Office of National Marine Sanctuaries
Office of Response and Restoration

Screening Level Risk Assessment Package

Edmund Fitzgerald

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National Oceanic and
Atmospheric Administration

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Photo: Photograph of *Edmund Fitzgerald*
Source: http://www.noaanews.noaa.gov/stories2006/s2633.htm

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Project Background

The past century of commerce and warfare has left a legacy of thousands of sunken vessels along the U.S. coast. Many of these wrecks pose environmental threats because of the hazardous nature of their cargoes, presence of munitions, or bunker fuel oils left onboard. As these wrecks corrode and decay, they may release oil or hazardous materials. Although a few vessels, such as USS *Arizona* in Hawaii, are well-publicized environmental threats, most wrecks, unless they pose an immediate pollution threat or impede navigation, are left alone and are largely forgotten until they begin to leak.

In order to narrow down the potential sites for inclusion into regional and area contingency plans, in 2010, Congress appropriated $1 million to identify the most ecologically and economically significant potentially polluting wrecks in U.S. waters. This project supports the U.S. Coast Guard and the Regional Response Teams as well as NOAA in prioritizing threats to coastal resources while at the same time assessing the historical and cultural significance of these nonrenewable cultural resources.

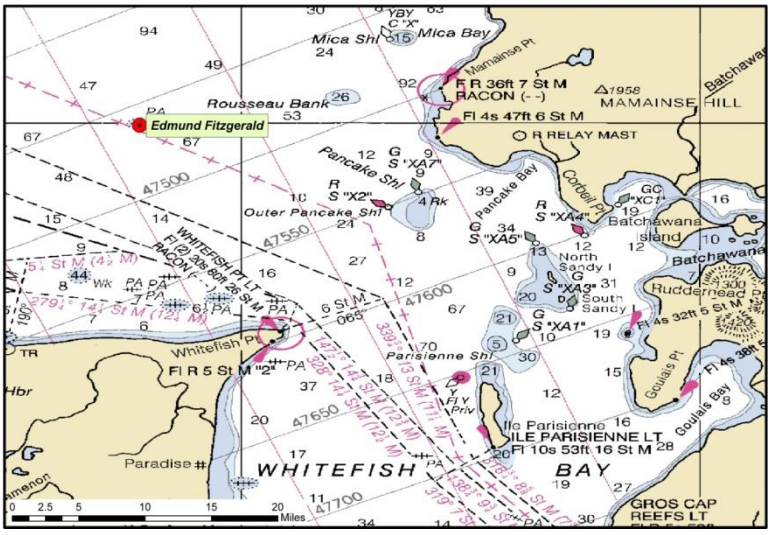
The potential polluting shipwrecks were identified through searching a broad variety of historical sources. NOAA then worked with Research Planning, Inc., RPS ASA, and Environmental Research Consulting to conduct the modeling forecasts, and the ecological and environmental resources at risk assessments.

Initial evaluations of shipwrecks located within American waters found that approximately 600-1,000 wrecks could pose a substantial pollution threat based on their age, type and size. This includes vessels sunk after 1891 (when vessels began being converted to use oil as fuel), vessels built of steel or other durable material (wooden vessels have likely deteriorated), cargo vessels over 1,000 gross tons (smaller vessels would have limited cargo or bunker capacity), and any tank vessel.

Additional ongoing research has revealed that 87 wrecks pose a potential pollution threat due to the violent nature in which some ships sank and the structural reduction and demolition of those that were navigational hazards. To further screen and prioritize these vessels, risk factors and scores have been applied to elements such as the amount of oil that could be on board and the potential ecological or environmental impact.

Executive Summary: *Edmund Fitzgerald*

The freighter *Edmund Fitzgerald*, broken in two and sunk during a severe storm in Lake Superior in 1975, was identified as a potential pollution threat, thus a screening-level risk assessment was conducted. The different sections of this document summarize what is known about the *Edmund Fitzgerald*, the results of environmental impact modeling composed of different release scenarios, the ecological and socio-economic resources that would be at risk in the event of releases, the screening-level risk scoring results and overall risk assessment, and recommendations for assessment, monitoring, or remediation.



Based on this screening-level assessment, each vessel was assigned a summary score calculated using the seven risk criteria described in this report. For the Worst Case Discharge, *Edmund Fitzgerald* scores Medium with 12 points; for the Most Probable Discharge (10% of the Worse Case volume), *Edmund Fitzgerald* scores Low with 10 points. Given these scores and a high level of data certainty, NOAA recommends that the site be noted in the Area Contingency Plans so that if a mystery spill is reported in the general area, this vessel could be investigated as a source. Surveys of opportunity should be used to assess the wreck for corrosion and structural integrity. Outreach efforts with the technical and recreational dive community as well as commercial and recreational fishermen who frequent the area would be helpful to gain awareness of localized spills in the general area of the wreck site.

Vessel Risk Factors		Risk Score	
Pollution Potential Factors	A1: Oil Volume (total bbl)	Med	
	A2: Oil Type		
	B: Wreck Clearance		
	C1: Burning of the Ship		
	C2: Oil on Water		
	D1: Nature of Casualty		
	D2: Structural Breakup		
Archaeological Assessment	Archaeological Assessment	Not Scored	
Operational Factors	Wreck Orientation	Not Scored	
	Depth		
	Confirmation of Site Condition		
	Other Hazardous Materials		
	Munitions Onboard		
	Gravesite (Civilian/Military)		
	Historical Protection Eligibility		
		WCD	MP (10%)
Ecological Resources	3A: Water Column Resources	Low	Low
	3B: Water Surface Resources	Med	Low
	3C: Shore Resources	Med	Med
Socio-Economic Resources	4A: Water Column Resources	Low	Low
	4B: Water Surface Resources	Med	Low
	4C: Shore Resources	Med	Med
Summary Risk Scores		12	10

The determination of each risk factor is explained in the document. This summary table is found on page 37.

SECTION 1: VESSEL BACKGROUND INFORMATION: REMEDIATION OF UNDERWATER LEGACY ENVIRONMENTAL THREATS (RULET)

Vessel Particulars

Official Name: *Edmund Fitzgerald*

Official Number: 277437

Vessel Type: Freighter

Vessel Class: Great Lakes Bulk Carrier

Former Names: N/A

Year Built: 1958

Builder: Great Lakes Engineering Works, River Rouge, MI

Builder's Hull Number: 301

Flag: American

Owner at Loss: Northeastern Mutual Life Insurance Company

Controlled by: N/A **Chartered to:** N/A

Operated by: Columbia Transportation Division of the Oglebay Norton Company

Homeport: Milwaukee, WI

Length: 729 feet **Beam:** 75 feet **Depth:** 38 feet

Gross Tonnage: 13,632 **Net Tonnage:** 8,686

Hull Material: Steel **Hull Fastenings:** Welded **Powered by:** Oil-fired steam

Bunker Type: No. 6 Fuel Oil **Bunker Capacity (bbl):** 2,714

Average Bunker Consumption (bbl) per 24 hours:

Liquid Cargo Capacity (bbl): 0 **Dry Cargo Capacity:** 860,950 cubic feet

Tank or Hold Description: 860,950-cubic-foot cargo hold divided by two non-watertight transverse "screen" bulkheads. There were two fuel tanks located in the space previously occupied by the coal bunker, immediately aft of the cargo holds.

Casualty Information

Port Departed: Burlington Northern Railroad Dock, Superior, WI

Destination Port: Detroit, MI

Date Departed: November 9, 1975

Date Lost: November 10, 1975

Number of Days Sailing: 1

Cause of Sinking: Storm

Latitude (DD): 46.9985

Longitude (DD): -85.11

Nautical Miles to Shore: 15

Nautical Miles to NMS: N/A

Nautical Miles to MPA: 5.01

Nautical Miles to Fisheries: Unknown

Approximate Water Depth (Ft): 530

Bottom Type: Mud

Is There a Wreck at This Location? Yes, wreck has been positively located and identified

Wreck Orientation: Broken into two parts, the bow is on an even keel and the stern is inverted

Vessel Armament: None

Cargo Carried when Lost: 26,116 tons of taconite pellets

Cargo Oil Carried (bbl): 0

Cargo Oil Type: N/A

Probable Fuel Oil Remaining (bbl): ≤ 1,191

Fuel Type: No. 6 Fuel Oil

Total Oil Carried (bbl): ≤ 1,191

Dangerous Cargo or Munitions: None

Munitions Carried: N/A

Demolished after Sinking: No

Salvaged: Yes, partially and illegally

Cargo Lost: Yes

Reportedly Leaking: No

Historically Significant: Yes

Gravesite: Yes

Salvage Owner: Not known if any

Wreck Location

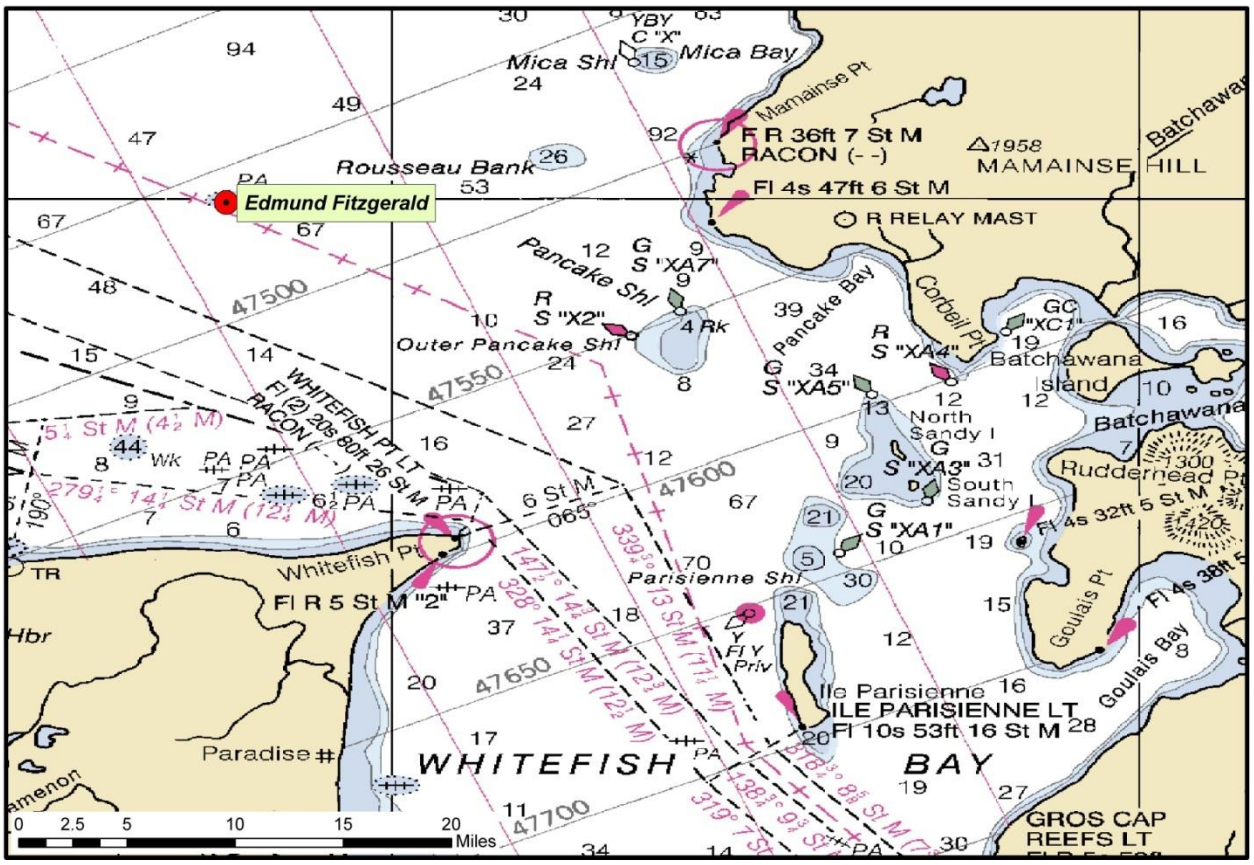


Chart Number: 14961

Casualty Narrative

"About 1915 EST., on November 10, 1975, the Great Lakes bulk cargo vessel SS *EDMUND FITZGERALD*, fully loaded with a cargo of taconite pellets, sank in eastern Lake Superior in position 46 59.91 N, 85 06.6'W, approximately 17 miles from the entrance to Whitefish Bay, Michigan. The ship was en route from Superior, WI, to Detroit, MI, and had been proceeding at a reduced speed in a severe storm. All the vessel's 29 officers and crewmembers are missing and presumed dead. No distress call was heard by vessels or shore stations.

The Safety Board considered many factors during the investigation including stability, hull strength, operating practices, adequacy of weathertight closures, hatch cover strength, possible grounding, vessel design, loading practices, and weather forecasting.

The National Transportation Safety Board determines that the probable cause of this accident was the sudden massive flooding of the cargo hold due to the collapse of one or more hatch covers. Before the hatch covers collapsed, flooding into the ballast tanks and tunnel through topside damage and flooding into the cargo hold through non-weathertight hatch covers caused a reduction of freeboard and a list. The hydrostatic and hydrodynamic forces imposed on the hatch covers by heavy boarding seas at this reduced freeboard and with the list caused the hatch covers to collapse.

Contributing to the accident was the lack of transverse weathertight bulkheads in the cargo hold and the reduction of freeboard authorized by the 1969, 1971, and 1973 amendments to the Great Lakes Load Line Regulations."

-http://www.uscg.mil/history/WEBSHIPWRECKS/EdmundFitzgeraldNTSBReport.pdf

General Notes

No general notes for *Edmund Fitzgerald* contained within the RULET database.

Wreck Condition/Salvage History

"The wreckage lies approximately 17 miles northwest of Whitefish Point, MI. The wreckage consists of an upright bow section, an inverted stern section, and debris from a missing 200-foot midship portion. The bow section is 276 feet long, inclined 15 degrees to port from the upright, extends from the stem to a location between hatches Nos. 8 and 9, and is buried in mud up to the 28-foot draft mark.

