Underwater Archaeology of the Maya Area: A History and Study of the Methodological Approaches for the Recovery and Treatment Of Cultural Materials Recovered from a Freshwater Environment

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Abstract

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The history of underwater archaeology in the Maya area is long and colorful. Work has been done for three purposes: 1. To discover trade routes and practices; 2. To investigate formerly terrestrial sites now submerged; and 3. To discern ritual practices. This thesis will focus on the third objective. Water has been known to be of ritual significance to the maya for thousands of years. Offerings were deposited into the waters of cenotes (natural wells), lakes and pools. Also focused on in this thesis are the subjects of recovery, preservation and conservation. Conservation is looked at in relation to water chemistry and artifact type, so that if artifacts were recovered during the 1998 field season, they could be properly conserved. Research was conducted at a series of pools that lie along a limestone cliff at Cara Blanca, Belize. These pools exhibit several aspects that are indicative of cosmological importance: multiple possible cave openings; the presence of a structure close to the water among others. The pools' possible ritual significance was examined through underwater investigation, under the auspices of Dr. Lisa Lucero, during the 1998 field season.

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Introduction

This thesis is the culmination of over a year of research, both in the library and in the field. In addition to a review of literature and research of underwater archaeology in the Maya area, research was conducted both in a controlled environment (a.k.a. the NMSU indoor swimming pool at the Natatorium) and in the field, at the Maya site Cara Blanca in Belize.

The first section is a review of literature and the history of Underwater archaeology in the Maya area. My purpose in going into detail about prior methodology is to give a sense of the foundation of the research conducted by myself under the auspices of the Valley of Peace Archaeological (VOPA) Project, under the direction of Dr. Lisa Lucero. This section gives the main justifications for research and main types of waterbodies in which research is conducted.

The next section is entitled "Mapping." This section gives a preliminary outline of procedures. These procedures have been adapted to the specific environment that was found at Cara Blanca, in Belize. They were developed through a combination of library research and experimentation at the NMSU indoor swimming pool. The sources found were a combination of both freshwater and saltwater excavations, some with a generous budget, others with limited resources. As part of the research for this section, I developed a mapping method whereby a minimum of datums are employed, limiting the amount of possible error.

Section three deals with a study that was performed to gauge the effects of submergence on cultural objects. In an effort to understand what to expect when objects are uncovered, it is

imperative to understand the effects of submergence in water. Another important aspect of this study is the fact that this study was performed in freshwater, which is unusual. Most excavations in underwater archaeology take place in saltwater, which effects objects differently. Within this section are several subsections, each dealing with a different type of artifact. These include ceramics, lithics, shell, wood and bone. This section explains what is happening to the objects and why.

Section four deals with the preservation of artifacts. Although superficially similar to Section three, this section is based on research conducted both in salt and freshwater, and deals more with the contrast between salt and freshwater preservation. Again, this section is subdivided into sections on ceramics, glass, paper, wood, bone, and rubber/celluloid. The wide range of topics covered makes this section a valuable source.

Section five deals with archaeological recording, adapted to be performed underwater. In this section, I go into some detail about basic archaeological recording, as well as recording, cataloging, and photographic systems specifically designed to be used underwater.

Section six deals with excavation. Little time was spent in developing excavation techniques, although it is important to know the methodology. Most of the excavation techniques were adapted from saltwater excavations involving large quantities of metals which corrode (i.e. shipwrecks).

Section seven concerns the recovery of artifacts. This section deals with the effects of pressure on the artifacts and safe ways to transport objects from an area of high pressure to

an area of relative low pressure. In this section, I discuss the effects of pressure on artifacts, in terms of effects of pressure on the human body. To this end, SCUBA (Self Contained Underwater Breathing Aparatus) terms are used, these being measurements in feet. In scientific recording, the metric system is employed, however, SCUBA still uses english recording. Because of this, measurements that are given in regards to diving and pressure exertion are given in feet, with the metric equivelent listed behind in parenthases.

Section eight concerns the conservation of artifacts. It gives an overview of justifications for conservation. Several categories of artifacts are discussed individually, including ceramics, glass, paper, wood, lithics, bone, and rubber/celluloid. In general, this section gives details on stabilizing, testing for salt contamination, and storage.

Finally, Section 9 contains the results of the 1998 VOPA field season. Along with a detailed explanation of the two dives completed, I also include a general description of the area. All figures are listed after section 9.

A Brief History of Previous Underwater Research in the Maya Area

The history of underwater archaeology in Mesoamerica is long and colorful. In fact, many of the underwater techniques now commonly used by underwater archaeologists the world over were developed and first used in this area. Despite the wealth of research for the entire region, little work has been done to date in inland pools, especially in Belize (See Fig 1). Most of the work that has been done has been for three purposes: 1) to discover trade routes and practices; 2) to investigate sites that once had been on land, but due to water levels rising are now submerged; and 3) to discern ritual practices;. The focus of this thesis will be to examine aguadas and pools for signs of ritual use via research with the valley of Peace Archaeological (VOPA) Project.

The first of these purposes has been served by excavation at presumed ports on the coasts. Some such sites are Xelha, Quintana Roo, Cerros and Wild Cane. There are, of course, many others. Heather McKillop (1995) has investigated Cerros. Her purpose in this was to discern ancient salt trade routes of the Maya. She was able to establish that the site was entirely devoted to salt production, there were no residential buildings. She was also able to establish that the salt was not used for processing and preserving fish from the coastal waters. The specialization of this site shows a degree of crafts specialization that is rarely seen in the Maya. The site also fulfills the third goal of underwater research already conducted in the area, the investigation of once terrestrial sites that are now submerged.

Evidence of Maya watercraft has been sparse. Historic accounts tell us that these canoes were made of hard wood, and varied in size from one-man dugouts to larger craft capable of carrying 40 to 50 people (Andrews and Corletta 1995). A canoe has never been archaeologically recovered from any port site. Ports have been found and excavated at Xelha and at Isla Cerritos. These sites contain high retaining walls and structures that open into gaps in the coral structure, giving the perfect access to the calm waters of the Gulf of Mexico and the Caribbean Sea. Navigation between ports ranged from a simple navigation among a series of interconnected mangrove estuaries to braving coastal reefs.

Other sites are investigated that are believed to have been of a terrestrial nature. Already mentioned earlier is the site of Cerros, a salt production site along the Belize coast, which was submerged when ocean levels rose. Other sites that meet these criteria are Consejo, Corozal and Sartenja, all located along the north coast of Belize. One site of particular interest that falls into this category is that of Carwash Cave, near Tulum. At this site, divers found what appears to be a hearth at a depth of 27 meters; this is believed to be the first evidence of seal level changes in Early Archaic times (Andrews and Corletta, 1995, Coke et al., 1990). Charcoal dated from this hearth has yielded a date of 8250± 80 years b.p. Cave divers Mike Madden and Pete Turner discovered this site in 1986.

Three main types of bodies of water can be found inland in the Maya area: cenotes, lakes and pools. The first two of the three have been investigated extensively from the time the Maya were "discovered" by the western world.

The most memorable of the cenotes to have been investigated is the Cenote of Sacrifice at Chichen Itza. The cenote is located 400 meters north of the main plaza and is connected to the main plaza by a sacbe, a raised causeway. The cenote has an approximate diameter of 60 meters, and its maximum depth is 13.4 meters. Along the southern edge of the cenote is a structure, so close to the cenote that part of it has fallen into the water (See Sharer 1995 figure 7.3). This is repeated throughout the Maya area in association with sacred bodies of water. It has been known since colonial times, via the writings of Bishop Landa, that the cenote figured heavily in the religious activities of the occupants of Chichen Itza (Tozzer 1941). These accounts were justifications of the notably harsh conversion methods practiced by Landa and others. Through his writings he strove to prove that the native peoples were savage, and therefore, did not need to be treated with the respect shown to a human being. Included in his descriptions were numerous accounts of human sacrifice. Over time, these descriptions flowered form descriptions of victims being thrown into the water to the sacrifice of virgins. However, numerous osteological studies of the remains recovered by the researchers discussed below have shown that the "inhabitants of the well" were a mixed lot of males, females and children (Saul and Saul 1989, Hooten 1940).

No mention is made as to whether any of the skulls recovered shows signs of skull modification, such as elongation or dental modification. Such distinctions would be helpful in reconstructing the status of the individuals sacrificed, which would help to gain an insight into the religious importance of the sacrifice. If the sacrifice is extremely important and indeed

the nobility is divinely chosen, the better sacrifice would be the one closer to the gods, or more noble (Freidel 1986). One example of the added importance of the nobility as sacrificial offerings is evinced by Tozzer (1941). Another example of the elevated status of important sacrificial victims is their depiction in stelae still with elaborate headdresses (Schele 1984) or identified by hieroglyphic depictions along their legs (Sharer 1994). Understanding who went into the well (here or elsewhere) will give us a clearer idea of what role these sacrifices played in the overall ideology of the Maya.

Edward Thompson made the first successful attempt to dredge the Cenote of Sacrifice, between 1904 and 1911. Lowering from a nine-meter high boom, Thompson lowered a dredge with a 2.5 cubic foot capacity bucket and dragged the bottom. This method is not only dangerous for those operating the machinery; it is also extremely destructive. It destroys all evidence of provenience and context, thus giving us an incomplete picture of the ritual nature of these deposits. In 1909, Thompson began helmet diving, but visibility in the cenote was poor and a combination of the two methods was used. Among the objects removed from the cenote by Thompson were god, silver and copper artifacts, as well as jade, shell, chert, obsidian, ceramic vessels and figurines and human and faunal remains.

The first map of the cenote floor was not made until 1935, when Manuel Cirerol Sansores mapped and conducted a study of the cenote's physical properties (Andrews and Corletta 1995, Folan 1966). In 1954, more studies were made, as were recommendation for further investigative techniques. These techniques recommended the drainage of the cenote with pumps (Andrews and

Corletta 1995, Folan 1966). It was this year, too, that the Aqualung was first used, however, its usefulness was limited due to poor visibility. The site was investigated again in 1960 and 1961 by INAH, led by William Folan, CEDAM, a Mexican exploratory club led by Pablo Bush Romero and the National Geographic Society (NGS), led by Norman Scott and Bates Littlehales. This expedition used a newly developed device called an airlift, basically a large vacuum used to remove sediment and small artifacts from the pool floor. Work was halted following an assessment by INAH officials that too many artifacts were damaged by the airlift (for an explanation of airlifts, see "Excavation", this paper).

The last excavation of the cenote took place during three months in 1967 and 1968. Once again, INAH, CEDAM and were involved, along with Unlimited Expeditions (EL). The most significant thing that this expedition did was water clarification. In order to increase visibility, attempts were made to clear the water by chlorination filtration and soda ash. Flocculation, with infusions of chlorine and muratic acid proved to be the only effective means of clarification. However, no one was concerned with lasting effects on the water table, and these considerations must be made when it is remembered that cenotes are natural wells, where a constant supply of ground water is percolating through the limestone. Inevitably, whatever is added to the water in the cenote will be added and dispersed through the entire water table. Even after these extensive steps toward clarification of the cenote, diver activity soon muddied the waters once again. The final suggestion was that only when a complete stratigraphic study could be done should any further exploration be attempted. The only way, of course, to have a

complete stratigraphic study of the floor is to drain the entire cenote and use a sealant to stop ground water seepage. For the reason of the immense time and monetary commitment that would be needed for such an undertaking, no further exploration of the cenote has been attempted.

In 1966, Stephan de Borhegyi leading an expedition conducted a preliminary reconnaissance of archaeological sites in the southern highlands of Chiapas, Mexico. One site surveys was that of Chinkultic, and the exploration of its Cenote Azul was planned. The location of the cenote was of extreme interest, as it was located at the foot of a cliff immediately beneath the site's main pyramid. The first underwater exploration was carried out in 1966, with a second in 1968, which revealed a large deposit of ceramics on the north shore of the cenote. It was determined that a proper investigation would require the draining of the cenote, and this was undertaken in March of 1969. Although hampered by the natural water table (this was the main reason that an emptying of the Cenote of Sacrifice was not attempted), they significantly lowered the water level to the point where excavation could be carried out along the shore by using artificial levels (Mericle 1971). A stratigraphic sequence could not be determined, and for this reason, excavation was stopped. Evidence obtained from these excavation shows that objects were tossed from the shoreline or from the top of the cliff on its south side.

Another major cenote that has been explored is the Well of Time, also known as Cenote Xlacah, located at the site of Dzibilchaltun. The site of Dzibilchaltun is located 22 km from the north coast of Yucatan. Excavations at the site have shown an

occupation period ranging from the Middle Formative (ca. 800 b.c.) to the early colonial period. Investigations at the site were conducted between 1956 and 1966. During the years of 1956 and 1959, divers explored Xlacah, in association with the site. The diving was conducted by local, University of Florida and NGS divers (see Fig 2). Due to the involvement of NGS, an account of the "adventure" was written by Luis Marden and published in National Geographic Magazine.

Reading more like a dime novel than a report, it does provide a few important details. For instance, a number of diverse objects were recovered from the cenote, including decorated and undecorated ceramics, jade masks and thousands of beads (Marden 1959, Taschek 1994). Most ceramics found date to the Late and terminal classic periods, a pattern also found in the Cenote of Sacrifice. This connection points to a cult of ritual offerings during that time (Andrews and Corletta 1995, Marden 1959). Few human remains were recovered from this cenote, suggesting that human sacrifice was not practiced at this site, as opposed to the Cenote of Sacrifice at Chichen Itza. One interesting parallel here between Xlacah and the Cenote of Sacrifice is the presence of a structure. Marden states:

> On the north rim of the cenote stands a great mound of rubble. As we dived day after day; we became convinced that much of the worked stone from the facing of this pyramid had at some time in the past slid into the deep waters of the well (Marden 1959: 114).

