Office of National Marine Sanctuaries
Office of Response and Restoration

Screening Level Risk Assessment Package

Jacob Luckenbach

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National Oceanic and
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Photo: Photograph of *Jacob Luckenbach*
Source: http://channelislands.noaa.gov/shipwreck/dbase/gfmns/jluckenbach1.html

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Project Background

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

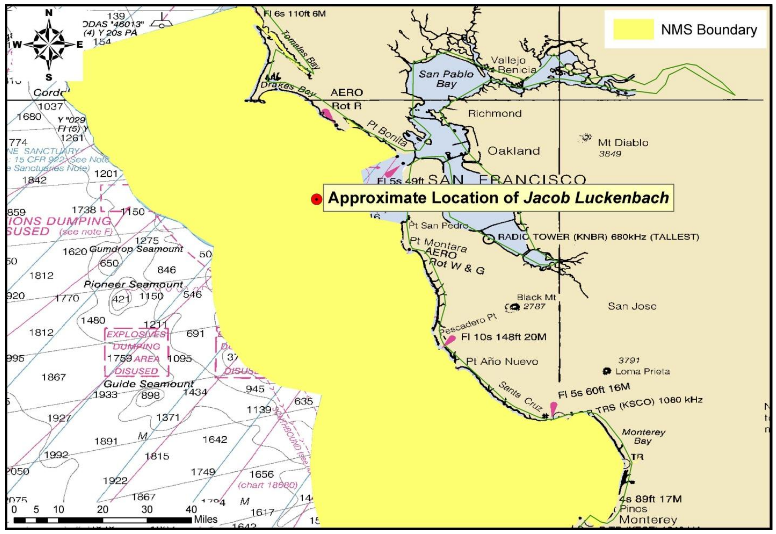
In order to narrow down the potential sites for inclusion into regional and area contingency plans, in 2010, Congress appropriated $1 million to identify the most ecologically and economically significant potentially polluting wrecks in U.S. waters. This project supports the U.S. Coast Guard and the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

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

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

Additional ongoing research has revealed that 87 wrecks pose a potential pollution threat due to the violent nature in which some ships sank and the structural reduction and demolition of those that were navigational hazards. To further screen and prioritize these vessels, risk factors and scores are applied to assess potential elements in determining risk, from the amount of oil potentially on board in fuel and cargo, to the potential ecological and environmental impacts.

Executive Summary: *Jacob Luckenbach*



The freighter *Jacob Luckenbach*, sunk after a collision off the Golden Gate, California in 1953, was identified as a potential pollution threat, thus a screening-level risk assessment was conducted. The *Jacob Luckenbach* is better studied than many wrecks and was the target of an intensive oil removal project in 2002, but some oil is known to remain on the wreck.

The different sections of this document summarize what is known about the *Jacob Luckenbach*, 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, *Jacob Luckenbach* scores High with 15 points; for the Most Probable Discharge (10% of the Worse Case volume), *Jacob Luckenbach* scores Medium with 12 points. In summer 2002, the U.S. Coast Guard and the trustees removed much oil from the vessel and sealed the remaining oil inside the vessel. Therefore, NOAA recommends that this site be reflected within the Area Contingency Plans and an active monitoring program should be implemented. Outreach efforts with the technical and recreational dive community as well as commercial and recreational fishermen who frequent the area would be helpful to gain awareness of 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: *Jacob Luckenbach*

Official Number: 246389

Vessel Type: Freighter

Vessel Class: C3-S-A2 Type Liberty Ship (8,000 gross ton class)

Former Names: *Sea Robin*

Year Built: 1944

Builder: Ingalls Shipbuilding, Pascagoula, MS

Builder's Hull Number: 411

Flag: American

Owner at Loss: Luckenbach Steamship Co.

Controlled by: Unknown

Chartered to: Pacific Far East Lines

Operated by: Pacific Far East Lines

Homeport: New York, NY

Length: 468 feet

Beam: 69 feet

Depth: 29 feet

Gross Tonnage: 7,869

Net Tonnage: 4,615

Hull Material: Steel

Hull Fastenings: Welded

Powered by: Oil-fired steam

Bunker Type: Heavy fuel oil (Bunker C)

Bunker Capacity (bbl): 10,881

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: Korea

Date Departed: July 14, 1953

Date Lost: July 14, 1953

Number of Days Sailing: < 1

Cause of Sinking: Collision

Latitude (DD): 37.67279

Longitude (DD): -122.7933

Nautical Miles to Shore: 12.47

Nautical Miles to NMS: 0

Nautical Miles to MPA: 0

Nautical Miles to Fisheries: Unknown

Approximate Water Depth (Ft): 177

Bottom Type: Unknown

Is There a Wreck at This Location? Yes, the location of the wreck has been established

Wreck Orientation: Portions of the wreck are resting on one side and parts are listed to the side

Vessel Armament: None

Cargo Carried when Lost: Miscellaneous automotives and tanks

Cargo Oil Carried (bbl): 0

Cargo Oil Type: 0

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

Fuel Type: Heavy fuel oil (Bunker C)

Total Oil Carried (bbl): ≤ 8,500

Dangerous Cargo or Munitions: Unknown

Munitions Carried: Possibly munitions destined for the Korean War

Demolished after Sinking: No

Salvaged: Yes, partially (100,000 gallons of oil removed in 2002)

Cargo Lost: Yes

Reportedly Leaking: No

Historically Significant: Unknown

Gravesite: No

Salvage Owner: Not known if any

Wreck Location

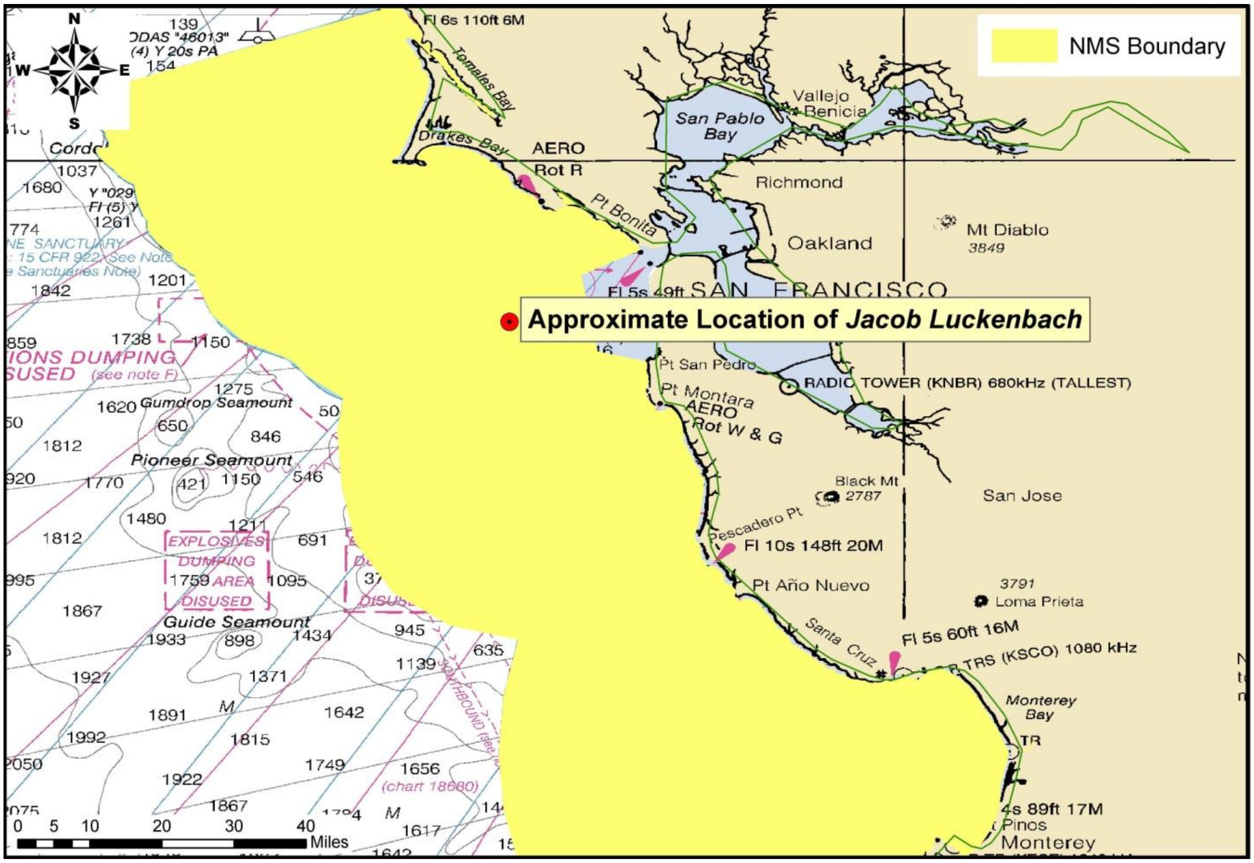


Chart Number: 18020

Casualty Narrative

"Collided with the *Hawaiian Pilot* [sister ship] in foggy conditions and sank within 30 minutes.

