Marine

THE NATIONAL WEATHER SERVICE MARINER REPORT (MAREP) PROGRAM

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ABSTRACT

Marine warnings and forecasts are a major element of the National Weather Service (NWS) mission. Yet, despite information from satellites and observations from ships, data buoys, offshore platforms, and coastal stations, large expanses of ocean and the Great Lakes remain data voids. Shipping, fishing, recreational- boating, and offshore exploration in these data-sparse areas represent a wealth of information. To take advantage of these potential observers, the NWS, in cooperation with the Marine Advisory Service of the NOAA Sea Grant Office, has launched a Mariner Report (MAREP) program. Patterned after aviation Pilot Reports (PIREPs), the MAREP concept seeks to recruit private coastal marine radio stations and mariners on a volunteer basis to relay weather and sea state observations to NWS forecast offices. These data are combined with other information to issue/update marine warnings and forecasts. Where possible, products are relayed back to the radio stations for broadcast to mariners as a payback for their participation. As of October 1984, there are 30 MAREP locations around the country supplying an average, per site, of 6 to 30 reports a day to NWS. Automation techniques to minimize manual workload are being tested at sites on the east and Gulf coasts. Results from these tests and experience gained from the present network will form the basis of a national MAREP program. A nationwide MAREP network is planned involving approximately 100 radio collection sites to provide expanded data coverage within the 200-mile Exclusive Economic Zone and the Great Lakes.

1. INTRODUCTION

An important mission of the National Weather Service (NWS) is the provision of warnings and forecasts in the marine environment to support safe and efficient operations by public maritime activities (3). Twenty-four Weather Service Forecast Offices and approximately 50 smaller Weather Service Offices provide marine prediction services for designated coastal, offshore, high seas, and Great Lakes areas (figure 1). Merchant ships, fishermen, recreational boaters, offshore drilling, and coastal communities depend on these services for their safety, livelihood, and leisure. The contribution of these activities to the nation's economy within the 200-mile Exclusive Economic Zone (EEZ) is greatly dependent on the ability to conduct operations in the face of environmental conditions that can change from dead calm to hurricane proportions in a matter of hours.

2. FORECAST FORMULATION AND DATA DEPENDENCY

It has often been stated that predicting future events is both a science and an art. Forecasting, whether it be the outcome of a horse race, the economy, or the weather, depends upon the collection and analysis of pertinent data that portray past and present conditions. A simple technique, of course, is assembling the data into a trend of events and extrapolating this trend to some future time. More sophisticated forecast techniques are based on numerical models derived from mathematical representations of physical processes. These models use observed data to predict future events. Weather forecasters make use of both methods. The output from computerized numerical models is adjusted by the forecaster's evaluation of present and past conditions to formulate a forecast of weather elements in both space and time. This forecast formulation process is a function of the quality and quantity of detailed weather observations. It is not surprising that, in meteorology, the higher the number and frequency of accurate observations, the more accurate and detailed the forecast.

Forecasters are faced with a difficult challenge in predicting winds, waves, visibility, precipitation, and general weather conditions for periods out to 5 days. They must also warn of the onset of oceanic and Great Lakes storms on scales ranging from tens to thousands of square miles, as much as 24 hours in advance. these are basic requirements for maritime activities (4,5) to plan operations and make decisions on whether to leave port, change a navigation route, head for safe harbor, safeguard personnel, equipment, and cargo, etc. Yet from the coastline to the high seas there are relatively few representative weather observations available for use in numerical models and by the forecaster (6). This paucity of information limits the ability to provide detailed quantitative predictions of oceanic weather elements. The challenge is especially great within the EEZ and the Great Lakes, which posses the highest concentration, diversity, and range of marine activities and mariner experience. These areas also exhibit the greatest variability of wind and sea state due to land-sea interaction, bathymetry, and ocen thermal structure.

Forecasters generally rely on weather observations from fixed observing stations reporting hourly or more frequently (i.e., both the time and space coordinates are fixed or known ahead of time). Airport observing stations are an example of this reliability. They provide a complete depiction of surface weather conditions. So-called "special" reports by human observers and automated stations, based on elements exceeding threshold values (e.g., reduction of visibility to less than one mile), alert forecasters to rapidly changing conditions that could be the basis for issuing a warning. Satellites, radar, and upper air soundings complete the major elements in the observation system, but are limited in their ability to provide quantitative information.

3. FILLING DATA GAPS

Despite the diversity of data sources, additional observations are needed by the forecaster to monitor conditions and respond with detailed warnings and forecasts on a localized basis. Severe storm spotter networks, and cooperative observers help to fill in data gaps and assist forecasters to respond to severe weather situations affecting life and property (7). For example, in the NWS aviation program, airport observations are the basis for terminal forecasts but do not provide enough information for flying conditions predicted in Route and Area Forecasts and In-flight Advisories. To help meet these requirements, aviators for many years have provided Pilot Reports (PIREPs) of conditions aloft: turbulence, icing, visibility, cloud bases and tops, and winds (8). Balloon-borne upper air soundings and vertical temperature profiles by satellite provide indicators of these elements, but do not substitute for direct observations of in-flight weather conditions.

Observations by citizens on the ground and pilots in the air are invaluable to forecasters and represent a "self-help" mechanism by which data fed into the forecast system are fed back to the cooperator in the form of updated weather information. In the case of PIREPs, pilots are also helping each other by alerting their fellow aviators to trouble ahead even before the forecast is amended or a warning issued. This pattern of cooperation-response translates into enhanced safety, efficiency, and cost savings.

