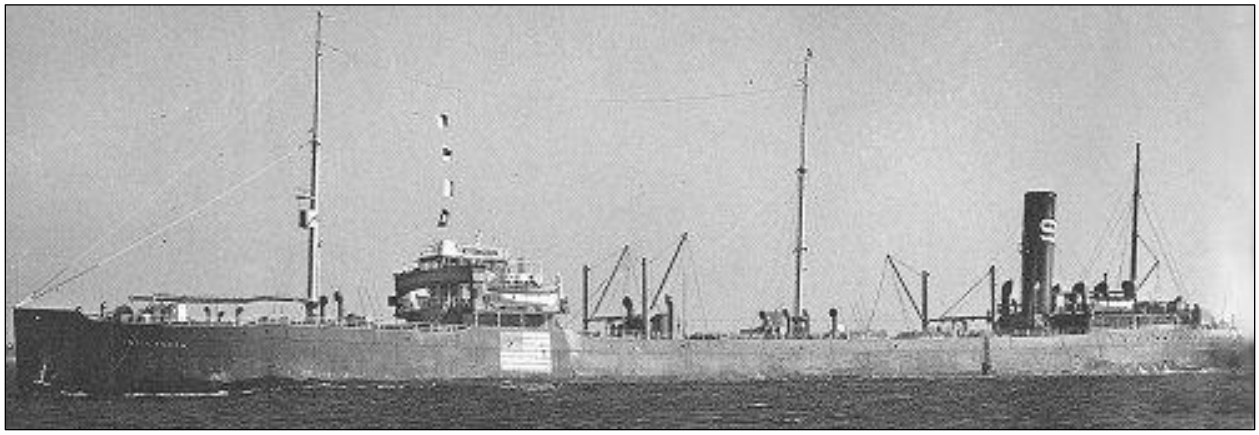
Office of National Marine Sanctuaries
Office of Response and Restoration

Screening Level Risk Assessment Package

India Arrow



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National Oceanic and
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Photo: Photograph of *India Arrow*
Source: http://www.uboat.net/allies/merchants/1314.html

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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.

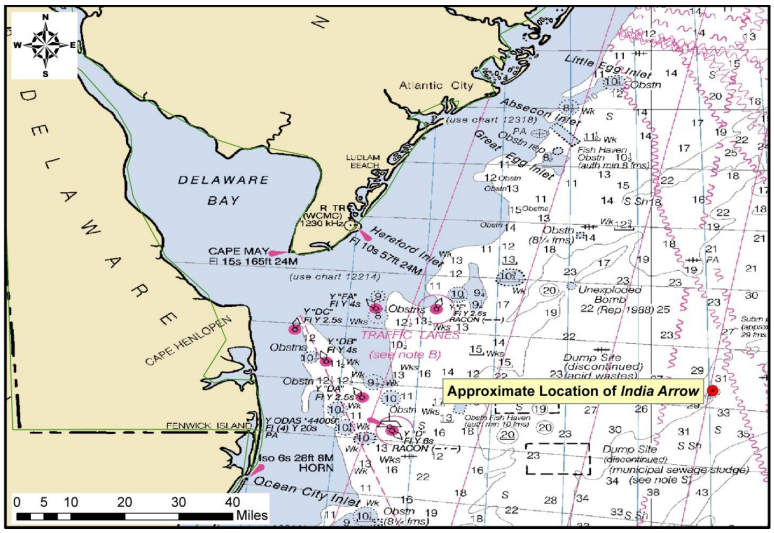
The potential polluting shipwrecks were identified through searching a broad variety of historical sources. NOAA then worked with Research Planning, Inc., RPS ASA, and Environmental Research Consulting to conduct the modeling forecasts, and the ecological and environmental resources at risk assessments.

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: *India Arrow*

The tanker *India Arrow*, torpedoed and sunk during World War II off the coast of New Jersey 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 *India Arrow*, 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.



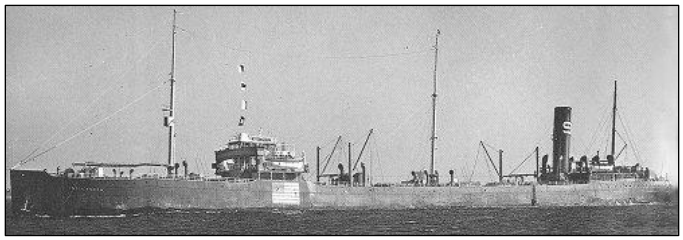
Based on this screening-level assessment, each vessel was assigned a summary score calculated using the seven risk criteria described in this report. For the Worst Case Discharge, *India Arrow* scores High with 15 points; for the Most Probable Discharge (10% of the Worse Case volume), *India Arrow* scores Low with 10 points. Given these scores for the *India Arrow*, and the higher level of data certainty, NOAA recommends that this site be considered for an assessment to better determine structural integrity and how much fuel still remains aboard this vessel. The first step in this process would be to interview the two local divers who have reported that the cargo tanks are empty and could provide photographs of the vessel condition. Also, general notations should be made 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. 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 changes 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	Med	Low
	3B: Water Surface Resources	Med	Low
	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		15	10

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

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

Vessel Particulars



Official Name: *India Arrow*

Official Number: 221086

Vessel Type: Tanker

Vessel Class: 8,327 gross ton class tanker

Former Names: N/A

Year Built: 1921

Builder: Bethlehem Steel Company, Quincy, MA

Builder's Hull Number: 1387

Flag: American

Owner at Loss: Socony-Vacuum Oil Co. Inc.

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

Operated by: Socony-Vacuum Oil Co. Inc.

Homeport: New York, NY

Length: 468 feet **Beam:** 62 feet **Depth:** 32 feet

Gross Tonnage: 8,327 **Net Tonnage:** 5,176

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

Bunker Type: Heavy fuel oil (Bunker C) **Bunker Capacity (bbl):** 5,328

Average Bunker Consumption (bbl) per 24 hours: 229

Liquid Cargo Capacity (bbl): 97,750 **Dry Cargo Capacity:** Unknown

Tank or Hold Description: Vessel had 10 cargo tanks divided port and starboard by an oil-tight longitudinal bulkhead

Casualty Information

Port Departed: Corpus Christi TX

Destination Port: New York

Date Departed: Unknown

Date Lost: February 4, 1942

Number of Days Sailing: Unknown

Cause of Sinking: Act of War (Torpedo and Shellfire)

Latitude (DD): 38.55846

Longitude (DD): -73.83457

Nautical Miles to Shore: 60

Nautical Miles to NMS: 233

Nautical Miles to MPA: 0

Nautical Miles to Fisheries: Unknown

Approximate Water Depth (Ft): 190

Bottom Type: Sand

Is There a Wreck at This Location? Unknown, the listed coordinates are based on coordinates for the wreck from various fishing websites and are believed to be relatively accurate.

Wreck Orientation: Inverted (turtled)

Vessel Armament: None

Cargo Carried when Lost: 88,369 bbl of diesel fuel

Cargo Oil Carried (bbl): 88,369

Cargo Oil Type: Medium fuel oil

Probable Fuel Oil Remaining (bbl): ≤ 5,328

Fuel Type: Heavy fuel oil (Bunker C)

