FISH FROM AFAR: MARINE RESOURCE USE AT CARACOL, BELIZE

by

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ABSTRACT

The ancient Maya had strong ties to the sea. The trade, transportation and use of marine resources were important not only to coastal Maya communities, but also to the heavily populated cities that lay many miles inland. A review of zooarchaeological evidence recovered from excavations at the inland site of Caracol, Belize suggests that the inhabitants imported marine fish for food, marine shell for working into trade items, and sharks teeth and stingray spines for ritual use. This thesis examines the manner in which fish and other marine resources were used, procured and transported from the coast to the site of Caracol. The possibility that certain marine fish might have been transported alive to the site is explored. An examination of present day fishing and animal husbandry practices suggests that many species could have survived an inland trip in ancient times if transported under conditions that allowed for water exchanges and minimized stress. Marine resources had important economic and ritual significance to the people of Caracol. Understanding the methods by which these valuable items were transported and traded ultimately facilitates a greater understanding of the economic and socio-political relationships among these ancient polities.

Dedicated to David, “The Librarian”

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CHAPTER 1: INTRODUCTION

The ancient Maya city of Caracol flourished in the tropical jungles of what is now Belize between 300 B.C. and A.D. 1050. The city is located in the Maya Mountains, far from the Caribbean coastline, yet archaeological evidence reveals that the inhabitants of this inland city were interested in the sea, and the creatures that lived there. Like the elite inhabitants of other inland Maya cities, residents of Caracol imported fish and other marine resources for use as food, as implements, as adornments and for ritual purposes.

The recovery of marine shell and faunal bone material from marine animals at archaeological excavations in Caracol is evidence that a thriving trade network in marine products occurred between the ancient Maya inhabitants of the city and the Caribbean coast, but the mechanics of how this trade occurred are poorly understood. This study investigates how this trade might have occurred, and whether marine fish could have been delivered alive from the coastal waters to the residents of this important Maya city.

Caracol: Background

The ancient Maya archaeological site of Caracol is located in the eastern foothills of the Maya Mountains in southern Belize (Figure 1). Situated on the Vaca Plateau, the site is located approximately 500 m above sea level (Chase and Chase 1987:1). The site today is dense subtropical forest (Miller and Miller 1994). The plateau on which the site is located is bordered by a deep valley to the northwest, and forest shrouded hills to the southeast. The climate is fairly dry, with an average annual precipitation varying between 1500-2500 mm. (Healy 1983). The closest river is the Macal River, located 15 km west of the epicenter of the site (Chase and

Chase 1987:1), and it is not navigable; the nearest navigable waterway is the Belize River, which branches into the Macal at what is now San Ignacio, Belize.

The ancient Maya inhabitants of Caracol resolved the problem of a lack of permanent contiguous water resources by constructing a vast array of water reservoirs throughout the site (Crandall 2009). They also managed landscape hydrology through agricultural terracing. Evidence of agricultural terracing was initially recorded during early mapping of the site (Healy et al, 1983; Chase and Chase 1998:8). Recent investigations using airborne LiDAR technology, however, have shown that the site was more extensively terraced than initial investigations revealed (Chase et al. 2011). Like other forested areas in the Peten Biotic Province, the Vaca Plateau would have initially provided habitat for a diverse collection of fauna utilized by the ancient Maya; however, as the forest was cleared for settlement and agriculture, many of these species would have become less abundant (Pohl 1976).

Archaeological investigation has shown that Caracol began as a collection of villages during the Middle Preclassic Period (900-300 BC) (Teeter and Chase 2004:157). During the Late Preclassic Period (300 BC-250 AD), the inhabitants of Caracol began construction of the elite residences, ceremonial plazas and other monumental architecture that began to define the epicenter of the site (Chase and Chase 1994:2, 2006:41). The city grew and consolidated during the Early Classic Period (AD 250-550), remaining a minor polity in the area until AD 562, at which time it gained its independence from the powerful city of Tikal. During the next hundred years, the city grew in importance, becoming a major power and trade center, eventually reaching a size of 177 km2, with over 100,000 inhabitants (Chase and Chase 1994:5). Caracol then became an urban center, connecting to outlying areas via a collection of causeways that stretched to suburban administrative areas (Chase and Chase 2001:159). Caracol reached the height of its power during the Classic Period, around the 7^{th} Century. At that time the city would have been one of the largest in the Maya lowlands, straining its resources to feed its inhabitants. Despite its success, the city epicenter was abruptly abandoned circa AD 890 (Chase and Chase 2000). The exact reason for this abandonment is not clear, but may have had its roots in environmental or socio-political causes (Teeter and Chase 2004:159).

Archaeological Investigations at Caracol

The ruins at Caracol were discovered in 1937 by a logger in search of marketable hardwood trees (Chase and Chase 1987:3). Although noted, the site remained unexplored and unexcavated for over a decade. In 1950, archaeologists Linton Satterthwaite and A.H. Anderson began a three-year investigation of the site, exposing some of the monumental architecture and initiating some early mapping of the area (Beetz and Satterthwaite 1981). Little work was done at the site until the 1980's, when Paul Healy conducted the first ecological assessments of the site and uncovered evidence of extensive agricultural terracing (Healy et al. 1983). In 1985, Arlen Chase and Diane Chase began what would eventually become a long-term investigation of the site, encompassing more than twenty-five years of excavation that has continued to this date. During this time, the site was extensively surveyed and mapped, revealing it to be one of the largest sites in the lowland Maya area (Chase and Chase 1987:1; Chase et al. 2009:2). Extensive investigation has been conducted in the epicenter resulting in the excavation and consolidation of much of the monumental architecture and the opening of the epicenter of the site to tourists.

Excavation has also been conducted in various parts of the site, revealing extensive settlement and embedded nodes of architecture that provided an infrastructure for administration and trade (Chase and Chase 1998:2; Chase and Chase 2007a:4). This long-term approach to research has provided archaeologists with a detailed history of the city. Epigraphy on monuments recovered from the site have provided researchers with a history of Caracol's rulers from A.D. 331 through A.D. 859. These investigations have also recorded Caracol's rise to power, from a smaller polity under the dominion of Tikal, Guatemala to its defeat of Tikal in A.D. 562 and its subsequent defeat of Naranjo in A.D. 631 (Chase and Chase 1989:1; Martin and Gruber 2000:72). Success in warfare preceded a florescence at Caracol, resulting in an increase in population, trade and prestige (Chase and Chase 2007a:7).

Faunal Analysis at Caracol

Initial analysis of faunal remains recovered from archaeological excavations at Caracol was conducted by June Morton (1987). Morton's work concentrated on 537 elements from excavations conducted at the site during the 1985 and 1986 seasons. Morton identified 8 species, primarily terrestrial animals indigenous to the surrounding areas. Stingray spines, recovered from a human burial were the only marine resource identified. Morton concluded that stingray spines, used for ceremonial purposes, were the only evidence of animal resource trade at Caracol. No evidence of other marine fish use was recorded in this study.

A subsequent detailed analysis of the faunal assemblage from Caracol was conducted by Wendy Giddons Teeter using information collected from excavations at the site between 1985 and 1998. Teeter (2001) analyzed over 84,000 pieces of animal bone recovered from a wide variety of contexts that included refuse deposits, burials, caches, in-situ floors, and construction fill. In addition to identifying bone to the most discrete taxonomic unit, Teeter examined the context of the assemblage to determine the subsistence and ceremonial practices of the ancient Maya residents across time. This detailed analysis became the subject of Teeter's 2001 University of California PhD. dissertation, and resulted in a number of other publications (Chase et al. 2004; Teeter 2004; Teeter and Chase 2004). Teeter identified 197 skeletal elements representing eight different taxa of marine fish from various contexts at Caracol.

Both Teeter and Morton relied on analysis of skeletal components for their investigations; thus, their research is focused primarily on vertebrate fauna. Vertebrates, however, were not the only important marine resource used at Caracol. Marine shell from a large variety of mollusk species has been recovered from the site. Cobos (1994) also reported on evidence of worked shell and ornaments, suggesting that shell workshops were a significant part of the local economy. Marine shell, primarily *Strombus gigas* and *Spondylus americanus,* are also found in burials and ritual contexts at Caracol, suggesting their importance as a ceremonial item (Chase and Chase 1998).

While Teeter's analysis ended with material collected in the 1998 season, excavations have continued annually at Caracol under the direction of Arlen F. Chase and Diane Z. Chase. Additional faunal material has been recovered but is not yet fully analyzed. This includes items readily identified as the remains of marine fauna, such a sting ray spines and shark teeth (Chase and Chase 2009).

This study draws from published data and season reports regarding faunal remains recovered from Caracol during archaeological excavations conducted and supervised by Arlen F. Chase and Diane Z. Chase, as well as those faunal remains identified by Wendy Giddens Teeter between 1995 and 1998.

CHAPTER 2: WATER-BORNE NAVIGATION AND TRADE

Maya Canoes

The only direct archaeological evidence of Maya waterborne travel is a wooden canoe paddle recovered from the ancient salt works settlement of K'ak Naab in the offshore islands of southern Belize (McKillop 2005, Figure 2). Maya navigation and sea travel is known primarily from artistic depictions of canoe paddlers, the presence of Maya settlements on offshore islands, and ethnohistorical accounts. Canoe use for coastal trade was well established by the time Columbus arrived in the Caribbean. Scribes for Columbus describe the explorer's encounter with a trade canoe on his fourth voyage to the Americas:

> " There arrived a canoe full of Indians, as long as a galley and eight feet wide. It was loaded with merchandise from the west, almost certainly from the land of Yucatan, for that was near there (the bay islands) a matter of thirty leagues or a little more. There was in the middle of the canoe a shelter … of palm matting, which they call *petites* in New Spain. Inside and under this were their women and children, possessions, and merchandise, so that neither rain nor sea water could wet anything ." (Morison, 1963:326-327).

The use of canoes for sea-going transportation goes back at least to the Late Preclassic period, as evidenced by settlement in offshore sites like Cozumel (Andrews 1998), Marco Gonzalez (Graham and Pendergast 1989) and Mojo Cay (McKillop 2004b). Canoes were likely used to facilitate inland trade as early as the Middle Preclassic. Evidence of sea fish and other marine resources can be found at Caracol and other inland Maya sites dating to the Late Preclassic period (Teeter and Chase 2004:167; Healy et al. 2004:123).

Thompson (1949) analyzed types and sizes of Maya canoes utilized in the trade routes around the Yucatan. He also correlated the sizes of these vessels with different uses and with the implements used to propel them, such as paddles and poles. Thompson compared local canoes in use at the time of his writing to descriptions of canoes used by the ancient Maya, noting similarities, such as the raised bow and stern depicted in some images and the shallow water canoes with the raised platforms both front and rear. This design has survived to the present day, being historically used for river travel in Mesoamerica.

No Maya dugout canoes have thus far been recovered during archaeological excavation, but their form and function can be discerned by images left behind. Classic Maya iconography often displays deities in the act of fishing (Figure 3). Many of the scenes portray the gods engaged in using a variety of fishing technologies from spears to nets. Taube (2010:209) suggests that many of these representations depict the Maya Rain God, Chak, and that the supernatural act of fishing evokes rain. The Dresden Codex displays elaborately costumed deities paddling in small wooden vessels.