4. THE MARINE DATA BASE

In the marine environment, forecasters do not have the benefit of a dense network of fixed, hourly reporting, marine observing stations. About 40 coastal and deep ocean moored buoys and 31 automated coastal headland stations are distributed along the nation's 12,400 mile coastline (figure 2). The headland stations report wind speed and direction, wind gusts, sea-level pressure, and air temperature, but data are not available for waves, sea-water temperature, and visiblity. All of these parameters (except visibility) are reported by the buoy network. The offshore oil and gas industry has been very cooperative in providing additional marine data to NWS, but these are primarily in the northwest Gulf of Mexico where most of the nation's offshore energy production is located and reports vary in frequency. The Coast Guard provides observations from about 190 coastal stations (9). However, most of the locations are not representative of the land-sea transition zone, are not reported hourly, and the number of stations is diminishing due to budgetary considerations and personnel reductions.

The major element of the marine data base farther offshore is represented by merchant ships that participate in the international Volunteer Observing Ship (VOS) program organized by the World Meteorological Organization (10). There are a total of 7000 VOS ships worldwide. The United States has recruited and maintains over 1800 of these vessels (11). The VOS system makes a vital contribution to the World Weather Watch program by providing data to major meteorological processing centers for use in numerical forecast guidance, local and regional forecasts, and climatological applications, and research. The VOS reports are distributed to NWS forecast offices with marine responsibilities and are available to external users such as commercial meteorologists, oceanographers, and private sector ship routing companies.

VOS observations (12) are normally taken only every 6 hours at synoptic reporting times (00 GMT, 06 GMT etc.). However, only two of the four reports per day are transmitted to NWS because of radio officer watch schedules. These reports are subject to delay and can reach forecasters hours after observation time. Reports are generally confined to major transoceanic trade routes and in areas where ships try to make use of or avoid prevailing ocean currents. Very few VOS reports are available within 50 miles of shore as ship personnel are usually busy with various navigational and communication tasks related to port arrivals and departures. In addition, ships normally avoid heading into known areas of severe weather, which further reduces the amount of valuable information on storm movement and intensity that could be derived from wind, air pressure, and wave observations. These factors result in a relatively small number of ship weather observations being available to NWS in near real time as indicated in figure 3.

An example of the large differences in data amounts between land to sea is shown in figure 4, which compares roughly equivalent areas. Land stations outnumber coastal and ocean stations by more than 2 to 1. Factoring in the frequency of reporting, the 24-hour land-to-ocean observation ratio becomes greater than 4 to 1.

5. THE MARINER REPORT PROGRAM

NWS marine forecasters are continually on the firing line to provide reliable warnings and forecasts to the maritime public. Each day literally thousands of craft ranging from small pleasure boats, to hundred-foot fishing trawlers, to ocean-going freighters ply the waters near the U.S. coast and on the Great Lakes. Each of these vessels represents a potential observing platform whether or not meteorological instruments are carried on board. To take advantage of this potential observing capability, the NWS has developed a Mariner Report (MAREP) program to obtain at-sea weather observations in real time (13, 14, 15).

MAREPs are patterned after aviation PIREPs. Mariners are recruited on a volunteer basis to report marine weather elements while underway or at their point of operation such as an offshore fishing ground. The term MAREP was deliberately coined as a corollary to PIREP to convey to the mariner his or her kinship with the aviator in terms of navigation and the effects of weather on safety and operating efficiency. The links between MAREP observers and forecasters are marine radio facilities known as Limited Coast Stations (LCS). These are licensed by the Federal Communications Commission (FCC) to provide two-way radio services for local or regional maritime groups via VHF-FM and HF-Single Sideband (16). The FCC has approved the participation of LCS's in the MAREP program.

Figure 5 is a schematic of the MAREP concept. Fisherman, harbor pilots, tug and barge operators, recreational boaters, and other mariners provide voice reports of weather conditions in plain language to the LCS either on a pre-arranged schedule or when conditions differ significatly from the forecast. The radio operator at the LCS copies the reports on a log sheet. At the conclusion of the reporting period the observations are relayed to the NWS forecast office by phone, telecopier, or computer terminal. The MAREPs are used by the marine forecaster along with other data to: a) to issue an immediate warning if the MAREPs indicate existing or potentially hazardous weather such as high winds and waves; b) amend a previously issued forecast due to a significant but non-critical change; or c) formulate the next scheduled forecast.

A major feature of the program is the payback or self-help aspect. Warnings, amendments, or scheduled marine forecasts are relayed back to the LCS immediately for braodcast to the mariners who initially supplied the MAREPs as well as to other vessels "working" the same frequencies as the radio station. This payback mechanism reinforces and encourages MAREP participation because mariners know that their observations are being used to update area-wide information. Moreover, the reliability and accuracy of warnings and forecasts is improved by the availability of more data to the forecaster. In addition to these broadcasts, updated forecast information is aired immediately by NOAA Weather radio, Coast Guard communications stations, and marine public correspondence stations operated by communications companies. These are the primary weather dissemination outlets serving maritime activities. The payback broadcast aspect of MAREPs via LCS's broadens the NWS dissemination program to insure the mariners' access to marine warnings and forecasts.

MAREPs were begun in 1975 in Kodiak, Alaska. Peggy Dyson, the wife of a fisherman, operates a Limited Coast Station to provide communications for Alaska fishing fleets operating hundreds of miles into the Gulf of Alaska, across the Aleutians, and the Bering Sea. The NWS Alaska Region initially recruited Mrs. Dyson to make supplementary weather broadcasts. She later expanded her services to include the collection of weather reports. An average of 30 observations a day, seven days a week are relayed through the MAREP program in Kodiak. On countless occasions, fishermen have stated the these reports made the difference between life and death because of the resultant warnings that were issued. Mrs. Dyson has been recognized on numerous occasions for her contributions to maritime safety.

