Contributions in Ethnobiology

Small Things Forgotten: Artifacts of Fishing in the Petén Lakes Region, Guatemala

Prudence M. Rice, Don S. Rice, and Timothy W. Pugh

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Cover image: Composite illustration of paired fishes painted on Late Classic Maya polychrome vases, generally considered to represent the Hero Twins as catfish in the Popol Vuh myth, swimming in a river of blood. Drawn from photographs in the Kerr Maya Vase Database: (top row, left to right) K5088, K5464, K3266; (bottom row, left to right; images reversed) K8678, K7522, K8678 (http://research.mayavase.com/kerrmaya.html).

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Acknowledgments

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Chapter 1. Introduction to Lowland Maya Fish and Fishing

A common, but typically neglected, artifact category in the ancient Maya lowlands of the Yucatán Peninsula (eastern Mesoamerica) consists of small pieces of pottery with notches in opposing edges. Sometimes referred to in Spanish as *mariposas* because of their quasi-butterfly shape, these artifacts are usually called *pesas* (weights) on the assumption that they served as weights of some sort, presumably as sinkers for fishing nets or lines. *Pesas* are found in varied sizes, shapes, colors, and weights from the Middle Preclassic or Formative period through Contact and Colonial times (ca. 800 BC–AD 1500/1700) at lacustrine, riverine, and coastal sites (see Phillips 1979:13–14). More than 1400 of these objects have been recovered in our archaeological excavations in the southern Maya lowlands, specifically in the central lakes region of the Department of El Petén, northern Guatemala (Figure 1.1). Our interest in the sinkers is part of ongoing efforts to understand the social, political, and economic histories of the Mayas in the lakes district.

The present study considers these artifacts in terms of the long-term interrelations between the Mayas and their lacustrine environment: exploitation of aquatic resources and environmental changes, both anthropogenic and natural. We begin with a brief overview of lowland Maya fishing and related ritual as revealed in ancient art and in ethnohistorical and ethnographic sources. The broader context of the central Petén lakes' archaeology, environment, and piscifauna is outlined in Chapter 2, followed by a discussion of fishing with nets and the uses of sinkers (Chapter 3). Chapters 4 and 5 provide detailed characterization and inter-comparison of *pesas*/sinkers from six sites or site areas in the area during the Preclassic, Classic, and Postclassic/Contact periods (Table 1.1). Activities related to fishing include net making and repair, and we discuss evidence for fiber-working at two sites (Chapter 6). As discussed in Chapters 7 and 8, our findings relate to general (regional) and specific (site and individual structure) patterns of manufacture and use of *pesas* as they speak to long-term Maya economic strategies of exploiting lacustrine resources in this dynamic environment. One specific interpretation is that the reduction in the sizes and weights of these artifacts from Preclassic through Postclassic/Contact periods is a proxy for the declining size of available fishes, and might reflect "fishing down the food web," or targeting ever smaller fish.

The Lowland Setting

The Yucatán Peninsula, occupied for approximately three thousand years by Mayan language-speaking peoples, subsumes a diverse range of rich aquatic environments. The penin-

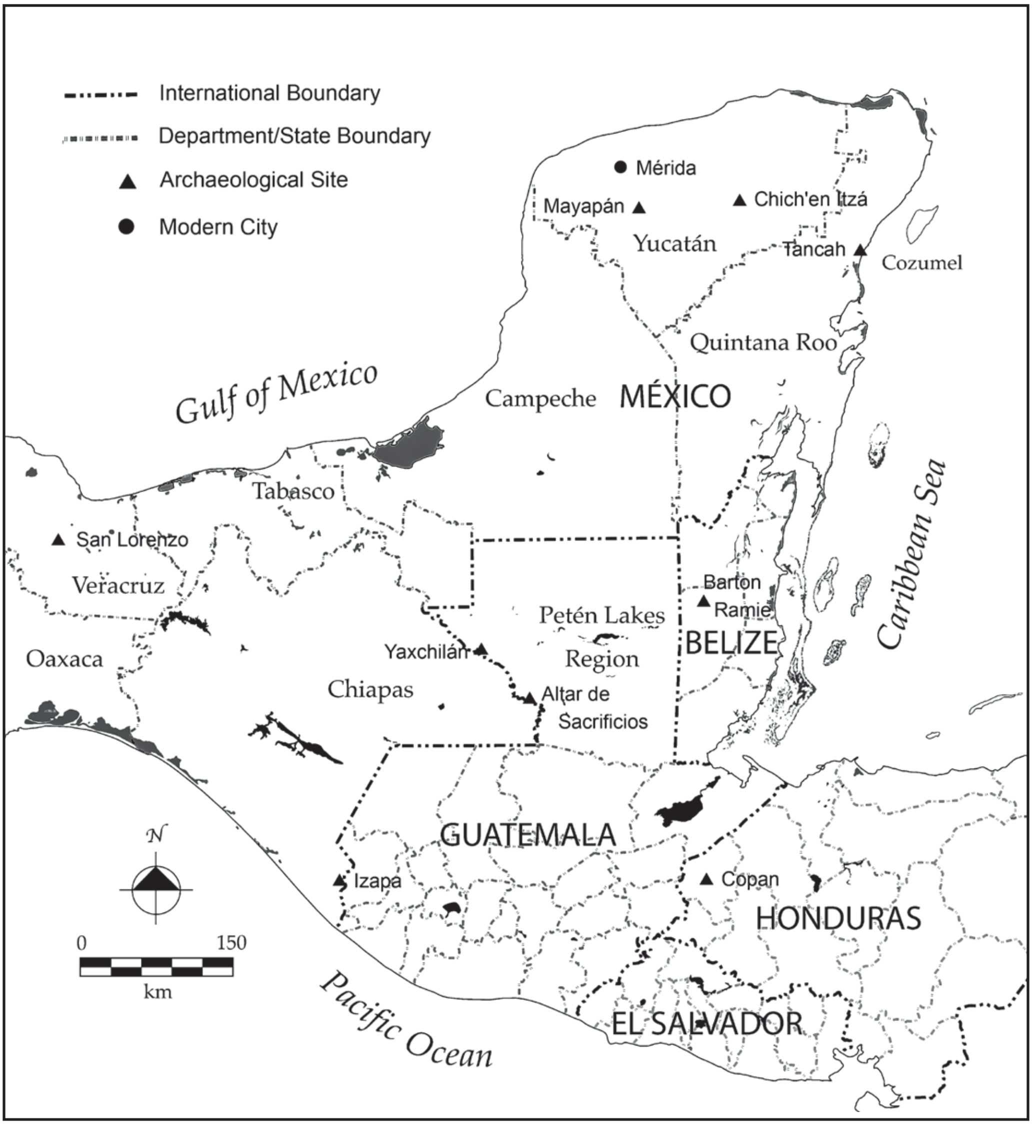


Figure 1.1. Map of Mesoamerica, showing modern political divisions, some of the sites mentioned in the text, and the location of lakes region of central Petén.

sula's shoreline, with coasts, tidal lagoons, estuaries, and river mouths, gives access to marine resources of the Caribbean Sea and the Gulf of Mexico. The interior is punctuated by seasonal and permanent water bodies, including water-filled sinkholes more commonly known as *cenotes* (Hispanicization of Yukateko *dz'onot*) in the north and *juleques* (Itzaj *jul-ek'*) in the south; also *aguadas* (seasonally filled depressions), *bajos* (seasonal thicket-like swamps), and *civales* or *zukches* (seasonal sawgrass [*Cladium jamaicense*] swamps). Petén, in the south-central interior of the peninsula, shares the underground karst drainage of the north, but also boasts interior surface drainage into lakes of various sizes. Major rivers and tributaries

Table 1.1. General periodization of Maya occupation of the lowlands and the Petén lakes region.

General Period	Dates (Greg.)	Petén Period	Dates (Greg.)
Colonial	Post-ca. AD 1525	Colonial	AD 1697–1820
		Contact	AD 1524–1697
Postclassic	AD 950/1000–1525	Late Postclassic	AD 1400–1524
		Middle Postclassic	AD 1200–1400
		Early Postclassic	AD 950/1000–1200
Classic	AD 200–950/1000	Terminal Classic	AD 830–950/1000
		Late Classic	AD 600–830
		Early Classic	AD 200–600
Preclassic/Formative	~1100 BC–AD 200	Terminal Preclassic	0–AD 200
		Late Preclassic	400 BC–0
		Middle Preclassic	900/800–400 BC
		Terminal Early Preclassic	~1100–900/800 BC

flow east through Belize and debouch into the Caribbean Sea, while others drain the west and head northwest through Chiapas and Tabasco into the Gulf of Mexico. It is hardly surprising, then, that fish, shellfish, mollusks, waterfowl, turtles, crocodiles, and other aquatic life would be important components of ancient lowland Maya diet, economy, and ritual.

Unfortunately, little information is available about the economics of ancient Maya fishing and fishing technology (Pohl 1985:40). With respect to the former, this is a consequence of both preservation and archaeological excavation strategies: Time-consuming procedures like fine water-screening or flotation to recover small fish bones and scales are not always undertaken (Stanchly 2004). Concerning technology, the lack of information is primarily a matter of preservation: Fishing paraphernalia (nets, traps, creels) were generally made of organic materials that decompose in the warm, wet lowland climate. In other words, the small, notched net and line weights or *pesas* of fired clay are the most common and reliable archaeological indicators of fishing activity.

For varied insights into ancient Maya fishing and technology, we can turn to art, myth, and Colonial accounts, but *pesas* are nowhere apparent in the imagery. Indeed, surprisingly little information is available to provide interpretive analogies for their production and use.

Ancient Mesoamerican Art and Ritual

Fish appear in art and associated mythology throughout Mesoamerica beginning in late Early and Middle Formative (or Preclassic) times. Archaeologists' interest in marine life in art and ritual begins with the Gulf coastal Olmec shark deity *Xok* (Arnold 2005; Finamore and Houston 2010; Jones 1991; Miller and Taube 1993:152; see also Benson 1977), and continues via occasional recovery of shark teeth and stingray spines at sites throughout the culture area during most of its history. Freshwater fish and fishing have received somewhat less attention.

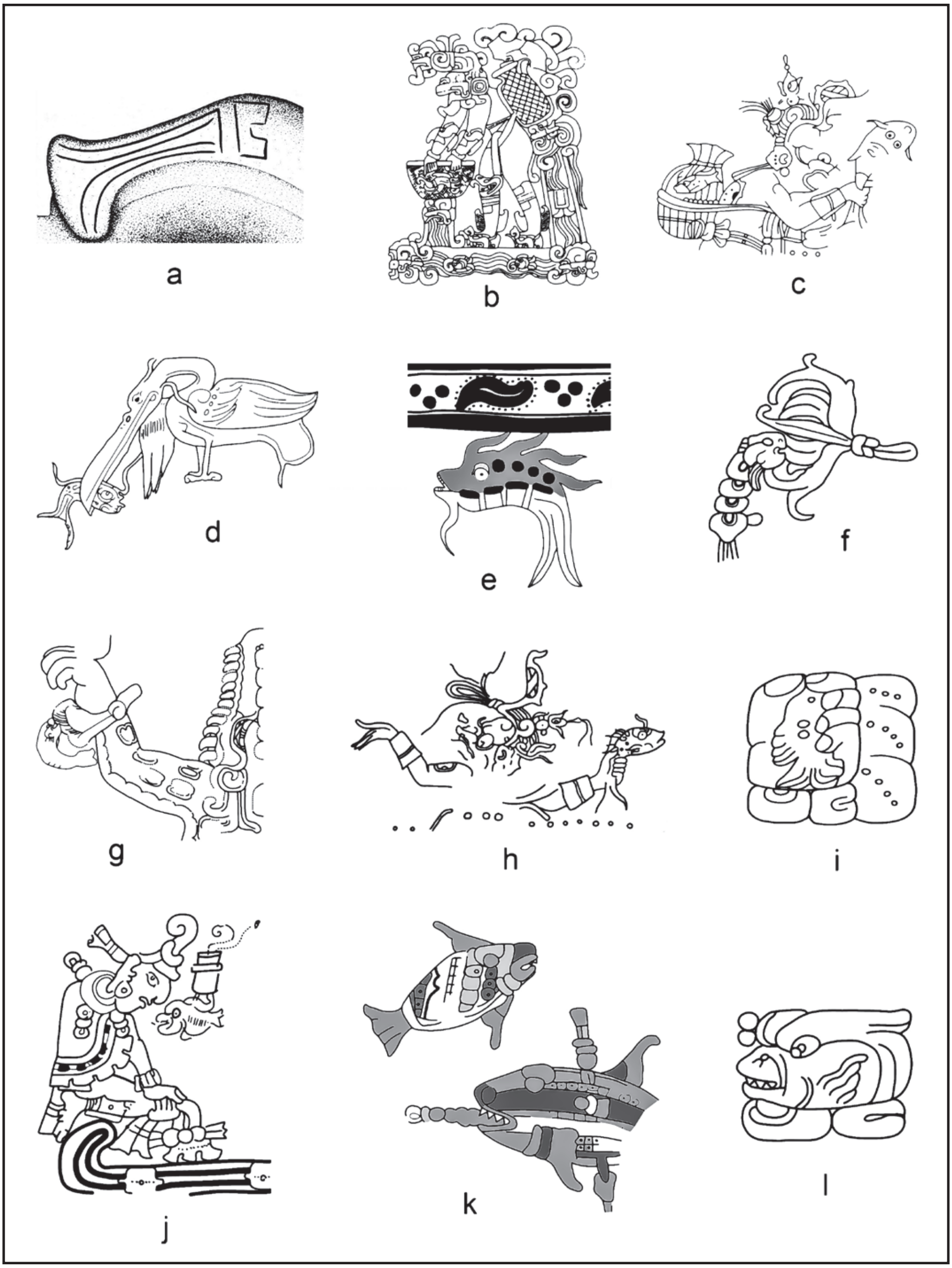
Fish imagery is widespread in early Mesoamerican pottery. Modeled fish heads are seen on *tecomates* (neckless jars) in late Early Formative Pacific coastal Soconusco (Rosenswig 2010:215). In the Petén lakes region, Middle Preclassic black-slipped and red-slipped pottery from Nixtun-Ch'ich', on the western shore of Lake Petén Itzá, includes incised and modeled fish faces and fins as well as a "shark"/Earth motif (Figure 1.2a; Rice 2009:Figures 9 and 10); these resemble motifs from Copan, Honduras (Fash 1991:Figure 33), San Lorenzo, Veracruz, Mexico (Coe and Diehl 1980 v.I:Figure 147a), and central Chiapas, Mexico (Lee 1989:Figure 9.3).

At Late Formative Izapa, in the Pacific drainage of Chiapas, Stela 1 shows the rain deity Chaak fishing in rain-making ceremonies and wearing a creel, a basket-like container carried on the back or shoulder (Figure 1.2b). Early Classic Maya rulers are sometimes shown on carved stelae as fishermen with stylized fish—probably jade ornaments—on their wrists and ankles. On Late Classic Maya polychrome pottery (see Kerr n.d.), fish—often having a cartoon-like mouthful of teeth (perhaps tropical gar?)—may be depicted with waterbirds (e.g., a cormorant holding a fish in its hooked beak [Figure 1.2d]) or with the so-called Waterlily Monster or Serpent (see MacDonald and Stross 2012). Multiple nearly identical vessels show paired catfish (Figure 1.2e), which may relate to the episode in the highland K'iche' Maya *Popol Vuh* creation epic when the Hero Twins self-immolate, their bones ground and thrown into a river, and five days later they emerge as catfish (Tedlock 1996:130–132). The Hero Twin Xbalanque may be named after *xb'alamq'e*, a Pokomchí (K'iche'an) word for the category of spiny-finned fish that includes perch and bass (Tedlock 1996:280)[1].

Associations of fish with waterlilies (*Nymphaea* spp.) in Classic Maya iconography, sometimes fish nibbling waterlilies on the front of lords' headdresses (Figure 1.2f), call to mind

Figure 1.2. *(Opposite)* Fish in Mesoamerican and Maya art (note frequent representation of teeth in their mouths): a, "shark" motif incised on the broad, modeled rim of a Middle Preclassic black-slipped (Desprecio Incised) dish from Nixtun-Ch'ich'; b–c, supernatural figures, likely the Maya rain and lightning god Chaak, fishing and outfitted with creels: b, Late Preclassic Stela 1, Izapa Group A, Mound 58 (redrawn from Norman 1973:Plate 2); c, Classic carved bone from Tikal Temple 1, Burial 116 (redrawn from Montgomery 2000); d, cormorant holding a fish in its beak; detail from Late Classic Polychrome vase (from K4687); e, one of a pair of catfish, a frequent motif on Classic polychrome vases (detail from K3266); f, fish nibbling waterlily headdress (detail from Machaquila Stela 4, after drawing by Ian Graham); g, left front limb of a crocodilian with a fish nibbling on a waterlily tied to its "wrist" on Late Classic Copán Altar T (after Puleston 1977:Figure 4); h, fishing by hand, detail from carved bone from Tikal Burial 116 (redrawn from Schele 1988:Figure 10.5c); i, Maya fish-in-hand glyph *tzak* "to conjure (holiness)" (after Montgomery 2002:242); j, one of two fishermen in a canoe, either deploying or hauling in a net; note fish with smoking pot (detail from the Dresden Codex; after Villacorta and Villacorta 1930:66); k, two fish from a mural in Mayapán Temple of the Fisherman (Str. Q-95); both are marine triggerfish (possibly *Xanthichthys ringens?*), known for their aggressive behavior and teeth (redrawn from illustration by Anne Deane in Peraza Lope and Masson 2014:Figure 2.24); l, Maya glyph *kakaw* (cacao), representing the head of a fish (after Montgomery 2002:132).

the symbiotic importance of flora and fauna in raised agricultural fields (Puleston 1977:458–462). Late Classic Copán Altar T depicts a giant crocodilian "earth monster," Itzam Cab Ain, with fish nibbling daylilies tied to its wrists and ankles (Figure 1.2g).Waterlilies release oxygen into the water and restrict algae growth by providing shade and cooler temperatures,



and by consuming nutrients and contaminants. The distinctive headdresses might denote individuals with water-management responsibilities (Fash 2010:82).

Despite the fairly prominent roles of aquatic creatures in art and mythology, little is known about Classic Maya ritual involving freshwater or marine fish or fishing. Stingray spines were used for ritual bloodletting, and they or stone effigies of the spines are encountered in ritual deposits. Images painted or carved on pottery, stelae, and bone show supernaturals fishing with spears, baskets, and nets, and carrying creels (e.g., Figure 1.2b, c). These images indicate that this gear is important not only in quotidian activity but is also associated with fishing as a "supernatural act": rulers or deities (the rain god Chaak) "portrayed as fishermen who conjure gods and ancestral souls as their symbolic catch" (Taube 2004:76–77). In fact, the Maya "fish in hand" glyph is read *tzak* "to conjure" (Figure 1.2i). The depiction of creels in widely separated periods and areas of Mesoamerica (Figure 1.2b, c) suggests they were either prominent in certain long-lived rituals, or were widely used in relatively shallow areas, such as rivers or lake edges. Moreover, the lack of other fishing tools in these Classic scenes hints that fishermen (or deity-impersonators) waded in the water and part of the ritual may have included catching fish by hand (Figure 1.2c, h).

In the Postclassic period, the Maya Dresden Codex shows net-fishing from a canoe (Figure 1.2j; Villacorta and Villacorta 1930:66–67). In the northern lowlands, murals at the Temple of the Warriors at Chich'en Itza depict fishing activity and at Mayapán a mural in Temple Q-95 illustrates the watery Underworld with fish (Figure 1.2k), a bound crocodile, and a water serpent (Peraza Lope and Masson 2014:95–96).

Colonial History and Ethnography

Little is known about Maya ritual involving freshwater or marine fishing in the Colonial period following conquest by Spain. In the late sixteenth century in Mérida, Yucatán, Bishop Diego de Landa reported that coastal fishers participated with hunters in a celebration with feasting and dances, followed by communal net-fishing on the shore (Landa in Tozzer 1941:155–156). Sometimes fishing was preceded by "sacrifices and offerings to their false gods, offering candles, *reales* of silver and *cuzcas* [beads]" (Tozzer 1941:156n788, citing López de Cogolludo). The gods of fishing are variously transcribed as Ah Kak Nexoi (Ah Kak Ne Xoc?), Ah Pua (Ah Ppuh Ha; Ah Pula), and Ah Cit Dzamal Cum (Ah Citz and Amalcun) (Tozzer 1941:156nn789–91). A 1695 conquest account about the Ch'olti'-Lacandon in lowland Chiapas mentions "two large nets . . . with their floats, and for weights clay (balls) well sewn on" found in a residence (Hellmuth 1977:426). Landa (in Tozzer 1941:190–191) noted that in coastal fishing the Mayas used "trammel [vertically positioned] nets, hooks, and other instruments." Fish were dried, salted, or roasted and sold in places as distant as 20–30 leagues (ca. 80–120 km; 50–75 mi).

In Colonial times as well as the present, bows and arrows were used in fishing in Yucatán (Roys 1972:47), among the Lacandon Mayas in Chiapas (Nations and Clark 1983), in Veracruz (Wing 1980:117), and elsewhere (Ruz 1998). The Lacandons used light-weight wooden arrow tips (Nations 1989:454) or stone points tied with string and a float, to make it easier to retrieve both fish and point (Barrera 2005:32). In early twentieth-century Belize, fish were caught "by rope, hook, harpoon, lance, nets, and traps made of thin bamboo strips" (Villa Rojas 1969:253, citing Gann 1918:25–26). The last suggest the "wickerwork fishpots [creels? traps?] adapted to the cenotes" in Yucatán (Roys 1972:47). Fishermen cast nets with sinkers to trap schools of fish feeding at the mouths of underwater caves in Quintana Roo (Miller 1977:101). Perhaps the fullest account of twentieth-century coastal fishing comes from Veracruz (Wing 1980:107–122).

Varied ichthytoxins were made from plant roots, bark, and other parts (Ruz 1998:370), frequently from plants in the Sapindaceae family. For example, a vine or *bejuco* of the *Serjania* genus was used in Belize (Thompson 1930:90), Veracruz (Wing 1980:117), and Petén (Atran et al. 2004:109, 125) and the Lacandons applied the resin of *chechem* (*Metopium brownei*; poisonwood) to their arrows (McGee 1990:39; Soustelle 1933:161). Wild yam tubers (*Dioscorea composita*) were once used for fish poison along the Gulf coast (Wing 1980:117).

Chapter 2. The Petén Lakes: Environment, Archaeology, and Fishes

The central Petén lakes region of northern Guatemala encompasses a chain of eight lakes extending ~80 km east-west in an area of 100–300 m amsl elevations (Figure 2.1). These lakes—Sacpuy, Petén Itzá, Petenxil, Quexil, Salpetén, Macanché, Yaxhá, Sacnab (west to east)—formed along a fault in the Cretaceous–Tertiary karstic limestone platform of the Yucatán Peninsula at roughly 17° North latitude. These water bodies were, and still are, prime locations for fishing.