There was extensive damage to the forward deckhouse and there were several holes in the bow shell plating. The rest of the shell plating extending back to the rupture was intact. The No. 1 hatch cover was entirely inside the No. 1 hatch and showed indications of buckling from external loading. Sections of the coaming in the way of the No. 1 hatch were fractured and buckled inward. The No. 2 hatch cover was missing and the coaming on the No. 2 hatch was fractured and buckled. Hatches Nos. 3 and 4 were covered with mud, however, one corner of hatch cover No. 3 could be seen in place. Hatch cover No. 5 was missing. A series of 16 consecutive hatch cover clamps were observed on the No. 5 hatch coaming. Of this series, the first and eighth were distorted or broken. All of the 14 other clamps were undamaged and in the open position. The No. 6 hatch was open and a hatch cover was standing on end vertically in the hatch. The hatch covers were missing from hatches Nos. 7 and 8 and both coamings were fractured and severely distorted. The bow section abruptly ended just aft of hatch No. 8 and the deck plating was ripped up from the separation to the forward end of hatch No. 7.

The stern section was upside down and inclined 10 degrees from the vertical away from the bow section. All bottom plating was intact from the stern to a location between hatches Nos. 17 and 18 where the vessel had separated. The rudder and propeller were undamaged with the rudder positioned no more than 10 degrees from centerline.

There was mud-covered wreckage extending out from the ruptured end of the stern section, but no identification of what part of the ship it came from can be determined. Three hatch coamings and a hatch cover were lying next to the stern section. One of the hatch coamings bore the numeral 11.

A few of the deck vents on the starboard side of the bow section could be seen above the mud. One vent near hatch No. 5 was torn away from the deck, leaving an opening in the deck at the base of the vent pipe. The vents on the ort side of the bow section were covered with mud. Neither the spare propeller blade nor the hatch cover crane was visible and they have not been located."

-http://www.uscg.mil/history/WEBSHIPWRECKS/EdmundFitzgeraldNTSBReport.pdf

Archaeological Assessment

The archaeological assessment provides additional primary source based documentation about the sinking of vessels. It also provides condition-based archaeological assessment of the wrecks when possible. It does not provide a risk-based score or definitively assess the pollution risk or lack thereof from these vessels, but includes additional information that could not be condensed into database form.

Where the current condition of a shipwreck is not known, data from other archaeological studies of similar types of shipwrecks provide the means for brief explanations of what the shipwreck might look like and specifically, whether it is thought there is sufficient structural integrity to retain oil. This is more subjective than the Pollution Potential Tree and computer-generated resource at risk models, and as such provides an additional viewpoint to examine risk assessments and assess the threat posed by these shipwrecks. It also addresses questions of historical significance and the relevant historic preservation laws and regulations that will govern on-site assessments.

In some cases where little additional historic information has been uncovered about the loss of a vessel, archaeological assessments cannot be made with any degree of certainty and were not prepared. For vessels with full archaeological assessments, NOAA archaeologists and contracted archivists have taken photographs of primary source documents from the National Archives that can be made available for future research or on-site activities.

Assessment

Because *Edmund Fitzgerald* sank in 1975, records relating to the loss of the vessel were not part of the National Archives record groups examined by NOAA archaeologists and the local Coast Guard District or Sector may have access to more records about this wreck than are available at the National Archives. This means that the best assessment on the sinking of the ship probably still comes from the U.S. Coast Guard's Marine Board of Investigation Report written about this vessel and from the National Transportation Safety Board's Marine Accident Report.

Given that there were no survivors of the accident and weather prevented the wreckage from being surveyed until May 1976, it is not known if oil was lost from the ship during the sinking event or shortly thereafter. If the U.S. Coast Guard decides to assess this vessel, it should be noted that this vessel is of historic significance and will require appropriate actions be taken prior to any actions that could impact the integrity of the vessel. This vessel may be eligible for listing on the National Historic Register. The site is also considered a gravesite and appropriate actions should be undertaken to minimize disturbance to the site.

Background Information References

Vessel Image Sources: http://www.noaanews.noaa.gov/stories2006/s2633.htm

Construction Diagrams or Plans in RULET Database? No

Text References:
-http://www.uscg.mil/history/WEBSHIPWRECKS/EdmundFitzgeraldNTSBReport.pdf
-http://www.uscg.mil/hq/cg5/docs/boards/edmundfitz.pdf

-http://www.boatnerd.com/fitz/
-http://www.ssefo.com/
-Many additional sites can be found through a simple internet search

Vessel Risk Factors

In this section, the risk factors that are associated with the vessel are defined and then applied to the *Edmund Fitzgerald* based on the information available. These factors are reflected in the pollution potential risk assessment development by the U.S. Coast Guard Salvage Engineering Response Team (SERT) as a means to apply a salvage engineer's perspective to the historical information gathered by NOAA. This analysis reflected in Figure 1-1 is simple and straightforward and, in combination with the accompanying archaeological assessment, provides a picture of the wreck that is as complete as possible based on current knowledge and best professional judgment. This assessment ***does not*** take into consideration operational constraints such as depth or unknown location, but rather attempts to provide a replicable and objective screening of the historical date for each vessel. SERT reviewed the general historical information available for the database as a whole and provided a stepwise analysis for an initial indication of Low/Medium/High values for each vessel.

In some instances, nuances from the archaeological assessment may provide additional input that will amend the score for Section 1. Where available, additional information that may have bearing on operational considerations for any assessment or remediation activities is provided.

Each risk factor is characterized as High, Medium, or Low Risk or a category-appropriate equivalent such as No, Unknown, Yes, or Yes Partially. The risk categories correlate to the decision points reflected in Figure 1-1.

Each of the risk factors also has a "data quality modifier" that reflects the completeness and reliability of the information on which the risk ranks were assigned. The quality of the information is evaluated with respect to the factors required for a reasonable preliminary risk assessment. The data quality modifier scale is:

- **High Data Quality:** All or most pertinent information on wreck available to allow for thorough risk assessment and evaluation. The data quality is high and confirmed.
- **Medium Data Quality:** Much information on wreck available, but some key factor data are missing or the data quality is questionable or not verified. Some additional research needed.
- **Low Data Quality:** Significant issues exist with missing data on wreck that precludes making preliminary risk assessment, and/or the data quality is suspect. Significant additional research needed.

In the following sections, the definition of low, medium, and high for each risk factor is provided. Also, the classification for the *Edmund Fitzgerald* is provided, both as text and as shading of the applicable degree of risk bullet.

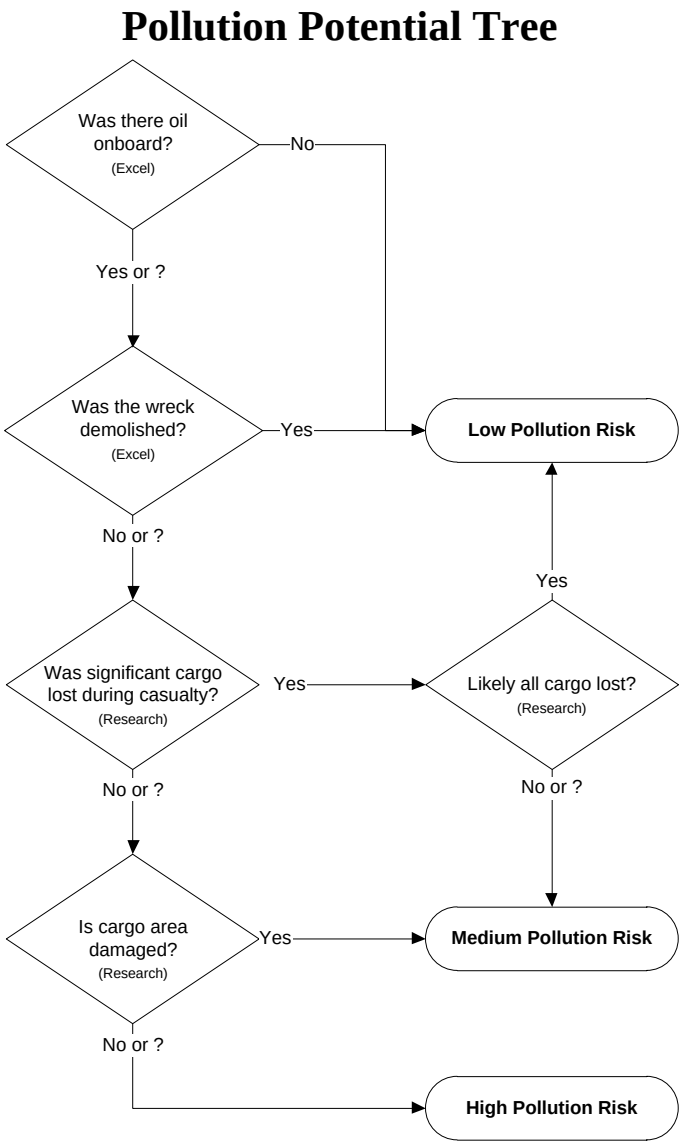


Figure 1-1: U.S. Coast Guard Salvage Engineering Response Team (SERT) developed the above Pollution Potential Decision Tree.

Pollution Potential Factors

Risk Factor A1: Total Oil Volume

The oil volume classifications correspond to the U.S. Coast Guard spill classifications:

- **Low Volume: Minor Spill** <240 bbl (10,000 gallons)
- **Medium Volume: Medium Spill** ≥240 – 2,400 bbl (100,000 gallons)
- **High Volume: Major Spill** ≥2,400 bbl (≥100,000 gallons)

The oil volume risk classifications refer to the volume of the most-likely Worst Case Discharge from the vessel and are based on the amount of oil believed or confirmed to be on the vessel.

The *Edmund Fitzgerald* is ranked as Medium Volume because it is thought to have a potential for up to 1,191 bbl, although some of that may have been lost at the time of the casualty due to the storm and breakup of the vessel. Data quality is medium.

The risk factor for volume also incorporates any reports or anecdotal evidence of actual leakage from the vessel or reports from divers of oil in the overheads, as opposed to potential leakage. This reflects the history of the vessel's leakage. There are no reports of leakage from the *Edmund Fitzgerald*.

Risk Factor A2: Oil Type

The oil type(s) on board the wreck are classified only with regard to persistence, using the U.S. Coast Guard oil grouping[1]. (Toxicity is dealt with in the impact risk for the Resources at Risk classifications.) The three oil classifications are:

- **Low Risk: Group I Oils** – non-persistent oil (e.g., gasoline)
- **Medium Risk: Group II – III Oils** – medium persistent oil (e.g., diesel, No. 2 fuel, light crude, medium crude)
- **High Risk: Group IV** – high persistent oil (e.g., heavy crude oil, No. 6 fuel oil, Bunker C)

The *Edmund Fitzgerald* is classified as High Risk because the bunker oil was No. 6 fuel oil, a Group IV oil type. Data quality is high.

Was the wreck demolished?

Risk Factor B: Wreck Clearance

This risk factor addresses whether or not the vessel was historically reported to have been demolished as a hazard to navigation or by other means such as depth charges or aerial bombs. This risk factor is based on historic records and does not take into account what a wreck site currently looks like. The risk categories are defined as:

- **Low Risk:** The wreck was reported to have been entirely destroyed after the casualty
- **Medium Risk:** The wreck was reported to have been partially cleared or demolished after the casualty
- **High Risk:** The wreck was not reported to have been cleared or demolished after the casualty
- **Unknown:** It is not known whether or not the wreck was cleared or demolished at the time of or after the casualty

The *Edmund Fitzgerald* is classified as High Risk because there are no known historic accounts of the wreck being demolished as a hazard to navigation. Data quality is high.

Was significant cargo or bunker lost during casualty?

[1] Group I Oil or Nonpersistent oil is defined as "a petroleum-based oil that, at the time of shipment, consists of hydrocarbon fractions: At least 50% of which, by volume, distill at a temperature of 340°C (645°F); and at least 95% of which, by volume, distill at a temperature of 370°C (700°F)."
Group II - Specific gravity less than 0.85 crude [API° >35.0]
Group III - Specific gravity between 0.85 and less than .95 [API° ≤35.0 and >17.5]
Group IV - Specific gravity between 0.95 to and including 1.0 [API° ≤17.5 and >10.0]

Risk Factor C1: Burning of the Ship

This risk factor addresses any burning that is known to have occurred at the time of the vessel casualty and may have resulted in oil products being consumed or breaks in the hull or tanks that would have increased the potential for oil to escape from the shipwreck. The risk categories are:

- **Low Risk:** Burned for multiple days
- **Medium Risk:** Burned for several hours
- **High Risk:** No burning reported at the time of the vessel casualty
- **Unknown:** It is not known whether or not the vessel burned at the time of the casualty

The *Edmund Fitzgerald* is classified as High Risk because there was no report of fire at the time of casualty. Data quality is high.

Risk Factor C2: Reported Oil on the Water

This risk factor addresses reports of oil on the water at the time of the vessel casualty. The amount is relative and based on the number of available reports of the casualty. Seldom are the reports from trained observers so this is very subjective information. The risk categories are defined as:

- **Low Risk:** Large amounts of oil reported on the water by multiple sources
- **Medium Risk:** Moderate to little oil reported on the water during or after the sinking event
- **High Risk:** No oil reported on the water
- **Unknown:** It is not known whether or not there was oil on the water at the time of the casualty

The *Edmund Fitzgerald* is classified as Unknown Risk because there were no survivors from the ship to make a report of oil on the water. Data quality is low.

Is the cargo area damaged?

Risk Factor D1: Nature of the Casualty

This risk factor addresses the means by which the vessel sank. The risk associated with each type of casualty is determined by the how violent the sinking event was and the factors that would contribute to increased initial damage or destruction of the vessel (which would lower the risk of oil, other cargo, or munitions remaining on board). The risk categories are:

- **Low Risk:** Multiple torpedo detonations, multiple mines, severe explosion
- **Medium Risk:** Single torpedo, shellfire, single mine, rupture of hull, breaking in half, grounding on rocky shoreline
- **High Risk:** Foul weather, grounding on soft bottom, collision
- **Unknown:** The cause of the loss of the vessel is not known

The *Edmund Fitzgerald* is classified as High Risk because the vessel broke apart in a storm and sank. Data quality is high.

Risk Factor D2: Structural Breakup

This risk factor takes into account how many pieces the vessel broke into during the sinking event or since sinking. This factor addresses how likely it is that multiple components of a ship were broken apart including tanks, valves, and pipes. Experience has shown that even vessels broken in three large sections

can still have significant pollutants on board if the sections still have some structural integrity. The risk categories are:

- **Low Risk:** The vessel is broken into more than three pieces
- **Medium Risk:** The vessel is broken into two-three pieces
- **High Risk:** The vessel is not broken and remains as one contiguous piece
- **Unknown:** It is currently not known whether or not the vessel broke apart at the time of loss or after sinking

The *Edmund Fitzgerald* is classified as Medium Risk because it broke into at least two pieces at the time of casualty; the bow and stern sections remain intact and there is a large debris field between these sections. Data quality is high.

