Great Lakes Storm November 9-11,1998: Edmund Fitzgerald Remembered

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The author wishes to express his respect toward the Captains and crews of the Great Lakes shipping industry. The issue of the great tragedy of the Edmund Fitzgerald would rather be kept solemn by many. The intent of this article is to show how the interaction between the National Weather Service and marine interests has progressed in the last 24 years.

On 10 November 1975, the most notorious Great Lakes shipping disaster occurred. The **SS Edmund Fitzgerald** sank and it's crew of 29 men perished in the deep waters of Lake Superior during an intense storm which had developed over the central United States and made a bee-line for the western Great Lakes.

Twenty-three years later, a case of deja vu settled in on the anniversary of the **SS Edmund Fitzgerald**. From 9 - 11 November 1998, a storm of equal proportions developed over the same area as the **Fitzgerald** storm and followed a similar path toward the western Great Lakes. However, this time there was an improved forecast, warning, and dissemination system in place.

Final Voyage of the SS Edmund Fitzgerald

On 9 November 1975, **Fitzgerald** began loading at Burlington Northern Railroad Dock No. 1, in Superior, WI. The ship's final voyage would carry taconite; destined for Detroit, MI (Figure 1).

Fitzgerald departed at full speed of approximately 14 Knots (16 mph). Two hours into the voyage, the ship arrived at a point near Two Harbors, MN. The **SS Arthur M. Anderson**, owned by the United States Steel Corp., bound for Gary, IN proceeded eastward on a similar course as **Fitzgerald**. The two ships were approximately 10 to 20 miles apart.

Routine weather reports, via radio, were made at 0600 UTC (0100 EST) and 1200 UTC (0700 EST) by the **Fitzgerald** on 10 November. At 1220 UTC (0720 EST), a normal radio report was made to the company office. The report indicated the estimated time of arrival was indefinite due to weather.

Fitzgerald headed northeast away from the recommended shipping lanes along the south shore of Lake Superior. (Strong northeast storm force winds caused extremely high waves at the end of the fetch on the south shore of the lake).

Fitzgerald's new course passed approximately half way between Isle Royal and the Keewanaw Peninsula. At this point, the ship turned eastward to parallel the northern shore of Lake Superior and then southeast-ward along the eastern shore. **Fitzgerald** reached a point approximately 11 miles Northwest of Michipicoten Island at 1800 UTC (1300 EST), 10 November. The ship passed to the West of Michipicoten West End Light. At this point, **Fitzgerald** changed course to pass north and east of Caribou Island on a southeast heading toward Whitefish Bay, MI.

The **SS Edmund Fitzgerald** sank near the International Boundary Line some time after 0015 UTC (1915 EST). Her final coordinates were 46°59.9'N, 85°06.6'W.

