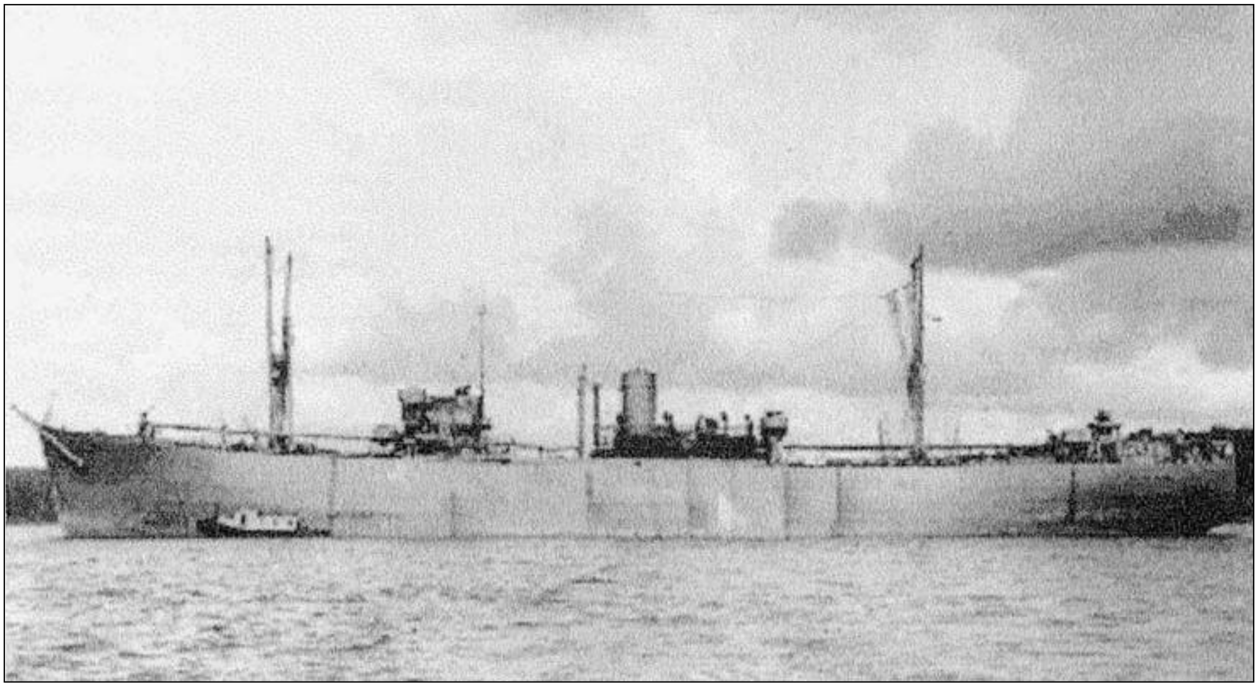
Office of National Marine Sanctuaries
Office of Response and Restoration

Screening Level Risk Assessment Package

Empire Knight



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National Oceanic and
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Photo: Photograph of *Empire Knight*
Source: http://www.wreckhunter.net/images/EmpireKnight-Clancy2.jpg

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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.

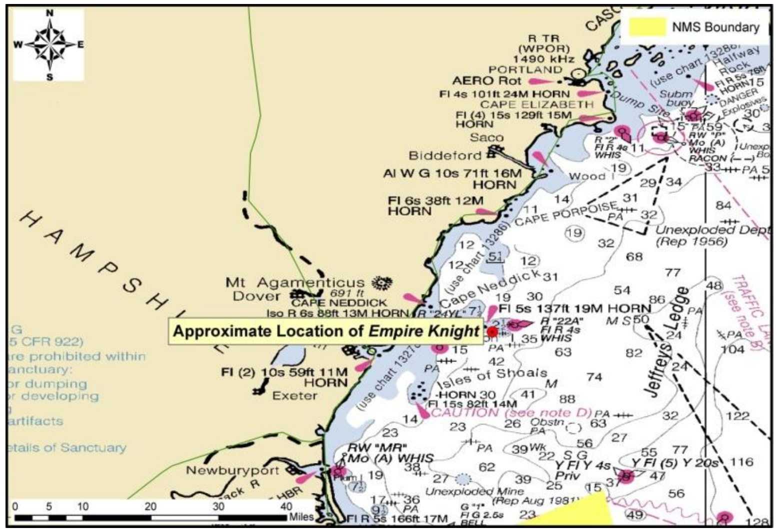
In order to narrow down the potential sites for inclusion into regional and area contingency plans, in 2010, Congress appropriated $1 million to identify the most ecologically and economically significant potentially polluting wrecks in U.S. waters. This project supports the U.S. Coast Guard and the 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: *Empire Knight*



The freighter *Empire Knight*, grounded and sunk in 1944 off the coast of Maine in 1944, 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 *Empire Knight*, 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.

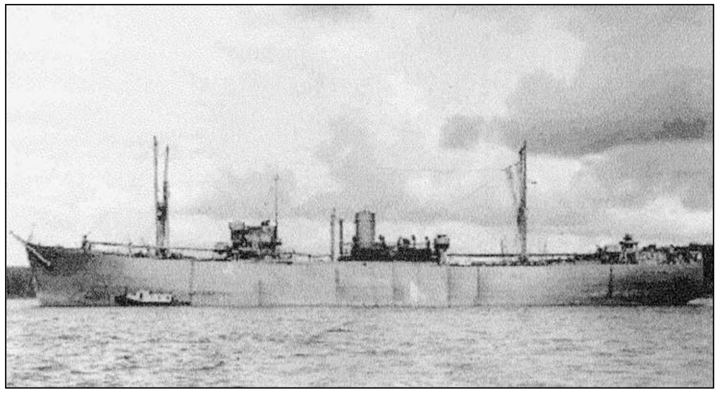
Based on this screening-level assessment, each vessel was assigned a summary score calculated using the seven risk criteria described in this report. For the Worst Case Discharge, *Empire Knight* scores Low with 11 points; for the Most Probable Discharge (10% of the Worse Case volume), *Empire Knight* also scores Low with 10 points. Given the low scores for both Worst Case Discharge and a Most Probable Discharge for the *Empire Knight*, and the higher level of data certainty about the vessel, NOAA recommends that this site be noted in the Area Contingency Plans as necessary to answer future questions about the pollution risks associated with this particular vessel, and that if a mystery spill is reported in the general area, this vessel could be investigated as a source. Should additional information become available that would suggest a greater level of concern, then an active monitoring program could be implemented or an assessment undertaken. Outreach efforts with commercial and recreational fishermen who pass by the area would be helpful to gain awareness of any significant changes or further deterioration of the 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	Med	Med
	3B: Water Surface Resources	Med	Low
	3C: Shore Resources	Low	Low
Socio-Economic Resources	4A: Water Column Resources	Low	Low
	4B: Water Surface Resources	Med	Med
	4C: Shore Resources	Low	Low
Summary Risk Scores		11	10

The determination of each risk factor is explained in the document. This summary table is found on page 39.

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

Vessel Particulars



Official Name: *Empire Knight*

Official Number: 169017

Vessel Type: Freighter

Vessel Class: British Liberty Ship

Former Names: N/A

Year Built: 1942

Builder: William Doxford & Sons, Ltd., Sunderland

Builder's Hull Number: Unknown

Flag: British

Owner at Loss: Ministry of War Transport (Buries Markes, Ld. Managers)

Controlled by: Unknown

Chartered to: Unknown

Operated by: Unknown

Homeport: Sunderland

Length: 428 feet

Beam: 56 feet

Depth: 35 feet

Gross Tonnage: 7,244

Net Tonnage: 5,099

Hull Material: Steel

Hull Fastenings: Riveted

Powered by: Oil engines

Bunker Type: Marine Diesel

Bunker Capacity (bbl): Unknown

Average Bunker Consumption (bbl) per 24 hours: Unknown

Liquid Cargo Capacity (bbl): Unknown

Dry Cargo Capacity: Unknown

Tank or Hold Description: Unknown

Casualty Information

Port Departed: St. John, New Brunswick, Canada **Destination Port:** New York

Date Departed: Unknown **Date Lost:** February 11, 1944

Number of Days Sailing: Unknown **Cause of Sinking:** Grounding

Latitude (DD): 43.0287 **Longitude (DD):** -70.50449

Nautical Miles to Shore: 6.5 **Nautical Miles to NMS:** 21

Nautical Miles to MPA: 0 **Nautical Miles to Fisheries:** Unknown

Approximate Water Depth (Ft): 210 **Bottom Type:** Sand

Is There a Wreck at This Location? The exact accuracy of the listed coordinates is not know, but the wreck site is well known

Wreck Orientation: Broken in two pieces, the stern section is listing to starboard

Vessel Armament: Unknown

Cargo Carried when Lost: General Cargo and War Supplies, 221 flasks mercury

Cargo Oil Carried (bbl): 0 **Cargo Oil Type:** N/A

Probable Fuel Oil Remaining (bbl): Likely ≤10,000 based on gross tonnage **Fuel Type:** Marine Diesel

Total Oil Carried (bbl): ≤10,000 **Dangerous Cargo or Munitions:** Yes (Mercury)

