Office of National Marine Sanctuaries
Office of Response and Restoration

# Screening Level Risk Assessment Package

## *Puerto Rican*


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National Oceanic and
Atmospheric Administration

Office of National Marine Sanctuaries
Daniel J. Basta, Director
Lisa Symons
John Wagner

Office of Response and Restoration
Dave Westerholm, Director
Debbie Payton
Doug Helton

Photo: Photograph of *Puerto Rican*
Source: http://www.uscg.mil/hq/cg5/docs/boards/puertorican.pdf

# Table of Contents


**Project Background** ..... ii

**Executive Summary** ..... 1

**Section 1: Vessel Background Information: Remediation of Underwater Legacy Environmental Threats (RULET)** ..... 2

Vessel Particulars ..... 2
Casualty Information ..... 3
Wreck Location ..... 4
Casualty Narrative ..... 4
General Notes ..... 5
Wreck Condition/Salvage History ..... 5
Archaeological Assessment ..... 5
Assessment ..... 5
Background Information References ..... 5
Vessel Risk Factors ..... 6

**Section 2: Environmental Impact Modeling** ..... 12

Release Scenarios Used in the Modeling ..... 12
Oil Type for Release ..... 13
Oil Thickness Thresholds ..... 13
Potential Impacts to the Water Column ..... 14
Potential Water Surface Slick ..... 15
Potential Shoreline Impacts ..... 18

**Section 3: Ecological Resources At Risk** ..... 21

Ecological Risk Factors ..... 25

**Section 4: Socio-Economic Resources At Risk** ..... 31

Socio-Economic Risk Factors ..... 34

**Section 5: Overall Risk Assessment and Recommendations for Assessment, Monitoring, or Remediation** ..... 39

# 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.

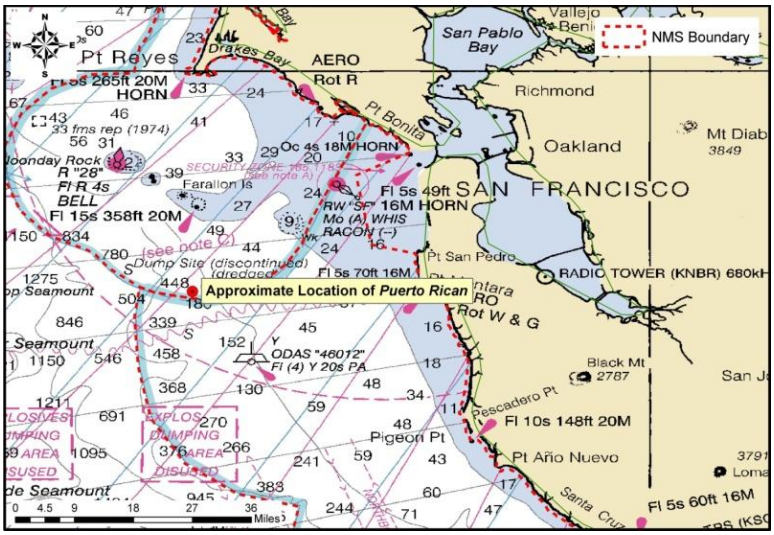
The potential polluting shipwrecks were identified through searching a broad variety of historical sources. NOAA then worked with Research Planning, Inc., RPS ASA, and Environmental Research Consulting to conduct the modeling forecasts, and the ecological and environmental resources at risk assessments.

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: *Puerto Rican*

The tanker *Puerto Rican*, which exploded and sank off the Golden Gate, San Francisco in 1984, 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 *Puerto Rican*, 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.



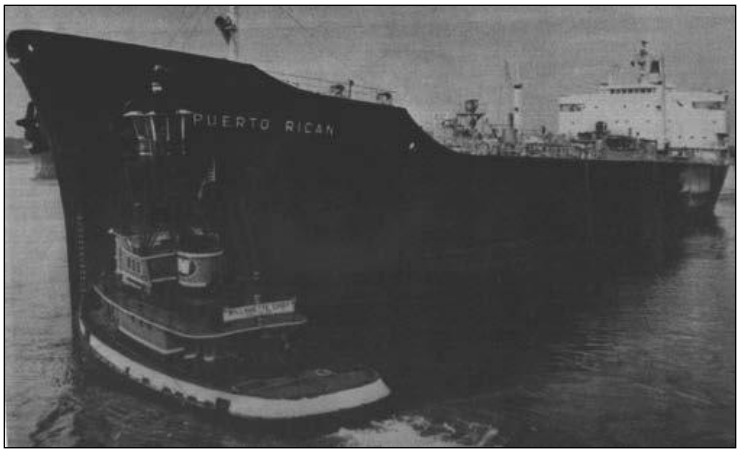

Based on this screening-level assessment, each vessel was assigned a summary score calculated using the seven risk criteria described in this report. For the Worst Case Discharge, *Puerto Rican* scores High with 15 points; for the Most Probable Discharge (10% of the Worse Case volume), *Puerto Rican* scores Medium with 12 points. Given these scores, and higher level of data certainty, NOAA recommends that this site be reflected within the Area Contingency Plans so that if a mystery spill is reported in the general area, this vessel could be investigated as a source. It should be considered for further assessment to determine the vessel condition, amount of oil onboard, and feasibility of oil removal action. At a minimum, an active monitoring program should be implemented. Outreach efforts with 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 | Low | Low |
| | 3B: Water Surface Resources | High | Med |
| | 3C: Shore Resources | Med | Low |
| Socio-Economic Resources | 4A: Water Column Resources | Med | Med |
| | 4B: Water Surface Resources | High | Med |
| | 4C: Shore Resources | Med | Med |
| Summary Risk Scores | | 15 | 12 |

The determination of each risk factor is explained in the document. This summary table is found on page 40.

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

## Vessel Particulars




**Official Name:** *Puerto Rican*

**Official Number:** 535000

**Vessel Type:** Tanker

**Vessel Class:** Unknown

**Former Names:** Unknown

**Year Built:** 1971

**Builder:** Bethlehem Steel Company, Sparrows Point, MD

**Builder's Hull Number:** 4633

**Flag:** American

**Owner at Loss:** Bankers Trust Company, 16 Wall Street New York, NY

**Controlled by:** Unknown **Chartered to:** PPG Industries, Inc., 1 PPG Place, Pittsburg, PA

**Operated by:** Keystone Shipping Co., 313 Chestnut Street, Philadelphia, PA

**Homeport:** New York, NY

**Length:** 632 feet **Beam:** 90 feet **Depth:** 48 feet

**Gross Tonnage:** 20,295 **Net Tonnage:** 15,922

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

**Bunker Type:** Heavy Fuel Oil (Bunker C) **Bunker Capacity (bbl):** Unknown

**Average Bunker Consumption (bbl) per 24 hours:** Unknown

**Liquid Cargo Capacity (bbl):** Unknown **Dry Cargo Capacity:** Unknown

**Tank or Hold Description:** Unknown

## Casualty Information

**Port Departed:** San Francisco, CA

**Destination Port:** New Orleans, LA

**Date Departed:** October 31, 1984

**Date Lost:** October 31, 1984

**Number of Days Sailing:** 1

**Cause of Sinking:** Explosion and Fire

**Latitude (DD):** 37.51

**Longitude (DD):** -123.0117

**Nautical Miles to Shore:** 23

**Nautical Miles to NMS:** 0 (Inside Gulf of the Farallones NMS)

**Nautical Miles to MPA:** 0

**Nautical Miles to Fisheries:** Unknown

**Approximate Water Depth (Ft):** 1,476

**Bottom Type:** Continental Margin

**Is There a Wreck at This Location?** These coordinates may not be entirely accurate but the location of the wreck is known

**Wreck Orientation:** Unknown

**Vessel Armament:** None

**Cargo Carried when Lost:** 91,984 bbl of lubricating oil and additives

**Cargo Oil Carried (bbl):** 91,984

**Cargo Oil Type:** Multiple Oil Types

**Probable Fuel Oil Remaining (bbl):** 8,500

**Fuel Type:** Heavy Fuel Oil (Bunker C)

**Total Oil Carried (bbl):** 100,484

**Dangerous Cargo or Munitions:** No

**Munitions Carried:** None

**Demolished after Sinking:** No

**Salvaged:** Yes, the bow section was salvaged

**Cargo Lost:** Yes, partially

**Reportedly Leaking:** No

**Historically Significant:** No

**Gravesite:** Yes

**Salvage Owner:** Not known if any

## Wreck Location

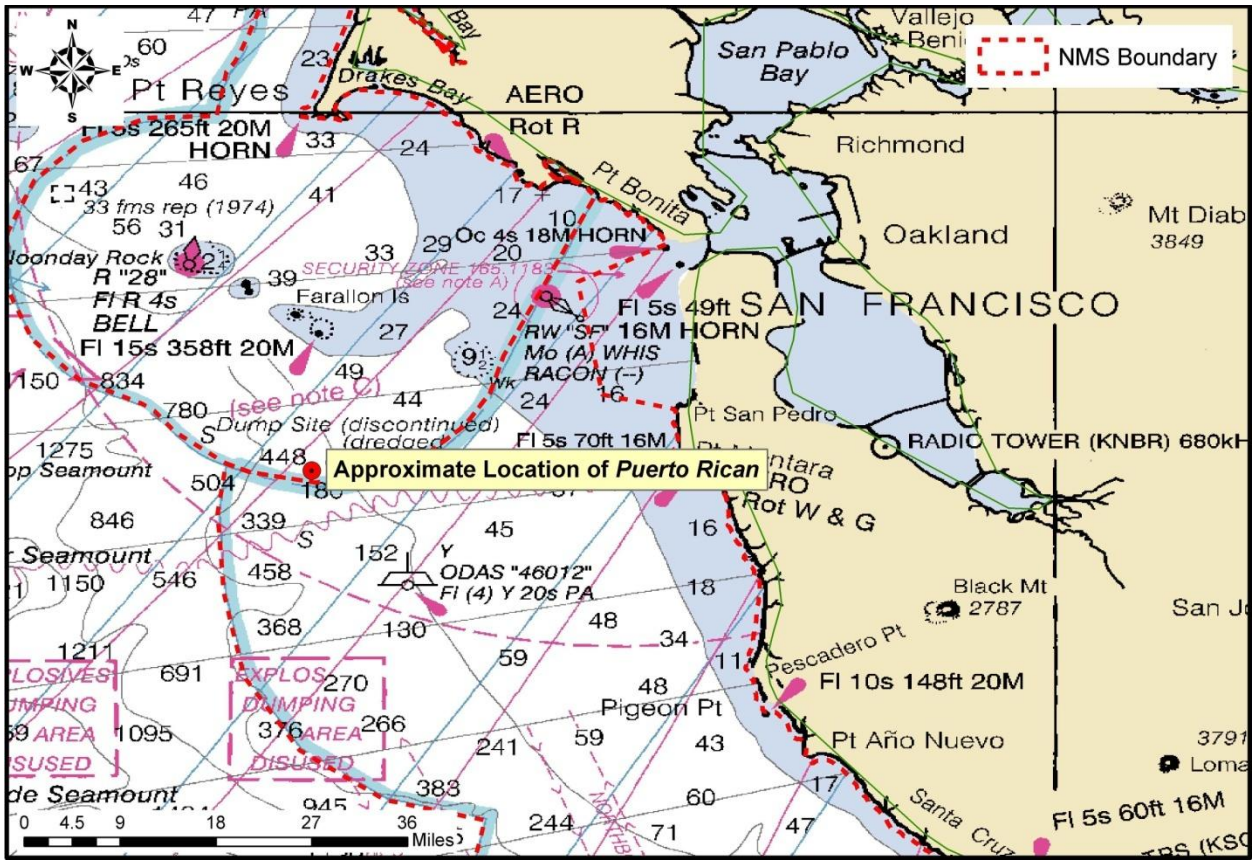



**Chart Number:** 18020

## Casualty Narrative

"Under master James C. Spillane, *Puerto Rican* arrived in San Francisco Bay on October 25, 1984, and called at Richmond and Alameda. She loaded a cargo of 91,984 bbl of lubrication oil and additives, took on 8,500 bbl of bunker fuel, and departed for sea shortly after midnight on October 31, bound for New Orleans. At 3:24 a.m., as she was disembarking the pilot outside the San Francisco Bay Entrance Channel, an explosion occurred near the No. 6 center-independent tank, which blew flames several hundred feet into the air, knocked the pilot and two crew members into the water, and folded back an immense section of the deck measuring nearly 100 feet square. The pilot boat *San Francisco* rescued pilot James S. Nolan and third mate Philip R. Lempiere, but able seaman John Peng was lost.

