NDBCM WO145-1

ARTMENT OF COMMERCE ● NATIONAL OCEANOGRAPHIC AND ATMOSPHERIC ADMINISTRATION

NATIONAL OCEAN SURVEY

NATIONAL DATA BUOY CENTER

A STUDY OF THE UTILITY OF DATA FROM EXPERIMENTAL ENVIRONMENTAL REPORTING BUOY (XERB-1) AND OCEAN WEATHER STATION (OWS) HOTEL

(FEBRUARY 1, 1970 – JULY 31, 1971)

A STUDY OF THE UTILITY OF DATA FROM EXPERIMENTAL ENVIRONMENTAL REPORTING BUOY-1 (XERB-1) AND ANALOGOUSLY OCEAN WEATHER STATION (OWS) HOTEL DURING THE PERIOD FEBRUARY 1, 1970 - JULY 31, 1971

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EXECUTIVE SUMMARY

Under Contract NAS8-27743, The Center for the Environment and Man (CEM) has undertaken a Study of the Need, Use and Incremental Benefits of Environmental Data from the Experimental Environmental Reporting Buoy (XERB-1) and, analogously, Ocean Weather Station (OWS) HOTEL, covering the period February 1, 1970, to July 31, 1971. The XERB-1 buoy is located off the U.S. east coast at 36.5°N, 73.5°W and OWS HOTEL is stationed at 38°N, 71°W. This study has been accomplished by a review of the literature, by use of information obtained at the National East Coast Winter Storms Conference (August 19-20, 1971), and by performing a mail and personal interview Survey of Federal Government and industrial environmental data users in the central and northeast Atlantic coast regions.

In this study the surface data collection capabilities of Ocean Weather Station (OWS) HOTEL have been treated as representative of a second data buoy, such as XERB-1. Upper air data, such as that presently being collected by OWS HOTEL, may at some future time also be collected by unmanned data buoys, at least to heights of about 10,000 m. OWS HOTEL and XERB-1 also collect limited amounts of subsurface data; however, use of such data has not been considered in this study.

To determine the need, use, and incremental benefits derived from the availability of XERB-1/OWS HOTEL (hereinafter referred to as XERB and HOTEL, for brevity) data, CEM identified 44 significant storms during the 18-month period between February 1, 1970, and July 31, 1971. Seven of the storms were selected for specific consideration in a Survey Questionnaire. For each of the seven storms, CEM prepared six questions concerning the use of XERB/HOTEL surface data for detection, location, analysis, and prediction. Three additional questions concerning upper air data from HOTEL were also prepared for each storm. Respondents were requested to indicate whether the surface or upper air data were Critical, Important, of Some Use, or of No Use for detecting, locating, analyzing and predicting environmental features and parameters.

National Weather Service members from the National Meteorological Center (NMC) and six Weather Service Forecasting Offices (WSFOs), together with the Environmental Data Service (EDS) National Oceanographic Data Center (NODC), five industrial environmental forecasting organizations, and one research group agreed to participate in the Survey. Field trips were made to the NWS Headquarters, NWS NMC, three NWS WSFOs, five industrial environmental forecasting organizations, and the research group to discuss their responses to the Survey. A total of 15 organizations and groups responded to the Survey, with 12 completing all or part of the Survey Questionnaire.

<u>Need for East Coast Marine Meteorological and Oceanic Data</u>

A compilation of needs for marine environmental data was made from

1. Review of the literature
2. Requirements Collection Study in 1967-1968
3. Letter to Senator Brooke Requesting Buoy/Ship Observations
4. National East Coast Winter Storms Operations Plan
5. Data Needs Expressed by Survey Respondents.

The impact of winter storms on the U.S. east coast has been well documented; it continues to grow as population, industries and recreation continue to expand along the shores of the Atlantic. Accurate and timely prediction of heavy snowfalls, flooding rains, high winds, heavy seas, destructive high tides, and storm surges along the coast can significantly reduce loss of life, property damage and disruptions to business and transportation.

Requirements for extensive environmental data collection were established during the 1967-1968 Study of the Feasibility of National Data Buoy Systems. The 1969 letter to Senator Brooke from six meteorologists in the Boston area requesting 2 ships and 9 data buoys to alleviate the forecasting problem for southern New England is an example of a specific need. In 1970, the National East Coast Winter Storms Operations Plan was formulated in response to problems posed by sparsity of data in the Western Atlantic.

Respondents to the Survey stated a number of needs. Many users strongly expressed the desire that XERB/HOTEL surface data be transmitted hourly over teletypewriter Service A or at least 3-hourly over Service C. The latter requirement has been satisfied since September 21, 1971.

A variety of more general requirements was expressed for data from additional buoys and Ocean Weather Ships. Several users expressed needs for data from 2-3 rows of data buoys off the east coast with intervals between the buoys ranging from 60-300 n mi. About 10 to 35 data buoys would satisfy the various networks described by data users during the Survey. Data from these networks would be used to satisfy the needs of ship track routing, aviation terminal forecasting, private meteorological applications, scheduling off-shore oil drilling operations and 12-hr to 36-hr coastal environmental prediction, as well as the shorter-range local meteorological and oceanic forecasting tasks.

Use of XERB/HOTEL Data

To facilitate a relative evaluation of XERB/HOTEL data use as a function of type of application, topical question, user category, and storm period, a simple procedure was employed to weight each entry in the Survey answer matrix as follows.

1. Critical to Success - 1.00
2. Important - 0.67
3. Of Some Value - 0.33
4. Of Little or No Use - 0.00

The respondents judged that the XERB/HOTEL surface data were most applicable for detecting and locating specific meteorological features in the immediate vicinity of the buoy and ship and of somewhat lower utility for prediction, although still Important for that use. The average utility scores over all seven storms ranged from a high of 0.74 for Location to a low of 0.62 for Prediction. The usefulness of XERB/HOTEL surface data was considered greatest for a newly-forming or intensifying coastal storm, with over 80 percent of the responses indicating that XERB/HOTEL data were either Critical or Important.

The utility scores for upper air data for the three principal user categories (NWS NMC,NWS WSFOs and industrial environmental data users) varied significantly from the overall score of 0.68. The NWS National Meteorological Center score of 0.13 reflects the limited impact that two additional data points might have on numerical analysis and prediction results, derived from numerical models employing large time and space scales. The more direct application of HOTEL upper air data for specific uses results in a higher utility score (0.56) for NWS WSFOs and an even higher score (0.82) for industrial users, where the utility ranged from Important to Critical.

The estimates of surface data utility for all users increased from 0.65 to 0.77 during the first five storm periods. The increasing data utility during much of the 18-month period may reflect greater awareness of the availability of XERB/HOTEL data and increased credibility assigned to the data, as experience was gained in its use.

Incremental Benefits Stemming from XERB/HOTEL Data

A compilation of incremental benefits was obtained from

1. Report on National East Coast Winter Storms Operation During Winter 1970-1971
2. Letter from Chief of Operations Eastern Region, NWS
3. Benefits Obtained by NWS Eastern Region, Regional Weather Center
4. Benefits Obtained by Survey Respondents.

Benefits stemming from XERB/HOTEL surface data include better detection, more precise location and improved analysis and short-range prediction of newly-forming and intensifying coastal storms. Additional benefits include an improved analysis of surface pressure and wind fields and the detection and more precise location of frontal systems.

Incremental benefits derived from HOTEL upper air data include improved analyses of upper-level flow and moisture and temperature advection. These analyses are essential for predicting the movement of storm systems and precipitation amount and type more accurately. Resultant amended forecasts and critical weather warnings produce economic and social benefits for the general public, commerce and industry in coastal regions of the northeastern U.S. Other benefits noted from the employment of XERB/HOTEL data include:

(1) establishing climatological normals of various environmental parameters,

(2) serving as a reliable standard to judge reports from nearby vessels, and corroborating reconnaissance aircraft data when available, and

(3) providing data for research.

Conclusions

The marine environmental data reported by XERB/HOTEL during the 18-month period covered by this study have partially satisfied the stated needs for such data. Additional data buoys or other data collection platforms are needed to completely satisfy existing needs. For a variety of data users on the east coast, the surface data from XERB/HOTEL and the upper air data from HOTEL have proved to be of Critical or Important Use in detecting, locating, analyzing and predicting environmental features and parameters. The amended forecasts and improved coastal warning have resulted in economic and social benefits for east coast industries and inhabitants. It is probably safe to suggest that similar benefits were accrued by military users of environmental information in this region.

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ACKNOWLEDGMENTS

Meaningful results were obtained only through the extensive cooperation and interest of many individuals in the government and private industry. The study has benefited from the close cooperation and guidance afforded by members of the National Oceanic and Atmospheric Administration, particularly Mr. R. A. Zettel of the National Data Buoy Center (NDBC) who served as the Technical Representative, Mr. F. P. Ostby, Co-Technical Representative for the National Weather Service, and CDR W. Flanders (USCG) who is responsible for XERB operations.

When at CEM, Mr. L. Clem (now with the National Data Buoy Center) formulated the activities of the study as the proposed Principal Investigator. The NDBC provided detailed inputs on the availability and content of XERB-1 data during the study period. Miss F. Parmenter of the National Environmental Satellite Service provided ATS-3 film loops of the seven selected storm periods. Surface and 500-mb facsimile maps for the entire 18-month period were made available by Mr. C. Bagley of the Travelers Weather Service. Mr. E. Davis of CEM provided consultative assistance during the course of the study.

The Survey visits required cooperation and contributions from many people. Mr. F. Ostby of the NOAA National Weather Service Meteorological Operations and Mr. R. Nolan of the NOAA NWS Eastern Region contributed considerable time and effort in coordinating visits and government responses to the Survey.

The 1971 Interdepartmental East Coast Winter Storm Conference held at New York University on August 19-20, 1971 provided an important opportunity for discussion and information exchange with participants, including Messrs. K. Johannessen, S. Simplicio, S. Grimm and E. Cartwright of NOAA.

Any errors in the interpretation and use of information provided by contributors are, of course, solely the responsibility of the authors of this report.

The following individuals contributed at Survey trip visits and/or to the preparation of Questionnaires:

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Dr. V. Cardone	New York University
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Mr. N. Macdonald	WBZ-TV, Boston, Mass.
Mr. P. Leavitt	Northeast Weather Service
Mr. R. Rice	Northeast Weather Service
Mr. K. Garee	Travelers Weather Service

1.0 INTRODUCTION

Under Contract NAS8-27743, The Center for the Environment and Man (CEM) has undertaken a Study of the Need, Use and Incremental Benefits of Environmental Data from the Experimental Environmental Reporting Buoy (XERB-1) and, analogously, Ocean Weather Station (OWS) HOTEL, covering the period February 1, 1970, to July 31, 1971. The XERB-1 buoy is located off the U.S. east coast at 36.5°N, 73.5°W and OWS HOTEL is stationed at 38°N, 71°W. This study has been accomplished by a review of the literature, by use of information obtained at the National East Coast Winter Storms Conference (August 19-20, 1971), and by performing a mail and personal interview Survey of Federal Government and industrial environmental data users in the central and northeast Atlantic coast regions. CEM has compiled and analyzed results from all these sources.

CEM recognizes that ideally a survey study of this kind is conducted in real time to provide the most complete and accurate evaluation of data usefulness. The retrospective study described in this report, however, is an important step in establishing the utility of the data, and should prove useful in the decision process concerning the continued operation of XERB-1 and OWS HOTEL and future implementation of other environmental data collection platforms off the U.S. east coast.

The impact of winter storms on the U.S. east coast has been well documented; it continues to grow as population, industries and recreation continue to expand along the shores of the Atlantic. Because many of the more significant winter storms develop in intensity as they move north-northeastward over the ocean adjacent to the coast, there is a need for more upper air, surface and subsurface marine environmental data from the ocean regions contiguous to the U.S. east coast. Such data are of use in detecting, locating, analyzing, and predicting oceanographic and meteorological events associated with significant storms. Requirements for extensive environmental data collection were established during the 1967 Study of the Feasibility of National Data Buoy Systems [1,2].

In this study the surface data collection capabilities of Ocean Weather Station (OWS) HOTEL have been treated as representative of a second data buoy, such as XERB-1. Upper air data, such as that presently being collected by OWS HOTEL, may at some future time also be collected by unmanned data buoys, at least to heights of about 10,000 m. OWS HOTEL and XERB-1 also collect limited amounts of subsurface data; however,use of such data has not been considered in this study.

To determine the need, use, and incremental benefits derived from the availability of XERB-1/OWS HOTEL* data, CEM identified 44 significant storms during the 18-month period between February 1, 1970 and July 31, 1971. Seven of the storms were selected for specific consideration in a Survey Questionnaire. For each of the seven storms, CEM prepared six questions concerning the use of XERB/HOTEL surface data for detection, location, analysis, and prediction. Three additional questions concerning upper air data from HOTEL were also prepared for each storm. Respondents were requested to indicate whether the surface or upper air data were Critical, Important, of Some Use, or of No Use for detecting, locating, analyzing and predicting environmental features and parameters. Participants in the Survey included National Weather Service (NWS) members from the National Meteorological Center, (NMC) and six Weather Service Forecasting Offices (WSFOs), together with the Environmental Data Service (EDS), National Oceanographic Data Center (NODC), five industrial environmental forecasting organizations, and one research group.

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*For brevity,throughout the remainder of this report, the Experimental Environmental Reporting Buoy will be designated XERB, and Ocean Weather Station HOTEL will be called HOTEL.

Field trips were made to the NWS Headquarters, NWS NMC, three WSFOs, five industrial environmental forecasting organizations, and the research group to discuss their responses to the Survey.

The review of the literature and the analysis of the Survey clearly established that XERB/HOTEL are serving needs of the environmental data-using community; that for most of the data users the upper air and surface data are Important or Critical for detecting, locating, analyzing and predicting east coast storm conditions; and that considerable benefits are being derived from the data reported by these two platforms.

The next section of this report discusses the background of the need and use of marine environmental data relative to east coast winter storms. Section 3 describes the contents of the Questionnaire. Section 4 presents a quantitative analysis of the use of XERB/HOTEL data, in terms of seven specific storms and three categories of data users. Needs, uses, and benefits associated with XERB/HOTEL data are summarized in Section 5. The conclusions of the study are given in Section 6. Recommendations for additional work and references are presented in Section 7 and 8 respectively. A Bibliography follows Section 8 and the Appendices contain numerous substantiating documents.

2.0 BACKGROUND

Due to the high density of population that is found between Boston, Massachusetts, and Washington, D.C., severe coastal storms are of grave concern to New England and the Middle Atlantic States. Accurate and timely prediction of heavy snowfalls, flooding rains, high winds, heavy seas, destructive high tides and storm surges along the coast can significantly reduce loss of life, property damage and disruptions to business and transportation. Mather et al. [3] have shown that the frequency of damaging storms along the east coast of the United States increased in the last decade of the period 1935-1964. This increase was attributed both to increased coastal development and a slight intensification of coastal cyclones during this period.

Extra-tropical cyclones(storms) frequently originate in the Gulf of Mexico and typically move across the southeastern United States. They often reform and/or intensify off Cape Hatteras where moisture and energy from the warm Gulf Stream is available. These events often occur very rapidly with little warning (due to lack of observations) and effect severe weather conditions along the U.S. east coast. Some storms move eastward or northeastward into the Atlantic Ocean while others move in a more northerly direction along the Atlantic Coast. The positioning of a "blocking High" to the east and northeast over the North Atlantic influences the storm's direction of movement and may slow down its progress, thus prolonging the effects along the east coast. Mather et al. [4], from an analysis of data bracketing a 42-year period, concludes that coastal storms of moderate to severe intensity might be expected at any place along the east coast The frequency varies from an average of once every 1.4 years in New York and New Jersey to once every 4.2 years in Georgia.

It should be noted that climatological records indicate that at most locations in coastal New England or the Middle Atlantic states, snowfall amounts in excess of ten inches from a single storm occur less than once per winter. Thus, a major snowstorm of this dimension is a relatively rare event. Notwithstanding climatology, in the past decade or so, such snowfalls have occurred four or five times in a single winter at many locations in this region. During the fall and spring, of course, major extra-tropical storms are most likely to produce heavy rains and winds with damaging high tides.

Cry [5] analyzed the frequency of tropical cyclones (hurricanes, tropical storms and tropical depressions) significantly affecting the United States during the period 1942-1961 On the average, approximately 5 tropical cyclones affect some part of the region from the Carolinas to New England each year, one of which attains hurricane intensity. However, in 1954, two major destructive hurricanes struck the North Atlantic Coastal region within 10 days.

The prediction of the effects of coastal storms is critically dependent on (1) the forecast of movement and changes in intensity of the cyclone center derived from numerical models run on large centrally located computers and (2) the forecast of the resultant precipitation amounts and intensities, as well as surface winds at a given location, which is fundamentally a local forecasting problem. The local forecaster, faced with that problem, must rely heavily on the "numerical product" from the weather centers.* In general, for coastal storms, the two most frequent critical forecasting decisions are (1) the direction of movement and degree of development expected during the forecast period when the cyclone is centered in the region about Cape Hatteras, and (2) the likelihood of the storm's slowing its forward

* At a weather center, raw environmental data are computer-processed and manually processed to generate products (analyses and predictions) which are made available to users for their respective use.

progression or stalling off the Northeast Coast, and hence affecting specific local regions for prolonged periods.

There has been a significant increase in skill in numerical prediction over the years as numerical models have been continuously refined to more realistically simulate complex atmospheric processes. However, accurate numerical prediction of the East Coast cyclone remains a major problem. Leary [6] has shown that the operational six-layer primitive equation model (Shuman and Hovermale [7]) of the National Meteorological Center systematically under-estimates cyclone intensification over the ocean and there is a tendency for storms to occur north and east of the forecast position. It may be assumed that sparsity of data off the east coast is a significant factor.

Furthermore, the difficulty of forecasting local weather events remains acute during generation and propagation of east coast storms. In attempts to alleviate the snow prediction problem, for example, Spiegler and Fisher [8] and Browne and Younkin [9] have established the climatological distribution of snowfall amounts relative to the location and movement of 850 mb low centers as a tool for the local forecaster. Spar [10, 11] has evaluated the use of Primitive Equation Precipitation forecasts for use in local snow prediction and concludes that they are not yet satisfactory for this purpose.

While further improvements in forecasting models and procedures on a variety of time and space scales may prove of value to many prediction problems, it is quite clear that in coastal areas one of the most substantial limitations is data sparsity over adjacent ocean waters. The data simply do not permit adequate specification and analysis of initial-time conditions for the deterministic models, If one uses statistical forecasting techniques (e.g., Veigas and Ostby [12]), the lack of data is even more critical.

Many examples could be cited to illustrate the critical requirement for offshore synoptic weather reports for the detection, location, analysis and prediction of these east coast environmental phenomena. In recent years, major "surprise" snowstorms have hit the New York Metropolitan area with 18-20 inches on February 8-10, 1969, and up to a foot of snow on Easter Sunday, March 29, 1970. The earlier storm stalled for a 12-hour period offshore. Of even greater devastation was the record-breaking snowstorm in the Boston area on February 24-28, 1969. Up to three feet of snow was officially recorded over a 100-hour period. Again, due to a blocking pattern, the storm remained nearly stationary southeast of Boston for three days. The precise location and track were impossible to determine because of a lack of surface weather observations in the vicintiy of the storm.

Satellite photography is helpful for detection and location of storms but insufficient for prediction. The Applications Technology Satellite (ATS) data, for example, permit some indirect inferences regarding the pressure, temperature and wind fields, but are not sufficiently definitive for forecasting. Ships-of-opportunity will normally avoid the most critical regions, i.e., expected storm tracks. Reconnaissance aircraft, which may be based several hours from the critical storm area, give broad coverage over the region making them quite useful for detection and diagnosis. However, for prediction purposes, continuing information at fixed locations is essential as the storm develops and moves.

There have been a number of reactions to the pressing problem of lack of data off the east coast and its impact on the ability to predict coastal storms. One such reaction in 1969 was a letter to Senator Brooke of Massachusetts from six meteorologists in the Boston area suggesting the locations of 2 ships and 9 buoys required to improve 6-12 hour and 12-36 hour forecasts for

New England. The recommended positions are shown in Fig. 2-1, along with the locations of XERB and HOTEL. The letter is given in Appendix A. Funds for the operation of HOTEL were appropriated by Congress later in 1969.

As a consequence of the sparsity of data in the Western Atlantic, the National East Coast Winter Storm Operations Plan [13] was formulated. This plan was developed by an Ad Hoc Group functioning under the purview of the Subcommittee on Basic Meteorological Services (SC/BMS) within the Interdepartmental Committee for Meteorological Services (ICMS). Under this plan, valuable special weather observations are provided to the National Weather Service through the cooperative efforts of the Departments of Commerce, Defense and Transportation. These special data include aircraft reconnaissance reports, surface observations from the experimental buoy XERB and surface and upper-air observations from Ocean Weather Ship HOTEL. Experimental Regional Weather Center (RWC), New York coordinates aerial reconnaissance requests and issues summaries of reconnaissance data.

During the period February 1, 1970, through July 31, 1971, XERB surface observations were taken hourly and transmitted on the Service C teletypewriter circuit and Hurricane Teletypewriter Circuit 7072 at the four synoptic times (0000 GMT, 0600 GMT, 1200 GMT and 1800 GMT). Each transmission included the current observation and the previous six hourly observations. The data transmitted consist of wind direction, wind speed, categorical precipitation amount, barometric pressure, air temperature, pressure tendency and change, sea surface temperature and the difference in sea surface and air temperature, dew point temperature, and wave height. The details of the Service C message format are given in Appendix B. Beginning September 21, 1971, XERB surface observations are routinely being transmitted on the Service C teletypewriter circuit every 3 hours. Each transmission includes the current observation and the previous two hourly observations.

