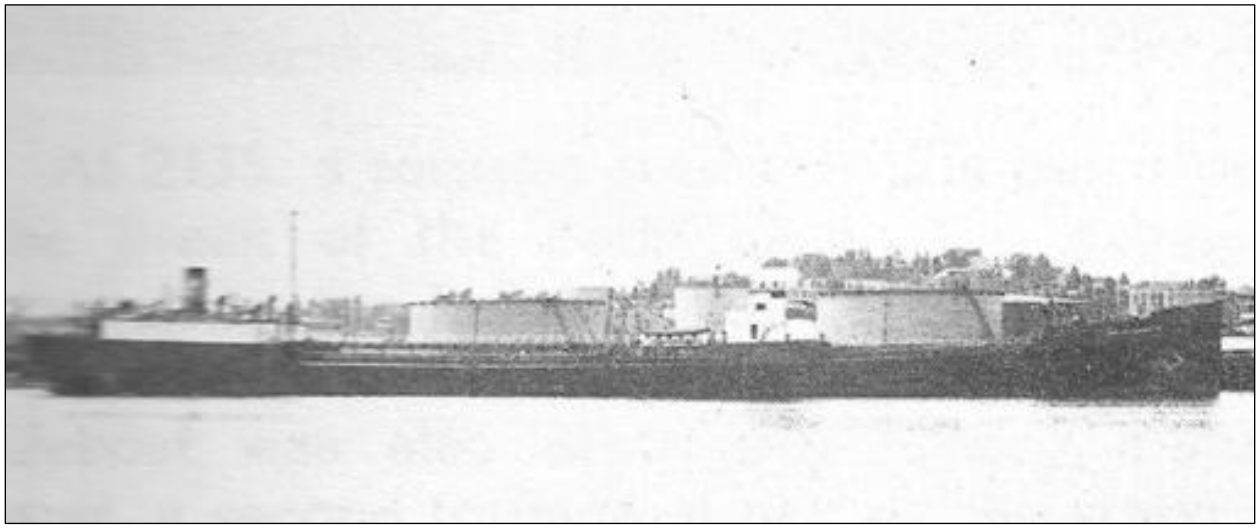
Office of National Marine Sanctuaries
Office of Response and Restoration

Screening Level Risk Assessment Package

Pan-Massachusetts



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National Oceanic and
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Photo: Photograph of *Pan-Massachusetts*
Courtesy of The Mariners' Museum Library, Newport News, VA

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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.

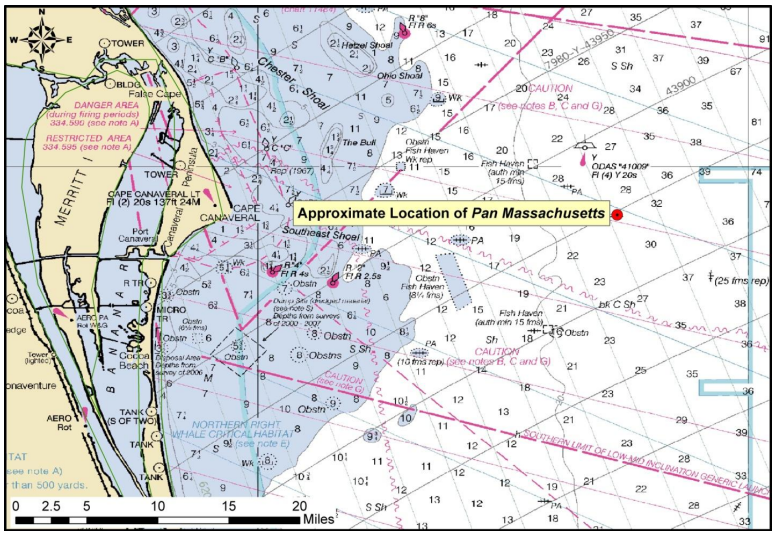
The potential polluting shipwrecks were identified through searching a broad variety of historical sources. NOAA then worked with Research Planning, Inc., RPS ASA, and Environmental Research Consulting to conduct the modeling forecasts, and the ecological and environmental resources at risk assessments.

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: *Pan-Massachusetts*

The tanker *Pan-Massachusetts*, torpedoed and sunk during World War II off the coast of central Florida in 1942, 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 *Pan-Massachusetts*, 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.



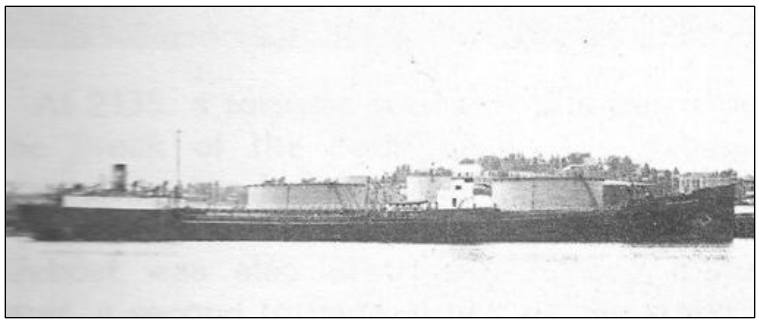
Based on this screening-level assessment, each vessel was assigned a summary score calculated using the seven risk criteria described in this report. For the Worst Case Discharge, *Pan-Massachusetts* scores Medium with 14 points; for the Most Probable Discharge (10% of the Worse Case volume), *Pan-Massachusetts* scores Low with 11 points. Given these scores, and the higher level of data certainty, NOAA recommends that this site be noted in Area Contingency Plans, and that surveys of opportunity be used to attempt to gather more information on the vessel condition and the location of the stern section. At a minimum an active monitoring program should be implemented. 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 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	High	Med
	3B: Water Surface Resources	High	Med
	3C: Shore Resources	Med	Low
Socio-Economic Resources	4A: Water Column Resources	Med	Low
	4B: Water Surface Resources	High	High
	4C: Shore Resources	Med	Low
Summary Risk Scores		14	11

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: *Pan-Massachusetts*

Official Number: 217457

Vessel Type: Tanker

Vessel Class: 7,600 gross ton (11,600 dwt) class tanker

Former Names: *War Cape*/*Triumph*; M.S. *Triumph*

Year Built: 1919

Builder: Bethlehem Steel Company, Alameda, CA

Builder's Hull Number: 167A

Flag: American

Owner at Loss: National Bulk Carriers Inc.

Controlled by: Unknown **Chartered to:** Unknown

Operated by: Unknown

Homeport: New York, NY

Length: 456 feet **Beam:** 56 feet **Depth:** 35 feet

Gross Tonnage: 8,202 **Net Tonnage:** 6,025

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

Bunker Type: Heavy Fuel Oil (Bunker C) **Bunker Capacity (bbl):** 5,730

Average Bunker Consumption (bbl) per 24 hours: Unknown

Liquid Cargo Capacity (bbl): 104,000 **Dry Cargo Capacity:** Unknown

Tank or Hold Description: Vessel had nine cargo tanks divided port and starboard by an oil-tight centerline bulkhead

Casualty Information

Port Departed: Texas City, TX

Destination Port: New York

Date Departed: February 15, 1942

Date Lost: February 19, 1942

Number of Days Sailing: ≈ 5

Cause of Sinking: Act of War (Torpedoes)

Latitude (DD): 28.45028

Longitude (DD): -80.13309

Nautical Miles to Shore: 23.5

Nautical Miles to NMS: 168

Nautical Miles to MPA: 0

Nautical Miles to Fisheries: Unknown

Approximate Water Depth (Ft): 300

Bottom Type: Sand

Is There a Wreck at This Location? The listed coordinates may not be accurate but the location of the wreck is known as the wreck in infrequently visited by TEC divers

Wreck Orientation: Inverted (Turtled)

Vessel Armament: None

Cargo Carried when Lost: 104,000 bbl of refined petrol, gas, kerosene, and diesel

Cargo Oil Carried (bbl): 104,000

Cargo Oil Type: Light and Medium Fuel Oils

Probable Fuel Oil Remaining (bbl): ≤12,000

Fuel Type: Heavy Fuel Oil (Bunker C)