Response by the U.S. Coast Guard was immediate, and the burning tanker was towed to sea in order to minimize the chance of a disastrous oil spill on the sensitive areas of San Francisco Bay, the adjacent ocean shoreline, and the Gulf of the Farallones National Marine Sanctuary. By the following afternoon, the fires had been extinguished, but on November 3, *Puerto Rican*, her hull weakened by explosion and fires, broke in two sections, releasing 30,000 bbl of oil into the water. The stern section, containing 8,500 bbl of fuel oil, sank at 37 degrees, 30.6 minutes north latitude and 123 degrees, 007 minutes west longitude, one mile inside the boundaries of the sanctuary. The remains at a depth of 1,476 feet have been thoroughly surveyed by side-scan sonar."
-http://channelislands.noaa.gov/shipwreck/dbase/gfmns/puertorican.html

## General Notes

No notes available in database.

## Wreck Condition/Salvage History

Only the stern section sank, and the wreckage has been surveyed by side-scan sonar.

## 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

No archaeological assessment was prepared for *Puerto Rican*. This shipwreck is not a historical shipwreck and records relating to the loss of the vessel were not part of the National Archives record groups examined by NOAA archaeologists. It is likely that the local U.S. Coast Guard District or Sector has access to many more records about this wreck than are available at the National Archives.

## Background Information References

**Vessel Image Sources:** http://www.uscg.mil/hq/cg5/docs/boards/puertorican.pdf

**Construction Diagrams or Plans in RULET Database?** No

**Text References:**

http://www.uscg.mil/hq/cg5/docs/boards/puertorican.pdf
CA Lands database #1515
CA Lands Com database for GIS #158
http://channelislands.noaa.gov/shipwreck/dbase/gfmns/puertorican.html

## Vessel Risk Factors

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

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

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

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

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

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

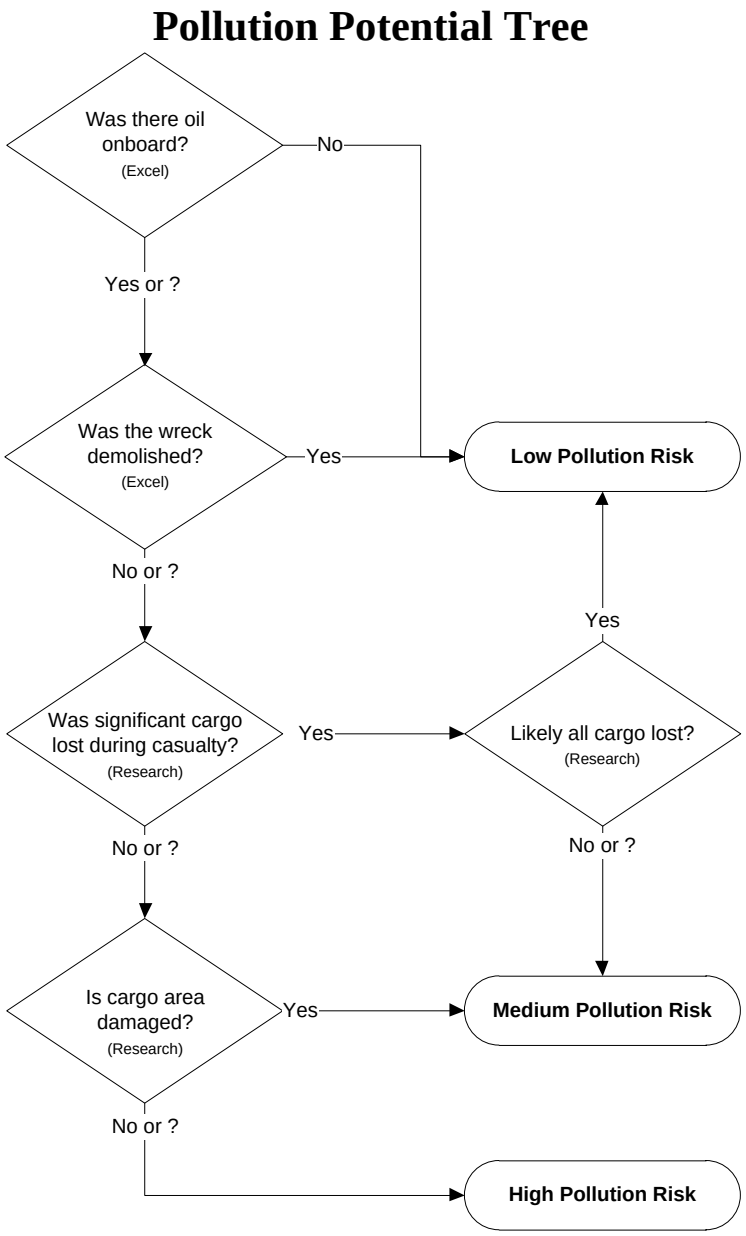



**Figure 1-1:** U.S. Coast Guard Salvage Engineering Response Team (SERT) developed the above Pollution Potential Decision Tree.

## Pollution Potential Factors

### Risk Factor A1: Total Oil Volume

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

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

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

The *Puerto Rican i*s ranked as High Volume because it is thought to have a potential for up to 20,225 bbl based on the amount of oil and additives believed to remain in the sections of the ship that sank, although some of that was lost at the time of the casualty due to the explosion and breakup of the vessel. Data quality is medium.

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

### Risk Factor A2: Oil Type

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

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

The *Puerto Rican* is classified as High Risk because the bunker oil is heavy fuel oil, a Group IV oil type. Data quality is high.

***Was the wreck demolished?***

### Risk Factor B: Wreck Clearance

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

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

The *Puerto Rican* 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.

[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]

***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 *Puerto Rican* 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 *Puerto Rican* is classified as Medium Risk because the oil was reported to have spread across the water as the vessel went down, and it continued to leak. 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 *Puerto Rican* is classified as Low Risk because there were multiple explosions, a large fire, and the vessel broke in half. 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 *Puerto Rican* is classified as Medium Risk because it is broken into two pieces. Data quality is high.

## Factors That May Impact Potential Operations

### Orientation (degrees)

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

The location of the *Puerto Rican* is known, but the current orientation is unknown. Data quality is low.

### 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 *Puerto Rican* is 1,476 feet deep. Data quality is high.

### Visual or Remote Sensing Confirmation of Site Condition

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

The location of the *Puerto Rican* has been surveyed. 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 *Puerto Rican* did not carry any munitions. Data quality is high.

## Vessel Risk Factors Summary

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

**Table 1-1:** Summary matrix for the vessel risk factors for the *Puerto Rican* 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 20,225 bbl, not reported to be leaking | **Med** |
| | A2: Oil Type | High | Bunker oil heavy fuel oil, a Group IV oil type | |
| | B: Wreck Clearance | High | Vessel not reported as cleared | |
| | C1: Burning of the Ship | High | A significant fire was reported | |
| | C2: Oil on Water | High | Oil was reported on the water; amount is not known | |
| | D1: Nature of Casualty | High | Explosions, fire, and structural breakup | |
| | D2: Structural Breakup | High | The vessel broke in two at the time of sinking | |
| **Archaeological Assessment** | Archaeological Assessment | Low | The most accurate assessment of the sinking probably comes from the Marine Board of Investigation Report, an accurate assessment was prepared | **Not Scored** |
| **Operational Factors** | Wreck Orientation | Low | Currently unknown | **Not Scored** |
| | Depth | High | 1,476 | |
| | Visual or Remote Sensing Confirmation of Site Condition | High | The location has been surveyed | |
| | Other Hazardous Materials Onboard | High | No | |
| | Munitions Onboard | High | No | |
| | Gravesite (Civilian/Military) | High | Yes | |
| | Historical Protection Eligibility (NHPA/SMCA) | High | No | |

# SECTION 2: ENVIRONMENTAL IMPACT MODELING

To help evaluate the potential transport and fates of releases from sunken wrecks, NOAA worked with RPS ASA to run a series of generalized computer model simulations of potential oil releases. The results are used to assess potential impacts to ecological and socio-economic resources, as described in Sections 3 and 4. The modeling results are useful for this screening-level risk assessment; however, it should be noted that detailed site/vessel/and seasonally specific modeling would need to be conducted prior to any intervention on a specific wreck.

**Release Scenarios Used in the Modeling**

The potential volume of leakage at any point in time will tend to follow a probability distribution. Most discharges are likely to be relatively small, though there could be multiple such discharges. There is a lower probability of larger discharges, though these scenarios would cause the greatest damage. A **Worst Case Discharge** (WCD) would involve the release of all of the cargo oil and bunkers present on the vessel. In the case of the *Puerto Rican* this would be about 21,000 bbl (rounded up from 20,225 bbl) based on current estimates of the maximum amount of oil remaining onboard the wreck.

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

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

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

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

**Table 2-1:** Potential oil release scenario types for the *Puerto Rican*.

| Scenario Type | Release per Episode | Time Period | Release Rate | Relative Likelihood | Response Tier |
|---|---|---|---|---|---|
| **Chronic (0.1% of WCD)** | 21 bbl | Fairly regular intervals or constant | 100 bbl over several days | More likely | Tier 1 |
| **Episodic (1% of WCD)** | 210 bbl | Irregular intervals | Over several hours or days | Most Probable | Tier 1-2 |
| **Most Probable (10% of WCD)** | 2,100 bbl | One-time release | Over several hours or days | Most Probable | Tier 2 |
| **Large (50% of WCD)** | 10,500 bbl | One-time release | Over several hours or days | Less likely | Tier 2-3 |
| **Worst Case** | 21,000 bbl | One-time release | Over several hours or days | Least likely | Tier 3 |

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

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

**Oil Type for Release**

The *Puerto Rican* contained a maximum of 12,500 bbl of lubricating oil (a Group II oil) as cargo and 8,500 bbl of bunker fuel oil (a Group IV oil) based on estimates of how much cargo and bunker oil was contained in the sections of the ship that sank. Because the bulk of the oil likely remaining on board is heavy fuel oil, the oil spill model was run using heavy fuel oil.

**Oil Thickness Thresholds**

The model results are reported for different oil thickness thresholds, based on the amount of oil on the water surface or shoreline and the resources potentially at risk. Table 2-2 shows the terminology and thicknesses used in this report, for both oil thickness on water and the shoreline. For oil on the water surface, a thickness of 0.01 $g/m^2$, which would appear as a barely visible sheen, was used as the threshold for socio-economic impacts because often fishing is prohibited in areas with any visible oil, to prevent contamination of fishing gear and catch. A thickness of 10 $g/m^2$ was used as the threshold for ecological impacts, primarily due to impacts to birds, because that amount of oil has been observed to be enough to mortally impact birds and other wildlife. In reality, it is very unlikely that oil would be evenly distributed on the water surface. Spilled oil is always distributed patchily on the water surface in bands or tarballs with clean water in between. So, Table 2-2a shows the number of tarballs per acre on the water surface for these oil thickness thresholds, assuming that each tarball was a sphere that was 1 inch in diameter.