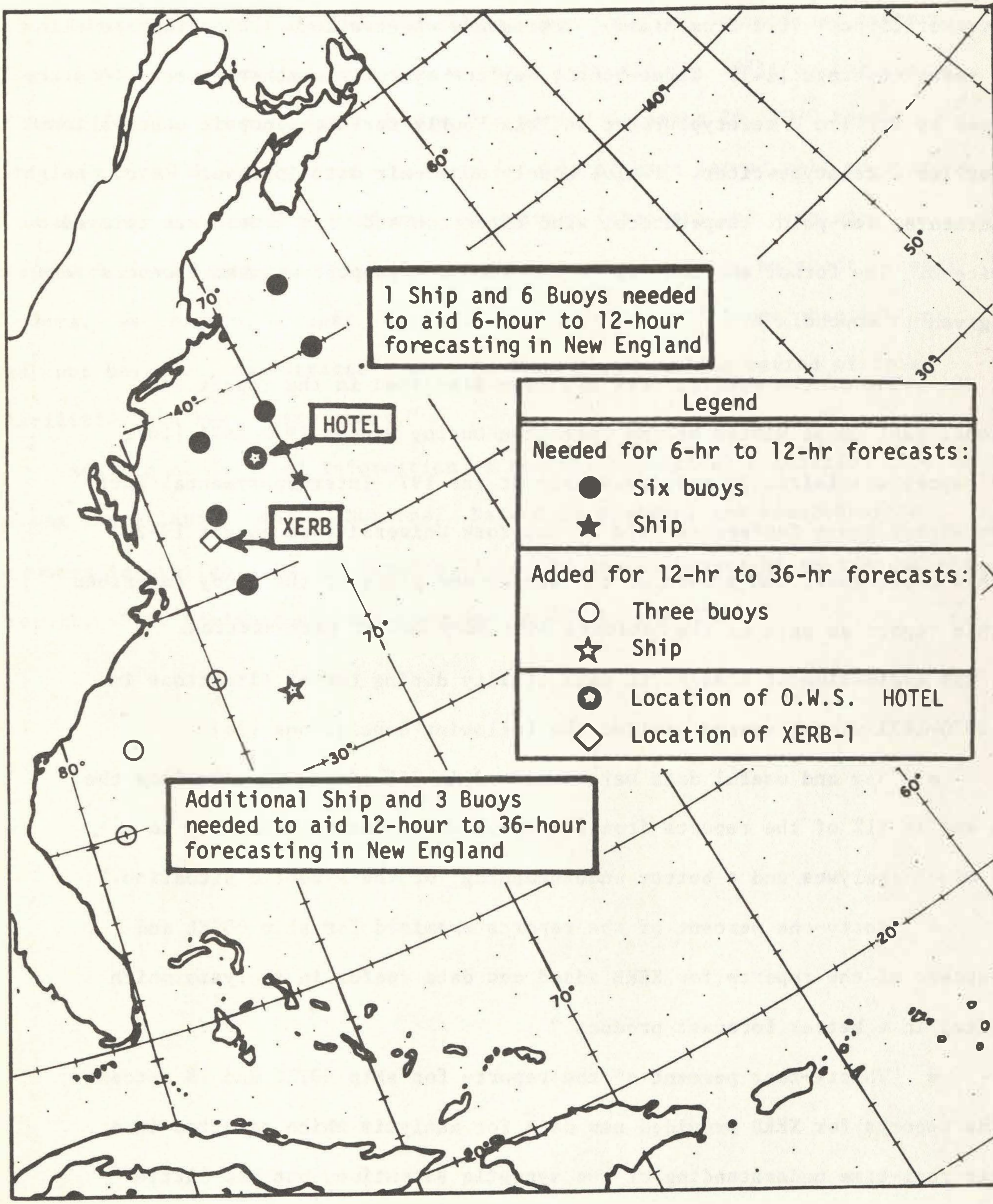

Fig. 2-1 Positions for Data Buoys and Ocean Weather Stations, recommended in letter to Senator Brooke.

HOTEL provides routine hourly surface observations (on the Hurricane Teletypewriter Circuit 7072 from Miami), rawinsonde observations (12-hourly) and limited radar coverage [14]. Three-hourly surface synoptic weather observations are relayed by Service O teletypewriter and six-hourly surface-synoptic observations by Service C teletypewriter. Twelve hourly upper-air data (pressure level, height, temperature, dew-point temperature, wind direction and wind speed) are relayed on Service O. The format and content of the surface-synoptic weather transmissions are given in Appendix B.

The value of the special data has been discussed in the report on National East Coast Winter Storms Operation During Winter 1970-1971 [14]. This report was initially made available at the 1971 Interdepartmental East Coast Winter Storm Conference held at New York University on August 19-20. At this conference, CEM presented the status and plans of the study described in this report as part of the National Data Buoy Center presentation.

The evaluation of XERB/HOTEL data utility during threat situations in the 1970-1971 winter season yielded the following conclusions [14].

- "New and useful data were received in 75% of the reports from the ship and in 61% of the reports from the buoy, which added materially to more exact analyses and a better understanding of the synoptic situation."

- "Forty-one percent of the reports examined for ship HOTEL and 43 percent of the reports for XERB added new data useful in analysis which resulted in a better forecast product."

- "Thirty-four percent of the reports for ship HOTEL and 18 percent of the reports for XERB provided new data for analysis which resulted in a better real-time understanding of the synoptic situation, but had little effect on forecasts."

In addition, Mr. Charles G. Knudsen, then Chief of Operations, Eastern Region, NWS, has commented in a letter dated February 19, 1971, on the use of XERB/HOTEL data on nine dates during the period December 26, 1970, through February 8, 1971. He states, "...they [the data] have served well to improve the accuracy and timeliness of several weather forecasts and warnings, issued for New England, the mid-Atlantic states, and/or the adjacent coastal waters. We caution, however, that the full potential of these observations may not have yet demonstrated itself in that the operating period of these facilities has been quite short."

Additional detailed information on the meteorological prediction problem along the Atlantic Coast, National Data Buoy Systems, and oceanographic sensors is available in the reports listed in the bibliography section of this report. This bibliography was provided to CEM by the NDBC.

3.0 DEVELOPMENT OF THE SURVEY QUESTIONNAIRE

An important phase of the study was the development of a Questionnaire that would elicit from a variety of users an informative response regarding the utility of XERB/HOTEL data. To achieve this objective, the Questionnaire was prepared in five sections or enclosures as follows:

- Enclosure 1 - Excerpts from a February 19, 1971 Letter from Chief of Operations, Eastern Region, NWS, to Chief of the Emergency Warning Branch, NWS
- Enclosure 2 - Description of Significant Weather Occurrences and Availability of XERB and HOTEL Data
- Enclosure 3 - Description of Seven Selected Storm Periods and Associated Questionnaires
- Enclosure 4 - Description of East Coast and Western North Atlantic Storm Periods During February 1, 1970 - July 31, 1971 and General Questionnaire Forms
- Enclosure 5 - Questions Concerning Utility of XERB and HOTEL Data in Non-Storm Conditions.

The initial effort consisted of determining the significant weather events that occurred during the period February 1, 1970,through July 31, 1971, and establishing the availability and completeness of XERB/HOTEL data during this period. A total of forty-four significant weather occurrences affecting the east coast and adjacent waters north of Cape Hatteras was identified from surface and 500-mb facsimile maps provided by the Travelers Weather Service. The approximate time of the forty-four weather events and their relationship to XERB/HOTEL data availability are shown in Fig. 3-1.

Several overall comments should be made regarding limitations to XERB/HOTEL data availability and quality. During the first month of the period (February 1970), XERB and HOTEL data were largely unavailable. Since HOTEL was off station during April through July 1970 and April through July 1971, there were no ship data during these two 4-month periods. XERB data were frequently not available during the following periods: July-August 1970, November-December 1970, and March-April 1971.

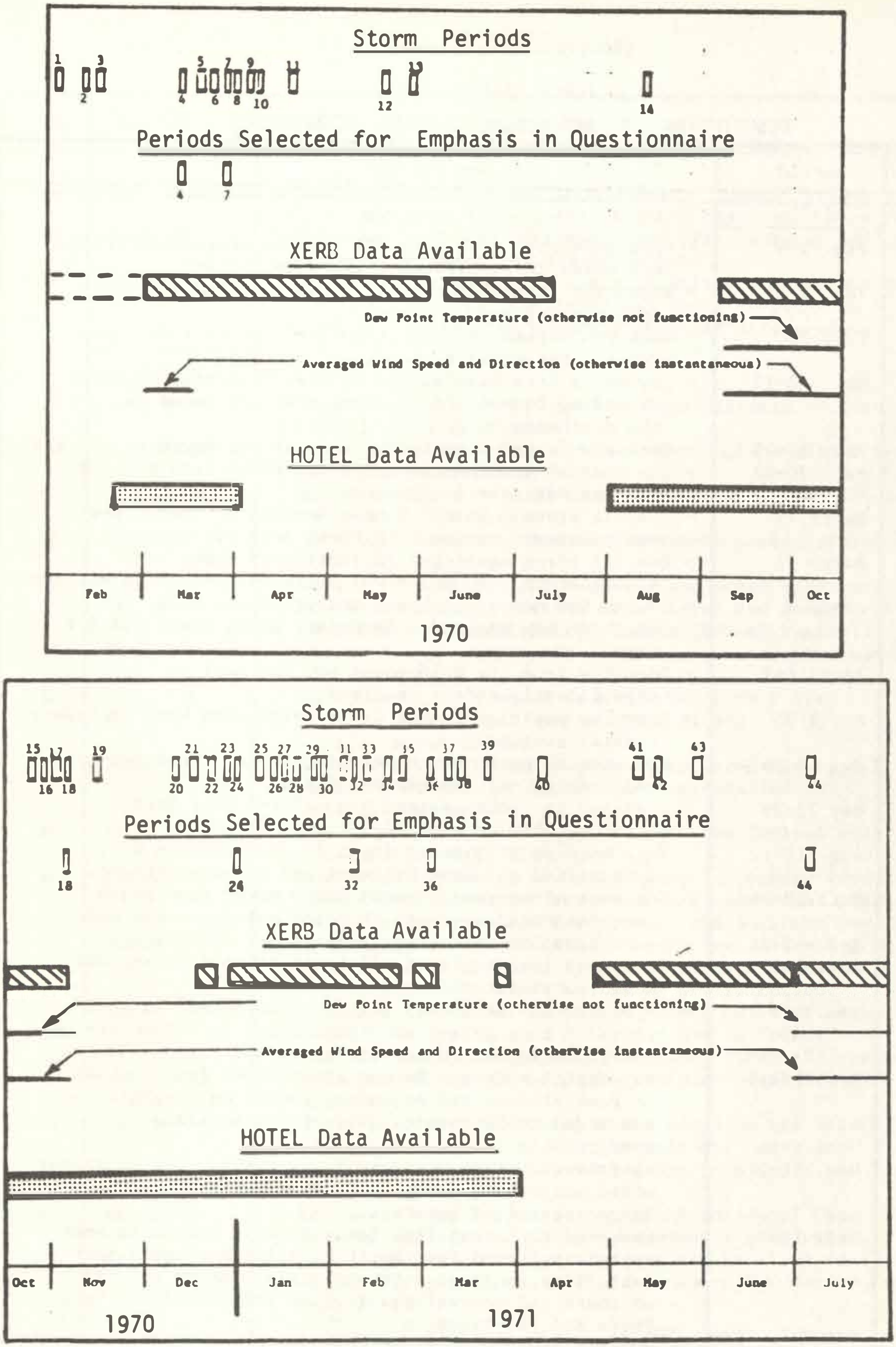

Fig. 3-1. Correlation of significant weather events and the availability of XERB and HOTEL data.

TABLE 3-1

DESCRIPTION OF INDIVIDUAL WEATHER OCCURRENCES

No.	Period	Description
	1970	
1	Feb. 3-4	- Wave developed near Cape Hatteras on stationary front and moved north-northeast into New England.
2	Feb. 9-11	- Secondary formed in central North Carolina and moved into New England.
3	Feb. 15	- Weak low formed off Mid-Atlantic Coast on stationary front. Not a major storm.
4*	Mar. 12-13	- Low moved from Mississippi to West Virginia; vigorous secondary formed off Cape Hatteras and moved to the northeast.
5	Mar. 18-19	- Weak low formed near Delaware coast and moved to the east.
6	Mar. 20-23	- Two coastal systems; second storm moved from Alabama to Cape Hatteras to Cape Cod.
7*	March 29	- Coastal storm - Easter Sunday Snowstorm - developed on southeastward moving cold front just off coast.
8	March 31	- Coastal strom developed on stationary front over southeastern U.S. and moved northeast over Cape Hatteras.
9	April 2	- 971-mb low moved northeast through Greak Lakes and northern New England. Secondary along coast did not form.
10	April 6-7	- Deep low from the Gulf moved too far east to significantly affect mainland.
11	April 20	- Deep low positioned over Great Lakes with weak secondary coastal system.
12	May 17-19	- Slow moving north-south oriented front. Weak low formed and stalled off eastern New England.
13	May 25-26	- Weak low in southeastern U.S. filled over North Carolina with passage of new cold front.
14	Aug. 10-12	- Weak wave on stationary front in southeastern U.S. intensified off Cape Hatteras and moved northeast.
15	Oct. 22-24	- Two coastal systems; second storm moved from South Carolina coast to south of Maine and on to the east.
16	Oct. 25-26	- Low intensified off Cape Hatteras and moved east.
17	Nov. 1-2	- Secondary low developed off South Atlantic Coast and moved northeast off coast.
18*	Nov. 4-5	- Major storm. Secondary low moved northeast to just south of Long Island and intensified to 978-mb center. Heavy precipitation and strong winds.
19	Nov. 13-15	- Two coastal storms. Second storm moved from Alabama to Pennsylvania and secondary formed on Virginia coast and moved to northeast. Widespread moderate precipitation.
20	Dec. 11-12	- Major Snowstorm in southern New England. Low in midwest moved eastward and two secondary lows off coast prolonged period of snowfall.
21	Dec. 16-17	- Low moved northeast from Texas to Ohio and an intense secondary formed over North Carolina and moved northeast close to coast. Strong winds. Heavy snow in northern and central New England and inland New York State and Pennsylvania.

* Selected for detailed consideration in Survey.

TABLE 3-1 (Continued)

No.	Period	Description
22	Dec. 21-24	- Two system originated in Mid-West. Coastal redevelopment off northern Maine coast produced heavy snow over Maine.
23	Dec. 26	- Intense low moved northeast from Cape Hatteras well off coast. Deepened to 953-mb center.
24*	Dec.31-Jan.1	- Low moved from Georgia coast to Delaware coast and to east-northeast. New Years Day Storm deepened to 984-mb center with moderate snow and strong winds.
	1971	
25	Jan. 9	- Wave from Gulf moved south of Cape Hatteras without significant development.
26	Jan.13-14	- Weak low moved across northern New England with a weak secondary off coast.
27	Jan. 15	- Wave developed on cold front over Virginia and intensified well off coast.
28	Jan. 20	- Intense Nova Scotia low with a 956-mb center pressure produced heavy seas.
29	Jan. 25	- Weak low developed off Hatteras and moved east-northeast.
30	Jan.26-27	- Low moved through eastern Great Lakes and merged with secondary in southeastern Canada (961-mb center).
31	Feb. 5	- 975-mb low in western Great Lakes; weak coastal secondary low developed.
32*	Feb. 7-8	- Two coastal lows moved from southeastern U.S.: (1) passed just east of Long Island (2) moved inland.
33	Feb. 13	- Low moved well inland from western Carolinas to N.Y. State/Northern New England and intensified to 974-mb center.
34	Feb. 20	- Low moved from west to east across New England and intensified well off coast.
35	Feb.22-23	- Low moved northeast to Great Lakes; secondary formed south of Long Island and moved east-northeast producing significant snowfall for central and northern New England.
36*	March 3-4	- An intense (record-breaking 961-mb low in New England) system moved up coast from southeastern states with associated high winds and heavy precipitation.
37	March 7	- A strong coastal storm formed at the point of occlusion near 40°N latitude on a rapidly moving front.
38	March 11	- Weak secondary developed on occluded front off coast.
39	Mar.19-20	- Secondary developed on occluded front north of 40°N latitude.
40	Apr.5-7	- An intense spring coastal storm moved up the entire length of Atlantic Coast with high winds and heavy snow inland.
41	May 8-9	- A moderate secondary coastal strom formed off the Virginia Coast and moved northeast.
42	May 15-16	- Low moved over northeastern states inside of Cape Hatteras and intensified to the northeast over open water.
43	May 28-31	- Low formed on stationary front along Carolina Coast and moved north-northeast to off Southern New Jersey coast and filled.
44*	July 4-6	- A moderate tropical storm, ARLENE, moved northeast too far off coast to significantly affect mainland.

* Selected for detailed consideration in Survey.

Figure 3-1 also shows that during much of the 18-month period, the dew-point temperature was not available from XERB and the wind speed and wind direction were instantaneous rather than averaged values. One other data problem that should be noted concerns barometric pressure, which was often about two millibars too low.

A brief description of each of the forty-four weather occurrences is presented in Table 3-1. From this group, seven significant weather events were selected for detailed consideration in the Questionnaire. The data and storm type during each selected weather event are shown in Table 3-2. The seven storm periods were chosen with several criteria in mind. First, it was desired that both XERB and HOTEL data were available. This was the case for the first five selected periods. During the sixth period (March 3-4, 1971), XERB data were largely unavailable, and during the seventh period (July 4-6, 1971; Tropical Storm Arlene), there were no HOTEL data. Second, it was desired that the weather events be of different types. Third, it was desired that the occurrence of the events be distributed throughout all seasons. Table 3-2 shows that the second and third criteria were met.

TABLE 3-2

SELECTED WEATHER EVENTS

Period*	Date	Storm Type
4	March 12-13, 1970	Low from southeast U.S.
7	March 29, 1970	Secondary low on moving front
18	November 4-5, 1970	Primary low in midwest with coastal secondary; and secondary low on moving front
24	December 31, 1970-January 1, 1971	Low from southeast U.S.
32	February 7-8, 1971	Low developed on stationary front and low from southeast U.S.
36	March 3-4, 1971	Low from southeast U.S.
44	July 4-6, 1971	Tropical Storm ARLENE

*Period Numbers are correlated to the total set of 44 significant events listed in Fig. 3-1.

In the Questionnaire, one-page descriptions and storm track maps were given for each of the seven significant weather events. The track maps for each of the seven storms are shown in Fig. 3-2. The detailed storm descriptions are given in Appendix C.

Each one-page storm description was followed by a set of specific questions concerning the utility of XERB and/or HOTEL data. The nine topics covered during each of the seven storm periods are listed in Table 3-3.

TABLE 3-3

NINE TOPICAL QUESTIONS

Number	Topics
1	Newly-Forming Coastal Storm
2	Intensifying Coastal Storm
3	Cold and Warm Fronts
4	Surface Pressure Gradient; Surface Wind Direction and Speed
5	Sea Surface Conditions (Wave/Height, Direction and Period)
6	Precipitation: Areal Extent, Type, Intensity, Duration
7	Upper-Level Significant Features (Troughs, Ridges, Closed Lows, Short Waves)
8	Upper-Level Flow (Wind Speed and Direction, Vorticity, Divergence)
9	Upper-Level Temperature and/or Moisture Advection

The first six topics deal with the utilization of surface data from XERB and/or HOTEL. The final three topics are concerned with the use of upper-air data from HOTEL only. Under each topic specific comments were made or questions raised that were pertinent to the meteorological situation during the period in question.

For each topic, the answer matrix shown in Table 3-4 was provided. The respondent was requested to place one check in the applicable column to indicate the degree of utility of XERB/HOTEL data for detection, location, analysis and prediction.