Munitions Carried: Unknown

Demolished after Sinking: No **Salvaged:** Yes, partially

Cargo Lost: Yes, partially **Reportedly Leaking:** No

Historically Significant: Unknown **Gravesite:** Yes

Salvage Owner: Not known if any

Wreck Location

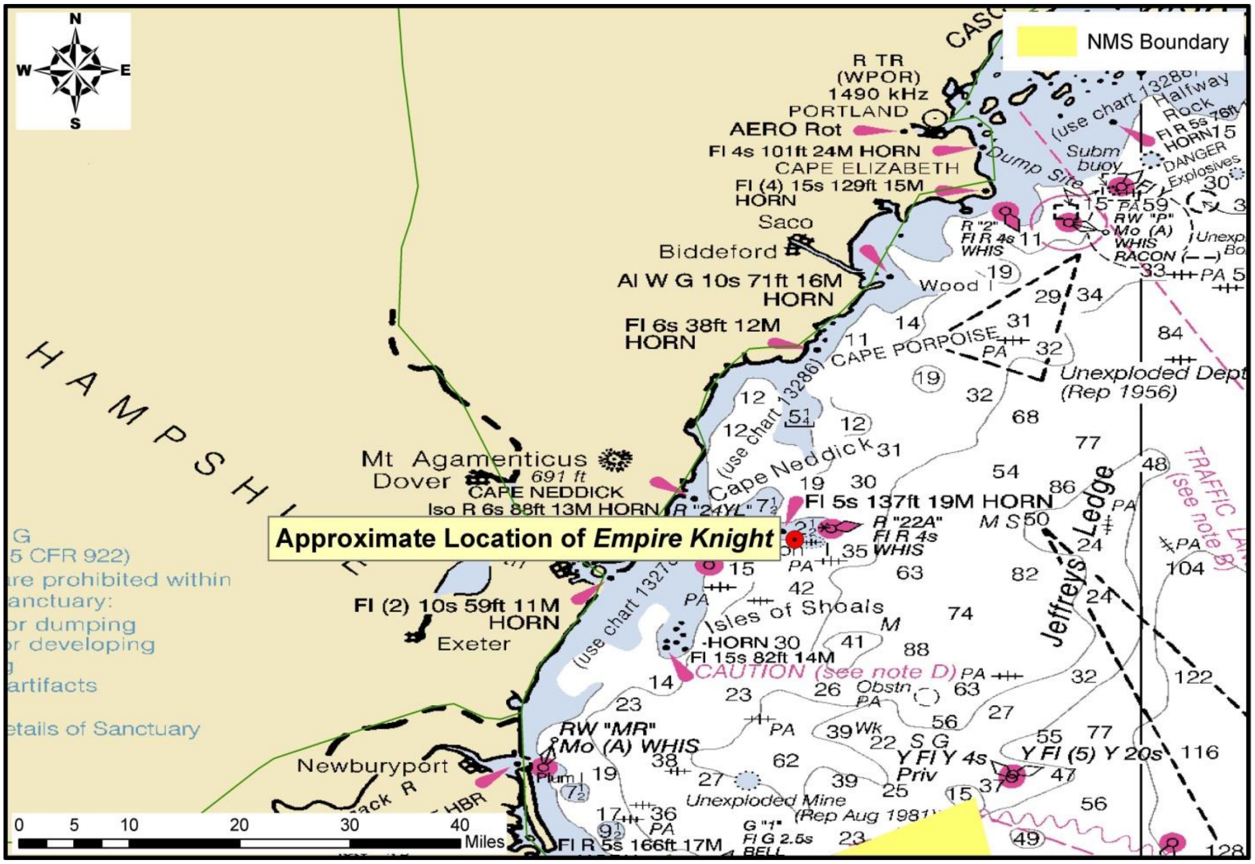


Chart Number: 13003

Casualty Narrative

In February 1944 the M/V *Empire Knight*, a 428-foot British freighter ran aground on Boon Island Ledge, Maine and later broke into two sections. The stern section which included the ship's cargo holds sank in approximately 260 feet of water, one and one half miles from Boon Island Ledge.

General Notes

NOAA Automated Wreck and Obstruction Information System (AWOIS) Data:
HISTORY

DESCRIPTION-

NO.204; CARGO, 7244 GT,SUNK 2/11/44 BY MARINE CASUALTY; POS. ACCURACYWITHIN 1 MILE; COVERED 150 FT IN 210 FT; REPORTED THROUGH EASTERN SEA FRONTIER 5/19/44; POS. LAT. 43-01-43N, LONG. 70-30-18W.

27 NO.804; FTR., 7244 GT; SUNK 2/11/44 IN 210 FT.; PART OF HULL ONLY,COVERED APPROX. 150 FT. 17 NO.1296; 7244 GT, FTR. SUNK 2/11/44 IN LAT. 43-07-00N, LONG. 70-25-39W, IN DEPTHS OVER 200 FT.FTR., 7244 GT; SUNK 2/11/44 IN 156 FT; PART OF WRECK IN LAT. 43-07-00N,LONG. 70-25-42W. AND OTHER PART IN LAT. 43-01-42N, LONG. 70-30-18W.

Wreck Condition/Salvage History

"The stern section is located at a water depth of 260', at 43-06-19 N / 070-27-09 W, approximately 2 miles south of Boon Island. Due to the presence of large amounts of hazardous mercury cargo, the U. S. Coast Guard has declared a Permanent Safety Zone around this wreck site. Dredging, diving, salvaging, anchoring and fishing are prohibited in this area."
-http://www.wreckhunter.net/DataPages/empireknight-dat.htm

Information about the safety zone is published in the Federal Register Vol. 60, No. 218, p. 56968 on 13 November 1995.

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

The loss of *Empire Knight* was caused by grounding and not as a result of war, which means that NOAA archaeologists have not located many historic sinking reports that would enable archaeologists to provide additional assessment about the shipwreck on top of the casualty narrative included in this packet. Some additional analysis can be made, however, based on additional documents that NOAA has been able to locate.

From a Lloyd's Register of Shipping survey report that we obtained from the National Maritime Museum in Greenwich, we have learned that *Empire Knight* carried diesel oil for its engines in double bottom tanks nos. 2, 3, 5, 6, and 7. Although we do not know the capacities of just these tanks, we do know that the combined length of the vessel's double bottom was 356.2 feet and that the combined capacity of all double bottom tanks was 1,182 tons (approximately 8,628 bbl). We have also ascertained that the ship was equipped with two donkey boilers used to power steam-operated machinery onboard the ship. These boilers utilized a heavy fuel oil with a flash point over 150 degrees Fahrenheit, but we do not know what tanks this oil was stored in and in what quantities.

Since the vessel ran aground, split in half, and sonar images of the wreck (Figure 1-1) show large sections of the bottom of the hull peeled back, it is likely that large amounts of the diesel oil was lost during the sinking process, but the amount of oil that could remain on the site cannot be estimated with any degree of accuracy. Because the site is restricted due to the mercury that is still onboard, there are no recreational diving reports available for the site. Since the U.S. Coast Guard has surveyed the shipwreck multiple times, however, and U.S. Coast Guard contract divers have salvaged some of the cargo of mercury, it is possible that the local U.S. Coast Guard District or Sector also has additional information about the shipwreck that NOAA archaeologists have been unable to locate.

Figure 1-1: Side scan sonar images of *Empire Knight* from Klein Associates (Source: http://www.l-3klein.com/?page_id=17).

Should the vessel be assessed, it should be noted that this vessel is of historic significance and will require appropriate actions be taken under the National Historic Preservation Act (NHPA) and the possibly the Sunken Military Craft Act (SMCA) prior to any actions that could impact the integrity of the vessel. This vessel may be eligible for listing on the National Register of Historic Places and is considered a gravesite and appropriate actions should be undertaken to minimize disturbance to the site.

Background Information References

Vessel Image Sources: http://www.wreckhunter.net/images/EmpireKnight-Clancy2.jpg; http://www.l-3klein.com/?page_id=17

Construction Diagrams or Plans in RULET Database? No

Text References:

-AWOIS database

-http://www.federalregister.gov/articles/1995/11/13/95-27866/safety-zone-sunken-vessel-mv-empire-knight-boon-island-me

-http://www.wreckhunter.net/DataPages/empireknight-dat.htm

Vessel Risk Factors

In this section, the risk factors that are associated with the vessel are defined and then applied to the *Empire Knight* 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 1-2 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 1-2.

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.

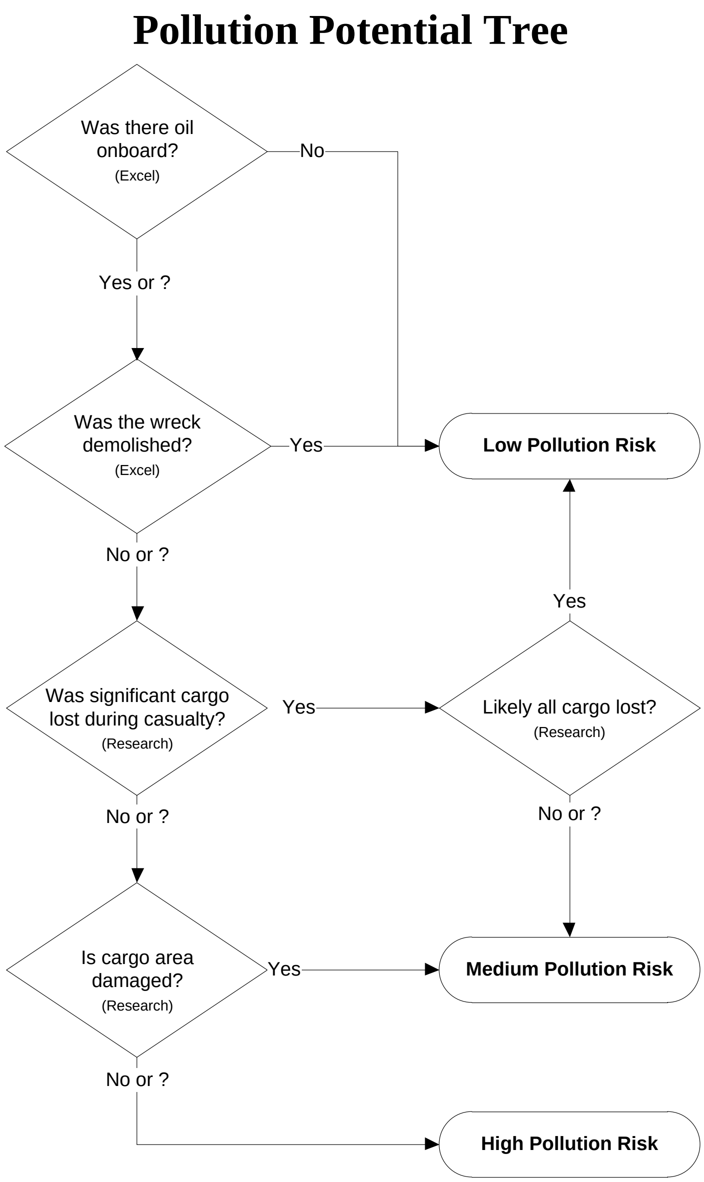


Figure 1-2: U.S. Coast Guard Salvage Engineering Response Team (SERT) developed the above Pollution Potential Decision Tree.