0440 July 14th 1953
S/S *Hawaiian Pilot* collided with the vessel -- striking her on the starboard quarter -- vessel heavily damaged in danger of sinking
1330 July 15th 1953
Casualty reports made out & turned in to U.S. Coast Guard
[Reference: Official Log of the *Jacob Luckenbach*, signed by Captain and Purser]

In this case, both vessels, operating under fog and low visibility conditions, saw each other on their radarscopes while they were miles apart. Both vessels had ample opportunity to plot a series of two or more bearings and ranges to determine the course and speed of the other. Neither vessel did this. Had the Master of the *Hawaiian Pilot* taken this precaution, he would have known that the object he mistakenly assumed to be the San Francisco Lightship on the radarscope was, in reality, the *Jacob Luckenbach*; and, collision, no doubt, would have been avoided."
-http://channelislands.noaa.gov/shipwreck/dbase/gfmns/jacobluckenbach.html

General Notes

AWOIS Data

HISTORY NM31/53(8/1/53)-- WRECK, BUOYS ESTABLISHED. THE HAVISIDE CO. ADVISES THAT TWO SMALL CAN BUOYS PAINTED ALUMINUM HAVE BEEN TEMP. EST. 430 FEET APART AT BOW AND STERN OF THE WRECK OF THE S.S. *JACOB LUCKENBACH*. APPROX. POS. 37-40-30N, 122-47-30W. MARINERS ADVISED TO KEEP CLEAR. NM32/53(8/8/53)-- WRECK OF *JACOB LUCKENBACH* HAS BEEN CHAIN DRAGGED TO A DEPTH OF 10 FMS. (SUPERSEDES NM31/53). BUOY MARKING WRECK HAS BEEN REMOVED. APPROX. POS. 37-40-24N, 122-47-36W. NM122/56 (11/20/56)-- DEPTHS LESS THAN 30 FT. REPORTED OVER CERTAIN PORTIONS OF THE WRECK OF *JACOB LUCKENBACH* LOCATED IN APPROX. LAT. 37-40.5N, LONG. 122-47.5W. CL721/53--INFO. ABOVE MADE INTO NOS CHART LETTER. CL664/68--CGD TWELVE TO COMDT. COGARD. DRAGGING AND SCUBA OPS. INDICATE MIN. DEPTH OF AT LEAST 60 FT. OVER OLD WRECK CHARTED IN POS. 37-40.3N, 122-47.6W. DIVERS REPORT BASED ON SINGLE CONTACT WITH WRECK KINGPOST INDICATES WRECK IS HEELED-OVER. ECHO SOUNDINGS INDICATE WRECK ABOUT 300 DEGS. TRUE HEADING. RECOMMEND SEA LANES DATA BE PUBLISHED AS PROPOSED AND CHARTS PRINTED. LNM26/68(4/17/68)-- HYDRO. SURVEY INDICATES OBSTRUCTION 48 FT. BELOW SURFACE. LESSER DEPTHS POSSIBLE. CAN, ORANGE/WHITE VERT. STRIPES, TEMP. EST. IN APPROX. LAT. 37-40.3N, 122-47.6W UNTIL COMPLETION OF SURVEY. LNM36/68(5/10/68)-- TWO INT. ORANGE BUOYS, PREVIOUSLY TEMP. EST. IN APPROX. POS. 37-40.3N, 122-47.6W, DISCONTINUED. CAN BUOY, ORANGE/WHITE VERT. STRIPES WILL REMAIN IN ABOVE POS. FOR ABOUT 1 WEEK. LNM37/68(5/14/68)--CAN BUOY DISCONTINUED. NM18/68--REPEATS ABOVE INFO. CL1033/68--"MINUTE MEMO" C32 TO C323 DATED 6/19/68. CG WIRE DRAG ON 6/17/68 HUNG AT 73.5 FT., CLEARED 69.5FT (PREDICTED) IN POS. LAT. 37-40.55N, LONG. 122-47.61W. .15 MILES N OF OLD CHARTED POSITION. CONSIDERED GOOD AND MUCH BETTER THAN APRIL POS. (ABOVE CL664/68) WHICH PLOTTED 0.1 S OF OLD CHARTED POS. LNM50/68(6/27/68)--USC&GS ADVISES THAT A HYDRO. SURVEY (COAST GUARD) OF WRECK CHARTED IN APPROX. POS. 37-40.3N, 122-47.6W INIDCATES A PRELIMINARY CLEARED DEPTH OF 69 FT. PRESENTLY CHARTED AS CLEARED TO 11 FATHOMS AND LABELED WK ON CHART 18645 EDITION DATED 11/24/84. CL659(85)--LNM31/85--THE WRECK OF *JACOB LUCKENBACH*,PRESENTLY CHARTED AT POS. LAT. 37-40-33N, LONG. 122-47-37W WITH LD OF 11 FMS. HAS BEEN SURVEYED AND FOUND TO BEAR 162 DEG TRUE 347M FROM CHARTED POS. AT POS. LAT.37-10-22.3N, LONG. 122-47-32.2W. LD OF 9.5F MLLW WAS OBSERVED USING AN ECHO SOUNDER. (ENTERED 2-24-86 MCR) DESCRIPTION**** MESSAGE, NOAA SHIP DAVIDSON TO 12TH CGD, ALAMEDA, CA, 11700Z JULY 1985. JACOB LUCKENBACK (SIC) LOCATED (RAYDIST CONTROL) IN LAT. 37-40-22N, LONG. 122-47-32W. BEARS 347 METERS, 162 DEGS. FROM CHARTED POS. (CHART 18645, 19TH ED.) AND 10.05NM, 99 DEGS. FROM FARALLON LIGHT (LLNR 52). LORAN-C TD'S (9940 CHAIN) 16034.2W, 27168.3X, AND 43165.2Y. MINIMUM ECHO SOUNDER DEPTH WAS 9FMS. (PREDICTED MLLW). WIRE DRAG OR DIVE LD NOT ATTEMPTED. WILL RETURN FOR LD IN SEPT., 1985 IF HEADQUARTERS CONCURS. 24 NO.1156; CARGO, 7869 GT; SUNK 7/53 BY MARINE CASUALTY; POSITION ACCURACY 1 MILE; LEAST DEPTH 30 FT (SOURCE UNK) LOCATED 10/30/53 (SOURCE UNK) **** MEMO, CONFIRMA

Wreck Condition/Salvage History

The SS *Jacob Luckenbach* is an often cited example of a potentially polluting wreck and is a landmark in the development of underwater assessment and removal technologies. Frequent mystery oil spills had oiled birds and shorelines along the central California coast for years. After a particularly large mystery spill in late 2001, the state and federal agencies established a task force to identify the source. Using a combination of oil fingerprinting, satellite imagery, and hindcast modeling, the wreck of the S.S. *Luckenbach* was identified as the source. In 2002, the U.S. Coast Guard contracted with Titan Maritime to assess, locate, and remove the remaining oil from the hull. The assessment included development of a 3-D model of the vessel. Some oil remained in the tanks, but much of the oil had migrated extensively within the wreck via corroded vents and piping, and oil was found in over 30 compartments on the vessel. Some of these compartments were inaccessible and the oil was left onboard. Removal operations were complicated by the water depths, currents, temperature, cargo, and wreck orientation, but an estimated 2,380 bbl (approx 100,000 gallons) of heavy bunker fuel were removed from the sunken vessel over the summer of 2002 (Hampton et al, 2003).

The oil removal efforts from the *Jacob Luckenbach* are well documented in a number of scientific and trade journals, contemporary newspaper articles, television documentaries, and agency reports. These reports are in general agreement on the amount of oil recovered during the cleanup, but vary widely in their estimates of the amount remaining on the wreck. Estimates range from 11,500 gallons (Habib, 2011) 29,000 gallons (Hampton et al., 2003; Luckenbach Trustee Council, 2006), to 85,000 gallons (U.S. Department of the Interior). The amount released during the sinking and during the periodic mystery spills is estimated to be "in excess of 300,000 gallons (USCG, 2008), suggesting that the amount still trapped in the hull would be less than 60,000 gallons[1]. Regardless of the estimate, there is general consensus that the remaining pockets of oil on the wreck cannot be safely removed.

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

[1] The vessel was outbound and sank shortly after loading with 456,960 gallons of fuel. If 100,000 gallons was recovered, and 300,000 spilled of the years, less than 60,000 gallons would remain.

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 *Jacob Luckenbach* for this effort as Section 106 compliance efforts were undertaken during the assessment and removal activities in 2002. 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 more records and assessment information about this wreck from the initial oil removal operations.

Background Information References

Vessel Image Sources: http://channelislands.noaa.gov/shipwreck/dbase/gfmns/jluckenbach1.html

Construction Diagrams or Plans in RULET Database? Yes, ONMS has paper capacity plans for a C3-S-A2 Type Liberty Ship

Text References:

-http://channelislands.noaa.gov/shipwreck/dbase/gfmns/jacobluckenbach.html

-AWOIS database #50130

-CA Lands Shipwreck Database #1434

-An internet search for *Jacob Luckenbach* will bring up lots of additional material

