FLORIDA COASTAL DATA NETWORK

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1. INTRODUCTION

The application of wave and tide data to coastal engineering problems has been demonstrated frequently by university and government research organizations. However, problems faced by practicing coastal engineers are often solved without recourse to such data, since it is frequently not available for the required location. The high cost and low reliability of long term wave measurement is the primary factor limiting the wider application of analysis techniques requiring wave energy and wave direction parameters. In order to improve this situation several organizations, notably the Army Corps of Engineers, Coastal Engineering Research Center (CERC), Peacock (1974), and the California Department of Navigation and Ocean Development, Seymour (1976), have employed advanced electronics and computer techniques to reduce the cost of wave measurement. The Florida Coastal Data Network (CDN) is a similar effort which due to the special problems of Florida wave climate has employed advanced instrumentation not only to reduce cost, but to provide additional capability. Like other tropical and sub-tropical regions, Florida's coastal environment is characterized by relatively infrequent but severe tropical storms. In many coastal engineering applications, the specification of the hurricane-associated storm surge and storm waves will be the major design criteria. The Florida CDN was created in order to provide field measurements of waves and tides year-around as well as during hurricanes.

A measurement program of this nature must respond to both the immediate needs of practicing engineers as well as to research needs. Since it is unrealistic to hope for measurements of hurricane conditions at every location, the long term goal of research is to produce better models of storm waves and surge. Field measurements are required to assist in the formulation and validation of models. In the near term, actual measurements of both normal and severe waves and tides are the most reliable design input for the shallow and intermediate water depths.

Unfortunately, the severity of hurricanes, which makes them of interest to coastal engineers, also creates problems for instruments. Very few standard instrumentation installations have survived hurricanes. Most successful hurricane wave measurements have been made by either large, deep water buoys or from oil production platforms in intermediate or shallow water depths. Most tide records of storm surge are from sheltered gages in bays or estuaries. Since large, offshore structures such as oil platforms are unavailable in Florida coastal waters, other strategies were investigated. Mounting instruments on existing piers was rejected due to the historically low survivability of such structures. Consistent with the low cost goals, a completely bottom-mounted instrument in a survivable structure was chosen. In order to gain as much benefit as possible from the high cost of installing and maintaining an installation, multiple purposes were defined. Each station was required to transmit wave and tide data over telephone lines to a central location. Additionally a self-contained power and recording capability was required for hurricane conditions.

Measurement sites were chosen at approximately equally spaced intervals around the coast (Figure 1). Specific locations were determined by considerations such as regular bathymetry, absence of nearby obstructions or inlets, and logistics. A target water depth of ten meters was specified in order to guarantee survivability during storm conditions and to provide measurements in the transition region between deep and shallow water. This water depth generally corresponds to distances of about one kilometer offshore on the East coast and over two kilometers on the Gulf coast.

2. INSTRUMENTATION

Absolute reading pressure transducers are bottom mounted on a completely self-contained electronics cylinder. The cylinder contains a microcomputer controlled data acquisition system (Howell, 1978) which can operate according to an internally stored program or upon commands received from shore. The shore connection supplies power to continuously charge internal batteries as well as two-way data communications using a standard computer interface (Figure 2).

A digital cassette recorder controlled by the microcomputer completes the underwater instrumentation.

The instrument cylinder is mounted inside a large steel tripod which is anchored at each apex to steel pipes jetted into the bottom sediment. The cylinder may be easily installed or removed by divers (Figure 3).

