NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

NATIONAL WEATHER SERVICE

CRESCENT CITY STORM
AUGUST 16, 1972

Report by Office of Meteorological Operations
National Weather Service Headquarters
In Conjunction with Western Region Headquarters
March 1973

PREFACE

A NOAA National Weather Service (NWS) survey team composed of Chester L. Glenn, Public Service Meteorologist, NWS Regional Headquarters, Salt Lake City, Utah; Raymond Williams, Guidance Forecaster, WSFO, San Francisco, California; and James D. Wakefield, Meteorologist-in-charge, WSFO Portland, Oregon, reviewed the NWS system performance during the Crescent City, California, storm of August 16, 1972. Matthew H. Kulawiec, Regional Warning Coordination Center, Salt Lake City, provided an analysis of guidance supplied to NWS forecasters. The survey team findings were reviewed and this report was prepared by the staff of the NWS Associate Director for Meteorological Operations.

Because this was a maritime disaster, the U.S. Coast Guard convened a Marine Board of Investigation, whose transcript will be submitted to the National Transportation Safety Board.

EXECUTIVE SUMMARY

On Wednesday, August 16, 1972, between the hours of 0600 and noon PDT, a small but intense storm that had apparently developed very rapidly moved up the coast of northern California and extreme southern Oregon causing high winds along a 100-mile coastal and offshore strip from Eureka, California, to near North Bend, Oregon. The low pressure system then moved inland about noon with considerably decreased winds. Strongest winds were from a southerly direction, reaching at least 65 knots in places.

At least 10 boats were sunk and 100 others badly damaged, and 13 people are known dead or missing. The casualties were mostly fishermen who had been fishing off Point St. George (near the California-Oregon border) and whose boats sunk or were driven northward before the wind onto rocks or islands in trying to reach safety.

Findings

Although warnings were not issued soon enough to inform early departing fishermen, warnings were hoisted well ahead of high winds at all display stations on the northern California coast except for Crescent City, where display flags were not available.

A review of the actions taken by the Eureka office indicates they promptly apprised WSFO San Francisco, the Humboldt Bay Coast Guard Station, Eureka Boat Basin and the general public of the developing storm.

Neither WSFO San Francisco nor WSFO Portland had dedicated marine forecasters at this time. This prevented them from carrying out their marine responsibilities adequately. Since the storm, a dedicated marine unit has been established at WSFO San Francisco. WSFO Portland is still without a dedicated marine focal point.

Weather reporting points along the immediate shoreline are gradually being lost as the Coast Guard Carries out its Lighthouse Automation Program (LAMP). The only hourly wind reports were from stations a few miles inland from the coast. It was not until the storm reached Brookings, Oregon, that its strength was known.

There is a scarcity of weather data for offshore (particularly from ships) and immediate coastal areas which inhibited the possibility of making an accurate surface analysis and forecasting storms for even a short period (4 to 12-hour range).

The rapid movement and the lack of knowledge concerning the storm's intensity precluded any forecast well in advance of occurrence (12 to 24-hour range).

The Limited Fine Mesh (LFM) model display area has its boundary too close to the west coast to be useful in forecasting many of these mesoscale storms 24 hours in advance. Accurate analysis is impaired by the lack of observational data **over the oceans.**

There is a continuing need for mesoscale analysis at WSFO's and WSO's and checking by NMC of computer rejected observations, because the machine analysis smooths many small-scale severe weather producing features.

Dynamic models capable of accurately predicting the behavior of cyclonic disturbances as small as 300 km diameter are needed.

Satellite picture capability at WSFO San Francisco was limited to a few daylight hours.

The Medford WSR-57 radar observed in detail this weather system as it approached the Pacific coast.

The best way, at present, to reach boats is by radio through commercial broadcast stations and Citizen Band.

Some visual display stations had not been recently visited by Weather Service personnel; therefore, displaymen were not familiar with their duties and responsibilities.

Present satellite and radar technology does not provide direct information on surface winds or their gustiness.

There are indications that this storm system had both extratropical and tropical characteristics.

It would have been extremely difficult, if not impossible, to forecast the strength of the gusty winds from the available data.

The Radar Report and Warning Coordination Circuit (RAWARC) is the prime means for the exchange and coordination of critical radar information between NWS stations and needs to be scheduled with automatic station callup.

There is no NOAA Weather Wire Service in California and 19 other states. In these states, forecasts, warnings, and general information must be transmitted on RAWARC.

There was no warning coordination between WSFO San Francisco and WSFO Portland.

Recommendations

That recovery be made as rapidly as possible from the degradation of the coastal and oceanic reporting network. It is imperative that more data, particularly wind, be obtained along the coast and seaward.

NOAA should continue its program for the development and deployment of the Data Buoy System. NOAA should expedite the development, procurement, and deployment of the NWS Automatic Data Acquisition systems. The communication capability of the AMOS should be increased to include radio and telephone so that Coast Guard radio, teletypewriter and power sources can be utilized (Coastal AMOS Experiment - CAMEX). The DARDC, for winds only, should be installed as quickly as feasible.

That a concerted education program be mounted to inform the marine public of the communications facilities available for warnings and to promote the NWS VHF-FM continuous radio weather program.

As frequently as feasible, all disseminators of warnings, news media, Coast Guard stations, display stations, etc., should be visited by NWS personnel to improve working relationships.

Adequately staff the Satellite Field Service Stations (SFSS) at WSFO San Francisco to obtain maximum usage of weather satellite data. Every effort should be made to use data available from weather satellites as a prediction and warning tool. A marine forecast focal point position should be established at WSFO Portland.

NOAA should also accelerate the implementation of its Plan to Improve Local Weather Forecasts and develop and carry out a program related to mesoscale weather phenomena analyses and prediction.

The RAWARC circuit should be scheduled with automatic callup of stations and the NOAA Weather Wire Service should be expanded as soon as funds are available to reduce the routine traffic on RAWARC.

The program started by NMFS and WSFO San Francisco to obtain limited weather data from the tuna fleet should be continued and expanded to other marine operators and other offshore areas of sparse weather data.

The new ship voice-weather-code program should be encouraged by NOAA and the Coast Guard to increase the number of vessels participating.

The Regional Warning Coordination Center (RWCC) should be fully staffed to monitor and coordinate warnings and forecasts issued within their area of responsibility. The installation of "red phones" in WSFO's will speed the necessary coordination.

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CHAPTER I

CRESCENT CITY STORM OF AUGUST 16, 1972

A small intense storm, which developed rapidly during the night, swept through the fishing grounds and the coastal area between Eureka, California, and North Bend, Oregon, during the morning of Wednesday, August 16, 1972, (See figure 1.). Strongest winds were from a southerly direction, reaching at least 65 knots in gusts at some places. Once the low moved inland, the winds decreased rapidly.

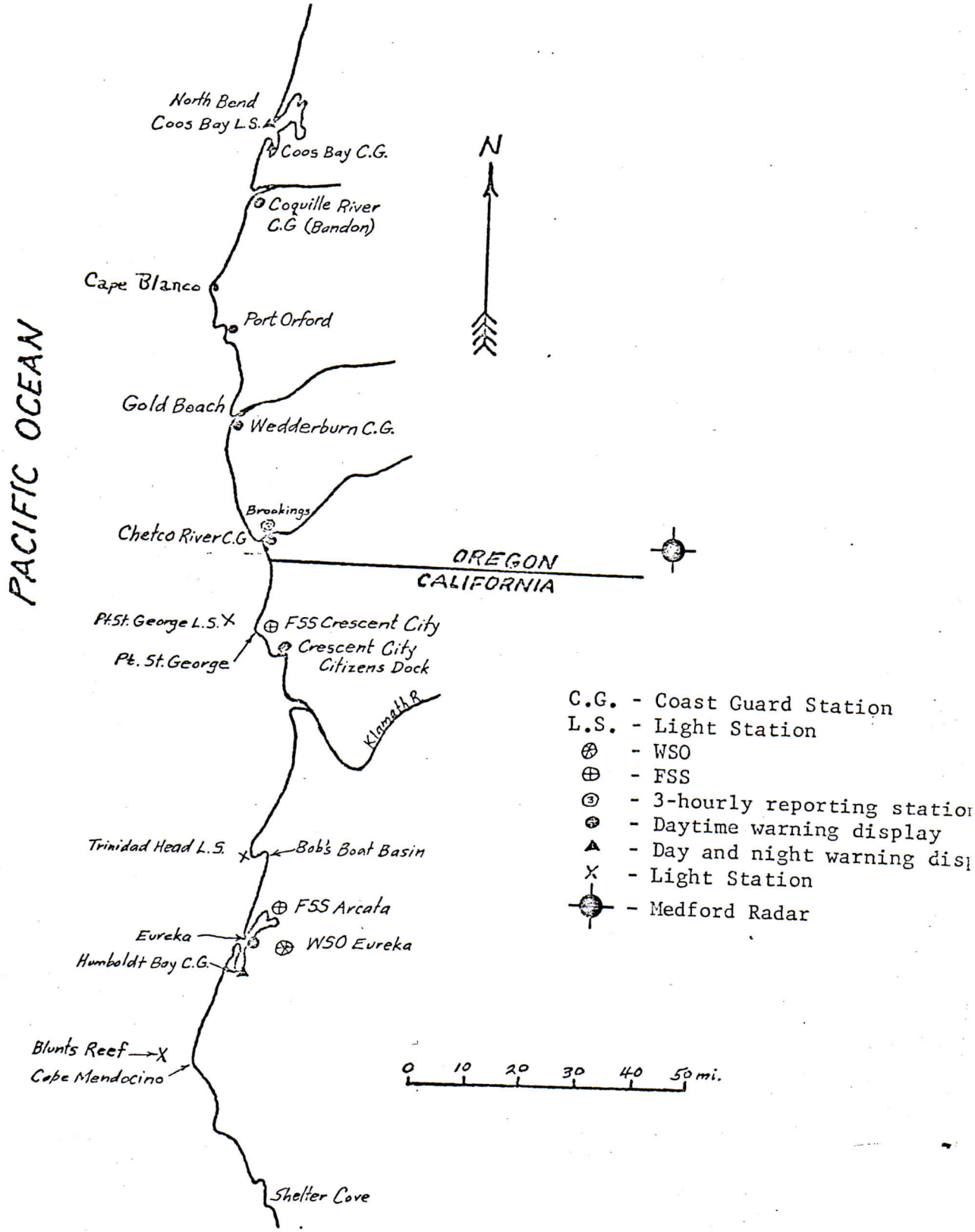
Eye witness acount as stated verbally by Everett Draper, Skipper of the PACIFIC RAIDER.