Vessel Risk Factors

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

Pollution Potential Tree

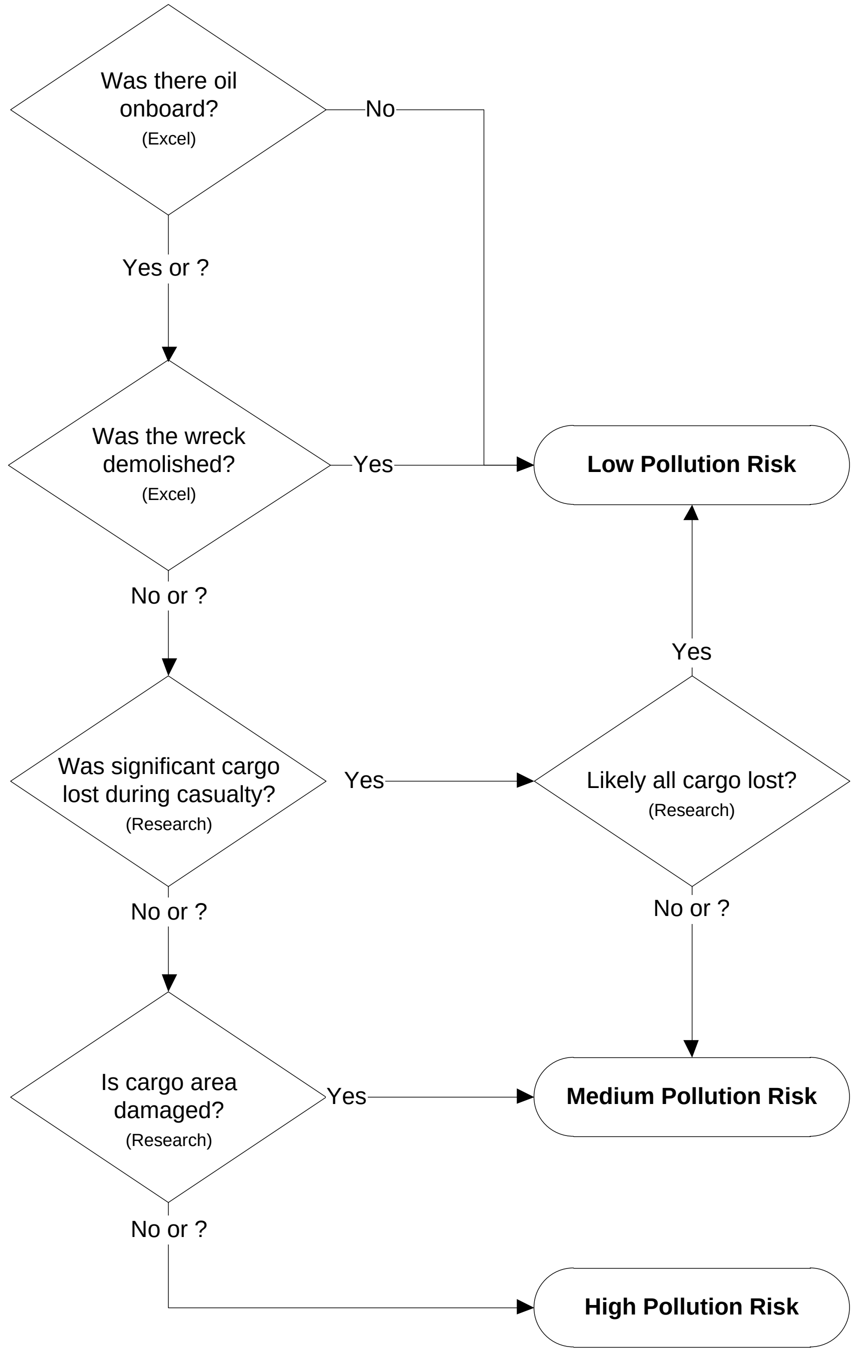


Figure 1-1: U.S. Coast Guard Salvage Engineering Response Team (SERT) developed the above Pollution Potential Decision Tree.

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

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 *Jacob Luckenbach* is provided, both as text and as shading of the applicable degree of risk bullet.

Pollution Potential Factors

Risk Factor A1: Total Oil Volume

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

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

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

The *Jacob Luckenbach i*s ranked as Medium Volume based on the estimate of 700 bbl remaining onboard after the 2002 removal actions. 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 have been multiple confirmed reports of leakage from the *Jacob Luckenbach* in the past.

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[2]. (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)

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

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

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

Was significant cargo or bunker lost during casualty?

Risk Factor C1: Burning of the Ship

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

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

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

Risk Factor C2: Reported Oil on the Water

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

- **Low Risk:** Large amounts of oil reported on the water by multiple sources
- **Medium Risk:** Moderate to little oil reported on the water during or after the sinking event
- **High Risk:** No oil reported on the water

- **Unknown:** It is not known whether or not there was oil on the water at the time of the casualty

The *Jacob Luckenbach* is classified as High Risk because no oil was known to have been reported spreading across the water as the vessel went down. Data quality is high.

Is the cargo area damaged?

Risk Factor D1: Nature of the Casualty

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

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

The *Jacob Luckenbach* is classified as High Risk because it sank as a result of a collision, and the vessel is broken into three sections. Data quality is high.

Risk Factor D2: Structural Breakup

This risk factor takes into account how many pieces the vessel broke into during the sinking event or since sinking. This factor addresses how likely it is that multiple components of a ship were broken apart including tanks, valves, and pipes. Experience has shown that even vessels broken in three large sections can still have significant pollutants on board if the sections still have some structural integrity. The risk categories are:

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

The *Jacob Luckenbach* is classified as Medium Risk because it is broken into three sections. Data quality is high.

Factors That May Impact Potential Operations

Orientation (degrees)

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

Portions of the wreck of *Jacob Luckenbach* are resting on one side and other portions are listing to the side. Data quality is high.

Depth

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

The *Jacob Luckenbach* is 175 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 *Jacob Luckenbach* is known and 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 *Jacob Luckenbach* had munitions destined for the Korean War onboard. Data quality is high.

Vessel Pollution Potential Summary

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

Table 1-1: Summary matrix for the vessel risk factors for the *Jacob Luckenbach* 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 700 bbl, reported to be leaking in the past	**Med**
	A2: Oil Type	High	Bunker oil is heavy fuel oil, a Group IV oil type	
	B: Wreck Clearance	High	Vessel not reported as cleared	
	C1: Burning of the Ship	High	No fire was reported	
	C2: Oil on Water	High	No oil was reported on the water	
	D1: Nature of Casualty	High	Collision	
	D2: Structural Breakup	High	The vessel is broken into three sections	
Archaeological Assessment	Archaeological Assessment	Low	The best assessment still comes from the initial salvage of the vessel so a detailed assessment was not prepared	**Not Scored**
Operational Factors	Wreck Orientation	High	Listing or resting on one side	**Not Scored**
	Depth	High	175 feet	
	Visual or Remote Sensing Confirmation of Site Condition	High	Wreck has been surveyed and visited by divers	
	Other Hazardous Materials Onboard	High	No	
	Munitions Onboard	High	Munitions for the Korean War	
	Gravesite (Civilian/Military)	High	No	
	Historical Protection Eligibility (NHPA/SMCA)	High	NHPA and possibly SMCA	

SECTION 2: ENVIRONMENTAL IMPACT MODELING

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

Release Scenarios Used in the Modeling
The potential volume of leakage at any point in time will tend to follow a probability distribution. Most discharges are likely to be relatively small, though there could be multiple such discharges. There is a lower probability of larger discharges, though these scenarios would cause the greatest damage. A **Worst Case Discharge** (WCD) would involve the release of all of the cargo oil and bunkers present on the vessel. In the case of the *Jacob Luckenbach* this would be about 700 bbl of Bunker C fuel oil based on current estimates of the maximum amount of oil remaining onboard the wreck after the 2002 removal actions.

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

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

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

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

Table 2-1: Potential oil release scenario types for the *Jacob Luckenbach*.

Scenario Type	Release per Episode	Time Period	Release Rate	Relative Likelihood	Response Tier
Chronic (0.1% of WCD)	1 bbl	Fairly regular intervals or constant	100 bbl over several days	More likely	Tier 1
Episodic (1% of WCD)	7 bbl	Irregular intervals	Over several hours or days	Most Probable	Tier 1-2
Most Probable (10% of WCD)	70 bbl	One-time release	Over several hours or days	Most Probable	Tier 2
Large (50% of WCD)	350 bbl	One-time release	Over several hours or days	Less likely	Tier 2-3
Worst Case	700 bbl	One-time release	Over several hours or days	Least likely	Tier 3

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

For the large and WCD scenarios, the duration of the release was assumed to be 12 hours, envisioning a storm scenario where the wreck is damaged or broken up, and the model simulations were run for a period of 30 days. The releases were assumed to be from a depth between 2-3 meters above the sea floor, using the information known about the wreck location and depth.

As discussed in the NOAA 2013 Risk Assessment for Potentially Polluting Wrecks in U.S. Waters, NOAA identified 87 high and medium priority wrecks for screening-level risk assessment. Within the available funds, it was not feasible to conduct computer model simulations of all 87 high and medium priority wrecks. Therefore, efforts were made to create “clusters” of vessels in reasonable proximity and with similar oil types. In general, the wreck with the largest potential amount of oil onboard was selected for modeling of oil release volumes, and the results were used as surrogates for the other vessels in the cluster. In particular, the regression curves created for the modeled wreck were used to determine the impacts to water column, water surface, and shoreline resources. The *Jacob Luckenbach*, with up to 700 bbl of heavy fuel onboard, was clustered with the *Puerto Rican*, which was modeled at 21,000 bbl of heavy fuel oil. Figure 2-1 shows the location of both vessels.

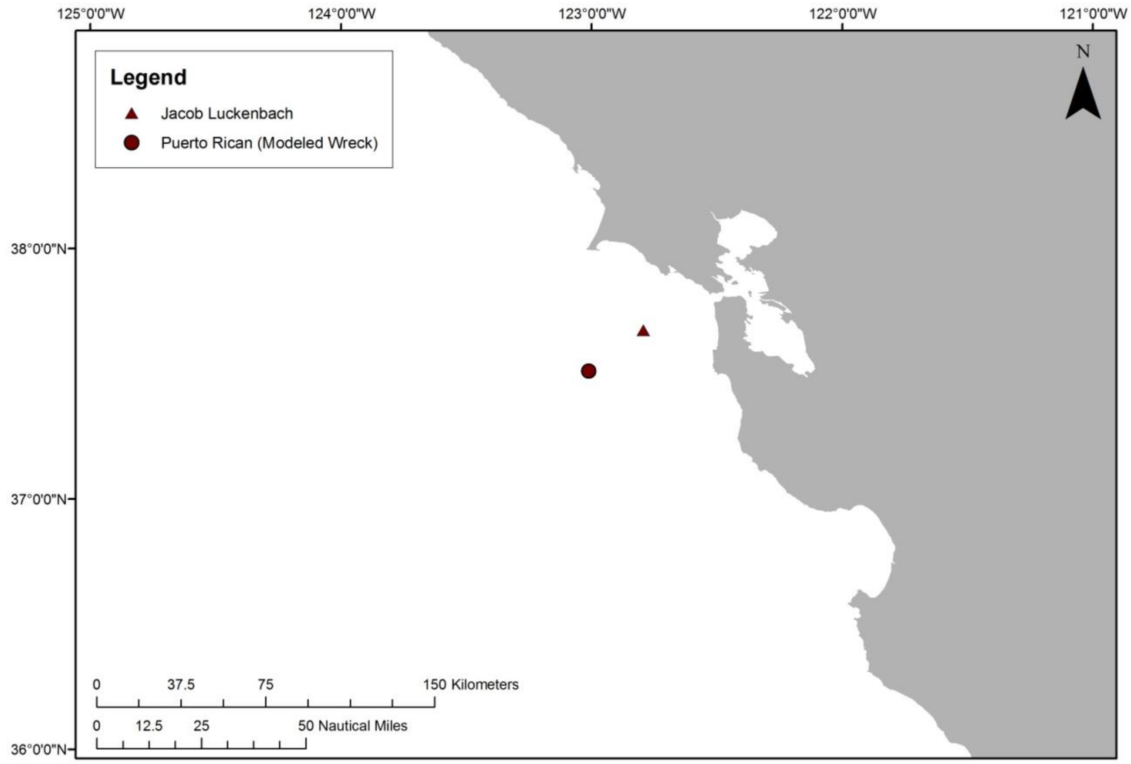


Figure 2-1: Location of the *Jacob Luckenbach* (red triangle), the wreck discussed in this package, and the *Puerto Rican* (red circle) which was the wreck that was actually modeled in the computer modeling simulations. The results for the *Puerto Rican* are used to estimate the impacts of releases from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

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 *Jacob Luckenbach* contained a maximum of 700 bbl Bunker C fuel oil as the fuel (a Group IV oil). Thus, the spill model for the *Puerto Rican*, which was run using heavy fuel oil, was used for this scoping assessment of the *Jacob Luckenbach*.

