A Research Proposal Submitted To

U. S. Nuclear Regulatory Commission

HYDRODYNAMIC AND METEOROLOGICAL MEASUREMENTS OF HIGH WIND OVER SHALLOW WATER ALONG THE COAST OF FLORIDA

Submitted By

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Introduction

A program to monitor meterological parameters during hurricanes was initiated by the Coastal and Oceanographic Engineering (COE) Laboratory in 1976. The initial phase of this work was devoted to program philosophy and instrumentation development. The next stage was the construction and deployment of the instrumentation. Presently there are five operating stations along the east coast of Florida. This system was operational during Hurricane David (8/25/79) and was successful in obtaining the first nearshore storm surge and storm wave data. See "Memorandum on Data Obtained During Hurricane David (8/25/79 - 9/7/79) and Fredrick (8/29/79 - 9/14/79)" submitted to U.S. NRC under contract number NRC-04-76-175 on February 19, 1980.

This proposal describes the existing program (see Figure 1), discusses the importance and the need for this data, proposes research to be conducted this year and outlines four additional years of work.

There has been an increase in the awareness of the need for the data being obtained by this program. Perhaps the existence of a relatively inexpensive, reliable system for obtaining this badly needed data is in part responsible for this renewed interest.

The motivation and purpose for this work was presented in detail in earlier proposals so only a summary will be presented here.

Purpose

The potential destruction due to hurricanes is increasing at a rapid rate due to the ever increasing rate of construction in the coastal areas and due to the lack of adequate building codes and coastal construction control lines. Extreme sea state parameters such as maximum surge and extreme wave heights expected during a given time period are essential in coastal zone management planning. Hurricane meteorological and oceanographic processes are extremely complex. Thus, numerical models for storm surge and storm waves, by necessity, must contain many simplifying assumptions. Since the results from these models are used so extensively, it is essential that they be tested and calibrated with measured nearshore data. Storm evacuation routes, coastal construction control lines, building codes, insurance rates, designs of coastal and ocean structures, etc. are all based on numerically predicted extreme sea state values.

Instruments for measuring waves and tides under ordinary conditions have an extremely low probability of surviving hurricane conditions and the data from those few that have is very questionable. To the best of the author's knowledge the wave data obtained during hurricane David is the first nearshore storm wave data in existence. Some offshore oil companies are known to have deep water storm wave data measured from platforms, but this data is preparatory. Hurricane instrumentation must be carefully designed and strategically located if it is to withstand the extreme forces generated during severe storms.

The criteria used in designing the University of Florida system was: "Design the lowest initial and maintenance cost system that would reliably measure and record storm surge and storm wave data and survive." The system's survivability under hurricane conditions was tested for the first time during Hurricane David. As stated above, it was a complete success.

The closer the instrumentation is to the path of the hurricane center, the more valuable the data. The drop off in value with distance from the center depends on such hurricane parameters as intensity, radious to maximum winds, etc., such local parameters as bathemetry and the numerical model to be calibrated and verified. A method for estimating the quality or usefulness of the measured data based on these quantities would be most useful.

In addition, a study is needed to establish the minimum quantity and quality of data needed to adequately verify and calibrate the more promising numerical models. If the NRC is interested, a separate proposal to investigate these two topics will be written and submitted for consideration.

It is clear, however, that data for a range of hurricane intensities from locations with widely differing continental shelves is needed. In this respect Florida is a perfect testing ground since 1) its coast is very susceptible to hurricanes (see Figure 2) and 2) there is a wide variation in its offshore bathemetry ranging from very narrow steep slopes along the lower east coast to a wide flat continental shelf on its west coast.

The cost of hurricane damage from a number of past hurricanes is given in Tables 1 and 2*. As pointed out earlier, the same hurricane striking the same location would be much more costly today due to increased population and construction in those areas. If only a small fraction of the damange and loss of lives could be prevented by better predictive models, the cost of hurricane research would be recovered many times.

