CATASTROPHIC DISASTER IN THE MARITIME ARCHAEOLOGICAL RECORD: CHASING THE GREAT STORM OF 1913

By

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The Great Lakes host thousands of shipwrecks. The Lakes are positioned to receive the blunt force of two polar fronts during the winter season, this can result in cataclysmic storm activity. In 1913, the two fronts combined to create one of the most devastating maritime disasters in Great Lakes' history. Close to 300 people died, with 40 commercial vessels badly damaged or sunk, creating the largest fiscal disaster to ever hit the Great Lakes. The storm affected all five Great Lakes. This thesis, therefore, looks at the possibility of connecting shipwrecks within the archaeological record to the storms that wrecked them. This thesis will account for not only wind direction in conjunction with bow heading, but will look at variables that may also affect wrecking patterns, such as wooden or steel construction, and sail or steam propulsion.

CATASTROPHIC DISASTER IN THE MARITIME ARCHAEOLOGICAL RECORD:

CHASING THE GREAT STORM OF 1913

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Master of Arts in Maritime Studies

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DEDICATION

This is dedicated to my parents, who encouraged and supported me, regardless of the endeavor.

ACKNOWLEDGMENTS

This thesis would not have been possible without Dr. Brad Rodgers, who had the patience to help me tease out ideas, add insight to mine, and help me grow as an archaeologist and a writer. This thesis was rooted in the work of the National Weather Service of Detroit; their retrospective model created in 2013 streamlined the research for wind direction. I was only able to visit one of the Great Storm of 1913 shipwrecks, those who assisted with coordinates for vessels as well as personal insight having been on the wrecks or who have studied them in depth allowed for me to compile their knowledge into a workable research model. And my mother, who edited this thesis.

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CHAPTER 1: INTRODUCING THE WHITE HURRICANE

Natural disasters may leave recognizable, indelible prints on the maritime archaeological record. This thesis will explore the notion that shipwrecks caused by weather events can demonstrate, through a careful examination of their wreckage, such data as wind direction, wind speed, sea direction, and other disaster conditions. This thesis aims to create an explanatory model of the Great Storm of November 1913 by looking at shipwrecks' bow heading, and then comparing them to the storm fronts' actual movement. The model should, through archaeological analysis, connect shipwrecks from the 1913 Storm to the weather system that caused their wrecking. Importantly, this thesis will introduce the hypothesis that combining archaeological data with the historic recording of weather events may allow researchers to frame predictive models to explain not only the site formation process for a known wreck in a known storm, but can be used in reverse to explain and identify unknown wrecks given known storms. Simply put, can strandings and founderings be used as meteorological vectors to dovetail with historic storm accounts and produce identifying data?

The Great Storm of 1913, which occurred November 7th through the 10th, damaged commercial vessels across the Great Lakes with 19 destroyed or sunk. These bulk carriers and barges have been documented from a historical perspective, though little archaeology has been done to document these wrecked ships (Cooper 1989:92-101). This is an important oversight as the inland seas create specific transformation processes that may mask or hide shipwreck evidence during a given catastrophic event (O'Shea 2002:211). A century after wrecking, it is necessary to look at these wrecked vessels as a case study to understand the long-term effects of storms on archaeological data in the inland seas.

The November, 1913 Storm devastated the Great Lakes. The storm was the combination of two massive weather fronts colliding. A low-pressure cell of cold air, from Canada, pushed down while another front rushed east from the American Rockies. This cold front absorbed heat as it passed over the Great Plains. Of the two, the one from the Rockies was the most volatile front and would eventually combine with the Canadian front to create the Great Storm of 1913. The final contributing factor was from the lakes, which were experiencing a particularly warm season with the water retaining massive amounts of heat energy. This would prove disastrous when the two low pressure systems pushed into the Great Lakes Basin (NOAA 2013b). The freakish resultant air mass collision resulted in the deaths of 248 persons, 19 sunken vessels, and 21 vessels stranded on shore, see FIGURE 1.1 (Barcus 1960:144; Brown 2002:203). This cyclone was the most destructive storm to sweep the sweetwater seas in historic times. In viewing this event, it can be seen that historic records are biased and only account for large company-owned bulk carriers and freighters (*Detroit News* 1913:1). Unaffiliated sailors navigating smaller craft that were caught in the storm have forever been lost to the Lakes' graveyard without a trace in the historical record.

The Great Storm of 1913 is the perfect candidate to begin to understand the relationship between wreck patterns and the ferocity of a particular storm incident. The Great Lakes are large enough to create legendary natural catastrophes. When a storm strikes unannounced, there is not necessarily a means of avoiding it. The lakes represent the largest bodies of fresh water in the world, but lack of sea room in certain areas make riding out a several-days-long storm difficult. This establishes the Great Lakes as one of the most proportionally high ship wrecking areas in the world. It is estimated that the lakes are the final resting place for anywhere between 10,000 to 50,000 ships and many of their crew (Thompson 2004:back cover).

FIGURE 1.1. Map of Total Loss and Stranded Vessels from the 1913 storm, with incorrect orientation and wreck position (Brown 2002:203).

It is the purpose of this thesis to postulate that an understanding of the relationship between shipwreck location and storm incidents may allow the possibility of interpreting the reason for a shipwreck location when researchers have no other historical records at their disposal. From an archaeological and meteorological view, the 1913 Storm has much to offer. There have been other Great Lake's storms that have lived up to the reputation as the "Witch of November"; these include: Lake Superior and Lake Huron's storm of 1905, Lake Erie's Black Friday of October 1916, and Lake Michigan's Armistice Day blow of November 1940 (Ratigan 1960:109). These "witches" are formed from the collision of extreme low and high pressure systems that create the monstrous storms that periodically hit the Great Lakes. These historical storms wreaked havoc on maritime activities and communities, but no storm on the Lakes stretched further and caused as much fiscal damage as the Great Storm of 1913 (NOAA 2013a).

This thesis has the potential to add to the current process of identifying shipwrecks. A data set or a catalogue of recorded storm activity will be needed and must include: dates, wind direction and speed, longevity of storm, and affected areas in a bull's eye pattern from greatest effect to least. Contextual placement may eventually allow the construction of a predictive site formation model. If abandonment and accidental wrecking events are eliminated, shipwreck patterns may correlate with storm fronts while their archeological and geographic positioning may make it possible to accurately place unidentified wrecks into the context of the storms that destroyed them. This study will have to take into account historical records of wrecks, weather fronts, contemporary water currents, archaeological cultural (c-) and non-cultural (n-) transforms, and the geographic positioning of wrecks. Cultural transforms are culturally created, such as looting, salvaging, purposeful burning, or graffiti. Non-cultural transforms are environmental factors; this includes wave action, ice, currents, earthquakes, animal habitation, or sediment formation (Schiffer 1987:7).

In this explanatory model, vessels must be categorized as stranded or foundered; wreck type identification is part of the depositional transformation process. Stranded vessels may align with the shore, whereas foundered vessels may be affected by lake currents during the depositional phase, all of these vessels are affected by storm winds. The wreck of *Louisiana,* put in this theoretical foundation, can help clarify the postulates and details of the hypothesis. This wreck was stranded in 1913, everyone survived, it was historically and archaeologically recorded in 1989; these factors make it the perfect candidate to be one of the case studies for this thesis. Since it was historically recorded and surveyed, this wreck will lend itself to researchers attempting to understand the non-cultural and cultural transformations that have occurred since its wrecking (Cooper 1989:92-104). If this theory or thesis can be proven through an analysis of

Louisiana and other wreck sites from the Great Storm of 1913, it may offer one avenue for ship identification to the thousands of wrecked vessels that lay unnamed in the Great Lakes.

RESEARCH METHODOLOGY

The goal of this thesis is to discover whether it is possible to use shipwrecks as positional storm vectors. Provided these storms are historically catalogued, it should be possible to trace the shipwrecks back to the storm that caused their demise. As mentioned, there were 19 ships that were lost in the Storm of 1913 and there were at least 21 more that were stranded. The Great Storm of 1913's weather fronts will be plotted and compared to where the wrecks are now positioned using archaeological reports, Statistical Package for the Social Sciences (SPSS), Google Earth, and historical accounts. A map must first be made to show the location of each known vessel; as yet there is no map that accurately portrays the location of the shipwrecks from the Great Storm of 1913. Plotting the shipwrecks to their correct shoreline will be the macro study of this thesis and will test the general principle of whether the storm fronts put the shipwrecks on the "correct" shoreline according to the wind direction.

The bow and stern of each wrecked vessel will be converted to points on a coordinate plane and then to a vector. This will indicate the direction of the shipwreck's bow orientation and perhaps the wind direction. This thesis may find "negative weather vanes," there may be a difference between steam and sail powered vessels. Steam propulsion is a different variable because a steamship under power may be expected to wreck differently than a sailing ship, whose movements are more dependent on the wind and currents. There may also be a difference in wooden versus steel steamships, with wooden vessels potentially becoming ineffective during a large enough storm. "During heavy seas wooden steamers were often forced to slow or even idle their engines ----When needed most they work least------because wooden ships flex so much that the steam machinery could be damaged," Commander Stephen Champlin to Sec. of Navy Mason (Rodgers 1996:28).

The U.S. Weather Bureau recorded the storm's "progress” and wind direction throughout the Great Lakes’ cyclone. FIGURE 1.2 shows the two weather systems that created the Great Storm of 1913 as recorded by the National Weather Service and as reanalyzed by NOAA (NOAA 2013b). The map shows the two low pressure fronts about to meet over the Great Lakes Basin. Overlaying weather fronts with a shipwreck’s projected vectors, bow and stern, may show whether wreck patterns more closely relate to the storm fronts or if sailors trying to survive the storm more drastically influenced wreck positions. Disaster theory speculates that people can influence the final resting place of a wreck while in the wrecking process (Gibbs 2006:4 –11). SPSS will be used to graph the vessels’ positioning and storm’s movement to test for statistical significance and test this theory.

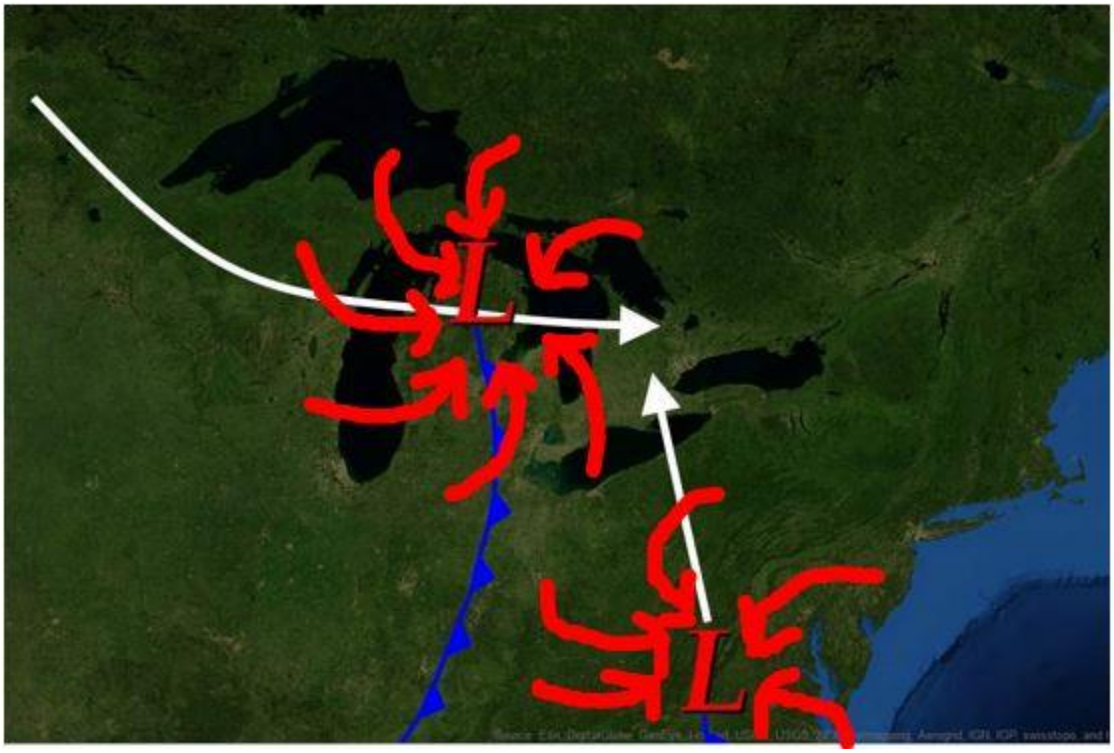


FIGURE 1.2. General Map of Described November 1913 Weather Fronts (NOAA 2013b).

The research for this project will take an archaeological and historical approach; but it must also rely on an understanding of how weather fronts work in order to interpret the storm data from 1913. It will also encompass retrieving data from each known shipwreck, which as mentioned includes coordinates of bow and stern, when possible. This thesis will rely on evidence from the physicality of wreck orientation, married with the incident comparison of the storm. Statistical analysis is needed to prove or disprove the theory behind catastrophic storms having the greatest influence on the wrecking position of a ship.

Prior to understanding the relationship between storm fronts and wreckages, it is necessary to have an understanding of overall loss patterns in the Great Lakes. November is the month of storms (Ratigan 1960:109). To fully comprehend the Lakes, this work must dovetail the loss patterns in the Great Lakes with known historic weather events and a thorough explanation of storm patterns, geography, and temporal patterns. The National Weather Service of Detroit's Retrospective Model of the Great Storm of 1913 will be used to show storm direction, wreckages, storm fronts, and water currents. SPSS will provide the statistical interpretation of this data.

It is the contention of this research that the story of the Great Storm of 1913 can be retold objectively using retrievable data. This project will rely heavily on newspapers as primary resources. Accessible newsprint, directly related to the storm, comes from: *Chicago Record-Herald, Cleveland News, Detroit Free Press, Duluth Herald,* and *Superior Tribune.* Besides utilizing newspapers, the National Oceanic and Atmospheric Administration curates multiple sources cataloguing the weather surrounding this event as well its immediate aftermath (Deedler 2007). Secondary sources that are utilized are: Brown's, *White Hurricane*, Barcus' *Freshwater Fury, Marine Review Vol. 43* and *Marine Review Vol. 44* (*Marine Review Vol. 43* 1914; *Marine*

Review Vol. 44 1915; Barcus 1960; Brown 2002). These are impressive sources because of their portrayal of the storm through the use of historic accounts married with the accurate movement of the storm (Brown 2002:232 –241). These sources include historical newspapers and personal accounts that were most adamant about collecting information about the various wrecks across the lakes (Barcus 1960:103 –106, 141 –150; Brown 2002:242 –244).

There are maps that depict the general vicinity of the wrecks from the White Hurricane, but there are no maps that accurately portray the location of each wreck. Even Brown's 2002 map incorrectly plots *Louisiana* on the southern side of Washington Island, whereas the vessel lies on the northern side of the island; there are a few more incorrectly placed vessels on Brown's map (2002:203). The correct position of *Louisiana* can be seen in FIGURE 1.3. To understand the wrecking patterns of the 1913 shipwrecks, their locations must be accurately plotted, including the ship's orientation to the shore. This encapsulates a macro and micro study of the Great Storm of 1913 and its victims. There will be another map symbol that shows the general location of shipwrecks with unknown locations; general locations will be ascertained from historic records predicting where vessels may have sunk. These map indications will not further the thesis but they will help express the scope and presence of the storm event. As these wrecks are discovered, their positioning can be used to test the explanatory modeling presented by this thesis.

Louisiana will be the specific case study within the broader study of the 1913 storm. This ship is documented in David Cooper's *Survey of Submerged Cultural Resources in Northern Door County: 1988 Field Season Report*. In this report, the shoreline was left out of the site map (Cooper 1989). This detail will be added by retrieving the coordinates of the bow and stern and imposing them on an up-to-date Great Storm of 1913 shipwreck map. Drawings of the wreck will accurately show where the bow and stern are relative to the shore; this should give insight into how the ship wrecked relative to wind, sea, and current direction compared to Weather Bureau data.

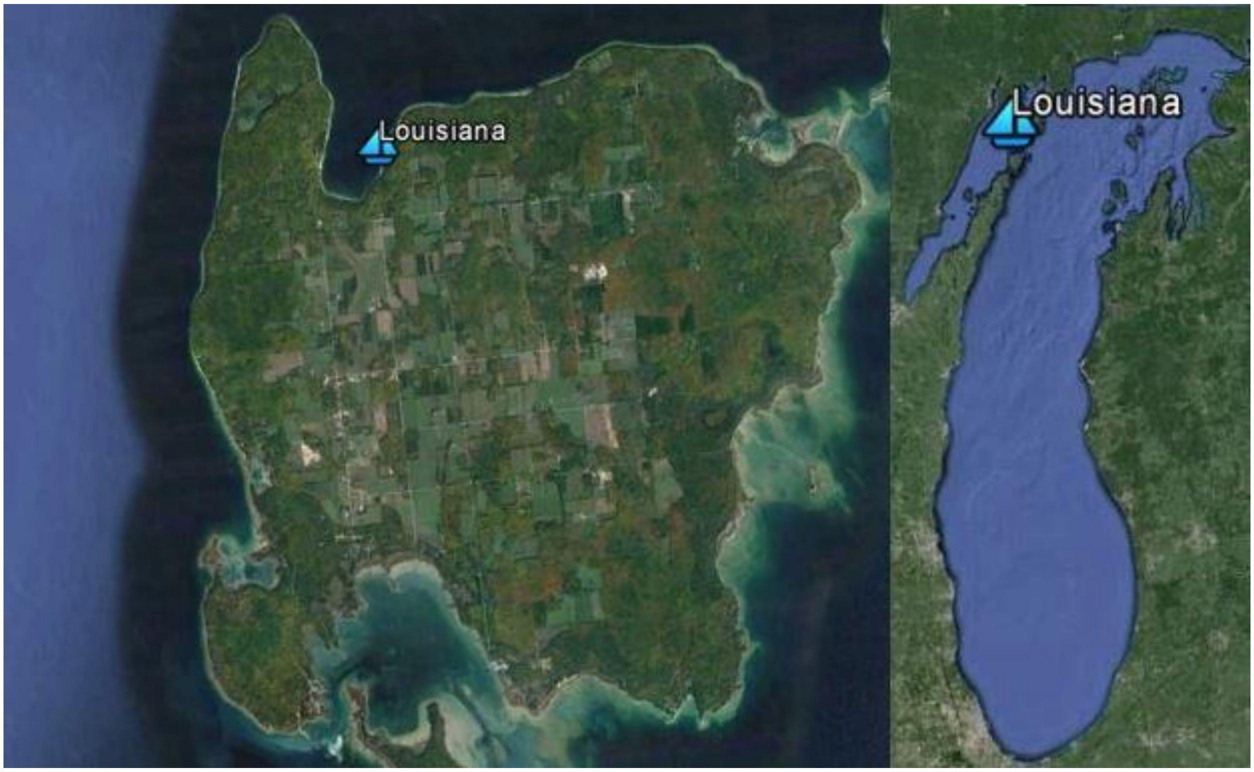


FIGURE 1.3 *Louisiana* Location, Washington Island, Lake Michigan, WI N 45° 23.98’ / W 86° 55.36’ (Author/Google Earth)

Louisiana is the first puzzle piece in understanding whether the position of a shipwreck can give way to the specifics of a storm incident. One test subject is not enough for an in-depth statistical study; therefore, this thesis will utilize various state heritage centers and the state of Michigan’s database on Great Lakes shipwreck locations to ascertain exact positioning of other wrecks lost in the White Hurricane. To have more test subjects for the SPSS comparison, this study will also draw on ships affected by the Great Storm of 1913, but not necessarily destroyed by the storm. This means the stories of crew and vessels that maneuvered safely out of the storm and vessels left at the dock during the storm will be included in the analysis process.

This thesis uses SPSS to find statistical significance. In order to effectively use the tool to find that comparison, it is necessary to add other variables, into the equation to see if there are other factors that may also be affecting wreck position or detracting from the initial hypothesis, which states that wind direction is the biggest factor influencing wreck position. These variables will include: light or loaded, length, beam, tonnage, wooden or steel, and sail or steam.

PREVIOUS RESEARCH

Investigating factors influencing the wrecking process has gained popularity since Muckelroy (1976) and further with Schiffer (1987). This thesis is dependent on studies focusing on site formation processes. O'Shea (2002) has spear-headed the mindset that shore-scattered shipwrecks may still add knowledge to the archaeological record; he also pushes for the broad regional study of shipwrecks rather than micro studies of individual shipwrecks. One non-cultural transformation process that is almost universally destructive across the lakes is ice shove; this has and will continue to affect shallow shipwreck sites' orientation (Lenihan 1987:235, 278). Gibbs pushed this paradigm of macro studies by looking into disaster responses of sailors while in the wrecking process as first explained by psychologist Leach, who put disaster response in five critical stages which include: pre-impact, impact, recoil, rescue, and post-trauma (Leach 1994:24; Gibbs 2006:4 –5).

Risk response and preparation will be a key aspect when looking at the shipwrecks during the Great Storm of 1913; shipwrecks that do not strictly correlate with the storm's wind patterns may have been manipulated by the crew to change the expected natural wrecking pattern, or they may have lost power during said storm. Despite captains having decades of experience, many still went out in the storm. Thompson's *Graveyard of the Great Lakes* offers pivotal information concerning the factory mind-set that company officers often demonstrated, often pushing safety limits to make more runs across the lakes (Thompson 2000:331 –368). His work explains why captains were willing to venture into gale-like conditions. Souza's work adds insight to factory mind-set behavior because of her explanation of risk management, including economic factors that push for more risky behavior (Souza 1998:113 –130).

There have been other studies that have looked at how site formation processes have occurred alongside storm incidents; these include factors such as: historical storm activity, climate patterns, overwash deposits, and sediment features (Mitchell and Thomas 2001:77 –113; Kam-bui and Murnane 2004: 13–57). While this does not directly tie into the thesis, it does pertain to a better understanding of why a wreck may have moved since the wrecking event, keeping in mind that site formation process is occurring and may also naturally transform any disaster landscape (Jones 2012:3). Key to this thesis is a thorough understanding of risk management and disaster response. Part of this thesis will quantify whether sailors' actions during the November storm had a greater effect on the shipwreck's final resting place than the storm itself (Leach 1994; Souza 1998; Gibbs 2006).

A parallel study survey is underway to understand historic storms and shipwrecks off the coast of Ireland. This study most closely follows the idea that wrecked ships can give clues to their wrecking process. The research is being conducted by the Centre of Maritime Archaeology, the School of Environmental Studies, and the University of Ulster Coleraine. This study will attempt to take a broad survey of shipwrecks that correlate with historic storms in an attempt to measure the power of these storms. The goal is to relate meteorological stations with the distressed vessels' recorded observations of the storm (Forsythe et al 2000:247).

If calamitous storms leave an observable archaeological imprint, then an explanatory model can be created to aid researchers; it is plausible to conclude that in the future, unidentified shipwrecks caused by storms may be placed in relation to the historic storm that caused the wrecking event. By overlaying the Great Storm of 1913's fronts with shipwrecks' coordinates converted to vectors, there may be insight into correlating the two. This is only possible if a ship has not been unpredictably manipulated by the crew in the wrecking event and if cultural and non-cultural transforms have not severely altered the disposition of the wreck site. It is also possible that human actions or the shoreline have had the final influence on the positioning of a wrecked vessel. This thesis will test the hypothesis that shipwrecks caused by catastrophic storms in the Great Lakes leave identifiable explanatory wrecking markers that identify the storm that caused said wrecking.

There are drawbacks to this hypothesis; even if there is a relationship in matching historical storms with shipwrecks, there is not necessarily a way to identify the shipwreck if there are not comprehensive historical records identifying which ships wrecked in historical storms. This hypothesis likely cannot name a ship, it can only add to the overall data of a storm and its casualties. Due to the potential inability to name a wreck once it is aligned with a historic storm, some may find it unwarranted to pursue this thesis topic, however, adding context to a wreck is always insightful into its life history. Once a shipwreck is linked with a storm, researchers may go to historical records to identify wrecked ships associated with a historic storm. This has the potential to narrow the list of possibilities once a wreck is associated with a storm. Even if never identified, compiling information for regional studies would benefit the archaeological record for future study. Another drawback could be the randomization of more sudden, localized storms that produce tremendous intensity in a given small area. Storms, such as the famous, "White Squalls," have confused the overall weather record in the Great Lakes, as witnessed in the sinking of *Alvin Clark* in 1869 (Van Harpen 2006:81).

Regardless of whether or not this hypothesis is proven, it will add insight into the wrecking and site formation processes of wrecks caused by storms on the Great Lakes. It will push for a more thorough understanding of pre-wrecking events, and result in the need for either non-cultural or cultural transformations processes to be studied more in-depth. This thesis hopes to identify a recognizable pattern that allows researchers to match storm-foundered shipwrecks with the historic storm that caused their demise.

CHAPTER 2: LOSS PATTERNS ON THE GREAT LAKES

This thesis attempts to explain the Great Lakes' intense atmospheric displays and their effects on ships wrecked during such cataclysmic demonstrations. To recognize the power of the Great Storm of 1913, this chapter will include an overview of general weather patterns during the fall to winter months on the inland seas and compare it with the Great Storm of 1913. This section relies on information from the National Weather Service of Detroit and National Oceanic and Atmospheric Administration resources, created specifically for the Centennial Anniversary of the Great Storm of 1913. This chapter will examine wind patterns and wave heights that became the "meteorological bomb" that ensued November 7th through 11th, 1913 (Clark et al. 2013). Also detailed will be the human and financial devastation as indicated by the ships lost.

"NORMAL" WEATHER TRENDS ON THE LAKES

This section will give a background as to why the Great Lakes region becomes volatile when polar fronts cross into the area. It will also look to major historic storms as well as their monthly placement. This will demonstrate the aggressiveness of the Lakes' intense weather during November and provide the human toll from such weather.

The Great Lakes have plagued sailors for centuries with storms; hazardous weather comes without warning and easily turns into infamous gales. Unbridled atmospheric displays were one of the largest motivating factors for the creation of the National Weather Service, which was first proposed in 1869 by Wisconsin Representative Halbert E. Paine (NOAA 2013a).

Cold polar fronts colliding with warm air masses are the usual culprits behind severe winter storms in the Great Lakes. These opposing air masses consist of contrasting temperatures and air densities. Conflicting fronts create instability in the atmosphere. The root of this comes from the intensity that is associated with low pressure systems. These system disturbances become winter storms if three conditions are met: cold air, moisture, and lift. Rising moist air creates clouds and precipitation; this can lead to fronts (Rank 2009). Storms on the lakes' areas can also lead to lake-effect snow. This type of snow forms because the lakes retain a certain level of warmth, even as cold air masses move over the water bodies. The lower level air is heated by the lake; the lake's moisture, now in the air, evaporates into the higher bodies of cold air. This rise occurs because warm air is less dense than cold air. As warm air rises, it begins to cool. The moisture that was once in the warm air condenses and forms clouds, which in turn trigger snowfall (NOAA 2013c). This is illustrated in FIGURE 2.1. Intense snowfall and plummeting temperatures are disastrous for mariners on the lakes. Vessels can ice over making them exceedingly top heavy and almost impossible to maneuver in hurricane-like conditions.