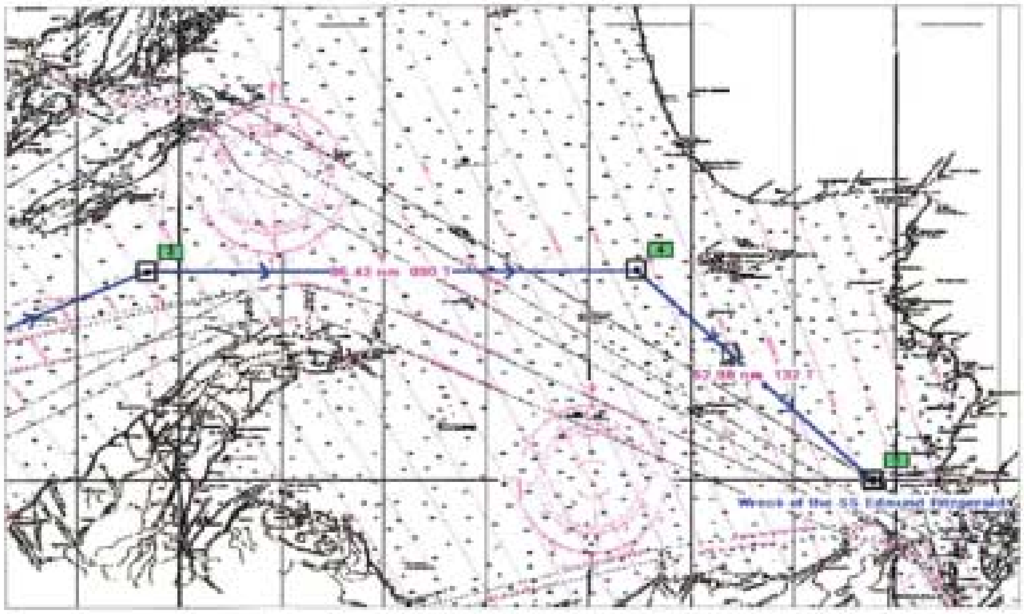

Figure 1. Actual track of the SS Edmund Fitzgerald and the location where the ship sunk in Lake Superior. The numbers in the boxes along the track represent approximate waypoints where the Fitzgerald changed course. Waypoint number 5 marks the location of the wreck.

SS Edmund Fitzgerald Encountered Weather

The storm of historical proportions developed over the Oklahoma Panhandle on 8 November, and by 1200 UTC (0700 EST), on 9 November, this strengthening storm was located over southern Kansas (Figure 2).
The track at this time was to the northeast with a minimum barometric pressure of 29.53" of Hg. On 9 November at 1200 UTC (0700 EST), National Weather Service (NWS) forecast maps for surface conditions out to 36-hours predicted that the storm would track in a northeast direction and pass just south of Lake Superior by 0000 UTC on 11 November (1900 EST 10 November).
The NWS made several revisions to the forecasts by gradually increasing the wind speed and wave heights.

Gale warnings were issued in early forecasts on 9 November for the eastern portions of Lake Superior. Successive forecasts indicated winds would increase from the east-northeast at 25 to 37 knots during the night of 9 November. Since the low was forecast to pass south of Lake Superior, winds were expected to gradually shift around to the north and then northwest.
Gale warnings were upgraded to storm warnings at 0700 UTC (0200 EST) on 10 November. Later forecast revisions called for winds to increase to 35 to 50 knots from the northeast and then diminish slightly to 28 to 38 Knots from the northwest on Tuesday, 11 November. Waves were forecast to build to 8 to 16 feet by Monday afternoon.

A cold front extended about 20 miles west of Caribou Island, Ontario and was moving at a speed of 20 to 25 knots toward the east. Earlier forecasts projected the low to pass just south of Lake Superior. The forecasters noticed the low would pass slightly further north over the eastern end of Lake Superior and forecasts had to be revised.

Based on the latest position and forecast track of the storm, the forecasters knew the wind speed was under forecast. A revision to the forecast was made at 2139 UTC (1639 EST) on 10 November. The wind was increased to 38 to 52 knots from

Figure 2. Storm track of the Edmund Fitzgerald Storm November 9-10, 1975.

the northwest. Gusts to 60 knots were also expected.

The early forecasts for this event indicated an increase in wind speed as the storm moved northeast. However, the forecasts considerably under estimated the strength of the storm and its motion.

Each forecast revision had stronger forecast winds than the previous forecast. This was likely a result of limited forecast guidance and a reaction, by the forecasters, to the deepening storm.

Another difficult situation the forecasters encountered was how to handle the changing wind directions and speeds as the low moved over the lake. The ultimate goal is to convey a clear and concise forecast. However, this storm did not prove to be easy to describe the forecast wind conditions.

Ships that were built in the 1970s were thought to be invincible and that they could handle rough seas. The improving technology allowed engineers to design larger ships. According to the Port Meteorological Officer stationed in Cleveland, Ohio, the larger and stronger ships gave crews a false sense of security. Crews and the shipping industry took the risk and battled the strong winds and rough seas the Great Lakes had to offer.

The combination of a complex forecast, the need to frequently update the forecasts, and the unknown risks encountered by the ship's crew contributed to the demise of the Edmund Fitzgerald.

The effects of the storm finally abated by 0600 UTC (0100 EST) on 11 November.

The final track of the storm was just north of the forecast track on 9 November. The storm moved from the northeast corner of Kansas on 9 November to east central Iowa, central Wisconsin on 10 November, Marquette, Michigan, west of Michipicoten Island on Lake Superior, White River, Ont., southern tip of James Bay, and finally to eastern Hudson Bay on 11 November. The lowest recorded pressure of the storm was 28.95" Hg.