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

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

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

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

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

**Potential Impacts to the Water Column**

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

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

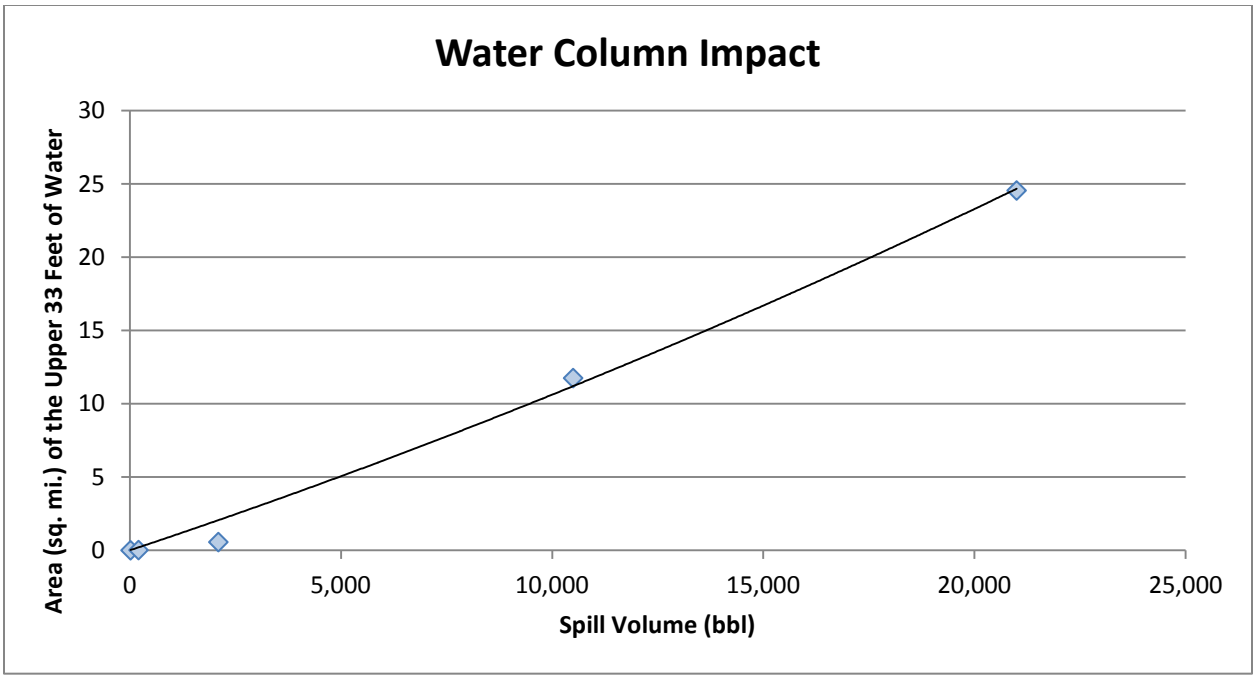



**Figure 2-1:** Regression curve for estimating the volume of water column at or above 1 ppb aromatics impacted as a function of spill volume for the *Puerto Rican*.

**Potential Water Surface Slick**

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

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

| Scenario Type | Oil Volume (bbl) | Estimated Slick Area Swept Mean of All Models | |
|---|---|---|---|
| | | 0.01 g/m$^2$ | 10 g/m$^2$ |
| **Chronic** | 21 | 110 mi$^2$ | 110 mi$^2$ |
| **Episodic** | 210 | 360 mi$^2$ | 360 mi$^2$ |
| **Most Probable** | 2,100 | 1,200 mi$^2$ | 1,200 mi$^2$ |
| **Large** | 10,500 | 3,000 mi$^2$ | 3,000 mi$^2$ |
| **Worst Case Discharge** | 21,000 | 4,500 mi$^2$ | 4,50 mi$^2$ |

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

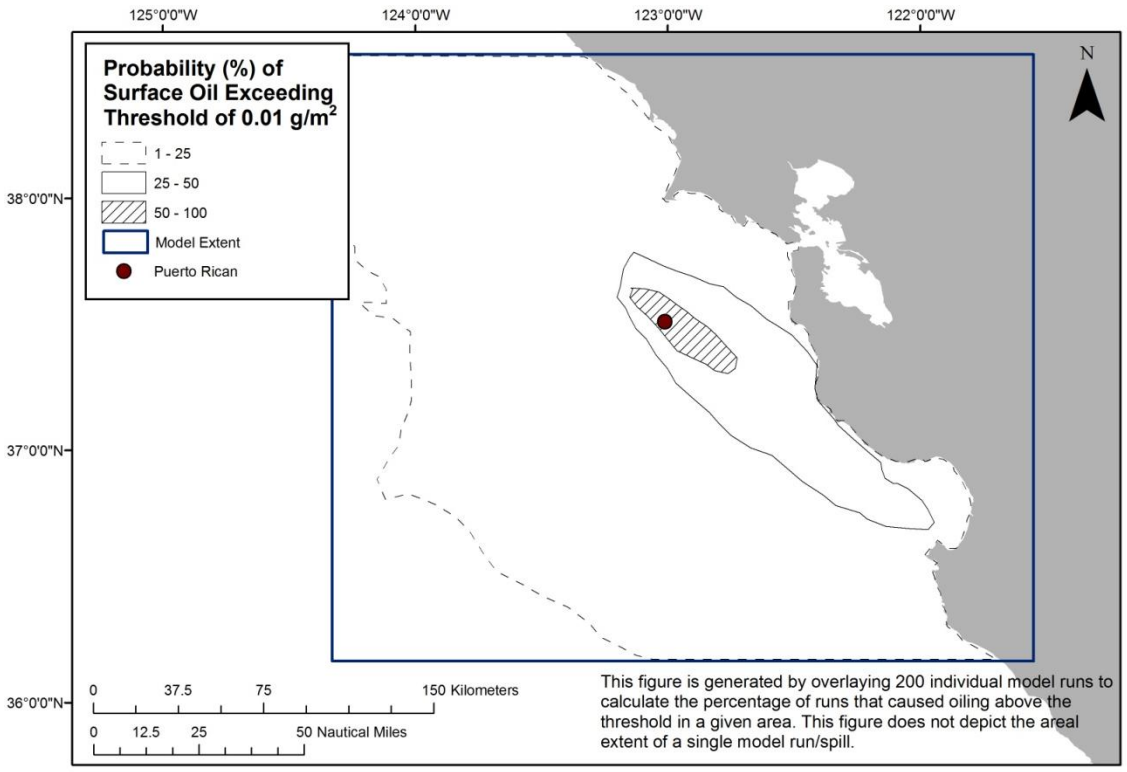



**Figure 2-2:** Probability of surface oil (exceeding 0.01 g/m$^2$) from the Most Probable spill of 2,100 bbl of heavy fuel oil from the *Puerto Rican* at the threshold for socio-economic resources at risk.

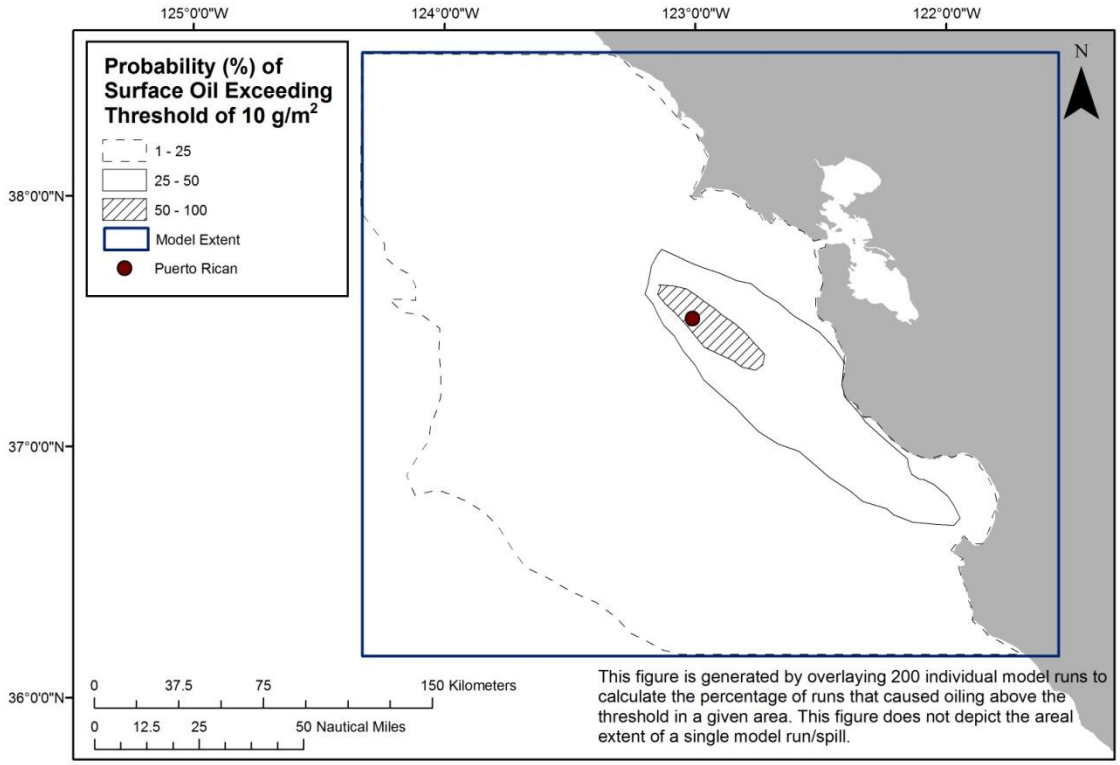



**Figure 2-3:** Probability of surface oil (exceeding 10 g/m$^2$) from the Most Probable spill of 2,100 bbl of heavy fuel oil from the *Puerto Rican* at the threshold for ecological resources at risk.