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*Taken from NOAA Technical Memorandum NWS NHC 7, August 1978.

Existing System

The existing system can be divided into two categories, the coastal data network and the hurricane field crew operation.

With funding from the U.S. Nuclear Regulatory Commission and the State of Florida, the COE Department at the University of Florida developed, over the past four years, a system for measuring storm surge, storm wave and ambient wave and tide conditions at a number of sites along the coast of Florida. For a detailed description of this unique system see Howell, G. L. (1978); "A Micro-Processor Based Underwater Data Acquisition System", UFL/COEL/TR/038, . (Also Howell, G. L., "Florida Coastal Data Network", to be presented at the 17th International Conference on Coastal Engineering in Sydney, Australia, March 1980.) At present there are five operating stations along the east coast (see Figure 1). A directional array installed off Clearwater on the west coast of Florida will be fully operational soon (operational in storm mode only at this time). Sea Grant provided funding for the Clearwater station.

Each station is comprised of: a steel tripod structure located on the bottom in approximately 30 feet of water about 3,000 feet from shore, an underwater instrumentation package (referred to here as the Florida Underwater Package) attached to the tripod and a shore station which connects the cable leading from the instrumentation package to a telephone line. The central data acquisition computer is located at the Coastal Engineering Laboratory in Gainesville. By simply calling a station, real time wave data at that location can be recorded by the central computer. The underwater instrument package contains a programmable microprocessor and is capable of recording data internally on a cassette tape, when conditions warrant. This is the mode of operation during a severe storm or hurricane since under these conditions the cable and the telephone line will most likely be destroyed. The system can be placed in "storm mode" either from Gainesville or from the shore station. Some of the stations have been operational for a period of two years and the reliability of the system has been remarkable.

New shore stations have been designed and one has been built and is presently being tested. This system will significantly add to the capabilities and substantially reduce telephone costs. Among other things, the new shore station will be able to turn on the instrument package at pre-determined intervals, perform some preliminary data reduction operations (calculate signficant wave height, etc.) record the data and then transmit this information to Gainesville at high data rates in the evening when telephone rates are less expensive. It should be noted that daily tide data is important even to those interested only in storm surge. The componenet of the surge due to the storm can only be obtained if the ambient tide is known. Most existing tide data is from gages located on bays, waterways, etc.connected to the ocean by tidal inlets. The relationship between the tide 3,000 feet offshore and these points is not well understood and is a research subject itself.

A team composed of selected laboratory personnel has been equipped and trained to place instrumentson shore in the path of oncoming hurricanes. This is far more difficult than might be expected. Our inability to accurately predict the path of a hurricane and thus the point of landfall makes this task very difficult. Once landfall is relatively certain there is little time for the field crew to reach that point, place the instruments and pull out to a safe location. Under the very adverse conditions at that time, high winds, heavy rains, difficulty of entering a region being evacuated, etc., it is difficult to know where and at what elevation to place the instruments.

The following procedure has evolved over the last three years and appears to work satisfactorily. Approximately twenty-four hours prior to the anticipated landfall the field crew is assembled and deployed with instruments and survival equipment to a point on a major highway near the point of anticipated landfall. The hurricane location, direction, intensity, etc. as reported by NOAA National Weather Service in Miami is monitored at the central control station in Gainesville and this information is communicated to the field crew. The central station personnel has access to detailed aerial photographs, beach surveys, topography cahrts, etc. (from COE and Florida Department of Natural Resource files) for the populated shoreline of Florida. As the eye of the hurricane approaches the photographs and charts for that area are examined carefully for possible instrument locations. When it appears certain that the hurricane will make landfall at a particular point, detailed information regarding instrument location is communicated to the field crew leader. In many cases the precise power pole, building, etc. for locating the instrument is given; in other cases only the street name and the instrument elevation. There are many important decisions that must be made by the field crew leader regarding placement of the instruments and the safety of the crew. The field crew leader must truly be an experienced and responsible person. After the instruments have been installed the field crew evacuates to a predetermined point and waits out the storm. When the storm has passed the crew returns to the area and surveys the instruments using Florida Department of Natural Resources benchmarks.