> I went out Saturday, August 12, 1972, from Eureka and returned at 4:25 a.m., Wednesday, August 16. I drag fished about 18 miles off Point St. George Light Station until about 7 p.m., Tuesday, August 15. I then proceeded for Humboldt Bay on a straight course angling towards Humboldt Bay Bar. At midnight, I was between Patricks Point and Redding Rock (7 miles offshore) - flat calm, no weather or seas. At about 2 a.m. off Mad River about 4 miles offshore - flat calm, no weather, or seas. At 3 a.m. just north of the bar, flat calm, no seas or weather. At 4 a.m., off Fairhaven Coast Guard Station in Humboldt Bay - flat calm, no weather or seas. I docked at 4:25 a.m. at Lazio's - flat calm, no wind or weather. At 4:30 a.m. I saw Fred Brown, Skipper of the BLUEFIN. He stated, "A few minutes ago it was dead calm. Now the wind is picking up. Don't think I shall go out. Jim Riley on the INA just radioed in that he is coming in since the wind suddenly started to pick up and he is taking seas over the bow at 300 fathoms (about 14 miles) west of Trinidad." Dale Kennedy on CHALLENGER told Everett that while fishing at Mack Arch off Oregon coast (about 9 miles offshore from 5 miles south of Rogue River Reef) on August 16, the wind was dead calm the entire trip until between 10:30 a.m. to 11 a.m. Then within 5 minutes the wind increased to about 70 knots from the south.

Small craft warnings were issued by Weather Service Forecast Office (WSFO) San Francisco for the coast of northern California at 6 a.m. PDT and were changed to gale warnings at 6:15 a.m. At the time these warnings were issued the wind was starting to increase at Eureka, one of the first points hit by the storm. However, it did not reach its peak at the Eureka Weather Service Office (WSO) until 8:35 a.m. when the fastest mile, at 30 mph, was recorded. Later estimates showed that velocities were much higher at the coast. Damaging winds then moved northward up the coast reaching Brookings, Oregon, at about 10:40 a.m. with gusts to 65 knots (75 mph). Minor damage extended another 30 miles up the coast after which the low moved inland and winds decreased. On the basis of the Brookings report, gale warnings were issued by WSFO Portland for the southern Oregon coast at 11 a.m.

FIGURE I

Coast of Northern California and Southern Oregon



Although gale warnings for the northern California coast were issued well ahead of the peak of the storm, velocities on and just off the coast were strong enough to have justified a higher category of warning (Storm Warning). However, because of lack of wind reports in the immediate coastal area, forecasters had to depend on wind reports from inland stations where velocities were much lower, and therefore, tended to be misleading. Only one ship report was received--this was from a Coast Guard cutter on patrol. It was not until the Brookings report of 65 knots that the full force of the storm was observed.

At least 10 boats were sunk and 100 others badly damaged, and 13 people are known dead or missing. The casualties were mostly persons who had been fishing off Point St. George (near the California--Oregon border) and whose boats were sunk or driven northward before the wind onto rocks or islands. Boats used in this area range generally from 18 to 50 feet in length, and many are poorly equipped and operated by people with very little experience. Many boats ran into trouble attempting to put in at the Chetco River Harbor, Oregon, which was almost inaccessible at the time due to high winds and waves.

Many unmanned boats anchored in southward-facing harbors were driven onto beaches or rocks and damaged. Strong southerly winds rarely occur during the summer, so harbors opening southward are used only in the summer as protection against the prevailing northwesterly winds. Storm damage was generally confined to the open water and the immediate coastal area. A chronology of the observations and warnings associated with this system follows:

CHRONOLOGY OF KEY EVENTS

0500 PDT: The 6-hourly weather reports from Arcata and Brookings at 1200 GMT showed a rapidly falling barometer, and at about this time a number of fishermen noted the "bottom falling out of the barometer."

0534 PDT: The Coast Guard Cutter CAPE CARTER, 20 miles west of Humboldt Bay Coast Guard Station, reported by radio, "The wind is from the south about 45 to 50 knots. Seas are building rapidly about 8 to 10 feet and building and the barometer is very erratic." WSO Eureka gave observation to WSFO San Francisco at about 0610 PDT.

0535 PDT: The duty man at WSO Eureka sent a message by RAWARC to WSFO San Francisco (telephone lines were busy) telling of increasing winds and a need for small craft warning.

0558 PDT: WSO Eureka notified Humboldt Bay Coast Guard and Eureka Boat Basin that a small storm of severe intensity was developing and recommended that no boat be allowed to go out and recommended that caution be used. Commercial radio stations were then notified.

0600 PDT: San Francisco issued small craft warning for Cape Mendocino to Point St. George, and placed it on the Coast Guard teletype (to reach the displaymen), and sent it to the FAA for Service C transmission. The log of the Humboldt Bay Coast Guard Station (Eureka) shows that this warning was hoisted at 0615 PDT.

0605 PDT: WSFO San Francisco phoned Eureka with the small craft warning. Eureka told San Francisco that gale warnings were now needed since reports from the nearby power station showed 40-knot winds.

0615 PDT: WSFO San Francisco issued gale warnings. The log of the Humboldt Bay Coast Guard Station shows that this warning was hoisted at 0647 PDT.

0600-0835 PDT: Wind was rising at Eureka but did not peak at the WSO until 0835 when the fastest mile of 30 mph was recorded.

0640 PDT: WSFO San Francisco issued an amended forecast for the northwest California Zone, including the gale warnings that had been issued.

0800-0835 PDT (Approximately): Boat damage occurred at Bob's Boat Basin at Trinidad. Wind was estimated to have reached 60 knots at Trinidad Head Light Station at about this time.

0930 PDT (Approximately): Coast Guard Cutter CAPE CARTER hit its worst weather and received its first rescue call.

0930 PDT (Approximately): Rescue operations commenced at Chetco River (Oregon) Coast Guard Station.

1000 PDT: Arcata wind reached its peak of 20 knots with gusts to 30.

1050 PDT: Strongest wind occurred at Crescent City (South 30 knots with gusts to 43).

1030-1100 PDT: Strongest winds occurred at Brookings (gusts to 65 knots).

1100 PDT: Gale warnings were issued by WSFO Portland.

1405 PDT: Strongest wind occurred at North Bend, Oregon (gusts to 26 knots).

CHAPTER 2

DATA ACQUISITION

Surface Observation Networks

The surface observing networks provide basic data for many uses, and they include a variety of data collection systems which are, to the extent feasible, tailored to serve all appropriate uses. In general, the networks are divided into two classes: (a) the stations that provide data for immediate use and for record purposes, and (b) the substations that provide data primarily for record purposes.

The network of reporting stations in the western states is shown in figure 2. These stations are manned to provide complete surface observational data on assigned schedules. Observations taken at these stations provide a data base for all weather analysis forecasting, warning, and weather service programs of the nation and a significant input to the climatology of the nation. At the present time the spacing between stations in this area averages about 100 to 200 miles. To describe adequately the phenomena of the severe weather type, the spacing between stations should be about 30 to 60 miles. This spacing would require the installation of nearly nine times as many surface observing facilities as now exist in that area. To achieve that density nationwide, about three times as many stations would be required for these purposes at a cost of $45 million.