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.[3] Because oil often strands onshore as tarballs, Table 2-2a shows the number of tarballs per m^2 on the shoreline for these oil thickness thresholds, assuming that each tarball was a sphere that was 1 inch in diameter.

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

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

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

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

Potential Impacts to the Water Column

Impacts to the water column from an oil release from the *Jacob Luckenbach* 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

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

scenarios, which is shown in Figure 2-2, which is the regression curve for the *Puerto Rican*. Using this figure, the water column impacts can be estimated for any spill volume. On Figure 2-2, arrows are used to indicate the where the WCD for the *Jacob Luckenbach* plots on the curve and how the area of the water column impact is determined.

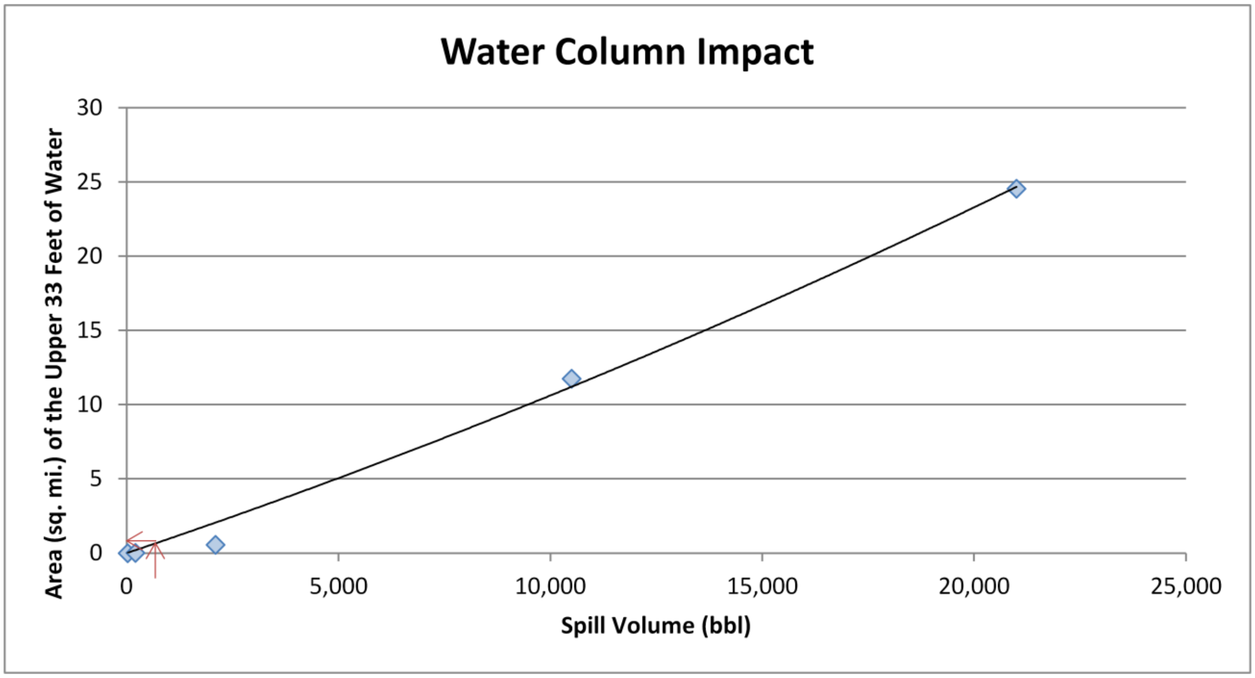


Figure 2-2: Regression curve for estimating the area of water column at or above 1 ppb aromatics impacted as a function of spill volume for the *Jacob Luckenbach*. This regression curve was generated for the *Puerto Rican*, which has the same oil type and similar volume of potential releases as the *Jacob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

Potential Water Surface Slick

The slick size from an oil release is a function of the quantity released. The estimated water surface coverage by a fresh slick (the total water surface area "swept" by oil over time) for the various scenarios is shown in Table 2-3, as the mean result of the 200 model runs for the *Puerto Rican* then using the regression curve shown in Figure 2-3 to calculate the values for the different release scenarios for the *Jacob Luckenbach*. Note that this is an estimate of total water surface affected over a 30-day period. The slick will not be continuous but rather be broken and patchy. Surface expression is likely to be in the form of sheens, tarballs, and streamers. In the model, the representative heavy fuel oil used for this analysis spreads to a minimum thickness of approximately 975 g/m^2, and the oil is not able to spread any thinner, owing to its high viscosity. As a result, water surface oiling results are identical for the 0.01 and 10 g/m^2 thresholds. The location, size, shape, and spread of the oil slick(s) from an oil release from the *Jacob Luckenbach* will depend on environmental conditions, including winds and currents, at the time of release and in its aftermath. Refer to the risk assessment package for the *Puerto Rican* for maps (Figs. 2-2 and 2-3) showing the areas potentially affected by slicks using the Most Probable volume and the socio-economic and ecological thresholds.

Table 2-3: Estimated slick area swept on water for oil release scenarios from the *Jacob Luckenbach*, based on the model results for the *Puerto Rican*.

Scenario Type	Oil Volume (bbl)	Estimated Slick Area Swept Mean of All Models 0.01 g/m2	10 g/m2
Chronic	1	17 mi2	17 mi2
Episodic	7	59 mi2	59 mi2
Most Probable	70	200 mi2	200 mi2
Large	350	480 mi2	480 mi2
Worst Case Discharge	700	700 mi2	700 mi2

The actual area affected by a release will be determined by the volume of leakage, whether it is from one or more tanks at a time. To assist planners in understanding the scale of potential impacts for different leakage volumes, a regression curve was generated for the water surface area oiled using the five volume scenarios for the *Puerto Rican*, which is shown in Figure 2-3 and referenced in Table 2-3. Using this figure, the area of water surface with a barely visible sheen can be estimated for any spill volume from the *Jacob Luckenbach*.

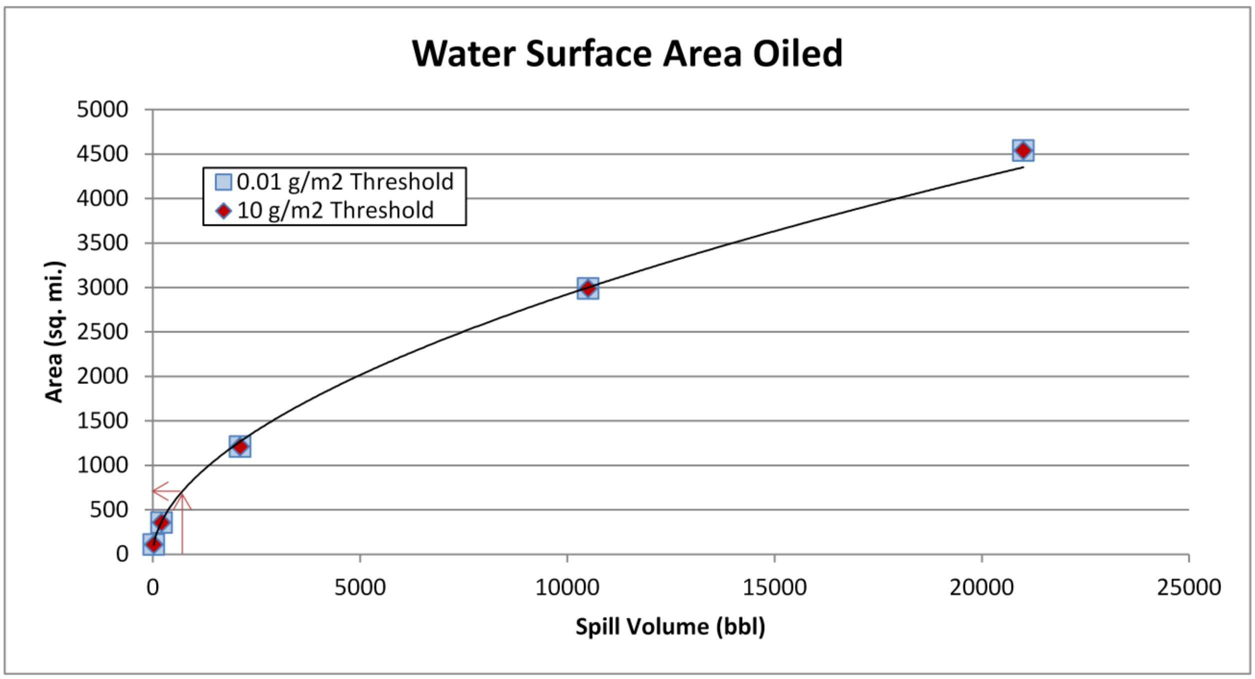


Figure 2-3: Regression curve for estimating the amount of water surface oiling as a function of spill volume for the *Jacob Luckenbach*, showing both the ecological threshold of 10 g/m2 and socio-economic threshold of 0.01 g/m2, based on the model results for the *Puerto Rican*. The arrows indicate where the WCD for the *Jacob Luckenbach* falls on the curve and how the area of water surface impact can be determined for any spill volume. 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. (Refer to Figure 2-6 in the *Puerto Rican* package to see the probability of oil stranding on the shoreline at concentrations that exceed the threshold of 1 g/m^2, for the Most Probable release). However, the specific areas that would be oiled will depend on the currents and winds at the time of the oil release(s), as well as on the amount of oil released. Estimated miles of shoreline oiling above the socio-economic threshold of 1 g/m^2 and the ecological threshold of 100 g/m^2 by scenario type are shown in Table 2-4.