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

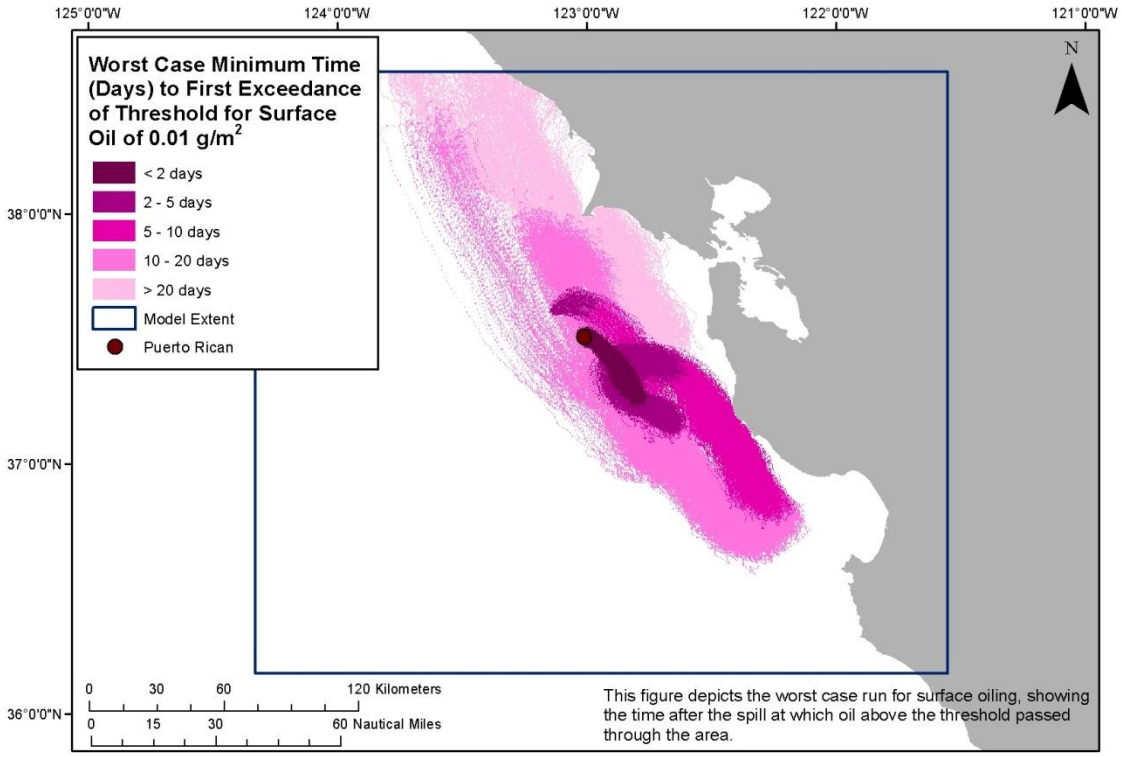



**Figure 2-4:** Water surface oiling from the Most Probable spill of 2,100 bbl of heavy fuel oil from the *Puerto Rican* shown as the area over which the oil spreads at different time intervals.

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

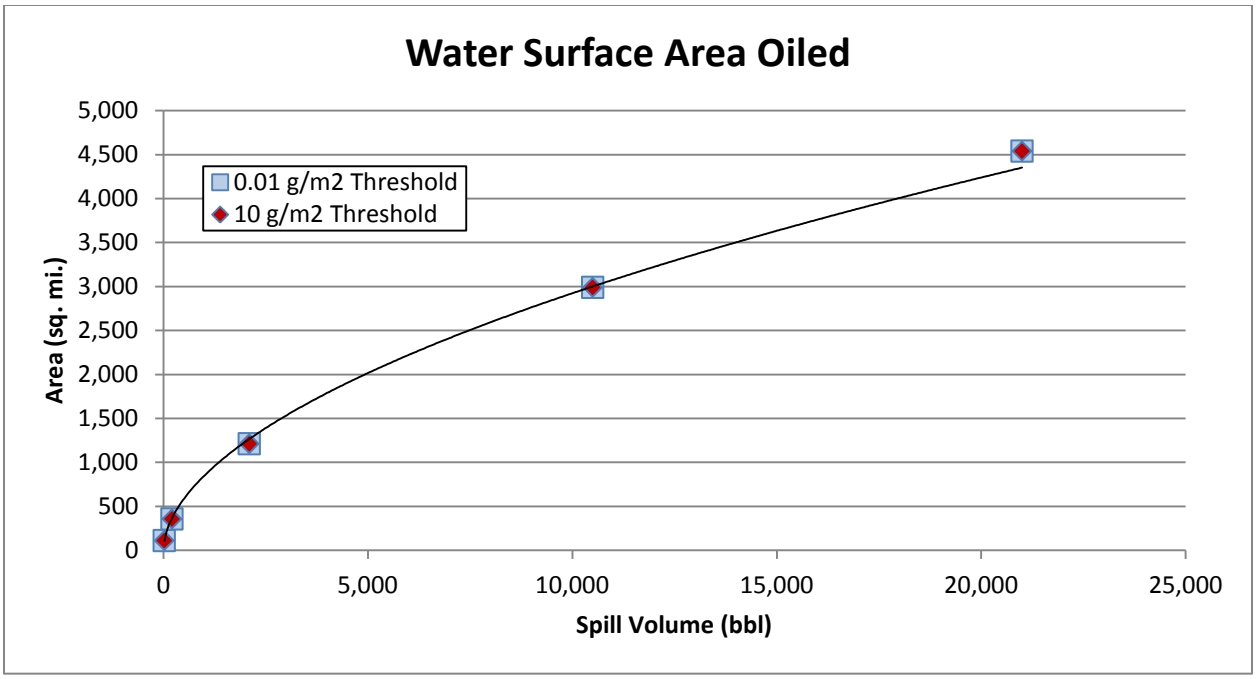



**Figure 2-5:** Regression curve for estimating the amount of water surface oiling as a function of spill volume for the *Puerto Rican*, showing both the ecological threshold of 10 g/m$^2$ and socio-economic threshold of 0.01 g/m$^2$. The curves for each threshold are so similar that they plot on top of each other.

**Potential Shoreline Impacts**

Based on these modeling results, shorelines from 80 miles north to 130 miles south of the Golden Gate are at risk. Figure 2-6 shows the probability of oil stranding on the shoreline at concentrations that exceed the threshold of 1 g/m$^2$, for the Most Probable release of 2,100 bbl. However, the specific areas that would be oiled will depend on the currents and winds at the time of the oil release(s), as well as on the amount of oil released. Figure 2-7 shows the single oil spill scenario that resulted in the maximum extent of shoreline oiling for the Most Probable volume. Estimated miles of shoreline oiling above the threshold of 1 g/m$^2$ by scenario type are shown in Table 2-4.

**Table 2-4:** Estimated shoreline oiling from leakage from the *Puerto Rican*.

| Scenario Type | Volume (bbl) | Estimated Miles of Shoreline Oiling Above 1 g/m$^2$ | | | |
|---|---|---|---|---|---|
| | | Rock/Gravel/Artificial | Sand | Wetland/Mudflat | Total |
| **Chronic** | 21 | 1 | 5 | 0 | 6 |
| **Episodic** | 210 | 1 | 9 | 0 | 10 |
| **Most Probable** | 2,100 | 2 | 11 | 0 | 13 |
| **Large** | 10,500 | 4 | 14 | 0 | 18 |
| **Worst Case Discharge** | 21,000 | 6 | 17 | 0 | 23 |

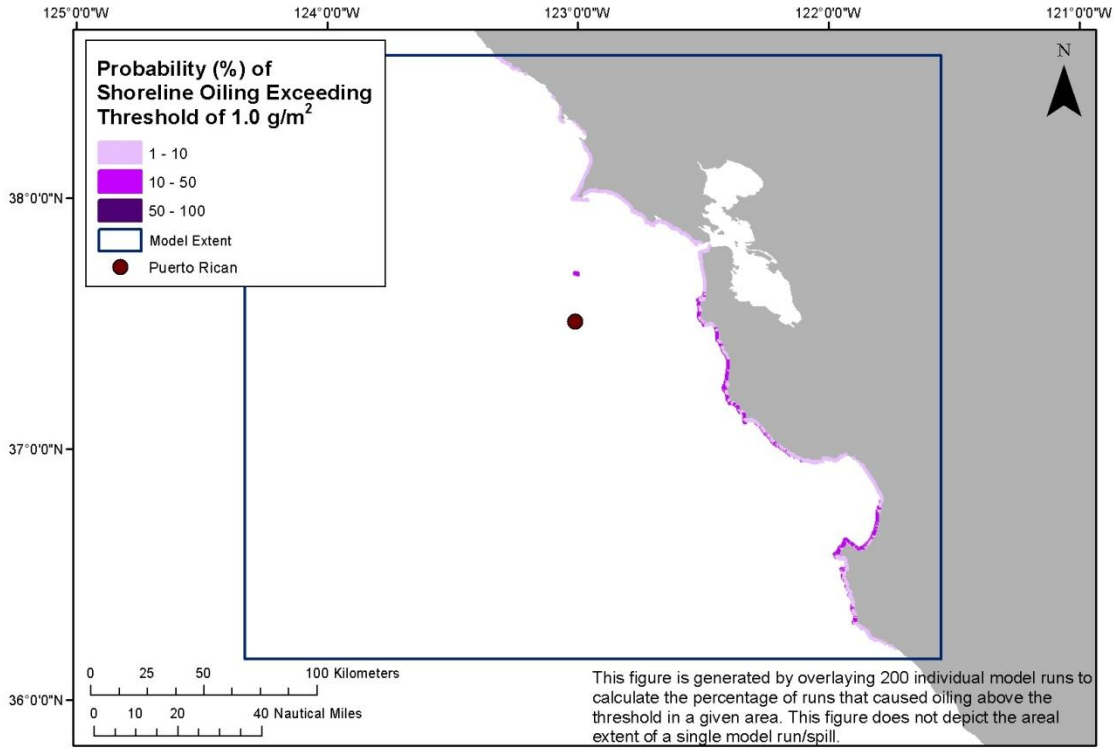



**Figure 2-6:** Probability of shoreline oiling (exceeding 1.0 g/m$^2$) from the Most Probable Discharge of 2,100 bbl of heavy fuel oil from the *Puerto Rican*.

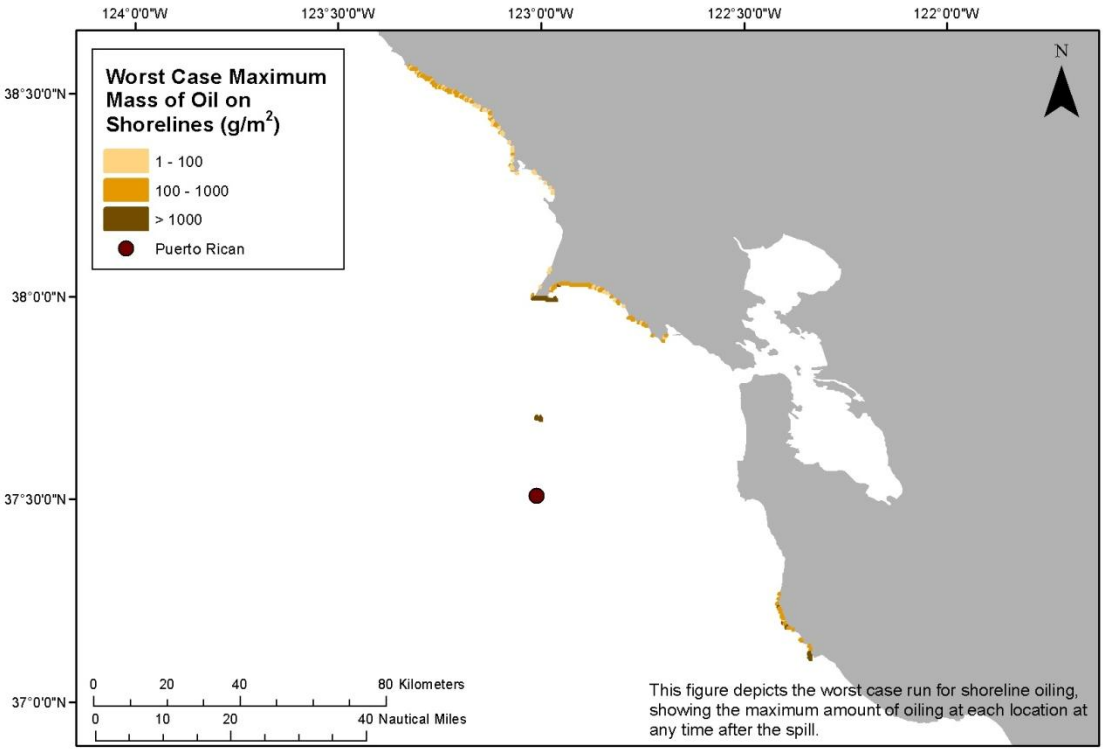



**Figure 2-7:** The extent and degree of shoreline oiling from the single model run of the Most Probable Discharge of 2,100 bbl of heavy fuel oil from the *Puerto Rican* that resulted in the greatest shoreline oiling.