The instruments placed by the field crew consist of wind anemometers and maximum level recorders. At present two anamometers are installed on the coast near the predicted path. As many maximum level recorders as time allows are installed along and normal to the coast. A more detailed description of these instruments is given in the Hurricanes David and Fredrick data reports.

Program Proposed for 1980

A number of agencies have expressed interest in this program and some have promised funding beginning in 1980. A brief description of the total effort proposed for 1980 will be given followed by a more detailed description of that proposed to the U.S. Nuclear Regulatory Commission. First and foremost in importance is the continuation of the existing system, i.e., the maintenance of the system as it exists today. Second, the station at Jacksonville, Florida should be completed making a total of six stations on the east coast. The hardware and permits exist, only the installation remains. Next, a field station should be installed in the vicinity of Charlotte Harbor, perhaps off one of the barrier islands in that vicinity. Next, a station should be established in the general vicinity of Steinhatchee, Florida, north of Cedar Key. After discussions with Dr. Garcia at the Waterways Experiment Station it has been decided that stations with direct communication links with shore (by cable or telemetry) are desirable over the so-called uncabled systems. This system is more expensive but there is a higher probability of obtaining data during a hurricane. There is also the added advantage of being able to monitor ambient tides and waves during normal conditions.

The Waterways Experiment Station has expressed interest in and has given verbal commitment to the funding of a portion of the existing operation and to the placement of a station at Steinhatchee. This proposal to the U.S. Nuclear Regulatory Commission is therefore for partial support of the existing operation and for the construction and deployment of a station in the vicinity of Charlotte Harbor.

There are many factors involved in the selection of a field station site, some theoretical some practical. Possible sites include points off the barrier islands in that area such as Captiva and the mainland to the north and south. As a result of the very wide and flat continental shelf on the west coast of Florida depths of 25 to 30 feet are located from 3 to 6 miles offshore. The economic analysis comparing cable systems to telemetry systems is not yet completed, but it is likely that the telemetry system will prove most feasible. If this is the case, a tripod will be placed in approximately 25 feet of water similar to those on the east coast and the Florida Underwater Package cabled to a small platform or buoy located near the tripod in water of less depth. A solar panel placed on the tower will provide power for charging the batteries and for transmitting ambient wave and tide data. A transceiver at the shore station will connect the underwater package to a telephone line and then to the computer in Gainesville.

Once again the advantages of this system are: 1) by using the system daily and knowing that it is functioning properly the chance of obtaining storm data is enhanced and 2) wave and tide data under normal conditions can be obtained. As pointed out earlier ambient tide data is needed so that the storm can be extended from the total elevation measurements during a hurricane.

A data report will be submitted after each hurricane. To expedite the submission of data from Hurricanes David and Fredrick a memorandum containing approximately 85% of the reduced data was submitted first. The report will be submitted as soon as the data reduction is completed. The data format will be approximately that used for the memorandum but of higher quality.

Also included in the work proposed for 1980 is the updating of the bibliography on existing storm surge models started by Dr. Latif (former University of Florida research faculty).

Program Proposed for 1981-1984

There are several meteorological and oceanographic parameters that need to be measured during the land fall of a hurricane. These include: wind magnitude and direction, a time series record of the water elevation onshore, barometric pressure, current magnitude and direction, wave direction and a number of lesser important quantities. As with the 1980 project however, the first priority is to maintain the existing system. The funding requested from the U.S. Nuclear Regulatory Commission for the years 1981 through 1984 will be used in conjunction with funding from other agencies to maintain the existing system and to acquire and reduce hurricane data when hurricanes occur. Funds to establish additional stations off the west coast of Florida will be sought from other agencies (see Figure 1). Funds to develop and/or purchase additional instruments to monitor the above mentioned parameters will also be sought from other agencies. As always the entire data set from these measurements will be reported to the U.S. Nuclear Regulatory Commission. Funds will also be sought to use the existing and future data to calibrate and verify the most noteworthy of the numerical models in the public domain.