Factors That May Impact Potential Operations

Orientation (degrees)

This factor addresses what may be known about the current orientation of the intact pieces of the wreck (with emphasis on those pieces where tanks are located) on the seafloor. For example, if the vessel turtled, not only may it have avoided demolition as a hazard to navigation, but it has a higher likelihood of retaining an oil cargo in the non-vented and more structurally robust bottom of the hull.

The bow of the *Edmund Fitzgerald* is upright on an even keel and the stern is inverted, a large debris field exists between both sections. Data quality is high.

Depth

Depth information is provided where known. In many instances, depth will be an approximation based on charted depths at the last known locations.

The *Edmund Fitzgerald* is 530 feet deep. Data quality is high.

Visual or Remote Sensing Confirmation of Site Condition

This factor takes into account what the physical status of wreck site as confirmed by remote sensing or other means such as ROV or diver observations and assesses its capability to retain a liquid cargo. This assesses whether or not the vessel was confirmed as entirely demolished as a hazard to navigation, or severely compromised by other means such as depth charges, aerial bombs, or structural collapse.

The wreck of the *Edmund Fitzgerald* has been surveyed and confirmed structurally intact many times by ROV and a hard-suit diver. Data quality is high.

Other Hazardous (Non-Oil) Cargo on Board

This factor addresses hazardous cargo other than oil that may be on board the vessel and could potentially be released, causing impacts to ecological and socio-economic resources at risk.

There are no reports of hazardous materials onboard. Data quality is high.

Munitions on Board

This factor addresses hazardous cargo other than oil that may be on board the vessel and could potentially be released or detonated causing impacts to ecological and socio-economic resources at risk.

The *Edmund Fitzgerald* did not carry any munitions. Data quality is high.

Vessel Risk Factors Summary

Table 1-1 summarizes the risk factor scores for the pollution potential and mitigating factors that would reduce the pollution potential for the *Edmund Fitzgerald*.

Table 1-1: Summary matrix for the vessel risk factors for the *Edmund Fitzgerald* color-coded as red (high risk), yellow (medium risk), and green (low risk).

Vessel Risk Factors		Data Quality Score	Comments	Risk Score
Pollution Potential Factors	A1: Oil Volume (total bbl)	Medium	Maximum of 1,191 bbl, not reported to be leaking	**Med**
	A2: Oil Type	High	Cargo is heavy fuel oil, a Group IV oil type	
	B: Wreck Clearance	High	Vessel not reported as cleared	
	C1: Burning of the Ship	High	No burning of the ship reported	
	C2: Oil on Water	Low	Unknown, no survivor reports	
	D1: Nature of Casualty	High	Breakup in a storm	
	D2: Structural Breakup	High	Vessel broke into at least two pieces	
Archaeological Assessment	Archaeological Assessment	Low	The best sinking assessment comes from the U.S. Coast Guard; no archaeological assessment was prepared	**Not Scored**
Operational Factors	Wreck Orientation	High	Bow is upright, stern is inverted	**Not Scored**
	Depth	High	Wreck is 530 feet deep	
	Visual or Remote Sensing Confirmation of Site Condition	High	The wreck has been surveyed multiple times	
	Other Hazardous Materials Onboard	High	No	
	Munitions Onboard	High	No	
	Gravesite (Civilian/Military)	High	Yes	
	Historical Protection Eligibility (NHPA/SMCA)	Medium	Vessel may be historically significant	

SECTION 2: ENVIRONMENTAL IMPACT MODELING

To help evaluate the potential transport and fates of releases from sunken wrecks, NOAA worked with RPS ASA to run a series of generalized computer model simulations of potential oil releases. The results are used to assess potential impacts to ecological and socio-economic resources, as described in Sections 3 and 4. The modeling results are useful for this screening-level risk assessment; however, it should be noted that detailed site/vessel/and seasonally specific modeling would need to be conducted prior to any intervention on a specific wreck. In the Great Lakes, ice cover of varying extent may be present during the winter season. However, the presence and movement of lake ice was not included in the modeled scenarios. If ice cover is present at the time of a release, the oil would become trapped under the surface of the ice and remain there (unweathered) until the ice thaws. Upon thawing, the oil would be released, and would follow a trajectory similar to those estimated by our modeling.

Release Scenarios Used in the Modeling

The potential volume of leakage at any point in time will tend to follow a probability distribution. Most discharges are likely to be relatively small, though there could be multiple such discharges. There is a lower probability of larger discharges, though these scenarios would cause the greatest damage. A **Worst Case Discharge** (WCD) would involve the release of all of the cargo oil and bunkers present on the vessel. In the case of the *Edmund Fitzgerald* this would be 2,000 bbl (rounded up from the 1,191 bbl onboard) based on current estimates of the amount of oil remaining onboard the wreck.

The likeliest scenario of oil release from most sunken wrecks, including the *Edmund Fitzgerald*, is a small, episodic release that may be precipitated by disturbance of the vessel in storms. Each of these episodic releases may cause impacts and require a response. **Episodic** releases are modeled using 1% of the WCD. Another scenario is a very low chronic release, i.e., a relatively regular release of small amounts of oil that causes continuous oiling and impacts over the course of a long period of time. This type of release would likely be precipitated by corrosion of piping that allows oil to flow or bubble out at a slow, steady rate. **Chronic** releases are modeled using 0.1% of the WCD.

The **Most Probable** scenario is premised on the release of all the oil from one tank. In the absence of information on the number and condition of the cargo or fuel tanks for all the wrecks being assessed, this scenario is modeled using 10% of the WCD. The **Large** scenario is loss of 50% of the WCD. The five major types of releases are summarized in Table 2-1. The actual type of release that occurs will depend on the condition of the vessel, time factors, and disturbances to the wreck. Note that, the episodic and chronic release scenarios represent a small release that is repeated many times, potentially repeating the same magnitude and type of impact(s) with each release. The actual impacts would depend on the environmental factors such as real-time and forecast winds and currents during each release and the types/quantities of ecological and socio-economic resources present.

The model results here are based on running the RPS ASA Spill Impact Model Application Package (SIMAP) two hundred times for each of the five spill volumes shown in Table 2-1. The model randomly selects the date of the release, and corresponding environmental, wind, and ocean current information from a long-term wind and current database.

When a spill occurs, the trajectory, fate, and effects of the oil will depend on environmental variables, such as the wind and current directions over the course of the oil release, as well as seasonal effects. The magnitude and nature of potential impacts to resources will also generally have a strong seasonal component (e.g., timing of bird migrations, turtle nesting periods, fishing seasons, and tourism seasons).

Table 2-1: Potential oil release scenario types for the *Edmund Fitzgerald*.

Scenario Type	Release per Episode	Time Period	Release Rate	Relative Likelihood	Response Tier
Chronic (0.1% of WCD)	2 bbl	Fairly regular intervals or constant	100 bbl over several days	More likely	Tier 1
Episodic (1% of WCD)	20 bbl	Irregular intervals	Over several hours or days	Most Probable	Tier 1-2
Most Probable (10% of WCD)	200 bbl	One-time release	Over several hours or days	Most Probable	Tier 2
Large (50% of WCD)	1,000 bbl	One-time release	Over several hours or days	Less likely	Tier 2-3
Worst Case	2,000 bbl	One-time release	Over several hours or days	Least likely	Tier 3

The modeling results represent 200 simulations for each spill volume with variations in spill trajectory based on winds and currents. The spectrum of the simulations gives a perspective on the variations in likely impact scenarios. Some resources will be impacted in nearly all cases; some resources may not be impacted unless the spill trajectory happens to go in that direction based on winds and currents at the time of the release and in its aftermath.

For the large and WCD scenarios, the duration of the release was assumed to be 12 hours, envisioning a storm scenario where the wreck is damaged or broken up, and the model simulations were run for a period of 30 days. The releases were assumed to be from a depth between 2-3 meters above the sea floor, using the information known about the wreck location and depth. It is important to acknowledge that these scenarios are only for this screening-level assessment. Detailed site/vessel/and seasonally specific modeling would need to be conducted prior to any intervention on a specific wreck.

Oil Type for Release

The *Edmund Fitzgerald* contained a maximum of 1,191 bbl of bunker fuel oil (a Group IV oil). Thus, the oil spill model was run using heavy fuel oil.

Oil Thickness Thresholds

The model results are reported for different oil thickness thresholds, based on the amount of oil on the water surface or shoreline and the resources potentially at risk. Table 2-2 shows the terminology and thicknesses used in this report, for both oil thickness on water and the shoreline. For oil on the water surface, a thickness of 0.01 g/m^2, which would appear as a barely visible sheen, was used as the threshold for socio-economic impacts because often fishing is prohibited in areas with any visible oil, to prevent contamination of fishing gear and catch. A thickness of 10 g/m^2 was used as the threshold for ecological impacts, primarily due to impacts to birds, because that amount of oil has been observed to be enough to mortally impact birds and other wildlife. In reality, it is very unlikely that oil would be evenly distributed on the water surface. Spilled oil is always distributed patchily on the water surface in bands or tarballs

with clean water in between. So, Table 2-2a shows the number of tarballs per acre on the water surface for these oil thickness thresholds, assuming that each tarball was a sphere that was 1 inch in diameter. For oil stranded onshore, a thickness of 1 g/m^2 was used as the threshold for socio-economic impacts because that amount of oil would conservatively trigger the need for shoreline cleanup on amenity beaches. A thickness of 100 g/m^2 was used as the threshold for ecological impacts based on a synthesis of the literature showing that shoreline life has been affected by this degree of oiling.[2] Because oil often strands onshore as tarballs, Table 2-2b shows the number of tarballs per m^2 on the shoreline for these oil thickness thresholds, assuming that each tarball was a sphere that was 1 inch in diameter.

Table 2-2a: Oil thickness thresholds used in calculating area of water impacted. Refer to Sections 3 and 4 for explanations of the thresholds for ecological and socio-economic resource impacts.

Oil Description	Sheen Appearance	Approximate Sheen Thickness		No. of 1 inch Tarballs	Threshold/Risk Factor
Oil Sheen	Barely Visible	0.00001 mm	0.01 g/m^2	~5-6 tarballs per acre	Socio-economic Impacts to Water Surface/Risk Factor 4B-1 and 2
Heavy Oil Sheen	Dark Colors	0.01 mm	10 g/m^2	~5,000-6,000 tarballs per acre	Ecological Impacts to Water Surface/ Risk Factor 3B-1 and 2

Table 2-2b: Oil thickness thresholds used in calculating miles of shoreline impacted. Refer to Sections 3 and 4 for explanations of the thresholds for ecological and socio-economic resource impacts.

Oil Description	Oil Appearance	Approximate Sheen Thickness		No. of 1 inch Tarballs	Threshold/Risk Factor
Oil Sheen/Tarballs	Dull Colors	0.001 mm	1 g/m^2	~0.12-0.14 tarballs/m^2	Socio-economic Impacts to Shoreline Users/Risk Factor 4C-1 and 2
Oil Slick/Tarballs	Brown to Black	0.1 mm	100 g/m^2	~12-14 tarballs/m^2	Ecological Impacts to Shoreline Habitats/Risk Factor 3C-1 and 2

Potential Impacts to the Water Column

Impacts to the water column from an oil release from the *Edmund Fitzgerald* will be determined by the volume of leakage. Because oil from sunken vessels will be released at low pressures, the droplet sizes will be large enough for the oil to float to the surface. Therefore, impacts to water column resources will result from the natural dispersion of the floating oil slicks on the surface, which is limited to about the top 33 feet. The metric used for ranking impacts to the water column is the area of water surface in mi^2 that has been contaminated by 1 part per billion (ppb) oil to a depth of 33 feet. At 1 ppb, there are likely to be impacts to sensitive organisms in the water column and potential tainting of seafood, so this concentration is used as a screening threshold for both the ecological and socio-economic risk factors for water column resource impacts. To assist planners in understanding the scale of potential impacts for different leakage volumes, a regression curve was generated for the water column volume oiled using the five volume scenarios (Figure 2-1). Using this figure, the water column impacts can be estimated for any spill volume.

[2] French, D., M. Reed, K. Jayko, S. Feng, H. Rines, S. Pavignano, T. Isaji, S. Puckett, A. Keller, F. W. French III, D. Gifford, J. McCue, G. Brown, E. MacDonald, J. Quirk, S. Natzke, R. Bishop, M. Welsh, M. Phillips and B.S. Ingram, 1996. The CERCLA type A natural resource damage assessment model for coastal and marine environments (NRDAM/CME), Technical Documentation, Vol. I - V. Office of Environmental Policy and Compliance, U.S. Dept. Interior, Washington, DC.