Table 2-4: Estimated shoreline oiling from leakage from the *Jacob Luckenbach*, based on the modeling results for the *Puerto Rican*.

Scenario Type	Volume (bbl)	Estimated Miles of Shoreline Oiling Above 1 g/m^2	Estimated Miles of Shoreline Oiling Above 100 g/m^2
Chronic	1	3	0
Episodic	7	5	0
Most Probable	70	8	1
Large	350	10	5
Worst Case Discharge	700	12	7

The actual shore length affected by a release will be determined by the volume of leakage and environmental conditions during an actual release. To assist planners in scaling the potential impact for different leakage volumes, a regression curve was generated for the total shoreline length oiled using the five volume scenarios for the *Puerto Rican*, as detailed in Table 2-4 and shown in Figure 2-4. Using this figure, the shore length oiled can be estimated for any spill volume from the *Jacob Luckenbach*.

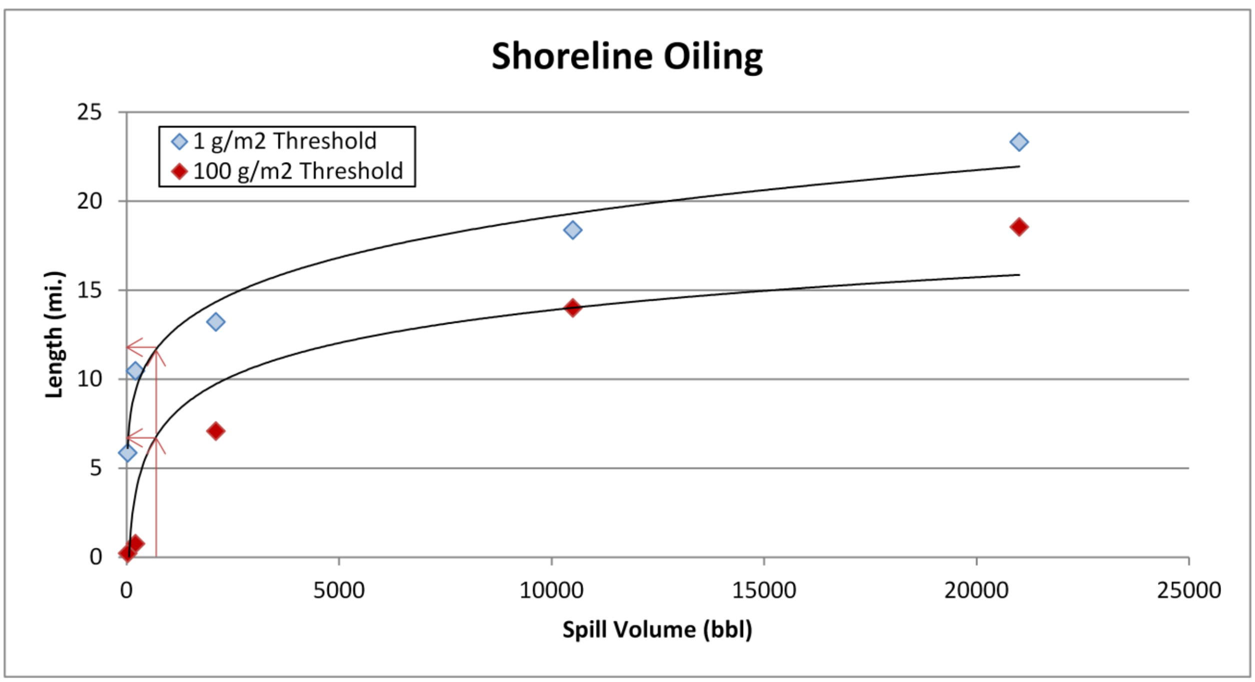


Figure 2-4: Regression curve for estimating the amount of shoreline oiling at different thresholds as a function of spill volume for the *Jacob Luckenbach*, based on the model results for the *Puerto Rican*. The arrows indicate where the WCD for the *Jacob Luckenbach* falls on the curve and how the length of shoreline impact can be determined for any spill volume.

SECTION 3: ECOLOGICAL RESOURCES AT RISK

Ecological resources at risk from a catastrophic release of oil from the *Jacob Luckenbach* include numerous guilds of birds and marine mammals (Table 3-1). Significant bird nesting colonies and 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 • Alcids, diving birds, gulls, grebes, phalaropes, and pelagic species (black-footed albatrosses, shearwaters and storm petrels) • Higher diversity and concentration can be found closer to shore Estuaries/lagoons are important habitats for wading birds, pelicans, raptors, shorebirds and waterfowl	Albatross in Dec-Aug; Storm-petrels, sooty shearwater in Mar-Nov; Xantus' murrelet in Jul-Oct; Loons, grebes, scoters in Sep-May;
Bird Nesting and Hotspots	<u>*Farallon Islands (numbers are counts of nesting birds):*</u> Extremely high concentrations of nesting seabirds in Farallones NMS • Pigeon guillemot (>1,000), rhinoceros auklet (516), tufted puffin (128), black oystercatcher (22), western gull (approx. 20,000), ashy storm-petrel (1,990), Leach's storm-petrel (1,400), double-crested cormorant (486), pelagic cormorant (approx. 500), Brandt's cormorant (approx. 12,000), Cassin's auklet (18,807), common murre (approx. 165,000) Surrounding waters support high concentrations of diving birds, gulls and seabirds, including marbled murrelet (FT,SE) and peregrine falcon	Common murre nests Dec-Jul, molts Jul-Sep Other species: Nesting varies but is between Feb-Nov Adults present year round
	<u>*Points Reyes to Golden Gate Strait*</u>: Pt. Reyes National Seashore has high diversity of overwintering and migratory birds (pelagic, diving, alcids, shorebirds). Nesting (number of birds): • Colonial nesters (12 sites present): Ashy storm-petrel (45), black oystercatcher (12), Brandt's cormorant (1862), common murre (23,5000), pelagic cormorant (482),pPigeon guillemot (920), rhinoceros auklet, tufted puffin (4), western gull (322) • Western snowy plover (FT) nests on beaches • California least tern (FE,SE) nesting site at Rodeo Lagoon • Peregrine falcons nest at Pt. Reyes National Seashore • California black rail (ST) nests in Bolinas Lagoon	*Nesting (months correspond to entire geography unless otherwise noted):* Peregrine falcons: Feb-Jul Ashy storm-petrel: Feb-Nov: Brandt's cormorant, pigeon guillemot: Feb-Aug California black rail: Mar-Jun Western gull: Mar-Aug Black oystercatcher, pelagic cormorant, western snowy plover: Mar-Sep Tufted puffin: Apr-Nov Rhinocerous auklet: Apr-Sep Common murre: Dec-Jul
	<u>*Golden Gate Strait:*</u> Nearshore waters are a hotspot for migratory grebes and scoters and overwintering loons	*Migrating*: Grebes/scoters: Mar-Apr and Sep-Nov Loons: Oct-May

Species Group	Species Subgroup and Geography	Seasonal Presence
Bird Nesting and Hotspots	*Golden Gate Straight to Moss Beach:* Nesting (number of birds): • Colonial nesters (6 sites present): Black oystercatcher (10), Brandt's cormorant (124), common murre (246), pelagic cormorant (84), pigeon guillemot (146), western gull (82) • Western snowy plover and marbled murrelet nesting on beaches • Bank swallow nesting sites High concentrations of grebes, gulls, scoters, shorebirds, pelicans, low-moderate concentration of many other species	*Nesting:* Bank swallow: Mar-Aug
	Half Moon Bay: Nesting (number of birds): • Colonial nesters (5 sites present): Black oystercatcher (1), Brandt's cormorant (37), Pelagic cormorant (245), pigeon guillemot (54), western gull (2) • Marbled murrelet nesting in high concentrations • Western snowy plover nesting near Ano Nuevo State Reserve • Black oystercatcher and wading birds nesting in area High concentrations of marbled murrelet in nearshore waters	*Nesting:* Marbled murrelet: Apr-Jul Wading birds: Feb-Aug Black oystercatcher: Mar-Sep
	Half Moon Bay to Santa Cruz: Nesting (number of birds): • 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) • Marbled murrelet (high concentration), Western snowy plover (med-high concentrations) High concentrations of marbled murrelet, common murre, seabirds, diving birds, brown pelicans in nearshore waters by Santa Cruz	*Nesting:* FCassin's auklet: Feb-Aug Double-crested cormorant: Mar-Aug Marbled murrelet: Apr-Oct
	Monterey Bay: Nesting: • Monterey Bay: Black oystercatcher (4), Brandt's cormorant (2651), pelagic cormorant (207), pigeon guillemot (145), Western gull (152) • California least tern (FE/SE) – N. half Monterey Bay • Western gull (30), Caspian tern (20) nesting in Elkhorn slough • Western snowy plover (high concentrations) nesting on S half Monterey Bay on Sandy Bay High concentration of ashy storm-petrel, shearwaters and common murres and nesting species; moderate concentrations of marbled murrelet	*Nesting:* Caspian tern: Apr-Aug California least tern: May-Aug *Hatching:* California least tern: Apr-Sept
	Carmel Highlands to Big Sur: Nesting: Black oystercatcher (55), Brandt's cormorant (7,521), common murre (1,663), double-crested cormorant, pelagic cormorant (269), pigeon guillemot (176), western gull (244) • California condor (SE,FE) present inland from Carmel Bay to Big Sur • High concentration of diving birds	*Nesting:* Diving birds: Apr-Aug
Reptiles	Leatherback sea turtles (FE): • High concentrations offshore of San Francisco and Point Reyes, also in Monterey Bay • Med concentrations in nearshore waters	Leatherback: May-Nov