Based on the success of MAREPs in Alaska, NWS began developing plans for a nationwide MAREP network in cooperation with the Marine Advisory Service (MAS) of the NOAA Sea Grant Office (17). MAS can be considered the maritime counterpart of the Agricultural Extension Service. State MAS extension agents provide expertise and information to fishermen, seafood processors, recreationsl boaters, and coastal marine activities on matters relating to productivity, operating methods, safety, and technology. MAREPs are considered a natural extension of the agents' roles in linking NOAA services to marine endeavors.

NWS forecast offices in each coastal State are working with State MAS program leaders and Sea Grant colleges to recruit volunteer MAREP observers and coastal radio stations. To date there are 30 MAREP programs in operation in 21 of the 30 coastal States including the Great Lakes (figure 6). The NWS goal is to expand the program to provide MAREP capability to all MWS coastal forecast offices. The number and location of observations on any given day varies with fishing and transport operations, fish migratory habits, boating season, regulated fishing days, and even the weather. The average number of reports collected per day ranges from about six to 30 for each MAREP collection site, representing new meteorological data in key areas previously unavailable to marine forecasters.

6. MAREP AUTOMATION

As MAREPs develop into a regular part of a mariner's navigational routine, NWS must develop an efficient mechanism to collect and process these data. A demonstration project was begun in January 1984 to automate the relay of MAREPs from, and the delivery of updated information to, the LCS's. Two MAREP programs were selected for the project: Lewes, Delaware, and the Gulf of Mexico (Biloxi, Mississippi; Cameron, Louisiana; and Port Lavaca, Texas). The LCS's at these locations were supplied with either a TRS-80 Model 100 terminal or an Apple IIe microcomputer for the entry of MAREPs. The radio operator transmits the observation collectives into the NWS Automation of Field Operations and Services (AFOS) computer system either directly through an asynchronous communications port or via a host microcomputer linked to AFOS. The collective is reviewed by the forecaster for errors and the message header is quickly modified for transmission of the collective to other NWS offices linked by AFOS. The radio operator also uses his terminal to access warnings and updated marine forecasts based on the MAREPs.

In the case of Lewes, Delaware, (figure 7), users of the marine products issued by the Washington, D.C., forecast office call them up from the University of Maryland Extension Service computer. The Lewes LCS can obtain updated local weather information for Cape Henlopen, Delaware, to Virginia Beach, Virginia, and the Continental Shelf (CONSHELF) area from Hudson Canyon to Cape Hatteras, as well as all marine warnings and forecasts for the entire eastern seaboard issued by other NWS offices. This complete marine information package is automatically collated and transmitted to the University of Maryland computer by the AFOs system at the Washington, DC., forecast office on a scheduled basis and arranged in a menu format for product selection (figure 8). The Lewes MAREP radio station is thus able to broadcast any product for the Atlantic area that might be requested by mariners. Other NOAA marine information related to fisheries, oceanographic data, notices to mariners, nautical chart updates, etc. make this system a comprehensive Marine Information Service for anyone with a microcomputer and a telephone communications interface.

The automated MAREP and product access demonstrations are being evaluated by NWS as the basis for a national MAREP automation plan. This is a joint project with the NOAA Sea Grant Office to extend the capabilities afforded by the University of Maryland Marine Information Service to all Sea Grant Colleges around the country as well as continuing the recruitment of MAREP observers and volunteer radio stations. MAREP automation means more coastal and offshore data for forecasters, greater efficiency in data relay and processing, improved warnings and forecasts, and convenient access by the MAREP LCS's to a wide range of updated NOAA marine products.

7. SUMMARY AND CONCLUSIONS

Forecast formulation begins with an anlysis of current and prior atmospheric conditions. The more extensive the data base in space and time, the better the output from numerical models and the better the operational forecast issued to the user. The paucity of representative and frequent marine observations makes the marine forecaster's job expecially challenging. The large number of commercial and pleasure craft operating within the 200-mile EEZ affords NWS the opportunity for improving marine data acquisition and providing more dependable marine services. The joint NWS - NOAA Sea Grant MAREP program is recruiting mariners and coastal radio stations to relay weather observations for use with other data sources to update warnings and forecasts. Mariner participation is encouraged by users being able to receive the latest information directly from the MAREP collection sites in addition to standard marine dissemination outlets. Plans are being made to expand the present network of 30 MAREP locations to about 100 sites around the country in the coming years, providing forecasters with a significantly improved marine data base within the 200-mile EEZ. In addition, the program will be automated through the use of small microcomputers at the MAREP sites for more efficient input of data to NWS and retrieval of updated products. The product access part of the MAREP program is planned via State Sea Grant college computer facilities. Automated MAREP demonstrations now underway are testing the concept that the product access part of the MAREP program will be based on Sea Grant college computer facilities.

