MARITIME TULUM: A CREATIVE HISTORY

by Vel Lena Steed

Department of Marine Transportation

Texas A&M University at Galveston

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Approved by:

William A. Seitz, Head, Dept. of Marine Sciences
and
Ralph G. Davis, Dean, Texas Maritime College

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Preface

The invitation to accompany an expedition studying Maya ruins on the coast of the Yucatan Peninsula conjures up romantic images and stirs adventurous hearts. I was not one to turn down such an opportunity. Apart from the lure of Caribbean waters and a mysterious civilization, the work which the expedition planned to accomplish was an important consideration. With a project design combining archeology and anthropology, it was to be determined if the impressive ruins of Tulum could have functioned as a navigational aid for the Maya waterbourne trade. Team members were a mixture of professional archeologists and individuals with different levels of expertise in various fields. My involvement as part of the navigational team found me somewhat of an amateur compared to the many who had been doing work in Mayan studies for years. However, this fact does not prevent my sharing the information I have gathered nor does it render my comments any less important to those interested in the details of this investigation from a mariners viewpoint.

I would like to acknowledge the sponsoring institutions of this project. They include the National Geographic Society, the Instituto Nacional de Antropologia e Historia (INAH), the Institute of Nautical Archaeology (INA), and the Kempner Fund. Special thanks must also be given to project director, Pilar Luna; Michael Creamer and other members of the INAH Team; and, especially, my advisors in this project Dr. Seitz and Dr. Estes.

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I. Introduction

As one surveys the coast of the Yucatan, even today, one of the most impressive sights is the Mayan ruins of Tulum. Compared to the great city of Seville by Spanish explorers, the town and its largest structure "El Castillo" stand out from the shoreline and are visible from the sea for many miles. To what purpose was this structure dedicated by its builders, and what does its presence tell us about the civilization which erected it? In this paper, I will attempt to answer these questions based on a combination of historical research into the earliest Spanish accounts of the area, and upon a recent archeological expedition of which I was a member. I will propose a theory that this ruin represents a pre-Columbian lighthouse utilized in an active coastal trade in the last (Decadent) period of the Maya.

The organization of the paper is as follows. The first section gives a brief review of the history of the Maya from the Classic cultural period at Tikal and later at Chitzen Itza, to the so-called Decadent period more than a thousand years later characterized by a very powerful merchant class. It will be seen that this evolution coincided with a gradual movement of the active population centers towards the coast, and the development of a sophisticated trading society with important centers at Tulum and Cozumel. The second section contains a quite detailed discussion of the period of Spanish discovery of the Maya in which Tulum played an important part. From these accounts, it can be seen that the Maya, while not the equal of the Europeans

in maritime skill, nevertheless had developed the ability to carry on long-distance sea trade and were active in it. The next section focuses on the area of Tulum and its historical and archeological position as a Mayaport. Finally we present our own findings from an expedition to Tulum during the summer of 1985. At that time, we performed a modern day simulation of a landing at Tulum using a canoe similar to those of the Maya. In addition, very detailed measurements both from land and at sea were made of the capabilities of the structures to act as navigational aids at night. (Considerable supporting details can be found in the appendicies.)

In the sections detailing the results of the expedition, I have made a number of comments from my own standpoint as a student majoring in marine transportation and looking at the archeological aspects from the point of view of an amateur. Thus, I have given some attention to the nature of the marine geography around Tulum including currents, winds, beaches, anchorages, obstacles and the barrier reef. These factors confront the mariner today as they did in the time of the Maya, and their evaluation forms an important part of this work.

II. Mayan Historical Perspective

Today's knowledge of the rise, evolution and fall of the Maya is derived primarily from five major sources. First, there exist a number of historical records (by Spanish and native writers) dating from the time of the conquest, the most important being those of Landa, Cogolludo, and Villagutierre. These accounts necessarily reflect the Maya of the sixteenth century which were undoubtably quite different from those of the Classic period of over 1000 years before. In addition, while these accounts may provide our most reliable evidence regarding the Maya of that time, the Spaniards of that period also destroyed much of the original Mayan literature. In particular, Bishop Landa in his fervour to spread the Christian religion, burned massive amounts of what he considered idolatrous texts.

The second source of general knowledge are a few native books which were not destroyed. These works, called the Codices, were studied by Spanish chroniclers who reported that they dealt with astronomy, magic, medicine, divination and history. Only three volumes escaped "salvation" by the Spanish: the Codex Peresianus; the Troano-Cortesian; and the Dresden Codex. The style of the latter matches closely that of wall paintings found at Tulum and, therefore, is thought to date from the Post-Classic period during which Tulum flourished, and perhaps it even was produced by an artisan from that town. (Thompson, 1931)

Native historical records were also discovered and translated into Spanish. The two most important of these are the Chiliam-Balaam and the Popul-Vuh. They both outline in a very

sketchy fashion, various parts of Maya history. The absence of any mention of Tulum in the Chiliam-Balaam except in a religious context is, as discussed below, consistent with the archeological evidence that Tulum's period of influence occurred long after the Classic Mayan period.

Another major source which has aided scholars in their quest to piece together the Maya puzzle are the monuments, or Stelae. These stone monoliths were erected often, every five or ten years in many cases, and were marked with exact dates. The hieroglyphics have been diciphered so as to be able to convert them into the Gregorian calendar system. These Stelae may also have been helpful markers along inland trade routes, and perhaps even along the coast as indicated in several frescos at Chitzen Itza discussed below.

The final source of Maya history is obtained from oral traditions. When the Spaniards first arrived in Yucatan, they found a culture with laws, a moral code and judges. The natives were under the domination of a strict priesthood connected with the worship of numerous gods and goddesses. Because this native priesthood was systematically eradicated by the Spanish, much of the knowledge of the ancient language, religious ceremonies and history which had been handed down for over 1500 years was lost. Still, some members of the minor priesthood remained who were capable of repeating certain prayers and rituals which once had been carried out by the high priests. However, because of the extreme religious persecution of the Indians, when interrogated, they would naturally disclaim any knowledge of or participation

in the ancient religion. According to Thompson (Thompson 1931) some of the old customs thought to have long since vanished are still resurfacing in some remaining Maya tribes.

In addition to these historical sources, archeological evidence has been accumulated at an accelerating rate for more than a hundred years. Beginning with the pioneering work of Stephens, Catherwood, and others in the nineteenth century and continuing with the work of Morley and Lothrop sponsored by the Carnegie Institution, archeologists have studied most of the prominant remains found at many Maya sites including those at Tulum. During the past 25 years, however, studies have also been carried out on non-permanent (wooden) structures at quite a number of sites. This work has included sites at Cerros, Coba, Colha, Copan, Cuello, Lamanai, Pusilha, El Mirador, Quirigua and Tonina, but not yet at Tulum. This modern surge of information has almost revolutionized our understanding of the Maya at this time.

For the purposes of this paper, it is helpful to divide the evolution of Mayan civilization into four periods. The first is the Classic period which began about 300 AD and ended in about 1000 AD. The second is the Florescent period running from about 1000 AD to 1200 AD. The third is the Decadent period between 1200 and 1500 AD. The final period is the Colonial period characterized by the conquest by the Spanish. Figure 1 shows the Maya world during these periods, and includes highlighting for the specific areas mentioned in the text. For reference, the area of focus of this research is Tulum located on the Northeast coast of the Yucatan near the island of Cozumel.

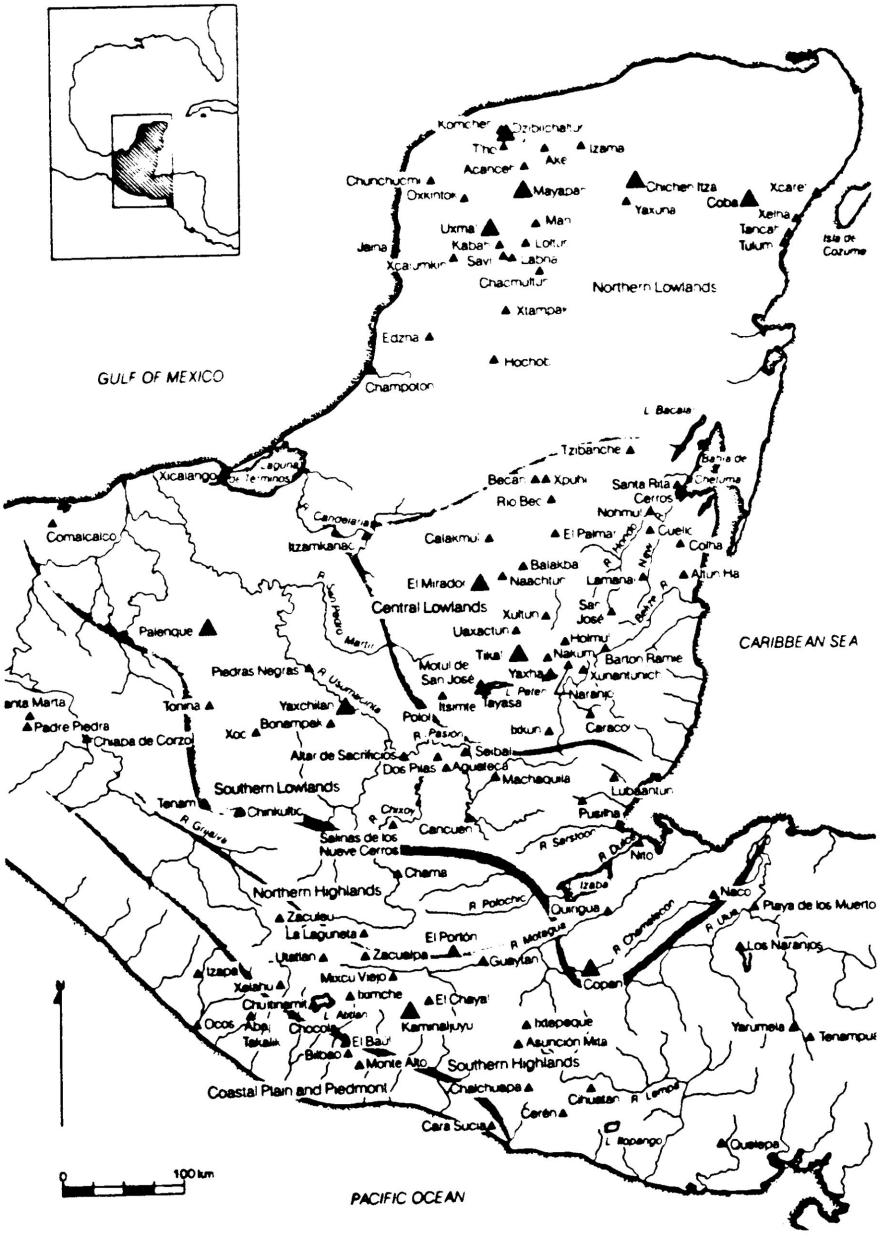


Figure 1 : The world of the pre-Columbian Maya. The highlighted areas are those mentioned in the text.

The history of the Maya during the Classic Period is dominated by the major centers in the southern and central lowlands. There Tikal was one of the earliest known centers to erect a monument commemorating its independence and importance. (Morley 1983: 102). Tikal's influence extended throughout the lowland region. According to Morley's account

> "Tikal seems to have controlled much of the central lowland trade, possibly acting as the central redistribution center for lowland goods destined for other regions and for foreign commodities (such as obsidian) entering the lowlands. ... Tikal could be viewed, in a sense, as the Rome, 'the eternal city', of the lowland Maya"

Around 535 AD, the so-called Middle Classic hiatus began in the southern areas and lasted to as late as 692. While the reasons for this decline are unclear and may have been due to uprisings in central Mexico (Willey and Bullard, 1965), it provided the opportunity for other centers to develop and to assert a greater measure of independence. Thus although Tikal regained its position as the primary center in the region, many lesser centers also began to develop. It is during this period that the first monuments in the northern Yucatan region at Coba and Chitzen Itza were erected. Morley, (Morley 1925, Chitzen Itza, An Ancient American Mecca, National Geographic Magazine) writes

> "But the Mayan Dark Ages were approaching. Art, architecture and learning were soon to suffer a temporary eclipse. ... The Maya during the Seventh Century were forced to abondon the Old Empire region, where they had wrought so laborously and had achieved so splendidly, and to seek new homes elsewhere."

The final dramatic decline in the intellectual and cultural activites of the classic lowland Maya occured between 790 and 889 AD. By the end of this period no further monuments were erected, and hieroglyphic texts and calendrical dates were no longer recorded (Morley 1983: 140). The reasons for the decline are the subject of intense debate even today, and will not be discussed here since the period of Tulum's importance occurs much later. One interesting theory, however, for the decline of Tikal is given below

> "The economic relationships between the lowland Maya and other peoples of Mesoamerica suggest another theory for the demise. The changes in Mesoamerican long-distance trade networks that mark the Terminal Classic may have isolated the southern and central lowland Maya from the economic and political powers that came to dominate the Postclassic. During this period the Putun Maya rose to power and appear to have monopolized the seacoast trade routes that become increasingly important at the end of the Classic period. The investigation of a Postclassic port-of-trade on Isla de Cozumel, off the coast of Yucatan, related the demise to the failure of the traditional lowland elite to recognize the importance of the new sea trade around the Peninsula. As a result, the old land routes were largely abandoned, and the lowland Maya became isolated economically. A case for the rise and fall of Tikal, specifically, can be constructed around the site's position of control over trans-lowland canoe routes. When these routes diminished in importance, the site appears to have fallen on hard times and was eventually abandoned." (Morley 1983: 147)

The initial early seventh century settlements at Chitzen Itza discussed above were abandoned suddenly about 668 AD (Morley, 1925) for some unknown reason. The Itza Maya then wandered westward and founded a new capital called Chakanputun near modern Campeche. They remained there until 948 AD when fire destroyed that city and they returned to reoccupy Chichen Itza in 987 AD. This began the time known as the Florescent period

during which the three northern Yucatan cities of Chichen Itza, Uxmal and Mayapan ruled the Maya world and shared equally the government of the peninsula until 1224 AD.

This approximately 200 year period is the true Mayan Renaissance. Great buildings of stone were erected and these Mexicanized Putun Maya became the dominant culture in the area. Even as late as the period of Spanish conquest Bishop Landa wrote of Chichen Itza

> "Chichen Itza is a very fine site, ten leagues from Izamal and eleven from Valladolid. It is said that it was ruled by three lords who were brothers who came into that country from the west, who were very devout, and so the built very beautiful temples and they lived very chastely without wives."

The Putun Maya, as the above passage suggests, are believed possibly to have had significant economic and political ties far to the west in Mexico around Tula, the capital of the Toltec state. The exact relationship with Tula remains unclear, but it is known that the leader of the group of Putun Maya who established the new capital at Chichen Itza was named Nacxit Xuchit and he carried the Mexican title Quetzalcoatl ("feathered serpent"). The expansion of this peripheral group of Putun Maya at the end of the Classic period is in the words of Thompson (Thompson 1970: 5) "comparable to Macedonian aggrandizement at the expense of Classic Greece when the latter was past its cultural peak."

According to murals and sculptures of the period, the "Alliance of Mayapan" was not always peaceful. As the drawing from the Temple of the Warriors in Figure 2 clearly shows, these hostilities included primitive sea battles. In fact, the

Figure 2: A fresco from the Temple of the Warriors at Chichen Itza showing golden haired enemy being thrown into the sea from his canoe. The fish in the picture are marine life and not found in fresh water streams. The title of the piece is "Fragments of Marine Battle" and it is from areas 20 and 21 in the Temple.

evidence collected to date (particularly the very widespread presence of orange coastal pottery throughout the Mayan world) shows that the Putun Maya had by this time developed large sea-going canoes with which they established a trading network. According to Morley (1983: 159)

> "By the tenth century the Putun seem to have developed large sea-going canoes, which they used to control the coastal trade routes that were to change the fortunes of Postclassic Yucatan. Former peripheral areas, such as the northeastern coast, (Tulum's location) began to attract the sizable populations necessary to maintain port facilities and connecting inland routes."

The Maya chronicles indicate that the alliance was broken in 1221 and the single city of Mayapan became dominant. The precise details of this change are still unclear, but political intrigue played an important role. According to the Mayan writings of the period the crisis was precipitated by the kidnapping of the wife of the ruler of Chichen Itza by the ruler of Izamal. In the war which followed, Hunac Ceel, the ruler of Mayapan conquered and sacked Chichen Itza. By this time the ruler of Chichen Itza was known as the "Very Red Man" and the people of that city were known as the "Holy Men of the Itza". Their defeat marked a transition from domination by the priest classes to a new domination by powerful merchant elite families. It is during the relatively peaceful 250 year Mayapan period which followed (dubbed the Decadent period by many historians) that the trading centers along the eastern Yucatan coast florished.