Total Oil Carried (bbl): 93,697

Dangerous Cargo or Munitions: No

Munitions Carried: No

Demolished after Sinking: No

Salvaged: No

Cargo Lost: Yes

Reportedly Leaking: No

Historically Significant: Yes

Gravesite: Yes

Salvage Owner: Not known if any

Wreck Location

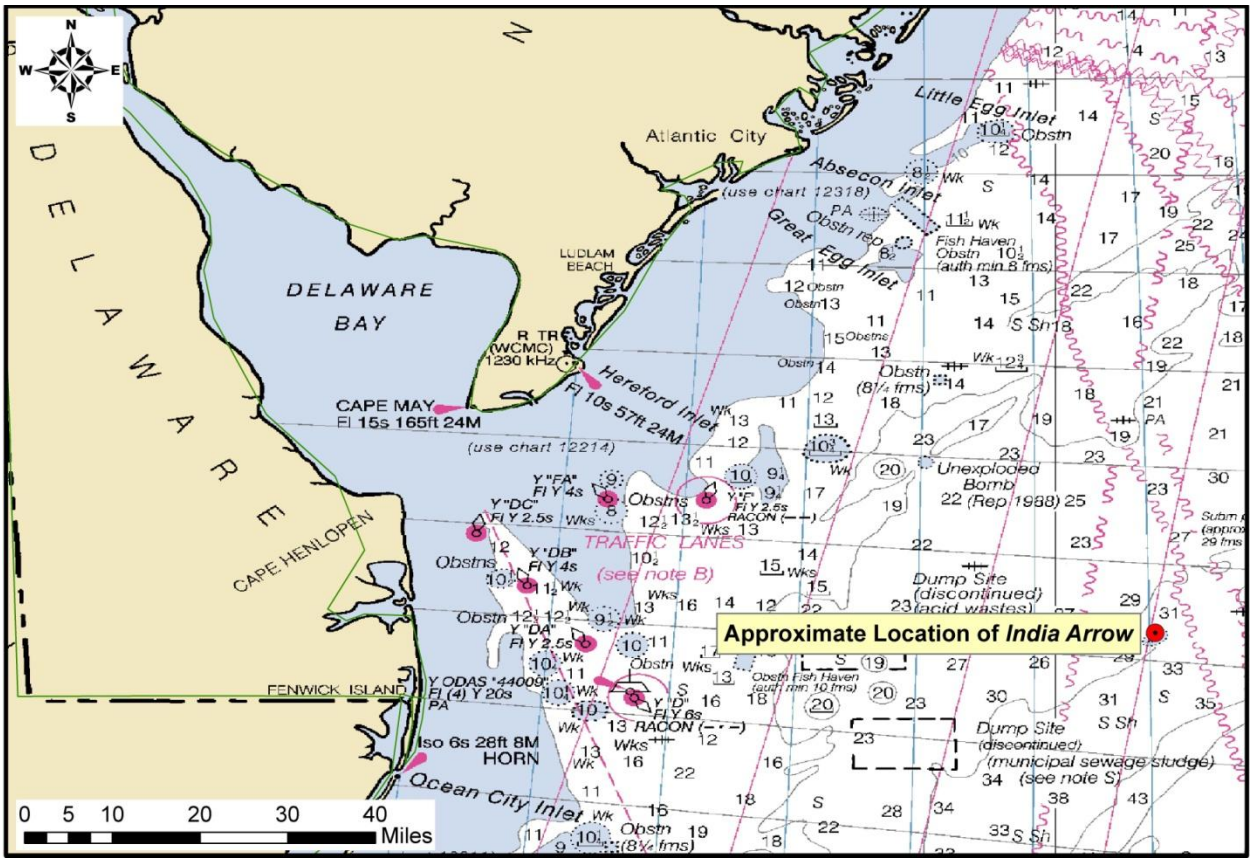


Chart Number: 13003

Casualty Narrative

"At 01.53 hours on 5 Feb, 1942, the unescorted and unarmed *India Arrow* (Master Carl Samuel Johnson) was torpedoed by *U-103* about 20 miles southeast of Cape May, New Jersey, while steaming a nonevasive course at 10.5 knots. The torpedo struck the starboard quarter at about the #10 bunker. The ship caught fire and began to sink rapidly by the stern. Only a distress signal without position could be sent before the dynamo failed. The nine officers and 29 crewmen immediately began to abandon ship, but were only able to launch one lifeboat. Two boats were destroyed by the explosion and a third was pulled beneath the water by the sinking tanker, drowning 18 of the 20 occupants in it.

The U-boat then surfaced and fired seven shells from her deck gun at two minutes intervals from a distance of 250 yards into the bow section which remained above water as the stern was sinking. Two men died as a result of the shelling. Only one officer and eleven crewmen survived in the lifeboat, set sail and headed for shore. They were picked up on 6 February by the American 24 foot fishing skiff *Gitana* (Frank Marshall and John Shaw) 20 miles southeast off Atlantic City and taken to the U.S. Coast Guard station there."
-http://www.uboat.net:8080/allies/merchants/ships/1314.html

General Notes

AWOIS Data:

DESCRIPTION
NO.416; TANKER, 8327 GT; SUNK 2/4/42 BY SUBMARINE; POSITION ACCURACY WITHIN 1 MILE; POSITION ESTABLISHED BY ESF 12/6/43. NO.519; TK, 5176 NT SUNK 2/4/42.

SURVEY REQUIREMENTS NOT DETERMINED.
TKR; TORPEDOED 2/4/42 IN 180 FT WITH 88,369 BARRELS OF DIESEL FUEL; 8827.

Wreck Condition/Salvage History

The wreck is lying upside down in 190 feet of water. Diver interviews have informed NOAA that nothing remains in the tank structures of the vessel, if there is any oil still onboard the vessel it would be trapped in the bunker fuel tanks.

"The *India Arrow* was a tanker (sister ship of *Dixie Arrow* sunk off Hatteras) sunk in WWII and today rests nearly turtled in 190 fsw about 60 miles off Cape May. My buddy Bill Bedford and I were looking forward to diving this wreck, which has been described as “have to see” by Gary Gentile, for a long time. We finally got the chance to dive her on Saturday off Harold Moyer’s boat the *Big Mac*. Tom Packer and Steve Gatto tied us in pretty quickly and let us know via a com’s unit “holy shit that’s a huge propeller” that we were tied in near the stern. Coming down the line the visibility was crystal clear on the surface. The wreck came into view at about 130’ and we hit the top of the wreck (the keel) at about 165’. The visibility was great on the bottom and probably 40-50’. We did a quick orientation and systems check before heading over to check out the massive single propeller. This prop cannot be described as anything but huge. It rises 20-30 feet off the bottom and the equally huge rudder has broken off and lies just aft resting on the fantail...We got back near the tie in and it was easy enough to swim right inside the wreck past a huge set of bollards that loomed on the deck overhead...Back inside and forward and I came to the engine and boilers which were truly impressive. Being inside this wreck was just incredible. It was so wide open and the ceiling (keel) so high that it was like being in a huge dark cathedral. Here and there rust holes allowed emerald green light to filter through and at points along the center line you could look port and starboard and see out both sides of the wreck. After passing the boilers the wreck is broken and I came out here and reluctantly headed back to the anchor line on the outside of the wreck.”
-http://downtoolong.com/2007/06/25/india-arrow/

Archaeological Assessment

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

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

shipwrecks. It also addresses questions of historical significance and the relevant historic preservation laws and regulations that will govern on-site assessments.

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

Assessment

The tanker *India Arrow* was initially included as source of potential oil pollution based on the cargo it was carrying at the time of its loss. When the vessel sank, it was carrying a cargo of 88,369 bbl of diesel oil and had a bunker capacity of 5,328 bbl of Bunker C fuel oil. Based on these numbers alone, the shipwreck would still appear to be a high priority shipwreck. Additional information collected by NOAA during the course of this study, however, suggests that there is a low likelihood of a significant amount of oil remaining onboard.

From archival research, we have learned that the ship was torpedoed once between the number 10 tank and the bunker tanks (Fig. 1-1). This torpedo pushed in the transverse bulkhead that separated the number 10 tank from the bunker tanks and set the aft end of the ship on fire. The German submarine then proceeded to shell the vessel, causing extensive damage. The Eastern Sea Frontier War Diary account of the sinking stated, "six well-aimed shells plunged into the bow of the India Arrow setting off a fire that spread over the whole ship." Soon after, the vessel sank by the stern and came to rest in an inverted orientation on the seafloor.

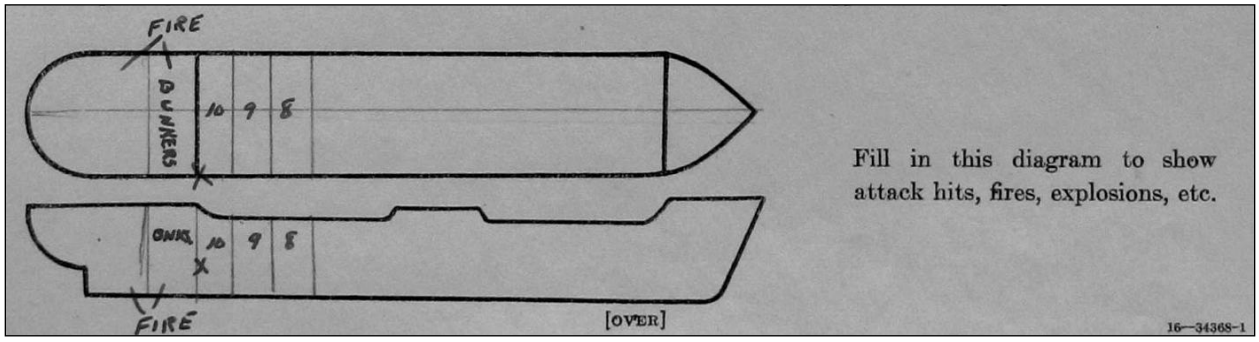


Figure 1-1: U.S. Coast Guard diagram of the location of torpedo impact on *India Arrow* (Image courtesy of National Archives, Washington, DC).

Although the inverted orientation of the shipwreck could have trapped oil in the more structurally robust underside of the hull, a local diver interviewed during this study stated that he had been inside all of the cargo holds and that they were empty. Another diver was interviewed about the wreck in an article in the July 20, 2011 issue of The Daily Times of Salisbury, MD. This article stated that, "The *India Arrow* would have posed a greater ecological threat due to the nature of its cargo, but Green's travels through the inside of the boat have indicated to him that the holds that used to contain oil have all emptied out, meaning any damage done from its fuel cargo has long since transpired."

Even though the divers did not address whether there could be any oil left in the ship's bunker tanks, the location of the torpedo impact and the fire on the stern of the vessel make it seem unlikely that significant amounts of fuel oil could remain, but this cannot be guaranteed since NOAA archaeologists have never directly surveyed the site.