The association of structures near the water edge has also been found at Cara Blanca (Lucero 1997) During the 1997 VOPA season, the area was mapped and it was noted that along the western edge of the pool a structure was eroding into the pool. Although weather did not permit the collection of ceramic samples, it was

noted by Lucero in the field report that the pool was in association with limestone cliffs and that structures lined the edge, with one so close that it was eroding into the pool (see fig 3). These features are also found in the two previously discussed cenotes and these have been found to hold cultural deposits.

Lakes are the second type of body of water found in the Maya area. Work has been done at many lakes throughout the Maya area. The first of these to be discussed is Lake Peten Itza, in Guatemala. Work began in 1959 to find the remains of a stone horse said to have been thrown into the lake by missionaries in 1618 (Borhegyi 1963). Although the horse was not recovered, many incense burners and ceramics were, dating from the late preclassic to contact period. Some appear to have been offerings to the Rain god, as is evidenced by their ceremonial type (Borhegyi 1960).

Investigations at Lake Amatitlan, Guatemala shows the first use of the aqualung in the Maya highlands in 1954. In that year, amateur divers began a loose exploration. In 1955, they began to recover pre-Hispanic specimens, and over the proceeding three years recovered over 400 ceramic vessels. Stephan de Borhegyi joined the project and produced the first map of the lake, including all sites on or near the lakeshore, as well as nine underwater sites. Ceramics recovered have extremely exotic designs portrayed on them, ranging from spider monkeys, papaya fruits and flowers, snakes, lizards and human heads. Chac or Tlaloc were also represented along with a fertility god and a death god (Borhegyi 1961). The styles of these artifacts range from those clearly influenced by Teotuihacan to those influenced

by contact from the central Mexican highlands. From the geographic diversity of the materials recovered it was clear that the lake was the focus of pilgrimages from different regions, according to the types of the ceramics from all over the highland area. Few human remains have been recovered, but representations of Xipe Totec, the god associated with sacrifice have been found; this indirect evidence for human sacrifice dates to the Classic period, earlier than the evidence for human sacrifice found at Chichen Itza. The waters at Lake Amatitlan are notoriously warm, and this has been used by Suzanne de Borhegyi to claim that the lake was used by the prehistoric peoples of the area as a curative and magical place (Borhegyi 1961). The structures along the shore are in association with the hotsprings, which has been described as a "shrine."

Lake Guija, El Salvador was investigated in 1960, and was found to contain a few censor fragments dating to the Postclassic (Borhegyi 1960) and two late Postclassic effigy censers, both depicting the god associated with sacrifice, Xipe Totec (Boggs 1976). Also found at this site was an early Classic engraved jade plaque (Houston and Amaroli 1988).

While doing a reconnaissance of lakes in Guatemala in 1960, Stephen de Borhegyi found a number of lakes to be devoid of ritual debris. In the case of Lake Atitlan, in western Guatemala, utilitarian ceramics were found, which were thought to have fallen into the lake from the surrounding slopes. Also during this reconnaissance, Borhegyi explored Lake Atescatempa, Guatemala and Lake Ixpaco, Guatemala. Neither of these produced any cultural remains, let alone any ritual deposits.

Pools have only been studied marginally, and only then when dry. It is for this reason that more research should be done in these bodies of water, especially while still containing water.

Due to the nature of underwater archaeology, the issue of necessity must be carefully assessed. Underwater archaeology because it is even more destructive than most archaeology should only be done when an important aspect of the cultural system can be found submerged. Some examples of this include searching for ritual deposits to gauge the importance of water ideology among the Maya and the discovery of trade practices. Objects that have been underwater for extended periods of time are more susceptible to environmental stresses and change. They are also a lot more fragile. Competent professionals must carry out this research with an eye toward the eventual conservation of the materials recovered. Steps must be taken to insure that little harm is brought to either the underwater environment or to the underwater cultural environment.

Where it is determined to be necessary, underwater archaeology has been very useful in determining the roles of both trade and religion in the lives of the Maya. Several conclusions can be drawn from the work that has been done involving the ritual sacrifice into water; these could not be made without the underwater research. Sacrifice of objects, especially ceramics, into water was common throughout the Maya area. The distribution of sacred water sites does not concentrate in any one geographic location. Most of the artifacts brought to the surface as a result of this research date to the late or terminal Classic, perhaps indicating an ideological shift. Certain concepts remain the same throughout the Maya area in respect to water ritual.

All sites have ceramics deposited ritually; these are determined from their non-utilitarian appearance. These ceramics contain an amazing variety of pictorial representations, from waterlilies to representations of Xipe Totec. Underwater archaeology has also shown quite effectively that there was a good amount of geographic variation in the ritual practices. At the Cenote of Sacrifice at Chichen Itza, many human skeletal remains were found, whereas, not many have been found in other areas. Clearly water was an important aspect of Maya ritual, and this has been brought to the attention of scholars mainly through the work of underwater archaeologists recovering artifacts from sacred water sources.

Cultural activity has also been discerned from looking at the underwater archaeological record. It is rather paradoxical, artifacts recovered from the underwater environment are more fragile, but many things also preserve much better. This is because they have less access to environmental stresses. We have been able to find that at Cerros, the salt production site on the Belize, coast that there were no occupational residences. The site was a purely trade and service oriented site. We have also been able to show that people arrived on the Yucatan peninsula much earlier than previously expected, due to the discovery near Tulum of the hearth now submerged at a level of 27 meters.

More refined excavation techniques and a more focussed eye on conservation and treatment will no doubt add to what we have already learned about the Maya through underwater archaeology. Rigorous research designs and more systematic methods that will produce more substantive anthropological results must accompany these new techniques. For the simple reason that much of the

investigation to date was conducted by recreational divers or those who did not have proper certification, the scientific community is reluctant to accept much data from underwater sites. If archaeologists can learn from the mistakes of those who have gone before us, especially Thompson's excavation of the Cenote of Sacrifice, the future of underwater archaeology in the Maya area will be an illustrious one indeed.

Mapping

Before any underwater activity involving the removal or disturbance of artifacts a pre-disturbance survey will need to be done. The simplest of surveys is simply a surface examination. This is done to determine the perimeter of the site. Divers can swim along the floor of the pool and determine the dimensions of the cultural debris. Once it is ascertained by the divers the size of the site, grid lines may be placed in the sediment of the pool carefully along the cardinal points (Green 1990). The use of a wrist or hand held compass is important and useful to this end. The grid lines themselves should be of brightly colored string, as color distortion can be a problem underwater. The term "site" used in the context of underwater mapping is used to refer to the cultural deposit on the pool floor. It does not refer to any larger area of cultural groupings or complexes.

Once the actual dimensions of the site have been determined, it is necessary to pick a datum point from which everything in the site can be measured. It is for this reason that sites can be split up in order to make measurements from a central point more accurate. This datum is usually placed in the center of the site, or portion of the site to be mapped. The placement of this is usually helped by the placement of a baseline. This baseline should be placed along the long axis of the site, if one exists. It is extremely important to correctly map in the datum, if this is off even a bit, all the measurements taken will be wrong. Once the datum is established, mapping can proceed at a faster pace. The most accurate method of underwater mapping is distance-angle measurement (Green 1990, Marx 1975).

Tools needed for Pre-disturbance/Preliminary Survey/Mapping:

- Brightly colored string
- Large Pole to be used as a semi-permanent datum underwater.

Distance-angle measurement requires only two divers, and for this principal reason it was suited for the VOPA 1998 investigations of Cara Blanca. Diver 1 is stationed at the datum; he or she is the recorder. This is another advantage of this method, only one recorder is needed. If more than one recorder is used, eventually errors will occur. Oral communication is impossible underwater, and therefore asking which point the other diver happens to be measuring is impossible. Diver 1 has a tablet or clipboard with an end of a tape and a hand held compass. Diver 2 swims from the datum to the object to be mapped; he or she carries the zero end of the tape. Stopping over the object, being sure that the tape is not resting on the floor, Diver 2 signals to Diver 1. Diver 1 then measures distance and bearing to the object. All of this is then placed on a tablet, to be mapped in on the surface.

Distance angle measurement is particularly useful for the horizontal mapping of the pool floors that are needed to make a three-dimensional map of the pools. This method requires a bit more equipment, including a difficult to find enlarged protractor. This compass enables the recorder to get extremely precise angle measurements. Also necessary is one tape, preferably brightly colored. This method is principally used to map groups or cluster of artifacts. For more precise location of artifacts, other forms of mapping need to be employed.

Tools needed for Distance-angle measurement:

- One 25 or 50 meter tape, preferably brightly colored.
- One enlarged protractor, to measure angle from datum.
- Recording supplies, including a writing tablet, water-safe paper, and pencil.

Two other forms of underwater methods are of use to small scale projects. Both of these methods are modeled after land methods. The first of these is rectangular measurement (Lange 1997). This method is facilitated by the placement of gridlines in order to establish temporary baselines in both north-south and east-west directions. Once gridlines have been placed, objects can be measured up from the baselines. This method is very accurate within a two meter area. This is mainly used for concentrated clusters where it is important to note the exact location of every object. These objects can be mapped into a grid at the underwater site.

Tools needed for Rectangular measurement:

- Two 10 or 25 meter tapes, preferably brightly colored.
- String for baselines
- Recording materials.

The other method is Trilateration (Green 1990). In this method, semi-permanent points are established along the baseline. Two points should be staked or spiked into the sediment of the pool floor, whichever has the least chance of harming cultural debris. Each point is attached to the zero end of the tape, thus facilitating the minimum of two divers. Distance is measured from each tape. This method is accurate when measuring objects over two meters (Lange 1997). One advantage of this method is the near

absence of necessary equipment. All that is needed are two tapes, the brighter colored the better, and materials to set up the baseline. Also needed are stakes or spikes. Generally, stakes are used in all occasions as they have less chance to damage artifacts. However, in some cases, such as rocky outcrops or coral outcrops, steel spikes may be screwed into the rock face. There is an inherent danger in this type of mapping, this being the presence of two recorders. This is not such a large problem, because the divers are in the same position, but care must be taken to record the points in the same order. Points recorded underwater are then plotted on the surface. The protractor is used to measure out the appropriate distance and an arc is drawn. Measurement must be very exact so that the intersecting arcs cross in the appropriate place.

Tools needed for Trilateration:
- Two 25 or 50 meter tapes, preferably brightly colored.
- Recording materials sufficient for two recorders.

Whatever strategy employed, the recorder(s) requires certain equipment. For distance-angle measurement and Trilateration, a slate or clipboard to record point measurements is required; for rectangular measurement, a clipboard with a stamped grid would work best. Although difficult to find water-safe paper, it is possible, and can be imprinted with a standard grid. Water-safe paper can be written on with simple graphite pencils. These pencils should be tied to the clipboard, as divers would lose them in profusion if they were not connected.

Equipment needed for Recording:
- Clipboard, preferably brightly colored with a prestamped grid
- Water-safe paper, to write upon

- Graphite pencils
- Water-safe tape to secure paper to clipboard
- String

During excavation, a three-dimensional map should to be drawn. For this, we will be able to combine the horizontal techniques of distance-angle measurement. This will provide half of the data necessary. The second set of data required will be elevations of the pool floors, in order to show their relationship to the artifacts and to the underwater datum established during mapping. Recording depths of artifacts can be a problem. I can see one way to accomplish an accurate measurement for elevation. This is a modified triangulation technique. If a surface datum can be fixed on the surface at a known height, the non-zero end of a tape can be fixed to it. (See figure 4 for explanation and example) From the surface, the distance and angle measurement can be taken. This will give us the hypotenuse length and the opposite angle. If measured down from a 90°, we now have all three angles and one length. With this we can discern the other two lengths and the other two angles. This method is both reliable and rudimentary. The only necessary tools are an elementary knowledge of algebra, a reliable recorder on the surface, a tape and a protractor to measure the angle.

Tools needed for modified triangulation technique for taking elevation:

- Knowledge of algebra
- Component calculator with sin function
- One 50 to 100 meter tape
- One protractor
- Recording materials

Other methods have been proposed for the accurate recording of depth. The most promising of these was the concept of a hand-held

depth detector that could be placed in the sediment next to the artifact. However, these were developed to take depth measurement for sport divers. This skews the measurement a bit. These depth detectors were developed to tell the diver how much pressure the diver is under (ever 33 feet equals another atmosphere of pressure), and therefore measures depth by the amount of pressure exerted on the instrument. The depth measures expressed by these hand-held depth gauges are not accurate enough to give a true depth, they only give an approximate measure of the pressure exerted, which is also contingent upon the altitude that the diver starts at. For our purposes, a modified triangulation technique is more practical and more reliable.

Effects of Submergence on Cultural Objects: A Summary of the National Reservoir Inundation Study

The national reservoir inundation study was conducted by Lenihan et al. from 1976 to 1980, and has been of great assistance to me in gauging the effects of submergence of artifacts in a freshwater environment. The purpose of the study was to provide a framework for discerning the preservation of an object before removal from the aquatic environment, specifically reservoirs. Lenihan et al. subjected various materials to submergence for up to one year, with checks performed every four months. The materials subjected to the tests were: ceramics; lithics; shell; wood and bone. Each of these will be discussed in detail later.

Ceramics

This portion of the study was performed by Ware and Rayl. Ceramics used in this experiment were gathered from La Bajada Hill, forty miles outside of Albuquerque, NM, where the tests were conducted at the University of New Mexico. Many different variables were used in this test, from firing temperature to composition of paint. Three firing temperatures were used, classified as low (600°C), medium (750°-900°C) and high (1050°C). In other literature, these are defined, respectively as terracottas, earthenwares and stonewares (Singly 1988). Two different tempers were used, those being an organic temper made from plant fiber and an inorganic temper made from crushed sandstone. Finally, all were decorated with a simple bar design.

