SEAGRANT special report no.17
MAY, 1979

MARINE SCIENCE TEACHERS RESEARCH EXPERIENCE

two reports

BY: Cheryl Cook
Joseph T. Green

University of Miami Sea Grant

EDITED BY:
Barbara Burke
Mr. Al Volker

FOREWORD

University of Miami Sea Grant sponsored two highly successful three-day workshops for Dade and Monroe County high school marine science teachers at the University's Environmental Field Station on Pigeon Key in March 1977 and May 1978.

During these workshops, several teachers mentioned they had never had the experience and undergone the disclipine of carrying out a formal research project under professional supervision. Out of these discussions came the Marine Science Teachers Research Experience.

High school teachers who had attended previous workshops were invited to meet with Dr. Barbara Burkett, professor of invertebrate biology, and Mr. Al Volker, whose Public Education and Information Services project was separately funded by the Office of Sea Grant (NOAA). The teachers were allowed to volunteer research subjects or allowed to pick from a list prepared by Dr. Burkett. The teachers were told they could, if they wished, serve as Principal Investigators and enlist their students as lab assistants, Dr. Burkett listed a number of conference dates when she would be available for advice and counsel. The teachers were also told a final written report would be expected from them.

Two teachers of the original six, Cheryl Cook and Joseph T. Green, pressed their projects through to completion and their final reports are published herein. A third teacher, Mabel Fentress Miller, conducted a cooperative investigation with Dr. Don Moore, of the Rosenstiel School of Marine and Atmospheric Science . Awaiting confirmation of identification, and journal publication, her work could result in extension of range of a bivalve gastropod found by Miller for the first time in the Florida Keys.

It is believed that this research experience, designed to upgrade the quality of marine sciences instruction in South Florida, is unique in Sea Grant and might well be carried forward by ongoing college and institutional programs.

Al Volker
Sea Grant Public Education
and Information Services
University of Miami

A SURVEY OF HABITAT OF CROCODYLUS ACUTUS IN SOUTH FLORIDA

JOSEPH T. GREEN

MARINE BIOLOGY TEACHER

MIAMI CENTRAL HIGH SCHOOL

MIAMI, FLORIDA

ABSTRACT

There is more potentially suitable habitat for *Crocodylus acutus* in South Florida than the limited number of individuals comprising the total population now occupies. This conclusion was determined by a six month survey that involved more than 600 field hours and included the area from Cape Sable on the west to Key Largo to the Interama tract on the north. The areas believed to be the population center were surveyed several times.

The survey evaluated the suitability of habitat based on the following criteria:

1) Sufficient protection of shoreline to provide calm water.

2) Shoreline with adjacent water to a minimum of one meter.

3) Shore elevation sufficient to provide drainage for nests.

4) Degree of obvious human interference.

5) Generally healthy biotic community.

6) Physical properties including salinity, temperature, dissolved oxygen, turbidity, and water depth.

The data generated was compared to the known and suspected populations and to the data reported in the literature.

INTRODUCTION

This survey was intended to determine the present status of crocodile habitat in Florida. Habitat suitability is an issue because a great part of the historical range of *C. acutus* in Florida has been altered by urban development. It was necessary to examine the habitat requirements of American crocodiles contained in literature. Much of the information describing the habitat requirements in this report is in the supplement which is the result of the literature search. The supplement also includes a set of proposals for preserving the crocodile in Florida, most of which are not original. Reiteration of these sound proposals is appropriate because the recovery of the American crocodile is marginal in a time when other organisms are responding favorably to preservation programs. By design, this survey report is not intended to report all the relevant data describing American crocodiles. The information about the specifics of nesting, behavior, predation, etc., is the concern of other researchers. The value of this survey is the determination that sufficient suitable habitat exists in and outside of Everglades National Park; therefore, it is necessary to examine other limiting factors to determine the cause of *Crocodylus acutus'* failure to respond to preservation programs.

METHODS

A literature search preceeded the field studies. This search was intended to develop criteria significant to *C. acutus* habitat requirements and define more precisely the extent of the range of *C. acutus* in South Florida. This search was extensive; including the libraries of University of Miami, F.I.U., Library of Congress, National Geographic Society, numerous personal collections and United States Weather Bureau records.

An initial field survey of known habitat in northeastern Florida Bay was made to generate input for comparison and contrast with the results of the literature search. The following observations were completed in the field during the initial survey:

A. Zonation on North Nest Key
B. Plankton sampling at:
   1. Taylor River (mouth and interior ponds)
   2. Mud Creek (mouth)
   3. Trout Creek
   4. Trout Cove
   5. Davis Cove
   6. Alligator Bay
   7. Madeira Bay
   8. Long Sound
C. Temperatures were recorded at each plankton sampling site.
D. Quadrat study, North Nest Key.
E. Wildlife listing
F. Physical observation of:
   1. Water depth and adjacent shore elevation
   2. Turbidity
   3. Salinity (at plankton sampling sites)
G. Interviews of all persons in this study area

The entire coastal area of South Florida from Interama to Key Largo to Cape Sable was observed for physical suitability. This area was surveyed at least one time from surface transport and once by twin engine, fixed wing air craft. The southern most keys, emphasizing Big Pine Key, were surveyed from a 4 wheel drive truck.

The aerial survey included five observers and the pilot.

The first pass of two for each section was at an altitute of 1000 feet and the second pass was at 4000 feet. Photographic and written data was recorded for later evaluation.

Surface surveys were conducted primarily from canoes. Approximately 75% of the coastal area was surveyed exclusively by canoe; the remaining 25% was from a combination of powerboat and canoe. The canoe is a superior tool except when time and distance make power expedient.

Several areas were surveyed from the surface more than one time. These are:

1. Interama (3)
2. Black Point (2)
3. Turkey Point (3)
4. Northern Key Largo (interior) (5)
5. Card Sound Bridge and Steamboat Creek (7)
6. Manatee Bay (3)
7. Long Sound (5)
8. Coot Bay (2)
9. Madeira Bay and Little Madeira Bay (3)

(*) Indicates number of times

Zonation and quadrat observations for diversity and density were conducted at Black Point, Key Biscayne, Big Pine Key and east cape of Cape Sable in addition to the initial survey.

Persons encountered in the field were interviewed whenever possible.

Because many of the limiting factors for the population of *C. acutus* are incompletely understood, the evaluation of suitability was determined by the following physical factors:

1. Shore elevation adjacent to protected waters
2. Water depth on approach
3. Degree of obvious human impact

RESULTS AND DISCUSSION

Crocodylus acutus has a narrow range of tolerance to limiting factors, especially during the reproductive cycle. Suitability of habitat must include an examination of the following limiting factors:

1. Food-predation
2. Temperature
3. Availability of nest sites
4. Population density
5. Enemies or predators
6. Salinity

Using these criteria, the following observations have been made.

There has been extensive habitat destruction in South Florida. Biscayne Bay, in particular, has been dramatically altered by dredge and fill operations in the twentieth century. The attendant disruption of the biotic community and the balances of salinity and water flow has impacted the population of American crocodiles in the area as might be expected. Other parts of the range in Florida also have been altered by the presence of humans and human development. Population studies in those areas do not indicate by any measurable change in population resulting from the alteration or mere presence of humans; however, it must be considered that human presence is a change in habitat which ultimately affects crocodile population.

A sizable number of potentially suitable nest sites can be identified throughout the entire part of the range in Florida. These unused sites have the necessary height above high tide, drainage, water depth on the approach and protection from rough water to make them seem to be suitable nest sites. Additionally, the potential sites are no more disturbed by human presence than the active site areas around the population epicenter. Nest site availability does not appear to be a limiting factor to the crocodile population.

Salinity changes in the survey areas have been observed by field studies. The changes generally show a trend toward more saline coastal water as opposed to the less saline coastal water of the recent historical past. The general trend is not a smooth change; but, it is a change involving periods when the coastal water actually becomes less saline at times. The trend in salinity is generally agreed to be resultant from diversion on the mainland by canals and dikes and by removal of water from the Biscayne Aquifer for urban use. The impact of increasing salinity on crocodiles is not totally clear. Laboratory research indicates that increasing salinity could be a limiting factor on population; but field observation does not support that conclusion. Finally, even if increasing salinity is not a limiting factor on crocodile population, it is a profound habitat change for other organisms which comprise the food webb and therefore must ultimately impact on the population of crocodiles.

There remains a considerable expanse of habitat which is at least marginally suitable for crocodiles if physical as opposed to biotic criteria are examined. A large part of Biscayne Bay is still physically suitable in that small creeks, ponds and inlets exist there. Northeastern Florida Bay is protected by Federal Regulation and Key Largo has areas like the Basin Hills tract where development has failed. The unused canals and spoil banks of the deserted development now support a small but apparently viable population of crocodiles. Availability of physically suitable habitat does not seem to be limiting crocodile population at this time.

An examination of the biotic criteria important to crocodile habitat is beyond the scope of this survey, but a generalization is relevant based on observation and research. The biotic community appears to be failing. Everglades Park Fishery statistics and interviews, which agree unanimously, indicate serious changes occurring in the middle 1970's. Since *Crocodylus acutus* is at the top of the food chain in this estuarine environment, changes will surely affect their population.

THE FLORIDA CROCODILE

Crocodiles occur in Florida from Naples on the west coast, south to Cape Sable, throughout Florida Bay and into the Keys, and north from Florida Bay to Pompano Beach. It is uncertain how many inhabit the area. Any statement about total population is a guess with a high error probability. The individuals inhabiting South Florida are more highly concentrated in the Madeira Bay, Little Madeira Bay, and Joe Bay area of the northeastern coast of Florida Bay than in other parts of the range in South Florida.[1] Sightings out of northeast Florida Bay decrease as distance from the population center increases. The sightings which are at the extreme northern ends of the range are probably solitary sightings of storm moved or wandering individuals. It is not established that the Florida crocodiles are territorial, therefore, movement may be somewhat more pronounced than expected if they were a species which is highly territorial.

On September 25, 1975, *Crocodylus acutus* was placed on the Endangered Species List of the U.S. Fish and Wildlife Commission according to Federal Regulation 40 (187): 44149. The placement was another in a series of efforts to maintain a viable number of individual crocodiles. In dramatic contrast with efforts to preserve the alligator which has been perhaps too successful, the efforts for preservation of *Crocodylus acutus* have produced no measurable increase in numbers. Since the related species at least superficially resemble one another, it might be expected that efforts which benefit one would benefit the other. Both have had periodic pressure from human predation and hide hunting. Both have been pressured by habitat destruction resulting from urban development.

There are, however, some notable differences between alligators and crocodiles, which may account for the poor results of the latter. Important among these are:

1. Alligators are temperate and crocodiles tropical.

2. Alligators are more inclined to tolerate human presence than the shyer crocodile; therefore, alligators are more vulnerable to hunting; alligators will show greater change when hunting pressure changes.

3. The available, suitable habitat in Florida is many times greater for the alligator than for the crocodile.

4. One of the alligator's primary food items, garfish, is in no serious decline while mullet, an important food of crocodiles is in a serious state of decline if Florida Bay Fishery statistics are indicative of population.

5. The weather during the several years since most of the effort toward encouraging crocodilian population has greatly favored the more temperate alligator rather than the tropical *Crocodylus acutus*.

6. Valuable water front property is generally the favored nesting sites of crocodiles. The particular combination of high ground, deep adjacent channels or ponds, and relatively calm water is competed for by humans and crocodiles. The crocodiles lose. Alligator nests, on the other hand, are only incidentally competitors for land desired by human development.

In all, the effort to preserve crocodiles and alligators must be made independently of one another, if we are concerned with *Crocodylus acutus*.

POPULATION ESTIMATE

There are probably several hundred individual adult crocodiles in South Florida. It is possible that this number fluctuates wildly, decade by decade. The most important cause of the fluctuation would be the cyclical pattern of weather in South Florida; however, at no time is it probable that the area ever carried a large viable population. The present population may be 20-50% of the maximum ever carried.[2] The available suitable habitat has diminished even as the total population has diminished.