The Central Petén Lakes' Environment

Several decades of limnological studies indicate that the waters are characterized by variable but typically high levels of sulfate[2], a consequence of environmental drying at the end of the last glacial period. This drying led to formation of evaporites, notably gypsum (hydrated calcium sulfate or $CaSO_4$; see Hodell et al. 2006:28), and the lower strata of sediment cores

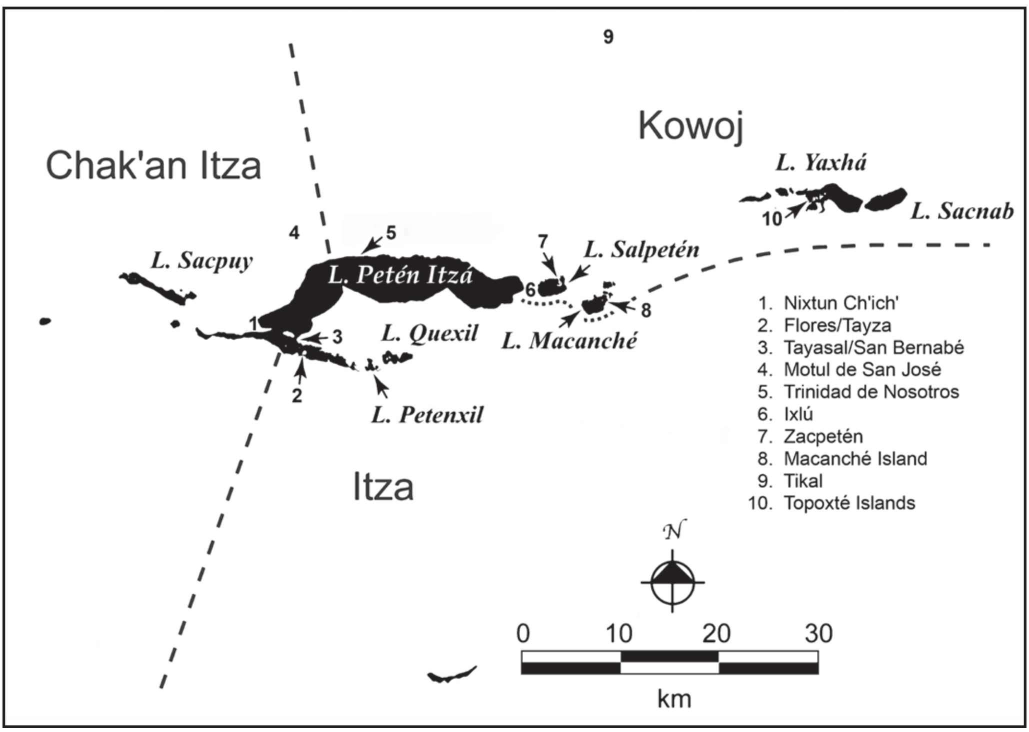


Figure 2.1. Map of the central Petén lakes region showing the individual lakes and location of sites mentioned in the text.

include nodules of sulfur (in Lake Petén Itzá) and crystals of gypsum (in Lake Salpetén). The basins began filling with water around the beginning of the Holocene, ca. 9000 BP, in response to increased rainfall and rising sea levels (Curtis et al. 1998; Leyden 2002:91–92). During the relatively moist conditions of the Middle Holocene, lake stages were considerably higher: Excavation of soil pits around Lake Salpetén, perhaps then joined with Lake Petén, yielded aquatic gastropods at elevations as much as 7.5 m above the present water level (Rosenmeier et al. 2002:176). Lowering of lake levels and vegetation changes accompanied regional climatic drying beginning around 4500 cal yrs BP, followed by an increased moisture regime beginning about 3000 cal yrs BP (Mueller et al. 2009:138–139). Pollen evidence suggests that small groups of semi-sedentary horticulturalists might have begun occupying the lake basins and clearing the forest as early as 4000 years ago (Leyden 2002).

Physiographically, the basins are characterized by steep northern shores and gently rising southern margins. Numerous islands and peninsulas formed, in part, by the collapse of *cenotes*, lie at the edges of the lakes and were heavily occupied, especially in the Postclassic and Spanish Contact periods. Many *juleques* and *aguadas* also punctuate the mainland around the lakes. The lakes are closed drainages with small seasonal streams emptying into them. Water levels vary within annual cycles based on rainy season (June through December) rainfall, runoff, and evaporation, as well as in unpredictable multi-decadal cycles, but the role of the underlying karst in both seepage and groundwater inputs is not well understood.

The lake waters stratify thermally during the months of North American summer (May–August), when warm surface waters (ca. 29–31°C) overlie cooler bottom waters (ca. 24–25°C) (Brenner 2017). As temperatures cool during the late rainy season and early dry-season winter (November through February), surface waters cool and sink because of their higher density. The lakes "turn over" with mixing of the warmer, better oxygenated waters, and a breakdown of the thermocline.

Lake Petén Itzá, at an elevation of 110 m amsl, is the largest and deepest of the Petén lakes with a surface area of ~100 km^2 and a maximum depth of 165 m (Brenner 2017; Hodell et al. 2006, 2008). The lake's waters are slightly brackish and alkaline, with a pH of 8, and dominated by calcium carbonate, magnesium, and sulfate ions (Covich 1976; Hodell et al. 2008:Table 1; Mueller et al. 2009:134). The elongate northern main body of Lake Petén covers approximately 32 km east-west and is 3 km wide. When the Spanish conquistador Hernán Cortés (1986:373) encountered it in 1525, he thought it was an arm of the sea until he tasted the fresh water. The lake's smaller southwestern basin consists of two east-west extensions covering approximately 14 km; the narrow, shallow (~5 m or less) western finger presents a large littoral zone whereas the slightly broader and deeper eastern "thumb" shelters numerous small islands.

Lake Salpetén lies immediately east of the main body of Lake Petén Itzá, separated from it by a low, narrow isthmus. Covering an area of 2.55 km^2 and with a maximum depth of ~34 m, the lake's waters are saline or brackish, with a high pH (8.5) and high calcium sulfate from gypsum outcrops (Anselmetti et al. 2007; Rosenmeier et al. 2002:184). Fishing opportunities are present in an *aguada* and a sinkhole on the Zacpetén peninsula, in addition to the lake itself. Until the Early Preclassic period Lakes Salpetén and Petén Itzá might have been joined as a function of high water levels.

Lake Macanché, east of Lake Salpetén at a higher elevation, has an area of 2.2 km^2 and a maximum depth of around 57 m. Its deep waters are high in magnesium sulfate (similar to Epsom salts) and residents describe occasional fish kills resulting from eruption of sulfurous gases from the lake bottom. Two small, water-filled *juleques* lie on the elevated mainland just north of the island and a small stream drains into the lake just below these sinks.

Lake Quexil (also seen as Eckixil) and shallow Lake Petenxil (or Petenchel) lie just east of the small southeastern thumb of Lake Petén Itzá and south of the Tayasal Peninsula. Lake Quexil covers an area of 2.1 km^2 and is approximately 32 m deep; two small islands lie off its western shore. The southern shores of these two lakes were modified and joined by canals and raised fields (Rice 1996).

Canals and low-lying wetlands around the Petén lakes, predominant on their southern shores, would have been rich areas for obtaining fish and other fauna commonly associated with raised-field cultivation (Dahlin 1979:33–34; Siemens and Puleston 1972; Thompson 1974). Although these fields were likely used for foodstuffs such as maize and beans, they might also have been used to cultivate cotton (*Gossypium* sp.) or cacao (*Theobroma cacao;* chocolate), both of which were noted by Franciscan father Andrés de Avendaño y Loyola in 1696 (1987:42): "a great deal of cotton … though but little" of cacao. Both crops were important to the Mayas, the cotton used in weaving beautiful textiles and the seeds or beans of the cacao pods used both as a currency and to make a beverage consumed by elites. Symbiotic relationships exist in the case of cacao, as the trees are pollinated by insects (midges; Chironomids) whose larvae in aquatic environments are eaten by fish (Dahlin 1979:35), and the Maya hieroglyph for cacao (*kakaw, ka-ka-wa*) is a fish (Figure 1.2l). Similarly, seasonal streams, shallow vegetated lake margins, and canals might have been "fish refuges," areas where fish are trapped in shrinking pools of water as the dry season advances (Thompson 1974:300). In addition, the canal systems might have doubled as fish farms. Ancient canals in an area of raised fields in northern Belize were re-excavated in the 1970s, and within several months 13 fish species had moved in (Puleston 1977:455–456, Table 1).

Archaeology and Occupational History of the Lake Basins

The central Petén lacustrine district experienced substantial occupation from the Terminal Early Preclassic period (beginning around 1100 BC) through the AD 1697 Spanish conquest of the Itzas. Two large Classic dynastic centers are found in the region, Yaxhá on the north shore of Lake Yaxhá in the east, and Motul de San José (Foias and Emery 2012) on the northwest shore of Lake Petén Itzá in the west. These sites and others, discussed below, demonstrate strong Late and Terminal Classic affiliations with the political realm dominated by Tikal to the north through their epigraphy, architectural programs, and artifact assemblages.

Our archaeological research in the central Petén lakes began in 1973 with the Central Petén Historical Ecology Project (CPHEP), directed by the late eminent ecologist Edward S. Deevey Jr. Deevey was interested in tropical lakes as repositories of environmental histories—his hope was that they dated back into the Pleistocene—as well as records of anthropogenic impacts. He and his team analyzed water chemistries and sediment cores in Lakes Yaxhá and Sacnab, while the Rices carried out transect surveys and test-pitting excavations to assess population distributions around the watersheds (Deevey et al. 1979). Continuing limnological and ecological studies have been undertaken by Deevey's former students, especially Mark Brenner and his students and colleagues. As reviewed above, their findings have greatly informed our understanding of the environment and ecological contexts of ancient and modern human occupation of the region.

In the early 1990s, our archaeological research moved westward and the focus changed owing to collaborations with ethnohistorian Grant D. Jones (1998). Jones's archival studies allowed him to reconstruct the geopolitical structures of two rival groups in the lakes region, the Itzas and the Kowojs, at the time of Spanish conquest. Beginning with excavation of Zacpetén in the late 1990s, we concentrated our efforts on Postclassic and later occupations. Our field strategies transformed correspondingly. From the beginnings of CPHEP, our projects principally entailed excavation of 1 x 2 m test soundings to determine occupational and constructional histories. With the new focus on late occupations, we prioritized horizontal areal "clearing" operations: removing uppermost humus and recent soils (Level 1) and structural collapse (Level 2) layers to expose the latest living surfaces. Fieldwork eventually settled on Lake Petén Itzá under the direction of the Rices and then Pugh. Following excavations on the Tayasal Peninsula (Pugh et al. 2014), Pugh headed to Nixtun-Ch'ich' on the western edge of the lake. In 2014, he initiated yet another research focus: investigation of the earliest (Middle Preclassic and earlier) occupation of Nixtun-Ch'ich' (Pugh and Rice in press).

Except for this recent Preclassic focus, these projects were directed primarily toward Postclassic occupations, as the islands and peninsulas in the lakes were significant foci of Postclassic settlement. These communities include the following sites:

Macanché Island is a small, triangle-shaped protrusion of land near the northeastern apex of Lake Macanché. The single mound on the island was investigated by William Bullard in 1968 and again by Proyecto Lacustre in 1979. Bullard's excavations lacked reliable stratigraphic controls, and most of the excavated material came from Late Postclassic midden south and west of the larger structure (Rice 1987).

Zacpetén occupies a small peninsula jutting into Lake Salpetén from its north shore (Figure 2.2). Extensive clearing of 17 Postclassic structures, accompanied by test-pitting, revealed construction beginning in the Middle Preclassic, with the site's Late and Terminal Classic importance—and affiliations with Tikal—indicated by two carved stelae and an altar. Zacpetén is known for its Late Postclassic and Contact period settlement (Pugh 2001; Rice and Rice 2009).

The site of Ixlú (*ixlu* "catfish") occupies the low, narrow isthmus separating Lakes Petén Itzá and Salpetén just south of the steep escarpment that forms the lakes' northern shorelines (Figure 2.3; Rice and Rice 2016). Excavations in 1994 opened 16 test pits, and 14 Postclas-

Figure 2.2. Map of the peninsular site of Zacpetén in Lake Salpetén. Note structure Group 747, Group 719, and temple assemblage Group C.

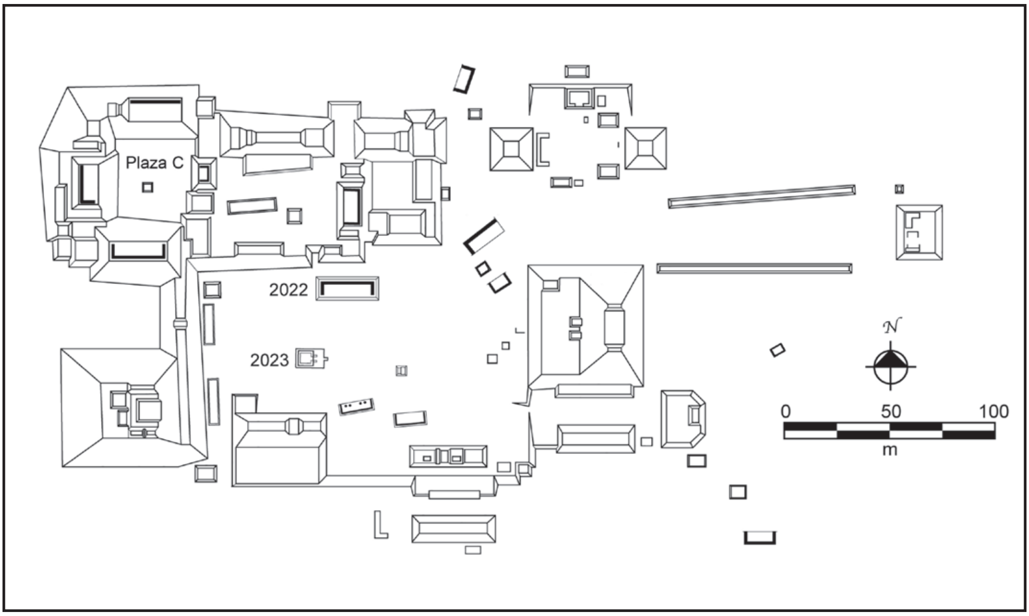


Figure 2.3. Map of the isthmian site of Ixlú. Note Structures 2022 and 2023 in the Main Plaza.

sic structures were cleared in 1998. With construction beginning in the Middle Preclassic period, Classic and Terminal Classic Ixlú was a satellite of Tikal, boasting several carved monuments, a twin-pyramid complex, and two ballcourts.

The site of Tayasal sprawls over the western part of the eponymous peninsula that divides the main body of Lake Petén Itzá from its southern arm, just north of Flores Island (see Chase 1983). It was heavily occupied during the Classic and Postclassic periods (Figure 2.4). Both the peninsula and the site were (mis-) named in the early twentieth century in the mistaken belief that the Postclassic and Contact-period Itza capital known as Tayza (*ta-itza*) or Nojpeten (*noj peten* "big island") was situated there, rather than on Flores Island immediately to its south (see Rice and Rice 2017b). In the early eighteenth century, after the conquest of the Itzas, the Spaniards forced many of the remaining Mayas in the area to move to new mission sites around western Lake Petén Itza, two of which were on the Tayasal Peninsula: short-lived San Bernabé just north of the western tip and San Miguel to the south, still a flourishing community.

Nixtun-Ch'ich' occupies a low area on the western edge of Lake Petén Itzá and over the Candelaria Peninsula stretching eastward into the lake (Figure 2.5). This large site, "discovered" and tested in 1995, was occupied from the Terminal Early Preclassic period (Pre-Mamom pottery) through the conquest of the Itzas and establishment of the briefly occupied early eighteenth-century San Jerónimo mission. Excavations in 2007 included a 32 m-long centerline salvage trench, Operation 1, over the south face of Mound ZZ1 (Rice 2009). Recent excavations in the city's civic-ceremonial core on the mainland indicate that its unusual gridded layout was imposed during the Middle Preclassic period (Pugh and Rice in press).

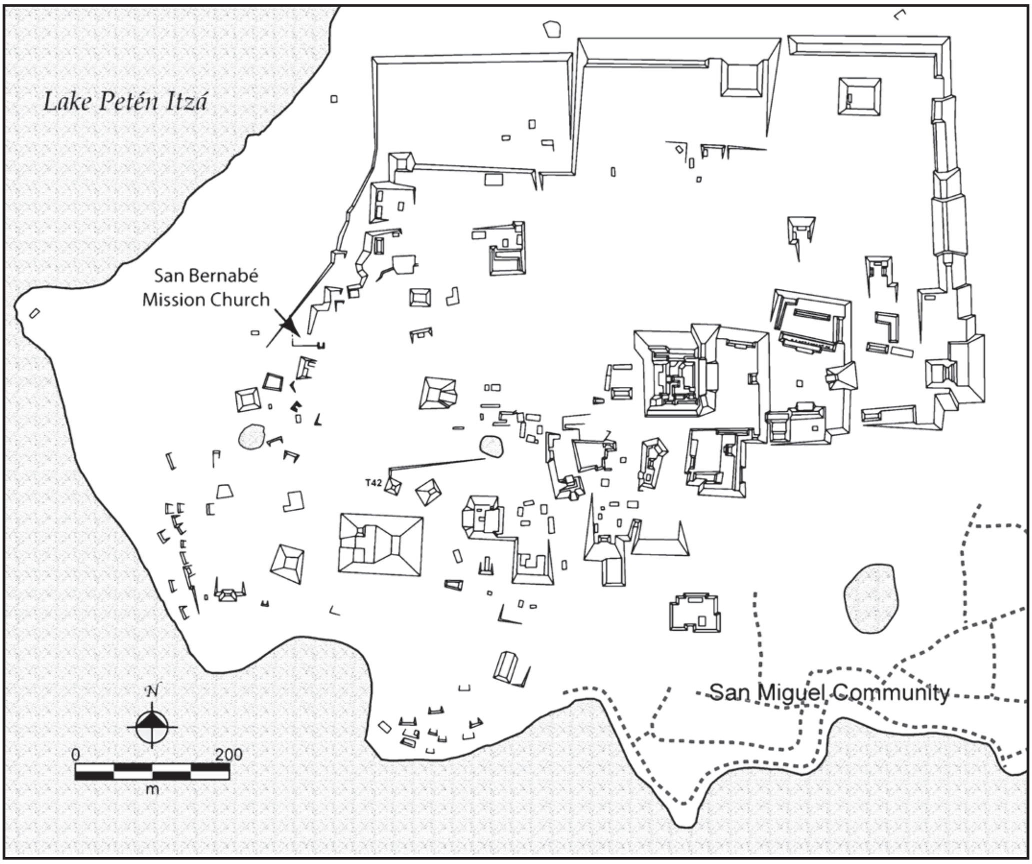


Figure 2.4. Map of western Tayasal and the San Bernabé mission, with the location of the Structure T31 mission church marked.

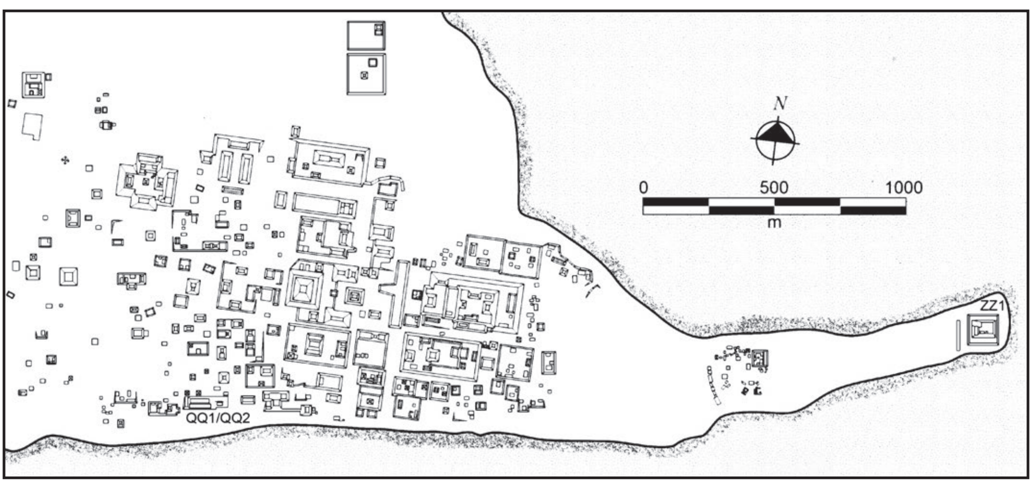


Figure 2.5. Map of Nixtun-Ch'ich', showing the mainland portion and some of the structures on the Candelaria Peninsula. Note locations of Mound ZZ1 on the tip of the peninsula and paired Structures QQ1/QQ2 on the southwestern shore of the mainland.

Until recently, our archaeological test-pitting programs did not include zooarchaeological analyses. Faunal material from Bullard's excavations on Macanché Island was analyzed by Mary Pohl, but no fish remains were noted (in Rice 1987:232). The clearing strategy implemented in the late 1990s permitted recovery of substantial domestic and ritual debris, including pottery, lithics, and faunal remains, sometimes as de facto refuse. Except for analysis of remains from Zacpetén Structure 719 (Rice et al. forthcoming), study of the archaeofauna still lags, however.

Freshwater Fishes of Central Petén

Some 178 species of fishes inhabit the fresh waters of Guatemala's lakes and rivers (Ixquiac Cabrera et al. 2010:3; Kihn et al. 2006; Miller 1966; Valdez-Moreno et al. 2005; Butler 2013). The warm waters of the lakes and *cenotes* in central Petén are home to a subset of these species, notably those that can tolerate some salinity. Spaniards in the lakes region immediately after the conquest described "a great quantity of fish, large ones, medium sized ones, and small ones, very flavorful and good to eat" (Hellmuth 1977:437, translating Villagutierre; see e.g., Villagutierre 1983).

Most studies of Petén's fishes have focused on Lake Petén Itzá. A recent extensive sampling of fishes in the lake identified "20 fish species from 8 families including 18 native (7 families) and 2 non-native" (Table 2.1; Barrientos 2015:23). The most common fish are three genera of the perciform family Cichlidae (subfamily Cichlasomatinae): the giant cichlid (*Petenia*

Table 2.1. Fishes of Lake Petén Itzá and northern Belize (Class Osteichthyes, Subclass Actinopterygii).

Order	Family	Genera and Species
Siluriformes	Pimelodidae (catfish)	[a]*Rhamdia quelen* (3-barbeled; nocturnal, opportunistic carnivore)
Synbranchiformes	Synbranchidae (eels)	[a]*Synbranchus marmoratus* (marbled swamp eel); *Ophisternon aenigmaticum* (obscure swamp eel)
Lepisosteiformes	Lepisosteidae (gar)	[a, b]*Atractosteus tropicus* (tropical gar)
Perciformes (perch-like fish, bass)	Cichlidae	[a, c]*Petenia splendida* (*blanco*); [a, c]*Cichlasoma urophthalmus* (native Mexican mojarra); [c]*C. friedrichsthali*; [c]*C. salvini*; *Thorichthys affinis; Amphilophus robertsoni; Paraneetroplus melanurus*
Cypridontiformes	Poeciliidae (livebearers)	[c]*Poecilia petenensis* (Peten molly); [c]*P. mexicana;* [c]*Belonesox belizanus; Gambusia sexradiata; G. yucatana*
Clupeiformes	Clupeidae (herrings)	*Dorosoma* (possible species *petenense*, *anale; sardinas leche*)
	Atherinidae (silversides)	*Atherinella alvarezi*
	Characidae (tetras)	*Astyanax aenus; Hyphessobrycon compressus*

[a] Recovered at Trinidad de Nosotros, Petén (Thornton 2012:Table 12.1).
[b] See note 3.
[c] Also recovered in field canals, Albion Island, Belize (Puleston 1977:Table 1).
Source: Barrientos 2015:Table 2.2; also Butler 2013; Fishbase 2017.

splendida Günther 1862), the *mojarra* (*Cichlasoma* or, recently, *Mayaheros urophthalmus*), and *Thorychthys affinis*. Although the giant cichlid is the most important economically today, *T. affinis* (yellow meeki), averaging 14 cm long, accounted for 50% of the fish biomass and numbers in the sampling (Barrientos 2015:22).

P. splendida—known locally as *pez blanco* ("white fish") or *blanco,* and sometimes as bay snook or red bay snook—is the most important fishery species in the lakes area and throughout much of lowland Mesoamerica *(*Barrientos 2015; Quintana 2015). It is a tasty whitefish occasionally found on local restaurant menus, fried with onions, garlic, or other seasonings and served whole. Aggressively piscivorous, carnivorous, or omnivorous, *blancos* are distinguished by their large, protrusible jaws that enable them to ingest sizeable prey by suction. Their natural diet varies seasonally, but the submersed littoral aquatic vegetation (especially eel grass, *Vallisneria americana*) in the shallow waters of southern and western Lake Petén is the *blanco's* preferred habitat—and thus a favored fishing area (Barrientos 2015:17; Quintana 2015:13).

Blancos can range in size up to about 44 cm (males) and 1 kg in weight, although in Lake Petén Itzá recently captured fish of both sexes were in the same size classes: length less than 25 cm and rarely larger than 30 cm (Barrientos 2015:41, 44, Table 4-1). In another recent study of 594 tagged fish from Lake Petén, length ranged from 16.6 to 43.4 cm, with a mean of 27.4 cm (Quintana 2015:14, 24). Recent studies showed that the *blanco* was underfished at an annual exploitation rate of 0.37, well below the population's maximum sustainable yield, although the local perception is one of overfishing and it is officially listed as "threatened" (Barrientos 2015:88–96; Quintana 2015:26–27). *P. splendida's* coloration is described as *dorada* (golden), with three variants: silver, yellow, and red (Ixquiac Cabrera et al. 2010:18–19).

The *mojarra*, also known as the Mayan cichlid or Mexican *mojarra*, feeds on plants and animal prey, including apple snails (*Pomacea flagellata*; also consumed by humans) and other hard-shelled invertebrates (Robins 2017). *Mojarra* are tolerant of a wide range of water conditions, including salinity, making them well adapted to the Petén lakes. Also a food fish, *mojarras* commonly range from 10–19 cm to ~39 cm, and weigh up to 1.1 kg (Page and Burr 1991). This brownish fish has seven to nine broad vertical stripes on its body and an eye-like spot at the base of its tail.