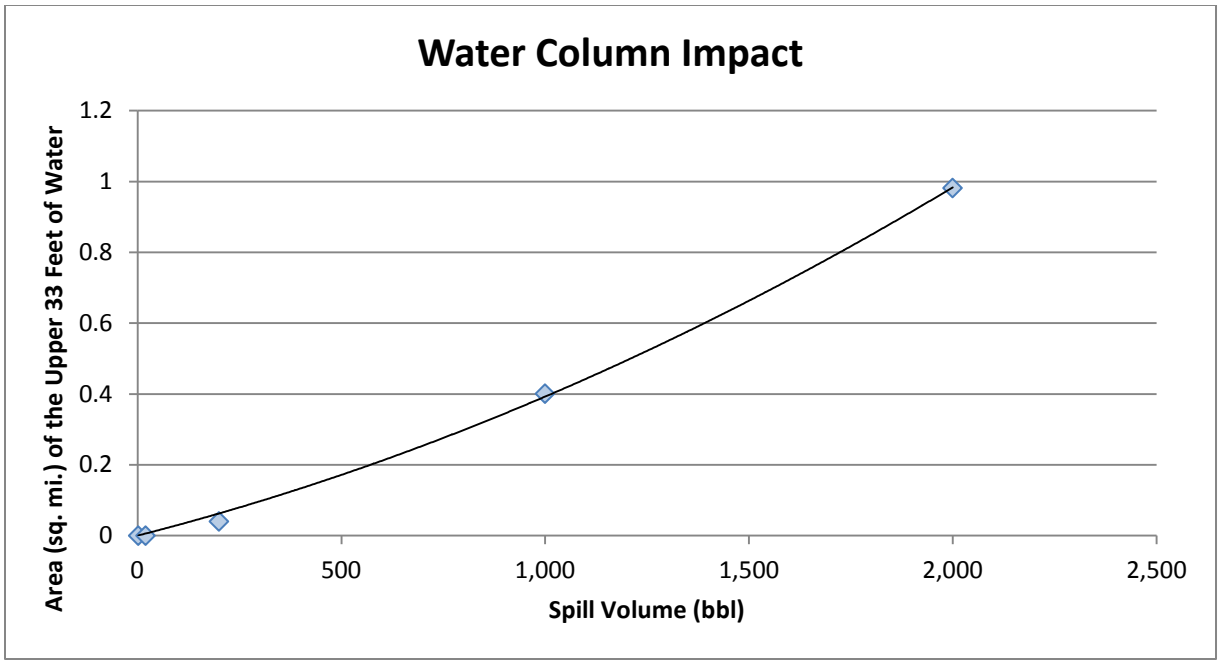


Figure 2-1: Regression curve for estimating the volume of water column impacted as a function of spill volume for the *Edmund Fitzgerald*.

Potential Water Surface Slick

The slick size from an oil release from the *Edmund Fitzgerald* is a function of the quantity released. The estimated water surface coverage by a fresh slick (the total water surface area "swept" by oil over time) for the various scenarios is shown in Table 2-3, as the mean result of the 200 model runs. Note that this is an estimate of total water surface affected over a 30-day period. In the model, the representative heavy fuel oil used for this analysis spreads to a minimum thickness of approximately 975 g/m^2, and is not able to spread any thinner. Thus, the results for the slick area swept are identical for the 0.01 and 10 g/m^2 thresholds. The slick will not be continuous but rather be broken and patchy and in the form of sheens, tarballs, and streamers.

Table 2-3: Estimated slick coverage on water for oil release scenarios from the *Edmund Fitzgerald*.

Scenario Type	Oil Volume (bbl)	Estimated Slick Area Swept Mean of All Models	
		0.01 g/m^2	10 g/m^2
Chronic	2	22 mi^2	22 mi^2
Episodic	20	85 mi^2	85 mi^2
Most Probable	200	270 mi^2	270 mi^2
Large	1,000	630 mi^2	630 mi^2
Worst Case Discharge	2,000	900 mi^2	900 mi^2

The location, size, shape, and spread of the oil slick(s) from an oil release from the *Edmund Fitzgerald* will depend on environmental conditions, including winds and currents, at the time of release and in its aftermath. The areas potentially affected by oil slicks, given that we cannot predict when the spill might occur and the range of possible wind and current conditions that might prevail after a release, are shown in Figure 2-2 and Figure 2-3 using the Most Probable volume and the socio-economic and ecological thresholds.

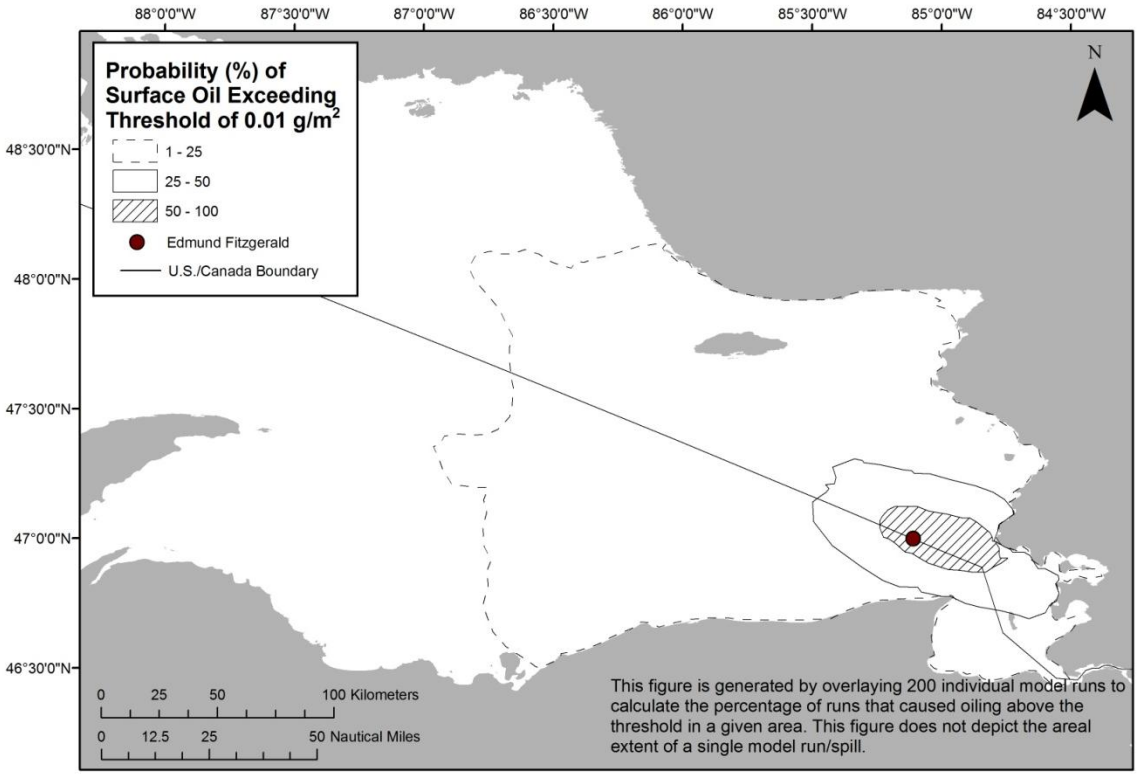


Figure 2-2: Probability of surface oil (exceeding 0.01 g/m^2) from the Most Probable spill of 200 bbl of heavy fuel oil from the *Edmund Fitzgerald* at the threshold for socio-economic resources at risk.

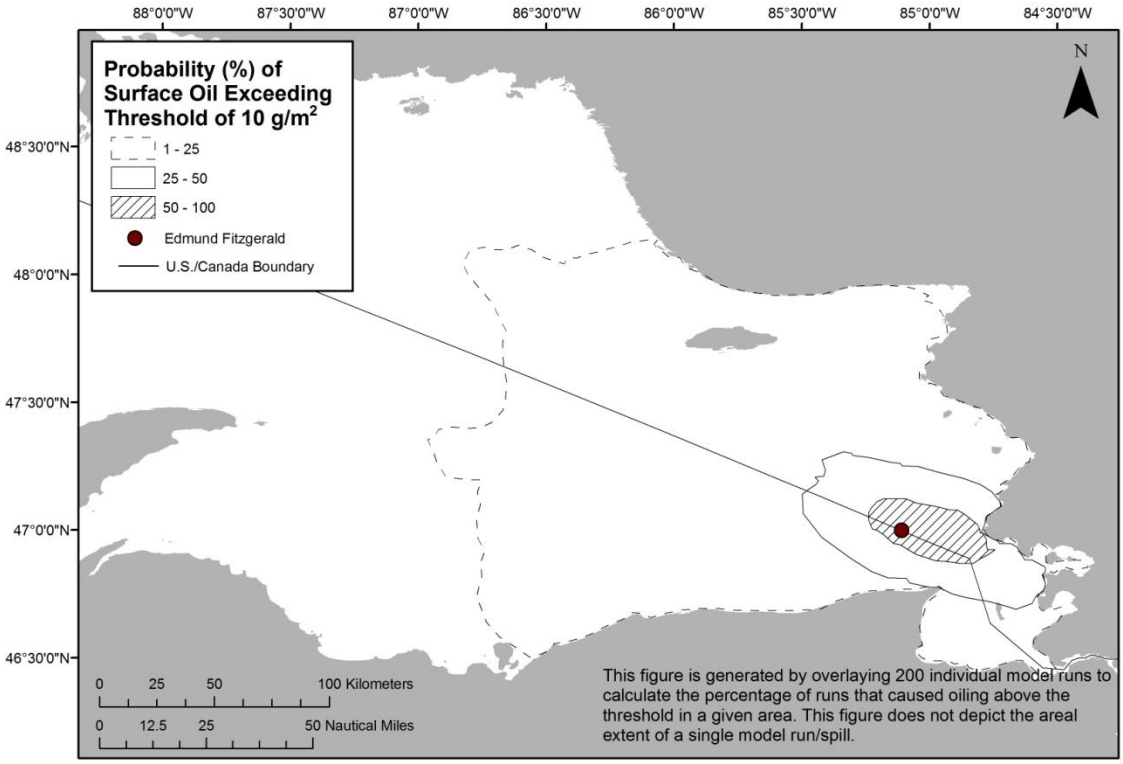


Figure 2-3: Probability of surface oil (exceeding 10 g/m^2) from the Most Probable spill of 200 bbl of heavy fuel oil from the *Edmund Fitzgerald* at the threshold for ecological resources at risk.

The maximum potential cumulative area swept by oil slicks at some time after a Most Probable Discharge is shown in Figure 2-4 as the timing of oil movements.

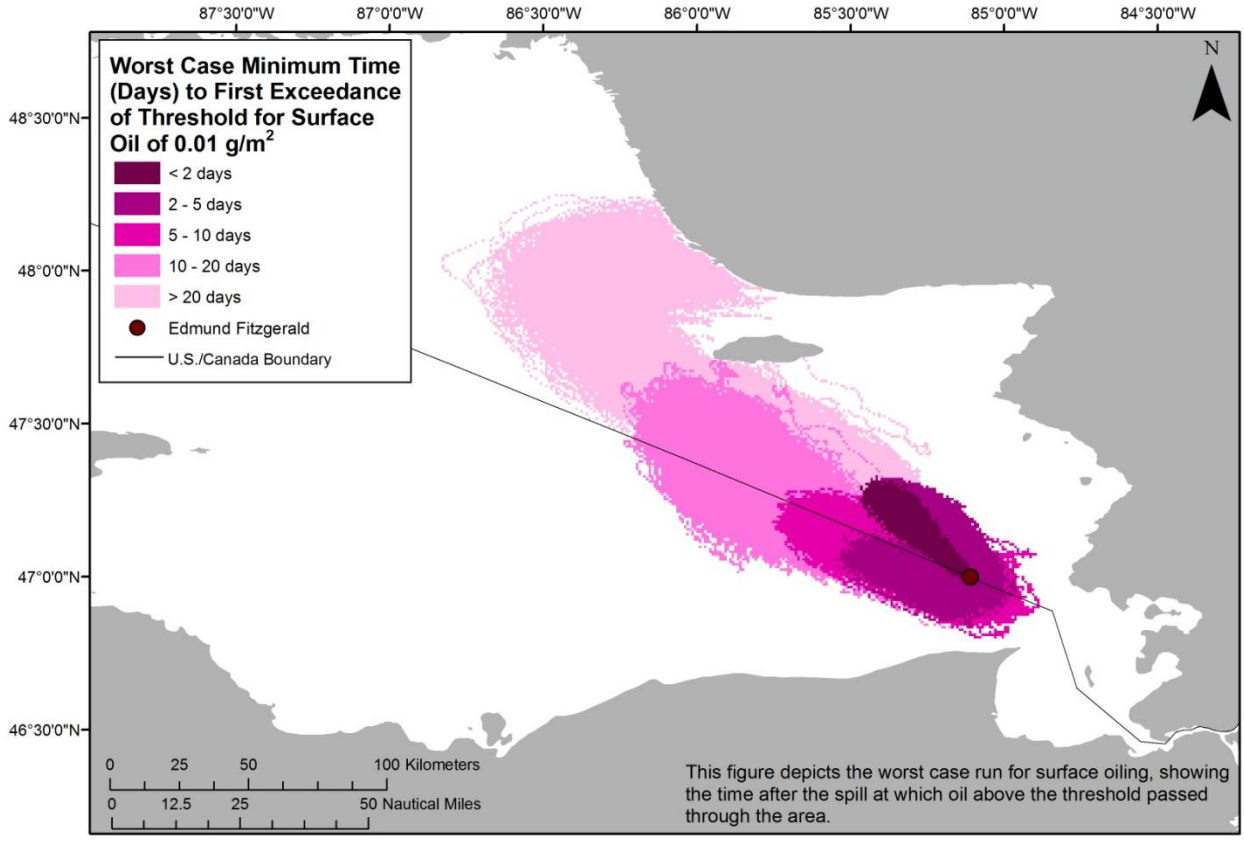


Figure 2-4: Water surface oiling from the Most Probable spill of 200 bbl of heavy fuel oil from the *Edmund Fitzgerald* shown as the area over which the oil spreads at different time intervals.

The actual area affected by a release will be determined by the volume of leakage, whether it is from one or more tanks at a time. To assist planners in understanding the scale of potential impacts for different leakage volumes, a regression curve was generated for the water surface area oiled using the five volume scenarios, which is shown in Figure 2-5. Using this figure, the area of water surface with a barely visible sheen can be estimated for any spill volume.

Potential Shoreline Impacts

Based on these modeling results, shorelines along both the U.S. and Canadian shorelines of eastern Lake Superior are at risk. Figure 2-6 shows the probability of oil stranding on the shoreline at concentrations that exceed the threshold of 1 g/m^2, for the Most Probable release of 200 bbl. However, the specific areas that would be oiled will depend on the currents and winds at the time of the oil release(s), as well as on the amount of oil released. Figure 2-7 shows the single oil spill scenario that resulted in the maximum extent of shoreline oiling for the Most Probable volume. Estimated miles of shoreline oiling above the threshold of 1 g/m^2 by scenario type are shown in Table 2-4.

