrounding the site and will include a summary of the major geological events that heavily influenced the types of wildlife found in the area at the time of occupation, a description of the climatic patterns for the region, and an introduction to the flora and fauna, past and present.

Geology

The Great American Biotic Interchange occurred roughly three million years ago and was the result of the formation of a land bridge connecting North and Central America to the continental island of South America (Carr 1953, Rich and Rich 1983, and Webb 1997). Before the formation of this land bridge, the fauna of Central America was similar to that of North America; however, the climate was that of a tropical rainforest as opposed to the more temperate climate found further north. After the creation of the land bridge, climatic changes were noted in the area, leaving it drier than before and allowing for a pan-american faunal interchange that favoured those animals adapted to a drier, tropical savannah (Rich and Rich 1983 and Webb 1997). The faunal assemblage at the time of occupation at the site of Santa Isabel is highly dependent upon these events and represents a mixture of the Nearctic (North American) and the Neotropical (South American) faunal assemblages (Ryan et al 1970, Rich and Rich 1983, and Webb 1997), as discussed below.

The two lakes found within Nicaragua, Lake Managua and Lake Nicaragua, are both fresh water lakes today, but were originally confluent with the Pacific Ocean to the west. Extensive volcanic action resulted in these two lakes becoming land-locked – a phenomenon commonly referred to as the "trapped ocean" theory (Healy 1980). Over time, the salt water was replaced with fresh water within these lakes by rainfall and runoff from the Central Highlands, in combination with drainage by the Rio San Juan.

Although the lakes were once connected to the Pacific Ocean they are currently inhabited by a variety of marine species found only in the Atlantic Ocean, such as the Atlantic bull shark (*Carcharhinus leucas*) and the tarpon (*Tarpon atlanticus*) (Carr 1953, Ryan et al 1970, and Healy 1980). It is believed that these Atlantic species migrated up the Rio San Juan from the Atlantic Ocean and were trapped within the lakes after earthquakes effectively blocked the San Juan channel (Carr 1953).

A chain of volcanoes, running from the northwest to the southeast parallel to the Pacific Ocean, cuts across Nicaragua (Figure 2). These volcanoes lie along three major fault lines and have actively participated in the sculpting of western Nicaragua's varied landscapes. Two of these volcanoes – Concepción and Maderas – make up Ometepe Island, which is situated in the middle of Lake Nicaragua, and can be seen from the site of Santa Isabel. Volcanic activity in this area was much more frequent in the past (Renou 1980) and gave rise to the very fertile soils of the region that consist mainly of deep, porous ash deposits (Stevens 1964).

Climate

The climate of Nicaragua varies considerably throughout the country and includes regions classified as wet tropical, tropical wet and dry, and mild highland (Ryan et al 1970 and Healy 1980). The Isthmus of Rivas itself can be classified either as tropical wet and dry or as tropical savannah because of the distinct wet and dry seasons experienced in the region and the initial predominance of semi-deciduous tropical hardwood forests. Annual temperatures fluctuate between 24°C and 30°C with the relative humidity never falling below 50 %, even in the cooler winters (Ryan et al 1970 and Healy 1980). There is generally 1500-1800 mm of rainfall annually during the wet season, which extends from May through to October (Healy 1980 and Renou 1980).

Flora

Prior to the colonization of Nicaragua in the 1500s, the Isthmus of Rivas was predominantly covered by semi-deciduous tropical hardwood forests (Table 1) (Ryan et al 1970 and Healy 1980). The landscape has become quite altered over time and very few of these forests remain intact today, having been replaced by commercial crops and cattle ranches, or cut down for use as fuel or lumber (Ryan et al 1970).

Because of the fertility of the region, it has always been an agricultural centre of the country. Traditionally and during the present day, maize, beans, squash, cotton, and tobacco are the primary cultivates grown in the region (Healy 1980 and Renou 1980), with rice, sorghum, coffee, and sugarcane being added more recently (Koebel 1925, Healy 1980, Renou 1980, and USLC 2005). Many tropical fruits have also been introduced into the region, the most important being bananas (Koebel 1925, Healy 1980, Renou 1980, and USLC 2005). Across the region, the natural flora has been replaced by domestic plants, the majority of which are still being grown for consumption within the country rather than being produced for exportation.

Fauna

As mentioned above, the Biotic Interchange greatly affected the types of animals found along the Isthmus of Rivas, as well as throughout the rest of Central America. The faunal assemblage is a conglomeration of Nearctic (i.e. white-tailed deer, raccoon, and cougar) and Neotropical (i.e. peccary, opossum, parrot, and armadillo) animals (Ryan et al 1970). There is an extreme diversity of fauna in the region including a multitude of mammalian (Table 2), avian, reptilian, and fish species. The abundance and diversity of faunal species has suffered in this region as the result of drastic changes to the environment over the past 500 years, as well as the increased pressure on many animal species as the result of various human activities (Ryan et al 1970 and Healy 1980).

Few species, other than marine crustaceans from either coast and freshwater fish from Lake Nicaragua, are economically important to the region today (Renou 1980). In the past, however, the abundant wildlife was an extremely important part of the diet of early inhabitants of the isthmus. Freshwater fish and turtles, as well as two species of deer, peccary, armadillo, iguana, several bird species, and even boa constrictors constituted a large proportion of early diets (Ryan et al 1970, Joyce 1971, and Healy 1980). In addition to the dietary benefits of the local fauna, early inhabitants of the isthmus also exploited the region's natural resources for wealth, prestige, and ritual. The coveted quetzalcoatl bird was abundant in the region and its tail feathers were traded to neighbours, near and far for elite goods not readily available in the region (Healy 1980).

Methods and Materials

Recent excavations at the site of Santa Isabel were conducted by *Proyecto Santa Isabel, Nicaragua*, based out of the University of Calgary. Excavations were conducted over three years (2003-2005), from June through August each year. Identification of the faunal remains was conducted during the 2005 field season and was overseen by Bryanne Hoar (University of Calgary) and Angelica Lopez-Forment (Escuela Nacional de Antropología e Historia, Mexico). Mammalian remains were identified by Lopez-Forment, freshwater and marine shell was identified by Oscar Davalos (Universidad Nacional Autonoma de Nicaragua, Nicaragua), and the remainder of faunal remains were identified by Hoar, with help from members of the field crew. There were six major categories of faunal remains recovered and analyzed: Reptiles/Amphibians, Fish, Molluscs, Birds, Mammals, and Arthropods.

Due to unforeseen circumstances, the comparative collection was limited to a mere six skeletons – four fish species (*Cichlasoma citrinellum, Cichlasoma tuba, Cichlasoma* spp., and *Centropomas* spp); one bird (*Meleagris gallopano*); and one reptile (*Boa constrictor*). Because of the lack of available resources, identification of the faunal remains was very general. Reptiles were identified to the class level while classification of better known classes (i.e. mammals) was more exact and the majority of remains were identified to the family or genus level. To maintain consistency throughout, formal analyses of the data were limited to the class level.

The lack of resources also limited the types of analyses that could be conducted on the faunal remains. Mammalian, avian, arthropod, and fish remains were well identified and both element name and side could be assigned for the majority of the remains analysed. Reptile/amphibian remains were not as well identified. Because of this, the minimum number of individuals (MNI) could not be calculated for reptiles. As such, comparisons were based on calculations of the number of identified specimens (NISP) only.

NISP is not necessarily the most reliable method to use for comparing relative abundances between faunal classes since it does not take into account the differences in the total number of elements between classes (Reitz and Wing 2003). Using this analytical method one would expect classes with a greater number of elements (i.e. fish) to be relatively over-represented in the faunal assemblage, while classes with fewer elements (i.e. molluscs) would be under-represented. In order to correct for differential bias in identification and fragmentation of different elements, all calculated values of NISP were divided by the number of identified elements recovered per class, as described by Perkins and Daly (1968). Unknown or unidentifiable elements and fragments were excluded from the analysis.

Preservation is also an issue when using NISP. Different elements (i.e. bone, teeth, shell) are not always equally preserved and the elements of different species can show differential preservation (Reitz and Wing 2003). Thankfully, the preservation of faunal remains at the site of Santa Isabel was incredible and a wide range of faunal elements was well-preserved at the site, even small, fragile elements such as the ribs of fish.

NISP values of the six classes of animals were compared for the overall site; comparisons were also conducted between proportions of the total faunal remains for each class. NISP and proportions were then compared between six of the seven loci excavated at the site. Locus 6 was not compared to the other loci because only eleven faunal remains were found at this locus: ten reptile bones and one bird bone. By comparison, the average number of faunal remains at the other six loci was 3720.

MNI was calculated as described in Reitz and Wing (2003) for fish, mammals, and birds only. The most common diagnostic element identified in each taxon was used to estimate MNI. MNI calculations were based on symmetry in these three taxa, therefore only the left or the right elements (depending on which was more abundant in the taxa being analyzed) were included in the analysis. Multiplicity of specific axial elements was also accounted for in the analyses. For example, the total number of mammalian cervical vertebrae was divided by seven because a single mammal could potentially leave seven cervical vertebrae in the archaeological record. MNI was calculated using both species (or lowest taxonomic classification) and age for mammals only. Further analysis of mammal element distribution was also conducted to help determine status differences between loci as based on the quality of cuts of meat (Jackson and Scott 2003).

Formal statistical analysis was conducted using the Chi-Square Goodness-of-Fit test ($p = 0.05$) and compared either NISP or MNI values. It was assumed that if all loci were equivalent in status to one another and there were no distinct processing sites, then the relative abundances of each animal taxa at each loci would be equivalent to the relative abundances calculated for the overall site.

Results

ANIMAL TAXA

Reptiles/Amphibians

A total of 6642 bones were identified as either reptilian or amphibian at the site. Of these, 6498 were included in subsequent analyses; thirteen individual elements were identified. Two-thirds (n = 4329) of all reptile/amphibian remains were identified as turtle shell, mostly freshwater species. Another 20 % of the total (n = 1309) was constituted by vertebrae, 44 % (n = 576) of which were identified as snake vertebrae. Other reptiles identified in the faunal assemblage included caiman and iguana. There was a diversity of species and a wide range of sizes of reptile/amphibian bones recovered from the site of Santa Isabel.