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

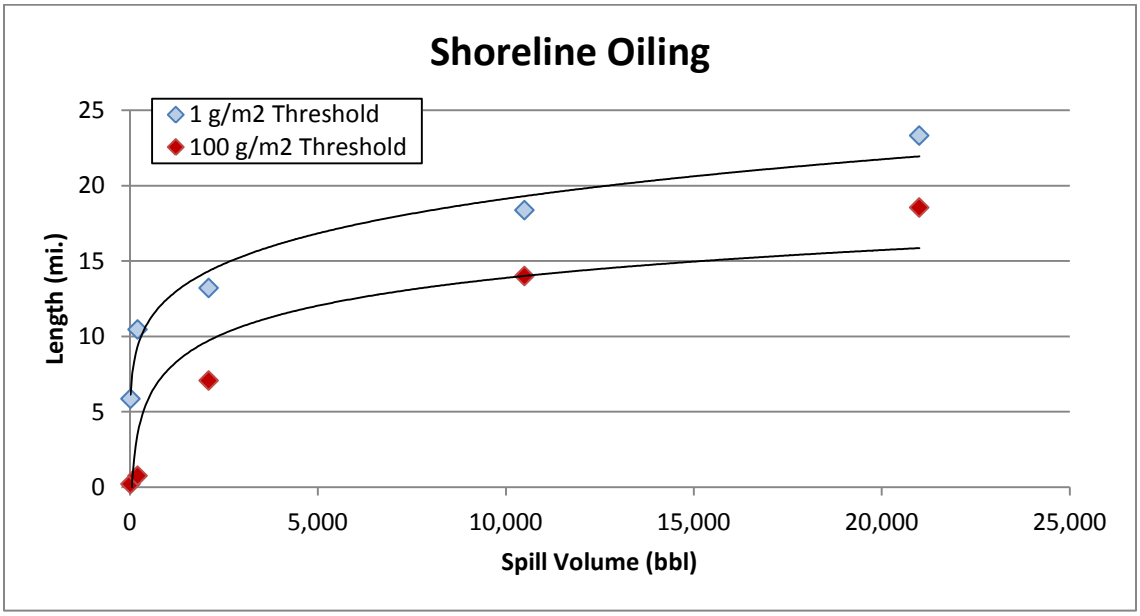



**Figure 2-8:** Regression curve for estimating the amount of shoreline oiling at different thresholds as a function of spill volume for the *Puerto Rican*.

***The worst case scenario for shoreline exposure*** along the potentially impacted area for the WCD volume (Table 2-5) and the Most Probable volume (Table 2-6) consists primarily of rocky shores, gravel beaches, and sand beaches.

**Table 2-5:** Worst case scenario shoreline impact by habitat type and oil thickness for a leakage of 21,000 bbl from the *Puerto Rican*.

| Shoreline/Habitat Type | Lighter Oiling<br>Oil Thickness <1 mm<br>Oil Thickness >1 g/m² | Heavier Oiling<br>Oil Thickness >1 mm<br>Oil Thickness >100 g/m² |
|---|---|---|
| Rocky and artificial shores/Gravel beaches | 32 miles | 15 miles |
| Sand beaches | 27 miles | 24 miles |
| Salt marshes and tidal flats | 1 mile | 0 miles |

**Table 2-6:** Worst case scenario shoreline impact by habitat type and oil thickness for a leakage of 2,100 bbl from the *Puerto Rican*.

| Shoreline/Habitat Type | Lighter Oiling<br>Oil Thickness <1 mm<br>Oil Thickness >1 g/m² | Heavier Oiling<br>Oil Thickness >1 mm<br>Oil Thickness >100 g/m² |
|---|---|---|
| Rocky and artificial shores/Gravel beaches | 11 miles | 8 miles |
| Sand beaches | 32 miles | 18 miles |
| Salt marshes and tidal flats | 0 miles | 0 miles |

# SECTION 3: ECOLOGICAL RESOURCES AT RISK

Ecological resources at risk from a catastrophic release of oil from the *Puerto Rican* include numerous guilds of birds and marine mammals (Table 3-1). Significant bird nesting colonies and marine mammal haul-out sites occur in the region. There are large numbers and dense concentrations of wintering marine birds. Dolphins and whales are commonly found in Pacific waters at high concentrations. Leatherback sea turtles forage in the area in high concentrations and will be at risk from any potential release of oil.

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

| Species Group | Species Subgroup and Geography | Seasonal Presence |
|---|---|---|
| **Birds** | Pacific waters are foraging grounds for many species<br>• Alcids, diving birds, gulls, grebes, phalaropes, and pelagic species (black-footed albatrosses, shearwaters and storm petrels)<br>• Higher diversity and concentration can be found closer to shore<br><br>Estuaries/lagoons are important habitats for wading birds, pelicans, raptors, shorebirds and waterfowl | Albatross in Dec-Aug;<br>Storm-petrels, sooty shearwater in Mar-Nov;<br>Xantus' murrelet in Jul-Oct;<br>Loons, grebes, scoters in Sep-May; |
| **Bird Nesting and Hotspots** | *Farallon Islands (numbers are counts of nesting birds):*<br>Extremely high concentrations of nesting seabirds in Farallones NMS<br>• Pigeon guillemot (>1000), rhinoceros auklet (516), tufted puffin (128), black oystercatcher (22), western gull (approx. 20,000), ashy storm-petrel (1990), Leach's storm-petrel (1400), double-crested cormorant (486), pelagic cormorant (approx. 500), Brandt's cormorant (approx. 12,000), Cassin's auklet (18,807), common murre (approx. 165,000)<br>Surrounding waters support high concentrations of diving birds, gulls and seabirds, including marbled murrelet (FT,SE) and peregrine falcon<br><br>*Points Reyes to Golden Gate Strait:*<br>Pt. Reyes National Seashore has high diversity of overwintering and migratory birds (pelagic, diving, alcids, shorebirds).<br>Nesting (number of birds):<br>• Colonial nesters (12 sites present): Ashy storm-petrel (45), black oystercatcher (12), Brandt's cormorant (1862), common murre (23,5000), pelagic cormorant (482),pigeon guillemot (920), rhinoceros auklet, tufted puffin (4), western gull (322)<br>• Western snowy plover (FT) nests on beaches<br>• California least tern (FE,SE) nesting site at Rodeo Lagoon<br>• Peregrine falcons nest at Pt. Reyes National Seashore<br>• California black rail (ST) nests in Bolinas Lagoon<br><br>*Golden Gate Strait:*<br>Nearshore waters are a hotspot for migratory grebes and scoters and overwintering loons | Common murre nests Dec-Jul, molts Jul-Sep<br><br>Other species:<br>Nesting varies but is between Feb-Nov<br><br>Adults present year round<br><br>*Nesting (months correspond to entire geography unless otherwise noted):*<br>Peregrine falcons: Feb-Jul<br>Ashy storm-petrel: Feb-Nov:<br>Brandt's cormorant, pigeon guillemot: Feb-Aug<br>California black rail: Mar-Jun<br>Western gull: Mar-Aug<br>Black oystercatcher, pelagic cormorant, western snowy plover: Mar-Sep<br>Tufted puffin: Apr-Nov<br>Rhinoceros auklet: Apr-Sep<br>Common murre: Dec-Jul<br>*Migrating*:<br>Grebes/scoters: Mar-Apr and Sep-Nov<br>Loons: Oct-May |

| Species Group | Species Subgroup and Geography | Seasonal Presence |
|---|---|---|
| **Bird Nesting and Hotspots** | *Golden Gate Straight to Moss Beach:*<br>Nesting (number of birds):<br>• Colonial nesters (6 sites present): Black oystercatcher (10), Brandt's cormorant (124), common murre (246), pelagic cormorant (84), pigeon guillemot (146), western gull (82)<br>• Western snowy plover and marbled murrelet nesting on beaches<br>• Bank swallow nesting sites<br>High concentrations of grebes, gulls, scoters, shorebirds, pelicans, low-moderate concentration of many other species | *Nesting:*<br>Bank swallow: Mar-Aug |
| | *Half Moon Bay:*<br>Nesting (number of birds):<br>• Colonial nesters (5 sites present): Black oystercatcher (1), Brandt's cormorant (37), Pelagic cormorant (245), pigeon guillemot (54), western gull (2)<br>• Marbled murrelet nesting in high concentrations<br>• Western snowy plover nesting near Ano Nuevo State Reserve<br>• Black oystercatcher and wading birds nesting in area<br>High concentrations of marbled murrelet in nearshore waters | *Nesting:*<br>Marbled murrelet: Apr-Jul<br>Wading birds: Feb-Aug<br>Black oystercatcher: Mar-Sep |
| | *Half Moon Bay to Santa Cruz:*<br>Nesting (number of birds):<br>• Colonial nesters (10 sites): Black oystercatcher (48), Brandt's cormorant (312), Cassin's auklet (24), double-crested cormorant, marbled murrelet (ft, se; 600), pelagic cormorant (261), pigeon guillemot (2046), rhinoceros auklet (225), western gull (1398)<br>• Marbled murrelet (high concentration), Western snowy plover (med-high concentrations)<br>High concentrations of marbled murrelet, common murre, seabirds, diving birds, brown pelicans in nearshore waters by Santa Cruz | *Nesting:*<br>FCassin's auklet: Feb-Aug<br>Double-crested cormorant: Mar-Aug<br>Marbled murrelet: Apr-Oct |
| | *Monterey Bay:*<br>Nesting:<br>• Monterey Bay: Black oystercatcher (4), Brandt's cormorant (2651), pelagic cormorant (207), pigeon guillemot (145), Western gull (152)<br>• California least tern (FE/SE) – N. half Monterey Bay<br>• Western gull (30), Caspian tern (20) nesting in Elkhorn slough<br>• Western snowy plover (high concentrations) nesting on S half Monterey Bay on Sandy Bay<br>High concentration of ashy storm-petrel, shearwaters and common murres and nesting species; moderate concentrations of marbled murrelet | *Nesting:*<br>Caspian tern: Apr-Aug<br>California least tern: May-Aug<br><br>*Hatching:*<br>California least tern: Apr-Sept |
| | *Carmel Highlands to Big Sur:*<br>Nesting: Black oystercatcher (55), Brandt's cormorant (7521), common murre (1663), double-crested cormorant, pelagic cormorant (269), pigeon guillemot (176), western gull (244)<br>• California condor (SE,FE) present inland from Carmel Bay to Big Sur<br>• High concentration of diving birds | *Nesting:*<br>Diving birds: Apr-Aug |
| **Reptiles** | Leatherback sea turtles (FE):<br>• High concentrations offshore of San Francisco and Point Reyes, also in Monterey Bay<br>• Med concentrations in nearshore waters<br>• Low concentrations offshore<br>Olive ridley (FT) and green (FT) sea turtles can also occur but this is outside of their normal range<br><br>Coastal streams can also be home to California red-legged frog (FT) and San | Leatherback: May-Nov |