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

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 *Empire Knight* is ranked as High Volume because, the best estimate is that the vessel could have the potential to carry up to 10,000 bbl based on the size of the vessel, although some of that may have been lost at the time of the casualty due to the breakup of the vessel. Data quality is low because the actual bunker capacity of *Empire Knight* is not known.

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 *Empire Knight*.

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 *Empire Knight* is classified as Medium Risk because the bunker oil is marine diesel, a Group II 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:

[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]

- **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 *Empire Knight* 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?

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 *Empire Knight* is classified as High Risk because there was no known 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 *Empire Knight* is classified as High Risk because no reports examined during this study report oil spreading across the water as the vessel went down. Data quality is medium.

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 *Empire Knight* is classified as Medium Risk because it struck a rocky ledge and is broken into two sections. 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 *Empire Knight* is classified as Medium Risk because it is broken into two pieces. 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 stern section of the *Empire Knight* is listing approximately 40 degrees to starboard. 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 stern of the *Empire Knight* is 210 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 location of the bow and stern of the *Empire Knight* is known. The stern is protected by an exclusion zone. 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.

The *Empire Knight* carried mercury as part of the cargo. 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.

It is not currently known if the *Empire Knight* had munitions for onboard weapons, or if the cargo of war goods also included munitions. Data quality is low.

Vessel Pollution Potential Summary

Table 1-1 summarizes the risk factor scores for the pollution potential and mitigating factors that would reduce the pollution potential for the *Empire Knight.* Operational factors are listed but do not have a risk score.

Table 1-1: Summary matrix for the vessel risk factors for the *Empire Knight* 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)	Low	Maximum of 10,000 bbl, not reported to be leaking	**Med**
	A2: Oil Type	High	Bunker oil is marine diesel, may have small amount of Bunker C oil for steam donkey boilers	
	B: Wreck Clearance	High	Vessel not reported as cleared	
	C1: Burning of the Ship	High	No fire was reported	
	C2: Oil on Water	Medium	No reports of oil on water in the reports located during this study	
	D1: Nature of Casualty	High	Struck a ledge and broke in half	
	D2: Structural Breakup	High	Vessel is broken in half	
Archaeological Assessment	Archaeological Assessment	Medium	The best analysis of the sinking and wreckage probably still comes from information the U.S. Coast Guard has access to, but the analysis of where oil was stored and the capacities is believed to be very accurate	**Not Scored**
Operational Factors	Wreck Orientation	High	Stern is listing 40 degrees to starboard	**Not Scored**
	Depth	High	Stern is 210 feet deep	
	Visual or Remote Sensing Confirmation of Site Condition	High	Stern has been surveyed and partially salvaged	
	Other Hazardous Materials Onboard	High	Vessel carried mercury as part of the cargo	
	Munitions Onboard	Low	Unknown	
	Gravesite (Civilian/Military)	High	Yes	
	Historical Protection Eligibility (NHPA/SMCA)	High	NHPA and possibly SMCA	

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.

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 *Empire Knight* this would be 10,000 bbl based on current estimates of the maximum amount of oil remaining onboard the wreck.

The likeliest scenario of oil release from most sunken wrecks, including the *Empire Knight*, 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 *Empire Knight*.

Scenario Type	Release per Episode	Time Period	Release Rate	Relative Likelihood	Response Tier
Chronic (0.1% of WCD)	10 bbl	Fairly regular intervals or constant	100 bbl over several days	More likely	Tier 1
Episodic (1% of WCD)	100 bbl	Irregular intervals	Over several hours or days	Most Probable	Tier 1-2
Most Probable (10% of WCD)	1,000 bbl	One-time release	Over several hours or days	Most Probable	Tier 2
Large (50% of WCD)	5,000 bbl	One-time release	Over several hours or days	Less likely	Tier 2-3
Worst Case	10,000 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 *Empire Knight* contained a maximum of 10,000 bbl of marine diesel as the fuel oil (a Group II oil). Thus, the oil spill model was run using light 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 *Empire Knight* 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, which is shown in Figure 2-1. Using this figure, the water column impacts can be estimated for any spill volume. Note that the water column impact decreases for the worst case discharge 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. of the Interior, Washington, DC.

because a significant amount of oil is removed from the water column due to sedimentation in the modeling results. Increased sedimentation will increase impacts to benthic habitats.

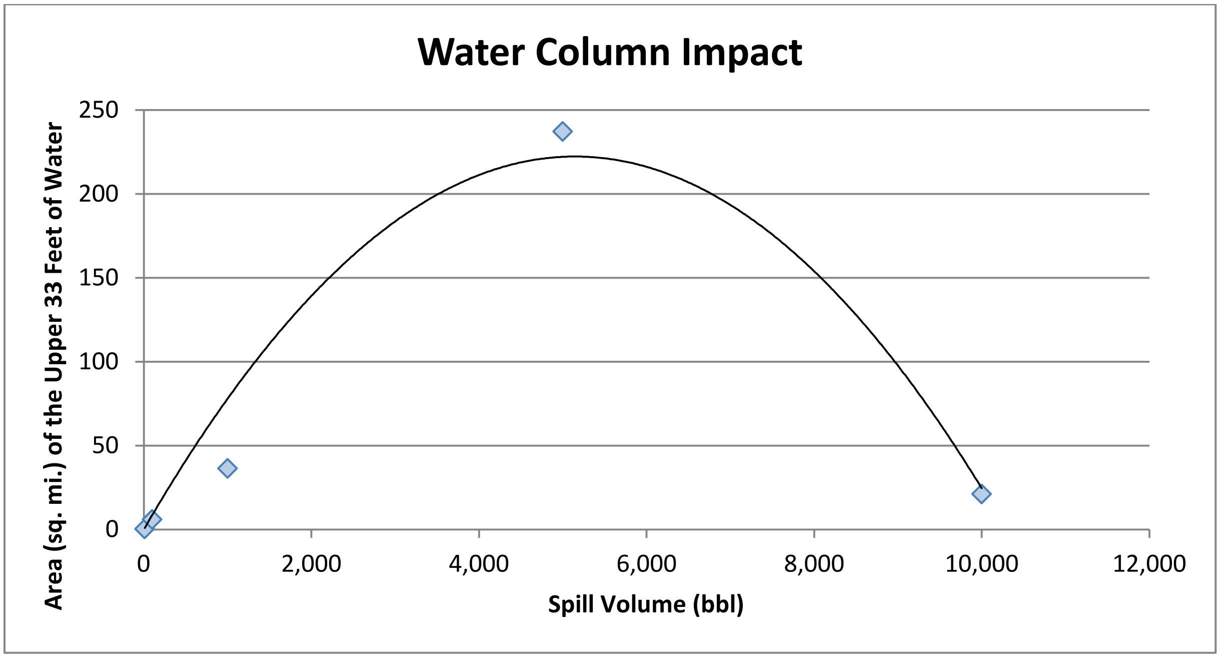


Figure 2-1: Regression curve for estimating the volume of water column impacted at or above the threshold of 1 ppb aromatics as a function of spill volume for the *Empire Knight*.

Potential Water Surface Slick

The slick size from an oil release from the *Empire Knight* 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. The slick will not be continuous but rather be broken and patchy due to the subsurface release of the oil. Surface expression is likely to be in the form of sheens, tarballs, and streamers.

Table 2-3: Estimated slick area swept on water for oil release scenarios from the *Empire Knight*.

Scenario Type	Oil Volume (bbl)	Estimated Slick Area Swept Mean of All Models	
		0.01 g/m²	10 g/m²
Chronic	10	130 mi²	13 mi²
Episodic	100	630 mi²	50 mi²
Most Probable	1,000	2,000 mi²	200 mi²
Large	5,000	4,700 mi²	560 mi²
Worst Case Discharge	10,000	6,800 mi²	900 mi²

The location, size, shape, and spread of the oil slick(s) from an oil release 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.