Comparison of the number of reptile/amphibian remains using NISP values between loci demonstrated a significant difference in distribution across the site (Figure

3) (chi-square goodness of fit; df = 4, $\chi^2_{crit} = 9.49$; $\chi^2 = 16.7$). Fewer than expected reptile/amphibian remains were recovered from Locus 1, whereas more than expected reptile/amphibian remains were recovered from Locus 7. Observed values at all other loci were similar to the expected values calculated from the proportional representation of reptile/amphibian remains for the overall site.

Molluscs

A total of 1253 marine, freshwater, and terrestrial shells and shell fragments were recovered. Only 774 were identifiable to shell type – bivalve or gastropod. Two-thirds (66 %) of all identified shell recovered was from bivalve species, with the other one-third (34 %) made up of gastropods. One quarter (74 %) of shell was identified as freshwater (no species were identified) and 19 % was identified as marine (Table 3). A single terrestrial gastropod shell was recovered, belonging to *Euglandina* sp. (wolfsnail).

Comparison of the number of mollusc shells calculated using NISP between loci demonstrated a significant difference in distribution across the site (Figure 4) (chi-square goodness of fit; df = 4, $\chi^2_{crit} = 9.49$; $\chi^2 = 43.3$). Fewer than expected shells were recovered from Loci 3-5 and 7, whereas more than expected shells were recovered from Locus 1. Observed values at Locus 2 were similar to the expected values calculated from the proportional representation of mollusc shells for the overall site.

Fish

A total of 10502 fish bones were recovered from the site of Santa Isabel, with 6007 identified to element (n = 32). Approximately one-third (32%) of all fish remains were identified to species level using the available comparative collections. Of these, 46 % were classified as *Cichlasoma tuba* (cichlid), 36 % as *C. citronella*, 16 % as *C.* sp. (guapote pequeño), and 3 % as *Centropomus* sp. (snook). 185 ganoid scales, identified as belonging to *Astractosteus tropicus* (tropical gar), were also recovered from the site and it is possible that many of the unspeciated bones also belonged to this species. Two shark teeth were also recovered. Because of the close proximity of the site to Lake Nicaragua, it is possible that these teeth may have belonged to the world's only freshwater shark, a descendent of *Carcharinus leucas* (bull shark) (Healy 1980).

Comparison of the number of fish remains using NISP values between loci demonstrated a significant difference in distribution across the site (Figure 5) (chi-square goodness of fit; df = 4, $\chi^2_{crit} = 9.49$; $\chi^2 = 11.8$). Fewer than expected fish elements were recovered from Locus 2, whereas more than expected fish remains were recovered from Locus 4. Observed values at all other loci were similar to the expected values calculated from the proportional representation of fish bones for the overall site.

MNI estimates were calculated according to the most common diagnostic element. On average, MNI estimates were much higher than the NISP values for individual loci (x = 15.0) (Table 4); the MNI estimate (n = 268) was much higher than the NISP value (n = 188) for the overall site. Comparison of the MNI estimates for fish between loci demonstrated a significant difference (Figure 6) (chi-square goodness of fit; df = 4, $\chi^2_{crit} = 9.49$; $\chi^2 = 15.4$). Once again, there were fewer than expected fish remains recovered from Locus 2, but more than expected recovered from Locus 1.

Birds

A total of 1243 bones were identified as bird; 1178 were identified to element (n = 18). Wing bones constituted 17 % of all bird bones, while 12 % of the bones were leg bones and only 4 % were part of the pectoral girdle. Although there were a variety of sizes of bone, suggesting that several bird species were found at the site, an appropriate comparative collection was not available to identify these bones to the species level. Several of the larger bones were similar to the domestic turkey skeleton and may have been a domestic turkey, or another large bird such as *Crax rubra* (great curassow) (Amadon 1983) or *Cathartes aura* (turkey vulture) (Stiles and Janzen 1983). Several dense long bones lacked the characteristic pneumatization of birds, suggesting that species of diving duck were exploited at the site (Pough et al 2005).

Comparison of the NISP of bird remains between loci demonstrated no significant difference in distribution across the site (Figure 7) (chi-square goodness of fit; df = 4, $\chi^2_{crit} = 9.49$; $\chi^2 = 5.28$). However, fewer than expected bird elements were recovered from Locus 1 and there were more elements than expected recovered from Locus 2. Observed values at all other loci were similar to the expected values calculated from the proportional representation of bird elements for the overall site.

MNI estimates were calculated according to the most common diagnostic element. On average, MNI estimates and NISP values were roughly equivalent for individual loci (x = -0.50) (Table 4); however, the NISP value (n = 65) was higher than the MNI estimate (n = 47) for the overall site. Comparison of the MNI estimates for birds between loci demonstrated no significant difference (Figure 8) (chi-square goodness of fit; df = 4, $\chi^2_{crit} = 9.49$; $\chi^2 = 2.24$). In accordance with the results from comparison of NISP values, there appear to have been more bird remains than expected recovered from Locus 2.

Mammals

A total of 2689 mammal bones were recovered from the site, with 2082 classified as belonging to one of thirty-two identifiable elements. The majority of bones (86 %) were identified to order or lower taxonomic level (Table 5). The majority of identified mammal remains were deer (57 %), followed by armadillo (32 %), opossum (4 %), and rabbits or hares (3 %). The remaining taxa combined made up less than 4 % of the total.

The deer bones were further analyzed to compare the relative abundances of various elements or cuts of meat at the six loci. Because deer bones were well-described and found in relatively large amounts at each loci (compared to other identified species of this body size), these remains were used to assess butchering patterns across the site. By comparing element representation at each locus, the relative status of loci and/or potential processing sites could be identified.

Elements were divided into three major categories initially (Table 6): cranial elements (17 %), post-cranial axial elements (26 %), and appendicular elements (57 %). Each of these categories was then further subdivided. The three most common cranial elements were loose teeth (53 %), mandibles (16 %), and cranial bones of the braincase (16 %); post-cranial axial elements were mostly ribs (29%), thoracic vertebrae (28 %), and lumbar vertebrae (15 %); and the most common appendicular elements were phalanges (26 %), ulnas and/ or radii (13 %), and tarsals (12 %). Hindlimbs (33 %) and forelimbs (32 %) were equally represented in the faunal assemblage. The various types of deer remains were equally distributed across the site and no individual ~~loci~~ locus had consistently higher or lower cuts of meat.

Comparison of the NISP values for mammal remains between loci demonstrated a significant difference in distribution across the site (Figure 9) (chi-square goodness of fit;

df = 4, χ^2_{crit} = 9.49; χ^2 = 11.3). Fewer than expected mammal elements were recovered from Locus 1, whereas more than expected mammal remains were recovered from Locus 2. Observed values at all other loci were similar to the expected values calculated from the proportional representation of mammal elements for the overall site.

MNI estimates were calculated according to the most common diagnostic element. On average, MNI estimates were higher than the NISP values for individual loci (x = 5.20) (Table 4); the MNI estimate (n = 77) was higher than the NISP value (n = 65) for the overall site. Comparison of the MNI estimates for mammals between loci demonstrated a significant difference (Figure 10) (chi-square goodness of fit; df = 4, χ^2_{crit} = 9.49; χ^2 = 34.0). Results for this comparison support those obtained from the comparison of NISP values, with fewer than expected mammal remains recovered from Locus 1 and more than expected recovered from Locus 2.

Arthropods

Only 33 arthropod elements were recovered at the site of Santa Isabel, all of which were chelipeds of crabs. Species was not determined, although all elements were very similar and likely constituted a single genus and/ or species of crab.

Comparison of the number of arthropod remains using NISP values between loci demonstrated a significant difference in distribution across the site (Figure 11) (chi-square goodness of fit; df = 4, χ^2_{crit} = 9.49; χ^2 = 24.7). Fewer than expected arthropod elements were recovered from Locus 2, whereas there were more than expected arthropod remains recovered from Locus 5. Observed values at all other loci were similar to the expected values calculated from the proportional representation of arthropod elements for the overall site.

Across Site and Between Loci Comparisons

Overall Site Comparison

There were 22362 faunal elements recovered in total across the site of Santa Isabel (Figure 12). Almost half of all remains were classified as fish (47 %), while 30 % were reptile/amphibian and 12 % were mammal. Number of identified specimens was also calculated for each of the six major taxa of animals recovered (Figure 13A). The across site comparison of NISP demonstrated marked differences from the overall count and these were the values used in all analyses. Using NISP to compare relative frequencies, reptiles/amphibians (41%) constituted the greatest proportion of the overall faunal assemblage, followed by molluscs (31 %), and then fish (15 %) (Figure 13B).

Comparison of observed values for all animal taxa to expected values (Figure 14) (n = 83.3; assuming each taxa should be equally represented within the faunal assemblage when using standardized NISP values) demonstrated a significant difference in proportional representation (chi-square goodness of fit; df = 4, $\chi^2_{crit} = 9.49$; $\chi^2 = 915$). Figure 15 illustrates the relative proportions of each class at six of the seven loci excavated. Only the number of fish remains was similar to expected values. Arthropods, birds, and mammals were all underrepresented in the overall faunal assemblage, whereas molluscs and reptiles/amphibians were overrepresented.

Locus 1

There were 5822 faunal remains recovered from Locus 1, representing each of the six major taxa (Figure 16). Molluscs constituted 41 % of the total, followed by reptiles/amphibians (35 %), and then fish (14 %). According to the chi-square distribution, when comparing NISP values, there were more mollusc shells than expected and fewer reptile/amphibian, mammal, and bird elements than expected recovered from Locus 1. Comparison of MNI estimates demonstrated that there were more fish remains than expected and much fewer mammalian elements. Compared to the other loci, Locus 1 had the most mollusc shells and the least bird, mammal, and reptile/amphibian remains.

Locus 2

A total of 4956 faunal remains were recovered from Locus 2, representing each of the six major taxa (Figure 17). Reptiles/amphibians constituted 40 % of the total, followed by molluscs (32 %), and then fish (12 %). According to the chi-square distribution, when comparing NISP values, there were more bird and mammal elements than expected and fewer arthropod and fish elements than expected recovered from Locus 2. Comparison of MNI values for birds, fish, and mammals support these results. Locus 2 had the most bird and mammal remains and the least arthropod and fish remains of all loci.

