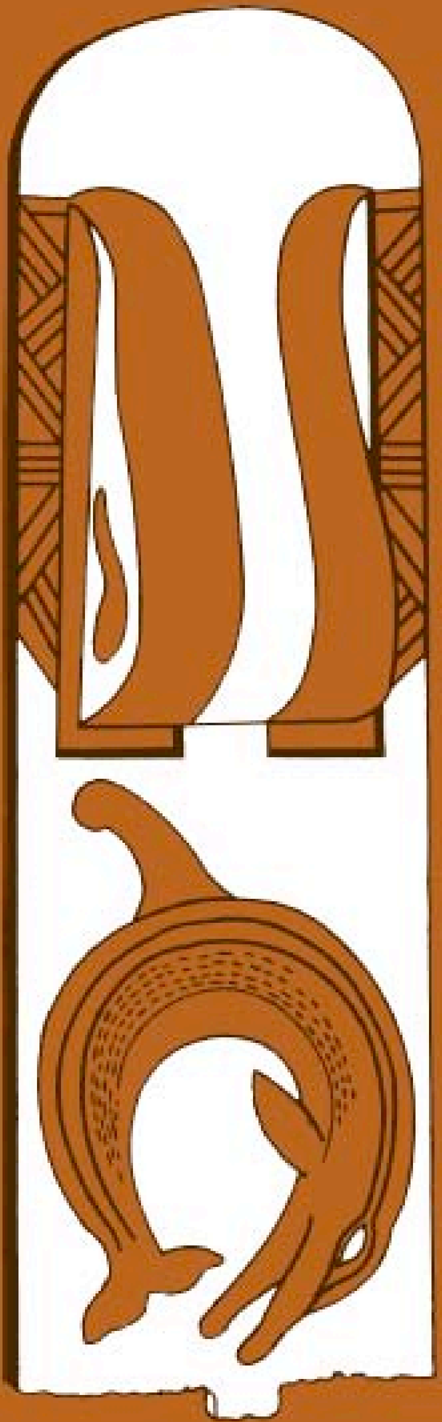

The Evolution of the Calusa

A Nonagricultural Chiefdom on the Southwest Florida Coast

Randolph J. Widmer

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The development of the key dwellers in this direction, is attested by every key ruin—little or great—built so long ago, yet enduring the storms that have since played havoc with the mainland; is mutely yet even more eloquently attested by every great group of the shell mounds on these keys built for the chief's houses and temples; by every lengthy canal built from materials of slow and laborious accumulation from the depths of the sea. Therefore, to my mind, there can be no question that the executive, rather than the social side of government was developed among these ancient key dwellers to an almost disproportionate degree; to a degree which led not only to the establishment among them of totemic priests and headmen, as among the Pueblos, but to more than this—to the development of a favored class, and of chieftains even in civil life little short of regal in power and tenure of office.

—Frank Hamilton Cushing
(1896:413)

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Preface

Southwest Florida is a unique region of the United States. Having grown up in south Florida, I took for granted many of the special features of the unusual environment of the area. The extraordinarily good fishing had always impressed me, and I silently observed on many occasions that it would be impossible for anyone who could fish to starve in coastal south Florida. I remember vividly, as an adolescent, standing on a pier and watching the coastal water turning to a white froth for as far as the eye could see up and down the coast as predatory fish attacked an incredible shoal of mullet on their migratory run. Not until later did I discover that prehistoric Indians had relied on the very fish resources I enjoyed so much for sport.

I read an article by Goggin and Sturtevant (1964) which argued for the nonagricultural economic base for the aboriginal Indians, known at contact as the Calusa, who lived on the southwest Florida coast. These Indians and their prehistoric predecessors apparently developed a society with a highly structured hierarchical political organization, known as a chiefdom, characterized by a number of inherited positions, called ranks. Because chiefdoms are usually associated with agricultural societies, I became interested in how this type of society developed, independent of agriculture.

From 1969 on, I began rigorously to investigate what I intuitively took to be obvious, that the southwest Florida coast could indeed support a highly ranked chiefdom without agriculture. Although I disciplined myself not to leap from intuitive gut feelings about the productivity of the region, I confess that my belief that such an adaptation was possible guided my research, and a more systematic understanding of how this adaptation worked became my goal.

My first archaeological field experiences were in north Florida, rather than southwest Florida. In 1970, however, I had the opportunity of working on Marco Island with the Florida Division of Archives and History. This was my first exposure to the archaeology of south Florida. I remember finding it difficult to believe the incredible Caxambas site 8Cr107, composed of shell, was aboriginal. I then began to realize that this site was not an anomaly and that there were others, such as Key Marco and Goodland, now covered by houses, that were probably villages of the Calusa or their antecedents. This discovery reaffirmed my belief that this chiefdom was not only possible but had actually existed. I therefore became committed to the study of the Calusa and their antecedents. I recognized, as had investigators before me, that the distinctive environment of the Calusas had made their chiefdom possible.

As an undergraduate, I read a book by W. T. Sanders and B. J. Price entitled *Mesoamerica: The Evolution of a Civilization*. The theoretical approach they used in the book could, I thought, equally be applied to a study of the Calusa. Since William Sanders was at Pennsylvania State University, I decided to go there to carry out such a study. It took me a while to convince him that a highly ranked chiefdom was possible without agriculture, but eventually he concurred with my findings. Much to my surprise, I found out that a noted authority on the paleoenvironment of southwest Florida, William Spackman, was also at Pennsylvania State, and so I was able to take advantage of his guidance and data.

Near the beginning of my research on the background of the Calusa, I realized two things: first, that an incredible amount of work had been done in the area over a very long period and, second, that in spite of this long history of research, no one had synthesized the work. In fact, southwest Florida was the only area of Florida for which there was no synthesis. This book is intended to provide one, but it is also intended to be a theoretical model of the evolution of a nonagricultural chiefdom, the Calusa. In this model, I have attempted to tie together a series of substantive layers, each of which is independent yet essential for producing the model. These layers include the specific geological, ecological, environmental, and archaeological data relevant to the area. They are held together by anthropological and ecological method and theory.

Because the archaeological data are limited, and will always be so, I have begun with theory to construct the model. For example, after one hundred years of archaeological investigations in southwest Florida, we still have no idea what an aboriginal house in this region looked like. Furthermore, without theoretical guidance, facts have little context. In an ecological theoretical model as developed here, however, what appear to be incomplete archaeological data become very useful and "complete." Therefore, I make no apology for what may be regarded by many as pushing beyond the limits permitted by the data. The model, as developed here, is hypothetical and should always be so considered. It should be subjected to rigorous testing, and modified or discarded by new findings. In this book I hope to convince readers that southwest Florida is indeed a very important archaeological area, not because of the quantity or sensitivity of sites but because of its anthropological significance. Where else can one find nonagricultural chiefdoms as highly ranked as the Calusa?

It is ironic to think that this area would have gone completely without anthropological notice if it were not for brief ethnohistoric references to the sociopolitical ranking. It is by sheer luck that we have the ability reasonably to hypothesize that these coastal shell middens were the remains of one of the highest ranked chiefdoms ever to have existed in aboriginal North America.

It is hoped that this book will appeal to readers other than those interested in Florida archaeology. The methods and theory utilized in this case study have wide application beyond southwest Florida, including other tropical and temperate coastal areas of the world.

It is only through the generous assistance and cooperation of numerous individuals and agencies that this work is possible. I would like to thank the Florida Division of Archives, History and Records Management for providing me with the opportunity to participate in the numerous projects conducted in southwest Florida. I particularly thank James J. Miller, Wilburn A. Cockrell, L. Ross Morrell, B. Calvin Jones, and George Percy for the technical and administrative assistance and moral support over the years that led to this book. I would also like to thank Jerald T. Milanich and William H. Marquardt of the Florida State Museum for data regarding fieldwork recently conducted in southwest Florida. I am greatly indebted to Richard Faust, John E. Ehrenhard, and Gregory Komora of the Southeastern Center of the National Park Service for generously providing the five volumes of their recent survey of the Big Cypress Preserve; without these documents, many of the conclusions drawn in the model would not have been possible. I have had many stimulating conversations with John W. Griffin on southwest Florida archaeology and I greatly appreciate his advice and discussion.

I am particularly grateful for the patience and understanding of William T. Sanders, David L. Webster, James W. Hatch, Gabriel Escobar, William Spackman, Jr., and Fredrick M. Williams. Their guidance and suggestions are greatly appreciated.

I am particularly indebted to Rebecca Storey for her editorial assistance on this manuscript, and more important, for her valuable advice on the theoretical and substantive aspects of this book.

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The Evolution of the Calusa

1

Introduction

On Friday, June 4, 1513, just two months after Ponce de León made his historic landing on the east coast of Florida, the earliest landing by Europeans in the southeastern United States (Lowery 1911), he arrived in the vicinity of Charlotte Harbor on the southwest Florida coast, where he encountered a hostile aboriginal group which we know as the Calusa (Lowery 1911; Quinn 1977). The Calusa, under the pretense of trading, attacked Ponce de León's fleet with a force of twenty canoes. The Spanish forces thwarted the attack, and a Spanish messenger was sent with two prisoners taken in the battle to Carlos, the Calusa chief, in order to make peace. On the next day, the Indians informed the Spanish that the cacique would come to the ship the next day, and indeed he did, "for at eleven of the clock, eighty canoes well equipped attacked the nearest ship and fought from morning till night" (Lowery 1911:142–143).

This attack clearly demonstrated the existence of a highly organized and centralized political system which could mobilize a large number of warriors in a relatively short period of time. The feat is quite remarkable for an aboriginal North American group and is clearly indicative of the complex sociopolitical organization associated with a highly developed chiefdom. What is astonishing is that the mobilization and implementation of this highly organized military attack were accomplished by a society which was nonagricultural, subsisting solely on wild food resources, primarily coastal aquatic foods (Goggin and Sturtevant 1964; Widmer 1978). It is somewhat ironic that one of the first North American aboriginal groups contacted by Europeans was probably the most atypical group on that continent. On the other hand, it is fortunate that the situation occurred, because it has provided an example of an unusual, seemingly paradoxical anomaly in comparative cultural anthropology, namely the existence of a ranked, nonagricultural society.

My aims in this study are twofold. The first is to compile, for the first time in one place, all of the pertinent archaeological, environmental, and geological data relevant to the evolution of aboriginal occupation in southwest Florida. Such a synthesis has never before been attempted for this area, the only area in Florida to lack one. From this compilation, I will develop a specific, integrated, dynamic model of cultural adaptation to serve as a stimulus to future researchers in this region to develop hypotheses that go beyond simple culture-historical concerns.

A more general aim of this specific case study of southwest Florida is to provide important insights into the topic of coastal adaptation, particularly regarding the effects of sea-level rise on the modification of settlement, subsistence, and sociopolitical patterns through time, but also regarding the circumstances under which coastal resources are used to the exclusion of other resources. I argue that the southwest Florida example shows that the rising post-Pleistocene sea covered the earlier settlement and subsistence remains and that the earlier occupations utilized coastal resources in a manner very different from that of the Calusa. I will attempt to demonstrate how tropical, inshore, coastal resources differ from other resource bases and require different types of social and political systems for successful adaptation.

The study has been divided into ten chapters. This first chapter includes a brief ethnographic sketch of the Calusa, a statement of the problem, and its importance in the realm of anthropological theory. In the second chapter I outline the theoretical positions, the methodological steps, and the data which will be used to accomplish the aims of this study. In chapter 3 I discuss the history of archaeological research in southwest Florida to provide a first useful synthesis for this region and, more important, to explain why certain sites were excavated and certain classes of data collected. The discussion also serves to show the direction and timing of the changes and oscillations in research interests for this area.

In chapter 4 I present the cultural history of southwest Florida from the earliest occupation up to the contact period. I have done so for two reasons: first, southwest Florida has been the only area of Florida lacking such a cultural history, and second, it establishes the dates and names of the various archaeological periods found within the region and a description of the material traits which characterize the archaeological components. Although a cultural history may seem unnecessary in a purportedly processual study, it renders descriptive digressions in subsequent chapters unnecessary. This cultural history also establishes the temporal positioning necessary to sustain the argument that certain adaptational shifts occurred in southwest Florida. Also, because of certain problems pertaining to the quality of the data base, extensive reordering or expansion of the traditional chronological sequence as it is presently known was required. Thus, the cultural chronology for southwest Florida presented here is original. Chapter 4 also contains the archaeological data supporting a revised chronological sequence.

In chapter 5, I describe the environment of south Florida in the early sixteenth century, when Europeans first encountered the Calusa, and discuss the various factors which make it distinctive, including climate, hydrology, environment, and vegetative patterns. I also discuss how the various ecological characteristics of each particular environmental zone have different levels of productivity as a result of their trophic relationships and energy flow. These differing productivities will be evaluated for their potential to provide resources for human use.

In the sixth chapter the environment is placed into a diachronic perspective to reveal how various sea-level, hydrological, and paleoenvironmental characteristics have changed through time, and how they resulted in environments in south Florida very different from what we see today. In chapter 7 I present the diachronic model of adaptation, incorporating the various data discussed and compiled in earlier chapters together with newly introduced processual cultural information. I attempt to show how and why the evolution of this adaptation occurred, and equally important, why the various steps in the evolution of this adaptation emerged at the times that they did.

The specific economic features which have evolved and characterize the Calusa adaptation are treated in chapter 8. These features include the structure of the subsistence base, the technology, the risks and fluctuations involved in resource procurement, and the importance of various resource items in the economy.

In chapter 9, I discuss how the various settlement, demographic, and economic patterns result in the generation of a series of sociopolitical features which are seen as necessary for survival, and hence, adaptation in this area. The population of southwest Florida has grown as a result of a series of environmental shifts linked ultimately to the post-Pleistocene rise in sea level. Most notable in this growth trajectory is the development of a ranked sociopolitical organization. I attempt to account for the timing of the evolution of this adaptation and suggest that the same factors responsible for the development of the Calusa were important in the rise of similar adaptations elsewhere. In the final chapter the role of the southwest Florida coastal study is placed in cross-cultural ethnological perspective.

Ethnographic Background of the Calusa

The Calusa were one of the first North American aboriginal societies contacted and described by European explorers of the New World. The Calusa are known mostly through three primary historic documents of the sixteenth century: Fontaneda (1944), Solís de Merás (1964), and Zubillaga (1946). Goggin and Sturtevant (1964) and Lewis (1978) have presented a comprehensive ethnohistoric reconstruction of the Calusa based on these sources, with additional references from other contemporary material. Their syntheses will be summarized here.

The Calusa inhabited the southwest coast of Florida from the Charlotte Harbor

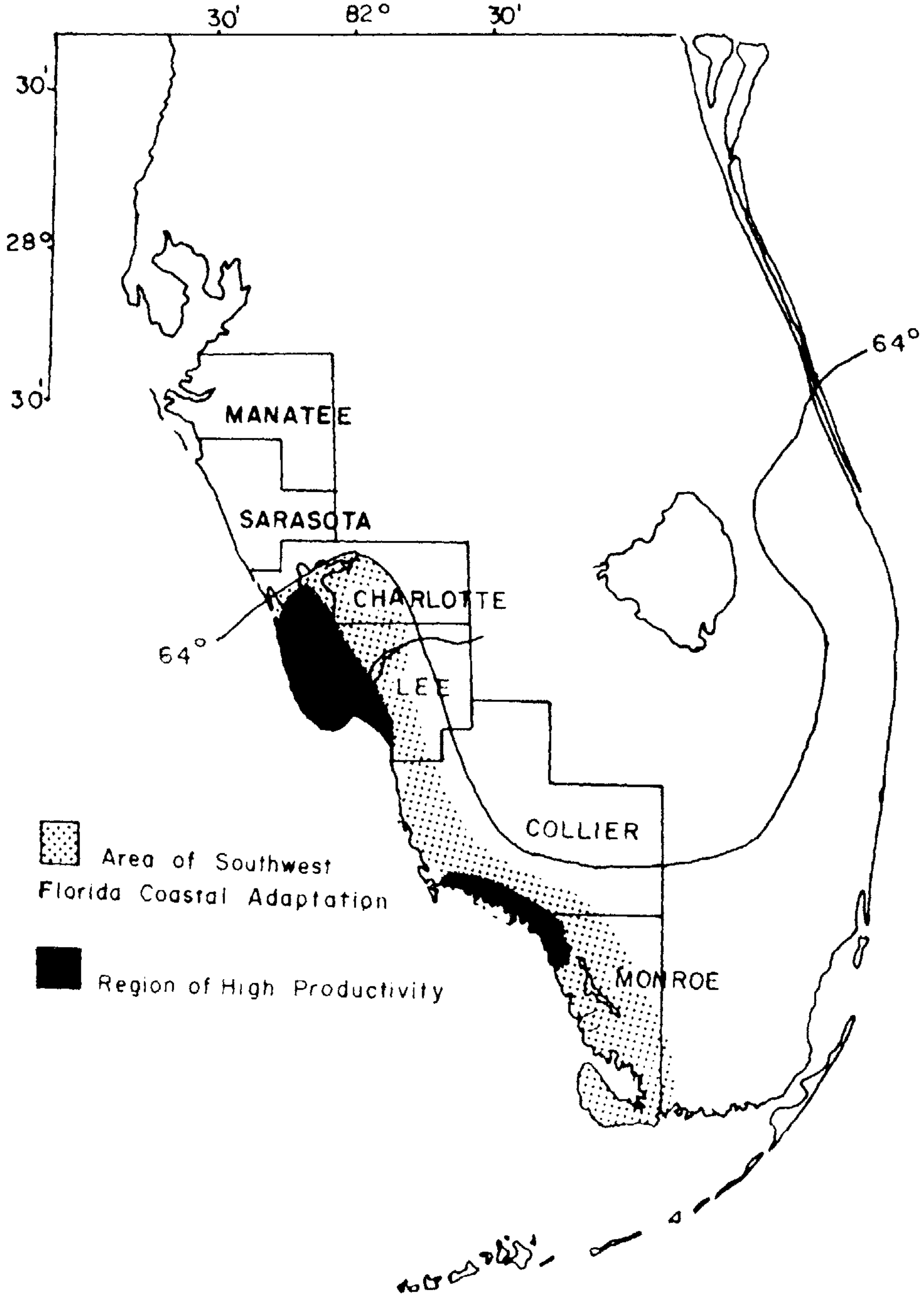

Figure 1. Location of Southwest Florida Coastal Adaptation

area southward, corresponding to the region indicated in figure 1. The principal town of the Calusa is called Calos and is thought to be the site of Mound Key, a thirty-hectare shell mound complex in Estero Bay. A series of high mounds, one of which is ten meters in elevation, is found on the site. A low marshy area is thought to represent a former canal which bissected the island. The population for the Calusa region (that is, southwest Florida) is estimated to have been between 4,000 and 7,000, with Calos having had a population of approximately 1,000. This population figure is probably conservative, as will be discussed later. Fontaneda (1944) states that about fifty villages were subject to Carlos, the paramount chief at the time of his report, of which twenty-five are inland and two are in the Florida keys. If this statement is accurate, there would be about twenty-three towns along the southwest coast.

The subsistence of the Calusa was almost assuredly nonagricultural, with fish and shellfish comprising the bulk of the diet and supplemented by land fauna such as deer, raccoon, reptiles, and also avifauna. Roots were an important subsistence item of the interior groups, but there is no evidence pointing to their primary subsistence utilization on the southwest coast, although there is reference to their inclusion in tribute paid to Carlos.

The Calusa were probably bounded to the north by the Tocobaga and to the east by a group referred to as the Mayaimi, who were located around the shore of Lake Okeechobee. The Ais, Jeaga, and Tequesta were located further east on the Atlantic coast of Florida. With the exception of the Tocobaga, the Calusa were allied at various times with these other groups. The central figure of authority in this alliance was the paramount chief of the Calusa. All of the ethnohistoric sources, without exception, point to the prominence of the paramount chief Carlos, and numerous accounts mention that tribute was paid to him. Apparently, political alliances were maintained through marriage, and a chief's wives came from towns subordinate to him. Menéndez, the governor of Florida in the mid-sixteenth century, reported that Carlos offered his sister to him in marriage because he was so impressed by Menéndez's display of goods, food, and soldiers—in other words, by his political power.

The ethnohistoric sources mention several statuses among the Calusa, including a paramount chief, the chief of the main town, and chiefs or local headmen of subordinate towns. In the main town were nobles and captains who presumably had political and religious duties. The sources also mention a chief priest who at one particular time was a brother of the chief and shared his religious information (Zubillaga 1946:288, 309). Another status position was that of capitán general, as it was referred to by the Spanish. The position was held by the husband of a chief's sister and was inherited by the man's son. This individual may also have been the chief priest. There was also a second capitán position beneath the capitán general.

The paramount chief was clearly differentiated from the rest of the populace in terms of sumptuary display. He had a forehead ornament of gold, beaded leg bands, and a wooden bench or stool, which represented his title to office. (Similar wooden benches or "thrones" are common in many African chiefdoms and states.) Subjects of the paramount chief were expected to be deferential to him. The paramount chief was greeted in a special manner; the subject knelt and raised the hands palms up, at which time the chief placed his hands on top of them. The paramount chief possessed religious knowledge known only to him and the chief priest. In fact, adequate religious knowledge by a chief was necessary for his legitimization as a chief. When a chief or his principal wife died, sons and daughters of his subjects were sacrificed.

Succession to paramount chief is known for five successions within the chiefly lineage. Senequne, the second paramount chief, succeeded his brother, whose name is not known, and his sister's husband served as his capitán general. Carlos succeeded his father, Senequne. At Carlos's death in 1567, he was followed by Felipe, a cousin (the son of his father's sister) as well as the brother of one of his three wives. Felipe married his full sister. This was a custom reserved for and expected of the ruling lineage. Finally, the chieftainship went to Pedro, first cousin and heir of Carlos.

The authority of the paramount chief probably included that of the chief priest, the captain general, and the second captain, although the degree of authority appears to have vacillated. This may be due to inconsistencies in the sources, or perhaps because the references were really to other regions or groups within south Florida, where the political structure might have been different or more fluid. Carlos's political power and hegemony on a regional basis are clear from the evidence that he personally supervised the redistribution of gold and silver taken from Spanish shipwrecks to other chiefs in south Florida, even in the territory of the Ais on the Atlantic coast.

Ceremonial construction, including temple mounds, burial mounds, and canals, is known through both ethnohistoric references and archaeological data. Numerous references are made in the historic sources to temples, and the archaeological record clearly reveals many examples of temple-mound structures, such as the one mentioned at Mound Key. Aboriginally dug canals are also common in southwest Florida. These canals are in some cases more than 4 km in length, 10 m in width and 2 m in depth. They are apparently without economic function but are, rather, ceremonial in nature, and at least one of the canals leads to a series of burial mounds that appears to have been isolated from the main settlement.

According to Father Juan Rogel, a missionary stationed at Calos, the Calusa pantheon included three deities who governed the world. These deities were ranked hierarchically, the first deity being the greatest. This deity governed or pertained to phenomena of nature, such as movements of the stars and weather. The second deity pertained to political matters, such as the rule and government of the region. The third, and least important, deity pertained to warfare. The hierarchical nature of the Calusa pantheon, however, may have been a result of the misconception of Rogel. Human sacrifice was required by one of the deities because it ate human eyes. The sacrifices were made in a temple situated on top of a mound, and the head of the victim was later carried in a dance. One ceremony involved a masked procession down from the temple and through a small valley. This procession was accompanied by singing and was viewed by the inhabitants of Calos. Various archaeological and ethnohistoric sources make it clear that the burial mound, ossuaries, and charnel houses were separate from the main settlements (Goggin and Sturtevant 1964; Bullen 1978; Lewis 1978). The mounds were always guarded and were decorated with figures of turtles, barracuda, and other animals, whose function was to appease the dead. There apparently was a standardized, ritual cult, analogous but distinct from the Southern Cult, in south Florida. This is known primarily from archaeological sources. The two most distinguishing artifacts are a two-sectioned tablet with a tenon on one end usually made of metal, stone, or wood, and a metal-crested bird ornament.

Warfare was prevalent, if not a chronic condition, among the Calusa. The name Carlos, used by the Spanish to refer to the Calusa paramount chief, actually referred to the province in the aboriginal lexicon and meant "fierce people." At the time of the Spanish contact during the mid-sixteenth century, the Calusa were at war with the Tocobaga and Serrope. The Calusa tried to get the Spanish to intervene and help them defeat the Tocobaga, who held ten or twelve Calusa hostages. The chief played an important role in warfare, directing his assistants in the preparation of bows and arrows and in the location and timing of ambushes. In one instance, four village chiefs, who were considering switching allegiance to a hostile group, were executed by the paramount chief and their heads displayed in a dance during a ceremony.

The craft and technological abilities of the Calusa were quite developed by indigenous North American standards. They made elaborately carved shell gorgets and plummets, wooden implements, and masks and even had the ability to work silver, gold, and copper by hammering and embossing. The wooden figures and masks from Key Marco and Fort Center display a high standard of technical ability and aesthetic quality, although the degree of craft specialization or the existence of a horizon style is unknown.

Trade and exchange were highly developed in all portions of Florida. The captive Fontaneda was himself "traded" throughout Florida and thereby came to learn several languages. The occurrence of shark teeth in the Lake Okeechobee area and the presence of ceramics from this region in the southwest Florida coastal area further confirm the existence of a trade network in south Florida. There are some references to exchange in the south Florida region in the ethnohistoric sources, but the specific nature of the exchange or its location is either unclear or not specifically attributed to the southwest coast.

Little is known of the demise of the Calusa. Historic references suggest that during the seventeenth century the population of south Florida was much reduced and that the settlements were no longer permanent (Wenhold 1936). By the middle of the eighteenth century, almost no trace of the original Calusa inhabitants remained, having been relocated by the Spanish to the Caribbean when Spain ceded Florida to Great Britain in the mid-eighteenth century (Sturtevant 1978). Occupants of the southwest coast now consisted of seasonal fishermen from Cuba and Apalachee groups from the north, who moved in during British rule (Sturtevant 1978). The Calusa and other indigenous south Florida groups were replaced by the Seminole in the mid-nineteenth century, who, surprisingly, never occupied the coast but instead kept exile in the remote interior regions.

The Anthropological Significance of the Calusa Sociopolitical Evolution

If the tropical, coastal ranked adaptation represented by the Calusa is possible, why are similar adaptations at other times and in other places so rare? Tropical, coastal estuarine zones have unusually high quality and abundant food resources (high in fat and protein). These coastal zones are usually located adjacent to terrestrial areas with long photoperiods, which favor the production or collection of plant resources by human groups. Plant resources, however, are limited in protein and fat and so it becomes advantageous for the groups to integrate high-quality coastal resources with the high-energy plant resources. Exclusive reliance on high-quality coastal resources, I believe, emerges only in regions where the terrestrial potential for crop production or intensive plant harvesting is low, such as south Florida.

While numerous studies of sociopolitical evolution have been made for terrestrial, agricultural adaptations (see Sanders et al. 1979; R. M. Adams 1981), to my knowledge only the Northwest Coast of North America has been subject to empirical studies of coastal adaptations similar to the present one (Fladmark 1975; Ames 1981). Still, these coastal adaptations are markedly different from the one in southwest Florida, since the latter adaptation was tropical and involved pseudocatadromous (Myers 1949), rather than anadromous, fish resources. Pseudocatadromous fish spend their lives in the inshore estuarine zones and breed offshore at sea, the opposite of anadromous fish, and are therefore available throughout the year. Even during periods of offshore spawning these fish aggregate in large masses before moving offshore and are at optimal availability for human use. Some species, notably sea trout, spend their entire life cycle in the estuary. Thus the availability of pseudocatadromous fish in tropical estuarine environments is dependent on the primary productivity of the habitat, since that is where they obtain their food. In an anadromous inshore habitat, primary productivity is not important because the waters are used mainly for breeding rather than feeding.

Although several synchronic studies of tropical coastal adaptation have been undertaken (Voorhies 1976; Stark 1977) some of which involve chiefdom-type adaptations (e.g., my earlier work on the Calusa [Widmer 1978]), none of these studies investigated the diachronic aspects which are important to an understanding of the timing of sociopolitical evolution in general. Much is known about the evolution of the demographic, subsistence, settlement, and sociopolitical characteristics of terrestrial cultural systems but not for tropical coastal adaptations, particularly not for those trajectories which lead to complex sociopolitical adaptations.

The role of aquatic resources in human adaptation has recently become a subject of increased anthropological interest, largely as a result of a reexamination of the economics of hunting-and-gathering adaptations in light of current ecological theory relating to demography, carrying capacity, feeding strategy, and energy flow (see Lee and Devore 1968; Sahlins 1972; Binford 1977), with its implications for the evolution of various adaptive strategies, both in the economic and sociopolitical dimensions. Namely, hunters and gatherers are not as energetically stressed as previously thought.

It is also becoming increasingly clear that the ecological structures of aquatic resources diverge markedly from those of their terrestrial counterparts (E. P. Odum 1963; Osborn 1977; Schalk 1977). Thus, it is not surprising that aquatic hunting-and-gathering adaptations would result in adaptive forms not typical of those associated with terrestrial hunting and gathering. Murdock (1968:15) noticed that the stability and abundance of marine resources in some regions led to the development of sedentary habitation and a higher degree of cultural complexity than is typically associated with hunting and gathering. Because of this, sedentary fishing adaptations are not considered by Murdock to be hunting-and-gathering economies but are classified instead as marginal subsistence—that is, as atypical hunting-and-gathering economies (Murdock 1968:15).

Despite the apparent evidence for the ability of aquatic resources to provide an economic base for sedentary village life and complex sociopolitical organization, there are still two diametrically opposed views on the quality and importance of aquatic food resources as a human subsistence base. One view is that, on the whole, aquatic resources are "inferior" to terrestrial ones. This reasoning was initially based on the observation that terrestrial hunting-and-gathering adaptations predate aquatic adaptations (G. Clark 1952:62; M. N. Cohen 1977:79, 83; Osborn 1977:158–159), indicating that the latter are not as desirable as the former. Opposing this view, Sauer (1961:262–264), Binford (1968), Murdock (1968), Suttles (1968a and b), Stuart (1977:271), and Fairbridge (1984) consider aquatic resources to be stable and abundant. Fairbridge, in fact, has gone so far as to suggest that the initial occupation of the American continent was basically the result of a coastal migration based on shellfish resources.

Moseley (1975:5) has probably taken the most extreme viewpoint in suggesting that maritime resources, and not agriculture, are responsible for the development of the highly stratified state-level social organization on the Peruvian coast. To him, the maritime resources provide a preadaptation to irrigation agriculture:

"I realized that the social organization of the *maritime population was, in fact, very complex*, highly evolved, and a majority of the behavioral characteristics associated with later coastal civilization had emerged independently of any significant agricultural input" (Moseley 1975:5; emphasis in the original).

The question of whether aquatic resources are or are not inferior to terrestrial forms is not a trivial one. Its importance lies in our need to relate adaptive strategies to ecological theory so as to develop more fully an explanatory basis for sociopolitical organization and its evolution.

One of the problems central to the evaluation and analysis of human use of aquatic resources is the choice of terms used to describe various aspects of aquatic environments. A considerable amount of the controversy regarding an understanding of aquatic adaptations stems from misuse of specific terms—that is, the expansion of a specific term to a general one. "Marine" and "anadromous" are the most common examples of inaccurately used terms, but others, such as "coastal," are also misapplied.

To avoid this problem, an ecological approach is required, one which characterizes resource potential in energetic terms, that is, in primary productivity and trophic structure (H. T. Odum 1957; E. P. Odum 1963; D. M. Gates 1971). Only in this way can the "quality" of an environment be determined, which is particularly important because aquatic environments exhibit the full range of variability in net primary production of dry organic matter found in the biosphere, from a low of 2 g/m^2/year for the open sea to a high of 4,000 g/m^2/year for certain algal beds and reefs (Whittaker 1975:224, table 5). Because of this diversity in primary production, it should be obvious that a generalized statement applicable to *all* aquatic ecosystems is unjustified. Instead, the energetic structure of each aquatic ecosystem must be individually investigated and studied, rather than a particular ecosystem simply being characterized in terms of its exceptions to a general pattern, as has been so common in the past. That is, the fact that a single extractive *technological* system—fishing—crosscuts several environmental types does not justify characterizing the system as a single adaptation. To do so is comparable to classifying lowland South American root-crop agriculture with Mesoamerican seed-crop agriculture on the basis that they both involve the use of domesticated plants. Therefore, it is necessary to view adaptive systems, and any development to sociocultural complexity, as responses to specific ecological situations which relate ultimately to primary productivity and trophic structure.

A major theoretical question arises from this. If some coastal conditions favor the independent and autonomous development of complex societies without the use of agriculture, then why do these societies not predate those derived from agricultural economies? One might appeal to the simple solution that they are actually earlier than the complex societies in terrestrial situations but have been drowned or destroyed by the rise of the post-Pleistocene sea. This hypothesis is difficult, if not impossible, to evaluate archaeologically, however. One may argue that this question is similar to the paradox of the testability of Sauer's (1952) hypothesis regarding the priority of root crops over seed crops in the origin of agriculture, to which Mangelsdorf (1953) argued that because root crops do not keep in the moist tropical conditions in which they were originally supposed to have been domesticated and because they produce no pollen, it is impossible to test the hypothesis.

As a result of this paradox, it is necessary to test this hypothesis of precocious coastal complex development indirectly by appeal to a model which will incorporate the environmental characteristics for the various periods of time in which the evolution of the prehistoric adaptation took place and then to evaluate the potential of these various, possibly different, environments for the development of complex sociopolitical forms. The construction of such a model requires a considerable body of relatively detailed geological and paleoenvironmental data to evaluate accurately the potential for human resource utilization through time in a specific area. Fortunately, a substantial corpus of detailed paleoenvironmental data is available for south Florida, and it is of sufficient quality to facilitate the construction of the type of model necessary for this study.

By analyzing the capability of a coastal zone to support various distinct adaptations at specific points in time, it is possible to construct a model of the sequence of processual steps which lead up to the complex sociopolitical adaptation, as known from the protohistoric period, and to account for the specific timing of the particular adaptations which developed in the evolutionary trajectory. Therefore, we need not concern ourselves with the "untestable hypothesis" problem, because the hypothesis can be addressed indirectly.

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Theoretical and Methodological Considerations in a Study of Coastal Adaptation

The paradigm followed in this study is cultural materialism (Harris 1968, 1979; Price 1982). Its underlying principle maintains that "the causes of behavior are most parsimoniously sought with consistent reference to the material conditions of life" (Price 1982:709). As a paradigm, cultural materialism subsumes within it a number of theoretical positions, the most important of which is natural selection. Applying this theory to human groups and to their cultural systems is important, because the economic, social, and political characteristics of cultural systems are then considered to be adaptive. That is, these components do not exist for random or spurious reasons but instead have differential survival value in varying environmental circumstances. Therefore, the particular characteristics which develop during the histories of cultural systems are viewed as the result of the differential survival value of the traits in question.

Human sociocultural behavior can also be considered within the context of ecological theory, since human populations interact with their natural environment as does any species. It is hoped that by understanding the specific ecological processes and components which characterize an environment, we can account for the various aspects of human subsistence strategy, demography, and sociopolitical organization.

The cultural characteristics thought to have developed in reference to constraints and synecological conditions of the physical environment do not do so in a random fashion but, instead, are hierarchically ordered in a logical progression starting with the most basic subsistence-oriented phenomena up to the more variable sociopolitical features. A methodology has been developed which allows the more precise analytical investigation of the effect of environmental conditions on cultural phenomena, namely, the culture core model of Julian Steward (1955). This method allows a mechanism for generating particular sociocultural features from certain constraints or characteristics found within an environment. The culture core approach does not maintain that all sociocultural variables can be explained by direct reference to environmental conditions, since many sociocultural traits have no relationship to adaptation. Instead, this approach attempts to account for the development of a particular technology which will be effective in obtaining resources from a particular environment, with its inherent constraints, limitations, and characteristics. As a result, a series of decisions and behavioral responses will develop to implement the technological system effectively for adaptive purposes, that is, increased survival advantage. These behavioral decisions will take into account seasonal variability and differential resource productivity and availability.

The sociopolitical system should show certain aspects or characteristics which are direct responses to technoeconomic interactions which occur in a particular environment. These responses are adaptive because they will tend to capture and circulate more energy through the cultural system (R. N. Adams 1981:608) and will therefore have differential survival value over those competing systems which do not capture or circulate as much energy. It is absolutely essential that these sociopolitical features have differential efficiency and net capture ratios in a cultural system and hence adaptive advantage. If sociocultural phenomena are not so considered, then it is impossible to predict or account for the existence of certain sociopolitical characteristics in a particular environmental setting. These phenomena then could be attributed to stochastic processes, invention, diffusion, or other "historical" explanations. If such phenomena are attributable to random factors, they cannot be explained through use of an ecological or systematic anthropological approach.

It is not necessary that all aspects of sociopolitical organization and ideology be ascertained to have greater efficiency than other possible types of behaviors. They must not, however, greviously impact the efficiency of a sociopolitical system, that is, they must be at least neutral, because if they are not, overall system efficiency and/or energy capture would diminish, and they would eventually be replaced by more efficient forms. Thus, in the *long run*, it is not necessary that all ideological features be directly explicable as having adaptive advantage. Still, it is clear that those features of the ideological system tending to reinforce or encourage behaviors which function more effectively in the sociopolitical and economic tiers of the culture core hierarchy will have greater differential survival value, and will therefore be maintained, than those which either do not or those which actually interfere with the efficiency of the cultural system. In Steward's formulation of the culture core model, he was clear in noting that not all aspects of sociocultural phenomena can be explained in reference to the culture core, and in fact, he pointed out that there is a systematic drop-off in the frequency with which cultural phenomena can be included in the culture core as one proceeds up the hierarchical strata from the economic, into the sociopolitical, and finally to the ideological realm.

The strategy of the culture core is ideal for archaeology because the frequency of data classes recovered parallel the frequency of phenomena which can be attributed to the culture core. That is, it is relatively easy to characterize and reconstruct the natural environment, since the environment is independent of human behavior. The technological features of an archaeological culture are usually preserved, and therefore, it is a straightforward procedure to reconstruct this aspect of the culture. The reconstruction of the economy is inferential and requires indirect data, but it is nonetheless easier to reconstruct than the sociopolitical characteristics, which in turn are much more accessible than the ideological aspects in archaeological contexts. Therefore, not only is the culture core model advantageous theoretically, since it actually is a methodological extension of the theory of natural selection, but equally important, it can be easily implemented because the levels of cultural phenomena which are subsumed in the culture core are those most readily observed and reconstructed archaeologically. Thus, the culture core model is ideal for linking archaeological data to the paradigm of cultural materialism.

The culture core will be utilized in this study as both a theoretical and methodological approach in the analysis of the history of adaptation on the southwest Florida coast. It is argued that adaptation in an area will generate particular economic, technological, and social characteristics as a consequence of the nature of the ecological structure of the environment and its characteristic resource base. This perspective has been shown to be particularly applicable to some maritime adaptations:

> For a maritime ecosystem that is semi-isolated in a region that offers no feasible alternate economic pattern or ecosystem to exploit, it is surmised that any succeeding culture will have made adjustments largely the same as those of its predecessors from which it may have, in fact, taken on many adaptive elements. This is assuming that the latter had made, at the minimum, a satisfactory adjustment (D. Clark 1977:192).

This statement is particularly applicable to the southwest Florida coast because the area has no viable alternative resource base, that is, agriculture, for exploitation with the limited technology available prehistorically.

The culture core approach will be expanded considerably from that envisioned by Steward, but this expansion represents a refinement of analysis rather than a theoretical or methodological departure. The specific area of study, the southwest Florida coast, has a particular type of resource base which would necessitate a narrow range of potential adaptation and culture core development. Furthermore, there are zones of varying resource predictability and abundance. These variables will be examined ecologically for both the structure of the particular ecosystems and the amount and flow of energy through them.

A massive body of ecological data exists for the southwest Florida coast, largely as a result of the potential impact of the intense residential development in recent years. Detailed commercial and sport-fish landing records will also be cited to characterize the resource base. Although fish-catch data can be very misleading if exclusively used to characterize the subsistence potential of a resource base (Schalk 1977), when they are grounded in ecological perspective, they are very useful and complementary to the more scientifically generated ecological data. A general classification of the ecological variables pertinent to human adaptation in the area and their spatial distribution will be reconstructed. The different ecological variables related to differential productivity and reliability will then be correlated with the general classification, and from this, a crude measure of the productivity of the resource base, as it pertains to human subsistence, and its spatial and temporal variability (i.e., predictability and dependability) will be presented.

This synthesis will provide the environmental framework for understanding the development of the distinctive sociocultural forms of adaptation seen in this region. This is not to suggest that all aspects of the adaptation and its evolution can be directly related to and explained in terms of environmental characteristics but only that some adaptational differences can be accounted for in this way.

Recently there has been in human ecology an increased emphasis on the study of anthropological subsistence patterns through the use of optimal-foraging models (Winterhalder and Smith 1981; Keene 1982). These have been very successful in specifically modeling the subsistence system within the framework of natural selection. Optimal-foraging strategy provides a method for evaluating the most favorable means of obtaining required nutrients by a society, whether they be calories, protein, or vitamins, in a given environment. This optimal strategy of resource procurement determines the settlement patterning and seasonality of group activities. Most of these studies, however, have been performed in terrestrial regions with a limited range of resource items which have specific seasonal, autoecological, and behavioral characteristics which make it relatively easy to rank their desirability and therefore their contribution to the diet of a human population.

In a tropical coastal aquatic environment, this modeling is not so easy, because many of the techniques used for subsistence extraction are not prey-specific. For example, seine netting, hook-and-line, weir, and trap fishing all catch whatever fish happens by. As a result, it is difficult to predict the types and frequencies of specific fish which will be taken, although there is certainly some expectation regarding size and type of catch.

Of course, this statement does not apply to all forms of coastal fishing. It is perfectly feasible to rank the desirability of certain fish resources, a single or a few species, which aggregate seasonally and then intensely harvest them, for example, anadromous fish such as salmon and herring. But in tropical, inshore fishing, it is not always possible to predict the type of fish which will be taken by a given technique, because a wide range of different fish species may be stochastically taken, although there is no change in input effort, technology, or subsistence-procurement behavior. This is not to say that it is impossible to rank the particular value of a resource item. As Frake and Cordell (1978:9) have noted, however, there has never been a comprehensive study of traditional fishing in which catch and effort have been measured, mortality estimated, and a value obtained for the "exploitative index." Thus, without these empirical measures, it is impossible to rank with accuracy the desirability of certain prey items, even if they are pursued individually. It is generally known that certain fishing techniques are more effective than others under varying seasonal and temporary environmental conditions. For example, there are the relative cost-and-return expectations of inshore net fishing versus offshore net fishing, deep-water long-line fishing versus inshore spearing, and so on. Traditional ethnographic fishing groups which employ a variety of different techniques have differing levels of expectation regarding their return for the energy and capital invested. These are the key variables in interpreting the effectiveness of fishing, not the captured species themselves. Thus, as has been shown in a number of ethnographic examples, it is the techniques of fishing and the timing of their implementation which are ranked according to the net production of their return, rather than the specific prey (Jamaica [Davenport 1960], Sri Lanka [Alexander 1977], and Malaysia [Firth 1966]). It is therefore not as yet possible to generate an elegant optimal-foraging model for tropical coastal adaptations.

Still, because these subsistence strategies tend to maximize their net yield, this behavior can be theoretically understood, using other general behavioral and ecological models for analyzing feeding strategy or other aspects of adaptation. Since human populations articulate with an environment, just as other species do, theoretical principles which have been developed from ecological studies of other animals can have direct applicability to human populations as well, particularly as they relate to increased energy capture and efficiency. For example, Pianka (1974), in a discussion of evolutionary ecology, shows how an animal will adapt its feeding strategy to the structure of its environment to maximize the capture of energy and resources necessary to its survival.

Pianka (1974:206) suggests that there are two basic types of environments: fine-grained, with evenly spaced food resources, and "patchy," which are characterized by heterogeneous, dispersed food resources. The archaeological area under investigation here is viewed as a fine-grained environment in Pianka's classification. In such an environment, a consumer will rank prey items or types from those providing highest harvest per unit of time (and/or energy) to those which have the lowest yields. "So long as the time or energy saved in reduced search is greater than the increase in time or energy expended in increased pursuit, the diet should be enlarged to include the next, less rewarding, kind of prey

. . . the time per item eaten should be less in a food-dense environment than in a food-sparse one" (Pianka 1974:208). As a result of this principle, the behavioral response of the animal should be sedentary settlement, because it is able efficiently to exploit a wide variety of resources which have stable, long-term availability and to obtain the maximal amount of energy per unit of energy expended in capture. Therefore, there is no need for movement, since it would only add to the cost of capture.

Sedentary settlement is also a favorable response for sociocultural reasons not solely related to subsistence efficiency. Sedentary settlement provides for more efficient mating arrangements and increased group defense. It is suggested that sedentary settlement alleviates some of the pressures of the incest taboo and mating requirements by increasing the chances of finding available mates on a regular basis, and as a result, tends to act as a nucleating factor as well as improving subsistence efficiency. In effect, sedentary settlement should occur if an environment has sufficient quality and structure, since it would be energetically beneficial and therefore adaptive. Sedentary settlement would result in greater population density due to the nucleating effect, while increased population size and even greater density would result from newly established increased growth rates. These changes brought about by sedentary settlement have important implications for sociopolitical evolution, which will be discussed later.

Correlated with this type of subsistence strategy is the prediction that productive environments should be utilized in a more specialized manner than unproductive ones. The unusually wide variety of technological implements indicates specialization of food procurement in the economic system of the Calusa. Because of the ecological principle presented here, there is an energetic advantage to large, sedentary, population aggregates in highly productive regions, since there is little lost energy and/or time in requisite pursuit of prey, and thus a higher net return of energy.

Recently, Binford (1980) has considered the relationship of environmental type and human resource utilization and its implication for the development of behavioral and settlement patterns in hunters and gatherers worldwide. Binford noted that there are two basic strategies of resource procurement which are analogous to Pianka's feeding strategies in fine-grained and patchy environments. Although the outcome of Binford's study seems somewhat divergent from what is seen in coastal environments, it is not theoretically contradictory, as will be demonstrated. Binford (1980) sees a continuum of hunter-gatherer subsistence and settlement behavior. At one end is a *logistical strategy*, where there occurs "labor accommodations to incoherent distributions of critical resources or conditions which otherwise restrict mobility" (Binford 1980:10). Such human groups are "task specific," setting out to capture specific resource items. As a result, a number of limited, redundant, highly visible resource areas would occur, and distinct, functional artifact assemblages would be behaviorally recorded, indicative of pursuit of individual prey or resource items (Binford 1980). At the opposite end of the continuum, Binford (1980) recognized a foraging or "mapping on" type of strategy in which a population uses resource areas where the resources are evenly distributed. Resource items in this environment are redundant in location and evenly distributed, and the frequent movement of individuals from area to area results in a mobile settlement strategy. Binford would expect less archaeologically visible sites, with artifact assemblages indicative of ephemoral, overlapping, functional characteristics, to be a result of the increased mobility in subsistence pursuits.

Binford (1980:13–15) went on to develop a model, incorporating ecological principles of energetics and trophic structure, to predict when a "logistic" versus a "mapping on" strategy will be optimal and hence utilized by hunters and gatherers. Pivotal to this is the role of sedentary settlement. Using 168 cases of hunters and gatherers from Murdock's (1967) cross-cultural summary, Binford noted that sedentary settlement, which he associated with an environment with heterogeneous resource zones and a "logistic" subsistence strategy, is also correlated with short growing seasons. Binford (1980:15) points out that increased mobility in patchy environments does not solve the problem of resource procurement, since such movement would simply add to the cost of resource procurement without increasing the resource yield. An important aspect of Binford's model, which he alludes to but does not specifically elaborate on, is the *demographic composition of the specific task group.* For hunters and gatherers in high latitudes, only males engage in subsistence activities for some portions of the year (Binford 1980), and so moving women during these periods would add to the total cost of the subsistence regime of a group *without* yielding a net increase in resource procurement. This suggests that the sexual division of labor in the subsistence activity is an essential variable in the optimal-foraging strategy. The "sedentary" nature of such northern-latitude adaptations, as illustrated by this example, might seem to contradict the theoretical feeding-strategy behavior predicted by Pianka's model if sexual division of labor were not taken into account.

Additionally, there is a seeming contradiction in Binford's "mapping on" strategy for tropical, fine-grained environments. Following Binford's model, one would predict a continual residential shift within a homogeneous, fine-grained resource patch rather than sedentary settlement. Pianka (1974) seems to suggest the opposite—that increased movement only adds to the cost of resource procurement, and as has been suggested for southwest Florida, sedentary settlement should be the favorable response. This contradiction between the predictions of Pianka and Binford for similar environments is misleading, because one important variable of "fine-grained" environments has not been considered—*food density.* It seems clear that terrestrial, tropical adaptations are fine-grained, but in most cases food density for humans is low, particularly for certain resources such as protein (Gross 1975), or else is widely dispersed (Beckerman 1979). This is undoubtedly reflected in the findings of Binford, who notes no sedentary and only a single semisedentary hunting-and-gathering ethnographic example out of twelve tropical cases (Binford 1980:14, table 2).

Tropical coastal environments, however, particularly those of the estuarine type, are both "fine-grained" *and* "food dense," and the latter feature is important in distinguishing this environment from those typified by Binford. There are two reasons for this distinction. The first is that a group of a given size can utilize a food-dense fine-grained patch for a longer period of time than a food-sparse fine-grained patch. Therefore, abandonment of a high-density patch *before* the net capture rate diminishes below the level when movement to a new patch is more advantageous than the continued exploitation of that patch only results in added subsistence cost *without* a net advantage in resource procurement. All other things being equal, a patch with greater food density will thus result in a more sedentary population than a food-sparse patch. The second reason is that food-dense environments should be used in more specialized ways than food-sparse environments because the search-time-per-item-captured should be less in the former (Pianka 1974:208). The combination of fine-grained environments and high food density, characteristic of some tropical coastal ecosystems like those of southwest Florida, result in settlement subsistence strategies different from those predicted by Binford's model. Binford (1980:18) pointed out that any conditions which restrict residential mobility in hunters and gatherers would tend to favor a "logistic" subsistence and settlement strategy.

Fishing adaptations have been viewed as departures from the more "normal" range of hunter-gatherer subsistence-settlement behavior, even before the introduction of Binford's model. Murdock (1968:15), for example, recognized that fishing adaptations often have marine food supplies so plentiful and stable, that they are able to adopt an exclusively sedentary mode of life and a cultural complexity usually associated with intensive agriculture. As a result, Murdock omitted sedentary fishermen from the category of hunting-and-gathering people. Later, in another study of hunters and gatherers, Murdock (1969:144–145) did not like the dichotomy between food gathering and food production as applied to fishing adaptations. Noting that food collecting using fishing techniques more closely resembles food production by agriculture, he classified fishing as an intermediate economic pattern positioned between food production and food collection. Murdock (1969:144) notes that of the forty-one societies in his sample which he classifies as having predominantly fishing economies, twenty-two of them, over half, are sedentary. Because of this and the very low frequency of sedentary settlement in hunting, collecting, and pastoral economies (only three cases out of seventy-one), he considers fishing economies to have an intermediate position between nomadism and sedentism. More important, he adds that "fishing (including shellfishing and the pursuit of aquatic animals) is the only relatively simple mode of subsistence that appears to be conducive to a settled way of life" (Murdock 1969:144).

The association of sedentary settlement with a fishing adaptation has been established, although not necessarily for all fishing adaptations. Two fishing societies with sedentary settlement are recorded ethnographically, the Calusa and the Manus of the Admiralty Islands, adjacent to the north coast of eastern New Guinea. Both societies have villages of more than two hundred individuals and predominantly fishing economies. Fishing accounts for 90 percent of the Manus' subsistence base, and collecting accounts for the remaining 10 percent (Murdock 1969). More important, both of these groups inhabit similar ecological zones, namely tropical, mangrove coastal swamps. The fact that sedentary settlement is a possible and favorable response in coastal situations is very important for demographic reasons.

Demographic Consideration

Demographic characteristics are important in understanding the relationship of a population with its environment, and more important, its history of adaptation. Since, under the theory of natural selection, adaptation can be measured only as differential survival value, the demographic characteristics of a population represent in part that measure. It has long been recognized that increased population size and density are correlated with more complex forms of sociocultural integration (Sanders and Price 1968; Baker and Sanders 1972; Carneiro 1972; Netting 1972). These complex forms have little or no adaptive utility in groups with small populations because of the energetic expense of their maintenance. Therefore, it is necessary to evaluate the demographic characteristics of human groups both descriptively—the specific age and sex composition, the mortality and the fertility of a group—and processually, that is, how do the various demographic components operate to result in the specific characteristics of an adaptation? These processual considerations involve both the biological potential of human demography and sociocultural influences on this potentiality.

Consideration of the processual features of human demography is essential because demographic characteristics are the result of the interaction of a human population with the environment. Howell (1976:38) has made a strong case "for the conceptualization of the problem of paleodemography as one involving a constant biological capacity to respond to various environmental situations." This implies that the biological, demographic capacities of humans have not changed through time, and as a result, any differences in the demographic characteristics of human populations, whether separated by space or time, are a result of sociocultural and subsistence economic patterns pertaining to particular population situations and histories. Howell (1976:36) goes on further to construct four basic types of populations which respond to various environmental situations. The demographic patterns which emerge are a response to both the food supply, which affects total fertility, and the incidence of pathogens in an environment,

Table 1
Generation of Potential Human Demographic Patterns

Population Patterns	Food Supply		Pathogene Level	
	Fertility* = 8 (High)	Fertility = 5 (Low)	High	Low
Type 1	X			X
Type 2		X		X
Type 3	X		X	
Type 4		X	X	

*Fertility is the average number of children born to a woman completing her reproductive span. Adapted from Howell (1976:36).

which affects mortality. The particular types of demographic patterns which result from this cross-tabulation have been presented in table 1.

The mathematical outcome of the matrix in table 1 is that Type 1 populations are growing, Type 2 and Type 3 populations are stable, and Type 4 populations are declining and will eventually become extinct. From an evolutionary perspective, human population history should shift from a Type 2 population to a Type 1 and then to a Type 2 or 3 as density or critical carrying capacity is reached. This is reflected in a population growth rate estimated for the Pleistocene of 0.01 percent, 0.1 percent during the Neolithic expansion, and then steady state when carrying capacity was either reached or could no longer be raised (Hassan 1981). Acknowledgment of the existence of these types in an evolutionary or population history perspective for human groups brings up an important theoretical question concerning why the shift in demographic types occurs.

Critical to the resolution of this issue is the role of carrying capacity in population analysis. Closely linked, and actually inseparable from the concept of carrying capacity, is the concept of population pressure (Hassan 1981). Carrying capacity is the theoretical upper limit for population growth, the maximum population which can be sustained in a given environment with a given technology. In hunting and gathering societies, achieved population is usually well below carrying capacity (Hayden 1975). Hassan (1981:166–168) has thus characterized effective actual carrying capacity as the *critical carrying capacity*, recognizing the operation of some limiting factor, such as Liebig's law of the minimum, which reduces the actual carrying capacity to some constant percentage of potential carrying capacity. The concept of critical carrying capacity is expressed as follows: "*Maximum human population size is dependent on the quantity of nutritionally critical foodstuffs, which are present in minimum amounts, at the time within the span of a few generations of their least abundance*" (Hassan 1981:166, emphasis in the original). The critical carrying capacity, or any carrying capacity, need not be fixed and can be increased through intensification (see Boserup 1965). Intensification, however, does not always happen, and it is particularly rare in hunters and gatherers, who tend to maintain their population stability through cultural means, such as infanticide (Birdsell 1953), or else through indirect environmental dampening, such as low fertility, as is suggested by Howell (1976) for the !Kung San. If this is true, as Bronson (1972), Bender (1975), Cowgill (1975), and Hassan (1981) have argued, how can population pressure be considered causative in population growth and sociopolitical evolution (cf. Boserup 1965; Spooner 1972; M. N. Cohen 1977; Sanders et al. 1979).

Population pressure will often exist in a population, but it will have differential effects on the cultural system. The real question, then, is, when does population pressure lead to intensification of the economic system, or under what conditions will dampening factors result in a steady-state demographic history, as Howell (1976) suggests? At various times in history some shift from a Type 2 to a Type 1 demographic profile occurred, and it is necessary to understand why and under what circumstances it did so. The answer to this question, as can be seen in table 1, lies in a shift in completed fertility schedules from 5 to 8.

Sedentary settlement appears to be the processual key which results in a shift in the fertility schedule from low to high, and hence from a relatively stable to a growing population history (Kolata 1974; Binford and Chasko 1976; Howell 1976; Lee 1980; M. N. Cohen 1980; Hassan 1981). While it is agreed that sedentary settlement results in a shift of fertility schedule, the specific mechanism responsible for the rise in fertility is not known. It appears that the increase in fertility may be linked to increased food supply, either through increased critical-fat levels (Frisch and MacArthur 1974; Frisch 1978; Howell 1979; M. N. Cohen 1980; Hassan 1981) or through relaxation of the length of lactation brought about by the increased availability of new supplies of weaning food (Lee 1980).

Sedentary habitation seems to result from two situations, both of which are related to increases in the critical carrying capacity. In the first instance, there can be environmental shifts, such as those which occurred at the end of the Pleistocene. This appears to have been the case in the Near East, where sedentary settlement developed when the climate enhanced the exploitation and storage of wild plant and animal resources (Reed 1977; Redman 1978). In Mesoamerica, sedentary settlement appears to have evolved slowly in response to the long genetic manipulation of teosinte, which increased the importance of this resource in the subsistence base as its productivity rose. There was then a gradual increase in population size as mobility decreased, which eventually led to sedentary habitation and village life (Flannery 1972a). Productive coastal zones can also promote increased sedentary settlement, as is seen in the Calusa example here and also in the Manus of the Admiralty Islands (Mead 1930).

The Manus are a very important group, because they represent a sedentary, tropical fishing adaptation. Peri, one of the villages of this society, has fertility information for the fifteen women of childbearing age (Mead 1930:app. 8). Although Mead does not give the ages of the women, she does specifically state that all of these women are still of childbearing age. Mead records two women who have given birth to nine children, and two which have given birth to eight children. These figures clearly demonstrate the high fertility potential of women living in a sedentary, nonagricultural, fishing community.

Besides the ethnographic analogy of the Manus, it is also possible directly to evaluate the potential fertility of a paleodemographic sample through the use of the archetype of fertility developed by Henneberg (1976). Henneberg noted a regularity in the *cumulative* proportion of the total births completed by each woman of childbearing age in all populations, irrespective of the birth interval and/or age-specific fertility rates (1976:42–43). The method he used was a uniformitarian application of biological characteristics of human fertility performance. If the mortality structure (i.e., life table of a skeletal population or any other type of population) is known, it is possible to compute a "potential gross reproductive rate." This measure represents the total reproductive potential remaining after the deaths of women who are still of childbearing age. From this, it is possible to calculate the average family size by simply multiplying the potential gross reproductive rate (R_{POT}) by the completed fertility (U_C), the average number of children born to a woman by the end of childbearing. The latter value, as suggested by Howell (1976), is about eight, although Henneberg (1976) suggests a lower value of seven as well. Both of these calculations will be used here. It is also possible to calculate the Net Reproductive Rate (R_O). This measure takes into consideration the mortality of subadults as well. The calculation of the Net Reproductive Rate is determined by the following equation:

$$R_O = R_{POT}(0.5)(U_C)\,\frac{100 - (d_O - 15)}{100}$$

In this formula, $d_O - 15$ is the proportion of liveborn children who die before they enter the reproductive period. This value is taken from the life table. The value of 0.5 is a correction factor to adjust to an approximately equal sex ratio at birth. If the resultant value of R_O is greater than 1.0, the population is increasing; if it is less than 1.0, it is declining. When R_O equals 1.0, the adults of the succeeding generation will have the same age structure and be equal in number to the present generation. When it equals 2.0, therefore, one adult is replaced by two adults, a rate of double in one generation, or about 3.5 percent. It should be emphasized that the resultant values of R_O are the *potential* replacement rates possible and do not necessarily represent the actual rates.

The implementation of Henneberg's method (1976) requires life-table information. Unfortunately, only one skeletal population exists for the southern Gulf coast of Florida, and it is located north of the study area. For the historic period, however, subsistence patterns for this population appear to be similar to those of the Calusa (Larson 1980:211–213). A further limitation is the lack of adult cohorts of precise ages and of five-year age spans. Thus, the resulting life table is rather imprecise, particularly as it relates to the fitting of Henneberg's age categories. In spite of these limitations, the life table for this population provides an important direct demographic, and cultural, example relevant to the study of coastal adaptation. This life table will be introduced in chapter 8, along with a more specific discussion of the fitting of the paleodemographic data from this example to the method of Henneberg (1976).

Demography is considered to have an important role in the evolution of the coastal adaptation in southwest Florida, not only because of the shifting population characteristics through time, which are demographic in nature and thus can be modeled in a demographic framework, but also because of the known sociopolitical correlates of certain demographic attributes. It has also been argued that such issues as population growth, population pressure, and rate of population increase cannot be adequately addressed without their specific evaluation and measurement. Demographic method and theory can overcome the data deficiencies of the case study here, which lacks some empirical quantitative data, and can generate meaningful parameters for characterizing the population history and the processes responsible for the evolution of the adaptive system on the southwest Florida coast.

Anthropological Theory and Ethnographic Analogy

In archaeology, there recently has been a growing interest in the generation of theory completely independent from that generated and utilized by ethnographers (see Clarke 1968). As Price (1982) has suggested, however, unless archaeology addresses the central problems of general anthropology, it runs the risk of becoming merely a data-retrieval operation. I am arguing here for a "uniformitarian" treatment of the sociopolitical aspects of the human condition, irrespective of whether they are found as extant behavioral systems or as extinct cultural residues. Such treatment logically follows the same treatment of the economic and demographic characteristics of the human species as well. Not only is this principle theoretically justifiable, it is also methodologically necessary, because such an assumption is the *only* way to link the behavioral characteristics of extant sociocultural systems with extinct cultural systems. If there is *not* the explicit recognition that all sociopolitical features are universally applicable to human societies, then it becomes impossible otherwise to suggest what characteristics or features are appropriate in a systematic way.

The above statements do not imply that this situation occurred for all periods in the archaeological history of hominid evolution. Binford (1973) has provocatively shown that the behavior represented by settlement and subsistence systems of presapiens hominids may have differed from what is known about contemporary hunter-and-gatherer resource exploitation. This does *not* present a problem here, however, since sapienization occurred no later than 40,000 years ago (see Krantz 1980), and the initial human occupation in the study area did not take place until less than 15,000 years ago, well after the most conservative estimate of the date of sapienization. Thus, it is maintained that the potential behavioral repertoire of prehistoric and protohistoric aboriginal occupants of south Florida was identical to modern ethnographic examples.

The acceptance of a uniformitarian behavioral repertoire for all humans allows the use of ethnographic analogy, a very powerful analytic method for the archaeological reconstruction of past sociocultural systems. Ethnographic analogy in archaeology is nothing more than the logical extension of the comparative method of ethnology to include archaeological societies. Its use requires the acceptance of one important assumption, which is subject to considerable debate—that all of the possible combinations of potential sociocultural adaptations which have existed throughout sapiens history are recorded ethnographically. Although such an assumption may not be completely correct, enough ethnographic situations are currently extant or have been recorded during the last two or three centuries so that the entire spectrum of prehistoric cultural experience since the end of the Pleistocene probably is covered. This situation is true at least for tropical coastal systems, which are a rare adaptation in the archaeological record.

The theoretical justification of ethnographic analogy again lies in the use of the culture core model. Under this model, when two similar environmental situations are seen, similar economic, demographic, and sociopolitical features should occur for a similar given technological system. In other words, similar environments and their characteristic limitations of energy flow, trophic structure, and resource regimes should pose similar problems to human groups, and these problems should be solved with similar economic and sociopolitical means. This is not to suggest, however, that sociopolitical options will be identical, but that they will be more similar in common environments.

In the initial stages of the research for this study, I wanted to use a comparative, systematic set of ethnographic data which related sociopolitical and population-density factors to various types of tropical coastal environments with known measurements of differential productivity and resource features. I further wanted the various adaptations within the comparative ethnographic study to have the same macropopulational history, and I wished to use exclusively nonagricultural subsistence resources. I believed that through the systematic study of differing coastal adaptations, certain cross-cultural correlations could be generated and that the studies of Birdsell (1953, 1957, 1968, 1977) would provide such a model. Unfortunately, it was not feasible to follow these inclinations for the following reasons.

Birdsell (1953) clearly recognized that the coastal and insular groups of Australia deviated markedly from his population-density predictor for interior "tribes." This predictor was based on the positive correlation of increased rainfall and population density. On the average, the 119 coastal tribes had density ratios 1.33

times higher than what would be predicted from rainfall alone. This observation is an important one in itself, because it demonstrates that on the *average*, at least for Australia, carrying capacity for hunter-gatherers is higher if they include coastal resources in their subsistence regime. For the 14 mainly or partially insular tribes, this ratio rises to 2.47, while for the 13 completely insular tribes, the density ratio is 2.86, indicating a carrying capacity 2.86 times greater than that predicted for interior mainland groups without access to coastal resources.

Even more significant is the residual category which Birdsell (1953) calls unearned surface water, that is, water available from sources other than precipitation, for example, water flowing in rivers. For this environmental category, Birdsell noted that the population density ratios increase dramatically with decreased distance from the mouths of rivers. The five geographically lowest tribes on the Murray River have density ratios 38.46 times that predicted by the rainfall formula. Such ratios clearly demonstrate the dramatic, differential carrying capacity in this coastal-riverine zone.

Birdsell (1953) groups the 119 mainland coastal tribes into twelve coastal sections, each of which has a specific density-ratio figure. The density ratios in these coastal zones range from 0.0 to 5.44 and obviously include a considerable amount of environmental diversity and productivity. Unfortunately, Birdsell does not indicate why the mainland coastal zones and their tribes were grouped as they were, nor does he indicate the characteristic features of these coastal zones or give productivity measures. If these data were presented, it would be possible to obtain some idea of differential carrying capacity of hunters and gatherers utilizing different coastal environments. Birdsell notes that the tropical zones had higher density ratios than the temperate zones.

To use Birdsell's data in a more systematic way, as I originally intended, it would be necessary to identify the ecological and spatial characteristics of his coastal divisions. It is not known, however, whether the coastal divisions correspond with any real ecologically distinctive divisions. Still, this lack does not negate the value of the general finding of his studies, which clearly indicate that, on the average, tribes which incorporate coastal resources into their subsistence regimes have higher population densities than those which do not.

A similar pattern of increased carrying capacity in coastal versus interior adaptations is recorded for North America as well. Kroeber (1939:145) noted that for the North American continent as a whole, exclusive of Mexico, for the period of early contact of each aboriginal group by Europeans, coastal residence led to a population density five-to-ten times that found in the interior nonagricultural regions and at least two times greater than in agricultural areas. Osborn (1980) sees this as paradoxical, because he does not consider "marine resources" to be more productive than terrestrial resources. He suggests a resolution of this problem in two ways. One of these is to include the total marine area utilized by a coastal adaptation in its population density calculation. The second solution is to consider coastal exploitation in areas of high terrestrial-plant production—that is, tropical zones—as being for protein rather than calories and thus an extremely advantageous complement to the nutrient-deficient diet characteristic of plants alone.

These factors would certainly pertain to many North American coastal adaptations but not to the Calusa nor to the tropical coastal aboriginal occupation of the Kaiadilt of Bentinck Island in the Gulf of Carpentaria, Australia. These hunters and gatherers use exclusively aquatic resources, with the bulk of their food being obtained from the coastal zone (Tindale 1977). Tindale (1977:249), after correcting for actual area exploited as suggested by Osborn, calculated a population density of 2.7 persons/km^2. This density is higher than all the hunter-and-gatherer population-density figures listed by Hassan (1981:8), except for the Haida and the California acorn-game-fish people.

All coastal adaptations, of course, are not "rich," and such is not to be expected. Dense coastal populations which do not use or rely heavily on plant resources are probably also relatively rare. In most cases, adjacent interior, terrestrial regions are suitable for alternative resources, especially plants. Thus, exploitation of interior resources is feasible and actually energetically advantageous, as Osborn (1980) has correctly argued. Ethnographic analogies which lack interior plant resources of sufficient quantity to provide a major portion of the subsistence base, as do the Calusa, are few.

One group which meets this requirement is the Manus of the Admiralty Islands, adjacent to New Guinea (Mead 1930; Murdock 1969). This society has a total population size of some 2,000 individuals residing in eleven permanent coastal villages composed of houses on piles built on tidal flats, each with a population of about 200 individuals. The Manus appear to have originally had a chiefdom sociopolitical organization, but with the introduction of British rule, the system collapsed: "the Manus have the idea of rank, of hereditary leadership in war, of blood carrying certain prerogatives of dress and privilege" (Mead 1930:178). Murdock (1969) has coded this society in the Human Relations Area Files (HRAF) as having a subsistence base of which 90 percent is attributable to fishing and the remaining 10 percent composed of tree resources, sago palm (Mead 1930). Agriculture is not a component of the subsistence economy of this society, and fishing represents the main subsistence activity. Other subsistence resources seem to be of minor importance. This demonstrates, despite Osborn's objections, that fishing resources, in at least one tropical coastal adaptation, operate independently of a "protein strategy." Coastal resources can, in a tropical environment, be used for the caloric portion of the subsistence base and can support large populations. Still, it seems reasonable that when coastal zones border productive agricultural regions such as in Malaysia (Firth 1966), the interior plant resources will provide the caloric balance in the diet.

The Calusa type of adaptation, characterized by a high population size and density subsisting primarily on coastal resources to the *exclusion* of agricultural products, will occur in those regions where agriculture or use of natural plant resources is either restricted or impossible. Trade is an intermediary solution to this resource disequilibrium and can allow the exchange of plant resources with their caloric surplus for high protein coastal products. Nevertheless, it seems doubtful that the exchange value in nonmarket economies would be such that plant resources could be effectively traded to account for over 50 percent of the subsistence base. An inspection of mixed farming-and-fishing communities in Murdock's (1969) survey, which shows about a 50–50 mix for tropical areas, supports such a conclusion.

Complicating the situation in Florida is that agricultural societies, such as Timucuan groups, possibly the Tocobaga, and the Mayaimi, which relied on intensive harvesting of wild plant remains, had access to adequate if not abundant coastal, riverine, and lacustrine protein resources. What would the incentive be for these groups to trade for resources which they presumably already have in sufficient quantities? The exchange of high-quality protein resources is not a viable strategy for increasing *caloric* intake in the Calusa subsistence base. As Osborn (1980) indicates, although such exchange would be energetically advantageous for the Calusa, it could not be energetically supported by the surrounding groups. This situation might account for the exploitative tribute seen in this adaptation, since the Calusa would receive little *subsistence* value in true exchange relationships.

Theoretically, plants provide at least ten times more calories than animals because of their trophic position. Although plants provide high amounts of calories (carbohydrates), they are usually deficient in protein and fat. However, this deficiency requires only small or moderate amounts of animal flesh for dietary complementation. Although animal flesh provides calories it does so at an energetic return of only about one-tenth that of plants. Therefore, from an optimal dietary and ecological perspective, the subsistence base should be mostly composed of plant resources, to provide calories, complemented by small or moderate amounts of animal resources to provide needed protein and fat.

Since aquatic animals, like fish, do not compete or interfere with human dietary plant exploitation or agriculture as do terrestrial animals, such as livestock or wild game, their use allows expansion of plant utilization and agriculture without affecting the availability of animal food resources. Therefore, where possible, coastal or aquatic animal resources would be more advantageous in the diet than terrestrial animal resources for protein complementation.

This is probably why in other parts of the world, such as the Mexican Gulf and Pacific coasts, the southeastern United States, Polynesia, Southeast Asia, and India, the optimal subsistence mix includes both agricultural and coastal resources. Tropical coastal adaptations without agriculture would be rare in the ethnographic record. It seems, however, that the exclusive reliance on tropical coastal resources in some way results in complex forms of sociopolitical organization which would not be characteristic of economies that incorporated both agricultural or natural plant resources and coastal faunal resources.

The Distinctive Characteristics of Fixed, Coastal Fishing Economies

Osborn (1980) has correctly pointed out that mid-latitude (tropical) populations, where plant food is abundant and not seasonally variable, would opt to use marine resources for protein, rather than relying only on foods higher in calories, since the former tends to be more limiting in such areas. In many areas, this protein is actually obtained through trade of fish for agricultural produce, as is the case for the Efik of Africa (Horton 1971), many New Guinea groups (Chowning 1977), and particularly in Malaysia (Firth 1966) and Sri Lanka (Alexander 1977).

Often, because the fishing economies are specialized sectors of larger state-level market economies, as is true in Malaysia and Sri Lanka, the complexity and organization of the fishing activity is implicitly assumed to be a result of the state-level system and is therefore seen as a correlate of it. These specialized, complex fishing systems, however, do not necessarily require a state-level system and instead can arise out of the managerial requirements of inshore tropical fishing.

Frake and Cordell (1978) have reviewed this problem and have commented that because of the assumption that fishing is a correlate of the state, there has been a lack of understanding of tropical coastal fishing in traditional society, particularly in terms of the relationship between demographic pressure and food production. A number of studies of fishing adaptations demonstrate that tropical *inshore* (coastal) fishing systems are very different from *offshore* open-water (pelagic marine) fishing systems (Frake and Cordell 1978) and generate very different sociopolitical systems.

Frake and Cordell (1978) point out that offshore fishing is characterized by common property or access rights but that tropical inshore fishing systems are not. Many studies (Forman 1970; Johannes 1976; Alexander 1977; Tindale 1977; Cordell 1978) have shown that, as a result of two characteristics of inshore coastal productivity, coastal fishing zones are either privately owned or that specific tenure rights govern their use.

Johannes (1976) notes that when reefs are owned in common, little regard is given the problem of overfishing and each fisherman tries to maximize his individual catch, because if he does not, some other fisherman will fish the area instead. As a result, an individual fisherman is competing with other fishermen for the resources of a fixed and limited area. When a tract is privately owned, however, an individual can monitor its use and practice a conservative fishing strategy. "When reef and lagoon tenure exist, the long-term disadvantage of over-harvesting (reduced yield in the future) as well as short-term advantage (larger immediate yields) accrue to the owners and it is clearly to their advantage to harvest in moderation" (Johannes 1976:9). From an adaptive perspective, if reef fishing forms a necessary component in the subsistence system (i.e., nonmarket), then such common fishing rights to these areas will not be long-lived.

Tindale (1977) has shown that among the Kaiadilt, the Australian aboriginal group living on Bentinck Island, the leading man of each clan has strict rights over the resources within the territorial limits of each clan. "This man claimed the right to a share of all major food items, especially dugong and turtle, taken within the recognized area of his *dolnoro* (clanlike group), the limits of which extended out to sea as far as it was possible to gather food at the lowest tides" (Tindale 1977:257). Thus, even among this nomadic hunting-and-gathering insular group, the concept of corporate ownership of inshore coastal fishing areas is well established. Associated with this concept is higher leadership positions than are usually seen among Australian groups. "The *dolnorodangka* (leading man) seems to have more authority than is generally the case in other Australian tribes, wherein it is difficult to define any regular form of chieftainship" (Tindale 1977:258). Forman (1970) has shown that in Brazil, fishing captains have exclusive coastal tenure rights over use of certain fishing areas.

Not all tropical inshore fishing systems lead to exclusive ownership or use of coastal fishing zones, however. Instead, a complex set of rules develops to govern the use of these areas. Cordell (1978) has shown that in Brazil, because tides regulate the temporal availability of fish in an area, there is a schedule which orders the sequence of fishing and the length of time when fishermen can work an area. In Sri Lanka, Alexander (1977) has described how the fishing is organized. In the community Alexander studied, only two areas of beach can be fished at any given time; yet there are forty nets in the community. The produce of the fishing effort is communal property, with owners of nets receiving a share of the catch. The size of the share depends on the size of the individual catch and whether the owner's net was used. As a result, a rotating system of net use has evolved. The fisherman has a choice of using his net or relinquishing his turn if he believes that the fishing will not be good that day. Thus, a complex system of scheduling seems to be necessary to regulate fishing activity, not only to make it more productive, but also to minimize potential disputes.

Another important feature of this type of fishing is that it is a continuous, daily subsistence activity and not merely the seasonal undertaking characteristic of anadromous fishing systems found in the more northern latitudes, such as the Pacific Northwest coast of North America (Schalk 1977). The continuous regulation that is therefore necessary reinforces the role of the leader, fosters the formation of more permanent leadership positions, and clearly encourages the development of hereditary leadership positions, such as those associated with chiefdoms. A corollary to this situation is that as the number of individuals involved in fishing increases so does the potential for disputes and hence a greater need for coordination and management.

It seems clear that tropical inshore fishing systems differ from those which are either offshore or in northern latitudes. For efficient implementation of the former, their ownership, or a control of access to them, is required. The lack of both restrictions will lead to either overexploitation of the resource base or else increased competition and conflict over access to it, which in the extreme case can lead to the failure to exploit the resource at all, since cooperative activity is often required for successful implementation of any fishing activity.

The Role of Leadership in Tropical Coastal Fishing Systems

The characteristics of tropical coastal fishing systems provide a potential for leadership development that appears to be more precocious than in other economic systems of comparable population size and density. This observation raises the question of whether there is something "special" or "unusual" about this form of fishing adaptation with regard to the evolution of a complex sociopolitical organization. The potential for leadership and differential hierarchical behavior is, I believe, universal in human beings. This behavior therefore has the *potential* for expression in all human populations at all times. It is not, however, found in all cultural situations, particularly in institutionalized form, because environmental conditions and cultural systems sometimes do not favor, in an adaptive sense, its development. In fact, in many cases it would be maladaptive, since it would disrupt resource procurement and subsistence patterning, that is, the need for many hunter-gatherers to share meat resources. When population size and density increase, however, and if the resource base requires management and coordination, then an individual will be able to exercise the latent hierarchical behavior, because such behavior will be adaptively advantageous.

It appears that fixed tropical coastal resources require such management to be effectively utilized. As a result, leadership (differential hierarchy) is tolerated or allowed to emerge, because in the long run it is beneficial in an adaptive sense for the cultural system. The greater the need for the coordination of fishing activities, such as arbitrating disputes and planning and managing resource procurement and redistribution, the greater the likelihood that differential hierarchical behavior among individuals will emerge. Since the *potential* for hierarchical behavior "inherent" or "uniformitarian" in.the human species, it does not present a "puzzling" or crucial origin as Flannery (1972b) suggests. Tropical coastal adaptations, I contend, have certain features or characteristics which allow this precocious leadership development.

Archaeological Studies of Tropical Coastal Adaptations

Archaeological investigations of tropical coastal adaptations are not common because of their limited areas, their isolated locations, and the lure of more traditional archaeological interests. Three studies of adaptations in such environments have been conducted to date in North America. One was my study of the southwest Florida coast (Widmer 1978). The other two studies are from Mesoamerica, one located on the Gulf coast of Vera Cruz, Mexico (Stark 1977), the other on the Pacific coast of Chiapas, Mexico (Voorhies 1976). Both studies represent the current level of archaeological research in these environments. They are ecological in orientation and have as their goals reconstructing the adaptation to the tropical mangrove environment. The studies deal with the adaptations exclusively from a synchronic perspective and are not primarily concerned with their diachronic development, although Stark does briefly discuss shifts in faunal exploitation. Stark originally set out to find the early preceramic settlements postulated by Coe and Flannery (1967) and MacNeish (1967) to be found in these coastal zones. Stark could not find any of these early occupations, but she does not explain why. She then proceeds to build an ecosystem model to characterize the coastal estuarine adaptation.

Voorhies (1976) identified a preceramic occupation in the coastal region of Pacific Chiapas. Like Stark, she recognizes the role of energetics in the adaptation and attempts to reconstruct the demography of the population, economic patterns, and settlement patterns. Voorhies (1976:28–29) recognizes the distinctiveness of a tropical coastal adaptation with pseudocatadromous fish resources, noting the advantage of these species, which live in estuaries and breed offshore, over anadromous species, which are highly seasonal in terms of their availability for human populations. Yet in spite of this very important recognition (the first such distinction of these two types of fish resources), she does not believe that coastal populations can rely solely on such resources: "It is my impression that *no* coastal population has ever depended exclusively on an aquatic environment for the provision of its basic needs" (Voorhies 1976:10, emphasis in the original).

Voorhies also recognizes the expansion of the estuary environment at the end of the Pleistocene when the sea level began to rise. She makes no specific mention, however, of the particular history of this sea-level rise, nor does she discuss why the Chantuto adaptation occurred at 3000 to 2000 B.C. This criticism also applies to Stark's (1977) study. The treatment of diachronic questions was not an aim of the research designs, but without their consideration the studies represent static, descriptive models of the suppposed interaction of cultural systems with the environment. These studies further suffer from the inability adequately to model the ecological structure of the coastal environment with its particular trophic structure and energetic relationships. Thus, the two studies are founded on assumptions about how the ecological aspects of the environment should have been.

These researchers must not be faulted for the shortcomings of their studies. At the time the studies were conducted, the necessary data and knowledge, both specific and general, on the tropical coastal ecology did not exist, a limitation recognized by the researchers. Therefore the statements and conclusions were valid for their time. Since then, an enormous and sophisticated body of data on tropical coastal ecology and geology has been assembled which now makes it possible to understand more precisely the trophic structure, energy flow, and productivity of mangrove tropical estuaries, and their relationship to human populations. Even now, however, in-situ archaeological and ecological data are lacking for these areas of Mexico, necessitating the use of general models of ecology and anthropology generated from other environmental and cultural situations which have similar processual features.

It is very difficult to discuss adaptation from a synchronic perspective because, as suggested earlier, it becomes a potential tautology; everything present must then be adaptive. A diachronic approach that incorporates specific sea-level history, paleoenvironmental history, and ecological characterization of the environment in energetic terms must be used. A study of adaptation requires the study of a population within a specifically controlled environmental history.

Diachronic Ecology

The same ecological characteristics may not be valid for all phases of the prehistoric adaptation. Thus, one must determine precisely the history of the environmental conditions in the study area. This is of the utmost importance, not only for the sake of accurate environmental reconstruction, but, more important, for theoretical reasons. An important principle of the culture core strategy is that the environment will constrain, if not determine, the particular technological and economic features of a sociopolitical system. Therefore, the accuracy of an economic model is determined by the accuracy of the characterization of the environment at any point in time. The intimate association of sociocultural and environmental characteristics necessary to a cultural-ecological study clearly demands a paleoenvironmental history that is as accurate as possible, particularly because of the inherent limitations in the archaeological record.

For a diachronic study of coastal adaptation, with a diachronic perspective, the specific history of sea-level rise in the area of concern must be understood. Unfortunately many studies of sociocultural change or evolution in coastal zones do not address sea-level change at all. It is becoming clear that generalized worldwide eustatic sea-level curves are inadequate for use in regional sea-level histories, since the post-Pleistocene rheological (deformation and flow of inner core material) history differs regionally (J. A. Clark et al. 1978; J. A. Clark and Lingle 1979). This means that two different and contradictory sea-level histories in eustatically stable areas may both be accurate.

Archaeologists have long recognized that sea level has risen since the end of the Pleistocene and has greatly affected the location and visibility of archaeological sites (Goggin 1948a; G. Clark 1952; Binford 1968). But, not until recently, most notably in Australia (Bowdler 1977; Chappell and Thoms 1977; Jones 1977; Tindale 1977) and in Brazil (Fairbridge 1976), have archaeologists drawn on specific, locally derived sea-level histories in order to interpret the effect of sea-level position on the sequence of archaeological settlement and subsistence patterns. Much of the failure to do so lies in the lack of local sea-level histories.

Many archaeological studies (i.e., Binford 1968; J. W. Griffin 1974; Fladmark 1975; Gagliano 1977; R. Jones 1977; Cockrell and Murphy 1978; Ruppé 1980; G. Clark 1985) do acknowledge the effect of sea-level change on coastal occupation, but most of these studies are concerned with the drowning, and hence potential loss, of sites from the archaeological record; others focus on the potential effects of a gradually landward migrating population with its potential political impact on interior groups. Implicit in these studies is the assumption that the coastal environment at any point in the sea-level history is approximately the same. This need not be and is usually not the case, because the rate of sea-level rise in the Late Pleistocene and Early Holocene, as compared with later periods, determines the effect on the configuration and ecological characteristics of coastal environments. There may also be, as in south Florida, a concurrent rise in the water table to a point where surface flow is considerable, altering the entire character of the environment.

A detailed knowledge of the history of sea-level rise, hydrology, geology, sedimentology, and paleoenvironmental data for a region is necessary to reconstruct the paleoenvironmental conditions at various periods in a regional history. Fortunately, south Florida has a very comprehensive set of paleoenvironmental data which provides for a substantial environmental reconstruction for the period during which cultural evolution has taken place.

Not all coastal environments undergo dramatic radical shifts in their environmental conditions through time, as has happened in south Florida. Indeed, the south Florida paleoenvironmental history for the post-Pleistocene is probably unique. Still, it is absolutely imperative that such environmental change or lack of it be documented and that the nature of the change be understood in ecological terms.