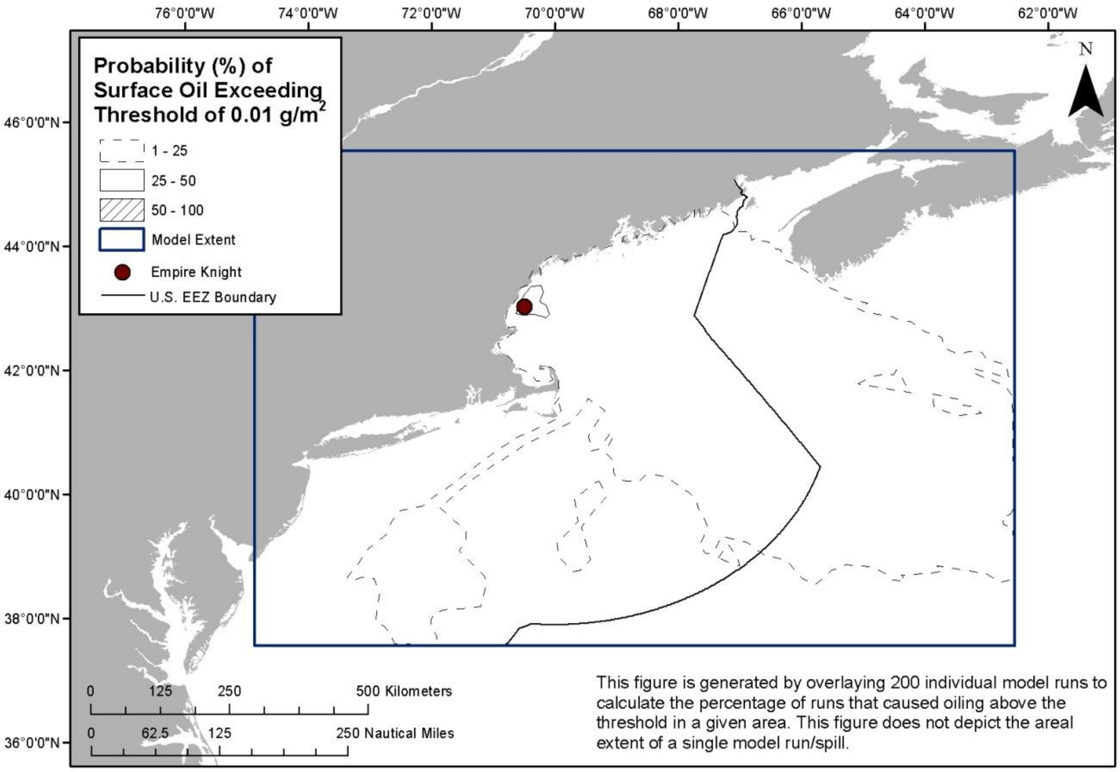


Figure 2-2: Probability of surface oil (exceeding 0.01 g/m²) from the Most Probable spill of 1,000 bbl of light fuel oil from the *Empire Knight* at the threshold for socio-economic resources at risk.

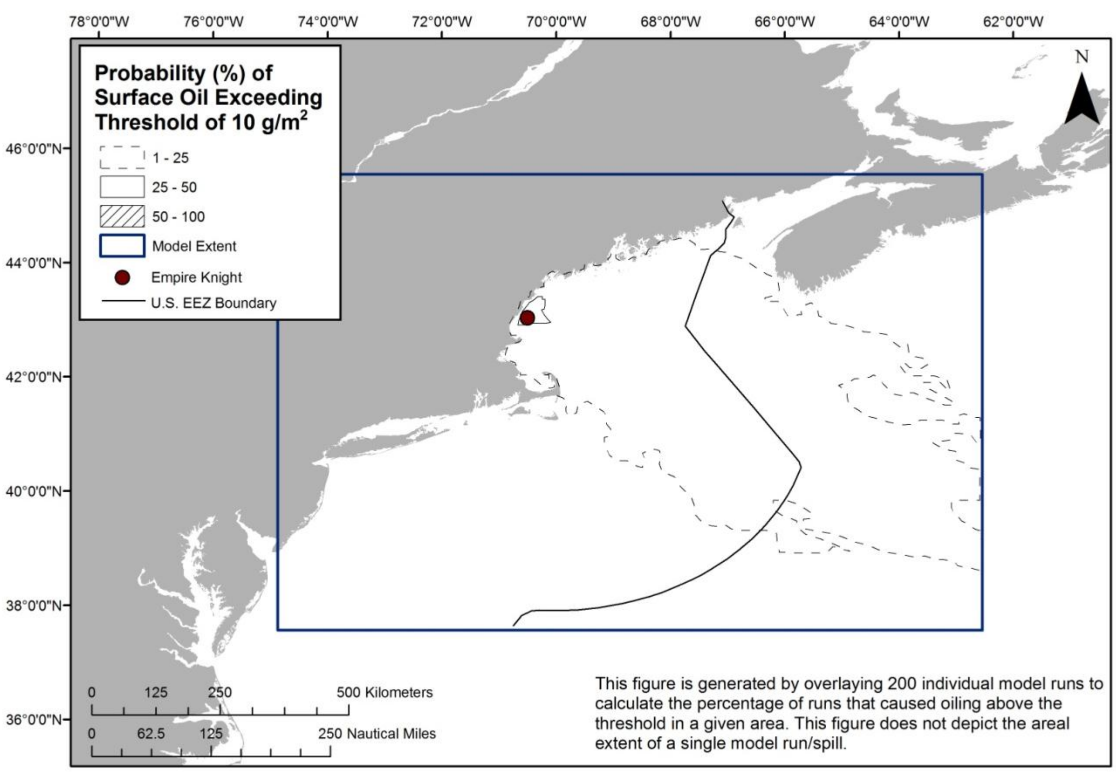


Figure 2-3: Probability of surface oil (exceeding 10 g/m²) from the Most Probable spill of 1,000 bbl of light fuel oil from the *Empire Knight* at the threshold for ecological resources at risk.

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.

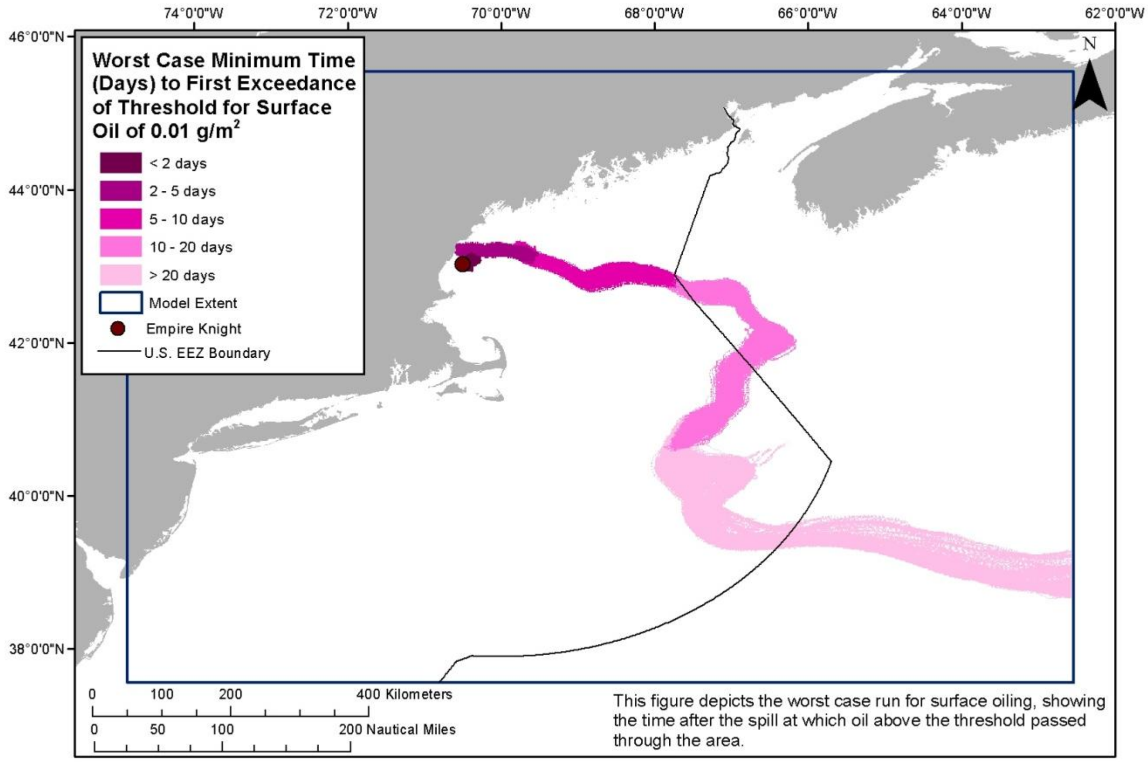


Figure 2-4: Water surface oiling from the Most Probable spill of 1,000 bbl of light fuel oil from the *Empire Knight* shown as the area over which the oil spreads at different time intervals.

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.

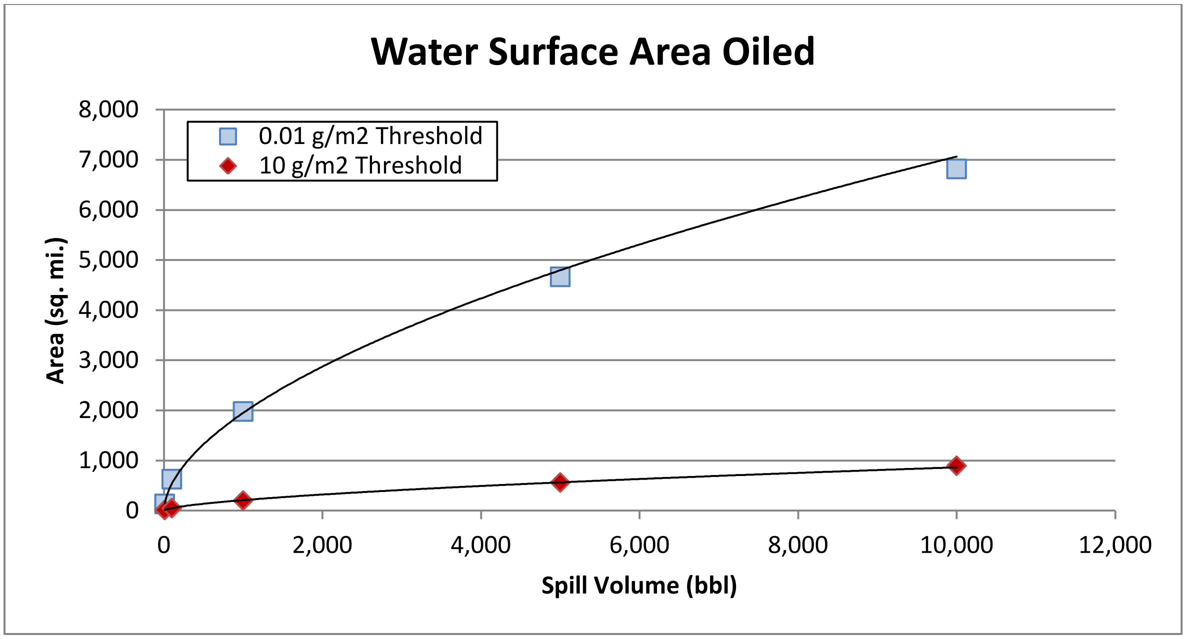


Figure 2-5: Regression curve for estimating the amount of water surface oiling as a function of spill volume for the *Empire Knight*, showing both the ecological threshold of 10 g/m² and socio-economic threshold of 0.01 g/m².