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FOOTNOTES AND REFERENCES

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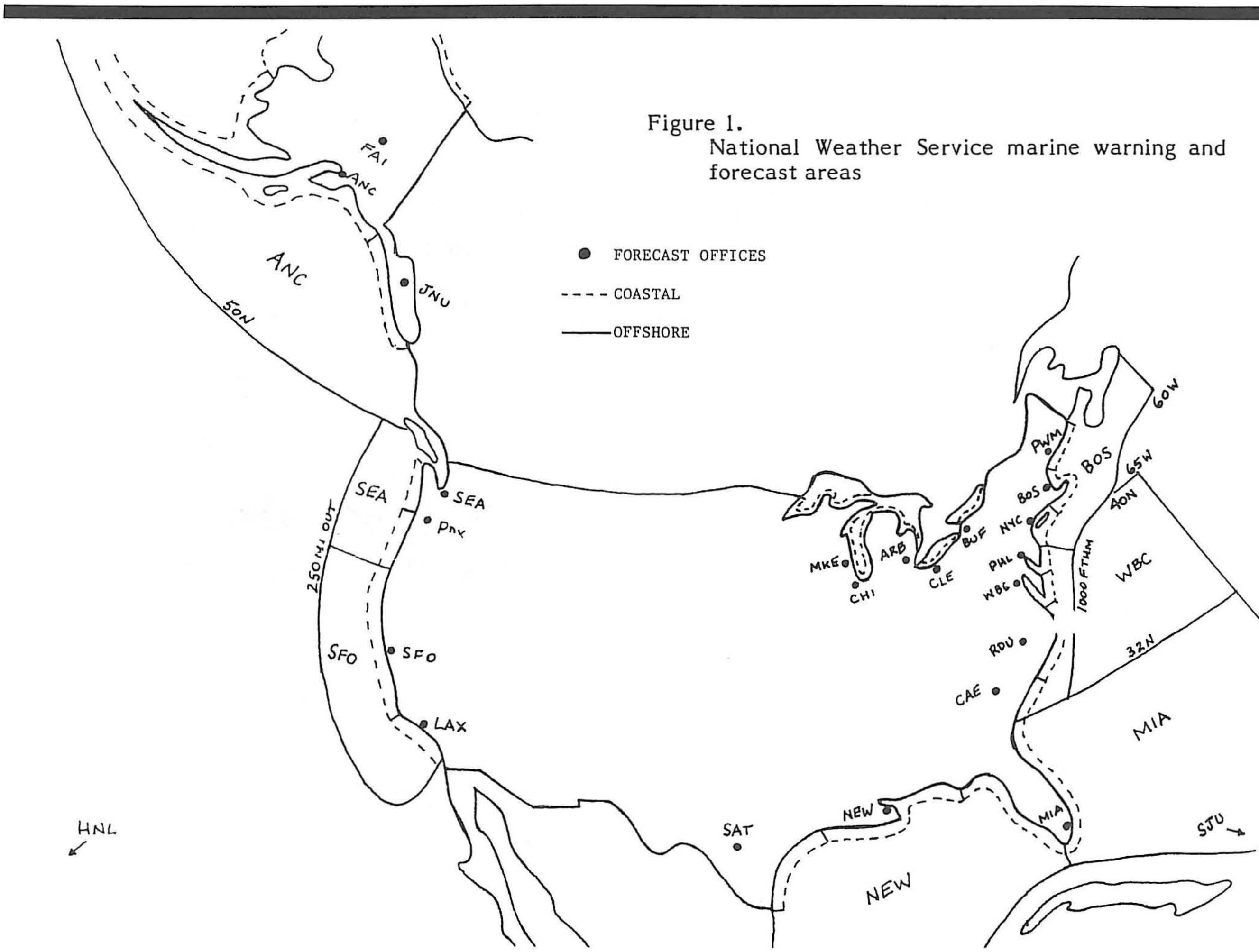