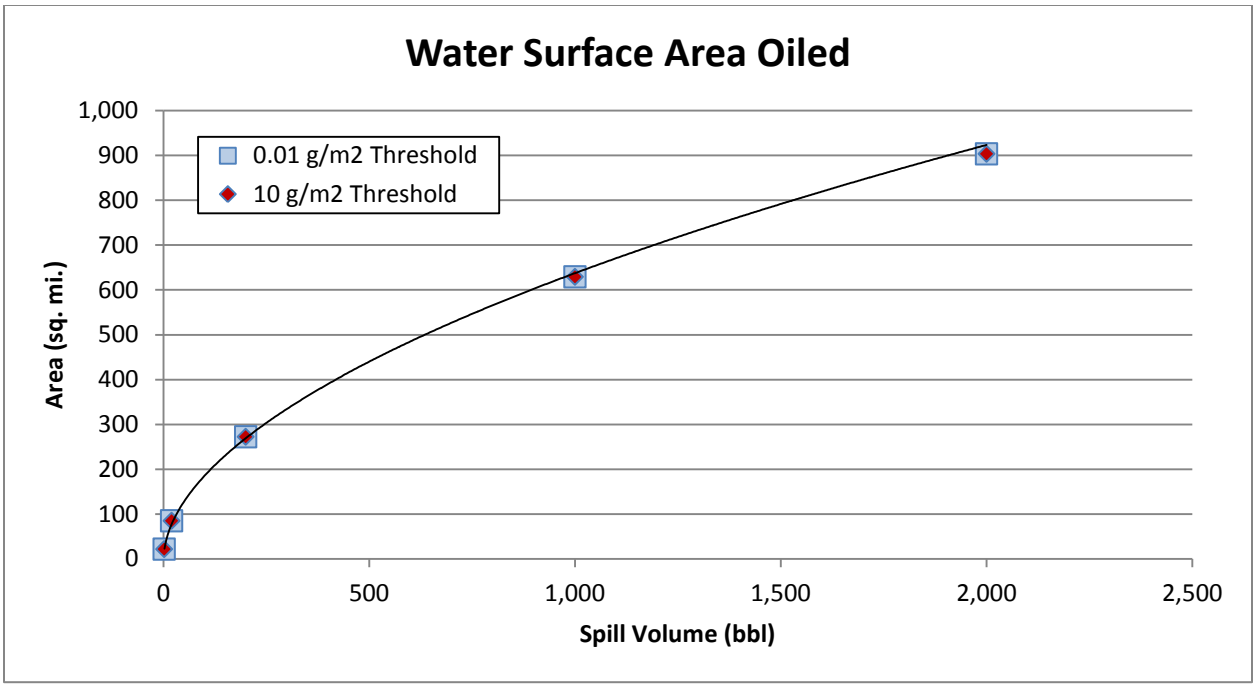


Figure 2-5: Regression curve for estimating the amount of water surface oiling as a function of spill volume for the *Edmund Fitzgerald*, for both the ecological threshold of 10 g/m^2 and socio-economic threshold of 0.01 g/m^2.

Table 2-4a: Estimated shoreline oiling from leakage from the *Edmund Fitzgerald*. (U.S. and Canada).

Scenario Type	Volume (bbl)	Estimated Miles of Shoreline Oiling Above 1 g/m^2			
		Rock/Gravel/Artificial	Sand	Wetland/Mudflat	Total
Chronic	2	4	2	0	6
Episodic	20	11	6	0	17
Most Probable	200	16	9	1	25
Large	1,000	17	9	1	27
Worst Case Discharge	2,000	18	10	1	28

Table 2-4b: Estimated shoreline oiling from leakage from the *Edmund Fitzgerald*. (U.S. only).

Scenario Type	Volume (bbl)	Estimated Miles of Shoreline Oiling Above 1 g/m^2			
		Rock/Gravel/Artificial	Sand	Wetland/Mudflat	Total
Chronic	2	0	1	0	1
Episodic	20	0	4	0	4
Medium	200	0	5	1	6
Large	1,000	0	6	1	7
Worst Case Discharge	2,000	0	6	1	7

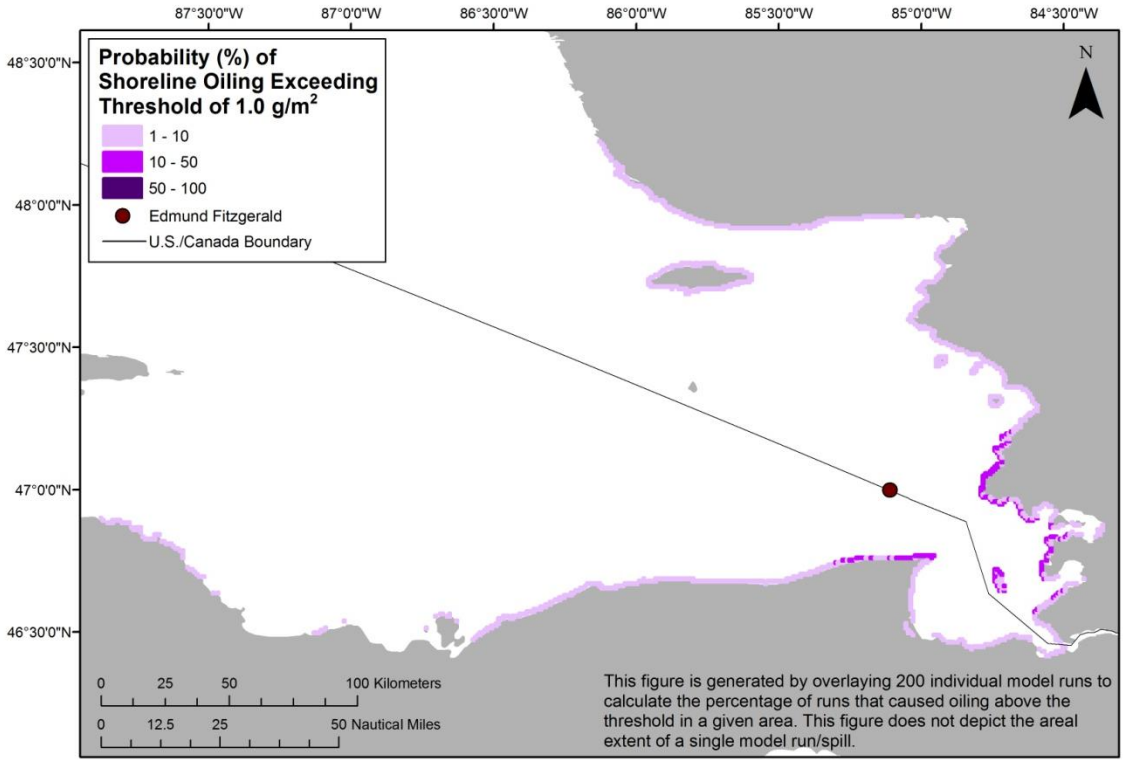


Figure 2-6: Probability of shoreline oiling (exceeding 1.0 g/m^2) from the Most Probable Discharge of 200 bbl of heavy fuel oil from the *Edmund Fitzgerald*.

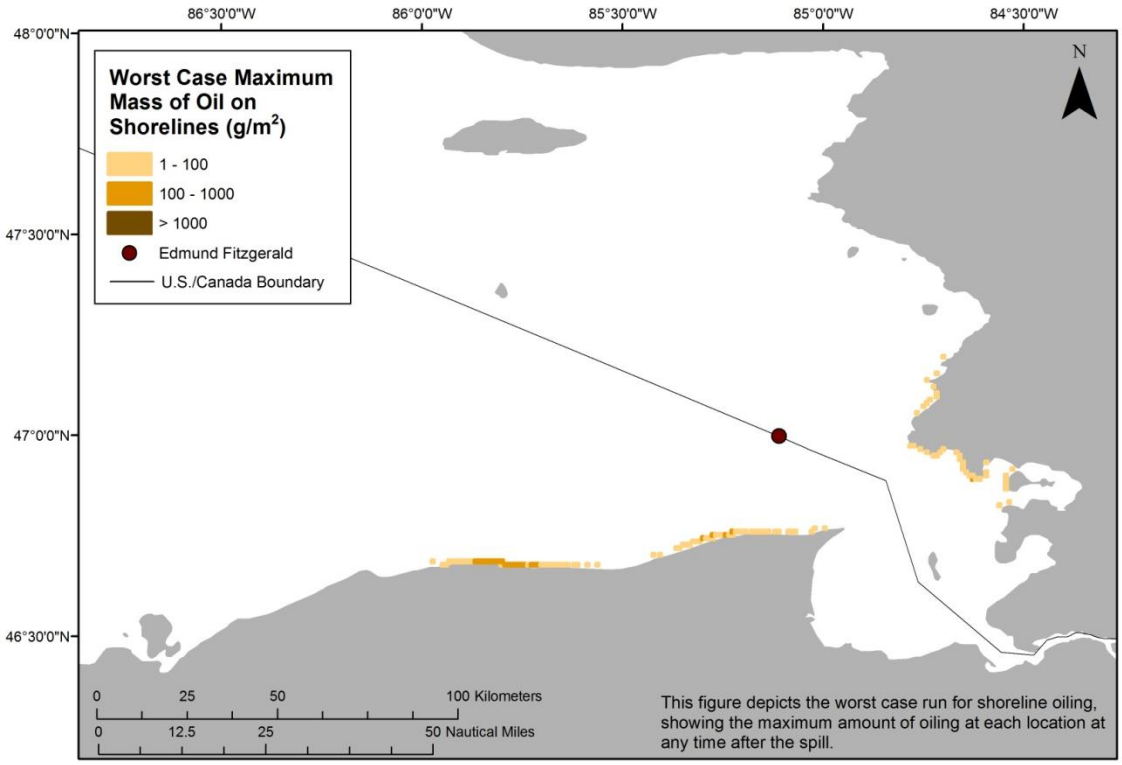


Figure 2-7: The extent and degree of shoreline oiling from the single model run of the Most Probable Discharge of 200 bbl of a heavy fuel oil from the *Edmund Fitzgerald* that resulted in the greatest shoreline oiling.

The actual shore length affected by a release will be determined by the volume of leakage and environmental conditions during an actual release. To assist planners in scaling the potential impact for different leakage volumes, a regression curve was generated for the total shoreline length oiled using the five volume scenarios, which is shown in Figure 2-8. Using this figure, the shore length oiled can be estimated for any spill volume.

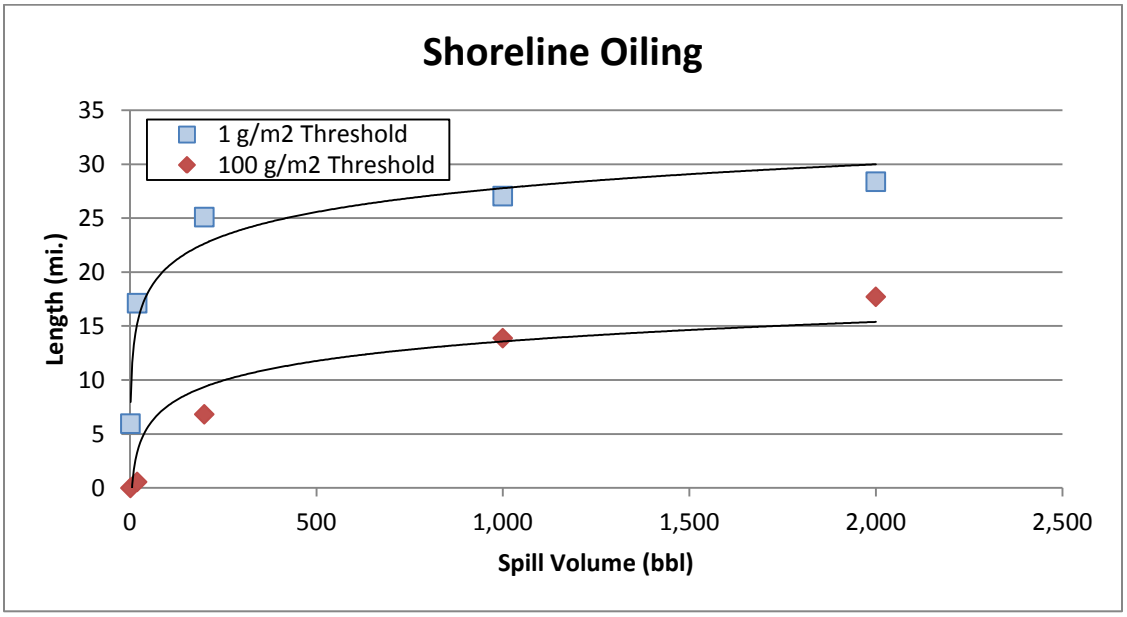


Figure 2-8: Regression curve for estimating the amount of shoreline oiling at different thresholds as a function of spill volume for the *Edmund Fitzgerald*.

The worst case scenario for shoreline exposure along the potentially impacted area for the WCD volume (Table 2-5) and the Most Probable volume (Table 2-6) consists primarily of sand beaches and rocky and artificial shores. Few wetlands are at risk.

Table 2-5: Worst case scenario shoreline impact by habitat type and oil thickness for a leakage of 2,000 bbl from the *Edmund Fitzgerald*.

Shoreline/Habitat Type	Lighter Oiling Oil Thickness <1 mm Oil Thickness >1 g/m²	Heavier Oiling Oil Thickness >1 mm Oil Thickness >100 g/m²
Rocky and artificial shores/Gravel beaches	29 miles	21 miles
Sand beaches	40 miles	24 miles
Wetlands	2 miles	0 miles

Table 2-6: Worst case scenario shoreline impact by habitat type and oil thickness for a leakage of 200 bbl from the *Edmund Fitzgerald*.

Shoreline/Habitat Type	Lighter Oiling Oil Thickness <1 mm Oil Thickness >1 g/m²	Heavier Oiling Oil Thickness >1 mm Oil Thickness >100 g/m²
Rocky and artificial shores/Gravel beaches	14 miles	0 miles
Sand beaches	43 miles	7 miles
Wetlands	1 mile	0 miles

SECTION 3: ECOLOGICAL RESOURCES AT RISK

Ecological resources at risk from a catastrophic release of oil from the *Edmund Fitzgerald* (Table 3-1) include migratory shorebirds, waterfowl, and raptors. Beaches and nearshore islands are nesting areas for shorebirds, and coastal wetlands are important staging areas for waterfowl during migrations. Shallow nearshore areas are also important habitat for migrating and spawning fish in the region.

Table 3-1: Ecological resources at risk from a release of oil from the *Edmund Fitzgerald*.
(FT = Federal threatened; FE = Federal endangered; ST = State threatened; SE = State endangered).