The stage is now set for the final period of the Maya, namely the Colonial period and their conquest by the Spanish conquistadors. Before then, however, it appears that a series of

disasters (including war in 1496, pestilence in 1480, a hurricane in 1464 and the destruction of Mayapan in 1441 due to a revolt) had left the major centers at Mayapan and at Chichen Itza empty. Thus when the conquerors came, they encountered a civilization widely dispersed and clinging to the coast. It is this civilization which forms the subject of the next section, and most clearly reflects the Maya of Tulum's day.

The early Spanish accounts predate the ultimate conquest of the Maya in 1540. That conquest, which is outside of the scope of this paper, occurred only after two unsuccessful attempts in 1527 and in 1535. In fact, as late as 1536, Morley states (Morley 1983: 174) that the Spanish had withdrawn completely from the Peninsula. But the Maya, forever a cultured and intelligent race, understood that their end was at hand. They named their last pre-conquest capital Mani, meaning in Maya "it is passed."

III. Spanish Contact With Tulum and Maritime Maya

While there is general acceptance of the idea that the Maya of the 14th and 15th centuries were capable of maritime trade, much of this belief is based on direct accounts by the explorers who first encountered this civilization. Because these accounts evoke so strongly the sense of difficulty associated with sea travel in this period, we will present in some detail their voyages and their accounts of meetings with seafaring Maya.

The modern history of the Maya starts with the Spanish accounts of Columbus' last voyage. This first recorded contact between the Old and New Worlds begins the story of one of the most tragic downfalls of a civilization and its people. The Spanish Conquest of the Maya practically obliterated a culture that had existed for well over a thousand years.

In 1502, Columbus, with four ships captained by his brother Bartholomew and Francisco de Porras, proceeded to Hispaniola, the island now called Santo Domingo. (See Figure 3). After receiving a denial from the Governor of Santo Domingo, Nicolas de Ovando, to enter that harbor for shelter and repair, Columbus and his ships weighed anchor and set sail. Scattered temporarily by bad weather, they rejoined four days later at the southern end of Santo Domingo.

Much needed repairs and fears of another storm caused further delay, but finally the small fleet continued thier journey westward. They first touched Jamaica, then rounded the southern islands of Cuba, and afterwards settled on a southwesterly course. After several days, they came upon a small

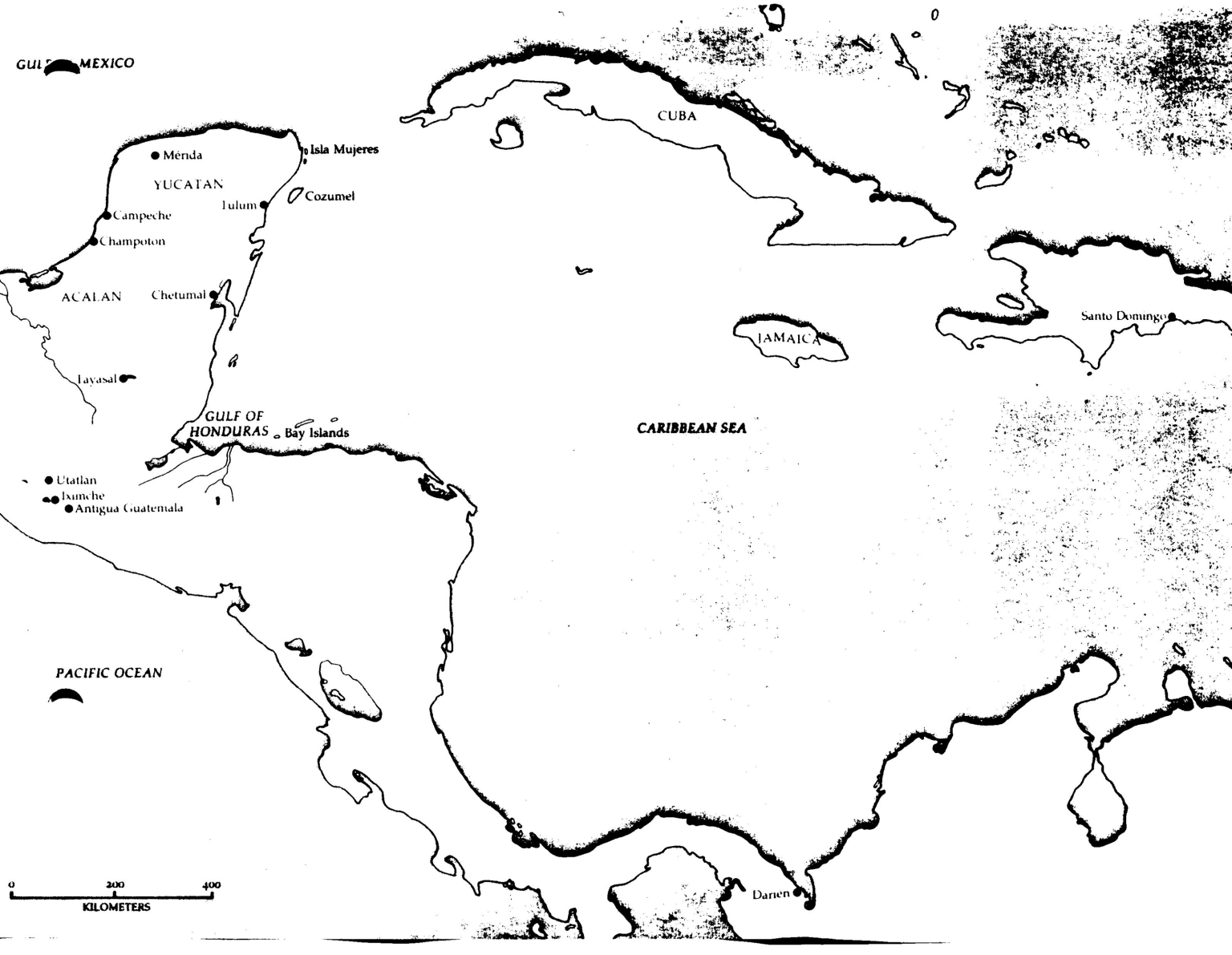


Figure 3 : The Spanish Main of the early explorers of the Yucatan

island which they named Isla de los Pinos. This island had the native name of Guanaja and belonged to the Islas de la Bahia (Bay Islands) off the north coast of the Spanish Honduras.

> "Bartholomew Columbus was sent ashore early in August, 1502, to investigate the country, but before he met any natives, he saw coming from the west, a great dugout canoe, manned by twenty-five Indians, who, according to contemporaneous statements, were so frightened by the sight of the big Spanish ships that they did not flee." (Blom 1936: 2-3)

In Bartholomew's report to Genova, he describes the encounter with the canoe at Guanaja.

> "The canoe was eight feet wide. They had in it much clothing of the kind which they weave of cotton in this land, such as cloth woven with many designs and colors, shirts which reach only to the knees, and some square pieces of cloth which they use for cloaks, calling them 'zuyen'; knives of flint, swords of very strong wood with knives of flint set along the edges and foodstuff of the country."

There were also cast copper bells, copper hatchets, crucibles for melting copper, cocao beans (which they valued the most), and a fermented drink of maize.

Over the center of the canoe was a canopy, under which was seated a wealthy merchant who was probably the owner or chief. (Blom 1936: 2-5) Apparently he had taken his family along on the voyage as the palm-leaf shelter amidships was occupied by women and children. All of this was such that the Spaniards had seen nothing comparable to it in the New World. Unlike the naked Indians of the Caribbean with whom Columbus was familiar, they were a timid and proper people who immediately re-covered themselves when their clothing was pulled. This gave the Admiral much pleasure and he treated them with great kindness. He held a long conference with the chief and learned there was a great land

to the west called Maiam. The Spaniards presented the natives with some trinkets, while they took samples of all the native merchandise. Then they parted, Columbus to steer eastward, and the natives to continue westward to their native country, Maiam. Columbus passed through several perilous adventures on his way back to Hispaniola and by September 1504, had reached Spain once again. Most historians consider the canoe that he encountered to have come from the Yucatan, mentioning that had he gone west as the occupants of the canoe suggested, he would have been credited with the discovery of this land. (Sabloff and Rathje 1975: 76; Blom 1936: 4,5)

There are references which suggest that Yucatan was officially discovered in 1508, though at that time there was no real effort made to explore or conquer it. (Harrisse 1892 in Lothrop 1924: 13; Sauer 1966 in Henderson 1981:31) By 1511, however, there were several established Spanish colonies in the Caribbean and further contact was inevitable. At approximately this time, a caravelle bound from Darien in Panama to Santo Domingo went aground on the shoals off of Jamaica. The ship foundered and sank, but nineteen men escaped in a small boat without sails or food. The Yucatan Current carried them westward for two weeks, during which time seven men died. The dozen survivors drifted ashore on the east coast of the Yucatan where they were siezed by unfriendly natives. Juan de Valdivia, the commander and four others met quick deaths as a sacrifice, while Geronimo de Aguilar, Gonzalo de Guerrero and five others were temporarily spared until they could be fattened for a later

cannibalistic feast. Aguilar described the situation,

> "I together with six others remained in a coop, in order that for another festival that was that was approaching, being fatter, we might solemnize their banquet with our flesh."

The Spaniards managed to escape before appeasing the native appetites, but after journeying for some distance they were again recaptured. According to Lothrop (Lothrop 1924)

> "All historians place this scene of their second capture at Chetumal and at Xamanzana, 5 leagues away, except Sanchez de Aguilar, who says that they fell into the hands of Kinich, lord of Zama, which is believed to be the city now known as Tulum."

Geronimo de Aguilar eventually rejoined his countrymen, bringing with him valuable information about Maya culture as well as some knowledge of the language. Guerro, however, married a Mayan and rose to a position as a military commander in the service of the lord of Chetumal. He died in 1536 in Honduras while commanding a flotilla of Maya war canoes, defending the commercial interests of Chetumal against the Spanish. (Henderson 1981: 31; Lothrop 1924: 13; Morley 1983: 569-71).

The first lengthy exploration of the Yucatan occurred in 1517. Francisco Hernandez de Cordoba, a colonist of Cuba, set sail with three ships and more than a hundred men from Havana. Although he and his crew may have wanted to venture either northward toward the Bahamas or south to the Honduras, they were persuaded to sail directly westward as well, in search of new lands. (Chamberlain 1966: 11). According to a member of the crew Bernal Diaz del Castillo

> "...we sailed from Havana on the on the north side and twelve days later doubled the Punta de San Antonio...", (the westernmost point of Cuba) "Having doubled the point and at high sea we sailed at a venture toward the west,

> without knowing of shoals, currents or the winds which usually blow at that latitude, and at our great risk because at that time a storm struck us which lasted two days and nights." (Wagner 1942:59)

In good weather that followed, the expedition continued southward before the wind towards the eastern Yucatan. As another member of the party describes "... the pilot ... heard some little waves striking against the sides of the vessel. By this he knew he was near land", and ordered soundings to be taken. (Wagner 1942:56). Soon thereafter land was sighted. "From the ship we saw a large town which seemed to be about two leagues from the coast. Seeing it was so large and that we had never seen in Cuba or Espanola one so large, we named it 'el Gran Cairo'." (Diaz del Castillo in Wagner 1942:59). There is some question as to the precise location of this landing, but it is clear that it was either on or near the small island named Isla de las Mujeres. That island is known to have contained a number of salt beds which was an important commodity being traded in the Maya world. (Andrews, 1983:16).

After anchoring off of "el Gran Cairo", the expedition was approached by richly dressed Indians, again in great canoes. Diaz del Castillo writes

> "We saw ten very large canoes....approaching by oar and sail full of native Indians of that town. The canoes are made like troughs, large and of heavy timber, hollowed out by art. They are all of one piece and many hold forty persons". (Wagner 1942:59)

According to Wagner, this is the only mention in the accounts of the Spanish explorers which mentions the use of sails on native vessels. The Indians went aboard the Spanish vessels, and remained for some time. They returned the next day with more

canoes and invited the Spaniards to come ashore. Although the natives had made many signs of peace, the foreigners were led into an ambush. The attack was unsuccessful and the Spaniards returned to their ship taking with them several gold objects which they had plundered from houses in the area. (Wagner 1942:61; Chamberlain 1966:12)

The expedition continued westward past the provinces of Conil and Maya. (Lothrop 1924:14) Again making landfall, this time near the native towns of Campeche and Champoton, they were once more attacked and this time defeated by fierce local Maya. This caused their return to Cuba, and within two weeks of his return Cordoba died. But his exagerated reports of having discovered a rich, new land aroused the interest of many. As a result, Diego Velazquez, lieutenant governor of Cuba organized another expedition under the command of Juan de Grijalva.

Grijalva, in command of four ships and two hundred men, set sail from Cuba on April 8, 1518 and reached the island of Cozumel in May. They put into port on the northwest side of the island at the site named San Miguel (Friedel and Sabloff 1984:163). The Maya fled into the interior of the island at the sight of the Spaniards and Grijalva claimed Cozumel in the name of the crown. Next the expedition sailed southward along the Yucatan coast. On May 7, they passed

> "...three large towns separated from each other by about two miles. There were many houses of stone, very tall towers, and buildings covered with straw... We followed the shore day and night and the next day towards sunset we perceived a city or town so large that Seville would not have seemed more considerable nor better; one saw there a very large tower; on the shore was a great throng of Indians, who bore two standards which they raised and lowered to signal us to approach them; the

> commander did not wish it. The day we came to a beach near which was the highest tower we had seen and one discerned a very considerable town; the country was watered by many rivers; we discovered a bay so large that a fleet might enter. It was lined with wooden buildings set up by fishermen".

The identification of the large town, comparable to Seville, was most probably four smaller archeological sites known today as Xelha, Tancah, Soliman and Tulum, which because of their close proximity may have given the impression of a continuous city when viewed from the sea. (Tegeler 1975:59) The largest of the sites was most likely the ancient town of Zama (today considered to be Tulum) and the "highest tower" most certainly had to be the the Castillo of Tulum. (Morley 1983: 572) The bay mentioned is undoubtably Bahia de la Ascension so named because it was discovered on Ascension Thursday, 1518.

Following this voyage, more excitement was engendered among the Spaniards and a third expedition set out under the command of the famous explorer Cortes. Again Cozumel was visited, and again the natives practiced the passive resistance of fleeing into the interior of the island. This was noted by Tegeler (1975:59) to be in sharp contrast to the behavior of the mainland Maya who resisted actively as discussed above.

Cortes, nevertheless, managed to arrange a meeting with Cozumel's leaders and gained their confidence. He was thus able to learn from some merchants about the presence of "bearded men" on the mainland. He suspected that these might be Europeans and sent messengers to bring them back to Cozumel. In this manner, Geronimo de Aguilar, whose misfortunes have been previously described, was ransomed back from the Maya and became an

invaluable interpreter. From that time forward, Cozumel appears to have been a regular port of call for the Spanish ships traveling between Mexico and Cuba.