Figure 1.
National Weather Service marine warning and forecast areas

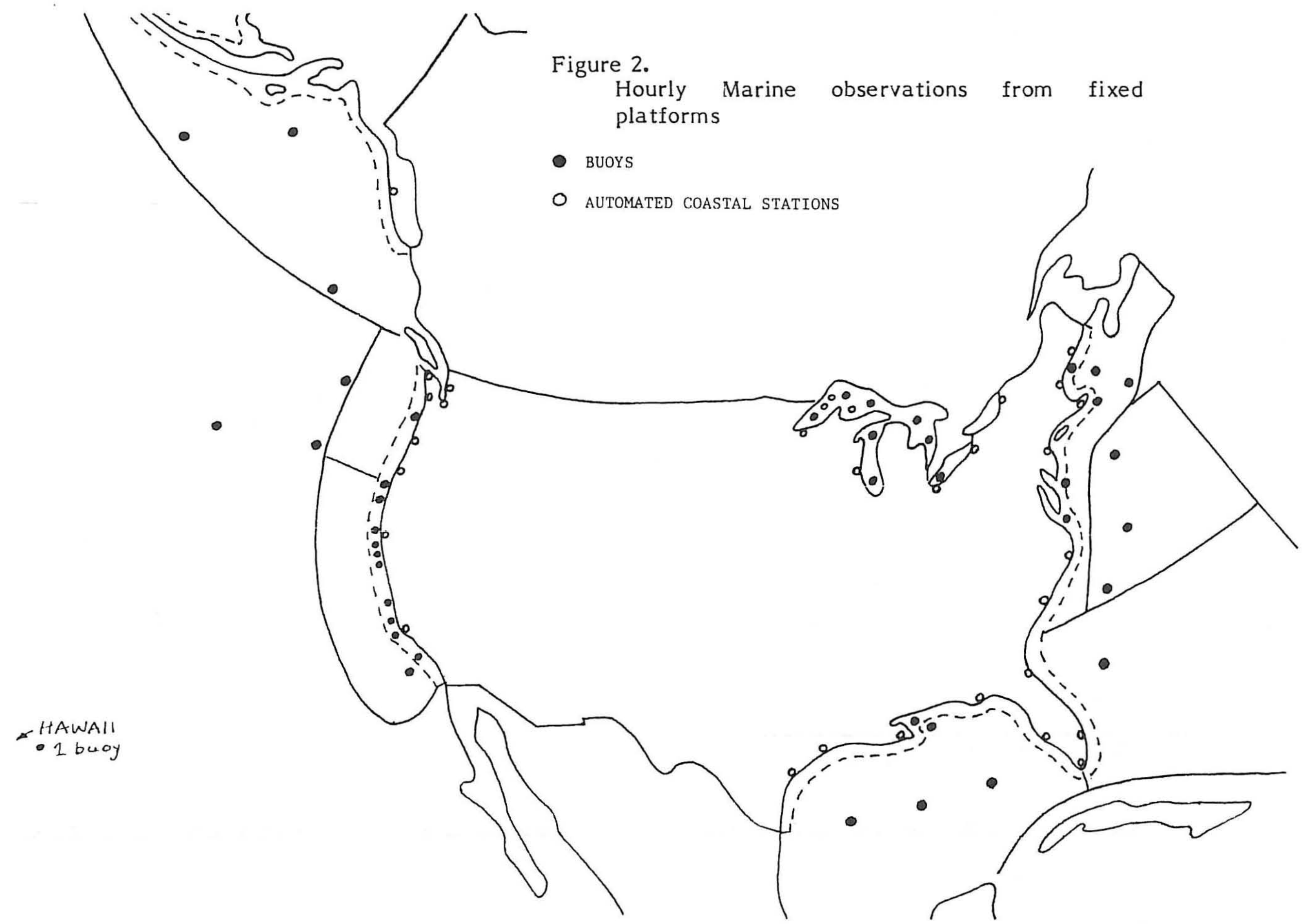


Figure 2.
Hourly Marine observations from fixed platforms

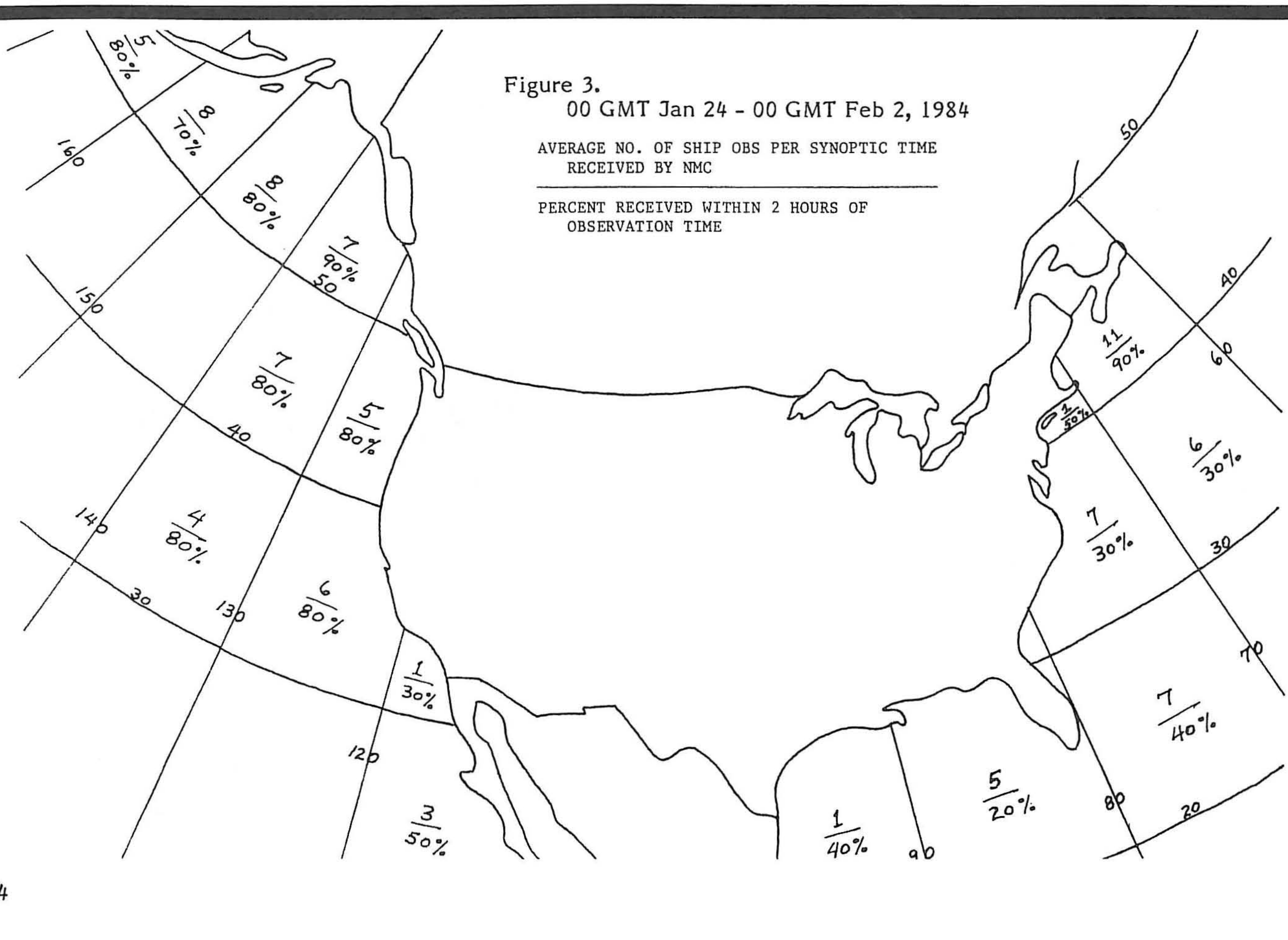


Figure 3.
00 GMT Jan 24 - 00 GMT Feb 2, 1984

Figure 4.
Numbers of land vs. marine observations

FIXED STATION REPORTS (6 BUOYS, 6 AUTOMATED COASTAL, 12 USCG STATIONS)