Species Group	Species Subgroup and Geography	Seasonal Presence
	• Low concentrations offshore Olive ridley (FT) and green (FT) sea turtles can also occur but this is outside of their normal range Coastal streams can also be home to California red-legged frog (FT) and San 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. <u>Haul-out sites</u> *Farallon Islands*: • California sea lion (1,300-12,000) • Stellar sea lion (FT; 60-200) • Northern elephant seal (200-800) • Northern fur seal (20-100) • Harbor seal (~150) *Pt. Reyes*: • Northern elephant seal • Harbor seal (1,000s) • Stellar sea lion (0-13) • California sea lion (11-1,388) *Double Point/Stormy Stack*: Harbor seal (~900), California sea lion (~200) *Bolinas Lagoon and surrounding points*: Harbor seal (~500) *Point Bonita*: Harbor seal (~100), California sea lion (30), *Point Lobos (Seal rock)*: Harbor seal (~100), California sea lion (~ 350) *James V. Fitzgerald Marine Reserve/Sail Rock*: Harbor seal (~200), California sea lion (94) *Three Rocks to Eel Rocks*: Harbor seal (~350) *Pescadero Point*: Harbor seal (~300) *San Mateo* Coast beaches: Harbor seal (~250) *Point Ano Nuevo/Ano Nuevo Island* • California sea lion (~5,000) • Harbor seal (~90) • Northern elephant seal • Stellar sea lion Sea otters (FT) common from Pigeon Point to Ano Nuevo (56 individuals) *Pelican Rock and vicinity*: Harbor seal (~400) and elephant seal *South of Sandhill Bluff*: Sea otter (~200), harbor seal (~300) *Santa Cruz area*: Sea otter (190), California sea lions (~150) *Southern Monterey Bay*: Sea otter (287)	*Pupping:* Sea otter: Jan-Mar California sea lion: May-Aug Northern fur seal: May-Aug Harbor seal: Mar-May/Jun Northern elephant seal Pup: Dec-Mar Molt: Apr/May-Jun/Jul

Species Group	Species Subgroup and Geography	Seasonal Presence
	Pacific Grove: • Harbor seal (~500) • California sea lion (~1,100) • Sea otter (~254) *Cypress Point/Pescadero Point*: • California sea lion (~600) • Harbor seal (~1,000) • Sea otter (~91) *South Carmel Bay (Pinnacle Point to Rocky Point)*: • Sea otter (~95) • 1 Steller sea lion (at Lobos Rock) • California sea lion (>100) • Harbor seal (~200) *Rocky Point to Point Sur*: • California sea lion (~500) • Sea otter (~300) • Harbor seal (800) at Point Sur	
Whales and dolphins	*Coastal*: Gray whale, harbor porpoise (San Francisco stock – 8,500, Monterey Bay stock – 1,600), bottlenose dolphin *Offshore*: Sei whale (FE), sperm whale (FE), *Kogia* spp., Baird's beaked whale, Cuvier's beaked whale, *Mesoplodon* spp. • All but sei whale are deep-diving and feed on squid *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 *Concentration areas*: • Half Moon Bay area: High concentrations of blue whales (Jun-Nov) and humpback whales (Mar-Nov) • Monterey Bay area: High concentrations of dolphins, blue whale (Jun-Nov), sea lions, Dall's porpoise	*Seasonal presence:* Blue whale: Jun-Nov Baird's beaked whale: May-Oct *Calving*: Minke whale: Mar-May Sei whale: Sep-Mar Sperm whale: Jun-Aug *Mating:* Sperm whale: Jul-Sep
Fish	<u>*Anadromous:*</u> • Coho salmon (FE/SE) – spawn in 5 streams, all north of Monterey Bay • Steelhead (FT/ST) – all streams in this area are critical habitat • Striped bass (nearshore May-Sep) Adults concentrated in nearshore habitats Oct-Jun and further offshore from Apr-Sep <u>*Estuarine*</u>: • Tidewater goby (FE) nest in sand burrows in brackish estuarine areas • Eelgrass beds are important nursery grounds for many species, including California halibut	*Spawning*: Coho: Nov-Feb Steelhead: Nov-Apr Juveniles migrate out of coastal streams mid-Jun

Species Group	Species Subgroup and Geography	Seasonal Presence
	<u>*Intertidal*</u>: • California grunion spawning runs occur on sand beaches • Surf smelt spawn in the upper intertidal zone of coarse sand/gravel beaches; eggs adhere to the substrate • Rocky intertidal areas are habitat for monkeyface prickleback, some species of rockfish, and larval fish <u>*Pelagic*</u>: Important habitat for forage fish (sardine, anchovy) and large predators (white shark) and other ecologically important species • Basking sharks filter feed near the surface • Ocean sunfish bask in surface waters of the open ocean <u>*Demersal (groundfish)*</u>: • Many species of rockfish (>20) are found in the area • Adult rockfish and halibut spawn in deeper offshore waters in winter/spring • Kelp beds are important juvenile habitat for groundfish • Much of the area is groundfish Essential Fish Habitat • Several areas in Monterey Bay and near Santa Cruz are rocky reef Habitat Areas of Particular Concern	California grunion spawning: Mar-Aug
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) Beach/sand associated: • 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 • Squid – over soft bottom, 0-600+ feet • Clams - Geoducks, manila, gaper, razor clam, pismo clam • Bay and ocean shrimp Areas of high invertebrate concentration or diversity: • Intertidal - Bolinas area (Bolinas Point, Duxbury Point and Bolinas Lagoon), Bird Island, Moss Beach, James V. Fitzgerald Marine Reserve, • *Loligo* squid spawn in nearshore waters from Moss Landing to Pacific Grove • Pacific littleneck clam spawning concentration in Shelter Cove	*Mating:* Dungeness crab: mate spring, *Spawning*: Dungeness crab: Jun-Sep Littleneck clam: Apr-Sep *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 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 *Jacob Luckenbach* are generally available at each U.S. Coast Guard Sector. They can also be downloaded at: http://response.restoration.noaa.gov/esi. These maps show detailed spatial information on the distribution of sensitive shoreline habitats, biological resources, and human-use resources. The tables on the back of the maps provide more detailed life-history information for each species and location. The ESI atlases should be consulted to assess the potential environmental resources at risk for specific spill scenarios. In addition, the Geographic Response Plans within the Area Contingency Plans prepared by the Area Committee for each U.S. Coast Guard Sector have detailed information on the nearshore and shoreline ecological resources at risk and should be consulted.

Ecological Risk Factors

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

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

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

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

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

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

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

In the following sections, the definition of low, medium, and high for each ecological risk factor is provided. Also, the classification for the *Jacob Luckenbach* is provided, both as text and as shading of the applicable degree of risk bullet, for the WCD release of 700 bbl and a border around the Most Probable Discharge of 70 bbl. Please note: The probability of oiling cannot be determined using the regression curves; probability can only be determined from the 200 model runs. Thus, the modeling results and regression curves for the *Puerto Rican* are used to estimate the values used in the risk scoring for the **degree of oiling only**.

Risk Factor 3A: Water Column Impacts to EcoRAR

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

Risk Factor 3A-1: Water Column Probability of Oiling of EcoRAR (not scored)

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

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

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

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

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

The *Jacob Luckenbach* is classified as Medium Risk for degree of oiling for water column ecological resources for the WCD of 700 bbl because the mean volume of water contaminated in the model runs was 12 mi^2 of the upper 33 feet of the water column. For the Most Probable Discharge of 70 bbl, the *Jacob Luckenbach* 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 (not scored)

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

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

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

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

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

The *Jacob Luckenbach* is classified as Medium Risk for degree of oiling for water surface ecological resources for the WCD because the mean area of water contaminated in the model runs was 3,100 mi^2. It is classified as Low Risk for degree of oiling for the Most Probable Discharge because the mean area of water contaminated was 900 mi^2.

Risk Factor 3C: Shoreline Impacts to EcoRAR

The impacts to different types of shorelines vary based on their type and the organisms that live on them. For the modeled wrecks, shorelines were weighted by their degree of sensitivity to oiling. Wetlands are the most sensitive (weighted as "3" in the impact modeling), rocky and gravel shores are moderately sensitive (weighted as "2"), and sand beaches (weighted as "1") are the least sensitive to ecological impacts of oil. <u>In this risk analysis for the *Jacob Luckenbach*, shorelines have NOT been weighted by their degree of sensitivity to oiling because these data are available only for modeled vessels. Therefore, the impacts are evaluated only on the total number of shoreline miles oiled as determined from the regression curve</u>.

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

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

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

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

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

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

The *Jacob Luckenbach* is classified as Medium Risk for degree of oiling for shoreline ecological resources for the WCD because the mean length of shoreline contaminated in the model runs was 14 miles. It is classified as Low Risk for degree of oiling for the Most Probable Discharge because the mean length of shoreline contaminated in the model runs was 8 miles.

Considering the modeled risk scores and the ecological resources at risk, the ecological risk from potential releases of the WCD of 700 bbl of heavy fuel oil from the *Jacob Luckenbach* 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 700 bbl** of heavy fuel oil from the *Jacob Luckenbach*.

Risk Factor	Risk Score			Explanation of Risk Score	Final Score
3A-1: Water Column Probability EcoRAR Oiling	Low	Medium	High	N/A: Only available for modeled vessels	Low
3A-2: Water Column Degree EcoRAR Oiling	Low	**Medium**	High	The mean volume of water contaminated above 1 ppb was 12 mi^2 of the upper 33 feet of the water column	
3B-1: Water Surface Probability EcoRAR Oiling	Low	Medium	High	N/A: Only available for modeled vessels	High
3B-2: Water Surface Degree EcoRAR Oiling	Low	**Medium**	High	The mean area of water contaminated above 10 g/m^2 was 3,100 mi^2	
3C-1: Shoreline Probability EcoRAR Oiling	Low	Medium	High	N/A: Only available for modeled vessels	Med
3C-2: Shoreline Degree EcoRAR Oiling	Low	**Medium**	High	The length of shoreline contaminated by at least 100 g/m^2 was 14 mi	

For the Most Probable Discharge of 70 bbl of heavy fuel oil, the ecological risk from potential releases from the *Jacob Luckenbach* is summarized 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. 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 – Low, because so few miles of shoreline are at risk

Table 3-3: Ecological risk factor scores for the **Most Probable Discharge of 70 bbl** of heavy fuel oil from the *Jacob Luckenbach*.