Species Group	Species Subgroup and Geography	Seasonal Presence
Birds	Many species and guilds of birds are present in the area, including • Waterfowl: mallard, black duck, common goldeneye, red-breasted merganser, Canada goose, greater scaup, whistling swan, snow goose, lesser scaup, long-tailed duck, white-winged scoter, surf scoter, American wigeon • Diving birds: common loon, grebes • Shorebirds: greater yellowlegs, lesser yellowlegs, red knot, least sandpiper, dunlin, western sandpiper, sanderling, ruddy turnstone, semipalmated sandpiper • Gulls and terns: herring gull, black tern, Caspian tern (ST), ring-billed gull, common tern (ST), glaucous gull, great black-backed gull • Wading birds: great blue heron, green heron, Virginia rail, sora, black-crowned night-heron, American bittern, great egret, snowy egret, cattle egret, yellow-crowned night-heron, yellow rail (ST), sandhill crane • Raptors: peregrine falcon, bald eagle, red-shouldered hawk *Concentration areas*: • Large herring gull colonies and blue heron rookeries are present on Lizard Islands, Entrance Island, Ossifrage Island, Agrawa Islands, Chêne Island, and Iroquois Island • Double-crested cormorants present at Steamboat Island and Ella Islet • Historic piping plover nesting locations at Grand Marais Beach and Whitefish Point • Sandhill cranes present at Shore Ridges Conservation Area, mouth of the Goulais River • Grand Marais beach – herring gull, peregrine falcon (SE), bald eagle nesting; historic piping plover nesting location • Lake Superior Provincial Park – peregrine falcons nest on the cliffs • Flowerpot Islands – large concentrations of great blue herons, herring gulls • Mouth of the Goulais River – duck and woodcock breeding in marsh • Ile Parisienne has high concentrations of raptors, shorebirds, nesting waterfowl • Steamboat Island is important nesting habitat for herring gulls and double-crested cormorant • Mouth of Harmony River – large colonies of ring-billed gull and common tern • Cozens Cove, Squaw Island, Jordan Island – large herring gull colonies • Vrooman Island – ring-billed gulls, herring gulls *Migratory bird areas* • Whitefish Point is a funnel for migrating waterbirds, passerines, and raptors (50-70,000 birds pass by each fall): 12-21,000 red-necked grebes, red-breasted merganser (max 1,708/day), common loon (>1,000 day), common	*Breeding* Herring gull present Mar-Dec, nests Apr-Aug Great blue heron nests May-Sep Colonial waterbirds nest Apr-Aug Double-crested cormorant present Apt-Oct, nests Apr-Aug Sandhill crane nests Apr-May *Migrating* Common loon, grebe spp. present May-Sep Canada goose present Apr-May, Aug-Nov Dabbling ducks present Apr-May, Aug-Sep Diving ducks present Apr-May, Aug-Sep Shorebirds present May-Aug, Sep Osprey, peregrine falcon Apr-Nov

Species Group	Species Subgroup and Geography	Seasonal Presence
	terns (ST; 300 per season), Bonaparte's gull (3,643 per season) during fall migration • Offshore Dore point to Point Isacor is major spring staging area for long-tailed ducks and other divers • Driftwood and Sandy Beach are staging areas for mergansers, mallards, teals, black ducks in spring • Migratory grebes, diving ducks, loons feeding in shallows near Deadman's Cove during migration • Caribou Island – important location for migratory shorebirds • Batchawana Island – fall stopover for migratory waterfowl	
Mammals	• Raccoons, mink, river otter, beavers all occur in the area and are common by water • Caribou occur on the Canadian shoreline and have been observed swimming near Devils Warehouse Island and Cape Gargantua • Moose are rare in Michigan but present along the Canadian shoreline • Gray wolf (FE) is rare but can occur and forage in nearshore habitats	More active in summer
Fish	Nearshore habitats are important habitats for several species of fish: • Lake whitefish are abundant near shorelines in the fall and spawn in shallow rock or sand bottomed lake waters less than 25 feet deep • Lake trout spawn on nearshore shoals throughout the area of potential impact • Brook trout spawn over hard substrate along the lakeshore • Rainbow trout spawn in the mouths of rivers • Brook and rainbow trout often use areas near the mouths of rivers • Lake sturgeon (ST) spawn upriver, migrate through nearshore waters in April • Coho and Chinook salmon spawn in the fall in lake tributaries • Smelt present in most streams in the spring	Spring spawning fish: lake sturgeon, walleye, rainbow trout Fall spawning fish: Lake whitefish, lake trout, salmon

The Environmental Sensitivity Index (ESI) atlases for the potentially impacted coastal areas from a leak from the *Edmund Fitzgerald* are generally available at each U.S. Coast Guard Sector. They can also be downloaded at: http://response.restoration.noaa.gov/esi. These maps show detailed spatial information on the distribution of sensitive shoreline habitats, biological resources, and human-use resources. The tables on the back of the maps provide more detailed life-history information for each species and location. The ESI atlases should be consulted to assess the potential environmental resources at risk for specific spill scenarios. In addition, the Geographic Response Plans within the Area Contingency Plans prepared by the Area Committee for each U.S. Coast Guard Sector have detailed information on the nearshore and shoreline ecological resources at risk and should be consulted.

Ecological Risk Factors

Risk Factor 3: Impacts to Ecological Resources at Risk (EcoRAR)

Ecological resources include plants and animals (e.g., fish, birds, invertebrates, and mammals), as well as the habitats in which they live. All impact factors are evaluated for both the Worst Case and the Most Probable Discharge oil release from the wreck. Risk factors for ecological resources at risk (EcoRAR) are divided into three categories:

- Impacts to the water column and resources in the water column;

- Impacts to the water surface and resources on the water surface; and
- Impacts to the shoreline and resources on the shoreline.

The impacts from an oil release from the wreck would depend greatly on the direction in which the oil slick moves, which would, in turn, depend on wind direction and currents at the time of and after the oil release. Impacts are characterized in the risk analysis based on the likelihood of any measurable impact, as well as the degree of impact that would be expected if there is an impact. The measure of the degree of impact is based on the median case for which there is at least some impact. The median case is the "middle case" – half of the cases with significant impacts have less impact than this case, and half have more.

For each of the three ecological resources at risk categories, risk is defined as:

- The **probability of oiling** over a certain threshold (i.e., the likelihood that there will be an impact to ecological resources over a certain minimal amount); and
- The **degree of oiling** (the magnitude or amount of that impact).

As a reminder, the ecological impact thresholds are: 1 ppb aromatics for water column impacts; 10 g/m^2 for water surface impacts; and 100 g/m^2 for shoreline impacts.

In the following sections, the definition of low, medium, and high for each ecological risk factor is provided. Also, the classification for the *Edmund Fitzgerald* is provided, both as text and as shading of the applicable degree of risk bullet, for the WCD release of 2,000 bbl and a border around the applicable degree of risk bullet Most Probable Discharge of 200 bbl.

Risk Factor 3A: Water Column Impacts to EcoRAR

Water column impacts occur beneath the water surface. The ecological resources at risk for water column impacts are fish, marine mammals, and invertebrates (e.g., shellfish, and small organisms that are food for larger organisms in the food chain). These organisms can be affected by toxic components in the oil. The threshold for water column impact to ecological resources at risk is a dissolved aromatic hydrocarbons concentration of 1 ppb (i.e., 1 part total dissolved aromatics per one billion parts water). Dissolved aromatic hydrocarbons are the most toxic part of the oil. At this concentration and above, one would expect impacts to organisms in the water column.

Risk Factor 3A-1: Water Column Probability of Oiling of EcoRAR

This risk factor reflects the probability that at least 0.2 mi^2 of the upper 33 feet of the water column would be contaminated with a high enough concentration of oil to cause ecological impacts. The three risk scores for water column oiling probability are:

- **Low Oiling Probability:** Probability = <10%
- **Medium Oiling Probability:** Probability = 10 – 50%
- **High Oiling Probability:** Probability > 50%

Risk Factor 3A-2: Water Column Degree of Oiling of EcoRAR

The degree of oiling of the water column reflects the total volume of water that would be contaminated by oil at a concentration high enough to cause impacts. The three categories of impact are:

- **Low Impact:** impact on less than 0.2 mi^2 of the upper 33 feet of the water column at the threshold level
- **Medium Impact**: impact on 0.2 to 200 mi^2 of the upper 33 feet of the water column at the threshold level
- **High Impact:** impact on more than 200 mi^2 of the upper 33 feet of the water column at the threshold level

The *Edmund Fitzgerald* is classified as High Risk for oiling probability for water column ecological resources for the WCD of 2,000 bbl because 100% of the model runs resulted in contamination of more than 0.2 mi^2 of the upper 33 feet of the water column above the threshold of 1 ppb aromatics. It is classified as Medium Risk for degree of oiling because the mean volume of water contaminated was 1 mi^2 of the upper 33 feet of the water column. For the Most Probable Discharge of 200 bbl, the *Edmund Fitzgerald* is classified as Low Risk for oiling probability for water column ecological resources because 0% of the model runs resulted in contamination of more than 0.2 mi^2 of the upper 33 feet of the water column above the threshold of 1 ppb aromatics. It is classified as Low Risk for degree of oiling because the mean volume of water contaminated was 0 mi^2 of the upper 33 feet of the water column.

Risk Factor 3B: Water Surface Impacts to EcoRAR

Ecological resources at risk at the water surface include surface feeding and diving sea birds, sea turtles, and marine mammals. These organisms can be affected by the toxicity of the oil as well as from coating with oil. The threshold for water surface oiling impact to ecological resources at risk is 10 g/m^2 (10 grams of floating oil per square meter of water surface). At this concentration and above, one would expect impacts to birds and other animals that spend time on the water surface.

Risk Factor 3B-1: Water Surface Probability of Oiling of EcoRAR

This risk factor reflects the probability that at least 1,000 mi^2 of the water surface would be affected by enough oil to cause impacts to ecological resources. The three risk scores for oiling are:

- **Low Oiling Probability:** Probability = <10%
- **Medium Oiling Probability:** Probability = 10 – 50%
- **High Oiling Probability:** Probability > 50%

Risk Factor 3B-2: Water Surface Degree of Oiling of EcoRAR

The degree of oiling of the water surface reflects the total amount of oil that would affect the water surface in the event of a discharge from the vessel. The three categories of impact are:

- **Low Impact:** less than 1,000 mi^2 of water surface impact at the threshold level
- **Medium Impact:** 1,000 to 10,000 mi^2 of water surface impact at the threshold level
- **High Impact:** more than 10,000 mi^2 of water surface impact at the threshold level

The *Edmund Fitzgerald* is classified as Medium Risk for oiling probability for water surface ecological resources for the WCD because 32% of the model runs resulted in at least 1,000 mi^2 of the water surface affected above the threshold of 10 g/m^2. It is classified as Low Risk for degree of oiling because the mean area of water contaminated was 900 mi^2. The *Edmund Fitzgerald* is classified as Low Risk for oiling probability for water surface ecological resources for the Most Probable Discharge because 0% of the

model runs resulted in at least 1,000 mi^2 of the water surface affected above the threshold of 10 g/m^2. It is classified as Low Risk for degree of oiling because the mean area of water contaminated was 270 mi^2.

Risk Factor 3C: Shoreline Impacts to EcoRAR

The impacts to different types of shorelines vary based on their type and the organisms that live on them. In this risk analysis, shorelines have been weighted by their degree of sensitivity to oiling. Wetlands are the most sensitive (weighted as "3" in the impact modeling), rocky and gravel shores are moderately sensitive (weighted as "2"), and sand beaches (weighted as "1") are the least sensitive to ecological impacts of oil.

Risk Factor 3C-1: Shoreline Probability of Oiling of EcoRAR

This risk factor reflects the probability that the shoreline would be coated by enough oil to cause impacts to shoreline organisms. The threshold for shoreline oiling impacts to ecological resources at risk is 100 g/m^2 (i.e., 100 grams of oil per square meter of shoreline). The three risk scores for oiling are:

- **Low Oiling Probability:** Probability = <10%
- **Medium Oiling Probability:** Probability = 10 – 50%
- **High Oiling Probability:** Probability > 50%

Risk Factor 3C-2: Shoreline Degree of Oiling of EcoRAR

The degree of oiling of the shoreline reflects the length of shorelines oiled by at least 100 g/m^2 in the event of a discharge from the vessel. The three categories of impact are:

- **Low Impact:** less than 10 miles of shoreline impacted at the threshold level
- **Medium Impact:** 10 - 100 miles of shoreline impacted at the threshold level
- **High Impact:** more than 100 miles of shoreline impacted at the threshold level

The *Edmund Fitzgerald* is classified as High Risk for oiling probability for shoreline ecological resources for the WCD because 99% of the model runs resulted in shorelines affected above the threshold of 100 g/m^2. It is classified as Medium Risk for degree of oiling because the mean weighted length of shoreline contaminated was 29 miles. The *Edmund Fitzgerald* is classified as High Risk for oiling probability to shoreline ecological resources for the Most Probable Discharge because 98% of the model runs resulted in shorelines affected above the threshold of 100 g/m^2. It is classified as Medium Risk for degree of oiling because the mean weighted length of shoreline contaminated was 11 miles.

Considering the modeled risk scores and the ecological resources at risk, the ecological risk from potential releases of the WCD of 2,000 bbl of heavy fuel oil from the *Edmund Fitzgerald* is summarized as listed below and indicated in the far-right column in Table 3-2:

- Water column resources – Low, because the area of potential water column exposures above the threshold is very small, averaging only 1 mi^2
- Water surface resources – Medium, because of the number of large nesting bird colonies and concentration of migratory birds in the potential impact areas, and the persistence of tarballs that can be transported long distances. It should be noted that oil on the surface will not be continuous but rather be broken and patchy and in the form of sheens, tarballs, and streamers
- Shoreline resources – Medium, because oil is likely to strand quickly and heavily, and these beaches are used by many shorebirds for nesting and by many shorebirds as migratory stopovers

Table 3-2: Ecological risk factor scores for the **Worst Case Discharge of 2,000 bbl** of heavy fuel oil from the *Edmund Fitzgerald*.