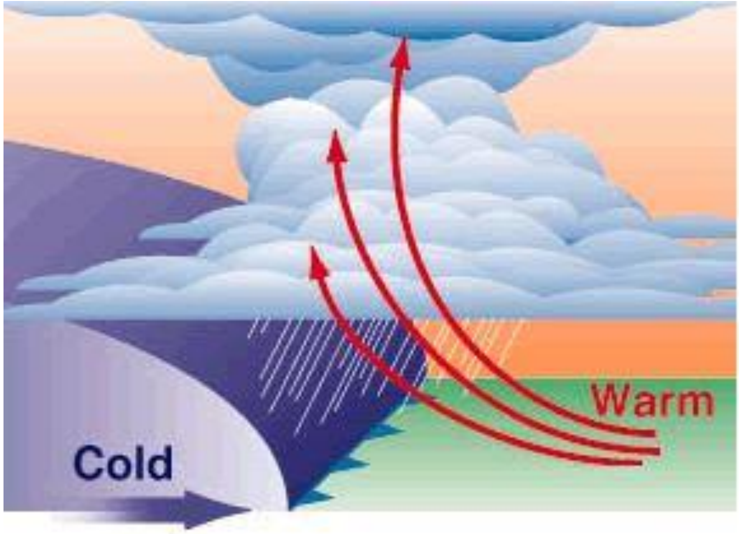


FIGURE 2.1. Illustration of cold front reacting with warm air to create clouds and precipitation (National Earth Science Teachers Association 2012).

In addition to lake effect, polar fronts come from the mid-Pacific and Arctic; most are halted by the Rockies, though a few disturbances cross the mountains. Storm fronts that come out of the Colorado Rockies are called "Colorado cyclones"; storm fronts that come out of the Canadian Rockies are called "Alberta cyclones" or "Alberta Clippers." As fronts surge eastward they converge over the Great Lakes. The Great Lakes create their own unique weather patterns.

The polar fronts that collide in the Great Lakes Basin propel weather to strike and create other storms that continue south or east (Rank 2009). These polar fronts contain varied barometric pressure which create storm movement as pressure flows from high to low areas. Since the Great Lakes retain summer heat, once polar fronts meet warmer waters, weather systems become unpredictable.

As mentioned, the Great Lakes are subject to unpredictable duress from weather systems. TABLE 2.1 lists six infamous storms that hit the Great Lakes. They are listed in chronological order and were chosen based on the severity of the storm as indicated by lives lost and ships lost. The table also indicates that while Great Lakes' storms are severe, they do not necessarily affect all of the Lakes. The table shows that all of the lakes do get hit by weather fronts and that, while rare, multiple lakes can be affected by one or two weather systems simultaneously.

Storm	Date	Lake(s) Affected	Ships Lost	Lives Lost
Terrific Storm of 1835	November 11, 1835	Erie, Michigan, Ontario	17	254
1905 Blow/ *Mataafa* Blow	November 25, 1905	Superior, Huron	20	32
Great Storm of 1913	November 7-11, 1913	Superior, Erie Michigan, Huron, Ontario	12 sunk, 30+ stranded, crippled	248+
Black Friday	October 20, 1916	Erie	4	49
Armistice Day Blizzard	November 11-12, 1940	Michigan	3	66
Wreck of *Edmund Fitzgerald*	November 10, 1975	Superior	1	29

TABLE 2.1. Six disastrous storms that have affected the Great Lakes (Mansfield 1899:306-8; Ratigan 1960:109; Wolff 1966: 306-308; National Transportation Safety Board 1978:2; LeMay 2005).

The storms listed above, with the exception of the "Terrific Storm of 1835," do not compare with the Great Storm of 1913 in terms of duration, fiscal damage, and areas affected with the convergence of two polar fronts.

POLAR FRONTS AND THE GREAT STORM OF 1913

The Great Storm of 1913 is of particular interest because of its wide reach across the Great Lakes. Every lake was affected, with the exception of Lake Ontario, which did not suffer a commercial shipping loss. This storm can be classified as a “meteorological monster” (Clark et al. 2013), because it fed off two separate low weather systems. The front systems combined and continued to intensify over the inland seas because of the waters’ retained summer heat and an unusually warm fall (Brown 2002:1).

On 6 November through 8 November, and originating somewhere in the southern United States, a weak pressure system moved east, from the Rockies, to the Atlantic Ocean. Moving south from Canada came a low pressure system associated with cold, Arctic air. The Arctic system approached the Great Lakes’ Basin on 7 November. In front of the Arctic system were strong southwest winds; behind it were strong northwest winds (Clark et al. 2013). The cold front reacted violently to the warm lakes. FIGURE 2.2 shows storm 1 and storm 2 as two separate fronts.

Moderate temperatures plunged below freezing as the Arctic front moved into the United States. This front moved to the Upper Peninsula of Michigan which immediately began to cause storm force winds and high waves on Lake Superior; it is named the “Pre-Storm.” On Saturday the 8th, the second low pressure system, originating from the Rockies, continued to develop along the Gulf Coast (Wagenmaker et al. 2013:9).

To complicate this pattern, an unusual strong upper level jet stream ushered in from the south; this caused the low pressure system that had been developing in the east to push north. The low pressure Arctic system had been weakening over Lake Huron and began to move southeast. Winds had died down and waves subsided creating a lull on the lake after a day of storms. In a matter of eight hours from when the jet stream pushed the low pressure Gulf system north, the fronts met and created one massive low pressure front system near Washington, DC (Wagenmaker et al. 2013:10). The front that had developed on the Atlantic had collected excessive amounts of moisture. This intensified the second low pressure front as it traveled north. Moisture cannot be sustained in cold air, so after freezing, water vapor came down in the form of excessive precipitation. The low pressure southern front became dominant and ushered in the deadliest part of the Great Storm of 1913 (Wagenmaker et al. 2013:11). Barometers plunged to 29.1 inches Hg as the Great Storm of 1913 became deadly (Clark et al. 2013; Wagenmaker et al. 2013:11). FIGURE 2.3 shows the location of the fronts when they combined to create the "White Hurricane" (Wagenmaker et al. 2013:11). Severe storms can ensue in the coming 12 to 24 hours if barometers rapidly drop from 29.8 inches Hg (Science Company 2014).

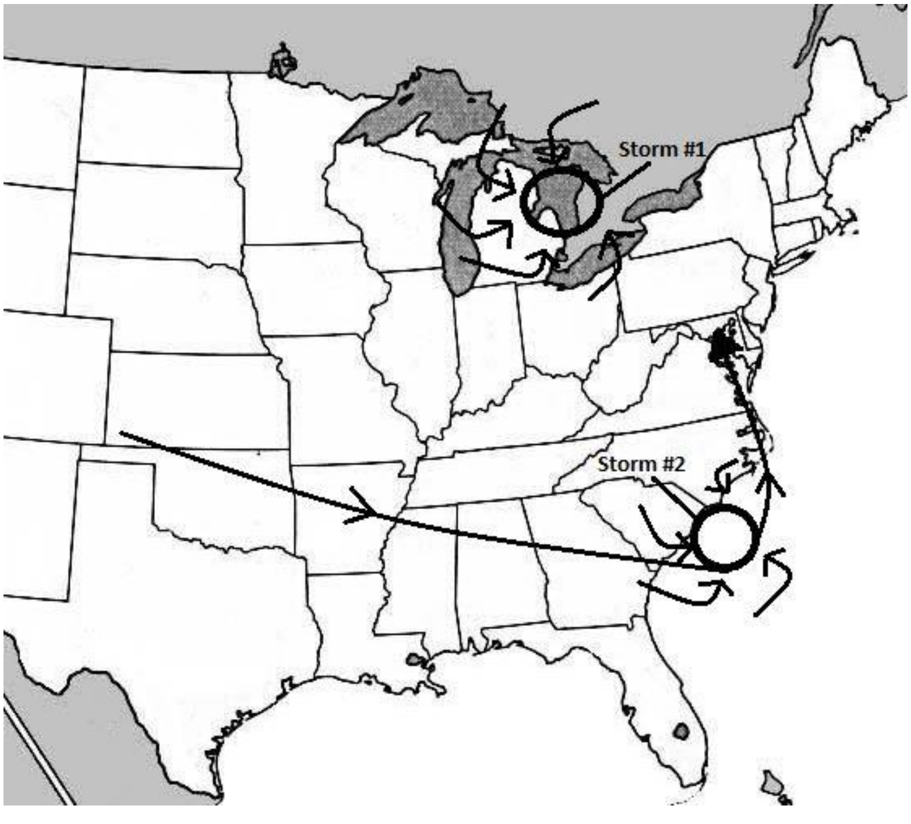
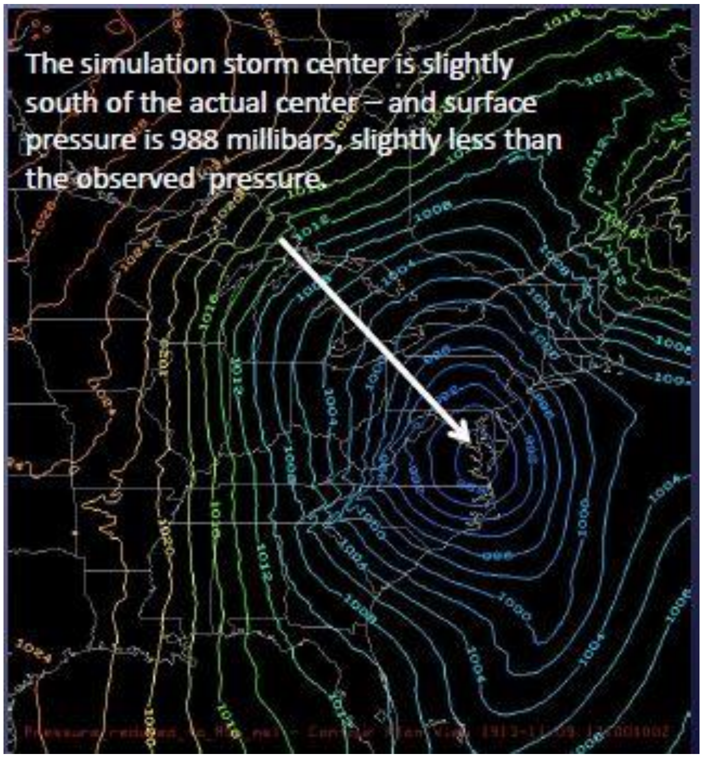


FIGURE 2.2. Locations of low pressure systems before combining, 9 November 1913. Map created by author (Wagenmaker et al. 2013:10).



The simulation storm center is slightly south of the actual center – and surface pressure is 988 millibars, slightly less than the observed pressure.

FIGURE 2.3. Merger of storms close to Washington, DC, retrospective model results (Wagenmaker et al. 2013:11).

Ships harbored on the western Lake Huron shore since it is generally considered the weather shore and presumed safest. When the gale moved and the lows converged, Lake Huron's western shore became one of the deadliest areas of the storm (Barcus 1960:5). Over Lake Erie, on 9 November, the central pressure fell to 28.6 inches Hg as the low pressure system moved north-northwest. Northwest Minnesota's barometric pressure was recorded at 30.54 inches Hg. The contrasting pressures, combined with their proximity, produced intense storm winds for four days; vessels dealt with 90 miles per hour winds and waves pushing 36 feet (Clark et al. 2013;NOAA 2013a;Wagenmaker et al. 2013:5). The presence of such monstrous waves in the Great Lakes is alarming and partially explained by the fact that freshwater is lighter than saltwater, allowing freshwater waves to more easily stack up than saltwater waves (Barcus 1960:5).

It took 12 hours for the storm to move out of the Great Lakes area and north of Toronto; the storm did not lose any of its power during this time. It was not until Monday morning that the storm began to weaken and disappear to the northeast (Wagenmaker et al. 2013:11 –14).

In 1913, broadcast systems were still in early development; not surprisingly sparred on by the Great Storm of 1913 and the disaster that ensued. Weather Bureau forecasters sent warnings to over 100 stations along the shores of the Great Lakes via telegraphs before the weather fronts smashed into the Lakes. The warnings were sent out 12 to 24 hours in advance as forecasters reacted to dropping barometers. Even though stations were decorated with warnings, many sailors were unaware of deteriorating conditions. Warnings were issued 7 November, but vessels that were already out of sight from the shore would be caught in the midst of the storm since ship to ship communications were not yet readily available (NOAA 2013a).

INSIGHT TO THE RETROSPECTIVE NUMERICAL MODEL

Despite the Weather Bureau's knowledge of the Great Lakes' shores, there were little to no wind reports for the interior of the lakes; the Bureau was only able to take recordings from cities on the southern side of the lakes. Though Lake Huron suffered the worst losses, winds were equally as strong on Lake Erie, often sustaining up to 50 to 70 miles per hour while gusts reached 85 to 90 miles per hour (Clark et al. 2013; Wagenmaker et al. 2013:16 –28). For the Centennial Anniversary of the Great Storm of 1913, the National Weather Service and National Oceanic and Atmospheric Administration (2013) created a retrospective numerical model with the hope to demonstrate wind speed, wind direction, and wave height.

The Great Storm of 1913 is often classified as the "White Hurricane" (Brown 2002:title). The National Weather Service of Detroit organized the storm into "Pre-Storm," and "White Hurricane." The Pre-Storm, out of Canada, halted over Lake Superior and Lake Michigan from 7

–8 November. The Great Storm of 1913 became a meteorological monster when the secondary front originating from the Gulf combined with the Canadian front from 9 –11 November (Wagenmaker et al. 2013:7).

Radios were not common on commercial vessels during the early 20th century. Ship companies did not find it necessary to buy radios for company ships, especially because radio stations were not consistently placed throughout the Great Lakes' shores. Adequate radio transmission stations would not be installed into vessels until after World War II (Thompson 2004:74-6). With no radio system, ship captains had no foresight into the weather systems headed their way, nor were they aware of the damage that the Pre-Storm had already caused. Numbers may be underreported without real-time radio transmissions, while TABLE 2.2 shows recorded White Hurricane losses.

Storm	Date	Lake(s) Affected	Ships Lost	Lives Lost
White Hurricane	November 7-11, 1913	Superior, Michigan, Huron, Erie	12 sunk 30+ driven ashore, crippled	248+

TABLE 2.2 Great Storm of 1913 quick statistical reference (Wagenmaker et al. 2013:2).

The Great Storm of 1913 retrospective numerical weather simulation was the result of a NOAA regional collaboration which drew on the expertise of the National Weather Service stationed in Detroit. The numerical model's purpose was to show a contemporary audience what sustained wind speeds and wave conditions were like during the Great Storm of 1913. Conditions during the storm had not been previously mapped. The simulation was meant to give insight into the storm and conditions mariners faced (NOAA 2013b).

The simulation was difficult to create because polar systems are not predictable and do not usually strike the Great Lakes area with such aggression. There is no good comparative modern equivalent storm that gave researchers a base to work their model against. This model was difficult to create because the storm occurred 100 years ago, weather forecasters did not have comprehensive observations of surface as well as upper air conditions. It was only with the advent of more advanced technology that complex mathematical equations, comprising atmospheric and oceanic movement of water and air, could be developed for past weather systems. Computers have aided meteorologists who are now capable of seeing real time calculations of weather patterns (NOAA 2013b).

The 20th Century Reanalysis Project provided a comparable state of the atmosphere in early November 1913; this gave the presumed initial conditions (NOAA 2013b). These conditions were needed before the analysis project could begin because 1913 Great Lakes did not have adequate observation and buoy stations that could track atmospheric conditions regularly. Much of the information used for the simulation was based on anecdotal evidence; this included sustained wind speeds, gusts, and wave heights. This simulation was created 100 years after the storm event occurred, leaving room for some error (Wagenmaker et al. 2013:5).

Researchers utilized the Weather Research and Forecast (WRF) model in order to predict the hourly forecasts of: mean sea level, pressure in millibars, sustained wind speeds at the surface in knots, wind gusts at the surface in knots, and three-dimensional equivalents of the potential temperatures. This aided in recreating the atmospheric conditions. The model drew from NOAA Great Lakes Environmental Research Laboratory, which used the Donelan Wave Model (GDM) to simulate the approximations for significant wave heights, dominant wave period, and the wind and wave directions. The significant wave height was recorded using the average height of the highest 33rd percentile. There was also a comparison of peak wave heights; this was calculated using the average of the highest fifth percentile from wave energy distribution. Highest achievable wave heights were predicted for the "worst case scenarios" that bulk carriers may have dealt with during the Great Storm of 1913 (NOAA 2013b; Wagenmaker et al. 2013:6).

In order to calculate “significant waves,” the computer simulation measured the mean of computer-generated waves. If the mean of waves had a positive skew, the significant waves would average as the largest one-third (33%) and the maximum waves would average as the highest one-twentieth section (5%). This model is acceptable because waves are not consistent. There was great anticipation for the computer wave simulation because prior to the creation of the model, the only record of mid-lake waves came from the few survivors of the storm. Anecdotal observations put waves as high as 35 feet on Lake Huron and Lake Superior during the climax of the storm, this agrees with the retrospective model (Wagenmaker et al. 2013:29 – 30).

CHASING THE WHITE HURRICANE OF 1913

November can be warm or cold on the Great Lakes. The water retains summer warmth, while receiving polar fronts from the Arctic and mid-Pacific. The Pre-Storm of 1913 occurred when an uncharacteristically warm Great Lakes Basin encountered an Arctic low pressure system. Warning flags were signaled as early as 10:00 am on Friday, 7 November on Lake Superior when the low pressure system was discovered. The United States Weather Bureau telegraphed a storm warning to all of the stations on the Great Lakes,

> HOIST SOUTHWEST STORM WARNINGS TEN A.M…. STORM OVER UPPER MISSISSIPPI VALLEY MOVING NORTHEAST….BRISK TO HIGH SOUTHWEST WINDS THIS AFTERNOON AND TONIGHT SHIFTING TO NORTHWEST SATURDAY ON UPPER LAKES….WARNINGS ORDERED THROUGHOUT THE GREAT LAKES…. (Barcus 1960:2).

Unfortunately, the warnings went unheeded by many captains; the United States Weather Bureau was in its infancy and their predictions were often considered inaccurate.

Generally on the Great Lakes, the shipping season ends when the lakes freeze over. By November, Great Lakes' captains knew their runs across the lakes were limited, so many ventured into the lakes knowing that it would be one last chance to make money for their companies and a storm was arriving within a matter of hours. White Hurricane mariners did not recognize the severity of the storm that lay ahead, especially because most storm warnings had an expiration of 24 hours. This low pressure system was so powerful that by evening, storm winds hit the lakes. The persistence of the storm made the United States Weather Bureau send out another storm warning by 10 am Saturday. The life of the storm would theoretically extend at least another 24 hours (Barcus 1960:2-3; Wagenmaker et al. 2013:8).

Within 24 hours of detection, the low pressure system moved across the Upper Peninsula of Michigan. Lake Superior and Lake Michigan were hit with intense storm weather; this included gale winds and high waves that quickly affected vessels on Superior and Michigan (Cooper 1989:93;Wagenmaker et al. 2013:9). TABLE 2.3 shows some of the early victims of the storm. The locations for vessels stranded during the morning of 8 November, 1913, are not specifically given here for the sake of brevity. Foundered and stranded shipwreck locations will be looked at, in depth, in Chapter 4.

Date	Estimated Time	Lake	Vessel	Occurrence	Lives Lost	Location
November 8,1913	Midnight	Michigan	*Louisiana*	Stranded	0	Washington Harbor, WI
November 8, 1913	Morning	Superior	*Turret Chief, L.C. Waldo, Huronic, Nottingham*	Stranded	0	Various Locations

TABLE 2.3 Indication of first vessel lost during Great Storm of 1913 (Cooper 1989:93) and indication of ships driven ashore on Lake Superior by the morning of November 8, 1913 (Wagenmaker et al. 2013:9).

Saturday, 8 November, ushered in the low pressure front that had developed along the Gulf Coast. This front was directly south of the Arctic front. Wind and waves increased; lake water transformed to sheets of ice halting the progress of sailors seeking shelter. Mariners that had neglected the warnings or who were already on the sweetwater seas by the time warnings were posted were increasingly likely to be trapped between storm and shoreline (Barcus 1960:3-4; Wagenmaker et al. 2013:9). FIGURE 2.4 shows the retrospective model of the two storms merged that would soon wreak havoc on the mariners out on the Lakes.

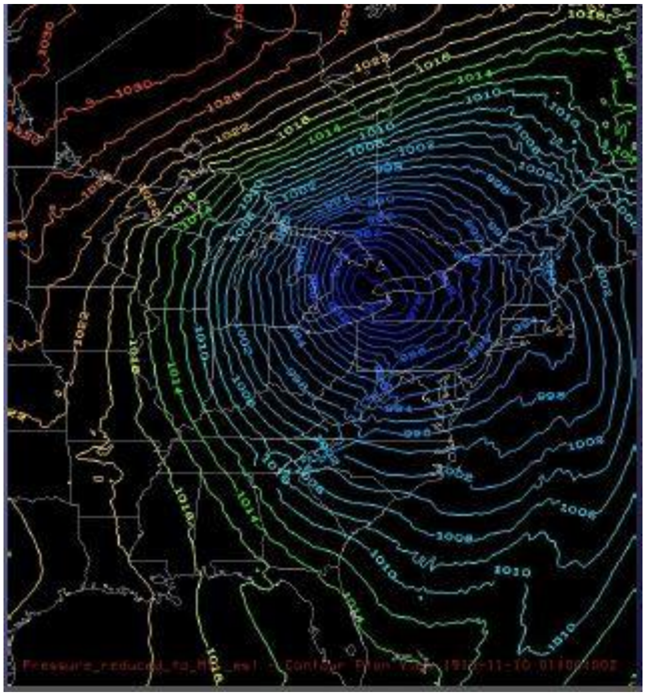


FIGURE 2.4. 8 pm Sunday; 9 November, 1913. Two storm fronts merged and moving in on the Great Lakes (Wagenmaker et al. 2013:12).

Part of the danger associated with working on the Great Lakes was the push to make as many runs across the lakes before winter iced over transportation routes. Many ports scheduled last runs to be in November. Historically, this month was the most dangerous month to voyage across the Great Lakes due to unexpected storms (Thompson 2004: 99, 272). This was a dangerous mentality as it pushed captains to make poor decisions while on the lakes; it made many gamble unfairly with the lives of their crew when the weather was debatable (Hemming 1992:9-10).

The 1913 gamble for Lake captains began when the first low pressure system began to weaken. The Alberta cyclone had been powerful over Lake Superior, but once it went over Lake Huron, the storm deceptively eased (Wagenmaker et al. 2013:10). This pause in storm power falsely assured some captains that the Lakes were calm and the storm was in the process of blowing itself out. Saturday, 8 November at 10:00 pm, waves on Lake Huron averaged 6 feet in height; maximum wave height was 8 feet. It did not take long for waves to dramatically increase (Wagenmaker et al. 2013:30).

By 8 am, Sunday, 9 November, the two separate storms combined to form one massive storm; this storm merger can be seen in FIGURE 2.5 (Wagenmaker et al. 2013:10 –16). The low pressure system passed over Erie, Pennsylvania and was recorded at 28.61 inches Hg (969 millibars). The storm plowed north and settled in the upper Great Lake, when the fronts combined. The winds associated with the merged storms increased. The winds on the upper lakes were 25 knots (28.8 mph) and gusts were up to 40 knots (46 mph). Lake Huron and Lake Erie's weather conditions severely worsened as the White Hurricane increased its intensity (PC Weather Products 2004; Wagenmaker et al. 2013:12, 16).

Lake Michigan and Lake Huron dealt with increasing winds as the low moved into Pennsylvania at 1 pm Sunday, 9 November. Gusts raged to 45 –50 knots (51.2 –57.5 miles per hour). By late afternoon, the low moved northwest towards the lakes. Waves on Lake Superior began diminishing by 10 am, however, Lake Huron experienced a rise in average waves, up to 12 feet. The pressure continued to decrease. Quick drops make winds stronger and colder.

Vessels were in the lakes at this point; some had entered the lakes thinking the danger was over as the pre-storm ebbed in power (Wagenmaker et al. 2013:12 –18).

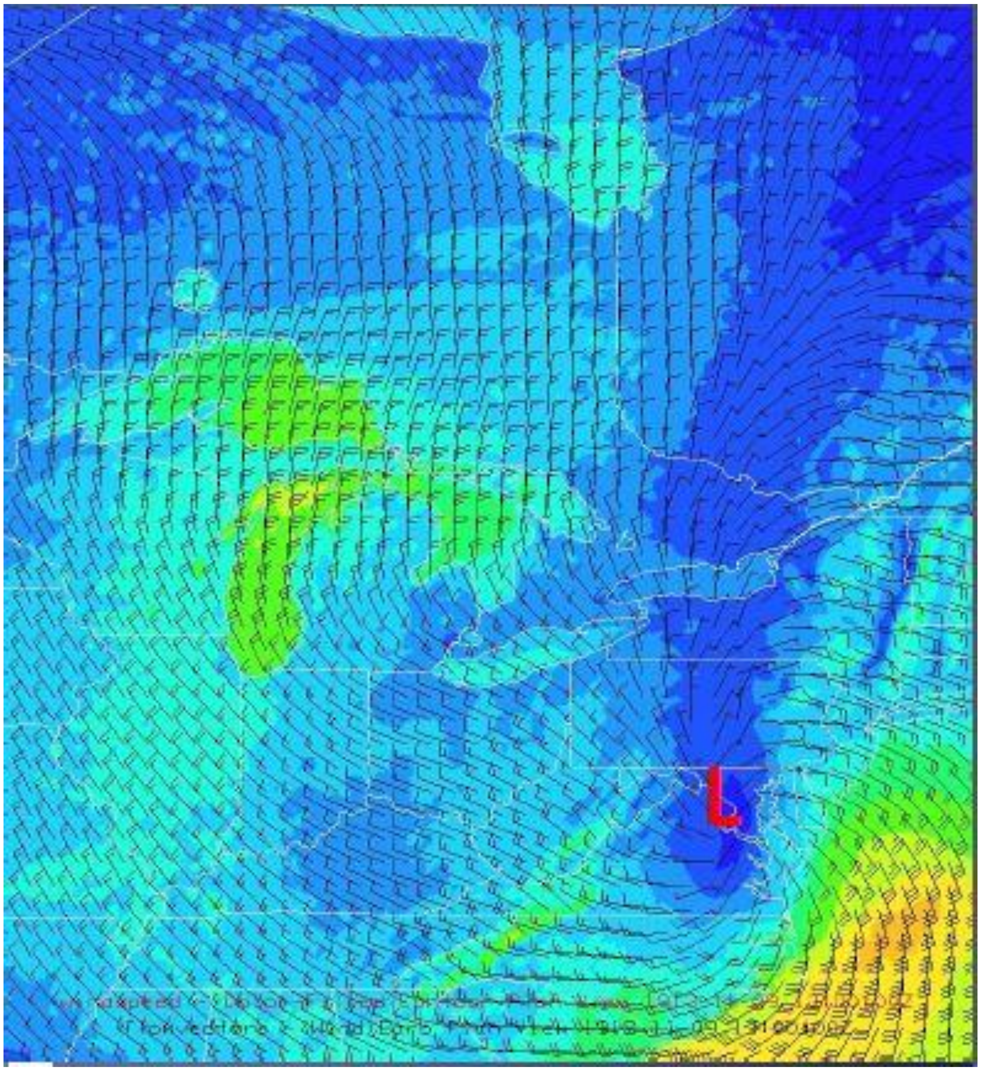


FIGURE 2.5. 8 am Sunday, 9 November 1913; systems merge. Image shows Lakes (green) in conjunction with the low pressure system (Wagenmaker et al. 2013:16).