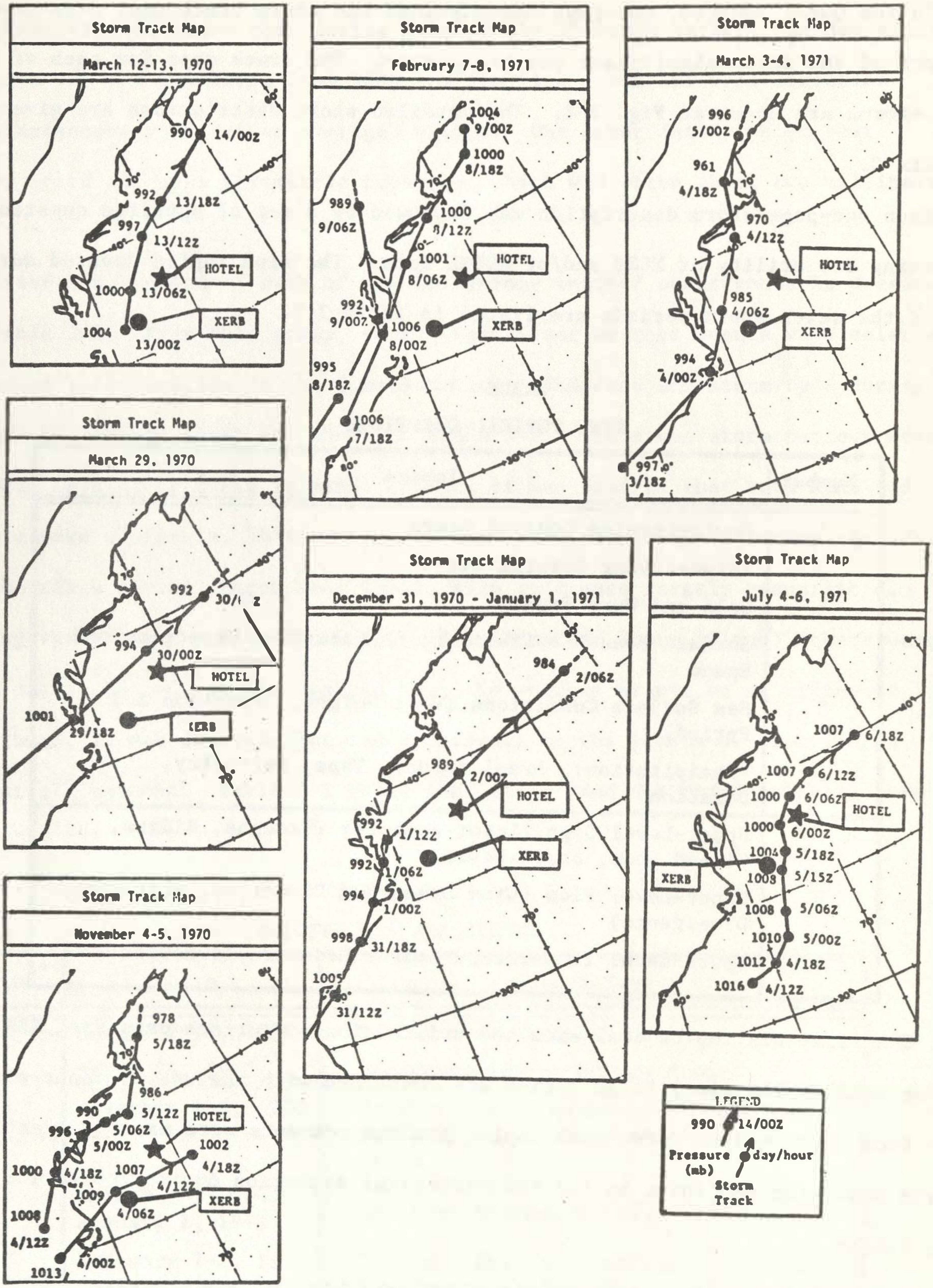

Fig. 3-2. Storm Track Maps for seven selected weather events.

TABLE 3-4

QUESTIONNAIRE ANSWER MATRIX FOR SURFACE DATA

Place one check (✓) in each applicable column

Degree of Utility of XERB/ HOTEL Surface Data	Detection	Location	Analysis	Prediction
1. Critical to Success for:				
2. Important for:				
3. Of Some Value for:				
4. Of Little or No Use for:				

For this storm please check one of the following:

☐ XERB data of greater importance than HOTEL data
☐ XERB data of equal importance to HOTEL data
☐ XERB data of less importance than HOTEL data

It is clearly recognized that all four columns of the matrix are not necessarily applicable under each topic. The respondent was also requested to indicate the relative importance of the XERB and HOTEL data by checking one of three boxes provided beneath the answer matrix. This evaluation is, of course, only applicable to the first six topics that deal with both XERB and HOTEL surface data. Finally, ample space was provided for comments to explain the judgments regarding the degree of data utility and respondents were encouraged to make explanatory remarks. Appendix C contains the one-page descriptions and topical information given in the Survey for each of the seven periods selected for emphasis.

While the Survey emphasized the seven selected storms, shorter descriptions were given of the remaining 37 weather occurrences during the 18-month period of interest and the availability of XERB/HOTEL data with each occurrence was indicated. Respondents were encouraged to fill out additional survey forms for storms that they considered significant.

All respondents were requested to fill out one Questionnaire in which they evaluated the overall utility of XERB/HOTEL data throughout the entire 18-month period. A form was also included in the Questionnaire to allow respondents to comment on the utility of XERB and HOTEL data for non-storm applications such as research, ship track routing, search-and-rescue and other uses.

The responses to the Survey can be grouped into the following classes:

- Seven selected storm periods - answer matrix and comments
- Other storm periods - answer matrix and comments
- Entire 18-month period - answer matrix and comments
- Non-storm applications of data
- Letter response to survey.

The analysis of the results in the following section reflects the varied characteristics of the survey responses. While statistical and analytical evaluations of the survey results are clearly desired, it is equally important to assess and synthesize qualitatively the many detailed oral and written responses obtained during the course of the study.

4.0 ANALYSIS OF RESPONSE TO THE SURVEY

Most of the data users contacted in the survey can logically be grouped into three classes:

(a) NOAA NWS National Meteorological Center,

(b) NOAA NWS Weather Service Forecast Offices (WSFOs) and

(c) Industrial environmental forecasting organizations.

The presentation of the results will reflect this classification. In this section we have carefully documented the important characteristics of the Survey responses and also analyzed the degree of XERB/HOTEL data utility suggested. The analysis also reflects two concepts:

(1) the surface data from HOTEL are treated as representative of a second data buoy, and

(2) the upper air data from HOTEL may in the future be collected by unmanned data buoys, possibly to heights of about 10,000 m.

4.1 Responses to the Survey

The overall response to the Survey is shown in Table 4-1. A dot indicates that the type of response described by the column heading was received. For example, the reply to the Survey from the WSFO in Washington consisted of

(a) an evaluation of the utility of the XERB/HOTEL data during the seven selected storm periods,

(b) an evaluation of the data utility during some additional storm periods and

(c) a letter or summary page with further comments.

While responses to the Survey were quite thorough and detailed, for several reasons not all topical questions were answered. For example, a respondent may not have been concerned with a particular storm period. One or more of the questions within a storm period may have involved uses of the data that were not of concern to him. Or, for a given question, the respondent may have felt that one or more of the potential applications of the XERB/HOTEL data (detection, location, analysis and prediction) were difficult to evaluate or did not fit the situation.

TABLE 4-1

OVERALL RESPONSE TO THE SURVEY

No.	Organization Preparing Questionnaire	Questionnaire: Seven Storms	Questionnaire: Other Storms	Questionnaire: General Evaluation	Questionnaire: Non-Storm Applications	Letter or Summary Comments
1	NWS Natl. Meteorolog. Center*	●		●		●
2	NWS RWC/WSFO New York*	●	●	●		
3	NWS WSFO Washington, D. C.*	●	●			●
4	NWS WSFO Boston, Mass.*	●		●		
5	NWS WSFO Columbia, S.C.	●				
6	NWS WSFO Raleigh, N. C.					●
7	NWS WSFO Philadelphia, Pa.	●				●
8	NWS WSFO Portland, Maine					●
9	EDS National Oceanographic Data Center*					●
10	American Airlines New York*			●		
11	Travelers Weather Service*	●		●	●	●
12	Bendix Commercial Serv.Corp.*	●		●	●	●
13	WBZ-TV (1)*	●	●			●
14	WBZ-TV (2)*	●		●		
15	Northeast Weather Service*	●				●
16	New York University*			●	●	

*Personal visit made to discuss Questionnaire with respondent(s).

Table 4-2 summarizes the number of responses to the Questionnaire by user category for each of the seven storm periods and the general evaluation. It should be noted at this point that while the response from the NWS National Meteorological Center is contained in a single Questionnaire, it does represent the expert judgment of several staff members of the Analysis and Forecast Division of the National Meteorological Center. Additional information on the completeness of response to the Questionnaire is given in Section 4.3, where the method of numerically weighting the results is discussed.

TABLE 4-2

NUMBER OF RESPONSES TO QUESTIONNAIRE ACCORDING TO USER CATEGORY

User Category	Storm Period							General Evaluation
	1	2	3	4	5	6	7	
NWS NMC	1	1	1	1	1	1	1	1
NWS WSFO Offices	5	4	4	4	4	4	4	2
Private Meteorologists	5	4	5	5	5	5	5	5
Total Responses	10	9	10	10	10	10	10	8

Prior to discussing the results obtained, it is important to establish the mission of the respondents and any other factors that might impact on the type of response obtained. This information is summarized in Table 4-3. Two major points are made in the following.

- The primary use of HOTEL upper air data at NWS NMC is as additional data input to numerical analysis and prediction procedures carried out on a computer. The importance of the XERB/HOTEL data to the other users is more readily determinable, because direct and immediate use may be made of the data, for example, to personally check and/or modify an analysis or forecast.

TABLE 4-3

RESPONDENTS MISSION AND REMARKS RELATIVE TO QUESTIONNAIRE RESPONSES

No.	Organization	Primary Mission	Remarks
1	NWS National Meteorological Center	Preparation for national distribution of analysis & prediction products, primarily computer derived.	Evaluation of impact of XERB/HOTEL data on computer products difficult to assess, particularly for prediction. Questionnaire completed by A&FD Staff.
2	NWS RWC/WSFO New York	RWC is coordinating office for Eastern Region WSFO's. Public, aviation, marine and specialized forecasts for assigned area.	RWC material including daily Evaluation Reports provided basis for Questionnaire response. Location of N.Y. emphasizes use of XERB data.
3	NWS WSFO, Washington	Public, aviation, marine and specialized forecasts for assigned area.	D.C. location emphasizes use of XERB data.
4	NWS WSFO Boston, Mass.	Public, aviation, marine and specialized forecasts for assigned area.	Boston location emphasizes use of HOTEL data. Synoptic maps prepared at WSFO, Boston provided basis for Questionnaire response.
5	NWS WSFO Columbia, S.C.	Public, aviation, marine and specialized forecasts for assigned area.	Location reduces importance of XERB/HOTEL data.
6	NWS WSFO Philadelphia, Pennsylvania	Public, aviation, marine and specialized forecasts for assigned area.	Location emphasizes use of XERB data.
7	American Airlines, N.Y.	Terminal forecasts of weather parameters affecting aviation, e.g., visibility, precipitation, etc.	General evaluation made.
8	Travelers Weather Service	TV/Radio & private forecasts	Location emphasizes use of HOTEL data.
9	Bendix Commercial Service Corporation	Ship Track Routing Services	XERB important because located in heavy traffic lane near coast.
10 & 11	WBZ-TV	TV/Radio public forecasts	Location emphasizes use of HOTEL data. Two Questionnaires completed.
12	Northeast Weather Service	Specialized forecasts for commercial, municipal & utility users.	Northeast Weather Service data used for completing Questionnaire. HOTEL more important.
13	New York University	Research using XERB/HOTEL data.	General evaluation made.

- The importance of XERB/HOTEL data may vary as a function of region. HOTEL surface and upper-air data are particularly important for New England and adjacent coastal areas. XERB surface data are quite important for the Mid-Atlantic States. To the south of Cape Hatteras, the usefulness of either XERB or HOTEL data is likely to diminish. The locations of the respondents to the Survey and of XERB/HOTEL are shown in Fig. 4-1.

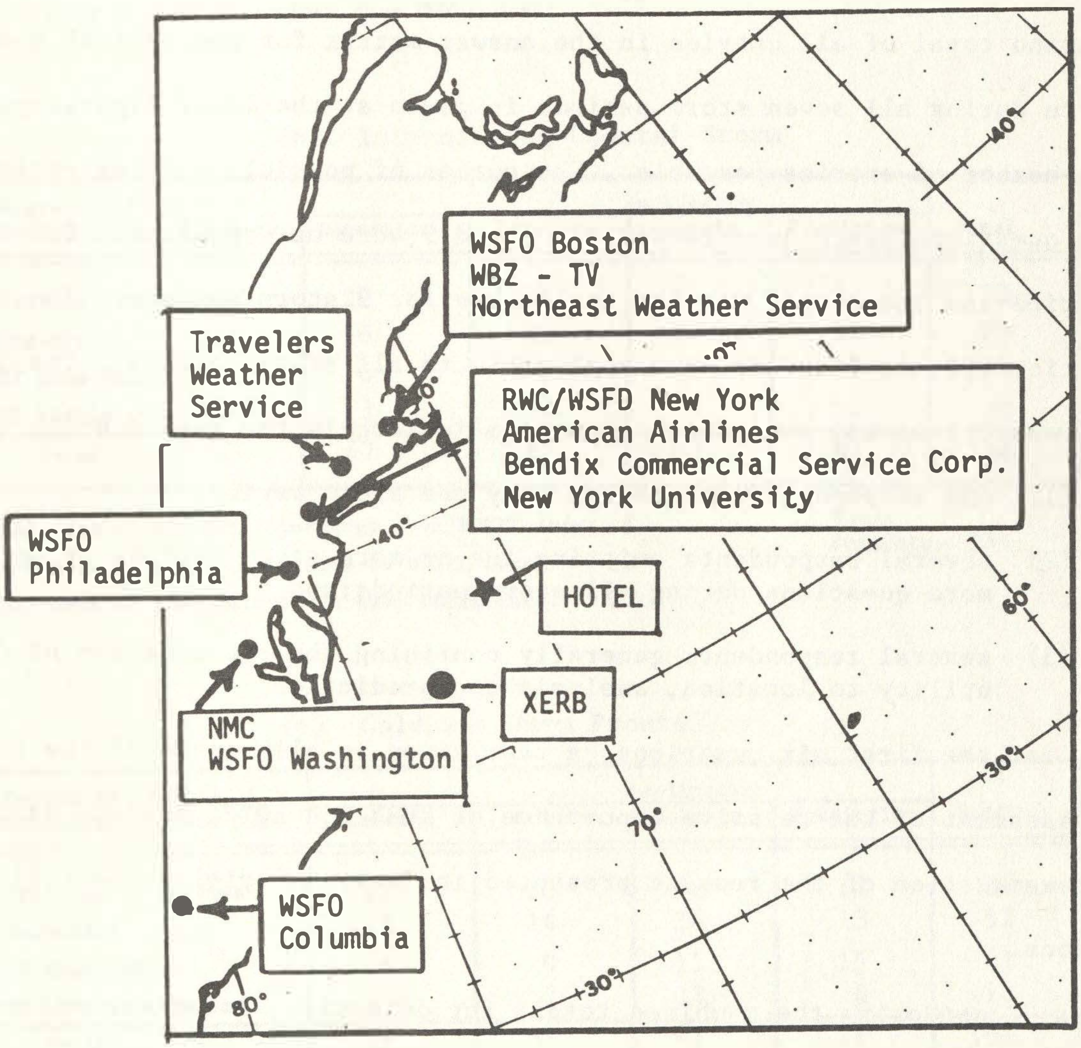

Fig. 4-1. Locations of Questionnaire respondents

4.2 Analysis of Response by Topical Question

Eleven of the 13 respondents to the Questionnaire evaluated the utility of XERB/HOTEL data during all or some of the seven selected storm periods. The results are presented in Table 4-4 (a)-(i). Each of the nine tables contains the total response from all eleven data users for all seven storm periods for the indicated topical question. The numbers in the matrix indicate the total number of responses. For example, in Table 4-4 (a), there are 12 entries indicating that XERB/HOTEL surface data are important for the detection of newly-forming coastal storms.

A grand total of all entries in the answer matrix for the topical question of concern during all seven storm periods is given at the lower right,together with the number of entries possible. The number of possible entries varies among the nine questions,since Questions 3, 7, 8 and 9 were not applicable for one storm period and Question 1 was not applicable for 3 storm periods. The remaining Questions (2, 4, 5 and 6) were applicable to all storm periods. The difference between the actual and possible entries is largely the result of

(1) one respondent considering only one storm period;

(2) several respondents omitting one or more storm periods or one or more questions during all storm periods;and

(3) several respondents generally confining their evaluation of data utility to location, analysis and prediction.

Finally, for the first six questions, a tabulation is also given of the respondents assessment of the relative importance of XERB and HOTEL surface data.

An examination of the results presented in Table 4-4 yields the following conclusions.

- Considering the combined totals for detection, location, analysis and prediction, well over half the entries for each of the 9 topical questions indicated that the degree of utility of the XERB/HOTEL surface data and HOTEL upper-air data was either characterized as "Important" or "Critical to Success."

TABLE 4-4

RESPONSE TO QUESTIONNAIRE FOR EACH TOPICAL QUESTION

(a) Newly-Forming Coastal Storm

Degree of Utility of XERB/HOTEL Surface Data	Application				Total
	Detection	Location	Analysis	Prediction	
Critical to Success	16	21	21	8	66
Important	12	17	15	18	62
Of Some Value	3	3	4	6	16
Of Little or No Use		2	2	3	7
Total	31	43	42	35	151

XERB data of greater importance than HOTEL data: 13

XERB data of equal importance to HOTEL data: 18

XERB data of less importance than HOTEL data: 11

Total Possible: 208

(b) Intensifying Coastal Storm

Degree of Utility of XERB/HOTEL Surface Data	Application				Total
	Detection	Location	Analysis	Prediction	
Critical to Success	22	37	36	27	122
Important	16	22	19	22	79
Of Some Value	6	6	6	11	29
Of Little or No Use	3	2	2	1	8
Total	47	67	63	61	238

XERB data of greater importance than HOTEL data: 8

XERB data of equal importance to HOTEL data: 20

XERB data of less importance than HOTEL data: 27

Total Possible: 364

(c) Cold and Warm Fronts

Degree of Utility of XERB/HOTEL Surface Data	Application				Total
	Detection	Location	Analysis	Prediction	
Critical to Success	21	30	26	12	89
Important	11	14	14	13	52
Of Some Value	6	9	11	15	41
Of Little or No Use	1	2	2	6	11
Total	39	55	53	46	193

XERB data of greater importance than HOTEL data: 6

XERB data of equal importance to HOTEL data: 26

XERB data of less importance than HOTEL data: 21

Total Possible: 312

TABLE 4-4 (Continued)

(d) Surface Pressure Gradient (Wind Direction and Speed)

Degree of Utility of XERB/HOTEL Surface Data	Application				Total
	Detection	Location	Analysis	Prediction	
Critical to Success	22	23	21	15	81
Important	18	17	32	27	94
Of Some Value	6	9	10	11	36
Of Little or No Use	2	3	2	4	11
Total	48	52	65	57	222

XERB data of greater importance than HOTEL data: 7
XERB data of equal importance to HOTEL data: 16
XERB data of less importance than HOTEL data: 26

Total Possible: 364

(e) Sea Surface Conditions

Degree of Utility of XERB/HOTEL Surface Data	Application				Total
	Detection	Location	Analysis	Prediction	
Critical to Success	12	13	8	8	41
Important	12	16	24	24	76
Of Some Value	7	8	13	8	36
Of Little or No Use	1	2	2	4	9
Total	32	39	47	44	162

XERB data of greater importance than HOTEL data: 6
XERB data of equal importance to HOTEL data: 17
XERB data of less importance than HOTEL data: 19

Total Possible: 364

(f) Precipitation

Degree of Utility of XERB/HOTEL Surface Data	Application				Total
	Detection	Location	Analysis	Prediction	
Critical to Success	16	23	19	19	77
Important	9	11	15	12	47
Of Some Value	14	15	17	20	66
Of Little or No Use	6	7	8	10	31
Total	45	56	59	61	221

XERB data of greater importance than HOTEL data: 4
XERB data of equal importance to HOTEL data: 12
XERB data of less importance than HOTEL data: 24

Total Possible: 364

TABLE 4-4 (Continued)

(g) Upper-Level Significant Features

Degree of Utility of HOTEL Upper-Air Data	Application				Total
	Detection	Location	Analysis	Prediction	
Critical to Success	16	19	15	18	68
Important	10	13	19	15	57
Of Some Value	2	5	11	7	25
Of Little or No Use	6	8	3	5	22
Total	34	45	48	45	172

Total Possible: 312

(h) Upper-Level Flow

Degree of Utility of HOTEL Upper-Air Data	Application				Total
	Detection	Location	Analysis	Prediction	
Critical to Success	18	23	17	21	79
Important	9	9	19	13	50
Of Some Value	3	6	8	8	25
Of Little or No Use	5	6		5	16
Total	35	44	44	47	170

Total Possible: 312

(i) Upper-Level Temperature and/or Moisture Advection

Degree of Utility of HOTEL Upper-Air Data	Application				Total
	Detection	Location	Analysis	Prediction	
Critical to Success	19	25	17	21	82
Important	10	9	17	10	46
Of Some Value	3	6	12	9	30
Of Little or No Use	4	5	3	7	19
Total	36	45	49	47	177

Total Possible: 312

- The usefulness of the XERB/HOTEL surface data was considered greatest for a Newly-Forming Coastal Storm (Question 1) and an Intensifying Coastal Storm (Question 2) where over 80% of the responses gave a Critical or Important utility.
- More than half the responses considered the XERB/HOTEL surface data Critical to Success for the detection of a Newly-Forming Coastal Storm and the location and analysis of an Intensifying Coastal Storm during the seven storm periods.
- Only for the first question was XERB surface data considered of relatively greater importance than HOTEL surface data. For this question (Newly Forming Coastal Storms), the location of the XERB buoy for detecting and locating a newly-forming storm is very good. The procedure of transmitting XERB data every six hours reduced its importance relative to the HOTEL data in the minds of some respondents and this is reflected in the XERB/HOTEL comparative tabulations for the other 5 topical questions.*
- The XERB/HOTEL surface data were considered of least utility for Question 6 (Precipitation: Areal Extent, Type, Intensity and Duration). The fact that 43% of the responses indicated either Some Value or Little or No Use reflects:

  (1) the complexity of the problem of analyzing and predicting precipitation and the limited impact of two surface data points on this problem; and

  (2) the importance of upper-air data for precipitation analyses and prediction.
- The value of HOTEL upper-air data was clearly evidenced by more than two-thirds of the responses to Questions 7-9 indicating either Critical or Important data utility.

*As noted elsewhere, XERB data are now being transmitted every three hours. At critical times, XERB data can be obtained every hour.