Potential Shoreline Impacts

Based on these modeling results, shorelines from east of Acadia National Park, to as far south as Cape Cod, Massachusetts, are at risk. Figure 2-6 shows the probability of oil stranding on the shoreline at concentrations that exceed the threshold of 1 g/m², for the Most Probable release of 1,000 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/m² by scenario type are shown in Table 2-4.

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

Scenario Type	Volume (bbl)	Estimated Miles of Shoreline Oiling Above 1 g/m²			
		Rock/Gravel/Artificial	Sand	Wetland/Mudflat	Total
Chronic	10	2	0	0	2
Episodic	100	3	0	0	3
Most Probable	1,000	1	0	0	1
Large	5,000	1	0	1	2
Worst Case Discharge	10,000	1	1	1	3

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

Scenario Type	Volume (bbl)	Estimated Miles of Shoreline Oiling Above 1 g/m²			
		Rock/Gravel/Artificial	Sand	Wetland/Mudflat	Total
Chronic	10	2	0	0	2
Episodic	100	3	0	0	3
Most Probable	1,000	1	0	0	1
Large	5,000	1	0	1	2
Worst Case Discharge	10,000	1	1	1	3

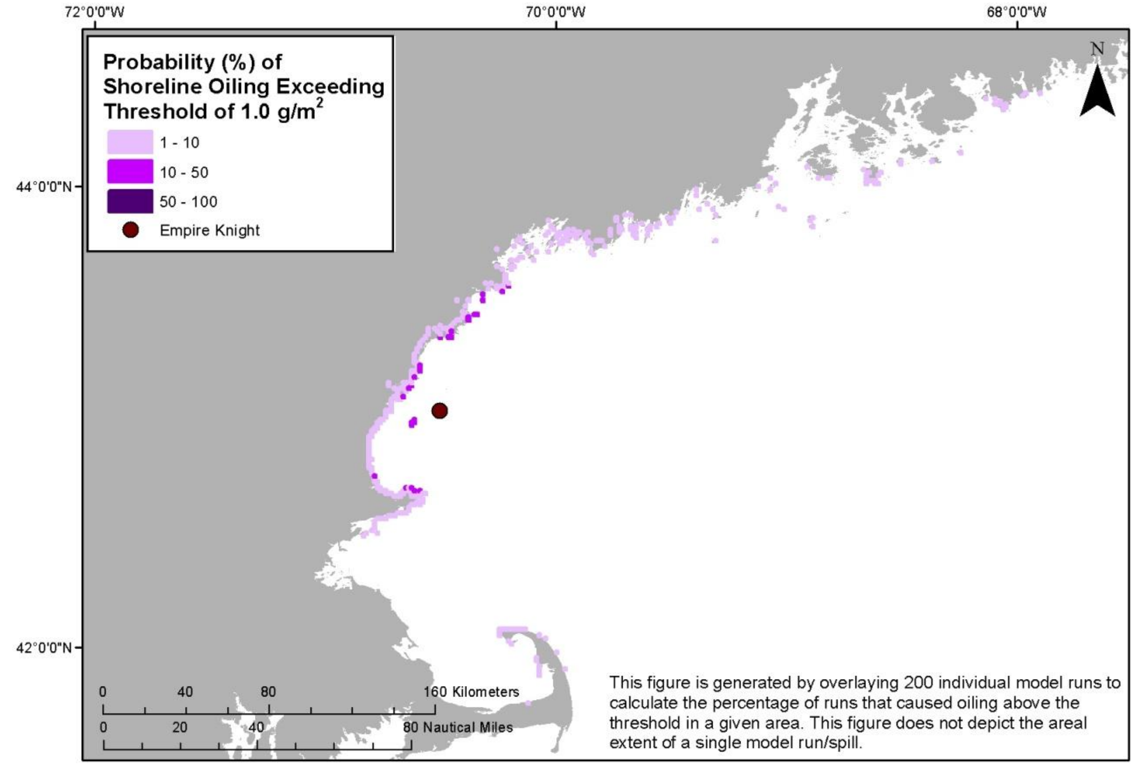


Figure 2-6: Probability of shoreline oiling (exceeding 1.0 g/m²) from the Most Probable Discharge of 1,000 bbl of light fuel oil from the *Empire Knight*.

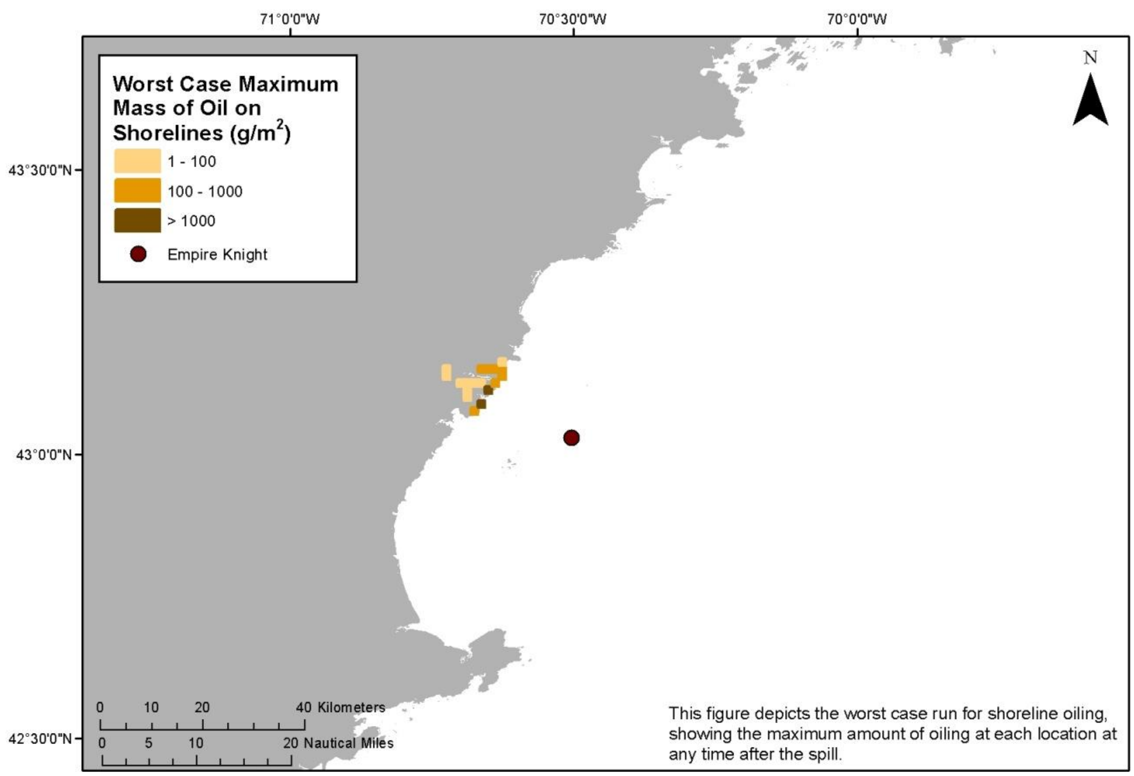


Figure 2-7: The extent and degree of shoreline oiling from the single model run of the Most Probable Discharge of 1,000 bbl of light fuel oil from the *Empire Knight* that resulted in the greatest shoreline oiling.

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.

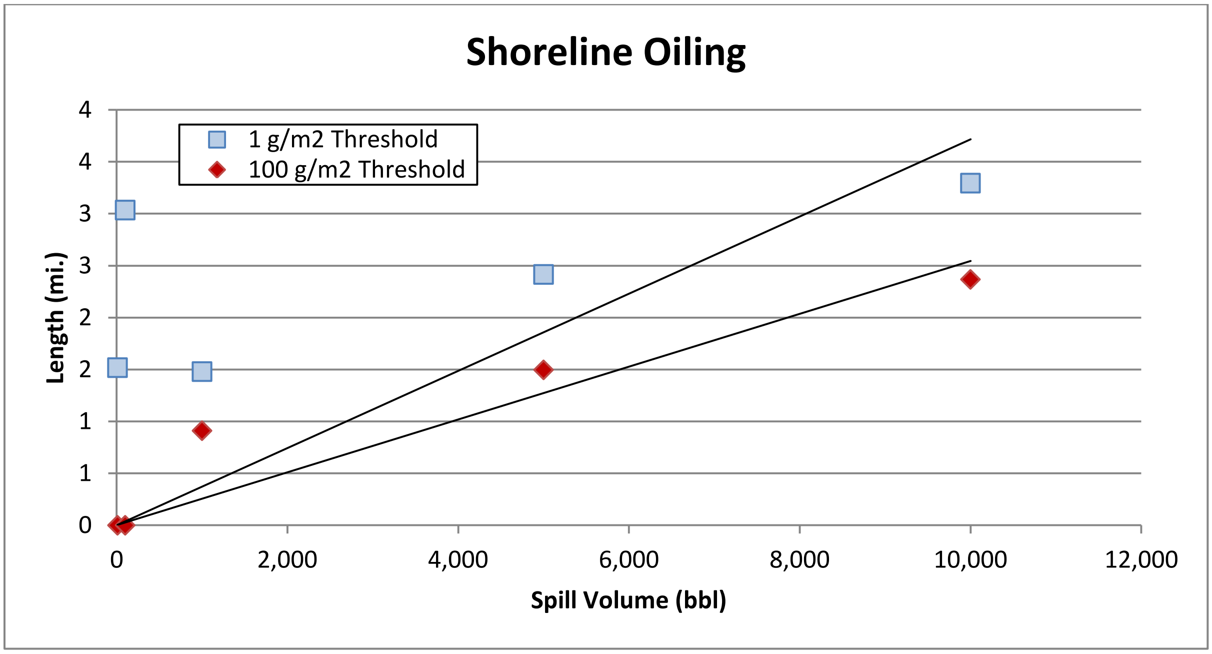


Figure 2-8: Regression curve for estimating the amount of shoreline oiling at different thresholds as a function of spill volume for the *Empire Knight*.