The **SS Edmund Fitzgerald** encountered winds and seas that were forecast by the NWS. The following are some actual weather observations that were reported by the crew of the **Fitzgerald**: At 0600 UTC (0100 EST) on 10 November, the ship was about 20 miles due south of Isle Royal and reporting winds from the northeast at 52 knots and waves of 10 feet. Then, six hours later, **Fitzgerald** reported she was about 35 miles north of Copper Harbor, MI, and reported winds from the northeast at 35 knots and waves of 10 feet.

This was the final weather report sent by **Fitzgerald.**

The nearby vessel **SS Arthur M. Anderson** was in the vicinity of the **Fitzgerald** when the weather observations were reported. The **Anderson** substantiated **Fitzgerald's** weather observations at 0600 UTC (0100 EST) and 1200 UTC (0700 EST) on 10 November.

Further west (approximately 15 miles southwest of the **Anderson**), a Canadian motor vessel **Simcoe** reported winds from the west at 44 knots and waves 7 feet at 1800 UTC (1300 EST) on 10 November. An automated weather sensing unit at Stannard Rock was reporting winds from the west-northwest at 50 knots, gusting to 59 knots. At 0000 UTC on 11 November (1900 EST 10 November), Stannard Rock was reporting west-northwest winds at 40 knots, gusting to 65 knots.

Great Lakes Storm - November 9-11, 1998

Storm Track and History

A major storm system developed over the Four Corners region of the United States on 8 November 1998 and moved rapidly east to the Oklahoma Panhandle (Figure 3). By 1500 UTC (1000 EST) on 9 November 1998, the storm had deepened to a central pressure of 29.47" Hg. Further deepening was

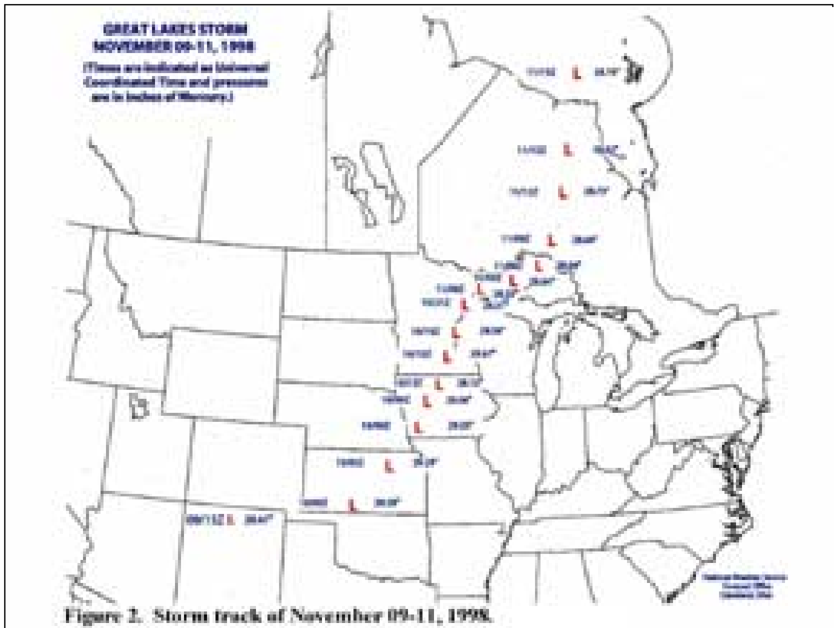

Figure 3 - The storm track of the Great Lakes Storm, November 9-11, 1998.

expected to occur during the next 36 hours. The storm began to track northeast through Kansas, southeast Nebraska, central Iowa, southeast Minnesota, to northern Wisconsin where the central pressure dropped to 28.51" Hg at approximately 2100 UTC (1600 EST) on 10 November. This is the lowest recorded pressure of the storm and fell well below the minimum pressure of the **Edmund Fitzgerald** storm (28.95" Hg). Gale warnings were issued at 1500 UTC (1000 EST) on 9 November for Lake Superior. East-southeast winds to 30 knots were forecast for the early portions of Monday night but were forecast to increase to gale strength to 35 knots late at night. Waves were forecast to build to 6 to 8 feet overnight. Winds were expected to shift to east-northeast and increase to 45 knot gales on Tuesday while waves were forecast to continue to build to 8 to 12 feet during the day.