Many vessels on Lakes Superior, Michigan, and Huron were down-bound towards the St. Clair River; other up-bound vessels tried to pass Port Huron on Lake Huron. As time increased, so did the storm's power. The storm crossed Pennsylvania and headed towards eastern Lake Erie. By 4:40 pm on Sunday, gusts close to Cleveland peaked at 62 knots (71.3 mph), and wave height increased (Wagenmaker et al. 2013:17 – 18, 31 – 32). TABLE 2.4 shows two more vessels lost on the lakes around six in the evening on 9 November. FIGURE 2.10, on page 36, shows cities, rivers, and lake locations for vessels affected during the Great Storm of 1913.

Date	Estimated Time	Lake	Vessel	Occurrence	Lives Lost	Location
November 9th	6 pm	Huron	*Argus*	Foundered	28	Pointt Aux Barques, MI
November 9th	6 pm	Superior	*Henry B. Smith*	Sank	23	Marquette, MI

TABLE 2.4 Briefing of the loss of *Henry B. Smith*, *Argus* and crew (Hemming 1992:45; Brown 2002:203; Wagenmaker et al. 2013:32).

Sunday evening, just three hours past the simulation's last results, winds increased to 65 – 70 knots (74.8 – 80.6 mph) in Georgian Bay. Winds amplified over Lake Erie and Lake Huron, indicated in FIGURE 2.6. The low pressure system was located between Buffalo and Erie; it slowly moved northwest. Storm winds branched over Lake Superior, Michigan, Huron, and Erie; the winds brought heavy snows that affected vessels on the lakes as well as cities along the lakes' front.

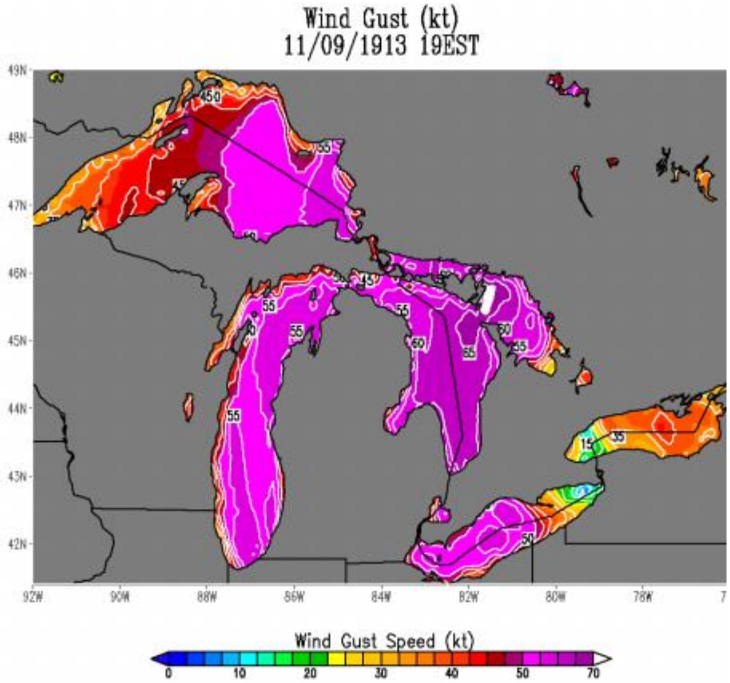


FIGURE 2.6. Wind gust speed Sunday, 9 November at 7pm (Wagenmaker et al. 2013:19).

In two hours, Lake Huron's simulated waves increased to a maximum height of 24 feet. The simulation calculated waves occurring every 10 seconds with significant waves occurring every 50 seconds, and maximum waves occurring every 200 seconds. The upper lake area had colder air, so stronger lake effect snow squalls hit the area; lake conditions for mariners deteriorated as the day progressed. (*Cleveland Plain Dealer* 1913:1; Wagenmaker et al. 2013:19, 33).

Lake Huron's weather conditions worsened; by 8 pm, winds exceeded 70 knots and maximum waves occurred every three minutes and 20 seconds. Waves were estimated at 28 feet in height (Wagenmaker et al. 2013:34). The National Weather Service and NOAA (2013) placed the center of the low between Erie and Buffalo, with a low of 28.76 inches Hg(974 millibars). See TABLE 2.5 for vessels affected on 9 November.

Date	Estimated Time	Lake	Vessel	Occurrence	Lives Lost	Location
November 9th	8-10 pm	Huron	*Howard Hanna Jr.*	Stranded	0	Port Austin, MI
November 9th	8-10 pm	Huron	*John McGean*	Sank	28	Point Aux Barques, MI
November 9th	8-10 pm	Huron	*Isaac M. Scott*	Foundered	28	Alpena, MI
November 9th	8-10 pm	Huron	*H.P. Hawgood*	Stranded	0	Port Huron, MI
November 9th	8-10 pm	Huron	*Hydrus*	Foundered	25	Goderich, Ontario

TABLE 2.5 Vessels and crew affected from 8-10 pm on 9 November (Brown 2002:203 –204; Wagenmaker et al. 2013:34).

Detroit measured winds as high as 52 knots (60 mph) and Port Huron measured as high as 58 knots (67 mph) by 8 pm. Sunday night, 9 November continued to worsen; by 10 pm, gale winds covered all of Lake Huron. Winds were projected between 69 – 78 knots (80 – 90 mph), see TABLE 2.6. At the height of the storm many vessels would be lost to the lake within hours of each other (Wagenmaker et al. 2013:20).

Date	Estimated Time	Lake	Vessel	Occurrence	Lives Lost	Location
November 9th	11 pm	Huron	*Charles S. Price*	Foundered	28	Harbor Beach, MI
November 9th	11 pm	Huron	*Regina*	Foundered	20	Port Sanilac, MI
November 9th	11 pm	Huron	*P.O. Mills*	Stranded	0	Harbor Beach, MI

TABLE 2.6. Vessels and crew affected around 11 pm on 9 November (Brown 2002:203; Wagenmaker et al. 2013:35).

By 10 pm, waves reached a maximum height of 32 feet. It was nearly impossible to navigate the inland seas; waves crashed over smaller boats and capsized vessels as large as 500 feet. Heightened waves were a huge hazard to mariners (Wagenmaker et al. 2013:35). FIGURE 2.7 illustrates the ferocity of the storm inland.

FIGURE 2.7. E. 105th St., Cleveland, Ohio, Nov. 11, 1913 (*Cleveland Plain Dealer* 1913:1).

Monday morning, 10 November, did not ease mariners' troubles; London, Ontario received the new low pressure system by 1 am. This made winds over Lake Erie begin to move westerly; in turn, winds increased close to Buffalo. Waves reached 36 feet near Port Austin, Michigan. At this point, gusts over Lake Superior and Lake Michigan reached 70+ knots (80+ mph). The computer simulation makes the low pressure system halt over southwest Ontario around 4 am. This is the first time winds begin to decrease over Lake Huron. Lake Huron was subject to 10 consecutive hours of gusts qualifying as hurricane winds from 6 pm on Sunday, 9 November to 4 am, Monday, 10 November. Hurricane winds were widespread over the eastern part of Lake Superior and the northern part of Lake Michigan. Central Lake Superior received gusts matching 70+ knots (80+ mph) by 7 am, the low still over southwest Ontario. The most powerful winds breached Superior and Michigan at this time. The Captain of *Harvester*, estimated gusts as high as 87 knots (100 mph) by 4:30 am just west of Michipicaten Island, Lake Superior (Wagenmaker et al. 2013:21 – 23, 36 – 37). See TABLE 2.7 for vessels affected on the morning of 10 November.

Date	Estimated Time	Lake	Vessel	Occurrence	Lives Lost	Location
November 10th	12 am	Huron	*Wexford*	Foundered	20	Goderich, ON
November 10th	12 am	Huron	*James Carruthers*	Foundered	22	Grand Bend, ON
November 10th	12:30 am	Huron	*Motoa*	Stranded	0	Point Aux Barques, MI

TABLE 2.7. Vessels and crew affected by storm after midnight on 10 November (Brown 2002:203 –204; Wagenmaker et al. 2013:36).

Lake Superior received 36 foot maximum waves along Pictured Rocks National Lakeshore by 6 am on of 10 November. Within the hour, winds over southern Lake Huron decreased slightly allowing experienced captains more maneuverability against crashing waves and storm force winds. The computer simulation projected waves as high as 38 feet east of Munising Harbor around 8 am; Sylvania reported massive waves near Whitefish Point over Lake Superior at 10 am. Simultaneously, waves increased to 22 feet in the eastern basin pushing towards Buffalo as winds over Lake Erie pushed west to southwest (Wagenmaker et al. 2013:39).

Hurricane force winds pushed forward on the eastern side of Lake Erie. Winds were blowing southwesterly; maximum waves were estimated to be 24 feet. *Lightship 82* was lost close to Buffalo (United States Coast Guard 2014).

While the time is unknown, it is estimated it was lost close to midday, Monday, 10 November. Toledo's harbor water levels were 6 feet below normal; it is presumed that high winds pushed surging waters into Buffalo Harbor. Lake Michigan experienced a break in high winds after 13 hours of hurricane force gusts. Eastern Lake Erie still experienced hurricane gusts; Buffalo recorded experiencing winds as high as 70 knots (80 mph) around 2 pm. Winds finally began to subside close to noon on 10 November, though maximum waves still pushed 32 feet close to Marquette and Munising (Wagenmaker et al. 2013:24 – 27, 40). See TABLE 2.8 for the vessel lost midday on 10 November.

Date	Estimated Time	Lake	Vessel	Occurrence	Lives Lost	Location
November 10th	Midday	Erie	*Lightship 82*	Lost	6	Buffalo, NY

TABLE 2.8 Vessel and crew affected on 10 November, 1913 close to Buffalo Harbor (Brown 2002:203 –204; Wagenmaker et al. 2013:40).

Southwest Ontario dealt with the low pressure system for 16 hours. By four in the afternoon, Monday, 10 November, hurricane gusts on Lake Superior began to decrease, though they were still considered storm force winds. That evening, around 7 pm, the computer simulation indicates that the low pressure system began to move to the northeast across Ontario. The low pressure system was decreasing in power though storm gusts were still evident across Lakes Superior, Michigan, Erie, and Ontario; this can be seen in FIGURE 2.8. It was not until midnight, 11 November that the White Hurricane weakened its hold over the Great Lakes; it took four days for the storm to move into the northeast, near Quebec and disappear (Wagenmaker et al. 2013:24 – 27, 40, 42).

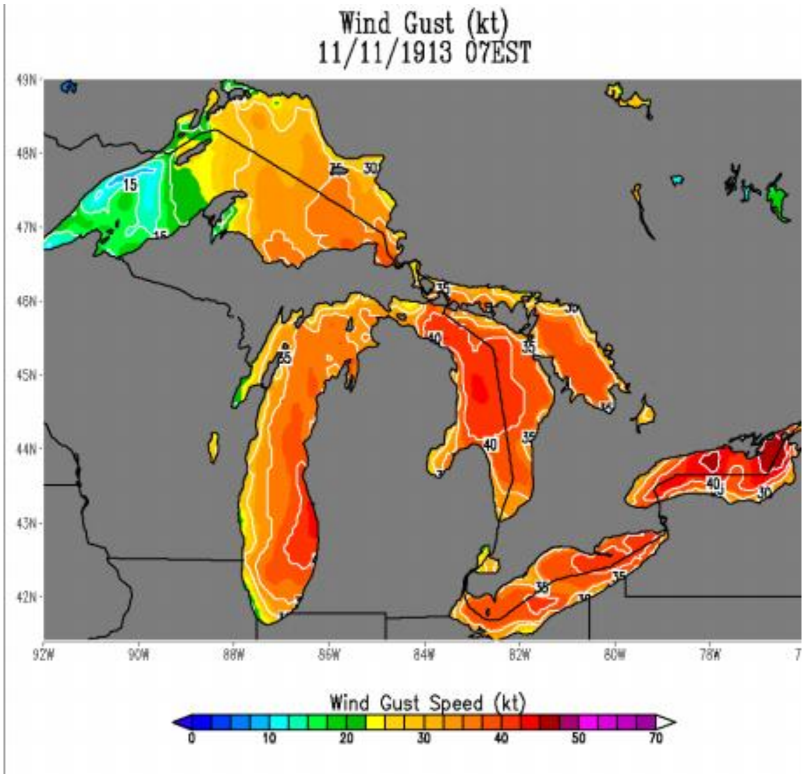


FIGURE 2.8. 11 November; storm dissipating (Wagenmaker et al. 2013:27).

The storm barely moved for 12 hours on Sunday night while still influencing wind and waves. By Monday morning, the storm's center was north of Toronto; the pressure was 28.79 inches Hg (975 millibars). The simulation's storm pressures are predicted to be fairly accurate; the computer placed the storm just west of the actual location and gave the storm's pressure 28.70 inches Hg (972 millibars). The storm did not move east until Monday evening; this made the storm weaken over the Toronto area. FIGURE 2.9 shows the front losing power and dissipating Monday evening. The simulation is surprisingly accurate compared to actual observations. Lack of atmospheric measuring technology meant that no upper atmospheric conditions could be gauged, including what the upper atmospheric high and low pressures were (Wagenmaker et al. 2013:15).

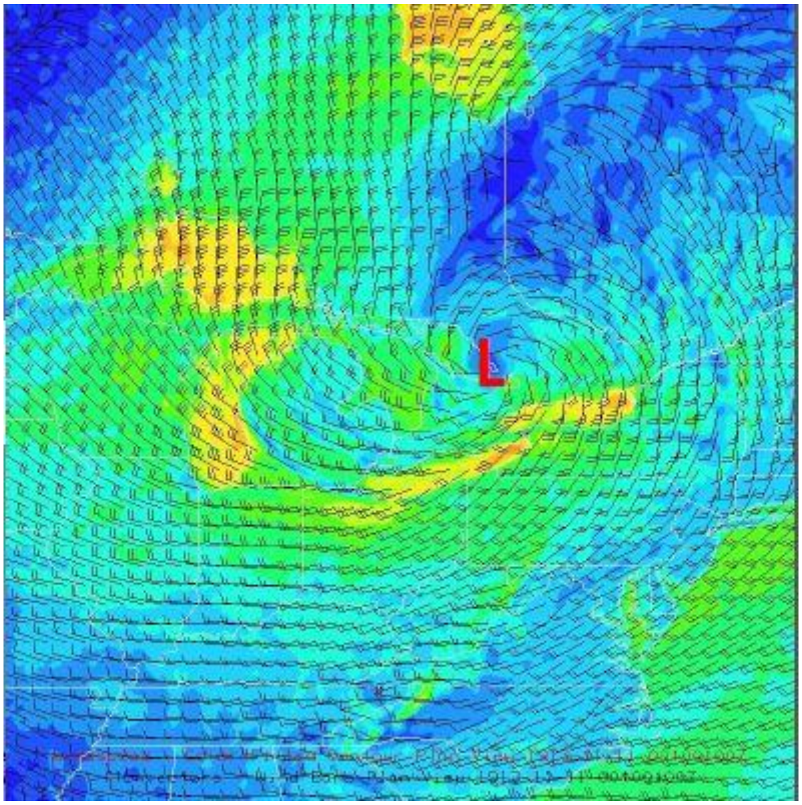


FIGURE 2.9. Monday, 7 pm, storm weakens and moves north (Wagenmaker et al. 2013:26).

The main front hit the lakes from the southeast on Sunday, 9 November. This resulted in hurricane winds and recurrent gusts over 80 miles per hour. Hurricane force is greater than 74 miles per hour (National Weather Service and NOAA 2013); the numerical simulation projected winds that were sustained hurricane force for hours at a time; Huron – 10 hours; Superior – 20 hours; Michigan – 13 hours; Erie – 16 hours. The computer simulation, combined with anecdotal evidence, attributes Lake Huron with wind gusts over 90 miles per hour on the evening of 9 November. That night, from 6 pm to midnight, a total of nine vessels and more than 200 people were lost in the storm. Southern Lake Huron experienced wind speeds from 45 knots to over 70 knots in a matter of hours (Wagenmaker et al. 2013:28, 37).

Waves of intimidating height accompanied hurricane winds across the Great Lakes. Survivors of the storm told of waves as high as 36 feet; these anecdotal waves were confirmed by the computer simulation as well as by wave theory (Wagenmaker et al. 2013:43). These huge waves drastically affected bulk carriers crossing the lakes. The larger the random wave, the more likely the breakpoint is farther offshore (Thornton and Guza 1983:5925). Researchers predict waves doubled in height on 9 November starting in the afternoon and increasing until evening. The space directly northwest of Michigan's eastern "thumb," the mouth of Saginaw Bay, Michigan, was riddled with large waves. Waves become larger when a lake is orientated in the direction of the wind since the wind has more fetch. Lake Huron runs north to south; with proper wind conditions, the waves reached as high as 36 feet, and with a return frequency of less than three and a half minutes. Significant waves occurred in intervals of 10 seconds (Wagenmaker et al. 2013:43).

The Great Lakes are not forgiving to storm-caught vessels. Rogue waves may occur in the middle of the Lakes, but captain and crew must also be wary close to shore as they must contend with shoals and bluffs. As the Great Lakes are inland seas; mariners have little sea room and nowhere to outrun a storm when one strikes.

Chapter 2 gave a quick comparison of gales on the Great Lakes and the Great Storm of 1913 as well as an overview of the storm's progression. This chapter introduced the destruction of the weather event in terms of people and vessels lost while compared to the wind forces and wave heights (Clark et al. 2013). Chapter 3 will set the theoretical bases for this thesis which postulates that wind direction and shipwrecked bow direction are related; the chapter looks at potential confounders that may interfere with the explanatory model.

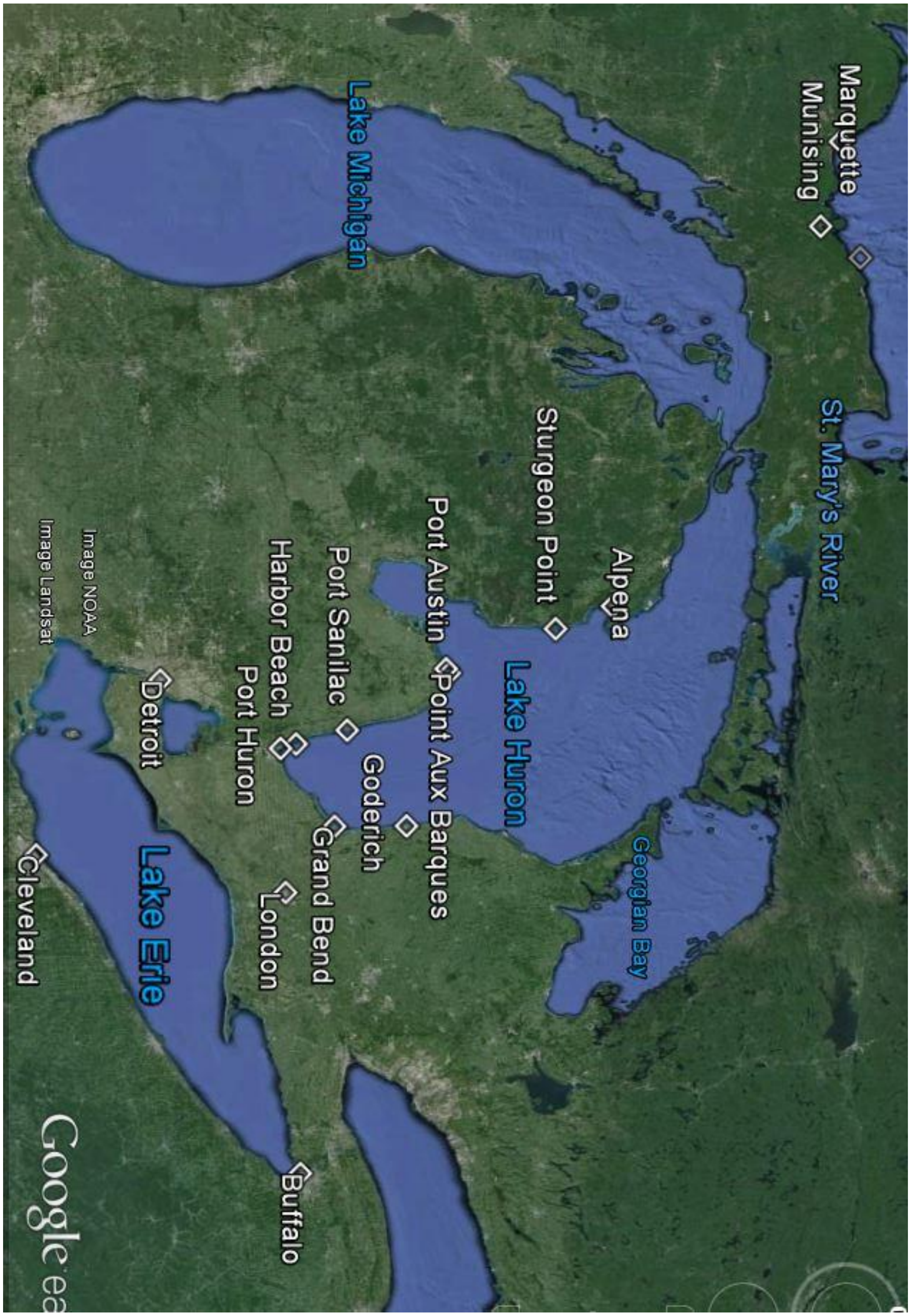


FIGURE 2.10. Cities, Lakes, Rivers of the Great Lakes Basin (Google Earth)

CHAPTER 3: GROUNDING WEATHER AND VESSELS IN THEORY

This thesis will rely on three theoretical approaches to supply the groundwork to the Great Storm of 1913 shipwreck-orientation explanatory model. This maritime disaster featured the convergence of two low pressure systems that resulted in the loss of hundreds of people and affected dozens of vessels. Yet despite sustained hurricane force winds, the affected vessels do not lie in perfect orientation with the historic storm winds. Therefore, this thesis has to discern how the crew, desperate for survival, overcame the predicted environmental transformations that affected the vessels during the initial wrecking event. To comprehend variables affecting the vessels, this thesis will explore the cultural transformations of risk management, disaster response, pre, and post depositional processes. Thompson states, “You don’t have to study many wrecks before you’re likely to notice some distinct patterns emerging….They include the size of the fleet operating….the level of technological development, the status of government regulation, and the attitudes and behaviors of those within the industry –the human factor” (Thompson 2000:9). There are variables that must be examined to help explain wrecking patterns.

RISK ASSESSMENT

This section looks at how corporations, government, and society view and assess risks. It is necessary to understand why mariners venture onto the lakes during stormy conditions before beginning to calculate an explanatory model for shipwreck orientation. As described, captains and crews generally work on the Great Lakes until the Lakes freeze over. General bad weather and cataclysmic squalls during the transitional months contribute to a seasonal bias of ships wrecked during the stormy months from fall to winter (Forsythe 2000:248). This section will look at risk assessment to explain why crew members, captains, and companies were willing to risk everything for one last run across the lakes before the shipping season ended. Risk is defined as “a systematic way of dealing with hazards and insecurities induced and introduced by modernity itself” (Beck 1992:21). In this context, modernity is analogous to 20th century American capitalism. Mariners often risk their safety for what may amount to one extra day of work (Thompson 2004:100).

Government allows risky behavior because without taking necessary risks, societies do not expand. Corporate groups, which take on a state-like presence, as well as government agencies must communicate with the public, and often turn risky behaviors into ritualized accepted behaviors for the sake of profit margins. There are acceptable and unacceptable risks in terms of jobs as well as how many people are affected by a risk (Crook 1999:170,173). Risk in American society becomes accepted when there is chance for financial gain. Risks are culturally and socially constructed, and perceptions of risk are created to maintain a certain way of life (Souza 1998:113-4). Mariners during the Great Storm of 1913 accepted risks when they went out into the November gale. They assessed their seamanship with the financial incentive to work longer.

Risk taking is part of Great Lakes shipping culture. Outdated equipment on vessels are not uncommon and even new vessels can easily fall victim to a powerful storm, despite the Coast Guard’s best effort to ensure vessel safety (Thompson 2004:368). Each time a ship leaves port, crew and company are betting on returning safely home with monetary rewards for their work. Crews bet against the chances of being lost at sea, a fate that would bring potential financial ruin to the owners, and devastation to the family of the crew (Souza 1998:113).

Shipping has high risks, but general good weather and high financial gain can overrule safe behavior. Risky behavior may be overlooked because it can be viewed as calculable and therefore, mariners can reason themselves into believing they are safe (Edwald 1991:202). With the right amount of luck, a captain may be fortunate with weather, crew competency, and fitness of vessel. Luck in multiple shipping events may contribute to overconfidence which may push a risk-taking captain and crew into a storm for which they are unprepared (Thompson 2004:353). There was a clear economic incentive to ship since people were being paid to ship cargo from Point A to Point B by the quickest route possible.

High risks tend to be measured on an individual scale, however, mariners are a sub-population of high risk individuals (Dean 1999:139). Individuals can be tricked into a false sense of security when high risk-experiences turn out favorably for them, or if risks seem minimal for the activity. A constant, favorable outcome can lower an individual's estimate of the actual amount of risk involved in an activity by adding bias to the decision making process, even if the individual once counted an activity as risky behavior (Souza 1998:115). This mentality can be seen when experienced sailors venture into storm-state waters, or when outdated vessels are still pushed for runs past their safe-use date. FIGURE 3.1 shows a captain taking risks in high-seas without a safety rope.

FIGURE 3.1. Captain Rob Munday on board unknown vessel in the mid-1940s (Walker 2013).

Outdated vessels may fall into the “one more voyage hypothesis” (Murphy 1983:75). This means that the ship was used for “one more voyage” past its safe-use limit. The reason for using vessels longer than their safe-use limit is because the longer a ship is used to work, the greater the economic return on the initial investment (Souza 1998:129). Even if a vessel can no longer be insured in a cost and benefit analysis, it was often historically more cost-effective to use the ship until it broke down past possible repair status than prematurely abandon the vessel and upgrade to a faster, more efficient ship. By 1913, metal ships were gaining popularity on the Lakes. Regardless of metal ships being popular, they were not the only vessels on the lakes; there were still many wooden vessels, such as *Louisiana* and *Halstead* (University of Wisconsin Sea Grant and Wisconsin Historical Society 2003). Wooden vessels were not structurally prepared for hurricane winds; these were hard conditions even for the most up-to-date vessels (National Marine Sanctuaries and NOAA 2013). This is especially true for wooden vessels with steam propulsion, as the hull worked, or distorted, it may move more than an engine’s tolerance, essentially leaving a vessel dead in the water (Royal Institution of Naval Architects 1860:65; Elliot Bay Steam Launch Co. 2002; Wooden Boat Forum 2002).

Great Lakes captains and crew know that they have a job that can become dangerous quickly. People bordering the Great Lakes have seen weather change rapidly once winter is close. Yet, even in the midst of a storm, not all sailors refuse to work. Crews had to trust the command of the captain and captains were put under enormous stress to make multiple runs across the Lakes before they froze (*Marine Review Vol. 43* 1914:433; Thompson 2000:331 – 368). There are typical characteristics associated with individuals in high-risk occupations. Such characteristics include: self-recruitment, strong traditions, and socially established norms of risk acceptance and risk behavior (Hovden 1987:54). Unfortunately, this can lead to a fatalistic attitude (Souza 1998:114). This attitude, and competition with other shipping companies, creates a push to make more runs across the Lakes than previous seasons. If mariners refuse work when there is a hint of storm weather, cargo would not reach its destination port on time. This would severely alter the livelihoods dependent on the movement of cargoes. Crews and captains felt compelled to push themselves on the Lakes in order to keep their jobs and had to adapt their mentality of how they viewed risk (*Marine Review Vol. 43* 1914:433).