1980 Budget

Salaries

D. M. Sheppard, P. I.	5%/6 mos.	$ 852
G. L. Howell, Co-P.I.	20%/6 mos.	2,041
Scientific Programmer	40%/6 mos.	2,848
Engineer II	50%/6 mos.	3,560
Engr Tchn III	50%/6 mos.	2,553
Lab Mech Mach II	50%/6 mos.	3,028
Elect Tchn II	30%/6 mos.	1,973
Lab Supv II	20%/6 mos.	1,503
Illustrator II	10%/6 mos.	558
Clerk Typist III	5%/6 mos.	192
Graduate Asst	33%/6 mos.	2,262
	Total Salaries	$21,370
	Fringe Benefits	3,786
	Total Salaries & Fringe Benefits	$25,156

OCO	1,708

Expense

Electronics Component Expense	4,500
Materials for Tripod and Tower	3,000
Travel (Vehicle expense, per diem, etc.)	15,000
Expendable supplies	2,600
Publication costs	500
Total Expense	$25,600
Indirect Costs (44.4% of MTDC)	22,536
Total	$75,000

1981 Budget

Salaries

D. M. Sheppard, P.I.	5%/12 mos.	$ 1,874
G. L. Howell, Co-P.I.	15%/12 mos.	3,367
Scientific Programmer	20%/12 mos.	3,133
Engineer II	20%/12 mos.	3,133
Engr Tchn III	20%/12 mos.	2,246
Lab Mech Mach II	20%/12 mos.	2,664
Elec Tchn II	20%/12 mos.	2,894
Lab Supv II	10%/12 mos.	1,653
Illustrator II	10%/12 mos.	1,227
Clerk Typist III	5%/12 mos.	423
	Total Salaries	$22,614
	Fringe Benefits	4,349
	Total Salaries & Fringe Benefits	$26,963

OCO

OCO	524

Expense

Electronics Components Expense	1,000
Travel	5,000
Expendable Supplies	1,000
Publications Costs	300
Total Expense	$7,300
Indirect Costs (44.4% of MTDC)	15,213
Total	$50,000

1982-1984 Budgets	Amount Requested Per Year	$50,000
	Total 5 year proposed budget	$275,000

TABLE I

The deadliest United States hurricanes of this century.

DEADLIEST HURRICANES, UNITED STATES 1900-1977
(40 or more deaths)

	HURRICANE	YEAR	CATEGORY	DEATHS
1.	Texas (Galveston)	1900	4	6000
2.	Florida (Lake Okeechobee)	1928	4	1836
3.	Florida (Keys/S. Texas)	1919	4	600-900#
4.	New England	1938	3*	600
5.	Florida (Keys)	1935	5	408
6.	AUDREY (Louisiana/Texas)	1957	4	390
7.	Northeast U.S.	1944	3*	390@
8.	Louisiana (Grand Isle)	1909	4	350
9.	Louisiana (New Orleans)	1915	4	275
10.	Texas (Galveston)	1915	4	275
11.	CAMILLE (Miss./La.)	1969	5	256
12.	Florida (Miami)	1926	4	243
13.	Diane(Northeast U.S.)	1955	1	184
14.	Florida (Southeast)	1906	2	164
15.	Mississippi/Alabama/Pensacola	1906	3	134
16.	AGNES (Northeast U.S.)	1972	1	122
17.	HAZEL (South Carolina/N.C.)	1954	4*	95
18.	BETSY (Fla./La.)	1965	3	75
19.	CAROL (Northeast U.S.)	1954	3*	60
20.	Southeast Florida/La.-Miss.	1947	4	51
21.	DONNA (Fla./Eastern U.S.)	1960	4	50
22.	Georgia/Carolinas	1940	2	50
23.	CARLA (Texas)	1961	4	46
24.	Texas (Velasco)	1909	3	41
25.	Texas (Freeport)	1932	4	40
26.	South Texas	1933	3	40
27.	Hilda (Louisiana	1964	3	38
28.	Louisiana (Southwest)	1918	3	34
29.	Florida (Southwest)	1910	3	30
30.	CONNIE (North Carolina)	1955	3	25
31.	Louisiana (Central)	1926	3	25

* Moving more than 30 miles per hour.
\# Over 500 of these lost on ships at sea.
@ Some 344 of these lost on ships at sea.