Weather reporting stations (in addition to National Weather Service Offices) in the affected coastal area on August 16:

Humboldt Bay, California (Coast Guard Station),
3 observations/day telephoned to WSFO San Francisco

WSO Eureka, California
3 observations/day entered on Service C teletypewriter circuit (0330-2115 only)

Arcata, California (FSS)
Hourly observations on Service A teletypewriter circuit

Trinidad Head, California (Coast Guard Light Station)
4 observations/day telephoned for entry on Coast Guard Teletypewriter circuit

Crescent City, California (FSS)
Hourly observations from 0600 to 2100 LST, entered on Service A teletype circuit

St. George Reef (Coast Guard Light Station)
4 observations/day radioed for entry on Coast Guard teletype circuit

Brookings, Oregon (paid observer - Mr. LeClair)
8 observations/day telephoned to WSFO Portland, then entered on Service C teletypewriter circuit and converted to Aviation Code and entered on Service A teletypewriter circuit.

Cape Blanco, Oregon (Coast Guard Loran Station)
6 observations/day phoned to WSFO Portland for entry on Service C teletypewriter circuit.

Coos Bay, Oregon (Coast Guard Station)
8 observations/day entered on CG teletypewriter circuit and also sent to WSFO Portland and WSFO Seattle on a tie-line.

The vital surface observations during this storm were taken, transmitted and received as described in the weather reporting program. Coastal offices during the approach of the storm reported barometer falling (1 to 2 mb/hour), rain (.01 to .05 inch/hour) and 10 to 20-knot winds. Gusts of 25 to 30 knots generally occurred one to two hours before the center of the storm passed the reporting offices. The chronology of key events indicates the time of the peak gusts as reported by the observing offices.

Automatic Data Acquisition Systems

To supplement the basic surface observing network with data from remote unmanned locations or part-time stations or where a particular type of data is needed, the NWS has developed the following automatic observation equipment.

1. Automatic Meteorological Observing Stations (AMOS).

The AMOS evaluates temperature, dewpoint, wind, pressure and sometimes visibility and, at manned stations, the observer supplements the AMOS observations with required data. AMOS requires 110 VAC, 60 Hz power and can transmit directly on the Service A teletype circuit. Figure 2 shows the operational AMOS network in the West and 36 more stations are being procured.

2. Remote Automatic Meteorological Observing Station (RAMOS).

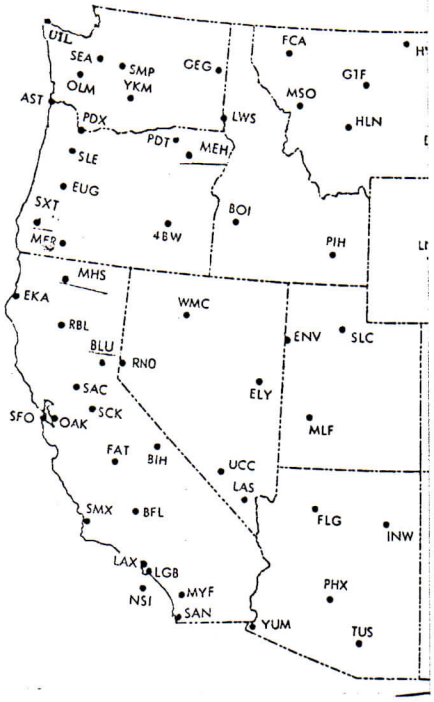
The RAMOS system is modular in concept, designed to operate in a wide variety of environments, capable of measuring a wide variety of parameters, and has four communications options: direct dial-up, dedicated telephone line, radio and satellite. The target date for procurement of production units is late 1973.

3. Device for Automatic Remote Data Collection (DARDC).

DARDC is a battery powered device used to collect binary coded decimal information from one to four hydro/meteorological instruments and transmit the data to a collection center via telephone. A telephone coupler permits a teletypewriter printout. Some DARDC--wind only--installations have been made at coastal stations. Six more will be installed during the late summer of 1973. One of these wind only installations will be at Trinidad Head, California.

Upper Air Observations

Upper air observations include measurements of pressure, temperature, water vapor, and wind direction and speed at various levels in the atmosphere from the surface up to about 100,000 feet. The primary type of upper air observation is the rawinsonde observation, which is taken at 94 NOAA ground stations.



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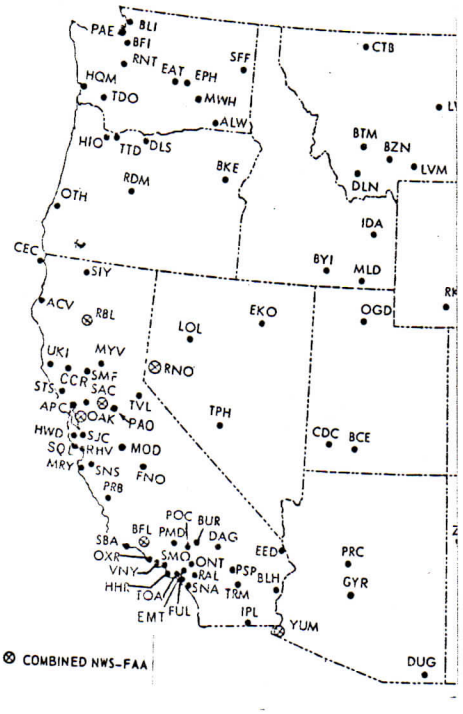

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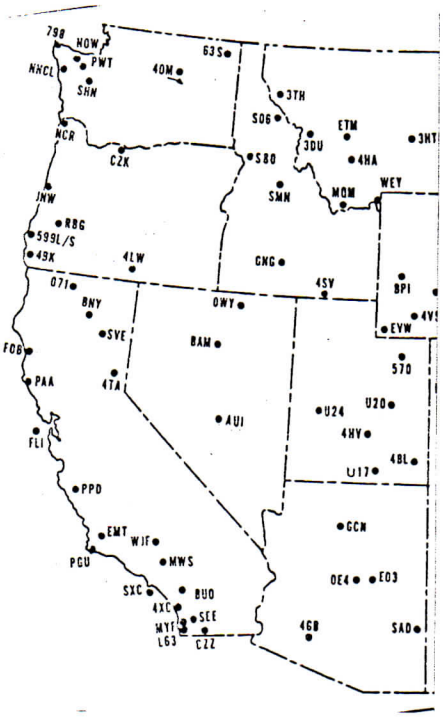
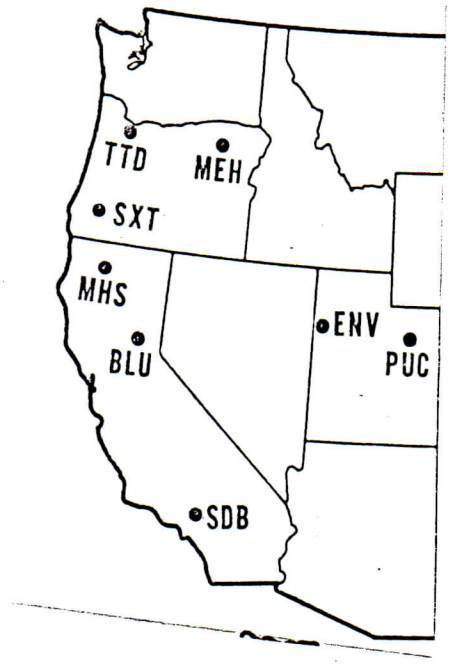


COOPERATIVE



AUTOMATIC OBSERVATIONS

FIGURE 2 - SURFACE OBSERVING STATIONS

Upper air stations are spaced at intervals of 250 to 350 miles. (See figure 3.) To the west of the storm area, the nearest upper air observations are taken at Ocean Vessel Stations 4YN, approximately 1000 nautical miles southwest of San Francisco, and 4YP, approximately 900 nautical miles west northwest of Seattle. All upper air stations recorded and transmitted their scheduled observations. In addition, supplementary upper air wind information is obtained by tracking pilot balloons with theodolites. This information is used to supplement the observations obtained from the synoptic upper air network. Figure 4 shows the network of these stations in the western United States. All pilot balloon observations were taken as scheduled and transmitted.

The present NWS Upper Air Plan calls for an upper air network spacing of about 250 miles between stations. This spacing is adequate to support data requirements for predictions of large-scale weather events. Experience in severe local thunderstorm and other mesoscale storms forecasting indicates that the network is too gross for predicting phenomena indicative of heavy or excessive precipitation. On a nationwide basis the spacing between upper air stations would have to be reduced by half and the frequency of observations doubled if the density required for a significant improvement in predictions of such phenomena are to be realized. This improvement would cost about eight times that of the existing upper air observations network or $125 million. Because of the high costs of such a network, alternative means need to be used. Initial success in obtaining temperature soundings from satellites suggests a partial alternative for increasing network density. In November 1972, satellite sounding became routine in the National Meteorological Center analyses of ocean areas where data was available. The period of use has been too short to reach quantitiative conclusion on their impact on forecasts. Use of this alternative source of data combined with radar and satellite cloud imagery coupled with the existing upper air observations may eventually permit the forecaster to observe the small details of structures needed for their prediction.