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 shores. Salt marshes and tidal flats near tidal inlets are also at risk.

Table 2-5: Worst case scenario shoreline impact by habitat type and oil thickness for a leakage of 10,000 bbl from the *Empire Knight*.

Shoreline/Habitat Type	Lighter Oiling Oil Thickness <1 mm Oil Thickness >1 g/m^2	Heavier Oiling Oil Thickness >1 mm Oil Thickness >100 g/m^2
Rocky and artificial shores/Gravel beaches	2 miles	2 miles
Sand beaches	4 miles	4 miles
Salt marshes and tidal flats	7 miles	2 miles

Table 2-6: Worst case scenario shoreline impact by habitat type and oil thickness for a leakage of 1,000 bbl from the *Empire Knight*.

Shoreline/Habitat Type	Lighter Oiling Oil Thickness <1 mm Oil Thickness >1 g/m^2	Heavier Oiling Oil Thickness >1 mm Oil Thickness >100 g/m^2
Rocky and artificial shores/Gravel beaches	2 miles	2 miles
Sand beaches	0 miles	0 miles
Salt marshes and tidal flats	1 mile	0 miles

SECTION 3: ECOLOGICAL RESOURCES AT RISK

Ecological resources at risk from a catastrophic release of oil from the *Empire Knight* (Table 3-1) include numerous guilds of birds that use shorelines and coastal waters. The islands of coastal Maine support an incredible diversity and abundance of nesting seabirds, migrating shorebirds and passerines, and overwintering waterfowl. Shorelines in this region are important haul-out and pupping sites for seals. Coastal waters are summer foraging habitat for several species of large whales. Nearshore regions also support productive commercial fisheries for fish and invertebrate species.

Table 3-1: Ecological resources at risk from a release of oil from the *Empire Knight*.
(*FT = Federal threatened; FE = Federal endangered; ST = State threatened; SE = State endangered; SSC = Species of special concern).

Species Group	Species Subgroup and Geography	Seasonal Presence
Birds	*Important areas* • Coastal Maine is important breeding habitat for arctic terns (ST) • Over 365 of Maine's coastal islands have recent records of seabird nesting • Shoreline from Casco Bay south is critical to least tern (FE, SE) and piping plover (FT, SE) nesting • High concentrations of migratory shorebirds and songbirds in Hampton Harbor and at Isles of Shoals, NH *Maine nesting sites (numbers are in pairs)* • Jenny Island (in Casco Bay): common tern (753), small numbers of roseate and arctic terns, common eiders • Stratton Island (in Saco Bay): northern limit of wading bird nesting (glossy ibis, little blue heron, great egret, tri-colored heron, American oystercatcher, least tern), southern limit of Arctic bird nesting (common eider, black guillemot, arctic tern) • 96% of Maine's population of roseate terns (FE) nest at Eastern Egg Rock and Stratton Island *Massachusetts nesting sites* • Manchester/Gloucester area: double-crested cormorant, gulls, little blue heron, great egret, snowy egret, black-crowned night-heron, glossy ibis, Canada goose, mallard • Rockport and offshore islands: cormorant, herring and great black-backed gull, glossy ibis, black-crowned night heron *New Hampshire* • Isles of Shoals: common tern (ST, 1,000s), roseate tern (FE, SE; 100), arctic tern (1-7), common eider (50-60), black guillemot (sporadic nesters), herring gull, great black-backed gull, double-crested cormorant (50-100)	*Nesting*: Arctic tern nests May-Jun Least tern, roseate tern, common tern, piping plover nesting May-Aug Double-crested cormorant nests Apr-Jul Generally, seabird nesting season Apr-Aug *Migrating*: Shorebird migration Aug Most summer residents leave by Sep Fall waterfowl migration Sep-Oct
Pinnipeds	Harbor seals and gray seals are common. Harp seals and hooded seals are transitory. Additional Arctic species have been sighted but are not common. *Concentrations*: • 30-40,000 harbor seals in coastal Maine and Isle of Shoals population • Harbor seal rookeries at the rocks offshore of Beckman's Point (20-70) and Plaice Cove (10-45), Seal Rocks (10-20), Square Rock (200-600) • Gray seals present on Square Rock	Harp seals present Jan-May Harbor seals pup May-Jun Gray seals pup Dec-Feb
Cetaceans	*Common to Gulf of Maine*: North Atlantic right whale (FE), fin whale (FE), minke	Right, humpback, fin

Species Group	Species Subgroup and Geography	Seasonal Presence
	whale, humpback whale (FE), Atlantic white-sided dolphin, harbor porpoise *Also present*: blue whale (FE), sei whale, pygmy sperm whale, sperm whale (FE), northern bottlenose whale, beaked whale, beluga, killer whale, long-finned pilot whale, white-beaked dolphin, bottlenose dolphin, common dolphin, striped dolphin	present in summer Atlantic white-sided dolphin calves Jun-Jul; Harbor porpoise calves May-Jun
Fish	Coastal streams/estuaries • Atlantic sturgeon (FT) spawn in Kennebec and Penobscot Rivers • Alewife and American shad spawn in all streams • Juvenile anadromous fish use nearshore waters as nursery habitat • High concentration of smelt and striped bass in Rye Harbor • High concentration of winter flounder in Hampton Harbor Marine • Nearshore waters support high concentrations of anadromous fish • Offshore ledges and banks support highly productive fisheries, including Atlantic halibut, Atlantic cod, winter flounder, witch flounder, American plaice, hake, monkfish	American shad spawn May-Nov Alewife common offshore in fall, spawn Mar-May
Invertebrates	Atlantic surf clam, softshell clam, bay scallop, northern quahog, and blue mussels are all present in bays and nearshore environments. American lobster, rock crabs, northern shrimp and sea scallop beds all found in nearshore areas. Areas of high concentration areas are listed below: • Blue mussels around Manomet Point • Softshell clam beds common in bays of Maine • American lobsters migrate inshore in the summer; rocky intertidal areas may be important nursery habitat	Northern shrimp spawn Nov-May Mussels spawn in spring
Benthic Habitats	Submerged aquatic vegetation (mostly eelgrass) is critical to numerous species and occurs inside of bays and sounds throughout the region; Casco Bay has large beds Rockweed can be found along rocky shores from Maine north and is important habitat for juvenile fish, invertebrates and birds	Year round

The Environmental Sensitivity Index (ESI) atlases for the potentially impacted coastal areas from a leak from the *Empire Knight* 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 based on a 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 *Empire Knight* is provided, both as text and as shading of the applicable degree of risk bullet, for the WCD release of 10,000 bbl and a border around the Most Probable Discharge of 1,000 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 *Empire Knight* is classified as Medium Risk for oiling probability for water column ecological resources for the WCD of 10,000 bbl because 17% 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 21 mi^2 of the upper 33 feet of the water column. For the Most Probable Discharge of 1,000 bbl, the *Empire Knight* is classified as High Risk for oiling probability for water column ecological resources because 99% 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 36 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 *Empire Knight* is classified as Medium Risk for oiling probability for water surface ecological resources for the WCD because 29% 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 Low Risk for degree of oiling because the mean area of water contaminated was 900 mi^2. The *Empire Knight* is classified as Low Risk for oiling probability for water surface ecological resources for the Most Probable Discharge because 2% 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 201 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 *Empire Knight* is classified as Medium Risk for oiling probability for shoreline ecological resources for the WCD because 50% of the model runs resulted in shorelines affected above the threshold of 100 g/m^2. It is classified as Low Risk for degree of oiling because the mean weighted length of shoreline contaminated was 5 miles. The *Empire Knight* is classified as Low Risk for oiling probability to shoreline ecological resources for the Most Probable Discharge because 8% of the model runs resulted in shorelines affected above the threshold of 100 g/m^2. It is classified as Low Risk for degree of oiling because the mean weighted length of shoreline contaminated was 2 miles.

Considering the modeled risk scores and the ecological resources at risk, the ecological risk from potential releases of the WCD of 10,000 bbl of light fuel oil from the *Empire Knight* is summarized as listed below and indicated in the far-right column in Table 3-2:

- Water column resources – Medium, because the presence of many important fish and shellfish resources in nearshore shallow habitats at risk
- Water surface resources – Medium, because of the seasonally very large number of marine mammals and nesting and migratory birds that use ocean, coastal, and estuarine habitats at risk. 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 and streamers
- Shoreline resources – Low, because of the lower likelihood of significant amounts of light fuel oil to strand onshore and a light fuel oil is less persistent than heavier oils

Table 3-2: Ecological risk factor scores for the **Worst Case Discharge of 10,000 bbl** of light fuel oil from the *Empire Knight*.