Two types of shore boxes are available. The first, a real time shore station, consists of a power supply and a telephone connected modem (Figure 4). Using the shore box, a central computer in Gainesville may interrogate the underwater microcomputer, and record a time series of water pressure in real time. The second type of shore box, the

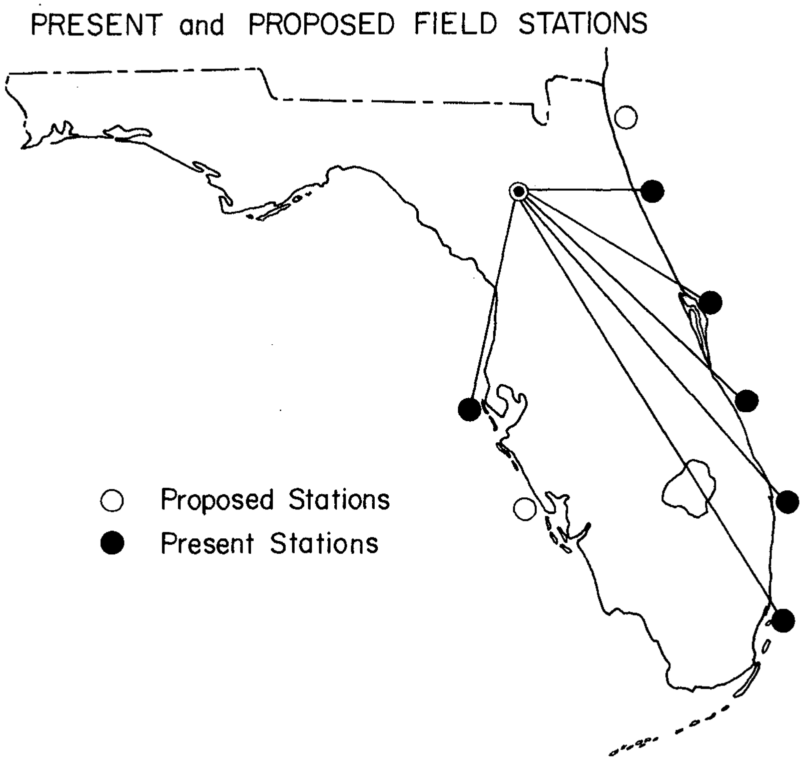

PRESENT and PROPOSED FIELD STATIONS
Proposed Stations
Present Stations

Figure 1

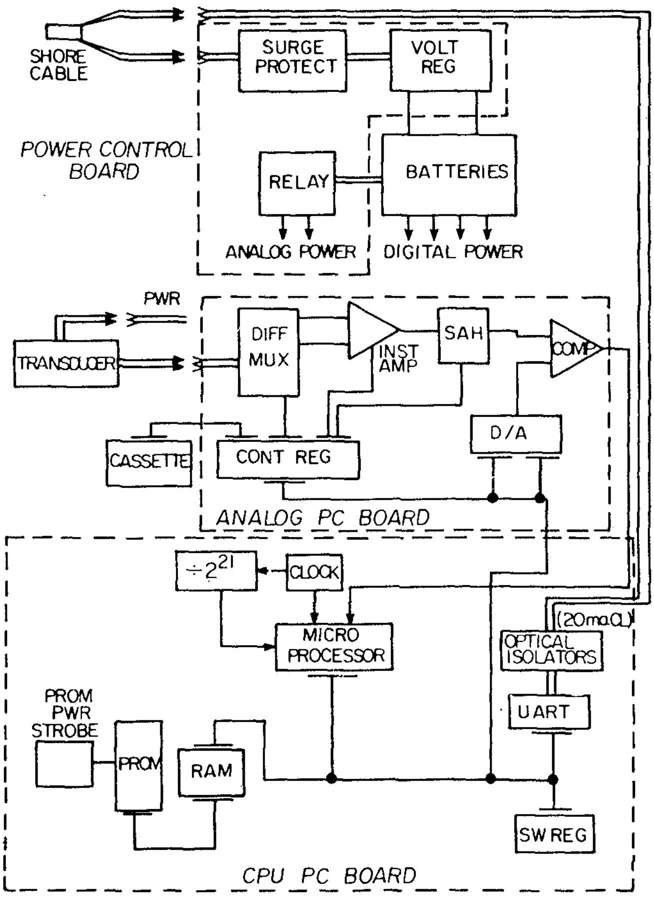


Figure 2
Block Diagram of Underwater Data Acquisition System.