DISASTER RESPONSE

This section looks at how people respond to disasters and how that may affect the outcome of shipwreck orientation. Part of the explanation encompasses the randomness that is associated with predictable responses from people under catastrophic stress. Non-cultural transformation processes have been studied in depth (Muckelroy 1976; Stewart 1999; Ward 1999; Wheeler 2002). N-transforms are quantifiable and the scientific method may be applied to them. Human behaviors are hard to measure; human responses in disaster scenarios do not follow a specific, quantifiable equation, especially with the different variables of a wrecking.

To grasp the processes that form the archaeological record, Muckelroy presented a flow diagram to show how organized artifact assemblages transform to the clusters of seemingly disorganized artifacts that are witnessed on archaeological sites, seen in FIGURE 3.2. Further, there have been studies that have begun to investigate behavior responses; this would come before “The Process of Wrecking” in Muckelroy’s model. Looking at human behaviors rather than solely environmental processes that affect a wrecked vessel offers a dynamic approach that creates “operational models reflecting the progress of a disaster” (Leach 1994:6). Through the process of evaluating human behaviors in disaster scenarios, a disaster response framework has been created that applies to maritime disasters and human responses.

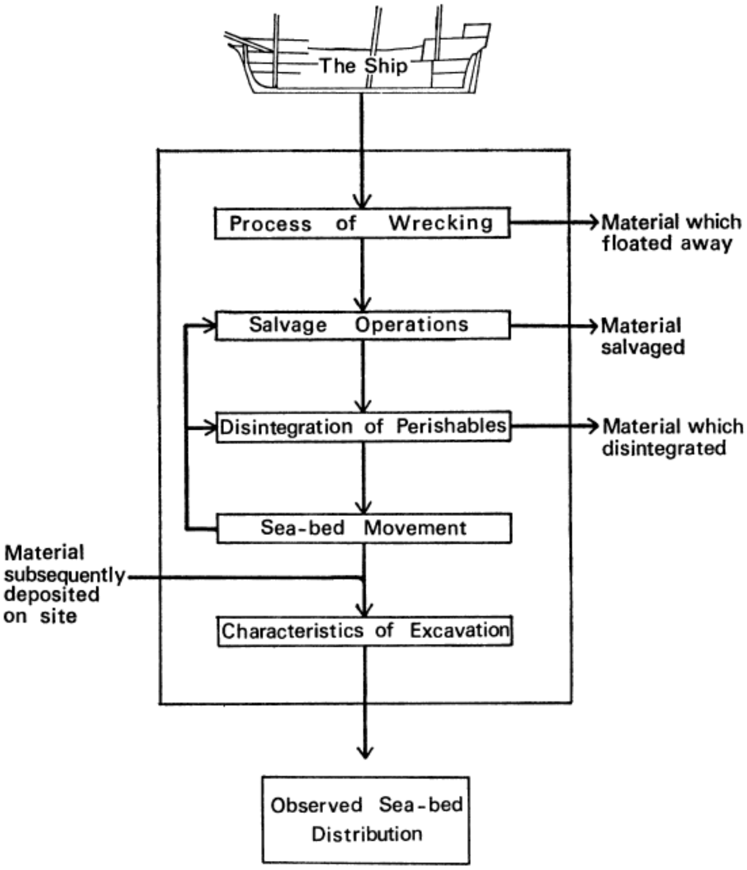


FIGURE 3.2. Muckelroy's 1976 Transformation Flow Diagram (Muckelroy 1976:282).

Disaster response is presented within the depiction of the ship that begins the flow diagram. If actions are significantly appropriate during the pre-wrecking process, it is possible to avoid the wreck entirely. Archaeologists must look further into the pre-wreck nature of a ship, its crew, and its contents; Muckelroy suggests that it would benefit archaeologists to begin looking at shipwreck sites with a consistent framework. This would aid a more scientific approach while trying to understand human behaviors (Gibbs 2002:1).

It is commonly perceived that there are two categories of shipwrecks: catastrophic and intentionally abandoned. Catastrophic wrecks are unintentional, be it through structural defects, explosions, founderings, strandings, or collisions. Leach's 1994 work represents the disaster and response framework; it applies to catastrophic shipwrecks. Gibbs first recognized and used Leach's framework which applied to maritime disaster framework,

1.) Pre-Impact Stage – The period before the disaster event.
    a. Threat Phase – When the possibility of the disaster is identified.
    b. Warning Phase – When the disaster is imminent.
2.) Impact Stage – During the disaster event and immediately afterwards.
3.) Recoil Stage – Commencing when the immediate threat to life has receded.
4.) Rescue Stage – When the person or group is removed from danger.
5.) Post-trauma Stage – Medium to long-term responses to the disaster (Gibbs 2006:4 –5).

Gibbs recognized that simultaneous to these disaster responses, there are environmental forces acting independently on the physical structure and contents of a vessel, plus cultural remains. Environmental factors are independent; the crew responds to environmental factors, though not always in a well thought-out fashion.

The pre-impact stage includes the training of the crew, which is comprised of the experience of the captain and crew as well as how much safety training had been practiced prior to the threat phase. In terms of the Great Storm of 1913, the pre-impact phase can include whether captains opted to go out in the storm, if they chose to dock their vessel at port, if they tried to outrun the storm until they got to an area that they assumed was a safe zone, or if they headed into the storm. Great Lakes' captains and crews know that November is a month of storms, referring to it as "the curse of the eleventh month" (Thompson 2000:207). Also key to the pre-impact stage is how the vessel was constructed and maintained, as well as the route used, equipment, stowage, type and density of cargo, hull material, propulsion type, and repairs of the vessel (Gibbs 2006:5).

The threat phrase begins when there is a physical threat. Once a hazard is recognized, the threat phase includes the short term aspect of people responding to the threat. Response actions are varied and include: complete failure to act on the hazard, acting in an appropriate manner, acting appropriately but unable to mitigate the threat, or not acting appropriately to the threat. It is possible to fail to recognize the threat as a true hazard, which in turn would encourage someone to misjudge suitable actions to take in response to the threat (Gibbs 2006:7-8). Gusts reaching 90 miles per hour are a high intensity risk factor, as vessels fought for hours before foundering. This includes the dynamics of a vessel under steam or sail. Experienced steam captains would head into the storm, presenting the reinforced bow to the waves in order to protect their hull from taking the brunt of waves. Heading into the waves also keeps the ship from being blown onto a lee shore or reef (Boatsafe 2009;Pascoe 2014).

The impact phase, after the hazard is considered imminent, may last seconds to hours depending on the conditions of the catastrophe (Leach 1994:25). The way a ship wrecks may be dependent on the crew reacting to a threat, environmental factors, or both. The wreck may be considered a reflection of the moments before the wrecking event. These actions may include heading a vessel into the wind or stranding a vessel on a nearby shore. It is possible, potentially for a steam powered vessel like *Wexford*, to lose engine power and then lose their footing in a storm. *Wexford* acts as an outlier for the explanatory model because despite being a steam powered vessel, it foundered on the lee side of the lake, opposite of the other steam powered vessels on Lake Huron (Carroll 2010:190). This may be because the vessel lost power and the captain was unable to head the vessel into the storm. Human actions prior to the wrecking and subsequent non-cultural and cultural transforms all are part of the final positioning of a wrecked vessel.

Many vessels in the Great Storm of 1913 were refloated after being stranded (*Marine Review Vol. 44* 1915:41 –44). Some of these vessels have historical records pinpointing the area that they were wrecked, but the exact bow and stern positioning prior to being removed from their stranded position is not known and, therefore, will not apply to this study for the sake of the explanatory model. Refloated vessels may be included in maps showing the effects of the White Hurricane without confusing explanatory maps as long as it is indicated in the map.

FORMATION AND DEPOSITIONAL THEORY

This section looks at the archaeological shipwreck site as a dynamic process. Vessels are affected by their environment. This may limit the amount of information attainable for an explanatory model and may make it impossible to create a predictive model. Since transformation processes may be detrimental to shipwrecks, it is necessary to create a systematic and methodological framework for surveys and excavations when examining wreck sites so that transferable observations may be applied to less detailed wreck sites.

The shoreline is riddled with wave activity; the hydrodynamic environment may change often between local climate patterns and intense storms surrounding vessels, this results in variable deterioration. Storms may be severely destructive to an archaeological site; multiple storms could leave a site permanently changed (Przywolnik 2002:150).

Maritime archaeologists must grasp formation theory because it deals with two major problems that have the potential to confuse researchers. Depositional theory looks at how materials pass from one systematic context to an archaeological site; what once was an on-going behavioral system transforms to a static behavioral process. Post-depositional and recovery processes look at what happens to the materials in the archaeological site as well as their spatial interrelationships between time and where they are deposited and when they are recovered. The process of discovery and recovery is not inherently perfect and can severely bias the archaeological record; this has the potential to skew the perception of the archaeologist (O'Shea 2002:212).

Prior to the depositional phase of a shipwreck, the crew, the vessel, and all of its contents operate within the same ongoing systematic context (Souza 1998:47 –48;O'Shea 2002:212). The pre-wrecking event entails the efforts of the crew to survive which may drastically over compensate storm forces. This can be seen when ships head into storm forces, or conversely when they lose power during the storm. Mariners struggling against the Great Storm of 1913 faced hurricane-force winds; their efforts during the storm may be reflected by vessels pointing into the wind if the sea anchors were used or if powered vessels headed into the storm.

Vessels that run aground may break apart and leave archaeologists to piece them back together in their original construction. These vessels may be more drastically affected by ice shove on a yearly basis and salvage efforts, which would alter their original orientation to shore. Other vessels may turn turtle and permanently capsize. This changes how the vessel sinks as it is possible that the capsized vessel will float several hours or days before sinking (Carroll 2010:145). This study encompasses some capsized vessels. *Charles S. Price* was the mystery ship that floated bottom up after the storm. The vessel did not sink for a few days and it was not until a diver went down to physically identify the ship that its true identity was known (*Port Huron Times-Herald* 1913:1). *Isaac M. Scott* and *Regina* also capsized (National Marine Sanctuaries and NOAA 2013). FIGURE 3.3 shows an upside down *Charles S. Price* prior to identification.

FIGURE 3.3. *Charles S. Price* turned turtle after November 1913 storm, Lake Huron (*Marine Review 43* 1914:432).

One approach that can be used for the broader understanding of depositional theory as well as within the context of this thesis is to classify wreck types. The map created by Brown in his book *White Hurricane: A Great Lakes November Gale and America's Deadliest Maritime Disaster,* is a map indicating which vessels were stranded and which ones foundered (Brown 2002:203). This thesis further divides the wrecks by indicating which stranded vessels suffered a total loss and which ones were capable of being refloated after the maritime disaster. How a vessel wrecked is revealing of the ferocity of the storm as well as the final contributions to the wreck site from the crew. Weather is revealing and needs to be part of shipwreck studies. "If the local weather and water conditions are known, or can be determined, a great deal can be predicted regarding the expected aspect and condition of the wreck, and the distribution of the wreckage. If they are not known, it may be possible to infer them from the condition of the wreck" (O'Shea 2002:213). Conditions of the Great Storm of 1913 were recorded;

meteorologists were able to record many of the conditions close to shore and in the larger towns. Survivors of the storm were able to tell their observations of the wind, gusts, and waves in the middle of the lakes. During the early 20th century, meteorologist had no way to accurately measure storm variables in the middle of the lakes where ships met their demise. The retrospective model is used as the backbone to the statistical analysis portion of this thesis.

Archaeological sites are riddled with extracting filters and scrambling devices. Extracting filters are “processes that remove material from the site so that they are not present for discovery,” and scrambling devices are “processes that move material from their primary context” (O’Shea 2002:214). Extracting filters are detrimental to archaeological interpretation because they physically remove evidence from a site. Scrambling filters tend to also disrupt archaeological interpretation, though this thesis will look at scrambling filters as part of the formulaic equation to explain site formation processes. Scrambling filters are not consistently “randomizing” nor do they always create “pattern diminishing effect.” Scrambling filters may introduce a consistent framework for organization in the site because many cultural and non-cultural transformation processes are inherently patterned (O’Shea 2002:214). This includes wind patterns, ice shove, salvage efforts, and wave action. These filters may affect how archaeologists view stranded vessels from the Great Storm of 1913. One drastic pattern is that the majority of strandings on the Great Lakes are stern to the beach, this includes a variety of wind and current directions (Wayne Lusardi 2015, elec. comm.). This scrambling filter may sort the difference between wrecks in severe storms versus wrecks that occurred during milder weather. Vessels by the shore may by more drastically altered by environmental factors that affect the vessels’ bow heading.

Non-cultural transformation processes can severely change a site. One non-cultural transformation process that is unique to cold climate areas is ice shove. This natural phenomenon is on-shore ice push; it tends to occur on lakes larger than five miles in diameter and is the result of wind, currents, and changes in temperature. It tends to occur close to spring when ice thaws and winds increase (Lake Ice 2014). When lake ice begins to break apart with increasing temperatures, it becomes light enough to be moved by strong winds. When the wind is in excess of 30 miles per hour, broken pieces of ice can pile on to the shore. When the foremost piece of ice breaches the shore, the ice behind the ice edge will ram the foremost ice and create huge ice piles pushing onto the shore. Strong winds can make ice surge onto the shore with enough force to destroy homes. This pile up has been recorded as high as 36 feet in low gradient shorelines (Kives 2013). Ice shove can affect shipwreck site location because it can push a wreck out of context if a wreck is shallow. If the on-shore ice shove is thick enough, it may push a storm-wrecked vessel out of its original context; though because the keel is often the heaviest assemblage and more likely to be buried by sediment, it may be less affected by the ice shove process.

Another non-cultural transformation process, similar to ice shove, is the occurrence of windrow ice on the Great Lakes. Ice is a powerful non-cultural transformation process. In winter, the Great Lakes glasses over with sheets of ice; the ice may be broken up from wave action and from icebreakers. Once a sheet of ice is broken into large chunks, the wind may move the ice into partly inclined floating masses called windrows (Hilton 2002:9). Windrows are similar to ice shove, except there is no contact with the shore.

LOUISIANA

Louisiana was the first vessel to be stranded by the Great Storm of 1913. Fortunately, the entire crew survived and the captain was able to recount the events leading up to the wrecking event. Captain McDonald hoped to protect his vessel and crew by heading into Washington Harbor, Washington Island, Lake Michigan. The wind pushed over 70 mph, which resulted in the vessel being unable to hold its anchors in heavy seas. The captain did not continue to drive into the storm, despite *Louisiana* being a steamer. He opted to drop anchor. The anchor cables would ultimately break, resulting in the vessel being pushed into the southeast part of the harbor by the storm (Wisconsin Sea Grant and Wisconsin Historical Society 2015). This may have been Captain McDonald's choice, to drop anchors rather than power into the storm, knowing that his vessel's engines would become ineffective in the storm. The wreck of the wooden bulk freighter, *Louisiana* lays parallel to shore on the northern end of Washington Island in Washington Harbor, though that may have not always been the case. Immediately after the wrecking event, the crew opted to stay in the vessel in hopes of riding out the storm since the waves were too high and unpredictable to make a safe journey to shore. By morning, however, the vessel caught fire and the entire crew had to jump ship in a life-saving raft to avoid being burned alive. Though there were doubt among the crew, all eventually made it safely to shore (Wisconsin Sea Grant and Wisconsin Historical Society 2015). *Louisiana* is close to shore today, so close that a lifeboat seems unnecessary. This perpetuates the idea that *Louisiana's* position may have significantly changed since its initial wrecking event.

Cultural transformations may be difficult to calculate since they can be unpredictable. Housing developments are now situated across the entire island and there are permanent residents that live on the peripheries of Washington Harbor. FIGURE 3.4 depicts the population settlement and *Louisiana* on Washington Island. A population close to a wreck site could increase cultural site formation processes on a wreck. Dredging also occurs in the harbor; therefore, it is possible that the vessel has been moved from its initial deposition context. Due to its proximity to the shoreline, it is likely that this vessel has been affected by non-cultural transformation processes. The bottom of the southeast harbor is bedrock, so it is likely that the vessel has not shifted drastically. Ice shove may be the most plausible culprit if the wreck has moved; yet the wreck is not as scattered and disarticulated as would be expected of ice shove.

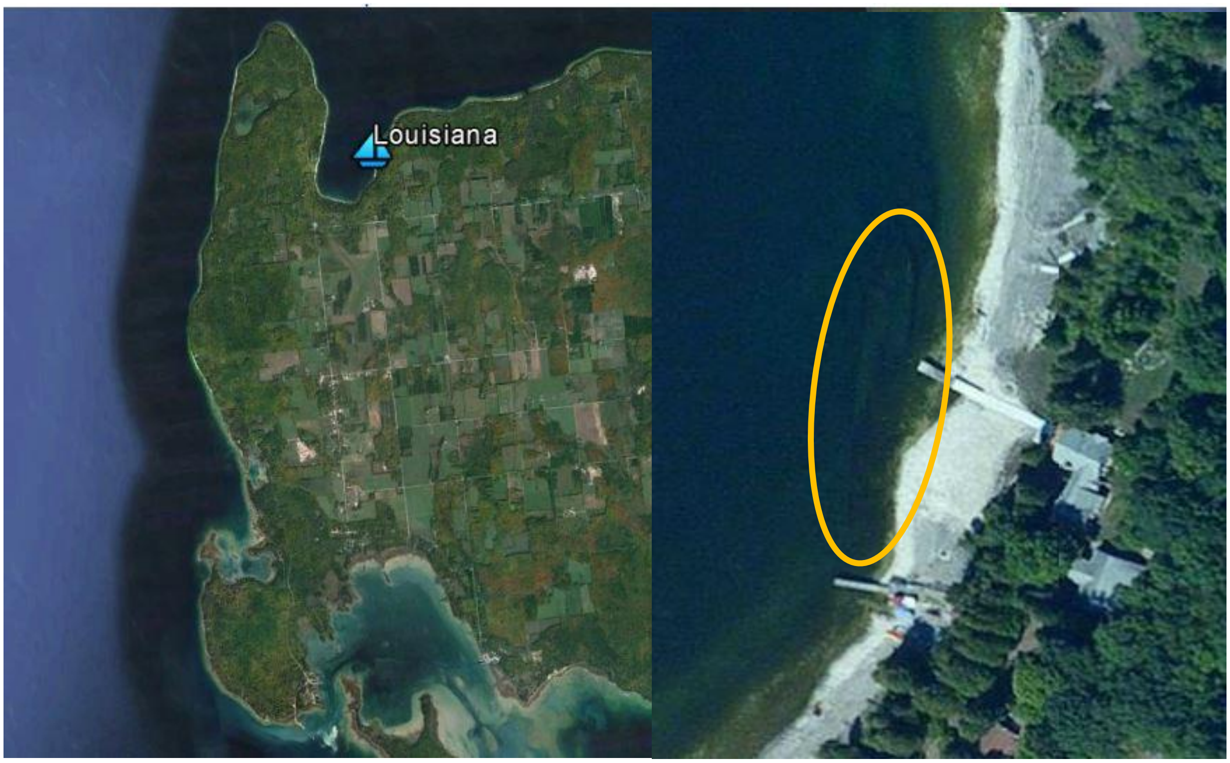


FIGURE 3.4. Sunken *Louisiana* today in context with housing development (Author; Google Earth; Flash Earth 2015).

Wooden vessels can be more fragile than composite and metal ships, and therefore, more likely to be broken up by wind, ice, or wave action (O'Shea 2002:217). The initial wrecking process, in the case of *Louisiana*, seems to have contributed tremendously to the damage of the vessel, though it is impossible to know for sure due to the fire that occurred almost immediately after the wrecking. Once *Louisiana* was wrecked, it lost timbers and disarticulated wreckage may have occurred. Wreckage of the wooden bulk carrier is distributed high on the beach, far from the water's normal reach, indicating a high intensity storm, or that the wreck has been salvaged. Since the keel is the backbone of the vessel that was used to understand the initial wrecking pattern, as seen in historical pictures as well as to determine the vessel's orientation today, which appears to differ slightly from the initial wrecking. The keel assembly is at the bottom (Dear and Kemp 2006:298) and unless the vessel has capsized, may be the best starting point to understand a vessel's orientation to shore.

Another cultural transformation process prevalent on the Lakes is salvage. After a shipwreck, companies or insurance agents may sell the wreck to salvors in an attempt to get the highest return from their wrecked vessel. Salvaging on the Great Lakes was common; this includes refloating a wrecked but intact vessel. The boiler of *Louisiana* is said to have been salvaged May 1920. In August 1920, salvagers also removed the engine and scattered much of the wreck in the process. The propeller, propeller shaft, and rudder are missing as well and may have been salvaged during this time (Wisconsin Sea Grant and Wisconsin Historical Society 2015).

The previous section worked through different site formation processes and theories that had the potential to have changed the wreck sites in the Great Storm of 1913. Behavioral archaeology comes to the forefront here as it is concerned with site formation processes that transform the systemic context of a site and the dynamic relationship between humans and cultural material. To understand artifacts and human behavior, it is first necessary to understand the processes and transformations that have occurred since deposition

CHAPTER 4: METHODOLOGY FOR AN EXPLANATORY MODEL

This thesis aims to create an explanatory model that will reveal a pattern between ships stranded and foundered during the Great Storm of 1913 and the storm fronts that wrecked them. To catalogue these wrecks, this project visits historic newspapers, Marine Reviews circa 1913, and secondary sources to find shipwrecks and their known locations. This thesis relied on modern technologies (GPS, UTM, Loran numbers) to ascertain accurate ship coordinates as well as understand the storm's movement from the recently created retrospective model. The final step of this thesis was to use the information stated above to see if there is statistical significance in the values of the shipwrecks' coordinates in correlation with the storm's movements.

This chapter opens by identifying the methodology used to gather and analyze information. This section will begin by looking at primary and secondary sources and later attempt to more accurately plot the wrecks on a macro scale creating maps to show wreck orientation. Regardless of the outcome, this thesis will immediately improve the current positioning of Great Storm of 1913 shipwrecks from Brown's 2002 shipwreck map of November, 1913 vessels (Brown 2002:203).

PRIMARY SOURCES

The maps created were twofold: one to show where each wreck location is, where the refloated vessels were, and where the missing wrecks are assumed to be; the other map created shows the orientation of each vessel that was wrecked during the storm. These maps fulfill different purposes: one to enhance the general positioning of the Great Storm of 1913 shipwrecks, the other to give a more scientific approach in the understanding of shipwrecks and storm movement in the Great Lakes to see if there is a pattern or equation that may be gleaned from the information to help explain the November, 1913 wrecking positions. Another possibility, if an explanatory model is created, is to see if unidentified shipwrecks may be later correlated to the storm that wrecked them. It should be noted that if an equation is found, it would only be applicable to the Great Lakes because of the meteorological differentiations worldwide.

It was necessary to create both maps using as many primary sources as possible rather than rely on secondary sources containing the positions of the Great Storm of 1913 shipwrecks for this study. Primary sources ensured that each vessel was individually examined and exact coordinates were found or approximated rather than gauged to be in the same position as that displayed in another map. There were exceptions, but most locations were gleaned from historic newspapers or from people who had actually visited these locations and saved the coordinates using GPS. Newspapers referenced included: *The Washington Times, The Ogden Standard, The Sturgeon Advocate, Buffalo News, Cleveland Plain Dealer, Sault Evening News, Detroit News, Globe,* and the *Port-Huron Times Herald.* Newspapers did not offer exact coordinates; they offered geographic references that were applicable when referring to a map. Newspapers varied from large papers interested in the entire scope of the November storm to local newspapers that only had information relevant to their geographic area. Multiple newspapers were helpful to cross-reference one another as well as add more information to the scope of individual shipwrecks (*The Ogden Standard* 1913:8; *The Washington Times* 1913:1). Historical newspapers occasionally offered exact mileage and heading to a shipwreck (*Buffalo News* 1914a:1;1914b:10; *Globe* 1913:1).

Another means to approximate the location of a wrecked and then refloated vessel, since coordinates were not available, was to use historical photographs that showed stranded vessels prior to being moved. These photographs were attained from repositories of Life-Saving

Stations, Wisconsin Sea Grant, Wisconsin Historical Society and Thunder Bay Research Collection (Webb 2004; Swayze 2014). There are no coordinates associated with newspaper and historical repository photographs, however, there seems to be a larger degree of accuracy with these historical photographs versus relying on newspapers for mileage between known and unknown locations. The advantage of photographs is that reference points in the photograph can still be seen and compared with satellite imagery from Google Earth and Flash Earth. FIGURE 4.1 shows stranded vessel *Louisiana* in the foreground of its location in Washington Harbor, Washington Island, Wisconsin. The remnants of *Louisiana* are still in place, or close to this same orientation today. In the background of the historical photograph lies stranded vessel, *Halstead*. *Halstead* was quickly refloated and reused, so coordinates are not available. The historical photograph allows for the vessel to be fairly accurately placed in Google Earth.

The steamer Louisiana after she was destroyed by fire, in Washington Harbor. In the background, the schooner Halsted can be seen on the beach.

FIGURE 4.1. Total loss *Louisiana* in foreground, stranded vessel *Halstead* in background (Swayze 2014).

With the exception of *Louisiana*, GPS coordinates for other wreck sites were not taken first-hand, the thesis relies instead on individuals or dive shops who visited these site (*Dive Site*

Directory 2008; National Marine Sanctuaries and NOAA 2013; Wayne Lusardi 2014, pers. comm.).

Since Brown's Great Storm of 1913 map was constructed (2002:203), *Henry B. Smith* has been located 30 miles due north of Marquette, Michigan. The coordinates have not been made publically available, however, a member of the exploration team gave the vessel's approximate orientation through degree headings as well as a digitized representation of the wreck as of 2013. In FIGURE 4.2, Ken Merryman and crew not only gave location and orientation, but a digital rendering of the vessel that shows the condition after a century resting at the bottom of Lake Superior at more than 500 feet in depth (Ken Merryman 2015, elec. comm.).

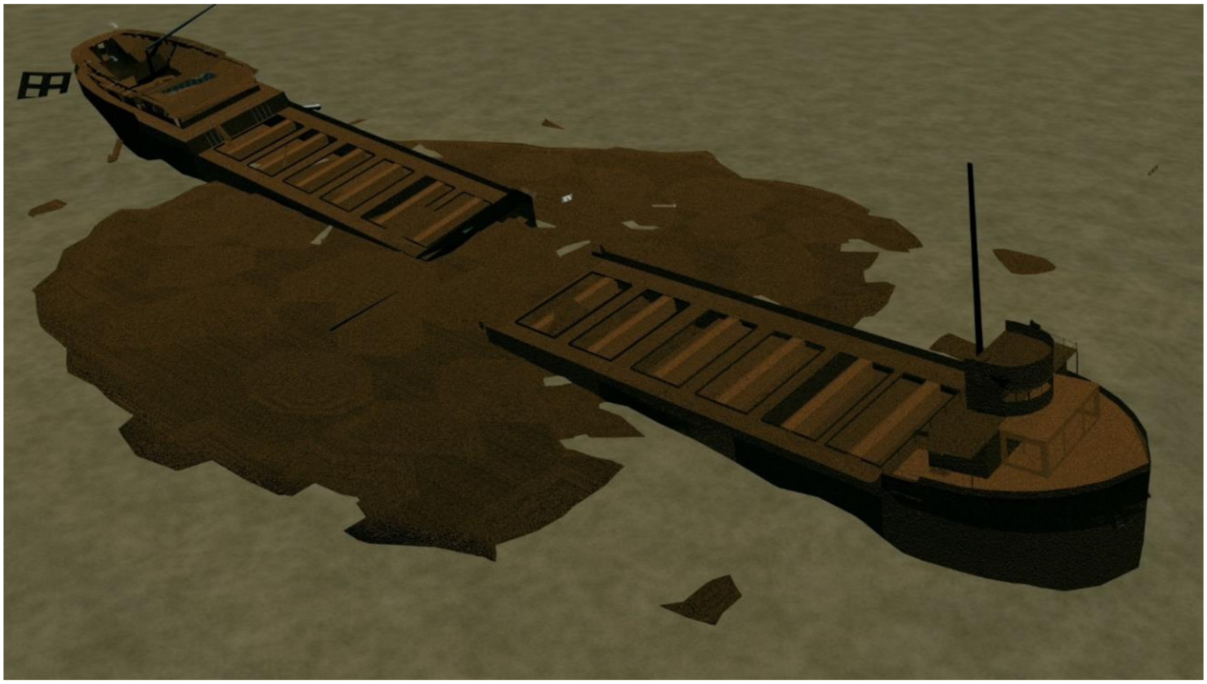


FIGURE 4.2. Digital rendering of *Henry B. Smith* after 2013 discovery (Courtesy of Ken Merryman 2015, elec. comm.).