Archaeological Data Requirements

It is possible to create a temporal model of paleoenvironmental characteristics of south Florida and then to superimpose on it a model of expectation of population history and cultural change. The result would be nothing more than a reasonable hypothesis, but the introduction of archaeological data would act as a partial test of such a hypothesis. The data would thus be incorporated into the diachronic paleoenvironmental data, and the result would be a more powerful, multifactorial model of adaptation.

Although comprehensive archaeological surveys with chronological phasing and precise settlement typology are desirable, they are lacking for much of south Florida. The use of chronological settlement data in this study will therefore be incomplete and subject to considerable interpolation from a traditional archaeological perspective.

In spite of the limitations of the archaeological data base, if the deficiencies are considered in a theoretical, problem-oriented framework, many of them can be overcome. The archaeological data are well enough known to permit their use in an integrated model of cultural adaptation. In fact, many of the culture-historical problems pertaining to the data base can actually be resolved if we consider them within a diachronic theoretical model of cultural adaptation.

There are phase-specific settlement and subsistence data for many archaeological sites in southwest Florida. If caution is applied, they can be used as type sites, that is, sites representative of specific demographic, settlement, economic, and sociopolitical characteristics. These characteristics can then be integrated into larger settlement-subsistence system models. The completeness of these phase-specific settlement-subsistence system models will vary because of the data limitations for each period. Still, these settlement-subsistence types, when considered within an environmental, ecological framework, can provide reasonable reconstructions of the history of cultural adaptation in southwest Florida. The archaeological record, when viewed from a theoretical, ecological framework of adaptation, with precise characterizations of the environment and its change through time, becomes remarkably complete, irrespective of its data limitations from a traditional culture-historical perspective.

3

The History of Archaeological Research in Southwest Florida

Professional archaeological interest in southwest Florida began about a hundred years ago and started as a result of the area's use as a winter vacation area (Milanich and Fairbanks 1980). Simmons's (1884) description of the extensive shell mounds in the Port Charlotte area was the first acknowledgment of the archaeology of southwest Florida. He observed in Charlotte Harbor twenty-five "shell heaps," including sites on Useppa Island, Mondongo Key, Patrico Key, and Garden Key. No excavation, maps, or discussion of artifacts were included in his report. Kenworthy (1883) reported a number of large mounds in the southern part of the state, including mounds on Pine Island and Gasparilla Island in Charlotte Harbor, and mounds in the Lake Okeechobee basin, including Fort Center and Fisheating Creek. More important, Kenworthy reported on a series of aboriginal canals, including one on Pine Island and one just south of Naples between Gordon's Pass and John's Pass. Kenworthy also mentions the existence of an alleged aboriginal canal at the headwaters of the Caloosahatchee near Lake Okeechobee. Kenworthy made no excavations or collections, although he did provide a map showing the location of the canal south of Naples. These canals were further reported on by Douglass (1885).

In 1895, Colonel Durnford, a British officer, formed a small expedition to explore the aboriginal canals and mounds reported by Kenworthy (1883) and Douglass (1885). It had come to the attention of one of the expedition members, Charles Wilkins, that some artifacts had been recovered by a Captain W. D. Collier at Marco Island while he was digging muck for a garden. Wilkins proceeded to Key Marco and initiated a small excavation in the area where Captain

Collier was digging. Wilkins recovered numerous wooden artifacts in a single day (Cushing 1896:329). Colonel Durnford, hearing of Wilkins' findings, proceeded to Marco and began his excavations. He duplicated the finds of both Collier and Wilkins by unearthing rope, netting, gourd fragments, wooden pegs, and shell and ceramic artifacts. These he reported on in the *American Naturalist* (Durnford 1895).

Colonel Durnford also excavated in a mud-capped, sand burial mound which was situated on top of a shell midden. In this mound he found skeletal material and even noted traumatic injuries to the bone (Durnford 1895:1037–1038). No artifacts were recovered during his excavations. Durnford does not specifically give the location of this mound, but his observations that it is 8 or 10 km (5 or 6 miles) from Key Marco, is the second highest elevation in the area (Caxambas being the highest), and has water on both sides of it clearly indicate that this mound is on Horr's Island and is none other than the Blue Hill Mound.

Durnford brought the artifacts which he recovered from southwest Florida to the University of Pennsylvania Museum to ascertain their significance. At that time, Frank Cushing of the Bureau of American Ethnology happened to be at the museum and confirmed that they were aboriginal and important (Cushing 1896: 330). He concluded that they were the remains of "some phase of life in southern Florida as that of the Ancient Pile Dwellers of Switzerland, or the Pile and Platform Builders of the Gulf of Aracaibo on the Bayous of the Orinoco in Venezuela" (Cushing 1896:330).

Based on these initial observations, Cushing initiated a preliminary field trip for the University of Pennsylvania Museum to investigate at firsthand the excavations of Colonel Durnford (Cushing 1895). Cushing could not directly proceed to Key Marco, and so he examined much of the coast in the Port Charlotte area as well. Cushing duplicated the reports of Durnford and concluded that the finds were not isolated but instead were "more or less typical of no fewer than eleven others of these shell settlements later examined on various keys or on out-lying reefs of Pine Island, and the Mainland below Punta Rassa" (Cushing 1895:1134). Cushing found wooden artifacts at Key Marco where Durnford, Wilkins, and Collier had excavated earlier, and at Demorey's Key, Cushing recovered a shell *Busycon* pick with its "mango" handle still attached. He also observed the remains of pile works which "suggested that these great shell settlements had been surrounded inside and out by post-supported platforms" (Cushing 1895:1134). The observations were reported in greater detail in the 1896 report of the Pepper-Hearst Expedition (Cushing 1896:331–335).

Cushing further elaborated on exploration of mounds, shell heaps, and reefs in the Pine Island Sound–Port Charlotte area. He reports on excavations at Josslyn's Key and Demorey's Key, and he explored the site of Battey's Landing on Pine Island, which consisted of nine large foundations and five courts covering 30 to 34 hectares. More important, he described what he thought to be the "greatest, except one, of all the monuments of the ancient key builders on the Florida coast" (Cushing 1896:342), the exception being Key Marco. This monument consists of a "canal and gigantic mounds and others inland to which it led." Cushing also visited Mound Key, noting its height, before heading south to Key Marco.

As a result of the success of the initial field reconnaissance, a full-scale expedition under the financial backing of Dr. Pepper, an eminent Philadelphia physician and amateur archaeologist and Phoebe Hearst, both associated with the University of Pennsylvania, was launched. The excavation focused on a triangular, mucky, mangrove fringed bayou which Cushing called "Court of the Pile Dwellers" (1896:356). The excavations, performed under extremely trying conditions, resulted in the collection of great quantities of cultural material, both "perishable" (i.e., wood, netting, and cordage) and nonperishable (such as ceramics and shell). Cushing's investigations represented the first systematic excavation in southwest Florida. He used a grid system of ten-foot squares, and he even mapped his earlier excavations and those of Collier, Wilkins, and Durnford. Not only did he provide a map of the excavation of the Court of the Pile Dwellers, but he also produced the first stratigraphic profile of southwest Florida. He did not relate chronological or cultural divisions to it, however, as Walker (1883) had done at Cedar Key farther north on the Gulf coast.

More important, Cushing was the first to evaluate the Key Marco finds from an anthropological perspective. He related many of the design elements found on Key Marco artifacts to Middle Mississippian iconography to the north, rather than to the closer Caribbean, and thereby provided a comparative context for the material. He also was the first to distinguish the unique character of the adaptation, pointing out the unusual productivity of the coastal environment as evidenced by the following statement: "Again, no waters in the world so teem with food-producing animals—molluscks (*sic*), fishes, crustacea and turtles—as do these waters of the lower Florida Gulf-Coast" (Cushing 1896:396). He also realized that the settlements, because of the coastal adaptation, would be adjacent to these resources. Cushing was really the first anthropologist to consider coastal adaptation on a cross-cultural comparative basis. He thought that the same kind of adaptations would be found in other parts of the world where coastal environments were similar. This pattern of coastal adaptation, he suggested, represented a "Shell Age phase of human development and culture" (Cushing 1896:411). Cushing clearly foresaw the role environment plays in shaping cultural phenomena and how these features arise independently of culture contact:

> If one but glimpses at the natives of like low sea-lands of let us say, Borneo, Papua, Southeast Asia and certain Polynesian regions, he will see how close a parallelism in arts—and probably, too, even institutions and religion—obtain between the key dwellers as indicated by their art remains, and these peoples not in any wise related to them. He will see that merely by similar condition of natural surroundings, these parallelisms have been wrought to a point that is, in many details of the products of these wide-sundered peoples, no less than astounding. [Cushing 1896:406n.]

Finally, and perhaps of more lasting significance, Cushing was the first anthropologist to evaluate the sociopolitical significance of the archaeological remains of southwest Florida. He even correlated them with the chiefdom level of sociopolitical organization and identified causal elements which led to this development.

> But the men of the desert sea waters, here among the keys, were beset by dangers far greater than those of human foemen, necessitating far more arduous communal effort in the construction of places, rather than houses, of harbors and storm defenses, rather than fortified dwellings; and the construction of these places under such difficulty and stress, led to far more highly concerted action and therefore developed necessarily not only sociologic organization nearly as high [as the Zuñi], but perforce a far higher *executive* governmental organization.
>
> The development of the Key Dwellers in this direction, is attested by every key ruin—little or great—built so long ago, yet enduring the storms that have since played havoc with the mainland; is mutely yet even more eloquently attested by every great group of shell mounds on these keys built for the chief's house and temples; by every lengthy canal built from materials of slow and laborious accumulation from the depths of the sea. Therefore, to my mind, there can be no question that the executive, rather than social side of government, was developed among these key dwellers to an almost disproportionate degree; to a degree which led not only to the establishment among them of totemic priests and headmen, as among the Pueblos, but to more than this—to the development of a favored class, and of chieftains even in civil life short of regal in power and tenure of office. [Cushing 1896:412–413, emphasis in the original]

Surprisingly, Cushing did not correlate the "Key Dwellers" with any particular ethnographic group located in the area, the most obvious being the Calusa. This is probably because of the lack of any synthesis of the Calusa by anthropologists at the time. It was not until Mooney published his *Handbook of American Indians* (1910) that a description of the Calusa was introduced into the anthropological literature, although references to this group were found in the historic documents pertaining to south Florida, and Brinton (1859) and Smith (Fontaneda 1944) discussed the Calusa and other groups of peninsular Florida.

It appears that Cushing attributed the "Key Dwellers" to a prehistoric aboriginal group which shared a common ancestry with historic groups of the Southeast. He specifically acknowledges that mounds were built and used by historic groups in the Southeast (Cushing 1896:403), and he suggested an independent development of the mounds of the southwest Florida coast and those in the heartland of the Southeast. He also suggested, however, that the interior mound builders ultimately derived their culture from sea-dwelling people farther up the Gulf, and that such a group was ancestral to both regions. Cushing believed that a sea-dwelling preceded a mound-building way of life and was ultimately derived from South America (Cushing 1896:408). Thus, Cushing anticipated the concept of the Formative culture as later developed by Ford (1966, 1969), a sedentary life style derived from South America, although couched in a unilineal evolutionary construct typical of that time.

I have dwelt at considerable length on Cushing's observations because they seem to have been all but ignored. Even P. Phillips's (1973) introduction to the republication of Cushing's report failed to point out the anthropological contribution he made, instead criticizing the substantive aspects of his research. Yet in spite of his cavalier approach to using data, Cushing anticipated many of the current ideas regarding southwest Florida. Thus, the publication of *Exploration of Ancient Key Dweller's Remains on the Gulf Coast of Florida* (Cushing 1896) marks the initiation of anthropological archaeology in southwest Florida. Cushing's use of comparative ethnographic and ethnological data in lieu of direct historical continuity represents a truly processual approach considerably ahead of its time. It is unfortunate that the "Boasian" penchant for particularism and attention to data resulted in the overlooking of his important contribution to archaeological research.

Although the anthropological contributions of Cushing's interpretations were for the most part ignored, the significance of the archaeological materials from Key Marco were appreciated. Because of the success of the Pepper-Hearst expedition, Clarence B. Moore diverted his attention from the burial mounds along the rivers of northern Florida and headed south in his steamship *Gopher* to try to duplicate Cushing's success at other sites along the southwest Florida coast.

Moore made trips to southwest Florida in 1900, 1904, 1906, and 1907; reports on his first two seasons were published in 1900 and 1905 and those of his later two seasons were published in 1907. In Moore's first field season, he visited the site of Indian Old Field, a shell heap on the northeast shore of Pine Island, and also trenched a burial mound located adjacent to the aboriginal canal earlier reported by Cushing (1896), Douglass (1885), and Kenworthy (1883), located about three-quarters of a mile from Indian Old Field. Moore's investigation recovered thirty-eight burials and steel, glass, and silver grave goods (Moore 1900:362). Moore also investigated Mondongo and Joseffa keys, located just north of Pine Island, Josslyn's Key, Demorey's Key, and Mound Key. Moore established that the shell fence on Demorey's Key was nineteenth century in date, and he also accurately measured the height of the mound on Mound Key and found it to be 9.4 m (31 ft.), rather than 18.3 m (60 ft.) as Cushing had described it.

Moore (1900:367) conducted extensive excavations in the muck canals and courts of Mound Key, hoping to duplicate Cushing's findings at Key Marco, with no success. Moore also excavated a burial mound on Mound Key "finding nothing of particular interest," but he stated that numerous European artifacts came from it. Thus, Moore's was the first recognized excavation of a protohistoric site. Moore did not, however, attribute it to the Calusa.

Moore then proceeded south to Marco Island and excavated in the "courts" and "muck ponds" of the Key Marco site immediately adjacent to the "Court of the Pile Dwellers" excavations. His excavations in this area did not reveal any perishable items, only shell plummets and axes. He subsequently proceeded to Goodland Point, also on Marco Island, and excavated several burials from small burial mounds in the mangroves. In these he found caches of "shell cups" (Moore 1900:372), and Moore reported and illustrated several shell artifacts recovered from the area by the property owners.

Moore continued south, visiting the Blue Hill Mound on Horr's Island and noting that it had been thoroughly dug through, thereby substantiating that this was the mound Durnford had excavated. Moore headed south from Marco into the Ten Thousand Islands and reported shell mounds at Gomez's Old Place near Coon Key, Dismal Key, Kikahatchee (*sic*) Key, Russell's Key, Wiggin's Key, Chockoloskee Key, and sites on the Turner and Chatham rivers (Moore 1900: 379–380). Moore's archaeological exploration represents the first one south of Horr's Island in southwest Florida.

Moore was impressed with the extensive shell heaps but was of the opinion "that archaeological opportunities offered there are more for the surveyor than for the excavator" (Moore 1900:380), a statement apparently attributable to Moore's fancy for decorated ceramic caches from burial mounds, which did not appear on the southwest Florida coast. Moore was of the opinion that the preservation of wood artifacts was accidental and concurred with Cushing that Key Marco was an isolated case. He also thought the sand mounds in Florida had contained a core of objects carved in wood which had not lasted.

In 1904, Moore returned to investigate the archaeological remains of southwest Florida. The most notable aspect of his 1904 field season was the complete excavation of the burial mound he had begun on Pine Island the previous season. During his second excavation of this mound, 219 individuals were unearthed, including 4 closely flexed burials, 37 loosely flexed burials, one burial disturbed by another, and 177 skulls. Only a single plain ceramic bowl was recovered. Numerous sherds of "inferior ware" were found in the mound, except for three or four decorated sherds of the same vessel which appears to be Englewood Incised (Moore 1905:306, fig. 6), three check-stamped sherds, one notched rim, and two loop handles.

Moore (1907:307) makes note that no historic materials were associated with the burials at the base of the mound, although such material occurred in other parts of the mound. These artifacts included a glass cross, glass beads, five steel axes, three pairs of scissors, two broad chisels, three steel knives, one steel pruning knife, one steel chisel, one steel rod, three silver beads, and a pendant of glass. On the evidence of these artifacts, Moore concluded that the mound was a "good example of a mound distinctly post-Columbian" (Moore 1905:308).

Moore also excavated a sand burial mound on Shell Creek near Punta Rassa (Moore 1905:309), where he encountered seven flexed burials and no artifacts, although previous local diggers reported finding many glass beads. A small number of sherds were found, including Englewood and check-stamped sherds.

Moore proceeded south and stopped at Mound Key and Marco. He (1907:310) stopped excavating, however, and instead concentrated on the collection of surface material, no doubt because of the dearth of ceramic caches in the southern burial mounds and the extremely unlikely possibility of duplicating Cushing's remarkable discoveries.

Moore also revisited some of the sites in the Ten Thousand Islands. During his trip to Chockoloskee Key, a Mr. McKinney had recovered three wooden objects from trenches dug to extract muck for agricultural use. The recovered objects included a black mangrove maul, a wooden cup, and a drilled wooden plaque of two sections and were described and illustrated by Moore (1905:313–314). From here Moore went farther south along the coast to Lostman's Key and noted shell causeways and platforms on the north end of the island.

As a consequence of the first two seasons of research in southwest Florida, Moore made a series of generalizations regarding the archaeology of the area.

> As a result of this part of our journey of the season of 1904, we formed certain conclusions, and fortified others which we had previously expressed in print, namely:
>
> (1) That while the shell deposits of the southwestern coast of Florida are of great interest as monuments of the aborigines, their contents offer little reward to the investigator.
>
> (2) That the sand mounds of the southern Florida coast were built mainly for domiciliary purposes, and that such as contain burials yield but little pottery, whole vessels being practically absent.
>
> (3) That these burial mounds contain but few artifacts of interest and that such artifacts as are met with in the smaller ones, and superficially in the larger ones, are often of European origin, making a strong contrast with the mounds of the northwestern Florida coast and of St. John's river.
>
> (4) That failure of the aborigines to place earthenware with the dead, in mounds along the southern Florida coast, did not arise through lack of its possession, but rather that the custom of doing so did not obtain there. Fragments of earthenware, though fewer in number and of far inferior quality on an average than in central and northern Florida, are met with along the southern Florida coast. Similarly, along the whole eastern coast of Florida, entire vessels seem to be absent from the mounds, though inland, in the northern part of the peninsula, at least, whole vessels are fairly abundant.
>
> (5) That while the muck, i.e., mud and organic matter, which fills the canals and small artificial harbors of the Ten Thousand Islands, in one instance yielded so rich a reward to Mr. Cushing's labors it seems likely, as Mr. Cushing believed, that the objects of wood found by him at the town of Marco, Key Marco, were present there through some particular cause. Certain it is that extensive digging in the muck by Mr. Cushing and by ourselves in other localities, yielded nothing of wood, and that ditch-making and the like by the inhabitants of the Ten Thousand Islands have brought to light, so far as we can learn, almost nothing of that material. An attempt to duplicate a discovery such as Mr. Cushing's would resemble a search for a needle in a hay-stack. [Moore 1905:304]

In spite of these relatively negative comments regarding the potential of southwest Florida for archaeological investigation, Moore made two more expeditions to southwest Florida in 1906 and 1907. He did no excavation during these visits, instead obtaining specimens of stone and shell artifacts from local residents. Thus, at the end of these four years of research in southwest Florida, Moore had collected, described, and illustrated an extensive range of shell and stone artifacts, including hafted and unhafted gastropod picks and adzes; various shell gorgets, plummets, scrapers, and columella tools; and numerous decorated stone plummets. In contrast to Cushing, Moore was more concerned with the artifactual material of southwest Florida, particularly the collection of museum-quality specimens, than with the ethnological significance of the aboriginal remains of southwest Florida. This is even further evidenced by Moore's (1919) response to Hrdlička's (1919) comment that the southwest Florida coast south of Key Marco was supposed to be of no great account as far as aboriginal remains were concerned. Although Moore (1919:401) was not prepared to admit that "*the region of the coast south of Key Marco was supposed to be of no great account as far as aboriginal remains were concerned*" (emphasis in the original), he proceeds to state:

> Our own experience and that of others has convinced us that in the shell-heaps of the southwest Florida coast, which extend southward from above Cedar Key, practically nothing of interest has been found that can compensate one for the heavy outlay of time and money needed for their demolition.
>
> An accurate survey of the shell site on Turner River might be of interest, but it is our belief that digging into the shell deposits hereafter will be more frequently suggested than done. [Moore 1919:401]

Hrdlička was the next anthropologist to investigate the archaeological remains on the southwest Florida coast. His first visit was to the region of Fort Myers (Hrdlička 1917), but in the fall of 1918, Hrdlička initiated an anthropological survey of southwest Florida (Hrdlička 1919, 1922). Hrdlička (1922) was aware of the earlier research in the area by Cushing and Moore and was of the opinion that these studies were insufficient for the purposes of physical anthropology, irrespective of Moore's contention to the contrary (Moore 1919). Hrdlička carried out no excavations at the time of his survey but did describe in considerable detail the numerous sites of the Ten Thousand Islands, including many of those visited earlier by Moore but only briefly discussed. He also explored farther south than Moore had, going all the way to Cape Sable.

Hrdlička made important statements regarding the differential productivity of the environment. He even noted that the area from Fort Myers to Naples is covered with a thin pine forest and that the region "could never have furnished the means of existence to any large Indian population" (Hrdlička 1922:19), a comment which is substantiated in this study.

Besides visiting many of the same sites as Moore, Hrdlička discovered a pristine site, previously unrecorded by Moore and undisturbed by homesteaders, located on the Whitney River. He described a series of conical mounds and heaps and even suggested the site as a "national reservation" (Hrdlička 1922:29–31).

Hrdlička (1922:48–51) was impressed by the richness of the archaeological remains in southwest Florida, particularly in the Ten Thousand Islands from Key Marco to Gopher Key but also in the less frequently occurring sites south of Lostman's River. He saw these remains as representing different site types—including shell heaps, shell mounds, shell-and-muck mounds, and canals leading to the inland shelter of ponds for Indian canoes—and he attributed different functions to each. The shell heaps ranging in size from less than half a hectare to upward of 20 hectares he considered to be habitational platforms rather than kitchen middens. The low soil-and-shell heaps occur occasionally in the area and usually contain burials. Canals and harbors were necessary components of sites in southwest Florida and are "local and necessary developments due to peculiar environmental conditions."

Hrdlička also thought that the archaeological sites in the Ten Thousand Islands south of Chatham River were more secluded than those to the north, which suggested to him that the southern sites were associated with increased warfare. More important, Hrdlička linked the archaeological remains of the Ten Thousand Islands directly with those of Charlotte Harbor and suggested that they were the remains of the same culture, people, and period. He even went further to suggest for the first time an ethnographic correlation of the archaeological remains of this area:

> judging from such scant notes as have been preserved to us on the Indians of the southwestern coast of the peninsula the inhabitants and builders of the great shell heaps could have been no other than the "Caloosas" (or "Calusas") who gave their name to the Caloosahatchee River, the stream flowing between Lake Okeechobee and Charlotte Harbor. [Hrdlička 1922:50]

Thus, Hrdlička was the first to provide a functional criterion to different site types in southwest Florida and to consider this area a culturally distinct region, identical in culture, people, and period. More specifically, he associated the area with the Calusa Indians. He thus introduced three important research questions for future investigators: "The remaining problems are just what became of all this population as well as of the northern coast group; exactly what these groups were; and whether or not the remains of the Caloosas group may have merged with parts of the Seminole Tribe" (Hrdlička 1922:51). Hrdlička, therefore, rekindled an anthropological interest in southwest Florida which Moore (1919) had written off from a practical archaeological perspective.

In 1923, Fewkes, chief of the Bureau of American Ethnology, made a preliminary survey of the southwest coast of Florida (Stirling 1924). The survey was instigated because of the scanty facts generated by previous research, irrespective of the quantity of earlier work in the area, particularly in respect to the problems raised by Hrdlička.

Fewkes was especially attracted to this region because of the supposed West Indian affinities of its prehistoric inhabitants. This was suggested by the place name of Caxambas. This word, with the different orthography of Cacimbas, occurs in Cuba, where Fewkes had earlier examined several artifacts called Cacimbas de las Indias. Fewkes was interested in how this name became applied to the region of Florida. He also saw certain similarities between the artifacts of the two areas.

The survey was seen as an initial reconnaissance to locate sites for excavation. He visited many of the sites previously reported, including Key Marco, Caxambas, Chockoloskee, Lostman's Key, and Horr's Island, as well as an interesting cluster of previously unreported shell heaps at Porpoise Point.

Subsequent to Fewkes's survey, Henry Collins of the Division of Ethnology, U.S. National Museum, conducted archaeological fieldwork in the winter of 1927 and 1928 (Collins 1929). His specific research goal was to supply data on certain aspects of Calusa culture and physical type. Collins reported shell heaps on Captiva Island, some of which were gradually accreted midden refuse, while others were constructed of secondary fill. He also noted a trench or canal associated with one of them.

Collins then proceeded to excavate a sand burial mound on Captiva Island. This mound had been previously looted, but enough of the mound was intact for him to obtain seventy skulls "in condition to be measured." The burial mound included flexed primary burials and secondary bundle burials. Also associated with this burial mound was a border of large conch shells arranged in two rows around one side of the mound periphery and a pavement of sherds sloping up from the basal periphery on the opposite side. The mound appears to be pre-Columbian, since there was no mention of associated European grave goods.

In 1930 M. W. Stirling of the Bureau of American Ethnology began archaeological investigations in southwest Florida (Stirling 1931a, 1931b, 1933). His principal work for the season was the excavation of the Blue Hill Burial Mound on Horr's Island, located just south of Marco Island. Stirling's excavation of the mound revealed a clay floor six feet above the mound base, which he interpreted as the floor of a temple structure, since it was surrounded by post holes, some of which still contained the decaying remains of wooden posts (Stirling 1931a). More than 250 burials were excavated from the mound with interments occurring both above and below the floor. Burials found above the floor contained European glass beads and iron axes, while those below the floor were without European materials. Stirling suggested that the mound contained both a pre-Columbian and early post-Columbian component. He does not mention the upper mud cap that was observed by Durnford and Moore, more than likely because it was destroyed by the earlier excavations. Its former existence seems obvious, as witnessed by the preservation of wooden posts, which would be shielded from leaching moisture by the semi-impervious, cementlike mud cap, as Durnford described. Unfortunately, the materials, both skeletal and artifactual, from the Blue Hill Mound have never been analyzed and reported on further.

In 1933 and 1934 extensive excavations were conducted by the Smithsonian Institution in south Florida in conjunction with the Federal Emergency Relief Project (Stirling 1935a). These researches were not conducted in the southwestern coastal area south of the Cape Haze Peninsula but instead were focused on the coastal region to the north and the interior section near Lake Okeechobee. In this latter area, the Belle Glade habitation site and adjoining sand burial mound were excavated by Gene M. Stirling (Stirling 1935b:57–58). These excavations and the resultant material were briefly described by M. W. Stirling (1935b:374–376) and later more completely analyzed, described, and reported on by Willey (1949a).

D. L. Reichard excavated four small sand mounds in Manatee County (Stirling 1935a:60). These excavations and their resultant materials were briefly described by Stirling (1935b:378–383), who noted the wide variety of burial customs, including cremation, in these mounds. G. R. Willey (1949b) later analyzed both the excavations and artifacts and published a complete report on them. A shell burial mound on Perico Island and a large sand burial mound near Englewood, in Sarasota County, were excavated by Marshall T. Neuman (Stirling 1935a:60). These excavations, too, were briefly described by Stirling and later reported on more completely by Willey (1949b).

Willey (1949b:344–346) also briefly summarized and described five sites which had been previously excavated in Charlotte County, the southernmost in his Gulf Coast study. These sites include the Cayo Palus burial mound, excavated by Montague Tallant; the Gasparilla sand mound, excavated by Moore; a collection of material from the Widder Creek site; the 1930s Heye Foundation excavation of a shell midden near Punta Gorda by Mr. Tubeyfille; and the Hickory Bluff site, visited by Moore. Unfortunately, no other Charlotte County sites are discussed, nor are any for Lee and Collier counties to the south.

M. W. Stirling (1935b:372–374) was able to provide some initial generalizations about the archaeology of south Florida based on this fieldwork. He believed that the entire southern Florida region, from Lake Okeechobee south, was occupied by the Calusas and forms an archaeological unit, although it shows ties to the north. He considered the spear thrower, bone projectile points, and wooden plaques characteristic material traits of this region. He noted that all the sites investigated were closely related, that none could not be closely tied to the Calusa, and that material from prehistoric sites differs little from material from historic period sites, save for the addition of European trade goods. Based on the homogeneity and cultural uniformity of the trade goods, he thought the Calusa to be a late migration into south Florida. He was further impressed by the lack of West Indian material traits in south Florida, despite the propinquity of the region.

M. W. Stirling (1936) expanded on many of these points in his article "Florida

Cultural Affiliations in Relation to Adjacent Areas." This article is noteworthy, because it is the first discussion in the archaeological literature on Florida of ceramic types and archaeological culture areas. M. W. Stirling (1936:353) noted three distinctive ceramic wares for the Florida central coast between Tampa Bay and Charlotte Harbor. These are the Safety Harbor ware, the Weeden Island ware, and the Arcadia ware. He also introduced the initial classification of south Florida ceramics, which he termed Glades ware (Stirling 1936:355), and noted its minimal decoration, except for notched lips and a few "crudely incised rim designs." He also classified the region between the Kissimmee and Indian rivers, and all of the peninsula from Lake Okeechobee to the Florida Keys as the Glades region. This area, he suggested, was characterized by the inferior Glades ware ceramics, perforated shell hoes, shell plummets, antler adze sockets, and bone projectile points. He noted the continuity in the material culture of prehistoric and protohistoric sites in Florida:

> it is a significant fact that none of the remains found in prehistoric sites differ materially from those definitely attributable to the Calusa and Timucua. If an earlier people occupied the peninsula, they must have constituted a sparse population without the art of pottery making. [Stirling 1936]

Goggin (1949a:13) concurs that the modern period of Florida archaeology began with Stirling's work. Still, in spite of the generalizations derived from the archaeological projects conducted in southwest Florida, namely, excavations on Captiva Island and at the Blue Hill Mound on Horr's Island, none of the data from these investigations has been fully reported. This is in distinct contrast to the excavations in southeast Florida and along the south-central Gulf Coast, which were written up by Willey (1949a, 1949b).

During the same year, 1936, John M. Goggin visited a shell heap at Gordon's Pass, near Naples. He described the stratigraphy which was exposed from previous excavation of the shell heap for road material. By noting the position of ceramics from horizontally distinct proveniences along tilted, horizontally accumulated stratigraphic layers, Goggin was able to determine that plain ceramics were earlier than incised ceramics. This stratigraphic relationship was reported along with a technical description of the ceramics, which he called Glades Gritty ware, and the associated surface decoration (Goggin 1939). The most frequent decorative technique was the feathered design, later to become known as Gordon's Pass Incised. Thus, Goggin initiated the first stratigraphic separation of Glades ceramics and initiated a new stage of research in south Florida, one which focused on the temporal and spatial aspects of Glades archaeology.

At about the same time, Frederick W. Sleight (1941) wrote a brief review of the archaeological history and significance of the Ten Thousand Islands and announced a proposal of the Committee on Archaeology of the Florida Historical Society to survey and excavate this region. Sleight spent a considerable amount of time in 1940 in the Ten Thousand Islands and reported an unnamed sand burial mound in the area, whose location was not disclosed, as well as other shell heaps. He further noted that the ceramics in the burial mound were finer, thinner, and similar to those ceramics found in the interior of Florida (Sleight 1941:7).

As well as can be discerned from the literature, no extensive excavation or survey resulted from the Florida Historical Society proposal, presumably because of the onset of World War II. An important point had been reached by this time in the history of archaeological research in southwest Florida. All the large habitation sites or "shell heaps" in the area had been found, and most of the burial mounds had been found and excavated, resulting in the collection of rather modest grave lots.

Subsequent to 1944, Goggin continued his active research in south Florida as part of the large Yale Caribbean Anthropological Program (Goggin 1947:114; 1949a:13–14). This work was specifically designed to sort out spatially and chronologically the ceramics of the Glades area. Goggin's research, conducted at a number of sites in south Florida (Goggin 1940, 1941, 1944a, 1944b), allowed him in 1947 to subdivide south Florida into three subareas and to establish a stratigraphic sequence for south Florida. Subsequent research has shown his work to be remarkably accurate, even with the addition of radiocarbon dating.

Goggin also excavated a site with Frank Sommer on Upper Matecumba Key (Goggin and Sommer 1949) and began a comprehensive report on the archaeology of the Glades area, which he continually revised and edited until his death but which, unfortunately, was never completed or published (Goggin 1963). Goggin (1949a:17) went beyond the simple chronology and culture-area descriptive approach and defined the Glades region as containing a distinctive cultural tradition termed the Glades Tradition. His intention was to characterize the entire lifeway of an archaeological culture in a particular area over a certain period of time. More specifically, he defined the Glades Tradition as being "based on the exploitation of the food resources of tropical coastal waters, with secondary dependence on game and some use of wild plant foods. Agriculture was apparently never practiced, but pottery was extensively used" (Goggin 1949a:28).

Goggin (1948a, 1949a) also early recognized that the environment in the past was different from that seen in south Florida today, and he recognized the role of both environmental change and sea-level rise as factors affecting the Glades Tradition. "During man's occupation in the Glades area certain features of the environment changed. The rising sea level isolated some village sites and may have created more extensive marshes" (Goggin 1949a:30). Thus, Goggin had anticipated to some extent the potential of sea-level changes to modify environment.

In the 1950s and early 1960s, universities, the National Park Service, and local archaeological societies initiated much of the research in South Florida. The primary contribution of this period were increased site inventory, refinement of chronology, the recognition of regional cultural diversity, the identification of sites for potential excavation, and the beginning of an interest in settlement and subsistence patterns in southwest Florida. Archaeological attention was being directed toward the southwest Florida coast, with interest in the Ten Thousand Islands and the Port Charlotte–Pine Island Sound area.

Stratigraphic testing of some large shell heaps was initiated during this period, and a relatively long span of occupation was documented for at least two of them. Investigation at Useppa Island, in Pine Island Sound, revealed a stratified ceramic sequence with an initial fiber-tempered ceramic occupation (J. W. Griffin 1949). W. H. Sears (1956) mapped and conducted stratigraphic tests at the Turner River site. His excavations revealed a long ceramic sequence and what he believed to be a horizontal accretion of the shell heaps from the interior toward the water's edge, a pattern which Goggin (1939) had also found at Gordon's Pass. Goggin (1949b) also discerned a long ceramic sequence at the Goodland Point site on Marco Island from seriation of horizontally discrete surface collections.

Goggin (1954) conducted a site survey and inventory of the Cape Haze Peninsula, and in the same year, Bullen and Bullen (1956) also conducted a survey of this region and tested many of the sites. They established a chronological sequence for the area from ceramic markers traded into the area from the north, noting that the area is far south from the heartland of Weeden Island and Safety Harbor phases and that these periods are chronological rather than cultural in form (Bullen and Bullen 1956:2–3). Most of the ceramics found in their tests were sand-tempered plain and Belle Glade Plain, with small percentages of northern Weeden Island and the Safety Harbor series, some Glades Tooled and a moderate amount of late Mission period material. Bullen and Bullen (1956:51) attributed this Mission period material to groups moving south into the area after the breakup of the mission system in 1704. They also noted the absence in this area of the Glades series ceramic types.

The date 1964 marks the appearance of the most important article concerning the archaeology and ethnography of southwest Florida. In that year, the summary review article on the Calusa appeared (Goggin and Sturtevant 1964). This article synthesized the pertinent archaeology and ethnohistory for the southwest Florida region and pointed out the anthropological importance of the Calusa, namely, their achievement of a highly ranked level of sociopolitical organization *without* the use of agriculture. The article remains to this day the best summary on Calusa ethnography and archaeology and has rekindled research in southwest Florida, particularly from the perspective of the origin of this distinctive, ranked, coastal adaptation.

In 1965, stratigraphic excavations were conducted in the Key Marco midden (Van Beck and Van Beck 1965), which is actually a location on the Key Marco site. This important work is the first reported excavation at this site since Moore's (1900) visit. A stratigraphic sequence for the site was derived from these test excavations. Of equal if not greater importance is that the faunal material recovered from these tests was analyzed by Wing (1965). Her report represents the first systematic analysis of vertebrate faunal remains from a southwest Florida coastal site and led the way for further research on southwest Florida subsistence patterns.

In 1966 W. H. Sears (1967) conducted an archaeological survey in the Cape Coral area at the mouth of the Caloosahatchee River. His survey recorded six archaeological sites, some of considerable size. Most of these sites are long, linear, shell middens on the beach edge. Sears's survey corroborated the ceramic characteristics found by the Bullens (1956) and led him to suggest that the Charlotte Harbor–Pine Island Sound region is a culturally distinctive region with northern borders somewhere between Cape Haze and Tampa and the southern boundary above Key Marco (W. H. Sears 1967:102).

Beginning in the late 1960s, and extending into the 1970s, the Florida state archaeologist and the staff of the Division of Archives and History, State of Florida, began a long-term, large-scale program of survey and excavation on Marco Island. This research was initiated in anticipation of and in conjunction with the residential development of the island. In 1967 and 1968, extensive excavations were conducted by L. Ross Morrell on Caxambas Point, resulting in the discovery of stratified, fiber-tempered sites and large, pure Glades I sites (Cockrell 1970:2). During the 1967 season, eight 3-m squares and one 9-by-1-m trench were excavated in the Caxambas shell midden, 8Cr107x2. Excavation revealed a shell midden extending 2 m below the water line (Cockrell 1970:37).

The 1968 season focused on the excavation of the sites on the dune ridge. These sites contained stratified deposits which included fiber-tempered ceramics. This find confirmed the existence of an early occupation on Marco Island similar in date to that recorded in the Charlotte Harbor region (Griffin 1949; Bullen and Bullen 1956).

In 1969 Cockrell made a more extensive archaeological survey of the island and tested several sites. The results are presented in his master's thesis (Cockrell 1970). Cockrell's contribution was not only the discovery and documentation of significant occupation on Marco Island in the Pre-Glades time; more important was his determination that the adaptation during this earlier Pre-Glades period was markedly different from that in the later Glades Tradition. Cockrell noted that there was a shift from generalized hunting and gathering with nonsedentary occupation in Pre-Glades times to a specialized exploitation of coastal resources with sedentary villages during the Glades period.

In 1970 and again in 1971 Cockrell returned to Marco Island to continue excavations aimed at better documentation of this early Pre-Glades adaptation on Marco Island. Numerous sites were tested and faunal assemblages collected. These assemblages have been analyzed by Cumbaa (1971) and represent important data on intersite subsistence diversity. In 1972 Joseph Hutto of the Archives and History Department, State of Florida, continued the surveying and excavation on Marco Island and tested a pure Glades I Early site and numerous nonceramic Pre-Glades sites as well.

In 1973 I conducted an archaeological survey of many of the remaining previously unsurveyed portions of the island and mapped and described in more detail many of the sites already discovered (Widmer 1974). Thus by 1974 Marco Island was the most intensively researched coastal region of southwest Florida, and it is an important area for the generation of the evolutionary model of coastal adaptation in southwest Florida.

J. W. Griffin (1974), at this same time, briefly reviewed and summarized his research conducted in the Everglades National Park. He defined two distinctive types of habitation sites: large coastal shell middens and smaller, interior, black-earth middens. He suggests that the shell middens are base villages and the black-earth middens represent short-term hunting camps for the same population. Also in his review, Griffin noted the effect of sea level on site character and settlement location, and he reported on stratigraphic shifts in the faunal assemblages from the Bear Lake site. These shifts, he suggested, are apparently due to environmental changes in area. This represents the first suggestion that changes in faunal assemblages through time might be due to environmental causes, either on a seasonal basis or from a more permanent ecological shift.

Gilliland (1975) published the comprehensive catalog of the material remains excavated from Key Marco by Cushing. The catalog includes a description of the site, a complete history of exploration at the site, and important information pertaining to subsistence, chronology, and cultural relationships. Her work represents the first comprehensive discussion of this site since Cushing's original report.

In the Charlotte Harbor area, Jerald T. Milanich of the University of Florida began in 1975 the stratigraphic excavation of the Wightman site, which is located on Sanibel Island (Fradkin 1976). These excavations were conducted to obtain a stratigraphic sequence of archaeological and faunal material in order to understand more specifically how the cultural system of the population at this site adapted to the environment. Highly specialized and fine-grained faunal and floral recovery techniques were employed, and a large number of radiocarbon dates were obtained. The excavations and analysis of material were reported on by Arlene Fradkin (1976) in her master's thesis. Her study documented conclusively the importance of coastal resources, particularly fish, in the subsistence pattern at this site. She further demonstrated the absence of floral resources, in spite of specific research methods and techniques to recover these materials.

An intensive archaeological survey of the J. N. "Ding" Darling National Wildlife Refuge on Sanibel Island was performed by Kennedy (1978). In all, eleven prehistoric archaeological sites were recorded in the reserve. These include eight sites in the mangrove-wetlands region and three on the upland-dune region. The sites include a nonceramic, upland shell site, a late prehistoric/contact-period site with an associated canal, a possible burial mound, two shell middens with plain sand-tempered ceramics, and six shell middens in the mangrove swamp environment.

In 1977, I excavated an interior site on a small tidal creek of the Peace River (Widmer 1986). The purpose of the excavation was to complement our knowledge of intersite settlement and subsistence diversity in the southwest coastal adaptation. It was hypothesized that this site might be a peripheral agricultural hamlet, complementing a primarily estuarine subsistence base, since it was located in a region with marginal environmental-resource potential, namely a sandy pine flatwood, suggesting agriculture as the only viable subsistence activity for a hamlet-sized community. It now seems, however, that the site functioned as a fishing hamlet or collection station, exploiting estuarine resources when sea level or the water table was at a higher stand than today.

In the 1970s, research also focused on a unique archaeological resource in the present coastal zone of southwest Florida. These are the karst ponds and sinkholes of southwest Florida, including Warm Mineral Springs (Cockrell 1973, 1974, 1975, 1976; Clausen et al. 1975; Cockrell and Murphy 1978), Little Salt Spring (Clausen et al. 1979), and the Bay West site (Beriault et al. 1981). These sites document the existence of preceramic human occupation in south Florida as far back as 13,000 B.P. They further document a substantial population size for the Middle Archaic period, 6500 to 4000 B.P., and a distinctive mortuary pattern of aquatic burial. Also of importance is the recovery of wooden artifacts dating to this period, which show stylistic attributes similar to the Key Marco material and therefore suggest historical continuity of the art styles and presumably of the population in south Florida.

Perhaps the most intensive, comprehensive archaeological survey conducted to date was that performed by the National Park Service in the Big Cypress National Preserve, located immediately adjacent to the Ten Thousand Islands (Ehrenhard et al. 1978, 1979, 1980, 1981; Ehrenhard and Taylor 1980). This survey used a sophisticated method of aerial-photo interpretation, refined through "field truth" checking. In all, 394 archaeological sites were recorded. Limited testing and surface collections indicate that the sites contain extremely rich faunal deposits and numerous coprolites. Ceramic analyses and an extensive run of sixty-four radiocarbon determinations document an occupation dating from as early as 3200 B.P. to the present, with most of the dates occurring after 1500 B.P.

McMichael (1982) reported on a comprehensive ten-week survey and program of testing on Horr's Island directed by Jerald Milanich. Research was concentrated on the sites visited by M. W. Stirling. Stratigraphic tests were placed in many of the sites, profiles recorded, and faunal remains recovered and analyzed. McMichael (1982) determined, through radiocarbon dating, that all the shell sites on the west half of the island date to 4000 to 4500 B.P. and are nonceramic. A comprehensive analysis of faunal material for a site of the Archaic period showed that it complements material analyzed by Cumbaa (1971) on Marco Island.

In 1979 Milanich and Chapman (Milanich et al. 1984) initiated extensive tests on Useppa Island and obtained a sequence of archaeological material from 4000 B.P. up to the eighteenth century. Complex stratigraphy, consisting of superimposed strata of different materials, was encountered in their excavations. They also discovered an Archaic period shell columella manufacturing area, the first specialized craft activity area recorded in southwest Florida. Vast quantities of faunal materials were recovered, indicating the use of a wide range of species and a very high reliance on fish. A detailed ceramic study, including both stylistic and technological analysis, was also performed.

In 1983 Marquardt initiated archaeological research on Josslyn Island. His subsequent publication (1984) contained a description of the site, a detailed contour map of it, and volumetric estimates. Marquardt also discussed the importance of formation processes to the interpretation of the site's function and history. In 1985 Marquardt continued research in the Charlotte Harbor region and conducted test excavations on Josslyn Island, which revealed massive quantities of faunal materials, and deep, complex stratigraphy, as on Useppa Island (Marquardt et al. 1985). Hale (1985) has also attempted to model the change in the estuarine area of the Charlotte Harbor–Pine Island Sound as sea level fluctuated during the past 4,000 years. This preliminary work has culminated in a multidisciplinary research project in the Pine Island Sound funded by a grant from the National Science Foundation (Marquardt 1985). This work will focus on the collection of data for testing and refining the model presented here. These data include the documentation, coring, and limited testing of archaeological sites; geoarchaeological analysis; photogrammetric mapping and remote sensing; refinement of chronologies by means of technical analysis of excavated ceramics; paleoethnobotanical analysis; and the collection and analysis of zooarchaeological specimens (Marquardt 1985:12).

Ironically, this is the first research in southwest Florida supported by the National Science Foundation, in spite of the fact that the area is one of the most archaeologically important ones in North America. It is hoped that it is just the beginning of such research in this fascinating archaeological region.

This history of research in the southwest Florida area demonstrates that although a great deal of research, some of remarkable insight (see Cushing 1896; Hrdlička 1922), has been produced, the area is still very poorly known. For example, there has yet to be *any* large-scale excavations on *any* southwest Florida archaeological site larger than 10 hectares in area. Morrell's excavation in 1967, a total of only 81 m^2, represents the most spatially extensive excavation of any of the large shell heaps in southwest Florida, and no more than 25 m^2 have been excavated in any of the later Calusa period sites (after A.D. 800). Furthermore, not one single house plan has been uncovered or mapped for this area, although postholes have been recorded. Adding to the problem is the poor understanding of the chronology of the Charlotte Harbor–Pine Island Sound area, a result, for the most part, of the absence of decorated ceramics. Any chronological assessment of sites must be by radiocarbon determinations or cross-dating using the infrequent decorated ceramics from adjacent areas. Easy chronological assessment of sites from only small samples obtained from the surface is therefore impossible. The problem has resulted in the omission of a chronology for the Caloosahatchee cultural area in the recent synthesis of Florida archaeology by Milanich and Fairbanks (1980:23, table 1). The history of research, although long and illustrious, is nonetheless deficient when compared with other areas of the state, such that Milanich and Fairbanks (1980:xi) consider the "entire southwest Florida coastal region" as being "in need of urgent research."

4

The Prehistory of Southwest Florida

The specific phase and period names and artifact markers introduced here will be integrated in the subsequent chapters with the geology, ecology, demography, and subsistence and settlement patterns, and so no mention of these characteristics will be presented in this chapter. The taxonomy will follow typical usage developed for the eastern United States for the preceramic time periods (J. B. Griffin 1967) and that used by Milanich and Fairbanks (1980) for later periods. For the early portions of the chronology, the concept of horizon will be used, since its recognition of a particular style or complex of materials which are restricted in time yet found over a wide geographic area (Willey and Phillips 1958) adequately characterizes the spatial, chronological, and contextual aspects of the material culture without assuming any similarities in adaptations. Where the spatial distributions of archaeological material of a given time period are more limited, as is the case with the later ceramic complexes, period or phase designations will be used. It should be emphasized again that if phase names are used, they do not refer to adaptational aspects but instead only to the temporal, spatial, and material aspects of a given complex. In other words, phases will be redefined for the purpose of this chapter to equate with periods.

Tables 2, 3, and 4 show the chronological position of archaeological periods and horizons. Included in the tables are the associated artifact types identifying the period and the general spatial distribution of the periods. The tables largely follow one prepared by Milanich and Fairbanks (1980, table 1), with some modifications and elaborations, although these authors presented no specific chronology for southwest Florida.

Table 2

Cultural Chronology for South Florida During the Glades Tradition

	CULTURE AREAS		
Dates	Circum-Glades	Caloosahatchee	Belle Glade
	Glades IIIc-European goods + IIIB below	Caloosahatchee V European goods	
A.D. 1513			
	Glades IIIB-Glades Tooled, Safety Harbor	Caloosahatchee IV Safety Harbor, Pinellas, Glades Tooled	
A.D. 1400			
	Glades IIIA-Surfside Incised, St. Johns Check-Stamped	Caloosahatchee III Englewood ceramics	Period IV Belle Glade Plain predominates
A.D. 1200			
	Glades IIC-Plantation Pinched + Glades Plain		
A.D. 1000			
	Glades IIA-Matecumbe Incised, Key Largo Incised		
A.D. 900			
	Glades IIA-Incised wares of Gordon Pass, Key Largo, Sanibel, Opa Locka, Miami Incised	Caloosahatchee II Increase in Belle Glade Plain through time	Period III Increase in Belle Glade Plain
A.D. 700			

Table 2 (continued)

Cultural Chronology for South Florida During the Glades Tradition

	CULTURE AREAS		
Dates	Circum-Glades	Caloosahatchee	Belle Glade
	Glades I (Late)-Ft. Drum Incised and Punctated, Cane Patch		Period III Increase in Belle Glade Plain
A.D. 500			
			Period II
A.D. 200			
	Glades I (Early) Glades Plain	Caloosahatchee I Sand Tempered Plain	Period I Sand Tempered Plain
500 B.C.			

Table 3

Cultural Chronology for South Florida
During the Pre-Glades Period

Date	Period	Diagnostic Ceramics
500 B.C.		
	Transitional	Norwood Plain
2950 B.P.		
	Pre-Glades III	Orange Plain and Incised, Perico Incised, Steatite
3500 B.P.		
	Pre-Glades II	Orange Plain, Perico Plain, St. Johns Plain
4000 B.P.		
	Pre-Glades I (Late)	Fiber-tempered plain, Orange Plain
5000 B.P.		
	Pre-Glades I (Early)	Non-ceramic Mount Taylor Culture-cemetery, pond burials, atlatl, socketed bone points, Archaic broad-stemmed points, Newman Lake CSPP, Levy, Putnam, Marion
7000 B.P.		

The Paleoindian Period (13,500 to 9900 B.P.)

THE CLOVIS HORIZON (13,500 TO 10,500 B.P.)

Initial occupation of south Florida probably dates to the Early Paleoindian period at approximately 13,000 B.P. In northern and central Florida, fluted and lanceolate stone projectile points typical of this time period are commonly found eroding from river beds (Waller 1970; Waller and Dunbar 1977; Milanich and Fairbanks 1980). These projectile points include Clovis, Suwannee, and Simpson types (Bullen 1975a; Milanich and Fairbanks 1980). Other associated artifacts, as evidenced by contextual association at the terrestrial Paleoindian site at Silver Springs (Neill 1958; Hemmings 1975), include thumbnail scrapers, blade knives, and gravers. Waller (1971) suggests that a distinctive, unifacially flaked, hafted knife known as the Waller knife is included in this period.

Early Paleoindian components (sites with evidence of occupation dating to a certain period) in south Florida are uncommon, but the only known site is well

Table 4
Cultural Chronology During the Paleoindian and Archaic Periods

Date	Southeastern United States	North Florida	South Florida
7000 BP			
	Post-Kirk Early Archaic	Arrendondo Points Hamilton Points	Poorly Known
8000 BP			
	Kirk Horizon-Early	Archaic Kirk Points	None
9500 BP			
	Big Sandy Horizon	Bolen Points Big Sandy Points	Continuation of Dalton, no Big Sandy
9900 BP			
	Late Paleoindian Dalton Horizon	Dalton Points	Dalton Points, bone points, non-returning boomerang, socket wooden point, oak mortar, atl-atl spur
10,500 BP			
	Early Paleoindian Clovis Horizon	Clovis Suwannee	Wood tools only
13,500 BP			

dated and has excellent contextual integrity. The earliest-known human occupation in south Florida dates from 13,500 to 12,500 B.P. at the unusual Little Salt Spring site (Clausen et al. 1979). Unlike the regions to the north, no lithic outcrops suitable for chipped stone tool production are present in south Florida, and therefore the fluted and lanceolate projectile points which form a distinctive horizon marker for the rest of the eastern United States are not known for the area. This lack, of course, does not preclude the possibility that such points were used there. The fact that only one component for this time period is known undoubtedly presents a severe problem of sampling bias for the early period.

In south Florida, the artifacts associated with this earliest period were manufactured exclusively from wood. It is indeed fortunate that unusually favorable conditions at the Little Salt Spring site resulted in the preservation of numerous bone and wooden artifacts for several periods. A single wooden stake thrust through an extinct tortoise, *Geochelone crassiscutata*, is the only evidence from south Florida of an early occupation contemporary with other fluted-point complexes to the north (Clausen et al. 1979). The wooden stake was radiocarbon dated at 12,030 ± 200 B.P., and a carbonate fraction from the tortoise bone was dated at 13,450 ± 190 B.P. This material was found in situ on a ledge at a depth of 26 m below present spring surface and 20.9 m below the present mean sea level. No other evidence of human occupation dates to this Early Paleoindian period (Clausen et al. 1979:611).

Admittedly, the evidence for an Early Paleoindian occupation is slim. If bone and wood tools were used to the exclusion of stone tools, terrestrial evidence of an Early Paleoindian occupation would be difficult to determine, since such tools would either not be preserved or would be indistinguishable from those found in later contexts. Only radiocarbon dating of in situ specimens, such as was done at Little Salt Spring, can resolve this dilemma.

DALTON HORIZON (10,500 TO 9900 B.P.)

The Late Paleoindian period in the southeastern United States is characteristically referred to as the Dalton Horizon and dates between 10,500 and 9900 B.P. (Goodyear 1982). This horizon is characterized by the distinctive Dalton projectile point and a series of lithic tools, including blades, end scrapers, side scrapers, and a form of chipped stone adze (Goodyear 1982).

In Florida, projectile points with similar Dalton Horizon morphological attributes include Tallahassee, Santa Fe, and Beaver, as well as the traditionally recognized Nuckolls Dalton (Bullen 1975a; Milanich and Fairbanks 1980). Milanich and Fairbanks (1980) find no problem placing this material in the Late Paleoindian period, although stratigraphic data are lacking. Such an assignment is in perfect agreement with Goodyear's (1982) chronological assessment of the Dalton material.

Unlike the Early Paleoindian period, the Dalton Horizon is better documented in south Florida. Cultural materials for this period include both lithic and shell, as well as bone and wooden artifacts. All of the material ascribable to this period comes from two important sites in southwest Florida: Warm Mineral Springs (Clausen et al. 1975; Cockrell and Murphy 1978) and Little Salt Spring (Clausen et al. 1979).

The assemblage of archaeological material from Little Salt Spring for this time period is unusually comprehensive, and a series of eight radiocarbon dates have been obtained for the artifacts and features. These dates range from 10,980 to 8955 B.P., suggesting that at least in south Florida, the Late Paleoindian period with Dalton projectile points ranges to 9000 B.P., rather than the 9900 B.P. suggested by Goodyear (1982). I will discuss the implications of this difference more fully in a later chapter.

The late Paleoindian artifacts from Little Salt Spring are exclusively antler and wood, the most important being a nonreturning oak boomerang. This artifact is the beaked or necked variety, similar to those used in Australia, India, and western Europe, and should not be confused with the curved rabbit stick used in the Great Basin and the Southwest (Clausen et al. 1979). Also recovered from the site were a socketed, antler projectile point with the tip of the dart shaft articulated in its base and a wooden mortar of oak, dated to 9080 ± 250 B.P. (Clausen et al. 1979:611). Numerous (quantity not given) wooden stakes were recovered in situ, having been driven into the sediments at the edge of the basin where it enters the reentrant (at a depth of 12 m below the present water surface), at the edge of the water position at 9000 B.P. Two of these stakes have been dated at 9645 ± 160 B.P. and 9500 ± 120 B.P. The function of these stakes is unknown (Clausen et al. 1979).

At the nearby site of Warm Mineral Springs, cultural and human osteological material was recovered from a sinkhole whose water level, as at Little Salt Spring, is now considerably elevated over its former position, resulting in the drowning and preservation of the originally aerially deposited artifacts.

Two human bones, a juvenile ilium and sacral vertebra, were recovered from submerged sediments and dated to 10,260 ± 190 B.P. (Clausen et al. 1975). This date was substantiated by independent geological investigation in a nearby portion of the strata sealed in situ by tufa deposits, where three radiocarbon determinations yielded dates of 8920 ± 190, 9350 ± 190, and 9220 ± 180 B.P. Five additional stratigraphic dates were obtained from these excavations as well, one of which is the 10,260 ± 190 B.P. date for level 4, which dates the skeletal material. The other dates, from top to bottom, are: level 1, 9420 ± 150 B.P.; level 2, 10,020 ± 180 B.P.; level 3, 10,630 ± 210 B.P.; and level 5, 9880 ± 230 B.P. These dates show tight clustering around 10,000 B.P. (Clausen et al. 1975). William Royal, a local resident, has reportedly removed portions of seven skulls and skeletal material representing thirty individuals from these sediments (Clausen et al. 1975:197). No artifacts were reported in association with the 1972 excavations.

Cockrell and Murphy (1978) also conducted research at Warm Mineral Springs and report a burial interred on the 13-m ledge of this spring. They further list sixteen radiocarbon determinations from the general area. These dates span from approximately 8300 to 10,500 B.P., with nine of these dates being older than 10,000 B.P., six dates ranging between 9000 and 10,000 B.P., and only one date whose range is exclusively earlier than 9000 B.P. (Cockrell and Murphy 1978:3, fig. 3). Associated with this burial was a carved shell atlatl spur. No mention of the type of shell was given, but if this atlatl spur was fabricated from nonfossil marine shell, it would indicate a considerable distance between origin of the raw material and its place of final deposition.

Cockrell and Murphy (1978:figs. 4–6) illustrate numerous lithic and bone artifacts recovered from the spring by William Royal. Included in these are a worked antler point, a tenoned bone artifact, a polished bone needle, what appears to be a perforated bone atlatl weight, a retouched fossil shark's tooth, a pressure-retouched fossil bone tool, which appears to be a Waller knife, and more important, three Greenbrier stone projectile points, two of which are illustrated. These points are characteristic of the Dalton Horizon (DeJarnette et al. 1962; Goodyear 1982) and so seem to place the skeletal remains temporally in the Late Paleoindian period and with the typical southeastern Dalton Horizon.

Although the lack of Early Paleoindian period projectile points at Little Salt Spring is due to the minimal representation of this component in general rather than a distinctive artifactual difference, it appears, in any case, that lithic points of the Late Paleoindian era are equally rare. Particularly considering the paucity of this material in the natural environment, as was suggested for the Early Paleoindian period, tools and artifacts are likely to be primarily of bone and wood. Any artifactual difference between this period and the later period, other than stylistic (i.e., Greenbrier versus Clovis projectile points), appears attributable to temporal rather than to functional differences.

The Early Archaic Period (9900 to 7000 B.P.)

THE BIG SANDY HORIZON (9900 TO 9000 B.P.)

The initial Early Archaic period in Florida is represented by the Big Sandy Horizon (Tuck 1974). This horizon is typologically a development, at least as far as projectile points are concerned, of the preceding Dalton Horizon. It is characterized by the initial appearance of corner- and side-notching on stone projectile points. Projectile points associated with this horizon, as suggested by Tuck (1974:75), include Big Sandy I, Kessel Side-Notched, Hardaway Side-Notched, and Bolen Beveled and Plain. These latter point types are found throughout north and central Florida. To the point types listed by Tuck can be added the Charleston Corner-Notched, of about 9900 B.P., and the Amos Corner-Notched type, which dates from 9900 to 8980 B.P. (Broyles 1971:55–56). Both of these types are found in excellent stratigraphic context in the St. Albans site in West Virginia. Chapman has also identified Early Archaic point types which belong to this complex in his deep stratigraphic excavations in the valley of the Little Tennessee River. He believes that these types, called categories 37 and 38, are similar to the Charleston Corner-Notched points and has dated the strata in which they occur at 7485 ± 270 B.C. (9435 ± 150 B.P.) (Chapman 1977:50–51).

Surprisingly, no components containing projectile points attributable to this horizon have as yet been found in south Florida. This brings up an important question alluded to earlier in the discussion of the Dalton Horizon. It seems clear that the Big Sandy Horizon dates from 9900 to 8900 B.P., but the Dalton Horizon material in south Florida appears to extend into this time period as well, with a terminal date of about 9000 B.P., 900 years later. Part of this problem stems from the uncertainty over the chronological placement in the developmental scheme proposed by Goodyear (1982) and Tuck (1974) of the three projectile points from Warm Mineral Springs, identified as Greenbrier by Cockrell and Murphy (1978). Typologically, the Greenbrier point seems more closely related to the Dalton Horizon than to the Big Sandy Horizon, but the radiocarbon dates from Warm Mineral Springs, from 10,630 ± 210 to 8920 ± 190 B.P., span both periods. Nor can it be suggested that because there are dates which are appropriate for the Big Sandy time range, such an occupation is present, the reason being that many of these dates come from noncultural contexts. There are, however, cultural materials which have been dated to this time period from Little Salt Spring, namely the oak mortar and wooden stakes, and so the lack of Bolen projectile points should not necessarily be interpreted as a lack of occupation, particularly in light of the general paucity of lithic artifacts in south Florida.

Bullen (1968a:6) does not chronologically distinguish Dalton Horizon material from Big Sandy material in his *temporal* scheme for Florida projectile points. He does delineate two distinct lithic traditions in his "Dalton Complex," one which includes Dalton, Santa Fe, and Tallahassee points, and another which includes Greenbrier, Hardaway, and Bolen points. The distinguishing feature is that the latter point tradition is notched, whereas the former is not. Why he cannot see the chronological distinction shown elsewhere (Tuck 1974) is puzzling, as is his inclusion of Greenbrier into an otherwise Big Sandy complex, although admittedly, Greenbrier of any of the types is the best candidate for being "transitional" between Dalton and Big Sandy.

In summary it appears that it is difficult accurately to separate a distinct Big Sandy from a Dalton temporal unit. The difficulty appears to be due to a lack of projectile points, seemingly a function of no stone outcrops in the region, rather than lack of occupation. Dates on cultural material clearly span the suggested time range of both horizons, with Greenbrier (i.e., Dalton Horizon projectile points) definitely in evidence. Thus, the discussion of the Late Paleoindian period by default should include the Big Sandy Horizon of the initial Early Archaic.

THE KIRK HORIZON (9000 TO 8000 B.P.)

The next Early Archaic horizon found in the southeastern United States is the Kirk Horizon (Tuck 1974:76–78). The diagnostic projectile points for this horizon are the Kirk Corner-Notched and Kirk Stemmed types (Tuck 1974) and the bifurcate-based Lecroy and St. Albans types, which seem to have an intermediate chronological placement between the earlier Kirk Corner-Notched and the later Kirk Stemmed types (Chapman 1979; Wesler 1983). These point types have a broad geographical distribution and are found throughout the entire eastern United States. This horizon is well dated. Radiocarbon determinations of 8800 ± 320 B.P., 8850 ± 320 B.P., and 8930 ± 160 B.P. have been obtained for the three Kirk Horizon strata from the St. Albans site in West Virginia (Broyles 1971:47). In Tennessee, dates of 9435 ± 270 B.P., 9350 ± 215 B.P., 9410 ± 290 B.P., 9175 ± 240 B.P., 8715 ± 140 B.P., and 8525 ± 355 B.P. were obtained for Kirk levels from the Icehouse Bottom site, and dates of 9110 ± 145 B.P. and 9330 ± 150 B.P. were obtained from Kirk Corner-Notched levels at Rose Island (Chapman 1977:161–162), as well as a date of 8020 ± 190 B.P. for Kirk Stemmed points (Chapman 1975:48).

In Florida, no stratigraphic excavations have yielded Kirk Horizon projectile points, nor are there radiocarbon dates falling in this range. Kirk projectile points do occur in northern and central Florida but only as minority types (Milanich and Fairbanks 1980:51). It has been suggested (Bullen 1975a, 1976; Milanich and Fairbanks 1980) that the Arrendondo and Hamilton projectile points typify the later portion of the Early Archaic period. Neill (1964:197), however, has suggested, on typological grounds, that Arrendondo projectile points develop out of lanceolate forms, which would place them prior to the Big Sandy Horizon. There is, however, no stratigraphic evidence for any of the above placements. These points seem to be morphologically similar to the Early Archaic projectile point Kanawaha Stemmed, which dates to 8160 ± 100 B.P. at the St. Albans site (Broyles 1971:59). Bullen (1968a:37) has suggested that the smaller Arrendondo point may be related to the Lecroy point, which is slightly earlier than the Kanawaha point at the St. Albans site, dating to 8350 ± 100 B.P.

THE POST–KIRK HORIZON EARLY ARCHAIC (8000 TO 7000 B.P.)

It appears that Early Archaic period projectile points found in Florida subsequent to the Kirk Horizon are different from those found in other areas of the southeastern United States. Furthermore, the lack of stratified sites with well-dated early archaic sequences anywhere in Florida prevents lithic cross-dating with established Early Archaic sequences from other areas of the southeastern United States. The problem is worsened by the lack of lithic outcrops in south Florida and thus of stone tools.

In general, the Early Archaic period anywhere in Florida is poorly understood. Although some parts of Florida appear to have been occupied during this time period, south Florida may not have been one of them.

The Middle Archaic Period (7000 to 4000 B.P.)

The Middle Archaic archaeological record in Florida, particularly in southwest Florida, is much better known than that of the Early Archaic. Some very distinctive and surprising cultural traits appear at this time. We are fortunate that two sites, Little Salt Spring (Clausen et al. 1979) and the Bay West site (Beriault et al. 1981) document the material culture of this period extremely well, since both are situated in peat deposits which have preserved wood and bone artifacts. Another important Middle Archaic site is the Gauthier site, a cemetery located near Cocoa, on the east-central coast (B. C. Jones 1981). Other important sites with components dating to this period include the Tick Island site (Jahn and Bullen 1978), located on the St. Johns River, and the Palmer site (Bullen and Bullen 1976), located on the southwest Florida coast near Sarasota. Numerous other, smaller Middle Archaic components are also known for southwest Florida.

The Middle Archaic period is well dated with five radiocarbon dates from Little Salt Spring, ranging from 6830 ± 155 B.P. to 5220 ± 90 B.P., and two radiocarbon dates of 5900 ± 130 B.P. and 6010 ± 150 B.P. from site A-356 in north-central Florida (Clausen et al. 1975:208).

Other Middle Archaic sites seem to date slightly later. One is the Middle Archaic component of the Tick Island site, referred to more specifically as the Mount Taylor period (Goggin 1949a; Jahn and Bullen 1978; Milanich and Fairbanks 1980). Here, four radiocarbon dates ranging from 5450 ± 300 B.P. to 5030 ± 200 B.P. date the preceramic Archaic burial stratum (Bullen and Milanich in Jahn and Bullen 1978:22). Similar dates of 5625 ± 100 and 4935 ± 100 B.P. have been obtained from a midden in the dunes on Useppa Island (Milanich et al. 1984:270). On Horr's Island, McMichael (1982:54) has recently tested a number of preceramic shell middens and has obtained a series of dates ranging from 4120 ± 85 to 3890 ± 80 B.P. Similar nonceramic shell middens are known on Marco Island and are assumed to be Middle Archaic in date (Widmer 1974). A possible preceramic site, CP-NPS-370, has been recorded in the Big Cypress Swamp survey (Ehrenhard et al. 1981). This site is also distinctive in that it contains a midden burial.

Artifactually, this period is typified by large, broad-stemmed projectile points, which are the most common points found throughout Florida (Bullen 1968a:30). Within this stemmed group are a series of types which differ only slightly in shouldering and stemming. These include Levy, Marion, Putnam, and Newman Lake points. At Little Salt Spring, Newman Lake points are the associated point type (Clausen et al. 1979), although this artifact class does not appear to occur frequently. No mention of lithic artifacts other than projectile points is made for the Little Salt Spring site (Clausen et al. 1979). Five stone projectile points were recovered from the Bay West site, one of these being a Newman Lake and the other four being Levy variants (Beriault et al. 1981:48–49). Other lithic material at the Bay West site includes a stone biface knife tip and lithic debitage, including a large chert spall and twelve to sixteen small chert flakes (Beriault et al. 1981:49).

The most common Middle Archaic artifacts appear to be tapered bone points, 10 cm in length, made from deer long bones (Clausen et al. 1979:612). Two of these points were also recovered from the Bay West site, as was a bone atlatl hook. Three bone atlatl hooks were also recovered from the Gauthier site along with a bone atlatl handle and a composite antler headdress in situ on either side of the skull. This headdress was decorated with an engraved linear motif. The hair was drawn through a slot in the antler pieces on each side of the head and held in place with racoon penis bones (B. C. Jones 1981). A bone harpoon tip and a shark tooth were also associated with a burial at this site (B. C. Jones, oral communication, 1983).

It is fortunate that preservation permitted the recovery of wooden artifacts at the Little Salt Spring and Bay West sites. These artifacts included a pointed oak digging stick dated at 6830 ± 155 B.P., and a small, incomplete, carved wooden plaque from Little Salt Spring. This plaque is similar in style to those found in later contexts in south Florida (Clausen et al. 1979). The wooden assemblage from the Bay West site was more extensive and included wooden handle plugs found with atlatl spurs and cylindrical shafts, some with incising; a tenoned post or club; and a distinctive group of four shaped and drilled tools interpreted as "fire sticks" (Beriault et al. 1981:46).

Shell tools are a common artifact type during this period, particularly after 5500 B.P. Such tools occur both in interior and coastal sites in Florida, indicating active exchange and movement of these materials. Shell artifacts recovered from the preceramic midden deposits at the Palmer site include picks, hammers, and chisels fabricated from marine gastropods and perforated pelecypod shells, which may have been used for net weights (Bullen and Bullen 1976:11). Similar tools are recorded for the Middle Archaic levels at Tick Island (Jahn and Bullen 1978) and from the preceramic levels at the Bluffton site, also on the St. Johns River (Bullen 1972). Shell tools are reported from the Middle Archaic deposits at Little Salt Spring but are not described (Clausen et al. 1979:612). Shell beads are reported from the burials at the Gauthier site (B. C. Jones 1981), suggesting ornamental use as well. Surprisingly, no shell tools were found at the Bay West site (Beriault et al. 1981:49).

Shell tools, except for the atlatl spur found at Warm Mineral Springs, are not known for the Early Archaic and Paleoindian periods. More emphasis on shell tools, irrespective of whether sites are coastal or interior, occurs during the Middle Archaic.

The most interesting, and potentially most rewarding, cultural aspect of the Middle Archaic period is a distinctive mortuary pattern unique to south Florida. The dead were interred in shallow ponds and sloughs, which provided exceptional preservation of bone and wood. The interments are intentional and include bodies placed in both primary and secondary positions. The corpses were originally interred within moist peat deposits on the slopes of the pond below the water level. Beriault et al. (1981:54) have hypothesized that the wooden stakes found in close association with the burials were driven into the peat to hold the burial mats in place. Secondary burial is suggested by rodent gnawing on some of the long bones from the Bay West site (Beriault et al. 1981).

These cemeteries are substantial in size, with the one at Little Salt Spring having an area of 0.6 hectares and an estimated 1,000 interments (Clausen et al. 1979:613). An estimated 35 or 40 individuals were recovered from the Bay West site (Beriault et al. 1981), 110 individuals were recovered from the Gauthier site, and an additional 40 or 50 are thought to have been destroyed by previous disturbance (B. C. Jones 1981:81). The Gauthier site is interesting because it reveals three distinct social statuses. They consist of interments without mortuary offering; a few with only shell beads, atlatls, or economic tool kits; and a single adult male with a total of fifty-two artifacts, including the composite headdress described earlier, a shell bead, an atlatl, a unilaterally barbed harpoon, and other lithic artifacts (B. C. Jones, oral communication, 1983). Solitary burials are another type known for this period, as evidenced by a single midden burial at the site CP-NPS-370 in the Big Cypress Swamp (Ehrenhard et al. 1981).

Thus, we see considerably more material evidence of human occupation in south Florida starting about 7000 B.P.: sites and artifacts attributable to this period are more numerous, and cemeteries begin to occur. Although burials are known for the earlier Archaic period and possibly the Paleoindian, they do not appear to be as regularized (i.e., in groups or cemeteries), nor are they as frequent. Also during this time period, we see the development of a distinctive mortuary pattern and an artistic style, the former extending into Hopewell times in Florida (W. H. Sears 1971, 1974) and the latter up until historic times (Gilliland 1975; Clausen et al. 1979). Shell tools become frequent as well. If we exclude ceramics, the roots of the Glades Tradition from a material perspective began at this time.

The Late Archaic, or Pre-Glades, Period (4000 to 2700 B.P.)

The Late Archaic period is differentiated from the Middle Archaic in Florida by the addition of a single cultural trait, ceramics; the earlier Middle Archaic material culture continued to be used. In south Florida, this period is often referred to as Pre-Glades (Goggin 1949a; Cockrell 1970), an admirable usage because it is strictly chronological. The number of Late Archaic components, as determined by the occurrence of Late Archaic ceramics, is considerably less than in the earlier Middle Archaic period, which might suggest less occupation during this time, a shift in settlement pattern, or else a lack of ceramics in some sites of this period. This question will be addressed in chapter 7.

The ceramics which characterize this period are distinctive in that they are tempered with palmetto fiber (Brain and Peterson 1970), providing a horizon marker for the coastal region of the southeastern United States from 4500 B.P. to 3000 B.P. (Bullen and Stoltman 1972). In Florida the period encompassing the production of fiber-tempered pottery is known as the Orange period (Bullen 1972) and, based on a series of four radiocarbon dates from the Palmer site, is thought to date from 4000 to 3000 B.P., with a date of 4050 ± 125 B.P. for the earliest Orange ceramics (Bullen and Bullen 1976:13, table 2).

Bullen has further divided this period into five temporally distinctive subperiods on the basis of seriation and radiocarbon placement of stratigraphically distinct stylistic motifs and attributes (Bullen 1972; Milanich and Fairbanks 1980:156, table 3). The most recent of these periods, Orange 5, has been termed the Transitional period. This period is characterized by the introduction of semi-fiber-tempered, temperless plain, and temperless incised sherds (Bullen 1970: 64).

This stratigraphy was established prior to the intensive excavation conducted on Marco Island, however, which shows a somewhat different ceramic sequence from that developed for the Orange period in the St. Johns River area. The sequence presented here incorporates these findings, and differs in many respects from the chronology proposed by Bullen (1972) for the Orange period. A comparison of the two sequences is shown in table 5. The basic concept of an initial undecorated period followed by a decorated period is the same, but the temporal priority of the tempering materials in the ceramics differs. The original stratigraphic sequence for the Orange period, which was developed for the St. Johns River area, is relatively straightforward and without substantial problems. Along the Florida Gulf coast, however, at least as far north as the Askew site and south to Marco Island, limestone tempering is found in association with Orange ceramics. In fact, the earliest sites along the southwest Florida coast include untempered chalky ceramics and limestone-tempered ceramics as well as the usual fiber-tempered Orange ceramics.

Part of the confusion results from Bullen and Askew's (1965:213–214) belief that the limestone-tempered Perico Island ceramics were post-Transitional period (i.e., after 2500 B.P.). Their investigations, however, indicate fourteen sherds of the same sand-and-limestone-tempered vessel plus another sherd of the same type from a different vessel in the lowest level of Test 2 at the Askew site in Citrus County. This level contained no other sherds and was stratigraphically lower than a level which contained Orange Plain sherds. In the basal level of Test 1, located at the same depth as the lowest level in Test 2, only plain sherds were found, including one Orange Plain, one sand-tempered plain, one "semi-Pasco/semi-Orange" plain, and one St. Johns Plain.

Table 5
Comparison of Chronological Sequences for
the North and South Florida Late Archaic

	St. Johns Late Archaic Sequence	South Florida Late Archaic Sequence
2450 BP		
	Transitional - Norwood Plain	Transitional - Norwood Plain
2950 BP		
	Orange IV-Orange Plain and Incised, St. Johns Plain	
3200 BP		Pre-Glades III-Orange Plain and Incised, Perico Incised, steatite sherds
	Orange III-Plain and Incised, steatite sherds	
3450 BP		
	Orange II-Plain and Tick Island Incised and Punctate	
3600 BP		Pre-Glades II-Orange Plain, St. Johns Plain, Perico Plain
3800 BP		
	Orange I-Orange Plain	
3950 BP		
	Mount Taylor	Pre-Glades I Late-Orange Plain
4500 BP		
		Pre-Glades I Early-Coastal sites but no ceramics
5000 BP		

A similar situation exists at the Canton Street site, where only plain sherds are found in the lowest three levels of the site, 91 to 150 cm deep (36- to 60-in. zones). These sherds include St. Johns, Perico Island, and Pasco Plain sherds, as well as Orange Plain sherds. Thus, Bullen had evidence of the early co-occurrence of fiber-tempered and limestone-tempered wares. Surprisingly, limestone-tempered sherds (Perico and Pasco series) were not encountered at the Palmer site, but ceramics were generally scarce at this site (Bullen and Bullen 1976).

This occurrence was initially noted by Willey (1949b:172), who analyzed the ceramic assemblage excavated by Marshall T. Newman from a small shell midden on Perico Island. In this collection are 229 Glades Plain sherds (a later type), 281 Perico Island Plain sherds, seven Perico Island Incised and five Perico Island Linear Punctate (Willey 1949b:179). The Perico sherds are distinguished by having crushed-limestone tempering. Also in this collection were 14 fiber-tempered plain sherds, which Willey classified as St. Simon's Plain but which would now be called Orange Plain, one Orange Incised sherd, and two St. Johns Incised sherds. The St. Johns ceramic series is distinctive because of its chalky, temperless paste. Thirteen Biscayne Plain sherds are also included, although these would now be classified as St. Johns Plain (Bullen 1968b).

Willey (1949b:178) notes that there was no stratigraphic data available from the excavations and that it was impossible to say whether the Perico Island series was earlier than the Glades period. He thought that the Perico Island series ceramics were later than Glades Plain, because at that time Glades Plain was established as the earliest ceramic type in south Florida. This is essentially the position followed by Bullen and Askew (1965) but supposedly now based on stratigraphic evidence. Another situation exists along the north-central Gulf coast, however, which further confuses the issue; that is, the existence of another limestone-tempered ceramic series known as the Pasco series (Willey 1949b:446–447) thought to date to the Weeden Island period. This type was developed by Goggin (1948b) for central Florida, but Willey (1949b:447) stated that "the southwestern part of central Florida may be the hearth of the type, but it also extends to the Gulf Coast." He describes the ware as heavily tempered with fine-to-large limestone lumps. Willey (1949b) did not consider this series as representing a separate period and included these ceramics with other Weeden Island types.

Bullen (1970:64) clearly recognizes that St. Johns Plain, Perico, or Pasco ceramics and semi-fiber-tempered wares developed *before* the manufacturing of fiber-tempered wares ceased by 3000 B.P. He does not, however, say how long before this date. The specifics of this problem need to be thoroughly discussed to justify the chronology presented here. Bullen et al. (1978) have classified these ceramics quite differently from Willey and have confused not only the original typological attributes but, more important, their temporal and geographical distinctiveness. They distinguish Pasco Plain from Perico Plain primarily on temper size, with Perico having fine-to-medium crushed limestone and incurving rims and Pasco having medium-to-large temper and straight rims. This distinction of temper size was *not* made in Willey's (1949b) original type descriptions nor was the distinction in rim form. The original type description for the Pasco series reads: "open and slightly constricted bowls with unmodified rims" Willey (1949b:447). Willey (1949b:365) thought the Perico Plain "may be the prototype of Pasco series pottery which is found further north." Thus, Willey saw a geographical distinction in this ceramic series, one which seems no longer to be implied in the current use of these type names.

The resolution to this problem, as I see it, is that plain ceramics in documented stratigraphic contexts clearly antecede decorated ceramics, *irrespective* of the tempering agent. The type Pasco Plain is not necessarily a late type, since the criteria for its recognition violate the type descriptions and hence the late temporal placement. I suggest that *all* limestone-tempered ceramics south of Pinellas County be referred to as Perico, *unless* a stratigraphic context is known to exist that places it in a Weeden Island context. Resolution of the temporal placement of these ceramics is essential for the discussion of adaptive changes involving ceramics pertaining to this period which will be presented in chapter 7.

The development of a Pre-Glades chronology for southwest Florida is derived exclusively from the the research conducted at Marco Island (Morrell 1969;

Cockrell 1970; Widmer 1974). This is expanded from the preliminary chronology for this period established at an earlier date (Widmer 1974).

Cockrell's excavation of the sealed Pre-Glades midden 8Cr112 provides the most representative ceramic sequence for the area. This sequence was established from 56 m^2 of excavation of a site approximately 45 m in diameter. The site was dug in natural stratigraphic levels and yielded a ceramic assemblage of 169 sherds (Widmer 1974:app. 1).

Unlike the coastal shell middens such as Palmer and Canton Street and the shell heaps of the St. Johns River, the dune ridge sites on Marco Island, although having some oyster shell, are primarily middens of terrestrial faunal refuse, and as a consequence, do not have the exaggerated site volume. Although stratigraphic compression and its associated decreased site thickness and vertical attenuation may result in stratigraphic mixing, this was not a problem at 8Cr112. The site had sufficient thickness of strata (80 cm), which were clearly differentiated.

Since a larger absolute area and volume of site can be excavated in the nonshell middens, together with the stratigraphic compression, a greater frequency and density of ceramics can be obtained than in shell midden sites. Furthermore, nonshell midden sites are not subject to the same episodic formation processes—which can severely bias limited testing—as shell middens, and so the resultant stratigraphy should be less subject to sampling error.

The stratigraphic distribution of the ceramics show a gradual decrease in popularity through time with a marked increase in the percentage of Perico Island Plain at the expense of St. Johns Plain, the latter not being represented in the uppermost stratigraphic zone. Of considerable importance is that even in the latest level, Orange Plain predominates over Perico Island Plain 58 percent to 42 percent. Another important observation is that as at Canton Street and the Askew site, only plain ceramics, irrespective of tempering agent, were recovered. There are no decorated sherds at 8Cr112 and, furthermore, no steatite or semi-fiber-tempered sherds typical of later occupations both on Marco Island and in the St. Johns River valley. Most surprising is the unusually early date—4965 ± 100 B.P. (I-6550)—for the lowest cultural strata at this site, a date considered to be accurate. This date may be too early for the ceramic occupation and may represent an earlier preceramic component which cannot be stratigraphically distinguished, particularly since preceramic occupations have been dated to 4000 B.P. on Horr's Island (McMichael 1982).

Two other early ceramic sites are known on Marco Island. These are the immediately adjacent 8Cr110 and 8Cr111. Both of these sites have only Orange Plain sherds, to the exclusion of any other type. According to tests by Hutto (Widmer 1974), the latter site had five fiber-tempered sherds restricted to the top veneer of the midden, with primarily nonceramic shell midden underneath. This early preceramic coastal occupation is here termed Pre-Glades I Early. These sites suggest that an exclusively Orange Plain deposit is probably earlier than one containing Perico sherds, as evidenced by the frequency distribution at 8Cr112, and therefore represents the initial ceramic subperiod of the Pre-Glades sequence, which is here termed Pre-Glades I Late. Pre-Glades II is then the addition of St. Johns Plain and Perico Plain to the ceramic assemblage.

At the site 8Cr107x1, a series of five radiocarbon determinations date a somewhat later Pre-Glades occupation on Marco Island. These dates range from 3500 to 3050 B.P. (Cockrell 1970:67). The ceramics from this site included all of the paste characteristics found at 8Cr112—that is, temperless, fiber, and limestone—but also included incised decorations. Importantly, there was only Perico Island Incised, no plain. Also recovered were St. Johns Plain and steatite sherds. These materials together with their chronological position, ignoring the St. Johns and Perico Island sherds, correlate well with Bullen's Orange 3 and 4 periods and are referred to here as Pre-Glades III.

Outside of Marco Island, only a few other sites in south Florida have yielded fiber-tempered pottery. These sites include one on nearby Horr's Island, where eight fiber-tempered sherds were collected from the surface of a small shell midden (McMichael 1982:78); one on Useppa Island (J. W. Griffin 1949), where fiber-tempered sherds have recently been recovered in stratigraphic context along with some steatite sherds in disturbed context (Marquardt, letter to author, 1984); one on Turtle Bay, where a single sherd has been found; and two on the Cape Haze Peninsula (Bullen and Bullen 1956:51). Four additional sites on the Cape Haze Peninsula also contain Orange Plain sherds (Goggin 1954, cited in Bullen and Bullen 1956:50). Marquardt also found fiber-tempered pottery eroding out near the Howard Mound near Bokeelia (Marquardt, letter to author, 1984). J. W. Griffin (1974:343–344) states that fiber tempering is rare south of Marco Island, and to date only a single sherd, eroding from the water's edge at the Onion Key site in the Everglades National Park, has been reported for the area.