Risk Factor	Risk Score			Explanation of Risk Score	Final Score
3A-1: Water Column Probability EcoRAR Oiling	Low	Medium	High	100% of the model runs resulted in at least 0.2 mi^2 of the upper 33 feet of the water column contaminated above 1 ppb aromatics	Low
3A-2: Water Column Degree EcoRAR Oiling	Low	Medium	High	The mean volume of water contaminated above 1 ppb was 1 mi^2 of the upper 33 feet of the water column	
3B-1: Water Surface Probability EcoRAR Oiling	Low	Medium	High	33% of the model runs resulted in at least 1,000 mi^2 of water surface covered by at least 10 g/m^2	Med
3B-2: Water Surface Degree EcoRAR Oiling	Low	Medium	High	The mean area of water contaminated above 10 g/m^2 was 900 mi^2	
3C-1: Shoreline Probability EcoRAR Oiling	Low	Medium	High	99% of the model runs resulted in shoreline oiling of 100 g/m^2	Med
3C-2: Shoreline Degree EcoRAR Oiling	Low	Medium	High	The length of shoreline contaminated by at least 100 g/m^2 was 29 mi	

For the Most Probable Discharge of 200 bbl, the ecological risk from potential releases from the *Edmund Fitzgerald* is summarized as listed below and indicated in the far-right column in Table 3-3:

- Water column resources – Low, because of the very small area of water column impacts
- Water surface resources – Low, because of the relatively small area above thresholds that pose risks to birds. It should be noted that oil on the surface will not be continuous but rather be broken and patchy and in the form of sheens, tarballs, and streamers
- Shoreline resources – Medium, because oil is likely to strand quickly and heavily, and these beaches are used by many shorebirds for nesting and by many shorebirds as migratory stopovers

Table 3-3: Ecological risk factor scores for the **Most Probable Discharge of 200 bbl** of heavy fuel oil from the *Edmund Fitzgerald*.

Risk Factor	Risk Score			Explanation of Risk Score	Final Score
3A-1: Water Column Probability EcoRAR Oiling	**Low**	**Medium**	**High**	0% of the model runs resulted in at least 0.2 mi^2 of the upper 33 feet of the water column contaminated above 1 ppb aromatics	**Low**
3A-2: Water Column Degree EcoRAR Oiling	**Low**	**Medium**	**High**	The mean volume of water contaminated above 1 ppb was 0 mi^2 of the upper 33 feet of the water column	
3B-1: Water Surface Probability EcoRAR Oiling	**Low**	**Medium**	**High**	0% of the model runs resulted in at least 1,000 mi^2 of water surface covered by at least 10 g/m^2	**Low**
3B-2: Water Surface Degree EcoRAR Oiling	**Low**	**Medium**	**High**	The mean area of water contaminated above 10 g/m^2 was 270 mi^2	
3C-1: Shoreline Probability EcoRAR Oiling	**Low**	**Medium**	**High**	98% of the model runs resulted in shoreline oiling of 100 g/m^2	**Med**
3C-2: Shoreline Degree EcoRAR Oiling	**Low**	**Medium**	**High**	The length of shoreline contaminated by at least 100 g/m^2 was 11 mi	

SECTION 4: SOCIO-ECONOMIC RESOURCES AT RISK

In addition to natural resource impacts, spills from sunken wrecks have the potential to cause significant social and economic impacts. Socio-economic resources potentially at risk from oiling are listed in Table 4-1 and shown in Figures 4-1 and 4-2. The potential economic impacts include disruption of coastal economic activities such as commercial and recreational fishing, boating, vacationing, commercial shipping, and other activities that may become claims following a spill.

Socio-economic resources in the areas potentially affected by a release from the *Edmund Fitzgerald* include very highly utilized recreational beaches along the southern shore of Lake Superior. Many areas along the entire potential spill zone are widely popular seaside resorts and support recreational activities such as boating, diving, sightseeing, sailing, fishing, and wildlife viewing. There are several state parks along the shore, as well as a national recreation area and national lakeshore.

Shipping lanes run through Sault Ste. Marie into Lake Superior towards the vital port of Duluth, which has 3,265 port vessel calls of 45 million tonnage annually. There is also a power plant that uses Lake Superior water in its intakes.

Commercial fishing is somewhat important to the region. Regional commercial landings in Lake Superior for 2009 exceeded $2.4 million. There is a Tribal Nation on the shore of Lake Superior that also uses these waters for subsistence fishing.

In addition to the ESI atlases, the Geographic Response Plans within the Area Contingency Plans prepared by the Area Committee for each U.S. Coast Guard Sector have detailed information on important socio-economic resources at risk and should be consulted.

Spill response costs for a release of oil from the *Edmund Fitzgerald* would be dependent on volume of oil released and specific areas impacted. The specific shoreline impacts and spread of the oil would determine the response required and the costs for that response.

Table 4-1: Socio-economic resources at risk from a release of oil from the *Edmund Fitzgerald*.

Resource Type	Resource Name	Economic Activities
Shore Communities	Marquette, MI Grand Marais, MI Whitefish Point, MI	Potentially affected lake resorts and beach-front communities in northern Michigan. Many of these recreational activities are limited to or concentrated into the late spring into early fall months.
National Seashores	Pictured Rocks National Lakeshore	National seashores provide recreation for local and tourist populations as well as preserve and protect the nation's natural shoreline treasures. National seashores are coastal areas federally designated as being of natural and recreational significance as a preserved area. The national seashore in Lake Superior is considered a "lakeshore."
National Park	Grand Island National Recreation Area	National parks and recreation areas provide unique opportunities for recreational activities while preserving our nation's natural and historic treasures.

Resource Type	Resource Name	Economic Activities
National Wildlife Refuges	Seney NWR Huron Islands NWR Harbor Island NWR	National wildlife refuges in Michigan may be impacted. These federally-managed and protected lands provide refuges and conservation areas for sensitive species and habitats.
State Parks	Brimley State Park, MI Tahquamenon Falls State Park, MI Muskallonge Lake State Park, MI	Coastal state parks are significant recreational resources for the public (e.g., swimming, boating, recreational fishing, wildlife viewing, nature study, sports, dining, camping, and amusement parks). They provide income to the Michigan. Many of these recreational activities are limited to or concentrated into the late spring into early fall months.
Tribal Lands	Bay Mills Indian Reservation, MI	Bay Mills Indian Reservation is home to over 700 tribal members.
Commercial Fishing	A number of fishing fleets use Lake Superior waters for commercial fishing purposes.	
	Minnesota	Total Landings (2009): $228,000
	Michigan	Total Landings (2009): $1.12M
	Wisconsin	Total Landings (2009): $1.16M
Ports	There is a vital commercial port industry in Lake Superior that could potentially be impacted by spillage and spill response activities. The port call numbers below are for large vessels only. There are many more, smaller vessels (under 400 GRT) that also use these ports.	
	Duluth, MN	3,265 port calls annually
Power Plants	Presque Isle Power Plant, MI	A power plant on Lake Superior has industrial water intakes that are at risk.

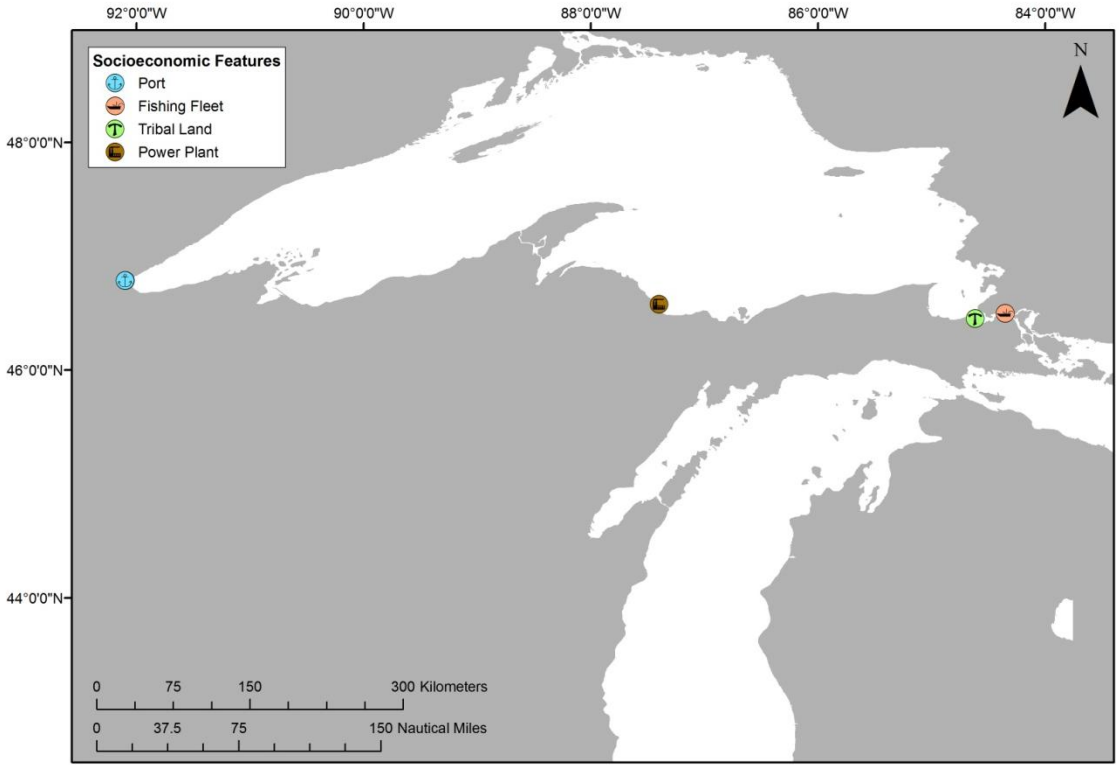


Figure 4-1: Tribal lands, ports, and commercial fishing fleets at risk from a release from the *Edmund Fitzgerald*.

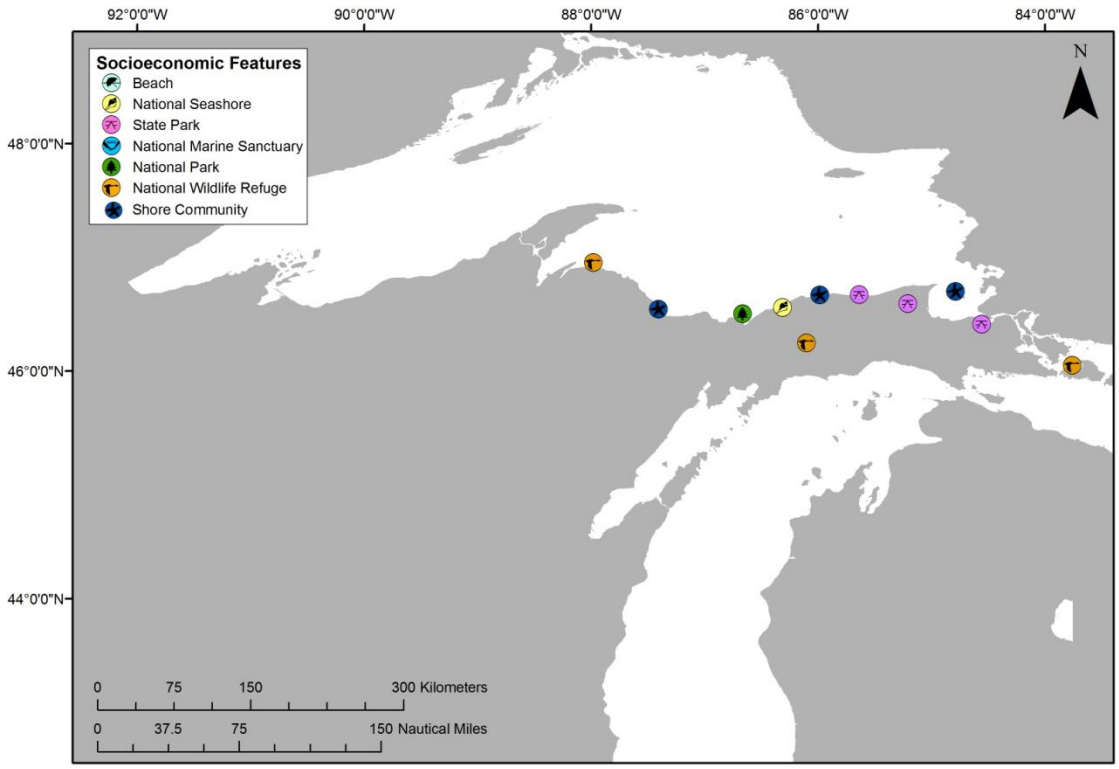


Figure 4-2: Beaches, coastal state parks, Federal protected areas at risk from a release from the *Edmund Fitzgerald*.

Socio-Economic Risk Factors

Risk Factor 4: Impacts to Socio-economic Resources at Risk (SRAR)

Socio-economic resources at risk (SRAR) include potentially impacted resources that have some economic value, including commercial and recreational fishing, tourist beaches, private property, etc. All impact factors are evaluated for both the Worst Case and the Most Probable Discharge oil release from the wreck. Risk factors for socio-economic resources at risk are divided into three categories:

- **Water Column:** Impacts to the water column and to economic resources in the water column (i.e., fish and invertebrates that have economic value);
- **Water Surface:** Impacts to the water surface and resources on the water surface (i.e., boating and commercial fishing); and
- **Shoreline:** Impacts to the shoreline and resources on the shoreline (i.e., beaches, real property).

The impacts from an oil release from the wreck would depend greatly on the direction in which the oil slick moves, which would, in turn, depend on wind direction and currents at the time of and after the oil release. Impacts are characterized in the risk analysis based on the likelihood of any measurable impact, as well as the degree of impact that would be expected if there were one. The measure of the degree of impact is based on the median case for which there is at least some impact. The median case is the "middle case" – half of the cases with significant impacts have less impact than this case, and half have more.

For each of the three socio-economic resources at risk categories, risk is classified with regard to:

- The **probability of oiling** over a certain threshold (i.e., the likelihood that there will be exposure to socio-economic resources over a certain minimal amount known to cause impacts); and
- The **degree of oiling** (the magnitude or amount of that exposure over the threshold known to cause impacts).

As a reminder, the socio-economic impact thresholds are: 1 ppb aromatics for water column impacts; 0.01 g/m^2 for water surface impacts; and 1 g/m^2 for shoreline impacts.

In the following sections, the definition of low, medium, and high for each socio-economic risk factor is provided. Also, in the text classification for the *Edmund Fitzgerald* shading indicates the degree of risk for the WCD release of 2,000 bbl and a border indicates degree of risk for the Most Probable Discharge of 200 bbl.