Risk Factor	Risk Score			Explanation of Risk Score	Final Score
3A-1: Water Column Probability EcoRAR Oiling	Low	Medium	High	N/A: Only available for modeled vessels	Low
3A-2: Water Column Degree EcoRAR Oiling	Low	**Medium**	High	The mean volume of water contaminated above 1 ppb was 1 mi^2 of the upper 33 feet of the water column	
3B-1: Water Surface Probability EcoRAR Oiling	Low	Medium	High	N/A: Only available for modeled vessels	Med
3B-2: Water Surface Degree EcoRAR Oiling	**Low**	Medium	High	The mean area of water contaminated above 10 g/m^2 was 900 mi^2	
3C-1: Shoreline Probability EcoRAR Oiling	Low	Medium	High	N/A: Only available for modeled vessels	Low
3C-2: Shoreline Degree EcoRAR Oiling	**Low**	Medium	High	The length of shoreline contaminated by at least 100 g/m^2 was 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 *Jacob Luckenbach* include 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, which accommodate 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. A release could impact fishing fleets where 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.

Spill response costs for a release of oil from the *Jacob Luckenbach* 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 *Jacob Luckenbach*.

Resource Type	Resource Name	Economic Activities
Tourist Beaches	Anchor Bay Big Sur Bodega Bay Carmel Carmel Highlands Castroville El Granada Gualala Half Moon Bay Jenner Monterey Moss Beach Pacifica Pebble Beach Pescadero Santa Cruz Sea Ranch	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. Many of these recreational activities are limited to or concentrated into the late spring through the early fall months.

Resource Type	Resource Name	Economic Activities
	Stinson Beach	
National Seashores	Point Reyes National Seashore	National seashores provide recreation for local and tourist populations while preserving and protecting the nation's natural shoreline treasures. National seashores are coastal areas federally designated as being of natural and recreational significance as a preserved area.
National Marine Sanctuaries	Cordell Bank NMS Gulf of the Farrallones NMS Monterey Bay NMS	National marine sanctuaries provide unique opportunities for recreation and nature study.
National Wildlife Refuges	Farallon NWR Marin Islands NWR Ellicott Slough NWR 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 Ano Nuevo State Reserve Bean Hollow State Beach Fort Ross State Historic Park Garrapata SP Grey Whale Cove SP Julia Pfeiffer Burns SP Manresa State Beach Marina State Beach Montara State Beach Moss Landing State Beach Mt. Tamalpais SP Point Lobos State Reserve Point Sur Lightstation State Historic Park San Gregorio State Beach Schooner Gulch State Beach Seacliff State Beach Sonoma Coast State Beach Sunset State Beach Tomales Bay SP Twin Lakes 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.
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

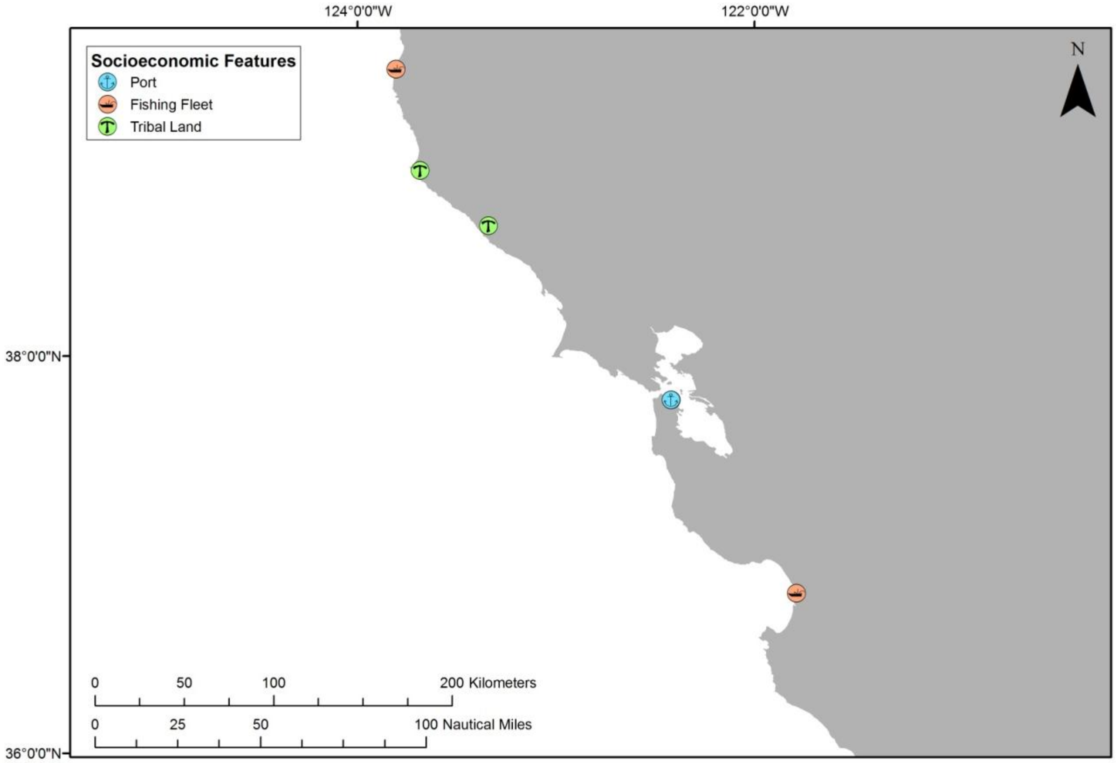


Figure 4-1: Tribal lands, ports, and commercial fishing fleets at risk from a release from the *Jacob Luckenbach*.

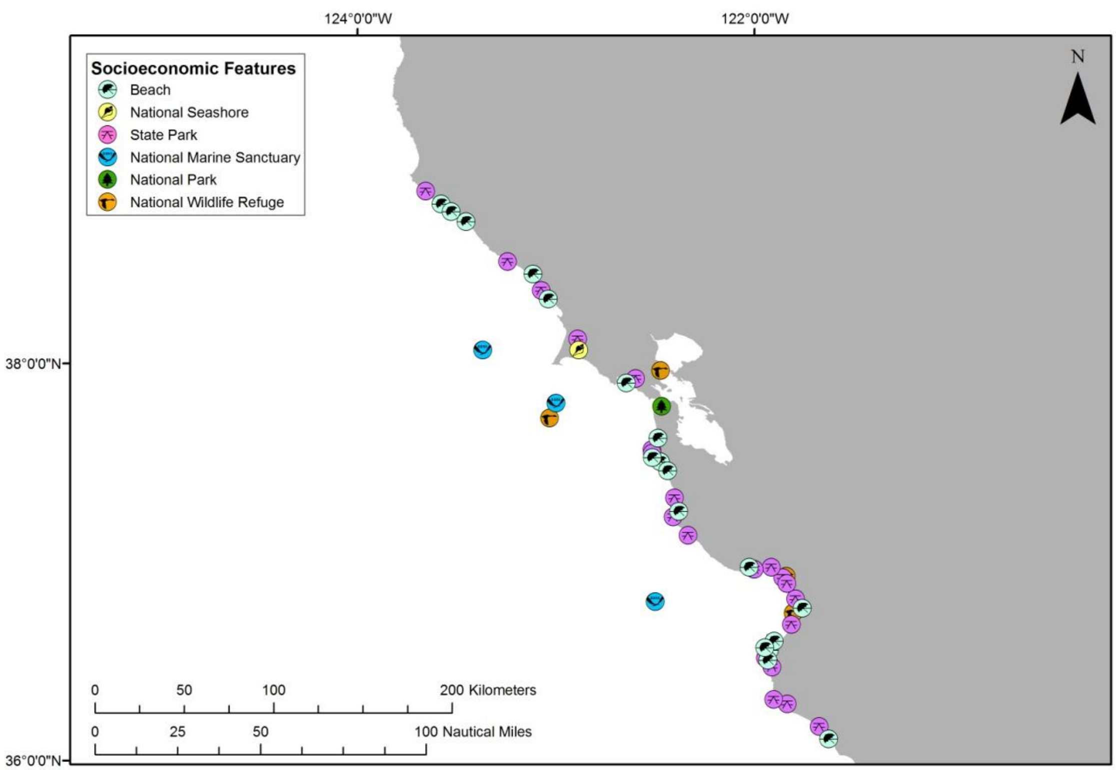


Figure 4-2: Beaches, coastal state parks, and Federal protected areas at risk from a release from the *Jacob Luckenbach*.

Socio-Economic Risk Factors

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

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

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

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

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

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

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

In the following sections, the definition of low, medium, and high for each socio-economic risk factor is provided. Also, in the text classification for the *Jacob Luckenbach*, shading indicates the degree of risk for a WCD release of 700 bbl and a border indicates degree of risk for the Most Probable Discharge of 70 bbl. Please note: The probability of oiling cannot be determined using the regression curves; probability can only be determined from the 200 model runs. Thus, the modeling results and regression curves for the *Puerto Rican* are used to estimate the values used in the risk scoring for the **degree of oiling only**.

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

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

The three risk scores for oiling are:

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

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

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

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

The *Jacob Luckenbach* is classified as Medium Risk for degree of oiling for water column socio-economic resources for the WCD of 700 bbl because the mean volume of water contaminated in the model runs was 12 mi^2 of the upper 33 feet of the water column. For the Most Probable Discharge of 70 bbl, the *Jacob Luckenbach* 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 (not scored)

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

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

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

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

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

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

The *Jacob Luckenbach* is classified as Medium Risk for degree of oiling for water surface socio-economic resources for the WCD because the mean area of water contaminated in the model runs was 3,100 mi^2. The *Jacob Luckenbach* is classified as Low Risk for degree of oiling for water surface socio-economic resources for the Most Probable Discharge because the mean area of water contaminated was 900 mi^2.