Total Oil Carried (bbl): ≤ 116,000

Dangerous Cargo or Munitions: No

Munitions Carried: None

Demolished after Sinking: No

Salvaged: No

Cargo Lost: Yes, partially

Reportedly Leaking: No

Historically Significant: Yes

Gravesite: Yes

Salvage Owner: Not known if any

Wreck Location

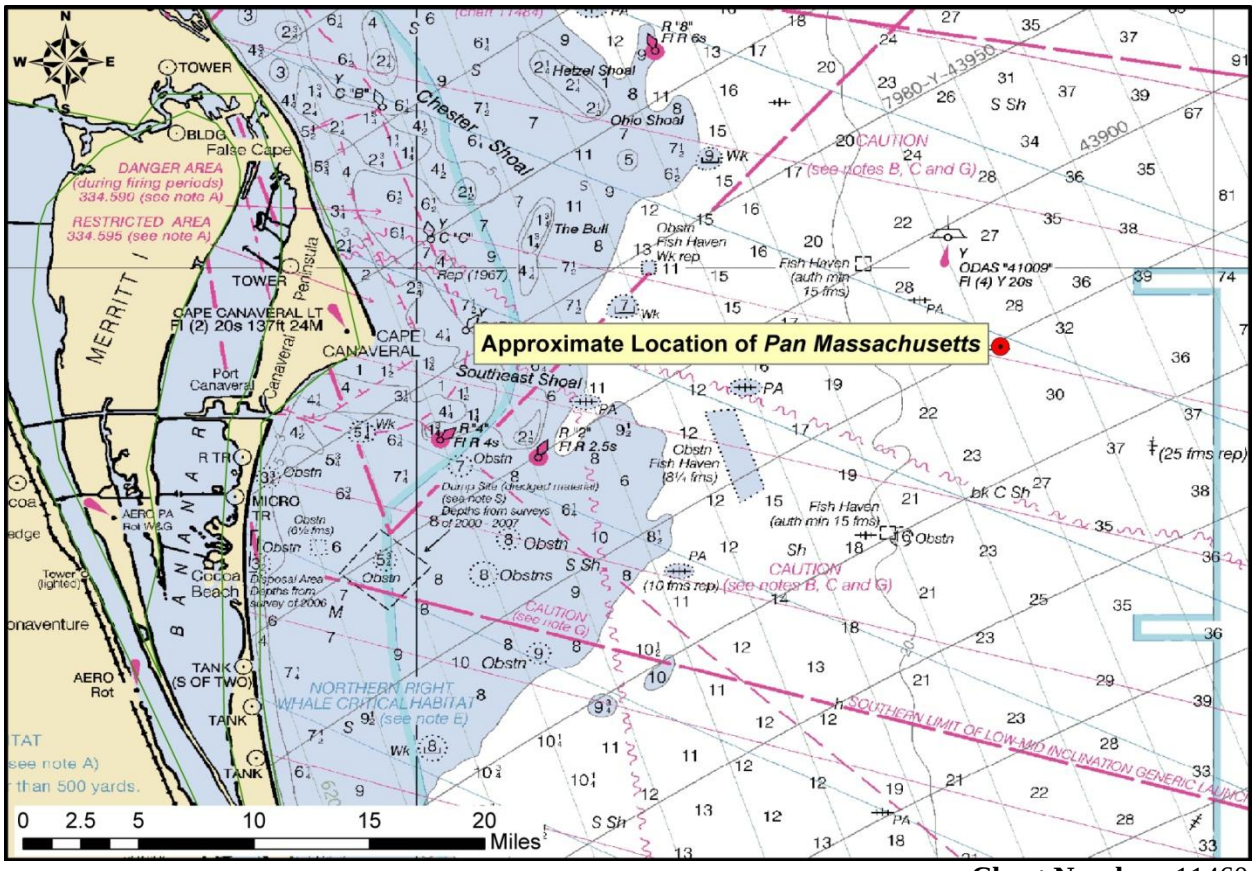


Chart Number: 11460

Casualty Narrative

"At 19.45 hours on 19 Feb, 1942, the unescorted and unarmed *Pan Massachusetts* (Master Robert E. Christy) was hit by two torpedoes from *U-128* about 20 miles off Cape Canaveral, while steaming at 13.5 knots in misty and squally weather. The torpedoes struck on the starboard side amidships and ruptured the tanks and deck. The explosions sprayed the cargo over the length of the vessel and ignited it, turning the tanker into a burning inferno but the full tanks prevented the cargo to explode. Some of the nine officers and 29 crewmen on board jumped overboard and swam underneath the flames to open spots and others went forward and escaped into the water by lowering a mooring line over the side because all lifeboats became victims of the flames before they could be launched. Three officers and 17 crewmen were lost.

The British steam tanker *Elizabeth Massey* immediately put out a lifeboat to pick up the men in the water, but rough seas hampered the effort until the U.S. Coast Guard ship USS *Forward* (WAGL 160) took the lifeboat in tow and moved with it through the wreckage. Some bodies were recovered and placed on board the U.S. Coast Guard ship, while all survivors were brought to the tanker and taken to Jacksonville, Florida."
-http://www.uboat.net:8080/allies/merchants/ships/1350.html

General Notes

AWOIS Data:
DESCRIPTION
NO.843; TANKER 8201 GT; SUNK 2/19/42 BY SUBMARINE; POS. ACCUR. 1-3 MILES 2/19/42.

SURVEY REQUIREMENTS NOT DETERMINED.
TKR; 8201 TONS; TORPEDOED 2/19/42 IN 150 FT.

Wreck Condition/Salvage History

"The wreck was indeed broken in two. We had slammed into the fracture point of the bow section at the point of the aftermost tank, just in front of where the boilers and engine would be found. Sections of the wreck were spread out in the sand to the south around this point. One piece appeared to be a portion of bulkhead with portholes. With the wreck laying NE-SW, we began to circumnavigate the wreck. Just forward of the line, a cavernous opening allowed penetration into the interior. Due to the massive size of the hole and presence of debris adjacent to this area, it is feasible to assume that this may be the point where one of the torpedoes slammed into the hull. Joe and I ventured inside, noting the abundant Oculina coral that adorned the interior surfaces. This appeared to be one of the tanks; vertical ladders along the separating bulkheads were the only noticeable structure. I noticed some brass valves and piping in the sand under and around these tanks, more evidence that this wreck was a tanker... The wreck has a near vertical bow, the obtuse angle providing more clues that the wreck is the tanker Pan Massachusetts. Turning the corner and finning along the other side, I soon saw the large starboard anchor tight in its hawse pipe... Eventually reaching the fracture point, I saw a line running along the sand bottom. At the time, I didn't realize that it was our upline; the current had pulled the balls under the water and the angle of our line was actually running down into the sand instead of up! We were able to pry the line loose from the wreck as we were flung off the wreck and out over the sand, the poly balls eventually popping to the surface. Upon our exit, I noticed a debris trail heading off to the west which may lead to the missing stern section – something to check out on our next visit…While we were not able to find any positive identification to the wreck's identity, due to the architecture and size of the wreck, as well as the absence of any other large wrecks near the reported sinking location, we are pretty confident that the wreck is that of the *Pan Massachusetts*."
-http://uwex.us/061801.htm

"The *Pan Mass* was a large tanker sunk in World War II and was the first WWII casualty off the Florida coast. She now rests inverted in just shy of 300fsw. However, this section, known locally as the "Copper Wreck" consists of just the bow section forward of the machinery spaces - the stern section lies approximately, very roughly of course, one to two miles away. Since we again had a smoking 3.6kt current, we deployed 0.13nm from the wreck; this time we had a bit more rapid descent -- I found myself at the fracture point filming a 100-pound Warsaw grouper while my bottom timer still registered one minute. The vis on the *Pan Mass* was incredible -- perhaps 70 feet... We set about exploring the wreck in the wonderful conditions. She seemed like a totally different wreck. We could now clearly see her fracture point and a transverse bulkhead that had fallen outward to the sand. Access to the interior was permitted through the fracture point and various openings in the hull and between tanks. While swarmed by AJS, I played around with the large grouper for a while, before opting to scooter the [perimeter] of the wreck in search of more prey. The two teams gathered a lot of awesome video, though we only spotted

that one large Warsaw. He liked the attention as he followed us around to the bow and back towards the fracture. After a couple laps and scootering across through the interior of the wreck, we again worked towards the bow to ascend for decompression after 20 minutes. It was a phenomenal dive."- http://uwex.us/080402.htm

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

NOAA archaeologists have located little additional historic documentation on the sinking of the tanker *Pan-Massachusetts* that would allow much additional historical assessment about the shipwreck on top of the casualty narrative included in this packet. We do know from archival research that two explosions (now known to have been torpedoes) rocked the tanker amidships (Fig. 1-1). The ship broke apart amidships immediately and began to sink with the stern section on fire and the deck ruptured. The survivors of the attack reported seeing a large hole in the starboard side of the ship approximately 12 feet by 15 feet with the plates bent inwards.

Today, divers report that the wreck of *Pan-Massachusetts* lies broken in half in approximately 300 feet of water. The stern section has not been discovered, and the bow section lies inverted on the seafloor. A local diver interviewed during this study reported that the tanks immediately forward of the hull break are open to the sea and empty, but that the tanks forward of these are intact and could presumably still retain large quantities of cargo oil that has been trapped in the underside of the hull. Although the stern has never been located, it is likely that some of the tanks were damaged by the fire that spread to the aft most section of the ship and may no longer contain oil.

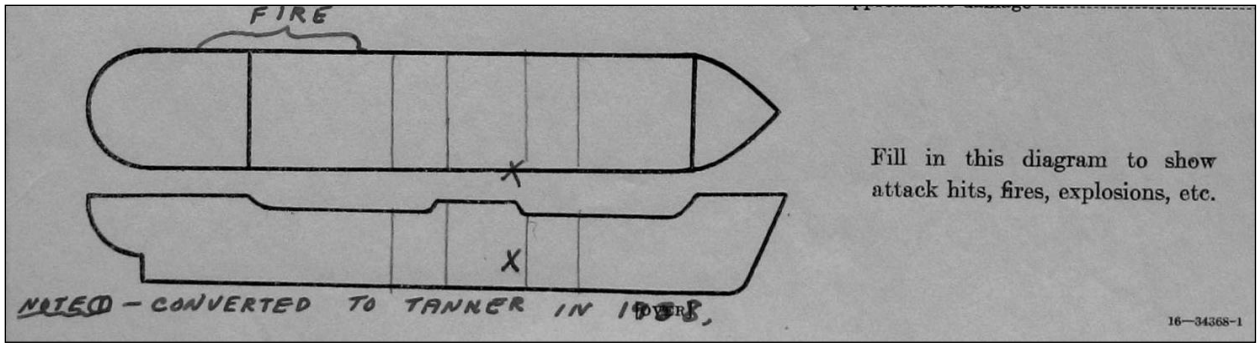


Figure 1-1: U.S. Coast Guard diagram of the location of torpedo impacts on *Pan-Massachusetts* (Image courtesy of National Archives, Washington, DC).

The only way to conclusively determine the condition of the stern, however, will be to examine this section after it is discovered. Should the vessel 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 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 Historic Register. The site is also considered a war grave and appropriate actions should be undertaken to minimize disturbance to the site.

Background Information References

Vessel Image Sources: Mariners Museum, Newport News VA

Construction Diagrams or Plans in RULET Database? No

Text References:
http://www.uboat.net/allies/merchants/1350.html;
http://uwex.us/061801.htm;
http://uwex.us/080402.htm;
AWOIS database;
NIMA database;
Global Wrecks database

Vessel Risk Factors

In this section, the risk factors that are associated with the vessel are defined and then applied to the *Pan-Massachusetts* 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.