Locus 3

There were 363 faunal remains recovered from Locus 3, representing each of the six major taxa (Figure 18). Reptiles/amphibians constituted 61 % of the total, followed by fish (23 %), and then birds (9 %). According to the chi-square distribution, when comparing NISP values, there were fewer mollusc shells than expected recovered from Locus 3 and more reptile/amphibian elements recovered. There were no differences detected when MNI values of birds, mammals, and fish were compared for this locus.

Locus 4

There were 3435 faunal remains recovered from Locus 4, representing each of the six major taxa (Figure 19). Reptiles/amphibians constituted 40 % of the total, followed by molluscs (24 %), and then fish (22 %). According to the chi-square distribution, when comparing NISP values, there were more fish elements than expected and fewer mollusc shells than expected recovered from Locus 4. There was no difference detected for MNI estimates of fish. Overall, Locus 4 had the most fish remains when compared to the five other loci.

Locus 5

A total of 599 faunal remains were recovered from Locus 5, representing each of the six major taxa (Figure 20). Reptiles/amphibians constituted 51 % of the total, followed by fish (19 %), and then arthropods (14 %). According to the chi-square distribution, when comparing NISP values, there were more arthropod elements than expected and fewer mollusc shells than expected. Locus 5 had the most arthropod chelae relative to other animal classes of all loci compared.

Locus 6

There were only eleven faunal remains recovered from Locus 6, representing only two of the six major taxa – reptiles/amphibians and birds. The sample size was too small and compromised comparative results; therefore, Locus 6 was removed from all comparisons.

Locus 7

There were 1386 faunal remains recovered from Locus 7, representing each of the six major taxa (Figure 21). Reptiles/amphibians constituted 62 % of the total, followed by fish (16 %), and then molluscs (12 %). According to the chi-square distribution, when comparing NISP values, there were more reptile/amphibian elements than expected and fewer mollusc shells than expected recovered from Locus 7. Compared to the other loci, Locus 7 had the most reptile/amphibian remains and the least amount of mollusc shell.

Discussion

There was a wide variety of faunal remains recovered from the site of Santa Isabel, Nicaragua, constituting six major animal classes. The diversity of faunal remains (at all taxonomic levels) indicates that the people that inhabited this area had a varied diet. All utilized resources would have been available in the local environment of the site at the time of occupation, except for marine resources. However, the distance to the Pacific Ocean is limited and trade for marine resources may not have been necessary to acquire these resources, although trade with more coastal peoples may have occurred.

Animal Taxa

Almost half of all the faunal elements recovered were fish, not surprising considering the close proximity of the site to both Lake Nicaragua and the Pacific Ocean. Most of the fish bones excavated at Santa Isabel were relatively small, suggesting that the inhabitants of the area fished primarily for smaller species and/ or individuals (less than one foot in length). Identified elements also suggested that freshwater resources were much more important than were marine species. All fish bones classified to the species level were freshwater species, except for the tropical gar, which is found in marine environments.

The abundance of reptile/amphibian (namely turtle) remains would suggest that these resources were amongst the most abundant and efficient sources of animal protein in the area. Once again, the faunal assemblage suggests that freshwater and/or mud turtles were a more important part of subsistence strategies than were sea turtles. Other reptiles identified in the faunal assemblage include *Ctenosaura similis* (an iguana species that is preferred over the more common green iguana) (Fitch and Hackforth-Jones 1983), *Caiman crocodilus* (spectacled caiman) (Dixon and Staton 1983), and several unknown species of snakes. Because the area was tropical at the time of occupation (Ryan et al 1970 and Healy 1980), lizards and snakes would have been abundant in the area. Iguanas and snakes, especially larger species such as *Boa constrictor* (Greene 1983) and *Crotalus durissus* (tropical rattlesnake) (Scott 1983) continue to be eaten by indigenous peoples today.

Molluscs were also an abundant resource; however, it is unclear whether the amount of shell excavated is representative of dietary contribution. Many of the bivalve shells and shell fragments that were excavated at Santa Isabel could have been acquired (through trade or gathering) for other purposes, such as production of jewellery or ornamentation, and showed signs of cultural alteration. Most of the gastropod shells were too damaged to detect tool marks and freshwater species may have been too fragile to drill. However, according to Figure 15, the locus farthest from the lake shore – Locus 7 – had the fewest mollusc shells of all loci compared (relative to expected values), suggesting that at least some molluscs were being collected for subsistence.

Mammals were among the more rare faunal remains recovered at the site. These animals may have been more difficult to acquire than fish, turtles, or molluscs, but in the case of deer, may have provided more meat per time invested. The two most prevalent mammal species were white-tailed deer (*Odocoileus virginianus*) and armadillo (*Dasypus novemcinctus*). Defensive behaviour of armadillos is similar to turtles in that they rely predominantly on their external armour for protection, although they will initiate a characteristic leap-hop to avoid the grasp of potential predators (Wetzel 1983). Unfortunately for armadillos, this defence mechanism is useless against humans and renders them easy prey.

Bird remains were very diverse and further classification of these remains to the species level may prove interesting. Most of the remains were from middle sized species, approximately the size of a chicken, and most likely contributed to the diet of early inhabitants. Bones of some smaller species that likely were not a part of early diets were also excavated at the site, but these bones constituted a small proportion of the total. Evidence of larger species was also found at the site, however, there is no conclusive evidence to suggest that domesticated turkeys were raised at Santa Isabel. Wild turkeys (*Meleagris gallopavo*) are only found as far south as Mexico (Edwards 1972) and introduction of turkeys to Nicaragua would have required anthropogenic intervention.

Across Site and Between Loci Comparisons

Distribution of the faunal remains indicated that there was not a random dispersal of animal class across the site, as would be expected if access to resources was independent of locus. Ethnohistorical sources for the region suggest that deer hunting may have been a symbol of status in Nicaragua and that hunting was highly structured and limited to the elite class (Stone 1966). While Locus 2 had more mammal remains than expected – possibly indicating a higher status area – analysis of the distribution of deer elements demonstrated that all six loci compared had equal access to this resource.

Despite differences between the loci, the overall representation of animal class at each locus suggests they were all approximately equal in status. Although each locus had significantly more or less faunal remains of one or more animal class, no clear relationship between social status and dietary composition could be determined. However, if hunting of deer was limited to the elite class (Stone 1966), Locus 2 may be higher in status than the other loci. Locus 2 had the most mammal and bird remains of all loci compared and deer elements constituted 55.9 % of the mammal assemblage at this locus.

PREVIOUS EXCAVATIONS

The types and abundances of animals recovered during recent excavations contrasts sharply with the analysis of previous excavations. An earlier faunal analysis of excavations in 1959 and 1961 by Pohl and Healy (1980) differs drastically from this analysis. Results obtained in the earlier analysis are similar with respect to mammals and reptiles, but none of the other animal classes. Many of the same mammalian species were noted, albeit at different frequencies and reptiles were limited to turtles, which was the most abundant reptile recovered during recent excavations. The most marked difference between the two faunal analyses was the lack of fish and birds recorded for the initial excavation. Pohl and Healy (1980) indicate a single fish element (compared to 10502 from recent excavations) and no bird bones (compared to 1243).

Pohl and Healy (1980) also reached two main conclusions that were not strongly supported by the 2003-2005 excavations. The first, and less contentious, of these conclusions was that the early inhabitants of Santa Isabel traded game for marine resources. This conclusion was based largely on the presence of marine shell at the site; however, the site of Santa Isabel is relatively close to the Pacific Ocean and inhabitants may have had access to marine resources in the absence of trade networks. In addition, deer remains were the most abundant game resource utilized at the site and constituted a mere 12 % of the total assemblage. Available data is not sufficient to determine whether game from Santa Isabel was traded for marine resources with peoples closer to the coast.

Pohl and Healy (1980) also concluded that the distribution of faunal resources was not egalitarian. As mentioned earlier, the increased amount of mammal, and possibly bird and reptile/amphibian remains, at Locus 2 may support this conclusion; however, the other five loci do not show any clear evidence of stratification. In addition, the distribution of deer elements across the site (the basis of Pohl and Healy's conclusion) was egalitarian. Although Pohl and Healy's (1980) conclusion was supported by ethnohistoric sources (Stone 1966), re-evaluation of the ceramic chronology at Santa Isabel (McCafferty and Steinbrenner 2005) suggests that the site was occupied prior to the Postclassic and ethnohistoric sources may not be representative of this earlier time period.

Conclusion

Analysis of the faunal remains excavated from the site of Santa Isabel, Nicaragua suggest that inhabitants of the site had a diverse and varied diet that included seven different classes of animals – reptiles, amphibians, fish, molluscs, birds, mammals, and arthropods. Although classification of the faunal remains was limited by available resources, NISP values for each class suggested that reptiles/amphibians constituted the greatest proportion of the faunal assemblage, followed by fish and molluscs. The distribution of resources was not random across the site, however, there was no clear indication of status differences between the six loci compared. Incorporation of other artifact types (ceramincs, lithics, ornamentation, etc.) may clarify any status differences between loci.