Hammond (1981) described canoes depicted in the engravings found in the burial of a ruler in the inland Maya city of Tikal. The engravings were found with grave goods in the burial chamber of Jasow Chan K'awiil, who ruled Tikal from A.D. 682 to 734. The images, engraved on bone, illustrate several figures riding in canoes (Figure 4). The bones carry texts that describe the figures in the canoe - believed to be Jasow Chan K'awiil as a deity paddling his canoe into the underworld. Accompanying Jasow Chan K'awiil on his journey are deities, some depicted as animals (Schele and Miller, 1986: 271). Several of the scenes show the deities fishing, apparently catching fish by hand and depositing them in a creel. Hammond suggests that while the personages in the boats are clearly meant to suggest supernatural deities, the boats themselves are likely representations of the shallow draft vessels used by the Maya for coastal and river trade.

A number of three-dimensional carvings of Maya canoes have been recovered from Maya archaeological sites, including Altun Ha (Hammond 1981:181) Mojo Cay (McKillop 1985:343) and Jaina (Finamore and Houston 2010:189). Often referred to as "gravy boat" canoes, these models show the shallow draft vessels with rimmed edges both fore and aft and wide floors for transporting cargo (Figure 5) , and bear a marked resemblance to modern canoes still in use today (Figure 6). These miniature canoes were made of clay or carved in bone (Hammond 1981:181, McKillop 1985) and were likely children's toys or representations used in rituals (Finamore and Houston 2010:189).

Canoes of this style would have been of great use in coastal and river trade, facilitating the transportation of marine shell and other items to inland population centers. They also would have been used for reef fishing, where shallow draft vessels would have an advantage. Finamore (2010:154) suggests that this design could not have been used in open water or rough seas where it could have been swamped with water. It is possible that oceangoing watercraft varied in shape and design. McKillop (2010:98) further notes that coastal Maya traders would have required specialized knowledge of currents, weather, shoals and navigation in order to negotiate safely in the sea.

While many examples of Maya art depict deities navigating the underworld or battling sea monsters, some Maya art depicts humans engaged in fishing and maritime pursuits. A mural found in the Temple of the Warriors at Chichen Itza displays fishing scenes. These scenes appear to be maritime in content, suggesting familiarity with the sea and sea-going fishing practices, even though Chichen Itza is an inland site.

Unlike other early societies, the Maya lacked either beasts of burden or wheeled vehicles; thus the canoe became the primary vehicle with which to facilitate long-distance transportation and trade. Its use allowed the Maya to access both food and ritual items from the sea, and to move other desirable items, such as obsidian and jade, from one marketplace to another.

Maya Coastal and Inland Trade

Caracol, as well as other inland sites, relied heavily on coastal sites and trading centers in order to obtain fish, salt and other marine resources. Coastal trading ports were usually located in close proximity both to the sea and to the river waterways used to transport goods to the inland centers (McKillop 2004a:33).

Masson (2002:9) suggests that the economics of trade in the Maya lowlands was based on resource heterogeneity that saw coastal polities providing salt, fish, and marine shell to inland populations in exchange for meat, produce, cotton and other goods. McKillop (2010:5) further notes that coastal polities not only controlled the trade in marine resources, but also used the demand for inland resources to expand coastal trading networks.

Some researchers have linked specific inland sites to specific coastal sites, documenting common items at both locations that suggest a trading relationship. Mock (1997) has suggested that just such a relationship exists between the Northern River Lagoon site and the inland site of Colha, based on identical ceramics found at both sites. Similar relationships have been suggested for sites such as Lamanai and Marco Gonzalez (Graham and Pendergast 1989:8) and for Chichen Itza and Isla Cerritos (Andrews et al. 1989, Cobos 2010:164)

The Belize River

The Belize River is the closest navigable river to Caracol, lying approximately 38 km from the site. The Belize River is one of the largest in the country and the ancient Maya would have relied heavily on it, both as a water source, and for waterborne transportation. The Belize River has two principal tributaries, the Mopan River and the Macal River. The Macal River, as previously mentioned, is one of the closest permanent water sources to the Maya site of Caracol (Chase and Chase 1987:1). Unsuitable for waterborne navigation due to its swift current (A. Chase personal communication 2010), the Macal River drains water from the Maya Mountains and joins the Belize River approximately 2 km north of the modern Cayo District town of San Ignacio. From here, the Belize River flows in an east-northeasterly direction to the Caribbean Sea, collecting water from major tributaries along the way.

Coastal trading ports such as Mojo Cay may have provided marine goods and resources to inland sites in the central part of Belize. Located at the mouth of the Belize River, the island site of Mojo Cay could have facilitated the importation of marine items to inland sites using the Belize River as its primary conduit (McKillop 2004b:37).

CHAPTER3: THE IMPORTANCE OF FISH AND MARINE PRODUCTS

Maya Use of Marine Resources

While it is expected that the coastal Maya would have made significant use of marine resources, it is less clear how significant marine resources actually were to inland Maya economies. Certainly, inland sites were dependant on coastal resources for luxury and ceremonial items, such as stingray spines and marine shell. Many inland sites, including Caracol, did make use of marine resources as food (Chase et al. 2004:15; Powis, et. al.1999:6; Wing, 1975:383) but researchers disagree as to how important marine fish was to the Maya diet. Lange (1971) suggested that much of the Maya population of the Yucatan Peninsula was dependant on marine resources as a primary protein source, particularly in the Late Classic Period. While isotopic studies of the Maya diet do not support this theory (White and Schwartz 1989), there is evidence to suggest that the ancient Maya inhabitants of many inland sites went to considerable effort and expense to import marine fish to supplement their diet (Teeter 2001:81; Wing 1975:379; Wing and Steadman 1980:328).

Investigations into occupation of coastal communities in the Maya area suggest that many of these communities remained active and thriving well into the Terminal and Postclassic Periods, after most inland cities were abandoned (Hamblin 1984:3; McKillop 2004b:256; Seidemann and McKillop 2007:303). Access to marine resources and tree-crop diets may have provided subsistence alternatives to the coastal Maya that were not available to their inland counterparts (Seidemann and McKillop 2007:310). Lamanai, though located inland, continued to make use of available marine resources well into the Colonial period, long after many other Maya urban centers were abandoned (Emery 1999).

Bishop Diego de Landa documented the extensive fishing industry of the Maya in the Yucatan after the arrival of the Spanish:

> "The others pursue their fisheries on a very large scale, by which they eat and sell fish to all the country. They are accustomed to salt the fish, to roast it and to dry it in the sun without salt and they take into account which of these methods each kind of fish requires, and the roasted keeps for days, and is taken twenty or thirty leagues for sale, and for eating it they cook it again, and it is well flavored and sound. The fish they kill and which are found on that coast are very excellent and very fat skates and trout…" (Tozzer 1941:190).

Landa also describes a number of marine species that were particularly favored by the Maya fishermen, both for consumption and trade. Chronicles such as these, while they were written during the contact period, suggest that fishing and commercial trade in food fish were profitable occupations that utilized contacts and trade routes and that had likely been in place for generations.

Lange (1971) suggested that seafood was salt-preserved in large quantities and traded inland to feed the rapidly burgeoning Maya population. While this theory has not been supported by archaeological evidence, Lange does argue convincingly for the evidence of strong inland demand for marine food items.

Abundant evidence also exists for the ceremonial or religious use of both marine fish and mollusks (Wing 1977:50-51). The demand for these items were remarkably consistent across the Maya Lowlands, with some items, such as sting ray spines, being found in similar contexts throughout this vast area.

Fish Use at Caracol

Evidence suggests that the inhabitants of Caracol were willing to expend considerable energies to import marine fish, both for ritual use and as a supplement to their diet. The isotopic analysis of human bone recovered from Caracol indicates that the elite inhabitants of Caracol included marine fish in their diet (Chase et al. 2004). The Caracol elite were not the only inland Maya supplementing their diet with fish brought from the coast. Stable isotope analysis on the bones of elite individuals recovered from the Maya site of Lamanai, Belize revealed that high ranking male individuals included seafood in their diet, but high ranking females did not (White, 2005:375).

Teeter's investigation into animal use at Caracol revealed that a diverse number of marine vertebrates were used at Caracol (Teeter 2001; Teeter 2004; Teeter and Chase 2004). Teeter identified 194 fish elements from at least 8 different taxa at Caracol. While a number of elements recovered could be identified only to the level of *osteichthyes* (bony fish), a number of elements could be identified to at least the Family level. Teeter found that reef fish dominated the number of identified taxa at Caracol (Teeter 2001:81). Stingray, grouper, jack, snapper, parrotfish, and barracuda were among the identified remains found at Caracol. Sharks were represented by teeth found in ritual caches (Chase and Chase 1998; 2007b). Sea catfish (Ariidae), a resident of deeper Caribbean waters, was also found (Teeter 2001:76). In order to attempt to determine why these animals would be worth the significant effort it would have taken to import them, a brief review of the uses of each species is in order.

Stingrays

Teeter (2001:72) found that stingrays were the most common species of fish remains recovered at Caracol. Teeter identified at least fifty tail spine elements in burials and caches at Caracol that ranged in date from the Preclassic to the Late Classic Period. Teeter (2001:73) also noted that at least three caches and one burial contained stingray vertebrae or cranial elements. Figure 7 portrays what is thought to be a collection of vertebral centra representing a single individual stingray from a later deposit recovered in 2008 (Chase and Chase 2008). The use of vertebra centra appears to be limited to ceremonial caches and offerings, which Teeter (2001:87) interpreted as being restrictive of their possession or use.

The presence of stingrays at archaeological sites throughout Mesoamerica is nearly ubiquitous due to the demand for their spines. For the Maya, stingray spines had very strong religious and ceremonial significance, thus they are found in caches and burial offerings throughout the Maya world (Beaubein 2004:45-52; Chase and Chase 1998:316; Hamblin 1985:169; Moholy-Nagy 2004:199; Pohl 1983:75). The spine of the stingray was often used in bloodletting rituals to pierce the tongue, ears and penis (deBorhegyi 1961:283; Miller and Taube

1993:46 Schele and Miller 1986:71; Sharer 1994:108; Thompson 1966:284:). It is described by Bishop Diego de Landa in his chronicle of the Maya of the Yucatan:

> "They offered sacrifices of their own blood, sometimes cutting themselves around in pieces, and they left them in this way as a sign. Other times they pierced their cheeks, at others their lower lips. Sometimes they scarify certain parts of their bodies, at others they pierced tongues in a slanting direction from side to side, and passed bits of straw through the holes with horrible suffering; Others slit the superfluous part of the virile member, leaving it as they did their ears…" (Tozzer 1941: 113-114).

Bloodletting ceremonies by Maya nobles are graphically depicted in Maya art, most notably at the site of Yaxchilan, where a number of stone sculptures celebrate the ceremonial bloodletting of several high status individuals (Schele and Miller 1986:189; Tate 1991). This ceremony, integral to Maya religion, gave the royal Maya access to the gods and confirmed the divine right of kingship (Schele and Freidel 1990:87). It is not surprising, then, that stingray spines would be found throughout the Maya world, or that they would be in high demand among the elites of all sites (McKillop 2004a:222).

Stingrays are elasmobranchs, related to sharks; as such, their skeletons are composed primarily of cartilage (Rick et. al. 2002:113). Their bodies are round, with thick wings on either side that they use to propel themselves along the bottom of the sea (Figure 8).

They are commonly found in shallow coastal areas and estuaries with sandy bottoms. They feed on shellfish, and often conceal themselves from predators by covering themselves with sand. They are hunted for food in many cultures around the world (Taylor 1997:216).