All were decorated either with organic paint, derived from dandelion extract, or from mineral paint, derived from crushed manganese dioxide. Also included in the experiment was a sample group of unfired clay. Also, some were slipped and some were not.

Prior to firing, tiles were assigned to groups: Group IA: mineral paint/organic temper, fired at 750°; Group IIA: organic paint/rock temper, fired at 600°; Group IB: organic paint/rock temper, fired at 900° and Group IIB: mineral paint/rock temper, fired at 1050°. After the paint and slip was applied, the tiles were fired for 12 hours, and then immediately submerged in water. Representatives of each Group were placed in 30 controlled water chemical solutions, with one tile per Group, per container, to be set aside as a baseline time zero standard. The samples were left in the water solutions for one year, with checks every four months.

During these checks, the samples were removed from the water, weighed, measured and subjected to tensile strength tests. Sample numbers decreased with each test. Ware and Rayl attribute this to handling, the effects of wetting and drying. Many of the samples in group IIA completely disintegrated after only four months of immersion, significantly lowering the sample size for that group.

After one year, all of the samples were pulled, and various tests were performed upon them. The first of these was a visual examination. The attributes selected to be tested in this manner were hardness, color, surface texture, and pigment properties; all attributes were measured qualitatively. Group IA showed a high incidence of surface pitting. The mineral paint was faded but intact. Color was faded compared to an uninundated control group. Group IIA was most affected; in fact, very few survived.

Those that did survive were soft and in poor condition. Orangic paint was absent on most pieces and where it was present, it was extremely faded, as was the ceramic color itself. Group IB were in a poorer condition than group IA, in spite of being fired at a higher temperature. The organic paint was faded, though not as much as the mineral paints. The color was also faded. Group IIB sustained immersion far better than the previous three groups. The authors attributed this to the higher firing temperature. Mineral paint faded, but was basically intact. Although not as pronounced as in groups IA and IIA, the clay color is slightly faded. Also, these ceramics were not as soft as the previous three groups.

The authors drew several conclusions from these set of data. First, firing temperature is an important variable to determine deterioration. On a lesser scale, deterioration may be attributed to temper type. Essentially, the use of sand or stone as a temper weakens the paste (Shepard 1956). Clay may be strengthened by the addition of the carbonaceous temper. These grains carbonize during firing to raise the internal temperature of the ware.

The second test the ceramics were subjected to was a water chemistry analysis. This method basically tested to see how the addition of the ceramics affected the water chemistry of the solutions that the ceramics were placed in during inundation. Results of water chemical analysis show a leaching of calcium and trace elements of potassium, magnesium and silica during the first two weeks of immersion. After this two week period, additional artifacts were added to these water vats, and so it would have been impossible to tell whether the change in water

chemistry was due to the presence of the ceramics or other cultural objects.

The third test was X-ray diffraction analysis. Thirty-three samples and one raw clay control were subjected to X-ray diffraction to determine their mineralogies. Samples from group IA and IIA tend to approximate the mineralogy of the raw clay control. The differences expressed between these groups, the authors attribute to differences in firing temperatures. Groups IB and IIB contain higher amounts of quarts and chloride. X-ray diffraction demonstrated considerable variability among the various ceramic groups between fired and unfired clays.

Lithics

Chipped stone made of chert and obsidian flakes were used for their experiments. Chert was obtained from Texas, and consisted of a medium-to-dark gray cryptocrystalline material. Obsidian was obtained from northern New Mexico, and is internally fractured and exhibits a "foamy" cortex. In addition to flaking these chips off of a core, a worked surface was also produced on each lithic by grinding on a belt sander for three to five seconds. These samples were weighed every four months. After one year, the samples were weighed, and flakes were observed for qualitative changes and subjected to electron microprobe, atomic absorption and neutron activation analysis.

The visual analysis was conducted after 12 months of inundation, and no qualitative changes in wear patterns could be discerned. This result was expected by the authors, given that chert and obsidian are very resistant to chemical weathering

processes. In addition to visual analysis, electron microprobe analysis was conducted. Not surprisingly, obsidian samples were indistinguishable between inundated and noninundated. Some chert samples exhibited fracturing. Neutron activation analysis was also conducted. These tests also showed that there was no significant differences between the samples immersed and the control samples also analyzed. The results of this tests showed that while some leaching of trace elements from chert may have occurred, it is more likely that a dilution effect is indicated, since many of the chert samples developed weathering rinds. Atomic absorption analysis showed that no significant difference in trace elements between inundated and noninundated controls.

For this experiment ground lithic material, also chert and obsidian, were subjected to inundation. These samples were also removed at four month intervals and weighed. For these samples, significant weight loss was noted for both types at each time interval. In addition to weight loss, atomic absorption analyses at four and eight months indicate several constituent elements were leaching into the water solutions.

Shell

Clam and Oyster shell were used to assess the impact of water chemical variability on artifcatual shell. Five samples of each clam and oyster were immersed for 12 months. At the end of this time period, the samples were removed and subjected to tests, including visual tests, X-ray diffraction and atomic absorption analyses.

Visual tests were performed to study for morphology, surface texture, color and sheen. For comparative purposes, the inundated samples were compared to pre-inundation photos. The overall conclusion reached by the authors was that inundation caused the bleaching of the samples. Dissolution of the shell and extreme chalkiness of the preserved portion were also attributed to inundation. X-ray diffraction analysis showed that there was little change in the mineralogy of the samples.

Water chemical analysis was conducted due to the significant weight loss exhibited by the majority of shell samples during inundation. Atomic absorption of analysis was conducted to determine what elements were being added from the shell to the water solution. Calcium was leached into the water, as was potassium and sodium in some cases. However, the potassium may reflect a contaminant from the ceramics also in the solution. The overall conclusions reached by the analysis of whole shells was that acidic water solutions are highly destructive after only short periods of inundation, but other chemical variables have a minimal effect on shell deterioration rates. Ground shell was also inundated, and exhibited the same pattern. Both oyster and clam showed considerable calcium leaching during relatively brief periods immersion periods, and this process is accelerated in acidic environments. Ground oyster shell leaching rate remained constant for the 12 month interval; however clam shell leaching rates declined from four to eight months after immersion.

Wood

For the inundation experiment, one hardwood (white oak) and one softwood (ponderosa pine) were used; these woods were cut into one inch cubes and were evaluated at four month intervals. After 12 months, all samples were removed and subjected to visual analysis, water chemical analysis and were weighed. Analysis was conducted to answer the following question: 1) what structural changes can be expected following brief episodes of inundation, and can these changes be predicted on the basis of the observed chemical interactions? and 2) do these changes that result from inundation influence the differential preservation of wood? For the 1998 VOPA season, the second question is of more interest. Visual analysis was conducted to assess morphology, color and surface texture impacts from exposure to water solutions. After inundation, oak exhibited linear splitting along the grain of the wood; pine, however, exhibited no cracking. To assess color, the authors used Munsell color charts, color photos and representatives control standards. No wood exhibited warping or distortion. Water chemical analysis showed no conclusive evidence of chemical leaching. At the end of the 12 month period, all wood was removed and allowed to dry at room temperature (68°) for a minimum of three weeks. In some instances, there was a marked increase in weight, at other times, it was not noticeable.

Bone

Three types of bone were used for the experiment, cow, deer and rabbit. Care was taken by the operators to make sure that the animals were from the same geographical area, of the same variety, sex and age at slaughter. All of the cow and deer bones were baked in a kiln at low temperature until most of the soft tissues were charred and could be removed, both in order to deflesh the bones but also to simulate the charred condition that often preserves bone in an archaeological setting. The tibiae were then cut to a standard dimension, first by sawing off the epiphyses of the whole bones and second by using only relatively uniform diathesis for the test samples. Each shaft was cut down the midline, and each half shaft was then cut perpendicular to the shaft midline at two cm intervals, producing haft shaft bone arches used as test samples. Rabbit bones were prepared by using a radial blade to cut one cm long sections from the shaft portion of each femur; they could not be prepared in the same manner as the cow or deer due to their greater paucity.

At the end of the 12 month test period, all bone samples were removed from solution, weighed and photographed. These analyses were to answer the following questions: 1) what chemical changes in archaeological bone can be expected following brief periods of inundation; and 2) do chemical changes in bone that result form inundation influence the differential preservation of bone in a submerged, freshwater environment? As with wood, the second question is of much more interest to us here.

Visual analysis was conducted to assess the impacts resulting from exposure to the 30 different water solutions that were used for the experiment. For the most part, bone degradation was consistent within each category of bone. Deer appeared to be

least affected, the bone mass remained extremely dense and contained little cancellous tissue. Cow is little affected by the chemical interaction, although cancellous tissue showed a tendency to slough off, the dense bone matrix remained intact. Rabbit was most affected, however, the observed impacts were minimal. Slight alteration was observed within the rabbit bone group as a whole.

Results from water chemical analysis showed that at least some of the bones were leaching calcium into their water solutions. Sodium, potassium and magnesium increases were also found. The leached ions are consistent with chemical composition of bone.

The authors, when reviewing the data for this experiment came to the conclusion that the data was not conclusive to any certainty. They blamed this on the considerable variability in size and robusticity (especially within the cow category), and emphasized that more lead time was needed to properly prepare samples for this type of inundation experiment.

Preservation of Artifacts

In general, we can expect to find objects that, if they have survived inundation and adapted to the higher pressure environment, are in a good state of preservation. We also have an advantage over artifacts that have been found in salt water; this being the simple fact that artifacts are much more likely to preserve in freshwater than in saltwater (Marx 1975:66). Salt water adds insoluble and soluble salts that can eat away at objects until they are prominently destroyed, or cannot be brought to the surface for fear of damage (Ballard 1987). Singley states, "Unlike salt water, freshwater has a much lower concentration of chlorides, so that damage resulting from salt contamination, like intensive corrosion and crystallization on the surface is much less (1988:8). In her work at Cerros, Belize, McKillop (1995) found that larger ceramic sherds were present in the salt production areas than she would have found if the site had been on land. This was attributed to the fact that when a site is in an area where access to is limited, as is the case with submerged sites, less disruption or "stamping" of the artifacts will appear.

In general, we are interested in the probable preservation of all materials, including inorganics and organics, from rock to ceramics to paper. The following summaries are offered as possible preservation scenarios, presented by various researchers as summaries of their experiments and observations in the field.

Ceramics

Ceramics will probably the most abundant type of artifact to be found in Cara Blanca, ceramics are generally found in profusion all through the Maya lowlands. Low-fired ceramics, terracottas (below 1000°C) and earthenwares (1000°-1200°C), have a much higher chance of deterioration. Pearson (1987), who worked in salt water conditions, found that many of these wares had crazed and flaking glazes with partial dissolution of the clay body. However, Singley (1988) who works in freshwater, found simply a softening of the fabric. Seemingly, these differences in preservation can be attributed to the chemical makeup of the water in contact with the ceramic. One point of agreement between researchers who work in salt water and those who work in fresh water is that glazes are very fragile. The main component of any glaze is a type of silica, which is modified to lower the melting point to something attainable. These glazes are applied during the firing process, which melts them into the fabric of the ceramic, both providing a finish and a seal to the clay body. Water current movement and the movement of sediment can cause the deterioration of these glazes by the constant abrading of the sediment against the ceramic. The equivalent to this process would be stripping wood with sandpaper to remove a layer of paint. With the removal of the glaze, which had added a protective layer over the more vulnerable clay, the porous body of these earthenwares and terracottas is much more susceptible to deterioration (Pearson 1987).

With the absence of a protective layer, stone-boring organisms can penetrate terracottas and earthenwares. In addition to the danger of these stone-borers, the water chemistry of the water

may have an affect. As was shown through the National Reservoir Inundation Study, the more acidic the water solution is, the more likely the dissolution of the clay body is (Ware and Rayl 1981). In addition to the acidity of the water, the materials submerged with the ceramic may affect its preservation. Both organic and inorganic material buried in context with the ceramic may stain (Pearson 1987, Singley 1988). In the case of the Maya area, we do not expect to find metals, since the preliminary ceramics data shows no post-classic sherds on the surface surrounding the pools (Osterholtz n.d.). However, iron stains may be derived from clays in the sediment, and we must be careful in our conclusions and recovery (Pearson 1987).

High-fired wares, stonewares (1200°-1300°C) survive submergence much better. Because they are fired at such a high temperature, they become a form of stone, making them virtually impregnable to most things that disintegrate ceramics (Pearson 1987). It is for this reason that these are much more likely to appear in an underwater archaeological record than terracottas or earthenwares.

Glass

The preservation of glass is included here for the simple reason that we anticipate the discovery of obsidian blade fragments if this is a ritual depositional site. Obsidian is a volcanic glass, susceptible to alkaline water. Generally, the more alkaline the water is, the worse deterioration is. The glass leaches alkalis, causing the thickness of the glass to decrease, weakening the overall strength of the piece. In addition to the

loss of thickness, layers of hydrating silica may alter the clarity and/or color of the piece. Weathered glass reflects light instead of refracting it (Singly 1988). Glass buried in acidic sediment with a pH of greater than three has a better chance of survival.