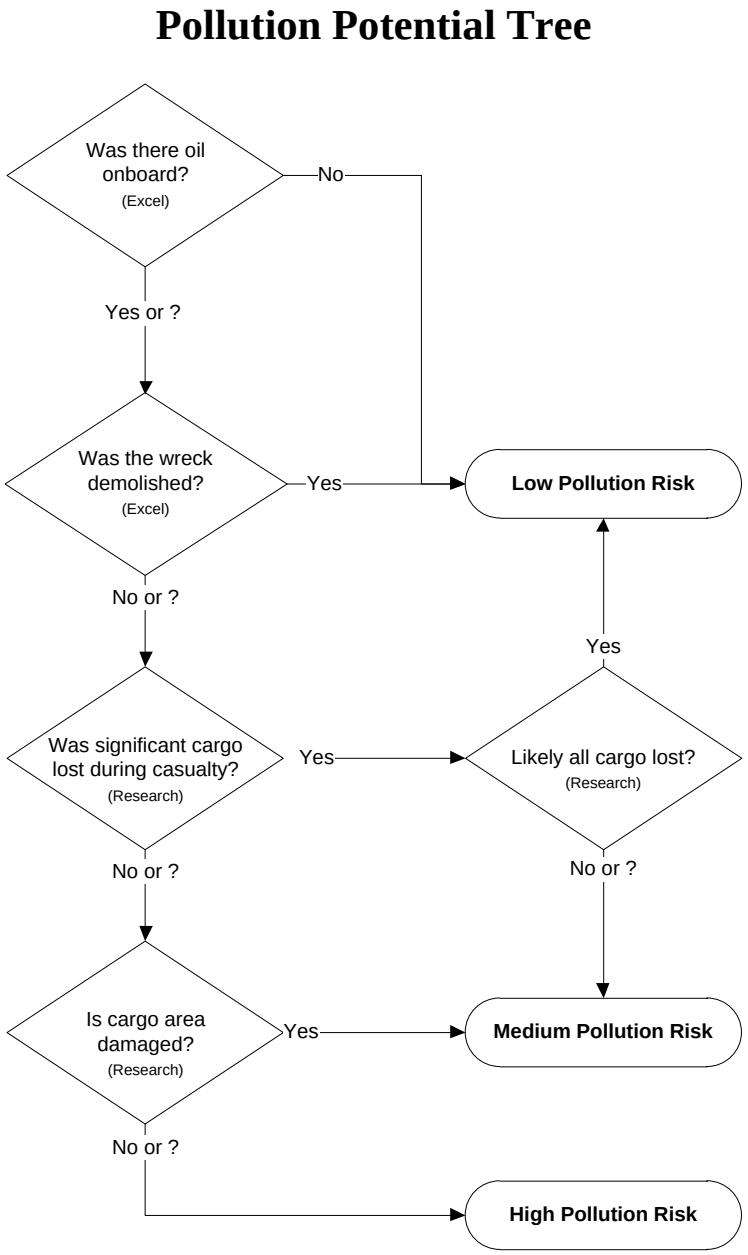


Figure 1-2: U.S. Coast Guard Salvage Engineering Response Team (SERT) developed the above Pollution Potential Decision Tree.

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.

In the following sections, the definition of low, medium, and high for each risk factor is provided. Also, the classification for the *Pan-Massachusetts* 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 *Pan-Massachusetts* is ranked as High Volume because it is thought to have a potential for up to 104,000 bbl of refined petrol, gas, kerosene, and diesel as cargo and up to 12,000 bbl of Bunker C fuel oil, although some of that may have been lost at the time of the casualty or after the vessel sank. 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 *Pan-Massachusetts*.

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:

[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]

- **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 *Pan-Massachusetts* is classified as Medium Risk because the cargo includes various light refined products, which are Group II oil types. 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 site 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 *Pan-Massachusetts* 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 *Pan-Massachusetts* is classified as Medium Risk because a significant fire was reported at the time of the casualty. Data quality is high.

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 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 know whether or not there was oil on the water at the time of the casualty

The *Pan-Massachusetts* is classified as Medium Risk because oil was reported to have spread across the water as the vessel went down. Data quality is high.

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 *Pan-Massachusetts* is classified as Low Risk because there were two torpedo detonations and the vessel is broken into at least 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 *Pan-Massachusetts* is classified as Medium Risk because it is broken into at least two sections. The stern has never been located. 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 section of the *Pan-Massachusetts* is inverted (turtled) and the stern has never been located. 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 bow of the *Pan-Massachusetts* is 300 feet deep and the stern has never been located. 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 *Pan-Massachusetts* has been visited by technical divers. 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 *Pan-Massachusetts* did not carry any munitions. Data quality is high.

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 *Pan-Massachusetts.* Operational factors are listed but do not have a risk score.

Table 1-1: Summary matrix for the vessel risk factors for the *Pan-Massachusetts* 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 116,000 bbl, not reported to be leaking	**Med**
	A2: Oil Type	High	Cargo includes light refined products, Group II oil types	
	B: Wreck Clearance	High	Vessel not reported as cleared	
	C1: Burning of the Ship	High	A significant fire was reported	
	C2: Oil on Water	High	Oil was reported on the water; amount is not known	
	D1: Nature of Casualty	High	Two torpedo detonations	
	D2: Structural Breakup	High	The vessel is broken into at least two sections	
Archaeological Assessment	Archaeological Assessment	High	Detailed sinking records and site reports of this ship exist, assessment is believed to be very accurate	**Not Scored**
Operational Factors	Wreck Orientation	High	Bow is inverted, stern is unknown	**Not Scored**
	Depth	High	Bow is 300 ft, stern is unknown	
	Visual or Remote Sensing Confirmation of Site Condition	High	Bow has been visited by technical divers	
	Other Hazardous Materials Onboard	High	No	
	Munitions Onboard	High	No	
	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 *Pan-Massachusetts* this would be about 116,000 bbl (104,000 bbl of refined petrol, gas, kerosene, and diesel as cargo and up to 12,000 bbl of Bunker C fuel oil) based on estimates of the maximum amount of oil remaining onboard the wreck.

The likeliest scenario of oil release from most sunken wrecks, including the *Pan-Massachusetts*, 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 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 *Pan-Massachusetts*.

Scenario Type	Release per Episode	Time Period	Release Rate	Relative Likelihood	Response Tier
Chronic (0.1% of WCD)	116 bbl	Fairly regular intervals or constant	100 bbl over several days	More likely	Tier 1
Episodic (1% of WCD)	1,160 bbl	Irregular intervals	Over several hours or days	Most Probable	Tier 1-2
Most Probable (10% of WCD)	11,600 bbl	One-time release	Over several hours or days	Most Probable	Tier 2
Large (50% of WCD)	58,000 bbl	One-time release	Over several hours or days	Less likely	Tier 2-3
Worst Case	116,000 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.

As discussed in the NOAA 2013 Risk Assessment for Potentially Polluting Wrecks in U.S. Waters, NOAA identified 87 high and medium priority wrecks for screening-level risk assessment. Within the available funds, it was not feasible to conduct computer model simulations of all 87 high and medium priority wrecks. Therefore, efforts were made to create "clusters" of vessels in reasonable proximity and with similar oil types. In general, the wreck with the largest potential amount of oil onboard was selected for modeling of oil release volumes, and the results were used as surrogates for the other vessels in the cluster. In particular, the regression curves created for the modeled wreck were used to determine the impacts to water column, water surface, and shoreline resources. The *Pan-Massachusetts*, with up to 116,000 bbl of mostly light fuels onboard, was clustered with the *Lubrafol*, which was modeled at 80,000 bbl of light fuel oil. Figure 2-1 shows the location of both vessels.

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.

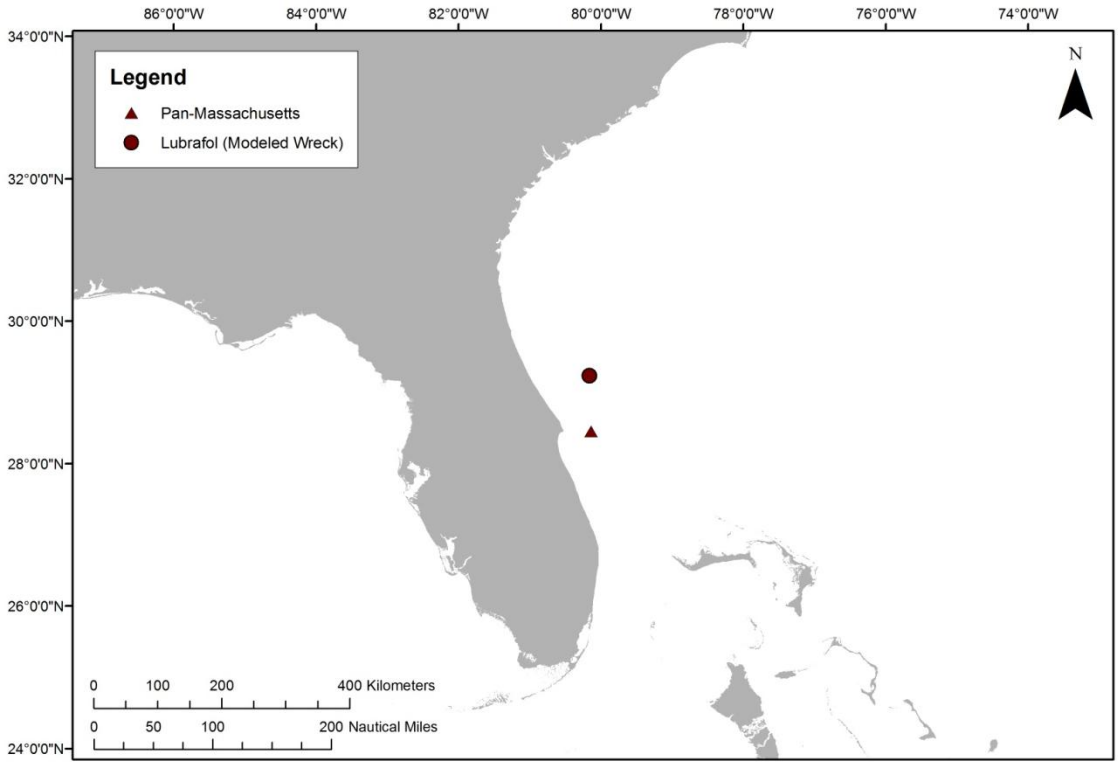


Figure 2-1: Location of the *Pan-Massachusetts* (red triangle), the wreck discussed in this package, and the *Lubrafol* (red circle) which was the wreck that was actually modeled in the computer modeling simulations. The results for the *Lubrafol* are used to estimate the impacts of releases from the *Pan-Massachusetts*, as discussed in the text.