Another common fish is the cyprinodont known as a molly: *Poecilia petenensis* (Petén molly). Able to live in brackish water, mollies bear their young live, feed on insects and vegetation (algae), and range in size from 8 to 12 cm.

Two kinds of indigenous baitfish and prey of carnivorous fish can be found in the Petén lakes. *Sardinas* are members of the genus *Dorosoma*, probably *petenense* (threadfin shad; *anale* is found in rivers but not brackish waters) (Butler 2013; Ixquiac Cabrera et al. 2010). These small (usually ~2.5 cm; rarely >15 cm), schooling fish flock to disturbances along lakeshores and deposit their eggs on aquatic vegetation. They typically have a deep belly and a silvery body that is darker on the back. Another baitfish, known by the Itzaj Mayan term *ajp'ulta'*, is a small, dark gray minnow: *p'ul* refers to a water jug and *ta'* means excrement (C. A. Hofling, pers. comm. 2013).

Archaeological investigations at the site of Trinidad de Nosotros, a port/harbor for the Classic center of Motul de San José on the high northern shore of Lake Petén Itzá, recovered remains of nearly 1500 fish (Thornton 2012). These include *blanco*, *mojarra*, and other cichlids plus swamp eel, gar[3], and catfish. Excavations in Structure FF-1, overlooking the harbor, yielded 28 *pesas* from its Early Postclassic occupation (Moriarty 2004:21). Only smaller fish were recovered at Trinidad, whereas larger specimens were identified at Motul, 2 km to the northwest (Thornton 2012:354). Freshwater fauna (turtles, fish, mollusks) were abundant in the Postclassic period.

Recent studies reveal that the availability of different species in Lake Petén Itzá varies by season, likely a function of lake stage: Fish biomass or density (number of individual fish per 100 m^3) is highest in the dry season and lowest in the rainy season, when water levels rise and fish disperse to newly inundated shallows (Barrientos 2015:23–24). July had the lowest biomass, although that of *blanco* did not vary. Of the 18 native fish species identified in the study, nine were present in every month sampled and five in three months or less; some were captured only in the dry season (e.g., Poeciliidae: *Belonesox belizanus*, *Gambusia yucatana*, and *Poecilia petenensis,* whereas catfish were found only in the rainy season [Barrientos 2015:23]). Nonetheless, a diversity index showed no significant difference in species richness in any sampled month. Presumably this same, albeit low, seasonality would also have obtained for the ancient Mayas.

Fishing Today

Lake Petén Itzá presents a wide range of conditions for fish and fishing. Surface conditions vary diurnally, seasonally, and spatially, largely as a function of prevailing easterly winds. Typically, the air and surface waters are calm in the mornings, but as the wind picks up in the afternoons the water may become choppy with whitecaps in large open areas. Although this can be dangerous for canoe travel, local fishermen say it brings fish to the surface. During the rainy season, strong thunderstorms sweep across Petén from east to west and the winds can be violent—with correspondingly rough wave action, especially at the west end of the lake—particularly at the start of the season. In ancient recognition of this phenomenon, Motul de San José, a Classic Maya site on the northwestern shore of the lake, and perhaps the western lake basin in general, was called Ik'a' or "windy water" (Tokovinine and Zender 2012). In smaller, more enclosed areas of Lake Petén and in the region's smaller lakes the waters are ordinarily calm except during storms.

Artisanal fishing in Lake Petén Itzá takes place from the shoreline, canoes, or motorized *lanchas* in the early mornings but primarily at night (frequently using officially banned nets;

Quintana 2015:30). The shallow, quiet waters of southwestern Lake Petén Itzá are decidedly popular, as are the coves and sinkholes at the edges of all the lakes (see Barrientos 2015:17). Bait consists of small fishes (*sardinas*) or balls of *masa* (ground corn dough for tortillas). In our experience, and informants agreed, in modern times *sardinas* are caught by trapping in soda or beer bottles baited with *masa* and set in a few inches of water near the shore; fish are drawn by the *masa* dough, but then cannot find their way out of the bottle. *P'ulta'* minnows are caught in small hand nets at the shallow edges of bodies of water. It is likely that the ancient Mayas caught both kinds of baitfish with fine-mesh nets.

Fishermen use traps, spears and harpoons, and gill and cast nets (Quintana 2015:13). The harpoon or *fisga*, made of cane and fixed with four to five hooked steel points, is used to capture large fish, turtles, and also crocodiles (Lara López 1990:29). Net fishing is more important along the south shore and around Flores Island than on the steep north shore of Lake Petén Itzá (N. Schwartz, pers. comm. 2012). Conversations with local informants also indicate that netting is important in the shallow, vegetated southern waters, suggesting a general association with the littoral zone. Traps are made with quartered flexible stems of the *b'ayal* or Areca palm (Atran et al. 2004:25) and, depending on their size, these might have been large enough to capture not only fish but also turtles. The crushed stem of the *Serjania triquetra* vine is used as poison as is the wood of *Piscidia piscipula* (*jab'in;* Atran et al. 2004:109, 125), the latter found in archaeological context at Zacpetén (Lake Salpetén). Both contain rotenone (see Sackett 2012).

Given the late twentieth-century's rapidly growing populations and tourism around Lake Petén Itzá, particularly on its southern and eastern shores, there has been concern about the quality of the lake waters. Cultural eutrophication has been noted in the small, heavily populated southwestern basin as a result of nutrient inputs through agricultural practices and sewage deposition (Rosenmeier et al. 2004), although the latter should have been eased through a recent public works project installing sanitation facilities. The sustainability of "open-access, artisanal" fishing in Lake Petén has recently been the focus of biologists' research (Barrientos 2015; Quintana 2015). Two government agencies oversee fishing in Lake Petén, although management plans (limits on size, quantity, season) do not exist and fishing is unrestricted (Quintana 2015:28). Of varying fishing modes—gill nets, cast nets, spears, harpoons, and hook and line—only line fishing is technically allowed today (Quintana 2015:13).

Chapter 3. Fishing Nets and Sinkers

Fishing nets are made in a range of sizes and shapes for efficiently collecting specific kinds of fish in specific kinds of water conditions. Nets may be tended and deployed by casting and hauling, or they may be untended and set in a fixed position. All nets would have been useful for catching quantities of fish temporarily stunned by poisons.

Nets

Whether tended or untended, fishing nets typically need floats on one edge to keep them from completely submerging. On the Caribbean coast these floats were frequently made of pumice (Freidel 1978:250; McKillop 1984:31), but gourds would have sufficed in calmer waters. In Petén, these devices also might have been made of the wood of the *b'ojon* tree (*Cordia alliodora*; laurel, Spanish elm), which "floats like a cork" (Hofling with Tesucún 1997:181). In addition, its bark can be used to make tumplines and ropes. Nets typically also need weights at the bottom to make them sink to the desired depth and stay in place when deployed vertically. It is recommended that the weights of the sinkers attached to a gill net be gauged by its floats: for each float the sinkers should weigh three to five times more than the float can lift (Rosman 1980).

The mesh size of nets is determined by target fish size, and the types of nets used vary with water movement, depth, and fish behavior. In riverine and coastal fishing in southern Veracruz (Wing 1980), casting nets had a standard spacing of (lead) weights to loops, and mesh size was given in terms of *dedos* (finger widths). Mesh spacers[4] were made of a type of bamboo, possibly *Chusquea* (Wing 1980:108) but more likely *Otatea*.

Seines are long, rectangular nets deployed over a large area of shallow water with the bottom of the net resting on the floor. They typically require cooperative efforts, as two or more people must haul the ends to shore and gradually bring them together to trap the fish, and thus fishing with large seines is often a communal event. Other seines may be thrown or cast (casting nets) and monitored by one or more people. A trawl net is a large funnel-shaped device made of window-screening material today, with a metal hoop at the top; it is dragged along the bottom of the lake from a boat. Smaller, fine-mesh dip nets, with or without handles, might have been used to scoop fish from seines, to capture small fish or baitfish near shore, or to bring in fish caught on lines.

One type of casting net, sometimes called a purse-seine net, is locally known as an *atarraya*. This device might have been introduced by the Spaniards, the term reflecting Arabic influence on Spanish technologies (Glick 1999). A *petenero* near Ixlú, observed making an *atarraya*, used purchased plastic twine, which was manipulated with a long, narrow, wooden needle-like tool; he made his own lead weights (see also Wing 1980). Nets had two mesh sizes, ~1 cm for small and 3–4 cm for larger fish, but the placement of knots or weights was not formally measured. It takes him four months to make a net 5 m in diameter, which he sells for the equivalent of about US $320 (E. Chan, pers. comm. 2013). One such *attarraya* owned by the Chan family of San Benito, on the edge of Lake Petén, was made of thin, green plastic twine and measured 5 m in diameter and 2 m from top to bottom openings; mesh size was about 2.5–3 cm. Closely spaced cylindrical lead weights lined the bottom edge. About 20–25 strings of thicker plastic were attached at intervals to the bottom edge, extended to the top, and threaded through a narrow plastic cylinder attached to a long rope. To bring in the captured fish, the fisher pulls on the rope, which draws up the strings and closes the bottom of the net, trapping the fish inside. The net with its lead weights is heavy, perhaps 4.5 to 5 kg, and requires considerable practice to drape over the arm and shoulder and cast properly.

A common fixed net is the gill net, suspended vertically in the water between two stakes to catch fish that become entangled in the mesh by their gills. Two types of gill nets are described today as flag-style and tie-down or sinking style. Flag-style nets have a top line that is stretched between two fixed locations, but no bottom line of sinkers. They are used in still waters of ponds or lakes. Tie-down gill nets may be positioned to rest on the bottom of the water body, near the surface, or in between. The trammel net (*trasmallo*) is a more complex kind of gill net incorporating varying mesh sizes to capture different sizes of fish. In Petén, fixed nets might have been placed to trap fish in the small streams draining into the lakes, or to catch fish living in the canals associated with raised fields on shallow lakeshores.

Fishing with nets is technically illegal in Lake Petén Itza today (and forbidden in Lake Yaxhá, which is part of the Maya Biosphere Reserve[5] [Barrientos 2015]), but nonetheless gill nets continue to be used illegally.

Sinkers (*Pesas*)

Pesas, commonly interpreted as fishing net or line sinkers or weights, are recovered in archaeological deposits dating as early as Preclassic times in the Maya lowlands. An earlier tabulation of published dimensions of 1689 *pesas* from Maya sites in Yucatán, Belize, Guatemala, and Honduras revealed a wide range in length from 1.0 to 10.0 cm, and in weight from 0.85 to 138 g (Rice 1987:Table 14). Larger/heavier artifacts of notched pottery and stone are found in areas of rough, fast-moving, and/or deep waters, such as along the Caribbean coast (Eaton 1976, 1978; McKillop 1984:30, Figure 5; Phillips 1979). Smaller and lighter weights are found at sites near shallower and/or calm waters of lakes and ponded areas of streams. As will be seen, the weights recovered around the Petén lakes fall at the low end of these size ranges.

Sinkers are of two forms: worked sherds and formed pellets. Worked-sherd weights, made throughout the lakes' occupational history, are secondary artifacts: fragments of broken pottery, slipped and unslipped, with notches cut into opposite sides (Figure 3.1a–c). Some are rough-outs: crudely shaped, irregular pieces retaining the chipped edges of preliminary shaping, and possibly unfinished (Figure 3.1c6). More typically the edges are ground smooth and the fragment modified into more or less circular, oval, rectangular, or square shapes. In cross-section they are flat or slightly curved, depending on what part of a vessel the original fragment represents. Occasionally, sherd weights were made from rims (Figure 3.1a2). Pel-

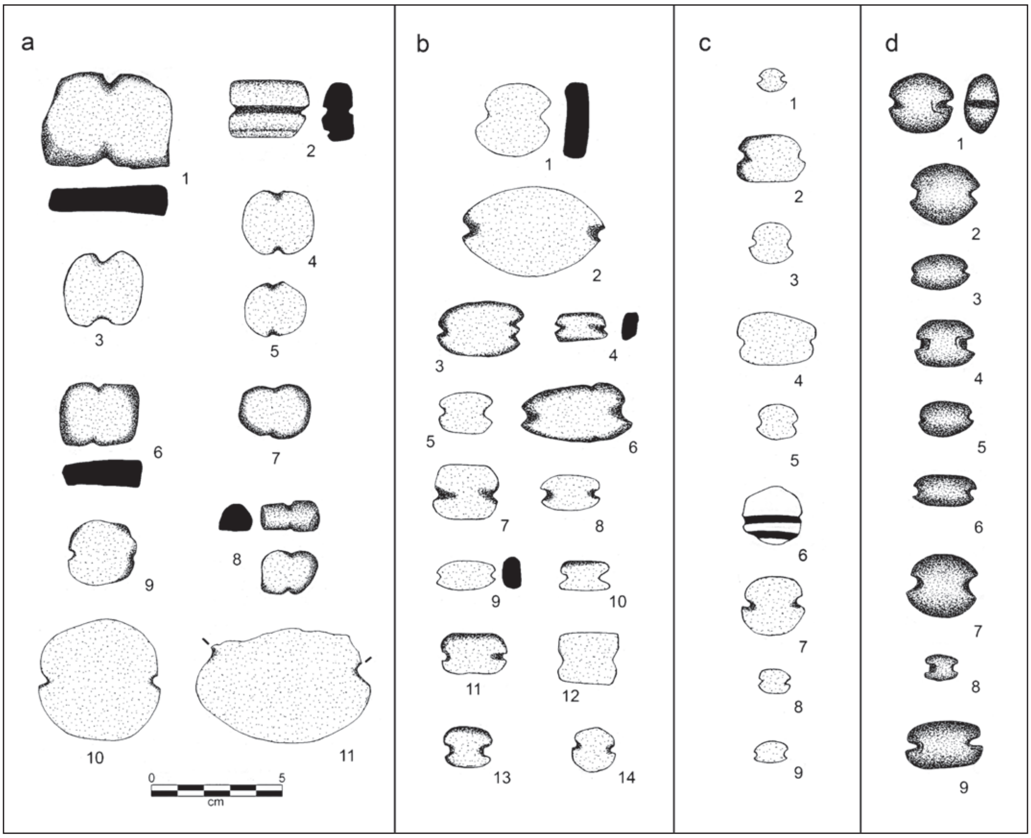


Figure 3.1. Worked-sherd and pellet *pesas;* note different sizes and shapes of sinkers and notches. a, Preclassic: 1–5, Ixlú: 1, lot 30339, ash paste; 2, Guitarra Incised (note circumferential groove); 3, lot 28017; 4, lot 25134; 5, lot 28982; 6–9, 11, Nixtun-Ch'ich', Juventud Red: 6, lot 43158; 7, lot 43158; 8, lot 43187; 9, lot 43542; 11, lot 43190; 10, lot 43515; b, Classic: all but no. 4 from Nixtun-Ch'ich': 1, ZZ1, lot 41991; 2, ZZ1, lot 43201; 3, Str. QQ1/4, lot 1020 (note double-notch on right); 4, Ixlú, lot 20344; 5, ZZ1, lot 43507; 6, ZZ1, lot 41989 (not traces of side-notches); 7, Str. QQ1, lot 3454; 8, ZZ1, lot 43145; 9, ZZ1, 43078; 10, ZZ1, lot 43108; 11, ZZ1, Fine Orange, lot 41965; 12, ZZ1, 43201; 13, Str. QQ1, lot 3675; 14, ZZ1, lot 41983; c, Postclassic worked-sherds: 1, Ixlú, lot 20355; 2, Nixtun-Ch'ich' ZZ1, Paxcamán Red, lot 45027; 3, Nixtun-Ch'ich' Str. QQ1, Paxcamán Red, lot 3649; 4, Zacpetén, CCP ware, lot 2223; 5, Nixtun-Ch'ich' Str. QQ1, lot 3594; 6, Ixlú, Ixpop Polychrome, lot 451; 7, Nixtun-Ch'ich' ZZ1, Paxcaman Red, lot 44374; 8, Nixtun-Ch'ich' ZZ1, lot 43086; Nixtun-Ch'ich' ZZ1, lot 44354. d, Postclassic pellets: 1, Quexil Island, Str, Q3, lot 1789; 2, Ixlú, SIP ware, lot 2219; 3, Nixtun-Ch'ich' ZZ1 lot 43545; 4, Nixtun-Ch'ich' ZZ1, lot 44363; 5, Nixtun-Ch'ich' ZZ1, lot 43031; 6, Nixtun-Ch'ich', QQ1, flattened pellet, lot 3589; 7, Nixtun-Ch'ich' ZZ1, black-slipped, lot 43190; 8, Nixtun-Ch'ich' ZZ1, lot 45085; 9, Zacpetén Str. 747, lot 10503.

let or bead weights (Figure 3.1d), also called *perlas*, are unique to the Postclassic and later periods in the Petén lakes region and are discussed further below.

Both types of artifacts are similar in size and shape to modern metal weights and sinkers used in line fishing and sold in sports stores, such as split shot weights and varied (bank, bullet, disk, egg, trolling) sinkers used in deeper waters. Split shot weights, for example, are small spheres in a range of sizes (that is, a range of weights) used in live-bait line fishing. Anglers recommend attaching them 20–50 cm or more above the bait (see also Kaminsky and Schwipps 2011:146). Sinkers for both net and line fishing are ideally rounded or oval and smooth, so that they do not snag on either the netting or submerged vegetation. *Pesas* affixed to nets should all be approximately the same weight.

Characterizing Petén Sinkers: Methods

Observations on the 1400+ sinkers from six central Petén lakes region sites or lake basins were recorded on EXCEL spreadsheets using 13 variables, including provenience data (five variables), condition (estimate of breakage), and shape or form, color/type/paste (if identifiable), and dimensions: weight, length, width, and thickness. Weights were measured in grams on a digital scale and recorded to two decimal places; linear dimensions were measured in centimeters with digital calipers and likewise recorded to two decimal places. Length was measured most often between notched edges (usually but not always the greatest dimension of the artifact). Maximum width was sometimes difficult to measure owing to curved or otherwise uneven edges, but was generally orthogonal to length. Individual artifacts sometimes exhibited variable thickness, particularly if they were formed from rim fragments, but rather than taking multiple measurements and averaging them, thickness was measured in the approximate center of the artifact. Because these objects were frequently broken, some measurements could not be made.

The data on these artifacts were collected over several years and as the study expanded new variables (e.g., color, shape, pottery type) were added to the metrics, resulting in some inconsistencies in recording. For example, color was more frequently noted with Nixtun-Ch'ich' and Ixlú *pesas*, and types or paste wares for the Zacpetén materials. With benefit of hindsight, it also might have been useful to record characteristics of the notches, such as depth, width, and U- or V-shape.

The samples of sinkers can be considered independent of each other (different sites/producers) although, as is true of most kinds of archaeological samples, they are not truly random (they are cluster samples). The question asked of these data concerned the presence/absence of significant differences—among sites, structures within sites, *perlas* versus sherds, and types or wares—and what the differences might reveal about variations in fishing activity or strategy. The simple null hypothesis (H_0) is that no differences existed: that is, the attributes of different kinds of sinkers, or from different sites and structures, sampled the same population. Because the most salient attribute of these artifacts is their weight, this metric is the primary focus here.

The dimensions of the *pesas* were intercompared by t-tests and analysis of variance to determine the likelihood that they sampled different populations of producers. Unpaired Student's t or difference of means tests (Kirkman 1996) were applied—primarily to Postclassic artifacts—after assessing the distributions for normality or lognormality via Kolmogorov-Smirnov tests[6]. Comparisons also included one-way, standard weighted-means analysis of variance (ANOVA) for independent samples and the Tukey post-hoc HSD test. This latter, the HSD ("honestly significant difference") test, automatically identifies specific significant differences between cases (sites, structures) in each analysis run. Because the on-line statistical program (Lowry 2017) only permitted comparison of five cases at a time, various combinations of dimensional data from the sites, and from different locations (structures) within the sites, were analyzed. The ANOVA model is based on several assumptions, two of which (normality, no significant outliers) were occasionally violated by these samples. Early analyses of the Postclassic sinkers showed that the dimensions, especially weight, may have lognormal rather than strictly normal distributions. This raises issues of outliers, as the distributions are distinctively right-tailed, with most measurements clustered near the lower end and a few in the higher end. We return to this point below.

Chapter 4. Petén Lakes' Preclassic and Classic Sinkers

Our overall population of analyzed ceramic net weights was recovered as a product of long-term interest in the late occupations of the Petén lakes area. This research focus permitted fine-grained analysis and comparisons of Postclassic *pesas* among sites and structures, but such detail is unfortunately lacking for the sinkers dating to the Preclassic and Classic periods. None of these early artifacts can be reliably attributed to primary contexts. Some came from single-phase fills of test units excavated to determine construction histories. Most were found in chronologically mixed fills as well as in upper (Levels 1 and 2) Postclassic/Contact-period deposits, and are roughly dated by characteristics of type, slip, and paste. Because of the idiosyncratic recovery contexts, they by no means represent "assemblages" in the same sense as the Postclassic sinkers. Here we isolate these early Preclassic and Classic artifacts to begin to identify and compare characteristics of and changes in these artifacts—and in fishing strategies—through time.

Preclassic-Period Sinkers

Sinkers made from Preclassic pottery types were recovered only at Ixlú (n = 9) and Nixtun-Ch'ich' (n = 23) (Table 4.1). However, none were found in the actual Middle Preclassic construction levels excavated in the large Mound ZZ1 Op. 1 salvage trench at the latter site.

Compared with the *pesas* of other sites and periods, the Preclassic sinkers from Nixtun-Ch'ich' were found to be unusual in several characteristics. One is the position of the notches: 14 were "side-notched" rather than end-notched: that is, the notches were placed on the short (width) axis (that is, the long side) rather than the long axis (short end) of the artifact (Figure 3.1a). This placement is rarely noted in other time periods. Another concerns shape: seven were round in plan view.

The most unusual trait of the Preclassic *pesas* was their size and particularly their weight (Table 4.2) in comparison to the

Table 4.1. Frequencies of Preclassic pottery types/wares of sinkers at Nixtun-Ch'ich' and Ixlú.

	Nixtun-Ch'ich'		
Type	**Md. ZZ1**	**Other**	**Ixlú**
Juventud Dichrome	1		
Sierra Red		3	1
Mars Orange	1		
Zapote Striated	1		
Achiotes Unslipped		1	7
Late T. Precl. Paste	3		
Other	5	1	
Total	18	5	9

Table 4.2. Dimensions (in g and cm) of Preclassic and probable Preclassic sinkers from Ixlú (n = 8) and Nixtun-Ch'ich' (n = 18).

	Weight	Length	Width	Thick.
N	22	24	24	26
Mean	9.06	3.22	2.375	0.76
Max.	33.86	6.78	5.28	1.3
Min.	2.38	2.9	1.6	0.37
Spread	31.48	3.88	3.68	0.93

Classic and Postclassic sinkers discussed below. Of 11 complete artifacts from Mound ZZ1 Op. 1, most of which (except for Zapote Striated type) appear to be Middle Preclassic, the mean weight was 9.33 g. This statistic is biased by including the largest and heaviest *pesa* of the entire Petén lakes collection of all periods, which was made of Middle Preclassic Juventud Red pottery: it measured 5.83 cm long, 5.37 cm wide, 0.81 cm thick, and weighed 33.86 g. Another, of which only half remained, was 6.78 cm long and 0.86 cm thick (Figure 3.1a11).

Excavations in the north part of the Mound ZZ1 Op. 1 trench uncovered the remains of Structure B-2, which had been ritually terminated around the end of the Terminal Preclassic period or the beginning of the Early Classic. Deposit 1 on the floor south of Structure B-2, associated with the termination, included unusual ceramic artifacts (Rice 2009:413–414, Figures 9 and 10) plus 26 notched sherds in a single 2 x 2 m unit. Another 37 sinkers were recovered in adjacent units, including nine under a retaining wall, plus the exceptionally large Preclassic *pesa* just mentioned. The dimensions of 62 sinkers (excluding this large one) are given in Table 4.3. We consider them to be the remains of a fishing net that was part of Deposit 1[7].

Table 4.3 Dimensions (in g and cm) of *pesas* in and associated with Terminal Preclassic Deposit 1, Mound ZZ1, Nixtun-Ch'ich'.