A fourth subperiod of the Pre-Glades period in south Florida is known as the Transitional period, following Bullen (1959, 1970). This subperiod is characterized by ceramics containing an admixture of sand and fiber as tempering agents. In northern Florida, these ceramics are known as the Norwood series (Phelps 1965; Bullen 1970). Sites dating to this period are found scattered throughout south Florida and are much more common than in the earlier subperiods of the Pre-Glades period. Six sites in the Big Cypress Swamp have Pre-Glades components characterized by sand and fiber-tempered ceramics (Ehrenhard et al. 1978, 1979). One of these may be a pure Transitional component, namely, CP-NPS-14 (Ehrenhard et al. 1978). At another site in the Big Cypress Swamp, Platt Island, a component was dated to 2545 ± 100 B.P., which would provide a terminal date for this subperiod. The Plaza site, also in the Big Cypress Swamp, contained no discernible component, but shell from level 6 of a test pit yielded a date of 3110 ± 80 B.P., about 150 years too early for the Transitional period but probably not that out of line given the curatorial nature of marine shell tools in an interior site.

Semi-fiber-tempered sherds have been found at both the Fisheating Creek site

(Goggin 1951:158) and Fort Center (J. W. Griffin 1952; E. O. Sears and W. H. Sears 1976; W. H. Sears 1982) near Lake Okeechobee, on the southeast coast at the Peace Camp site (Mowers and Williams 1972:9) and at the Markham Park Mound No. 2 site (Williams and Mowers 1977), both in Broward County, and from the 202d Street site in Dade County (Laxson 1962).

Semi-fiber-tempered sherds have been found on the southwest coast at Useppa Island (Griffin 1949), the Wightman site on Sanibel Island (Fradkin 1976:53), and from Onion Key (J. W. Griffin 1974). Cockrell (1970) found several semi-fiber-tempered sites on Marco Island as well.

In spite of the increase in the number of components when compared with the preceding Pre-Glades I, II, and III subperiods, these Transitional components are nonetheless ephemeral and soon are replaced by exclusively sand-tempered plain ceramics. This transition is documented stratigraphically at the site 8Cr107x2, x3, where only fiber-tempered sherds are reported, not limestone-tempered ones (Cockrell 1970:70), a lack which substantiates, in part, the early position of limestone tempering. Still, plain limestone-tempered pottery is found in a few sites in the Big Cypress Swamp which are associated with St. Johns Plain and semi-fiber-tempered ceramics, but no Orange series sherds have been discovered. It may be that only limestone-tempered ceramics are found as majority types south of Marco Island, a situation which is consistent with the natural distribution of sabal palmetto (see Brain and Peterson 1970:72, fig. 1). This would explain in part the rarity of fiber-tempered ceramics south of Marco and the spotty distribution of semi-fiber-tempered sherds.

The Glades Tradition (2500 B.P. to Contact)

Subsequent to about 2500 B.P. the archaeological material culture in south Florida takes on a distinct appearance, which separates it sharply from other areas of Florida and of the southeastern United States:

> Of all the cultural complexes in Florida, the Glades Tradition is perhaps the easiest to define. Agriculture was apparently never practiced, but pottery was extensively used. This was present throughout the span of the tradition and was fairly good in quality, although it was neither the best in ware or decoration. Its sand-tempered paste and decorative motifs are distinctive, but apparently reflect early influence from neighboring areas. [Goggin 1949a:28]

Goggin (1949a:28–32) went on to note the striking material continuity of the Glades Tradition with the earlier Archaic period, as reflected in its exhaustive use of wood, fiber, bone, and shell tools, particularly the latter two. He further stated that no other culture in Florida, and perhaps in the Southeast, has as great a diversity of artifact forms. Using the full cultural-tradition approach Goggin discussed the adaptive aspects of this tradition and its relation to a tropical coastal environment.

In Goggin's (1947) original definition of the culture areas of Florida, the south Florida area, corresponding with the Glades Tradition, was called the "Glades area." J. W. Griffin (1974, 1976) and W. H. Sears (1967) have rightfully objected to the extension of the use of the term "Glades area" to the entire region of south Florida, as Goggin (1947) advocated. This is because not all of the south Florida area is "Glades," and also the specific environmental zone, the Everglades, had originally the sparsest population and was not typical of the Glades Tradition as defined by Goggin (1947).

To avoid this problem, following Larson (1980), I will call the culture area the "south Florida region." I have departed somewhat from Larson's original term, the "south Florida sector," because it includes nontropical areas much farther north of the Florida peninsula (Larson 1980:5, fig. 1). I wish here to keep Goggin's original concept and geographical distribution of the Glades area but to replace the term itself with one that is less specific and misleading.

Goggin (1947) went on further to subdivide the Glades area into three subareas based on stratigraphic sequences obtained in each of these areas. Unfortunately, as J. W. Griffin (1974, 1976) has pointed out, he chose to use ethnographic group names to refer to two of these areas, and subsequent work shows that the original subdivisions were an artifact of the then limited research. A revised subdivision of the south Florida region, incorporating more recent fieldwork, will be presented shortly.

The Glades Tradition, even in its earliest manifestations, is a distinctive one, as was originally noted by Goggin (1949a) and reaffirmed by J. W. Griffin (1976). Although I do not wish to go into detail at this time, reserving such discussion for a later chapter, it is important to realize that a new way of life was developing in south Florida at this time: villages appeared, ceramics were plentiful, and all regions of south Florida were either used or occupied. Otherwise, however, little, if any, change in the material culture occurred. The mortuary customs and artistic styles continued, and strong emphasis was still placed on shell and bone tools, a carryover from the Middle Archaic period. These continued styles led Goggin (1949a) to conclude that the Glades area was a conservative region. Clausen et al. (1979:612–613) agree with this Archaic conservatism but see its origin in a somewhat different and surprisingly nonenvironmentally related adaptive view, contrary to Goggin's position:

> The conservative, somewhat atypical nature of the Glades Tradition may be attributable to compression of an Archaic culture into the southern Florida area by later, possibly agricultural, peoples entering the peninsula from the north around the time of the development and ahead of ceramics, rather than to environmental forces or influences from the Caribbean area. The idiosyncrasies of the Glades Tradition may reflect the effect of isolation of a strongly independent Archaic culture brought

> about by their hostility toward encroaching groups to the north and their containment by sea on three sides in southern Florida. [Clausen et al. 1979:612–613]

Ties between the Glades Tradition and the previous Archaic period are clear, with dramatic cultural shifts occurring as a result of a distinctive adaptation previously unrecorded in the area.

Although there is some confusion over the chronology for the Pre-Glades sequence in south Florida, such is not the case for the Glades Tradition. After 2500 B.P., the ceramic sequence is one of the best-documented ceramic sequences in eastern North America. This is a result of the extensive stratigraphic excavations of Goggin (1939, 1944a, 1947, 1949b, 1950a, 1950b, 1951). More important, this chronology has been verified by exhaustive radiocarbon determinations to provide not only a relative but also an absolute chronology. There are nineteen radiocarbon determinations from excavation of Glades period sites in the Everglades National Park (J. W. Griffin 1974:343), sixty-two radiocarbon determinations from test excavations conducted in the Big Cypress Swamp (Ehrenhard et al. 1978, 1979, 1980, 1981; Ehrenhard and Taylor 1980), and twenty-three radiocarbon determinations from the Granada site, near Miami (J. W. Griffin 1983b). Thus, the ceramic sequence which follows, at least for the southern portion of south Florida, is fairly well established stratigraphically. The situation for the northern half of the southwest Florida coast is not so well understood for reasons which will be discussed shortly.

The initial period of the Glades Tradition is known as Glades I and is divided into two subperiods, Glades I Early and Glades I Late. The Glades I Early is characterized by the exclusive occurrence of a sand-tempered plain ware, Glades Plain. This ceramic type begins about 500 B.C., assumedly after the Transitional period. No other decorated ceramics are associated with this type. The earliest Glades I Early component is found at Fort Center, radiocarbon-dated to 450 ± 150 B.C. (uncorrected) in association with a Period I occupation (W. H. Sears 1974; 1982:116). The Glades I Early period lasts until about A.D. 500 (J. W. Griffin 1974, 1976), but Griffin (1983b:28, fig. 5) has recently suggested, on the basis of five radiocarbon dates which cluster prior to A.D. 500 for the Glades I Early period at the Granada site, that the terminal date for this period is A.D. 200. This chronology is followed by Carr and Beriault (1984:2). The stratigraphy on which this early placement is based, however, seems to be too mixed to justify it. "The time range indicated, B.C./A.D. to A.D. 300, should fall within Glades I Late . . . , but the associated ceramic sample is far from clear. . . . The samples came from very near the bottom of a deep deposit, which, unfortunately, displayed considerable mixture throughout" (J. W. Griffin 1983b:25).

Because of the problems of mixed stratigraphy at Granada, the existence of an A.D. 280 date for the pure Glades I Early site of 8Cr107x2, x3, suggests that, at least for the southwest Florida coast, the terminal date is later. The more conservative A.D. 500 as the ending date for this period seems more appropriate for the entire south Florida region and so will be used. This period is apparent in all areas of south Florida. No regional variation in ceramics occurs at this time, except possibly in the Lake Okeechobee area.

There is a problem in isolating Glades I Early components, because the diagnostic type Glades Plain occurs in all subsequent subperiods of the Glades Tradition as well. Therefore, stratigraphic or areal components without decorated pottery, a situation typical of later periods, must be isolated to determine the existence of an early component. Also, small tests or sampling of sites is insufficient because in the later decorated periods, the decoration is restricted to a small band below the rim, resulting in a large class of residual, plain, body sherds which originally were part of decorated vessels. Even if plain rims are found, such vessels are associated temporally with decorated sherds, and so quantitatively adequate samples are necessary in order to determine the existence of these components.

Besides the substantial, almost pure Glades I Early component isolated at 8Cr107x2 and x3 on Marco Island and dated to A.D. 280 (Cockrell 1970:77), the large 3-hectare site, 8Cr117, also on Marco Island, is exclusively Glades I Early, lacking any decorated ceramics (Widmer 1974). There appears to be a Glades I Early component at the bottom of the Addison Bay site, located near Marco Island, and one at the Turner River Jungle Garden site (Laxson 1966). Glades I Early components are well represented in the Big Cypress Swamp, as evidenced by radiocarbon dates to this period. Ten of the thirty-one sites tested and dated had components dating to this period (Ehrenhard et al. 1981), suggesting a dramatic tenfold increase from the Transitional period in the occupation- or use-involved ceramics of the Big Cypress Swamp. The increase occurs in a very short period of time. Even with the difficulties of detecting this subperiod, we see a rapid expansion of components of the subperiod in all areas of south Florida at this time.

At the Fort Center site in the Okeechobee basin, Sears's excavations have enabled him to break the Glades I period into two subperiods (W. H. Sears 1974, 1982; J. W. Griffin 1976; Milanich and Fairbanks 1980). Both of these periods have predominantly Glades Plain ceramics but are quite distinctive in other respects. Period I lasts from 500 B.C. to A.D. 200. Period II begins at A.D. 200 and is thought to terminate sometime between A.D. 600 and A.D. 800 (Sears 1982: 184–190). The four radiocarbon dates for Period II range from 10 B.C. to A.D. 460. I have arbitrarily decided to use A.D. 500 as the termination of Period II, so it will coincide with the end of Glades I Early, since subsequent to this date, distinctive regional ceramic sequences occur in south Florida. Before this time, ceramics are uniformly Glades Plain in all areas of south Florida (J. W. Griffin 1976:19), although the type Belle Glade Plain begins to appear during Period II (Milanich and Fairbanks 1980:187; W. H. Sears 1982:112, fig. 7.1).

These two periods, I and II, at Fort Center are distinctive and important for two reasons. One is that the existence of maize horticulture has been documented from pollen samples for both of these periods. Associated with the early period is a circular ditch for drainage, while the later period has raised fields used for planting to avoid the high water table (W. H. Sears 1974:347–348; 1982:185–189).

The other important cultural feature found at Fort Center during Period II is the distinct mortuary ceremonialism, which appears to be a carryover of earlier Middle Archaic patterns, although a few more northernly Hopewellian traits are found as well. The mortuary complex for this time period consists of two features: one is a flat-topped mound which was used to prepare interments, and the other is a mortuary pond with a charnel house situated on a pile platform in its center (W. H. Sears 1971:326–327; 1982:186–189). Bodies of the dead were initially interred on the mound to the west of the pond, evidenced by the large numbers of human teeth and small human bones found in the living debris of the mound. These findings suggest that these bones were lost through careless or rough handling (W. H. Sears 1971:327; 1982). This would result when the flesh and connective tissue of the bodies decayed. The teeth and the small bones from the hands and feet would be left behind when larger longbones, ribs, and skulls were removed to the platform on the charnel pond.

An artificial pond, five feet deep, was dug during this period. In the center of this pond, a structure was built incorporating large, carved wooden birds as supporting and decorative members. Oak trunks and unshaved timber were also used for the structure, and small carvings were placed on these as well. More than 300 burials, all bundled and most partially articulated, were placed on the platform. The very few imperishable objects that accompanied the dead consist of a number of plummets, a celt, a few bone pins, and some projectile points. Numerous Hopewell-like artifacts were recovered from the pond, the living area, and the small platform mound, but the latter were not found to be associated with burials. These artifacts include platform pipes, a galena hemi-cone, and quartz-crystal plummets. Also found in the pond was a long pole socketed at one end to hold carved, wooden animal effigies with tenoned bases (W. H. Sears 1971:326–328; 1982).

As can be seen, in spite of Hopewellian influence at the site, the mortuary ceremonialism has strong links with the Middle Archaic period cemeteries. This mortuary pattern is present at this site only during Period II, however.

Mortuary patterning in coastal sites is poorly known. A possible shell burial mound might be associated with the pure Glades I Early village 8Cr117 (Widmer 1974). There may, however, be an example of a muck-pond, charnel-house burial pattern similar to that found at Fort Center at 8Cr46, located near the Goodland Point site on Marco Island (Hrdlička 1922; Goggin 1949b; Widmer 1974). Here, Moore (1900:372) mentions a burial area consisting of low undulating mounds situated in the mangroves, with skeletal material encountered in muck below shell deposits. These observations were confirmed by Violet Hanley, who excavated in the area in 1946 (Goggin 1949b). Although this burial area has never been dated, it can be assumed to belong to Glades I Early for the following reasons. First, burial mounds are not known for any area of south Florida prior to A.D. 500 (Glades I Early). Instead, the charnel house in the middle of a pond is the known method of interment, at least at Fort Center. In this area of Marco Island, an aboriginal canal leads up to the place where the skeletal material is found (Hrdlička 1922; Widmer 1974).

Second, it has been suggested that the low undulating mounds containing skeletal material are the location of a burial preparation area, as mentioned at Fort Center (W. H. Sears 1971, 1982). Moore notes that "parts of disjointed skeletons had been buried just below a shell deposit" (1900:372). He is clear to point out that the skeletons were not complete. Cultural material, including chert projectile points, limestone plummets, shell disks and celts, and a large limestone spike, were found associated with the bone. Importantly, no ceramics are listed with the material. It is possible, according to the amount of cultural material of a mortuary offering nature, that this is the burial area. Still, the close association with the aboriginal canal and the existence of only fragmentary skeletal remains in muck, suggestive of mortuary patterning of this period, indicate an early, pre–A.D. 500 context and surely no later than Glades IIC, or A.D. 1200. In any case, our knowledge of the mortuary behavior during this Glades I Early period is poorly known.

SOUTH FLORIDA PREHISTORY AFTER A.D. 500

Sometime about A.D. 500, and possibly earlier (J. W. Griffin 1983a; Carr and Beriault 1984), decorated ceramics occur in some of the areas of south Florida. A distinctive ware appears with a soft paste fired a dirty white and distinctive exterior striations scraped with a tool. This type of ceramic is known as Belle Glade Plain (Willey 1949a:25–26). In another area of south Florida, decorated ceramics do not appear at all except as rare trade items until very late in the sequence, about A.D. 1200. Thus, starting about A.D. 500, three distinct ceramic trajectories are seen for south Florida.

These trajectories have specific geographical locations and serve to divide south Florida into three cultural areas (see fig. 2): the Circum-Glades area, which forms a band running from Naples on the southwest coast south into the Keys and north along the Atlantic coast to Palm Beach, including the interior region of south Florida below the Lake Okeechobee basin; the Belle Glade area, which consists of the region of the Lake Okeechobee basin; and the Caloosahatchee area, which extends along the Gulf coast from Naples to the Cape Haze Peninsula but centers around Pine Island Sound, San Carlos Bay, Estero Bay, and the mouth of the Caloosahatchee River (J. W. Griffin 1974, 1976). Carr and Beriault (1984) have further subdivided the Circum-Glades area into three areas—the Ten

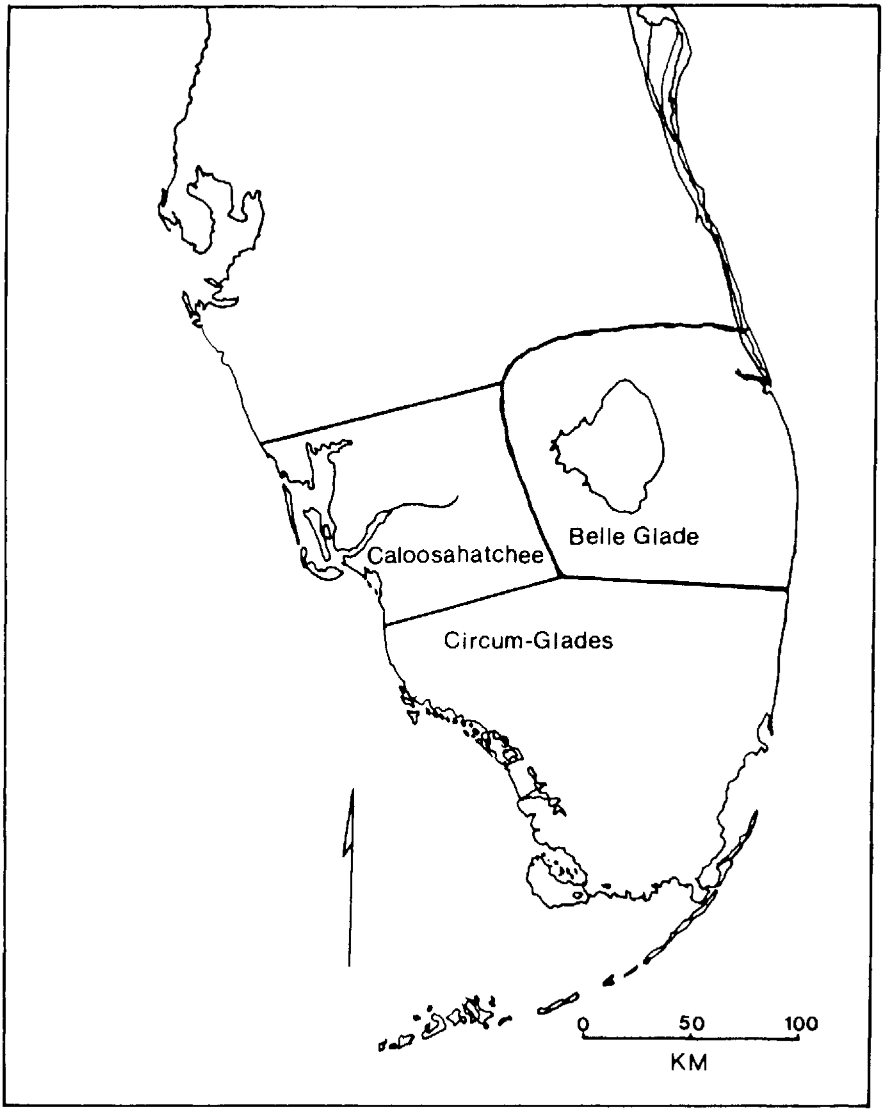


Figure 2. Archaeological Areas within the South Florida Region

Thousand Islands area, the Everglades area, and the East Okeechobee area—on the basis of ecological and ceramic differences. J. W. Griffin et al. (1979:39) suggest that after A.D. 1000 to 1200, the northern border of the Circum-Glades shifts south to between Boca Raton and Fort Lauderdale and is replaced by the Belle Glade sequence.

CERAMIC SEQUENCES FOR THE CIRCUM-GLADES AREA

Glades I Late (A.D. 500 to 700)

The initial decorated ceramic period for the Circum-Glades is known as Glades I Late and is characterized by the appearance of three ceramic types, Cane Patch Incised (Goggin 1950a), Fort Drum Punctate (Goggin 1944a; Willey 1949a; Goggin 1950b) and Fort Drum Incised (Goggin 1950b; Willey 1949a). Another type which is very similar, if not identical, to Cane Patch Incised is Turner River Linear Punctate (Ehrenhard et al. 1978:117–118), which probably also dates to this time period. Vessel forms are simple open bowls in this period (Goggin 1950a:238). Glades Plain continues as the majority ware through this period and all the others as well.

Glades IIA (A.D. 700 to 900)

The Glades IIA period is marked by the replacement of the previous types with six incised ceramic types, including Gordon Pass Incised (Goggin 1939, 1944a; Willey 1949a), Sanibel Incised (Goggin 1944a; Willey 1949a), Key Largo Incised (Goggin 1944a, 1950a; Goggin and Sommer 1949; Willey 1949a), Opa Locka Incised (Goggin 1944a, 1950a; Goggin and Sommer 1949; Willey 1949a); Dade Incised (Goggin and Sommer 1949; Willey 1949a), and Miami Incised (Goggin 1944a, 1950a; Goggin and Sommer 1949; Willey 1949a). Vessel forms remain unchanged. Carr and Beriault (1984:3) note that Gordon Pass Incised and Sanibel Incised, common types on the southwest Florida coast, are infrequent in southeast Florida, where Miami Incised and Opa Locka Incised are the typical forms. For this reason, they consider southeast Florida and southwest Florida to be distinct culture areas, referred to as the Everglades area and the Ten Thousand Islands area, respectively.

Glades IIB (A.D. 900 to 1000)

By A.D. 900, and possibly as early as A.D. 800, the two distinct ceramic traditions of the Everglades area and the Ten Thousand Islands area no longer exist, and all of the Circum-Glades area has a unified ceramic tradition (Carr and Beriault 1984:3). This subperiod is distinguished by the disappearance of the previous incised types, with the exception of Key Largo Incised, which continues and becomes a distinctive temporal marker as the incised arcs now extend onto the lip (Goggin 1950a:245). A new type, Matecumbe Incised, appears, as does a new vessel shape, incurving bowls (Goggin 1950a:238).

Glades IIC (A.D. 1000 to 1200)

The Glades IIC subperiod is very difficult to isolate, because its identification requires deep stratigraphic excavation (J. W. Griffin 1976) and because it consists exclusively of the ceramic types Plantation Pinched (Goggin 1950a; J.W. Griffin 1976) and Glades Plain. No other decoration is seen at this time, and Plantation Pinched is a very scarce type (J. W. Griffin 1976). A few grooved lips are also found during this period.

Glades IIIA (A.D. 1200 to 1400)

The Glades IIIA period is marked by the return of decorated pottery, namely, the type Surfside Incised (Goggin 1944a, 1950a; Goggin and Sommer 1949; Willey 1949a). This type, according to J. W. Griffin (1976), is reminiscent of Mississippian-like decorative techniques seen to the north, notably Pinellas Incised. He further notes that this incised design is distinctive from earlier Glades decoration. Trade wares dating to this time period also are common, including Englewood Incised. These ceramics also occur in the late components of the Belle Glade area and in the southeastern coastal sites (Willey 1949a). "Englewood-like" sherds have been found at the Turner River site (W. H. Sears 1956:55) and a few Englewood-like incised sherds were found at the Marco midden as well (Van Beck and Van Beck 1965).

Another ceramic series which appears during this time period and is considered a temporal marker is the St. Johns series ceramics, formerly called the Biscayne series in south Florida (Goggin 1949b). The ceramic type St. Johns Check-Stamped, a chalky, temperless ware common during this time period in the northern St. Johns valley, was considered by Goggin (1949b) to be a marker of this period. St. Johns Plain also occurs along with the decorated types in Glades IIIA levels at the Marco midden (Van Beck and Van Beck 1965) and at the Granada site (J. W. Griffin 1983c:53).

By A.D. 1200, numerous trade sherds, occurring in quantities considerably greater than those seen from A.D. 500 to A.D. 1200, are found in ceramic assemblages in the Circum-Glades area. It is possible that the occurrence of these northern ceramic types in all areas of south Florida marks the initiation of the pan-Florida trading network, which incorporated groups with at least six different languages, as described by Fontaneda (1944) for the early sixteenth century. This would be the most reasonable explanation for the occurrence of these northern ceramic types in south Florida. Also, it seems that these shifts reflect important sociopolitical changes at the regional level.

Glades IIIB (A.D. 1400 to 1513)

The Glades IIIB period is marked by the replacement of the type Surfside Incised by undecorated vessels with extensively modified lips. This ceramic type is known as Glades Tooled (Goggin 1949b). Lip treatment consists of crenulated "pie crust" pinching of the rims, folding and dowel impression of the rims, and notching (J. W. Griffin 1976). Carinated bowl forms appear for the first time. It appears, based on the stratigraphy at the Marco midden, that the St. Johns series, including St. Johns Plain, continues into the period. The relationship of the St. Johns series to Glades IIIB is poorly known, however. Safety Harbor and Pinellas Plain ceramics occur as minor trade wares as well, probably because Glades Tooled is a very scarce type and therefore not very useful as a marker unless the ceramic assemblage is large. This can be seen at the Goodland Point site, on Marco Island, where Goggin could not isolate a Glades IIIB component, although a Glades IIIC period component, with Spanish olive jar fragments, could be isolated (Goggin 1949b).

Glades IIIC (A.D. 1513 to 1750)

This period is differentiated from Glades IIIB only by the addition of European goods. It corresponds ethnographically to many of the ethnohistorically known groups which inhabited south Florida, including the Tekesta, the Key Indians, and also some of the west-coast groups south of the Calusa heartland that may be affiliated politically, if not ethnically, with the Calusa. J. W. Griffin (1976) has given a terminal date of 1750 for this period, a date which is in line with the final exodus of "Caloosa" refugees, consisting of about eighty families, from the Florida Keys to Havana in 1763, as a result of the Spanish secession of Florida to England (Sturtevant 1978).

It should be noted that a distinctive period from 1704 to 1763, typified by sherds of the Leon-Jefferson period of northwest Florida, exists in south Florida (J. W. Griffin 1976). An excellent example of this component occurs at the John Quiet site, on the Cape Haze Peninsula, where Jefferson Complicated-Stamped, Miller Plain, and olive-jar sherds were located (Bullen and Bullen 1956:33). From the amount of this material, migration of northern groups into the area, rather than trade, is indicated. J. W. Griffin (1976) suggests that the occurrence of these materials represents displaced Apalachee Spanish Mission Indians after the British-Creek raids on north Florida settlements in 1704, an interpretation supported by Sturtevant (1978:141), who further notes the great social and biological effects of Creek and English raids on south Florida Indians as a result of the lack of garrisons in Spanish south Florida.

CERAMIC SEQUENCES FOR THE CALOOSAHATCHEE AREA

The Caloosahatchee area represents one of the most perplexing chronological situations in south Florida, because throughout its post–500 B.C. ceramic history it is characterized for the most part by plain sand-tempered ceramics of the Glades Plain type. W. H. Sears (1973:31–33) has characterized the ceramics of the central Gulf coast of Florida as having primarily plain sand-tempered bowls in the early periods developing into the variously tempered or untempered Pinellas Plain late-prehistoric types. These vessels are the majority ware in village and midden contexts. Another minority class of ceramics, the decorated wares of the Weeden Island, Safety Harbor, and Englewood periods, occur in special mortuary and ritual contexts and are useful chronological markers only when burial mounds are associated with villages and middens.

Although Sears does not specifically indicate it, these statements also seem to apply to the Caloosahatchee area. The above facts together with the occurrences of trade and ceremonial wares in archaeological sites in the Caloosahatchee area form the basis of a tentative chronology for the region, one which follows in many respects chronologies proposed by Bullen and Bullen (1956) and Luer and Almy (1982). It should be noted that because of the changing frequency of occurrence of plain ware types and the scarcity of ceremonial and trade wares, large ceramic assemblages, preferably from deep stratified contexts, are the most desirable for documenting temporal change. These assemblages need to be further reinforced, however, by extensive radiocarbon dating of stratified deposits, as was done at the Wightman site on Sanibel Island (Fradkin 1976) and at Useppa Island (Milanich et al. 1984). Thus, the chronological sequence follows.

Caloosahatchee I (500 B.C. to A.D. 700)

The period is defined from the work of Fradkin at the Wightman site (Fradkin 1976) and the Solana site (Widmer 1986). Two types of ceramics characterize this period, sand-tempered and laminated sand-tempered plain (Fradkin 1976: 54–56; Widmer 1986). This period is similar in many respects to Periods I and II in the Belle Glade area, with the important exception of a complete absence of Belle Glade ceramics in the Caloosahatchee area. Although no comparisons are made with the types Glades Plain and Belle Glade Plain at the Wightman site, the laminated ware is clearly different from the later type (Milanich and Fairbanks 1980:186). This type is also present at Fort Center, where it is referred to as Laminated-contorted Plain and has been clearly distinguished from Belle Glade

Plain (W. H. Sears 1982:24–25). It is found primarily in Period II context, where it has roughly the equivalent frequency percentage as in the Caloosahatchee area (W. H. Sears 1982:112, fig. 7.1). At Solana, laminated ceramics comprise 6.6 percent of the ceramic assemblage (Widmer 1986:53–54), which was dated between A.D. 180 and 600 (Widmer 1986:46, table 1). Surprisingly, laminated ceramics are not mentioned in Test B at Useppa Island, which dates to this time period (Milanich et al. 1984). The small sample size, seventy sherds spanning the period A.D. 200 to the historic era, may have precluded the inclusion of this type, however, particularly since only twenty sherds were utilized in the analysis from the lowest two zones, Strata VIA and VIB, thought to represent this time period (Milanich et al. 1984).

The absence of Belle Glade ceramics in any of the sites in the Caloosahatchee area before A.D. 700 is quite surprising, particularly since such sherds appear by A.D. 100 or so at Fort Center, although in very low frequencies (W. H. Sears 1982:112, fig. 7.1). This absence could indicate that interaction between these areas was minimal during this time (A.D. 100 to 800); that it did not involve ceramics if it did exist; or that the sites so far investigated dating to this period in southwest Florida did not have political or economic access to these ceramics. It could also be the case that Belle Glade ceramics associated with the earlier portion of Period II at Fort Center are actually intrusive from later times. The seriation performed by Sears, however, does indicate increased frequency throughout Period II, suggesting that the early appearance of these ceramics is not intrusive.

St. Johns Plain sherds appeared as a minority type at the Solana site, comprising 0.3 percent, 11 sherds, of the ceramic assemblage of 3,384 sherds. No sherds of this type were recovered from the Wightman site, but this is probably a function of sampling error, since the assemblage there consisted of only 776 sherds. These sherds are found in minute quantities in Period II at Fort Center (Sears 1982). Only three decorated sherds were recovered from Solana, one each of curvilineal complicated stamped, dentate stamped, and simple stamped. This is consistent with a Hopewellian time frame, as is seen at Fort Center during Period II, and suggests that these sherds, although clearly minority types, can be present in Caloosahatchee I contexts if the sample size is large (i.e., 3,500 or more sherds).

Caloosahatchee II (A.D. 700 to 1200)

The Caloosahatchee II period is marked by the dramatic increase of Belle Glade ceramics in the area. The initial starting date of the period has not been firmly established, but A.D. 700 is suggested, since no Belle Glade ceramics were found at the Wightman site (Fradkin 1976) and ceremonial-mound use in the area dates to sometime after A.D. 700. The best stratigraphic evidence in the Caloosahatchee area is found at the John Quiet site, on the Cape Haze Peninsula (Bullen and Bullen 1956). In the lower levels of the Bullens' excavation, an increase in the popularity of Belle Glade ceramics relative to sand-tempered plain is seen from the earliest level to the later levels. It should be noted that these are still nondecorated levels. Table 6 illustrates this shift in popularity through time, combining the lowest levels from the two test sites.

Table 6
Frequency Shift in Belle Glade Plain and
Sand-tempered Plain Ceramics at the John Quiet Site,
Cape Haze Peninsula

Level	Belle Glade Plain	Sand-Tempered Plain
Level 5	48 (19+29) [73.8%]	17 (7+10) [26.1%]
Level 6	28 (22+6) [43.7%]	36 (27+9) [41.3%]
Level 7	30 (25+5) [26.8%]	82 (76+6) [72.5%]
Level 8	6 (6+0) [5.6%]	101 (100+1) [94.4%]
Level 9	1 (1+0) [7.1%]	13 (13+0) [92.8%]

Adapted from Bullen and Bullen (1956)

The increase in popularity of Belle Glade ceramics through time is seen here, which is also characteristic of the later Period II and Period III frequencies at Fort Center, which are roughly equivalent in time. W. H. Sears (1982) does not give frequency data and instead provides a seriation chart which illustrates that Belle Glade ceramics become a majority form of secular ware in Period III. It should also be noted that as well as can now be determined no decorated ceramics occur at this time.

Caloosahatchee III (A.D. 1200 to 1400)

The Caloosahatchee III period is best identified by the appearance of St. Johns trade wares, notably St. Johns Check-Stamped, which, as mentioned earlier, is thought to make its appearance in south Florida at this time, and is also characterized by the appearance, where it can be detected, of Englewood period ceramics in the Caloosahatchee area. The Englewood period, as originally defined by Willey (1949a:471), is known primarily from burial mounds in the Manatee County region of Florida and therefore represents a specialized ritual-mortuary context, one which would not be typically found in middens and villages (W. H. Sears 1973). The temporal placement proposed here is in line with that of Willey, who placed it as transitional between the earlier Weeden Island II period and the later Safety Harbor period. Surprisingly, more Englewood sherds have been identified in the Circum-Glades area than in the Caloosahatchee area, in spite of the latter's being closer to the Manatee region.

Caloosahatchee IV (A.D. 1400 to 1513)

This period is a readily recognizable temporal unit, characterized by the appearance of numerous trade wares, both "sacred" (W. H. Sears 1973) and secular from all adjoining regions of Florida. These types include Glades Tooled ceramics from the south, which have been found at the Big Mound Key, the John Quiet, and the Cash sites; on the Cape Haze Peninsula (Bullen and Bullen 1956); and at the site L-91-A at the mouth of the Caloosahatchee River. From the north, the ceremonial ceramics of the Safety Harbor series are found in burial mounds in the area (Moore 1900, 1905) and also sparsely in midden deposits as well (Bullen and Bullen 1956). The utilitarian ceramic type Pinellas Plain occurs quite frequently, both in the Cape Haze Peninsula region (Bullen and Bullen 1956) and at the mouth of the Caloosahatchee River (W. H. Sears 1967).

Bullen (1978:50) has suggested that the Safety Harbor Phase is the archaeological manifestation of the ethnohistoric group the Tocobaga. This is partly accurate, but this phase, as represented by its ceramics, is not isomorphic with the Tocobaga, particularly since Safety Harbor ceramics extend geographically into the Charlotte Harbor area (Bullen 1969:418), which is the heartland of the Calusa (Goggin and Sturtevant 1964), and also into southeast Florida (Willey 1949a). The Aquí Está burial mound is interpreted by Bullen (1969) as representing a Tocobaga enclave in an otherwise Calusa territory. A more reasonable interpretation, the one suggested here, is that Safety Harbor material culture is typical of *both the Tocobaga and the Calusa, and that it cannot be used exclusively to distinguish the Calusa from the Tocobaga.* The isomorphic correlation of the Safety Harbor Phase with the Tocobaga appears to be a result of the poorly known southern distribution of Safety Harbor material. This complex is well represented in the Caloosahatchee region and in considerably greater amounts than was originally thought. Thus, Safety Harbor material in the Caloosahatchee region is associated with the Calusa and not the Tocobaga.

Caloosahatchee IV (A.D. 1513 to 1750)

This period refers to the period of European contact and is recognized by the appearance of European artifacts associated with aboriginal artifacts and also with material from the Leon-Jefferson Mission period. Surprisingly, sites of this later period are quite common in the Caloosahatchee area, being found in the Cape Haze Peninsula (Bullen and Bullen 1956) and at the mouth of the Caloosahatchee River (W. H. Sears 1967). Also, a very early contact period (circa 1560)

Calusa burial mound on Pine Island was excavated by Moore (1900, 1905). Numerous European grave goods were associated with typical Caloosahatchee IV ceramic sherds in the fill (Moore 1905:306–307). It is also at this time that the tenoned plaques made of European metal are found (Allerton et al. 1984).

CERAMIC SEQUENCES FOR THE BELLE GLADE AREA

The chronology of the Belle Glade area is not completely known at present, but it appears to be closer to that of the Caloosahatchee area than the Circum-Glades (W. H. Sears 1974; J. W. Griffin 1976). A very different ceramic assemblage exists, however, at the two best-known archaeological sites in the area, Fort Center and Belle Glade. Ironically, the Belle Glade site has percentages of Glades I Late and Glades II decorated ceramics approximately equal to those from sites reported from the Circum-Glades proper. Willey (1949a) notes that Glades I Late and Glades II ceramic types occur at the Belle Glade site and form a combined frequency for their respective levels of occurrence of 4.8 percent of all ceramics in those levels. This is less, but not much, than the frequencies at Bear Lake in Goggin's (1950a) stratigraphic excavations in the Everglades National Park, where 6.9 percent of all sherds for these periods were decorated. More important, the 4.8 percent decorated Glades ware sherds are much greater than the sample recovered from the Marco midden, where only 2.2 percent of the sherds from the Glades I Late and Glades II levels are decorated. This seems to imply that Glades series decorated ceramics for the Glades I Late and Glades II periods are well represented at the Belle Glade site on the southeast edge of Lake Okeechobee and so may be more typical of the area than the Belle Glade series ceramics.

At the Fort Center site, however, on the western edge of Lake Okeechobee, not a single Glades series decorated sherd is present in the 54,890 sherd assemblage (W. H. Sears 1982). Instead, a sequence of sand-tempered plain and Belle Glade Plain sherds are found, with scattered northern trade wares. The frequency of sand-tempered plain diminishes through time so that by A.D. 1000, the Belle Glade series predominates. A similar situation occurs at the Belle Glade site *after* A.D. 900 to 1000, with the disappearance of Glades decorated sherds and an apparent duplication of the Period III ceramic profile seen at Fort Center. Not only does Belle Glade influence spread west into the Caloosahatchee area, it also spreads east toward the Atlantic coast and down the coast to near Fort Lauderdale, replacing the Circum-Glades ceramic types (Griffin et al. 1979:33; Carr and Beriault 1984:7). The regional distinction persists until historic times. This East Okeechobee area, as it is termed by Carr and Beriault (1984), is inferred to be the region of the historic group the Guacata (Griffin et al. 1979:33), following Swanton's (1952:131) description of the location of this "tribe." "Guacata," however, refers specifically to a town on the eastern edge of Lake

Okeechobee (Fontaneda 1944:13). Further, Fontaneda (1944:20) speaks of the cacique of Guacata, and the name may thus refer to a tribal group as well. What is known, however, is that the cacique of Guacata, be it a town or an ethnic division, was on similar political standing with the caciques of the Ais, Jeaga, and Tekesta. The relationship of the other towns on the lake to Guacata is not known, but they were probably independent. This supposition is supported in part by Fontaneda's statement that "they are masters of a large district of country, as far as a town they call Guacata, on the Lake of Mayami" (Fontaneda 1944:13).

It would seem then, that the Belle Glade site, at least during its latest protohistoric phase, is actually the town Guacata. This interpretation is based on the recovery of elaborate European grave goods from the burial mound at that site, including gold, silver, and copper items and glass beads (Willey 1949a:60–61). We know that Carlos himself divided up the gold and silver plundered from a Spanish shipwreck among the chiefs of the Ais, Jeaga, Guacata, Tekesta, and other groups to the north (Fontaneda 1944). The gold and silver found in the Belle Glade burial mound may actually be the spoils of this division.

The Chronological Placement of the Late Prehistoric Adaptation

As can be seen, the chronology for much of south Florida is somewhat poorly known. This is not simply a problem pertinent to cultural history per se but also relates directly to the understanding of the evolution of settlement systems in southwest Florida. The problem springs from the fact that surface collections from many of the sites in southwest Florida enable only the identification of the late period (i.e, post–A.D. 1400). Therefore, many researchers (Goggin and Sturtevant 1964; Milanich 1978; Milanich and Fairbanks 1980) have assumed that the very extensive political and demographic expressions which are found in southwest Florida are exclusively late manifestations, in part influenced by the Mississippian groups to the north. This assumption stems from the highly limited excavation done in this area. Other than the work of Morrell (1969) and Cockrell (1970) at Marco Island and Widmer (1986) at Solana, only limited stratigraphic testings have been conducted in southwest Florida. This has seriously impaired our archaeological ability to ascertain whether these extensive sites contain early components. Still, it is possible, by interpretation of the existing test excavation data and radiocarbon dates, to ascertain when these large villages with their ceremonial centers first appeared. It is not possible, however, to calculate precisely the number of sites that belong to the early period or their spatial extent.

One of the most surprising aspects of the archaeology of southwest Florida is that large sites, up to twenty-five hectares, with temple mounds indicative of substantial population size and density and obvious political hierarchy, occur by A.D. 800. Pivotal to a discussion of the archaeological data relevant for an early placement of what is essentially the Calusa adaptation is the chronological assignment of the best-known and most important archaeological site thus far investigated in southwest Florida, the Key Marco site.

The Chronological Placement of the Key Marco Site

The archaeolgical material recovered by Frank Cushing (1896) from the Key Marco site in Collier County, Florida, has long been recognized as some of the most spectacular cultural material excavated from the eastern United States. It is unique in some respects because of the unusual state of preservation of the organic material at the site. Because of the high degree of complexity and technical excellence of the wooden artifacts found, most southeastern archaeologists have long assumed that this material must have a late temporal position. James A. Ford suggested that the decorative motifs of the specimens suggest relationships to the Southern Cult. He noted that no European artifacts are found in the collection and that an expected date in the sixteenth or seventeenth century is not unlikely (Gilliland 1975:257). This comment was published in association with a radiocarbon sample, submitted to the University of Michigan for dating, which yielded a date of A.D. 1670 ± 70.

Goggin, in a letter to H. Newell Wardel on 12 May 1946, stated that he could date the Cushing site to the Glades IIIB period (late fifteenth century) on the basis of a sherd of Glades Tooled type, a marker for this period. He also noted that there were no historic artifacts from the site (Gilliland 1975:38); Gilliland agrees with a late-fifteenth-century precontact date for the site. Goggin and Sturtevant (1964:202) consider the Cushing collection as part of the "Glades" cult, a ceremonial complex analogous to the Southern Cult, found throughout south Florida, which dates the Cushing sample. They suggest the fifteenth century for this cult. Recently, Milanich (1978) has also suggested a late-fifteenth-century date, in spite of a series of six radiocarbon dates on material from this collection that, at face value, suggests the eighth or ninth century (see table 7). Cushing (1896:431, pl. 35) compared some of the stylistic motifs of the artifacts he recovered at Key Marco with the copper plate from the Etowah Mound, which has a known Middle Mississippian context and therefore also suggested a late temporal context. It was probably this comparison by Cushing which initiated the late placement of the site. Thus, for a period of more than seventy-five years, there was a consensus among archaeologists that the Cushing material and the Key Marco site were late prehistoric (i.e., post–A.D. 1400). The six radiocarbon dates published by Gilliland (1975:257) upset this belief and have been held suspect by at least one Florida archaeologist (Milanich 1978). Gilliland (1975: 37–38, 275), incorporating the findings of these dates, suggested that the site was occupied over an extended period, and she demonstrated the presence of sophisticated art forms in Florida at a very early date.

Table 7
Radiocarbon Dates from Key Marco

Artifact	Radiocarbon Determination	Date	Corrected Date
Wooden float peg	1100 - 1300 BP	A.D. 675 - 875	A.D. 920 - 690
Wooden post fragment	1125 ± 50 BP	A.D. 825 ± 50	A.D. 890 ± 50
Wooden paddle fragment	1920 ± 60 BP	A.D. 55 ± 60	A.D. 110 - 90
Wooden plaque fragment	1305 ± 60 BP	A.D. 670 ± 60	A.D. 690
Wooden mask fragment	1275 ± 50 BP	A.D. 700 ± 50	A.D. 730 - 700
Fiber fragment	280 ± 100 BP	A.D. 1670 ± 100	

Adapted from Gilliland (1975:Appendix E)

The idea of an earlier occupation for the Key Marco site is not new and was mentioned by Goggin (1964:77), who reported that according to Matthew Stirling, Gordon Pass Incised (then referred to as "feathered" design on Glades Gritty ware), a Glades II ceramic marker, "is found particularly on Key Marco." This is the first evidence of an earlier occupation at Key Marco, but it was never further investigated or discussed.

One of the reasons for the poor chronological control and general uncertainty of the temporal dimension is that there has been almost no archaeological excavation at the site since Moore and Cushing. In fact, no archaeological work was conducted at the Key Marco site until the 1960s, when Van Beck and Van Beck excavated in an area which they thought was 850 feet east of the Cushing site and separated from it by a small inlet (Van Beck and Van Beck 1965:1). In 1974 I surveyed the area where the Van Becks had stated the Cushing site was located (Widmer 1974). A thorough search of the area revealed no cultural material and instead only very recent beach ridge formation. A comparison of the oblique aerial photograph published in the Van Becks' report, which indicated the location of their test pits, with Cushing's (1896:420, pl. 30) map of Key Marco indicates that both the excavations by Cushing and the Van Becks were conducted on the Key Marco site, Cushing's Court of the Pile Dwellers excavation being located about 200 m southwest of the Van Becks' excavation.

Cockrell (1970:31–32) was the first to point out the Van Becks' mistaken belief about the location of their excavation, and he placed it on the Key Marco site map published by Cushing in the immediate vicinity of a "temple mound" with an elevation of 4.5 m (15 ft.). To avoid confusion in the future, I suggest that the entire area mapped by Cushing be referred to as the Key Marco site and that the excavations by Cushing and the Van Becks be referred to as the Court of the Pile Dwellers and the Marco midden excavations, respectively. Although at the same site, the investigations are spatially distinct. The distinction is no trivial matter, because it brings to bear some important data relevant to the dating of the Key Marco site, data which were previously ignored because there was thought to be no connection between the two excavations.

There are two classes of evidence for the chronological positioning of the Key Marco site: stratigraphic and stylistic criteria. The stratigraphic data will be considered first. The excavations by the Van Becks (1965), consisting of one 0.9 × 1.5 m (3 × 5 ft.) and one 1.5 m^2 (5 × 5 ft.) test pit, resulted in a stratified ceramic sequence for the Key Marco site. The deposits in which they excavated had cultural material to a depth of almost 3 m, with fifteen culture-bearing strata in Test A and nineteen in Test B. These tests yielded a very dense assemblage of ceramics, 2,197 sherds in Test A and 5,075 sherds in Test B. These tests reveal a stratified sequence of occupation for the site with the upper levels (1–8 in Test A and 1–9 in Test B) yielding Glades III marker types, while the lower levels contain exclusively Glades II material. The finds clearly demonstrate the presence of both Glades II *and* Glades III components.

More important, the sherd densities are as high, if not higher, in the Glades II levels as in the upper Glades III levels, with the highest density for sherds (729) in level 13 of Test B, a density higher than any of the Glades III levels in either test. This seems to indicate that the Glades II component is as strongly represented at the Key Marco site, if not more so, as the Glades III component. While a sample of two stratigraphic tests is not quantitatively sufficient to evaluate the areal distribution of these components, the sherd density patterns do suggest that Glades II was at least as large as the Glades III component. This is also supported by the observation that the Glades II deposits in Test B are as thick as those of the Glades III deposits.

If we consider sherd density to be related to the population density of the site (see Sanders et al. 1979), the earlier Glades II component appears to be as densely settled as the later Glades II component. Given the correlation of population size and density with sociopolitical complexity, the Glades II component at Key Marco is likely to be as politically complex as the later Glades III component. Therefore, to state that the high artistic expression, elaboration of technical skills, and possible craft specialization indicate complex political organization and therefore are solely associated with the late Glades III period, when such political complexity is ethnographically recorded, is misleading and unjustified, because population density and site nucleation, the necessary correlates for complex social organization, are also present in the Glades II components.

The problem still remains that the stratigraphic or occupational history of the site is not sufficiently understood from the samples to place the Cushing material accurately in its correct temporal context. Milanich (1978) has rejected the validity of the six radiocarbon dates listed in Gilliland, citing the probability of contamination, since the artifacts from which the samples were taken had been stored in areas subject to fumigation with pesticides. It is not possible to evaluate the accuracy of this statement without knowing the technical aspects of the processing of the samples, and so on. Therefore, it must be assumed that Milanich is correct and that the samples are of no use. It should be pointed out, however, that the radiocarbon dates fall within the Glades II range and in themselves are not out of place.

Stylistic motifs cannot be used exclusively to date these materials. As mentioned earlier, Cushing was the first to compare certain motifs found in the artifacts from excavations at the Court of the Pile Dwellers with those found on the copper warrior plate from the Etowah Mound. This artifact is known to have a Middle Mississippian temporal context, that is, A.D. 1250–1400 (Willey 1966; Larson 1971). Thus, it is tempting to suggest that the artifacts from the Court of the Pile Dwellers should date to this period. It should, however, be cautioned that Cushing selected only certain individual motifs from a number of different artifacts which contained other motifs *not* found or associated with the Southern Cult. We must remember that the stylistic representations of the southeastern ceremonial complex are of a distinctively integrated and internally consistent pattern (Krieger 1945; Waring and Holder 1945) and that numerous individual or discrete elements are found much earlier, as early as Hopewell temporal periods, including the negative-painting style and the cross motif (Willey 1949b). If we consider the entire context of the art represented in the artifacts excavated by Cushing from the Court of the Pile Dwellers at Key Marco, we see very few parallels with the Southern Cult or for that matter with the Mississippian temporal level.

Since the chronology of the Cushing artifacts is still in question, I suggest that the stratigraphic data from the Marco midden nevertheless indicates that the population size and density, and therefore the potential for sociopolitical complexity, existed at the Key Marco site by A.D. 800. Besides the evidence of substantial population at the Key Marco site, similar early (i.e., A.D. 800) dense occupation is seen at the Addison Bay site, located just east of Key Marco. Here, I have observed Glades I Late and Glades II sherds eroding out of unusually thick 4+ m shell-midden deposits on the outside circumference of the large 20 hectare site. Extensive mining for shell had left an "atoll-like" shell ring, with the interior having an exposed profile. What is important is that these pre–A.D. 1000 sherds were found eroding from the entire circumference of the exposed profile, suggesting that the entire surface area was occupied at the early time.

W. H. Sears (1956) found dense Glades IIA and IIB deposits at the Turner River site, with sherd densities for levels containing these ceramics greater than those for the later Glades III period. A similar situation is seen at the Goodland Point site (Goggin 1949b:table 2), where spatial components of the Glades II period are more frequent and denser than those attributable to the Glades III period. These sites indicate the existence of large, dense populations, usually associated with hierarchical social structure, at an early date.

The Existence of Ranking by A.D. 800 in Southwest Florida

The construction of nonmortuary ceremonial mounds consisting of secondarily deposited shell middens shortly after A.D. 700 is clearly documented at the Wightman site on Sanibel Island (Fradkin 1976:101–102). Three mounds of this type, connected by shell causeways, were found at the Wightman site, and Fradkin (1976:102) suggests that they were probably topped by temples, houses, or other structures. The interpretation of these mounds as platforms for either chiefs' houses or temples agrees with the ethnographic literature for the area (Goggin and Sturtevant 1964; Bullen 1978) and is consistent with the ceremonial interpretation of Milanich and Fairbanks (1980:244–246). The implication, then, is that platform mounds and causeways constructed of secondary fill appear by shortly after A.D. 700.

This mound development coincides with the demographic argument that sites in the Ten Thousand Islands have substantial, dense populations by A.D. 700 to

800, although minimal ceremonial and hierarchical sociopolitical data for this time period exists. My argument is that substantial population aggregates, both in terms of size and density, and the appearance of hierarchical sociopolitical occupation, as witnessed by platform mound and causeway construction, date to at least as early as A.D. 800 and that the pattern is *not* atypical. The political, demographic, settlement, and subsistence patterns which characterize the Calusa adaptation are well established, if not completely present, in southwest Florida by A.D. 800.

Burial patterning provides an important means of differentiating sociopolitical patterns between the Hopewellian period mortuary ceremonialism and that seen in the Late Prehistoric adaptation. These changes are consistent with ethnographically documented mortuary ceremonialism and provide further evidence for a ranked sociopolitical organization.

Mortuary Ceremonialism

Unfortunately, little information exists regarding the specific nature of the mortuary patterning of the Glades II–Caloosahatchee II period. No burial mounds in southwest Florida are known for this period; however, a substantial burial mound, dating to this time period, is found to the north along the coast at the Palmer site, near Sarasota. This burial mound dates to about A.D. 850, based on a radiocarbon date of 1100 ± 105 B.P. (Bullen and Bullen 1976:41). This date is consistent with the fact that *no* Englewood or Safety Harbor sherds occur in the burial-mound fill, and all the ceramics appear to date before A.D. 1100 (Bullen and Bullen 1976). Four hundred burials were recovered from this mound, with 75 percent flexed, 6.5 percent bundled, and 5.6 percent being isolated skulls. No extended burials were recovered, nor were there intentional ceramic interments. Bullen and Bullen further interpret the burial mound use as continuous, and they suggest that the burial pattern is suggestive of periodic group interments from a charnel house. The pattern, as was noted, is confirmed for Period II at Fort Center.

Further south, in Manatee County, another burial mound dating to this period, Parrish Mound 5, is known (Stirling 1935a; Willey 1949b). This burial mound is almost identical in type and date to that of the Palmer burial mound. As at Palmer, no ceramic offerings were noted and of the eighty-nine interments recovered, most were secondary and in poor condition. Still another burial mound which has a similar pattern to the two discussed above is the one excavated by Collins (1929:151–153) on Captiva Island, immediately adjacent to Sanibel Island. The results of this excavation have never been fully reported, and Collins himself commented only briefly on the excavations.

More than seventy skulls (burials?) were removed from a sand burial mound and were in quite good condition, judging from the photographs in Collins's report. Two strata existed at the mound, a crushed-shell-and-sand lower stratum and an upper sand stratum. The lower stratum was placed directly on top of mangrove muck at the water's edge. This lower stratum had formed a cementlike matrix with the bones embedded in it. The patterns of interment were similar to Palmer and Parrish 5, namely, flexed primary and secondary bundle burials. Importantly, the secondary burials were found only in the upper sand level of the burial. As at the Parrish 5 and Palmer mounds, no whole ceramic vessels were interred as grave goods, although it appears that sherds were placed around many of the skulls. A layer of gastropods sixteen to thirty-six inches in width encircled the mound at its base, sloping up its sides along one edge, while a similar pavement of sherds was seen along the other side.

Another candidate for a burial mound with a component dating to this period is the sand mound on the west side of Pine Island. Moore (1900:363) notes that although ceramics and even European artifacts were found in the mound, the basal and sub-basal burials and all but three bundle burials included *no* artifacts, closely paralleling the patterns for the other sites discussed above. The burials with ceramics and with European artifacts suggest a continuous use of this burial mound back to A.D. 800.

The similarities in mortuary behavior at the sites discussed above suggest a distinctive mortuary pattern during the Caloosahatchee II period, namely, continuous-use burial mounds with flexed and secondary interments, associated charnel houses, but no whole ceramic offerings, although sherds appear to have been intentionally placed near skulls. The Captiva burial mound indicates a chronologically distinctive and different initial mortuary pattern for the first interments, but this may be a function of the initial "inauguration" of a burial mound, rather than a chronological or cultural difference. The cementing of the burials in a sandy-shell matrix, however, indicates that at least some time had passed between interments in the two strata. Thus the early burials may form a distinct pattern, perhaps even dating to the Caloosahatchee I period. Another feature of these burials is their location away from the village areas.

No burial mounds dating to this period are known in the Circum-Glades area, although some of the sand burial mounds, such as Blue Hill, might have early components. As mentioned earlier, the poorly understood burial site 8Cr46 may date to this period, since no ceramics are associated with it. Site 8Cr108 on Marco Island contained numerous burials, but these burials have not yet been analyzed or placed in chronological context (Widmer 1974). Sand burial mounds exist in southeast Florida (Carr and Beriault 1984:6), but their temporal position appears to be poorly understood.

Hrdlička (1922:28) suggested that many of the muck-and-rotten-shell mounds in the area of the Ten Thousand Islands are probably burial mounds. These mounds have not, however, been investigated. Given the similarity in interment pattern for the period subsequent to A.D. 1200 in both the Caloosahatchee area and in the Ten Thousand Islands area, it may be that both areas shared similar mortuary behavior during the Glades II time period.

During the period from A.D. 1200 to A.D. 1513, ceramics are commonly interred as grave offerings in the sand burial mounds of both the Caloosahatchee area and the southwestern coastal zone of the Circum-Glades area. This is the only difference between the burial practices of this time period and that discussed for the earlier Glades II-Caloosahatchee II period. These ceramics include Englewood and Safety Harbor series. In many cases, as previously mentioned, burial mounds from earlier periods continued to be used in this period, most notably, the burial mound on Pine Island. Added to the group from this later period is a mound near Punta Rassa containing both Englewood and Safety Harbor sherds (Moore 1905), the Blue Hill Mound on Horr's Island (Durnford 1895; Moore 1900; Hrdlička 1922; Stirling 1931b), and the Aquí Está burial mound near Fort Myers (Bullen 1969:418).

Burial mound interments are not the exclusive mortuary pattern during this time, and at least one Glades IIIB midden burial, an extended interment with a Glades Tooled bowl offering, was recovered at the Cagel Hammock site (Mowers and Williams 1974). Midden burials are the exception in the Glades hammock sites (Mowers and Williams 1974:177), a situation confirmed by the results of the Big Cypress Swamp survey (Ehrenhard et al. 1978, 1979, 1980, 1981; Ehrenhard and Taylor 1980), where only a single such interment was recorded. Isolated burials in solution pockets in the surface of the Everglades area is also known (Carr and Beriault 1984:6).

The mortuary patterns during the protohistoric period, Glades IIIC-Caloosahatchee V period are very similar to those seen in the preceding period with the notable, and obvious, addition of European trade goods. These materials, in at least the cases of Old Indian Field Mound on Pine Island (Moore 1900, 1905) and Blue Hill Mound (Moore 1900; Hrdlička 1922; Stirling 1933), are stratigraphically separated from pre-Columbian deposits, although the aboriginal material, Englewood and Safety Harbor period ceramics, is identical in both periods. One other mound in the Caloosahatchee area, near Punta Rassa (Moore 1905:308–309), contained European material. The material is both unmodified items—such as knives, glass beads, axes, and silver crosses—and artifacts of gold, silver, and copper which are modified into aboriginal designs.

M. W. Stirling (1933:4) adds an interesting feature to the mortuary patterning during the period from his excavations in the Blue Hill Mound. Here, he found a clay cap, or floor, sealing the platform-burial mound six feet above its base. Into this clay floor were post holes, some of which still had the posts intact. He interpreted these as being indicative of a temple, but it appears that because of the large number of interments in this mound, more than 250, an interpretation of the structure as a charnel house is more appropriate. This seems more likely, since the two ethnohistoric groups in this area, the Tocobaga and the Calusa, both used charnel houses as part of their mortuary behavior (Goggin and Sturtevant 1964; Bullen 1978). Both Bullen and Goggin and Sturtevant also note the aboriginals' tremendous fear of the dead, which made them keep their charnel houses separate from their villages and always guarded.

Thus, we see a precedent for charnel houses and secondary burial of the dead but *not* the use of water to separate the dead from the living, except perhaps at Blue Hill, which is on an island without contemporary habitation. The belief that water safely separates the living from the dead was a common one in the southeastern United States (Hall 1976). It seems that the custom no longer existed in south Florida after A.D. 700.

Because mortuary offerings are not found in the earlier period (Glades II-Caloosahatchee II), it is difficult to determine whether status distinctions occur. The occurrence of burial mounds is, however, usually associated with a society with hierarchical status positions. The finding of European trade goods, including gold and silver, in burial mounds and the fact that this material was divided and distributed among chiefs by Carlos (Fontaneda 1944) point to the association of burial-mound interments at this period with hierarchical social systems of the ranked level. With the continuity of mortuary behavior indicated by the use of a single mound over a long period of time, a similar high-status differentiation for the early period as well is suggested.

Although sparse, the above mortuary, ceremonial, and population density data suggest that the adaptation which characterized the known Calusa society on the southwest coast of Florida occurred from A.D. 700 to A.D. 800. The data do not indicate a direct ethnic linkage between the Calusa and the earlier portion of this adaptation, although this could actually be the case. *All* aspects of the sociopolitical characteristics of the ethnohistoric Calusa clearly were not present at this time, particularly the interregional hegemony. The *basic* pattern of economic, sociopolitical, and demographic characteristics typifying the ethnohistorically known Calusa, however, were, I believe, present at A.D. 700 to A.D. 800.

5

The Environment and Ecology of Southwest Florida

The environmental characteristics of southwest Florida described here pertain to the premodern land-use conditions that were established about 2500 B.P. In recent times, land-use practices have drastically altered the environmental conditions (see Thomas 1974; Alexander and Crook 1984; DeGrove 1984; Gleason 1984; Parker 1984). The environment prior to 2500 B.P. will be discussed in the next chapter.

The Location of the Study Area

The southwest Florida Gulf coast, the specific region focused on in this study, comprises the coastal portions of Charlotte, Lee, Collier, and Monroe counties between the latitudes of 25° north and 27° north. This area lies within the 18° C (64° F) isotherm for the coldest month, which delineates the tropical rainy climate of Florida (Thomas 1974:92). The northernmost boundary of this region will be considered as equivalent to this isotherm (see fig. 1). This region corresponds archaeologically to the Glades area (Goggin 1947). As Larson (1980:4) points out, however, not all of this area is actually "glades," and he therefore defines this region as the south Florida sector. The south Florida sector, as delineated by Larson, does not utilize the tropical boundary, which is seen as an important environmental boundary, and so the area encompassed by this isotherm will be referred to as the south Florida region.

The Climate of South Florida

The climate of south Florida is classified Aw (tropical wet and dry) in the Köeppen (1931) system (Hela 1952; Thomas 1974). This climatic type has a definite and fairly long dry season in the winter and in the spring during the subtropical calm period. Temperatures are over 18° C for all periods of the year. The location of this zone today is illustrated in figure 1. Trewartha (1943) originally placed the northernmost boundary along the 27th latitude, a line from Fort Myers to Melbourne, which was the northernmost limit for the active growth of certain palms. Trewartha's area correlates well with Thomas's (1974) geographical positioning of south Florida with the exception of the "cold spot" seen in the area south of Lake Okeechobee.

This cold spot is thought to be due to the artificial lowering of the water table through the drainage practices of the last 100 years. Prior to these hydrological changes, frost would have been held in check by the large areal expanse of surface water in the Everglades (Thomas 1974:92). This central area south of Lake Okeechobee shows a 0.16° to 0.11° C (0.3° to 0.2° F) decrease per century, while other coastal regions show average temperature increases of 0.44° C (0.8° F) per century. These areas, unlike the Everglades, never had standing surface water, and as a result, temperature patterns reflect the actual climate. Removal of the surface water of the Everglades, however, altered the thermal characteristics of the region, although these differences are not statistically significant because of the large variation in temperature data for the area as a whole (Thomas 1974:93).

Precipitation in South Florida

The mean annual precipitation for south Florida is over 1,143 mm (45–55 in.) for all areas except for the Keys. There are, however, regional variations. In the northern portions of the southwest coastal sector, mean annual rainfall ranges from 1,143 to 1,270 mm (45–50 in.) and is 1,270 to 1,397 mm (50–55 in.) both in the western area immediately adjacent to the coast and in the coastal zone south of Fort Myers. Precipitation west of this southern coastal section ranges from 1,397 to 1,524 mm (55–60 in.) (see fig. 3).

The south Florida region shows marked seasonal variation in rainfall distribution, with most of this precipitation falling in the summer. This is graphically illustrated in table 8. Thomas (1974:86) notes that there are no long-term changes in rainfall patterns. There are, however, increases and decreases in rainfall patterns for each month of the year. These increases and decreases, as indicated by their fluctuations in standard deviations, seem to be part of the "normal" pattern of cyclical rainfall as indicated in figure 4.

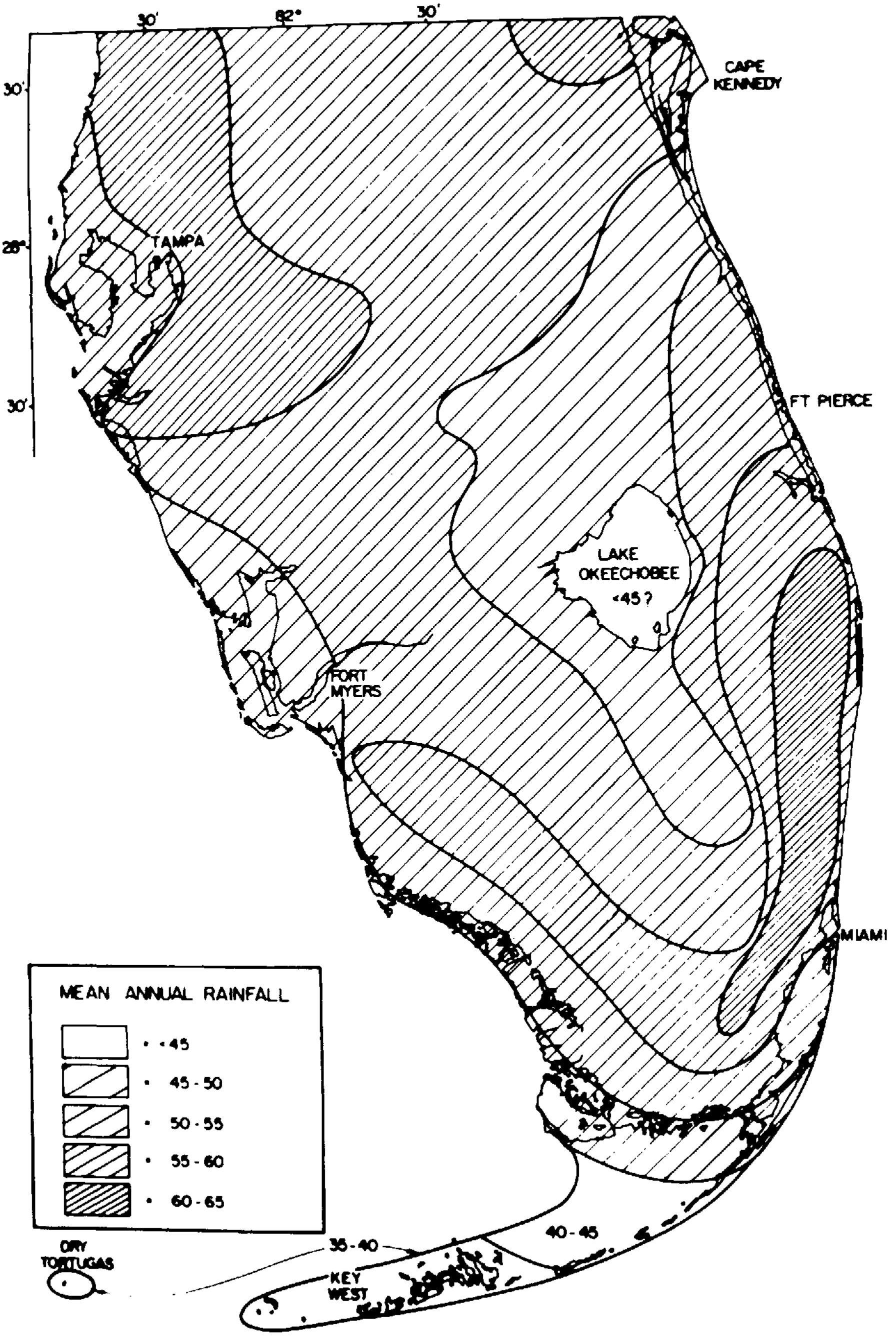


Figure 3. Rainfall Map for South Florida. Adapted from Thomas (1974)

Table 8
Seasonal Distribution of Rainfall in South Florida

Month	Rainfall		Area of Highest Rainfall
	Millimeters	Inches	
Jan	25.4 - 76.2	(1 - 4)	Northwest
Feb	25.4 - 101.6	(1 - 4)	Northwest
Mar	25.4 - 127.0	(1 - 5)	Northwest
Apr	50.8 - 101.6	(2 - 4)	Southeast
May	50.8 - 177.8	(2 - 4)	Southeast
Jun	101.6 - 254.0	(4 - 10)	Southeast
Jul	76.2 - 254.0	(3 - 10)	Northwest
Aug	101.6 - 254.0	(4 - 10)	Northwest
Sep	152.4 - 254.0	(6 - 10)	Southeast
Oct	50.8 - 254.0	(2 - 10)	Southeast
Nov	25.4 - 101.6	(1 - 4)	Southeast
Dec	25.4 - 76.2	(1 - 3)	Northwest

Adapted from Thomas (1974:Table 2)

There is also bimodality in the rainfall on a monthly basis (Thomas 1974:87), indicating an oscillation from wetter to drier conditions or vice versa. Although this fluctuation has been shown for the 1,524–1,651 mm (60–65 in.) mean annual region, the pattern holds true for the other rainfall regions as well (Thomas 1974:87).

The Hydrology of South Florida

Precipitation is largely responsible for the vegetational characteristics of south Florida, but hydrology plays an important role. The interior portion of south Florida centering on the area of Lake Okeechobee is part of the KLOE (Kissimmee–Lake Okeechobee–Everglades) drainage system (Parker 1984:28). This drainage system covers an area of 23,400 km^2 (9,000 square miles). West of the KLOE system is another large drainage system with an area of 6,400 km^2 which includes tidal forests, marshes and bays, and the Big Cypress Swamp (McPherson 1984:70). The relationship of these two hydrological areas in south Florida is shown in figure 5.

Water enters into both of these drainage systems exclusively as precipitation (Parker 1984:32), and surface water in both areas is the result of precipitation. Parker (1984:29) has calculated an estimated water budget for south Florida in the predrainage period and has suggested an average of 190 mm (7.5 in.), from a mean annual precipitation of 1,273 mm (50.1 in.) over a seven-year period, as the total runoff. Surprisingly, Lake Okeechobee did not play an important role in the

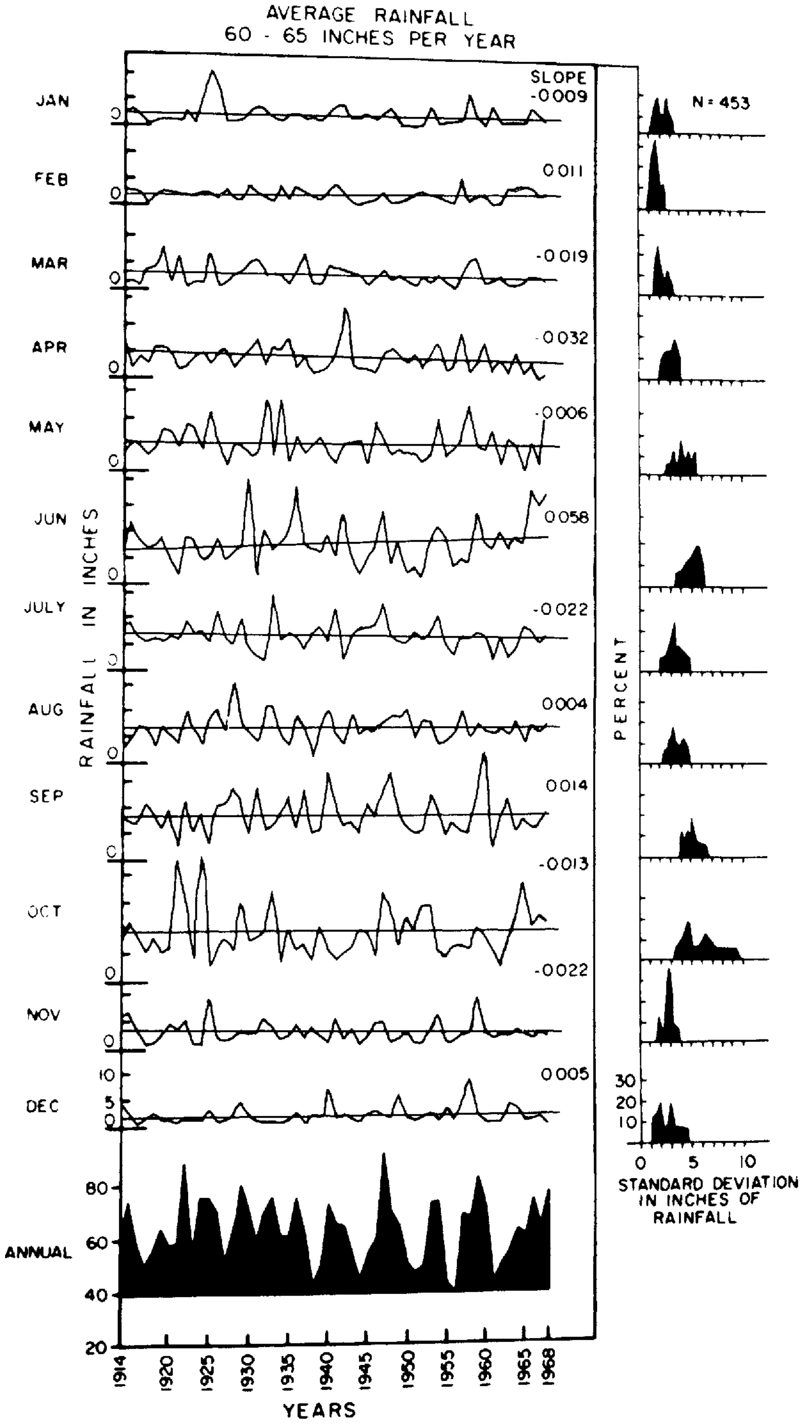


Figure 4. Cyclical Rainfall Pattern in South Florida. Adapted from Thomas (1974)

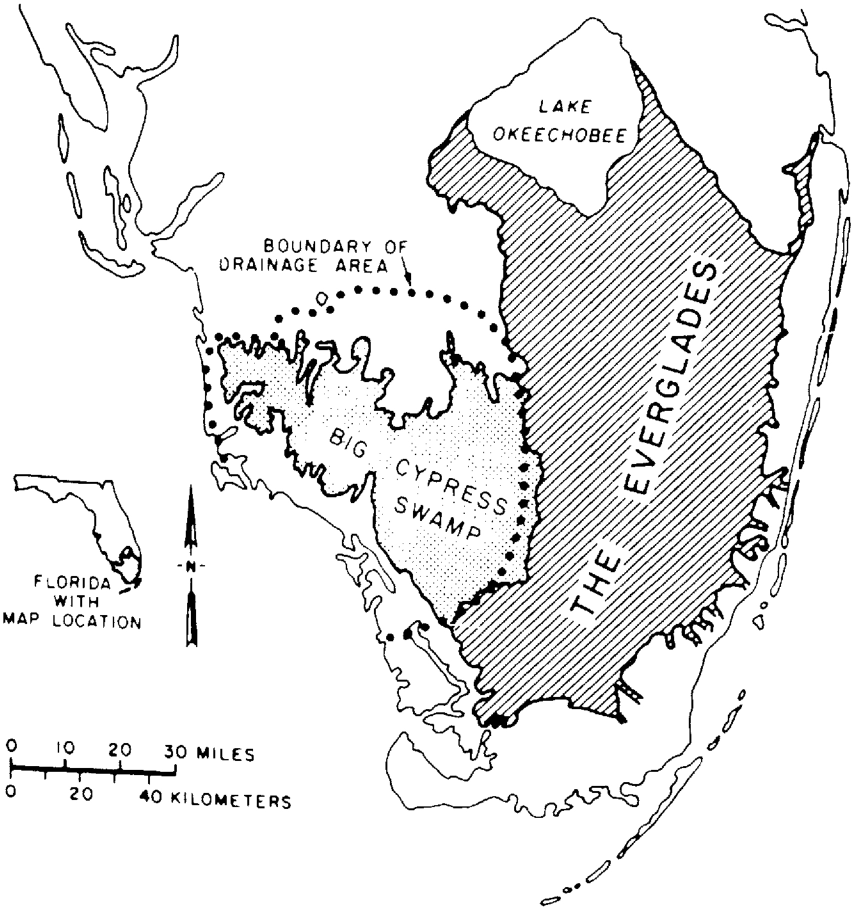


Figure 5. Hydrological Units of South Florida. Adapted from McPherson (1984)

predrainage runoff because precipitation and evapotranspiration balance each other (Parker 1984:32).

The surface-water runoff of the KLOE drains south and empties into two major discharge areas, the Shark River and the Taylor Sloughs to the south and the Caloosahatchee River to the west, which empties into Carlos Bay. Surface-water runoff of the Big Cypress Swamp drainage system flows slowly into the coastal area of the Ten Thousand Islands. Water in this area flows primarily southward through the Okaloacoochee Slough and into the Fakahatchee Slough, while the Corkscrew Swamp area, found north of the Big Cypress Swamp drainage area, drains west rather than south into the Gulf of Mexico (McPherson 1984:70).

The Geology of South Florida

Surface relief, although slight, has much to do with the drainage characteristics in south Florida and in turn is directly influenced by the geology of south Florida. Surface drainage in south Florida is exclusively north to south or east to west, owing to the tilting of the Florida Plateau to the west. The resultant relief ranges from a high of 5.1 m (17 ft.) in the northeast to a low at sea level in the southwest. Surface water tends to follow the natural bedrock contour, with the specific flow direction being related to the orientations of the exposed geological formations of the south Florida peninsula. The location of these formations has been illustrated in figure 6.

The orientation of the various formations strongly influences the flow and direction of freshwater drainage. Since the Tamiami Formation, which dates to the Miocene, has an elevation higher than either the Fort Thompson or Miami formations, which flank it to the east, surface runoff from the Big Cypress Swamp area flows south and west, with some water flowing east in the region of the swamp overlying the Miami Formation. The Everglades and its drainage system are confined to the latter two Pleistocene formations. The Anastasia Formation extends along the northern coastal zones of both the Atlantic and the Gulf of Mexico and is cut by the Caloosahatchee River valley. The northern extension of the Tamiami Formation and the high elevation of the Pliocene Caloosahatchee Formation form a topographic region known as the Immokalee rise, with a relief of more than eight meters (White 1970:140). This restricts southern drainage, instead funneling surface runoff into the Caloosahatchee River drainage and creating a western drainage from Lake Okeechobee.

The Immokalee rise was the only area of south Florida which was exposed during the Sangamon sea of the Pleistocene and existed as an island south of the mainland (Hoffmeister 1974). Soils in the area are primarily shallow sands on the pre-Pleistocene geological formations, while those on the Pleistocene and more recent geological formations are calcitic mud and sandy clay. Substantial deposits of organic sediments in the form of peat are found in the more continuously inundated areas of south Florida. These soils are generally poor for agriculture, although the organic soils are excellent if drained (J. W. Griffin et al. 1979).

Vegetational Zones within Interior South Florida

Five distinctive topographic-physiographic zones have been recognized for south Florida, four of which comprise the interior or noncoastal region (see fig. 7). The distinctive topographic differences between the two terrestrial regions flanking the coastal zone, the Big Cypress Swamp, and the Everglades, as well as the sandy flatwoods found to the north, can be attributed to their elevation, since relief indicates the potential depth of surface water and the type of vegetation

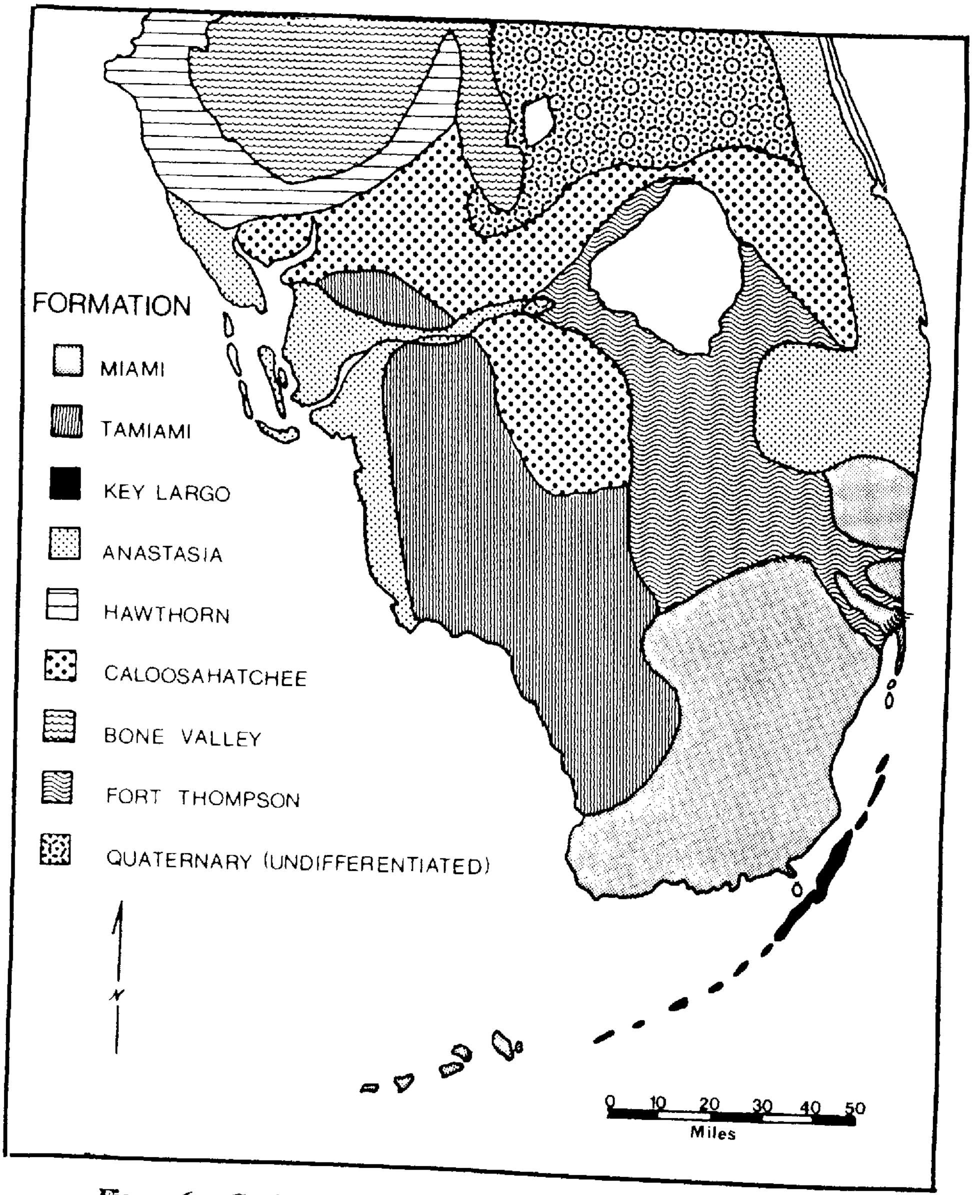


Figure 6. Geology of South Florida. Adapted from Smith (1968)

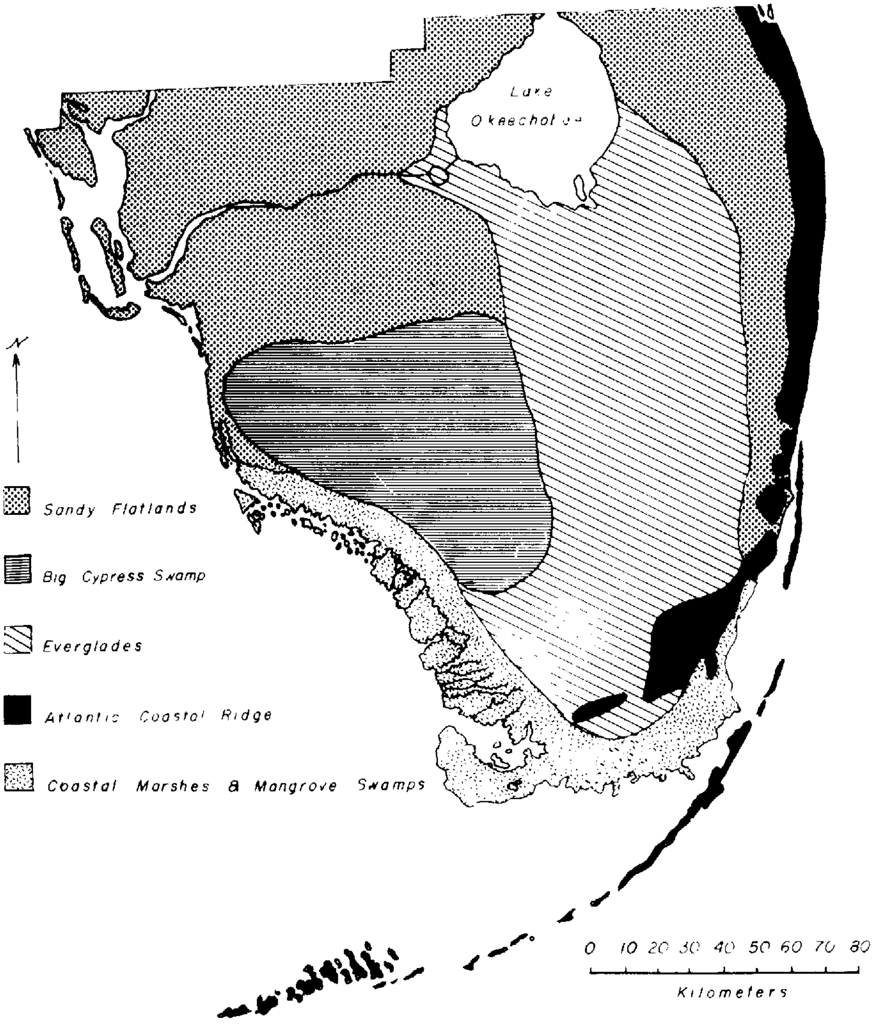


Figure 7. Topographic Zones of South Florida. Adapted from Parker (1984)

which would be found. The sandy flatwoods physiographic zone has the highest elevation and therefore the best drainage, and its vegetation is primarily mesic in character. The Big Cypress Swamp area has somewhat lower relief but is still seasonally inundated. Because of the relief, a hydric forest composition is found in the lower areas. The Everglades region has uniformly low topographic relief, which when combined with a long period of seasonal inundation has resulted in a distinctive vegetational complex.