It has been suggested that the Maya engaged primarily in the trade of only the stingray spines, which were small, portable and easily transported, and did not use the entire animal for food (deBorhegyi 1961; Hamblin 1985:169). Given the importance of stingray spines in Maya ceremonial uses, such trade undoubtedly existed. However, it is probable the Maya also used the entire animal, both for food and for ritual. The presence of stingrays in shallow coastal environments makes them attractive for exploitation by coastal inhabitants. Like sharks, stingrays are rich in protein and Vitamin A (Olson 1999). The bodies of stingrays contain large quantities of edible meat related to bone weight, making them an excellent food resource (Rick et. al. 2002:16).

Diego de Landa described the Maya fishing for stingrays after the arrival of the Spanish in the shallow coastal waters off of the Yucatan Peninsula:

> "There is another fish on this coast, which they call *Ba*, broad and round and good to eat, but very dangerous to kill and to meet, since it also does not know how to go into deep water, and likes to go into the mud where the Indians kill it with bow and arrows. And if they are careless in going near it or treading on it in the water, it at once has recourse to its tail, which is long and thin and it stabs

> with a saw, which it has, so seriously that it cannot be taken out from where he puts it without making the wound large, since its teeth are set in backwards in the way that is depicted here. The Indians use these little saws in cutting their flesh in the sacrifices of the devil and it was the duty of the priest to keep them, and so they had many of them. They are very nice, for they are very white bone, and curiously formed in the shape of a saw, so sharp and fine that it cuts like a knife."

Bishop Diego de Landa *"Relacion de las cosas de Yucatan"* (Tozzer 1941: 191). The spines of stingrays are modified dorsal spines located on the top of the tail. The edges of the spine are serrated, so that once the spine is driven into a victim, the spine either remains in the flesh or causes considerable tissue damage and bleeding as it is withdrawn (Taylor 1997:126). The stingray produces venom in a groove on the underside of the stinger; this venom is released into the victim when the thin membrane surrounding the stinger is ruptured. Stingray venom is found only in the spine. It is most toxic in live stingrays, as the venom is encased in an epidermal sheath that dissipates quickly once it is separated from the animal (Pedroso, 2007).

Envenomation from stingray wounds causes intense pain that is out of proportion to the apparent severity of the injury (Meyer 1997:24-25). Stingray injuries inflicted in the head or thoracic area can be fatal to dolphins (Walsh et. al 1988), sharks (de Borhegyi 1961:283) and humans (Meyer 1997:24). Stingray envenomation can cause necrosis at the site of the injury, if antibiotic therapy is not administered (Clark, 2007). The stingray barb often becomes dislodged in the process of a sting; if the animal survives its encounter with its unfortunate victim, in most cases the barb will grow back (Charles Manire, personal communication, 2010).

Andrews (1969) proposed the existence of a Maya ‘cult of the sea” where marine materials were an important component of rituals associated with life, death, and renewal. Maxwell (2000) has examined the record of marine materials at the Maya site of Tikal and discovered that numerous caches contained the remains of marine animals that were considered either toxic or dangerous. Of particular interest to Maxwell was the ritual use of stingray spines at Tikal. Maxwell proposed that the toxic state of stingray spines and other marine organisms (such as pufferfish, sponges, and coral) found in ceremonial connotations at Tikal made the objects more valuable for ritual purposes. Maxwell suggests that the dangerous aspects of these species, coupled with the possible physical effects of exposure to their toxins, would have enhanced the ritual experience of the participants and, possibly, increased the value of their sacrifice.

Maxwell also found that the incidence of stingray spines found in ritual caches was found to occur with the greatest frequency during the period between A.D.562 to 695. This corresponds to the time period known as the Tikal hiatus, when Tikal was presumably under the domination of Caracol after Caracol defeated Tikal in A.D. 562 (A. Chase 1991:35; Moholy-Nagy, 2003:77)

Stingray spines are by far the most represented elasmobranchs element at most Maya sites. However, the presence of stingray vertebral centra in caches and burials (Teeter 2001:73;

Beaubien, 2004:49) suggests ceremonial significance of the entire animal, requiring transportation of the entire animal to the site.

Sharks

Sharks at Caracol are represented by teeth in caches (Chase and Chase 1998) and have not been identified as to species. No vertebral centra have been recovered or identified.

Shark teeth have been recovered from a number of Maya sites (deBorhegyi 1961:275; Chase and Chase 1998:317; Hamblin 1984:24; Masson and Peraza 2008:175; Moholy-Nagy 2004:196). Often they are found in caches and burial offerings, some have been recovered drilled (de Borhegyi 1961:282; Hamblin, 1984:28) indicating they may have been worn as jewelry or attached to clothing. Ritual use of shark teeth may have included their utilization as a bloodletting tool. Shark teeth are often found in collections containing other marine items, including stingray spines, shell and coral, suggesting they were valued as a ceremonial item (deBorhegi 1961:282). Shark teeth may have been used for weaponry: Bishop Diego de Landa writes of "Bows and arrows which they carried in their quivers, pointed with flints or the very sharp teeth of fishes…." (Tozzer 1941:121).

Sharks appear to have held important religious significance to the Maya. Some linguistic scholars suggest that the word shark comes from the Maya *xook*. In Maya art, sharks are often represented as primordial sea monsters that were hunted by the Maize god.

Sharks were also likely prized for their meat. Shark meat is nutritious and would have provided an excellent source of protein and fat (de Borhegyi 1961:281); in addition, the liver contains large amounts of vitamins A & D (Kozuch and Fitzgerald 1989:146). Sharks could have been taken in coastal waters by Maya fishermen in canoes. Edward H. Thompson (1932:31-34) recounts a fishing expedition from the late 19th century off the coast of the Yucatan in which he accompanied two Maya shark fishermen in a small dugout canoe. In one night, using a minimum of equipment (a lance, two wooden mallets, large hooks, and rope), the fishermen managed to capture and kill seven large sharks.

Parrotfish

Parrotfish are often found at inland Maya sites. They may have been especially desired for their beauty, as they are extremely colorful and distinctive. Hamblin (1984:37) described parrotfish as one of the "most popular fishes" in the faunal assembly at Cozumel. The stoplight parrotfish (*Sparisoma viride),* the type identified by Teeter (2001) from the Caracol faunal assemblage, is generally found on offshore reefs (Humann and Deloach 2002). As such, considerable effort would have been required to catch and transport them from off- shore waters to coastal trading ports, and then from coastal areas to inland sites. Cranial elements of the parrotfish are very distinctive, and tend to preserve well at archaeological sites.

Other fish elements recovered from Caracol and identified by Teeter include Nassau grouper *(Epinephelus striatus)*, Horse eye jack *(Caranx latus),* unidentified species of snapper, the blue-striped grunt *(Haemulon sciurus)* and barracuda.

Although Caracol lies in close proximity to the Macal River, no fresh water fish remains have thus far been reported at the site.

The Presence of Marine Fish at Other Inland Sites

Archaeological evidence suggests that marine resources were regularly imported into inland Maya sites. Marine vertebrates were recovered in a number of burials and caches at the large Maya site of Tikal. Moholy-Nagy (2004:196) identified stingrays *(Dasyatis sp.),* Spiny puffer fish, Tiger shark (*Galeocerdo cuvieri)* and sawfish from Tikal's caches and burials.

At the inland site of Lubantuun, marine fish made up a large portion (39%) of the faunal remains recovered (Wing 1975:379). Wing identified shark vertebrae at the site, as well as snook (*Centropomus sp.),* grouper (Family Serranidae), stoplight parrotfish *(Sparisoma veride),* tuna *(Auxis sp.)* and jack *(Caranx sp.).* Jack was second only to deer at the site, indicating that marine fish formed a major resource for the ancient inhabitants.

Marine fish remains were also located at the inland site of Cahal Pech. Cahal Pech is located directly on the Belize River, approximately 110 km from the Caribbean coast. Archaeological investigations have uncovered the skeletal remains of a number of marine reef fish, including parrot fish (Family Scaridae), hog fish (Family Labridae), grouper (Family Serrenidae) and snapper (Family Lutjanidae) (Powis et al. 1999:6). The amount of marine fish recovered at Cahal Pech is significant, making up nearly 24% of the total assemblage (Healy et al. 2004). Cahal Pech's proximity to the Belize River may have facilitated the procurement of marine items, such as fish and shell, as the Belize River connects directly to the coast and was an effective route for canoe transport..

Use of Shell Items at Other Inland Maya Sites

This investigation is primarily concerned with the importation of fish products into Caracol; however, it would not be complete without a discussion of marine shells because the routes and methodology for transporting fish to inland sites were likely the same for marine shell. Marine shell found at archaeological sites in Mesoamerica tend to be far more durable than skeletal fish remains; thus, shell is more abundant in the archaeological record. The presence of marine shell at inland Maya sites is indicative of direct exploitation of coastal resources and the existence of complex long distance trading networks (Powis et al. 1999). In general, the most compelling evidence for the existence of long distance trade in marine resources comes from elite burials and other ritual deposits (McKillop 2004a).

Marine shell had particular significance for the ancient Maya. Like other marine items, shells had symbolic connections to the Maya interpretation of cosmology, the underworld and death (Andrews 1969:53; Moholy-Nagy 1985; Thompson 1950). In Maya art, God N is often depicted emerging from a conch shell; the goddess Ix Chel is also sometimes similarly portrayed (Pohl 1983:75). Both *Spondylus* shell and jade are associated with the Maize God (Freidel et al. 2002:51), and often appear together in burial offerings and caches (Finamore and Houston 2010). Shells may have been associated with bloodletting rituals, and are often found in caches with other bloodletting items, such as stingray spines and obsidian blades. Shells may have been used as a receptacle to catch blood during the rituals. The Madrid Codex shows a man and a woman drawing blood from their ears, and the blood is flowing into what appears to be shells (Hohmann 2002:157). At the Maya site of Copan, a cache uncovered at the base of the Hieroglyphic

Stairway contained a shell with the residue of what may have been human blood (Sharer 1994:539)

Perhaps because of their association with powerful deities and the underworld, marine shells and the items constructed from them were generally considered prestige goods or wealth items by the Maya (Trubitt 2003:260). At most inland sites, Maya elite would have had preferential access to items crafted from marine shell, such as jewelry or adornments sewn onto clothing (Emery 2003:499; Sharer 1994:440). Conch shells *(Stombus sp)* were used in the construction of musical instruments that were associated with the elite. Scenes depicting the use of conch trumpeters have been found painted on mural walls and on decorated polychrome vessels. Shell, particularly S*pondylus sp.,* is often found in burials associated with high-status individuals (Beaubien 2004:51; Chase and Chase, 2007b; Chase et al. 2008:136; Price et al. 2010; Trubitt 2003:261). Marine species, such as *Spondylus* and Strombus, were modified for personal adornment and may have been important indicators of social status as early as the Middle Preclassic Period. At the Maya site of K'axob, an early, elite adult male was buried with 2,019 shell beads (Aizpurua and McAnany 1999:120).

Hohmann (2002) identified areas of household shell ornament production at the Maya site of Cahal Pech. Cahal Pech is located on a promontory overlooking the Belize River. While smaller than Caracol, Cahal Pech also shows evidence of occupation from the Early Preclassic through the Terminal Classic Periods. Archaeological investigations at Cahal Pech have recovered marine shell remains that include queen conch *(Strombus gigas),* tusk shells (*Dentalia sp.),* olive shells *(Oliva sp.),* and marginella shells *(Prunam sp.)* in contexts dating from the

Middle Preclassic period (Powis et al. 1999:6). Hohmann (2002) found marine shell detritus and shell-working implements at the site dating from the Middle Preclassic Period, indicating the household production of shell ornaments. Worked marine shell, particularly queen conch *(Strombus sp),* was found in abundance at the site, and complete and broken shell beads in various stages of production were found at excavations around the site's periphery (Healy et al. 2004).