Should the vessel be assessed, it should be noted that this vessel is of historic significance and will require appropriate actions be taken under the National Historic Preservation Act (NHPA) and possibly the Sunken Military Craft Act (SMCA) prior to any actions that could impact the integrity of the vessel. This vessel may be eligible for listing on the National Register of Historic places. 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: http://www.uboat.net/allies/merchants/1314.html

Construction Diagrams or Plans in RULET Database? No

Text References:

-http://www.uboat.net/allies/merchants/1314.html

-AWOIS database

-http://downtoolong.com/2007/06/25/india-arrow/

Vessel Risk Factors

In this section, the risk factors that are associated with the vessel are defined and then applied to the *India Arrow* 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.

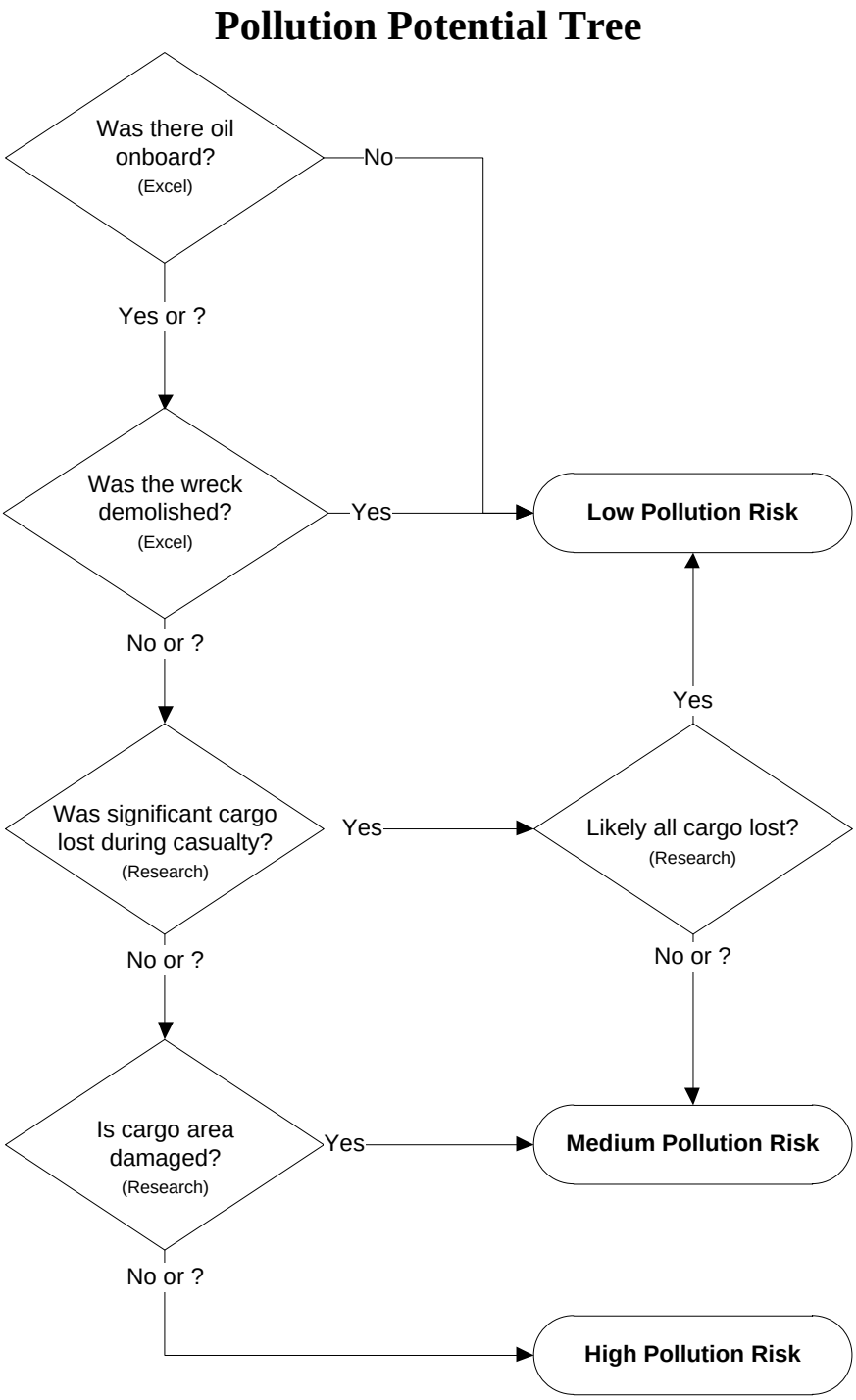


Figure 1-2: U.S. Coast Guard Salvage Engineering Response Team (SERT) developed the above Pollution Potential Decision Tree.

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 *India Arrow* 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 *India Arrow i*s ranked as High Volume because it is thought to have a potential for up to 93,697 bbl, although some of that was lost at the time of the casualty due to the explosions. 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 *India Arrow*.

Risk Factor A2: Oil Type

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

- **Low Risk: Group I Oils** – non-persistent oil (e.g., gasoline)

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

- **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 *India Arrow* is classified as Medium Risk because the cargo is diesel oil, a Group II oil type. Data quality is high.

Was the wreck demolished?

Risk Factor B: Wreck Clearance

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

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

The *India Arrow* 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 *India Arrow* is classified as Medium Risk because there was a significant fire reported at the time of casualty. Data quality is high.

Risk Factor C2: Reported Oil on the Water

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

- **Low Risk:** Large amounts of oil reported on the water by multiple sources
- **Medium Risk:** Moderate to little oil reported on the water during or after the sinking event

- **High Risk:** No oil reported on the water
- **Unknown:** It is not known whether or not there was oil on the water at the time of the casualty

The *India Arrow* 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 *India Arrow* is classified as Low Risk because there was one torpedo detonation, multiple shellfire hits, the tanks exploded, and fire swept across the vessel. 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 *India Arrow* is classified as High Risk because it is remained as one contiguous piece at the time of casualty; whether additional structural breakup occurred is unknown as location is unknown. 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 wreck of the *India Arrow* lies inverted on the seafloor. 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 *India Arrow* is 190 feet deep. Data quality is high.

Visual or Remote Sensing Confirmation of Site Condition

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

The wreck of the *India Arrow* is a popular technical diving site and is relatively structurally intact. 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 *India Arrow* 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 *India Arrow.* Operational factors are listed but do not have a risk score.

Table 1-1: Summary matrix for the vessel risk factors for the *India Arrow* 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 93,697 bbl, not reported to be leaking	**Med**
	A2: Oil Type	High	Cargo is diesel oil, a Group II oil type	
	B: Wreck Clearance	High	Vessel not reported as cleared	
	C1: Burning of the Ship	High	Significant fire reported	
	C2: Oil on Water	High	Oil was reported on the water; amount is not known	
	D1: Nature of Casualty	High	One torpedo detonation, shellfire, tank explosion	
	D2: Structural Breakup	High	The vessel remains as one contiguous piece	
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	Inverted	**Not Scored**
	Depth	High	190 ft	
	Visual or Remote Sensing Confirmation of Site Condition	High	Wreck is a popular technical dive site	
	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 (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 *India Arrow* this would be about 94,000 bbl (88,369 bbl of diesel as cargo and ≤5,328 bbl of Bunker C fuel oil) based on estimates of the maximum amount of oil remaining onboard the wreck at the time that the models were run.

The likeliest scenario of oil release from most sunken wrecks, including the *India Arrow*, 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 *India Arrow*.

Scenario Type	Release per Episode	Time Period	Release Rate	Relative Likelihood	Response Tier
Chronic (0.1% of WCD)	94 bbl	Fairly regular intervals or constant	100 bbl over several days	More likely	Tier 1
Episodic (1% of WCD)	940 bbl	Irregular intervals	Over several hours or days	Most Probable	Tier 1-2
Most Probable (10% of WCD)	9,400 bbl	One-time release	Over several hours or days	Most Probable	Tier 2
Large (50% of WCD)	47,000 bbl	One-time release	Over several hours or days	Less likely	Tier 2-3
Worst Case	94,000 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 *India Arrow*, with up to 94,000 bbl onboard, was clustered with the *Coimbra*, which was originally modeled at 29,000 bbl of light fuel oil. *Coimbra* was selected as the representative wreck for this cluster, but it was not the wreck with the largest volume of oil assumed to be onboard. Because it is not advisable to use regression equations to project beyond the maximum volume that was modeled, we ran an additional volume for *Coimbra* corresponding to the largest volume present in the cluster. These results were used as an additional data point to fit the regression equations and allow their appropriate use for release volumes up to 94,000 bbl. 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.