The initial floral map of south Florida was prepared by Davis (1943), who recognized sixteen vegetational assemblages indigenous to the area. Recently, however, McPherson et al. (1976) have regrouped these into ten vegetational assemblages. This scheme will be followed here and is presented in figure 8.

THE COMPOSITION OF SOUTH FLORIDA VEGETATIONAL ASSEMBLAGES

Pine Forest

The pine-forest vegetational type consists of open areas of pine (*Pinus elliottii*), cabbage palm (*Sabal palmetto*), saw palmetto (*Serona repens*), and scattered trees and shrubs. The ground cover is composed predominantly of grasses, including common general beardgrass (*Andropogan*), three-awn grass (*Aristida*), and panic-grass (*Panicum*). Also included in the ground cover are sedges, composites, and rushes. This forest type is found on higher elevations, at least 10 cm higher than areas of cypress forest, and is considered to be a fire-climax association that would succeed to a tropical-hammock forest in the absence of fire (McPherson 1984).

Tropical-Hammock Forest

The tropical-hammock forest vegetational type can potentially subsume a wide variety of vegetative communities, and so Craighead (1984) has suggested that the more general term for this category be "tree island." Craighead (1984) regards tree islands as containing all types of arboreal island communities, including tropical-hardwood hammocks, bay heads, cypress heads, willow heads, popash heads, and saline buttonwood hammocks. This usage is followed by McPherson (1984) and Duever (1984), and it is assumed that Davis (1943) followed it as well, since forms such as mixed swamp forest and cypress forest are subsumed under other categories. Therefore, the term "hammock forest" as used by Davis (1943) is equated with Craighead's (1984) tropical-hardwood hammock type.

Tropical-hardwood hammocks grow on slightly higher land than the surrounding moist areas and as a result are protected from fire (Craighead 1984:191; Duever 1984:129–130; McPherson 1984:71). These hammocks are found on slight limestone rises of harder bedrock which are pockmarked with solution holes usually filled with leaf and organic litter (Craighead 1984:192).

Floral composition of these hammocks is very diverse. Craighead (1984:196–197, app. 1) has included 72 tropical tree species, 13 temperate tree species, and

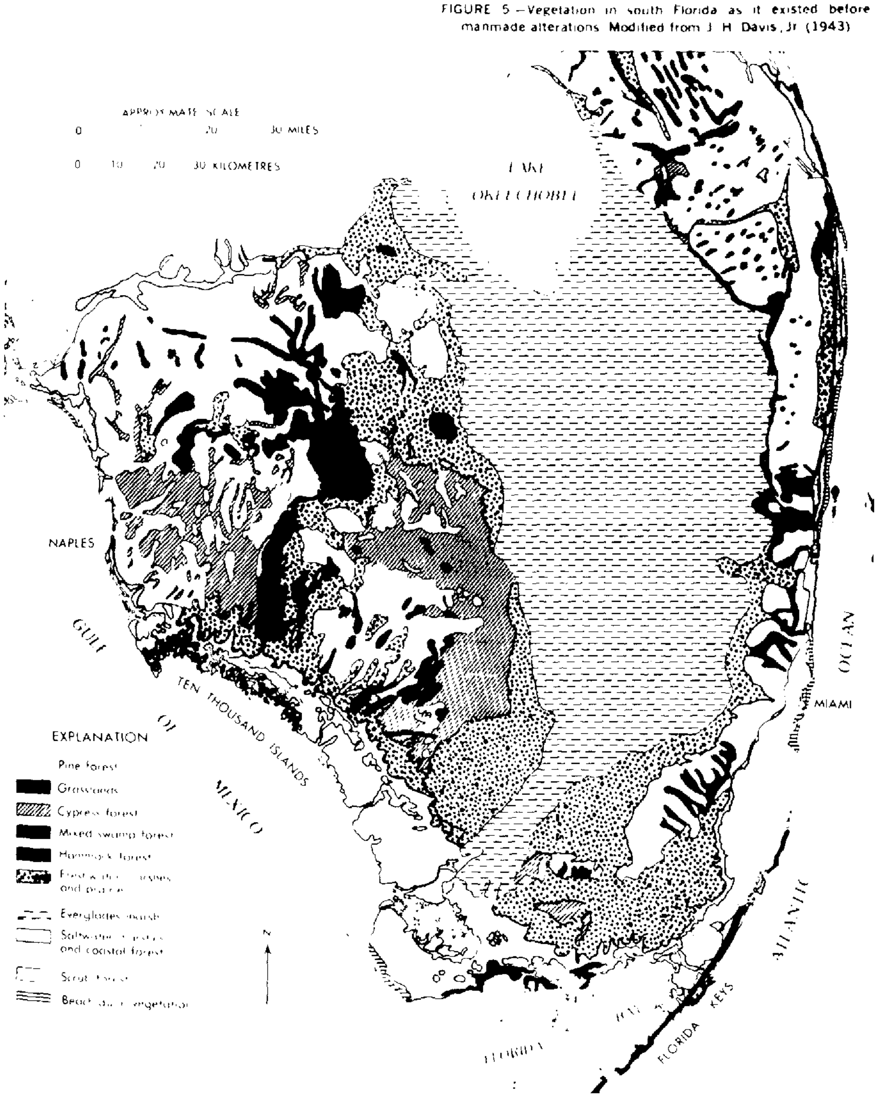


Figure 8. Vegetation Map of South Florida. Adapted from McPherson et al. (1976)

10 species of palms in his list of important tropical-forest hammock-tree species, with 170 species making up the natural arborescent flora. Species composition of the hammocks appears to be a function of size, attributable to the simple relation of area to seed availability introduced by birds and mammals (Craighead 1984: 194).

Interestingly, Craighead suggests that the Calusa were responsible for the introduction of many plants to hammock islands, including unidentified species of fish poisons made from one tree and two vines. He notes other species common to "Calusa Indian sites" that include soapberry, southern hackberry, persimmon, and mulberry.

Both McPherson (1984:71) and Duever (1984:132–133) have noted that the more northerly situated hammocks of the Big Cypress Swamp contain more temperate trees, with red maple (*Acer rubrum*) and laurel oak (*Quercus laurifolia*) dominating in the lower areas, and live oak (*Q. virginiana*) and cabbage palm common on higher areas. In the southern areas of the Big Cypress Swamp, tropical trees, including strangler fig (*Ficus aurea*), wild tamarind (*Lysiloma latesiliqua*), pigeon wood (*Coccoloba aversifolia*), gumbo limbo (*Bursea simaruba*), poison wood (*Meliopium toxiferum*), red bay (*Persea borbonia*), and coco plum (*Chrysobalanus icaco*), are dominant. These hammocks are important areas of habitation in an otherwise hydric environment and allow ready access to the faunal resources in these swamp and marsh areas.

Cypress Forest

The cypress forest vegetational type is composed of small cypress trees (*Taxodium*) with a sparse, scattered growth of herbaceous plants, such as sawgrass (*Cladium jamaicensis*) or beak rushes (*Rhynchospora*), growing on a thin layer of sand or marl soil overlying the limestone bedrock. Circular or egg-shaped stands of cypress trees, known as domes because of their profile, grow over much of the forest area (McPherson 1984:71). Larger trees may also be found in strands following drainage depressions. Small trees and shrubs, such as wax myrtle (*Myrica cerifera*), coco plum, and pond apple (*Annona glabra*), are found in the understory. The larger cypress trees, associated with dome or strand formations, are found in deeper pockets of the bedrock where water level and organic soils are deepest. Here, trees are better nourished, have faster growth rates, and are therefore larger (McPherson 1984:71).

Mixed Swamp Forest

The mixed swamp forest has dense stands of trees, shrubs, vines, ferns, and epiphytes that, as in the case of the cypress stands, follow low drainage areas.

Although elevation of these forests may be variable, most of the land surface is seasonally flooded for several months. These forests are a mixture of several tree and shrub species. One species may dominate a forest tract, depending on specific site conditions. For example, willow may predominate in small burned areas, while popash, pond apple, or cypress may predominate in deeper water. Cabbage palm, red maple, wax myrtle, coco plum, sweet bay (*Magnolia virginiana*), and red bay are widely distributed in this forest type. Hammock vegetation, such as laurel oak, dahoon (*Ilex cassine*), wild coffee (*Psychotria undata*), myrsine (*Myrsine guianensis*), and occasionally live oak and pine grow in more elevated, better-drained areas (McPherson 1984:71).

Freshwater Prairies and Marshes

This vegetational type includes prairies with mixed grasses, sedges, and other herbaceous plants but few trees. These prairies vary in species composition, depending on whether or not they are seasonally inundated. Prairies which are seasonally flooded are known as wet prairies, and their location is dependent on elevation. Plants composing wet prairies include maidensane (*Panicum hemetomon*), blackhead rush (*Schoenus nigicans*), star dichromea (*Dichromea colorata*), muhly (*Muhlenbergia capillaris*), freshwater dropwort (*Oxypolis filiformis*), ribbon lily (*Crinum americanum*), hempvine (*Mikania batatifolia*), low shrub stillingia (*Stillingia* sp.), with scattered marsh vegetation, notably sawgrass (McPherson 1984). Goodrick (1984) lists twenty-five species which commonly occur in wet prairies as well.

Marshes are found in areas where water is usually several centimeters deeper than in the wet prairies, and therefore the associated plants are more aquatic in habitat (McPherson 1984:72). Characteristic species include cattail (*Typha* sp.), dense sawgrass, pickerelweed (*Pontederia lanceolata*), arrowhead (*Sagittaria lancifolia*), fire flag (*Thalia geniculata*), water rush (*Rhynchospora innundata*), spike rush (*Eleocharis cellulosa*), and bladderwort (*Utricularia* sp.). This vegetation may be either dense or sparse (McPherson 1984:72).

Grasslands

Also known as dry prairies, grasslands differ from wet prairies in that they are on higher elevations and therefore are seldom inundated (McPherson 1984). Common species in these grassland communities include saw palmetto and some of the sedges and grasses associated with the pine-forest vegetational types (McPherson 1984).

Everglades

The Everglades consists of a distinctive complex of plants (Loveless 1959; Smith 1968), all aquatic in habitat, that form a mosaic composed of three distinct vegetational associations (Smith 1968). The location of these associations is dependent primarily on three factors: differences in elevation, differences in hydroperiod, and differences in vegetational forms (Smith 1968:85), with the latter factor a result of the initial two factors.

The vegetational communities of the Everglades are similar to those characteristic of the wet-prairie type, except for where the greater seasonal surface flow of water and increased amount of water results in a different composition. Smith (1968:65) has noted that the vegetational pattern of the Everglades is not unlike bars and channels found in braided streams. This pattern results in a mosaic of teardrop-shaped vegetational bars in a deepwater stream.

Three characteristic vegetational associations make up this mosaic pattern. Bayheads represent the highest elevation and vegetational complex in the Everglades. These are located on the northern or leading edge of the teardrop-shaped vegetational bars and often have one meter of elevation tapering in relief "downstream" (Smith 1968:64). This relief is associated with characteristic tree-island vegetation, which Smith (1968:76) refers to as the emergent tree-shrub environment. The vegetational assemblage is dominated by trees or shrubs, with *Myrica, Persea, Ilex, Salix,* and *Magnolia* being important members. Tree islands have a preponderance of woody plants and a dense, evergreen canopy. Because these vegetational zones have the highest elevations in the Everglades, they are inundated for the shortest period, and as a result, organic material decomposes faster, favoring nutrient recycling (Smith 1968).

An emergent, herbaceous vegetational community is found in the intermediate elevations in the lee of the bayheads. Sawgrass (*Mariscus jamaicensis*) is the dominant plant in this environment, as are other nonwoody plants, including *Sagittaria, Panicum, Osmunda, Blechnum, Gyrotheca,* and a few, low, scattered shrubs of *Salix, Myrica,* and *Cephalathus.* None of these dominates, except in local situations (Smith 1968:76).

The aquatic environment is found in those areas which have the longest hydroperiod, usually a continuous one. As a result, only submerged, floating-leaved and floating-plant forms are found in this vegetative assemblage (Smith 1968: 73). The floating-leaved aquatic plants are the most common, with *Nymphaea* predominating, *Nymphoidea* important, and an occasional occurrence of *Nuplar.* Floating plants are uncommon, with *Utricularia* being the only abundant floating form occurring in the Everglades. Submergent forms of flora are also scarce because of the frequent drying of the aquatic habitat (Smith 1968:74). *Sagittaria, Potamogeton,* and *Najas* are the typical submerged forms. Emergent forms of plants which can tolerate long periods of inundation are also found in the aquatic environment and include *Eleocharis, Rynchospora, Pontederia, Ludwigia, Crinum*, and *Hymenocallis* (Smith 1968:74).

Microalgae of the Benthos and Periphyton

Periphyton (floating masses of microalgae) are common in the freshwater aquatic environments of south Florida, particularly the Everglades. Periphyton is important because it represents the greatest biomass production in an otherwise low-production aquatic environment (Smith 1968; Wood and Maynard 1974). Wood and Maynard (1974:126–127) note that the two forms of microalgae, benthic and periphytic, do not differ appreciably and are often identical, with the benthic variety resulting from the sinking of periphyton to form benthic-algal mats.

Trophic Structure, Ecosystem Dynamics, and Productivity

The inland vegetative environments are determined primarily as a function of the seasonal inundation by water. As a result, it is convenient to separate this continuum into three distinct units, which in a gross sense relate to the three primary physiographic-topographic units which border the coastal zone. These are the sandy flatwoods, the Big Cypress Swamp, and the Everglades. The three units form a continuum from the driest to the wettest environments, although individual mosaics are found within the former two regions.

This division of interior environments is not arbitrary but instead follows important distinctions in trophic structure and ecosystem dynamics. In the case of the sandy flatwoods physiographic type, the ecosystem is principally of the terrestrial-forest type. In the Big Cypress Swamp, it is of the swamp-and-marsh type; while in the Everglades, it is lacustrine in nature. Although the latter two physiographic regions do not match up identically with these ecosystem types, they represent the most common ecosystems in those areas and so will be considered representative of them.

Specific measurements of net primary production in the interior environments of south Florida are few, and those which exist are limited in terms of controlling seasonal variation. They do not actually represent measurements of total net production occurring within the environments (see Smith 1968:91). Through the use of mean net primary-productivity figures for these various ecosystem types, however, we can evaluate their differential net primary production and hence their relative resource-production potential. Whittaker (1975:224, table 5.2) has listed the mean net primary-productivity figures for ecosystem types, and these values will be used here. The mean net productivity figures for the woodland and shrubland ecosystem type, corresponding to the sandy flatwoods, is 700 g/m^2. The mean figure for the swamp-and-marsh category, corresponding to the Big

Cypress Swamp, is 2000 g/m^2. The value of mean net primary production which Whittaker (1975) gives for lake and stream environments, corresponding here to the Everglades, is 250 g/m^2. The latter figure might be too low and will be adjusted upward, since a mean figure of 500 g/m^2 has been suggested for the Everglades (Smith 1968:91), and Westlake (1963) suggests a range of 100 to 500 g/m^2. It is probable that net primary production in the Everglades is a result of equal contribution of periphyton and emergent plant production.

What is important is that the Big Cypress Swamp physiographic region has the highest theoretical net primary production of the three areas, four times that of the Everglades and three times that of the woodland ecosystem type. It is possible partially to evaluate whether this theoretical difference in productivity has any empirical validity by comparing the density of one particular herbivore, the white-tailed deer, in the three areas.

Deer density in the Big Cypress Swamp is the highest recorded in south Florida, 1 for every 34.8 hectares (86 acres). The total south Florida average deer density is 1 for every 91.1 hectares (225 acres) (Layne 1984:284). Thus, the deer population in the Big Cypress Swamp is twice that found in south Florida on the average.

McPherson (1984:73) has stated that the biomass production in the undrained portion of the Fakahatchee Strand in the Big Cypress Swamp was twice that found in the drained portion, further noting that the availability of water controls the primary production of forest trees. It is difficult precisely to equate this difference in productivity with that between the Big Cypress Swamp and the sandy flatwoods zone. Since the pine-forest type is found in the better-drained—that is, most elevated—areas of the forest, then this equation is probably viable. Thus, it appears that the swamp-marsh environment in south Florida has at least a 2:1 (if not 3:1) ratio in productivity compared with the woodland type. This ratio is similar to the ratio suggested by Whittaker's data. Therefore, the *general* relationships hold true for south Florida as well.

The Role of Interior Resources in the Human Subsistence Base

Potential food resources for human exploitation from the interior region include a wide range of species. Since they provide supplemental resources to the coastal occupation, their role will be considered in the chapter on subsistence systems of the Calusa adaptation, rather than here. It is necessary, however, to address more fully the seasonal variation in production and resource availability in these interior regions, since it ultimately influences the coastal zone.

The climate of south Florida, as previously mentioned, has distinctive wet and dry seasons, which profoundly influence the character of the interior regions of south Florida. In spite of this, however, productivity remains constant throughout the year because of the lack of seasonal change in photoperiod and the low nutrient requirements of the interior plant types, particularly sawgrass (K. K. Steward 1984:163).

The interior regions of south Florida that flank the western coastal zone represent a distinctive and important area for resource utilization and trade during various periods in the history of southwest Florida adaptation. Still, the coastal zone was the area of habitation during the late prehistoric period, and coastal resources predicated the structure of the subsistence, settlement, and sociopolitical behavior of this adaptation.

The Southwest Florida Coast as a Region of High Aquatic Productivity

Because aquatic ecosystems are so complex, with exaggerated food webs and higher energetic turnover than terrestrial ecosystems, it is difficult specifically to measure or quantify "high productivity." It is not enough simply to say that a particular region has high productivity; this productivity must be accessible to human exploitation and be sufficiently stable and predictable to result in a viable resource base for human use.

Certain coastal, aquatic ecosystems can be much more productive for human exploitation than natural terrestrial, nonagricultural systems. Not only is their productivity extremely high—approaching, if not equaling, that possible with agricultural systems—but unlike anadromous fish resources, they are available on a continuous year-round basis, not just during the spawning period. This stability is due to the primary productivity of the region in general, which dictates the trophic structure of the area, rather than to the amenability of a river to the spawning behavior of certain fish species.

Not all coastal areas inherently possess unusually high productivity. Comparable coastal regions, however, those which display certain ecological features, can be reasonably assumed, on theoretical grounds, to have equally high productivity and to be favorable to human adaptation and exploitation, even to the exclusion of exploitation of terrestrial areas. The study area being investigated is an example of an unusually rich, coastal-estuary resource base and one without viable alternatives (i.e., agriculture or heavy dependence on floral resources). It should be remembered that the terrestrial regions which adjoin the study area, at least as understood from limited archaeological and ethnohistorical evidence, do not provide a resource base with very high productivity, even with the presence of agriculture (see W. H. Sears 1974, 1982).

THE ECOLOGICAL STRUCTURE OF THE SOUTHWEST FLORIDA COAST

The southwest Florida Gulf coast, the specific region focused on, comprises the coastal portions of Charlotte, Lee, Collier, and Monroe counties between latitudes 27° and 25° north. It should be noted that the northern boundary of this region, the isotherm, probably fluctuated through time, an important factor when considering the Calusa adaptive system.

The study area includes only two of the major topographic regions—coastal marsh–mangrove swamp and the sandy flatwoods. The former extends from Cape Sable in the southernmost region of the west coast north to Cape Romano. From here to the northern limits of the region, the mangrove coasts are replaced by sand beaches. The coastal portions, in part, make up what has traditionally been referred to as an estuary, "a semi-enclosed coastal body of water which has a free connection with the open sea and within which sea water is measurably diluted with fresh water derived from land drainage" (Pritchard 1967:3). This definition is limited, since it does not include the open beaches and other offshore ecosystem types also found in coastal regions. Therefore, the term "coastal ecosystem" has been proposed to refer to coastal regions in general (H. T. Odum et al. 1974:2). This term includes the more restricted "estuary," which is in fact the majority of the study region, as well as other coastal forms.

H. T. Odum and Copeland (1974:25–28) have noted that a coastal-classification scheme should stress energetic sources rather than physical characteristics and have presented such a classification. Their scheme avoids the ambiguity or inappropriateness of previous classifications, which are not grounded in ecological theory and are not easily related to energy-flow studies, and for these reasons it will be used. The term "estuarine" will be used to categorize resources found in the study area but only those within the physiographic context indicated in the above definition. This term is useful, since ecotypes and resources within this physiographic region appear to be more easily exploited than nonestuarine resources. Copeland and Odum (1974:104) have identified two categories of natural ecosystems within the study area, with several types within these categories. Table 9 lists the types and their characteristic energy sources or stresses identified in the study area.

Although a number of natural temperate ecosystem types are included, closer investigation reveals that they mimic natural tropical ecosystems in that they show less seasonal change. The two main categories do seem to correspond to the two major ecological-topographical areas in the study area: the B-1, B-3, and B-4 types occur in the sandy flatwoods ecological-topographical zone, and the C-5, C-6, and C-9 ecosystem types are found in the coastal marsh-mangrove swamps.

H. T. Odum and Copeland (1974) note the importance of the ecological classification scheme in understanding energetics. For coastal ecosystems, fluctuations in salinity and latitudinal temperature shifts are main sources of stress, functioning to control the diversity and variety of ecosystem types. The range in fluctuation in temperature and salinity can be directly related to the number of types within an ecosystem; the fewer the fluctuations, the greater the number of types (see fig. 9). This means that as one moves south, temperature and tidal

Table 9

Classification of Coastal Ecological Systems for the Southwest Florida Gulf Coast*

Category	Name of Type	Characteristic Energy Source or Stress
B Natural tropical ecosystems of high diversity	B-1 Mangroves	Light and tide
	B-3 Tropical Meadows	Light and current
	B-4 Tropical Inshore Plankton	Organic Supplement
	B-5 Blue Water Coasts	Light and low nutrients
C Natural temperate ecosystems with seasonal programming	C-5 Oyster Reefs	Current and tide
	C-6 Worm and Clam Flats	Waves and current
	C-7 Temperate Grass Flats	Light and current
	C-8 Oligohaline Systems	Saltwater shock zone, winter cold
	C-9 Medium Salinity Plankton Estuary	Mixing intermediate salinity with some stratification
	C-10 Tidal Marshes	Current and tide

*Adapted from H. T. Odum and Copeland (1974:25-28)

stresses decrease, although salinity variations often increase owing to erratic rainfall in the tropical and subtropical zones.

Two ecosystem types, mangroves and tropical meadows, are of primary importance in terms of potential resources available to human exploitation. Although these ecosystem types are discussed as closed systems, it is difficult to assess with accuracy the contribution of energy from these specific ecosystems to the higher-trophic-position consumers. It is recognized that other ecosystems, such as plankton production, provide energetic inputs into the food web, particularly as they relate to the consumers. Still, it is assumed that the ecosystem types are responsible for the major energetic inputs into the food web and thus ultimately to those resources utilized by human groups.

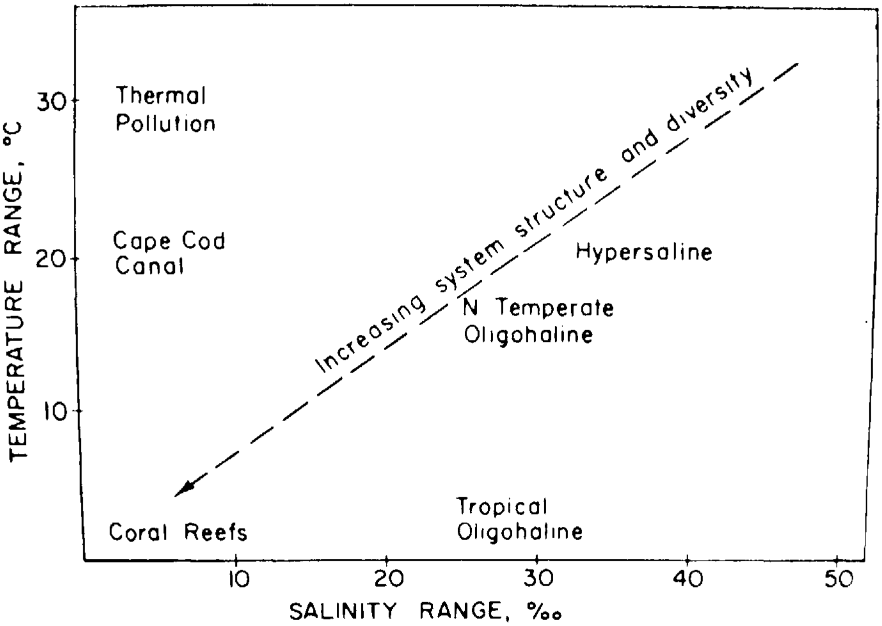


Figure 9. Ranges of Temperature and Salinity. Adapted from H. T. Odum and Copeland (1974)

Mangroves

Mangrove trees, which form the basis of the ecosystem type, are tropical and will not tolerate hard frost. In effect, they represent an indicator of the tropical zone of south Florida (Kuenzler 1974). The mangrove ecosystem is composed of three species of mangrove: red (*Rhizophora mangle*), black (*Avicennia nitida*), and white (*Laguncularia racemosa*) (Kuenzler 1974:347). Salinity is not important for the physiological survival of mangroves, but salt tolerance reduces competition from other species of trees.

Mangroves display ecological zonation which results primarily from differences in rooting, growth of seedlings and various adaptations to salinity, tide, and, to some extent, temperature. Red mangroves are the most tolerant of wide ranges of salinity and the most sensitive to cold but can sprout below low tide, whereas black mangroves cross-cut both zones. This forms a successional transect which is related to tidal coverage, the elevation, and the type of soil present in the study area (see fig. 10).

The food web associated with mangrove ecosystems includes both debris and detritus processes rather than the direct grazing characteristic of most terrestrial production systems. Red mangrove communities are particularly important in

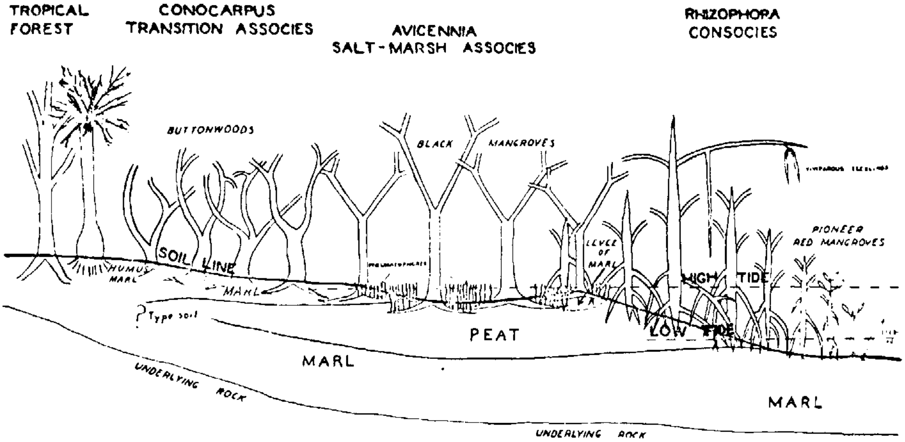


Figure 10. Ecological Zonation within a Mangrove Ecosystem. Adapted from Davis (1940)

these processes (W. E. Odum and Heald 1972; Kuenzler 1974; Heald et al. 1984), as their role in the food web in this ecosystem depends primarily on the relationship of tidal range and freshwater flow. Those communities situated within the intertidal zone, or which are close to streams or freshwater sheet flow areas, can contribute significantly to adjacent waters not necessarily directly in the mangrove ecosystem. The trophic structure of the food web based on the red mangrove has been presented in figure 11.

Mangrove-leaf litter and other woody debris, products of mangrove primary production dropped from the trees, form the primary energetic input into the food chain. This debris is broken down by direct grazing or browsing activities of amphipods such as shrimp and crabs. These organisms function to reduce leaf debris into small detrital particles, which are then utilized by bacteria and fungae, the most important form of energy transport in the mangrove-detrital food chain.

This microbial activity actually increases the relative potential food value of the disintegrating leaf particles, because there is a replacement of the leaf's original nutrient composition with microbial protein, which attach themselves to the particle. The addition of these microbes to the leaf particle (Heald et al. 1984: 150) results in a greater biological value in absolute energetic terms. This has

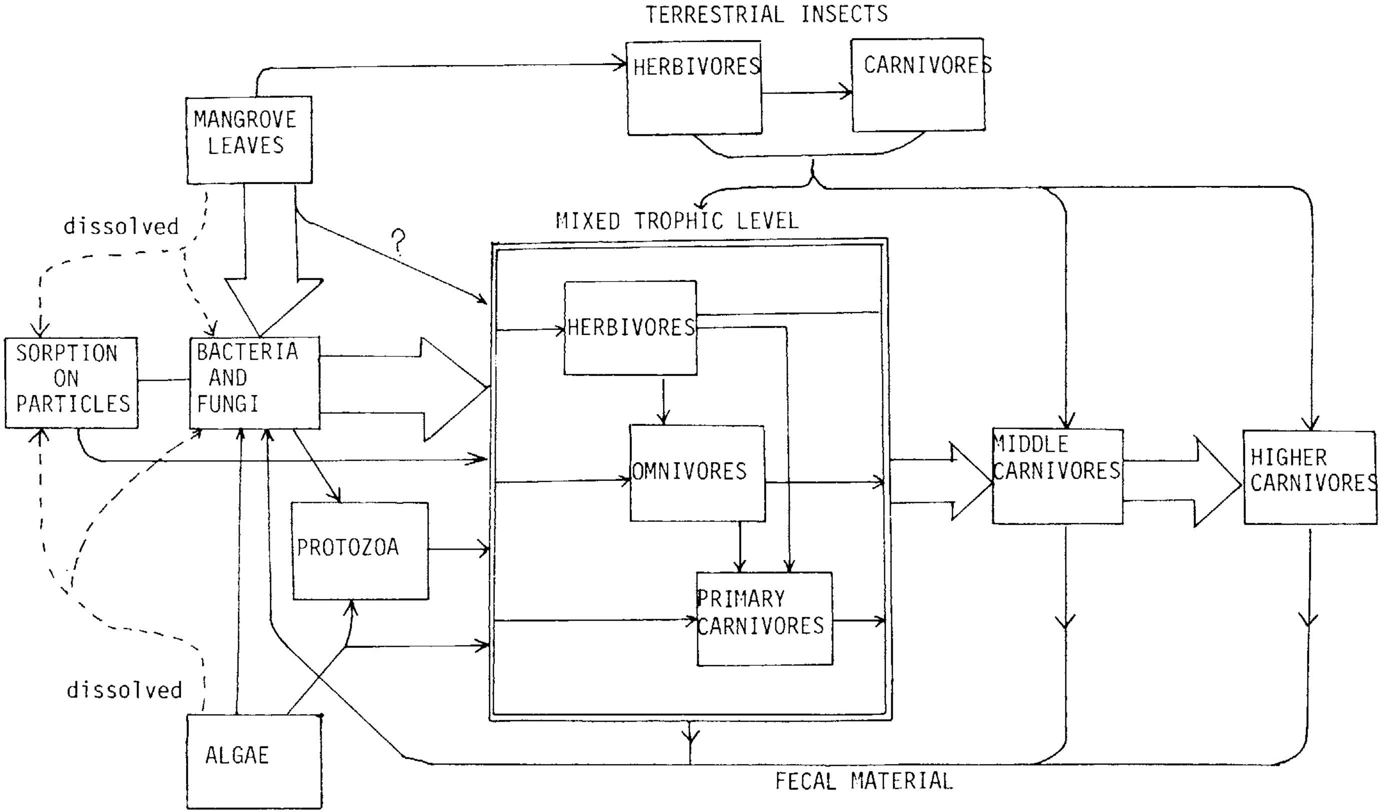


Figure 11. Energy Flow Diagram for a Mangrove Ecosystem. Adapted from W. E. Odum (1971)

been determined by empirical measurements of the caloric value of leaves which have been in the water for different lengths of time. Newly fallen leaves have a value of 5.0 kcal/g, whereas leaves which are two months old have a value of 5.3 kcal/g. The caloric value then declines to 4.9 kcal/g after six months (Heald et al. 1984:150). The greater value is important, because only the microbial nutrients—that is, bacteria and fungae—of the detrital particle are actually consumed by the next trophic level. The detrital particle, after being stripped of its microbial coating, is released as fecal material by mullet and other consumers. The microbial attack of the particle is repeated, and the particle decreases in size. This process recycles until the particle is completely consumed.

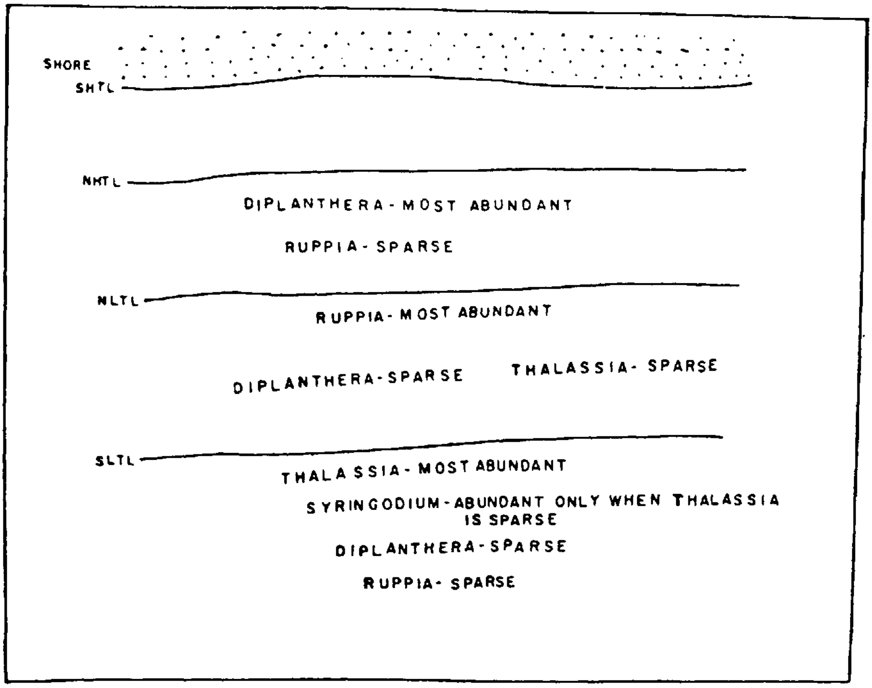
The striped mullet (*Mugil cephalus*) is the most important primary consumer of the detrital food web and most important in human exploitation as well. In south Florida, however, this trophic level also includes twelve species of crustaceans, five additional fish species and numerous copepods and isopods which appear to have developed assorted feeding strategies based on particle size (W. E. Odum and Heald 1972; Heald et al. 1984:151).

The secondary consumers include fishes which feed on the primary consumers. Heald et al. (1984:151) have divided this trophic level into lower, middle, and top carnivores. The lower level consists mostly of small fishes and juveniles of middle- and top-level carnivore species. The middle level consists of wading birds and most of the food and sport fish of this region. Also included here are some juveniles of top-level carnivores. The top-level carnivores are few in number and species, consisting of tarpon, barracuda, sharks, alligators and crocodiles, ospreys, and eagles.

Tropical Meadows

The marine tropical meadow is the other major ecosystem type found in the coastal ecosystem. These meadows are submerged vegetation, composed predominantly of turtle grass (*Thalassia testudium*), shoalgrass (*Halodule wrightii*), manatee grass (*Syringodum filiforme*), widgeon grass (*Ruppia maritima*), and *Halopnila* (H. T. Odum 1974:442; Zieman 1982), found in shallow, clear tropical waters. These grass beds, like mangrove swamp systems, have extremely high species diversity, and like mangroves, the food web is based on debris and detritus initiated in photosynthesis by the grasses, followed by microbial decomposition of older grass blades and consumption of the decomposed fragments by bottom organisms, which are in turn consumed by larger fish. Many of the bottom fauna are filter feeders which keep waters clear, aiding in plant photosynthesis as well as in the processing of detrital material (H. T. Odum 1974:442).

The species of grasses which compose tropical meadows show environmental zonation, as mangroves do. This zonation is based on both water depth and



Schematic drawing of seagrass zonation in shallow water. Valid only in areas with salinity over 25 ‰

Abbreviations are:

SLTL — slack low tide line
SHTL — spring high tide line
NHTL — neap high tide line
NLTL — neap low tide line

Figure 12. Summary Diagram of Bottom Plants. Adapted from R. C. Phillips (1960)

salinity factors. Figure 12 illustrates the zonation of sea grasses in Tampa Bay. In general, these grasses can occur from neap high tide to 7.5 m (25 ft.) deep, but are usually found in waters with moderate-current energy at depths of 0.6 to 7.5 m (2 to 25 ft.). Tropical meadows, although similar to temperate grass flats, differ in that there are fewer stresses and seasonal changes. Lower stress results in high species diversity and specialization, which develops a complex ecological organization of communities, because populations adapt in the absence of seasonal changes in temperature and food flows (H. T. Odum 1974). McNulty (1968) has determined the location and extent of tropical marine meadows in southwest Florida. The study area has a total of 283.3 km^2 of submerged marine meadows, with the majority lying in the coastal portions of Charlotte and Lee counties (fig. 13). The differential location of this ecosystem type has important implications for human exploitation of the coastal zone, which will be explored later.

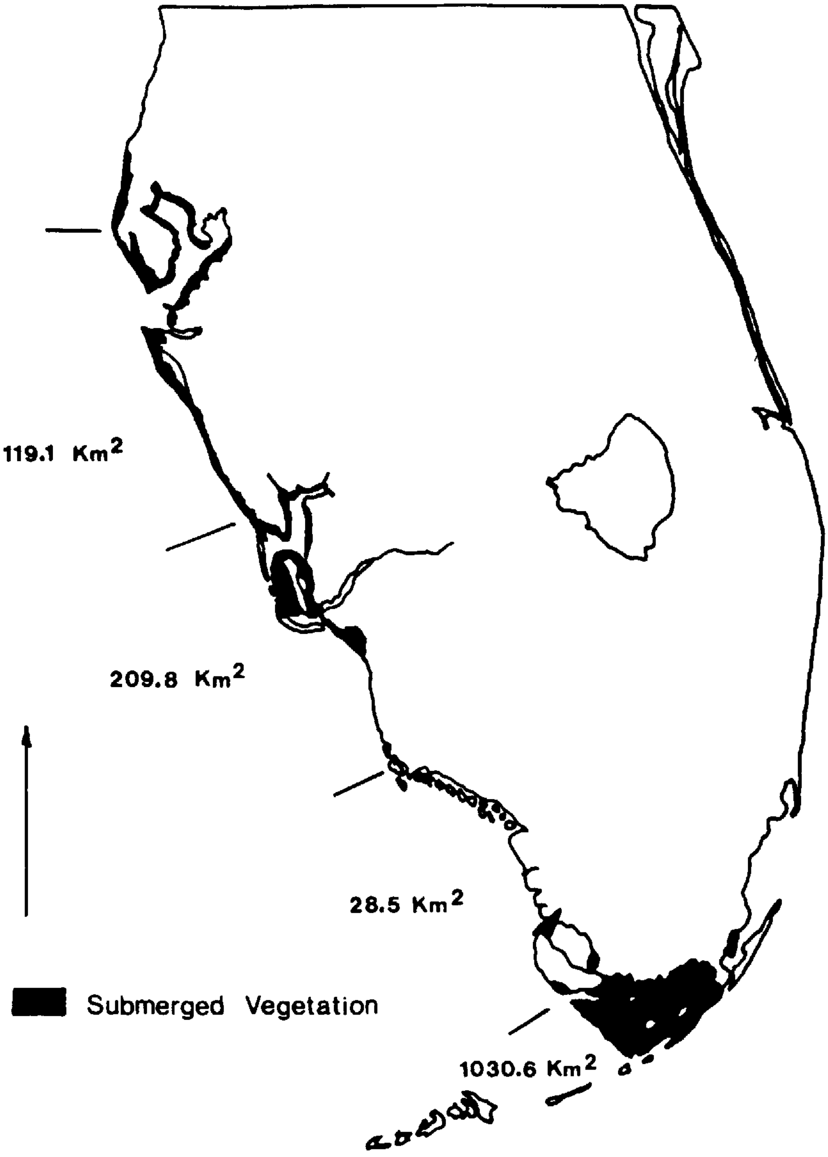


Figure 13. Bottom Marine Meadows of Southwest Florida. Adapted from McNulty (1968)

Salt Marshes

Marsh grasses replace the mangrove swamps in the interior regions immediately flanking the swamps of the southern coastal region and to a limited extent in the northern region. Two basic types of salt marshes are found in the area of southwest Florida. The black rush (*Juncus roemerianus*) marsh is found in the interior areas and forms almost pure stands. *Spartina spartinae*, and *S. bakeri*, and *Distichles spicata* replace *Juncus* seaward of this zone. This zonation is due to elevation (Cooper 1974:72–74), with the latter marsh occurring only at high tide. Seasonally dry saline plains are dominated by *Batis maritima* and *Sesuvium portulacastrum* (Olmstead and Loope 1984:174).

Salt marshes have very high net primary production (E. P. Odum 1963), but no specific measurements exist for tropical south Florida (Schomer and Drew 1982). Salt marshes are usually classified as temperate coastal ecosystems in the H. T. Odum and Copeland (1974) system, but since the photoperiod is longer in tropical southwest Florida, net primary production should be higher than in temperate zones. Empirical comparisons of the net primary production of *Spartina alterniflora* from different latitudes along the eastern seaboard of the United States tend to support this suggestion (Cooper 1974). In Georgia, biomass production averaged 1,600 g/m^2/year. This figure drops to 646 g/m^2/year in North Carolina, 361 g/m^2/year in Delaware, and to 325 g/m^2/year in New Jersey. Thus, it would be anticipated that net primary production in tropical southwest Florida would probably exceed 2,000 g/m^2/year, although such production has not been measured. Most of the biomass production enters the food web as debris rather than being directly grazed and is broken down and then transported via tidal action into the mangrove ecosystem as detritus, forming important nutrient and energetic inputs into the estuary system (Heald 1969).

OTHER ECOSYSTEMS

A tropical, inshore, plankton system also occurs within the shallow inshore regions. The energy input for this system is provided by light and by organic detritus transported from the mangrove ecosystem type. This type predominates where water is deep enough for plankton to dominate over bottom plants but where waters are shallow enough for nutrients to be cycled up from the bottom. These ecosystems achieve maximum stability where the influences of tide, waves, or sudden freshwater runoff is minimal. Because of their requirements, such ecosystems are uncommon in the continental United States (Marsh 1974: 488); one of the few such systems is located at the northernmost extreme of the Ten Thousand Islands (Copeland and Odum 1974:108).

Two remaining ecosystem types, tropical blue water coasts and tropical reefs, are not directly pertinent to human resource exploitation on the southwest coast, since evidence of their utilization is small. Still, these ecosystem areas, which lie off the coast of southwest Florida, are important to ecosystem interaction, providing important spawning grounds for primary and secondary consumers of mangrove and tropical-meadow ecosystems (Houde and Chitty 1976). Their productivity has an impact on the productivity of these trophic levels in the mangrove and tropical-meadow ecosystems, since they are dependent on the food chain of offshore coastal areas during certain portions of the life cycle.

Temperate Ecosystems

Temperate ecosystems, such as oyster reefs and clam flats, also provide important subsistence resources for human exploitation. These ecosystems occur throughout the study area and support a diversity of fauna, which complement the tropical ecotypes.

Certain features of the basic tropical ecosystems are pertinent to cultural-ecological analysis of aboriginal human adaptation. First, tropical ecosystem types show greater stability than temperate systems. Second, mangroves and tropical-marine meadows are distributed heterogeneously along the southwest Florida coast owing to the ecological zonation found within each ecosystem type as well as their topographic and physiographic determinants. Third, these systems are of high energy flow, in spite of the apparently exaggerated trophic structure with its three levels of secondary consumers and the inability of humans directly to utilize primary producers, such as mangroves and sea grasses. Thus, biomass available for human exploitation is quite high. Besides the usual light energy input into the system, lunar and earth-gravitational energy inputs in the forms of tides and currents increase the available energy in the system over that found in terrestrial environments alone. Fourth, much of the production of the various tropical ecosystems is transported into the estuary zone, thereby increasing available energy. A classic example is current or tidal detrital material transported from mangroves into marine meadows.

Measurements have been taken of the production of leaf litter for mangrove swamps in several areas. One is on North River estuary (Heald 1969), another is in Rookery Bay, north of Marco Island, and three other sites are located in the Ten Thousand Islands area (Pool and Lugo 1973). The studies show a range in production from 511 g/m^2 to 880 g/m^2. Snedaker and Brown (1982) have also produced an index of mangrove leaf litter production for six mangrove forest types. These values are 0 g/m^2 for impounded basins, 220 g/m^2 for dwarf (scrub) forests, 741 g/m^2 for flushed basins, 750 g/m^2 for hammock basins, 1,024 g/m^2 for overwash forests, 1,032 g/m^2 for fringe forests, and 1,120 g/m^2 in riverine forests. These values are *not* net primary productivity but only the production which drops into the swamp and is thus available for detritus decomposition. An estimate of the total net primary productivity, based on the breakdown of net primary productivity by part of the tree as calculated by Whittaker (1975), is only about 30 percent. If this estimate is accurate, it would indicate that total net primary productivity of mature mangrove forests, excluding impounded or dwarf forest categories, ranges from 1,570 g/m^2 to 3,700 g/m^2, similar to the range given by Whittaker (1975) for swamp environments. More important, only 5 percent of the leaves are directly consumed by terrestrial grazers (Heald 1969); the rest is available for aquatic consumption. Even more significant is that mangrove detritus accounts for only 35–60 percent of the suspended detritus, with the remainder being composed of sawgrass and other organic matter transported from interior ecosystems. The density of this detritus varies seasonally with lows of 2–23 mg/liter in the wet season to 49–93 mg/liter in the dry season (Heald 1969). Heald's study effectively shows the principle of increased availability of production due to transport from other areas, and it also demonstrates the very high productivity of the coastal environment. Figure 14 shows a generalized linear flow diagram which incorporates all the specific ecosystem types of coastal southwest Florida.

Although it is difficult empirically to derive whole system production figures from the limited studies of this type undertaken in the area, the differences in the amount of energy inputs into the various ecotypes should be reflected in the differential amounts of biomass in the various trophic levels (E. P. Odum 1971). Therefore, if the spatial variability of energy inputs and ecosystem types can be roughly determined, at least relatively, then the relative amounts of food resources available to humans can be determined for various geographical areas within the region. This analysis can be crudely tested by using commercial and sport-fish landing data.

These data should reflect relative differences in productivity from area to area. Although the degree of specificity for these areas, namely counties, are very crude, they do give an indication of the relative differences in biomass from area to area. Longitudinal fish-catch data are also useful and provide a rough index of the "carrying capacity" of the coastal ecosystems in the study area, particularly since trash fish such as catfish, rays, and sharks, important species archaeologically, are not included in the catch data. If contemporary fishing methods do not result in decreased yields through time, then it can be assumed that a mean catch figure represents a crude, minimal standing-crop figure for the particular species.

Commercial catch data from 1966 through 1975 (State of Florida 1966–1975) of a selected number of coastal fish presumed to have been important to prehistoric cultural systems have been used for this study (see fig. 15). Catch data have been compiled from six contiguous counties, two of which are north of the southwest coastal area.

As can be seen from figure 15, there is clearly a difference in the mean annual fish catch for the six counties. This is particularly evident if one discounts nonestuarine (i.e., offshore) fishes—Spanish mackerels, grouper, and bluefish—

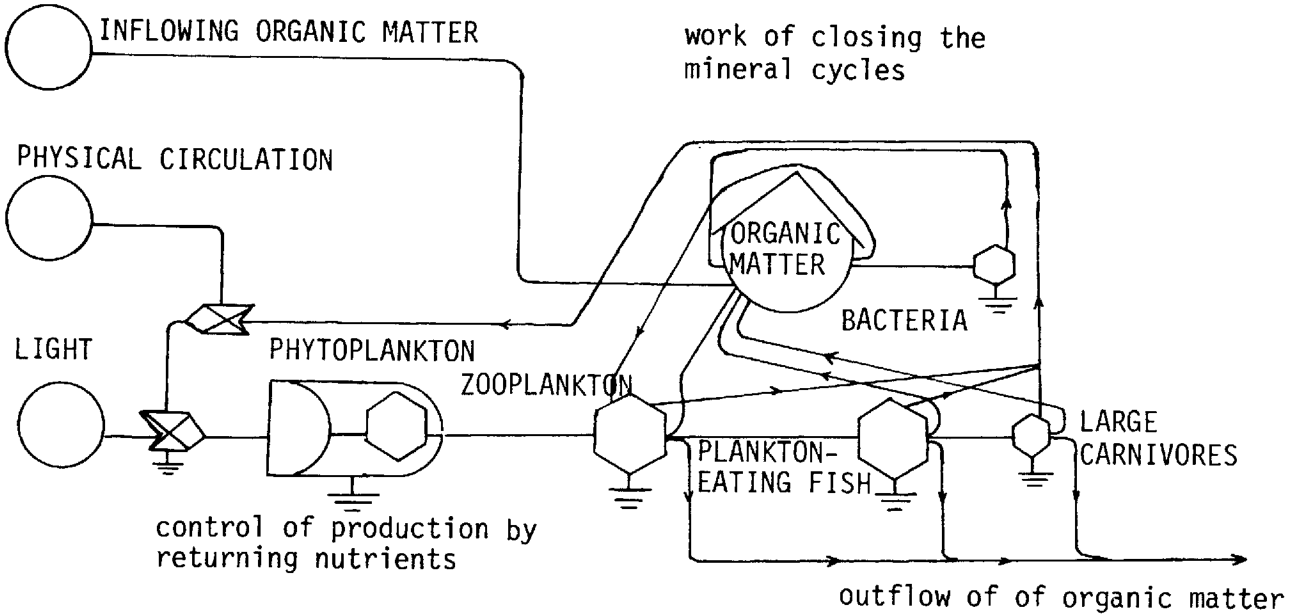


Figure 14. Generalized Linear Flow Diagram for a Coastal Ecosystem. Adapted from H. T. Odum and Copeland (1974)

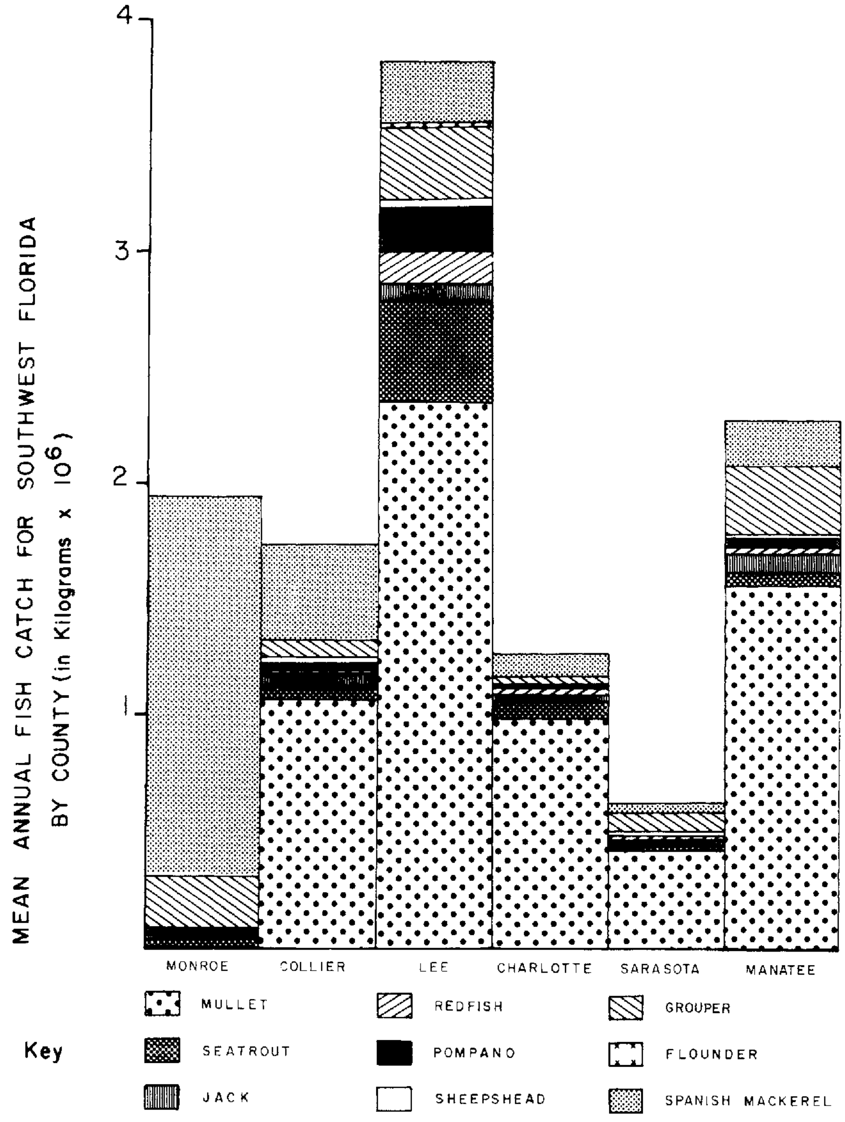


Figure 15. Mean Annual Commercial Fish Catch for Selected Species in Southwest Florida. Compiled from State of Florida (1966–1975)

which, although found in archaeological contexts, are less frequent owing to their offshore habitat. Because of this, they are rather more difficult to exploit in terms of labor and technology by aboriginal populations. Therefore, if we maintain that the aboriginal fishing is primarily estuarine (i.e., inshore), we see a marked increase in mean annual fish catch for estuarine species from under 250,000 kg/year in Monroe County to approximately 1.25 million kg/year in Collier County to 3 million kg/year in Lee County, then a drop to 1 million kg/year in Charlotte County to 0.5 million kg/year in Sarasota County. These figures suggest a circumscribed area of estuarine-fish productivity centered in Collier, Lee, and Charlotte counties. The actual mean annual-catch frequencies and their standard deviations have been provided in table 10. It should be noted that these data are only relative approximations of productivity, since each county is assumed to have equal linear shoreline, even though this is not actually the case (see fig. 1 for relative linear shoreline for each county).

THE LOCATION OF COASTAL AREAS OF HIGH PRODUCTIVITY

The structure of the trophic system of the southwest Florida coast can be used to map areas of relatively high productivity. It should be remembered that productivity in the sense used here is measured primarily in terms of the abundance of the upper trophic levels, those which are most pertinent to human exploitation, and not in terms of net primary production, the more accepted usage.

Regions of high productivity will be those with the largest number and area of favorable high energy ecotypes. Particularly important will be those areas containing overlapping ecotypes. This results not merely in ecotones, but in multiple ecological systems and, therefore, additive energy and nutrient inputs. Thus, particularly high productivity would be found in those areas which have large areas of marine meadows, large areas of mangroves, and large areas of tidal flow and/or rich current drainage.

There are two areas in the study region in which these conditions prevail: the Charlotte Harbor–Pine Island Sound–Carlos Bay area, and in the northern portion of the Ten Thousand Islands, from Everglades City north to Marco Island (fig. 1). Both of these locations correlate almost directly with the highest commercial fish-catch data presented earlier. Within each of them is a subarea with an even-greater area of marine grass; these two specific subareas are considered to have the highest productivity within the study area. One of these is immediately surrounding Pine Island (McNulty 1968), and the other is the Cape Romano–Marco Island area (Kinch and O'Hara 1976).

Two major river systems empty into Charlotte Harbor–Pine Island Sound–Carlos Bay: the Peace and the Caloosahatchee. The detrital nutrients, both from terrestrial and mangrove ecosystems, are transported and deposited in this area,

Table 10
Longitudinal Fish Catch Data by County, 1966-1975, in Kilograms x 1000

Species	Monroe	Collier	Lee	Charlotte	Sarasota	Manatee
	$\overline{X}$ SD	$\overline{X}$ SD	$\overline{X}$ SD	$\overline{X}$ SD	$\overline{X}$ SD	$\overline{X}$ SD
Bluefish	27.5 ± 13.4 (1.3%)	8.4 ± 3.4 (0.5%)	13.8 ± 6.9 (0.4%)	6.2 ± 4.1 (0.5%)	9.7 ± 2.4 (1.4%)	15.0 ± 7.6 (0.6%)
Jack	5.7 ± 4.8 (0.3%)	54.0 ± 22.0 (3.0%)	70.8 ± 43.3 (1.8%)	28.7 ± 25.1 (2.2%)	21.7 ± 13.5 (3.2%)	60.4 ± 72.8 (2.6%)
Black Drum	0.3 ± 0.9 (0.0%)	6.5 ± 3.6 (0.4%)	0.5 ± 0.6 (0.0%)	3.4 ± 1.7 (0.3%)	2.8 ± 1.7 (0.4%)	2.8 ± 2.9 (0.1%)
Redfish	0.3 ± 0.3 (0.0%)	9.2 ± 4.2 (0.5%)	145.3 ± 41.6 (3.7%)	36.3 ± 12.6 (2.8%)	9.9 ± 4.4 (1.5%)	56.0 ± 24.3 (2.4%)
Grouper	215.8 ± 66.1 (10.3%)	85.5 ± 47.1 (4.8%)	314.5 ± 90.0 (8.1%)	73.6 ± 54.8 (5.7%)	87.1 ± 51.6 (13.0%)	396.1 ± 74.5 (17.1%)
Mullet	5.4 ± 8.9 (0.3%)	1070.5 ± 349.3 (59.7%)	2346.8 ± 357.1 (60.2%)	990.5 ± 319.7 (76.8%)	427.4 ± 191.4 (63.8%)	1596.9 ± 312.3 (68.9%)
Pompano	36.6 ± 28.9 (3.0%)	57.6 ± 17.1 (3.2%)	193.6 ± 100.6 (5.0%)	13.3 ± 4.8 (1.0%)	14.5 ± 4.0 (2.2%)	25.0 ± 9.0 (1.1%)

(continued)

Table 10 (Continued)
Longitudinal Fish Catch Data by
County, 1966-1975, in Kilograms x 1000

Species	Monroe	Collier	Lee	Charlotte	Sarasota	Manatee
	$\bar{X}$ SD	$\bar{X}$ SD	$\bar{X}$ SD	$\bar{X}$ SD	$\bar{X}$ SD	$\bar{X}$ SD
Sea Trout	41.1 ± 25.8 (1.9%)	55.0 ± 55.4 (3.1%)	438.5 ± 50.0 (11.2%)	72.7 ± 15.2 (5.6%)	22.3 ± 11.3 (3.3%)	69.6 ± 19.9 (3.0%)
Sheepshead	0.6 ± 0.9 (0.0%)	10.2 ± 9.9 (0.6%)	29.4 ± 6.4 (0.7%)	20.1 ± 6.4 (1.6%)	11.8 ± 7.5 (1.8%)	8.9 ± 4.4 (0.4%)
Lane Snapper	4.9 ± 1.7 (0.2%)	0.1 ± 0.2 (0.0%)	2.2 ± 3.3 (0.0%)	0.1 ± 0.1 (0.0%)	- -	- -
Mangrove Snapper	122.0 ± 22.9 (5.8%)	7.2 ± 3.5 (0.4%)	64.9 ± 31.2 (1.7%)	4.6 ± 3.8 (0.4%)	0.7 ± 0.4 (0.1%)	1.1 ± 0.7 (0.0%)
Spanish Mackerel	1631.5 ± 520.8 (76.9%)	427.4 ± 122.4 (23.9%)	257.0 ± 57.4 (6.6%)	38.4 ± 15.0 (3.0%)	60.4 ± 33.6 (9.0%)	86.4 ± 32.9 (3.7%)
Flounder	- -	0.1 ± 0.1 (0.0%)	23.4 ± 8.7 (0.6%)	1.5 ± 0.5 (0.1%)	1.5 ± 1.3 (0.2%)	0.8 ± 0.6 (0.0%)
Sum $\bar{X}$s	2019.7	1791.7	3900.7	1289.4	669.8	2319.0

Compiled from State of Florida (1966-1975) one of the reasons for high productivity. Because Sanibel Island forms a barrier, much of these sediments are deposited in the estuary rather than transported offshore.

The northern region of the Ten Thousand Islands consists of numerous mangrove keys, separated by tidal flats and cuts which provide for transport of nutrients. Also significant, a marine tropical-plankton bay has been identified between Marco Island and the mainland (Copeland and Odum 1974). Areas with minimal areas of mangrove and marine meadow, and therefore low productivity, tend to circumscribe these regions, particularly north of Charlotte Harbor and between Estero Bay and Naples. The area south of the upper Ten Thousand Islands still maintains its mangrove coastline, but the edge area decreases in size and the marine meadows diminish in area (see figs. 7 and 13).

SEASONAL VARIATION IN FISH PRODUCTIVITY AND OTHER RISK FACTORS

An important feature of tropical ecosystems is the relative stability of primary production, since seasonal variation of solar radiation decreases as the equator is approached (D. M. Gates 1971). Since humans in this region do not directly exploit the primary-production trophic level, however, the variability in higher trophic levels must be considered. H. T. Odum and Copeland (1974:37–38) have shown that stress in estuaries is due to fluctuation of salinity and latitudinal temperatures, factors which regulate the diversity and variety of ecosystem types.

In south Florida, estuarine salinity fluctuations result primarily from freshwater runoff (Tabb et al. 1962; Thomas 1974; Schomer and Drew 1982). Data on longitudinal rainfall variability and salinity fluctuation for southwest Florida are presented in figures 4 and 16.

Schmidt (1979) has investigated the relationship of seasonal salinity variation due to rainfall and fish biomass in western Florida Bay, located in the Everglades National Park. His results indicate that 60 percent more fish in numbers and 68 percent more fish in biomass were collected during the wet season, June to November, than during the dry season, December to May. Gunter and Hall (1965:59) and Wang and Raney (1971:50, table 4) also report that fish are more frequent during months of lower salinities in the Caloosahatchee estuary. This would tend to suggest that fish stocks are higher and more predictable during the wet season.

Rapid fluctuation in salinity might also be a factor which interrupts the basic availability of fish resources. Unfortunately, no systematic study of the impact of such fluctuation has been conducted in the study area. The periodicity, frequency, and extent of these salinity changes are not obvious from the rainfall data, which are given in monthly increments in the studies cited above, thereby masking much of the suddenness of daily or episodic rainfalls. Springer and Wood-

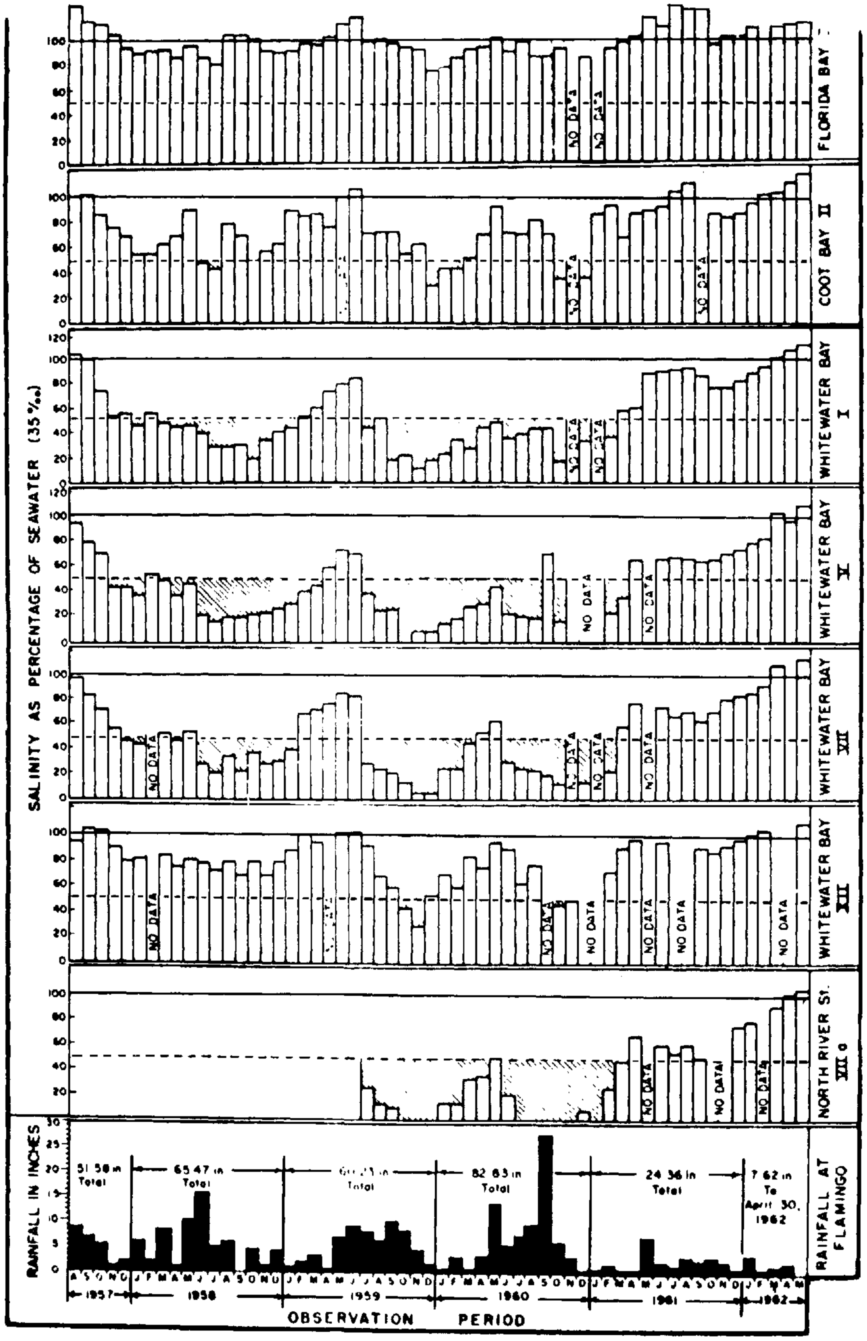


Figure 16. Erratic Rainfall and Salinities. Adapted from Tabb et al. (1962)

burn (1960) have noted, however, that fish mortality, particularly among catfish, is higher after a sudden reduction in salinity in the more brackish areas of Tampa Bay, located north of the study area. The sudden altering of salinities would also act to modify the composition of the fish species. Although some species, such as mullet, readily adjust to salinity changes and are at home in fresh or saltwater, other species would leave the estuary and still others would enter it as was observed by Schmidt (1979:670–671). This change in species might require an alteration of capture techniques and also a monitoring of salinity.

Although it seems clear that salinity fluctuations can have an adverse effect on estuaries, the effect on southwest Florida estuaries would be minimal on a seasonal basis, since the fish populations would adjust to this seasonal variability. Still, in the event of unusually high rainfall, the sudden, resultant salinity change could affect the fish populations adversely, thereby injecting a risk factor into the adaptive system.

An oscillating salinity zone in the estuary,, the normal result of seasonal and monthly wet and dry periods, is considered necessary for the maintenance of juvenile fish production (Schomer and Drew 1982:158–159). Therefore, any cyclical changes which alter this oscillation—that is, extended periods of drought—will reduce or alter the fish stock. Signs of these changes have been recorded in the Everglades National Park, resulting from a combination of drought conditions over the last twenty years and the diversion of freshwater discharge into the estuary (Schomer and Drew 1982:159). If such conditions existed in the past, they would have altered the structure of fish stocks as well, thus altering the Late Prehistoric adaptation and acting as an additional risk factor to the human population. The periodicity, frequency, and extent of these salinity changes which would have occurred in the past is unknown, but they seem likely to have existed.

Temperature in the region is stable and tends to support high species diversity. This is not to suggest that periodic cold waves do not cause fluctuations in species availability. Storey and Gudger (1936) and Storey (1937) have shown that sudden cold waves result in high mortality of fish populations in the study area. It is precisely because of the stability of the tropical regime in the study area that the fish populations are so susceptible to a sudden cold front. A climatic perturbation of subfreezing weather thus can drastically affect the quantity of available fish resources. It is not known to what extent these thermal shocks occurred in the past, but they are considered to be a risk factor in the northern Pine Island Sound–Charlotte Harbor region. Unlike in temperate environments, resources in tropical areas lack seasonality due to temperature. Nevertheless, the closeness of the temperate region to this tropical zone introduces the risk of subfreezing cold shock during the winter months, and so fish which are normally adjusted to mild water temperatures in shallow waters are susceptible.

Perhaps the most important aspect of seasonality relative to human exploitation is the spawning behavior of fishes in this region. Unlike anadromous fish, the fish species exploited by humans in southwest Florida are available in estuarine environments year-round. Most species do spawn offshore but only for short periods. At this time they actually become more densely aggregated because of mass schooling in estuarine areas before migrating to offshore regions. All species become most densely aggregated during spawning and therefore become most readily available for capture at this time. This is confirmed by Kinch and O'Hara (1976), who note that sport-fishing catch figures in the Ten Thousand Islands are highest for a particular species during the spawning season, although their data also show that all species are taken year-round.

Another distinctive feature of the southwest Florida coastal area is that, because of the high species diversity and biomass, there are complementary spawning seasons for fish species (Houde and Chitty 1976), which implies that there is an aggregation of some fish species at all times of the year. Together with the area year-round availability of all fish species, this results in a fairly stable biomass. There is, of course, some seasonal fluctuation in fish biomass, but the tendency is toward stable aggregation of fish resources throughout the year. Table 11 provides the spawning period, or other period of major aggregation, of certain fish species in southwest Florida.

It can be seen in the table that there is aggregation of fish species at all times of the year. These periods of aggregation should be considered in terms of the biomass available for each particular species, which has been roughly projected in figure 15, and it should be remembered that most of these species are continuously available throughout the year.

THE PREDICTABILITY OF THE RESOURCE BASE

I have attempted to show that fish resources are available on a year-round basis, in spite of a seasonal patterning of mass aggregation. This is not to imply that the fish resources are found homogeneously within the estuaries, however. An additional factor influences the availability and spatial distribution of fish resources—tides. Cordell (1978) has illustrated the importance of tides in predicting the location of fish resources in the coastal lowlands of southern Bahia, Brazil, a tropical estuary similar in major respects to the southwest Florida coast. Cordell comments on the influence of lunar-tide cycles on the Beirada fishing ground, a submerged mangrove-lined coastal plain similar to that found in the southern portion of the survey area:

> With regard to the fishing grounds . . . it is difficult to speak of production potential inherent in local waters, since pelagic fish schools enter the estuaries at various points in their migratory cycles. Fishermen's ability to capitalize on these migrations, particularly spawning runs, depends to a great extent on their knowledge of lunar tide periodicity. Through careful observation of the tide cycle, they are able

Table 11
Season of Maximum Availability of Selected Fish Species

SPECIES	MONTH											
	S	O	N	D	J	F	M	A	M	J	J	A
Sharks (Squalliformes) (1)									----	----	----	
Rays (Rajiformes) (1)											----	----
Spotfin mojarra (*Eucinostomus argenteus*) (2)	----	----							----	----	----	----
Gulf Toadfish (*Opsanus beta*) (2)						----	----	----	----			
Sea catfish (*Ariopsis felis*) (2)	----								----	----	----	----
Snook (*Centropomis* spp.) (3)									----	----	----	
Red Grouper (*Epinephelus morio*)(3)								----	----	----		
Jewfish (*Epinephelus itajara*) (3)											----	----
Gag grouper (*Myoteroperca microlepis*) (3)					----	----	----					
Jack crevalle (*Caranx hippos*) (4)	----	----	----	----	----	----	----	----	----	----	----	----
Pompano (*Trachinotus* spp.) (3)								----	----	----		
Mangrove snapper (*Lutjanus griseus*) (3)	----	----						----	----	----	----	----
Pinfish (*Lagodon rhomboides*) (2)			----	----	----	----						
Sheepshead (*Archosargus probatocephalus*) (2)						----	----	----	----	----		
Silver perch (*Bairdiella chrysura*) (2)					----	----	----	----	----			
Spotted sea trout* (*Cynoscion nebulosus*) (2)					----	----	----	----	----			
Sand sea trout (*Cynoscion arenarius*) (2)	----	----					----	----	----	----	----	----

(continued)

Table 11 (Continued)
Season of Maximum Availability of Selected Fish Species

SPECIES						MONTH						
	S	O	N	D	J	F	M	A	M	J	J	A
Spot (*Leiostomus xanthurus*) (2)				-	-	-	-					
Southern kingfish (*Menticirrhus americanus*) (2)				-	-	-	-	-				
Northern kingfish (*Menticirrhus saxatilis*) (2)	-	-	-	-								
Redfish (*Sciaenops ocellata*) (2)	-	-	-	-	-					-	-	-
Black drum* (*Pogonias cromis*) (2)		-	-	-	-							
Pigfish (*Orthopristis chysopterus*) (2)	-	-	-	-								
Mullet (*Mugil cephalus*) (3)			-	-	-							
Spanish mackerel (*Scomberomorous maculatus*) (3)			-	-	-	-	-	-				
Southern flounder (*Paralichthys lethostigma*) (3)		-	-	-	-	-	-					
Lined sole (*Achirus lineatus*) (2)	-	-	-	-								

* spawns in the estuary

(1) From Clark (1963); (2) From Schomer and Drew 1982:160 Table 31); (3) From Palik and Lewis (1983); (4) From Springer and Woodbury (1960).

> to cue in on the movements of different species on a daily basis. At the same time the variable influence of the tide along the course of the estuary determines the selection and positioning of all their fishing methods on a strictly mechanical basis. To net fish successfully in Beirada waters, one must master the art of timing tides. [1978:7–8]

Although the above statement concerns primarily pelagic-fish resources, the same factors are important in exploiting estuarine-fish resources during periods of either nonmigratory or mass aggregation behavior. This will be more clearly illustrated in the discussions of the feeding strategies of the specific fish species constituting the resource base used by human aboriginal populations. Important here is that although the southwest Florida estuarine-fish resources are available year-round with little seasonal variability, there is daily variability in the *geographical* location of fish resources and, equally as important, the *times* when fish can be taken, since fishing grounds containing fish are continually shifting in response to the changing tide. A spot which was good for fishing at a certain time at a certain place will not be good the next day at the same spatial and temporal coordinates. As tides wax, the potential feeding grounds of many species of fish become available for short periods of time, until the tide wanes and the fish leave. Therefore, fishing spots of high productivity are in many instances not fixed in either a temporal or geographical sense but are continuously distributed on the basis of tidal conditions (Cordell 1978:9).

In summary, the environment of coastal southwest Florida can be generalized as a highly productive, tropical coastal ecosystem, whose primary energetic base is built on the tropical marine-meadow and mangrove ecosystems. These systems form the basis of a highly diversified trophic structure of primary consumers and carnivores. Although such tropical environments display great stability, the close propinquity of this region to the temperate zonation and sudden influxes of freshwater during the wet season introduce stochastic risk factors which disrupt this basic stability. This coastal zone is also environmentally circumscribed, being bounded to the north and east by less productive, in energetic terms, ecosystems. This environment forms the potential resource base used by human adaptation in this area.

6

The History of Environmental Change in South Florida

The static view of the physiography and ecosystem described in the previous chapter may not have pertained to the past, since paleoenvironmental and geological conditions were much different in the Late Pleistocene through Middle Holocene than currently found in the coastal area of southwest Florida. The coastal zone of southwest Florida was influenced by geological and ecological processes to a much greater degree than other coastal zones of eastern North America. There are two reasons for this. The first is the very broad, relatively shallow and gently inclined continental shelf, which extends west from the present Florida peninsula. Global warming trends associated with the beginning of the Holocene resulted in the melting of the massive polar ice sheets of the Wisconsin period of the Late Pleistocene. This, in turn, resulted in the submergence of this coastal shelf with a transgressing sea level and a retreating coastline.

The other important factor is the proximity of the tropical southwest Florida coast to the subtropical zone to the north, since minor fluctuations in global temperature patterns can dramatically affect the environment and possibly alter the area's ecosystems. Both of these factors act as dynamic geological processes which alter the ecological setting, including the spatial distribution and relative areal extent of the physiographic environments and their associated ecosystem types present on the coast. Thus, the specific history of human utilization of the resources of the southwest Florida coast is conditioned in part by these dynamic geological and paleoenvironmental processes. An understanding of these specific histories is necessary for knowing the types of ecosystems present in the past and their spatial location.

A number of geological periods will be referred to in this chapter. Many of these are standard in usage, such as Wisconsin and Sangamon. The Holocene, however, will be partitioned into units which do not exactly follow normal usage, although the terminology followed here is similar in many ways to Gagliano's (1977). Table 12 has been constructed to present my usage explicitly and to provide a chronology of some of the important geological events which have taken place in south Florida. I have also included the scheme used by Gagliano (1977) and the sea-level positions for these periods. Table 13 summarizes the paleoenvironmental history of south Florida.

The Effect of Post-Pleistocene Sea Level on Coastal Configuration

Sea level was at a number of different positions during the Pleistocene, resulting in a series of beach terraces throughout the world. These varying sea levels were due to the expansion and shrinkage of ice sheets in the polar regions of the earth. The maximum advance of these ice sheets occurred during the Late Wisconsin glacial period, dated at 18,000 years B.P. (Watts 1975). At this time, the Laurentide ice sheet, centered over Hudson Bay, obtained its maximum thickness of 3,500 m. A similar ice sheet, the Fennoscandian, was located in Eurasia. These ice sheets bound up much of the the earth's moisture, resulting in a sea level of up to 120 m below its present position (Milliman and Emery 1968; J. A. Clark et al. 1978). Lower sea level due to glacial expansion occurred at earlier times during the Pleistocene (Cronin et al. 1981), but only the Late Wisconsin glacial advance and its associated sea levels will be considered here. Although it is possible that earlier (i.e., pre-Wisconsin) human occupation of the New World occurred in the long undifferentiated interstadial from 73,000 to 30,000 B.P. (MacNeish 1976), the sea level at this time was 7 m above its present position (Cronin et al. 1981), and all of south Florida, owing to its low elevation, would have been inundated. The effect of this sea-level position on the peninsula of Florida has been illustrated by mapping the shoreline position of the Sangamon sea (see fig. 17).

Regardless of the initial date of human entry into the New World, therefore, south Florida could not have been occupied by human beings prior to 30,000 B.P. This date also marks the beginning of the deteriorating climate, which eventually led to the maximum expansion of glacial ice (Watts 1980:389). The amount of water bound in the Wisconsin ice sheets corresponds inversely with the ocean volume, and so the 18,000 B.P. glacial maximum also corresponds with the maximal exposure of coastal shelf area, and possible areal occupation, of south Florida.

The exact maximal extent of the exposed coastal shelf of western south Florida is difficult to ascertain directly, because as the glacial ice melted, the earth readjusted its volume and shape when the compression of this weight was released.

Table 12
Geological Chronology of South Florida

Date	My Usage	Gagliano's	Sea Level	Geological Characteristics
Present			0 m	
	Late Holocene	Interval K	-1.5 m	Origin of modern coastal configuration & Big Cypress Swamp, sedimentation = sea-level rise, sea level slows dramatically
2700 BP				
		Interval J	-2.7 m	Water table rises to surface, formation of coastal zone, peat formation and sedimentation begins, origin of Lake Okeechobee, Everglades, Caloosahatchee River
4000 BP				
	Middle Holocene		- 4 m -12 m	
5500 BP				
		Interval I	-20 m	
7000 BP				
		Interval H4	-25 m	
8500 BP				
		Interval H3	-45 m	
9000 BP				
		Interval H2	-60 m	Surface water restricted to cenotes, water table -11 to -26 m, dunes become stable
10,500 BP	Early Holocene			
		Interval H1	-80 m	
12,000 BP				

Table 12 (Continued)
Geological Chronology of South Florida

Date	My Usage	Gagliano's	Sea Level	Geological Characteristics
		Interval G	Rising sea	
15,000 BP				
	Late Wisconsin	Intervals E & F	-100 m	Maximum exposure of Florida Peninsula, Maximum extent of glacial ice
18,000 BP				
	Wisconsin	Intervals C & D Interval B	Falling Sea	Lowered water table, no flowing rivers, no surface sediment, beginning of climatic deterioration, onset of glaciation
30,000 BP				
	Sangamon	Interval A	+ 7 m	Sangamon (Pamlico) sea inundates south Florida
73,000 BP				

Table 13

Paleoenvironmental History of South Florida

Date	Period	Climate	Vegetation	
			Terrestrial	Aquatic
Present	Late Holocene		Pollen Zone IA: Types and distribution same as today	Maximum extent of fresh, brackish and saltwater environments
2700 BP				
4000 BP	Middle Holocene	Same as today	Pollen Zone IB: Increase of pine & cypress Types same as today, but distribution is different	Mangrove peat, fresh, brackish, marsh, and interior peats
5500 BP				
	Early Holocene	Warmer summers, drier than today, wind subsides	Pollen Zone II: Initial appearance of different vegetation, pine, palmetto, oak, hickory, grass prairies and composites	Lily, cattail in wetter areas, no peats, Open beaches or hypersaline lagoon with mangrove fringe
12,000 BP				
	Late Wisconsin	Arid, windy July temp. = -12 deg. C, winters mild	Pollen Zone III: Tropical sand-dune vegetation, Rosemary scrub with some scrub oak & prairie-like vegetation	Open beaches or hypersaline lagoon with mangrove fringe
18,000 BP				
	Wisconsin			
30,000 BP				

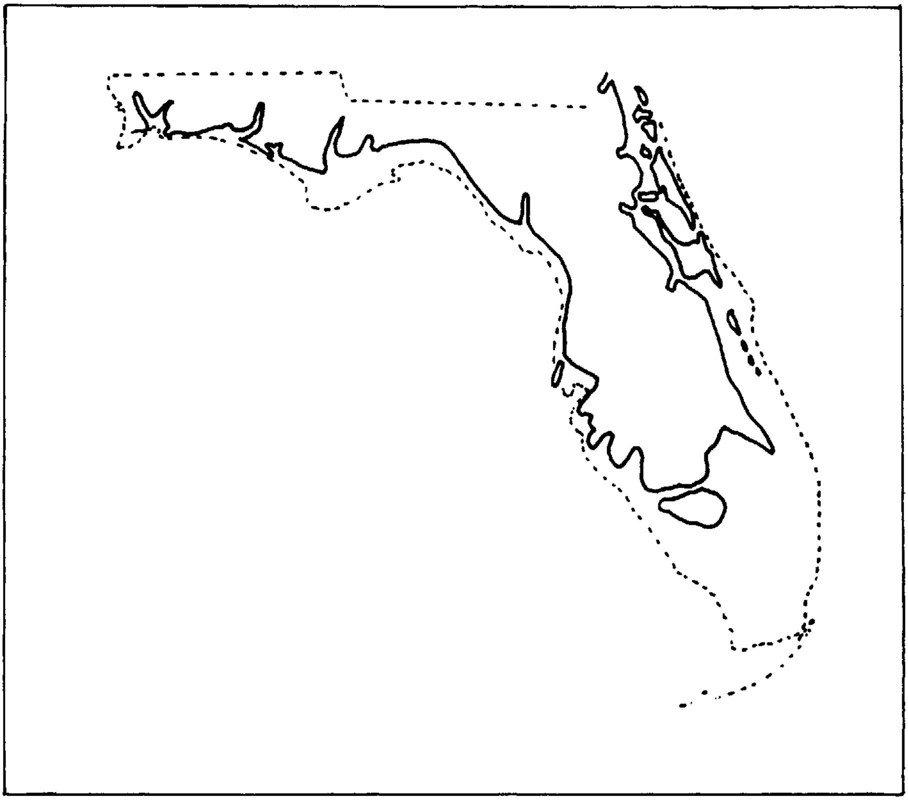


Figure 17. Shoreline of the Pamlico Sea. Adapted from Hoffmeister (1974)

This major change resulted in subtle readjustments of the earth's surface in relation to the eustatic sea level that are not directly related to local tectonic activity (J. A. Clark et al. 1978). For the purposes here, it will be assumed that no tectonic or crustal movement has taken place. Although not necessarily true, this assumption will not affect the general accuracy of the coastal formation processes and their timing. With this limitation in mind, the maximal extent of exposed coastal shelf can be determined by drawing the contour for the lowest sea-level position on a bathymetric map of the Florida coastal shelf.