Storm warnings were issued at 2100 UTC (1600 EST) on 9 November for the eastern two thirds of Lake Superior as winds were forecast to reach storm force of 50 knots on Tuesday. Waves were forecast to continue to build to 7 to 12 feet Tuesday and to 12 to 20 feet Tuesday night. The highest waves were forecast for the eastern two thirds of Lake Superior.

Storm warnings were issued for the rest of Lake Superior by 0900 UTC (0400 AM EST). Storm force winds were forecast to increase to 60 knots from the west-northwest on Wednesday with waves of 12 to 20 feet across the lake.

The forecasts that were issued by the NWS were consistent throughout the entire event. No major changes in the forecast were made when a new forecast was issued.

Overall, the forecasts for Lake Superior were accurate and gave the Captains and crews nearly 40 hours of lead time to prepare for the arrival of the storm and to move their vessels to safe harbor. As previously mentioned, the highest wind speeds were not expected to occur on Lake Superior until Wednesday, 11 November. Observations from various reporting stations indicated sustained winds on the lake were above 50 knots with gusts over 60 knots. The highest recorded wave height was 15 feet on Lake Superior. Waves were likely higher in locations where reporting sites were not available; especially on the down wind end of the lake where the greatest fetch occurred. More about the observations on Lake Superior and the rest of the Great Lakes will be discussed later in the Wind and Wave Reports section of this report.

The final track of the storm was across extreme western Lake Superior to northern Lake Superior and then on to James Bay and the Hudson Bay by 1500 UTC (1000 EST) on 11 November 1998. The storm's central pressure maintained a steady state averaging about 28.70" Hg as it moved from Lake Superior to the Hudson Bay. This storm followed a similar track as the **Edmund Fitzgerald** storm. Seas and winds were higher and stronger respectively, as reported by ships and buoys in the more recent storm than the historical storm. This is likely the result of an increase in the number of buoys and reporting stations on the Great Lakes.

A commercial shipping company called the NWS Office in Cleveland, Ohio to report that the storm was being compared to the **Fitzgerald** storm. Captains of the large vessels heeded warnings and dropped anchors during the storm in safe harbor. They were not about to take any chances with the storm.

National Weather Service Statements and Bulletins

The National Weather Service Forecast Office in Cleveland, Ohio is responsible for issuing storm outlooks for the entire Great Lakes as part of the marine enhancement program.

NWS Cleveland issued a storm outlook for the entire Great Lakes at 0530 UTC (0030 EST) on 9 November 1998. The first Storm Bulletin was issued at 1730 UTC (1230 EST) on 10 November and bulletins continued through 2200 UTC (1700 EST) on 11 November when all Storm Warnings for the Great Lakes were downgraded to Gale Warnings. A total of 10 reports were issued at three hour intervals.

Wind and Wave Reports

The highest wind gust reported on all of the lakes was from a ship anchored about 4 miles off of Sandusky Breakwater on Lake Erie; which is on the south shore of the lake. At 2050 UTC (1550 EST), on 10 November, the ship reported a wind gust to 98 knots (113 mph) from the west-southwest and waves of five feet. The low wave height of 5 feet was due to lack of fetch across the water. The highest waves occur at the downwind end of the lake. The maximum sustained wind speeds and gusts that occurred on each of the lakes as reported by various stationary observational points are as follows:

Lake Superior - northwest at 52 knots with gusts to 63 knots;
Lake Michigan - southwest at 41 knots gusts to 54 knots;
Lake Huron - south at 23 knots with gusts to 51 knots;
Lake Erie - southwest at 25 knots with gusts to 64 knots; and
Lake Ontario - southeast at 49 knots with gusts to 64 knots.

The highest waves reported on each of the lakes were as follows:

Lake Superior - 15 feet
Lake Michigan - 20 feet
Lake Huron - 14 feet

Lake Erie - 20 feet
Lake Ontario - 13 feet

Higher waves likely occurred at locations without reporting sites.

Today, ship Captains and crews heed warnings issued by the National Weather Service to protect not only their lives but their expensive ships and cargo. Captains will drop the ship's anchor in sheltered areas such as behind islands and in navigable rivers for protection.