Traditional population counting techniques do not readily apply when the individuals being counted are crocodiles. Population sampling produces indifferent results because the individuals move seasonally, are very shy, and some, if not most crocodiles, wander in meandering paths throughout the suitable range. Furthermore, it is rare to sight juveniles at all unless the nest is being observed and the individuals tracked after hatching.

One method of estimating population, a technique based on number of breeding females, suggests that as many as 500 crocodiles may exist. This method is based on studies of American alligators and *Crocodylus niloticus*, which indicate that breeding females in this reptilian group usually account for 4-5% of the total population. The method then depends on accurately counting and assessing nests. It is assumed that one nest represents one female. It is, however, very difficult to count nests in the estuarine habitat of *Crocodylus acutus* with its many ponds, canals, and mangrove lined shoreline. Two further difficulties complicate this procedure:

1. Two or more female crocodiles may use the same nest site.[3]

2. Crocodiles may not nest every year because of temperature factors affecting their metabolism or other regulatory mechanisms.

A third procedure depends upon estimates of annual production and mortality rates. Simply stated, we do not have sufficient data about mortality rates to use this procedure effectively.

At the extreme limits, most agree that no more than two to three thousand crocodiles ever comprised the total crocodile population of South Florida at one time. A realistic figure may be smaller than two thousand. Early observers created many problems in estimating the population from their writing. They were not certain that two crocodylian species inhabited Florida and even when they did know, they often used the names "alligator" and "crocodile" interchangeably. Some writers apparently used the names according to the dictates of fashionable writing at the time. Others simply did not know the difference and most were not prepared with sufficiently accurate biological or geographical knowledge to observe and record accurately.

Observers at the end of the 19th century and early 20th century do provide some interesting data for speculation. Dimock, in particular, described the entire present range of *Crocodylus acutus* in Florida and provides a record of crocodiles in that habitat which is consistent with observation made today. Writers describing the northern end of Biscayne Bay describe a very different resource at the turn of the century than is observed today. Many of those writers recorded crocodile sightings and nests in areas which are now bulkheaded and filled.

GEOGRAPHICAL RANGE

Crocodylus acutus is a large tropical reptile which lives in an esturine habitat. It has no serious mammalian competitors in that habitat. The range of *Crocodylus acutus* includes much of the Caribbean, the north coast of South America, Central America, Hispaniola, Jamaica, Cuba and South Florida. They seem to prefer warm, protected, brackish or fresh water. When *Crocodylus acutus* reaches modest size, it has no serious enemies except man.

Temperature is a most significant factor limiting the geographical range of crocodiles. *Crocodylus acutus* becomes torpid in 18°C (65°F) water if confined to the water. If not confined, they display some physical and some behavioral adaptions which enable them to survive limited periods of colder water. It is suspected that in the mangrove-lined canals, crocodiles will become dormant for cold of short duration. It is also likely that some individuals are more terrestrial when the water is cold. The success of these behaviors depends upon any period of cold being limited to a few days duration.

Temperature during nesting season is also a critical factor. Internal nest temperatures below 25°C cause nest failure. Extensive work with the eggs and nests of *Crocodylus novaeguinae* by H. R. Bustard indicate extensive crocodylian nest failure because the eggs do not incubate below 26°C. This is consistent with field observation of *C. acutus'* nest failure.

Salinity also limits *Crocodylus acutus*, but the specific mechanisms are not as obvious as temperature limits. Crocodiles have no obvious salt glands or other internal structures which are obviously salt regulations organs. W. A. Dunson has completed important work on the specifics of reptilian adaptions to the salt in marine environments including *C. acutus*. Dunson demonstrated that adult crocodiles can survive hypersaline conditions, but juveniles cannot tolerate hypersalinity in laboratory tests; however, the tests are laboratory tests and field observations indicate behavioral techniques exist for coping with salinity. In general, both laboratory and field observations substantiate the preference for less saline water. It is possible that the population will be healthier if they have access to less saline water after hatching.

Crocodiles prefer smooth, calm water. The mechanisms of breathing and especially floating with just eyes and nostrils emergant are more efficient in calm water than rough water. Estuarine habitats have ample smooth and calm water in canals, rivers, ponds and small bays.

BIOTIC CONSIDERATIONS

Crocodylus acutus has three phases of predation, dependent on age and size. The younger ones eat insects and other small organisms, many of which are terrestrial. The adults eat fish and crabs primarily and less frequently, small mammals, other reptiles and birds. The old adults have difficulty maintaining predation upon fish, birds and mammals. In any case, one of the primary food sources of adult crocodiles in Florida is mullet. This fish was once present in great numbers and has recently shown signs of serious depletion.

In the egg through young adult stages of development, crocodiles are preyed upon by raccoons, sharks, crabs, birds, and possibly alligators and other crocodiles. Nest loss by raccoons both before and at hatching accounts for some of the known predation. It is estimated that 15% of the eggs are lost to nest predation and that some smaller losses occur following the hatch. Additionally, researchers have reported an unusual number of bird tracks on or near the nests at the time of hatch. A final note is that some researchers report an unusual number of black tipped sharks in the areas of some of the Florida Bay nests.

Predation surely occurs upon the juveniles until size and strength tips in favor of the adult crocodile. Unfortunately, little is known of the specifics of predation after the hatchlings have survived a month or so.

Alligators and crocodiles do sometimes occupy the same territory within the habitat. There are few if any records of competition for territory between these species. Both prefer less saline water, but crocodiles are more likely to occupy the more saline water and alligators the less saline water. Seasonal movement of both species is evident. Both move inland in winter, alligators moving further inland and crocodiles replacing the alligators. In summer, the crocodiles move seaward, and the alligators replace them. Generally, crocodiles and alligators do not seem to be serious competitors and they tolerate the others presence peacefully.

The diet probably controls the movement of individuals as much as any consideration. There is speculation that the smaller juveniles so rarely observed may spend their time in the forest of mangroves where insects and small organisms would be present in sufficient numbers. In this microhabitat, the mangrove forest, it would be nearly impossible to observe juvenile crocodiles. Hatchling crocodiles demonstrate a proclivity for this type concealment immediately after hatching. Radio tracked hatchling crocodiles were found close to the open nest and hidden in holes, tunnels, and beach wrack by Mazzotti and Kushlan in 1978.

Only man is a serious threat to crocodiles in their native habitat. The threat by man is delivered in two forms. One is habitat destruction. The other is direct destruction by accident, hunting, or capriciousness. An alarming number of individuals are lost to the latter. Since hide hunting has nearly been eliminated, only a few crocodiles are destroyed for human use. Those are generally eaten and are very few in number if any.

Accidental death as a result of human encounters include car accidents, boat accidents and crocodile net encounters. The nature of these encounters is obvious; the human probably did not intend to destroy the animal but encountered the crocodile inadvertantly, thereby causing an unintended death.

The capricious destruction may occur when a crocodile becomes used to human presence. After being observed by many, as the one seen by many basking in full view of U.S. 1, someone with a high powered firearm may destroy the animal just to watch it die. The figures in human related crocodile mortality table below indicate that capricious shootings account for a very high percentage of crocodile mortality. It is also possible, perhaps probable, that the road deaths were also deliberate. The table itself does not include all the crocodile destruction and the true figures are likely to be much greater than the reported mortality.

HUMAN-RELATED CROCODILE MORTALITY IN SOUTH FLORIDA, 1971 - 1976

DATE	SIZE	LOCATION	PROBABLE CAUSE OF DEATH
Summer 1971	about 3 m	Northern Key Largo	Shot
September 1971	about 2.7 m	Sexton Cove, Key Largo	Shot
September 1972	2.5 m	Lake Surprise, Key Largo	Hit by car on road
July 1972	about 2.1 m	Lake Surprise, Key Largo	Floating dead, nest to highway
April 1974	45 cm	Northern Key Largo	Hit by car on road
June 1974	about 2.5 m	Blackwater Sound, Key Largo	Floating dead in canal
Summer 1974	about 3 m	Basin Hills	Shot as trophy
February 1975	about 3.7 m	Northern Key Largo	Shot
March 1975	1.2 m	Northern Key Largo	Hit by car on road
July 1975	1.0 m	Card Sound mainland	Hit by car on road
Spring 1975	1.0 m	Northern Key Largo	Shot and head removed (Ogden 1978)

Some recent crocodile mortality at the hands of humans includes:

Fall 1978	about 3 m	Key Largo	Possibly hit by boat
January 1979	about 4 m	Port Everglades, FPL cooling canals	Shot

The capricious destruction of alligators is recorded by Dimock in 1908. His statement regarding alligators is readily applicable to the American crocodile:

> "This creature has served as a target for nearly every rifle that was ever brought into the state and deserves a better fate than extinction."
>
> Dimock, 1908

Dimock also stated strongly that he believed the crocodile would be extinct in Florida in the first decade of the twentieth century because of the pressure of hunting. His description of Barnes Sound, with a trap at the entrance of every crocodile tunnel, gives cause to wonder how they survived at all.

CROCODILE POPULATION IN FLORIDA

"Crocodile hole" was a pond on Miami Beach which attracted curious visitors 75 years ago. It was a deep pond, 300 feet long and 40 feet wide. A small boat could enter through a narrow creek in the mangroves. Alfred Monroe claimed that hundreds of crocodiles could be seen there. Other observers reported that if one should quietly sneak up to the edge of "Crocodile hole" several crocodiles might be seen. Alva Moore Parks states that crocodiles are so timid that the curious had to sneak up to the pond. This pond was three miles from the mouth of Indian Creek and the bay. One of the early photographs of a crocodile was taken beside the pond. At that time Biscayne Bay had numerous fresh water springs and small creeks. Arch Creek, the Oleta River and the Miami River had crocodylian inhabitants before development. It is probably that there was a strong, if not numerous, population all along the coast of Biscayne Bay in the numerous streams and ponds.

North of Biscayne Bay there is little evidence of stable, viable populations. Some record exists of individuals and even of isolated nests. It is possible that these are wandering individuals that appeared in warm cycles and did not survive a cycle of cold winters.

That wandering could have accounted for many, if not all the northernmost sightings is demonstrated by the fact individuals have wandered north in recent years. One female crocodile, tag number 170, was caught in Pompano in 1978. Another was found dead in the Florida Power and Light Port Everglades power plant cooling canals in 1979. In 1974 a large adult was caught at Vero Beach, Indian River County. If a larger viable population existed in Biscayne Bay, then more wandering would be likely and sightings of those individuals would be more frequent.

Simply, it is unlikely that the range of *Crocodylus acutus* ever extended north of New River on the East Coast. Isolated, wandering individuals probably account for the early records of crocodiles north of Biscayne Bay.

The southern most Florida Keys currently carry no viable population. There is a photograph of a crocodile on a beach at Key West; the significance of the photograph is uncertain. It does not indicate that crocodiles ever lived regularly on the beaches of Key West. In the past, Pig Pine Key had nests and several other areas might be suspected of carrying population, but there is no evidence of the Keys ever carrying a sustained, viable population.

Crocodile number 170 was captured at Marathon shortly after her trip to Pompano and then she was captured again at Venetian Shores. Each release was at Jewfish Creek; if nothing else, the wanderings of crocodile 170 indicate how past observations may have placed the American crocodile far from the population epicenter.

The areas of the coast north of Biscayne Bay, north of Cape Sable and the Western Florida Keys are the range limits in South Florida. The Northern Florida Keys, Card Sound, Barnes Sound and Florida Bay are now and have traditionally been the most important centers of *Crocodylus acutus* population in Florida. The small changes which have occurred in the total range in Florida are primarily in the northern end of Biscayne Bay where development has destroyed suitable coastline. Card Sound, Barnes Sound, and Florida Bay have a small but viable population of crocodiles.

Northeastern Florida Bay is the epicenter of population of *C. acutus* in Florida. Even in this population center, sightings are rare and random. One guide claims never to have seen one in 24 years; yet, others might observe a crocodile from U.S. 1 near Key Largo. Sightings are uncommon because the population is small and the individual's usually shy of human presence. Crocodiles in northeastern Florida Bay generally inhabit the streams and mangrove lined ponds. In addition to wandering, previously mentioned, there is noticeable seasonal movement recorded in Florida Bay. Movement is toward the mainland interior in the winter and seaward in the summer. The movement and the shyness may account for the random sightings in an area which supports a viable crocodile population at this time.