Risk Factor	Risk Score			Explanation of Risk Score	Final Score
3A-1: Water Column Probability EcoRAR Oiling	Low	**Med**	High	17% 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	**Med**
3A-2: Water Column Degree EcoRAR Oiling	Low	**Med**	High	The mean volume of water contaminated above 1 ppb was 21 mi^2 of the upper 33 feet of the water column	
3B-1: Water Surface Probability EcoRAR Oiling	Low	**Med**	High	29% 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**	Med	High	The mean area of water contaminated above 10 g/m^2 was 900 mi^2	
3C-1: Shoreline Probability EcoRAR Oiling	Low	**Med**	High	50% of the model runs resulted in shoreline oiling of 100 g/m^2	**Low**
3C-2: Shoreline Degree EcoRAR Oiling	**Low**	Med	High	The length of shoreline contaminated by at least 100 g/m^2 was 5 mi	

For the Most Probable Discharge of 1,000 bbl, the ecological risk from potential releases of light fuel oil from the *Empire Knight* is summarized as listed below and indicated in the far-right column in Table 3-3:

- Water column resources – Medium, because of the likely smaller volume of water column impacts
- Water surface resources – Low, because the area affected is smaller, and light fuel oils tend to quickly break up into sheens that pose less risks to birds and marine mammals
- Shoreline resources – Low, because fewer miles of shoreline are at risk

Table 3-3: Ecological risk factor scores for the **Most Probable Discharge of 1,000 bbl** of light fuel oil from the *Empire Knight*.

Risk Factor	Risk Score			Explanation of Risk Score	Final Score
3A-1: Water Column Probability EcoRAR Oiling	Low	Med	**High**	99% 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	Med
3A-2: Water Column Degree EcoRAR Oiling	Low	**Med**	High	The mean volume of water contaminated above 1 ppb was 36 mi^2 of the upper 33 feet of the water column	
3B-1: Water Surface Probability EcoRAR Oiling	**Low**	Med	High	2% 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**	Med	High	The mean area of water contaminated above 10 g/m^2 was 201 mi^2	
3C-1: Shoreline Probability EcoRAR Oiling	**Low**	Med	High	8% of the model runs resulted in shoreline oiling of 100 g/m^2	Low
3C-2: Shoreline Degree EcoRAR Oiling	**Low**	Med	High	The length of shoreline contaminated by at least 100 g/m^2 was 2 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 *Empire Knight* include very highly utilized recreational beaches from Cape Cod and Nantucket, Massachusetts, up to northern Maine during summer, but also during spring and fall for shore fishing and wildlife viewing. A national seashore and national park would also potentially be impacted.

Shipping lanes run through the area of impact into the ports of Boston, MA, Portsmouth, NH, Portland, ME, and Searsport, ME, totaling over 1,080 vessel calls and 57 million tonnage annually.

Commercial fishing is economically important to the region. There are fishing fleets coming out of several coastal towns and cities with annual catches totaling $184.3 million.

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 *Empire Knight* 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 *Empire Knight*.

Resource Type	Resource Name	Economic Activities
Tourist Beaches	Rye, NH Hampton Beach, NH Scituate, MA Duxbury, MA Marshfield, MA Marblehead, MA Manchester-by-the-Sea, MA Newburyport, MA Gloucester, MA Wingaersheek Beach, MA Ipswich, MA Essex, MA Truro, MA Wellfleet, MA Provincetown, MA Chatham, MA York, ME Kittery, ME	Potentially affected beach resorts and beach-front communities in Massachusetts, New Hampshire, and Maine provide recreational activities (e.g., swimming, boating, recreational fishing, wildlife viewing, nature study, sports, dining, camping, and amusement parks) with substantial income for local communities and state tax income. Much of the coast is lined with economically valuable beach resorts and residential communities. Many of these recreational activities are limited to or concentrated into the late spring into early fall months.

Resource Type	Resource Name	Economic Activities
	Ogunquit, ME Kennebunkport, ME Old Orchard Beach, ME Cape Elizabeth, ME Popham Beach, ME Monhegan Island, ME Matinicus Isle, ME Vinalhaven, ME Frenchboro, ME Cranberry Isles, ME Winter Harbor, ME Jonesport, ME Cutler, ME Bar Harbor, ME	
National Seashores	Cape Cod National Seashore, MA	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.
National Parks	Acadia National Park	National parks also provide recreation for local and tourist populations and preserve and protect the nation's natural treasures.
National Wildlife Refuges	Thacher Island NWR (MA) Parker River NWR (MA) Great Bay NWR (NH) Rachel Carson NWR (ME) Pond Island NWR (ME) Franklin Island NWR (ME) Seal Island NWR (ME) Petit Manan NWR (ME) Cross Island NWR (ME)	National wildlife refuges in three states may be impacted. These federally managed and protected lands provide refuges and conservation areas for sensitive species and habitats.
State Parks	Salisbury Beach SP, MA Hampton Beach SP, NH Jenness State Beach SP, NH Wallis Sands Beach SP, NH Ordiorne Point SP, NH Crescent Beach SP, ME Two Lights SP, ME Quoddy Head SP, ME Popham Beach SP, ME Reid SP, ME Birch Point SP, ME Camden Hills SP, ME Warren Island SP, ME Lamoine SP, ME Roque Bluffs SP, ME	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 states. State parks in Maine are potentially impacted. Many of these recreational activities are limited to or concentrated into the late spring into early fall months.
Commercial Fishing	A number of fishing fleets use the area and surrounding waters for commercial fishing purposes.	
	Provincetown-Chatham, MA	Total Landings (2010): $19.9M
	Gloucester, MA	Total Landings (2010): $56.6M
	Portland, ME	Total Landings (2010): $18.8M
	Rockland, ME	Total Landings (2010): $10.6M
	Stonington, ME	Total Landings (2010): $45.3M
	Boston, MA	Total Landings (2010): $15.1M
	Jonesport, ME	Total Landings (2010): $18.0M

Resource Type	Resource Name	Economic Activities
Ports	There are a number of significant commercial ports in the Northeast 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.	
	Boston, MA	584 port calls annually
	Portland, ME	317 port calls annually
	Searsport, ME	100 port calls annually
	Portsmouth, NH	83 port calls annually

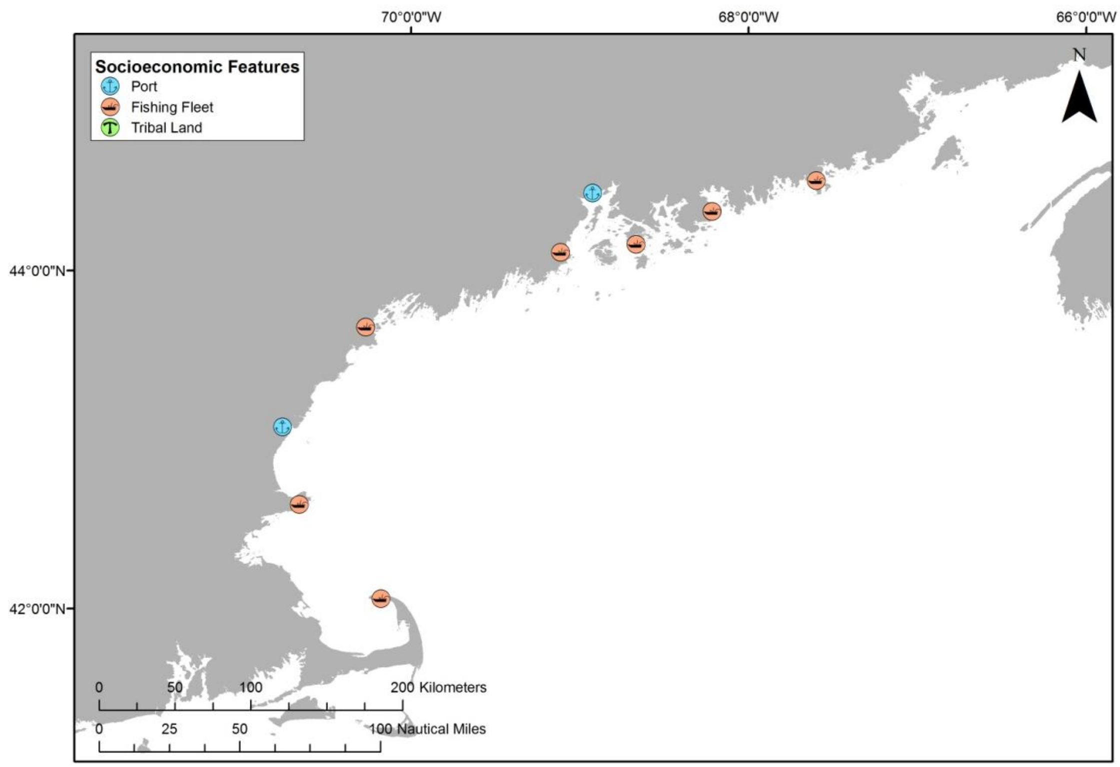


Figure 4-1: Tribal lands, ports, and commercial fishing fleets at risk from a release from the *Empire Knight*. (Note that there are no tribal lands at risk.)