Radar Network

Radar observations include the detection and measurement of precipitation, and identification and tracking of squall lines, hurricanes, tornadoes, and other severe storms. These observations provide almost continuous systematic measurements of location, height, and intensity of precipitation, and are reported hourly when precipitation is observed within the area and more frequently when conditions indicate severe storms or rapidly changing weather.

The nationwide radar network includes 88 NOAA stations, of which 38 are equipped with World War II surplus radars with limited capability (local use) and 50 are equipped with modern radars (WSR-57) specifically designed for weather surveillance. These modern radars are located mainly in the tornado belt of the Midwest and along the hurricane-vulnerable Gulf of Mexico and Atlantic coasts. NOAA's radar network is supplemented by observations from FAA, Air Force and Navy installations that participate in an interagency Federal network designed to provide 24-hour weather radar surveillance over critical areas of the nation. Figure 5 depicts the radar coverage in the western states.

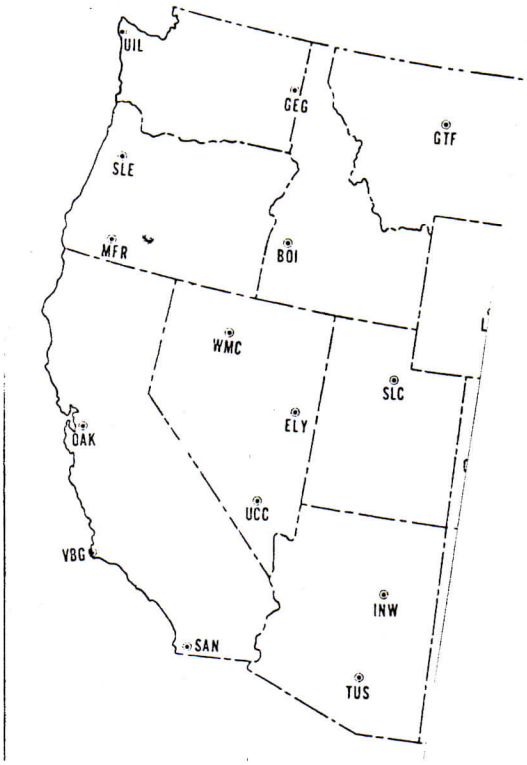


FIGURE 3 - RAWINSONDE NETWORK

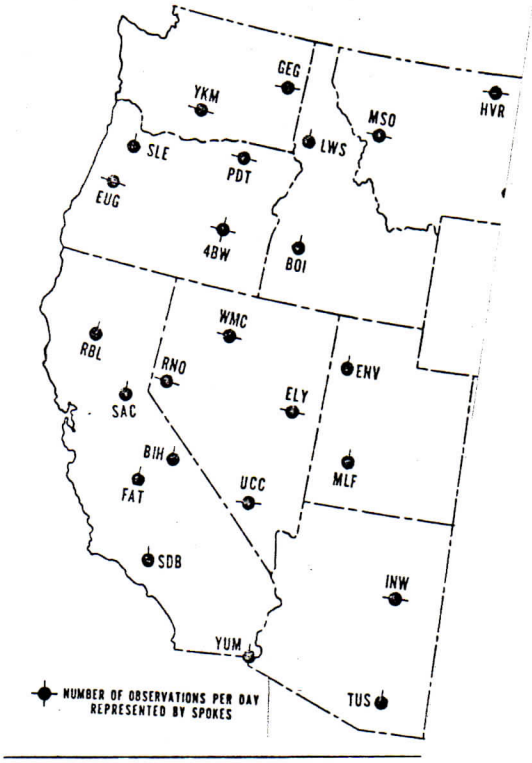


FIGURE 4 - PIBAL NETWORK

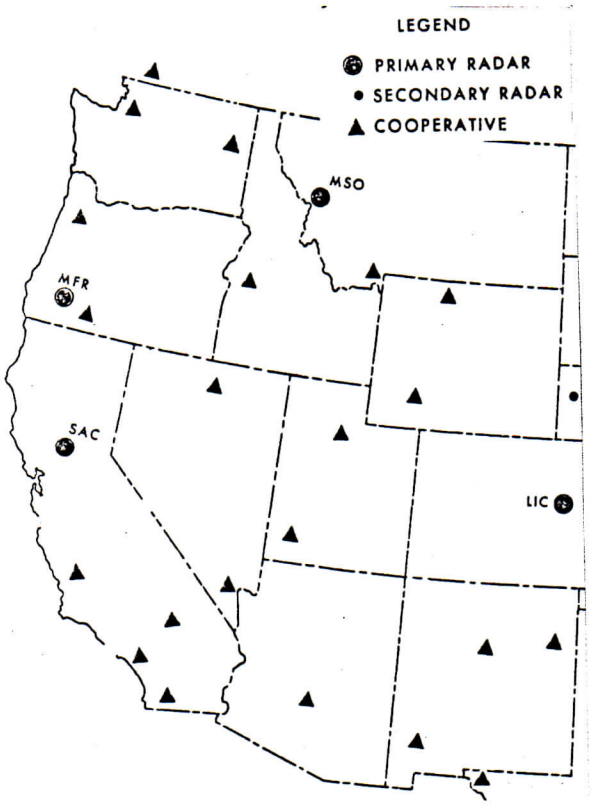


FIGURE 5 - RADAR NETWORK

The Medford WSR-57 radar is located atop Mt. Ashland, about 17 nautical miles south-southeast of Medford, elevation 7530 feet, with antenna about 7560 feet MSL. Looking toward Crescent City, this clears highest intervening peak (Dutchman's Peak) by 140 feet. All other terrain, looking toward Eureka to Brookings, is cleared by 500 feet or more. WSO Medford operates radar by a microwave link. It is able to reach as far south as Point Arena and therefore overlap the Sacramento radar coverage area. The Medford radar covers about 100 miles out to sea over the area covered by this storm.

Medford radar did detect and track echoes off and along California coast on August 16, beginning at about 2:30 a.m. through 11:30 a.m. when the echoes were off and along the southern Oregon coast. Echoes moved from SW to NE at 25-30 knots. Echoes were of light to very light intensity--this point verified by the small amounts of precipitation reported (0.2 Eureka; .24 Crescent City; .60 Brookings during a 13-hour period, with the greatest hourly amount .13).

There are two classes of radar uses--one for local warning purposes and the other as a network system. Local use radar provides information for short-period forecasts and warnings in the immediate area. The Federal Plan for Weather Radars and Remote Displays calls for a remoting system to be used to display the scope images via facsimile or slow scal television at locations distant from the primary radar set. This system is designed to permit the forecasters to make detailed analysis of precipitation patterns.

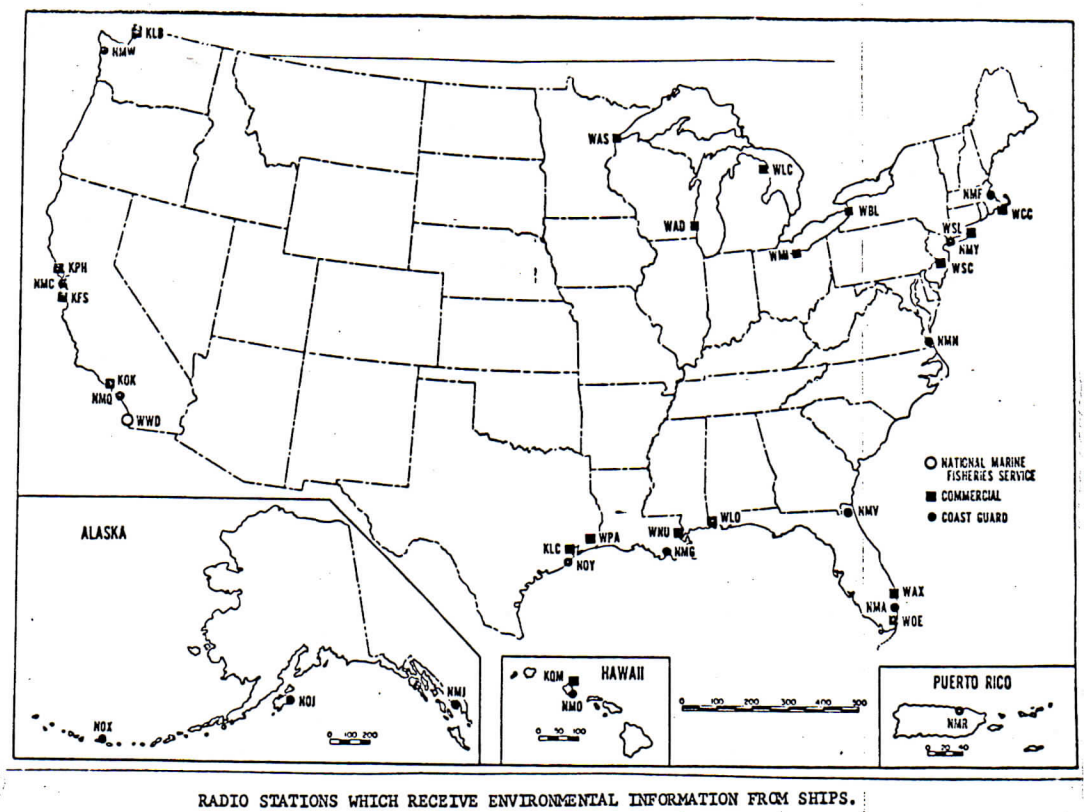
According to the Federal Plan, remote displays should be used to meet local use requirement when there is a suitable radar existing or planned within effective remoting distances and the local requirement does not demand a separate local use radar. NWS plans to install remoting equipment on all its WSR-57 radars to NWS offices within about 75 miles of the radar. Most offices are to be equipped with a remote display receiver with dial-call capability to permit receipt of radar data from any station within the area of forecast responsibility.