Risk Factor 4A-1: Water Column: Probability of Oiling of SRAR

This risk factor reflects the probability that at least 0.2 mi^2 of the upper 33 feet of the water column would be contaminated with a high enough concentration of oil to cause socio-economic impacts. The threshold for water column impact to socio-economic resources at risk is an oil concentration of 1 ppb (i.e., 1 part oil per one billion parts water). At this concentration and above, one would expect impacts and potential tainting to socio-economic resources (e.g., fish and shellfish) in the water column; this concentration is used as a screening threshold for both the ecological and socio-economic risk factors.
The three risk scores for oiling are:

- **Low Oiling Probability:** Probability = <10%
- **Medium Oiling Probability:** Probability = 10 – 50%
- **High Oiling Probability:** Probability > 50%

Risk Factor 4A-2: Water Column Degree of Oiling of SRAR

The degree of oiling of the water column reflects the total amount of oil that would affect the water column in the event of a discharge from the vessel. The three categories of impact are:

- **Low Impact:** impact on less than 0.2 mi^2 of the upper 33 feet of the water column at the threshold level
- **Medium Impact:** impact on 0.2 to 200 mi^2 of the upper 33 feet of the water column at the threshold level
- **High Impact:** impact on more than 200 mi^2 of the upper 33 feet of the water column at the threshold level

The *Edmund Fitzgerald* is classified as High Risk for oiling probability and Medium Risk for degree of oiling for water column socio-economic resources for the WCD of 2,000 bbl because 100% of the model runs resulted in contamination of more than 0.2 mi^2 of the upper 33 feet of the water column above the threshold of 1 ppb aromatics, and the mean volume of water contaminated was 1.0 mi^2 of the upper 33 feet of the water column. For the Most Probable Discharge of 200 bbl, the *Edmund Fitzgerald* is classified as Low Risk for both oiling probability and degree of oiling for water column socio-economic resources because 0% of the model runs resulted in contamination of more than 0.2 mi^2 of the upper 33

feet of the water column above the threshold of 1 ppb aromatics, and the mean volume of water contaminated was 0 mi^2 of the upper 33 feet of the water column.

Risk Factor 4B-1: Water Surface Probability of Oiling of SRAR

This risk factor reflects the probability that at least 1,000 mi^2 of the water surface would be affected by enough oil to cause impacts to socio-economic resources. The three risk scores for oiling are:

- **Low Oiling Probability:** Probability = <10%
- **Medium Oiling Probability:** Probability = 10 – 50%
- **High Oiling Probability:** Probability > 50%

The threshold level for water surface impacts to socio-economic resources at risk is 0.01 g/m^2 (i.e., 0.01 grams of floating oil per square meter of water surface). At this concentration and above, one would expect impacts to socio-economic resources on the water surface.

Risk Factor 4B-2: Water Surface Degree of Oiling of SRAR

The degree of oiling of the water surface reflects the total amount of oil that would affect the water surface in the event of a discharge from the vessel. The three categories of impact are:

- **Low Impact:** less than 1,000 mi^2 of water surface impact at the threshold level
- **Medium Impact:** 1,000 to 10,000 mi^2 of water surface impact at the threshold level
- **High Impact:** more than 10,000 mi^2 of water surface impact at the threshold level

The *Edmund Fitzgerald* is classified as Medium Risk for oiling probability and Low Risk for degree of oiling for water surface socio-economic resources for the WCD because 33% of the model runs resulted in at least 1,000 mi^2 of the water surface affected above the threshold of 0.01 g/m^2, and the mean area of water contaminated was 900 mi^2. The *Edmund Fitzgerald* is classified as Low Risk for both oiling probability and degree of oiling for water surface socio-economic resources for the Most Probable Discharge because 0% of the model runs resulted in at least 1,000 mi^2 of the water surface affected above the threshold of 0.01 g/m^2, and the mean area of water contaminated was 270 mi^2.

Risk Factor 4C: Shoreline Impacts to SRAR

The impacts to different types of shorelines vary based on economic value. In this risk analysis, shorelines have been weighted by their degree of sensitivity to oiling. Sand beaches are the most economically valued shorelines (weighted as "3" in the impact analysis), rocky and gravel shores are moderately valued (weighted as "2"), and wetlands are the least economically valued shorelines (weighted as "1"). Note that these values differ from the ecological values of these three shoreline types.

Risk Factor 4C-1: Shoreline Probability of Oiling of SRAR

This risk factor reflects the probability that the shoreline would be coated by enough oil to cause impacts to shoreline users. The threshold for impacts to shoreline SRAR is 1 g/m^2 (i.e., 1 gram of oil per square meter of shoreline). The three risk scores for oiling are:

- **Low Oiling Probability:** Probability = <10%
- **Medium Oiling Probability:** Probability = 10 – 50%
- **High Oiling Probability:** Probability > 50%

Risk Factor 4C-2: Shoreline Degree of Oiling of SRAR

The degree of oiling of the shoreline reflects the total amount of oil that would affect the shoreline in the event of a discharge from the vessel. The three categories of impact are:

- **Low Impact:** less than 10 miles of shoreline impacted at threshold level
- **Medium Impact:** 10 - 100 miles of shoreline impacted at threshold level
- **High Impact:** more than 100 miles of shoreline impacted at threshold level

The *Edmund Fitzgerald* is classified as High Risk for oiling probability for shoreline socio-economic resources for the WCD because 100% of the model runs resulted in shorelines affected above the threshold of 1 g/m^2. It is classified as Medium Risk for degree of oiling because the mean length of weighted shoreline contaminated was 66 miles. The *Edmund Fitzgerald* is classified as High Risk for oiling probability and Medium Risk for degree of oiling for shoreline socio-economic resources for the Most Probable Discharge as 100% of the model runs resulted in shorelines affected above the threshold of 1 g/m^2, and the mean length of weighted shoreline contaminated was 58 miles.

Considering the modeled risk scores and the socio-economic resources at risk, the socio-economic risk from potential releases of the WCD of 2,000 bbl of heavy fuel oil from the *Edmund Fitzgerald* is summarized as listed below and indicated in the far-right column in Table 4-2:

- Water column resources – Low, because a small area of water column would be impacted in fishing grounds
- Water surface resources – Medium, because a relatively small area of water surface would be impacted, but there are important shipping lanes in that area with limited alternative routing. It should be noted that oil on the surface will not be continuous but rather be broken and patchy and in the form of sheens, tarballs, and streamers
- Shoreline resources – Medium, because moderate lengths of high-value shoreline would be impacted

Table 4-2: Socio-economic risk factor ranks for the **Worst Case Discharge of 2,000 bbl** of heavy fuel oil from the *Edmund Fitzgerald*.

Risk Factor	Risk Score			Explanation of Risk Score	Final Score
4A-1: Water Column Probability SRAR Oiling	Low	Medium	High	100% of the model runs resulted in at least 0.2 mi^2 of the upper 33 feet of the water column contaminated above 1 ppb aromatics	Low
4A-2: Water Column Degree SRAR Oiling	Low	Medium	High	The mean volume of water contaminated above 1 ppb was 1.0 mi^2 of the upper 33 feet of the water column	
4B-1: Water Surface Probability SRAR Oiling	Low	Medium	High	33% of the model runs resulted in at least 900 mi^2 of water surface covered by at least 0.01 g/m^2	Med
4B-2: Water Surface Degree SRAR Oiling	Low	Medium	High	The mean area of water contaminated above 0.01 g/m^2 was 904 mi^2	
4C-1: Shoreline Probability SRAR Oiling	Low	Medium	High	100% of the model runs resulted in shoreline oiling of 1 g/m^2	Med
4C-2: Shoreline Degree SRAR Oiling	Low	Medium	High	The length of shoreline contaminated by at least 1 g/m^2 was 66 mi	

For the Most Probable Discharge of 200 bbl, the socio-economic risk from potential releases of heavy fuel oil from the *Edmund Fitzgerald* is summarized as listed below and indicated in the far-right column in Table 4-3:

- Water column resources – Low, because a small area of water column would be impacted in fishing grounds
- Water surface resources – Low, because a relatively small area of water surface would be impacted, but there are important shipping lanes in that area with limited alternative routing. It should be noted that oil on the surface will not be continuous but rather be broken and patchy and in the form of sheens, tarballs, and streamers
- Shoreline resources – Medium, because moderate lengths of high-value shoreline would be impacted

Table 4-3: Socio-economic risk factor ranks for the **Most Probable Discharge of 200 bbl** of heavy fuel oil from the *Edmund Fitzgerald*.

Risk Factor	Risk Score			Explanation of Risk Score	Final Score
4A-1: Water Column Probability SRAR Oiling	**Low**	**Medium**	**High**	0% of the model runs resulted in at least 0.2 mi^2 of the upper 33 feet of the water column contaminated above 1 ppb aromatics	**Low**
4A-2: Water Column Degree SRAR Oiling	**Low**	**Medium**	**High**	The mean volume of water contaminated above 1 ppb was 0 mi^2 of the upper 33 feet The mean volume of water contaminated of the water column	
4B-1: Water Surface Probability SRAR Oiling	**Low**	**Medium**	**High**	0% of the model runs resulted in at least 1,000 mi^2 of water surface covered by at least 0.01 g/m^2	**Low**
4B-2: Water Surface Degree SRAR Oiling	**Low**	**Medium**	**High**	The mean area of water contaminated above 0.01g/m^2 was 270 mi^2	
4C-1: Shoreline Probability SRAR Oiling	**Low**	**Medium**	**High**	100% of the model runs resulted in shoreline oiling of 1 g/m^2	**Med**
4C-2: Shoreline Degree SRAR Oiling	**Low**	**Medium**	**High**	The length of shoreline contaminated by at least 1 g/m^2 was 58 mi	

SECTION 5: OVERALL RISK ASSESSMENT AND RECOMMENDATIONS FOR ASSESSMENT, MONITORING, OR REMEDIATION

The overall risk assessment for the *Edmund Fitzgerald* is comprised of a compilation of several components that reflect the best available knowledge about this particular site. Those components are reflected in the previous sections of this document and are:

- Vessel casualty information and how the site formation processes have worked on this vessel
- Ecological resources at risk
- Socio-economic resources at risk
- Other complicating factors (war graves, other hazardous cargo, etc.)

Table 5-1 summarizes the screening-level risk assessment scores for the different risk factors, as discussed in the previous sections. The ecological and socio-economic risk factors are presented as a single score for water column, water surface, and shoreline resources as the scores were consolidated for each element. For the ecological and socio-economic risk factors each has two components, probability and degree. Of those two, degree is given more weight in deciding the combined score for an individual factor, e.g., a high probability and medium degree score would result in a medium overall for that factor.

In order to make the scoring more uniform and replicable between wrecks, a value was assigned to each of the 7 criteria. This assessment has a total of 7 criteria (based on table 5-1) with 3 possible scores for each criteria (L, M, H). Each was assigned a point value of L=1, M=2, H=3. The total possible score is 21 points, and the minimum score is 7. The resulting category summaries are:

Low Priority	7-11
Medium Priority	12-14
High Priority	15-21

For the Worst Case Discharge, *Edmund Fitzgerald* scores Medium with 12 points; for the Most Probable Discharge, *Edmund Fitzgerald* scores Low with 10 points. Under the National Contingency Plan, the U.S. Coast Guard and the Regional Response Team (RRT) have the primary authority and responsibility to plan, prepare for, and respond to oil spills in U.S. waters. Based on the technical review of available information, NOAA proposes the following recommendations for the *Edmund Fitzgerald*. The final determination rests with the U.S. Coast Guard.

Edmund Fitgerald	**Possible NOAA Recommendations**
	Wreck should be considered for further assessment to determine the vessel condition, amount of oil onboard, and feasibility of oil removal action
✓	Use surveys of opportunity to assess the wreck for corrosion and structural integrity
	Conduct active monitoring to look for releases or changes in rates of releases
✓	Be noted in the Area Contingency Plans so that if a mystery spill is reported in the general area, this vessel could be investigated as a source; Include coordination activities with Canada
✓	Conduct outreach efforts with the technical and recreational dive community as well as commercial and recreational fishermen who frequent the area, to gain awareness of changes in the site

Table 5-1: Summary of risk factors for the *Edmund Fitzgerald*.

Vessel Risk Factors		Data Quality Score	Comments		Risk Score
Pollution Potential Factors	A1: Oil Volume (total bbl)	Medium	Maximum of 1,191 bbl, not reported to be leaking		**Med**
	A2: Oil Type	High	Cargo is heavy fuel oil, a Group IV oil type		
	B: Wreck Clearance	High	Vessel not reported as cleared		
	C1: Burning of the Ship	High	No burning of the ship reported		
	C2: Oil on Water	Low	Unknown, no survivor reports		
	D1: Nature of Casualty	High	Breakup in a storm		
	D2: Structural Breakup	High	Vessel broke into at least two pieces		
Archaeological Assessment	Archaeological Assessment	Low	The best sinking assessment comes from the U.S. Coast Guard; no archaeological assessment was prepared		**Not Scored**
Operational Factors	Wreck Orientation	High	Bow is upright, stern is inverted		**Not Scored**
	Depth	High	Wreck is 530 feet deep		
	Visual or Remote Sensing Confirmation of Site Condition	High	The wreck has been surveyed multiple times		
	Other Hazardous Materials Onboard	High	No		
	Munitions Onboard	High	No		
	Gravesite (Civilian/Military)	High	Yes		
	Historical Protection Eligibility (NHPA/SMCA)	Medium	Vessel may be historically significant		
				WCD	**Most Probable**
Ecological Resources	3A: Water Column Resources	High	Medium to small releases of heavy fuel oils pose limited risks to fish, except when spawning in nearshore areas	**Low**	**Low**
	3B: Water Surface Resources	High	High concentrations of birds seasonally, of species that feed in nearshore areas	**Med**	**Low**
	3C: Shore Resources	High	High concentrations of shorebirds seasonally; many fish spawn at the mouths of rivers and nearshore where they could be exposed to stranded oil	**Med**	**Med**
Socio-Economic Resources	4A: Water Column Resources	High	Small area of water column would be impacted in fishing grounds	**Low**	**Low**
	4B: Water Surface Resources	High	A relatively small area of water surface would be impacted, but there are important shipping lanes in that area with limited alternative routing	**Med**	**Low**
	4C: Shore Resources	High	Moderate lengths of high-value shoreline would be impacted	**Med**	**Med**
Summary Risk Scores				**12**	**10**