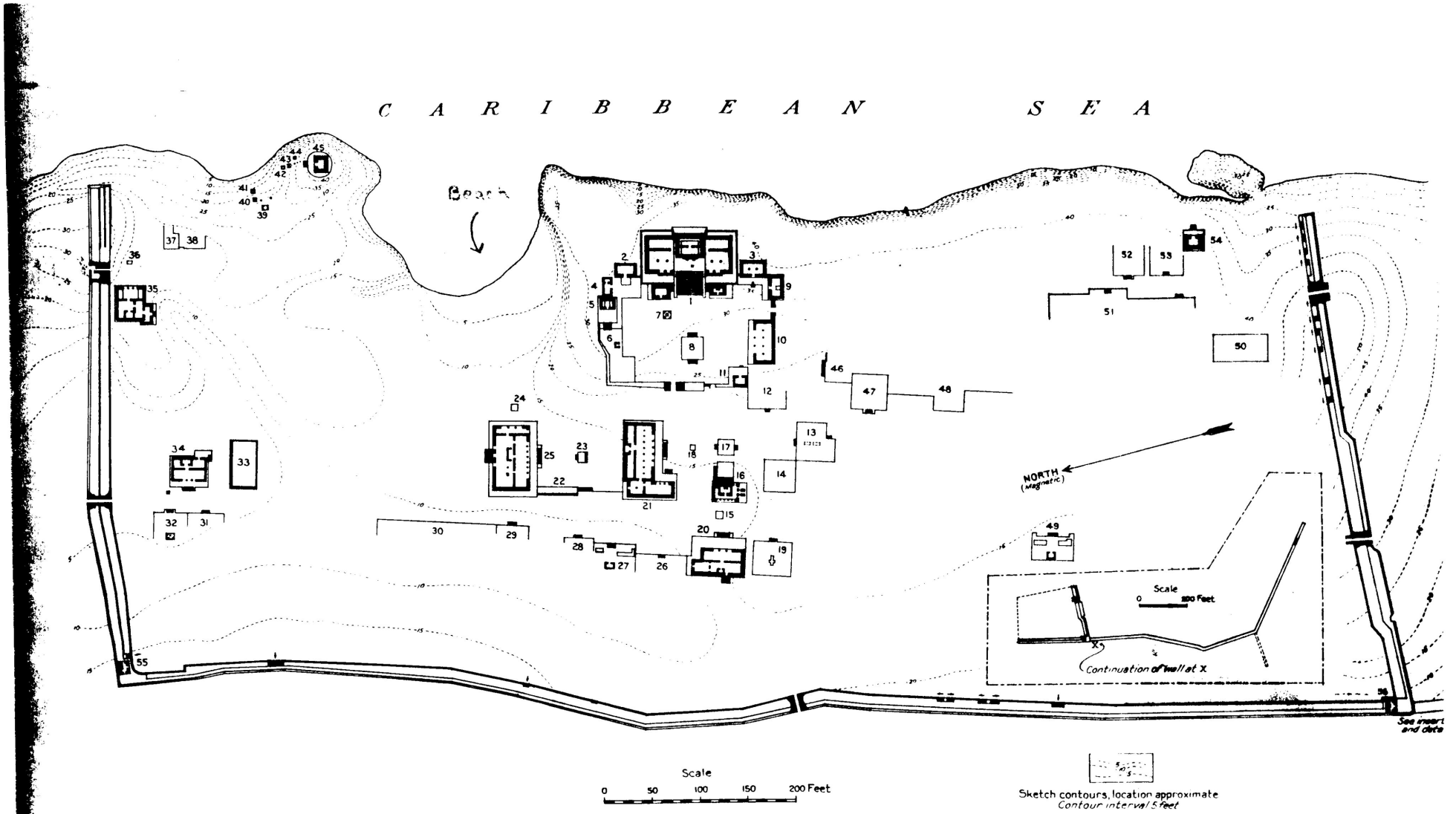
The pattern of these expeditions clearly established the Maya as a seagoing people capable of trade between the offshore islands and the mainland. The size and number of ocean going canoes indicated that this trade had become an important part of the Maya world, and the location of the sightings corresponds to ports utilized even until today. In what follows we will discuss the architecturally most dramatic of these ports - Tulum.

IV. Survey of Tulum as a Mayaport

We now restrict attention to the site at Tulum and the circumstantial evidence suggesting the hypothesis that the coastal structures there represent navigational aids to the Maya Putun traders.

Tulum was rediscovered by North Americans in 1848 when Stephens published his Incidents of Travel in the Yucatan. This pioneering effort predated by over 75 years the next expedition. That one in 1924, produced the classic work on Tulum by Lothrop, Tulum: An Archeological Study of the East Coast of Yucatan. This "tour-de-force" remains until today the most careful and complete analysis of the ruins. Figure 4 shows his detailed map of the ruins contained within the walls of the city. In this diagram, the main Castillo, the north structure, the south structure and the "landing beach" are highlighted.

The organization and location of the city provides the most compelling evidence for its role as a port and as a navigational aid. The entire Quinana Roo coast is protected by the second largest barrier reef in the world. For efficient ocean travel to have occurred, it would have been necessary for the Maya to traverse the reef at those few places where natural openings occur. Along the stretch of coast near Tulum, it is remarkable that the largest such opening lies directly opposite the main tower. Figure 5 shows a view parallel to the coast of this structure. From this picture and from the map in figure 4, it is clear that the main structure is of sufficient height to be seen from many miles away and hence would be capable, in principle, of



GENERAL MAP OF TULUM

Figure 4

LOTHROP (1924)

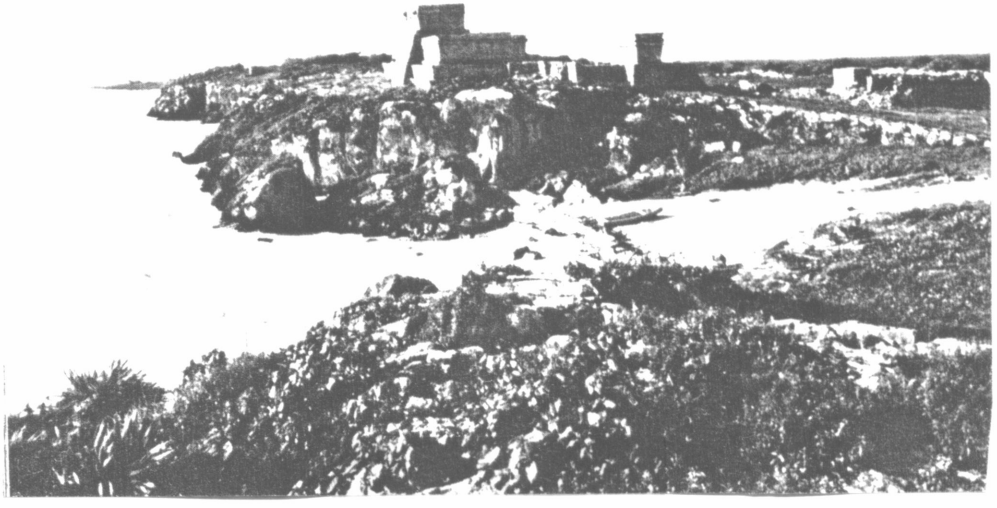


Figure 5 : The castillo at Tulum. Note the rocky cliff directly below the main tower, and the landing beach below.

being used for navigation. A second observation is that once inside the reef, the north structure (45 on the map) clearly could have been utilized as a marker to avoid the cliffs below the Castillo so as to provide for a safe landing along the beach where indicated. (See figures 4 and 6).

The quality of the landing area can be discerned from the picture, but more clearly by considering the topography as indicated by the contours (again on Lothrop's map). As we were to find out in our own investigations, the importance of a protected beach for landing a canoe even in fair weather during daylight should not be underestimated. Having landed, the beach slopes up to a fairly broad plateau at around 10 feet elevation, surrounding the major stone buildings in the center along the cliff. This area does not contain many permanent structures and could easily have been used for the storage of cargo and other goods in perishable warehouse structures.

Another piece circumstantial evidence for our hypothesis comes from the notable absence of "sacbes" or roads leading to the city. While initially it would appear that this might suggest absence of trade, what it really signifies is that the city looked mainly to the sea for its support, and required protection, via an impressive wall from the surrounding territory. This type of arrangement is exactly what would be expected of a major trading port which functioned as a way-station and transfer point for goods traveling northward from the cities in the south to the northern portions of the Mayan empire and to Cozumel. Such a transfer point, in addition to providing

Figure 6: View of the North Structure
from the Beach at Tulum

a central warehouse location, may also have been required so that smaller coastal traders could deliver their cargo in the relative security of the interior of the reef, prior to transfer to more seaworthy craft with experienced ocean going crews for the difficult passage to Cozumel. (See the discussion below of our own experiences in the Cozumel channel on board a modern ferry).

Other more general evidence of the use of navigational aids by the Maya along the northern Yucatan coast is seen in Figure 7. There Maya coastal ruins are marked with solid triangles and modern (present day) navigational aids are shown as the circled orange areas. It is almost impossible to ascribe this overlap to pure coincidence. Early eyewitness accounts by the Spaniards of early contacts with the Maya describe fires as being lighted on top of the structures as beacons to warn the island's inhabitants when raiders were approaching. (Sabloff and Rathje 1975:77) It is interesting to note that all of the structures appear to have been constructed during only a 300 year period and there is evidence that at one time at least 20 structures were involved. It would seem plausible, in light of the positioning of present navigational aids, that these structures comprised a coordinated navigational system in addition to being warning towers as suggested by Sabloff and Rathje.

Direct evidence of directional markers along the coast is found in Temple of the Warriors in Chichen Itza. Figure 8 is a closeup photograph of one of the frescos depicting a stela (tall pole in center of picture) along the seacoast. As discussed earlier, at inland sites these structures occur along sacbes to mark directions for travel. The identification of the marker

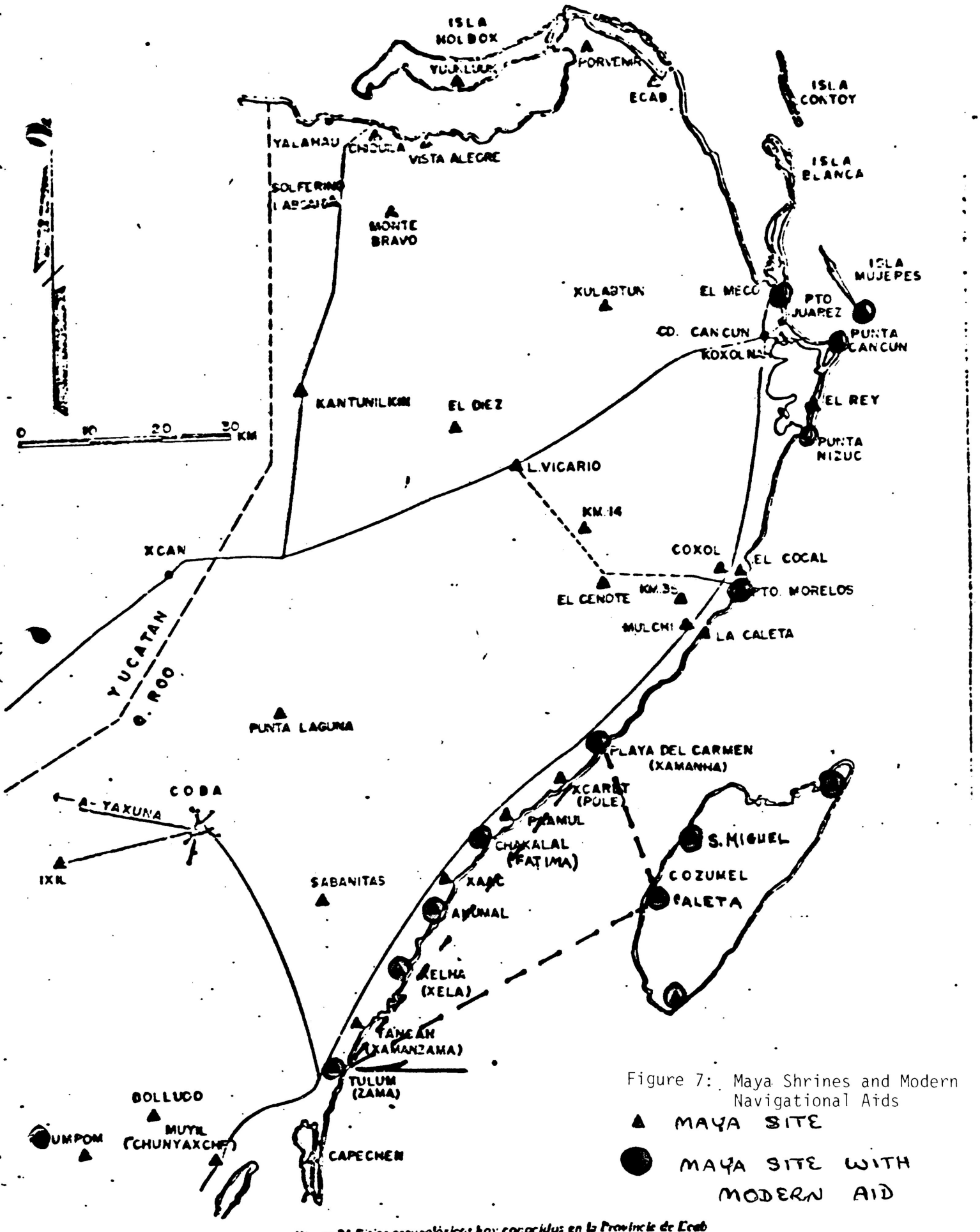


Figure 7: Maya Shrines and Modern Navigational Aids

Figura 21 Sitios arqueológicos hoy conocidos en la Provincia de Ecab

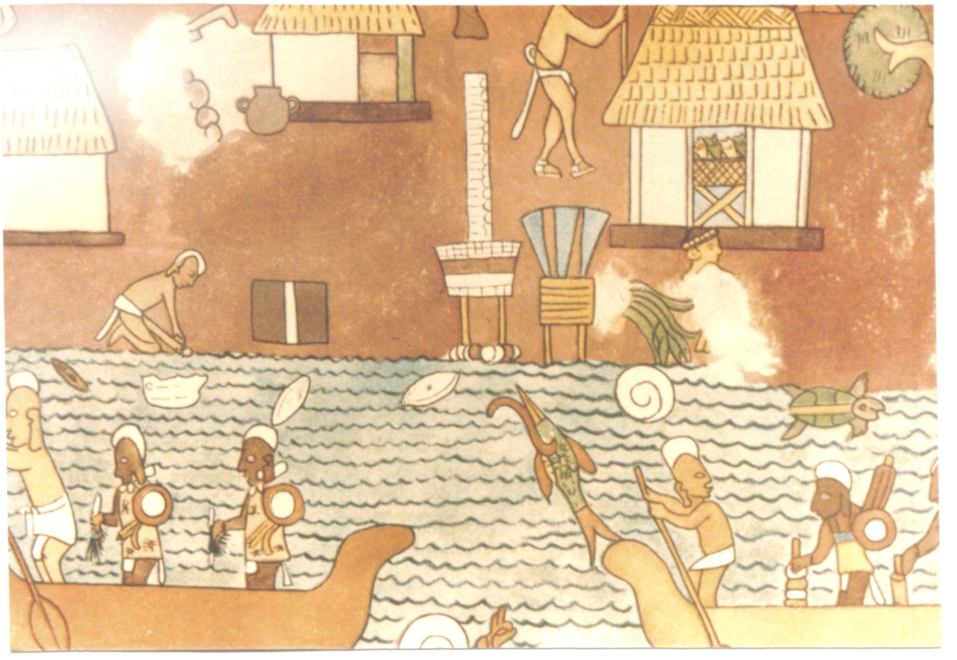


Figure 8: Close-up of a fresco at Temple of the Warriors in Chichen Itza. The tall pole at the center of the picture is a way sign or marker. Note the high prowed canoes in the foreground.

just to the right of the pole in the picture is as a "secondary device" (Morris 1931:480) It would not require too great an imagination to suggest that it represents a fire pot with the upwardly reaching bluish triagles representing the dispersion of the light. Figure 9 shows the full scene including numerous large canoes and depicting marine life found only along the coast and not along inland waterways.

A number of other minor pieces of evidence have also been collected regarding the maritime Maya. One which to our knowledge has not previously been described is found in figure 10 at the upper right hand corner. This fragment (also found at the Temple of the Warriors) shows the high prow of a seagoing canoe. What is unusual, however, is the presence of a lapstrake (the beige horizontal board in the background) which would have been useful to increase the freeboard for stability in oceanic conditions. This important modification of the typical canoe would have enabled the ancient Maya to venture far outside of the protecting reef in pursuit of long-distance trading opportunities.

Finally, while not direct evidence that the Maya carried on ocean commerce, the fact that they had developed an extremely accurate calendar system suggests that they had the expertise to carefully observe and understand the motion of the stars and planets. This capability has long been recognized by mariners to be crucial to navigation at night. A combination of shore lights such as we propose existed at Tulum and elsewhere for marking approaches to harbors, coupled with the ability to navigate

Figure 9: Full fresco scene showing a busy Mayaport containing several canoes. The various marine life are characteristic of salt water and would not be found in inland sites. Figure 8 previously presented a closeup view of the left hand portion of the fresco.

Figure 10: Several fragments from frescos at Chichen Itza. The fragment in the upper right shows the prow of an oceangoing canoe with the lapstrake in place to provide additional freeboard.

offshore via observation of the heavens would have enabled the ancient Maya to extend their trade routes to include passages involving night operations. The next section will complete the "circumstatial" evidence that Tulum existed as a Maya lighthouse.

V. Tulum Expedition: Summer 1985

The Tulum Experiment as carried out during the summer of 1985 is contained in the following section. It is primarily a narrative account with numerical data and calculations referenced in Appendix II. The purpose of the experiment, as discussed in section IV above, was to investigate via direct field experience the hypothesis that El Castillo at Tulum may have functioned as a pre-Columbian navigational aid.

On July 19, 1985, the day of our scheduled departure, the expedition members met early on the northwest side of Cozumel at a hotel dock provided by Aqua Safari. The team consisted at this point of Ric Hajovsky, Marie France Lemire, Pamela Holden, Bill Horn, Michael Creamer and myself. We would meet Pilar Luna, the project director, and her people at Tulum. Eagerly anticipating the days ahead, we loaded the crowded assortment of provisions and supplies aboard the dive boat Christopher K. (Figure 11) As the gear, canoe, food, buoys and other miscellaneous objects gradually got stowed, our hopes to ride across with the boat diminished. It became painfully obvious that the little vessel was overloaded and would not take even our small number of passengers.