AVERAGE NO. OF SHIP OBS PER SYNOPTIC TIME RECEIVED BY NMC

PERCENTAGE RECEIVED WITHIN 2 HOURS

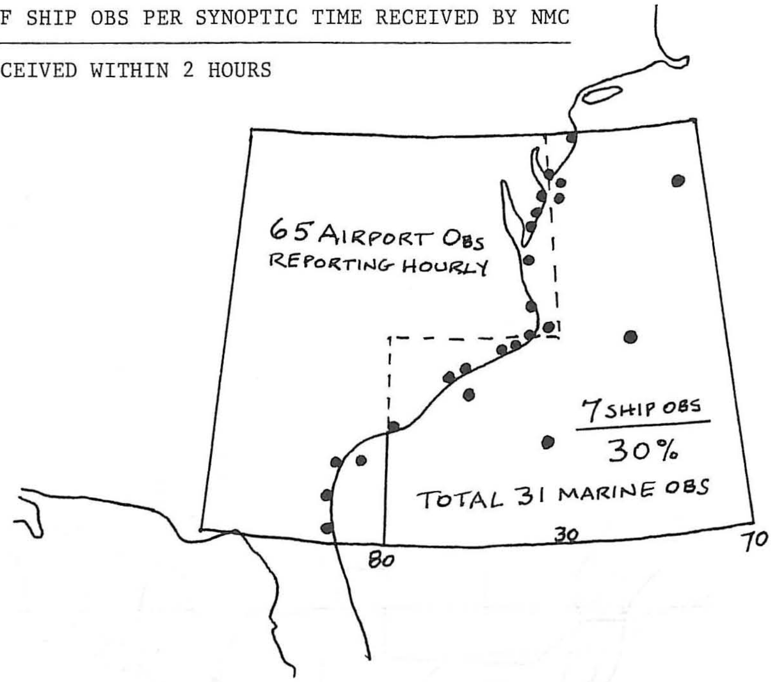
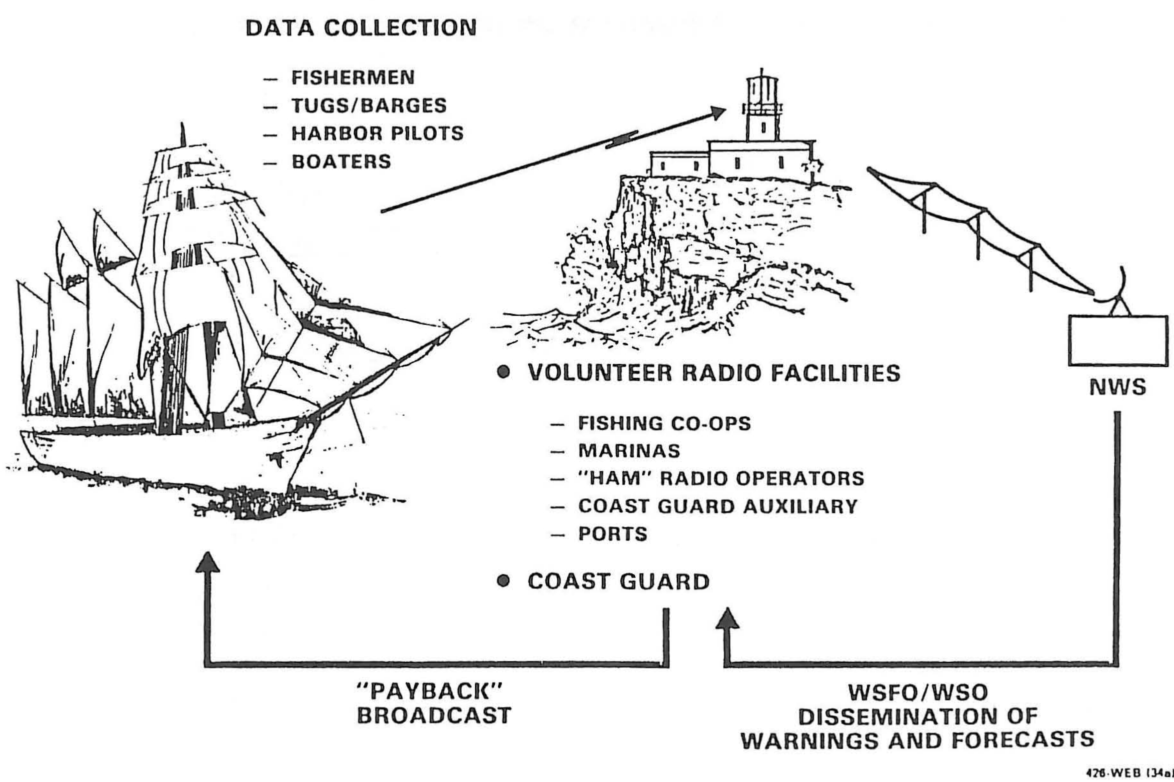