Evidence of shell workshops were also found in the ancient city of Tikal, Guatelmala. Marine shell at Tikal appeared to have both social and ceremonial significance. Moholy-Nagy (1985) found extensive use of *Spondylus* shells in elite burials dating to the Early Preclassic Period. Moholy-Nagy found that scarcely-worked *Spondylus* shells were found in elite tombs in numeric clusters of nine, and in specific positions related to the body of the interred in burials. Moholy-Nagy (1985:151) also found that the use of marine shells and other items, such as stingray spines, correlated with the elite; in contrast, local freshwater shells were associated with personages of lesser status.

At Copan, another inland site, marine shell is also associated with the elite. Located in what is now western Honduras, Copan has been extensively researched and the lineages of its ruling class meticulously decoded (Sharer 1994). Marine shells associated with elite burials have been found in a number of areas in Copan, including the royal interment of a woman in the "Margarita Tomb."   Upon excavation of the burial chamber, archaeologists discovered the remains of a woman lavishly decorated with sea shells (Bell 2002:97). Marine objects were common in elite burials and caches at Copan, with marine shell and even coral remains used to decorate the burial chambers of the deceased (Beaubien 2004). *Spondylus* shell was also commonly found in caches at Copan, particularly in caches associated with architecture. A lidded vessel in a cache offering was found during excavations in Group 10-45 and contained a jadite figure of the Maize god in a large *Spondylus* shell with four smaller shells placed at the cardinal points (Sharer, Miller and Traxler 1992).

At Caracol, preliminary analysis of shell recovered from archaeological excavations at the site indicates that the majority of marine shell imported into the city originated from the Caribbean Sea (Cobos 1994:140). Marine shells, particularly *Spondylus,* were frequently found among the offering contents of burials and caches (Chase and Chase 1998; Chase et al. 2008). The presence of marine shell in Preclassic burials (Chase and Chase 2006) suggests that the inhabitants of Caracol had the necessary trade networks in place at an early date to procure such items. In addition to scarcely-worked shell items found in burials and caches (Chase and Chase 1998), many pieces of worked shell also were recovered, including pendants, beads, earflares, anthropomorphic "Charlie Chaplin" figures, buttons, and inlay pieces (Cobos 1994:141). Pope (1994:150) notes the existence of shell workshops at Caracol, as indicated by the existence of concentrated numbers of whole shells, shell pieces, and shell debitage in general archaeological contexts.

CHAPTER 4: LIVE TRANSPORTATION OF FISH

The use of fish as food does not come without peril. The ingestion of bacteria associated with spoiled fish and the often fatal infections that follow could quickly decimate a population. The ancient Maya must have known the methods of preparing and storing fish so that they did not spoil. Various methods of fish preservation- including salting, filleting and drying- would likely have been used for the transportation of fish from the coast to distant inland destinations such as Caracol. However the transportation of some species of fish alive would have been possible, and is, in fact, suggested by some archaeological contexts.

The presence of fish vertebrae and cranial elements at Caracol (Teeter 2001:75) suggests that not all fish coming into the site were processed elsewhere. Ethnohistorical accounts of fish being prepared for trade, such as those described by Landa and recounted above, would produce processed fish with little or no skeletal remnants to be found by archaeologists during excavation. Wing (1977:51) suggests that vertebral remains could be recovered in such cases if the fish were simply split down the middle, smoked or salted, with the vertebral column being left intact. These methods are plausible, but do not account for the recovery of some individuals, such as stingrays, which appear to have been used for ceremonial purposes and deposited intact (Chase and Chase 2008a).

It is not likely that the intact remains of dead animals would be transported to the site in order to sell or trade their carcasses. Marine fish spoil rapidly once they have died; they are subject to bacterial contamination and, subsequently, bacteria- borne disease. Given the efforts that the Maya took at some sites to avoid the putrefaction associated with dead fish (Shaw

1985:5), it seems unlikely that one would undertake a long river journey with dead fish that would undoubtedly render the entire canoe of food and trade goods worthless.

Transporting fish alive to inland sites has been proposed as one means of acquiring the entire fish without having it spoil upon arrival. Healy and colleagues (2004:119) suggest that fish may have been transported up the Belize River in canoes partly filled with seawater. For ritual creatures, such as sponges and stingrays, seawater filled crocks might have been used to transport the items inland (Schele and Freidel 1990:200).

A canoe journey from the mouth of the Belize River to its apex at the modern town San Ignacio would take at least three full days (A. Chase, personal communication, 2009). A modern canoe race, La Ruta Maya Belize River Challenge, takes place each March and takes four days of paddling in three-man canoes on the Belize River, from San Ignacio to Belize City, approximately 180 miles (paddling for approximately 6 hours each day)- and this is downriver. Depending on river currents and seasonality, paddling from the Caribbean Sea to San Ignacio, upstream, would be considerably more arduous.

The transportation of live fish from reef areas, often located many kilometers off shore, to coastal trading areas, where they could be loaded onto canoes for the trip up river to inland sites, would require careful planning. Fish would have to survive in shallow water containers for at least four days and possibly longer. In the case of salt water fish, additional sea water would have to be carried to replace spilled water, or oxygen depleted water. Alternatively, the fish would have to be able to survive the lower salinity created by dilution with small amounts of river water when salt water was not available. Consequently, estuarine species, or at least species that could survive in brackish water, would be best suited for such a journey. However, hardy reef fish in good condition would also be candidates.

To determine if such transportation was possible, an examination of modern fish husbandry practices is in order. Aquarium curators and tropical fish retailers often transport live fish long distances in closed containers. While some aquarists use mechanical aids, such as fish aerators to increase dissolved oxygen in the water, and chemical enhancers to slow fish metabolism, a great many fish are simply transported in containers from one location to another over many hours or even several days.

Miller (1956) describes a typical fish transport container as being a plastic bag containing approximately 5 gallons of water placed in a single-ply cardboard box. Size of the fish determined the number placed in each container. Fish thus packaged were transported by motor vehicle and by air from the interior of Mexico to the town of Tiajuana. The elapsed time between capture and release of the live fish was 80 hours. Miller reported no mortalities among the transported fish.

Not every species of fish would survive transportation under these conditions. However, of these species whose remains were recovered at Caracol, small stingrays, grunts, sea catfish and parrotfish would be likely candidates (Dave Wert, personal communication, 2010). More modern research methods show that management of water quality enhances the survival rate of fish undergoing transport (Lim et al. 2003). Maintenance of water salinity improves water quality and, thus, enhances survivability.

Fishermen have known for generations that water quality must be maintained and fish must be kept alive long enough to get to market in the best possible condition. Modern fishing vessels use mechanical means to keep fish in a fresh state. Most modern fishing vessels are equipped with water aeration and circulation equipment to maintain water quality and keep fish alive until they can reach market. Prior to the availability of such mechanical devices, fishermen needed to rely on live bait wells to keep fish alive, sometimes for many days, during offshore trips for fish.

It is difficult today to find fishing boats with live wells that do not rely on mechanical means to keep fish alive. However, in the Bahamas, some older fishermen still fish the reefs with older boats that do not have aeration equipment in their fish holding tanks. Using the Bahamas as a reference point to make comparisons is valuable because many of the fish utilized there are the same as those found in the Maya area- at least to genus- and the history of the maritime economies between the ancient Maya and ancient Caribbean cultures share many similarities (McKillop 2010).

There are several fishermen in the Bahamas who use boats for offshore and reef fishing that do not have aeration equipment in its live well. These boats are generally older, and their live wells have been modified so that sea water is able to flow into the well with the motion of the boat, creating a continuous water exchange in the hold, and thus increasing oxygen content and improving water quality which allow the fish to survive longer in the hold. Typically, this modification involves creating openings in the hull of the boat to allow for a free exchange of sea water. The fishermen who utilize these vessels are often gone from port for many days, and the oldest of these fishing boats do not have refrigeration on board. Thus, the fish must remain alive in the hold until the fishermen can get them to the fresh fish market, located in Nassau on the Isle of New Providence, Bahamas.

One such fisherman, Jeremiah Gibson, has been fishing in Bahamian waters for over 60 years, and still conducts fishing charters which go out for four to six days. His vessel, *The Lively Hope*, is a wooden fishing boat approximately 22' long. The boat includes a live well in the hull, measuring approximately 6 feet by 6 feet by 5 feet (Figure 9). The live well was constructed with slats in the hull to allow water to exchange. I observed this boat in Nassau Harbor on two separate occasions in 2010 and 2011. At the time of the first examination, in September of 2010, the live well contained a live reef shark, a parrotfish, a Nassau grouper, and a number of live conchs.

Gibson stated the fish had been alive in the hold for three days while he had been out fishing the reef. Gibson was asked about stingrays, grouper, horse-eye jack, snapper, grunt, barracuda and parrotfish- all variations of taxa whose remains were recovered at Caracol. Gibson stated that he often caught grouper, jack, grunt, barracuda, and stingray and that many had remained alive in good condition, in the hold without aeration, for up to a week.

I observed the vessel a second time in April of 2011. At this time, Captain Gibson had been in port for about a day. At this time the hold contained a variety of live fish, including a black grouper, a parrotfish, some queen angelfish and a variety of smaller fish (Figure 10). Gibson stated that the fish in the live well had been alive between two and four days, with the large black grouper having been in the hold for four days.

I also observed a second, much larger, fishing vessel that employed a live well for transporting live fish to market. *The Surprise* is a 75 foot fishing vessel with a live well based out of Spanish Wells, near the island of Eleuthera in the Bahamas (Figure 11). *The Surprise* was built in 1962 constructed with a live well that allows seawater to flow into the hold through holes constructed into the hull. These holes allow for an exchange of seawater in the hold that will improve water quality, thus prolonging the life of the fish (Figure 12).

This vessel was observed in April of 2011 in the port of Nassau, Bahamas, after being at sea for approximately nine weeks. The captain of the vessel, Luther Higgs, advised that the vessel is used primarily for catching various species of snapper. Captain Higgs did not know the exact dimensions of the hold, but stated it would hold approximately three to four hundred "bags" of snapper, a "bag" being a large plastic bag that would hold 1-2 dozen frozen snapper of various sizes. Unlike *The Lively Hope*, *The Surprise,* does have a fish freezer on board. Captain Higgs advised that his usual method is to fill the hold with snapper, put these fish in the freezer for the remainder of the voyage, then fill the hold with snapper again that he transports alive to the market at Nassau Harbor.

Captain Higgs advised that snapper is a particularly delicate fish that spoils and decomposes quickly once dead. Alive, with good water exchange, snapper can be transported for many days. Captain Higgs said it was not unusual for snapper to survive in the hold of his vessel for many days, sometimes beyond a week or even two. Captain Higgs stated that he has also caught a number of other fish, including stingray and grouper, and that they will also survive many days in the live well. Stingrays in particular, he advised, can survive in brackish water for many days.

While not meant to draw direct comparisons between contemporary Bahamian fishermen and ancient Maya canoe traders, observation of the above fishing and animal husbandry practices strongly suggest that select fish could have been kept alive in containers for the journey up the Belize River if the conditions were right. Pottery vessels may have been used for such transport, as they could be constructed to hold the five gallons of water necessary for such transport. Alternatively, woven creels constructed of plant material, could have been lashed to the sides of the canoes below the water level. This arrangement would have confined the fish, but allowed the water to exchange freely. While no archaeological evidence currently exists for such transport, its possibility should not be discounted.