| Species Group | Species Subgroup and Geography | Seasonal Presence |
|---|---|---|
| | Francisco garter (SE, FE) snake | |
| **Pinnipeds and Sea Otter** | Harbor seals and California sea lions are common to rocky outcroppings throughout the area. Only larger aggregations are included below.<br><br><u>Haul-out sites</u><br>*Farallon Islands*:<br>• California sea lion (1300-12000)<br>• Stellar sea lion (FT; 60-200)<br>• Northern elephant seal (200-800)<br>• Northern fur seal (20-100)<br>• Harbor seal (~150)<br><br>*Pt. Reyes*:<br>• Northern elephant seal<br>• Harbor seal (1000s)<br>• Stellar sea lion (0-13)<br>• California sea lion (11-1388)<br><br>*Double Point/Stormy Stack*: Harbor seal (~900), California sea lion (~200)<br><br>*Bolinas Lagoon and surrounding points*: Harbor seal (~500)<br><br>*Point Bonita*: Harbor seal (~100), California sea lion (30),<br>*Point Lobos (Seal rock)*: Harbor seal (~100), California sea lion (~ 350)<br>*James V. Fitzgerald Marine Reserve/Sail Rock*: Harbor seal (~200), California sea lion (94)<br><br>*Three Rocks to Eel Rocks*: Harbor seal (~350)<br>*Pescadero Point*: Harbor seal (~300)<br>*San Mateo* Coast beaches: Harbor seal (~250)<br><br>*Point Ano Nuevo/Ano Nuevo Island*<br>• California sea lion (~5000)<br>• Harbor seal (~90)<br>• Northern elephant seal<br>• Stellar sea lion<br><br>Sea otters (FT) common from Pigeon Point to Ano Nuevo (56 individuals)<br><br>*Pelican Rock and vicinity*: Harbor seal (~400) and elephant seal<br>*South of Sandhill Bluff*: Sea otter ( ~200), harbor seal (~300)<br>*Santa Cruz area*: Sea otter (190), California sea lions (~150)<br>*Southern Monterey Bay*: Sea otter (287)<br><br>*Pacific Grove*:<br>• Harbor seal (~500)<br>• California sea lion (~1100)<br>• Sea otter (~254)<br><br>*Cypress Point/Pescadero Point*:<br>• California sea lion (~600)<br>• Harbor seal (~1000)<br>• Sea otter (~91) | *Pupping:*<br>Sea otter: Jan-Mar<br>California sea lion: May-Aug<br>Northern fur seal: May-Aug<br>Harbor seal: Mar-May/Jun<br><br>Northern elephant seal<br>Pup: Dec-Mar<br>Molt: Apr/May-Jun/Jul |

| Species Group | Species Subgroup and Geography | Seasonal Presence |
|---|---|---|
| | *South Carmel Bay (Pinnacle Point to Rocky Point)*:<br>• Sea otter (~95)<br>• 1 Steller sea lion (at Lobos Rock)<br>• California sea lion (>100)<br>• Harbor seal (~200)<br><br>*Rocky Point to Point Sur*:<br>• California sea lion (~500)<br>• Sea otter (~300)<br>• Harbor seal (800) at Point Sur | |
| **Whales and dolphins** | *Coastal*: Gray whale, harbor porpoise (San Francisco stock – 8500, Monterey Bay stock – 1600), bottlenose dolphin<br><br>*Offshore*: Sei whale (FE), sperm whale (FE), *Kogia* spp., Baird's beaked whale, Cuvier's beaked whale, *Mesoplodon* spp.<br>• All but sei whale are deep-diving and feed on squid<br><br>*Found in coastal and offshore waters*: Fin whale (FE), humpback whale (FE), minke whale, northern right whale (FE), Dall's porpoise, killer whale, long-beaked common dolphin, northern right-whale dolphin, Pacific white-sided dolphin, Risso's dolphin, short-beaked common dolphin, short-finned pilot whale<br><br>*Concentration areas*:<br>• Half Moon Bay area: High concentrations of blue whales (Jun-Nov) and humpback whales (Mar-Nov)<br>• Monterey Bay area: High concentrations of dolphins, blue whale (Jun-Nov), sea lions, Dall's porpoise | *Seasonal presence:*<br>Blue whale: Jun-Nov<br>Baird's beaked whale: May-Oct<br><br>*Calving*:<br>Minke whale: Mar-May<br>Sei whale: Sep-Mar<br>Sperm whale: Jun-Aug<br><br>*Mating:*<br>Sperm whale: Jul-Sep |
| **Fish** | *Anadromous:*<br>• Coho salmon (FE/SE) – spawn in 5 streams, all north of Monterey Bay<br>• Steelhead (FT/ST) – all streams in this area are critical habitat<br>• Striped bass (nearshore May-Sep)<br>Adults concentrated in nearshore habitats Oct-Jun and further offshore from Apr-Sep<br><br>*Estuarine*:<br>• Tidewater goby (FE) nest in sand burrows in brackish estuarine areas<br>• Eelgrass beds are important nursery grounds for many species, including California halibut<br><br>*Intertidal*:<br>• California grunion spawning runs occur on sand beaches<br>• Surf smelt spawn in the upper intertidal zone of coarse sand/gravel beaches; eggs adhere to the substrate<br>• Rocky intertidal areas are habitat for monkeyface prickleback, some species of rockfish, and larval fish<br><br>*Pelagic*:<br>Important habitat for forage fish (sardine, anchovy) and large predators (white shark) and other ecologically important species<br>• Basking sharks filter feed near the surface<br>• Ocean sunfish bask in surface waters of the open ocean | *Spawning*:<br>Coho: Nov-Feb<br>Steelhead: Nov-Apr<br><br>Juveniles migrate out of coastal streams mid-Jun<br><br>California grunion spawning: Mar-Aug |

| Species Group | Species Subgroup and Geography | Seasonal Presence |
|---|---|---|
| | *Demersal (groundfish)*:<br>• Many species of rockfish (>20) are found in the area<br>• Adult rockfish and halibut spawn in deeper offshore waters in winter/spring<br>• Kelp beds are important juvenile habitat for groundfish<br>• Much of the area is groundfish Essential Fish Habitat<br>• Several areas in Monterey Bay and near Santa Cruz are rocky reef Habitat Areas of Particular Concern | |
| **Invertebrates** | Reef/kelp associated (depth ranges): Black abalone (FE; 0-20 ft), Pinto abalone (0-70 ft), red abalone (0 -100 ft), red urchin (intertidal), purple urchin (0-300 ft)<br><br>Beach/sand associated:<br>• Dungeness crab move nearshore to spawn from Pt. Reyes to Pelican Lake, at Stinson Beach, Rodeo Lagoon, and from San Francisco south to Pescadero Rock<br>• Squid – over soft bottom, 0-600+ feet<br>• Clams - Geoducks, manila, gaper, razor clam, pismo clam<br>• Bay and ocean shrimp<br><br>Areas of high invertebrate concentration or diversity:<br>• Intertidal - Bolinas area (Bolinas Point, Duxbury Point and Bolinas Lagoon), Bird Island, Moss Beach, James V. Fitzgerald Marine Reserve,<br>• *Loligo* squid spawn in nearshore waters from Moss Landing to Pacific Grove<br>• Pacific littleneck clam spawning concentration in Shelter Cove | *Mating:*<br>Dungeness crab: mate spring,<br><br>*Spawning*:<br>Dungeness crab: Jun-Sep<br>Littleneck clam: Apr-Sep<br>*Loligo* squid: May-Jun |
| **Benthic Habitats** | Large kelp beds are found near Point Reyes, Pelican Lake, Shelter Cove, Santa Cruz, Opal Cliffs, Capitola, and along the coastline from Pacific Grove to Big Sur<br><br>Eelgrass is found in Drakes Estero and Bolinas Lagoon and eastern shore of Bolinas point | Year round |

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

## Ecological Risk Factors

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

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

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

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

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

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

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

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

In the following sections, the definition of low, medium, and high for each ecological risk factor is provided. Also, the classification for the *Puerto Rican* is provided, both as text and as shading of the applicable degree of risk bullet, for the WCD release of 21,000 bbl and a border around the Most Probable Discharge of 2,100 bbl.

### Risk Factor 3A: Water Column Impacts to EcoRAR

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

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

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

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

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

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

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

The *Puerto Rican* is classified as High Risk for oiling probability for water column ecological resources for the WCD of 21,000 bbl because 100% of the model runs resulted in contamination of more than 0.2 $mi^2$ of the upper 33 feet of the water column above the threshold of 1 ppb aromatics. It is classified as Medium Risk for degree of oiling because the mean volume of water contaminated was 25 $mi^2$ of the upper 33 feet of the water column. For the Most Probable Discharge of 2,100 bbl, the *Puerto Rican* is classified as High Risk for oiling probability for water column ecological resources because 99% of the model runs resulted in contamination of more than 0.2 $mi^2$ of the upper 33 feet of the water column above the threshold of 1 ppb aromatics. It is classified as Medium Risk for degree of oiling because the mean volume of water contaminated was 1 $mi^2$ of the upper 33 feet of the water column.

#### Risk Factor 3B: Water Surface Impacts to EcoRAR

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

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

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

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

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

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

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

The *Puerto Rican* is classified as High Risk for oiling probability for water surface ecological resources for the WCD because 100% of the model runs resulted in at least 1,000 $mi^2$ of the water surface affected above the threshold of 10 $g/m^2$. It is classified as Medium Risk for degree of oiling because the mean area of water contaminated was 4,500 $mi^2$. The *Puerto Rican* is classified as High Risk for oiling probability for water surface ecological resources for the Most Probable Discharge because 52% of the model runs

resulted in at least 1,000 $mi^2$ of the water surface affected above the threshold of 10 $g/m^2$. It is classified as Medium Risk for degree of oiling because the mean area of water contaminated was 1,210 $mi^2$.

### Risk Factor 3C: Shoreline Impacts to EcoRAR

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

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

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

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

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

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

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

The *Puerto Rican* is classified as High Risk for oiling probability for shoreline ecological resources for the WCD because 74% of the model runs resulted in shorelines affected above the threshold of 100 $g/m^2$. It is classified as Medium Risk for degree of oiling because the mean weighted length of shoreline contaminated was 23 miles. The *Puerto Rican* is classified as High Risk to shoreline ecological resources for the Most Probable Discharge because 68% of the model runs resulted in shorelines affected above the threshold of 100 $g/m^2$. It is classified as Low Risk for degree of oiling because the mean weighted length of shoreline contaminated was 8 miles.