	26 *Pesas* in Single Unit				Total 62 *Pesas* Assoc. w. Deposit			
	Wt	L	W	Th	Wt	L	W	Th
Mean	2.41	2.16	1.58	0.47	2.32	2.27	1.66	0.47
Max.	9.5	3.42	2.72	0.71	10.98	4.62	4.83	0.71
Min.	1.14	1.66	1.14	0.36	0.55	1.06	0.95	0.33
Spread	8.36	1.76	1.58	0.35	10.43	3.56	3.88	0.38

Classic-Period Sinkers

Notched-sherd sinkers made of Classic-period pottery types and wares (Figure 3.1b) were recovered at all sites in Postclassic contexts (Levels 1 and 2) and in Classic contexts penetrated by test units excavated to date construction sequences. *Pesas* were identified as Classic by a combination of traits including paste, slip, and thickness. Although some Preclassic and Postclassic pottery included volcanic ash tempering, this was infrequent and ash-tempered pastes were routinely considered Classic in date unless this was contraindicated by other attributes. Classic slips were sometimes distinguishable by their thinness and luster (Peten Gloss ware) as distinct from the thicker and often waxy feeling Preclassic slips, but this was inconsistent because of erosion. Thickness was useful because Classic pottery was customarily thinner-walled than Preclassic vessels. Nonetheless, Classic ceramics in the lakes region are highly variable, compared with those of the Preclassic and Postclassic periods, in paste, slip, thickness, color, and other attributes.

The Operation 1 salvage trench through Nixtun-Ch'ich' Mound ZZ1 is the only locus in the lakes region where our excavations penetrated substantial Classic construction fills. Here we consider 86 sinkers from these deposits—essentially everything below Postclassic Levels 1 and 2 and excluding Preclassic fills—and we exclude all artifacts that are clearly Preclassic (on the basis of type and side-notching). These 86 *pesas*, in other words, are considered to represent sinkers made and used in the Classic period (Table 4.4), although we would not be surprised if a few unusually large, thick—and therefore heavy—*pesas* were actually Preclassic artifacts. Among these 86 artifacts, eight weighed more than 8.0 g, four of which weighed more than 10 g.

Table 4.4. Dimensions (in g and cm) of 86 Classic and probable Classic notched-sherd sinkers from Classic fills in Mound ZZ1.

	Weight	Length	Width	Thick.
N	86	84	86	86
Mean	3.38	2.36	1.8	0.51
Max.	17.12	5.39	4.83	1.1
Min.	0.74	1.32	1.08	0.33
Spread	16.38	4.07	3.75	0.67

Table 4.5 compares the mean dimensions of 222 Classic and probable Classic sinkers from all contexts at seven sites or structures plus Mound ZZ1. It can be seen that they are quite similar. In fact, ANOVA analysis of the weights of 110 of these artifacts (excluding Macanché, Zacpetén Structure 719, and Nixtun-Ch'ich' Mound ZZ1) showed that they appear to be from the same population of makers ($p = 0.56$), indicating that the fishers of these sites were fishing to a similar target-sized fish. The 11 Macanché sinkers are larger and heavier, but those artifacts were not included in the ANOVA.

In length, the Classic *pesas* from the five sites in Table 4.5 differed, but with a low level of significance ($p = 0.034$). Specifically, the artifacts from Zacpetén and Ixlú are longer than

Table 4.5. Mean dimensions (in g and cm) of 222 Classic and probable Classic notched-sherd *pesas* at Petén lakes sites.

Site	N	Weight	Length	Width	Thick.
Macanché Island	11	6.34	3.25	2.21	---
Zacpetén Structure 719	27	4.50	2.55	1.88	0.64
Zacpetén other	40	3.44	2.39	1.73	0.88
Ixlú	25	3.32	2.36	1.81	0.56
Tayasal	16	3.28	2.19	1.66	0.61
Petenxil-Quexil	13	3.58	1.80	1.46	0.56
Nixtun-Ch'ich'					
ZZ1 Postcl. Levels	16	4.36	2.76	2.02	0.60
ZZ1 Classic Levels	86	3.38	2.36	1.80	0.51
Other Structures	28	2.59	2.19	1.58	0.56
MEAN (of means)		3.87	2.43	1.79	0.62

those from Petenxil and Quexil. In width ANOVA showed no significant differences among the *pesas* from the five sites, although the Mound ZZ1 and Macanché artifacts are wider. These slight differences are likely idiosyncratic to particular community standards or aesthetics, but possibly related to fishing strategies (see also below).

The weights of 222 Classic or probable Classic sinkers ranged from 0.74 g to 17.12 g, both extremes coming from the Mound ZZ1 trench. The heaviest artifacts, those weighing 8.0 g or more, come from Mound ZZ1 Classic levels and Postclassic levels at Zacpetén. These artifacts are discussed further in Chapter 7.

Chapter 5. Postclassic Contexts and Sinkers

Our excavations in the central Petén lake basins from the mid-1990s through 2014 were directed toward Late Postclassic and Spanish Contact period occupations. These were turbulent times after the Terminal Classic sociopolitical "collapse" and abandonment of many southern Maya lowland cities (see Aimers 2007; Demarest et al. 2004; Webster 2002). At Macanché Island, for example, the Terminal Classic (or Epiclassic) changes included smaller pottery vessel sizes, the use of the bow and arrow, cessation of use of large "utility bifaces," increased numbers and kinds of pottery fishing-net weights, and greater recovery of turtle remains (Rice 1987:237). Together these suggest increased reliance on aquatic resources, different (reduced?) forest cutting, different hunting techniques and/or quarry, and smaller domestic units of food production and consumption.

Multiple migration streams into the lakes region brought renewed populations and settlement shifts to the lakes' islands and peninsulas. The demographic mobility also brought attendant social stresses and, over time, a sharp ethnopolitical division developed between the eastern and western lakes area. The eastern basins of Lakes Yaxhá and Sacnab were occupied by a group or groups known in the Contact period as the Kowojs, while the western lakes (Petén Itzá and Sacpuy) were controlled by the powerful Itzas (Jones 1998). The stresses were exacerbated in the sixteenth and seventeenth centuries as immigrants from the north fled to the isolated Petén forests to escape the deadly diseases and harsh labor and tribute/tax demands of the new colonial regime. By the late seventeenth century, the two polities were deeply factionalized and at war: the Kowojs had expanded westward to the shores of Lake Petén, usurping former Itza territory, allying with a dissident Itza faction around Lake Sacpuy, and burning a part of the Itzas' island capital.

Postclassic structures differ considerably in form and construction from those of the Classic period (Pugh and Shiratori 2017). They consist of narrow rectangular halls with low masonry walls about 1–1.5 m high and upper walls and roofs of perishable materials. The wide front is typically open and may be colonnaded ("open" or "colonnaded" halls) with interior masonry benches. Civic-ceremonial structures, including elite residences and council houses, are often "tandem" halls, with open front and closed back rooms. Halls and other ritual structures (e.g., shrines, temples) may surmount elevated platforms of varying heights.

Our excavations focused on extensive horizontal clearing of these late structures through humus (Level 1) and collapse (Level 2) to their uppermost living surfaces, typically floors and benches. The contexts largely consisted of collapsed construction materials with de facto refuse left after abandonment of some of the structures. This permitted detailed analysis and comparisons of *pesas* among and between sites, among individual structures within sites, and in activity areas within structures.

Postclassic and Later Sinkers

Postclassic net weights were made of the three major paste wares used for slipped and unslipped pottery in the lakes region: Itza-related Snail-Inclusion Paste (SIP) ware and Kowoj Clemencia Cream Paste (CCP) ware for slipped pottery, and Montículo Unslipped ware used for Pozo Unslipped utilitarian vessels (Table 5.1)[8]. As mentioned, Postclassic *pesas* are of two kinds: worked (notched) sherds and pellets or beads. Pellets or *perlas* (Figure 3.1d) are primary artifacts: modeled (or perhaps molded) of clay, typically elliptical-to-semi-spherical or oblate (slightly flattened) spheres in plan and section, with U- or V-shaped notches (rarely completely encircling grooves) cut into the still-wet clay on the ends before firing. Considerably less common than notched sherds, these unslipped bead-weights are unique to the Postclassic. In the lakes area, they are made of Postclassic pastes and thus are Postclassic manufactures. This suggests that either fishers had access to the same clays potters used in making dishes and jars, whether directly from the clay source or from the potters, or that potters formed and fired the pellets. In other areas of the lowlands, *perlas* may appear in the Terminal Classic or earlier (Bartlett 2004:268).

Of the notched-sherd *pesas* recovered in these late contexts, most were formed using fragments of Postclassic pottery types and paste wares (Figure 3.1c), clearly dating them to the Postclassic period. Others, however, represented Preclassic and Classic types. Here we confront a conundrum: the possible use of worked-sherd sinkers of Preclassic and Classic types and pastes in Postclassic artifact assemblages: (1) Were these merely objects from older *refuse*, earlier fill material churned up by Postclassic construction or other activity and largely *ignored?* Or, (2) were they opportunistically *recycled artifacts*, that is, *sinkers* that Postclassic fishers brought from "archaeological" context back into "systemic" context (Schiffer 1972) and incorporated into their tool assemblages? Or, (3) were they *recycled refuse:* pieces of broken Preclassic or Classic pottery that Postclassic fishers scavenged and reworked into useful sinkers[9]? In one sense these distinctions are immaterial, but in another they relate to targeted fish sizes, labor investment in fishing tools, and possible belief systems. For example, such recycled artifacts might have had some symbolic or quasi-"magical" properties, as being related to ancestors. An illustration comes from the Lacandon Mayas of Chiapas, who made pilgrimages to the Classic site of Yaxchilan, home of the gods, to collect small stones to put in their "god pots" (incense burners) to facilitate communication with the supernaturals (McGee 1990:52).

In our analyses we take into consideration all three possibilities. That is, on the one hand we analyzed only definite Postclassic products: pellets plus worked-sherd sinkers of red-slipped CCP and SIP wares, the latter primarily Paxcamán Red type, made and used by the Itzas in the Lake Petén Itzá basin and adjacent areas[10]. We also analyzed *all* sinkers from Postclassic contexts on the assumption that the artifacts of earlier or undetermined types and wares were, or could have been, part of the assemblages of Postclassic *pesas* and actively used

Table 5.1. Postclassic and other *pesas* from sites in the Petén lakes area.

					Notched Sherds					
			Pellet		SIP		CCP		Other	
SITE	STR.	TOTAL	N	%	N	%	N	%	N	%
Macanché Island		*64*	*12*	*18.7*	*26*	*40.6*	*3*	*4.7*	*23*	*35.9*
Zacpetén	747	95	69	72.6	9	9.5	6	6.3	11	11.6
	732	76	18	23.7	16	21.0	17	35.5	15	19.7
	664	59	2	3.4	17	28.8	20	33.9	20	33.9
	719	198	34	17.2	85	42.9	49	24.7	30	15.2
	760	21	4	19.0	6	28.6	3	24.7	8	38.1
	615	27	0	0.0	14	51.9	1	3.7	12	44.4
	Grp A	50	0	0.0	21	42.0	4	8.0	25	50.0
	C-764	64	3	4.7	42	65.6	4	6.2	15	23.4
	C-767	50	1	2.0	30	60.0	3	6.0	16	32.0
Total Tabulated		*640*	*131*	*20.5*	*240*	*37.5*	*117*	*18.3*	*152*	*23.7*
Site Total[b]		*696*								
Ixlú	2023	59	1	1.7	39	66.1	0	0.0	19	32.2
	2022	54	9	16.7	13	24.1	0	0.0	32	59.3
	Gr. 2017	19	14	73.7	2	10.5	0	0.0	3	15.8
Total Tabulated		*132*	*24*	*18.2*	*54*	*40.9*	*0*	*0.0*	*54*	*40.9*
Site Total[b]		*152*								
Tayasal	T31	26	1	3.8	20	77.1	0	0.0	5	19.2
	T143	20	0	0.0	7	35.0	0	0.0	13[c]	65.0
	T52/53	28	0	0.0	9	32.1	0	0.0	19[c]	67.9
	Other	21	1	4.8	7	33.3	0	0.0	13[c]	61.9
Total Tabulated		*95*	*2*	*2.1*	*43*	*45.3*	*0*	*0.0*	*50*	*52.6*
Site Total[b]		*109*								
Petenxil		16	1	6.3	3	18.7	1	6.3	11	68.7
Quexil		29	4	13.8	9	31.0	1	3.5	15	51.7
Total Tabulated		*45*	*5*	*11.1*	*12*	*26.7*	*2*	*4.4*	*26*	*57.8*
Nixtun-Ch'ich'	ZZ1	303	19	6.3	28	9.2	0	0.0	256	84.5
	RR1/4	21	1	0.5	3	14.3	0	0.0	17	81.0
	QQ1	104	0	0.0	37	35.6	0	0.0	67[c]	64.4
	QQ2	28	0	0.0	13	46.4	1	3.6	14[c]	50.0
	Other	22	0	0.0	10	45.5	0	0.0	12	54.5
Total Tabulated		*478*	*20*	*4.2*	*91*	*19.0*	*1*	*0.2*	*366*	*76.6*
Site Total[b]		*507*								
Total Tabulated		***1454***	***194***	***13.3***	***466***	***32.0***	***123***	***8.5***	***671***	***46.2***

[a] "Other" includes Preclassic, Classic, and unidentified or unrecorded types or wares, such as Pozo Unslipped.
[b] "Site Totals" may exceed the sum of *pesas* tabulated here, because not all structures were included.
[c] Includes two or more Augustine Red (Tayasal Str. T52/53 had five).

by fishers. Third, we separated out Classic or probable Classic sherds for analysis (Table 4.4) to see if they might have been preferentially selected for use by the Postclassic inhabitants of these sites. In these analyses, as with the Classic artifacts discussed above, the dimensions are compared through t-tests and ANOVA.

Macanché Island

Macanché Island was occupied by the Itzas and then reoccupied by the expansionist Kowojs in the late Middle or Late Postclassic period. Most of the cultural material, including the sinkers, came from Late Postclassic midden south and west of the larger of two structures built on the island's single mound (Table 5.2; see Rice 1987). Bullard's 1968 excavations on the island recovered 50 *pesas*: 11 were made from Classic or Preclassic sherds and one was made of a local Fine Orange paste-ware imitation (Rice 1987:204). Nine pellet sinkers weighed between 1.60 and 5.88 g, with a mean of 3.76 g. Another 14 *pesas*, including three pellets, were recovered in Proyecto Lacustre excavations in 1979 and were measured but not weighed. Most of the notched-sherd weights were SIP ware except for three CCP sinkers.

Table 5.2. Dimensions (in g and cm) of 55 *pesas*[a] from Macanché Island.

		Weight	Length	Width
a. Bullard excavations (n = 41)	Mean	2.78	2.28	1.72
	Max.	12.62	3.92	2.73
	Min.	0.98	1.45	1.25
	Spread	11.64	2.47	1.48
b. Rice excavations (n = 11 + 3 pellets)	Mean	---	2.39	1.84
	Max.	---	3.52	2.74
	Min.	---	1.49	1.10
	Spread	---	2.03	1.64

[a] Including 11 Classic and Preclassic types.

Zacpetén

The peninsular site of Zacpetén (see Figure 2.2), like Macanché Island, was initially occupied by the Itzas and then taken over in the late Middle or Late Postclassic period by the Kowojs, who built two of their diagnostic temple assemblages there. Some structures appear to have been abandoned in the sixteenth century, but occupation of others, specifically Structure 719, may have lasted into the early years of the eighteenth century (Pugh 2001, 2003; Rice and Rice 2009). Zacpetén Structures 732 and 747 were clearly abandoned before the 1697 Spanish conquest; Structure 719 appears to have been occupied for some unknown time thereafter (Table 5.3; Rice et al. forthcoming).

Table 5.3. Late radiocarbon-date, 2σ-ranges (bimodal intercepts of calibration curve; 95% probability; cal years BP) from Zacpetén domestic structures.

			First Range		Second Range	
Structure	Sample ID	Material	Years	Prob.	Years	Prob.
719	Beta 107791	Maize in jar	1640–1700	25.3%	1720–1820	50.8%
732	AA35236	Copal in censer	1423–1509	91.7%	1600–1620	3.7%
747	Beta 112317	Wood in jar	1440–1530	52.4%	1550–1640	43.0%

Source: Pugh 2001:433, 446, 451, 2009:Table 5.2.

We cleared 17 Postclassic structures at Zacpetén, including five residences, ten buildings or areas in temple assemblage Groups A and C, and two in the Structure 719 group. The upper living surfaces of these structures yielded more than 600 net weights (Table 5.1). Three other cleared structures at Zacpetén yielded no sinkers. Most *pesas* were made from sherds and included SIP and CCP wares, plus Pozo Unslipped type, along with "other" wares.

Structure 747

Pellet weights were unusually common in the de facto refuse in Structure 747, a tandem residence (Pugh 2001:Figure 9-57). A broken Late Postclassic Chilo Unslipped jar (Figure 5.1) with 45 sinkers (42 were pellets) inside lay on the floor of the back room, and nine other *pesas* were found nearby. Fragments of ichthytoxic *Piscidia* wood (L. Newsom, pers. comm. n.d. to T. Pugh) were with the artifacts. Twenty-two additional pellets were found in this hall, 15 in a different, fairly restricted area of the back room. Notched sherds ($n = 26$) accounted for only 27.4% of all *pesas* recovered in Structure 747 (Table 5.4). Figure 5.2 shows the distributions of measurements of thickness, width, and length of all sinkers from Structure 747.

A t-test comparing the weights of the two sets of pellet sinkers, 42 of those with the Chilo jar and 22 elsewhere, showed they were significantly different ($t = 17.5$, $df = 65$, $p = <0.0001$). The weights of the notched sherds were compared with the set of smaller pellets and the differences were not statistically significant ($t = 0.288$, $df = 46$, $p = 0.77$). The *perlas* associated with the jar appear to have been intentionally heavier (and larger) than other sinkers in this structure (Figure 5.3).

Other Residential Structures

Structure 732 is a medium-sized, well-constructed tandem residence, apparently rapidly abandoned by the early sixteenth century, given the quantities of de facto refuse on the floor. Of the 86 sinkers scattered in both rooms and outside the building (Table 5.5; Pugh 2001:Figure 9-48), 18 (20.9%) were pellets and the remainder were notched sherds. Compared with other domiciles, Structure 732 has an unusually large proportion of sinkers of Kowoj-associated CCP (38.4%; including 6 *perlas*), and relatively larger quantities of CCP slipped pottery in general. It also has more types of pottery used for worked-sherd weights: besides the 27 CCP *pesas*, 16 were SIP, ten Pozo, and the remainder of other pastes. A t-test comparing the weights of CCP and SIP notched sherds indicated no significant difference ($t = -1.22$, $df = 39$, $p = 0.23$), although the SIP sherds had a higher standard deviation (1.97 vs. 1.47) and mean.

At Structure 664, a small tandem structure with relatively low quantities of artifacts remaining after abandonment, only two of 59 *pesas* (3.4%) were pellets. As at Structure 732, a comparatively large proportion of the sherd sinkers was of CCP ware ($n = 20$; 33.9%), paralleling larger quantities of CCP ware slipped ceramics. Seventeen sinkers were SIP ware. A t-test comparing the weights of the CCP and SIP sinkers showed no significant difference

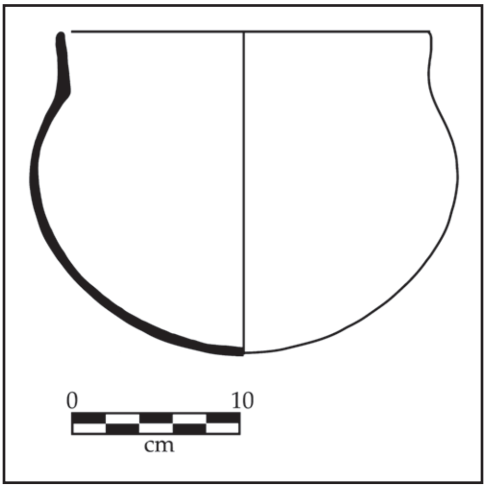


Figure 5.1. *(Left)* Reconstructed Chilo Unslipped jar associated with pellet weights and Piscidia wood in the back room of Zacpetén Str. 747.

Table 5.4. Dimensions (in g and cm) of 26 notched-sherd *pesas* in Zacpetén Structure 747.

	Weight	Length	Width	Thickness
Mean	3.32	2.21	1.57	0.58
Max.	8.4	3.72	2.81	0.79
Min.	1.3	1.37	0.99	0.34
Spread	7.1	2.35	1.82	0.45

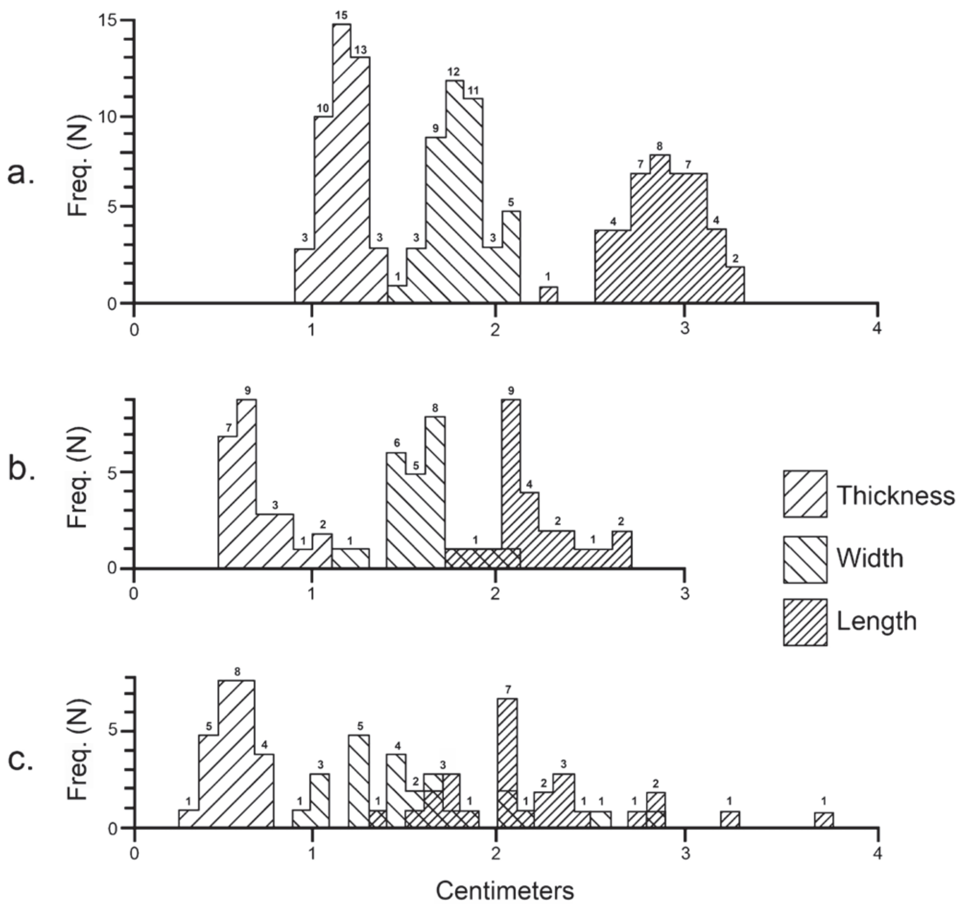


Figure 5.2. Frequency distributions of measurements (cm) of thickness, width, and length of sinkers from Zacpetén Structure 747: a, large pellets; b, other pellets; c, worked sherds.

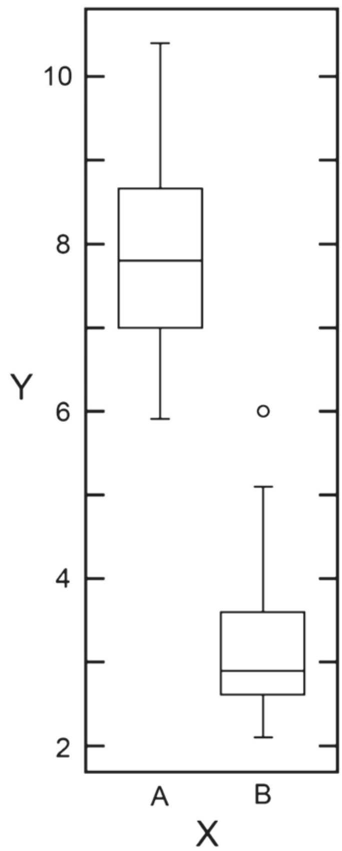


Figure 5.3. Boxplot comparing frequencies (Y) of weight (X; in g) distributions of two sets of pellet sinkers from Zacpetén Structure 747: A, large, found with Chilo jar; B, small.

($t = 1.3$, $df = 32$, $p = 0.20$), but, as with Structure 732, the SIP sherds had a higher standard deviation (1.16 vs. 0.787) and a greater spread of measurements.