Outside of references to the November, 1913 storm, this thesis is heavily rooted in theory and required the expertise of various archaeologists to build the explanatory model. Theory was a necessary component because it established what theories were already in place and what nautical archaeologists still called for to be researched (O'Shea 2002:211 –227; Gibbs 2006:1).

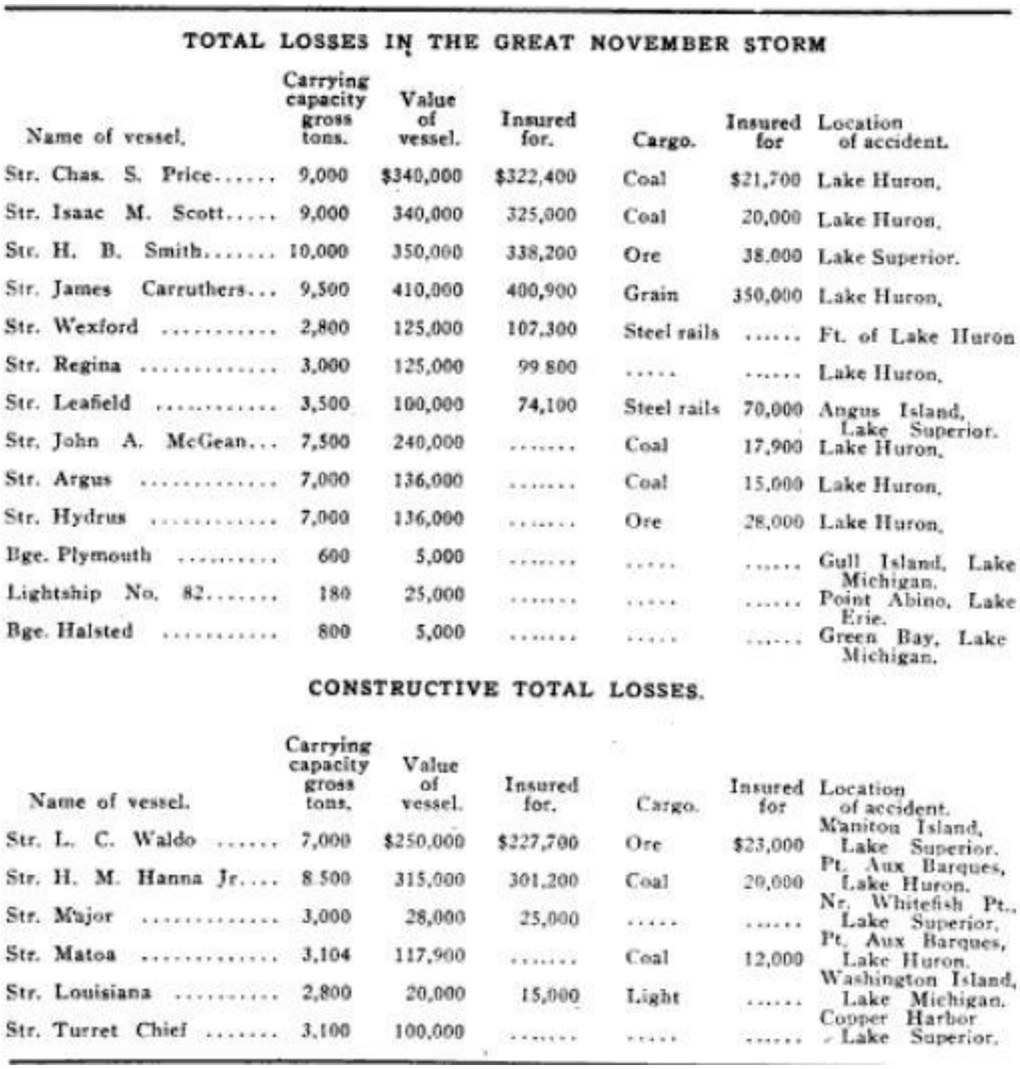
Looking at theory ensured that necessary components of factors influencing the wrecking process were examined as well as cultural and non-cultural transformation processes that affected the vessel at the post-depositional stage (Schiffer 1975:838 –841;Muckelroy 1976:282 – 288). These theories look at the wrecking process as a series of stages that could be broken down to encompass the different factors that affected the vessel's state in the archaeological record. Other theories explored looking at the human element in terms of disaster response. Disaster responses catalogue the actions people go through and the percentages of people able to make responsible or hazardous decisions during a time of crisis. The stages of disaster response delved into a psychological factor that often are neglected when deciphering the clues of a shipwreck (Gibbs 2006:6).

Theories surrounding maritime disaster events, produced thesis' variables. These variables must always be taken into account during any analysis and may explain why the November, 1913 shipwrecks may not align in a predictable manner. This thesis is a hypothesis so therefore may be proven null. If proven null, there needs to be a thorough understanding why associated randomness of shipwreck founderings may be impossible to explain.

SECONDARY SOURCES

Secondary sources provided the best way to understand the ferocity of the storm in an already analyzed manner. The first sources read was David Brown's *White Hurricane* (2002) and Frank Barcus' *Freshwater Fury* (1986). These sources gave an overall understanding of the storm, offered good reference sections on the storm, and furnished a base for what had not been covered concerning the Great Storm of 1913. These sources provided excellent information about the storm's movement, firsthand accounts of those who survived the storm, and the general placement of each wreck. Maps from Brown and Barcus were informative and helped visual learners understand the impact of the storm. The sheer volume of stranded and foundered vessels initiated the need to make an updated map. Vessels such as *C. W. Eliphicke* and *Donaldson*, which had wrecked on October 21, 1913 and were made impossible to salvage by the Great Storm of 1913, did not need to be included (*Marine Review Vol. 44* 1915: 41 –42; Brown 2002:203; Wachter and Wachter 2003:76).

Sources that also aided in filling the information gap were *Marine Review Vol. 43* and *Marine Review Vol. 44.* These were written in 1914 and 1915, respectively. These sources reviewed and interpreted crucial events of the previous year in the Great Lakes. The *Marine Reviews* not only gave the location of the vessels stranded, foundered, and refloated, but offered causality count, first-hand accounts from captains, and the financial costs of the storm. The *Marine Reviews* attempted to unravel why so many mariners and vessels were affected, and ultimately, examined the unprecedented ferocity of the storm (*Marine Review Vol. 43* 1914: 430 –444; *Marine Review Vol. 44* 1915: 41 –44). FIGURE 4.3 differentiates between the “Total Losses” and the “Constructive Total Losses” after the Great November Storm. The chart includes information such as carrying capacity, value of the vessel, what the vessel was insured for, the cargo, what the cargo was insured for, and the location of the accident, this being the most important information for the report. The cargo of each vessel was also important as it impacted whether the vessel was light or loaded, which was one of the factors in determining how easily a vessel was affected by the storm (*Marine Review* 1914:439).



TOTAL LOSSES IN THE GREAT NOVEMBER STORM

Name of vessel.	Carrying capacity gross tons.	Value of vessel.	Insured for.	Cargo.	Insured for	Location of accident.
Str. Chas. S. Price	9,000	$340,000	$322,400	Coal	$21,700	Lake Huron.
Str. Isaac M. Scott	9,000	340,000	325,000	Coal	20,000	Lake Huron.
Str. H. B. Smith	10,000	350,000	338,200	Ore	38.000	Lake Superior.
Str. James Carruthers	9,500	410,000	400,900	Grain	350,000	Lake Huron.
Str. Wexford	2,800	125,000	107,300	Steel rails	......	Ft. of Lake Huron
Str. Regina	3,000	125,000	99 800	.....	......	Lake Huron.
Str. Leafield	3,500	100,000	74,100	Steel rails	70,000	Angus Island, Lake Superior.
Str. John A. McGean	7,500	240,000	....	Coal	17,900	Lake Huron.
Str. Argus	7,000	136,000	....	Coal	15,000	Lake Huron.
Str. Hydrus	7,000	136,000	....	Ore	28,000	Lake Huron.
Bge. Plymouth	600	5,000	....	.....	......	Gull Island, Lake Michigan.
Lightship No. 82	180	25,000	....	.....	......	Point Abino, Lake Erie.
Bge. Halsted	800	5,000	....	.....	......	Green Bay, Lake Michigan.

CONSTRUCTIVE TOTAL LOSSES.

Name of vessel.	Carrying capacity gross tons.	Value of vessel.	Insured for.	Cargo.	Insured for	Location of accident.
Str. L. C. Waldo	7,000	$250,000	$227,700	Ore	$23,000	Manitou Island, Lake Superior.
Str. H. M. Hanna Jr.	8 500	315,000	301,200	Coal	20,000	Pt. Aux Barques, Lake Huron.
Str. Major	3,000	28,000	25,000	.....	......	Nr. Whitefish Pt., Lake Superior.
Str. Matoa	3,104	117,900	....	Coal	12,000	Pt. Aux Barques, Lake Huron.
Str. Louisiana	2,800	20,000	15,000	Light	......	Washington Island, Lake Michigan.
Str. Turret Chief	3,100	100,000	....	.....	......	Copper Harbor Lake Superior.

FIGURE 4.3 Total and Constructive Losses for Vessels of 1913 Storm (*Marine Review Vol. 43* 1914:439). This is not an inclusive list of stranded vessels.

Other secondary sources that proved to be invaluable were sources created by NOAA in anticipation of the 2013 centennial of the 1913 storm. These sources included information such as where the vessels are located today, modern assessments of how winds and gales are measured, interpretation of the storm and vessels affected, and how lake-effect snow works in conjunction with warm and cold air masses (National Marine Sanctuaries and NOAA 2013; National Weather Service and NOAA 2013; NOAA 2013a; NOAA 2013c). These sources added a sense of reliability to the general understanding of the storm as they were created by an institution rooted in the exploration of maritime history as well as meteorological sciences. They had the most up-to-date information concerning the “meteorological bomb” that hit the Great Lakes, November, 1913 (Clark et. al 2013; Wagenmaker et al. 2013:1 –45). This information included the transformation in thought from believing that there was a total of three fronts, two polar fronts and a warm front that resulted in the Great Storm of 1913 (Brown 2002:42, 213) to a more sophisticated manner of understanding the storm, which showed that the Lakes had been retaining heat, which in turn reacted with the low pressure fronts titled the “Pre-Storm” and eventual “White Hurricane” which crossed the Great Lakes Basin (Clark et. al 2013; Wagenmaker et al. 2013:7 –14).

Updated information adds insight into the storm and offers a jumping-off point where new research can attempt to unravel more about the historic storm. This thesis would not have been possible without NOAA and their collaborations with other researchers to re-look at the Great Storm of 1913.

Since this thesis is trying to create an explanatory model pertaining to the shipwrecks of the Great Storm of 1913 and the low pressure fronts that caused it, meteorological climate jargon was necessary to understand and use. Climatology uses its own set of definitions, however, there is little debate between these definitions. Regardless of the definition, various sites were used to create a common knowledge background for this thesis, including NOAA and Michigan Sea Grant (NOAA 2013c; Michigan Sea Grant 2013).

MACRO MAP

Prior to the creation of the orientation map, an updated map of the Great Storm of 1913, and the ships that it wrecked, the ships that were refloated, and the vessels still missing, was created. Older maps were helpful but were not always accurate. Problematic issues in older maps included: incorrect shipwreck locations, no differentiation between what wrecks had been found and which ones were still missing, and maps which included shipwrecks that were not actually caused by the November, 1913 storm. FIGURE 4.4 shows the most popular Great Storm of 1913 map.

To remedy the situation, a map was created that did not use any references from earlier secondary sources. The updated map was created solely from newspapers, *Marine Reviews Vol. 43* and *Vol. 44*, historic photographs, and from people who dove on the wrecks recreationally and scientifically.

The new map was made in Google Earth because it has the ability to put in exact coordinates, show the reefs, shoals, and points where vessels wrecked, and importantly has a built in distance finder while allowing for multiple data layers. The first wreck added to the map was *Louisiana*; the reasoning behind this was that this was the only site that had been visited and dived on by the author, it referenced a first-hand account, and it can be seen in Google Earth. Brown’s 2002 map mistakenly shows *Louisiana* on the eastern side of the Door County Peninsula when the wreck is actually in Washington Harbor on Washington Island. The placement marker is put directly in the center of the wreck. While researching *Louisiana*, a picture was found that had *Halstead* in the background (Swayze 2014). Using Google Earth in conjunction with knowledge of the Washington Harbor area allowed for the *Halstead* placement marker to be approximated on the map. FIGURE 4.5 shows a marker of the vessels on the updated map.

FIGURE 4.4. Depiction of vessels lost during the Great Storm of 1913 (Brown 2002:203).

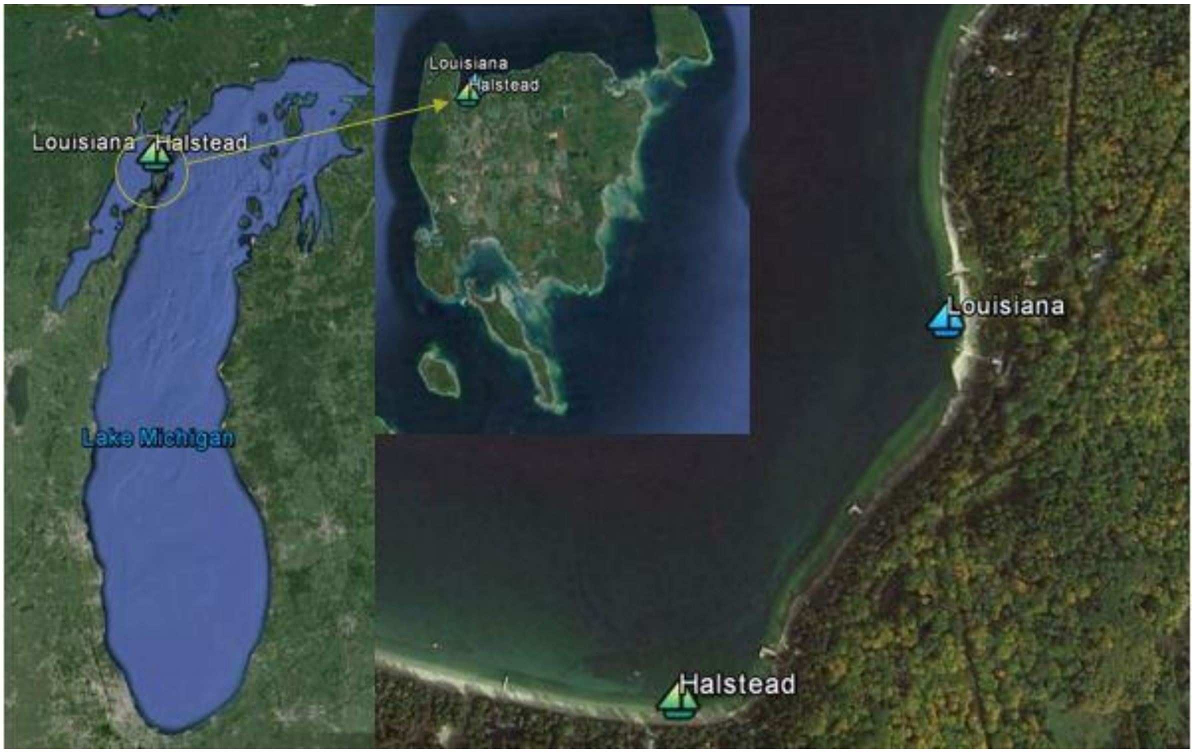


FIGURE 4.5. Location of *Louisiana* and *Halstead.* Blue indicates the vessel is still there, green indicates the vessel has been refloated or rebuilt.

Marine Reviews Vol. 43 and *Vol. 44* were the next sources read to see what belonged on the shipwreck map. These reviews are published annually since the November storm was so significant, more details of it were given in the following year (*Marine Review Vol. 44* 1915:41 – 44). These were good sources because they listed every accident on the Lakes and described where the accident was, so long as the vessel was not still missing. Even if the vessel was missing, the source had information regarding where the vessel was assumed to be. From these sources, a list was compiled of all the shipwrecks that were affected during the storm. From there, it was a matter of finding each shipwreck in a newspaper source concerning its whereabouts or look to modern sources to find the exact coordinates of a wreck. Shipwrecks were organized based on where they foundered or stranded. From there, each area was researched and put into a Google Earth map.

The other vessels affected by the November storm on Lake Michigan were *Plymouth* and *Pontiac.* The older map showed *Plymouth* on the northwest side of Washington Island, Green Bay. Historic newspapers indicate *Plymouth* and crew were lost close to Gull Island, Lake Michigan (*The Washington Times* 1913:1; *Marine Review Vol.* 43 1914:432, 439). The older map did not include *Pontiac*, which was alleged to have been stranded on the shoals by modern day Mackinac Bridge (*Marine Review Vol. 43* 1914:438). Newspapers indicate that there was not as much lake traffic on Lake Michigan. Despite many people purposely avoiding Lake Michigan during the storm, there was still much damage. Not only did *Pontiac* wreck and *Louisiana* catch fire after pounding into the shoals (Cooper 1989:93 –96), but *Plymouth* foundered. In addition, multiple people who tied their boats carefully to the docks lost their vessels due to the 2-inch cables breaking, adding these unnamed victims to the storm (*Sturgeon Bay* Advocate 1913:1) FIGURE 4.6 shows the stranded and foundered vessels in Lake Michigan. TABLE 4.1 shows source information for each wreck location.

FIGURE 4.6. Vessels stranded and foundered in Lake Michigan. Green indicates the vessel has been refloated or rebuilt, red represents that the vessel is lost.

Vessel	Source Information
Louisiana	Cooper 1989:93
Halstead	*Sturgeon Bay Advocate* 1913: 1; *Washington Times* 1913:1; Swazye 2014
Plymouth	*The Washington Times* 1913:1; *Marine Review Vol.* 43 1914:432, 439;
Pontiac	*Marine Review Vol. 43* 1914:438

TABLE 4.1. Vessels associated with source information on Lake Michigan.

Lake Ontario was the only Great Lake to come away unscathed after the Great Storm of 1913. Lake Erie had one ship founder, *Lightship Vessel No. 82* (*The Ogden* Standard 1913:8; *The Washington Times* 1913:1; *Marine Review Vol. 43* 1914:439; Berger and Dempster 2002:88). The rest of the vessels affected on Lake Erie were stranded and able to be refloated in the following days. One such vessel was the *G. J. Grammer* (*The Washington Times* 1913:1; *Marine Review 43* 1914:436 –437). Other vessels in close proximity to Lake Erie included those that were stranded in the St. Clair River, close to Detroit, and in Lake St. Clair; these vessels included: *Robert Fulton, Victory, W. G. Pollock,* and *Saxona* (*The Washington Times* 1913:1; *Marine Review Vol. 43* 1914:437 –439). The updated map took out vessels *C. W. Elphicke* and *Donaldson* because they had been wrecked on October 21, 1913 (*Marine Review Vol. 43* 1914:482; *Marine Review 44* 1915:41). The updated map also moved *Saxona* up the St. Clair River rather than in Lake St. Clair (*Marine Review Vol. 43* 1914:439). FIGURE 4.7 shows an updated version of Lake Erie, Lake St. Clair, and the St. Clair River. TABLE 4.2 shows vessels associated with source information on Lake Erie.

FIGURE 4.7. Depiction of vessels stranded and foundered in Lake Erie, St. Clair River, and Lake St Clair. Blue indicates foundered, green indicates refloat or rebuilt.

Vessel	Source Information
Lightship Vessel No. 82	*The Ogden Standard* 1913:8; *The Washington Times* 1913:1; *Buffalo* News 1914:1; *Marine Review Vol. 43* 1914:432, 440; Berger and Dempster 2002:88
G. J. Grammer	*The Washington Times* 1913:1; *Marine Review Vol. 43* 1914:436 –437
Robert Fulton	*The Washington Times* 1913:1
Victory	*Marine Review Vol. 43* 1914:438
W. G. Pollock	*Marine Review Vol. 43* 1914:437
Saxona	*Marine Review Vol. 43* 1914:439

TABLE 4.2 Vessels associated with source information on Lake Erie.

Lake Huron was hit the hardest by the Great Storm of 1913 in terms of lives lost and vessels foundered. On 9 November, from 6 pm until midnight, nine large vessels and over 200 men were lost to the storm (Wagenmaker et al. 2013:37). This was the most deadly six-hour period during the November storm. The updated map changes include some minor variations in vessel location based on differences gauged in newspapers versus the popular November storm map. A minor change is for the vessel *J. M. Jenks*, which had previously been located right outside of Midland, in a pocket of the Georgian Bay. The new map shows *J. M. Jenks* a few miles north of Midland; newspapers reported that *J. M. Jenks* had been stranded in the area of Midland but not in port (*The Washington Times* 1913:1). The other reasoning for this change is because in a storm with 90 mph gusts, it is hard to imagine that a vessel would have been able to make a tight turn to get into port. Another source says the vessel was a few miles north of Midland (Heden 1966:37).

Another change in the Lake Huron map is the more drastic repositioning in a few vessel locations. *John A. McGean* was originally shown to be north of the Oscoda Charter Township and it has been moved to be just east of Port Austin. This change comes directly from a modern day Maritime Waterway Trail, which has the vessel east of Port Austin; this location has coordinates that put the vessel southeast of Saginaw Bay (Michigan Heritage Water Trails 2014; Wayne Lusardi 2014, pers. comm.). The map also includes *Lightship Vessel No. 61*, which was stranded at the mouth of the St. Clair River; this vessel had not been included previously (*The Washington Times* 1913:1; Brown 2002:203).

The next relocated vessel was *A. E. Stewart*, taken out of the Lake Huron map and put into the Lake Superior map. The older map indicated the vessel was lost south of Thunder Bay when historical newspapers indicate that the vessel was actually stranded and refloated in Whitefish Bay, Lake Superior (*The Washington Times* 1913:1; *Marine Review Vol. 43* 1914:438). The vessel that was close to where the old map indicated *A. E. Stewart* to be was *Arcadian*, which was a vessel stranded on the reefs outside Sulphur Island, in Thunder Bay, Michigan (*The Washington Times* 1913:1).

The last alteration in the Lake Huron map is solely an interpretative difference between the ideas of where *James Carruthers* and *Hydrus* lie, as neither of these vessels have yet been found. The older map show *James Carruthers* and *Hydrus* in close proximity to *Wexford*, which are all in the southeastern side of Lake Huron. Research indicates that *James Carruthers* was en route to Midland, Ontario. This city is in the southeast corner of Georgian Bay. *James Carruthers* was one of the newest vessels on the Lakes; the vessel was heavy and built with extra steel to ensure seaworthiness (*Marine Review Vol. 43* 1914:435). This map indicates that the vessel foundered close to the turning point to get into Georgian Bay. The entrance to the Bay is small and with sustained gale force winds, the updated maps indicate the vessel was unable to make the turn. The other interpretive change goes with *Hydrus,* which was southbound to the St. Clair River (*Marine Review Vol. 43* 1914:435; NOAA and Regional Collaboration 2013). Rather than put the vessel close to *Wexford,* the updated map puts *Hydrus* southbound and on the western side of Lake Huron because that is where the strongest gusts were pushing (Wagenmaker et al. 2013:16 –27). FIGURES 4.8, 4.9, and 4.10 show the updated Lake Huron maps. TABLE 4.3 shows the source information for vessels affected by the storm on Lake Huron.

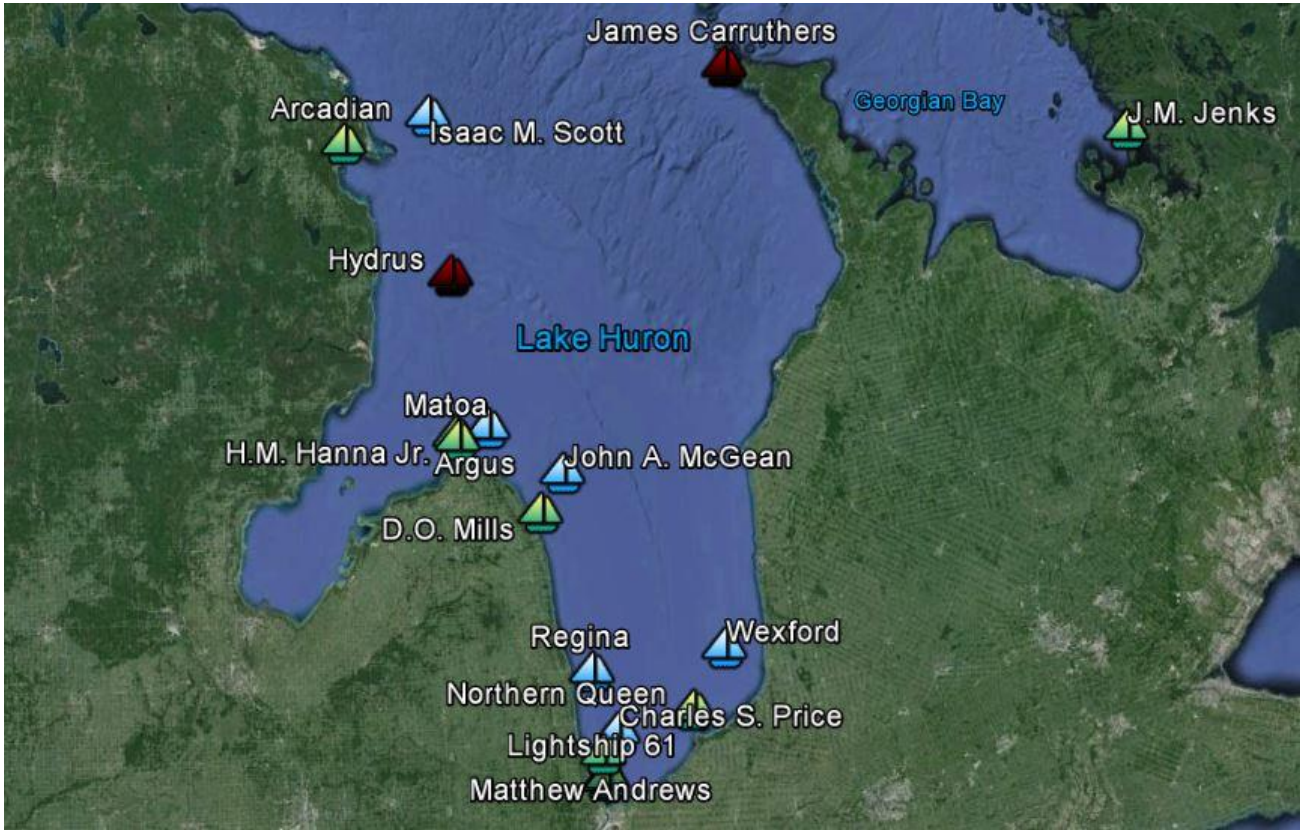


FIGURE 4.8. All recorded vessels lost on Lake Huron. Blue indicates the vessel is still there, green indicates the vessel has been refloated or rebuilt, red represents that the vessel is still lost.