The above comments and tables represent essentially an overview, tabulation, and preliminary analysis of the Questionnaire results. In the following section a further evaluation is made of XERB/HOTEL data utility by considering variations among data user categories, storm periods and type of data applications, as well as variations among topical questions.

4.3 Evaluation of Data Utility

To facilitate a relative comparison of data utility as a function of user category, storm period and type of application, a simple procedure was employed to weight each entry. The weights assigned are shown in Table 4-5. Thus, a score close to 0.67 indicates that the degree of utility for a particular user category or storm period can be assessed as Important,

TABLE 4-5

WEIGHTS ASSIGNED UTILITY CATEGORIES

Degree of Utility	Weight
1. Critical to Success	1.00
2. Important	0.67
3. Of Some Value	0.33
4. Of Little or No Use	0.00

The utility scores presented in the remainder of this section are compiled on the basis of the entries made and do not consider the absence of an entry. The reasons for the omission of an entry in the answer matrix were discussed in the proceeding section and in the majority of instances have nothing to do with data utility. However, so that the reader is clear on the size of the sample being evaluated relative to the possible size (an entry made in every column), we have included Table 4-6 for reference. For each of the respondent organizations, grouped according to user category, the table shows the total number of columns in the answer matrices for the seven storms (total number of entries possible), the actual number of entries and the percentage of entries.

TABLE 4-6

PERCENTAGE OF ANSWER MATRIX ENTRIES

No.	Organization	Seven Storm Periods		
		Total Columns	No. Entries	Percent
1	NWS National Meteorological Center	224	163	72.7%
2	NWS RWC/WSFO New York	224	140	62.5%
3	NEW WSFO Columbia	224	102	45.5%
4	NWS WSFO Boston	224	134	59.8%
5	NWS WSFO Washington	224	119	53.1%
6	NWS WSFO Philadelphia	224	24	10.7%
7	Travelers Weather Service	224	191	85.2%
8	WBZ-TV-1	224	224	100.0%
9	WBZ-TV-2	224	164	73.2%
10	Bendix Commercial Services	224	220	98.2%
11	Northeast Weather Service	224	224	100.0%
	Total	2464	1705	69.1%

The utility scores computed for each of three user categories and all users, according to topical questions, are given in Table 4-7. The scores reveal a number of important details concerning the nature of the responses to the Survey. The most important results and conclusions drawn from Table 4-7 are as follows.

- There is a significant variation among user categories from the overall scores of 0.70 and 0.68 for surface and upper-air data utility, respectively. The NWS NMC assessment of upper-air data utility reflects the limited impact that two data points might have on large-scale numerical analysis and prediction results. In contrast to this, the direct application of HOTEL upper-air data for general or specialized uses by NWS WSFOs and private data users results in much higher utility scores.

TABLE 4-7

UTILITY SCORES FOR USER CATEGORIES AND QUESTIONS

Topical Questions	User Category			All Users
	NMC	WSFO	Private	
1. Newly-Forming Coastal Storm	0.81	0.63	0.85	0.76
2. Intensifying Coastal Storm	0.63	0.66	0.86	0.77
3. Cold & Warm Fronts	0.50	0.62	0.80	0.71
4. Surface Pressure Gradient (Wind direction & speed)	0.56	0.58	0.78	0.70
5. Sea Surface Conditions	0.55	0.54	0.73	0.64
6. Precipitation	0.29	0.47	0.68	0.59
Average for Questions 1-6	0.55	0.58	0.78	0.70
7. Upper-Level Significant Features	0.13	0.56	0.78	0.64
8. Upper-Level Flow	0.12	0.58	0.84	0.70
9. Upper-Level Advection	0.15	0.55	0.85	0.69
Average for Questions 7-9	0.13	0.56	0.82	0.68
Average for All Questions	0.38	0.58	0.80	0.69

- All three classes of data users considered the greatest utility of the XERB/HOTEL surface data to be for a Newly-Forming Coastal Storm or an Intensifying Coastal Storm. The utility scores computed were 0.81 (Question 1) for NWS NMC, 0.66 (Question 2) for the WSFOs and 0.86 (Question 2) for private data users, indicating that the data were Critical or Important.
- All data users ranked the XERB/HOTEL surface data as least applicable to the topic of precipitation (areal extent, type, intensity and duration). As discussed previously, this reflects the complexity of precipitation analysis and prediction and the limited contribution of two data points to the problem.

Table 4-8 shows how the utility scores computed for each user group and all users varies as a function of storm period. The results are given separately for surface and upper-air data. The most interesting result in the table is the general increase in utility scores of all users of surface data from the first storm period through the sixth storm period. The results for the seventh storm period, Tropical Storm ARLENE, are not really comparable to the other periods as two of the six topical questions dealing with the utility of surface data were not applicable during this final storm period.

TABLE 4-8

UTILITY SCORES FOR USER CATEGORIES AND STORM PERIODS

(a) Surface Data

Storm Period	User Category			All Users
	NWS/NMC	NWS/WSFO	Private	
1. March 12-13, 1970	-	0.52	0.75	0.65
2. March 29, 1970	-	0.56	0.71	0.65
3. November 4-5, 1970	0.68	0.64	0.73	0.70
4. December 31, 1970 - January 1, 1971	0.52	0.60	0.77	0.69
5. February 7-8, 1971	0.58	0.60	0.91	0.77
6. March 3-4, 1971	0.44	0.60	0.85	0.73
7. July 4-6, 1971	0.51	0.59	0.74	0.66
Average for All Storm Periods	0.55	0.58	0.78	0.70

(b) Upper-Air Data

Storm Period	User Category			All Users
	NWS/NMC	NWS/WSFO	Private	
1. March 12-13, 1970	0.11	0.42	0.84	0.66
2. March 29, 1970	0.17	0.55	0.83	0.69
3. November 4-5, 1970	0.14	0.71	0.78	0.68
4. December 31, 1970 - January 1, 1971	0.17	0.54	0.85	0.70
5. February 7-8, 1971	0.11	0.54	0.75	0.62
6. March 3-4, 1971	0.11	0.61	0.89	0.72
7. July 4-6, 1971	-	-	-	-
Average for All Storm Periods	0.13	0.56	0.82	0.68

This indication of increased data utility during the latter part of the 18-month study period (February 1, 1970, to July 31, 1971) could be attributed to any one or a combination of the following factors.

(a) Increased awareness of the availability of XERB/HOTEL surface data and greater use was made of the data as the credibility was established.

(b) Increased competence gained from experience in utilizing the data for specific meteorological applications.

(c) More detailed recall of more recent storm period characteristics and specific uses made of XERB/HOTEL data.

It is reasonable to conclude that the first two factors would be operative during the 18-month study period. An on-going, real-time evaluation study would, perhaps, best demonstrate the importance of accumulated experience to an estimation of data utility.

Table 4-9 gives the utility scores arranged according to type of application of XERB/HOTEL data for each of the nine topical questions. In general, the respondents judged that the XERB/HOTEL surface and HOTEL upper-air data were most applicable for detecting and locating specific meteorological features in the immediate region, and were of slightly lower utility for an overall analysis. Surface data were of lesser importance for prediction. This ranking of utility according to application seems quite realistic, as the most direct use of the data is for detection/location of specific features and the least direct application of the data (although by no means least important) is for predicting the features. It should be noted that the respondents did report that XERB/HOTEL surface and HOTEL upper-air data contributed significantly to prediction, i.e., a score of 0.67 indicates that the data utility is considered Important, on the average, indicating that on at least some occasions it was Critical for some respondents.

Considering XERB/HOTEL surface data, the highest utility scores were for detection (0.81) and location (0.80) of a Newly-Forming Coastal Storm and the location (0.84) and analysis (0.80) of an Intensifying Coastal Storm. The lowest scores were for the prediction (0.56) of Cold and Warm Fronts and the prediction (0.54) of Precipitation. The detection (0.74) and location (0.73) of upper-level temperature and moisture advection represented the most-valued application of HOTEL upper-air data. This latter numerical result corroborates oral and written comments stressing the significant contributions of HOTEL upper-air data to the rain/snow forecasting problem.

TABLE 4-9

UTILITY SCORES FOR APPLICATION CATEGORY AND QUESTIONS

Topical Question	Application				All Applications
	Detection	Location	Analysis	Prediction	
1. Newly-Forming Coastal Storm	0.81	0.80	0.79	0.65	0.76
2. Intensifying Coastal Storm	0.74	0.84	0.80	0.70	0.77
3. Cold and Warm Fronts	0.78	0.78	0.74	0.56	0.71
4. Surface Pressure Gradient (Wind Direction & Speed)	0.75	0.72	0.72	0.64	0.70
5. Sea Surface Conditions	0.70	0.68	0.60	0.60	0.64
6. Precipitation	0.59	0.63	0.59	0.54	0.59
Average for Questions 1-6	0.72	0.74	0.71	0.62	0.70
7. Upper-Level Significant Features	0.62	0.66	0.64	0.65	0.64
8. Upper-Level Flow	0.71	0.72	0.67	0.69	0.70
9. Upper-Level Advection	0.74	0.73	0.66	0.65	0.69
Average for Questions 7-9	0.69	0.70	0.66	0.66	0.68
Average for All Questions	0.71	0.73	0.69	0.63	0.69

4.4 General Questionnaire

All respondents were requested to make a general evaluation of the XERB/HOTEL data during the 18-month period February 1, 1970 - July 13, 1971. As shown in Table 4-1, eight respondents submitted such as assessment. It should be noted that two of the eight respondents who contributed to the General Questionnaire did not provide evaluations of XERB/HOTEL data during any of the seven storm periods selected for emphasis in the Questionnaire. Similarly, five of the eleven respondents who evaluated the XERB/HOTEL data during the storm periods, did not contribute to the General

Questionnaire. Thus, the results of the responses to the General Questionnaire which are shown in Table 4-10 reflect a somewhat different sampling of data users than has been the basis for discussion in Section 4.1 through Section 4.3.

Even given the sample differences, the results obtained from the General Questionnaire closely parallel the data utility evaluations for the seven selected storm periods. Again, except for the topical question dealing with precipitation, well over half the total application entries indicate an "Important" or a "Critical" utility for both surface and upper-air data. Since the results from the General Questionnaire are closely analogous to those of preceding sections and the number of entries are small, the previous comments are considered sufficient.

TABLE 4-10

RESPONSE TO GENERAL QUESTIONNAIRE

(a) Newly-Forming Coastal Storm

Degree of Utility of XERB/HOTEL Surface Data	Application				Total
	Detection	Location	Analysis	Prediction	
Critical to Success	3	2	2	1	8
Important	4	5	6	4	19
Of Some Value	1	1		3	5
Of Little or No Use					
Total	8	8	8	8	32

XERB data of greater importance than HOTEL data: 2

XERB data of equal importance to HOTEL data: 1

XERB data of less importance than HOTEL data: 3

Total Possible: 32

(b) Intensifying Coastal Storm

Degree of Utility of XERB/HOTEL Surface Data	Application				Total
	Detection	Location	Analysis	Prediction	
Critical to Success	2	3	2	1	8
Important	5	5	6	5	21
Of Some Value	1			2	3
Of Little or No Use					
Total	8	8	8	8	32

XERB data of greater importance than HOTEL data:

XERB data of equal importance to HOTEL data: 3

XERB data of less importance than HOTEL data: 3

Total Possible: 32

(c) Cold and Warm Fronts

Degree of Utility of XERB/HOTEL Surface Data	Application				Total
	Detection	Location	Analysis	Prediction	
Critical to Success	3	3	2	1	9
Important	3	5	5	5	19
Of Some Value	1			1	2
Of Little or No Use				1	1
Total	7	8	8	8	31

XERB data of greater importance than HOTEL data:

XERB data of equal importance to HOTEL data: 4

XERB data of less importance than HOTEL data: 2

Total Possible: 32

TABLE 4-10 (Continued)

(d) Surface Pressure Gradient (Wind Direction and Speed)

Degree of Utility of XERB/HOTEL Surface Data	Application				Total
	Detection	Location	Analysis	Prediction	
Critical to Success	2	2	2	2	8
Important	4	4	6	4	18
Of Some Value	1			1	2
Of Little or No Use				1	1
Total	7	6	8	8	29

XERB data of greater importance than HOTEL data:

XERB data of equal importance to HOTEL data: 3

XERB data of less importance than HOTEL data: 2

Total Possible: 32

(e) Sea Surface Conditions

Degree of Utility of XERB/HOTEL Surface Data	Application				Total
	Detection	Location	Analysis	Prediction	
Critical to Success	2	3	3	1	7
Important	2	2	3	3	10
Of Some Value	1	1			2
Of Little or No Use	1	1	1	2	5
Total	6	6	6	6	24

XERB data of greater importance than HOTEL data:

XERB data of equal importance to HOTEL data: 2

XERB data of less importance than HOTEL data: 3

Total Possible: 32

(f) Precipitation

Degree of Utility of XERB/HOTEL Surface Data	Application				Total
	Detection	Location	Analysis	Prediction	
Critical to Success	1	1	1	1	4
Important	2	2	2	1	7
Of Some Value	2	3	3	3	11
Of Little or No Use					
Total	5	6	6	6	23

XERB data of greater importance than HOTEL data: 1

XERB data of equal importance to HOTEL data:

XERB data of less importance than HOTEL data: 4

Total Possible: 32

TABLE 4-10 (Continued)

(g) Upper-Level Significant Features

Degree of Utility of HOTEL Upper-Air Data	Application				Total
	Detection	Location	Analysis	Prediction	
Critical to Success	2	4	4	1	11
Important	2	2	2	5	11
Of Some Value	2		1		3
Of Little or No Use	1	1		1	3
Total	7	7	7	7	28

Total Possible: 32

(h) Upper-Level Flow

Degree of Utility of HOTEL Upper-Air Data	Application				Total
	Detection	Location	Analysis	Prediction	
Critical to Success	1	2	2	1	6
Important	3	3	4	5	15
Of Some Value	1		1		2
Of Little or No Use	1	1		1	3
Total	6	6	7	7	26

Total Possible: 32

(i) Upper-Level Temperature and/or Moisture Advection

Degree of Utility of HOTEL Upper-Air Data	Application				Total
	Detection	Location	Analysis	Prediction	
Critical to Success	2	2	2	1	7
Important	2	2	3	4	11
Of Some Value			1		1
Of Little or No Use	1	1		1	3
Total	5	5	6	6	22

Total Possible: 32

5.0 NEED, USE AND BENEFITS OF XERB/HOTEL DATA

5.1 Need for East Coast Marine Meteorological and Oceanic Data

The background discussion in Section 2 clearly reveals the need for environmental data off the east coast of the United States. The ever more dense concentrations of population and industry along the east coast increase the potential for loss of life, property damage and disruptions to business and transportation. The accurate and timely prediction of heavy snowfalls, flooding rains, high winds, heavy seas, destructive high tide and storm surges is possible only with adequate upper air, surface and subsurface marine environmental data from ocean regions contiguous to the U. S. east coast.

Marine atmospheric and oceanographic data requirements were collected in 1967 from more than 30 U.S. Government agencies and institutions receiving government support [1,2]. This compilation of requirements included an array of 270 observational sites having separations of approximately 50-200 nautical miles in the Coastal North America Region (within 400 n mi from the coast). A total of 47 data buoy sites was specified in a zone defined off the east coast of the United States. The upper air, surface and subsurface parameters measurable by buoys and the proposed sensing characteristics were also specified in this study.

As a consequence of an exceedingly heavy snowfall in the Boston area in February 1969, a letter was written to Senator Brooke of Massachusetts by six meteorologists in the Boston Area (given in Appendix A) explicitly stating requirements to satisfy a specific need. The authors of the letter suggested the locations (see Fig. 2-1) of 2 ships and 9 data buoys required to improve 6-12 hour and 12-36 hour forecasts for New England. Obviously, the subsequent deployment of XERB and HOTEL only partially satisfy this need.

Recognizing the problems posed by the sparsity of data in the Western Atlantic, the National East Coast Winter Storms Operations Plan [13] was developed by an Ad Hoc Group functioning under the purview of the Subcommittee on Basic

Meteorological Services (SC/BMS) within the Interdepartmental Committee for Meteorological Services (ICMS). The Operations Plan, pertaining to observations to be obtained from XERB and HOTEL, is extracted and shown in Appendix D. The details of the XERB/HOTEL surface data transmission, content and format are given in Appendix B.

In considering the needs expressed in the response to this Survey, it is important to note that the participating data users were primarily those who dealt directly with the data to produce an end product, i.e., an analysis, forecast or warning. The needs and uses expressed emphasize this aspect, rather than economic or social considerations. A summary of needs expressed by Survey respondents is given in Appendix E and grouped according to (1) remarks directly related to XERB/HOTEL and (2) remarks pertaining to a more general expression of need.

Many users strongly expressed the desire that XERB/HOTEL surface data be transmitted hourly over teletypewriter Service A or at least 3-hourly over Service C. Beginning on September 21, 1971, this latter requirement is being routinely met.

A variety of more general need was expressed for data from additional buoys and Ocean Weather Ships. Several users expressed needs for data from 2-3 rows of data buoys off the east coast with intervals between the buoys ranging from 60-300 n mi. About 10 to 35 data buoys would satisfy the various networks described by data users during the Survey. Examples of networks of buoys and individual buoys requested include:

(1) Bendix Commercial Service Corporation. Ten additional data buoys with a spacing about 180 miles apart in two lines off the U.S. east coast. The inner line extends from 29°N, 80°W to 47°N, 51°W (6 additional buoys) and the outer line extends from 32°N, 74°W to 38°N, 67°W (4 additional buoys).

(2) American Airlines. Three rows of data buoys stretching from Bangor, Maine, to Cape Hatteras, about 60 miles apart (approximately 33 data buoys required).

(3) NWS WSFO Boston. A line of about seven data buoys along approximately 38.5°N latitude from the coast to 60°W longitude, with a separation of about two degrees.

(4) Several Respondents. An additional data buoy to the east or southeast of the present location of XERB, at about 70°W longitude.

(5) Several Respondents. A data buoy placed on the edge or to the east of Georges Bank at about 42°N, 67°E.

Data from these networks would be used to satisfy the needs of ship track routing, aviation terminal forecasting, private meteorological applications, scheduling off-shore oil drilling operations and 12-hr to 36 hr coastal environmental prediction, as well as the shorter-range local meteorological and oceanic forecasting tasks.

5.2 Use of XERB/HOTEL Data

The Survey respondents were asked to evaluate the degree of utility of XERB/HOTEL data for the detection, location, analysis and prediction of ten environmental features or phenomena. Since the Survey emphasized seven storm periods, it must be clearly recognized that the evaluation of data use was primarily linked to situations of meteorological uncertainty. A detailed analysis of data use during the seven storm periods is presented in Section 4. In the following paragraphs these results are synthesized by considering XERB/HOTEL data use from three points of view: (1) type of application, (2) type of data user and (3) storm period. The scope of the analysis is limited to the use of XERB/HOTEL surface data and HOTEL upper air data for detection, location, analysis and prediction; the use of subsurface data is not discussed, because it was not within the scope of this study. The uses of subsurface data for commercial fishing, military, research, and other purposes is clearly recognized, however.

The variation in utility scores for all users according to type of application is shown in Fig. 5-1 for surface and upper air data.

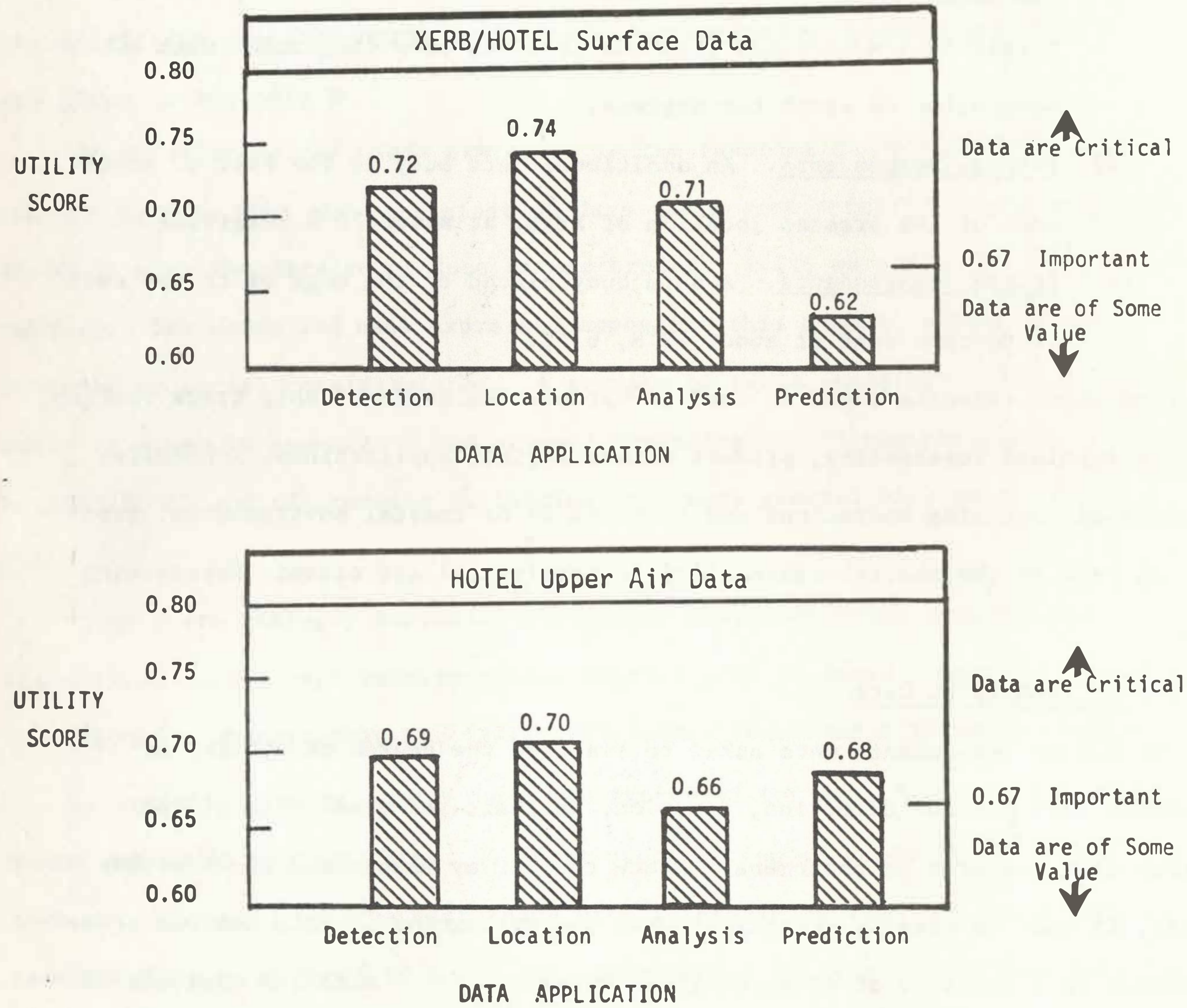

Fig. 5-1. Utility scores according to type of application

The respondents judged that the XERB/HOTEL surface data were most applicable for detecting and locating specific meteorological features in the immediate vicinity of the buoy and ship and of somewhat lower utility for prediction, although still "Important," i.e., a score of 0.62 indicates that the data utility is classified as Important. Much less variation in utility score according to type of application is noted for upper air data.