Milliman and Emery (1968) have suggested that the sea level at 15,000 B.P. was 130 m below its present position. Blackwelder et al. (1979) have noted that this is probably 30 m too deep and suggest a minimal lower sea level of 100 m. J. A. Clark and Lingle (1979:294) have also suggested 100 m of eustatic sea-level rise since 18,000 B.P. in their model of post-Wisconsin sea-level change. Thus, a maximal low sea-level position 100 m below the present position will be assumed here.

Inspection of the bathymetric contour for the Florida coastal shelf (fig. 18) indicates that submergence of the coastal plain of the Gulf of Mexico is quite dramatic, while the Atlantic coastal plain is only minimally submerged in terms of area. This difference is a result of the very shallow, broad continental shelf of the Gulf of Mexico adjacent to south Florida.

South Florida and its adjacent continental shelf are geologically classified as the Florida Platform and Escarpment (Brooks 1973:IIE-3; Gagliano 1977:4, fig. 1E). Stratigraphically, this formation consists of Paleozoic basement rocks of basalt covered with thick deposits of carbonate sediments dating from the early Cretaceous to the early Tertiary period (Brooks 1973). No significant accumulation of sediments has been added to the Florida Platform after the Late Miocene. Subsequent to this time, the sea level dropped dramatically, and only minimal stratigraphic accumulation of marine sediments occurred during higher Quaternary sea stands. These sediments were deposited in a lagoonal environment (Gagliano 1977), and this slow, in-situ accretion of sediments is responsible for the very stable nature of the Florida Plateau (Scholl et al. 1969:564). This is in marked contrast to deltaic sedimentation, like the 6,096 m (20,000 ft.) of Miocene and younger sediments deposited in the Mississippi River Delta (Brooks 1973) which accretes very rapidly and results in tremendous subsidence.

This stability of the Florida Plateau is very important in the discussion of Holocene sea-level fluctuations, since tectonic influence due to *sedimentation loading* is *not* a complicating factor (Scholl et al. 1969: n. 7). The Florida Plateau has further been subdivided into a series of geomorphological features (Gagliano 1977:132, fig. 3-38), which have been presented in figure 19.

The Downwarped Shelf is found between the −200-m and the −100-m contour and is located within the escarpment zone. Along the upper elevations of this shelf, starting at the −120-m contour, are a series of ridges, some of which have elevations of 18 m, formed when the Pleistocene sea level was at its lowest, possibly but not necessarily during the maximum Wisconsin glacial advance (Gagliano 1977:131). The most prominent of these ridges is Howell Hook, an arcate ridge 105 km in length which impounded a lagoon. East of Howell Hook is a series of patch reefs with elevations of 3–5 m at depths ranging from 137–156 m. The largest of these is 130 km^2 (Gagliano 1977). Another similar zone of patch reefs is found 160 km to the north at depths of 110–128 m.

The Downwarped Shelf is separated from the Florida Platform, referred to more specifically by Gagliano as the Middle Modified Karst Shelf (1977:134), by a band of distinctive, clearly defined escarpments and terraces. The most prominent of these lies at the −85-m contour and is continuous for a distance of 240 km (Gagliano 1977:134). East of this escarpment, between the −75-m and −70-m contour, a similar but less continuous escarpment is present, with a flat terracelike formation situated between the two escarpments.

Extending from north to south along the −80-m contour is a series of ridgelike features, which Gagliano (1977:134) interprets as barrier-beach complexes. Simi-

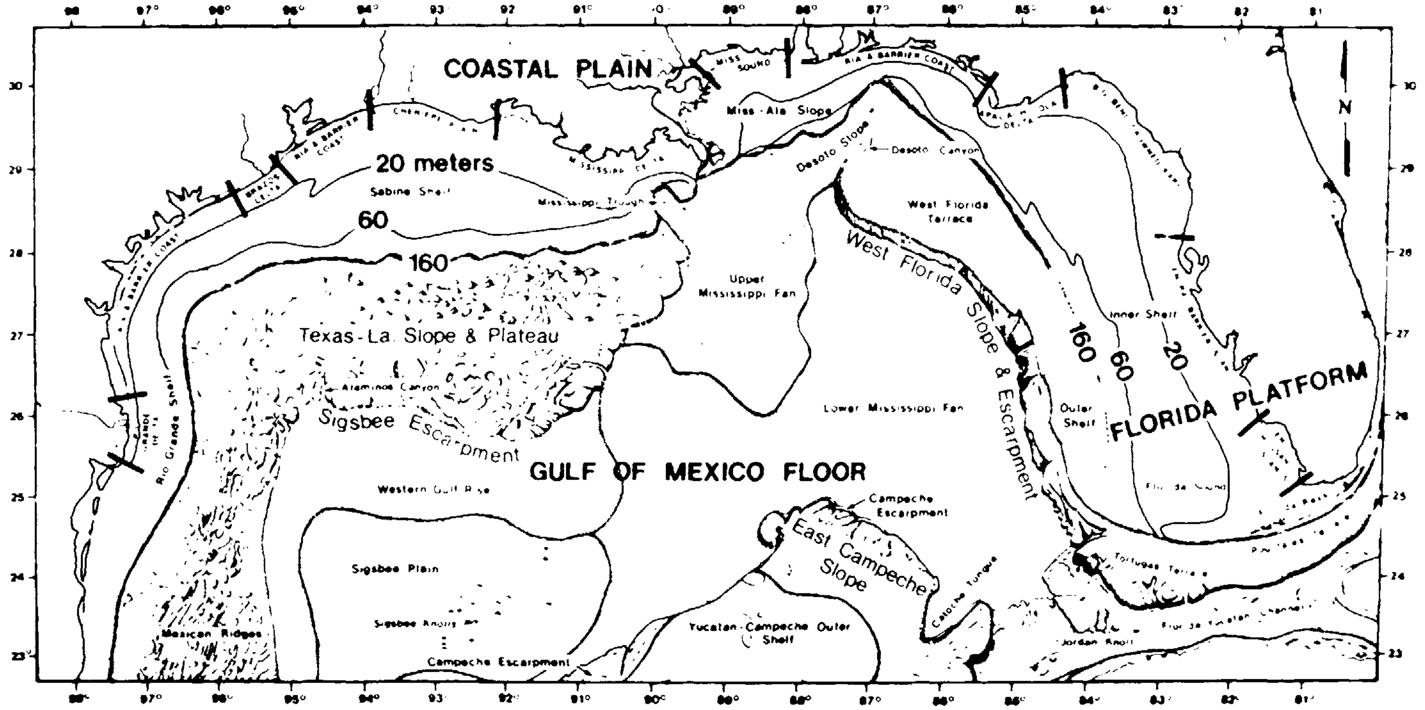


Figure 18. Bathymetric Map of the Gulf of Mexico. Adapted from Gagliano (1977)

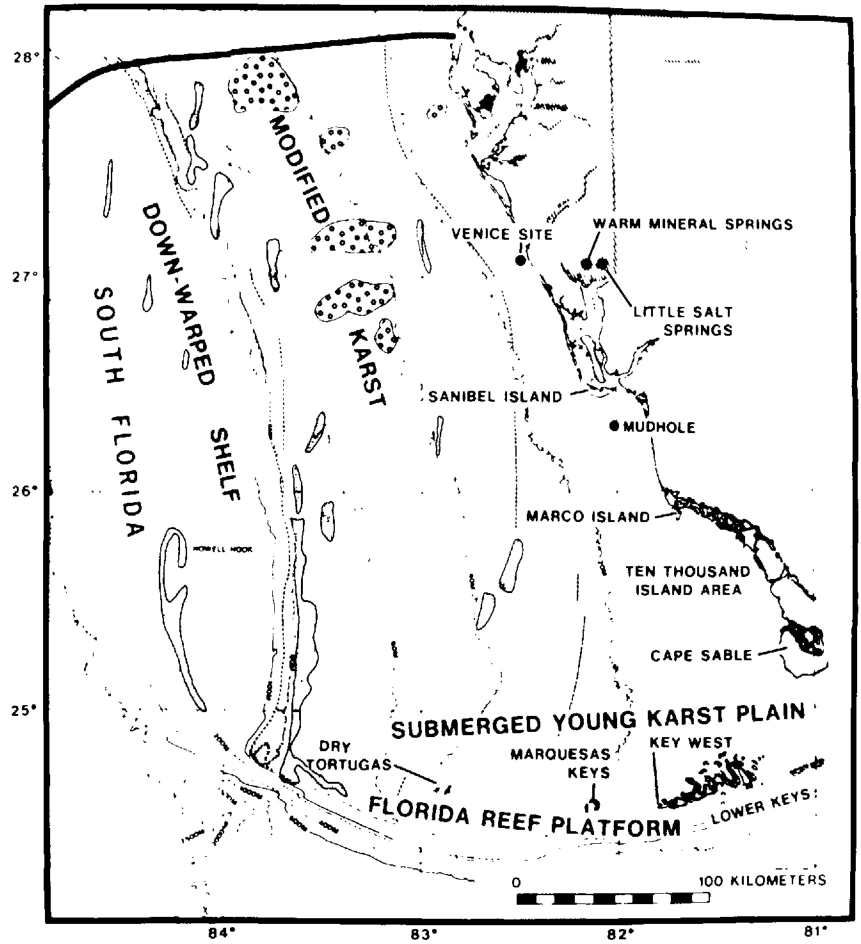


Figure 19. Southwest Florida Bathymetric Map. Adapted from Gagliano (1977)

lar features are found along the −70-m and −60-m contour lines (see fig. 19). The configuration of these figures is indicative of a dominant, longshore drift pattern from north to south (Gagliano 1977).

The middle shelf of the Florida Platform lies between the −55-m and −60-m contour and is characterized as a modified karst topography (Gagliano 1977), an area which may have contained former bays where coquinas and other lime sediments, which are susceptible to differential solution, were deposited. These features are indicated in figure 19. Numerous barrier-spit complexes and shore trends are found between the −40-m and −18-m contours.

Sinkholes are known to exist in the middle and inner shelf, although apparently they are not well developed. It seems that sinkholes and caverns become more frequent closer to shore (Brooks 1973:302; Gagliano 1977:135). Several "deep holes" which lie within a zone 16–65 km offshore have been reported by fishermen. One of these, the Mud Hole, is actually a submarine warm mineral spring, having a salinity of 19–20 ppt, a temperature of 36° C (97° F), and many trace elements (Pyle et al. 1974:298; Gagliano 1977:135). These submerged sinkholes are geologically homologous to those found on land, many of which contain fossil and cultural remains.

The superficial sediments of the submerged Florida Plateau are, for the most part, exclusively calcareous facies, with the exception of the inner shelf north of the Ten Thousand Islands, which instead has sandy facies (Enos 1974; Gagliano 1977). See figures 20 and 21.

The occurrence of calcareous sediments in much of the superficial facies on the submerged Florida Platform indicate a swampy, marsh-type environment, which would have been needed for their development (Gagliano 1977). They may not, however, have developed in situ during the post-Wisconsin sea-level rise but instead may be erosional remnants of earlier Miocene sediments redeposited by the rising sea level. The latter possibility has been suggested from sediment-core studies in the coastal plain of southwest Florida (Scholl 1964a; Smith 1968; Shier 1969) and is consistent with the sedimentary composition of the pre-Quaternary geological formations of the Florida Platform, which, as stated earlier, are lagoon deposits.

The existence of the barrier-beach complexes on the outer shelf is also indicative of the existence of sediment transport by longshore drift. Therefore, it appears that the superficial sediments of the submerged Florida Platform are erosional rather than autochthonous in origin.

It seems clear that areas of the Florida Platform presently submerged to depths of 100 m and possibly 130 m were exposed sometime between 18,000 B.P. and the present, and it is during this interval that many of the physiographic features described above were formed by the dynamic geological processes associated with a rising sea. It is essential to know the rate of sea-level rise to be able to evaluate accurately the impact of a rising sea on the coastal zone exposed at various periods of time, and more important, the type and areal extent of the various ecosystems which formed in these zones. Many of these environments have been described in the preceding chapter, but other ecosystems may have been present when conditions in the past were different from those of today.

Two factors are responsible for the coastal configuration at various times in the past: the *rate of sea-level rise* and the *slope and topography of the Florida Platform*. These factors are important for the following reasons. First, the post-Wisconsin sea may have risen at a rate too fast for the formation of stable, mature ecosystem types, such as mangrove forests, tropical-marine meadows, and salt marshes. Recall from the previous chapter that dwarf mangrove forests have one-

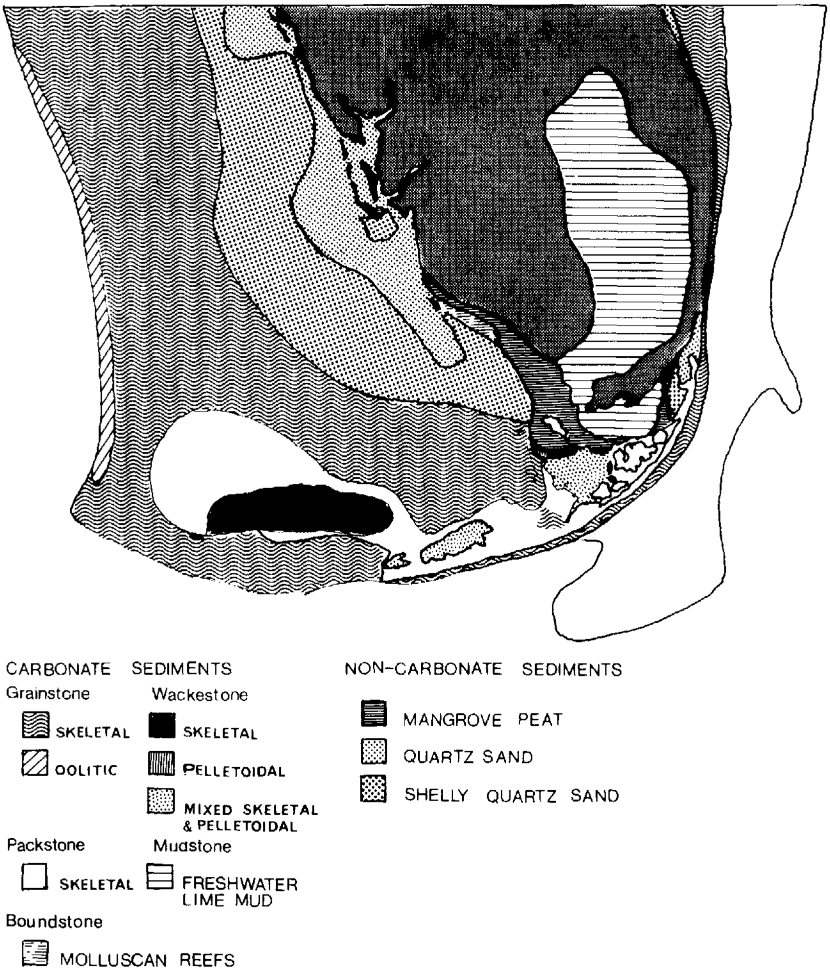


Figure 20. Submerged Sediment Types of South Florida. Adapted from Enos (1974)

fifth the leaf litter production of riverine mangrove forests. Additionally, the topography or slope of the Florida Platform may be such that the juxtaposition of a given sea level with a certain contour configuration of the exposed Florida Platform will result in differing frequencies of ecosystem types and varying areal distributions. Finally, it may be that during certain periods, sea-level rise is so rapid that coastal erosion allows only moderate or high-energy beach environments, with their limited range of ecosystem types (H. T. Odum et al. 1974).

It is assumed that the Florida Plateau has had little or no tectonic activity and

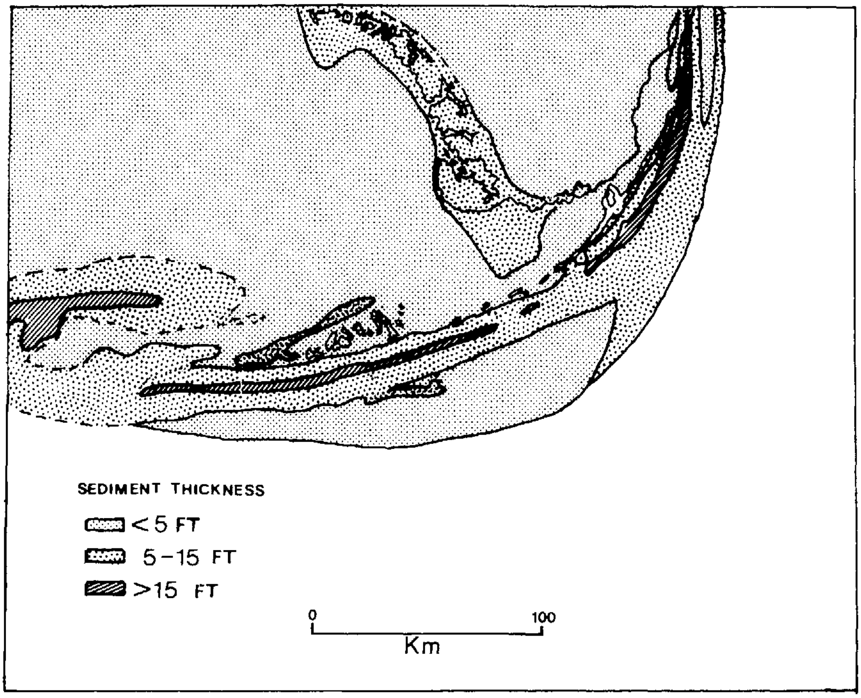


Figure 21. Submerged Sediment Thickness of South Florida. Adapted from Enos (1974)

that its bathyspheric contours have not significantly changed during the last 18,000 years. This assumption is mostly true, as evidenced by a subsidence rate of less than 0.1 cm/100 years for southwest Florida (Scholl et al. 1969:564, n. 14). Still, water loading of the Florida Platform, resulting from melting glacial ice and increased ocean-water volume, could cause subsidence of continental shelves in the deepest area, resulting in a differential subsidence, with the coastal shelf tilting seaward and a slight uplift of the exposed margin. This would occur only when a substantial volume of water had invaded the coastal shelf, and its effects would be seen late. Bloom (1967) has suggested that such coastal loading would have had minimal impact on the southwest Florida coast and would have resulted in a maximum emergence of only 1 m.

THE ESTABLISHMENT OF A HOLOCENE SEA-LEVEL CURVE

There is a consensus that eustatic sea level in southwest Florida has risen to its present position from a low at about 18,000 B.P. of −100-m to −130-m (Curray

1960; Milliman and Emery 1968; Scholl et al. 1969; Kuehn 1980; Fairbridge 1984). The specific nature of this sea-level rise, however, has not been agreed on. Three positions regarding the nature of the sea-level curve can be found in the literature. Two of these positions have been classified by Kuehn (1980); the third position is introduced here.

The Curvers

The adherents of the oscillating-curve model, primarily associated with Fairbridge (1961, 1976, 1984) and Mörner (1969), maintain that although sea level has risen since the Wisconsin glaciation, the rise is not a simple continuous one, but instead is composed of a series of minor transgressions and regressions, with the transgressions ultimately being greater than the regressions. A regression line drawn through these series of individual transgressive-regressive events would result in a continuous curve, but in actuality the true shape of the sea-level rise is that of an oscillating curve.

The theoretical basis for this position lies in the periodic climatic episodes of warming and cooling which occurred during the Holocene. Such episodes, which alternated about every 500 years (Bryson 1974), should result in shrinking and expansion of the polar-ice masses, which in turn would result in eustatic sea-level shifts as potential ocean-water volume is stored in ice. The result of these processes is a series of transgressive-regressive events along a curve which is basically rising through time. These oscillations would not be readily apparent during the earlier portion of the sea-level rise, since the rate of rise then is extremely fast. It is during the Middle Holocene, subsequent to 5500 B.P., when the rate of sea-level rise slowed considerably and the sea level had essentially reached its present position, that these oscillations would be most prominent.

Subsequent to 5500 B.P., eustatic sea level has fluctuated above and below its current position. The data utilized in the construction of the curve have been obtained from a number of areas of the world thought to be tectonically stable. The oscillating-curve model has the advantage of utilizing empirical data from numerous geographical regions, without the methodologically undesirable effect of masking real minor fluctuations in the sea-level curve by smoothing the data points. This advantage may not be justified, however, since the statistical nature of radiocarbon dating and the uncertain tectonic stability of many areas may result in invalid data points. Therefore, it might be that a sea-level curve can be realistically evaluated and constructed only if smoothing techniques are used.

The Smoothers

The followers of the smooth-curve model base their position primarily on data derived from studies of sea-level rise in southwest Florida (Scholl 1964a and b;

Spackman et al. 1966; Scholl and Stuiver 1967; Scholl et al. 1969). These data consist of a series of more than eighty radiocarbon datings of in-situ samples which show the relative position of the sea level after 5500 B.P., determined by drawing a curve below the depths of the dated freshwater sediments. Although the curve does not indicate the exact position of the sea level, it does show that the sea level could not have been above it. This method results in a smooth curve which shows a continuous rise in sea level from a position of about 4 m below the present level at 5500 B.P. to the present position, with the sea-level rise continuously slowing through time. It should be noted that the resultant submergence curve is not a regression line but simply a line drawn below the freshwater data.

This curve was not intended to represent the exact submergence curve, nor does it rule out minor oscillations in sea level, but it should represent the approximate average eustatic position of the sea level during the last 5,500 years (Scholl et al. 1969). Scholl et al. suggest that this approximation is on the order of ± 1.0 m of former eustatic sea level, a position which is followed by almost every researcher working on this problem on the southwest Florida coast (Smith 1968; Shier 1969; Davies 1980; Kuehn 1980).

The Numerical Modelers

The numerical-earth model is primarily the work of J. A. Clark and his associates (J. A. Clark et al. 1978; J. A. Clark and Lingle 1979) and is actually a model of how sea level should rise after the melting of the Wisconsin glaciation. The model assumes that because the earth is not rigid, there would have been a nonuniform rise in sea level as the ice sheets melted, depending on how far the coastal regions are from the glaciated areas. As a result, land masses in glaciated regions would rise relative to sea level, while those farthest removed from these areas would be submerged. The reason for this is that interior earth core material from these nonglaciated areas is depleted as it moves to uplifting areas (J. A. Clark et al. 1978:265).

This movement of earth material is based on the geophysical nature of the earth, which behaves both as an elastic material for stresses of short temporal duration, such as earthquakes, and as a fluid for stress of long temporal duration—that is, centrifugal force. The 20,000-year time span for the stresses resulting from glacial melting and relaxation of the earth is intermediate in duration, and since both viscous and elastic behaviors are involved, a Maxwell viscoelastic material is used as a rheological model.

Farrell and Clark (1976) developed an equation which would account for the change through time in the relative sea level in relation to the redistribution of ice and water on the earth's surface and its effect on the viscoelastic nature of the earth. The advantage of a model of this type is that no correction for eustatic sea-level rise is required, and it has the ability to predict a number of different sea-level curves for different parts of the world. Therefore, for any given rheological and glacial history, it is possible to calculate sea-level changes through time for any location. The model has further utility in that it can be evaluated by fitting data from diverse geophysical regions.

A series of zones with particular types of sea-level curves were generated from realistic histories of glacial retreat and fluctuations in the polar-ice masses subsequent to the glacial retreat (see fig. 22). The nature of the fluctuation in the glacial retreat, particularly whether sea level rose after 5000 B.P., is very important to the distribution of predicted Zones III, IV, and VI. Therefore two separate ice histories are used (J. A. Clark and Lingle 1979). One of the resultant models, the linear-ice-retreat model, assumes no water is added to the ocean after 5000 B.P. The other, the fluctuating-exponential-ice-retreat model, assumes that the sea level continued to rise 0.7 m after 5000 B.P. If the former model is correct, the Florida Peninsula would be in Zone III; however, if the latter model is accurate, this area would instead be in Zone IV. To complicate the issue further, the Florida Peninsula might instead be in Zone VI, coastal zones impacted by shelf-loading (J. A. Clark and Lingle 1979). The model sea-level histories relevant to the south Florida area will help us in resolving the situation.

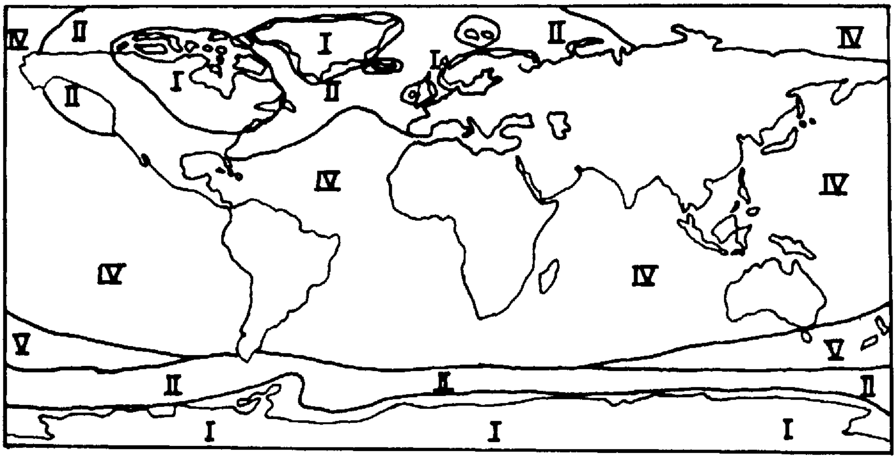
Zone III, time-dependent emergence, covers a very limited area of the globe, and its diagnostic feature is an emerged beach formed only a few thousand years ago. This beach would be difficult to observe empirically, since the emergence would be less than 0.5 m above the present sea level. In their original formulation, before they incorporated the Antarctic ice history, J. A. Clark and his colleagues cited south Florida as an example of Zone III (J. A. Clark et al. 1978), using the curves of Scholl and Stuiver (1967) and Curray (1965), discussed earlier, as data tests.

The curve for Zone IV, oceanic submergence, predicts 0.35 m of emergence beginning at 5000 B.P., followed by submergence of 0.15 m beginning sometime between 3000 and 2000 B.P.

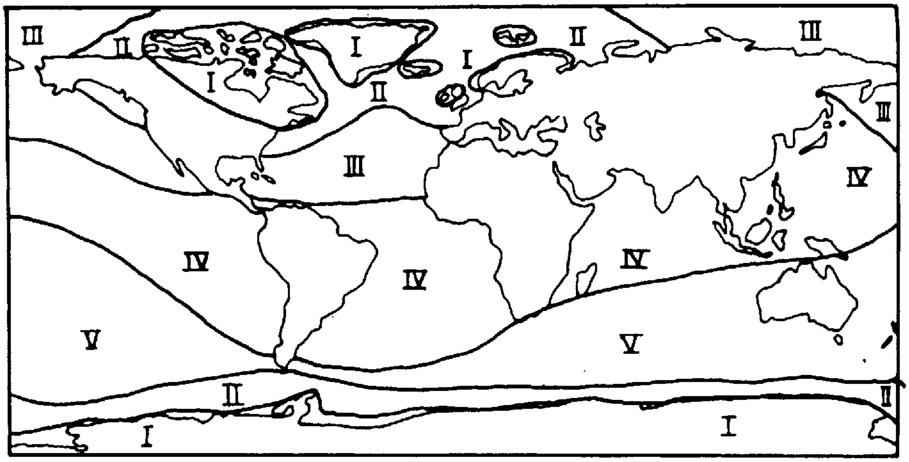
The curve for Zone VI, continental shoreline, predicts a sea level 2 m higher at 5000 B.P. than at present, and then subsidence subsequent to that initial stand. This curve is in line with the Holocene curve developed for coastal Brazil (Fairbridge 1976).

It might be considered that the numerical modeling approach does not adequately resolve the sea-level controversy after 5000 B.P., nor does it define the shape of the sea-level curve, particularly with respect to whether a linear or fluctuating-exponential model is appropriate. The real value of the numerical-earth model of sea-level rise is that it can readily explain and correlate apparently contradictory sea-level data. Thus, a smooth-type curve might be valid for southwest Florida (Scholl et al. 1969), while a different, oscillating sea-level curve is appropriate for coastal Brazil (Fairbridge 1976). The numerical-earth model, then, provides the theoretical basis for accepting regional derivations of sea-level curves, even though they may be contradicted by curves from other areas.

In general, there is little disagreement regarding the pre-5000 B.P. sea-level



Fluctuating exponential ice retreat history



Linear ice retreat history

Figure 22. Model Sea-Level Curve Zones. Adapted from Clark and Lingle (1979)

curve. The problem arises after 5000 B.P. Agreement on the sea-level rise in the Early Holocene may be due to a lack of data points from this earlier period, rather than to an actual consensus. Nevertheless, it is clear that there is a rapid sea-level rise up to this date. The implications of this rapidly rising sea in the Early Holocene are very important, particularly when considered with the to-

Table 14
Sea-Level Transgression for Southwest Florida, in Meters

Date BP	Sea Level	Rate of sea level Rise Per 100 Yrs (1,2)	Rate of Shoreline Transgression Per Year	
			(1)	(2)
15,000	- 128 m	-	-	-
14,000	- 125 m	0.84 m	-	-
13,000	- 115 m	-	-	-
12,000	- 95 m	2.0 m	8.3 m	3.4 m
11,000	- 73 m	-	-	-
10,000	- 55 m	2.2 m	30.4 m	11.6 m
9,000	- 45 m	1.5 m	37.5 m	21.0 m
8,000	- 30 m	-	-	-
7,000	- 20 m	1.5 m	37.5 m	21.0 m
6,000	- 12 m	-	-	-
5,000	- 4 m	-	-	-
4,500	- 4 m	0.213 m	-	-
4,000	- 2.75 m	0.151 m	-	-
3,500	- 2 m	0.107 m	-	-
3,000	- 1.8 m	0.075 m	-	15.2 m
2,500	- 1.2 m	0.053 m	-	-
2,000	- .90 m	0.038 m	-	1.6 m
1,500	-	0.027 m	-	-
1,000	-	0.019 m	-	0.3 m
500	-	0.017 m	-	-
0	-	-	-	-

(1) Rate from Milliman and Emery (1968)
(2) Rate from Kuehn (1980)

pography of the Florida Platform. The sea-level rise and the shoreline-regression rate for this period is shown in table 14. The shoreline-regression rate ranges from 3.4 to 8.3 m/year for 12,500 B.P. to 11,000 B.P., 11.6 to 30.4 m/year for the period 11,000 B.P. to 10,000 B.P., and 21.0 to 37.5 m/year for the period 10,000 to 7,000 B.P. These transgression rates have important ecological implications, particularly when combined with paleobotanical and paleoclimatic information for this period.

The Environment of South Florida during the Late Pleistocene and Early Holocene

The climate and environment during the Late Pleistocene and the Early Holocene were much different from those in south Florida today. Fortunately, an extensive body of paleoenvironmental data for this period in south Florida is available. At

18,500 B.P., western Atlantic surface temperatures off the Florida Peninsula were, surprisingly, only 3° C lower than today's (Watts 1980:380), while the 18,000 B.P. July temperature was 11° C colder than today and much drier as well (W. L. Gates 1976). These reconstructions are based on $0^{18}/0^{16}$ ratios obtained from deep-sea cores, foramenifera assemblages, and CLIMAP modeling (Watts 1980:391). Yet, in spite of these cooler summer temperatures, the Late Pleistocene and Early Holocene environment of south Florida was still tropical.

Carbone (1983:4–6) notes that a tropical environment is possible because the large continental ice sheets acted as barriers to cold, low-level arctic air masses, and so there would be less cold air coming into the area in the winter. The ice sheets themselves, however, would cool the summer air masses, which would also be drier because of the reduced evaporation.

These climatic conditions and their environmental consequences can be more specifically evaluated with palynological data from this period. It is extremely fortunate that a long, continuous pollen record dating from 37,000 B.P. until the present and including three pollen zones has been recovered from Lake Annie in south-central Florida (Watts 1975).

The initial pollen zone from the Lake Annie sequence, Pollen Zone III, begins at 37,000 B.P., and ends at approximately 13,000 B.P. It is characterized by high percentages of rosemary (*Ceratiola ericoides*), jointweeds (*Polygongela fimbriata*), *P. ciliata*, and spike moss (*Selaginella arenicoles*), with oak and assorted composites, including ragweed. The predominant plant cover during this period was rosemary scrub situated on sand dunes, with some stands of oak scattered among prairielike vegetation composed of composites. Pine was absent at this time. The vegetational record indicates that the environment was much drier than today, with insufficient soil moisture for the development of significant amounts of oak scrub. This aridity is also suggested by nonvegetational evidence, as indicated by the extremely slow sedimentation rate of only 0.7 m from 37,000 B.P. to 13,000 B.P. (Watts 1980:400). The pattern of environmental aridity recorded for this area is consistent with the worldwide pattern of aridity established for this period (Cronin et al. 1981), resulting from the locking up of atmospheric moisture in the polar ice sheets.

Pollen Zone II dates from 13,000 B.P. to 4700 B.P. and so corresponds with the Early Holocene, as it is used here. The vegetation of south-central Florida recorded in the pollen profile of Lake Annie at this time is very distinctive and quite unusual. The dry dune species found in the previous period are rare and are replaced by oak, composites, and grasses, with some pine, suggesting to Watts (1975:345) the existence of a desertlike sclerophyllous oak woodland or scrub, together with a prairie rich in composites. No modern vegetational equivalent of this arid environment exists in Florida today. Pollen Zone I dates subsequent to 4700 B.P. and will be addressed later when the Middle and Late Holocene are discussed.

The vegetational shift from the Wisconsin to the Early Holocene—that is, between Pollen Zone III and Pollen Zone II—is puzzling to Watts (1975:346), who cannot understand why a dry Late Pleistocene climate produced a sand dune vegetation, while an Early Holocene climate yielded oak scrub and prairies. Watts (1980:400) suggests that changes in temperature, wind force, and wind direction might be responsible for the change. The latter two factors might have been especially important.

With the sea level dropping as more and more water from the ocean went to polar ice sheets, the nonvegetated, unconsolidated sandy sediments on the Florida Platform, particularly north of Cape Romano, where sediments are sandy rather than calcareous, were exposed. The increased temperature gradients between the polar and equatorial areas caused much more wind force and activity, as suggested by Watts (1980). This wind force, coupled with the aridity, resulted in a surface topography of shifting sand dunes, which were difficult to stabilize, since only xeric wind-tolerant plants—shrubs such as rosemary—could establish themselves. As wind force subsided when the polar ice regions diminished in size, dunes became stable, and other larger and more diverse floras could become established on these dunes, including oak.

One of the patterns emerging in the Early Holocene is the appearance of a series of different vegetational zones. Research at the regional level is not yet complete enough to map out the terrestrial vegetation zones; however, it is possible to begin to see distinct regional differences in floral assemblages in south Florida by 9000 B.P. These patterns are seen in the pollen and macrofloral samples recovered from Little Salt Spring (Clausen et al. 1979) and Warm Mineral Springs (Clausen et al. 1975; Sheldon and Cameron 1976). Both of these sites are located in the coastal region of west Florida in Sarasota County but at 9000 B.P. were located in the terrestrial center of the Florida Platform at 9000 B.P. (see fig. 19).

Pollen obtained from Little Salt Spring, dating to 9920 B.P., was abundant and well preserved but contained only a relatively few species. Trees were represented by wax myrtle (*Myrica*), oak, pine, and hickory. Ferns, composites, and grasses were the only nontree pollen recovered. It is noteworthy that no pollen from aquatic or marsh plants was present, because it suggests that the spring at this time was dry in the upper basin, which in turn indicates that the water level was at least 11 to 12 m lower than at present (Clausen et al. 1979:609–610).

A similar situation is recorded at nearby Warm Mineral Springs (Clausen et al. 1975). Here, plant remains from Pollen Zone III sediments, dated from 9870 ± 370 B.P. to 9370 ± 400 B.P., include slash pine (*Pinus elliottii*), cabbage palm (*Sabal palmetto*), live oak (*Quercus virginiana*), laurel oak (*Q. laurifolia*), pepper-vine (*Ampelopsis arborea*), hickory (*Cayra* sp.), *Phylocacca rigida*, and sinkhole fern (*Thelypteris normalis*). Clausen and his colleagues suggest that the presence of these species indicates a temperature at 9000 B.P. similar to that of today in this region, except that the lower two zones, which span from 9870 ± 370 B.P. to 8520 ± 400 B.P., show more aridity. The drier climate is suggested by carbonate encrustations of sinkhole fern fronds and the geochemical condition necessary for deposition of calcitic mud and tufa, both as encrustations on submerged walls and as dripstone growths. Water level in the spring at this time was between 9.5 and 13 m below present spring depth (Clausen et al. 1975:197).

The aridity of the Late Pleistocene can be explained in part by the worldwide climatic patterns. There is no need, however, to invoke a similar global climatic pattern to account for the Early Holocene aridity characteristic of south Florida. In fact, south Florida today would continue to be classified as an arid climate if it were not for one important lacustrine feature, Lake Okeechobee, which is of relatively recent appearance.

Precipitation in south Florida is seasonal, with most of it occurring in the summer (Thomas 1974). There is also a tendency toward relatively higher coastal aridity in south Florida than in the interior. The coastal zone receives 25 cm less precipitation than does the interior (Gleason et al. 1984:319), owing to the summer convection and evaporation of vast quantities of water from Lake Okeechobee. Before Lake Okeechobee appeared, about 6000 B.P. (Brooks 1984), there was undoubtedly considerably less summer convectional thundershower activity and therefore more arid conditions. Thus, the existence of Early Holocene aridity patterns, similar to those seen during the Wisconsin, is due ultimately to the sea level, since it determines the depth of the water table and hence determined the origin of Lake Okeechobee (Brooks 1984).

Sheldon and Cameron (1976), on the other hand, after analyzing samples collected by Cockrell from Warm Mineral Springs, reconstruct a more mesic climate in the immediate vicinity of the spring during the Early Holocene, suggested by the occurrence of hazelnut, birch, ash, willow, cypress, cattail, and elm. They attribute this mesic character to the occurrence of "blue-grey clayey limestone" at a depth of 1.8–2.4 m (6–8 ft.) below the surface, which retains sufficient moisture despite a reduced water table. A similar wet period is seen between 9000 B.P. and 8000 B.P. in the basal peat layer of the slough adjoining Little Salt Spring (Clausen et al. 1979). Here the dominant pollens are from grasses, composites, and *Chenopodeacea*. These plants are mixed with considerable quantities of water lily (*Nymphaea*), cattail (*Typha*), and arrowhead (*Sagittaria*). Arboreal pollen consists of small amounts of oak, pine, and willow (*Salix*). It seems then, that these sinkholes and related features acted as mesic oases in an otherwise arid karst plain. The existence of this arid karst plain is indicated by the lack of any laterally extensive peat deposits in the interior south Florida area.

Faunal studies of the Late Pleistocene and Early Holocene periods also support the interpretation of more arid conditions at this time and, more important, seem to be more valuable for determining temperature than the existing floral studies. Little Salt Spring (Clausen et al. 1979) represents the best-dated faunal assemblage of the Early Holocene. A date of 13,450 ± 190 B.P. was obtained from an in-situ extinct giant land tortoise (*Geochelone crassiscutata*) killed and consumed by humans. Directly associated with this tortoise were two smaller individuals of the same species, an extinct box turtle (*Terrapene carolina putnami*) and an extinct ground sloth (*Megalonyx* sp.), as well as specimens of the extant species Florida cooter (*Chrysemys floridana*), land tortoise (*Gopherus polyphemus*), diamondback rattlesnake (*Crotalus adamanteus*), rabbit (*Sylvilagus* sp.), and wood ibis (*Mycteria americana*). Portions of either extinct mammoth or mastodon (*Mammuthus* or *Mammut*) and extinct bison were also found on the same ledge of the spring a few meters away (Clausen et al. 1979:203).

Another Late Pleistocene through Early Holocene fossil locality, dating from 30,000 B.P. to 3500 B.P., is that of Bed 2 of the Vero site, located on the southeast coast of Florida (Weigel 1962; Gagliano 1977). Although this bed appears to extend into the Middle Holocene, Gagliano (1977) considers it to be primarily Early Holocene in date, particularly in light of a radiocarbon date of 8200 ± 900 B.P. which was obtained from carbon collected from the lower third of the bed.

An assemblage of 122 vertebrate species, both extant and extinct, were recovered from this bed, including 4 fish, 7 amphibians, 27 reptiles, 37 birds, and 47 mammals. Also recovered were 28 terrestrial and freshwater invertebrates still extant today. Extinct vertebrate species include land tortoise (*Geochelone sellardsi*), stork (*Ciconia maltha*), passenger pigeon (*Ectopistes migratorius*), Harlan's ground sloth (*Paramylodon harlani*), Jeffersonian ground sloth (*Megalonyx jeffersonii*), two armadillos (*Dasypus bellus* and *Holmesina septentrionalis*), bog lemming (*Synaptomys australis*), capybara (*Hydrochoerus* sp.), wolf (*Canis ayersi*), fox (*Vulpis palmaria*), jaguar (*Panthera augusta*), saber-toothed cat (*Smilodon* sp.), mastodon (*Mammut* sp.), mammoth (*Mammuthus* sp.), peccary (*Mylohyus* sp.), horse (*Equus* sp.), camel (*Tanulpoloma mirifica*), and bison (*Bison* sp.), probably (*B. latifrons*). The faunal record of Bed 2 indicates warm, moderate conditions, not significantly different from those today (Gagliano 1977:276–277).

The distribution of the Late Pleistocene terrestrial fossils in the West Indies also supports the reconstruction of more arid conditions (Pregill and Olson 1981). These fossils are primarily xerophytic in habitat and are found primarily in areas of the West Indies which today are too mesic for their existence. These same species, however, are extant in many areas of the West Indies which still have a xeric habitat, suggesting an increased range and more xeric conditions throughout the West Indies during the Late Pleistocene. South Florida is considered to be one of these relic areas, containing at least one extant obligate xeric species, the burrowing owl. Prior to 10,000 or 12,000 B.P., this form was found throughout the West Indies (Pregill and Olson 1981).

Pregill and Olson (1981) suggest that the extinction of many of these Pleistocene forms occurred subsequent to 12,000 or 10,000 B.P., when more mesic conditions developed in many but not all areas of the West Indies. These observations are consistent with the other data previously presented, and when all are considered together, they allow a reasonable reconstruction of the Late Pleistocene and Early Holocene environment of south Florida.

The aridity documented for the Late Pleistocene and Early Holocene in south Florida in conjunction with, and in part a result of, a lower sea level has important consequences for the water table and sedimentation of this region and, ultimately, the ecology of the actual coastal zone during this period.

The lower sea level and arid climate, due to low precipitation, resulted in a water table much lower than at present. The surface level of the water in Little Salt Spring was 26 m below its present level at 13,500 B.P. and 11 to 12 m below at 10,000 B.P. (Clausen et al. 1979:610); and the level in nearby Warm Mineral Springs was 9.5 to 13 m below the present surface at 10,000 to 9,000 B.P. (Clausen et al. 1975). This is confirmed by the relatively recent origin of Lake Okeechobee at 6000 B.P. (Brooks 1984; Gleason et al. 1984). Furthermore, because of the lower water table, none of the springs exposed at this time was discharging surface water. Instead, these springs were sinkholes and cenotes, implying that there were few, if any surface streams in south Florida. There may have been some streams west of the −40-m submarine contour. East of this contour, only a series of sinkholes and cenotes would have existed, scattered throughout the karst region of the exposed Florida Platform.

On the exposed Florida peninsula, these sinkholes are particularly common in the Miocene Tamiami Formation, which is quite permeable and acts as aquifer. The position of the water table of this aquifer is hydrostatically related to the sea level. As sea level rises, so will the water table. It is possible that some of these cenotes and sinkholes-springs on the now-submerged continental shelf might have discharged surface water when the water table rose to the level of the ground surface. Mud Hole is an example of one of these springs (Gagliano 1977). Even so, the surface water responsible for sedimentation would have been negligible, since the two major drainages of south Florida today, the Caloosahatchee River and the Everglades, did not exist.

SUMMARY

In the Late Pleistocene, the physiography of south Florida consisted of a recently exposed, broad peninsula with minimal soil development. It is topographically a relatively low relief karst landscape, with superficial sediments consisting of loose, unconsolidated sands or eroded, calcareous mud and marl. The water table would have been very low, resulting in few surface streams and rivers, and so surface water would have been restricted to cenotes and sinkholes scattered throughout the karst plain. This landscape appears to have contained a series of constantly shifting sand dunes, at least in certain parts of the exposed Florida Platform. These dunes seemed to have formed from the combination of high wind velocities and the availability of loose, unconsolidated sediments. July temperatures during this period were 11° C cooler than today, but these cooler summers did not appear to affect the overall tropical regime, since winter temperatures were mild, nor did it appear directly to affect the type of fauna present (Watts 1975).

The increased aridity of the climate at this time, however, has profound ecological importance. Vegetation on these dunes appears to have been rosemary scrub. Prairielike vegetation, consisting of assorted composites with a few scattered stands of sclerophyllous oak scrub, was found throughout the nondune area. Soil moisture was insufficient for the formation of significant amounts of oak scrub, and pine was totally absent. A wide range of fauna was present. Many species were xeric, although not necessarily all, and numerous species became extinct sometime during the Late Pleistocene and the subsequent Early Holocene. The environmental conditions appear to have been quite homogeneous, but this might be an artifact of insufficient sampling. No modern analogy to this environment exists in south Florida.

Somewhat similar climatic conditions continued into the Early Holocene period. The aridity seen in the preceding period continued, but slightly more mesic conditions may have existed in *localized* areas, notably around sinkholes and springs. This aridity does not appear to be derived from global climatic patterns, as it did for the Late Pleistocene, but instead resulted from a lack of evaporation and convective precipitation, since surface water was scarce.

There was still little or no flowing surface water, although the water table appears to have been elevated enough for the expansion of more mesic floral assemblages. Mesic conditions seem to have been maintained by impervious geological strata which retained sufficient reserves of rainwater. Vegetation during the Early Holocene included xeric scrub oak thickets and woods, interspersed among grassy prairies. More mesic conditions would have prevailed around the sinkholes, which acted as oases where mesic plants, such as hickory, birch, ash, and hazelnut, would flourish, as would a few hydric forms, such as cattail, arrowhead, cypress, and water lily.

The closest contemporary analogy to this Early Holocene environment is the northeast Yucatán peninsula, an exposed karst plateau of the same geological strata as much of the Florida Platform (see fig. 18). Because of its increased surface elevation, it currently has sinkholes and cenotes and a complete absence of flowing surface water. In spite of the obvious homologous origin of these two peninsulas, the environmental analogy should not be considered exact, since although the vegetation is for the most part xeric, the floral components are different. Furthermore, the soils are very different, with those of the Florida Platform having been derived from relatively recently exposed marine formations, while those of the Yucatán were formed in an aerobic context over a much longer period of time, since the greater elevation of the Yucatán peninsula kept it from being submerged during the Pleistocene. The soils are ultimately derived from marine deposits, however, even though they are substantially older.

There are certain commonalities in the fauna of the two areas, most notably *Geomyda*, an extinct tortoise. In spite of the specific difference between these two areas, it is important to note their similarity in terms of hydrology and the basic type of floral and faunal community. Also important is the almost complete absence of sedimentation, which provides for highly productive fluvial environments (H. T. Odum 1974). I do not mean to imply that the terrestrial environment of this time and of the preceding Late Pleistocene was not productive. In fact, if we compare this area of south Florida with similar tropical grasslands and prairies (savannas) in Africa, we see that it probably had unusually high primary productivity (Bell 1971). It seems obvious from the faunal asssemblages that these grasslands supported a wide diversity of animals, much more diverse than is found in the area today. This high productivity, however, is restricted to the terrestrial environments, since river discharge and coastal sedimentation, necessary for highly productive estuaries, did not exist, and terrestrial productivity was limited seasonally by rainfall, a major stress in the environment of this time.

The Coastal Environment during the Late Pleistocene and Early Holocene

The discussion to this point has focused primarily on the terrestrial area of the Florida Plateau, a reasonable starting place, since the available paleoenvironmental data for south Florida are more complete. Most of the contemporary coastal information is either under water or has been destroyed by the rising ocean and thus is difficult to investigate directly. Therefore, it is necessary to interpret or, more precisely, to model the coastal environment using geodynamic, climatological, and ecological variables which were operating at this time. No distinction will be drawn between the Late Pleistocene and Early Holocene periods, since identical coastal conditions apply to both. Minor differences are to be expected between these periods, due to an ever increasing rate of sea-level rise, but the outcome is largely the same.

The complete lack of coastal sedimentation from *riverine* or other alluvial deposition prior to 5500 B.P. severely limits the potential productivity of the coastal zone and results in a coastal environment much different from that of today, described in the previous chapter. Compounding these differences is a very dynamic, rising sea level. It appears that other than moderate- or perhaps high-energy beaches, the only type of coastal ecosystem similar to that of the present-day southwest Florida coast would have been the tropical marine meadow. Although such environments are possible, it seems that even this ecosystem type would be less productive than at present because of the lack of nutrients supplied from fluvial transport. Only one other coastal ecosystem type of any consequence can possibly result from the combination of coastline dynamics and lack of sedimentation. This is the hypersaline lagoon (Copeland and Nixon 1974; H. T. Odum and Copeland 1974).

Hypersaline lagoons would form only if barrier beach ridges with low-lying swales behind them were present. The series of long, linear ridges located west of the −80-m contour could be indicative of these hypersaline lagoons, although it is difficult, if not impossible, to determine if these were formed prior or subsequent to 18,000 B.P. It is possible that such beach-ridge deposits did not exist during all periods of the Late Pleistocene through Early Holocene and thus that such hypersaline lagoons did not exist. Instead, simple moderate- or high-energy beaches may have been present. Still, the prevailing longshore drift pattern of today and the submerged barrier-beach complexes identified by Gagliano (1977) suggest that such hypersaline lagoons were present during this period, if not characteristic of them.

Biotic communities living in hypersaline waters must have the ability to adapt to osmotic problems resulting from high salinity, differential ion precipitation, and strange dissolved oxygen, temperature, and Ph regimes (Copeland and Nixon 1974). Such environments would seem to have reduced productivity when compared with other coastal ecosystem types.

Because the shoreline was rapidly transgressing, the basic coastal environment, regardless of the specific composition of ecosystem types, would have been in an arrested successional regime. Such a regime is particularly important with regard to the stability and productivity of mangrove forests, which, as noted earlier, provide important energies to the coastal environment. It is doubtful that mangrove forest ecosystems would have been extensive during this period, although environmental conditions would have permitted its existence, since a rapidly rising sea would drown mangrove forests before they could mature. Mangrove forests can be maintained in stands of immature individuals as long as seeds, which float, are available. Such seeds need not come from the immediate area, as long as there are mature trees somewhere. It may also be the case that even if the mangroves reached sufficient age for reproduction their limited size resulted in lower production of deciduous leaves, since much of the production would have been invested in standing biomass, including boles and roots, calculated as being one-fifth that of mature riverine forests.

Davis (1940) noted that pioneer red mangrove (*Rhizophora*) grow in water averaging 0.40 m (16 in.), while mature *Rhizophora* grow in water 0.25 m (10 in.) deep or less. A rapidly rising sea level, as is recorded for southwest Florida at this time, would have forced an inland retreat of the mangrove forest zone, with the peat produced by these forests covered by marine sediments (Kuenzler 1974:360). To carry the argument one step further, if the rate of sea-level rise is unusually fast, as has been determined by Milliman and Emery (1968) and Kuehn (1980) (see table 12), mangroves may not reach maturity before they are inundated by the rising sea. A mean difference of 15 cm (6 in.) in water depth represents this drowning. Based on a rate of sea-level rise of 84 cm/100 years, a mangrove tree could have only eighteen years in which to grow before being inundated, resulting in a forest of only immature or small individuals (since mangroves in Florida take twenty to twenty-five years to mature [Davis 1940]), which produce little leaf litter, and therefore little energy.

Although the above example refers specifically to red mangrove, the same situation applies to other species of mangrove, owing to the zonation pattern of these species. Rapid sea-level rise and the resultant drowning of very immature mangrove forests would leave minimal peat development. In some cases, mangroves may be so small that no peat develops, or in other cases the erosive action of a rapidly rising sea level would preclude the preservation of any peat that is formed.

As far as can be determined from a literature search of the Gulf of Mexico, no drowned peat deposits, or other sediments which contain mangrove or estuarine-type environments, have been dated to these periods in southwest Florida, although submerged mangrove peat has been dated to 8010 ± 165 B.P. on Alligator Reef in the Atlantic off the Florida Keys (Robbin 1984). Instead, the submerged coastal plain is covered by quartzy sand in the areas where water depth is greater than 18 m. Beyond this depth, more shells and shell detritus are found in the sediments (Enos 1974; Gagliano 1977:IIE-16). See figure 20. These sediments are consistent with a rapidly transgressing sea with low- to high-energy beaches and suggest a lack of extensive estuaries or mangrove forests for this period. The most conservative statement which can be made is that such environments have not been preserved.

The sedimentary data also substantiate the lack of alluvial discharge onto the southwest Florida coastal shelf. Russell (1967) concurs and has gone on to suggest that it is appropriate to call the Middle Holocene and later the "Age of the Estuaries," implying that it is only after 5500 B.P. that such estuaries, at least in southwest Florida, begin to form.

There is a consensus that there was a rapid sea-level rise during the Late Pleistocene and Early Holocene. If transgressive-regressive fluctuation oscillations existed in the sea-level curve, however, the rise might have resulted in a series of lagoonal formations or more extensive mangrove forests. Still, even if these occurred the rapidly rising sea would have destroyed these habitats and without the energy of river-transported sediments would have added little to the productivity of the coastal zone. The existence of regressive sea stands and their environmental consequences prior to 5500 B.P. are of little importance.

SUMMARY

The coastal environment prior to 5500 B.P. was characterized by moderate- to high-energy beaches, probably with barrier island, beach-ridge complexes and possibly mangrove-fringed lagoons behind them. Such lagoons, if they existed, would be hypersaline, and thus the biotic communities present in them would be severely limited and productivity generally low.

The coastal zone would have been tropical and fringed with mangroves, but because of the ever-rising sea level, coastal submergence would arrest the maturation of mangroves and severely limit or render impossible the formation of extensive mangrove forests. The minimal amount or total absence of fluvial freshwater input into the coastal zone would further affect the potential productivity of the coastal ecosystem.

A contemporary example of such an environment appears to be the Río Lagarto coastal zone of the northern Yucatán peninsula. The saline waters of the impounded lagoon of Río Lagarto do permit the growth of red mangrove, but lack of freshwater fluvial discharge into the lagoon together with the high trans-evaporation rate severely restrict the diversity of plant and animal communities and, hence, the productivity of the coastal zone compared with estuarine environments. The analogy is not an exact one, however, because the Late Pleistocene and Early Holocene coast, as envisioned here, would be rapidly inundated under a progressively rising sea, resulting in a coastal zone less productive than the adjoining interior, terrestrial zones. Thus, human utilization of this zone would be more restricted than it would be later.

The discussion thus far pertains only to the area south of Sanibel Island. In the coastal zone north of this area, a series of drowned submarine drainages are located between the −60- and −40-m contour, dating from 14,000 to 8,000 B.P. (Ballard and Uchupi 1970). Prior to this period, environmental situations identical with those previously discussed existed for the region north of Sanibel Island.

It appears that during the initial part of the Early Holocene, the sea was at a level which resulted in the surface discharge of water from springs along this part of the coast. These springs were located west of the −40-m contour, and since the water table was 26 m below its present position in the central portion of the exposed peninsula at 13,500 B.P., these drainages probably occurred somewhere where the water table intercepted or was close to the surface topography.

Brackish estuaries would be expected to have occurred at the mouths of these drainages and have higher productivity and resource potential than the hypersaline lagoons described above, although they would still be subject to rapid drowning as sea level rose. The estuarine resources, however, and more important, the "unearned" surface water—that is, water which does not result from rainfall (Birdsell 1953)—would foster the growth of mesic habitats along the banks of these drainages, perhaps gallery forests. Sedimentation would still be minimal, since the springs and their drainages would be flowing through limestone, and the aridity of the interior region would result in little organic nutrient input from surface runoff caused by precipitation. Still, the fluvial margins of these drainages would provide excellent habitats for faunal and floral resources, particularly compared with the arid interior regions.

Surprisingly, these drainages are not present after 8000 B.P., presumably because of differential porosity of the surface geology between the −40- and −20-m submarine contour or else decreased rainfall or subsurface water discharge. The absence of these features may also be due to the slower sea-level rise past the −40-m submarine coastline, which resulted in erosion of these features. Since sea-level rise was extremely rapid before this time, these features would have been preserved between the −60- and −40-m contours because there was minimal time for severe erosion (Ballard and Uchupi 1970). It should be emphasized that these conditions existed only in the coastal zone *north* of Sanibel Island.

The ecosystem type that would have existed at the mouths of these drainages have no modern analogies in the ecosystem classification system devised by H. T. Odum and Copeland (1974). The mouths of these drainages would have had characteristics of the oligohaline type (Copeland et al. 1974; H. T. Odum and Copeland 1974) but would also be similar to those of a neutral embayment if the freshwater discharge rates were low and constant, a situation which is suggested. The rapidly rising sea level would have brought with it additional stress in the ecosystem, one not present in contemporary ecosystems, which may have been characteristic of ecosystems with strong tidal range.

The Environment during the Middle Holocene

By 5500 B.P., the sea level had reached sufficient height, approximately −4-m, to raise the water table high enough to provide both the discharge of water from springs and the storage of surface water in lakes. The most important lake was Okeechobee, but the entire hydrology of the Florida aquifer was influenced so that substantial discharge of subsurface water occurred (Gleason et al. 1984). This change had important implications for the vegetation of interior south Florida, because a tremendous volume of surface water now became available for evaporation and later precipitation during summer convectional thunderstorms (Gleason et al. 1984:319). The climate of this period became much moister than the Late Pleistocene and Early Holocene. As a result, both the coastal and terrestrial environments of south Florida began to take on their contemporary form, and essentially modern climatic patterns and vegetation types, although not their distribution, were established.

The hydric surface conditions of Lake Okeechobee and the Everglades were conducive to the formation of a broad range of hydric plant communities previously absent. The formation of these plant communities was in turn responsible for the initiation of freshwater peat deposits at 5500 B.P., and marine and brackish water peats also began to be formed in the coastal zones. No peat, freshwater or marine, is recorded from southwest Florida prior to 5500 B.P. (see appendix).

Vegetational changes recorded in the sediments from Lake Okeechobee, Taylor Slough, and the Everglades (Brooks 1984; Gleason et al. 1984) at 5000 B.P. indicate that hydric plants were appearing for the first time in the low-lying interior basins, which formerly were dry prairies. These newly formed hydric plant communities made distinctive peat types which have characteristic plant associations. These freshwater peat types and their associated plant assemblages are Okeechobee muck (custard apple muck), formed in custard apple swamps; Okeelanta peaty muck, in elderberry willow swamps; Everglades peat, formed from sawgrass marsh; Loxahatchee peat, associated with water lily sloughs; Gandy peat, formed by tree-hammock plant communities; *Rhizophora* peat, formed by red mangrove swamps; and sedimentary sapropels, formed from allochthonous detritus.

Whether all of these peat types have existed from 5000 B.P. on is not known, since stratigraphy has not been established in all areas. Furthermore, the post-drainage conditions of the interior wetlands may have been responsible for some of the peat types (Gleason et al. 1984). In all cases, however, peats are associated with increased surface flow of water and a water table at or above the surface, the latter being essential for peat formation.

Besides the origin of these hydric plant communities, the earlier, distinctive, upland floral assemblage *Quercus-Ambrosia*, Pollen Zone II, is replaced at 4715 ± 95 B.P. by the *Pinus-Myrica*, Pollen Zone IB, recorded by Watts (1975) at Annie Spring, which is dominated by high percentages of pine pollen and gradually increasing oak. Substantial amounts of wax myrtle (*Myrica*) and some *Taxodium, Ilex, Gordoria,* and *Serona* are also found in this pollen zone, suggesting a long-leaf pine (*Pinus palustris*) forest along with cypress swamps and bayheads.

At 2630 ± 85 B.P., Pollen Zone IA, pollen assemblages of bald cypress and pine increase at the expense of oak. Approximately at this time, 2700 B.P., cypress swamps increased in area in Florida (Watts 1975, 1980). Environmental conditions of south Florida had become similar to those seen today, however, because the rising sea level was at a sufficient elevation to allow for the emergence of the physiographic features and their vegetational components which we see today in their contemporary distributions. Cypress stands and swamps were especially prominent because they require very hydric conditions.

The correlation of this date with the date at which sea-level rise dramatically slows (Kuehn 1980) is certainly not coincidental and, instead, demonstrates the dynamic interrelationships of sea level, hydrology, physiography, and vegetation in southern Florida.

The date of 2700 B.P. seems to be the best approximation of the earliest time at which the environment as we know it today of both the coastal and interior regions of south Florida developed. Not only does this date represent the formation of the contemporary environment, in types of ecosystems present, but more important, it represents the time at which the location and spatial distributions of these ecosystems are essentially the same as their present distributions. I do not wish to imply that minor fluctuations have not existed subsequent to 2700 B.P. Clearly they have, but the major resource zones were established by this time, and subsequent *major* modification by natural, non-man-made processes did not take place. Cyclical and seasonal fluctuations in environmental conditions, particularly hurricanes but droughts and fires as well, have drastic effects on the ecology and hydrology of south Florida (Tebeau 1974; Alexander and Crook 1984; Gentry 1984; Gleason et al. 1984), as would a sea-level position higher than that of today.

SEA-LEVEL RISE IN THE MIDDLE HOLOCENE

The specific nature of the sea-level rise subsequent to 5500 B.P.—that is, whether smooth or oscillating—is an important issue, because it is during this period that the coastal zone becomes stable enough for human occupation. At approximately 5500 B.P., the rate of sea-level rise slowed to a range estimated to be somewhere between 8.3 cm/100 years (Scholl et al. 1969:56) and 21.3 cm/100 years (Kuehn 1980). The latter rate is considered accurate, since it is based on actual peat sedimentation rates and changes in elevations of freshwater marine peat interfaces in a transect of offshore peat profiles.

It is thought that sea-level rise data are most representative of the actual coastal history the closer they are to the study area, irrespective of the accuracy of the particular theoretical position—that is, smoothers versus curvers. The numerical-modeling approach is not specifically useful for resolving the accuracy of either of the above two schools, nor is it useful for independently predicting the type of Holocene sea-level history for southwest Florida, since three different histories are possible. Therefore, the data themselves will provide the basis for evaluating relative sea-level rise for south Florida.

There are overwhelming data which clearly establish a continuous rise in sea level for southwest Florida from 5500 B.P. to the present (Scholl 1964a and b; Spackman et al. 1966; Scholl and Stuiver 1967; Smith 1968; Scholl et al. 1969; Shier 1969; Davies 1980; and Kuehn 1980). All these studies use smoothing techniques for plotting sea-level data. Scholl et al. (1969:564, n. 7) state that age uncertainty of their samples, which are equivalent to the samples used by the other studies cited above, is about 100 to 300 years, while elevation errors are on the order of 0.3 m, except for larger errors associated with peat samples located above bedrock but below dense sediments, which are subject to compaction of as much as 0.5 m when thicker than 1.0 m. Such errors imply that there might be datum points which are at variance with a curve drawn between such points.

While the curve is accurate overall, it may not be possible to measure small-scale (i.e., ± 0.5 m) oscillations at certain specific points of time, particularly when the sea rises to a level close to its present position. Scholl and Stuiver (1967:451) note that the southwest Florida sea-level data are not complete enough to rule out the possible rapid, low-amplitude (0.5 m) excursions of the sea level above the contemporary position during the last 1500 to 1000 years; they further add that sediments which would be deposited during such higher sea-level excursions might be overlooked because of their similarity to hurricane deposits (Craighead 1964; Scholl and Stuiver 1967:451). Also, any organic sediments (i.e. peat) deposited above a higher sea level would be subject to erosion and might be destroyed.

In conclusion, there is a general agreement by all researchers working in southwest Florida that sea level rise began to slow at 6000 to 5000 B.P. and that the sea level at 4000 B.P. was approximately 4 m below its present position. The rate of rise diminishes through time, with a marked decrease at 2700 B.P. (Scholl 1964a and b; Scholl and Stuiver 1967; Smith 1968; Scholl et al. 1969; Shier 1969; Davies 1980; Kuehn 1980).

I do not mean to imply that there has never been a higher than present stand of sea level in southwest Florida subsequent to 5500 B.P. Prior to the development of radiocarbon dating, it was thought that the Silver Bluff shoreline, which is above the present sea level, was Holocene in age. Radiocarbon dating, however, has placed this sea stand in the Sangamon period of the Pleistocene, circa 100,000 to 30,000 B.P. (Hoffmeister 1974; Cronin et al. 1981).

Claims of a higher sea-level stand at 5000 to 4000 B.P. have been made for the Florida coast. One of these claims concerns the beach-ridge complex of St. Vincent Island on the northwest Florida coast (Stapor 1975; Stapor and Tanner 1977). A similar claim is suggested for a beach-ridge complex on Sanibel Island, a barrier island of the Port Charlotte–Pine Island Sound region (Missimer 1973), and a final claim is suggested for the Cape Romano area of southwest Florida (Holmes and Evans 1963).

Stapor and Tanner (1977) claim that the Holocene sea level increased about 1.5 m at about 5000 B.P. Subsequent to this, a fall in sea level occurs. Their evidence is the existence of a topographically high scarp, possibly Sangamon in date, which has been wave-cut with a series of low marsh, buried beach ridges located seaward of it. The only age estimates are provided by the location of archaeological sites on these features, which date from approximately 4000 to 3000 B.P. (Stapor and Tanner 1977:53). Although the ridges were formed prior to 4000 B.P., there is nothing to suggest (i.e., radiocarbon dating of the beach ridge) that they were formed by a higher sea level at 5000 B.P.

It is entirely possible, if not probable, that the oldest of these features, the ones with early cultural material on them, were formed by a Sangamon sea, and then later beach ridges were added on to these early ridges during the Middle Holocene, as is the situation at Horr's Island (McMichael 1982) and at Marco Island (Widmer 1974). There is no evidence to suggest that these features were formed during the Holocene and hence indicative of a higher Holocene. The only statement which can be made regarding the age of these early beach ridges is that they predate, by some *unspecified* amount of time, 4000 B.P.

Another claim for a higher sea stand is suggested for beach ridges on Sanibel Island, which is located in the northern sector of the study area (Missimer 1973). The second oldest set of beach ridges, known as the Wulfert Ridge set, has a maximal elevation on the highest ridge of 3 m (10 ft.) above sea level. This set of beach ridges has been dated at 2131 ± 100 B.P. and 2102 ± 85 B.P. for elevations of 1.8 to 2.1 m (6 to 7 ft.) and 2.4 to 3.0 m (8 to 10 ft.) respectively. Missimer (1973:388) believes that the systematic elevation change of the Wulfert Ridge set represents a sea-level stand 2.4 m (8 ft.) above present sea level at about 2100 B.P.

This position is inconsistent with in-situ peat and shell dates of this time, which show a low sea level: 2275 ± 200 B.P. for red mangrove peat 1.7 m (5.8 ft.) below present sea level from a core 0.4 km (0.25 mi.) offshore of the mouth of the Harney River (Kuehn 1980); 2,285 years ago (calendrical age) for mangrove peat in the Ten Thousand Islands 1.35 m below sea level (Shier 1969:489); and 2180 ± 110 B.P. for marine and freshwater shell 0.78 ± 0.33 m below present sea level (Scholl and Stuiver 1967:443). From these data, it appears that the Wulfert beach ridges of Sanibel Island are attributable to wave deposits associated with a hurricane or some other type of storm activity rather than in-situ deposition. This is not all that surprising, since Beach Ridge Set 1, the oldest on Sanibel Island, was formed when the sea level was at least 2.4 m (8 ft.) below the top of the beach ridges.

Holmes and Evans (1963) have suggested that the Ten Thousand Islands were formed during a higher sea stand, perhaps at Silver Bluff time, when longshore drift brought quartz material southward, forming a series of shell bars paralleling the coast. The sea level then fell to its present level, and the southward drift of sand was diverted west to form the Cape Romano shoals. Shier (1969), however, has shown that this scenario is not responsible for the formation of these islands, and hence no recourse to a sea stand higher than present is required. Even if the coastal dynamics presented above were responsible for the formation of these islands, they would have occurred in the Sangamon of the Pleistocene, rather than the Holocene, because it is now known that the Silver Bluff sea stand dates to this period (Hoffmeister 1974; Cronin et al. 1981).

In conclusion, there is no evidence of a sea level substantially higher than at present during the Middle Holocene on the southwest Florida coast. Still, slightly higher, rapid transgression, on the order of 1.0 m or less, is possible, since the geological sedimentary data are not well suited specifically to detect, and therefore to verify or to deny, the existence of such fluctuations.

The Formation of the Southwest Florida Coastal Zone

At approximately 5500 B.P., the rate of sea-level rise began to slow and the present coastal configuration evolved. A staggering body of research has accumulated regarding this coastal formation, whose history will be presented in two parts, one addressing the low-energy coast characteristic of the Ten Thousand Islands, and the other, the northern moderate-energy beach zone which runs from Cape Romano north to Cape Haze.

At 5500 B.P., the sea level, and hence the water table, was at a sufficient height for flowing surface water to occur on the Florida peninsula. The formation of Lake Okeechobee resulted in the development of two major drainages, the Caloosahatchee River, which flows west from Lake Okeechobee and discharges into the Pine Island Sound, and the Everglades, which flows south from the lake and empties its water into the Gulf of Mexico on the southwest coast of Florida in the region south of the Ten Thousand Islands.

With the formation of these drainages, extensive fluvial sedimentation occurred on the southwest Florida coast for the first time. This sedimentation and the in-situ sedimentation in the coastal zone complicate an interpretation of the initial coastline position for this period, since superficial bathymetry, used for determining relative coastline position for earlier periods, is no longer valid. Fortunately, extensive sediment cores have been obtained from the southwest Florida tidal plain which provide data sufficient for actually mapping coastal development.

THE TEN THOUSAND ISLANDS

The Ten Thousand Islands are today an archipelago of mangrove keys found adjacent to an arcate, concave coastline on the southwest Florida coast south of Marco Island. The seaward islands of this archipelago are characteristic of a low-energy coast and today are immune from beach-ridge development and longshore drift owing to their protected nature (Tanner et al. 1963). These islands are composed of unconsolidated sediments deposited over the last 5,000 to 6,000 years (Shier 1969), with the bedrock underlying these sediments the limestone of the Tamiami Formation, a marine deposition dating to the Late Miocene (Dubar 1958; Puri and Vernon 1964).

Bedrock relief and sea-level position determine the thickness of the Holocene sediments along the current southwest Florida tidal plain. The Tamiami Formation slopes gently seaward from an exposed position near the Tamiami Trail to a depth of 1.5 m (5 ft.) below mean sea level under the coastal margin of the mainland, 2.4 m (8 ft.) below mean sea level along the landward margin of the Ten Thousand Islands, 3 m (10 ft.) below mean sea level through the central zone of the Ten Thousand Islands, and finally to a depth of about 6 m (18 ft.) below mean sea level at the seaward edge of these islands (Shier 1969:491; Gleason et al. 1984:301).

The combination of slowly rising sea level and this low-angle, slightly dipping shelf favored the development of thick sedimentary deposits (Gleason et al.

1984), which resulted in a shallow, seaward-dipped plain with a slope of 0.86 m/km (1.8 ft./mi.). The surface of the Tamiami limestone bedrock is irregular, with a relief of several feet (Shier 1969:491), and is unconformably overlain by a layer 0.3 to 0.9 m (1 to 3 ft.) thick of stiff, marsh-deposited, blue-gray clayey sand which occurs locally throughout the Ten Thousand Islands. The tops of these marsh sediments are in all cases at least 3.9 m (13 ft.) below mean low tide. The spotty distribution of these marsh sediments is thought to be due to the topographic vagaries of the exposed bedrock or else a result of the erosive action of the rising sea (Shier 1969:491). It is not possible to determine whether the marsh sediments are freshwater or marine in origin, since fossils are missing, although it is thought that these clays and similar clays along the southwest Florida coast are pre-Holocene in age (Scholl 1964a; Smith 1968; Shier 1969).

The initial Holocene sediments were clean sands transported from the Cape Romano Shoals, or slightly silty sands containing peaty lumps, which lie directly on the Tamiami limestone or the clayey marsh deposits and appear to have accumulated as small bars in a shallow lagoon. The peat lumps are indicative of mangroves colonizing these bars. Fauna associated with these sediments consist of only a few species which tolerate both brackish and hypersaline conditions. Water circulation at this time was very limited (Shier 1969). The closest analogy to this environment would be present-day Florida Bay, although salinities would have been higher than in Florida Bay, owing to freshwater discharge from Taylor Slough (Gleason et al. 1984). Water circulation in Florida Bay seems to be greater as well because of greater tidal access.

As the sea level continued to rise, the lagoon behind these sand bars with their mangrove-fringe communities became deeper, and water circulation with the Gulf of Mexico improved. Tidal currents now brought in clay- and silt-size sediment, and organic silts began to form in shallow bays, protected by mangroves which became established in the matrix of the silt-clay sediments of the bay bottoms. Shier (1969) then suggests that oysters colonized the outer barrier sand islands as sea level continued to rise. This seems unlikely for several reasons.

The shifting sands of the barrier sand bars, which would have been exposed to strong tidal scouring and wave erosion, would not provide adequate substrate for the growth of oysters, since oyster larvae must rest on solid substrate such as shell, rock, or hard bottom to develop (Maghan 1967). Only the arched roots of red mangrove would provide such a substrate during this period, and these colonies were only minimally developed. Thus, the necessary hard substrate did not exist on the exposed sand bars. Also, optimum growth of oysters occurs within salinity ranges of 5 to 25 ppt, salinities greater than 30 ppt inhibit growth and reproduction and cause extensive damage by allowing invasion of predators (Maghan 1967), which is substantiated by an ecological study of the north Florida Bay located just south of the Ten Thousand Islands. Here, oysters are not found in high salinity waters but are usually in salinities below 30 ppt (Tabb et al. 1962:64), lower than the 32 to 35 ppt salinity which would be characteristic of the waters of the open Gulf of Mexico (Shier 1969). Therefore, these barrier sand bars, which would be exposed to the high salinities of the open Gulf, would not be conducive to the formation of oyster reefs.

If this is true, what is the origin of the oyster reefs which are found on the outer barrier sand bars? Erosion and redeposition of oyster shells, particularly those which would form on red mangrove roots is one possible explanation. This does not seem probable, however, since the waters on the seaward side of the barrier island sand bars would be too saline for oyster growth, nor does it seem possible for tidal currents to sweep oysters from more interior, low-salinity regions of the bay onto these sand bars, since tide would be going out and deposition would not be possible. Another possibility is that there were freshwater to brackish water transition zones seaward of the reef barriers in which oysters formed. Hurricanes and other strong wave action then deposited them on beach ridges, forming the barrier island. Such freshwater–brackish water transition zones have been recorded 1.6 km (1 mi.) seaward of the mouth of the Harney River (Spackman et al. 1966; Kuehn 1980). These zones postdate the age of the sand-bar formation (5000 B.P.) in the Ten Thousand Islands, however, and moreover, no such transition zone has been recorded for the Ten Thousand Islands area, primarily owing to the fact that freshwater runoff at this time exited to the south of the Ten Thousand Islands. Therefore, it seems unlikely that erosion and wave redeposition are responsible for the formation of oyster shells on these sand bars, nor is an in-situ origin of these reefs feasible. The most probable origin of these thick oyster reefs is anthropogenic. These shell "reefs" probably represent shell middens of early aboriginal use of the Ten Thousand Islands.

The hard substrate oyster reefs were probably formed when the sand-bar beach ridges were exposed aerially. These oyster heaps are as much as 1.5 m in thickness (Shier 1969:497, fig. 7). The rising sea level then inundated these oyster "reefs," and ecological conditions became favorable for the development of vermetid (worm rock) reefs on the hard oyster substrate. The vermetid reefs are formed by the sessile gastropod *Vermetus* (Thylaeodus) *nigricans* Dall. These animals produce calcareous tubes that fuse together to create a wave-resistant "rock" substrate. *Vermetus nigricans* requires salinities above 25 ppt and thrives in ocean salinities of 32 to 35 ppt. The animals are tropical and become established only where hard substrate is available in the intertidal zone. They are filter feeders, and strong currents are thus necessary for growth; however, they are not affected by turbidity (Shier 1969).

Once the initial vermetid colony was established, the reef rock formed an ideal substrate for further growth, which depended on two factors: the topography of the sand bars and the rate of sea-level rise. Where sand bars were broad and shallow, rapid lateral expansion was possible. In cases where sand bars had pronounced elevations, expansion into deeper water was slow, since a thick, solid, reef rock talus had to be formed in order to colonize the deeper water of the sand-bar slopes. Once the reef was established, vertical growth continued and was facilitated by a rising sea level, resulting in reef cores of considerable thickness, up to 2.7 m (9 ft.) in some cases (Shier 1969).

There are two types of vermetid reefs, deep-seated and shallow-seated. The deep-seated reefs, with thicknesses greater than 1.2 m (4 ft.), are associated with the earlier part of the Middle Holocene sea-level rise, which was quite rapid, and they represent the initial reef and key-forming features of the Ten Thousand Islands. As sea-level rise slowed, sedimentation kept pace with the rising sea, and so shallow-seated vermetid reefs, those which expanded laterally rather than vertically, formed seaward of the deep-seated reefs (Shier 1969). These shallow vermetid reefs are 0.6 to 1.2 m (2 to 4 ft.) thick and require strong water current to supply nutrients. This requirement and the animals' resistance to the effects of turbidity usually associated with other sessile molluscs favor a seaward position of these reefs as long as hard substrate is available.

Although it was suggested earlier that the vermetid reefs forming on sand bars developed on anthropogenic shell accumulations, not all vermetid reefs are formed from shell middens. Many of the shallow vermetid reefs studied by Shier (1969) formed on oyster bars situated on silt and shell or peaty-sand sediments (Shier 1969:fig. 8). These oysters probably attached themselves to mangrove roots, whose existence is evidenced by the peaty lumps which provided the substrate for oyster-reef formation. Further sea-level rise would result in inundation and destruction of the mangroves but would leave the oyster substrate behind.

As sea level rose, so did the available surface water runoff from the interior, and so salinities became more conducive to oyster growth as well. The oyster reefs were in turn colonized by vermetids as water became too saline for oyster growth, when marine transgression eventually outstripped the brackish environment. The vermetid reefs would form in the shallower regions of the lagoon, which were protected by the reef barriers. Lagoonal reefs are usually the younger, shallow, laterally expanding vermetid reef type, typical of a more slowly rising sea.

Sea level rose approximately 1.8 m (6 ft.) during the establishment of these deep-seated barrier reefs, and Shier (1969) suggests that they appear at approximately 3000 B.P., a date consistent with that of 3260 ± 65 B.P. for a mangrove peat 1.2 km (0.75 mi.) offshore of the mouth of Harney River, which was formed when the sea level was 1.8 m (6 ft.) below its present position. This sample was from the upper peat-marl interface, which is indicative of the sea-level position (Kuehn 1980). Scholl (1964a:361) also suggests that the sea level at 3300 B.P. was 1.74 ± 0.72 m (5.8 ± 2.4 ft.) below its present position.

As the rate of sea-level rise slowed, shallow vermetid reefs formed in the lagoonal system, and sedimentation began to keep pace with the rising sea (Shier 1969). This is thought to have occurred at 2000 B.P. (Shier 1969), a date also followed by Scholl (1964a, 1964b). The sea-level curve of Scholl and Stuiver (1967), however, would place this at a slightly earlier date, perhaps 2500 B.P., which is followed by Kuehn (1980:53, table 5), who places the shift in sea-level rate at 2775 B.P. It was probably at this time that the Ten Thousand Islands took on their present character, even though the sea level was still about 1.2 m (4 ft.) below its present position. This date also marks the beginning of the Late Holocene, which in the scheme followed here, dates the appearance of the modern coastal environment.

In the region south of the Ten Thousand Islands, coastal formation processes were somewhat different, ultimately resulting in a different coastal configuration. The present coast, as well as its position at about 5000 B.P., was too far south and east to develop sand-bar-type shoal deposits derived from longshore drift from the Cape Romano Shoals. Contemporary navigation charts show a lack of offshore shoals south of the latitude of the lower Ten Thousand Islands. The underlying bedrock depths and contours have been determined by Smith (1968: 103–105) for the southern southwest Florida coast. The slope of the coastal plain is similar to that of the Ten Thousand Islands area and has a contour configuration almost identical in shape to that of the contemporary coastline.

Of particular interest is the slightly higher bedrock bulge of the Cape Sable region, which may control the position of the cape (Scholl 1964a; Smith 1968). The slightly elevated bedrock in the Cape Sable area is probably a result of its more recent geological deposition. The bedrock here belongs to the Miami Formation of the Pleistocene, oolitic limestone deposited during the Sangamon (Hoffmeister 1974), rather than the Late Miocene Tamiami Formation found to the north. This distinctive geomorphological situation (see fig. 6) results in an erosional-depositional history in this area that differs from that of the Tamiami Formation.

Another important characteristic of the coast below the Ten Thousand Islands area is that it is the major discharge area for fresh water from the interior, notably from the Everglades. The Shark River Slough is the most important of the discharges, draining the Everglades and therefore Lake Okeechobee through a troughlike depression in the Miami oolite, a Pleistocene formation which as previously mentioned replaces the Tamiami Formation in this area (Gleason et al. 1984). A thick (3 to 5 m) peat sequence has accumulated in the Taylor Slough, another of the Everglades drainages, which, unlike the Shark River Slough, has emptied south into Florida Bay during the last 5,000 years (A. D. Cohen 1968; Spackman et al. 1969; Gleason et al. 1984).

The importance of this coastal peat sequence is that it is at least 4,000 years old (Spackman et al. 1969:6), indicating that the Lake Okeechobee and interior fresh water drainages, primarily the Everglades, have been discharging fresh water into the southern region of the southwest Florida coast during the last 5,000 years. This is not to suggest that there was no freshwater discharge into the Ten Thousand Islands area during the Middle Holocene. This is clearly not the case, as evidenced by the existence of oysters at this date. Oysters require reduced salinities, and so some fresh water was finding its way into this region, perhaps brought from the area to the south by tidal transport.

A more likely origin of fresh water, however, is groundwater seepage into the coastal zone as the water table rose in response to increasing sea-level elevation. Willis (cited in H. T. Odum et al. 1974:275) has observed that fresh water originating from the limestone bedrock has leached into the salt water of the Cross Florida Barge Canal. This intrusion of fresh water has reduced the salinity in the canal and has resulted in the production of thousands of bushels of oysters. Therefore, surface drainage and outflow is not necessary for reduced salinities and oyster production, since the sea level was too low for the water table to attain a position high enough to discharge surface water through the higher elevations of the interior coastal physiography of the Tamiami Formation which adjoined the Ten Thousand Islands. This is witnessed by the increased sedimentation rate after 2700 B.P., as discussed earlier, and by the lack of the Big Cypress Swamp, the physiographic feature presently in this area, prior to 2700 B.P. (Watts 1975, 1980; McPherson 1984).

The lack of barrier-reef development and increased water discharge in the southern region of the southwest Florida coast resulted in a marine transgressive history quite distinct from that of the Ten Thousand Islands, which has been thoroughly documented by numerous studies (Curray 1960; Scholl 1964a and b; Spackman et al. 1966, 1969; Davies 1980; Kuehn 1980; Gleason et al. 1984; Wanless 1984). At approximately 5000 B.P., before the coastal area had been transgressed by the modern sea-level position, the environment of the coastal region was freshwater marsh. This is clearly demonstrated by the recovery of peat and pollen in sediments from a core taken 2 km (1.25 mi.) seaward of the mouth of the Harney River. The peat and pollen from this core indicate the existence of a freshwater open marsh environment dominated by Cyperaceae, *Sagittaria*, and *Ovoidites*, with large amounts of *Pinus* in the pollen recovered from the matrix of the basal peat, located approximately 2.8 m (9.3 ft.) below sea level over sandy sediments (Kuehn 1980:35–37). The upper interface of marl and mangrove peat was dated at 4095 ± 75 B.P. A transect of additional cores placed sequentially at intervals toward the shore reveal a clear transition from freshwater peat through brackish peat and then to a marine mangrove peat (Kuehn 1980). This pattern is repeated in the core studies of the tidal plain (Smith 1968) and in Florida Bay (Davies 1980).

The vegetative transition represented by these peat types and their affiliated environments and vegetative components have been determined by Kuehn (1980: table 5). These are sawgrass prairie, composed of *Mariscus*, *Mariscus-Sagittaria*, and *Mariscus-Nymphaea* peats; brackish water *Spartina-Juncus* marsh, consisting of *Rhizophora-Juncus*, *Rhizophora-Mariscus*, and *Rhizophora-Acrostichum-Mariscus* peats; and mangrove swamps composed of *Rhizophora* root peat and *Rhizophora* sedimentary peat. These peat formations can be further categorized (Kuehn 1980) according to sedimentological energies responsible for their deposition. Pollen Zone II is marine and is subdivided into a coastal mangrove-fringe environment, composed of *Rhizophora, Avicennia, Laguncularia*, and forams palynomorphs and an inland mangrove-fringe environment consisting primarily of *Rhizophora, Laguncularia,* and *Conocarpus* forms. Pollen Zone I consists of brackish and freshwater environments and is further subdivided into three subzones; a brackish marsh environment consisting of *Typha, Conocarpus, Rhizophora*; a freshwater marsh comprised of open-marsh types, and *Pinus*; and a mixed basal headwater environment containing open-marsh types, *Pinus, Rhizophora,* and *Borrichia* palynomorphs.