Oil Type for Release

The *Pan-Massachusetts* contained a maximum of 104,000 bbl of refined petrol, gas, kerosene, and diesel as cargo and up to 12,000 bbl of Bunker C fuel oil. Because the cargo poses the greatest risks, the spill model for the *Lubrafol*, which was run using light fuel oil, was used for this assessment of the *Pan-Massachusetts*.

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 2-2a 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 *Pan-Massachusetts* 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 2-2, which is the regression curve for the *Lubrafol*. Using this figure, the water column impacts can be estimated for any spill volume. On Figure 2-2, arrows are used to

[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. Final Report, Office of Environmental Policy and Compliance, U.S. Dept. Interior, Washington, DC.

indicate the where the WCD for the *Pan-Massachusetts* plots on the curve and how the area of the water column impact is determined.

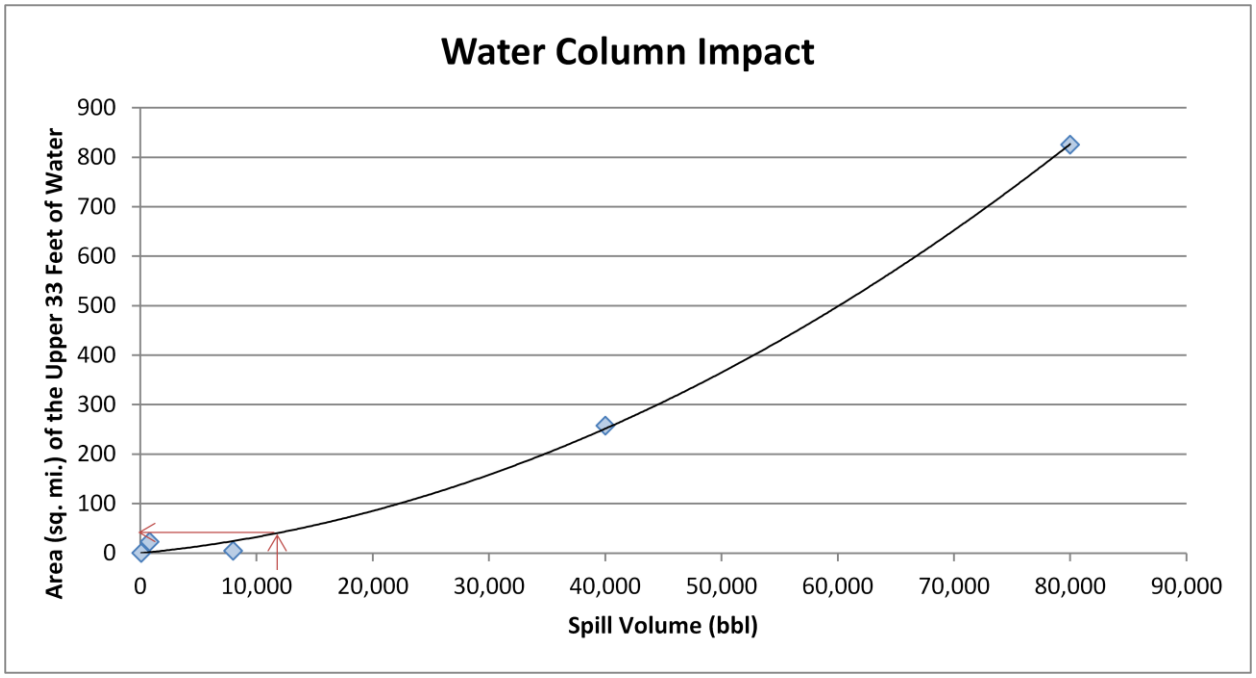


Figure 2-2: Regression curve for estimating the area of water column at or above 1 ppb aromatics impacted as a function of spill volume for the *Pan-Massachusetts*. This regression curve was generated for the *Lubrafol*, which has the same oil type and similar volume of potential releases as the *Pan-Massachusetts*. The arrows indicate where the Most Probable Discharge for the *Pan-Massachusetts* falls on the curve and how the area of water column impact can be determined for any spill volume.

Potential Water Surface Slick

The slick size from an oil release 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 for the *Lubrafol* then using the regression curve shown in Figure 2-3 to calculate the values for the different release scenarios for the *Pan-Massachusetts*. 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. Surface expression is likely to be in the form of sheens, tarballs, and streamers. The location, size, shape, and spread of the oil slick(s) from an oil release from the *Pan-Massachusetts* will depend on environmental conditions, including winds and currents, at the time of release and in its aftermath. Refer to the risk assessment package for the *Lubrafol* for maps (Figs. 2-2 and 2-3) showing the areas potentially affected by slicks using the Most Probable volume and the socio-economic and ecological thresholds.

Table 2-3: Estimated slick area swept on water for oil release scenarios from the *Pan-Massachusetts*, based on the model results for the *Lubrafol*.

Scenario Type	Oil Volume (bbl)	Estimated Slick Area Swept Mean of All Models	
		0.01 g/m²	10 g/m²
Chronic	116	2,400 mi²	490 mi²
Episodic	1,160	6,800 mi²	1,800 mi²
Most Probable	11,600	19,000 mi²	6,600 mi²
Large	58,000	40,000 mi²	16,000 mi²
Worst Case Discharge	116,000	55,000 mi²	24,000 mi²

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 for the *Lubrafol*, which is shown in Figure 2-3 and referenced in Table 2-3. Using this figure, the area of water surface with a barely visible sheen can be estimated for any spill volume from the *Pan-Massachusetts*.

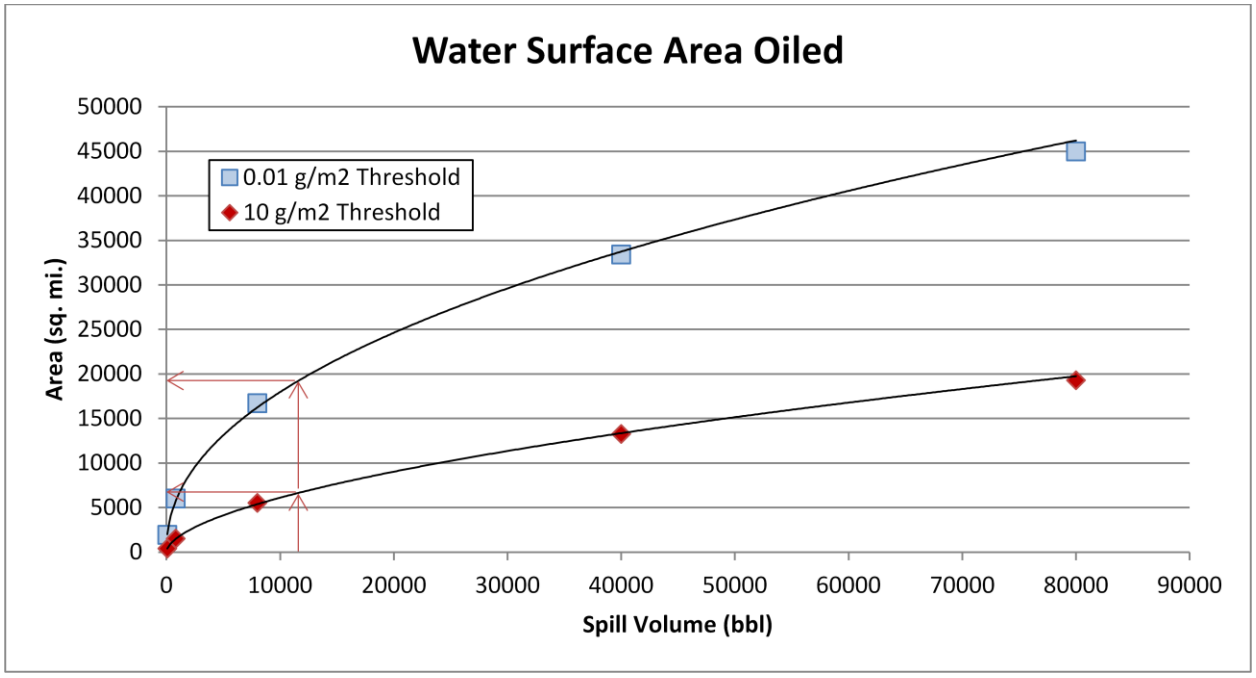


Figure 2-3: Regression curve for estimating the amount of water surface oiling as a function of spill volume for the *Pan-Massachusetts*, showing both the ecological threshold of 10 g/m² and socio-economic threshold of 0.01 g/m², based on the model results for the *Lubrafol*. The arrows indicate where the Most Probable Discharge for the *Pan-Massachusetts* falls on the curve and how the area of water surface impact can be determined for any spill volume.