Paper

Paper is covered here explicitly because if any existing Maya codexes are to be discovered, they will be found in caves in Belize, where preservation is at its height (Harrison, personal communication to Lucero, 1997). Since these caves are in association with the pools in question, we will have to be on the lookout for the preserved manuscripts, or at least be able to realize that there may once have been a manuscript there. Pearson (1987) did a lot of work with paper preservation, but his research was conducted on historically known sea vessels. Not only will the samples we find be older, they are also subjected to a much different environment. With submergence, fibers are forced apart and hydrogen bonding becomes markedly less effective. For this reason, the best chance for preservation will be those samples that were quickly buried in a silty sediment. This sediment protects the paper from currents and from some organisms that eat organics. However, even buried in sediment, paper is susceptible to bacteria and fungi which secrete enzymes that dissolve cellulose materials for food. Best preservation occurs in water and sediment that is very acidic, with a pH of greater than three.

Wood

When Thompson in 1904 began dredging the Cenote of Sacrifice at Chichen Itza, he kept finding carved wood idols. There was very little preservation of these pieces, not only during Thompson's expedition but also in successive ones, because, "the climate quickly rots and insects devour them [wooden artifacts]" (Coggins 1984: 26). This is a very easy way to say that water makes cellulose and hemicelullose soluble, breaking down networks by acid hydrolysis (Singley 1988). It will be remembered that Ware and Rayle's (1981) experiments showed cracking and flaking of the wood surface. In addition to the damage that water itself can cause, bacteria and fungi attack selectively.

Bone

During Thompson's investigations, he discovered numerous human remains, including one human skull incensario. The romantic notion of virgin maidens being thrown into the turgid water below has been debunked, as by Saul and Saul (1989). Saul and Saul found that about half of the skeletons found in the Cenote were children between the ages of four and twelve, one-fourth were adult males and the other one-fourth were adult females. At least one of these women had had a child, and wore the pelvic scars to prove it. For the Maya, human sacrifice was very important, even determining the political power of centers.

Not only were places of water used for sacrificial offerings, as shown in the Cenote of Sacrifice at Chichen Itza, but they

were also a place of burial. Little Salt Springs is a site on the Florida peninsula, and has a very interesting history. The site started out as a freshwater cenote in Paleolithic times. Water levels began to rise, and the natural sinkhole was covered over with salt water. During Paleolithic occupation of the area, the cenote was used as a burial ground. Stone, et al. (1990) have been conducting research at the cenote are fascinated by the preservation they see in the bone samples, both faunal and human. Part of the reason for their excellent preservation is that a peat bog formed in the cenote, and peat is notorious for preservation of human remains. "Parameters important to bone preservation changed during sedimentation as a consequence of fluctuations in both pond floral communities and water chemistry," conclude the authors.

As is evident with the categories of artifacts discussed above, water chemistry and floral components heavily influence the preservation of bone. If quickly buried in sediment rich in phosphate (or some other protective agent such as peat), the bone has a much better chance for survival. This is because the porosity of bone allows the absorption of water soluble humates and metallic salts that can be leached from the clays in the sediment (Pearson 1987).

Rubber/Celluloid

The Maya played a ballgame that was very important ideologically. Inscriptions from walls surrounding the ballcourts at Chichen Itza indicate that rubber balls were bounced from the players hips through stone rings high on the sides of the court.

While this may not be true of every site, or of ballgames whose courts date to an earlier era, the inscriptions here give us at least one possible explanation of how the game was played (Sharer 1994: 394). Because of the sacred nature of the game, it is assumed that the implements used in the execution of the game were also sacred, meaning the rubber balls. As we know that water was important ideologically, the balls may have been disposed of in a ritual manner, in a ritual place.

Preservation of rubber is generally good. They survive best in an environment where heat and light do not reach the object with frequency. With exposure to heat and light, they become sensitive to oxidation and deterioration. Also, the celluloid in the rubber may be softened by prolonged exposure to water. This is because the more porous the rubber is, the more water will get into the pores and have a much higher chance of causing damage. In addition to the damage caused by water, heat and light, rubber faces the added challenge of any organic submerged. This is the attack of microorganisms, which may cause deterioration or cause the rubber to crack.

Recording

Accurate recording is the cornerstone of a competent archaeological investigation. Archaeology, as a destructive science, does not allow for revision. Setting up a recording strategy before entering the water is possibly the most important aspect of underwater archaeology. A system should be predetermined before a pre-disturbance survey. Classes of artifacts, such as ceramics or lithics should be assigned to an appropriate designation. The designation of underwater or pool floor should be added to this numerical code. A list of these codes should be placed on a preformed sheet. These same codes should then be marked on survey tape or PVC plastic strips with a water-proof marker, such as a Sharpie. One copy of this list of codes will be kept on surface, the other taken by the underwater recorder. The underwater recorder then fills in pertinent data, such as the grid number, or whether or not the artifact is point located. The purpose of having two sets of code numbers is to cross check these once the divers return to the surface. Those places from which sediment samples are collected should also be flagged and marked in on the map and photographs (if applicable).

Photographic recording is extremely important. To this end, many have attempted to devise new and more efficient ways of photographic and video recording. Gifford (1998) describes a method developed and used at Little Salt Spring, a cenote site in Florida. To test this system, almost no sketches, still photographs or maps were compiled for the site. The excavation was merely taped once or twice a day. The controls of this experiment were a bit lax. For example, the site was filmed in

one square meter sections, regulated by a video square, simply a frame designed to isolate one meter sections to be filmed. Circular targets were then placed at five central points of the square. The height at which the divers held the camera were not kept constant. As Gifford says, "a diver videotaped the excavation surface and its tagged artifacts…at a constant height of about 50 centimeters" (Gifford 1998). No evidence is given as to how the divers maintained a constant height, or the exact height. Light distortion at any depth can be a problem. Without a frame or some other way to control the height of the camera, this technique seems to be a more supplemental than primary method of recording data.

Photomosiacing is an established method of documentation. However, the same guards must be placed on this method as on the method of videomosaicing. To compile a photomosaic, several overlapping photos should be taken at the same height and angle. Once developed, these should be cropped and placed on a photo table and a master photo of the cropped photos should be made. Photomosaics are best suited to large, scattered areas, where preservation of artifacts, especially wood and other organics, is not certain once taken out of the aquatic environment. For smaller areas, simple still photos are better suited.

Still photography is very reliable. Underwater cameras can vary greatly in expense and quality. Starting from splashproof handheld cameras, which can cost around $16 to Sea and Sea systems with a built-in strobes in a commercial housing that can cost $689 or more. Generally, the deeper the camera is capable of going, the more advanced and therefore more expensive it has to be. However expensive these cameras are, they are indispensable

for accurate representation of artifacts in situ. It is important to have control over the shutter speed. In clear water, a shutter speed of 125th of a second is fast enough so as to avoid over-exposure and still slow enough not to blur the image. Necessary film speed is designated by the clarity of the water. In the case of Cara Blanca, when photos and first hand descriptions have shown the water to be a clear blue, light and sediment distortion are not too much of a problem. For clear water, such as that of Cara Blanca, an ISO of 100 to 200 is generally sufficient.

Once an artifact is flagged, it should be photographed in situ. An object should be placed in the photograph in order to show scale, be it a diver or a photographic scale. Should later researchers have questions on the recovery and conservation of artifacts, photographs of the artifacts in situ can then be compared to those taken in the lab before and after conservation treatment. Also these photos are a photographic representation of the assigned level of the floor bottom. If desired, a pegboard can be taken down to the pool floor that contains such information as: level (floor of pool) designation; site designation; date; other important information such as excavators.

Cataloging of the artifacts must be meticulous. As stated earlier, a special designation should be given to the pool floor. This designation should be reflected in the overall catalog of artifacts. The cataloging system for underwater artifacts should be worked out before the divers go into the water, as they will need to carry a list of the designated cataloging numbers. Included in this list should be a number of spaces for the diver to fill in with point located artifacts. Once the entire form is

filled in, these numbers should be added to the overall catalog. Before adding underwater artifacts to the catalog, it must be checked that all the numbers and artifacts match. Treatment should also be meticulously recorded. Before any treatment commences, a photo should be taken and placed with the treatment record, as should a detailed description made after an examination of the untreated object. This record is a list of treatments done to the artifact, proportions of solutions used in these treatments, initials of the person conducting the treatment, date and personal observations.

Excavation

Due to budget and time constraints, not too much time was put into researching and developing techniques for excavation. Also, it was very difficult to find excavation techniques discussed that would be pertinent to us. Most underwater archaeological investigation is done on submerged ships in salt water, and neither one of these variables appear to be present in the pools of Belize.

Green (1990) explains basic excavation procedures. Green is a marine archaeologist, and his methods are based on the problems encountered in a marine environment. If it is determined that excavation is necessary, though, his basic procedures will be useful. Before excavating it is wise to check and make sure that the grid lines established when mapping are aligned precisely with the cardinal directions. The site is then further divided into one meter sections, defined by grid lines or a hard one meter frame, which can be constructed from one meter stick tapes fastened together.

Tools for excavation are fairly simple. Many of the excavation tools used for land archaeology are also used for underwater archaeology, including trowels and picks. In addition to elementary land tools, a diver's knife is indispensable. A diver's knife can be used as a scraper, a digging tool, and it is always a good idea that a diver carry a knife for emergencies. This piece of equipment should be with a diver anyway, but also makes a valuable excavation tool.

The site of Cara Blanca has a silty clay bottom. This makes tools for encrustation removal unnecessary. For larger, more prolonged excavation, should one be initiated in the future,

certain tools will be very important. Proper excavation techniques are exceedingly important, for the same reason that proper excavation techniques are important for land archaeology. We destroy as we excavate. It is for this reason that much of Thompson's work in the Cenote of Sacrifice at Chichen Itza, conducted in 1904, is sorely lamented (Coggins, 1992). Thompson, like other archaeologists of the area had heard tales of human sacrifice and treasures thrown in y the Maya. Thompson lowered a bucket from a boom positioned along the rim of the cenote and dredged the floor. This technique destroyed all semblance of context or provenience. Admittedly, he brought up a number of beautiful objects, but we have no idea how they fit together as sequential ritual depositions or how these ritual objects fit into the greater scheme of life at Chichen Itza.

As on land, not every object will be large enough to be recovered by the archaeologist at first glance. On land, this problem is solved by screening. Underwater, this is solved by the evacuation of sediment surrounding and covering an artifact by means of a vacuum tube attached to an air pump on the surface. This air pump draws up water, sediment and small artifacts (most vacuums have a maximum diameter of four inches). The material is shot out of the water onto a screen, usually of fine dimensions (one-fourth of an inch). Operators can then remove these artifacts and tag them according to the provenience of the grid below. Here again, communication is key. Normally, level sizes are predetermined, simply to limit confusion. The vacuum also solves the problem of removing sediment to see the layer below. In the case of the survey conducted by the VOPA crew in 1998, this was accomplished by a simple wave of the hand or flipper to

remove a few millimeters of sediment to allow us to see what is below.

An important part of excavation is the collection of sediment samples. Sediment is an excellent agent for the preservation of pollen and seeds. Once encased in the sediment, the seeds and pollen are safe from becoming dinner to scavengers or fish. If found in association with artifacts, these seeds and/or pollen can give us a clue as to the season in which the deposit was laid down. This is particularly useful inside ceramic vessels, whose protection will further shield these particles. These sediment samples can be taken by simply digging a small hole into the sediment, and collecting it with an olefin bag. These bags allow for the escape of moisture but do not allow the loss of sediment.

Recovery of Artifacts

If it is found to be necessary to remove artifacts from the aquatic environment, there are several methods that cause little damage to the objects themselves. Before discussing methodology for removing artifacts, it should be noted that these artifacts have been under a higher amount of pressure than the surface for hundreds of years. Roughly, the surface is defined as being one atmosphere of pressure (1 ATM). From this, the deeper we go, the more pressure is exerted on our bodies, or artifacts. Every 33 feet (approximately 11 meters) is defined as being one ATM. Therefore, at a depth of 33 feet, 2 ATM is exerted on the body (PADI 1994). This makes breathing twice as hard for the diver, since the air in the body is condensed. This is also true of artifacts. The air enclosed in the pores of low-fired ceramics or bone will condense, possibly causing the object to break or warp. Once an object is safely encased in sediment, it adjusts to the new amount of pressure. It will need to be discerned whether or not it is advisable to remove the object from this environment. Exposure to less pressure can force apart pores that have for so long been compacted to the point that the object may disintegrate. This was one major obstacle in the recovery of objects from Titanic (Ballard 1987). Salvage crews recovering that material simply took it up very slowly in a submersible.

Very fragile artifacts must be left in situ, if there is a remote chance that the artifact could fracture or break. For artifacts in this condition, photographic documentation will have to be sufficient. If it is determined that the artifact is indeed fragile, but its investigation will be of particular value, it

can be removed encased in sediment at a very slow rate of ascension. Removal in sediment calls for plastic trays to transport the artifact; these trays catch sediment which supports the artifact more than the diver can. Organics, which have a fairly good chance of preservation if buried in sediment, must be removed very carefully. Generally, they must be removed using support from planking or plywood sheets. The contact points between the artifact and the support must be padded. This method requires two divers to swim the platform with the support and padding to the surface, and again, care must be taken to ascent slowly, to avoid warping and breaking (Singley 1988). Fast ascension or inadequate protection in transit of the artifact can cause fractures and breakage that could be misinterpreted by a future researcher.

Another consideration, other than pressure, in the removal of artifacts is the difference in temperature at the bottom of the pool and at the surface. The deeper the water is, the cooler the temperature will be (PADI 1994). Colder temperatures cause materials to compact. If a quick ascension is done, this can cause a breakage or fracture of the artifact, especially if it is organic. This change in temperature is combated quite simply by a slow ascent. This allows for the artifact to adjust to the current temperature as the diver goes upward until finally the surface is reached, and along with it, the highest temperature.