In the western most parts of the state there are few records of crocodiles north of Cape Sable. Superficially, it would seem to be a suitable area; however, there are some measureable distinctions between Florida Bay and the environs north of Cape Sable. These distinctions are:

1. The area north of Cape Sable is climatically cooler than Florida Bay.

2. The fresh water in the area north of Cape Sable does not originate in the Biscayne Aquifer as it does with all the remainder of the crocodile range. See Figure 4

3. The fresh water north of Cape Sable is more highly mineralized than fresh water flowing into Florida Bay. See Figure 4

4. Protection from hurricane tides and surges is different when the topographical features of crocodile range and the area north of Cape Sable are examined.

A dieback population may inhabit the Ten Thousand Island area between cold cycles. Campbell found a clutch of hatchlings born in the 1950's in Chatham River. The mullet fishermen and guides report infrequent individuals at several locations; however, authenticated observations are rarely at the same sites. A viable population is suspected and being investigated; its existence is doubtful. The Ten Thousand Islands seems to be more suited than the area north of Naples but there is no source which indicates that crocodiles were ever strong anywhere north of Cape Sable.

The immediate area of Cape Sable has a problemsome population of crocodiles. They are observed on and all around the Cape infrequently. Credible sightings include: Tarpon Creek, Coot Bay, Coot Bay Pond, Whitewater Bay, Joe River, Little Shark River, East Cape Canal, and the Homestead Canal. In the Homestead Canal they share habitat with alligators. There is evidence that some of the Cape Sable population was introduced by release. If this is proven by DNA studies, it may indicate that Cape Sable was not acceptable to crocodiles in pre-development times.

There are several observations of the Florida portion of the range of *Crocodylus acutus* which should be noted that do not have obvious impact on the population. The striking characteristic is that the historical range boundaries approximates the same boundaries as several of the notable features of South Florida. Among these are:

1. The Biscayne Aquifer which has historically provided a substantial reserve and flow of fresh water. See Figure 4

2. The emergence of the Miami oolite formation. See Figure 3

3. The 76° curve of the average stream temperature. See Figure 2

4. The progression of a cold front into South Florida. See Figure 2.

It is remarkable that each of these physical features do conform in a curve to the area of this survey which is Cape Sable to Key Largo to the north end of Biscayne Bay. Numbers one and two are not obviously limiting to crocodile population. Three and four are more clearly limiting since temperature factors are important. In combination, these physical features must certainly have control of the extent of the range.

ACKNOWLEDGEMENTS

I wish to acknowledge the advice and assistance of Cheryl Cook, Kathy McCormick, Jim Gaither, Joe Ervine, Scott Julson, Sue Marchese, and Don Flynn. I also wish to recognize the advise and encouragement of Tom Pafford and Bardy Jones. Special note must be made of Dave Kleinman, science department chairman of Miami Central Senior High School, who cheerfully made facilities and equipment available when requested. Three others have given valuable assistance. These are: Dr. John Ogden, of National Audubon Society; Dr. Ross Wilcox of Florida Power and Light; and Dr. Howard Campbell, of the U.S. Fish and Wildlife Commission and team leader of the Crocodile Recovery Team.

[1] Mazzotti, Kushlan, "Distribution of the American Crocodile in Everglades National Park; May 1977 - October 1978" Summary.

[2] Ogden, John, "Status and Nesting Biology of the American Crocodile, *Crocodylus Acutus* in Florida", Journal of Herpetology, page 192.

[3] Patty, Wideman, Robertson, "Summary of the 1978 Nesting Season in Northeastern Florida Bay, Everglades National Park", page 1.

LITERATURE CITED

Abstein, Jack "Count Down for the Crocodile" Florida Wildlife, October 1976, pp. 10-12.

Allen, E. R., and W. T. Neill, "The Florida Crocodile", Nature Magazine, Vol 45, No. 2, 1952, pp. 77-80.

Austin, Robert J., and James A. Kushlan, Distribution of the American Crocodile in Everglades National Park, February--September, 1977.

-----Helicopter Surveys of Crocodile Habitat, March-September, 1977.

Barbour, T. 1923, The Crocodile in Florida, Occas. Papers Museum of Zoology, University of Michigan, No. 131, pp. 1-6.

-----The Vanishing Eden - A Naturalist's Florida, 1944.

Bartram, William, Travels.

Bean, N. M. "Crocodile Nest at Trout Creek," Everglades Natural History, Vol 1, no. 3, 1953, pp. 100-102.

Biscayne Bay: Past/Present/Future, Special Report No. 5, April 1976, University of Miami, Sea Grant.

Bustard, H. R. 1971, Brit. Journal of Herpetology, 4:198-200, "Temperature and Water Tolerances of Incubating Crocodile Eggs".

Dickinson, W. E. "In Quest of an Adult Crocodile," Everglades Natural History, Vol. 1, No. 4, 1953, pp. 151-156.

Dimock, A. W., and J. Dimock Florida Enchantments, New York, 1918..

Everglades Natural History, Vol 1, No. 3 (1953) pp. 100-103 Vol. 1, No. 4 (1953), pp. 151-156, Vol. 1, No. 2 (1957), pp. 66-75.

Gardiner, J., "Alligators in the Bahamas," Nature, Vol. 34, No. 384, 1886, p. 546.

Hornaday, W. T. (Note on the Florida Crocodile), American Naturalist, Vol. 5 (1875), p. 504.

-----1904, The American Natural History, Charles Scribner's Sons, New York, pp. 320-321.

International Union for Conservation of Nature, October 1973., Supplementary Paper no. 41, Crocodiles.

LeBuff, C. R. "The Range of Crocodylus Acutus Along the Florida Gulf Coast," Herpetologica, Vol. 13, Part 3 (1957), p. 188..

Maynard, C. J. (chapter 1) in C. Hallock (editor), Camp Life in Florida: A Handbook for Sportsmen and Settlers, New York, 1876.

Mazzotti, Frank J., and James A. Kushlan, Distribution of the American Crocodile in Everglades National Park, May 1977-October 1978, Crocodile Study Project, Report 9, Dec. 20, 1978.

Menziea, R. A., J. Kushland, H. C. Dessaver, "Low Degree of Genetic Variability in the American Alligator", Isozyme Bulletin-Vol. 12, 1979.

Moore, J. C. "A Mound on a Key in Florida Bay," Everglades Natural History, Vol. 1, no. 2 (1953), pp. 66-75.

-----"The Crocodile in the Everglades National Park," Copeia, (1953), No. 1, pp. 54-59.

Neill, W. T. 1971, The Last of the Ruling Reptiles, Columbia University Press, New York, pp. 486.

Ogden, J. C. and Singletary, 1973, "Night of the Crocodile", Audobon, 75:32-37.

Ogden, John C. "Status and Nesting Biology of the American Crocodile in Florida," Journal of Herpetology, Vo. 12, No. 2, (1978) pp. 183-196.

Parks, Arva Moore, The Forgotten Frontier.

Patty, P., and R. Wideman, W. Robertson, "Summary of the 1978 Crocodile Nesting Season in Northeastern Florida Bay, Everglades National Park".

Pierce, C. W., 1970 Pioneer Life in Southeast Florida, University of Miami Press, Coral Gables, Florida, pp. 264.

Rafinesque--Schmalz, C. S. (First Mention of a crocodile in Florida), Kentucky Gazette, New Series, Vol. 1, no. 29, July 18, 1822, p. 3.

Reid, George K., Richard D. Wood, Ecology of Inland Waters and Estuaries, Van Nostrand, 1976.

Simpson, Charles Torey, In Lower Florida Wilds, 1920, New York and London.

Smith, J. M. 1896, Notes on Biscayne Bay, Florida From the Report of U.S. Commissioner of Fish and Fisheries for 1895, U.S. Government Printing Office, Washington, pp. 169-191.

Stimson, L. A. "Off the Map", Florida Naturalist, Vol. 13, No. 5, 1940, pp. 80-82.

"William Adie Whitehead's Description of Key West," Tequesta, 1952, No. 12, pp. 61-67.

Willoughby, H. L., 1913 Across the Everglades, Philadelphia pp. 192.

Wyman, J. (note on the crocodile in Florida), Proceedings of the Boston Society of Natural History, 1869, pp. 78.

-----(Note on the Crocodile in Florida) American Journal of Sciences and Arts, Vol. 49, 1870, p. 105.