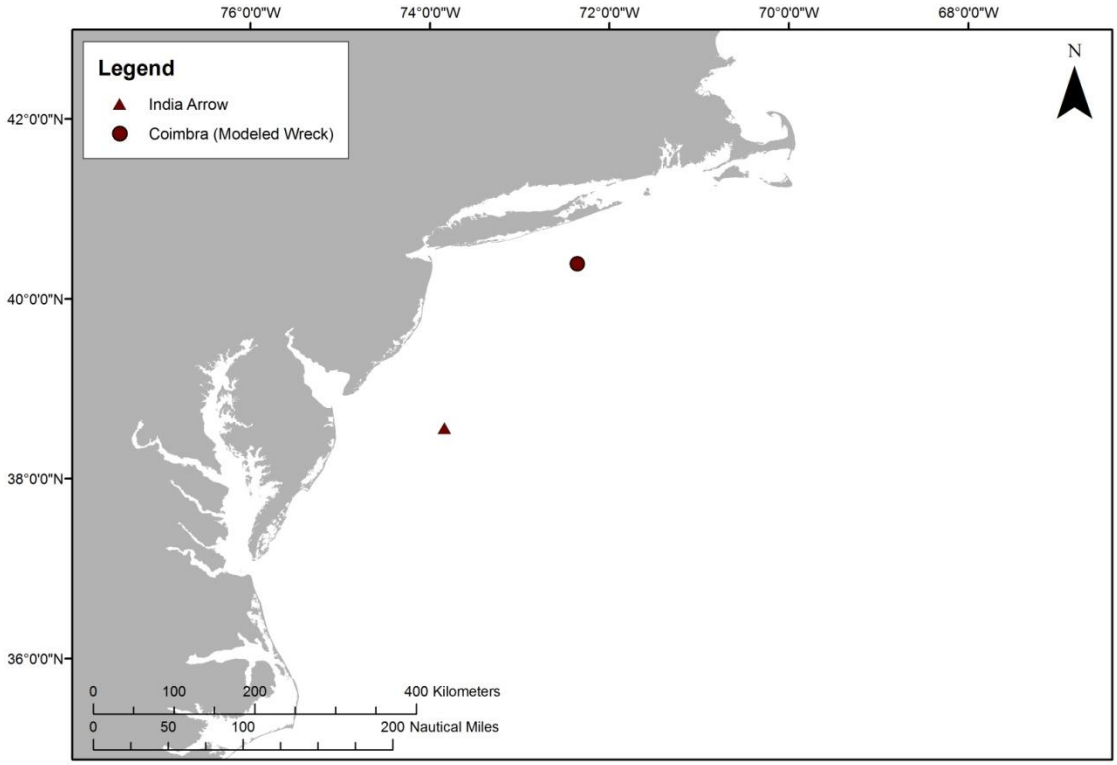


Figure 2-1: Location of the *India Arrow* (red triangle), the wreck discussed in this package, and the *Coimbra* (red circle) which was the wreck that was actually modeled in the computer modeling simulations. The results for the *Coimbra* are used to estimate the impacts of releases from the *India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

Oil Type for Release

The *India Arrow* contained a maximum of 88,369 bbl of diesel (a Group II oil) as cargo and ≤5,328 bbl of Bunker C fuel oil (a Group IV oil). Thus, the spill model for the *Coimbra*, which was run using light fuel oil, was used for this scoping assessment of the *India Arrow*.

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 *India Arrow* 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

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

scenarios, which is shown in Figure 2-2, which is the regression curve for the *Coimbra*. Using this figure, the water column impacts can be estimated for any spill volume. On Figure 2-2, arrows are used to indicate the where the Most Probable Discharge for the *India Arrow* plots on the curve and how the area of the water column impact is determined.

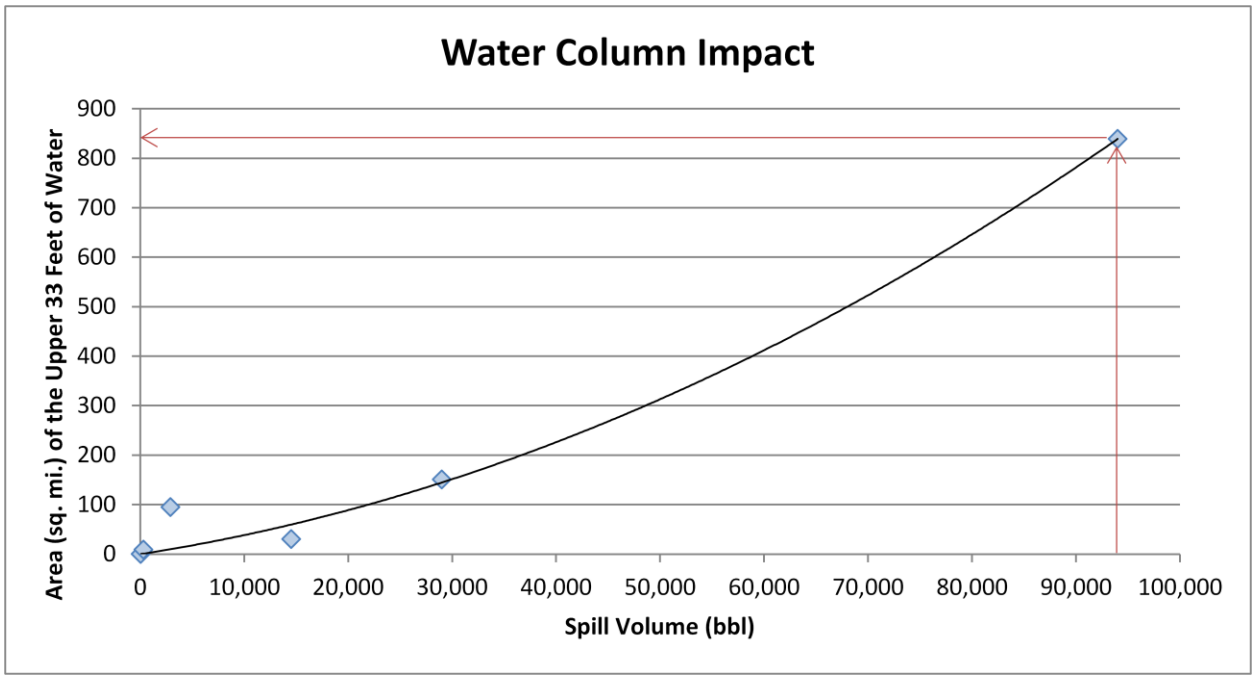


Figure 2-2: Regression curve for estimating the area of water column at or above 1 ppb aromatics impacted as a function of spill volume for the *India Arrow*. This regression curve was generated for the *Coimbra*, which has the same oil type and similar volume of potential releases as the *India Arrow*. The arrows indicate where the WCD for the *India Arrow* 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 median result of the 200 model runs for the *Coimbra* then using the regression curve shown in Figure 2-3 to calculate the values for the different release scenarios for the *India Arrow*. 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 *India Arrow* 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 *Coimbra* 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 *India Arrow*, based on the model results for the *Coimbra*.

Scenario Type	Oil Volume (bbl)	Estimated Slick Area Swept Mean of All Models	
		0.01 g/m²	10 g/m²
Chronic	94	1,200 mi²	98 mi²
Episodic	940	4,100 mi²	450 mi²
Most Probable	9,400	13,000 mi²	2,100 mi²
Large	47,000	31,000 mi²	6,100 mi²
Worst Case Discharge	94,000	44,000 mi²	9,700 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 *Coimbra*, 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 *India Arrow*.