The simplest and most reliable way to remove artifacts from an underwater environment is a mesh bag (Singley 1988). This is particularly useful in the recovery of mass objects or objects that do not require special protection, such as lithics. These can be used to transport items down to the floor, such as mapping

and excavation tools, and for the recovery of artifacts. They are also easy to procure, and can be bought in bright colors so as not to be lost on the pool floor. For large objects several other methods are available.

One way to remove large objects from the pool floors is to employ lifting bags (Marx 1975). These range in size from those designed to lift individual ceramics to those designed to lift up to 200 pounds of weight. These are little more than lightweight plastic bags that have attachments that can be tied to an artifact or placed around the artifact, almost like a net. These bags are then inflated by the diver by placing his regulator into it and purging it, sending out a rush of air, which fills the balloon and it rises to the surface. These must be used very carefully used so as not to harm the artifact. The diver must be very careful not to over-inflate the balloon, sending it too quickly to the surface and causing damage to the artifact. These are very useful when large objects must be lifted, and more than one can be combined to lift very heavy. They do require supervision, and this must be stressed above all else, the ascent must be carefully monitored for speed.

Vacuums are another tool used by many underwater archaeologists for the removal of sediment and small artifacts. This vacuum is operated by a pump located on the surface of a buoy with a mesh net to catch sediment and small artifacts. This is, in affect, screening the sediment. This is also a way that excess sediment can be removed from the site without it just settling in another place, as it does when the diver waves a fin or a hand to remove excess sediment. It has been discussed by Green (1990) that this is a decent way to take sediment samples,

but there are a few objections to that. First of all, there is no way to communicate to the divers where the sample is coming from, therefore no provenience can be designated for the sediment samples. The other problem that I see with this method is that small artifacts can be displaced or even broken by this action. These vacuums are very powerful; some can run at a depth of 50 feet. That is a lot of suction, and it pulls the artifacts up very quickly, causing damage in itself. The objects are then thrown into the air to land on a mesh net, where they are to be collected by an archaeologist running the pump. Also, the same problem of provenience is present with respect to artifacts. There is no way to ask the divers which section they are holding the vacuum in. For the purposes of the 1998 VOPA season, this method is too extreme. This may have its uses on larger-scale projects, but we simply don't need it at this point.

Also used on large-scale projects are lifts lowered from the surface to safely lift objects too heavy to be lifted by lifting bags or divers. Green goes into some detail about this. Most examples he gives are for the removal of large metal objects such as cannon, anchors and other large features.

Conservation of Artifacts

Conservation should not only make the object aesthetically acceptable to further researchers but also structurally sound (Hamilton 1998a). Conservation should begin the minute the artifacts are removed from the aquatic environment. Freshwater conservation is generally a lot simpler and more reliable than salt water conservation, simply because freshwater does not have the chlorides that salt water does. Generally speaking, it is acceptable to allow inorganics to dry slowly once taken out of the aquatic environment. This must be done carefully, though. A representative sample should be allowed to dry out of direct sunlight, if cracking or frosting occurs, specimens should then be stored in filtered water with a neutral pH. Organics should be kept in water at all times until conservation procedures can begin (Singley 1988). Large objects, such as features, should be brought up intact, and no encrustation should be removed from anything.

It is very important to keep the lab environment safe. For this reason, there should always be a minimum of two people in the lab at any one time. Also, no smoking, drinking or eating while in the lab. Protective clothing should also be worn when appropriate. In addition to these basic rules, any sort of treatment using large amounts of solvent or a long exposure time should be done outside and the technician performing the treatment should be dressed appropriately. All equipment should be turned off when the lab is not in use; the lab should be locked and the dispersal of its keys should be limited. Chemicals should be stored and disposed of properly.

Each of the categories of artifacts will be discussed separately. Throughout the descriptions of treatment methods, many references are made to various adhesives and consolidants. For a more thorough explanation of the various chemicals used, one should consult Singley 1988, pp. 90-97. This is a list and description of all regents, solvents and resins that were used in the conservation of freshwater materials. This is a particularly useful guide for us simply because there are no references to the numerous solutions designed to remove chlorides that build up in artifacts from exposure to salt water. Also useful is Hamilton's "Adhesives and Consolidants" (1998). This is a list of all of the regents used for removal of stains and encrustation. The important thing to remember about this source is that it was written for salt water use. For this purpose, it is an excellent comparative model for salt and freshwater methods. See Figure 5 (2 pages) for a sample VOPA conservation/treatment record form.

Ceramics (see fig. 6)

The first step in ceramics consolidation is washing. Sherds should be rinsed with tap water, then placed in distilled water overnight as a precaution against salt corrosion. After 24 hours, the water should be tested with a conductivity meter and a silver nitrate test, these are to test for chloride contamination. If there is no contamination, that is if the tests come back negative, the sherds may be removed and allowed to dry naturally, out of direct sunlight and in high relative humidity. If the tests come back positive, showing chloride contamination, the technician should continue soaking in deionized water that is

changed everyday until the results return negative (Singley 1988).

Ceramics should be washed in accordance to their firing temperatures. Terracottas and earthenwares should be placed in a five percent solution of tetrasodium of EDTA in distilled water. This should be followed by a washing in distilled water. This process will remove calcite which will inevitable have formed (Pearson 1987). Stonewares can be washed in a mild detergent, scrubbing the edges with the surface of a soft brush (Hamilton 1998b). Although this type of ceramic may be much better preserved, the technician must take care not to remove traces of food, paint pigments or soot left on the vessel.

An interesting new technique has developed in the past ten years as a reliable and non-time consuming technique of washing large amounts of organics. Neumann and Sanford have conducted a number of experiments with sodium (hexa)metaphosphate, available commercially in the name of Calgon. This method was found to be time efficient with 21 or more sherds to be washed at one time. The process is very simple, a solution of 40 g of Calgon liter per liter of distilled water. The artifacts were then allowed to soak in the solution for up to 12 hours. The benefit of being able to simply leave artifacts, especially ceramics, in a solution before heading off to a day in the field is obvious. For a small crew who cannot afford to spend an entire day washing artifacts, this is a wonderful time saver. This, however, is only one of the benefits of this solution. Ware and Rayl (1981) found that the clay body of the ceramic was markedly softened by exposure to water; Neumann and Sanford may have developed a way that helps to counteract that effect of submergence (1998). If

this not only safely cleans artifacts, but also increases their structural integrity as well, this will be an invaluable method. This is an ionic detergent, and therefore, where the following descriptions it calls for a non-ionic detergent to be used, this will not work. We are currently testing with a sample group of ceramics collected during the 1997 VOPA field season dating from the middle preclassic to the late classic period (Osterholtz 1997).

The next step is to remove stains without endangering the integrity of the ceramic. Some of the agents used to remove stains can chemically change the fabric or glaze of the ceramic, causing misinterpretations by later researchers. However, these regents are also highly effective in stain removal, so only some sherds are cleaned in order to leave a large enough sample to keep information that could be lost through exposure to these chemicals. These agents are oxalic acid, which will attack iron in earthenwares, and EDTA, which will dissolve carbonate tempers.

Oxalic acid is used to remove iron stains, to do this a five to ten percent solution of oxalic acid is applied using cotton wool packs, then sherds are tented under plastic to allow slow evaporative drying. A ten to fifteen percent solution of hydrogen peroxide applied in the same manner will also remove inorganic stains. Organic stains will turn a ceramic black; these can be removed with a ten to fifteen percent solution of hydrogen peroxide applied in the manner described above. If extensive organic or inorganic staining is present, the ceramic can be treated by total immersion in the above mentioned solutions for up to three days. During immersion, it is important to watch for hydrogen peroxide bubbling, that can cause already loose glaze to

come free. After all treatment, ceramics should be rinsed for two days in baths of distilled water that are changed daily.

On-site storage is not difficult. The ceramics should remain in distilled water baths that are changed daily until they can be properly dried. This drying procedure is simple. The ceramics are placed in a bath of distilled water with a relatively low percentage of alcohol in it, this percentage is increased daily to a point where the majority of the solution is alcohol, then the ceramics are allowed to dry. The use of the alcohol allows for a chemical drying of the interior pores, this prevents warping.

Glass (see fig. 7)

Glass is also subject to the chemical makeup of the water it is immersed in. Glass must be washed in tap water with a soft toothbrush and a non-ionic detergent. The pieces should then be rinsed over night in a bath of distilled water. After this, if no further consolidation is needed, they may be allowed to dry slowly in an environment of 40-60% relative humidity. When glass deteriorates, it loses the strength in its layers (Ware and Rayl 1981). These layers can become loose or even flake off. These degraded layers may be removed with a 3% hydrochloric acid (HCI) solution. After this treatment, the glass will need to be rinsed in daily changed baths of distilled water until the chloride tests that should be performed before any consolidation procedures can take place. Hydrochloric acid returns the glass to its original color, however this treatment has problems. Environmental evidence and original glass thickness are lost, rendering the treated samples useless for such tests as Obsidian

Hydration Testing (Singley 1988). For this reason, only a representative sample of the total glass objects recovered should be treated, leaving a representative sample for comparative and testing purposes.

Paper (see fig. 8)

Paper is inherently fragile after being in an aquatic environment. For this reason, little effort is put into consolidation, more effort is put into preservation. It is to this end that no effort is made to remove stains, as most stain removing agents would weaken already weak bonds, and most likely the fabric of the paper would disintegrate. The paper is then rinsed in a distilled water solution and tested for chloride contamination. Once these test results are negative, the paper than then be soaked in a one percent solution of methyl cellulose (Methocel) for five days. After this treatment, they should once again be rinsed in distilled water and then laid flat, sandwiched between two layers of mylar to keep flat (Singley 1988).

Wood

The goal in the conservation of wooden artifacts is to replace the water in the wood with a bulking agent. After rinsing in the distilled water, the wood is treated with polyethylene glycol (PEG), a water soluble agent applied by soaking, spraying or brushing. They are then rinsed yet again, and allowed to slowly dry.

Lithics

Because when fired, ceramics become a form of stone, the same conservation procedures are used for both. See above section and diagram for detailed description.

Bone (see fig. 9)

Bone is a very porous and fragile substance, and must be handled accordingly. From the moment of removal from the archaeological record, the bone should be kept saturated, and only in a laboratory environment should stabilization procedures be undertaken. If bone is in good condition, it can be washed with a soft brush and a drop or two of non-ionic detergent. Aside from washing with soap and water, alcohol can be used to facilitate drying. When washing bone in water, the amount of time the bone actually spends submerged should be limited. Any encrustation can be removed by brushing lightly with a brush and/or lightly scraping with wooden, plastic or metal tools.

Because bone is very porous, it has a tendency to stain. These stains fall into the categories of organic and inorganic. Organic stains may be removed with a five to ten percent solution of hydrogen peroxide applied by cotton wool packs. Inorganic or metallic stains may be removed by applying a five to ten percent solution of EDTA. After this application, the material should be rinsed in deionized water for two to three days (Singley 1988).

Drying methods vary by researcher. With their samples, Stone et al. (1990) allowed bone to slowly dry, in a high relative humidity. However, they also experienced the warping, splitting, cracking and exfoliation of outer layers with this method.

Singley (1988) prefers a slow drying method of sequential baths of deionized water and acetone. The method takes four hours, the first hour the bone is in a solution that is 75% water and 25 % acetone. Hour two is spent in a 50% water, 50% acetone solution. Hour three the solution changes to 25% water, 75% acetone, and finally hour four is spent in a 100% acetone solution. The acetone simply evaporates, allowing for later consolidation.

One way to replace the now empty cells in the bone with a substance to stabilize it is the apply polyvinyl acetate resin. For this method to be effective, the bone must be completely dry. With polyvinyl acetate emulsions, the effects become irreversible in a short time (Stone, et al. 1990, Brown 1974, Joukowsky 1980, Snow and Weisser 1984). These emulsions have also been shown to be susceptible to mold growth. They can also penetrate very poorly, protecting only the outer layers, allowing for the deterioration of the inner layers (Stone, et al. 1990, Brown 1974, Koob 1984, Storch 1983).

Another stabilizing agent is polyethylene glycol (PEG). Long term effects on structural stability are not known at this time, and this method should be used with the backup of a selective sample treated, and one not treated. Total immersion into a PEG solution is more desirable than simple application by brush or cotton wool pack. Acrylic Emulsions can be added to the bone when wet, or not completely dry (Stone, et al. 1990, Brown 1974). This may be useful, since, splitting and warping occur when the bone is allowed to dry without treatment. A 30-50% solution should be applied either by brushing or immulsion to the bone.

Consolidation is one of the last steps before storage. Resin solutions must be diluted to decrease the viscosity, thus

increasing the ability of the resin to penetrate material being treated (Hamilton 1998d). An excellent resin for use on faunal bone is Elmer's Glue All (Hamilton 1998e). It is applied by brush. The application process is such that one coat is applied, then the bone is allowed to dry. When dry, another coat of the resin is applied, and this is allowed to dry, and so on. This version works well, but total immersion works better. Whatever resin or method of application is used, for reconstruction or gluing the same resin should be used. The mixture is simply not as diluted when used as a glue. Again, Elmer's Glue All is acceptable for this purpose.

Rubber/Celluloid

Once removed for the aquatic environment, the rubber should be stored frozen. This is to stop any water still trapped in the cellular structure from escaping due to slow drying or a change in the ambient humidity. Keeping that water in the cells is very important, no dehydrating solvent should be applied. These solvents may dissolve celluloids and soften rubber, they may also remove waxes and oils artificially added to the rubber by man before deposition. In order to preserve the rubber without damaging it, it should be treated by soaking in a mixture of cold PEG (8%), Ethyl cellulose (2%), and glycerol (2%). After application of this mixture, the rubber should be stored in a cool dry place, out of contact with light (Singley 1988).