The overall utility scores by user category are shown in Fig. 5-2. The score for all users was 0.70 for surface data and 0.68 for upper air data.

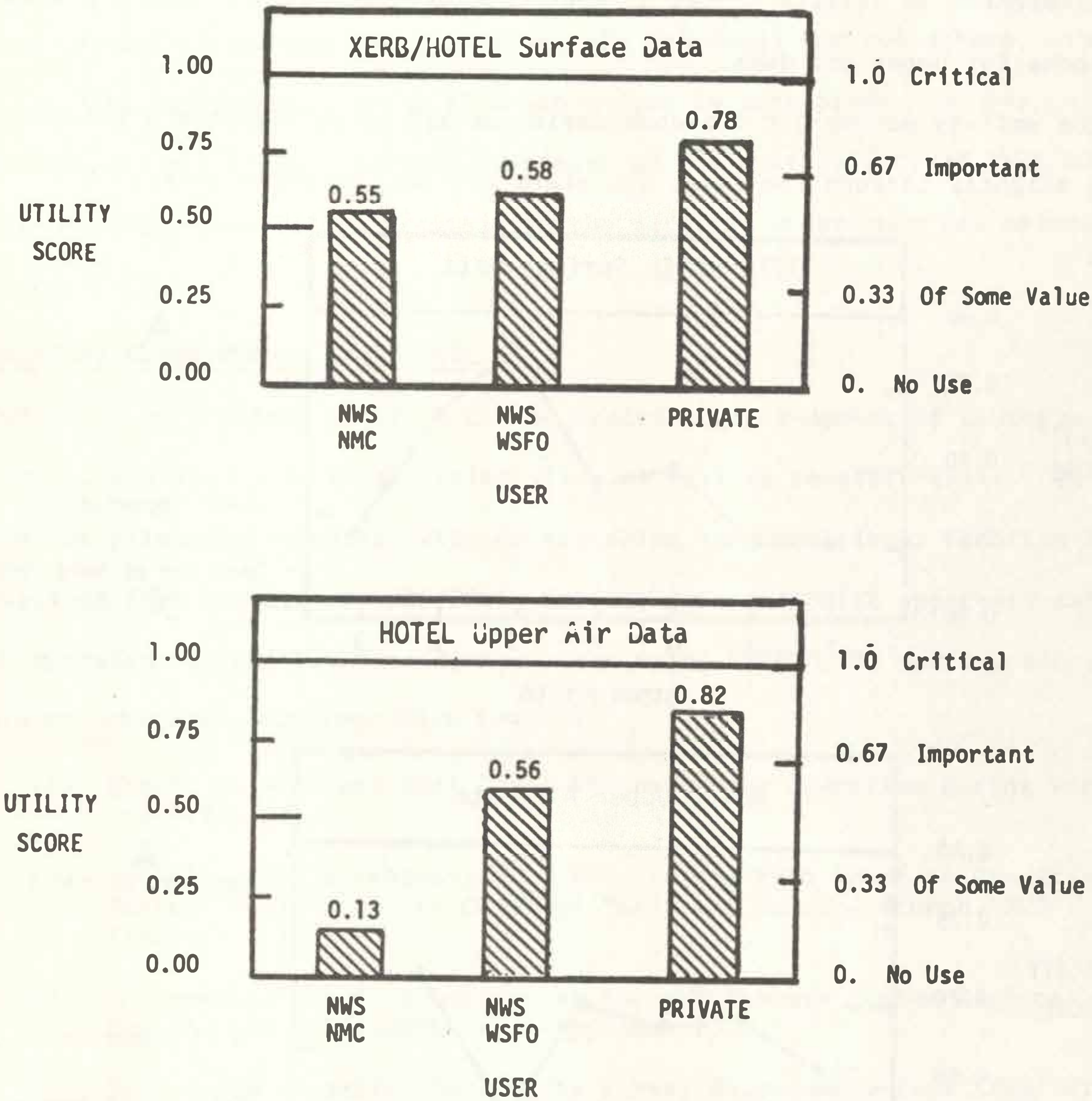

Fig. 5-2. Utility scores according to user classification.

The NWS National Meteorological Center assessment of upper air data utility reflects the limited impact that two additional data points might have on numerical analysis and prediction results, which are derived from numerical models employing a large time and space scale. The more direct application of HOTEL upper air data for specific uses results in higher utility scores for NWS Weather Service

Forecast Offices and, especially, for private users where the utility ranges from "Important" to "Critical." Since surface data is employed directly by all users, the differences in utility scores by user category for surface data are much smaller than those for upper air data.

The utility scores for the combination of all users exhibits a tendency to increase slightly through the first six storm periods, as shown in Fig. 5-3.

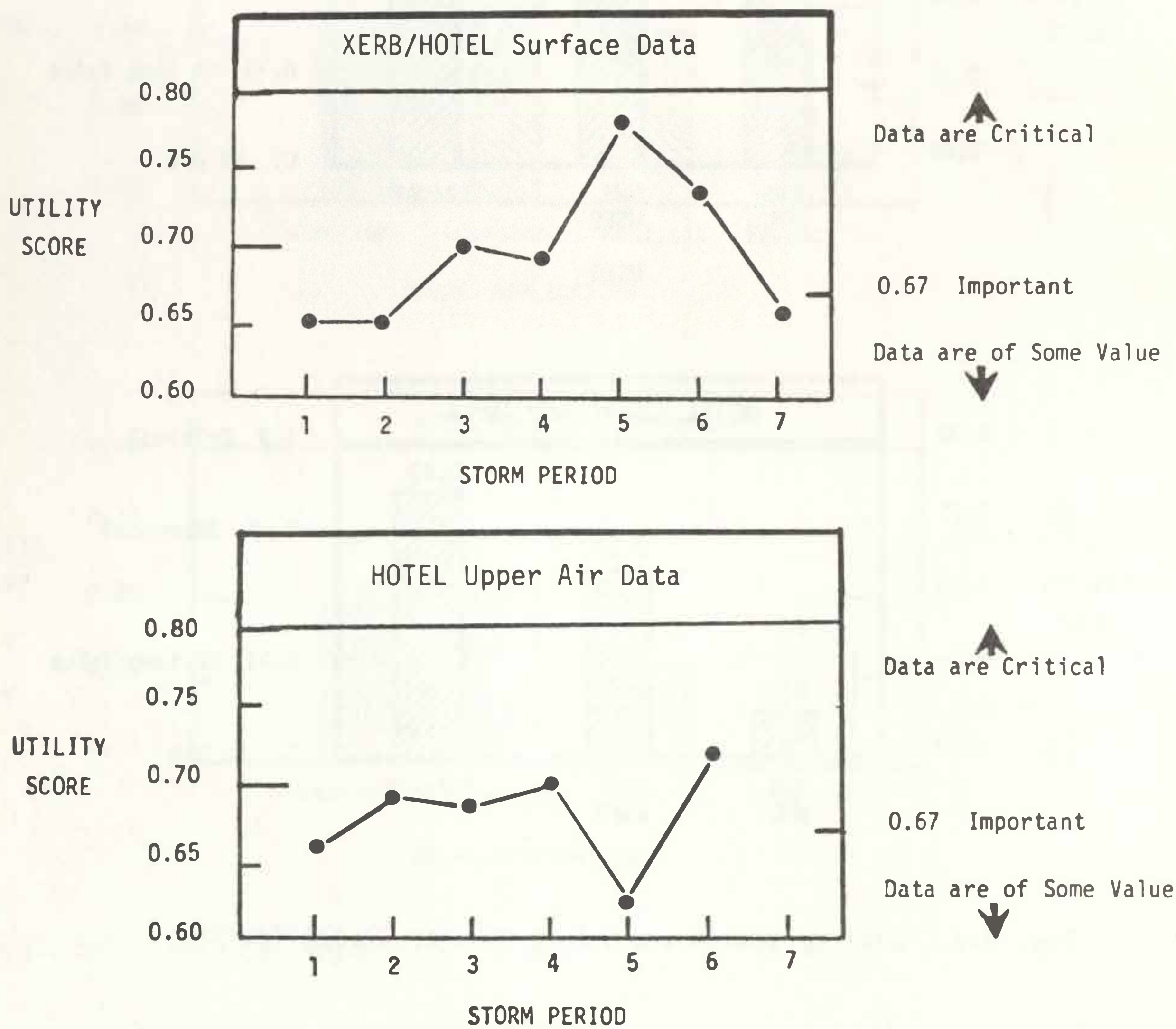

Fig. 5-3. Utility scores for seven storm periods.

The seventh storm period (Tropical Storm ARLENE) is not comparable to the first six periods, since two of the six topical questions pertaining to surface data and the three questions concerning upper air data were not applicable for this last storm. It was noted, however, that data from XERB were utilized by the National Hurricane Center for the four tropical cyclones affecting the U.S. east coast during the 1971 season, and special hourly reports were requested for HEIDI and special three hourlies (now routinely provided) for two others. The increasing data utility during the 18-month period is more pronounced for surface data and may reflect greater awareness of the availability of XERB/HOTEL data and increased credibility assigned to the data, as experience was gained in its use.

5.3 Benefits Derived from XERB/HOTEL Data

Potential or realized benefits can be described in a number of contexts such as economic, social, operational, scientific, as well as several others. In this study we are primarily concerned with establishing the operational benefits that were realized from the use of XERB/HOTEL surface data and HOTEL upper-air data.

An appraisal of the benefits derived from using XERB/HOTEL surface and upper air data was obtained from four main sources:

(1) Report on National East Coast Winter Storms Operation During Winter 1970-1971 [14].

(2) Excerpts From a February 19, 1971, Letter From Chief of Operations, Eastern Region, NWS to Chief of Emergency Warning Branch, NWS (Appendix F).

(3) Incremental Benefits Derived by the NWS Eastern Region Regional Weather Center From XERB/HOTEL Data (Appendix F).

(4) Incremental Benefits Derived by Survey Respondents from XERB/HOTEL Data (Appendix H).

In the first source,it was concluded that during threat situations,"New and useful data were received in 75% of the reports from the ship and in 61% of the reports from the buoy, which added materially to more exact analyses and a better understanding of the synoptic situation."

In the second source (Appendix F) eight periods were identified between December 26, 1970,and February 9, 1971,during which data from XERB and HOTEL:

"...have allowed for more accurate analysis, amended forecasts or the issuance of critical weather warnings."

The third source (Appendix G) was compiled from the daily evaluation reports prepared during the period December 30, 1970 through March 28, 1971, which were made available by the Regional Weather Center of the NWS Eastern Region. On 20 days during the 89-day period, specific comments were prepared by the RWC which qualitatively describe incremental benefits that were derived by this one data-using group. Ten of these comments are given in Appendix G. It should be held in mind that for the subject period, sixteen significant weather occurrences have been described in Table 3-1. On ten of the twenty days when incremental benefits were described, XERB data were not received or were not available in time for use; these conditions are indicated in Appendix G for the selected comments.

The fourth source -- the Survey visits and the Survey Questionnaire -- also contained qualitative information relative to incremental benefits. The remarks pertaining to the benefits (described in Appendix H) are grouped into those referring to

(1) the entire 18-month period or benefits obtained from specialized uses of the XERB/HOTEL data (e.g., research) and

(2) each of the seven selected storm periods.

The incremental benefits stemming from XERB/HOTEL surface data include

- detection and/or more precise location of a newly-forming or intensifying coastal storm,
- improved analysis of the surface pressure and wind field,
- detection and/or more precise location of surface frontal systems which may be accompanied by squalls, and
- improved analysis and short-range prediction of the movement and intensification of coastal storms.

The incremental benefits stemming from HOTEL upper air data include

- improved analysis of upper-level flow offshore and changes in the flow, which are critical to the steering concept for predicting the movement of surface low-pressure systems,
- improved analyses of upper-air moisture flow, vital for the prediction of precipitation amount, and
- improved analysis of upper-air temperature advection, important for the prediction of precipitation type.

The high quality of forecasts that has resulted from the National East Coast Winter Storms Operation and the contributing special data (including XERB/HOTEL) has been noted several times during the 1970-1971 winter season. Two examples are

(a) December 31, 1970 - January 1, 1971. It was reported in NOAA WEEK (vol. 2, no. 2, January 15, 1971) that Dr. Cressman, Director of NWS, commended forecasters at NWS National Meteorological Center and NWS Eastern Region for alerting the public to the probability of heavy snow 24 hours prior to the New Year's Eve storm. The metropolitan areas from the Virginias northward received more than eight hours warning.

(b) March 3-4, 1971 The Boston *Herald Traveler* contained an article on March 4,1971, which described the public benefits due to an early snow alert. Because of the alert, thousands of workers were sent home early, public events scheduled for the evening were cancelled and snow clearance crews were mobilized. In the evening the mixture of rain and snow changed to all snow and combined with winds gusting to 45 mph to produce hazardous driving conditions.

The direct operational benefits stemming from the use of XERB/HOTEL surface and HOTEL upper air data for these two periods are detailed in Appendices G and H.

A key concept expressed by several users participating in the Survey was the benefits derived from time-series data at a fixed point. The careful timing of weather events requires data from fixed locations; data from ships-of-opportunity do not provide this information. Other benefits noted from the use of XERB/HOTEL surface and upper air data (described in Appendix H) include:

(1) establishing climatological normals of various environmental parameters,

(2) serving as a reliable standard to judge reports from nearby vessels and corroborating aircraft reconnaissance data, and

(3) providing data for research.

6.0 CONCLUSIONS

The Survey and supporting material included in this study clearly substantiate the conclusion that the deployment of XERB and HOTEL is an important, but partial, satisfaction of a number of U.S. east coast environmental data needs. For a variety of data users on the U.S. east coast, the XERB surface data and HOTEL surface and upper air data have proved to be of Critical or Important Use in detecting, locating, analyzing and predicting environmental features and parameters. The use of XERB/HOTEL data by the NWS National Meteorological Center, the NWS WSFOs and industrial environmental forecasting organizations has resulted in direct operational benefits, which could be translated into economic and social benefits as well. It is probably safe to suggest that operational and economic benefits were also accrued by military users of environmental information in the U.S. east coast region.

It is apparent that the satisfaction of a number of data needs, reaffirmed by this study, requires additional data buoys, among a mix of complementary data collection platforms, e.g., satellite, aerial reconnaissance, etc. It is expected that the locations of additional data buoys would be determined following considerations of many factors. These include operational, archival and scientific needs and use. Additional factors to be considered are economic benefits and cost effectiveness, sparsity of data, meteorological considerations such as the degree of storm development (cyclogenesis) and variability (frontal zones), and oceanographic considerations such as variability and sea-air interaction, as well as the serviceability of buoys [15].

7.0 RECOMMENDATIONS FOR ADDITIONAL WORK

The information, experience and methodology developed in the present study could efficiently and effectively be used to conduct a real-time survey of data users. A survey undertaken during and just after a series of weather events would permit a more detailed and complete documentation of the uses of XERB/HOTEL data than was possible in the present study.

A complete and detailed evaluation of the value and utility of XERB/HOTEL data requires careful consideration of the availability, use and importance of other types of data. Specifically, the relative importance of Reconnaissance Aircraft data, Satellite data and Ship-of-Opportunity data should also be determined in the study.

It is important that all principal users of the data participate in the study. These users include NWS personnel in the Eastern Region and National Meteorological Center and military and commercial data users. The real-time survey should be conducted over a time period long enough to encompass a sufficient number and variety of weather events to provide data for valid statistical analyses. A six-month period including about thirty significant weather events would provide an adequate data sample.

A second study of value would be to test the effect on numerical analysis and prediction, using a fine scale model, of the presence or absence of data from platforms such as XERB and HOTEL. The planned Gulf of Mexico experimental network of NDBC data buoys offers such an opportunity.

The present study has clearly documented both the important utility of the XERB/HOTEL data and the strong desire for additional data from the oceans. The design and development of networks of ocean data buoys supplemented with ocean weather vessels will profit greatly from a detailed knowledge of utilization of data from the existing observational system.

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The Study of the Feasibility of National Data Buoy Systems (6 Volumes)

DOCUMENT NUMBER	REPORT TITLE
*AD 665-314	"A Summary of the Study of the Feasibility of National Data Buoy Systems"
*AD 664-617	"Vol. I, Part 1, National Requirements for Marine Meteorological and Oceanographic Data"
*AD 664-618	"Vol. I, Part 2, Buoy and Buoy Components Data Compilation and Analysis"
*AD 664-619	"Vol. I, Part 3, A Cost Effectiveness Evaluation of Buoy and Non-Buoy Systems for Marine Data"
*AD 664-670	"Vol. II, Cost-Benefits for a National Data Buoy Systems"
*AD 664-671	"Vol. III, Technical Development Plans for the National Data Buoy Systems"

The 1968 Development Planning Support Study (7 Volumes)

DOCUMENT NUMBER	REPORT TITLE
*AD 683-404	"A Summary of 1968 Development Planning Support Studies for the USCG National Data Buoy Development Project"
*AD 682-512	"Applicability of NDBS to Refined National Requirement for Marine Meteorological and Oceanographic Data - Vol. I"
*AD 682-513	"Applicability of NDBS to Refined National Requirement for Marine Meteorological and Oceanographic Data - Vol. II"
*AD 682-514	"Computer Programs for National Data Buoy Systems Simulated and Cost Models"
*AD 682-515	"Characteristics of NDBS; Their Impact on Data Use and Measurement of National Phenomena"
*AD 682-516	"Cost Effectiveness Sensitivity of National Data Buoy Systems: An Essay"
*AD 682-517	"An Analysis of Cruise Strategies and Costs for Deployment of NDBS"

U. S. C. G. Oceanographic Sensor Study (6 Volumes)

DOCUMENT NUMBER	REPORT TITLE
AD 711-322	"Vol. I, State-of-the-Art of Oceanographic and Meteorological Sensors" (Tutorial Discussion)
AD 711-323	"Vol. II, State-of-the-Art of Oceanographic and Meteorological Sensors" (Catalog)
AD 711-325	"Vol. III, The Survival Environment for Oceanographic and Meteorological Sensors"
AD 711-326	"Vol. IV, The Formatting and Transmission of Data from Oceanographic Sensors"
AD 711-327	"Vol. V, Analysis of Applying Standardization Techniques to Oceanographic Sensors"
AD 711-328	"Vol. IV, Test Requirements for Oceanographic and Meteorological Sensors"

Other National Data Buoy Project Reports

DOCUMENT NUMBER	REPORT TITLE
*AD 695-501	"Proceedings of the USCG Scientific Advisory Meeting"
AD 678-696	"Preliminary Concept Formulation Summary for National Data Buoy Systems"
*AD 856-046	"A Resume of National Data Buoy Development Planning"
AD 699-205	"Potential Transportation Benefits of Improved Environmental Prediction"
AD 702-797	"Long Range Development Plan"
AD 704-609	"National Data Buoy Development Project Concept Formulation Plan"
AD 722-596	"A Cost Effectiveness Methodology for Environmental Monitoring Systems"
	"Industrial Data Users Meeting"
	"Requirements Development Plan"

Related Works

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Note:
*Work performed by The Center for the Environment and Man, Inc. (formerly The Travelers Research Corp.).

APPENDIX A

LETTER TO SENATOR BROOKE
REQUESTING
BUOY/SHIP OBSERVATIONS

28 April 1969

Honorable Edward W. Brooke
United States Senator
Room 1251
New Senate Office Building
Washington, D.C. 20510

Dear Senator Brooke:

Recently, some of the Boston area meteorologists held a meeting to discuss your efforts to correct the obvious gap in the weather information required to forecast the movement and development of hurricanes and important wintertime northeast storms. We are pleased at your continuing interest in the problem and want to be of assistance as you push for action. With the coming of spring, we are fearful that there will be a tendency on the part of the agencies responsible to "let things ride". As meteorologists, we know that there is not an excessive period of time for planning solutions. Without your help, we have no doubt that the triangle between Nantucket, Bermuda and Hatteras will remain empty of weather observations. This letter contains our present detailed thoughts on the matter and may be used for whatever purposes you deem necessary.