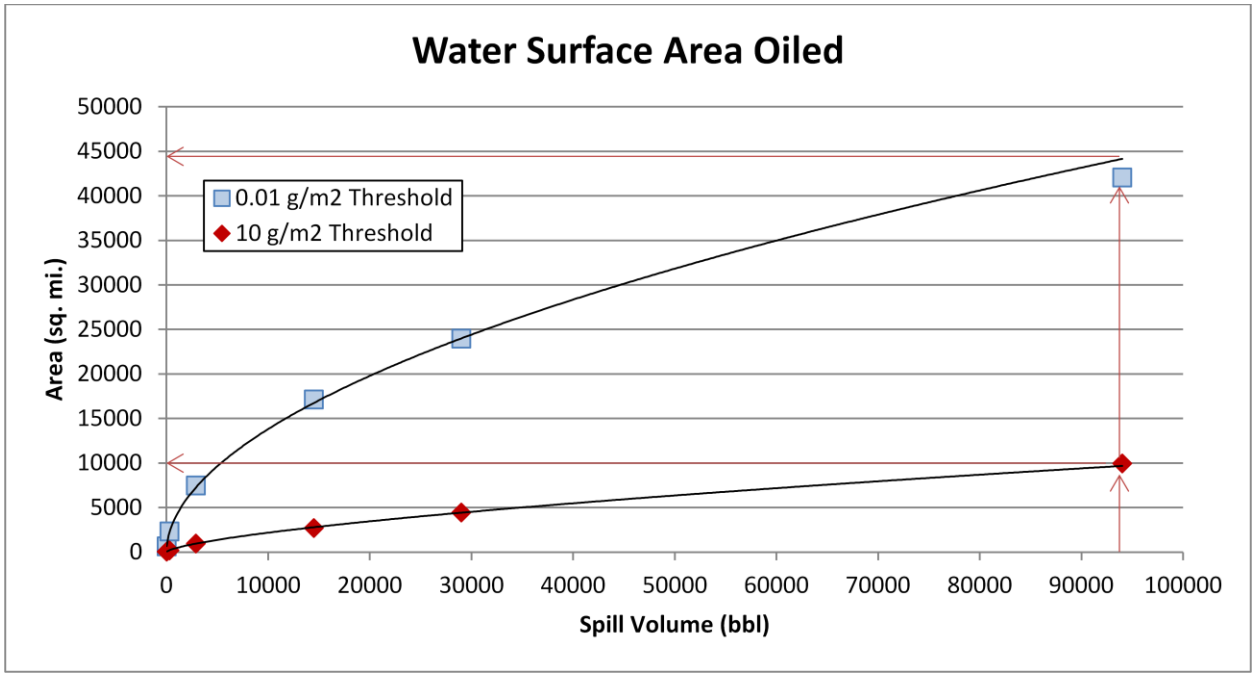


Figure 2-3: Regression curve for estimating the amount of water surface oiling as a function of spill volume for the *India Arrow*, showing both the ecological threshold of 10 g/m² and socio-economic threshold of 0.01 g/m², based on the model results for the *Coimbra*. The arrows indicate where the WCD for the *India Arrow* 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 Cape Cod, to as far south as Cape Lookout, North Carolina, are at risk. (Refer to Figure 2-6 in the *Coimbra* 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 *India Arrow*, based on the modeling results for the *Coimbra*.

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	94	0	0
Episodic	940	0	0
Most Probable	9,400	4	3
Large	47,000	20	17
Worst Case Discharge	94,000	40	34

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 *Coimbra*, 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 *India Arrow*.

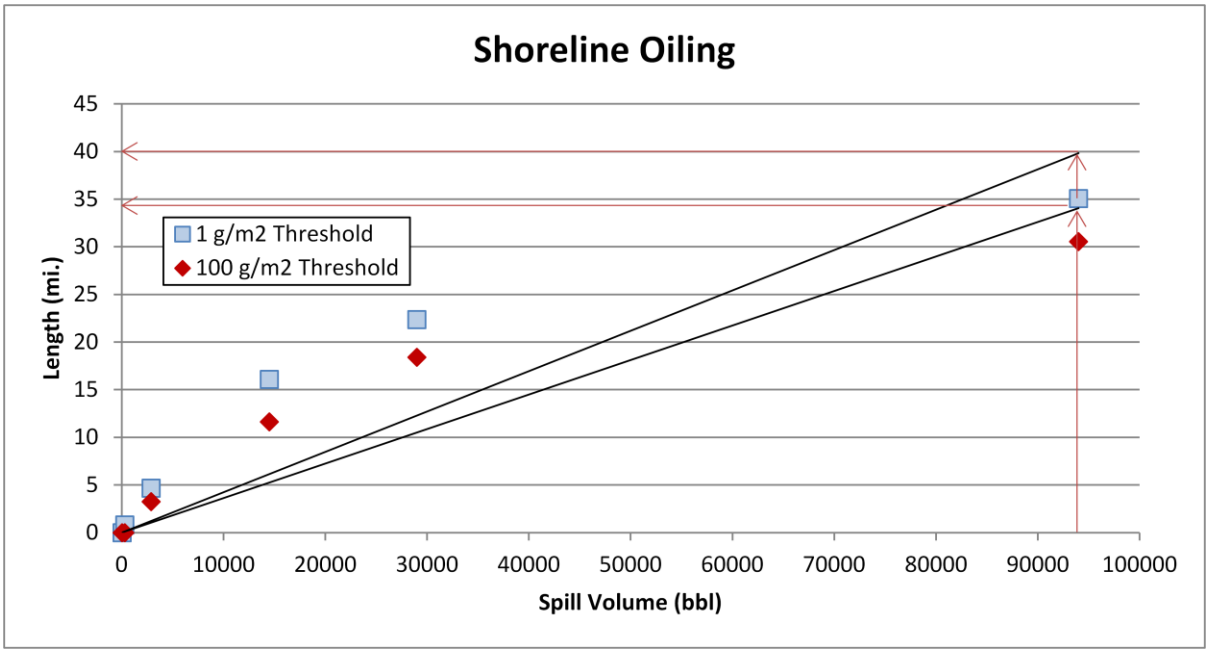


Figure 2-4: Regression curve for estimating the amount of shoreline oiling at different thresholds as a function of spill volume for the *India Arrow*, based on the model results for the *Coimbra*. The arrows indicate where the WCD for the *India Arrow* falls on the curve and how the length of shoreline 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 *India Arrow* 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 addition, this region is important for commercially important fish and invertebrates.

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

Species Group	Species Subgroup and Geography	Seasonal Presence
Pelagic Birds and Sea Ducks	• North and Mid-Atlantic inshore/offshore waters: 150K loons (RI is critical wintering habitat for a significant number of loons); 2K grebes; 1,000s of petrels; millions of shearwaters, storm-petrels, gulls; 300K boobies; 6K pelicans; 100,000s of cormorants, phalaropes, and terns; 10,000s of alcids; 1,000s of raptors, jaegers, and skimmers; 1.3 million sea ducks • Mouths of DE Bay and Chesapeake Bay, and Nantucket Island have high concentrations of species that are abundant over shoals (e.g., loons, pelicans, cormorants, sea ducks, gulls, terns, alcids); shoals off of Nantucket Island are largest on East Coast and concentrate millions of birds (very important for scoters and other sea ducks); shoals also occur off of Long Island • Audubon's shearwaters (50-75% of population) concentrate along the edge of the Continental Shelf off the coast of NC extending northward to the VA border (~3,800 pairs) • Northern gannet are abundant fall-spring throughout the coastal zone (often >3 km from shore) • Pelagic/waterbird bird use of RI waters is most diverse and abundant Fall through Spring, but 10,000s of birds have been observed feeding some summers	Terns, gulls present in spring/summer; Loons, sea ducks present in spring/fall Most surveys in winter but use of shoals and offshore waters varies by species group and occurs throughout the year; summer shoal use more common on northern shoals Shearwaters off of NC/VA: late summer

Sea Ducks	Sea ducks (mean and max distance of flocks to shore, 2009-2010 data)
	• Scoters (black, surf, and white-winged; 2 nm/8-13 nm)
	  ○ Cape Cod/Nantucket: 51-55K
	  ○ Nantucket Shoals: 9-36K
	  ○ LI Sound: 6-22K
	  ○ Off LI south coast: 8-19K
	  ○ Off NJ coast: 1K
	  ○ DE Bay: 12-14K
	  ○ Off MD/DE: 18-111K
	  ○ Chesapeake Bay: 34-73K
	  ○ Off Pamlico Sound: 4-43K
	• Long-tailed duck (2 nm/25 nm)
	  ○ Cape Cod/Nantucket: 31K
	  ○ Nantucket Shoals: 71-128K
	  ○ LI Sound: 3-7K
	  ○ Off LI south coast: 1-38K
	  ○ Off NJ coast: 1-6K
	  ○ Off MD/DE: 2K
	  ○ Chesapeake Bay: 17-31K
	• Common eider (<1 nm/19 nm)
	  ○ Cape Cod/Nantucket: 92-201K
	  ○ Nantucket Shoals: 2-6K
		Sea ducks surveyed in Winter (peak abundances). Migration from Oct-Apr

Species Group	Species Subgroup and Geography	Seasonal Presence
	○ LI Sound: 21-41K ○ Off LI south coast: 3.5K • Bufflehead, mergansers, goldeneyes (<1 nm/7-14 nm) ○ Cape Cod/Nantucket: 11K ○ LI Sound: 7K ○ Off NJ Coast: 9K ○ Off MD/DE: 3K ○ Ches. Bay: 14K ○ Off NC: 12K • Benthic community composition and water depth important for determining preferred foraging sites (not well known in all areas, some studies have been conducted) • RI: Most critical wintering areas for harlequin ducks occur north of spill area, but rocky coasts in MA and RI also important	
Shorebirds and Colonial Nesting Birds	Shorebirds and colonial nesting birds are abundant on small islands, beaches, and marshes throughout the region • VA Barrier Island/Lagoon System: most important bird area in VA and one of most along Atlantic Coast (of global/hemispheric importance): piping plover (FT), Wilson's plover, American oystercatcher, gull-billed tern, least tern, black skimmer (many of these species are state listed or of special concern in several states); most significant breeding population in state of waders; marsh nesters have center of abundance here; internationally significant stopover point for whimbrel, short-billed dowitcher, and red knot • Assateague Island, MD: globally important bird area due to 60+ pairs of nesting piping plovers; largest colony of nesting least terns in MD; important for migratory shorebirds • DE/NJ sides of DE Bay: extremely important migratory stopover point for several species of shorebirds (tied to horseshoe crab spawning): ruddy turnstone, short-billed dowitcher, red knot, etc. Delaware Bay is globally/hemispherically important as a migratory stopover site; red knots have decreased over 90% since 1990 and this is the most important stopover location for them. • NJ: Edwin B. Forsythe National Wildlife Refuge (NWR) and Sandy Hook: essential nesting and foraging habitat for imperiled beach nesters (piping plover, American oystercatcher, black skimmer, least tern). • Barrier islands on south shore of Long Island and islands/marshes on bay side: beach nesters (e.g., piping plovers), nesting wading birds, raptors, migrating shorebirds, wintering waterfowl etc. • Great Gull Island (LIS): one of the most important tern nesting sites in the world (1,600 pairs of roseate terns (FE), 10K common terns); Bird Island (and possibly Ram Island), MA is the other important site for roseate tern; together they make up 80% of the nesting population. • CT: Hammonasset Beach State Park: nesting saltmarsh sharp-tailed sparrow and migratory stopover point • RI and MA: Numerous important sites for beach and salt marsh habitats, including many NWRs that support breeding (e.g., least tern and piping plover) and migratory stopover points. • Cape Cod is a nationally significant migratory stopover site for numerous species; e.g., Monomoy NWR and South Beach are the most important habitats in New England for nesting piping plover, American oystercatchers, and major late-summer concentrations of shorebirds and roseate terns	Colonial and beach nesters peak Apr-Aug Migration typically Spring/fall, but varies by species and location and ranges from Feb-Jun/Aug-Dec
Raptors and Passerines	Lower Delmarva (Cape Charles area of VA): 20-80K raptors and over 10 million migrating passerines	Fall
Sea Turtles	Estuaries are summer foraging grounds for adult and juvenile green (FE) and	Adults and juveniles