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TABLE 1: Selected Flora of Rivas

Mahogany	*Swietenia macrophylla*	Lignum Vitae	*Guaiacum* sp.
Spanish Cedar	*Cedrela odorata*	Pine	*Pinus oocarpa*
Sapote	*Pachira* sp.	Ebony	*Diospyros virginiana*
Laurel	*Cordia* sp.	Sweet Gum	*Liquidambar styraciflua*
Cashew	*Anacardium* sp.	Ceiba	*Bombax ceiba*
Rubber	*Castilla* sp.	Banana	*Musa sapientum*
Balsa	*Ochroma* sp.	Plantain	*Musa paradisiacal*
Guava	*Psidium* sp.	Tobacco	*Nicotiana tabacum*
Cacao	*Theobroma cacao*	Squash	*Cucurbita* sp.
Sapodilla	*Achras zapota*	Beans	*Phaseolus* sp.
Coconut Palm	*Cocos nucifera*	Chili Pepper	*Capsicum* sp.
Rosewood	*Amyris balsamifera*	Corn	*Zea mays*

(after Healy 1980:13)

TABLE 2: Selected Mammals of Rivas

Opossum	*Didelphis marsupialis*	Collared Peccary	*Pecari tajacu*
Gray Fox	*Urocyon cineoargenteus*	Brocket Deer	*Mazama americana*
Squirrel	*Sciurus variegatoides*	White-tailed Deer	*Odocoileus virginianus*
Agouti	*Dasyprocta punctata*	Rabbit	*Sylvilagus floridianus*
Porcupine	*Coendu Mexicana*	Coyote	*Canis latrans*
Anteater	*Tamandua tetradactyla*	Jaguar	*Felis onca*
Raccoon	*Procyon lotor*	Two-toed Sloth	*Choloepus hoffmani*
Coati	*Nasua narica*	Kinkajou	*Potos flavus*
Tapir	*Tapirus bairdii*	Spider Monkey	*Ateles geoffroyi*
Weasel	*Mustela frenata*	Howler Monkey	*Allouatta palliata*
Ocelot	*Felis pardalis*	Cougar	*Felis concolor*

(after Healy 1980:15)

TABLE 3: Marine Molluscs Recovered at Santa Isabel, Nicaragua

Shell Type	Classification	Common Name	Number	Percent
bivalve	*Spondylus* spp.	thorny oyster	54	37.8
	Anadara similis	mangrove cockle	5	3.50
	Dosinia dunkeri	Venus clam	2	1.40
	Atrina spp.	penshell	1	0.699
	Glycymeris gigantea	giant bittersweet	1	0.699
gastropod	*Strombus* spp.	conch	12	8.39
	Morum spp.	morum	2	1.40
	Muricanthus ambigu	murex	1	0.699
	Fissurellidae	limpet	1	0.699
	Lyropecten spp.	scallop	1	0.699

TABLE 4: NISP and MNI Values for the Six Major Taxa Recovered from the Site of Santa Isabel, Nicaragua

Locus		Taxa	Total*	NISP	MNI (# of species)
Overall Site		Reptiles/Amphibians	6626	500	–
		Molluscs	1246	387	–
		Fish	10502	188	268
		Birds	1243	65	47
		Mammals	2689	65	77(14)
		Arthropods	33	33	–
	Total		**22339**	**1238**	**392**
Locus 1		Reptiles/Amphibians	2300	176	–
		Molluscs	460	205	–
		Fish	3832	69	121
		Birds	398	21	20
		Mammals	642	16	14(13)
		Arthropods	14	14	–
	Total		**7646**	**501**	**155**
Locus 2		Reptiles/Amphibians	1934	147	–
		Molluscs	433	115	–
		Fish	2424	43	55
		Birds	516	27	23
		Mammals	1231	30	51(13)
		Arthropods	2	2	–
	Total		**6540**	**364**	**129**
Locus 3		Reptiles/Amphibians	170	12	–
		Molluscs	45	0.5	–
		Fish	254	5	8
		Birds	32	2	1
		Mammals	26	0.8	4(4)
		Arthropods	0	0	–
	Total		**527**	**20.3**	**13**
Locus 4		Reptiles/Amphibians	1181	89	–
		Molluscs	255	53	–
		Fish	2974	50	68
		Birds	206	11	11
		Mammals	519	12	15(8)
		Arthropods	8	8	–
	Total		**5143**	**223**	**94**
Locus 5		Reptiles/Amphibians	253	19	–
		Molluscs	20	2	–
		Fish	352	7	11
		Birds	29	2	3
		Mammals	138	3	6(5)
		Arthropods	5	5	–
	Total		**797**	**38**	**20**
Locus 7		Reptiles/Amphibians	772	57	–
		Molluscs	33	12	–
		Fish	666	15	27
		Birds	61	3	5
		Mammals	133	3	6(5)
		Arthropods	4	4	–
	Total		**1669**	**94**	**38**

* total number of elements for the overall site includes elements recovered from Locus 6.

TABLE 5: Mammals Recovered at Santa Isabel, Nicaragua

Order	**Family**	**Species**	**Common Name**
Artiodactyla	Cervidae	*Mazama americana*	red brocket deer
		Odocoileus virginianus	white-tailed deer
	Tayassuidae	*Tayassu tajacu*	collared peccary
Carnivora	Canidae		dog family
	Procyonidae	*Bassariscus sumichrasti*	cacomistle
		Nasua narica	white-nosed coati
		Procyon lotor	northern raccoon
Lagomorpha	Leporidae	*Sylvilagus floridanus*	eastern cottontail
Metatheria	Didelphidae	*Didelphis marsupialis*	southern opossum
Rodentia	Agoutidae	*Agouti paca*	agouti paca
	Dasyproctidae	*Dasyprocta punctata*	Central American agouti
	Erethizontidae	*Coendus mexicanus*	porcupine
	Geomidae		pocket gopher
Xenarthra	Dasypodidae	*Dasypus novemcinctus*	nine-banded armadillo

TABLE 6: Mammal Elements Recovered at Santa Isabel, Nicaragua

Category	Element	Number	Percent
Cranial	braincase	28	16.28
	maxilla	10	5.81
	mandible	28	16.28
	tooth	92	53.49
	antler	14	8.14
	Total Cranial	**172**	**16.98**
Post-cranial Axial	cervical vertebra	21	7.78
	thoracic vertebra	76	28.15
	lumbar vertebra	41	15.19
	sacrum	4	1.48
	caudal vertebra	1	0.37
	rib	78	28.89
	Total Post-cranial Axial	**270**	**26.26**
Appendicular	unknown long bones	49	8.58
	phalanx	147	25.74
Forelimb	pectoral girdle	22	3.85
	humerus	31	5.43
	ulna/ radius	72	12.61
	carpal	19	3.33
	metacarpal	41	7.18
	Total Forelimb	185	32.40
Hindlimb	pelvic girdle	13	2.28
	femur	40	7.01
	patella	17	2.98
	tibia/ fibula	39	6.83
	tarsal	66	11.56
	metatarsal	15	2.63
	Total Hindlimb	190	33.27
	Total Appendicular	**571**	**56.76**

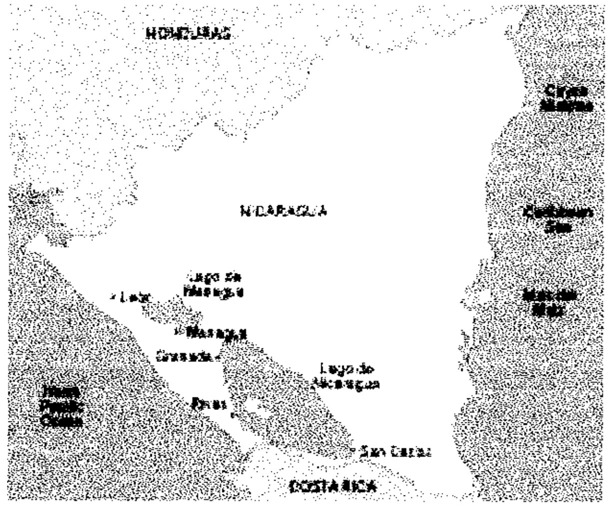


Figure 1: Map of Nicaragua. Major cities are indicated on the map. The site of Santa Isabel, Rivas, Nicaragua is located on the western shore of Lake Nicaragua north of the city of Rivas.

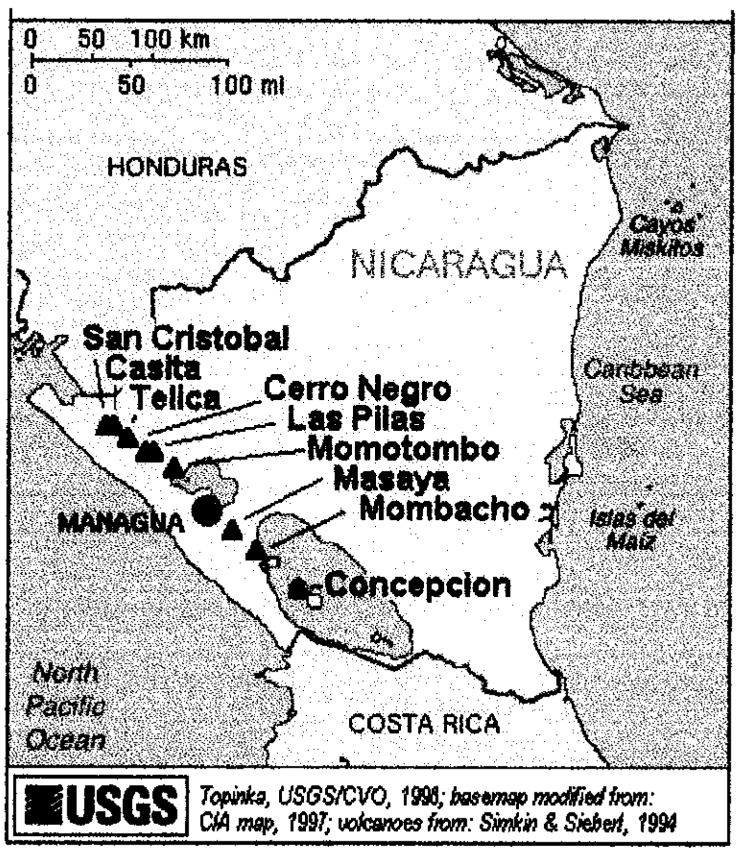


Figure 2. Map of Nicaragua. Major active volcanoes are indicated on the map. Ometepe Island in Lake Nicaragua consists of two volcanoes – Concepcion and Maderas, which is not indicated on the map because it is no longer active.