Potential Shoreline Impacts

Based on these modeling results, shorelines from as far north as Maryland to as far south as Cape Canaveral, Florida are at risk. (Refer to Figure 2-6 in the *Lubrafol* package to see the probability of oil stranding on the shoreline at concentrations that exceed the threshold of 1 g/m^2, for the Most Probable release). 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. Estimated miles of shoreline oiling above the socio-economic threshold of 1 g/m^2 and the ecological threshold of 100 g/m^2 by scenario type are shown in Table 2-4.

Table 2-4: Estimated shoreline oiling from leakage from the *Pan-Massachusetts*, based on the modeling results for the *Lubrafol*.

Scenario Type	Volume (bbl)	Estimated Miles of Shoreline Oiling Above 1 g/m^2	Estimated Miles of Shoreline Oiling Above 100 g/m^2
Chronic	116	0	0
Episodic	1,160	1	0
Most Probable	11,600	6	5
Large	58,000	30	24
Worst Case Discharge	116,000	60	48

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 for the *Lubrafol*, as detailed in Table 2.4 and shown in Figure 2-4. Using this figure, the shore length oiled can be estimated for any spill volume from the *Pan-Massachusetts*.

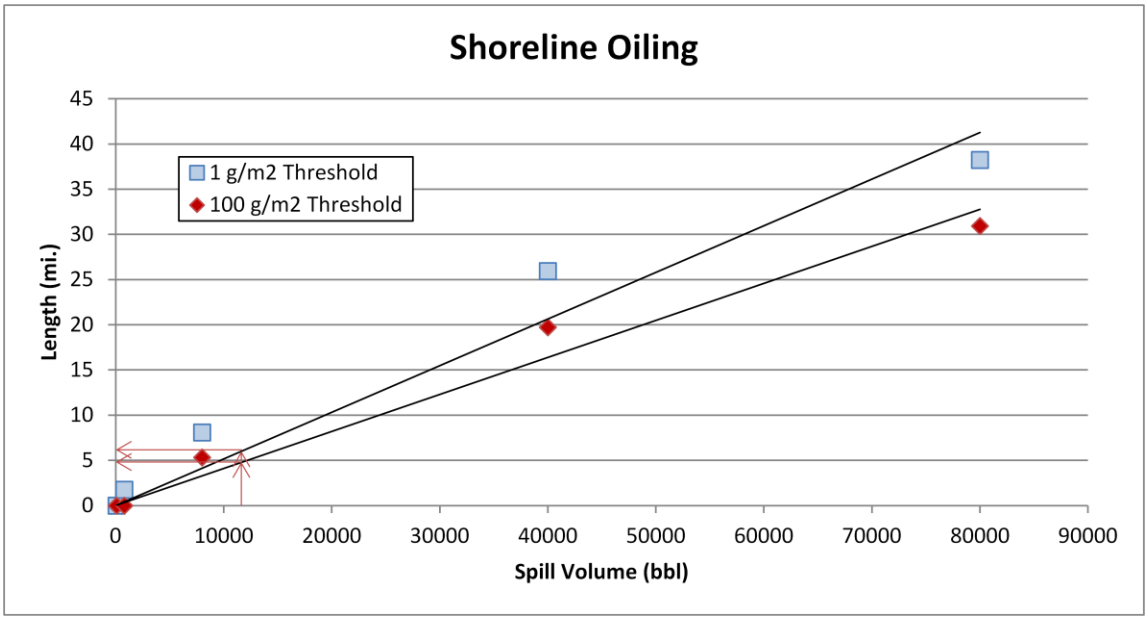


Figure 2-4: Regression curve for estimating the amount of shoreline oiling at different thresholds as a function of spill volume for the *Pan-Massachusetts*, based on the model results for the *Lubrafol*. The arrows indicate where the Most Probable Discharge for the *Pan-Massachusetts* falls on the curve and how the length of shoreline impact can be determined for any spill volume.

SECTION 3: ECOLOGICAL RESOURCES AT RISK

Ecological resources at risk from a catastrophic release of oil from the *Pan-Massachusetts* (Table 3-1) include numerous guilds of birds, particularly those sensitive to surface oiling while rafting or plunge diving to feed and are present in nearshore/offshore waters. As can be noted in the table, large numbers of birds winter in both coastal and offshore waters, and many of the beaches are very important shorebird habitat. In offshore habitats, birds are attracted to convergence zones, which is also where oil tends to be concentrated. The potentially affected region is important for commercially important fish and invertebrates.

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

Species Group	Species Subgroup and Geography	Seasonal Presence
Seabirds	• Outer Continental Shelf offshore Cape Hatteras, NC: greatest diversity of seabirds in SE U.S.; greatest density of tropical seabirds in SE U.S. Species include: shearwaters, storm petrels, Bermuda petrel • Significant percentage of the global population of black-capped petrel (FE) may be present in *Sargassum* mats off Cape Hatteras and Gulf Stream off SE U.S. coast • Audubon's shearwater (50-75% of population) concentrate along the Continental Shelf edge off NC, extending northward to the VA border (~3800 pairs)	OCS: Ranges by species but Mar-Nov peak Petrels off NC/VA coast during the summer through early fall and off SE U.S. coast in winter Shearwaters off of NC/VA: late summer
Pelagic Birds, Waterfowl, and Diving Birds	Coastal pelagic birds, waterfowl, diving birds • Mouth of Chesapeake Bay has high concentrations of species that are abundant over shoals (e.g., loons, pelicans, cormorants, sea ducks, gulls, terns, alcids); scoters are 10X more abundant than other species • Outer Banks, inshore waters NC to VA: Key foraging area for gulls and terns; key migration corridor for loons and sea ducks; NC's largest population of northern gannet and red-breasted merganser • Southeastern U.S. inshore/offshore waters: 150K loons, >15K pelicans, thousands of waterfowl, 100s of thousands of cormorants and terns, millions of gulls • Important Bird Areas (IBAs) for SC include Cape Romain National Wildlife Refuge (NWR), Deveaux Bank, and Beaufort barrier islands: Feeding, and over-wintering grounds for substantial numbers of waterfowl and sea birds as well as nesting for thousands of brown pelicans • Altamaha River Delta, GA: Nesting for >5K brown pelicans • Canaveral National Seashore: Two of the largest brown pelican rookeries on the east coast; 10's of thousands of overwintering waterfowl	Winter use of shoals (Dec-Mar); summer use of shoals likely farther north Terns, gulls present in spring/summer; Loons, sea ducks present in spring/fall; Waterfowl, gannets and red-breasted mergansers present in winter

Sea Ducks	Sea ducks (includes mean and max distance of flocks to shore, 2009-2010 data)
	• Surf scoter at 2 nm/8 nm: NC = 0-41,000; SC/GA = 0-100
	• Black scoter at 2 nm/13 nm: NC = 3,500-13,000; SC/GA = 0-15,000
	• Bufflehead, mergansers, goldeneyes (<1 nm/7-14 nm)
	  ○ NC = 12,000
	  ○ SC/GA = 5,000
		Sea ducks surveyed in winter (peak abundances); Migration from fall to spring (Oct-Apr)

Species Group	Species Subgroup and Geography	Seasonal Presence
Shorebirds and Colonial Nesting Birds	• Assateague Island, MD: globally important bird area due to 60+ pairs of nesting piping plovers • VA Barrier Island/Lagoon System: Most important bird area in VA and one of most along U.S. Atlantic coast: piping plover (FT), Wilson's plover, American oystercatcher, gull-billed tern, least tern, black skimmer; internationally significant stopover point for whimbrel, short-billed dowitcher, and red knot • Western Shore VA marshes: Extensive marshes support significant populations of many marsh nesting species • Outer Banks, Cape Hatteras NS, and Cape Lookout: Globally important for coastal birds with 365+ species • Battery and Bald Head Islands, NC: Largest colonies of wading birds in NC; globally significant site with >10K nesting pairs of white ibis • Cape Romain NWR, SC: Largest wintering concentration of American oystercatcher on east coast; supports 45%- 70% of SC nesting gull-billed tern and black skimmer respectively; Western Hemispheric Shorebird Reserve Network (WHSRN) of international importance with up to 7K shorebirds per day • Deveaux Bank and Edisto ACE Basin NWR: Globally recognized IBAs supporting 1,000s of nesting shorebirds including least tern (ST) and Wilson's plover (ST); >900 foraging wood stork (FE) • Bay Point Island IBA: Shorebirds and wading birds year round; wintering populations averaging >5K shorebirds per day of dunlin, dowitcher, western sandpiper, 500 red knot, sanderling, least tern (ST), Wilson's plover (ST), and piping plover (FT) • Pinckney Island NWR: Important rookery for white ibis, egrets, and herons • GA coast supports significant populations of resident and migratory wading and shorebirds with wading birds most abundant in summer; beach nesting least tern (ST), Wilson's plover (ST), piping plover (FT) and American oystercatcher • Wassaw NWR and Altamaha River Delta: Heron and egret rookery; migrating/wintering site for piping plover (FT) and American oystercatchers; nesting habitat for gull-billed, royal, and sandwich terns as well as black skimmer and wood stork (FE) • St. Catherines Island and Cumberland Island NS: Two of the most important feeding/wintering sites along the Atlantic coast with thousands of shorebirds and wading birds including least tern (ST), Wilson's plovers (ST), piping plover (FT), American oystercatcher, and wood stork (FE) • Northern FL: Globally recognized IBA (Nassau Sound) for breeding/roosting of threatened and endangered shorebirds; habitat supports numerous neotropical migrants in spring and fall • Cape Canaveral-Merritt Island: Globally recognized IBA supports around 8K wading birds (>150 pairs of wood stork) and 14K neotropical migrants • Pelican Island NWR: Large colonial waterbird rookery	Winter migration stop for plovers Colonial and beach nesters peak Apr-Aug Wading and shorebirds typically present year round
Sea Turtles	Nesting (annual counts, by state, along shorelines with most probable impacts): NC nesting • 650+ Loggerhead (FT) • <20 Green (FT) • <10 Leatherback (FE) SC nesting • 4,000+ Loggerhead (FT) • <5 Green (FT)	Nesting season: Loggerhead/Green (NC-GA) Adults: May-Aug Hatching: Jul-Oct Loggerhead/Green (FL) Adults: Apr-Oct Hatching: May-Nov