Storm Event Problems

Strong southwest winds forced shallow water away from Saginaw Bay and the basin on the west end of Lake Erie. This caused dangerously low water levels to occur and put vessels either in the basin or planning on navigating in the basin at risk. Tug boats that remained in the basin bottomed out due to low water levels.

Another vessel, the **Wolverine**, hit bottom at the Bay City Work Dock. The United States Coast Guard had to assist the vessel and no serious damage to the ship resulted.

Two duck hunters were reported missing on Saginaw Bay on Tuesday (10 November). The winds were so strong that the Coast Guard could not search for them until Wednesday morning. The duck hunters' boat ended up being caught on some rocks off of Sebewaing (Huron County). One of the duck hunters managed to walk to shore early Wednesday morning and the other duck hunter was lifted off the rocks by a Coast Guard helicopter later that morning. Both hunters were unharmed.

Thanks to improved forecasts, warnings, and dissemination, no lives were lost during this major Great Lakes Storm.

Improved National Weather Service Warning and Forecast Systems

The National Weather Service has made great strides over the last 20 years in the development of forecast and warning tools. Faster and more powerful computers allow forecasters to look at developing storms in great detail. This is a major step forward compared to the days of the **Fitzgerald**. Forecasters of the time relied on hand analyzed weather maps and crude, by today's standards, satellite and radar weather information. The hand analyzed charts consisted of a surface map taken from routine weather observations at airports across the United States and Canada. The upper air maps were plotted using upper air soundings from weather balloons launched twice-a-day at 0000 UTC and 1200 UTC. All of this information was fed into computers to generate weather forecast maps for the next few days.

The computer models of the '70s produced limited forecast data. Most forecasts were created by comparing the hand analyzed charts to the forecast maps. Wind speed and wave forecasts on the Great Lakes were difficult to make due to limited observation data. Frequently, the forecasts had to be updated based on ship and shore reports across the Great Lakes.

Communication systems of the '70s were limited to the technology of the time. Data transmission was very slow and forecasts had to be delivered from one place to another on paper rather than electronically. Ship to shore radios were the only means ship Captains had to receive the latest forecasts. The NWS used a Di-Fax system to receive weather forecast maps and noisy teletype machines to transmit and receive text data.

The NWS has undergone a major transformation over the last 10 years. A modernization plan was developed during the '80s to improve the warning and forecast systems in the NWS.

Next Generation Geostationary Operational Environmental Satellites (GOES - Next) have been launched during the '90s to improve coverage across North America. Satellites, already in place, were beyond their usable life and were in jeopardy of failing. The GOES satellites of the '90s allow forecasters to see rapid scan animation loops of clouds and moisture in great detail during significant storm events.

NWS Doppler radars have the ability to detect both precipitation and air movements inside of a storm and determine the wind direction and speed. This feature was not available with the radars of the '70s.

State-of-the-art computer systems called Advanced Weather Interactive Processing Systems (AWIPS) has been deployed in the NWS across the country. The AWIPS displays numerous data fields on two large computer monitors. The forecaster is able to overlay satellite data over surface weather observations while looking at Doppler radar data on the other monitor. The imagery can be animated and updated automatically. This is especially useful when looking at radar and satellite data. A third monitor is used to edit text documents, such as: marine forecasts, marine weather statements, or special marine warnings and storm warnings.

A network of buoys has also been deployed on the Great Lakes to report wind and wave conditions to the forecaster.

Computer generated weather forecast models have improved over the last 20 years and have replaced outdated models. The computer models provide detailed forecast parameters that display wind speed and direction, temperature, relative humidity, cloud levels, the location and forecast track of storm systems, and wave height forecasts. As computing power increases, smaller scale phenomena in the atmosphere such as lake effect precipitation and lake breezes are being simulated with greater precision.

A denser network of land surface weather observations from Automated Surface Observation Systems (ASOS) and marine weather observations such as buoys and ship reports, also aids in providing more data for detailed forecasts.

The result will be improved weather forecasts because small scale changes in the atmosphere will be detected earlier and with greater precision.

The NWS will continue to strive for improved forecast, warning, and dissemination systems to ensure the safety of marine interests. ⚓

Acknowledgments

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