Considering the modeled risk scores and the ecological resources at risk, the ecological risk from potential releases of the WCD of 21,000 bbl of heavy fuel oil from the *Puerto Rican* is summarized as listed below and indicated in the far-right column in Table 3-2:

- Water column resources – Low, because the area of highest exposure occurs in open shelf waters without any known concentrations of sensitive upper water column resources
- Water surface resources – High, because of the seasonally very large number of wintering, nesting, and migratory birds that use ocean and coastal habitats at risk and offshore concentrations of sea turtles in the area. Historical spills have shown that even small releases can impact large numbers of marine birds in winter. It should be noted that oil on the surface will not be continuous but rather be broken and patchy and in the form of sheens, tarballs, and streamers
- Shoreline resources – Medium, because most of the likely oiled shorelines are exposed rocky shores, where oil persistence is short-term, and sand beach which are relatively easy to clean; however, many shorelines are heavily used by birds for nesting, feeding, and resting and there are many marine mammal haulouts at risk

**Table 3-2:** Ecological risk factor scores for the **Worst Case Discharge of 21,000 bbl** of heavy fuel oil from the *Puerto Rican*.

| Risk Factor | Risk Score | | | Explanation of Risk Score | Final Score |
|---|---|---|---|---|---|
| 3A-1: Water Column Probability EcoRAR Oiling | **Low** | **Medium** | **High** | 100% of the model runs resulted in at least 0.2 $mi^2$ of the upper 33 feet of the water column contaminated above 1 ppb aromatics | **Low** |
| 3A-2: Water Column Degree EcoRAR Oiling | **Low** | **Medium** | **High** | The mean volume of water contaminated above 1 ppb was 25 $mi^2$ of the upper 33 feet of the water column | |
| 3B-1: Water Surface Probability EcoRAR Oiling | **Low** | **Medium** | **High** | 100% of the model runs resulted in at least 1,000 $mi^2$ of water surface covered by at least 10 $g/m^2$ | **High** |
| 3B-2: Water Surface Degree EcoRAR Oiling | **Low** | **Medium** | **High** | The mean area of water contaminated above 10 $g/m^2$ was 4,500 $mi^2$ | |
| 3C-1: Shoreline Probability EcoRAR Oiling | **Low** | **Medium** | **High** | 74% of the model runs resulted in shoreline oiling of 100 $g/m^2$ | **Med** |
| 3C-2: Shoreline Degree EcoRAR Oiling | **Low** | **Medium** | **High** | The length of shoreline contaminated by at least 100 $g/m^2$ was 23 mi | |

For the Most Probable Discharge of 2,100 bbl, the ecological risk from potential releases of heavy fuel oil from the *Puerto Rican* is summarized as listed below and indicated in the far-right column in Table 3-3:

- Water column resources – Low, because the area of highest exposure is very small and occurs in open shelf waters without any known concentrations of sensitive upper water column resources
- Water surface resources – Medium, because of the seasonally very large number of wintering, nesting, and migratory birds that use ocean and coastal habitats at risk and offshore concentrations of sea turtles in the area. It should be noted that oil on the surface will not be continuous but rather be broken and patchy and in the form of sheens, tarballs, and streamers
- Shoreline resources – Low, because so few miles of shoreline are at risk

**Table 3-3:** Ecological risk factor scores for the **Most Probable Discharge of 2,100 bbl** of heavy fuel oil from the *Puerto Rican*.

| Risk Factor | Risk Score | | | Explanation of Risk Score | Final Score |
|---|---|---|---|---|---|
| 3A-1: Water Column Probability EcoRAR Oiling | **Low** | **Medium** | **High** | 99% of the model runs resulted in at least 0.2 $mi^2$ of the upper 33 feet of the water column contaminated above 1 ppb aromatics | **Low** |
| 3A-2: Water Column Degree EcoRAR Oiling | **Low** | **Medium** | **High** | The mean volume of water contaminated above 1 ppb was 1 $mi^2$ of the upper 33 feet of the water column | |
| 3B-1: Water Surface Probability EcoRAR Oiling | **Low** | **Medium** | **High** | 52% of the model runs resulted in at least 1,000 $mi^2$ of water surface covered by at least 10 $g/m^2$ | **Med** |
| 3B-2: Water Surface Degree EcoRAR Oiling | **Low** | **Medium** | **High** | The mean area of water contaminated above 10 $g/m^2$ was 1,200 $mi^2$ | |
| 3C-1: Shoreline Probability EcoRAR Oiling | **Low** | **Medium** | **High** | 68% of the model runs resulted in shoreline oiling of 100 $g/m^2$ | **Low** |
| 3C-2: Shoreline Degree EcoRAR Oiling | **Low** | **Medium** | **High** | The length of shoreline contaminated by at least 100 $g/m^2$ was 8 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 *Puerto Rican* include very highly utilized recreational beaches along the California coast. 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. Three national marine sanctuaries, a national park, and a national seashore are in the potential impact area. There are numerous state parks and beaches, as well as beach-front communities.

A release could impact shipping lanes that run through the area of impact into the port of San Francisco, which had 2,997 vessel port calls annually with 180.5 million tonnage.

Commercial fishing is economically important to the region. Regional commercial landings for 2010 exceeded $31.3 million.

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

Spill response costs for a release of oil from the *Puerto Rican* 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 *Puerto Rican*.

| Resource Type | Resource Name | Economic Activities |
|---|---|---|
| **Beaches** | Anchor Bay<br>Big Sur<br>Bodega Bay<br>Carmel<br>Carmel Highlands<br>Castroville<br>El Granada<br>Gualala<br>Half Moon Bay<br>Jenner<br>Monterey<br>Moss Beach<br>Pacifica | Potentially affected beach resorts and beach-front communities along the California coast 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.<br><br>Many of these recreational activities are limited to or concentrated into the late spring into early fall months. |

| Resource Type | Resource Name | Economic Activities |
|---|---|---|
| | Pebble Beach<br>Pescadero<br>Santa Cruz<br>Sea Ranch<br>Stinson Beach | |
| **National Seashores** | Point Reyes National Seashore | National seashores provide recreation for local and tourist populations as well as preserve and protect the nation's natural shoreline treasures. National seashores are coastal areas federally designated as being of natural and recreational significance as a preserved area. |
| **National Marine Sanctuaries** | Cordell Bank NMS<br>Gulf of the Farrallones NMS<br>Monterey Bay NMS | National marine sanctuaries provide unique opportunities for recreation and nature study. |
| **National Wildlife Refuges** | Farallon NWR<br>Marin Islands NWR<br>Ellicott Slough NWR<br>Salinas River NWR | National wildlife refuges in California may be impacted. These federally-managed and protected lands provide refuges and conservation areas for sensitive species and habitats. |
| **State Parks** | Andrew Molera State Park<br>Ano Nuevo State Reserve<br>Bean Hollow State Beach<br>Fort Ross State Historic Park<br>Garrapata SP<br>Grey Whale Cove SP<br>Julia Pfeiffer Burns SP<br>Manresa State Beach<br>Marina State Beach<br>Montara State Beach<br>Moss Landing State Beach<br>Mt. Tamalpais SP<br>Point Lobos State Reserve<br>Point Sur Lightstation State Historic Park<br>San Gregorio State Beach<br>Schooner Gulch State Beach | 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 state. Many of these recreational activities are limited to or concentrated into the late spring into early fall months. |
| **State Parks** | Seacliff State Beach<br>Sonoma Coast State Beach<br>Sunset State Beach<br>Tomales Bay SP<br>Twin Lakes State Beach | |
| **Tribal Lands** | Manchester-Point Arena Indian Reservation | The Manchester-Point Arena Rancheria is a federally recognized tribe of Pomo Indians in California. There is a total population of 212. |
| | Stewarts Point Indian Reservation | The Kashia band of Pomo Indians of the Stewarts Point Rancheria is a federally-recognized tribe. The population of the reservation is over 86. |
| **Commercial Fishing** | A number of fishing fleets use the surrounding waters for commercial fishing purposes. | |
| | Fort Bragg | Total Landings (2010): $6.8M |
| | Moss Landing | Total Landings (2010): $9.4M |
| | San Francisco | Total Landings (2010): $15.1M |
| **Ports** | The port of San Francisco is a significant port in the area of impact. The port call numbers below are for large vessels only. There are many more, smaller vessels (under 400 GRT) that also use these ports. | |
| | San Francisco | 2,997 port calls annually |

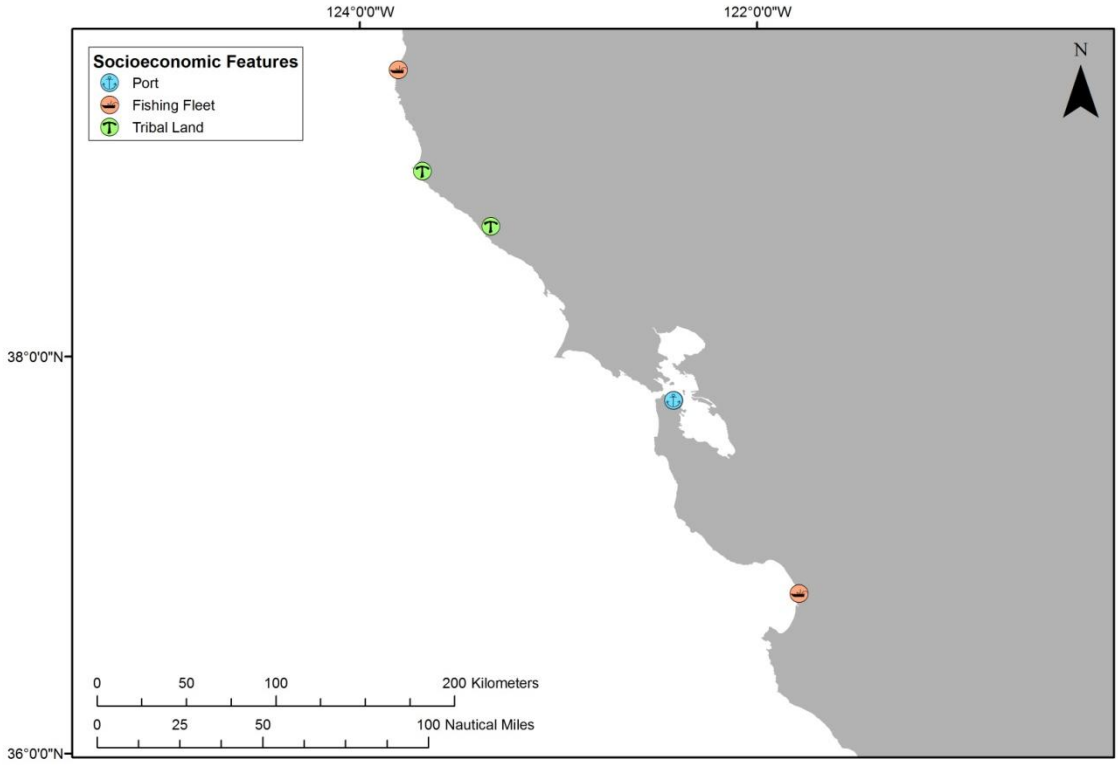



**Figure 4-1:** Tribal lands, ports, and commercial fishing fleets at risk from a release from the *Puerto Rican*.

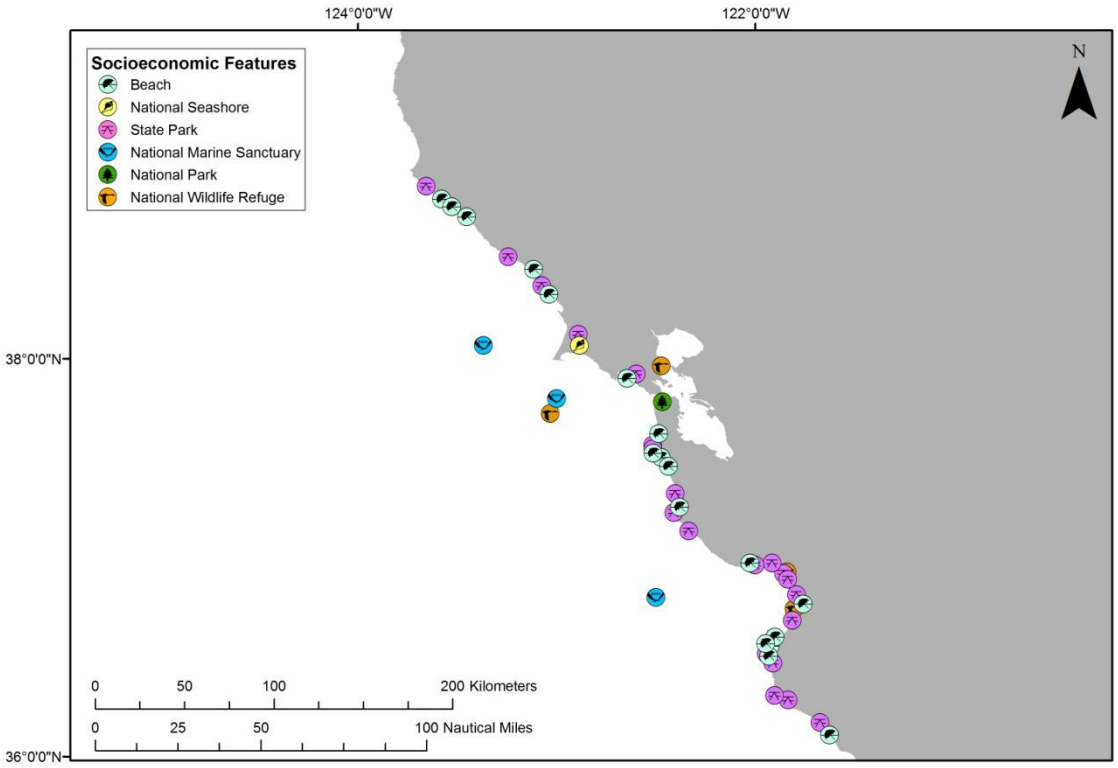



**Figure 4-2:** Beaches, coastal state parks, and Federal protected areas at risk from a release from the *Puerto Rican*.