Species Group	Species Subgroup and Geography	Seasonal Presence
	• <5 Leatherback (FE) GA nesting • <2,000+ Loggerhead (FT) • <5 Green (FT) • <15 Leatherback (FE) FL nesting (Nassau – Brevard) • 26,000+ Loggerhead (87% in Brevard) • 7,950 Green (95% in Brevard) • 165 Leatherback (61% in St. Lucie) Distribution: • Offshore hot spots not well known • Young associate with *Sargassum* mats off Cape Hatteras • Bays and sounds are foraging grounds for juvenile green, loggerhead, and Kemp's ridley (FE)	Leatherbacks Adults: Mar-Jul (NC-GA) Feb-Aug (FL) Hatching: May-Oct (NC-GA) Mar-Sep (FL) In water: Year round with Apr-Dec peak
Marine Mammals	*Baleen whales*: Primarily North Atlantic right whale (FE) with occasional humpback whale (FE), and minke whale • Right whales are critically endangered (<400 individuals left) coastal waters in the potential spill area are used as calving grounds *Inshore cetaceans:* Bottlenose dolphin frequently use coastal waters including creeks, bays, and sounds throughout potential spill area *Offshore cetaceans*: Risso's dolphin, striped dolphin, clymene dolphin, Atlantic spotted dolphin, spinner dolphin, short-finned pilot whale, pantropical spotted dolphin • Often associated with shelf edge features, convergence zones (fronts), and *Sargassum* mats (summer) *Deep diving whales:* Sperm whale (FE), pygmy sperm whale, beaked whales (5 species present) forage in deep waters along the shelf *Pinnipeds and Sirenians*: • Juvenile harbor and hooded seals can sometimes occur as far south as N. FL during the winter • West Indian manatees are present year round in the potential spill area; concentrated along the FL coast with common summer sightings as far north as NC	Adults migrate from feeding grounds in North Atlantic to breeding grounds further south in the winter; Right whales with calf Nov-Mar Bottlenose dolphins present year round Harbor and hooded seals present during the winter; Manatees year round and coastal waters during summer
Fish and Inverts	Coastal ocean waters support many valuable fisheries and/or species of concern in the region: • *Benthic or bottom associated*: Snapper, grouper, black sea bass, butter fish, goose fish, shrimp (white, pink, brown, and rock), golden crab • *Midwater*: Atlantic mackerel, Spanish mackerel, shortfin squid, bluefish, menhaden, cero, cobia • *Pelagic*: Bluefin tuna, yellowfin tuna, wahoo, dolphinfish, bigeye tuna, swordfish, marlin, sailfish • *Diadromous*: Alewife, blueback herring, American shad, hickory shad, Atlantic tomcod, American eel, Atlantic sturgeon (Fed. species of concern), shortnose sturgeon (FE), and striped bass • *Estuarine dependent*: Southern flounder, redfish, spotted seatrout, blue crab, Atlantic croaker, spot, weakfish, shrimp • *Estuarine resident*: Eastern oyster Important concentration/conservation areas are:	Benthic and midwater species are present throughout the year Bluefin tunas present fall-spring with other pelagic fish present year round Anadromous fish migrate inshore to spawn in fresh water in the spring American eel migrates offshore to spawn in the winter

Species Group	Species Subgroup and Geography	Seasonal Presence
	• Pelagic species can be more concentrated around the shelf break and at oceanographic fronts in the region • The Point (offshore of Cape Hatteras) – Essential Fish Habitat/Habitats Areas of Particular concern (EFH/HAPC) for coastal migratory pelagics and dolphin/wahoo • Ten Fathom Ledge – South of Cape Lookout • Big Rock- SE of Cape Lookout • Primary nursery areas in NC bays – for estuarine dependent species • Charleston Bump Complex EFH • Grey's Reef National Marine Sanctuary, GA • Numerous artificial reefs off SC, GA, and FL • Large aggregations of sharks (i.e. lemon shark, bull shark) can be found by nearshore ledges in SE Florida during the winter. • *Sargassum* off Cape Hatteras, NC and Florida is important habitat for juvenile of some pelagic fish species (i.e. dolphinfish, jacks, triggerfish) • Striped croaker (NOAA species of concern) occupy nearshore hard-bottom habitats from Sebastian Inlet north	Estuarine dependent fish migrate offshore in the fall/winter to spawn; Juveniles and adults use estuaries during the spring/summer
Benthic Habitats	Submerged aquatic vegetation is critical to numerous species and occurs inside of bays and sounds throughout the region with the greatest concentrations in FL coastal waters Scattered hard-bottom sites are located off NC and are considered HAPC for reef-associated fishes (including the areas listed above)	Year round

The Environmental Sensitivity Index (ESI) atlases for the potentially impacted coastal areas from a leak from the *Pan-Massachusetts* 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 *Pan-Massachusetts* is provided, both as text and as shading of the applicable degree of risk bullet, for the WCD release of 116,000 bbl and a border around the Most Probable Discharge of 11,600 bbl. Please note: The probability of oiling cannot be determined using the regression curves; probability can only be determined from the 200 model runs. Thus, the modeling results and regression curves for the *Lubrafol* are used to estimate the values used in the risk scoring for the **degree of oiling only**.

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 (not scored)

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 *Pan-Massachusetts* is classified as High Risk for degree of oiling for water column ecological resources for the WCD of 116,000 bbl because the mean volume of water contaminated was 1,600 mi^2 of the upper 33 feet of the water column. For the Most Probable Discharge of 11,600 bbl, the *Pan-Massachusetts* is classified as Medium Risk for degree of oiling because the mean volume of water contaminated was 39 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 (not scored)

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 *Pan-Massachusetts* is classified as High Risk for degree of oiling for water surface ecological resources for the WCD because the mean area of water contaminated in the model runs was 24,000 mi^2. It is classified as Medium Risk for degree of oiling for the Most Probable Discharge because the mean area of water contaminated was 6,600 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. For the modeled wrecks, shorelines were 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. In this risk analysis for the *Pan-Massachusetts*, shorelines have NOT been weighted by their degree of sensitivity to oiling because these data are available only for modeled vessels. Therefore, the impacts are evaluated only on the total number of shoreline miles oiled as determined from the regression curve.

Risk Factor 3C-1: Shoreline Probability of Oiling of EcoRAR (not scored)

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 *Pan-Massachusetts* is classified as Medium Risk for degree of oiling for shoreline ecological resources for the WCD because the mean length of shoreline contaminated in the model runs was 48 miles. It is classified as Low Risk for degree of oiling for the Most Probable Discharge because the mean length of shoreline contaminated in the model runs was 5 miles.

Considering the modeled risk scores and the ecological resources at risk, the ecological risk from potential releases of the WCD of 116,000 bbl of light fuel oil from the *Pan-Massachusetts* is summarized as listed below and indicated in the far-right column in Table 3-2:

- Water column resources – High, because a large area of water column is potentially affected and would occur in areas of the seasonal use of shelf habitats for spawning by commercially important fish and shellfish
- Water surface resources – High, because of the large area sweep by floating oil and importance of this area for pelagic and coastal birds and sea turtles. 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 – Medium, because of the lower likelihood of significant amounts of light fuel oil to strand onshore and most of the potentially impacted shorelines are sand beaches where a light fuel oil would not be as persistent as heavier oils

Table 3-2: Ecological risk factor scores for the **Worst Case Discharge of 116,000 bbl** of light fuel oil from the *Pan-Massachusetts*.

Risk Factor	Risk Score			Explanation of Risk Score	Final Score
3A-1: Water Column Probability EcoRAR Oiling	Low	Medium	High	N/A: Only available for modeled vessels	High
3A-2: Water Column Degree EcoRAR Oiling	Low	Medium	High	The mean volume of water contaminated above 1 ppb was 1,600 mi^2 of the upper 33 feet of the water column	
3B-1: Water Surface Probability EcoRAR Oiling	Low	Medium	High	N/A: Only available for modeled vessels	High
3B-2: Water Surface Degree EcoRAR Oiling	Low	Medium	High	The mean area of water contaminated above 10 g/m^2 was 24,000 mi^2	
3C-1: Shoreline Probability EcoRAR Oiling	Low	Medium	High	N/A: Only available for modeled vessels	Med
3C-2: Shoreline Degree EcoRAR Oiling	Low	Medium	High	The length of shoreline contaminated by at least 100 g/m^2 was 48 mi	

For the Most Probable Discharge of 11,600 bbl of light fuel oil, the ecological risk from potential releases from the *Pan-Massachusetts* 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 – Medium, because the area affected is smaller, but there are still a large number of birds and sea turtles 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 fewer miles of shoreline are at risk

Table 3-3: Ecological risk factor scores for the **Most Probable Discharge of 11,600 bbl** of light fuel oil from the *Pan-Massachusetts*.