The decision was made to have Bill and his two deck hands (who we knew as Poncholo and Bolas) bring the boat across Cozumel Channel the 17 miles to Tulum. The others would arrange for transportation to meet them there. My wish to first see Tulum by water faded as I stepped aboard the ferry bound for Playa del Carmen.

Figure 11: (a) and (b)

(a) 'Loading the Christopher K.'

(b) 'Developing a Port List'

During the crossing, one soon became aware of the swift current. I learned that it could be as strong as 2-3 knots in mid channel where the water reaches depths of 400-450 meters. Even with the advantage of modern horsepower, the ferry could not head directly for the landing on the mainland. To have done so would have meant being set much further down the coast than we wanted. To reach the ferry dock, we had to steer a course about 7-10 degrees more west in order to compensate for the N-NE current. With a question forming in my mind, I thought about the Maya canoes that were said to have gone between the mainland and Cozumel. Surely, I reasoned, it would not have been a simple feat to go back and forth in those paddle-powered vessels. How much more would this current have affected their crossing? I wondered if they might have sought additional power from the wind in the form of sails. I felt sure that if they were mariners of any sort they must have been well aware of the major effects the strength of wind and current can have on watercraft. The nine mile ferry ride provided an excellent opportunity to muse over the various possibilities.

Arriving at Playa del Carmen, we wasted no time in finding transportation headed south for Tulum. Amidst tourists and natives, pushing kids and honking vehicles, we managed to gain standing room on the right bus. As we pulled out onto the jungle-lined highway, I made an entry on my recorder, "1105, it has started to rain".

My first view of Tulum came not from the sea as I had hoped, but rather from land in much the same was as many of the archeologists before me had seen it. Though they most assuredly

lacked the addition of bustling merchants and gawking sightseers, I felt that I experienced the same view of the ruins as even Lothrop or Stephens must have had.

Today, the site has been cleared and planted with grass and palm trees, but the layout is still exactly as Lothrop drew. (see Figure 4) The ruins are surrounded on three sides by a wall about 5-6 meters high and over 2000 feet long, thus encompassing several acres. How much area outside the enclosed land was occupied is still uncertain. Most of the sources on Tulum agree that there were some perishable sites beyond the walls, but these have yet to be fully investigated. Lothrop in his classic study of the ruins has catalogued over 55 individual structures. Our work primarily involved only the major seaward facing buildings that he labeled structure 1, structure 45 and structure 54. We refer to them simply as "El Castillo" (Figure 12), "the North Structure" (Figure 6), and "the South Structure" (Figure 13) respectively.

El Castillo is by far the most imposing structure of the complex. It is built atop steep, limestone cliffs, commanding a spectacular view from a total height of 20.2 meters. Overlooking the eastern sea, its two-windowed face seems to watch the incessant flow of waves breaking on the shallow reef offshore. Perhaps, in the prosperous times of Mayan traders, it once stood a more vigilant guard over that reef as a Mayan lighthouse.

With this in mind, we began our study to determine whether the El Castillo might possibly have functioned as a pre-Columbian aid to navigation. If we were able to demonstrate that

Figure 12: Front and Back View, with Cross-Section of El Castillo

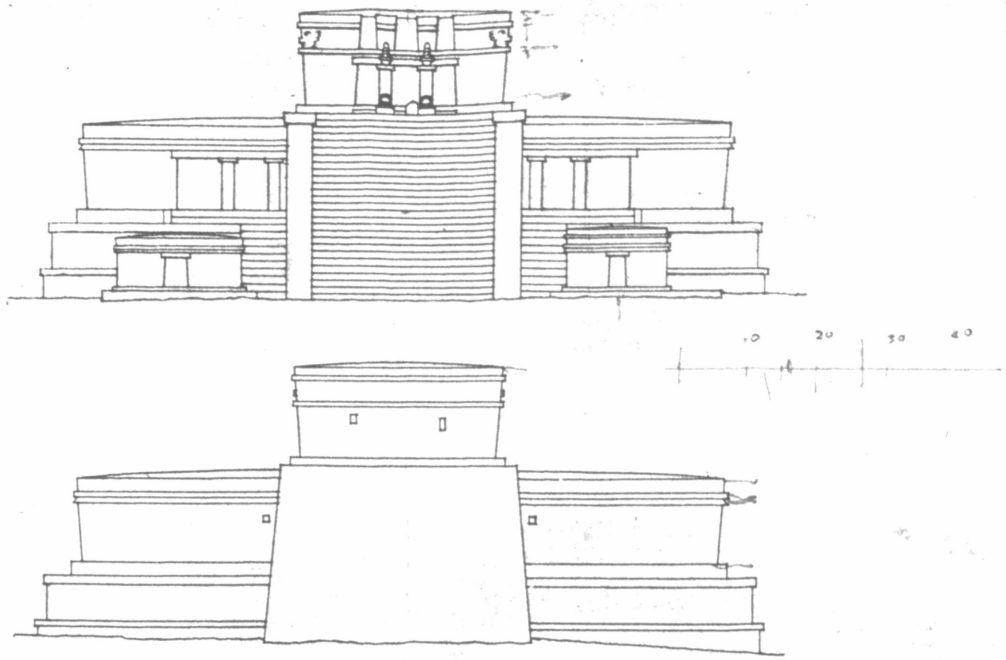


FIG. 42.—East and west elevations of the Castillo, Tulum.

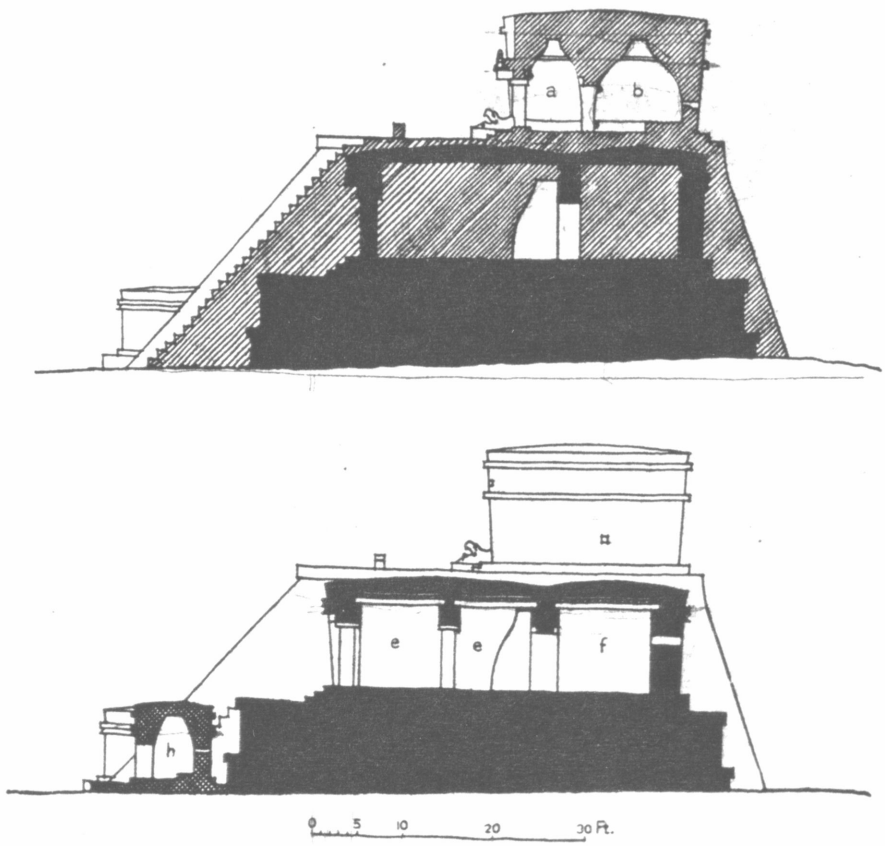


FIG. 43.—Cross-section of the Castillo, Tulum.

LOTHROP (1924)

Figure 13: View of the South Structure as seen from the El Castillo

capability, we believed it would serve as a starting point to survey other coastal sites, which together might have formed the sophisticated network of navigational aids about which we speculated in section IV.

The rise of the Putun merchant class has previously been discussed, but there are parts of the story still lacking. Only very general descriptions of Maya waterbourne trade and its routes have been published, and I have been unable to find any detailed study of the intricacies involved with actually supporting such an advanced network of trade. Accepting that the Putun were heavily involved with transporting goods and people by water, one cannot help but wonder by what means they piloted themselves. The most obvious answer is that they navigated by day taking visual bearings on the coast, and at night, they rested ashore. This may suffice as a plausible explanation, however, I am inclined to believe that the Putun were capable of nocturnal navigation. To do so would increase navigational hazards, but the resulting "transfer time" of any one cargo would practically be cut in half. Thus, an important economic factor might have been motivation for establishing an interrelated coastal system of daytime and night aids. Though our expedition's work did not attempt to undertake this type of large scale study, it has focused on a part of that idea by exploring Tulum's possible use as a lighthouse for night time navigation.

The team had much work to complete in the short span of the allotted four days (See Appendix I: Experiment Outline). By mid-afternoon, 19 July, most of our group had arrived on site, with additions being Pilar Luna, Juan Antonio Sillar and Bud Brinkley.

Setting up the encampment north of the walled ruins, we transfered the water-drenched provisions and gear ashore. By the time all had been put in order, rooms chosen, and dinner prepared, evening had settled upon us. I later crawled into my hammock, pleasantly tired and looking forward to a restful sleep. I learned an invaluable lesson that night - the rainy season and palm-thatched palapas are not an ideal combination!

The rising sun was a welcome reminder that soon everything would be dried out. We awoke early, set the breakfast rotation, and made plans for the day's events.

During the morning hours, the first dive team, Pam and Bill, along with boat operators Michael, Bolas and Poncholo, set buoys marking the reef entrance and three major coral heads inside. These buoys would double as markers to help us obtain survey data for experiment repeatability and as an added safety feature for the Christopher K during the night experiments.

After lunch, the second dive team (Ric, Marie, France and Juan Antonio) rotated with the first and took underwater tape measurements of the anchored buoys. Michael and I took bearings from the north window on the seaward face of El Castillo to the buoys. (Figure 17). These would later be used in conjunction with vertical sextant angles from the boat to tie the whole arrangement into position with respect to the shore. The detailed data showing the positions of the buoys and the distances involved is found in Appendix II.

By 1800 hours that evening, we were ready to perform the night experiment of taking the boat through the reef and

obtaining bearing measurements on the El Castillo lights. We split into two parties, one aboard the boat, and the other on land. Marie France, Pamela and Juan Antonio formed our shore parth. They placed two gas lamps on the low bench inside the El Castillo under the north and south windows. This light was to simulate the low-level intensity that might have been produced by the Maya using dirt filled terracota pots of fire. The land party tended these gas lamps and stood by for assisting as necessary. Ric and Bill in the Zodiac (a small motorized rubber raft) illuminated the buoys with flashing strobes and then joined the shore party. The rest of the group boarded the Christopher K and as the sun began setting, headed toward the reef entrance.

Following the coast south from our anchorage, we picked up first what appeared to be the south light. Abeam of the El Castillo, but still within protected water, the lights from the windows glowed as two eyes of an ancient Mayan god. (See frontpiece of this report). We turned east and proceeded toward the reef. What followed was a series of maneuvers and a complete North-South pass outside the reef to test the limits of the light angles. (See Appendix II for details) As the final pass was made through the reef entrance, it was agreed by all those aboard that the alignment of the Castillo lights made the North entrance the preferred channel. It seemed very clear that a craft of even the Christopher K's draft could safely navigate into the harbor using the Tulum lights as a horizontal ranging system to define the limits of "safe water" through the reef cut.

By 2100 hours we were anchored again and had joined the land party by Zodiac. Back at the encampment, "talk around the

dinner-fire" led into a detailed discussion of the day's events, wonderful theories, and the schedule for tomorrow. The Christopher K would be leaving at noon, with the canoe, the dive gear and four of our people (Bill, Pam, Poncholo and Bolos) for the second phase of the study.

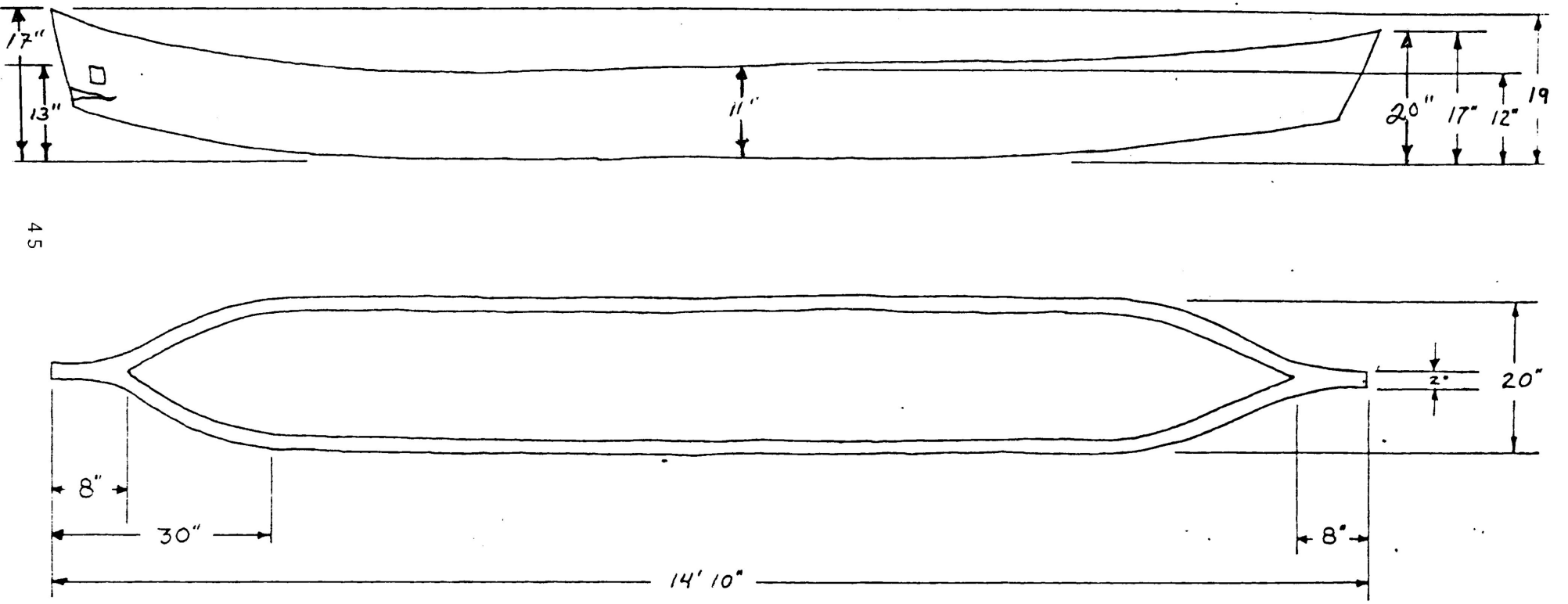
Sunday morning, July 21, 1985, our third day at Tulum, started early with a planned canoe experiment. Wanting to somehow test the actual capability of landing a traditional dugout, we located a small river canoe. (See figures 14 and 15). Ric Hajovsky maneuvered the unstable craft expertly through the surf to the beach to achieve a very successful landing without taking on any significant water. This was surprising in comparison to our small Zodiac which practically "swamped" everytime it came near the crashing surfline.

The last experiment left to complete was taking vertical sextant angles from each buoy to tie the diver's measurements into the shore. The boat was maneuvered alongside each buoy and the anglular distance was measured. (Refer to the following picture, note buoy on the port side.) Knowing the height of El Castillo from direct measurements, and the opposite angle from the sextant measurement, it was then a simple matter of trigonometry to obtain the distance offshore. (See Appendix II and Figure 16 for details). After the angle was measured, we recovered the buoy. At 1300 hours the Christoper K returned to Cozumel, while we returned to Tulum and spent the remainder of the day exploring the ruins in the vicinity.

Monday morning I was awakened at sunrise. After attempting

Figure 14: Traditional Mayan-type River Canoe used to explore the possibility of safely landing on Tulum's beach.