First off, let's state what we think is the preferred solution, understanding that this solution may require some time.

1. A weather ship, stationed near 37° North Latitude, 70° West Longitude, to provide an anchor to which the rest of the observations could be tied. It may seem that we are over-emphasizing the value of an expensive weather ship. In a sense, we are, because we feel that it is the key, not only to the immediate forecasting problem in New England, but absolutely vital in the research efforts necessary to understanding the development and movement of these storms.

and either

2a. Six weather buoys at

42°N,	67 1/2°W
40°N,	67 1/2°W
39°N,	70 °W
39°N,	72 1/2°W
37°N,	73 °W
35°N,	73 °W

These buoys should routinely make and report a minimum of one observation every three hours during ordinary weather and once every hour during storm situations. These reports should include (but not necessarily be limited to):

i. Wind direction and speed
ii. Barometric pressure
iii. Temperature
iv. Precipitation (rain, snow, etc.)

These data should be relayed rapidly over communications facilities such that they will be in Boston and available to <u>all</u> forecasters within an hour.

or

2b. Reconnaissance planes to fly around and through the storm, tracking its motions, and measuring the wind, temperature, rain and snow near the ocean surface. These traverses around and through the storm center should be at least as frequent as once every three hours, and the data again should be quickly available in Boston. The reconnaissance of the winter storms will be more difficult than that of hurricanes because of fundamental differences between the two. For example, the center of a hurricane at a height five to ten miles above the ocean surface is almost exactly over the center of the storm down near the surface. The center of a "northeaster" in the now "empty triangle" at five to ten miles above the ground may be five hundred miles to the west. The need for low level reconnaissance of northeasters, in addition to reconnaissance at middle and high levels is therefore obvious, as are the fundamental differences in the measurements involved. The decision to send out the planes should be in the hands of the Meteorologists-in-Charge (MIC) of the Weather Bureau forecast offices in Boston, New York and Washington.

This combination of one weather ship, plus either buoys or reconnaissance planes in the Bermuda, Hatteras, Nantucket triangle is intended for the improvement of forecasts of weather six to twelve hours in the future. We would be remiss in our duty if we did not point out that there are important (though less pressing) forecasting requirements in the twelve to thirty-six hour period too! No real solution to this range of problems is in sight without at least the following:

A second weather ship at 32°N, 73°W
and
weather buoys at 33°N, 75°W
32°N, 78°W
30°N, 79°W

The observations will assist in increasing the accuracy of the "computer" forecasts from Washington, one of our most valuable tools for forecasting a day or two ahead.

We understand from our friends at the U.S. Weather Bureau that a practical buoy system is currently under evaluation, and that the best course at present may be to sit tight and await the results of the evaluation. Even while awaiting these results, every effort should be made to station a weather ship in the empty triangle, and we wholeheartedly back your present efforts in this direction.

However, realistically, let's consider in detail what should be done for next fall and winter (July 69 - March 70) under the worst possible circumstances--that is, assuming only reconnaissance planes will be available. We feel the way to best utilize these planes and other easily available resources is the following:

1. During the period from July through the end of March, the planes should be on call to be alerted by the Meteorologists-in-Charge (MIC) in Boston, New York and Washington. The planes should probably not be based near Boston--but perhaps in Bermuda--a spot not likely to be affected by the storms. Alerts would be called when conditions seem ripe for a coastal storm development. Since storms will not always develop during one hundred percent of the alerts, there will be necessarily more alerts than storms.

2. When alerted, the planes should plan their routing so that at 0000 and 1200 Universal Time (7:00 A.M. and P.M. E.S.T.) they will be near the location of the projected weather ship (37°N, 70°W) at a pressure level of 500 millibars (around 18,000 feet) or capable of obtaining the winds, height and temperature of the 500 millibar level. In between these times, the planes should be flying a very low level pattern (below 1000 feet) so that the position of the surface storm center is accurately located and its pressure measured at least once every three hours, with regular reports of the wind, temperature, and precipitation in the area between the storm center and U.S. coast to the west and north and somewhat out to sea toward the northeast, until the storm is at a point well north or east of Nantucket Island. Again, the need of the low level traverses arises because of the westward tilt of the storm center with height.

3. During the alert periods, the upper-air sounding stations at Cape Hatteras, Nantucket Island, New York (currently Kennedy Airport) and Wallops Island should be required to send up rawinsondes not only at their regular times of 0000 U.T. and 1200 U.T., but also at 0600 U.T. and 1800 U.T. There is a possibility that a similar

schedule should be followed at Nashville, Pittsburgh and Buffalo too, but time and experience will better answer for these stations. Bermuda sends up four soundings per day already.

4. These special data should be sent promptly on a circuit(s) such that the data is available in Boston within an hour or less after the measurements are made.

It's obvious, Senator Brooke, that this letter raises many detailed technical questions, about which you may feel unfamiliar. We suggest that it may be more beneficial to our mutual cause if a technical meeting were to be arranged in Boston, <u>under your auspices.</u> The purpose of this meeting would be to have a presentation to the Boston meteorological community by the Weather Bureau people from Washington. The meteorologists here would have a chance at this meeting not only to ask about technical details, but also to make constructive comments for the consideration of the people from Washington. In the fullest sense, we picture this as a working meeting.

We would be surprised, however, if such a meeting were not of considerable interest to the general public here in Boston. If you think this is a worthwhile idea, we would be happy to assist in contacting any other concerned meteorologists.

Sincerely,

[The letter was signed by the following persons]

Don Kent
Meteorologist, WBZ-TV

Norman MacDonald
Meteorologist, WBZ-TV

Bruce Schwoegler
Meteorologist, WBZ-TV

Robert Copeland
Meteorologist, WHDH-TV

Peter Leavitt
President, Weather Services, Inc.

Fred Ward
Meteorologist, WNAC-TV

APPENDIX B

TRANSMISSION, CONTENT AND FORMAT OF XERB AND HOTEL SURFACE DATA

XERB DATA TRANSMITTED ON SERVICE C TELETYPEWRITER CIRCUIT AT 00Z,06Z,12Z AND 18Z; PREVIOUS HOURLY OBSERVATIONS ARE INCLUDED WITH CURRENT OBSERVATION

ERB1 $99L_aL_aL_a$ $7L_oL_oL_oL_o$ $YYGGi_w$ /ddff $//RRR_p$ PPPTT ///// //app
$0T_aT_aT_dT_d$ $1T_wT_wT_wt_T$ $3//H_wH_w$

Symbol	Definition and Remarks
ERB1	First group of message
99	Indicator for recognition of buoy message
$L_aL_aL_a$	Latitude in degrees and tenths (36.5°N)
7	Quarter of the globe
$L_oL_oL_oL_o$	Longitude in degrees and tenths (73.5°W)
YY	Day of the month
GG	Time (GMT) of observation (whole hours)
i_w	Wind indicator (1 = meters/sec.; OTHER = knots)
dd	True direction FROM which wind is blowing (tens of °)
ff	True wind speed (usually meters/sec; see i_w)
RR	Rainfall in past hour (// = less than .25 m m; 80 = .25 mm or more this hour)
R_p	Rainfall in past 6 hours (/ = less than .25 mm; 8 = .25 mm or more this hour)
PPP	Atmospheric pressure in millibars (10 digit, unit digit, tenths)
TT	Temperature of the air in whole degrees celsius (°C)
/////	Blank group
// or 00	No movement
a	Three hour pressure tendency (2-increasing.1 millibar or more; 4-little change; 7-decreasing .1 millibar or more)
pp	Amount of pressure change in past 3 hours in millibars (unit digit, tenths)
0	Indicator for $T_aT_aT_dT_d$ group
T_aT_a	Difference between air temperature and sea surface temperature in half degrees celsius (tens digit, unit digit)
T_dT_d	Temperature of the dew point in whole degrees (celsius)
1	Indicator figure for $T_wT_wT_wt_T$
$T_wT_wT_w$	Temperature of the sea surface in degrees and tenths (celsius)
t_T	Tenths figure of the air temperature reported by TT
3	Indicator figure for $3//H_wH_w$ group
H_wH_w	Height of sea waves in half meters

Service C Message
31 July 1971 18Z

```
7070 WBC128
SMVD1 KWBC N 311922
SHIP
NT
ERB1  99355 70735 31121 /1925 ///// 22225 ///// 00768 00124 12527
3//030
NT
ERB1  99355 70735 31121 /2123 ///// 22125 ///// 20/// 00224 12459
3//030
ERB1  99365 70735 31131 /1906 ///// 23026 ///// 00/// 00324 12471
3//030
ERB1  99365 70735 31141 /1907 ///// 22926 ///// 00/// 00224 12432
3//030
ERB1  99365 70735 31151 /1707 ///// 23025 ///// 00008 00224 12437
3//030
ERB1  99355 70735 31161 /1808 ///// 23225 ///// 00202 00224 12508
3//030
ERB1  99365 70735 31171 /2208 ///// 23025 ///// 00201 00124 12517
3//030
```

Note: XERB data are now transmitted every three hours on Service C teletypewriter circuit. Each transmission includes the current observation and the previous two hourly observations.

HOTEL DATA

Hourly surface observations are transmitted on Circuit 7072. Three-hourly surface-synoptic weather observations are transmitted from Ocean Weather Ship HOTEL on Service O teletypewriter; six-hourly surface-synoptic observations appear on Service C.

Twelve-hourly upper-air data (pressure level, height, temperature, dew-point, wind direction and wind speed) are transmitted on Service O teletype. The format and content of the surface synoptic weather transmission are given below.

The symbolic form of the synoptic weather code (FM 21D)[1] for ships is shown below:

SHIP $99L_aL_aL_a$ $Q_cL_oL_oL_oL_o$ $YYGGi_we$
$Nddff$ $VVwwW$ $PPPTT$ $N_hC_LhC_MC_He$
D_sV_sapp $0T_sT_sT_dT_d$ $1T_wT_wT_wt_Te$ $2I_sE_sE_sR_s$
$3P_wP_wH_wH_w$ $d_wd_wP_wH_wH_w$ ICE $c_2KD_ir_ie$

Symbol	Definition and remarks
SHIP	First group of message
99	Indicator for recognition of ships message
$L_aL_aL_a$	Latitude in degrees and tenths
Q_c	Quarter of the globe
$L_oL_oL_oL_o$	Longitude in degrees and tenths
YY	Day of the month (GMT)
GG	Time (GMT) of observation (whole hours)
i_w	Wind indicator
N	Total cloud amount (fraction of celestral dome covered by clouds).
dd	True direction FROM which wind is blowing (tens of °).
ff	True wind speed (knots)
VV	Horizontal visibility (yards or naut. miles)
ww	Present weather
W	Past weather
PPP	Atmospheric pressure reduced to sea level (millibars)
TT	Temperature of the air in whole degrees celsius (°C).
N_h	Amount of sky covered by all C_L (C_M) clouds present
C_L	Low cloud types
h	Height of base of lowest cloud observed
C_M	Middle cloud type
C_H	High cloud type
D_s	Ships course made good during past 3 hours
V_s	Ships average hourly speed made good during past 3 hours (knots).
a	Three hour pressure tendency
pp	Amount of pressure change during past 3 hours
0	Indicator for $T_sT_sT_dT_d$ group
T_sT_s	Air sea temperature difference in half degrees (celsius)
T_dT_d	Temperature of the dewpoint in whole degrees (celsius).

Symbol	Definition and remarks
1	Indicator figure for $T_wT_wT_wt_T$
$T_wT_wT_w$	Temperature of the sea surface in degrees and tenths (celsius).
t_T	Tenths figure of the air temperature reported by TT
2	Indicator figure for $I_sE_sE_sR_s$ group
I_s	Source of ice accretion
E_sE_s	Thickness of ice accretion in centimeters
R_s	Rate of ice accretion
3	Indicator figure for $P_wP_wH_wH_w$ group
P_wP_w	Period of sea waves in seconds
H_wH_w	Height of sea waves
d_wd_w	True direction FROM which swell waves are coming
P_w	Period of swell waves
H_wH_w	Height of swell waves
ICE	Plain language to precede $c_2KD_ir_ie$ group
c_2	Kind of ice
K	Effect of ice on navigation
D_i	Bearing of ice edge
r_i	Distance of ice edge
e	Orientation of ice edge

APPENDIX C

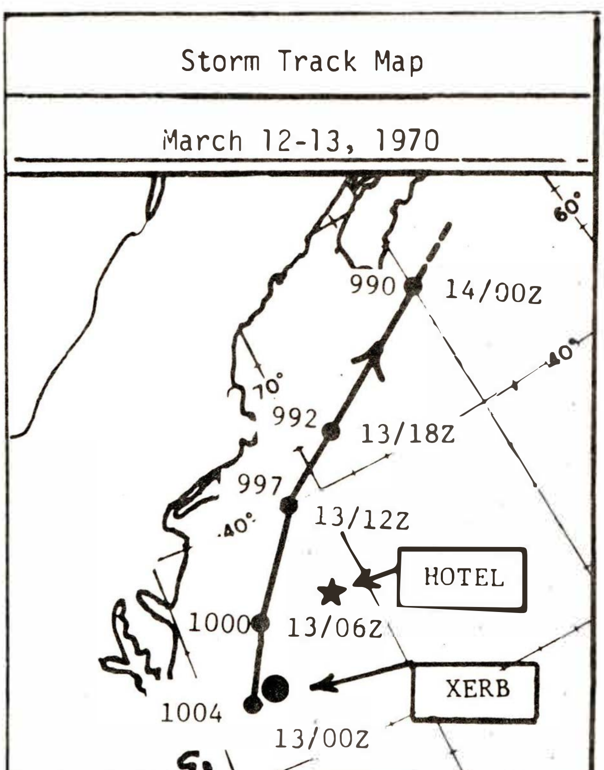
DESCRIPTIVE MATERIAL AND TOPICAL QUESTIONS CONTAINED IN QUESTIONNAIRE ASSOCIATED WITH SEVEN SELECTED STORM PERIODS

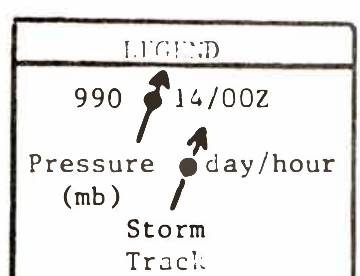
Period 4: March 12-13, 1970 **Storm Type:** LOW FROM SE U.S.

XERB/HOTEL Data Availability: Both were reporting. XERB data were plotted on surface facsimile maps for the following times: 12/00Z, 12/06Z, 13/00Z, 13/06Z, 14/00Z. XERB data were reported on teletype for all hours except 12/11Z. HOTEL surface data were plotted: 11/18Z, 12/00Z, 12/06Z, 12/18Z, 13/00Z, 13/06Z,13/12Z, 13/18Z,14/00Z. HOTEL upper-air data were plotted on the 500-mb chart for all dates from 11/12Z - 14/00Z.

Description of Storm: At 11/18Z, an east-west stationary front was located through North Carolina, northern Alabama and curving to the south through central Mississippi into the Gulf. At 12/00Z, a low forms in southern Mississippi and moves (with little change of central pressure) to north central Alabama (12/06Z), central Tennessee (12/12Z), extreme western Virginia (12/18Z) and West Virginia (13/00Z). At 13/00Z, a secondary forms on the warm front off Hatteras and follows the track indicated in the accompanying map. The secondary, during its formation stage, is just west of the location of XERB and its initial movement takes it somewhat west of the location of HOTEL. The period from 13/00Z - 13/06Z is a critical one for predicting the movement and development of the coastal storm. This was the first major coastal storm for which the XERB and HOTEL data were available. Precipitation was predominantly rain along the coast with snow inland. Moderate snow over most of New England occurs at 13/18Z.

At 500-mb, at 13/00Z, a broad trough over the central U.S. is centered just west of the Mississippi River and a weak ridge oriented NNW-SSE is located over New York State. Flow along the east coast is WSW with maximum speeds over the southeastern states exceeding 100-kt by 13/12Z. A short wave over the mid-Atlantic States at 13/12Z backs the flow somewhat and eliminates the ridge.





COMMENTS ASSOCIATED WITH NINE TOPICS

No.	Topic	Comment
1.	Newly-Forming Coastal Storm	The incipient storm was in the vicinity of XERB during the period 12/18Z - 13/06Z.
2.	Intensifying Coastal Storm	The intensifying storm was in the vicinity of HOTEL during the period 13/03Z - 13/09Z.
3.	Cold and Warm Fronts	During the period 12/21Z - 13/15Z, warm and cold frontal passages occurred at both locations (XERB and HOTEL).
4.	Surface Pressure Gradient; Surface Wind Direction and Speed	Moderate increases in pressure gradient and wind speed were occurring while the storm was passing west of the XERB/HOTEL locations.
5.	Sea Surface Conditions (Wave /Height, Direction and Period)	
6.	Precipitation: Areal Extent, Type, Intensity and Duration	Particularly in reference to the intensity and type (rain/snow) for coastal areas.
7.	Upper-Level Significant Features (troughs, ridges, closed lows,short waves)	At 13/00Z, a key question concerned the effect of a short-wave approaching the coast on a weak ridge located over New York State and New England.
8.	Upper-Level Flow (wind speed and direction, vorticity, divergence)	Of particular interest was the strong west-southwesterly flow and the degree of backing of the wind flow that might occur.
9.	Upper-Level Temperature and/ or Moisture Advection	Particularly in reference to the rain/snow forecast problem for coastal areas.

Period 7: March 29, 1970 Storm Type: SECONDARY LOW ON MOVING FRONT

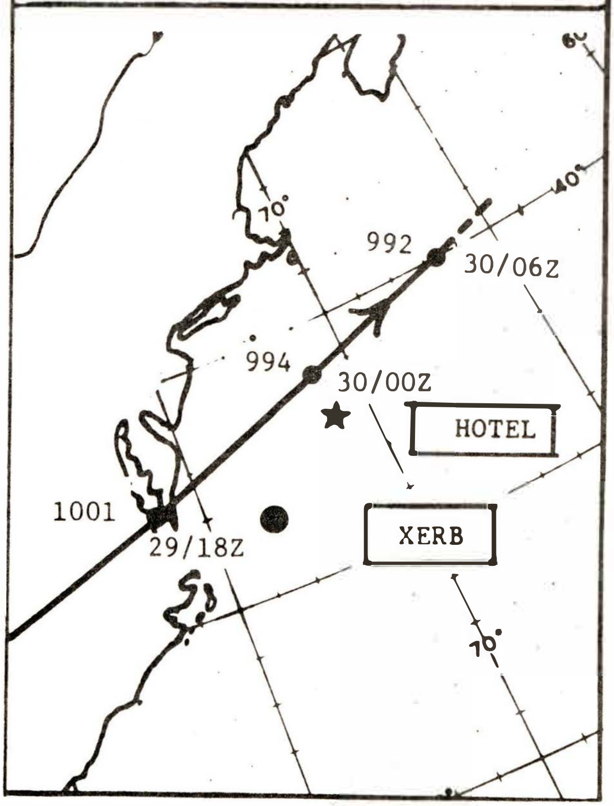
XERB/HOTEL Data Availability: Both were reporting. XERB data were plotted on the 29/00Z facsimile map. XERB data were reported on teletype for all hours in the period. HOTEL surface and 500-mb data were plotted on all facsimile maps in the period 29/00Z - 30/06Z.

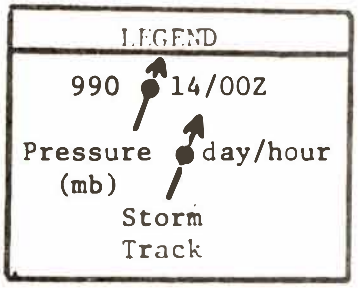
Description of Storm: By the 29/00Z,a NNE - SSW oriented cold front had reached central New York State and eastern Pennsylvania,with a more E-W orientation into central Kentucky. A 1005-mb wave is located on the front in eastern Tennessee at 29/06Z and moves rapidly east-northeastward to the coastline just north of Norfolk by 29/18Z as shown on the accompanying track map. By this time, the northern sector of the cold front is well off the New England and Mid-Atlantic coastline and cold air is well established setting the stage for the late season Easter Sunday Snowstorm. The low intensifies over open water and moves rapidly to the east-northeast. Snowfall of moderate intensity results in accumulations of a foot in inland southern New England and 30 kt winds occur along the coast.

At 500-mb, a strong short wave over Kentucky/Tennessee at 29/12Z moves rapidly to the mid-Atlantic coast by 30/00Z and is far off the coast by 30/12Z.

Storm Track Map

March 29, 1970





COMMENTS ASSOCIATED WITH NINE TOPICS

No.	Topic	Comment
1.	Newly-Forming Coastal Storm	Not applicable.
2.	Intensifying Coastal Storm	During the period 29/18Z - 30/00Z, the storm is close to but north of the XERB/ HOTEL locations. The speed of movement and northerly component of movement are critical factors.
3.	Cold and Warm Fronts	Warm and cold frontal passages occur at both locations during the period 29/15Z - 30/00Z.
4.	Surface Pressure Gradient; Surface Wind Direction and Speed	Intensifying pressure gradients and wind speeds occur during the period 29/18Z - 30/00Z.
5.	Sea Surface Conditions (Wave /Height, Direction and Period)	
6.	Precipitation: Areal Extent, Type, Intensity and Duration	The precipitation type and duration over mainland areas was critically dependent on the speed and direction of movement during the period 29/18Z - 30/06Z.
7.	Upper-Level Significant Features (troughs, ridges, closed lows,short waves)	The position, intensity and speed of movement of the strong short wave over the east coast at 30/00Z was most important.
8.	Upper-Level Flow (wind speed and direction, vorticity, divergence)	
9.	Upper-Level Temperature and/ or Moisture Advection	Particularly with regard to rain/snow forecasting problem in coastal areas.