Risk Factor	Risk Score			Explanation of Risk Score	Final Score
3A-1: Water Column Probability EcoRAR Oiling	Low	Medium	High	N/A: Only available for modeled vessels	Med
3A-2: Water Column Degree EcoRAR Oiling	Low	Medium	High	The mean volume of water contaminated above 1 ppb was 39 mi^2 of the upper 33 feet of the water column	
3B-1: Water Surface Probability EcoRAR Oiling	Low	Medium	High	N/A: Only available for modeled vessels	Med
3B-2: Water Surface Degree EcoRAR Oiling	Low	Medium	High	The mean area of water contaminated above 10 g/m^2 was 6,600 mi^2	
3C-1: Shoreline Probability EcoRAR Oiling	Low	Medium	High	N/A: Only available for modeled vessels	Low
3C-2: Shoreline Degree EcoRAR Oiling	Low	Medium	High	The length of shoreline contaminated by at least 100 g/m^2 was 5 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 *Pan-Massachusetts* include recreational beaches from North Carolina to northeastern Florida that are very highly utilized during summer, and are still in use during spring and fall for shore fishing. Three national seashores and two coastal national monuments would potentially be affected. 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. The Gray's Reef National Marine Sanctuary off Georgia would also potentially be affected, along with a large number of coastal state parks.

A release could impact shipping lanes, which accommodate nearly 9,000 annual port calls annually with a total of over 382 million tonnage. Commercial fishing is economically important to the region. A release could impact fishing fleets from southern Virginia to Florida where regional commercial landings for 2010 exceeded $212 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.

Spill response costs for a release of oil from the *Pan-Massachusetts* 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 *Pan-Massachusetts*.

Resource Type	Resource Name	Economic Activities
Tourist Beaches	Myrtle Beach, SC Hilton Head Island, SC Tybee Island, GA Fernandina Beach, FL Atlantic Beach, FL St. Augustine Beach, FL Daytona Beach, FL Palm Coast, FL	Potentially affected beach resorts and beach-front communities in Virginia, Maryland, North Carolina, South Carolina, Georgia, and northeastern Florida 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 through the early fall months.
National Marine Sanctuary	Gray's Reef National Marine Sanctuary (GA)	Gray's Reef National Marine Sanctuary is one of the largest near shore live-bottom reefs in the southeastern U.S. The Sanctuary is popular with recreational anglers, boaters, and more experienced divers.

Resource Type	Resource Name	Economic Activities
National Seashores	Cape Hatteras National Seashore, NC Cumberland Isl. National Seashore, GA Canaveral National Seashore, FL	National seashores provide recreation for local and tourist populations while preserving and protecting the nation's natural shoreline treasures. National seashores are coastal areas federally designated as being of natural and recreational significance as a preserved area. As a barrier island, Assateague Island is is known for its feral horses. Cape Hatteras is known for its Bodie Island and Cape Hatteras Lighthouses. Popular recreation activities include windsurfing, birdwatching, fishing, shell collecting, and kayaking. Constantly changing from ocean activity, this barrier island provides refuge for the endangered piping plover, seabeach amaranth, and sea turtles.
National Parks	Fort Pulaski National Monument, GA Fort Sumter, National Monument, SC	Two coastal national historic monuments provide education in Civil War history.
National Wildlife Refuges	Mackay Island NWR (NC) Currituck NWR (NC) Pea Island NWR (NC) Cedar Island NWR (NC) Waccamaw NWR (SC) Cape Romain NWR (SC) Ernest F. Hollings ACE Basin NWR (SC) Pickney Island NWR (SC) Savannah NWR (SC) Tybee NWR (SC) Wassaw NWR (GA) Harris Neck NWR (GA) Blackbeard Island NWR (GA) Wolf Island NWR (GA) Merritt Island NWR (FL)	National wildlife refuges in four states may be impacted. These federally managed and protected lands provide refuges and conservation areas for sensitive species and habitats.
State Parks	Myrtle Beach SP, SC Huntington Beach SP, SC Edisto Beach SP, SC Hunting Island SP, SC Skidaway Island SP, GA Fort McAllister SP, GA Bulow Plantation Ruins SP, FL Washington Oaks Gardens SP, FL Amelia Island SP, FL Fort Clinch SP, FL Guana River SP, FL Anastastia SP, FL Faver-Dykes SP, FL Green Mound Archaeological SP, FL Bulow Creek SP, FL Tomoka SP, FL	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 several states 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 potentially affected waters for commercial fishing.	
	Hampton Roads Area, VA	Total Landings (2010): $75.4M
	Chincoteague, VA	Total Landings (2010): $3.5M
	Ocean City, MD	Total Landings (2010): $8.8M
	Chincoteague, VA	Total Landings (2010): $3.5M

Resource Type	Resource Name	Economic Activities
	Beaufort-Morehead City, NC	Total Landings (2010): $9.2M
	Belhaven-Washington, NC	Total Landings (2010): $3.7M
	Elizabeth City, NC	Total Landings (2010): $5.4M
	Engelhard-Swanquarter, NC	Total Landings (2010): $10.6M
	Oriental-Vandemere, NC	Total Landings (2010): $8.4M
	Sneads Ferry-Swansboro, NC	Total Landings (2010): $5.4M
	Wanchese-Stumpy Point, NC	Total Landings (2010): $22.0M
	Brunswick, GA	Total Landings (2010): $5.1M
	Cape Canaveral, FL	Total Landings (2010): $6.5M
	Charleston-Mt. Pleasant, SC	Total Landings (2010): $9.9M
	Darien-Bellville, GA	Total Landings (2010): $5.2M
	Fernandina Beach, FL	Total Landings (2010): $4.7M
	Georgetown, SC	Total Landings (2010): $6.0M
	Mayport, FL	Total Landings (2010): $11.0M
	Savannah, GA	Total Landings (2010): $5.0M
	Thunderbolt, GA	Total Landings (2010): $3.4M
Ports	There are a number of significant commercial ports along the Atlantic coast 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.	
	Baltimore, MD	2,100 port calls annually
	Morehead City, NC	85 port calls annually
	Wilmington, NC	550 port calls annually
	Brunswick, GA	304 port calls annually
	Charleston, SC	1,818 port calls annually
	Elba Is., GA	37 port calls annually
	Fernandina, FL	3 port calls annually
	Jacksonville, FL	1,641 port calls annually
	Port Canaveral, FL	38 port calls annually
	Savannah, GA	2,406 port calls annually

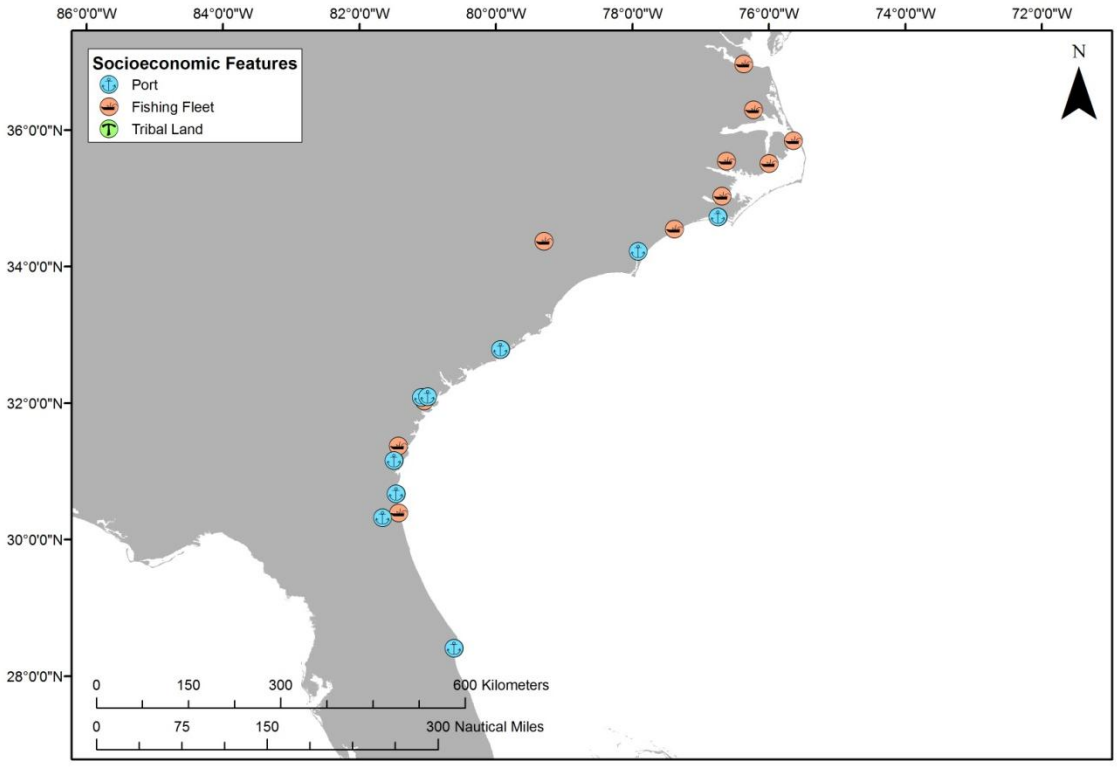


Figure 4-1: Tribal lands, ports, and commercial fishing fleets at risk from a release from the *Pan-Massachusetts*. (Note that there are no tribal lands at risk.)