Figure 3
Dry run of instrument installation in underwater tripod mount. Note top retaining plate in foreground and anchoring pipes at apexes.

REAL TIME SHORE STATION

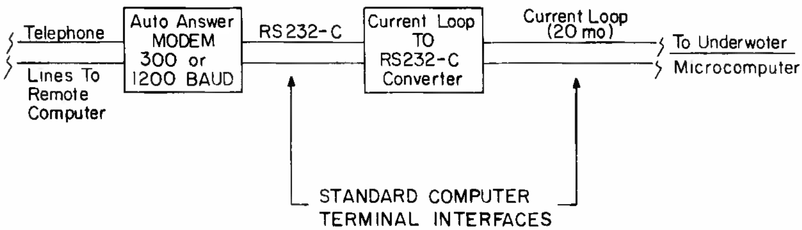


Figure 4

buffered data shore station, consists of a high performance microcomputer with 0.5 megabytes of disc storage, and a high speed modem (Figure 5). This shore station may be programmed to record data internally at scheduled intervals and has a limited analytical capability to record more data when certain parameters exceed a preset threshold. It is primarily employed to reduce long distance telephone charges by as much as a factor of 50 over the real time station.

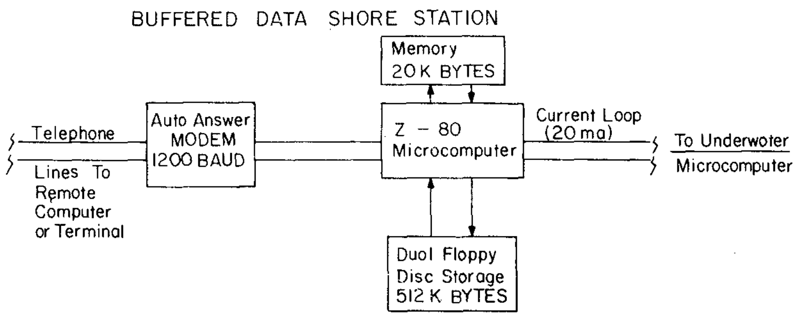
At present, all CDN stations are programmed to operate in two modes. The first, a field station mode, allows data to be recorded in Gainesville over standard dial-up telephone lines. During these calls, a complete check of the underwater system is carried out by inspecting status indicators and exercising test routines. The second, called storm mode, is entered on command from Gainesville. Once entered, the underwater microcomputer automatically records (on the internal cassette) a seventeen minute data record and a four minute data record every hour for six days. The long and short records are spaced to give equal off-times during the hour. Once storm mode has been entered, data recording will continue even if the shore station and cable are lost.

3. DATA ANALYSIS

Just as important in reducing costs as a wave gage system are the data analysis techniques employed. Spectral analysis by digital computer has made a significant contribution to cost reduction, however most real systems still require significant time from skilled technicians to process all data records. This is due to inevitable errors and artifacts inherent in any instrumentation system. For the CDN a significant effort has been made to automate data analysis, achieving a goal that 90% of all records are analyzed without human intervention, and a minimum amount of effort required for the remainder.

The central computer at Gainesville can generate power spectra statistics of any recorded file immediately after the data has been recorded. This capability is useful for applications requiring real time data for operational purposes or in following the development of storms. A sample report output is shown in figure 6.

Figure 7 shows the routine procedure used for acquiring daily data from each station. Monthly summaries of recorded data are produced regularly and spectrally analyzed data are stored in archival files for long term statistical analysis.