# Socio-Economic Risk Factors

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

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

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

The impacts from an oil release from the wreck would depend greatly on the direction in which the oil slick moves, which would, in turn, depend on wind direction and currents at the time of and after the oil release. Impacts are characterized in the risk analysis based on the likelihood of any measurable impact, as well as the degree of impact that would be expected if there were one. The measure of the degree of impact is based on the median case for which there is at least some impact. The median case is the "middle case" – half of the cases with are 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 *Puerto Rican* shading indicates the degree of risk, for the WCD release of 21,000 bbl and a border indicates degree of risk for the Most Probable Discharge of 2,100 bbl.

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

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

The three risk scores for oiling are:

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

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

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

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

The *Puerto Rican* is classified as High Risk for oiling probability and Medium Risk for degree of oiling for water column socio-economic resources for the WCD of 21,000 bbl because 100% of the model runs resulted in contamination of more than 0.2 $mi^2$ of the upper 33 feet of the water column above the threshold of 1 ppb aromatics, and the mean volume of water contaminated was 25 $mi^2$ of the upper 33 feet of the water column. For the Most Probable Discharge of 2,100 bbl, the *Puerto Rican* is classified as High Risk for oiling probability for water column socio-economic resources because 99% of the model runs resulted in contamination of more than 0.2 $mi^2$ of the upper 33 feet of the water column above the threshold of 1 ppb aromatics. It is classified as Medium Risk for degree of oiling because the mean volume of water contaminated was 1 $mi^2$ of the upper 33 feet of the water column.

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

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

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

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

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

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

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

The *Puerto Rican* is classified as High Risk for oiling probability and Medium Risk for degree of oiling for water surface socio-economic resources for the WCD because 100% of the model runs resulted in at least 1,000 $mi^2$ of the water surface affected above the threshold of 0.01 $g/m^2$, and the mean area of water contaminated was 4,500 $mi^2$. The *Puerto Rican* is classified as High Risk for oiling probability for water surface socio-economic resources for the Most Probable Discharge because 52% of the model runs resulted in at least 1,000 $mi^2$ of the water surface affected above the threshold of 0.01 $g/m^2$. It is classified as Medium Risk for degree of oiling because the mean area of water contaminated was 1,200 $mi^2$.

### Risk Factor 4C: Shoreline Impacts to SRAR

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

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

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

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

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

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

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

The *Puerto Rican* is classified as High Risk for oiling probability for shoreline socio-economic resources for the WCD because 76% of the model runs resulted in shorelines affected above the threshold of 1 $g/m^2$. It is classified as Medium Risk for degree of oiling because the mean length of weighted shoreline contaminated was 63 miles. The *Puerto Rican* is classified as High Risk for oiling probability and Medium Risk for degree of oiling for shoreline socio-economic resources for the Most Probable Discharge as 75% of the model runs resulted in shorelines affected above the threshold of 1 $g/m^2$, and the mean length of weighted shoreline contaminated was 38 miles.

Considering the modeled risk scores and the socio-economic resources at risk, the socio-economic risk from potential releases of the WCD of 21,000 bbl of heavy fuel oil from the *Puerto Rican* is summarized as listed below and indicated in the far-right column in Table 4-2:

- Water column resources – Medium, because while a relatively small area of the water column would be affected, there are sensitive offshore resources at risk including national marine sanctuaries
- Water surface resources – High, because while a medium offshore water surface area would be affected, there are sensitive offshore resources at risk including national marine sanctuaries. It should be noted that oil on the surface will not be continuous but rather be broken and patchy and in the form of sheens, tarballs, and streamers
- Shoreline resources – Medium, because a moderate length of high-value and sensitive shoreline would be impacted

**Table 4-2:** Socio-economic risk factor ranks for the **Worst Case Discharge of 21,000 bbl** of heavy fuel oil from the *Puerto Rican*.

| Risk Factor | Risk Score | | | Explanation of Risk Score | Final Score |
|---|---|---|---|---|---|
| 4A-1: Water Column Probability SRAR Oiling | Low | Medium | High | 100% of the model runs resulted in at least 0.2 $mi^2$ of the upper 33 feet of the water column contaminated above 1 ppb aromatics | Med |
| 4A-2: Water Column Degree SRAR Oiling | Low | Medium | High | The mean volume of water contaminated above 1 ppb was 25 $mi^2$ of the upper 33 feet of the water column | |
| 4B-1: Water Surface Probability SRAR Oiling | Low | Medium | High | 100% of the model runs resulted in at least 1,000 $mi^2$ of water surface covered by at least 0.01 $g/m^2$ | High |
| 4B-2: Water Surface Degree SRAR Oiling | Low | Medium | High | The mean area of water contaminated above 0.01 $g/m^2$ was 4,500 $mi^2$ | |
| 4C-1: Shoreline Probability SRAR Oiling | Low | Medium | High | 76% of the model runs resulted in shoreline oiling of 1 $g/m^2$ | Med |
| 4C-2: Shoreline Degree SRAR Oiling | Low | Medium | High | The length of shoreline contaminated by at least 1 $g/m^2$ was 63 mi | |

For the Most Probable Discharge of 2,100 bbl, the socio-economic risk from potential releases of heavy fuel oil from the *Puerto Rican* is summarized as listed below and indicated in the far-right column in Table 4-3:

- Water column resources – Medium, because while a relatively small area of the water column would be affected, there are sensitive offshore resources at risk including national marine sanctuaries
- Water surface resources – Medium, because a moderate offshore water surface area would be affected where there are sensitive offshore resources at risk including national marine sanctuaries. It should be noted that oil on the surface will not be continuous but rather be broken and patchy and in the form of sheens, tarballs, and streamers
- Shoreline resources – Medium, because a moderate length of high-value and sensitive shoreline would be impacted

**Table 4-3:** Socio-economic risk factor ranks for the **Most Probable Discharge of 2,100 bbl** of heavy fuel oil from the *Puerto Rican*.

| Risk Factor | Risk Score | | | Explanation of Risk Score | Final Score |
|---|---|---|---|---|---|
| 4A-1: Water Column Probability SRAR Oiling | **Low** | **Medium** | **High** | 99% of the model runs resulted in at least 0.2 $mi^2$ of the upper 33 feet of the water column contaminated above 1 ppb aromatics | **Med** |
| 4A-2: Water Column Degree SRAR Oiling | **Low** | **Medium** | **High** | The mean volume of water contaminated above 1 ppb was 1 $mi^2$ of the upper 33 feet of the water column | |
| 4B-1: Water Surface Probability SRAR Oiling | **Low** | **Medium** | **High** | 52% of the model runs resulted in at least 1,000 $mi^2$ of water surface covered by at least 0.01 $g/m^2$ | **Med** |
| 4B-2: Water Surface Degree SRAR Oiling | **Low** | **Medium** | **High** | The mean area of water contaminated above 0.01 $g/m^2$ was 1,200 $mi^2$ | |
| 4C-1: Shoreline Probability SRAR Oiling | **Low** | **Medium** | **High** | 75% of the model runs resulted in shoreline oiling of 1 $g/m^2$ | **Med** |
| 4C-2: Shoreline Degree SRAR Oiling | **Low** | **Medium** | **High** | The length of shoreline contaminated by at least 1 $g/m^2$ was 38 mi | |

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

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

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

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

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

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

For the Worst Case Discharge, the *Puerto Rican* scores High with 15 points; for the Most Probable Discharge, the *Puerto Rican* scores Medium with 12 points. Under the National Contingency Plan, the U.S. Coast Guard and the Regional Response Team have the primary authority and responsibility to plan, prepare for, and respond to oil spills in U.S. waters. Based on the technical review of available information, NOAA proposes the following recommendations for the *Puerto Rican*. The final determination rests with the U.S. Coast Guard.

| ***Puerto Rican*** | **Possible NOAA Recommendations** |
|---|---|
| ✓ | Wreck should be considered for further assessment to determine the vessel condition, amount of oil onboard, and feasibility of oil removal action |
| | Location 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 *Puerto Rican*.

| Vessel Risk Factors | | Data Quality Score | Comments | | Risk Score |
|---|---|---|---|---|---|
| **Pollution Potential Factors** | A1: Oil Volume (total bbl) | Medium | Maximum of 20,225 bbl, not reported to be leaking | | **Med** |
| | A2: Oil Type | High | Bunker oil heavy fuel oil, a Group IV oil type | | |
| | B: Wreck Clearance | High | Vessel not reported as cleared | | |
| | C1: Burning of the Ship | High | A significant fire was reported | | |
| | C2: Oil on Water | High | Oil was reported on the water; amount is not known | | |
| | D1: Nature of Casualty | High | Explosions, fire, and structural breakup | | |
| | D2: Structural Breakup | High | The vessel broke in two at the time of sinking | | |
| **Archaeological Assessment** | Archaeological Assessment | Low | The most accurate assessment of the sinking probably comes from the U.S. Coast Guard Marine Board of Investigation Report, an accurate assessment was prepared | | **Not Scored** |
| **Operational Factors** | Wreck Orientation | Low | Currently unknown | | **Not Scored** |
| | Depth | High | 1,476 | | |
| | Visual or Remote Sensing Confirmation of Site Condition | High | The location has been surveyed | | |
| | Other Hazardous Materials Onboard | High | No | | |
| | Munitions Onboard | High | No | | |
| | Gravesite (Civilian/Military) | High | Yes | | |
| | Historical Protection Eligibility (NHPA/SMCA) | High | No | | |
| | | | | **WCD** | **Most Probable** |
| **Ecological Resources** | 3A: Water Column Resources | High | Water column impacts likely offshore in areas without known concentration areas of sensitive resources | **Low** | **Low** |
| | 3B: Water Surface Resources | High | Seasonally very large number of birds and offshore concentrations of sea turtles at risk | **High** | **Med** |
| | 3C: Shore Resources | High | At risk shorelines are mainly exposed rocky shores and sand beaches, though there are many sensitive resources | **Med** | **Low** |
| **Socio-Economic Resources** | 4A: Water Column Resources | High | While a relatively small area of the water column could be affected, there are sensitive offshore resources at risk including national marine sanctuaries | **Med** | **Med** |
| | 4B: Water Surface Resources | High | While a moderate offshore water surface area could be affected, there are sensitive offshore resources at risk including national marine sanctuaries | **High** | **Med** |
| | 4C: Shore Resources | High | Moderate length of high-value and sensitive shoreline could be impacted | **Med** | **Med** |
| **Summary Risk Scores** | | | | **15** | **12** |