Species Group	Species Subgroup and Geography	Seasonal Presence
	loggerhead (FT) sea turtles, especially Chesapeake Bay and Long Island Sound. Leatherback (FE), loggerhead, Kemp's ridley (FE) present offshore. Greens occur in VA, NJ, and DE but are rare further north. *Nesting:* Loggerheads nest on sand beaches south of Delaware. Kemp's ridley, green, and leatherback turtles may nest occasionally on the NC Outer Banks	present spring/summer Loggerheads Nest: Mar-Nov Hatch: May-Dec
Marine Mammals	*Baleen whales*: North Atlantic right whale (FE), humpback whale (FE), fin whale (FE) and minke whales are more common offshore but can move inshore to feed on forage fish and zooplankton. • Right whales are critically endangered (300-400 individuals remaining) and use this area as a migratory pathway • *Inshore cetaceans:* Atlantic white-sided, bottlenose dolphin, harbor porpoise and killer whales use coastal waters out to the shelf break. *Offshore cetaceans*: Northern bottlenose whale, pilot whales, Risso's dolphin, striped dolphin, common dolphin, Atlantic spotted dolphin, spinner dolphin • Often associated with shelf edge features and convergence zones *Deep diving whales:* Sperm whale (FE), beaked whales (5 spp present) forage in deep waters and canyons in the region. *Pinnipeds*: Gray seals and harbor seals are common during the winter, using Block Island as a haulout. Stray hooded seals and other sea lions can occur	Baleen whales migrate through the area spring and fall; males and juveniles may stay year round Dolphins more common in southern part of study area, during summer Harbor porpoises calve May-Aug Sperm whales present spring–summer
Fish & Invertebrates	Coastal ocean waters support many valuable fisheries and/or species of concern in the region: • Benthic: American lobster, sea scallop, scup, summer flounder, winter flounder, black sea bass, Atlantic rock crab, goosefish, Atlantic surf clam, butterfish, • Midwater: Atlantic mackerel, Atlantic herring, longfin squid, shortfin squid, striped bass, bluefish, menhaden, spiny dogfish sharks, spot, weakfish • Pelagic: bluefin tuna, yellowfin tuna, wahoo, dolphinfish, bigeye tuna, swordfish • Diadromous: alewife, blueback herring, American shad, Hickory shad, American eel, Atlantic sturgeon (Fed. species of concern) Pelagic species can be more concentrated around the shelf break and at oceanographic fronts in the region Estuaries are important nursery grounds for many of these species, and support many fisheries-blue crab, shrimp, horseshoe crab, Eastern oyster Important concentration/conservation areas are: • Nantucket Lightship closed area (S of Nantucket) • Great South Channel – boulder and cobble substrate thought to be nursery area for cod • EFH for highly migratory species occurs in the area, including swordfish, bluefin tuna, yellowfin tuna, bigeye tuna, shark species • Juvenile and adult bluefin tuna aggregate in the area in the winter Norfolk Canyon, Veatch Canyon, Oceanographer Canyon, and Lydonia Canyon are gear-restricted because they are important habitat for golden tilefish and monkfish	Generally spawn during the warmer months (except winter flounder) Juveniles of many species use estuaries, seagrass, and hard-bottom habitats as nursery areas Many coastal fish migrate seasonally either across the shelf or east-west (winter flounder)
Benthic Habitats	Submerged aquatic vegetation (mostly eelgrass) is critical to numerous species and occurs inside of bays and sounds throughout the region	Year round

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

Ecological Risk Factors

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

Ecological resources include plants and animals (e.g., fish, birds, invertebrates, and mammals), as well as the habitats in which they live. All impact factors are based on a Worst Case and the Most Probable Discharge oil release from the vessel. 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 *India Arrow* is provided, both as text and as shading of the applicable degree of risk bullet, for the WCD release of 94,000 bbl and a border around the Most Probable Discharge of 9,400 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 *Coimbra* 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 *India Arrow* is classified as High Risk for degree of oiling for water column ecological resources for the WCD of 94,000 bbl because the mean volume of water contaminated in the model runs was 840 mi^2 of the upper 33 feet of the water column. For the Most Probable Discharge of 9,400 bbl, the *India Arrow* is classified as Medium Risk for degree of oiling because the mean volume of water contaminated was 36 mi^2 of the upper 33 feet of the water column.

Risk Factor 3B: Water Surface Impacts to EcoRAR

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

Risk Factor 3B-1: Water Surface Probability of Oiling of EcoRAR (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 *India Arrow* is classified as Medium 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 9,700 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 2,100 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 *India Arrow*, 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 *India Arrow* 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 34 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 3 miles.

Considering the modeled risk scores and the ecological resources at risk, the ecological risk from potential releases of the WCD of 94,000 bbl of light fuel oil from the *India Arrow* is summarized as listed below and indicated in the far-right column in Table 3-2:

- Water column resources – Medium, because water column impacts occurred mostly far offshore where sensitive water column resources are less concentrated
- Water surface resources – Medium, because although there can be very large number of wintering, nesting, and migratory birds that use ocean, coastal, and estuarine habitats at risk, light fuel oils on the surface will not be continuous but rather be in the form of sheens that pose lesser risks to birds, sea turtles, and marine mammals
- Shoreline resources – Medium, because most of the shoreline at risk is composed of sand and gravel beaches where light fuel oils are not expected to persist, although these beaches are used by many shorebirds and sea turtles for nesting and many shorebirds as wintering and migratory stopovers

Table 3-2: Ecological risk factor scores for the **Worst Case Discharge of 94,000 bbl** of light fuel oil from the *India Arrow*.

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 840 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 9,700 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 34 mi	

For the Most Probable Discharge of 9,400 bbl of light fuel oil, the ecological risk from potential releases from the *India Arrow* is summarized as listed below and indicated in the far-right column in Table 3-3:

- Water column resources – Low, because of the very small area of water column impacts that occurred mostly far offshore where water column resources are less concentrated
- Water surface resources – Low, because although there can be very large number of wintering, nesting, and migratory birds that use ocean, coastal, and estuarine habitats at risk, light fuel oils on the surface will not be continuous but rather be in the form of sheens that pose lesser risks to birds, sea turtles, and marine mammals
- Shoreline resources – Low, because of the small amount of potential shoreline oiling

Table 3-3: Ecological risk factor scores for the **Most Probable Discharge of 9,400 bbl** of light fuel oil from the *India Arrow*.

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	**Low**
3A-2: Water Column Degree EcoRAR Oiling	**Low**	**Medium**	**High**	The mean volume of water contaminated above 1 ppb was 36 mi^2 of the upper 33 feet of the water column	
3B-1: Water Surface Probability EcoRAR Oiling	**Low**	**Medium**	**High**	N/A: Only available for modeled vessels	**Low**
3B-2: Water Surface Degree EcoRAR Oiling	**Low**	**Medium**	**High**	The mean area of water contaminated above 10 g/m^2 was 2,100 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 3 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 *India Arrow* include recreational beaches from North Carolina to Massachusetts that are very highly utilized during summer, and are still in use during spring and fall for shore fishing. Hotspots for chartered fishing vessels and recreational fishing party vessels include along the New Jersey shore, off the mouth of Delaware Bay, and off the outer banks of North Carolina. 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.