RESEARCHED SIGHTINGS - RECENT AND HISTORICAL

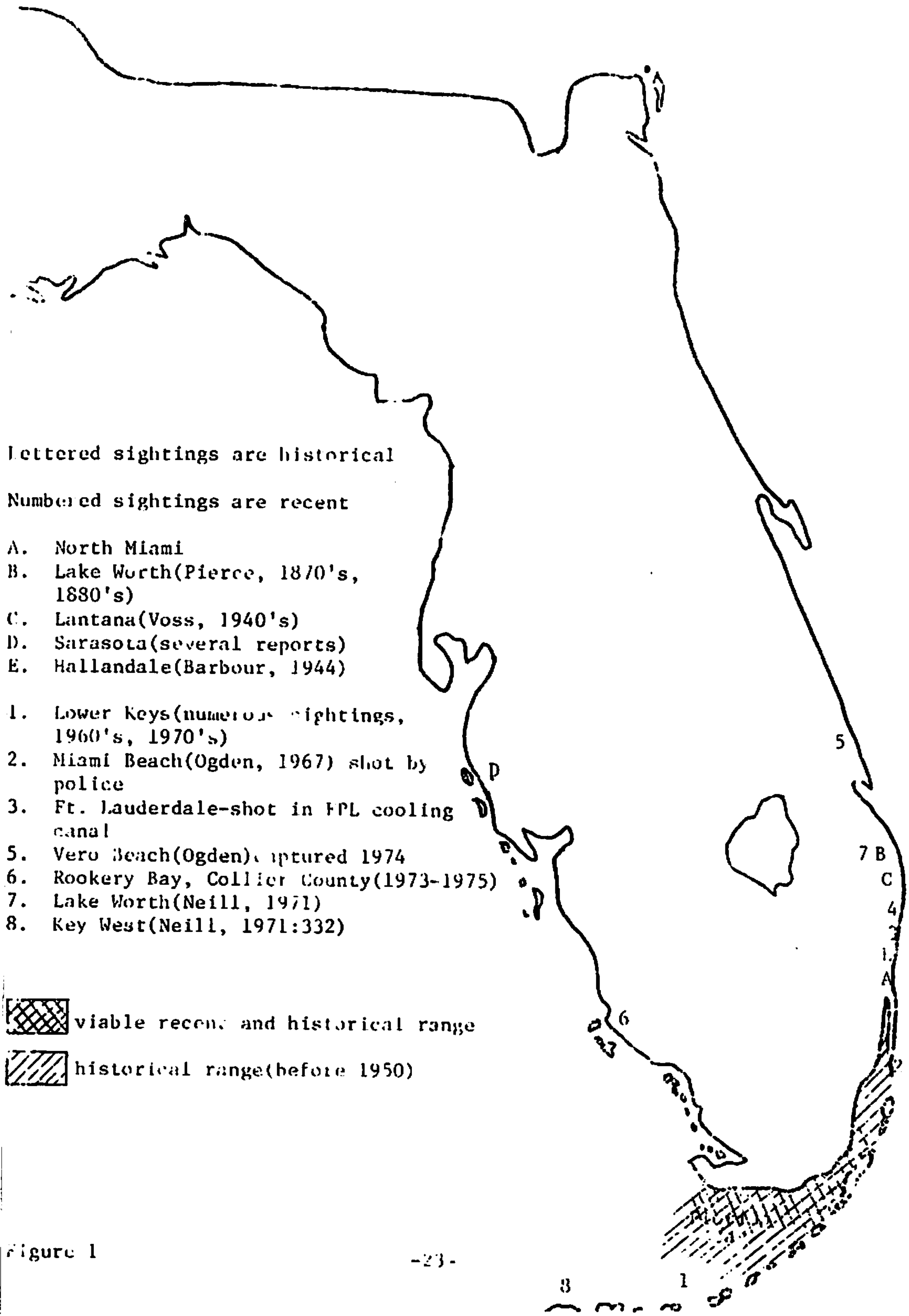
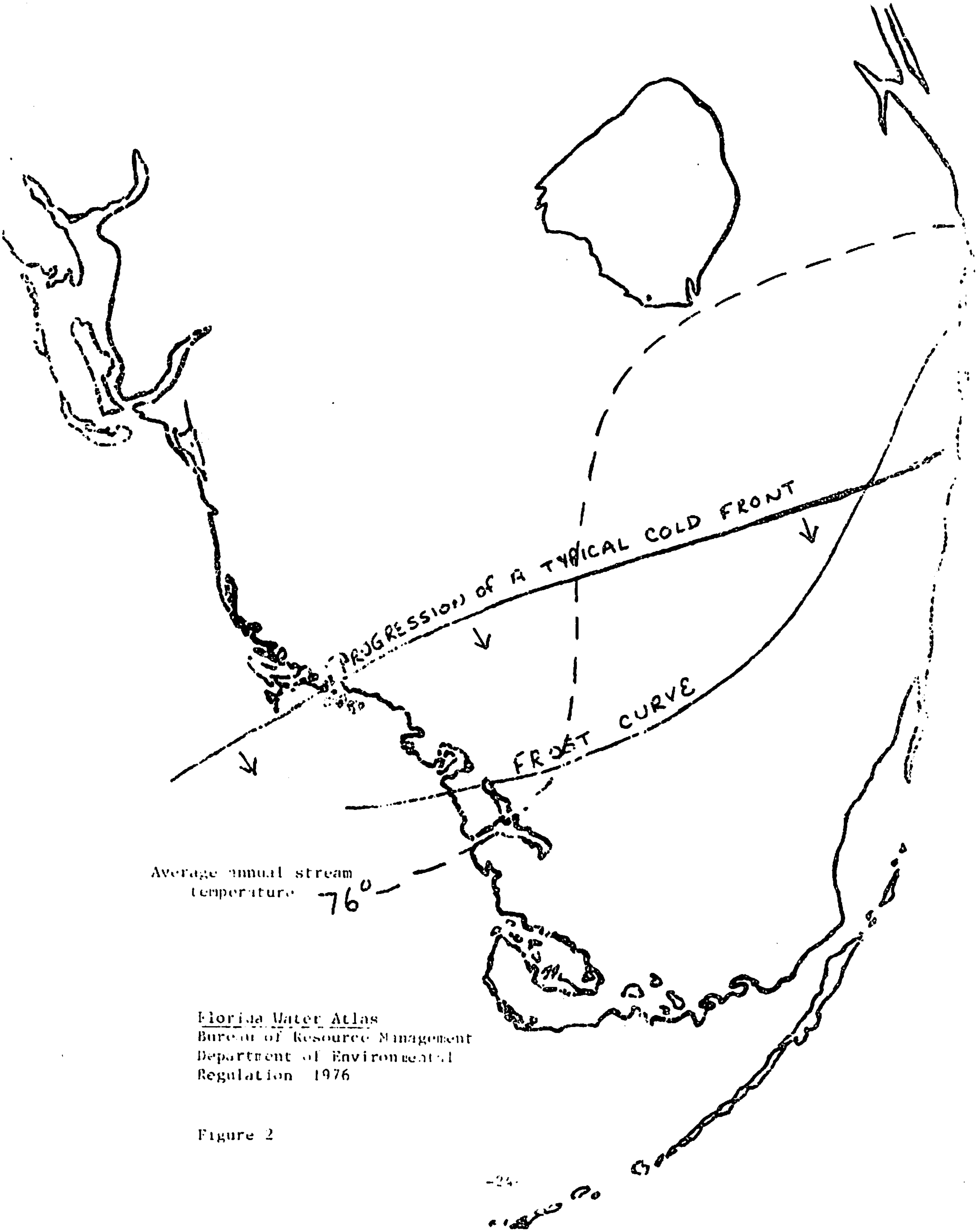
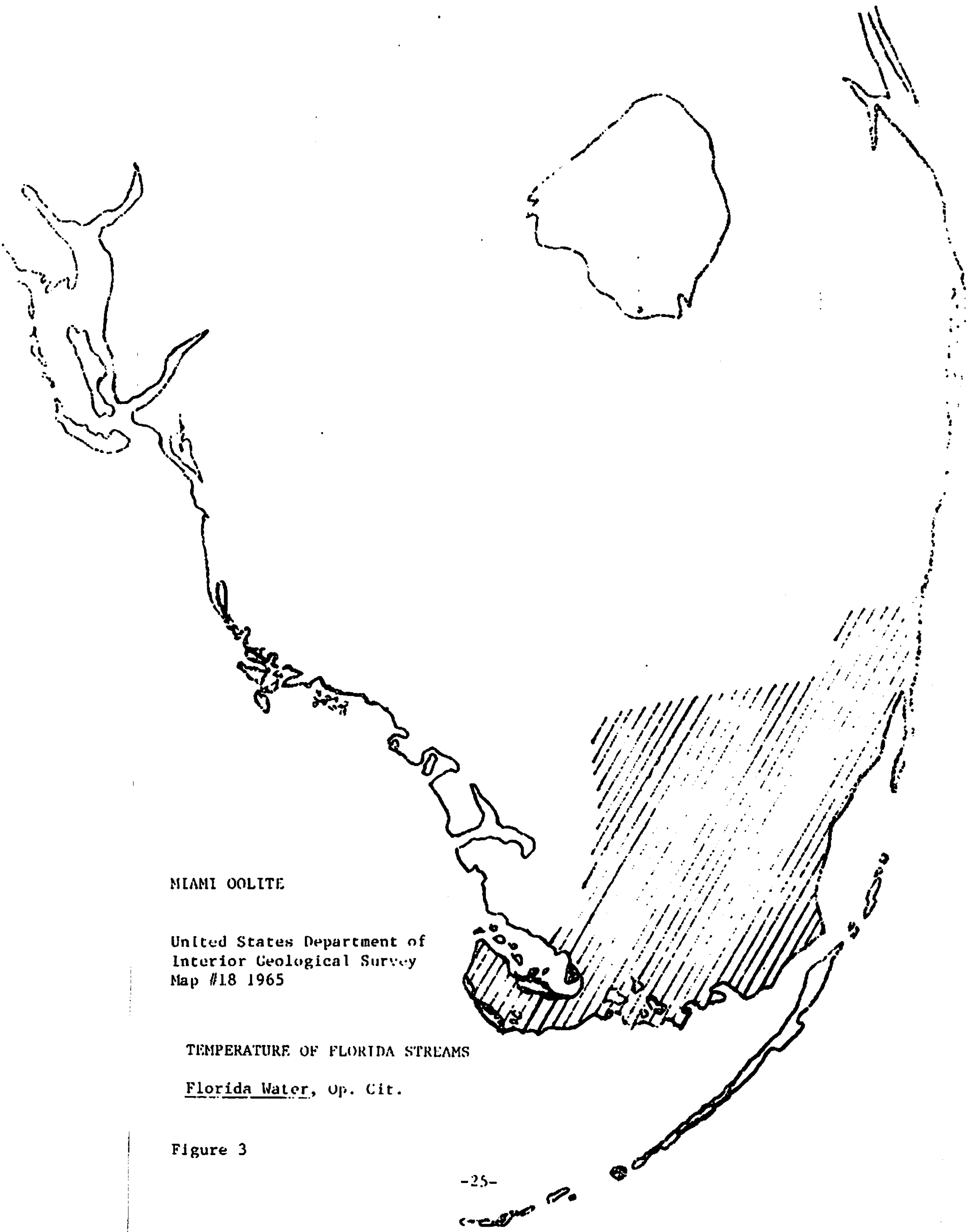


Figure 1



Florida Water Atlas
Bureau of Resource Management
Department of Environmental
Regulation 1976

Figure 2



MIAMI OOLITE

United States Department of
Interior Geological Survey
Map #18 1965

TEMPERATURE OF FLORIDA STREAMS

Florida Water, Op. Cit.

Figure 3

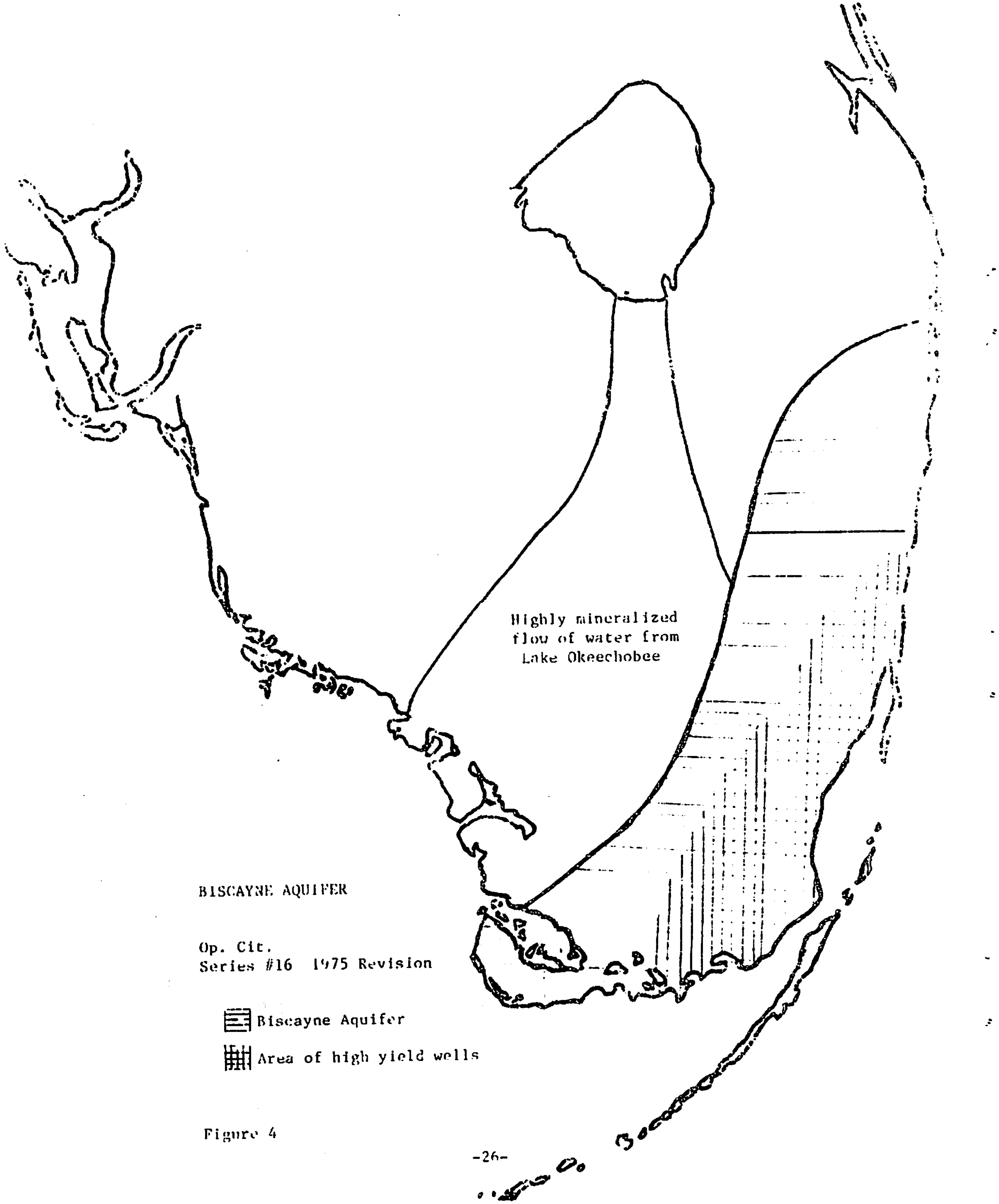

Highly mineralized
flow of water from
Lake Okeechobee
BISCAYNE AQUIFER
Op. Cit.
Series #16 1975 Revision
Biscayne Aquifer
Area of high yield wells