In general, laboratory conservation has four main steps. The first is storage prior to treatment. All artifacts should be kept

in their aquatic environment, changed only to a filtered, fresh water. This water is tested daily for pH and chloride contamination. Only after there is no sign of contamination is treatment to begin. This is the second step, an evaluation of the conservation processes that should be used. Before treatment, every artifact should be photographed and described by the technician performing the conservation (this is discussed in the section in this paper titled "Recording"). This pre-treatment evaluation helps us to decide which methods should be used, and which should not. The third step is cleaning. This must be done very carefully so as not to wash off paints or other remnants that may be left intact on the object. Part of this is encrustation removal. All of this stain and encrustation removal must be done with an eye toward the preservation of the artifact. The final step is treatment to stabilize the object. During cleaning, some objects lose a large amount of internal integrity. For example, bone, if it is not consolidated after cleaning, will eventually crack and warp because all of the water has been removed form the cells, and has not be replaced by anything else. We use synthetic resins to strengthen and protect these artifacts for future researchers.

Research Results from the 1998 VOPA field season

The site of Cara Blanca was a major focus of the 1998 VOPA field season. The site was further mapped and investigated both terrestrially and underwater. The purpose of this research was to ascertain if cosmological factors were of an important influence in the choice to build the settlement in an agriculturally deficient area. According to Fedick (1996), the area in question is inadequate for farming unless reclamation and conservation techniques are employed (see also Lucero 1997).

The site has certain elements that are known to have ideological significance: 1. The presence of a structure so near the edge of the pool that it is eroding into it; 2. Numerous possible cave opening; and 3. The presence of waterlilies in adjoining pools, indicating water purification and power.

My research was to aid in the exploration of the pools themselves. Mapping techniques that have been tested in the indoor pool at the NMSU Natatorium were used here to determine the presence or absence of ritual objects, and to help retrieve and conserve them.

Exploration at the pool we labeled as Pool 1 was a two stage process. Due to bad roads and the near absence of trails, any exploration needed to be planned ahead of time. The first of our visits to Cara Blanca was an exploratory and planning mission. Pool 2 was discovered to the west of Pool 1. Pool 1 was also investigated further. Andrew Kinkella took depth measurements from different points in Pool 1 by tying a large plumb bob to the end of a 50 meter nylon tape and swimming out to various points in the pool. Depths ranged from 17.4 meters approximately 20 meters from the edge of Structure 1 to 39.3 meters at roughly the

center of the pool to 26.9 meters about 75 meters from Structure 1.

We had decided to limit the dive to two 20 minute dives, with a maximum depth of 60 feet. This meant that according to the depth readings by Kinkella done on the first excursion, we would need to stay along the shelf which we felt lay around the pool before dropping to the pools maximum depth in the center.

Cara Blanca measures approximately 100 meters in length (east-west) and approximately 61 meters wide (north-south). We located our best dive "platform" on the south side and began the first dive at approximately 12:30 p.m. A guideline had been cut for us to make descent easier, and we followed this down to our predetermined maximum depth of 60 feet. Visibility was very poor, under 10 feet, and the water was a cloudy yellow-orange color. From our dive platform, we headed roughly southwest until finding the shelf that runs along the pool. Staying close to this shelf we began to slowly ascend following a white path that was very distinctive from the rest of the rock face underwater. As we neared the surface, we discovered that this white path led from a looter's trench, and probably marked their method of removing the soil and superfluous artifacts from the trench. Two sherds were collected from this path, although they probably do not represent ritual disposal into the pool; they were probably just discarded from the looter's trench (See fig 10). Our total bottom time for Dive 1 was 20 minutes.

Dive two began at 3:46 p.m., when we began from the dive platform and headed west then north toward the cliff, which appears on the north side of the pool. The purpose of this dive was to see the extent of the shelf that we discovered on Dive 1

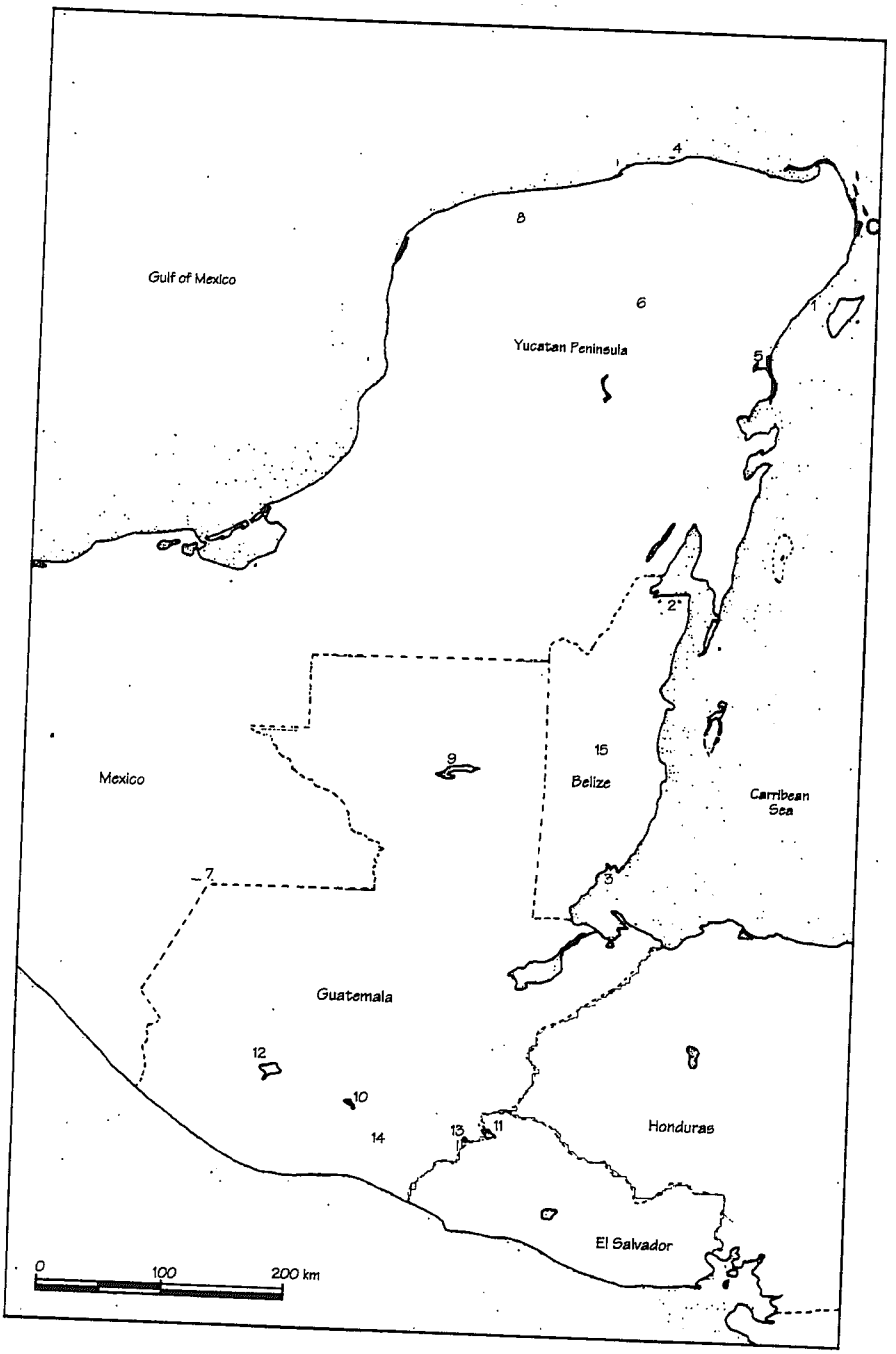
to be about 40 feet in depth. However, in attempting to follow this shelf, we got tangled up in a clump of trees, the algae on which made poor visibility even worse. Upon finding these trees, we doubled back and followed the shelf the other way. As pointed out earlier, everything was covered in a thick layer of dark algae, which with the flip of a fin detached from the rock to show the surface. The surface of this rock was weathered, suggesting that water levels have in the past been significantly different. Total bottom time for Dive 2 was 25 minutes. Nothing was collected from this dive.

The best conclusion that I can draw from this summer's research is this: Lack of evidence is not evidence of lack. There are several reasons for coming to this conclusion: 1. The pool was much deeper than first thought, it is entirely possible for cultural objects to have fallen down the inwardly sloping walls of the pool to a reserve in the center; 2. Due to the extreme depth of the pool, we could not investigate this using standard SCUBA equipment (A special type of SCUBA is required for depths this deep, and special certification and equipment is necessary for NITROX diving, where the diver breathes enriched Nitrogen as a way of staying down longer); and 3. We were very limited in the scope of our investigation due to the remoteness of the location; if there had been any kind of diving accident, we had a two mile hike and then a three hour tractor ride to the nearest village, we knew that we had to be careful. For this reason, we padded the PADI dive table times and had longer intervals between dives, just to be on the safe side.

In the future, for further underwater research to be conducted, NITROX divers need to be brought in to probe the

depths near the center. Also, the water will need to be tested to determine its chemical makeup in order to facilitate conservation if any artifacts are recovered. I suspect that there is something interesting about the water chemistry, due to the lack of aquatic life in the pool. Only near the surface did we encurr any fish at all, and they were all very small. At the depth of approximately five to ten feet, the fish disappeared. There is a tremendous amount that can be learned from this pool and others like it about Maya settlement patterns. The Maya, like all civilizations, were dependent upon the quality of the soil around them. So why did they build in places like this one, with little appeal for agriculture? The common denominator in settlements such as these is the presence of a water source. Investigating these water sources will help us to understand the Maya's reasons for settlement in such areas.

Figure 1.
Map of the Maya Area, showing sites discussed



Sites discussed in text:

1. Xelha
2. Cerros, Consejo, Corozal, Sarteneja
3. Wild Cane
4. Isla Cerritos
5. Carwash Cave (Tulum)
6. Cenote of Sacrifice (Chichen Itza)
7. Cenote Azul (Chinkultic)
8. Cenote Xlacah (Dzibilchaltun)
9. Lake Peten Itza
10. Lake Amatitlan
11. Lake Guija
12. Lake Atitlan
13. Lake Atescatempa
14. Lake Ixpaco
15. Cara Blanca

Figure 2.
Cenote Xlacah: A cross Section
Courtesy of Natoinal Geographic Magazine 1959

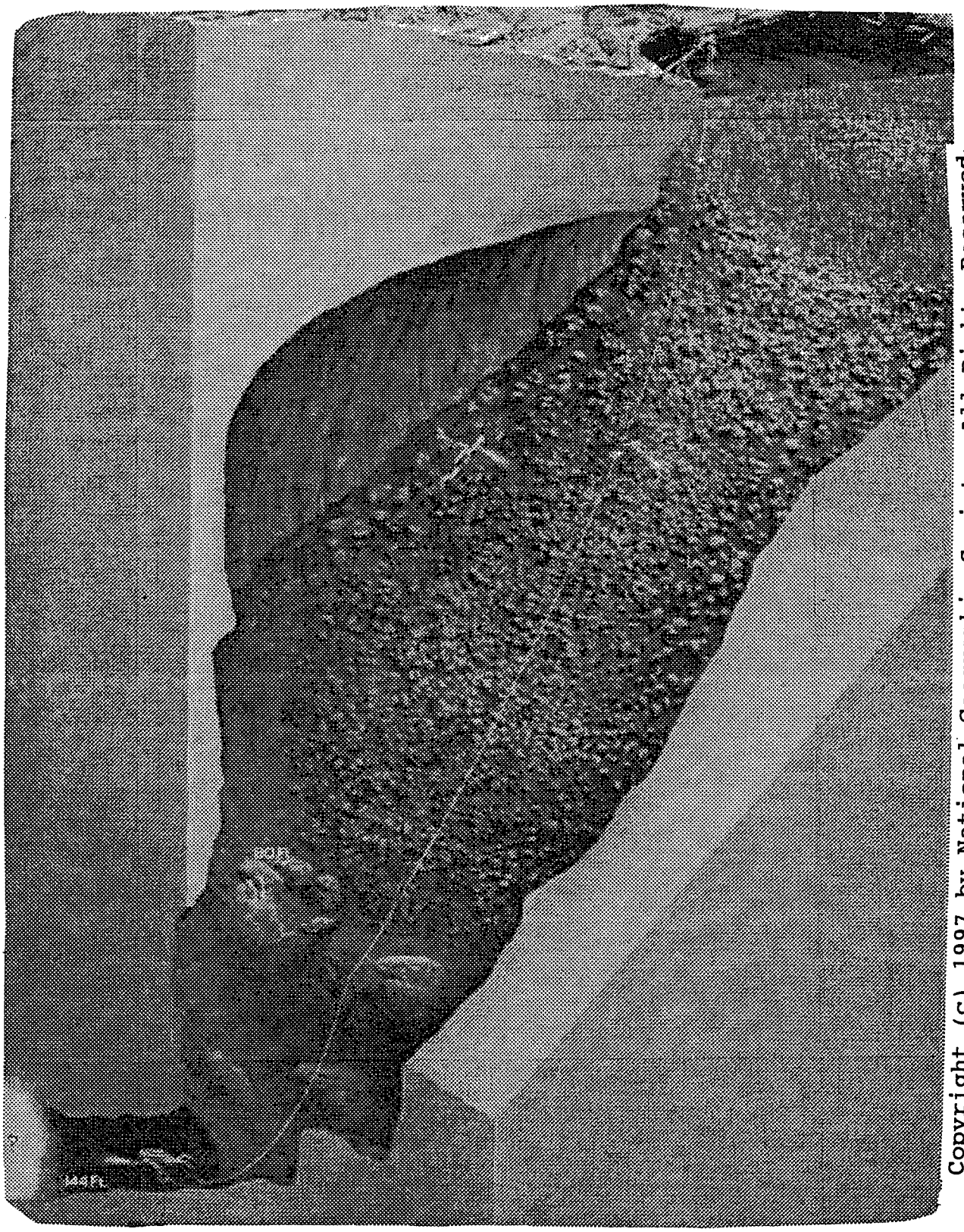


Figure 3.
Map of Cara Blanca Pool 1
Showing relationship between structures and pool
Courtesy of Lucero 1998