Ship Observations

The NWS solicits the cooperation of merchant ships of U.S. and foreign registry and nonmilitary U.S. Government ships in order to obtain weather reports from oceanic areas. About 2,000 ships participate in this program; some of which make four weather reports each day by radio when underway and others report only when in data sparse areas. All ships are asked to send special radio reports when tropical storms or hurricanes are encountered. These observations are received at shore radio stations (see figure 6) then relayed to NMC for operational oceanic analyses and transmitted on domestic and international data links.

Environmental Satellite Data

Because this storm apparently developed during the night, there were no satellite pictures available to assist in forecasting or warning. Direct readout pictures from ESSA-8 were only available to WSFO San Francisco at 12:11 p.m., PDT, August 15, and again 24 hours later when the storm was entering the Oregon coast. NOAA's Application Technology Satellite (ATS-1) photos were received by WSFO San Francisco at 3:25 p.m., August 15, and 2:41 p.m. PDT, August 16.



RADIO STATIONS WHICH RECEIVE ENVIRONMENTAL INFORMATION FROM SHIPS.

FIGURE 6

The following satellite pictures were available to NWS offices:

National Weather Facsimile System (NAFAX)
A digitized composite chart available late afternoon. ATS-1 chart valid about 4 p.m., PST, and transmitted an hour or two later.

Forecast Office Facsimile System (FOFAX)
Automatic Picture Transmission (APT), composite and ATS charts similar to those on NAFAX but of better quality.

Eureka receives only NAFAX pictures while San Francisco and Portland receive both NAFAX and FOFAX.

The satellite pictures of August 15 gave no indication of the developing storm only a cloud mass moving towards the California coast. This prompted WSFO's San Francisco and Portland to forecast some rain for the 16th.

WSFO San Francisco did not have the staff or facilities to produce a film loop of the ATS-1 pictures, but one was prepared by the National Environment Satellite Service (NESS). This loop was studied and compared to film loops of other rapidly developing storm systems, and it is the opinion of NESS that this was the first of a kind and there was no way they could estimate the surface winds. An interesting feature was the presence of anticyclonic curvature cirrus canopy over clouds of maximum cyclonic curvature.

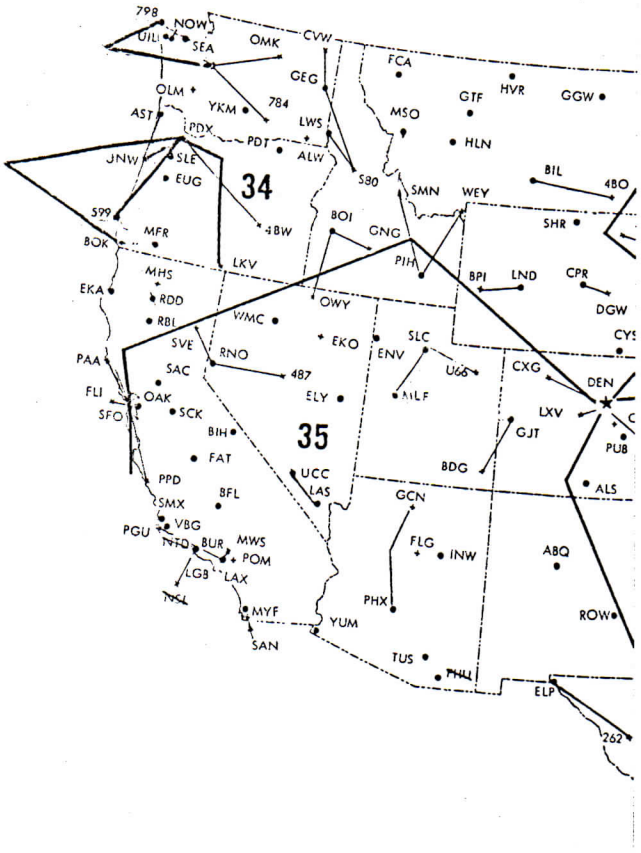
Communications

Meteorological data are collected and distributed by a variety of communications systems, including teletypewriter, telephone, and facsimile. Four major communication networks provide service for data collection and warning dissemination:

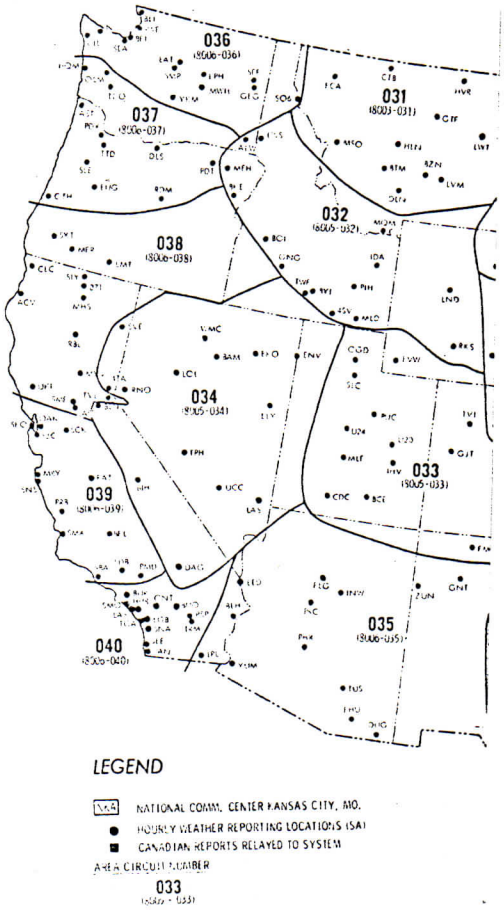
1. Service C is a scheduled teletypewriter network operated by the FAA, collects and distributes most of the United States synoptic surface and upper air data as well as basic public forecasts and warnings. (See figure 7.)

2. Service A is a scheduled teletypewriter network operated by the FAA and collects and distributes hourly surface observations. It is primarily an aviation system and carries products of the Aviation Weather Service. (See figure 8.)

3. RAWARC (Radar Report and Warning Coordination System) Teletypewriter Network partially scheduled 75 or 100 words per minute circuit operated by NOAA National Weather Service. It collects and distributes radar reports and storm warning information. (See figure 9.)



SERVICE C TELETYPE NETWORK
FIGURE 7



SERVICE A TELETYPE NETWORK
FIGURE 8

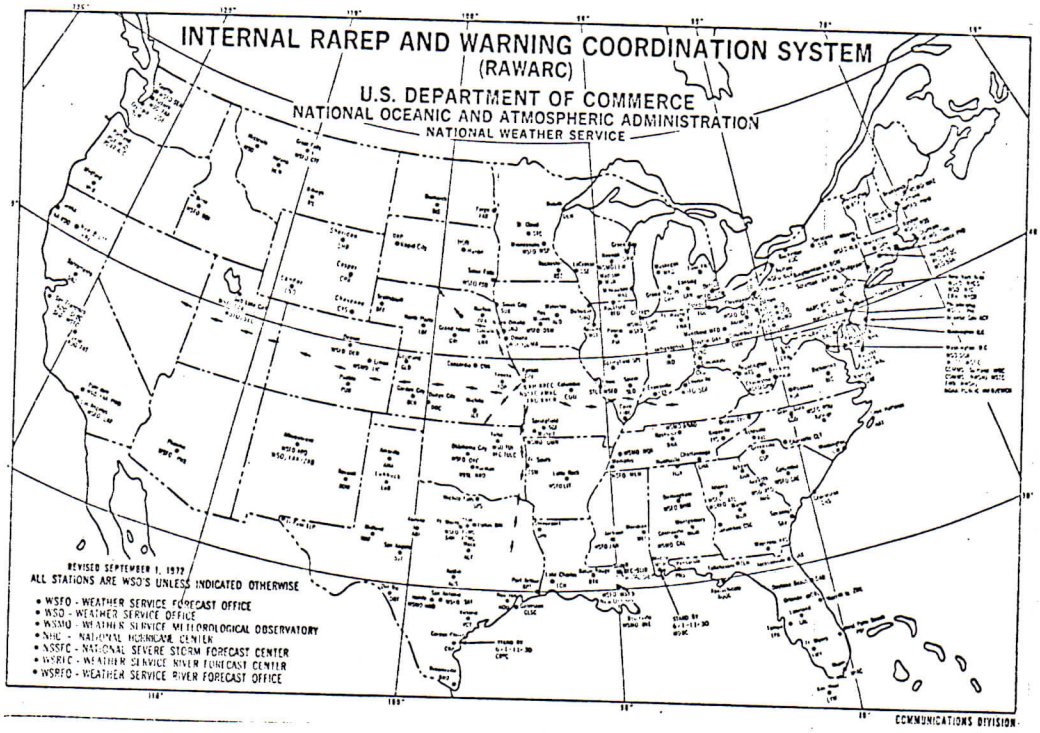


FIGURE 9

The RAWARC system is mostly unscheduled and carries state and zone forecasts and delayed upper air observations in addition to its regular traffic in the western states. Communicators must wait for a break in the transmission before being able to enter a message into the system. In a busy COMMS Center, such as WSFO San Francisco, there are many teletypewriter circuits to monitor and to relay traffic between, in addition to preparing tapes for routine state, zone and marine forecasts. At the time of the Crescent City storm, the communicator at WSFO San Francisco had to prepare advisory tapes for three tropical cyclones.