Structure 760 yielded 22 sinkers, seven of which were CCP; of those, three were flattened oval *perlas*. An unusual elongated oval (7.8 x 4.1 cm) *pesa* (or perhaps a spacer?) was made of the same paste used for late Chilo Unslipped type, unevenly pinched and thinned (0.7 cm) with the fingers. Excluding this artifact, the 21 sinkers' mean weight was 2.7 g.

Group 719

Structures 719, 720, and 721, a tandem hall, small shrine, and temple, respectively, occupy a low saddle on the west side of the peninsula. Structure 719 (Figure 5.4), one of the largest tandem structures at Zacpetén and probably originally an elite residence, was remodeled into a council house (*popol nah*). It may have been the latest structure occupied in the community after Spanish conquest and resettlement of indigenous groups in the lakes area (Pugh 2001:456–457; Pugh et al. 2009). Abundant artifacts and refuse in the back room suggest varied activities and functions (Yacubic 2014:196–199; Rice et al. forthcoming).

The recovery of 224 sinkers in and around Structure 719 suggests that fishing and possibly net-making or

Table 5.5. Dimensions (in g and cm) of 61 Postclassic sinkers in and around Zacpetén Structure 732.

		Weight	Length	Width	Thickness
a. Pellets (n = 18)	Mean	2.99	2.22	1.65	0.73
	Max.	8.1	2.74	2.18	1.10
	Min.	1.3	1.67	1.26	0.55
	Spread	6.8	1.07	0.92	0.55
b. Notched sherds of CCP ware (n = 27)	Mean	3.0	2.22	1.74	0.60
	Max.	8.1	3.70	2.61	0.79
	Min.	1.3	1.60	1.16	0.44
	Spread	6.8	2.10	1.45	0.35
c. Notched sherds of SIP ware (n = 16)	Mean	3.67	2.49	1.72	0.62
	Max.	8.5	3.69	2.29	0.97
	Min.	1.0	1.78	1.26	0.35
	Spread	7.5	1.91	1.03	0.62

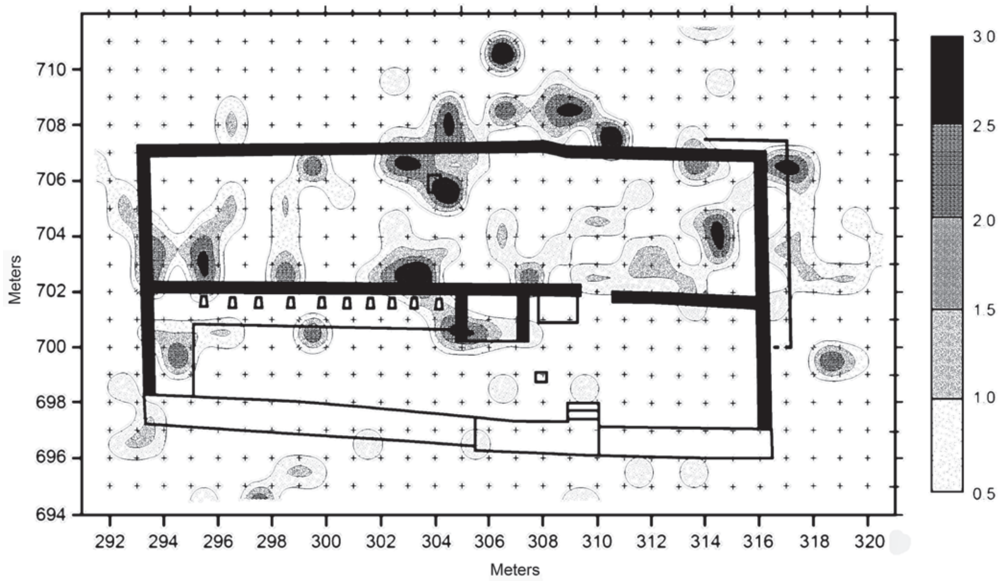


Figure 5.4. Plan of Zacpetén Structure 719, showing spatial distribution of sinkers (after Pugh 2001:Figure 9-23).

repair were important. Analysis of faunal remains recovered both inside and outside the structure revealed quantities of *pez blanco* (mostly jaw and cranial elements), along with one gar, one freshwater drum, one cichlid, and several bony fish and miscellaneous Osteichthyes (S. deFrance and A. Boileau, pers. comm. 2016). Only 34 (15.2%) of the sinkers were pellets: all but two (of CCP) were of unslipped (likely Pozo) paste and highly variable in dimensions (Table 5.6a). Both CCP and SIP notched-sherd weight distributions had significant outliers (Figure 5.5). A t-test suggested that both SIP and CCP sinkers came from the same population ($t = -0.279$, $df = 124$, $p = 0.78$), but, as in Structures 732 and 664, the CCP *pesas* had a narrower spread and a lower standard deviation (1.32 vs. 1.8).

Table 5.6. Dimensions (in g and cm) of 160 Postclassic sinkers in and around Zacpetén Structure 719.

		Weight	Length	Width	Thickness
a. Pellets (n = 32)	Mean	4.97	2.50	1.76	0.98
	Max.	10.6	3.94	2.49	1.37
	Min	1.20	1.44	0.99	0.65
	Spread	9.40	2.50	1.73	0.72
b. Notched sherds of SIP ware (n = 81)	Mean	2.75	2.06	1.53	0.60
	Max.	9.40	3.95	2.64	0.93
	Min.	0.60	1.1	0./91	0.36
	Spread	8.80	2.85	1.73	0.57
c. Notched sherds of CCP ware (n = 47)	Mean	2.89	2.15	1.67	0.60
	Max.	8.60	3.94	2.49	0.93
	Min.	0.90	1.32	1.00	0.43
	Spread	7.70	2.62	1.49	0.50

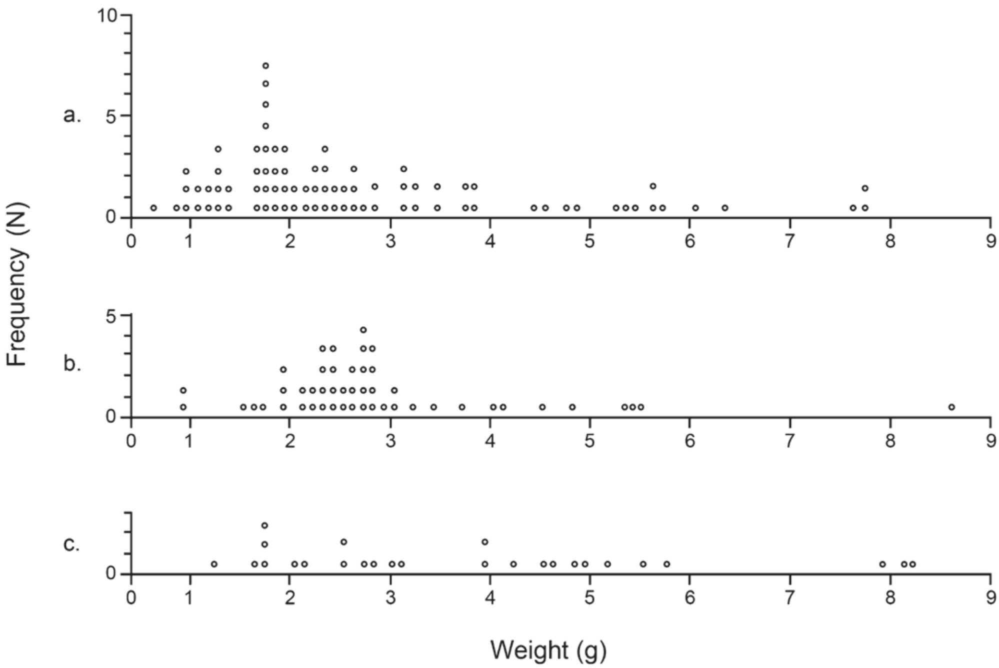


Figure 5.5. Comparative frequencies of grouped weights (in 1 g intervals) of Postclassic sinkers in Zacpetén Structure 719: a, SIP ware worked sherds; b, CCP ware worked sherds; c, pellets.

Temple Assemblages

Temple assemblages, diacritical indicators of Kowoj occupation in Petén, consist of four or more structures (including open halls) arranged around a plaza and centered on a west-facing temple on its east side. Zacpetén temple assemblage Group A yielded far fewer weights than did Group C (Table 5.1; Figure 5.6), although more structures were excavated in the former; *perlas* and CCP sinkers were notably scarce in both.

Group A comprises six structures (Pugh 2001:227–361; Pugh and Rice 2009:95–105) and a mass grave (Op. 1000; Pugh 2001:279–296; Duncan 2005, 2009). Sinkers were scarce (n = 50); none were pellets and only four were of CCP ware. All but four (92.0%) sinkers were recovered from the open halls: 19 from Structure 606, a large, two-part hall on the north side of the plaza, and 27 from smaller Structure 615 in the southwest corner.

In the southern Group C temple assemblage (Pugh and Rice 2009:105–108), 64 sinkers came from the temple, Structure 764 (Table 5.1): 42 (65.6%) of these were of SIP ware, only four were CCP, and only three pellets were recovered. Similarly, of the 50 *pesas* in open hall Structure 767, 30 (60%) were of SIP ware and only three were of CCP; only one pellet was found. T-tests showed the sinkers, both SIP and non-SIP wares, from both structures to be highly similar in weight: nearly identical in central tendencies and likely to represent the same population (p values ranged from 0.43 to 0.56), although standard deviations differed.

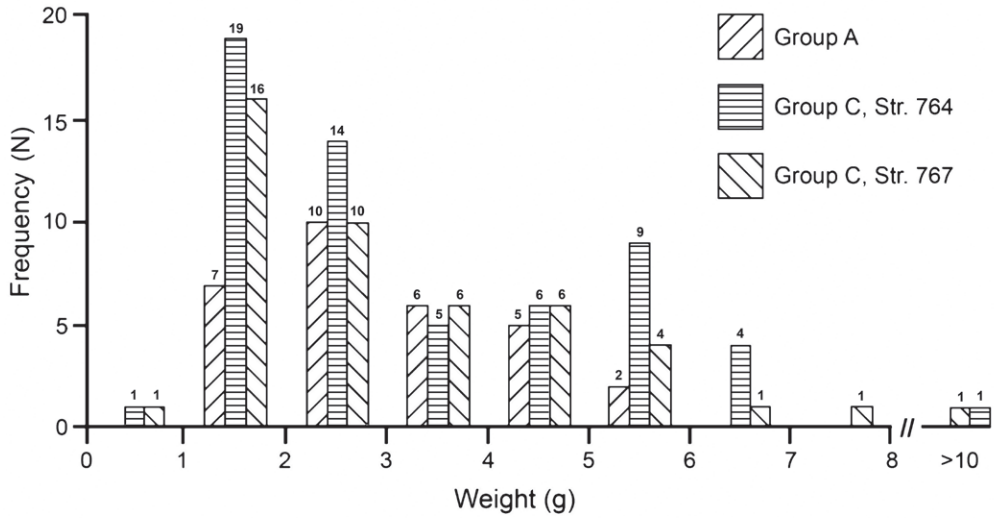


Figure 5.6. Comparative frequencies of grouped weights (in 1 g intervals) of sinkers from Zacpetén temple assemblage Group A (all structures) and Group C.

Comparisons

The frequencies of *pesas* at Zacpetén varied by functional context. Sinkers were common in residences, particularly in Structures 732 and 747, and council Structure 719. All three buildings were distinguished by large amounts of de facto refuse on their floors, suggesting hasty abandonment. Moreover, these were the three largest of the five excavated residences and represented elite (Structure 719) through middle-status (Structure 732) households. Of the total of 684 *pesas*, 136 (19.9%) were pellets. No *perlas* were among the 50 weights in the Group A temple assemblage and only four came from Group C.

The weights of notched-sherd sinkers of SIP, CCP, and "other" pastes from Structures 719, 747, 732, and 664 are shown in Figure 5.7. SIP *pesas* consistently showed greater variability in weight (a wider range and higher standard deviation) than those of CCP. The greatest length, width, and weight of Zacpetén sinkers were measured on two worked sherds of Pozo Unslipped paste. In Structure 747, length, width, and weight have much wider spreads among the worked-sherd sinkers as compared with the pellets. Length and width overlap considerably, suggesting a preference for rounder rather than rectangular shapes, carelessness in manufacture, or both.

Of the pellet *pesas*, 121 (89%) were recovered in domestic Structures 747 and 732 and the council Structure 719. They were uncommon in CCP ware, comprising only 5.9% (n = 8) of the total. Comparing their dimensions (Table 5.7), the greatest variability occurs in Structure 719: the lowest minimum, the highest maximum, and the greatest spread of all metrics except thickness. Similarly, the SIP notched-sherd *pesas* from Structure 719 display the lowest mean and the highest maximum and spread of measurements of length, width, and weight. This

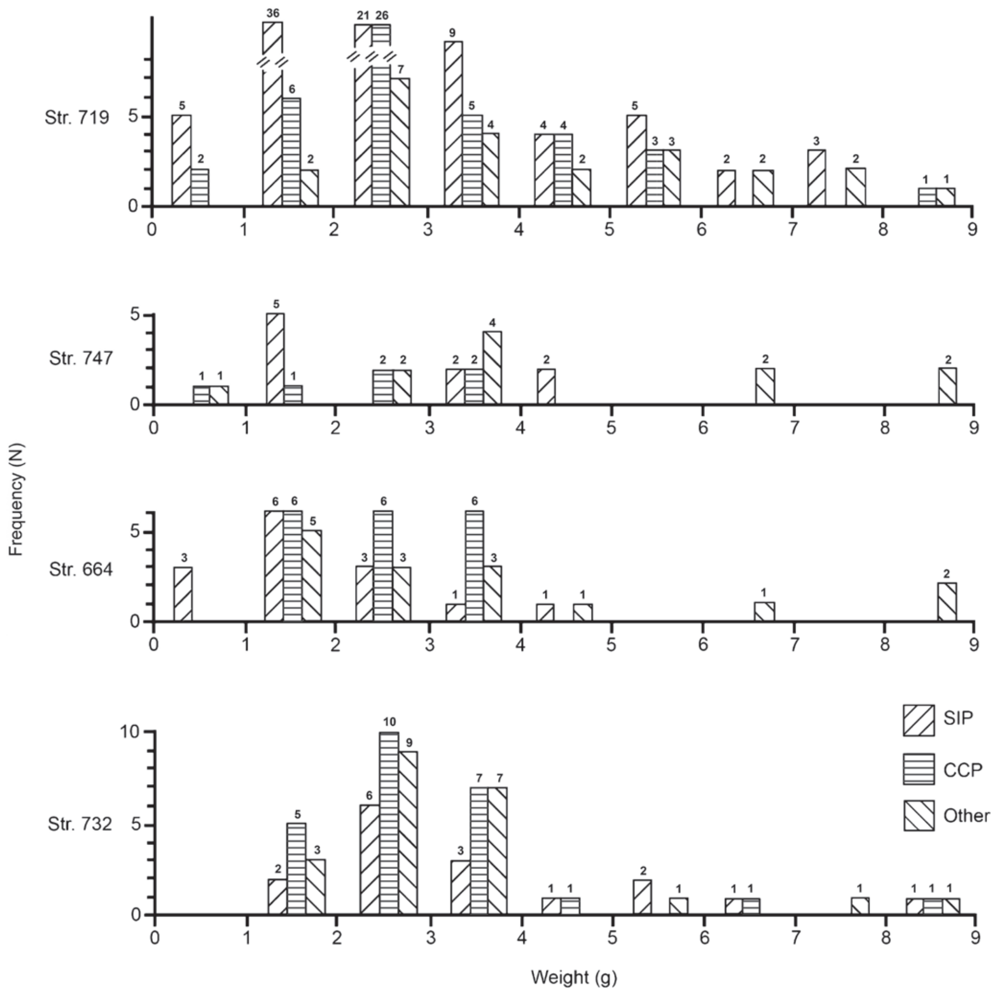


Figure 5.7. Comparative frequencies (Y axis) of grouped weights (in 1 g intervals) of notched-sherd sinkers at four Zacpetén structures, by ware (SIP, Snail-Inclusion Paste; CCP, Clemencia Cream Paste; "other"). Structure 719 had three pesas greater than 9 g (not shown): one of SIP, one of Pozo, and one of "other" paste.

high variability is likely a consequence of the proposed role of Structure 719 as a *popol nah*, a focal place for civic-ceremonial life for the groups who might still (or have newly) gathered there during the stressful times of the end of the seventeenth century.

The *perlas* in Structure 747 have a bimodal weight distribution. Those associated with the Chilo jar and *Piscidia* wood in the back room have a narrow range of length, width, and thickness measurements (Table 5.7a; Figure 5.3); they exhibit the lowest spread on all measures (except thickness) and the highest means and minimums. The other pellets are among the lowest measurements: the 15 *perlas* in the back room have a mean weight of about half of those with the jar. We interpret the artifacts with the jar as a fishing kit: relatively uniform-sized net

Table 5.7. Comparative dimensions (in g and cm) of 119 pellet *pesas* at three Zacpetén structures.

		Weight	Length	Width	Thickness
a. With Jar in Str. 747 (n = 44)	Mean	7.77	2.86	1.78	1.17
	Max.	10.40	3.24	2.08	1.43
	Min.	5.90	2.38	1.46	0.95
	Spread	4.50	0.86	0.62	0.48
b. Elsewhere in Str. 747 (n = 25)	Mean	3.28	2.07	1.59	0.69
	Max.	6.80	2.65	2.00	1.01
	Min.	2.10	1.70	1.18	0.52
	Spread	4.70	0.95	0.82	0.49
c. Str. 719 (n = 32)[a]	Mean	4.97	2.50	1.76	0.98
	Max.	10.6	3.94	2.49	1.37
	Min.	1.20	1.44	0.99	1.37
	Spread	9.40	2.50	1.73	0.72
d. Str. 732 (n = 18)	Mean	2.99	2.22	1.65	0.73
	Max.	8.10	2.74	2.18	1.10
	Min.	1.30	1.67	1.26	0.55
	Spread	6.8	1.07	0.92	0.55

[a] Excluding two, one of which was unfinished.

weights—perhaps part of a stored but now-disintegrated net itself—plus an ichthytoxin to stun the fish. The residents of Structure 747 likely engaged in fishing as a domestic economic activity. The relative abundance of pellets raises the question whether the residents of the domiciles other than Structure 732 did not engage in net-fishing, if they took the nets with them when they abandoned their homes, or if the *perlas* were later scavenged by the remaining residents.

The weights of Paxcaman/SIP *pesas* from five structures at Zacpetén were compared and not found to be significantly different ($p = 0.073$) (Table 5.8). That is, fishers occupying these sites and edifices—both residential and civic-ceremonial (two in temple assemblages)—used sinkers of statistically similar weights, representing a single population of artifacts.

Table 5.8. Mean weights (g) of 160 SIP/Paxcamán notched-sherd sinkers from Zacpetén temple assemblages (TA), a council house, and residences (see Figure 2.2).

	615 – Hall, TA Group A	767 – Hall, TA Group C	719 – *Popol Nah*	664 – Resid.	732 – Resid.
N	18	28	82	16	16
Mean	2.97	3.25	2.77	2.01	3.66
St. Dev.	0.72	2.15	1.79	1.16	1.97

Ixlú

Ixlú's occupation extended into the Late Postclassic and Contact periods, when it was probably known as Saklemakhal or Chaltunha, an entrepôt and eastern port of the Itzas (Rice and Rice 2016). Late in the site's history Plaza C of the Acropolis was modified by the expansionist

Kowojs into their distinctive temple assemblage arrangement (see Figure 2.3). Five structures in the large Main Plaza formed dual Petén versions of “basic ceremonial groups” or BCGs (Proskouriakoff 1962:89–91), both focused on Ixlú’s largest open hall, Structure 2022. A shrine in the western part of the BCG, Structure 2023, was unusual in its deposits of human remains (Duncan 2011; Rice and Rice 2016:69–77). Explorations at Ixlú recovered 152 *pesas*, of which 25 (16.4%) were formed pellets (Table 5.1). Ninety-one (59.9%) of the sinkers were recovered from Structures 2023 and 2022 (Table 5.9).

Tests of significance compared the weights of the *pesas* in Structures 2022, 2023, and nine other Ixlú structures (excluding temple assemblage Structures 2034 and 2041). The sinkers in Structure 2023 were significantly different from those of 2022 ($t = -2.92$, $df = 85$, $p = 0.0045$) and from the comparators ($t = 3.22$, $df = 90$, $p = 0.0018$).

Pellet weights were common in the three structures of the 2017 group (a BCG), chiefly in Structure 2015, but were rare to absent elsewhere. Two pellet shapes were noted at Ixlú and had different spatial occurrences. Fifteen were relatively spherical, including 14 in the Structure 2017 group, with a mean weight of 2.63 g (range 2.0–3.6 g) and mean length, width, and thickness of 1.7, 1.5, and 1.1 cm, respectively. Ten beads—including eight of the nine in Structure 2022—were oblate spheres, circular in plan and elliptical in cross-section. Slightly heavier than the spheres, the latter’s mean weight was 2.97 g (range 2.5–3.3 g) and mean length, width, and thickness were 1.86, 1.85, and 0.8 cm, respectively. All *perlas* seemed to be made of the same relatively fine-textured and light tan unslipped paste used for Pozo Unslipped jars at Ixlú.

The Postclassic Ixlú sinkers exhibited several characteristics that set them apart from those at other sites in the lakes region. One is their consistently small size: in length, *pesas* ranged from 1.07 cm to 4.91 cm and only 11 (7.2%) were greater than 3.0 cm. Weights ranged from 0.4 g to 8.9 g and 26 *pesas* (17.1%) weighed 1.0 g or less. Of the 59 sinkers associated with

Table 5.9. Dimensions (in g and cm) of 137 Postclassic *pesas* from Ixlú.

		Weight	Length	Width	Thick.
a. Structure 2023 (n = 58 notched sherds + 1 pellet)	Mean	1.76	1.75	1.31	0.52
	Max.	8.00	2.99	2.29	0.85
	Min.	0.40	1.07	0.74	0.29
	Spread	7.6	1.92	1.55	0.56
b. Structure 2022 (n = 24 notched sherds + 8 pellets)	Mean	2.82	2.08	1.66	0.59
	Max.	9.50	3.97	2.54	1.12
	Min.	0.50	1.09	0.94	0.32
	Spread	9.0	2.88	1.6	0.8
c. Other structures[a] (n = 45 notched sherds, + 1 pellet from Str. 2020)	Mean	2.89	2.3	1.77	0.6
	Max.	26.0	4.91	4.17	1.27
	Min.	0.8	1.38	1.03	0.34
	Spread	25.2	3.53	3.14	0.93

[a] Structures 2003, 2006, 2010, 2015, 2016, 2017, 2018, 2020, 2021, 2034, 2041.

Structure 2023 (Table 5.9a), only 11 (18.6%) weighed 2.5 g or more; only one was a pellet and seven were blanks, lacking notches. Among the 32 *pesas* in the open hall, Structure 2022 (Table 5.9b), were eight *perlas*. The sinkers here were larger and heavier than those in shrine Structure 2023, with 14 (43.75%), including all the pellets, weighing 2.5 g or more. These artifacts also exhibit a greater spread of values on all dimensions.

Postclassic notched-sherd sinkers solely of the Paxcamán ceramic group from Ixlú were compared as three sets: Structure 2022, Structure 2023, and "other" structures (individually yielding few sinkers) (Table 5.10; see also Rice and Rice 2016). Again, the weights were found to be significantly different ($p = < 0.0001$). In particular, the Tukey test revealed that the SIP sinkers from the large open hall, Structure 2022, were significantly heavier than those elsewhere at the site. Comparison of the weights of SIP sinkers from Structure 2023 with those from Zacpetén Structure 719 further illustrate these contrasts (Figure 5.8) and a t-test concluded that they did not sample the same populations: $t = 4.89$, $df = 119$, $p = < 0.0001$.

In addition, none of the *pesas* from Ixlú were made from sherds of CCP ware. More than half of the 127 notched-sherd weights were made of SIP ware, primarily monochrome Paxcamán Red but also one artifact of Sacá Polychrome and one of Trapeche Pink. Seven of the Paxcamán artifacts were unnotched "blanks." The SIP sinkers were highly variable in dimensions: the 39 artifacts in Structure 2023 were small, with a mean weight of 1.32 g, compared with a mean of 3.79 g for 11 SIP *pesas* in Structure 2022. Finally, the SIP *pesa* shapes exhibited considerable variation, ranging from oval (19), rectangular (32), parallel-sided (25), and roundish to square (15). They were often slightly asymmetrical, both in size (comparing the two sides separated by the notches) and in shape (like a slice of bread: one edge relatively straight and the opposite curved). Perhaps the differ-

Table 5.10. Mean weights (g) of 65 SIP/Paxcamán notched-sherd sinkers from Ixlú.