The initial brackish water environment forming in the coastal zone during the Middle Holocene would be a juncus marsh similar to those seen today in the interior tidal plain. Such a marsh is recorded at a position 2 km (1.25 mi.) off the mouth of Harney River in core 76-12 and dates sometime prior to 4095 ± 75 B.P. (Kuehn 1980). This marsh-type environment was then replaced by mangrove swamp forest, which deposited thick peat, with 3.3 m (11 ft.) of marine, black mangrove peat deposited in the onshore core 59-T1 at the mouth of the Harney River (Spackman et al. 1966).

The vegetative transition, unlike that seen in the Ten Thousand Islands area, was a continuous process, primarily resulting from a transgressing sea bringing increasingly saline water to the exposed shoreline. Spackman et al. (1966:148) believe that the existence of fresh water flowing from the interior for 5,000 years, together with the very flat attitude of the Florida Plateau, resulted in a gradual rather than an abrupt transition in the vegetation, as witnessed in the peat profile. Added to this is the deposition of fine organic sediments and the back-wave scouring. As Wanless (1974:195) has noted: "Paralic mangrove peats adjacent to a focus of freshwater drainage tend to be wide and thick, channeled accumulates that yield gradationally inland to freshwater peat." Therefore, it appears that freshwater influx has tempering or moderating effects on marine transgression and that shoreline configuration and environmental gradients of earlier coastlines are similar to the contemporary coastline, only positioned farther west.

A comparison of bedrock slope and of depth below surface of sediments of the Ten Thousand Islands area (Shier 1969) and the southern coastal tidal plain (Smith 1968) show some subtle yet very important differences between them. While both of these coastal plain bedrock slopes are very slight, the bedrock slope in the south is much more gradual than that in the northern area, with a slope of 0.12 m/km (0.67 ft./mi.) in the Shark River area and a slope of 0.05 m/km (0.30 ft./mi.) in the Cape Sable area, compared with a slope of 0.34 m/km (1.82 ft./mi.) in the Ten Thousand Islands area. The slope in the Ten Thousand Islands is thus three to six times greater than that along the south coast.

These slope differences are due to the distinct geological formations in the two areas, with the more tilted, Late Miocene Tamiami Formation older than the shallower and flatter Pleistocene Miami Formation. The Tamiami Formation, being pre-Pleistocene in age, was probably subjected to a number of erosional episodes, both marine and aerobic. The younger Miami Formation was not so adversely affected. The steeper incline of the Tamiami Formation resulted in stronger wave energies, and together with the sand material available for transport and deposition from the Cape Romano Shoals, produced a chain of pronounced sand bars at an early period, earlier than the shell detritus beach ridges on Cape Sable.

The coastal progradation occurring in the Cape Sable area today was not taking place during the Middle Holocene, as evidenced by a mangrove peat buried 3.15 m (10.5 ft.) below mean sea level under an old beach ridge which is dated at 4950 ± 120 B.P. (Smith 1968). Beach-ridge development began sometime after this date and before the 1980 ± 100 B.P. date for the inner beach ridge of the Northwest Cape (Smith 1968). A date of around 2700 B.P., the beginning of the Late Holocene, is considered a reasonable approximation for the initiation of the beach-ridge development of Cape Sable, since it is at this date that sea level slows and progradation can outstrip transgression. This is evidenced by the seaward movement of the Cape Sable beach ridges through time (Smith 1968).

The change of shoreline environment on Cape Sable from a protected, low-energy mangrove marine-marl transgressive sequence to a higher energy shell beach is thought to be due to a change in coastal configuration caused by a northern retreat of the Northwest Cape (Gleason et al. 1984). Prior to this retreat, the Cape Sable area was environmentally similar to the margins of Florida Bay. As the northern coast retreated, however, higher wave energies in the now unprotected area led to the formation of shell ridges. It was the geologically exposed western position of the cape which ultimately led to its history of active beach ridge dynamics.

Although the coastal environment in the region south of the Ten Thousand Islands from 4000 B.P. on is identical to that found there today, it should not be assumed that the coastal zone would be utilized by human groups during the Middle Holocene in the same way as it was by the later Calusa. The rate of sea-level rise is a very important factor in the thickness of peat deposition and sedimentation in general. As Kuehn (1980) has pointed out, early transgressive peat records from freshwater to marine are usually very thin and poorly defined in core samples, because the rate of sea-level rise during the Middle Holocene outstrips peat production and sedimentation. It is not until the rate of sea-level rise slows to about 10 cm per century that substantial, thick deposits of peat accumulate. This statement is graphically illustrated in the peat transect off the mouth of the Harney River (Spackman et al. 1966), which has been presented in figure 23.

Although the rate of the Middle Holocene sea-level rise is relatively slow when compared with that for the Early Holocene, and peats and sediments do form during the Middle Holocene, the rate of sea-level rise is still rapid enough to suppress productivity to a level lower than would be found in the present-day coastal configuration. Thus, "stability" of the environment, as well as productivity, is lower than would be found during the subsequent Late Holocene, which begins about 2700 B.P., and we should expect to have a cultural carrying capacity

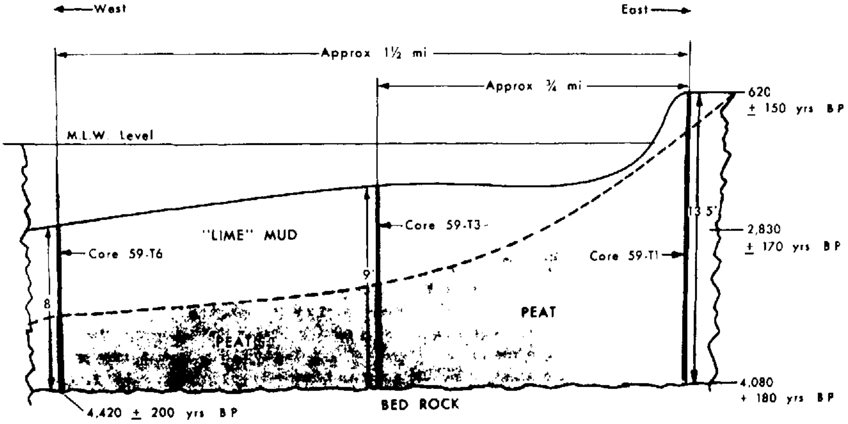


Figure 23. Peat Profile of Harney River. Adapted from Spackman et al. (1966)

and adaptation to the coastal zone during the Middle Holocene different from that during the Late Holocene. In sum, the important factor in human utilization of the coastal zone during this time is the *rate* of sea-level rise, since identical ecosystem types are found from at least 4000 B.P. on, and possibly as early as 5000 B.P.

THE MARCO ISLAND AREA

The Marco Island area of the southwest Florida coast represents a physiographic anomaly, one which contains important implications for this study. The specific geological history of this area is poorly known and so can be discussed only in a general manner. Marco Island represents the southernmost moderate-energy beach on the Florida west coast, except for Cape Sable (Tanner 1960). Extending west from a series of beach ridges are a number of mangrove keys and forests. Thus, this area has both protected bay-type environments and a series of sand beach ridges associated with moderate-energy coasts to the north. It is not these features which make the island unusual but, rather, an elliptical dune ridge with a pronounced elevation ranging from 3 to 15 m (10 to 50 ft.). This elliptical feature transects the southern part of Marco Island and makes up the majority of Horr's Island, located just to the south of it. The long axis of this ellipse runs north-south, and it is bissected east-west by a small tidal creek and has an interior body of water known as Barfield Bay. Although the specific age of this dune is not known, it is certainly pre-Holocene. It was probably formed by the strong winds of the Late Pleistocene subsequent to the retreat of the sea during the Sangamon. In many respects, the appearance of the ridge is similar to Carolina bays elliptical dunes found along the Pleistocene marine terraces of the Atlantic coast (White 1970). Its sandy sediments lie on the Tamiami Formation and therefore postdate the Late Miocene.

The western margins of the island are broad mangrove forests with about 1 m of peat overlying sandy sediments, determined by inspection of a 250-m dragline cut into the mangrove forest from its margin on the Marco River (Widmer 1974). These forests are primarily black mangroves with red mangroves fringing the adjacent open water. It appears that the mangrove forests of Marco Island are relatively recent, dating to the Late Holocene. Their formation is thought to be due to transgression of the sea over a broad, flat series of beach ridges, which suggests that the island was much larger prior to the Late Holocene and had a predominantly terrestrial environment.

It is also probable that the island was connected to the mainland during the Middle Holocene and then cut off as tidal scouring increased as the sea-level rose. This interpretation is consistent with the archaeological data and also with the shoal formation, barrier-reef evolution of the Ten Thousand Islands.

Marco Island, therefore, consists of a pre-Holocene sandy depositional remnant, probably aeolian in origin with areas of marked topographic relief, jutting from the mainland. Marine transgression added Holocene beach ridges to this sandy area exposed to the Gulf of Mexico and resulted in the formation of mangrove forests and keys dissected by numerous tidal creeks and passes in the protected, sediment-trapping interior margins. If the history of this formation is analogous to the history of the formation of Cape Sable and that of the development of the Ten Thousand Islands, it probably took place about 2,700 to 2,000 years ago.

THE NORTHERN COAST OF SOUTHWEST FLORIDA

The coastal zone stretching from Naples, just north of Marco Island, to the southern tip of Estero Bay is considered an area of relatively low productivity compared with zones to the north and south because of its geology and coastal configuration. This region is geologically composed of the relatively young and elevated Anastasia Formation, which is thought to date to the Sangamon and to be contemporaneous with the Miami Formation (Puri and Vernon 1964). Unlike the coastal zones to the south, this region has an exposed westerly position, resulting in a moderate-energy beach with minimal lagoonal, bay, and estuary development.

The bathymetry of the Gulf of Mexico just off the barrier beaches in this area shows that the water depth drops off sharply to 3 m at only a short distance (100 to 200 m) from shore. Mean low-water depths of 6 m are encountered less than a kilometer from the beach. When these bathymetric characteristics are coupled with the relatively steep slope of the submerged coastal shelf in this region and the lack of drainages (and hence sedimentation in the lagoonal zone), very different coastal features result. The combination of above factors resulted in a continuous cycle of beach ridge formation, erosion, and reformation as the sea transgressed. Thus, a similar coastal configuration was present in this area from the Middle Holocene to the present, with the only difference between these periods being a slight (1 km or less) westerly position of the shoreline. A transgressing sea level in this area simply resulted in the erosion of the existing coastline. Longshore drift carried these erosional sediments south, and undoubtedly provided the material for the formation of the extensive series of beach ridges making up the western region of Marco Island. This region lacked the mangrove swamps and wide shallow estuaries associated with high productivity throughout its Holocene history.

North of this zone, from Estero Bay to the Cape Haze Peninsula, the situation was very different and led to the formation of a distinctive, highly productive estuary zone, the Charlotte Harbor–Pine Island Sound region. Unlike the coastal zone south of Marco Island, very little research on the sedimentology and Holocene geology has been conducted in this region. There is only the study by Missimer (1973) of the beach-ridge formation in this area, a contemporary study of the sediments from Charlotte Harbor (Huang and Goodell 1967), and a reconstruction of the Middle Holocene coastal zone by Hale (1985). Therefore, much of the reconstruction of this area is highly tentative. General processes of Holocene sedimentation and sea-level rise are sufficient, however, to provide a reasonably accurate knowledge of the formation of this area.

As mentioned earlier, prior to 5500 B.P., the sea level was about 6 m below its present position and the rate of sea-level rise to this point was too rapid to permit the formation of complex and stable lagoons and estuaries. This lagoon and estuary development was further restricted by the complete absence of surface-water drainage, and hence, any transported sediments. Thus, all sediments were either marine or in situ in origin—that is, quartzy sand, crushed and redeposited shell detritus, or patchy peat from the coastal mangrove fringe. Beach ridges and sand bars were only minimally developed and were quickly inundated by a rising sea before sediments could be added to them. Still, by 5000 B.P. the water table was sufficiently elevated to produce alluvial flow from interior regions. Two of the rivers, the Peace, which drains the Kissimee watershed, and the Caloosahatchee, which drains Lake Okeechobee, began transporting and depositing deltaic sediments. At the same time, sea level had slowed enough to permit the formation of a barrier island chain across the mouths of these rivers, forming a brackish estuary with considerable sedimentation behind it. Sanibel Island is the largest of this chain of barrier islands, and the earliest beach ridge of this island has been dated to 4310 ± 120 B.P. (Missimer 1973:386). In all, a series of seven to twelve sets of beach ridges have formed subsequent to this date and have provided sediments which have gone into the formation of the unusually rich marine meadows. The earliest set of beach ridges composing Sanibel Island were formed when the sea level was 1.8 to 2.4 m (6 to 8 ft.) below its present position, as determined by measurements of mangrove-peat thickness in areas of Sanibel Island adjacent to Pine Island Sound (Missimer 1973:383). This observation shows a continuous, uninterrupted history of sedimentary deposition for the Pine Island Sound region subsequent to at least 4000 B.P., and more probably 2700 B.P., since this is the time at which sea level slowed.

It seems that sedimentation has kept pace with sea-level rise to provide a spatially stable estuary since 2700 B.P., although there has obviously been lateral expansion of the mangrove zone into the interior terrestrial locations as sea level rose, resulting in increased areas of mangrove forests through time, as was seen on Marco Island. Thus, a stable, productive ecosystem similar to that seen today was established in the Pine Island Sound–Charlotte Harbor area by 2700 B.P. The formation and evolution of the coastal configuration of this area is similar to that of the Marco Island area, in that the broad early beach-ridge formations were quickly replaced by mangrove forests. The major difference is that sedimentation in the Pine Island Sound–Charlotte Harbor area, as well as the amount of protected estuary, was much greater than in the region to the south. Unlike the Ten Thousand Islands and, more important, the area south of the Ten Thousand Islands, rising sea level had little influence on altering the configuration of the coastline subsequent to 4000 B.P. Instead, once the initial barrier-island chain was formed, additional beach ridges were deposited through time, resulting in a slightly prograding shoreline (Missimer 1973).

Of particular interest, although not discussed by Missimer (1973), is the origin of Pine Island. It appears that this feature was formed at an earlier sea stand, possibly during the Sangamon, and may be associated with sedimentation and beach ridge development of the rivers and sea level at that time.

Reconstruction of the Middle Holocene Coastline Configurations

The reconstructed coastal configurations that follow are only relative approximations, intended to demonstrate changing coastal configuration through time; they are *not* intended to represent actual coastline configuration. It is not possible at this time and it may never be possible to reconstruct the absolute coastal configuration for any period earlier than the present.

The dynamic processes involved in coastal evolution are extremely complicated, and the variable role any one factor might have in relation to all other factors would result in different outcomes. In spite of this, I feel reasonably confident that the following reconstructions are adequate, at a relative level, for providing the environmental background in which human cultural systems have adapted.

A 5500 B.P. date has been chosen for the initial coastline map, since this period marks the beginning of the Middle Holocene period, that time in which modern coastal formation processes began. It is assumed that offshore peats were minimally formed at this time and that sedimentation had not yet actually occurred. This assumption is substantiated by a complete absence of any peats of Holocene sediments prior to 5500 B.P., other than some marine peats from the Florida Keys (see append.). Therefore, it is possible to plot coastal configuration as a simple function of the juxtaposition of the sea-level position with the bedrock topography. Errors are obviously inherent in this procedure because of, for example, the varying thicknesses of overlying, consolidated (non-Holocene) sediments and the uncertainty of the actual position of the sea level for a particular point in time.

It was initially thought that because of the existence of a continuous −3-m (−10-ft.) bedrock contour for the southwest Florida coast, the sea level would be mapped at this position. Inspection of appendix A reveals that mangrove peat is situated on this contour and has a depth of 3.1 m (10.5 ft.) below mean sea level (Smith 1968). This sample dates to 4950 ± 120 B.P. and should therefore date the position of the sea level and coastline at approximately 5000 B.P. This date seems too early, however, when compared with numerous others obtained from freshwater peats in cores from Florida Bay (Davies 1980) at depths of about 3 m (10 ft.) below mean sea level (see append.). These data indicate the existence at Nine Mile Bank of basal freshwater peat dating from 5190 B.P. at 3.8 m (12.9 ft.) below mean sea level, and at nearby Man-O-War Key of basal peat dating from 4770 ± 100 B.P. at 3.3 m (11.2 ft.) below mean sea level. Basal freshwater peat at the mouth of the Harney River was also dated at 4080 ± 180 B.P. at a depth of 4.0 m (13.5 ft.) below mean sea level. It therefore seems more reasonable to use the −5.4-m (−18-ft.) bedrock contour for the minimal sea-level position at 5500 B.P. This contour would allow for an additional 0.3 to 0.9 m (1 to 3 ft.) of consolidated sediments and thus place the actual contour at about −4.5-m (−15-ft.), a shoreline/sea-level position which is consistent with the sea-level curve of Scholl et al. (1969).

It is not necessary to interpolate the −5.4-m (−18-ft.) bedrock contour for the southern southwest coast from the coastline contour of Smith (1968); instead the 4-m submarine contour from the bathymetric map of Ballard and Uchupi (1970) will be used. This should allow for the addition of 1 m of consolidated sediments and 1 m of unconsolidated sediments, resulting in an approximate bedrock depth of 6 m, close to the −5.4-m (−18-ft.) bedrock contour. This assumes a continuous slope, which is justified for modeling purposes. The coastal configuration—that is, the junction of the land with the sea—for 5500 B.P. is presented in figure 24.

The preparation of the coastal configuration for 4000 B.P. is not as straightforward as for the initial Middle Holocene position, because sedimentation is well under way at this time, and, therefore, bedrock contours cannot be directly used. An unusually large number of cores have been taken from coastal sediments, however (Scholl 1964a; 1964b; Spackman et al. 1966; A. D. Cohen 1968; Smith

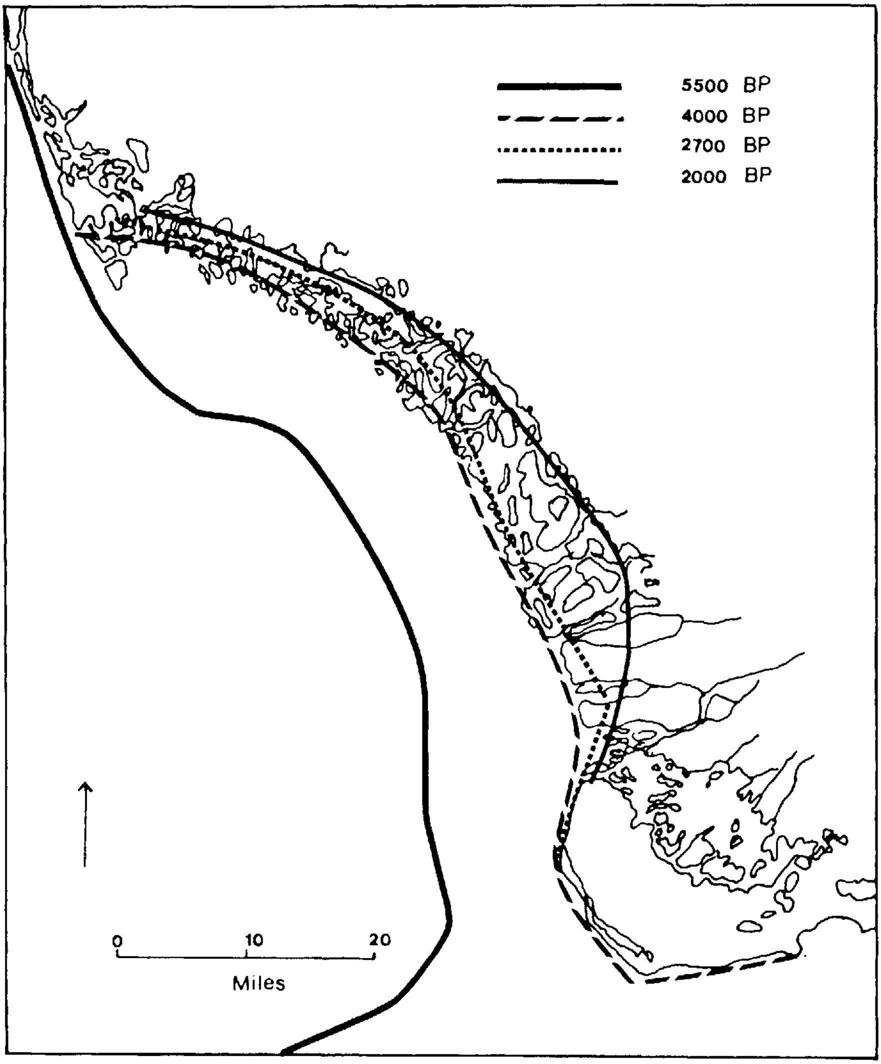


Figure 24. Southwest Florida Shoreline Positions from 5500 to 2000 B.P.

1968; Davies 1980; Kuehn 1980), and from these, a relatively reasonable placement of the sea level for this time and subsequent levels for 2700 B.P. and 2000 B.P. can be made (see fig. 24).

It is not possible at this time to generate a set of coastline positions for the Charlotte Harbor–Pine Island Sound region as was done for the Ten Thousand Islands region because both the process of deposition and the types of sediments are entirely different. The sediments of Charlotte Harbor are primarily quartz sand (Gould and Steward 1955; Huang and Goodell 1967; Enos 1974), and so it is difficult to determine without coring whether these are more recently transported materials, rather than materials deposited in situ such as vermetid worm rock and mangrove peat. These characteristic sediments of the Ten Thousand Islands region made it possible to model the locations of the earlier coastal positions.

Stahl (1970) has demonstrated that very thick Holocene sediments derived from the open ocean have backfilled the Tampa Bay estuary through tidal action. A similar situation might have occurred in Charlotte Harbor, since tidal regime and sediment type are similar, and so sediment buildup would keep pace with if not outstrip sea-level rise. This would make it impossible to determine the sediment depth at a specific point in time and, more important, its relationship to the sea-level position. Therefore, without the coring and analysis of in-situ organic sediments, reconstruction of the Middle Holocene coastline and estuary history for the Charlotte Harbor–Pine Island Sound region is impossible.

Hale (1985) has attempted to model the Middle Holocene estuary configuration of the Charlotte Harbor–Pine Island Sound estuary, but the lack of cores of in-situ sediments makes such a task impossible. Huang and Goodell (1967) have made a study of the sediments of Charlotte Harbor. Their sample, however, was primarily of surface sediments, with a few cores extending to a depth of 20 cm. Such cores are clearly insufficient for subbottom profiling and mapping of the sediments, for radiocarbon determinations, and for environmental analysis of pollen and macrophytes, which is necessary in order to match the quality of results produced south of Marco Island.

The sea-level rise for the period subsequent to 2000 B.P. is clearly one of a generally rising sea but at a much slower rate. It is when the sea level begins to reach its present position that the low-amplitude oscillations or fluctuations might be seen. Before this time, such minor oscillations would be difficult to record, since peat and sediment compaction, and statistical variance in radiocarbon dating, when viewed in the context of a more rapidly rising sea level, would result in a suppression of these oscillations. Subsequent to 2000 B.P., however, the sea level is close enough to its present position, about 1 m lower, that such oscillations might be visible. If there were global temperature fluctuations resulting in melting or freezing of the polar-ice sheets these oscillations would be expected and would result in a change in ocean volume and hence eustatic sea-level changes (J. A. Clark and Lingle 1979; Fairbridge 1984).

The importance of these minor sea-level fluctuations on human adaptation to a relatively stable coastal environment make it necessary to determine whether such oscillations occurred after 2000 B.P. As was done for the Middle Holocene, substantive data derived solely from the study area will be used in the assessment of the existence of these oscillations, particularly those incursions of the sea above its present position.

There do appear to be a few suggestions that sea-level oscillations have resulted in transgressive-regressive peat sequences. At Crane Key in the Florida

Bay, a 10-cm (4-in.) mangrove peat layer dated at 1230 ± 80 B.P. is overlain by a marine carbonate mud. This is suggestive of the typical marine transgressive sequence. On top of this overlay of mud, however, a marine peat composed of *Avicennia*, dating to A.D. 1365 ± 100, is found (Davies 1980:138). It might be that this mangrove peat is indicative of a regression, but it is equally possible that the mud sandwiched between these peats is storm deposited. The uppermost peat layer is in turn overlain by a carbonate mud indicative of a return to marine transgression.

Smith (1968:151) further documents the possibility of regression in his cores 11-A, 12, 25, 35, 36, and 41, all of which were taken from sawgrass marshes within the coastal plain. Each of these cores contains superficial peat of the emergent, herbaceous, freshwater type; *Rhizophora* peats are found deeper. Whether this situation can be termed regressive depends on whether sawgrass is tolerant of salinity. It does not appear to be, since *Juncus* and *Spartina* usually succeed red mangrove, not sawgrass, on the interior, brackish, coastal plains (Davis 1940; Kuenzler 1974). Still, regression is not necessarily indicated. Another possibility is that the superficial peat results solely from a higher discharge than is seen today in fresh water from the interior, resulting in the brackish zone being farther west. This possibility is particularly important, since the discharge of water from the interior has been drastically altered in recent times (Tebeau 1974; DeGrove 1984). Therefore, the reversal in the peat sequence is not necessarily due to sea-level fluctuations.

Gleason et al. (1984:317) discuss a transgressive sequence found at the south end of the Taylor Slough. Here *Rhizophora* peat overlies freshwater calcitic mud in a band along the latitude of the northernmost tips of Little Madeira Bay and Seven Palm Lake. North of this zone is a wider band, which reveals interfingering between freshwater and brackish water sediments. Gleason et al. (1984) question whether the band suggests a multiplicity of small-scale transgression-regression events. They state that "at the present, the answer to this question is in abeyance because the reliability of the criteria used to determine transgression-regression relationships fail in faintly brackish water situations" (1984:317).

It appears that the possible transgression-regression sequences seen in these cores might be attributable to volume and rate of freshwater discharge, since these data are from the southern coast discharge area, and so fluctuations in peat and sediment types need not be directly influenced by eustatic sea-level oscillations. The Crane Key example does not, however, seem to be related to potential differences in the freshwater discharge and, instead, appears to be linked to sea-level fluctuation. Besides the geological data discussed above, there seem to be some archaeological data suggestive of a transgression-regression event.

The Turkey Hammock site is situated on a hammock island east of the Chatham River, bordering a sawgrass prairie and extending east into this prairie a distance of 30 m. The site is unusual in that the soil matrix consists of about 50 percent black soil and about 50 percent *Melongena corona* shells (Ehrenhard et al. 1978). This gastropod is classified as a species found in salinities above 28 ppt, occasionally below (Tabb et al. 1962:50). If one assumes that these gastropods were collected from the immediately adjacent waters and marl flats, which is reasonable from an energetic perspective, then the salinities in the area of the hammock island would have to have been higher than they are today. This implies either decreased freshwater runoff at this time or else a higher sea-level position.

An even more convincing archaeological example of a sea level higher than the present position comes from the Solana site (Widmer 1986). The Solana site is on the western bank of Broad Creek, a small tributary of the Peace River, approximately 1 km from the junction of the creek and the southern margin of the Peace River. It is in the vicinity of Cleveland, Florida, approximately 7 km upriver from Punta Gorda. The site has a number of circular rings of barnacles, oysters, and mussels, suggesting a former piling structure. The elevation of these rings is 0.6 m above the present mean high water as measured at the junction of the Peace River with Broad Creek. The elevation of these ring features was able to be determined quite accurately, with an error of no more than 1.0 cm, because of a Florida Department of Transportation (DOT) benchmark of known elevation situated on the site. The benchmark is calibrated in National Geodetic Vertical Distance (NGVD) and was directly tied into the water level at the Peace River, provided by the Florida DOT, and the elevations of the archaeological data.

What is not precisely known, however, is the relationship of the mean high water at the Peace River location, to the mean high water for the sea level on the adjacent coast. It is therefore difficult to determine whether the increased water level, as recorded at the Solana site, is purely a function of eustatic sea-level rise, since substantial contemporary water-control projects have altered the original hydrology and drainage characteristics of the Peace River (Tebeau 1974; DeGrove 1984). This activity has reduced and modified the water table of much of south Florida and has altered the discharge rates of the Caloosahatchee and Peace rivers.

Although it is possible that an increased water table was responsible for the higher position of the shell piling rings, I do not believe that predrainage, hydrological conditions alone could account for this situation, particularly since the salinity levels of the site environment during its occupation are clearly in the 28 to 35 ppt range, as evidenced by the molluscan faunal assemblage (Widmer 1986). This condition suggests a higher sea level, and the high position of the water level during the occupation of the site is probably a result of a *combination* of slightly higher sea level and a slightly higher water table. Related to this is the fluctuation of the water table at the site during its excavation. In the initial stages of excavation, the water table was low, permitting excavation to a depth of 30 cm above the NGVD. When rains were heavy, however, the water table rose to 90 cm above NGVD, in many areas inundating cultural strata.

Such seasonal fluctuations of tide heights and water tables are characteristic of coastal regions with marked wet and dry seasons. Smith (1968) has discussed in detail the complications created by seasonal and gradational changes—that is, distance from the coast—and the range in velocity of tidal fluctuation in determining the "level" of the water surface. The importance of this is that it is possible for only small oscillations above the present sea level to result in a rise in water level in interior coastal regions, such as that associated with the Solana site.

Effects of Sea-Level Rise on Coastal Utilization

The rapidly rising sea level, from a position about 100 m below its present position at about 18,000 B.P. to a position approximately 6 m below present sea level by 5500 B.P., did not result in stable coastlines which would permit the establishment of mangrove forests. Mangrove trees had only eighteen years to become established and grow before they were inundated by the rising sea. Also, because little or no surface water was flowing from the interior at this time, no organic sediments could be trapped behind barrier sand bars and beach-ridge complexes. The resulting coastline was a very unproductive barrier sand beach with a narrow hypersaline lagoon behind it. This is an extremely different environment from that seen in the area today.

Because of this environmental condition, large, dense human populations would not be expected in the coastal zone. Instead, a small, low-density, dispersed population, probably similar to those associated with generalized hunters and gatherers, would be found, since interior terrestrial ecosystems would be more productive and more stable.

The coastal utilization would certainly not exclude resource procurement in the interior terrestrial region. On the contrary, it is believed that the procurement of coastal resources by human groups in the area would be minimal and would account for only a small percentage of the total subsistence effort, both in time expended in coastal exploitation and in amount of resources obtained. Therefore, a nomadic, low-density adaptation primarily focused on the exploitation of terrestrial natural resources with only occasional, sporadic, generalized, or perhaps seasonally specialized use of the coastal zone would be expected in south Florida during this time.

By 5500 B.P., the rate of sea-level rise slowed dramatically, and sedimentation also increased significantly as the water table rose and the present coastline came into existence. Still, the sea-level rise was rapid enough to outstrip sedimentation. It was at this time that the coastal environment became attractive for human exploitation and the initial exploitation of estuarine resources began. Not until 2700 B.P., however, did the rate of sea-level rise slow enough and the water table rise high enough to provide environmental conditions similar to those which exist today, both on the coast and in the interior. These environmental conditions refer to both spatial distribution and level of productivity. During the Middle Holocene, human groups were adjusting their subsistence, settlement, social, and population characteristics to the increasing productivity occurring in the coastal zone.

By 2700 B.P., the coastal environment stabilized and reached its highest level of productivity, sufficient for the predominant exploitation of the coastal resources by human groups in south Florida. It is probable that the coastal adaptation characteristic of the Calusa began at this time. The evolution to the maximum population density in the area could not have occurred until the environmental conditions were such that a sedentary existence could be maintained. This was not possible until 2700 B.P.

The problem of verifying or testing the scenario with archaeological data is obvious; the rising sea level has either eroded archaeological sites or else submerged them under water or under unconsolidated sediments. In spite of these problems, however, some drowned archaeological sites are known in this area (Gagliano 1977).

7

A Dynamic Model of the Prehistoric Coastal Adaptation in Southwest Florida

The evolution of the prehistoric coastal adaptation in southwest Florida and the specific timing of the stages in its development are the result of the interplay of environmental, ecological, demographic, geological, and sociopolitical variables. These variables have been schematically presented in figure 25.

The Initial Occupation

Although it is possible that humans were present in the New World prior to 13,500 B.P. (MacNeish 1976, 1982), no human occupation is recorded in south Florida prior to this date. This lack is not necessarily a reflection of sampling deficiency or, more important, of the obscuring of early occupations by the rising sea. It may have been for environmental reasons. The period from 37,000 to 13,000 B.P. has been characterized by Watts (1975) as being much drier than today, with soil moisture insufficient even for the development of scrub oak. High winds and shifting sand dunes during this time also suggest that the moisture in south Florida was low, perhaps too low for permanent human habitation, although there may have been some sinkholes between the −60- and −30-m submarine contour at this time which were suitable for habitation. It is assumed here, however, that prior to 13,000 B.P., the environment of south Florida was too inhospitable for human occupation.

For whatever reason, the date of 13,000 B.P. marks the initial human occupation of south Florida. This occupation is seen as a pioneering movement of hunt-

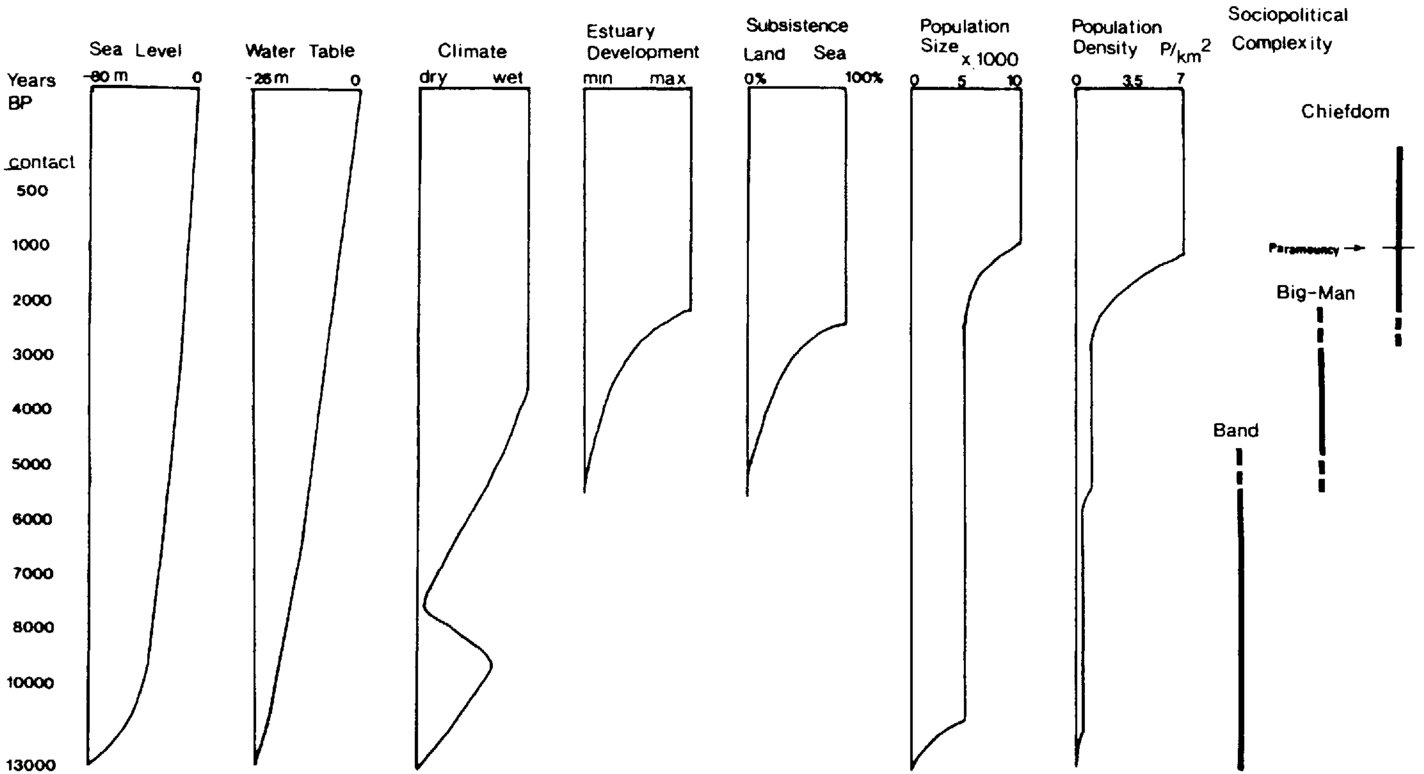


Figure 25. Dynamic Relationships of Southwest Florida Prehistory

er-gatherer peoples into an environment different from that during 37,000 to 13,000 B.P. The colonization of this previously unutilized new environment would probably have been quite rapid. Hunter-gatherer populations in pioneering situations appear to be capable of rapid population growth. Birdsell (1957) has suggested a doubling rate in a single generation, a population growth rate of about 3.5 percent annually, for the peopling of Australia from an initial colony of twenty-five. This is based on empirical observations by Birdsell (cited in Hassan 1981:203) of the unusually high initial-growth phases of the Cape Barren Island and Tristan de Cunha hunter-gatherer groups. Hassan (1981:201–203) suggests that this figure is too high and, instead, considers a growth rate of 0.1 percent per year, or a doubling rate every seven hundred years, for the peopling of America.

A figure somewhere between these two values is probably a reasonable rate for the initial colonization of south Florida, because a resident population was close at hand, and expansion into this zone required a maximal lineal expansion of only 300 km, instead of continental distances. A 1.0 percent growth rate, with a doubling rate every seventy years, is therefore suggested. Using this rate and a seed population of 25, that of a small hunter-gatherer band, a population of 3,600 could be obtained in five hundred years. This is a reasonable approximation given the current archaeological and ecological data for 13,000 B.P.

The earliest archaeological evidence for human utilization of south Florida corresponds with the shift in the environment which occurred about 13,500 B.P. This is the extinct tortoise bone from Little Salt Spring with a date of 13,450 ± 190 B.P. Although this date is a little early, the wooden stake which was driven into the tortoise bone was dated at 12,030 ± 200 B.P., more in line with Pollen Zone II. The archaeological evidence for occupation is admittedly sparse in comparison with that for the northern peninsula of Florida, where occurrences of fluted points are well documented. Stone tools are not known in south Florida for this period, which might seem to indicate a distinctive regional adaptation and perhaps isolated demographic units that did not interact with groups in the northern portion of Florida. Such an interpretation would be based on the expectation that if groups were interacting at this time, some of these temporally diagnostic tools would be found, particularly in surface collections.

Material of this period is known only from Little Salt Spring, however, which would have originally been located in the arid interior region in the middle of the south Florida peninsula, not on the coast as it is today. Lack of tools elsewhere suggests that most habitation sites were located in the now-drowned coastal region to the west, where the environment was more conducive to aboriginal utilization, instead of in the arid, waterless interior. The very low water level in the spring at this time, at least 26 m below the present spring surface, suggests that surface water would have been difficult to obtain. The entire south Florida peninsula, as it is exposed today, would have been an arid, waterless marginal area on the periphery of the major habitational zone when the sea level was almost 100 m below its present position. This area would have been used as a hunting range at considerable distances from base camps, which would probably have been near sinkholes or in the fluvial valleys on the now-drowned Florida Plateau located between the −20- and −60-m submarine contours. Lithic tools, obtained through interaction with groups in northern Florida, should be found, if they existed, in the −20- to −60-m area around the postulated habitation sites. The few lithic tools used in the interior and lost in hunting would have become buried under Holocence sediments and difficult to locate.

The initial early populations which inhabited south Florida possibly included the coastal zone as part of their resource procurement area. This use of the area, however, was probably only minimally developed, because the ecosystem types that would have been present in the coastal strand were much different from those found today. Only the area north of Sanibel Island would have streams or rivers discharging fresh water into the coastal zones to produce brackish estuaries. These estuaries, subject to severe salinity changes as sea level rose, would have been very restricted in size and discharge volume. In areas to the south, barrier-beach strands, if they existed, would have had hypersaline lagoons behind them. Both of these ecosystem types have lower productivity than coastal zones found in contemporary brackish estuaries, due to the extreme limitations placed on plants and animals characteristic of the types. If such coastal strands did not exist, only moderate-energy beaches with their restricted faunal and floral components would have been present. Such resource zones, as ascertained from ethnographic data, do not seem to attract human exploitation. This is best illustrated in Birdsell's (1953) study of Australian coastal populations.

In his discussion of the coastal populations of Australian aborigines, Birdsell (1953) noted that, on a gross level, access to coastal resources increased population density by one-third over that predicted for inland "tribes," according to his rainfall equation. The local group inhabiting the area from Eyre Peninsula westward across the coastline of the Great Australian Bight to Geography Bay, however, had an unusually low density ratio of 0.7. A ratio of 1.0 is the predicted relationship of a tribal unit with a population of 500 in a given area on the basis of rainfall potential. A ratio of 0.7 means that only 350 people can be supported in the same-sized area. Birdsell (1953) suggests that this situation may be explained by the total lack of streams, even transient ones, by the limiting factor of very scarce surface water in the form of springs and soaks, and by the absence of watercraft.

All of the conditions in the Australian example, probably including the cultural factor, pertain to south Florida at this time, at least below the latitude of Sanibel Island. Thus, the coastal region is not seen as an attractive region for human exploitation compared with the interior zone, even though the latter zone is less than ideal.

The two extant regions in the Gulf of Mexico where similar environments exist today include the northwest Yucatán coast and the south Texas–north Mexico coast. The south Texas coast is a possible test example of the human resource potential of the hypersaline coastal environment during the sixteenth century. It should be cautioned, however, that this lagoon was not always hypersaline, as is evidenced by oyster-shell middens in Baffin Bay and the Laguna de Madre (Arnold 1941, Hester 1980), and it is not necessarily the case that the poorly known Coahuiltecans, as described ethnohistorically, were using the Laguna de Madre when it was hypersaline. Still, the disappearance of oyster shells from the upper levels of sites in this coastal region perhaps indicates that the bay had become hypersaline by the protohistoric Coahuiltecan period (Hester 1980).

Further evidence of the poorer environmental conditions in the Laguna de Madre is possibly reflected in fewer and smaller sites along its shore than in the coastal zones north of Corpus Christi (Arnold 1941; Scurlock et al. 1974; Aten 1983, 1984). Hunter-gatherers, the Coahuiltecans, were living here when Cabeza de Vaca landed on their coast in 1528 (Newcomb 1961). These Coahuiltecan "tribes" lived at the most precarious subsistence level. Newcomb (1961:39) stated that "of all the Texas Indians the Coahuiltecans had the fewest usable natural resources and consequently lived the harshest, most difficult life." Even considering the harshness of the arid interior region, these bands did not extensively utilize the hypersaline lagoons of Baffin Bay and the Laguna de Madre, preferring instead interior locations along freshwater streams. Only two bands, the Malaguite and the Borrado, are located on this coastal zone (Newcomb 1961:35, map 1).

Just to the north of the mouth of the Nueces River, however, the Karankawa groups, consisting of five principal bands, occupied the brackish coastal estuary zone. Aten (1983:63) suggests a protohistoric Karankawa population of 4,000 to 6,000 inhabiting an area of 14,200 km^2 in 1700. The higher population estimate would mean a population density of about 0.42/km^2. Populations have not been estimated for the two bands occupying the coastal zone south of the Karankawan groups. If we arbitrarily assign equal band size for the Karankawan bands and the coastal Coahuiltecan bands, which is probably an overestimate for the latter, the population density is over half (0.4) that found in the Karankawan groups, since there are five Karankawan groups and two Coahuiltecan bands, or approximately 0.17/km^2, which is in the lower range of hunter-gatherer densities listed by Hassan (1981:8, table 4).

This comparison demonstrates that not all coastal environments are favorable to human resource procurement, particularly the hypersaline-ecosystem type. Where we find these environments, they are invariably associated with arid interior regions where freshwater discharge into the coastal embayment is absent or minimal. As a result, carrying capacity is dramatically reduced compared with the adjacent interior areas. It is tempting to use the ethnohistoric Coahuiltecans as a specific model for the expectation of resource utilization and population density for south Florida at this time, but without specific knowledge of the types of floral and faunal resources in south Florida, it would be dangerous to attempt to do so. It is also not possible to model the frequency and distribution of sinks and surface water in the now-drowned area of the coastal plain. It is conceivable, however, that the Coahuiltecan analogy is a close one.

Another possible explanation for the paucity of archaeological remains in the area is that the entire south Florida region, including the exposed coastal shelf area, was a marginal area and only minimally utilized. Early sites such as Little Salt Spring would therefore reflect the southernmost extension of hunting or resource procurement by groups with territories and base camps established in the northern peninsula of Florida. This explanation is not plausible, since these northern groups would have access to lithic raw material, and we should therefore expect to see a few stone projectile points in this region. In any case, it appears that by 13,500 B.P. this interior region of south Florida was of minimal resource potential. Interestingly, the only definite in situ faunal element associated with this human utilization is an extinct tortoise which has a xeric habitat.

It is possible, however, to construct a general model of the location and characteristics of the primary occupational area in south Florida for 13,000 B.P. The location is determined by the hydrostatic relationship between the sea level and the water table and the geomorphological characteristics of the coastal plain. Data from Little Salt Spring indicate that the water table at 13,500 B.P. was at least 26 m below the present surface. It is possible to locate the approximate area where surface water would be found by intercepting the submarine topography of the then exposed coastal plain with the depth of the water table, assuming that the water table is level for all of the peninsula, which is actually not the case. This region would be located approximately 50 km west of the present coastline. To the east, up the sloping coastal plain, the water table would have been at an increasing depth below the surface and therefore more difficult to exploit.

In general the area of south Florida is believed to have had scattered regions of water in an otherwise arid environment at 13,000 B.P. It is hypothesized that the optimal resource zone for human occupation and utilization would have been located wherever the water table intercepts the surface topography, a situation determined by the sea level. Hunter-gatherer groups would have located their base camps in this area and probably differentially utilized the interior regions in frequencies correlated with the depth of the water table and the availability of surface water.

This type of environment, characterized by scattered permanent water sources in an otherwise arid tropical region, is similar in many ways to those environments of the Kalahari Desert (Lee 1979) and central Australia (Birdsell 1953), where permanent water holes rather than flowing surface streams provide water.

Thus, an adaptation with demographic, settlement, and subsistence patterns similar to those of the !Kung Bushmen (Lee 1979), central Australian groups (Birdsell 1953), or the Coahuiltecan groups (Newcomb 1961) might be present. There are, of course, important differences between these regions and south Florida during 13,000 B.P., including the type of fauna and flora and, more important, the differential value of these resources in human resource exploitative patterns. Such compositional differences in potential resources can have dramatic impact on settlement, subsistence, and demographic patterning. One example of how specific resources affect different adaptations is seen in the extensive mongongo nut groves which dramatically influence seasonal movements and aggregation of the !Kung population (Lee 1979).

It is possible that fluvial drainages of either a continuous or intermittent nature issued from some of the exposed springs which would have been situated along the northern region of the coastal zone at this time. This situation would obviously have resulted in different subsistence and settlement regimes in this area, even if the specific types of resources were similar to those in the interior. These drainages would be extremely favorable to human occupation because the increased water would raise the carrying capacity in an otherwise arid environment.

Similarities in the general *type* of environment do not necessarily result in identical adaptations, but certain constraints or limiting factors, most notably water, will strongly influence settlement and demographic patterns.

In spite of these problems, it is possible hypothetically to model the population size at about 13,000 B.P. for this south Florida area. The population density for south Florida probably would have ranged somewhere between the density values of hunters and gatherers living in grasslands (0.17 persons/km^2) and those living in semidesert (0.035 persons/km^2), as determined by a carrying-capacity model developed by Hassan (1981). This value is only a relative approximation and should not be considered an empirical reconstruction of the population which lived in the region at 13,000 B.P. It is merely used as a baseline for modeling early population size and density.

The area of south Florida assumed to have been inhabitable at 13,000 B.P. extends from the −80-m submarine contour east to a distance of about 60 km inland of the present shoreline of the Gulf of Mexico. The north-south limits extend from the Manatee-Sarasota county line to Cape Sable. This region is estimated to be approximately 62,500 km^2. Multiplying the population-density estimates of Hassan by this figure results in a population range of 2,188 to 10,625, with a mean of 6,406 persons. A population figure of about 5,000 would not seem unreasonable for this area, and for convenience this number will be used.

The differential depth of the water table on the exposed coastal plain and its correlated availability of surface water are important factors in environmental zonation, carrying capacity, and potential human land use patterns at this time. Three basic resource zones have been reconstructed for this early adaptation (see fig. 26). The first of these (Zone I) would have been the coastal plain north of the latitude of Sanibel Island extending from the −20-m contour, where the surface intercepts the water table, to the −80-m contour, which would have been the approximate shoreline at 13,000 B.P. (Ballard and Uchupi 1970). This area is distinctive from the other coastal zones to the south in that it contains a series of

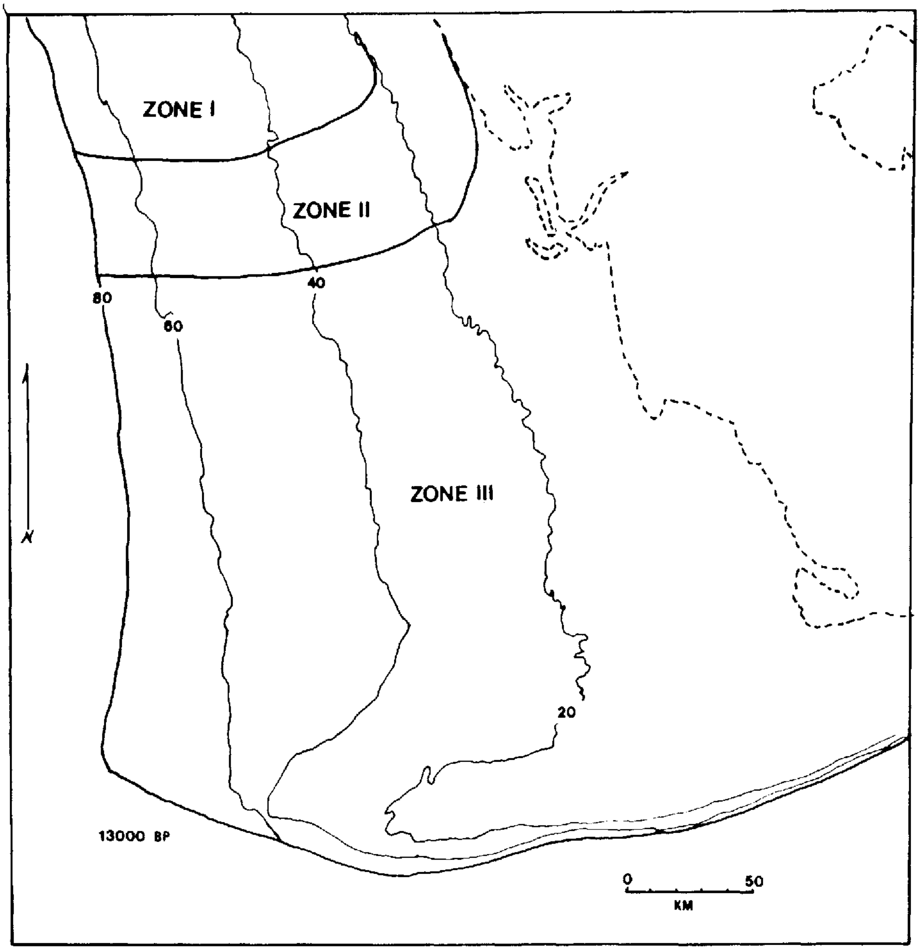


Figure 26. Location of Southwest Florida Resource Zones at 13,000 B.P.

drainages, probably originating from springs, which transect the coastal plain. These streams, without well-developed floodplains, would have acted as mesic ribbons, perhaps containing gallery forests, extending through an otherwise arid environment. Small estuaries might have been located at the mouths of these drainages where coastal resources could have been exploited, most notably shellfish but also fish. These resources, however, would have composed only a small part of the total subsistence regime.

This coastal plain zone would have contained the maximal population density and probably base camps. Both floral and faunal resources would have been exploited, the latter to include both large and small animals, some extinct and some extant, adapted to mesic and xeric conditions. The environment in the most favorable areas within Zone I probably could support macroband aggregation at optimal seasons of the year. Most ceremonial activity, including mortuary behavior, would have taken place in this region in association with the larger seasonal population aggregation sites. No type sites are known for this zone for this early period, since it is now under water.

A second resource zone (Zone II), adjacent to the south and east of this region, would be characterized by a series of mesic oases located at sinkholes scattered throughout the karst plain. Because of the higher elevation, however, little or no fluvial surface water would have issued from these springs and sinks. Both floral and faunal resources would be exploited, the latter including large and small game. This region would have been visited seasonally by smaller microband or extended family units, with all ages and sexes represented, as documented at Warm Mineral Springs by the remains of a child of about six, who apparently fell into the sink. Two type sites exist for this resource zone: Warm Mineral Springs and Little Salt Spring.

The third resource zone (Zone III) is immediately adjacent to the preceding zone, both to the east and south. It has a characteristic xeric environment with only a few deep sinkholes scattered over the landscape. These sinkholes do not appear to have mesic margins associated with them. Because of this, floral resources were not important in these areas, nor were mesic fauna, notably deer. Instead, smaller reptiles and mammals were probably exploited and possibly larger, extinct herd animals which might have seasonally occupied the extensive prairies which would have been found in the Lake Okeechobee basin during the rainy season. No kill sites, however, which might be typical of the hunting of prairie herds, are known for this area, although if they did exist, they are probably buried under the Holocene water and sediments of the KLOE drainage system.

The Early Paleoindian component of the Little Salt Spring site represents a good example of a small, xeric, game extraction-hunting site in the Zone III region. The single prismatic blade found in the deep, otherwise culturally sterile strata at the Solana site might represent a similar component as well. Such exploitation would not necessarily require elaborate or durable technology, and because of this, numerous such occupations might have existed which are not preserved. This situation is readily seen at the earliest component of the Little Salt Spring site, where the only artifactual evidence is a single wooden artifact and a prepared clay hearth. Fortunately in this case the contextual evidence was well preserved. These sites most likely had extremely ephemeral use, and because of their hunting correlates, would have been used only by adult males. The location of the eastern and southern margins of the zone is unknown and probably depended on the availability of water, either carried by hunters or accessible in surface form. This region would have been utilized primarily during the wet summer season, when the arid conditions are mitigated and the climate is more conducive to faunal exploitation.

The location of these three resource zones is dependent upon the relationship of the water table to the land surface. Since the position of the water table is dependent on the location of the sea level, however, a rising sea not only inundates regions of the coastal peninsula but results in the elevation of the water table. The interplay of these processes results in a lateral, easterly shift of the resource zones into the interior of peninsular south Florida. What this means is that the absolute locations of these zones differed in different periods, although the relative positions among the zones did not change. A dynamic profile of the locations of these resource zones relative to sea level and water table position for the period from 13,000 B.P. to 6000 B.P., along with the location of related sites, is provided in figure 27. In effect, a lateral encroachment of Zones I and II into Zone III takes place.

During the time of the Dalton Horizon of the Late Paleoindian period, we see much greater evidence of human utilization of the exposed area, with three components recorded for this time period. Also, considerably more archaeological material is found at two of these sites, including stone projectile points at one. Taken at face value, such evidence might suggest increased population and also increased interaction with northern populations. Instead, the identical environmental situation seen in the earliest period has shifted to the east.

The water table at this time is approximately 12 m lower than it is today. Therefore, the location of permanent water holes and springs at 10,000 B.P. was not near the −26-m submarine contour but instead near the −12-m contour, a distance of 13 km to the east. Thus, as the entire settlement pattern is shifted east, more of the archaeological evidence of occupation can be seen—that is, temporary camps. The hypothetical locations of these zones for this period have been presented in figure 28.

Sites which can be interpreted as base camps were still not present on the land surface of today. Sites of this type would have been located near the springs whose water was closest to the surface, about the −12-m contour, and would be drowned. The location of another settlement type, the temporary camp, which in the Early Paleoindian occupation was covered by the present sea level, was exposed by 10,000 B.P. Archaeological evidence shows that the coastal zone was utilized to some extent, as indicated by the marine-shell atlatl spur from Warm Mineral Springs (Cockrell and Murphy 1978). The coastal zone may have been utilized to some extent earlier, but the available evidence is from the Late Paleoindian period, circa 10,000 B.P.

Only a shift in their spatial location distinguishes the two Paleoindian periods. This shift is thought to have resulted from the lateral, easterly migration of sinks and water holes, as the sea level continued to rise and to raise the water table. Therefore, since technology, environment, climate, and resource zones, as reflected in the vegetational record for this period (Pollen Zone II) from Lake Annie are similar, we can discuss both of these periods as a single adaptation.

The initial south Florida adaptation probably exploited both faunal and floral

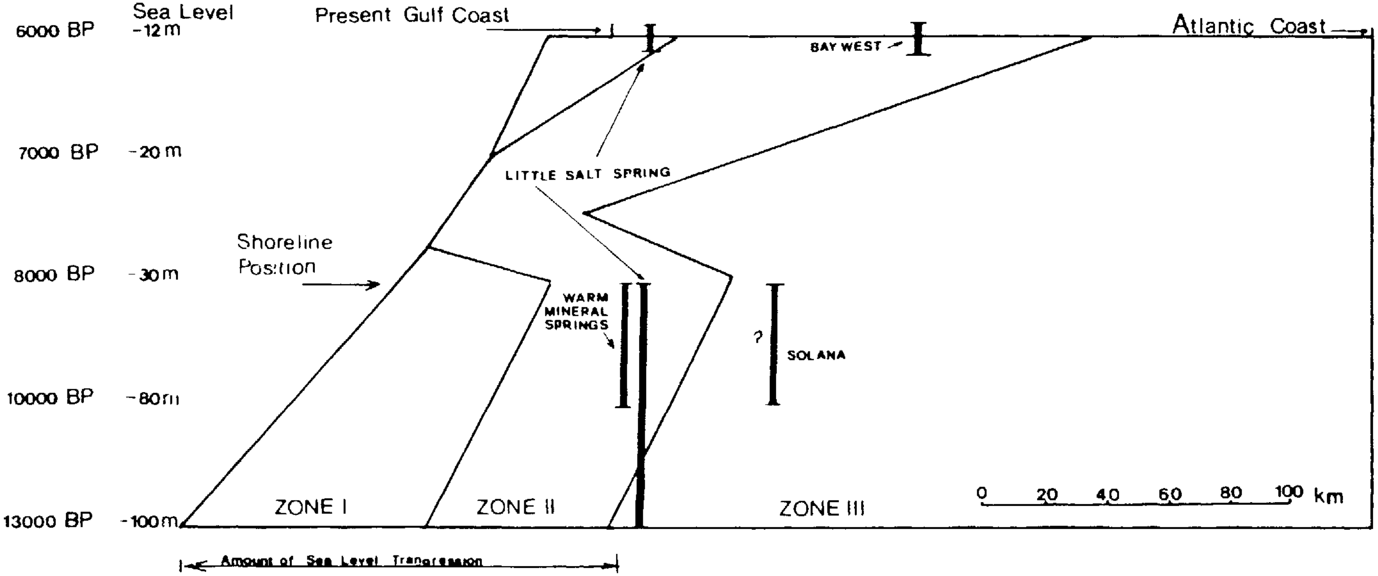


Figure 27. A Dynamic Profile of Resource Zones in South Florida from 13,000 to 6000 B.P.

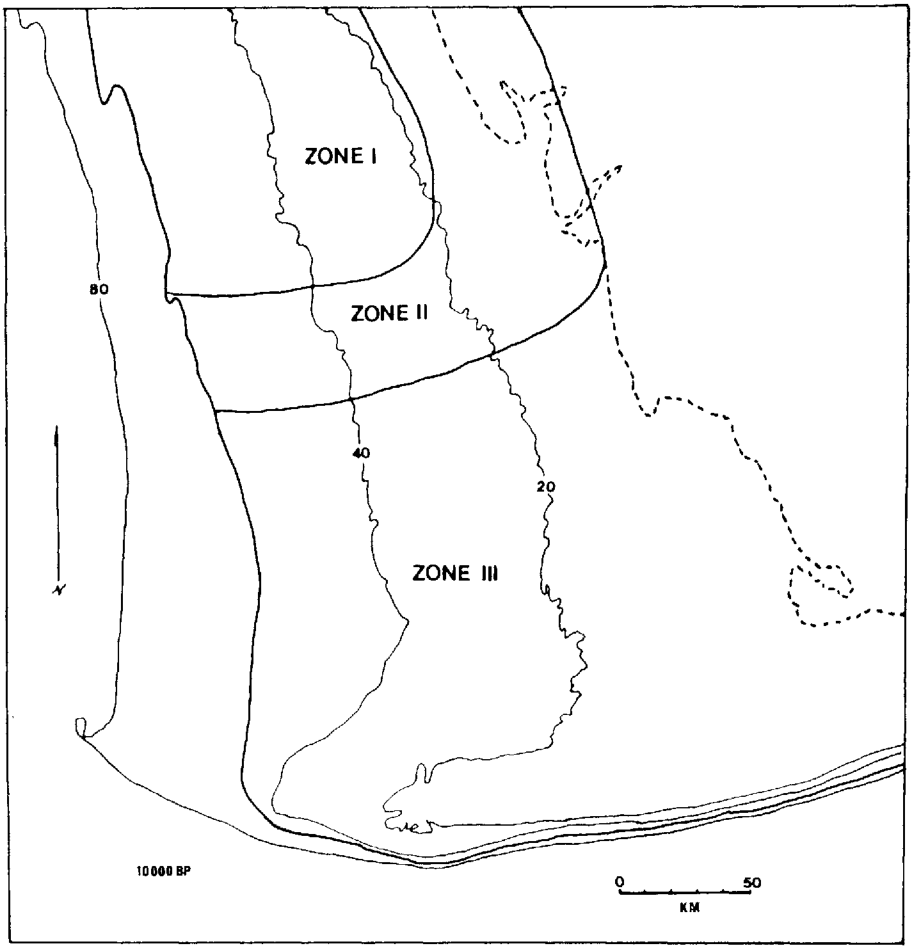


Figure 28. Location of Southwest Florida Resource Zones at 10,000 B.P.

resources during this time period. Only a single faunal species was known to be directly used, the tortoise mentioned previously. Other fauna, both extinct and extant, were found in direct association and include the extinct box turtle *Terrapene carolina putnami*, and the extinct ground sloth *Megalonyx* sp. Associated extant fauna include the Florida cooter turtle (*Chrysemys floridana*), the Florida red-bellied turtle (*Chrysemys nelsoni*), the gopher tortoise (*Gopherus plyphemus*), the diamondback rattlesnake (*Crotalus adamanteus*), the rabbit (*Sylvilagus* sp.), and the wood ibis (*Mycteria americana*). Extinct bison and either immature mastodon or mammoth (*Mammut* or *Mammuthus* sp.) were located a few meters away (Clausen et al. 1979). These animals are small and xeric species, with the exception of the wood ibis and two freshwater turtles. Importantly, no floral resources or deer appear in the pre-10,000 B.P. faunal and floral assemblage. Deer may not have moved into this area yet, and thus it would seem that the use of this region in the Early Paleoindian period was exclusively for the exploitation of faunal resources.

More mesic conditions are recorded at Little Salt Spring for the Late Paleoindian period, and a wider range of resource items are seen. Thus, evidence of the use of mesic resources in the adaptation is now (10,000 B.P.) visible. It includes the exploitation of deer and, more important, hickory nuts, as evidenced by their shells. An oak mortar found dating to this period was probably used for processing plant foods. Small mammals were exploited as well, as evidenced by a nonreturnable boomerang in the assemblage of this time period. These resources, I suggest, were also exploited in the earlier period, but the resource zone was shifted farther west and is currently submerged. Thus, the differences which are seen between the Early and Late Paleoindian components of the Little Salt Spring site are due to a lateral shift of the location of the resource zone and the accompanying shift in settlement-pattern location. I believe that no changes in carrying capacity and population growth occurred during this time, once the initial carrying capacity was reached, shortly after 13,000 B.P.

Not only does a rising sea level transgress the coastal plain, drowning territory for habitation; it also elevates the water table, making surface water accessible farther inland. As a result, the location of the resource zones are shifted eastward, while the site locations themselves are fixed, and thus site *function* changes rather than demography of the region as a whole. This is best illustrated at Little Salt Spring.

At 13,000 B.P., when the water level was −26 m, the Little Salt Spring site was a temporary, ephemeral, overnight hunting camp in a xeric environment, whereas at 10,000 B.P., the site had more mesic floral and faunal assemblages and functioned as a seasonal camp occupied by a corporate family or minimal band. This shift, I propose, happened without a concurrent population increase. Social organization at this time would probably have been that typically associated with mobile hunting and gathering (Lee and Devore 1968). Such groups would be egalitarian and have flexible group membership with ambilocal residence and ambilateral or patrilineal type of kinship.

The Early Archaic Adaptation

The known sites and possibly the entire south Florida region were apparently abandoned during Early Archaic times. Why this situation occurred is extremely puzzling. Clausen et al. (1979) suggest that the period was one of increased moisture and mesic forest development. This hypothesis is not borne out, however, by the Lake Annie pollen profile, which instead shows the frequency of oak (indicative of aridity) at its highest and pine (indicative of moistness) and cypress at their lowest (Watts 1975:346, fig. 2). In fact the pollen profile for the Early Archaic period looks like a reversal of the environmental conditions of Pollen Zone I, which suggests an extremely arid environment in south Florida. Environmental aridity is also suggested by the depositional context of archaeological materials dating to this time period. Late Paleoindian projectile points are commonly buried under deep aeolian deposits of sand, in some cases over 2 m in thickness (Bullen 1975b:81), further indicating aridity. This aridity would lead to a lack of ground cover in many areas, which would thus expose the soil surface to wind scouring and deposition. It is possible that this environmental situation disrupted floral and faunal relationships and may have marked the final extinction of the remaining Pleistocene fauna. Modern faunal forms, such as deer, could probably retreat to more mesic conditions to the north, while other obligate tropical species, such as sloth, may not have been able to retreat from the dessicating conditions.

In any case, the extreme disruption of existing faunal biomass through the increased aridity would certainly lower the attractiveness of the area for resource exploitation. We would therefore expect a withdrawal of human population from this region as conditions, at least as far as human exploitation of the area is concerned, returned to those existing before 13,000 B.P. While this scenario is only hypothetical, it makes sense in terms of the timing of Pleistocene extinction in south Florida, which is thought to have occurred at this time (Weigel 1962; Gagliano 1977), and also in terms of the pollen sequence for the region as seen at Lake Annie (Watts 1973).

Another related factor that may have led to the abandonment of south Florida was the possible disappearance of the fluvial drainages between the −60- and −40-m submarine contours as the sea inundated these drainages. This, when combined with potentially drier conditions, would have resulted in a lack of surface drainage from springs, particularly if no permeable geological regions existed along some stretches of the submarine coastal plain between the −40- and −20-m contours.

In any event, contraction of the population as dessicating conditions prevailed appears to have taken place. It is probable that only Resource Zones II and III were present in south Florida during the Early Archaic period (9000–7000 B.P.). Their location is shown in figure 29.

Only scattered sinkholes and cenotes would have been found in the coastal zone. The carrying capacity of south Florida as a whole would have been lower, since well-watered areas became scarcer, and thus populations would have been smaller. The arid interior zone, which now had possibly even shifted west as a result of dessication, would be utilized to a much lesser extent than in the earlier Paleoindian period, since regional population would be lower and resources in this zone were probably fewer. As a result, it seems that the exposed continental shelf of south Florida would have been unoccupied. It is also possible that popu-

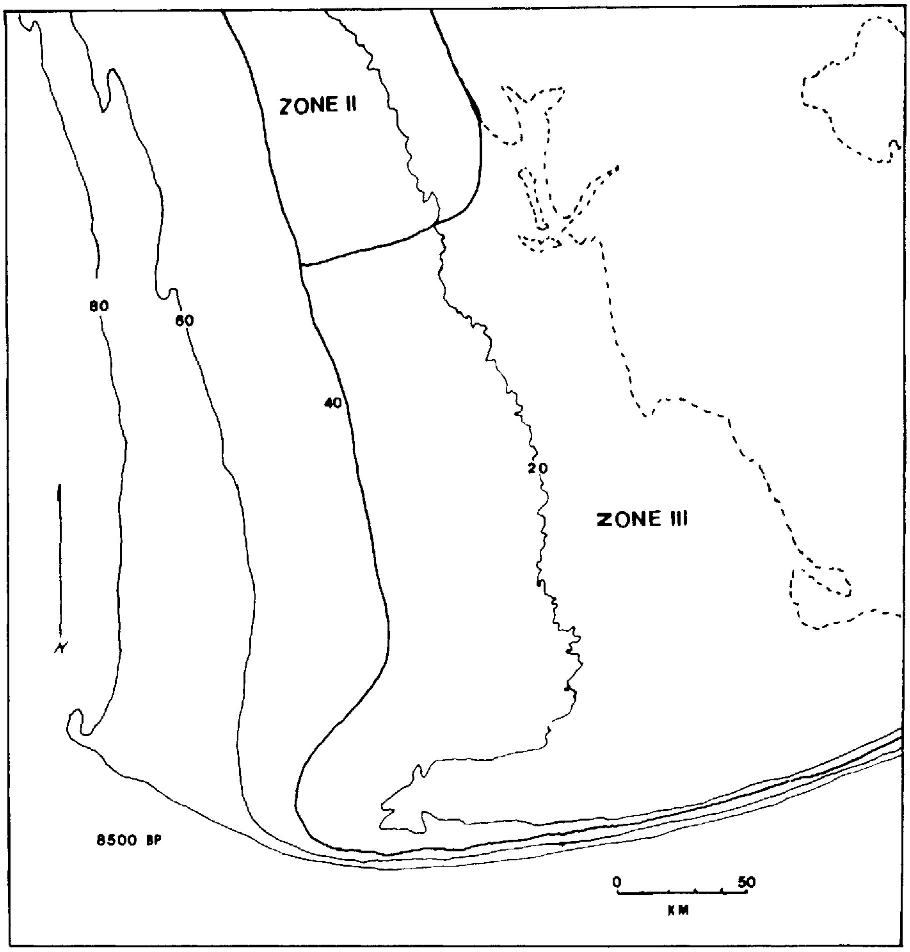


Figure 29. Location of Southwest Florida Resource Zones at 8500 B.P.

lations retreated north and the entire south Florida region was abandoned, but this appears to be an extreme position although little intensive survey has been conducted in all regions of south Florida.

The Middle Archaic Adaptation

At about 6500 B.P., there appears to have been a shift to more mesic conditions throughout the Florida peninsula, and as the sea level continued to rise, the water table rose and more surface water became available in ponds and sloughs in the interior regions of northern south Florida. Local xeric conditions still prevailed over most of south Florida, since Lake Okeechobee was not yet extant. Also, the rate of sea-level rise began to slow, resulting in a more stable coastal resource zone. Freshwater discharge is still at a minimum, however, and so few if any brackish estuaries were present. The increased availability of surface water throughout south Florida would possibly have resulted in higher critical carrying capacity, or may instead have reflected the conditions which existed in Resource Zone I, postulated for the Paleoindian period, which has now shifted inland and become archaeologically visible.

The dynamic settlement model for the period prior to 5000 B.P. is hypothesized as correlating to a gradient of resource zones based on the occurrence of available surface water, with a continued easterly shift of settlement following the shift in the available surface-water gradient. Thus, the most productive Zone I resources modeled for the Paleoindian period are now located along the present-day coast, with the scattered mesic sinkhole area (Resource Zone II) located east and south of this region, and the xeric, waterless Zone III still farther east and south. Thus, by 6500 B.P. the resource zones were close to their present positions, as can be seen in figure 30.

This lateral shift in resource zones through time has been presented in sequential plans in figures 28 to 30 and in the dynamic profile across Florida. These figures illustrate the relationship of sea-level position, site locations, and lateral location of the three resource zones occurring from 13,000 to 6000 B.P. in south Florida.

The lateral shift of resource zones from west to east and a concurrent settlement-subsistence shift would lead us to expect to find the Zone I resource environment exposed by 6500 B.P., and this seems to have been the case. At Little Salt Spring, the water table had risen high enough to initiate the discharge of water into a slough at 6500 B.P. (Clausen et al. 1979). Adjacent to this slough is a large 1–2 hectare Middle Archaic habitation site, which is interpreted here as a base camp, possibly indicative of macroband social grouping. This interpretation is based on the estimation by Clausen et al. (1979) of more than a thousand individuals buried in the cemetery in the slough.

The smaller extended family or microband temporary camps associated with the Zone II environment would have now been located farther east and south, although these sites could also have been located within Resource Zone I as well. If this reconstruction is accurate, there should now be an example of a temporary camp located farther east, and the Bay West site appears to represent such a site. This site has a mortuary area with only thirty-five to forty individuals, clearly suggesting a lower frequency of use and population aggregation, as compared with the Middle Archaic component at Little Salt Spring. To complete the settlement system proposed here, the arid Zone III environment, located even farther east, would possess the small, ephemeral hunting camps. Such camps could also be located in arid and less desirable locations within Resource Zones I and II.

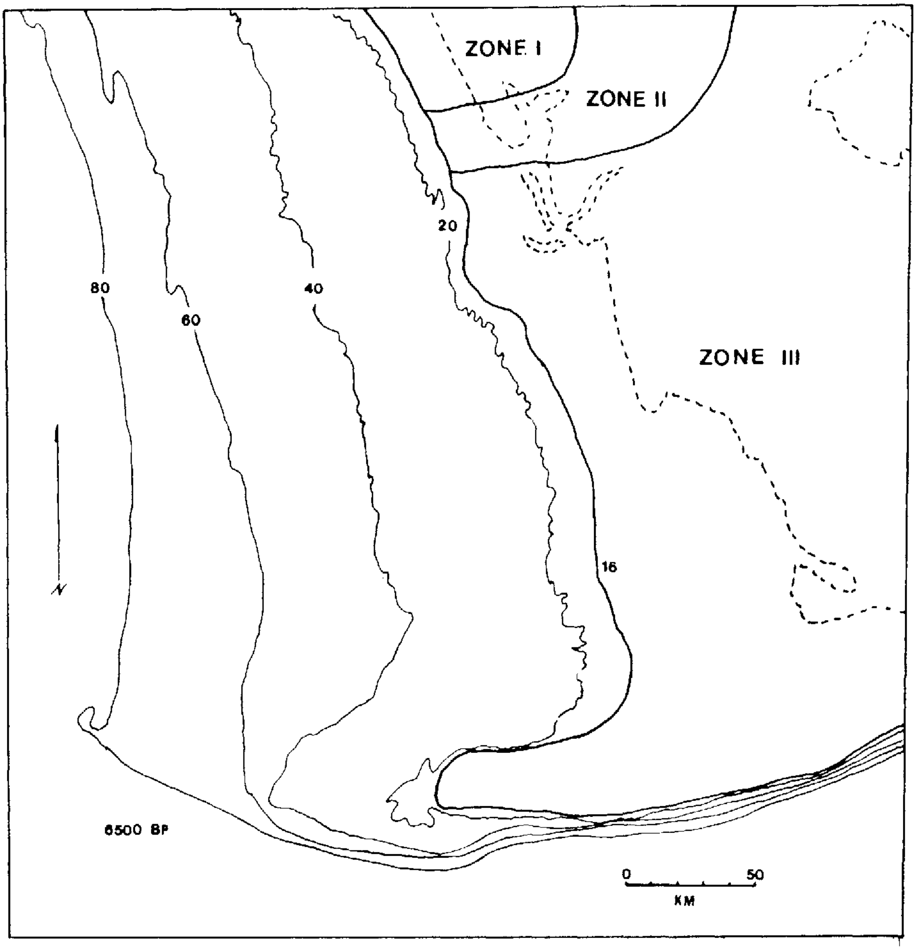


Figure 30. Location of Southwest Florida Resource Zones at 6500 B.P.

This type of site should become more common in these zones, since there would be greater population density in this area and more frequent use of the closer marginal districts within the zone rather than longer excursions into the arid interior, particularly since a number of faunal species, notably Pleistocene forms, were now absent from this area.

These conditions may have resulted in an abandonment of this interior arid Resource Zone III environment or at least a reduction in intensity of use. No sites are known in this zone, more likely a reflection of incomplete archaeological knowledge of the area than of the utilization of the zone.

The population density of south Florida as a whole seems to have been higher in the Middle Archaic period than in previous periods. There does *not* appear to have been an increase in population size, however, because as the sea level and water table rises, the Resource Zones I and II replace the unoccupied and sparsely used Zone III. Thus, population density would have increased solely as a function of the loss in area of the low-resource-potential arid Zone III while the areas of the other two more productive zones remained approximately the same.

There is another important theoretical outcome of this situation, one which may differ from other laterally shifting settlement patterns as a result of sea-level rise. Binford (1968) suggested that lateral movement of settlement systems brought about by rising sea level would result in conflict between existing interior groups. Such conflict would lead to warfare and intensification of subsistence techniques, namely agriculture, and ultimately the development of complex political positions. Such a situation did not occur in south Florida, since the interior region (Resource Zone III) was for the most part void of occupation, and therefore carrying capacity was not affected, as it might have been in other coastal zones of the world.

The social organization at this time was probably characteristic of mobile hunters and gatherers. Leadership positions may have been developing, but such positions would have been achieved from task-specific accomplishments of older, dominant males. The individual interred with lavish grave goods at the Middle Archaic cemetery at the Gauthier site would be representative of such a leadership position. No corporate leadership positions typical of the "big-man" type of political organization would be expected to arise from this settlement-subsistence pattern.

The Middle Archaic subsistence patterns would have been somewhat different from those of the Paleoindian period, since the Pleistocene fauna had become extinct by this time. Although the specific types of species changed, however, hunting patterns would not have altered the *general* features of hunting, most notably the percentage of meat in the diet. The potentially greater percentage of mesic habitats and their associated floral resources, it seems, would have been a more important factor in determining hunting patterns than the actual species composition. Therefore, the shift from Pleistocene fauna to Holocene animals such as deer does not appear to have influenced settlement patterns or demographic patterns, at least at the level of specificity modeled here.

The Pre-Glades Adaptation

About 5500 to 4500 B.P., dramatic changes occurred in the environment of south Florida, which effectively turned a desert environment into a swamp. Associated with these changes are equally dramatic shifts in the cultural adaptation. The shift to a modern floral *composition* probably occurred at this time but not the modern floral *distribution*. By 5500 B.P. the water table had risen to a position high enough to prompt the beginning of the hydric regime in the interior of south Florida, notably the appearance of Lake Okeechobee. Surface water was now available for evaporation and precipitation as rain, resulting in considerable amounts of freshwater discharge into estuaries. The surface drainage and its resultant increased sedimentation in the western coastal zone of south Florida, in conjunction with the slowing rate of sea-level rise, resulted in the formation of brackish estuaries and the extensive distribution of their favorable ecosystem types, mangrove forests, tropical marine meadows, and coastal marshes. Oyster beds and other filter-feeding organism habitats developed as well.

The estuaries became attractive resource zones, resulting in a reorganization of the subsistence and settlement patterning at this time. Furthermore, they continued to increase in stability, areal extent, and productivity until about 2700 B.P., when their maximal spatial configuration was established, as a result of the continued slowing of the sea-level rise, and the increased flow of freshwater discharge into the coastal zone as the water table rose.

The favorable changes in the character and productivity of the coastal zone would be expected to induce a concurrent shifting of settlement and subsistence patterns to take advantage of the increased resources. This view is supported by the archaeological evidence from Marco Island.

Marco Island is a unique topographic anomaly in south Florida; it is located in the coastal zone and has unusually high relief in the form of an arcate dune ridge with an elevation of 3–16 m above present sea level. Archaeological sites are situated on these dunes because of their immediate proximity to the estuaries, and a sequence of occupation spanning 5,000 years has been recorded on this island. Such a long recorded sequence is unusual, because many of the site types elsewhere, particularly for the earlier period, have been inundated by the 4 m of sea-level rise which has occurred since 5500 B.P. On Marco Island, however, even the earliest sites are preserved. The sites are more remarkable in that they document the shift from terrestrial to coastal adaptation as a response to the establishment of the expansive estuaries brought about by increased freshwater discharge from the interior and ever-increasing sea-level position.

The initial occupation on Marco Island, as can be determined in open-site situations, appears to have been at about 5000 B.P., toward the end of the Middle Archaic period, here referred to as Pre-Glades I Early. All the sites of the Pre-Glades adaptation have been recognized by the occurrence of molluscs, whose remains are easily observed, preserved bone tools, and vertebrate faunal remains. The earliest of these middens have neither ceramics nor lithics associated with them, the latter a reflection of their distance from the source of raw material and also probably the replacement of stone with shell as a source for many tool types.

All the sites on Marco Island, both during the initial occupation and those of succeeding periods within the Pre-Glades adaptation, are located close to each other on the same dune, adjacent to identical environmental-resource zones (see fig. 31). As a result, any change in the subsistence pattern as determined by analysis of the faunal remains can be interpreted as reflecting shifts in the use of resources because of environmental change or change in exploitative strategy and not because of differences in the immediate site environment. Therefore, it should be possible explicitly to document the change in subsistence patterns on Marco Island during this period and use this example as a model of changing adaptation for southwest Florida.

Marco Island was probably first occupied during the Pre-Glades I Early period, about 5000 B.P., because of the development of a new and highly productive estuarine zone along the coast, which resulted in a complete change in the subsistence pattern of the Pre-Glades period. Oyster-reef environmental types would not have appeared in the previous period, the Middle Archaic, and so the area of Marco Island would have been characterized as a Resource Zone III environment with minimal potential for occupation.

The change in environment was so abrupt and distinctive that the form of adaptation was completely altered, as were site locations and settlement patterns. The emergence of the estuary zone along the coast created a new niche for human exploitation. A shift therefore took place in terms of subsistence and settlement patterning in the zone. This shift in emphasis and importance of coastal resources was a gradual one, spanning the period from 5000 B.P. to 2700 B.P., because the sea level is steadily rising but at a continually slowing rate. The slowing of the rate of sea-level rise and the rising of the water table resulted in increased sedimentation and peat production, the rate of accumulation of which can be used as a gauge of primary productivity and hence productivity of the estuary zone, since it reflects the base of the energetic input into the trophic structure.

Estuarine productivity continued to increase in the coastal zone from 5500 B.P. to 2700 B.P. Alterations in adaptations as a result of this increased productivity should be reflected in changes in settlement and subsistence patterns. There appears to be some evidence of this at Marco Island.

The earliest Pre-Glades sites on Marco Island, 8Cr110 and 8Cr111, date to about 5000 B.P. Although no detailed analysis has been performed on the faunal collections from these Pre-Glades I sites, inspection of the faunal remains showed them to be composed of terrestrial and aquatic forms in approximately equal amounts.