4. Coast Guard Teletypewriter Network - operated by the Coast Guard with the Search and Rescue Pacific (SARPAC) being the main teletypewriter circuit connecting Communications Centers and Coast Guard radio stations along the Pacific coast. NWS and Coast Guard offices usually have input to SARPAC through a feeder circuit with manual relay of weather observations and warnings at a Coast Guard COMMS Center or radio station.

Findings and Recommendations

1. Finding

There is a scarcity of wind data appearing on the circuits for the offshore and immediate coastal areas. There has been a sharp decrease in reporting stations from these areas over the last few years. The only hourly wind reports available are from stations a few miles inland and it was not until the storm reached Brookings did its full intensity become known. In addition, this storm was small and moved very rapidly so that the increase in winds was not reflected at the coastal offices until the strong and gusty winds suddenly were indicated on their three or six hourly observations.

Recommendation

That the degradation of the weather reporting network be stopped and some recovery be made. It is imperative that more data, particularly wind, be obtained along the immediate coast and seaward. NOAA should continue its program for the development and deployment of the Data Buoy System. NOAA should expedite the development, procurement, and deployment of the NWS Automatic Data Acquisition systems. The communication capability of the AMOS should be increased to include radio and telephone so that Coast Guard radio, teletypewriter and power sources can be utilized (Coastal AMOS Experiment-CAMEX). The DARDC, for winds only, should be installed as quickly as feasible.

Arrangements also need to be made for increasing the frequency of observations by coastal offices during the approach of this type of storm.

2. Finding

Along the immediate shoreline, reporting points are gradually being lost as the Coast Guard carries out its LAMP program of automating light stations. Recently the Blunts Reef report was discontinued, and Point St. George will be lost to the same program soon. The report from Blunts Reef (off Cape Mendocino--see Figure 1) would have been invaluable in the current disaster since this was probably the first reporting station struck by the high wind. The FAA reduced the number of Crescent City observations from 24 per day to 16 per day on June 23, 1973.

Recommendation

It is imperative that more data, particularly wind, be obtained along and seaward of the immediate coast. Otherwise we will always risk being unware of the nature of a sneak storm until it is already upon us. Attempts have been made to arrange for automatic weather data from the automated light stations; but suitable automatic weather stations are still in the process of development, and procurement may be several years away.

Arrangements have been made with the Coast Guard to place wind only equipment on the Blunts Reef Buoy, with installation probable for April 1973.

3. Finding

Few merchant vessels have radio officers on duty during nighttime hours to transmit their weather reports; therefore, very few ship weather reports are available for operational analysis at 0500 PDT (1200Z). The National Weather Service authorizes radio officer overtime to a limited number of ships (about 140) to obtain these nighttime reports. Unfortunately, the number of reports from overtime ships is not sufficient to provide data to maintain a good oceanic surface analysis.

Recommendations

Port meteorological officers should urge authorized merchant vessel radio officers to transmit the 12Z observations, especially near the coasts. The new (October 1, 1972) ship voice-weather-code program should be encouraged by NOAA and the Coast Guard to increase the participation of vessels. The program of National Marine Fisheries Service (NMFS) and WSFO San Francisco to obtain limited weather data from the U.S. tuna fleet should be expanded to other marine operators.

The West Coast Marine Circuit was recently implemented (February 1973) in order to provide a unified and effective means of collecting environmental information received at coastal stations from ships at sea. It also provides an efficient and rapid means for distributing marine warnings and forecasts to those stations for broadcast. The circuit is operated in a half-duplex mode at a speed of 150 words per minute. The circuit connects the National Meteorological Center and the WSFO San Francisco with the following radio stations:

KPH	Point Reyes, CA (RCA)	WWD	La Jolla, CA (NMFS
NMC	Point Reyes, CA (USCG)	KOK	Los Angeles, CA (ITT)
NMCI	San Francisco, CA (RCA)	WPA	Port Arthur, TX (RCA)
KFS	San Francisco, CA (ITT)	KLC	Galveston, TX (ITT)

As funds become available, the circuit should be extended northward along the West Coast at least as far as Seattle, and possibly along the Alaskan Coast.

Coast Guard vessels should continue reporting weather conditions with unusual weather conditions being reported by patrol and rescue aircraft.

4. Finding

Satellite picture capability at WSFO San Francisco was limited to a few daylight hours and with the failure of ATS-1, satellite data are now restricted to twice daily at about 12-hour intervals.

NOAA-2 now provides infrared nighttime pictures to the San Francisco WSFO. These nighttime pictures are also being relayed to other weather offices by facsimile.

Recommendation

NOAA should continue its plans to launch the first GOES prototype during the winter of 1973. This will give San Francisco continuous coverage of the eastern Pacific by spring of 1974.

5. Finding

While the film loop would have been little or no help in this storm, loops have proved to be very useful in forecasting severe storms and hurricanes. WSFO San Francisco had neither the staff nor the facilities to produce film loops from the ATS-1 satellite pictures.

Recommendation

The NWS should implement its plan to staff the San Francisco Satellite Field Service Station (SFSS) with nine forecasters and an oceanographer to provide round-the-clock photographic and data interpretation support by January 1974.

6. Finding

Satellite photos do not provide direct surface wind information.

Recommendation

NESS should continue to study and develop methods for estimating surface winds and detecting rapidly intensifying storm systems for use by SFSS meteorologists.

7. Finding

The Radar Report and Warning Coordination Circuit (RAWARC) is the prime means for the exchange and coordination of critical radar information and warnings between NWS stations, but in the West the circuit is overloaded with general weather information, forecasts and delayed weather data. Communicators must wait for a break in transmissions to send a message.

Recommendation

The RAWARC circuit should be scheduled with automatic callup of stations and the NOAA Weather Wire Service should be expanded as soon as funds are available to reduce the routine traffic on RAWARC.

CHAPTER 3

ANALYSIS AND PREDICTION

To assist local NWS offices in fulfilling their responsibility for warning the public and marine interests of impending storms, the NWS has established two forecast echelons.

On a national level the National Meteorological Center (NMC) in Suitland, Maryland, provides initial guidance on the location and movement of weather systems and their associated clouds and precipitation. The Weather Service Forecast Office (WSFO) uses this guidance to make forecasts for its area of responsibility (usually one state). The WSO uses the forecast issued by the WSFO, incorporates into it certain local details, and issues it to the public and specialized users. The WSO is responsible for warnings for its county warning area and for apprising the WSFO of needed forecast and warning amendments.

NMC, a largely computerized facility, provides a variety of analyses and prediction products covering the Northern Hemisphere. Similar graphic displays with higher resolution cover the continental states and adjacent waters. This basic guidance material, covering a period up to 5 days, is distributed to NWS offices over the National Facsimile Network (NAFAX) and some special guidance material to WSFO's over the Forecast Office Facsimile System (FOFAX).

The long range 500 millibar (approximately 18000 feet) guidance (72- and 48-hour) issued by NMC and verifying the evening prior to the storm showed the low center too far south and west. The 36-hour guidance verifying at 1200Z (5 a.m., PDT) was good.

Quite often the Limited Fine Mesh (LFM) (grid length of about 118 miles) is more successful in coping with small scale features than the products generated by the large scale grids used for hemispheric guidance. In this case, the 12-hour guidance for the period from 0000Z to 1200Z August 16, the critical time, did show good agreement in locating the upper air center, but misforecast the intensity. The LFM Display Area (Figure 10) has its western boundary too near the west coast to be useful for 24-hour forecasting.

The LFM surface guidance verifying at 5 a.m., PDT was 180° out of phase with a high forecast to be where the intense low was located. The objective surface progs, which are computed on the larger grid, contained the same error. The subjective surface progs added little, if any, improvement to the objective progs.