Figure 15: Specifications of
Mayan-type Canoe

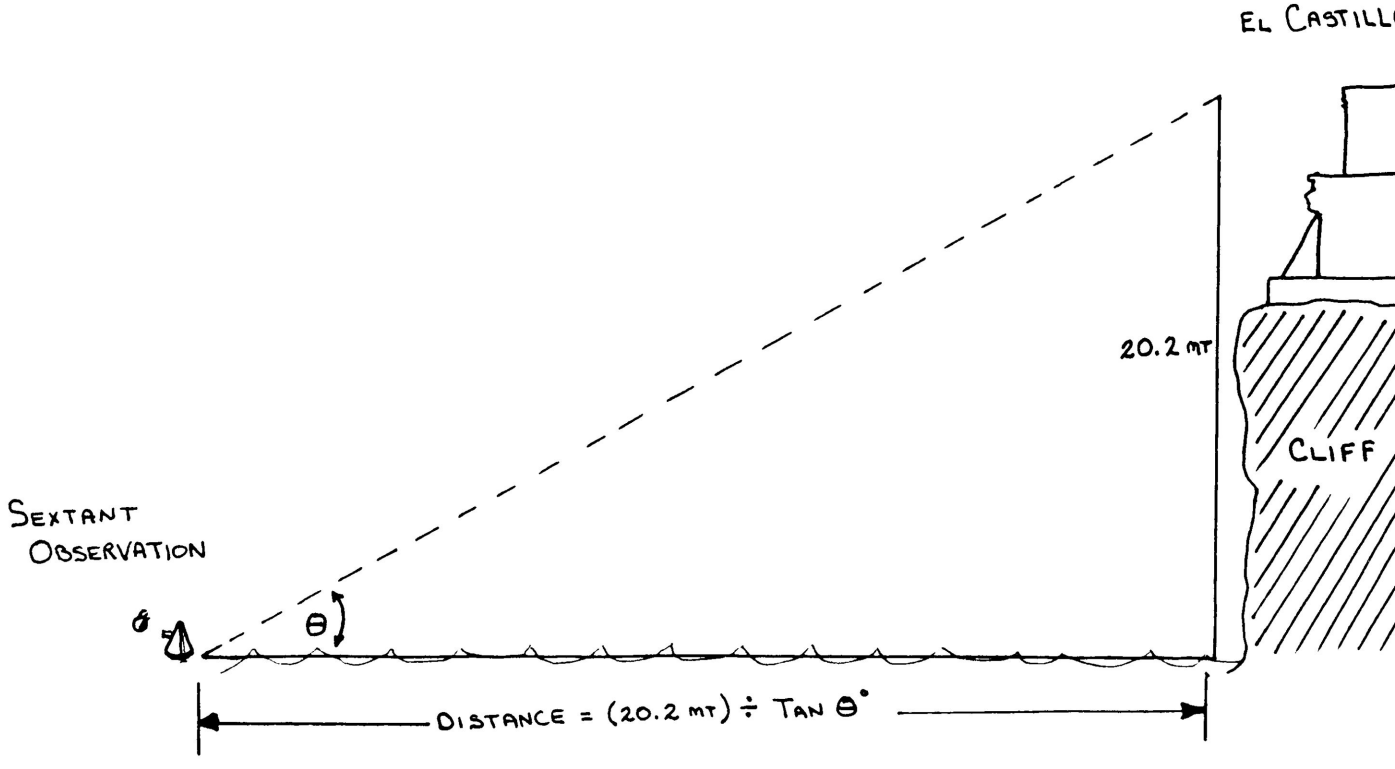


SCALA: 1" = 50 cm (MEDIDAS NOTADO IN PULGADAS)
(measurements noted in inches)

DUGOUT CANOE USED IN 1985 TULUM EXPERIMENT
FROM "EL PORTAL", COZUMEL

HAJOUSKY

Figure 16: PICTORIAL REPRESENTATION OF VERTICAL SEXTANT ANGLES TAKEN FROM THE WATER



to take morning stars once again, I finally gave in to the fact that conditions would not permit it. Already the Mayas were awake in the North tower (or so one could imagine by the amount of activity around that little ruin). Gas lamps had been placed in the structure and again in El Castillo. The Zodiac, with Michael and Pilar, was making north-south passes within the harbor taking a visual survey of how the windows in El Castillo might have functioned in conjunction with the North tower. The strengthening light of day soon made the lights only a faint glimmer that soon vanished altogether. From what they were able to determine, the north structure could have helped bring traffic safely inside the reef south from Sante Fe Point, as well as serving craft landing on the Tulum beach as discussed earlier in section IV.

After the Zodiac made its final landing, we dismantled it and carried all the gear back to the encampment. There a thorough fresh water washdown was given to everything. Waiting for things to dry, we held a short sextant handling class down on the beach. After that small break we took measurements of the cliff and El Castillo to obtain their total height. Climbing upon the top of the El Castillo, we could see the reef entrance and coral obstructions very distinctly. When at water level or even on the cliff, the glare of the sun prevents one from accurately "reading the water". Only with added height, as we now had, does one get a complete picture of the layout of the underwater hazards. It seemed an interesting coincidence that we were practically at the same height as the moder Tulum lighthouse to the south. This was an unexpected grand finale! Seeing the

view of the harbor from this height of eye enabled us to clearly identify the obstruction-free channel to the northern side of the reef entrance. This was in keeping with the results of the night experiment. Because we picked up the south light at both extremes of the entrance, we concluded that the North window produced the narrower angle of the two light spreads. During the times when both North and South lights could be discerned, it was agreed that safe water would have been available to enter through the reef entrance. However, they were visibly at their brightest when a 'head on view' placed you within this northern channel. Figure 17 presents a summary of these conclusions and further more detailed measurements are again found in Appendix II.*

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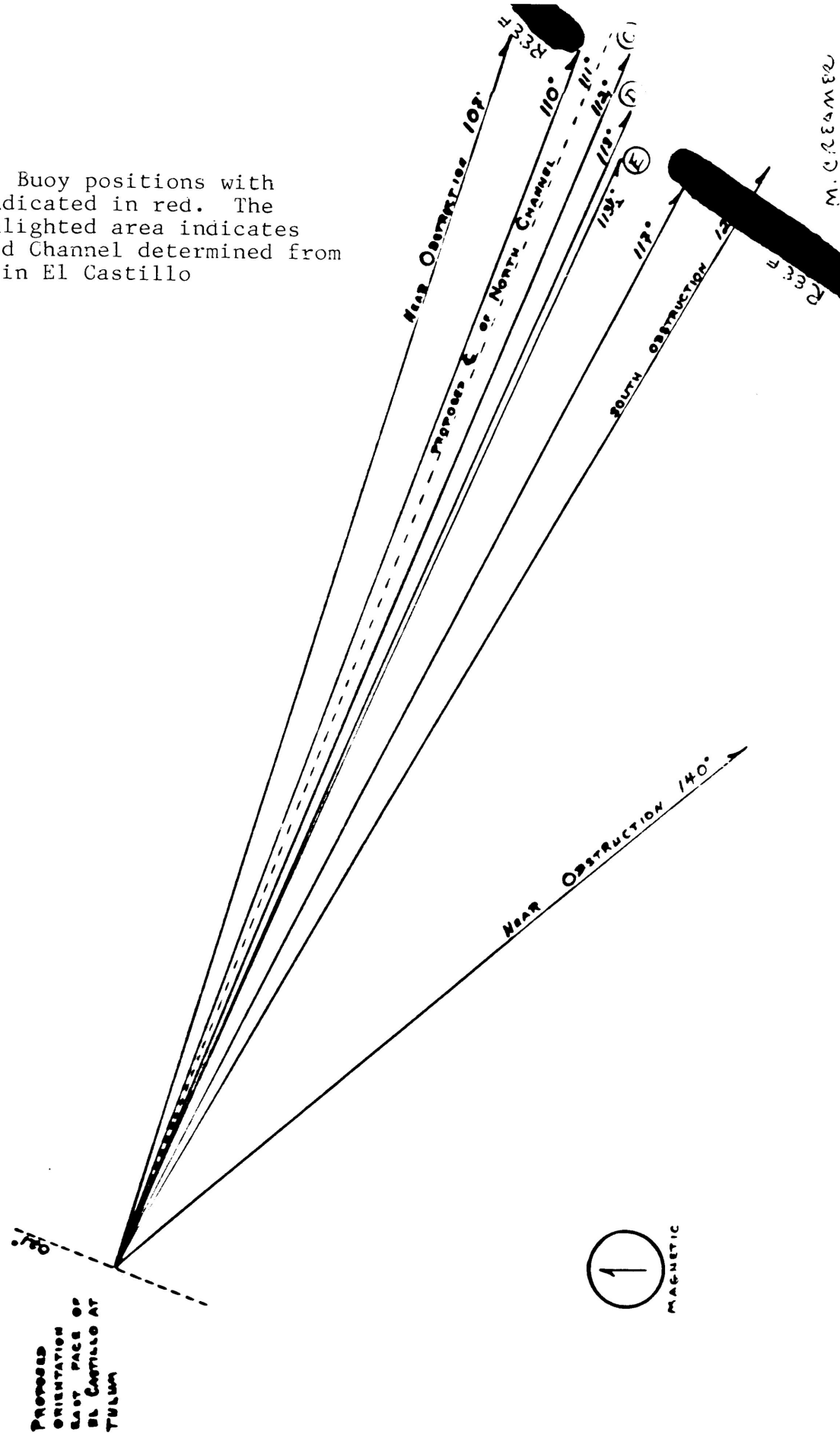
*The team, with several new people, returned to the Tulum site on August 20, 1985. We completed approximately two and a half days of field work. Buoys were repositioned as closely as possible to their original placement. Several new buoys were also used to mark different coral heads. A survey baseline was established between the INAH encampment, El Castillo, the south structure and the modern lighthouse and survey work using a transit then established angles from each structure to the buoys. At this writing, several inconsistencies in the survey work preclude any final evaluation of the results of this second Tulum experiment and it is therefore not analyzed in detail here.

Figure 17: Buoy positions with the reef indicated in red. The yellow highlighted area indicates the prefered Channel determined from the lights in El Castillo



VI. Conclusions and Further Plans

Our field simulation of the approach to Tulum through the protecting barrier reef demonstrated conclusively that Mayan trade could indeed have utilized this structure for nightime navigation as depicted in the artist's drawing in figure 18. The failure of this experiment would have caused serious doubt about the years of study and investigation concerning the role of sea-trade in Mayan civilization. But nagging questions and grander speculations remain to be investigated.

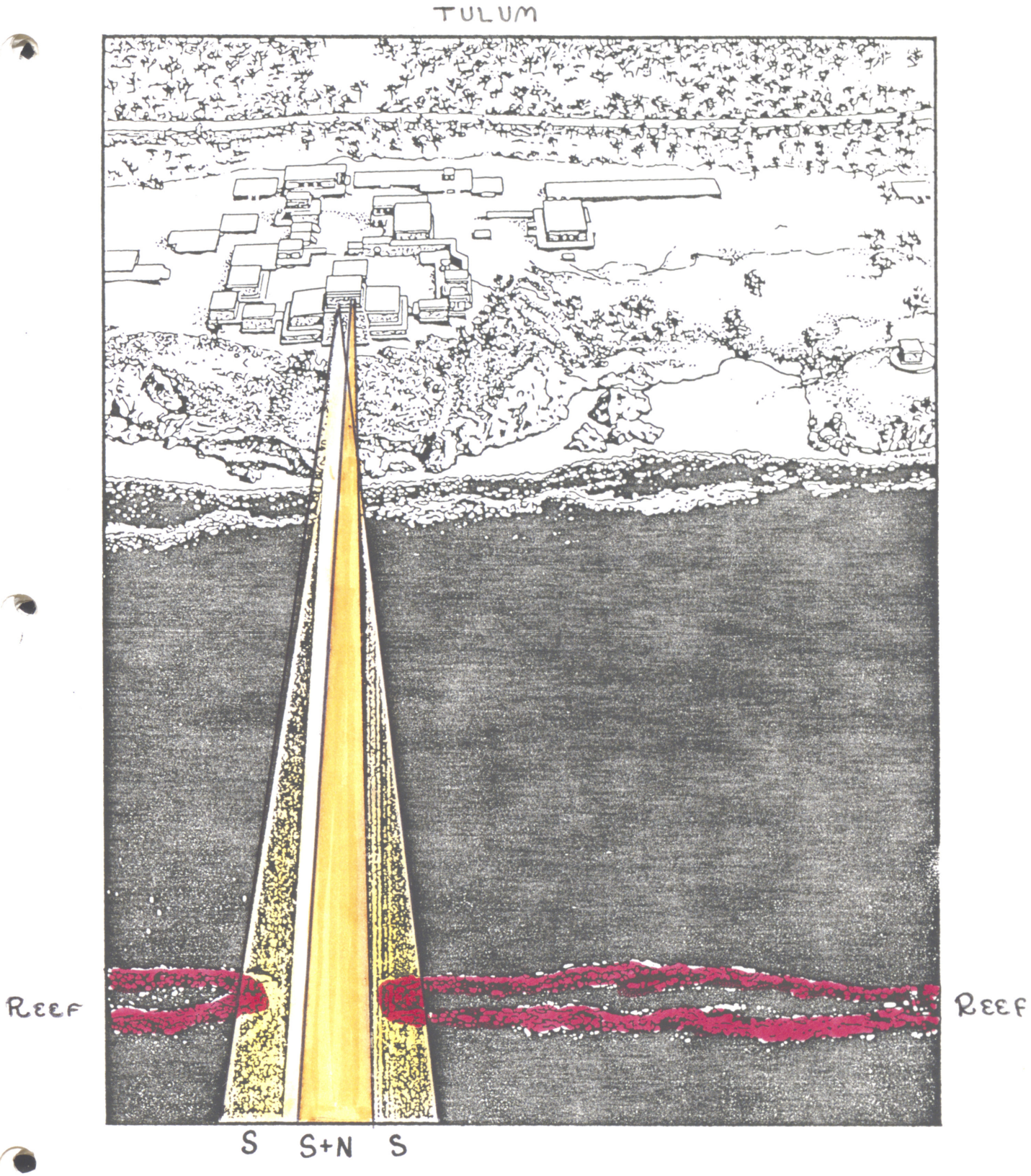
Question 1: Given our careful measurements of the dimensions of the upper set of windows in El Castillo which were utilized in this experiment, it is clear that both are in principle visible at angles in excess of those appropriate for safe navigation.

Question 2: The interior of the rooms containing the windows is in almost all respects consistent with dwellings of the elite found at inland sites on Cozumel and elsewhere. If this were a dwelling, could the windows have been used only at times when weather required a beacon visible at long range?

Question 3: If the answers to the questions posed above suggest only limited use, how did the reef passage occur under normal circumstances?

Figure 19 showing the face of El Castillo provides a clue to one possible resolution of these remaining problems. If one looks just below the man standing on the upper deck, one sees the north lower window. Similarly in the other picture in figure 19, one can see the south lower window. However, in each picture, both of the upper windows remain visible. Thus the lower windows, while not as prominant from a distance, nevertheless provide a more limited angular region over which both can be seen. Therefore, in times of good visibility during which these windows

Figure 18: Artist's pictorial representation of Tulum site showing angular light spread from El Castillo



CANRIGHT & CREAMER

can be seen from outside of the reef, they may provide a more accurate mark for the small reef opening than do the more visible windows.

Finally, I would like to discuss follow-on projects which are being considered.

First, the role of the North and South structures in navigation inside the harbor may be studied via methods similar to those employed in 1985.

Second, an experiment studying the ability of the lower windows to locate the reef opening should be carried out.

Third, a study might be carried out placing brightly colored (red and blue) partitions behind the upper Castillo windows. This suggestion results from some of my wilder speculations based upon an almost futuristic drawing found in Lothrop's work. (Figure 20). In this plate, Lothrop is depicting the walls behind the upper windows as he found them in 1924. Since light dispersion depends upon color, were the Maya to have used such colors, the angular range for the observation of the upper windows would have been more limited, thereby providing a more accurate fix on the position of the reef opening. This theory, would reduce the concerns expressed in question 1 above.

Finally, in the event that the possibility of night navigation is accepted at Tulum, similar projects should be undertaken along the coast to determine the extent to which the coastal ruins may be considered as a navigational system, rather than a collection of relatively isolated sites.