Cumbaa (1971) has analyzed the faunal remains of six sites on Marco Island. One of these is a Pre-Glades II site, 8Cr112, which shows a gradually increasing reliance on coastal resources compared with the earlier Pre-Glades I site. At this site 35.2 percent of the fauna are terrestrial, 13.9 percent freshwater, 6.5 percent brackish water, and 44.4 percent marine. Here there is an approximate 15 percent reduction in terrestrial forms from Pre-Glades I times. At 8Cr107 we see the continued trend of increasing reliance on coastal vertebrate fauna. This site consists of a series of six distinct spatial components dating from the Pre-Glades III and Transitional periods. Unfortunately, Cumbaa did not present separate component faunal data, instead lumping all the tests together. Nevertheless there is a

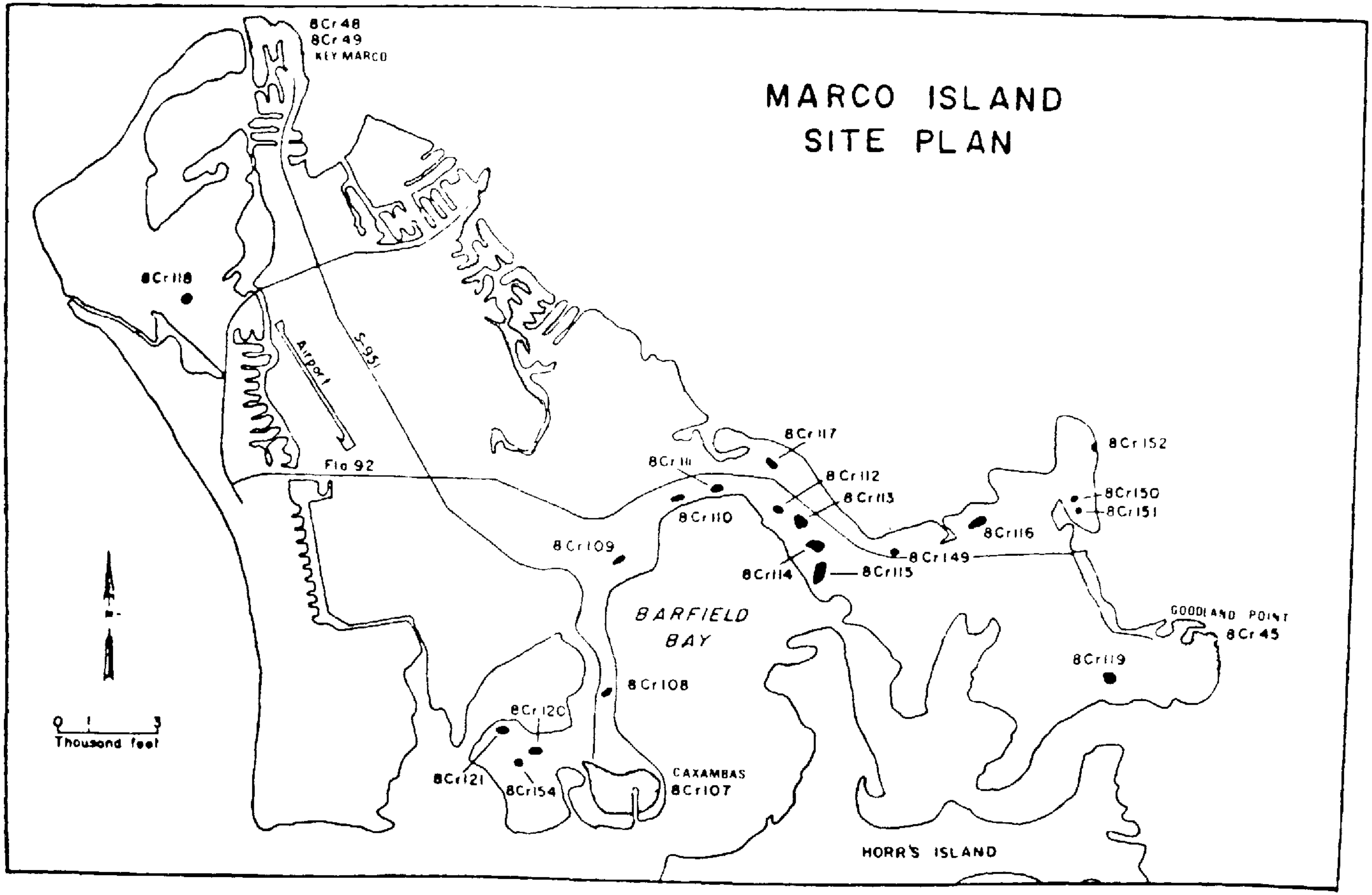


Figure 31. Marco Island Site Location Map

Table 15
Shift in Faunal Exploitative Pattern on Marco Island

			Percentage of Fauna			
Period	Site	MNI	Land	Fresh Water	Brackish Water	Salt Water
Glades II-III	Marco Midden(1)	609	3.7	0.1	2.8	92.4
Glades I	8Cr120(2)	534	0.7	0.2	0.2	98.9*
Glades I	8Cr108(2)	45	2.2	-	-	97.8**
Glades I	Cr107x2(2)(A)	1148	5.0	0.3	1.3	93.4
Glades I	8Cr107x3(2)	272	8.9	1.8	3.0	86.3
Transitional/ Pre-Glades III	8Cr107x1(2) (Tests 1-6)(B)	768	15.1	4.2	2.1	78.2
Pre-Glades II	8Cr112(2)(C)	108	35.2	13.9	6.5	44.4
Pre-Glades I	8Cr110(3)	-	50		50	

(1) From Wing's(1965) totals of Tests A and B, Marco Midden, placed into Cumbaa's (1972) habitats
(2) Cumbaa (1972)
(3) Widmer inspection of fauna
* 91.2% of marine are Ariidae
**86.7% of marine are Ariidae
(A) Radiocarbon date of A.D. 280 (uncorrected)
(B) Radiocarbon date of 1450 - 1110 B.C. (uncorrected)
(C) Radiocarbon date of 3015 ± 100 B.C. (uncorrected)

shift to 78.2 percent marine fauna, an increase of over 50 percent, with a further reduction in terrestrial fauna. The shift in vertebrate faunal exploitative pattern for sites of the Pre-Glades and Glades periods on Marco Island is shown in table 15.

The shift in faunal exploitation seen on Marco Island during the Pre-Glades period correlates closely with that predicted by a model of estuarine development, that is, a gradual increase in the number of coastal faunal resources and a reduction of terrestrial forms as the estuaries became established, grew in size, and increased in productivity. This shift in subsistence composition is not a reflection of lateral shifting of the resource zones as sea level rises, since there is a complete lack of components dating to the Pre-Glades I through III periods in the Big Cypress Swamp, located in the interior region immediately adjacent and west of the coastal zone. The interior area adjoining the coast was not as productive and would have been used only sporadically, distinctly less than that of the previous Middle Archaic period, since human habitation is now situated along a coastal strand which includes both the estuaries and their immediately adjacent terrestrial zones. The interior zone east of the utilized terrestrial zone probably acted as a refuge area for the replacement of vertebrate faunal resources hunted in the zone immediately adjacent to the coast.

There is a seemingly peculiar anomaly in the Pre-Glades faunal history. The highest frequency of freshwater faunal remains is found in the Pre-Glades II period, with a *decrease* in freshwater faunal remains through time (see table 15). This situation is the opposite of what would be expected from the sea-level and hydrology history. Surface-occurring fresh water should become more frequent through the Pre-Glades period, and therefore, resource exploitation should reflect this increase, as these habitats and their fauna expand. I would speculate that the reason for the anomaly is that Barfield Bay was originally a freshwater pond, completely encircled by the dune system of Marco and Horr's islands, with no tidal access during its earlier history. As the sea level rose, salt water eventually invaded Barfield Bay, and freshwater resources were no longer available. This scenario, suggested only as a hypothesis, could easily be tested by core sampling the sediments in Barfield Bay and determining if there are changes from freshwater to saltwater peat and pollen.

The shift in faunal exploitation from primarily terrestrial to coastal species during the Pre-Glades period is interpreted as a reflection of the increased estuarine area and its correlate productivity as the coastal environment evolves. In spite of these changes, however, there does not appear to be a dramatic shift in population numbers during this period, although much of the evidence for this population would now be inundated by the sea (see R. J. Ruppé 1980). There is no evidence of large permanent villages at this time, although large, seasonally occupied base camps might be found in the now-drowned estuary zone of the Ten Thousand Islands.

Many of the outer islands of the Ten Thousand Islands chain appear to have been formed on oyster-shell middens on barrier sand bars, which were later inundated by the rising sea and colonized by vermetid reefs. Since these sites have exaggerated site volume relative to similar terrestrial sites without shell, however, I suggest that no sites existed in southwest Florida, drowned or otherwise, which would represent permanent villages during the Pre-Glades period. Instead, I suggest that such sites represent large, temporary base camps, perhaps up to three hectares in extent (slightly larger than the Middle Archaic base camp at Little Salt Spring), but are more numerous because roughly the same-size population as was found in the Middle Archaic period is now concentrated in the coastal zone. As a result, effective population density in the coastal zone increases over that hypothesized for Resource Zones I and II of preceding periods.

One of the characteristics of southwestern coastal sites is that their shell deposits extend well below the level of the low tide. Therefore, it may be that many of them, such as 8Cr107, have substantial Pre-Glades components. Nevertheless, the environment at this time does not appear to have been productive enough for the establishment of sedentary fishing villages. As a result, the impetus for increased fertility, which we know correlates with sedentism (Kolata 1974; Binford and Chasko 1976; Hassan 1981), is not yet present.

The best ethnographic example to use as an analogy or model of the probable settlement-subsistence pattern in southwest Florida during the Pre-Glades period appears to be the Andaman Islanders (Radcliffe-Brown 1922; Coon 1971). The Andaman Islands are estimated to have had a pre-European-disease population of about 5,500 on a land area estimated at approximately 6,950 km^2 (2,500 sq. mi.) (Radcliffe-Brown 1922). These estimates result in a mean population density of approximately 0.79 persons/km^2, although population density varied from island to island (Coon 1971). This is a moderate population density, about midway between the range 0.02 to 9.5 persons/km^2 for the hunting-and-gathering populations listed by Hassan (1981:8) and similar to that of other tropical hunter-gatherers, such as the Ituri pygmies.

The Andamanese exploited coastal and terrestrial resources in what appears to be about equal proportions. Murdock (1969:137) lists fishing as the main subsistence technique, accounting for 40 percent of the diet. The Andamanese settlements consisted of about forty to sixty individuals residing in villages of single-family huts or circular communal huts. These "villages" were temporarily inhabited, and village location shifted throughout the year. Occupation in rainy-season villages was usually longer than at other times of the year, often for up to four months. The Andamanese were a society of the "big-man" social type, with microband leaders chosen according to age and sex, and had only personally achieved statuses (Coon 1971).

Macroband aggregations also took place annually. These were for the purposes of arranging marriages and adoptions. A superior headman, or two headmen, would preside over the aggregation for the purpose of quelling disorders (Coon 1971). The superior headmen positions were occupied by influential men of achieved status who could arrange the annual macroband aggregations. Unfortunately, we do not know the size of the macroband aggregation. Endemic fighting appears to have been the rule among all "tribes" of the Andaman Islands.

The subsistence, settlement, demographic, and sociopolitical characteristics of the Pre-Glades adaptation, as well as the type of environment, a tropical coastline, appear to parallel closely the Andaman Island situation. An additional interesting feature of the Andamanese is that although hunters and gatherers, they possessed ceramic vessels, also found in the Pre-Glades period. Thus, the Andamanese seem to be an appropriate example of an ethnographic type which could be found in the southwest Florida area.

The Pre-Glades time probably saw no major population growth, although there was a reorganization and change in the faunal resources exploited with a concurrent change in settlement pattern. No floral remains have been recovered from the Pre-Glades sites on Marco Island, and these resources may have been more important in determining the critical carrying capacity with estuarine resources. In tropical regions floral resources are more important numerically in the caloric intake of hunters and gatherers (Lee 1968; Murdock 1968). If protein rather than calories was the limiting factor in tropical areas, however, as has been suggested by Harris (1977), then the shift in faunal exploitation to aquatic resources might have increased the critical carrying capacity. This was possibly the case during the later portion of the Pre-Glades period. Increases in population density at this time, however, are interpreted as a reflection of the increase in critical carrying capacity, which results from environmental change and *not* any major cultural innovations or changes, a contention which seems to be confirmed by the archaeological record.

An elevation of the critical carrying capacity would allow increased population without major shifts in the fertility pattern. It may have been that the relaxation of fertility-dampening cultural factors, such as infanticide, long postpartum sex taboos, and abortions, could have resulted in a subtle increase in the population growth rate. Mortality may also have been reduced under these conditions of slightly higher critical carrying capacity, since endemic fighting and warfare, which we know existed in the Andamanese culture, might have been relaxed as competition over resources was temporarily suppressed by increased productivity in the immediate environment.

I suggest that the population during the Pre-Glades time would not yet have been sedentary, since the reliance on terrestrial faunal resources was still present. Such reliance combined with a reliance on floral resources would probably have necessitated a shifting settlement pattern of seasonally occupied hamlets or villages. It might have been that the duration of occupation at any one seasonal hamlet increased through time. I would hypothesize here, however, that not until full sedentary habitation occurred did fertility rise and the population rate increase substantially over that found in the Pre-Glades period.

The Glades Adaptation

At approximately 2700 B.P., the sea level rose to a position which is optimal for the formation of highly productive coastal environments, and the rate of sea-level rise slowed. Also at this time, the interior, terrestrial environments, as described earlier, were in their present-day spatial distributions. I suggest that the productivity of the coastal environment subsequent to this date is considerably greater than in the previous, Pre-Glades, period, from 5500 to 2700 B.P., because of the increased area of coastal ecosystems, increased productivity in these ecosystems as a result of increased sedimentation and water flow from the interior, and increased productivity of the freshwater aquatic swamp zone which now flanks the coastal zone, the Big Cypress Swamp. None of the above conditions prevailed in south Florida prior to 2700 B.P.

The change in environmental conditions about 2700 B.P. were so dramatic that we see a complete transformation in the cultural adaptation in south Florida subsequent to this date. This adaptation is known as the Glades Tradition (Goggin 1947). Goggin was the first specifically to demonstrate that the adaptation characteristic of the Glades Tradition was one which focused on the exploitation of wild tropical plant and animal resources, especially seafood. Since marine and estuarine resources were so important in this tradition, J. W. Griffin (1976) has suggested that the use of the term "Glades" connotes utilization of one particular portion of the south Florida environment and so should be replaced. I believe, however, that this term has merit as it stands, since it has already been defined and is in the literature. Although imprecise in terms of its connotation (the more specific usage should be "Everglades"), it is accurate in that it refers to environmental patterns which pertain to south Florida subsequent to 2700 B.P. Therefore, in spite of the semantic imprecision of the term "Glades," the definition of the characteristics of the adaptation and the environments in which this adaptation is found are well-established:

> It [the Glades Tradition] is based on the exploitation of the food resources of the tropical coastal waters, with secondary dependence on game and some use of wild plant foods. . . . The relation of the Glades Tradition to the environment is very close. All food was derived from wild products systematically gathered in their season. Seafood was perhaps the most important food source, and apparently many varieties were eaten. The use of many minor forms suggests a systematic testing of local species to determine the shellfish suited for food. Other marine foods included such diverse forms as whales and echinoderms, sharks and crabs, and rays and crawfish. Even sailfish and marlin were obtained in the Gulf Stream. [Goggin 1949a:28, 29]

Since the present environment of south Florida was fully established at 2700 B.P., and it is markedly different from the preceding periods, a markedly different and distinctive form of settlement-subsistence pattern, demography, and sociopolitical system would be expected, and such appears to be the case. Goggin (1949a:31) saw this shift as a result of "the integration of the intruding culture in terms of the local environment" and went on to state that it was not until Glades II times that the initial adjustment was successfully made. This interpretation was made without knowledge of Pre-Glades period occupation in southwest Florida. From the research conducted on Marco Island, however, the Glades Tradition appears to have developed in situ, although the initial period was seen as an adjustment to the local environment. This view simply pushed back the initial movement into the Glades area to 5000 B.P.

Cockrell (1970:85) was the first to note the distinctive difference in settlement and subsistence pattern between the Pre-Glades period and the later Glades Tradition. Cockrell (1970:85), however, saw the Pre-Glades characteristics at Marco Island as being due to inefficient utilization of the environment and a "period of adaptation to the peculiarities of the Glades area." Since it was not until 2700 B.P., the end of the Pre-Glades period, that the contemporary environmental characteristics were completely established, the shift to "efficient exploitation" is not cultural or technological in nature but appears to be due, instead, to a gradual readjustment to the expanding estuarine environment brought about by stabilization of the sea level. This does not necessarily rule out any technological change, but no such change is seen in material-culture inventory.

I do not mean to suggest that no sociopolitical or demographic changes occurred as a result of *increased* reliance on estuarine resources. They clearly did, but I believe that no archaeologically measurable period of technological development or adjustment was required in the subsistence technology or resource procurement to allow an effective utilization of the changing environment, since the changes were *quantitative*, increased estuarine and swamp areas, rather than qualitative, that is, new environmental types. It is possible that new and improved technology evolved during the Glades I Early period—that is, nets, fish traps, or weirs—which resulted in increased fish yields relative to terrestrial resources. But at this stage of research there is no archaeological evidence suggesting when these shifts might have occurred.

The shift to an almost exclusive reliance on estuarine resources occurred during the Early Glades I period. By A.D. 280, the coastal subsistence pattern was clearly formed (see table 15), with 94.7 percent of the faunal remains (MNI) being brackish water and saltwater forms. This pattern is almost identical to the later Glades II and III subsistence frequencies (see table 15), which seems to imply that the coastal-subsistence orientation was established in the earliest portion of the Glades Tradition, in the Early Glades I period.

Not only was the subsistence pattern clearly established but so were the settlement patterns. On Marco Island, the small, temporary camps, 60 m in diameter, located on the dune ridges were no longer occupied (with two notable exceptions). Instead, all habitation was at the water's edge, indicating the importance of direct access to water. This shift occurred in the very earliest stage of Glades I and is documented at the 8Cr107x2 site. At that site in 1967 Morrell found hollow casts of what appear to be pilings forced down into the shell heaps; the pilings are contemporary with water-worn sherds (Cockrell 1970). This evidence certainly indicates substantial permanent structures, possibly pile dwellings, on a tidal flat. The site has been radiocarbon dated at A.D. 280, 1.5 m below the surface (Cockrell 1970:70). That level was nowhere near the bottom, with the midden extending to a depth well below the low-tide mark. A similar situation was seen at 8Cr117, another Early Glades I site on Marco Island (Widmer 1974).

These settlements are quite large, 20 hectares for 8Cr107 and 4 hectares for 8Cr117, which seems to indicate permanent year-round habitation by multiple-lineage groups. Because these groups would now be sedentary, the fertility function can increase significantly over that seen in the previous period (see chapter 2). Although the exact reasons for such an increase are not as yet known, the correlation has clearly been established (Kolata 1974; Binford and Chasko 1976; Hassan 1981). Therefore, the southwest Florida coast probably began to be rapidly colonized.

I hypothesize that the rapidity of colonization would have resulted from a fissioning process, typical of expanding agricultural populations like the Yąnomamö in the Orinoco Valley of Venezuela (Chagnon 1977). The fissioning process could have occurred in southwest Florida, because the environment is basically open, permitting the formation of new settlements. On the other hand, hypothetically, there would also have been strong pressures toward the formation of large settlements. Large, nucleated villages would have acted as magnets, drawing in population and reducing the total number of settlements, resulting in an increase in density and size. These settlements would have been located in the most convenient locations for accessing the most productive resource areas. The theoretical reasons favoring sedentary village formation are as follows: the environment was now sufficiently productive to support sedentary villages (this situation did not exist prior to 2700 B.P.); sedentary villages would have been composed of several lineages, which would allow intrasettlement exogamy and thus would maximize the efficiency of arranging marriages; large sedentary villages would have been effective for defense against raids; and the increased productivity of cooperative work activities would have favored large population aggregates.

Population could have grown relatively unchecked, because of the higher potential-growth rate brought about by an increased fertility associated with sedentary habitation and because much more area of highly productive coastal resource zone was available than had been earlier. Since unoccupied frontier existed, village fissioning could have continued until the new critical carrying capacity was reached. It is hypothesized that an achieved "big-man" type of social organization was present at this time, because with an open environment, village fissioning would have occurred before populations became too large or dense to have required a hereditary chief with ascribed status. Since fissioning was possible, conflict levels would have been minimally developed.

Eventually, village fissioning would no longer have been possible. When populations grew to an extent that one lineage had demographic preponderance over another and could have provided economic and kin support to establish or rank that lineage appreciably higher than all others in a village, ascribed status would have developed. This development of ranking is hypothesized as a response to increased population growth in a situation without the potential for village fissioning.

In the initial stages of the development of ranking, the incipient political centralization would have been brought about by internal village disputes, with minimal military problems, since village fissioning was still possible. Therefore, chief or village-headman statuses need not have been hereditarily fixed, since their range of conflict resolution would have been limited.

Still, as village fissioning no longer became a feasible means of conflict resolution, both internally and in terms of the circumscription of resources as the critical carrying capacity is reached, the need for the increased effectiveness and frequency of leadership decisions arose, and hereditary chiefs and ranking could have developed. Ranking would not have developed until the threshold of critical carrying capacity was reached, probably by A.D. 800, and it was at this time that the late aboriginal adaptation, as represented ethnohistorically by the Calusa, became established. Goggin (1949a) believes that this is when the adjustment to the Glades area finally became successful, but I suggest that in actuality it was when the critical carrying capacity or population threshold was reached. Population probably increased slightly after this time, but such an increase would have been a reflection of minor shift in environmental productivity, intensification of the subsistence activity, and possibly interregional exchange of subsistence.

The model of sociopolitical development hypothesized above is somewhat supported by archaeological data from south Florida. Almost *all* sites have components dating from A.D. 800 on, while only some have earlier components, consistent with a fission model of population increase. Also, it appears that Glades I Early sites are smaller in size than those dating after A.D. 800. This pattern is confirmed for the Key Marco site, which has no Glades I Early component; the Wightman site, where the post–A.D. 800 component is substantially larger; and numerous other sites along the southwest coast. This maximum demographic filling in by A.D. 800 is also seen in the freshwater swamp and marsh zones of the Big Cypress Swamp, where the majority of sites have equal representations of both Glades II and Glades III components.

The exploitation of this interior freshwater swamp and marsh zone was extremely intense compared with Pre-Glades use. Sites in this region are small, circular black-dirt middens with sparse cultural material but staggering quantities of faunal remains and coprolites (Ehrenhard et al. 1978). The limited size of these sites, and the extreme concentration of faunal remains suggest specialized, interior hunting-and-collecting expeditions of limited duration into this zone from permanent year-round villages in the coastal sector of the Ten Thousand Islands. The faunal resources would be processed at these sites and the meat, skins, and other usable by-products brought back to the villages, which would account for the minimal representation of these resources in coastal middens. Bone tools may have been manufactured in these areas as well.

On Marco Island two specialized fishing stations, 8Cr108 and 8Cr120, might have been present in the Glades I Early period. These sites are situated on the dune ridges, the only two Glades Tradition sites thus known, and have almost identical faunal remains (see table 15). Both sites have the typical Glades Tradition faunal subsistence pattern of over 90 percent (MNI) marine resources, but at these sites the majority of all marine resources are of the family Ariidae (sea catfish) (Cumbaa 1971). The sites are also quite small, unlike the typical Glades I permanent villages. They are interpreted as specialized-fishing camps, focusing on one particular species, or perhaps group of species, found in a distinct environment or captured with a particular technology; the catch was processed at the sites and then brought back to the villages. Cumbaa (1971) adds that the users of the sites specialized in collecting from Roberts and Barfield bays. He further comments on the unusually high frequency of catfish otoliths, since no other sites on Marco Island had similar frequencies, and suggested that the bodies were dried or smoked for later use and that the heads were boiled and eaten on the spot, with the otoliths being the only elements preserved intact after long cooking. This interpretation seems to be reasonable and is consistent with that hypothesized for the interior utilization.

J. W. Griffin (1974:374) also reports a specialized turtle-collection site during the earliest component (A.D. 500–800) of the Bear Lake site, farther south in Everglades National Park. Sea turtles make up 48.6 percent of the faunal remains. Because the turtles were relatively young, Griffin suggests that they were taken from the water rather than from the beaches of Florida Bay. This mode of collection can be interpreted as another example of specialized collecting in this early time period and in any case is indicative of the harvest of a particular age structure. The Bear Lake midden and the two dune sites on Marco Island seem to document the existence of specialized subsistence pursuits *prior* to the maximum demographic filling in of southwest Florida. If such pursuits did exist, there was little or no difference between the subsistence pattern in the earliest periods of the Glades Tradition and those subsequent to A.D. 800, and villages, 3–20 hectares in area, and temporary campsites for specialized hunting, fishing, collecting, and processing were the only settlement types during the period. I hypothesize that most of the hunting, fishing, and collecting stations were highly temporary, particularly in the Glades I Early period. They may have been occupied only for a short duration, or overnight, possibly by only limited age-and-sex portions of the base village, that is, adult males. This interpretation would account for the low frequency of ceramics in many of these sites.

Later in the Glades Tradition, after population had increased to critical carrying capacity, some of these stations may actually have become permanently inhabited, and their occupants may have functioned as specialized "producers" who were economically, socially, and politically linked to larger permanent villages. This usage would have been particularly feasible where hunting-collecting stations were close to villages. Also, certain types of specialized collecting, such as of seasonal fruits, berries, and shellfish, and concomitant processing activities would not necessarily have involved extended periods of time away from the main village by all members of a local group but instead just by certain age-sex components of a base population. Such activities, particularly with canoe transport, could be easily accomplished by the young and old of both sexes. Thus, different types and frequencies of artifacts—ceramics, for example—would be found at different sites.

Therefore, I am in agreement with J. W. Griffin's (1974) characterization of two types of archaeological sites for southwest Florida, the black-earth middens and the large shell middens, which served as base villages. I am inclined to believe, however, that the villages were permanent, and that all other sites were used in a manner similar, if not identical, to the fields of agriculturalists. Thus, although a considerable amount of time was spent at these resource-procurement locations, the population resided in permanent villages located in the coastal zone.

An increase in population from 3,000 to perhaps 10,000 inhabitants took place on the southwest Florida coast, I suggest, from 600 B.C. to A.D. 800, a span of approximately 1,400 years. Such an increase would represent a doubling of population every 700 years or more specifically about 0.1 percent per year, a rate considered in line with Upper Paleolithic population increase (Hassan 1981). Although this rate may seem very low, it is modeled as steady, continuous, and uninterrupted. The rate is also in line with an expansion of hunter-gatherers into a new environment, irrespective of the increased fertility resulting from sedentary habitation. Thus, even the conservative figure for the general fertility pattern of hunters and gatherers can readily accommodate the growth rate.

If we argue that these large sedentary villages, or sedentary habitation of any kind, did not occur until A.D. 280 (the earliest date at which such villages are definitely documented with the Calusa-type subsistence pattern), 520 years would be required for the necessary population expansion. This increase could be accounted for within this time period by a growth rate of 0.25 percent, which would yield a doubling of population approximately every 280 years. This doubling rate is reasonable for agricultural people, and if the Glades people were sedentary, one would expect comparable growth rates, but whether the rate is correct requires further investigation.

Unfortunately, phase-specific settlement data are not adequate precisely to trace population history through time, as has been done in other archaeological regions of the world, notably the basin of Mexico (Sanders et al. 1979) and the Near East (R. M. Adams 1981). It is possible, however, to evaluate the potential fertility of the population in this area for this trajectory. This evaluation should provide a reasonable upper limit to the potential growth rate which the population can maintain. To make such an evaluation requires fitting archaeological-skeletal demographic data to an archetype (i.e., uniformitarian) notion of how fertility operates during the various reproductive cohorts of a population.

The skeletal population from the Bayshore Homes burial site, which is dated about A.D. 1000 (W. H. Sears 1960), has been selected. The site is on the Gulf Coast of Florida but is located outside of the southwest Florida coastal area, near St. Petersburg. Larson (1980), after reviewing the ethnohistoric chronicles, has concluded that maize agriculture was either not present or minimally represented in the inhabitants' subsistence economy, but it is not known whether this situation pertains to the period of the burial sample. We know from Menéndez (Solís de Merás 1964) that the population in the Tampa Bay area was similar to that for southwest Florida in the mid-sixteenth century. Therefore, the Bayshore Homes burial population is being used as a model for demographic characteristics in south Florida at this time period. That the sample dates after the A.D. 800 population threshold projected for south Florida is not considered a problem, because the population should be even more limited in terms of fertility, mortality, and carrying capacity. This should result in an even more conservative conclusion than is probably true of the period being investigated.

Two limitations in the skeletal population from the Bayshore Homes burial mound, however, must be considered before the analysis can begin. The first is the sample size. Only 114 individuals, out of a total estimated 500 individuals, compose the burial population, and as a result, the analysis may be subject to serious sampling error. W. H. Sears (1960) states that the burial sample is "representative" of the mound, and so its size should not necessarily be a problem. The second problem, more serious, is that the original aging of the skeletal population was not done in five-year cohorts (Snow 1962), whereas the method of ascertaining population-growth potential developed by Henneberg (1976) uses five-year cohorts. The life-table data must, therefore, be transformed into five-year cohorts, which has been done by assuming a *linear* distribution of deaths within each of the original cohorts. Although the new cohort breakdown may not be an accurate reflection of the actual number of deaths per cohort, I believe that the problem is not serious, because only a few years overlap in the most important reproductive cohorts and so the percentage of error is small. Table 16 shows the original age breakdown and the modified age breakdown. This transformation allows the net reproduction rate to be calculated for the Bayshore Homes site, using the juveniles who died before age fifteen. Since subadult underrepresentation is common in many burial excavations, a more conservative survivorship rate of 60 percent seemed more appropriate than the actual survivorship value of 68.6 percent, and so two different net reproductive rates were calculated using these different values. The more conservative, completed-fertility value of seven was also used; this figure, I believe, is compatible with sedentary populations irrespective of the subsistence base and therefore is applicable here.

The resulting net reproduction rates range from a low rate of 1.253 to a high of 1.433. This range indicates that for every generation of reproducing-age adults, ages fifteen–forty-five, or every 30 years, 1.253 or 1.433 adults of the same age will be added to the population. Since a net reproductive rate of 2.0 represents a doubling every 30 years, 1.253 means a doubling rate every 121 years, whereas a net reproduction rate of 1.433 gives a doubling every 70 years. The former figure represents a growth rate of approximately 0.58 percent per year, and the latter one a growth rate of 1.0 percent. Even the conservative rate resulting from Henneberg's calculations is more than twice that predicted for the growth rate in south Florida for the most conservative population history of 520 years at a growth rate of 0.25 percent. This seems to indicate that the population increase seen in south Florida during this period is reasonable in terms of our expectations of population growth suggested on archaeological grounds.

Notably, the population growth rate proposed archaeologically, even in the most conservative history, is *lower* by at least 50 percent than that which is theoretically possible under the most conservative assumptions. This lower rate has important implications, since there were obviously stochastic short-term environmental perturbations, which would have had a dampening effect on fertility

Table 16
Bayshore Homes Life Table

Original Cohort	D_X	% Deaths	New Cohort	How Transformed N %	New D_X	d_X	s_X	d_{XSX}
13-20	7	.875	15-19	5(.875) + 0	4.37	.056	.94	.052
21-25	23	4.6	20-24	1(.875) + 4(4.6)	19.28	.246	.70	.171
26-36	25	2.5	25-29	1(4.60) + 4(2.5)	14.60	.187	.51	.095
			30-34	5(2.50) + 0	12.50	.160	.35	.056
36-70	25	.735	35-39	1(2.50) + 4(.735)	5.44	.070	.28	.019
			40-44	5(.735) + 0	3.68	.047	.23	.010
			45-70	25(.735) + 0	18.38	.235	0	0
					-----			-----
					78.25			.403

Proportion 15 to 70 = .686

Proportion 0-14 = .314

$R_{POT} = 1 - d_{XSX} = .597$

$R_0 = R_{POT}\ (.5)(U_C)[(100 - 0.314)/100]$

R_{POT} = .597 (gross potential reproductive rate)

U_C = 7 (completed fertility)

.314 = proportion of live births who die before age 15

R_0 = 1.433 (net reproductive rate)

R_0 = 1.253 (with an adjusted juvenile survivorship of 60%)

and an aggravated effect on mortality occurring during this period. These events probably included cold fronts and hurricanes, thundershowers with severe dilution of the estuaries, and droughts and fires. All of these perturbations could have resulted in seasonal fluctuations in resource availability. Adverse conditions might be exaggerated in certain years during this population history, seriously affecting the overall growth rate of the trajectory, with the growth rate at times perhaps being lowered or even negative. Therefore, it would be highly unusual to have an "actual" or, better stated, projected growth rate similar or identical to the biologically potential growth rate.

It is difficult to say exactly how much lower the actual rate should be, but 50 percent does not seem too high, since many of the variables are not controllable. Therefore, I suggested that for any given period in the trajectory of this population history, a growth rate well below the biological potential was operating. This is analogous, not homologous, to the acknowledgment that potential carrying capacity among hunter-gatherers is never achieved, and instead, a critical carrying capacity is established well below the theoretical potential. Thus, numerous fertility-dampening factors, both cultural and environmental, suppress the biological potential for maximum fertility.

In spite of this dampening, however, the population on the southwest Florida coast seems to have steadily grown at a rate between 0.1 percent and 0.25 percent. The ability to support such a growth rate was probably due to the raising of the critical carrying capacity, which had prevented similar modest but continuous growth after the initial colonization of south Florida at 13,000 B.P. Changes in environmental conditions at 2700 B.P. probably resulted not only in shifts in subsistence and settlement patterning but shifts in population characteristics as well, with the beginning of population growth due to increased fertility.

Although it now seems that many sites dating to the Pre-Glades period are now drowned and that the coastal occupation during that time was responsible for the formation of the Ten Thousand Islands, the same factors were not operating then. The settlement-subsistence reorientation during the Pre-Glades period was accompanied not by an increase in population size but by density at the local level. The settlement readjustments undoubtedly resulted in increased density, however, and with it, the potential for development of leadership positions and non-egalitarian sociopolitical development.

Not until the development of the Glades Tradition and, more important, the reaching of the critical carrying capacity at A.D. 800 or so were population size and density sufficient for the development of ranking and of the chiefdom level of sociopolitical organization. Once village fissioning could no longer be a viable mechanism in the resolution of disputes and once the cultural carrying capacity was reached, the increased efficiency capture rate of resource procurement through conflict resolution, implementation of coordinated labor activities, and coordination of village defense became important cultural necessities and were institutionalized within a ranked lineage system. Population levels had reached the critical carrying capacity on a *regional* basis by A.D. 800 as a result of increased population growth brought about through the sedentary habitation now possible in the highly productive estuarine environments formed by 2700 B.P., and it is at this time that the complex form of sociopolitical development, characteristic of the Calusa, evolved. This is several hundred years earlier than what is traditionally thought for southwest Florida (Milanich 1978), but from a processual perspective this seems to have been possible.

It should be emphasized that at A.D. 800, critical carrying capacity seems to have been reached on a pan-southwest-coast level. Carrying capacity might have been reached on a local level well before this time and would have been if daughter villages had fissioned from an initial village and had surrounded it. Such a situation would have had the potential of fostering the differential development of leadership among sites in the parent village because of internal stresses brought about by differential access to subsistence resources. The number of such socially circumscribed groups, however, compared with daughter villages with potential for expansion, would increase through time but would not be important in the shift to chiefdoms at the *regional* level until pressures from circumscription were widespread. It seems, then, that social circumscription, as well as environmental circumsciption, at the *regional* level was also established by A.D. 800, a position consonant with the pan-southwest-coast development of chiefdoms.

8

The Subsistence and Settlement Characteristics of the Calusa Adaptation

The settlement and subsistence characteristics of the post–A.D. 800 occupation of southwest Florida are reconstructed from archaeological data generated through past field research. Unfortunately, archaeological survey data necessary for the precise phasing and reconstructing of settlement patterns are absent for many areas of southwest Florida. Thus, the settlement pattern presented here should be viewed as only a tentative reconstruction.

On the other hand there is at present a sufficient body of faunal data analyzed at a sophisticated level to allow a reasonable reconstuction of the subsistence pattern. The sociopolitical characteristics of the post–A.D. 800 occupation are not as easily reconstructed from the archaeological data base at this time and so must be theoretically modeled. For this reason, the evolution of the sociopolitical features is discussed in the next chapter.

The resource base available for human exploitation in this region is primarily estuarine in nature, with fish and shellfish composing the majority of the subsistence. Sixteenth-century primary ethnohistoric sources repeatedly emphasize the abundance of fish in the region (e.g., Fontaneda 1944:66–67; Zubillaga 1946:356; Solís de Merás 1964:148). Upland-game and wild and domestic plant resources are of minimal importance in terms of total calories, as is known from archaeological, ethnohistoric, and ecological data. Goggin and Sturtevant (1964: 183) characterize the subsistence as nonagricultural; numerous historic references of the sixteenth century specifically mention that agriculture was not practiced. Of particular interest is that when Menéndez visited the cacique Carlos in the middle of February 1566, only broiled and roasted fish of several kinds and raw, boiled, and roasted oysters were served (Solís de Merás 1964:148). This menu explicitly indicates that plant foods were not used, suggesting that plant resources were either unavailable or simply not used at this particular time.

The Contribution of Interior Resources to the Subsistence Pattern

It has long been recognized that interior, or noncoastal, resources were utilized in the subsistence base of the Calusa coastal adaptation. From the analysis of subsistence remains of coastal sites, however, these resources do not seem to be present in any quantity. In my earlier discussion of these interior resources, I had no way of quantitatively evaluating their contribution to the coastal adaptation (Widmer 1978). Now, with the large body of site information generated by the Big Cypress Swamp survey (Ehrenhard et al. 1978, 1979, 1980, 1981; Ehrenhard and Taylor 1980), a renewed consideration of the role of interior resources in the coastal adaptation is feasible. We are fortunate in having faunal assemblages from two of these sites, the Hinson and Platt Island sites (Ehrenhard et al. 1978), and it is now possible to compare the different faunal assemblages. Of considerable interest and importance is the existence of coprolites in these black-earth middens, which have the potential to provide a direct measure of what was actually consumed (see table 17).

The obvious difference between these faunal resources and those from the coastal sites is the greater number of mammals. Mammals account for 11.2 percent of the minimum number of individuals (MNI), which is more than 2.7 times

Table 17
Faunal Data from the Platt Island Site

Class	MNI %	Total[(1)] Usable Meat(gms)	Usable Meat %	Kcal/[(2)] 100 gms	Total Kcals	% Total Kcals
Mammals	11.2	238,360	58.1	126	357,034	60.2
Birds	2.4	8,090	1.6	233	18,850	3.2
Reptiles	29.9	78,875	16.2	89	70,199	11.8
Amphibians	15.5	32,100	6.6	97	31,137	5.2
Fish	40.9	85,200	17.5	136	115,872	19.5
Total	99.9	487,625	100.0		593,092	99.9

(1) Based on mean animal weight/usable meat for MNI of each species (from Fradkin 1976:Appendix D). (2) Values used for each taxon are for deer, duck, turtle, and catfish from Watt and Merrill (Fradkin 1976:92, table VI). Data Compiled from Ehrenhard *et al.* (1978).

Table 18
Energetic Composition of the Coastal Fauna, Wightman Site

Class(1)	MNI %	Total(2) Usable Meat(gms)	Usable Meat %	Kcal/(3) 100 gms	Total Kcals	% Total Kcals
Mammals	2.7	54,088	5.8	126	68,151	5.7
Birds	1.5	3,539	0.4	233	8,246	0.7
Reptiles	1.9	1,655	6.4	89	1,473	0.1
Amphibians	-	-	-	-	-	-
Fish	93.9	817,782	87.5	136	1,112,184	93.4
Total	100.0	934,782	100.1		1,190,054	99.9

(1) Sea mammals and sea turtles are not included in the calculations. (2) Based on mean animal weight/usable meat for MNI of each species (from Fradkin 1976:Appendix D). (3) Values used for each taxon are for deer, duck, turtle, and catfish from Watt and Merrill (Fradkin 1976:92, table VI). Data compiled from Fradkin (1976).

that seen in any of the coastal sites. More important, mammals provide 60.2 percent of all the kcals in the faunal assemblage. The factor responsible for this difference is the high frequency of deer, which account for 70.6 percent of the kcal contribution of mammals, more than 10 times the value obtained for deer from the Wightman site (see table 18).

Fish account for 40.9 percent of the fauna, but because of the small size of the fish species, they contribute only 19.5 percent of the energetic budget. This value is half the caloric contribution for the same percentage of MNI seen on the coast. Birds have the same lack of importance as in the coastal sites, but reptiles and amphibians account for 11.8 percent and 5.2 percent respectively, of the total kcal contribution. The faunal contribution, as might be expected, is very general in character. This is in keeping with the wide range of habitats and vegetational zones found in the Big Cypress Swamp. All of the faunal species occupy aquatic swamp environments, including species normally associated with terrestrial regions, like deer, with all nonmammals, except for a few snakes, being obligate aquatic animals. Thus, in spite of the inland location, the environment is still predominantly aquatic in character.

The relationship of the faunal resources found in the interior aquatic environment to those found on the coast poses a very interesting question. I suggested earlier that these interior sites are possibly specialized hunting sites occupied by special task groups from the permanent villages on the coast. If this is true, it would explain the unusually dense faunal remains on sites with limited surface area. Such an interpretation is also supported by particular carrying capacity estimates of deer in the Big Cypress Swamp. Although it was mentioned earlier that net primary productivity of the Big Cypress Swamp is much higher than the sandy flatwoods and the Everglades and that deer densities are the highest in south Florida, the deer-density ratio in the swamp is still only 1 deer to 34 hectares (86 acres). This is below the density range of 1 deer to 32 hectares (80 acres) to 1 to 4 hectares (10 acres) provided by Taylor (1956) for North America. It therefore seems that deer would be a low-value resource item compared with the coastal resources. As a result, deer should be a less desirable subsistence item than in other parts of North America.

This conclusion does not rule out that deer, along with the other fauna, might be brought into coastal sites. In fact, it might be that such interior resource zones, while seemingly not as desirable as coastal estuaries, are necessary buffer zones in times of stress or as population growth and density create pressure on coastal resources. Such a situation might necessitate increased interior utilization. Josslyn Island (Marquardt et al. 1985) might be an example of such a situation. Here, deer densities increased in the uppermost level of the test unit. It is doubtful that the increased deer frequency is due to local increases in hunting, since the Charlotte Harbor–Pine Island Sound area has a high population density and a circumscribed insular character. Therefore, increased deer utilization seems to be a function of either intensification of interior hunting or perhaps trade.

Archaeological evidence shows no freshwater fauna found in coastal sites and no saltwater fauna found in interior sites. Furthermore, coprolite analysis from the Hinson Mound and Platt Island sites identify only freshwater fish forms, and in fact the faunal diet as revealed in the coprolites parallels identically that found in the midden assemblage, except of course for the lack of larger mammal bones (Ehrenhard et al. 1978:109). No saltwater forms have been identified in these samples. Therefore, it appears that if there was any exchange of food resources, it was minor and one way, from the interior to the coast. Evidence of this need not be visible in the coastal midden faunal assemblages if large game such as deer were processed in the interior regions and the meat, skins, and bone tools sent to the coastal groups. There is a possible example of this situation at the Solana site, where, other than bone-tool fragments, the only deer was a single piece of the condyle of a medipodial bone, perhaps a by-product of tool production (Widmer 1986). The very small size of most of these black-earth middens does suggest special-task group hunting and processing activities for the eventual use of coastal groups.

The distance and search-and-capture energy involved is not as great as it would be in terrestrial hunter-gatherer adaptations because of the high transportation efficiency provided by canoes. Sanders and Santley (1985) have calculated an efficiency forty times that of human transport of food resources on foot. This would facilitate the seemingly surprisingly intensive use of the interior freshwater swamp and marsh zone, in spite of its low deer population. Although deer residing in the swamp are sparse by North America standards, analysis of their trophic position, compared with other freshwater resources in the interior zone, makes them very attractive indeed from an energetic procurement perspective, at least regarding animal exploitation.

The faunal resources recovered from archaeological sites in the Big Cypress Swamp have been placed into their trophic positions. Higher carnivores are represented by white ibis, snowy egret, panther, bobcat, yellow-crowned night heron, bear, alligator, gar, bass, skunk, and raccoon. Middle carnivores included in the faunal assemblage are opossum, catfish, snakes, bowfin. The primary carnivores consist of frogs, siren, some turtles, and bream, and herbivores are represented by deer, turtles, ducks, rabbit, rats, muskrats, squirrel, and crayfish.

It should be cautioned that many of the species can be found in several trophic positions, depending on their dietary range at any moment. It should also be pointed out that the trophic structure includes both aquatic and terrestrial species. Although it is misleading to include both in the same structure, doing so shows that it is the species in the lower trophic position which are exploited. It also shows a considerably larger number of herbivores and primary carnivores than is seen in the coastal trophic positions. Therefore, although overall productivity may be greatly reduced from that on the coast, there are a large number of lower trophic position animals, such as deer, which have a large body mass, that make a useful complement to the coastal diet. This dietary complement is particularly important with regard to possible seasonal shifts in productivity due to environmental stress—that is, hurricanes or cold spells—or to vagaries of population disequilibrium, which can come about through stochastic fluctuations in the human demographic history of the area.

Thus, this interior swamp zone acts as a buffer area for resource exploitation and as a result adds to the potential stability of the system by raising the level of the initial carrying capacity with additional food items and raising the minimum subsistence level (Perlman 1980). Although increased "cost" of these resources may result, they should be available on a continuous basis. Therefore, although the resources by themselves are probably not sufficient to support sedentary populations, the existence of efficient canoe transportation and the wide range of resource items available make the interior swamp zone an important refuge for maintaining stability in ordered resource procurement on the coast, a principle noted by Perlman (1980).

The dispersed, patchy occurrence of these resources, notably deer, and their low densities would favor individual, or small task-group exploitation rather than coordinate-group activity, as is often seen in the Northeast (Webster 1979), or for that matter, northern Florida (Swanton 1946).

Turtles are also an important energetic component, because although aquatic, they are in many cases herbivores, and thereby provide a slightly lower trophic position. Turtles are one aquatic species which can develop considerable standing crop by shortcutting the food chain (Reid 1961:324–325), just as mullet do in estuarine environments. Thus, from a trophic-position perspective, turtles are an efficient resource item in the freshwater aquatic ecosystem, and this is clearly reflected in their significant contribution to the interior, freshwater subsistence base.

The significance of interior freshwater swamp and marsh resources is that they are *supplemental* to those on the coast because of the reduced overall densities of faunal forms and the greater concentration, turnover, and predictability of the coastal fauna with respect to yield. Certain interior resource items, however, even though dispersed and scarce, have large "package" size and provide a useful resource, which, while "suboptimal" compared with coastal resources, may provide important dietary complementation in times of shortages of coastal resources brought about by stochastic perturbations. Thus, it is argued that this interior buffer zone is utilized at varying degrees of intensity, according to the varying subsistence requirements predicated by availability of coastal resources. Such use would result in an increase in the overall critical carrying capacity by providing alternative resource items which have a stabilizing influence on the subsistence base (Perlman 1980).

Floral Resources

It seems clear that agriculture for subsistence purposes does not appear to have been practiced on the southwest Florida coast or in the interior region immediately adjacent to the coastal zone. This conclusion was first reached by Goggin and Sturtevant (1964:183–184). Murdock (1969:141) agrees with this assessment in his coding of the subsistence for this group. Larson (1980:211–214) has reviewed this question and has concluded that maize agriculture was not practiced in south Florida during the contact period. Despite what appears to be almost overwhelming evidence that agriculture was not practiced or at least was not important in the subsistence base of the southwest Florida coastal economy, the nonagricultural nature of southwest Florida coastal subsistence has been challenged (Gilliland 1975:35; Dobyns 1983). The appraisal of Gilliland is, unfortunately, based on secondary and tertiary sources, only one of which is contemporaneous with the historic contact of the aboriginals, and that is actually a secondary account given to Laudonnière by informants. Since Laudonnière was associated with agricultural groups, the phrase "in the time of harvest," which Gilliland interprets as possibly indicating agriculture, might actually refer to these northern Timucuan groups rather than the Calusa. The phrase (quoted from Swanton 1922, cited in Gilliland 1975:35) reads as follows: "Moreover, they told me, that every year, in the time of harvest, this savage king (Carlos) sacrificed one man, which was kept expressly for this purpose, and taken out of the number of Spaniards, which by tempest, were cast away upon the coast." This passage could as easily refer to a time of the year as well as a specific subsistence activity.

The other line of reasoning is that *Cucurbita pepo* and *Lagenaria siceraria* were found at the Key Marco site, located in the study area. Both of these plants are domesticated. Cutler (1975:255–256) notes, however, that the single cucurbit found is of the variety *ovifera*, which belongs to a yellow-flowered ornamental gourd. Cutler thinks that these gourds were used for net floats, not food, and further suggests that all of the gourds (*Lagenaria*) were used for floats as well. Thus, while "agriculture" undoubtedly was practiced, it was primarily for nonsubsistence purposes.

Dobyns (1983:126–130) also argues that the Calusa were agricultural. He suggests that the Calusa relied not only on maize but also on coontie (*Zamia* sp.). This latter conviction is based on his identification of the trufflelike root used by the inhabitants of Lake Mayaimi for making bread, which was mentioned by Fontaneda (1944:13), as *Zamia*. This identification is erroneous, however, since the root mentioned by Fontaneda is an emergent aquatic plant, while *Zamia* is an obligate xeric species. Furthermore, no *Zamia* pollen has ever been recovered from *any* archaeological site in south Florida, including the Fort Center site, where ample pollen samples from a variety of contexts were analyzed (W. H. Sears 1982). The lack of *Zamia* in the Fort Center site is especially important, since Fort Center has a protohistoric component and is located in the specific location mentioned by Fontaneda, Lake Mayaimi, now known as Lake Okeechobee.

Dobyns' argument with respect to maize is based on a southern landing in the Charlotte Harbor region for both the Cabeza de Vaca and the DeSoto expeditions. Milanich (1987) has recently demonstrated that these landings could not have been as far south as Charlotte Harbor and that the statements mentioning maize agriculture, which are attributed by Dobyns to the Calusa, actually refer to the Tocobaga situated in the Tampa Bay area.

A wide variety of wild plant resources are found in the region bordering the coastal zone of south Florida. Fradkin (1976:114–117) lists more than seventy edible wild plant species of potential subsistence use. This is not to suggest that all of these resources were used, but assuredly many of them were. The important questions regarding these resources are: To what extent were they utilized in the diet? What was their dietary potential? What effect did they have on scheduling the subsistence activity?

Ethnohistoric resources indicate that wild fruits were gathered in the Florida Keys area (Fontaneda 1944:66–67) and that roots were important in the subsistence areas surrounding Lake Okeechobee (Fontaneda 1944:67–68). Zubillaga (1946:356) also mentions the use of the prickly pear cactus fruit (*Opuntia* spp.) for the southwest coast. Besides the prickly pear cactus, saw palmetto berries (*Serenoa repens*), the coco plum (*Chrysobalanus icaco*), wild grapes (*Vitis* spp.), and cabbage palm berries and "hearts" (*Sabal palmetto*) are also available in the survey area (Larson 1980).

Murdock (1969:141) suggests that the gathering of wild plant resources accounted for 20 percent of the Calusa subsistence base. This statement might seem contradictory with what is now known about hunter-gatherer resource utilization, which predicts that the closer a hunter-gatherer adaptation is to the equator the more plants should be used in the diet (Lee 1968). Thus, it would seem that tropical hunter-and-gatherer adaptations, of which the Calusa are an example, should use larger quantities of floral resources in the diet. This does not appear to be the case.

Two factors help to resolve this paradox. The first is that the interior, terrestrial ecosystems bordering the coastal zone of southwest Florida are, for the most part, flooded swamps or marshes. Most, but not all, floral resources would be located on hammocks and elevated terrain, which are very limited in total area and very dispersed throughout south Florida, south of Naples. It is true that the interior area east of the Charlotte Harbor subarea is better drained and floral resources are not as dispersed. But generally, the size and distribution of the resource patch is scattered, adding considerably to the cost of collecting.

Another reason the Calusa did not use large amounts of floral resources is that most of the resources are small fruits and berries, and because the region is tropical, as are many of the species, complementary seasonal fruiting takes place. Thus, the potentially productive harvest of the floral resource base is scattered throughout the year, rather than being seasonably clustered like many temperate-forest nut trees. The scattered harvest tends to minimize the effectiveness of intensive, seasonal procurement of many edible species, since the number of fruit is small due to the wide variety of plants, the high species diversity, and the limited areal patches in which they grow. Furthermore, the large, continuously available starchy roots, used by many hunter-gatherer adaptations for the bulk of their calories, are not typically found on the hammocks of south Florida, which border the coast and are not available to provide high-yield low-cost energy. These factors tend to confirm the limited role of floral resources in south Florida.

It is interesting to note that plant resources are not an important part of the caloric intake of at least one other hunter-gatherer tropical coastal group, the Onge of the Little Andaman Islands. Meehan (1977:521–522) actually calculated the approximate observed caloric intake for a period of thirty days, between 17 December and 16 January, of a population of forty-one individuals (see table 19).

Surprisingly, vegetables provided only 15.9 percent of the caloric intake of the group. This finding is remarkably similar to Murdock's suggestion for the vegetable content of the Calusa diet. More interesting, the patterns of faunal exploitation of the Onge follow those observed for interior, freshwater faunal assemblages, with deer replacing the pig in the south Florida example. Still, the Onge data are limited in that they apply only for a single month, and it is not known whether this is typical of the entire yearly subsistence cycle. Climate during this time of the year is characterized as cool and dry (Radcliffe-Brown 1922:4), the same as that for south Florida at the same time of the year.

Fruits of the saw palmetto and the coco plum and prickly pear have been specifically mentioned as being consumed by the south Florida inhabitants in the

Table 19
The Caloric Intake of the Onge

Food Category	Gross Weight Kg	Edible Flesh Kg	Number of Kcals	Percent of Diet
Pig	575	472	1,460,000	69.0
Turtle	34	24	36,000	1.7
Fish	224	179	245,000	11.6
Bivalves	14	3	2,000	0.1
Crab	22	12	11,000	0.5
Vegetables	259	259	337,000	15.9
Honey	15	15	25,000	1.2
Fruits	0.5	p	p	
Totals	1144	964	2,116,000	99.5

Days observed = 30, Population = 41, p = present
Adapted from Meehan (1977)

Spanish chronicles (Fontaneda 1944; Zubillaga 1946) and also by Jonathan Dickinson (Andrews and Andrews 1945). It seems that saw palmetto may have been a seasonably important autumnal crop (Larson 1980) in the northern area of the southwest Florida coast, since this plant is common in the open pine flatlands, as mentioned earlier. The coco plum also ripens in the fall (Larson 1980) and is found in the open prairies, both wet and dry, and in other areas. It does not appear that the caloric values of these resources are sufficient to provide a very large percentage of the diet, nor does it seem that these fruits occur in surplus quantities amenable to storage. This suggestion is based on Dickinson's statement regarding the harvesting of palm berries, coco plums, and sea grapes by hunter-gatherer groups on the Florida east coast. He says that "the time of these fruits being over, they have no other till the next spring" (Andrews and Andrews 1945:36). Surprisingly, no mention is made of the use of the pith of the cabbage palm for food, either ethnohistorically or by anthropologists. This would seem to suggest lack of use of this resource. The use of roots in the diet in south Florida is mentioned several times by sixteenth-century Spanish writers. The most notable is Fontaneda, who describes the roots used by the Mayaimi, who lived on the shore of Lake Okeechobee:

> On this lake, which lies in the midst of this country, are many towns, of thirty or forty inhabitants each; and as many more places there are in which people are not so numerous. They have bread of roots, which is their common food, the greater part of the time; and because of the lake, which rises in some seasons so high that the roots cannot be reached in consequence of the water, they are for some time without eating this bread. Fish is plenty and very good. There is another root, like the

> truffle over here, which is sweet; and there are other different roots of many kinds; but when there is hunting, either deer or birds, they prefer to eat meat or fowl. [Fontaneda 1944:13]

Fontaneda mentions more than three different roots and discusses two of them specifically. The first may be the corms of the spike rush (*Eleocharis* sp.). This "root" is one of the most important vegetable resources utilized by the Anbara of coastal Australia (Meehan 1977). The spike rush is also utilized aboriginally in North America. J. H. Steward (1938:25, 53) reports that the Owen Valley Paiute ate the roots and the seeds of the spike rush (*Eleocharis* sp.). Another possibility is that the root in question is *Sagittaria* sp. Possible evidence of its use might be indicated at the Fort Center site (E. O. Sears 1982), where *Sagittaria* pollen is common in all environmental zones, including those where it does not grow. One thing that is clear in Fontaneda's statement, which has been overlooked in previous studies, is that these roots are found in areas prone to flooding, suggesting an aquatic habitat. This would tend to point to these resources as one or both of the above two species. The other trufflelike root which Fontaneda describes has been identified by Buckingham Smith, the original translator of the Fontaneda manuscript, as the mud potato, *Apios tuberosa*. This seems to be a reasonable interpretation, although neither Goggin and Sturtevant (1964) nor Larson (1980) comment on the identification.

There has been some suggestion that *Zamia* was used for flour in south Florida. This plant is extremely common throughout the hammocks of that area (Small 1921). But Sturtevant (1960:12–13) feels that neither *Zamia* nor *Smilax* was used in south Florida aboriginally and instead that both plants were brought into the area by the Seminoles.

It seems clear that these roots were not intentionally planted by the indigenous aboriginal groups of South Florida, nor do they seem capable of providing for many people, as witnessed by Fontaneda's population estimates for the towns on the lake. It also appears that they were collected in insufficient quantities to act as surplus for trade.

W. H. Sears (1971, 1974, 1982) and E. O. Sears and W. H. Sears (1976) have suggested that the ridge-field systems found in the Lake Okeechobee basin were utilized for maize agriculture, but only in the earlier period, before A.D. 1000. There is no evidence to suggest that these ridges were utilized for agriculture after that time, nor is agricultural practice mentioned by Fontaneda. A further consideration of Fontaneda's statement quoted above is that the Indians who lived on Lake Okeechobee preferred deer or birds to plant resources. It is difficult to interpret whether this is a statement of dietary preferences or a statement regarding the actual frequency of resource procurement.

None of these plant remains has been recovered from archaeological contexts in the survey area, and this situation is not a result of sampling bias. Three recent archaeological excavations in the area, one at the Wightman site on Sanibel

Island (Fradkin 1976), the excavations on Useppa Island (Milanich et al. 1984), and the other at the Solana site (Widmer 1986) have failed to recover floral remains despite adequate methodology and recovery techniques. Excavations conducted at the Solana site (Widmer 1986) failed to yield any floral remains, despite a specific research design aimed at recovering them. Extensive flotation of 40-cm sampling columns from thirty-seven of the 2-m provenience units and 130 features failed to yield floral remains. The particular archaeological context identified at this site, namely a pile dwelling on a once-submerged tidal flat, however, would probably preclude the recovery of such remains, even if they were utilized.

The lack of floral remains from these three archaeological sites is inconclusive in terms of evaluating the significance of the floral component of the subsistence base, since this is a very limited sample and not representative of other sites in the coastal zone. Marquardt et al. (1985) have, however, recovered charred seeds in the flotation samples from Josslyn Island.

In southeast Florida, however, copious floral remains have been recovered from the excavations at the Granada site (Scarry 1983:222–230). These include the seeds of false mastic (*Mastichodendron foetidissimum*), coco plum (*Chrysobalanus icaco*), cabbage palm (*Sabal palmetto*), saw palmetto (*Serenoa repens*), sea grape (*Cocoloba* spp.), and hog plum (*Ximenia americana*). Saw palmetto berries have also been recovered from the Jungerman site on the Florida east coast (Jordan 1963:17). Besides those floral items mentioned by ethnohistorical sources, numerous other edible berries and plant foods are found in tropical south Florida (Morton 1968; Fradkin 1976:app. B). Most of these wild plants do tend to be concentrated in certain areas (Larson 1980:222–223), especially in the interior regions of southern Florida. The saw palmetto, for example, is found in extensive patches in the pine flatwoods regions. These wild plant resources ripen primarily in the fall, and Larson (1980:223) suggests that intensive collection of these floral resources took place in southern Florida at this time. The extent to which the southwest coastal region participated in this activity is difficult to evaluate, but the possibility that it did do so should not be discounted. Unidentified floral resources have been found in the coprolites from the Hinson site (Ehrenhard et al. 1978).

So, in spite of the availability of wild floral resources in limited quantities along the southwest Florida coast, their known utilization in the adjacent interior areas, and the known ethnographic reliance of hunter-and-gatherer adaptations on wild floral resources, these resources do not appear to play a major role in the subsistence base of the Calusa, at least according to ethnohistoric and direct archaeological evidence.

Clearly, coastal resources, primarily fish, represent the energetic base for the late aboriginal adaptation. This resource base structures the settlement and sociopolitical pattern of organization.

Coastal Resources

One of the points I wish to make in this book is that it is the faunal resources which predicate the structure of adaptation; while plant resources were utilized, they were not the critical or limiting aspect of the subsistence base. In many respects, the situation is analogous to that in the Northwest Coast, where the fishing component of the adaptation structures the socioeconomic system in spite of a greater utilization of plant resources than on the southwest Florida coast (Suttles 1968a and 1968b; Schalk 1977).

Terrestrial faunal elements are found in archaeological contexts in southwest Florida, but they occur in minute amounts at most sites, particularly the late sites. Although the northern coastal regions of the study area are bordered by pine flatwoods environments and many of the keys and islands have such environments as well, their limited area makes the contribution of these resource zones for sustained, dense, sedentary populations somewhat unfeasible. As argued previously, however, I do not mean to suggest that terrestrial resources were *not* in fact utilized but that they were not the determining factor in the subsistence strategy of this coastal adaptation. This is reflected in the faunal assemblages from sites in the area.

Faunal assemblages exist for six late coastal sites; all are located within the two high-productivity areas identified for the southwest coast. Two of the assemblages are from Marco Island; another is from Sanibel Island, adjacent to Pine Island Sound; one is from Josslyn Island and one from Useppa Island, both located in the sound; and the remaining sample is from the Solana site, in the Peace River drainage. Unfortunately there is no direct comparability among the assemblages from the six sites because of the different types of recovery techniques used. On the Caxambas site (Cumbaa 1971) on Marco Island, the technique used was mechanical sifting through expanded lathe. The Key Marco site, also located on Marco Island, is represented by two collections, one identified as the Marco midden sample and recovered with 12-mm (1/2-in.) hardware cloth. The other collection is from Cushing's excavations, and no screening at all was used. The inherent bias in sampling from this site is obvious. Faunal elements from the Wightman site, located on Sanibel Island, were retrieved from screening with fine windowscreen (Fradkin 1976:40), as were the collections from Useppa Island (Milanich et al. 1984), Josslyn Island (Marquardt, written communication to author, May 1986), and Solana (Widmer 1986). It should also be noted that such a direct comparison as presented here may be complicated by the small sample sizes, which may not be representative of the actual subsistence patterns at the respective sites (see table 20).

Aquatic mammals, such as seals, whales and porpoises, and marine turtles have not been considered in this study; their inclusion would tend to increase further the amount of reliance on coastal aquatic resources. All of the sites, with

Table 20

Comparative MNI Faunal Values for Southwest Florida Coastal Sites

Classes(1)	Caxambas MNI	Caxambas %	Marco Midden(2) MNI	Marco Midden(2) %	Wightman MNI	Wightman %	Useppa Island MNI	Useppa Island %	Josslyn Island MNI	Josslyn Island %	Solana MNI	Solana %
Mammals	54	4.1	14	2.4	7	2.7	7	2.5	7	0.5	3	1.7
Birds	11	0.8	14	2.4	4	1.5	8	2.9	12	0.9	6	3.4
Reptiles	32	2.4	19	3.3	5	1.9	5	1.8	11	0.8	5	2.9
Amphibians	0	0.0	0	0.0	0	0.0	2	0.7	0	0.0	1	0.7
Fish	1214	92.6	536	91.9	246	93.9	257	92.1	1271	97.7	160	91.4
Totals	1311	99.9	583	100.0	262	100.0	279	100.0	1301	99.9	175	100.0

(1) Sea mammals and sea turtles are not included in the above calculations.

(2) Cushing's Key Marco excavations have not been included, due to bias in collection procedures. His excavations are at the same site.

Compiled from Wing (1965), Cumbaa (1971), Fradkin (1976), Milanich et al. (1985), Marquardt (Personal communication 1986), and Widmer (1986).

the exception of Cushing's excavation at Key Marco, indicate that fish remains, based on MNI counts, constitute 90 percent of the vertebrate faunal assemblage. Grayson (1978), however, has recently commented on the degree of representativeness of MNI counts to actual faunal utilization. While it is recognized that MNI counts for different species vary, the comparative use of MNI figures for this area is necessary for relative evaluation of faunal subsistence composition, since the Caxambas faunal study does not include element counts *and* MNI counts.

The MNI figures by themselves are not very useful, since they do not directly indicate the energetic composition of faunal remains. Fradkin (1976) has converted the MNI values for the various faunal categories at the Wightman site into usable meat weights by multiplying the edible percentages of the animal by the mean live weight of each species found in the site. When this figure is multiplied by the MNI, a total meat value results for each species. The energetic contributions can then be determined for each of the faunal categories by using the caloric values listed in the U.S. Department of Agriculture food composition handbook (Watt and Merrill 1963). Table 16 presents these data for the Wightman site, and we see that not only do fish represent 90 percent of the vertebrate faunal assemblage in MNI, but that they also represent 90 percent of the vertebrate fauna in energetic terms, that is, kcals.

These data indicate a considerable dependence on fish in the southwest Florida coastal subsistence pattern, as measured by both MNI and calories. This pattern is found at all the sites in this region, discounting the biased Cushing sample from Marco Island. The proportion of estuarine forms would increase even more if sea mammals and sea turtles were added to the calculations. Wading birds can also be considered a component of coastal ecosystems. The pattern which develops, then, is one of almost exclusive reliance on estuarine and offshore fauna. What these figures do not indicate is the faunal diversity.

The data in table 21 illustrate the broad range of coastal aquatic resources, from which more than thirty species of fish were utilized. Of even greater significance is the range and feeding behavior of these species. The seasonality of important commercial and sport fishes was discussed previously, but the data are relevant only if these resources were being harvested. All of the species which were used in the evaluation of seasonality are found in archaeological contexts, indicating that continuous year-round exploitation of fish resources, including their maximum period of availability, is possible within this region. Such a situation would not be possible with anadromous fish resources, such as salmon of the Northwest Coast, since they are available only during the spawning season.

The Subsistence Base from the Perspective of Energy

Although the faunal data presented indicate a wide range of fish species utilized, too strict an adherence to MNI counts might yield a false perspective regarding the

Table 21
Faunal Remains from Southwest Florida Coastal Sites

Taxon	Common Name	Caxambas	Marco Midden	Key Marco	Wightman	Josslyn Island	Solana
CLASS MAMMALIA	mammals						
Rodentia cf. *Sigmodon*	hispid cotton rat	-	-	-	1(1)	1(3)	1(1)
Didelphis marsupialis	opposum	1	-	-	-	-	-
Canis familiaris	domestic dog	2	-	5	-	-	-
Urocyon cinereoargenteus	gray fox	-	-	1	-	-	-
Procyon lotor	racoon	5	4(4)	1	2(22)	-	1(1)
Lynx rufus	bobcat	1	-	1	-	-	-
Sylvilagus spp.	rabbit	3	-	-	-	-	-
Odocoileus virginianus	white-tailed deer	40	10(13)	6	4(25)	1(5)	1(1)
Monachus tropicalis	monk seal	7	-	-	-	-	-
Cetacea	whale, dolphin	42	-	1	1(10)	-	-
CLASS AVES	birds						
Gavia immer	loon	6	-	1	1(1)	-	1(1)
Moris bassana	gannet	-	-	1	-	-	-
Phalacrocorax auritus	cormorant	2	-	1	-	-	-
Ardea herodias	great blue heron	3	1(1)	1	-	-	-
Casmerodias albus	American egret	-	1(1)	1	-	-	-
Egretta thula	snowy egret	-	-	2	-	-	-
Guara alba	white ibis	-	-	1	-	-	-
Aythya affinis	lesser scaup duck	-	5(7)	-	3(7)	-	-
Lophodytes cullatus	hooded merganser	-	2(3)	-	-	-	-
Mergus serrator	red-breasted merganser	-	2(3)	1	-	-	-

Table 21 (Continued)
Faunal Remains from Southwest Florida Coastal Sites

Taxon	Common Name	Caxambas	Marco Midden	Key Marco	Wightman	Josslyn Island	Solana
CLASS AVES	birds						
Carthartes aura	turkey vulture	-	1(1)	8	-	-	-
Coragyps atratus	black vulture	-	-	1	-	-	-
Meleagris gallopavo	turkey	2	-	-	-	-	-
Pandion haliaetus	osprey	1	-	-	-	-	-
Numenius americanus	long-billed curlew	-	1(1)	1	-	-	-
Larus argentatus	herring gull	-	1(1)	2	-	-	-
Larus delawarensis	ring-billed gull	-	-	1	-	-	-
Thalasseus maximus	royal tern	-	-	1	-	-	-
Parulidae	warbler	-	-	-	-	1(1)	-
CLASS REPTILIA	reptiles						
Chelydra sp.	snapping turtle	7	1	1	-	1(1)	-
Pseudemys sp.	cooter turtle	-	-	-	-	1(1)	-
Kinosternon sp.	mud turtle	1	3(5)	-	1(2)	1(2)	1(1)
Terrapene carolina	box turtle	1	4(5)	18	3(105)	1(1)	-
Malaclemmys terrapin	diamond-back terrapin	4	5(16)	7	-	-	-
Trionynx ferox	soft-shell turtle	-	1(1)	1	-	-	-
Deirochelys reticularia	chicken turtle	-	1(5)	3	-	-	-
Gopherus polyphemus	gopher turtle	18	4(8)	1	1(1)	-	-
Emydidae	box, water turtles	-	-	-	-	-	1(2)
Cheloniidae	green turtle	40	24(224)	4	2(6)	-	-
Alligator mississipiensis	alligator	-	1(1)	3	-	-	-

Table 21 (Continued)
Faunal Remains from Southwest Florida Coastal Sites

Taxon	Common Name	Caxambas	Marco Midden	Key Marco	Wightman	Josslyn Island	Solana
CLASS REPTILIA	reptiles						
Coluber constrictor	black racer	1	-	-	-	-	-
Natrix sp.	water snake	1	-	-	-	-	-
Elaphe sp.	rat snake	1	-	-	-	-	-
Masticphis flagellum	coachwhip	1	-	-	-	-	-
Pituophis mugitis	bull snake	1	-	-	-	-	-
Drymarchon corais	indigo snake	1	-	-	-	-	-
CLASS AMPHIBIA	amphibians						
Anura	toads, frogs	-	-	-	-	-	1(1)
CLASS CHONDRICHTHYES	cartilagenous fishes						
Galeoidea	sharks	244	-	-	-	-	-
Lamnoidei	mackerel sharks	-	6(16)	6	-	-	-
Isurus sp.	mako shark	-	-	-	-	-	-
Scyliorhinoidei	cat-requiem-hammerhead sharks	-	27(179)	27	4(72)	-	-
Ginglymostoma cirratum	nurse shark	-	-	-	2(2)	-	-
Carcharhinidae	requiem shark	-	-	1	2(24)	-	4(13)
Carcharhinus spp.	requiem shark	-	-	-	3(96)	1(2)	-
Carcharhinus acronotus	blacknose shark	-	-	-	1(1)	-	-
Carcharhinus maculipinnus	spinner shark	-	-	-	2(2)	-	-
Galeocerdo cuvieri	tiger shark	-	-	1	1(7)	-	-

Table 21 (Continued)
Faunal Remains from Southwest Florida Coastal Sites

Taxon	Common Name	Caxambas	Marco Midden	Key Marco	Wightman	Josslyn Island	Solana
CLASS CHONDRICHTHYES	cartilagenous fishes						
Rhizoprionodon terraenovae	Atlantic sharpnose shark	-	-	-	3(37)	-	-
Sphyrna spp.	hammerhead shark	-	-	-	5(455)	-	-
Sphyrna turbo	bonnethead shark	-	-	-	-	-	1(1)
Rajiformes	sawfish, rays, skates	-	-	-	3(20)	-	3(4)
Dasyatis sp.	stingray	-	-	-	-	1(13)	3(4)
Pristis sp.	sawfish	9	3(7)	1	1(1)	-	-
Aetobates marinari	spotted eagle ray	-	9(19)	2	-	-	-
Myliobatidae	eagle rays	36	3(3)	-	-	-	-
CLASS OSTEICHTHYES	bony fishes						
Lepiosteus sp.	gar	-	-	-	-	-	1(1)
Elops saurus	ladyfish	-	-	-	1(1)	1(15)	-
Megalops atlanticus	tarpon	6	1(1)	-	-	-	-
Albula vulpes	bonefish	-	-	-	-	-	1(1)
Clupeidae cf. *Brevoortia*	menhaden	-	-	-	1(1)	4(17)	-
Clupeidae	herrings	-	-	-	-	(166)	-
Ariidae	catfish	106	-	-	88(603)	(123)	(29)
Ariopsis felis	sea catfish	-	101(457)	8	10(202)	21(213)	28(270)
Barge marinus	gafftopsail	-	9(16)	3	2(3)	1(6)	3(8)
Strongylura sp.	needlefish	-	-	-	-	1(12)	-
Cyprinodontidae	killfish	-	-	-	-	-	3(6)

Table 21 (Continued)
Faunal Remains from Southwest Florida Coastal Sites

Taxon	Common Name	Caxambas	Marco Midden	Key Marco	Wightman	Josslyn Island	Solana
CLASS OSTEICHTHYES	bony fishes						
Serranidae	groupers	-	-	-	11(63)	-	-
Epinephelus spp.	jewfish, hind	15	-	1	35(303)	-	-
Myoteroperca spp.	grouper, gag	8	1(1)	-	-	-	-
Carangidae	jacks	-	-	-	1(1)	(4)	1(1)
Chloroscombrus chrysurus	Atlantic bumper	-	-	-	-	1(1)	-
Caranx cf. *hippos*	crevalle jack	76	31(77)	3	4(5)	2(1)	5(23)
Trachinotus carolinus	pompano	5	-	-	-	-	-
Centropomis sp.	snook	80	52(135)	3	2(3)	-	-
Orthopristis chrysoptera	pigfish	-	-	-	-	64(102)	-
Haemulidae/Sparidae	grunts/porgies	-	-	-	-	26(37)	-
Sciaenidae	"croakers"	9	-	-	4(9)	-	(4)
Cynoscion spp.	sea trout	6	4(4)	4	8(29)	7(16)	(11)
Leiostomus xanthurus	spot	-	-	-	-	9(10)	-
Micropogon undulatus	common croaker	-	-	-	-	-	1(2)
Pogonias cromis	black drum	26	36(94)	6	2(4)	-	3(3)
Sciaenops ocellata	redfish	3	32(94)	-	8(13)	3(4)	1(2)
Bairdiella chrysoura	silver perch	-	-	-	-	10(35)	-
Sparidae	porgies	-	-	-	3(13)	9(21)	-
Archosargus probatocephalus	sheepshead	463	199(860)	-	2(4)	3(91)	3(9)
Lagodon rhomboides	pinfish	-	-	-	1(1)	70(151)	-
Chaetodipterus faber	spadefish	19	-	-	-	-	-
Scarus sp.	parrotfish	-	-	-	-	2(2)	-

Table 21 (Continued)
Faunal Remains from Southwest Florida Coastal Sites

Taxon	Common Name	Caxambas	Marco Midden	Key Marco	Wightman	Josslyn Island	Solana
CLASS OSTEICHTHYES	bony fishes						
Mugil spp.	mullet	9	-	6	5(24)	1(2)	1(3)
Sphyraena sp.	barracuda	-	-	4	-	-	-
Triglidae cf. *Prionotus*	sea robin	-	-	-	1(4)	-	-
Opsanus sp.	toad fish	22	17(28)	-	24(252)	2(9)	1(1)
Bothidae	flounder	-	2(2)	-	-	-	-
Paralichthys spp.	southern flounder	-	-	-	3(5)	1(3)	-
Trichiurus sp.	cutlassfish	1	-	-	-	-	-
Scombridae	mackerel	1	-	-	-	-	-
Tetradontidae cf. *Lagocephalus*	puffer	-	-	-	8(16)	-	-
Sphoeroides sp.	puffer	-	-	-	-	2(2)	2
Diodontidae	burrfish, cowfish	58	-	-	35(123)	-	1(1)
Chilomycterus schoepfi	striped burrfish	-	2(2)	-	2(226)	6(11)	-

Values are minimum number of individuals (MNI). Values in parentheses are number of fragments.

Sources: Data on the Caxambas site are from Cumbaa (1971); Data on the Marco Midden are from Wing (1965); Data on the Wightman site are from Fradkin (1976:Table 7); Data on the Ussepa Island site are from Milanich et al. (1985); data on the Josslyn Island site (Test A, Level 22) were provided by Marquardt (written personal communication, May 1986); and data on the Solana site are from Widmer (1986).

importance of fish resources in energetic terms. Cultural and natural transformation processes result in the differential preservation of faunal remains (Schiffer 1976; Grayson 1978) and the sampling bias inherent in the collections. To mitigate the problems brought about by these processes, it seems advantageous to evaluate the contribution of the various fish species composing the subsistence base from an ecological perspective, rather than relying solely on empirical observations derived from the frequency of remains found in archaeological sites.

In a theoretical sense, the fewer the trophic levels to the final consumer, the more energy there is available to that consumer. Humans, being final consumers, would more efficiently capture (in a gross-energetic sense) energy by exploiting the lower trophic levels. One of the characteristics of marine ecosystems, however, is the elaboration of the number of trophic levels.

Fish are usually in the carnivore levels in the trophic structure and therefore are more "costly" to capture. One species, however, the mullet (*Mugil cephalus*), is somewhat unique in that it is a relatively large fish (0.5 to 2 kg) which feeds directly from the first trophic level, telescoping the food chain and bypassing the accompanying loss of energy. It therefore has the potential of producing a much greater fish biomass than fish species which are in the third or fourth carnivore level (W. E. Odum 1970b:223). Those regions which support high mullet biomass should be quite attractive to human populations. As mentioned earlier, the general productivity of the survey area was determined primarily by relative fish-catch data. W. E. Odum (1970b) has shown that grass beds and detrital systems are the most favorable for mullet production and that increases in areas of these favorable environments will correlate with higher mullet biomass.

Figure 15 supported this observation and pointed not only to the high frequency of mullet in the fish-catch counts but also to the dramatically greater mullet catches in those counties, Lee and Collier, which contain the two areas of high productivity identified earlier. The fact that mullet are extremely plentiful in this region is of little importance if they are not also easily exploitable, in net energetic terms, by humans. The feeding behavior and continuous schooling of mullet do, however, make them an attractive resource for exploitation by various cultural systems. Mullet, even during nonspawning periods, are schooling fish (Futch 1966) and do not disperse in solitary units. W. E. Odum (1970b:231–232) has shown that in areas with tidal influence, there is a relationship of food ingestion and tidal stage. As a result, optimum feeding grounds become accessible as the tide rises. Human populations can potentially take advantage of tidal knowledge to predict the occurrence of mullet in certain areas on a daily basis. Not only mullet but most other estuarine fish are influenced by the opening up of feeding grounds due to rising tides (Tabb et al. 1962), thereby also allowing predictions concerning location and capture of these resources. Cordell (1978) has shown the importance of such tidal fluctuations in the fishing strategy of coastal Brazil.

Because of the increased mullet biomass, much more extensive carnivore biomass is also possible in these areas of high productivity. This is empirically reflected in the fish-catch data presented in figure 15. Many predators feed extensively on mullet during various growth stages (Springer and Woodburn 1960; Tabb and Manning 1961; Tabb et al. 1962; Gunter and Hall 1965; W. E. Odum 1970a; Wang and Raney 1971). These predators would predicate their feeding strategies on the movements of mullet, which are themselves highly influenced by tidal movements, and therefore the location of these predators would be predictable as well.

The lack or minimum representation of mullet in archaeological contexts has puzzled anthropologists working in this area for some time (Wing 1965; Larson 1980). Although mullet remains have been recovered from most recently excavated sites in south Florida, their frequencies in archaeological sites are much lower than their favorable trophic position would seem to suggest. This discrepancy with ecological criteria and commercial-catch data might be a result of certain cultural practices or natural transformation processes. Such cultural practices might include the processing of fish on beaches rather than in villages or perhaps the drying and grinding of the remains, so that bones would either be discarded or pulverized. At present it is impossible adequately to resolve this dilemma, particularly since there are specific ethnohistoric references to the use of mullet by inhabitants of south Florida (see Larson 1980).

On the other hand, the desirability of sea catfish is empirically demonstrated in the faunal assemblage based on fragment and MNI figures (see table 21). Catfish are the most frequent faunal remains found at the Wightman, Josslyn Island, Useppa Island, and Solana sites and the second most frequent at the Marco midden and Caxambas sites. It should be pointed out that catfish are probably underrepresented at the Marco midden, due to 12-mm (1/2-in.) screening, and also at the Caxambas site as well. Analysis of the faunal assemblage from the Solana site clearly indicates that sea catfish are the preponderant elements, which clearly illustrates the high degree of reliance on this subsistence resource.

Ecologically, the choice of sea catfish as a primary resource makes sense. Sea catfish are available in large numbers in shallow tidal flats but in colder weather retreat into deeper water which is not affected by cold-air stress (Larson 1980: 105). Theoretically, the effects of seasonal-temperature shifts should be of less significance the farther south one goes. This is indeed the case for the southwest Florida coast. "*Ariopsis felis* [sea catfish] is abundant at all times of the year throughout the North River [located in the southernmost area of the study area] including mangrove lined ponds and small creeks that drain the *Juncus* marshes in the headwater region" (W. E. Odum and Heald 1972:699). The implications in this statement are extremely important, since the relative availability of this resource to humans would be drastically increased when it is present in shallow, tidally influenced waters throughout the year. Additionally, the movements into tidally dictated feeding grounds could be predicted by monitoring the tides. As a third advantage, the low trophic position of this species suggests a high biomass, and its diversified food habits allow it to adapt successfully to different habitats

(W. E. Odum and Heald 1972:699). To summarize, the effective biomass of this species, which trophically is one of the most abundant of exploited fish, is doubled as a result of its year-round availability in southwest Florida. This availability and its predictability of occurrence make it an attractive subsistence item for the coastal adaptation.

In spite of the ecological pressures for use of fish species of the lower trophic levels and the numerically high frequency of sea catfish remains at archaeological sites in the area, most faunal elements from these sites are of carnivores. This greater frequency need not necessarily be a result of differential preservation or cultural practices. Larson (1980:123) has suggested that the high representation in faunal assemblages of top-level carnivores is due to their schooling behavior, which makes them more easily taken with weirs or nets. But since most of the fish represented in archaeological contexts are schooling fish this argument is not convincing. Indeed, only toadfish, flounder, grouper, barracuda, sharks, and rays, of those found in archaeological contexts, are nonschooling fish, and even these latter two groups mass aggregate during the spring (E. Clark 1963; E. Clark and Von Schmidt 1965).

Of considerable interest is the nature of the utilization of the lower trophic levels by southwest Florida coastal inhabitants and their occurrence in archaeological contexts. With the noteworthy exception of mullet and pinfish, herbivores and primary and middle carnivores are numerous in archaeological contexts. This situation is not unexpected, considering that these species should provide more return of energy than species in the highest trophic level. Still, fewer species in these lower trophic levels can be effectively exploited by humans, owing to the smaller general size of the individuals. So although the lower-trophic-level species are more numerous in quantity, their availability for human exploitation might actually be reduced.

It appears that cultural practices are responsible for the differential faunal preservation and the underrepresentation of the smaller-sized fish class, those which would be in lower trophic levels. Ehrenhard et al. (1978:109–112) have shown that large quantities of faunal bone are found in coprolites from sites in the Big Cypress Swamp, comprising 9.2 percent of the mean sample weight of the sixteen coprolites analyzed. Five hundred and seventy-one bone fragments were identified to at least the class level, and 540 of these (94.5 percent) were fish. The remaining elements were reptiles, birds, and amphibians. No mammals were found in the samples. These data seem to indicate differential preservation of fish faunal elements due to food processing and gustatory behavior. It seems clear that fish of the lower trophic position, as suggested by their small size, were consumed, perhaps in large quantities, and that the absence of these small fish remains in faunal assemblages is probably because they were consumed whole.

It seems therefore that not only is it possible for human adaptive systems effectively to crop the top-level carnivores, in terms of both individual biomass and high species diversity, but they can also focus on the lower trophic levels, thereby taking advantage of the greater potential biomass, even though fewer numbers of species are available. One feature of the marine ecological structure is that species of the higher trophic level tend to increase in size, whereas in terrestrial systems, the reverse is often the case. It is thus advantageous for humans to concentrate on the middle levels of the marine food pyramid. Hence, in energetic terms, the prehistoric inhabitants can have their cake and eat it too. The fauna utilized in the coastal adaptation placed into the trophic food web proposed by W. E. Odum (1970a) illustrates this principle.

Higher carnivores utilized by coastal inhabitants include seal, porpoise, some whales, turkey vulture, snowy egret, American egret, cormorant, white ibis, great blue heron, osprey, black vulture, barracuda, rays, sharks, tarpon, black drum, alligator, crevalle jack, mackerel, pompano, sea trout, redfish, ladyfish, gafftopsail catfish, snook, jewfish, grouper, and snapper. Middle carnivores utilized in the Late Prehistoric adaptation include sea catfish and toadfish. Primary carnivores found in the subsistence base are sheepshead and pinfish, while the herbivores include mullet, oysters and bivalves, and sea turtles.

Sea mammals and sea turtles also form a part of the subsistence base, as is known archaeologically. These animals obviously should be of importance in this region because of their large biomass. The archaeological evidence suggests that sea mammals and sea turtles are more common in the southern region of the southwest Florida coast, but it is dangerous to make such statements with such limited data for comparison. Green turtle remains are quite common at sites on Marco Island, and numerous green turtle remains are present in the faunal collection from the Bear Island site in the Everglades National Park (J. W. Griffin 1974). Sea turtles should be energetically advantageous to exploit because they are not only large, but are also in the herbivore trophic level. Sea turtles feed on grass banks on Florida's west coast (Wing 1963), and the numerous regions of sea grass in this area should be favorable to their distribution, making them a viable resource for human exploitation.

The remains of a minimum of forty-two cetacean individuals from the Caxambas site on Marco Island seem to indicate that these mammals were of considerable importance in the diet of certain populations on the southwest Florida coast. Although the remains have not been specifically identified, it can be assumed that they include the bottlenose dolphin (*Tursiops truncatus*), the most common cetacean in the area. This species' habitat is within estuaries and shallow inshore water, rather than out at sea, and it is found throughout the year in the region (Schmidly 1981).