BUFFERED DATA SHORE STATION
Memory
20K BYTES
Auto Answer
MODEM
1200 BAUD
Telephone
Lines To
Remote
Computer
or Terminal
Z - 80
Microcomputer
Current Loop
(20 ma)
To Underwater
Microcomputer
Dual Floppy
Disc Storage
512 K BYTES

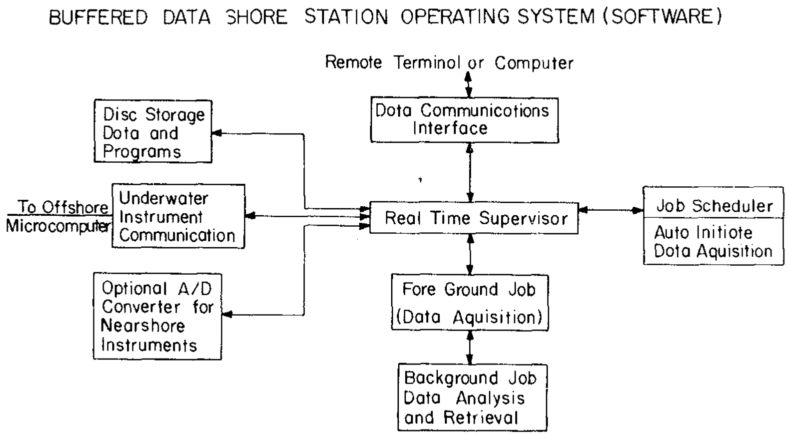

BUFFERED DATA SHORE STATION OPERATING SYSTEM (SOFTWARE)
Remote Terminal or Computer
Data Communications
Interface
Disc Storage
Data and
Programs
To Offshore
Microcomputer
Underwater
Instrument
Communication
Real Time Supervisor
Job Scheduler
Auto Initiate
Data Aquisition
Optional A/D
Converter for
Nearshore
Instruments
Fore Ground Job
(Data Aquisition)
Background Job
Data Analysis
and Retrieval

Figure 5

COASTAL DATA NETWORK
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WAVE DATA ANALYSIS REPORT FORMAT B VERSION I.2
POWER SPECTRUM

FILENAME	STATION	JULIAN DAY	YEAR	LOCAL TIME
M8A31F	MARINELAND	304	1978	6:47

TIME SERIES STATISTICS (CM)