The eastern Pacific surface analysis is limited by very sparse ship reports during the night, but the NMC analysis was poor because some available data was not used. This was true for charts transmitted on NAFAX at 2:36 a.m., 5:37 a.m., and 8:33 a.m., PDT. This occurs because NMC analyzes for the

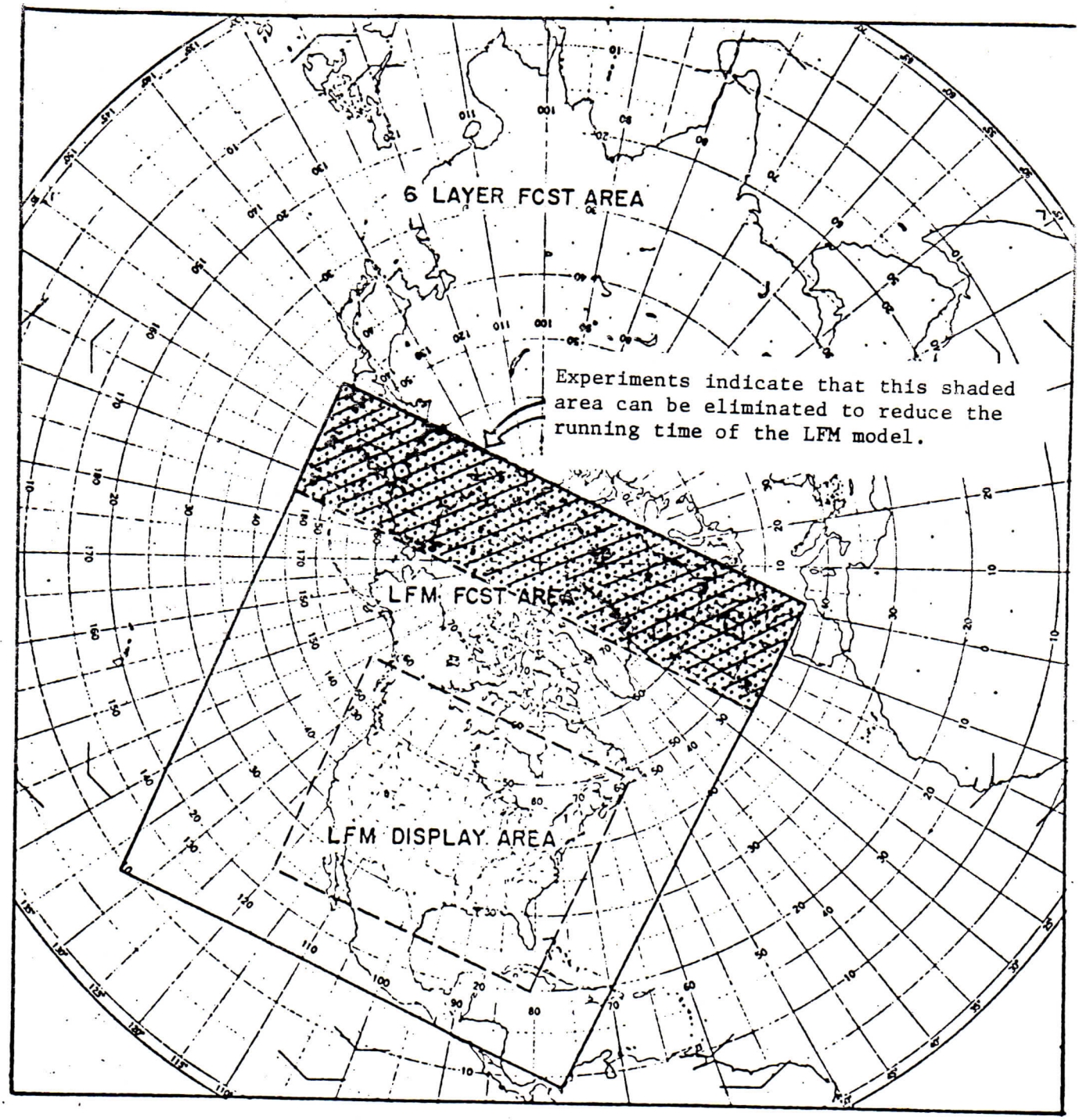


FIGURE 10 - LFM and PE FORECAST AREAS

major features--not small scale. The sectional maps prepared for local use at WSFO San Francisco were more representative of the low pressure system.

A post analysis of the storm reveals that it may have been a hybrid tropical-extratropical storm called a subtropical cyclone. This would explain the apparent rapid development and the rapid weakening when the storm moved inland. The upper air observation taken at Medford, Oregon, was a tropical marine sounding more characteristic of a system which had a long history over water, but this is not the case with this storm. The sea-surface temperature about one mile offshore from Eureka was 10° warmer than normal. The anticyclonic curvature of the cirrus canopy over the active cloud mass in the low pressure trough was shown by ESSA-8 and ATS-1 satellite photographs taken on August 15. This suggests a thermal origin of the clouds by the release of latent heat of condensation.

WSFO San Francisco is responsible for the general weather forecasts for northern California. Their marine weather forecast and offshore waters warning area includes from Point St. George to Point Conception and much of the north Pacific east of 180°. They are also the Eastern Pacific Hurricane Center, and at the time of this storm, they were issuing advisories on three tropical cyclones.

WSFO Portland issues the state and zone forecasts for Oregon and has marine forecast and warning responsibilities for the offshore waters from Point St. George, California, to North Head, Washington.

WSO Eureka issues forecasts for Eureka and vicinity and has warning responsibility for Del Norte and Humboldt counties. They have the responsibility of notifying WSFO San Francisco whenever the marine weather situation requires the issuance or change of a warning. When immediate action is required for the safety of life and property, they will issue and disseminate the appropriate warning, whenever they cannot contact the WSFO.

Findings and Recommendations

1. Finding

There is a scarcity of weather data for offshore (especially nighttime ship reports) and immediate coastal areas which inhibits the possibility of an accurate surface analysis and forecasting the storm even for a short period (4 to 12-hour range).

Recommendation

NOAA should continue its program for the development and deployment of the Data Buoy System and other remote observing and telemetering equipment,

particularly wind from offshore and immediate coastal areas. The program started by NMFS and WSFO San Francisco to obtain limited weather data from the tuna fleet should be continued and expanded to other marine operators and other areas of sparse weather data. The new ship voice-weather-code program should be encouraged by NOAA and the Coast Guard to increase the number of vessels participating.

2. Findings

The rapid movement and lack of knowledge concerning the storm's intensity precluded any forecast well in advance of occurrence (12 to 24-hour range).

Dynamic models capable of accurately predicting the behavior of cyclonic disturbances as small as 300 km diameter are needed. These models should include the effect of sea surface temperature on the behavior of these disturbances. The land-sea boundary effects on winds should also be incorporated.

There is a continuing need for mesoscale analysis at WSFO's and WSO's and checking by NMC of computer rejected observations, because the machine analysis smooths (initialization process) many small-scale severe weather producing features.

Recommendation

NOAA should also accelerate the implementation of its Plan to Improve Local Weather Forecasts and develop and carry out a program related to mesoscale weather phenomena analyses and prediction. Sea surface temperature should be incorporated into dynamic prediction models.

3. Finding

The Limited Fine Mesh (LFM) display area boundary is too close to the west coast to be useful in forecasting many mesoscale storms 24 hours in advance even if the LFM analysis were capable of detecting the system. The accuracy of the analysis is restrained by the lack of oceanic weather data.

Recommendation

The western boundary of the LFM display area should be extended westward if the number of ship weather observations can be increased and satellite soundings improve the analyses.

4. Finding

WSO Eureka spent considerable time trying to telephone observational data and requesting warnings from WSFO San Francisco.

Recommendation

"Red phones" restricted to warning or forecast coordination between WSO's and WSFO or WSFO and WSFO should be installed.

5. Finding

WSFO Portland was not aware for 3 hours that gale warnings had been issued for Point St. George to Cape Mendocino, California, by WSFO San Francisco. The Portland forecaster then decided that the storm would move inland on the northern California coast; therefore, warnings would not be required on the Oregon coast. As soon as the high winds were reported at Brookings, WSFO Portland issued gale warnings.

Recommendation

The Regional Warning Coordination Center (RWCC) should be fully staffed to monitor and coordinate warnings and forecasts issued within their area of responsibility. The installation of "red phones" in WSFO's will speed the necessary coordination.

6. Finding

Neither WSFO San Francisco nor WSFO Portland had dedicated marine forecasters at this time. This prevented them from carrying out their marine responsibilities adequately.

Since the storm, a dedicated marine unit has been established at WSFO San Francisco. WSFO Portland is still without a dedicated focal point.

Recommendation

A marine forecast focal point position should be established at WSFO Portland.

7. Finding

Present satellite and radar technology does not provide direct information on surface winds or their gustiness.

Recommendation

Studies should be undertaken to determine if surface winds and their gustiness can be interpreted from satellite photos and radar echoes.

CHAPTER 4

DISSEMINATION

Communications

Forecasts for states or state sections and adjacent waters are disseminated by WSFO's to WSO's on Service C teletype network and warnings are contained within these forecasts. Amended forecasts are transmitted when circuit time is available.