Size is an important variable in determining whether animals could be transported alive. The size of the animal would be constrained by the size of the container in which it was transported. Thus, smaller animals with strong ritual significance would have been the most likely candidates for live transport.

Stingrays, as previously described (see Chapter 3) are animals with strong ritual significance. Teeter (2001:72) found that stingrays were the most common species of fish recovered at Caracol. Most of the stingray remains recovered at Caracol were found in caches and deposits, indicating their high value as a ceremonial item.

In 2008, 52 stingray vertebrae were recovered in a cache deposit during the excavations of a plaza in front of Structure C21 at Caracol (Chase and Chase, 2008a). The vertebrae were photographed by the archaeologist, with scale, as part of the archaeological investigation (Figure 7). Although the original vertebrae were not available for inspection in this study, the photograph provided an opportunity to make an estimation of the size of the stingray for the purpose of determining if it was small enough to be transported alive as described. Based on the size and shape of the vertebrae, it was determined that the animal was most likely a member of the genus *Dasyatis*, which includes a number of stingray species found in Caribbean waters. The size of the stingray can be estimated using an allometric formula developed by Reitz et al. (1987).

As used in zooarchaeology, allometric equations relate proportional changes between measured parts of an animal as size increases (Reitz et al, 1987). The skeletal elements of an animal scale allometrically with body size (Peters 1983) As described by Reitz, et al (1987)., the scaling relationship can be predicted using the following formula (4.1):

$$\log Y = \log a + b(\log x) \tag{4.1}$$

In this formula, *b* represents the slope of the line, *a* represents the *y* intercept, *x* represents the independent variable (skeletal measurement), and *y* represents the dependent variable (estimated body mass). Many Vertebrate characteristics scale allometrically, but for this study the most useful was bio mass, or live body weight, and total length in relation to the measure of the most anterior vertebrae.

To estimate the standard length and live weight of the stingray recovered from Caracol, the height and width of the most anterior vertebrae were measured (Table 1) These data were correlated with data collected from similar species represented in the the zooarchaeological comparative collection at the Florida Museum of Natural History (Table 2). The above allometric formula was used to calculate the estimated total length and weight of the stingray (Table 3).

These data indicate that the Caracol stingray was approximately 650 mm in length and weighed approximately 1500 grams. The accuracy of this prediction is based on the assumption that the vertebrae recovered from this deposit represent a single animal, and that the largest of the vertebrae recovered were also the most anterior. If these assumptions are correct, the stingray would have been small enough to have been carried alive from Caribbean waters to Caracol, providing adequate water quality was maintained throughout the journey.

CHAPTER 5: DISCUSSION AND CONCLUSION

Preservation and Recovery of Archaeological Fish Remains

The recovery of marine vertebrates from archaeological sites in the Maya lowlands is difficult, as fish bone generally does not preserve well in the humid conditions generally encountered there. Teeter (2001) noted that the best bone preservation at Caracol occurred in those areas that were protected from the elements, such as cache vessels with lids and those areas covered with structural fill.

The preservation of shark and stingray remains at archaeological sites is especially problematic. Sharks and rays are composed primarily of cartilage, not bone, which generally does not preserve well at archaeological sites (Rick et al. 2002:111). In general, only the vertebral centra, teeth, spines, and dermal denticles of sharks and rays remain in a sufficient state of preservation to be recovered. In addition, identification of sharks and rays is often difficult; in sharks, often only the anterior centra are useful for identification beyond classification to Order (Kozuch and Fitzgerald 1989:147); and stingray spines recovered from archaeological sites are generally not identifiable to species.

Zooarchaeologists must rely on material most often excavated by others. Excavation techniques are determined by a variety of factors that include: financial, time and staffing constraints; seasonality, location, weather; and, the type of structure being excavated. Often it is not practical or possible to excavate every site using methodologies that would be most appropriate for recovering and identifying faunal remains-and excavation decisions are appropriately made based on larger project objectives. Still, zooarchaeologists must often make the best analysis they can from the material they are given, recognizing that there may be biases inherent in the sampling methodology (Emery 1999:64).

The data from Teeter's analysis was derived from thirteen field seasons conducted from 1985 through 1998 (Teeter and Chase 2004). Teeter noted that while the recovery of faunal material was always an important objective during excavations, excavation techniques did not always allow for the optimal recovery of all faunal materials. Teeter noted that at Caracol all excavation occurs by hand, and that no screening is conducted unless a special deposit, such as a cache or burial, is noted, or other contextual factors indicate the need for this. Screening was usually conducted using ¼" mesh screening, and special deposits were thoroughly screened-and then gone through by hand- until the entire deposit was completely excavated (Teeter 2001). In special cases at Caracol, flotation was also done on deposits considered to be full of refuse.

Although the above methodology resulted in the recovery of over 84,000 pieces of animal bone and a zooarchaeological sample that allowed for interpretations to be made based on context and behavior (Teeter and Chase 2004), it is still subject to the limitations of sampling bias, particularly relating to the recovery of marine animal remains.

The recovery of marine fish remains from archaeological sites is especially difficult. Shaffer and Sanchez (1994) found that quantitative results of animal remains may be biased in favor of larger species if only coarse (1/4inch) screening is used. James (1997) estimated that 90% of marine fish remains may be lost through ¼ inch screening alone. During zooarcheological research on the Caribbean island of Carriacou, LeFebvre (2007:937) demonstrated that 98% of the total sample of bony fish biomass would not have been recovered without the inclusion of fine screening (1/16 inch). Other studies have also demonstrated the positive correlation between screen size and faunal recovery (Reitz and Wing 2008:147-150; Walker 1992).

The types of species present at an archaeological site may also influence zooarchaeological interpretations. For example, vertebral elements of marine fish are among the best preserved and most frequently encountered in many faunal assemblages; however, the identification of fish vertebrae is made more problematic by the extreme variation in morphology within the spinal column of most fish. In addition, the caudal vertebrae of different species within the same family are often similar, further complicating identification (Colley 1990). The cranial elements of some species of fish may not preserve well; by contrast, the cranial elements of the family Scaridae (such as parrot fish) preserve well and are extremely distinctive, making their recovery and subsequent identification more likely.

Cultural factors may also play a role in determining the recovery of faunal remains. Recovery depends on excavation occurring in areas where the remains are deposited. Differential disposal of fish remains often occurs at Maya sites, especially since olfactory considerations may have been an issue (Emery 2004:24). Fish remains may be burned, buried, or disposed of in water (where archaeological excavations rarely occur). Shaw (1985:7) analyzed fish remains from the coastal site of Colha and found that fish remains from that site were generally disposed of in a single pit that appeared to have been utilized for that purpose. Other cultural factors that may determine how faunal remains are recovered include whether they were included in architectural fill and the type of building maintenance procedures that were practiced. Ancient cooking and food storage practices also influenced how and when faunal remains entered the archaeological record.

Food preparation practices also factor into what faunal remains are available for recovery. Fish that is dried, filleted, or salted -as described by Landa (Tozzer1941:190) - would likely be prepared for transportation at the point of origin. In this situation, the cranial and most of the vertebral portions of a fish would be removed before transportation occurred; consequently, no skeletal remains would be available for recovery during excavations at the receiving site. At Mayapan, vertebrae ratios were compared between catfish and non-catfish species; and it was determined that catfish were being imported into the site as whole specimens. In contrast, non-catfish species were being recovered only with post cranial elements, indicating that they were likely being processed at coastal locations and transported into the site after being butchered (Masson and Peraza 2008:174).

In light of the above considerations, it is likely that marine fish are underrepresented in the analyzed faunal assemblage at Caracol. Teeter and Chase (2004) acknowledge that the collection of 197 identified marine elements is small, but also add that the context and chronology indicate that the demand for marine products likely resulted in considerable resources being invested in their importation.

Implications for Long Distance Trade

Zooarchaeology can tell us many things about the possibility of long-distance trade in the Maya world. At its most basic, the identification of faunal elements in areas far outside their natural geographic range is evidence of long distance transport and trade (Hamblin 1984). The recovery of marine fish remains and other marine fauna from Caracol and at other inland sites clearly illustrates that this long distance trade occurred, however the methodology of how these items were transported is somewhat more obscure. The presence of reef fish, such as parrotfish, at coastal Maya sites suggests that fishing technology was sophisticated enough to support transport over water, some 55 km offshore in some cases, and to return with fish in usable condition for food (Wing and Hammond 1974). The presence of reef fish remains at inland sites such as Caracol (Teeter 2001) Lubantuun (Wing 1975), Cahal Pech (Powis et al.1999) and others suggests that the ancient Maya had a strong demand for such fish; the ability to transport it long distances; and, the ability to preserve or otherwise keep it in good condition until it could arrive at the site of its intended use.

Coastal trade has been linked to the emergence of strong northern polities such as Chichen Itza during A.D. 950-1200, after the collapse of major urban centers in the southern lowlands (Finamore 2010). Other scholars, (Andrews 1990, 2003; Cobos 2004) see this emergence as being much earlier, but still linked to coastal trade. It should be noted that even in the south, coastal trading centers such as Marco Gonzalez (Graham and Pendergast 1989), Mojo Cay (McKillop 2004b) and others remained thriving after the collapse. Lamanai, an inland site located on the New River, appeared to survive the lowland collapse, perhaps because of its association with the trading port of Marco Gonzalez. Despite its loss of prominence, Caracol shows evidence of occupation through at least 900 AD (Chase and Chase 2007c, 2008b) in conjunction with a continuation of the importation of fish and other marine items. It is possible that those sites that maintained access to marine resources were able to sustain occupation for longer than those that did not.

It is likely that most of the marine fish transported to Caracol were preserved through filleting, salting, drying, or some other method and were transported with other trade goods through the usual networks of coastal and inland river trade. It is also possible, however, that some species of particular ritual significance or that was particularly desired as a luxury food item, might have been transported alive to the site. It has been suggested that this could be accomplished in canoes partly filled with water, but it also could have occurred in pottery vessels that would easily have held smaller animals of ritual significance, such as stingrays, or with animals of great beauty, such as parrotfish.

The recovery of cranial and vertebral fish remains from inland sites such as Caracol suggests that at least some fish were not butchered and prepared for inland sale as described in ethnohistorical accounts. An examination of present day fishing and animal husbandry practices reveals that many of these species could have survived an inland trip if transported in conditions that allowed for water exchanges and that minimized stress.

Ritual Fauna

The possibility of transporting marine animals alive to inland Maya sites for ritual purposes in antiquity should not be overlooked. Particular species with strong ritual connotations, such as stingrays, might have been valuable offerings for a particular ceremony or burial. Maxwell (2000) has argued that toxic marine animals, such as stingrays, might have held great significance as ritual objects. Transporting these animals alive to ceremonial sites would have enhanced their value, as their venom would have remained fully potent and intact. Small stingrays, which can survive for many days in shallow brackish water conditions, could possibly be transported in ceramic vessels as suggested by Schele and Freidel (1990:200). The use of such methods could explain the recovery of what appear to be the remains of entire organisms from caches such as those recovered at Caracol (Chase and Chase 2008a). The transportation of live animals over great distances would have been costly in terms of labor and equipment. While it is unlikely that such effort would be expended on everyday food items, it may have occurred for items that were reserved for special ritual events or as particular luxury food items for the elite

Future Directions for Research

There are many questions that remain unanswered about the importance of marine resources to the large inland population centers of the ancient Maya like Caracol. Though it is generally accepted that waterborne trade was essential to the inhabitants of these inland centers, the practicalities and mechanics of such trade are poorly understood. We are just beginning to understand the political economies of inland polities and many questions, such as which polities controlled trade routes during any given period, have yet to be determined.