Figure 4

FLAMINGO RANGER STATION; TEMPERATURE RECORDS NOTING SPRING COLD SNAPS

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
high															85	83	83	84	84	84	85	79	84	83	80	85	83	76	78	79	
4/78 *low*															68	66	62	60	74	73	64	63	68	63	65	65	58	54	59	65	
														86	87	85	85	88	81												
5/78														71	59	60	66	62	67												
																										80	XX	84	81	81	
4/77												W A R M														57	XX	44	55	55	
5/77															W A R M																
										83	80	80	77	82	75	80															
4/76										54	53	52	55	59	58	61															
5/76															W A R M																
4/75															W A R M																
5/75															W A R M																
															90	89	88	85	84	84	84	84	85	86	88	88	82	83	82	84	
4/74															60	59	63	59	54	54	57	56	60	64	59	52	54	54	55	52	
5/74															W A R M																
4/73															W A R M																
5/73															W A R M																
4/72															W A R M																
5/72															W A R M																
4 71															W A R M																
5/71															W A R M																

U.S. Weather Bureau Records

FIGURE 5

FLAMINGO RANGER STATION; TEMPERATURE RECORDS NOTING SPRING COLD SNAPS

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
4/70	*high* *low*														W A R M																
5/70 (high)	93	85	83	80	83	86	86	82	83	83	83	85	83	83	83	82	82	84	85	85	86	85	83	83	84	85	85	85	83	83	80
5/70 (low)	68	65	61	65	65	60	57	63	64	69	63	63	65	63	63	64	65	68	70	70	68	64	72	72	68	69	76	71	72	72	
4/69															W A R M																
5/69															W A R M																
4/68															W A R M																
5/68															W A R M																
4/67 (high)															80	81	82	82	85	82	79	81	82	82	84	82	87	84	79	79	
4/67 (low)															68	60	61	66	69	67	77	74	74	65	75	70	71	67	57	57	
5/67 (high)	80	81	80	82	84	83	83	84	84	86	86																				
5/67 (low)	60	62	61	59	67	67	76	71	71	70	70																				
4/66 (high)															83	84	80	85	86	86	82	82	83	83	85	84	87	85			
4/66 (low)															64	62	60	58	62	66	64	61	62	60	62	67	65	68			
5/66															W A R M																
4/65															W A R M																
5/65															W A R M																
4/64 (high)				82	89	81	82	82	81	80	80	83																			
4/64 (low)				66	65	65	63	62	64	62	64	70																			
5/64															W A R M																
4/63															W A R M																
5/63															W A R M																

FIGURE 6

CAPE SABLE RANGER STATION

DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
	high																														
3/61	*low*													WARM																	
4/61														WARM																	
4/60														WARM																	
5/60														WARM																	
																						87	86	85	84	83	79	82	83	85	
4/59																						71	68	68	64	58	58	62	69	66	
	86	84	81	82	82	89	84	81	82	83	85	86																			
5/59	62	61	63	60	60	66	62	59	61	61	68	74																			
4/58														WARM																	
								81	82	86	87																				
5/58								58	55	56	65																				
															86	83	82	82	84	85	83	84	84	84	85	86	85	82	83	85	
4/57															68	62	66	61	66	71	66	65	59	68	62	68	67	67	68	67	
	86	87	88	85	85	85	86	82	86	84	86																				
5/57	69	68	67	68	69	69	70	69	69	69	72																				
4/56														WARM																	
5/56														WARM																	
																							84	82	85	85	64	88			
4/55																							67	62	59	59	61	65			
	87	82	87	83	87																										
5/55	63	59	59	64	64																										
															85	84	83	82	87	87	83	82	75	84	85	84	85	86			
4/54															66	65	65	62	63	66	67	61	66	64	63	67	68	68			
				86	87	89	87	87	88	89	88	86																			
5/54				68	69	67	62	60	64	65	68	71																			

FIGURE 7

DISCUSSION OF INTERVIEW RESULTS

Park biologists look primarily at Madeira Bay with some overlap to Cape Sable and the northern Keys. They do not often examine other areas where crocodiles are found; furthermore, they have not been enthusiastic about sharing their knowledge of their research area with others.

Mullet fishermen, who have no reason to appreciate the National Park System, have spent many years in Florida Bay and have their own speculations about the status of Florida Bay, the crocodile population, and the Park Service. Like most others, the mullet fishermen in Northeast Florida Bay believe that water diversion is a most significant problem.

The Islamorada Fishing Guides blame everyone for the decline of the Florida Bay fishery and especially they blame the mullet fishermen. That they blame the mullet fishermen, who use nets, was demonstrated by the co-ordinated, almost vicious attack on them at the workshops Everglades National Park organized in February, 1979. The guides are a self-serving group whose positive virtue is pointing out that the total fishery is in a serious state of decline. They are quite willing for others to sacrifice so that they can take wealthy tourist fishermen to the fish. They are adamantly opposed to solutions which may restrict them; e.g., the establishment of power boat corridors in Florida Bay to reduce wheel-ditching, crocodile boat encounters, sediments, and wildlife disturbances.

The guides, like the park biologists, the mullet fishermen, the academic community, and environmental lobbying groups have knowledge to share.* The human problem seems to be that of working together. It may already be too late for Florida Bay.

*A common statement of all is that much too great a percentage of the effort of law enforcement is given specifically to drug enforcement, which is a serious problem in the area; but, it diverts such a great percentage of the total law enforcement that resource protection is in a state of disarray from neglect. In the four hundred hours or more surveying the habitat in Everglades National Park, no resource protection personnel were seen.

Appendix I

The place of Cuba's population of *Crocodylus acutus* is incompletely researched and it is probably too late to initiate a project because of the impounding program in Cuba. Information from Cuba indicates that crocodile farms have been established for hide procurement. Several researchers working with crocodylians report that wandering may be a normal behavior and this is certainly indicated by the wandering *Crocodylus acutus* in South Florida. The problem is whether any significant movement from Cuba has occurred. Such movement could replace population loss. If recruitment from Cuba was significant to population stability, then the termination of that movement could account for the lack of recovery in Florida. Such a movement would certainly depend upon population density factors and behavior dynamics which encouraged migration. It becomes a more plausible explanation when temperature records are examined because the winters of 1939 - 1940 and 1957 - 1958, for example, must have taken a heavy toll on the crocodile population despite behavioral techniques for dealing with the cold. Cooperation with Cuba may be an important factor in dealing with the population of American crocodiles in Florida.

A fact which is significant regarding the security of the world population of *Crocodylus acutus* is that the population in Florida may be the most secure in the entire range. Other countries generally do not have consistent programs to protect them. If American crocodiles are to survive, Florida is probably the best resource for their preservation. Apparently, 1978 was a good year for nesting following several poor years. We will have to wait to observe how many of the hatchlings become adults to determine if Florida is going to experience an increase in population. Several proposals follow this statement.

Appendix I

PROPOSALS

I. END NETTING IN NORTHEAST FLORIDA BAY TO:

1. Protect food of crocodile and other species (silver mullet primarily).
2. Reduce crocodile net encounters.
3. Protect sensitive Bay bottom from net dragging and center mounted engine, boat damage.

II. END OF POWER BOATING IN NORTHEAST FLORIDA BAY. Establish rules similar to other wilderness areas. This is to:

1. Establish several more camp sites for non-power travel and prohibit all other land fall to encourage alternate styles of use.
2. Reduce crocodile boat encounters.
3. Reduce destruction of Bay bottom by wheel ditching.
   a. Reduce erosion.
   b. Reduce particulate suspension.
   c. Reduce destruction of marine grasses.
4. Reduce pollutants from underwater exhaust by high power outboards in shallow bay.
5. Reduce noise pollution.

III. STIFF ENFORCEMENT OF DELIBERATE DESTRUCTION OF ANY CROCODILE, ANYWHERE, AND THE EDUCATION OF THE PUBLIC.

IV. EXTREME CAUTION IN INTRODUCTION OF NEW ORGANISMS: ESPECIALLY CROCODILES FROM OUT OF AREA.

V. RESTORE HISTORICAL BALANCES AS MUCH AS POSSIBLE.

1. Intrusion fill or dams for Flamingo-Coot Bay Canal.
2. C-111 changed to facilitate fresh water into Taylor Slough.
3. Pumping to Taylor Slough.
4. Clean up canals - enforcement of pollution laws.
5. Facilitate increased flow of water between Florida Bay and Barnes and Card Sound.
6. Purchase of Palo Alto and purchase of Basin Hills for crocodile and wildlife preserve.

Appendix II

VI. GREATER AGENCY CO-OPERATION INCLUDING THESE GROUPS:

1. Scientific community.
2. Political lobbies.
3. Everglades National Park, Biscayne National Monument, and John Pennekamp State Park.

VII. IMPROVEMENT OF PARK FACILITIES AND VISIBILITY ON KEY LARGO. CONSTRUCTION OF VISITORS CENTER ON KEY LARGO WHICH IS VERY VISIBLE, SUGGESTED SITE, JUST SOUTH OF U.S. 1 AND CARD SOUND ROAD JUNCTION. INTERPRETIVE PERSONNEL AND TRIPS FOR VISITORS. JOBS IN THIS CENTER FOR MULLET FISHERMEN.

VIII. ENCOURAGE COMMUNICATION WITH CUBAN SCIENTIFIC AND POLITICAL COMMUNITY TO ESTABLISH BODY OF DATA ABOUT MIGRATION AND CROCODILE IMPOUNDING.

IX. MONITOR PHOSPHATE AND OTHER CHEMICALS FROM FARMS WHICH ARE IN THE DRAINAGE TO NORTHEASTERN FLORIDA BAY.

These proposals are not for crocodiles alone, but for the saving of Florida Bay Resource. In a real sense the crocodiles are reflective of the status of the health of Florida Bay itself.

Appendix II

A FIELD STUDY OF THE INTERRELATIONSHIP OF BOSTRYCHIA AND RHIZOPHORA MANGLE

CHERYL COOK

MARINE BIOLOGY TEACHER
MIAMI CENTRAL HIGH SCHOOL
MIAMI, FLORIDA

ABSTRACT

A field study lasting five years (1974-1979) involving collecting data in established quadrants of red mangroves.

This data shows the growth of red mangroves as a function of the increase in their DBH (diameter breast height). This study also shows the significant number of diatoms, microinvertebrates, protozoans and worms, associated with the red alga Bostrychia which grows abundantly on the roots of live red mangroves. By knowing the average diameter and length of prop roots, the number of prop roots per tree and sample population counts from the Bostrychia, the number of microorganisms per tree that are associated only with Bostrychia can be calculated.

There are many organisms that apparently have been completely overlooked in past research as part of the intricate food web of the mangrove ecosystem.

INTRODUCTION

Mangroves

Rhizophora mangle, commonly called red mangrove, is a member of the Rhizophoraceae which consists of seventeen genera and seventy or more species (Carlton, 1975). This comprises much of the "mangrove" vegetation throughout the tropic and subtropic coastlines.

There are three basic growth forms of red mangroves:

1. Dwarf or scrub form: one to two meters in height, sparse leaves, roots which are nearly as long as the plant is tall. These occur where sediment is packed tightly and rock is exposed.
2. Intermediate form: bushy, most productive, found along interfaces of land and open water.
3. High mixed form: bushy tops, well formed trunk before branching, ten to fifteen meters tall, trunk thirty centimeters or better in diameter. These occur where sediments are thick and deep.

Davis(1940) studied the mangroves of Florida and described seven community types, one of which is the "Mature *Rhizophora* Consocies". This community is dominated by red mangroves, often growing on deep mangrove peat. This is the coastal band community of Teas(1974). The coastal band community is the band of mature mangroves (intermediate and mixed growth forms) bordering the bay and edging creeks that lead into Biscayne Bay. Generally this community is from ten to 250 meters wide and consists of tall (ten to fifteen meters) and widely spaced trees (Teas, 1976).