Figure 5.
MAREP "self-help" concept



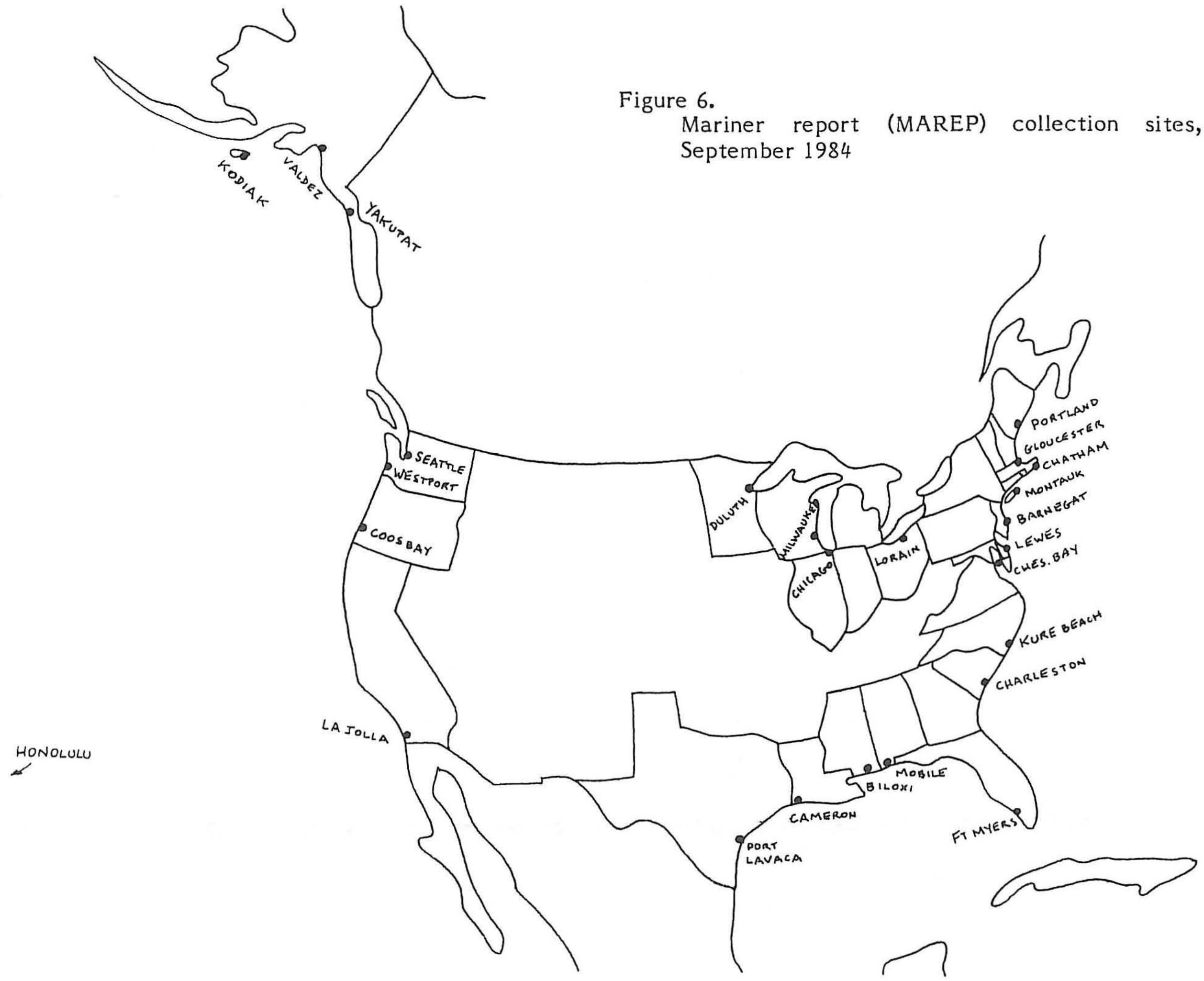


Figure 6.
Mariner report (MAREP) collection sites, September 1984

Figure 7.
Mid-atlantic automated MAREP demonstration

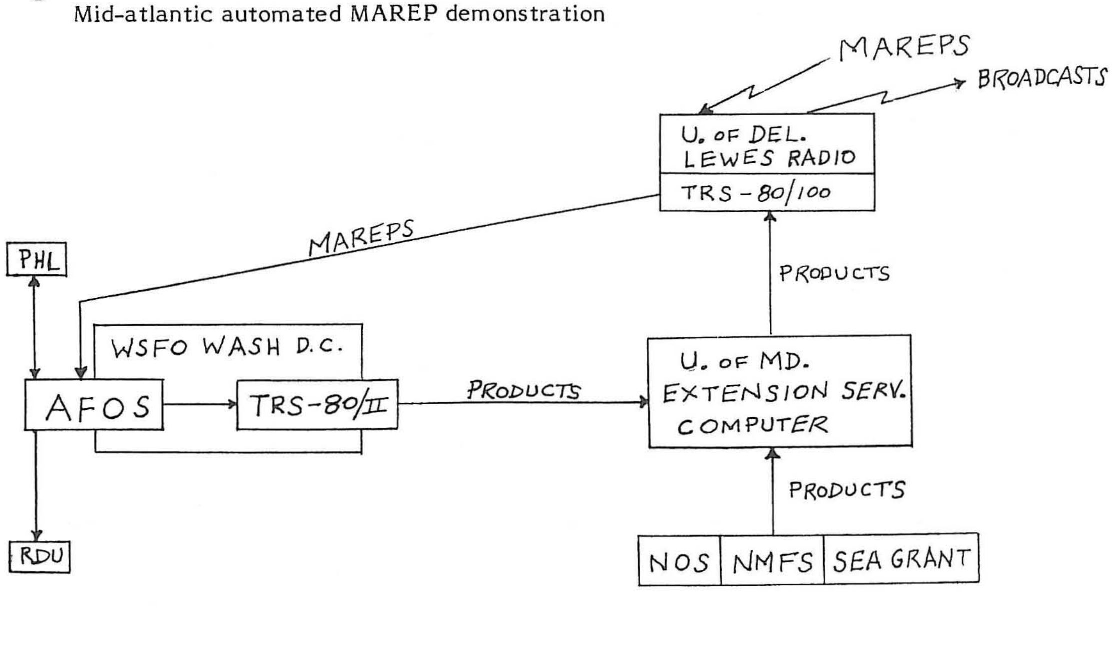


Figure 8.
Menu of Marine Weather Products available from University of Maryland Extension Service Computer

N.O.A.A
NATIONAL WEATHER SERVICE
MENU OF MARINE WEATHER PRODUCTS

7501	BAYS AND SOUNDS MENU
7601	COASTAL WATERS MENU
7701	OFFSHORE WATERS MENU
7711	TROPCL STORM ADVIS
7801	HIGHSEAS MENU
7850	TIDE CONVERSION TABLE
7900	N.O.S. MENU
7920	N.M.F.S. MENU
7940	OFFICE OF SEA GRANT MENU

FOLLOWING BAYS MENU

7502	= BUZZARDS BAY
7503	= NARRAGANSETT BAY
7504	= LONG ISLAND SOUND
7505	= DELAWARE BAY
7506	= CHESAPEAKE BAY/NORTH OF BALTIMORE HARBOR
7507	= BALTIMORE HARBOR TO PATUXENT RIVER
7508	= PATUXENT RIVER TO WINDMILL POINT
7509	= SOUTH OF WINDMILL POINT
7510	= TIDAL POTOMAC
7511	= ALBEMARLE AND PAMLICO SOUNDS

FOLLOWING COASTAL MENU

7602	= EASTPORT TO MERRIMACK RIVER OUT 25 MILES
7603	= MERRIMACK RIVER TO WATCH HILL OUT 25 MILES
7604	= WATCH HILL TO MONTAUK POINT OUT 20 MILES
7605	= MONTAUK POINT TO MANASQUAN OUT 20 MILES
7606	= MANASQUAN TO CAPE HENLOPEN OUT 20 MILES
7607	= CAPE HENLOPEN TO FENWICK ISLAND OUT 20 MILES
7608	= FENWICK ISLAND TO CHINCOTEAGUE OUT 20 MILES
7609	= CHINCOTEAGUE TO VIRGINIA BEACH OUT 20 MILES
7610	= VIRGINIA BEACH TO LITTLE RIVER INLET OUT 20 MILES
7611	= LITTLE RIVER INLET TO SAVANNAH OUT 20 MILES