AVG	MIN	MAX	RMS
1079.003	961.339	1195.182	37.518

SPECTRAL STATISTICS CORRECTED TO WATER DEPTH

MEAN (CM)	TOTAL ENERGY (CM-CM)	S.D. (CM)
1079.114	2283.146	47.782

SPECTRAL PEAK (HZ)	SWH (CM)
0.109	131.129

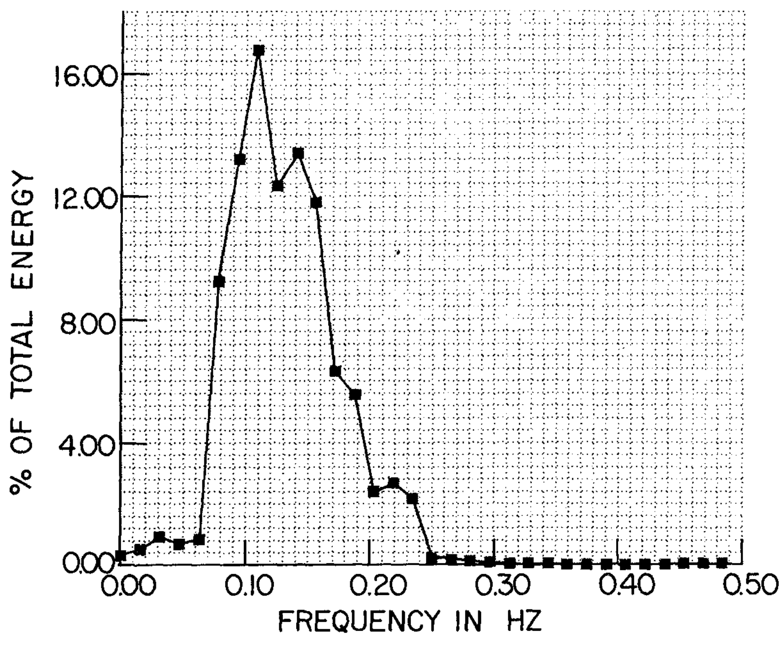

Figure 6

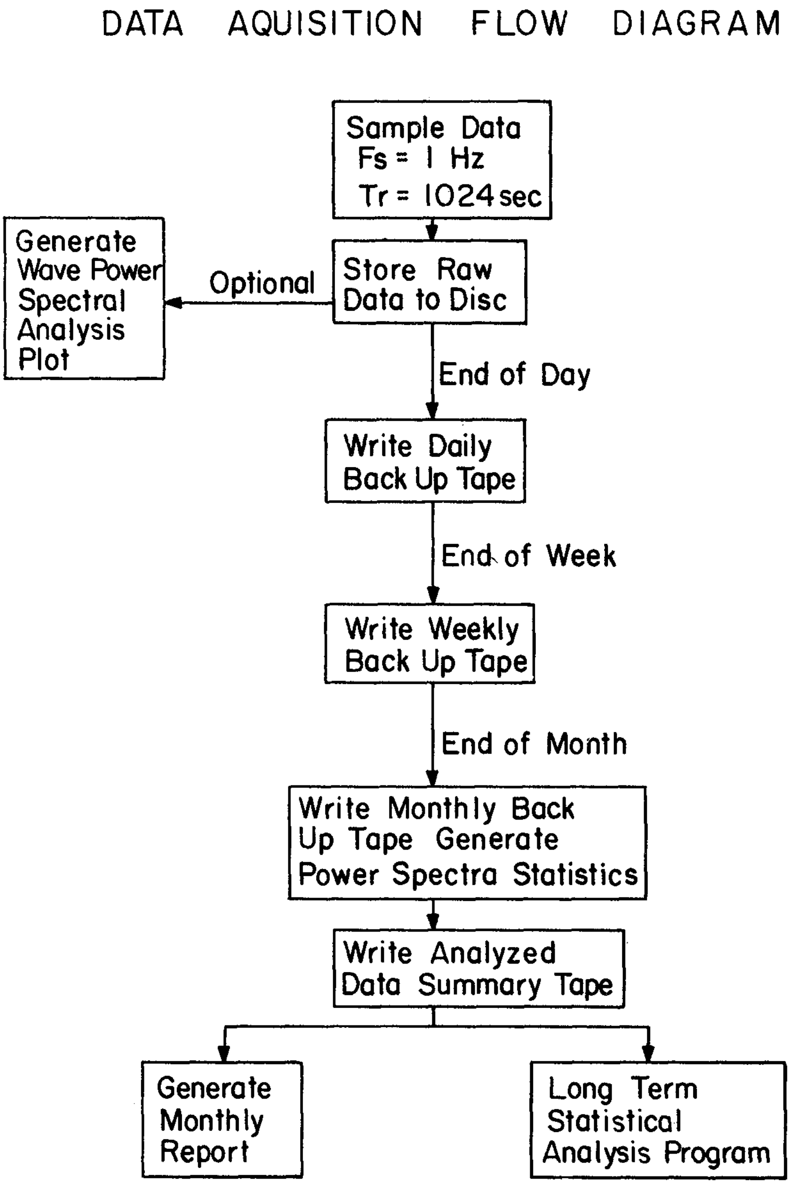
DATA AQUISITION FLOW DIAGRAM
Sample Data
Fs = 1 Hz
Tr = 1024 sec
Store Raw
Data to Disc
Optional
Generate
Wave Power
Spectral
Analysis
Plot
End of Day
Write Daily
Back Up Tape
End of Week
Write Weekly
Back Up Tape
End of Month
Write Monthly Back
Up Tape Generate
Power Spectra Statistics
Write Analyzed
Data Summary Tape
Generate
Monthly
Report
Long Term
Statistical
Analysis Program