ADDENDUM

Louisiana	1893	-	2000
South Carolina/Georgia	1893	-	1000-2000
Georgia/South Carolina	1881	-	700

TABLE 2

The costliest United States hurricanes of this century.

COSTLIEST HURRICANES, UNITED STATES 1900-1977
(More than $50,000,000 damage)

HURRICANE	YEAR	CATEGORY	DAMAGE (U.S.)
1. AGNES (Northeast U.S.)	1972	1	$2,100,000,000
2. CAMILLE (Miss./La.)	1969	5	1,420,700,000
3. BETSY (Fla./La.)	1965	3	1,420,500,000
4. DIANE (Northeast U.S.)	1955	1	831,700,000
5. ELOISE (Northwest Fla.)	1975	3	550,000,000#
6. CAROL (Northeast U.S.)	1954	3*	461,000,000
7. CELIA (S. Texas)	1970	3	453,000,000
8. CARLA (Texas)	1961	4	408,000,000
9. DONNA (Fla./Eastern U.S.)	1960	4	387,000,000
10. New England	1938	3*	306,000,000
11. HAZEL (S.C./N.C.)	1954	4*	281,000,000
12. DORA (Northeast Fla.)	1964	2	250,000,000
13. BEULAH (S. Texas)	1967	3	200,000,000
14. AUDREY (La./Tex.)	1957	4	150,000,000
15. CARMEN (Louisiana)	1974	3	150,000,000
16. CLEO (Southeast Fla.)	1964	2	128,500,000
17. HILDA (Louisiana)	1964	3	125,000,000
18. Florida (Miami)	1926	4	112,000,000
19. Southeast Fla./La.-Miss.	1947	4	110,000,000
20. Northeast U.S.	1944	3*	100,000,000+
21. BELLE (Northeast U.S.)	1976	1	100,000,000
22. IONE (N. Carolina)	1955	3	88,000,000
23. Southwest and Northeast Fla.	1944	3	63,000,000
24. Southeast Florida	1945	3	60,000,000
25. Southeast Florida	1949	3	52,000,000+

* Moving more than 30 miles per hour.
\# Includes $60,000,000 in Puerto Rico.