Because animals and their products were a trading commodity during ancient times, much can be learned from the study of their remains. Future research in this vein at Caracol should include continued examination of faunal remains as they are uncovered, with particular reference to context and an understanding of animal use for religious, subsistence and ideological purposes. The role of marine animals in trade relationships, with emphasis on transportation and commerce, should be explored. A full understanding of these relationships would assist archaeologists in developing a better understanding of these ancient societies.

APPENDIX A : MAPS, DRAWINGS AND PHOTOGRAPHS

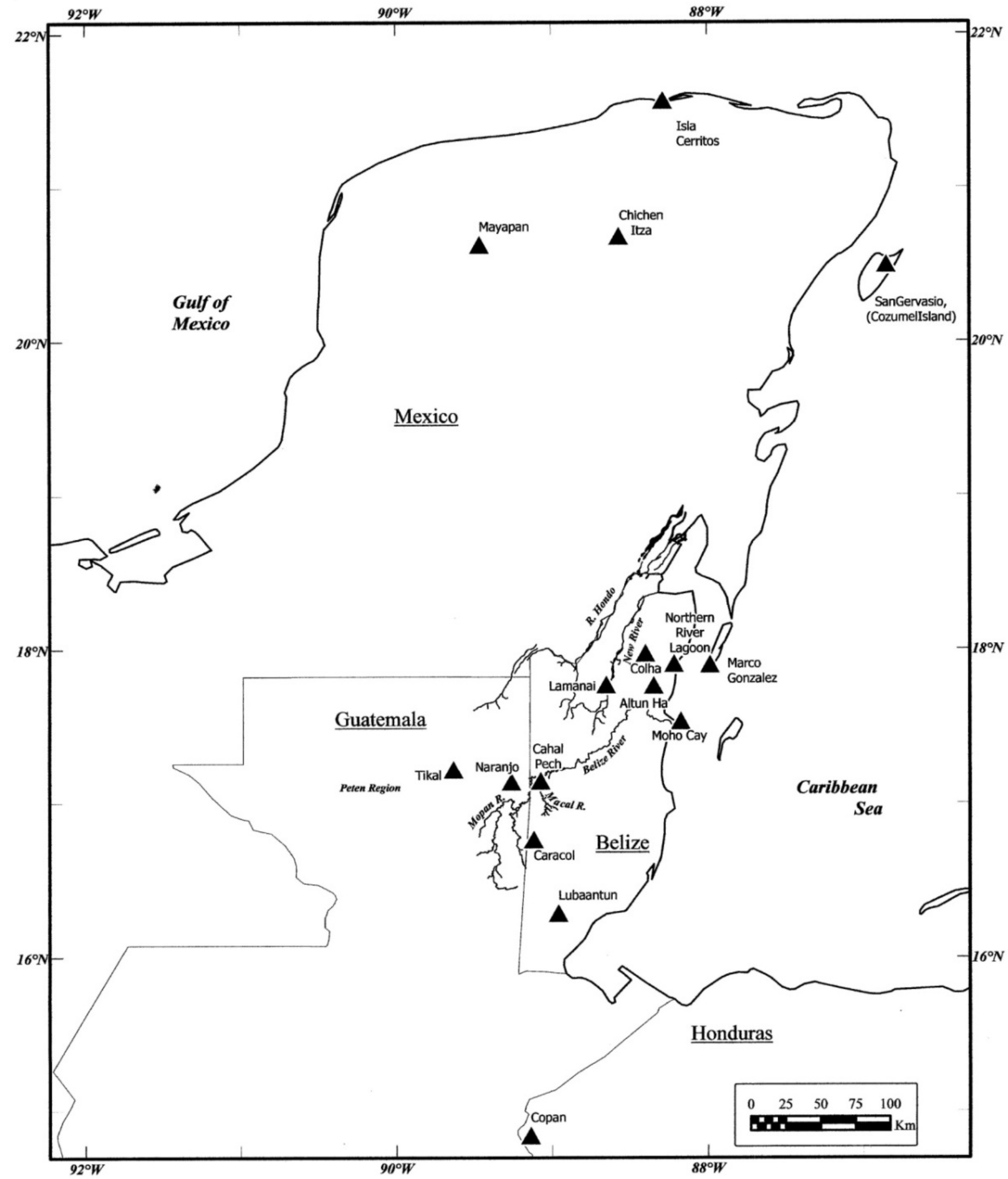

Figure 1: Selected Maya sites and key rivers, referenced in the text. Site locations from Witschey, Walter R. T. and Clifford T. Brown, *Electronic Atlas of Ancient Maya Sites*, http://MayaGIS.smv.org accessed June 12, 2011. Map by Witschey.

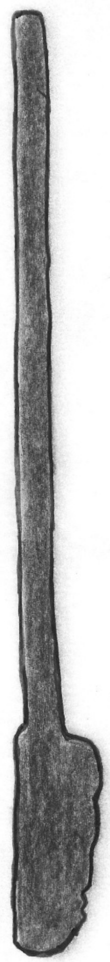

Figure 2: A wooden canoe paddle recovered from the K’ak’ Naab’ site at the salt works in Punta Ycacos, Belize. After McKillop 2010, page 40.

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Figure 3: Detail of a carved bone depicting deities engaged in fishing, Late Classic Period, Burial 116, Tikal, Guatemala. (After Annemarie Seuffert in Taube 2010:210).

Figure 4: Detail of bone engraving depicting deities riding in canoes. Engravings on bone found in Late Classic Period burial, Tikal, Guatemala. (After Annemarie Seuffert in Finamore 2010:151).

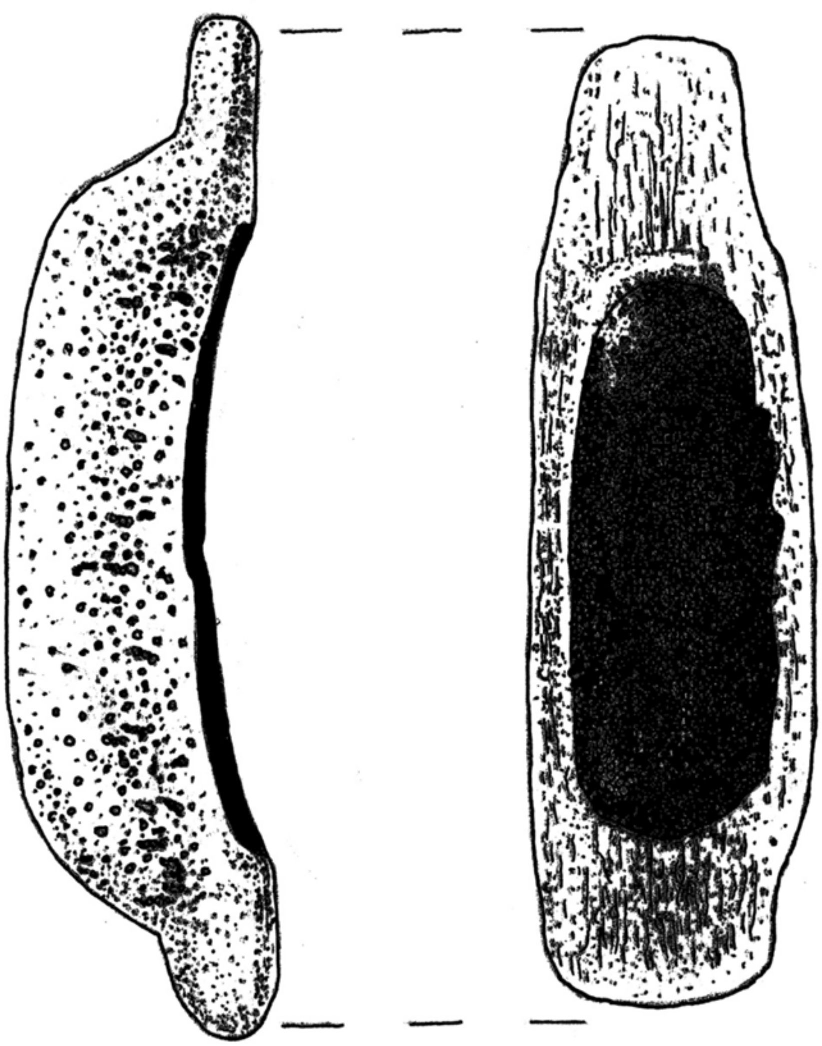

Figure 5: Model of canoe carved from manatee bone. Recovered from the Maya trading site of Mojo Cay, Belize. (After McKillop 1985:343).

Figure 6: Late 18th century canoe. From Verzcruz, Mexico Photo courtesy of David Smith

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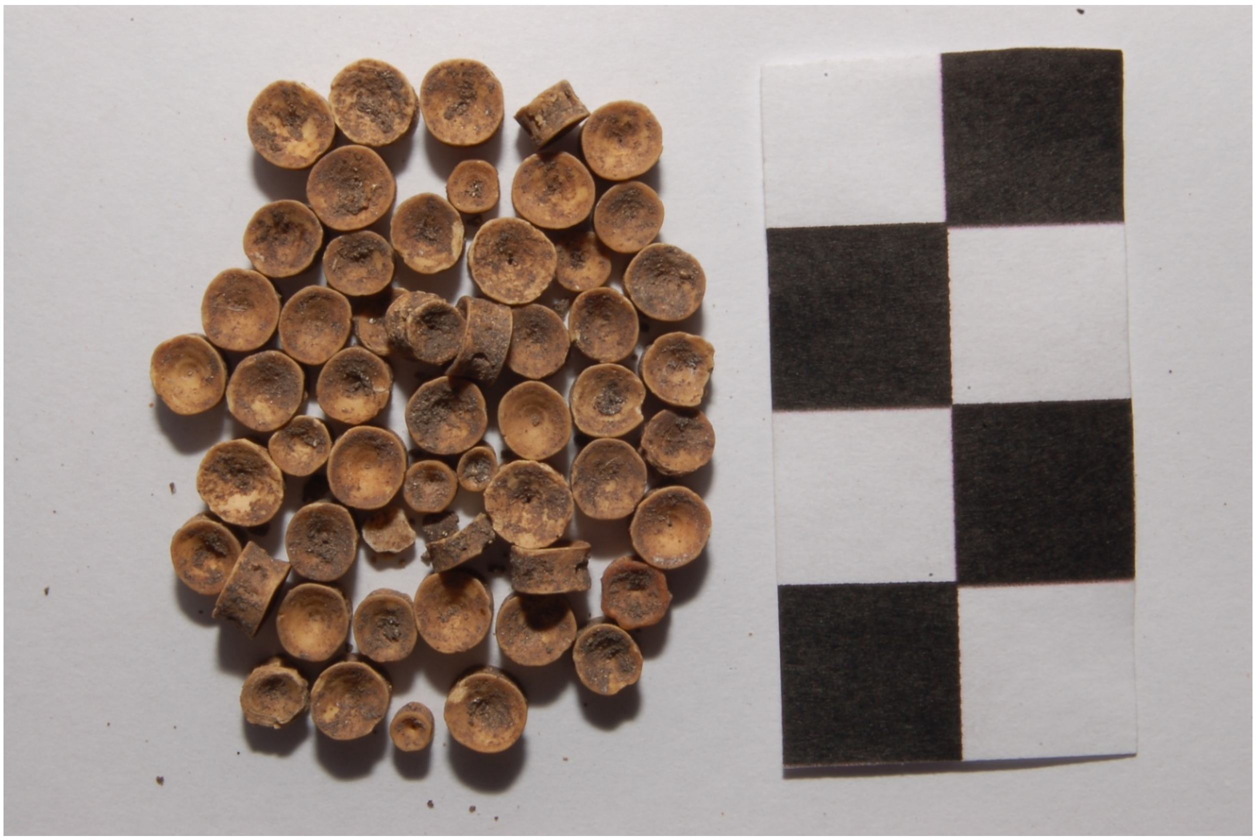

Figure 7: Collection of 52 Sting Ray Centra, taken from cache deposit, Caracol Belize. Photo courtesy of Dr. Arlen Chase and Dr. Diane Chase.