	Str. 2022	Str. 2023	Misc. Strs.
N	11	39	15
Mean	3.79	1.32	1.93
St. Dev.	3.00	0.61	0.70

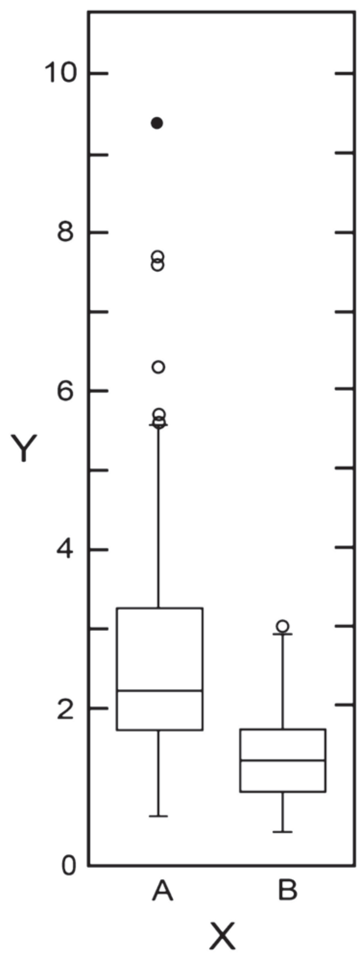


Figure 5.8. *(Right)* Boxplot comparing frequencies (Y) of weight (X; in g) distributions of Postclassic notched-sherd sinkers of SIP ware in Zacpetén Structure 719 (A) with Ixlú Structure 2023 (B).

ent persons making the sinkers produced different shapes to identify their individual contributions to community fishing activities.

The overall light weight and small size of Ixlú sinkers suggest a distinctly different pattern of fishing: possibly specifically targeting smaller fish (bait fish?), or use of lines rather than nets, or fishing in calm and/or shallow waters. This might relate to the site's location immediately north of two ports created by straightening and artificially extending the mouths of two streams that drain the southeastern Lake Petén Itzá basin (Rice and Rice 2016). In the 1990s, small dried fish were served as bar snacks near Ixlú, and this may be a local specialty with some time depth. On the other hand, the smallest sinkers are from Structure 2023, a shrine in the Main Plaza that incorporated unusual deposits of human crania and post-cranial remains, presumably dedicatory. Thirty-nine of the 59 *pesas* at Structure 2023 came from its exterior southwest (rear) corner, which may indicate that a net once lay there. This net, with its small sinkers, might have been a dip net used in ritual fishing, perhaps while wading.

Lakes Quexil and Petenxil

Lakes Quexil, Petenxil, and Petén Itzá were joined by ancient canals easily traversed by canoe (Rice 1996). Vestiges of raised (or ditched) fields can be seen between the eastern tip of Lake Petén Itzá and Lake Petenxil, and at the shallow southeast corner of Lake Petenxil near a *cenote*. More such agricultural engineering likely existed in this general area but is now silted over with the rises and falls of lake stages. These basins were probably the "breadbasket" for the Postclassic and Contact-period Itzá elites of Tayza, providing maize and other crops (Rice and Rice 2017a). We assume that here, as elsewhere in areas of raised fields in the lowlands, fishing might have been a secondary productive activity.

Investigations of the southern Petenxil basin and the two islands in the western portion of Lake Quexil by Kevin Schwarz (2004) recovered 42 *pesas*. Sixteen of these came from Petenxil, recovered in clearing the upper living surface of Group 1, a small *plazuela* group of three structures on a low hilltop (Schwarz 2004:147). One was a pellet; one sherd weight was CCP ware and three were SIP ware. They were all small, with a mean weight of 1.72 g (range 0.8 to 2.4 g).

Twenty-five *pesas* were recovered in excavations at ten structures on the Quexil Islands, principally from Structure 21 (n = 10), a sizeable residence on the northwest corner of the eastern island. Seven notched-sherd sinkers were made of SIP ware and one was of CCP; 4 were formed *perlas*. Another appeared to have been made of slate-like stone (weight 1.9 g). Unlike the sinkers from Petenxil Group 1, the Quexil *pesas* were large and heavy, with a mean weight of 5.14 g (Table 5.11); only two weighed less than 2.5 g, and seven weighed more than 7 g.

Separating the Quexil sinkers by form and type, the mean weight of definitely Postclassic artifacts (4 pellets, 5 SIP sherds, and 1 CCP sherd) was 5.08 g (range 1.93 to 15.4, the latter a

Table 5.11. Dimensions (in g and cm) of 25 notched-sherd[a] *pesas* at the Quexil Islands.

	Weight	Length	Width	Thick.
Mean	5.14	2.24	1.70	0.64
Max.	15.40	4.11	2.35	1.38
Min.	1.60	1.22	1.04	0.35
Spread	13.8	2.89	1.31	1.03

[a] Omitting the slate *pesa*.

perla). Excluding these Postclassic artifacts, the remaining "other" sinkers had a mean weight of 5.21 g (n = 12). Compared with the large sinkers from Tayasal Structure T52 (below), the Quexil *pesas* are heavier still and with a greater range of weights.

Tayasal

Recent (2009–2012) excavations by Proyecto Arqueológico Tayasal (PAT), directed by Pugh, focused on Postclassic, Contact-, and early Colonial-period occupations on the western Tayasal Peninsula. Ninety-five weights were recovered by this project (Table 5.12); only two formed pellets were noted (one of SIP ware in Structure T31) and no weights were made of CCP sherds. The sinkers from Tayasal and the San Bernabé mission (see Figure 2.4) are discussed in greater detail elsewhere (Rice forthcoming-b).

An unusual cache was found just north of the base of a possible baptismal font in Structure T31, the San Bernabé mission church. It consisted of fragments of multiple cichlids,

Table 5.12. Dimensions (in g and cm) of 95 *pesas*[a] from Tayasal and San Bernabé.

		Weight	Length	Width	Thick.
a. Structure T31 (n = 26)	Mean	1.87	1.92	1.51	0.52
	Max.	5.01	2.75	2.27	0.79
	Min.	0.32	1.36	0.97	0.25
	Spread	4.69	1.29	1.30	0.54
b. Structure T143 (n = 20)	Mean	2.20	2.05	1.48	0.57
	Max.	5.65	3.76	2.01	0.78
	Min.	1.20	1.32	1.00	0.42
	Spread	4.45	2.44	1.01	0.36
c. Group 23, Structures T52 (n = 21) and T53 (n = 7)	Mean	4.84	2.86	2.03	0.67
	Max.	10.90	4.51	3.03	0.91
	Min.	2.50	2.20	1.48	0.49
	Spread	8.40	2.31	1.55	0.42
d. 14 other structures at Tayasal and San Bernabé (n = 21)	Mean	3.53	2.12	1.77	0.60
	Max.	13.68	4.37	3.26	1.01
	Min.	0.72	1.33	1.04	0.34
	Spread	12.96	3.04	2.22	0.67

[a] Includes two pellets, one from Structure T31 and one from Structure T19.

the bones including cranial and vertebral elements, indicating the caching of whole fish (Pugh et al. 2016:55, 64), with 19 sinkers in and around it. Also in the cache were turtle and *Pomacea* shell fragments[11] and a pottery drum. Late Postclassic/Contact-period residential Structure T143, northeast of the church, yielded 20 sherd sinkers (Table 5.12b), and 28 worked-sherd *pesas* were recovered at Structures T52 and T53 (Table 5.12c).

The sinkers from domestic Structure T52, including four of Augustine Red type (plus one in Structure T53), are significantly larger and heavier than those of the church ($t = 5.87$, $df = 40$, $p = < 0.0001$). T-test comparisons of weights among *pesas* from the church and from other Tayasal/San Bernabé structures revealed no significant differences, however ($t = –0.995$, $df = 39$, $p = 0.33$; $t = 2.33$, $df = 42$, $p = 0.25$). When the weights of the Tayasal sinkers are compared with those from all structures at Ixlú except Structure 2023, they also appear to sample the same population ($t = 0.223$, $df = 57$, $p = 0.82$).

The SIP/Paxcaman worked-sherd sinkers from Tayasal and the San Bernabé mission were inter-compared in terms of the mission church (Structure T31) versus other structures and versus artifacts made of another Postclassic type/group, Augustine Red, rarely used elsewhere (Table 5.13). The probability that these artifacts were made to the same weight standard is $p = 0.0057$, and the Tukey test indicated that the significant difference was between the Paxcamán artifacts at the mission church and the larger and heavier (and more variable) sinkers of Augustine Red.

Table 5.13. Mean weights (g) of 38 SIP and Augustine notched-sherd sinkers from Tayasal and San Bernabé.

	Paxcamán/SIP		Augustine
	Str. T31	Misc. Strs	
N	18	12	8
Mean	1.88	4.06	4.59
St. Dev.	1.03	2.61	3.13

Nixtun-Ch'ich'

Nixtun-Ch'ich', a large, long-lived city with an unusual gridded layout, lies in the western territory of the Chak'an Itza faction, allied with the Kowojs at the time of conquest (Figure 2.5; Pugh et al. 2016). Excavations were initially focused on its Late Postclassic occupation, which appears to have been concentrated in scattered small barrios or neighborhoods throughout the site.

A total of 507 *pesas* was recovered in Nixtun-Ch'ich' excavations through 2014. Of the 478 tabulated, 303 (63.4%) were from Mound ZZ1, 132 (27.6%) from open hall structures in Groups QQ1 and QQ2, and the remaining 43 (9%) from excavations elsewhere. Some of the notched-sherd sinkers were well made and symmetrical, often with very carefully smoothed edges. Only one worked-sherd *pesa* was made of CCP ware. One *pesa* from the 1995 excavations, excluded here, was a heavy (10 g) rectangular sherd with deep notches, made of the paste of the very late Ixkamic Unslipped type.

Mound ZZ1 on the eastern tip of the Candelaria Peninsula was salvage-excavated by Operation 1, an axial trench through its south face (Rice 2009). In addition, late Structures ZZ1/1 and ZZ1/2 on the platform's lower tier were surface-cleared, along with clearing refuse on the slope below. Of the 303 *pesas* recovered from these and related Mound ZZ1 excavations, 128 (42.2%) came from the uppermost humus and collapse levels and can be associated with the two late dwellings and their refuse. Only 19 *pesas* were formed pellets. These were primarily of reddish-orange-brown-fired SIP ware, used for slipped pottery, rather than the gray/tan paste for Pozo Unslipped utility wares common elsewhere (e.g., Zacpetén Structure 747). Dimensions of 17 of the ZZ1 pellet sinkers are given in Table 5.14a. Two were spherical and one was oblate (as at Ixlú), one had only a single notch, and another had an encircling longitudinal groove.

In the southwestern part of Nixtun-Ch'ich', approximately 3 km distant from Mound ZZ1, Postclassic Group QQ1 (Structures QQ1/1-1 through QQ1/1-4) produced 104 sinkers, Group QQ2 yielded 58, and 20 came from Structure RR1/4 (including a flat pellet). A t-test comparing the weights, lengths, and widths of all *pesas* in Group QQ1 (Table 5.14b) with those of Group QQ2 (Table 5.14c) found no significant differences. However, comparison of the weights of sinkers from QQ1 and QQ2 against ZZ1 revealed that the differences were significant ($t = 4.65$, $df = 265$; $p = 0.0001$)—the ZZ1 *pesas* are heavier (see Figure 5.9)—and lengths were also significantly different ($t = 4.6$, $df = 254$, $p = 0.0001$). Similarly, the ANOVA test applied to 89 Paxcamán/SIP worked-sherd sinkers from ZZ and QQ (Table 5.15) shows that these might represent different populations of makers ($p = 0.014$), the significant difference occurring between the *pesas* of Mound ZZ1 and QQ2. In other words, the sinker data support our supposition (discussed elsewhere) that at least two small Postclassic/Contact period communities lie within the area of the site of Nixtun-Ch'ich'. Artifacts from Mound ZZ1 likely are from the early eighteenth-century mission established there, and the heavier weights suggest the possibility of fishing in deeper waters.

Table 5.14. Dimensions (in g and cm) of 178 sinkers from three Nixtun-Ch'ich' structure groups.

		Weight	Length	Width	Thick.
a. Mound ZZ1 (n = 17 pellets)	Mean	3.68	2.27	1.88	0.74
	Max.	5.63	2.71	2.47	1.16
	Min.	1.37	1.54	1.18	0.39
	Spread	4.26	1.17	1.29	0.77
b. Group QQ1 (n = 103 notched sherds[a])	Mean	2.62	2.12	1.57	0.57
	Max.	7.92	3.38	2.52	0.86
	Min.	0.36	1.17	0.72	0.26
	Spread	7.56	2.78	1.80	0.60
c. Group QQ2 (n = 58 notched sherds)	Mean	2.28	1.99	1.55	0.54
	Max.	11.70	3.55	2.85	0.97
	Min.	0.85	1.45	1.05	0.32
	Spread	10.85	2.10	1.82	0.65

[a] Excluding an exceptionally large *pesa* of Preclassic pottery.

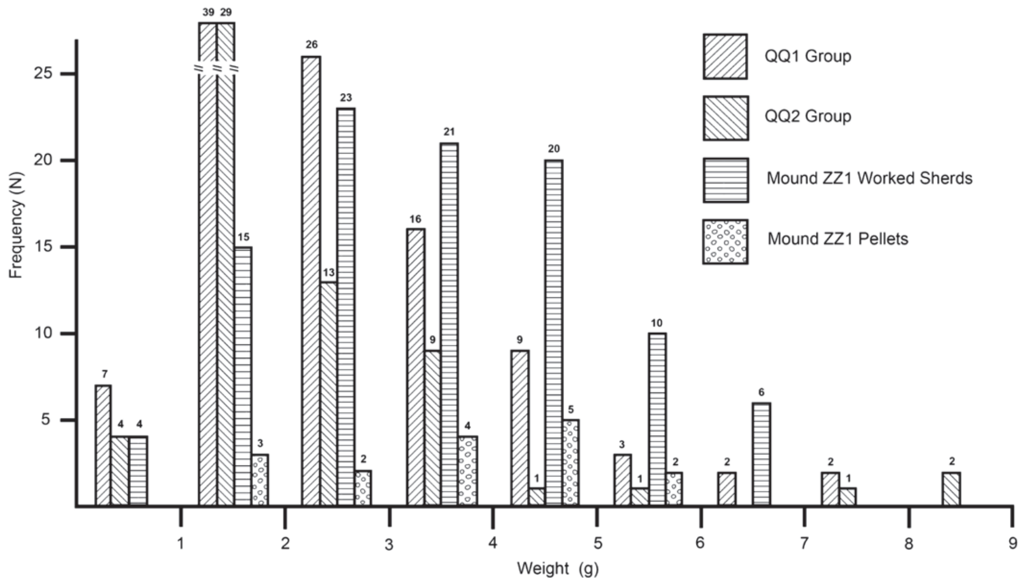


Figure 5.9. Comparative frequencies of grouped weights (in 1 g intervals) of sinkers from Nixtun-Ch'ich' structure groups QQ1 and QQ2, and Mound ZZ1. Eight outliers (not shown) weigh more than 10 g.

Table 5.15. Mean weights (g) of 92 Postclassic notched-sherd sinkers from Nixtun-Ch'ich'.

	Md. ZZ1	Str. QQ1	Str. QQ2	Misc. Strs.
N	29	34	13	16
Mean	3.05	2.33	1.63	2.27
St. Dev.	1.23	1.38	0.53	1.85

Chapter 6. Fiber-Working and Net-Making

In principle, the *pesas* found at sites in the lakes region, which we interpret as artifacts of fishing, might also or instead have been used in working fibers and weaving textiles: for example, to weight the warp threads in vertical warp-weighted looms or the weft threads in a weaving frame (Kent and Nelson 1976). However, the pre-Hispanic Mayas, like those of the present day, wove textiles on back-strap looms—sometimes depicted in Classic figurines—which did not require warp weights (although weft weights could have been used).

The most common artifacts associated with textile production in pre-Columbian Mesoamerica are spindle whorls. These objects may be "formal" whorls made of fired clay (probably in molds) or carved stone, or they may be primary or secondary artifacts: pottery disks, formed independently or more typically shaped from broken fragments, with perforations in the center. The whorls and disks act as flywheels for spinning thread on a slender shaft inserted through the central hole. Key dimensions of these artifacts are weight, which correlates with fineness of the fibers and thickness of the thread created, and diameter, which controls spinning speed; speed in turn relates to the tightness of the twists. In Postclassic and Colonial highland central Mexico, two size categories of whorls are associated with different fibers: smaller (16–35 mm diam.) and lighter-weight (10 g or less) artifacts for spinning fine cotton thread, and larger, heavier whorls (>15 to 20 g) for coarser maguey fibers (Brumfiel 1996; Parsons 1972; see also Halperin 2017; Kamp et al. 2006; McCafferty and McCafferty 2000; Nichols et al. 2000).

Some non-textile, fiber-working activities are likely correlated with fishing, specifically making the string or twine for netting and the rope for the "frame" of the net at top, bottom, and sides. Families engaged in net-fishing might have "co-crafted," making and repairing their own nets, and this activity could include other kinds of fiber-working such as making cordage and ropes for "tumplines, weaving straps, and architectural applications, such as bindings for house poles, roofing and walls" (Looper 2006:86), as well as hammocks and woven bags of various sizes for hanging household items, carrying goods to market, and other uses.

To explore the possibility of net-making and repair in the lakes region, we examined the distribution and dimensions of spindle whorls in Postclassic contexts at Zacpetén and Mound ZZ1 Op. 1 at Nixtun-Ch'ich' as test cases (Table 6.1). Few of these artifacts or other fiber-working tools were recovered from either site[12]. At Zacpetén, only one whorl of carved limestone was recovered (from Structure 747, likely a Classic found object or heirloom), plus two plain whorls of clay and 32 centrally perforated disks of pottery, interpreted as ad hoc whorls. At Nixtun-Ch'ich', five whorls of clay and 30 disks were recovered in the upper levels of Mound ZZ1.

Table 6.1. Worked-sherd disks/spindle whorls at Postclassic Zacpetén.

		Whorl		Clay Disk		Needle
Str. No.	**Type**	**Stone**	**Clay**	**Perf.**	**Unperf.**	
606	Hall; A				2	
648	Residence				1	
664	Residence			3	3	
719	*Popol nah*			6	3	
721	Temple				2	
732	Residence		1	4	2	1
747	Residence	1		1	1	
748	Residence			1	1	
758	Residence			1		
764	Temple, C		1	5	1	
766	Altar, C			1		
767	Hall, C			8	2	
1000	Mass grave			1		
1001	Open area			1		
Total		1	2	32	18	1

The weights and diameters of the Zacpetén and Nixtun-Ch'ich' spindle whorls (formal and perforated disks) were measured (Table 6.2)[13], along with comparable measurements of sherd disks lacking perforations (possibly blanks?). Like the *pesas*, some of these were very well shaped, with smoothed edges, while others—perhaps unfinished?—were only crudely modified sherds. Many of the disks were broken, making accurate weight measurements impossible. For these artifacts, the actual weight was recorded along with an estimate of what percentage of the object was missing. An "adjusted" weight was then estimated by multiplying the actual weight by the appropriate figure to approximate the total weight. In addition, the diameter of some of these broken disks could not be measured.

The dimensions of the sherd disks, perforated and unperforated, from these sites exhibit a wide range of weights and diameters, with Zacpetén having the widest range or spread and

Table 6.2. Comparison of dimensions (in g and cm) of perforated sherd disks from Postclassic contexts at three Petén lakes' sites.

	Zacpetén				Ixlú				Nixtun-Ch'ich'[a]			
	Diameter[b]		**Weight[c]**		**Diameter[b]**		**Weight[c]**		**Diameter[b]**		**Weight[c]**	
	< 3.5	**> 3.5**	**< 10**	**> 10**	**< 3.5**	**> 3.5**	**< 10**	**> 10**	**< 3.5**	**> 3.5**	**< 10**	**> 10**
N	17	9	17	15	1	9	3	7	16	8	12	10
Mean	3.28		16.0		4.93		23.5		3.49		6.32	
Max.	6.93		72.4[c]		6.59		45.4		5.2		25.5	
Min.	1.67		1.5		2.19		2.3		2.3		3.4	
Spread	5.26		70.9		4.40		43.1		2.9		22.1	

[a] Data from C. Halperin, pers. comm. 2016. All but four artifacts are Late or Terminal Classic types/wares.
[b] Six disks were too fragmentary for measurement of diameter.
[c] Adjusted weights (see text).

those from Nixtun-Ch'ich' ranging more narrowly. Formal spindle whorls from 13 sites in the Yucatán Peninsula varied from 1.2 to 5.75 cm in diameter and from 1.0 to 30.0 g weight (Hernández Álvarez and Peniche May 2012:443), generally smaller and lighter than the dimensions of the Petén sites. They fall within the ranges of artifacts for spinning both fine cotton and heavier maguey fibers in central Mexico, suggesting that the whorls at these sites were used with varied kinds of fibers.

Although the Petén artifacts were mostly larger than those of Yucatán, those in the lower ranges were probably used for spinning cotton fiber for textiles, which is considered a female activity (Hernández Álvarez and Peniche May 2012:455)[14]. Nevertheless, there was not a clear bimodal distribution: although these artifacts could be divided into the size categories of the Mexican artifacts, this was clearly an artificial division, as the disks exhibited a continuum of sizes with no clear clusters or gaps in the measurements (Figure 6.1)[15].

The heavier disks (>10 g) are of special interest. In central Mexico such whorls are associated with spinning plant fibers thicker than cotton. In the lowlands such fibers might have come from yucca, maguey, various bromeliads, or the bark of various trees (Coe and Diehl 1980 v.II:95), including the same fig bark used to make paper (*Ficus cotinifolia*). In Gulf coastal Veracruz fishing nets were made of *ixtle* (*Aechmea*) bromeliad fiber (Wing 1980:108). The Lacandon Mayas made nets "from bark which has been soaked for a month in water and then worked into strings" (Duby and Blom 1969:285).

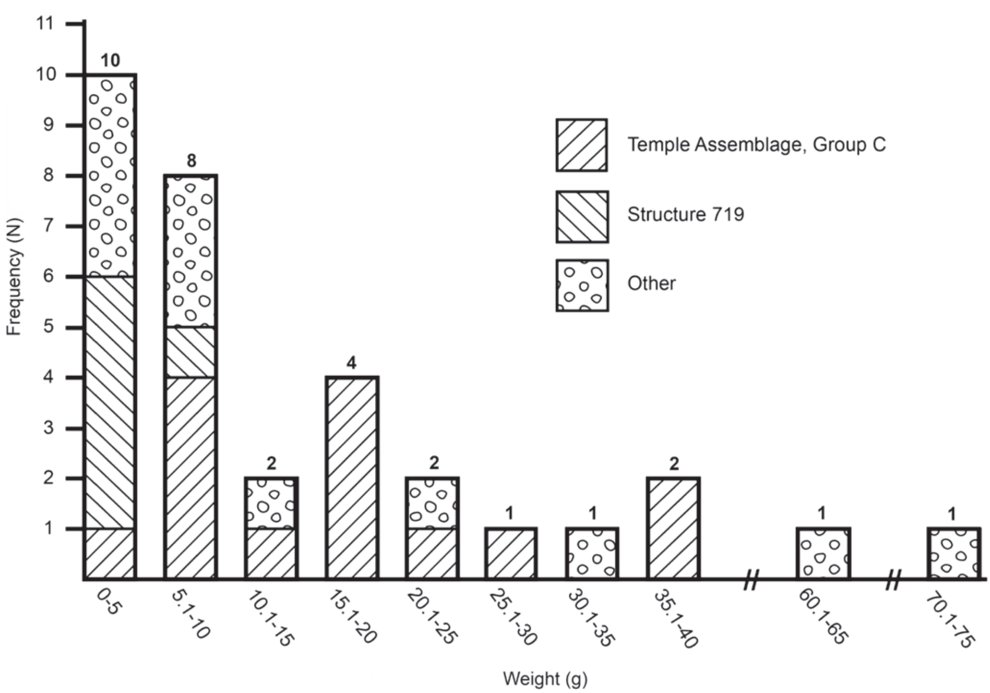


Figure 6.1. Frequency distribution of the weights (g) of 32 Zacpetén perforated disks.