State, zone and local forecasts, watches and warnings are disseminated by NOAA Weather Wire Service (NWWS) (see figure 11) to the news media, some state and local offices, and other NWS offices. The NWWS is intrastate, but an "overlay" circuit carries traffic between State Relay Centers. Where NWWS is not available, this traffic must be transmitted to other NWS offices on RAWARC; this is the case in California. In metropolitan areas, such as San Francisco, which have no NWWS, forecasts, watches and warnings are relayed on a local loop to wire services, news media and local officials.

Forecasts and warnings are transmitted on the NOAA VHF-FM radio system (see figure 12) at frequencies of 162.55 MHz and 162.40 MHz and 24 hours a day.

FIGURE 11
NOAA WEATHER WIRE SERVICE

FIGURE 12
NOAA VHF-FM WEATHER

When small craft, gale, or storm warnings are initiated or terminated, the messages should be disseminated as soon as possible on NOAA Weather Wire, NOAA VHF-FM broadcast, and as otherwise required to reach Coast Guard and commercial marine radio stations.

Responsible WSFO's or WSO's shall insure that messages are also sent promptly to the visual warning display stations on their dissemination list.

Visual warning displays (flags, pennants, and lights) are a traditional part of NWS marine services. However, the effectiveness of visual displays is severely limited because they alert only those who are within sight. This system cannot provide updated information to the mariner once he has passed from within visual range. The policy of the NWS is to stress the importance to the mariner of having appropriate radio facilities and keeping up with the latest available marine warnings and information.

The following visual warning display stations were in operation on August 16, 1972:

CALIFORNIA: Humboldt Bay Coast Guard Stations (Day & Night)
(Backed up by harbormaster in daytime only)

Crescent City Coast Guard Cutter (Day & Night)
(Backed up by harbormaster in daytime only)

OREGON: Chetco River Coast Guard Station (Day)
Wedderburn Coast Guard Station (Day)
Port Orford Harbormaster (Day)
Coquille River Coast Guard Station (Day)
Coos Bay Coast Guard Station (Day & Night)
Coos Head Coast Guard Lookout (Day & Night)

Forecasts and warnings are disseminated over a number of radio and radio telephone facilities:

1. Coast Guard radio telephone provides warning broadcasts on a frequency of 2670 kHz with prior announcements on their disaster frequency of 2182 kHz.

2. National Weather Service provides a continuous VHF-FM radio weather broadcast, which includes warnings, with station KEC-82 located in Eureka, California, broadcasting on a frequency of 162.400 MHz.

3. Commercial radio stations broadcast marine forecasts and warnings.

4. In a few locations, arrangements have been made with Citizen Band radio networks to broadcast warnings.

In addition, forecast and warning information may be obtained through a special National Weather Service marine service telephone. Telephone numbers, radio stations, radio frequencies, and times of broadcast may all be found on two National Weather Service Marine Weather Service Charts - Eureka, California, to Canadian Border and Eureka to Point Conception, California.

User Response

The Humboldt Bay Coast Guard Station promptly displayed the marine warning flags and made marine warning broadcasts upon receipt of the warnings from WSFO San Francisco. The harbormaster at Crescent City was the secondary displayman and had no flags to display because the only set was onboard the Coast Guard Cutter CAPE CARTER, the primary display station, which was on patrol.

Most of the fishing vessels had either been at sea throughout the night or departed prior to the issuance of the warnings on August 16. Few fishermen monitor the Coast Guard radio warnings, but rather listen to Citizens Band (CB) radio for fishing reports. It was over CB that most learned of the storm as reported by fishermen caught in it. A few received the warning over CB from friends onshore, and they in turn relayed the warnings to nearby vessels.

The Coast Guard Lifeboat Station at Chetco River, Oregon, received a call from the Sheriff's Department in Crescent City about 9:30 a.m., PDT, to assist boats fleeing the storm. They immediately began emergency actions.

Findings and Recommendations

1. Finding

NOAA Weather Wire Service (NWWS) is not available in California and several other western states, and this requires all forecasts, watches, warnings and general weather information to be transmitted on RAWARC. This inhibits the warning coordination purpose of RAWARC.

Recommendation

The NWWS system should be completed as rapidly as feasible to improve the warning distribution to the news media and NWS offices and to reduce routine traffic on RAWARC.

2. Finding

The NOAA VHF-FM station at Eureka had just become operational at the time of the storm and few people were aware of this service.

Recommendation

That a concerted educational program be mounted to inform the public, and especially the marine interests, of the communications facilities available for warnings and to promote the NWS VHF-FM continuous radio weather program.

3. Finding

Some marine warning displaymen were unfamiliar with the NWS marine warning service and one had no flags.

Recommendation

As frequently as feasible, all disseminators of warnings, news-media, Coast Guard stations, display stations, etc., should be visited by NWS personnel to improve working relationships and to insure that flags are available.

4. Finding

The Coast Guard Station at Humboldt Bay was aware that small craft warnings were needed for at least 45 minutes prior to the issuance by WSFO San Francisco. But this C.G. Station had instructions from C.G. 12th District Headquarters for displaying, relaying to other display stations, and broadcasting only those warnings received from WSFO San Francisco via the C.G. teletypewriter circuit.

NWS Regional Directors have the authority to make arrangements with the Coast Guard District Office for Coast Guard personnel, who make official weather and sea condition observations to initiate small craft displays at selected sites.

Recommendation

These arrangements with the Coast Guard should be initiated at all necessary sites to improve boating safety.

5. Finding

The best way, at present, to reach boats is by radio through commercial broadcast stations and Citizen Band.

Recommendation

Commercial radio stations should be urged to make prompt and frequent broadcast of NWS warnings and to utilize the weather information on NOAA VHF-FM. The establishment of CB radio warning nets should be encouraged.

CHAPTER 5

PROGRAM RESPONSIBILITIES

The objective of the marine weather service program of the National Weather Service is to provide meteorological and certain oceanographic services that will further the safety of life and property and improve the efficiency of marine operations on the high seas, along the coasts, on the Great Lakes, and on other inland waters such as rivers, lakes, and reservoirs.

For coastal waters, the waters within about 20 miles of the coast, including bays, harbors, and sounds, the marine forecasts and warnings are intended to serve the recreational boating and fishing public. The National Weather Service Office (WSFO), San Francisco, is responsible for providing marine forecasts and warnings for the coastal waters from Point Conception to and including Point St. George. WSFO Portland, Oregon, has that responsibility for the coastal waters from Point St. George to North Head. Weather Service Office (WSO) Eureka has the responsibility for issuing warnings for nearby waters if a local weather situation requires issuance or change of a warning, and appropriate action has not been taken by the assigned WSFO.

According to the NWS Operations Manual, primary responsibility for the issuance of marine warnings rests with the WSFO assigned that responsibility. However, if a local weather situation requires issuances or change of a warning, and the appropriate action has not been taken by the assigned WSFO, the local WSO will immediately contact the responsible WSFO. If the responsible WSFO cannot be reached, or when immediate action is required for the safety of life and property, the WSO will issue or change the warning as required, disseminating the warning according to established procedures, including the notification of displaymen within the local area. The responsible WSFO will be contacted as soon as possible.

Marine warnings include:

Small Craft Warning (changed to Small Craft Advisory January 1, 1973). The Small Craft Warning alerts mariners to weather and sea developments, either present or predicted, which are considered potentially hazardous to small boats. Hazardous conditions include winds up to 33 knots and/or dangerous local sea conditions. It remains the responsibility of the mariner, based on his boat handling experience and the size, type, and characteristics of his craft, to determine if the weather and sea conditions are hazardous for his planned operations.

When a mariner becomes aware of a Small Craft Advisory, he should take immediate action to obtain the latest marine forecast in order to determine the reason for the advisory. The lower limit of the Small Craft Advisory is 18 knots, unless otherwise established by the regional headquarters, taking into account the exposure of the beach, the type of craft in the area, season of the year, and any other pertinent factors, e.g., wave generation by offshore vs. onshore winds. Small Craft Warnings may also be issued for hazardous sea conditions irrespective of wind criteria.

Gale Warning. A warning of sustained winds within the range 34 to 47 knots. Wind speeds and wave heights will be stated in the warning.

Storm Warning. A warning of sustained winds of 48 knots or more, with no upper limit. As in all wind warning messages, the predicted wind speeds and wave heights will be stated.

Findings and Recommendations

1. Finding

A review of the actions taken by the Eureka offices indicates they promptly apprised WSFO San Francisco, the Humboldt Bay Coast Guard Station, Eureka Boat Basin and the general public of the developing storm. However, their actions would have been more effective if they had issued small craft warnings when they were not immediately able to contact the WSFO.

Recommendation

Station drills for all natural disaster should be conducted to ensure that the staff is familiar with NWS Operations Manual Instructions and that the Station Duty Manual is current.

2. Finding

Boating is one of the nation's fastest growing forms of recreation. Ever increasing numbers of people are becoming boat operators and they are unfamiliar with weather hazards over the waters.

Recommendation

NOAA should increase its participation in boat shows and programs promoting boating safety and supply educational materials to those for public distribution.