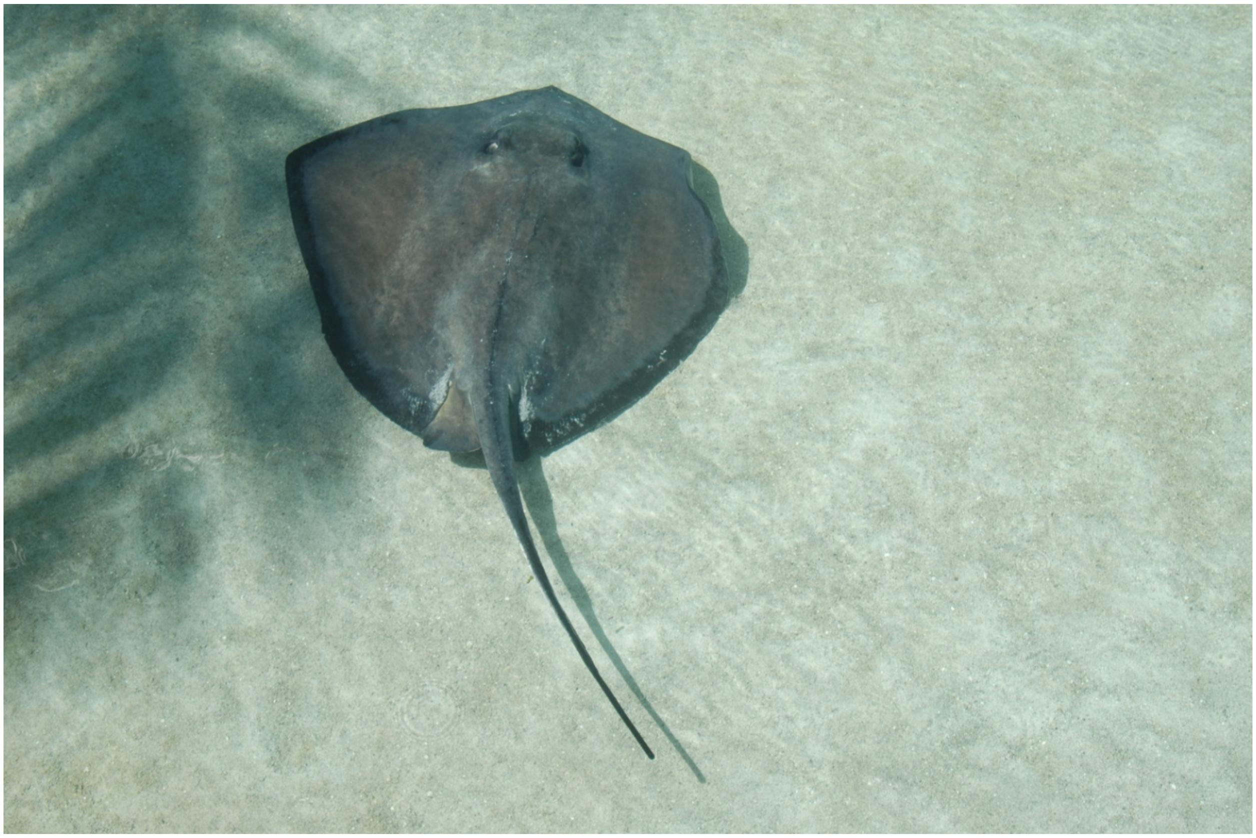

Figure 8: Southern stingray, *Dasyatis Americana*, often found in Caribbean waters. Photo courtesy of David Smith.

Figure 9: *The Lively Hope.* Bahamian fishing vessel with non aerated live well. Photo courtesy of David Smith.

Figure 10: Live well of the fishing boat *"Lively Hope"*, showing live fish from a four-day fishing expedition. Note the slats in the bottom of the hold to allow for water exchange. Photo courtesy of David Smith.

Figure 11: Bahamian fishing vessel, *"The Surprise"*, at port in Nassau Harbor. The live well is in thecenter of the boat. Photo courtesy of David Smith.

Figure 12: Close up of live well on *"The Surprise"*. Note the holes in the bottom of the well to allow for water exchange. Photo courtesy of David Smith.

APPENDIX B: TABLES

Table 1: Vertebrate height and width measurements (in mm) from the largest vertebrae pictured in Figure 7. Measurements were taken from the photograph.

Caracol stingray		
Dasyatis sp.		
Vertebrae	**Vht**	**Vwd**
1	4.27	5.10
2	4.31	5.06
3	4.56	5.01
4	4.04	4.60
5	4.49	4.94
6	3.85	4.46
7	4.65	5.24
8	3.89	4.41
9	4.06	4.40
10	4.38	5.03
11	4.14	4.71
12	4.67	5.23
13	4.17	4.72
14	3.62	4.24
15	3.69	4.23

Table 2: Table 3: Vertebrae height and width measurements (in mm) of ray species from the Zooarchaeology Collection at the Florida Museum of Natural history.

		Vertebrae	**VHt**	**VWd**			**Vertebrae**	**VHt**	**VWd**
Z3702	*Raja eglanteria*	1	4.50	5.00	Z807	*Dasyatis centrova*	1	19.95	20.15
		2	4.41	4.92			2	19.42	20.02
		3	4.25	4.78			3	19.32	19.66
		4	4.59	5.20			4	16.41	17.05
		5	4.02	4.44			5	18.87	19.28
		6	4.48	4.80			6	18.53	19.91
		7	4.52	4.67			7	19.51	19.85
		8	4.57	5.04			8	18.12	18.98
		9	4.29	4.97			9	18.44	18.88
		10	4.40	4.80			10	18.20	19.66
		11	4.31	4.89			11	19.39	19.62
		12	3.60	4.33			12	18.12	19.18
		13	4.46	4.64			13	17.57	18.96
		14	4.47	4.78			14	18.12	19.10
		15	4.36	4.79			15	17.59	18.67
		16	4.24	4.84			16	18.78	19.41
		17	4.28	4.48			17	16.20	17.31
		18	4.41	4.70			18	18.30	19.11
		19	3.62	3.88			19	17.29	18.43
		20	4.18	4.47			20	18.50	19.15
		21	4.31	4.60			21	17.17	17.90
		22	4.27	4.78			22	19.14	19.64
		23	3.86	4.26			23	15.65	16.45
		24	4.27	4.78			24	18.16	19.35
		25	3.74	3.88			25	17.63	18.00
		26	4.43	4.65			26	16.49	17.46
		27	4.42	4.77			27	17.60	18.57
		28	4.29	4.73			28	17.25	18.06
		29	4.37	4.86			29	17.45	18.02
		30	3.96	4.49			30	16.61	17.30
		31	3.61	4.01			31	16.51	16.93
		32	3.79	4.13			32	16.94	17.35
		33	4.42	4.76			33	13.47	13.97
		34	3.90	4.28			34	16.39	17.12
		35	3.81	4.02			35	16.99	17.66
		36	4.15	4.53			36	15.49	16.43
		37	3.83	4.06			37	16.04	16.89
		38	3.47	3.66			38	15.69	15.74

		Vertebrae	VHt	VWd			Vertebrae	VHt	VWd
		39	4.04	4.31			39	16.49	17.21
		40	3.45	3.58			40	15.53	15.87
Z3821	*Raja eglanteria*	1	2.82	3.31	Z1604	*Dasyatis sabina*	1	3.31	3,78
		2	2.77	3.2			2	3.23	3.72
		3	2.80	3.25			3	3.29	3.54
		4	2.52	2.76			4	3.29	3.57
		5	2.57	2.84			5	3.27	3.57
		6	2.44	2.79			6	3.28	3.64
		7	2.77	3.04			7	3.25	3.48
		8	2.73	3.25			8	3.28	3.47
		9	2.75	3.10			9	3.27	3.33
		10	2.82	2.88			10	2.91	3.11
		11	2.78	3.23			11	3.26	3.43
		12	2.52	2.75			12	3.26	3.43
		13	2.48	2.87			13	3.26	3.42
		14	2.82	3.12			14	3.42	3.83
		15	2.48	2.69			15	3.25	3.55
		16	2.68	2.81			16	3.29	3.49
		17	2.81	2.97			17	3.33	3.58
		18	2.69	2.70			18	3.28	3.48
		19	2.72	2.94			19	3.27	3.48
		20	2.66	2.81			20	3.43	4.09
		21	2.68	2.73			21	3.27	3.94
		22	2.45	2.66			22	3.32	3.53
		23	2.46	2.97			23	3.23	3.48
		24	2.26	2.84			24	3.27	3.63
		25	2.91	3.07			25	3.25	3.65
		26	2.64	2.89			26	2.75	3.01
		27	2.69	2.93			27	3.15	3.3
		28	2.78	2.81			28	2.28	2.45
		29	2.46	2.88			29	2.64	2.89
		30	2.42	2.68			30	2.37	2.55
		31	2.72	2.86			31	3.10	3.43
		32	2.67	2.74			32	3.20	3.49
		33	2.72	2.85			33	3.31	3.63
		34	2.57	2.95			34	3.10	3.25
		35	2.19	2.46			35	2.85	2.92
		36	2.38	2.47			36	2.65	2.74
		37	2.3	2.61			37	2.40	2.60

		Vertebrae	VHt	VWd			Vertebrae	VHt	VWd
		38	2.05	2.14			38	2.34	2.54
		39	2.15	2.62			39	2.28	2.47
		40	1.79	2.36			40	2.17	2.44
Z3822	*Raja eglanteria*	1	5.61	6.03	Z1665	*Dasyatis sabina*	1	3.08	3.40
		2	5.77	6.44			2	2.58	2.72
		3	5.46	5.91			3	2.82	3.19
		4	5.40	5.90			4	2.30	2.51
		5	5.33	5.49			5	2.91	3.11
		6	5.51	5.71			6	2.85	3.15
		7	5.55	6.06			7	2.90	3.13
		8	5.60	5.72			8	2.74	2.99
		9	4.65	4.93			9	2.92	3.31
		10	5.59	6.01			10	2.90	3.26
		11	5.16	5.88			11	2.59	2.83
		12	4.96	5.14			12	2.88	3.24
		13	5.37	5.63			13	2.74	3.04
		14	5.28	5.74			14	2.77	3.13
		15	4.93	5.09			15	2.88	3.28
		16	5.48	5.93			16	2.74	3.03
		17	4.60	5.13			17	2.91	3.10
		18	5.23	5.63			18	2.82	3.03
		19	5.50	6.01			19	2.79	3.28
		20	5.37	5.56			20	2.87	3.11
		21	5.28	5.76			21	2.86	3.22
		22	5.47	5.57			22	2.86	3.23
		23	4.54	5.04			23	2.77	3.19
		24	4.66	5.72			24	2.78	3.23
		25	4.61	4.76			25	2.88	3.26
		26	4.46	4.63			26	2.86	3.07
		27	5.43	5.83			27	2.87	3.11
		28	4.67	5.28			28	2.42	2.64
		29	4.5	5.06			29	2.87	3.14
		30	4.88	5.22			30	2.26	2.46
		31	4.21	4.58			31	2.88	3.29
		32	4.62	4.73			32	2.49	2.73
		33	3.94	4.40			33	2.68	2.88
		34	5.59	5.88			34	2.76	3.08
		35	4.19	4.58			35	2.23	2.48
		36	4.65	4.92			36	2.51	2.75