Heavy disks, perforated and unperforated, were recovered at both Zacpetén and Nixtun-Ch'ich', but were heavier (greater mean, maximum, and spread) at Zacpetén. There, 14 of the total of 32 disks (42.4%) were recovered in the Group C temple assemblage. These include ten of the 14 heaviest perforated disks (10 g or greater) and seven of the nine disks with the greatest diameter (>3.5 cm). The lighter weight (<10 g) perforated disks were more common in residential structures (n = 7) and the Structure 719 council house or *popol nah* (n = 6), for a total of 13 of 17 (76.5%). The same is true of disks with smaller diameters: 8 and 5, respectively (8 of 17; 76.5%). This same relationship does not clearly hold for the 20 pottery disks lacking perforations.

As for associations with *pesas* and fishing, perforated-disk spindle whorls were recovered in minimal numbers in the Zacpetén residences that yielded large quantities of sinkers: for example, six whorls compared with 198 *pesas* in Structure 719, and five in domestic Group 747, which had a fishing kit. Similarly, in the upper levels of Nixtun-Ch'ich' Mound ZZ1, which yielded 128 *pesas*, only ten of 22 disks (45.5%) and two of four formal whorls had weights or adjusted weights greater than 10 g, and the means and upper limits are significantly lower than the disks at Zacpetén. These data suggest that spinning threads or twine for net-making and repair was not a domestic "co-craft" activity that accompanied fishing. Fibers may have been spun in locations other than the structures excavated; or, the nets may have been sufficiently durable that they needed only infrequent repair; or, perhaps whorls made of wood or other perishable material were used.

The comparatively high frequency of perforated-sherd spindle whorls in the Zacpetén Group C Postclassic temple assemblage was initially perplexing. Spinning thread is generally considered a female-gendered activity in Mesoamerica and activities in Maya temple contexts—particularly in the colonnaded-halls (possibly men's houses?) such as Structure 767 in Group C—male-gendered. Differences in sizes and weights of disks between residential and civic-ceremonial contexts doubtless relate to the kinds of nets or other items being produced: their overall size as well as their thread and mesh sizes. The twine for fish nets (or lines) must strike a balance between thickness—the thinner the better—and strength to catch and hold the fish without breaking. The finest threads might have been for small hand nets with fine mesh, and coarser, stronger, fibers for large casting or seine nets used to catch larger and more powerful fish. In the case of Group C, it is likely that men there used the larger, heavier artifacts to spin coarser, non-cotton fibers such as tree bark or bromeliad fibers for heavier ropes with a variety of uses[16].

Alternatively, possibly certain women were allowed in temples for specific purposes, such as making clothing for priests for particular rituals or foaming cacao beverages, as among the Lacandons (Pugh 2006:376–377, 379). Or, perhaps the worked-sherd disks were used in divining (Brown 2000:330) or even gaming, given a possible *patolli* layout on the Structure 764 temple.

Chapter 7. Petén *Pesas* in Broader Chronological and Other Contexts

The most parsimonious and reasonable explanations for the notched-sherd *pesas* and pellets at sites in the Maya lowlands is that they were used in fishing, most likely as net weights but also in line fishing. With respect to the central Petén lakes area, this assumption or interpretation is supported by: (1) the abundance of these objects at lakeside sites in the basins; (2) recovery of numbers of these artifacts in apparent sets or close spatial proximity, including a Terminal Preclassic dedicatory deposit in Nixtun-Ch'ich' Mound ZZ1 and a Postclassic set with a known ichthytoxin in Zacpetén Structure 747; and (3) the well-known gustatory appeal of the fishes in the Petén lakes, preeminently the *pez blanco*.

Comparisons of Weight

One way of looking at variability in the Postclassic sinkers is to compare their weights—the primary variable of interest—among and within sites. Table 7.1 provides these data for the sites and structures with the greatest quantities of Paxcamán (SIP) sinkers. Differences were significant at $p = 0.000339$: Ixlú sinkers were significantly ($p < 0.05$) lighter in weight than those from all structures at Zacpetén and from Nixtun-Ch'ich' Mound ZZ1 ($p < 0.01$). Within Nixtun-Ch'ich', the sinkers from Mound ZZ1 were significantly ($p < 0.05$) heavier than those from the southwestern barrio, Structures QQ1, QQ2, and RR4/1.

With respect to pellet weights, only Zacpetén and Ixlú yielded substantial numbers of these artifacts (Table 7.2). As mentioned, Zacpetén Structure 747 had a smashed Postclassic jar with 45 pellet weights and fragments of the ichthytoxin *Piscidia* (*jab'in*) wood, and another 23 smaller pellets were found elsewhere in this structure. The pellets at both sites

Table 7.1. Mean weights (g) of SIP ware (Paxcamán) *pesas* at Ixlú, Zacpetén, and Nixtun-Ch'ich'.

	Ixlú	Zacp. Str. 719	Zacp. Other	N-C Md. ZZ1	NC Southwest
N	65	82	51	28	48
Mean	21.88	2.77	2.85	3.04	2.14
St. Dev.	1.60	1.80	1.50	1.25	1.20

Table 7.2. Mean weights (g) of 142 Postclassic pellet sinkers from Zacpetén and Ixlú.

	Zacpetén Structures				Ixlú
	747 (lrg)	747 (sml)	719	732	
N	45	23	32	17	25
Mean	7.0	3.15	4.83	2.83	2.67
St. Dev.	1.05	0.92	3.11	0.94	0.64

were made of the clay used for unslipped pottery but differed in shape: at Zacpetén they were elliptical or oval; at Ixlú they occurred as spheres and oblate spheres.

ANOVA revealed significant patterns of differences in the weights of these artifacts. In particular, the large pellets from residential Structure 747 were significantly heavier than all others, and the pellets from the council house Structure 719 (see Pugh et al. 2009) are also significantly heavier (and have a larger standard deviation) than those from Structures 732 and Ixlú (all $p = < 0.01$). The weights of the pellets from Ixlú, Zacpetén Structure 732, and the smaller pellets from Structure 747 were not significantly different. We interpret the large pellets with the jar in Structure 747 as a fishing kit: relatively uniform-sized weights for a net—perhaps a stored but now-disintegrated net itself—plus poison to stun the fish. This, together with the other pellets in that structure, suggests that fishing was an important component of the residents' household economy, hardly surprising given its location on a low rise on the eastern side of the peninsula between the edge of Lake Salpetén and a small *aguada*.

Color

Color was another attribute recorded in the database, albeit inconsistently. Most sinkers had eroded surfaces, but it is not clear if that is because eroded pottery fragments were originally selected for making *pesas* or if slips were eroded from repeated immersion in water, or both.

Color seems to vary chronologically. Among the 14 mostly Middle Preclassic *pesas* from Nixtun-Ch'ich' Mound ZZ1, the emphasis seems to be on red or red-orange colors (Table 7.3). Later, the Classic-period Maya makers of these artifacts seem to have favored dark colors, such as black, gray, or brown, as evident in sinkers in Terminal Preclassic Mound ZZ1 Deposit 1, in Classic-period fills, and also at other sites in the lakes area. (It bears noting here that black-slipped pottery was not common in the lakes area in the Late Classic—unlike in, say, western Belize—and red slips predominated throughout the entire occupational sequence.) In the upper levels of Mound ZZ1, dating to the Postclassic through early Colonial periods, the emphasis is reversed, with nearly 50% of the weights (excluding pellets) again of red paste or red-slipped sherds, primarily sherds of Paxcamán Red monochrome and related

Table 7.3. Colors of notched-sherd sinkers from Op. 1, Mound ZZ1, Nixtun-Ch'ich', by general date/context.

	Preclassic		Deposit 1 + Adjacent		Classic–Postclassic		Colonial		Total
Color	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	
Red/Orange	11	78.6	10	16.1	21	18.9	53	48.2	95
Black/Gray			39	62.9	60	54.1	25	22.7	124
Brown/Tan			8	12.9	11	9.9	1	1.0	20
Cream/Light	1	7.1	1	1.6	8	7.2	4	3.6	14
Eroded/Unsl.	2	14.3	1	1.6	7	6.3	11	10.0	21
Not rec'd			3	4.8	4	3.6	16	14.5	23
Total	14	100.0	62	99.9	111	100.0	110	100.0	297

(Itza SIP ware) decorated types (e.g., Ixpop Polychrome, Figure 3.1c6). For unknown reasons, large, round sherds are typically light colored: cream, tan, buff, or pale pink or orange.

Might the colors of the pottery sinkers have had any relation to success in fishing? This question raises issues about anecdotal and scientific evidence for color vision in fishes. Fish retinas, like those of humans, have two kinds of photoreceptors, light-sensitive rods and color-sensitive cones. Fish can detect color shadings, shape, and movement (NEFSC 2015) and recent research suggests color vision in fish was present 300 million years ago (Tanaka et al. 2014). An earlier study showed that the cichlids known as oscars (*Astronotus ocellatus*) could be trained to recognize the colors red, blue, yellow, and green (Arora and Sperry 1963).

But color sensitivity and visibility is also a function of the photic environment: the amount of light (brightness and contrast). These features in turn vary with water depth and clarity: in general, light colors or red might attract (or not repel) some fish near the surface in clear water, but with depth colors ordinarily appear gray or black (Kaminsky and Schwipps 2011:207). The color of the *pesas* might relate to the depth at which they were used. Color vision may also vary in the breeding season. Among cichlids in Lake Malawi (Africa), color sensitivity varies with habitat and foraging strategies, and the underlying genetic mechanisms may be common to all perciform fish (Parry et al. 2005:1738).

Over time during the Classic period the Petén lake waters likely gradually increased in turbidity with accelerated runoff, possibly making color issues moot. In any case, it might be significant that some of the *pesas* vaguely resemble *Dorosoma* in size and shape: these baitfish are small, roughly oval in silhouette, and silver-gray in color. Many of the sinkers, especially the Postclassic pellets and the Classic-period worked-sherd weights at Nixtun-Ch'ich', are also small, gray, and oval-ish. Some *pesas* might have served simultaneously as line weights and as lures, resembling the small, schooling fish or *p'ult'a* the *pez blanco* enjoyed as food and increasing the success of individual line-fishing efforts.

Dimensions

Tables and histograms of the Petén *pesas*' dimensions showed patterns suggesting increasing standardization through time[19]. The most explicit expression of such standardization is seen in Postclassic pellet sinkers, primary artifacts specifically shaped of clay (by potters or by fishers). At Zacpetén Structure 747, for example, the pellets were formed to two size standards, the larger ones in the fishing kit associated with a jar and ichthytoxin, and within each group the objects exhibited a narrow range of variability in dimensions, shape, color, and weight (Table 5.4).

Even earlier in the Classic period there seems to have been some agreement in the ratio of mean length to mean width in these artifacts (Table 7.4). The Zacpetén and Ixlú Classic *pesas*, for example, have rectangular or oval shapes, with length:width ratios about 4:3. The artifacts

Table 7.4. Ratios of mean lengths and widths of Preclassic and Classic sinkers.

						Nixtun-Ch'ich'		
	Mac.	**Zacp.**	**Ixlú**	**Tay.**	**Pet/Q**	**ZZ1**	**Misc**	**Precl**
Length	3.15	2.39	2.36	2.19	1.8	2.76	2.15	3.24
Width	2.21	1.73	1.81	1.66	1.46	2.02	1.58	2.51
Ratio	5:3.5	~4:3	~4:3	4:3	5:4	~4:3	~4:3	~4:3

from Macanché Island, various locations at Nixtun-Ch'ich', and Preclassic sinkers are also close to those proportions, although several sherds from Macanché were nearly square. Sinkers from Petenxil/Quexil and Mound ZZ1 have shapes more closely approaching square or round.

The question, of course, is what these similarities and differences in *pesa* size and proportions mean. The most obvious conclusion is that Classic Maya fishers throughout the lakes region were fishing for similarly sized fish with similar technology, in this case similarly weighted nets or lines. Another possibility, albeit unlikely, is that these artifacts were made to a certain size standard by some kind of "specialists." But these worked-sherd sinkers are ad hoc tools, probably made by the fishers themselves, and they occur in varied shapes and proportions at individual sites. As suggested, different shapes might identify individual makers of these artifacts to tag their contributions to communal fishing activity.

Classic and Postclassic Comparisons

Virtually all the Classic *pesas* analyzed here were recovered from Postclassic contexts, raising the question, as mentioned earlier, of whether these artifacts might represent scavenging by Postclassic fishers, either reusing Classic sinkers or reworking Classic pottery fragments. The data in Tables 4.4 and 4.5 and the ANOVA analysis indicate that the weights of the Classic artifacts from different sites at different lakes are not significantly different, and probably reflect a shared standard of weighting nets to capture a common size of fish.

In the case of Zacpetén, the large quantities of recovered sinkers allow us to compare definitely Postclassic artifacts with those of earlier (or unknown) types. The mean dimensions of Postclassic notched-sherd sinkers (Table 5.8) were compared with those of 27 sinkers of non-Postclassic types (Classic and "other") found at Structure 719 (Table 7.5). ANOVA found no significant difference in weight between SIP and CCP wares, whereas the difference between those two Postclassic wares and the heavier non-Postclassic pottery was significant at $p = 0.000115$. This finding suggests that the residents were not scavenging older sherds to work into new sinkers with typical Postclassic dimensions. It does not, however, resolve the issue of whether the inhabitants of Structure 719 might have recycled older, heavier *pesas* (Classic or "other") into active use ("systemic" context).

Table 7.5. Comparative mean dimensions (in g and cm) of 160 notched-sherd sinkers of Postclassic pottery with 27 sinkers of Classic or probable Classic (non-Postclassic) types at Zacpetén Structure 719.

	Weight	Length	Width	Thickness
SIP ware	2.75	2.06	1.53	0.6
CCP ware	2.89	2.15	1.67	0.6
Non-Postcl.	4.5	2.55	1.88	0.64

At Ixlú, comparison of Postclassic (Paxcamán) and Classic or probable Classic notched-sherd sinkers (Table 7.6) reveals that the latter are heavier than most of the Postclassic artifacts, as also seen in the comparison of sinkers at Zacpetén Structure 719 (Table 5.6). The Classic *pesas* of Ixlú, however, are similar in all dimensions to the heavier *pesas* from Structure 2022. This suggests some long-term comparability in fishing strategies between Classic-period Ixlú fishers and those occupying Structure 2022. Or, fishing strategies practiced in Late Postclassic *popol nahs* (Zacpetén Structure 719 and possibly Ixlú Structure 2022) may have been different from those in other structures, perhaps being more communally oriented.

Table 7.6. Mean dimensions (in g and cm) of Ixlú Paxcamán vs Classic notched-sherd *pesas*.

	N	Weight	Length	Width	Thick.
Misc. Strs. Paxc.	19	1.91	1.89	1.43	0.55
Str. 2023 Paxc.	39	1.32	1.61	1.19	0.49
Str. 2022 Paxc.	13	3.79	2.51	1.79	0.55
Classic	25	3.32	2.36	1.81	0.56

Excavation of uppermost Levels 1 and 2 at Mound ZZ1 yielded 89 notched-sherd sinkers. These were separated into Paxcaman types in SIP ware, and Classic and "other" (non-Preclassic and Postclassic) wares and types, for purposes of comparing mean weights (Table 7.7). Although the SIP pottery has a lower spread of values and a lower mean weight than that of Classic and "other" sherds, the difference was not statistically significant at the $p < 0.05$ level. These data suggest that the Postclassic inhabitants of Nixtun-Ch'ich' Mound ZZ1 might indeed have scavenged Classic *pesas* and/or notched Classic sherds to make sinkers. Such a practice is not at all unlikely, given that it was the location of a post-conquest mission church and two contemporaneous residences. These circumstances might have greatly disrupted normal fishing routines, as well as the making of net sinkers. The sinkers in ZZ1 Postclassic Levels 1 and 2 are highly variable, including three described as "crudely made," two with no notches, two with only one notch, one with multiple notches, and four side-notched, which

Table 7.7. Weights (in g) of 89 notched-sherd sinkers from Levels 1 and 2 at Nixtun-Ch'ich' Mound ZZ1.

	Postclassic SIP ware (n = 17)	Classic (ash paste) (n = 12)	"Other" (n = 60)
Mean	3.57	3.96	4.12
Max.	5.39	6.38	16.26
Min.	1.28	1.3	0.87
Spread	4.11	5.08	15.39

might be Preclassic. One of the artifacts with no notches was large (3.5 cm 1ong; 3.4 cm wide; 0.66 cm thick; 12.34 g) and may have been a spacer or gauge.

Similarly, the mean dimensions of 63 notched-sherd sinkers of Postclassic (SIP ware, plus two of Pozo Unslipped) from all excavations at Nixtun-Ch'ich' other than Mound ZZ1 were compared with 28 artifacts of Classic pottery, excluding Preclassic and unknowns (Table 7.8). ANOVA did not find any significant difference in weights among the samples, and even when the comparison was restricted to Structure Group QQ2 and "Other" locations, the level of significance was only p = 0.04995.

Figure 7.1 displays the distribution of grouped weights of 222 Classic sinkers (note that quantities differ from those on Table 5.1 because reliable weights could not be measured on some of the latter owing to breakage). Like similar histograms of the weights of Postclassic

Table 7.8. Difference in dimensions (in g and cm) among notched-sherd sinkers made of Postclassic wares (n = 63) and Classic pottery types (n = 28) at Nixtun-Ch'ich' (other than Mound ZZ1).

	N	Weight	Length	Width	Thickness
Postc. QQ1	34	2.33	1.98	1.49	0.53
Postcl. QQ2	13	1.63	1.88	1.47	0.46
Postcl. Other	16	2.27	2.0	1.39	0.54
Classic	28	2.59	2.19	1.58	0.56

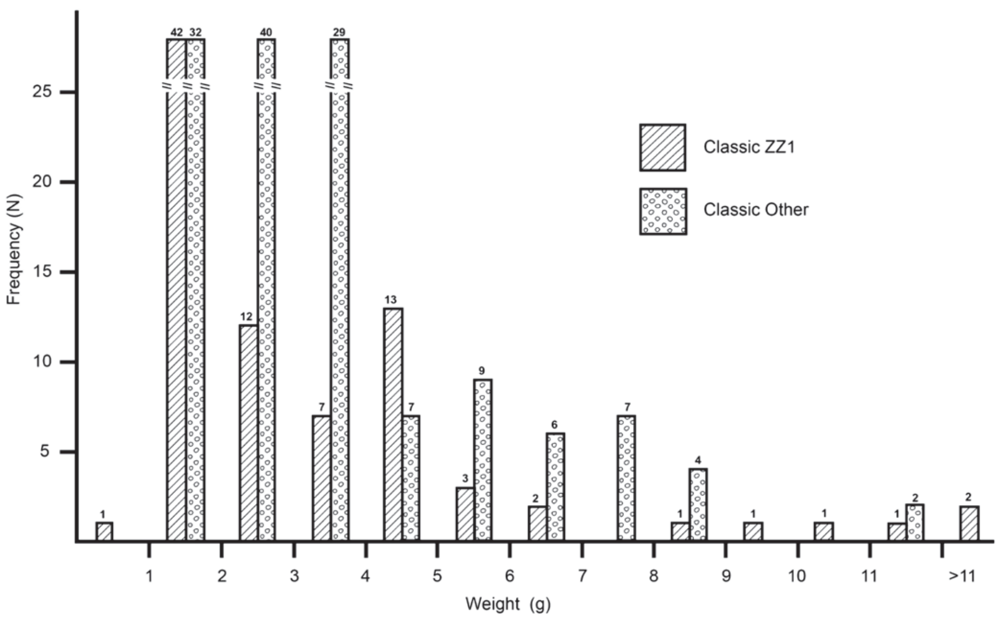


Figure 7.1. Comparative frequencies of grouped weights (in 1 g intervals) of 222 Classic and probable Classic *pesas*. Hatched bars represent 86 Classic and probable Classic sinkers from Classic levels of Nixtun-Ch'ich' Mound ZZ1; dotted bars represent 136 Classic or probable Classic sinkers from Postclassic levels at Zacpetén (n = 60), Ixlú (n = 21), Tayasal (n = 13), Quexil-Petenxil (n = 12), and "other" contexts at Nixtun-Ch'ich' (n = 30).

and all sinkers (e.g., Figures 5.5, 5.7, and 5.9), all are right-tailed, clustering at the left end with a long "tail" of measurements to the right (larger values). That is, when graphed by structure or site, with weight as the X axis, the majority of the artifacts weigh in the lower (left) end of the range, but a small number of outliers were markedly heavier than the others. This "lognormal" distribution (see note 6) of *pesa* weights results from the cumulative increase or multiplication of the three independent dimensional variables (width, length, thickness): as *pesas*' size increases, their weight grows logarithmically.

Figure 7.1 suggests a slightly different picture of Classic sinkers in that it may be the extremes, the spread, and the standard deviations that are more informative than the means with regard to differentiating Classic and Postclassic artifacts (Table 7.9). Classic weights ranged from 0.74 g to 17.12 g, both low and high extremes coming from the Mound ZZ1 trench. Only one of the Classic *pesas* weighs less than 1.0 g, a low range that is not uncommon among Postclassic sinkers, especially at Ixlú (see Figures 5.5–5.7, 5.9; Table 5.9). Similarly, 27 (12%) of 222 Classic or probable Classic sinkers weigh more than 6 g, whereas this range is much less common among Postclassic sinkers, particularly artifacts weighing more than 8 g. The heavier artifacts, those weighing 8.0 g or more, come from Mound ZZ1 Classic levels and Postclassic levels at Zacpetén.

These figures on *pesa* weights support the conclusion that Postclassic notched-sherd artifacts made by Postclassic peoples using Postclassic pottery wares and types were, overall, lighter in weight than those made on Classic pottery and recovered in Classic contexts. Postclassic sinkers were smaller and had a narrower spread of weight and other measurements. The distributions of weights of Classic and "other" (non-periodized) sinkers found in

Table 7.9. Comparison of means and standard deviations of weights (g) of Classic and Postclassic SIP ware notched-sherd sinkers at sites in the Petén lake basins.

	Classic[a]			**Postclassic**		
	N	**Mean**	**St. Dev.**	**N**	**Mean**	**St. Dev.**
Macanché	11	6.34		24	2.14	0.99
Zacpetén	40	3.44	1.97			
Str. 719				82	2.77	1.80
Other				51	2.85	1.49
Ixlú	25	3.32	1.46	65	1.88	1.60
Tayasal	16	3.28	2.74			
Str. T31				17	1.85	1.06
Other				12	4.06	2.61
Pet/Quexil	13	3.58	2.49	7	3.54	2.09
N-C ZZ1	16	4.36	1.44	28	3.04	1.25
Other	35	2.71	1.48			
Southwest				48	2.14	1.19
Total	156			334		
MEAN of means		3.55			2.51	
Range		2.71–6.34	1.44–2.74		1.85–4.06	0.99–2.61

[a] From Table 6.

Postclassic contexts, on the other hand, most markedly exhibited a longer right "tail," with more and heavier weights. The degree to which these Classic artifacts might have been incorporated into Postclassic net-weight assemblages, perhaps for special purposes, is unknown.

Chronological and Geographical Variations

The nearly three millennia-long occupation/construction sequence penetrated by the Operation 1 trench into Mound ZZ1 at Nixtun-Ch'ich' revealed some variations in *pesas* that appear to have chronological significance. For example, Preclassic sinkers were not abundant (and were rare in Preclassic contexts) and either were not used or were not commonly made of fired ceramic in the Middle Preclassic period. At coastal Tancah, the earliest excavated levels at Structure 44 produced "many notched sinkers or 'spacers' made of small pieces of hard limestone" (Miller 1977:100), and at Cozumel weights were also made of coral and shell (Phillips 1979:4)[17]. This also might have been true of Petén in various periods: two end-notched weights from upper levels of Mound ZZ1 were made of smooth, flat, round or oval stones, and one from Quexil appeared to be slate.

Sinkers made of Preclassic pottery types are generally large, heavy, fairly crudely formed, and often round. As noted, the largest and heaviest *pesa* of this Petén collection, from Nixtun-Ch'ich', was round and weighed 33.86 g. In addition, early weights are frequently "side-notched" with indentations placed at their width (their long sides) rather than on their shorter ends. Similar traits are often seen in Preclassic weights and/or coastal areas elsewhere[18]:

- At Preclassic K'axob, near Pulltrouser Swamp and the New River in Belize, 8 of 29 worked-sherd *pesas* had notches on the sides (Bartlett 2004:269, Figure 10.8).
- At Cerros, northern Belize, 56 of 365 sinkers (15.3%) were side-notched and were the heaviest of three weight categories (Garber 1986:119–120).
- At Cuello, northern Belize, 15 *pesas* of primarily Juventud Red type were found in a cluster in refuse, as if they had been in a perishable container; they weighed 12.3 to 22.0 g, with a mean of 16.6 g (Hammond et al. 1991:355).
- Among 198 *pesas* at Dzibilchaltun (Yucatán), 20 km south of the Gulf coast, three large examples were side-notched. Length varied between 3.0 and 5.1 cm (mean 3.73 cm); width ranged from 2.0 to 3.45 cm (mean 2.55 cm); weights are not given (Taschek 1994:222, Figure 61g–i).