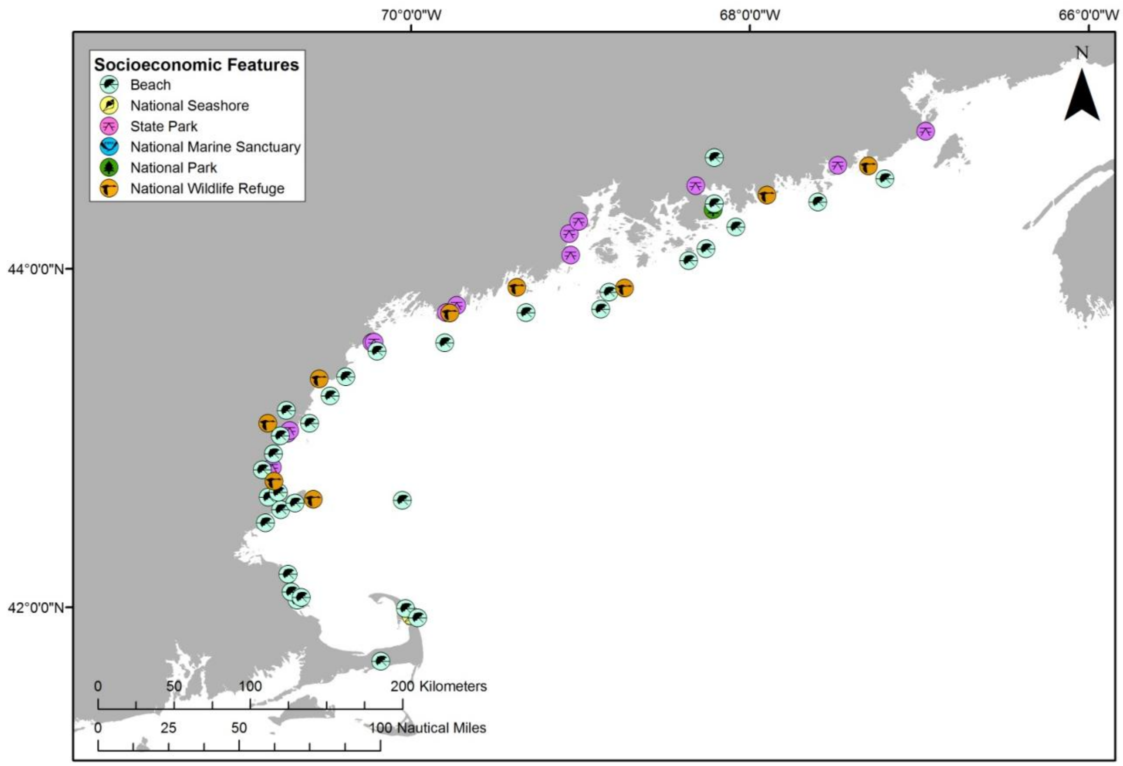


Figure 4-2: Beaches, coastal state parks, and Federal protected areas at risk from a release from the *Empire Knight*.

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 *Empire Knight* shading indicates the degree of risk for the WCD release of 10,000 bbl and a border indicates degree of risk for the Most Probable Discharge of 1,000 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 *Empire Knight* is classified as Medium Risk for oiling probability and Medium Risk for degree of oiling for water column socio-economic resources for the WCD of 10,000 bbl because 17% 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 21 mi^2 of the upper 33 feet of the water column. For the Most Probable Discharge of 1,000 bbl, the *Empire Knight* is classified as High Risk for oiling probability for water column socio-economic resources because 99% 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 was classified as Medium Risk for degree of oiling because the mean volume of water contaminated was 36 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 *Empire Knight* is classified as High Risk for oiling probability and Medium Risk for degree of oiling for water surface socio-economic resources for the WCD because 83% 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 6,820 mi^2. The *Empire Knight* is classified as High Risk for oiling probability for water surface socio-economic resources for the Most Probable Discharge because 54% 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. It is classified as Medium Risk for degree of oiling because the mean area of water contaminated was 1,980 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 *Empire Knight* is classified as High Risk for oiling probability for shoreline socio-economic resources for the WCD because 60% of the model runs resulted in shorelines affected above the threshold of 1 g/m^2. It is Low Risk for degree of oiling because the mean length of weighted shoreline contaminated was 6 miles. The *Empire Knight* is classified as Medium Risk for oiling probability and Low Risk for degree of oiling for shoreline socio-economic resources for the Most Probable Discharge as 10% 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 3 miles.

Considering the modeled risk scores and the socio-economic resources at risk, the socio-economic risk from potential releases of the WCD of 10,000 bbl of light fuel oil from the *Empire Knight* is summarized as listed below and indicated in the far-right column in Table 4-2:

- Water column resources – Low, because a relatively small area of water column would be impacted in important fishing grounds
- Water surface resources – Medium, because a moderate area of offshore surface waters would be impacted in areas with shipping lanes and fishing grounds. 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 – Low, because a relatively small length of shoreline would be impacted in high-value areas

Table 4-2: Socio-economic risk factor ranks for the **Worst Case Discharge of 10,000 bbl** from the *Empire Knight*.

Risk Factor	Risk Score			Explanation of Risk Score	Final Score
4A-1: Water Column Probability SRAR Oiling	Low	Medium	High	17% 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 was above 1 ppb was 21 mi^2 of the upper 33 feet of the water column	
4B-1: Water Surface Probability SRAR Oiling	Low	Medium	High	83% of the model runs resulted in at least 1,000 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 6,820 mi^2	
4C-1: Shoreline Probability SRAR Oiling	Low	Medium	High	60% of the model runs resulted in shoreline oiling of 1 g/m^2	Low
4C-2: Shoreline Degree SRAR Oiling	Low	Medium	High	The length of shoreline contaminated by at least 1 g/m^2 was 6 mi	

For the Most Probable Discharge of 1,000 bbl, the socio-economic risk from potential releases of light fuel oil from the *Empire Knight* is summarized as listed below and indicated in the far-right column in Table 4-3:

- Water column resources – Low, because a relatively small area of water column would be impacted in important fishing grounds
- Water surface resources – Medium, because a moderate area of offshore surface waters would be impacted in areas with shipping lanes and fishing grounds. 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 – Low, because a relatively small length of shoreline would be impacted in high-value areas

Table 4-3: Socio-economic risk factor ranks for the **Most Probable Discharge of 1,000 bbl** from the *Empire Knight*.

Risk Factor	Risk Score			Explanation of Risk Score	Final Score
4A-1: Water Column Probability SRAR Oiling	Low	Medium	**High**	99% of the model runs resulted in at least 0.2 mi² 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 was above 1 ppb was 36 mi² of the upper 33 feet of the water column	
4B-1: Water Surface Probability SRAR Oiling	Low	Medium	**High**	54% of the model runs resulted in at least 1,000 mi² of water surface covered by at least 0.01 g/m²	Med
4B-2: Water Surface Degree SRAR Oiling	Low	**Medium**	High	The mean area of water contaminated above 0.01 g/m² was 1,980 mi²	
4C-1: Shoreline Probability SRAR Oiling	Low	**Medium**	High	10% of the model runs resulted in shoreline oiling of 1 g/m²	Low
4C-2: Shoreline Degree SRAR Oiling	**Low**	Medium	High	The length of shoreline contaminated by at least 1 g/m² was 3 mi	

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

The overall risk assessment for the *Empire Knight* 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 particular 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, *Empire Knight* scores Low with 11 points; for the Most Probable Discharge, *Empire Knight* also scores Low with 10 points. Under the National Contingency Plan, the U.S. Coast Guard and the Regional Response Team 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 *Empire Knight*. The final determination of what type of action, if any, rests with the U.S. Coast Guard.

Empire Knight	**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 attempt to locate this vessel and gather more information on the vessel condition
	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
✓	Conduct outreach efforts with the commercial and recreational fishermen who pass by the area, to gain awareness of changes in the site

Table 5-1: Summary of risk factors for the *Empire Knight*.

Vessel Risk Factors		Data Quality Score	Comments		Risk Score
Pollution Potential Factors	A1: Oil Volume (total bbl)	Low	Maximum of 10,000 bbl, not reported to be leaking		**Med**
	A2: Oil Type	High	Bunker oil is marine diesel, may have small amount of Bunker C oil for steam donkey boilers		
	B: Wreck Clearance	High	Vessel not reported as cleared		
	C1: Burning of the Ship	High	No fire was reported		
	C2: Oil on Water	Medium	No reports of oil on water in the reports located during this study		
	D1: Nature of Casualty	High	Struck a ledge and broke in half		
	D2: Structural Breakup	High	Vessel is broken in half		
Archaeological Assessment	Archaeological Assessment	Medium	The best analysis of the sinking and wreckage probably still comes from information the U.S. Coast Guard has access to, but the analysis of where oil was stored and the capacities is believed to be very accurate		**Not Scored**
Operational Factors	Wreck Orientation	High	Stern is listing 40 degrees to starboard		**Not Scored**
	Depth	High	Stern is 210 feet deep		
	Visual or Remote Sensing Confirmation of Site Condition	High	Stern has been surveyed and partially salvaged		
	Other Hazardous Materials Onboard	High	Vessel carried mercury as part of the cargo		
	Munitions Onboard	Low	Unknown		
	Gravesite (Civilian/Military)	High	Yes		
	Historical Protection Eligibility (NHPA/SMCA)	High	NHPA and possibly SMCA		
				WCD	**Most Probable**
Ecological Resources	3A: Water Column Resources	High	Many important fish and shellfish resources in nearshore shallow habitats at risk	**Med**	**Med**
	3B: Water Surface Resources	High	Seasonally very large number of marine mammals and nesting and migratory birds	**Med**	**Low**
	3C: Shore Resources	High	Very small amount of shoreline impact likely	**Low**	**Low**
Socio-Economic Resources	4A: Water Column Resources	High	A relatively small area of water column would be impacted in important fishing grounds	**Low**	**Low**
	4B: Water Surface Resources	High	A moderate area of offshore surface waters would be impacted in areas with shipping lanes and fishing grounds	**Med**	**Med**
	4C: Shore Resources	High	A relatively small length of shoreline would be impacted in high-value areas	**Low**	**Low**
Summary Risk Scores				**11**	**10**