FOLLOWING OFFSHORE MENU

7702	= SYNOPSIS OF MAJOR MAP FEATURES
7703	= SABLE ISLAND TO NORTHEAST CHANNEL
7704	= GEORGES BANK FROM NORTHEAST CHANNEL TO GREAT SOUTH CHANNEL
7705	= GREAT SOUTH CHANNEL TO (AND INCLUDING) HUDSON CANYON
7706	= HUDSON CANYON TO BALTIMORE CANYON
7707	= BALTIMORE CANYON TO HATTERAS CANYON
7708	= HATTERAS CANYON TO BLAKE RIDGE
7709	= EXTENDED OUTLOOK
7710	= GULF STREAM PLOT
7711	= TROPICAL STORM WARNINGS AND ADVISORIES
7712	= EAST OF 1000 FATHOMS TO 65 DEGREES WEST

FOLLOWING HIGHSEAS MENU

7802	= WARNINGS AND FORECASTS
7803	= ALL OTHER FORECASTS

NATIONAL OCEAN SERVICE MENU
****

7901	NOTICE TO MARINERS
7910	NAUTICAL CHARTS CATALOG

OFFICE OF SEA GRANT MENU

7941	= NOTICE TO MARINERS
7942	= SEA GRANT CALENDAR

TIDE CONVERSION TABLE

ADD OR SUBTRACT THE HOURS AND MINUTES FROM THE TIDE TIMES GIVEN IN PRODUCT NUMBER 7510 TO FIND THE TIMES OF HIGH AND LOW TIDE FOR THE FOLLOWING POINTS.

CHAIN BRIDGE.........	+ 0:20
MARYLAND PT..........	- 3:35
POINT LOOKOUT,MD.....	- 7:40
SOUTH RIVER,MD.......	- 4:20
FT.MC HENRY,MD.......	- 2:10
ST.MICHAELS,MD.......	- 5:15
TANGIER IS.,VA.......	- 9:10
HAMPTON ROADS,VA.....	-12:00
SINEPUTENT BAY,MD....	- 8:30
BENNING RD.,DC.......	+ 0:15
GUNNSTON COVE,VA.....	- 0:50
COLONIAL BEACH,VA....	- 5:45
COVE PT.,MD..........	- 6:17
SANDY POINT,MD.......	- 3:40
HAVRE DE GRACE,MD....	+ 1:00
CRISFIELD,MD.........	- 8:10
CAPE CHARLES,VA......	-12:15
WACHAPREAGUE,VA......	-13:15
OCEAN CITY,MD........	-13:30
CAPE HENLOPEN,DE.....	-13:30