A release could impact shipping lanes from New York east of Cape Cod, and into Narragansett Bay. Coastal waters off Rhode Island and southern Massachusetts are popular sailing locations. A proposed offshore wind farm site is located in Nantucket Sound. Commercial fishing is economically important to the region. A release could impact fishing fleets where regional commercial landings for 2010 exceeded $600 million. Cape May-Wildwood, NJ and Hampton Roads, VA were the 6th and 7th nationally ranked commercial fishing ports by value in 2010. The most important species by dollar value present in and around the Mid-Atlantic are sea scallops, surf clams, ocean quahogs, menhaden, striped bass, and blue crab.

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 *India Arrow* 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 *India Arrow*.

Resource Type	Resource Name	Economic Activities
Tourist Beaches	Ocean City, MD Rehoboth Beach, DE Dewey Beach, DE Indian Beach, DE Bethany Beach, DE Middlesex Beach, DE Fenwick Island, DE Cape May, NJ Wildwood, NJ Avalon, NJ Atlantic City, NJ	Potentially affected beach resorts and beach-front communities in Massachusetts, Rhode Island, New York, New Jersey, Delaware, and North Carolina 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 east coast of New Jersey, northeastern Delaware, the southern coast of Long Island, New York, the southern coast of Rhode Island, and the southwestern shore of Massachusetts and Martha's Vineyard, Massachusetts, are lined with economically valuable beach resorts and residential communities.

Resource Type	Resource Name	Economic Activities
	Ocean City, NJ Absecon Beach, NJ Ludlam Beach, NJ Seven Mile Beach, NJ Margate City, NJ Peck Beach, NJ Ventnor City, NJ Brigantine Beach, NJ Beach Haven, NJ Spray Beach, NJ Brant Beach, NJ Long Beach, NJ Point Pleasant Beach, v Seaside Park, NJ Ortley Beach, NJ Ocean Beach, NJ Normandy Beach, v Ocean Beach, NY Fire Island Pines, NY Southampton, NY East Hampton, NY Westhampton Beach, NY Montauk, NY Block Island, RI East Matunuck State Beach, RI Roger W. Wheeler State Beach, RI Scarborough State Beach, RI Newport, RI Martha's Vineyard, MA	Many of these recreational activities are limited to or concentrated into the late spring through the early fall months.
National Seashores	Cape Hatteras National Seashore, NC Assateague Island National Seashore, MD and VA Fire Island National Seashore, NY	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. Assateague Island 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. The barrier island provides refuge for the endangered piping plover, seabeach amaranth, and sea turtles. Fire Island, a barrier island south of Long Island, has the historic William Floyd House and Fire Island Lighthouse.
National Wildlife Refuges	Prime Hook NWR (DE) Bombay Hook NWR (DE) Cape May NWR (NJ) Edwin B. Forsythe NWR (NJ) Seatuck NWR (NY) Wertheim NWR (NY) Amagansett NWR (NY) Block Island NWR (RI) Ninigret NWR (RI) Trustom Pond NWR (RI) Sachuest Point NWR (RI) Nomans Land Island NWR	National wildlife refuges in seven states may be impacted. These federally-managed and protected lands provide refuges and conservation areas for sensitive species and habitats.

Resource Type	Resource Name	Economic Activities
	(MA) Mashpee NWR (MA) Nantucket Island NWR (MA) Monomoy NWR (MA) Fisherman Island NWR (VA) Eastern Shore of Virginia NWR (VA) Wallops Island NWR (VA) Chincoteague NWR (VA) Back Bay NWR (VA) Mackay Island NWR (NC) Currituck NWR (NC) Pea Island NWR (NC) Cedar Island NWR (NC)	
State Parks	Assateague State Park, Maryland Delaware Seashore State Park, DE Cape Henlopen State Park, DE Cape May Point State Park, NJ Corson's Inlet State Park, NJ Barnegat Lighthouse State Park, NJ Island Beach State Park, NJ Robert Moses State Park, NY Shadmoor State Park, NY Camp Hero State Park, NY Montauk State Park, NY Salty Brine State Park, RI Fishermen's Memorial State Park, RI Beavertail State Park, RI Wetherill State Park, RI Brenton Point State Park, RI Fort Adams State Park, RI Horseneck Beach State Park, MA Demarest Lloyd State Park, MA Fort Phoenix State Park, MA Nasketucket Bay State Park, MA	Coastal state parks are significant recreational resources for the public (e.g., swimming, boating, recreational fishing, wildlife viewing, nature study, sports, dining, camping, and amusement parks). They provide income to the states. State parks in the states of Massachusetts, Rhode Island, New York, New Jersey, Delaware, and Maryland are potentially impacted. Many of these recreational activities are limited to or concentrated into the late spring into early fall months.
Tribal Lands	Shinnecock Indian Reservation, NY	Shinnecock Indian Reservation, New York, is home to over 500 tribal members. (Note this reservation has been recognized by New York State but not by the U.S. Bureau of Indian Affairs)
	Narragansett Indian Reservation, RI	Narragansett Indian Reservation, Rhode Island, is home to 2,400 tribal members.
	Wampanoag Indian Reservation, MA	Wampanoag Indian Reservation, Massachusetts, is home to over 2,000 tribal members.
Commercial Fishing	A number of fishing fleets use the New York Bight area and surrounding waters for commercial fishing purposes.	
	Atlantic City, NJ	Total Landings (2010): $17.3M
	Belford, NJ	Total Landings (2010): $2.2M
	Cape May-Wildwood, NJ	Total Landings (2010): $81M

Resource Type	Resource Name	Economic Activities
	Chincoteague, Virginia	Total Landings (2010): $3.5M
	Montauk, NY	Total Landings (2010): $17.7M
	New London, Connecticut	Total Landings (2010): $10.6M
	Newport, RI	Total Landings (2010): $6.9M
	Ocean City, Maryland	Total Landings (2010): $8.8M
	Point Pleasant, NJ	Total Landings (2010): $22.8M
	Stonington, Connecticut	Total Landings (2010): $18.5M
Ports	There are a number of significant commercial ports in the Northeast that could potentially be impacted by spillage and spill response activities. The port call numbers below are for large vessels only. There are many more, smaller vessels (under 400 GRT) that also use these ports.	
	Camden, NJ	249 port calls annually
	Claymont, DE	19 port calls annually
	Delaware City, DE	211 port calls annually
	Gloucester, NJ	180 port calls annually
	New York/New Jersey	5,414 port calls annually
	Newport, RI	95 port calls annually
	Philadelphia, PA	914 port calls annually
	Providence, RI	128 port calls annually
	Salem, NJ	52 port calls annually
	Wilmington, DE	443 port calls annually
Other Resources	Cape Wind Offshore Wind Farm (proposed), MA	Rated to produce up to 468 megawatts of wind power with average expected production will be 170 megawatts which is almost 75% of the 230 megawatt average electricity demand for Cape Cod and the Islands of Martha's Vineyard and Nantucket.

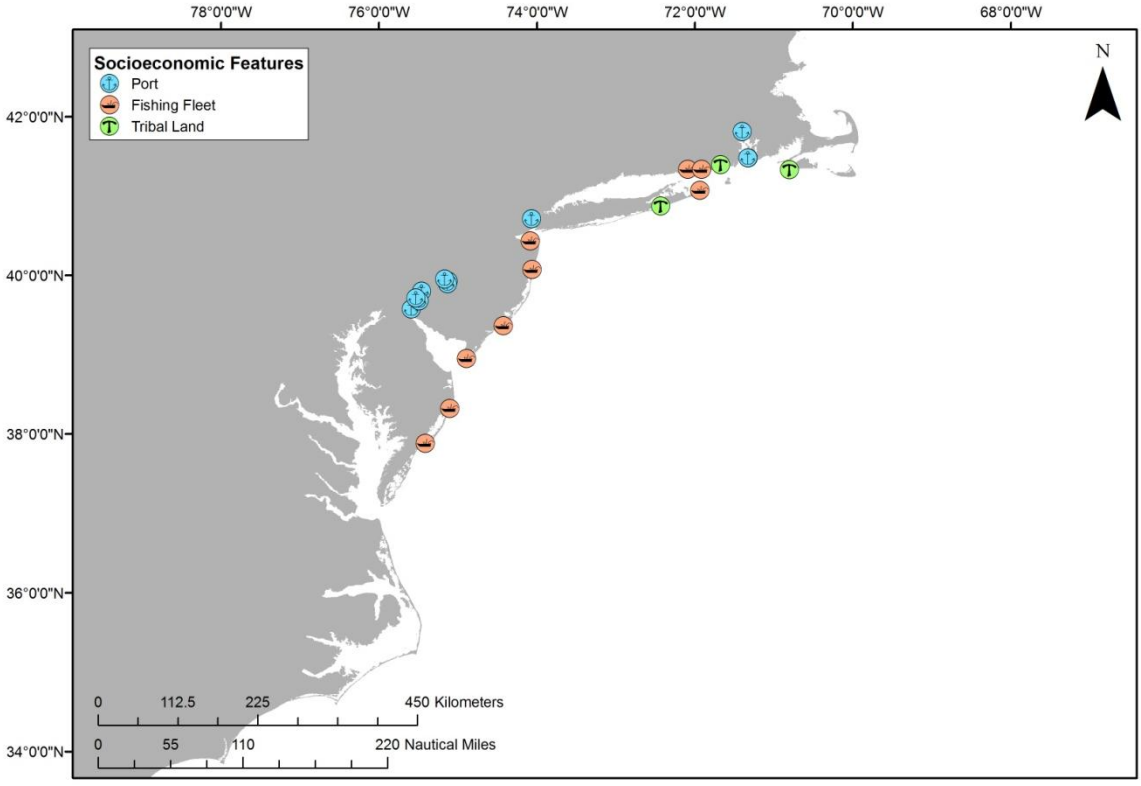


Figure 4-1: Tribal lands, ports, and commercial fishing fleets at risk from a release from the *India Arrow*.