Technology and Economy

The Postclassic period witnessed the creation of primary artifacts for fishing: specially formed clay beads or pellets, relatively standardized formal "tools" to weight nets. This late innovation hints that fish and fishing might have assumed greater economic (and presumably dietary) importance to Maya lowlanders[20]. These bead-like weights or *perlas* might have been made for and used by individuals or households with greater investment in fishing success—perhaps in pisciculture, and/or targeting particular species. But pellet weights were, overall, uncommon, usually comprising less than 20% of the recovered sinkers in Petén. They seem to be more common in the east at sites along the Caribbean coast.

More casual fishermen may have continued to make do with worked-sherd net weights. Comparisons here focused on the use of fragments of pottery of the Postclassic Paxcamán ceramic group (SIP ware), made and used by the Itzas, because that was the most common and widespread (and consistently recorded) material. The Kowojs' cream-colored CCP ware was extremely rare in the Lake Petén Itzá basin, limiting its use as a comparator, and sinkers of Pozo Unslipped type were not reliably distinguished from other unslipped types in the database.

If these sinkers were used in line fishing, the size range suggests that Maya anglers observed the same advice given to fishers today: keep varied sizes and kinds of weights at hand to adjust the presentation of bait to changing wind and water conditions (Kaminsky and Schwipps 2011:45–46). One possible argument against the use of *pesas* as line weights is the rarity of fish hooks: in 40 years of working in the Petén lakes region, we have found no prehispanic hooks and only a few are reported in other collections (e.g., Barton Ramie and Altar de Sacrificios; Wing and Hammond 1974:134). Hooks may have been another kind of ad hoc fishing tool, made of perishable material such as wood or thorns from spiny trees, or from shell. Or, the fishing line could have been tied through the gills of the baitfish, "hooking" the fish that swallowed it.

If *pesas* were used with nets, as we suspect, the range of sizes contradicts the advice given to net-makers today (Rosman 1980) and may suggest something specific (albeit unknown) about their functionality. Smaller weights may have been used with smaller, lighter-weight hand or dip nets to catch smaller schooling fish or bait near the shoreline, or in landing nets for bigger fish caught by line from canoes. Larger, heavier *pesas* were used for larger nets with larger mesh sizes, such as seines or casting nets, to catch bigger fish in deeper or moving water in rivers. The few *pesas* significantly outside the weight range of the majority of each set may have been interspersed among the lighter weights, or perhaps placed at the ends of fixed nets to anchor them more firmly in the soft lake-bottom detritus or to accommodate currents.

Regardless of what types of net/line sinkers were used, fishers in the Petén lakes could have captured lacustrine fauna—including turtles, diving birds, and crocodiles[21] as well as fish—not only for local consumption but also, after smoking and drying, for consumers at more distant locales. Ultimately, then, the extent to which Postclassic pellet weights can be considered a proxy indicator of a significant economic shift cannot be reliably determined without more quantitative data on Postclassic faunal assemblages.

The data in Table 4.5 for the Classic period indicate similar mean weights of *pesas* at Zacpetén (other than Structure 719), Ixlú, Tayasal, Lakes Petenxil/Quexil, and Classic levels of Nixtun-Ch'ich' Mound ZZ1. This suggests shared fishing strategies among the residents of small Lake Salpetén, very large Lake Petén Itzá, and tiny Lakes Petenxil and Quexil. Weights at Macanché Island are substantially heavier, but the sample size is only 11 *pesas* and we are unsure what this difference might mean. Similarly, at Nixtun-Ch'ich' the mean weights of Classic sinkers differ between the heavier *pesas* from Postclassic levels at Mound ZZ1 and other locations at the site.

The mean weight for Postclassic sinkers is only 1 g lower than that for the Classic period, but the *pesas* from Ixlú and also the early eighteenth-century San Bernabé church structure (T31) are exceptionally light in weight. This suggests that, whether by intent or by happenstance, fishing was taking place in very calm and/or shallow waters, and/or the target species were quite small.

The overall heavier range of all *pesas* in the Petenxil and Quexil basins (Table 5.11)—and also Tayasal Structures T52 and T53 (Table 5.12a)—might reflect different fishing strategies or locations. They might have been used to securely position untended vertical fixed nets across the streams that drain into Lake Petén Itzá from the south, or to trap fish in the canals of raised fields and/or fish farms in this area, or to catch heavier animals such as turtles. Another possibility comes from the Conquest-period toponym Alain or Yalain, which means "place of young crocodiles/alligators" (Hofling with Tesucún 1997:154). We believe this place, never firmly located by Spanish priests and conquerors, comprised the southern shores of Lakes Petenxil and Quexil, and likely extended farther east (Rice and Rice 2017a). It might have been a breeding ground for crocodiles (Rice forthcoming-a).

Why Declining Weights?

The mean of mean weights of Classic and Postclassic sinkers in Table 7.9, considered with the mean of Preclassic artifacts (Table 4.2), reveals declining weights of these artifacts through nearly three millennia. Presumably the proximate cause reflects different fishing strategies pursued by the Maya occupants of the Petén lakes region over time, adjusting the weights of their net sinkers to the weights of the fish in the lake: that is, netting smaller fish or fishing at shallower depths, or both. Or, perhaps there was greater participation of women and children in fishing, using lighter-weight paraphernalia, with males concentrating on terrestrial hunting, farming, trade, warfare, or other activities. Optimal foraging theory (e.g., Smith 1983) suggests, and empirical observations confirm, that fishers across time and space tend to want to maximize their yield by collecting the largest fish, providing the greatest amount of biomass (food: meat, calories) per unit effort. We have to ask, therefore, what is the ultimate cause of what seems like sub-optimal behavior? Were larger fish unavailable to be caught in the Petén lakes? Multiple factors might have been involved, including idiosyncratic behavioral choices, changes in lake levels and water quality, shifts in fishing niches, or decisions to increase yield by mass capture of larger quantities of smaller fishes. Here we address two more systemic possibilities: decline in water quality and "fishing down."

The overall reduction in sinker weights may be a proxy for a decline in the quality of lake waters over the millennia. Limnological studies of sediments deposited in the lakes have revealed worsening conditions for aquatic life in the lakes during the Classic period, with soil erosion and heavy sediment (colluvium) deposition, several meters thick, beginning in the Late Preclassic (Anselmetti et al. 2007) and continuing through Classic and Postclassic times (Deevey et al. 1979; Rosenmeier et al. 2002). These inputs of fine clay soils from the cleared forests and architectural hardscaping in the riparian zone contribute to habitat degradation. They increase turbidity, thus limiting light penetration and impacting the food web by inhibiting growth of aquatic plants and grasses (macrophytes), and affecting the creatures that feed on them. However, these terrestrial inputs also include nutrients, commonly anthropogenic phosphorus, which can stimulate plant and algal growth and reduce dissolved oxygen concentration to the point of hypoxia and culturally induced eutrophication. If such adverse conditions were present in the Petén lakes as a result of heavy colluviation, this could have affected catches of large fish at the highest trophic levels.

"Fishing down" or "fishing down the food web" is a term used to describe the transitions in fish size in marine catches through time that result from unsustainable fishing practices (Pauly et al. 1998). This phenomenon is a consequence of selective removal (overfishing) of large, long-lived, piscivorous fish, gradually leading to catches dominated by smaller, faster-growing, planktivorous species, which may in turn be serially depleted. Fishing down, then, is fishing from higher to lower trophic levels in the marine food web. The same processes can also occur in inland, freshwater fisheries with unrestricted access, although this has only recently begun to be studied (Allan et al. 2016). The outcome is often collapse of the high-trophic stock and a loss of biodiversity. Historically overfished stock may be unable to recover because of biotic and abiotic—and anthropogenic—stresses. The delicate balance may be further upset by natural characteristics of fish species and populations in any system: small fish greatly outnumber large fish (about 50% are smaller than 15 cm length), while large fish are fewer and have lower growth rates, and thus are more prone to depletion (Allan et al. 2016:1043).

Over time, fishing down in inland waters can be characterized by the following (Allan et al. 2016:1044): initial overfishing results in an immediate increase in the weight of total catch, followed by a plateau, and then the mean size/weight of caught fishes declines. Fishers today respond to this declining prey size by reducing the mesh size of their nets: "consistent declines in net mesh sizes may be an indicator of the state of the fishery, as small-meshed nets are expensive and time-consuming to make and usually will be adopted by fishers only out of necessity" (Allan et al. 2016:1044).

It is not known if overfishing occurred in the Petén lakes at any point, nor, if it did occur, if it specifically targeted the desirable *pez blanco* and/or *mojarra*, or if it was overfishing of the entire piscine assemblage, a common problem in tropical regions (see Allan et al. 2016:1045–1047). What is known, however, is that there was a reduction in mean weights and particularly in the ranges of weights of sinkers from Preclassic through Classic to Postclassic times. This suggests, by ethnographic analogy, the use of smaller-mesh, lighter-weighted nets … which in turn suggests catching smaller fishes.

Archaeological Data on Fish Consumption

Little information is available concerning diets of the ancient Mayas in the lakes region, and specifically the contribution of fish. Faunal analyses carried out as part of the excavations of the Topoxté Islands in Lake Yaxhá did not identify fish by genus/species (Hermes 2000)[22]. Analyses of ^{15}N isotopes of 52 human skeletal elements from Topoxté revealed a decline in Postclassic meat consumption but without clearly distinguishing aquatic sources (fish, mollusks) from terrestrial mammals (Wright et al. 2000:163).

The most detailed zooarchaeological study of aquatic fauna at a lakeside site comes from Trinidad de Nosotros, particularly its harbor, on the north shore of Lake Petén Itzá, where 1⁄16-inch water screening permitted recovery of tiny fish bones and other remains (Thornton 2012). Approximately 75% of the Postclassic assemblage represented aquatic taxa, in contrast to only 10% of the Late Classic assemblage. Perhaps exploitation of aquatic resources, such as fish, turtle, mollusks—especially *jute* (*Pachychilus* spp.) and *Pomacea*—and crocodiles, increased in the Postclassic in response to Classic-period degradation of terrestrial fauna habitats through a combination of soil erosion, regional deforestation, and possible droughts. Overall, 12% of the individual specimens at Trinidad were freshwater fish (see Table 2.1; Thornton 2012:Table 12.1, 349, 351). Some of the remains from the harbor may have resulted from fish-processing as much as from consumption and notably, given the possibility of fishing down, the fishes are described as "small" (Thornton 2012:341).

Elsewhere, preliminary study of a sample of faunal remains from in and around the Zacpetén Structure 719 council house revealed a broad range of large terrestrial mammals (white-tailed deer, brocket deer, peccary, tapir), smaller animals (armadillo, agouti, rodents), varied birds (including turkey), and fish (mainly *Petenia*, but also other cichlids and bony fish) (DeFrance and Boileau, pers. comm. 2016).

Chapter 8. Discussion and Conclusions

Our attention to the excavated net and/or line sinkers, mostly secondary artifacts made by shaping and notching broken pottery fragments, was an effort to ascertain whether they illuminated Maya economic strategies and patterns of aquatic resource use in the basins of the central Petén lakes over a nearly 3000-year span. Fish are, of course, only one category of lacustrine fauna, along with turtles, fowl, reptiles, and mollusks, and evidence for the capture of these creatures abounds in zooarchaeological assemblages. But unlike these other fauna, archaeological recovery of small freshwater fish remains requires fine-screening, a specialized and time-consuming (hence expensive) procedure. Fortunately, fishing is the only activity associated with acquisition of lacustrine fauna in moist tropical areas that has a reliably associated non-perishable material culture index: net or line weights of pottery or stone. *Pesas*, then, not only register the human behavior of making and using these tools, but they also stand as proxy indicators for the kinds and sizes of fish taken and for the dynamic environments they inhabit.

In the Petén lakes region, the relatively few Preclassic (ca. 1100 BC to AD 200) sinkers we recovered are unusually large and heavy compared with those of later periods: mean weight 9 g (n = 18; Table 4.2). We tentatively interpret this as indicating "baseline" conditions for Maya fishing: clean, well-oxygenated waters occupied by large fishes in optimal habitats[23]. But a drying period at the end of the Late Preclassic (ca. AD 100–200) brought major environmental changes throughout the Maya region, from the desiccation of Lake Miraflores at Kaminaljuyú in the highlands (Valdés 2011:77) to the silting of lowland bajos and loss of perennial water sources (Dunning et al. 2011:96). As mentioned, heavy deposition of eroded soils is revealed in cored sediments from several lake basins, the result of increasingly large settlements and severe deforestation.

The degradation of the aquatic environment caused by these activities may be reflected in the significantly smaller and lighter weight net sinkers recovered in the Classic period (AD 200–950/1000). Indeed, it is seen in the *pesas* believed to represent a net in a special deposit at Nixtun-Ch'ich' dated by ceramics to the Terminal Preclassic-Early Classic transition (ca. AD 200). These sinkers (n = 62) had a mean weight of 2.32 g (Table 4.3), less than one-third that of the (mostly Middle) Preclassic artifacts. With some exceptions, Classic sinkers from the lakes showed a remarkable uniformity in weight (means ranging from 3.3 to 3.6; Table 4.4) and in length-width proportions (Table 7.4).

Zooarchaeological analyses of faunal assemblages in the lakes area and elsewhere have led to hypotheses of "dietary resource depression" by the end of the Classic period (Emery 2007). This is indicated primarily by reduced quantities of large terrestrial mammals such as deer (*Odocoileus virginianus*), the preferred prey in the Late Classic for both dietary and ritual consumption, especially by elites. In such circumstances of reduced protein availability, the dietary contributions of fish and other aquatic fauna may have increased (as per the Trinidad de Nosotros fauna discussed in Chapter 7).

The Terminal Classic in the southern lowlands is marked by the "collapse" of Classic civilization and the abandonment of large cities. In the lakes area, the depopulation was not as severe as elsewhere (Rice and Rice 1990) and appears to have been partly counteracted (at least in the west) by in-migration. The causes of the disruptions are long debated and range from overpopulation, disease, and warfare to soil exhaustion and drought. A habitat analysis of various parts of the lowlands based on zooarchaeological assemblages indicated that Late Classic environmental mismanagement may not have been as severe as assumed, with mature and secondary forest habitats showing surprising resilience (Emery and Thornton 2008). And paleolimnological and palynological studies reveal that a lowland tropical forest ecosystem was re-established in the Lake Petén Itzá watershed by the early Postclassic period, AD 1000–1200 (Mueller et al. 2010). This presumably would have aided recovery of forest mammal populations hunted for their meat.

The excavations leading to recovery of the pottery sinkers discussed herein were mainly directed toward questions about Postclassic and Contact-period (ca. AD 1000–1700) occupations in the Petén lakes, and most of the *pesas*—including the pellet introduction or innovation—date to these centuries. These excavations permitted not only site-by-site but also structure-by-structure and ceramic type-by-type analyses. The contribution of the present study is to illustrate the continuing decline in the weights of the net/line sinkers: from a Classic mean of 3.55 g to a Postclassic mean of 2.51 g (Table 7.9), a decline of 29.3%. In addition, the range of weights significantly declined.

The reduced weight of the sinkers is a proxy for complex cultural and environmental circumstances that resulted in a decrease in fish sizes in the lakes. Cultural/behavioral factors may include changing fishing practices, strategies, and technology, such as who fishes, where and when they fish, fishing intensity, variations in kinds and sizes of nets, and use of nets versus lines. None of these changes can be directly investigated archaeologically, except for the introduction of primary artifacts (pellets) for sinkers, which suggest differences in the socioeconomic identity of fishers and the contribution or intensity of their fishing. Environmental factors include changes in the kinds, sizes, and density of fish species and populations, which may in turn be a response to human predation (e.g., fishing down) or to changes in the aquatic systems brought about by terrestrial inputs and other variables such as precipitation and fluctuating water levels (see Pérez et al. 2010). At present we cannot specify the operative factor or factors behind the decline, except to note the growing awareness of the fishing-down problem worldwide, and the contingent circumstances of degradation of the Petén lakes' habitats.

In conclusion, we note that pottery fishing sinkers found at Maya archaeological sites are typically counted, measured, sometimes weighed, briefly mentioned in reports … and then forgotten. Remains of piscifauna are typically identified by taxa and discussed in terms of diet and economy. But little effort is devoted to integrating these artifacts and ecofacts with the behavior (human and piscine) involved in making-using-procuring them, or with the environmental conditions in which they existed. Exotic marine fauna (sharks, rays, conchs) long have been privileged by Mayanists (e.g., Benson 1977; Finamore and Houston 2010) whereas freshwater fish and fishing are largely ignored (cf. Ruz 1998). Yet these lowly remains can contribute to a better understanding of lowland Maya domestic economy and resource use.

Notes

1. Tedlock (1996:280) refers to a “family” of spiny-finned fishes that include perch and bass, but in modern biological nomenclature these fish are in the “Order” Perciformes. Catfish are in a different Order, Siluriformes.

2. Sulfur content of the water of some of the lakes has been measured (in milliequivalents, meq/l^{-1}): Salpetén 68.9; Macanché 4.9; Petén Itzá 3.2. Compare with Lakes Yaxhá and Sacnab at less than 1.0 meq (M. Brenner, pers. comm. n.d.; cited in Rice 1987:106).

3. Tropical gar (known locally as *pejelagarto,* literally “fish alligator”) may have come from rivers such as the San Pedro Mártir and Subín, where they are fished today.

4. Along the southern Florida coast, small rectangular artifacts of shell are proposed as gauges or spacers for making nets (Walker 2000). Similar objects were not noted in the Petén artifact assemblages, although the occasional “unfinished” (un-notched) *pesas* or other worked sherds could have served this purpose. More commonly, gauges could have been made of wood or other perishable materials, as in Veracruz, or simply “measured” by finger-widths (*dedos*).

5. The Maya Biosphere in Petén is a natural reserve created by the Guatemalan government in 1990 to protect the largest remaining area of tropical forest in Central America, along with its native fauna and impressive archaeological sites, from poaching, logging, looting, and other illegal activities.

6. Lognormality is revealed by Kolmogorov-Smirnov tests (e.g., Kirkman 1996). A lognormal distribution describes a variable whose logarithm (exponent; number of multiplications) has a normal distribution (a bell curve). It is a continuous probability distribution that represents the statistical expression of the multiplication (rather than addition) of several random, independent variables (Park and Bera 2009; Weisstein 2017). Variables in many social and natural science fields are distributed lognormally (see Limpert et al. 2001).

7. Similarly, the 88 worked-sherd *pesas* from the surface of Dzibilchaltun Structure 605 represent a net (Taschek 1994:222). Also, 123 notched sherds from Structure N10-4 at Lamanai (D. Pendergast, pers. comm. 2014) and 70 sherd sinkers at Altun Ha Structure F-1 likely do as well.

8. The use of Pozo Unslipped for *pesas*, both sherds and pellets, was inconsistently recorded. Postclassic Augustine Red type was rarely used for sinkers: fewer than a dozen were noted, and those at Tayasal and the QQ1 group at Nixtun-Ch'ich'. Sherd weights in Postclassic contexts also included Preclassic and Classic types, but it was impossible to discern if these earlier artifacts were scavenged for reuse or if the sherds were scavenged and reworked into sinkers.

9. A similar question arises with respect to Postclassic obsidian arrow points. Although the bow-and-arrow is a Postclassic technology in the lakes region (with a few examples dating to the Terminal Classic), some of them might have been formed from scavenged and recycled Preclassic or Classic blade fragments.

10. Here we omit sinkers made of other Postclassic types and paste wares, including Montículo Unslipped type/ware and the Itzas' red-slipped Augustine ceramic group.

11. This cache is reminiscent of Early Classic water-themed structural caches at Tikal, which consisted of turtle remains, *Pomacea* shells, snakes, sometimes articulated crocodile skeletons, and miscellaneous small birds and other fauna (Moholy-Nagy 2003:64, 69).

12. Stone spindle whorls are generally recovered in low frequencies throughout the Classic lowlands—only 26 (plus 25 of clay) in all of Tikal (Moholy-Nagy 2003:46), but 198 in a deposit in Belize (Kamp et al. 2006)—and most commonly in burials, belying the political and economic importance of textiles. Perhaps whorls were more commonly made of wood or other perishable materials (Hernández Alvarez and Peniche May 2012. See Chase et al. 2008:128–129 for discussion of the sparse archaeological occurrence of whorls and other weaving tools).

13. Five disks of Postclassic pastes at Zacpetén—three of CCP and two of Paxcaman Red—were tiny, weighing between 1.5 and 2.3 g, with diameters of 1.7–1.9 cm and bore holes of 2.6–3.0 mm. It is difficult to conceive of these having a spinning function, and they likely served some other purpose, perhaps as some kind of sequin-like *adorno* or as the backing for earrings or other jewelry (e.g., Chase et al. 2008:128).

14. Other materials that might have been spun include "yucca/palm, nettles, milkweed, hemp, feathers, hair, rabbit or dog fur, and silk tree" (*Ceiba*) fibers (Kamp et al. 2006:414).

15. Size continua are also evident among the Classic-period whorls of nearby Motul de San José (Halperin 2008:Table 1) and Caracol in western Belize (Chase et al. 2008:Table 1).

16. It may be significant that one of the effigy or image incense burners in the temple structure of Group C featured an effigy of a female deity, perhaps Ixchel/Chakchel, goddess of weaving (Pugh and Rice 2009:158, 281–282).

17. The use of non-ceramic materials might partly explain the lack of notched sherds and presumably significant fishing activity in some areas. For example, it is difficult to understand the scarcity of notched sherd weights in residential areas at Copán, adjacent to the Copán River: only three worked (but not notched) sherds of rectangular or oval shape were noted (Willey et al. 1994:209). At Punta de Chimino in Lake Petexbatun, perforated sherd disks about 2–3 cm in diameter were found in midden material including fish bones, and were interpreted as net weights (A. Demarest, pers. comm. 2015).

18. A similar but even larger object, called a "cleft brick," 9 cm long, was recovered from the late Formative San Lorenzo A phase at La Venta (Coe and Diehl 1980 v.I:Figure 400a), and a side-notched sherd was recovered in debris dating to the Early Postclassic Villa Alta phase (Coe and Diehl 1980 v.I:Figure 398h).

19. In contrast, analysis of 1437 pesas from Preclassic through Late Postclassic times at Cozumel detected no temporal patterns in size or form (Phillips 1979:13).

20. Some 80 notched ceramic artifacts were recovered at the Topoxté Islands, three described as primary (pellets?) and 77 as secondary (presumably worked sherds) (Hermes and Calderon 2000). They are described by their shape (ellipsoid, round, rectangular) but neither frequencies nor measurements are given.

21. *Crocodylus moreletii* inhabits the interior lowlands, including the Petén lakes. See Rice forthcoming-a.

22. It is difficult to discern to what extent this might represent "real" behavior, as few studies compare Classic vs. Postclassic faunal assemblages and those that do carefully note caveats about locational, functional, and status differences among contexts of recovery and about non-comparable recovery methods such as screen size (e.g., Thornton 2012:351–355). The source or origin of the Postclassic pellet innovation in Petén is unknown, although it may relate to eastern (Belize, Quintana Roo) contacts, where pellet sinkers are present slightly earlier.

23. This is not to say that smaller fish were ignored. At Trinidad de Nosotros, on the northern shore of Lake Petén Itzá, large quantities of the remains of small fishes were found in (probably Late) Preclassic contexts at a "middle-status residential platform" (Thornton 2012:343–344, 348). These were probably cooked in soups (Thornton 2012:341).

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Small Things Forgotten: Artifacts of Fishing in the Petén Lakes Region, Guatemala

Small pieces of notched pottery at lowland Maya archaeological sites served as sinkers or weights (*pesas*) for fishing nets and lines. More than 1400 of these artifacts recovered from six sites in the central Petén lakes region dated to the Preclassic, Classic, and Postclassic/Contact periods. Thirteen variables of the sinkers were analyzed, including provenience, dimensions, pottery type, and shape, with comparisons among sites and individual structures within sites—including locations of probable decomposed fishing nets. The weights of these artifacts declined dramatically between Preclassic and Classic times, and then less abruptly in the Postclassic, when they began to exhibit signs of standardization: a smaller range of dimensions and use of specially formed pellets. The decline in weight suggests capture of smaller fish, and may reveal changes in water quality, fishing strategies, or "fishing down the food web."

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