Risk Factor 4C: Shoreline Impacts to SRAR

The impacts to different types of shorelines vary based on economic value. For the modeled wrecks, shorelines have been weighted by their degree of sensitivity to oiling. Sand beaches are the most economically valued shorelines (weighted as “3” in the impact analysis), rocky and gravel shores are moderately valued (weighted as “2”), and wetlands are the least economically valued shorelines (weighted as “1”). In this risk analysis for the *Jacob Luckenbach*, shorelines have NOT been weighted by their degree of sensitivity to oiling because these data are available only for modeled vessels. Therefore, the impacts are evaluated only on the total number of shoreline miles oiled as determined from the regression curve.

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

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

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

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

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

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

The *Jacob Luckenbach* is classified as Medium Risk for degree of oiling for shoreline socio-economic resources for the WCD because the mean length of shoreline contaminated in the model runs was 19 miles. The *Jacob Luckenbach* is classified as Medium Risk for degree of oiling for shoreline socio-economic resources for the Most Probable Discharge because the mean length of shoreline contaminated was 13 miles.

Considering the modeled risk scores and the socio-economic resources at risk, the socio-economic risk from potential releases of the WCD of 700 bbl of heavy fuel oil from the *Jacob Luckenbach* 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 moderate 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 700 bbl** of heavy fuel oil from the *Jacob Luckenbach*.

Risk Factor	Risk Score			Explanation of Risk Score	Final Score
4A-1: Water Column Probability SRAR Oiling	Low	Medium	High	N/A: Only available for modeled vessels	Med
4A-2: Water Column Degree SRAR Oiling	Low	**Medium**	High	The mean volume of water contaminated above 1 ppb was 12 mi^2 of the upper 33 feet of the water column	
4B-1: Water Surface Probability SRAR Oiling	Low	Medium	High	N/A: Only available for modeled vessels	High
4B-2: Water Surface Degree SRAR Oiling	Low	**Medium**	High	The mean area of water contaminated above 0.01 g/m^2 was 3,100 mi^2	
4C-1: Shoreline Probability SRAR Oiling	Low	Medium	High	N/A: Only available for modeled vessels	Med
4C-2: Shoreline Degree SRAR Oiling	Low	**Medium**	High	The length of shoreline contaminated by at least 1 g/m^2 was 19 mi	

For the Most Probable Discharge of 70 bbl, the socio-economic risk from potential releases of heavy fuel oil from the *Jacob Luckenbach* is listed below and indicated in the far-right column in Table 4-3:

- Water column resources – Medium, because while a 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 while a relatively small 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 4-3: Socio-economic risk factor ranks for the **Most Probable Discharge of 70 bbl** of heavy fuel oil from the *Jacob Luckenbach*.

Risk Factor	Risk Score			Explanation of Risk Score	Final Score
4A-1: Water Column Probability SRAR Oiling	**Low**	**Medium**	**High**	N/A: Only available for modeled vessels	**Med**
4A-2: Water Column Degree SRAR Oiling	**Low**	**Medium**	**High**	The mean volume of water contaminated above 1 ppb was 1 mi^2 of the upper 33 feet of the water column	
4B-1: Water Surface Probability SRAR Oiling	**Low**	**Medium**	**High**	N/A: Only available for modeled vessels	**Med**
4B-2: Water Surface Degree SRAR Oiling	**Low**	**Medium**	**High**	The mean area of water contaminated above 0.01 g/m^2 was 895 mi^2	
4C-1: Shoreline Probability SRAR Oiling	**Low**	**Medium**	**High**	N/A: Only available for modeled vessels	**Med**
4C-2: Shoreline Degree SRAR Oiling	**Low**	**Medium**	**High**	The length of shoreline contaminated by at least 1 g/m^2 was 13 mi	

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

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

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

Table 5-1 summarizes the screening-level risk assessment scores for the different risk factors, as discussed in the previous sections. As noted in Sections 3 and 4, each of the ecological and socio-economic risk factors each has two components, probability and degree. Of those two, degree is given more weight in deciding the combined score for an individual factor, e.g., a high probability and medium degree score would result in a medium overall for that factor. Please note: <u>The probability of oiling cannot be determined using the regression curves; probability can only be determined from the 200 model runs. Thus, the modeling results and regression curves for the *Puerto Rican* were used to estimate the values used in the risk scoring for the **degree of oiling only**</u>.

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, *Jacob Luckenbach* scores High with 15 points; for the Most Probable Discharge, *Jacob Luckenbach* 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 *Jacob Luckenbach*. The final determination of what type of action, if any, rests with the U.S. Coast Guard.

Jacob Luckenbach	**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 *Jacob Luckenbach*.

Vessel Risk Factors		Data Quality Score	Comments		Risk Score
Pollution Potential Factors	A1: Oil Volume (total bbl)	Medium	Maximum of 700 bbl, reported to be leaking in the past		Med
	A2: Oil Type	High	Bunker oil is heavy fuel oil, a Group IV oil type		
	B: Wreck Clearance	High	Vessel not reported as cleared		
	C1: Burning of the Ship	High	No fire was reported		
	C2: Oil on Water	High	No oil was reported on the water		
	D1: Nature of Casualty	High	Collision		
	D2: Structural Breakup	High	The vessel is broken into three sections		
Archaeological Assessment	Archaeological Assessment	Low	The best assessment still comes from the initial salvage of the vessel so a detailed assessment was not prepared		Not Scored
Operational Factors	Wreck Orientation	High	Listing or resting on one side		Not Scored
	Depth	High	175 ft		
	Visual or Remote Sensing Confirmation of Site Condition	High	Wreck has been surveyed and visited by divers		
	Other Hazardous Materials Onboard	High	No		
	Munitions Onboard	High	Munitions for the Korean War		
	Gravesite (Civilian/Military)	High	No		
	Historical Protection Eligibility (NHPA/SMCA)	High	NHPA and possibly SMCA		
				WCD	**Most Probable**
Ecological Resources	3A: Water Column Resources	High	Area of water column affected above thresholds are relatively small and far offshore where sensitive resources are less concentrated	Low	Low
	3B: Water Surface Resources	High	Heavy fuel oil forms persistent tarballs that can affect large numbers of wintering marine birds	High	Med
	3C: Shore Resources	High	Exposed rocky shores and sand beaches support many marine mammal haulouts and large numbers of birds	Med	Low
Socio-Economic Resources	4A: Water Column Resources	High	There are sensitive offshore resources at risk including national marine sanctuaries	Med	Med
	4B: Water Surface Resources	High	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 would be impacted	Med	Med
Summary Risk Scores				15	12

Notes:
29,000 gallons remain trapped in the wreck.
(http://www.farallones.org/e_newsletter/2006-01/Luckenbach.htm)

100,000 gallons of fuel oil were removed from the wreck. There remains approximately 85,000 gallons that could not be reached during the lightering operation, and this oil may be released in the future as the wreck continues to deteriorate.
http://www.interior.gov/restoration/library/casedocs/upload/CA_Luckenbach_Seabird_Mortality.pdf

Divers from a marine consulting company have since removed approximately 100,000 gallons of bunker oil from various pockets and compartments where it is trapped in the wreck. The remaining oil cannot be safely removed and has been sealed inside.
http://sanctuarysimon.org/monterey/sections/other/sporadic_luckenbach.php

In the summer of 2002, the U.S. Coast Guard, using approximately $20 million from the OSLTF, conducted oil removal operations. These efforts relied upon divers breathing mixed gas and living in a pressurized chamber for up to a month. They used vacuum hoses to pump oil from the vessel to a barge stationed on the surface. During these operations, approximately 100,000 gallons of oil were removed (McCleneghan 2003). Because the oil was located in over 30 different compartments on the vessel, complete oil removal was difficult, and approximately 29,000 gallons that were not removable remain onboard. The remaining holes in the vessel were sealed at the completion of the response actions.
http://www.gc.noaa.gov/gc-rp/luckenbach_final_darp.pdf

The story of the *Luckenbach*, its discovery, its impacts, and the response operations has been widely documented. Related publications include:

Elliott, G. 2002. The SS *Jacob Luckenbach*: A Ghost Story. *California Coast & Ocean* 18: 14-17.

Hampton, S., R.G. Ford, H.R. Carter, C. Abraham, and D. Humple. 2003. Chronic oiling and seabird mortality from the sunken vessel SS *Jacob Luckenbach* in central California. *Marine Ornithology* 31:35-41.

Nevins, H.R. and H.R. Carter. 2003. Age and sex of Common Murre *Uria aalge* recovered during the 1997-98 Point Reyes Tarball Incidents in Central California. *Marine Ornithology* 31:51-58.

McCleneghan, K. 2003. Ghost of the *SS Jacob Luckenbach*: The hunt for clues to a killer. *Outdoor California* 64: 4-11. Also in *Oil Spill Intelligence Report* XXV, 12 December 2002.

McGrath, G.G., J.A. Tarpley, H.A. Parker-Hall, A. Nack. 2003. The investigation to identify the SS *Jacob Luckenbach*: Using technology to locate a hidden source of oil that caused years of impacts and the future implications of sunken shipwrecks. *Proceedings of the 2003 International Oil Spill Conference.* American Petroleum Institute. Washington, DC

Parker-Hall, H.A., S. Hampton, and J. Haas. 2003. Integrating trustee issues into a balanced response: Working toward a common goal. *Proceedings of the 2003 International Oil Spill Conference*. American Petroleum Institute. Washington, DC.

Hampton, S. and M. Zafonte. 2005. An analysis of factors influencing beached bird collection during the *Luckenbach* 2001-2002 oil spill. *Proceedings of the Pacific Seabird Group and The Waterbird Society Annual Meeting.* Portland, OR

Addassi, Y.N., K. Jennings, M. Ziccardi, J. Yamamoto, and S. Hampton. 2005. Longterm wildlife operations: Adaptations to traditional Incident Command Structure (or ICS). A case study of the *SS Jacob*

Luckenbach. *Proceedings of the International Oil Spill Conference.* American Petroleum Institute. Washington, DC.

Massey, G., Hampton, S. M. Ziccardi. 2005. A cost/benefit analysis of oiled wildlife response. *Proceedings of the 2005 International Oil Spill Conference*. American Petroleum Institute. Washington, DC.

http://www.uscg.mil/npfc/docs/PDFs/nrd/Luckenbach_Partial_Determination.pdf