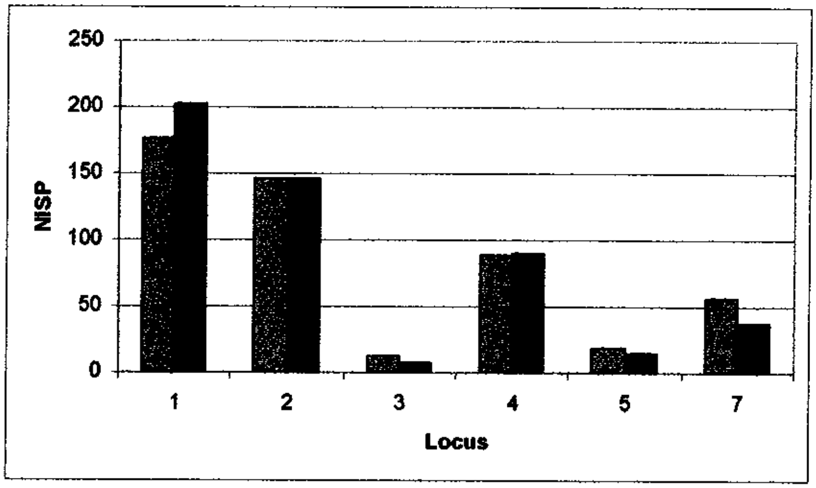


Figure 3: Observed and expected NISP values for reptile/amphibian elements for the six major loci (1-5 and 7). There was a significant difference found between loci (df = 4; χ^2 = 16.7). This difference is likely due to the observed values at Loci 1 and 7. Observed values are shown in blue and expected values are shown in burgundy.

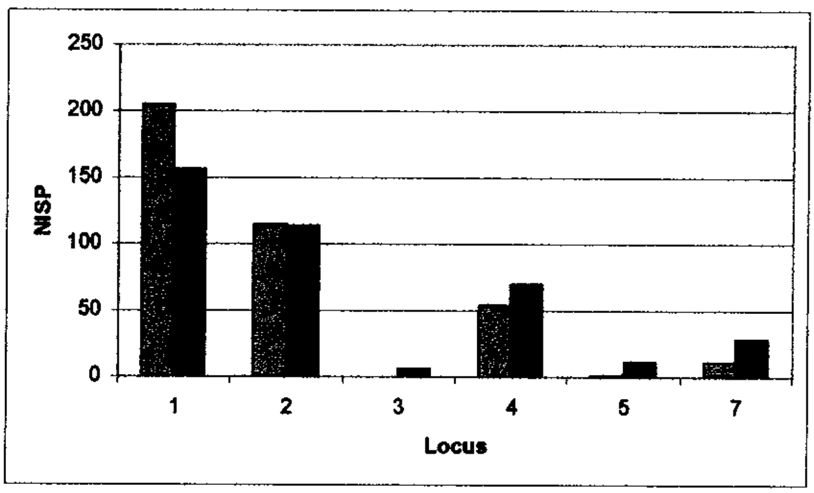


Figure 4: Observed and expected NISP values for mollusc shell for the six major loci (1-5 and 7). There was a significant difference found between loci (df = 4; χ^2 = 43.3). This difference is likely due to the observed values at all loci, except Locus 2. Observed values are shown in blue and expected values are shown in burgundy.

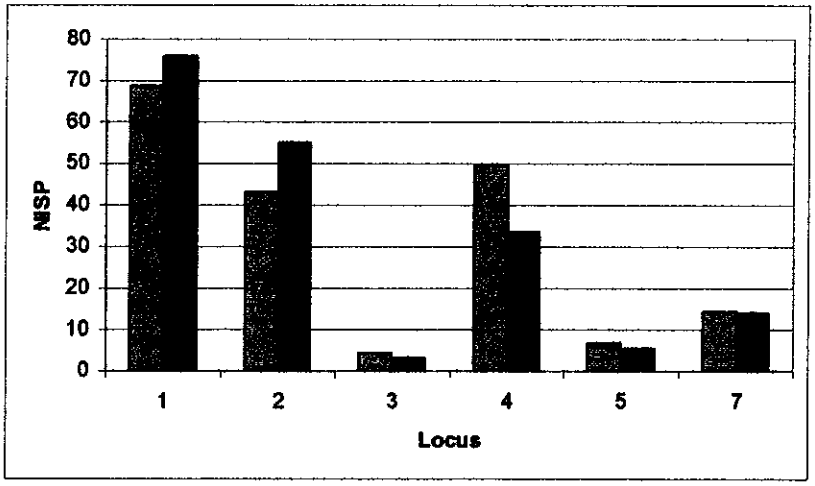


Figure 5: Observed and expected NISP values for fish remains for the six major loci (1-5 and 7). There was a significant difference found between loci (df = 4; χ^2 = 11.8). This difference is likely due to the observed values at Loci 2 and 4. Observed values are shown in blue and expected values are shown in burgundy.

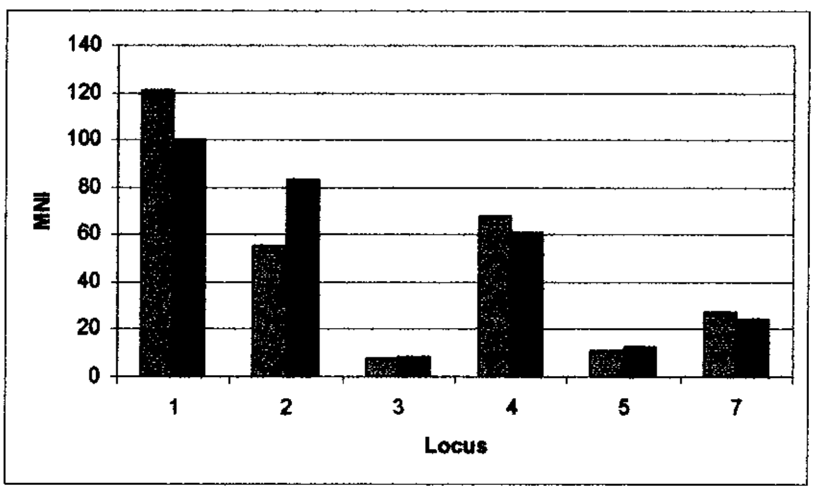


Figure 6: Observed and expected MNI values for fish remains for the six major loci (1-5 and 7). There was a significant difference found between loci (df = 4; χ^2 = 15.4). This difference is likely due to the observed values at Loci 1 and 2. Observed values are shown in blue and expected values are shown in burgundy.

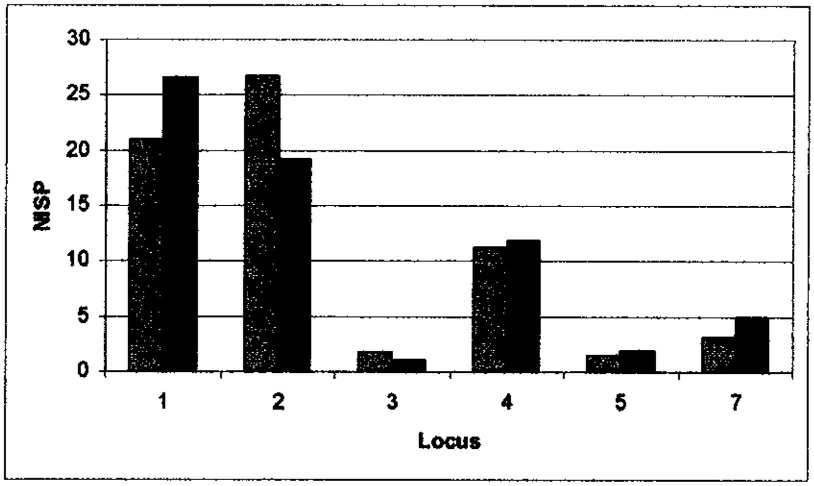


Figure 7: Observed and expected NISP values for bird remains for the six major loci (1-5 and 7). There was no significant difference found between loci (df = 4; χ^2 = 5.28), although Locus 1 had fewer than expected bird elements and there were more elements than expected recovered from Locus 2. Observed values are shown in blue and expected values are shown in burgundy.

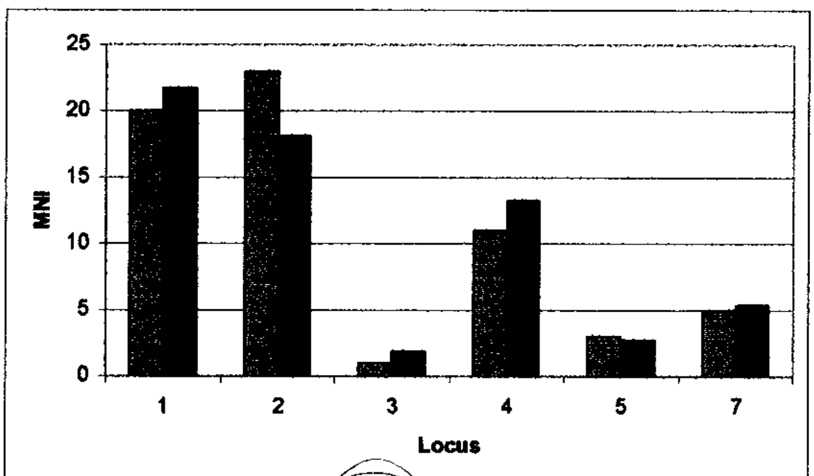


Figure 8: Observed and expected MNI values for bird remains for the six major loci (1-5 and 7). There was no significant difference found between loci (df= 4; χ^2 = 2.24), although and there were more elements than expected recovered from Locus 2. Observed values are shown in blue and expected values are shown in burgundy.

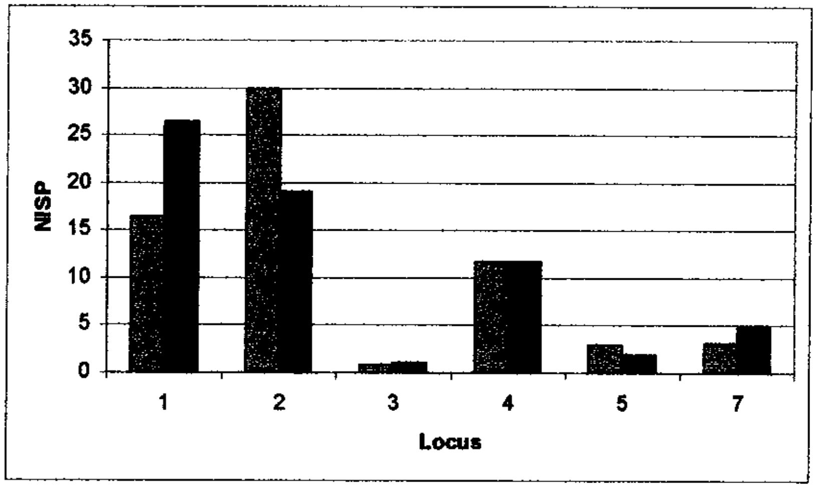


Figure 9: Observed and expected NISP values for mammal remains for the six major loci (1-5 and 7). There was a significant difference found between loci (df = 4; χ^2 = 11.3). This difference is likely due to the observed values at Loci 1 and 2. Observed values are shown in blue and expected values are shown in burgundy.