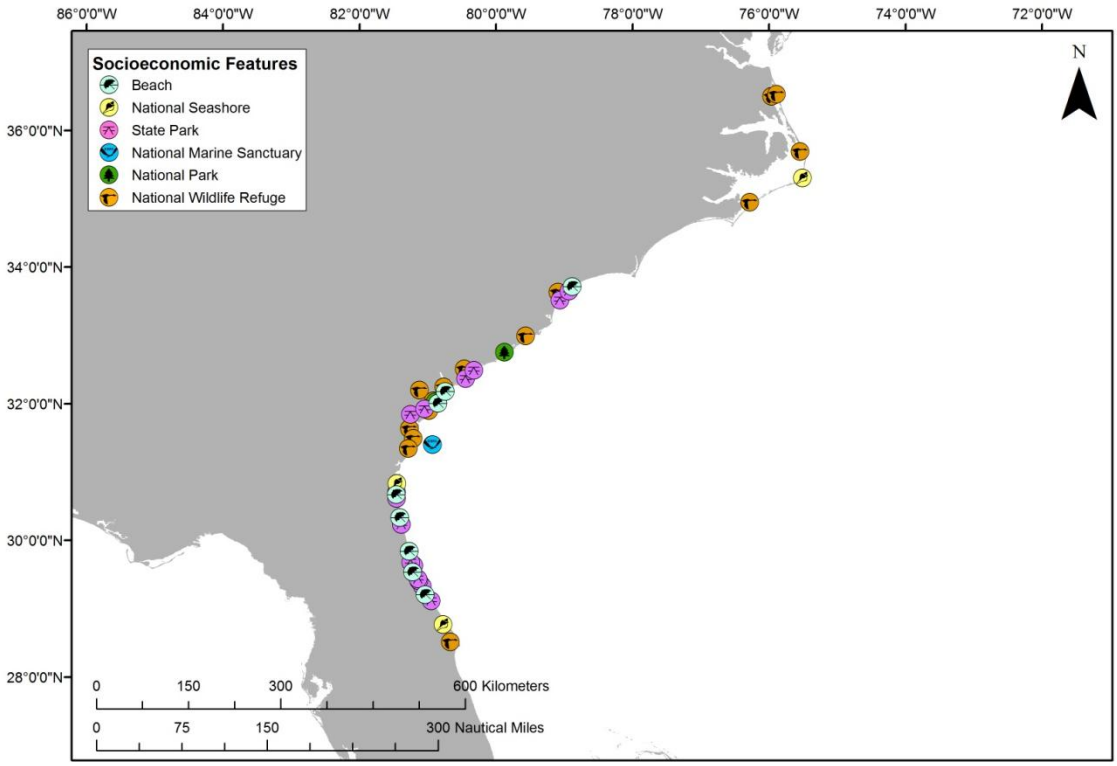


Figure 4-2: Beaches, coastal state parks, and Federal protected areas at risk from a release from the *Pan-Massachusetts*.

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 socio-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 *Pan-Massachusetts*, shading indicates the degree of risk for a WCD release of 116,000 bbl and a border indicates degree of risk for the Most Probable Discharge of 11,600 bbl. Please note: The probability of oiling cannot be determined using the regression curves; probability can only be determined from the 200 model runs. Thus, the modeling results and regression curves for the *Lubrafol* are used to estimate the values used in the risk scoring for the **degree of oiling only**.

Risk Factor 4A-1: Water Column: Probability of Oiling of SRAR (not scored)

This risk factor reflects the probability that at least 0.2 mi2 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 *Pan Massachusetts* is classified as High Risk for degree of oiling for water column socio-economic resources for the WCD of 116,000 bbl because the mean volume of water contaminated in the model runs was 1,600 mi^2 of the upper 33 feet of the water column. For the Most Probable Discharge of 11,600 bbl, the *Pan Massachusetts* is classified as Medium Risk for degree of oiling because the mean volume of water contaminated was 39 mi^2 of the upper 33 feet of the water column.

Risk Factor 4B-1: Water Surface Probability of Oiling of SRAR (not scored)

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 *Pan Massachusetts* is classified as High Risk for degree of oiling for water surface socio-economic resources for the WCD of 116,000 bbl because the mean area of water contaminated in the model runs was 55,000 mi^2. The *Pan Massachusetts* is classified as High Risk for degree of oiling for water surface socio-economic resources for the Most Probable Discharge because the mean area of water contaminated was 19,000 mi^2.

Risk Factor 4C: Shoreline Impacts to SRAR

The impacts to different types of shorelines vary based on economic value. For the modeled wrecks, 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"). In this risk analysis for the *Pan Massachusetts*, shorelines have NOT been weighted by their degree of sensitivity to oiling because these data are available only for modeled vessels. Therefore, the impacts are evaluated only on the total number of shoreline miles oiled as determined from the regression curve.

Risk Factor 4C-1: Shoreline Probability of Oiling of SRAR (not scored)

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 *Pan Massachusetts* is classified as Medium Risk for degree of oiling because the mean length of shoreline contaminated in the model runs was 60 miles. The *Pan Massachusetts* is classified as Low Risk for degree of oiling for shoreline socio-economic resources for the Most Probable Discharge because the mean length of shoreline contaminated was 6 miles.

Considering the modeled risk scores and the socio-economic resources at risk, the socio-economic risk from potential releases of the WCD of 116,000 bbl of light fuel oil from the *Pan-Massachusetts* is summarized as listed below and indicated in the far-right column in Table 4-2:

- Water column resources – Medium, because a moderate area of water column would be impacted in fishing grounds
- Water surface resources – High, because a relatively large area of offshore surface water would be impacted including important shipping lanes and a national marine sanctuary. 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 – Medium, because a moderate to small length of shoreline would be impacted in areas with high-value and sensitive resources

Table 4-2: Socio-economic risk factor ranks for the **Worst Case Discharge of 116,000 bbl** of light fuel oil from the *Pan-Massachusetts*.

Risk Factor	Risk Score			Explanation of Risk Score	Final Score
4A-1: Water Column Probability SRAR Oiling	Low	Medium	High	N/A: Only available for modeled vessels	Med
4A-2: Water Column Degree SRAR Oiling	Low	Medium	**High**	The mean volume of water contaminated above 1 ppb was 1,600 mi^2 of the upper 33 feet of the water column	
4B-1: Water Surface Probability SRAR Oiling	Low	Medium	High	N/A: Only available for modeled vessels	High
4B-2: Water Surface Degree SRAR Oiling	Low	Medium	**High**	The mean area of water contaminated above 0.01 g/m^2 was 55,000 mi^2	
4C-1: Shoreline Probability SRAR Oiling	Low	Medium	High	N/A: Only available for modeled vessels	Med
4C-2: Shoreline Degree SRAR Oiling	Low	**Medium**	High	The length of shoreline contaminated by at least 1 g/m^2 was 60 mi	

For the Most Probable Discharge of 11,600 bbl, the socio-economic risk from potential releases of light fuel oil from the *Pan-Massachusetts* 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 – High, because a relatively large area of offshore surface water would be impacted including important shipping lanes and a national marine sanctuary. 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 a small length of shoreline would be impacted in areas with high-value and sensitive resources

Table 4-3: Socio-economic risk factor ranks for the **Most Probable Discharge of 11,600 bbl** of light fuel oil from the *Pan-Massachusetts*.

Risk Factor	Risk Score			Explanation of Risk Score	Final Score
4A-1: Water Column Probability SRAR Oiling	**Low**	**Medium**	**High**	N/A: Only available for modeled vessels	**Low**
4A-2: Water Column Degree SRAR Oiling	**Low**	**Medium**	**High**	The mean volume of water contaminated above 1 ppb was 39 mi^2 of the upper 33 feet of the water column	
4B-1: Water Surface Probability SRAR Oiling	**Low**	**Medium**	**High**	N/A: Only available for modeled vessels	**High**
4B-2: Water Surface Degree SRAR Oiling	**Low**	**Medium**	**High**	The mean area of water contaminated above 0.01 g/m^2 was 19,000 mi^2	
4C-1: Shoreline Probability SRAR Oiling	**Low**	**Medium**	**High**	N/A: Only available for modeled vessels	**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	

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

The overall risk assessment for the *Pan-Massachusetts* 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 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. As noted in Sections 3 and 4, each of 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. Please note: The probability of oiling cannot be determined using the regression curves; probability can only be determined from the 200 model runs. Thus, the modeling results and regression curves for the *Lubrafol* were used to estimate the values used in the risk scoring for the **degree of oiling only**.

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, the *Pan-Massachusetts* scores Medium with 14 points; for the Most Probable Discharge, the *Pan-Massachusetts* scores Low with 11 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 *Pan-Massachusetts*. The final determination rests with the U.S. Coast Guard.

Pan Massachusetts	**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
✓	Location of stern is unknown; Use surveys of opportunity to attempt to locate the stern 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 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 *Pan-Massachusetts*.

Vessel Risk Factors		Data Quality Score	Comments		Risk Score
Pollution Potential Factors	A1: Oil Volume (total bbl)	Medium	Maximum of 116,000 bbl, not reported to be leaking		**Med**
	A2: Oil Type	High	Cargo oils are light refined oils, Group II oil types		
	B: Wreck Clearance	High	Vessel not reported as cleared		
	C1: Burning of the Ship	High	A significant fire was reported		
	C2: Oil on Water	High	Oil was reported on the water; amount is not known		
	D1: Nature of Casualty	High	Two torpedo detonations		
	D2: Structural Breakup	High	The vessel is broken into at least two sections		
Archaeological Assessment	Archaeological Assessment	High	Detailed sinking records and site reports of this ship exist, assessment is believed to be very accurate		**Not Scored**
Operational Factors	Wreck Orientation	High	Bow is inverted, stern is unknown		**Not Scored**
	Depth	High	Bow is 300 ft, stern is unknown		
	Visual or Remote Sensing Confirmation of Site Condition	High	Bow has been visited by technical divers		
	Other Hazardous Materials Onboard	High	No		
	Munitions Onboard	High	No		
	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	Large spills of a light fuel oil can have significant impacts to water column resources; smaller spills are less persistent in open water	**High**	**Med**
	3B: Water Surface Resources	High	Under the WCD, slicks spread over large surface areas; smaller spills are less persistent; even light sheens can become concentrated in convergences with *Sargassum* mats which host many species	**High**	**Med**
	3C: Shore Resources	High	Mostly expect to have light oiling by a light fuel oil on outer sand beaches	**Med**	**Low**
Socio-Economic Resources	4A: Water Column Resources	High	Moderate area of water column could be impacted in fishing grounds	**Med**	**Low**
	4B: Water Surface Resources	High	Relatively large area of offshore surface water could be impacted including important shipping lanes and a national marine sanctuary	**High**	**High**
	4C: Shore Resources	High	Moderate to small length of shoreline could be impacted in areas with high-value and sensitive resources	**Med**	**Low**
Summary Risk Scores				**14**	**11**