EXISTING and PROPOSED COASTAL DATA NETWORK FIELD STATIONS

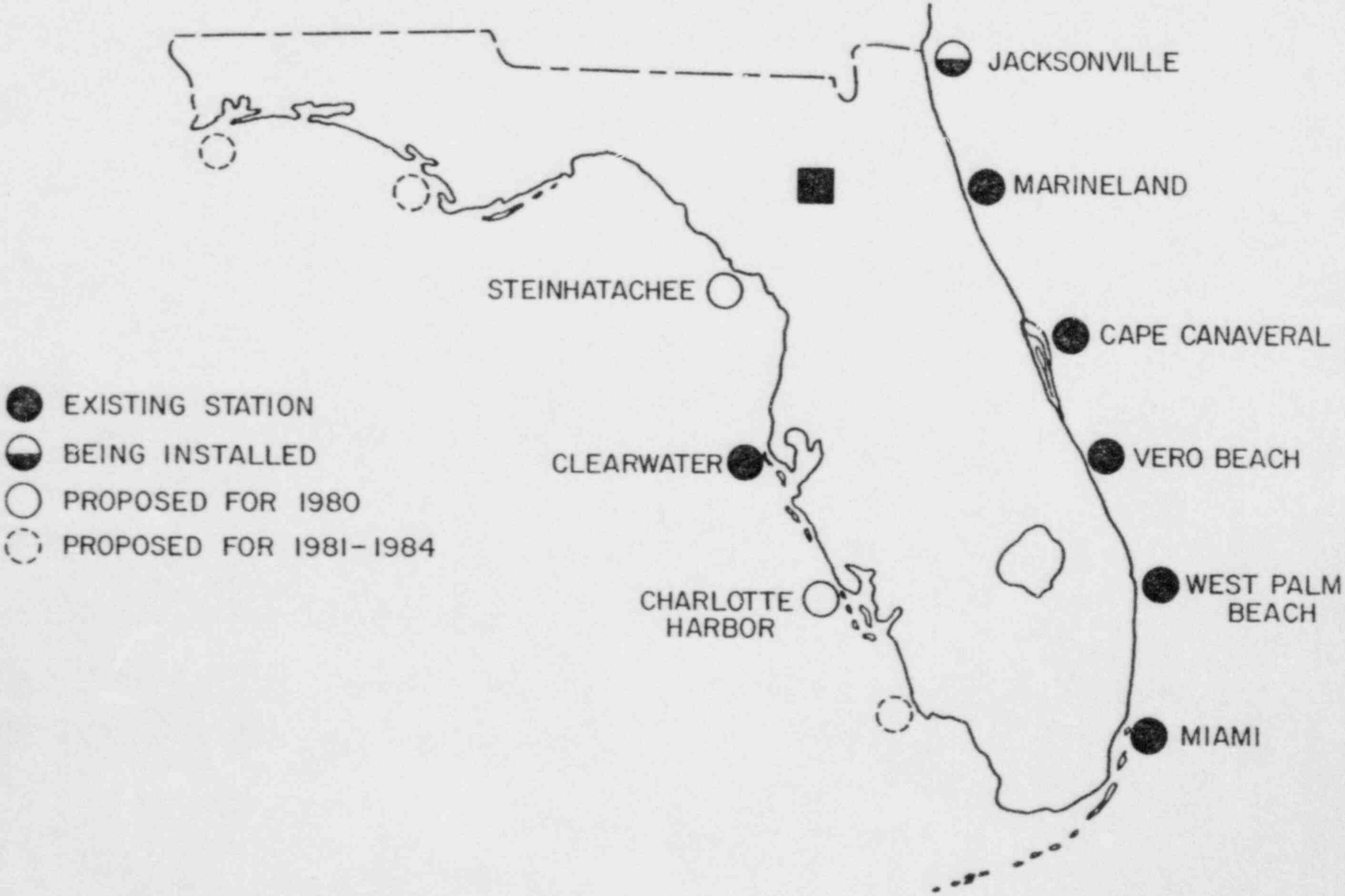


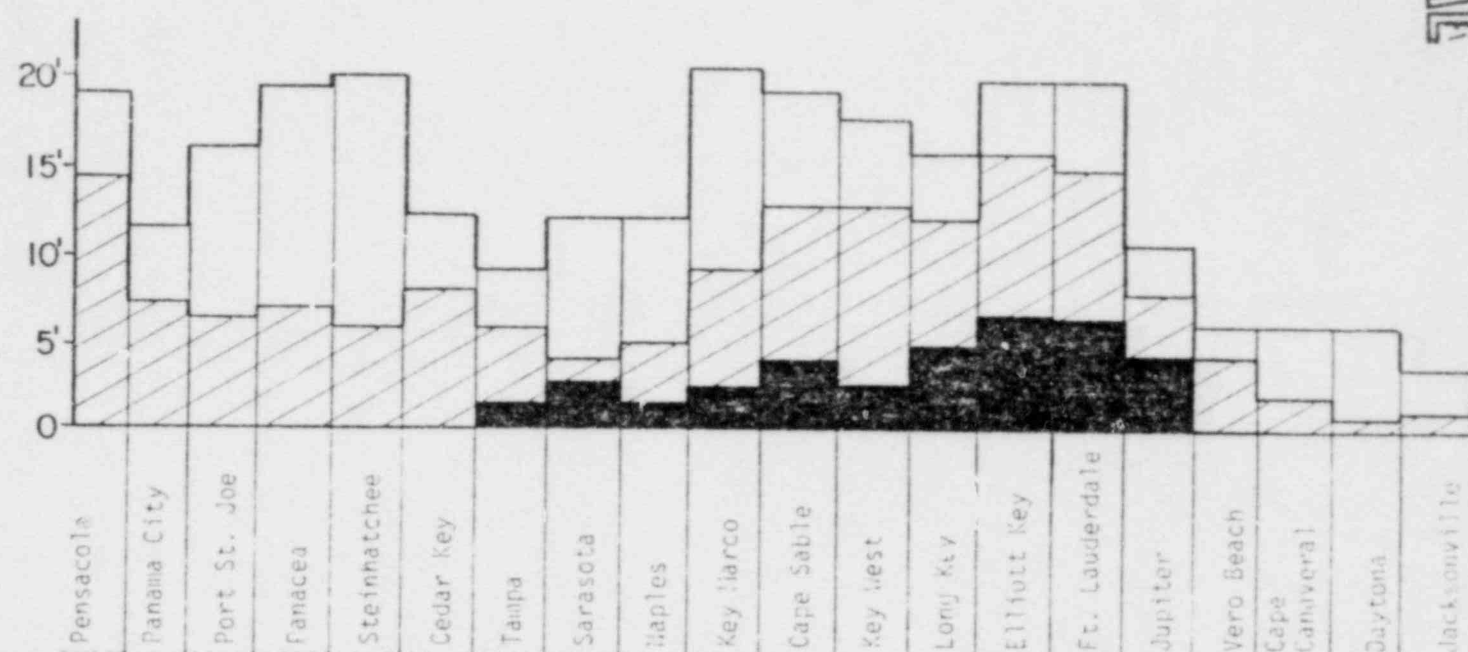
FIGURE 1

"All areas of Florida have experienced at least one hurricane during this century. The question then is the degree to which each area of the State can expect to be hit by a hurricane.

Probability of occurrence is based on long-term trends established by historical data. This is an imprecise method of forecasting but the only one available at the present. This figure describes in histogram form the percentage probability that a tropical storm (40 - 73 mph winds), hurricane (74+ mph), or great hurricane (125+ mph)* will occur in a 50 mile segment of the Florida coastline."

FIGURE 2

PROBABILITY THAT A TROPICAL STORM, HURRICANE OR GREAT HURRICANE WILL OCCUR IN ANY ONE YEAR IN A FIFTY MILE SEGMENT OF THE COASTLINE