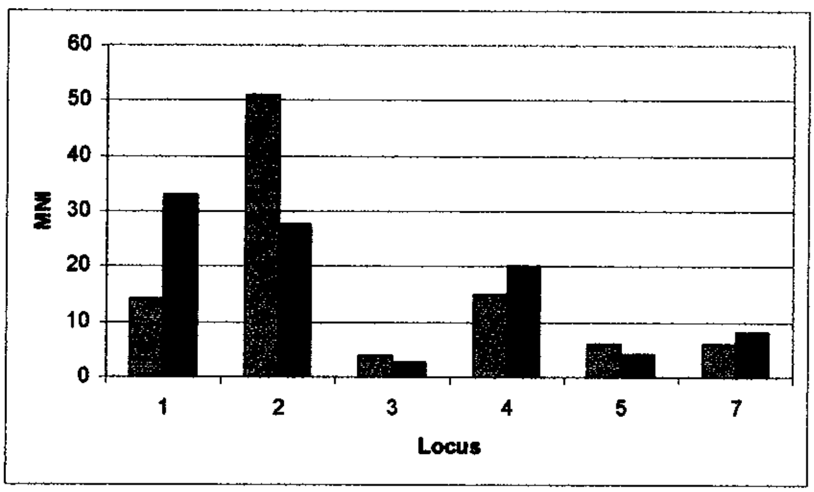


Figure 10: Observed and expected MNI values for mammal remains for the six major loci (1-5 and 7). There was a significant difference found between loci (df = 4; χ^2 = 34.0). This difference is likely due to the observed values at Loci 1 and 2. Observed values are shown in blue and expected values are shown in burgundy.

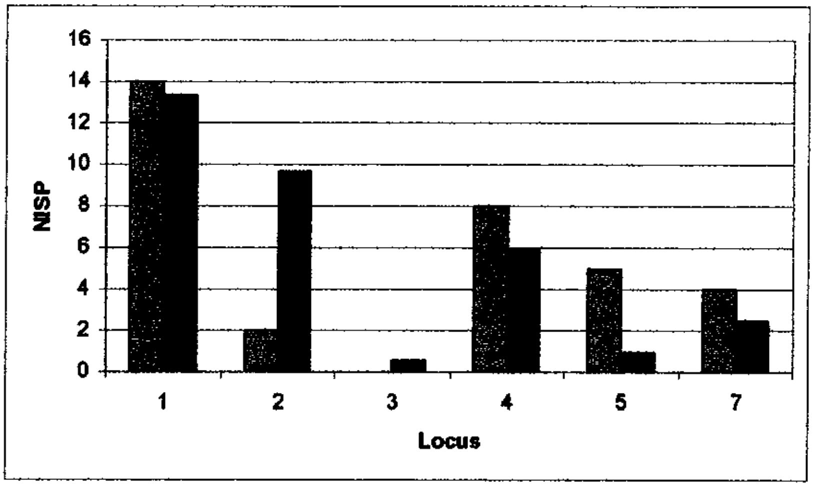
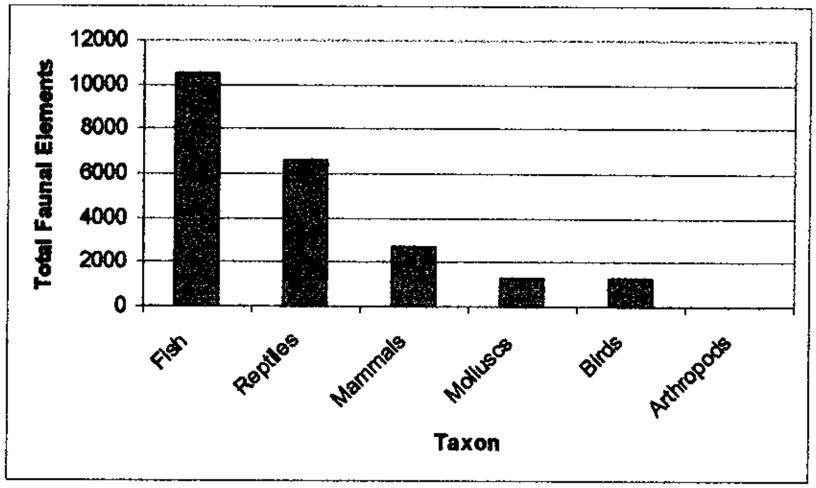


Figure 11: Observed and expected NISP values for arthropod remains for the six major loci (1-5 and 7). There was a significant difference found between loci (df = 4; $\chi^2 = 24.7$). This difference is likely due to the observed values at Loci 2 and 5. Observed values are shown in blue and expected values are shown in burgundy.

A)



B)

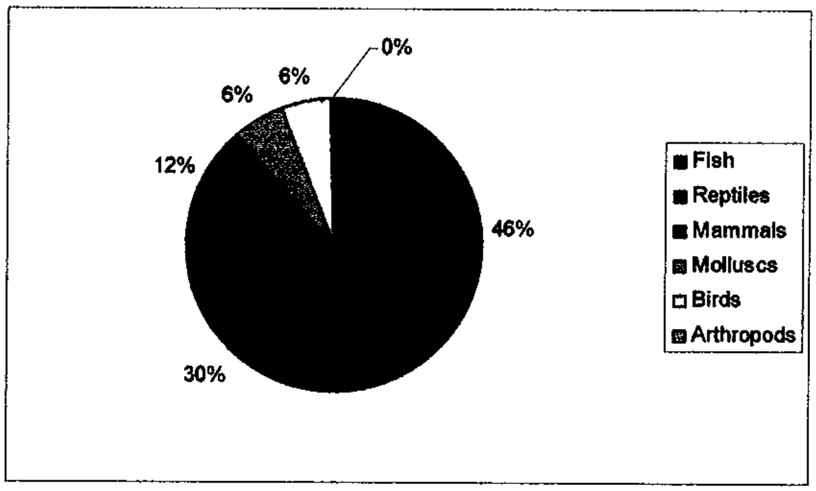
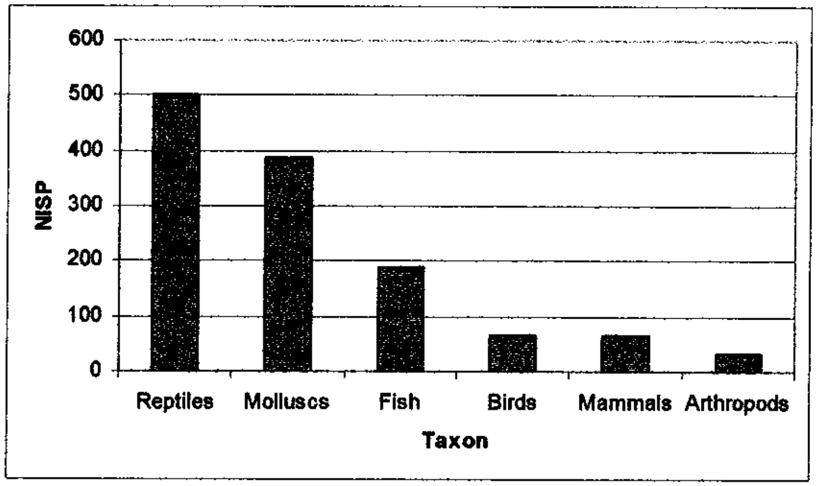


Figure 12: Comparison of the total number of elements recovered for each major taxa of animal across the site of Santa Isabel. The total includes all bone fragments not included in the NISP calculations. A) Number of elements found for each of the six categories; B) amount of remains recovered for each of the categories as a proportion of the total number of faunal remains recovered.

A)



B)

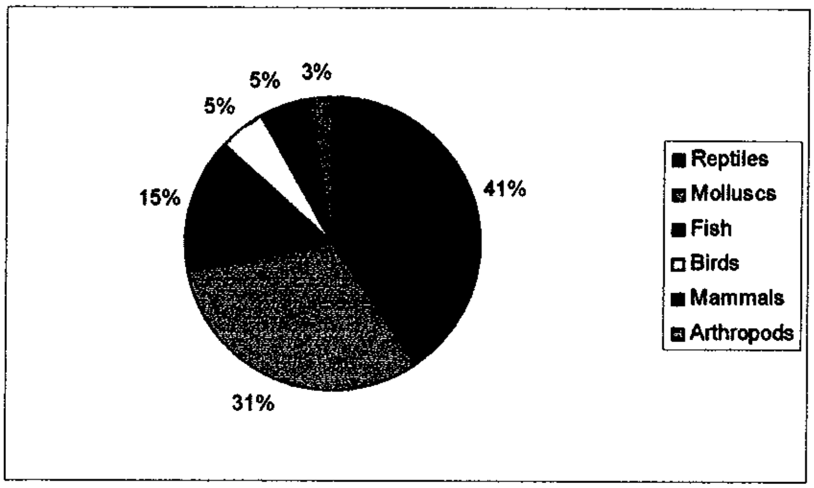


Figure 13: NISP for each of the six major taxa of animals compared across the site of Santa Isabel, Nicaragua. A) NISP for each of the six categories; B) NISP for each of the categories as a proportion of the total.