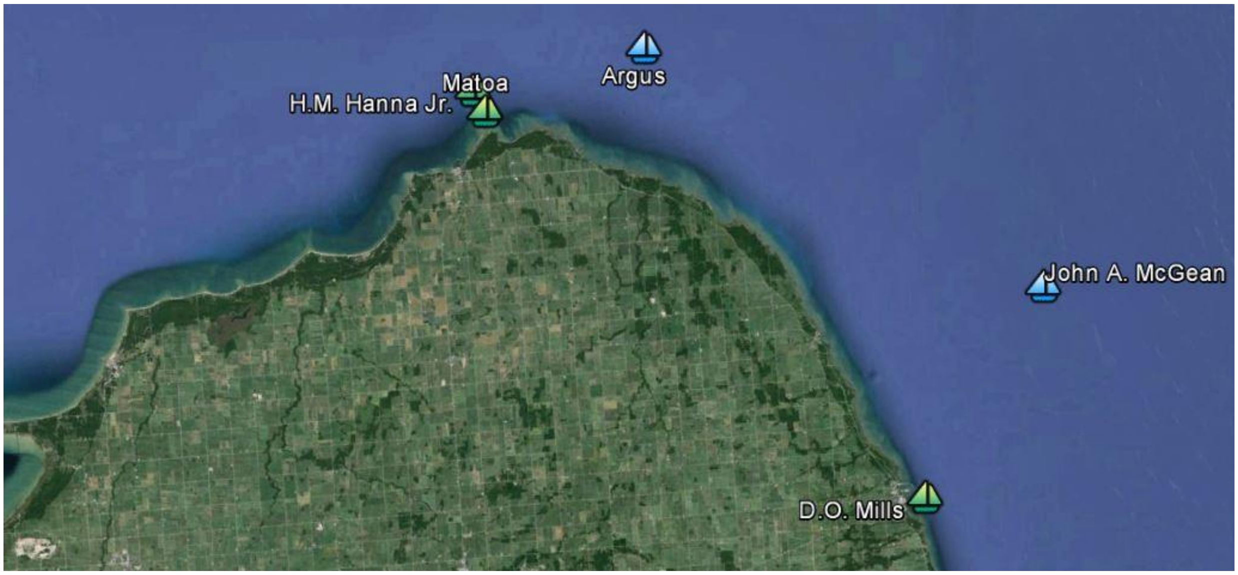


FIGURE 4.9. Detail of western Lake Huron. Blue indicates the vessel is still there, green indicates the vessel has been refloated or rebuilt.

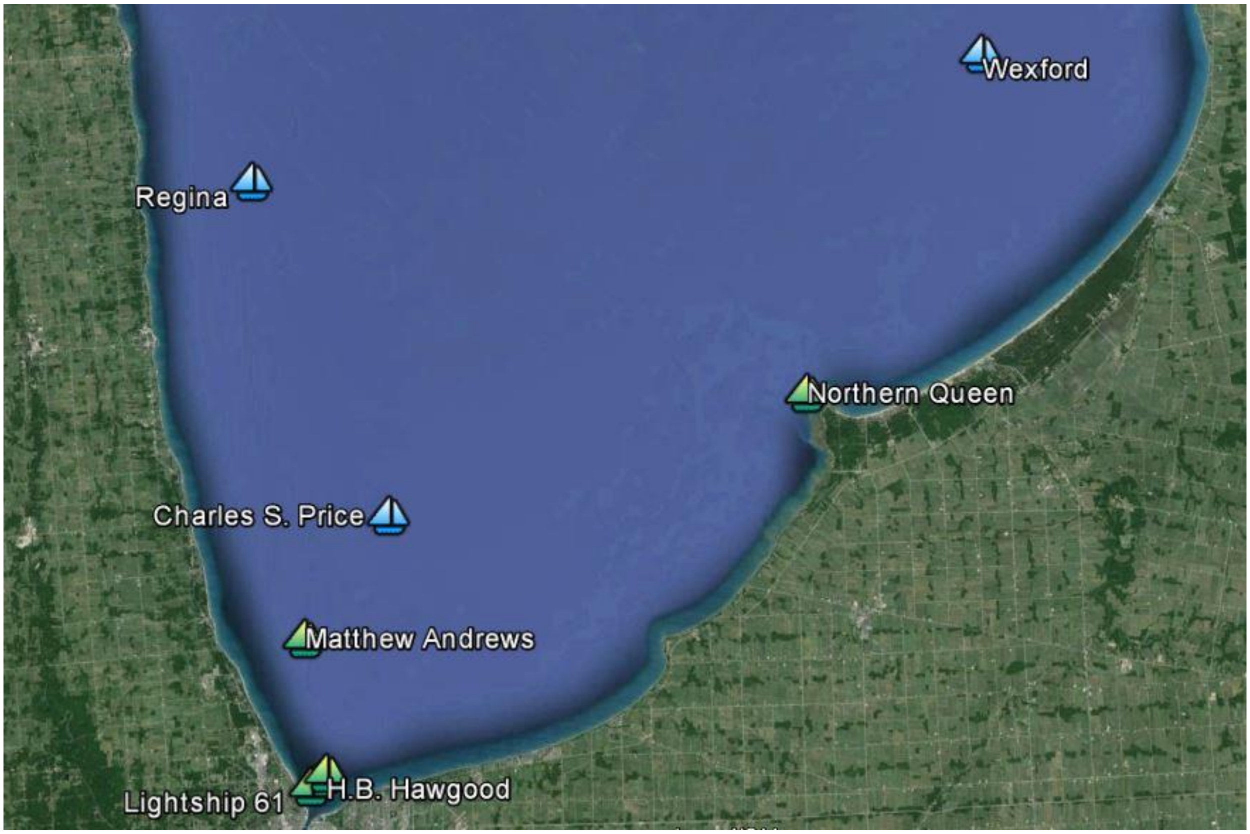


FIGURE 4.10. Detail of southern Lake Huron. Blue indicates the vessel is still there, green indicates the vessel has been refloated or rebuilt.

Vessel	Source Information
J. M. Jenks	*The Washington Times* 1913:1; *Marine Review Vol. 43* 1914:438
James Carruthers	*Marine Review Vol. 43* 1914:435
Isaac M. Scott	National Marine Sanctuaries and NOAA 2013; Wayne Lusardi 2014, pers. comm.
Arcadian	*The Washington Times* 1913:1
Hydrus	*Marine Review Vol. 43* 1914:435; NOAA and Regional Collaboration 2013
Matoa	*The Washington Times* 1913:1; *Marine Review Vol. 43* 1914:432
H. M. Hanna Jr.	*The Washington Times* 1913:1; *Marine Review Vol. 43* 1914:430, 443
John A. McGean	Michigan Heritage Water Trails 2014; Wayne Lusardi 2014, pers. comm.
D. O. Mills	*Marine Review Vol. 43* 1914:438
Wexford	Dive Site Directory 2008
Regina	*Marine Review Vol. 43* 1914:439; Wayne Lusardi 2014, pers. comm.
Charles S. Price	Wayne Lusardi 2014, pers. comm.
Northern Queen	*Maritime Review Vol. 43* 1914:439
H. B. Hawgood	*The Washington Times* 1913:1; *Maritime Review Vol. 43* 1914:437
Matthew Andrews	*The Washington Times* 1913:1
Lightship Vessel No. 61	*The Washington Times* 1913:1
Argus	Jared Diamond 2015, elec. comm.

TABLE 4.3. Source information for vessels affected by the storm on Lake Huron.

The next section of the map is St. Mary's River. The original map showed *F. G. Hartwell* and *J. T. Hutchinson* at the northwest side of the river; it showed *Meaford* at the bottom of St. Mary's River. Newspaper sources indicate that *Hartwell* and *Hutchinson* are in the correct position before being refloated, however, the sources indicate that *Meaford* was in the second northern-most bend the St. Mary's River (*Marine Review Vol.* 43 1914:439). Another difference in the maps is the placement of *Scottish Hero*. The older map said the location was unknown and it was assumed that it was lost somewhere in Lake Superior. Newspaper sources say, "The steamer *Scottish Hero* was driven ashore in Mud Lake and eight lights near the West Neebish cut were put out and washed away" (*The Sault Evening News* 1913:1). Research indicated that the vessel was en route to Lake Superior (*Marine Review Vol. 43* 1914:439). There is no Mud Lake off St. Mary's River today, however, there is a Munuscong Lake off St. Mary's River, which used to be named Mud Lake in the early 1900s (Ahart et al. 2014:497). This reasoning would put *Scottish Hero* on the western side of Munuscong Lake. FIGURE 4.11 shows the wrecks in the St. Mary's River. TABLE 4.4 shows source information for vessels affected on the St Mary's River.

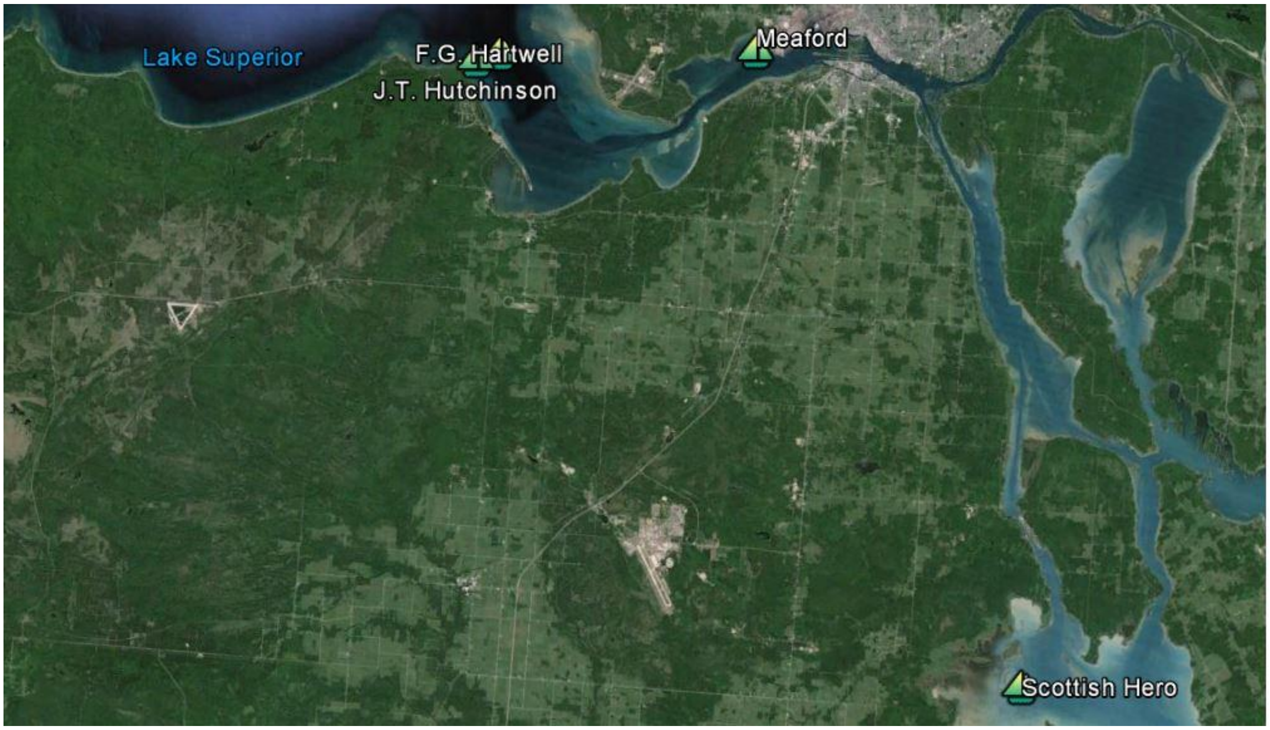


FIGURE 4.11. Sault Strait Marie wrecks. Green indicates the vessel has been refloated or rebuilt.

Vessel	Source Information
Scottish Hero	*Sault Evening News* 1913:1; Ahart et al. 2014:497
Meaford	*Marine Review Vol.* 43:439
F. G. Hartwell	*The Washington Times* 1913:1; *Marine Review Vol. 43* 1914:437
J. T. Hutchinson	*The Washington Times* 1913:1; *Marine Review Vol. 43* 1914:438

TABLE 4.4. Shows source information for vessels affected on the St. Mary's River.

Lake Superior is the largest of the Great Lakes; it was hit by both the pre-storm and the Great Storm. The majority of the ships affected by the storm were in the southeast corner of the lakes, close to the locks at Sault Strait Marie. In the original map, *William Nottingham* was wrecked in the Apostle Islands, however, newspapers indicate "that the steamer *Nottingham* ran aground on Paresian Island, twenty miles from Whitefish Bay" (*Globe* 1913:1; *Marine Review Vol.* 43 1914:437). *A. E. Stewart* was re-located in the new map to be in Whitefish Bay (*The Washington Times* 1913:1; *Marine Review Vol. 43* 1914:438). *Henry B. Smith* was found in 2013. It is close to the spot where the original placement marker indicated; updated information shows the vessel almost 30 miles due north of Marquette (Ken Merryman 2015, elec. comm.).

Huronic, Major, Turret Chief, L. C. Waldo, and *Leafield* were all in similar spots as the older map. These vessels were cited in both the *Marine Reviews* as well as newspapers (*Washington Times* 1913:1; *Marine Review Vol. 43* 1914:430 –444; *Marine Review Vol. 44* 1915:41 –44). There appears to be a lot of stranded vessel congestion in Whitefish Bay. The cause of this may be from vessels leaving the Sault Locks, which at its widest, is only about a mile wide, and then rapidly having to deal with the winds that accompany a large lake. Once on Lake Superior, mariners would have to face unprotected waters that greeted them with raging winds and gigantic waves. FIGURE 4.12 shows the updated map of the vessels foundered and stranded on Lake Superior. TABLE 4.5 shows source information for vessels affected on Lake Superior.

The vessels indicated on the maps above are the ones that foundered or were stranded in such a manner that they needed assistance to get out of the reefs, shoals, and shores. Many other vessels were stranded by the November storm, but were able to free themselves; others lost anchors, hatches and a variety of other parts from their vessels (*Marine Review Vol. 43* 1914:439; *Marine Review Vol. 44* 1915:42 –43). TABLE 4.6 includes stranded vessels mentioned in *Marine Review Vol. 44* that were not mentioned in the 1914 annual report. The strandings were mild and did not jeopardize the crew as the aforementioned wrecks (*Marine Review Vol. 43* 1914:430 –444). These vessels were not included in the study because this thesis focuses on vessels stuck in a manner that were unable to free themselves, be it through the ferocity of the storm or as an effect of their own responses during the disaster. FIGURE 4.13 shows the updated map.

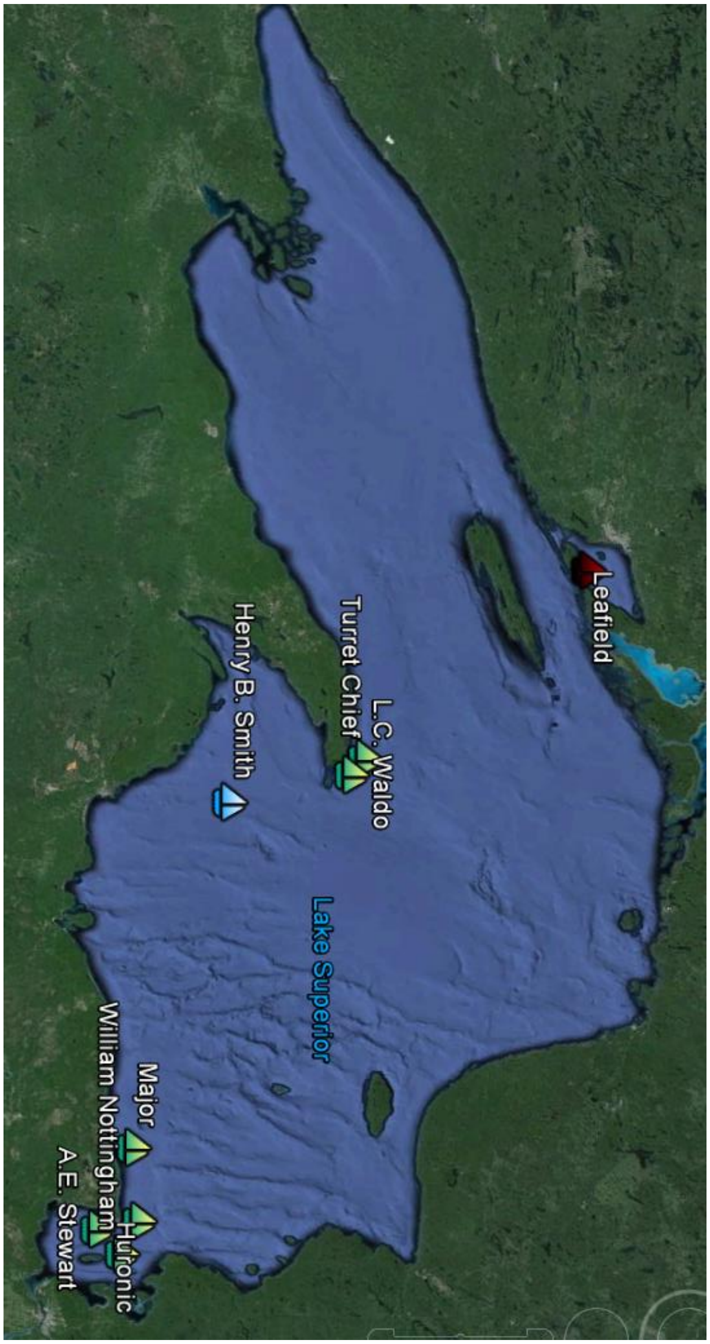


FIGURE 4.12. Map of foundered and stranded ships in Lake Superior. Blue indicates the vessel is still there, green indicates the vessel has been refloated or rebuilt, red represents that the vessel is still lost.

Vessel	Source Information
William Nottingham	*Globe 1913:1; The Washington Times* 1913:1; *Marine Review Vol. 43* 1914:438
Huronic	*The Washington Times* 1913:1; *Marine Review Vol. 43* 1914:439
Major	*Marine Review Vol. 43* 1914:439
A. E. Stewart	*The Washington Times* 1913:1; *Marine Review Vol. 43* 1914:438
L. C. Waldo	*Ogden Standard* 1913:8; *The Washington Times* 1913:1
Turret Chief	*Ogden Standard* 1913:8; *The Washington Times* 1913:1; *Marine Review Vol. 44* 1915:41
Henry B. Smith	Ken Merryman 2015, pers. comm.
Leafield	*Ogden Standard* 1913:8; *The Washington Times* 1913:1; *Marine Review Vol. 43* 1914:432

TABLE 4.5. Source information for vessels affected on Lake Superior.

Date	Vessel	Accident	Location
Nov. 8	*Edward Buckley*	Ran Ashore	Harbor Beach, Lake Huron
Nov. 8	*Col. J. M. Schoonmaker*	Ran Ashore	Mission River, Lake Superior
Nov. 8	*C.F. Ann Arbor No. 4*	Ran Ashore	Green Island, Lake Michigan
Nov. 8	*Athens*	Ran Ashore, Released After Lightened	Livingstone Channel, Detroit River
Nov. 9	*Rhoda Emily*	Beached In Storm	Harbor Beach, Lake Huron

TABLE 4.6. Other vessels stranded by the November Storm, self-recovered (*Marine Review Vol. 44* 1915:43).

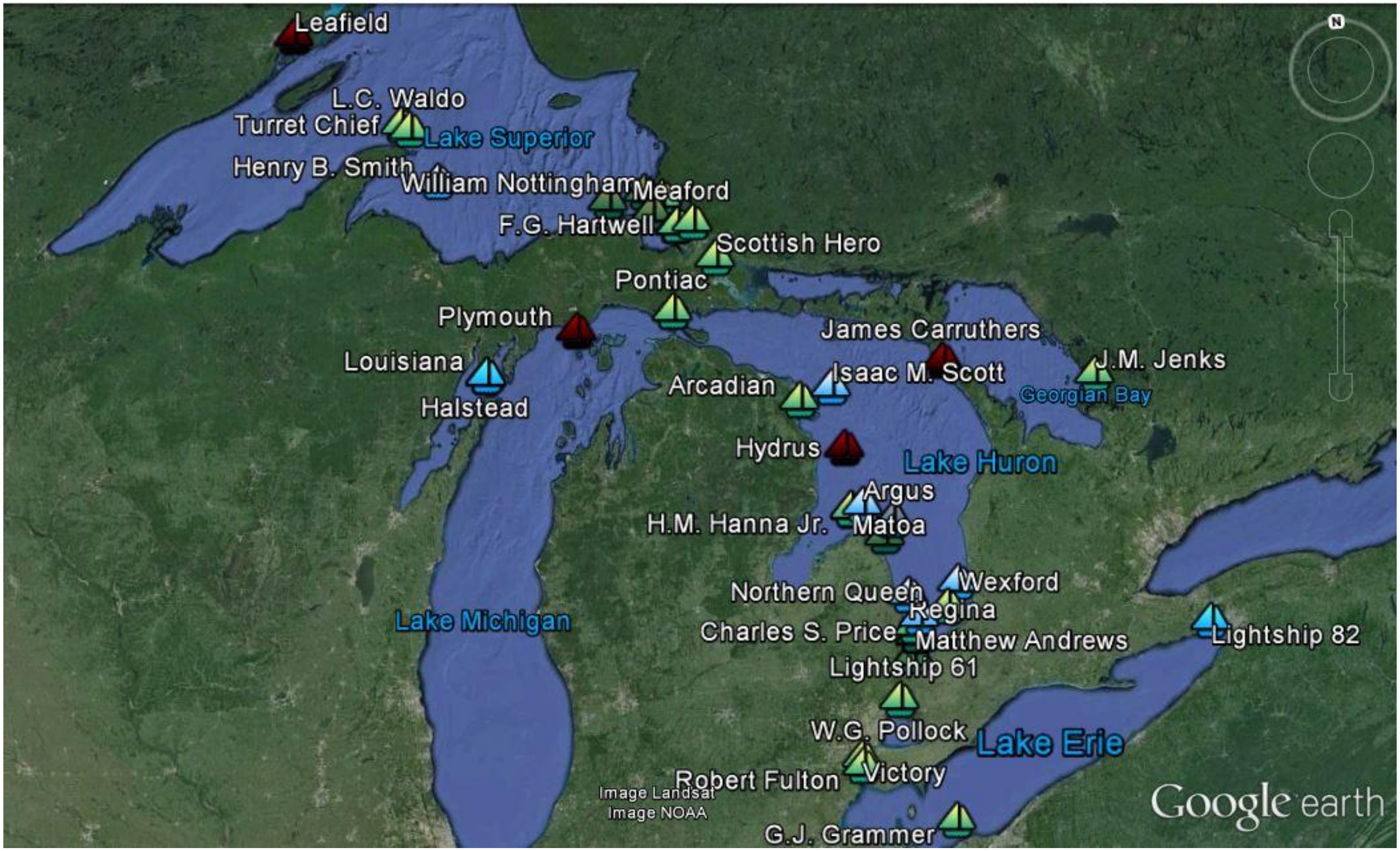


FIGURE 4.13. Updated map of vessels affected during the November, 1913 storm.

ORIENTATION MAP

The next part of the map-making process is based on the orientation of vessels foundered or stranded during the storm. The data becomes more limited in this section as most of the vessels affected by the storm did not have their bow and stern direction recorded prior to being removed or refloated. The data may be so limited here in that it may be impossible to make a true assessment of whether an explanatory model is possible to make or if vessel orientation during a foundering or stranding process is randomized to the individual shipwreck. The following section will attempt to design maps using vessel orientation as the basis for shipwreck placement.

Once again, the first example of shipwreck orientation on the updated map will be *Louisiana,* as that was the first wreck visited by the author. This wreck's bow currently faces south, however the original picture of *Louisiana* stranded shows the vessel's bow pointing southeast (picture in previous section). A major cultural transformation process affecting the vessel is that in 1920, the vessel's engines and boilers were salvaged. Historic photographs show the vessel rising high above the waterline, yet today the vessel is entirely submerged. The stranded vessel has been notably affected by cultural processes as well as non-cultural transformation processes, which include yearly ice, particularly in the form of ice shove (Wisconsin Sea Grant and Wisconsin Historical Society 2015). FIGURE 4.14 shows *Louisiana* shortly after wrecking in the November storm.

Halstead was also stranded in Washington Harbor, Washington Island, Wisconsin. This vessel was refloated quickly after the Great Storm because it was able to face the storm without too much damage. The bow and stern have been located using a historical photograph that shows the vessel broadside at the end of the harbor (Wisconsin Sea Grant and Wisconsin Historical

Society 2015). FIGURE 4.15 illustrates the vessel with its bow and stern in a west to east position. FIGURE 4.16 shows both vessels orientated using Google Earth.

FIGURE 4.14 *Louisiana* shortly after wrecking and burning in the November storm ice (Wisconsin Sea Grant and Wisconsin Historical Society 2015).

FIGURE 4.15. *Halstead* stranded on Washington Island, bow facing west (Wisconsin Sea Grant and Wisconsin Historical Society 2015).

FIGURE 4.16. Illustration of vessels *Louisiana* and *Halstead* bow and stern position. Arrow points in direction of bow (Cooper 1989:93; Wisconsin Sea Grant and Wisconsin Historical Society 2015).

Lake Superior also has two wreck orientation sites, *Henry B. Smith,* and *L. C. Waldo. Smith* was found in 2013; the team that found the shipwreck offered its general location a little less than 30 miles due north of Marquette, as well as the bow’s direction, the heading between 10 and 20 degrees (Ken Merryman 2015, elec. comm.). *L. C. Waldo* is no longer on Lake Superior as it was refloated to another location after the storm; however, its location and orientation is known because of the captain’s account during the storm, which can be seen in Frank Barcus’ *Freshwater Fury* (1960:33 –44) and a historical photograph (Webb 2004). FIGURE 4.17 shows a historical photograph of *L. C. Waldo* and FIGURE 4.18 shows vessel orientation on Lake Superior.

FIGURE 4.17. Vessel *L. C. Waldo* stranded on Manitou Island after hitting Gull Rock (Webb 2004).

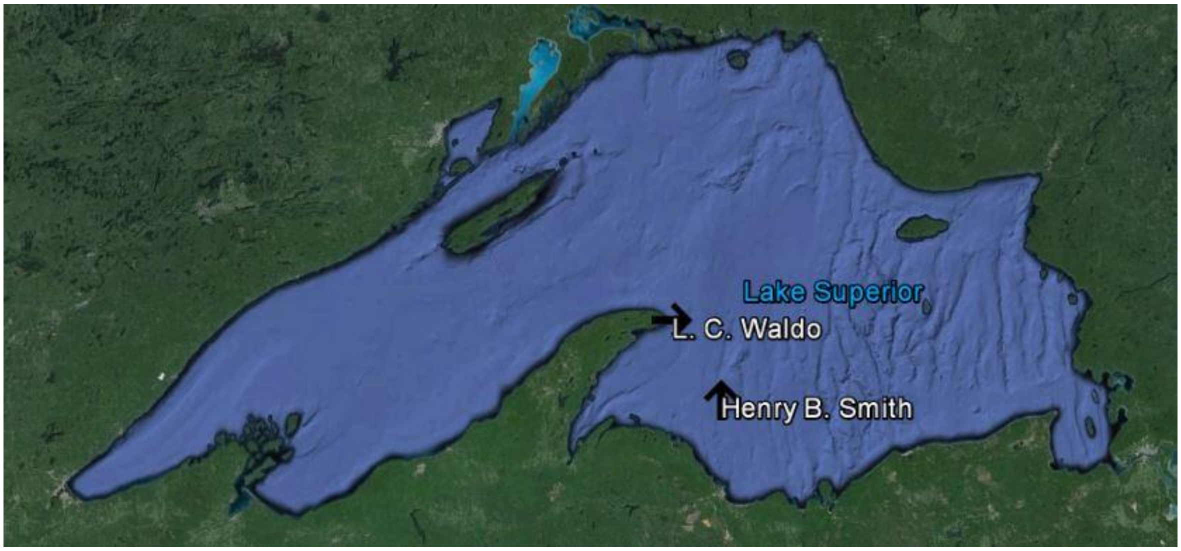


FIGURE 4.18. Vessels *Henry B. Smith* and *L. C. Waldo*’s orientation in Lake Superior (Barcus 1960:33 –44;Ken Merryman 2015, elec. comm.).