The role of the red mangrove, Rhizophora mangle, is often depicted in the following manner. The leaf and tree collect between prop roots and begin to decompose. Decomposition is accomplished by bacteria and fungi which turn it into detritus (Heald, 1971). This detritus then becomes the basis of the food web of a healthy tropical estuary.

Benthic Algae

Few studies have been done on benthic algae associated with red mangroves. The most comprehensive study of the benthic algal flora of Biscayne Bay was that of Taylor(1928) at Dry Tortugas. Taylor(1960) listed 395 species for Florida. The main benthic alga associated with red mangroves is Bostrychia (family Rhodomelaceae).

Diatoms, Protozoans, Microinvertebrates and Worms

Diatoms, protozoans, microinvertebrates and worms were the four major groups of microscopic organisms counted. Weber's(1971) work on common diatoms as well as Newell's(1973) work on marine plankton were used as guides to identify the microscopic organisms.

STUDY SITE

Interama

The Interama site, known as the Graves Tract until 1960, consists of approximately 600 hectares along northern Biscayne Bay (Figure 1). Interama lies south of Sunny Isles Causeway, between the Intracoastal Waterway and Biscayne Boulevard (U.S. 1). It extends south to about N.E. 135th Street. The western one fourth of the property had been farmed or otherwise disturbed before 1928 (Teas,1976). The soils are mostly marl in the southern portion, becoming peat toward the north. The Oleta River cuts through the tract near the Sunny Isles Causeway.

Much of the southwestern portion has been extensively altered by construction of Florida International University. The northwestern portion also has been altered by the construction of Metropolitan Dade County North Regional Fire Department, Dade County Public Safety Department and the Pollution Control Project. There are numerous roads, both asphalt and graded marl, throughout the tract (Figure 1).

Quadrants were marked for study about 0.16 km from the Oleta River off a side road near the bridge connecting Interama with Sunny Isles Causeway (Figure 1). This area receives tidal water due to a drainage ditch cut through the area.

Red mangroves of the Interama tract were chosen for the following reasons:

1. They are easily accessible by car or on foot.
2. These mangroves are one of two remaining mature red mangrove populations in North Biscayne Bay.

METHODS

Three quadrants measuring 10 x 10 m were marked. Every two meters along the quadrant perimeter lines a marking ribbon was tied to subdivide the quadrant into quadrats for easier mapping (Figures 2, 3, 4).

All trees (a tree is defined as any plant over one meter tall) were tagged with numbered plastic tags. These tagged trees were mapped (Figures 2, 3, 4).

On every visit to the site the following general information was recorded:

1. Date
2. Names of participating students
3. Time of arrival
4. Wind direction (determined by compass)
5. Wind speed (approximated by guess and weather report on television)
6. Percent cloud cover
7. Temperature of air (by thermometer)
8. Temperature of water (by thermometer)
9. Tide level
10. Time of departure

Specific information was collected on each visit. This information included:

1. Number of seedlings in the quadrant (a seedling is defined as any red mangrove less than one meter tall).

2. DBH (diameter breast height in centimeters). Determined by placing a meter stick perpendicular to the main trunk of the tree and taking the circumference at one m from the ground. If the tree branched at this point the first point above the branching was measured.
3. The number of prop roots per tree. Since a red mangrove prop root rebranches many times, only the prop root that arose from the trunk with the greatest diameter was counted.
4. The number and general type of arthropods, e.g. arachnids; mollusks; and other macroorganisms were counted.
5. One sample of *Bostrychia* per prop root per tree was collected.

This *Bostrychia* was placed in 125 ml tap water and allowed to soak twelve hours. The number of macroorganisms that emerged from the sample was recorded.

Microscopic examination determined the number of diatoms, microinvertebrates, protists and worms that used the *Bostrychia* as a habitat.

The *Bostrychia* was dried to constant weight in an oven at eighty degrees centigrade and the weight of the dry biomass recorded.

The water that contained the *Bostrychia* was allowed to settle after the removal of the *Bostrychia*, and all but fifteen ml of liquid was decanted. The remaining water-sediment mixture then was used to take population counts of the micro flora and fauna.

Method of determination of the number of organisms per tree:

Using 100 power magnification the field diameter was 1.8 mm. The area is then calculated to be 2.54 mm^2. The area of the cover slip (24 x 24 mm) is 576 mm^2. Therefore there are 226.8 fields per slide.

There are an average of 19 drops per one ml of sample, a total of 285 drops per sample.

It took three drops to a slide to completely cover the area under the cover slip.

Three field counts per three drops was recorded. The average length of a prop root covered with *Bostrychia* was 45.7 cm. The average diameter was 7.2 cm.

The number of trees whose prop roots were covered with *Bostrychia* was 25. The average number of prop roots per tree was 13.

RESULTS

The number of red mangroves that died in quadrant B increased from 19% in 1974 to 52% by 1979 (Figure 5). Those that lived increased in growth, determined by the increase in DBH in 1976 to that in 1979. The average increase in growth of DBH of red mangroves from 1976 to 1979 was 8.9% (Table 1). The remaining trees appeared healthy except for B-3, where one side trunk died. The average height of this red mangrove population was nine to twelve meters.

There were two distinct varieties of snails; the mangrove snail (Melampus) and the cone snail (Littorina angliofera). Mangrove snails were quite numerous (approximately 42 snails per tree) and were found near the water level staying just above the water.

The number of seedlings increased 667% from 1976 to 1979 (Figure 6).

There were an abundant variety of diatoms, protozoans, microinvertebrates and worms. It was calculated that the total number of microorganisms per tree was as follows:

Table 2

Diatoms	2.00×10^9
Protozoans	1.27×10^9
Microinvertebrates	1.81×10^8
Worms	3.62×10^7

Weber's (1971) Guide to the Common Diatoms was used to identify diatoms. Most genera described in Weber were represented in the population counts of diatoms from the *Bostrychia*.

DISCUSSION AND CONCLUSIONS

The red mangrove system is unique. A wide variety of macroorganisms live in and among the mangroves as well as visit the mangroves for food (Davis, 1940; Morton, 1965). Only recently have definitive studies of the contributions of red mangroves to the maintenance of environmental quality and a high productivity of desirable fisheries been undertaken (Heald and Odum, 1969; Heald, 1971; Morton, 1965; Odum, 1971).

Results of this study show that Bostrychia, which grows on living red mangrove prop roots, is a habitat for an impressive number of organisms. These organisms are also part of the complex food web, adding to the total productivity (Table 2) of the tropical esturine system of North Biscayne Bay.

It is impossible to return the Bay to its previous unspoiled and highly productive past for many reasons, a prime one being population and all its attendant problems. As more facts are gathered about the complex interdependency of the organisms of the Bay it will be easier for people to understand the necessity of restoring the nursery ground over much of the Bay. To restore the nurseries it will be necessary to restore the conditions needed to maintain them. Red mangroves are one of the most important factors - very productive not only of themselves (Heald, 1971), but also of other organisms such as *Bostrychia* and its epifauna. These other organisms thus greatly increase the basis of the food web of North Biscayne Bay.

By restoring these nurseries, the welfare of the dependent organisms will improve, as also will the welfare of humans who depend on these nurseries for their food.

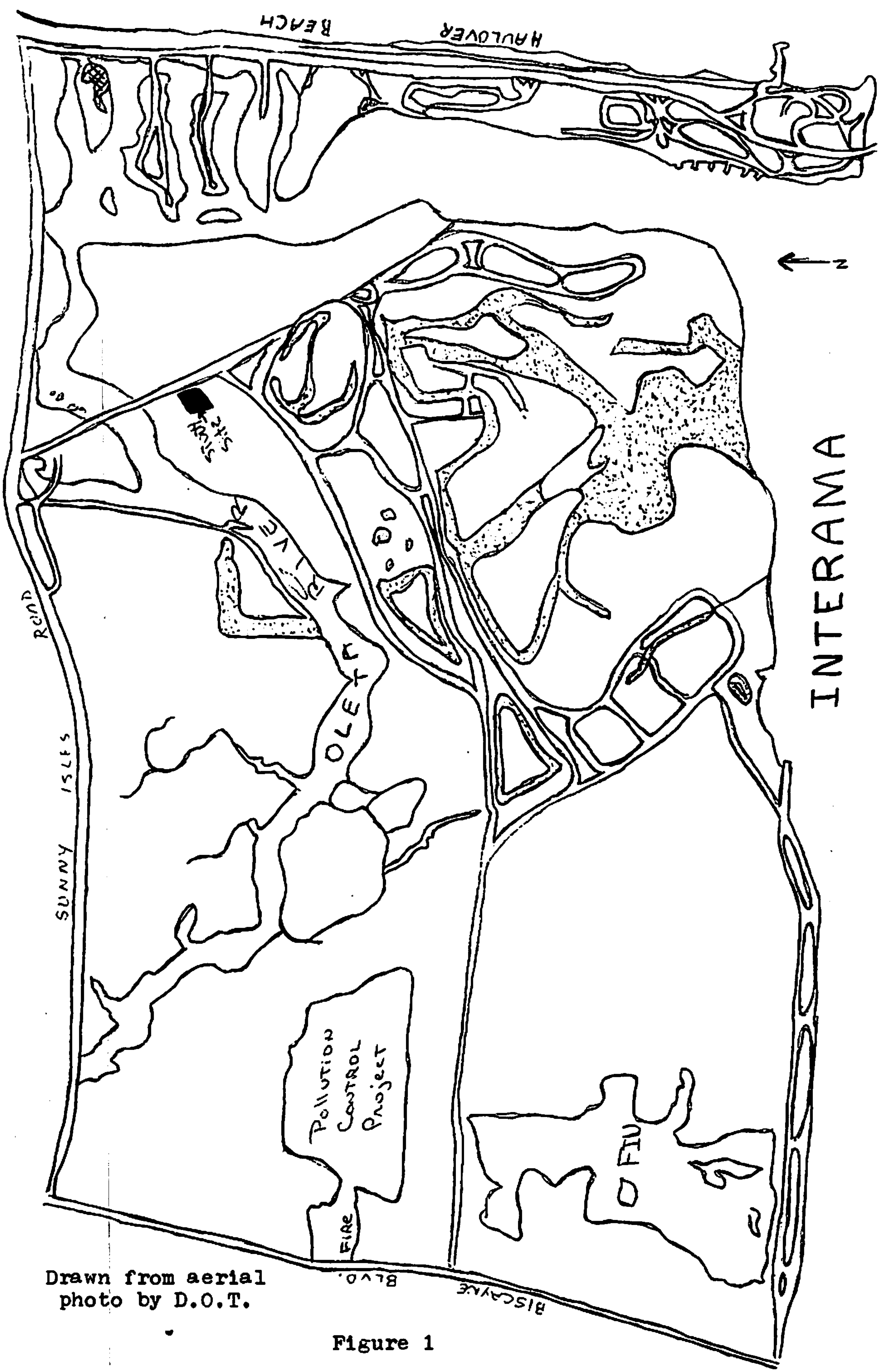
ACKNOWLEDGEMENTS

This study could not have been done without the generous help of the many students who slapped no-see-ums and sloshed around in the muck to collect data. I especially appreciated the efforts of Vicki Gollattscheck and David Vinciguerra who helped set up the study site and train others; Charlene McCormick for correlating and processing much of the data collected; Patty D'Orazio for reproducing the map of Interama. I wish to thank Terry Green and David Kleinman, fellow faculty members, for their patience, understanding, time , knowledge and for being there when I needed them. Finacial support for this work was provided by the participants and Miami Central Marine Biology Club. Sea Grant Sponsorship for publication of this study is greatly appreciated.

Table 1 Comparison of DBH and number of prop roots per tree in 1976 and 1979 to show the growth rate of red mangroves over a period of time.