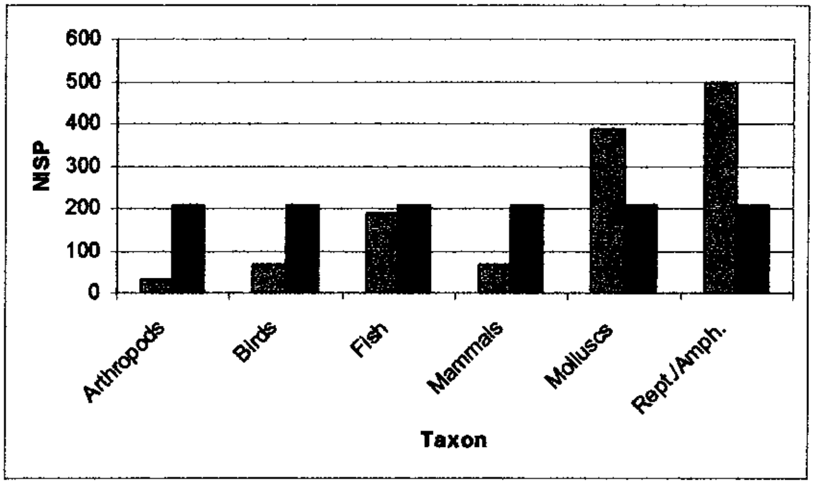


Figure 14: Observed and expected values for all six animal taxa for the overall site of Santa Isabel, Nicaragua. There was a significant difference found between taxa (df = 4; $\chi^2 = 915$). Fish was the only taxon with observed values similar to the expected value of 206 elements when assuming all taxa should be equally represented at the site. Observed values are shown in blue and expected values are shown in burgundy.

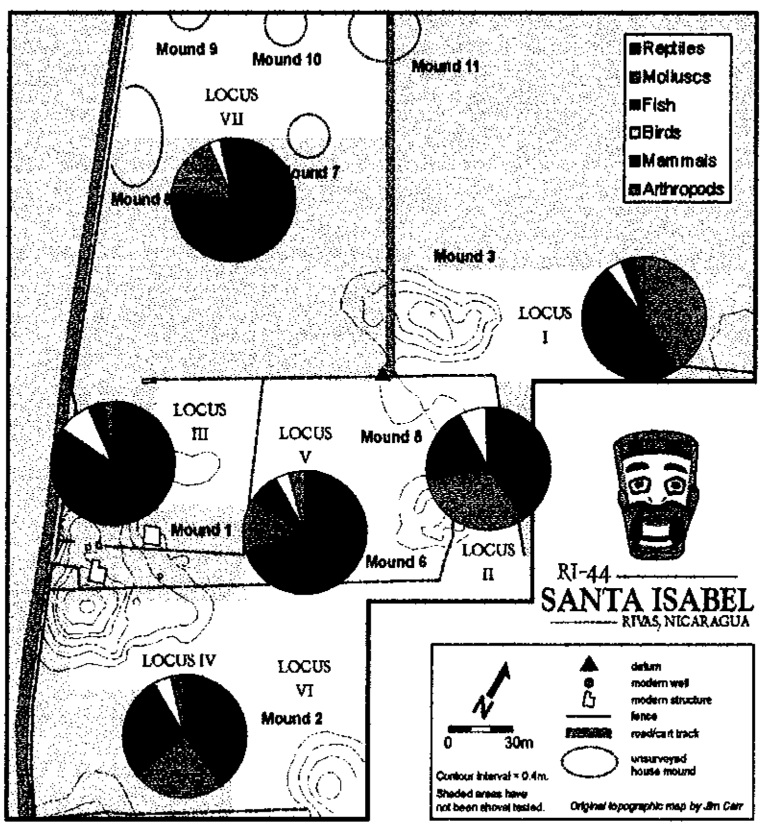
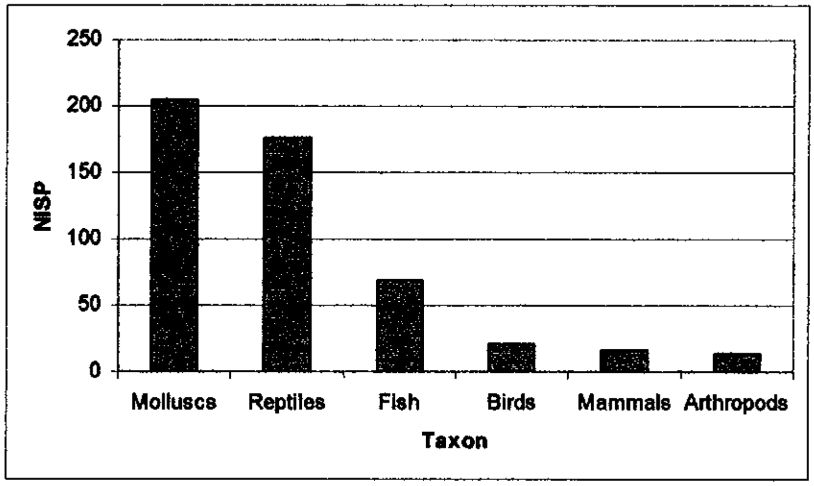


Figure 15: Map of Santa Isabel showing the six loci being compared. Pie charts illustrate the proportional representation of each animal class at all loci. Lake Nicaragua is to the east of the site and the Pacific Ocean is to the west.

A)



B)

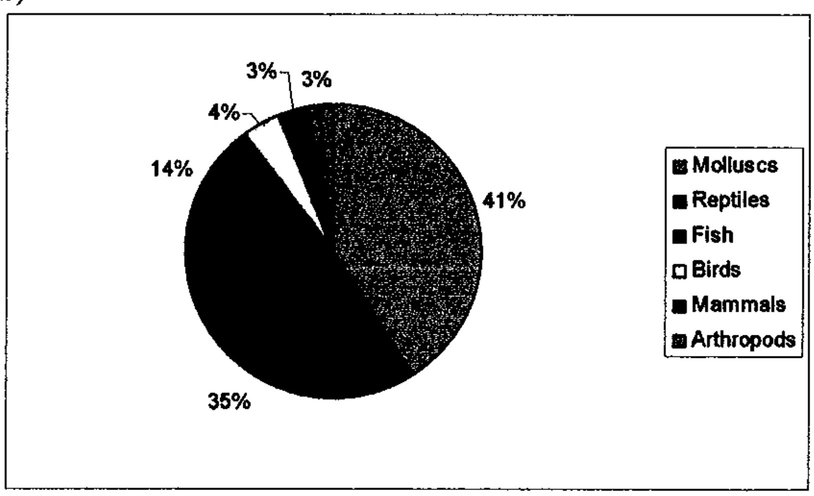
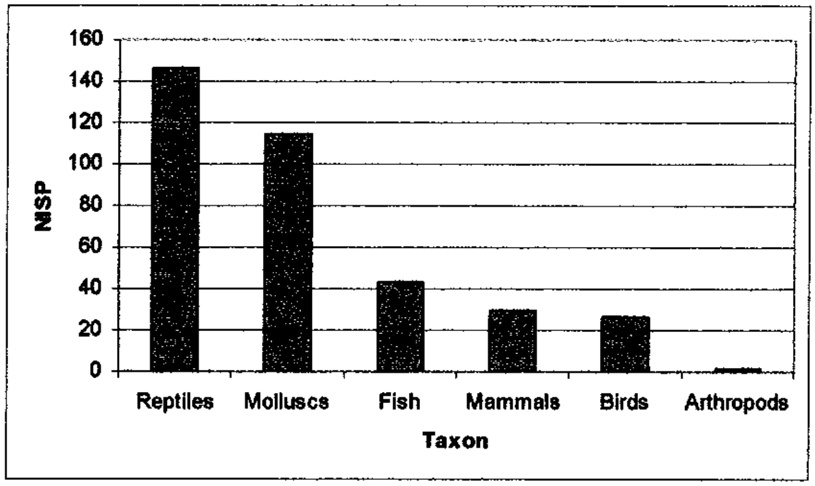


Figure 16: NISP for each of the six major taxa of animals recovered at Locus 1. A) NISP for each of the six categories; B) NISP for each of the categories as a proportion of the total.

A)



B)

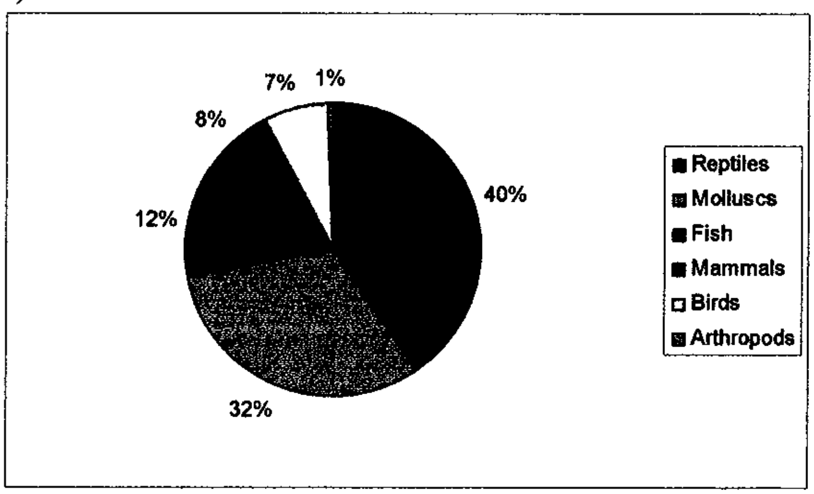
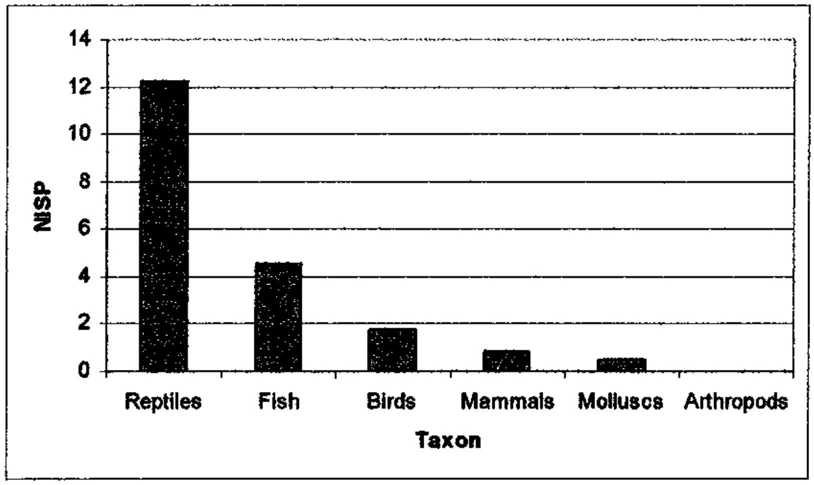


Figure 17: NISP for each of the six major taxa of animals recovered at Locus 2. A) NISP for each of the six categories; B) NISP for each of the categories as a proportion of the total.