Figure 7

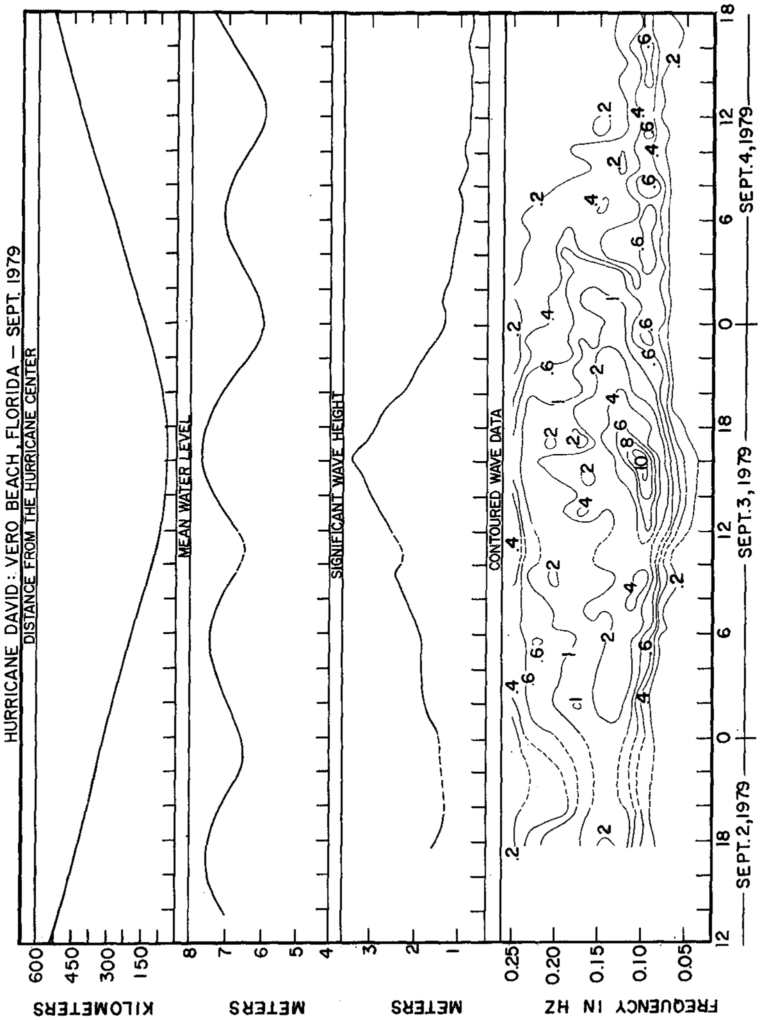
HURRICANE DAVID: VERO BEACH, FLORIDA – SEPT. 1979
DISTANCE FROM THE HURRICANE CENTER
KILOMETERS
MEAN WATER LEVEL
METERS
SIGNIFICANT WAVE HEIGHT
METERS
CONTOURED WAVE DATA
FREQUENCY IN HZ
SEPT.2,1979
SEPT.3,1979
SEPT.4,1979

Figure 8

4. RESULTS

CDN has successfully recovered regular wave data from the oldest stations for a period of three years. Data sets are now large enough that a variety of analysis projects are feasible. In addition hurricane David which moved up the Atlantic coast in September 1978 passed directly over two measurement sites. Data from these stations were obtained as planned and are now being analyzed. Figure 8 shows composite plots of tide and significant wave height from one station. A contour plot of constant spectral energy density lines as a function of time is also shown. These data were calculated using spectral analysis techniques and depth attenuation correction by linear wave theory assumptions. Thus, some error can be anticipated in the most severe time periods.

5. CONCLUSIONS AND FUTURE DEVELOPMENTS

A combination of advanced instrumentation with designed in maintenance features and improved data analysis procedures have improved the economy and reliability of single point wave measurements. Progress still needs to be made in the area of wave direction measurements both in the area of instrumentation and data analysis. The tools and techniques developed by the Florida CDN, can readily take advantage of the rapid cost-performance increases of microelectronics. The time is approaching when coastal engineers may have reliable and economical long term measurements of basic parameters for site-specific and problem-specific applications. Finally a new breed of small, intelligent instruments based on the microcomputer is already under development. These instruments will bring analytical capability, decision making, and flexibility to previously passive observers of coastal phenomena.

6. REFERENCES

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