Tree #	DBH in cm 1976	DBH in cm 1979	% DBH increase	Number of prop roots 1976	1979
1	15.0	15.7	4.7%	17	20*
3	11.3	11.8	4.4%	21	15*
5	4.9	5.8	18.4%	6	7
15	13.5	14.8	9.6%	18	18
19	11.3	12.3	8.8%	15	17*
20	9.0	9.2	2.2%	18	19*
21	8.4	9.1	8.3%	8	10
22	10.8	11.4	5.5%	14	15
24	9.6	10.5	9.4%	3	4
25	8.3	9.1	9.6%	22	24
27	15.9	18.8	18.8%	12	13
30	8.9	9.8	10.0%	7	18
33	20.4	22.4	9.8%	19	20*
34	7.9	8.7	10.1%	12	14
35	5.4	5.7	5.5%	1	2

*These were complex mangroves with more than one main trunk. Only the prop roots off the main trunk were counted.



Drawn from aerial
photo by D.O.T.

Figure 1

Figure 2 TREE LOCATION QUADRANT B 1974

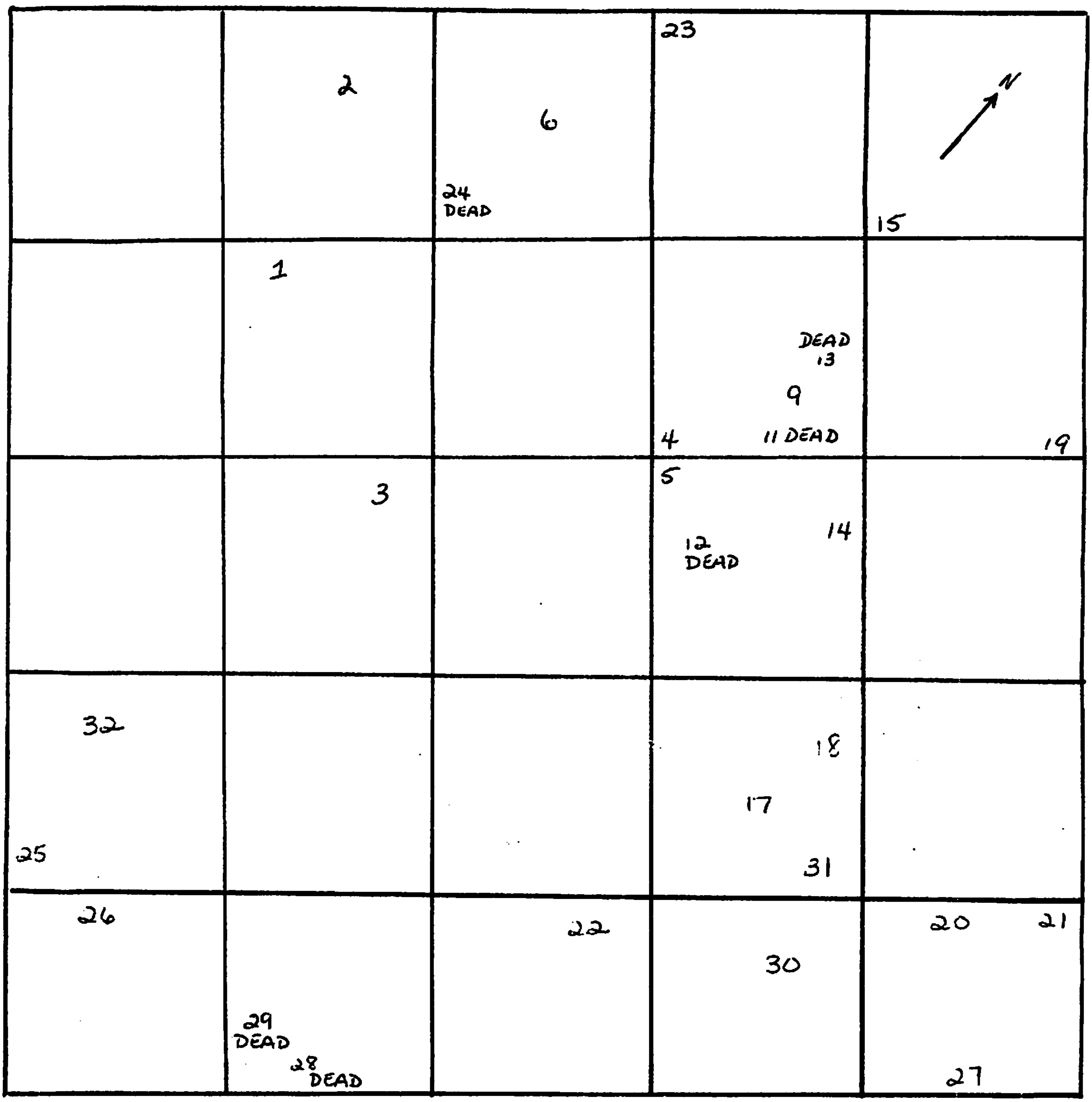


Figure 3 TREE LOCATION QUADRANT B 1976

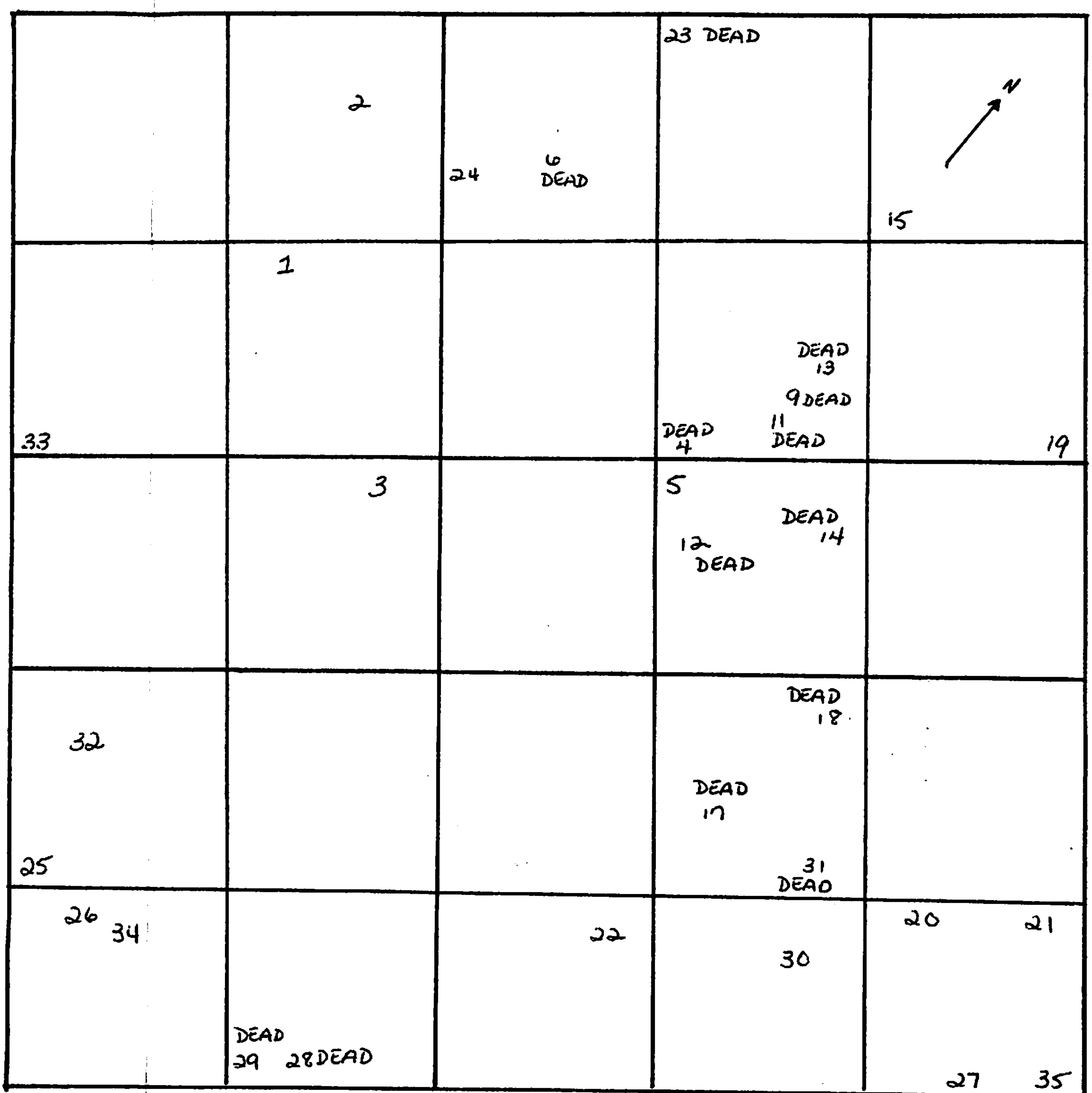


Figure 4 TREE LOCATION QUADRANT B 1979

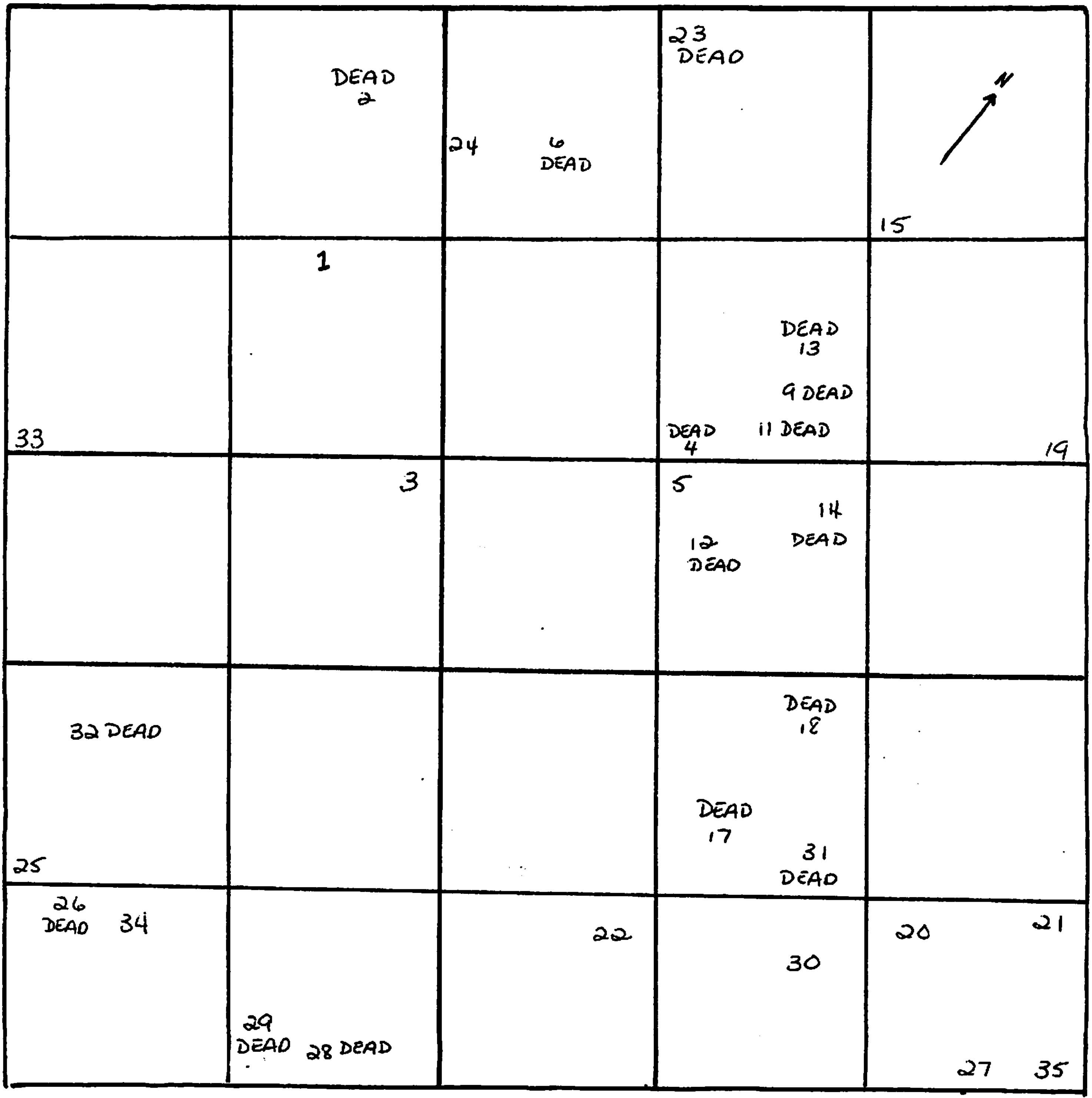


Figure 5 The number of trees that died over a period of 5 years in quadrant B

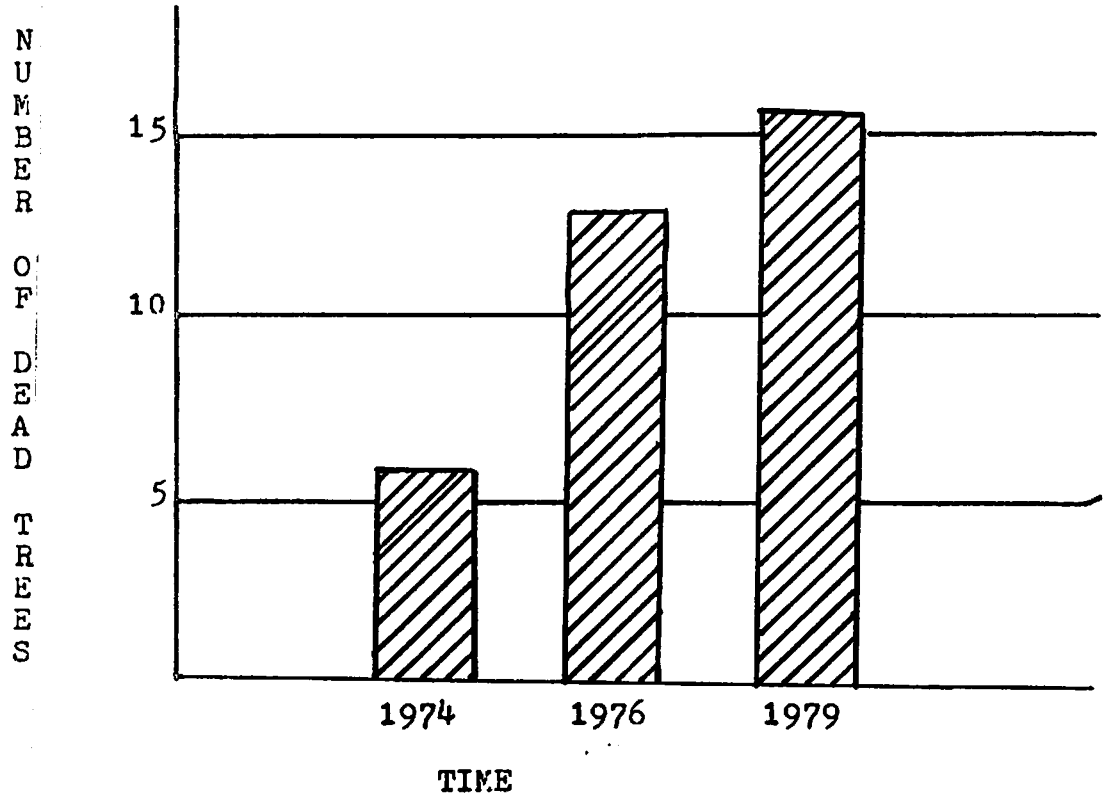
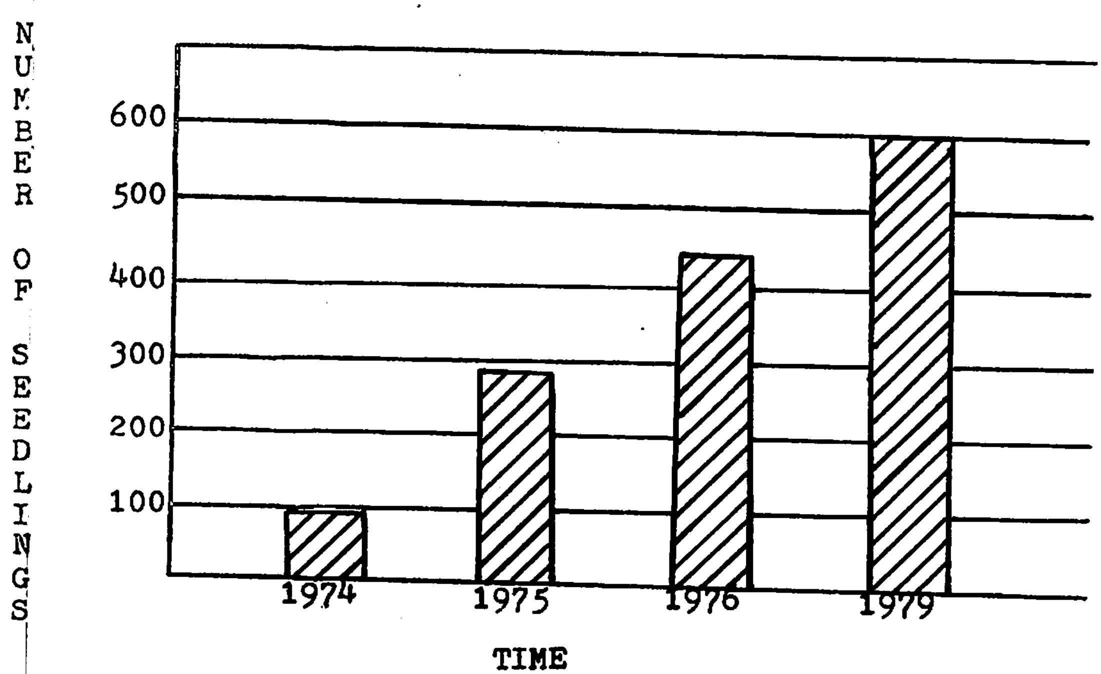


Figure 6 The number of seedlings over a period of 5 years in quadrant B



REFERENCES AND LITERATURE CITED

Brown, L.R., 1978, The Twenty-ninth Day (Accommodating Human Needs and Numbers to the Earth's Resources), W.W. Norton and Co. Inc., N.Y. pp 13-19.

Carlton, J.M., 1975, A Guide to Common Florida Salt Marsh and Mangrove Vegetation. Florida Marine Research Publication, No. 6 pp 22-23.

Craighead, F.C., 1964, Land, mangroves and hurricanes. Bull. Fairchild Tropical Gardens. 19: 1-28.

Davis, J.H., Jr., 1940, The ecology and geologic role of mangroves in Florida. Carnegie Institute. Wash. 32: 303-412.

de Sylva, D.P., 1970, Ecology and distribution of post-larval fishes of Southern Biscayne Bay, Florida. RSMAS, U. of Miami. Progress Report to the Environmental Protection Agency. Division of Water Quality Research, Water Quality Office, contract FWQA 18050 DIV 198 pp.

de Sylva, D.P., 1976, Ecology and distribution of post-larval fishes of Southern Biscayne Bay, Florida. RSMAS, U. of Miami. Final Report to the Environmental Protection Agency. Division of Water Quality Research, Water Quality Office, contract FWQA 18050 DIV 2nd In Preparation.

Eldred, B., C.R. Futch, and R.M. Ingle, 1972, Studies of juvenile spiny lobsters Panulieus argus, in Biscayne Bay, Florida. Special Report, Fla. Dept. of Natural Resources, Volume 35 15 pp.

Eldred, B., 1960, A note on the occurrence of the shrimp, Panaeus brasiliensis Latreille in Biscayne Bay, Florida. Quarterly Journal, Fla. Academy of Sciences, Volume 23 No. 2 pp 164-165

Hanlon, R., F. Bayer, G. Voss, 1975, Guide to the mangrove, buttonwood, and poisonous shoreline trees of Florida, the Gulf of Mexico, and the Caribbean Region. Sea Grant Field Guide Series, No. 3 Univ. of Miami Sea Grant Program.

Handbury, T.H., 1896, Report on the preliminary examination of Biscayne Bay. In: Notes on Biscayne Bay, Florida by H.M. Smith. U.S. Commission of Fish and Fisheries, Report of the Commission of Fish and Fisheries for the year ending June 30, 1895. Appendix 2 Part 21 pp 189-191.

Heald, E.J., 1971, Production of organic detritus in a South Florida estuary. Sea Grant Tech. Bull. No. 5 Univ. of Miami 11 pp.