		Vertebrae	VHt	VWd			Vertebrae	VHt	VWd
		37	4.54	4.90			37	2.38	2.63
		38	4.69	5.06			38	2.37	2.61
		39	4.41	4.62			39	2.84	3.21
		40	3.88	4.29			40	2.21	2.42
Z3824	*Raja eglanteria*	1	4.39	5.46	Z1232	*Dasyatis americana*	1	4.67	4.92
		2	4.36	4.36			2	4.74	4.96
		3	4.36	4.36			3	4.82	4.86
		4	4.36	4.36			4	4.73	5.06
		5	4.36	4.36			5	4.85	5.02
		6	4.36	4.36			6	4.77	4.98
		7	4.36	4.36			7	4.84	5.01
		8	4.36	4.36			8	4.56	4.86
		9	4.36	4.36			9	4.87	5.03
		10	4.36	4.36			10	4.76	4.99
		11	4.32	4.47			11	4.82	5.02
		12	4.26	5.42			12	4.73	4.88
		13	4.27	4.93			13	4.85	4.99
		14	4.32	5.16			14	4.78	4.82
		15	4.35	5.03			15	4.65	4.89
		16	3.65	4.18			16	4.73	4.87
		17	4.32	4.76			17	4.82	4.97
		18	3.97	4.58			18	4.60	4.86
		19	4.35	4.77			19	4.79	4.93
		20	4.35	4.67			20	4.72	4.77
		21	3.62	3.76			21	4.53	4.57
		22	3.69	4.09			22	4.71	4.79
		23	3.32	3.71			23	3.54	3.90
		24	4.36	4.73			24	4.78	4.85
		25	3.84	4.26			25	4.43	4.48
		26	4.34	4.73			26	4.74	4.92
		27	4.05	4.13			27	4.69	4.72
		28	4.34	4.79			28	4.56	4.75
		29	3.90	4.34			29	4.38	4.46
		30	4.37	4.73			30	3.51	3.83
		31	3.18	3.97			31	4.47	4.59
		32	4.32	4.83			32	3.68	3.88
		33	4.31	4.70			33	4.24	4.35
		34	3.80	4.43			34	4.70	4.98
		35	4.33	4.66			35	4.69	4.77
		36	4.31	4.80			36	4.11	4.21

		Vertebrae	VHt	VWd			Vertebrae	VHt	VWd
		37	3.03	3.48			37	3.77	3.91
		38	3.91	4.59			38	4.78	4.82
		39	3.46	4.37			39	3.56	3.87
		40	3.21	3.78			40	4.82	4.98
Z3825	*Raja eglanteria*	1	4.63	5.22	Z2777	*Dasyatis sabina*	1	3.47	3.84
		2	4.54	5.10			2	3.01	3.23
		3	4.62	5.17			3	3.45	3.84
		4	4.53	4.82			4	3.26	3.64
		5	4.22	4.86			5	3.26	3.76
		6	4.84	5.32			6	3.40	3.79
		7	4.62	5.02			7	3.46	3.77
		8	4.50	5.12			8	3.42	3.8
		9	4.32	5.00			9	3.30	3.72
		10	4.57	4.98			10	3.48	3.81
		11	4.58	5.06			11	3.48	3.79
		12	4.62	5.18			12	3.47	3.82
		13	4.52	5.01			13	3.09	3.45
		14	4.48	5.15			14	2.45	2.77
		15	4.00	4.63			15	3.07	3.54
		16	4.57	5.12			16	3.18	3.65
		17	4.57	5.08			17	3.52	3.75
		18	4.16	4.60			18	3.07	3.49
		19	4.57	5.08			19	3.31	3.65
		20	4.49	4.81			20	3.47	3.85
		21	4.52	5.21			21	3.33	3.51
		22	3.28	3.95			22	3.46	3.79
		23	4.40	5.05			23	3.27	3.60
		24	4.44	5.19			24	3.34	3.72
		25	4.56	5.08			25	2.82	3.21
		26	4.63	5.24			26	3.32	3.67
		27	3.63	3.99			27	3.18	3.62
		28	3.55	3.98			28	3.13	3.50
		29	4.50	5.09			29	2.79	2.99
		30	3.92	4.46			30	2.64	2.75
		31	3.82	4.16					
		32	4.05	4.30					
		33	3.86	4.62					
		34	3.42	4.14					
		35	4.13	4.27					
		36	3.58	4.24					

		Vertebrae	VHt	VWd			Vertebrae	VHt	VWd
		37	4.22	4.46					
		38	4.19	4.35					
		39	4.40	5.11					
		40	4.14	4.40					
Z3830	*Raja eglanteria*	1	4.64	5.13	Z3405	*Dasyatis Sabina*	1	3.61	4.01
		2	4.61	5.08			2	3.63	4.13
		3	4.03	4.41			3	3.61	3.93
		4	4.50	4.88			4	2.95	3.42
		5	4.51	4.77			5	3.59	3.76
		6	4.56	4.96			6	3.65	3.96
		7	4.57	5.17			7	3.56	4.11
		8	4.5	5.12			8	3.66	4.11
		9	4.53	4.75			9	3.6	3.95
		10	4.46	5.1			10	3.24	3.54
		11	4.50	5.12			11	3.48	3.86
		12	4.67	5.16			12	3.44	3.96
		13	4.30	4.54			13	3.01	3.50
		14	4.56	4.97			14	3.26	3.40
		15	4.54	5.00			15	3.42	3.80
		16	4.40	4.73			16	3.62	3.93
		17	4.45	4.90			17	3.61	4.06
		18	4.58	4.97			18	3.76	4.33
		19	4.63	5.15			19	3.56	4.05
		20	4.59	5.13			20	3.58	4.04
		21	4.65	5.02			21	3.66	3.89
		22	4.28	4.67			22	3.64	4.05
		23	4.57	5.08			23	3.65	4.02
		24	4.35	4.90			24	3.58	3.98
		25	4.88	5.32			25	3.63	4.02
		26	4.56	5.12			26	3.25	3.43
		27	4.20	4.54			27	3.63	3.89
		28	4.81	5.07			28	3.55	4.07
		29	4.46	4.87			29	3.52	4.05
		30	4.71	5.15			30	3.61	3.91
		31	4.46	5.03					
		32	3.44	4.00					
		33	4.05	4.34					
		34	4.29	4.85					
		35	4.08	4.25					
		36	3.38	3.98					

		Vertebrae	VHt	VWd			Vertebrae	VHt	VWd
		37	4.04	4.20					
		38	4.42	4.97					
		39	3.17	3.73					
		40	3.99	4.12					
Z3874	*Raja eglanteria*	1	3.51	4.41	Z11282	*Dasyatis americana*	1	3.30	3.79
		2	3.85	4.22			2	3.34	3.79
		3	3.40	4.18			3	3.33	3.70
		4	3.69	4.53			4	3.30	3.71
		5	3.00	3.13			5	3.33	3.69
		6	3.95	4.25			6	3.29	3.70
		7	3.38	4.10			7	3.28	3.63
		8	3.78	4.30			8	3.26	3.72
		9	3.76	4.09			9	3.32	3.69
		10	3.74	4,31			10	3.12	3.54
		11	3.83	4.34			11	3.29	3.62
		12	3.83	4.14			12	3.26	3.59
		13	3.18	4.25			13	3.27	3.66
		14	3.46	4.14			14	3.10	3.46
		15	3.81	3.93			15	3.24	3.61
		16	3.72	4.18			16	3.15	3.55
		17	3.16	3.62			17	3.30	3.72
		18	3.75	4.09			18	3.27	3.68
		19	3.83	4.12			19	3.20	3.50
		20	3.55	3.72			20	3.28	3.66
		21	3.42	3.82			21	3.29	3.51
		22	3.72	4.33			22	3.22	3.64
		23	3.40	3.97			23	3.11	3.57
		24	3.45	4.35			24	2.95	3.37
		25	3.73	4.24			25	2.91	3.32
		26	3.80	4.01			26	3.24	3.63
		27	3.27	3.77			27	3.19	3.40
		28	3.81	4.02			28	3.11	3.39
		29	3.69	3.92			29	3.16	3.43
		30	3.57	3.96			30	3.16	3.50
		31	2.38	2.76					
		32	2.91	3.14					
		33	3.80	4.25					
		34	3.08	3.58					
		35	2.95	3.34					
		36	3.38	4.29					

		Vertebrae	VHt	VWd			Vertebrae	VHt	VWd
		37	3.09	3.68					
		38	3.77	4.11					
		39	3.22	4.11					
		40	3.76	4.01					
Z387 6	*Raja eglanteria*	1	3.92	4.61	Z11285	*Dasyatis americana*	1	2.99	3.2
		2	3.83	4.23			2	2.88	3.23
		3	3.90	4.35			3	2.91	3.27
		4	3.19	3.35			4	2.90	3.20
		5	3.52	3.78			5	2.97	3.16
		6	3.91	4.22			6	2.90	3.25
		7	3.92	4.23			7	2.88	3.04
		8	3.93	4.63			8	2.81	2.86
		9	3.79	4.14			9	2.90	3.06
		10	3.89	4.39			10	2.89	3.25
		11	3.51	3.69			11	2.92	3.21
		12	3.44	3.83			12	2.90	3.09
		13	3,91	3.45			13	2.90	3.22
		14	3.77	4.05			14	2.98	3.18
		15	3.91	4.23			15	2.78	3.06
		16	3.87	4.24			16	2.98	3.11
		17	3.66	3.98			17	2.93	3.26
		18	4.10	4.63			18	2.88	3.17
		19	4.06	4.52			19	2.76	3.03
		20	3.68	4.16			20	2.68	2.79
		21	3.88	4.37			21	2.90	3.20
		22	3.89	4.36			22	2.92	3.13
		23	3.50	3.95			23	2.95	3.20
		24	4.00	4.39			24	2.88	3.13
		25	3.09	3.27			25	2.88	3.22
		26	3.64	4.33			26	2.99	3.13
		27	4.01	4.39			27	2.53	2.83
		28	3.45	3.73			28	2.66	2.73
		29	3.95	4.27			29	2.78	3.05
		30	3.28	3.56			30	2.66	2.89
		31	3.71	4.39					
		32	3.31	3.60					
		33	3.06	3.43					
		34	3.46	3.92					
		35	3.96	4.41					

		Vertebrae	VHt	VWd			Vertebrae	VHt	VWd
		36	3.87	4.37					
		37	3.15	3.40					
		38	3.98	4.41					
		39	3.44	3.60					
		40	3.49	3.67					

Table 4: Estimated size calculations of archaeological specimen *(Dasyatis sp)*, recovered from a Pre Classic cache at Caracol in 2008.

	Measurement (mm)	**N =**	**R^2**	**Intercept a**	**Slope b**	**Estimate**
Vht vs. TL(mm)	4.67	16	0.53	2.498197271	0.466710011	646.51
Vht vs. Bio(g)	4.67	16	0.906950374	1.080538223	3.126450862	1489.78
Vwd vs TL	5.23	16	0.530762084	2.457706464	0.493691966	649.26
Vwd vs Bio(g)	5.23	16	0.871766848	0.858843089	3.234791369	1524.21

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