The final orientation map is of Lake Huron, which was affected most severely. The vessels orientated on this map are: *Wexford, H. M. Hanna Jr., Regina, Charles S. Price, Isaac M. Scott, John A. McGean* and *Argus.* The positioning for *Wexford* comes from Paul Carroll, a marine historian who visited the wreck after it was discovered and who stays in close contact with divers on the wreck who plot the wreck's position (Paul Carroll 2015, elec. comm.). The positioning for *H.M. Hanna Jr.* is taken from a first-hand account. The chief engineer reported his experiences on Lake Huron on *H. M. Hanna Jr.* in *Marine Review Vol. 43* (1914:443). Orientation coordinates for *Regina* came from state maritime archaeologist, Wayne Lusardi (2014, pers. comm.). *Regina* capsized but is still in one piece, the coordinates are from the stern and the mid-ship. The orientation for *Isaac M. Scott, John A. McGean,* and *Argus* came from technical diver, Jared Daniel, a worker at Anchor Bay Scuba (2015, elec. comm.). Information for *Charles S. Price*'s orientation came from a variety of dive shops, all of whom agreed on the positioning (Jared Daniel 2015, elec. comm.; Wayne Brusate 2015, elec. comm.). FIGURE 4.19 and 4.20 shows Lake Superior and the vessels sunk and stranded.

FIGURE 4.19 Vessel orientation, southern end of Lake Huron (Wayne Lusardi 2014, pers. comm.;Jared Daniel 2015, elec. comm.; Paul Carroll 2015, elec. comm.).

FIGURE 4.20. Vessel orientation in the middle of Lake Huron (Jared Daniel 2015, elec. comm.; *Marine Review Vol. 43* 1914: 430, 433).

WEATHER DATASETS AND SHIPWRECK PLACEMENT

The following section builds a retrospective model to see how hard the winds were blowing as well as what time the wind was blowing when a vessel was lost. This is a necessary step before SPSS analysis. SPSS, Statistical Package for the Social Sciences, is a software program that is used for statistical analysis; it works to allow researchers the power to compute statistically significant correlations among other easy-to-use research based tools. This section relies on the retrospective model that was made for the centennial anniversary of the November storm. There is a caveat to the times associated with each wrecking, and that is because most vessels lacked onboard radio communication; the times of each wrecking will be estimated (Wagenmaker et al. 2013:3). The storm halted its progress over various storm centers for 10 to 20 hour periods, which should allow enough leeway for wrecked vessels to be accurately paired with the direction of the wind. These storm centers were areas that had sustaining hurricane force winds, meaning more than 74 mph (Wagenmaker et al. 2013:28). The tables will be organized by the date each vessel wrecked; the wind direction will be taken from the area each vessel wrecked on the map in conjunction with the time the vessel was stranded or became foundered. The retrospective model has information on 7 and 8 November, however, this model does not begin until the two fronts combine. To get wind direction, old, hand drawn maps from *Environment Canada –Toronto,* will be used. The combined fronts moved clockwise and it will be assumed that the pre-storm moved clock-wise as well. The wind speed will be gathered from personal accounts. The tables below will only have the wrecks whose orientation is known. FIGURE 4.21 shows the hand drawn map from *Environment Canada –Toronto* on 8 November, 1913, 8am (Wagenmaker et al. 2013:8). This figure is what the following table will be based upon.

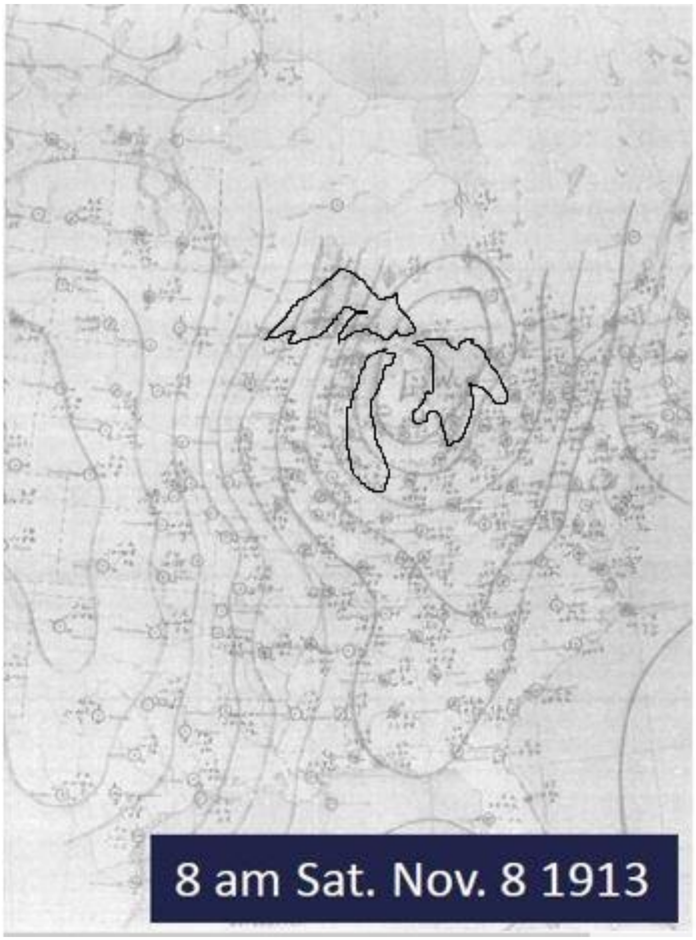


FIGURE 4.21. Hand drawn map from *Environment Canada –Toronto* on 8 November, 1913, 8am (Author; Wagenmaker et al. 2013:8). Lake Superior, Michigan, Huron are outlined.

TABLE 4.7 depicts the vessels affected by the storm on November 8, 1913, whose bow and stern direction are fairly well estimated based on historical photos, first-hand accounts, or the vessel being in place today. November 8 is not included in the up-to-date retrospective model, so wind speed and direction were estimated using first-hand accounts in combination with contemporary weather maps. *Louisiana* is still resting in Washington Harbor, Washington Island, Wisconsin. *L. C. Waldo* wrecked on Manitou Island, close to the northeast end of the Keweenaw Peninsula. *Waldo* was refloated; it is in this study because the first-hand accounts of the captain allowed its orientation of wrecking to be known. Having ships whose orientation were known immediately following the storm will add another level of understanding to the study because it allows a ship's location to be known without a century of non-cultural and cultural transformation processes.

Lake	Vessel	Time	Wind Direction	Wind Speed	Bow to Stern
Michigan	*Louisiana*	12 –2am	NW	70 mph	S –N*
Superior	*L. C. Waldo*	6 –10pm	NNW	70 mph	E –W

TABLE 4.7. Vessels affected on Saturday, 8 November, 1913 (Cooper 1989:93; Webb 2004; NOAA and Regional Collaboration 2013; Wagenmaker et al. 2013:8, 16).
*Vessel originally positioned SE –NW in 1913

TABLE 4.8 looks at the vessels affected on Sunday November 9, 1913. *Henry B. Smith* was found in 2013; its coordinates are not specifically given. The exploration team that found the vessel gave the general location as well as the vessel's orientation (Ken Merryman 2015, elec. comm.). *H. M. Hanna Jr.* was another vessel stranded by the November storm; the vessel was shortly refloated after the storm and reused. This vessel holds a similar position to *L. C. Waldo*, by putting it in the SPSS analysis; it may be possible to see how much vessels change during a century of non-cultural and cultural transformation processes, or it may show that ships wreck randomly and understanding shipwreck orientation cannot be calculated.

Lake	Vessel	Time	Wind Direction	Wind Speed	Bow to Stern
Superior	*Henry B. Smith*	5 –8pm	N	65 mph	N –S
Huron	*H. M. Hanna Jr.*	10 –11pm	NW	80 mph	NW –SE

TABLE 4.8. Vessels affected on Sunday, 9 November, 1913 (*Marine Review Vol. 44* 1915:493; NOAA and Regional Collaboration 2013; Wagenmaker et al. 2013:3, 26 –20).

TABLE 4.9 looks at the vessels that are believed to have been affected by the Great Storm the evening of the 9th through the morning of the 10th. The following vessels had no survivors and none were found in the immediate aftermath of the storm. *Lightship Vessel No. 82* was found in 1914, and in 1915 the vessel was recovered and rebuilt, however there are no descriptions of the orientation of the vessel prior to being salvaged (United States Coast Guard 2014). *Wexford*, was found in 2000; there are still missing vessels on the Great Lakes affected by the November storm (NOAA and Regional Collaboration 2013). The orientation of the following vessels have not been tracked since their demise. Their orientation is what it is today, up-to-date.

Lake	Vessel	Time	Wind Direction	Wind Speed	Bow to Stern
Erie	*Lightship 82*	6pm –2am	SW	70 mph	*
Huron	*Wexford*	6pm –2am	NW+	25 –75 mph	SE –NW
Huron	*Isaac M. Scott*	6pm –2am	NW+	60 –80 mph	S –N
Huron	*John A. McGean*	6pm –2am	NW+	60 –80 mph	NW –SE
Huron	*Regina*	6pm –2am	NW+	25 –75 mph	NW –SE
Huron	*Charles S. Price*	6pm –2am	NW+	60 –75 mph	S –N
Huron	*Argus*	6pm –2am	NW+	60 –80 mph	SW –NE
Michigan	*Halstead*	5pm (Mon)	NW	60 mph	W –E

TABLE 4.9. Vessels presumed to be affected on Sunday, 9 November, 6pm through Monday November 10, 2am 1913 (National Marine Sanctuary and NOAA 2013; Wagnemaker et. al. 2013:21 –27; United States Coast Guard 2014; Wayne Lusardi 2014, pers. comm.; Jared Daniel 2015, elec. comm.; Wisconsin Sea Grant and Wisconsin Historical Society 2015).

**Lightship Vessel No. 82* was found “1-7/8 mi NNE from station at 63 feet; diver reported hull intact but interior wrecked, and no bodies found” (United States Coast Guard 2014). Reports do not say which way vessel was orientated, however, thought it important to identify specific location of wreck after winter of its wrecking.

+Close to 2 am the low shifts, the upper part of Lake Huron receives northern winds and the southern part of Lake Huron receives western winds (Wagenmaker et al. 2013:18 –22).

This chapter looked at the primary and secondary sources used in the creation of the updated maps for the Great Storm of 1913. The updated maps combined historical secondary sources, historical newspapers, and first-hand accounts to discover the location of vessels foundered and stranded during the storm. The second map section looked at the orientation of the vessels in conjunction with time, wind direction, and wind speed during the storm. This section does have a margin of error since foundered vessels do not have first-hand accounts of when they were lost to the storm. The maps show multiple orientations despite an almost constant north or northwest wind. The following chapter will take vessel orientation post storm and plot orientations and wind direction into SPSS to see if there is any correlation or statistical significance between the resting place of the vessels and the storm that wrecked them.

CHAPTER 5: ANALYZING SHIPWRECKS, WIND DIRECTIONS, AND CONFOUNDERS

This chapter looks at shipwreck orientation in conjunction with wind direction to see if there is statistical significance between the two variables. The analysis relies on Statistical Package for Social Sciences (SPSS) to make the analysis. Previous chapters looked at the November, 1913, storm's movement, the orientation of the vessels, and confounders that may nullify the analysis. This chapter will look at SPSS in a variety of ways, including various factors that may explain why a vessel wrecked or stranded in a particular direction. The Great Storm of 1913 has been retrospectively analyzed 100 years after its occurrence by NOAA and this thesis to better understand the story behind the vessels and lives lost during the storm. Other historically significant storms in the Great Lakes have not been analyzed to this same degree. This chapter will focus on how SPSS is used, define key terms used in statistical processing, and the data collected using SPSS in conjunction with vessel and wind direction.

USING SPSS

SPSS is a computer software program that allows for complex statistical analyses with a fairly basic understanding of the program without the complex calculations. This program, though simple to use, does demand that users are familiar with conceptual statistics. Data needs to be set up correctly as the program will not compensate for incorrect or sloppy data entry. SPSS is a comprehensive program that gives more information than is generally needed in the output screen. This means that SPSS users need to be familiar with the program as well as the information they mean to acquire, and not get lost in the statistical results pages.

This thesis will decide whether there is statistical significance in shipwreck bow orientation combined with knowledge of the storm events, specifically wind direction during the wrecking event. Statistical significance means that the results of data are not likely to occur randomly. Finding statistical significance means that there is a relationship between variables. Statistical significance can be strong or weak depending on how significant the relationship is as well as the sample size in a study (StatPac 2014). Sample size is a proportion of a population. The larger the sample size, the more likely the study is going to accurately depict a true representation of the population as well as find significant statistics (StatPac 2014). If analysis shows that data is statistically significant, then the null hypothesis may be rejected, meaning there is not just random relationship variations within a dataset.

There will be two different datasets; one specifically looking at the orientation of the vessels in conjunction with the wind direction, the other dataset looking at what side of each lake the vessels are aligned with wind direction. Eleven vessels sank off the immediate lakeshore during the storm, seven of which have known locations. Foundered vessels with unknown locations include: *James Carruthers, Hydrus, Plymouth,* and *Leafield. Louisiana* was stranded and caught fire before becoming permanently part of Washington Harbor. *H. M. Hanna Jr., L. C. Waldo,* and *Halstead* were stranded and prior to being refloated, their positions were recorded either through historical photographs or through oral accounts of the storm event. These vessels are also included in the orientation dataset analysis.

Having a small sample size does not make the study irrelevant, though it does drop the amount of confidence researchers may have in the results. There are a few terms that directly relate to one another. These terms include: margin of error, confidence level, population size, sample size, cross-tabulation, and chi-square. Population size is the total amount of subjects that researchers are interested in studying. In the case of the Great Storm of 1913, population size varies depending on what researchers' interests are. If researchers are interested in all vessels affected, then the population size would be 39; if researchers are interested in vessels permanently affected by the storm that have not moved since their wrecking event, then the population size would be 12 vessels. Since population size may be impossible to survey due to missing information, sample size is used in statistics. Sample size is the amount of subjects surveyed (Raosoft 2004). Four vessels from the November, 1913, storm have not been found. These vessels cannot be used in the Macro Map or the Orientation Map. The vessels whose location are known and orientations are known, combined, are the sample size. Sample size differs depending on the dataset in this thesis. The Macro Map has a sample size of 35, whereas the Orientation Map has a sample size of eight and 11 depending on the study.

Margin of error is, "the amount of error that you can tolerate. If 90% of respondents answer *yes*, while 10% answer *no*, you may be able to tolerate a larger amount of error than if the respondents are split 50-50 or 45-55. Lower margin of error requires a larger sample size." The Macro Map includes the locations of 35 of the 39 vessels known to have been affected by the Great Storm of 1913. Having 35 of 39 vessels leaves this study with a 6% margin of error. The Orientation Map has eight of the 10 vessels permanently affected by the storm, which gives the study a margin of error of 17%. The Orientation Map that includes all known vessel orientations out of the vessels affected on the map is 11 out of the 39 vessels. This leaves researchers with a margin of error of 26% (Raosoft 2004). The Orientation Maps have a large margin of errors. While this is not ideal, it does not make the study useless, but does call for larger amounts of storm and wrecked vessel data in future research.

Confidence level is, "the amount of uncertainty you can tolerate." The higher amount of confidence a researcher desires, the higher the sample size needed. Confidence levels for this study stayed at 95%. Confidence levels and margin of error are directly related to one another. If confidence level diminishes, so does the percentage of margin of error. For example, for the

Macro Map, if the sample size stays the same as the above explanation, but confidence level drops to 90%, than the margin of error decreases from 6% to 5% (Raosoft 2004).

Cross-tabulation is used to test hypotheses. This function allows researchers to test if variables are related to one another (White and Korotayev 2004:1). Cross-tabulation was used to compare wind direction, orientation, and general location on the lake. A chi-square test is used to compare observed data with an expected hypothesis (McLaughlin and Noel 1996). Part of this includes understanding what is significant. To be significant in this study, the Pearson's chi-square, the P value, must be less than or equal to .05 for the null hypothesis to be void.

USING SPSS WITH NOVEMBER, 1913, AND 2013 DATA

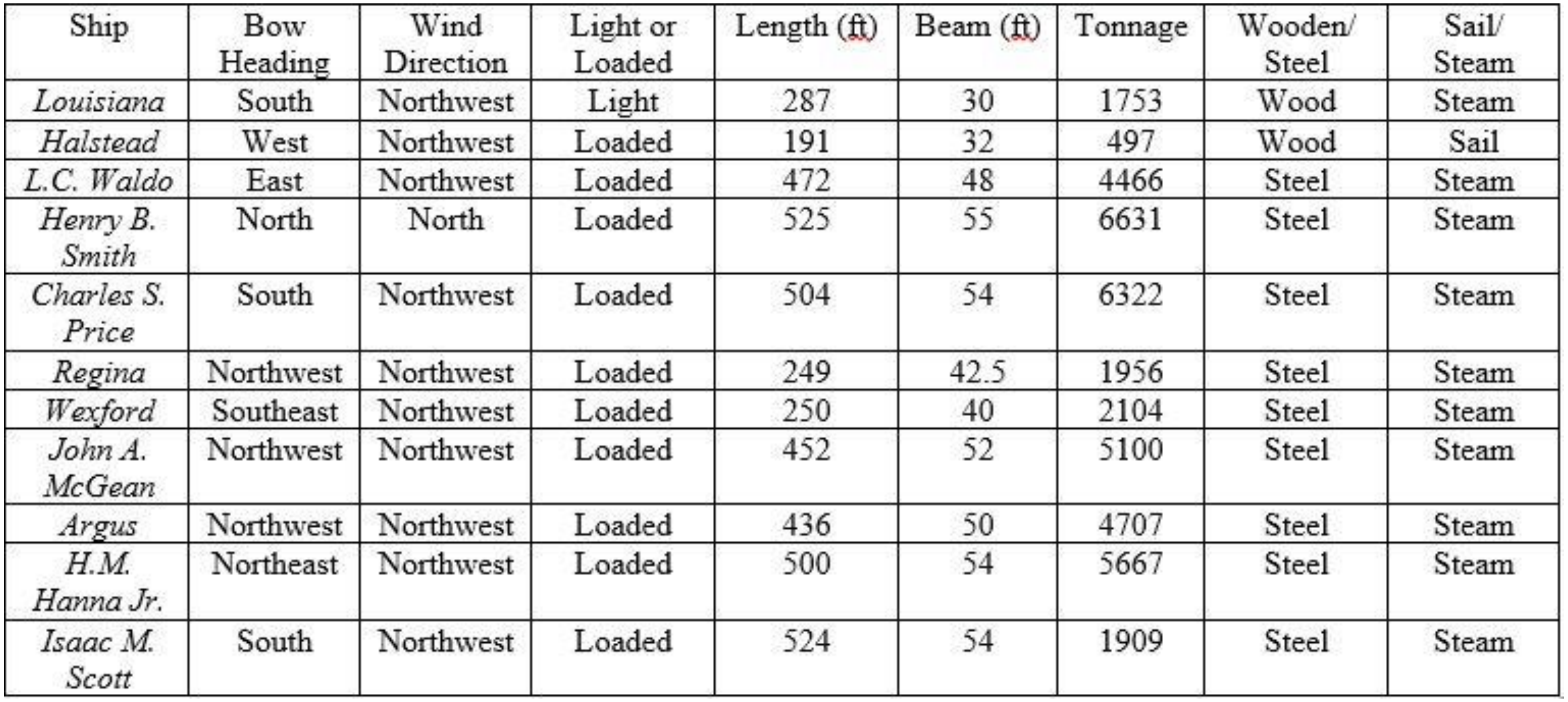
The Great Storm of 1913 is a good beginning candidate to work on the conjunction of explanatory models and SPSS because the storm affected more vessels than other catastrophic storms on the Great Lakes (Ratigan 1960:109), there is a good record where the vessels were (*Marine Review Vol. 43* 1914:430 –444), and a retrospective weather model has been made showing the wind and waves every couple of hours during the storm (Wagenmaker et al. 2013:19 –39). The following section will go through three datasets; one with the general vessel locations on the lake, and the other with the orientation of vessels permanently affected on the lakes, and the last with all known vessel orientations known, included stranded and refloated vessels. This section will show the data entered as well as the output results of the data in SPSS. The dataset will move from large scale of where shipwrecks are to where the orientation of vessels are.

ELIMINATING UNNECESSARY DATA

When using cross-tabulation, it behooves the researcher to use a minimum of five different factors that may influence the results. This allows the data to speak for itself in the sense that it shows if there is a more significant factor that affects, in this case, the orientation of the shipwrecked vessel. Cross-tabs have the potential to show statistical significance. Before continuing with the hypothesis of this thesis, it was necessary to see if there were any factors that proved to be more significant in affecting the orientation of the vessel than wind direction.

To do this, a table was set-up to include various factors that may have affected the vessel. These factors not only included wind direction, but whether the vessel was light or loaded, the length, beam, tonnage, wooden or steel, and sail or steam. These factors were used in the cross-tabs to see what was the most significant factor affecting bow heading. By creating a cross-tabs using various factors at the onset, it would allow this thesis to quickly find the most significant factor affecting the bow orientation, which would allow all future cross-tabs to avoid excess data that would only confound results. See TABLE 5.1 for multiple factor cross-tab data.

The above information was processed through cross-tabulation in SPSS. The results were expected, with the wind direction being the strongest link to bow heading. Here are the resulting chi-square significances: wind direction, 0.088; light or loaded, 0.817; vessel length, 0.277; beam, 0.194; tonnage, 0.277; wooden or steel, 0.368; sail or steam, 0.088. The findings show that wind direction most strongly correlates with bow heading as well as sail or steam



Ship	Bow Heading	Wind Direction	Light or Loaded	Length (ft)	Beam (ft)	Tonnage	Wooden/ Steel	Sail/ Steam
Louisiana	South	Northwest	Light	287	30	1753	Wood	Steam
Halstead	West	Northwest	Loaded	191	32	497	Wood	Sail
L.C. Waldo	East	Northwest	Loaded	472	48	4466	Steel	Steam
Henry B. Smith	North	North	Loaded	525	55	6631	Steel	Steam
Charles S. Price	South	Northwest	Loaded	504	54	6322	Steel	Steam
Regina	Northwest	Northwest	Loaded	249	42.5	1956	Steel	Steam
Wexford	Southeast	Northwest	Loaded	250	40	2104	Steel	Steam
John A. McGean	Northwest	Northwest	Loaded	452	52	5100	Steel	Steam
Argus	Northwest	Northwest	Loaded	436	50	4707	Steel	Steam
H.M. Hanna Jr.	Northeast	Northwest	Loaded	500	54	5667	Steel	Steam
Isaac M. Scott	South	Northwest	Loaded	524	54	1909	Steel	Steam

TABLE 5.1. Representation of factors that could affect bow heading for shipwrecked vessels.

propulsion. From this discovery, it was no longer necessary to continue to input the excess data in the following cross-tabs. Despite similar statistical significance, sail or steam will also be removed from this dataset because there is only one sail powered vessel in comparison with the remaining steam powered vessels with a known bow heading after wrecking. An issue with using the sail or steam data, for the time being, is that there is no way of knowing if the steam powered vessels lost power mid-storm, which would ultimately render them as effective as a sail powered vessel. When a larger dataset is acquired for Great Lakes vessels, sail or steam will be more useful. This may particularly become useful if steam powered vessels do not appear to align where they should, which may indicate to researchers that a vessel lost power during a catastrophic weather event. It was necessary to start with seven factors to match against bow heading in case that was a stronger significant factor than initially realized.

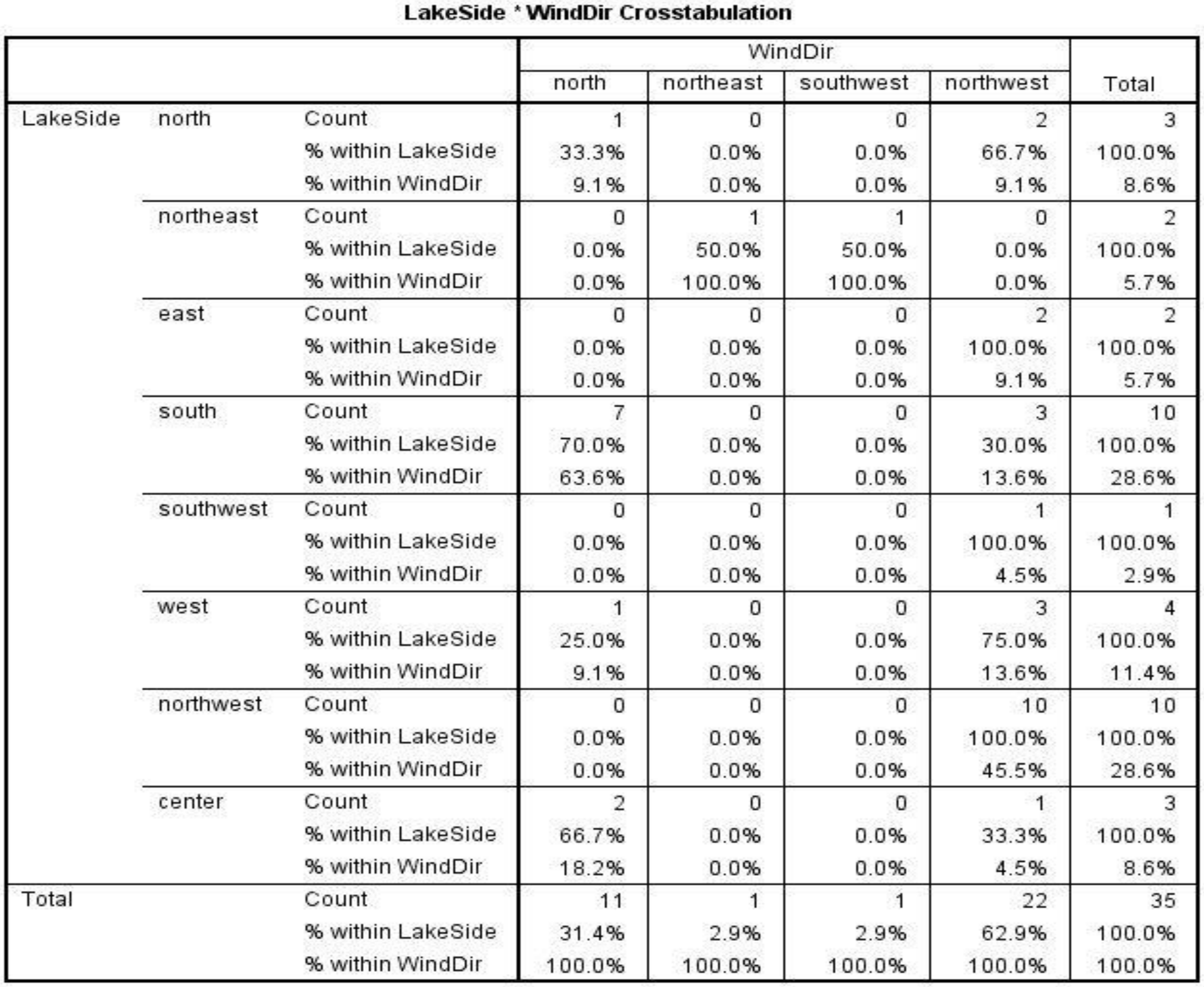
MACRO DATA SET

This study is simple; it does not include excess variables such as vessel length, beam, vessel composite, wave height, whether the anchor was thrown, etc. Despite knowing much of this information, the study limits itself to the most easily attainable information which includes wind direction, vessel orientation, and overall final resting place in the lakes. The study is simple because in the future, the study is interested in helping identify unidentified shipwrecks, so excess information is not included. TABLE 5.2 shows what information was inputted in SPSS. The following table after the input tables looks at vessel location on the lakes in conjunction with wind direction. The SPSS function used was “cross-tabs” found in “descriptive” statistics. Two outputs are given.