The West Indian seal (*Monachus tropicalis*) has also been recorded from the Caxambas site (Cumbaa 1971). This species is now extinct but was numerous before the nineteenth century. There is ethnohistoric evidence that seal was a sumptuary food item, at least in the Florida Keys during the sixteenth century. Fontaneda, in his memoir written about 1575, notes that "some of these Indians [that live in the Keys] eat seals, not all because there is a difference between chiefs and lesser chiefs and heads of houses" (Fontaneda 1944:66, cited in Larson 1980:163). This suggests that the presence of seal in some sites and not in others might be due to status differences. It should be cautioned, however, that absence of this species from a site might be due to sampling problems or to its lack of sumptuary value on the southwest coast.

Archaeological data also suggest a high reliance on sharks and rays in the subsistence. Part of this reliance might be a result of the mass aggregation of these fauna in the spring months (E. Clark 1963), which would favor intensive-exploitive strategies during these periods. Still, because of the large size of these animals, they represent more concentrated packages of energy, despite their higher trophic position, and exploitation would tend to maximize return of energy for expenditure of energy in capturing them if they are a predictable or reliable resource readily obtainable with the existing technology.

The sheer volume of shell in the middens of this area is quite impressive and immediately leads to the conclusion that these resources are obviously of considerable significance. Goggin (1949b) has stated that at the Goodland site on Marco Island, an estimated 150,000 m^3 of shell were removed from an area representing less than 5 percent of the site area. If extrapolated to the entire site volume, this would indicate that the site contains over 3 million m^3 of shell. Yet it is difficult to relate this volume directly to caloric values or to other faunal data, since many species, each with different shell-to-flesh and calorie-to-gram ratios, make up the southwest Florida coastal middens. Byrd (1976:71) has estimated that 1.0 m^3 of clam shell (*Rangia cuneata*) yields approximately 67 kg of edible meat. Clams contain only 76 calories per 100 g of edible meat, while oysters, which have even less edible meat per volume of shell, contain only 66 calories per 100 g of edible meat (Watt and Merrill 1963). In caloric terms these 67 kg of edible meat, represented by 1.0 m^3 of archaeological shell, equal the calories available from a single large deer represented by approximately 40 kg of edible meat.

In general, it is thought that shellfish are a minor component in the diets of coastal adaptations (Osborn 1977). Fradkin (1976) also does not think that shellfish were important at the Wightman site. Lightfoot and Ruppé (1980) have determined that oysters from the Venice estuary in the south-central Gulf coast of Florida could have supplied a small human population at 2000 B.P. for only a few weeks during the year. This is when the sea level was 1.8 m (6 ft.) below its present position. As a result, the supply of these resources was limited, and collection sites were sporatically visited for short periods. They suggest that 7.5-cm (3-in.) oysters from this shell midden yield approximately 20 g of edible animal each. Based on the raw-meat caloric value of 66 calories/100 g, each oyster yields 13.2 calories, and 152 oysters of 7.5 cm (3 in.) each would be required to provide the daily calorie intake of 2,000 calories per capita.

Lightfoot and Ruppé (1980) further go on to develop a carrying capacity model for oysters. They note that the Venice estuary system of 2,176,234 m^2 (2,381,000 sq. yd.) yields a maximum oyster count of 25,945,450, or 12 oysters per square meter (11/sq. yd.). This assumes a water influx of 10 l. per day per oyster. If 15 l. of water flow per day per oyster are required, the carrying capacity of oysters drops to 6.4/m^2 (7/sq. yd.). Using a mean density figure of 8.2 oysters per square meter (9/sq. yd.), they then proceed to develop the population size which can be supported by a given percentage of oysters in the diet. The tables which result, however, are not "carrying capacity," because the length of time in which a bed is depleted, or the oyster replacement rate, is not taken into consideration. In spite of these limitations, their tables do show that oysters from the Venice estuary could supply a population of only fifty for 18.7 years before the estuary would be exhausted, even if oysters represented 25 percent of the diet in an estuary with an area of 1,442,000 m^2 (Lightfoot and Ruppé 1980:55).

Meehan (1977) has investigated the role of shellfish in a group of contemporary coastal Anbara hunters and gatherers who live around the mouth of the Blyth River in Arnhem Land, northern Australia. A total of 7,000 kg of shellfish, of which 1,500 kg were edible flesh, was collected over a year, amounting to 1,200,000 kcals. Of interest is that shellfish collecting and fishing were the most frequent subsistence activities, occurring on 58 percent of the observed days (194). Yet the contribution to the diet ranged from 6 percent to 17 percent of the caloric intake of this group, depending on the season. Fishing provides the most calories of all the hunting-gathering activities the group practices.

Meehan (1977:524) explains the paradox of shellfish gathering in terms of division of labor based on age and sex. Shellfish gathering requires little physical strength or special skill. Therefore, unlike roots, which require extensive movement to locate (up to 20 km/day) and arduous digging, shellfish can be gathered by pregnant women or women with dependent children with no reduction in productivity. Furthermore, the low skill level necessary for shellfish collecting makes it feasible for children to engage in this subsistence activity. Therefore, in spite of the energetic limitations of shellfish as a dietary staple, they may provide a valuable subsistence resource collectible by certain age and sex categories of a population which cannot contribute to other subsistence activities. The ethnographic case presented here tends to suggest that shellfish constitute an important, if small, caloric and protein contribution to the diet over the course of the year. Their value lies in that they are a predictable resource which is unrestricted in exploitation to most members of a population and therefore a viable addition to the diet in terms of division of labor and energy input.

It should not be assumed that shellfish are a necessary component of the coastal-subsistence pattern. At the Solana site, there were few remains of shellfish that had been used for human food. Shell tools, small oysters, barnacles, and mussels were present, but the latter are interpreted as growth on pilings. Crown conch (*Melongina corona*) was the primary molluscan food remain found at the site. The crown conch develops exaggerated spines when living on oyster reefs (Abbott 1954:235; Tabb and Manning 1961:575–577). The specimens from the Solana site lack such spines, indicating that they lived in oyster-free environments. *Polinices ducplicatus*, *Busycon spiratum*, and *Fasciolaria* spp. are also present in smaller frequencies and are likewise interpreted as being food remains.

The Solana site, unlike any other coastal site thus far located in southwest Florida, is practically barren of shell. The site is significant in that it illustrates that shellfish are not a requisite component of the subsistence base of coastal sites in this region. These four molluscan species make up only 9.46 percent of the total edible meat represented by the total faunal assemblage at the Solana site (Widmer 1986:48).

Shellfish, such as oysters, may be an important resource on a seasonal basis, which has been suggested at the Venice site (Lightfoot and Ruppé 1980). In Meehan's study, shellfish has the highest frequency in the diet during January, the rainy season, which is the most difficult season of the year for the Anbara. During this month, 17 percent of the caloric intake was shellfish, and the Anbara themselves characterized the wet season as "shellfish time." A similar pattern of seasonal use is seen at the Venice shell midden, just north of the study area. Here, shellfish were not collected during the winter season. Oysters were consumed during the months of April to November (T. A. Ruppé 1980:69), the wettest months of the year. Thus, as Perlman (1980) has suggested, the use of this coastal resource as an adjunct to terrestrial resources acts as a stability factor—that is, it raises the limiting or critical seasonal resource and hence raises the overall "critical carrying capacity."

The Subsistence Technology

A technology is necessary to exploit the resource base of a particular environment. More important, the nature of this aspect of the economy shapes or influences the range of possible socioeconomic adjustments and responses a cultural system can make to the environment to adapt. It is useless to talk of the richness of an environment if a particular cultural system has no viable means of exploiting the resources within it.

One of the most important aspects of exploiting a coastal, particularly a fish, resource base is that it be accessible. Although fish and other estuarine and shoreline faunal resources are accessible from the water's edge, a watercraft greatly enhances the fishing endeavor. There is direct ethnohistoric and indirect archaeological evidence of canoes in southwest Florida. Goggin and Sturtevant (1964) summarize the pertinent ethnohistorical sources; archaeological evidence exists in the form of several toy canoe-shaped wooden vessels from the Cushing excavations of Key Marco (Gilliland 1975:55, pl. 15), as well as a wooden canoe paddle (Gilliland 1975:125, pl. 76). Cushing (1896:375) believed that the close juxtaposition of two of the toy canoes at Key Marco indicates the existence of catamaran-style double canoes. This type of canoe is reported by Jonathan Dickinson as being used by south Florida Indians (cited by Cushing 1896:365). Cushing believed that these catamarans represent the evidence for offshore navigation. The occurrence of deepwater pelagic faunal remains, such as sailfish, in archaeological contexts at Matecumbe Key (Goggin and Sommer 1949) and in southeast Florida middens (Willey 1949a) support this contention. The mako shark remains (*Isurus* sp.) from Key Marco (table 21) are further evidence of offshore-navigation ability, since this species does not frequent shallow offshore or coastal waters.

Fishing gear is also important in the exploitation of coastal, particularly fish, resources. The archaeological and ethnohistoric sources indicate a very broad and specialized range of technological implements for exploiting this environment. Numerous examples of harpoon and spear points have been recovered from Key Marco, including single-barbed bone harpoon points, stingray-spine spear points, and long, barbless, spikelike, alligator bone spear points. All these implements are interpreted by Gilliland (1975) as being used for fishing. The different attributes of these implements would seem to suggest functional differences and thus specialized techniques and implements for use in certain environments or for certain species.

Larson (1980:122) has presented two ethnohistoric examples of the use of spears or harpoons in south Florida. Jonathan Dickinson notes their use among the Jeaga:

> This morning the Cassekey looking on us with a mild aspect, sent his son with his striking staff to the inlet to strike fish for us; which was performed with great dexterity; for some of us walked down with him, and though we looked very earnestly when he threw his staff from him could not see a fish at which time he saw it, and brought it on shore on the end of his staff. Sometimes he would run swiftly pursuing a fish, and seldom missed when he darted at him. In two hours' time he got as many fish as would serve twenty men: there were others also fishing at the same time, so that fish was plenty. [Andrews and Andrews 1945:35]

The priest San Miguel also reports this method being used in south Florida in the sixteenth century. San Miguel specifically mentions the spearing of mullet:

> One fine day, in the morning, we arrived at an encampment where they had placed on the fire a pot with mullets as whole as God made them. I observed that they all had wounds in the little fin they have in the middle of the back. They strike them there with a small wooden point, like a tiny harpoon, set in a staff. [García 1902:208]

There is also a barbless, long spear point whose function is somewhat puzzling, since most prey would readily fall off. One which could have been obtained with a barbless spear point is crab, whose rigid shell would apply resistance to the point and so remain transfixed. Others would be flounder and bottom-dwelling rays. The long, piercing point would pass through the fish and into the bottom, thereby preventing the fish from escaping. The fish could then be secured by hand. The above species are all bottom-dwelling and capable of burrowing in the sand, thus avoiding capture by other means, particularly nets. Larson (1980:117) has suggested that the numerous double-pointed bone pins that have been recovered from archaeological sites in the region might have functioned as fishhooks. A hook and line is necessary to catch groupers (*Epinephelus* spp., *Mycteroperca* spp.) and some snappers (*Lutjanus* spp.). These fish are primarily offshore (Springer and Woodburn 1960) and are solitary in habitat, thereby negating the use of nets, weirs, or inshore tidal traps. They are frequently encountered in southwest Florida faunal assemblages and are probably the only species which cannot be effectively taken with other than hook and line. This technique, then, may be a specific adaptation for exploiting this resource, although other fish might be taken in the same manner, for example, jack, tarpon, and sharks. Larson (1980:81–86) points out the problems with use of hook and line for sharks, in that sharks could easily chew through leaderless lines.

Fish hooks are known from two sites in the study area, the Wightman site (Fradkin 1976:75) and Key Marco (Cushing 1896; Gilliland 1975), and there is a possible example from the Solana site (Widmer 1986). The examples from Key Marco are considered indicators of deep-sea fishing:

> We found four or five fish-hooks. The shanks or stems of these were about three inches long, shaped much like those of our own, but made from the conveniently curved main branches of the forked twigs of some tough springy kind of wood. These were cut off at the forks in such manner as to leave a portion of the stems to serve as butts, which were girdled and notched in, so that the sharp, barbed points of deer bone, which were about half as long as the shanks and leaned in toward them, could be firmly attached with sinew and black rubber-gum cement. The stems were neatly tapered toward the upper ends, which terminated in slight knobs, and to these, lines—so fine that only traces of them could be recovered—were tied by half-hitches, like turns of a bow string. Little plug-shaped floats of gumbo-limbo wood, and sinkers made from the short thick columellae of turbinella shells—not shaped and polished like the highly finished plummet-shaped pendants we secured in great numbers, but with the whorls merely battered off—seemed to have been used with these hooks and lines. That they were designed for deepsea fishing was indicated by the occurrence of flat reels or spools shaped precisely like fine-toothed combs divested of their inner teeth. There were also shuttles or skein-holders of hard wood, six or seven inches long, with wide semicircular crotches at the ends. But these may have served in connection with a double kind of barb, made from two notched or hooked crochet-like points or prongs of deer bone, that we found attached with fibre cords to a concave round-ended plate, an inch wide and three inches long, made from the pearly nacre of a pinna shell. Since several of these shining, ovoid plates were procured, I regarded them as possibly "Baiting-spoons," and this one with the barbed contrivance as some kind of trolling gear, though it may, as the sailors thought, have been a "Pair of grains," or may, like the hook proper, have been used for deep-sea fishing. [Cushing 1896:367]

Nets were a prominent feature of the southwest Florida subsistence technology. Bountiful netting was recovered from Cushing's excavation at Marco Island (Cushing 1896; Gilliland 1975):

> [shell balers] were abundant, as were also nets of tough fibre, both coarse and fine, knitted quite as is the common netting of our own fisherman today, in form of fine-meshed, square dipnets, and of coarse-meshed, comparatively large and long gill-nets. To the lower edges of these, sinkers made from thick, roughly perforated umboidal bivalves, tied together in bunches, or else from chipped and notched fragments of heavy clam shells, were attached, while to the upper edges, floats made from gourds, held in place by fine net-lashings, or else from long sticks or square-ended blocks, were fastened. Around the avenues of the court I was interested to find netting of coarser cordage weighted with unusually large-sized or else heavily bunched sinkers of shell, and supplied at the upper edges with long, delicately tapered gumbo-limbo float-pegs, those of each set equal in size, each peg thereof partially split at the larger end, so as to clamp double half-turns or ingeniously knotted hitches of the neatly twisted edge-cords with which all were made fast to the nets. [Cushing 1896:366]

Gourds (*Lagenaria siceraria*) were also used as net floats (Cutler 1975; Gilliland 1975). One of the gourds was even enclosed in cordage. Mesh size on the Key Marco material ranges from 3 cm to 6 cm (Gilliland 1975:244) and suggests that specific species were sought or different types of fishing grounds were systematically exploited. The use of "gill-nets," as they are classified by Cushing, indicates selective fish exploitation, since small fish will swim through, while larger fish will be trapped (Larson 1980).

The exact identity of the fiber used to produce this cordage and netting material is unknown but is probably palm fiber: "Positive identification of the fiber was not made but in two of the lots were fragments of fibrous leaf sheath margins of an unidentified palm. It is possible that the cords were composed of this for palm fibers are readily available and strong even when water-soaked" (Cutler 1975:256). If palm fiber is the material necessary for producing nets, it becomes a critical economic resource for subsistence which might influence other aspects of the sociocultural system and possibly is as significant as the fish resource itself.

Surprisingly, there is no ethnographic or archaeological evidence of the use of fish traps or weirs in the south Florida area on either coast. There is a reference by Garcilaso de la Vega of a fish weir in the vicinity of Tampa Bay (Larson 1980:125). Larson (1980) suggests that tidal traps, or weirs, are functionally dependent on sedentary village life. This would account for the absence of these devices along the Atlantic coast of south Florida, where the populations are presumably nomadic. But their lack in the southwest Florida coastal region is not explained. According to Larson (1980:99–100), tidal traps or nets are necessary for catching sharks. The nature of the shallow tidal mangrove pools, which abound in the survey area, certainly suggest the feasibility of weirs or traps. They would be very efficient for species such as catfish, and possibly mullet, which would be left behind in the entrapment when the tide went out.

Since such traps and weirs would be located beneath the water surface and not necessarily adjacent to the settlement, it would be difficult for archaeologists to find them, if possible at all. Such traps and weirs are, however, known to be effective in other tropical-mangrove estuaries. Analogies from West Africa illustrate types of weirs, traps, and other traditional methods which would be feasible with the environment and technological capabilities of the aboriginal adaptation. One such method is fence fishing, in which slats or poles are placed in a line so that the resulting fence encloses a mangrove shoreline. During the rising tide, the weir is opened to allow fish in and then closed to prevent escape of the fish. The stranded fish are then collected at low tide (Pillay 1967). This particular method would be very effective for snook, sheepshead, and mangrove snapper, which frequent the mangrove-root edges. Another very interesting method of fishing which might also be applicable to the southwest Florida coast is the "akadja" method used in Dahomey to catch *Tilapia* spp., mullet, and catfish:

> Large or circular or rectangular areas (as much as 2½ acres) are enclosed by driving long twigs or tree branches into the lagoon bed. Fishes take shelter among the foliage and in the enclosed area, feeding on the algal growth that develops. After a period of about four to six months the Akadja is enclosed by nets and the brush removed. Remarkably large quantities of fish are caught in this manner. [Pillay 1967:644]

The occurrence of toadfish (*Opsanus beta*) in faunal assemblages implies the use of traps. Toadfish are not active swimmers and are adapted for living in and under oyster shells (Gunter 1967:635). These fish would therefore have a natural habit of seeking out enclosed habitats. In fact, they commonly inhabit discarded cans and jars, and because of this behavior, could probably be attracted to partially enclosed containers, such as ceramic jars, placed in their habitat. Larson (1980:27) has brought up the possibility of fish poisoning on the southwest Gulf coast because of the presence of poisonwood (*Meetopium tixiferun*) among the flora of this region. Unfortunately, no ethnohistoric or archaeological evidence exists to support this use, and the tidal action in most regions of the southwest Florida coast would seem to preclude it. Fish poisoning is ineffective for catching many kinds of fish, including gar and bowfin (Cumbaa 1971:62).

There is little ethnohistorical and no archaeological reference to storage or preservation of foodstuffs. The only indication of storage comes from ethnohistoric accounts relating to whale hunting on the southeast coast of Florida, such as the sixteenth-century account of Acosta: "In fact they finish the killing [of the whale] and divide it and cut it into pieces, and from its abundant tough meat, drying and grinding it, they make true powder that they use for their food and it lasts a long time" (Acosta 1962, cited in Larson 1980:149). The late-sixteenth-century account of San Miguel also refers to the preservation of whale meat: "Thus they leave it [the dying whale] and return to land where the lifeless one is cast up by the sea and here they cut it into pieces and make jerky for their food supply, and *in particular* those from the interior country eat it" (García 1902, cited in Larson 1980:151, emphasis added).

These ethnohistoric references clearly indicate the presence of a preserving technology (drying) and storage. It is not known to what extent fish resources were dried or would need to be dried. In Menéndez's visit to the town of Calos in 1566, there was no mention of dried fish, although he does detail the types of processing used on the food served to his party (Solís de Merás 1964:148). The frequent availability of fish in general would preclude the necessity of drying. Large faunal specimens, however, such as shark and whales, could probably be more efficiently utilized when their potential energy could be stored, but the reference by San Miguel to their significance to interior populations suggests that they played a sumptuary role. This inference is based on the scarcity of the resource, whose trophic position increases the concentration of biomass at the expense of fewer individuals and results in increased capture time for these animals. Thus it seems that these resources would be sought only during their period of maximum availability. The value of this resource might not, therefore, be in terms of its actual consumable calories but instead in its converted energy, namely its sumptuary significance and the power obtainable through a patron-client relationship (see R. N. Adams 1975).

It appears that food-preserving and storage practices are selectively utilized, depending on stochastic vagaries in overall fish production. The excess digestible energy of seasonally available sea mammals, which is probably above and beyond subsistence needs, could be converted into power through sumptuary exchanges. San Miguel's reference seems to support this contention.

Settlement Patterning

The difficulty of accurately phasing archaeological components attributable to the Calusa-type adaptation—that is, those after A.D. 800—was noted earlier. This is a particularly severe problem in the Caloosahatchee subarea, where decorated ceramics are scarce. Therefore, the information regarding the settlement pattern for the post–A.D. 800 period is highly speculative, and I am assuming, as stated earlier, that there is no real shift in population size, number of sites, or the location of sites. This assumption has for the most part been supported by the limited excavations which have been carried out in the southwest coastal sites. Sites dating after A.D. 800 have the entire chronological sequence associated with them. Also, as mentioned earlier, ceramic densities at the sites tested in the area are the same for all levels, suggesting little demographic change or shifting of site location. It was hypothesized in chapter 7 that no more expansion into uninhabited areas by village fissioning would occur. As a result, with the incomplete settlement data it seems reasonable at this time to consider a single-settlement system for the period A.D. 800 to contact, one that hence is characteristic of the Calusa.

At present, three basic site types have been identified for the late southwest Florida adaptation (Widmer 1978). These are the large nucleated villages, which are characteristically ten hectares or larger in area; villages with sizes of three to four hectares; and small fishing hamlets, or collecting stations. Sanders et al. (1979) have suggested that the most direct way of estimating population is to derive family-residence figures and apply them to sites where domestic architecture is preserved. Mounds, presumably of residential nature, are common in the interior. Since archaeological data have not determined that these mounds are actually residential in nature, it seems more reasonable simply to use areal estimates at this stage.

The large village sites are assumed here to have had average populations of 400 individuals, a figure which follows that given by Murdock (1969:141). This figure is also in line with the estimation of population figures by Sanders and his colleagues (1979:54) based on density of ceramic refuse. They suggest population figures of 25 to 50 individuals per hectare for moderate site occupation. Projection of this estimate to the site size of 10 hectares yields a figure of 250 to 500. The figure of 400 does not seem unreasonable, particularly since population estimates for Calos, the provincial center, are often over 4,000. Fontaneda (1944) specifically mentions that there are twenty-three towns on the southwest Florida coast and two in the Keys.

There is some controversy over whether large sites were always as large as their spatial area suggests. W. H. Sears (1956), from his work at the Turner River site and on Goggin's excavation at the Goodland site (1949b), suggested that the large area of the sites in this region is due to shifting horizontal accretion of deposits rather than vertical deposition in a single location. Thus, the large size of these sites might be due to their long temporal occupation. This conclusion is based on the observation that more recent cultural material is found toward the water's edge. It should be added, however, that rising sea level may have obscured the early occupation at the original water's edge. No new data have been brought to bear on this issue, and for the purposes here it will be assumed that the maximal extent of the site was utilized at a single point in time, since there is ethnohistoric evidence of dense populations at the time of contact.

For the small villages, estimated population is fifty. I am basing this figure on the size given by Fontaneda (1944:13) for the villages of the Mayaimi. Possibly the figure is slightly low.

The remaining type site—the fishing hamlet, or collecting station—is a very common one, particularly now that the survey of the Big Cypress Swamp has resulted in the recording of almost 400 sites, most of which date to the period after A.D. 800. Most of the sites are small, usually under 1 hectare in area, with the largest no more than 1000 m^2. Such sites are interpreted as temporary task-specific collecting, hunting, or fishing stations, whose expeditions were launched from the permanent villages. It is possible that some of the larger collecting stations, such as the Hinson and Platt Island sites, had larger occupations, either permanent, as Ehrenhard et al. (1978) suggest, or else extended seasonal ones. Seasonality and duration of occupation are difficult to evaluate specifically at this time. Clearly, though, there was a minimum of exchange or movement of coastal resources into the interior, in spite of the relatively close spatial relationship of these coastal and interior marsh regions and the greater demographic weight of the coastal groups.

The site locations for the late-period occupation have been presented in figures 32 and 33. Only those sites known for the period that are relatively well-documented in the archaeological literature have been included. The patterns indicate a preponderance of two site types, the large, nucleated villages and the smaller villages. The Ten Thousand Island region has only a few of the smaller collecting stations. This may seem puzzling, but it should be remembered that the large number of such sites in the Big Cypress Swamp are located just behind the coastal zone.

Fortunately, a comprehensive understanding of the highly dispersed character of the occupation in the Big Cypress Swamp has been made possible by the large amounts of calcium carbonate in the water, which replaces bone (Ehrenhard et al. 1978) and thus affords excellent preservation. It is not surprising that ceramics were infrequently encountered in the surface collections. Although some sherds were possibly overlooked because of ground cover, which impaired visibility, the paucity of finds might also reflect a lack of use of ceramics at *some* of these sites. At some black-dirt middens, ceramics are more frequent, even under similar ground-cover conditions.

The important question is whether similar sites flank the coastal zone to the east of the Caloosahatchee subarea. I believe that they do. Because of sandy, acid soils, however, bone and vegetable preservation is poor in this region, and unless the sites were intensely utilized, they would lack visibility, particularly in the scrubby pine flatwoods environment. The large expanses of potential saw palmetto in this area, as mentioned earlier, suggest that collecting stations might be located here.

The Pine Island Sound–Charlotte Harbor area shows a similar pattern, with perhaps a few more collecting stations but not many more. What is not known is the nature of occupation in the marshy interior zone flanking this area. At present, only a single site, the Solana site (Widmer 1986), represents such a fishing hamlet. This site is now interpreted as a permanently occupied fishing village. The site size suggests an estimated population of fewer than forty people, in line with the village size mentioned by Fontaneda (1944). This site dates to A.D. 400, however, and therefore is not applicable to the period under discussion. It would seem that this settlement type disappears by A.D. 800, but the data to support this

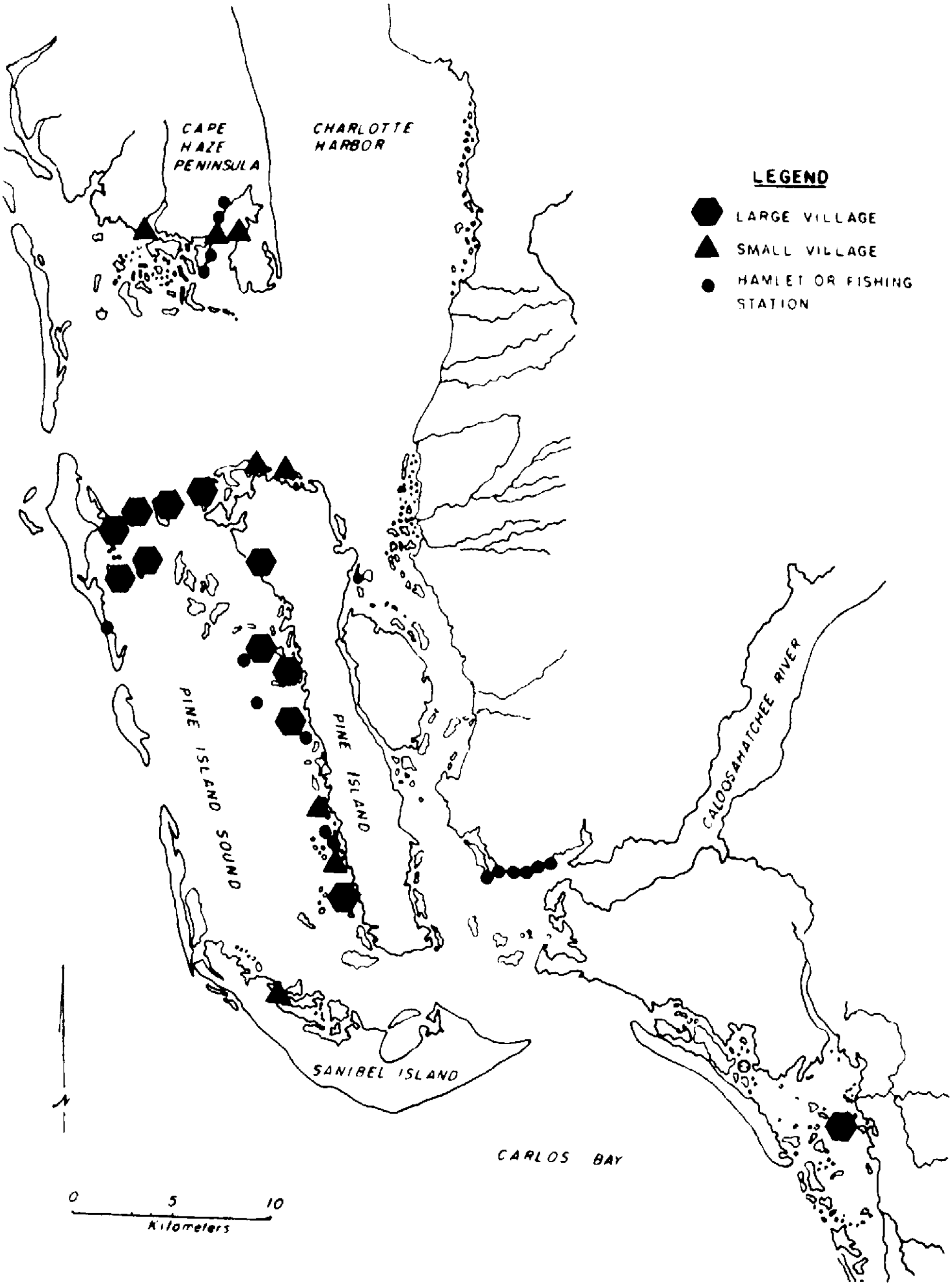


Figure 32. Charlotte Harbor–Pine Island Sound Late Prehistoric Settlement Pattern

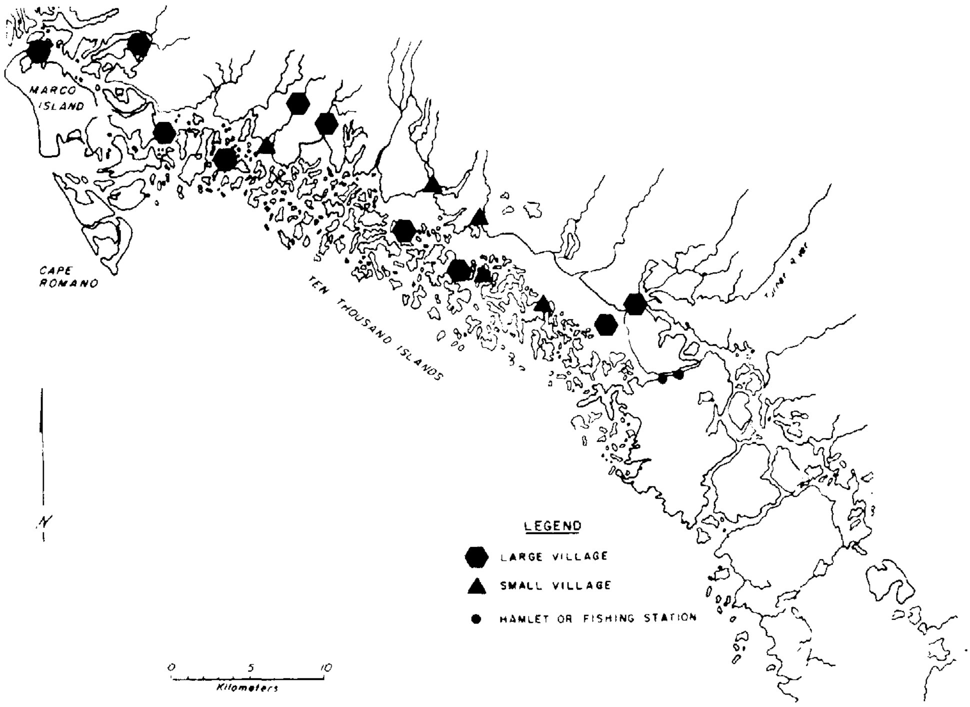


Figure 33. Ten Thousand Islands Late Prehistoric Settlement Pattern

conclusion are admittedly limited, and it may be that the type continues into the period subsequent to A.D. 800. The distribution of this type of site, in both time and space, is an important topic for future research.

The basic settlement system, which differs little in concept in the northern and southern coastal zones, is reconstructed as a series of large, nucleated villages, augmented by a few smaller villages, linearly placed in the coastal zone. A break in the large site distribution occurs south of Estero Bay and north of Naples. This is predictable because of the lack of a highly productive coastal zone in this area and is a further indication of the critical nature of coastal resources to the maintenance of this sedentary adaptation. These villages are interpreted as sedentary communities representing the only permanent settlement type for the coastal area. Inland and scattered throughout the coastal zone as well are a large number of temporary, sporadically occupied or utilized collection, fishing, and hunting stations, visited for brief periods probably by task-specific groups of limited demographic composition.

The population densities for the two coastal segments have been calculated from the population estimates for settlement types discussed earlier, 400 for the large villages and 50 for the small villages. It should be cautioned that these sites are *assumed* to be contemporaneous, an assumption which has no empirical validity. An area of 800 km^2 is estimated for the Pine Island Sound–Charlotte Harbor coastal zone. Multiplying the number of sites within this area—eleven large villages (excluding the large village in Estero Bay) and eight small villages—by the population estimates for size of site yields a population of 4,800. Population density is thus 6.0 persons/km^2.

In the Ten Thousand Islands area, calculations for the ten large villages and the five small villages yield a population of 4,250 occupying an area of 450 km^2, a density of 9.44 persons/km^2. (The hamlet and collection-station populations have not been included in these calculations, since the sites are not interpreted as permanent habitation sites.) The density figure is almost twice as high as that for the zone to the north; the figures would probably be more similar for the two areas if linear coastal distance were used rather than simply area. Still, this difference in density may be real and would explain the tremendous number of small collecting sites in the interior Big Cypress Swamp. These population figures are not that high and, interestingly, do not exceed the 9.5 persons/km^2 for the Haida of the Northwest coast of North America (Hassan 1981:8).

Combining the estimated population figures for the two areas yields a suggested population of 10,250 for the Calusa settlement system in the two highly productive coastal zones; a population of 10,000 is therefore not as unreasonable as Goggin and Sturtevant (1964) suggest. If we consider the entire territorial area utilized by the populations of the Calusa adaptation, as Osborn (1980) would suggest, the population densities would drop dramatically. Thus, the high-population density is not solely a function of the unusually high productivity in the coastal strip, since other resource zones with lower productivity are utilized, but this area is the most advantageous for permanent habitation.

9

The Sociopolitical Evolution of the Calusa Chiefdom

The key to the evolution of ranking—that is, chiefdoms—has to be grounded initially in demography. Such hierarchically organized systems are not tolerated in societies with small populations, since differential access to material goods carry a higher energetic cost to the members of a society, and small numbers usually are unable to create the energy surplus to maintain that kind of system. Also, the small size of competing kin units reduces the possibility that such a differential social hierarchy will be implemented. As a result, leadership in small societies is based on age and experience and is minimally developed. Therefore, the emergence of fixed leadership statuses, which characterize chiefdoms, requires a large population, at least larger than those found in mobile hunters and gatherers.

This demographic requirement has resulted in a too-strict linking of particular subsistence regimes with sociopolitical organization, that is, farming with chiefdoms. Fried (1967), however, was clear in stating that the type of economy need not be important, and he referred to North American groups in the Northwest Coast as examples. The significant condition is not economic but, rather, demographic. Still, as I have attempted to explain earlier, such a demographic base can come about only through sedentary settlement, since only sedentary settlement seems to generate the fertility rates which can maintain and produce large, growing populations. Large populations, of course, will not automatically arise out of sedentary settlement. It is entirely possible for groups to implement cultural practices which repress fertility and population increase. Such techniques include infanticide, abortion, and long postpartum sex taboos. These practices will be implemented, however, only if they are required to maintain population levels at or below the critical "carrying capacity." Both agriculture and highly productive tropical fishing adaptations have higher critical carrying capacities than the more typical seasonal hunting-gathering regimes for the reasons discussed earlier. As a result, high fertility can be realized and the cultural fertility checks need not be implemented, or, if they were implemented earlier, they can be relaxed. In agricultural systems, intensification of the system may be a more advantageous strategy from an energetic perspective than population regulation through infanticide. Pregnancy, after all, entails energetic costs and risks to the mother which would be for naught if the end result were infanticide. Although it is accepted that fertility tends to rise under sedentary conditions and that fertility dampening or population regulation is not implemented unless necessary, the fundamental question here is why the population of south Florida was sedentary.

The important question, in terms of sociopolitical implications, is why in a region of high productivity and relative environmental homogeneity are there large villages, sometimes clustered closely together, rather than dispersed hamlets scattered throughout the region, or for that matter, why are there large sedentary villages at all? This phenomenon can be examined by reference to ecological and economic parameters within the context of a population-pressure model and the maximization of energy capture.

Pianka (1974), in his discussion of evolutionary ecology, points out how an adaptive system in animals arises out of the highest net capture of energy in an environment. Although Pianka is dealing specifically with the biological evolution of feeding strategies, his model can be applied analogously to human hunter-gatherer adaptive strategies, since the model is consistent with the position that the cultural adaptive system will best exploit an environment in a way that maximizes the collection of energetic resources. Pianka (1974:200) illustrates that the nature of the environment and distribution of the resources within it will structure the type of feeding strategy an organism or species selects. That is, only those food items in the environment which result in the highest net capture of energy, or other critical resource such as protein, will be selected. The ability to obtain a net profit of the resource in question, however, depends on the distribution of the resources in the environment.

Pianka (1974:206) contends that there are two basic types of environments, fine-grained environments with evenly spaced food resources and "patchy" environments, characterized by heterogeneous, dispersed food resources. The area under consideration in this study is a fine-grained environment, according to the criteria of Pianka's classification. Following this argument, it seems that a behavioral response of an animal, in this case human groups, would be sedentary settlement, because it is able to exploit efficiently a wide variety of resources which are of a stable, long-term availability and to obtain the maximal amount of energy per unit of energy expended in capture. Therefore, there is no need for movement, since it would only add to the cost of capture.

Another important factor stimulating or allowing population nucleation is the need for cooperative activity to implement the technology. Also, the stochastic vagaries of fishing require reallocation of daily fish catch. Sedentary settlement provides an effective, efficient means of allocation of the fishing resources to the local group. This reallocation is also enhanced by canoe transport.

Sedentary settlement also makes for more efficient marriage arrangements and for better defense, which becomes more important as population grows to levels resulting in circumscription of the environment and more competition for resources. Sedentary settlement, I suggest, will alleviate some of the pressures of incest taboo and mating requirements and will tend to act as a nucleating factor, as well as improve subsistence efficiency. In effect then, sedentary settlement will occur if the environment is of sufficient quality and structure to allow the response for the reasons pointed out by Pianka, that is, that it is energetically beneficial to do so. This sedentary settlement in turn stimulates rapid population growth through increased potential fertility, which will ultimately result in a large population, if unchecked culturally or naturally.

Critical Resources in Southwest Florida

Thus, sedentary settlement develops in southwest Florida because it is energetically efficient. But it also has the potential of creating problems, which need to be resolved. Many of these problems involve distribution of critical resources, and their solution requires, in many cases, organizational capability of a centralized, hierarchical type, which opens the way for the development of a ranked sociopolitical system.

FISHING GROUNDS

The inshore fishing grounds are unquestionably the single most critical economic variable in the southwest Florida adaptation. They have fixed locations and are ranked in terms of their production. They operate, functionally, exactly as permanent-field agricultural plots do in terrestrial, agricultural economies. As was discussed in chapter 2, at a general theoretical level, fixed, tropical, inshore fishing systems need to be corporately owned or tenured for successful high production. Thus, it seems probable that the southwest Florida fishing grounds were corporately owned and managed, most likely by lineages. The origin of the ownership or tenure of these individual fishing grounds probably started early in the history of population expansion in the coastal zone, that is, after 2700 B.P. Logically, the largest, most productive grounds would have been utilized first, or at least would have provided an initial demographic advantage to the corporate group controlling or owning them. Since fissioning of villages would mean that the new ones occupied areas with either smaller or less productive fishing grounds or with dispersed fishing grounds, they would not be able to compete with the original villages in productivity. Thus, the initial colonizing lineage or corporate group would continue to gain a productive edge as the coastal zone filled in with population, and the less desirable fishing grounds would be left for the newest villages.

As pointed out in chapter 2, theoretical ownership and effective management of these fishing grounds is essential for maintaining profitable, continuous production of this resource base. The ownership and control by a lineage of the more productive fishing grounds would result in more absolute energy capture and transfer than is possible from less desirable fishing grounds. That differential energy base provides a clear means of establishing power and high-status positions, since there is greater potential for surplus, which can then be effectively exchanged with neighboring groups or lineages for power and status. That would allow the development of reciprocal obligations between chiefs, at both the local and the interregional level. The demographic edge—belonging to lineages that have become the largest owing to their control of good fishing grounds and the resulting additional energy—would also provide a military edge over other lineages or villages, further supporting the development of power and high status.

WATER

Fresh, potable water is a crucial resource in certain areas of coastal south Florida, because, for the most part, the coastal waters immediately adjacent to settlements are brackish or saline. The problem of access to fresh water has also been observed in the Chantuto adaptation of the mangrove coastal zone of Pacific Chiapas, Mexico (Voorhies 1976). A few springs are known on Pine Island, but as a rule, fresh water is very scarce. Periodic trips into the interior swamps or up rivers to obtain it would thus be necessary. Such travel would add greatly to the cost of obtaining the resource, although canoe transportation would somewhat minimize the energy needed. The situation would be particularly acute during the dry season, when the freshwater head of the estuary retreats inland.

It appears that artificial cisterns were constructed on many of the large sites for the purpose of capturing and storing rainwater (Cushing 1896:336; Hrdlička 1922). Construction of such features would require coordinated labor activity, and more important, would require the continual monitoring, maintenance, and cleaning of the cistern or pond to ensure the availability of a continuous water supply. Earle (1977) has shown that similar maintenance of irrigation canals was one of the main functions of Hawaiian chiefs. Such coordinated control of the cistern or reservoir, and its resultant increased productivity, could possibly lead to centralization of authority, but more than likely, this was not really a major, generative function of the cisterns.

The cisterns, or artificial ponds, when built, probably acted as nucleating features, encouraging sedentary settlement, perhaps at levels of social tension in excess of those which would normally be tolerated in small villages which do not need these resources. In other words, village fissioning might occur at lower population levels in villages without the need for stored water, as would be the case for agricultural villages located on freshwater rivers, whereas the cost of obtaining water on an individual basis in the interior, or the cost to a potential fissioning group of constructing a new cistern, may be too high to warrant fissioning. Thus, village population remains at a level higher than usually tolerated, which brings along with it higher social tension and the possibility of many disputes. This situation indirectly leads to a need for leadership or centralized authority for quelling these disputes. Since higher social tensions are tolerated, the ever-present need for individuals to resolve disputes would favor the development of fixed—that is, hierarchical—leadership and centralized authority, as has been argued by Netting (1972).

The continuous, high social tension levels and the resultant disputes would tend to act as a possible "autocatylitic device," as R. N. Adams (1978:303–304) would put it, which could result in a transformation from a "big-man" type leadership to a continuous, hierarchically centralized authority with inherited leadership positions, as is characteristic of chiefdoms.

FISHING GEAR

The making of nets, a crucial resource for a specialized fishing adaptation, seems to require some kind of exchange network operating over a large area to obtain natural resources used in the technology. Cutler (1975) has tentatively identified the net and cordage fiber recovered from the Key Marco site as palm. Only a few, limited, sandy islands in the northern Ten Thousand Islands area have the type of topographic conditions in which palms will grow. To a limited extent, they are also found in the interior. Since not necessarily all of the fiber used in cordage is palm, other suitable plant resources such as yucca, would also be found in better-drained interior regions. Therefore, it appears that groups in the mangrove-lined coastal areas south of Marco Island must have obtained this resource from some distance, presumably to the north in the sandy flatwoods area and in the interior hammocks. Such a situation could foster the development of patron-client relationships or the tenure and control of these areas by lineages, which could result in differential power available to an individual or group and, hence, centralization of power.

The Implementation of Subsistence Technology

Efficient, highly specialized, sophisticated, and balanced subsistence systems require management in many areas, such as procurement of raw materials and implementation of technologies designed to tap the productivity of the environment. The development of fixed, centralized power is thus permitted, or even encouraged, so that conflict may be minimized and economic stability maintained.

Besides the raw materials themselves, the production and use of nets in fishing require what appears to be a corporate group-task activity. Since the use of nets is a regular economic activity, one in which efficiency will increase fishing yields, the coordination and regulation of net fishing has adaptive advantage from an economic perspective. This leadership and control function can also be generated by a differential distribution of the specialized fishing gear as well. That is, those groups or lineages which have more nets or canoes or fishing gear will have a more important role in social control, with greater say in the management of these resources, including the human labor involved. Thus, the potential for the development of political centralization is evident at this level as well.

As Firth (1966:100–101) has shown for the Malay fishermen of Kelantan, the expert fisherman usually has his own boat and net and organizes the technical aspects of fishing. His ability to organize labor and equipment and his knowledge of local fishing conditions and the location of the fish are responsible for a successful catch. Individuals or groups who can accumulate such knowledge and resources can quickly achieve differential subsistence resources and increased status because they control and capture more energy. Thus, centralization arises out of the control of fishing equipment and labor and will be encouraged by the growth of such control.

Competition arising from tidal fluctuations of the primary resource location—in this case, fishing grounds—also fosters centralization. Although the study area is basically homogeneous, the location of resources shifts daily because of tidal fluctuations. As a consequence, the *times* which various, fixed, fishing grounds become available for fishing are continuously changing. Cordell (1978) has shown how tidal fluctuations and shifting of good fishing spots lead to conflict in coastal Brazil fishing systems. Unlike the fields used in agricultural systems, fishing grounds do not remain in fixed locations, and so temporary ownership of rights to them is difficult to establish without disputes (Cordell 1978:12). Regulatory social mechanisms are necessary to minimize possible conflicts. A group of individuals (i.e., a lineage) who can gain control over the monitoring and regulation of such resources has the potential to increase overall energy capture of the social unit by reducing the competition for these resources through a systematic programming and scheduling of their exploitation by members of various groups or villages. At the same time, this system provides the potential for developing differential control of or access to the areas, which will in turn result in the greater capture of energy by one group or lineage in relation to that of other groups. Such conditions, I believe, prevailed on the southwest Florida coast and were involved there in the evolution of ranking.

Seasonal and Stochastic Fluctuations

Vagaries and stochastic fluctuations in the subsistence base are a natural part of the coastal adaptation, and various organizational features are required to alleviate them. This situation is particularly advantageous to leaders or lineages which can solve the problem of temporary shortages through management decisions, because it allows the development of differential status positions and the reward of power for their stabilizing influence.

In the northern Charlotte Harbor–Pine Island Sound area, a region very close to the tropical zonation, any shifts in the location of the tropical isotherm, occurring in the form of sudden cold fronts of subfreezing weather, would affect the existing carrying capacity of the region. Since population size and density were so high, even minor fluctuations brought about by these cold spells would produce resource shortages and would intensify competition. Heavy fish mortality caused by sudden cold spells has been documented for the northern sector of this area (Storey and Gudger 1936; Storey 1937; Springer and Woodburn 1960), and it is probable that such events occurred prehistorically as well. Although no quantitative assessment of the effect of these weather fluctuations on the standing stock have been conducted, the results are nonetheless potentially deleterious.

Sudden influxes of fresh water into the estuary zone after heavy summer rains can also have a similar adverse effect on fish resources (Springer and Woodburn 1960). Even more serious are hurricanes, which disrupt fishing grounds and can destroy structures, fishing tackle, and canoes. Stochastic climatic stresses which would affect agricultural adaptations produce similar stresses in this coastal environment and its resource base. Such stresses would require centralization for the storage and redistribution of resources.

The immediate need to reallocate resources on a daily basis would continuously reinforce, from a political perspective, the role of a chief in maintaining the "redistribution" or sharing of the daily production. This has been shown to be the operating mechanism used by chiefs to obtain prestige in Northwest Coast groups (Piddocke 1965; Suttles 1968a). As mentioned in chapter 2, inshore coastal resources are not common property, open to all, and in this case, tenure is clearly corporate in nature, probably at the lineage level. Although *general* fish production for a given inshore area is known, it is difficult to ensure or predict production on a day-to-day basis, even if the tidal regime is known and monitored. Thus, there would have to be an elaborate network of continual communication between lineages to implement extensive panvillage sharing. This requirement would tend to favor "hypercoherency" in a sociopolitical system, since a large number of links with continual integration are necessary. These links could be between local, corporate lineage chiefs, who would redistribute production surpluses with each other. Such a system is consistent with a chiefdom hierarchy.

The Role of Redistribution in the Chiefdom

Redistribution as an integrating or necessary component of chiefdom society has currently come under attack (Earle 1977; Peebles and Kus 1977). The question has been raised whether stored surpluses are ever more useful in solving subsistence shortages in chiefdom societies than local relief. I believe that redistribution at the pancorporate group level is essential for the maintenance of adequate subsistence and that it is characteristic of tropical, inshore fishing economies, as has been demonstrated for Northwest Coast anadromous fishing economies (Piddocke 1965; Suttles 1968a). The type of shortages and fluctuations seen in the Calusa subsistence base are different from those characteristic of agricultural groups. They are inherent, repetitive, daily phenomena, where one village may be very successful in its local catch, not to mention the variations among the fishermen in the village, while another village may not be so lucky. Thus, this fluctuation can be evened out by daily or weekly reallocation of resources. This reallocation, of course, requires a system of redistribution with expectations of reciprocal exchanges. In many ways, the system would resemble the competitive feasting and "giveaways" among lineages of the potlatch system in the Northwest Pacific Coast (Piddocke 1965; Suttles 1968a). The overall surpluses, however, would not always be great, and so lavish feastings and giveaways would not be usual. Instead, a series of redistributions involving lesser lineage heads within the same village or between chiefs of different villages would be expected. This was the usual form of potlatch on the Northwest Pacific Coast and the type which Piddocke (1965) believes to be aboriginal.

The Calusa population was much larger that the Northwest Coast examples and resided in sedentary, permanent villages occupied yearround, which would have necessitated a larger number of redistributive transactions, because of the greater potential each day for local resource shortages. The need for reallocation would have stimulated the maintenance of large, nucleated villages, as long-term storage of fish resources does not appear to have been a totally effective solution to resource fluctuations. Because the fish resources are spread out throughout the year, even to include their periods of spawning and mass aggregation, the unusually high peaks in fish availability that are seen in the Northwest Coast are not present in southwest Florida. Thus, it is not possible to store fish for any length of time because it is not possible to accumulate the mass quantities to permit it. While undoubtedly some fish were dried and possibly some were smoked, these preservation methods, rather than solving all of the subsistence shortages, which occurred continuously, were probably used as a means of evening out short-term fluctuations in the resource base. Storage did not completely alleviate resource shortages in the Northwest Coast either. Although storage of some fish resources did occur, it did not function to alleviate long-term resource shortages. Such techniques would also not alleviate the need for redistribution of fish on a continuous, daily basis.

A continuous, daily reallocation of fish production has strong feedback effects for the development and reinforcement of a centralized polity and probably was the crucial factor in the Calusa adaptation. The reallocation on a day-to-day basis would act as part of the cultural means to deal with environmental perturbations which are strongly correlated with chiefdom-level society (Peebles and Kus 1977). Although the environmental perturbations were both pervasive and varied in the Calusa adaptation, productivity for the entire region was high enough that perturbations could be resolved through a properly planned and coordinated system of resource reallocation. Also reinforcing this reallocation system were the needs for arbitration of possible disputes over the use of corporate fishing territory and for implementation of the fishing technology for maximum production. These managerial components of inshore fishing are processual requirements for maintaining an adequate subsistence base for populations utilizing the resources. They even seem to operate in very low levels of population size and density. As mentioned earlier, the Kaiadilt aborigines of Bentinck Island, Australia, have "big men" presiding over clanlike kin groups. It seems that fixed, coastal inshore resources required organized management for successful implementation and that this management function emerges at population size and density levels below those normally requiring or correlated with such leadership positions. Thus, the threshold, as R. N. Adams (1978) terms it, to hereditary leadership can potentially occur at lower levels than for other types of adaptations because chiefs have an important and continuous role in maintaining the successful exploitation of the fixed resources they control and in making up the spatial deficiencies in production on a daily basis. The continuous need will clearly favor a permanence of the leadership role, and hence hereditary leadership can arise.

Prestige and status result from the power generated by the large sums of energy which are moved through the system, as R. N. Adams would predict (1975, 1981). But the amount of energy moved is much greater than in most other comparably sized adaptations because the number of transactions involving energy, especially on a daily basis, is greater than that in similar-sized agricultural adaptations. It is for this reason that leadership is precocious, as in the Kaiadilt adaptation cited above.

The Role of Demographic Processes in Chiefdom Development

It was mentioned earlier that population size and density are positively correlated with sociopolitical complexity; however, it is microdemographic processes which are important in the sociopolitical evolution of ranked societies, particularly the form found on the southwest Florida coast. The important processual shift in the demographic characteristics of human groups is the change in fertility and the resulting rapid growth potential. In a pioneering, open environment, like the one characterized by southwest Florida, this shift is especially important, both from a sociopolitical and demographic perspective. Although a case has been made for the relative homogeneity of the productivity of the two highly productive regions on the southwestern Florida coast, there obviously are differential zones of productivity within the area, although they are difficult to measure as they relate to human utilization. The measuring becomes somewhat easier to do from an archaeological perspective, since sites should initially be located in the most favorable environments, if one follows an adaptive model.

Because more productive areas can support larger populations, a demographic imbalance will occur. This imbalance will continuously be fueled by the high fertility rate resulting from sedentary settlement if fertility dampening does not take place. It may even be the case that fertility dampening through abortion or other population control may not drastically slow the growth potential, as is the case with the Y̨anomamö (Chagnon 1972; Neel and Weiss 1975), who practice both abortion and infanticide, but whose population is still growing.

More important, kin units which have greater net growth will control and move more energy, will have greater population numbers than other groups, and thus will be politically more important. The potential for this imbalance is inherent in the high-fertility schedules of sedentary groups, and they can be intercommunity or intracommunity in scope. As a result those kin groups which can capture more energy can realize the potential of high natural fertility—that is, they can provide the necessary subsistence for feeding large numbers of children and thus relax fertility dampening and population controls through subsistence surplus with adequate nutrition. Leadership is required in order to produce and capture effectively the energy necessary to maintain these larger demographic units. The result of such leadership, then, would be a kin group or unit whose average family size is greater than those who do not or cannot realize the full potential of their fertility. Thus, a positive feedback loop is initiated in groups which can do so. Once the initial move occurs, it fuels the managerial necessity to capture as much energy as feasible to continue sustained adequate nutrition for the demographic units. This behavior is adaptive, because the members derived from such fertility become part of the corporate unit, with potential for capturing more energy and resources; the resultant differential size of this corporate unit would mean increased status because more energy flows through this corporate system. As a result, there is more for a leader to convert into status or prestige. It should be noted that in such a scenario the energy is captured and generated solely by the specific kin group. This is a characteristic of the "big-man" type of society (Oliver 1955; Sahlins 1963). As long as access to all resources is equal, prestige, power, and status are simply functions of capturing more energy and converting it into status by expanding resource procurement. Thus, numerous, competing, corporate groups emerge, each with potential for expansion. As a result, population growth—that is, the production of more potential individuals to capture more energy—is accentuated, because more energy means more status, particularly if status is achieved, and such status is therefore accessible to a large number of individuals.

During this initial pioneering phase of growth, I suggest, population pressure is minimally expressed, and growth seems to be tolerated or even encouraged for social and political reasons. The resultant large population also means larger military components and increased resource capture to be converted into prestige by local leaders.

Once the pioneering phase is over, however, the situation changes. Now there is no unlimited population expansion and fissioning, because the environment is filled. It is circumscribed and what was beneficial, or at least benign, growth now becomes population pressure, which requires different decisions and strategies to resolve the problems of dwindling per-capita resources and increased competition for them. Those corporate groups which were originally located in the zones of highest resources, or which controlled the best fishing grounds, would have a distinct advantage in production, demography, and power over those in and controlling less favorable resource zones. Because of the restricted ability to intensify or augment per-capita resource procurement by expanding group production when the environment is filled and circumscribed, local corporate groups have a strong need to ensure their own permanent control over these resources. This situation facilitates and actually encourages the development of hereditary chiefs. Also, the initial groups which develop in this area should have greater military advantage because of their larger size. This advantage would be favorable for extracting surpluses, if any exist, through usurpation of other local groups.

While it seems clear that the pressures of circumscription and dwindling per-capita resources would tend to favor warfare, it is doubtful that war occurred in *endemic* proportions at the local intra-Calusa level, because cooperation is absolutely essential for implementation of the complex fishing technology and can be easily and seriously disrupted by punitive raiding at the intrasocietal level. The loss or destruction of fishing gear, such as nets or weirs, would represent a tremendous loss of resources, and the time and energy required to replace the equipment would mean a similar loss in potential fish production, a serious consequence to say the least. Undoubtedly, intrasocietal tensions would be high, but the potential for continuous, aggressive military action among local groups or villages would be minimal. The leadership function of a paramount chief would be to maintain intervillage alliances and resolve disputes.

There is a clear advantage to maintaining peaceful alliances among local corporate groups or villages, in spite of the apparent attractiveness of taking over, through military conquest, another village's productive zones. Also, if these resources were corporately owned, as is hypothesized to be the case, corporate members would be dispersed throughout the large, nucleated settlements of the Calusa society, due to exogamy rules, and so these individuals would be denied their share in the production of the usurped zone. This exogamy provides an additional stimulus for the reallocation of the fishing resources. Probably for these reasons intersocietal warfare was more prevalent than intrasocietal warfare. Interestingly, the early Spanish documents report only the intersocietal warfare, most notably that between the Calusa and the Tocobaga (Solís de Merás 1964).

Social Organization

The specific nature of the corporate units found in southwest Florida is not mentioned in the Spanish documents, other than what appears to be a patrilineal-descent system of chiefs (Goggin and Sturtevant 1964). Sahlins (1958) has demonstrated that two forms of descent systems are typical of chiefdoms in the Pacific: the unilineal descent-line system and the ramified system. Both the ramage-type corporate group and the unilineal descent group could have occurred in southwest Florida. Which type did occur seems to have depended on two conditions; the differential quality of resource zones in the area and the length of time the chiefdom was established. I hypothesize that the unilineal corporate descent group, rather than the ramage, existed during the Calusa adaptation and that probably the ramage system operated in the expansion period from 500 B.C. to A.D. 800. The rationale behind this interpretation is as follows.

In a ramage system, as fission of descent groups occurs, the leader of the newly formed group is ranked below the original leader of the original descent group, but the new leader and descent group maintain active affiliation with the parent group. As more groups splinter off, more hierarchical ranking of the offshoots occurs. Thus, the rank of the splintered lineages are measured as the distance from the original parent descent group.

In the unilineal descent group, however, when splintering occurs, the ties which link two groups soon dissolve (Sahlins 1958:201–202). Sahlins (1958) went on to suggest that the ramified system would develop in areas where there are a variety of scattered resource zones differentially exploited by families, or small groups of families, or where a single, patrilocal extended family could not efficiently exploit the entire range of resource items available in the area.

The unilineal descent corporate group would occur in areas where single family units could cope with the entire range of subsistence requirements. Sahlins further notes that as a result of these conditions, ramified systems should correlate with a scattered hamlet settlement pattern, while unilineal descent groups would be associated with settlement patterns characterized by nucleated villages (Sahlins 1958:202).

In the case of the evolution of the Calusa adaptation, following the analysis of Sahlins (1958), the earlier period, 500 B.C. to A.D. 800, is hypothesized as being characterized by much village fissioning into new territory. As fissioning occurs, however, the new corporate units formed may be too small either to implement the technology or to meet all of the required subsistence or resource needs.

Therefore, it would be advantageous to maintain kin ties with the parent corporate unit. Also, it may be a requirement of the splinter group to provide resources in excess of its own needs to the parent group, perhaps as surplus for conversion into prestige and power by leaders of the original corporate group. This would favor the integration of the splinter group into the political network of the parent community. The ramage system provides this mechanism.

The environment is basically redundant, however, and villages are nucleated. Therefore, by A.D. 800, when the area was filled in demographically and was environmentally circumscribed, this ramage-type system would no longer have been advantageous, particularly since lineage members would probably be well represented in most of the villages scattered throughout the regions. This circumscription is seen in Polynesia as well, where the unilineal descent group is more common on smaller islands, which are obviously more circumscribed than larger ones. Thus, kinship ties can be effectively maintained and can serve to link the villages together. Such links are particularly important, since under the proposed model the corporate lineages would hold claim to the various inshore fishing grounds scattered throughout the area. Therefore, kin members can access their share of the resources and, through exogamy, those of their affines. This mechanism would serve to reallocate fish resources.

Thus, as Sahlins would predict, corporate unilineal descent systems should be anticipated. The notions of relatedness to distant lineages, once that expansive growth has occurred, are probably lost, and a unilineal corporate descent group, rather than a ramage, is hypothesized as a more reasonable system after A.D. 800. This is not to suggest that all corporate lineages had the same degree of status or power. Clearly they did not. The apparently long and stable demographic history of the area after A.D. 800, the highly circumscribed nature of the area, and the large, nucleated villages characteristic of the settlement, however, make it difficult to envision ramages lasting for any length of time, particularly once the fissioning process terminated or slowed down as pioneering areas were filled in.

The Role of Warfare in the Chiefdom

Warfare also has an important role in the origin and maintenance of the Calusa political system. Warfare is endemic in the Calusa adaptation, just as it is in other parts of the southeastern United States (Larson 1972), and results, for the same reasons as Larson describes, in limited, highly circumscribed, fixed resource areas. Here, of course, such resource areas are fishing grounds and perhaps raw materials for the production of fishing gear; in the Southeast proper, they are agricultural lands. From a processual perspective, the two types of areas are identical. Because of the environmental circumscription of the high resource zones, they are subject to competition. This is clearly revealed in the Spanish documents. Carlos himself formed a marriage alliance with the governor of Florida, Pedro Menéndez, in the hope of obtaining his military alliance against the Tocobaga to the north (Solís de Merás 1964). It is also known that the Tocobaga kept Calusa hostages as well. It appears that the paramountcies, one centered near Tampa Bay and the other on the southwest coast, were competing for control over the entire coastal zone. While the distances between these two areas might seem quite great for such warfare, canoe transportation lessened it.

The reasons for intergroup warfare are several. One is to increase subsistence procurement, through punitive raiding for extractive tribute, and another is to maintain and defend sociopolitical boundaries. Still another reason is as a response to the high fertility rate and population growth which exist in the area, a situation ever pushing the resource potential of the environment. Thus, warfare, as a response to dwindling resources, acts to control or check population growth by maintaining boundaries or expanding resource zones (see Divale and Harris 1976). It should also be remembered that it is difficult to intensify the subsistence system without depleting the standing stock. Thus, warfare should be chronic by A.D. 700 to 800, when fissioning could no longer be easily accomplished without encroaching on other villages territories.

It is assumed that intra-Calusa village feuding did not take place for very long, or that it was quickly mitigated by political reorganization under strong paramountcies. Although the paramountcy was centered at Calos for five generations, it was possibly located elsewhere at one time and shifted with the vagaries of political situations. It is known that Carlos had trouble with some of his lesser village chiefs and executed four of them and displayed their heads at a public ceremony (Fontaneda 1944). So it seems, at least during the protohistoric period, that warfare was primarily interregional in scale, and this was probably also the case in the period before the region filled in demographically.

Interregional Trade and Exchange

Recently, considerable importance has been placed on the role of trade in the evolution of complex sociopolitical organizations (see Sabloff and Lamsberg-Karlovsky 1975). I do not believe that exchange was important in the evolution of the Calusa chiefdom, although it probably was important in the maintenance and, perhaps, the establishment of alliances and political ties among existing chiefdoms. This sort of exchange, however, undoubtedly involves sociotechnic and ideotechnic materials which have prestige value, and in fact such classes of materials are mentioned by Fontaneda (1944).

Trade of an exclusively economic nature would not have been very well developed among the Calusa and other south Florida groups for the simple reason that interior groups had few subsistence or technological items to trade. The resources available in both areas are redundant, the only exceptions being roots, which are found in the interior, and shells and shark teeth, which are coastal items.

It is known archaeologically that shark teeth and shells were traded into the interior, since these items are found there (Willey 1949a; W. H. Sears 1974). Roots would be a favorable exchange medium because of an energetic advantage in their trophic position over fish; these resources are mentioned in Fontaneda as having been part of the tribute paid to Carlos. It is probable, however, that the coastal items in the interior came from the east coast, not the southwest coast, a situation which is consistent with the political affiliations of some of the Lake Mayaimi groups.

Roots would not be important in the exchange to the southwest coast simply because of the demographic inequality of the interior and the coastal zone. Fontaneda is quite specific about the size of the communities and the number of them on Lake Okeechobee. The 25 villages of about 40 inhabitants give a total of 1,000 individuals. Adding 500 more for an equal number of places with smaller populations results in a population of 1,500, compared with 10,000 individuals on the coast. The interior groups probably could not produce or gather enough roots to make it a viable exchange item for coastal groups, particularly when only a limited number of coastal items were required. Thus, there would be little incentive to produce a surplus for coastal regions, and, more important, this surplus would have minimal caloric advantage for the interior groups. It should be remembered that protein is not limiting in the Lake Okeechobee region, where there is ample aquatic protein resources, including fish, frogs, and turtles, not to mention terrestrial fauna such as deer. Still, while this produce may not be advantageous for trade or exchange, it might be important as an exploitive-extractive tax by coastal groups. Because the Calusa had a large demographic base, at least eight times that found in the interior, political usurpation through military conquest was easy. Such usurpation, documented in Fontaneda's (1944) memoir, could result in a situation where interior groups would be forced to produce or to collect roots well in excess of their own needs to avoid punitive raids by numerically superior military groups from the coast. Therefore, threat of military coercion would be one means of obtaining excess roots from the interior. The incentive for production would be great, because military parties could raid villages which did not meet production quotas. The threat of military coercion would also foster political alliances and bolster the political power of the controlling coastal paramountcy. The demographic imbalance would result in a valuable adaptive advantage to military intensification, and I argue that this is one of the key reasons for the military profile found in the Calusa adaptation.

Another possible model for the role of interregional trade is that the production of surplus economic goods, be they subsistence, technological, or sociotechnic in nature, may be stimulated by chiefs of local groups or corporate kin groups in the interior. Production would be initiated by the interior chiefs in exchange for status or prestige items from the coastal zone. Such an exchange would benefit both interior local chiefs and coastal chiefs, since interior local chiefs could convert locally generated surpluses into power and prestige by obtaining foreign prestige items, while the coastal chiefs or paramount chief could use the surplus from the interior groups for low-energy-cost prestige items, which would be converted locally in his own group or village through redistribution into power and prestige. The situation would be a viable and beneficial means for obtaining power by both chiefs, particularly those on the coast. It would also provide an additional means of obtaining food resources for evening out short-term food shortages in the demographically more critically balanced coastal zone.

The model presented above is hinted at in the Spanish documents, where references to status items, such as seals and dried whale meat, are mentioned as being traded to interior groups (Fontaneda 1944; Larson 1980).

By processually reinterpreting the various sociopolitical and economic characteristics of the Late Prehistoric adaptation, it seems that there is little functional difference between this adaptation and other more typical Mississippian adaptations. The same factors and variables correlated with their development also occurred in the Calusa example; only the specifics—that is, fixed fishing grounds instead of agricultural fields—are different. Therefore, the Calusa are not as unusual or different as they might initially appear.

10

Summary and Conclusions

I have tried to show how environmental characteristics tended to shape the type of adaptation that emerged in southwest Florida and how the adequate implementation and maintenance of the adaptation required a series of behavioral responses of a sociopolitical nature. I have attempted to demonstrate the roles of various cultural and biological processes in this adaptation and to show how they favor and provide positive feedbacks for certain sociocultural practices.

I have also tried to show how these sociopolitical features should logically be generated by this system of adaptation and, more important, how this system of adaptation evolved the way it did. I have presented a diachronic model whose aim is to account for the particular timing of the characteristic features of the evolution of this adaptation. As a result, I believe it is safe to claim that this is an evolutionary, rather than a functional or culture-historical study.

The fact that the particular adaptation in question relies on nonagricultural resources is not important. The important point is that tropical coastal resources of the type characterized here are extremely productive, not only from the perspective of net primary productivity, but also as such productivity relates to energy available to humans, even from the higher trophic positions. I have also resolved the apparent paradox of why, if these environments are so productive, we find so few examples of this adaptation in other areas of the world. Clearly, it is not because of the scarcity of this type of resource area.

The answer lies in the fact that tropical coastal estuaries usually are located adjacent to highly productive agricultural land and so the utilization of coastal resources is integrated into agricultural subsistence patterns. Tropical estuaries contain high-quality food resources which are nutritionally complete. In fact, they have protein-to-calorie ratios much higher than are required by humans. The tropical latitude terrestrial zone is characterized by high primary productivity and hence extensive areas of favorable floral production, that is, agriculture. But plant resources are nutritionally deficient in protein, and so the production and potential intensification is limited by the availability of protein. Tropical coastal zones, however, produce copious amounts of protein, easily captured when compared with terrestrial protein because of the limited and fixed location of these resources. Therefore, wherever coastal regions with agricultural potential juxtapose the estuarine zones, an adaptive system will incorporate both components, either through trade or expansion. This situation is usually the case and is seen in Malaysia (Firth 1966), Sri Lanka (P. Alexander 1977), Polynesia (Sahlins 1958; Firth 1965; Goldman 1970) and possibly Mesoamerica (Bronson 1966; Lange 1971). Favorable exchange rates can be obtained between fish and plant produce, since many tropical, low-nutritive but high-energy crops, such as taro, sweet potatoes, and manioc, can be grown as long as adequate protein supplementation is available. Tropical estuaries of the high-energy type can meet these protein needs and those of intensive wet rice agriculturalists, as is seen in Malaysia.

Therefore, if calories are not limiting, we should expect population sizes at least 10 times and probably 100 times those found in tropical coastal adaptations, simply because of the trophic position of the resources involved. This is indeed the case, as can be seen in Polynesia, where population density ranges from 490 to 838 persons/km^2 on the smaller islands (Sahlins 1958:235, n. 49). This is at least 50 times, and in many cases more than 100 times, that calculated for the densest region of occupation in the southwest Florida coast. This is as it should be, based on the differences in the trophic position of the resources utilized.

South Florida is one of the rare tropical environmental regions where agriculture is not feasible in the adjoining interior. The Manus' ethnographic situation is another such example. The highly productive coastal zone is therefore very circumscribed, with an almost eight-to-one demographic edge on the interior population. Interestingly, it seems that maize agriculture was practiced for a while in the Lake Okeechobee area (W. H. Sears 1971, 1974; E. O. Sears and W. H. Sears 1976), possibly to take advantage of this trade potential, although more than likely the context was ritual. It seems to have been abandoned after A.D. 1000, most probably owing to the continuing rise of the water table, which compounded the difficulties—that is, drained areas followed by ridge-field development—encountered in growing the crop in the first place. For these reasons, few tropical coastal adaptations which rely primarily on fish are found.

The complementing of coastal fishing with agriculture may also be the reason why such exclusive coastal adaptations are common in the Formative period, such as Monagrillo, Barlavento (Willey 1972), and Chantuto (Voorhies 1976), but then seem to "disappear" with the advent of agriculture. It may simply be the case that as agriculture becomes more efficient, Late Formative adaptations incorporate their coastal components in such ways that they become specialized, dependent, subsistence strategies of larger systems. This is probably the situation occurring in Veracruz during the Classic and Post-Classic periods (Stark 1976) and at Pajón (Paillés 1976). This situation has been developed into a number of similar models for Mesoamerica (see Freidel 1976; Stark 1976; Zeitlin 1976).

Tropical coastal adaptations that do not have an agricultural component are vulnerable to the risks of their environment and do not have the moderating reserves of agriculture. As a result, the managerial controls must be intense and continuous to ensure an adequate operation of the economic system. This situation is conducive to the inherent leadership potential of humans and readily facilitates the emergence of formalized leadership. Initially, such leadership was probably temporary and nontransferable in nature, characteristic of the "big-man" type. In southwest Florida, formal leadership probably began to emerge by 5000 B.P. or so, as groups readjusted their emphasis to the increased productivity of coastal resources.

At 2500 B.P., the coastal adaptation was initiated, and by A.D. 280, this form of organization was transformed into a chiefdom type of inheritable leadership, possibly of the ramage type. This transformation would be facilitated by the need for continuity in the maintenance and regulation of efficient coastal resource exploitation. Paramountcies were not yet established, because this was a period of pioneering settlement, and as a result, circumscription, other than that at the local level, was not yet a serious problem.

By A.D. 700 to 800, however, critical carrying capacity of the coastal zone appears to have been reached. Chiefdoms were highly developed, as was warfare, and paramountcies had probably emerged. The corporate group had shifted to a unilineal descent type. Since village and lineage fissioning were no longer possible, there was no need to maintain ramage type links, particularly over the long 700-year history of the Calusa adaptation. Population pressure, once critical carrying capacity was reached, could not be relieved through subsistence intensification. As a result, political hegemony and annexation of interior groups became a viable strategy, facilitated by ready access to interior regions through canoe travel and the demographic edge of the coastal groups. Such hegemony favored and required a strong, stable political hierarchy, clearly seen in the paramountcy which existed during the contact period and possibly also seen archaeologically to some extent in the distribution of Safety Harbor ceramics throughout south Florida.

The timing of the evolution of this chieftaincy can be linked directly to the particular geological process responsible for the formation of the environment—the rising of the sea level. It is not adequate simply to state that sea-level rise has affected the characteristics of the coastal zone. It is absolutely essential to document the history of the effect of sea-level rise on environmental history, because human adaptations to the now-drowned coastal zones, since they are not visible, must be modeled. Without the detailed history of sea-level rise, of its effect on the type of coastal environments present, and of the spatial occurrence of the various environmental zones, it is impossible to reconstruct or model accurately, or even reasonably, the various types of adaptation through time.

I have argued in this study that the Calusa adaptation did not evolve until 2700 B.P., and that its emergence is directly linked to the slowing of the sea-level rise and the formation of the contemporary coastal environment as we see it today. Furthermore, I suggest that no complex form of sociopolitical adaptation developed independently of interior terrestrial resources *prior* to 5000 B.P. because of the unusually rapid rise in sea level, which would have drastically and dramatically affected potential adaptations in the coastal zone. The sea-level and coastline histories subsequent to 5000 B.P. may vary considerably from area to area, and no specific *general* statement can be accurately made regarding them irrespective of the existence of a eustatic sea-level curve because eustatic sea level varies with readjustment of the earth's volume from region to region. Therefore, specific regional case studies must be undertaken, as I have attempted to do here, to evaluate the relationship of sea level to coastline and its effect on the type of environment and the history of environments available for human utilization.

It is *not* valid to compare the particular different trajectories which occurred in different areas and suggest that they represent *general* processes. They do not. The particular, differing environmental histories must be factored out. The histories of adaptations will vary as the coastline ecologies vary, and the timing of developments of adaptations will vary just as the timing of the emergence of village life varies between the Near East and the New World (Flannery 1972a).

Thus, the development of an accurate, reasonable model of coastal change, both in area and in ecological characteristics, is necessary *before* an understanding is possible of how cultures have adapted to these changes. Therefore, the emergence of the Calusa adaptation only at 2700 B.P. is argued on theoretical grounds, not simply from the face value of the archaeological material. This system could not have evolved before this time, because the environmental conditions which would allow such development were not established.

The coastal adaptation as seen in southwest Florida is neither unique nor unusual, and in fact, corresponds precisely to sociopolitical expectations derived from studies of cultures utilizing other subsistence forms. Once the "unusual" features of a particular "atypical" adaptation, such as the present one, are put into the same perspective as others—that is, net production, energy flow, demography, risk, competition, and so on—it is easy to see how such adaptations operate. One can also see the similarities between diverse types of subsistence systems. It is the *processual* characteristics of such adaptations which are important, not the *typological*.

Clearly, tropical, inshore fishing adaptations are much closer to agricultural systems in terms of operation, management, and tenure than they are to hunter-gatherer adaptations, despite other differences. These similarities are what are adaptively important, not the type of resource itself. Such adaptations are seen to be not so strange or unusual if they are viewed in comparable conceptual terms to processually similar subsistence systems, that is, permanent field agriculture. Thus, the lumping of all "coastal resources" or "marine resources" into a common typological unit is dangerous, not only because it is inaccurate but, more important, because it masks the important processual characteristics which operate in different coastal-marine systems.

The particular conclusions which I have drawn for south Florida, and the diachronic model I have constructed, apply specifically to the south Florida situation, although many aspects of this evolution may apply to other coastal evolutionary sequences. One must consider these aspects in a processual manner, taking into consideration not only the sociocultural features at a given point in time but the conditions, including geological, ecological, and cultural, which existed throughout the trajectory of the evolutionary sequence in general. By doing so, one can expand the range of understanding of how groups adapt to particular environments successfully through time; thus one can make more powerful generalizations concerning sociopolitical evolution. I have in this study presented a model demonstrating how one adaptation coped with a series of different cultural and environmental situations through time. Archaeology uniquely allows for a real and powerful construction of models of sociocultural evolution which are adaptive solutions to environmental constraints, rather than merely culture-historical reconstructions.

It is hoped that similar studies will be inaugurated in other coastal regions, be they tropical, temperate, or arctic. G. Clark (1985) has made a study of the latter region, and an important understanding of settlement systems emerges from it. A similar study has been done for the upper Texas coast (Aten 1983, 1984). It is unfortunate that such studies are limited by a lack of necessary sea-level and paleoenvironmental history. The rewards of such interdisciplinary approaches should stimulate fertile cooperation on such problems.

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Appendix
Radiocarbon Determinations for the Middle and Late Holocene Sea-Level Position

Radiocarbon Date	Sediment or Peat Type	Location	Depth Below Mean Sea Level	Reference
8010 ± 195	Mangrove	Alligator Reef	7.2 m	Robbin 1984
7595 ± 85	Mangrove	Alligator Reef	7.2 m	Robbin 1984
7450 ± 165	Mangrove (marine)	Spy Key	0.76 m	Davies 1980
7400 ± 115	Organics	Man-of-War Key	3.45 m	Davies 1980
7280 ± 130	Mangrove	Alligator Reef	7.2 m	Robbin 1984
6850 ± 80	Basal freshwater	Shell Key Florida Bay	4.9 m	Robbin 1984
6060 ± 60	Mangrove	West of Marquesas	6.7 m	Robbin 1984
5500	Mangrove	Rodriguez Bank	4.3 m	Turmel and Swanson 1976
5370 ± 80	Basal freshwater	Harney River	2.7 m	Kuehn 1980
5190 ± 100	Basal freshwater	Nine-Mile Bank	3.93 m	Davies 1980
4950 ± 120	*Rhizophora*	Cape Sable	3.15 m	Smith 1968
4800 ± 100	Mangrove	Broad Creek	2.0 m	Robbin 1984
4770 ± 100	Basal freshwater	Man-of-War Key	3.4 m	Davies 1980
4695 ± 105	Basal freshwater	Russell Key II	3.25 m	Davies 1980
4420 ± 200	Basal untyped	Harney River	3.85 m	Kuehn 1980
4310 ± 100	Basal freshwater	Spy Key II	2.67 m	Davies 1980
4220 ± 80	Mangrove	Broad Creek	2.0 m	Robbin 1984
4210 ± 80	Freshwater	B54-65	2.36 m	Scholl and Stuiver 1967
4160 ± 140	Mangrove	Sands Cut	2.9 m	Robbin 1984
4150 ± 150	Mangrove	Broad Creek	2.0 m	Robbin 1984
4095 ± 75	*Rhizophora*	Harney River	2.7 m	Kuehn 1980
4080 ± 180	Basal freshwater	Harney River	4.0 m	Spackman et al. 1966
4080 ± 90	Mangrove	Sands Cut	2.5 m	Robbin 1984
4050 ± 90	Mangrove	Broad Creek	2.0 m	Robbin 1984
4015 ± 100	Freshwater	Crane Key II	2.74 m	Davies 1980
4015 ± 80	Basal freshwater	Harney River	2.8 m	Kuehn 1980
4000 ± 125	Freshwater	J3	1.86 m	Scholl and Stuiver 1967
3980 ± 80	Mangrove	Sands Cut	2.0 m	Robbin 1984

Appendix, continued

Radiocarbon Date	Sediment or Peat Type	Location	Depth Below Mean Sea Level	Reference
3970 ± 100	Mangrove	Broad Creek	2.0 m	Robbin 1984
3965 ± 70	Transitional *Conocarpus*	Joe Kemp Key	2.9 m	Davies 1980
3930 ± 263	Freshwater	62-100d	1.92 m	Scholl and Stuiver 1967
3800	Mangrove	Core Site 17, Ten Thousand Islands	3.85 m	Shier 1969
3730 ± 60	Calcitic mud with marine shells	JR4-65	1.98 m	Scholl and Stuiver 1967
3710 ± 70	Mangrove	Broad Creek	2.0 m	Robbin 1984
3690 ± 346	Organic matter below mangrove-marl interface	L46	1.77 m	Robbin 1984
3660 ± 85	Brackish	Harney River	2.28 m	Kuehn 1980
3650 ± 125	Freshwater	Q26	1.70 m	Scholl and Stuiver 1967
3600 ± 60	Calcitic mud	64-9C	1.71 m	Scholl and Stuiver 1967
3590 ± 60	Organic matter	64-24D	1.54 m	Scholl and Stuiver 1967
3440 ± 60	Organic matter	64-9D	1.71 m	Scholl and Stuiver 1967
3410 ± 60	Calcitic mud	64-24C	1.54 m	Scholl and Stuiver 1967
3408 ± 270	Freshwater	62-50C	0.91 m	Scholl and Stuiver 1967
3399	Marine marl contact	Harney River T6	2.76 m	Kuehn 1980
3344 ± 245	Mangrove	62-260D	1.49 m	Kuehn 1980
3260 ± 65	*Rhizophora*	Harney River	2.05 m	Kuehn 1980
3170 ± 70	Mangrove	Broad Creek	2.0 m	Robbin 1984
3160 ± 80	Untyped	JR4-65	1.98 m	Scholl and Stuiver 1967
3155 ± 100	Basal freshwater	Pigeon Key II	3.63 m	Davies 1980
2985 ± 169	Mangrove	62-100C	1.46 m	Scholl and Stuiver 1967
2905 ± 275	Marine shells	62-280C	1.21 m	Scholl and Stuiver 1967
2894 ± 273	Mangrove and freshwater	62-116DC	1.19 m	Scholl and Stuiver 1967
2850 ± 60	Mangrove	Broad Creek	2.0 m	Robbin 1984
2830 ± 170	Mangrove	Harney River T3	1.67 m	Spackman et al. 1966
2775 ± 200	*Rhizophora*	Harney River	1.47 m	Kuehn 1980
2740 ± 50	Calcitic mud	64-1B	1.01 m	Scholl and Stuiver 1967
2724 ± 288	Calcitic mud	L4A	1.53 m	Scholl and Stuiver 1967
2650 ± 90	Mangrove	Broad Creek	1.5 m	Robbin 1984
2580 ± 70	Mangrove	Sands Cut	1.5 m	Robbin 1984
2575 ± 100	Basal freshwater	Eagle Key	2.33 m	Davies 1980
2565 ± 190	Marine shells	V4B	0.82 m	Scholl and Stuiver 1967
2530 ± 80	Mangrove	Sands Cut	1.0 m	Robbin 1984
2466 ± 168	Marine shells	62-280C	0.97 m	Robbin 1984
2460	Mangrove	Rodriguez Key	1.5 m	Turmel and Swanson 1976
2440 ± 50	Mangrove	64-9B	1.37 m	Turmel and Swanson 1976
2420 ± 80	Calcitic mud	64-7B	0.95 m	Turmel and Swanson 1976
2370 ± 60	Mangrove	64-96	1.32 m	Turmel and Swanson 1976
2285	Mangrove	Core Site 7, Ten Thousand Islands	1.35 m	Shier 1969
2180 ± 110	Marine and freshwater shells	64-24B	0.78 m	Scholl and Stuiver 1967
2090 ± 90	Mangrove	Broad Creek	1.0 m	Robbin 1984
1990 ± 60	Freshwater	64-7A	0.89 m	Robbin 1984
1980 ± 80	Calcitic mud	64-26	0.62 m	Robbin 1984
1740 ± 60	Mangrove	Sands Cut	0.5 m	Robbin 1984
1698 ± 220	Marine shell	64-280B	0.48 m	Robbin 1984
1620 ± 60	Mangrove	64-1A	0.97 m	Robbin 1984
1230 ± 80	*Avicennia*	Crane Key II	0.83 m	Davies 1980
1065 ± 160	*Rhizophora*	Russell Key II	0.81 m	Davies 1980
1020 ± 60	Calcitic mud	64-19	0.25 m	Scholl and Stuiver 1967
1015 ± 85	*Rhizophora* and *Avicennia*	Jim Foot Key	0.71 m	Davies 1980
390 ± 190	$CaCO_3$ crust	Elliott Key	0.0 m	Robbin 1984
380	Mangrove	Core Site 8, Ten Thousand Islands	0.07 m	Shier 1969
360 ± 60	Mangrove	Sands Cut	0.0 m	Robbin 1984
285 ± 100	*Avicennia*	Crane Key	0.48 m	Davies 1980

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