Period 18: November 4-5, 1970

Storm Types: PRIMARY IN MIDWEST-COASTAL SECONDARY AND SECONDARY LOW ON MOVING FRONT

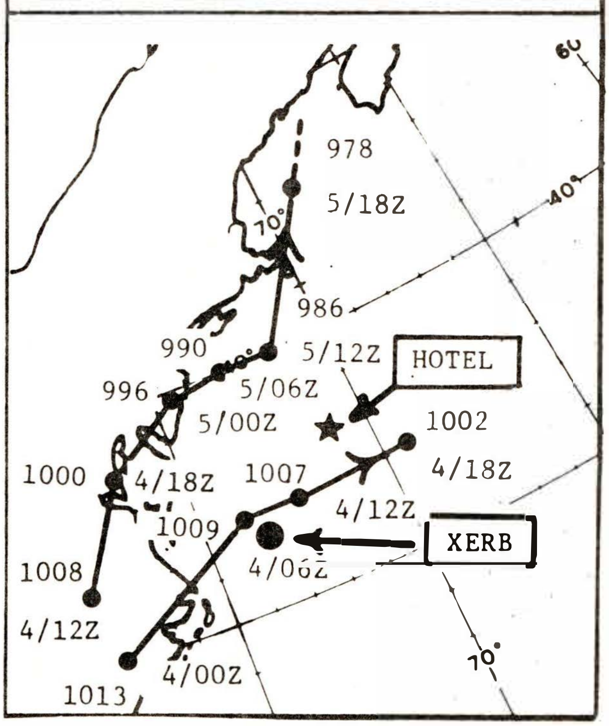
XERB/HOTEL Data Availability: Both were reporting. XERB data were plotted on 4/06Z and 5/00Z facsimile charts. XERB data were reported on teletype for all hours from 4/00Z - 5/06Z. HOTEL surface and 500-mb data were plotted on all facsimile charts during the period 4/00Z - 5/18Z.

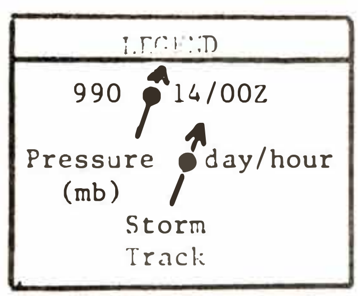
Description of Storm: By 4/00Z, an occluded front, extending from a filling low over the Great Lakes, reaches the east coast. A low on the front over North Carolina follows a path on November 4 as shown on the accompanying track map. After moving to the east between the XERB and HOTEL locations without significant intensification,an area of low pressure remains over Virginia. Rapid intensification begins after 4/12Z and the storm moves to the northeast as shown on the track map. This is a major rainstorm with heavy precipitation and high winds. Moderate rain is observed at many stations in southern New England and the Mid-Atlantic States. 40 kt winds are reported just off Hatteras. The period up to 4/18Z is a critical one in terms of evaluating the movement and relative development of the two storms.

At 500-mb at 4/00Z, a deep,4-contour closed low is centered just south of Illinois with southwesterly flow over the east coast. Wind speeds are 80 kt over the southeastern states. By 5/00Z, the closed low has moved with redevelopment to the Maryland/Delaware coast with strong southwesterly flow off the coast, as indicated by HOTEL's report of SW/95 kt.

Storm Track Map

November 4-5, 1970





COMMENTS ASSOCIATED WITH NINE TOPICS

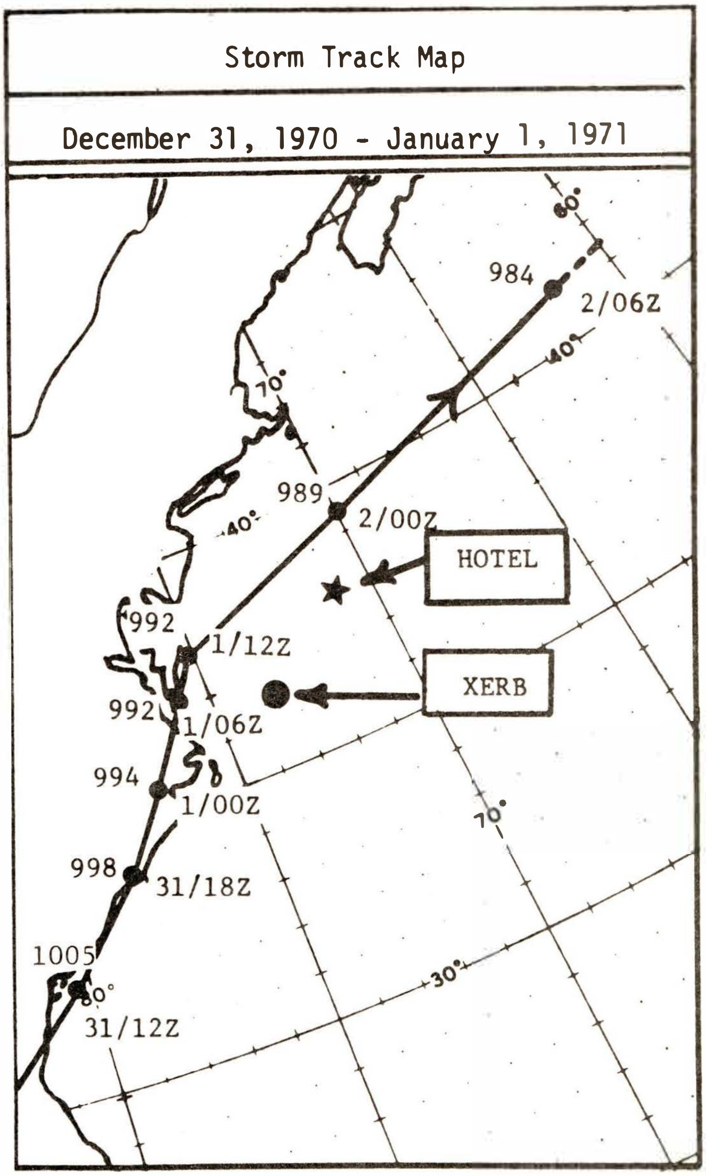
No.	Topic	Comment
1.	Newly-Forming Coastal Storm	Particularly during the period 4/00Z - 4/06Z.
2.	Intensifying Coastal Storm	For the first storm, the period 4/06Z - 4/18Z is of particular interest. The movement and development relative to the second storm are of critical importance. For the second storm the period 5/00Z-5/12Z is particularly important.
3.	Cold and Warm Fronts	The location of frontal systems poses particular difficulties up to 5/00Z.
4.	Surface Pressure Gradient; Surface Wind Direction and Speed	The relative intensity (pressure gradient) of the first system that moves to the east is critical.
5.	Sea Surface Conditions (Wave /Height, Direction and Period)	
6.	Precipitation: Areal Extent, Type, Intensity and Duration	The relatively slow movement of the second low during the period 5/00Z - 5/12Z is important with regard to precipitation duration over New England and the Mid-Atlantic States.
7.	Upper-Level Significant Features (troughs, ridges, closed lows,short waves)	The movement of the closed low is particularly critical during the period 5/00Z - 5/12Z.
8.	Upper-Level Flow (wind speed and direction, vorticity, divergence)	
9.	Upper-Level Temperature and/ or Moisture Advection	The availability of moisture during the maturing stage of second system (from 5/00Z on) is of concern.

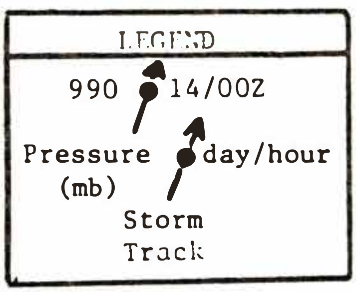
Period 24: December 31, 1970 - Jan. 1, 1971   Storm Type: LOW FROM SE U.S.

XERB/HOTEL Data Availability: Both were reporting. XERB data were plotted on the 2/06Z facsimile map. XERB data were reported on teletype for all hours in the period. HOTEL surface and 500-mb data were plotted on all maps during the period except for the 1/18Z surface map.

Description of Storm: A low originating in the Gulf intensifies along the Carolina coast and follows a track indicated in the accompanying chart. By 1/12Z, the system contains two centers, the second center located to the east of the locations shown at 1/12Z and 2/00Z. Of critical concern during the storm period was whether redevelopment to the east or more easterly movement of the low would carry it further off the coast reducing snow amounts in Mid-Atlantic and New England States. Moderate rain and winds NE/40kt were reported along the Virginia coast; 30 kt winds were commonly reported along the entire coast. The snow shield reached as far north as Albany and southern Vermont and New Hampshire. Moderate snow was reported in Washington,D.C., Virginia, West Virginia,Pennsylvania, Connecticut and Rhode Island. Connecticut received about 9 inches accumulation.

At 500 mb at 31/12Z, a pronounced trough was centered just east of the Mississippi River and a ridge was located along the Atlantic Coast and tilting to the northwest into the eastern Great Lakes. The wind flow was west-southwest along much of the coast, but west-northwest over New England. By 1/12Z the system is almost vertical with a closed low at 500-mb located over northeastern Virginia and Maryland.





COMMENTS ASSOCIATED WITH NINE TOPICS

No.	Topic	Comment
1.	Newly-Forming Coastal Storm	Most applicable near 1/12Z when a newly-forming center to the east results in a double-centered low.
2.	Intensifying Coastal Storm	During the period 1/06Z - 2/00Z the storm moves north and west of but fairly close to XERB/HOTEL locations.
3.	Cold and Warm Fronts	Passage of occluded front occurs in the period 1/00Z - 1/12Z.
4.	Surface Pressure Gradient; Surface Wind Direction and Speed	Particularly during the period 1/00Z - 2/00Z.
5.	Sea Surface Conditions (Wave /Height, Direction and Period)	
6.	Precipitation: Areal Extent, Type, Intensity and Duration	The duration of snowfall in New England and Mid-Atlantic States is critically dependent on the redevelopment or translation to the east of the storm after 1/12Z.
7.	Upper-Level Significant Features (troughs, ridges, closed lows,short waves)	Particularly the movement of ridge off the coast at 1/00Z and the movement of the closed low after 1/12Z at 500 mb.
8.	Upper-Level Flow (wind speed and direction, vorticity, divergence)	The backing of the wind flow at 500-mb between 31/12Z and 1/00Z is critical.
9.	Upper-Level Temperature and/ or Moisture Advection	

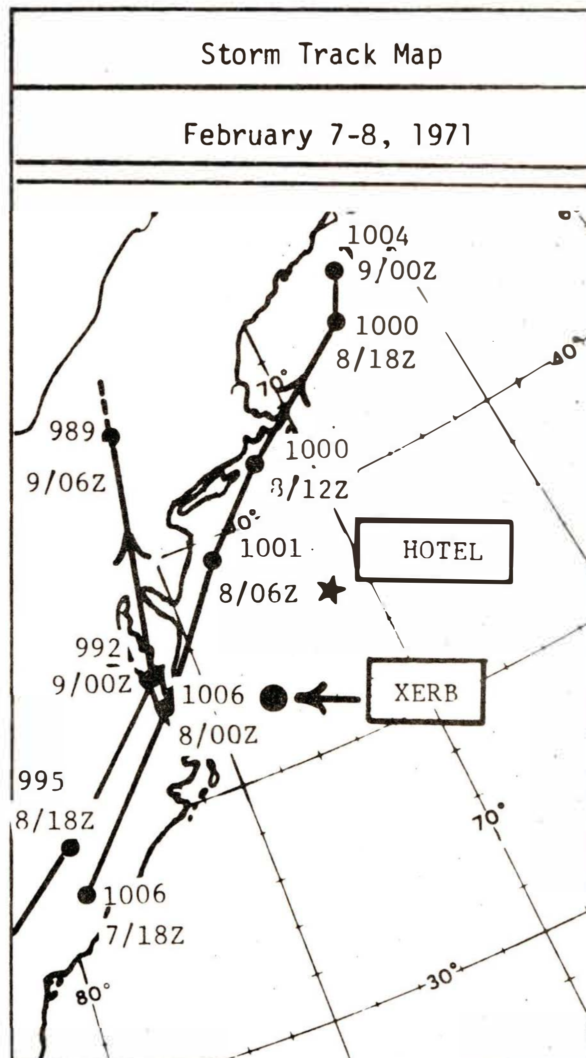
Period 32: February 7-8, 1971

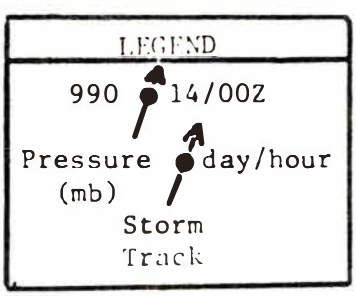
Storm Type: LOW DEVELOPS ON STATIONARY FRONT AND LOW FROM SE U.S.

XERB/HOTEL Data Availability: Both were reporting. XERB data were plotted on all surface facsimile maps in the period 8/06Z - 9/00Z. XERB data were reported on teletype for all hours in the period. HOTEL surface and 500-mb data were plotted on all facsimile in the period 7/12Z - 9/06Z.

Description of Storm: Two lows occur during the period. The first system forms on a stationary front near the Carolina coast and moves inside Hatteras to the northeast just off the coast as shown on the tracking chart. Significant intensification does not take place. The second system, somewhat more intense, moves from the Alabama coast to Chesapeake Bay and north into upstate New York. Moderate snow is reported in Pennsylvania, New York State, Connecticut and Maine in association with the first system, as ridging west of the coastline from a high pressure area moving off the New England coast maintains the cold air. A strong pressure gradient in the warm sector of the second system results in winds from the S-SSW/30-35 kt, as reported by XERB and HOTEL.

At 500-mb, a broad trough remains in the central U.S. during the entire period of interest, but shifts eastward during the passage of a series of short waves. 7/12Z to SSW by 9/00Z. The critical forecast time for the first system was 8/00Z and the second system 9/00Z.





COMMENTS ASSOCIATED WITH NINE TOPICS

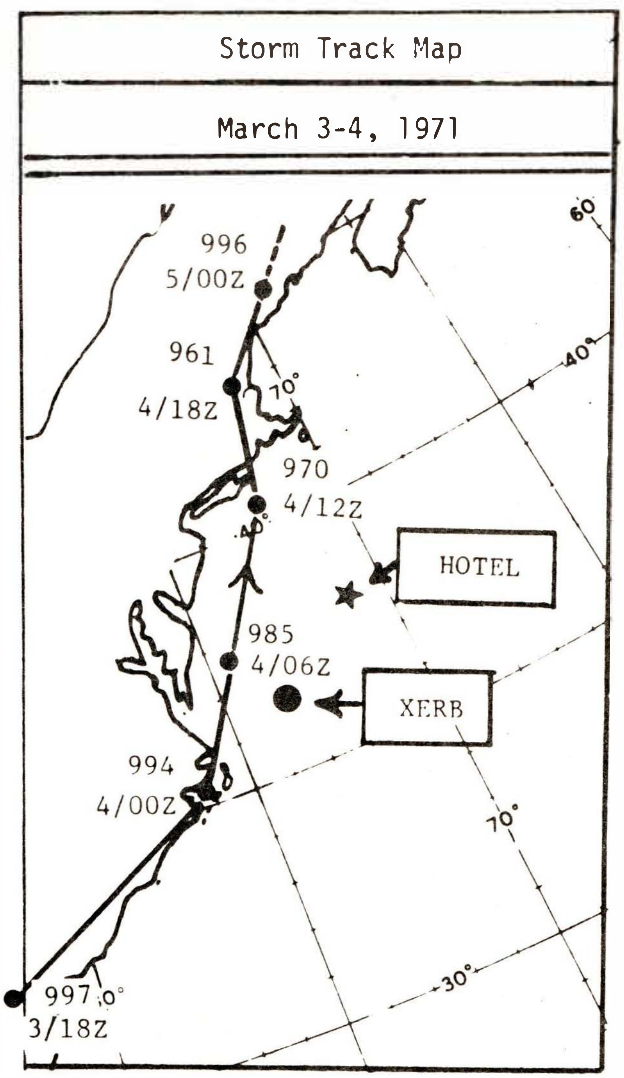
No.	Topic	Comment
1.	Newly-Forming Coastal Storm	Not Applicable.
2.	Intensifying Coastal Storm	During the period 7/21Z - 8/12Z the track of the first storm center was critical.
3.	Cold and Warm Fronts	From 7/18Z on, during the entire period, a series of cold, warm, and occluded frontal passages occur at both XERB and HOTEL locations.
4.	Surface Pressure Gradient; Surface Wind Direction and Speed	Particularly during the period 8/00Z - 8/06Z and at 9/00Z.
5.	Sea Surface Conditions (Wave /Height, Direction and Period)	
6.	Precipitation: Areal Extent, Type, Intensity and Duration	The type of precipitation occurring over coastal and near coastal areas was critically dependent on the direction of storm movement in period 8/00Z - 8/12Z.
7.	Upper-Level Significant Features (troughs, ridges, closed lows, short waves)	
8.	Upper-Level Flow (wind speed and direction, vorticity, divergence)	Particularly, backing of 500-mb wind along coast during period 7/12Z - 8/12Z.
9.	Upper-Level Temperature and/or Moisture Advection	Particularly the degree of warm advection at 850-mb and 700-mb during period 8/00Z - 8/12Z, with regard to occurrence of rain and snow over mainland.

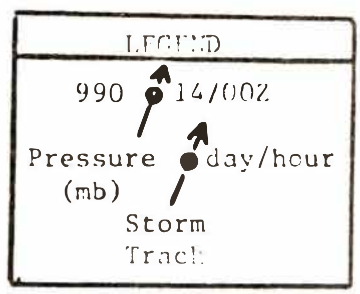
Period 36: March 3-4, 1971 Storm Type: LOW FROM SE U.S.

XERB/HOTEL Data Availability: Both were reporting. XERB data were plotted on surface facsimile for 3/12Z. XERB data were reported on teletype only at 3/00Z and 3/07 - 12Z. HOTEL surface data were plotted on maps from 3/00Z - 3/18Z and 4/06Z - 4/18Z. HOTEL 500-mb data were plotted on all maps during the period.

Description of Storm: A major coastal storm occurs as a low moves from southern Mississippi to Georgia and follows a path as indicated on the track chart passing just to the west of the XERB location. Record-breaking low pressures are measured over New England. Moderate rain,sleet and snow with high winds are widespread. Reports include moderate rain in Georgia,South Carolina,North Carolina, Virginia,Washington,D.C., Philadelphia, and New York City. Moderate sleet occurs in southern New England and moderate snow in northern New England. 30-40 kt winds are measured in the Mid-Atlantic States and New England.

At 500-mb at 4/00Z, a deep trough is located just east of the Mississippi Valley with strong southwesterly flow over the east coast (greater than 100 kt over southeastern states). A deep closed low and trough is located over New York State and Pennsylvania at 4/12Z and the wind flow over New England and the Mid-Atlantic Coast is from the SSW in excess of 100 kt.





COMMENTS ASSOCIATED WITH NINE TOPICS

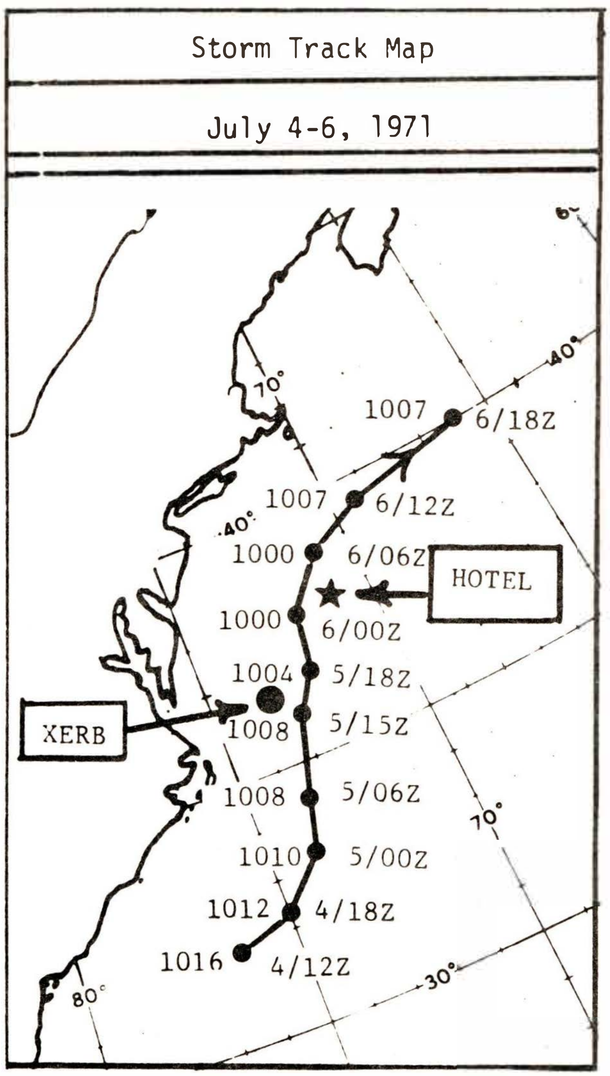
No.	Topic	Comment
1.	Newly-Forming Coastal Storm	At 3/18Z and 4/00Z a wave on the front to the northeast of the primary center is of concern.
2.	Intensifying Coastal Storm	The rapid intensification and movement of the storm in the period 4/00Z - 4/12Z is most critical.
3.	Cold and Warm Fronts	Frontal passages occur at both XERB and HOTEL locations in the period 4/00Z - 4/09Z.
4.	Surface Pressure Gradient; Surface Wind Direction and Speed	Rapidly intensifying pressure gradients and increasing speeds (50 kt) occur in the period 4/00Z - 4/18Z.
5.	Sea Surface Conditions (Wave /Height, Direction and Period)	
6.	Precipitation: Areal Extent, Type, Intensity and Duration	The precipitation type, intensity, and duration are critically dependent on the speed and direction of movement of the storm center during the period 4/00Z - 4/12Z.
7.	Upper-Level Significant Features (troughs, ridges, closed lows,short waves)	The rapid movement and intensification of the 500-mb closed low/trough in the period 4/00Z - 5/00Z is most significant.
8.	Upper-Level Flow (wind speed and direction, vorticity, divergence)	The intense (100 kt), almost southerly flow at 500 mb by 4/12Z over the Mid-Atlantic Coast and New England is a critical factor.
9.	Upper-Level Temperature and/or Moisture Advection	The degree of low-level warm advection occurring is of greatest interest at 4/00Z and 4/12Z.