A)



B)

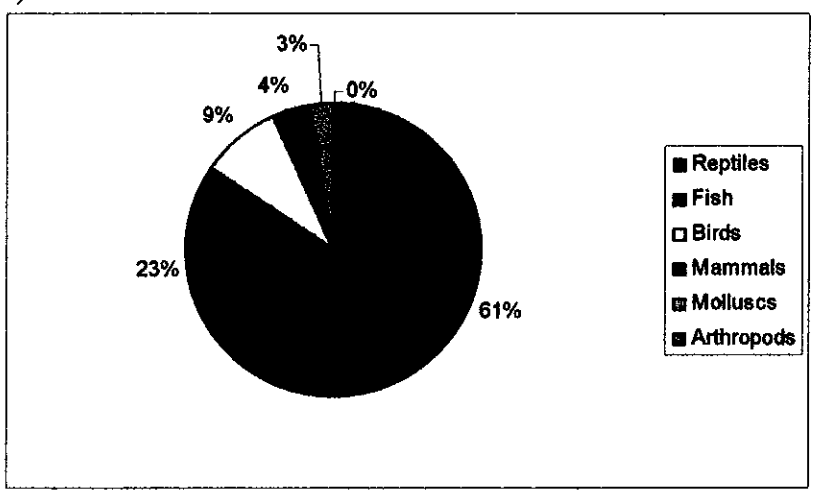
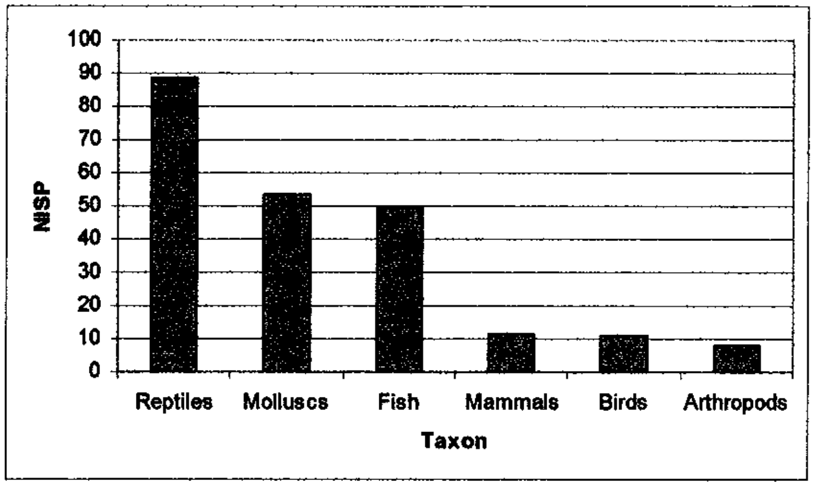


Figure 18: NISP for each of the six major taxa of animals recovered at Locus 3. A) NISP for each of the six categories; B) NISP for each of the categories as a proportion of the total.

A)



B)

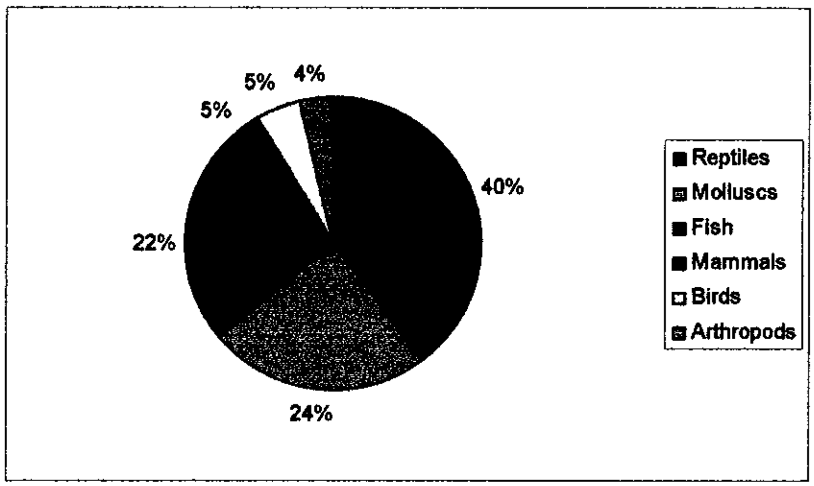
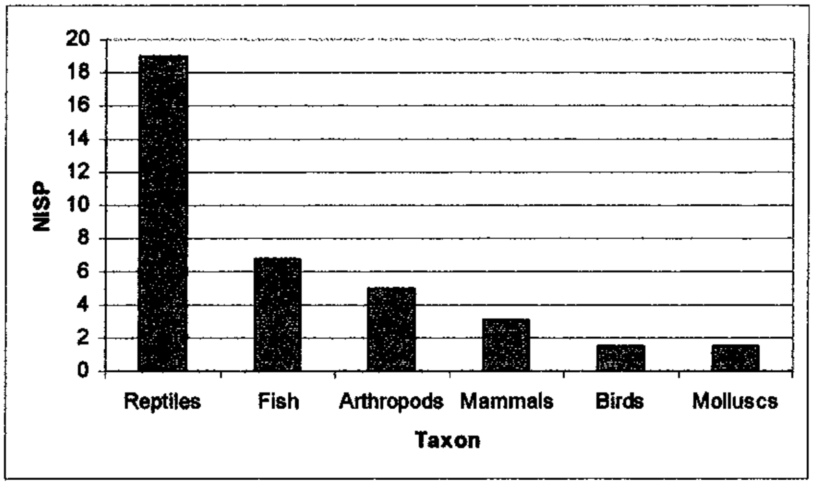


Figure 19: NISP for each of the six major taxa of animals recovered at Locus 4. A) NISP for each of the six categories; B) NISP for each of the categories as a proportion of the total.

A)



B)

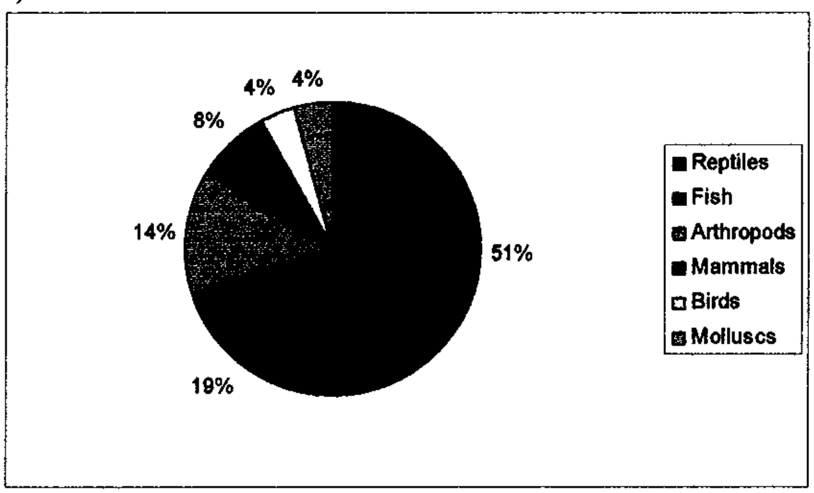
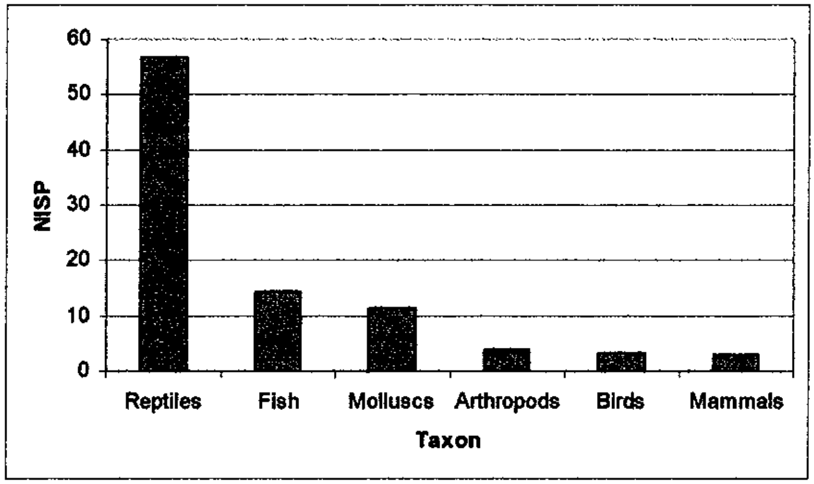


Figure 20: NISP for each of the six major taxa of animals recovered at Locus 5. A) NISP for each of the six categories; B) NISP for each of the categories as a proportion of the total.

A)



B)

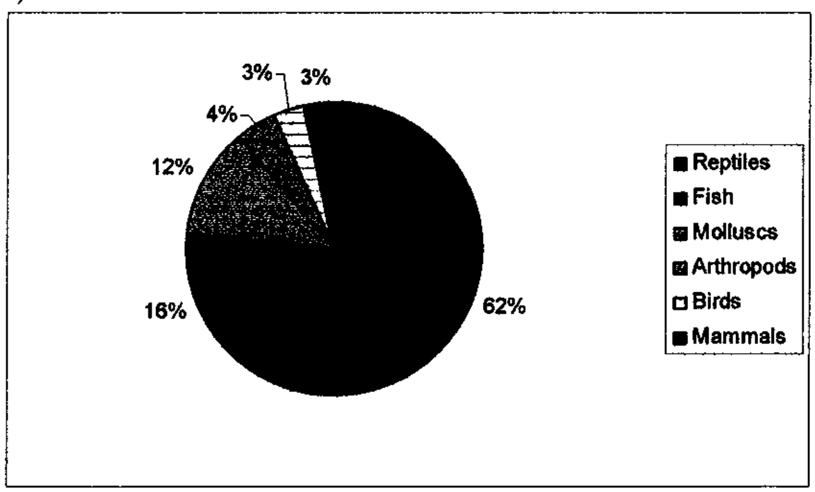


Figure 21: NISP for each of the six major taxa of animals recovered at Locus 7. A) NISP for each of the six categories; B) NISP for each of the categories as a proportion of the total.