	Pensacola	Panama City	Port St. Joe	Panacea	Steinhatchee	Cedar Key	Tampa	Sarasota	Naples	Key Marco	Cape Sable	Key West	Long Key	Elliott Key	Ft. Lauderdale	Jupiter	Vero Beach	Cape Canaveral	Daytona	Jacksonville
all tropical storms (40+ mph)	19	11	16	19	20	12	9	12	12	21	19	18	16	20	26	11	7	7	7	4
all hurricanes (70+ mph)	14	7	6	7	6	8	6	4	5	9	13	13	12	16	15	8	5	2	1	1
all great hurricanes (125+ mph)	0	0	0	0	0	0	1	2	1	2	4	2	5	7	7	5	0	0	0	0

SOURCE: Simpson, R. H. and Miles B. Lawrence, Atlantic Hurricane Frequencies Along the U. S. Coast, NOAA Technical Memorandum, NWS SR-58, Fort Worth, June 1971.

Quote and Figure taken from Hazard Analysis Florida Division of Disaster Preparedness, 1977.

*While the Saffir/Simpson Scale defines a "major" hurricane as one having winds greater than 111 mph, the probability statistics are based on Simpson and Lawrence's definition of "great hurricane", that being one with winds greater than 125 mph.

POOR ORIGINAL