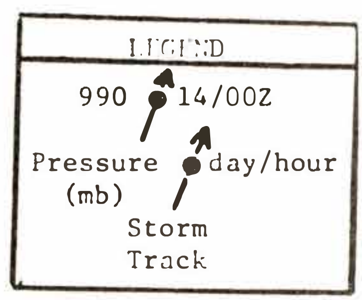
Period 44: July 4-6, 1971 Storm Type: TROPICAL STORM ARLENE

XERB/HOTEL Data Availability: Only XERB was reporting. XERB data were plotted on surface facsimile maps at the following times: 4/12Z;4/18Z; 5/18Z; 6/00Z and 6/06Z. XERB data were reported on teletype for all hours except 4/13Z and 4/19Z - 20Z.

Description of Storm: Tropical Storm ARLENE first formed in association with a front on 4/12Z but within 12 hours was well removed from the front and had taken on the characteristics of a tropical storm. The moderate tropical storm followed a path (as indicated on the track map) that was close to the XERB location and did not affect the mainland. During the period 5/00Z - 6/12Z, the movement of the storm had to be carefully watched for a shift toward the coast. The XERB buoy reported a 40 kt wind close to the storm center at 5/18Z.

At 500-mb, the major troughs and ridges were displaced north of 40°N latitude. A weak trough or closed low at 500-mb reflected the presence of ARLENE. By 6/12Z, an approaching trough produced winds at WSW/30 kt over the east coast north of Hatteras.





COMMENTS ASSOCIATED WITH NINE TOPICS

No.	Topic	Comment
1.	Newly-Forming Coastal Storm	Not Applicable.
2.	Intensifying Coastal Storm	Movement and intensification was particularly critical during the period 5/06Z - 6/06Z
3.	Cold and Warm Fronts	Not Applicable.
4.	Surface Pressure Gradient; Surface Wind Direction and Speed	ARLENE was most intense and organized with greatest pressure gradients during the period 5/15Z - 6/00Z.
5.	Sea Surface Conditions (Wave /Height, Direction and Period)	
6.	Precipitation: Areal Extent, Type, Intensity and Duration	
7.	Upper-Level Significant Features (troughs, ridges, closed lows,short waves)	No HOTEL data.
8.	Upper-Level Flow (wind speed and direction, vorticity, divergence)	No HOTEL data.
9.	Upper-Level Temperature and/or Moisture Advection	No HOTEL data.

APPENDIX D

DESCRIPTION OF XERB AND HOTEL OBSERVATIONS

FROM

NATIONAL EAST COAST WINTER STORMS OPERATIONS PLAN

EXTRACT FROM NATIONAL EAST COAST WINTER STORMS OPERATIONS PLAN, [13] CHAPTER 5 APPENDIX A, (pages 50-52).

b. Deployment of Experimental Environmental Reporting Buoy (XERB-1). (National Data Buoy Center, National Ocean Survey, NOAA)

(1) Description. A 40-foot discus buoy, deployed at latitude 36.5°N. and longitude 73.5°W. provides scheduled surface and limited sub-surface information.

(2) Environmental Data. Meteorological and oceanographic parameters are measured every hour and stored on magnetic tape. Present shore interrogation of buoy data is once every 3 hours, but the system is capable of more frequent interrogation. The meteorological and oceanographic elements sampled and stored aboard the buoy consist of the following:

- barometric pressure
- wind direction and speed
- air temperature
- dew point temperature
- sea-surface temperature
- global radiation
- precipitation
- wave heights
- surface current vector
- water temperatures

(3) Mission. The principal objective of this buoy consists of gathering needed engineering and environmental data to aid further development of prototype data buoys. The buoy, designated XERB-1, is basically experimental in nature; data will be telemetered to a Coast Guard operated Shore Collection Center for the National Data Buoy Center. These data are converted into physical units and then translated into WMO FM21D ship code and transmitted to NWS Suitland by means of Coast Guard Circuit GT 7990.

(4) Services Organization for the East Coast Storms Warning System. The USCG-operated National Data Buoy Center Shore Collection Center will routinely collect hourly synoptic information from the buoy eight times daily. Commencing at 0000GMT each day, groups of 3-hourly synoptics will be transmitted to Suitland within 1-hour of the last synoptic time in each group. RWC requests for special or more frequent interrogations during critical storm periods will be accommodated by phone request to the Miami Radio Station Duty Officer, telephone 305-233-3062. The start and stop time for special hourly reports should be given, and limited to 12-hour consecutive operation unless an emergency exists. In this case, consultation should also be made with the National Data Buoy Center Test Operations Division.

System maintenance, calibration, and final data quality verification are under the technical control of the National Data Buoy Center and its supporting contractors. Requests for system status and schedule information should be directed to the Test Operations Division of the National Data Buoy Center in Mississippi, telephone 601-688-2824.

c. Special Duty Offshore Weather Ship (Ocean Weather Station HOTEL--4 YH). (Coast Guard)

(1) Description. A Coast Guard cutter is deployed to man the Atlantic Ocean Weather Station (OWS) HOTEL in the vicinity of latitude 38°N. and longitude 71°W. (approximately 205 miles south of Martha's Vineyard Island and 200 miles east of the Virginia Capes).

(2) Time of Manning Station. The OWS HOTEL will be manned continuously during 8 months of the year (August through March) to cover both the east coast storm and hurricane seasons. During June and July, the weather ship will remain on a 24-hour standby status for emergency assignment to station. Thus, a total of 10 months coverage of the OWS HOTEL is provided.

(3) Meteorological Data. Hourly surface and radar reports and 6-hourly upper air observations are planned similar to the Ocean Weather Station procedures; synoptic observations will be taken by National Weather Service personnel and will be transmitted to Coast Guard Radio Station Washington (NMH) where it will be placed on the National Weather Service 7072 Circuit.

APPENDIX E

DATA NEEDS EXPRESSED BY SURVEY RESPONDENTS

DATA NEEDS EXPRESSED BY SURVEY RESPONDENTS

1. XERB/HOTEL Data

Many users strongly expressed the desire that XERB/HOTEL surface data be transmitted hourly over teletypewriter Service A and HOTEL upper air data also be transmitted over Service A. The users, noting the special importance of these data for the east coast, stressed that it should receive the widest possible dissemination. A number of users also commented that the transmission of XERB data every 3 hours over teletypewriter Service C would be desireable. This procedure has been implemented since completing the survey visits.

XERB data are occasionally received late and thus not plotted in time by NWS NMC for North American map transmission and hence are considered of less importance than HOTEL data in the Questionnaire response. If this shortcoming were corrected, the estimate of the usefulness of XERB/HOTEL data in surface analysis would be significantly enhanced.

2. General Need

The location of XERB and OWS HOTEL was generally considered to be good. The need for additional buoys and weather ships was expressed. Several users expressed the need for an additional buoy to the east or southeast of the location of XERB near about 70° W longitude. The need for an additional buoy, on the edge of Georges Bank, some 110 miles southeast of Cape Cod, was also indicated.

Several users expressed the need for 2-3 rows of data buoys off the east coast with intervals between the buoys ranging from 60-300 nautical miles. Between 10 and 35 data buoys would be required to satisfy the defined networks.

The ship track routing problem could be greatly ameliorated by as few as 50 data buoys distributed throughout the Deep Oceans of the Northern Hemisphere in areas of data sparseness.

The need for environmental data to be reported from data buoys include precipitation type and amount, as well as the standard parameters, reported in the surface marine synoptic code.

A Private Marine Environmental Consultant to the U.S. Marine Transportation Industry expressed a need for:

(a) A network of buoys to complement information-gathering systems already in existence,
(b) A "priority" definition to all marine weather observations to be carried forth into the Service "C" and Service "O" teletypewriter schedules,
(c) The inclusion of any buoy weather report on this "priority" Service "C" and Service "O" schedule.

If a priority definition cannot be offered, a suggestion was made that a special marine teletype service be organized to offer data from vessels, buoys, and Coast Guard light vessels and towers to the Private Consulting Sector, as well as the National Weather Service.

The SIRS-data buoy system combination appears to be the most reasonable way of obtaining adequate data for data-sparse ocean regions; such a system will be necessary to make any substantial improvement in 48-hour and longer forecasts.

APPENDIX F

EXCERPTS FROM A FEBRUARY 19, 1971 LETTER
FROM CHIEF OF OPERATIONS, EASTERN REGION, NWS
TO CHIEF OF EMERGENCY WARNING BRANCH, NWS

EXCERPTS FROM A FEBRUARY 19, 1971 LETTER
FROM CHIEF OF OPERATIONS, EASTERN REGION, NWS,
TO CHIEF OF THE EMERGENCY WARNING BRANCH, NWS

In the several months since surface observations have been available from the Coast Guard experimental buoy XERB and surface, radar and upper air observations have been available from OSV HOTEL, they have served well to improve the accuracy and timeliness of several weather forecasts and warnings issued for New England, the mid-Atlantic states, and/or the adjacent coastal waters. We caution however, that the full potential of these observations may not have yet demonstrated itself in that the operating period of these facilities has been quite short.

There have been several instances in which observations from XERB and HOTEL have allowed for more accurate analysis, amended forecasts or the issuance of critical weather warnings. The following are some of the events that have been identified in the period between 26 December 1970 and 9 February 1971:

31 December 1970: Data from Ship HOTEL provided a much needed verification of the position of an extensive but narrow off-shore ridge of high pressure. Such positioning allowed for an accurate determination of surface wind direction and speeds which were incorporated into an accurate forecast of sea conditions over a wide area of the Atlantic. It should be noted that no other data were immediately available in the area served by the buoy and ship.

1 January 1971: Rapid deepening accompanied the northward movement of a low pressure system which was formed over northern Florida. Observations from Ship HOTEL were the first indications that this intense storm was taking an east north-eastward course. This knowledge and the fact that the storm center was translating more to the East than suggested by on-shore observations assured the forecaster that another disruptive and costly accumulation of snow would not occur in New England. This permitted an earlier heavy snow watch to be cancelled early enough that road and snow removal crews were not placed on standby status or recalled to duty. It should also be noted that upper air data from Ship HOTEL provided a somewhat unexpected additional benefit in that they allowed for a direct correlation with aerial reconnaissance data being collected over the western Altantic. This correlation added much confidence to the accuracy of data in the numerous reconnaissance observations girding this deep off-shore system. Further, data from the buoy and Ship allowed for a more exacting analysis of this complex system which was developing an even more intense and strengthening center to the east. Such development would undoubtedly cause a greater potential for the retention of a cold air mass over New England.

15-16 January 1971: A potentially serious wave formed on the east-weste frontal surface passing through eastern North Carolina. Not infrequently, these waves intensify into "Hatteras Lows" as they migrate into coastal waters. From this point a major coastal storm frequently develops as a disturbance travels northeastward battering off-shore, coastal and even inland areas. Normally, a situation of this nature would warrant the issuance of weather watch and warnings over most of the mid Atlantic and northeastern seaboard. Fortunately, data from XERB and especially Ship HOTEL revealed that a separate wave was deepening in the vicinity of the ship. This would effectively eliminate the on-shore storm threat of the "Hatteras Lows" as well as any posed by its own development. Better definition of the system resulting from these observations also allowed for more accurate forecasts for the high seas.

20 January 1971: A large and deep storm centered southeast of Nova Scotia was propagating strong winds and heavy seas over much of the north Atlantic. Data from HOTEL and XERB provided the only immediate and scheduled information defining the westward extend of the gale force winds as well as the magnitude of seas and swells battering shipping over a broad area. Such information was readily incorporated into important off-shore forecasts and advisories.

26 January 1971: A vast and very intense winter storm developed over the Great Lakes region and quickly spread its severe weather pattern over the entire northeastern part of the country and beyond to several hundred miles at sea. Such storms, as bad as they may be, can cause the formation of a secondary system just off the Atlantic seaboard. It is this system which then can convert vast amounts of strengthening energy from the underlaying sea into precipitation and likely heavy snowfalls along the Atlantic seaboard. Close scrutiny of both surface and upper air data from the marine observing sites allowed for a continual vigil on such possible development. A small system did form but fortunately was followed with little development. Data from XERB and HOTEL were the primary sources of information for important off-shore forecasts of winds and seas.

8 February 1971: The 850 mb upper air data from Ship HOTEL was the first evidence that strong warm air advection was advancing into southern New England. This information updated earlier mostly on-shore data which suggested that heavy snow warnings would be in order for Rhode Island and eastern Massachusetts. Accordingly, and because of these off-shore data no such warnings were issued as forecast personnel felt that any precipitation would begin in the foregoing areas as snow and change to rain before there was an accumulation of four inches. Their interpretation was correct and no appreciable accumulation of snow occurred either in Rhode Island or in eastern Massachusetts.

Original letter
signed by

C. G. Knudsen

Chief, Operations
Eastern Region
National Weather Service

APPENDIX G

INCREMENTAL BENEFITS DERIVED BY
THE NWS EASTERN REGION REGIONAL WEATHER CENTER
FROM XERB/HOTEL DATA

INCREMENTAL BENEFITS DERIVED BY THE NWS EASTERN REGION
REGIONAL WEATHER CENTER FROM XERB/HOTEL DATA

Incremental Benefits Derived from XERB/HOTEL Data

1. January 9, 1971; 1200Z and 1800Z

Report of a southeast surface wind from HOTEL and a northeast surface wind from XERB indicates that the surface trough extends in a northeast direction from the low to between these two stations. Data from XERB aided in the surface analysis of the low pressure system off the U.S. east coast.

2. January 14, 1971; 1200Z

Data from XERB and HOTEL placed the developing surface trough between these two stations. This area was under watch for cyclogenesis.

3. January 26, 1971; 1800Z

Data from XERB and HOTEL probably aided greatly in the Boston Marine Forecast.

4. February 5, 1971; 1200Z

Data from HOTEL located a warm front and helped to fix the location of a weak coastal low off New Jersey. Data from XERB aided in fixing the location of the coastal low off New Jersey. The better analysis stemming from this added information resulted in coastal warnings.

5. February 8, 1971; 1200Z

Data from XERB and HOTEL aided in the preparation of the surface analysis and consequently extrapolations from it. By giving wind direction and force (from HOTEL), the data aided in preparing coastal warnings.

Incremental Benefits Derived from HOTEL Data (XERB Data not Available)

1. January 1, 1971; 0900Z to 2000Z

Data from HOTEL supplied control and single station information for correlation with storm aircraft reconnaissance data. It helped to fix the position of this deep storm and occluded front. Wind velocity data helped in the evaluation of the surface pressure gradient.

2. January 4, 1971; 1200Z

Data from HOTEL extended reliable observations which helped fill out the offshore weather fields at the surface and at altitudes. It also supplied 500 mb data for comparison with data obtained from a reconnaissance flight.

3. February 23, 1971; 1200Z

Data from HOTEL aided in locating the center of a secondary low and the associated fronts.

4. March 4, 1971; 1200Z

Data from HOTEL gave indications of the passage of the storm center to the west of its position. Following passage of the storm, HOTEL continued to provide much information regarding the intensity of the storm in the data-sparse region to the south of New England and east of the Atlantic Coast.

5. March 11, 1971; 0600Z to 1800Z

Data from HOTEL indicated that a warm front was south of its location and that cyclogenesis was taking place between the ship and the U.S. east coast. Data from HOTEL were used to establish the position of the center of a secondary low and the associated fronts of the coastal low. Data from HOTEL helped to determine the position and intensity of a low south of Nantucket. By using hourly reports from HOTEL the cold front was placed with a wind shift at 1300Z.

APPENDIX H

INCREMENTAL BENEFITS DERIVED BY SURVEY RESPONDENTS FROM XERB/HOTEL DATA

INCREMENTAL BENEFITS DERIVED BY SURVEY RESPONDENTS FROM XERB/HOTEL DATA

1. GENERAL REMARKS

Data from XERB and HOTEL help to define the pressure and wind field. Specifically, these data contribute to determining (1) the location of low pressure systems, (2) the strength and direction of moisture flow and (3) the configuration of the flow pattern. The data assist in positioning frontal systems which frequently may be accompanied by squalls. Upper-air data from HOTEL help to define upper-air steering and changes in steering.

XERB and HOTEL are the only U.S. stations that provide data in this region from the same location on a regular basis. Such data are important in establishing climatological normals of such diverse elements as weather, temperature, winds, wave heights, state of sea and water temperature. Observations from HOTEL serve as a reliable benchmark to judge reports from nearby vessels.

The careful timing of significant weather events such as frontal passages, pressure jumps etc., requires data from a consistent location. Vessels of opportunity do not afford such information.

XERB/HOTEL surface data and HOTEL upper-air data have been of great value in developing two simple manual objective forecasting aids.

The stable accuracy of XERB/HOTEL provides a benefit of greater value than obtained from "ordinary" ship reports. The relative usefulness of a piece of data often depends on whether other data are available in the vicinity. It is estimated that XERB/HOTEL are the only offshore reports in their 5° latitude-longitude "rectangle" about 10-20% of the time on the Northern Hemisphere chart, and a higher percentage - perhaps 40-60% on the North American maps. Since this "rectangle" is an important one from the standpoint of storm development, one can only conclude these reports are indeed very useful.

XERB data were used to establish a "ground truth"site and as an aide in a NASA mission to study radar sea return over the oceans as a function of wind speed.

The insolation measurements are being used to verify solar radiation absorbtion at the sea surface. This is part of a study to develop ocean circulation models.

2. March 12-13 1970

Close proximity of XERB was of great importance for analysis of size and depth of low center from its development stage as a wave on a front. During the period 12/1800Z-13/0900Z, HOTEL surface data were of greatest assistance in filling in vital wind field data in the area outside the center.

The wind directions at both XERB and HOTEL at 13/0600Z pinpoint the location of the low center. Pressure tendencies on the coast indicated deepening but the pressure at XERB and HOTEL verified this. Gale warnings were issued at 13/1000Z for offshore waters. HOTEL data showed a warm frontal passage between 13/0600Z and 13/1200Z. XERB data at the same time indicated a cold frontal passage.

3. March 29, 1970

Data from HOTEL and Nantucket light ship located the storm center (20/0000Z) and determined intensity. The forecast of precipitation at land stations was heavily dependent on the location and intensity information derived from HOTEL. Warnings of offshore gales were issued at 29/2200Z.

4. November 4-5, 1970

A northwest wind at HOTEL at 4/1800 Z identified and located a weak tripoint wave. The data showed that the primary center along the coast remained the dominant storm.

The elongation of the low center and the moisture inflow suggested by this elongation was critical for issuing heavy snow warnings for eastern West Virginia at 4/1600Z. The XERB/HOTEL data reports helped to define this moisture inflow. XERB and HOTEL reports were the only offshore data during the period 4/0000Z - 4/0600Z. Data from HOTEL clearly contributed to a more accurate analysis and helped to establish frontal positions during the period 4/1500Z - 4/2100Z.

5. December 31, 1970 - January 1, 1971

HOTEL in combination with other ships located a secondary center and determined the extent of the eastward translation of the storm system and thus the precipitation pattern.

Wind data at HOTEL helped to locate the double centered low and the continuing pressure falls at HOTEL despite the arrival of cold air indicated an intensifying storm translating to the east.

Data from HOTEL also assisted in locating frontal positions and defining the pressure and wind fields.

6. March 3-4, 1971

The time series data from HOTEL indicated that the frontal wave in the period 3/1800Z - 4/0000Z was of little importance. HOTEL data positioned the warm front at 04/0600Z and showed a definite cold frontal passage prior to 04/1200Z.

HOTEL data located a warm front south of the station at 04/0000Z. The fact that the magnitude of pressure falls at New York City was greater than that at HOTEL at 04/0600Z was critical in predicting the northward movement of the deepening storm. HOTEL was the only reliable source of the amplification of sea conditions at a single point.

Reports from HOTEL were the only ones available close to the frontal wave crest between 3/1800Z and 4/0000Z. Data from HOTEL were very useful in defining wind and pressure fields during the period 4/0000Z - 4/1800Z.

7. July 4-6,1971

While other reports were available, data from XERB certainly were useful in making a more confident analysis.

The buoy's observations from 05/0600Z-06/0600Z were critical in all aspects and an hourly watch of its data would be most meaningful as this storm threatens high density coastal shipping lanes. Data are sparse offshore due to traffic watch having priority over weather reporting on the vessel.