Figure 19: North and South windows of the lower level of the El Castillo

(a) North lower window

(b) South lower window

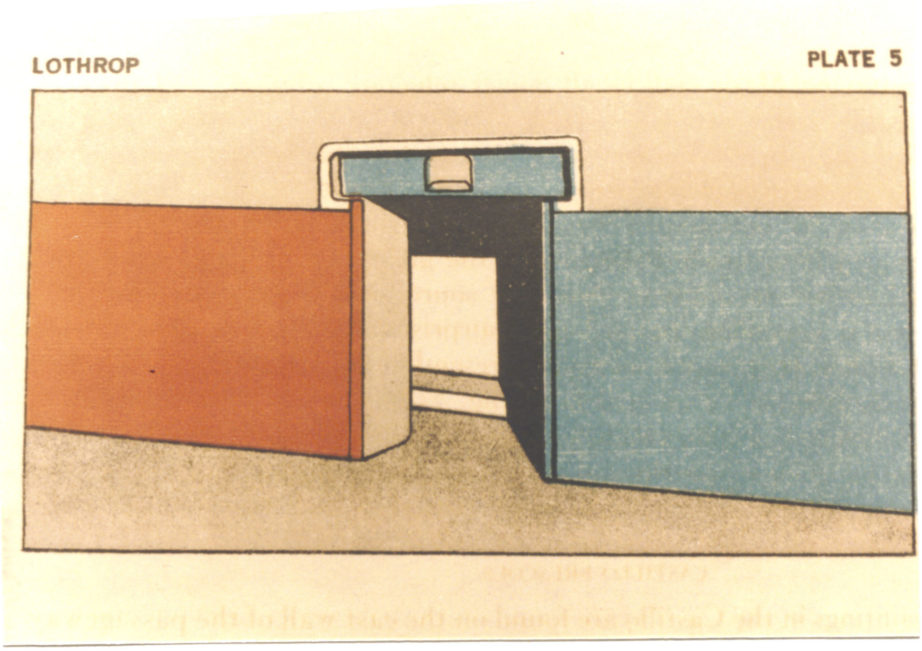


Figure 20:

Lothrop's Plate 5 depicting the walls as found in El Castillo

which served as altars. The vault of this and the next room is shaped like the neck of a bottle. The doorway leading to the inner room is illustrated on plate 5, A. It has a sunken panel painted a brilliant turquoise blue, with a geometrical figure in the center. The north half of the room was painted red and the south half blue.

The inner room (fig. 46) is a few inches longer than room *a* and 8 feet wide. At the corners of the door are four stone rings for hanging a curtain. Running across the back and ends of the chamber is a bench on which the present-day Indians

FIG. 45.—Room *a*, Castillo, Tulum.

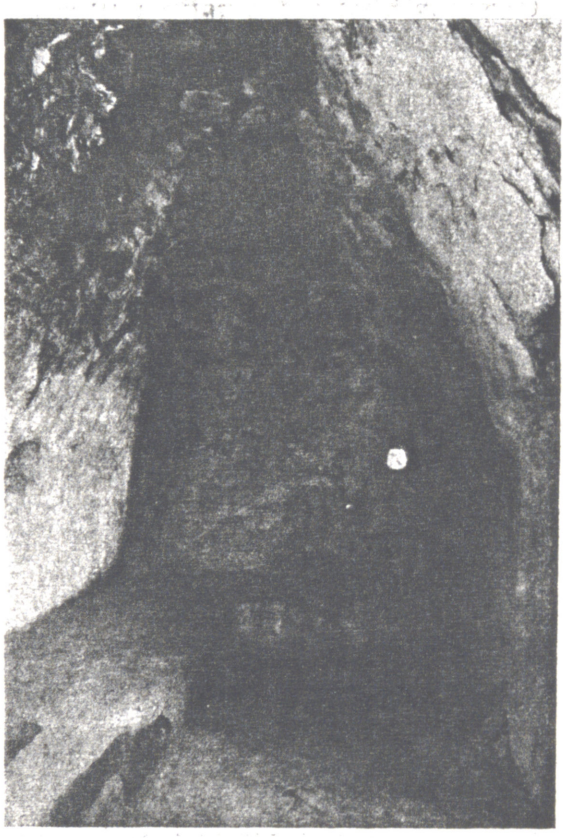


FIG. 46.—Room *b*, Castillo, Tulum.

have placed a small cross (fig. 10), to which they pray. Above the bench are four windows. The two in the east wall are splayed on the under side and command a magnificent view of the sea, some 70 feet below.

This final project involving the whole of the coastal Mayan world was proposed more than a half century ago by Mason in his work Silver Cities of Yucatan (Mason 1927:327

> "... a water route down the east coast of Yucatan. Strung along this reef-bound coast we found good canoe harbors connected with ruined trading towns at Xkaret, Paalmul, Chakalal, Ac, Acomal and Muyil....The canal that connects the two lakes east of the ruins of Muyil was not dug for the passage of pilgrims. Some of the high buildings overlooking the dangerous rocks that the trade winds whiten with foam were lighted to God, no doubt, but they were also excellent beacons to belated argosies bearing the incense and feathers and jade so dear to the deities of a nation of peaceful traders."

Appendix I: Day plans for the experiments at Tulum; Summer 1985.

V. DAY ONE

A. Minimum Goals to Accomplish

1. Assemble all team members <u>on</u> site

2. Set buoys & obtain bearings (Ø's)

3. Anchor boats

4. Secure sleeping arrangements

B. Proposed Itinerary

0600 . . . . .Breakfast

0700 . . . . .Depart Cozumel

. . . . .Arrive Tulum

. . . . .Buoys temporarily set;
boats anchor

. . . . .Buoys more securily set;
Ø's taken from land by Shore Party

. . . . .Dinner ashore & sleeping
arrangements made

V. DAY ONE Con.

C. Method

1. Boats arrive Tulum from Cozumel with all expedition members and equipment (or meet other team members as per agreement)

2. Outside reef entrance, launch Zodiac from Christopher K. with Operator, Dive Team #1, and buoys

3. Other boats stand-by while outside reef entrance, coral heads, and anchorage area are temporarily marked

4. Zodiac returns divers to serve as pilots for incoming boats

5. Boat with fathometer proceeds through reef entrance first; records depths as navigates in and anchors

6. All boats follow through reef opening and record magnetic heading and Ø of El Castillo; boats anchor

7. Dive Teams #1 & #2 reposition and secure buoys; mark inside of reef opening with unlit buoys

8. Shore Party lands and takes Ø's with handbearing compass & sextant on buoys from El Castillo ventanas, N caleta tower, and S wall tower

9. Dinner ashore and sleeping arrangements made (Tulum encampment optional)

10. At night if ashore, might take notice of orientation of N star relative to ventanas of El Castillo & other structures

VI. DAY TWO

A. Minimum Goals to Accomplish

1. Verify previous day's buoy Ø's
2. Obtain Ø's of buoys from the other structure ventanas
3. Obtain accurate data of the reef entrance, coral heads, and caleta
4. Perform nightime experiment to enter reef using lights from El Castillo

B. Proposed Itinerary

0700 . . . . .Breakfast

0800 . . . . .Boat, Dive, and Shore Parties commence taking Ø's and measurements

1200 . . . . .Lunch

1700 . . . . .Shore Party continue preparations for night's experiment; Boat Parties light buoys

Dusk . . . . .Shore Party light gas lamps; Boat Parties take stations

Perform Tulum Experiment

VI. DAY TWO Con.

C. Method

1. Daytime

a. Shore Party

1) Re-shoot Ø's of buoys from structure ventanas to verify their locations; check at least twice daily, esp. before using them for navigation

a) Have VHF contact to notify Boat & Dive Teams of any radical changes

2) El Castillo:

a) determine angle of buttress, N & S sides

b) report on buttress shadows as sun passes E to W

c) buttress width--compare to reef width dimension & width of lower ventanas

d) check for possible benches under or near ventanas

e) maximum height

f) details of ventanas, including:
(i) maximum height of each
(ii) width between each set
(iii) depth of each
(iv) window width
(v) principle orientation of each
(vi) detailed description of the window construction

(Check against 1984 readings)

3) Caleta

a) width and depth of beach

b) rise and fall of tide (with times)

c) slope of beach

VI. DAY TWO Con.

4) Other Structures Facing the Water

a) Measure the distance to S structure to El Castillo and from N structure to El Castillo

b) Orientation with Ø's from ventanas

b. Dive Teams #1 & #2

1) Divers verify setting of buoys

2) Obtain data & measurements, etc. of reef and surrounding area; as much as can be done, weather, & time permitting

3) Reef:

a) distance apart from entrance sides; draw sketch to show relative distances

b) each side's distance to El Castillo

c) observe and record channel angles relative to El Castillo buttress

d) water depth in reef entrance

4) Coral Heads:

a) depth

b) avg. diameter & avg. height

c) distance apart

d) Ø's to sides of reef entrance (N & S)

e) description of heads & surrounding area; sketch, if applicable

5) Chart Shoal inside of N. reef opening

6) Caleta:

a) investigate beach area; determine slope of bottom

b) bottom characteristics

VI. DAY TWO Con.

c. Boat Party

1) Monitor working VHF channel

2) Be on stand-by to assist as necessary

3) Obtain data from boat as available i.e. with fathometer, handbearing compass, LORAN, RADAR, SAT/NAV, SONAR, etc.

4) Reposition Chris-Craft to SAT/NAV position obtained from GYPSY (only if do not have SAT/NAV available)

5) Chart info as available on Tulum aerophoto blow-up and/or sketch of area

6) Note shadows N & S of El Castillo buttress relative to channel

2. Dusk

a. Larger vessel takes station outside reef

b. Smaller boat remains inside

c. Shore Party preparations continue

1) Place gas lights on tower bench, not windows

a) might put one in N structure while performing experiment reef entrance & see how/if it guides to the caleta (to be done if conditions permit)

2) Hang white sheet to simulate reflective white-wash surface in tower

VI. DAY TWO Con.

3) Fire extinguishers to be on hand

d. Communications firmly established with each party on working VHF channel

3. Nightime

a. Boat Parties

1) Both determine max/min. angles of El Castillo lights to reef opening buoys with bearing compasses

2) Purpose--to determine degree of accuracy tower windows focus light in relation to reef opening

3) Vessel outside, cruises parallel to reef:

a) takes bearings & distances off at points when lights become visible N, N & S together, and S only

b) records position and heading with each Ø

4) After data obtained, larger vessel to enter reef passage guided by smaller vessel, tower lights, and lighted buoys

5) Once inside, lead larger vessel to safe anchorage

6) Small boat returns outside reef & pilots back through reef entrance, takes N turn to caletta; determines how/if N structure sends light signal to aid in landing at caleta

a) takes Ø's, heading, position, etc.

VI. DAY TWO Con.

7) Attempt landing on the beach, if conditions permit

b. Shore Party

1) Set and tend lights in El Castillo and caleta N structure

2) Might consider taking a third person with them to assist landing on the beach

VII. DAY THREE

A. Minimum Goals to Accomplish

1. Repeat experiment of DAY TWO

2. Determine distance the Tulum lights are visible from sea as a discrete pair

3. Dive on outside of reef to determine feasibility of future expedition

B. Proposed Itinerary

0700 . . . . .Breakfast

0800 . . . . .Boat, Dive, and Shore Parties proceed as day before and/or as directed

1200 . . . . .Lunch

1700 . . . . .Proceed with Tulum Experiment as done in DAY TWO and as outlined

VII. DAY THREE Con.

C. Method

1. Check buoy placements and Ø's

2. Dive Teams #1 and #2 dive at entrance to reef opening to determine if subsequent dive expedition is feasible to look for evidence of pre-Columbian shipwreck

3. Nightime

a. Tulum Experiment conducted again to verify previous night's data

b. Once finished, larger vessel proceeds on a reciprocal course from El Castillo to determine the maximum distance at which the lights can be seen both with the naked eye and binoculars

c. Larger vessel afterwards returns to site and anchors, if possible

VIII. DAY FOUR

A. Minimum Goals to Accomplish

1. Check N & S reef entrances with Dive and Boat Teams

2. Shore Party to investigate modern navigational aid for evidence of Maya structure

3. Complete any outstanding work

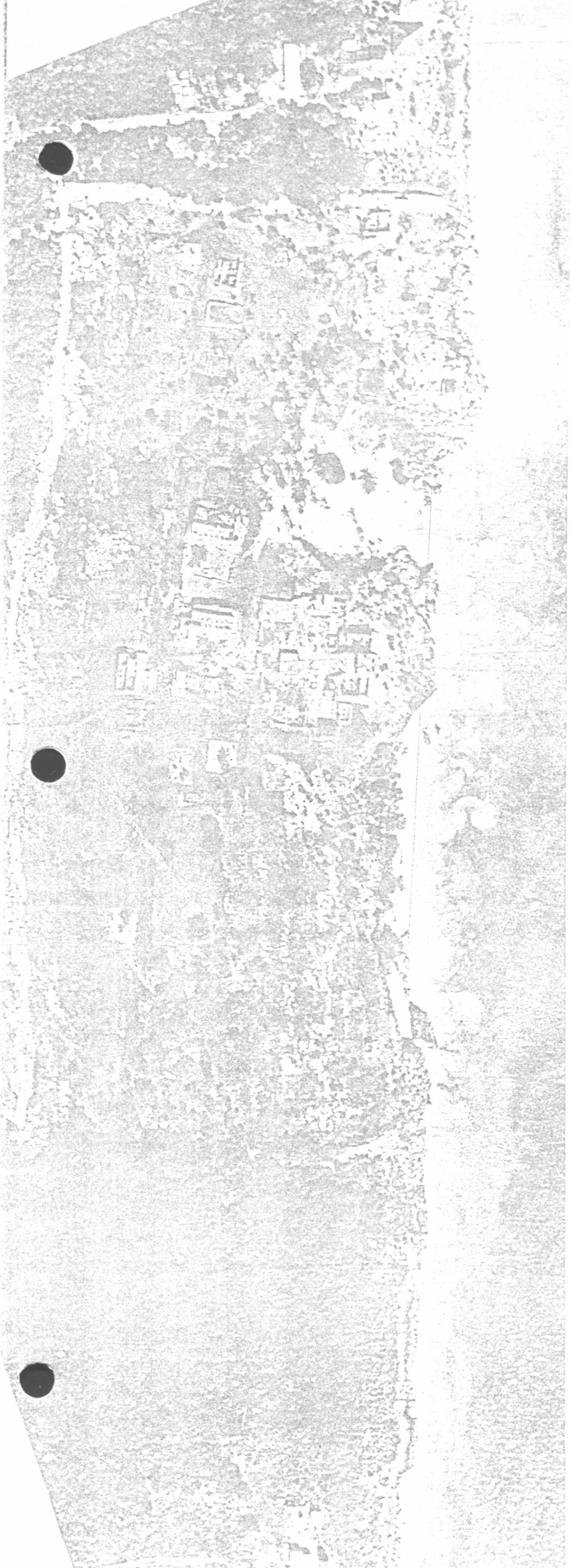
4. Return to Cozumel

B. Proposed Itinerary

0700 . . . . .Breakfast

All parties to continue as directed (Time, weather conditions, etc. permitting)

Appendix II: Field Measurments at Tulum: Summer 1985.



Appendix II: A

PHOTOCOPY OF AERIAL PHOTOGRAPH
DEPICTING TULUM SITE AND REEF ENTRANCE

Since there are no nautical charts of a large enough scale, this photograph was used to plot all data.

6 August 1985

Prehispanic Aids to Navigation

Summary of Buoy location and measurements taken during week of 21 July 1985

Buoys are plotted on bearings taken from El Castillo using Fujinon binoculars and with ranges derived from vertical sextant angles taken from the CHRISTOPHER K. when abeam of each buoy. Although consistent efforts have been made to minimize errors, this chart-like representation is only an approximation of the actual buoy settings.

The relationship between this data and that obtained by the Dive Team is graphically computed. By measuring across the graph to each buoy, a comparable distance results.

The two measurment systems have their extremes, but the smaller measurements of both sets of data indicate near agreement. The Dive Team measurements are probably more accurate for single tape measurements where the buoys are in close proximity. Whereas, the vertical sextant angles would seem to give better readings than step-and-repeat tape measurements. Although still subject to error, this could be greatly reduced by more clearly marking the mean water level and the top of the object viewed.

The usefulness of this chart will be to aid in repositioning the buoys for a second experiment. Additionally, the use of a transit ashore should greatly increase the accuracy in plotting buoy positions and so define the relation of the Tulum reef entrance channel to El Castillo.