Heald, E.J. and W.E. Odum, 1969, The Contribution of Mangrove Swamp to Florida Fisheries. Proc. Gulf and Carib. Fish Inst., 22nd Annual Session pp 130-135.

Heald, E.J., W.E. Odum, and D.C. Tabb, 1974, Mangroves in the estuarine food chain. Environments of South Florida: Present and Past. Miami Geological Soc. 2 pp 182-189.

Humm, H.J., 1976, Benthic Algae of Biscayne Bay. Biscayne Bay: Past/Present/Future. Special Report No. 5, Sea Grant, Univ. of Miami pp 71-93.

Idyll, C.P., D.C. Tabb and B. Yokel, 1968, The Value of Estuaries to Shrimp. Proc, Marsh and Estuary Mgt. Symposium, Louisiana State Univ. pp 83-90.

Kutkuhn, J.H., 1966, The Role of Estuaries in the Development of Commercial Shrimp Resources. Symposium Estuary Fish. Amer. Fish. Soc. Pub. 2 154 pp.

Low, R.A., 1973, Shoreline grassbed fishes in Biscayne Bay, Florida, with notes on the availability of clupeid fishes. M.S. thesis, RSMAS, Univ. of Miami 145 pp.

Lugo, A.E. and S.C. Snedaker, 1975, Properties of a Mangrove Forest in Southern Florida. Int. Symposium on Biol. and Management of Mangroves. Univ. of Fla. Press pp 170-212.

Miller, P.C., 1972, Bioclimate leaf temperature and primary production in red mangrove canopies in South Florida. Ecology, 53: 22-45.

Morton, J.F., 1965, Can the red mangrove provide food, feed and shelter? Econ. Bot., 19 pp 113-123.

Newell, G.E. and R.C. Newell, 1973, Marine Plankton, A Practical Guide. Hutchinson, Ltd., London.

Odum, W.E., 1971, Pathways of energy flow in a South Florida estuary. Sea Grant Tech. Bull. No. 7 Univ. of Miami 162 pp.

Pool, D.J., A.E. Lugo and S.C. Snedaker, 1975, Litter Production in Mangrove Forests of Southern Florida and Puerto Rico. International Symposium of Biol. and Management of Mangroves. Univ. of Fla. Press. pp 213-237.

Reyes-Vasquez, G., 1970, Studies on the diatom flora living on Thalassia testudinum. Konig in Biscayne Bay. Bull. Mar. Sci., 20: 105-134.

Sastrakusumah, S., 1971, A study of the food of juvenile migrating pink shrimp, Penaeus duorarum Burkenroad. Sea Grant Tech. Bull. No. 9 Univ. of Miami 37 pp.

Snedaker, S.C. and A.E. Lugo, 1973, The role of mangroves ecosystems in the maintenance of environmental quality and a high productivity of desirable fisheries. Bur. Sports Fish. Wildlife.

Tabb, D.C., D.L. Dubrow and R.B. Manning, 1962, The ecology of Northern Florida bay and adjacent estuaries. State of Florida Board of Conservation Technical Series #39, Institute of Marine Sci., Univ. of Miami 81 pp.

Taylor, W.R., 1960, Marine Algae of the Eastern Tropical and Subtropical Coasts of the Americas. Univ. of Mich. Press, Ann Arbor 870 pp.

Teas, H.J., 1974, Mangroves of Biscayne Bay. Mimeo, Dade County 107 pp.

Teas, H.J., 1976, Productivity of Biscayne Bay mangroves. Biscayne Bay: Past/Present/Future. Sea Grant, Special Report #5, Univ. of Miami pp 103-109.

Thorhaug, Anitra, Editor, 1976, Biscayne Bay: Past/Present/Future. Sea Grant Special Report #5, Univ. of Miami 314 pp.

Weber, C.I., 1971, A guide to the common diatoms at water pollution surveillance system stations. U.S. Environmental Protection Agency National Environmental Research Center, Analytical Quality Control Laboratory, Cincinnati, Ohio pp 101.