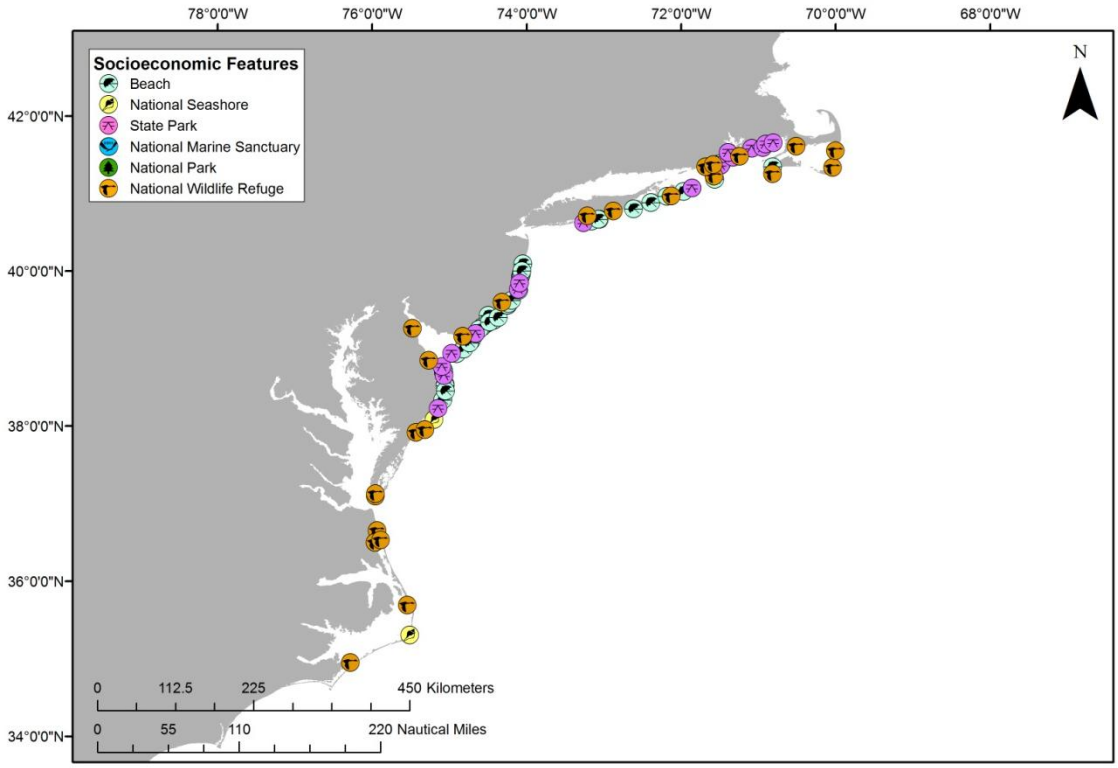


Figure 4-2: Beaches, coastal state parks, and Federal protected areas at risk from a release from the *India Arrow*.

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 *India Arrow*, shading indicates the degree of risk for a WCD release of 94,000 bbl and a border indicates degree of risk for the Most Probable Discharge of 9,400 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 *Coimbra* 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 mi^2 of the upper 33 feet of the water column would be contaminated with a high enough concentration of oil to cause socio-economic impacts. The threshold for water column impact to socio-economic resources at risk is an oil concentration of 1 ppb (i.e., 1 part oil per one billion parts water). At this concentration and above, one would expect impacts and potential tainting to socio-economic resources (e.g., fish and shellfish) in the water column; this concentration is used as a screening threshold for both the ecological and socio-economic risk factors.

The three risk scores for oiling are:

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

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

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

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

The *India Arrow* is classified as High Risk for degree of oiling for water column socio-economic resources for the WCD of 94,000 bbl because the mean volume of water contaminated in the model runs was 840 mi^2 of the upper 33 feet of the water column. For the Most Probable Discharge of 9,400 bbl, the *India Arrow* is classified as Medium Risk for degree of oiling because the mean volume of water contaminated was 36 mi^2 of the upper 33 feet of the water column.

Risk Factor 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 *India Arrow* is classified as High Risk for degree of oiling for water surface socio-economic resources for the WCD because the mean area of water contaminated in the model runs was 44,000 mi^2. The *India Arrow* 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 13,000 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 *India Arrow*, 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 *India Arrow* is classified as Medium Risk for degree of oiling for shoreline socio-economic resources for the WCD because the mean length of shoreline contaminated in the model runs was 40 miles. The *India Arrow* 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 4 miles.

Considering the modeled risk scores and the socio-economic resources at risk, the socio-economic risk from potential releases of the WCD of 94,000 bbl of light fuel oil from the *India Arrow* is summarized as listed below and indicated in the far-right column in Table 4-2:

- Water column resources – Medium, because a moderate water column area would be impacted in important fishing grounds
- Water surface resources – High, because a large offshore area would be affected in an area of important shipping lanes. 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
- Shoreline resources – Medium, because a moderate amount of shoreline would be impacted in areas with a large number of potentially vulnerable socio-economic resources located along the shoreline

Table 4-2: Socio-economic risk factor ranks for the **Worst Case Discharge of 94,000 bbl** of light fuel oil from the *India Arrow*.

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 840 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 44,000 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 40 mi	

For the Most Probable Discharge of 9,400 bbl, the socio-economic risk from potential releases of light fuel oil from the *India Arrow* is summarized as listed below and indicated in the far-right column in Table 4-3:

- Water column resources – Low, because a small water column area would be impacted in important fishing grounds
- Water surface resources – High, because a large offshore area would be affected in an area of important shipping lanes. 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
- Shoreline resources – Low, because a small amount of shoreline would be impacted in areas with a large number of potentially vulnerable socio-economic resources located along the shoreline

Table 4-3: Socio-economic risk factor ranks for the **Most Probable Discharge of 9,400 bbl** of light fuel oil from the *India Arrow*.

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 36 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 13,000 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 4 mi	

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

The overall risk assessment for the *India Arrow* 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 *Coimbra* 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, *India Arrow* scores High with 15 points; for the Most Probable Discharge, *India Arrow* scores Low with 10 points. The spread in the scores for the two release scenarios is due to the behavior of spills of light fuel, with smaller releases likely to be less persistent. 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 *India Arrow*. The final determination rests with the U.S. Coast Guard.

India Arrow	**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; first steps would be review the diver reports/photographs
	Location is unknown; Use surveys of opportunity to attempt to locate this vessel and gather more information on the vessel condition
	Conduct active monitoring to look for releases or changes in rates of releases
✓	Be noted in the Area Contingency Plans so that if a mystery spill is reported in the general area, this vessel could be investigated as a source
✓	Conduct outreach efforts with the 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 *India Arrow*.

Vessel Risk Factors		Data Quality Score	Comments		Risk Score
Pollution Potential Factors	A1: Oil Volume (total bbl)	Medium	Maximum of 93,697 bbl, not reported to be leaking		**Med**
	A2: Oil Type	High	Cargo is diesel oil, a Group II oil type		
	B: Wreck Clearance	High	Vessel not reported as cleared		
	C1: Burning of the Ship	High	Significant fire reported		
	C2: Oil on Water	High	Oil was reported on the water; amount is not known		
	D1: Nature of Casualty	High	One torpedo detonation, shellfire, tank explosion		
	D2: Structural Breakup	High	The vessel remains as one contiguous piece		
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	Inverted		**Not Scored**
	Depth	High	190 ft		
	Visual or Remote Sensing Confirmation of Site Condition	High	Wreck is a popular technical dive site		
	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	Area of water column affected above thresholds are far offshore where sensitive resources are less concentrated	**Med**	**Low**
	3B: Water Surface Resources	High	Seasonally very high concentrations of marine birds in coastal and shelf waters but light sheens pose lesser risks	**Med**	**Low**
	3C: Shore Resources	High	Mostly sand/gravel beaches at risk, where a light fuel oil is not likely to persist	**Med**	**Low**
Socio-Economic Resources	4A: Water Column Resources	High	A small to moderate water column area would be impacted in important fishing grounds	**Med**	**Low**
	4B: Water Surface Resources	High	High, because a large offshore area would be affected in an area of important shipping lanes	**High**	**High**
	4C: Shore Resources	High	Shoreline impacts in areas with a large number of potentially vulnerable socio-economic resources along the shoreline	**Med**	**Low**
Summary Risk Scores				**15**	**10**