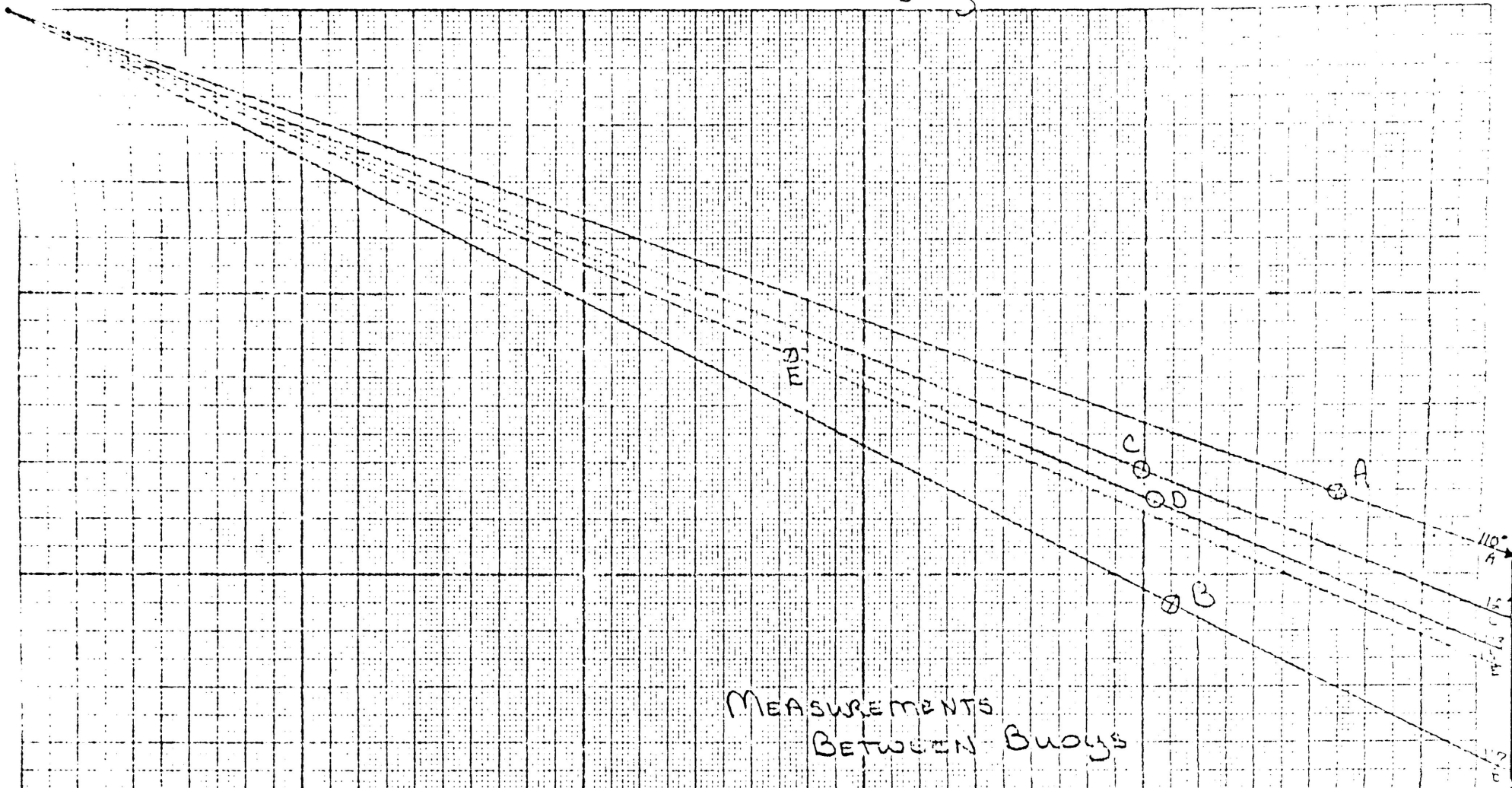
Submitted by:

Vel Lena Steed

Vel Lena Steed

cc: Peter Lunsford

Buoy Distances w/out Lift



Measurements Between Buoys

Buoys	Measured Dist. w/Vertical ∠'s	Dive Teams' Measurements	Difference
A - B	106.5 m	91.5 m	- 15 m
A - D	96 m	89.8 m	- 6.1 m
A - C	105 m	106.7 m	+ 1.7 m
B - D	57 m	54.9 m	- 2.1 m
D - C	18 m	18.3 m	+ 0.3 m
C - E	198 m	213.1 m	+ 15.1 m

⊕ indicates the average lengths of calculated vertical sextant angles for each buoy

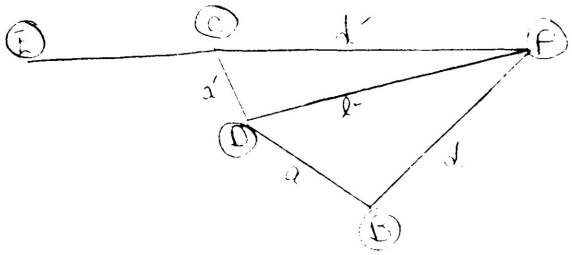
1 OF 2

EXPERIMENT DATA FROM WEEK OF 21 July 1985

TRIANGLES FOR ERROR ESTIMATING TUTORIAL

DIVE TEAM MEASUREMENTS

Points	Course	Range
A - E	300°	91.5 = d
A - B	225°	89.9 = b
B - D	170°	54.9 = a
A - C	350°	106.7 = d'
C - E	60°	155.5
C - D	170 deg 60°	155.5 / 18.3 = a'



Known	Find	
b, d, a	A	$\cos A = \frac{d^2 + b^2 - a^2}{2db}$ $= \frac{91.5^2 + 89.9^2 - 54.9^2}{2(91.5)(89.9)}$ $A = 35.22°$
d, a, A	D	$\sin D = \frac{d \sin A}{a}$ $= \frac{(91.5)\sin 35.22}{54.9}$ $D = 73.99°$
	B	$\sin B = \frac{(b)\sin A}{a}$ $= \frac{89.9\,(.5767)}{54.9}$ $B = 70.80°$
		$B + D + A = 180$ $35° + 74° + 71° = 180$
a', d', b	A'	$\cos A' = \frac{d'^2 + b^2 - a'^2}{2d'b}$ $= \frac{11384.89 + 8082.01 - 334.89}{2(106.7)(89.9)}$ $A' = 4.25°$
	D'	$\cos D' = \frac{b^2 + a'^2 - d'^2}{2ba'}$ $= \frac{8082.01 + 334.89 - 11384.89}{2(89.9)(18.3)}$ $D' = 154.43°$

TRIANGLES FOR BUOY SYSTEM

known : find C

$$\cos C = \frac{a'^2 + d'^2 - b^2}{2a'd'}$$

$$= \frac{334.89 + 11384.89 - 8089.01}{2(18.3)(106.7)}$$

$$C = 21.3^\circ$$

$$A' + D' + C = 180$$

$$4.3^\circ + 154.4^\circ + 21.3^\circ = 180$$

EXPERIMENT DATA
FROM WEEK OF
21 July 1985

DISTANCES FOR BUOYS USING VERTICAL ANGLES

HEIGHT OF EL CASTILLO: N = 10.9 m N = 20.2 m
Ē = 9.9 m

HEIGHT OF CLIFF: N = 9.3m Ē = 20.2 m
Ē = 10.33m

H_E = 1.83 m

ORIGINAL DATA Taken from buoys to shore

Buoy	H_s w/out Dip				
	①	②	③	④	⑤
A	1°-32.4'	1°-33.0'			
B	1°-39.6'	1°-39.2'	1°-41.8'	1°-41.0'	
C	1°-48.8'	1°-47.4'	1°-46.8'	1°-47.6'	1°-42.0'
D	1°-45.8'	1°-45.2'	1°-44.6		
E	2°-35.8'	2°-35.0'	2°-35.2'	2°-35.0'	
Ponchdo	1°-28.4'				

Buoy	H_s w/Dip of -2.2'				
	①	②	③	④	⑤
A	1°-30.2'	1°-30.8'			
B	1°-37.4'	1°-37.0'	1°-39.6'	1°-38.8'	
C	1°-46.6'	1°-45.2'	1°-44.6'	1°-45.4'	1°-44.8'
D	1°-43.6'	1°-43.0'	1°-42.4'		
E	2°-33.6'	2°-32.8'	2°-33.0	2°-32.8'	
Ponchdo	1°-26.2'				

EXPERIMENT DATA
FROM: WEEK OF
21 JULY 1985

	w/out DIP		w/ DIP	
BUOY A	① 20.2 / TAN 1.54°	= 751.36	① 20.2 / TAN 1.5033°	= 769.70
	② 20.2 / TAN 1.55°	= 746.51	③ 20.2 / TAN 1.5133	= 764.61
	AVG. LENGTH	748.93 m	AVG. LENGTH	767.15 m
BUOY B	① 20.2 / TAN 1.66°	= 697.02	① 20.2 / TAN 1.6233°	= 712.77
	② 20.2 / TAN 1.6533°	= 699.83	② 20.2 / TAN 1.6167°	= 715.71
	③ 20.2 / TAN 1.6967°	= 681.95	③ 20.2 / TAN 1.66°	= 697.02
	④ 20.2 / TAN 1.6833°	= 687.35	④ 20.2 / TAN 1.6467°	= 702.67
	AVG. LENGTH (1,2)	698.43 m		
	(3,4)	684.65 m		
	AVG. LENGTH	691.54 m	AVG. LENGTH	707.04 m
BUOY C	① 20.2 / TAN 1.8133°	= 638.05	① 20.2 / TAN 1.7767°	= 651.22
	② 20.2 / TAN 1.79°	= 646.37	② 20.2 / TAN 1.7533°	= 659.89
	③ 20.2 / TAN 1.78°	= 650.00	③ 20.2 / TAN 1.7433°	= 663.68
	④ 20.2 / TAN 1.7933°	= 645.17	④ 20.2 / TAN 1.7567°	= 658.64
	⑤ 20.2 / TAN 1.7833°	= 648.79	⑤ 20.2 / TAN 1.7467°	= 662.41
	AVG. LENGTH	645.68 m	AVG. LENGTH	659.17 m
	AVG. LENGTH ②③	648.19 m	AVG. LENGTH ②&③	661.79 m

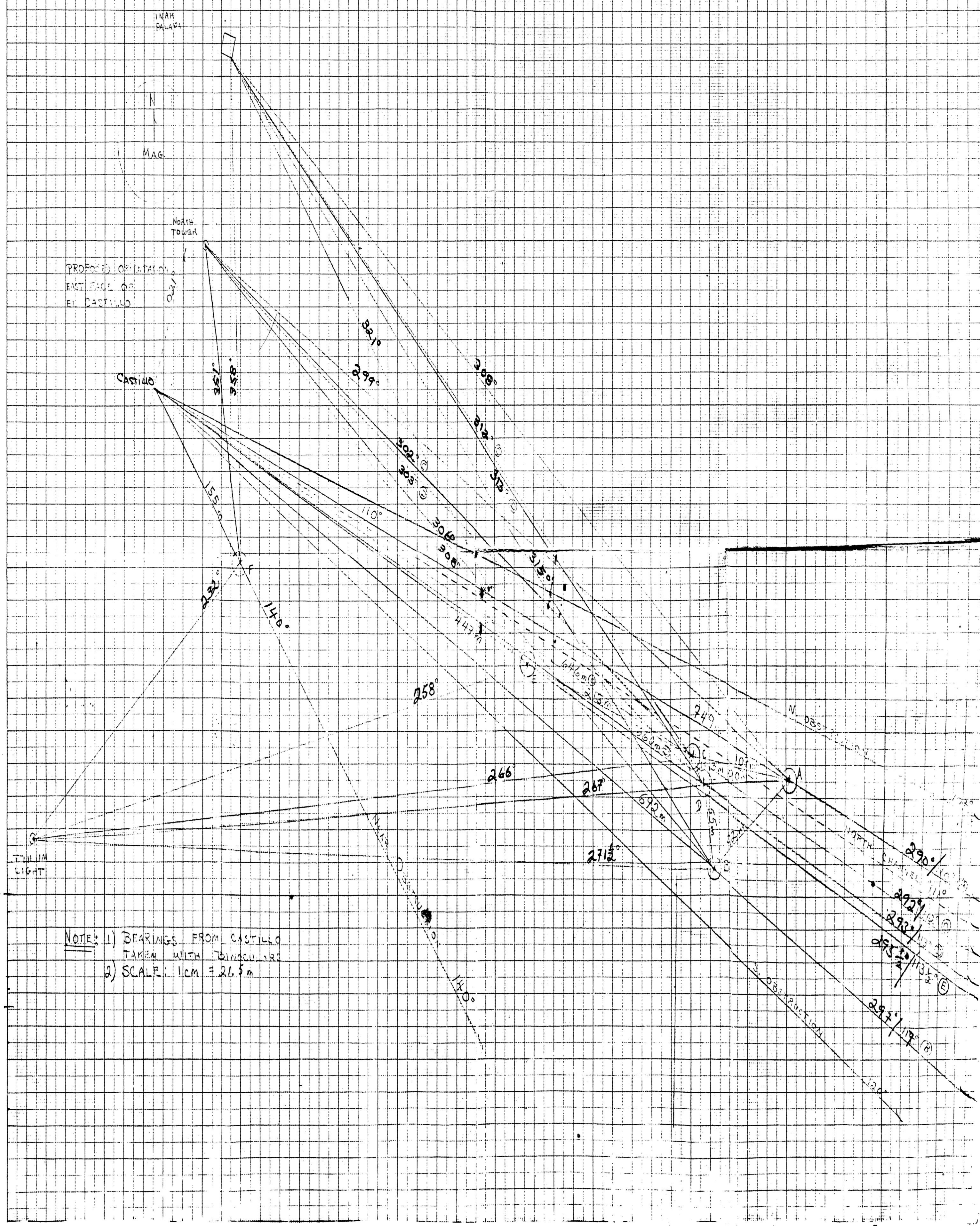
EXPERIMENT DATA
FROM WEEK OF
21 July 1985
3 OF 3

	w/out Dip		w/ Dip	
Buoy D	① 20.2 / TAN 1.7633°	= 656.15	① 20.2 / TAN 1.7267°	= 670.09
	② 20.2 / TAN 1.7533°	= 659.89	② 20.2 / TAN 1.7167°	= 673.997
	③ 20.2 / TAN 1.7433	= 663.68	③ 20.2 / TAN 1.7067°	= 677.95
	AVG. LENGTH	659.91	AVG. LENGTH	674.01m
	AVG. LENGTH ②③	661.79	AVG. LENGTH ②③	675.97m
Buoy E	① 20.2 / TAN 2.5967°	= 445.41	① 20.2 / TAN 2.56°	= 451.80
	② 20.2 / TAN 2.5833	= 447.71	② 20.2 / TAN 2.5467°	= 454.17
	③ 20.2 / TAN 2.5867	= 447.13	③ 20.2 / TAN 2.55°	= 453.57
	④ 20.2 / TAN 2.5833	= 447.71	④ 20.2 / TAN 2.5467°	= 454.17
	AVG. LENGTH (2,3,4)	447.52	AVG. LENGTH (2,3,4)	453.97 m
	AVG. LENGTH	446.99m	AVG. LENGTH	453.42 m
Ponchos	① 20.2 / TAN 1.4733°	= 785.38m	① 20.2 / TAN 1.4367°	= 805.43 m

Appendix II: C

GRAPHIC REPRESENTATION OF BUOY POSITIONS, DISTANCES, AND RELATED BEARINGS

BY: Creamer and Steed

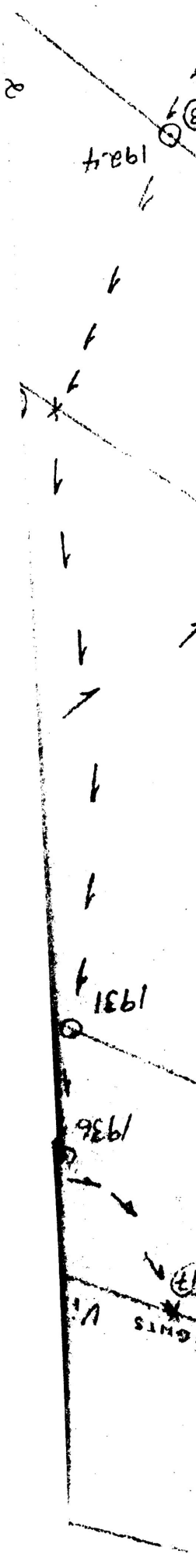

INAH PALAPA
N
MAG
NORTH TOWER
PROPOSED ORIENTATION EAST FACE OF EL CASTILLO
CASTILLO
155 m
232°
140°
258°
266°
267°
271½°
TULUM LIGHT
A
B
NORTH CHANNEL
N. OBSTRUCTION
S. OBSTRUCTION
NOTE: 1) BEARINGS FROM CASTILLO TAKEN WITH BINOCULARS
2) SCALE: 1cm = 21.5m

Appendix II: D

PROPOSED BOAT COURSE
1985 Tulum Survey

by:

Steed & Creamer

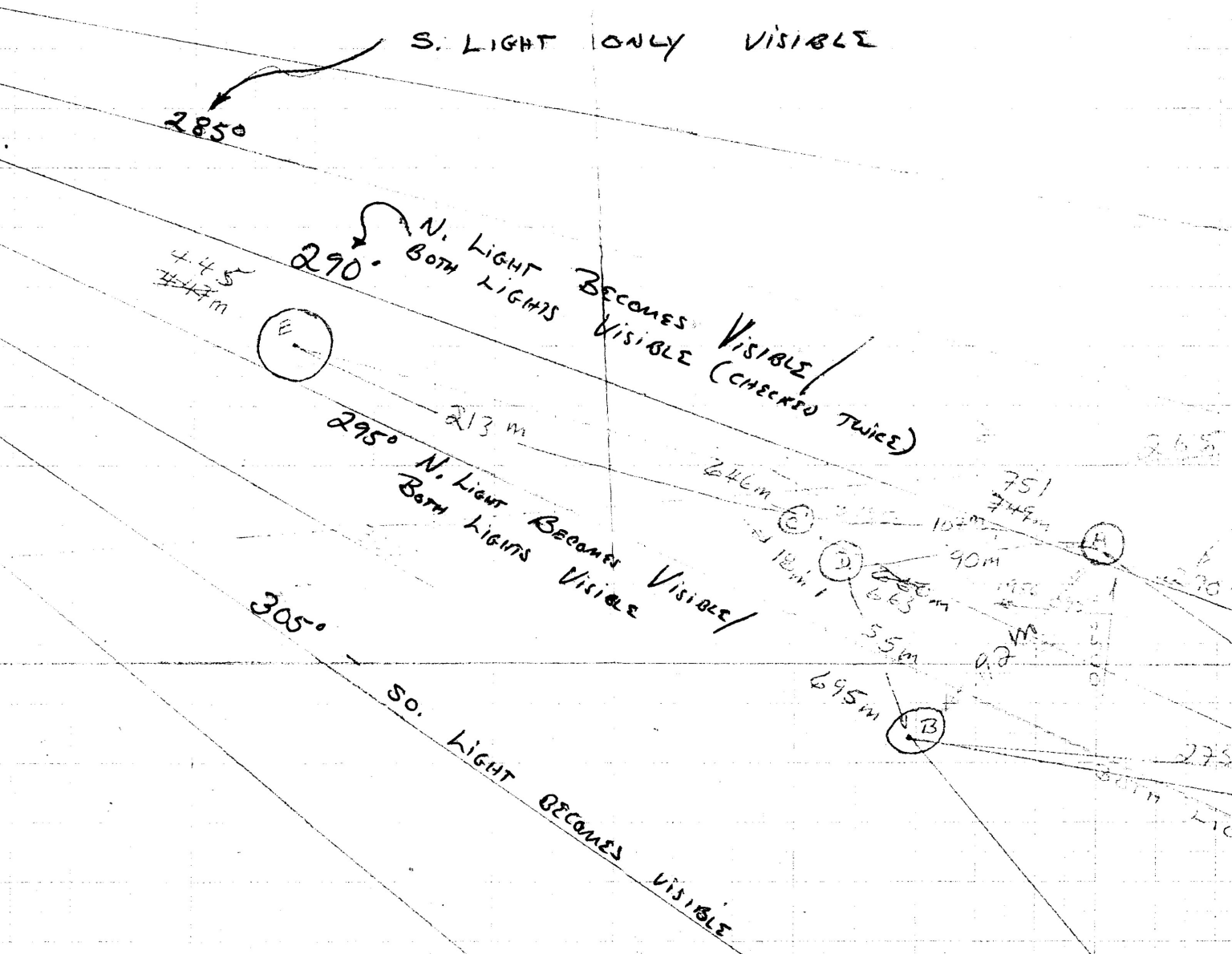


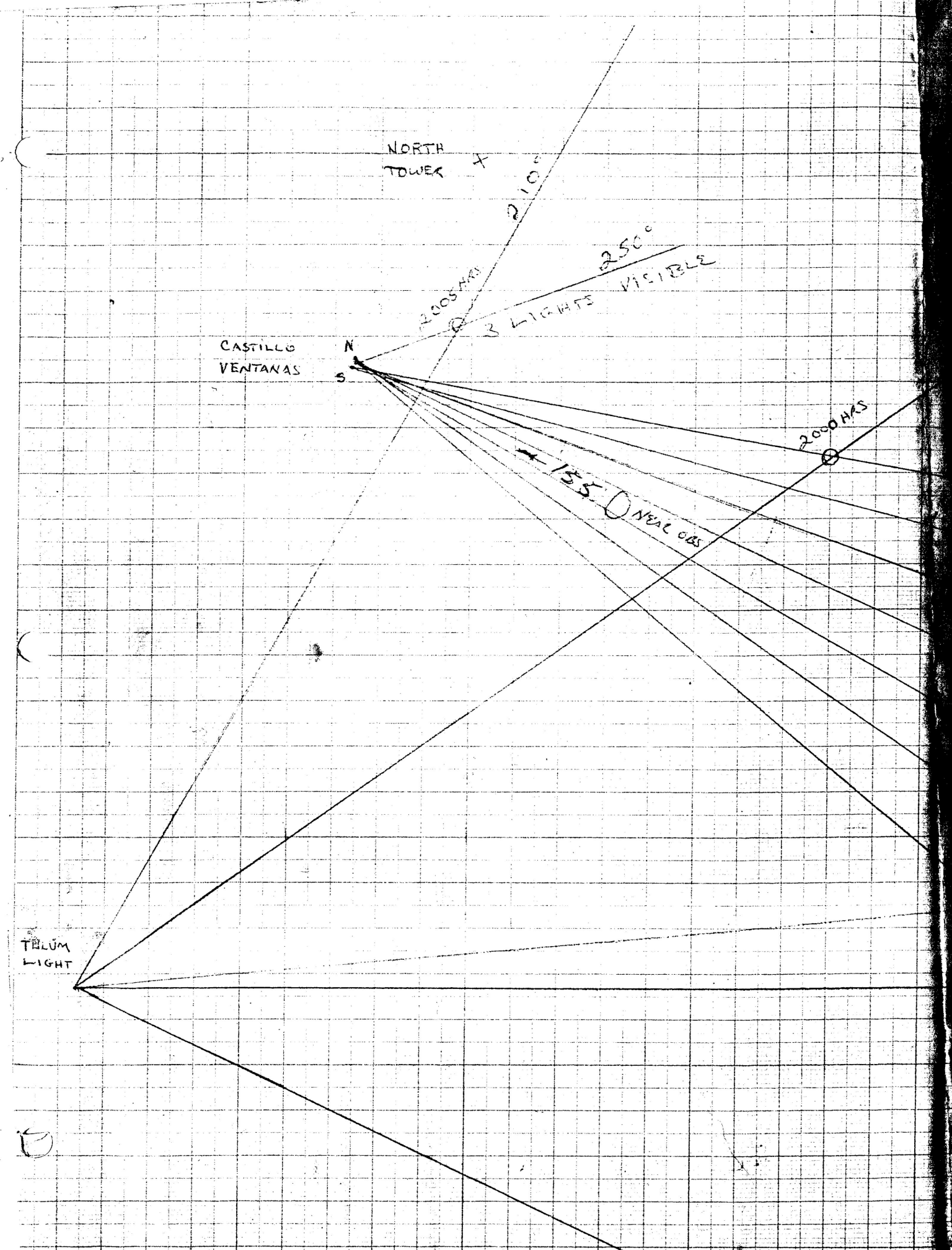
PROPOSED BOAT COURSE
1985 TULUM SURVEY
VEL LENA STEED & M. CREAMER
OVERLAY FOR AERO PHOTO CHART
NOTES:
1. BUOY PLACEMENT FROM FUJINON READINGS. +2° RELATIVE TO "HOCKEY PUCK"
2. BEARINGS W/ HOCKEY PUCK
INAH PALAPA
UP ANCHOR
EL CASTILLO
3 CASTILLO LIGHTS VISIBLE (INCL. N. FACE LIGHT)
CASTILLO ABEAM
255°
235°
LIGHT DISAPPEARS
SO. LIGHT ONLY CLEARLY VISIBLE
BOTH LIGHTS VISIBLE
SOUTH LIGHT VISIBLE
280°/100°
285°
270°
290°/110°
295°/115°
305°/125°
310°
320°
275°
TULUM LIGHT
N
SCALE: 1cm = 20m (APROX.)

Appendix II: E

GRAPHIC REPRESENTATION BEARINGS OF OUTER LIMITS OF LIGHT AS SEEN DURING THE NIGHT EXPERIMENT FROM THE WATER

By: Creamer and Steed


S. LIGHT ONLY VISIBLE
285°
N. LIGHT BECOMES VISIBLE/
BOTH LIGHTS VISIBLE (CHECKED TWICE)
290°
4.45
447m
E
213 m
295° N. LIGHT BECOMES VISIBLE/
BOTH LIGHTS VISIBLE
305°
SO. LIGHT BECOMES VISIBLE
246m
751
744m
90m
55m
695m
B

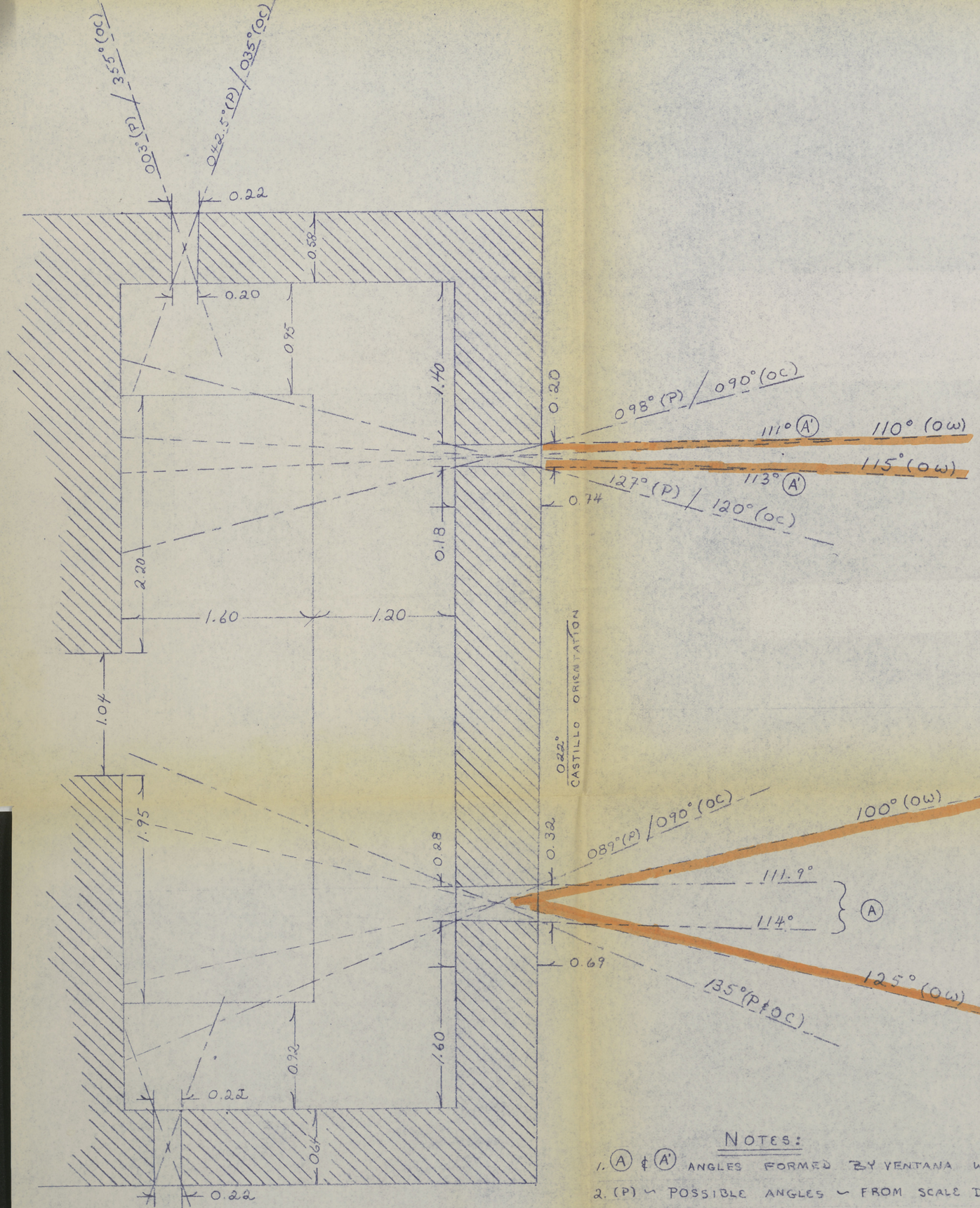

NORTH
TOWER
210°
250°
2005 HRS
3 LIGHTS VISIBLE
CASTILLO
VENTANAS
N
S
2000 HRS
155°
NEAR OBS
TULUM
LIGHT

Appendix II: F

DIMENSIONS OF EL CASTILLO FRONT ROOM AND FOUR WINDOWS, PLAN VIEW AND CROSS SECTION INCLUDED.

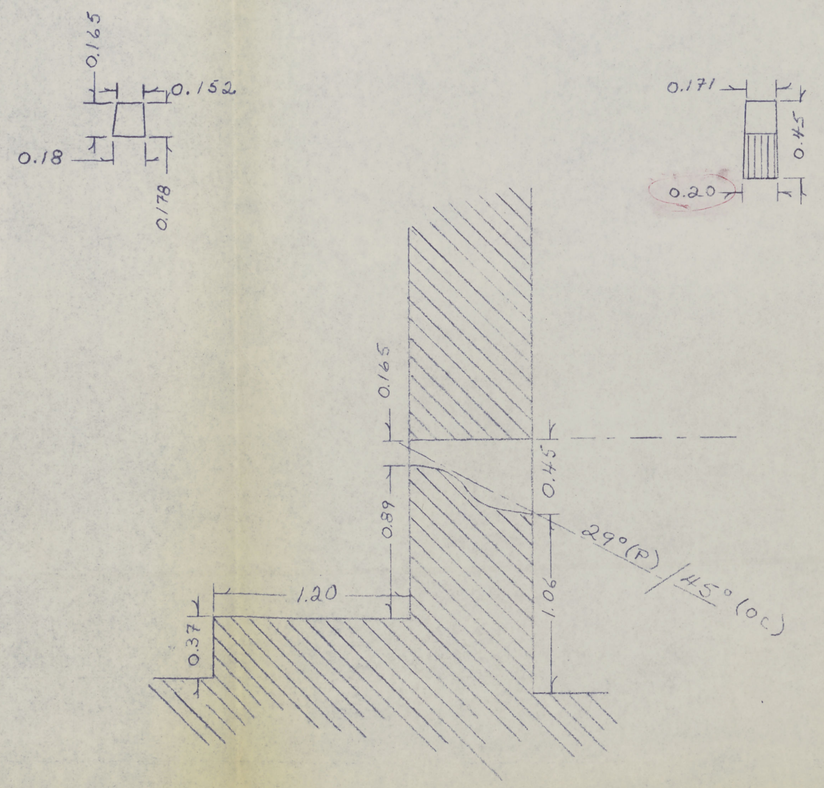
Orange highlight indicates the observed angular spread of light.

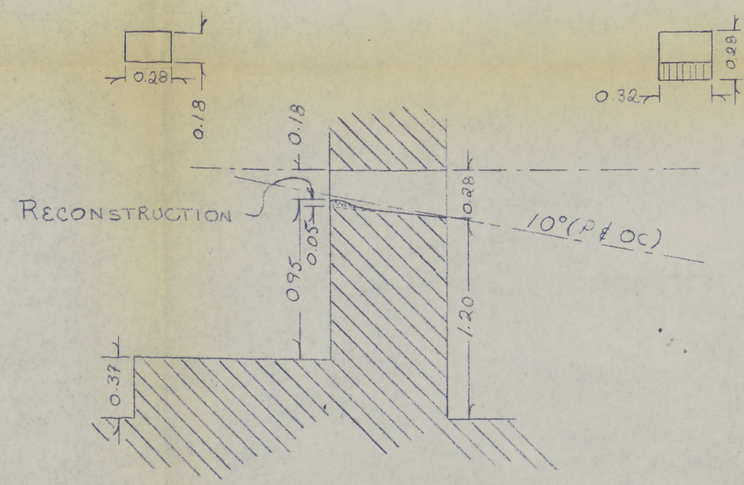
By: Creamer, Steed and Sillar



SCALE: 4cm. = 1m.

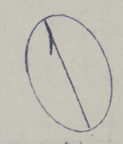
INTERIOR SECTION EXTERIOR





NOTES:

1. (A) & (A') ANGLES FORMED BY VENTANA WALLS
2. (P) ~ POSSIBLE ANGLES ~ FROM SCALE DWG
3. (OC) ~ ANGLES OBSERVED FROM EL CASTILLO ~ ROMERO & FLORES
4. (OW) ~ ANGLES OBSERVED FROM WATER ~ "HOCKEY PUCK"



MAGNETIC NORTH M.A.C. '86

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