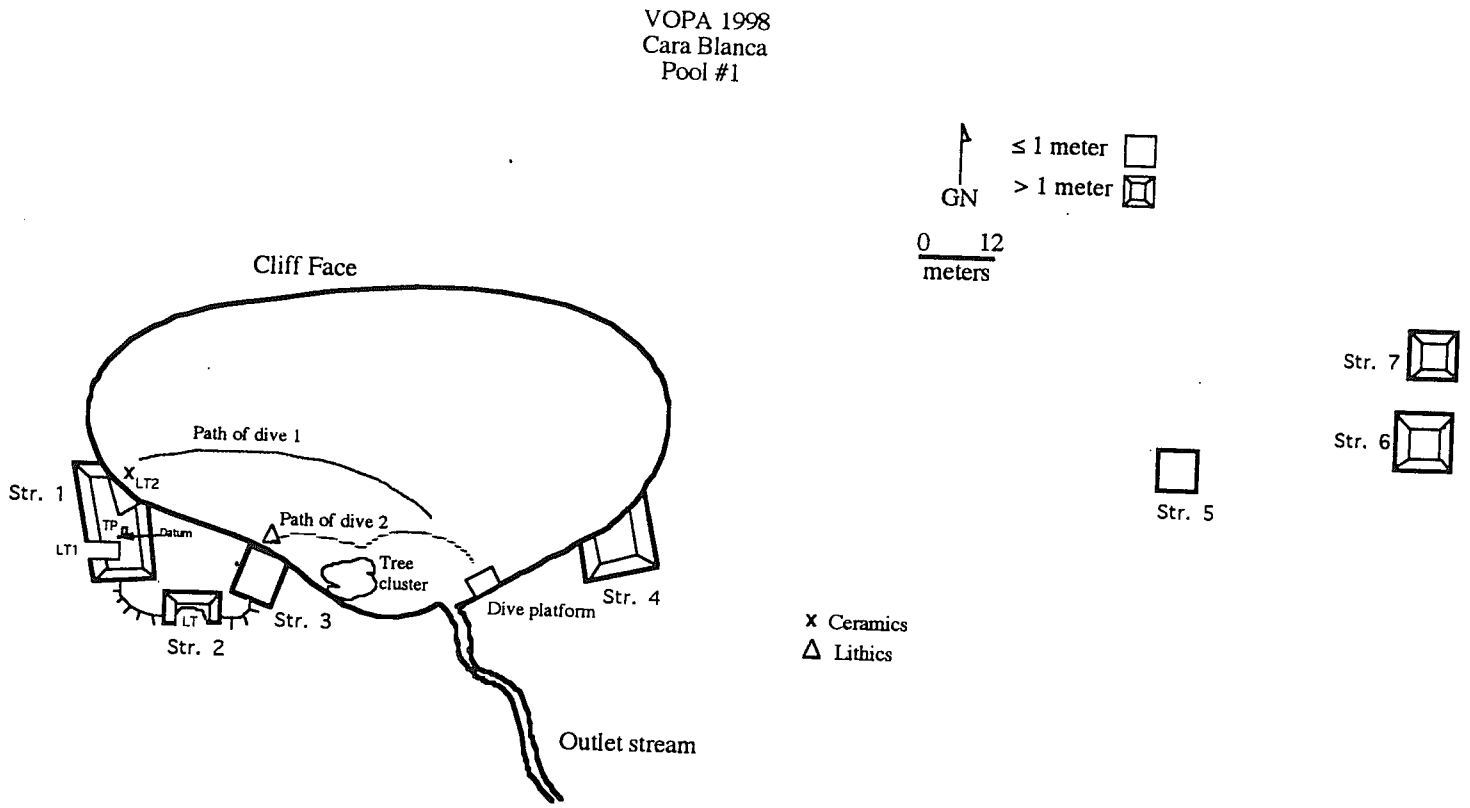
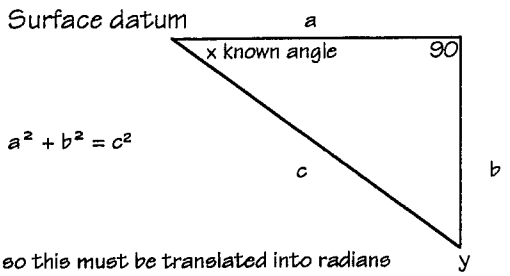


Figure 4.
Modified Triangulation Mapping Technique



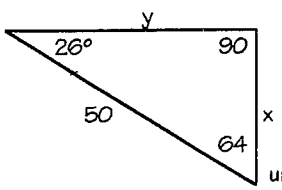
$a^2 + b^2 = c^2$

Sin Function:
Sin x = b/c
Sin operates in degrees, and so this must be translated into radians
degrees to radians: angle x $\Pi/180$

Underwater
Artifact/cluster

example;
Sin 26 = x/50

$26\Pi/180 = .453$
sin .453(50) = 22.33



underwater
cluster

To check use Pythagorean Theorem:
$22.33^2 + y^2 = 50^2$
to determine y use sin function
sine 64 = y/50
conversion to radians
$64\Pi/180 = 1.117$
sin 1.117(50) = 44.93
$22.33^2 + 44.93^2 = 50^2$

Figure 5.

VOPA Treatment/Conservation Record

General Information:
Site_____
Artifact Type_____
Artifact No._____
Frequency_____
Date of Recovery_____
Provenience: Reference Datum:_____
NW:_____ SW:_____
NE:_____ SE:_____
Crew Chief_____

Conservation Record:
Date Logged Into Conservation_____
Date Conservation Completed_____
Conservator_____

Pretreatment Record:

Description:_____
_____
_____
_____

Dimensions_____
Weight_____
Condition: E G P

Materials:
___ceramic ___lithic
___glass ___stone
___rubber/celluloid ___wood
___textile_____
___metal: non ferrous _____
___metal: ferrous

Recording: Datum_____
Photographs: Roll#_____ Exposure#_____
Sketch: Scale: ____cm = ____m

Post Excavation History:
___kept wet in ___deionized water
___water from source
___other _____
_____
___other _____
_____
_____

Examination Pre Treatment:
Chloride Test(s):
Date: Result:

Additional
Comments:_____
_____
_____
_____
_____
_____
_____

Priority for Treatment: 3 High 2 medium 1 low 0 none

Treatment:

Treatment Record:
Date: Treatment:

Treatment Summary:
Materials Used:
___Scalpel/pick
___chemical cleaning_____
___dewatered (solvent)_____
___coating/impregnation_____
_____

___mended
___bleached
___filled
___consolidated
___other_____
_____
_____

Photographic Record:

Date: Roll/Exposure: Descriptions: Place in Treatment Sequence:

Recommendations for Further Treatment:
_____
_____
_____

Figure 6.
Ceramic Conservation Guide

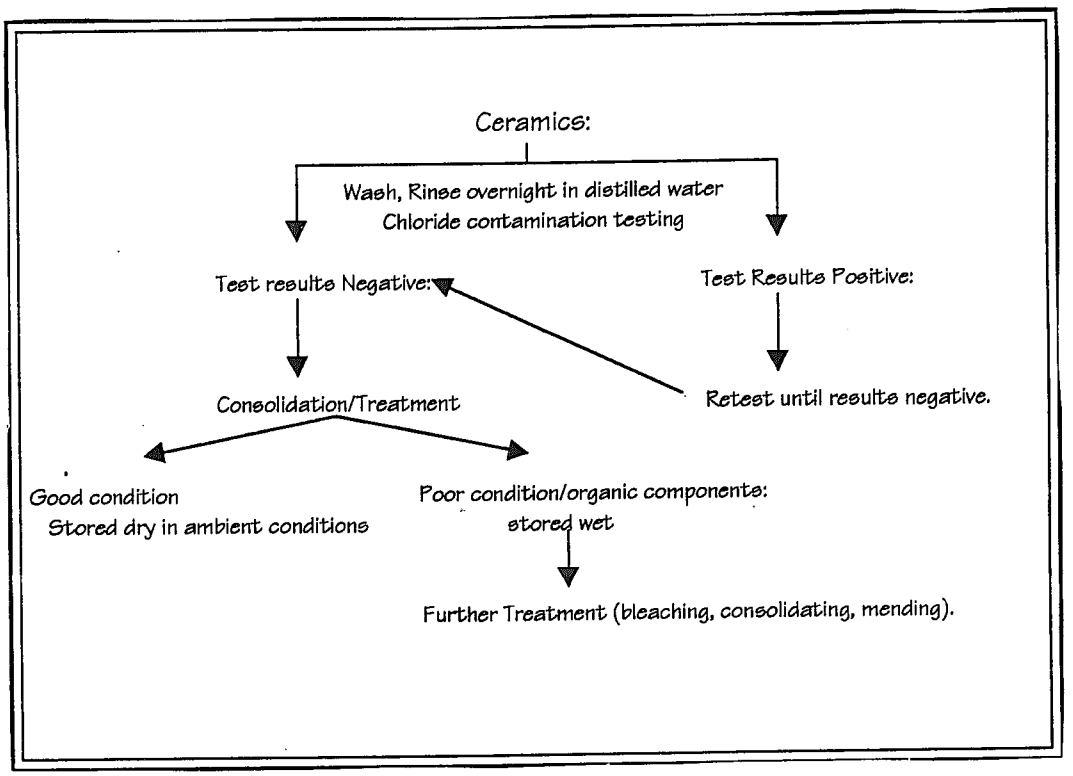


Figure 7.
Glass Conservation Guide

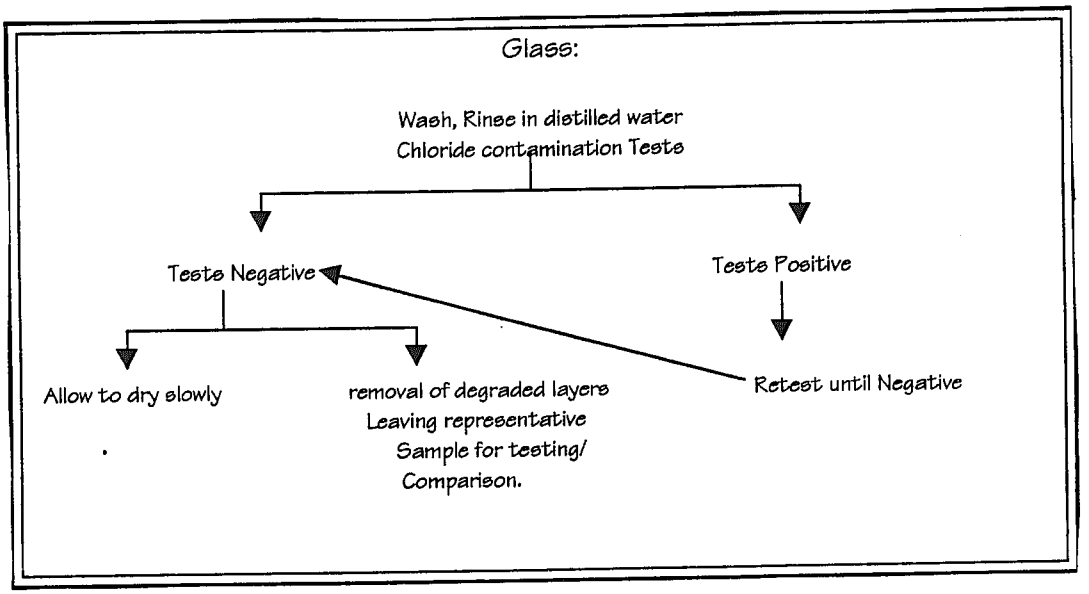


Figure 8.
Paper Conservation Guide

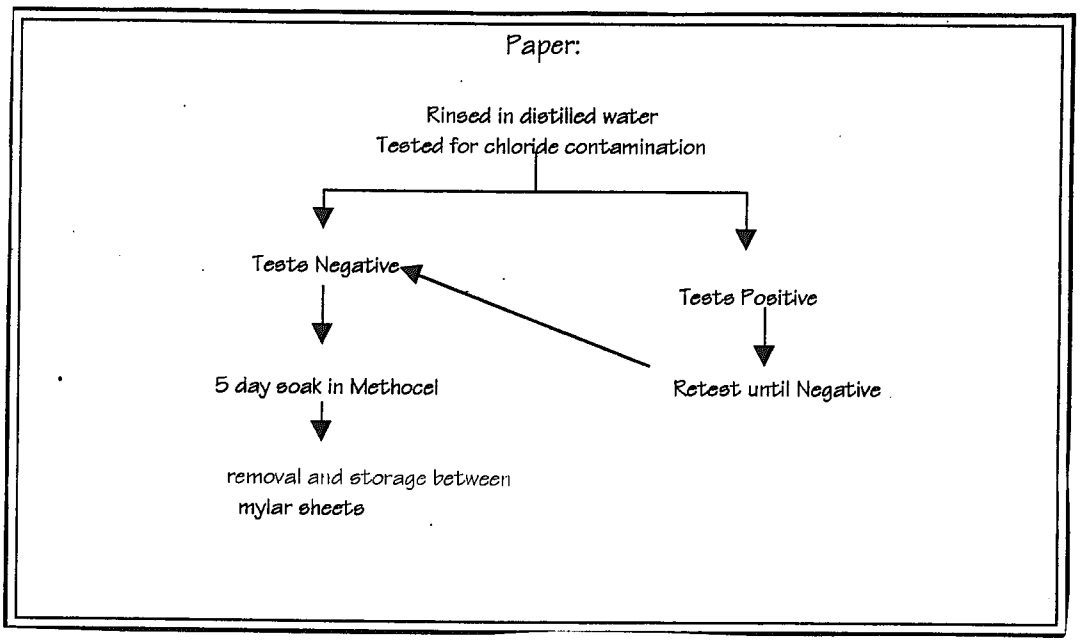


Figure 9.
Bone Conservation Guide

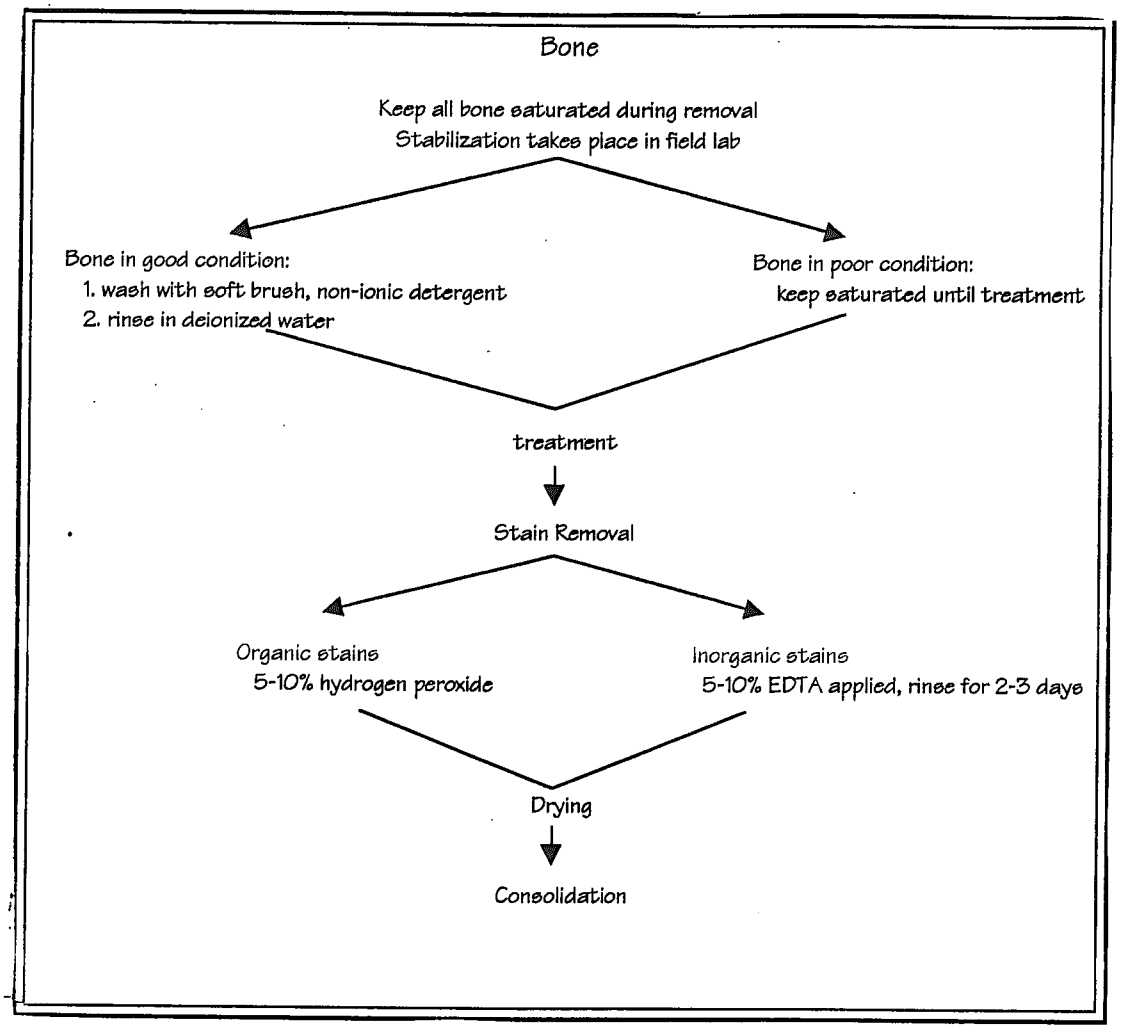
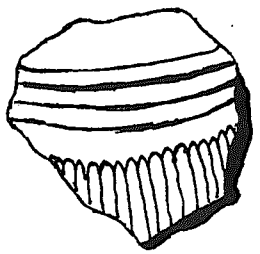


Figure 10.
Scale drawings of ceramics recovered from
Cara Blanca Pool 1



Incised shard collected
approx. 10 meters
Underwater Pool 1
Cara Blanca Below Mound 1
9 June 98

20 mm

References Cited:

Andrews, A.P. and R. Corletta.
1995 A Brief History of Underwater Archaeology in the Maya Area. *Ancient Mesoamerica* 6: 101-117.

Andrews, E.W.
1959 Dzibilchaltun: The City of the Lost Maya. *National Geographic Magazine*. CXV(1): 91-109.

Ballard, R.
1987 Epilogue for Titanic. *National Geographic Magazine* 172(4): 454-463.

Boggs, S.
1976 Dos Xipe Tetecs del lago de Guija. *Anals del Museo Nacional "David J. Guzman"* 49: 109-116. Administracion del Patrimonio Cultural, San Salvador.

Borhegyi, Stephen de.
1960 Underwater Archaeological Studies in Lake Amatitlan, Highland Guatemala. *American Philosophical Society Yearbook*: 547-551. Philadelphia.
1968 Archaeological Reconnaissance of Chinkultic, Chiapas, Mexico. *Middle American Research Institute, Publication No. 26*, pp. 119-134. Tulane University, New Orleans.
1969 Progress on the Preliminary Explorations of the Agua Azul Cenote, Chinkultic, Chiapas, Mexico, by the Milwaukee Public Museum. *Katunob* 6(4): 20-22.

Borhegyi, Suzzanne de.
1961 Gifts to the Rain God. *Lore* 11(4): 122-128. Milwaukee Public Museum, Milwaukee.
1963 The Horse God of Peten Itza. *Lore* 13(4): 114-119. Milwaukee Public Museum, Milwaukee.

Brown, M.K.
1974 A perspective compound for archaeological materials. *American Antiquity* 39:469-473.

Coggins, Clemoney Chase, ed.
1992 Artifacts from the Cenote of Sacrifice, Chichen Itza, Yucatan (Peabody Museum Memoirs, Vol. 10 No. 3). Harvard University Peabody Museum.

Coke, J., E.C. Perry, and A. Long.
1990 Seal-Level Curve. *Nature* 353(6339):25.

Folan, W.J.
1966 *The Sacred Cenote of Chichen Itza, Yucatan, Mexico.* Unpublished Master's Thesis, Department of Anthropology, Southern Illinois University, Edwardsville.

Freidel, D.
1986 Maya Warfare: An example of Peer Polity Interaction. In C. Renfrow and J. Chevy (eds.) *Peer Polity Interaction and Socio-Political Change*. Cambridge: Harvard University Press, pp. 93-108.

Gifford, John.
1998 "Improvements in Digital Video Mosaicking at Little Salt Spring." Marine Affairs, University of Miami. Little Salt Spring home page, World Wide Web, URL www.rsmas.miami.edu/groups/lss.html.

Green, Jeremy.
1990 Maritime Archaeology: A Technical Handbook. Academic Press.

2nd Edit 2004

Hamilton, D.
1998a Methods of Conserving Underwater Archaeological Material Culture, Casting and Molding in Conservation, Anth 605, Conservation of Cultural Resources I, Nautical Archaeology Program, Texas A&M University, World Wide Web, URL, http://nautarch.tamu.edu/class/anth605/file16.htm.
1998b Methods of conserving Underwater Archaeological Material Culture, Pottery Conservation, Anth 605, Conservation of Cultural Resources I, Nautical Archaeology Program, Texas A&M University, World Wide Web, URL, http://nautarch.tamu.edu/class/ant605/file16.htm.
1998c Methods of conserving Underwater Archaeological Material Culture, Overview of Conservation in archaeology, Anth 605, Conserving of Cultural Resources I, Nautical Archaeology Program, Texas A&M University, World Wide Web, URL, http://nautarch.tamu.edu/class/anth605/file1.htm.
1998d Methods of conserving Underwater Archaeological Material Culture, Conservation of Bone, teeth, Antler and Ivory, Anth 605, Conservation of Cultural Resources I, Nautical Archaeology Program, Texas A&M University, World Wide Web, URL, http://nautarch.tamu.edu/class/anth605/file3.htm.
1998e Methods of conserving Underwater Archaeological Material Culture, Adhesives and Consolidants, Anth 605, Conservation of Cultural Resources I, Nautical Archaeology Program, Texas A&M University, World Wide Web, URL, http://nautarch.tamu.edu/class/anth605/file2.htm.
Harrison, Peter.
1997 personal communication to Lucero.
Hooten, E.A.
1940 Skeletons from the Cenote of Sacrifice at Chichen Itza. In C.L. Hay et al. (eds.): The Maya and Their neighbors. New York: Appleton-Century. PP 272-280.
Houston, S. and P. Amaroli.
1988 *The Lake Guija Plaque*. Research Reports on Ancient Maya Writing No. 15. Center for Maya Research, Washington, DC.
Hurtado, E.D.
1961 Into the Well of Sacrifice: Treasure Hunt in the Deep Past. *National Geographic Magazine*. 120(4): 550-561.
Joukowsky, M.
1980 A complete manual of field archaeology. Englewood Cliffs, NJ: Prentice Hall.
Koob, S.P.
1984 The Consolidation of Archaeological Bone. In N.S. Bromwelle, E.M. Pye, P. Smith, and G. Thompson, eds., Reprints of the Contributions to the International Institute of Conservation's of historic and artistic works, Paris congress (adhesives and consolidates). London: the International Institute of Historic and artistic works, pp. 98-102.
Lange, R.
1997 Field Class Mapping Lectures (for Homol'ovi, Summer 1997). n.p.
Littlehales, B.
1961 Into the Well of Sacrifice: Return to the Sacred Cenote. *National Geographic Magazine*. 120(4): 540-549.
Lucero, L.

1997 Report: 1997 Field Season of the Valley of Peace Archaeological VOPA) Project. Submitted to the Department of Archaeology, Ministry of Tourism and the Environment, Government of Belize. Manuscript in possession of author.

Marden, L.
1959 Dzibilchaltun: Up from the Well of Time. *National Geographic Magazine*. CXV(1): 110-129.

Marx, Robert F.
1975 The Underwater Dig: An Introduction to Marine Archaeology. New York: Henry Z. Walck, Inc.

McKillop, H.
1995 Underwater archaeology, Salt Production and Coastal Maya Trade at Stingray Lagoon, Belize. *Latin American Antiquity* 6: 214-228.

Mericle, L.W.
1971 The Sacred Well at Chinkultic. *Lore* 21(4): 129-134. Milwaukee Public Museum, Milwaukee.

Neumann, T.W. and R.M. Sanford.
1998 Cleaning artifacts with Calgon. *American Antiquity* 63: 157-160.

Osterholtz, Anna.
1997 Ceramics of the Valley of Peace Archaeological (VOPA) Project. Technical report, not published. Manuscript in possession of author.

PADI
1994 PADI Open Water Diver Manual: The fun and adventure of learning to scuba dive. Santa Ana, CA: PADI.

Pearson, Colin, ed.
1988. Conservation of Marine Archaeological Objects (Buttersworth Series in Conservation and Museology). Buttersworth-Heinemann.

Saul, F.P. and J.M. Saul.
1989 Osteobiography: A Maya Example. In Iscan and Kennedy (editors) Reconstruction of Life Through the Skeleton. NY: Alan R. Liss, pp. 287-302.

Sharer, R.J.
1994 The Ancient Maya Fifth Edition. Stanford, CA: Stanford University Press.

Schele, L.
1984 Human Sacrifice Among the Maya. In E. Boon (ed.) *Ritual Human Sacrifice in Mesoamerica*. Washington, E.C.: Dunbarton Oaks, pp. 7-48.

Shepard, A. O.
1956 Ceramics for the archaeologist. Carnegie Institute of Washington, Publication No. 609, Washington, D.C.

Singley, K.
1988 The Conservation of Archaeological Artifacts from Freshwater Environments. South Haven, MI: Lake Michigan Maritime Museum.

Snow, C.E. and T.D. Weisesr
1984 The Examination and treatment of Ivory and Related Materials. in N.S. Bromwelle, in E.M. Pye, P. Smith, G. Thomson, eds.; Reprints of the Contributions to the International Institute for conservation of historic works, Paris Congress (Adhesives and Consolidants). London: the International Institute of Historic and Artistic Works, 141-145.

Stone, T., D. Dickel and G. Doran.

1990 The Preservation and Conservation of Waterlogged Bone from the Windover Site, Florida: A Comparison of Methods. *Journal of Field Archaeology* 17: 177-186.

Storch, P.S.
1983 Field and Laboratory Methods for handling Osseous Materials. *Conservation Notes* No. 6. Austin, TX Memorial Museum.

Taschek, J.
1994 *The Artifacts of Dzibilchaltun, Yucatan, Mexico: Shell, Polished stone, Bone, Wood, and Ceramics.* Publication No. 50. Middle American Research Institute, Tulane University, New Orleans.

Tozzer, A.M.
1941 *Landa's Relación de las Cosas de Yucatan.* Papers of the Peabody Museum of archaeology and Ethnology, No. 18. Harvard University, Cambridge.