Ship	Lake Lost In	Vessel Location	Wind Direction
Leafield	Superior	-	North
Turret Chief	Superior	Center	North
L. C. Waldo	Superior	Center	North
Henry B. Smith	Superior	South	North
Major	Superior	South	North
Huronic	Superior	South	North
William Nottingham	Superior	South	North
A. E. Stewart	Superior	South	North
J. T. Hutchinson	Superior	South	North
F. G. Hartwell	Superior	South	North
Meaford	St. Mary's River	North	North
Scottish Hero	St. Mary's River	West	North
Plymouth	Michigan	-	Northwest
Louisiana	Michigan	North	Northwest
Halstead	Michigan	North	Northwest
Pontiac	Michigan	North	Northwest
J. M. Jenks	Huron	Northeast	Northeast
Arcadian	Huron	Northwest	Northwest
Isaac M. Scott	Huron	Northwest	Northwest
Argus	Huron	Northwest	Northwest
Matoa	Huron	Northwest	Northwest
H. M. Hanna Jr.	Huron	Northwest	Northwest
John M. McGean	Huron	Northwest	Northwest
D. O. Mills	Huron	Northwest	Northwest
Wexford	Huron	East	Northwest
James Carruthers	Huron	-	Northwest
Hydrus	Huron	-	Northwest
Regina	Huron	West	Northwest
Northern Queen	Huron	East	Northwest
Charles S. Price	Huron	West	Northwest
Matthew Andrews	Huron	West	Northwest
Lightship 61	Huron	South	Northwest
H. B. Hawgood	Huron	South	Northwest
Saxona	St. Clair	North	Northwest
W. G. Pollock	St. Clair	Center	Northwest
Victory	St. Clair	South	Northwest
Robert Fulton	Erie	Northwest	Northwest
G. J. Grammer	Erie	Southwest	Northwest
Lightship 82	Erie	Northeast	Southwest

TABLE 5.2. Information inputted in SPSS Macro study. "-" designates unknown vessel location (*Marine Review Vol. 44* 1915:43 –44; Wagenmaker et al. 2013:16 –27).

TABLE 5.2 shows the name of the vessel, what lake the vessel foundered or was stranded in, which way the wind was blowing at the time of each wrecking, as well as where each vessel's general location was in proximity to the lake it wrecked in. SPSS headings were converted to numbers, north = 1, northeast =2, east =3, southeast =4, south =5, southwest =6, west =7, northwest =8, and center of lake was =9. They were converted so SPSS could compute.

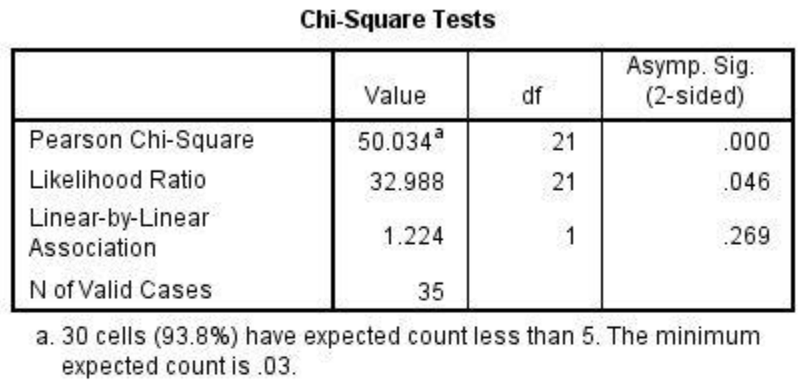


LakeSide * WindDir Crosstabulation

			WindDir				Total
			north	northeast	southwest	northwest	
LakeSide	north	Count	1	0	0	2	3
		% within LakeSide	33.3%	0.0%	0.0%	66.7%	100.0%
		% within WindDir	9.1%	0.0%	0.0%	9.1%	8.6%
	northeast	Count	0	1	1	0	2
		% within LakeSide	0.0%	50.0%	50.0%	0.0%	100.0%
		% within WindDir	0.0%	100.0%	100.0%	0.0%	5.7%
	east	Count	0	0	0	2	2
		% within LakeSide	0.0%	0.0%	0.0%	100.0%	100.0%
		% within WindDir	0.0%	0.0%	0.0%	9.1%	5.7%
	south	Count	7	0	0	3	10
		% within LakeSide	70.0%	0.0%	0.0%	30.0%	100.0%
		% within WindDir	63.6%	0.0%	0.0%	13.6%	28.6%
	southwest	Count	0	0	0	1	1
		% within LakeSide	0.0%	0.0%	0.0%	100.0%	100.0%
		% within WindDir	0.0%	0.0%	0.0%	4.5%	2.9%
	west	Count	1	0	0	3	4
		% within LakeSide	25.0%	0.0%	0.0%	75.0%	100.0%
		% within WindDir	9.1%	0.0%	0.0%	13.6%	11.4%
	northwest	Count	0	0	0	10	10
		% within LakeSide	0.0%	0.0%	0.0%	100.0%	100.0%
		% within WindDir	0.0%	0.0%	0.0%	45.5%	28.6%
	center	Count	2	0	0	1	3
		% within LakeSide	66.7%	0.0%	0.0%	33.3%	100.0%
		% within WindDir	18.2%	0.0%	0.0%	4.5%	8.6%
Total		Count	11	1	1	22	35
		% within LakeSide	31.4%	2.9%	2.9%	62.9%	100.0%
		% within WindDir	100.0%	100.0%	100.0%	100.0%	100.0%

TABLE 5.3. Shows cross-tabs for Macro Map, cross-tabs of wind direction and the side of the lake where the vessel was lost.

TABLE 5.3 shows in what part of the lake the vessel wrecked in comparison with the wind direction. One interesting aspect of the table, in terms of expected results, is that 100% of the vessels that sunk in the northwest part of their respective lake were also affected by northwest winds. The table shows that 10 of the vessels that sank in the northwest corner of their respective lakes were dealing with northwest winds during the storm. Clearly there are patterns; the table below explains the importance of the patterns.



Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	50.034[a]	21	.000
Likelihood Ratio	32.988	21	.046
Linear-by-Linear Association	1.224	1	.269
N of Valid Cases	35		

a. 30 cells (93.8%) have expected count less than 5. The minimum expected count is .03.

TABLE 5.4. This is a chi-square test table, it shows the null hypothesis to be void because the Pearson chi-square value is below .05.

TABLE 5.4 shows the Pearson's chi-square test. The value is less than .05. The value is not 0.0. The number lays outside three decimal places, which is why it shows up as .000 in the table. The hypothesis was that general vessel locations on the lakes would be dependent on wind direction during the storm. This Macro Map significance test was done first in order to work through SPSS while using values that are expected to reject the null hypothesis. The ocean easily has waves larger than the Great Lakes (Geology.com 2015), however, the Great Lakes offer a different type of peril: running out of navigable sea room. Ships in the Great Lakes cannot outrun or outmaneuver a storm as easily as ocean captains because there is not enough room to get out of the reach of a powerful storm, especially if the storm's center is in the middle of one of the Great Lakes (Wagenmaker et al. 2013:16 –33). The hypothesis was that vessels were more likely to founder or become stranded in accordance with the direction of the wind. The Pearson's chi-square test shows the hypothesis to be statistically significant meaning vessels on the Great Lakes, during the Great Storm of 1913, were more likely to wreck in the part of the lake from which the wind was blowing. This, at first, may seem counter intuitive and may reflect a variable imposed by steam power. Upon further thought, it is recognized that vessels with steam power would push into the storm, which would allow them the greatest chance of surviving the storm. The data, accordingly, makes sense.

ORIENTATION DATA SET

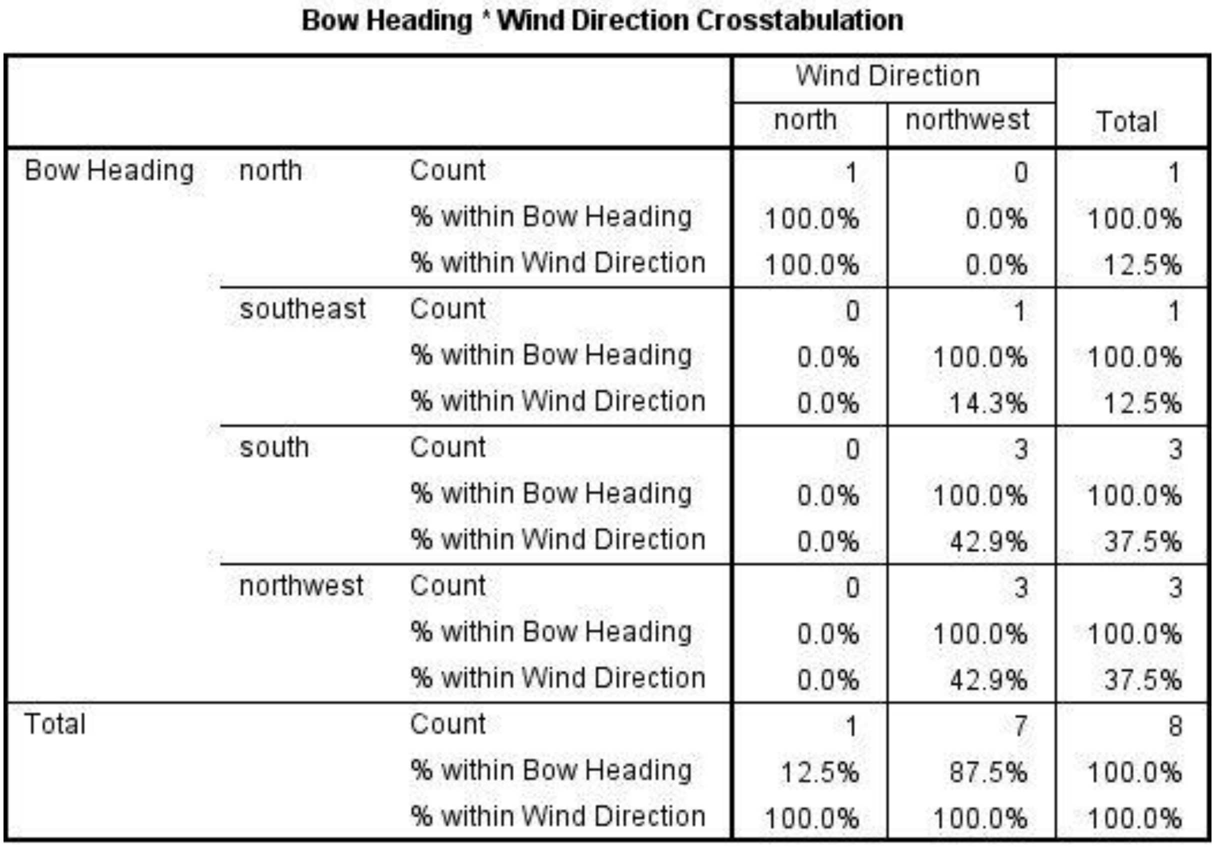
The second data set looks at vessels permanently lost to the November, 1913 storm. The difference between this data set and the data set analyzed above is that in order to qualify to be part of the this dataset, the vessels must still be resting in the Great Lakes. The data set is also different because rather than looking at the general location in the Great Lakes, the data set looks at the bow heading in conjunction with the way the wind direction was at the time of the foundering event. The table below shows the information entered in SPSS. There are eight vessels that have known bow headings out of the 12 vessels that have been permanently affected. There are four vessels that have still not been found from the November, 1913 storm event.

Vessel	Lake	Bow Heading	Wind Direction
Louisiana	Michigan	South	Northwest
Henry B. Smith	Superior	North	North
Charles S. Price	Huron	South	Northwest
Regina	Huron	Northwest	Northwest
Wexford	Huron	Southeast	Northwest
John A. McGean	Huron	Northwest	Northwest
Argus	Huron	Northwest	Northwest
Isaac M. Scott	Huron	South	Northwest

TABLE 5.5. Data set for shipwreck orientation data.

TABLE 5.5 was the input information used in the same manner as the Macro Map data set. The data was processed using cross-tabulation in order to determine if the Pearson's chi-square relationship was statistically significant. Before even beginning to use the input data to discover potential correlations, recognize that the sample size is only eight vessels. There are not enough data to decide whether there is true value in the output data unless the sample size is at least 20 vessels (Parkerson 2015, elec. comm.). The data being inputted is still of value as it is a stepping point for future studies if there seems to be some significance.

TABLE 5.6 looks at cross-tabulation for wind direction and foundered vessel orientation. There are only eight vessels whose bow orientation is known which makes this present more as a series of case studies rather than as an aid to an explanatory model for understanding whether vessels on the Great Lakes' permanent orientation is affected by the storm that wrecked them.

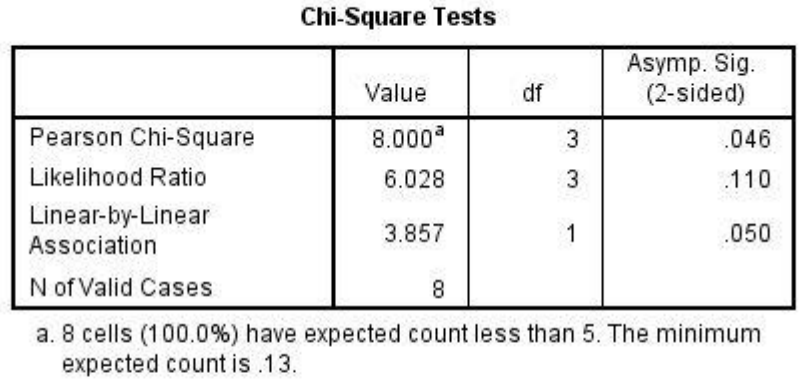


Bow Heading * Wind Direction Crosstabulation

			Wind Direction		Total
			north	northwest	
Bow Heading	north	Count	1	0	1
		% within Bow Heading	100.0%	0.0%	100.0%
		% within Wind Direction	100.0%	0.0%	12.5%
	southeast	Count	0	1	1
		% within Bow Heading	0.0%	100.0%	100.0%
		% within Wind Direction	0.0%	14.3%	12.5%
	south	Count	0	3	3
		% within Bow Heading	0.0%	100.0%	100.0%
		% within Wind Direction	0.0%	42.9%	37.5%
	northwest	Count	0	3	3
		% within Bow Heading	0.0%	100.0%	100.0%
		% within Wind Direction	0.0%	42.9%	37.5%
Total		Count	1	7	8
		% within Bow Heading	12.5%	87.5%	100.0%
		% within Wind Direction	100.0%	100.0%	100.0%

TABLE 5.6. Shows cross-tabs for wind direction and vessel orientation.

TABLE 5.6 finds three vessels that have bow orientations that face south during northwest winds, three vessels point northwest in northwest winds, one vessel points southeast, and one vessel points north in north winds. TABLE 5.7 indicates whether the output data is significant or not.



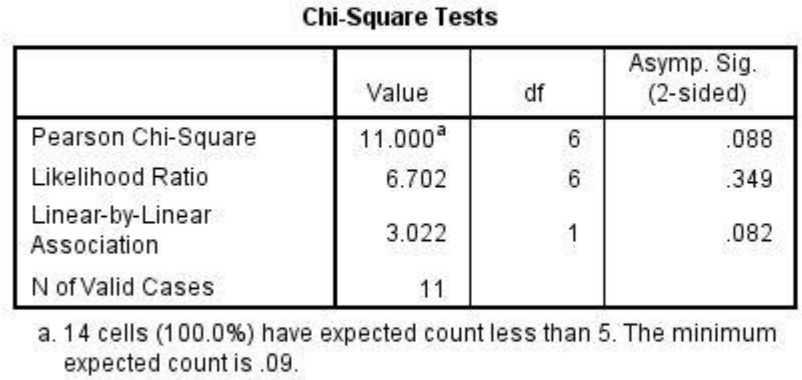
Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8.000[a]	3	.046
Likelihood Ratio	6.028	3	.110
Linear-by-Linear Association	3.857	1	.050
N of Valid Cases	8		

a. 8 cells (100.0%) have expected count less than 5. The minimum expected count is .13.

TABLE 5.7. This is a chi-square test table. It rejects the null hypothesis because the Pearson chi-square value is below .05, though because of the small sample size, this study calls for more data before concluding if it is possible to create an explanatory model of the storm.

TABLE 5.7 shows the Pearson's chi-square test at a value of 0.046. As decided earlier for this study, anything less than 0.05 is considered statistically significant and may prove the null hypothesis void. While the study may show there is significant data with bow headings correlating with wind direction, in the end, there is not enough data to statistically prove this significant. The following data adds three more vessels to the study, all of which were stranded and later refloated. They are added to show how much the Pearson's chi-square test changes with just three more data points.



Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	11.000[a]	6	.088
Likelihood Ratio	6.702	6	.349
Linear-by-Linear Association	3.022	1	.082
N of Valid Cases	11		

a. 14 cells (100.0%) have expected count less than 5. The minimum expected count is .09.

TABLE 5.8. This is a chi-square test table. It shows the null hypothesis to be true because the Pearson chi-square value is above 0.05. Thus, there is no relationship.

TABLE 5.8 looks at the changing Pearson's chi-square value when three more vessel orientations are added to the data set. These vessel's orientation to shore is known because of historical photographs and because of oral retellings of a stranding event from a member of a crew that survived. These vessels are still relevant because the stranding event took place because of the Great Storm of 1913. This is important to recognize because the bow heading in the middle data set may have changed in the past 100 years, even if only slightly. The Pearson's chi-square value changes to 0.088; this value is no longer statistically significant.

ANALYSIS AND RESULTS

This study began in an attempt to create an explanatory model for the Great Storm of 1913. Its hypothesis was that bow direction relates to with wind direction during a wrecking event for steam powered vessels. In the process of getting data ready for this study, a new map was created for the November, 1913 storm. This map corrects many of the locations for the vessels foundered or stranded during the storm event. The updated map was used to create the first data set. The hypothesis was that wrecked vessel location within an inland lake directly relates to the wind direction that occurred during the wrecking event. Running the cross-tabs as well as the Pearson's chi-square test found that hypothesis to be true. Vessels were more likely to become foundered or stranded in the part of the lake that the wind was blowing from, suggesting that captains steam head on into the wind in their best efforts to stay afloat. Being under sail or losing power mid-storm can prove to be disastrous if the gunnels or stern takes the brunt of the waves rather than the bow. This hypothesis was tested to fully understand the capabilities of SPSS; within the parameters of this study, this hypothesis proved true.

The second data set looked at bow heading in conjunction with wind direction to see if bow direction either directly or inversely related to wind direction, mimicking it like a vector line. This question was asked to have researchers in the Great Lakes try to focus on creating broader regional studies (O'Shea 2002:211). Pearson's chi-square test showed the data to be statistically significant. When the additional three stranded vessels were added to the study, the Pearson’ chi-square test was no longer significant, though the finding is suggestive.

Despite the Great Storm of 1913 being one of the largest storms to hit the Great Lakes as well as being the storm to affect the most vessels on the lakes in a four day period, there is not enough information from this event to conclusively determine whether bow heading correlates with wind direction during the time of wrecking, however, this does suggest that steamers headed into the wind before being overwhelmed (*Marine Review Vol. 44* 1915:41).

This study did create a new map for the storm, which includes the correct location of vessels affected by the storm for stranding and foundering events. This thesis also created a bow orientation map for the vessels that are still in the Great Lakes.

WAVES AND VARIABLES

The data above may leave readers wondering what factors may influence a vessel outside of powerful wind systems. There are multiple possible confounders that may influence a vessel’s wrecking location more than the extreme wind that caused its wrecking. The biggest variable, outside wind direction, appears to be whether a vessel is powered or under sail. As helpless as a crew may feel, the people on board a wrecking vessel have power to influence how it wrecks (*Marine Review Vol. 43* 1914:443). Crews and captains may opt to steam head into the wind, drop both anchors, one, or none. A crew and captain can try to reposition their vessel into a storm, or they may find the best option to be running aground as soon as possible to avoid capsizing in the middle of the lake during the storm. People have tremendous influence over the vessels they are on board, especially if the wrecking event is more than a couple hours long. The theories and ideas behind this thought were described in Chapter 3, “Grounding Weather, Vessels, and Humanity in Theory.”

Another variable that has the potential to drastically affect a vessel's foundering or wrecking event is wave action. The Great Storm of 1913 had sustained winds of over 70 mph and gusts reaching 90 mph. Waves continue to increase as they receive net energy, which can be from the force of wind on the upwind face of waves, or from the frictional drag of air moving over water (Lane 2015). Waves and wind do not always move in the same direction; this is particularly noticeable close to shore, where waves are seen to go into shore, which may be a different direction than the wind. For much of the storm, the wind appeared to blow north-northwest (Wagenmaker et al. 2013:16 –42). When looking at the map with the general positions of shipwrecks of the Great Storm of 1913, it appears that many ships were stranded or foundered on the western side of Lake Huron. There also appears to be a proportionally high amount of wrecks in Lake Huron's southern pocket as well as Lake Superior's southern pocket. Wave height and wave direction were given in the retrospective model, however, that model only showed wave height, not wave direction. There are rogue waves in the Great Lakes; these have the potential to spawn a wrecking event, especially because the Great Lakes are unique in often creating three rogue waves at once, the three sisters. Since rogue waves and wave direction was unknown, they were not added to the measured variables in this study, though this variable most likely had a large influence on vessels during the storm since large waves could break vessels (Ken Merryman 2015, elec. comm.).

Another factor to consider is the depth at which a shipwreck rests. The deeper the wreck, the more a vessel may have been influenced by the water column while sinking, which may manipulate the direction the bow faces. It is unlikely that vessels such as *Henry B. Smith*, which rests below 500 feet from the surface, was able to sink in a perfect uniform manner from the initial wrecking process (Ken Merryman 2015, elec. comm.). These factors will be considered more thoroughly once a larger data set has been compiled to account for significant variations between wrecks.

The largest confounders of this thesis are the Great Lakes themselves. The Great Storm of 1913 proved to be one of the most disastrous storms to ever cross the Great Lakes, however, the Great Lakes Basin is not a stranger to bad weather. Regular storm activity may consist of thousands of similar storms that have similar patterns, which incorporate wind direction, currents, and debris drift (Wayne Lusardi 2015, elec. comm.). The consistency of storms across the Great Lakes may confuse researchers when looking to relate a wreck to a particular storm. Known shipwrecks related to known storms must be compiled to understand the minor inconsistencies between large storm events, such as the shipwrecks explored within this thesis. Once large storms and their associated wrecks are examined, it may be possible to find the differences between large weather events and the overall regular storm activity of the Great Lakes.

Chapter 5 looked at the Great Storm of 1913's shipwrecks to assess their bow orientation in conjunction with variables that might be associated with bow direction to find the most statistically significant variable. Wind direction proved to be the most statistically significant factor when understanding shipwreck placement on the Great Lakes in a macro scale as well as bow orientation. Besides using SPSS to analyze the results, this chapter looked at variables that have the potential to confuse the analysis process. Despite the significance of these confounders in this thesis, these confounders excite the possibility of new avenues of research in broader Great Lakes and shipwreck research, as all these variables, when studied in depth, may offer more insight into the wrecking processes in the sweetwater seas.

CHAPTER 6: CONCLUSIONS

This thesis looks at the Great Storm of 1913; it created an updated map with all 39 commercial vessels affected by the Great Storm of 1913 as well as a map depicting the various orientations of 11 vessels affected by the storm. Eight of these vessels still reside in either Lake Superior, Lake Michigan, or Lake Huron. The study attempted to create an explanatory model for vessels wrecked by catastrophic disaster on the Great Lakes, but found that the Great Storm of 1913 did not have enough archaeologically documented vessels to create an adequate data set to determine whether their bow heading orientation is statistically significant, in terms of wind direction, to cause the wrecking.

This thesis urges Great Lakes shipwreck archaeologists to begin compiling data on vessels wrecked, wind direction, and bow heading. Large enough data sets need to be created to determine whether explanatory models can be made and if predictive models may be created for the future of shipwreck archaeology to help determine unidentified shipwrecks that appear to have foundered. Burn and collision victims are out of this model. Data sets should be broken into 10 year wrecking categories to account for potentially drastic non-cultural transformation processes. Once more data is compiled, studies may be broken down in more specific ways, such as combining variables like wind direction, bow heading, and whether a vessel was steam or sail powered to create a more comprehensive study. Future studies may also divide the Lakes into different studies; the fetch of each Lake differs and may create confounders that impede a combined study of all the inland Lakes.

LIMITATIONS

There are an array of factors that influence the wrecking patterns on the Lakes and have the potential to limit the possibilities of future explanatory and predictive models. The Great

Lakes are confined waters and therefore, the water may move in multiple directions. During a storm, the water on the surface may move in a complete opposite way as water 20 feet from the surface. Despite calm waters on the surface, water currents below the surface may still run strong hours after a storm. There are a variety of additional factors that may be impossible for SPSS to account for in terms of statistical significance because all factors have the potential to contribute to the final wrecking process. These factors may include: intended and final course of the vessel, crew's reactions and decisions, depth of water, density of vessel upon sinking, and loss of steerage or power. Once a grander scale of research has been conducted, researchers must also account for various mean Lake levels and compare them to different storm data. Mean Lake level can affect wave action, ice shove, sediment deposition, erosion rates, and the distance to the shore (Wayne Lusardi 2015, elec. comm.). These factors can play into the resting place for a vessel and may change a vessel's orientation over time if the change is drastic enough. These factors were not included in this thesis because the goal of this thesis was to create an explanatory model rather than a predictive model. In the future, if a predictive model is possible, these factors must be included and assessed when possible.

Other factors that may be accounted for is the placement of seaways. The entrance of St. Mary's River as well as the St. Clairs River are overwhelmed with shipwrecks, despite the wrecks not correlating with the general trend of steaming into the storm. This difference could simply stem from the rivers being a more protected environment, which made immediately adjusting to the open Lake an impossible task mid-storm. Once there is more data, these variables may be teased out to create a comprehensive study and potential explanatory model.

FINAL THOUGHTS

This thesis updated the current popular map depicting vessels stranded and foundered during the 1913 storm and it calls for more regional collaboration in the inland seas to create a broader understanding of ships foundered by catastrophic storm events.

The research found a pattern in sustained wind direction during a storm and the final resting place of vessels in conjunction with their location in the Lakes. This study used SPSS to find suggestive statistics that may show why a vessel’s bow orientation may rest in a particular way, however, this study more importantly found the factors that may influence the final positioning of a vessel. If a predictive model is to be created, a compilation of research is needed for the hundreds of known shipwrecks in the Great Lakes.

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